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

LiDAR Surveys and Flood Mapping of Malaking Ilog River

University of the Philippines Training Center
for Applied Geodesy and Photogrammetry
Mapua Institute of Technology

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For questions/queries regarding this report, contact:

Dr. Francis Aldrine A. Uy
Project Leader, Phil-LiDAR 1 Program
MAPUA Institute of Technology
City of Manila, Metro Manila 1002
E-mail: faauy@mapua.edu.ph

Enrico C. Paringit, Dr. Eng.
Program Leader, Phil-LiDAR 1 Program
University of the Philippines Diliman
Quezon City, Philippines 1101
E-mail: ecparingit@up.edu.ph

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

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

CHAPTER 1: OVERVIEW OF THE PROGRAM AND MALAKING ILOG RIVER

Dr. Chelo Pascua 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 in 2014 entitled "Nationwide Hazard Mapping using LiDAR" or Phil-LiDAR 1, supported by the Department of Science and Technology (DOST) Grants-in-Aid (GiA) Program. The program was primarily aimed at acquiring a national elevation and resource dataset at sufficient resolution to produce information necessary to support the different phases of disaster management. Particularly, it targeted to operationalize the development of flood hazard models that would produce updated and detailed flood hazard maps for the major river systems in the country.

Also, the program was aimed at producing an up-to-date and detailed national elevation dataset suitable for 1:5,000 scale mapping, with 50 cm and 20 cm horizontal and vertical accuracies, respectively. These accuracies were achieved through the use of the state-of-the-art Light Detection and Ranging (LiDAR) airborne technology procured by the project through DOST. The methods applied in this report are thoroughly described in a separate publication entitled "FLOOD MAPPING OF RIVERS IN THE PHILIPPINES USING AIRBORNE LIDAR: METHODS (Paringit, et. al. 2017) available separately.

The implementing partner university for the Phil-LiDAR 1 Program is the Mapua Institue of Technology (MIT). MIT 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 26 river basins in the Southern Tagalog Region. The university is located in Makati City in the province of Metro Manila.

1.2 Overview of the Malaking Ilog River Basin

The Malaking Ilog River Basin is one of the largest river basins, covering eight municipalities in Batangas, Quezon, and Laguna. Its tributaries drain those municipalities located at the southwestern flank of Mount Banahaw, while its main channel separates San Juan and Candelaria, defining the boundary between Batangas and Quezon.

Almost every year, municipalities along the river channel are severely affected by floods caused by typhoons, such as Glenda and Ruby in 2014 and Nina in 2016. Managing flood risk and reduction of potential damage is particularly challenging in these areas because timely solutions are crucial. In line with this, a possible solution is generating flood hazard maps that feature information that are vital to reduce flood risks: flood height and potential extent.

A combination of several technologies has been employed to produce flood hazard maps. One is the introduction of LiDAR data, which primarily contains elevation used to derive the Digital Elevation Model or DEM. From elevation values, one can infer the presence and behavior of water bodies (such as rivers, streams, ponds, and lakes) and structures (such as roads, bridges, and buildings). Next, important data such as discharge and rainfall events gathered through fieldwork are used as inputs to the hydrological model. The gathered data is used to generate hydrographs that is used to create the calibrated model. These generated outputs, along with LiDAR data, will then be input for the river hydraulic model. The final output for these processes will be flood hazard maps of the river basin. The final output for these processes are flood hazard maps of different return periods of the Malaking Ilog River Basin.

The flood hazard map indicates the flood prone areas within the river basin. With the accuracy and precision of the LiDAR data, one can determine the flood height in a particular point or area. The LGUs of San Juan, Candelaria, Sariaya and other affected municipalities can now determine the appropriate locations for agriculture, businesses, and government projects. Thus, we can now make our wisest decisions based on the flood hazard map – decisions that could save many lives and properties.

Malaking Ilog River Basin covers portions of the Municipalities of Sariaya, Candelaria, Tiaong, Dolores and San Antonio in Quezon; Alaminos and San Pablo City in Laguna; and Padre Garcia and Lipa City in Batangas. It is among the four hundred twenty-one (421) river basins identified by the DENR-RCBO, with a total area of 781 sq. km. and an estimated annual run-off of 1,250 million cubic meters (MCM).

Its main stem, Malaking Ilog River, is located in the northern part of San Juan, Batangas. It serves as boundary for Batangas and Quezon and is considered to have the largest watershed in the province of Batangas. According to Batangas Province Flood and Landslide Susceptibility Map of San Juan, Batangas created by DENR Mines and Geosciences Bureau (MGB), the area of Malaking Ilog and its tributaries are highly susceptible to flooding. On October 2012, the municipality of San Juan, Batangas underwent state of calamity due to heavy rainfall brought by typhoon Ofel. The typhoon caused Malaking Ilog and Lawaye River to rise that flooded 30 of 42 barangays of San Juan.

CHAPTER 2: LIDAR DATA ACQUISITION OF THE MALAKING ILOG FLOODPLAIN

Engr. Louie P. Balicanta, Engr. Christopher Cruz, Lovely Gracia Acuna, Engr. Gerome Hipolito, Ms. Pauline Joanne G. Arceo, and Engr. Gef F. Soriano

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).

2.1 Flight Plans

Plans were made to acquire LiDAR data within the delineated priority area for Malaking Ilog floodplain in Calabarzon. These missions were planned for 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 found in Table 1 and Table 2. Figure 1 shows the flight plan for Malaking Ilog survey.

Table 1. Flight planning parameters for Gemini LiDAR System.

Block Name	Flying Height (AGL) (m)	Overlap (%)	Field of View (θ)	Pulse Repetition Frequency (PRF) (kHz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
BLK18A	1200	30	50	200	30	130	5
BLK18B	1200	30	50	200	30	130	5
BLK18C	1200	30	50	200	30	130	5
BLK18E	1200	30	50	200	30	130	5
BLK18J	1200	30	50	200	30	130	5
BLK18O	1200	30	50	200	30	130	5
BLK18P	1200	30	50	200	30	130	5
BLK18Q	1200	30	50	200	30	130	5
BLK18R	1200	30	50	200	30	130	5
BLK18S	1200	30	50	200	30	130	5
BLK18T	1200	30	50	200	30	130	5
BLK18U	1200	30	50	200	30	130	5
BLK18V	1200	30	50	200	30	130	5
BLK18W	1200	30	50	200	30	130	5

Table 2. Flight planning parameters for Gemini LiDAR System.

Block Name	Flying Height (AGL) (m)	Overlap (%)	Field of View (θ)	Pulse Repetition Frequency (PRF)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
BLK18SA	1000	30	40	100	20	130	5
BLK18SB	1000	30	40	100	20	130	5

BLK18SC	1000	30	40	100	20	130	5
BLK18SD	1000	30	40	100	20	130	5
BLK18SE	1000	30	40	100	20	130	5
BLK18SF	1000	30	40	100	20	130	5
BLK18SK	1000	30	40	100	20	130	5
BLK18SL	1000	30	40	100	20	130	5

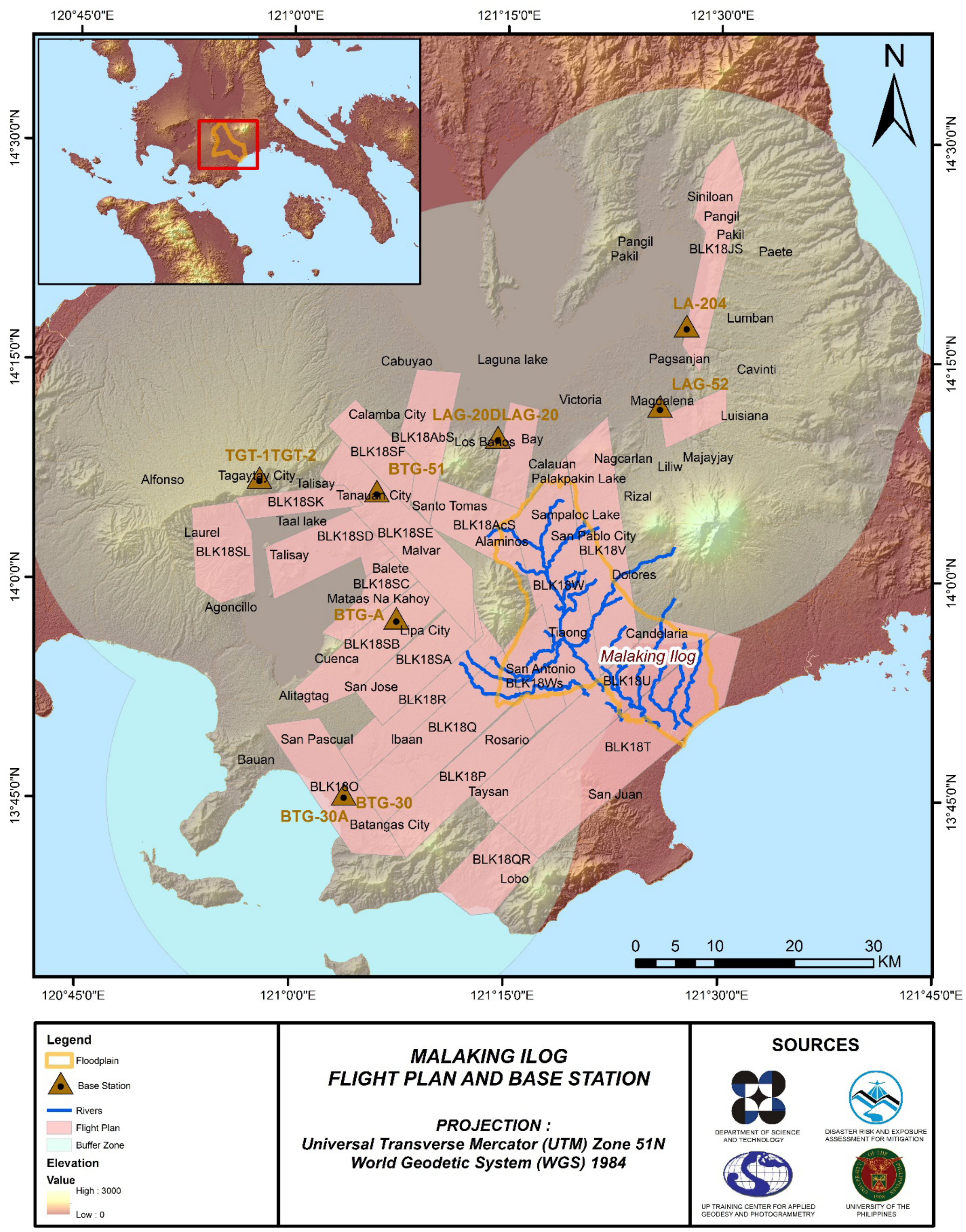

Figure 1. Flight plans and base stations used for Malaking Ilog floodplain.

2.2 Ground Base Stations

The project team was able to recover five (5) NAMRIA ground control points (GCPs): QZN-21, BTG-30, BTG-51, LAG-52, which are of second (2nd) order accuracy, LAG-20 which is of third (3rd) order accuracy, and one (1) NAMRIA benchmark, LA-204. The project team also established four (4) GCPs, BTG-A, BTG-30A, LAG-20D, and TGT-1. The certifications for the NAMRIA reference points are found in Annex 3 while the baseline processing reports for the established points are found in Annex 4. These were used as base stations during flight operations for the entire duration of the survey (December 22, 2015, January 9, 2016, August 26-29, 2016, and September 4-5, 2016). Base stations were observed using dual frequency GPS receivers, TRIMBLE SPS 882 and SPS 852. Flight plans and location of base stations used during the aerial

LiDAR acquisition in Malaking Ilog floodplain are shown in Figure 1.

Figure 2 to Figure 7 show the recovered NAMRIA GCPs within the area. In addition, Table 3 to Table 12 show the details about the NAMRIA control stations and established control points. Table 13 shows the list of all GCPs occupied during the acquisition together with the corresponding dates of utilization.

Figure 2. GPS set-up over BTG-30 in the vicinity of Brgy. Pallocan, Batangas City along the E side dike of Calumpang River, on the N side of Calumpang Bridge (a) and NAMRIA reference point BTG-30 (b) as recovered by the field team.

Table 3. Details of the recovered NAMRIA horizontal control point BTG-30 used as base station for the LiDAR Acquisition.

Station Name	BTG-30	
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	13° 45' 23.09641" North 121° 03' 43.87174" East 7.82000 meters
Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 3 PRS 92)	Easting Northing	506725.034 meters 1521226.752 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	13° 45'17.88182" North 121° 03' 48.83762" East 53.872 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	290477.094 meters 1521536.181 meters

(a)

(b)

Figure 3. GPS set-up over BTG-51 in the vicinity of Mabini Shrine in Brgy, Talaga, Tanuan City, Batangas (a) NAMRIA reference point BTG-51 (b) as recovered by the field team.

Table 4. Details of the recovered NAMRIA horizontal control point BTG-51 used as base station for the LiDAR Acquisition.

Station Name	BTG-51	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	14° 06’ 8.57112” North
	Longitude	121° 05’ 52.31002” East
	Ellipsoidal Height	152.36900 meters
Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 3 PRS 92)	Easting	510567.544 meters
	Northing	1559501.067 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	14° 06’ 3.27790” North
	Longitude	121° 05’ 57.24592” East
	Ellipsoidal Height	197.55100 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting	1559783.81 meters
	Northing	294641.94 meters

(a)

(b
)

Figure 4 GPS set-up over LAG-20 near the freedom park in University of the Philippines Los Baños (a) and NAMRIA reference point LAG-20 (b) as recovered by the field team.

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

Station Name	LAG-20	
Order of Accuracy	3rd	
Relative Error (horizontal positioning)	1 in 20,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	14° 9’ 53.86904” North
	Longitude	121° 14’ 20.35180” East
	Ellipsoidal Height	39.91400 meters
Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 3 PRS 92)	Easting	525799.268 meters
	Northing	1566435.481 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	14°9 ’48.57270” North
	Longitude	121°14’25.28172” East
	Ellipsoidal Height	85.26600 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting	309934.22 meters
	Northing	1566588.99 meters

(a)

(b
)

Figure 5. GPS set-up over LA-204 on Lumban Bridge, Lumban Laguna (a) and NAMRIA reference point LA-204 (b) as recovered by the field team.

Table 6. Details of the recovered NAMRIA vertical control point LA-204 used as base station for the LiDAR acquisition with re-processed coordinates.

Station Name	LA-204	
Order of Accuracy	2nd	
Relative error (horizontal positioning)	1 in 50,000	
Processed coordinates		
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	18° 03' 46.30032" North
	Longitude	121° 38' 38.76326" East
	Ellipsoidal Height	37.212 meters
Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 3 PRS 92)	Easting	568188.029 meters
	Northing	1997837.978 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	18° 03' 40.15861" North
	Longitude	121° 38' 43.36193" East
	Ellipsoidal Height	71.696 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting	356498.94 meters
	Northing	1997546.44 meters

Figure 6. GPS set-up over LAG-20D inside the UP Los Baños compound near LAG-20.

Table 7. Details of the established NAMRIA horizontal control point LAG-20D used as base station for the LiDAR acquisition with re-processed coordinates.

Station Name	LAG-20D	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1:50,000	
Geographic Coordinates Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	14° 9' 53.95582" North 121° 14' 20.28364" East 39.62900 meters
Geographic Coordinates World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	14° 9' 48.65929" North 121° 14' 25.21352" East 39.929 meters
Grid Coordinates Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	309932.197 meters 1566591.667 meters

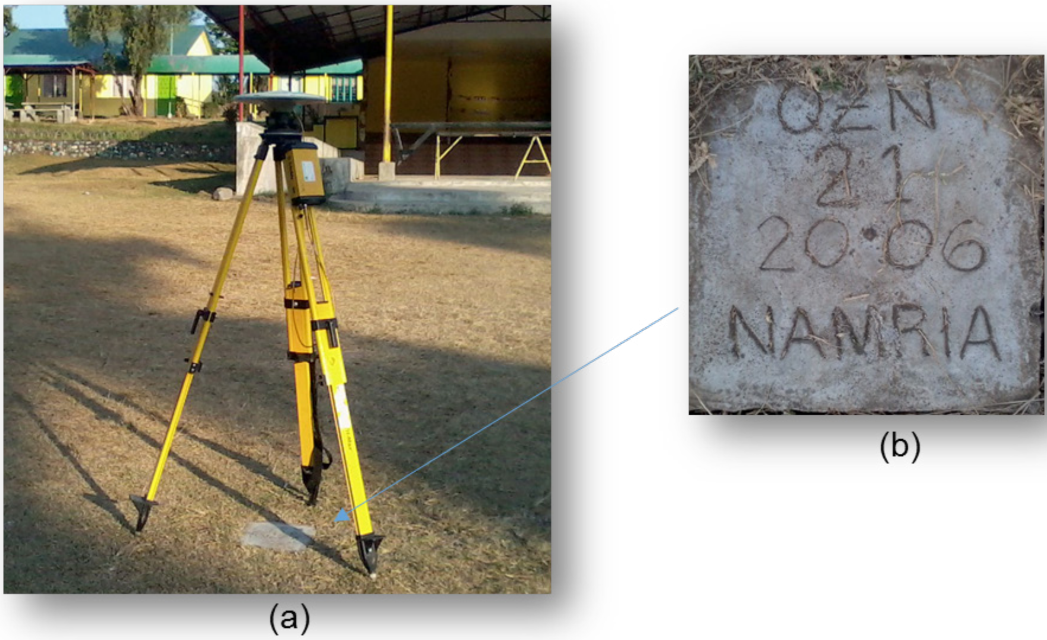

Figure 7. GPS set-up over QZN-21 inside Paaralang Elementarya ng Silangang Tiaong of Brgy. Poblacion III, Tiaong, Quezon Province (a) and NAMRIA reference point QZN-21 (b) as recovered by the field team.

Table 8. Details of the recovered NAMRIA horizontal control point QZN-21 used as base station for the LiDAR Acquisition.

Station Name	QZN-21	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1:50,000	
Geographic Coordinates Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	13° 57’ 44.31576” North 121° 19’ 27.34822” East 51.25800 meters
Grid Coordinates Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	535036.042 meters 1544027.063 meters
Geographic Coordinates World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	13° 57’ 39.07397” North 121° 19’ 32.29499” East 97.38200 meters
Grid Coordinates Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	318981.12 meters 1544101.56 meters

Table 9. Details of the recovered NAMRIA horizontal control point LAG-52 used as base station for the LiDAR acquisition..

Station Name	LAG-52	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1:50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	14° 12’ 4.64805” North 121° 25’ 41.33587” East 66.698 meters
Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 3 PRS 92)	Easting Northing	546212.761 meters 1570483.553 meters

Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	14° 11'59.35842" North
	Longitude	121° 25' 46.26158" East
	Ellipsoidal Height	112.41 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting	330382.29 meters
	Northing	1570462.41 meters

Table 10. Details of the established NAMRIA horizontal control point BTG-30A used as base station for the LiDAR acquisition with re-processed coordinates.

Station Name	BTG-30A	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1:50,000	
Geographic Coordinates Philippine Reference of 1992 Datum (PRS 92)	Latitude	13° 45' 22.92484" North
	Longitude	121° 3' 43.84397" East
	Ellipsoidal Height	7.896 meters
Grid Coordinates Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting	290476.321 meters
	Northing	1521531.468 meters
Geographic Coordinates World Geodetic System 1984 Datum (WGS 84)	Latitude	13° 45' 17.72826" North
	Longitude	121° 3' 48.80985" East
	Ellipsoidal Height	53.950 meters

Table 11. Details of the established NAMRIA horizontal control point BTG-A used as base station for the LiDAR acquisition with re-processed coordinates.

Station Name	BTG-A	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1:50,000	
Geographic Coordinates Philippine Reference of 1992 Datum (PRS 92)	Latitude	13° 57' 27.65020" North
	Longitude	121° 7' 18.59698 " East
	Ellipsoidal Height	373.826 meters
Grid Coordinates Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting	297103.192 meters
	Northing	1543753.102 meters
Geographic Coordinates World Geodetic System 1984 Datum (WGS 84)	Latitude	13° 57' 22.39320" North
	Longitude	121° 7' 23.54499" East
	Ellipsoidal Height	419.466 meters

Table 12. Details of the recovered NAMRIA horizontal control point TGT-1 used as base station for the LiDAR acquisition.

Station Name	TGT-1	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1:50,000	
Geographic Coordinates Philippine Reference of 1992 Datum (PRS 92)	Latitude	14° 07' 00.06415" North
	Longitude	120° 57' 38.31809 " East
	Ellipsoidal Height	613.234 meters
Grid Coordinates Philippine Transverse Mercator Zone 5 (PTM Zone 3 PRS 92)	Easting	279835.803 meters
	Northing	1561490.784 meters
Geographic Coordinates World Geodetic System 1984 Datum (WGS 84)	Latitude	14° 06' 54.775674" North
	Longitude	120° 57' 43.25314" East
	Ellipsoidal Height	658.040 meters

Table 13. Ground Control Points used during LiDAR Data Acquisition

Date Surveyed	Flight Number	Mission Name	Ground Control Points
February 10, 2014	1091P	1BLK18W41A	QZN-21
February 11, 2014	1095P	1BLK18U42A	QZN-21
February 12, 2014	1099P	1BLK18U43A	QZN-21
February 13, 2014	1103P	1BLK18VWS44A	QZN-21
February 13, 2014	1105P	1BLK18T44B	QZN-21
February 14, 2014	1107P	1BLK18QRS45A	QZN-21
February 14, 2014	1109P	1BLK18US45B	QZN-21
February 15, 2014	1111P	1BLK18QRS46A	QZN-21
February 18, 2014	1125P	1BLK18S49B	BTG-30, BTG-30A
December 22, 2015	3002P	1BLK18SB356A	BTG-51, BTG-A, TGT-1
August 26, 2016	3341P	1BLK18ABS238A	LAG-20, LAG-20D
August 26, 2016	3343P	1BLK18ACS238B	LAG-20, LAG-20D
August 27, 2016	3345P	1BLK18TSCALIB239A	LAG-20, LAG-20D
August 27, 2016	3347P	1BLK18TS239B	LAG-20, LAG-20D
August 29, 2016	3353P	1BLK18QRS241A	BTG-30, BTG-30A
September 4, 2016	3377P	1BLK18JS247A	BMLA-204, LAG-52
September 5, 2016	3381P	1BLK18OS248A	BTG-30, BTG-30A
January 9, 2016	3689G	2BLK18SVV009A	BTG-51, BTG-A

2.3 Flight Missions

Eighteen (18) missions were conducted to complete LiDAR data acquisition in Malaking Ilog floodplain, for a total of sixty three hours and forty two minutes (63+42) of flying time for RP-C9122 and RP-C9022. All missions were acquired using the Pegasus and Gemini LiDAR systems. Table 14 shows the total area of actual coverage and the corresponding flying hours per mission while Table 15 presents the actual parameters used during the LiDAR data acquisition.

Table 14. Flight Missions for LiDAR D\data A\acquisition in Malaking Ilog floodplain.

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
February 10, 2014	1091P	182.22	244.09	189.17	54.93	510	3	59
February 11, 2014	1095P	437.74	163.15	64.23	98.92	2	3	59
February 12, 2014	1099P	437.74	223.18	107.80	115.39	NA	3	53
February 13, 2014	1103P	229.38	249.87	139.83	110.05	NA	3	44

February 13, 2014	1105P	253.96	284.46	82.65	201.81	NA	3	36
February 14, 2014	1107P	263.60	161.48	17.05	144.43	295	3	35
February 14, 2014	1109P	183.78	189.53	78.88	110.65	NA	3	11
February 15, 2014	1111P	32.14	177.51	5.97	171.55	341	3	47
February 18, 2014	1125P	117.57	63.63	-	63.63	NA	2	20
December 22, 2015	3002P	658.24	280.86	-	280.86	613	3	21
August 26, 2015	3341P	238.41	118.74	-	118.74	NA	3	42
August 26, 2015	3343P	238.41	151.27	46.78	104.50	NA	3	30
August 27, 2015	3345P	238.41	199.86	164.15	35.71	NA	3	34
August 27, 2015	3347P	238.41	106.51	67.34	39.16	NA	2	31
August 29, 2015	3353P	386.74	171.86	8.56	163.31	NA	3	55
September 4, 2015	3377P	210.45	145.09	1.21	143.88	NA	3	13
September 5, 2015	3381P	287.25	200.93	7.21	193.72	NA	4	5
January 9, 2016	3689G	65.65	139.78	-	139.78	NA	3	47
TOTAL		4700.10	3271.80	7971.90	2291.02	1761	63	42

Table 15. Actual Parameters used during LiDAR Data Acquisiton.

Flight Number	Flying Height (AGL) (m)	Overlap (%)	Field of View (θ)	PRF (kHz)	Scan Frequency (Hz)	Average Speed (Kts)	Average Turn Time (Minutes)
1091P	1100	20	50	200	30	130	5
1095P	1200	30	50	200	30	130	5
1099P	1200	30	50	200	30	130	5
1103P	1200	30	50	200	30	130	5
1105P	1200	30	50	200	30	130	5
1107P	1200	30	50	200	30	130	5
1109P	1200	30	50	200	30	130	5
1111P	1200	30	50	200	30	130	5
1125P	1200	30	50	200	20	130	5

3002P	1100	15	50	200	30	130	5
3341P	1000	60	50	200	30	130	5
3343P	1000	60	50	200	30	130	5
3345P	1000	60	50	200	30	130	5
3347P	1000	60	50	200	30	130	5
3353P	1000	30	50	200	30	130	5
3377P	1100	30	50	200	30	130	5
3381P	1100	20	50	200	30	130	5
3689G	850	30	40	100	20	130	5

2.4 Survey Coverage

Malaking Ilog Floodplain is located in the province of Quezon. The municipalities of Padre Garcia, Rosario, Ibaan, Malvar, Taysan, and Santo Tomas in Batangas; San Pablo City, Alaminos, and Calauan in Laguna; Candelaria and Dolores in Quezon; are mostly covered by the survey. The list of municipalities and cities surveyed, with at least one (1) square kilometer coverage, is shown in Table 16. The actual coverage of the LiDAR acquisition for Malaking Ilog floodplain is shown in Figure 8.

Table 16. List of Municipalities/Cities Surveyed during Malaking Ilog Floodplain LiDAR survey.

Province	Municipality/City	Area of Municipality/City (km²)	Total Area Surveyed (km²)	Percentage of Area Surveyed
Batangas	Padre Garcia	40.70	40.67	100%
	Rosario	197.03	195.53	99%
	Ibaan	69.11	64.52	93%
	Malvar	35.93	31.84	89%
	Taysan	91.03	76.49	84%
	Santo Tomas	92.08	76.14	83%
	San Pascual	35.81	27.47	77%
	Tanauan City	111.77	74.25	66%
	San Juan	236.84	150.00	63%
	Lipa City	202.79	127.45	63%
	Cuenca	27.91	16.56	59%
	Lobo	199.87	101.69	51%
	San Jose	60.70	30.68	51%
	Talisay	49.78	19.73	40%
	Alitagtag	27.03	9.60	36%
	Bauan	51.31	13.72	27%
	Mataas Na Kahoy	17.59	4.10	23%
	Agoncillo	39.54	9.00	23%
	Batangas City	274.48	49.65	18%
	Balete	22.02	2.01	9%
	Laurel	69.53	4.22	6%
	Taal lake	241.24	8.00	3%
Cavite	Tagaytay	61.41	3.63	6%

Laguna	San Pablo City	180.93	158.33	88%
	Alaminos	60.56	51.41	85%
	Calauan	79.44	63.52	80%
	Bay	40.80	30.35	74%
	Calamba City	130.68	65.26	50%
	Los Ba±os	50.48	18.06	36%
	Luisiana	61.00	16.67	27%
	Majayjay	64.40	15.35	24%
	Nagcarlan	81.20	13.07	16%
	Pagsanjan	40.77	6.07	15%
	Magdalena	29.61	4.36	15%
	Cabuyao	45.70	6.23	14%
	Pangil	35.64	4.30	12%
	Liliw	36.20	4.09	11%
	Victoria	28.37	3.18	11%
	Rizal	24.02	2.09	9%
	Pakil	30.02	2.38	8%
	Lumban	117.34	4.99	4%
	Laguna lake	892.20	19.61	2%
	Siniloan	26.18	0.56	2%
	Cavinti	96.78	1.69	2%
	Paete	78.93	0.85	1%
Quezon	Candelaria	109.11	106.39	98%
	Dolores	60.34	57.08	95%
	San Antonio	158.33	107.48	68%
	Sariaya	198.91	109.68	55%
	Tiaong	61.28	26.10	43%
Total		5074.72	2036.10	40.12%

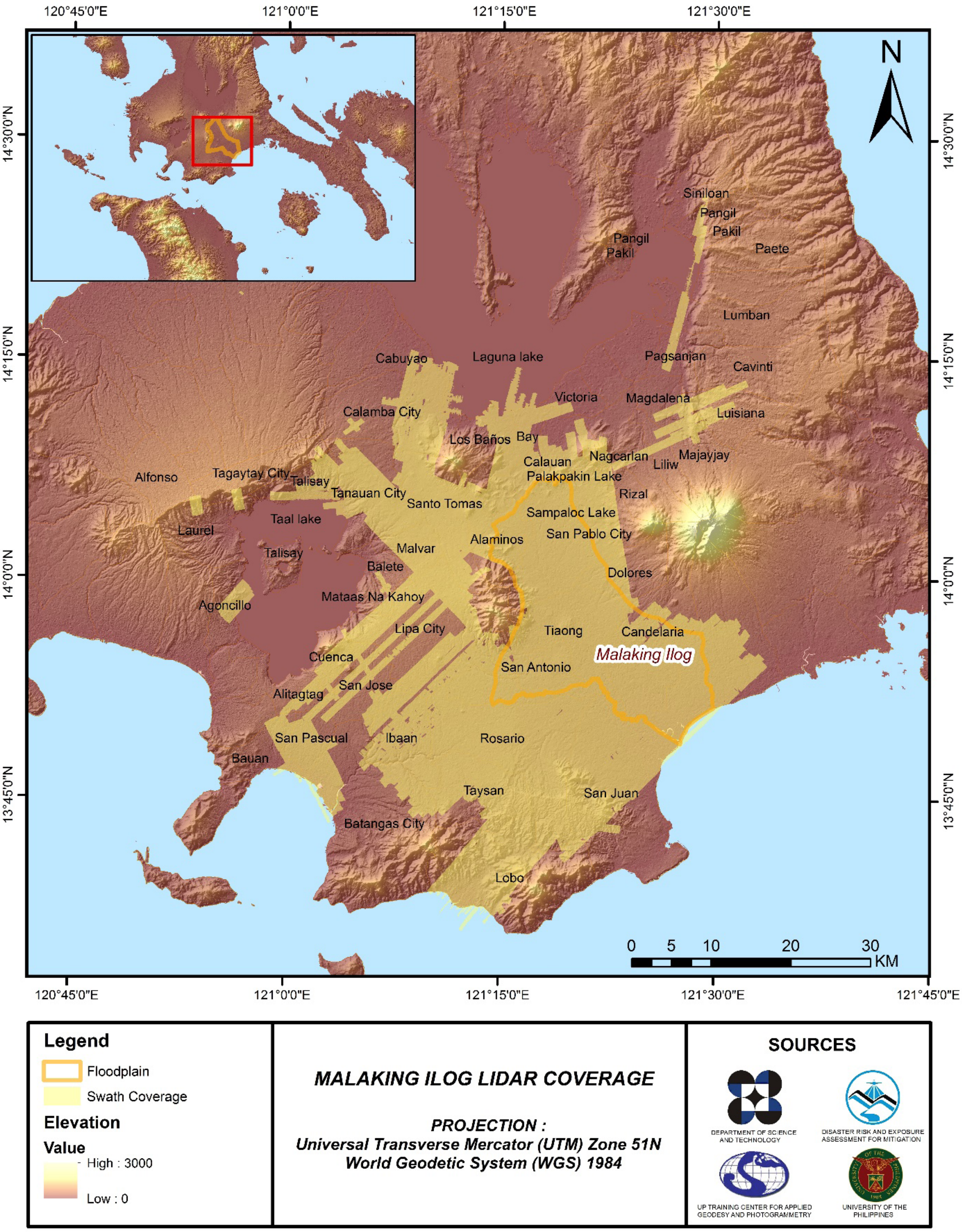

Figure 8. Actual LiDAR survey coverage for Malaking Ilog floodplain.

CHAPTER 3: LIDAR DATA PROCESSING OF THE MALAKING ILOG FLOODPLAIN

Engr. Ma. Rosario Concepcion O. Ang, Engr. John Louie D. Fabila, Engr. Sarah Jane D. Samalburo , Engr. Joida F. Prieto, Engr. Melissa F. Fernandez, Engr. Ma. Ailyn L. Olanda, Engr. Sheila Maye F. Santillan, Engr. Merven Matthew D. Natino, Engr. Ezzo Marc C. Hibionada, Ziarre Anne P. Mariposa

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

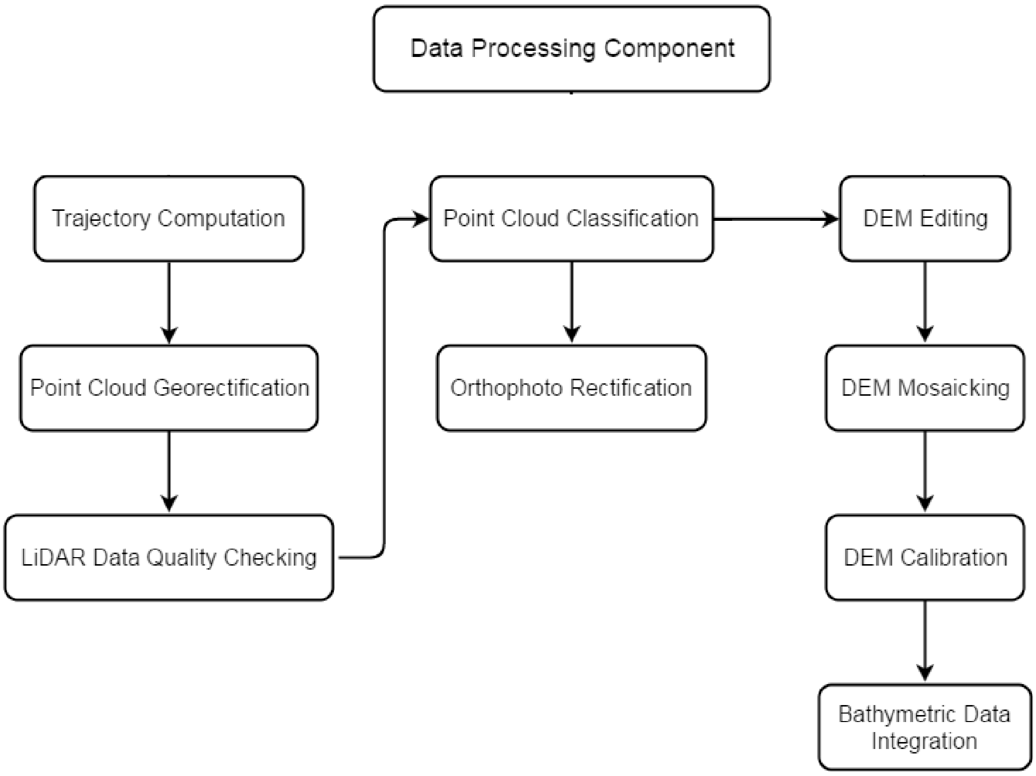

Figure 9. Schematic Diagram for Data Pre-Processing Component.

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 9.

3.2 Transmittal of Acquired LiDAR Data

Data transfer sheets for all the LiDAR missions for Malaking Ilog floodplain can be found in Annex 5. Missions flown during the first survey conducted on April 2014 used the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.) Pegasus system while missions acquired during the second survey on September 2015 were flown using the Gemini system and Pegasus and Gemini systems for missions acquired during the third survey on February 2016 over Tiaong, Quezon. The Data Acquisition Component (DAC) transferred a total of 314.73 Gigabytes of Range data, 3.68 Gigabytes of POS data, 219.90 Megabytes of GPS base station data, and 191.13 Gigabytes of raw image data to the data server on April 10, 2014 for the first survey, September 11, 2015 for the second survey, and February 28, 2016 for the third survey. The Data Pre-processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for Malaking Ilog was fully transferred on February 28, 2016, as indicated on the Data Transfer Sheets for Malaking Ilog floodplain.

3.3 Trajectory Computation

The Smoothed Performance Metrics of the computed trajectory for flight 3341P, one of the Malaking Ilog flights, which is the North, East, and Down position RMSE values are shown in Figure 10. The x-axis corresponds to the time of flight, which is measured by the number of seconds from the midnight of the start of the GPS week, which on that week fell on September 7, 2105 00:00AM. The y-axis is the RMSE value for that particular position.

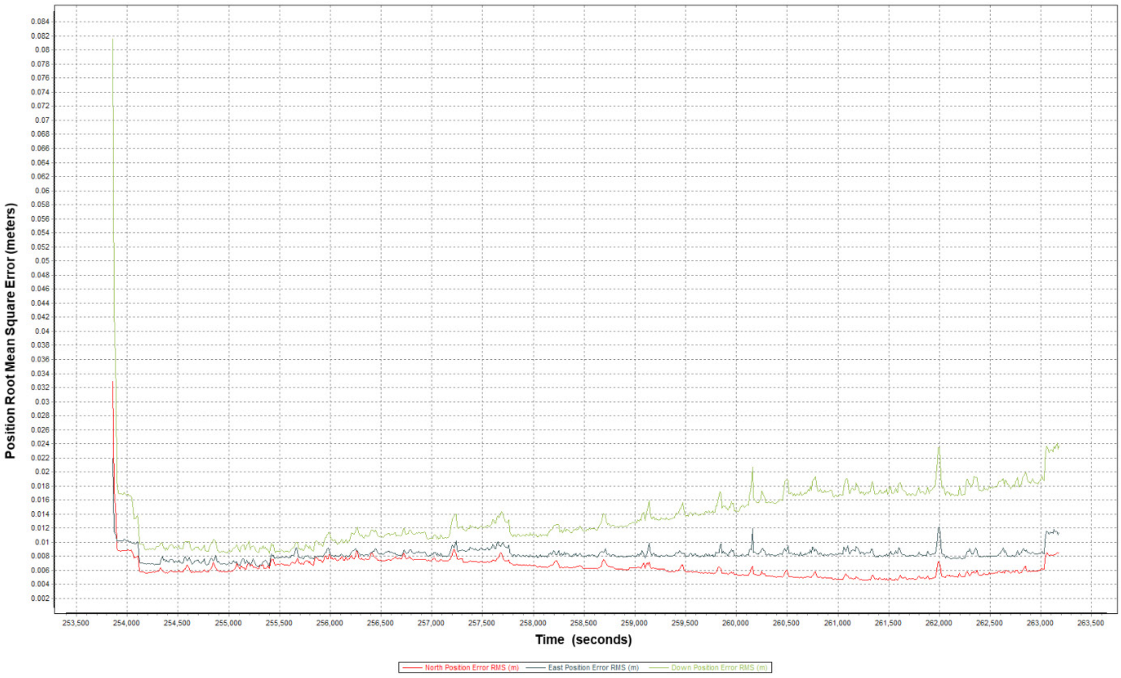

Figure 10. Smoothed Performance Metrics of a Malaking Ilog Flight 3341P.

The time of flight was from 253,900 seconds to 263,200 seconds, which corresponds to morning of September 7, 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 minimized the RMSE value of the positions. The periodic increase in RMSE values from an otherwise smoothly curving RMSE values correspond to the turn-around period of the aircraft, when the aircraft makes a turn to start a new flight line. Figure 10 shows that the North position RMSE peaks at 0.90 centimeters, the East position RMSE peaks at 1. 20 centimeters, and the Down position RMSE peaks at 2.40 centimeters, which are within the prescribed accuracies described in the methodology.

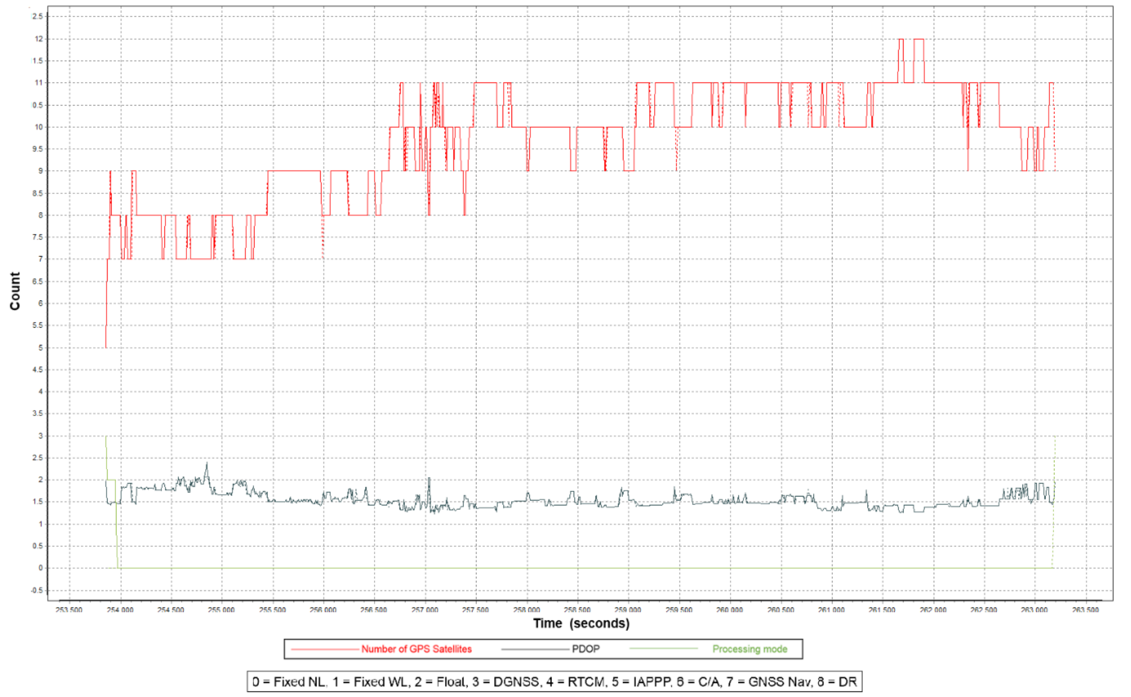

Figure 11. Solution Status Parameters of Malaking Ilog Flight 3341P.

The Solution Status parameters of flight 3341P, one of the Malaking Ilog flights, which are the number of GPS satellites, Positional Dilution of Precision (PDOP), and the GPS processing mode used, are shown in Figure 11. The graphs indicate that the number of satellites during the acquisition did not go down to 6. Majority of the time, the number of satellites tracked was between 7 and 12. The PDOP value also did not go above the value of 3, which indicates optimal GPS geometry. The processing mode stayed at the value of 0 for majority of the survey. The value of 0 corresponds to a Fixed, Narrow-Lane mode, which is the optimum carrier-cycle integer ambiguity resolution technique available for POSPAC MMS. All of the parameters adhered to the accuracy requirements for optimal trajectory solutions, as indicated in the methodology. The computed best estimated trajectory for all Malaking Ilog flights is shown in Figure 12.

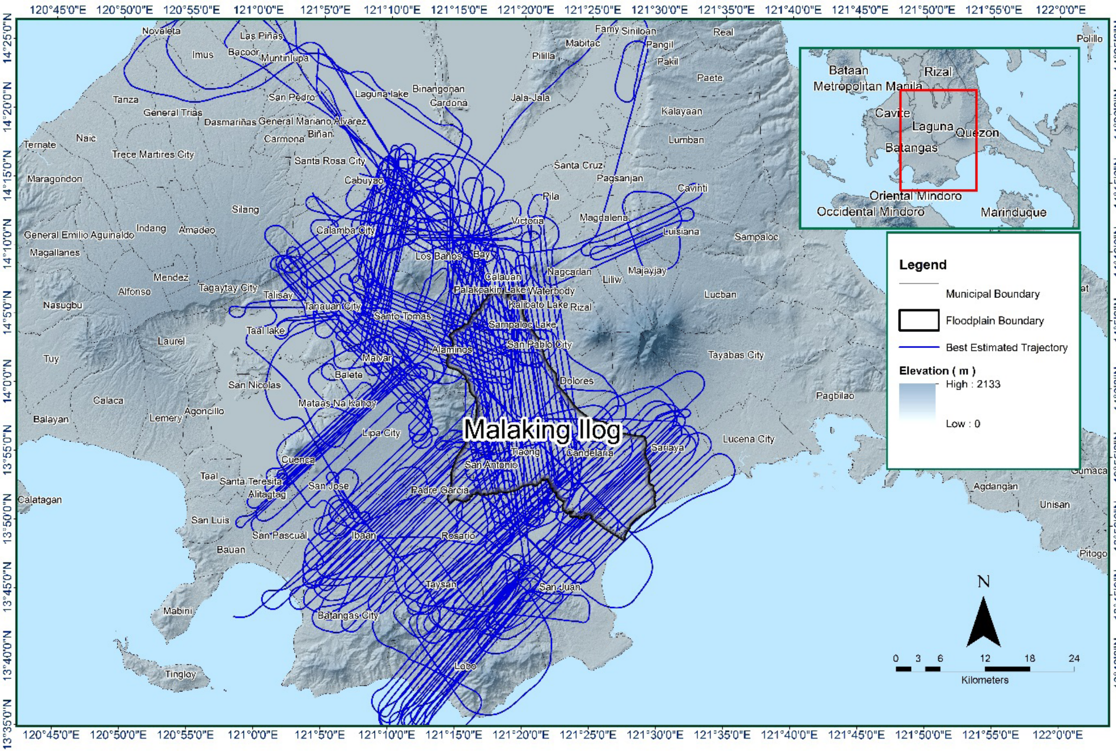

Figure 12. Best Estimated Trajectory for Malaking Ilog floodplain.

3.4 LiDAR Point Cloud Computation

The produced LAS data contains 188 flight lines, with each flight line containing one channel for the Gemini system and two channels for Pegasus system. The summary of the self-calibration results obtained from LiDAR processing in LiDAR Mapping Suite (LMS) software for all flights over Malaking Ilog floodplain are given in Table 17.

Table 17. Self-Calibration Results values for Malaking Ilog flights

Parameter	Absolute Value	Computed Value
Boresight Correction stdev	(<0.001degrees)	0.00021
IMU Attitude Correction Roll and Pitch Corrections stdev	(<0.001degrees)	0.000571
GPS Position Z-correction stdev	(<0.01meters)	0.0017

The optimum accuracy is obtained for all Malaking Ilog flights based on the computed standard deviations of the corrections of the orientation parameters. Standard deviation values for individual blocks are available in the Annex 8. Mission Summary Reports.

3.5 LiDAR Quality Checking

The boundary of the processed LiDAR data on top of a SAR Elevation Data over Malaking Ilog Floodplain is shown in Figure 13. The map shows gaps in the LiDAR coverage that are attributed to cloud coverage.

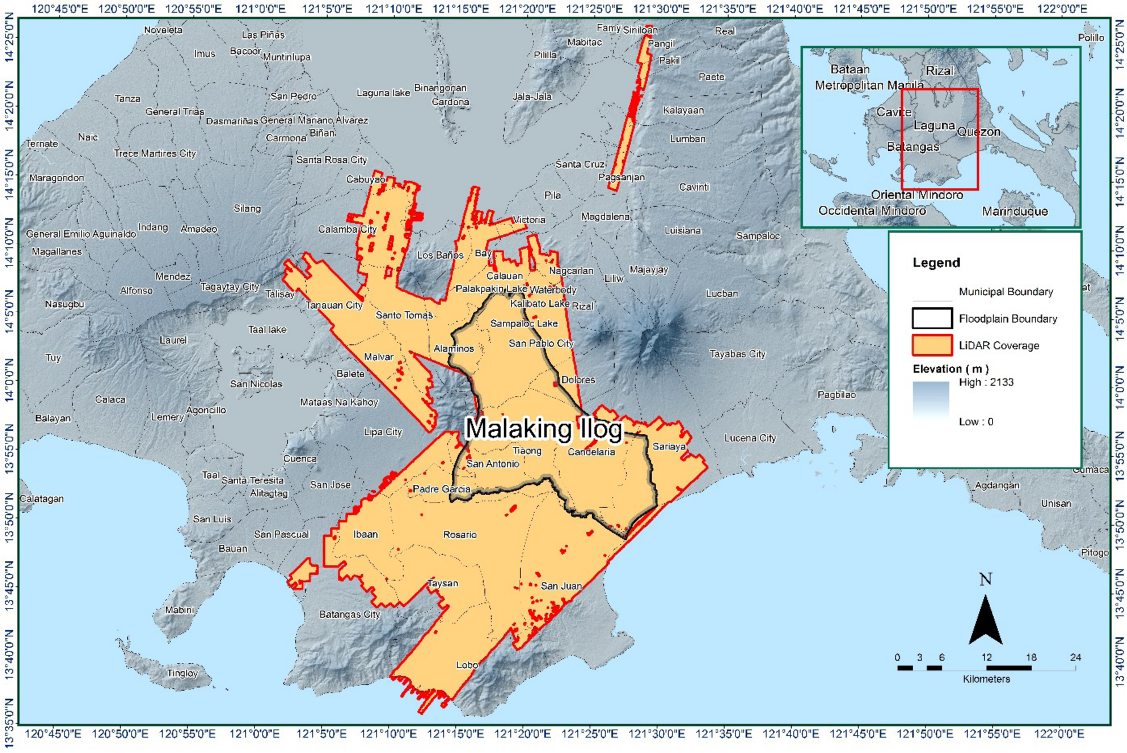

Figure 13. Boundary of the processed LiDAR data over Malaking Ilog Floodplain.

The total area covered by the Malaking Ilog missions is 2,452.02 sq.km that is comprised of eighteen (18) flight acquisitions grouped and merged into fifteen (15) blocks as shown in Table 18.

Table 18. List of LiDAR blocks for Malaking Ilog floodplain

LiDAR Blocks	Flight Numbers	Area (sq. km)
CALABARZON_Blk18A_additional	3377P	74.80
CALABARZON_Blk18W_additional	3345P	99.50
	3347P	
CALABARZON_Blk18A	3347P	227.59
	3343P	
	3341P	
CALABARZON_Blk18U_additional2	3353P	32.51
CALABARZON_Blk18U_supplement	3381P	180.66
Batangas_Blk18SE	3002P	138.62
Batangas_Blk18SE_additional1	3689G	11.97
Batangas_Blk18QRs1	1107P	158.90
Batangas_Blk18QR	1111P	179.49
	1125P	
Laguna_Blk18T	1105P	263.85
Laguna_Blk18U_supplement	1109P	179.70
Laguna_Blk18U	1095P	262.38
	1099P	
Laguna_Blk18VW_supplement	1103P	233.10
Laguna_Blk18W	1091P	242.24
Laguna_Blk18EFG_supplement	1111P	166.71

TOTAL	2,452.02 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 14. Since the Gemini system employs one channel, we would expect an average value of 1 (blue) for areas where there is limited overlap, and a value of 2 (yellow) or more (red) for areas with three or more overlapping flight lines while 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 for the Pegasus system.

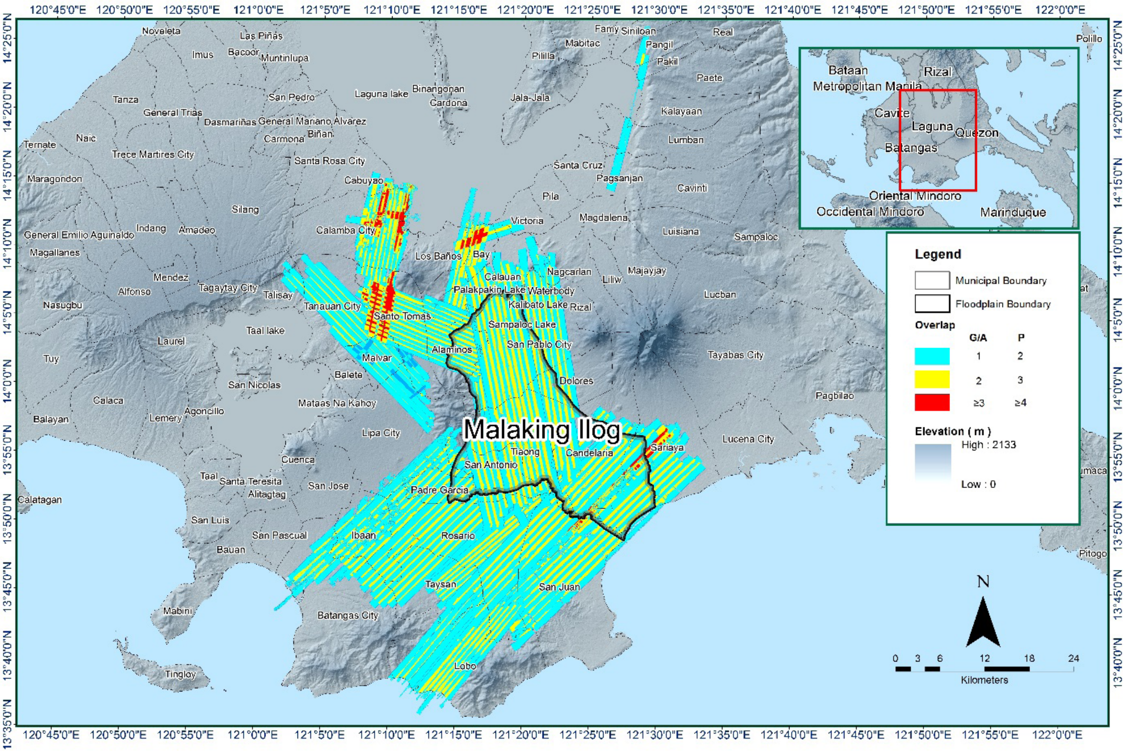

Figure 14. Image of data overlap for Malaking Ilog floodplain.

The overlap statistics per block for the Malaking Ilog floodplain can be found in Annex 8. One pixel corresponds to 25.0 square meters on the ground. For this area, the minimum and maximum percent overlaps are 28.76% and 60.87% respectively, which passed the 25% requirement.

The pulse density map for the merged LiDAR data, with the red parts showing the portions of the data that satisfy the 2 points per square meter criterion is shown in Figure 15. It was determined that all LiDAR data for Malaking Ilog floodplain satisfy the point density requirement, and the average density for the entire survey area is 2.56 points per square meter.

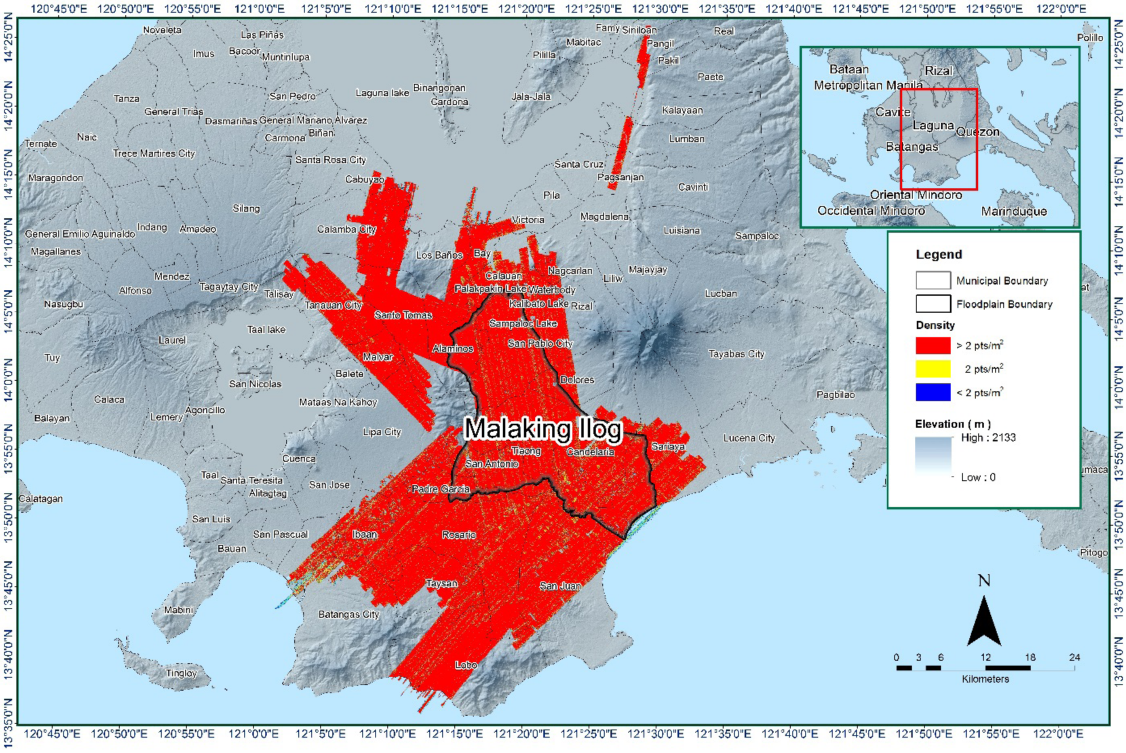

Figure 15. Pulse density map of merged LiDAR data for Malaking Ilog floodplain.

The elevation difference between overlaps of adjacent flight lines is shown in Figure 16. The default color range is from blue to red, where bright blue areas correspond to portions where elevations of a previous flight line, identified by its acquisition time, are higher by more than 0.20m relative to elevations of its adjacent flight line. Bright red areas indicate portions where elevations of a previous flight line are lower by more than 0.20m relative to elevations of its adjacent flight line. Areas with bright red or bright blue need to be investigated further using Quick Terrain Modeler software.

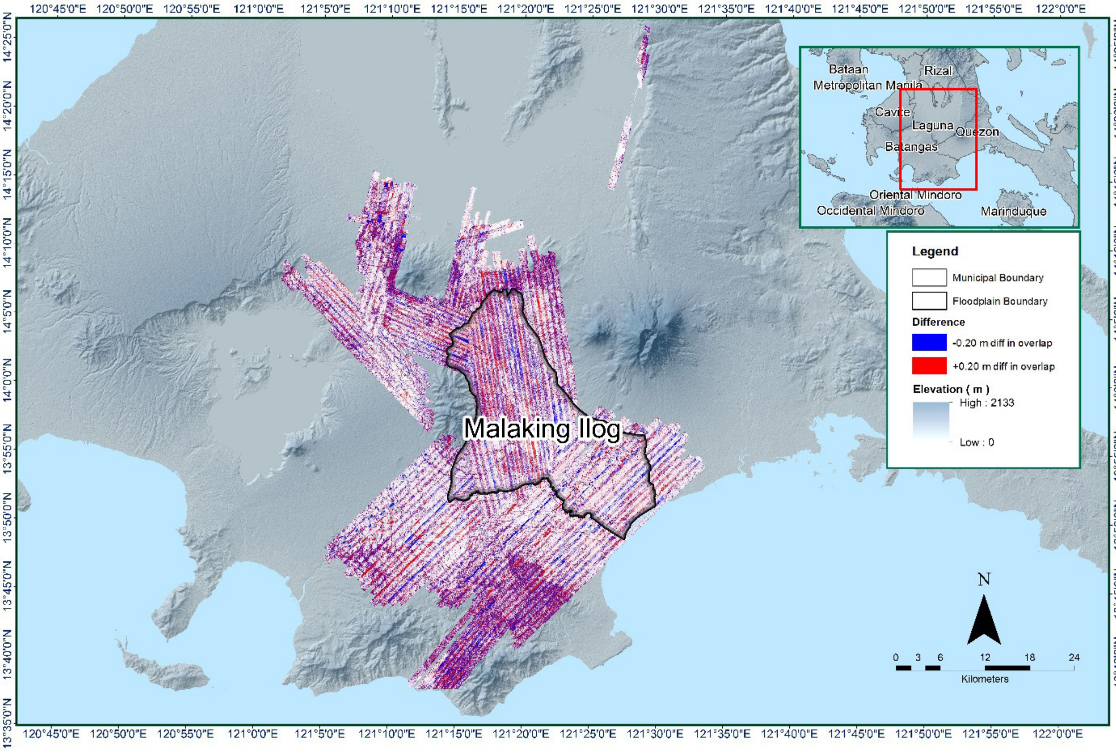

Figure 16. Elevation difference map between flight lines for Malaking Ilog floodplain.

A screen capture of the processed LAS data from a Malaking Ilog flight 3341P loaded in QT Modeler is shown in Figure 17. The upper left image shows the elevations of the points from two overlapping flight strips traversed by the profile, illustrated by a dashed red line. The x-axis corresponds to the length of the profile. It is evident that there are differences in elevation, but the differences do not exceed the 20-centimeter mark. This profiling was repeated until the quality of the LiDAR data becomes satisfactory. No reprocessing was done for this LiDAR dataset.

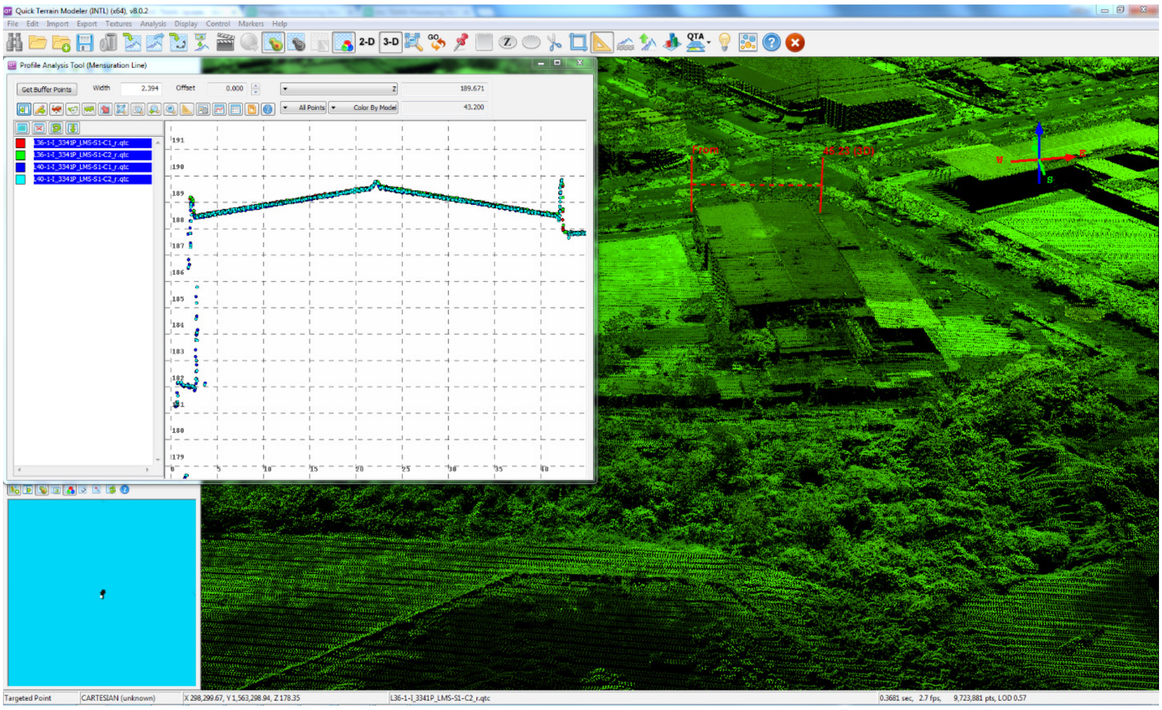

Figure 17. Quality checking for a Malaking Ilog flight 3341P using the Profile Tool of QT Modeler.

3.6 LiDAR Point Cloud Classification and Rasterization

Table 19. Malaking Ilog classification results in TerraScan.

Pertinent Class	Total Number of Points
Ground	2,258,635,406
Low Vegetation	2,265,684,756
Medium Vegetation	2,632,134,034
High Vegetation	3,374,420,455
Building	334,905,653

The tile system that TerraScan employed for the LiDAR data and the final classification image for a block in Malaking Ilog floodplain is shown in Figure 18. A total of 3,750 1km by 1km tiles 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 1,142.15 meters and 33.16 meters respectively.

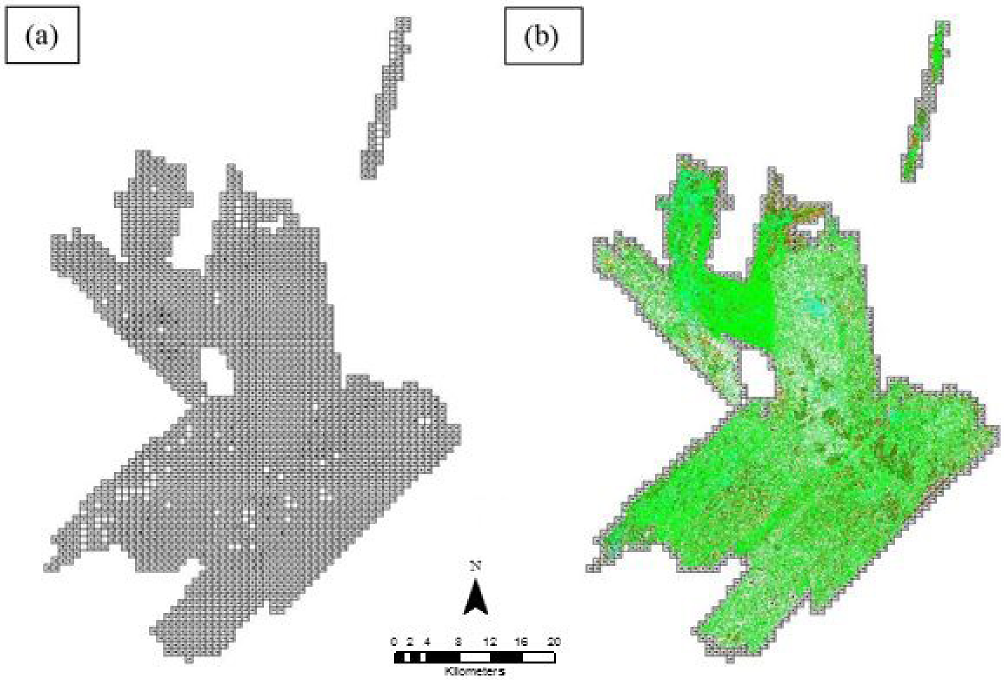

Figure 18. Tiles for Malaking Ilog floodplain (a) and classification results (b) in TerraScan.

An isometric view of an area before and after running the classification routines is shown in Figure 19. The ground points are in orange, the vegetation is in different shades of green, and the buildings are in cyan. It can be seen that residential structures adjacent or even below canopy are classified correctly, due to the density of the LiDAR data.

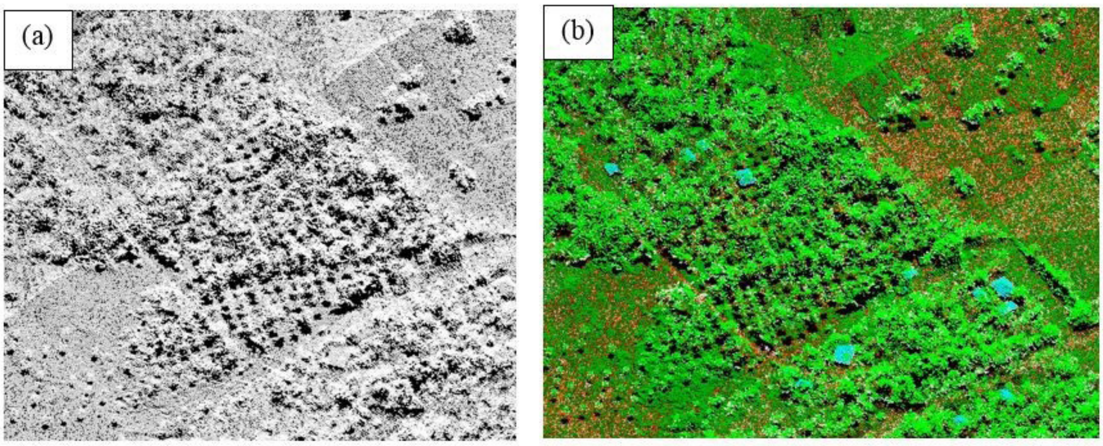

Figure 19. Point cloud before (a) and after (b) classification.

The production of last return (V_ASCII) and the secondary (T_ ASCII) DTM, first (S_ ASCII) and last (D_ ASCII) return DSM of the area in top view display are shown in Figure 20. It shows that DTMs are the representation of the bare earth while on the DSMs, all features are present such as buildings and vegetation.

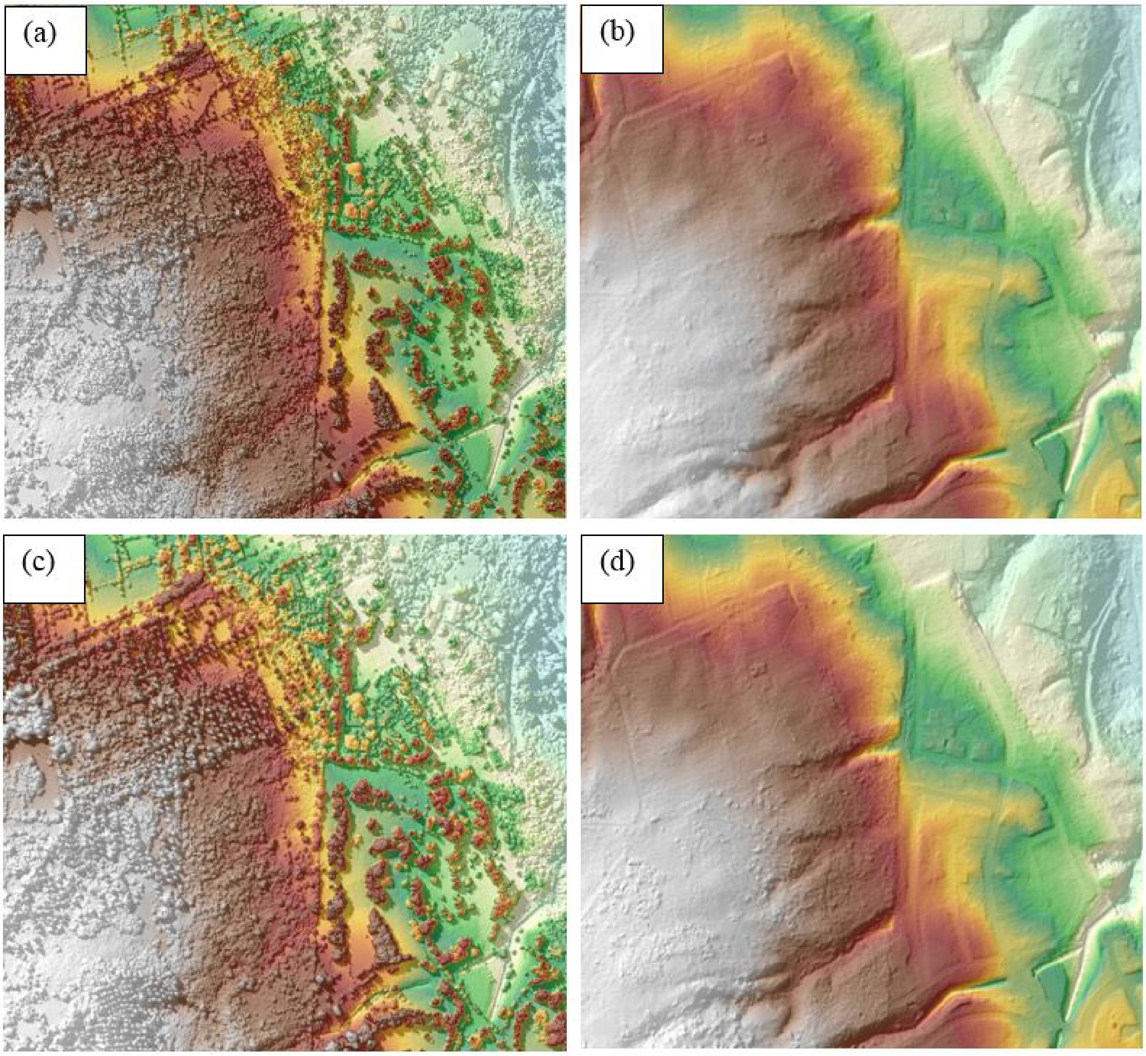

Figure 20. The production of last return DSM (a) and DTM (b), first return DSM (c) and secondary DTM (d) in some portion of Malaking Ilog floodplain.

3.7 LiDAR Image Processing and Orthophotograph Rectification

The 1,072 1km by 1km tiles area covered by Malaking Ilog floodplain is shown in Figure 21. After tie point selection to fix photo misalignments, color points were added to smoothen out visual inconsistencies along the seamlines where photos overlap. The Malaking Ilog floodplain has a total of 690.22 sq.km orthophotograph coverage comprised of 1,076 images. A zoomed in version of sample orthophotographs named in reference to its tile number is shown in Figure 22.

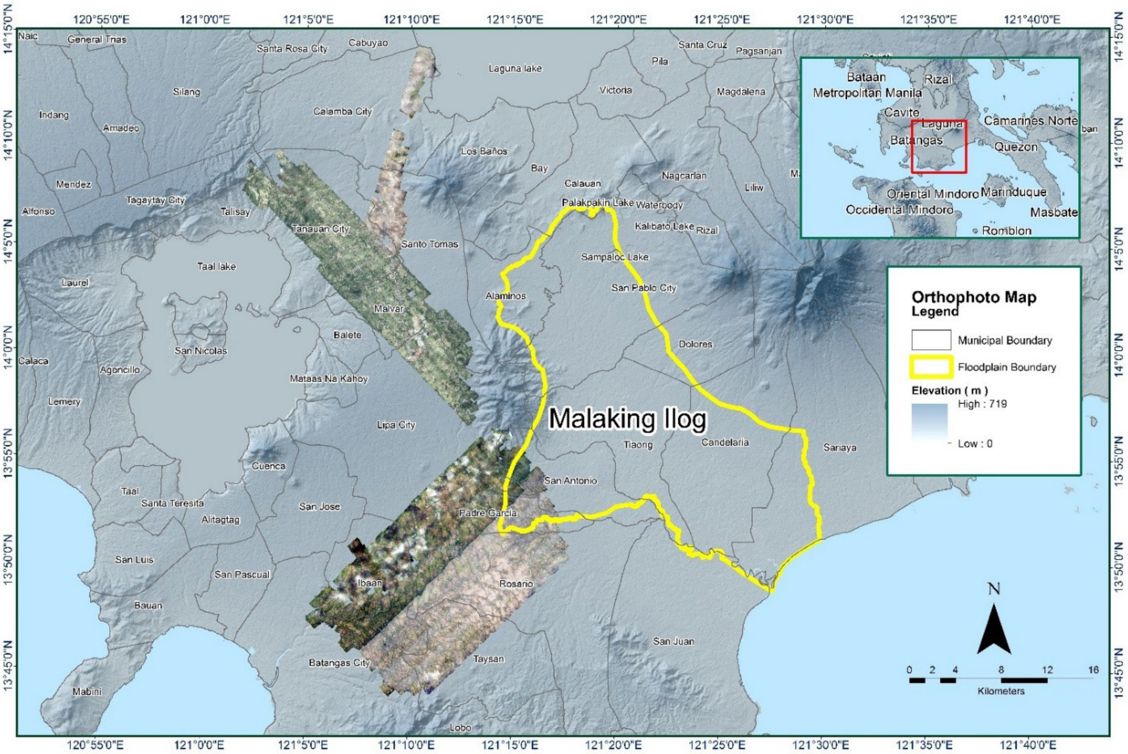

Figure 21. Malaking Ilog floodplain with available orthophotographs.

Figure 22. Sample orthophotograph tiles for Malaking Ilog floodplain.

3.8 DEM Editing and Hydro-Correction

Fifteen (15) mission blocks were processed for Malaking Ilog flood plain. These blocks are composed of Calabarzon, Batangas, and Laguna with a total area of 2,452.02 square kilometers. Table 20 shows the name and corresponding area of each block in square kilometers.

Table 20. LiDAR blocks with its corresponding area.

LiDAR Blocks	Area (sq.km)
CALABARZON_Blk18A_additional	74.80
CALABARZON_Blk18W_additional	99.50
CALABARZON_Blk18A	227.59
CALABARZON_Blk18U_additional2	32.51
CALABARZON_Blk18U_supplement	180.66
Batangas_Blk18SE	138.62
Batangas_Blk18SE_additional1	11.97
Batangas_Blk18QRs1	158.90
Batangas_Blk18QR	179.49
Laguna_Blk18T	263.85
Laguna_Blk18U_supplement	179.70
Laguna_Blk18U	262.38
Laguna_Blk18VW_supplement	233.10
Laguna_Blk18W	242.24
Laguna_Blk18EFG_supplement	166.71
TOTAL	**2452.02 sq.km**

Portions of DTM before and after manual editing are shown in Figure 23. The bridge (Figure 23a) is also considered to be an impedance to the flow of water along the river and has to be removed (Figure 23b) in order to hydrologically correct the river. The interpolated mountain (Figure 23c) has been misclassified and removed during classification process and has to be retrieved to complete the surface (Figure 23d).

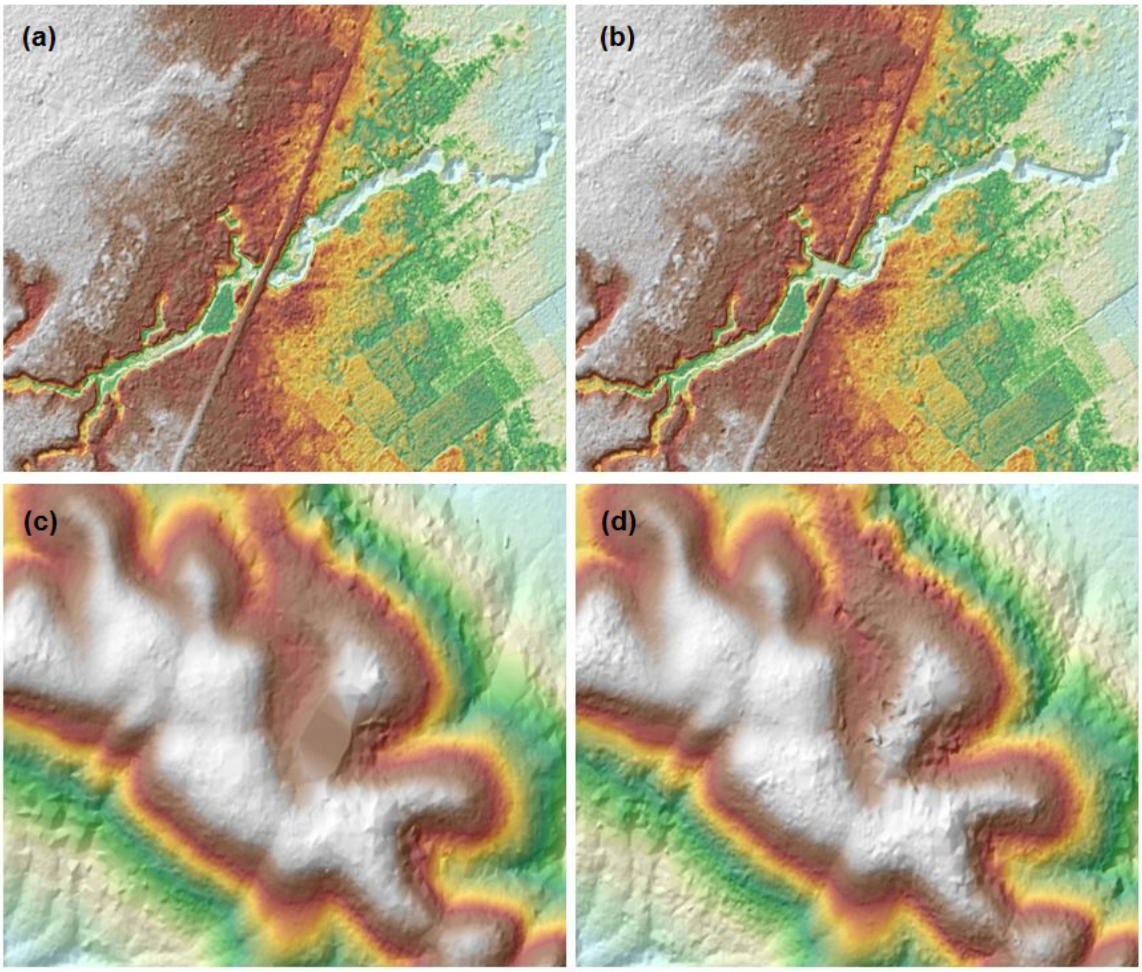

Figure 23. Portions in the DTM of Malaking Ilog floodplain – a bridge before (a) and after (b) manual editing; and a mountain before (c) and after (d) data retrieval.

3.9 Mosaicking of Blocks

Batangas_Blk18Z 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. Table 21 shows the shift values applied to each LiDAR block during mosaicking.

Mosaicked LiDAR DTM for Malaking Ilog floodplain is shown in Figure 24. It can be seen that the entire Malaking Ilog floodplain is 98.73% covered by LiDAR data.

Table 21. Shift Values of each LiDAR Block of Malaking Ilog floodplain.

Mission Blocks	Shift Values (meters)		
	x	y	z
CALABARZON_Blk18A_additional	0.99	0.99	-0.38
CALABARZON_Blk18W_additional	0.00	0.00	0.50
CALABARZON_Blk18A	0.00	0.00	0.00
CALABARZON_Blk18U_additional2	0.00	0.00	0.00
CALABARZON_Blk18U_supplement	0.00	0.00	0.00
Batangas_Blk18SE	0.00	0.00	0.00
Batangas_Blk18SE_additional1	0.00	0.00	0.00
Batangas_Blk18QRs1	0.00	0.00	-0.12
Batangas_Blk18QR	0.00	0.00	-0.05
Laguna_Blk18T	0.00	0.00	-0.15
Laguna_Blk18U_supplement	0.00	0.00	0.00
Laguna_Blk18U	0.00	0.00	-0.19
Laguna_Blk18VW_supplement	0.00	0.00	-0.27
Laguna_Blk18W	0.00	0.00	0.00
Laguna_Blk18EFG_supplement	0.00	0.00	-0.27

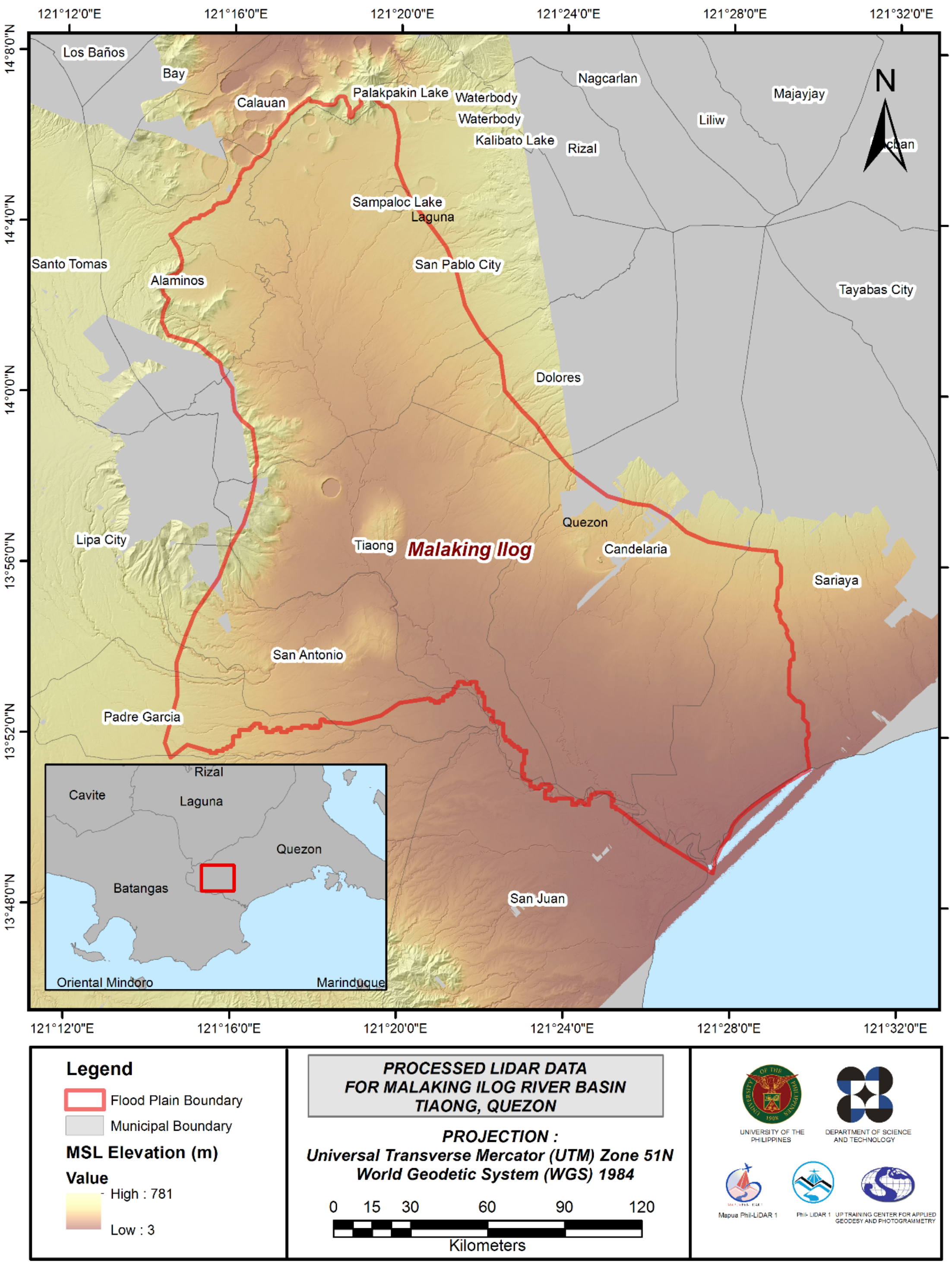

Figure 24. Map of Processed LiDAR Data for Malaking Ilog Flood Plain.

3.10 Calibration and Validation of Mosaicked LiDAR DEM

The extent of the validation survey done by the Data Validation and Bathymetry Component (DVBC) in Malaking Ilog to collect points with which the LiDAR dataset is validated is shown in Figure 25. A total of 24,251 survey points were gathered for all the flood plains within the provinces of CALABARZON wherein the Malaking Ilog floodplain is located. Random selection of 80% of the survey points, resulting to 19,401 points, was used for calibration.

A good correlation between the uncalibrated mosaicked LiDAR DTM and ground survey elevation values is shown in Figure 26. 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 2.97 meters with a standard deviation of 0.20 meters. Calibration of the LiDAR data was done by subtracting the height difference value, 2.97 meters, to the mosaicked LiDAR data. Table 22 shows the statistical values of the compared elevation values between the LiDAR data and calibration data.

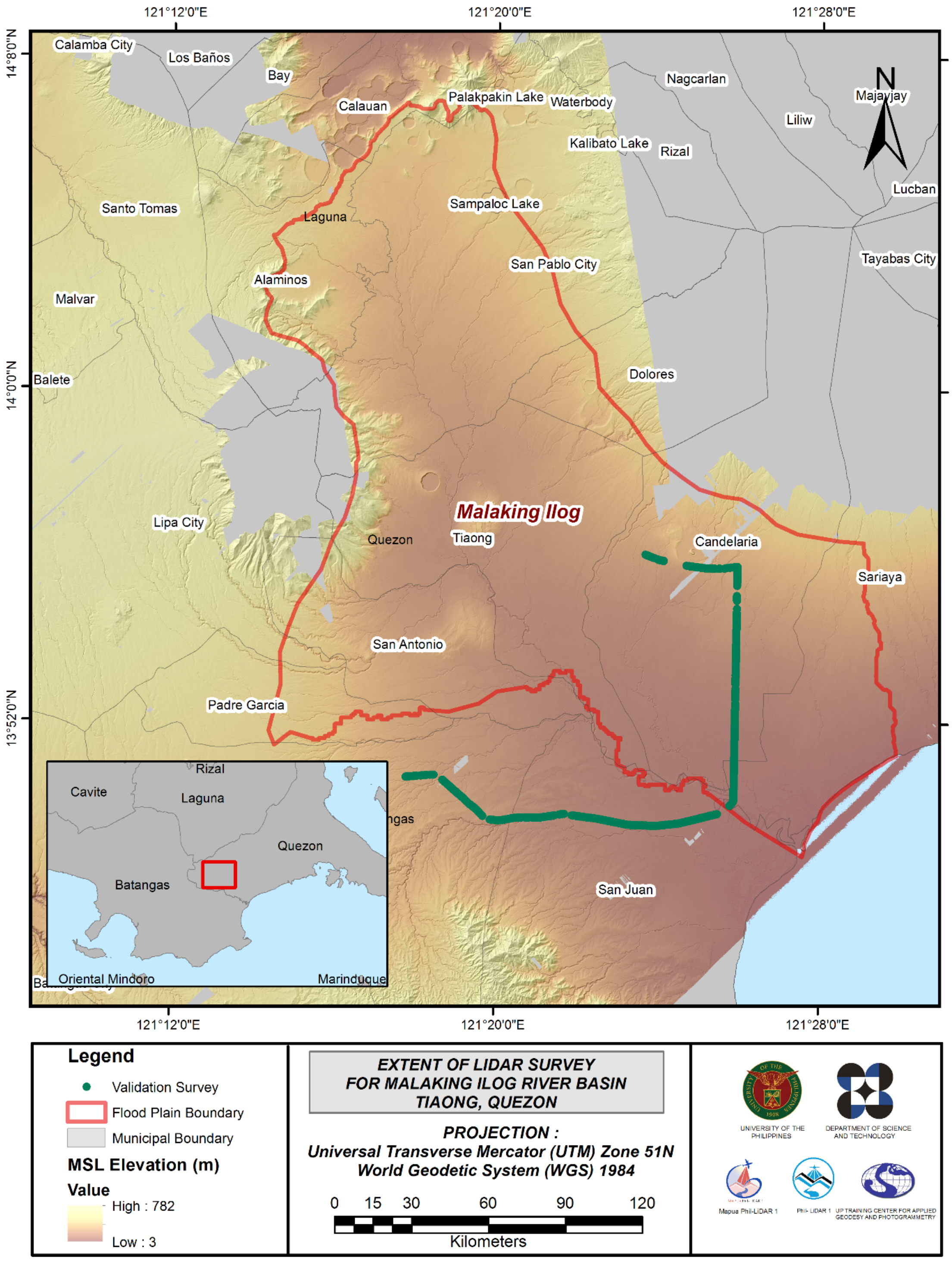

Figure 25. Map of Malaking Ilog Flood Plain with validation survey points in green.

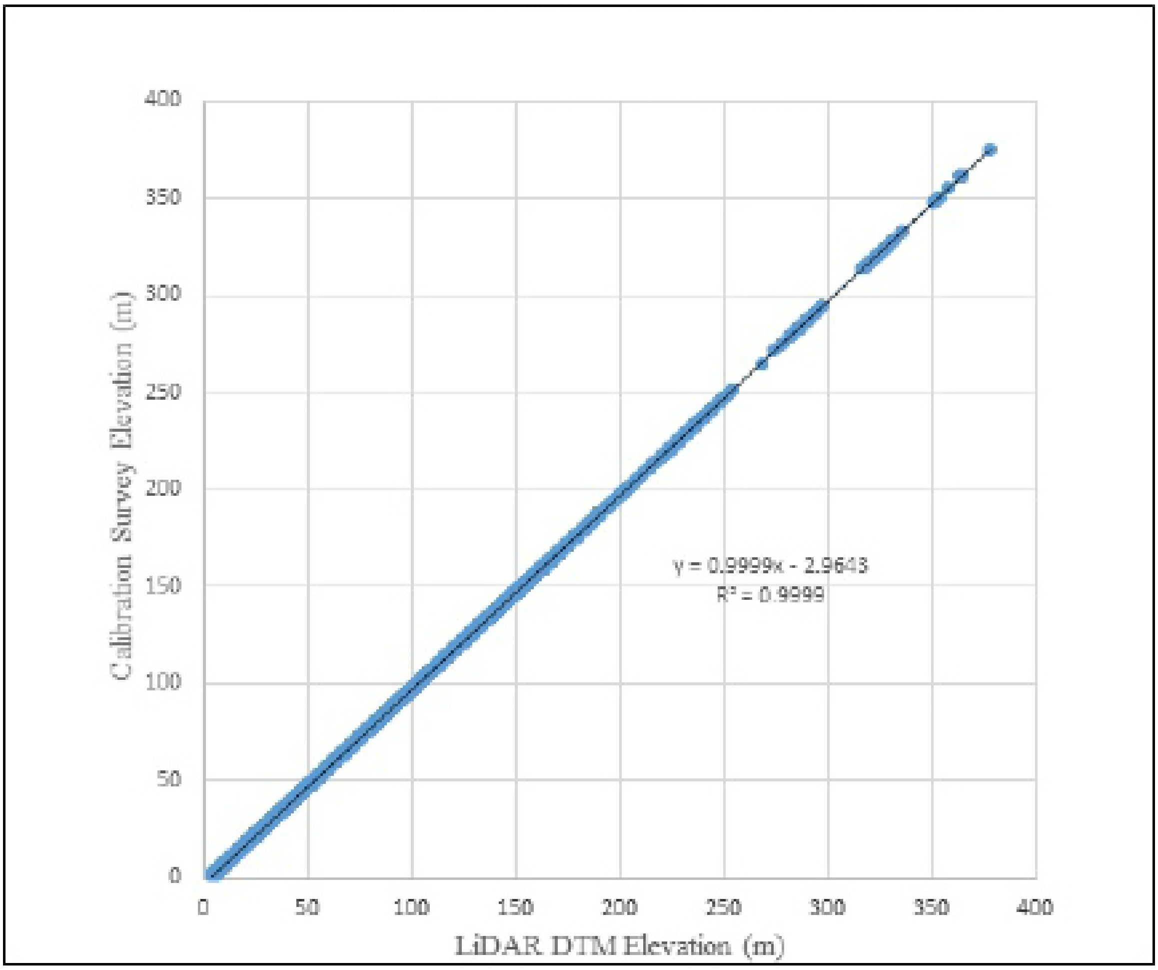

Figure 26. Correlation plot between calibration survey points and LiDAR data.

Table 22. Calibration Statistical Measures

Calibration Statistical Measures	Value (meters)
Height Difference	2.97
Standard Deviation	0.20
Average	-2.97
Minimum	-3.48
Maximum	-2.40

The remaining 20% of the total survey points were intersected to the flood plain, resulting to 219 points, were used for the validation of calibrated Malaking Ilog DTM. A good correlation between the calibrated mosaicked LiDAR elevation values and the ground survey elevation, which reflects the quality of the LiDAR DTM, is shown in Figure 27. The computed RMSE between the calibrated LiDAR DTM and validation elevation values is 0.13 meters with a standard deviation of 0.09 meters, as shown in Table 23.

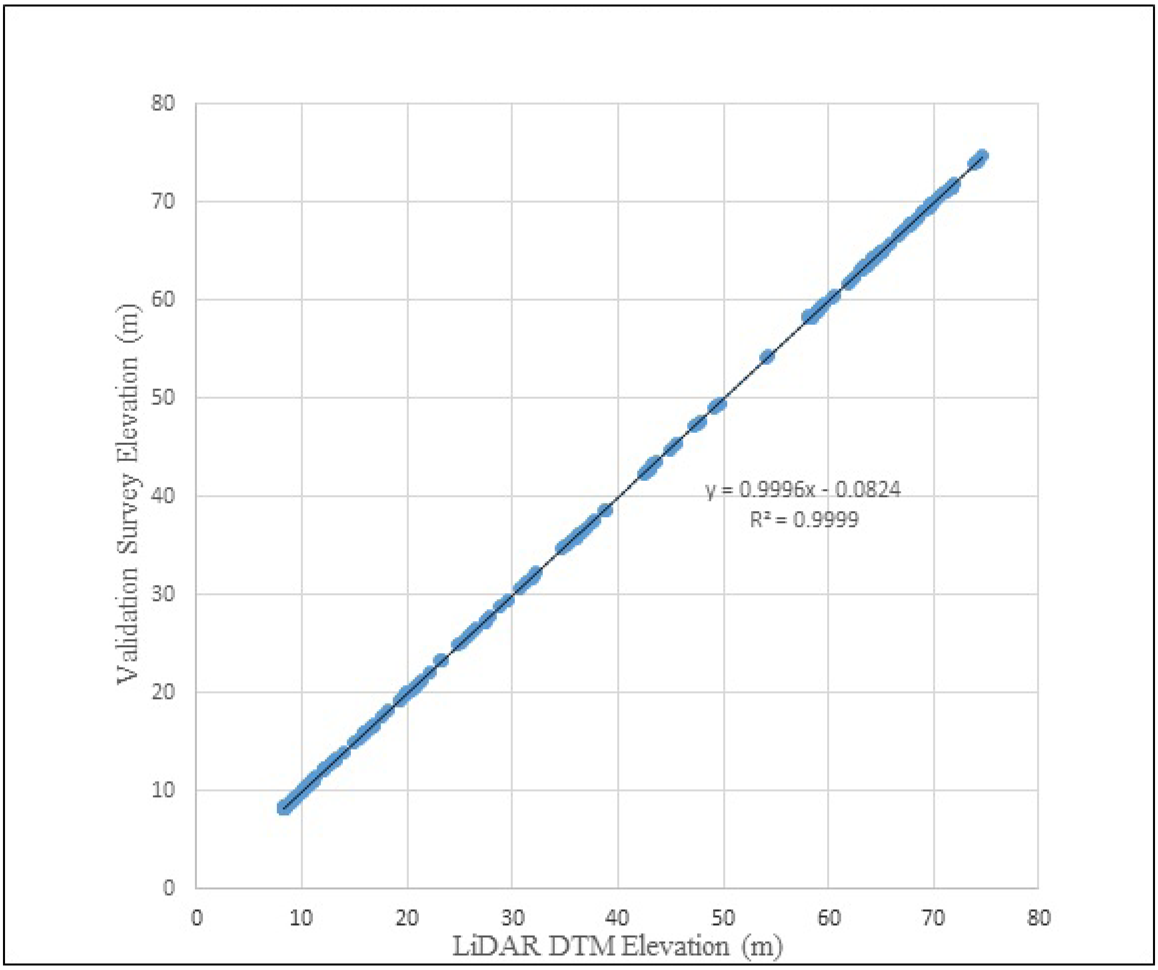

Figure 27. Correlation plot between validation survey points and LiDAR data.

Table 23. Validation Statistical Measures.

Validation Statistical Measures	Value (meters)
RMSE	0.13
Standard Deviation	0.09
Average	-0.10
Minimum	-0.31
Maximum	0.38

3.11 Integration of Bathymetric Data into the LiDAR Digital Terrain Model

For bathy integration, only centerline data was available for Malaking Ilog with 14,717 bathymetric survey points. The resulting raster surface produced was done by Inverse Distance Weighted (IDW) interpolation method. After burning the bathymetric data to the calibrated DTM, assessment of the interpolated surface is represented by the computed RMSE value of 0.25 meters. The extent of the bathymetric survey done by the Data Validation and Bathymetry Component (DVBC) in Malaking Ilog integrated with the processed LiDAR DEM is shown in Figure 28.

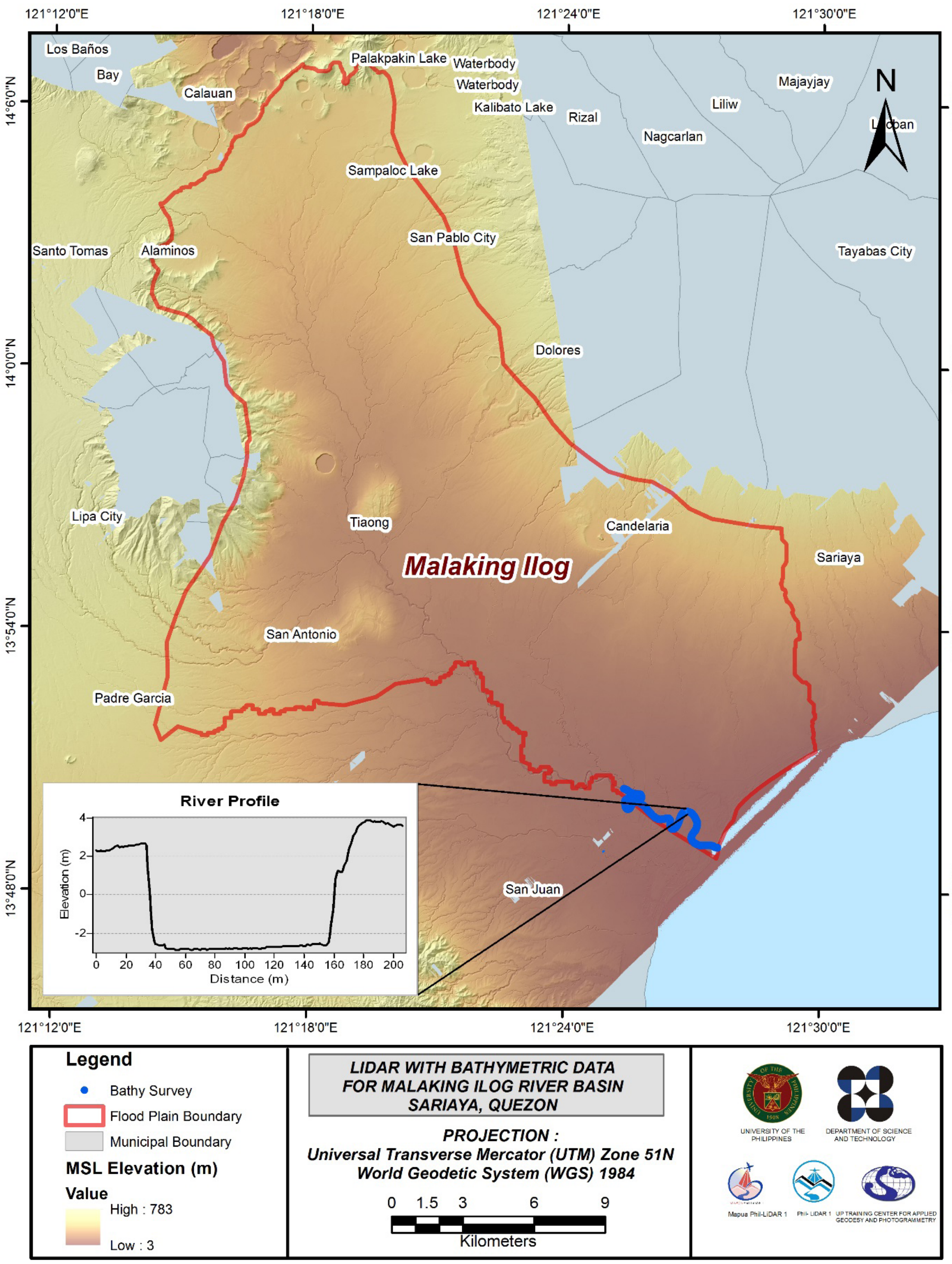

Figure 28. Map of Malaking Ilog Flood Plain with bathymetric survey points shown in blue

3.12 Feature Extraction

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

3.12.1 Quality Checking (QC) of Digitized Features' Boundary

Malaking Ilog floodplain, including its 200 m buffer, has a total area of 491.48 sq km. For this area, a total of 15.0 sq km, corresponding to a total of 6,101 building features, are considered for QC. Figure 29 shows the QC blocks for Malaking Ilog floodplain.

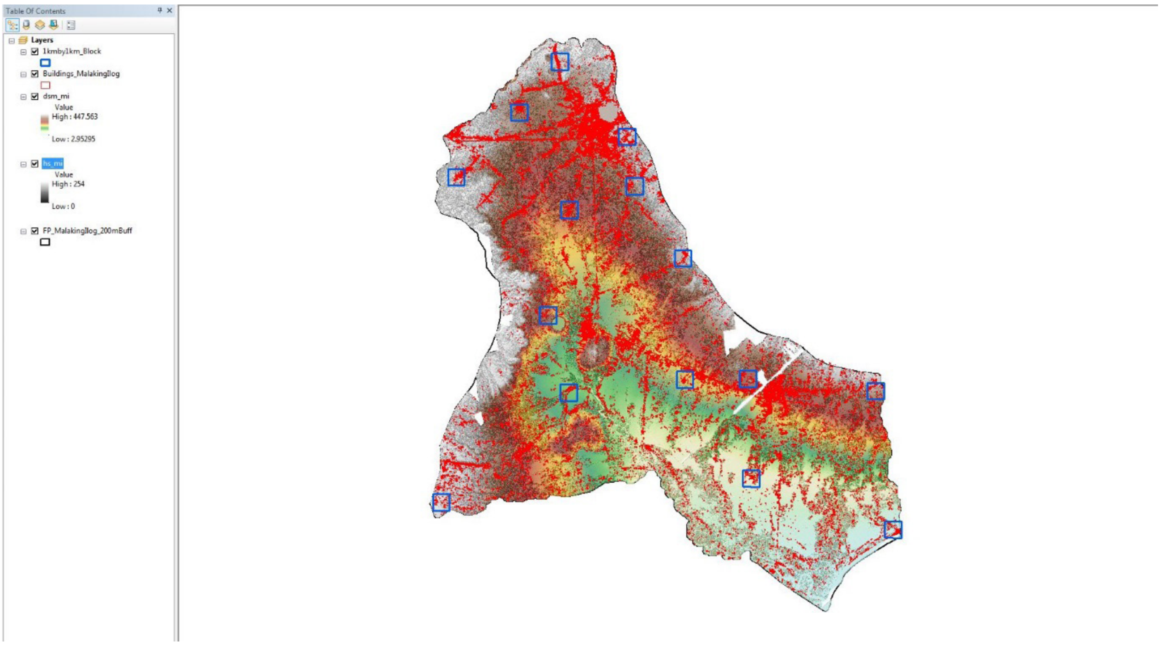

Figure 29. QC blocks for Malaking Ilog building features.

Quality checking of Malaking Ilog building features resulted in the ratings shown in Table 24.

Table 24. Quality Checking Ratings for Malaking Ilog Building Features.

FLOODPLAIN	COMPLETENESS	CORRECTNESS	QUALITY	REMARKS
Malaking Ilog	89.53	99.92	86.89	PASSED

3.12.2 Height Extraction

Height extraction was done for 5,690 building features in Malaking Ilog floodplain. Of these building features, none was filtered out after height extraction, resulting to 5,690 buildings with height attributes. The lowest building height is at 2.00 m, while the highest building is at 8.74 m.

3.12.3 Feature Attribution

The attributes were obtained by field data gathering. GPS devices were used to determine the coordinates of important features. These points are uploaded and overlaid in ArcMap and are then integrated with the shapefiles.

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 Malaking Ilog Floodplain

Facility Type	No. of Features
Residential	5,486
School	83
Market	1
Agricultural/Agro-Industrial Facilities	16
Medical Institutions	2
Barangay Hall	9
Military Institution	14
Sports Center/Gymnasium/Covered Court	10
Telecommunication Facilities	1
Transport Terminal	0
Warehouse	4
Power Plant/Substation	3
NGO/CSO Offices	0
Police Station	0
Water Supply/Sewerage	0
Religious Institutions	18
Bank	0
Factory	0
Gas Station	1
Fire Station	0
Other Government Offices	21
Other Commercial Establishments	21
Total	**5,690**

Table 26. Total Length of Extracted Roads for Malaking Ilog Floodplain

Floodplain	Road Network Length (km)					Total
	Barangay Road	City/Municipal Road	Provincial Road	National Road	Others	
Malaking Ilog	22.95	13.63	0.00	19.77	0.00	**56.35**

Table 27. Number of Extracted Water Bodies for Malaking Ilog Floodplain

Floodplain	Water Body Type					Total
	Rivers/ Streams	Lakes/ Ponds	Sea	Dam	Fish Pen	
Malaking Ilog	157	49	0	0	0	**206**

A total of 44 bridges and culverts over small channels that are part of the river network were also extracted for the floodplain.

3.12.4 Final Quality Checking of Extracted Features

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

Figure 30 shows the Digital Surface Model (DSM) of Malaking Ilog floodplain overlaid with its ground features.

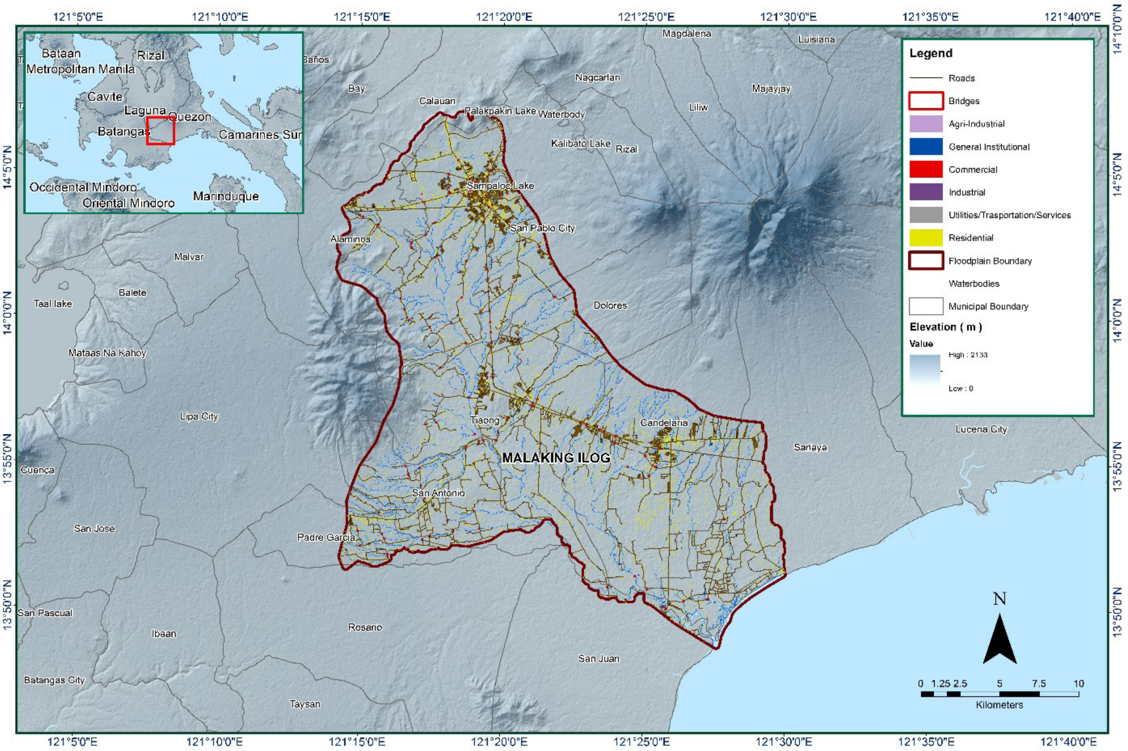

Figure 30. Extracted features for Malaking Ilog floodplain.

CHAPTER 4: LIDAR VALIDATION SURVEY AND MEASUREMENTS OF THE MALAKING ILOG RIVER BASIN

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

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

4.1 Summary of Activities

The Data Validation and Bathymetry Component (DVBC) conducted a field survey in Malaking Ilog River on May 15-22, 2014 and on September 2-6, 2014 with the following scope of work: GNSS control survey; cross-section and as-built survey at Bantilan Bridge in Brgy. Tipaz, San Juan, Batangas; ground validation data acquisition of about 30 km and bathymetric survey from the mouth of the river in Brgy. Poctol, San Juan, Batangas going upstream to Brgy. Manggalang-Bantilan, San Juan, Batangas. The survey covered an estimated total length of 8.5 kilometres using OhmexTM Single Beam Echo Sounder and GNSS PPK survey technique. The scope of work for Malaking Ilog River basin is shown in Figure 31.

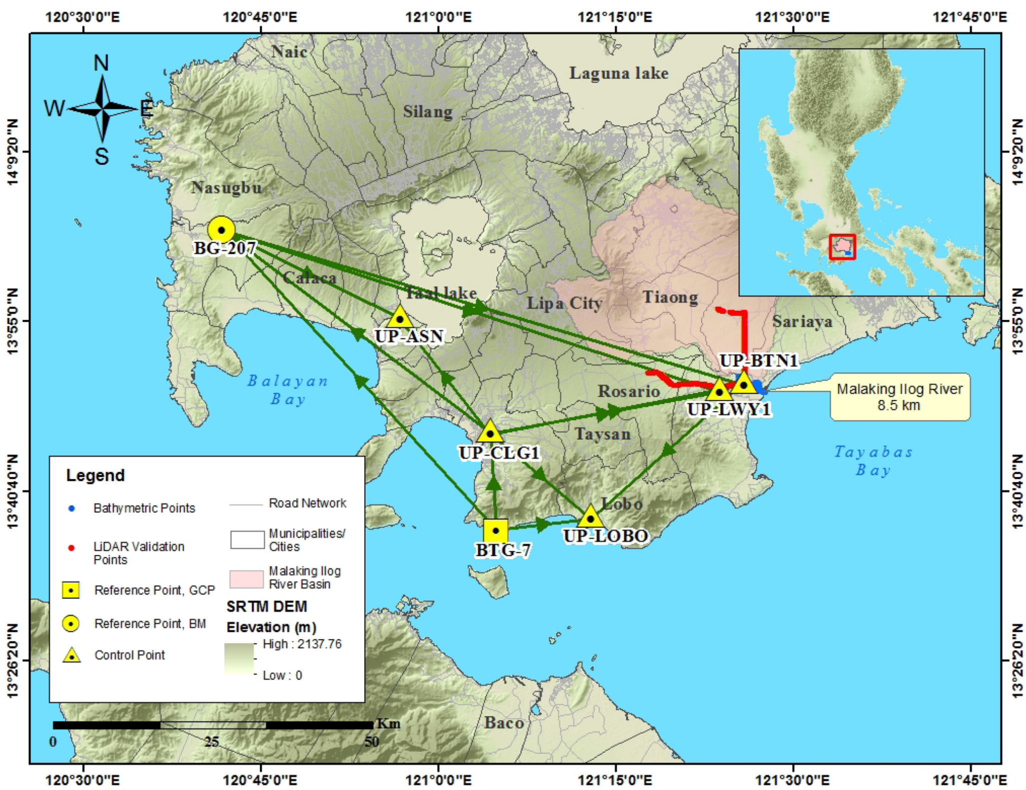

Figure 31. Survey extent for Malaking Ilog River Basin.

4.2 Control Survey

The GNSS network for this survey is composed of six (6) loops established on May 14 – 22, 2016 occupying the following reference points: BG-207, a first order BM in Brgy. Sabang, Municipality of Tuy; and BTG-7, a first order GCP located in Brgy. Dela Paz, Batangas City.

Five (5) control points were established at the approach of bridges namely UP-BTN at Bantilan Bridge in Brgy. UP-LOBO at Lobo Bridge in Brgy. Lagadlarin, Municipality of Lobo; UP-ASN at San Nicholas Bridge in Brgy. Poblacion, Municipality of San Nicholas, UP-CLG at Calumpang Bridge in Brgy. Kumintang Ibaba, Batangas City and UP-LWY at Lawaye Bridge in Brgy. Calitcalit, Municipality of San Juan.

The summary of reference and control points and its location is summarized in Table 28 while the GNSS network established is illustrated in Figure 32.

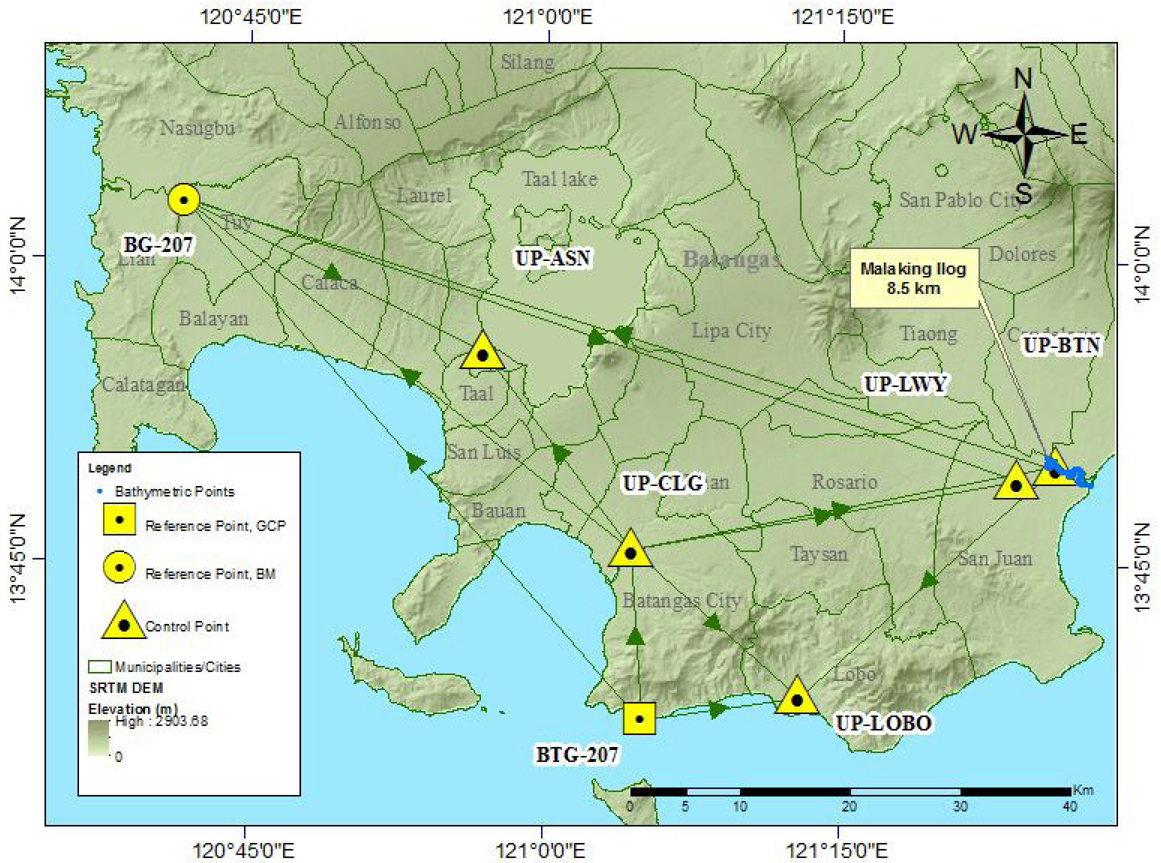

Figure 32. GNSS Network of Malaking Ilog River field survey.

Table 28. List of Reference and Control points used in Malaking Ilog survey (*Source: NAMRIA, UP-TCAGP)*.

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)				
		Latitude	Longitude	Ellipsoidal Height (m)	MSL Elevation (m)	Date Established
BG207	1st Order	-	-	65.606	22.502	2008
BTG-7	1st Order	13°37’19.49611”	121°04’56.32756”	66.192	-	1992
UP-ASN	UP Established	-	-	-	-	5-22-2014
UP-BTN	UP Established	-	-	-	-	5-21-2014
UP-CLG1	UP Established	-	-	-	-	5-21-2014
UP-LOBO	UP Established	-	-	-	-	5-21-2014
UP-LWY1	UP Established					5-22-2014

The GNSS set up on reference and established control points in Batangas are shown on Figure 33 to 39.

Figure 33. GNSS receiver, Trimble® SPS 985, set-up at BG-207 at Palico Bridge, Brgy. Luntal, Nasugbu, Batangas.

Figure 34. GNSS receiver, Trimble® SPS 985, set-up at BTG-7 in Dela Paz Lighthouse in Brgy. Dela Paz, Batangas City, Batangas.

Figure 35. GNSS receiver, Trimble® SPS 882, set-up at UP-ASN at San Nicholas Bridge, Brgy. Poblacion, San Nicholas, Batangas

Figure 36. GNSS base receiver, Trimble® SPS 852, set-up at UP-BTN at Bantilan Bridge, Brgy. Manggalang Banitilan, Sariaya, Quezon

Figure 37. GNSS base receiver, Trimble® SPS 852, set-up at UP-CLG1 in Calumpang Bridge, Brgy. Cumintang Ibaba, Batangas City, Batangas

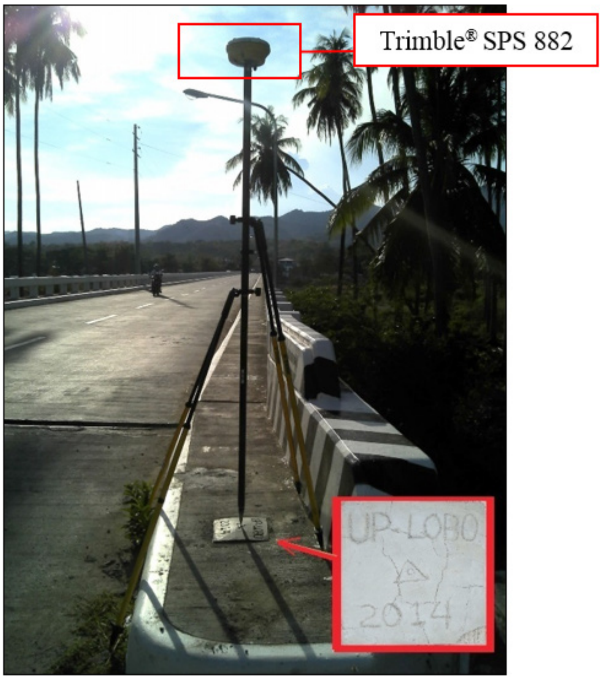

Figure 38. GNSS base receiver, Trimble® SPS 882, set-up at UP-LOBO, in Lobo Bridge, Brgy. Lagadlarin, Lobo, Batangas

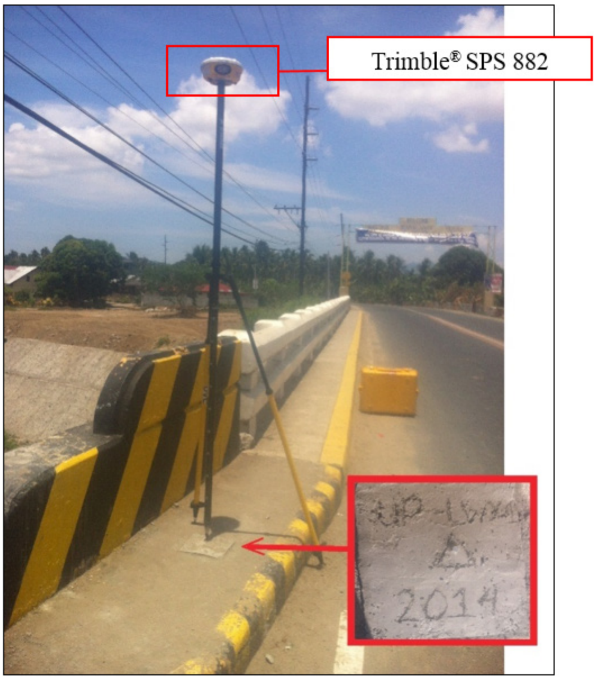

Figure 39. GNSS receiver, Trimble® SPS 882, set-up at UP-LWY1 at Lawaye Bridge, Brgy. Calitcalit-Mabalanoy, San Juan, Batangas.

4.3 Baseline Processing

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 case where one or more baselines did not meet all of these criteria, masking is performed. Masking is done by removing/masking portions of these baseline data using the same processing software. It is repeatedly processed until all baseline requirements are met. If the reiteration yields out of the required accuracy, resurvey is initiated. Baseline processing result of control points in Malaking Ilog River Basin is summarized in Table 29 generated by TBC software.

Table 29. Baseline Processing Report for Malaking Ilog River Basin Static Survey.

Observation	Date of Observation	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
UPCLG --- BTG7 (B11)	5-22-2014	Fixed	0.003	0.013	356°25’22”	15777.353	-8.962
BTG7 --- UPLOBO (B14)	5-22-2014	Fixed	0.008	0.037	80°16’20”	14501.810	-9.895
UPCLG --- UPBTN (B8)	5-21-2014	Fixed	0.004	0.018	78°44’11”	39325.812	-1.938
UPCLG --- UPBTN (B10)	5-21-2014	Fixed	0.023	0.082	78°44’11”	39325.931	-1.993
UPCLG --- UPBTN (B9)	5-21-2014	Fixed	0.018	0.032	78°44’11”	39326.011	-1.988
UPCLG --- BMBG207 (B7)	5-21-2014	Fixed	0.008	0.021	307°20’38”	51500.583	8.348
UPCLG --- UPLWY (B15)	5-22-2014	Fixed	0.004	0.015	79°31’48”	35577.341	6.690
UPCLG --- UPASN (B6)	5-21-2014	Fixed	0.005	0.020	322°34’54”	22553.641	-5.613
UPCLG --- UPLOBO (B12)	5-22-2014	Fixed	0.006	0.026	131°01’52”	20253.372	-0.954
UPBTN --- BMBG207 (B2)	5-21-2014	Fixed	0.066	0.086	286°35’24”	82928.558	10.191
BTG7 --- UPBTN (B5)	5-21-2014	Fixed	0.004	0.018	58°03’54”	44287.329	-10.884
BTG7 --- UPBTN (B3)	5-21-2014	Fixed	0.017	0.070	58°03’54”	44287.367	-10.925
BTG7 --- UPBTN (B4)	5-21-2014	Fixed	0.011	0.024	58°03’54”	44287.360	-10.823
UPBTN --- UPLOBO (B13)	5-22-2014	Fixed	0.011	0.045	228°04’35”	31344.157	0.983
BMBG207 --- UPLWY (B17)	5-22-2014	Fixed	0.015	0.033	107°58’47”	79868.067	-1.689

BMBG207 --- UPASN (B1)	5-21-2014	Fixed	0.005	0.022	115°58'50"	30324.834	-14.030
UPLWY --- UPASN (B16)	5-21-2014	Fixed	0.011	0.021	283°18'29"	50016.834	-12.285

As shown in Table 29, a total of seventeen (17) baselines were processed with reference elevation of point BG-207 and coordinates of BTG-7 held fixed. All of them passed the required accuracy.

4.4 Network Adjustment

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

<20cm and

Where:

x_e is the Easting Error,

y_e is the Northing Error, and

z_e is the Elevation Error

for each control point. See the Network Adjustment Report shown in Table 30 to Table 32 for the complete details.

The seven (7) control points, BG-207, BTG-7, UP-ASN, UP-BTN, UP-CLG, UP-LOBO and UP-LWY were occupied and observed simultaneously to form a GNSS loop. Coordinates of point BTG-7 and elevation value of BG-207 were held fixed during the processing of the control points as presented in Table 30. Through these reference points, the coordinates and elevation of the unknown control points will be computed.

Table 30. Control Point Constraints

Point ID	Type	East σ (Meter)	North σ (Meter)	Height σ (Meter)	Elevation σ (Meter)
BG-207	Grid				Fixed
BTG-7	Global	Fixed	Fixed		
Fixed = 0.000001(Meter)					

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. The fixed control point BG-207 and BTG-7, has no values for standard elevation and coordinates error, respectively.

Table 31. Adjusted Grid Coordinates.

Point ID	Easting (Meter)	Easting Error (Meter)	Northing (Meter)	Northing Error (Meter)	Elevation (Meter)	Elevation Error (Meter)	Constraint
MBG207	250979.768	0.014	1554083.399	0.009	22.502	?	e
BTG7	292538.897	?	1506749.028	?	20.801	0.072	LL
UPASN	278117.299	0.013	1540530.569	0.008	7.619	0.060	
UPBTN	330309.700	0.008	1529876.941	0.006	9.361	0.075	
UPCLG	291679.224	0.007	1522505.093	0.005	12.287	0.058	
UPLOBO	306852.492	0.014	1509086.720	0.008	10.498	0.094	
UPLWY	326716.786	0.013	1528689.759	0.008	18.019	0.064	

The network is fixed at reference points BG-207 and BTG-7 for elevation and coordinate values, respectively. With the mentioned equation , for horizontal; and for the vertical; the computation for the accuracy for the controls are as follows:

a. **BG-207**

horizontal accuracy = $\sqrt{((1.4)^2 + (0.9)^2}$
= $\sqrt{(1.96 + 0.81)}$
= 1.66 cm < 20 cm

vertical accuracy = Fixed

b. **BTG-7**

horizontal accuracy = Fixed

vertical accuracy = 7.2 cm

c. **UP-ASN**

horizontal accuracy = $\sqrt{((1.3)^2 + (0.8)^2}$
= $\sqrt{(1.69 + 0.64)}$
= 1.53 cm < 20 cm

vertical accuracy = 6.0 cm

d. **UP-BTN**

horizontal accuracy = $\sqrt{((0.8)^2 + (0.6)^2}$
= $\sqrt{(0.64 + 0.36)}$
= 1.0 cm < 20 cm

vertical accuracy = 7.5 cm

e. **UP-CLG**

horizontal accuracy = $\sqrt{((0.7)^2 + (0.5)^2}$
= $\sqrt{(0.49 + 0.25)}$
= 0.86 cm < 20 cm

vertical accuracy = 5.8 cm

f. **UP-LOB**

horizontal accuracy = $\sqrt{((1.4)^2 + (0.8)^2}$
= $\sqrt{(1.96 + 0.64)}$
= 1.48 cm < 20 cm
vertical accuracy = 9.4 cm

g. **UP-LWY**

horizontal accuracy = $\sqrt{((1.3)^2 + (0.8)^2}$
= $\sqrt{(1.69 + 0.64)}$
= 1.52 cm < 20 cm
vertical accuracy = 6.4 cm

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

Table 32. Adjusted Geodetic Coordinates.

Point ID	Latitude	Longitude	Ellipsoidal Height	Height Error (Meter)	Constraint
BMBG207	N14°02'47.32674"	E120°41'38.93608"	65.606	?	e
BTG7	N13°37'19.49611"	E121°04'56.32756"	66.192	0.072	LL
UPASN	N13°55'34.60792"	E120°56'47.03882"	51.610	0.060	
UPBTN	N13°50'00.87917"	E121°25'47.84870"	55.321	0.075	
UPCLG	N13°45'51.87502"	E121°04'23.55781"	57.236	0.058	
UPLOBO	N13°38'39.10157"	E121°12'51.89916"	56.291	0.094	
UPLWY	N13°49'21.47536"	E121°23'48.47095"	63.917	0.064	

The corresponding geodetic coordinates of the observed points are within the required accuracy as shown in Table 32. Based on the result of the computation, the accuracy condition is satisfied; hence, the required accuracy for the program was met.

The summary of reference and control points used is indicated in Table 33.

Table 33. Reference and control points and its location (Source: NAMRIA, UP-TCAGP).

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)			UTM ZONE 51 N		
		Latitude	Longitude	Ellipsoid Height (m)	Northing (m)	Easting (m)	Elevation in MSL (m)
BG207	1st Order	14°02'47.32674"	120°41'38.93608"	65.606	1554083	250979.8	22.502
BTG-7	1st Order	13°37'19.49611"	121°04'56.32756"	66.192	1506749	292538.9	20.801
UP-ASN	UP Established	13°55'34.60792"	120°56'47.03882"	51.61	1540531	278117.3	7.619
UP-BTN	UP Established	13°50'00.87917"	121°25'47.84870"	55.321	1529877	330309.7	9.361

UP-CLG1	UP Estab-lished	13°45'51.87502"	121°04'23.55781"	57.236	1522505	291679.2	12.287
UP-LO-BO	UP Estab-lished	13°38'39.10157"	121°12'51.89916"	56.291	1509087	306852.5	10.498
UP-LWY1	UP Estab-lished	13°49'21.47536"	121°23'48.47095"	63.917	1528690	326716.8	18.019

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

Cross section survey was done on February 4, 2015 at Bantilan Bridge in Brgy. Tipaz, San Juan, Batangas. A GNSS receiver, Trimble® SPS 882 in PPK survey technique was used to get the cross-section data of the river. The cross-sectional line for Bantilan Bridge is about 150 m with fifteen (15) cross-sectional points acquire using UP-BTN. The location map is shown in Figure 40, while the summary of gathered cross-section data is in Figure 41.

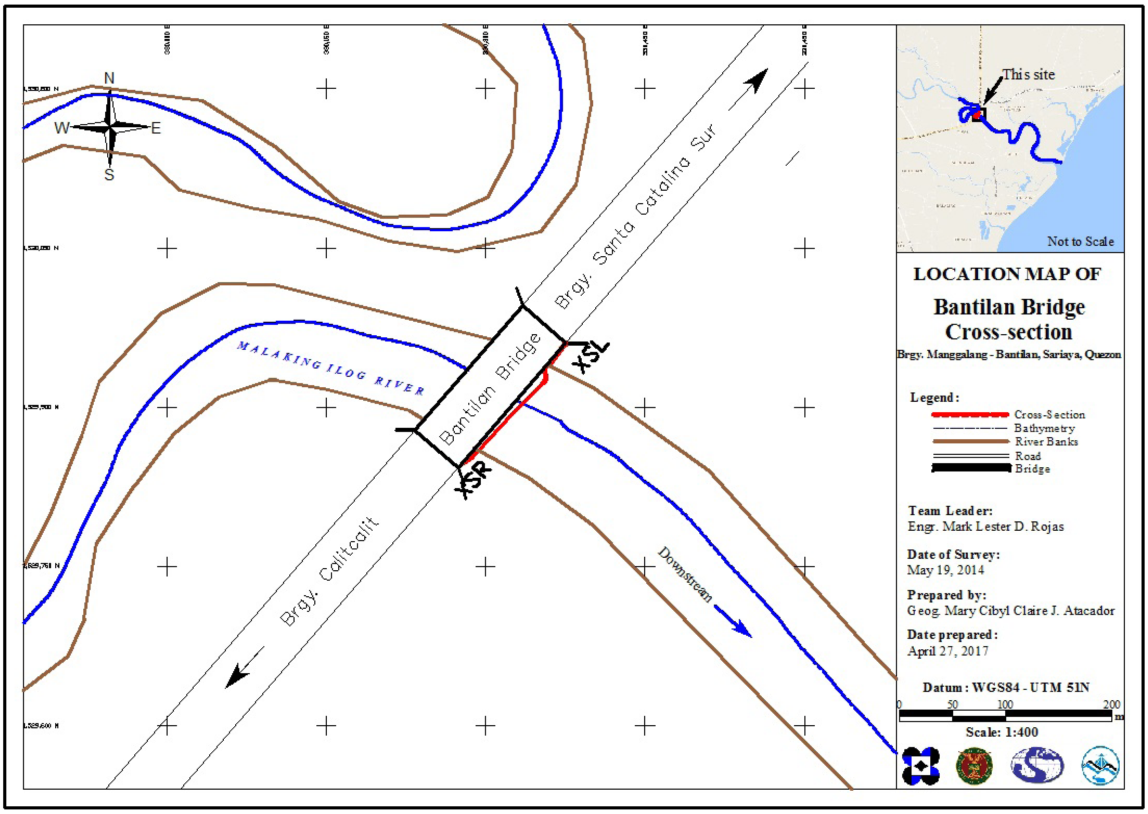

Figure 40. Bantilan Bridge cross-section location map.

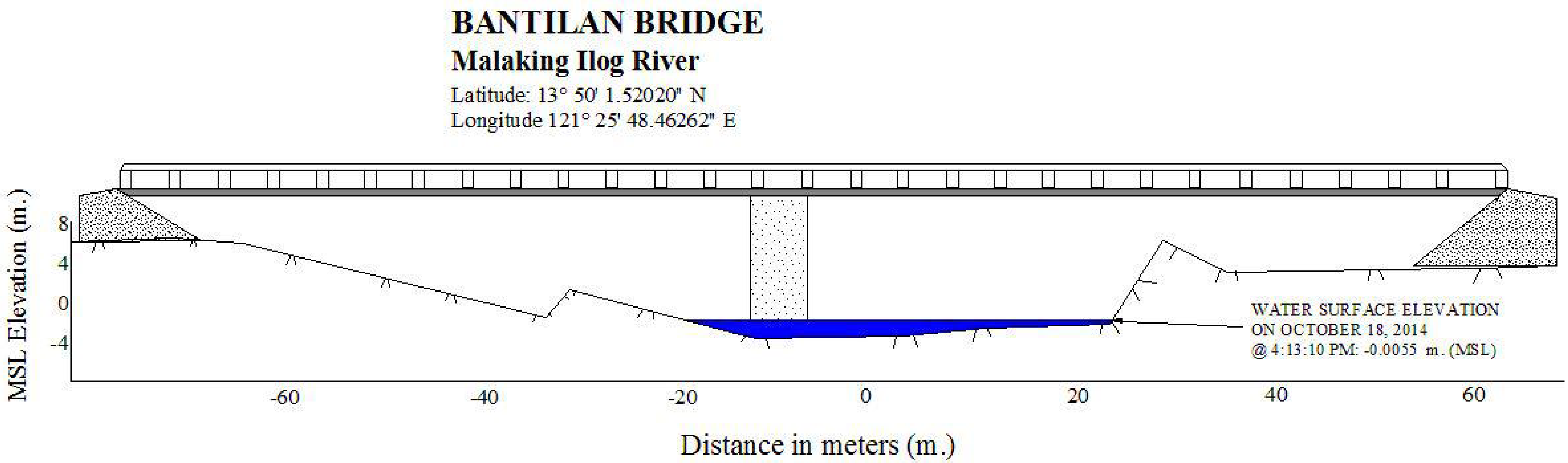

Figure 41. Bantilan bridge cross-section diagram.

Water level marking was performed to provide the HEIs reference for elevation referred from MSL. The water level marking is done on the abutment of the Bantilan Bridge as seen in Figure 42. As-built features of the bridge shall be acquired in the succeeding surveys in Batangas.

Figure 42. Bantilan Bridge Water Level Marking.

4.6 Validation Points Acquisition Survey

Validation Points Acquisition Survey was conducted on November 8, 2014 using a survey-grade GNSS Rover receiver, Trimble® SPS 882, mounted on top of the vehicle as shown in Figure 43. It was secured with cable ties to ensure that it was horizontally and vertically balanced. The antenna height was 2.09 m measured from the ground up to the bottom of notch of the GNSS rover receiver. The survey was conducted using PPK technique on a continuous topo mode using UP-BTN1 as base station.

Figure 43. Validation points acquisition survey setup.

Acquisition of validation points started from Brgy. Tipaz, San Juan, Batangas and traversed major roads going north to Brgy. Bucal Sur, Candelaria, and ended to Brgy. Alupay, Rosario, Batangas. The survey acquired a total of 2,835 ground validation points with an approximate length of thirty (30) km, as shown in Figure 44.

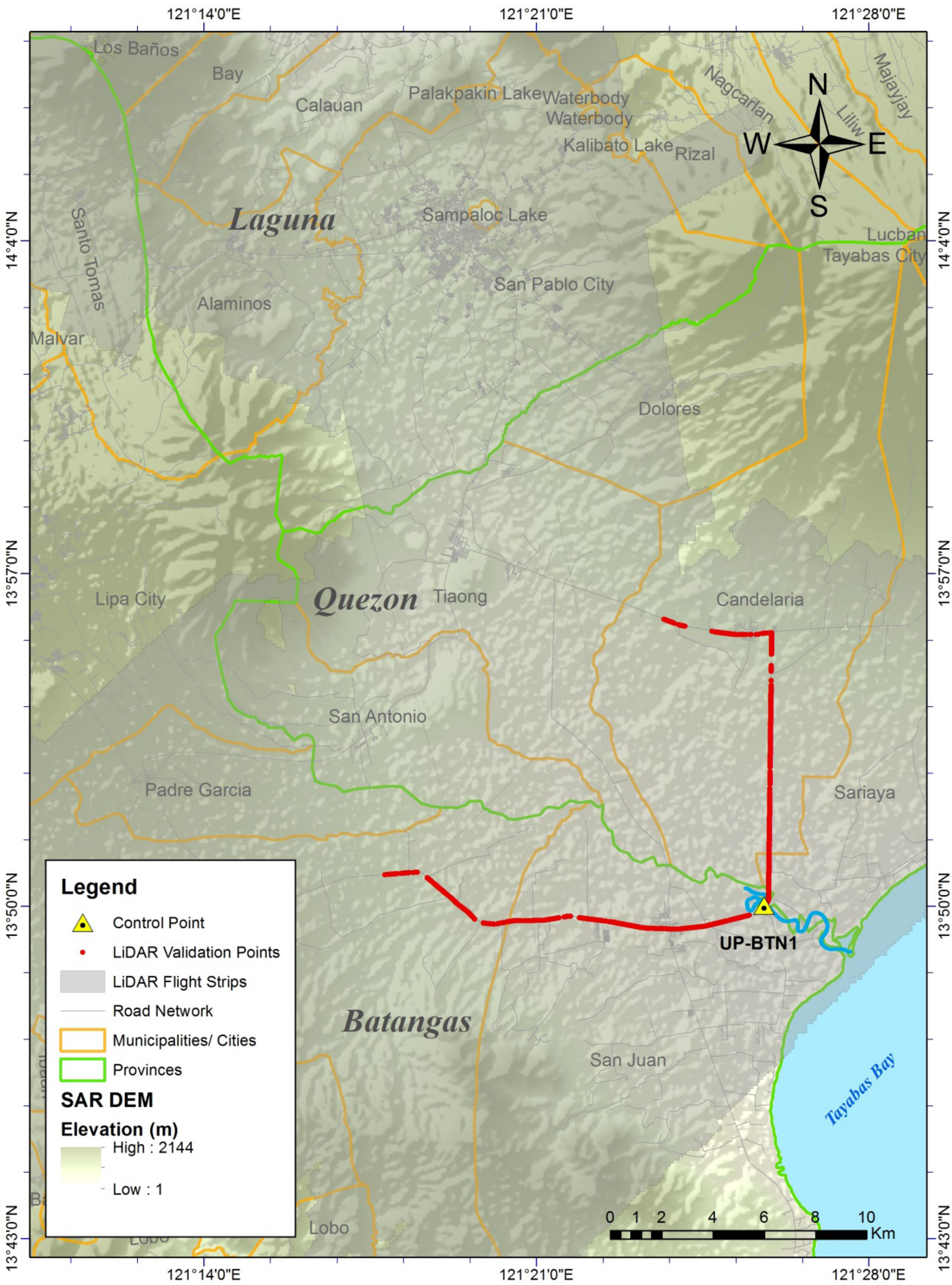

Figure 44. Validation points acquisition survey along Malaking-Ilog River Basin.

4.7 River Bathymetric Survey

Bathymetry survey was conducted on September 3, 2014 using OHMEX™ single beam echo sounder attached to a pole and a Trimble® SPS 882 GNSS receiver was installed at the side of a boat in PPK survey technique as shown in Figure 45. The survey started from the upstream in Brgy Tipaz, San Juan, Batangas with coordinates 13°50'21.96553" 121°25'25.47253" down to the mouth of the river in Brgy. Catmon, San Juan, Batangas with coordinates 13°49'01.81600" 121°27'37.13404". The control point UP-BTN was used as the GNSS base station all throughout the survey.

Figure 45. OHMEX^{TM} echo sounder setup, Malaking Ilog River Basin.

A total of 2,593 bathymetry points with an estimated length of 8.5 km were acquired starting from Brgy. Catmon up to Brgy. Tipaz in San Juan, Batangas. The extent of the bathymetric survey is shown in the map in Figure 46.

A CAD drawing ws produced to illustrate the Malaking Ilog riverbed profile, shown in Figure 47. There is no abrupt change in elevation of the river from upstream to downstream. The highest and lowest elevation observed were -0.5002 m and -6.513 m in MSL, respectively.

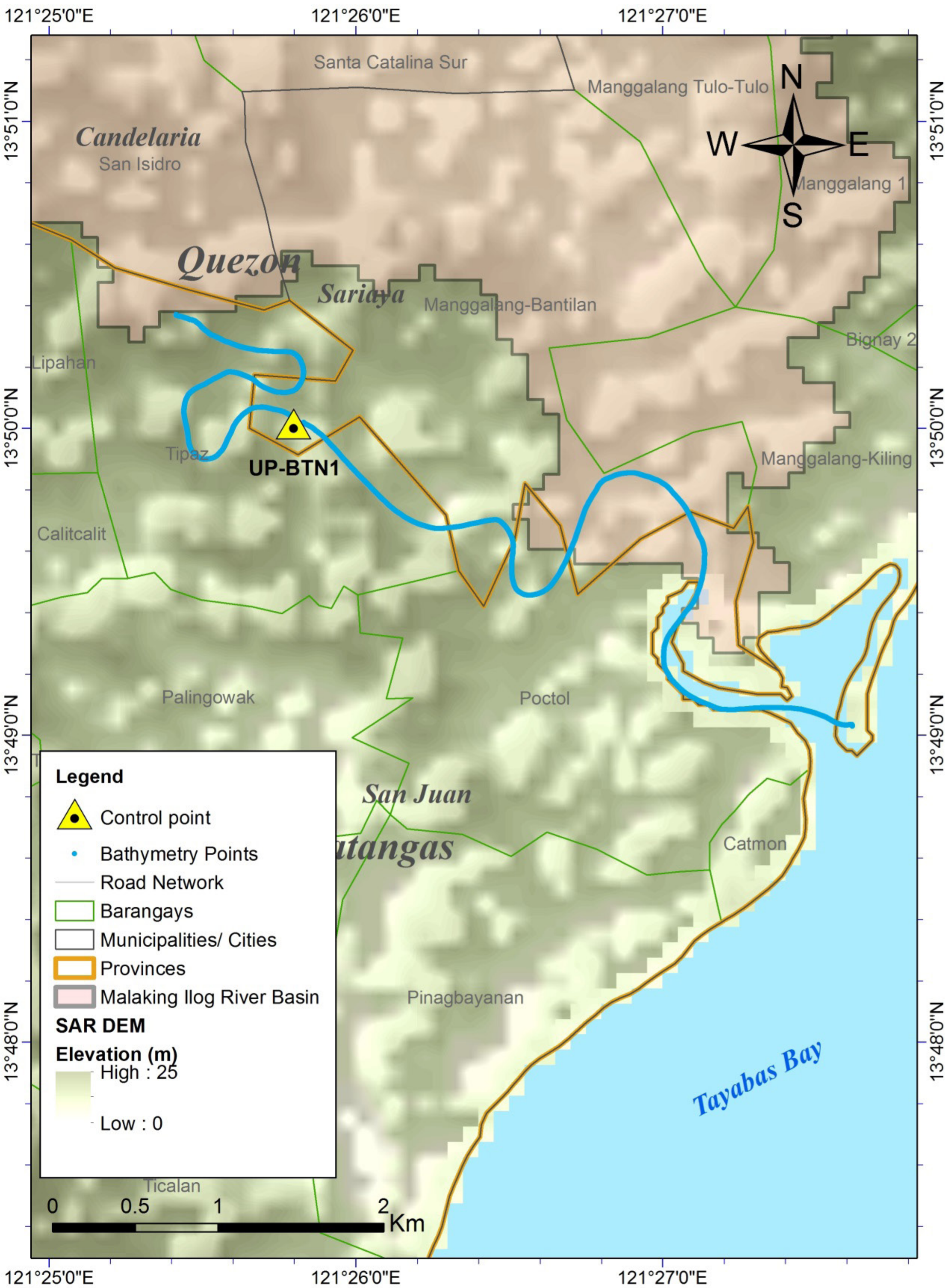

Figure 46. Bathymetric survey coverage for Malaking Ilog River

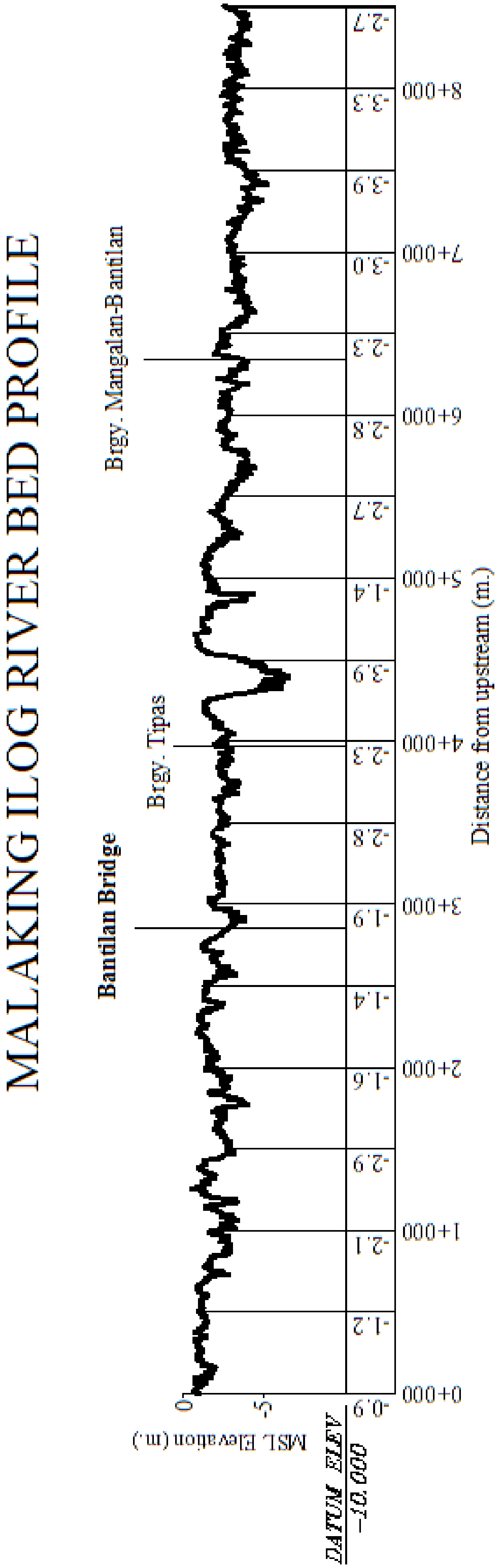

Figure 47. Riverbed profile of Malaking Ilog River

CHAPTER 5: FLOOD MODELING AND MAPPING

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

The methods applied in this chapter were based on the DREAM methods manual (Mahar, 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

Components and data that affect the hydrologic cycle of the river basin was monitored, collected, and analyzed. These include the rainfall, water level, and flow in a certain period of time.

5.1.2 Precipitation

Precipitation data was taken from two automatic rain gauges (ARGs) installed by the Department of Science and Technology – Advanced Science and Technology Institute (DOST-ASTI). This rain gauge is the Padre Garcia ARG (13°52’47.39”N, 121°12’46.22”E), located in Padre Garcia, Batangas (Figure 48). The precipitation data collection started from December 15, 2015 at 00:00 AM to December 15, 2015 at 23:45AM with a 15-minute recording interval.

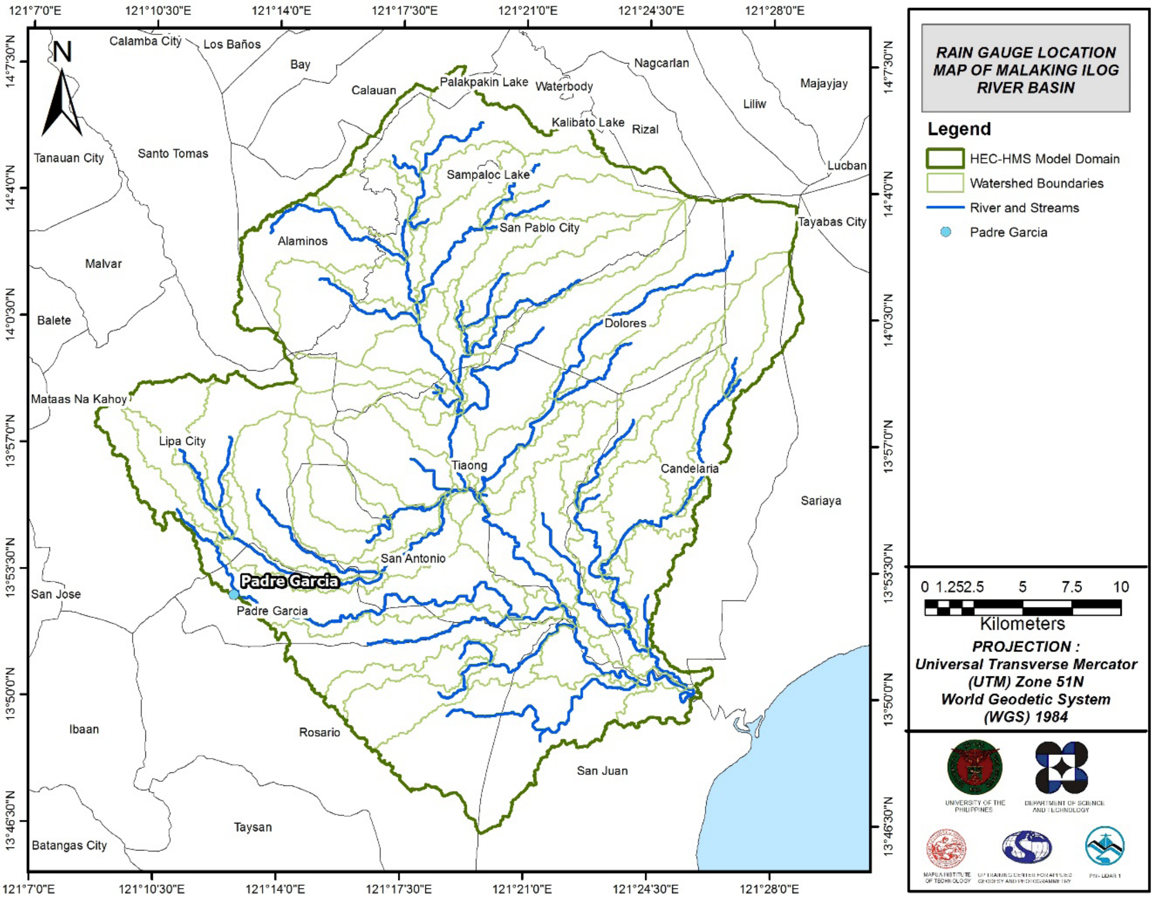

Figure 48. The location map of rain gauges used for the calibration of the Malaking Ilog HEC-HMS Model.

For Padre Garcia Rain Gauge, total rain for the event is 60.6 mm. Peak rain of 7.6 mm was recorded on 15 December 2015. The lag time between the peak rainfall and discharge is 6 hours and 55 minutes, as seen in Figure 54.

5.1.3 Rating Curves and River Outflow

A rating curve was developed at Bantilan Bridge, San Juan, Batangas (13°49’21.48”N, 121°23’48.25”E). It gives the relationship between the observed water levels from the Bantilan Bridge using depth gage and outflow of the watershed got using the flow meter at this location. It is expressed in the form of the following equation:

$$Q=a^{nh}$$

where, Q : Discharge (m^3/s),

h : Gauge height (reading from deployed depth gage at Bridge of Promise), and;

a and n : Constants.

For Bantilan Bridge, the rating curve is expressed as $Q = 0.000053e^{1.403789h}$ as shown in Figure 50.

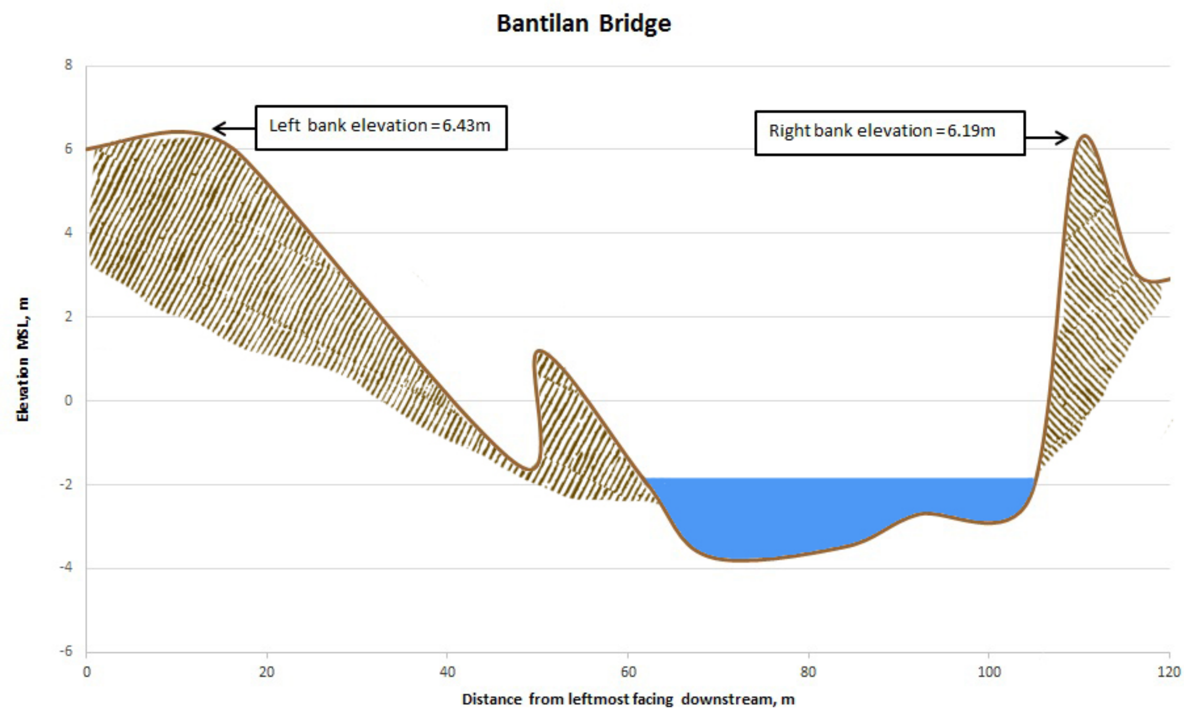

Figure 49. Cross-Section Plot of Bantilan Bridge.

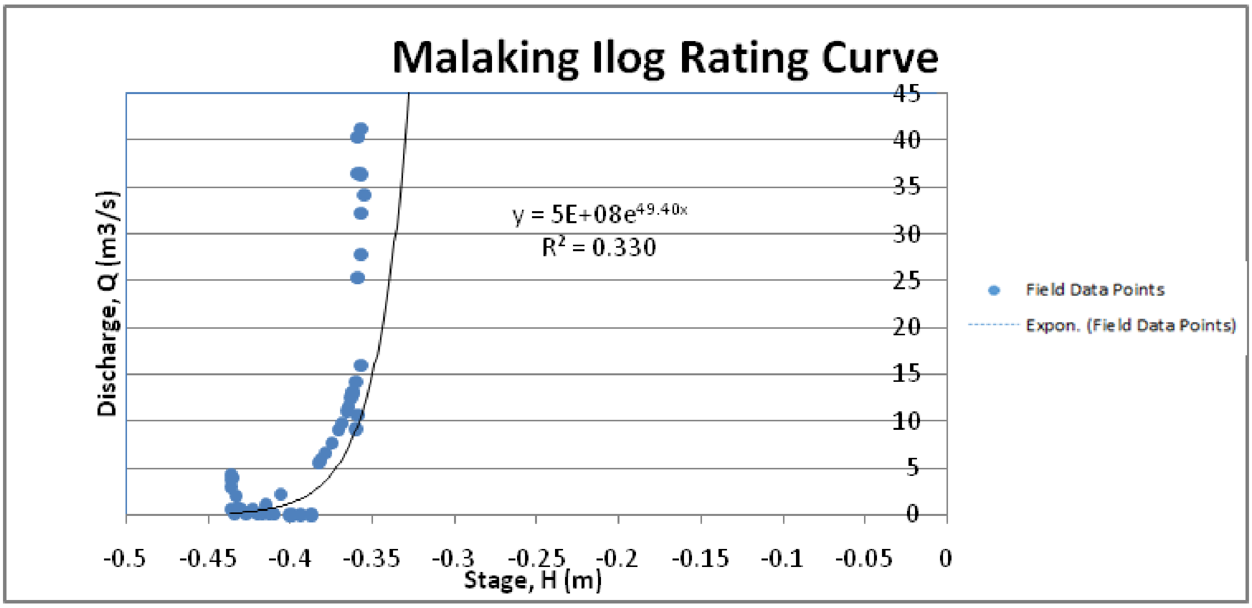

Figure 50. Rating Curve at Bantilan Bridge San Juan, Batangas.

This rating curve equation was used to compute the river outflow at Bantilan Bridge for the calibration of the HEC-HMS model shown in Figure 51. Peak discharge is 41.30 m^3/s at 15:10, December 15, 2015.

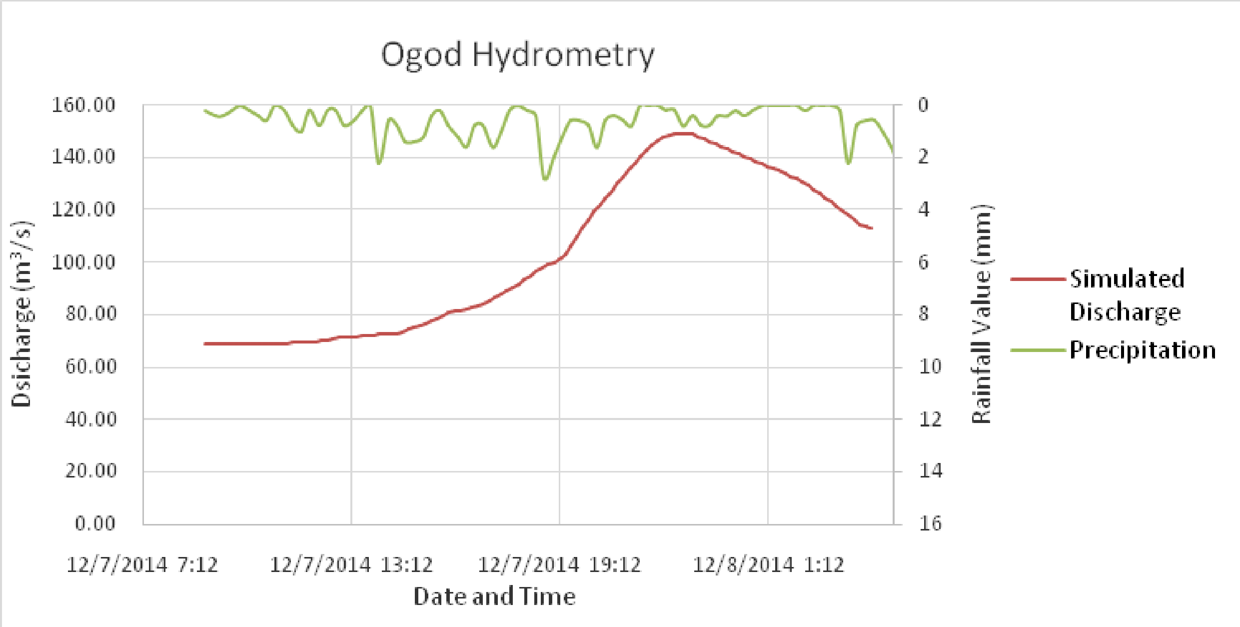

Figure 51. Rainfall and outflow data at Malaking Ilog used for modeling

5.2 RIDF Station

The Philippines Atmospheric Geophysical and Astronomical Services Administration (PAGASA) computed Rainfall Intensity Duration Frequency (RIDF) values for the Tayabas Gauge. This station chosen based on its proximity to the Malaking Ilog watershed. The extreme values for this watershed were computed based on a 54-year record.

Table 34. RIDF values for Tayabas Rain Gauge 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
2	21	32.7	42	59.3	83	99.9	128.2	161.5	195.9
5	29.6	42.1	52.5	77.3	116.1	143	192.6	232.3	279.5
10	35.4	48.3	59.4	89.2	138	171.5	235.2	279.3	334.9
15	38.6	51.8	63.3	96	150.3	187.6	259.3	305.7	366.1
20	40.9	54.3	66.1	100.7	159	198.9	276.1	324.3	388
25	42.6	56.2	68.2	104.3	165.7	207.5	289.1	338.5	404.8
50	48	62	74.7	115.5	186.2	234.3	329.1	382.5	456.7
100	53.4	67.8	81.1	126.6	206.6	260.8	368.8	426.2	508.3

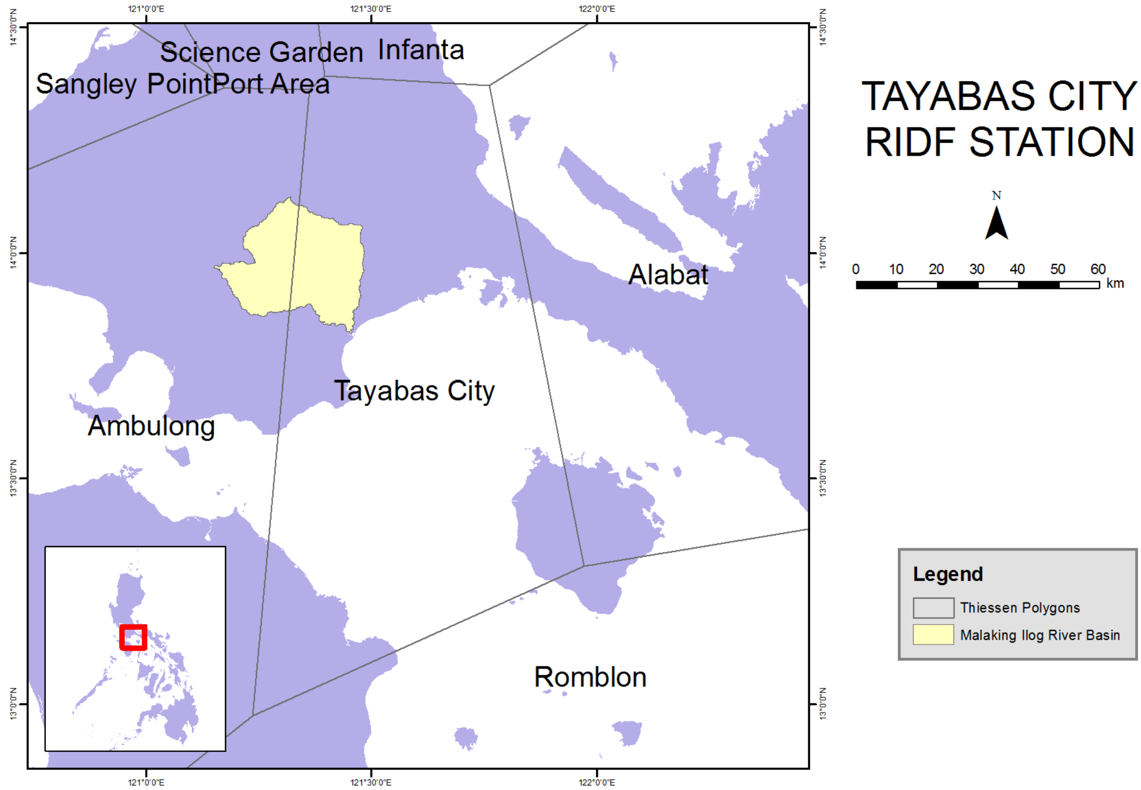

Figure 52. Tayabas RIDF location relative to Calumpang River Basin

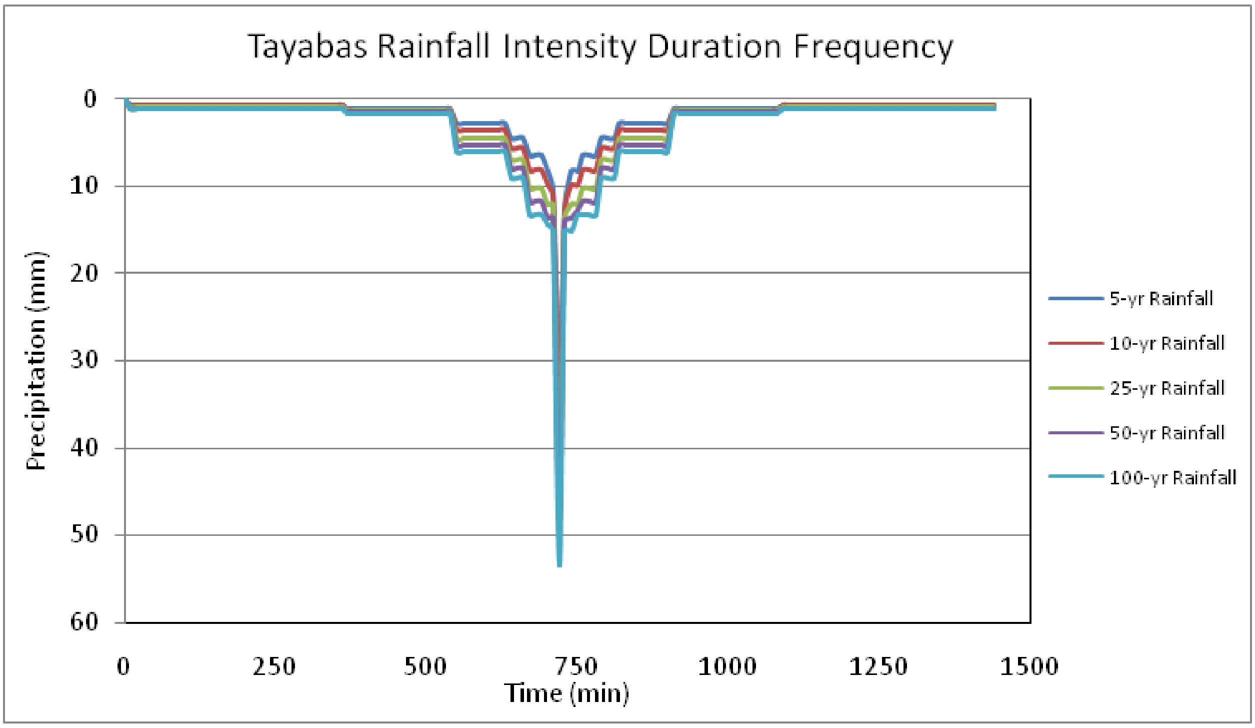

Figure 53. Synthetic storm generated for a 24-hr period rainfall for various return periods

5.3 HMS Model

The soil dataset was taken on 2004 from the Bureau of Soils; this is under the Department of Agriculture (DA). The land cover dataset is from the National Mapping and Resource information Authority (NAMRIA). The soil and land cover of the Malaking-Ilog River Basin are shown in Figures 54 and 55, respectively.

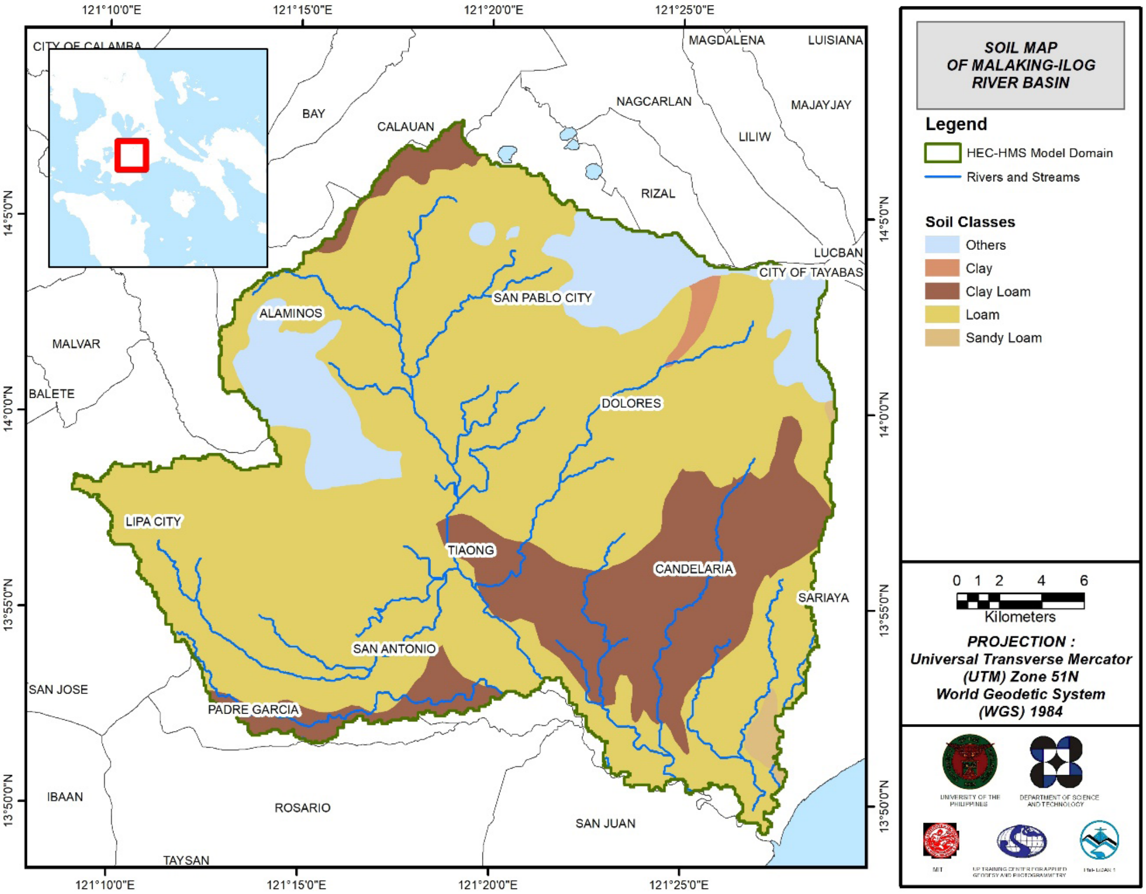

Figure 54. Soil Map of Malaking-Ilog River Basin

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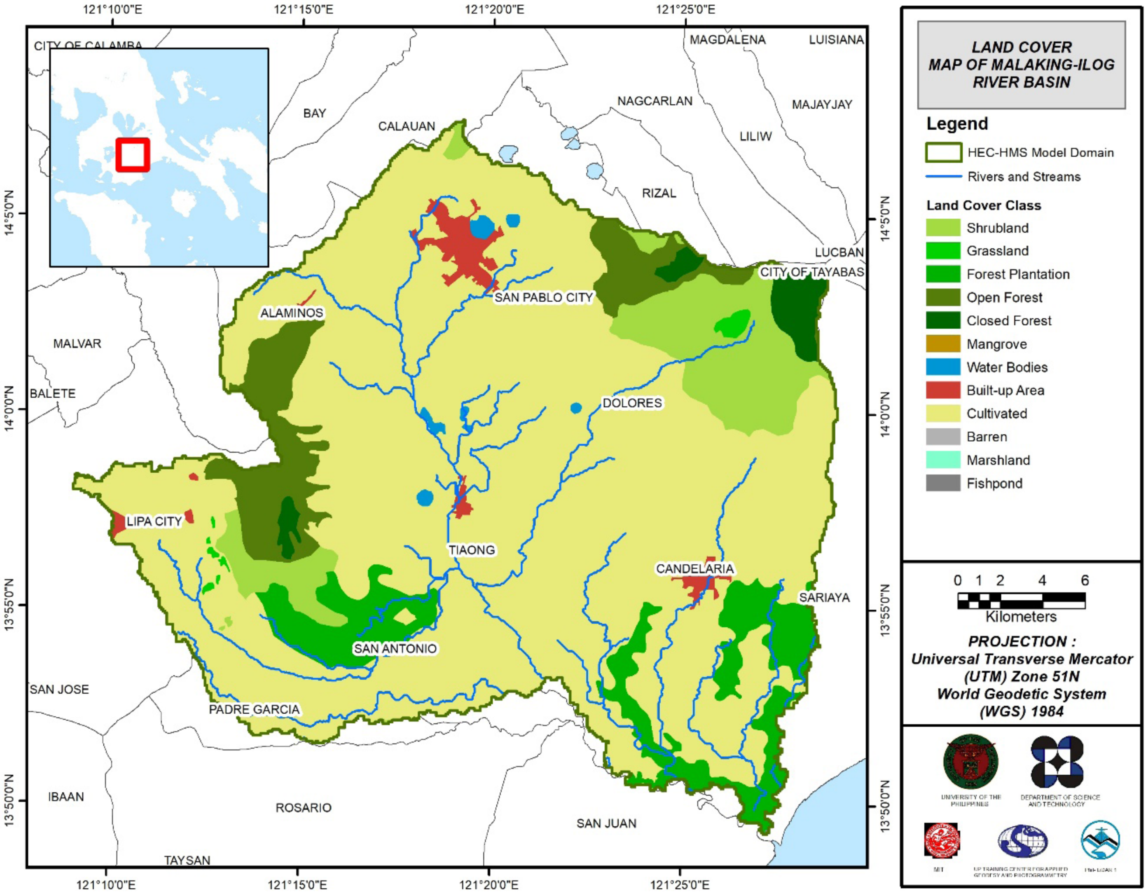
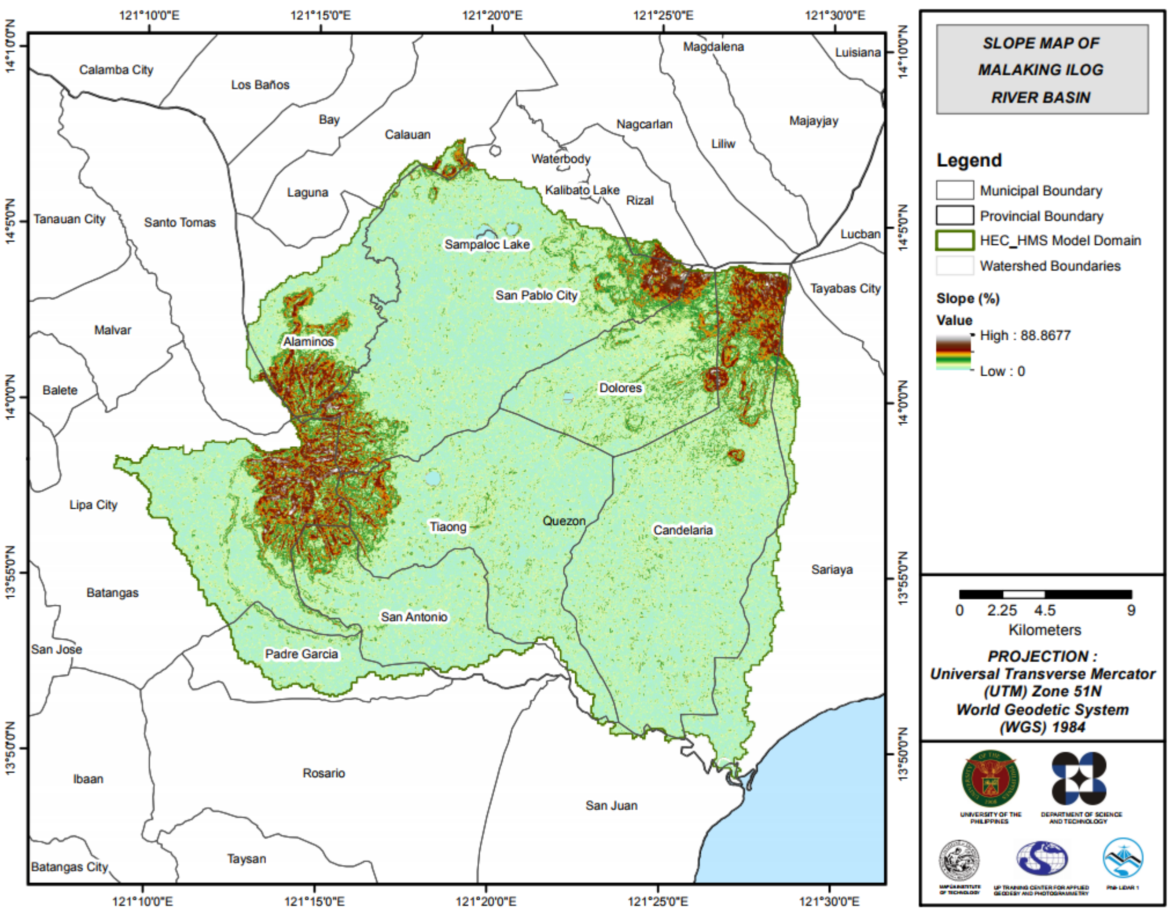


Figure 55. Land Cover Map of Malaking-Ilog River Basin

For Malaking-Ilog, the soil classes identified were clay loam, clay, loam and sandy loam. The land cover types identified were brushland, grassland, fishpond, built-up areas, inland water bodies, closed and open canopy forests, cultivated areas and tree plantations.



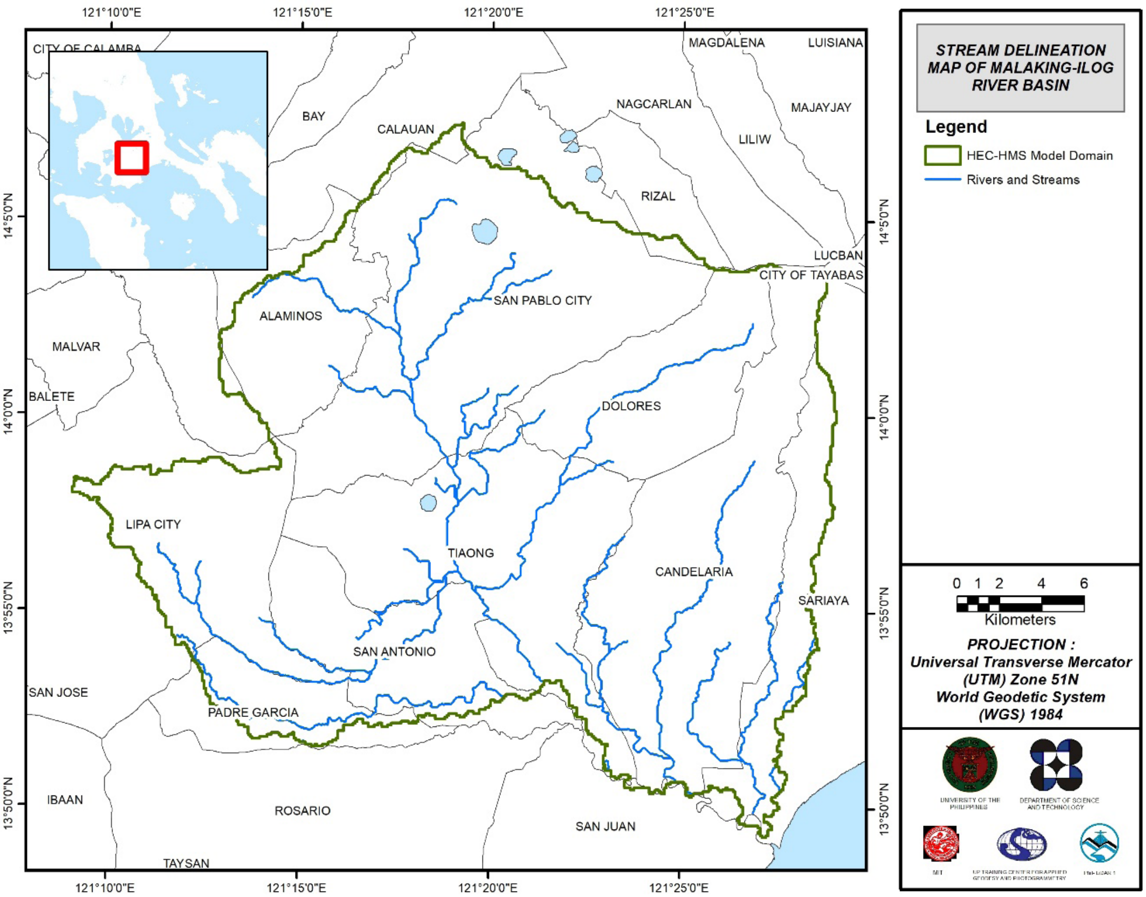


Figure 56. Stream delineation map of Malaking-Ilog river basin.

The Malaking Ilog basin model consists of 68 sub basins, 34 reaches, and 34 junctions. The main outlet is at the southeasternmost tip of the watershed. This basin model is illustrated in Figure 57. The basins were identified based on soil and land cover characteristic of the area. Precipitation was taken from an installed Rain Gauge near and inside the river basin. Finally, it was calibrated using the data from actual discharge flow gathered in the Bantilan Bridge.

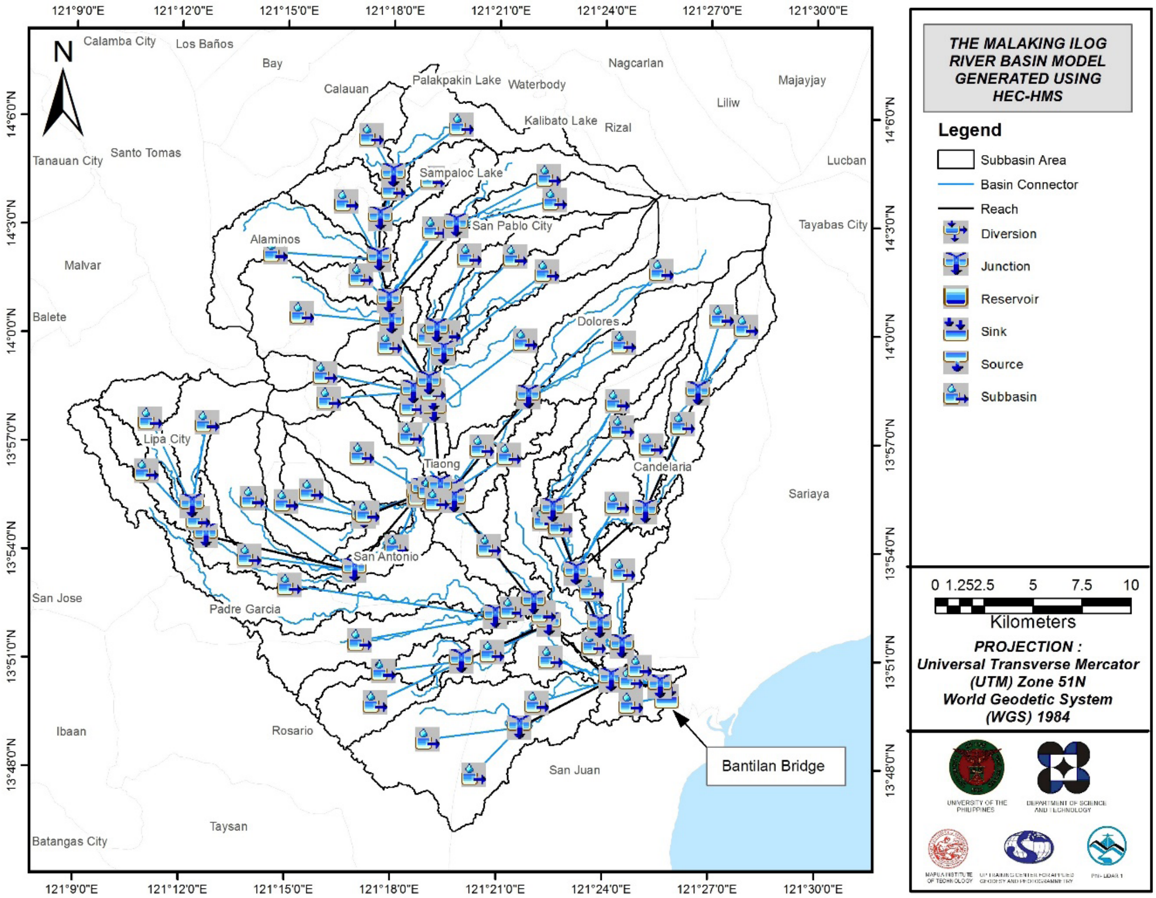


Figure 57. The Malaking Ilog River Basin Model Domain generated by HEC-HMS.

5.4 Cross-section Data

Riverbed cross-sections of the watershed are crucial in the HEC-RAS model setup. The cross-section data for the HEC-RAS model was derived using the LiDAR DEM data. It was defined using the Arc GeoRAS tool and was post-processed in ArcGIS.

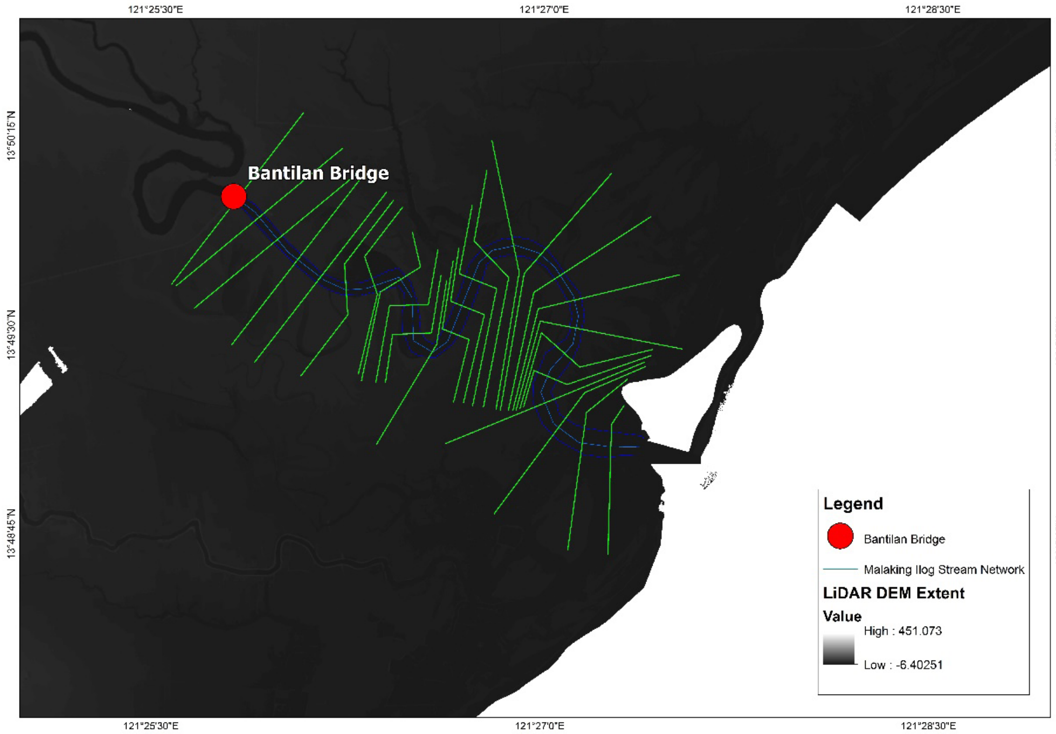


Figure 58. River cross-section of Malaking Ilog River generated through Arcmap HEC GeoRAS tool.

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 north of the model to the west , following the main channel. As such, boundary elements in those particular regions of the model are assigned as inflow and outflow elements respectively.

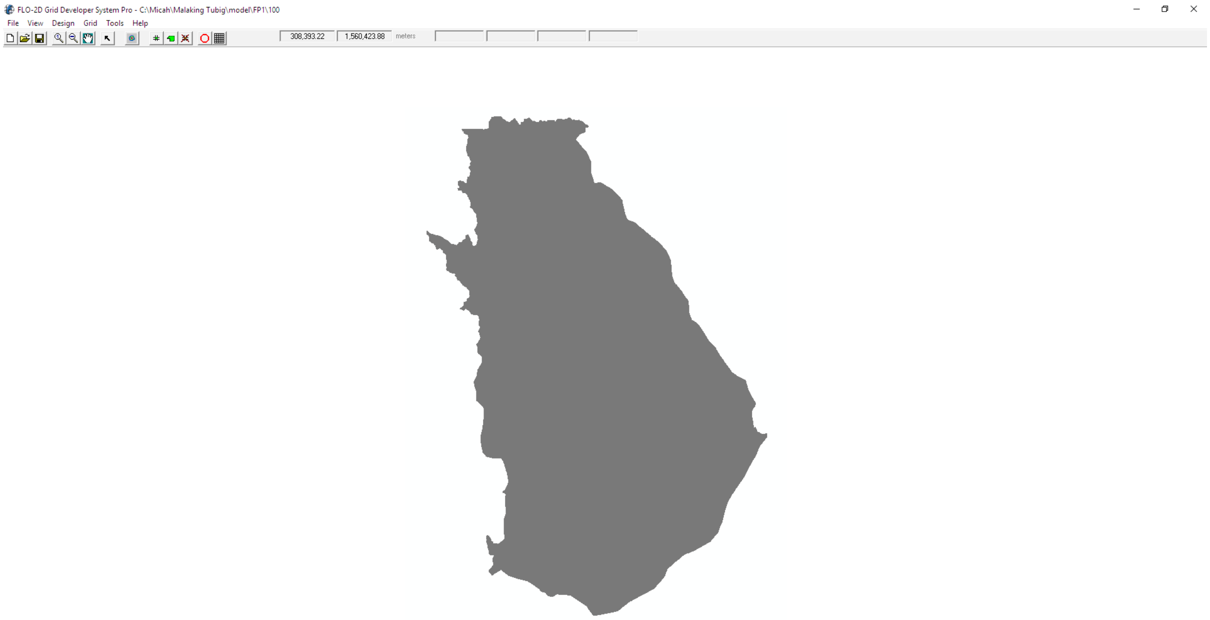


Figure 59. Screenshot of subcatchment with the computational area to be modeled in FLO-2D GDS Pro

The simulation is then run through FLO-2D GDS Pro. This particular model had a computer run time of 106.15173 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.

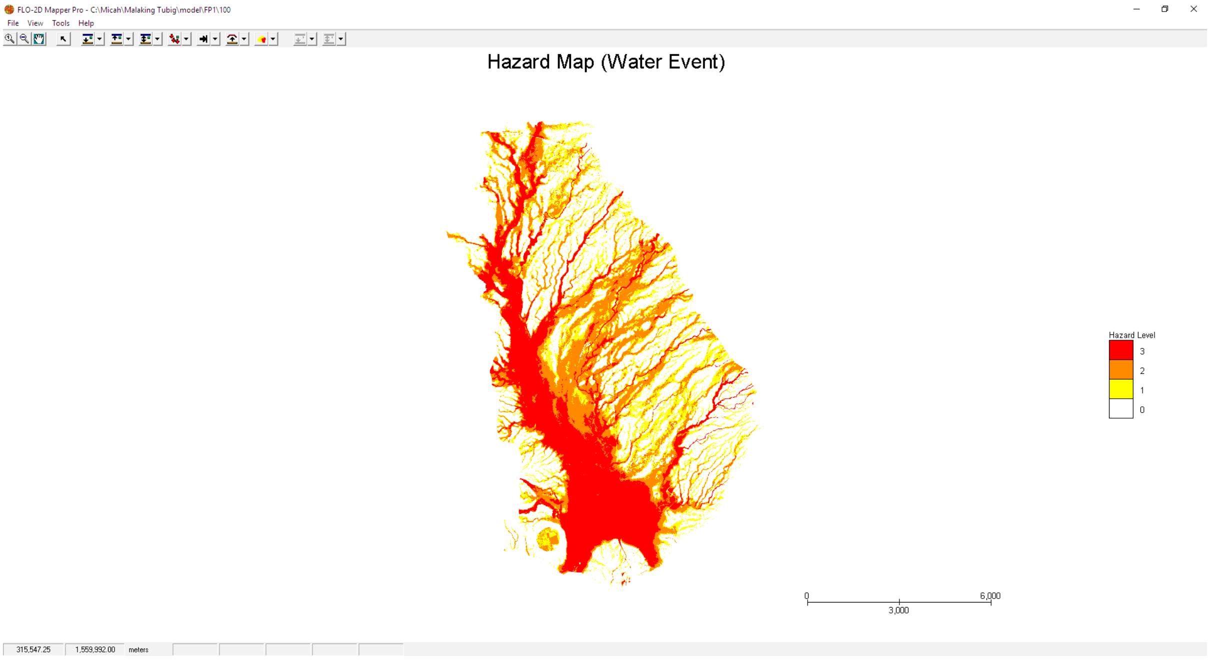


Figure 60. Generated 100-year rain return hazard map from FLO-2D Mapper

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 57251400.00 m^2.

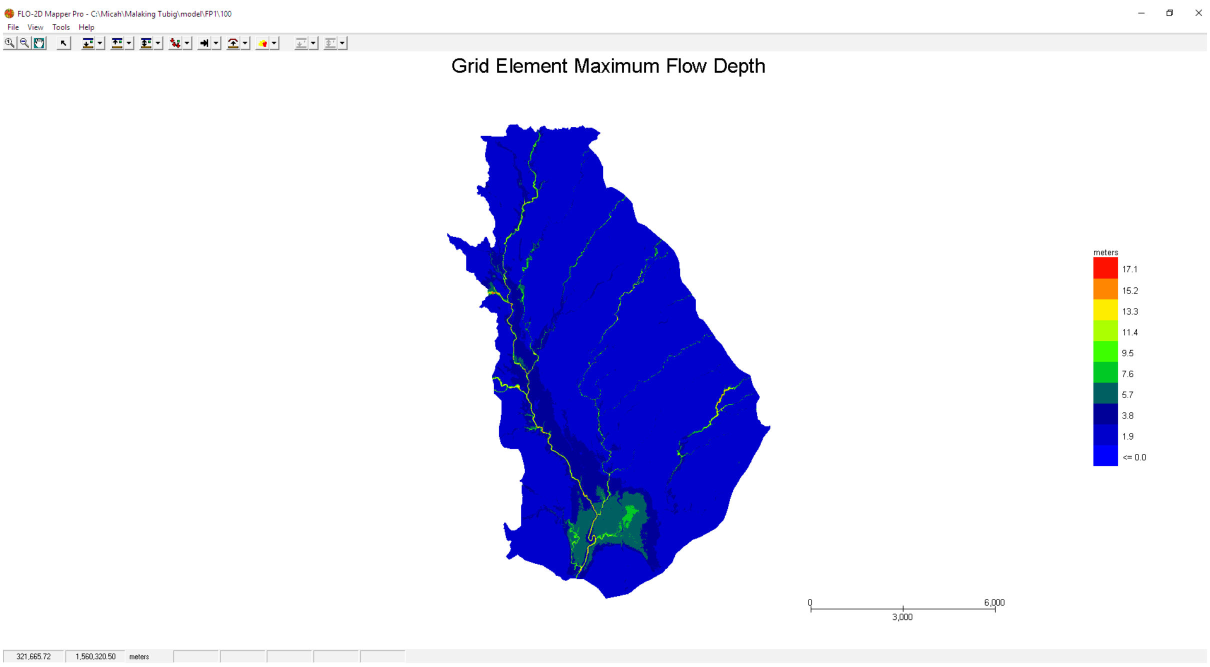


Figure 61. Generated 100-year rain return flow depth map from FLO-2D Mapper

There is a total of 114184147.59 m^3 of water entering the model. Of this amount, 47500660.78 m^3 is due to rainfall while 66683486.80 m^3 is inflow from other areas outside the model. 14608467.00 75 m^3 of this water is lost to infiltration and interception, while 14400968.56 m^3 is stored by the flood plain. The rest, amounting up to 84934093.68 m^3, is outflow.

5.6 Results of HMS Calibration

After calibrating the Malaking Ilog HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 11 shows the comparison between the two discharge data.

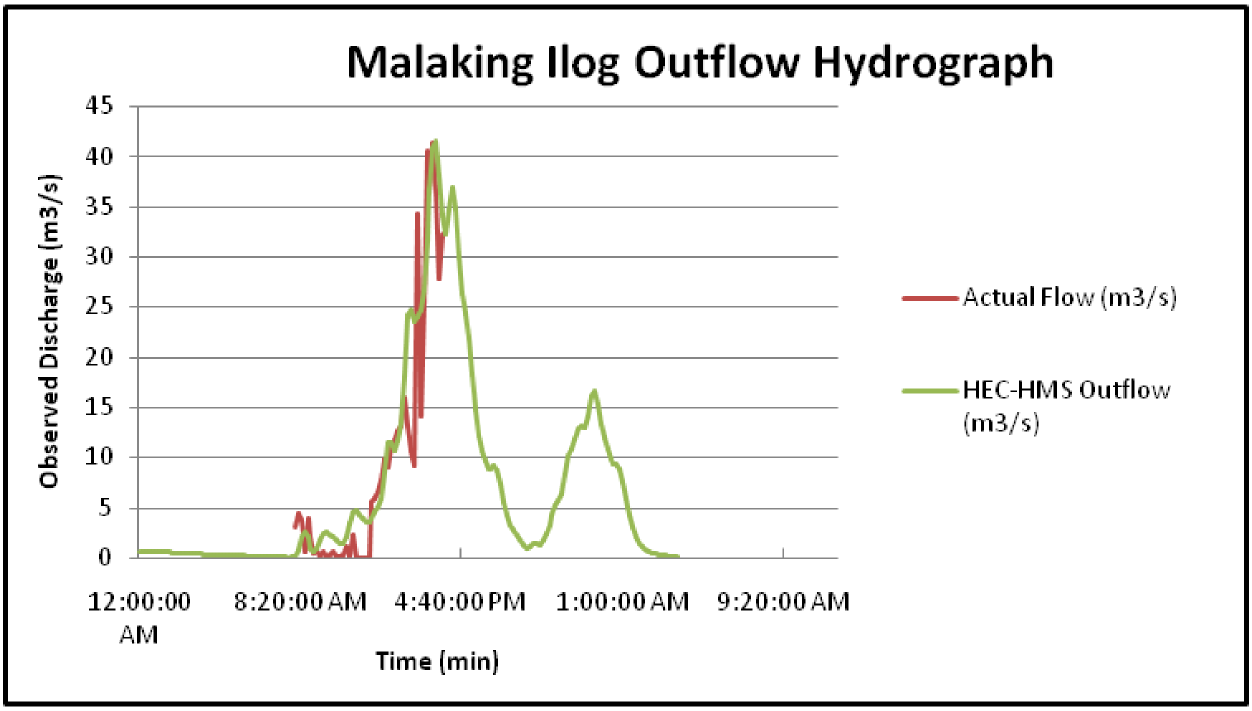


Figure 62. Outflow Hydrograph of Malaking Ilog produced by the HEC-HMS model compared with observed outflow.

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

Table 35. Range of Calibrated Values for Malaking-Ilog.

Hydrologic Element	Calculation Type	Method	Parameter	Range of Calibrated Values
Basin	Loss	SCS Curve number	Initial Abstraction (mm)	8.80 - 500
			Curve Number	28.91 – 49.51
	Transform	Clark Unit Hydrograph	Time of Concentration (hr)	0.092 – 3.72
			Storage Coefficient (hr)	0.017 – 4.58
	Baseflow	Recession	Recession Constant	0.00001
			Ratio to Peak	0.00015
Reach	Routing	Muskingum-Cunge	Manning's Coefficient	0.0001 – 0.0096

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 8.80mm to 500mm means that there is minimal to considerable 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 curve numbers of the watershed's subbasins range from 28.91 to 49.51. For Malaking-Ilog, the soil classes identified were clay loam, clay, loam and sandy loam. The land cover types identified were brushland, grassland, fishpond, built-up areas, inland water bodies, closed and open canopy forests, cultivated areas and tree plantations.

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 0.017 hours to 4.58 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. The Recession Constant throughout the basin is 0.00001 and the Ratio to Peak is 0.00015. These values influence the receding limb of the outflow hydrograph which in this case can be described as likely to quickly go back to its original discharge.

Manning's roughness coefficient of 0.0001 to 0.0096 corresponds to the common roughness values in Malaking-Ilog watershed.

Table 36. Summary of the Efficiency Test of Malaking Ilog HMS Model.

Accuracy Measure	Value
RMSE	4.9
r^2	0.33
NSE	0.84
PBIAS	-14.22
RSR	0.40

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was identified at 4.9.

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 0.33.

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 -14.22.

The Observation Standard Deviation Ratio, RSR, is an error index. A perfect model attains avalue of 0 when the error in the units of the valuable a quantified. The model has an RSR value of 0.40.

5.7 Calculated Outflow hydrographys and Discharge Values for different Rainfall Return Periods

5.7.1 Hydrograph using the Rainfall Runoff Model

The summary graph (Figure 63) shows the Malaking Ilog outflow using the Tayabas 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.

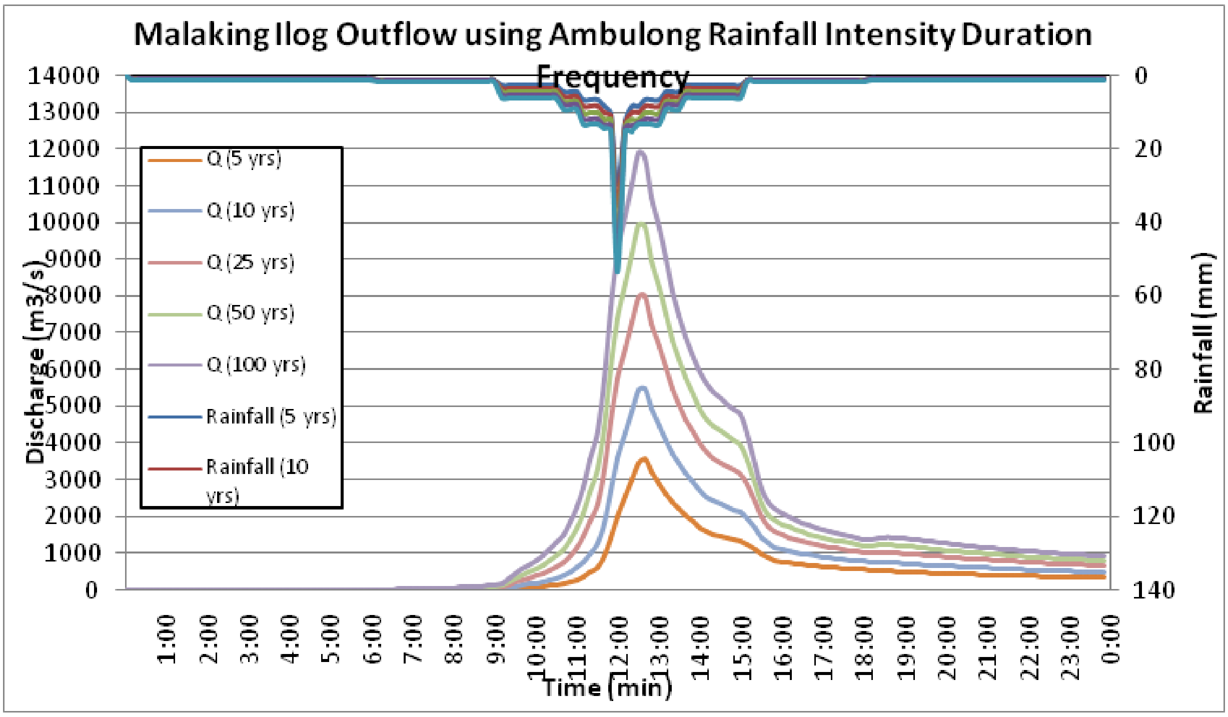


Figure 63. Outflow hydrograph at Malaking Ilog Station generated using Tayabas RIDF simulated in HEC-HMS.

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

Table 37. Peak values of the Malaking Ilog HECHMS Model outflow using the Tayabas RIDF.

RIDF Period	Total Precipitation (mm)	Peak rainfall (mm)	Peak outflow (m 3/s)	Time to Peak
5-Year	279.5	29.6	3569.5	12 hours
10-Year	334.9	35.4	5483.3	12 hours
25-Year	404.8	42.6	7990.8	12 hours
50-Year	456.7	48	9924.8	12 hours
100-Year	508.3	53.4	11905.3	12 hours

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. For this publication, only a sample output map river was to be shown, since only the Flood Acquisition and Validation Component (MIT-FAVC) base flow was calibrated. The sample generated map of Malaking Ilog River using the calibrated HMS base flow is shown in Figure 64.

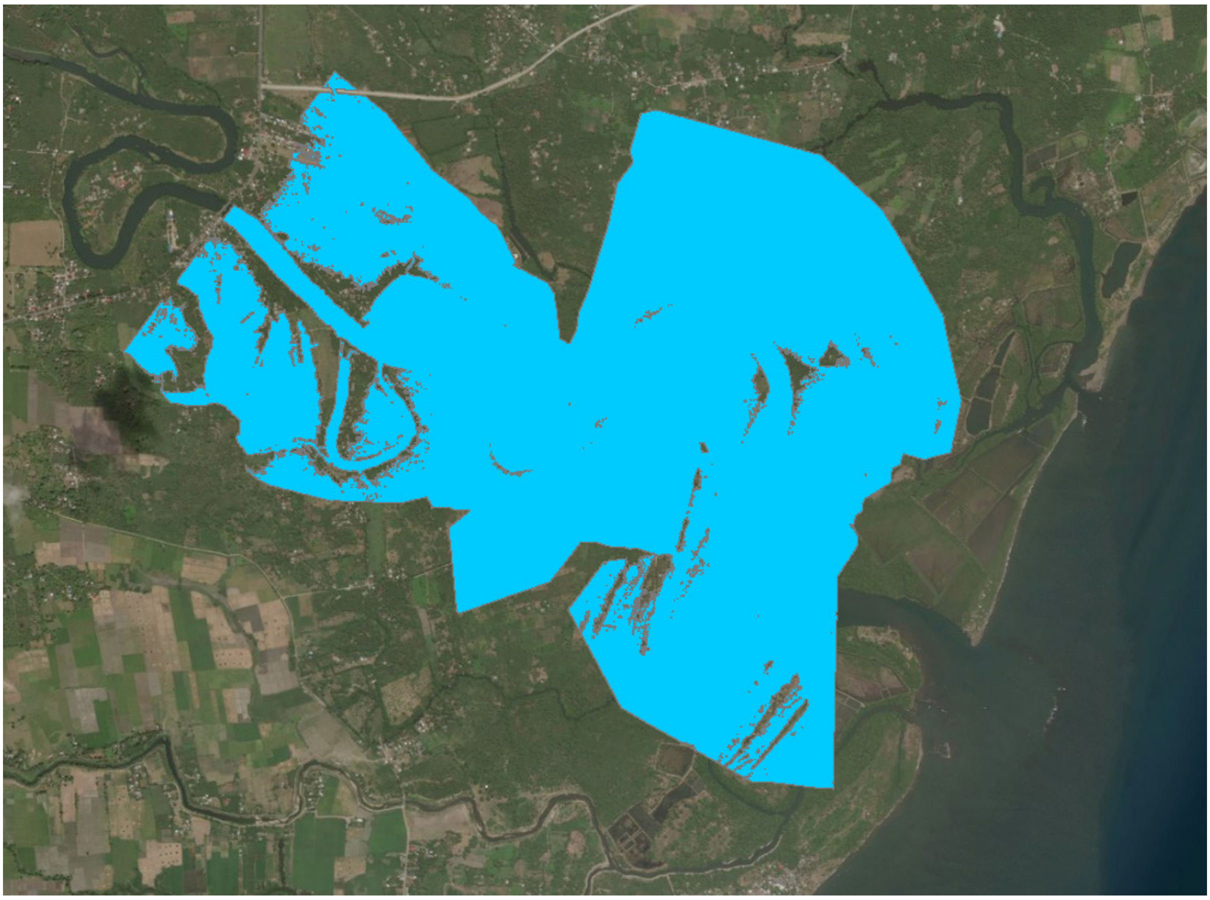


Figure 64. Sample output of Malaking Ilog RAS Model

5.9 Flow Depth and Flood Hazard

The resulting hazard and flow depth maps have a 10m resolution. Figure 65 to Figure 70 shows the 5-, 25-, and 100-year rain return scenarios of the Malaking Ilog floodplain.

Table 38. Municipalities affected in Malaking-Ilog floodplain.

Municipality	Total Area	Area Flooded	% Flooded
San Pablo	184.81	2.992	1.62%
Padre Garcia	39.28	2.41	6.12%
Sariaya	213.78	8.94	4.18%
San Juan	237.55	32.099	13.51%
Tiaong	118.93	20.22	17.00%
Alaminos	59.65	0.66	1.11%
Dolores	65.96	0.66	1.01%
Candelaria	136.74	11.028	8.07%
Rosario	199.04	7.96	4.00%
San Antonio	62.38	5.70	9.14%

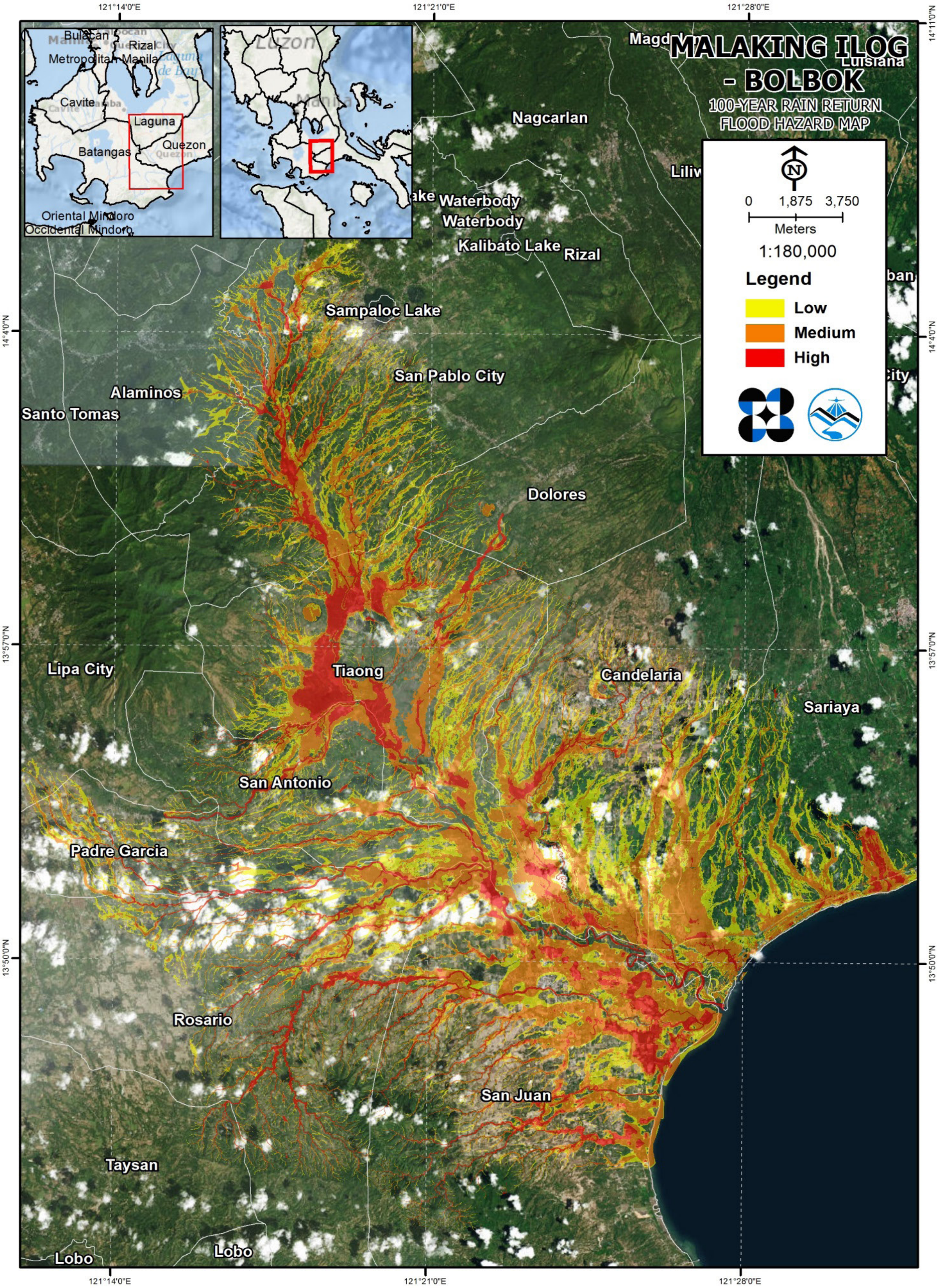


Figure 65. 100-year Hazard Map for Malaking Ilog-Bolbok Floodplain

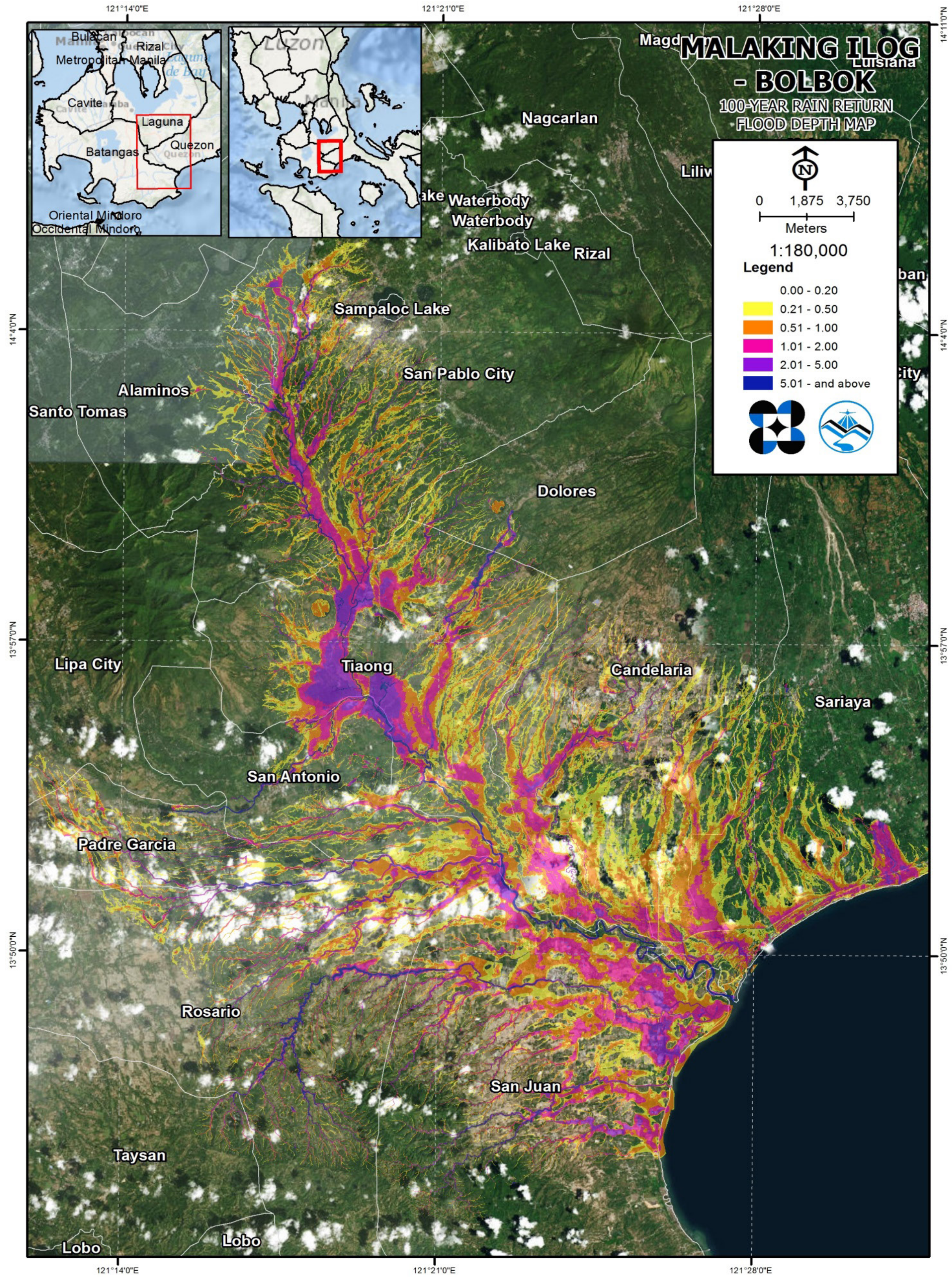


Figure 66. 100-year Flow Depth Map for Malaking Ilog-Bolbok Floodplain

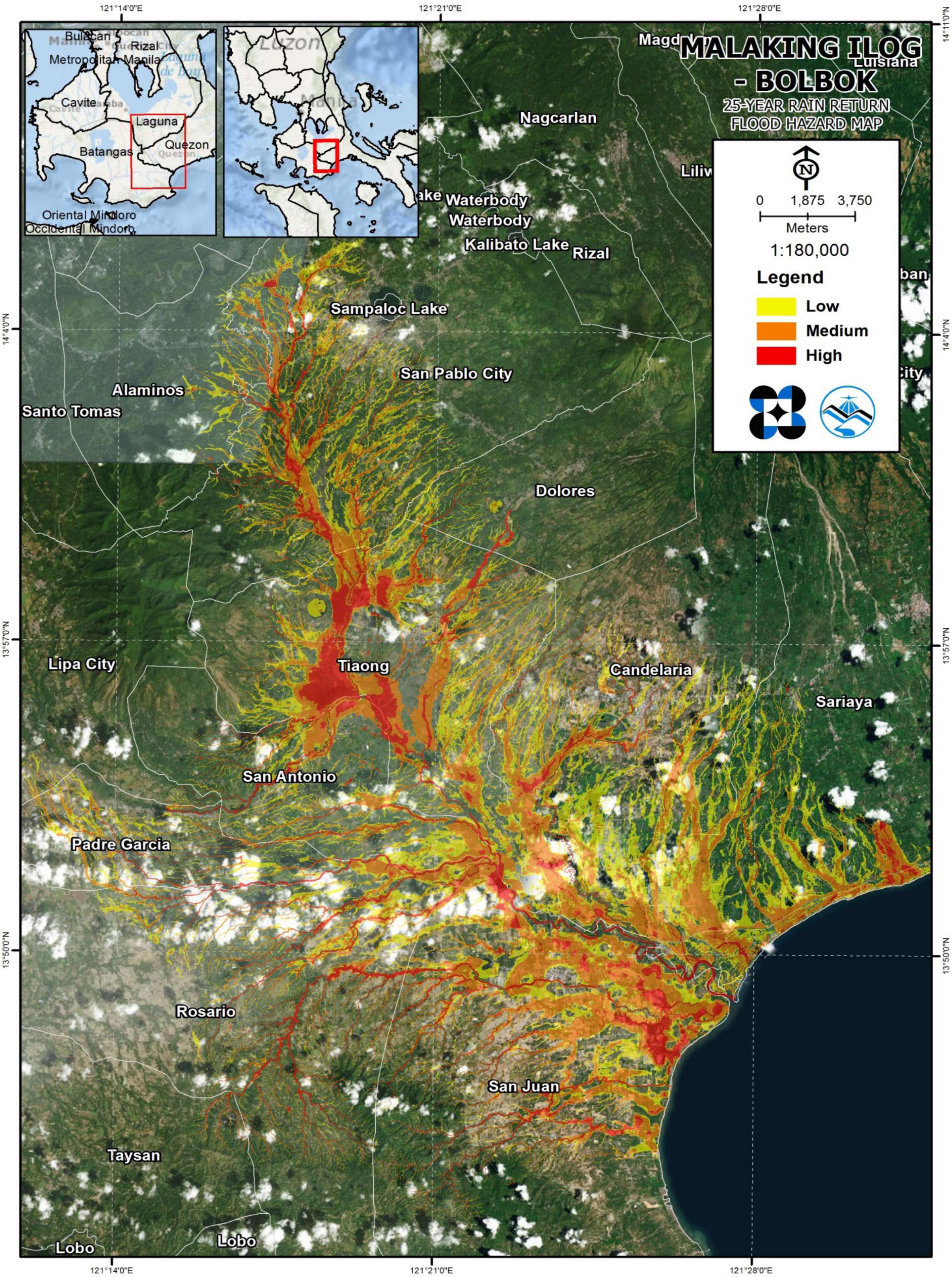


Figure 67. 25-year Hazard Map for Malaking Ilog-Bolbok Floodplain

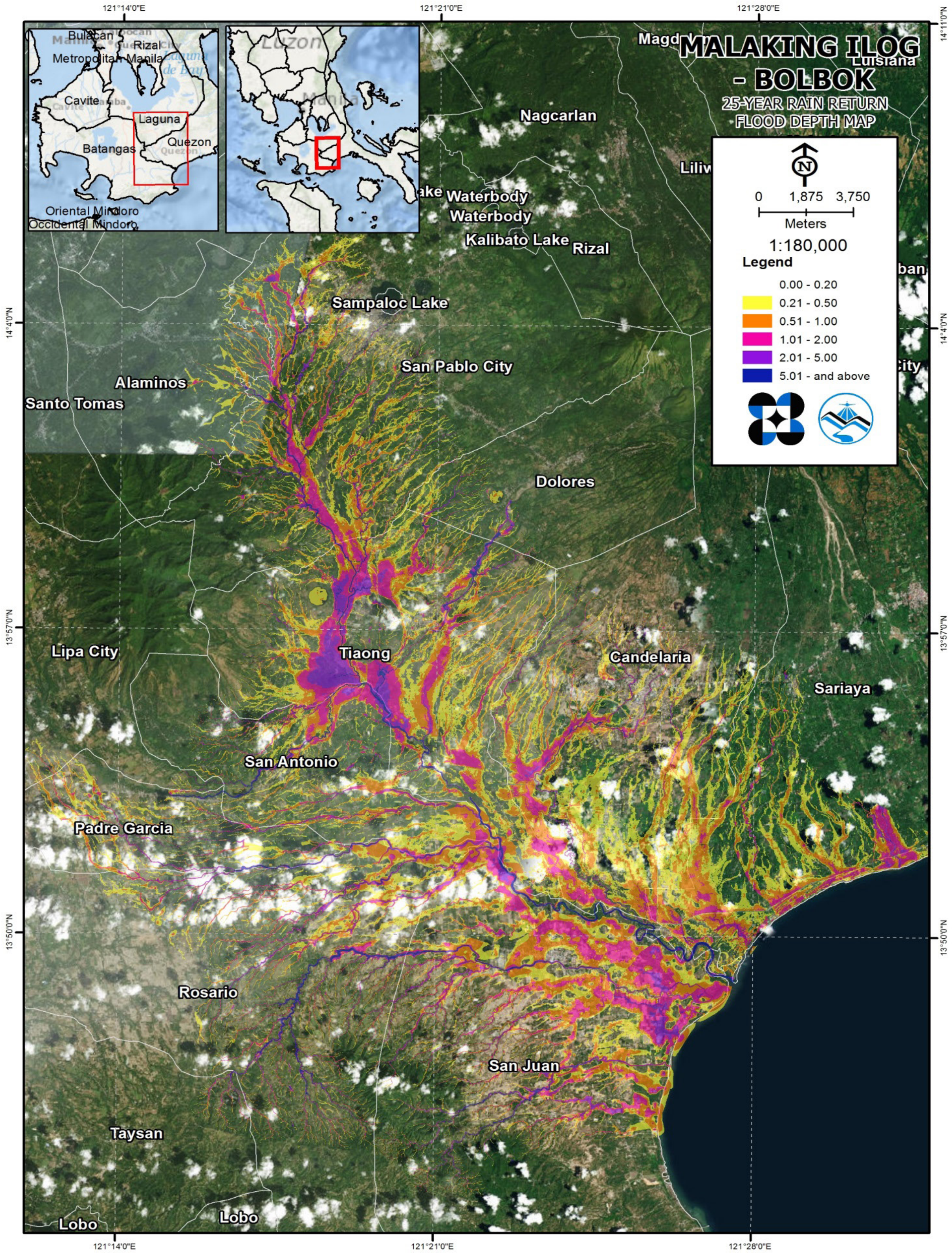


Figure 68. 25-year Flow Depth Map for Malaking Ilog-Bolbok Floodplain

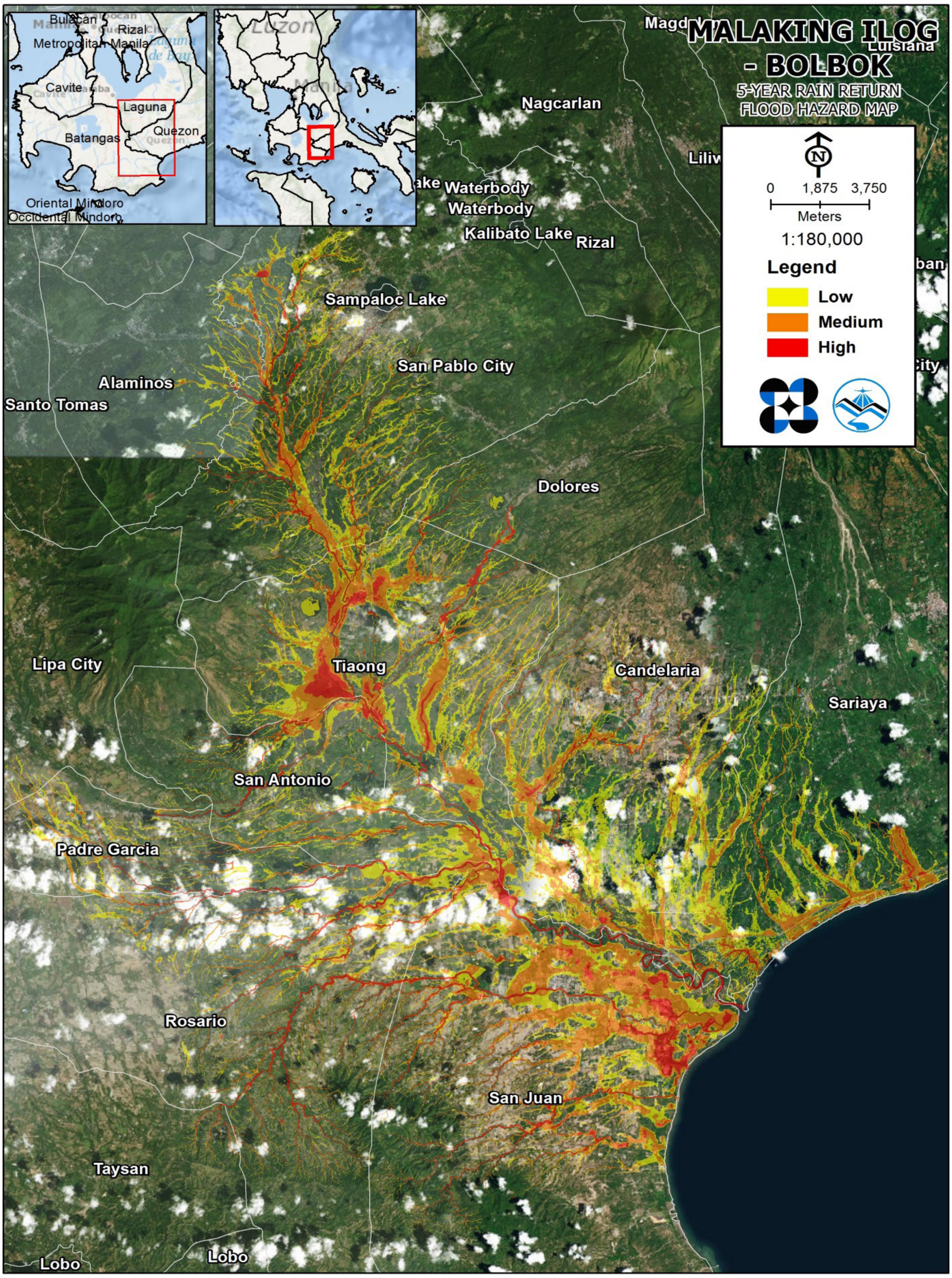


Figure 69. 5-year Hazard Map for Malaking Ilog-Bolbok Floodplain

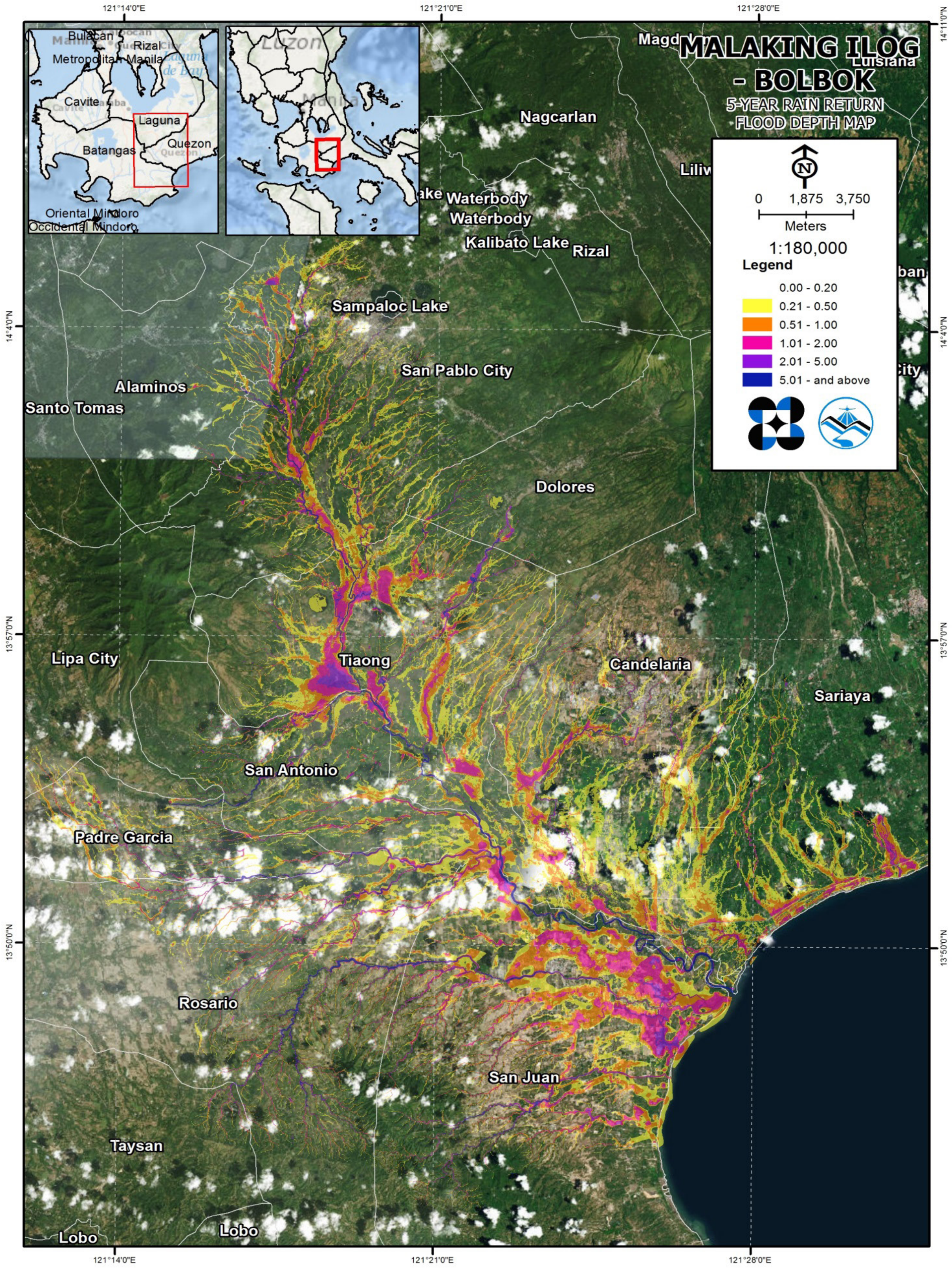


Figure 70. 5-year Flow Depth Map for Malaking Ilog-Bolbok Floodplain

5.10 Inventory of Areas Exposed to Flooding of Affected Areas

Listed below are the barangays affected by the Malaking-Ilog and Bolbok River Basins, grouped accordingly by municipality. For the said basin, ten (10) municipalities consisting of 228 barangays are expected to experience flooding when subjected to a 5-year rainfall return period.

For the 5-year return period, 2.70% of the municipality of San Pablo City with an area of 184.81 sq. km. will experience flood levels of less than 0.20 meters. 0.40% of the area will experience flood levels of 0.21 to 0.50 meters while 0.18%, 0.10%, 0.07%, and 0.04% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

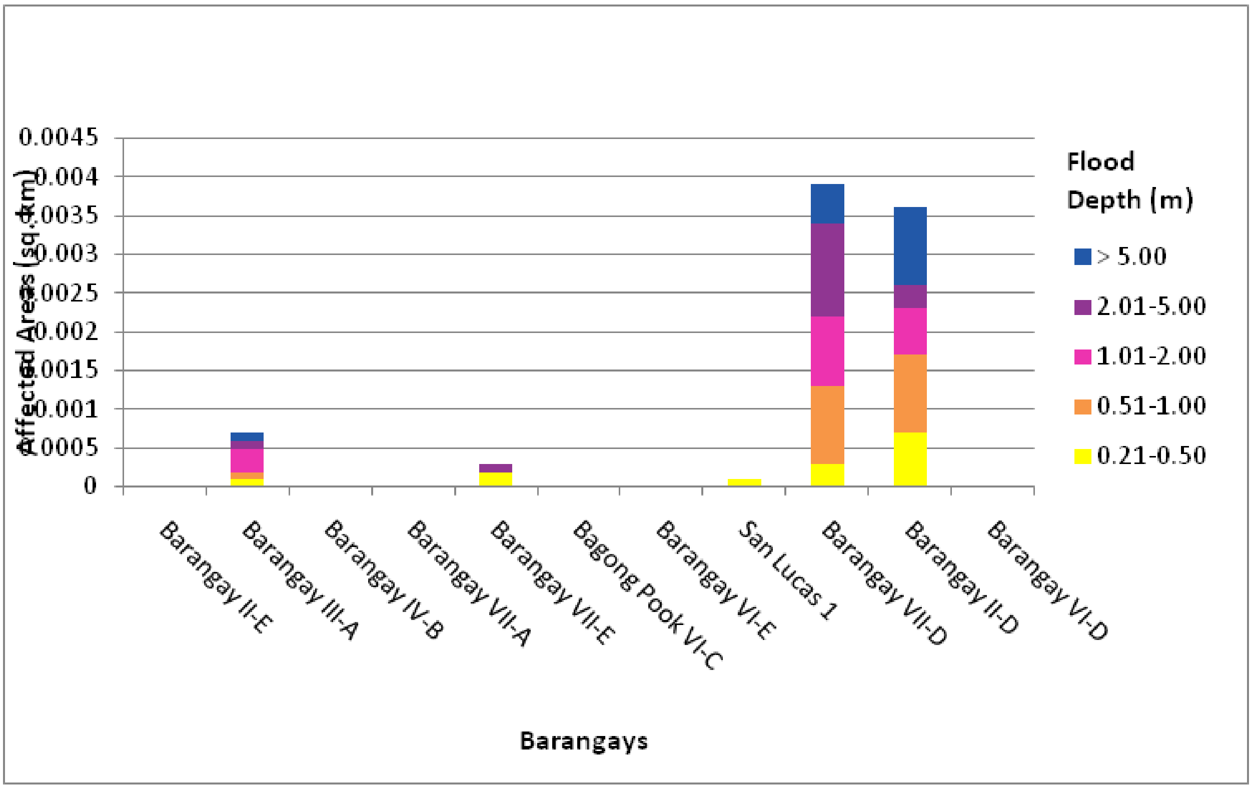
Table 39. Affected areas in San Pablo City, Laguna during a 5-Year Rainfall Return Period.

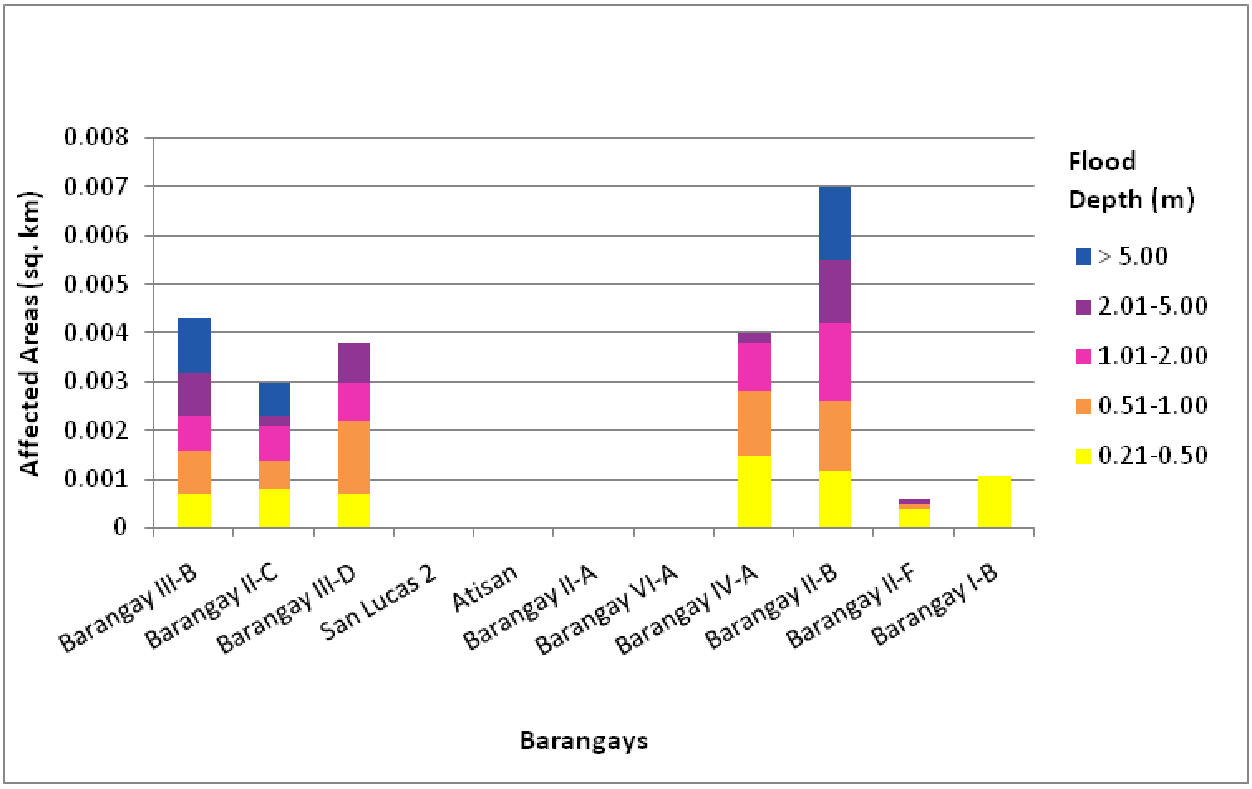
Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Barangay II-E	Barangay III-A	Barangay IV-B	Barangay VII-A	Barangay VII-E	Bagong Pook VI-C	Barangay VI-E	San Lucas 1	Barangay VII-D	Barangay II-D	Barangay VI-D
0.03-0.20	0.0012	0.0004	0.0001	0.0009	0.0003	0.0007	0.0004	0.0005	0.0014	0.002	0.0036
0.21-0.50	0	0.0001	0	0	0.0002	0	0	0.0001	0.0003	0.0007	0
0.51-1.00	0	0.0001	0	0	0	0	0	0	0.001	0.001	0
1.01-2.00	0	0.0003	0	0	0	0	0	0	0.0009	0.0006	0
2.01-5.00	0	0.0001	0	0	0.0001	0	0	0	0.0012	0.0003	0
> 5.00	0	0.0001	0	0	0	0	0	0	0.0005	0.001	0

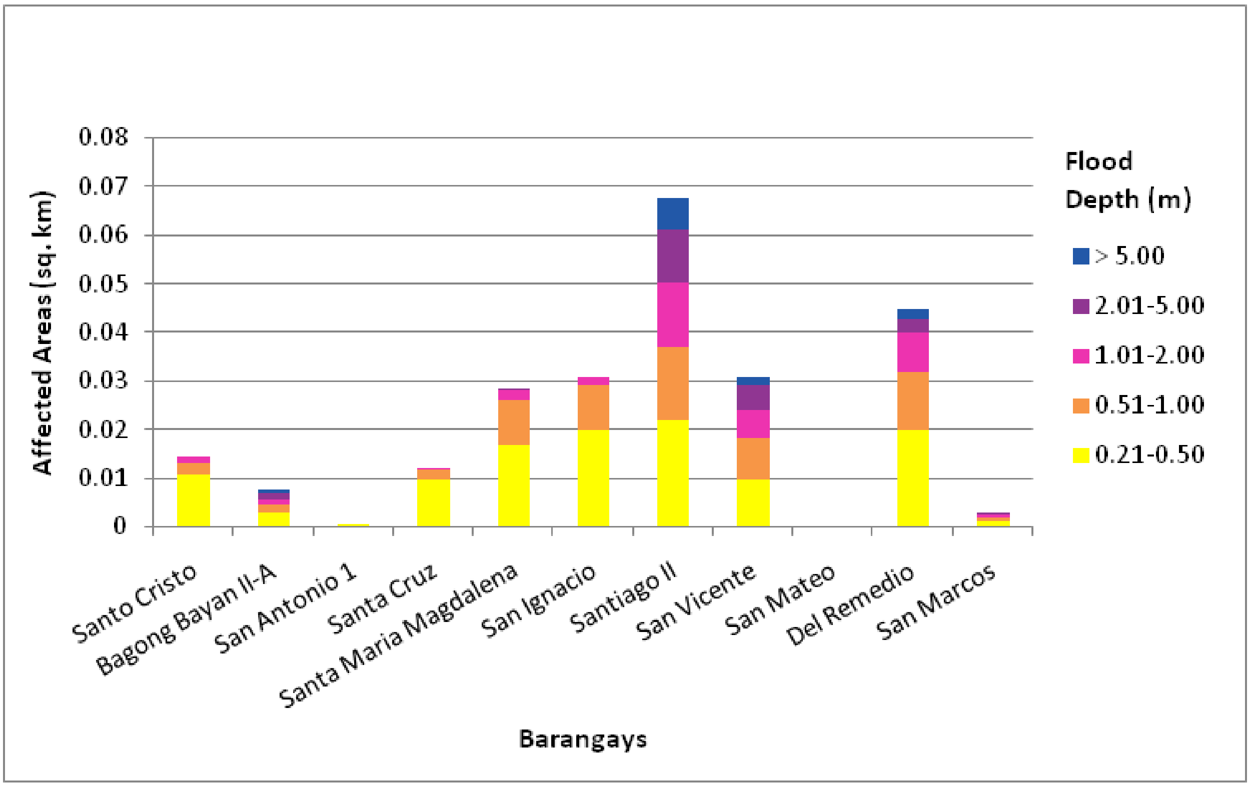
Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Barangay III-B	Barangay II-C	Barangay III-D	San Lucas 2	Atisan	Barangay II-A	Barangay VI-A	Barangay IV-A	Barangay II-B	Barangay II-F	Barangay I-B
0.03-0.20	0.001	0.002	0.0025	0.0026	0.0034	0.0068	0.0046	0.0018	0.0066	0.027	0.031
0.21-0.50	0.0007	0.0008	0.0007	0	0	0	0	0.0015	0.0012	0.0004	0.0011
0.51-1.00	0.0009	0.0006	0.0015	0	0	0	0	0.0013	0.0014	0.0001	0
1.01-2.00	0.0007	0.0007	0.0008	0	0	0	0	0.001	0.0016	0	0
2.01-5.00	0.0009	0.0002	0.0008	0	0	0	0	0.0002	0.0013	0.0001	0
> 5.00	0.0011	0.0007	0	0	0	0	0	0	0.0015	0	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Santo Cristo	Bagong Bayan II-A	San Antonio 1	Santa Cruz	Santa Maria Magdalena	San Ignacio	Santiago II	San Vicente	San Mateo	Del Remedio	San Marcos
0.03-0.20	0.026	0.065	0.08	0.066	0.094	0.097	0.078	0.11	0.12	0.14	0.22
0.21-0.50	0.011	0.003	0.0004	0.0099	0.017	0.02	0.022	0.0097	0.0001	0.02	0.0015
0.51-1.00	0.0022	0.0019	0	0.0021	0.0091	0.0093	0.015	0.0085	0	0.012	0.0007
1.01-2.00	0.0013	0.0009	0	0.0002	0.0024	0.0016	0.013	0.0058	0	0.008	0.0007
2.01-5.00	0	0.0012	0	0	0.0001	0	0.011	0.0051	0	0.0028	0.0001
> 5.00	0	0.0009	0	0	0	0	0.0065	0.0019	0	0.0018	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Santa Ana	San Francisco	San Gabriel	San Gregorio	San Antonio 2	San Juan	San Roque	Santa Monica	San Rafael	Soledad	Santa Felomina
0.03-0.20	0.38	0.16	0.23	0.3	0.22	0.37	0.37	0.43	0.37	0.64	0.33
0.21-0.50	0.028	0.024	0.015	0.011	0.031	0.05	0.023	0.07	0.15	0.063	0.15
0.51-1.00	0.016	0.024	0.0098	0.0092	0.0047	0.016	0.014	0.051	0.055	0.015	0.043
1.01-2.00	0.014	0.013	0.009	0.0095	0.0014	0.015	0.0072	0.039	0.023	0.009	0
2.01-5.00	0.0082	0.0045	0.0064	0.0069	0.0001	0.013	0.0009	0.031	0.017	0.0083	0
> 5.00	0.0014	0.0028	0.0062	0.0061	0	0.008	0	0.018	0.016	0.0074	0


0.0045
0.004
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
Affected Areas (sq. km)
Barangay II-E
Barangay III-A
Barangay IV-B
Barangay VII-A
Barangay VII-E
Bagong Pook VI-C
Barangay VI-E
San Lucas 1
Barangay VII-D
Barangay II-D
Barangay VI-D
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50


0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Affected Areas (sq. km)
Barangay III-B
Barangay II-C
Barangay III-D
San Lucas 2
Atisan
Barangay II-A
Barangay VI-A
Barangay IV-A
Barangay II-B
Barangay II-F
Barangay I-B
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50



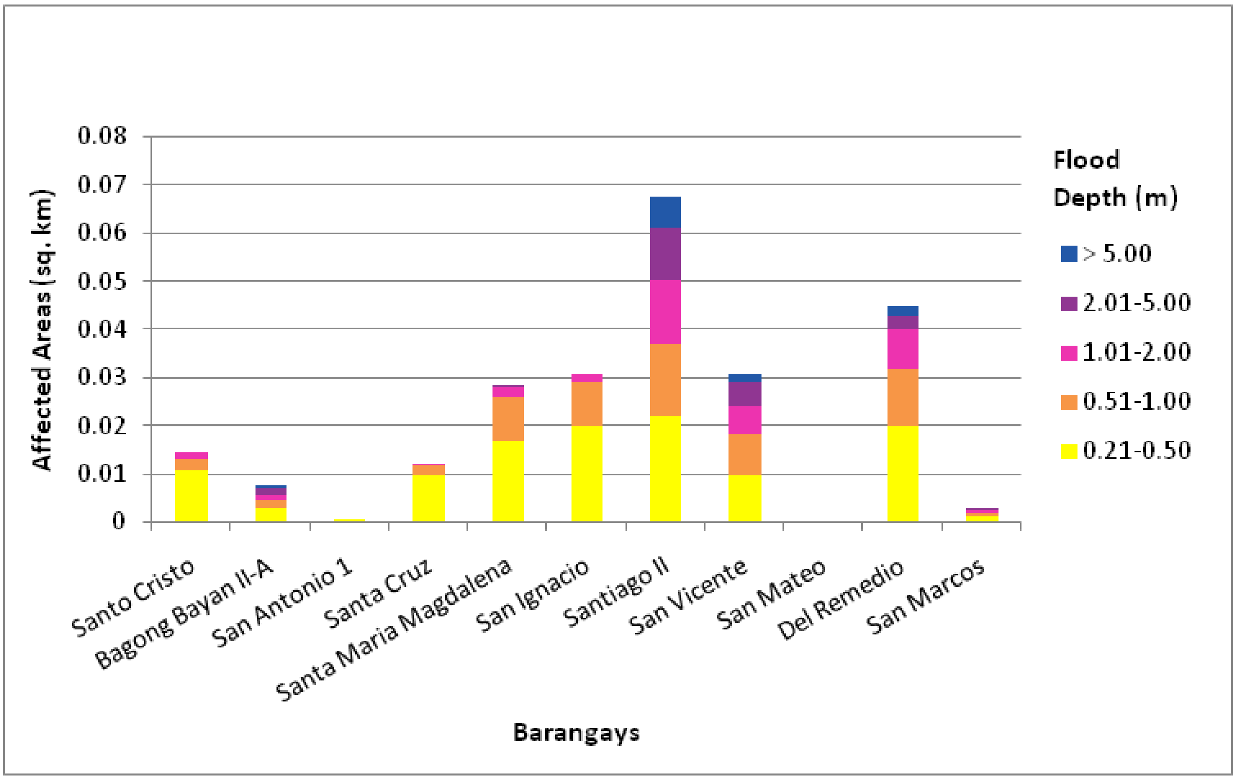


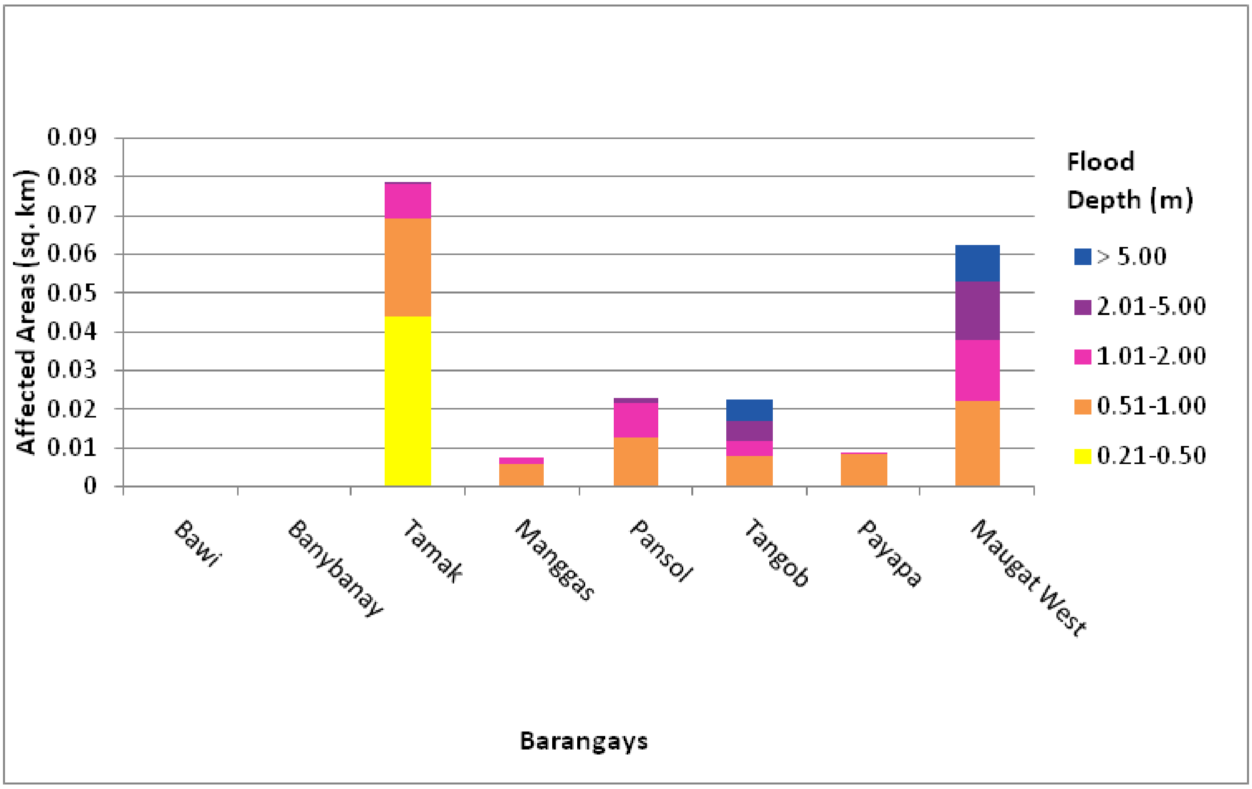
Figure 71. Affected areas in San Pablo City, Laguna during a 5-Year Rainfall Return Period.

For the 5-year return period, 8.02% of the municipality of Padre Garcia with an area of 39.28 sq. km. will experience flood levels of less than 0.20 meters. 1.32% of the area will experience flood levels of 0.21 to 0.50 meters while 0.58%, 0.34%, 0.21%, and 0.14% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 40. Affected areas in Padre Garcia, Batangas during a 5-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Padre Garcia (in sq. km.)							
	Bawi	Banybanay	Tamak	Manggas	Pansol	Tangob	Payapa	Maugat West
0.03-0.20	0.0077	0	0.053	0.12	0.14	0.16	0.19	0.19
0.21-0.50	0.0004	0	0.044	0.0077	0.018	0.024	0.0089	0.046
0.51-1.00	0	0	0.025	0.006	0.013	0.008	0.0084	0.022
1.01-2.00	0	0	0.0094	0.0016	0.0087	0.0038	0.0004	0.016
2.01-5.00	0	0	0.0002	0	0.0015	0.0053	0	0.015
> 5.00	0	0	0	0	0	0.0053	0	0.0092

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Padre Garcia (in sq. km.)							
	Bawi	Banybanay	Tamak	Manggas	Pansol	Tangob	Payapa	Maugat West
0.03-0.20	0.0077	0	0.053	0.12	0.14	0.16	0.19	0.19
0.21-0.50	0.0004	0	0.044	0.0077	0.018	0.024	0.0089	0.046
0.51-1.00	0	0	0.025	0.006	0.013	0.008	0.0084	0.022
1.01-2.00	0	0	0.0094	0.0016	0.0087	0.0038	0.0004	0.016
2.01-5.00	0	0	0.0002	0	0.0015	0.0053	0	0.015
> 5.00	0	0	0	0	0	0.0053	0	0.0092



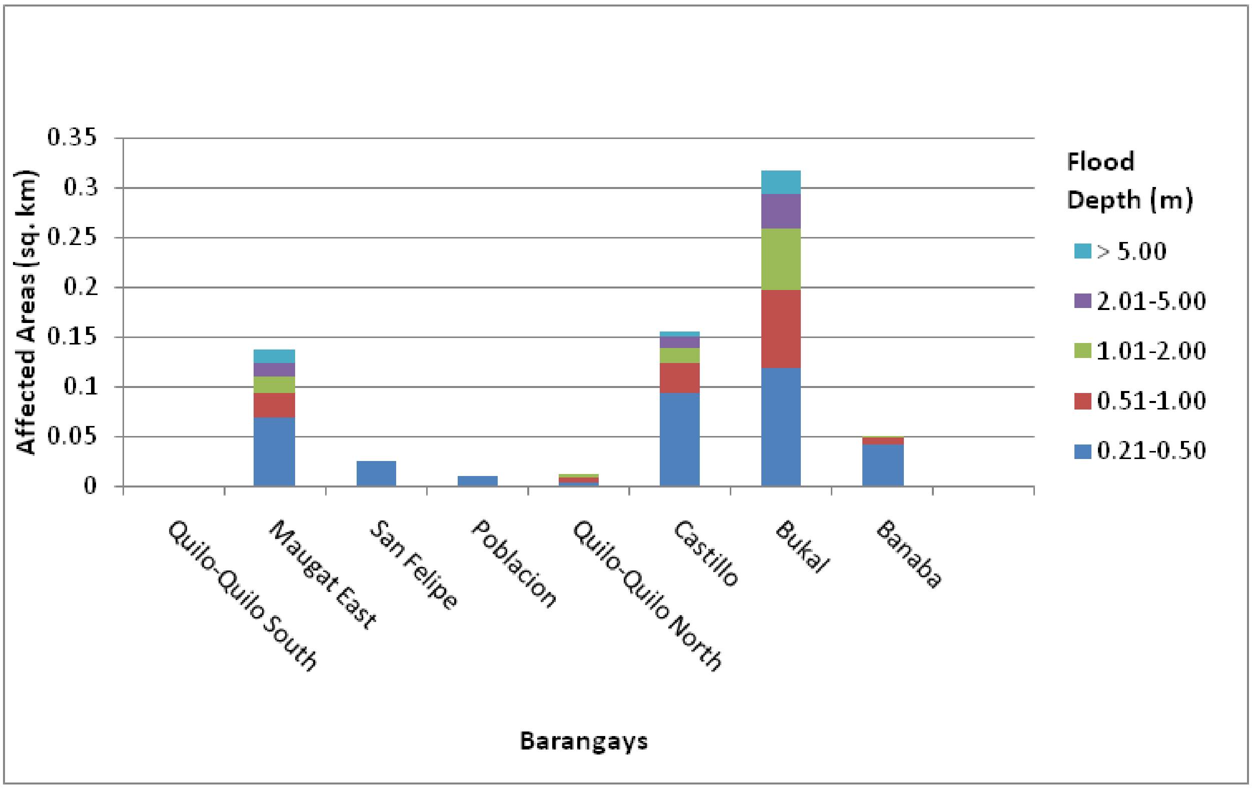


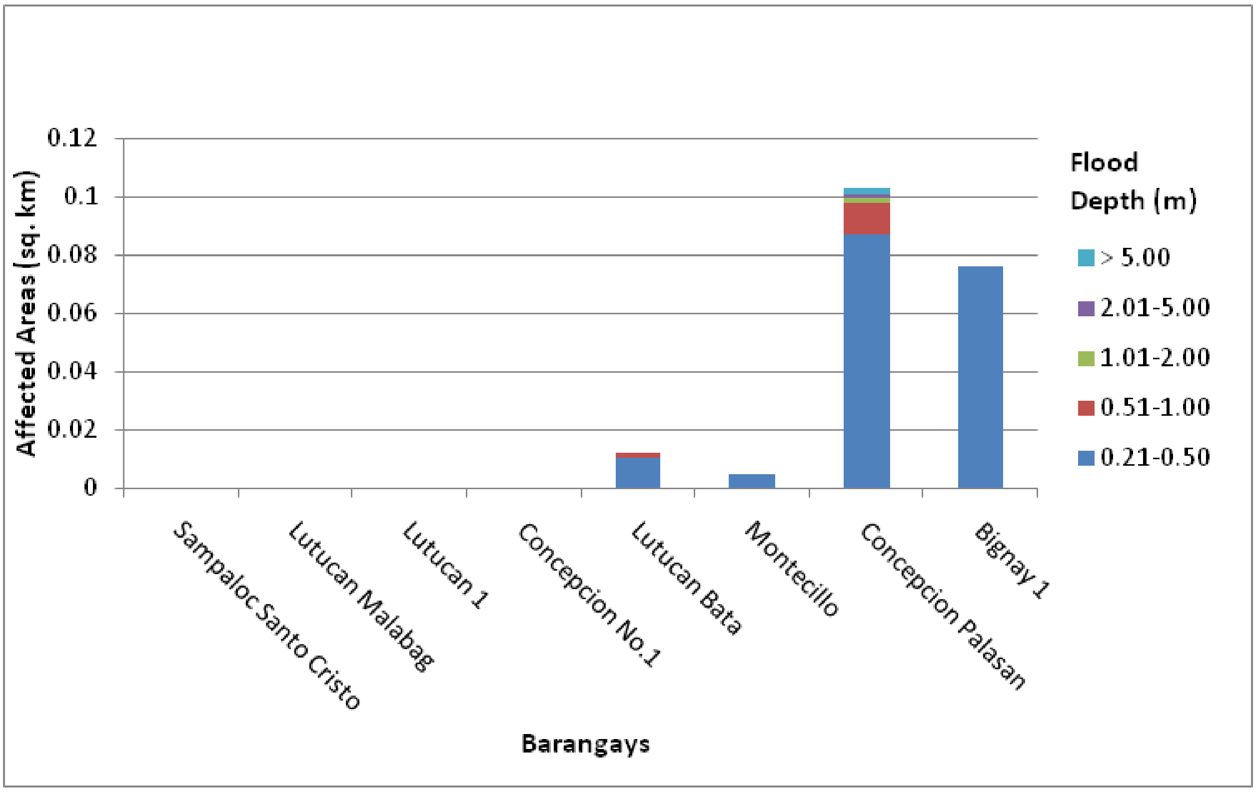
Figure 72. Affected areas in Padre Garcia, Batangas during a 5-Year Rainfall Return Period.

For the 5-year return period, 41.78% of the municipality of Sariaya with an area of 213.78 sq. km. will experience flood levels of less than 0.20 meters. 6.40% of the area will experience flood levels of 0.21 to 0.50 meters while 0.91%, 0.24%, 0.11%, and 0.25% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 41. Affected areas in Sariaya, Quezon during a 5-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Sariaya (in sq. km.)							
	Sampaloc Santo Cristo	Lutucan Malabag	Lutucan 1	Concep-cion No.1	Lutucan Bata	Montecillo	Concepcion Palasan	Bignay 1
0.03-0.20	0.001	0.029	0.01	0	0.21	0.52	0.9	1.29
0.21-0.50	0	0	0	0	0.011	0.0054	0.087	0.076
0.51-1.00	0	0	0	0	0.0013	0	0.011	0
1.01-2.00	0	0	0	0	0	0	0.0013	0
2.01-5.00	0	0	0	0	0	0	0.0011	0
> 5.00	0	0	0	0	0	0	0.0028	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Sariaya (in sq. km.)						
	Mang-galang 1	Mang-galang-Kil-ing	Guis-guis-Talon	Mang-galang Tulo-Tulo	Mang-galang-Ban-tilan	Guis-guis-San Roque	Bignay 2
0.03-0.20	1.49	1.27	1.22	2.68	2.96	1.12	2.71
0.21-0.50	0.17	0.25	0.3	0.064	0.44	0.95	0.16
0.51-1.00	0.037	0.045	0.024	0.0002	0.098	0.14	0.0019
1.01-2.00	0.0048	0.0019	0.0022	0	0.03	0.053	0
2.01-5.00	0	0.0005	0.0001	0	0.018	0.023	0
> 5.00	0	0.0086	0	0	0.075	0.01	0



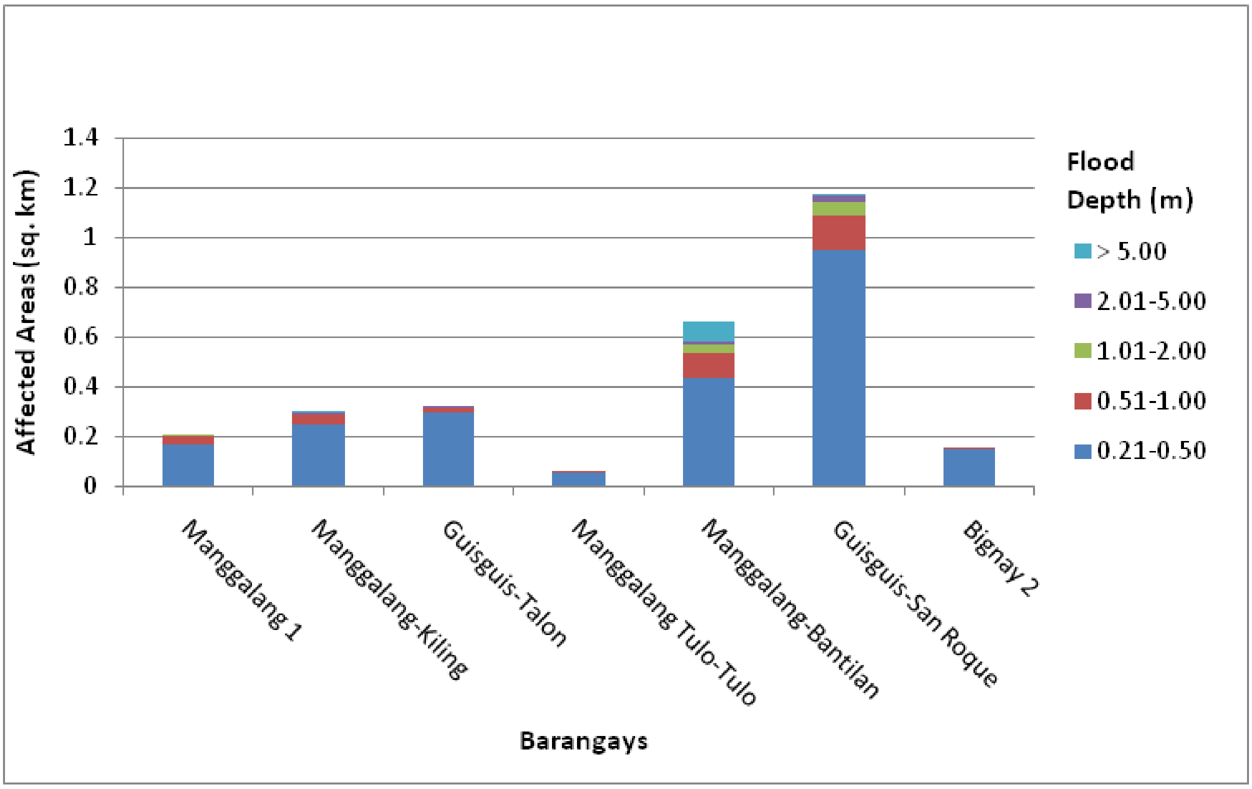


Figure 73. Affected areas in Sariaya, Quezon during a 5-Year Rainfall Return Period.

For the 5-year return period, 12.77% of the municipality of San Juan with an area of 237.55 sq. km. will experience flood levels of less than 0.20 meters. 4.08% of the area will experience flood levels of 0.21 to 0.50 meters while 0.91%, 0.33%, 0.16%, 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 the table are the affected areas in square kilometers by flood depth per barangay.

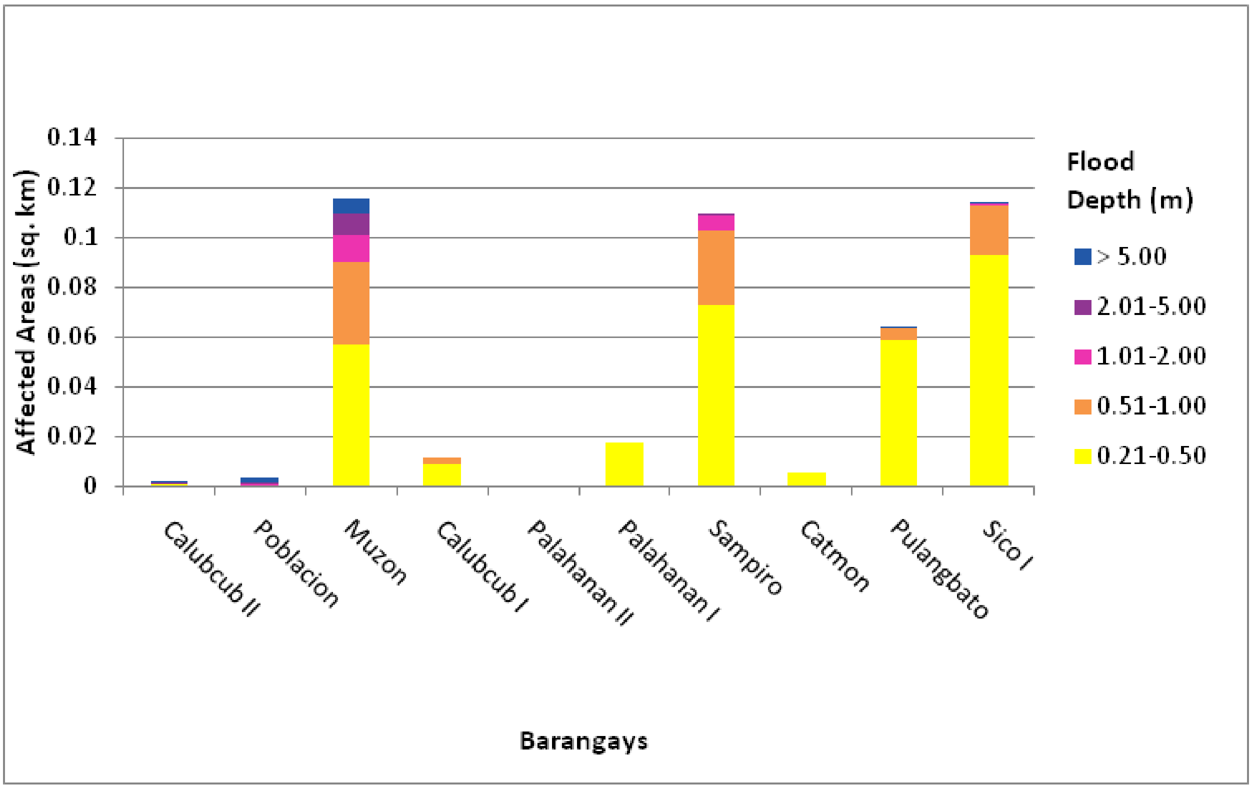
Table 42. Affected areas in San Juan, Batangas during a 5-Year Rainfall Return Period.

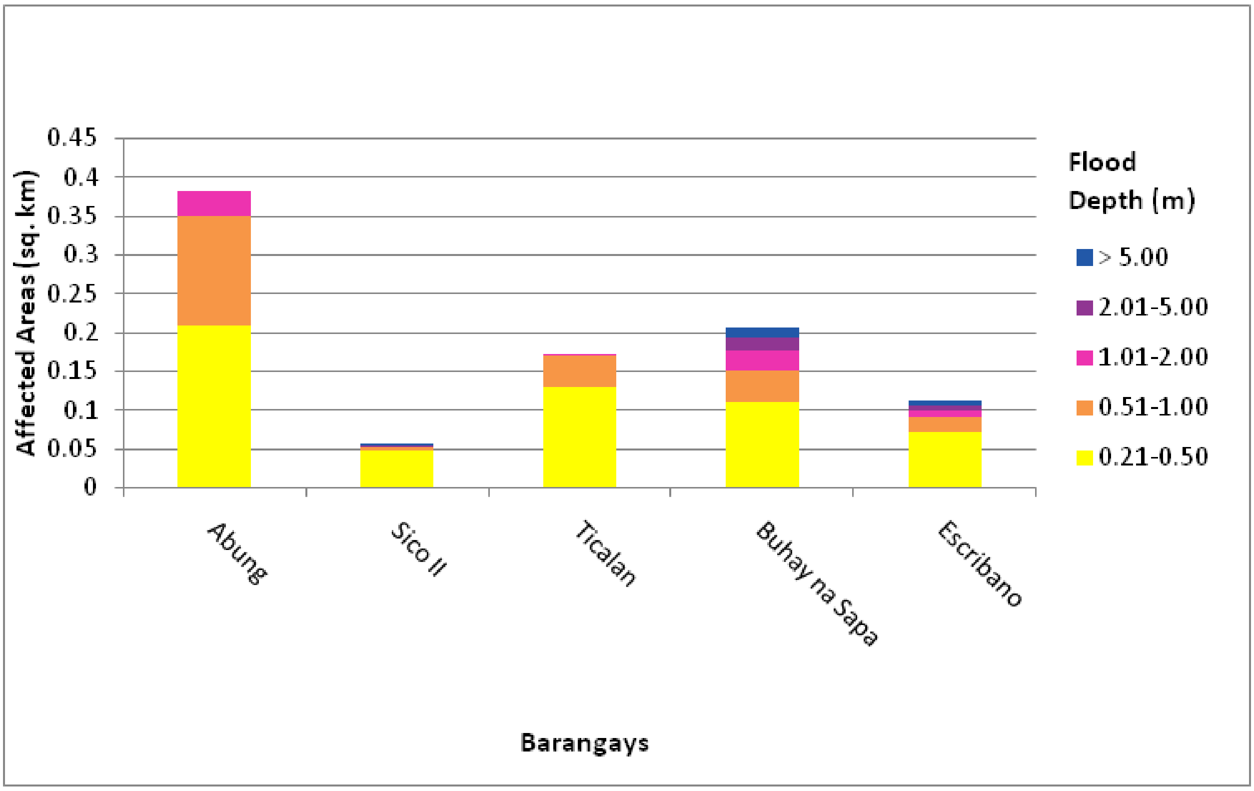
Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)									
	Calub-cub II	Pobla-cion	Muzon	Calub-cub I	Palahan-an II	Palahan-an I	Sampiro	Catmon	Pulang-bato	Sico I
0.03-0.20	0.0099	0.02	0.062	0.24	0.12	0.17	0.15	0.23	0.27	0.59
0.21-0.50	0.0012	0.0005	0.057	0.0095	0.0004	0.018	0.073	0.0056	0.059	0.093
0.51-1.00	0.0008	0.0007	0.033	0.0022	0	0	0.03	0	0.0052	0.02
1.01-2.00	0.0001	0.0004	0.011	0	0	0	0.0055	0	0.0001	0.0004
2.01-5.00	0.0002	0.0006	0.0088	0	0	0	0.0008	0	0	0.0004
> 5.00	0.0002	0.0019	0.0057	0	0	0	0	0	0.0001	0.0003

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)									
	Abung	Sico II	Ticalan	Buhay na Sapa	Escriba-no	Sapan-gan	Mabala-noy	Pinag-bayanan	Libato	Tipaz
0.03-0.20	0.28	0.81	0.65	0.79	0.67	0.78	0.84	1.07	1.59	0.88
0.21-0.50	0.21	0.05	0.13	0.11	0.073	0.29	0.025	0.88	0.4	0.53
0.51-1.00	0.14	0.0038	0.042	0.042	0.019	0.096	0.011	0.33	0.21	0.11
1.01-2.00	0.032	0.0016	0.0016	0.026	0.0078	0.03	0.011	0.028	0.11	0.057
2.01-5.00	0	0.0011	0	0.016	0.0073	0.0057	0.011	0	0.053	0.038
> 5.00	0	0.0005	0	0.012	0.0065	0.0003	0.014	0	0.027	0.011

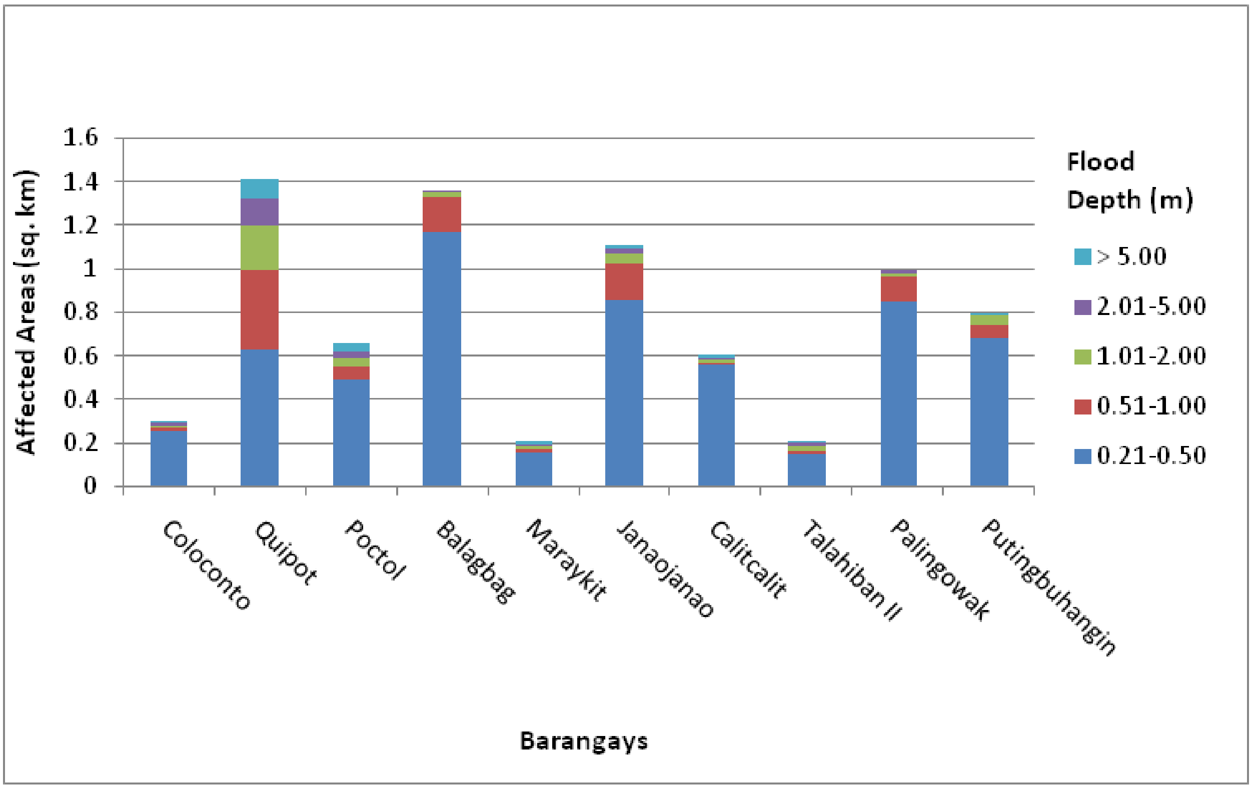
Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)									
	Colocon-to	Quipot	Poctol	Balag-bag	Maraykit	Janao-janao	Calitcalit	Tala-hiban II	Palin-gowak	Putingbu-hangin
0.03-0.20	1.23	1.47	1.67	1.16	1.42	1.6	1.16	1.56	1.37	3.04
0.21-0.50	0.26	0.63	0.49	1.17	0.16	0.86	0.56	0.15	0.85	0.68
0.51-1.00	0.013	0.36	0.067	0.16	0.013	0.16	0.011	0.02	0.11	0.065
1.01-2.00	0.0099	0.21	0.033	0.023	0.013	0.046	0.011	0.017	0.028	0.049
2.01-5.00	0.0094	0.12	0.029	0.0022	0.013	0.025	0.01	0.017	0.0016	0.0018
> 5.00	0.0077	0.094	0.04	0	0.012	0.019	0.012	0.0056	0	0.0001

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)	
	Talahiban I	Lipahan
0.03-0.20	2.21	2.22
0.21-0.50	0.39	0.48
0.51-1.00	0.075	0.011
1.01-2.00	0.01	0.0097
2.01-5.00	0.001	0.01
> 5.00	0	0.1





Affected Areas (sq. km)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Abung
Sico II
Ticalan
Buhay na Sapa
Escribano
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50



Affected Areas (sq. km)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Coloconto
Quipot
Poctol
Balagbag
Maraykit
Janaojanao
Calitcalit
Talahiban II
Palingowak
Putingbuhangin
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50

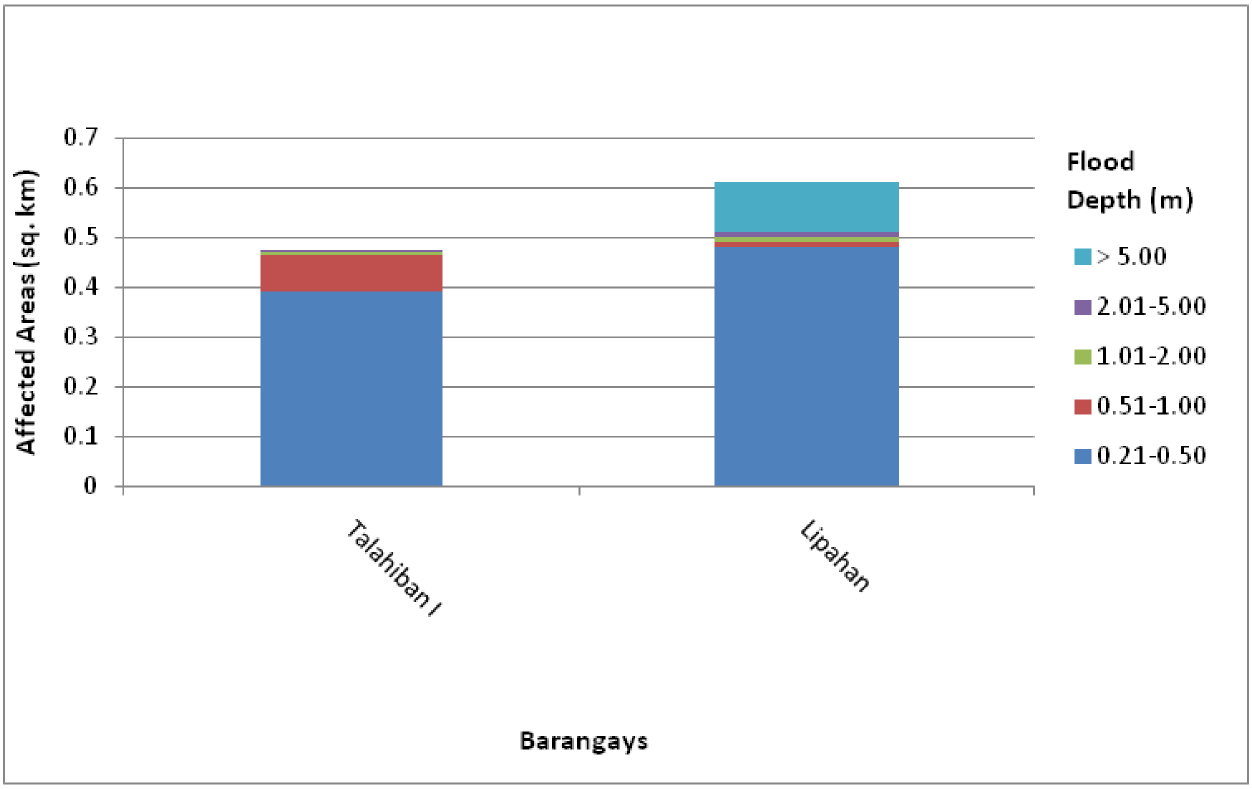


Figure 74. Affected areas in San Juan, Batangas during a 5-Year Rainfall Return Period.

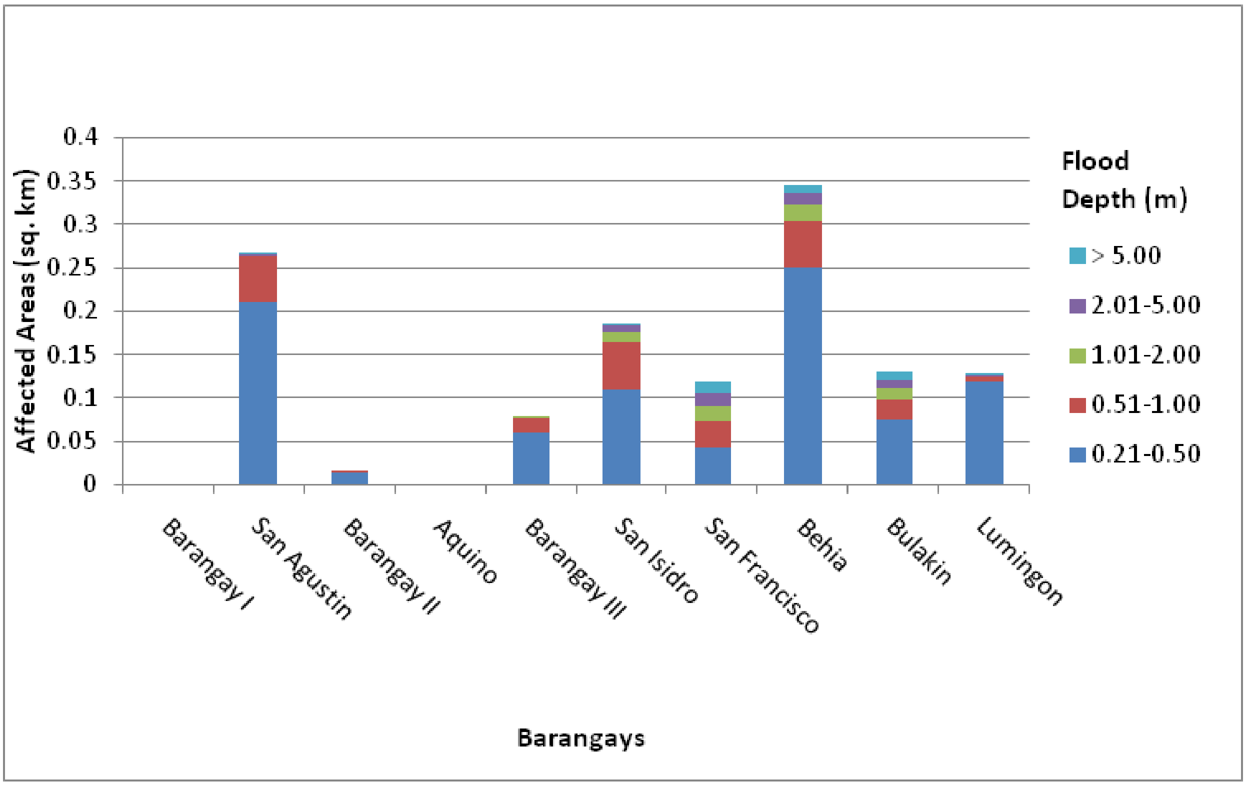
For the 5-year return period, 10.23% of the municipality of Tiaong with an area of 118.93 sq. km. will experience flood levels of less than 0.20 meters. 3.19% of the area will experience flood levels of 0.21 to 0.50 meters while 1.37%, 0.59%, 0.17%, and 0.11% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

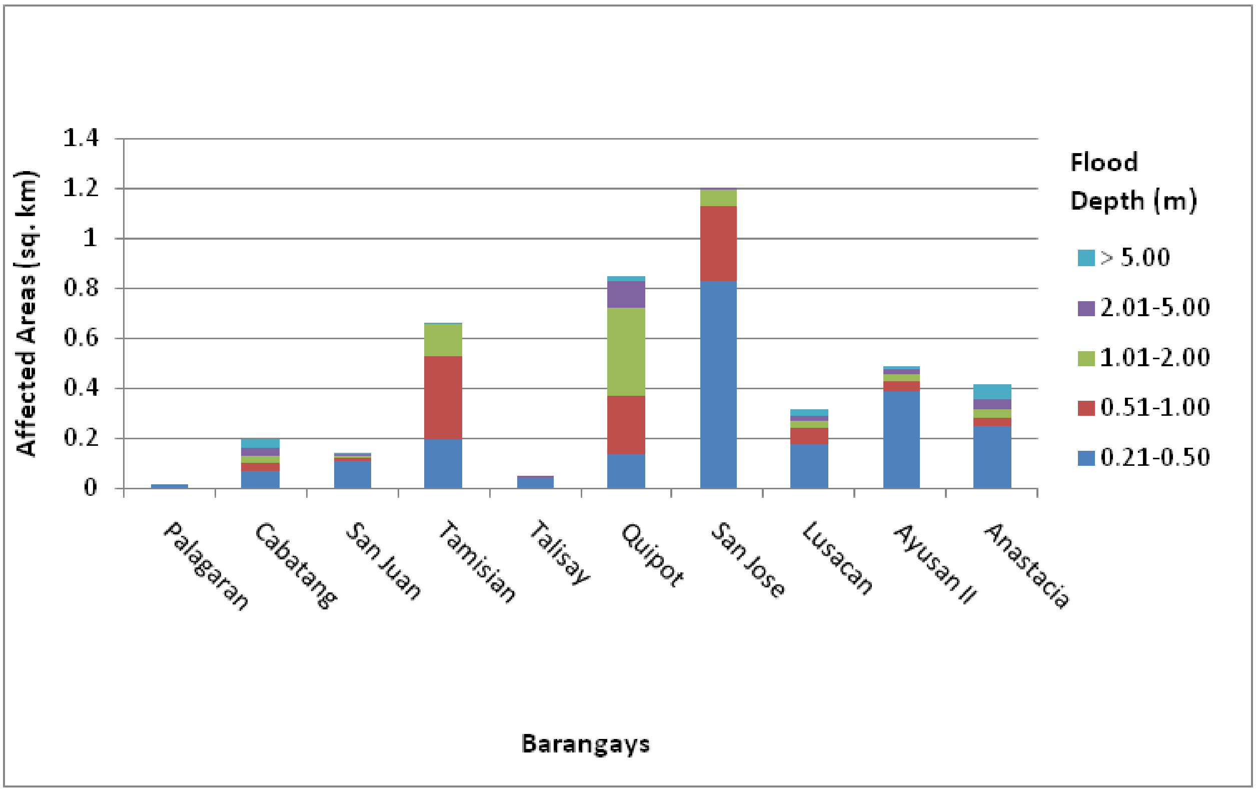
Table 43. Affected areas in Tiaong. Quezon during a 5-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Tiaong (in sq. km.)									
	Baran-gay I	San Agustin	Barangay II	Aquino	Barangay III	San Isidro	San Fran-cisco	Behia	Bulakin	Lumin-gon
0.03-0.20	0.012	0.25	0.02	0.043	0.072	0.13	0.5	0.5	0.59	0.37
0.21-0.50	0.0013	0.21	0.016	0.0017	0.06	0.11	0.044	0.25	0.075	0.12
0.51-1.00	0	0.053	0.0008	0.0006	0.018	0.054	0.029	0.054	0.023	0.0043
1.01-2.00	0	0.002	0	0.0003	0.0008	0.013	0.018	0.019	0.014	0.0018
2.01-5.00	0	0.0012	0	0.0001	0	0.0067	0.015	0.012	0.01	0.0017
> 5.00	0	0.0019	0	0	0	0.0019	0.013	0.0095	0.008	0.0012

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Tiaong (in sq. km.)									
	Palagaran	Cabatang	San Juan	Tamisian	Talisay	Quipot	San Jose	Lusacan	Ayusan II	Anastacia
0.03-0.20	0.49	0.75	0.72	0.47	1.05	0.29	1.81	1.12	0.78	0.92
0.21-0.50	0.021	0.074	0.11	0.2	0.045	0.14	0.83	0.18	0.39	0.25
0.51-1.00	0	0.033	0.016	0.33	0.0053	0.23	0.3	0.066	0.041	0.037
1.01-2.00	0	0.026	0.0075	0.13	0.0005	0.35	0.071	0.025	0.024	0.029
2.01-5.00	0	0.03	0.0065	0.0039	0.0003	0.11	0.0004	0.022	0.021	0.042
> 5.00	0	0.036	0.0056	0.0002	0	0.019	0	0.025	0.016	0.057

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Tiaong (in sq. km.)									
	Paiisa	Bula	Tagbakin	Lagalag	San Pedro	Cabay	Del Rosario	Bukal	Ayusan I	Lalig
0.03-0.20	1.03	0.56	1.49	1.45	0.84	2.18	2.33	0.93	1.13	1.47
0.21-0.50	0.071	0.47	0.2	0.12	0.48	0.29	0.37	0.58	1.01	0.87
0.51-1.00	0.0023	0.22	0.0068	0.02	0.23	0.0015	0.011	0.58	0.65	0.23
1.01-2.00	0.0003	0.079	0.0039	0.0029	0.047	0.0017	0.0063	0.42	0.056	0.048
2.01-5.00	0	0.012	0.0019	0.0028	0.024	0.002	0.0042	0.039	0.022	0.011
> 5.00	0	0.0087	0.0001	0.0028	0.015	0.002	0.0031	0.0098	0.02	0.0084


Affected Areas (sq. km)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Barangay I
San Agustin
Barangay II
Aquino
Barangay III
San Isidro
San Francisco
Behia
Bulakin
Lumingon
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50


Affected Areas (sq. km)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Palagaran
Cabatang
San Juan
Tamisian
Talisay
Quipot
San Jose
Lusacan
Ayusan II
Anastacia
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50

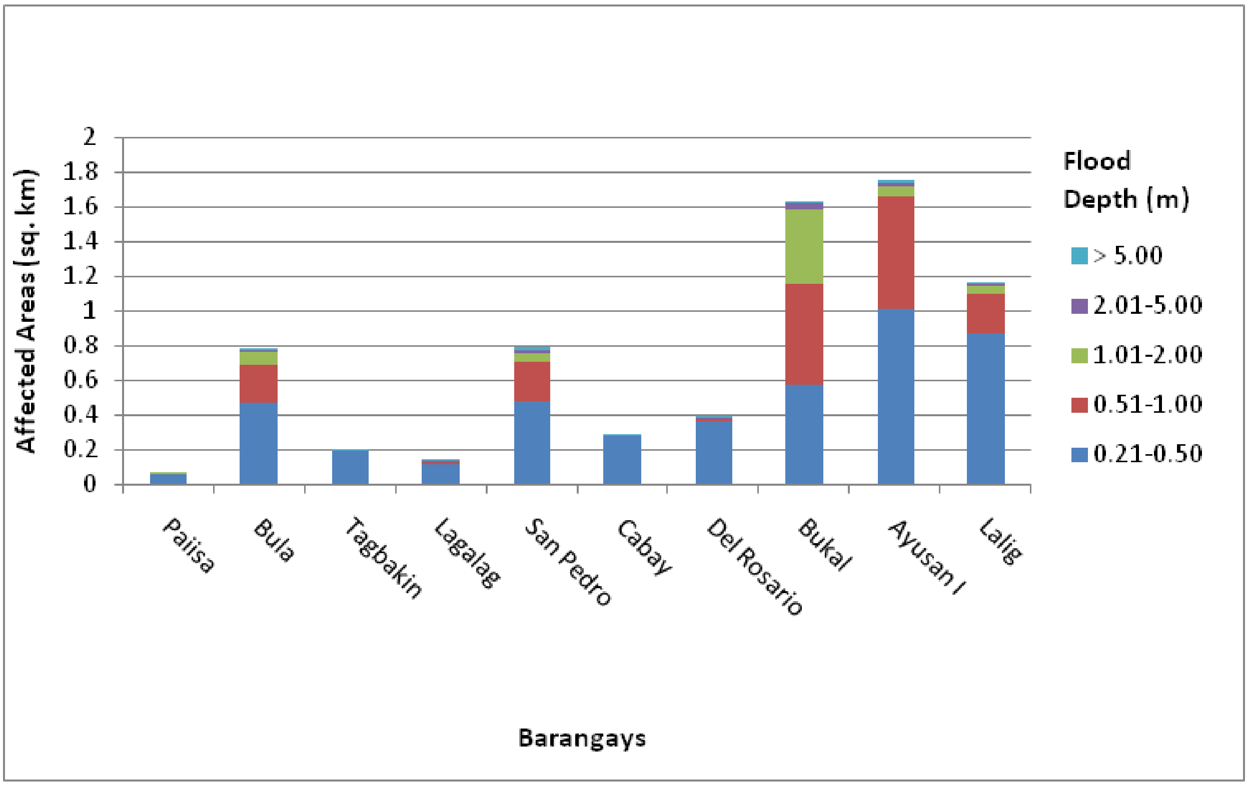


Figure 75. Affected areas in Tiaong. Quezon during a 5-Year Rainfall Return Period.

For the 5-year return period, 1.61% of the municipality of Alaminos with an area of 59.65 sq. km. will experience flood levels of less than 0.20 meters. 0.27% of the area will experience flood levels of 0.21 to 0.50 meters while 0.04%, 0.01%, 0.01%, and 0.01% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 44. Affected areas in Alaminos, Laguna during a 5-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Alaminos (in sq. km.)					
	San Miguel	Del Carmen	San Agustin	San Gregorio	San Roque	San Benito
0.03-0.20	0.0058	0.029	0.041	0.085	0.24	0.56
0.21-0.50	0.0006	0	0	0.022	0.019	0.12
0.51-1.00	0	0	0	0.009	0.0079	0.0088
1.01-2.00	0	0	0	0.0024	0.0054	0.0009
2.01-5.00	0	0	0	0	0.0045	0
> 5.00	0	0	0	0	0.0047	0

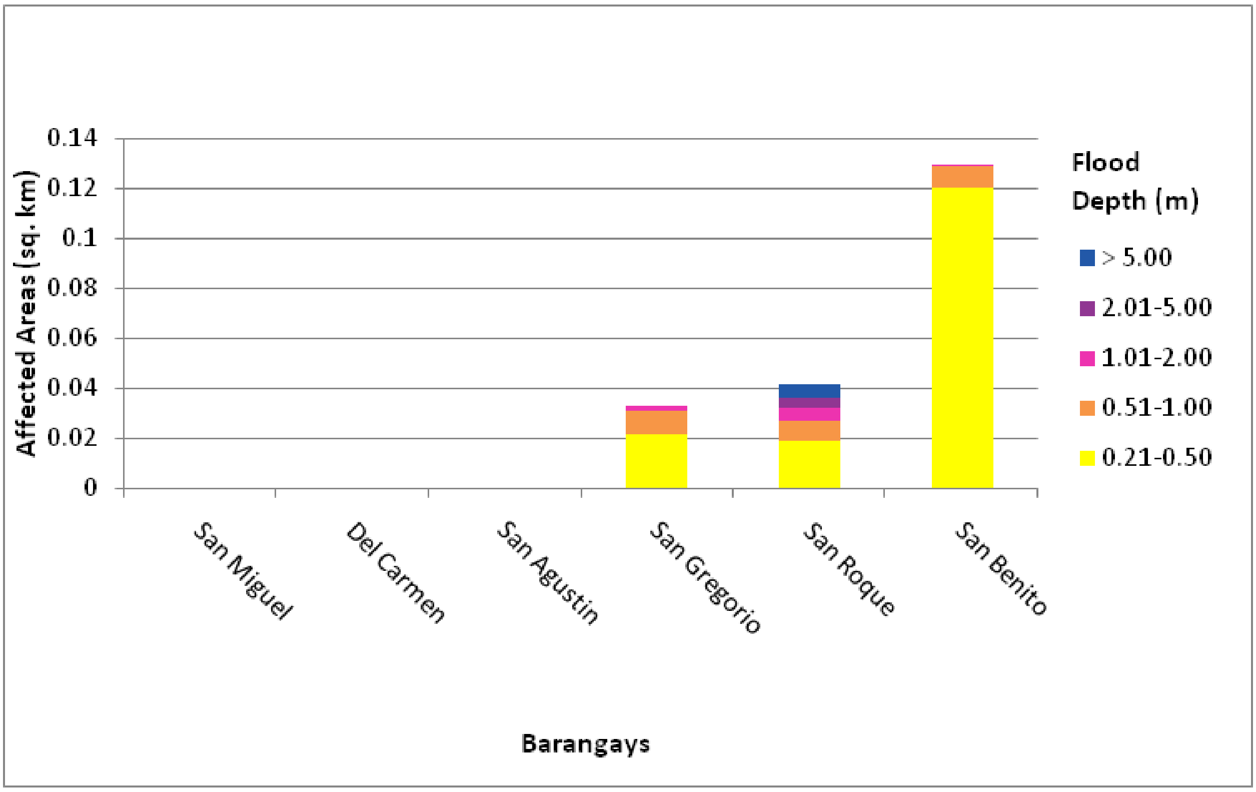


Figure 76. Affected areas in Alaminos, Laguna during a 5-Year Rainfall Return Period.

For the 5-year return period, 1.19% of the municipality of Dolores with an area of 65.96 sq. km. will experience flood levels of less than 0.20 meters. 0.24% of the area will experience flood levels of 0.21 to 0.50 meters while 0.17%, 0.11%, 0.08%, and 0.07% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 45. Affected areas in Dolores, Quezon during a 5-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Dolores (in sq. km.)				
	Antonino	Dagatan	San Mateo	Bungoy	Putol
0.03-0.20	0.0034	0.0842	0.0474	0.3589	0.2895
0.21-0.50	0.0007	0.0071	0.0157	0.0909	0.045
0.51-1.00	0	0.0048	0.0061	0.0668	0.0367
1.01-2.00	0	0.0027	0.0007	0.0491	0.0187
2.01-5.00	0	0.0033	0	0.0368	0.0142
> 5.00	0	0.0051	0	0.0319	0.0086

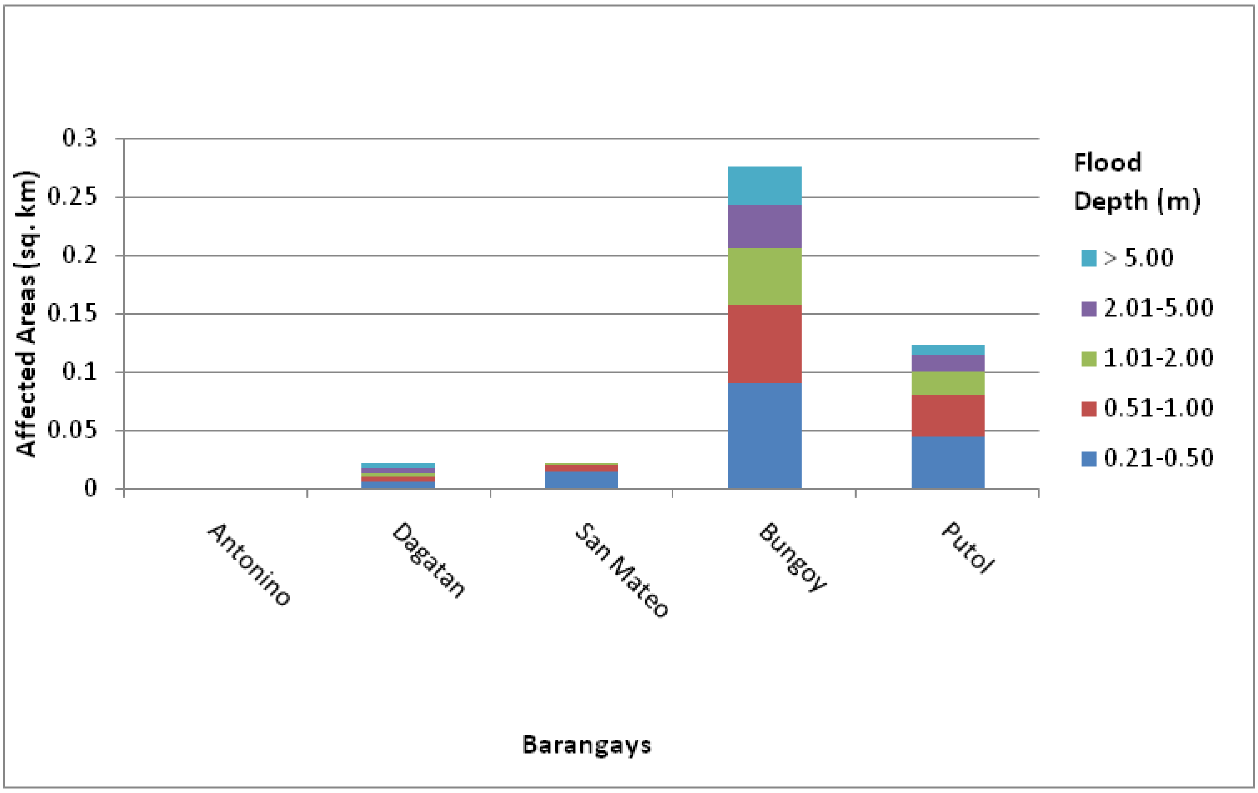


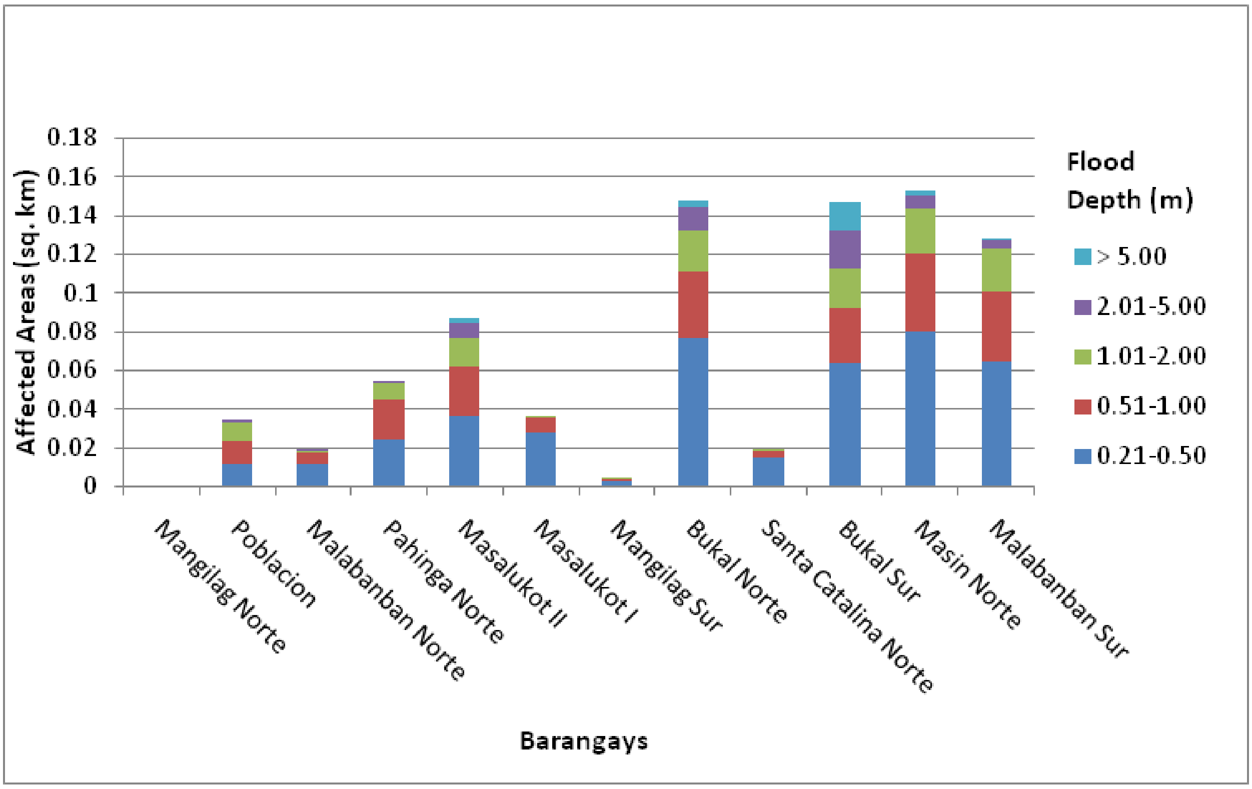
Figure 77. Affected areas in Dolores, Quezon during a 5-Year Rainfall Return Period.

For the 5-year return period, 16.28% of the municipality of Candelaria with an area of 136.74 sq. km. will experience flood levels of less than 0.20 meters. 2.19% of the area will experience flood levels of 0.21 to 0.50 meters while 0.37%, 0.22%, 0.12%, and 0.07% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 46. Affected areas in Candelaria, Quezon during a 5-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Candelaria (in sq. km.)											
	Mangilag Norte	Pobla-cion	Malabanban Norte	Pahinga Norte	Masalu-kot II	Masalu-kot I	Mangilag Sur	Bukal Norte	Santa Catalina Norte	Bukal Sur	Masin Norte	Malaban-ban Sur
0.03-0.20	0.0043	0.04	0.081	0.11	0.091	0.12	0.24	0.28	0.38	0.43	0.36	0.72
0.21-0.50	0.0004	0.012	0.012	0.025	0.037	0.028	0.0035	0.077	0.015	0.064	0.08	0.065
0.51-1.00	0	0.012	0.0058	0.02	0.025	0.0086	0.0012	0.034	0.0047	0.028	0.04	0.036
1.01-2.00	0	0.0092	0.0018	0.0092	0.015	0.0005	0.0006	0.021	0.0003	0.021	0.023	0.022
2.01-5.00	0	0.0016	0.0001	0.0005	0.0076	0	0	0.012	0	0.019	0.0073	0.0043
> 5.00	0	0	0	0	0.0023	0	0	0.0033	0	0.015	0.0028	0.0007

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Candelaria (in sq. km.)								
	Masin Sur	Pahinga Sur	San Andres	Buenavista West	Kinati-han II	Kinati-han I	Santa Catali-na Sur	Buenavista East	San Isidro
0.03-0.20	0.56	0.96	1.13	0.85	2.02	1.85	6.02	1.96	4.06
0.21-0.50	0.12	0.093	0.066	0.37	0.28	0.25	0.054	0.53	0.81
0.51-1.00	0.026	0.038	0.021	0.027	0.023	0.032	0.0052	0.04	0.076
1.01-2.00	0.018	0.037	0.0058	0.012	0.021	0.027	0.0001	0.012	0.043
2.01-5.00	0.014	0.025	0.002	0.011	0.0091	0.02	0	0.0033	0.021
> 5.00	0.012	0.02	0	0.0044	0.0033	0.011	0	0.0001	0.016



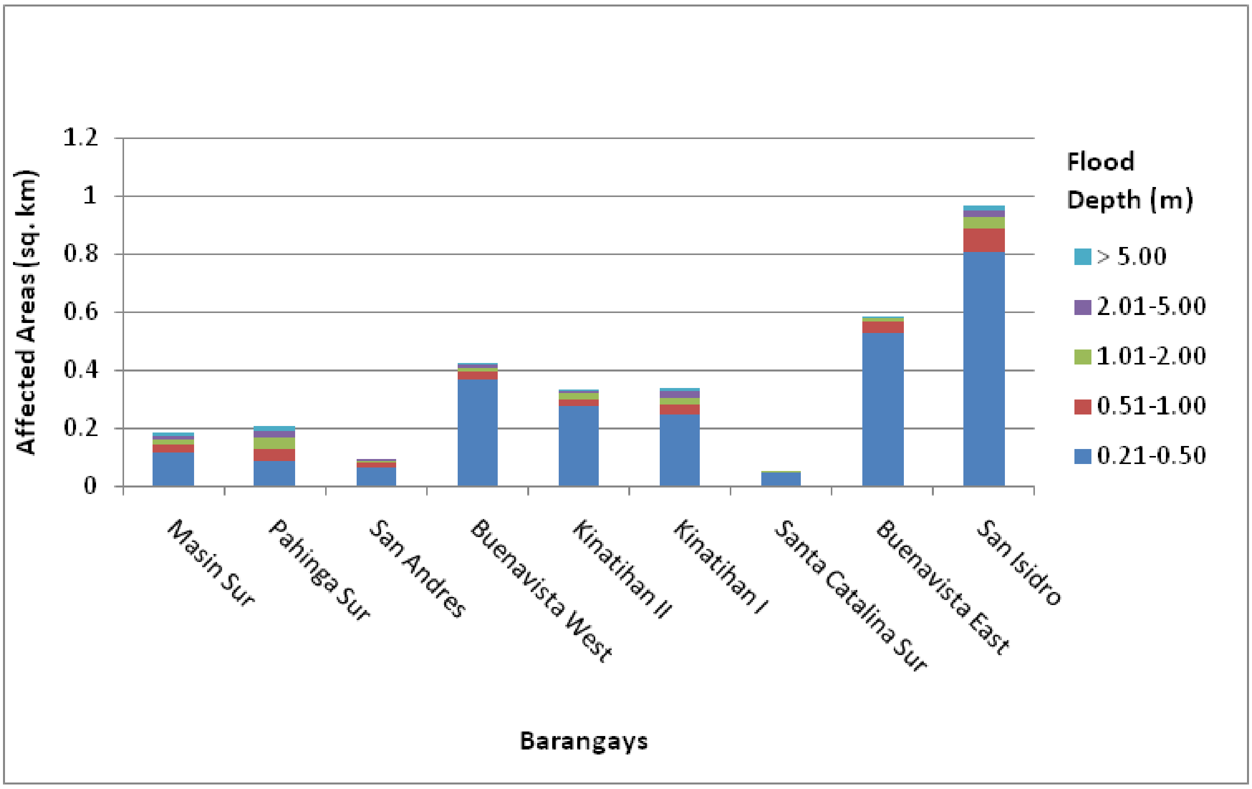


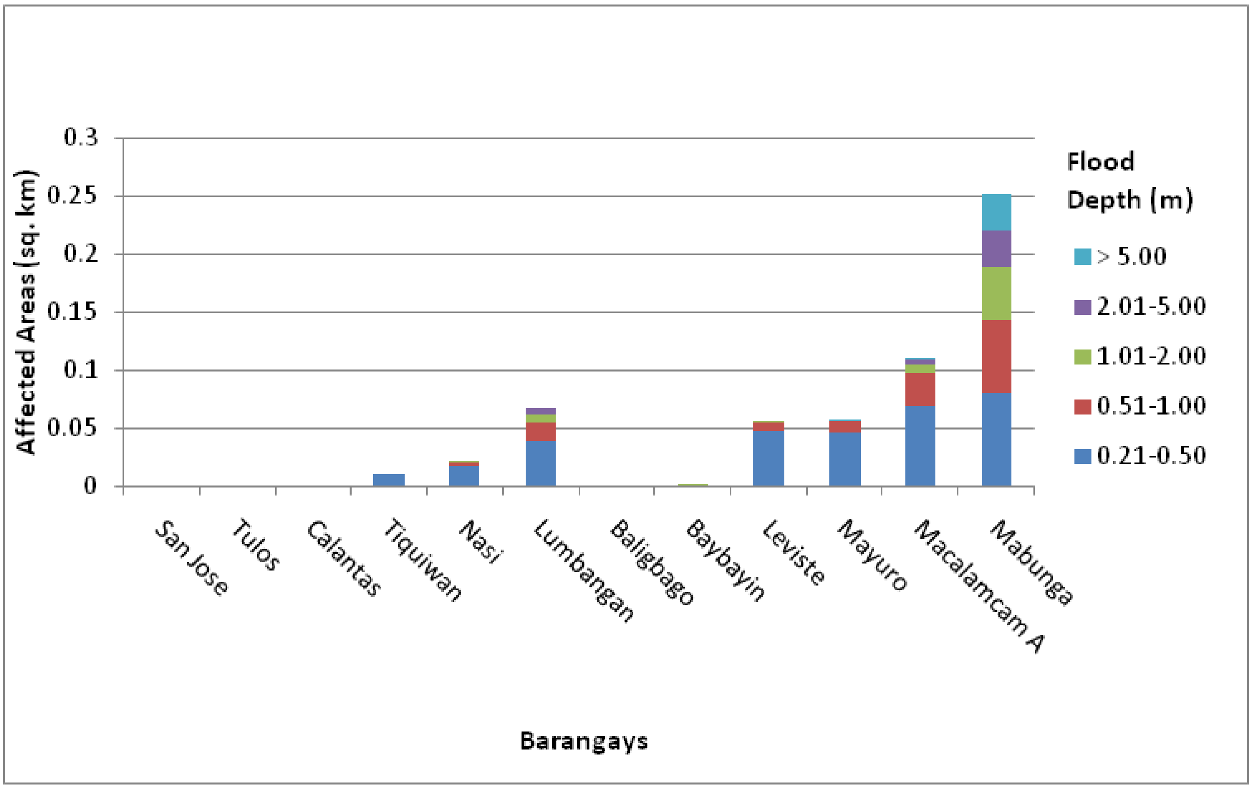
Figure 78. Affected areas in Candelaria, Quezon during a 5-Year Rainfall Return Period.

For the 5-year return period, 7.31% of the municipality of Rosario with an area of 199.04 sq. km. will experience flood levels of less than 0.20 meters. 1.72% of the area will experience flood levels of 0.21 to 0.50 meters while 0.72%, 0.40%, 0.24%, 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 47. Affected areas in Rosario, Batangas during a 5-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Rosario (in sq. km.)											
	San Jose	Tulos	Calan-tas	Tiqui-wan	Nasi	Lumban-gan	Baligba-go	Bayba-yin	Leviste	Ma-yuro	Macalamcam A	Mabun-ga
0.03-0.20	0.017	0.0036	0.0055	0.057	0.11	0.11	0	0.17	0.17	0.21	0.29	0.22
0.21-0.50	0	0	0	0.011	0.019	0.04	0	0.0014	0.049	0.047	0.07	0.081
0.51-1.00	0	0	0	0	0.0042	0.015	0	0.0009	0.0074	0.01	0.028	0.063
1.01-2.00	0	0	0	0	0.0001	0.0069	0	0.0009	0.001	0.0008	0.0076	0.045
2.01-5.00	0	0	0	0	0	0.0062	0	0	0	0.0003	0.0034	0.032
> 5.00	0	0	0	0	0	0	0	0	0	0.0007	0.0016	0.031

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Rosario (in sq. km.)										
	San Isidro	Bay-awang	Maba-to	Macalamcam B	Alupya	Natu	Maligaya	San Carlos	Salao	Pinagsibaan	Putingkahoy
0.03-0.20	0.29	0.31	0.71	1.4	0	0.54	0.55	0.65	1.34	1.34	1.5
0.21-0.50	0.1	0.16	0.23	0.11	0	0.11	0.21	0.21	0.14	0.21	0.55
0.51-1.00	0.039	0.08	0.091	0.041	0	0.018	0.097	0.11	0.064	0.11	0.2
1.01-2.00	0.026	0.063	0.053	0.031	0	0.0002	0.064	0.047	0.041	0.069	0.088
2.01-5.00	0.012	0.044	0.035	0.026	0	0.0005	0.049	0.0037	0.023	0.051	0.043
> 5.00	0.0073	0.031	0.027	0.018	0	0.0004	0.041	0	0.012	0.019	0.033



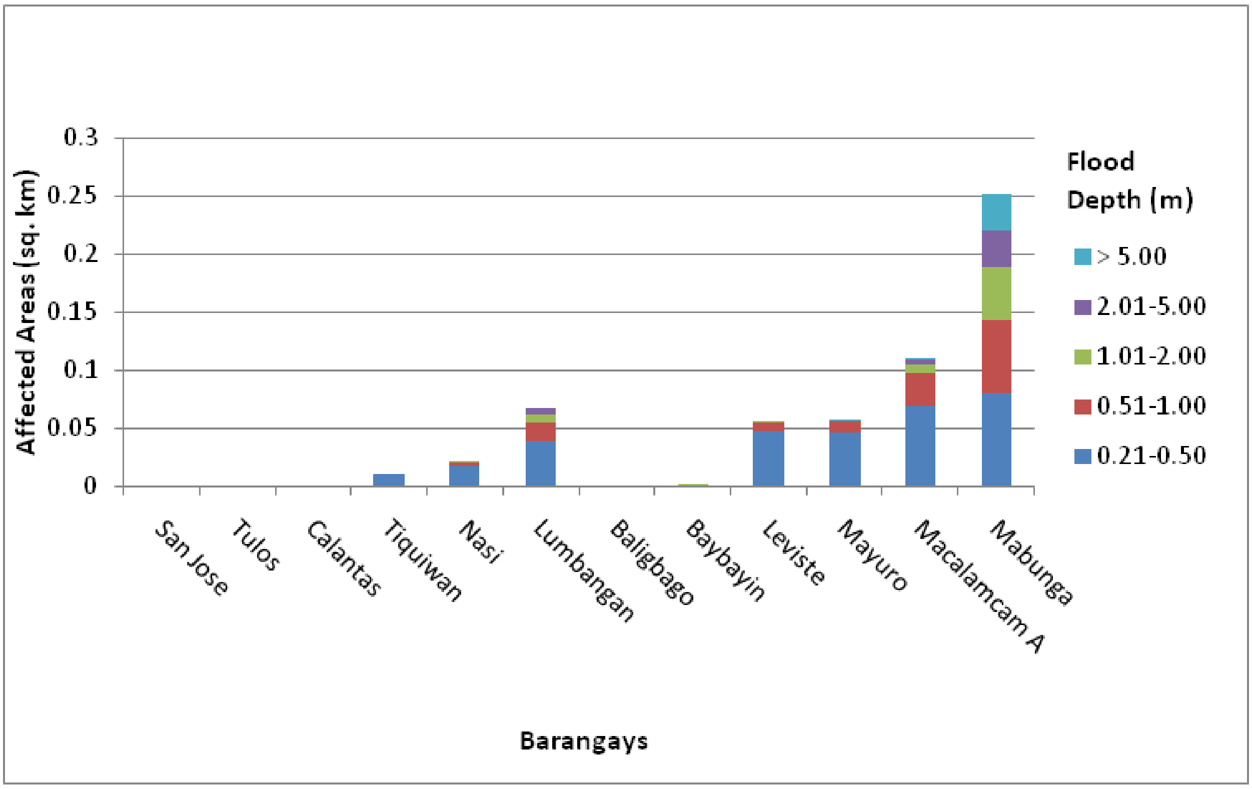


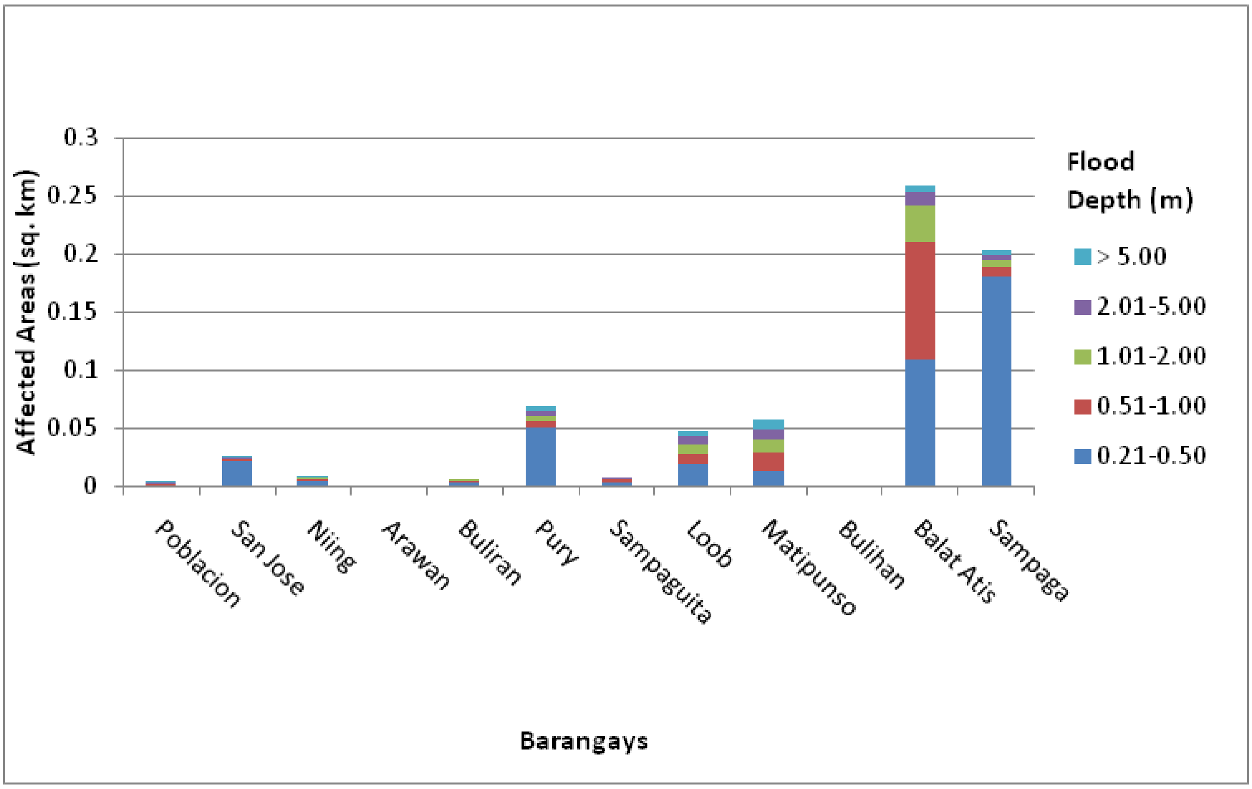
Figure 79. Affected areas in Rosario, Batangas during a 5-Year Rainfall Return Period.

For the 5-year return period, 5.26% of the municipality of San Antonio with an area of 62.38 sq. km. will experience flood levels of less than 0.20 meters. 1.04% of the area will experience flood levels of 0.21 to 0.50 meters while 0.47%, 0.37%, 0.15%, and 0.08% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 48. Affected areas in San Antonio, Quezon during a 5-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Antonio (in sq. km.)											
	Poblacion	San Jose	Niing	Arawan	Buliran	Pury	Sampaguita	Loob	Matipunso	Bulihan	Balat Atis	Sampaga
0.03-0.20	0.011	0.15	0.067	0	0.075	0.47	0.087	0.11	0.027	0	0.11	0.5
0.21-0.50	0.002	0.024	0.0062	0	0.0057	0.051	0.0041	0.02	0.014	0	0.11	0.18
0.51-1.00	0.0009	0.0007	0.0017	0	0.0003	0.0055	0.0026	0.0086	0.016	0	0.1	0.0093
1.01-2.00	0.0009	0.0007	0.0013	0	0.0005	0.005	0.0015	0.0085	0.011	0	0.032	0.0049
2.01-5.00	0.0003	0.0003	0.0006	0	0	0.0036	0.0001	0.0063	0.0093	0	0.011	0.0043
> 5.00	0.0011	0.0008	0.0005	0	0	0.0041	0	0.0052	0.0087	0	0.0057	0.0046

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Antonio (in sq. km.)							
	Callejon	Magsaysay	Corzaon	Sinturisan	Bagong Niing	Briones	Pulo	Manuel Del Valle, Sr.
0.03-0.20	0.86	0.6	0	0.69	0.66	0.97	0.31	1.49
0.21-0.50	0.075	0.067	0	0.092	0.11	0.2	0.34	0.12
0.51-1.00	0.033	0.026	0	0.037	0.038	0.07	0.25	0.048
1.01-2.00	0.023	0.02	0	0.011	0.02	0.037	0.29	0.04
2.01-5.00	0.022	0.014	0	0.0047	0.018	0.025	0.074	0.016
> 5.00	0.009	0.0064	0	0.0004	0.022	0.021	0.012	0.0093



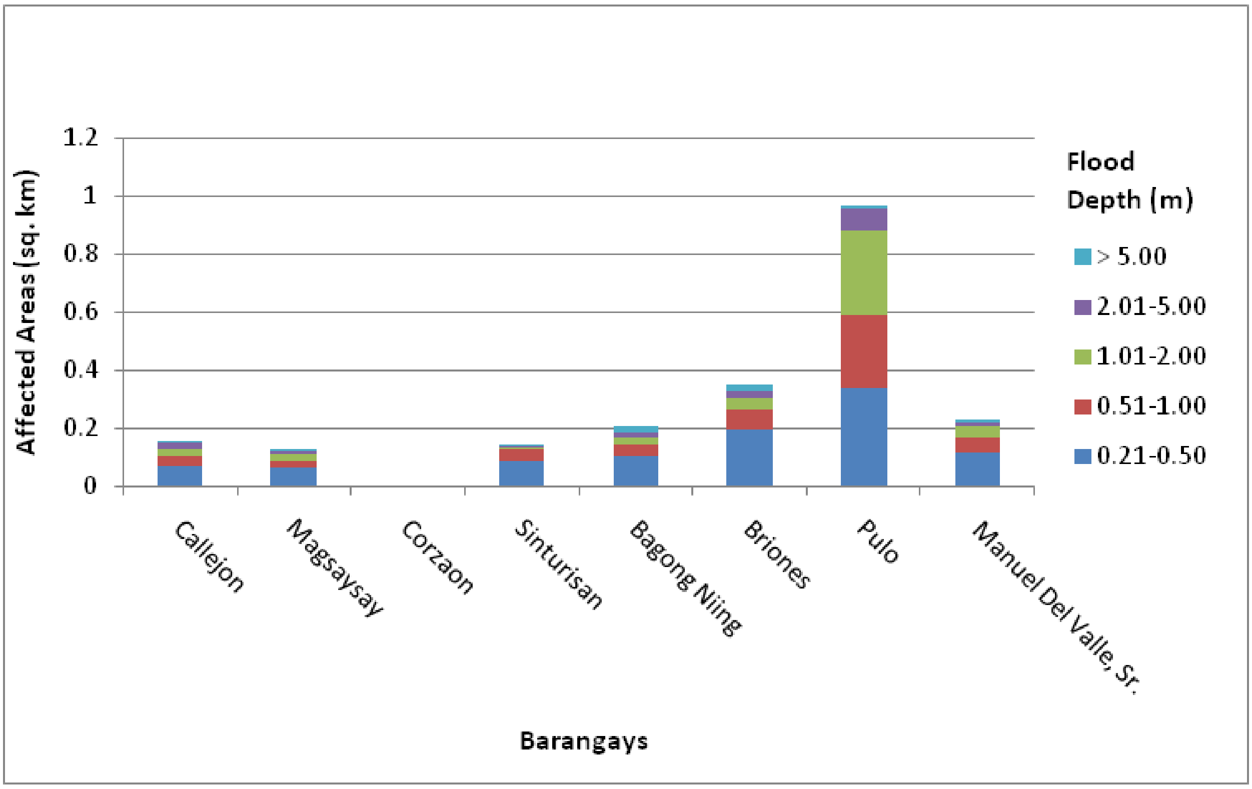


Figure 80. Affected areas in San Antonio, Quezon during a 5-Year Rainfall Return Period.

For the 25-year return period, 1.99% of the municipality of San Pablo City with an area of 184.81 sq. km. will experience flood levels of less than 0.20 meters. 0.32% of the area will experience flood levels of 0.21 to 0.50 meters while 0.15%, 0.08%, 0.06%, and 0.04% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

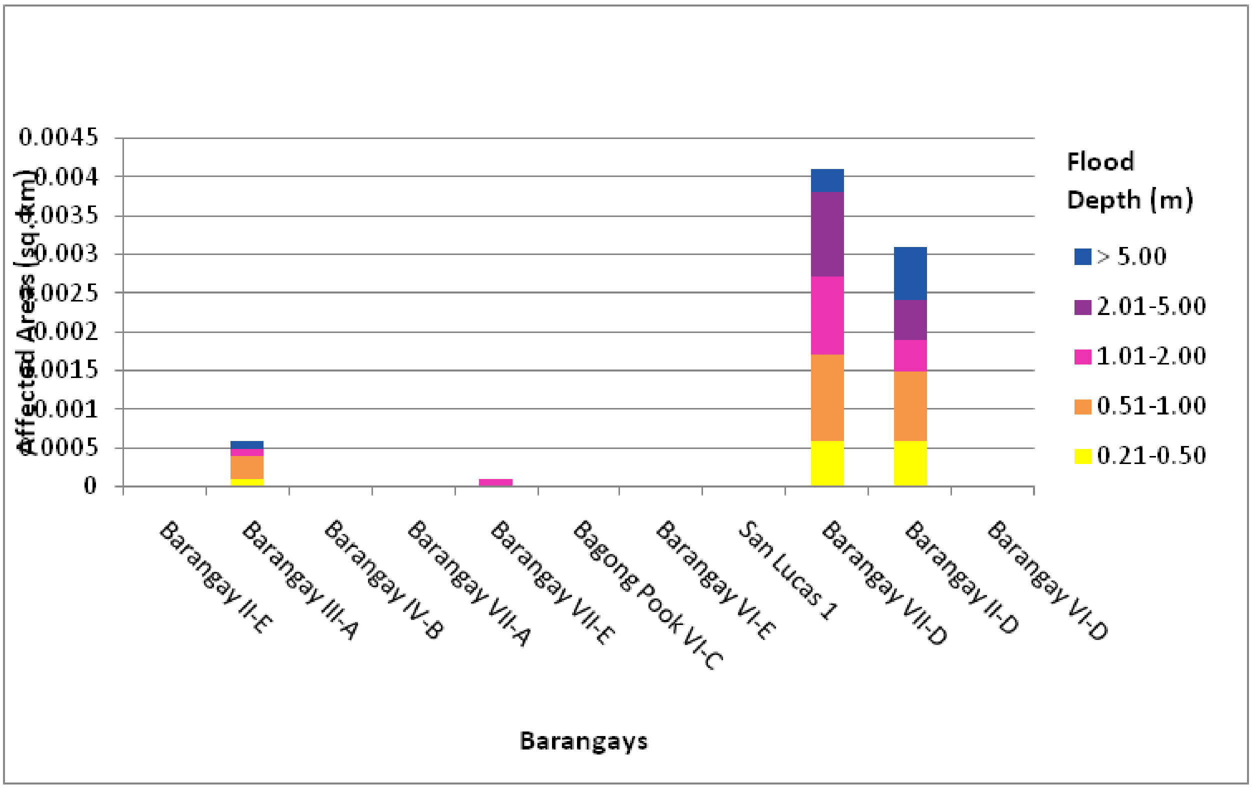
Table 49. Affected areas in San Pablo City, Laguna during a 25-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Barangay II-E	Barangay III-A	Barangay IV-B	Barangay VII-A	Barangay VII-E	Bagong Pook VI-C	Barangay VI-E	San Lucas 1	Barangay VII-D	Barangay II-D	Barangay VI-D
0.03-0.20	0.0004	0.0002	0.0001	0.0005	0.0004	0.0004	0.0002	0.0004	0.0004	0.0017	0.0025
0.21-0.50	0	0.0001	0	0	0	0	0	0	0.0006	0.0006	0
0.51-1.00	0	0.0003	0	0	0	0	0	0	0.0011	0.0009	0
1.01-2.00	0	0.0001	0	0	0.0001	0	0	0	0.001	0.0004	0
2.01-5.00	0	0	0	0	0	0	0	0	0.0011	0.0005	0
> 5.00	0	0.0001	0	0	0	0	0	0	0.0003	0.0007	0

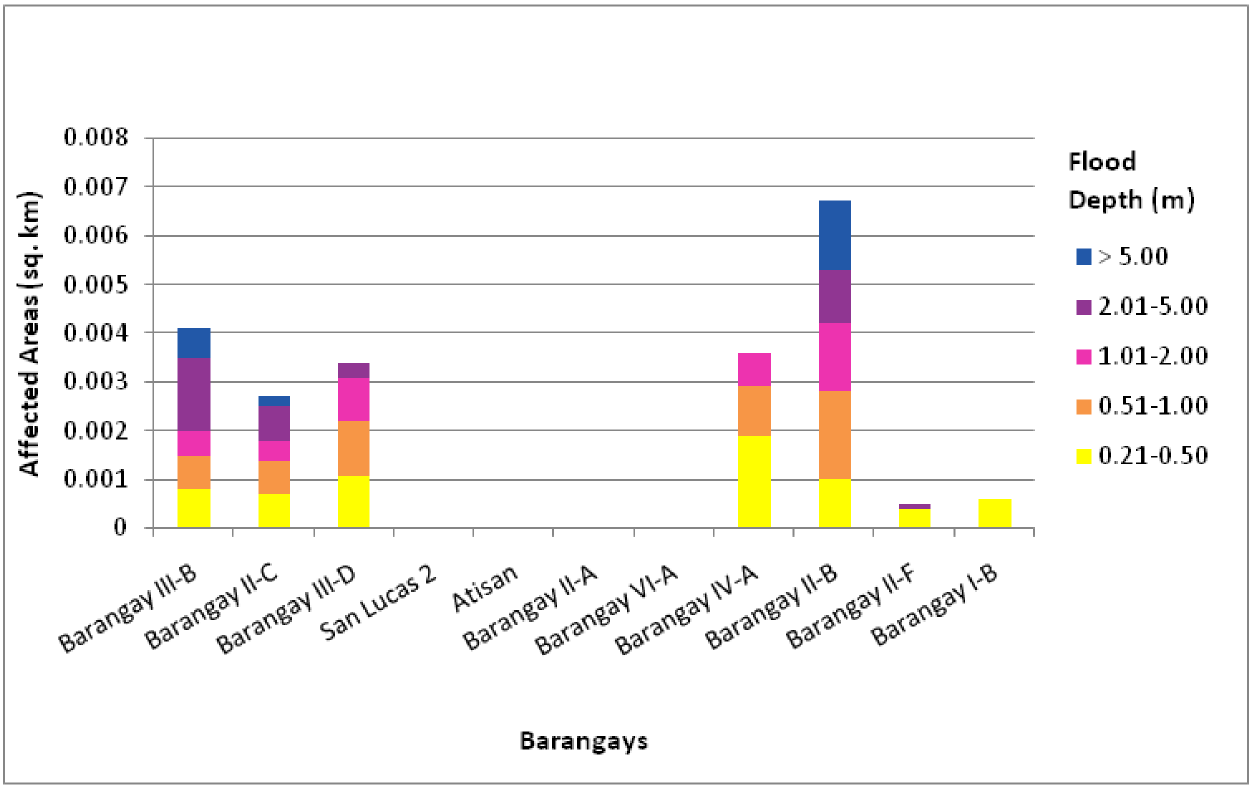
Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Barangay III-B	Barangay II-C	Barangay III-D	San Lucas 2	Atisan	Barangay II-A	Barangay VI-A	Barangay IV-A	Barangay II-B	Barangay II-F	Baran-gay I-B
0.03-0.20	0.001	0.0013	0.002	0.0022	0.0025	0.0045	0.0034	0.0016	0.0059	0.022	0.027
0.21-0.50	0.0008	0.0007	0.0011	0	0	0	0	0.0019	0.001	0.0004	0.0006
0.51-1.00	0.0007	0.0007	0.0011	0	0	0	0	0.001	0.0018	0	0
1.01-2.00	0.0005	0.0004	0.0009	0	0	0	0	0.0007	0.0014	0	0
2.01-5.00	0.0015	0.0007	0.0003	0	0	0	0	0	0.0011	0.0001	0
> 5.00	0.0006	0.0002	0	0	0	0	0	0	0.0014	0	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Santo Cristo	Bagong Bayan II-A	San Antonio 1	Santa Cruz	Santa Maria Magdalena	San Ignacio	Santiago II	San Vicente	San Mateo	Del Remedio	San Marcos
0.03-0.20	0.024	0.049	0.046	0.044	0.067	0.071	0.062	0.079	0.098	0.12	0.16
0.21-0.50	0.009	0.0027	0.0004	0.009	0.016	0.019	0.023	0.0099	0.0001	0.018	0.0018
0.51-1.00	0.002	0.0015	0	0.0013	0.0072	0.0063	0.014	0.0074	0	0.01	0.0008
1.01-2.00	0.0009	0.0004	0	0.0002	0.0011	0.0009	0.012	0.0055	0	0.0069	0.0014
2.01-5.00	0	0.0014	0	0	0	0	0.0074	0.0046	0	0.002	0
> 5.00	0	0.0012	0	0	0	0	0.0029	0.0008	0	0.0016	0

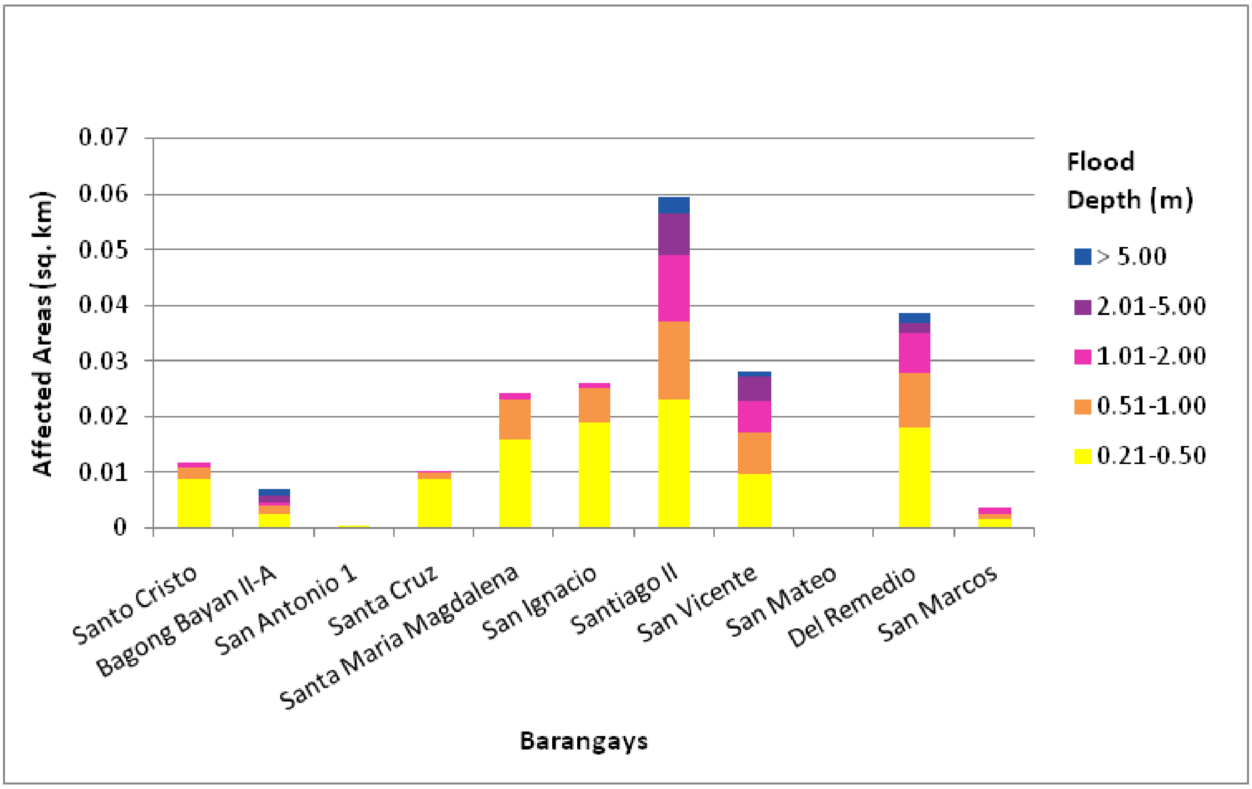
Affected Area (sq. km.) by flood depth (in m.)	**Area of affected barangays in San Pablo City (in sq. km.)**										
	Santa Ana	San Francisco	San Gabriel	San Gregorio	San Antonio 2	San Juan	San Roque	Santa Monica	San Rafael	Soledad	Santa Felomina
0.03-0.20	0.22	0.12	0.16	0.2	0.16	0.25	0.27	0.3	0.3	0.47	0.33
0.21-0.50	0.026	0.026	0.011	0.0099	0.022	0.033	0.021	0.061	0.11	0.052	0.1
0.51-1.00	0.016	0.021	0.01	0.0092	0.0037	0.015	0.013	0.056	0.034	0.012	0.027
1.01-2.00	0.013	0.009	0.0068	0.0079	0.0008	0.016	0.0063	0.027	0.021	0.0091	0
2.01-5.00	0.0065	0.0038	0.0065	0.0082	0.0001	0.013	0.0005	0.029	0.017	0.0086	0
> 5.00	0.001	0.0018	0.0078	0.0048	0	0.0062	0	0.012	0.016	0.0074	0



0.0045
0.004
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
Affected Areas (sq. km)
Barangay II-E
Barangay III-A
Barangay IV-B
Barangay VII-A
Barangay VII-E
Bagong Pook VI-C
Barangay VI-E
San Lucas 1
Barangay VII-D
Barangay II-D
Barangay VI-D
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50



0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Affected Areas (sq. km)
Barangay III-B
Barangay II-C
Barangay III-D
San Lucas 2
Atisan
Barangay II-A
Barangay VI-A
Barangay IV-A
Barangay II-B
Barangay II-F
Barangay I-B
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50



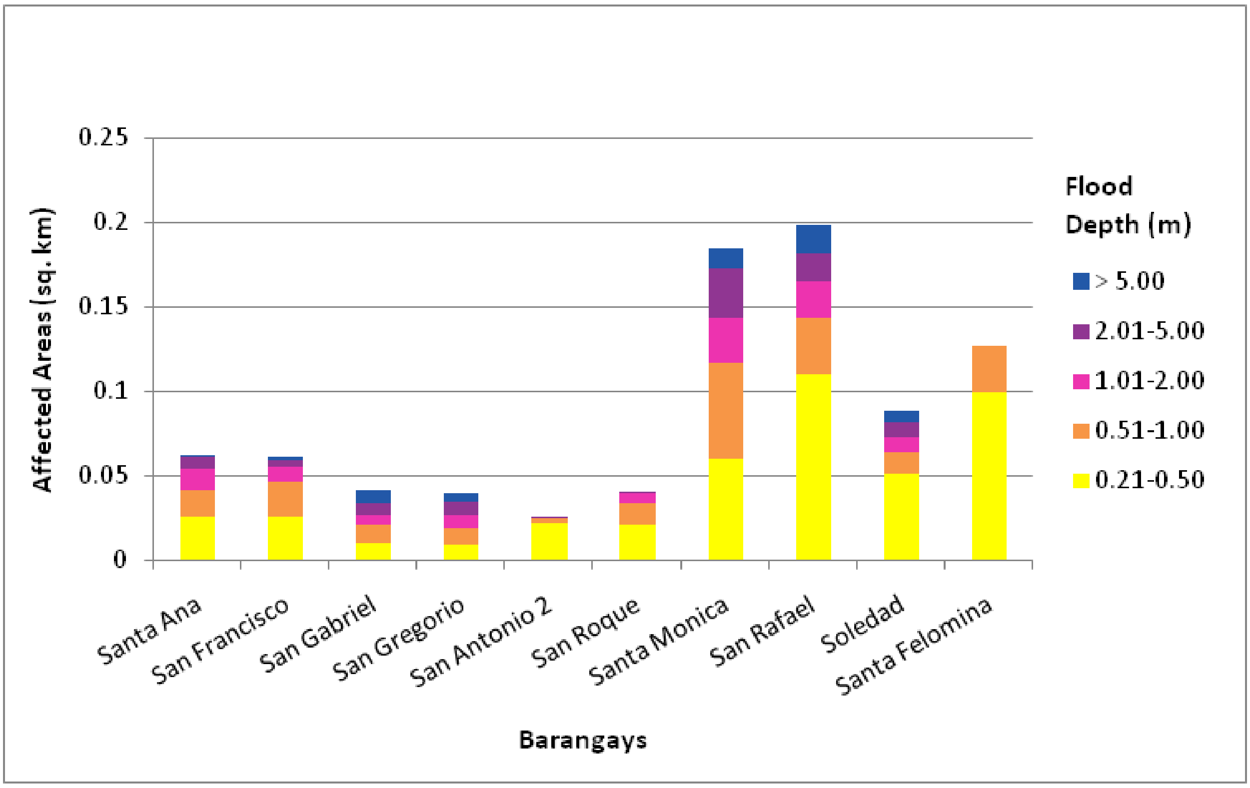


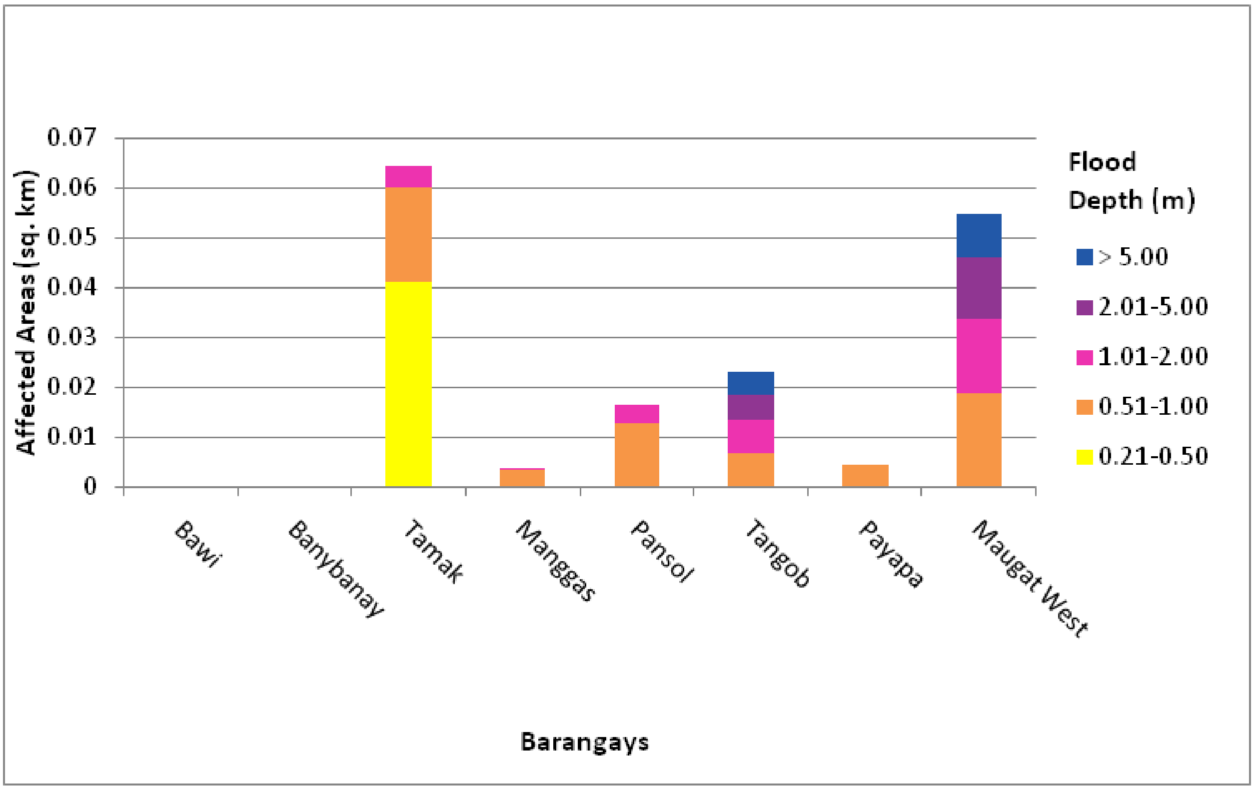
Figure 81. Affected areas in San Pablo City, Laguna during a 25-Year Rainfall Return Period.

For the 25-year return period, 6.45% of the municipality of Padre Garcia with an area of 39.28 sq. km. will experience flood levels of less than 0.20 meters. 1.07% of the area will experience flood levels of 0.21 to 0.50 meters while 0.51%, 0.26%, 0.16%, and 0.10% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 50. Affected areas in Padre Garcia, Batangas during a 25-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Padre Garcia (in sq. km.)							
	Bawi	Banybanay	Tamak	Manggas	Pansol	Tangob	Payapa	Maugat West
0.03-0.20	0.0069	0	0.05	0.087	0.11	0.13	0.16	0.14
0.21-0.50	0.0002	0	0.041	0.0095	0.017	0.017	0.0097	0.032
0.51-1.00	0	0	0.019	0.0037	0.013	0.0069	0.0045	0.019
1.01-2.00	0	0	0.0045	0.0002	0.0036	0.0067	0	0.015
2.01-5.00	0	0	0	0	0	0.005	0	0.012
> 5.00	0	0	0	0	0	0.0046	0	0.0088

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Padre Garcia (in sq. km.)								
	Quilo-Quilo South	Maugat East	San Felipe	Poblacion	Quilo-Quilo North	Castillo	Bukal	Banaba	
0.03-0.20	0.15	0.18	0.16	0.22	0.23	0.23	0.3	0.38	0
0.21-0.50	0	0.061	0.016	0.0058	0.0048	0.074	0.1	0.032	0
0.51-1.00	0	0.022	0	0	0.0044	0.023	0.08	0.0044	0
1.01-2.00	0	0.013	0	0	0.0001	0.013	0.046	0	0
2.01-5.00	0	0.014	0	0	0	0.0095	0.024	0	0
> 5.00	0	0.014	0	0	0	0.0037	0.01	0	0



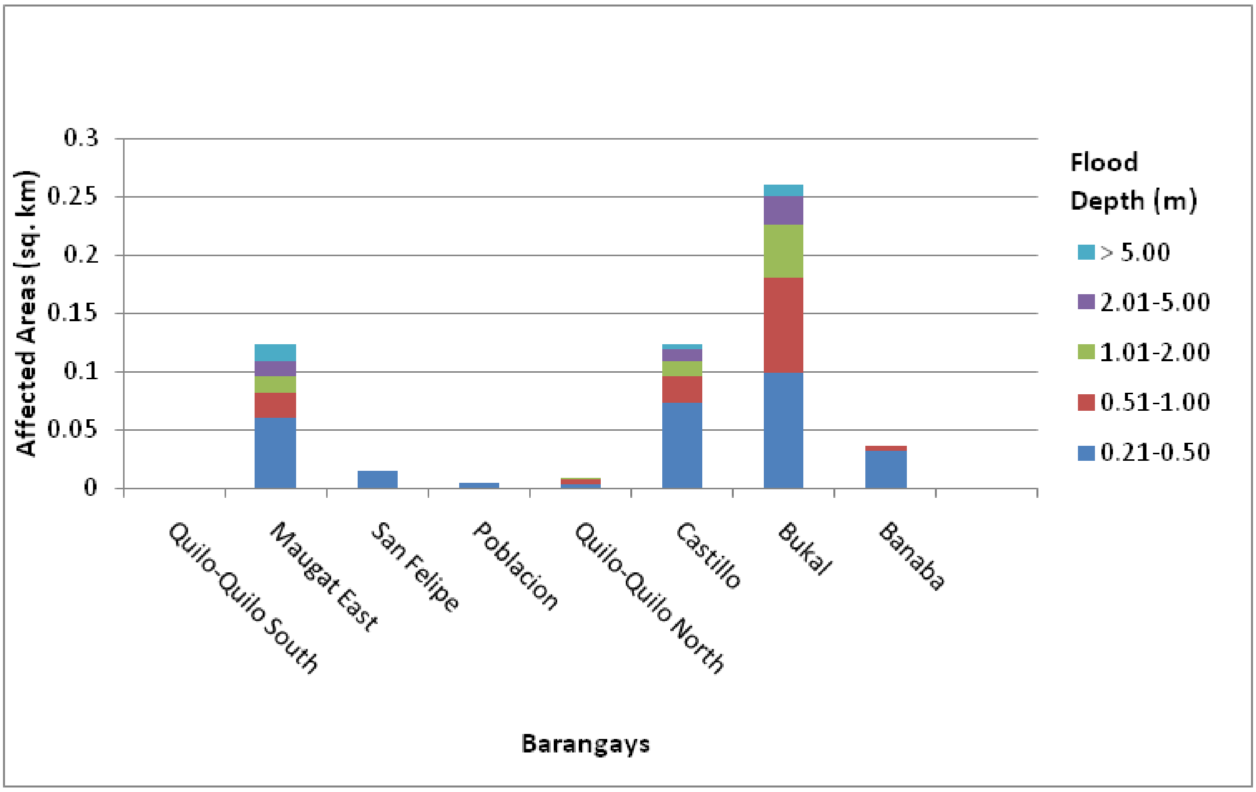


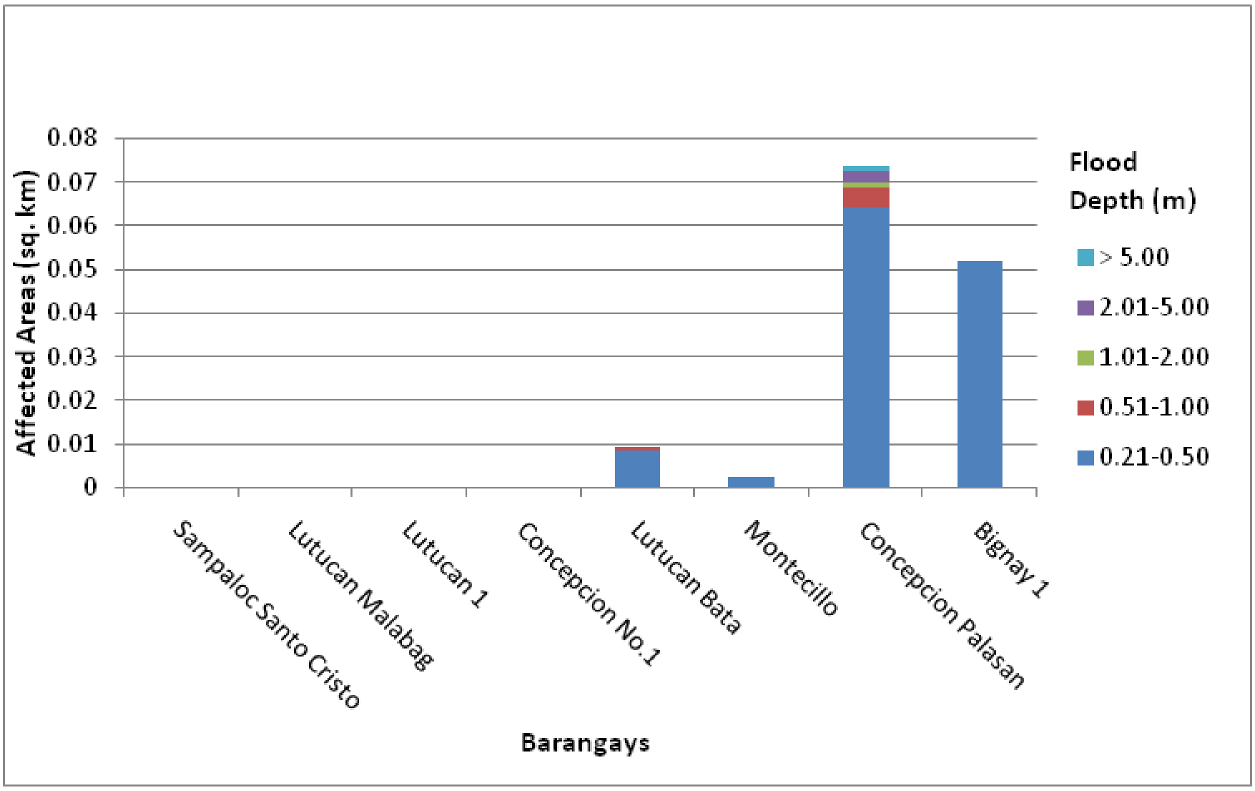
Figure 82. Affected areas in Padre Garcia, Batangas during a 25-Year Rainfall Return Period.

For the 25-year return period, 33.71% of the municipality of Sariaya with an area of 213.78 sq. km. will experience flood levels of less than 0.20 meters. 3.86% of the area will experience flood levels of 0.21 to 0.50 meters while 0.54%, 0.18%, 0.11%, 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. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 51. Affected areas in Sariaya, Quezon during a 25-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Sariaya (in sq. km.)							
	Sampaloc Santo Cristo	Lutucan Malabag	Lutucan 1	Concepcion No.1	Lutucan Bata	Montecillo	Concepcion Palasan	Bignay 1
0.03-0.20	0.0008	0.014	0.008	0	0.16	0.36	0.66	0.98
0.21-0.50	0	0	0	0	0.0086	0.0028	0.064	0.052
0.51-1.00	0	0	0	0	0.0008	0	0.0047	0
1.01-2.00	0	0	0	0	0	0	0.0012	0
2.01-5.00	0	0	0	0	0	0	0.0026	0
> 5.00	0	0	0	0	0	0	0.0012	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Sariaya (in sq. km.)								
	Manggalang 1	Manggalang-Kiling	Guisguis-Talon	Manggalang Tulo-Tulo	Manggalang-Bantilan	Guisguis-San Roque	Bignay 2		
0.03-0.20	0.99	0.94	1.09	2.09	2.41	1.37	2.17	0	0
0.21-0.50	0.13	0.17	0.19	0.018	0.22	0.57	0.091	0	0
0.51-1.00	0.024	0.023	0.0061	0.0001	0.065	0.086	0.0013	0	0
1.01-2.00	0.0028	0.0008	0.0004	0	0.027	0.037	0	0	0
2.01-5.00	0	0.0011	0	0	0.023	0.018	0	0	0
> 5.00	0	0.012	0	0	0.066	0.007	0	0	0



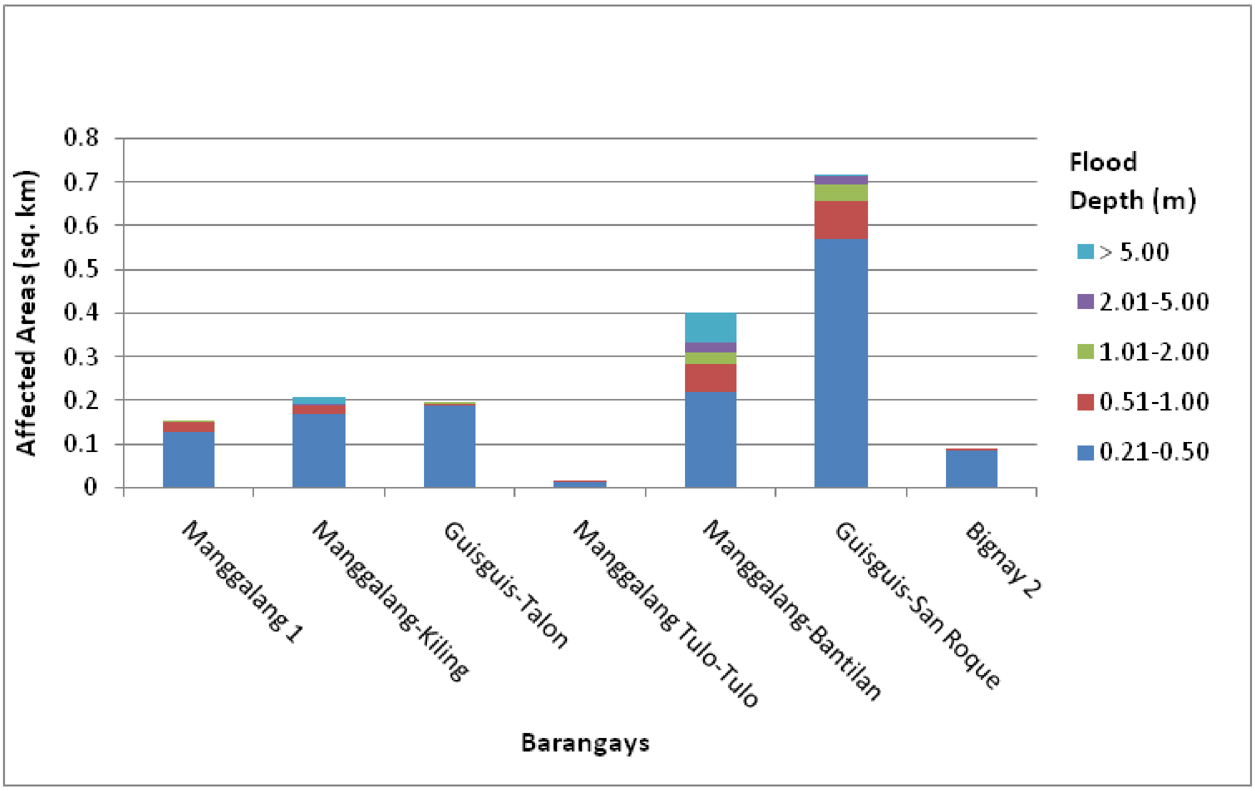


Figure 83. Affected areas in Sariaya, Quezon during a 25-Year Rainfall Return Period.

For the 25-year return period, 11.78% of the municipality of San Juan with an area of 237.55 sq. km. will experience flood levels of less than 0.20 meters. 3.14% of the area will experience flood levels of 0.21 to 0.50 meters while 0.72%, 0.24%, 0.13%, and 0.14% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

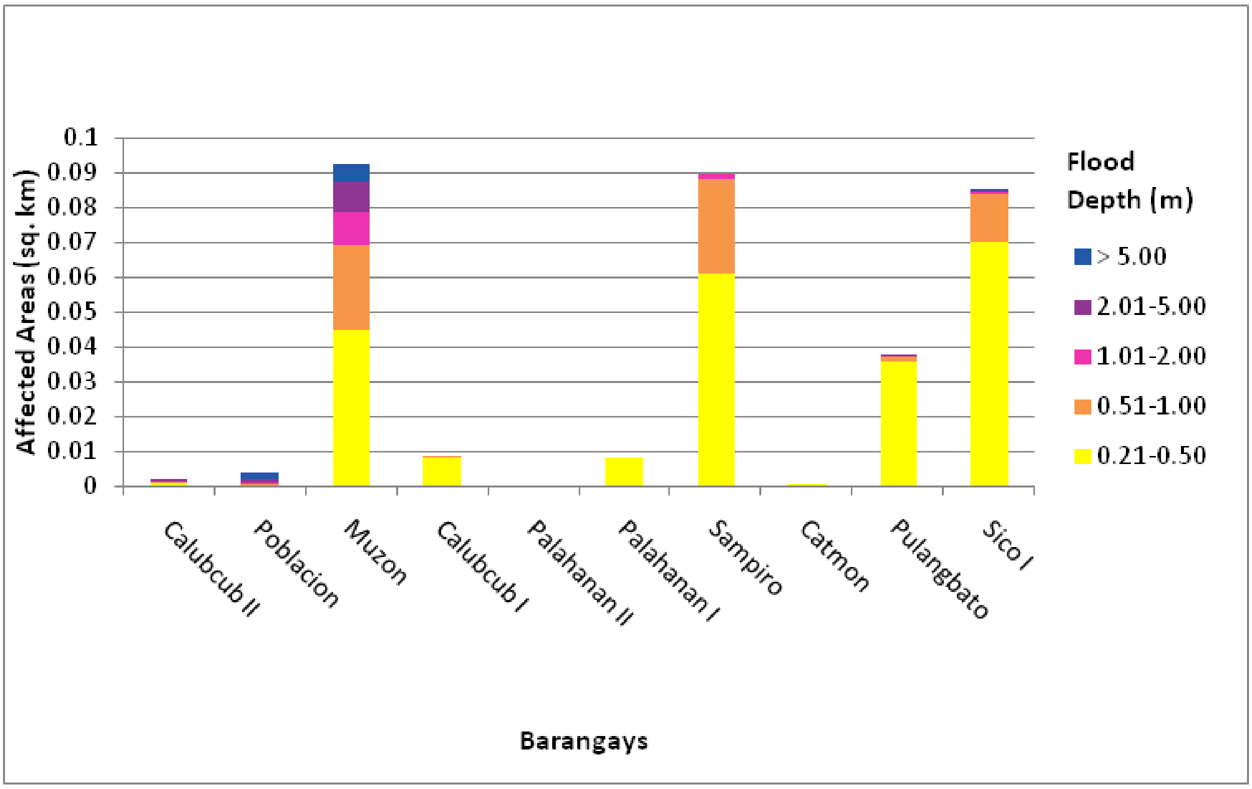
Table 52. Affected areas in San Juan, Batangas during a 25-Year Rainfall Return Period.

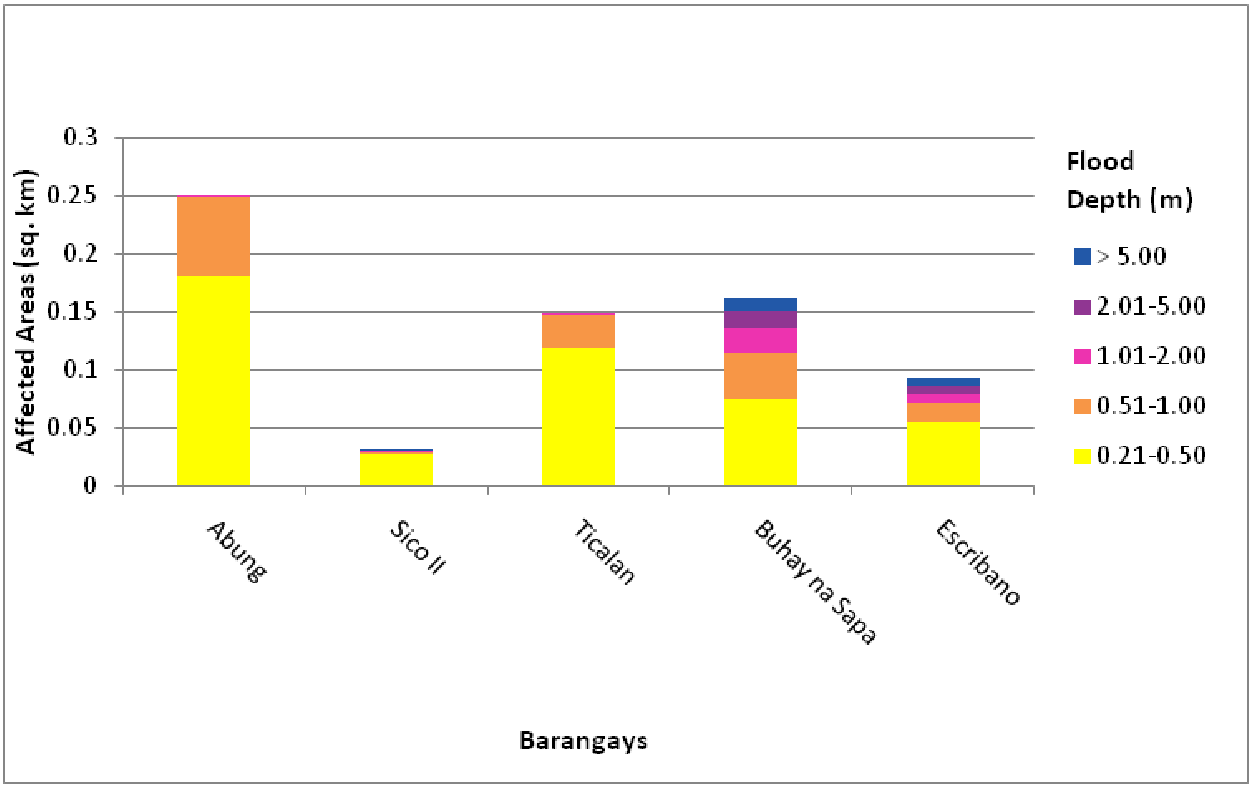
Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)									
	Calubcub II	Poblacion	Muzon	Calubcub I	Palahanan II	Palahanan I	Sampiro	Catmon	Pulangbato	Sico I
0.03-0.20	0.0084	0.012	0.068	0.15	0.091	0.13	0.14	0.22	0.24	0.4
0.21-0.50	0.0014	0.0005	0.045	0.0084	0	0.0084	0.061	0.001	0.036	0.07
0.51-1.00	0.0003	0.0007	0.024	0.0005	0	0	0.027	0	0.0018	0.014
1.01-2.00	0.0003	0.0004	0.0097	0	0	0	0.0015	0	0	0.0004
2.01-5.00	0.0002	0.0006	0.0083	0	0	0	0	0	0.0001	0.0004
> 5.00	0	0.0019	0.0054	0	0	0	0	0	0	0.0003

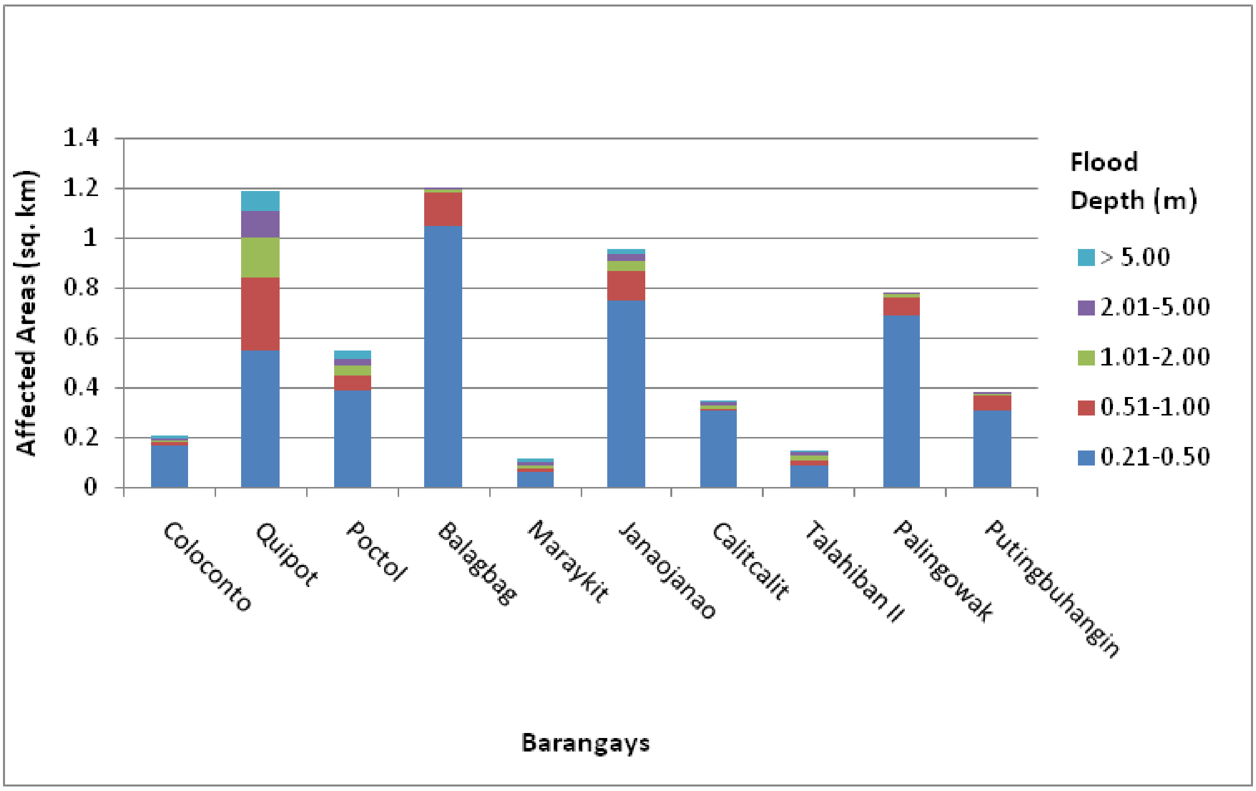
Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)									
	Abung	Sico II	Ticalan	Buhay na Sapa	Escribano	Sapangan	Mabalanoy	Pinagbayanan	Libato	Tipaz
0.03-0.20	0.29	0.58	0.49	0.62	0.64	0.74	0.78	1.01	1.35	0.99
0.21-0.50	0.18	0.028	0.12	0.076	0.055	0.26	0.021	0.82	0.36	0.34
0.51-1.00	0.07	0.0017	0.028	0.039	0.018	0.069	0.011	0.27	0.19	0.1
1.01-2.00	0.0007	0.0015	0.0013	0.021	0.0069	0.018	0.011	0.0093	0.089	0.047
2.01-5.00	0	0.001	0	0.015	0.0071	0.0011	0.01	0	0.046	0.012
> 5.00	0	0.0004	0	0.011	0.007	0	0.014	0	0.023	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)									
	Coloconto	Quipot	Poctol	Balagbag	Maraykit	Janaojanao	Calitcalit	Talahiban II	Palingowak	Putingbuhangin
0.03-0.20	1.22	1.34	1.38	1.17	1.41	1.55	1.32	1.52	1.45	2.55
0.21-0.50	0.17	0.55	0.39	1.05	0.066	0.75	0.31	0.093	0.69	0.31
0.51-1.00	0.013	0.29	0.062	0.13	0.013	0.12	0.011	0.019	0.073	0.059
1.01-2.00	0.01	0.16	0.041	0.018	0.013	0.042	0.011	0.018	0.019	0.018
2.01-5.00	0.0092	0.11	0.022	0.0019	0.014	0.023	0.01	0.016	0.0016	0.0004
> 5.00	0.0078	0.076	0.034	0	0.012	0.02	0.011	0.0054	0	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)	
	Talahiban I	Lipahan
0.03-0.20	2.11	2.01
0.21-0.50	0.28	0.31
0.51-1.00	0.052	0.011
1.01-2.00	0.0046	0.0093
2.01-5.00	0.0004	0.0093
> 5.00	0	0.095




Affected Areas (sq. km)
0.3
0.25
0.2
0.15
0.1
0.05
0
Abung
Sico II
Ticalan
Buhay na Sapa
Escribano
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50


Affected Areas (sq. km)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Coloconto
Quipot
Poctol
Balagbag
Maraykit
Janaojanao
Calitcalit
Talahiban II
Palingowak
Putingbuhangin
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50

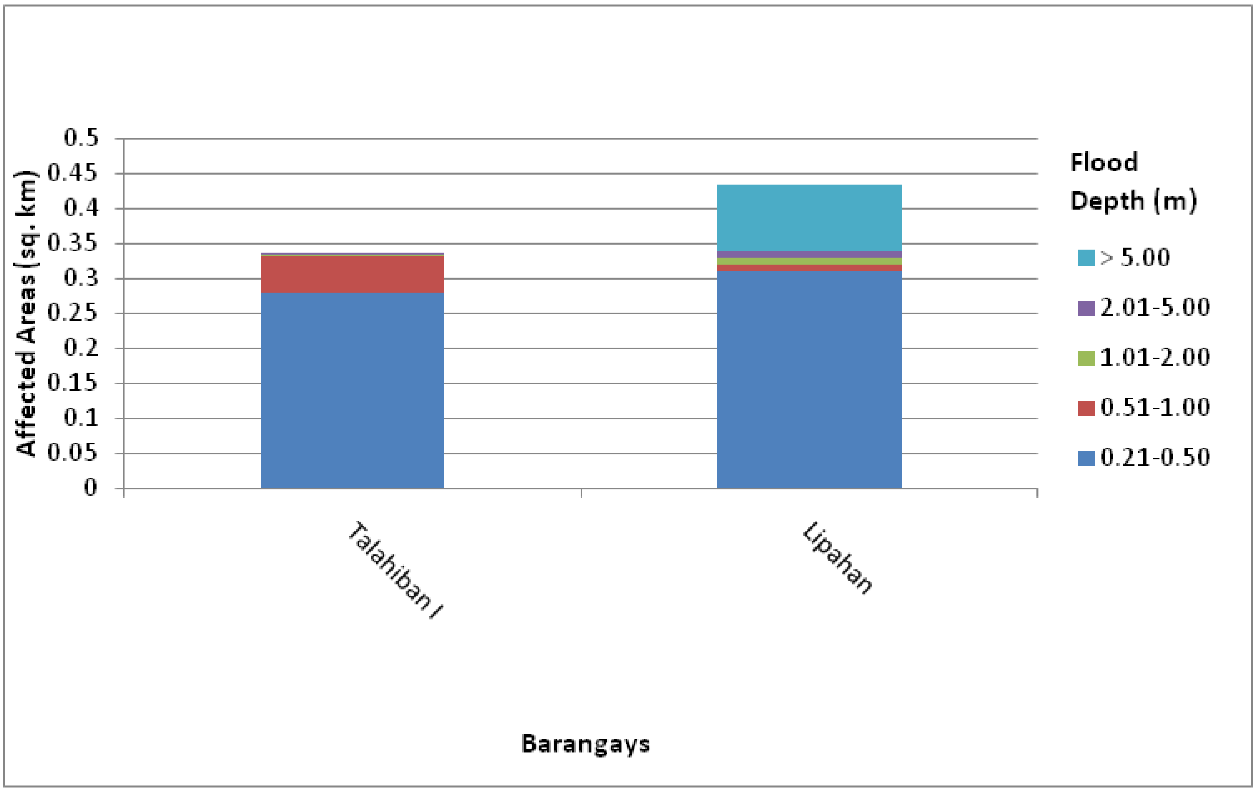


Figure 84. Affected areas in San Juan, Batangas during a 25-Year Rainfall Return Period.

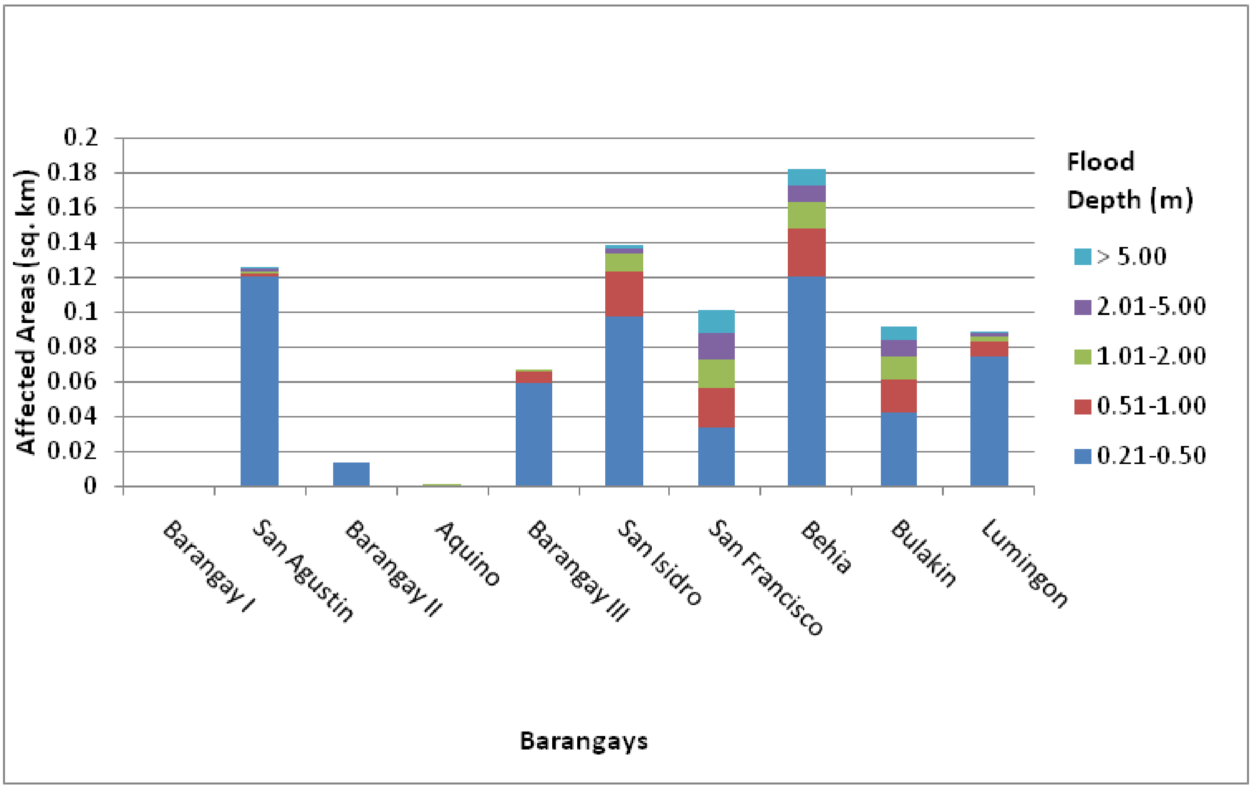
For the 25-year return period, 9.00% of the municipality of Tiaong with an area of 118.93 sq. km. will experience flood levels of less than 0.20 meters. 2.60% of the area will experience flood levels of 0.21 to 0.50 meters while 1.00%, 0.26%, 0.13%, and 0.09% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

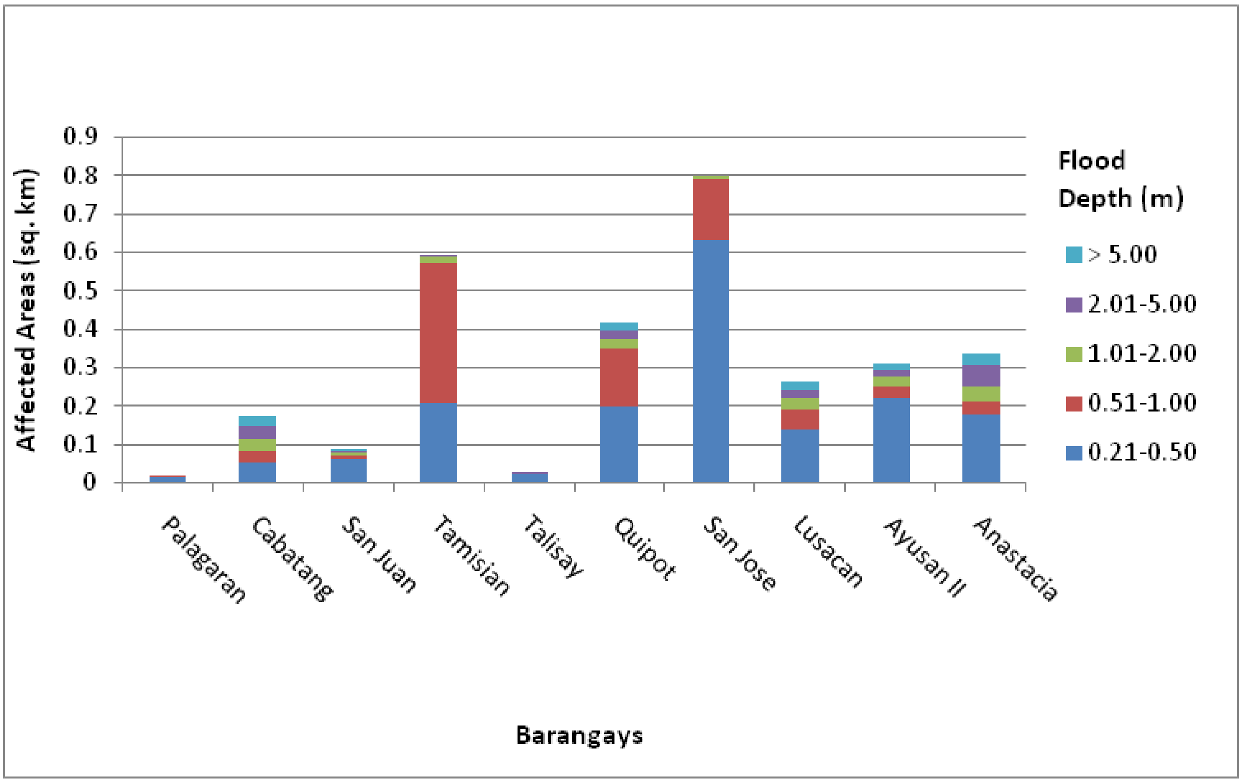
Table 53. Affected areas in Tiaong. Quezon during a 25-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Tiaong (in sq. km.)									
	Barangay I	San Agustin	Barangay II	Aquino	Barangay III	San Isidro	San Francisco	Behia	Bulakin	Lumingon
0.03-0.20	0.0096	0.19	0.016	0.033	0.063	0.28	0.34	0.47	0.45	0.38
0.21-0.50	0.0001	0.12	0.013	0.0014	0.06	0.098	0.034	0.12	0.043	0.075
0.51-1.00	0	0.0022	0	0.0006	0.0069	0.025	0.023	0.028	0.019	0.0084
1.01-2.00	0	0.0013	0	0.0003	0.0003	0.011	0.016	0.015	0.013	0.0032
2.01-5.00	0	0.0015	0	0	0	0.0029	0.015	0.0097	0.0095	0.0018
> 5.00	0	0.0012	0	0	0	0.0019	0.013	0.0096	0.0072	0.001

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Tiaong (in sq. km.)									
	Palagaran	Cabatang	San Juan	Tamisian	Talisay	Quipot	San Jose	Lusacan	Ayusan II	Anastacia
0.03-0.20	0.45	0.55	0.53	0.43	0.82	0.73	1.47	0.89	0.88	0.81
0.21-0.50	0.023	0.057	0.062	0.21	0.027	0.2	0.63	0.14	0.22	0.18
0.51-1.00	0.0002	0.03	0.011	0.36	0.0025	0.15	0.16	0.053	0.033	0.035
1.01-2.00	0	0.027	0.0076	0.021	0.0003	0.027	0.0056	0.027	0.023	0.037
2.01-5.00	0	0.037	0.006	0.0024	0.0001	0.02	0	0.022	0.02	0.054
> 5.00	0	0.026	0.0031	0	0	0.023	0	0.024	0.016	0.031

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Tiaong (in sq. km.)									
	Paiisa	Bula	Tagbakin	Lagalag	San Pedro	Cabay	Del Rosario	Bukal	Ayusan I	Lalig
0.03-0.20	0.93	0.62	1.21	1.21	0.68	1.62	1.85	0.91	1.15	1.4
0.21-0.50	0.065	0.4	0.08	0.082	0.52	0.16	0.14	0.6	1.03	0.78
0.51-1.00	0.0021	0.21	0.0066	0.006	0.096	0.0023	0.0092	0.61	0.34	0.15
1.01-2.00	0.0003	0.031	0.0039	0.0029	0.031	0.0014	0.006	0.26	0.032	0.022
2.01-5.00	0	0.01	0.0015	0.0026	0.019	0.0004	0.0039	0.03	0.02	0.0094
> 5.00	0	0.009	0	0.0028	0.014	0.0006	0.0036	0.0071	0.02	0.0084


Affected Areas (sq. km)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Barangay I
San Agustin
Barangay II
Aquino
Barangay III
San Isidro
San Francisco
Behia
Bulakin
Lumingon
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50


Affected Areas (sq. km)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Palagaran
Cabatang
San Juan
Tamisian
Talisay
Quipot
San Jose
Lusacan
Ayusan II
Anastacia
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50

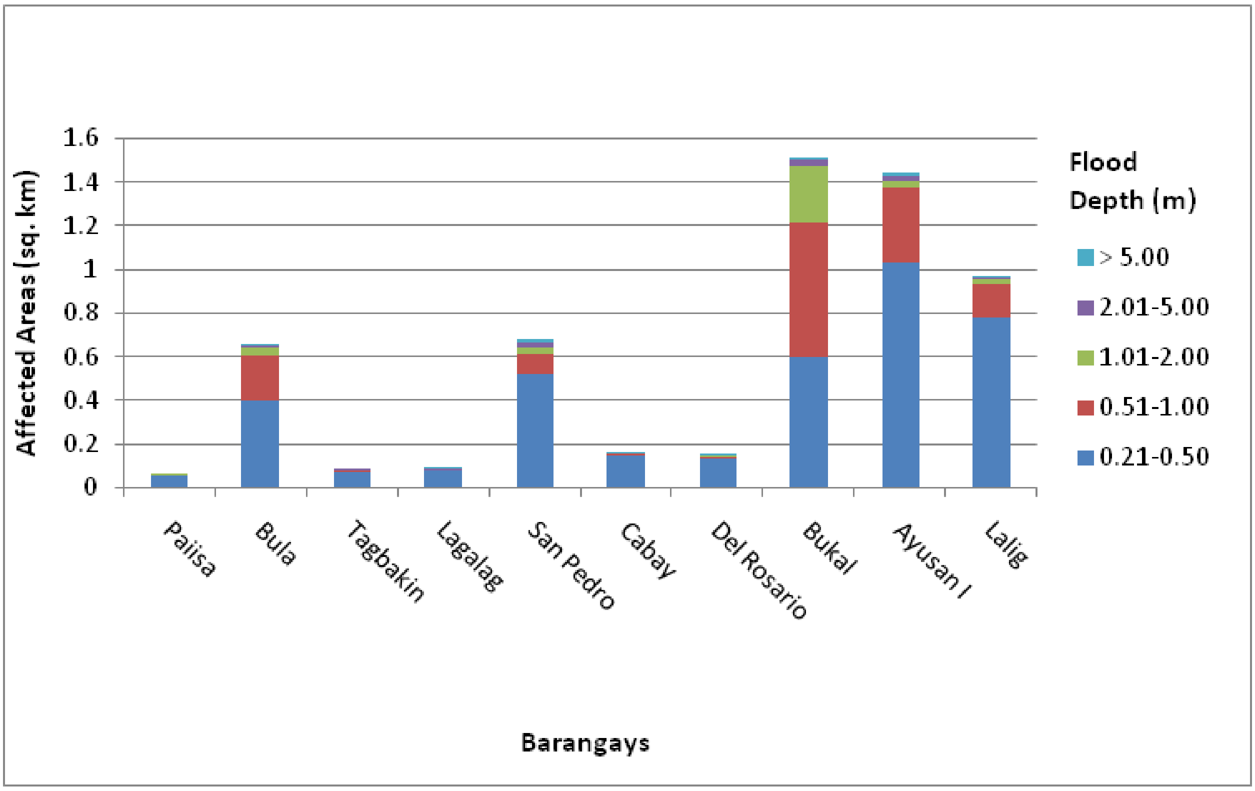


Figure 85. Affected areas in Tiaong. Quezon during a 25-Year Rainfall Return Period.

For the 25-year return period, 1.35% of the municipality of Alaminos with an area of 59.65 sq. km. will experience flood levels of less than 0.20 meters. 0.16% of the area will experience flood levels of 0.21 to 0.50 meters while 0.03%, 0.01%, 0.01%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 54. Affected areas in Alaminos, Laguna during a 25-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Alaminos (in sq. km.)					
	San Miguel	Del Carmen	San Agustin	San Gregorio	San Roque	San Benito
0.03-0.20	0.0059	0.019	0.025	0.067	0.17	0.52
0.21-0.50	0.0002	0	0	0.02	0.016	0.058
0.51-1.00	0	0	0	0.0065	0.007	0.0047
1.01-2.00	0	0	0	0.0008	0.0051	0.0004
2.01-5.00	0	0	0	0	0.0048	0
> 5.00	0	0	0	0	0.0028	0

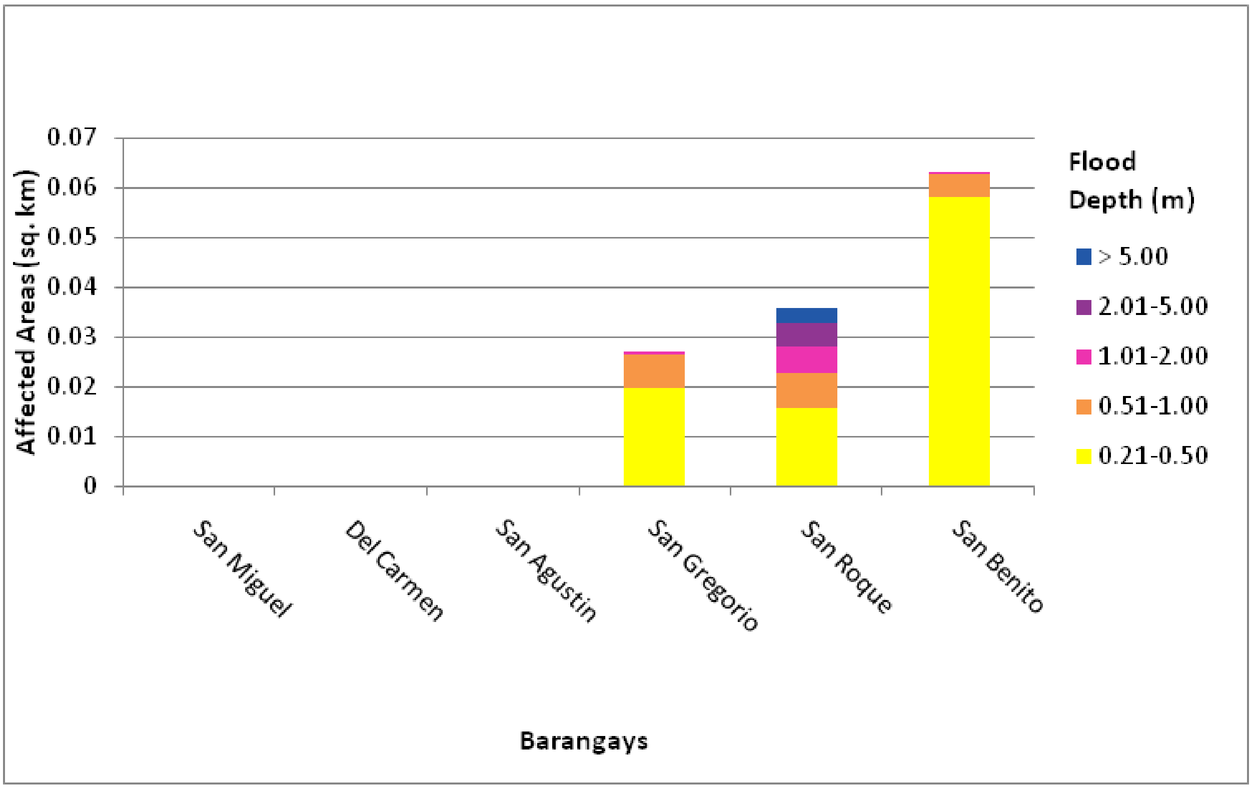


Figure 86. Affected areas in Alaminos, Laguna during a 25-Year Rainfall Return Period.

For the 25-year return period, 0.77% of the municipality of Dolores with an area of 65.96 sq. km. will experience flood levels of less than 0.20 meters. 0.22% of the area will experience flood levels of 0.21 to 0.50 meters while 0.16%, 0.10%, 0.08%, 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 55. Affected areas in Dolores, Quezon during a 25-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Dolores (in sq. km.)				
	Antonino	Dagatan	San Mateo	Bungoy	Putol
0.03-0.20	0.0031	0.0374	0.0344	0.2095	0.2218
0.21-0.50	0.0006	0.0073	0.0132	0.081	0.0461
0.51-1.00	0	0.0036	0.0043	0.062	0.0341
1.01-2.00	0	0.0037	0	0.0479	0.0168
2.01-5.00	0	0.0055	0	0.0351	0.0107
> 5.00	0	0.0027	0	0.0129	0.001

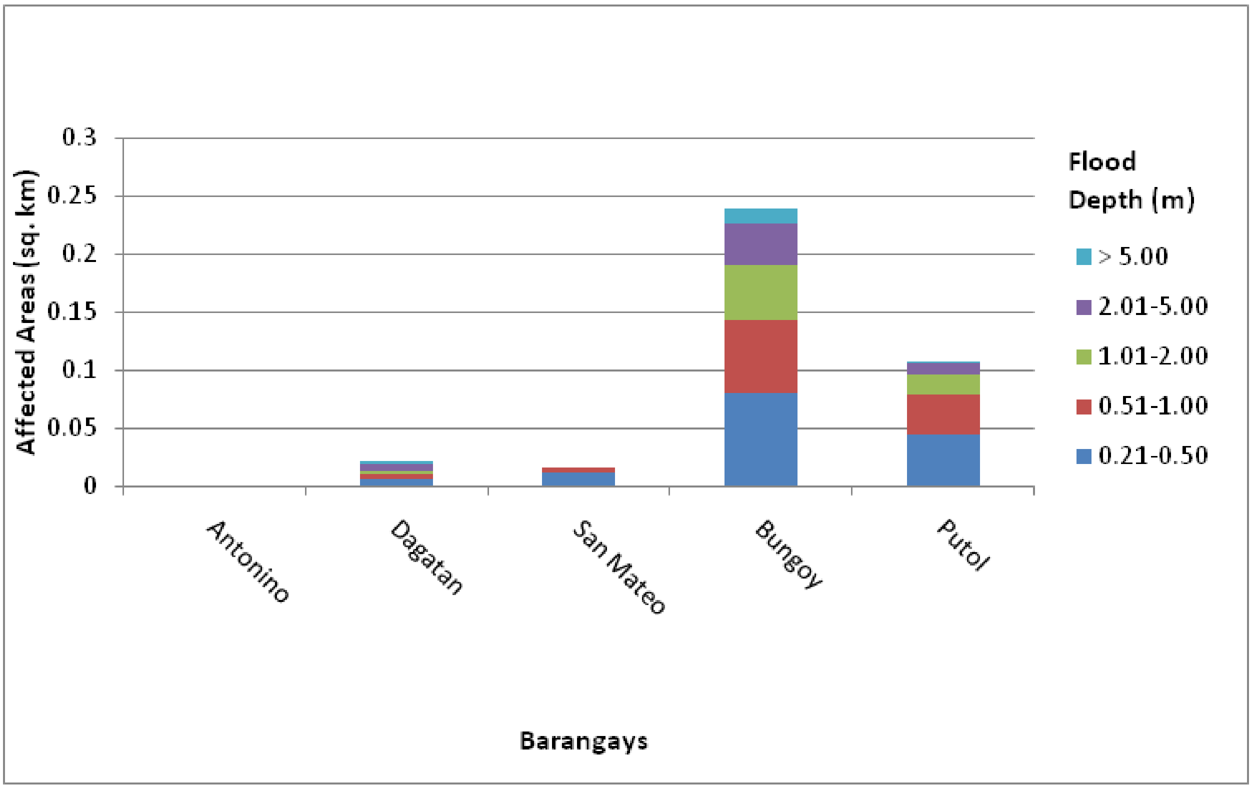


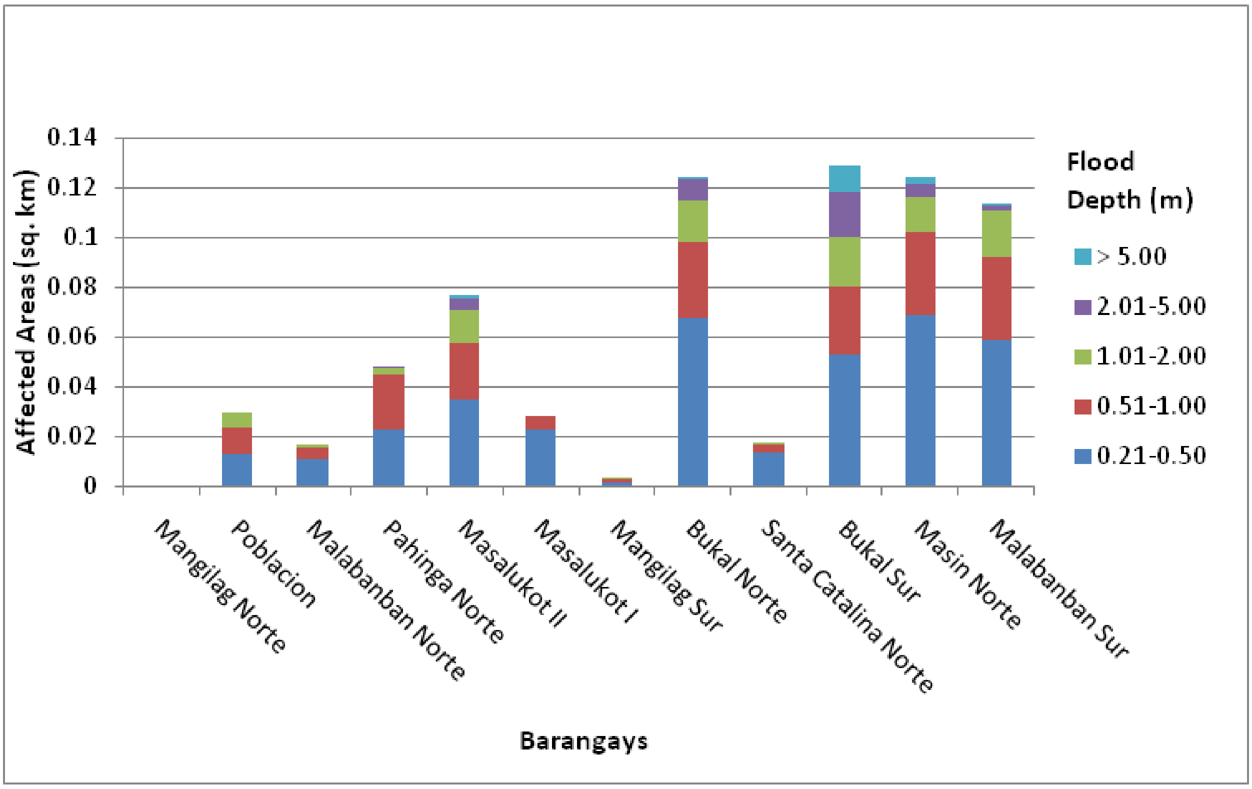
Figure 87. Affected areas in Dolores, Quezon during a 25-Year Rainfall Return Period.

For the 25-year return period, 12.18% of the municipality of Candelaria with an area of 136.74 sq. km. will experience flood levels of less than 0.20 meters. 1.30% of the area will experience flood levels of 0.21 to 0.50 meters while 0.31%, 0.19%, 0.10%, 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 56. Affected areas in Candelaria, Quezon during a 25-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Candelaria (in sq. km.)											
	Mangilag Norte	Poblacion	Malabanban Norte	Pahinga Norte	Masalukot II	Masalukot I	Mangilag Sur	Bukal Norte	Santa Catalina Norte	Bukal Sur	Masin Norte	Malabanban Sur
0.03-0.20	0.0041	0.025	0.057	0.074	0.081	0.098	0.16	0.24	0.32	0.33	0.28	0.51
0.21-0.50	0.0003	0.013	0.011	0.023	0.035	0.023	0.0023	0.068	0.014	0.053	0.069	0.059
0.51-1.00	0	0.011	0.0051	0.022	0.023	0.0053	0.0012	0.03	0.0037	0.027	0.033	0.033
1.01-2.00	0	0.0058	0.0012	0.0029	0.013	0	0.0006	0.017	0.0002	0.02	0.014	0.019
2.01-5.00	0	0	0	0.0005	0.0048	0	0	0.0085	0	0.018	0.0054	0.002
> 5.00	0	0	0	0	0.0011	0	0	0.0003	0	0.011	0.0024	0.0004

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Candelaria (in sq. km.)								
	Masin Sur	Pahinga Sur	San Andres	Buenavista West	Kinatihan II	Kinatihan I	Santa Catalina Sur	Buenavista East	San Isidro
0.03-0.20	0.45	0.7	0.83	0.85	1.61	1.51	3.53	1.69	3.3
0.21-0.50	0.08	0.074	0.045	0.23	0.15	0.083	0.038	0.35	0.36
0.51-1.00	0.022	0.036	0.018	0.018	0.023	0.032	0.0046	0.027	0.052
1.01-2.00	0.018	0.037	0.0047	0.012	0.02	0.027	0	0.011	0.036
2.01-5.00	0.013	0.023	0.0015	0.01	0.0088	0.019	0	0.0029	0.013
> 5.00	0.008	0.018	0	0.0029	0.0031	0.01	0	0.0001	0.0078



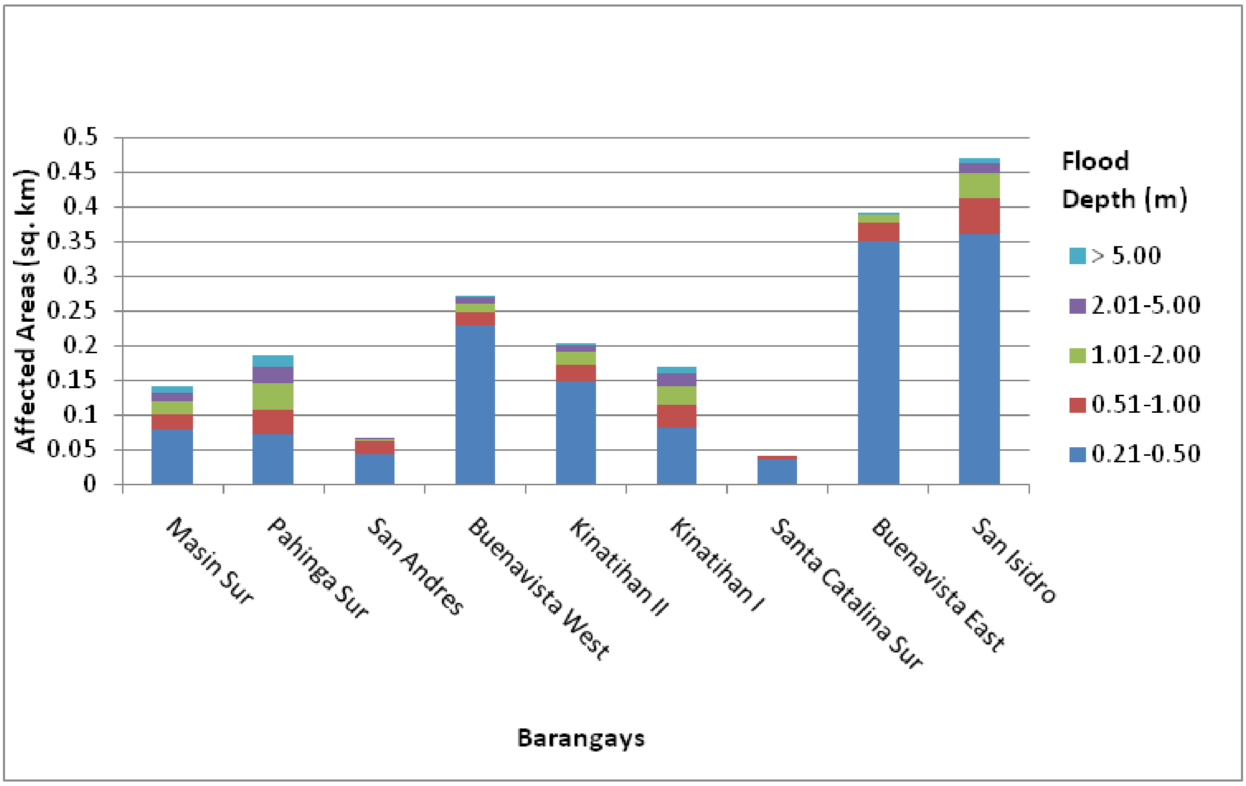


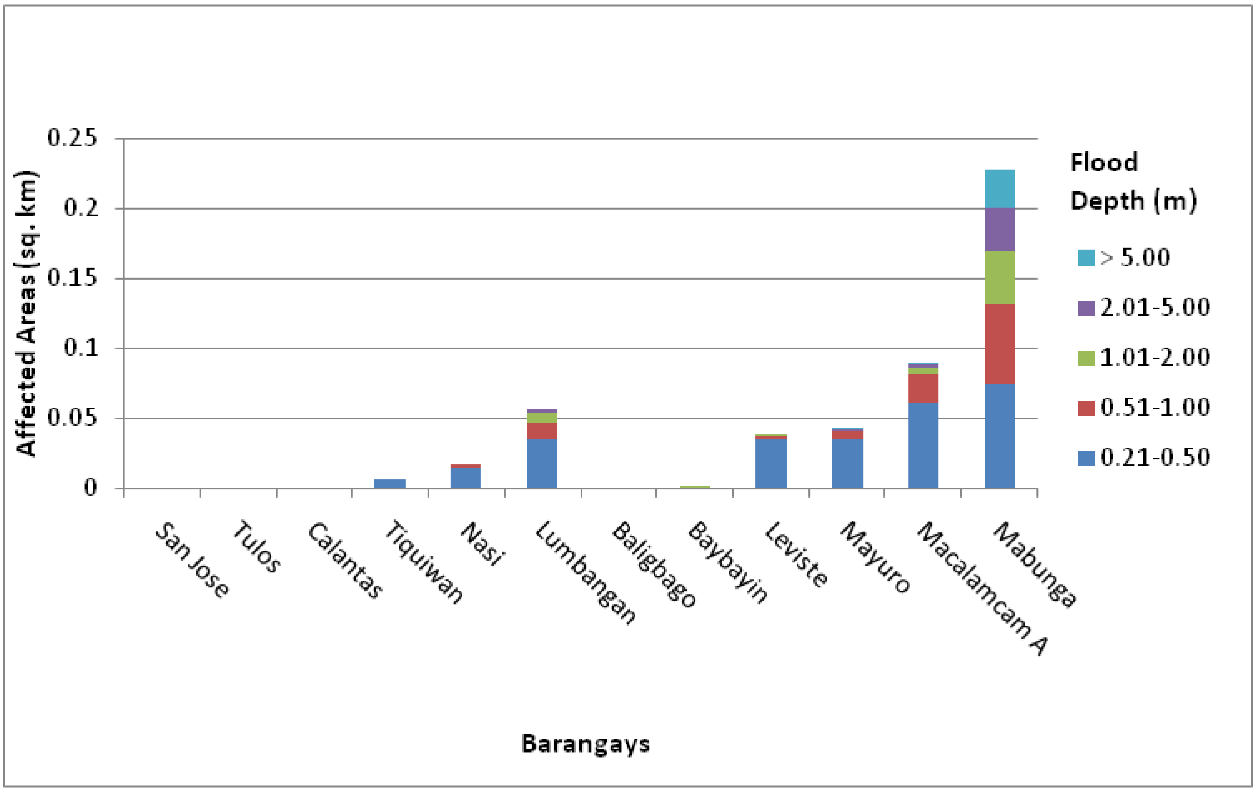
Figure 88. Affected areas in Candelaria, Quezon during a 25-Year Rainfall Return Period.

For the 25-year return period, 6.16% of the municipality of Rosario with an area of 199.04 sq. km. will experience flood levels of less than 0.20 meters. 1.37% of the area will experience flood levels of 0.21 to 0.50 meters while 0.58%, 0.31%, 0.19%, and 0.13% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 57. Affected areas in Rosario, Batangas during a 25-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Rosario (in sq. km.)											
	San Jose	Tulos	Calantas	Tiquiwan	Nasi	Lumbangan	Baligbago	Baybayin	Leviste	Mayuro	Macalamcam A	Mabunga
0.03-0.20	0.0078	0.003	0.0049	0.048	0.094	0.099	0	0.13	0.16	0.18	0.22	0.19
0.21-0.50	0	0	0	0.0075	0.015	0.035	0	0.0012	0.035	0.036	0.062	0.075
0.51-1.00	0	0	0	0	0.0024	0.012	0	0.0012	0.0042	0.0063	0.02	0.056
1.01-2.00	0	0	0	0	0	0.0075	0	0.0003	0.0002	0.0005	0.0045	0.038
2.01-5.00	0	0	0	0	0	0.0022	0	0	0	0.0002	0.0025	0.031
> 5.00	0	0	0	0	0	0	0	0	0	0.0007	0.0016	0.028

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Rosario (in sq. km.)										
	San Isidro	Bayawang	Mabato	Macalamcam B	Alupya	Natu	Maligaya	San Carlos	Salao	Pinagsibaan	Putingkahoy
0.03-0.20	0.26	0.28	0.55	1.14	0	0.48	0.5	0.56	1.1	1.07	1.35
0.21-0.50	0.086	0.13	0.18	0.083	0	0.084	0.17	0.18	0.12	0.18	0.4
0.51-1.00	0.034	0.07	0.07	0.036	0	0.007	0.069	0.08	0.055	0.11	0.16
1.01-2.00	0.018	0.043	0.037	0.031	0	0.0002	0.045	0.024	0.042	0.065	0.061
2.01-5.00	0.0093	0.031	0.027	0.025	0	0.0002	0.039	0	0.018	0.038	0.039
> 5.00	0.0047	0.021	0.025	0.017	0	0.0004	0.021	0	0.011	0.014	0.032



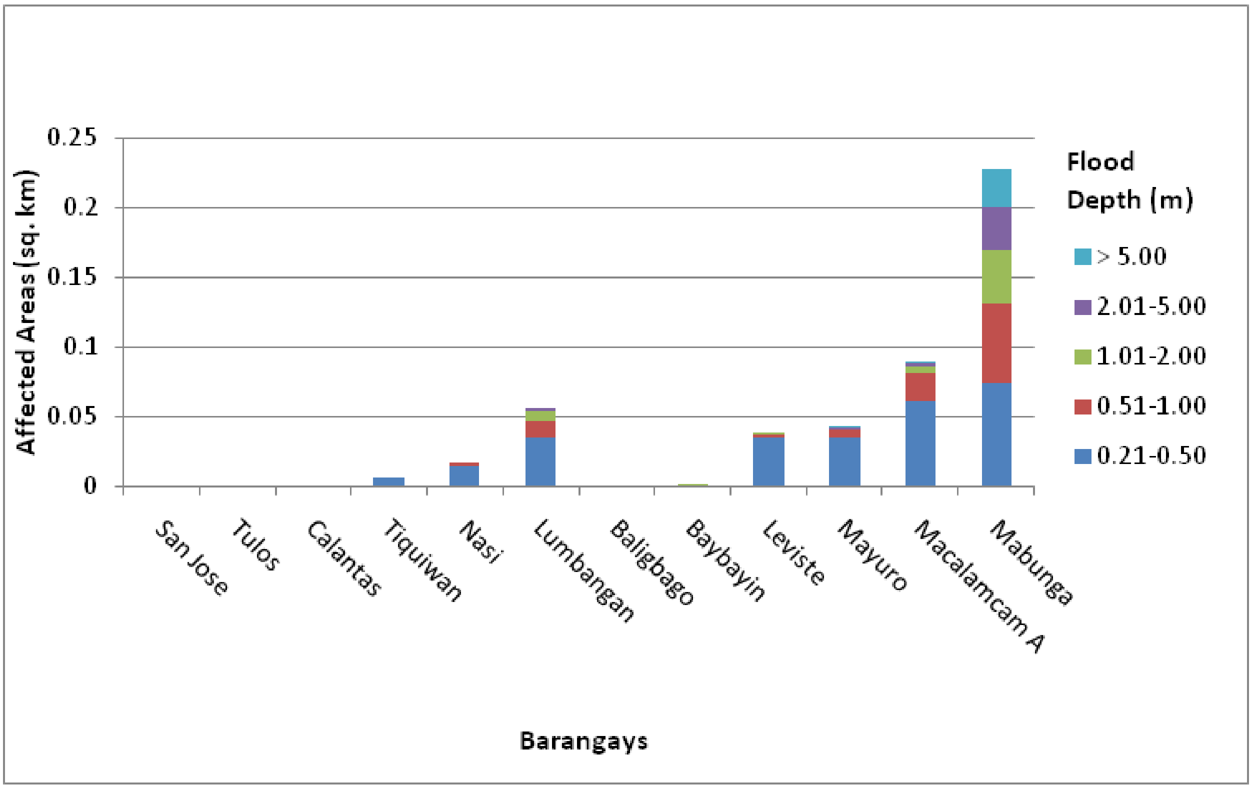


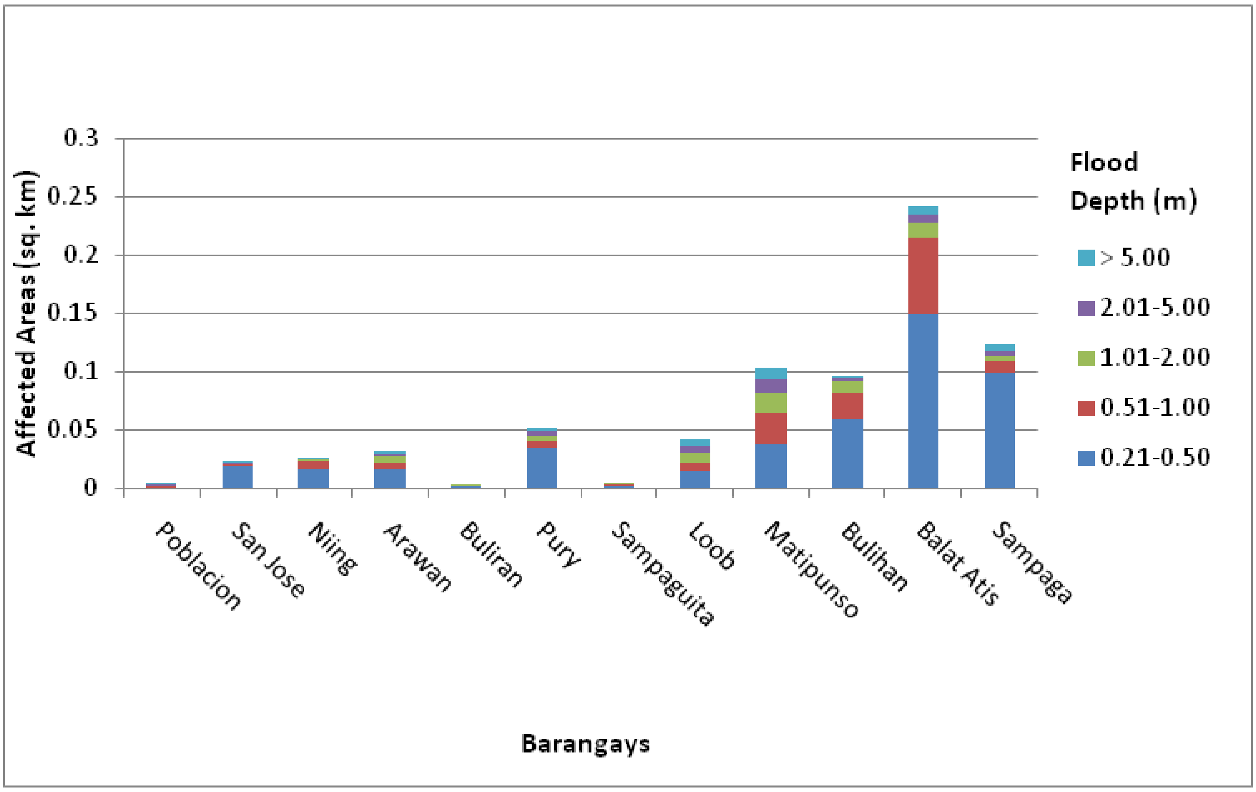
Figure 89. Affected areas in Rosario, Batangas during a 25-Year Rainfall Return Period.

For the 25-year return period, 5.42% of the municipality of San Antonio with an area of 62.38 sq. km. will experience flood levels of less than 0.20 meters. 0.97% of the area will experience flood levels of 0.21 to 0.50 meters while 0.42%, 0.18%, 0.11%, and 0.08% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 58. Affected areas in San Antonio, Quezon during a 25-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Antonio (in sq. km.)											
	Poblacion	San Jose	Niing	Arawan	Buliran	Pury	Sampaguita	Loob	Matipunso	Bulihan	Balat Atis	Sampaga
0.03-0.20	0.017	0.17	0.12	0.087	0.18	0.46	0.12	0.13	0.18	0.17	0.16	0.54
0.21-0.50	0.0026	0.021	0.017	0.017	0.0037	0.035	0.0025	0.015	0.038	0.06	0.15	0.1
0.51-1.00	0.0009	0.0007	0.0074	0.0064	0.0007	0.0056	0.0026	0.0081	0.028	0.023	0.064	0.009
1.01-2.00	0.0009	0.0007	0.0017	0.0046	0.0001	0.0049	0.0008	0.0077	0.016	0.01	0.014	0.0046
2.01-5.00	0.0002	0.0004	0.0006	0.0025	0	0.0036	0	0.0062	0.012	0.0031	0.0061	0.004
> 5.00	0.0011	0.0007	0.0005	0.0019	0	0.0041	0	0.0052	0.0096	0.0003	0.0071	0.0055

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Antonio (in sq. km.)							
	Callejon	Magsaysay	Corzaon	Sinturisan	Bagong Niing	Briones	Pulo	Manuel Del Valle, Sr.
0.03-0.20	0.55	0.46	0	0.59	0.76	0.71	0.67	1.34
0.21-0.50	0.056	0.055	0	0.073	0.13	0.16	0.29	0.1
0.51-1.00	0.028	0.025	0	0.026	0.056	0.058	0.18	0.049
1.01-2.00	0.023	0.019	0	0.0078	0.028	0.033	0.036	0.038
2.01-5.00	0.02	0.012	0	0.0015	0.021	0.025	0.012	0.014
> 5.00	0.0068	0.0063	0	0.0004	0.022	0.019	0.01	0.0097



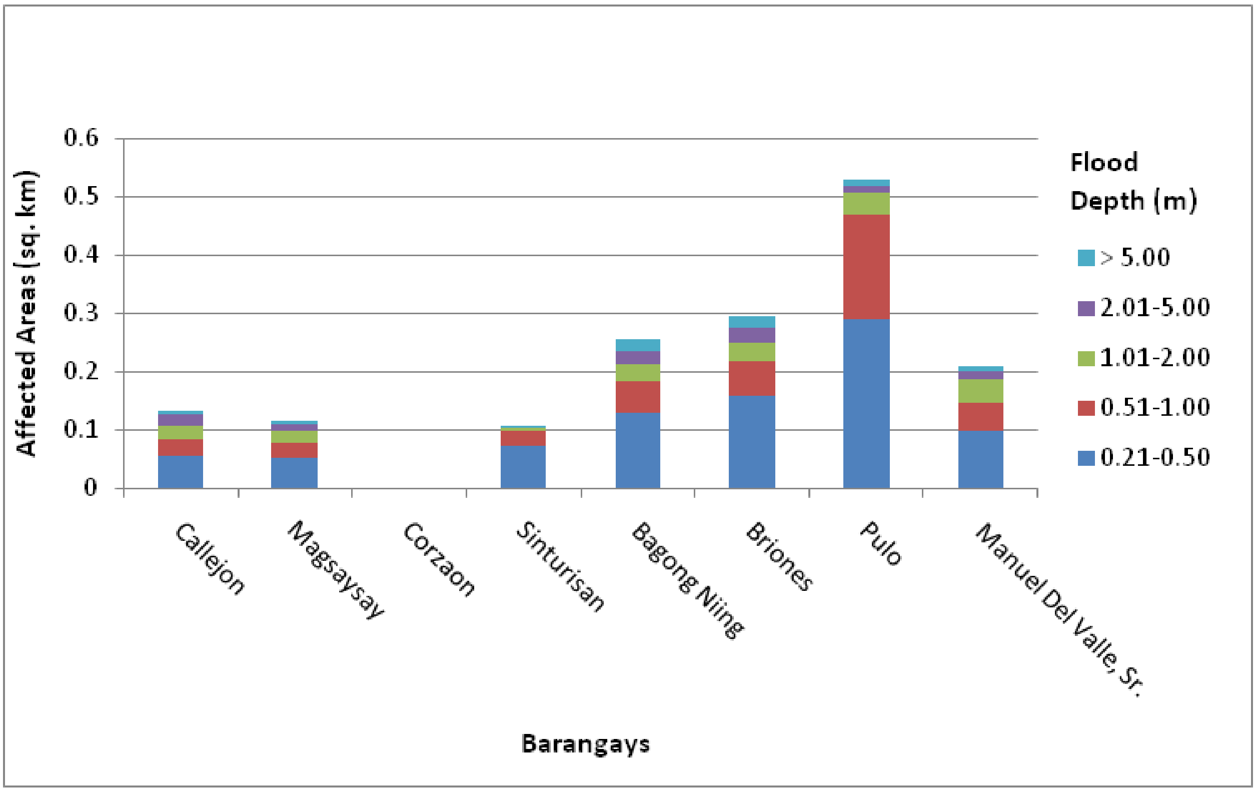


Figure 90. Affected areas in San Antonio, Quezon during a 25-Year Rainfall Return Period.

For the 100-Year return period, 2.70% of the municipality of San Pablo City with an area of 184.81 sq. km. will experience flood levels of less than 0.20 meters. 0.40% of the area will experience flood levels of 0.21 to 0.50 meters while 0.18%, 0.10%, 0.07%, and 0.04% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

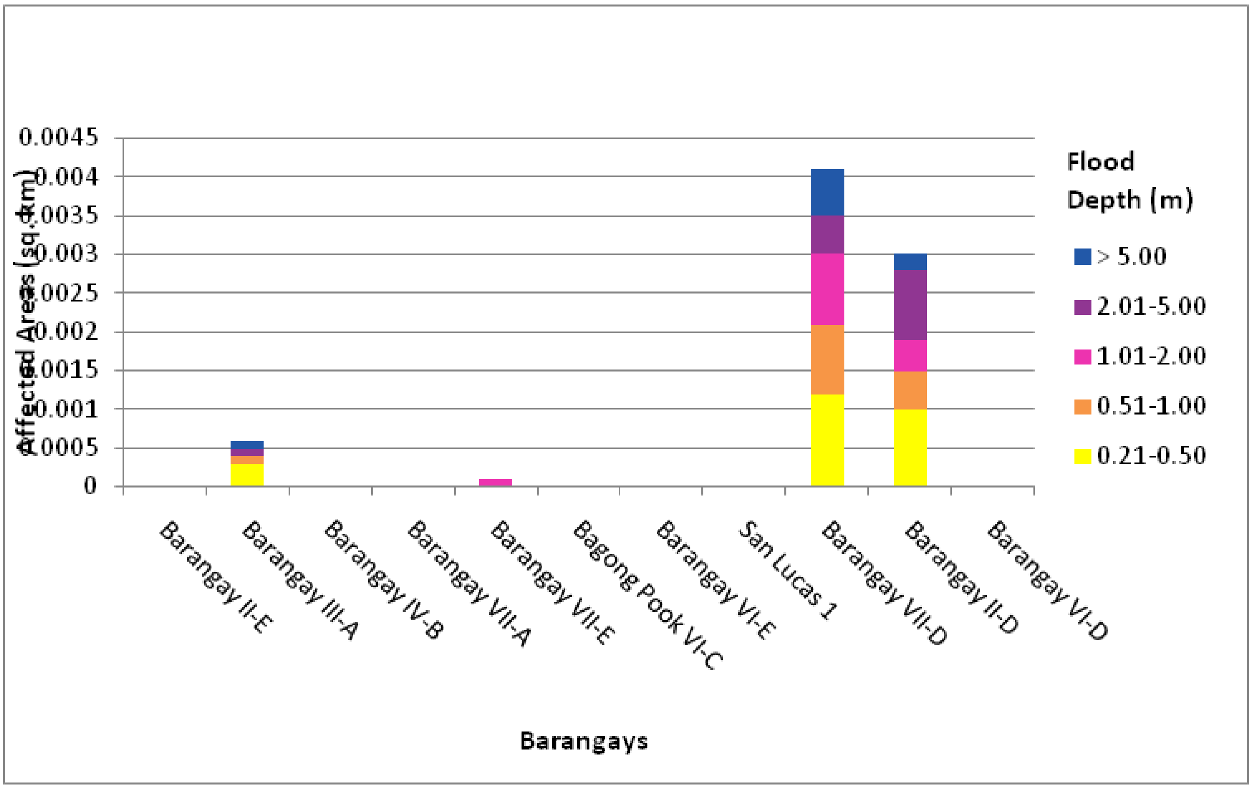
Table 59. Affected areas in San Pablo City, Laguna during a 100-Year Rainfall Return Period.

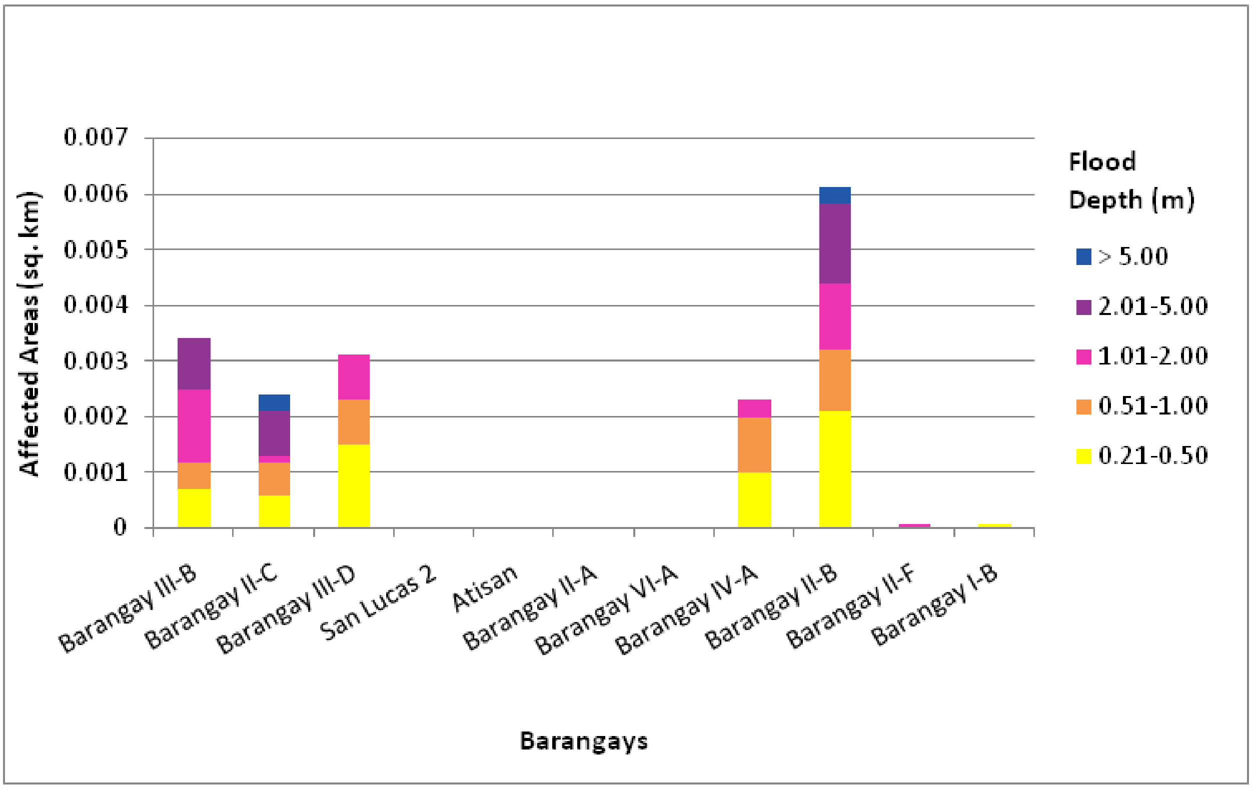
Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Barangay II-E	Barangay III-A	Barangay IV-B	Barangay VII-A	Barangay VII-E	Bagong Pook VI-C	Barangay VI-E	San Lucas 1	Barangay VII-D	Barangay II-D	Barangay VI-D
0.03-0.20	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0004	0.0008	0.0008
0.21-0.50	0	0.0003	0	0	0	0	0	0	0.0012	0.001	0
0.51-1.00	0	0.0001	0	0	0	0	0	0	0.0009	0.0005	0
1.01-2.00	0	0	0	0	0.0001	0	0	0	0.0009	0.0004	0
2.01-5.00	0	0.0001	0	0	0	0	0	0	0.0005	0.0009	0
> 5.00	0	0.0001	0	0	0	0	0	0	0.0006	0.0002	0

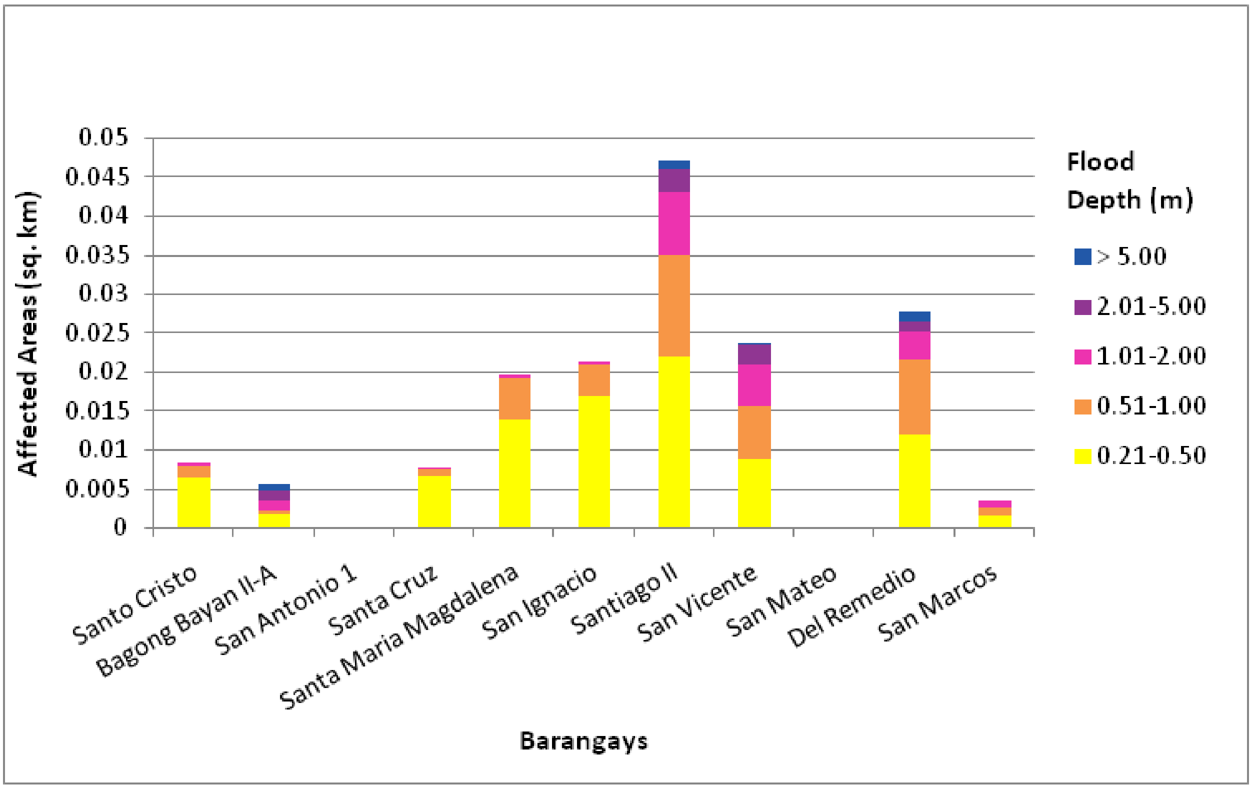
Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Barangay III-B	Barangay II-C	Barangay III-D	San Lucas 2	Atisan	Barangay II-A	Barangay VI-A	Barangay IV-A	Barangay II-B	Barangay II-F	Barangay I-B
0.03-0.20	0.0009	0.0011	0.0012	0.0015	0.0016	0.002	0.002	0.0021	0.0031	0.014	0.021
0.21-0.50	0.0007	0.0006	0.0015	0	0	0	0	0.001	0.0021	0	0.0001
0.51-1.00	0.0005	0.0006	0.0008	0	0	0	0	0.001	0.0011	0	0
1.01-2.00	0.0013	0.0001	0.0008	0	0	0	0	0.0003	0.0012	0.0001	0
2.01-5.00	0.0009	0.0008	0	0	0	0	0	0	0.0014	0	0
> 5.00	0	0.0003	0	0	0	0	0	0	0.0003	0	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Santo Cristo	Bagong Bayan II-A	San Antonio 1	Santa Cruz	Santa Maria Magdalena	San Ignacio	Santiago II	San Vicente	San Mateo	Del Remedio	San Marcos
0.03-0.20	0.021	0.03	0.031	0.033	0.042	0.048	0.048	0.05	0.054	0.068	0.069
0.21-0.50	0.0065	0.002	0.0003	0.0068	0.014	0.017	0.022	0.0088	0	0.012	0.0017
0.51-1.00	0.0016	0.0003	0	0.001	0.0053	0.004	0.013	0.0068	0	0.0096	0.001
1.01-2.00	0.0004	0.0014	0	0.0001	0.0004	0.0004	0.0081	0.0054	0	0.0037	0.0008
2.01-5.00	0	0.0012	0	0	0	0	0.0028	0.0025	0	0.0012	0
> 5.00	0	0.0008	0	0	0	0	0.0012	0.0002	0	0.0012	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Santa Ana	San Francisco	San Gabriel	San Gregorio	San Antonio 2	San Juan	San Roque	Santa Monica	San Rafael	Soledad	Santa Felomina
0.03-0.20	0.072	0.075	0.09	0.091	0.11	0.13	0.14	0.16	0.17	0.26	0.26
0.21-0.50	0.023	0.026	0.0094	0.0097	0.017	0.018	0.016	0.064	0.055	0.031	0.082
0.51-1.00	0.014	0.014	0.0068	0.0082	0.0029	0.016	0.01	0.033	0.022	0.01	0.0085
1.01-2.00	0.011	0.0056	0.0067	0.0071	0.0004	0.015	0.0039	0.025	0.014	0.0074	0
2.01-5.00	0.0023	0.0024	0.0082	0.006	0	0.0098	0	0.011	0.017	0.0077	0
> 5.00	0.0001	0	0.0053	0.0024	0	0.0047	0	0.0082	0.01	0.0079	0


0.0045
0.004
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
Affected Areas (sq. km)
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50
Barangay II-E
Barangay III-A
Barangay IV-B
Barangay VII-A
Barangay VII-E
Bagong Pook VI-C
Barangay VI-E
San Lucas 1
Barangay VII-D
Barangay II-D
Barangay VI-D
Barangays


0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Affected Areas (sq. km)
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50
Barangay III-B
Barangay II-C
Barangay III-D
San Lucas 2
Atisan
Barangay II-A
Barangay VI-A
Barangay IV-A
Barangay II-B
Barangay II-F
Barangay I-B
Barangays



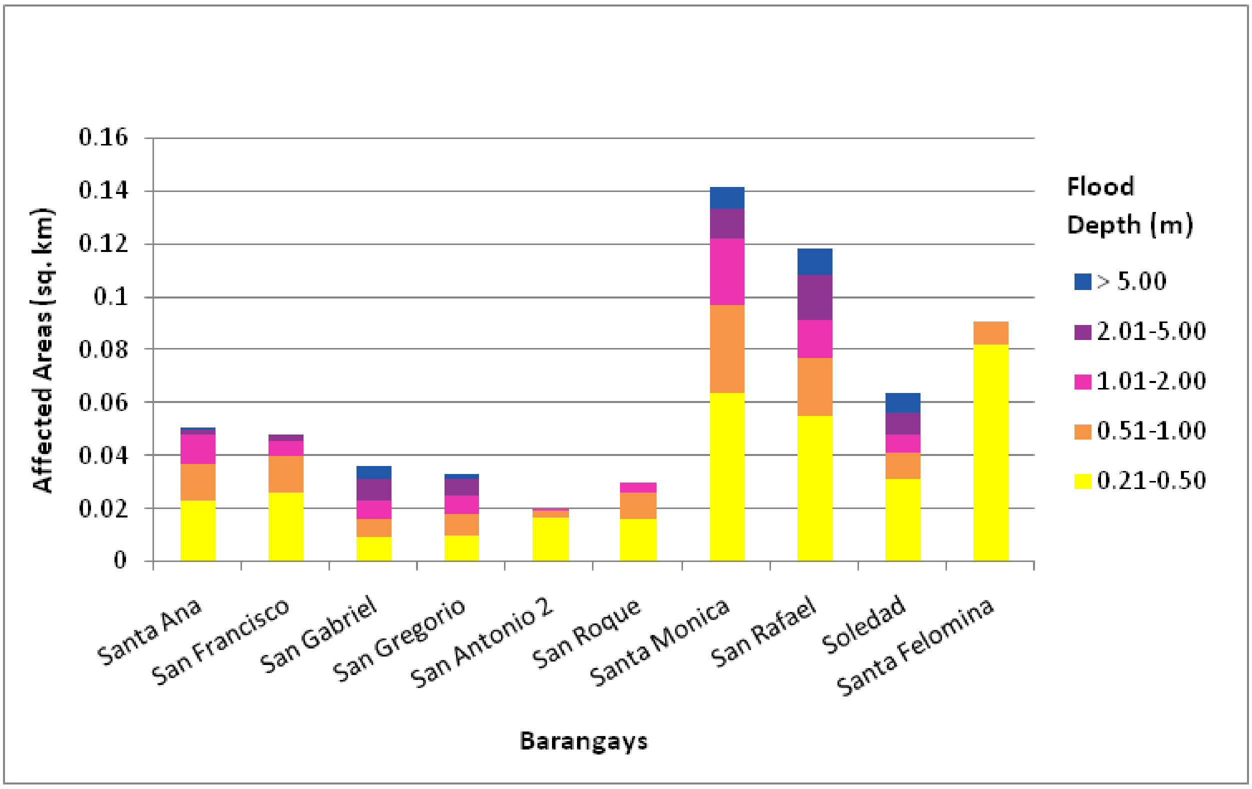


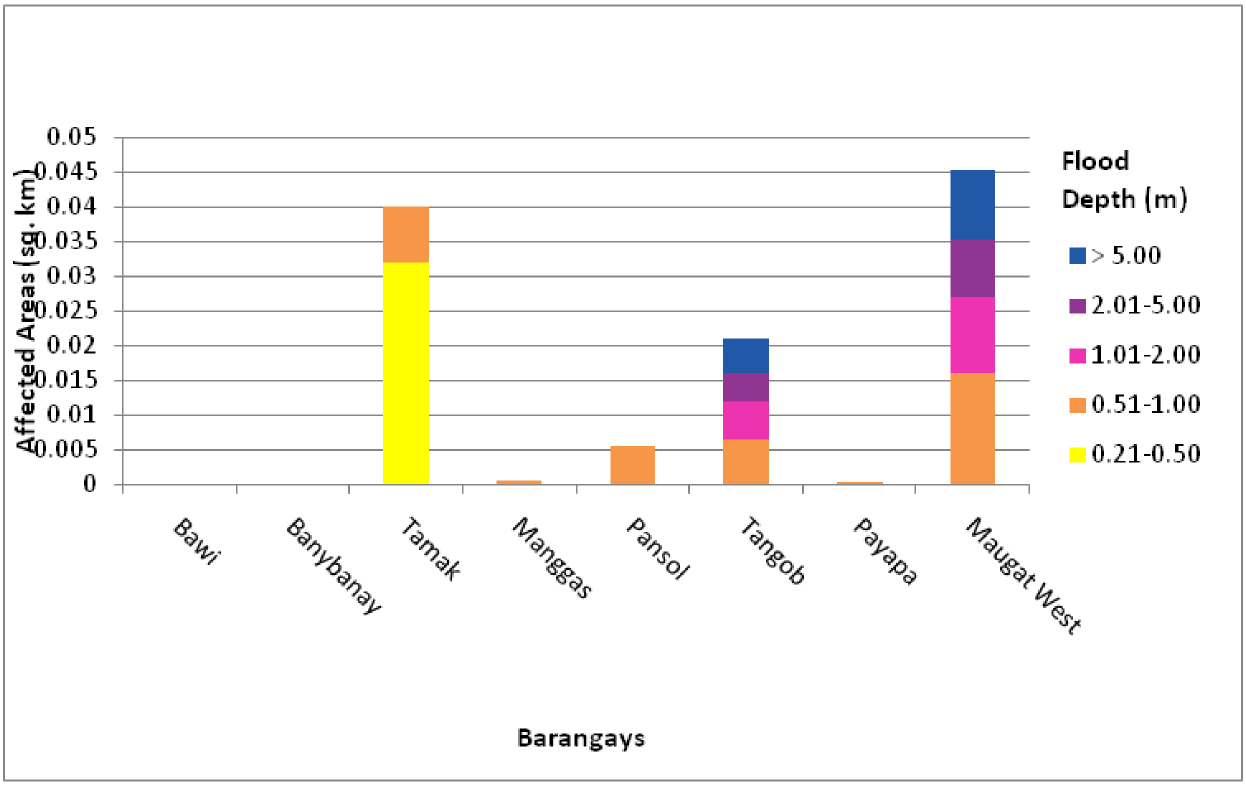
Figure 91. Affected areas in San Pablo City, Laguna during a 100-Year Rainfall Return Period.

For the 100-year return period, 4.56% of the municipality of Padre Garcia with an area of 39.28 sq. km. will experience flood levels of less than 0.20 meters. 0.84% of the area will experience flood levels of 0.21 to 0.50 meters while 0.33%, 0.18%, 0.11%, and 0.10% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 60. Affected areas in Padre Garcia, Batangas during a 100-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Padre Garcia (in sq. km.)							
	Bawi	Banybanay	Tamak	Manggas	Pansol	Tangob	Payapa	Maugat West
0.03-0.20	0.0054	0	0.05	0.053	0.077	0.087	0.098	0.1
0.21-0.50	0	0	0.032	0.0078	0.016	0.012	0.0088	0.023
0.51-1.00	0	0	0.008	0.0007	0.0057	0.0066	0.0004	0.016
1.01-2.00	0	0	0	0	0	0.0056	0	0.011
2.01-5.00	0	0	0	0	0	0.0038	0	0.0083
> 5.00	0	0	0	0	0	0.005	0	0.01

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Padre Garcia (in sq. km.)							
	Quilo-Quilo South	Maugat East	San Felipe	Poblacion	Quilo-Quilo North	Castillo	Bukal	Banaba
0.03-0.20	0.11	0.13	0.13	0.14	0.15	0.19	0.22	0.25
0.21-0.50	0	0.047	0.0055	0.0015	0.0055	0.051	0.1	0.019
0.51-1.00	0	0.018	0	0	0.0013	0.017	0.057	0.0006
1.01-2.00	0	0.014	0	0	0	0.013	0.026	0
2.01-5.00	0	0.015	0	0	0	0.0066	0.011	0
> 5.00	0	0.016	0	0	0	0.0046	0.0048	0



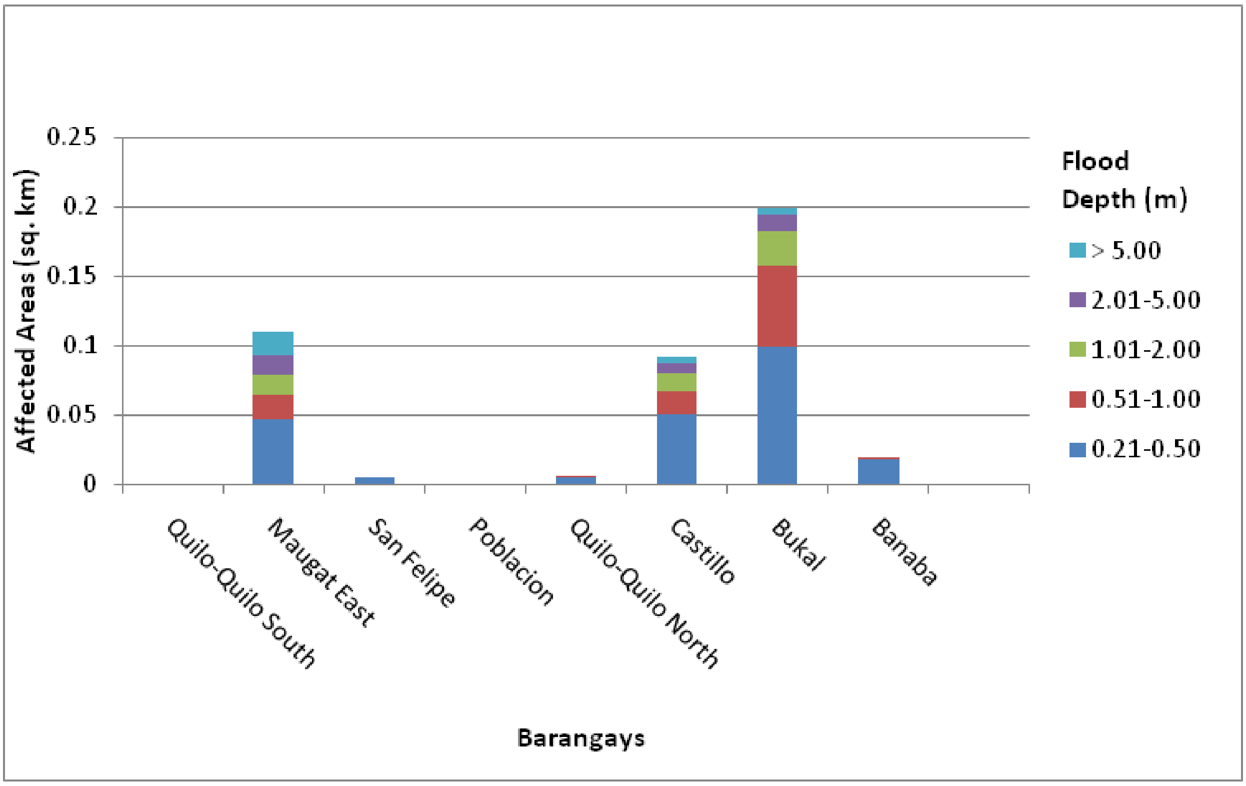


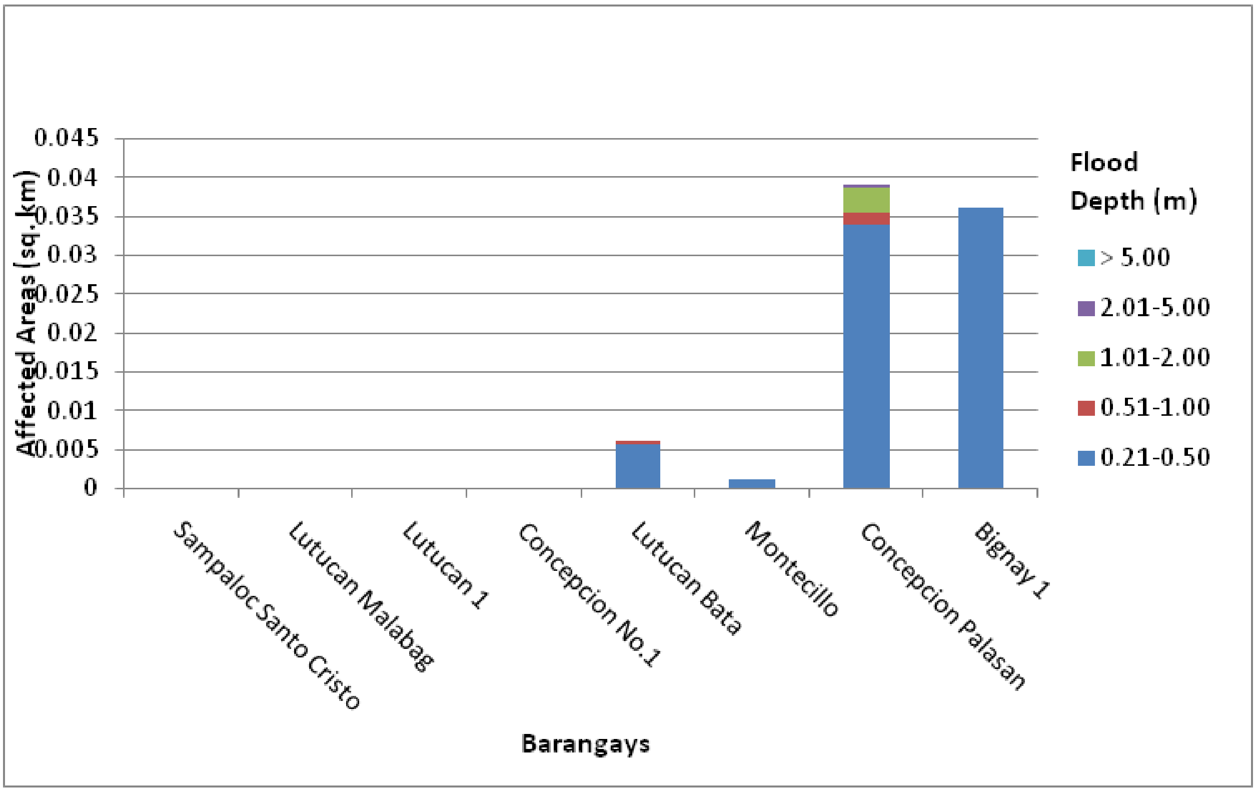
Figure 92. Affected areas in Padre Garcia, Batangas during a 100-Year Rainfall Return Period.

For the 100-year return period, 20.39% of the municipality of Sariaya with an area of 213.78 sq. km. will experience flood levels of less than 0.20 meters. 1.71% of the area will experience flood levels of 0.21 to 0.50 meters while 0.31%, 0.22%, 0.09%, and 0.04% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 61. Affected areas in Sariaya, Quezon during a 100-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Sariaya (in sq. km.)							
	Sampaloc Santo Cristo	Lutucan Malabag	Lutucan 1	Concepcion No.1	Lutucan Bata	Montecillo	Concepcion Palasan	Bignay 1
0.03-0.20	0.0007	0.0046	0.0054	0	0.1	0.18	0.41	0.52
0.21-0.50	0	0	0	0	0.0058	0.0012	0.034	0.036
0.51-1.00	0	0	0	0	0.0004	0	0.0015	0
1.01-2.00	0	0	0	0	0	0	0.0032	0
2.01-5.00	0	0	0	0	0	0	0.0003	0
> 5.00	0	0	0	0	0	0	0	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Sariaya (in sq. km.)						
	Manggalang 1	Manggalang-Kiling	Guisguis-Talon	Manggalang Tulo-Tulo	Manggalang-Bantilan	Guisguis-San Roque	Bignay 2
0.03-0.20	0.52	0.57	0.7	0.85	1.16	1.37	1.62
0.21-0.50	0.08	0.11	0.054	0.0036	0.14	0.16	0.048
0.51-1.00	0.011	0.0072	0.0011	0.0001	0.052	0.049	0.0009
1.01-2.00	0.0009	0.012	0.0002	0	0.05	0.02	0
2.01-5.00	0	0	0	0	0.019	0.015	0
> 5.00	0	0	0	0	0.008	0.0062	0



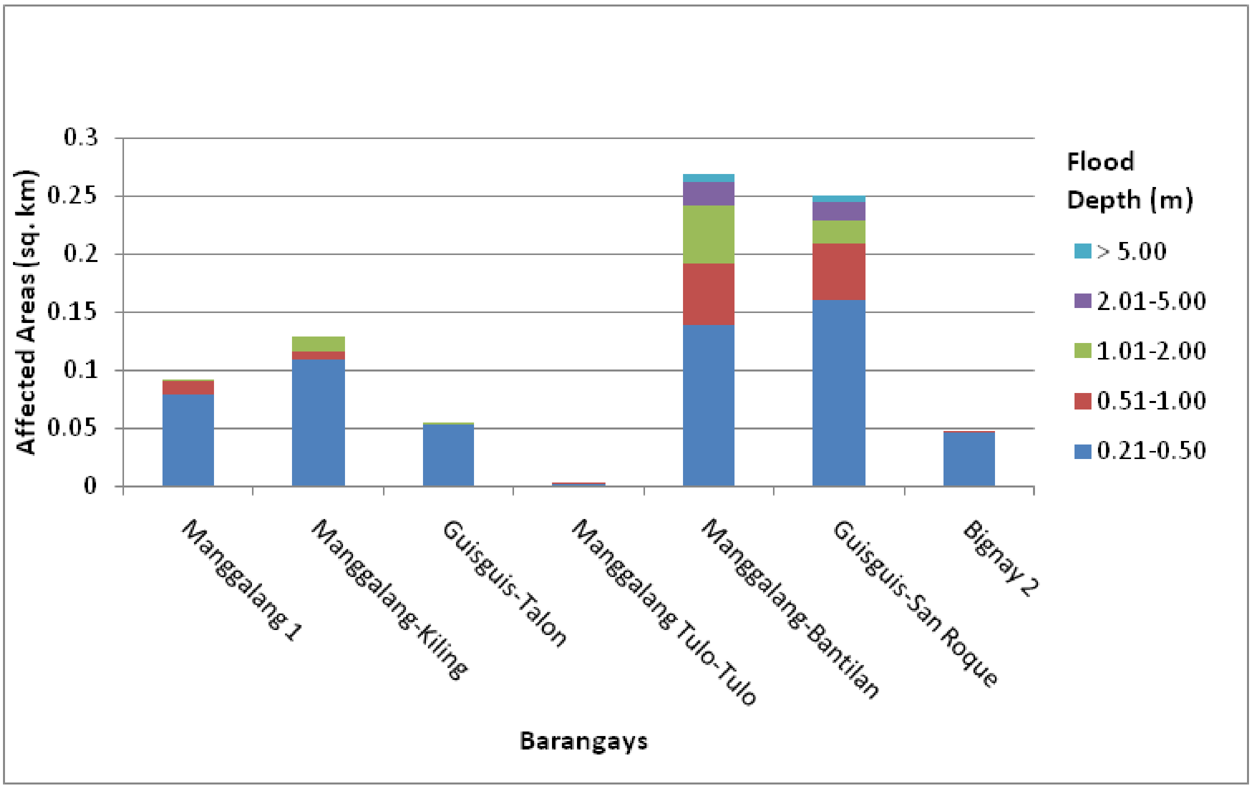


Figure 93. Affected areas in Sariaya, Quezon during a 100-Year Rainfall Return Period.

For the 100-year return period, 10.27% of the municipality of San Juan with an area of 237.55 sq. km. will experience flood levels of less than 0.20 meters. 2.33% of the area will experience flood levels of 0.21 to 0.50 meters while 0.50%, 0.19%, 0.11%, and 0.11% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

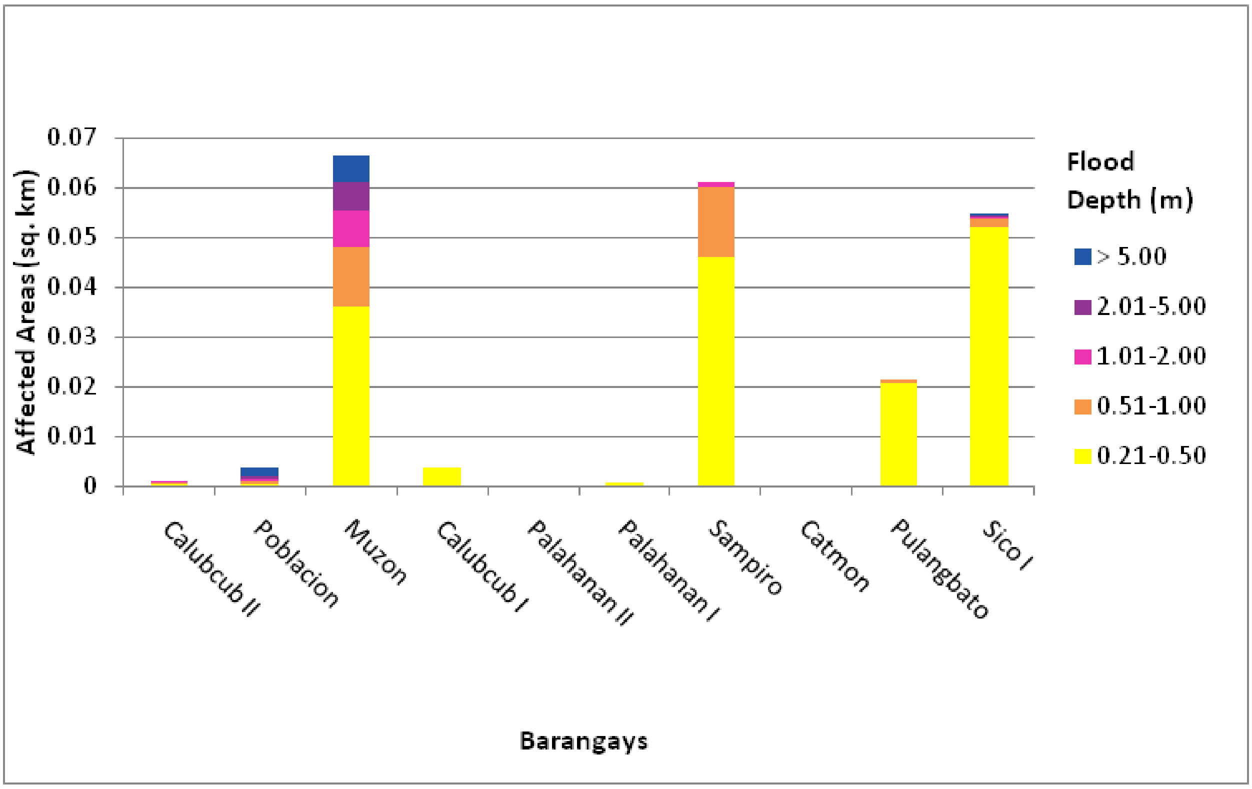
Table 62. Affected areas in San Juan, Batangas during a 100-Year Rainfall Return Period.

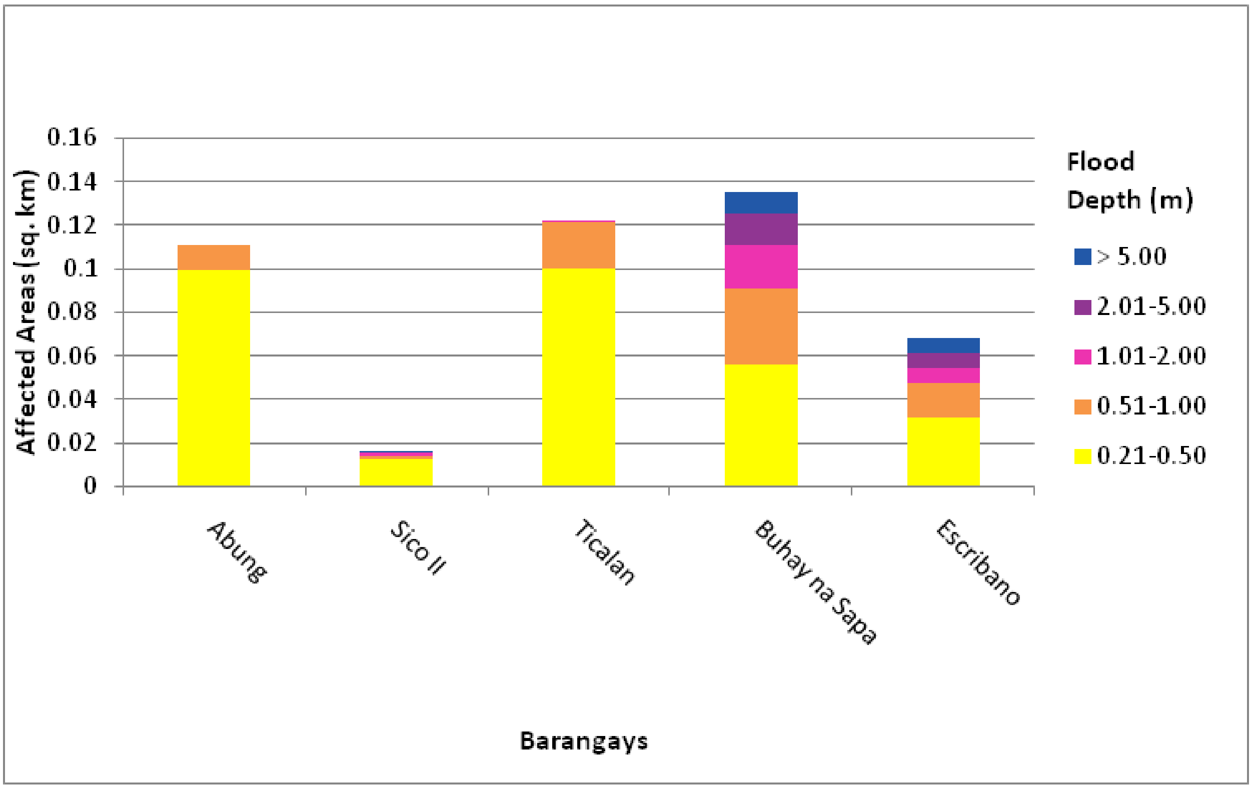
Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)									
	Calubcub II	Poblacion	Muzon	Calubcub I	Palahanan II	Palahanan I	Sampiro	Catmon	Pulangbato	Sico I
0.03-0.20	0.0066	0.0082	0.038	0.062	0.063	0.089	0.13	0.17	0.19	0.22
0.21-0.50	0.0006	0.0005	0.036	0.0039	0	0.0009	0.046	0	0.021	0.052
0.51-1.00	0.0004	0.0007	0.012	0	0	0	0.014	0	0.0004	0.0017
1.01-2.00	0.0002	0.0006	0.0073	0	0	0	0.0012	0	0	0.0004
2.01-5.00	0	0.0005	0.0058	0	0	0	0	0	0	0.0004
> 5.00	0	0.0018	0.0052	0	0	0	0	0	0	0.0003

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)									
	Abung	Sico II	Ticalan	Buhay na Sapa	Escribano	Sapangan	Mabalanoy	Pinagbayanan	Libato	Tipaz
0.03-0.20	0.28	0.34	0.43	0.48	0.57	0.63	0.66	0.95	0.95	0.96
0.21-0.50	0.099	0.013	0.1	0.056	0.032	0.2	0.016	0.76	0.29	0.34
0.51-1.00	0.012	0.0014	0.021	0.035	0.016	0.041	0.012	0.18	0.15	0.1
1.01-2.00	0	0.0015	0.0011	0.02	0.0067	0.0049	0.011	0.0035	0.07	0.034
2.01-5.00	0	0.0009	0	0.014	0.0071	0.0002	0.0099	0	0.038	0.0007
> 5.00	0	0.0002	0	0.01	0.0065	0	0.014	0	0.016	0

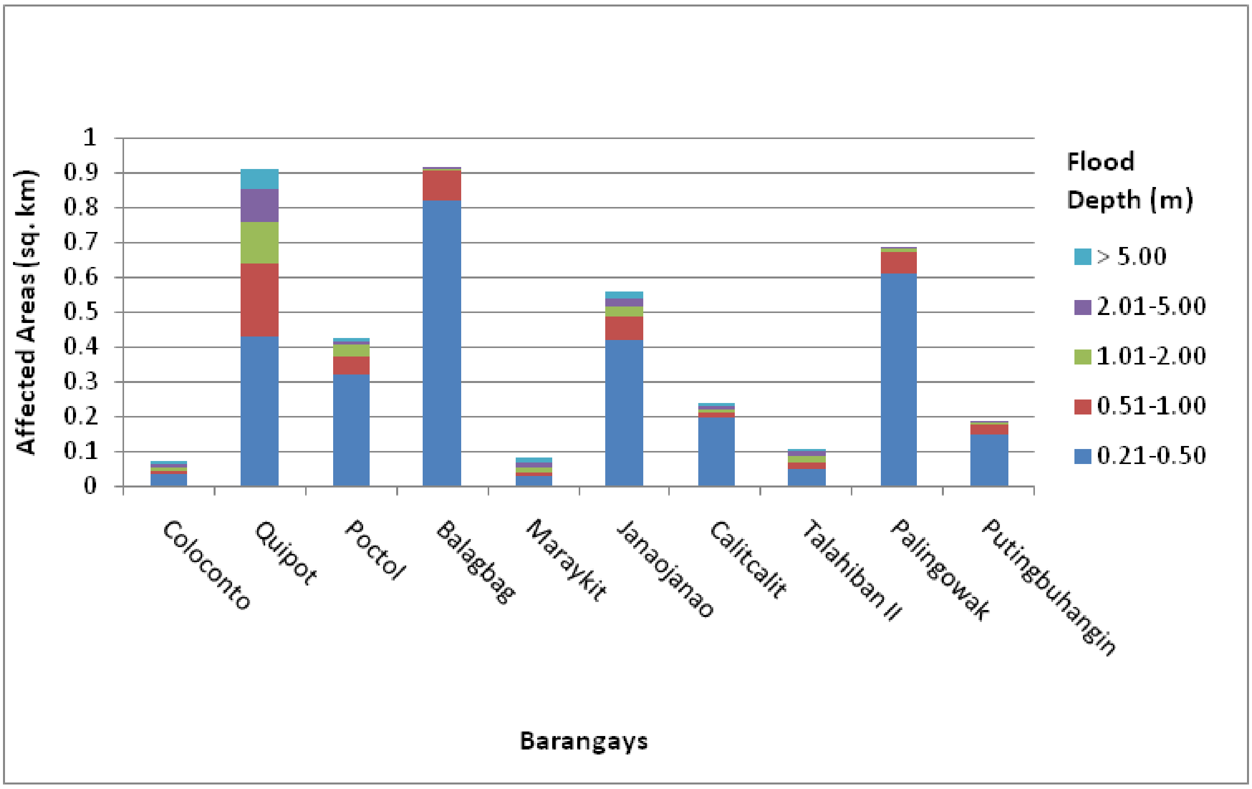
Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)									
	Coloconto	Quipot	Poctol	Balagbag	Maraykit	Janaojanao	Calitcalit	Talahiban II	Palingowak	Putingbuhangin
0.03-0.20	1.14	1.16	1.26	1.28	1.3	1.33	1.36	1.4	1.49	1.63
0.21-0.50	0.036	0.43	0.32	0.82	0.031	0.42	0.2	0.053	0.61	0.15
0.51-1.00	0.012	0.21	0.056	0.083	0.013	0.067	0.011	0.019	0.063	0.03
1.01-2.00	0.01	0.12	0.031	0.011	0.013	0.031	0.012	0.019	0.013	0.0099
2.01-5.00	0.0095	0.091	0.012	0.0017	0.015	0.021	0.01	0.014	0.0015	0.0001
> 5.00	0.0085	0.059	0.0079	0	0.012	0.019	0.011	0.0047	0	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)	
	Talahiban I	Lipahan
0.03-0.20	1.9	1.92
0.21-0.50	0.19	0.2
0.51-1.00	0.026	0.011
1.01-2.00	0.0009	0.0095
2.01-5.00	0	0.0093
> 5.00	0	0.095





Affected Areas (sq. km)
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Abung
Sico II
Ticalan
Buhay na Sapa
Escribano
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50



Affected Areas (sq. km)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Coloconto
Quipot
Poctol
Balagbag
Maraykit
Janaojanao
Calitcalit
Talahiban II
Palingowak
Putingbuhangin
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50

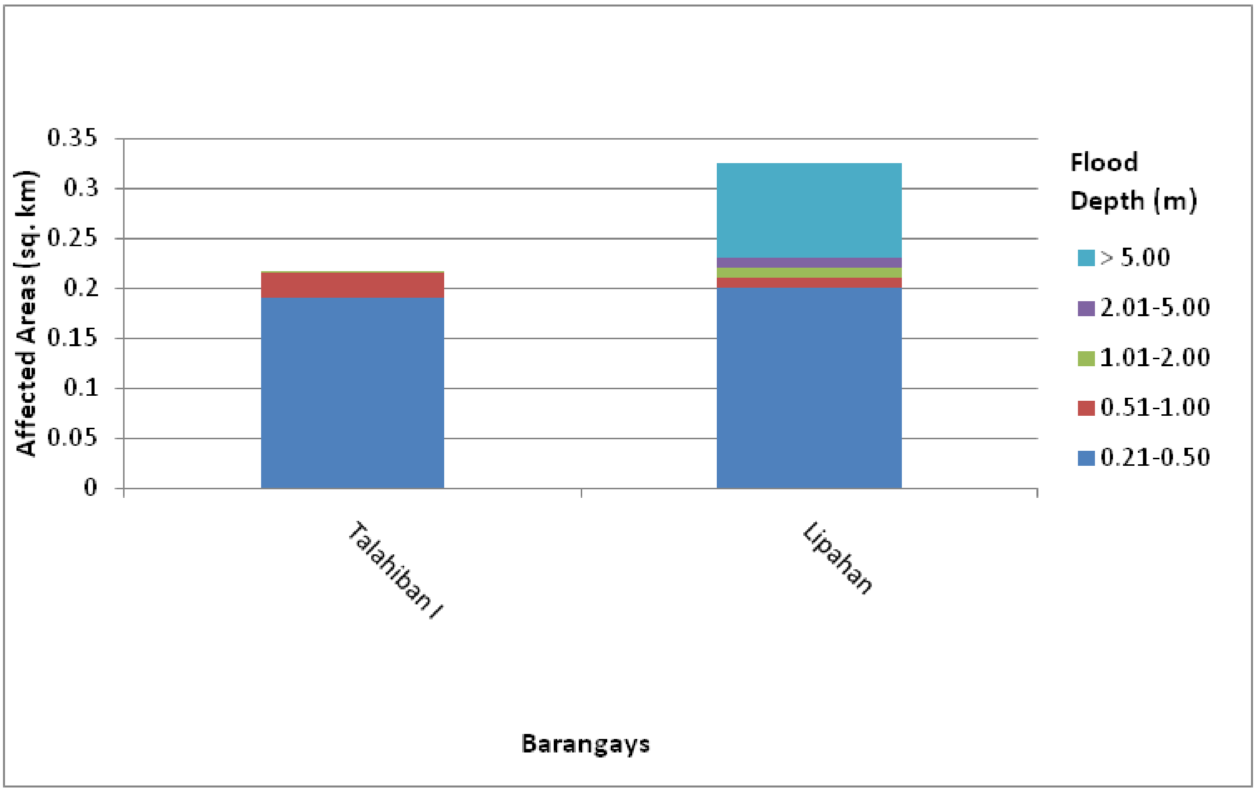


Figure 94. Affected areas in San Juan, Batangas during a 100-Year Rainfall Return Period.

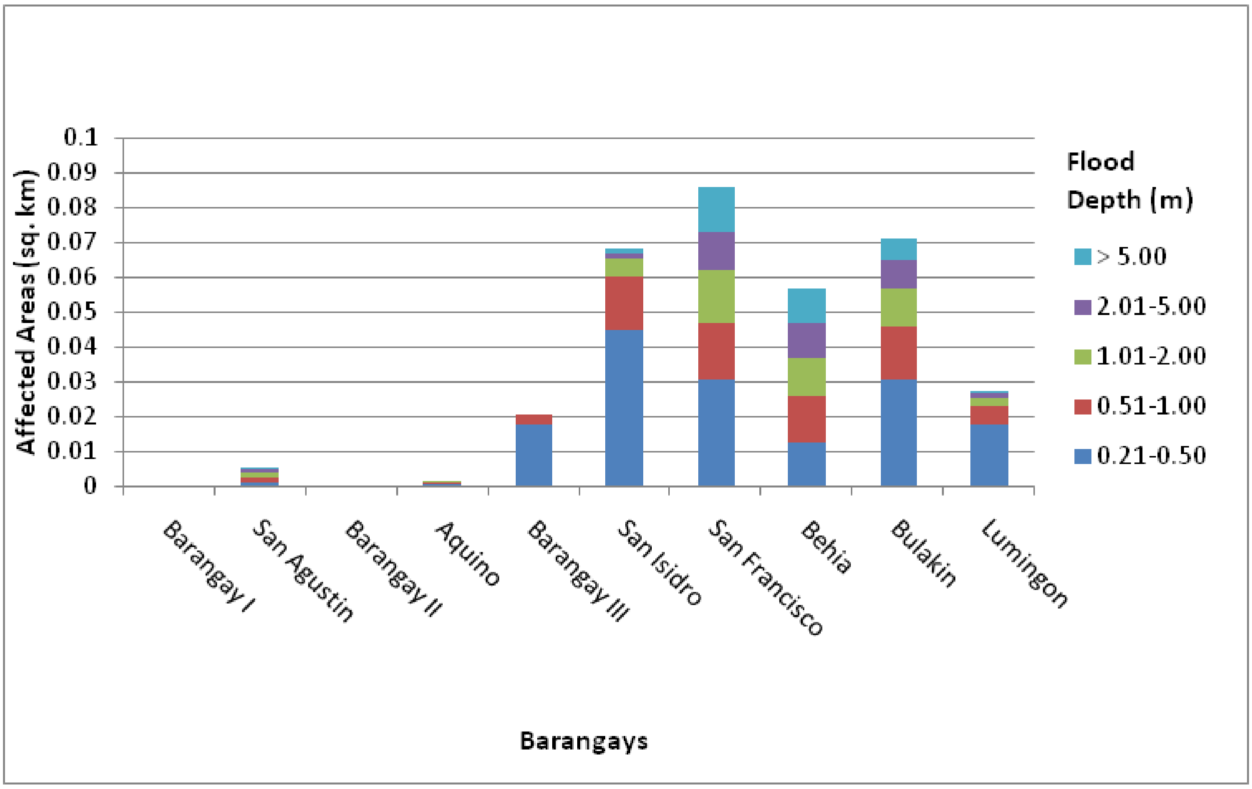
For the 100-year return period, 6.67% of the municipality of Tiaong with an area of 118.93 sq. km. will experience flood levels of less than 0.20 meters. 1.26% of the area will experience flood levels of 0.21 to 0.50 meters while 0.29%, 0.13%, 0.09%, and 0.07% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

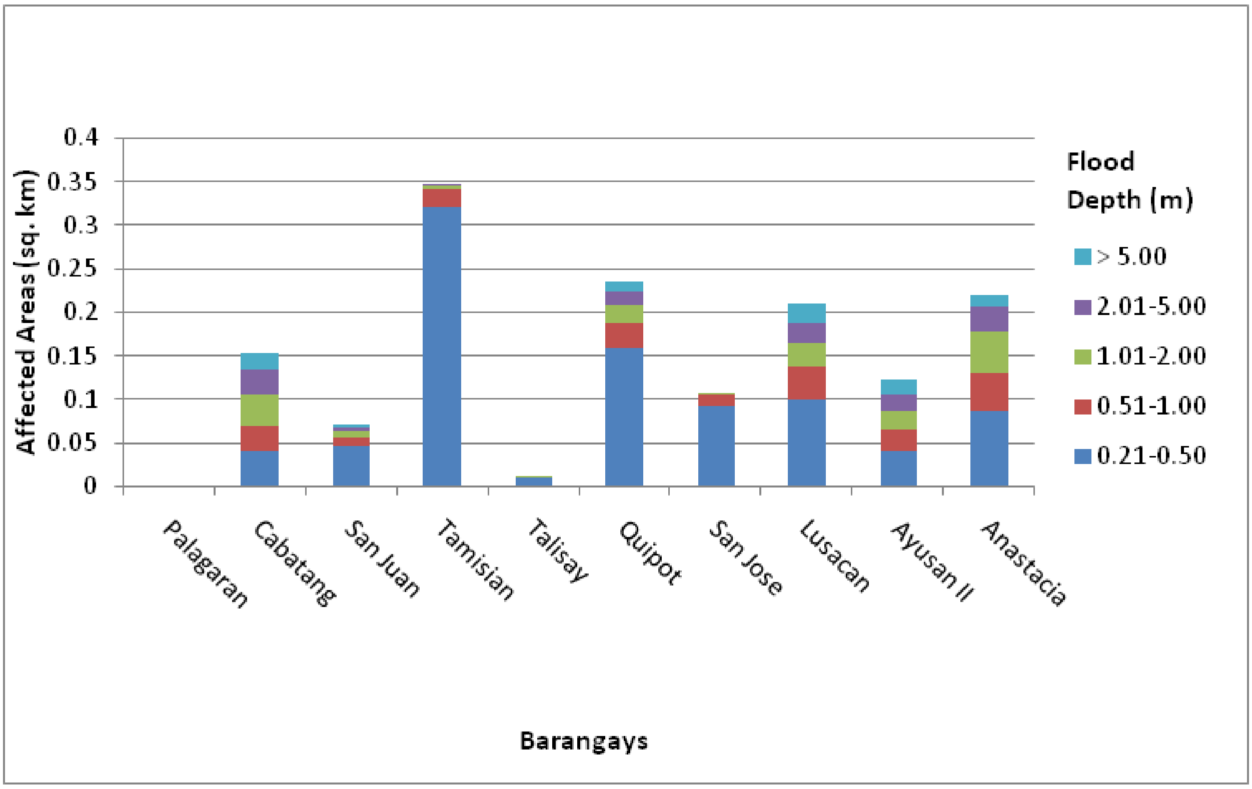
Table 63. Affected areas in Tiaong. Quezon during a 100-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Tiaong (in sq. km.)									
	Barangay I	San Agustin	Barangay II	Aquino	Barangay III	San Isidro	San Francisco	Behia	Bulakin	Lumingon
0.03-0.20	0.0015	0.0037	0.014	0.024	0.063	0.15	0.21	0.23	0.25	0.29
0.21-0.50	0	0.0013	0	0.0013	0.018	0.045	0.031	0.013	0.031	0.018
0.51-1.00	0	0.0014	0	0.0002	0.0029	0.015	0.016	0.013	0.015	0.0053
1.01-2.00	0	0.0017	0	0.0003	0	0.0052	0.015	0.011	0.011	0.0021
2.01-5.00	0	0.0008	0	0	0	0.0018	0.011	0.01	0.0081	0.0017
> 5.00	0	0.0006	0	0	0	0.0013	0.013	0.01	0.0059	0.0005

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Tiaong (in sq. km.)									
	Palagaran	Cabatang	San Juan	Tamisian	Talisay	Quipot	San Jose	Lusacan	Ayusan II	Anastacia
0.03-0.20	0.3	0.3	0.38	0.43	0.47	0.48	0.56	0.61	0.66	0.72
0.21-0.50	0.002	0.041	0.047	0.32	0.012	0.16	0.093	0.1	0.041	0.088
0.51-1.00	0.0001	0.03	0.009	0.021	0.0008	0.027	0.014	0.039	0.026	0.042
1.01-2.00	0	0.035	0.008	0.0043	0.0003	0.022	0.0013	0.026	0.021	0.049
2.01-5.00	0	0.028	0.0047	0.0008	0	0.015	0	0.022	0.019	0.027
> 5.00	0	0.019	0.0024	0	0	0.011	0	0.023	0.016	0.013

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Tiaong (in sq. km.)									
	Paiisa	Bula	Tagbakin	Lagalag	San Pedro	Cabay	Del Rosario	Bukal	Ayusan I	Lalig
0.03-0.20	0.73	0.78	0.81	0.83	0.86	0.89	0.89	1.03	1.41	1.46
0.21-0.50	0.016	0.24	0.02	0.05	0.13	0.055	0.02	0.62	0.35	0.43
0.51-1.00	0.0003	0.052	0.0067	0.004	0.035	0.0013	0.0085	0.23	0.035	0.031
1.01-2.00	0.0003	0.011	0.003	0.0026	0.021	0.0008	0.005	0.031	0.021	0.0099
2.01-5.00	0	0.0095	0.0015	0.0026	0.014	0.0005	0.0033	0.0084	0.02	0.0081
> 5.00	0	0.01	0	0.0028	0.0069	0.0003	0.0044	0.0047	0.017	0.0075


Affected Areas (sq. km)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Barangay I
San Agustin
Barangay II
Aquino
Barangay III
San Isidro
San Francisco
Behia
Bulakin
Lumingon
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50


Affected Areas (sq. km)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Palagaran
Cabatang
San Juan
Tamisian
Talisay
Quipot
San Jose
Lusacan
Ayusan II
Anastacia
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50

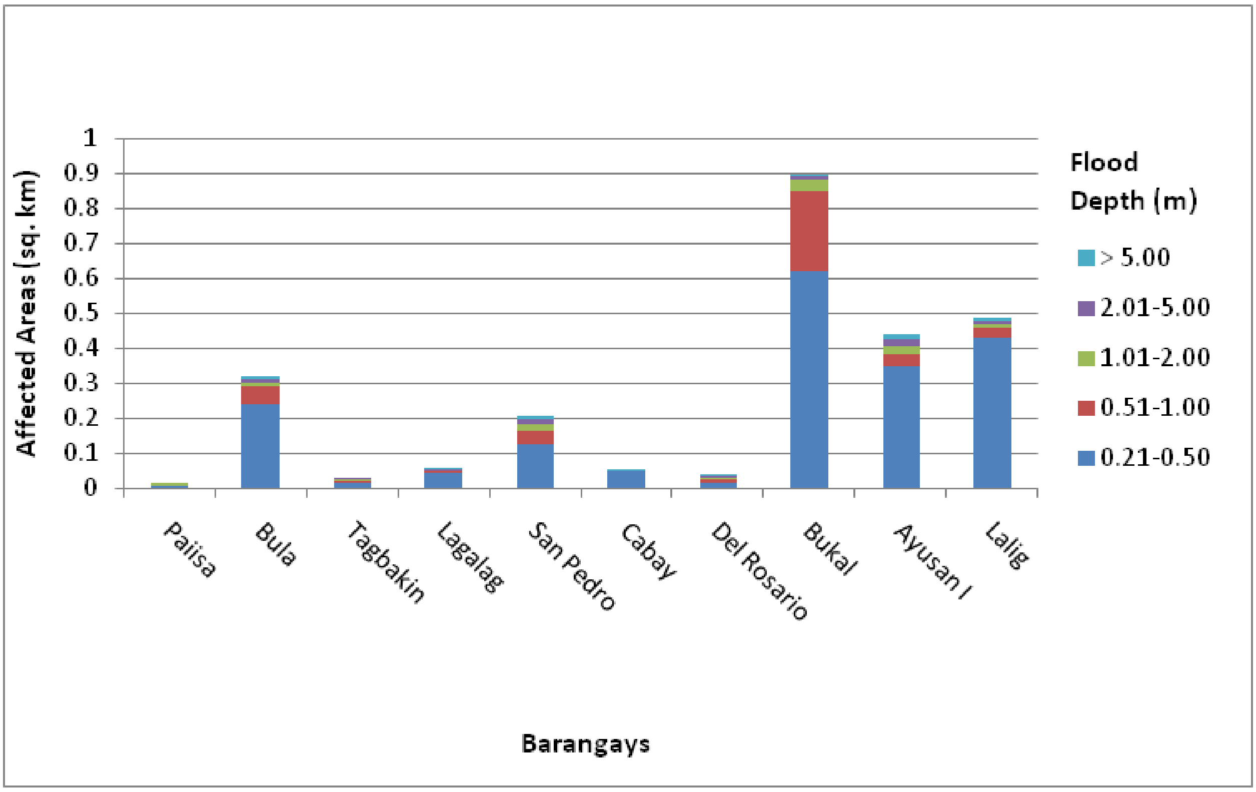


Figure 95. Affected areas in Tiaong. Quezon during a 100-Year Rainfall Return Period.

For the 100-year return period, 0.99% of the municipality of Alaminos with an area of 59.65 sq. km. will experience flood levels of less than 0.20 meters. 0.08% of the area will experience flood levels of 0.21 to 0.50 meters while 0.02%, 0.01%, 0.00%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 64. Affected areas in Alaminos, Laguna during a 100-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Alaminos (in sq. km.)					
	San Miguel	Del Carmen	San Agustin	San Gregorio	San Roque	San Benito
0.03-0.20	0.0049	0.011	0.014	0.053	0.12	0.39
0.21-0.50	0	0	0	0.016	0.01	0.02
0.51-1.00	0	0	0	0.0037	0.0064	0.0022
1.01-2.00	0	0	0	0	0.005	0
2.01-5.00	0	0	0	0	0.0028	0
> 5.00	0	0	0	0	0.0027	0

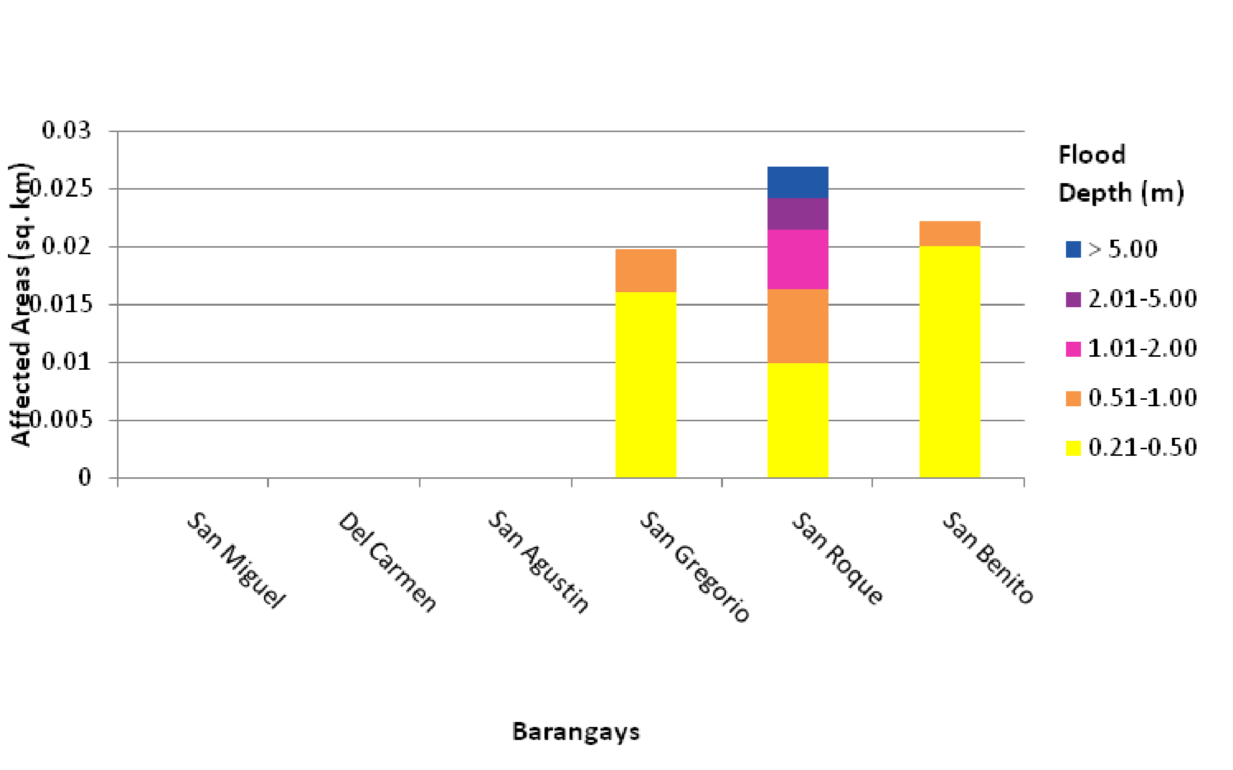


Figure 96. Affected areas in Alaminos, Laguna during a 100-Year Rainfall Return Period.

For the 100-year return period, 0.53% of the municipality of Dolores with an area of 65.96 sq. km. will experience flood levels of less than 0.20 meters. 0.22% of the area will experience flood levels of 0.21 to 0.50 meters while 0.15%, 0.08%, 0.02%, and 0.01% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 65. Affected areas in Dolores, Quezon during a 100-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Dolores (in sq. km.)				
	Antonino	Dagatan	San Mateo	Bungoy	Putol
0.03-0.20	0.0032	0.0171	0.0285	0.1458	0.1537
0.21-0.50	0.0001	0.0057	0.0098	0.0815	0.0473
0.51-1.00	0	0.0043	0.0012	0.0646	0.0292
1.01-2.00	0	0.0061	0	0.0309	0.015
2.01-5.00	0	0.0016	0	0.0116	0.0024
> 5.00	0	0	0	0.0033	0.0003

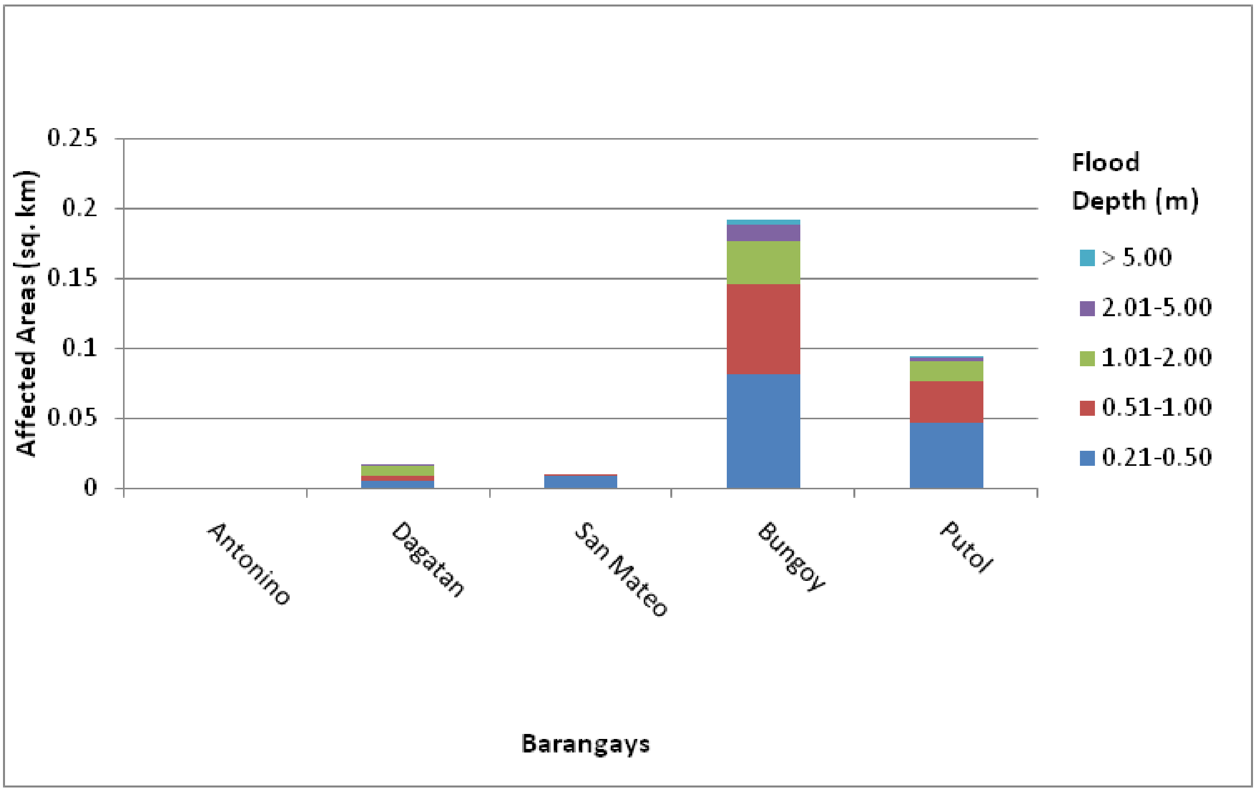


Figure 97. Affected areas in Dolores, Quezon during a 100-Year Rainfall Return Period.

For the 100-year return period, 6.90% of the municipality of Candelaria with an area of 136.74 sq. km. will experience flood levels of less than 0.20 meters. 0.64% of the area will experience flood levels of 0.21 to 0.50 meters while 0.26%, 0.16%, 0.07%, 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 66. Affected areas in Candelaria, Quezon during a 100-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Candelaria (in sq. km.)											
	Mangilag Norte	Pobla-cion	Malabanban Norte	Pahinga Norte	Masalu-kot II	Masalu-kot I	Mangilag Sur	Bukal Norte	Santa Catalina Norte	Bukal Sur	Masin Norte	Malaban-ban Sur
0.03-0.20	0.0036	0.018	0.025	0.052	0.07	0.077	0.093	0.18	0.19	0.21	0.22	0.24
0.21-0.50	0.0001	0.013	0.0093	0.026	0.032	0.015	0.0022	0.051	0.013	0.044	0.046	0.051
0.51-1.00	0	0.0065	0.0041	0.0097	0.02	0.0025	0.0011	0.024	0.0023	0.023	0.022	0.031
1.01-2.00	0	0	0.0005	0.0006	0.0087	0	0.0002	0.01	0.0001	0.02	0.0072	0.0086
2.01-5.00	0	0	0	0.0004	0.0023	0	0	0.001	0	0.012	0.0032	0.0009
> 5.00	0	0	0	0	0.0007	0	0	0	0	0.0016	0.0019	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Candelaria (in sq. km.)								
	Masin Sur	Pahinga Sur	San Andres	Buenavista West	Kinati-han II	Kinati-han I	Santa Catali-na Sur	Buenavista East	San Isidro
0.03-0.20	0.31	0.37	0.48	0.72	0.8	0.86	1.12	1.2	2.2
0.21-0.50	0.04	0.043	0.034	0.057	0.037	0.036	0.019	0.15	0.16
0.51-1.00	0.021	0.034	0.013	0.013	0.023	0.027	0.0034	0.021	0.05
1.01-2.00	0.014	0.036	0.0026	0.012	0.02	0.028	0	0.0098	0.034
2.01-5.00	0.0055	0.022	0.0009	0.0096	0.0083	0.022	0	0.0018	0.012
> 5.00	0.0045	0.014	0	0.001	0.0031	0.011	0	0	0.0074

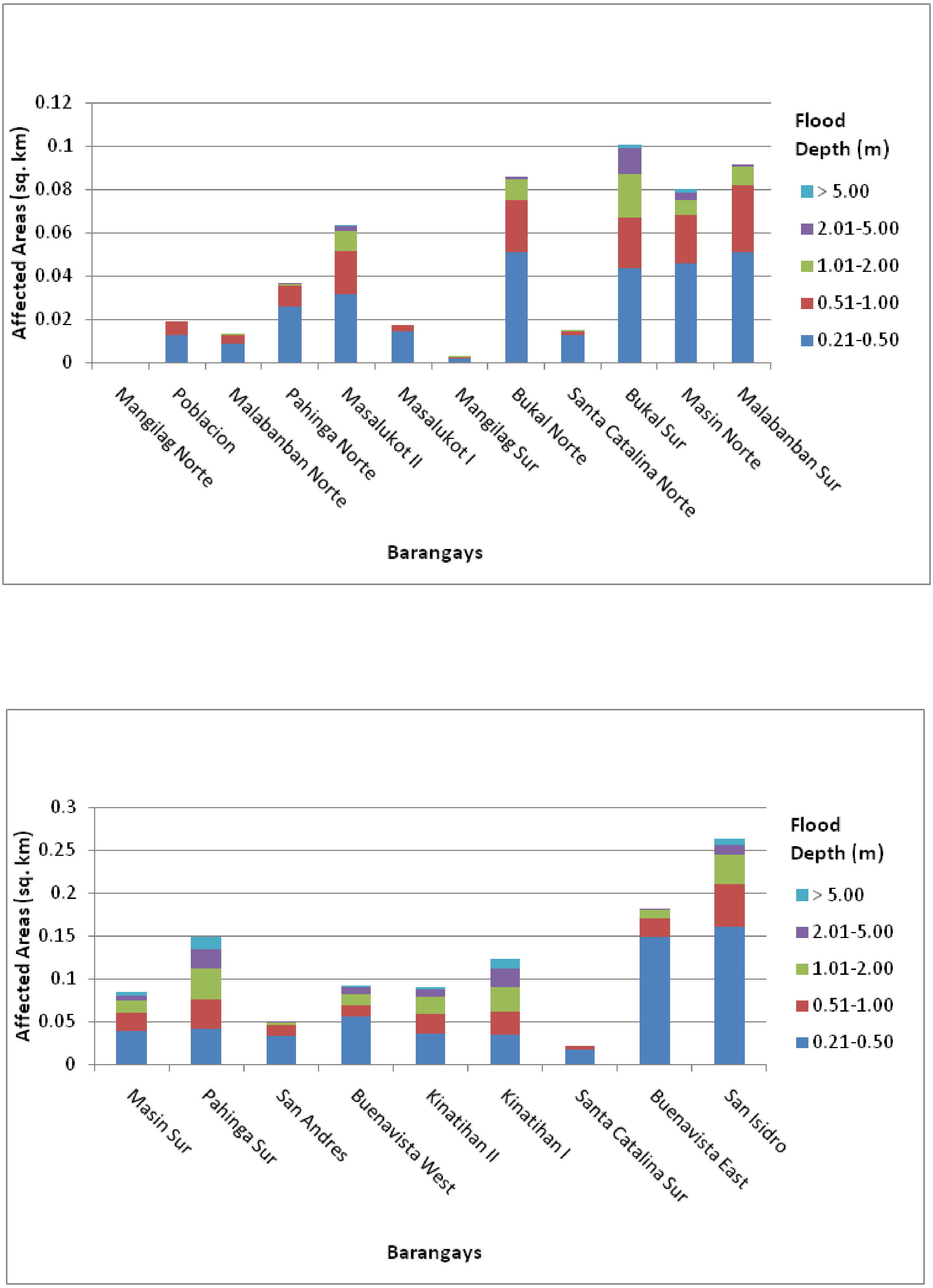


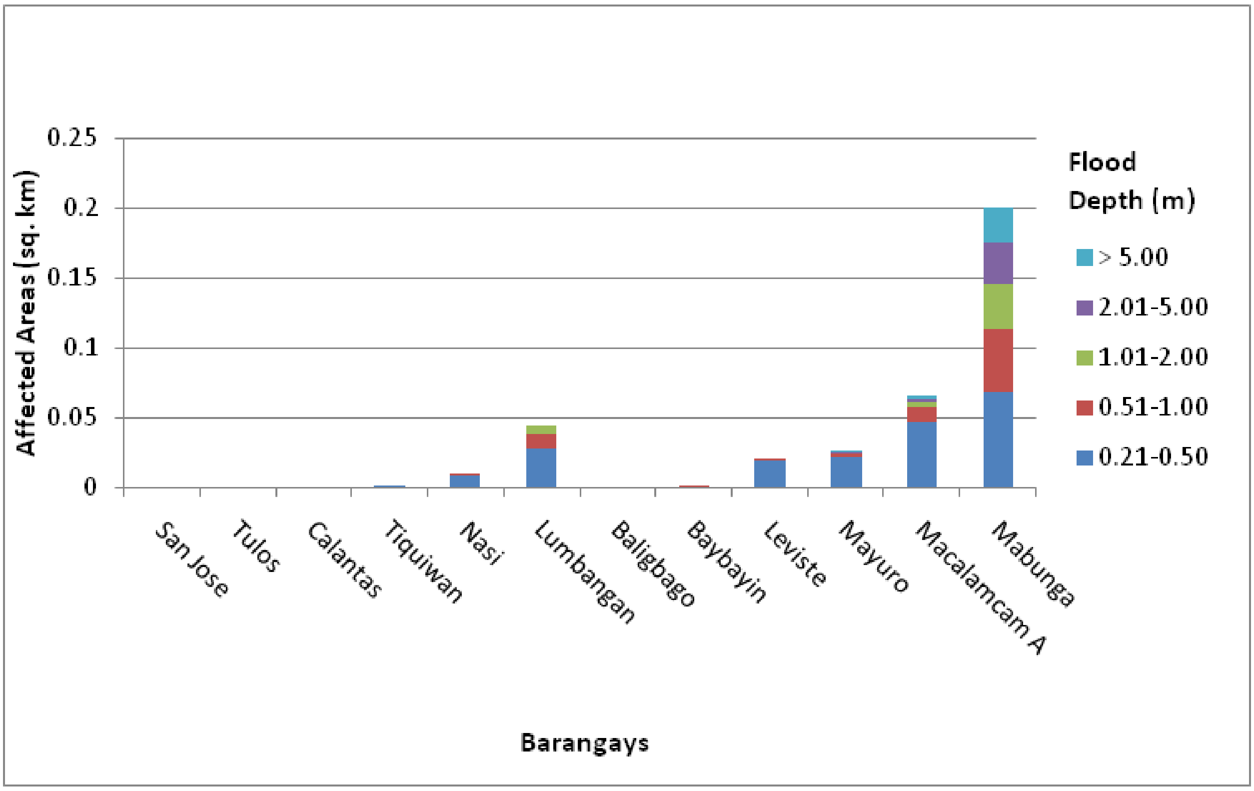
Figure 98. Affected areas in Candelaria, Quezon during a 100-Year Rainfall Return Period.

For the 100-year return period, 3.97% of the municipality of Rosario with an area of 199.04 sq. km. will experience flood levels of less than 0.20 meters. 0.97% of the area will experience flood levels of 0.21 to 0.50 meters while 0.40%, 0.23%, 0.15%, and 0.10% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 67. Affected areas in Rosario, Batangas during a 100-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Rosario (in sq. km.)											
	San Jose	Tulos	Calantas	Tiquiwan	Nasi	Lumbangan	Baligbago	Baybayin	Leviste	Mayuro	Macalamcam A	Mabunga
0.03-0.20	0.0014	0.0025	0.0037	0.038	0.075	0.083	0	0.091	0.14	0.15	0.15	0.17
0.21-0.50	0	0	0	0.0027	0.0095	0.028	0	0.001	0.02	0.023	0.047	0.069
0.51-1.00	0	0	0	0	0.0006	0.011	0	0.001	0.0016	0.0022	0.011	0.045
1.01-2.00	0	0	0	0	0	0.0058	0	0	0	0.0006	0.0034	0.032
2.01-5.00	0	0	0	0	0	0	0	0	0	0.0007	0.0021	0.029
> 5.00	0	0	0	0	0	0	0	0	0	0.0008	0.0023	0.025

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Rosario (in sq. km.)										
	San Isidro	Bayawang	Mabato	Macalamcam B	Alupya	Natu	Maligaya	San Carlos	Salao	Pinagsibaan	Putingkahoy
0.03-0.20	0.23	0.24	0.35	0.36	0	0.4	0.42	0.47	0.57	0.6	0.89
0.21-0.50	0.068	0.1	0.13	0.055	0	0.046	0.11	0.14	0.08	0.15	0.25
0.51-1.00	0.024	0.052	0.045	0.034	0	0.0004	0.047	0.042	0.046	0.089	0.094
1.01-2.00	0.012	0.035	0.029	0.027	0	0.0004	0.04	0.0002	0.036	0.049	0.039
2.01-5.00	0.0073	0.024	0.022	0.025	0	0.0002	0.018	0	0.016	0.028	0.03
> 5.00	0.0035	0.018	0.023	0.016	0	0.0003	0.015	0	0.0056	0.011	0.022



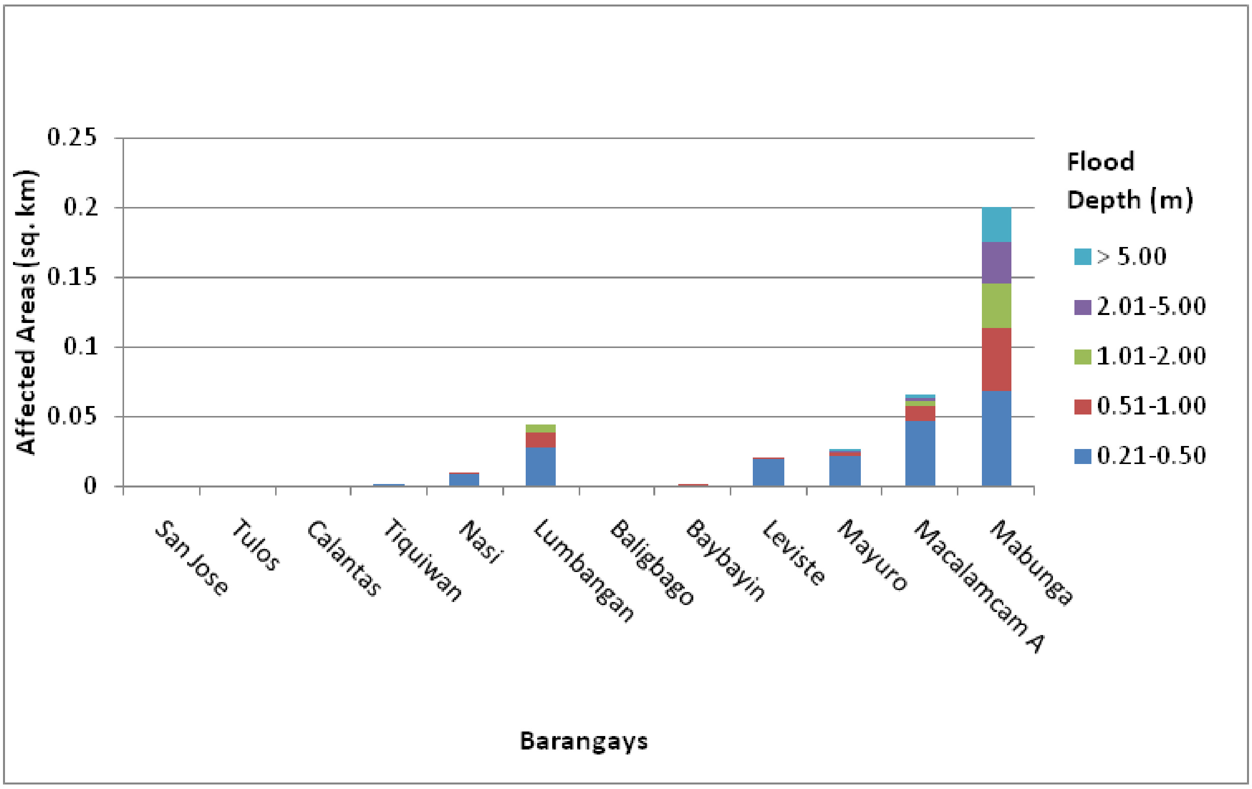


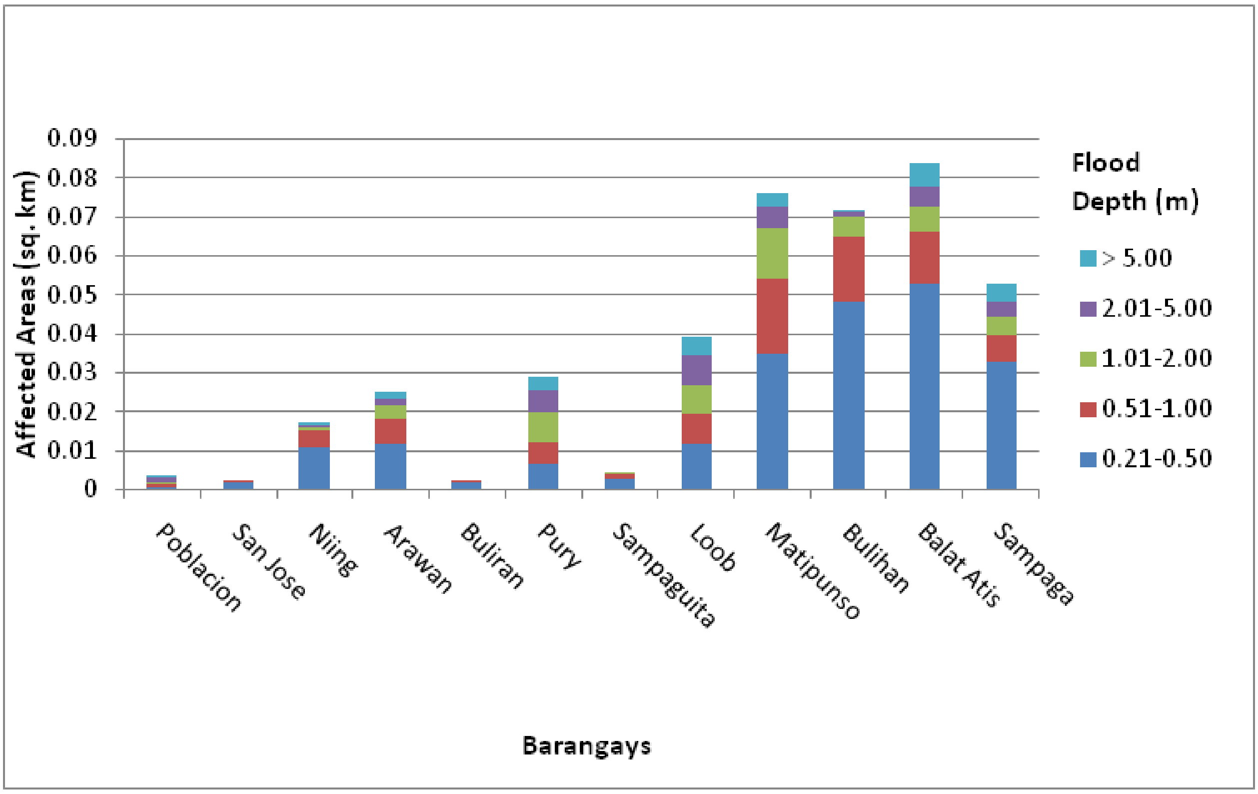
Figure 99. Affected areas in Rosario, Batangas during a 100-Year Rainfall Return Period.

For the 100-year return period, 3.07% of the municipality of San Antonio with an area of 62.38 sq. km. will experience flood levels of less than 0.20 meters. 0.59% of the area will experience flood levels of 0.21 to 0.50 meters while 0.22%, 0.14%, 0.09%, 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 68. Affected areas in San Antonio, Quezon during a 100-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Antonio (in sq. km.)											
	Poblacion	San Jose	Niing	Arawan	Buliran	Pury	Sampaguita	Loob	Matipunso	Bulihan	Balat Atis	Sampaga
0.03-0.20	0.0058	0.052	0.057	0.07	0.085	0.089	0.09	0.1	0.13	0.15	0.16	0.19
0.21-0.50	0.0009	0.002	0.011	0.012	0.0022	0.0069	0.0031	0.012	0.035	0.048	0.053	0.033
0.51-1.00	0.0008	0.0006	0.0045	0.0063	0.0004	0.0055	0.0014	0.0078	0.019	0.017	0.013	0.0065
1.01-2.00	0.0004	0	0.0007	0.0034	0	0.0076	0.0001	0.007	0.013	0.0049	0.0066	0.0048
2.01-5.00	0.0011	0	0.0006	0.0019	0	0.0058	0	0.0076	0.0057	0.0018	0.005	0.0038
> 5.00	0.0005	0	0.0009	0.0014	0	0.003	0	0.0049	0.0032	0.0001	0.006	0.0047

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Antonio (in sq. km.)							
	Callejon	Magsay-say	Corza-on	Sinturi-san	Bagong Niing	Bri-ones	Pulo	Manuel Del Valle, Sr. Manuel Del Valle, Sr.
0.03-0.20	0.2	0.31	0	0.37	0.4	0.43	0.44	0.87
0.21-0.50	0.039	0.038	0	0.053	0.093	0.092	0.2	0.068
0.51-1.00	0.024	0.024	0	0.014	0.042	0.04	0.019	0.05
1.01-2.00	0.023	0.016	0	0.0021	0.03	0.032	0.011	0.033
2.01-5.00	0.017	0.0092	0	0.0004	0.023	0.023	0.0098	0.011
> 5.00	0.0037	0.0044	0	0	0.016	0.013	0.0088	0.0095



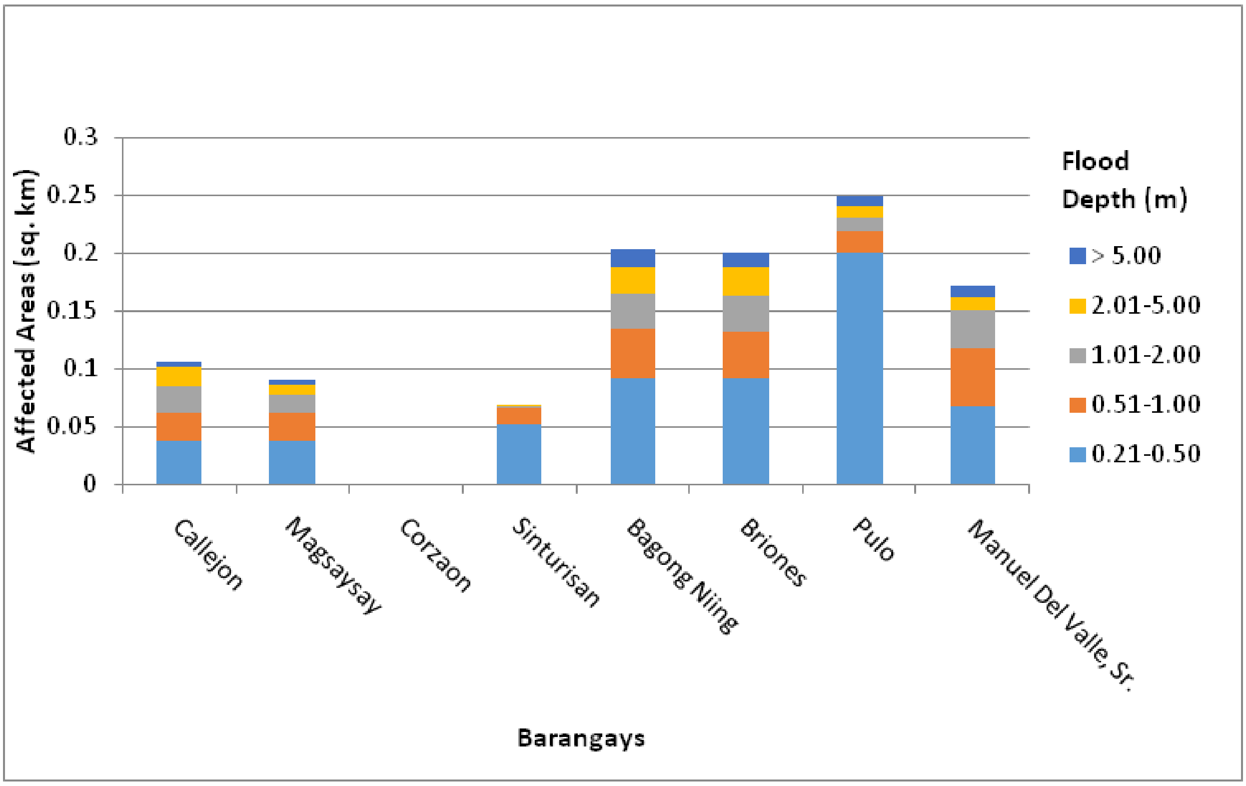


Figure 100. Affected areas in San Antonio, Quezon during a 100-Year Rainfall Return Period.

Moreover, the generated flood hazard maps for the Malaking-Ilog 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-year, 25-year, and 10-year).

Table 69. Areas covered by each warning level with respect to the rainfall scenarios

Warning Level	Area Covered in sq. km.		
	5 year	25 year	100 year
Low	13.15	11.41	10.31
Medium	18.1	21.55	22.03
High	6.3	12.41	17.24
TOTAL	37.55	45.37	49.58

5.11 Flood Validation

In order to check and validate the extent of flooding in different river systems, there is a need to perform validation survey work. 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 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 interview of some residents with knowledge of or have had experienced flooding in a particular area.

After which, the actual data from the field were 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 201 points randomly selected all over the Malaking-Ilog flood plain (Figure 86). Comparing it with the flood depth map of the nearest storm event, the map has an RMSE value of 0.22m. Table 42 shows a contingency matrix of the comparison.

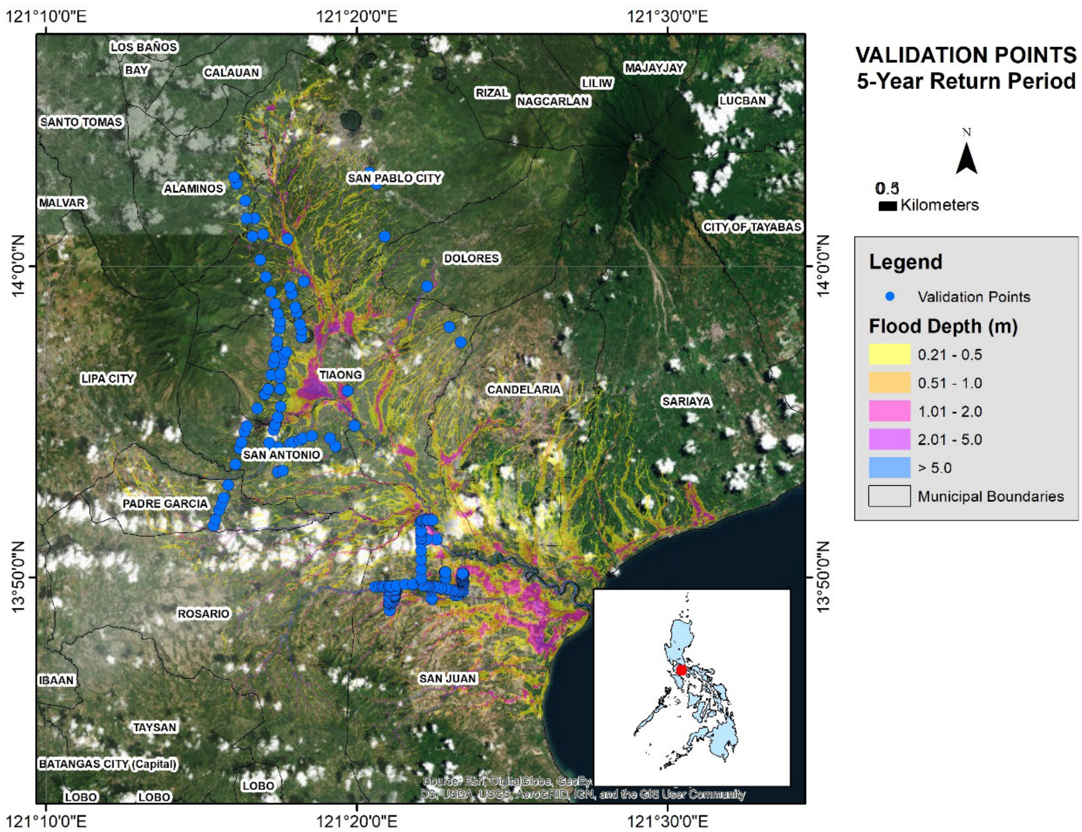


Figure 101. Validation points for 5-year Flood Depth Map of Malaking-Ilog-Bolbok Floodplain

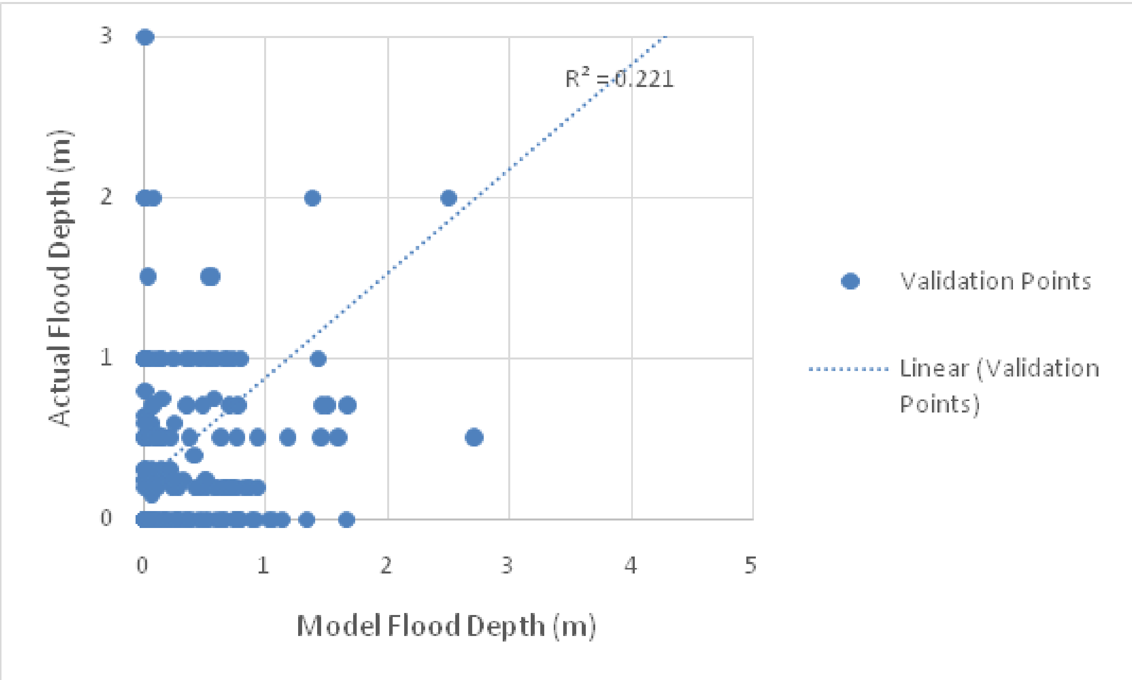


Figure 102. Flood map depth vs actual flood depth

Table 70. Actual Flood Depth vs Simulated Flood Depth

Actual Flood Depth (m)	Modeled Flood Depth (m)						
	0-0.20	0.21-0.50	0.51-1.00	1.01-2.00	2.01-5.00	> 5.00	Total
0-0.20	62	14	28	5	0	0	109
0.21-0.50	19	9	4	3	1	0	36
0.51-1.00	20	7	10	4	0	0	41
1.01-2.00	4	0	2	1	1	0	8
2.01-5.00	3	0	0	1	3	0	7
> 5.00	0	0	0	0	0	0	0
Total	108	30	44	14	5	0	201

The overall accuracy generated by the flood model is estimated at 42.29% with 85 points correctly matching the actual flood depths. In addition, there were 45 points estimated one level above and below the correct flood depths while there were 51 points and 13 points estimated two levels above and below, and three or more levels above and below the correct flood. A total of 4 points were overestimated while a total of 56 points were underestimated in the modelled flood depths of Malaking Ilog.

Table 71. Summary of Accuracy Assessment in Malaking-Ilog River Basin Survey

	No. of Points	%
Correct	85	**42.29**
Overestimated	60	**29.85**
Underestimated	56	**27.86**
Total	201	**100.00**

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 Malaking Ilog Floodplain Survey

PEGASUS

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, 1σ
Elevation accuracy (2)	< 5-20 cm, 1σ
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
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
Operating Temperature	-10°C to +35°C
Relative humidity	0-95% non-condensing

1 Target reflectivity ≥20%

2 Dependent on selected operational parameters using nominal FOV of up to 40° in standard atmospheric conditions with 24-km visibility

3 Angle of incidence ≤20°

4 Target size ≥ laser footprint5 Dependent on system configuration

GEMINI

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

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

1. LAG-20

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

February 04, 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: **LAGUNA**	
	Station Name: **LAG-20**	
Island: **LUZON**	Order: **3rd**	Barangay: **POBLACION**
Municipality: **LOS BAÑOS**		
	PRS92 Coordinates	
Latitude: **14° 9' 53.86904"**	Longitude: **121° 14' 20.35180"**	Ellipsoidal Hgt: **39.91400 m.**
	WGS84 Coordinates	
Latitude: **14° 9' 48.57270"**	Longitude: **121° 14' 25.28172"**	Ellipsoidal Hgt: **85.26600 m.**
	PTM Coordinates	
Northing: **1566435.481 m.**	Easting: **525799.268 m.**	Zone: **3**
	UTM Coordinates	
Northing: **1,566,588.99**	Easting: **309,934.22**	Zone: **51**

Location Description

LAG-20
Is located inside the UP Los Baños compound 25 m. NW from the Umali Hall building along Sanggumay Rd.; at the center of a concrete pavement, 0.7 m. from the edge of the stairs. Mark is a 2 mm. dia. brass rod centered on a 0.13 m. x 0.13 m. cement putty with inscription "LAG-20 NAMRIA 2000"

Requesting Party: **UP-DREAM**
Pupose: **Reference**
OR Number: **8795255 A**
T.N.: **2014-199**

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

9 9 0 2 0 4 2 0 1 4 1 2 5 9 5 8

CERTIFICATION INTERNATIONAL ISO 9001:2008 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

2. LA-204

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

February 13, 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: **LAGUNA** Station Name: **LA-204**	
Island: **LUZON**	Municipality: **LUMBAN**	Barangay: **PRIMERA PARANG**
Elevation: **8.5636 m.**	Order: **1st Order**	Datum: **Mean Sea Level**

Location Description

BM LA 204 is in Brgy. Primera 1st Parang, Lumban, Laguna. It is on top of the SE corner of the concrete sidewalk of Lumban Bridge, Station is along the national highway, 4m SE of road centerline. It is 10m SW of the barangay hall. 5m NE of the station is KM 94 post. Mark is the head of a 4" copper nail set on a drilled hole. Inscriobed on top of the 25cm x 25cm cement putty is
"BM LA 204, 2007, NAMRIA."

Requesting Party:	**UP-TCAGP**
Pupose:	**Reference**
OR Number:	**8795355 A**
T.N.:	**2014-321**

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

9902132014164807

CERTIFICATION INTERNATIONAL ISO 9001:2008
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

3. BTG-51

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

January 05, 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: **BATANGAS**	
	Station Name: **BTG-51**	
	Order: **2nd**	
Island: **LUZON**	Barangay: **TALAGA**	
Municipality: **TANAUAN**	MSL Elevation:	
	PRS92 Coordinates	
Latitude: **14° 6' 8.57112"**	Longitude: **121° 5' 52.31002"**	Ellipsoidal Hgt: **152.36900 m.**
	WGS84 Coordinates	
Latitude: **14° 6' 3.27790"**	Longitude: **121° 5' 57.24592"**	Ellipsoidal Hgt: **197.55100 m.**
	PTM / PRS92 Coordinates	
Northing: **1559501.067 m.**	Easting: **510567.544 m.**	Zone: **3**
	UTM / PRS92 Coordinates	
Northing: **1,559,783.81**	Easting: **294,641.94**	Zone: **51**

Location Description

BTG-51
From Star Expressway Exit, Tanauan City, turn right to Talisay and continue traveling W until reaching the Y-road. Station is located inside the Mabini Shrine, approx. 100 m. from the right side of the road. It is situated approx. 2 m. S of the flagpole, about 15 m. N from the gate of the said shrine. Mark is the head of a 4 in. copper nail centered and embedded on a 30 cm. x 30 cm. concrete block flushed on the ground, with inscriptions "BTG-51 2007 NAMRIA".

Requesting Party: **DOST-PCIEERD**
Purpose: **Reference**
OR Number: **8089513 I**
T.N.: **2016-0018**

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

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CERTIFICATION INTERNATIONAL ISO 9001:2008 ACCREDITED
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

4. BTG-30

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

February 19, 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: **BATANGAS**	
	Station Name: **BTG-30**	
Island: **LUZON**	Order: **2nd**	Barangay: **PALLOCAN**
Municipality: **BATANGAS CITY (CAPITAL)**		
	PRS92 Coordinates	
Latitude: **13° 45' 23.09641"**	Longitude: **121° 3' 43.87174"**	Ellipsoidal Hgt: **7.82000 m.**
	WGS84 Coordinates	
Latitude: **13° 45' 17.88182"**	Longitude: **121° 3' 48.83762"**	Ellipsoidal Hgt: **53.87200 m.**
	PTM Coordinates	
Northing: **1521226.725 m.**	Easting: **506725.034 m.**	Zone: **3**
	UTM Coordinates	
Northing: **1,521,536.18**	Easting: **290,477.09**	Zone: **51**

Location Description

BTG-30
Is in the vicinity of Brgy. Pallocan, Batangas City along the E side dike of Calumpang River, on the N side of Calumpang Bridge. It is about 0.67 m. WNW of the E edge of the dike, 1.3 m. ENE of the center of the concrete balluster and 50 m. NNE of the N side of the said bridge. Mark is the head of a 4" copper nail centered and embedded on top of a 30 cm. x 30 cm. cement putty set flushed to the pavement with inscriptions, "BTG-30 2004 NAMRIA".

Requesting Party: **UP DREAM**
Pupose: **Reference**
OR Number: **8795394 A**
T.N.: **2014-354**

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

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CERTIFICATION INTERNATIONAL ISO 9001:2008
ACCREDITED Quality Certification Body Accreditation No. MSA-001
CIP/4701/12/09/814

NAMRIA OFFICES:
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5. LAG-52

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

February 13, 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: **LAGUNA**
Station Name: **LAG-52**
Order: **2nd**

Island: **LUZON**		Barangay: **POBLACION**
Municipality: **MAGDALENA**		
	PRS92 Coordinates	
Latitude: **14° 12' 4.64805"**	Longitude: **121° 25' 41.33587"**	Ellipsoidal Hgt: **66.69800 m.**
	WGS84 Coordinates	
Latitude: **14° 11' 59.35842"**	Longitude: **121° 25' 46.26158"**	Ellipsoidal Hgt: **112.41000 m.**
	PTM Coordinates	
Northing: **1570483.553 m.**	Easting: **546212.761 m.**	Zone: **3**
	UTM Coordinates	
Northing: **1,570,462.41**	Easting: **330,382.29**	Zone: **51**

Location Description

LAG-52
Is located inside the compound of Magdalena Mun. Hall, less that a foot away S of the mun. flagpole. The said flagpole is about 20 m. N of the mun. bldg. Mark is the head of a 4 in. copper nail centered and embedded on a 30 cm. x 30 cm. cement putty, with inscriptions "LAG-52 2007 NAMRIA".

Requesting Party: **UP-TCAGP**
Pupose: **Reference**
OR Number: **8795355 A**
T.N.: **2014-318**

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

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CERTIFICATION INTERNATIONAL ISO 9001:2008
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www.namria.gov.ph

6. QZN-21

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

February 13, 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: **QUEZON**	
	Station Name: **QZN-21**	
Island: **LUZON**	Order: **2nd**	Barangay: **POBLACION III**
Municipality: **TIAONG**		
	PRS92 Coordinates	
Latitude: **13° 57' 44.31576"**	Longitude: **121° 19' 27.34822"**	Ellipsoidal Hgt: **51.25800 m.**
	WGS84 Coordinates	
Latitude: **13° 57' 39.07397"**	Longitude: **121° 19' 32.29499"**	Ellipsoidal Hgt: **97.38200 m.**
	PTM Coordinates	
Northing: **1544027.063 m.**	Easting: **535036.042 m.**	Zone: **3**
	UTM Coordinates	
Northing: **1,544,101.56**	Easting: **318,981.12**	Zone: **51**

Location Description

QZN-21
From Tiaong Municipal Hall, travel along the highway going to Lucena, then turn left to Dia St. until reaching Paaralang Elementarya ng Silangang Tiaong. Station is located on the open ground of the said school, 30 m. NE from the entrance gate. It is approx. 21 m. WNW from the NW corner post in front of the stage and 13.4 m. ESE from the concrete wall of the school. Mark is the head of a 4 in. copper nail centered on a 30 cm. x 30 cm. concrete monument flushed on the ground, with inscriptions "QZN-21 2006 NAMRIA".

Requesting Party: **UP-TCAGP**
Pupose: **Reference**
OR Number: **8795355 A**
T.N.: **2014-320**

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

1. BTG-A

Acceptance Summary

Processed	Passed	Flag	Fail
16	16	0	0

BTG-51 - BTG-A (10:17:13 AM-4:00:13 PM) (S1)

Baseline observation:	BTG-51 --- BTG-A (B1)
Processed:	1/6/2016 4:11:57 PM
Solution type:	Fixed
Frequency used:	Dual Frequency (L1, L2)
Horizontal precision:	0.003 m
Vertical precision:	0.013 m
RMS:	0.003 m
Maximum PDOP:	1.859
Ephemeris used:	Broadcast
Antenna model:	NGS Absolute
Processing start time:	12/21/2015 10:17:33 AM (Local: UTC+8hr)
Processing stop time:	12/21/2015 4:00:13 PM (Local: UTC+8hr)
Processing duration:	05:42:40
Processing interval:	1 second

Vector Components (Mark to Mark)

From:	BTG-51				
Grid		**Local**		**Global**	
Easting	294641.947 m	**Latitude**	N14°06'08.57113"	**Latitude**	N14°06'03.27790"
Northing	1559783.810 m	**Longitude**	E121°05'52.31001"	**Longitude**	E121°05'57.24592"
Elevation	152.867 m	**Height**	152.369 m	**Height**	197.551 m

To:	BTG-A				
Grid		**Local**		**Global**	
Easting	297103.192 m	**Latitude**	N13°57'27.65020"	**Latitude**	N13°57'22.39320"
Northing	1543753.102 m	**Longitude**	E121°07'18.59698"	**Longitude**	E121°07'23.54499"
Elevation	374.449 m	**Height**	373.826 m	**Height**	419.468 m

Vector					
ΔEasting	2461.246 m	**NS Fwd Azimuth**	170°48'36"	**ΔX**	-4333.540 m
ΔNorthing	-16030.708 m	**Ellipsoid Dist.**	16216.677 m	**ΔY**	2168.834 m
ΔElevation	221.582 m	**ΔHeight**	221.457 m	**ΔZ**	-15477.964 m

2

2. LAG-20D

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
LAG-20 --- LAG-20D (B1)	LAG-20	LAG-20D	Fixed	0.001	0.002	322°27'32"	3.356	0.015
LAG-20 --- LAG-20D (B2)	LAG-20	LAG-20D	Fixed	0.001	0.002	322°27'17"	3.358	0.012

Acceptance Summary

Processed	Passed	Flag	Fail
2	2	0	0

Vector Components (Mark to Mark)

From:	LAG-20				
Grid		Local		Global	
Easting	309934.222 m	Latitude	N14°09'53.86923"	Latitude	N14°09'48.57270"
Northing	1566588.991 m	Longitude	E121°14'20.35184"	Longitude	E121°14'25.28172"
Elevation	39.976 m	Height	39.914 m	Height	85.266 m

To:	LAG-20D				
Grid		Local		Global	
Easting	309932.197 m	Latitude	N14°09'53.95582"	Latitude	N14°09'48.65929"
Northing	1566591.667 m	Longitude	E121°14'20.28364"	Longitude	E121°14'25.21352"
Elevation	39.990 m	Height	39.929 m	Height	85.281 m

Vector					
ΔEasting	-2.025 m	NS Fwd Azimuth	322°27'32"	ΔX	2.079 m
ΔNorthing	2.677 m	Ellipsoid Dist.	3.356 m	ΔY	0.516 m
ΔElevation	0.015 m	ΔHeight	0.015 m	ΔZ	2.584 m

Standard Errors

Vector errors:					
σ ΔEasting	0.001 m	σ NS fwd Azimuth	0°00'26"	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

3. TGT-1

TGT-1 - BTG-A (8:02:03 AM-12:33:59 PM) (S4)

Baseline observation:	TGT-1 --- BTG-A (B4)
Processed:	1/6/2016 4:19:10 PM
Solution type:	Fixed
Frequency used:	Dual Frequency (L1, L2)
Horizontal precision:	0.008 m
Vertical precision:	0.017 m
RMS:	0.021 m
Maximum PDOP:	2.798
Ephemeris used:	Broadcast
Antenna model:	NGS Absolute
Processing start time:	12/22/2015 8:02:03 AM (Local: UTC+8hr)
Processing stop time:	12/22/2015 12:33:59 PM (Local: UTC+8hr)
Processing duration:	04:31:56
Processing interval:	1 second

Vector Components (Mark to Mark)

From:	BTG-A				
Grid		Local		Global	
Easting	297103.192 m	Latitude	N13°57'27.65020"	Latitude	N13°57'22.39320"
Northing	1543753.102 m	Longitude	E121°07'18.59698"	Longitude	E121°07'23.54499"
Elevation	374.473 m	Height	373.850 m	Height	419.492 m

To:	TGT-1				
Grid		Local		Global	
Easting	279835.803 m	Latitude	N14°07'00.06415"	Latitude	N14°06'54.75674"
Northing	1561490.784 m	Longitude	E120°57'38.31809"	Longitude	E120°57'43.25314"
Elevation	614.013 m	Height	613.234 m	Height	658.040 m

Vector					
ΔEasting	-17267.390 m	NS Fwd Azimuth	315°18'50"	ΔX	16999.982 m
ΔNorthing	17737.682 m	Ellipsoid Dist.	24750.750 m	ΔY	5522.228 m
ΔElevation	239.540 m	ΔHeight	239.384 m	ΔZ	17124.706 m

4. BTG-30A

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
BTG-30 --- BTG-30A (B2)	BTG-30	BTG-30A	Fixed	0.004	0.005	190°01'30"	4.793	0.078

Acceptance Summary

Processed	Passed	Flag	Fail
1	1	0	0

Vector Components (Mark to Mark)

From:	BTG-30				
Grid		Local		Global	
Easting	290477.094 m	Latitude	N13°45'23.09641"	Latitude	N13°45'17.88182"
Northing	1521536.181 m	Longitude	E121°03'43.87174"	Longitude	E121°03'48.83762"
Elevation	8.942 m	Height	7.820 m	Height	53.872 m

To:	BTG-30A				
Grid		Local		Global	
Easting	290476.221 m	Latitude	N13°45'22.94284"	Latitude	N13°45'17.72826"
Northing	1521531.468 m	Longitude	E121°03'43.84397"	Longitude	E121°03'48.80985"
Elevation	9.020 m	Height	7.898 m	Height	53.950 m

Vector					
ΔEasting	-0.872 m	NS Fwd Azimuth	190°01'30"	ΔX	0.096 m
ΔNorthing	-4.713 m	Ellipsoid Dist.	4.793 m	ΔY	1.457 m
ΔElevation	0.078 m	ΔHeight	0.078 m	ΔZ	-4.566 m

Standard Errors

Vector errors:					
σ ΔEasting	0.002 m	σ NS fwd Azimuth	0°01'04"	σ ΔX	0.002 m
σ ΔNorthing	0.001 m	σ Ellipsoid Dist.	0.001 m	σ ΔY	0.002 m
σ ΔElevation	0.002 m	σ ΔHeight	0.002 m	σ ΔZ	0.001 m

Annex 4. The LiDAR Survey Team Composition

Data Acquisition Component Sub-Team	Designation	Name	Agency/ Affiliation
PHIL-LIDAR 1	Program Leader	ENRICO C. PARINGIT, D.ENG	UP-TCAGP
Data Acquisition Component Leader	Data Component Project Leader – I	ENGR. LOUIE P. BALICANTA	UP-TCAGP
Survey Supervisor	Chief Science Research Specialist (CSRS)	ENGR. CHRISTOPHER CRUZ	UP-TCAGP
	Senior Science Research Specialist (SSRS)	LOVELY GRACIA ACUNA	UP-TCAGP
		ENGR. LOVELYN ASUNCION	
FIELD TEAM			
LiDAR Operation	Senior Science Research Specialist (SSRS)	JASMINE ALVIAR	UP-TCAGP
		JULIE PEARL MARS	UP-TCAGP
	Research Associate (RA)	KRISTINE JOY ANDAYA	UP-TCAGP
	RA	GRACE SINADJAN	UP-TCAGP
		MA. REMEDIOS VILLANUEVA	UP-TCAGP
		ENGR. LARAH PARAGAS	UP-TCAGP
		ENGR. IRO ROXAS	UP-TCAGP
		FAITH JOY SABLE	UP-TCAGP
Ground Survey, Data Download and Transfer	RA	JERIEL PAUL ALAMBAN	UP-TCAGP
		ENGR. CHRISTOPHER JOAQUIN	UP-TCAGP
		KENNETH QUISADO	UP-TCAGP
		ENGR. GEF SORIANO	UP-TCAGP
LiDAR Operation	Airborne Security	SSG LEEJAY PUNZALAN	PHILIPPINE AIR FORCE (PAF)
	Pilot	CAPT. MARK LAWRENCE TANGONAN	ASIAN AEROSPACE CORPORATION (AAC)
		CAPT. RANDY LAGCO	AAC
		CAPT. JEROME MOONEY	AAC
		CAPT. FRANK PEPITO	AAC

Annex 5. Data Transfer Sheet for the Malaking Ilog Floodplain

DATA TRANSFER SHEET
Apr 4, 2014

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS	POS	RAW IMAGES	MISSION LOG FILE	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
Jan 24, 2014	1023P	1BLK18B024A	PEGASUS	968MB	1.01MB	4.74MB	52.6MB	11.8GB	111KB	9.28GB	39.8GB	8.04MB	109B	245B	33.3KB	N/A	Z:\Airborne_Raw\1023P
Jan 25, 2014	1027P	1BLK18A025A	PEGASUS	1.51GB	1.62MB	5.69MB	194MB	7.11GB	83.9KB	14.3GB	N/A	6.71MB	112B	718B	105KB	N/A	Z:\Airborne_Raw\1027P
Jan 26, 2014	1031P	1BLK18C026A	PEGASUS	1.52GB	1.63MB	5.60MB	185MB	N/A	N/A	14.7GB	N/A	8.03MB	110B	62B	40.6KB	N/A	Z:\Airborne_Raw\1031P
Jan 29, 2014	1043P	1BLK18AS029A	PEGASUS	594MB	687KB	3.52MB	125MB	N/A	N/A	6.13GB	N/A	6.78MB	141B	352B	33.3KB	N/A	Z:\Airborne_Raw\1043P
Jan 31, 2014	1051P	1BLK18E031A	PEGASUS	1.28GB	1.60MB	5.47MB	189MB	14.4GB	154KB	13.3GB	N/A	2.28MB	217B	504B	78.5KB	N/A	Z:\Airborne_Raw\1051P
Feb 2, 2014	1059P	1BLK18F033A	PEGASUS	1.04GB	1.13MB	5.61MB	167MB	11.7GB	118KB	10.1GB	N/A	3MB	201B	421B	133KB	N/A	Z:\Airborne_Raw\1059P
Feb 3, 2014	1063P	1BLK18D034A	PEGASUS	1.18GB	853KB	5.17MB	144MB	19.2GB	174KB	18.5GB	N/A	5.95MB	191B	321B	29.3KB	N/A	Z:\Airborne_Raw\1063P
Feb 4, 2014	1067P	1BLK18H035A	PEGASUS	921MB	1.39MB	4.99MB	167MB	11.6GB	111KB	11.5GB	N/A	5.03MB	138B	383B	63.3KB	N/A	Z:\Airborne_Raw\1067P
Feb 5, 2014	1071P	1BLK18I036A	PEGASUS	1.62GB	1.81MB	4.91MB	157MB	16GB	157KB	15.4GB	N/A	2.50MN	193B	411B	95.2KB	N/A	Z:\Airborne_Raw\1071P
Feb 7, 2014	1079P	1BLKEFS038A	PEGASUS	451MB	603MB	3.17MB	132MB	4.97GB	55.8KB	5.51GB	N/A	3.01MB	194B	479B	69.9KB	N/A	Z:\Airborne_Raw\1079P
Feb 8, 2014	1083P	1BLK18J39A	PEGASUS	1.47GB	1.92MB	5.56MB	198MB	22.6GB	187KB	16.5GB	N/A	12.4MB	180B	604B	62.6KB	N/A	Z:\Airborne_Raw\1083P
Feb 9, 2014	1087P	1BLK18K40A	PEGASUS	1.28GB	1.77MB	5.19MB	188MB	16GB	139KB	14.8GB	N/A	10.7MB	186B	429B	32.8KB	N/A	Z:\Airborne_Raw\1087P
Feb 10, 2014	1091P	1BLK18W41A	PEGASUS	2.17GB	2.40MB	6.22MB	171MB	32.7GB	256KB	20.2GB	N/A	10.1MB	188B	426B	66.1KB	N/A	Z:\Airborne_Raw\1091P
Feb 11, 2014	1095P	1BLK18U42A	PEGASUS	1.16GB	1.58MB	7.92MB	235MB	96.9MB	1.61KB	14.9GB	N/A	11.4MB	205B	287B	76.7KB	N/A	Z:\Airborne_Raw\1095P
Feb 12, 2014	1099P	1BLK18US43A	PEGASUS	1.70GB	2.39MB	7.46MB	234MB	N/A	739B	20.7GB	N/A	11.4MB	205B	543B	95.2KB	N/A	Z:\Airborne_Raw\1099P
Feb 13, 2014	1103P	1BLK18VWS44A	PEGASUS	2.12GB	2.36MB	6.86MB	221MB	N/A	N/A	19.8GB	N/A	16.6MB	305B	429B	191KB	N/A	Z:\Airborne_Raw\1103P
Feb 13,2014	1105P	1BLK18T44B	PEGASUS	2.33GB	2.67MB	6.85MB	219MB	N/A	N/A	22.2GB	N/A	16.6MB	305B	394B	161KB	N/A	Z:\Airborne_Raw\1105P
Feb 14,2014	1107P	1BLK18QRS45A	PEGASUS	799MB	1.54MB	7.08MB	215MB	16.7GB	149KB	10.2GB	N/A	12MB	217B	N/A	N/A	N/A	Z:\Airborne_Raw\1107P
Feb 14,2014	1109P	1BLK18US45B	PEGASUS	N/A	1.87MB	5.61MB	183MB	N/A	N/A	15.9GB	N/A	12MB	217B	310B	195KB	N/A	Z:\Airborne_Raw\1109P

Feb 15,2014	1111P	1BLK18RS46A	PEGASUS	1.39GB	1.74MB	6.22MB	194MB	19.7GB	172KB	14.7GB	N/A	10.9MB	215B	559B	71KB	N/A	Z:\Airborne_Raw\1111P
Feb 17,2014	1119P	1BLK18O48A	PEGASUS	1.02GB	1.95MB	8.25MB	250MB	21.5GB	195KB	15.8GB	N/A	11.7MB	213MB	520B	41KB	N/A	Z:\Airborne_Raw\1119P
Feb 18, 2014	1123P	1BLK18OS49A	PEGASUS	1.38GB	1.81MB	6.46MB	193MB	N/A	N/A	14.7GB	N/A	12.6MB	213B	504B	43KB	N/A	Z:\Airborne_Raw\1123P
Feb 18,2014	1125P	1BLK18S49B	PEGASUS	374MB	665KB	4.21MB	144MB	N/A	N/A	5.57GB	N/A	12.6MB	213B	282B	79.7KB	N/A	Z:\Airborne_Raw\1125P
Feb 19, 2014	1127P	1BLK18S50A	PEGASUS	985MB	1.54MB	5.26MB	190MB	N/A	N/A	12.1GB	N/A	6.85MB	213B	507B	87.1KB	N/A	Z:\Airborne_Raw\1127P
Feb 20, 2014	1131P	1BLK18Z51A	PEGASUS	1.84GB	2.39MB	7.83MB	219MB	30.3GB	234KB	20GB	90.4GB	13.2MB	133B	310B	91.9KB	N/A	Z:\Airborne_Raw\1131P
Feb 20,2014	1133P	1BLK18Z51B	PEGASUS	1.06GB	1.41MB	4.71MB	169MB	18.9GB	140KB	12.1GB	N/A	13.2MB	133B	265B	91.9KB	N/A	Z:\Airborne_Raw\1133P
Feb 21, 2014	1135P	1BLK18Y52A	PEGASUS	1.64GB	2.04MB	7.95MB	236MB	7.41GB	117KB	17.4GB	33.9GB	7.52MB	133B	335B	91.9KB	N/A	Z:\Airborne_Raw\1135P
Feb 22,2014	1139P	1BLK18X53A	PEGASUS	2.19GB	2.45MB	7.52MB	238MB	29.3GB	239KB	21GB	N/A	6.71MB	133B	0B	147KB	N/A	Z:\Airborne_Raw\1139P
Feb 22, 2014	1141P	1BLK18S53B	PEGASUS	1.65GB	1.80MB	7.25MB	219MB	24GB	176KB	15.4GB	N/A	6.25MB	157B	410B	171KB	N/A	Z:\Airborne_Raw\1141P
28-Jan	1039P	1BLK18B028A	PEGASUS	2.06	36KB	11.8	185	NA	NA	19.1	NA	7.43	141B	242B	40.6	NA	Z:\Airborne_Raw\1039P

LOGS TOS RAW POINT

Received from

Name CHRIS ~~RA~~ ...
Position RA
Signature 06/23/14

Received by

Name JOIDA F. PRIETO
Position SSRS
Signature

DATA TRANSFER SHEET
CALABARZON 9/7/2015

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	
15-Aug	3299P	1BLK18KS227A	PEGASUS	535	614	5.45	143	na	na	10.4	na	3.73	1KB	1KB	222	NA	Z:\DAC\RAW DATA
26-Aug	3341P	1BLK18AbS238A	PEGASUS	1.49	NA	10.1	240	na	na	16.1	na	7.02	1KB	1KB	69	NA	Z:\DAC\RAW DATA
26-Aug	3343P	1BLK18AcS238B	PEGASUS	1.84	NA	9.44	214	na	na	17.9	na	5.96	1KB	1KB	59	NA	Z:\DAC\RAW DATA
27-Aug	3345P	1BLK18TS239A	PEGASUS	2.5	NA	7.11	177	na	na	22.5	na	5.99	1KB	1KB	NA	NA	Z:\DAC\RAW DATA
27-Aug	3347P	1BLK18TS239B	PEGASUS	0.99	NA	6.27	152	na	na	9.85	na	4.13	1KB	1KB	NA	NA	Z:\DAC\RAW DATA
29-Aug	3353P	1BLK18QRS241A	PEGASUS	1.91	NA	10.3	246	na	na	18.8	na	7.19	1KB	1KB	87.1	NA	Z:\DAC\RAW DATA
1-Sep	3365P	1BLK18BCS244A	PEGASUS	1.92	NA	8.57	192	na	na	18.2	na	8.61	1KB	1KB	41	NA	Z:\DAC\RAW DATA
2-Sep	3369P	1BLK18CS245A	PEGASUS	1.34	NA	7.43	154	na	na	13.5	na	35	1KB	1KB	54	NA	Z:\DAC\RAW DATA

Received from

Name C. JOAQUIN
Position RA
Signature

Received by

Name JOIDA F. PRIETO
Position SSRA
Signature
9/8/15

IC-2

DATA TRANSFER SHEET
Calabarzon 9/10/15

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	
17-Aug	3307P	1BLK18JS229B	Pegasus	972	756	6.66	171	na	na	9.59	na	18.4	1KB	1KB	1/42	na	Z:\DAC\RAW DATA
18-Aug	3309P	1BLK18AsS230A	Pegasus	1.17	757	7.65	202	na	na	11.9	na	19.4	1KB	1KB	88	na	Z:\DAC\RAW DATA
3-Sep	3373P	1BLK18OS246A	Pegasus	1.81	2.06	9.59	212	na	na	18.2	na	7.67	1KB	1KB	1	na	Z:\DAC\RAW DATA
4-Sep	3377P	1BLK18JS247A	Pegasus	1.29	777	8.1	196	na	na	13.4	na	6.43	1KB	1KB	61.6	na	Z:\DAC\RAW DATA
5-Sep	3381P	1BLK18OS248A	Pegasus	2.12	1.54	10.3	256	na	na	20.6	na	9.05	1KB	1KB	59/59	na	Z:\DAC\RAW DATA

Received from

Name C. Joaquin
Position RA
Signature [signature]

Received by

Name KC Bongat 9/11/15
Position SSRS
Signature KBongat

DATA TRANSFER SHEET
01/06/2016 Batangas

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	
12/22/2015 2	3002P	1BLK18SB356A	PEGASUS	2.71	1195	10.6	185	41.7	310	25.3	NA	27.5	1KB	1KB	137/134	NA	Z:\DAC\RAWDATA
12/29/2015 3	3669G	2BLK18SBC363A	GEMINI	NA	198	861	151	NA	NA	14.9	NA	7.42	1KB	1KB	NA	NA	Z:\DAC\RAWDATA
12/29/2015 2	3671G	2BLK18SBC363B	GEMINI	NA	96	473	85	NA	NA	7.41	NA	7.42	1KB	1KB	11	NA	Z:\DAC\RAWDATA
12/30/2015 5	3673G	2BLK18S364A	GEMINI	NA	221	1.28	195	NA	NA	16.6	NA	11.4	1KB	1KB	17	NA	Z:\DAC\RAWDATA

Received from

Name Kristine Andaya
Position RA
Signature

Received by

Name JOIDA F. PRIETO
Position SupSRS
Signature

01/06/2016

30026

16-02

DATA TRANSFER SHEET
Batangas 1/13/16

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	
21-Dec	3000P	1BLK18SB355A	pegasus	736	656	3.8	107	11.1	85	7.11	na	11.1	1KB	1KB	100	na	Z:\DAC\RAW DATA
6-Jan	3677G	2BLK18SK006A	GEMINI	NA	322	699	157	NA	NA	38.7	na	27.2	0KB	1KB	11	na	Z:\DAC\RAW DATA
6-Jan	3679G	2BLK18SDG006B	GEMINI	NA	60	401	131	NA	NA	12.8	na	27.2	0KB	1KB	5/3	na	Z:\DAC\RAW DATA
7-Jan	3681G	2BLK18SM007A	GEMINI	NA	226	0	209	NA	NA	24	na	18.5	0KB	1KB	NA	na	Z:\DAC\RAW DATA
8-Jan	3685G	2BLK18SF008A	GEMINI	NA	99	786	185	NA	NA	24.4	na	20.9	0KB	1KB	4/2	na	Z:\DAC\RAW DATA
8-Jan	3687G	2BLK18SGS008B	GEMINI	NA	214	0	172	NA	NA	17.2	na	20.9	0KB	1KB	4/20	na	Z:\DAC\RAW DATA
9-Jan	3689G	2BLK18SV009A	GEMINI	NA	201	1.54	219	NA	NA	16.3	na	12.9	0KB	1KB	23	na	Z:\DAC\RAW DATA
9-Jan	3691G	2BLK18SVV009B	GEMINI	NA	12.8	440	124	NA	NA	6.93	na	12.9	0KB	1KB	10	na	Z:\DAC\RAW DATA

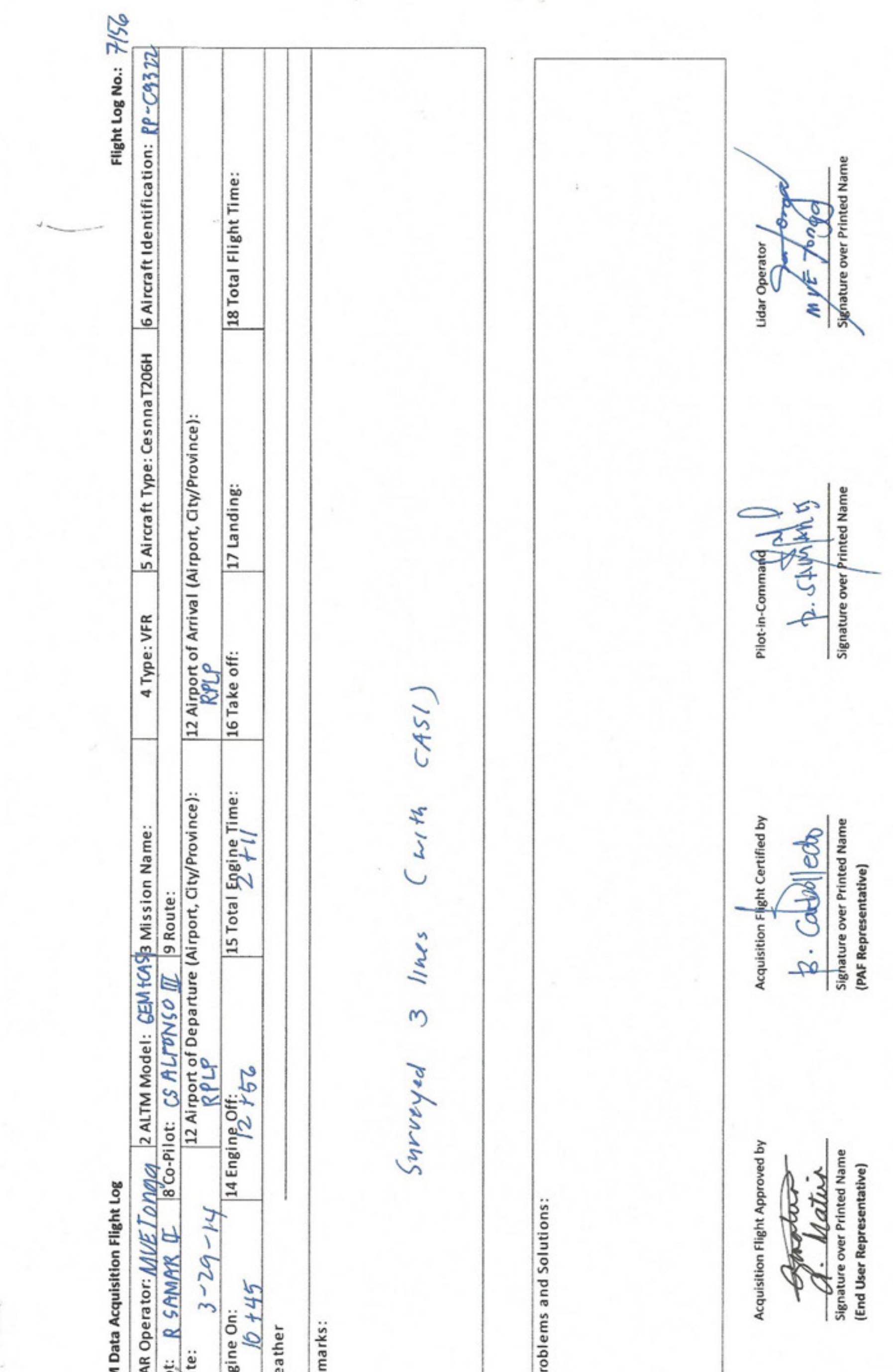
Received from
Name
Position
Signature

Received by
Name
Position
Signature 1/15/16

1I.-05

Annex 6. Flight Logs for the Flight Missions

Flight Log for 7156GC Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 7156

1 LiDAR Operator: MVE Tonga	2 ALTM Model: GEM+CAS	3 Mission Name:	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9322
7 Pilot: R SAMAR II	8 Co-Pilot: CS ALFONSO III	9 Route:			
10 Date: 3-29-14	12 Airport of Departure (Airport, City/Province): RPLP		12 Airport of Arrival (Airport, City/Province): RPLP		
13 Engine On: 10+45	14 Engine Off: 12+56	15 Total Engine Time: 2+11	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					

20 Remarks:

Surveyed 3 lines (with CASI)

21 Problems and Solutions:

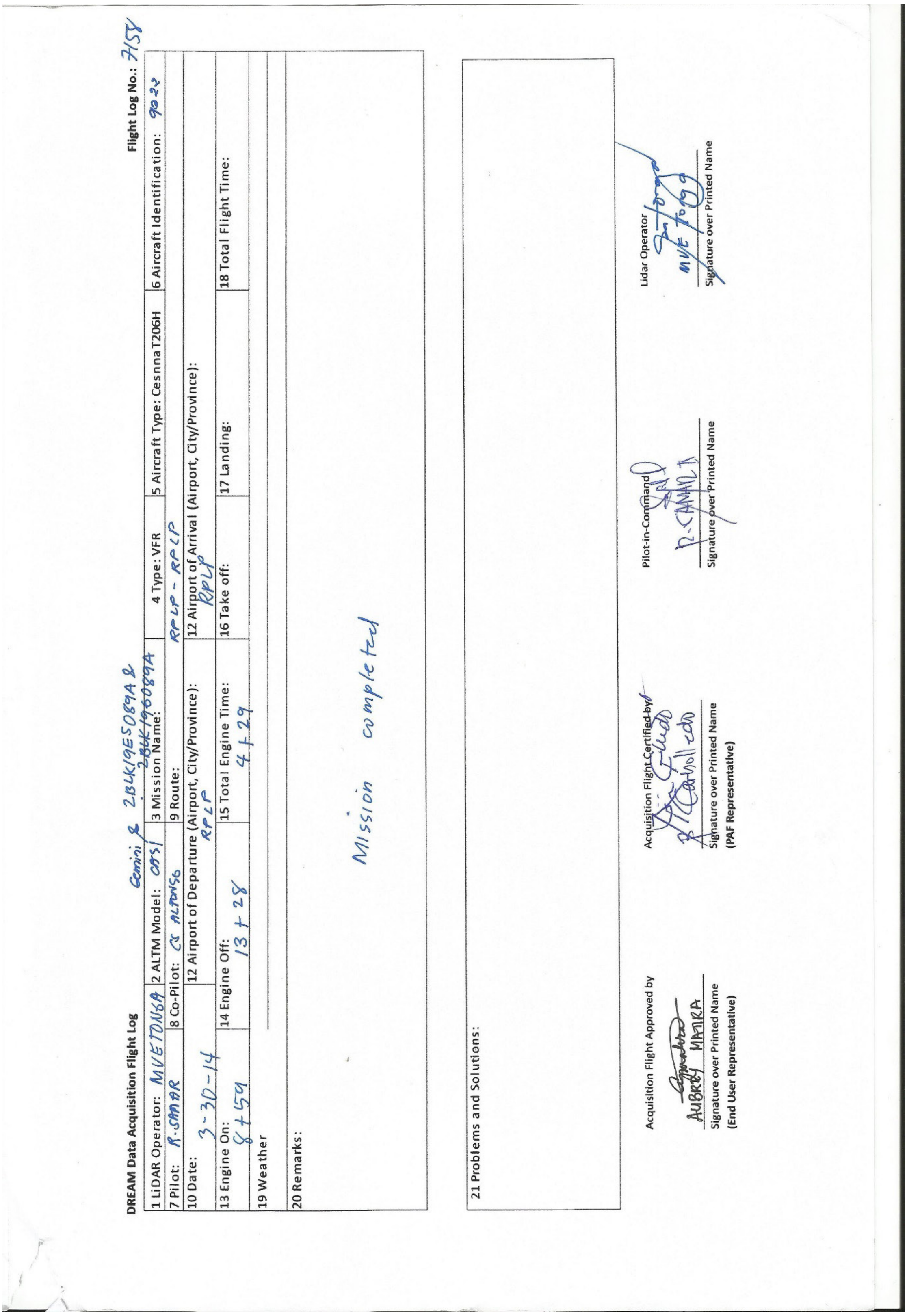
Acquisition Flight Approved by
A. Matias
Signature over Printed Name
(End User Representative)

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

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

Lidar Operator
MVE Tonga
Signature over Printed Name

Flight Log for 7158GC Mission



DREAM Data Acquisition Flight Log — Flight Log No.: 7158

1 LiDAR Operator: MVETONGA	2 ALTM Model: CAS1	3 Mission Name: Gemini & 2BLK19ES089A & 2BLK19G089A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9022
7 Pilot: R. SAMAR	8 Co-Pilot: CS ALFONSO	9 Route: RPLP - RPLP			
10 Date: 3-30-14	12 Airport of Departure (Airport, City/Province): RPLP		12 Airport of Arrival (Airport, City/Province): RPLP		
13 Engine On: 8+59	14 Engine Off: 13+28	15 Total Engine Time: 4+29	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					
20 Remarks: Mission completed					

21 Problems and Solutions:

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

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

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

Lidar Operator: MVE TONGA — Signature over Printed Name

Flight Log for 7160GC Mission

DREAM Data Acquisition Flight Log Gemini

Flight Log No.: 7160

1 LiDAR Operator: MVE Tonga	2 ALTM Model: CASI	3 Mission Name: 2BLK19IO90A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9322
7 Pilot: R. SAMAR	8 Co-Pilot: CS ALFONSO	9 Route: RPLP - RPLP			
10 Date: 3-31-14	12 Airport of Departure (Airport, City/Province): RPLP		12 Airport of Arrival (Airport, City/Province): RPLP		
13 Engine On: 7+57	14 Engine Off: 9+32	15 Total Engine Time: 1+35	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: cloudy					

20 Remarks:

Surveyed 1 line (without CASI)

21 Problems and Solutions:

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

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

Pilot-in-Command
Signature over Printed Name

Lidar Operator
MVE Tonga
Signature over Printed Name

Flight Log for 7161GC Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 7161

1 LiDAR Operator: MVE Tonga	2 ALTM Model: Gemini/CASI	3 Mission Name: 2BLK19I50908	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9322
7 Pilot: R. Samar II	8 Co-Pilot: C. Alfonso III	9 Route:			
10 Date: 3-31-14	12 Airport of Departure (Airport, City/Province): RPLP		12 Airport of Arrival (Airport, City/Province): RPLP		
13 Engine On: 15+8	14 Engine Off: 17+37	15 Total Engine Time: 2+29	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: cloudy					
20 Remarks: Successful flight; Surveyed 6 lines (with CASI)					

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
A. Matira		R. Samar II	MVE Tonga
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

Flight Log for 7167GC Mission

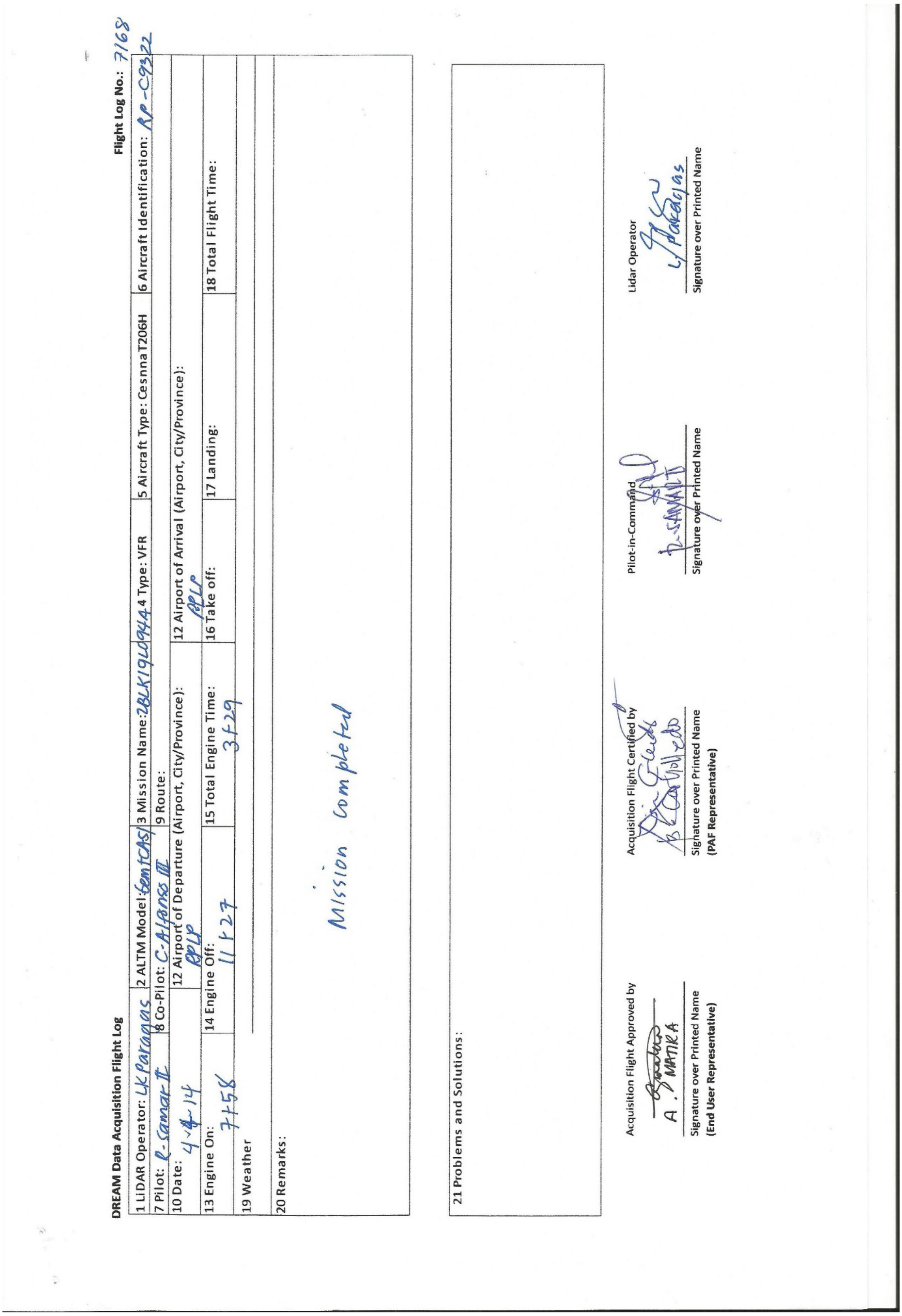
DREAM Data Acquisition Flight Log | **Flight Log No.:** 7167

1 LiDAR Operator: MUE Tongga	2 ALTM Model: Gemini CASI	3 Mission Name: 2BLK19K093A 2BLK19K093A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9322
7 Pilot: R. Samar II	8 Co-Pilot: CS alfonso III	9 Route:			
10 Date: 4-3-14	12 Airport of Departure (Airport, City/Province): RPLP		12 Airport of Arrival (Airport, City/Province): RPLP		
13 Engine On: 13+31	14 Engine Off: 17+24	15 Total Engine Time: 3+53	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					
20 Remarks: Mission completed					

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
A. MATIRA	K. Castillo	R. SAMAR II	MUE Tongga
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

Flight Log for 7168GC Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 7168

1 LiDAR Operator: LK Paragas	2 ALTM Model: GemtCAS	3 Mission Name: 2BLK19LQ944	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9322
7 Pilot: R-Samar II	8 Co-Pilot: C-Alfonso III	9 Route:			
10 Date: 4-4-14	12 Airport of Departure (Airport, City/Province): RPLP		12 Airport of Arrival (Airport, City/Province): RPLP		
13 Engine On: 7+58	14 Engine Off: 11+27	15 Total Engine Time: 3+29	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					
20 Remarks: Mission completed					
21 Problems and Solutions:					

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
A. MATIRA		R-SAMAR II	L Paragas
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

Flight Log for 7171GC Mission

DREAM Data Acquisition Flight Log Gemini 8 **Flight Log No.:** 7171

1 LiDAR Operator: LK Paragas	2 ALTM Model: CASI	3 Mission Name: 2BLK19M095A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9322
7 Pilot: R. SAMAR	8 Co-Pilot: GS ALFONSO	9 Route: RPLP - RPLP			
10 Date: 4-5-14	12 Airport of Departure (Airport, City/Province): RPLP		12 Airport of Arrival (Airport, City/Province): RPLP		
13 Engine On: 14+41	14 Engine Off: 17+40	15 Total Engine Time: 2+59	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					
20 Remarks: Mission completed					

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
A. MATIBA	B. Caballero	R. SAMAR	L. Paragas
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

Flight Log for 7172GC Mission

DREAM Data Acquisition Flight Log

Gemini 2BLK 5S

Flight Log No.: 7172

1 LiDAR Operator: MVE Tongco	2 ALTM Model: CASI	3 Mission Name: 2BLK D096A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9322
7 Pilot: R. SAMAR	8 Co-Pilot: OS ALFONSO	9 Route: RPLP - RPLP			
10 Date: 4-6-14	12 Airport of Departure (Airport, City/Province): RPLP		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 7+14	14 Engine Off: 11+49	15 Total Engine Time: 4+35	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					

20 Remarks:

Mission completed at BLK19C and surveyed 12 lines at BLK19D

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
A. MATIKA		R. SAMAR II	MVE Tongco
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

Flight Log for 7174GC Mission

DREAM Data Acquisition Flight Log Gemini 2 **Flight Log No.:** 7174

1 LiDAR Operator: LK Paragas	2 ALTM Model: GASI	3 Mission Name: 2BLK19F097B	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9322
7 Pilot: R. SAMOR	8 Co-Pilot: CS ALFONSO	9 Route: RPLP - RPLP			
10 Date: 7 Apr 14	12 Airport of Departure (Airport, City/Province): RPLP		12 Airport of Arrival (Airport, City/Province): RPLP		
13 Engine On: 7+39	14 Engine Off: 11+8	15 Total Engine Time: 3+29	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					
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)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	L. Paragas Signature over Printed Name

Flight Log for 7175 Mission

DREAM Data Acquisition Flight Log Gemini 9

Flight Log No.: 7175

1 LiDAR Operator: MVE Tonga	2 ALTM Model: CASI	3 Mission Name: 2BLK19H097A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9322
7 Pilot: R SAMAR	8 Co-Pilot: CS ALFONSO	9 Route: RPLP - RPLP			
10 Date: 7 Apr 14	12 Airport of Departure (Airport, City/Province): RPLP		12 Airport of Arrival (Airport, City/Province): RPLP		
13 Engine On: 15+3	14 Engine Off: 17+36	15 Total Engine Time: 2+33	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					
20 Remarks: Surveyed 10 lines					

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
A. MATIRA	B. Caballero	R. SAMAR	MVE Tonga
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

Flight Log for 7176GC Mission

DREAM Data Acquisition Flight Log Gemini 2 **Flight Log No.:** 7176

1 LiDAR Operator: LK Paragas	2 ALTM Model: CASI	3 Mission Name: 2BLK19HS098A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9322
7 Pilot: R. SAMAR	8 Co-Pilot: CS ALFONSO	9 Route: RPLP - RPLP			
10 Date: 4-8-14	12 Airport of Departure (Airport, City/Province): RPLP		12 Airport of Arrival (Airport, City/Province): RPLP		
13 Engine On: 7+23	14 Engine Off: 9+4	15 Total Engine Time: 1+41	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					

20 Remarks:

Flight aborted due to precipitation in the survey area

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
A. MATIRA	B. Corbolledo	R. SAMAR II	L. Paragas
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

Flight Log for 7184GC Mission

DREAM Data Acquisition Flight Log Gemini &

Flight Log No.: 7184

1 LiDAR Operator: LK Paragas	2 ALTM Model: 0351	3 Mission Name: 2BLK19J102A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9322
7 Pilot: RSAMAR	8 Co-Pilot: GS ALFONSO	9 Route: RP LP - RPLP			
10 Date: 4-12-14	12 Airport of Departure (Airport, City/Province): RP LP		12 Airport of Arrival (Airport, City/Province): RPLP		
13 Engine On: 6+42	14 Engine Off: 9+05	15 Total Engine Time: 2+23	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					
20 Remarks: surveyed 6 lines of BLK19J					
21 Problems and Solutions:					

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
A. Malan	B. Carbalido	R. CANARIA	L. Paragas
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

Flight Log for 7200GC Mission

DREAM Data Acquisition Flight Log Gemini & 2BLK19S110A **Flight Log No.:** 7200

1 LiDAR Operator: MV Tonga	2 ALTM Model: CASI	3 Mission Name: 2BLK19N110A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9322
7 Pilot: R. Samar	8 Co-Pilot: CS Alfonso	9 Route: RPLP - RPLP			
10 Date: 4-20-14	12 Airport of Departure (Airport, City/Province): RPLP		12 Airport of Arrival (Airport, City/Province): RPLP		
13 Engine On: 6+42	14 Engine Off: 10+47	15 Total Engine Time: 4+5	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					
20 Remarks: Mission Completed (BLKs N & S)					

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
A. Matira	B. Cortodedo	R. SAMAR II	MVG Tonga
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

Flight Log for 7204GC Mission

DREAM Data Acquisition Flight Log Gemini 9 2BLK19A112A **Flight Log No.:** 7204

1 LiDAR Operator: LK Paragas	2 ALTM Model: CASI	3 Mission Name:	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9022
7 Pilot: R. SAMAR	8 Co-Pilot: CS ALFONSO	9 Route: RPLP - RPLP			
10 Date: 4-22-14	12 Airport of Departure (Airport, City/Province): RPLP		12 Airport of Arrival (Airport, City/Province): RPLP		
13 Engine On:	14 Engine Off:	15 Total Engine Time:	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					
20 Remarks: Surveyed 6 lines at 19A & completed voids at BLK 19J					

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
A. Matias	B. Cabalfadis	R. SAMAR	J. Paragas
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

Flight Log for 7212GC Mission

DREAM Data Acquisition Flight Log Gemini 9

Flight Log No.: 7212

1 LiDAR Operator: MV Tonga	2 ALTM Model: CASI	3 Mission Name: 2BLK19PN6A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9322
7 Pilot: R. SAMAR II	8 Co-Pilot: CS ALFONSO III	9 Route: RPLP - RPLP			
10 Date: 4-26-14	12 Airport of Departure (Airport, City/Province): RPLP		12 Airport of Arrival (Airport, City/Province): RPLP		
13 Engine On: 0604H	14 Engine Off: 1015H	15 Total Engine Time: 4+11	16 Take off: 0608 H	17 Landing: 1011 H	18 Total Flight Time: 4+03
19 Weather					
20 Remarks: Mission completed without CASI (BLK19P)					

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
AV Matira	B. Caballero	R. SAMAR II	MVE Tonga
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

Flight Log for 7213GC Mission

DREAM Data Acquisition Flight Log Gemini 8 **Flight Log No.:** 7213

1 LiDAR Operator: LKParagas	2 ALTM Model: CASI	3 Mission Name: 2BLK05I16B	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9307
7 Pilot: R. SAMAR	8 Co-Pilot: CJ ALFONSO	9 Route: RPLP - RPLP			
10 Date: 4-26-14	12 Airport of Departure (Airport, City/Province): RPLP		12 Airport of Arrival (Airport, City/Province): RPLP		
13 Engine On: 1458H	14 Engine Off: 1733H	15 Total Engine Time: 2+35	16 Take off: 1501H	17 Landing: 1729H	18 Total Flight Time: 2+28
19 Weather	Cloudy				

20 Remarks:

Mission completed without CASI

(BLK 19 O)

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
A. Matin	R. Cartvel-do	R. SAMART	L. Paragas
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

Flight Log for 7216GC Mission

DREAM Data Acquisition Flight Log

Gemini

Flight Log No.: 7216

1 LiDAR Operator: MV Tongg	2 ALTM Model: CASI	3 Mission Name: 2BLK19AS118A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9322
7 Pilot: R. SAMAR	8 Co-Pilot: CS ALFONSO	9 Route: RPLP - RPLP			
10 Date: 4-28-14	12 Airport of Departure (Airport, City/Province): RPLP		12 Airport of Arrival (Airport, City/Province): RPLP		
13 Engine On: 0633H	14 Engine Off: 0944H	15 Total Engine Time: 3+11	16 Take off: 0638H	17 Landing: 0949 H	18 Total Flight Time: 3+03
19 Weather					
20 Remarks: Mission completed including voids (with CASI) BLK19A					
21 Problems and Solutions:					

Acquisition Flight Approved by

A. Matira

Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by

B. Satobledo

Signature over Printed Name
(PAF Representative)

Pilot-in-Command

R. SAMAR

Signature over Printed Name

Lidar Operator

MVE Tong

Signature over Printed Name

Flight Log for 3825G Mission

DREAM | Data Acquisition Flight Log

Flight Log No.: 3825

1 LiDAR Operator: MS REYES	2 ALTM Model: Gemini	3 Mission Name: 2BLK19JS FS 59B	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9022
7 Pilot: J MOONEY	8 Co-Pilot: D CABUDOL	9 Route:			
10 Date: Feb 28, 2016	12 Airport of Departure (Airport, City/Province): Legazpi		12 Airport of Arrival (Airport, City/Province): Legazpi		
13 Engine On: 1430	14 Engine Off: 1741	15 Total Engine Time: 3+11	16 Take off: 1435	17 Landing: 1736	18 Total Flight Time: 3+01
19 Weather	Cloudy on some areas				

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
- ○ DREAM Admin Activities

21 Remarks

Surveyed Blk 19JS & some parts of Blk 19FS

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
[signature]	Benjie Carbolledo	Jerome Mooney	MS REYES	N/A
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

Flight Log for 3829G Mission

D R E A M | Data Acquisition Flight Log

Flight Log No.: 3829

1 LIDAR Operator: MS REYES	2 ALTM Model: Gemini	3 Mission Name: 2BLK19 FS60B	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9022
7 Pilot: J Moorey	8 Co-Pilot: D Cabudol	9 Route:			
10 Date: Feb 29 2016	12 Airport of Departure (Airport, City/Province): Legazpi		12 Airport of Arrival (Airport, City/Province): Legazpi		
13 Engine On: 1456	14 Engine Off: 1713	15 Total Engine Time: 2+17	16 Take off: 1501	17 Landing: 1708	18 Total Flight Time: 2+07
19 Weather					

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
- ○ DREAM Admin Activities

21 Remarks

Surveyed Blk 19ES

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
[signature]	BENVIE CERBOLLEDO	[signature]	MS REYES	NA
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

Flight Log for 3843G Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 1197P

1 LiDAR Operator: R. PUNTO	2 ALTM Model: PEG	3 Mission Name:	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9022
7 Pilot: M. TANGONAN	8 Co-Pilot: B. DONGUINES	9 Route:			
10 Date: MAR. 8, 2014	12 Airport of Departure (Airport, City/Province): LA UNION		12 Airport of Arrival (Airport, City/Province): LA UNION		
13 Engine On:	14 Engine Off:	15 Total Engine Time: 2+59	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					
20 Remarks: MISSION SUCCESSFUL					

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Jasmine Alviar	MARLON TORRE	M.L. TANGONAN	PUNTO
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

Annex 7. Flight Status Reports

CALABARZON
(December 22, 2015; January 9, 2016; August 26 - 29, 2016; Sept 4 - 5, 2016)

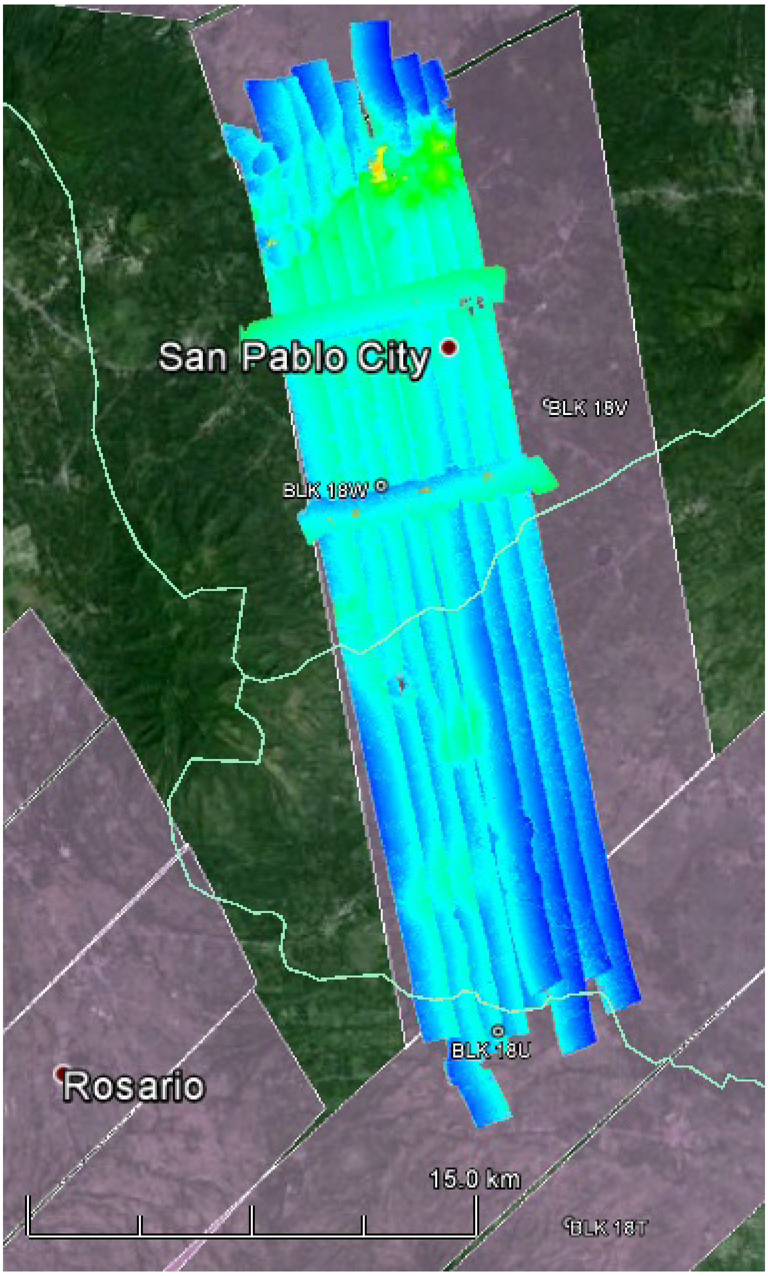
FLIGHT NO	AREA	MISSION	OPERATOR	DATE FLOWN	REMARKS
1091P	BLK 18WV	1BLK18W41A	J. Alviar	Feb 10	Mission completed at 1100m AGL
1095P	BLK 18UT	1BLK18U42A	R. Punto	Feb 11	Data acquired but with major voids due to heavy build up in the area
1099P	BLK 18UTS	1BLK18US43A	R. Punto	Feb 12	Data acquired but with major voids due to heavy build up in the area
1103P	BLK 18VWS	1BLK18VWS44A	J. Alviar	Feb 13	Mission completed in BLK 18V plus covered additional area adjacent to BLK 18W; 1200m Flying height
1105P	BLK 18T	1BLK18T44B	J. Alviar	Feb 13	Mission completed; covered BLK 18T and extended to cover coastline; 1200m flying height
1107P	BLK 18PQ	1BLK18QRS45A	R. Punto	Feb 14	Mission completed; changed orientation of flight plan to avoid PAF base restriction in Lipa; 1200m flying height
1109P	BLK 18UTS	1BLK18US45B	J. Alviar	Feb 14	Mission completed; covered remaining voids in BLK 18US at 1200m flying height
1111P	BLK 18QR and 18ES	1BLK18RS46A	F. Sable	Feb 15	Data acquired but aborted mission due to strong wind, heavy build up and traffic especially in Laguna area; 1200m flying height
1125P	BLK 18OS	1BLK18S49B	R. Punto	Feb 18	Data acquired at 1200m flying height
3002P	BLK 18SABEK TANAUAN, MALVAR, TALISAY	1BLK18S356A	J ALVIAR	22-Dec-15	SURVEYED BLK 18SABEK
3341P	BLK 18AbS	1BLK18AbS238A	KJ ANDAYA	26-Aug-15	Voids due to low cloud ceiling Lines cut due to army base restriction Without Digitizer and Camera
3343P	BLK 18AcS	1BLK18AcS238B	G. SINADJAN	26-Aug-15	Supplementary flight, area completed Without Digitizer and Camera
3345P	BLK 18TS	1BLK18TS239A	LK PARAGAS	27-Aug-15	Calibration flight Experienced POSAV error Without Digitizer and Camera

3347P	BLK 18TS	1BLK18TS239B	G. SINADJAN	27-Aug-15	Finished area TS Hazy with precipitation at the end of survey Without Digitizer and Camera
3353P	QRS	1BLK18QRS241A	MR VILLANUEVA	29-Aug-15	Mission Completed Without Digitizer and Camera
3377P	BLK 18JS	1BLK18JS247A	G. SINADJAN	4-Sept-15	Laser off due to Clouds Line cut due to low visibility on terrain Without Digitizer and Camera
3381P	BLK 18OS	1BLK18OS248A	I. ROXAS	5-Sept-15	Line cut due to heavy cloud buildup Without Digitizer and Camera
3689G	BLK 18SAB LIPA, SAN JOSE	2BLK18SBC363A	R PUNTO	9-Jan-16	SURVEYED BLK 21AB

LAS/SWATH BOUNDARIES PER FLIGHT

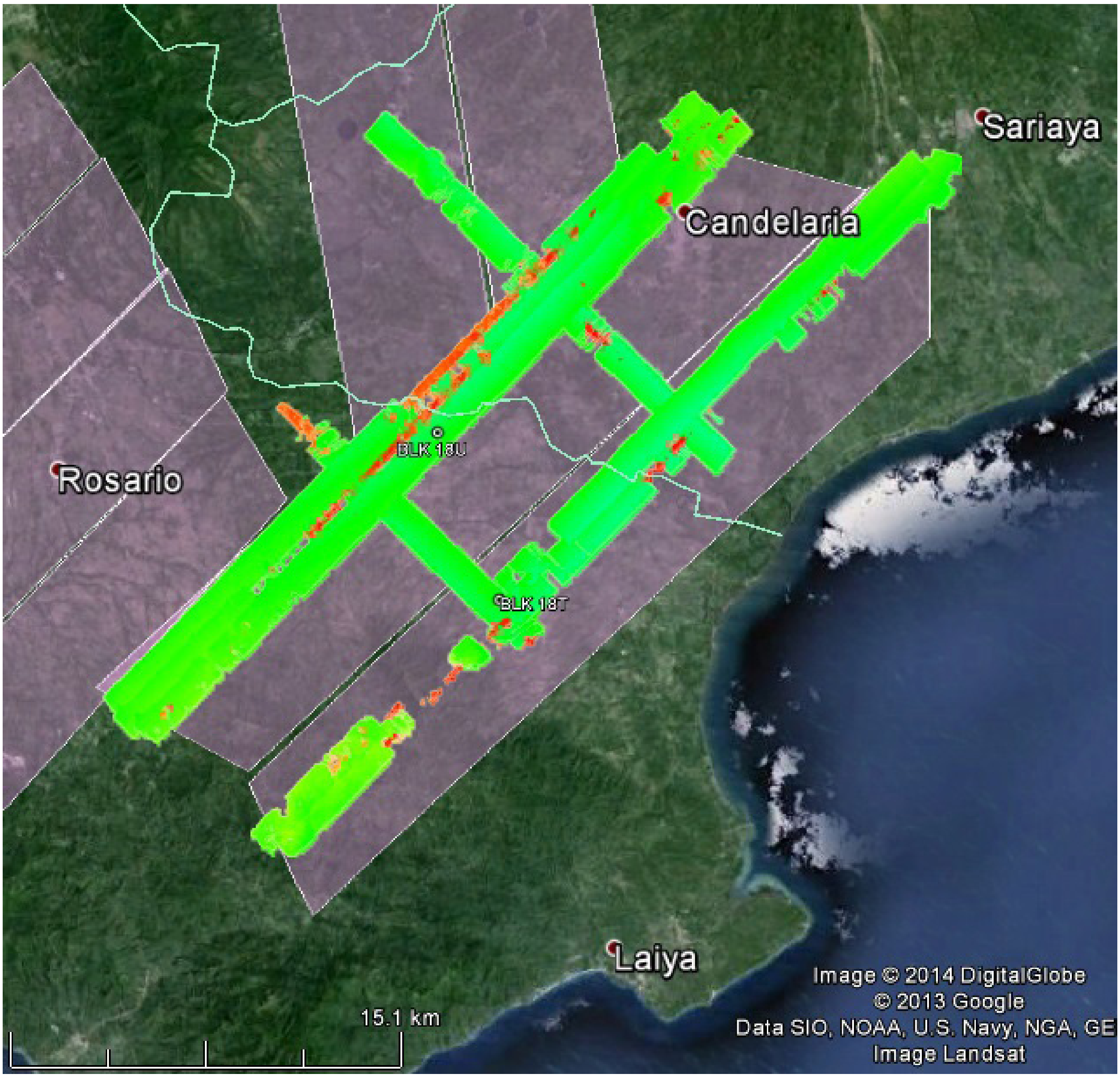
Flight No. : 1091P
Area: BLK 18WV
Mission Name: 1BLK18W41A

LAS



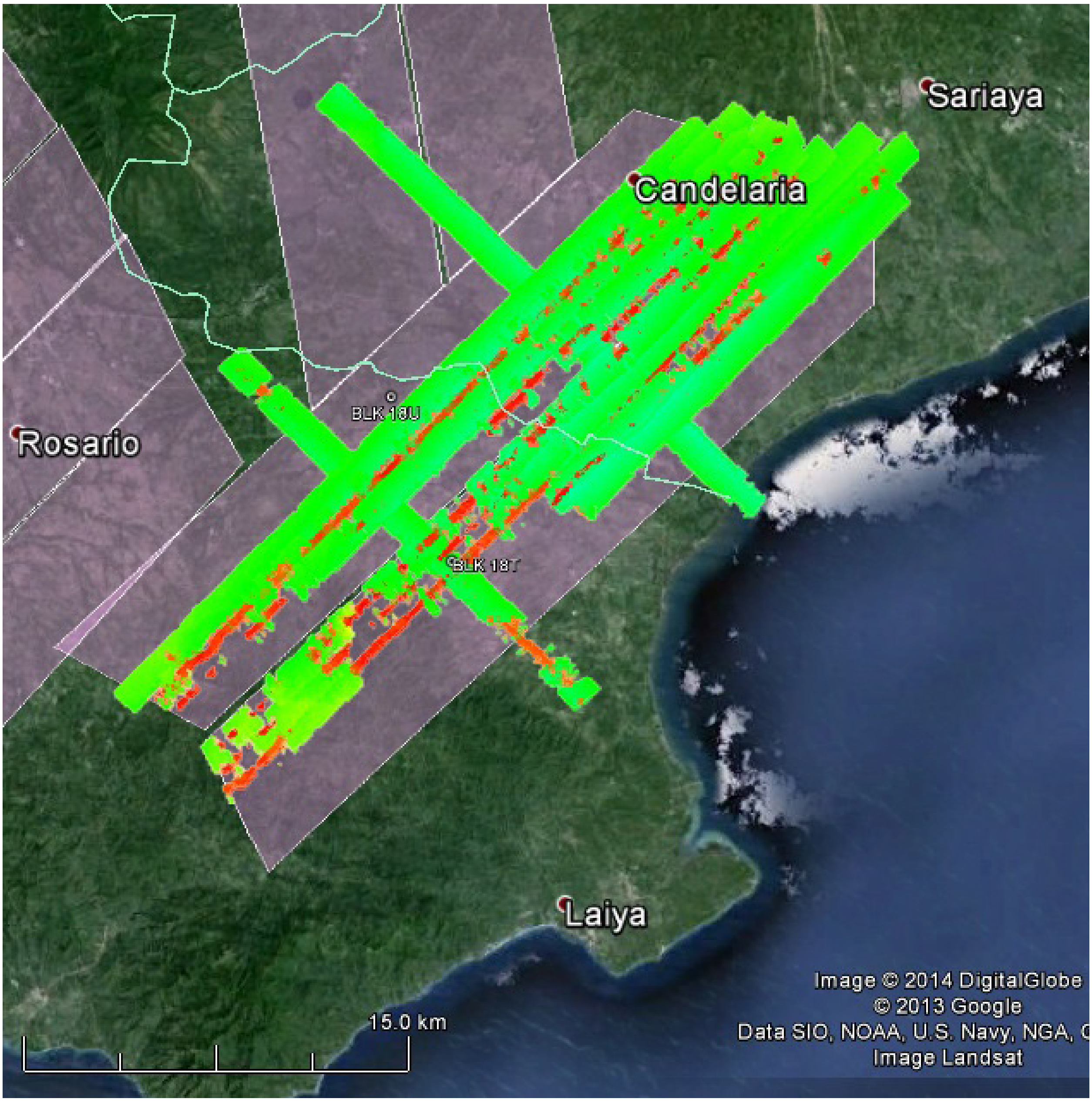
Flight No. : 1095P
Area: BLK 18UT
Mission Name: 1BLK18U42A

LAS



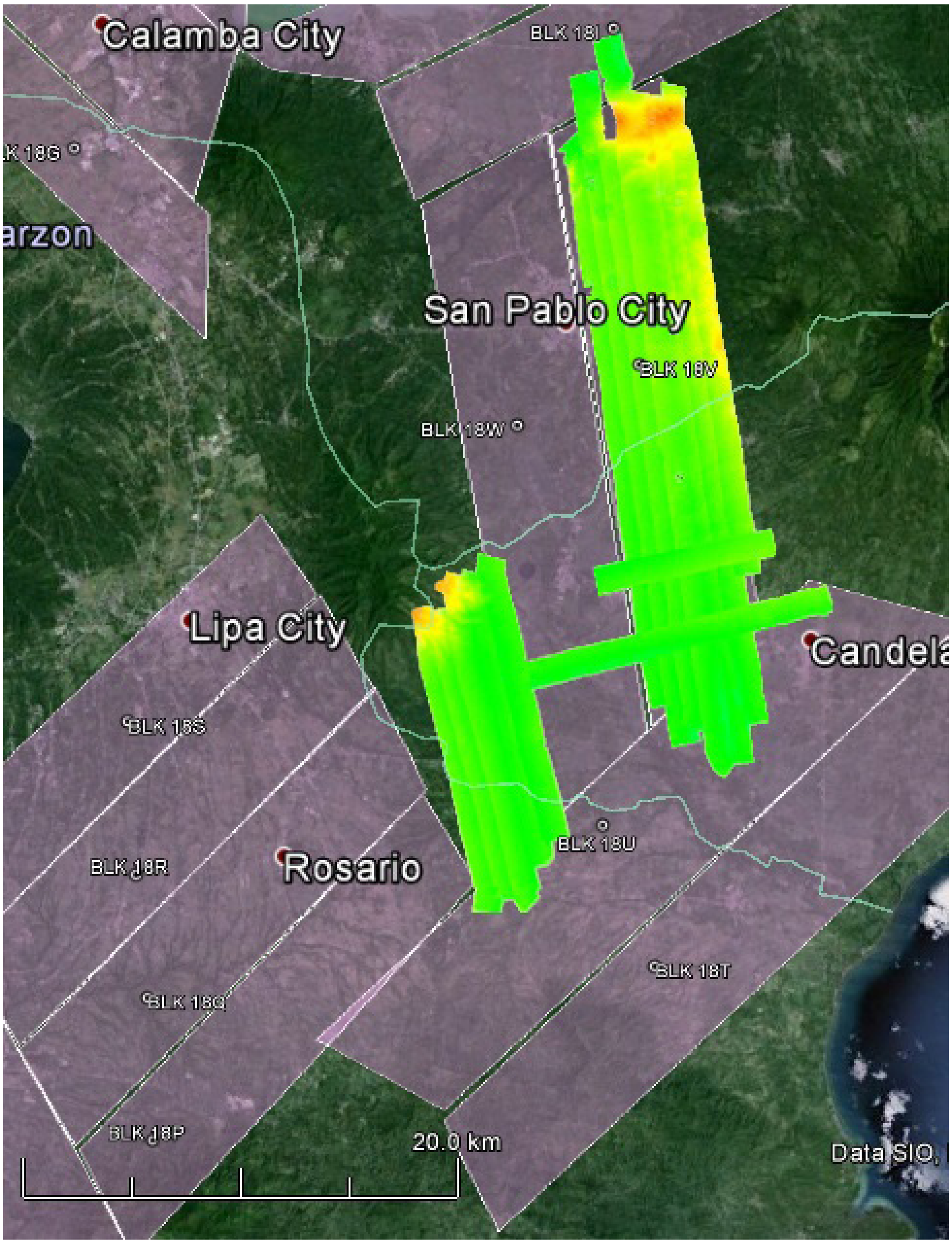
Flight No. : 1099P
Area: BLK 18UTS
Mission Name: 1BLK18US43A

LAS



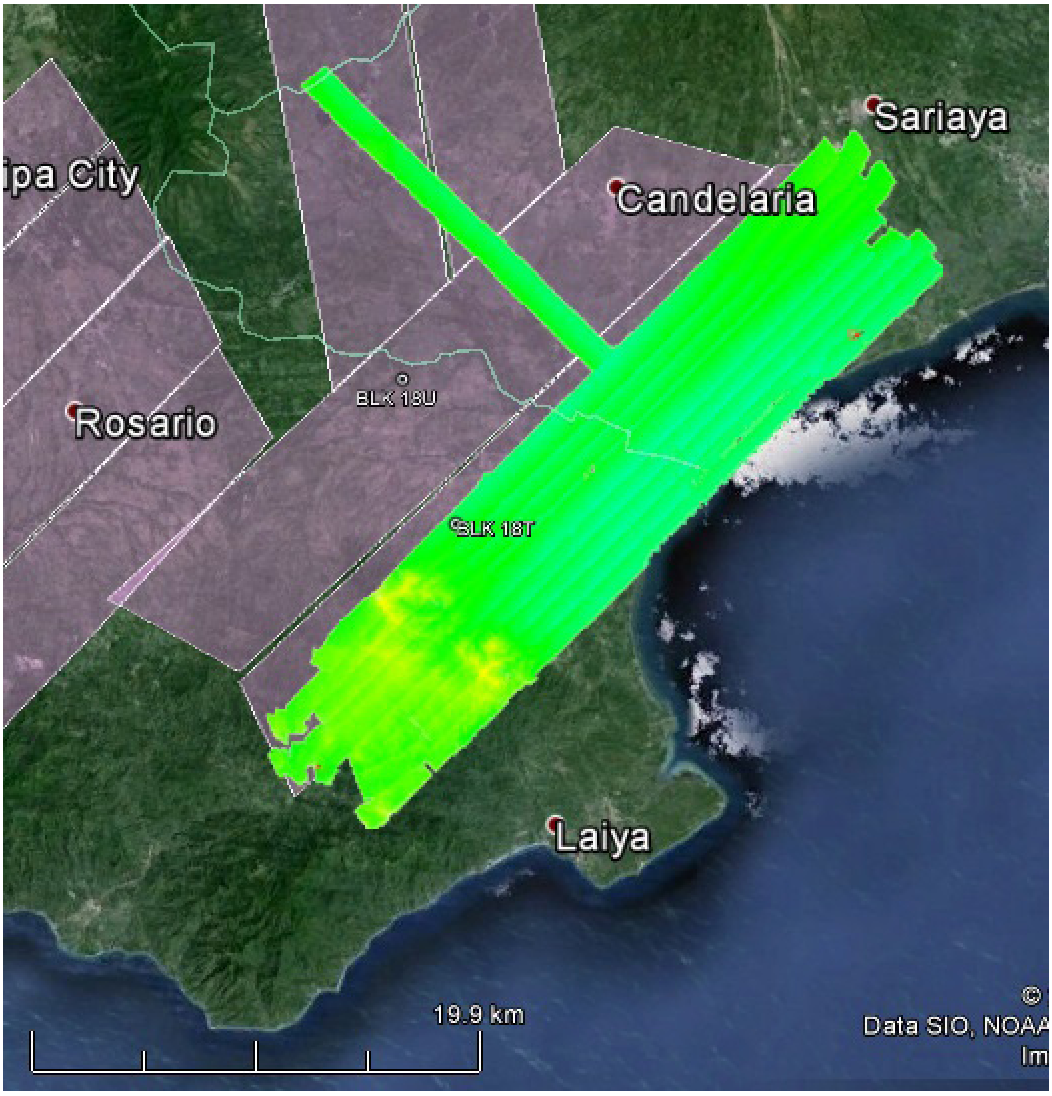
Flight No. : 1103P
Area: BLK 18VWS
Mission Name: 1BLK18VWS44A

LAS



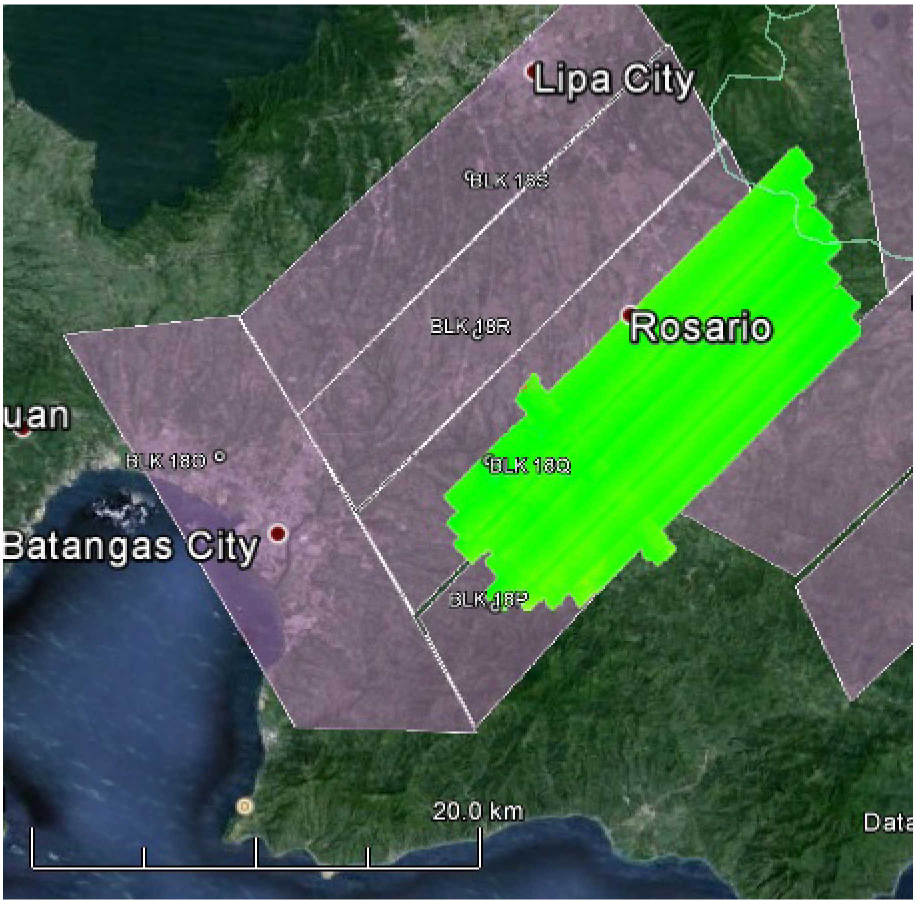
Flight No. : 1105P
Area: BLK 18T
Mission Name: 1BLK18TS44B

LAS



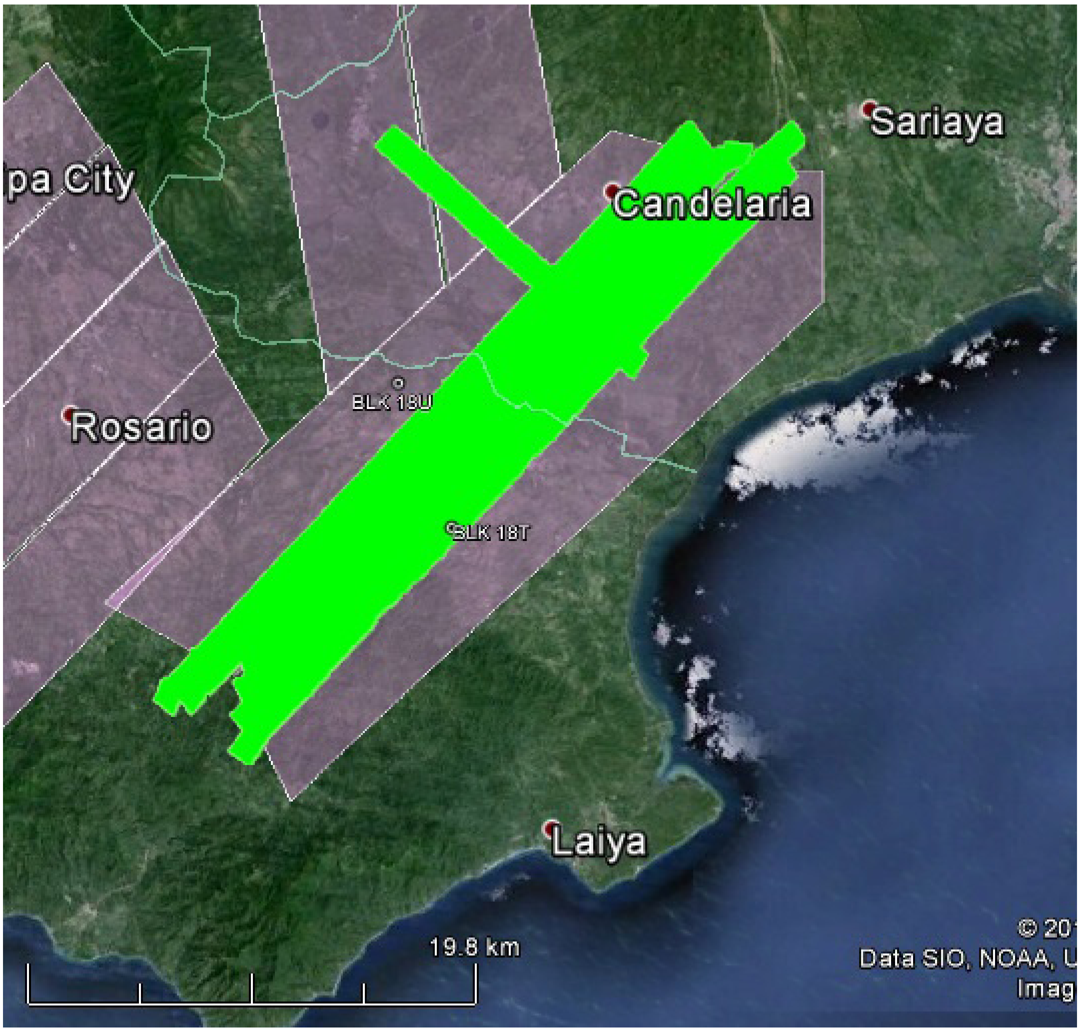
Flight No. : 1107P
Area: BLK 18PQ
Mission Name: 1BLK18QRS45A

LAS



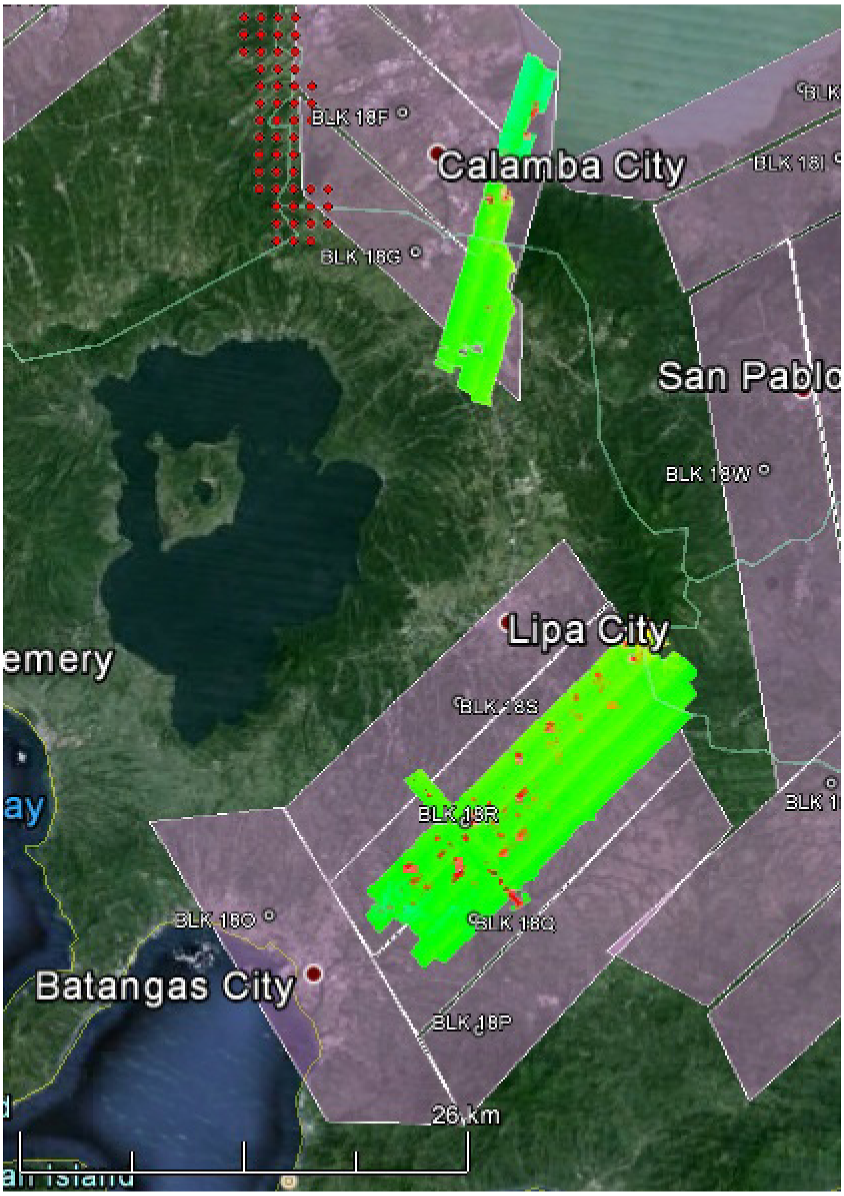
Flight No. : 1109P
Area: BLK 18UTS
Mission Name: 1BLK18US45B

LAS



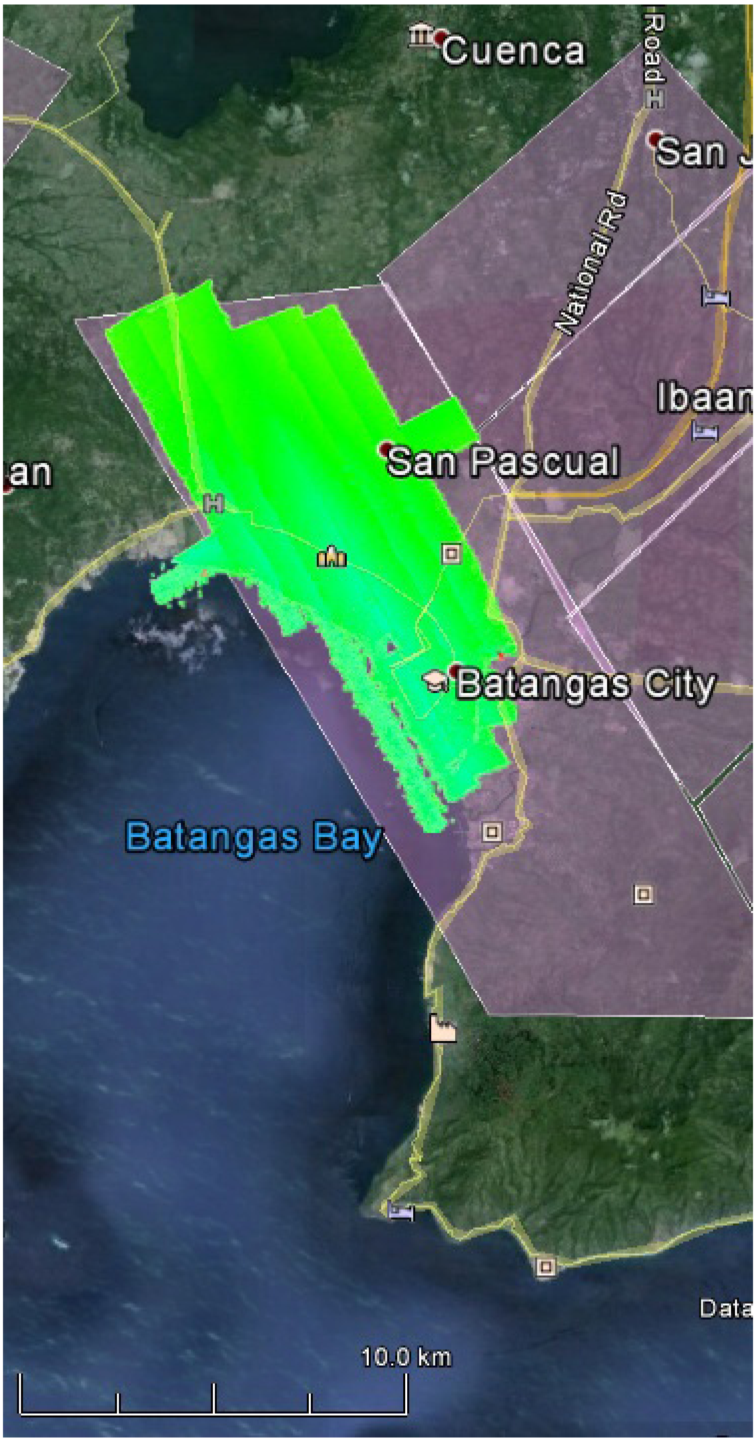
Flight No. : 1111P
Area: BLK 18RS AND BLK 18ES
Mission Name: 1BLK18RS46A

LAS



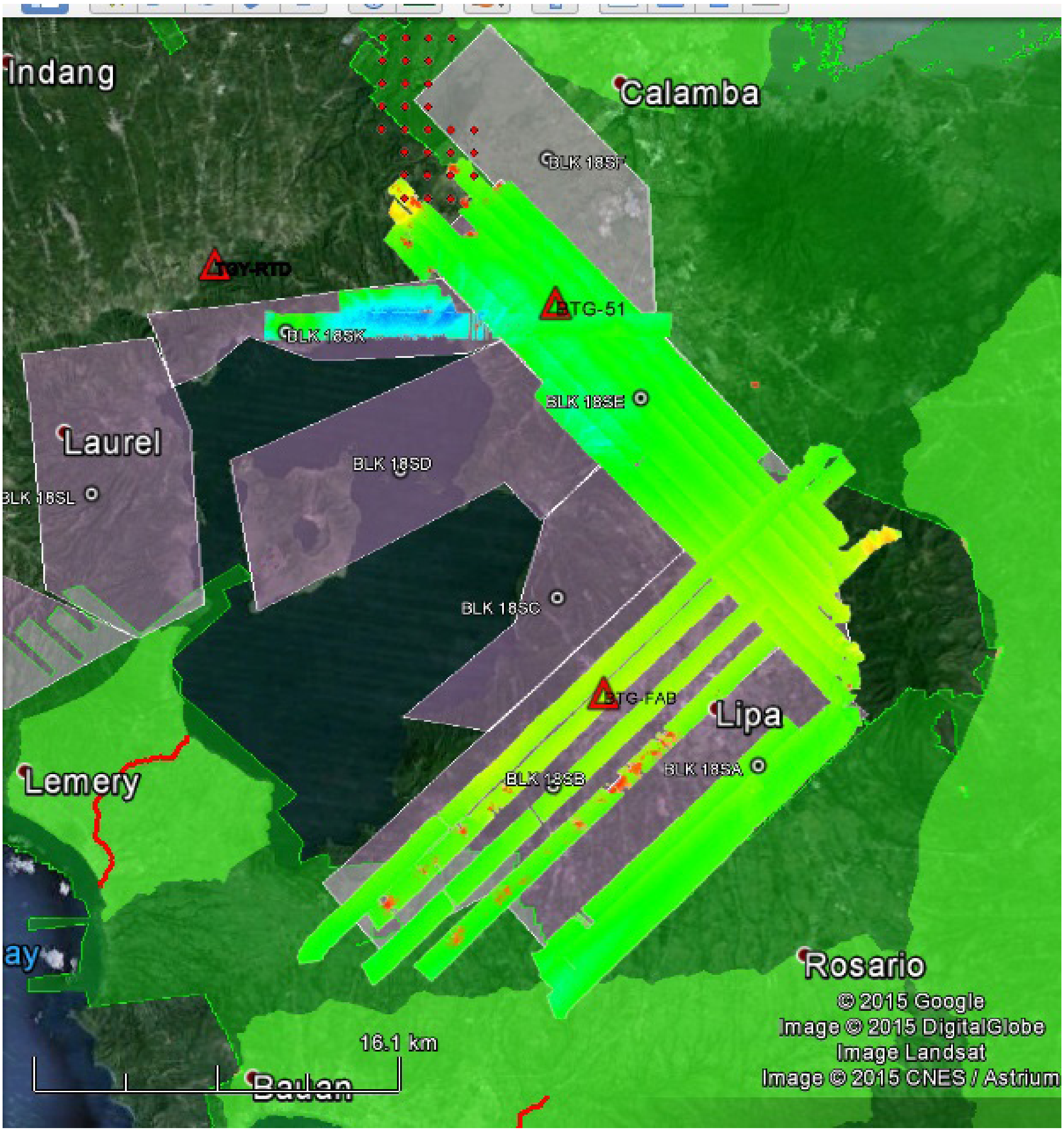
Flight No. : 1125P
Area: BLK 18Os
Mission Name: 1BLK18OS49B

LAS



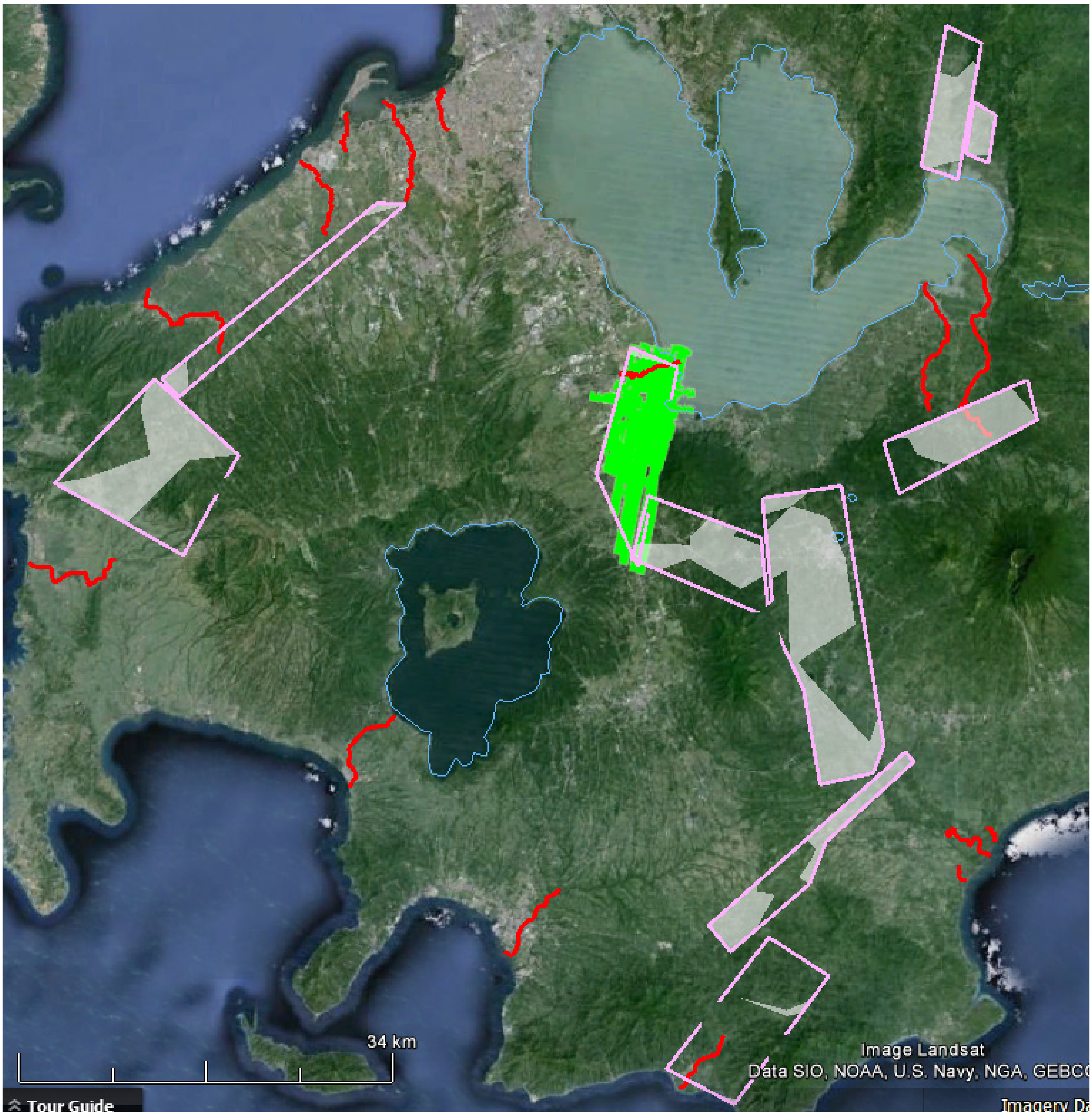
Flight No. :	3002P	
Area:	BLK 18SABEK	
Mission Name:	1BLK18S356A	
Parameters:	PRF: 200 kHz;	Scan Frequency: 30 Hz; FOV: 50 deg;

LAS/SWATH



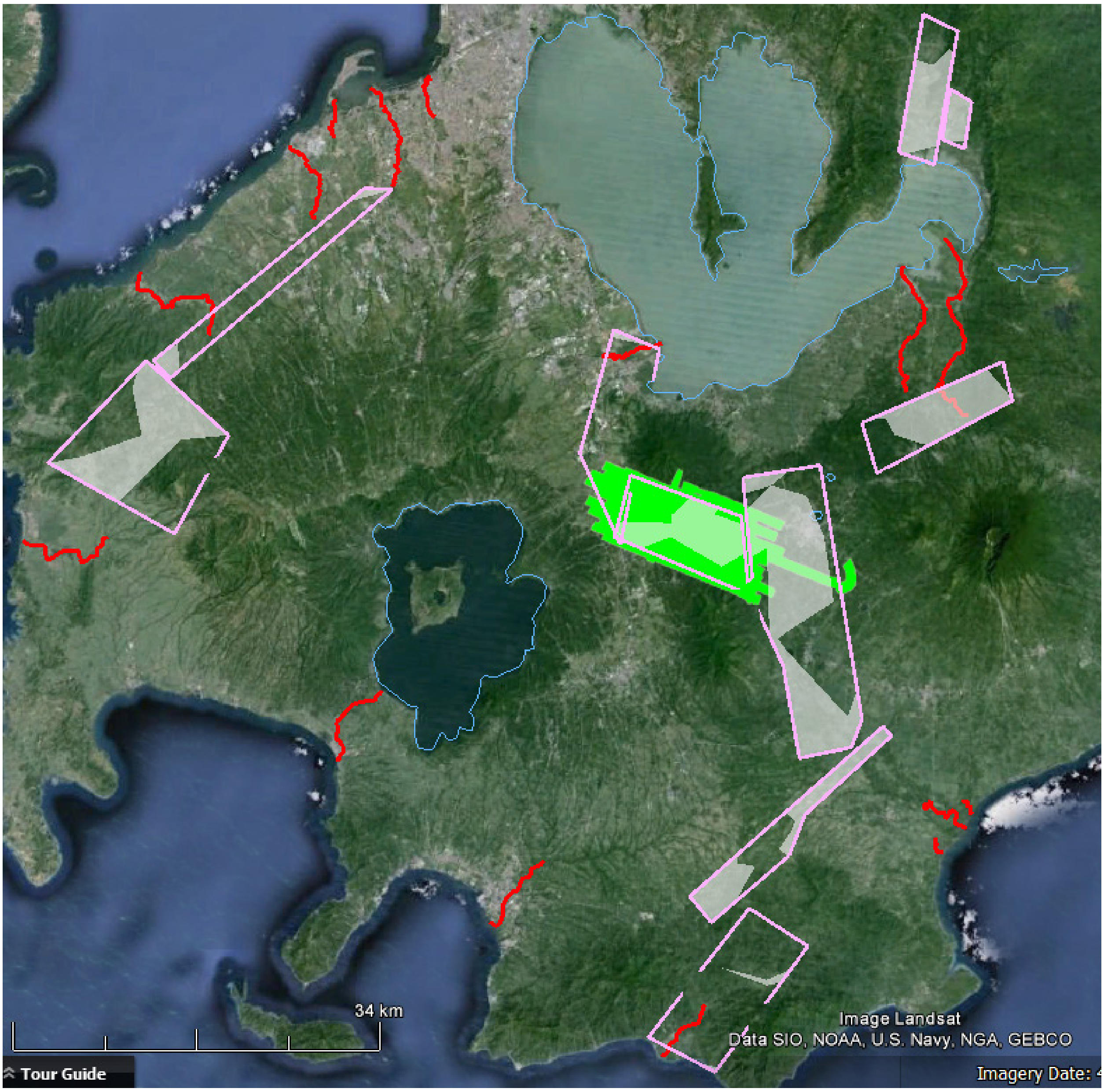
Flight No. :	3341P	
Area:	BLK 18AbS	
Mission Name:	1BLK18AbS238A	
Parameters:	PRF: 200 kHz;	Scan Frequency: 30 Hz; FOV: 50 deg;

LAS/SWATH



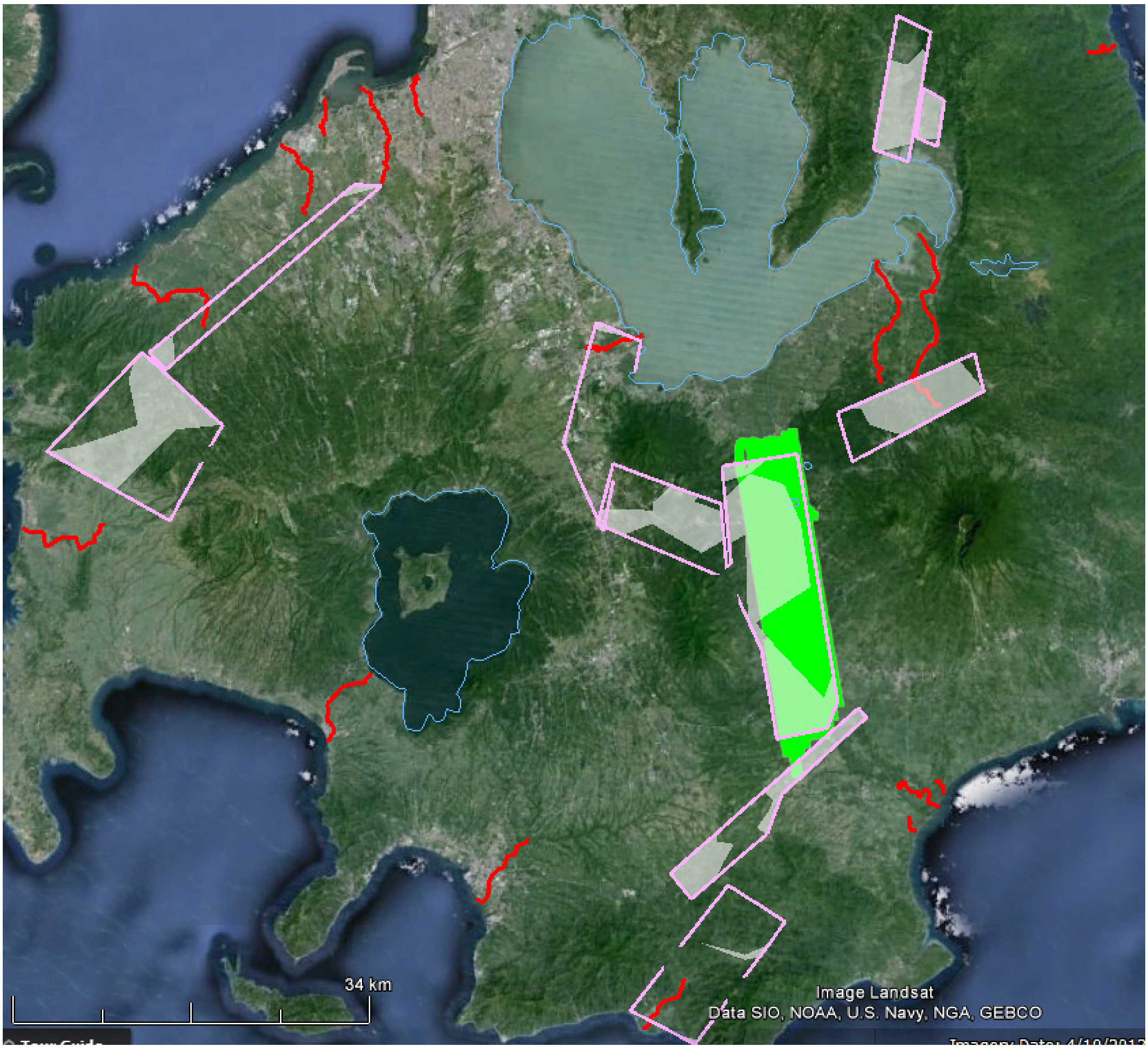
Flight No. :	3343P	
Area:	BLK 18AcS	
Mission Name:	1BLK18AcS238B	
Parameters:	PRF: 200 kHz;	Scan Frequency: 30 Hz; FOV: 50 deg;

LAS/SWATH



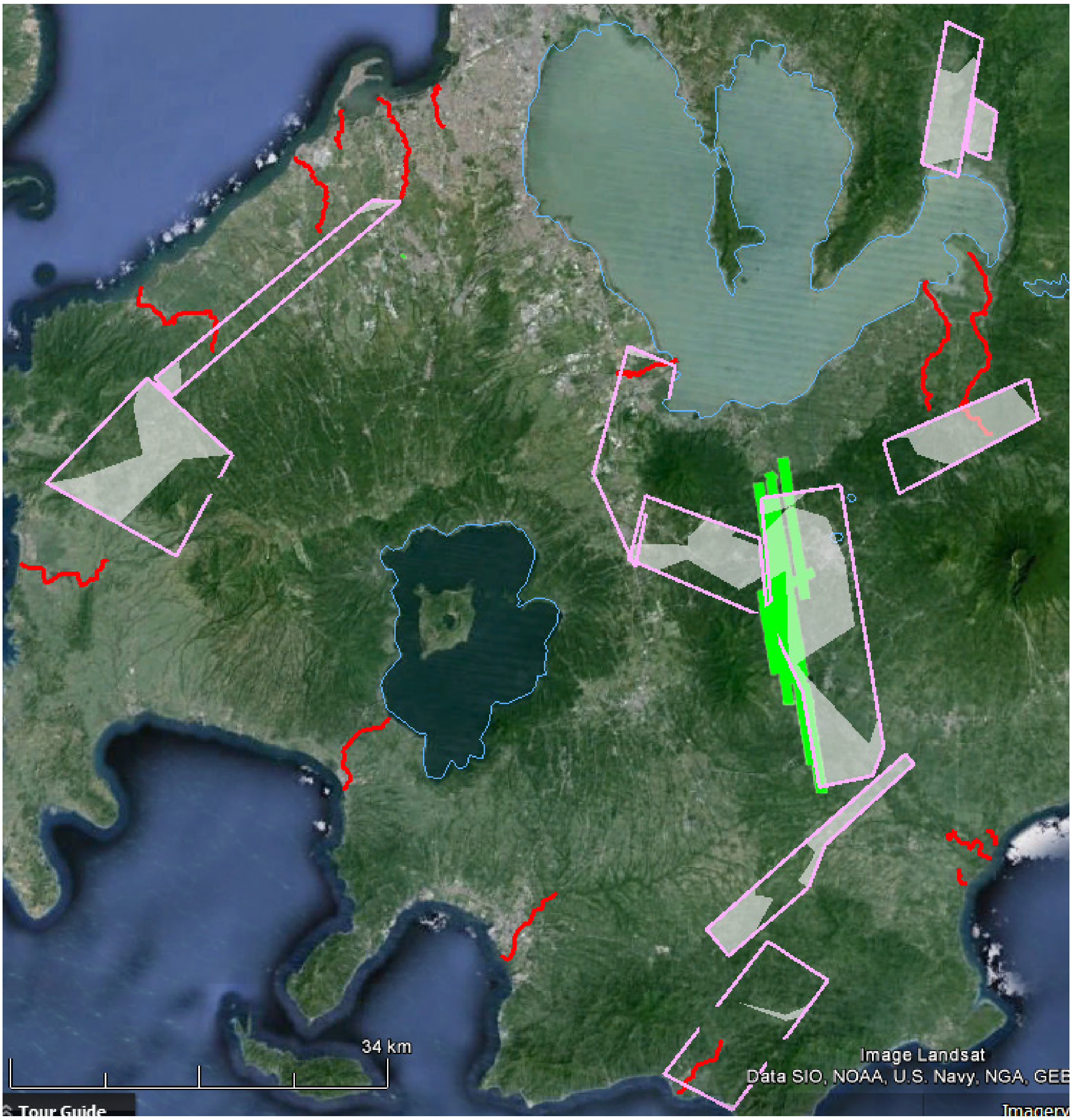
Flight No. :	3345P	
Area:	BLK 18W	
Mission Name:	1BLK18TS239A	
Parameters:	PRF: 200 kHz;	Scan Frequency: 30 Hz; FOV: 50 deg;

LAS/SWATH



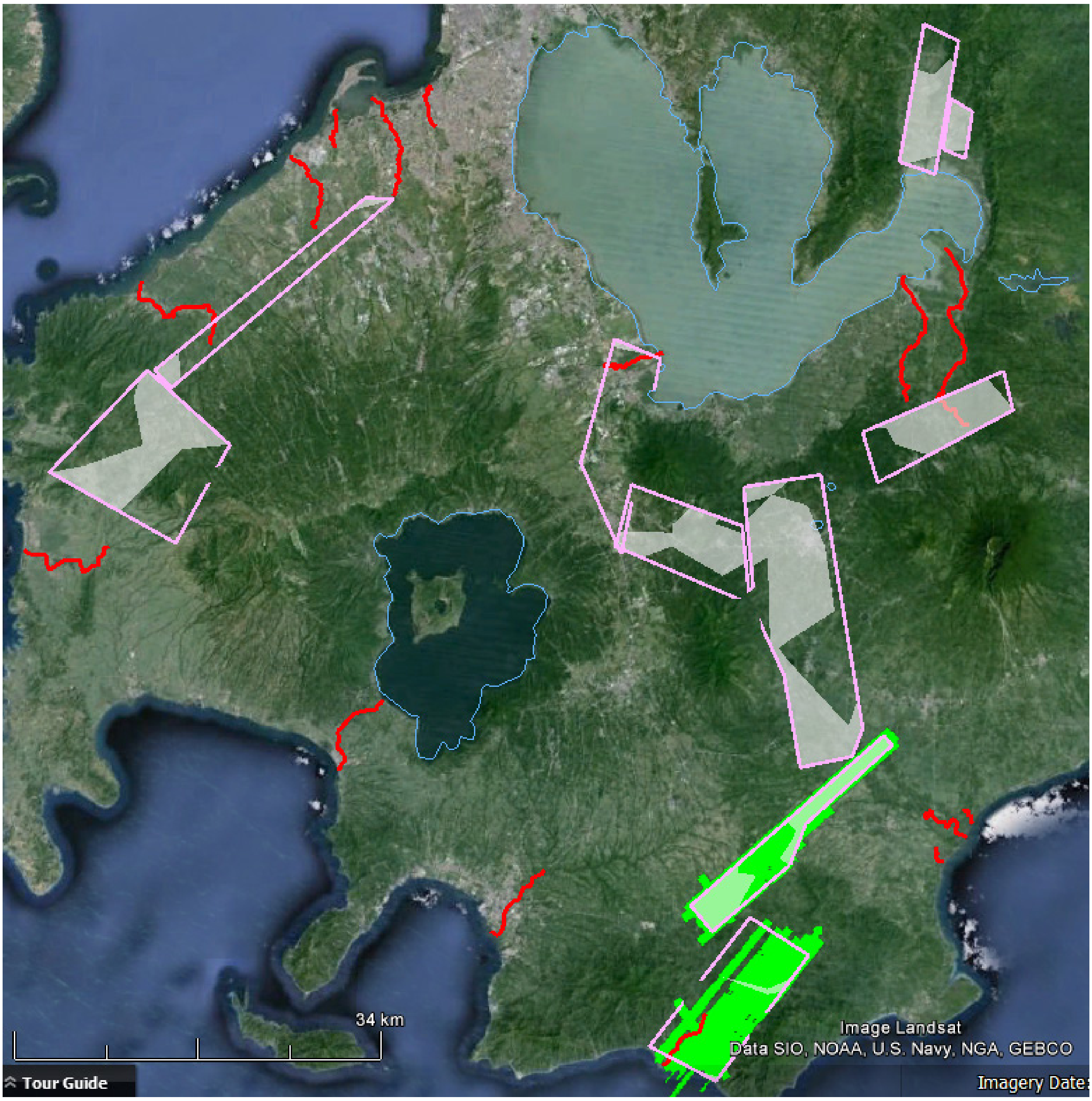
Flight No. :	3347P
Area:	BLK 18TS
Mission Name:	1BLK18TS239B
Parameters:	PRF: 200 kHz; Scan Frequency: 30 Hz; FOV: 50 deg;

LAS/SWATH



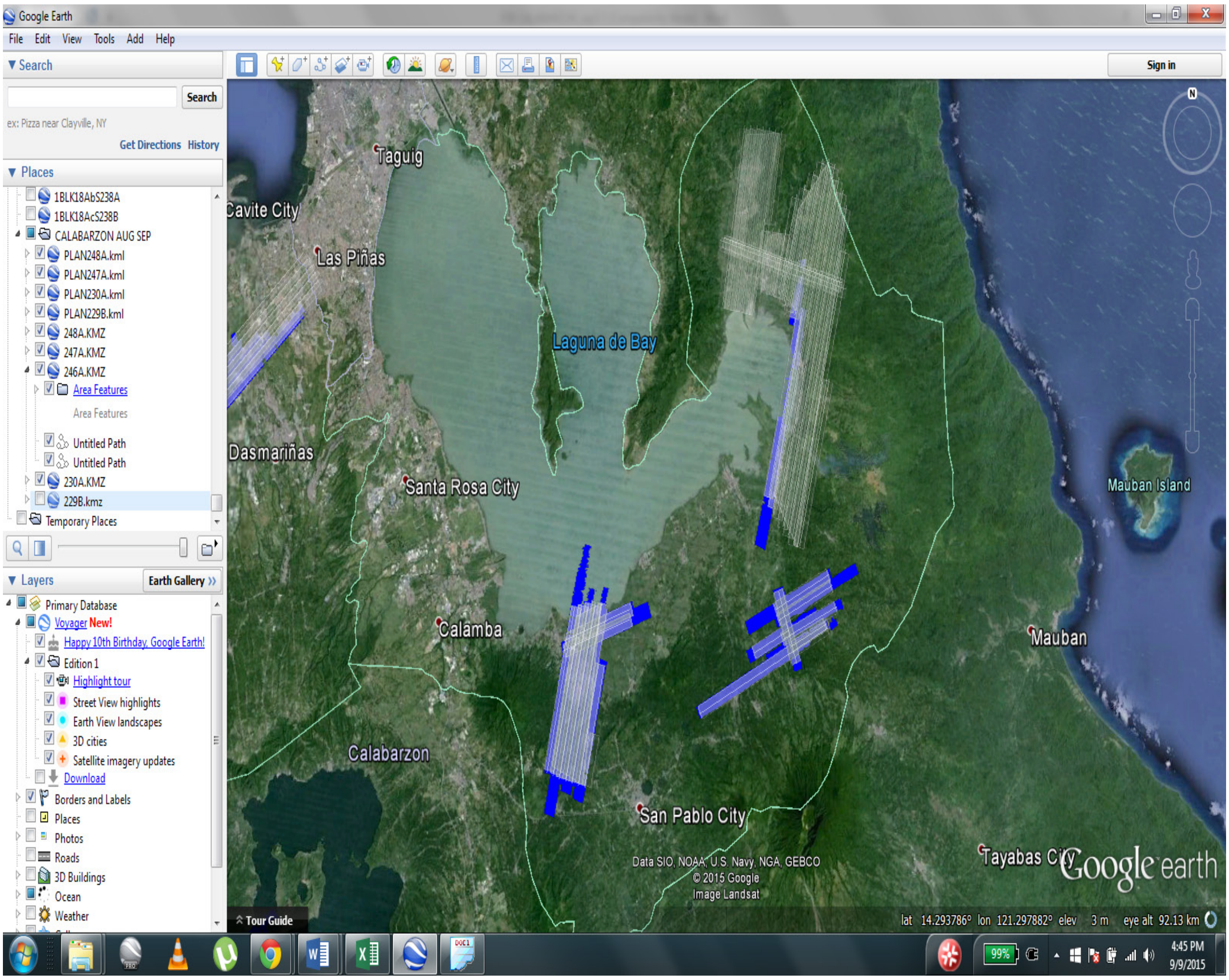
Flight No. :	3353P	
Area:	QRS	
Mission Name:	1BLK18QRS241A	
Parameters:	PRF: 200 kHz;	Scan Frequency: 30 Hz; FOV: 50 deg;

LAS/SWATH



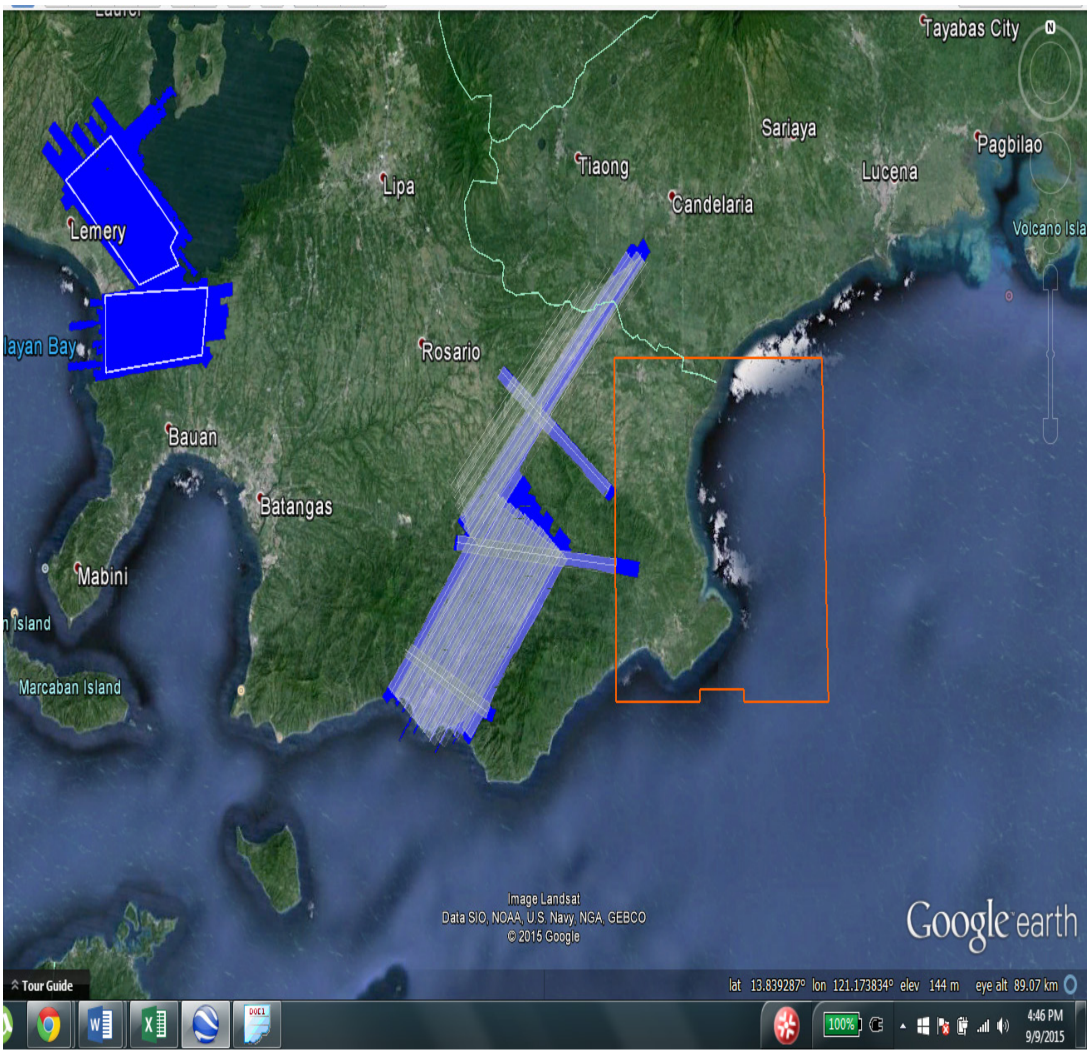
Flight No. : 3377P
Area: BLK
Mission Name: 1BLK18JS247A
Parameters: PRF: 200 kHz; Scan Frequency: 30 Hz; FOV: 50 deg;

LAS/SWATH



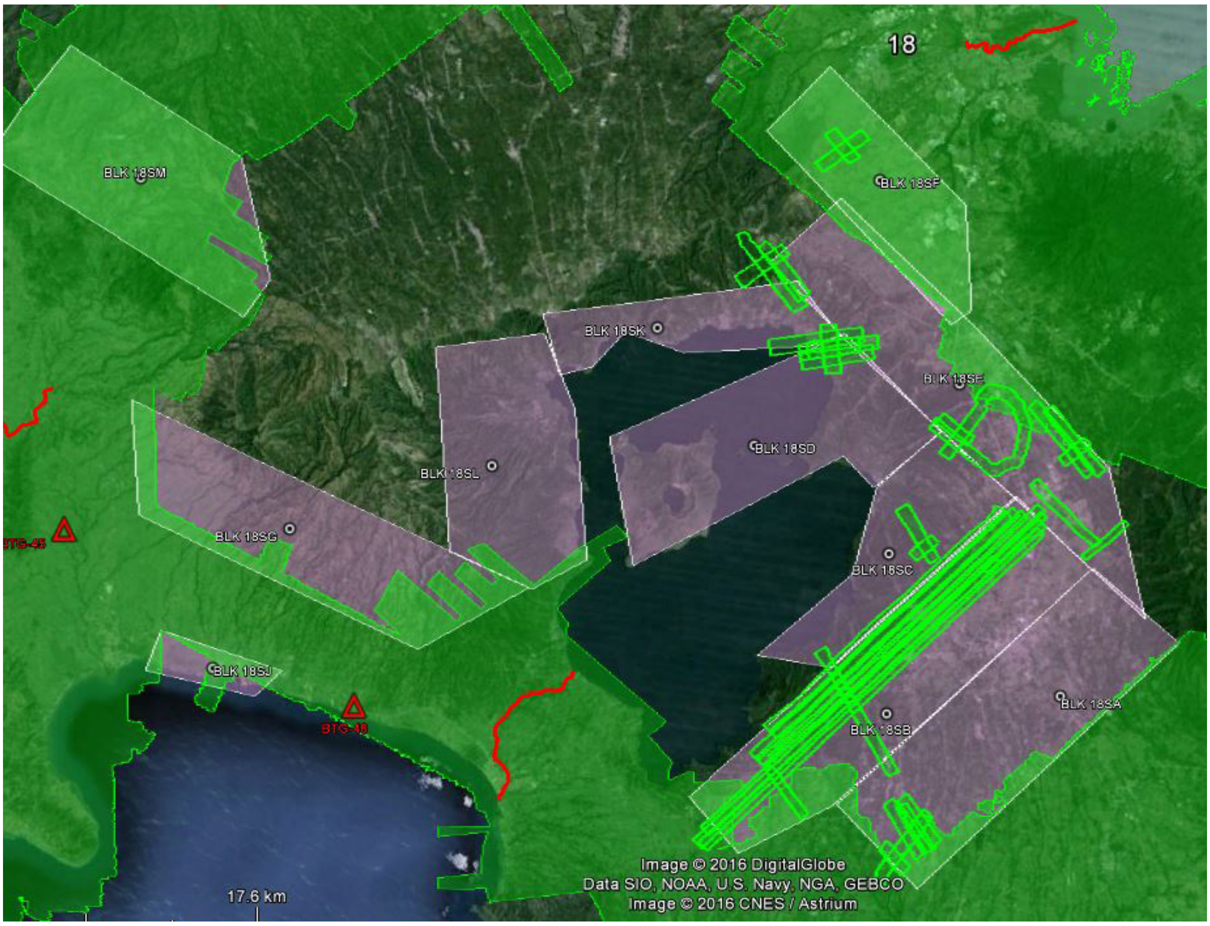
Flight No. : 3381P
Area: BLK 18
Mission Name: 1BLK18OS248A
Parameters: PRF: 200 kHz; Scan Frequency: 30 Hz; FOV: 50 deg;

LAS/SWATH



Flight No. :	3689G				
Area:	GAPS IN BLK 18KDBEF				
Mission Name:	2BLK18SV009A				
Parameters:	PRF 142	SF	40	FOV	50

SWATH



Annex 8. Mission Summary Report

Flight Area	Calabarzon
Mission Name	**Blk 18A_additional**
Inclusive Flights	3377P
Range data size	13.4 GB
POS	196 MB
Base data size	6.43 MB
Image	NA
Transfer date	September 4, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.53
RMSE for East Position (<4.0 cm)	2.14
RMSE for Down Position (<8.0 cm)	3.00
Boresight correction stdev (<0.001deg)	0.000301
IMU attitude correction stdev (<0.001deg)	0.012698
GPS position stdev (<0.01m)	0.0029
Minimum % overlap (>25)	36.35
Ave point cloud density per sq.m. (>2.0)	2.33
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	168
Maximum Height	501.78 m
Minimum Height	38.87 m
Classification (# of points)	
Ground	111,360,106
Low vegetation	60,609,921
Medium vegetation	75,433,878
High vegetation	151,436,855
Building	13,069,991
Orthophoto	No
Processed by	Engr. Irish Cortez, Engr. Edgardo Gubatanga Jr., Engr. Monalyne Rabino

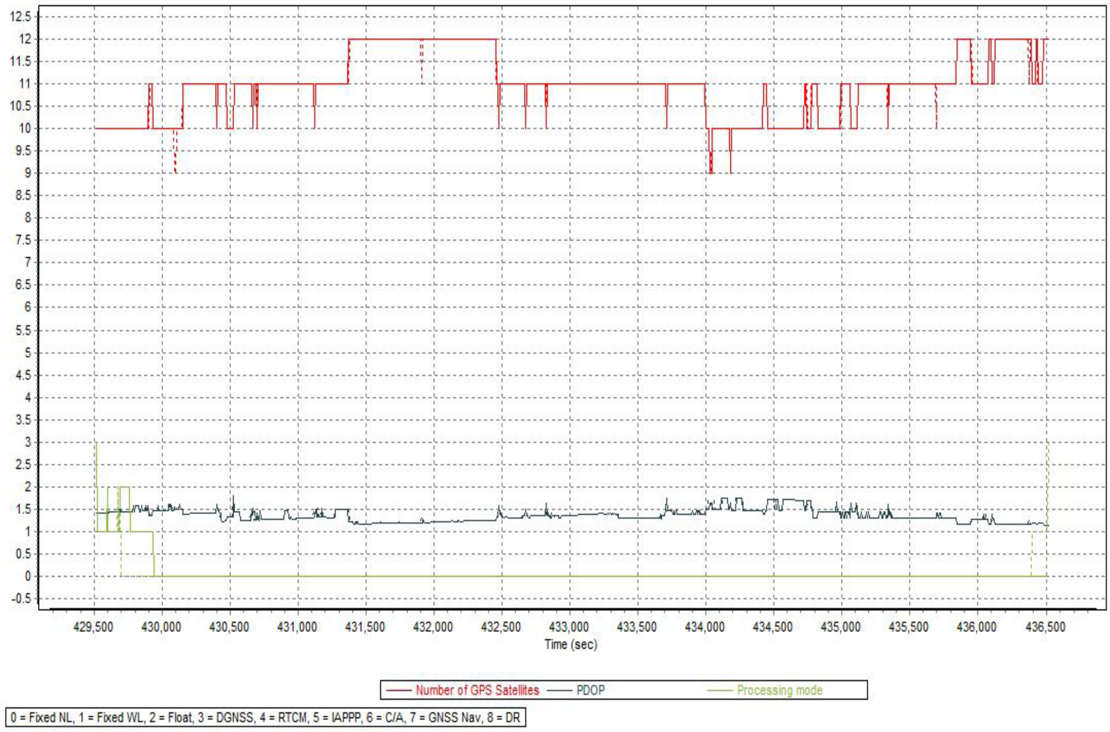


Figure 1.1.1 Solution Status

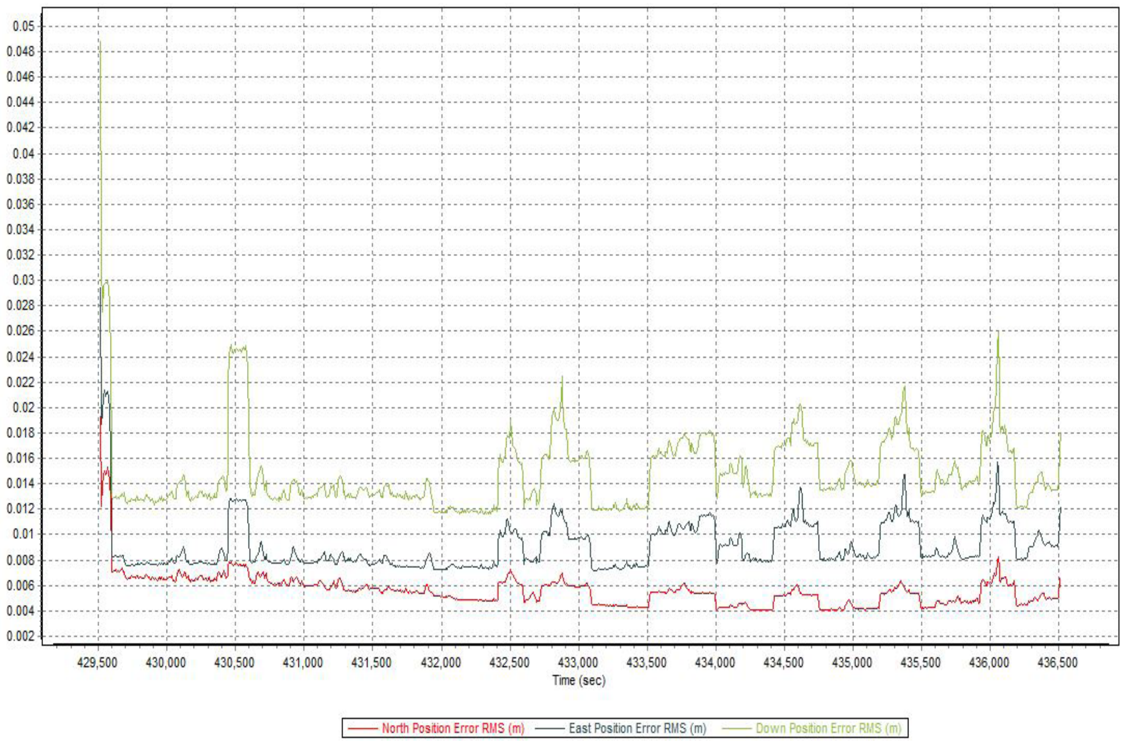


Figure 1.1.2 Smoothed Performance Metric Parameters

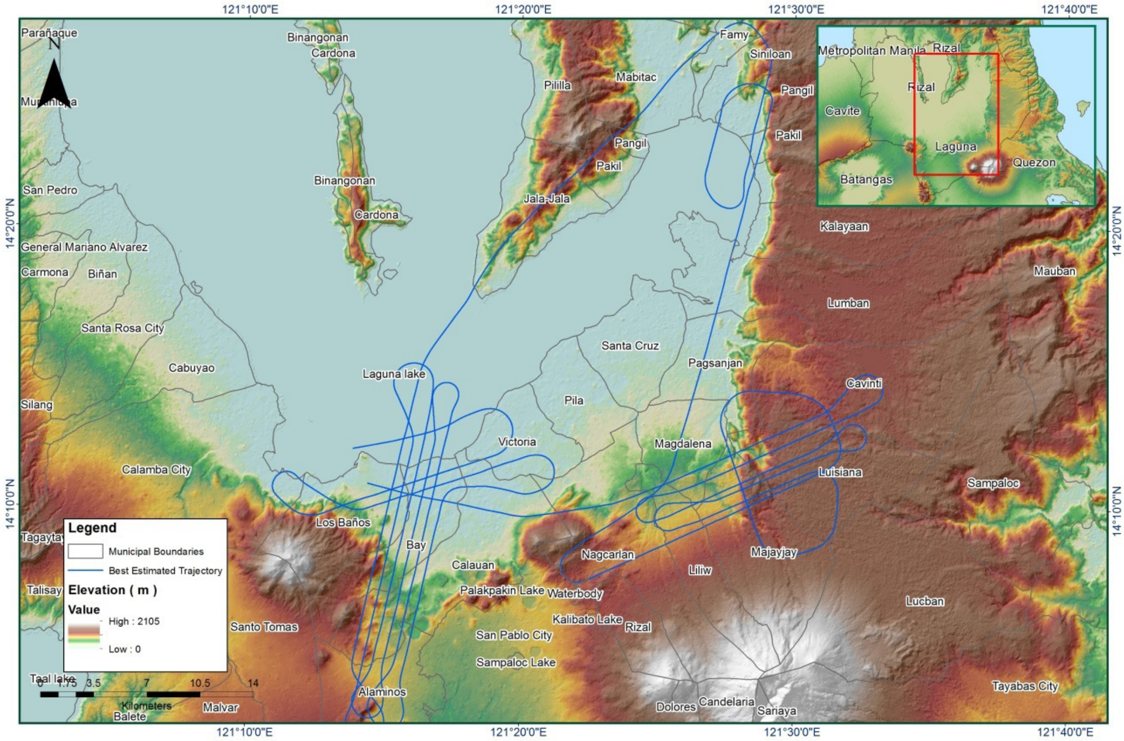


Figure 1.1.3 Best Estimated Trajectory

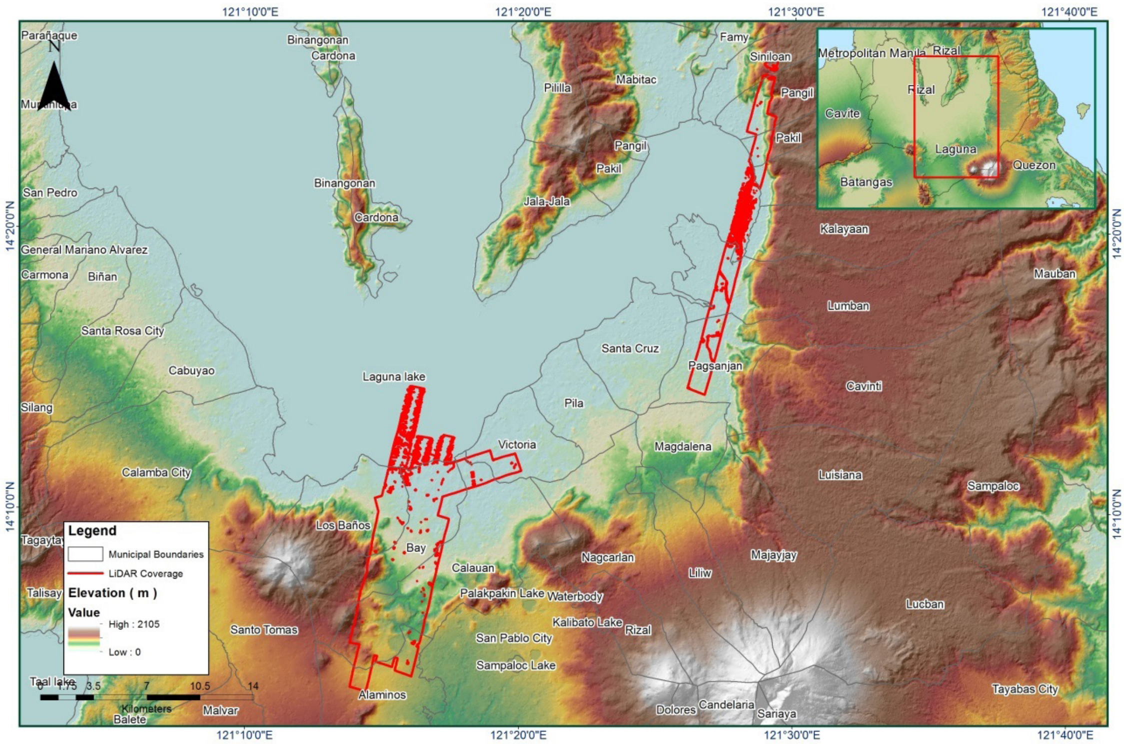


Figure 1.1.4 Coverage of LiDAR data

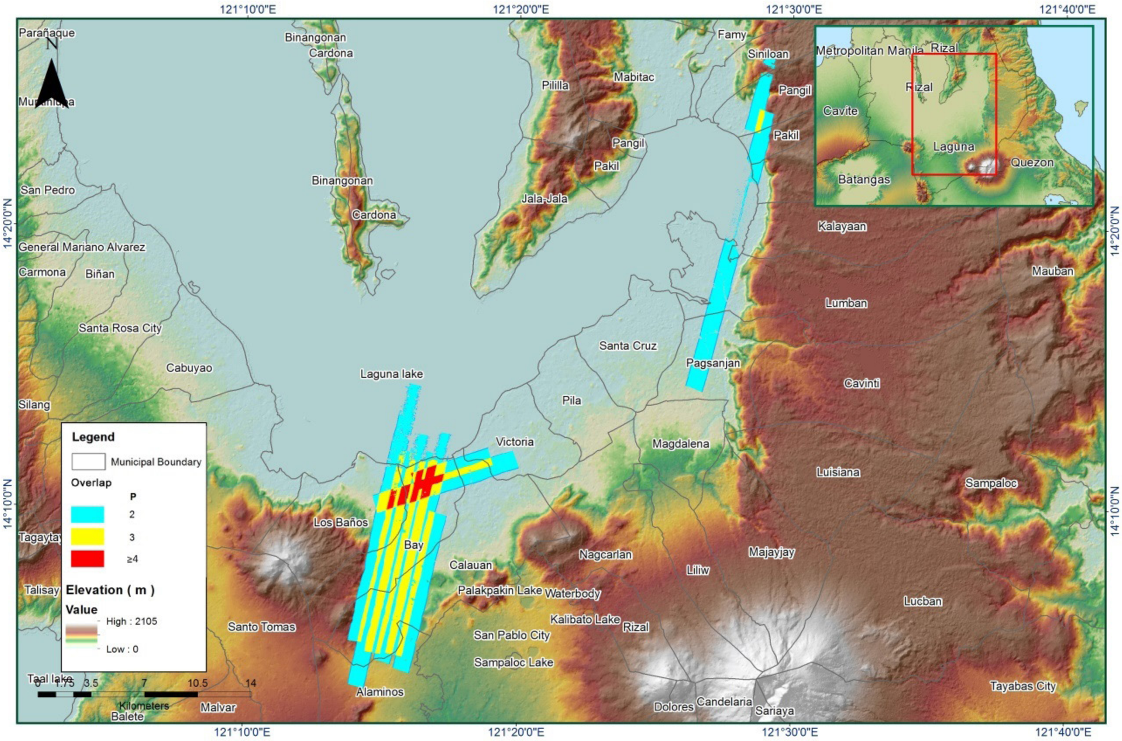


Figure 1.1.5 Image of data overlap

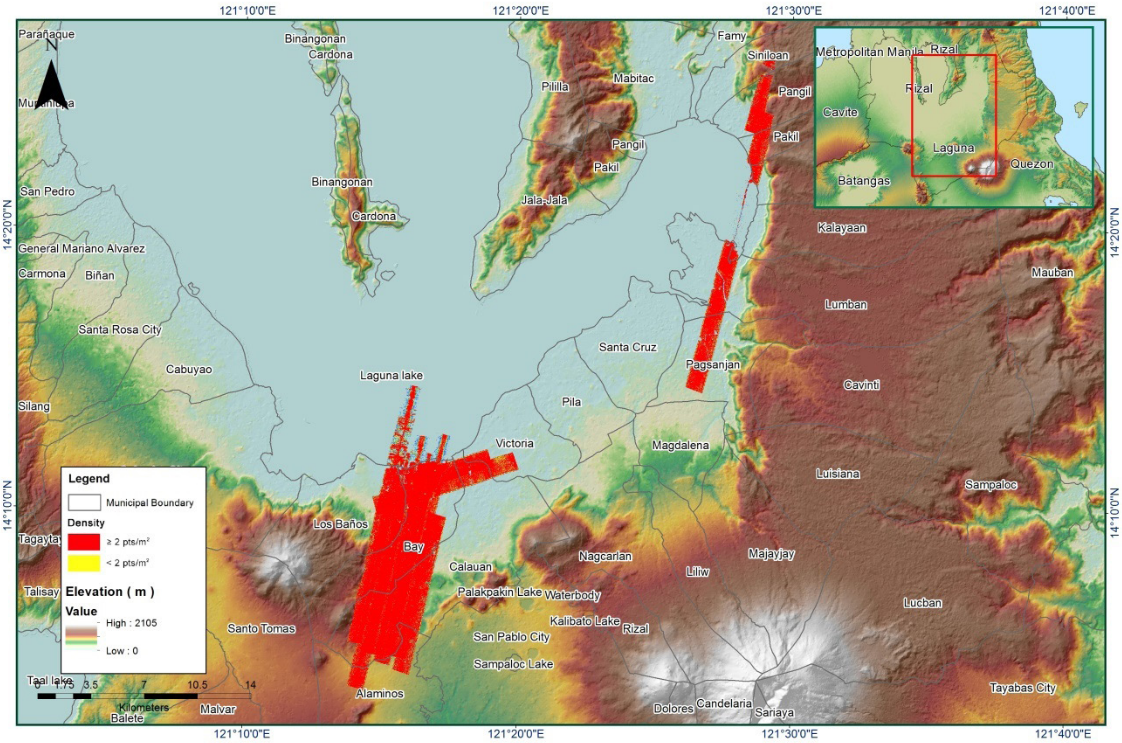


Figure 1.1.6 Density map of merged LiDAR data

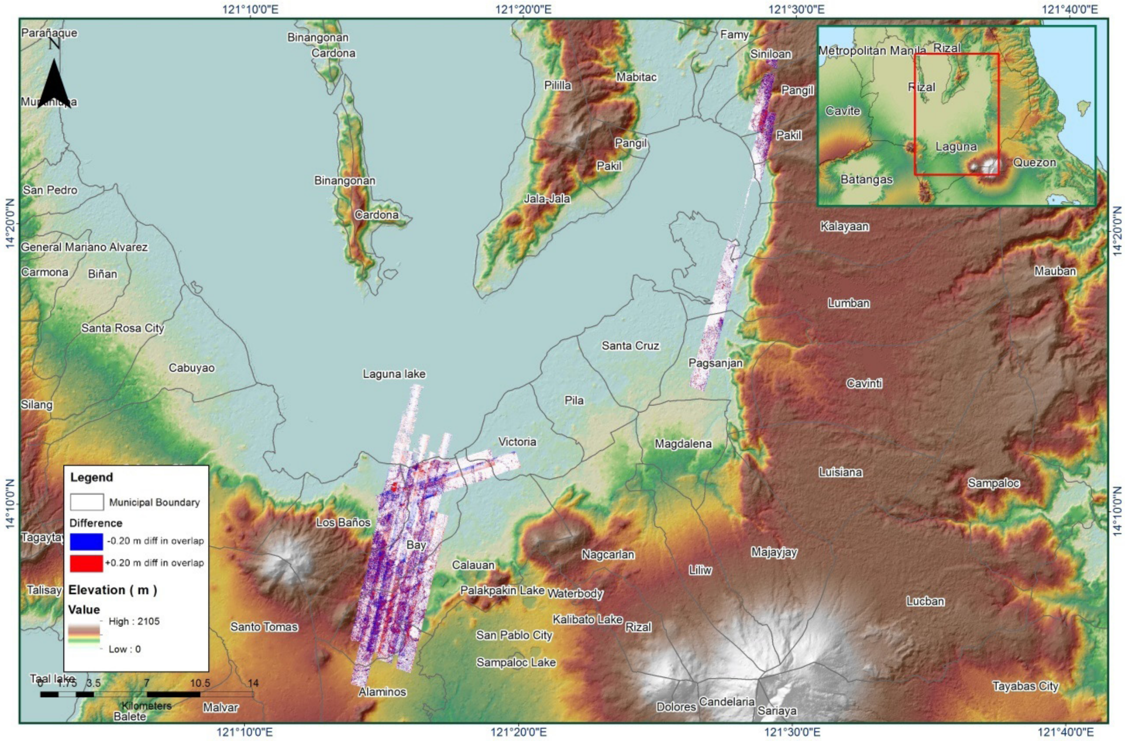


Figure 1.1.7 Elevation difference between flight lines

Flight Area	**CALABARZON**
Mission Name	**Blk18W_additional**
Inclusive Flights	3345P, 3347P
Range data size	32.35 GB
POS	329 MB
Image	N/A
Transfer date	9/8/2015
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)	1.6
RMSE for East Position (<4.0 cm)	1.7
RMSE for Down Position (<8.0 cm)	2.8
Boresight correction stdev (<0.001deg)	0.000210
IMU attitude correction stdev (<0.001deg)	0.000571
GPS position stdev (<0.01m)	0.0017
Minimum % overlap (>25)	51.19%
Ave point cloud density per sq.m. (>2.0)	3.19
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	310
Maximum Height	559.57 m
Minimum Height	59.37 m
Classification (# of points)	
Ground	255,896,595
Low vegetation	250,448,090
Medium vegetation	363,614,645
High vegetation	276,078,698
Building	39,501,449
Orthophoto	No
Processed by	Engr. Sheila-Maye Santillan, Engr. Chelou Prado, Engr. Melissa Fernandez

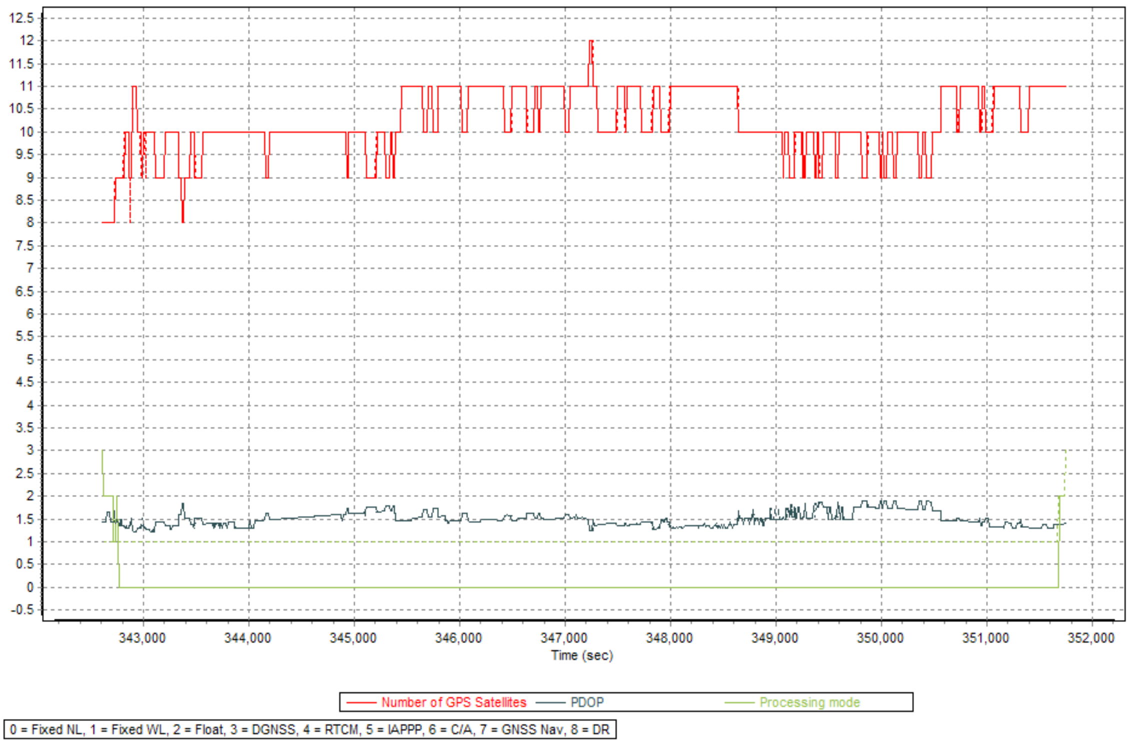


Figure 1.2.1. Solution Status

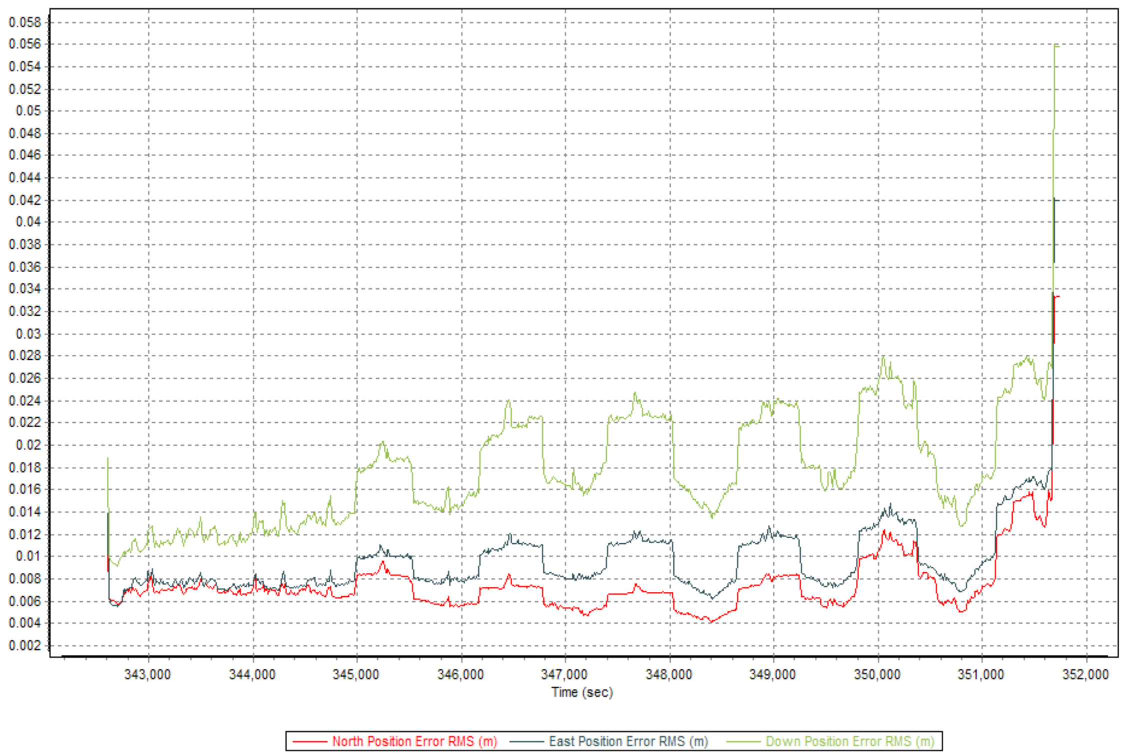


Figure 1.2.2. Smoothed Performance Metrics Parameters

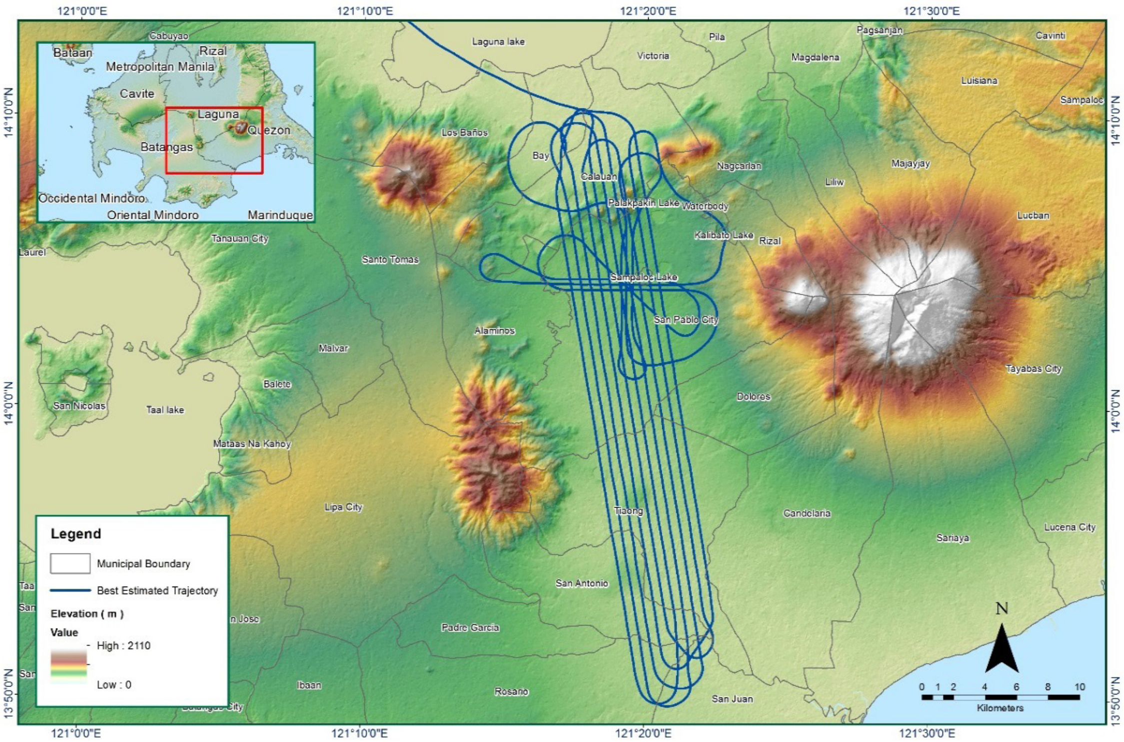


Figure 1.2.3. Best Estimated Trajectory

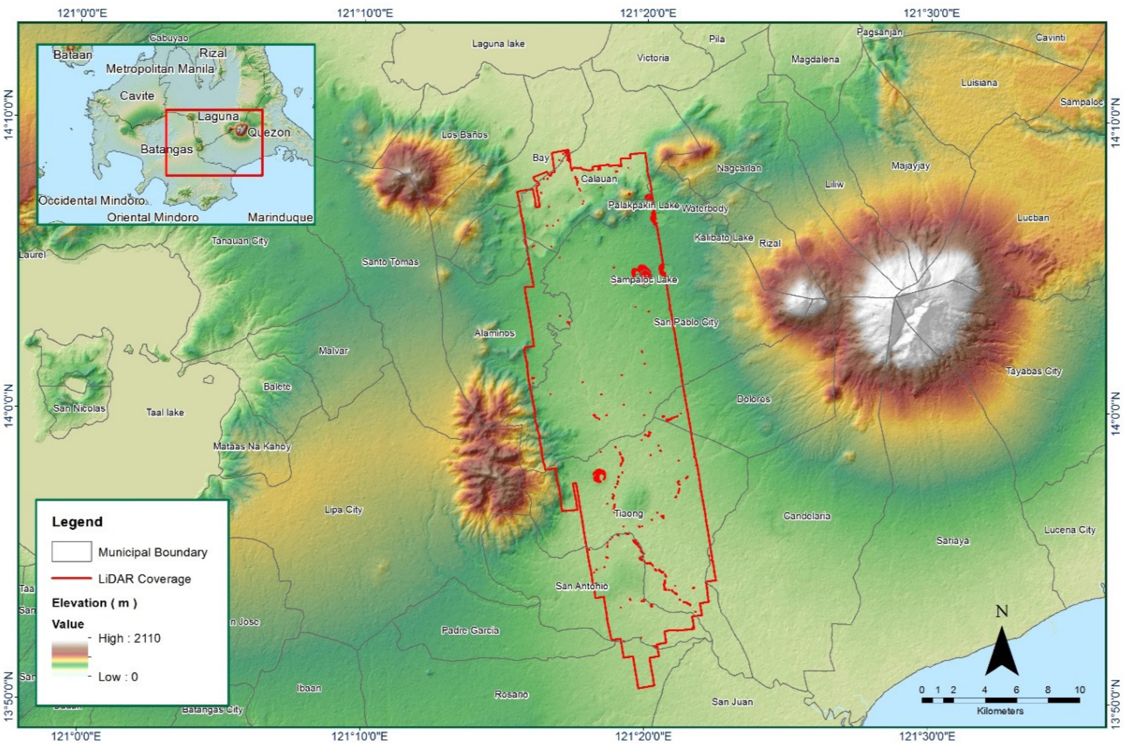


Figure 1.2.4. Coverage of LiDAR data

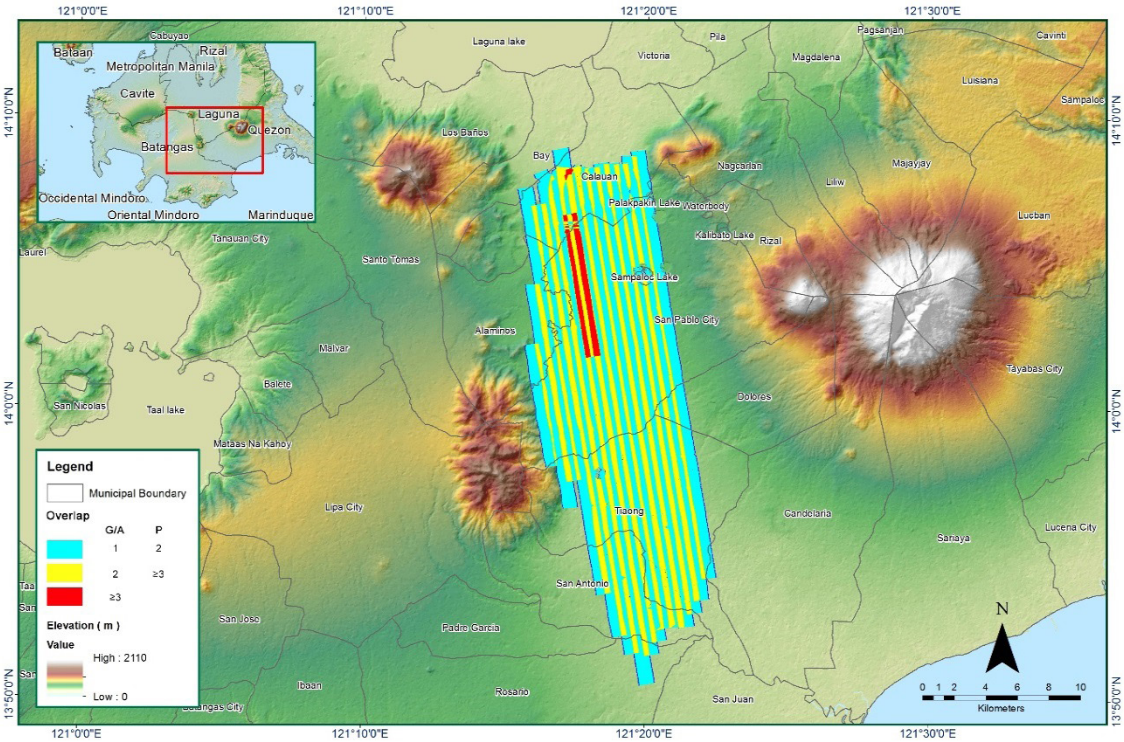


Figure 1.2.5. Image of data overlap

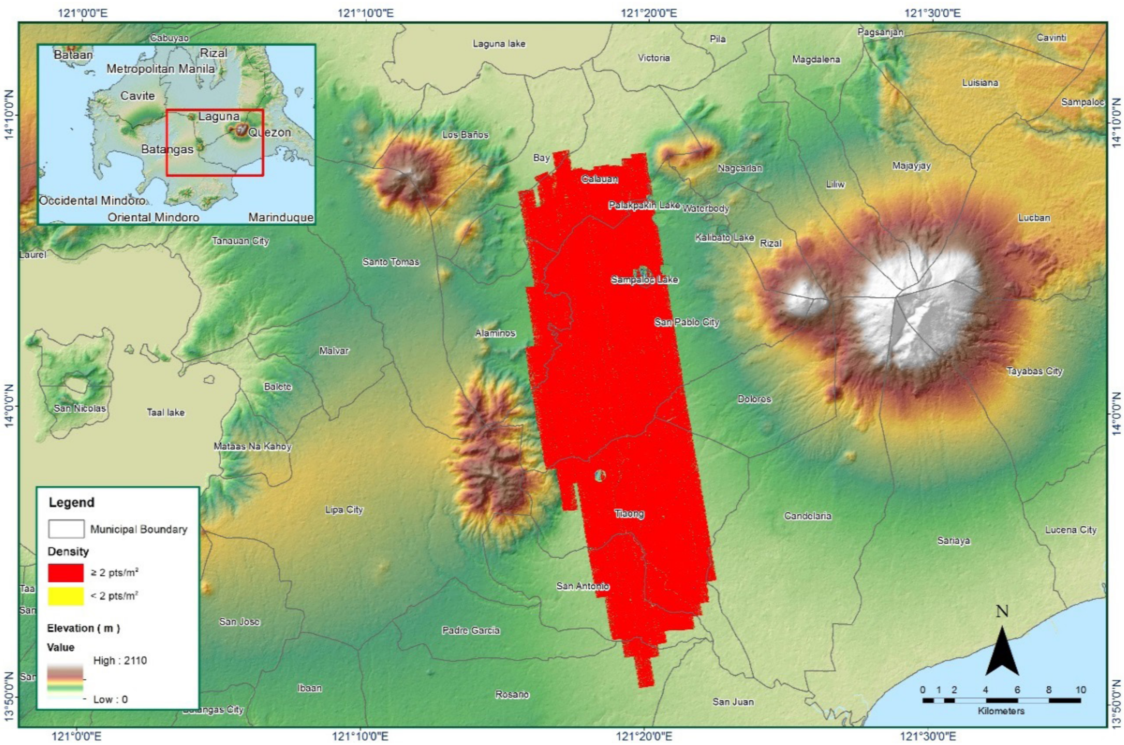


Figure 1.2.6. Density map of merged LiDAR data

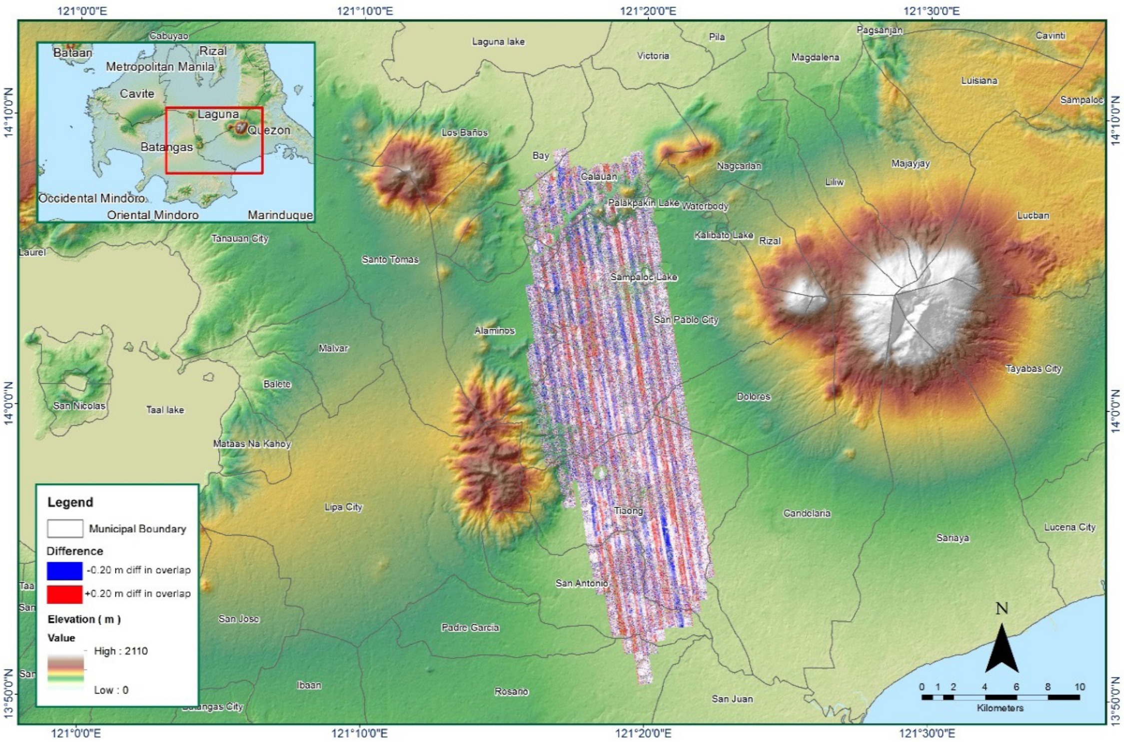


Figure 1.2.7. Elevation difference between flight lines

Flight Area	CALABARZON
Mission Name	**Blk18A**
Inclusive Flights	3341P, 3343P, 3345P, 3347P
Range data size	66.35 GB
POS	783 MB
Image	N/A
Transfer date	09/08/2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	0.9
RMSE for East Position (<4.0 cm)	1.2
RMSE for Down Position (<8.0 cm)	2.3
Boresight correction stdev (<0.001deg)	0.000180
IMU attitude correction stdev (<0.001deg)	0.008241
GPS position stdev (<0.01m)	0.0029
Minimum % overlap (>25)	46.85%
Ave point cloud density per sq.m. (>2.0)	3.78
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	315
Maximum Height	622.28 m
Minimum Height	39.80 m
Classification (# of points)	
Ground	207,376,754
Low vegetation	191,940,130
Medium vegetation	390,654,042
High vegetation	533,413,130
Building	90,096,623
Orthophoto	No
Processed by	Engr. Irish Cortez, Engr. Velina Angela Bemida, Kathryn Claudyn Zarate

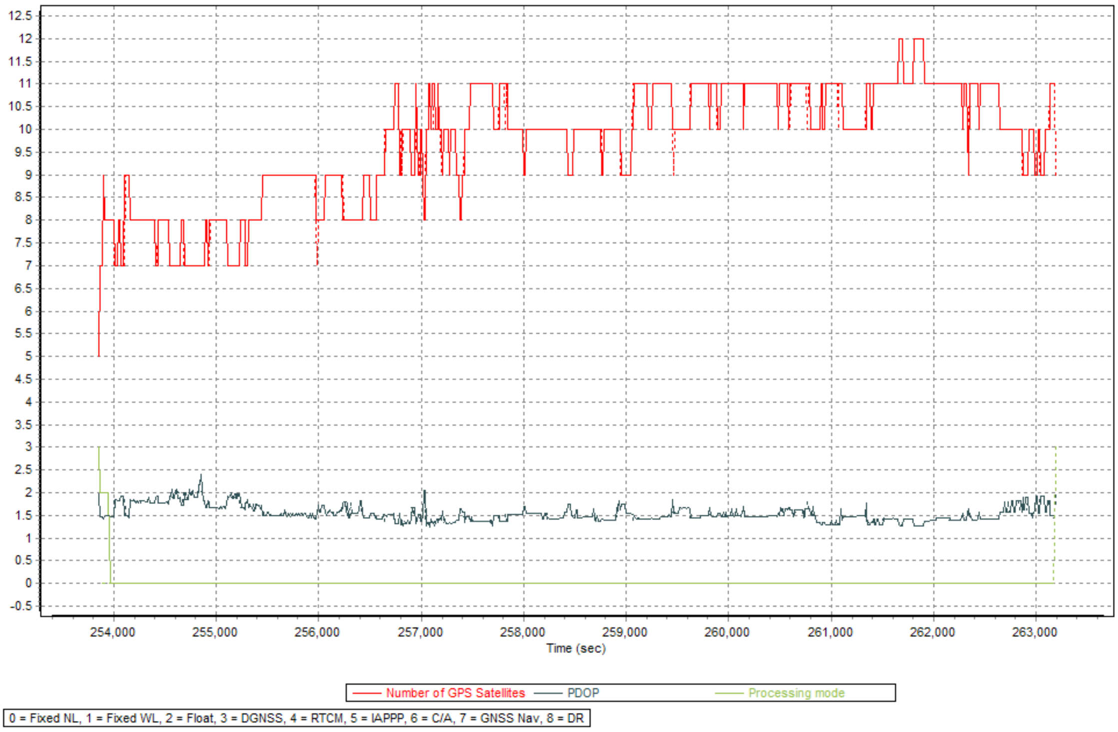


Figure 1.3.1. Solution Status

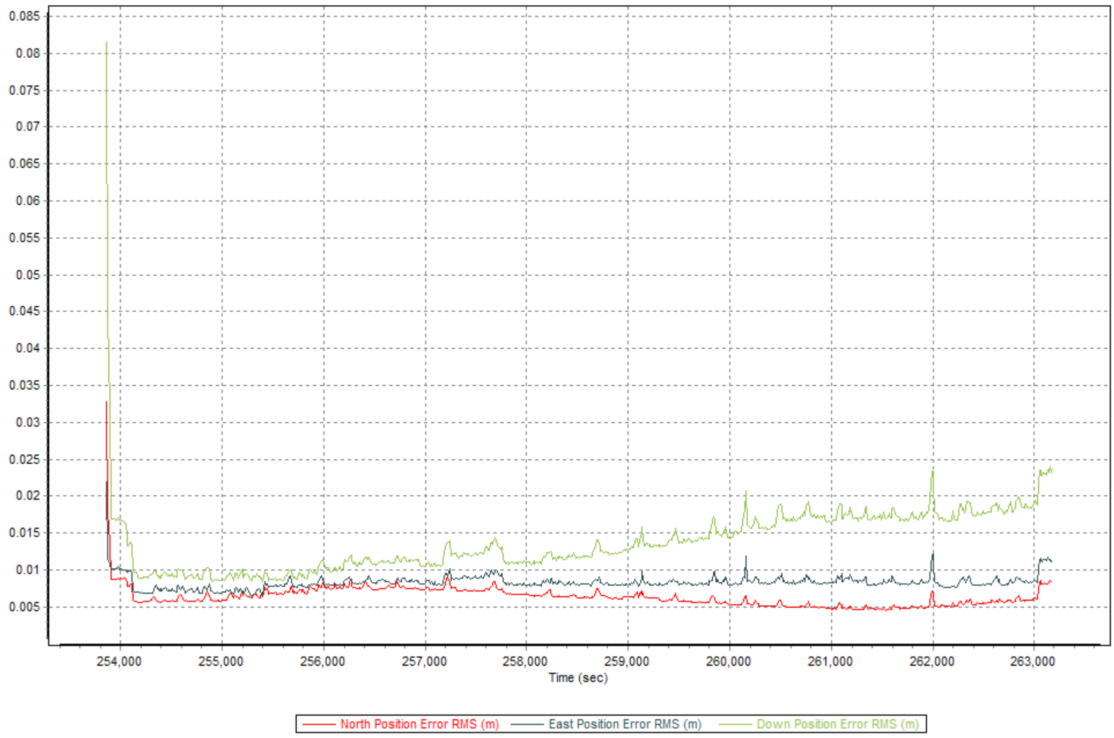


Figure 1.3.2. Smoothed Performance Metrics Parameters

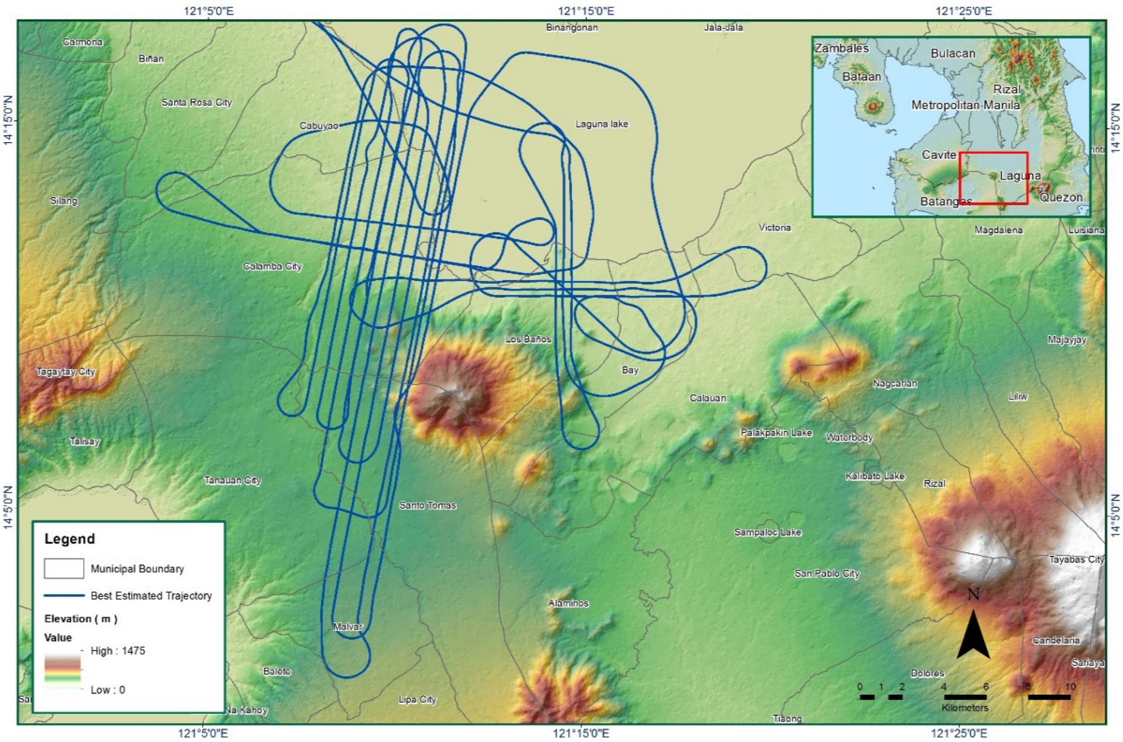


Figure 1.3.3. Best Estimated Trajectory

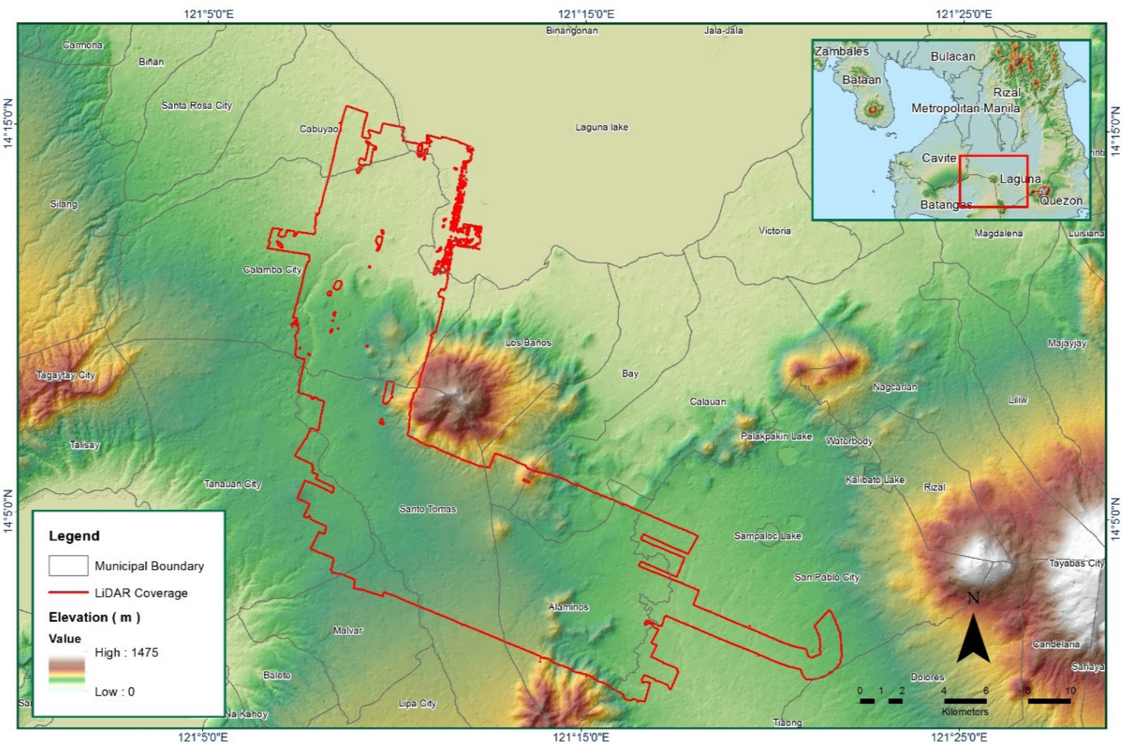


Figure 1.3.4. Coverage of LiDAR data

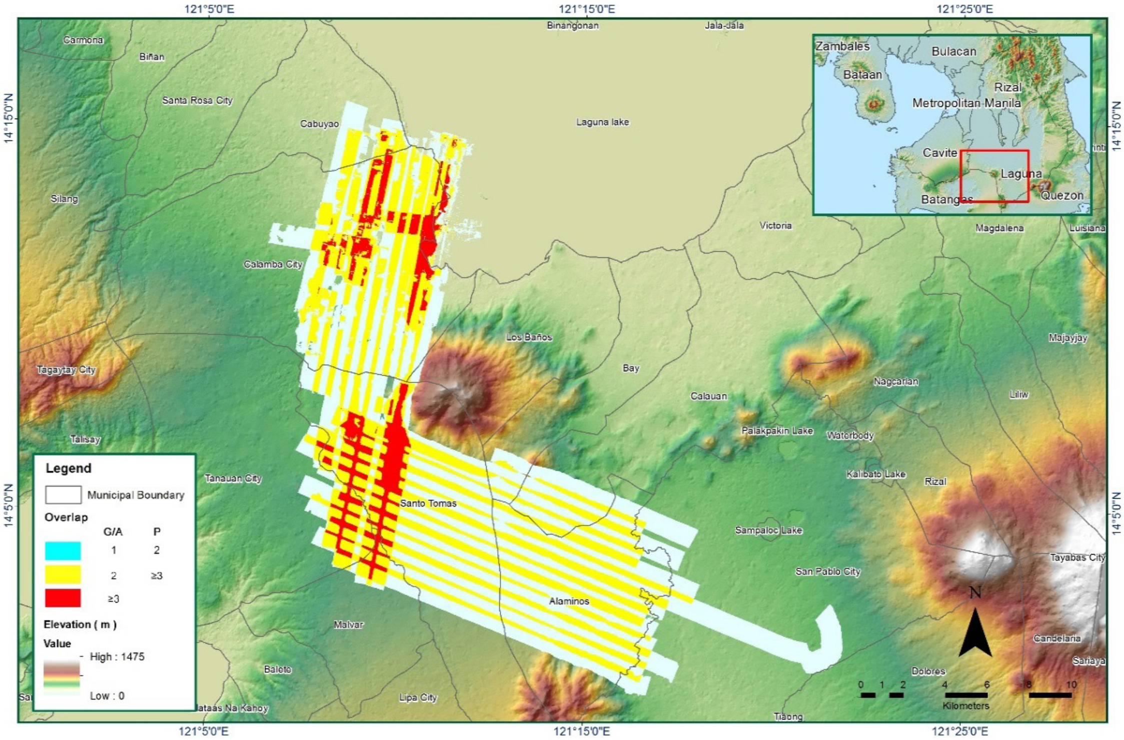


Figure 1.3.5. Image of data overlap

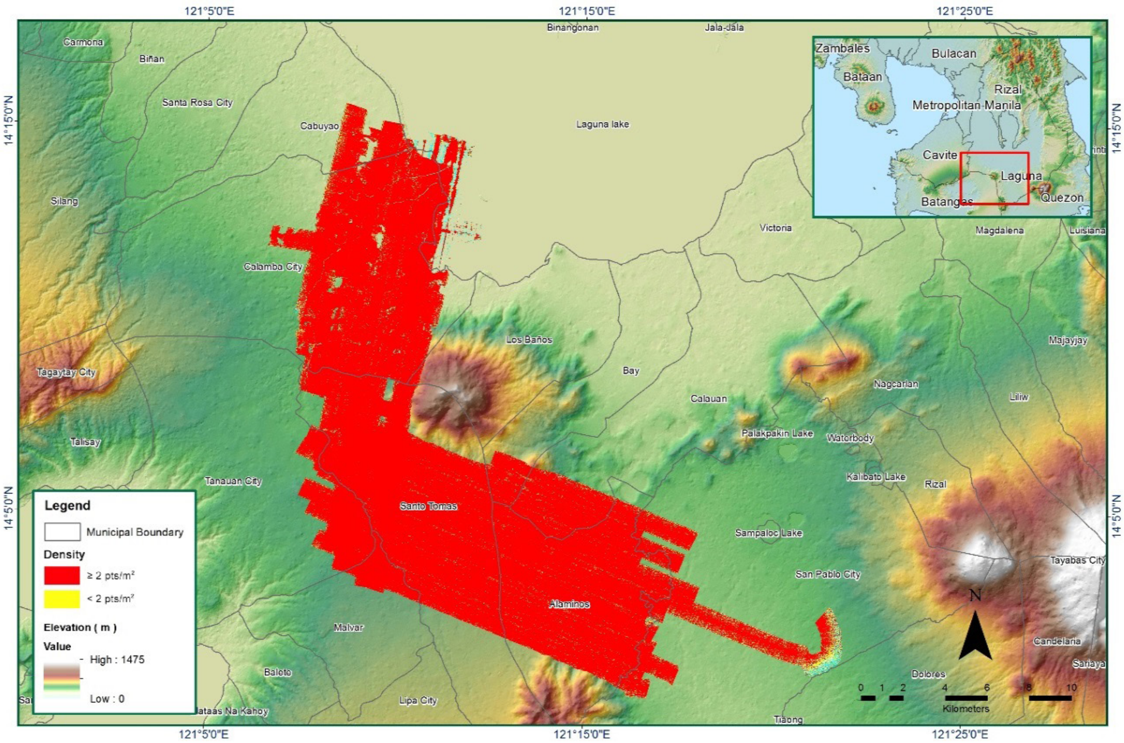


Figure 1.3.6. Density map of merged LiDAR data

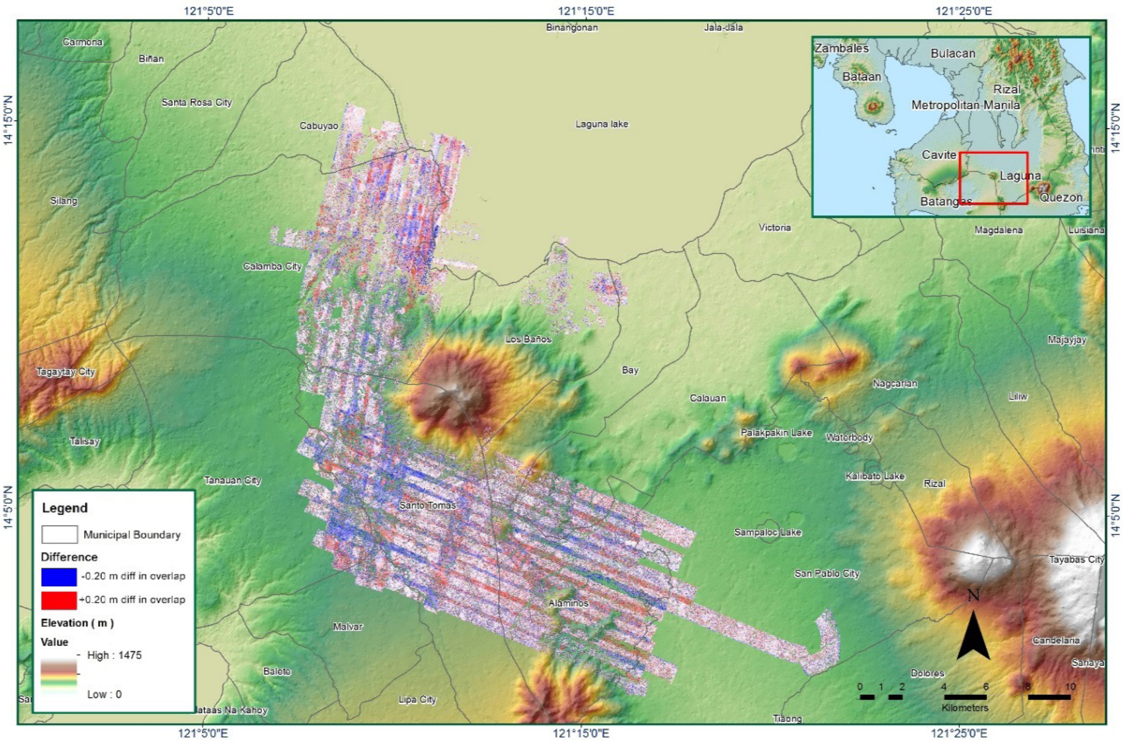


Figure 1.3.7. Elevation difference between flight lines

Flight Area	Calabarzon
Mission Name	**Blk18U_additional2**
Inclusive Flights	3353P
Range data size	18.8 GB
POS	246 MB
Image	N/A
Transfer date	September 08, 201
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)	1.2
RMSE for East Position (<4.0 cm)	1.6
RMSE for Down Position (<8.0 cm)	3.4
Boresight correction stdev (<0.001deg)	0.000181
IMU attitude correction stdev (<0.001deg)	0.000961
GPS position stdev (<0.01m)	0.0026
Minimum % overlap (>25)	28.76%
Ave point cloud density per sq.m. (>2.0)	2.12
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	96
Maximum Height	675.31 m
Minimum Height	56.06 m
Classification (# of points)	
Ground	44,442,219
Low vegetation	23,699,835
Medium vegetation	49,151,202
High vegetation	77,592,096
Building	3,236,522
Orthophoto	No
Processed by	Engr. Abigail Joy Ching, Engr. Edgardo Gubatanga Jr., Marie Denise Bueno

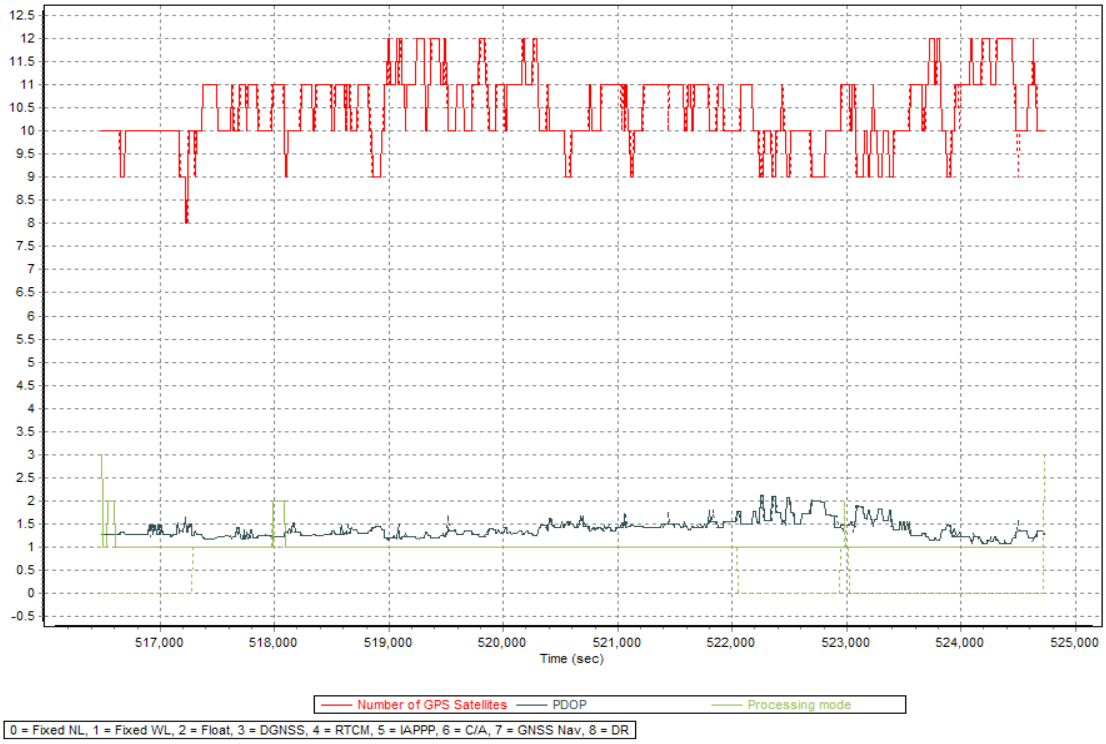


Figure 1.4.1. Solution Status

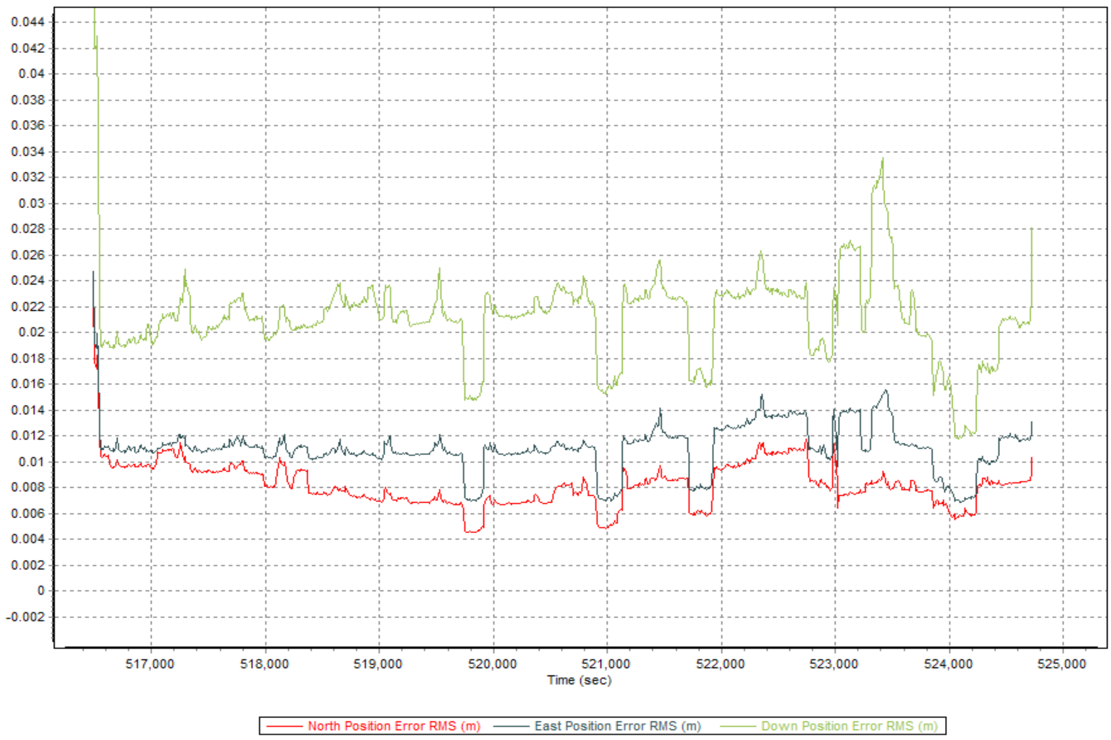


Figure 1.4.2. Smoothed Performance Metrics Parameters

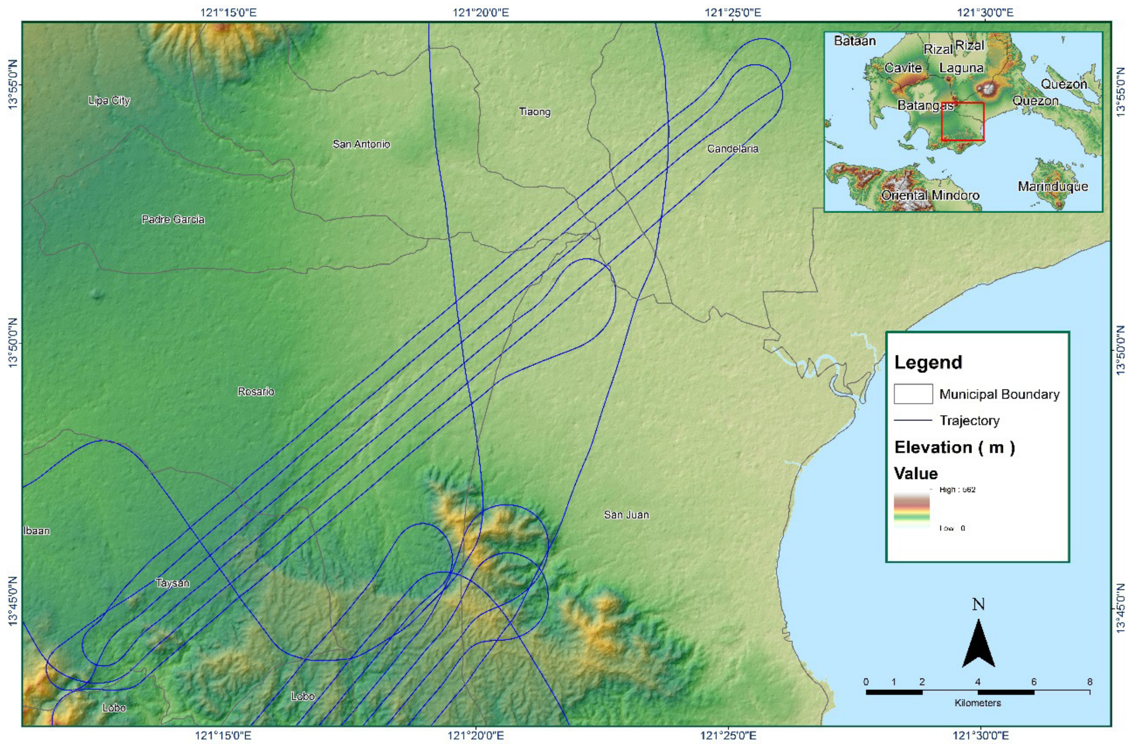


Figure 1.4.3. Best Estimated Trajectory

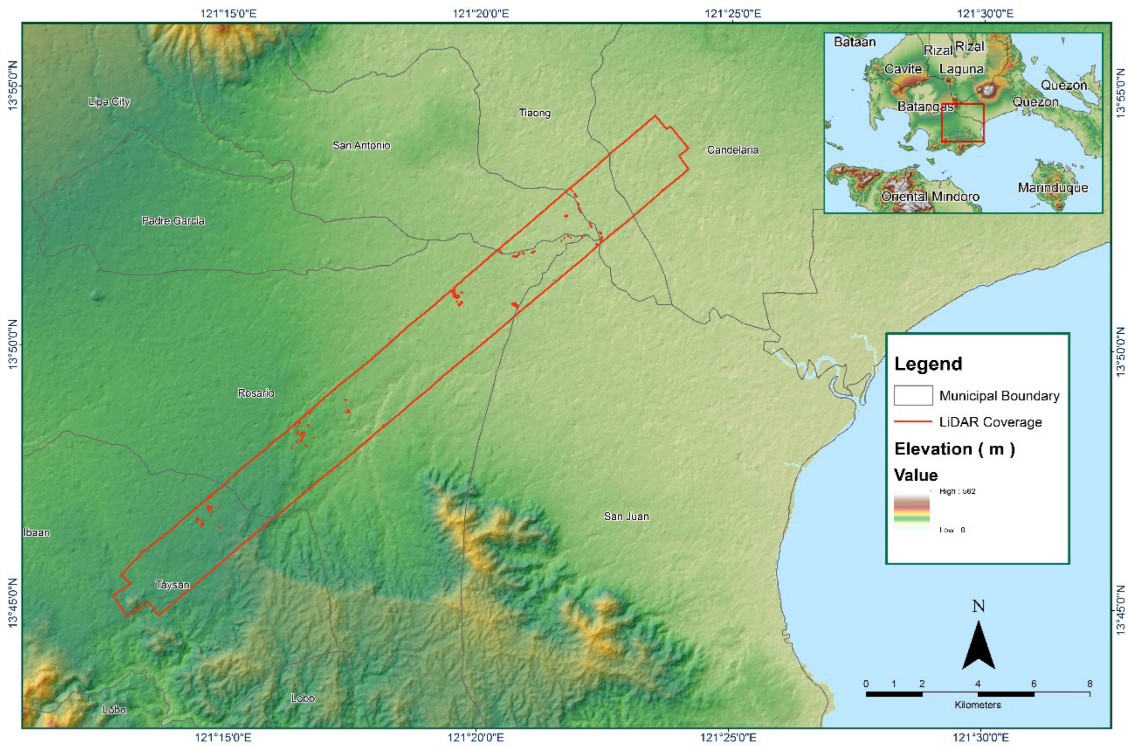


Figure 1.4.4. Coverage of LiDAR data

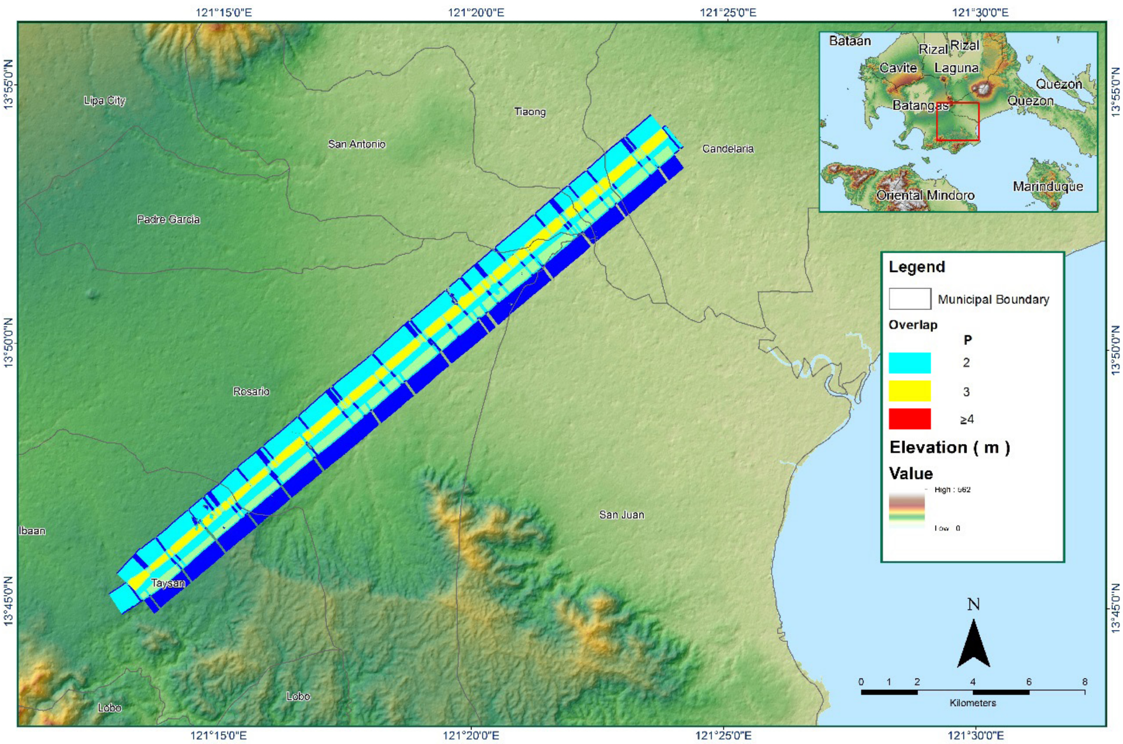


Figure 1.4.5. Image of data overlap

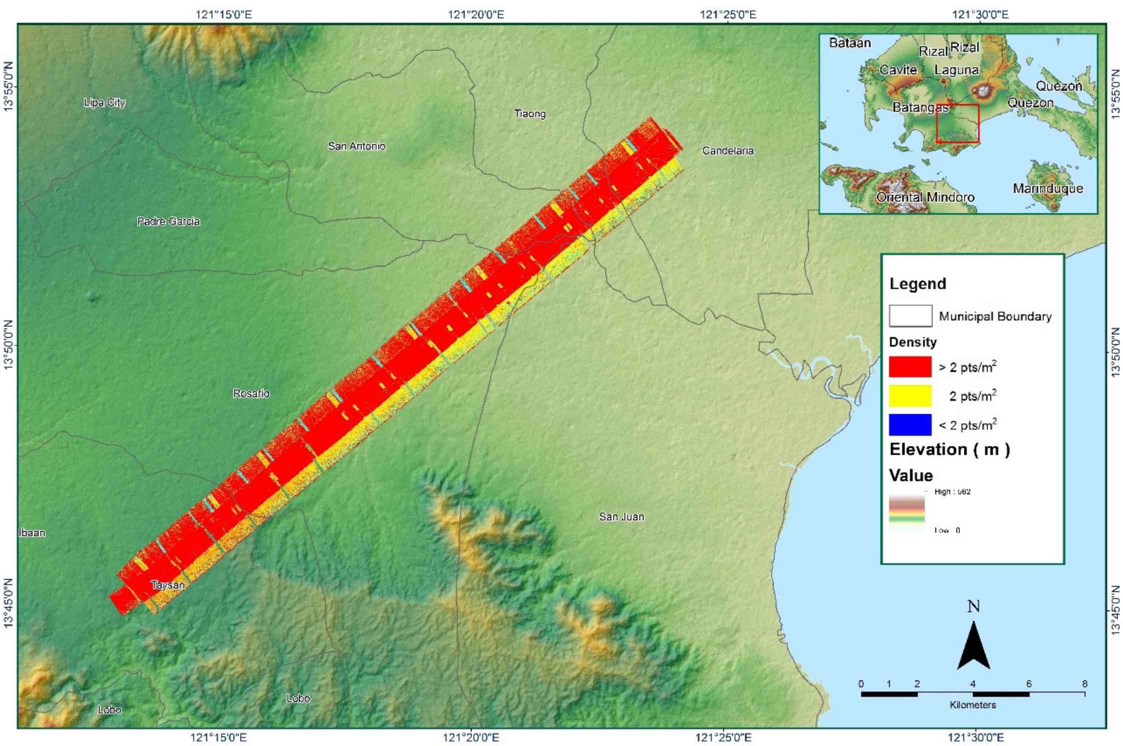


Figure 1.4.6. Density map of merged LiDAR data

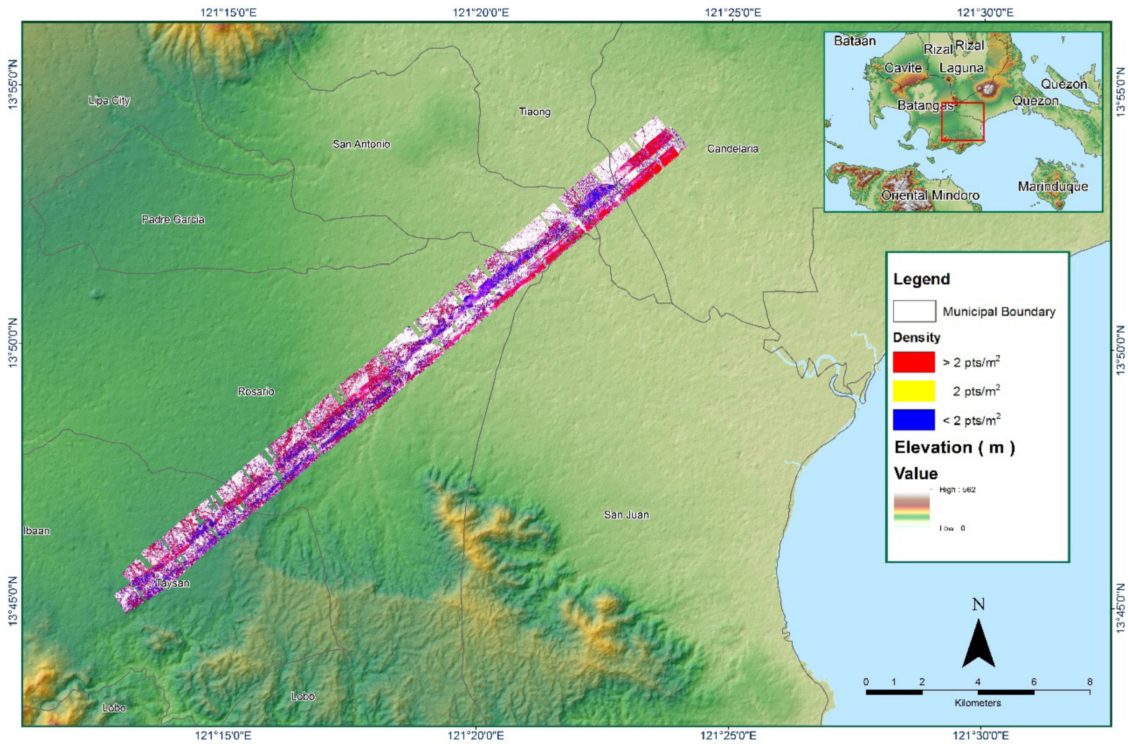


Figure 1.4.7. Elevation difference between flight lines

Flight Area	CALABARZON
Mission Name	**Blk18U_supplement**
Inclusive Flights	3381P
Range data size	20.6 GB
POS	256 MB
Image	N/A
Transfer date	09/11/2015
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)	1.1
RMSE for East Position (<4.0 cm)	2.0
RMSE for Down Position (<8.0 cm)	3.3
Boresight correction stdev (<0.001deg)	0.000232
IMU attitude correction stdev (<0.001deg)	0.000478
GPS position stdev (<0.01m)	0.0073
Minimum % overlap (>25)	33.91%
Ave point cloud density per sq.m. (>2.0)	3.00
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	248
Maximum Height	1142.15 m
Minimum Height	33.16 m
Classification (# of points)	
Ground	116,430,535
Low vegetation	71,532,461
Medium vegetation	215,467,664
High vegetation	328,004,432
Building	10,242,231
Orthophoto	No
Processed by	Engr. Jennifer Saguran, Engr. Melanie Hingpit, Jovy Ann Narisma

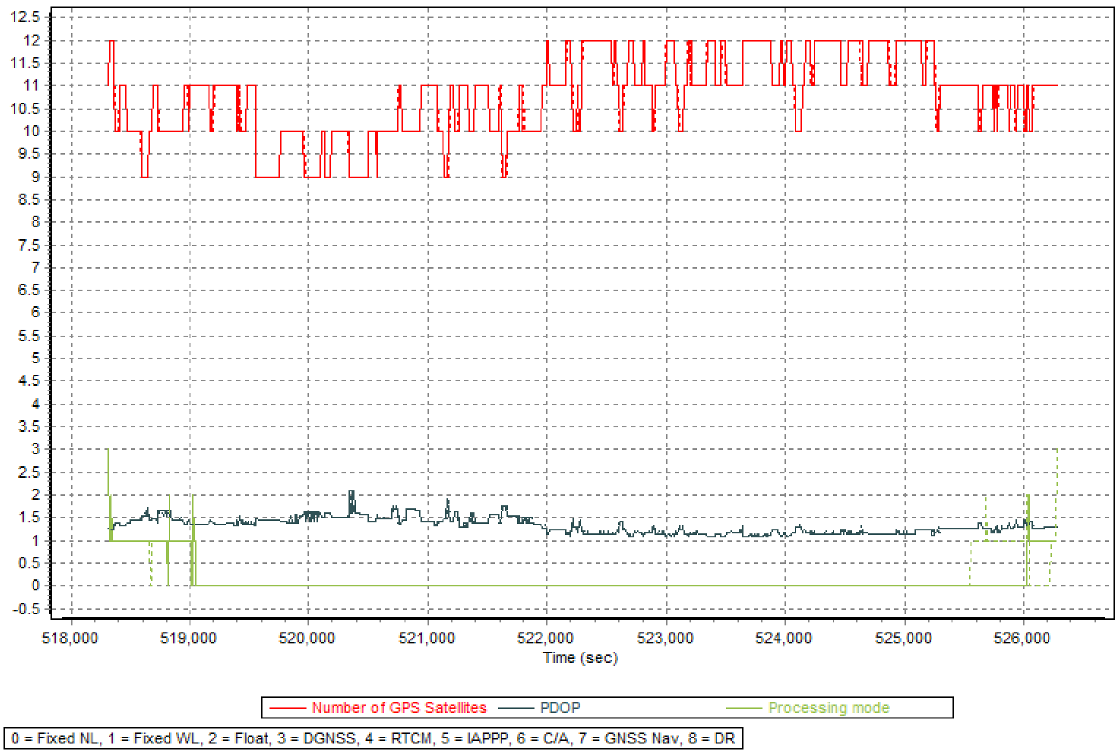


Figure 1.5.1. Solution Status

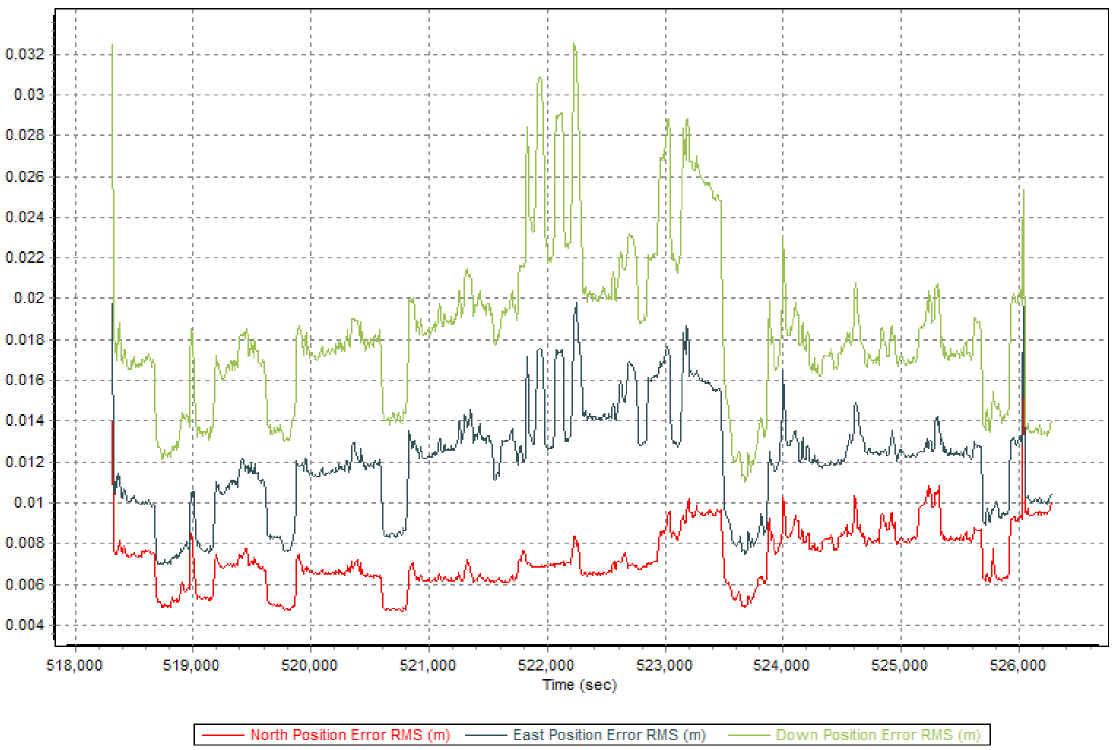


Figure 1.5.2. Smoothed Performance Metrics Parameters

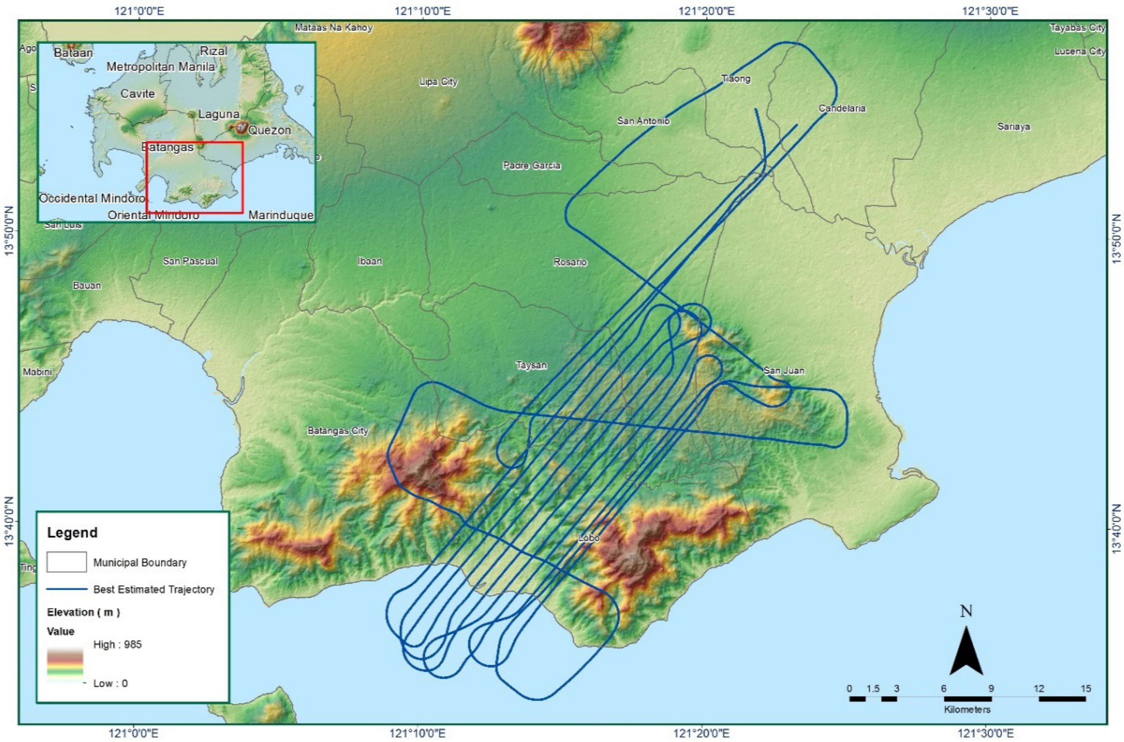


Figure 1.5.3. Best Estimated Trajectory

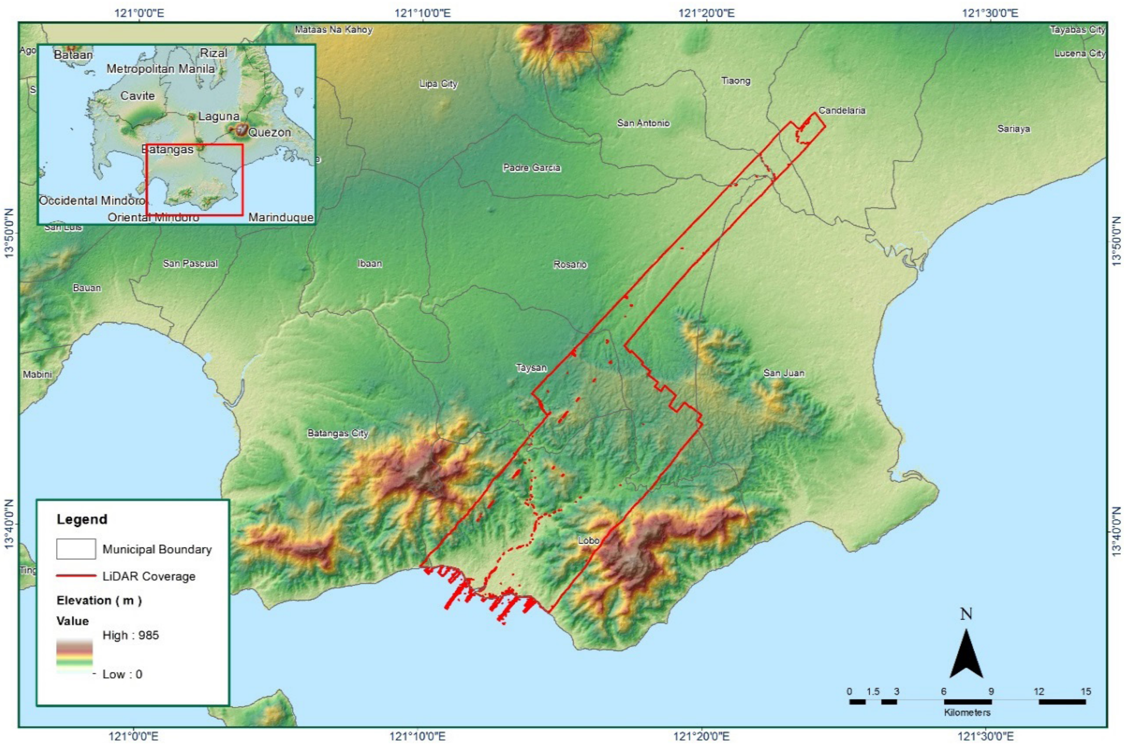


Figure 1.5.4. Coverage of LiDAR data

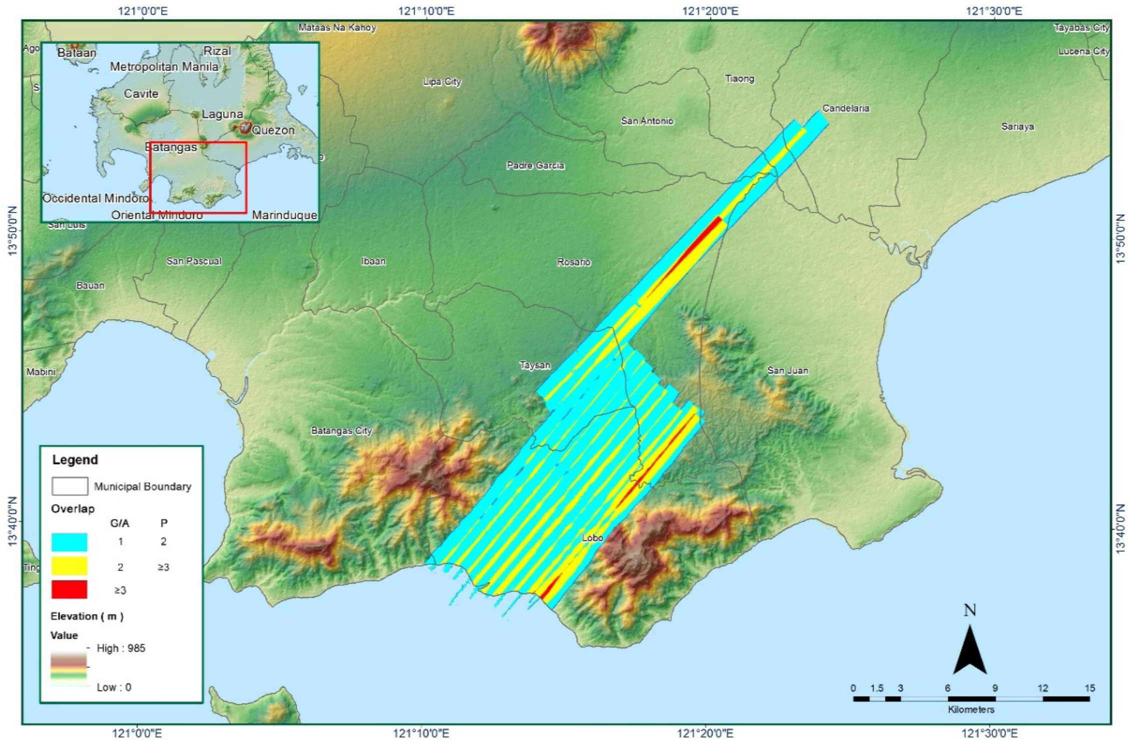


Figure 1.5.5. Image of data overlap

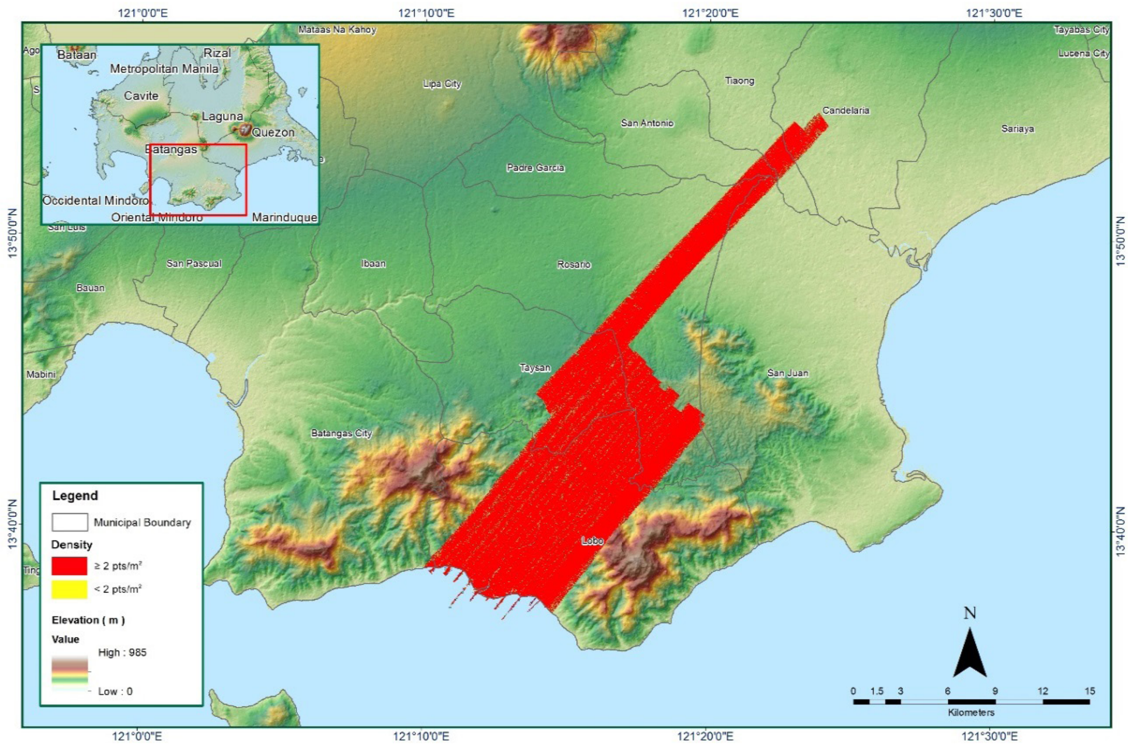


Figure 1.5.6. Density map of merged LiDAR data

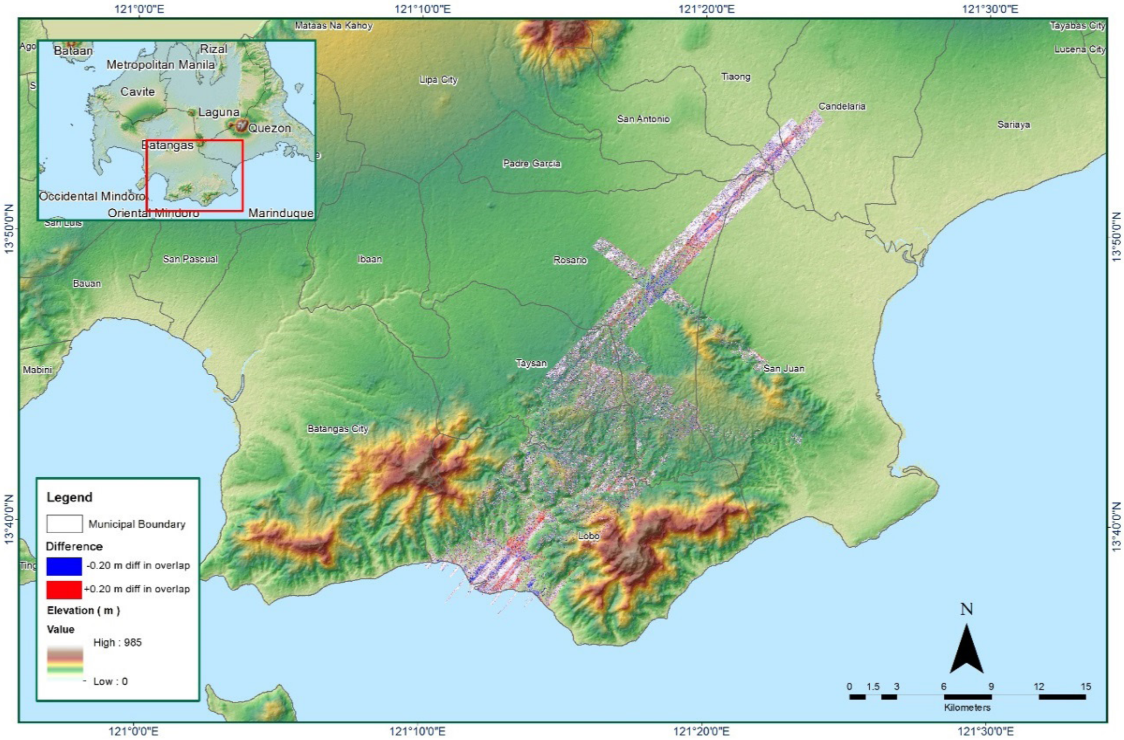


Figure 1.5.7. Elevation difference between flight lines

Flight Area	Batangas 2
Mission Name	**Blk18SE**
Inclusive Flights	3002P
Range data size	25.30 GB
POS	185 MB
Image	41.70 GB
Transfer date	January 6, 2016
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)	1.048
RMSE for East Position (<4.0 cm)	1.268
RMSE for Down Position (<8.0 cm)	3.76
Boresight correction stdev (<0.001deg)	0.000217
IMU attitude correction stdev (<0.001deg)	0.000261
GPS position stdev (<0.01m)	0.0006
Minimum % overlap (>25)	14.71
Ave point cloud density per sq.m. (>2.0)	2.66
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	193
Maximum Height	699.45 m
Minimum Height	60.55 m
Classification (# of points)	
Ground	132,053,075
Low vegetation	85,887,777
Medium vegetation	167,372,542
High vegetation	98,695,053
Building	19,318,091
Orthophoto	Yes
Processed	Engr. Sheila-Maye Santillan, Engr. Jovelle Anjeanette Canlas, Engr. Melissa Fernandez

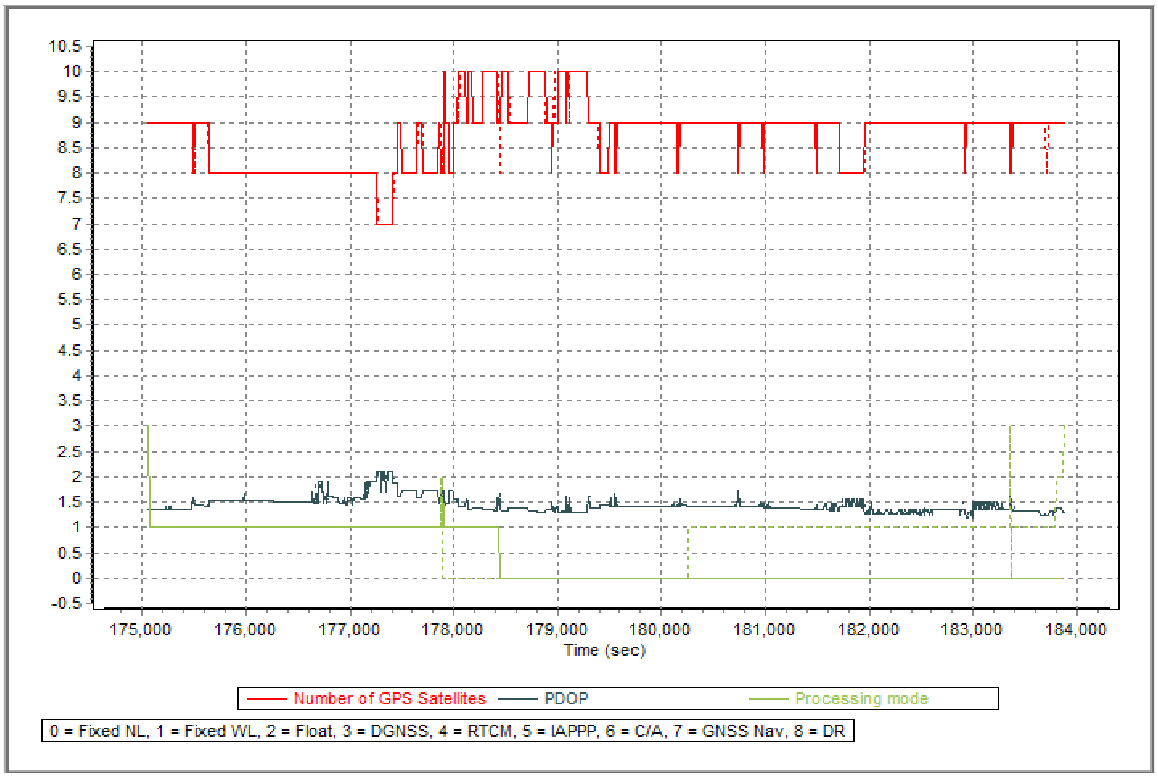


Figure 1.6.1. Solution Status

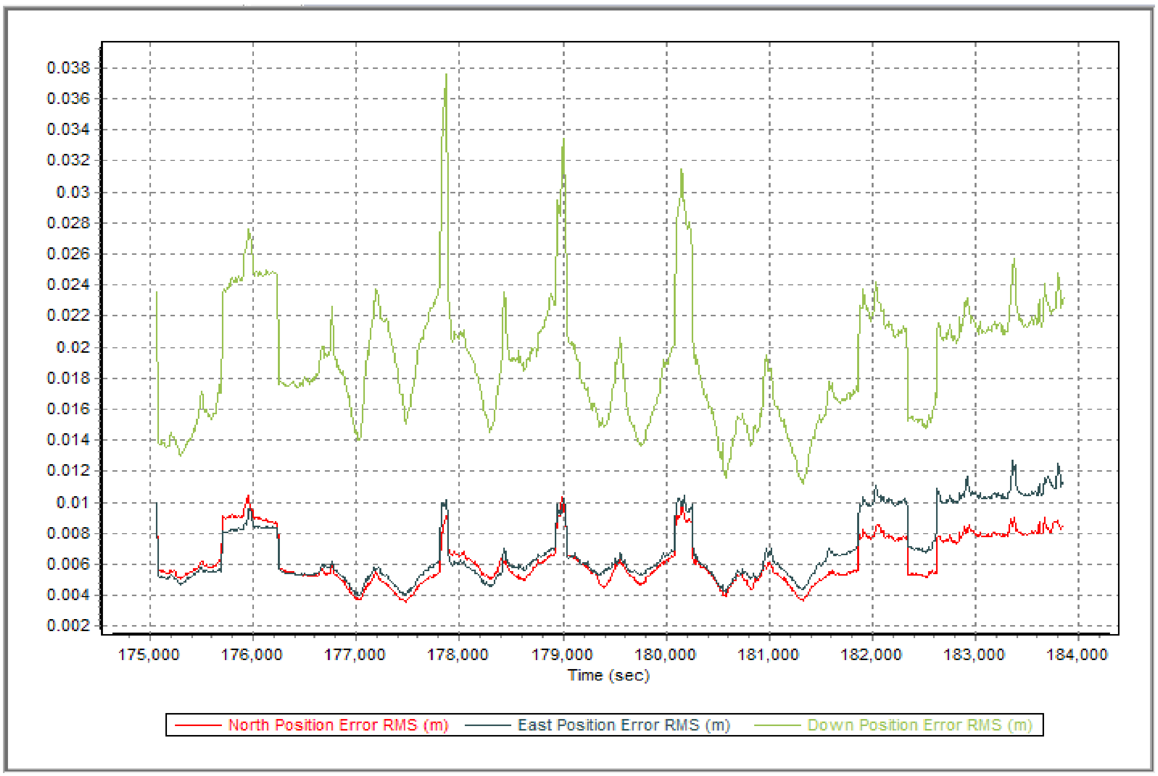


Figure 1.6.2. Smoothed Performance Metric Parameters

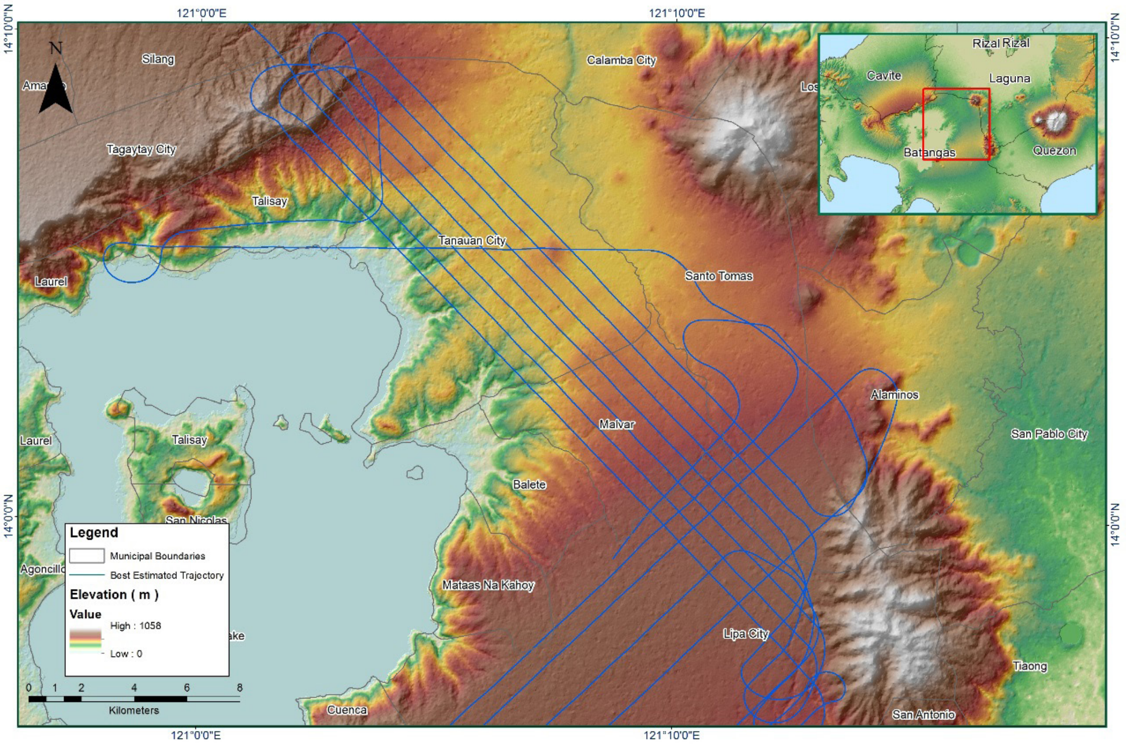


Figure 1.6.3. Best Estimate Trajectory

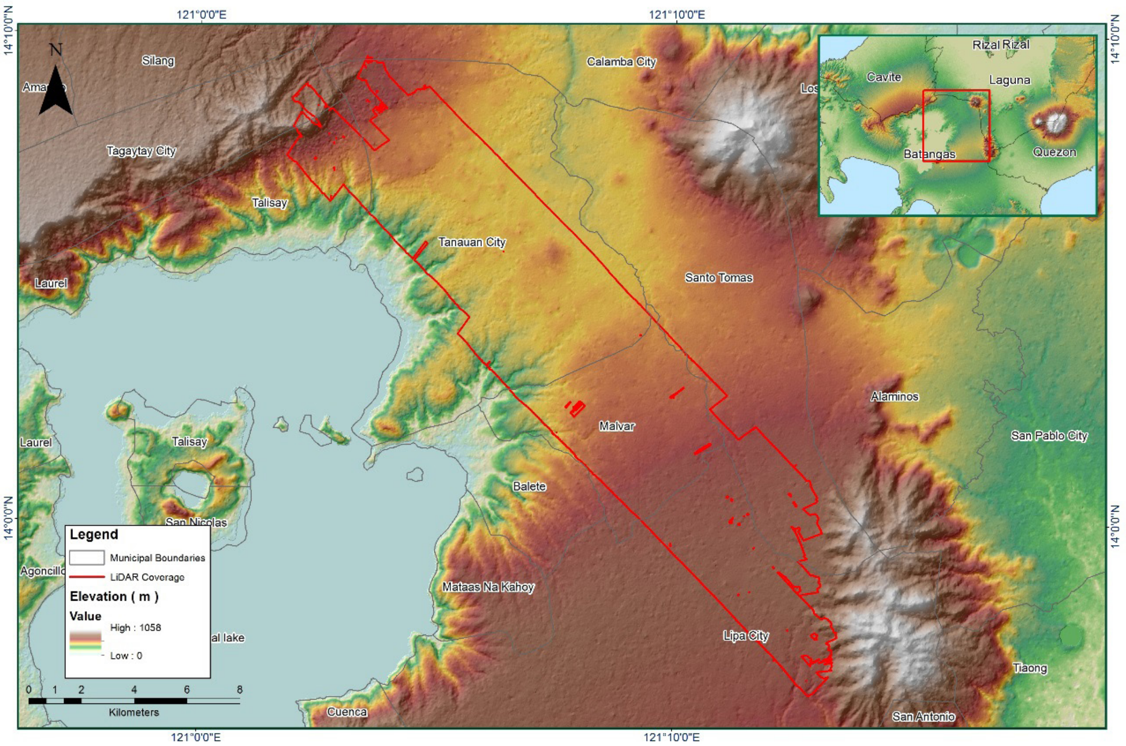


Figure 1.6.4. Coverage of LiDAR data

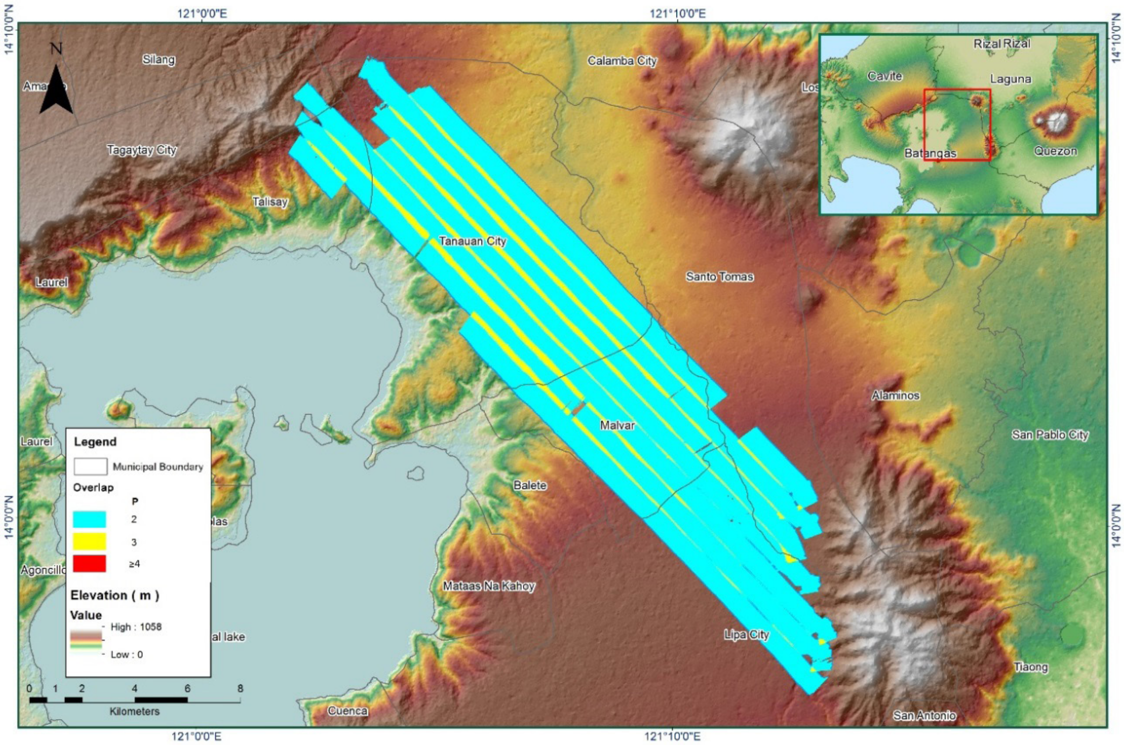


Figure 1.6.5 Image of data overlap

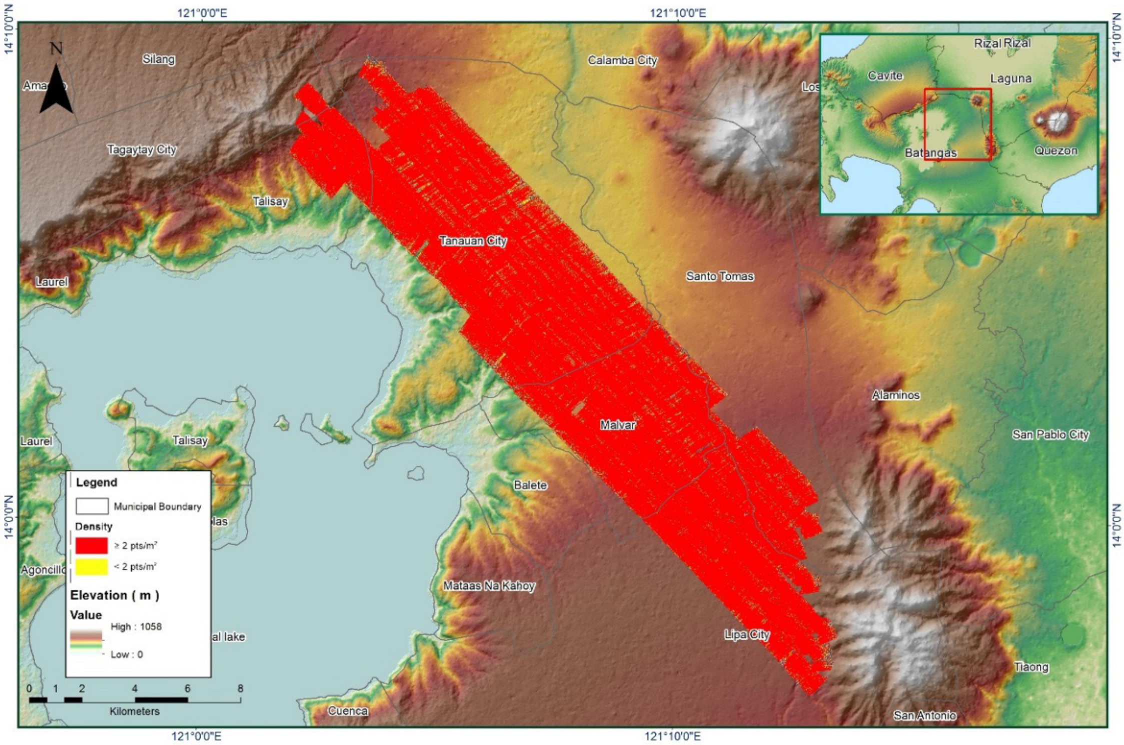


Figure 1.6.6 Density Map of merged LiDAR data

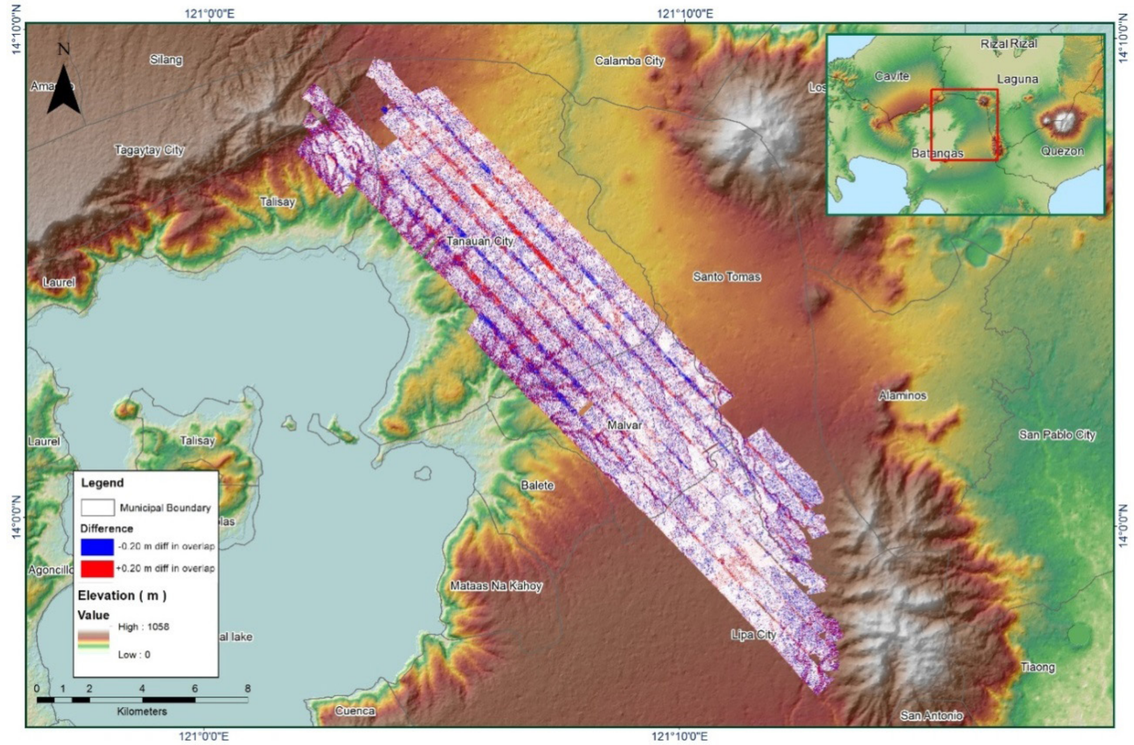


Figure 1.6.7 Elevation Difference Between flight lines

Flight Area	**Batangas 2**
Mission Name	**Blk18SE_additional1**
Inclusive Flights	3689G
Range data size	16.30 GB
POS	219 MB
Image	NA
Transfer date	January 15, 2016
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)	0.9594
RMSE for East Position (<4.0 cm)	1.1895
RMSE for Down Position (<8.0 cm)	3.2368
Boresight correction stdev (<0.001deg)	0.000239
IMU attitude correction stdev (<0.001deg)	0.000238
GPS position stdev (<0.01m)	0.0012
Minimum % overlap (>25)	15.47
Ave point cloud density per sq.m. (>2.0)	3.94
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	39
Maximum Height	445.60 m
Minimum Height	137.30 m
Classification (# of points)	
Ground	5,715,855
Low vegetation	7,279,724
Medium vegetation	16,985,682
High vegetation	13,838,471
Building	504,685
Orthophoto	No
Processed by	Engr. Angelo Carlo Bongat, Engr. Edgardo Gubatanga Jr., Jovy Ann Narisma

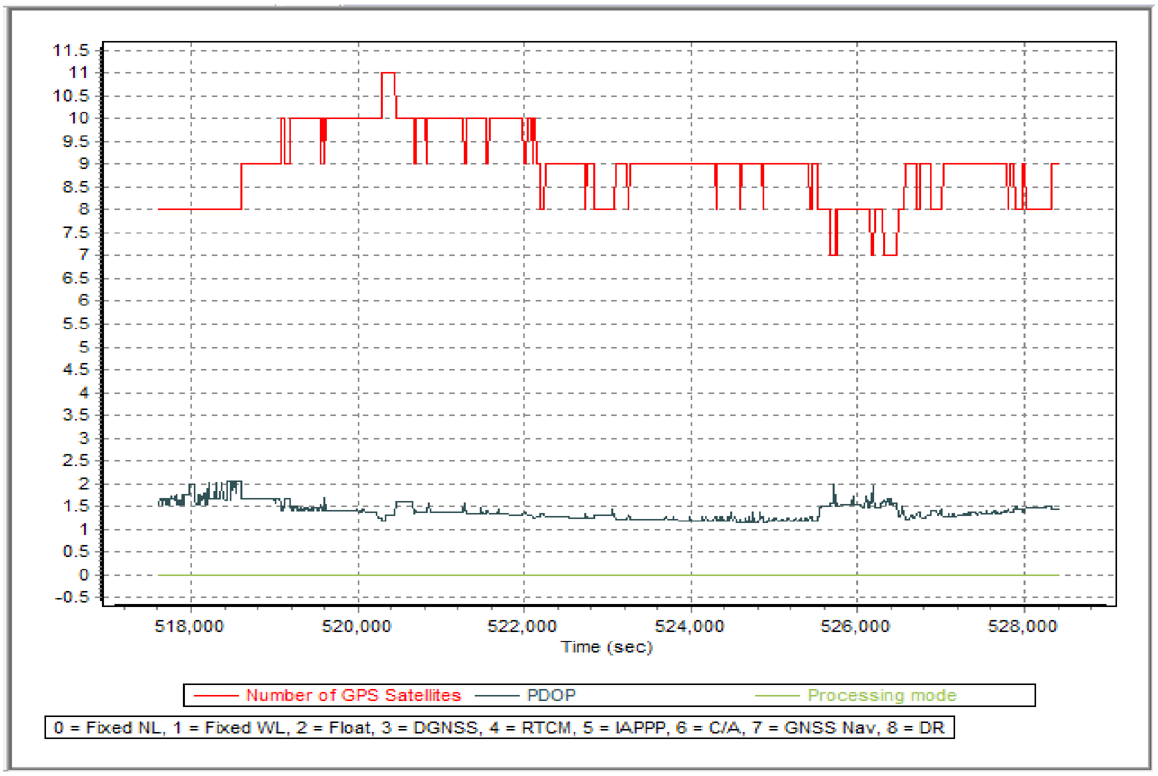


Figure 1.7.1. Solution Status

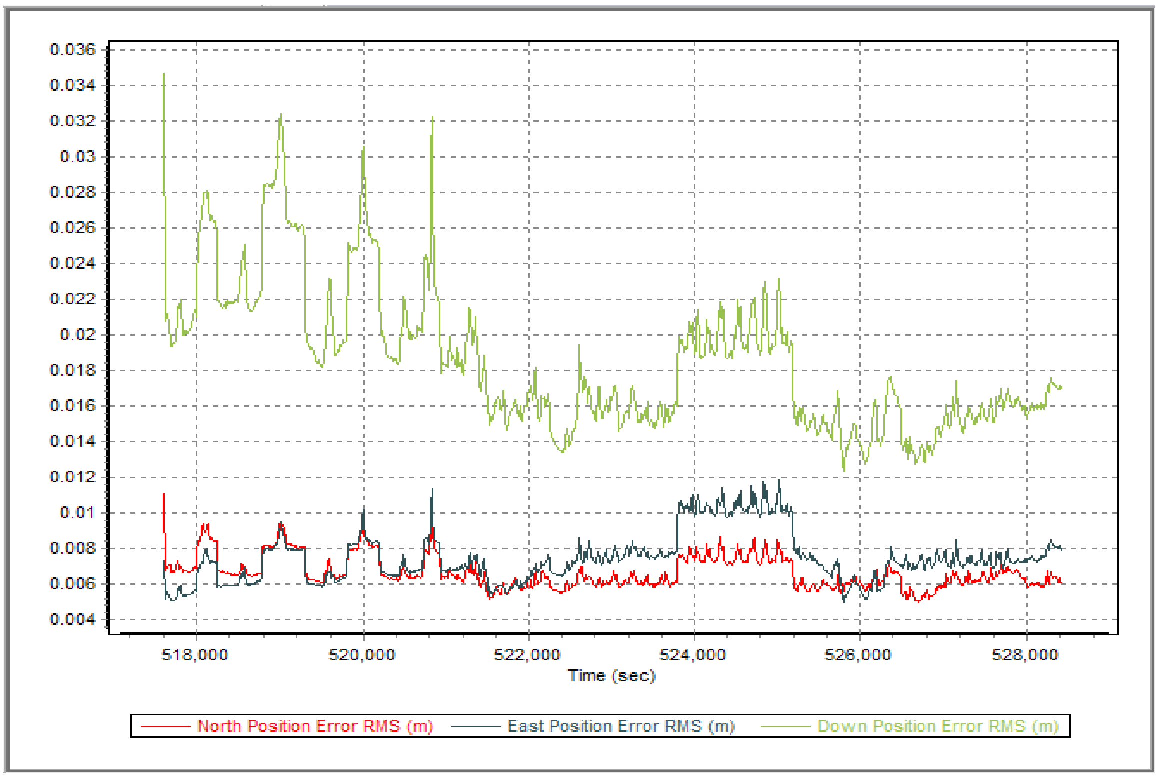


Figure 1.7.2. Smoothed Performance Metric Parameters

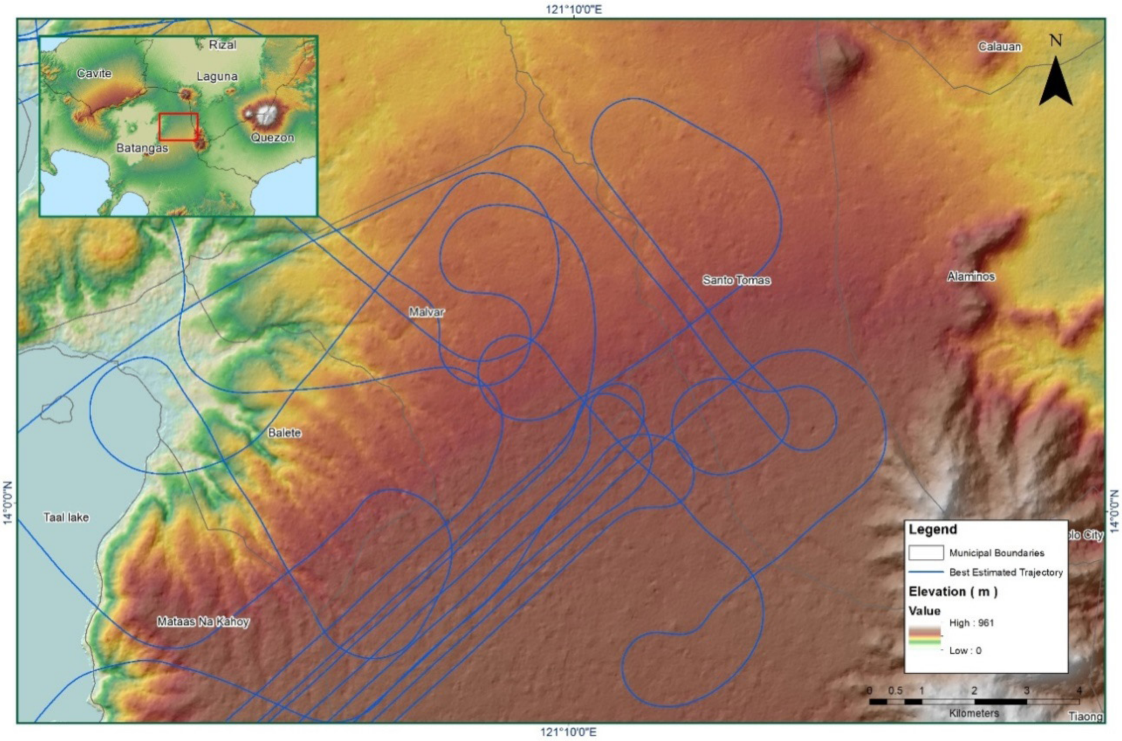


Figure 1.7.3. Best Estimate Trajectory

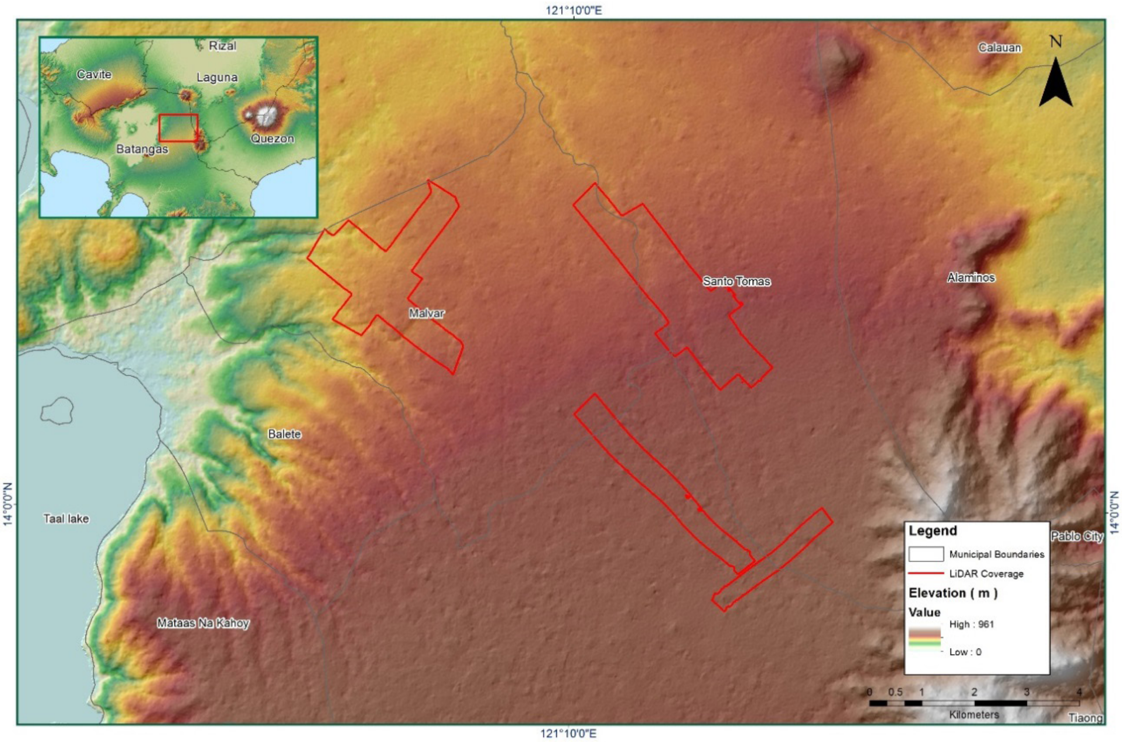


Figure 1.7.4. Coverage of LiDAR data

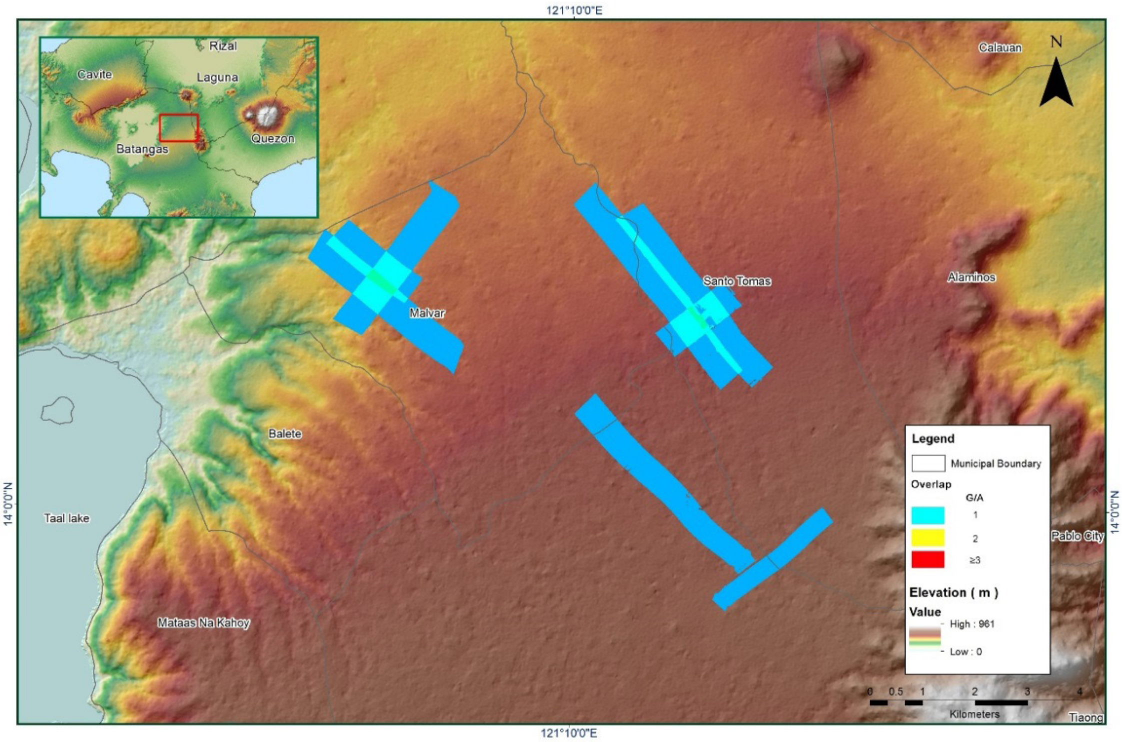


Figure 1.7.5 Image of data overlap

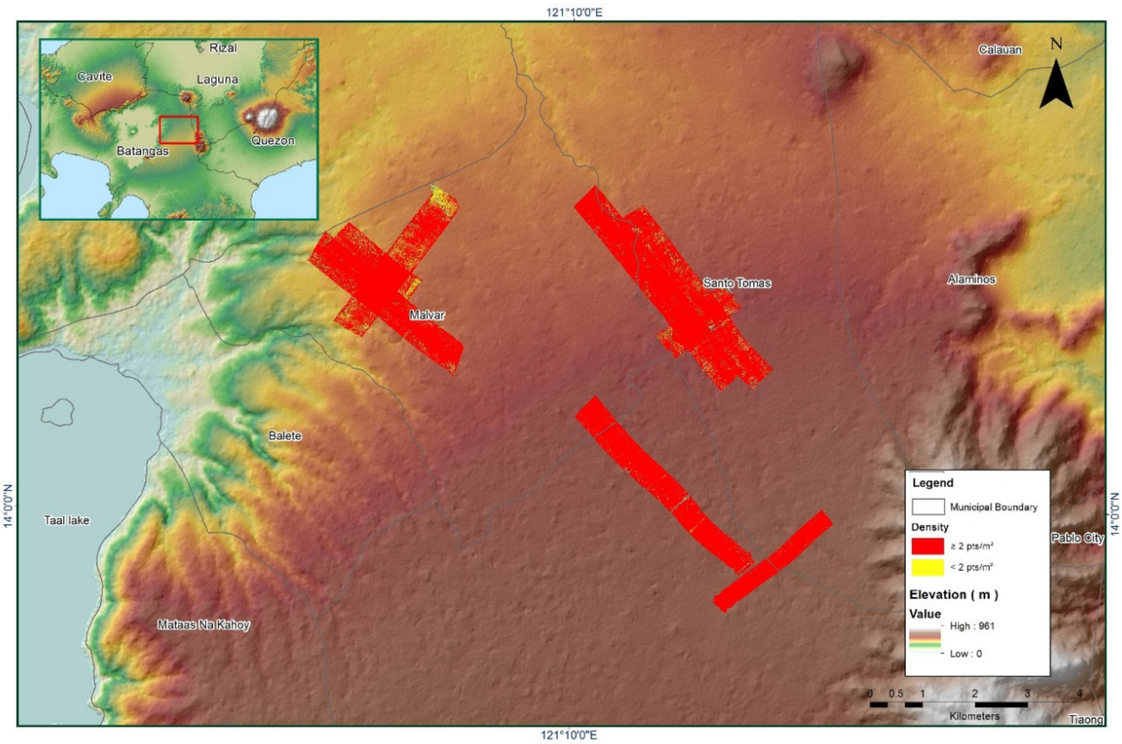


Figure 1.7.6 Density Map of merged LiDAR data

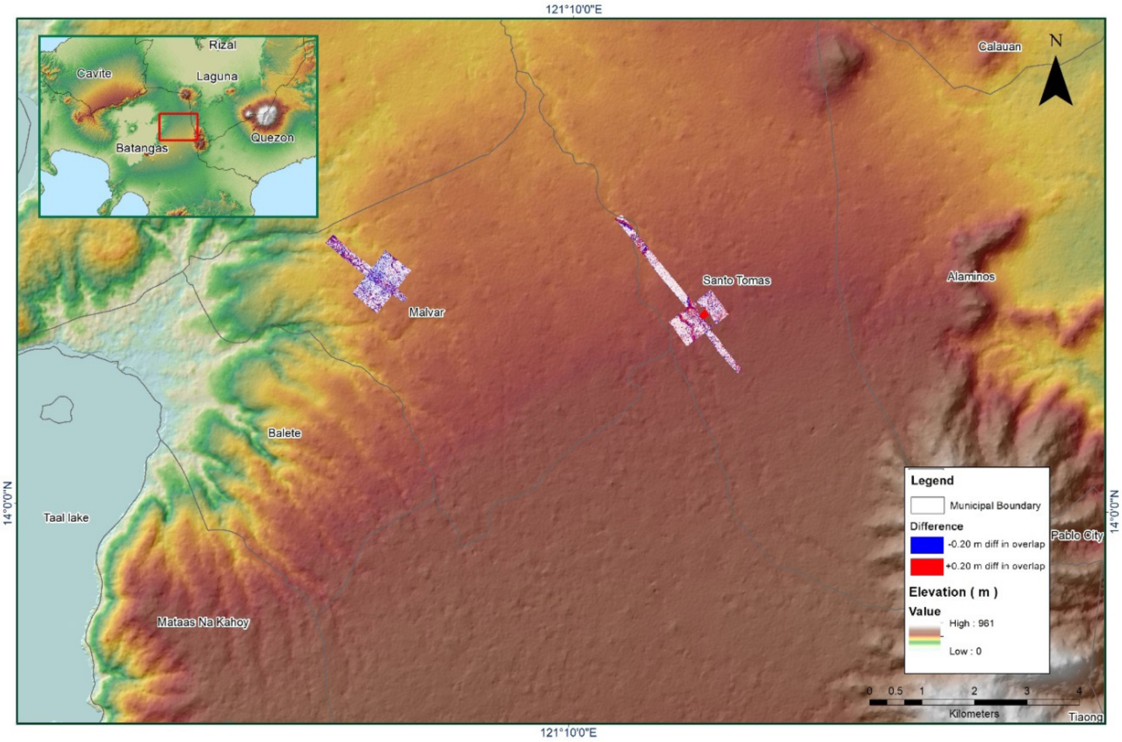


Figure 1.7.7 Elevation Difference Between flight lines

Flight Area	Batangas
Mission Name	**Blk18QR_supplement1**
Inclusive Flights	1107P
Range data size	10.2 GB
POS data size	215 MB
Base data size	12 MB
Image	16.7 GB
Transfer date	April 14, 2014
Solution Status	
Number of Satellites (>6)	No
PDOP (<3)	No
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	0.96
RMSE for East Position (<4.0 cm)	1.25
RMSE for Down Position (<8.0 cm)	5.13
Boresight correction stdev (<0.001deg)	0.000544
IMU attitude correction stdev (<0.001deg)	0.001183
GPS position stdev (<0.01m)	0.0102
Minimum % overlap (>25)	33.45
Ave point cloud density per sq.m. (>2.0)	1.97
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	203
Maximum Height	424.07 m
Minimum Height	37.25 m
Classification (# of points)	
Ground	127,864,102
Low vegetation	116,063,635
Medium vegetation	96,973,073
High vegetation	155,630,114
Building	11,308,922
Orthophoto	Yes
Processed by	Engr. Jennifer Saguran, Engr. Melanie Hingpit, Ailyn Biñas

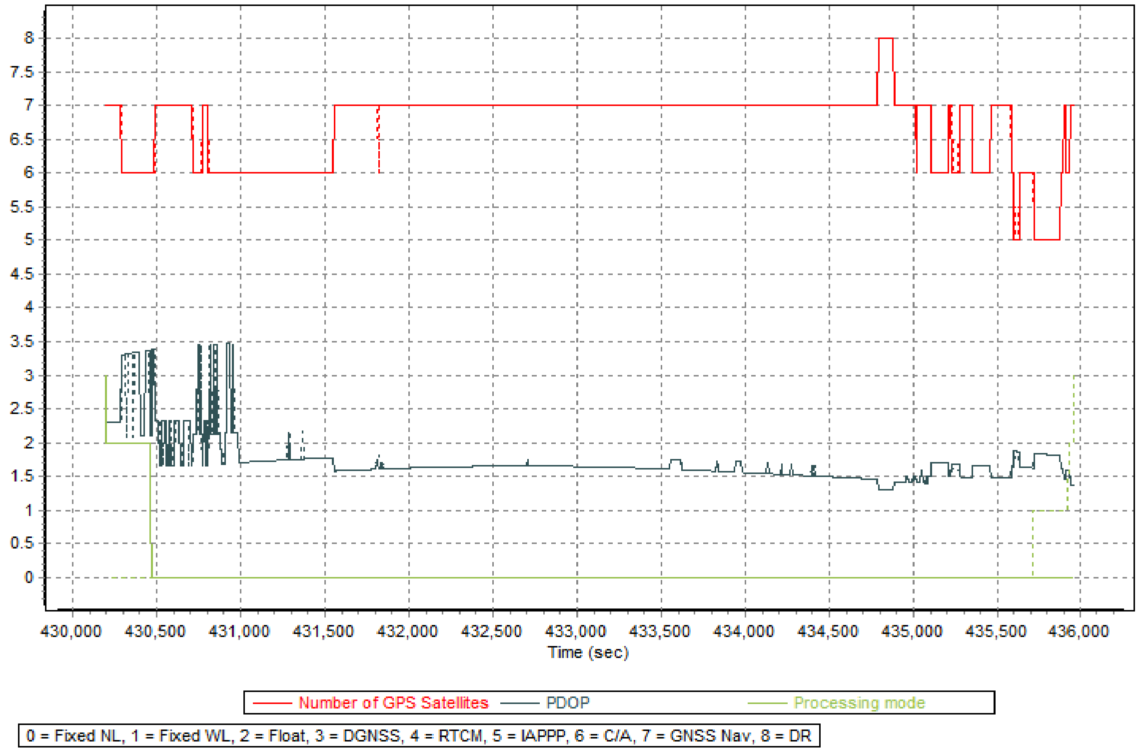


Figure 1.8.1. Solution Status

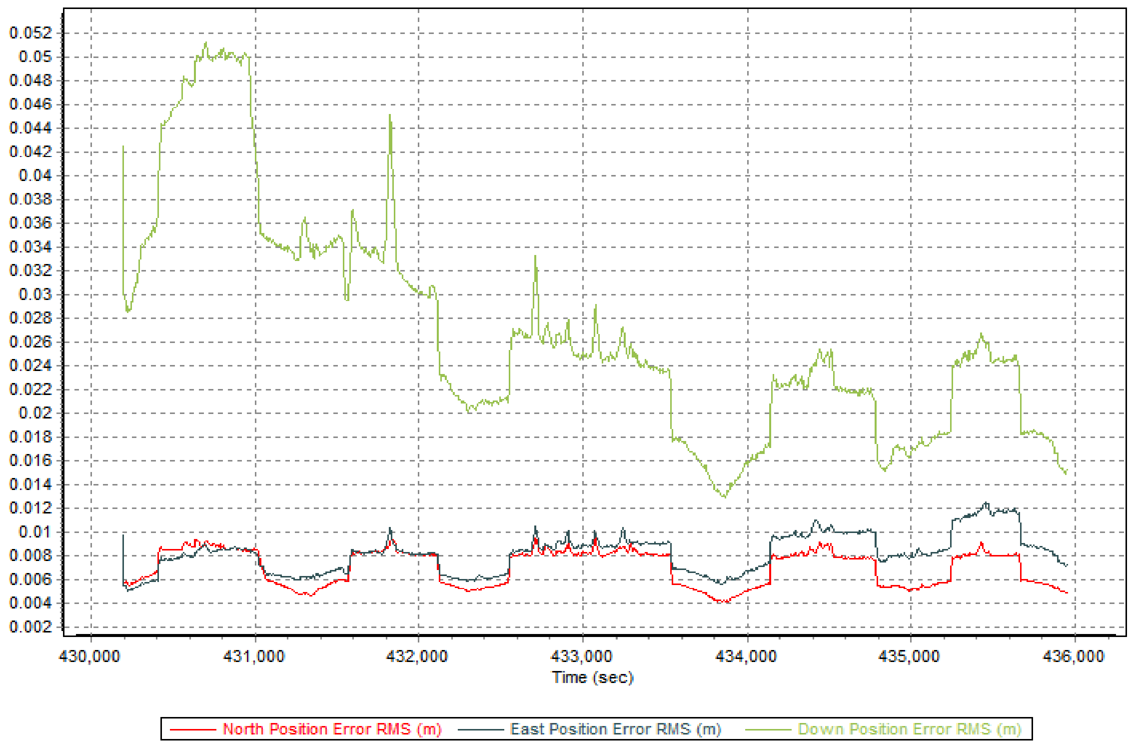


Figure 1.8.2. Smoothed Performance Metric Parameters

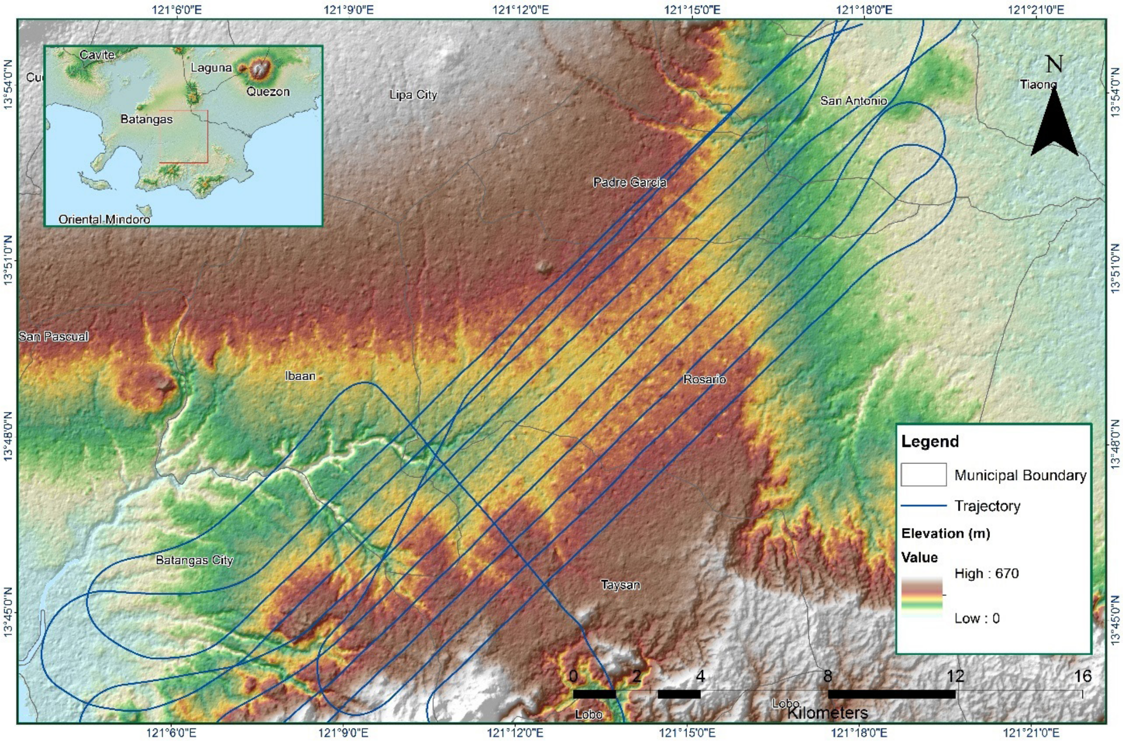


Figure 1.8.3. Best Estimated Trajectory

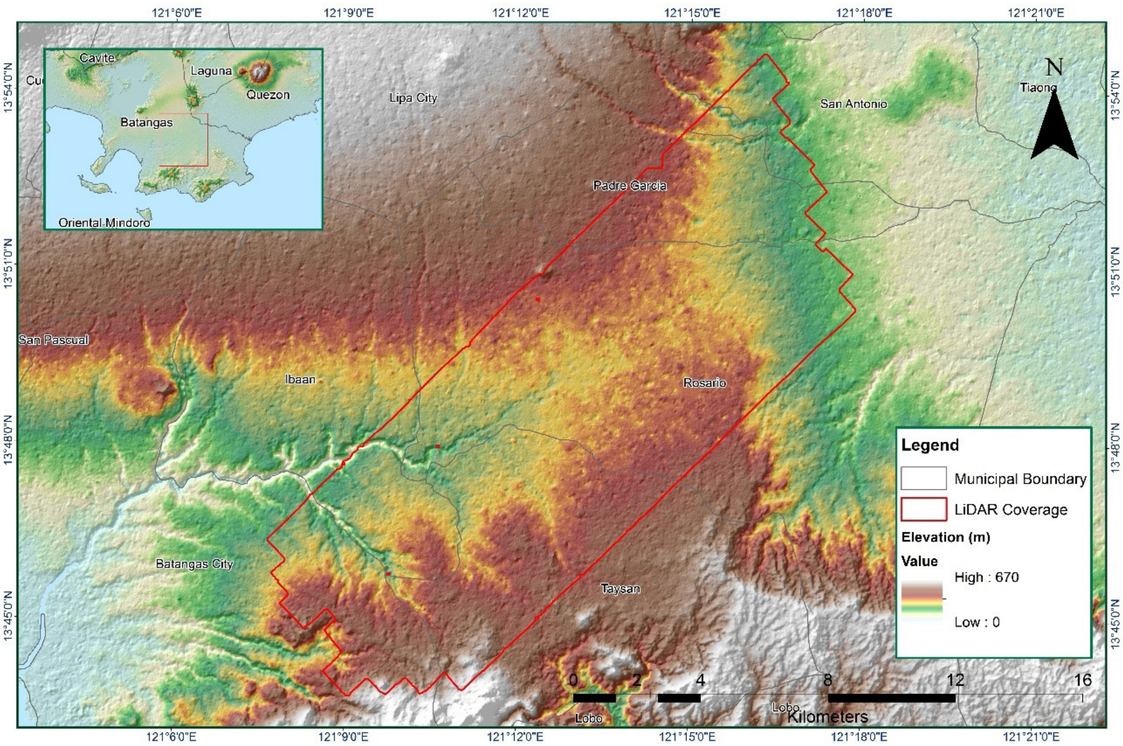


Figure 1.8.4. Coverage of LiDAR Data

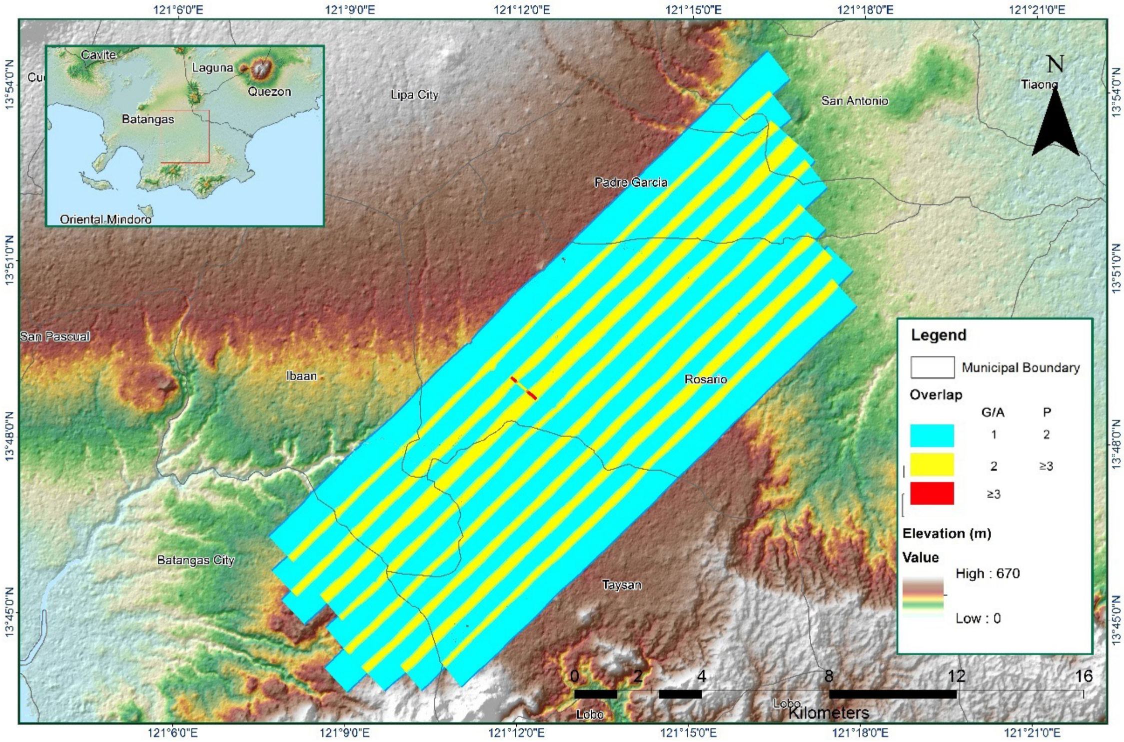


Figure 1.8.5. Image of data overlap

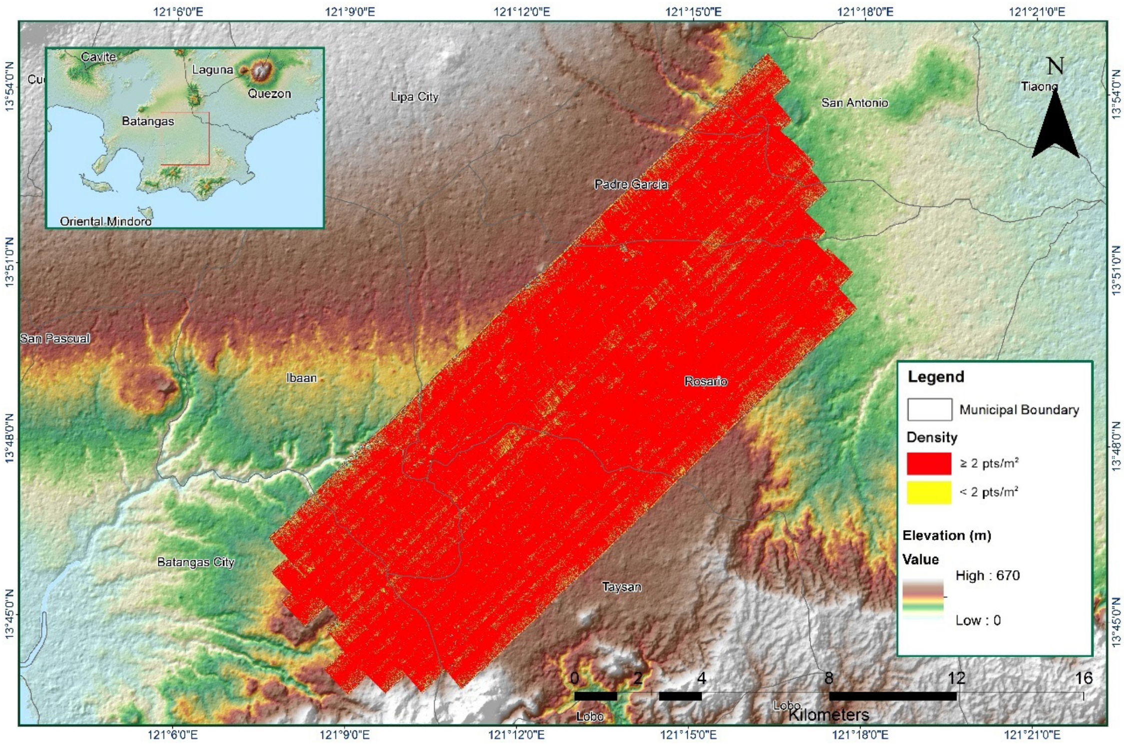


Figure 1.8.6. Density map of merged LiDAR data

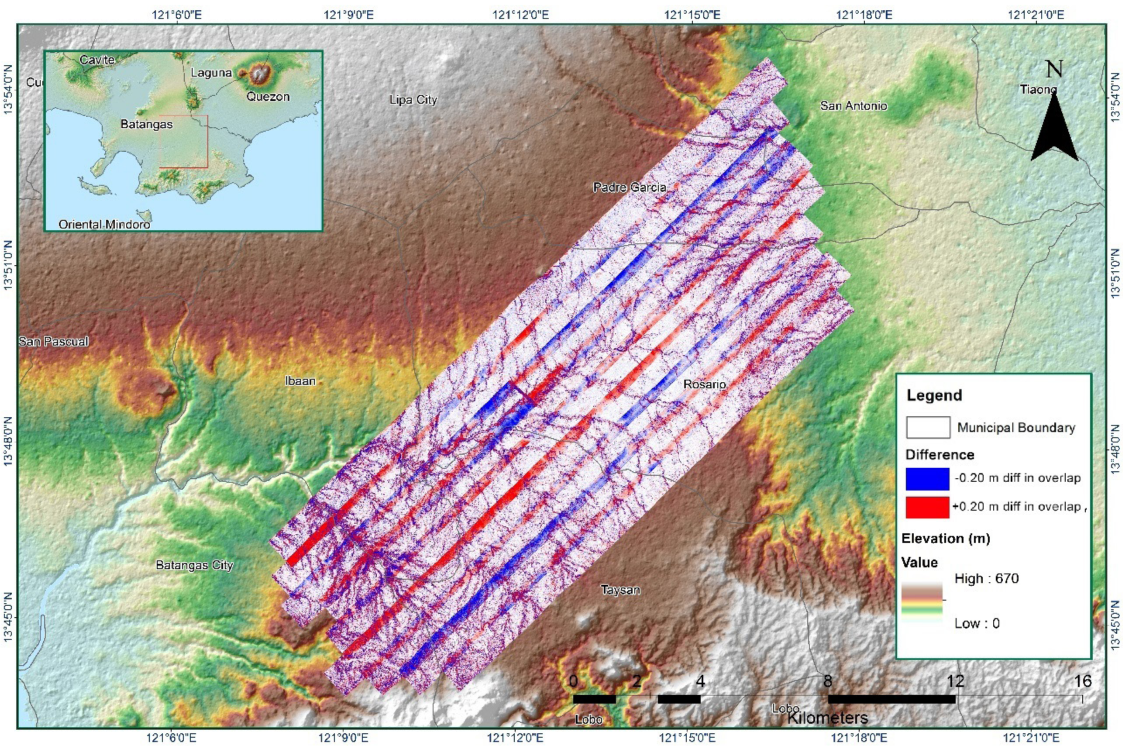


Figure 1.8.7. Elevation difference between flight lines

Flight Area	Batangas
Mission Name	**Blk18QR**
Inclusive Flights	1111P, 1125P
Range data size	14.7 GB
POS data size	194 MB
Base data size	10.9 MB
Image	19.7 GB
Transfer date	April 14, 2014
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)	1.11
RMSE for East Position (<4.0 cm)	1.38
RMSE for Down Position (<8.0 cm)	3.05
Boresight correction stdev (<0.001deg)	0.000419
IMU attitude correction stdev (<0.001deg)	0.000506
GPS position stdev (<0.01m)	0.0294
Minimum % overlap (>25)	60.87
Ave point cloud density per sq.m. (>2.0)	2.36
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	240
Maximum Height	858.77 m
Minimum Height	46.29 m
Classification (# of points)	
Ground	125,111,499
Low vegetation	188,073,929
Medium vegetation	174,188,362
High vegetation	204,736,395
Building	22,904,374
Orthophoto	Yes
Processed by	Engr. Carlyn Ann Ibañez, Engr. Christy Lubiano, Ryan James Nicholai Dizon

Figure 1.9.1. Solution Status

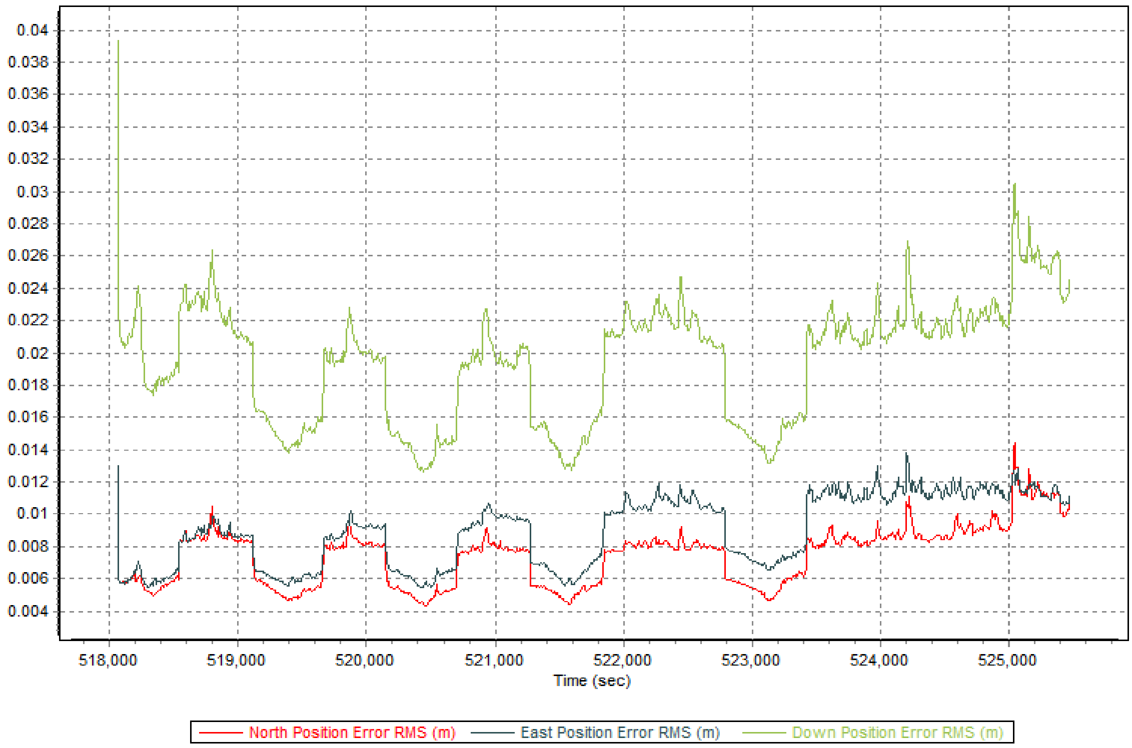


Figure 1.9.2. Smoothed Performance Metric Parameters

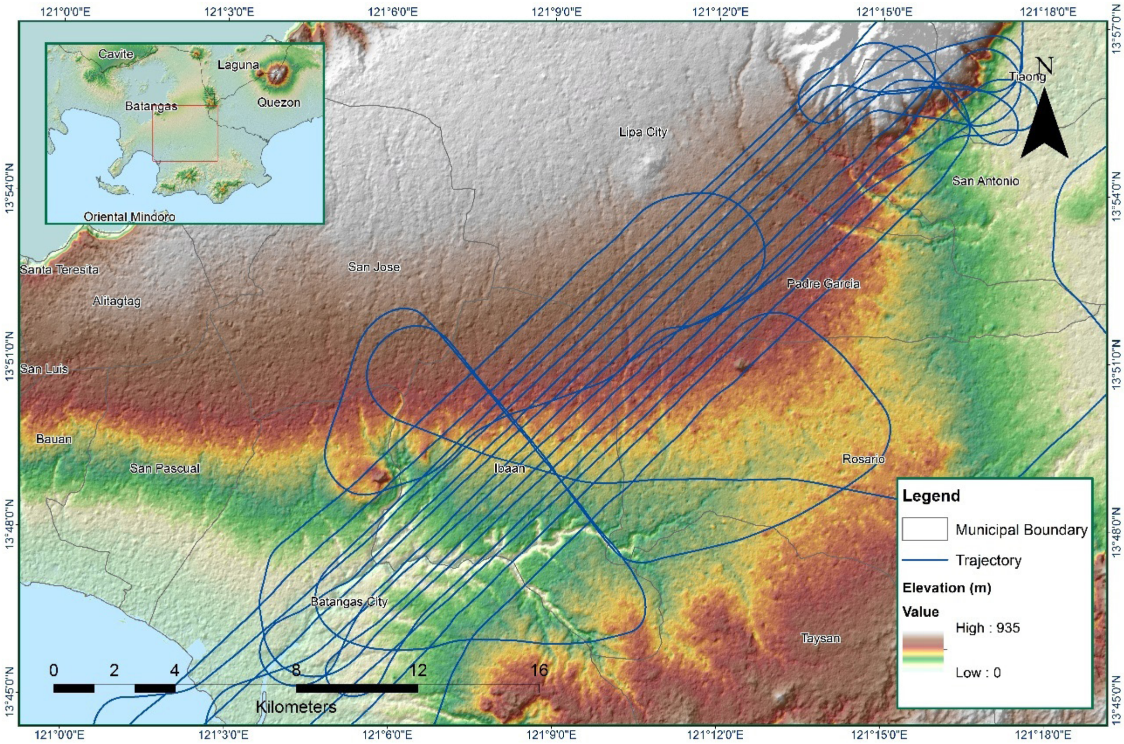


Figure 1.9.3. Best Estimated Trajectory

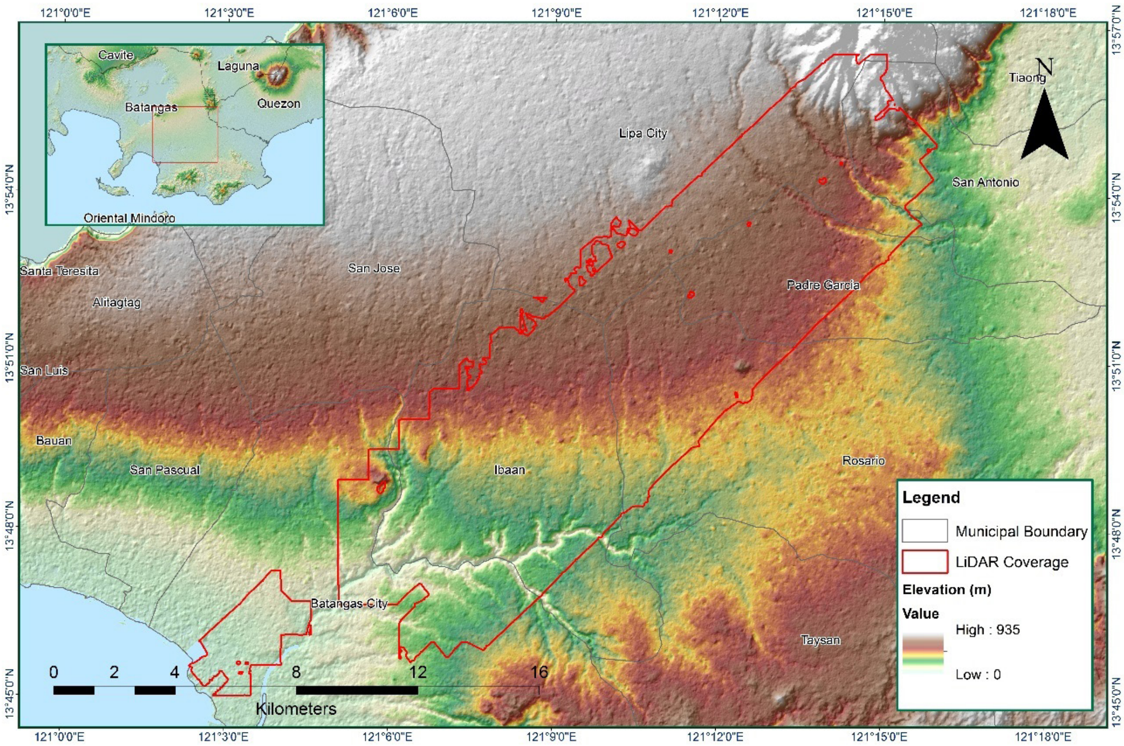


Figure 1.9.4. Coverage of LiDAR Data

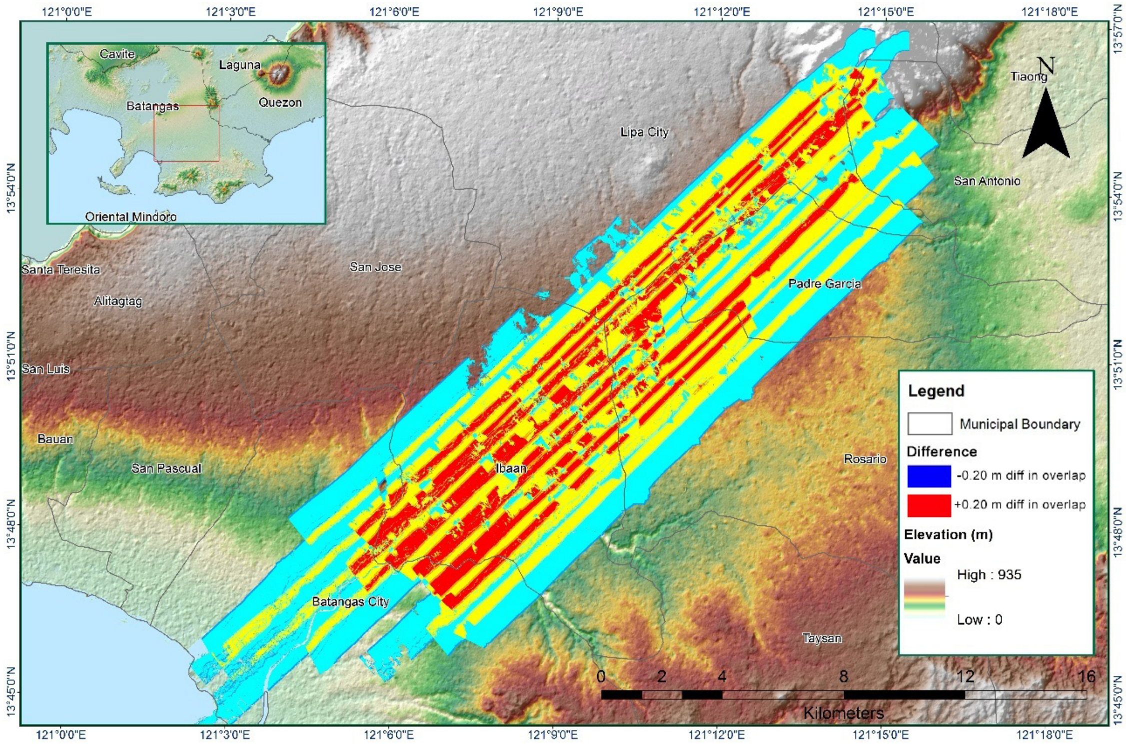


Figure 1.9.5. Image of data overlap

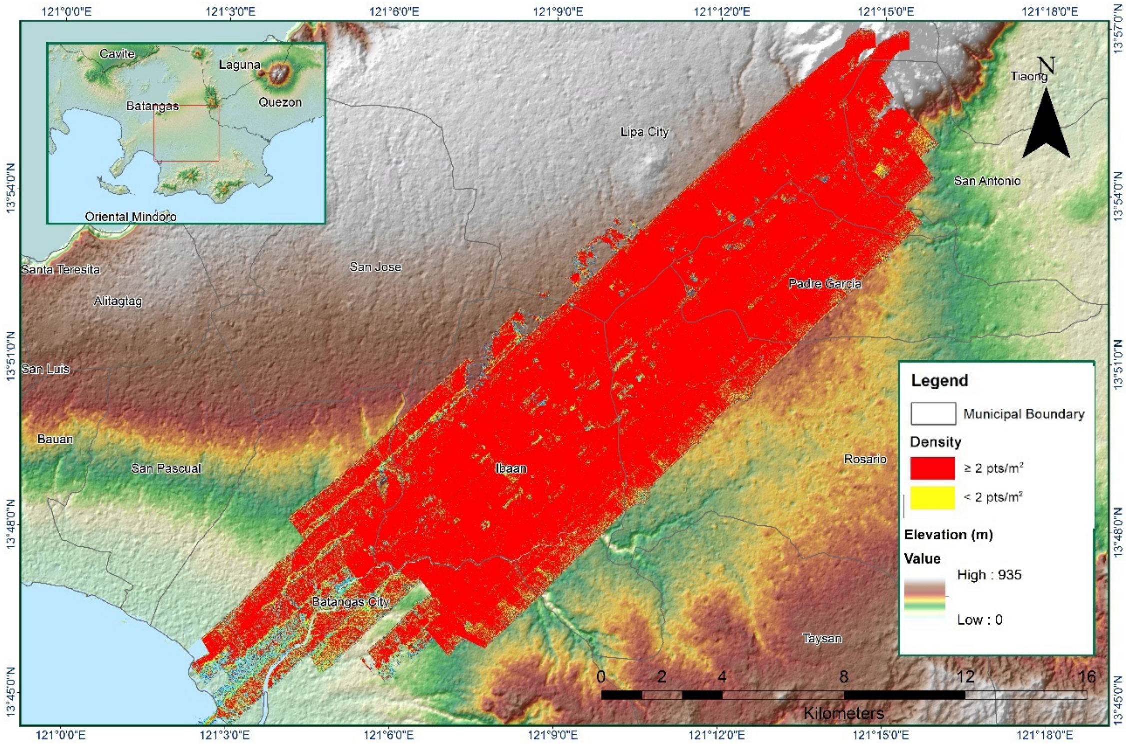


Figure 1.9.6. Density map of merged LiDAR data

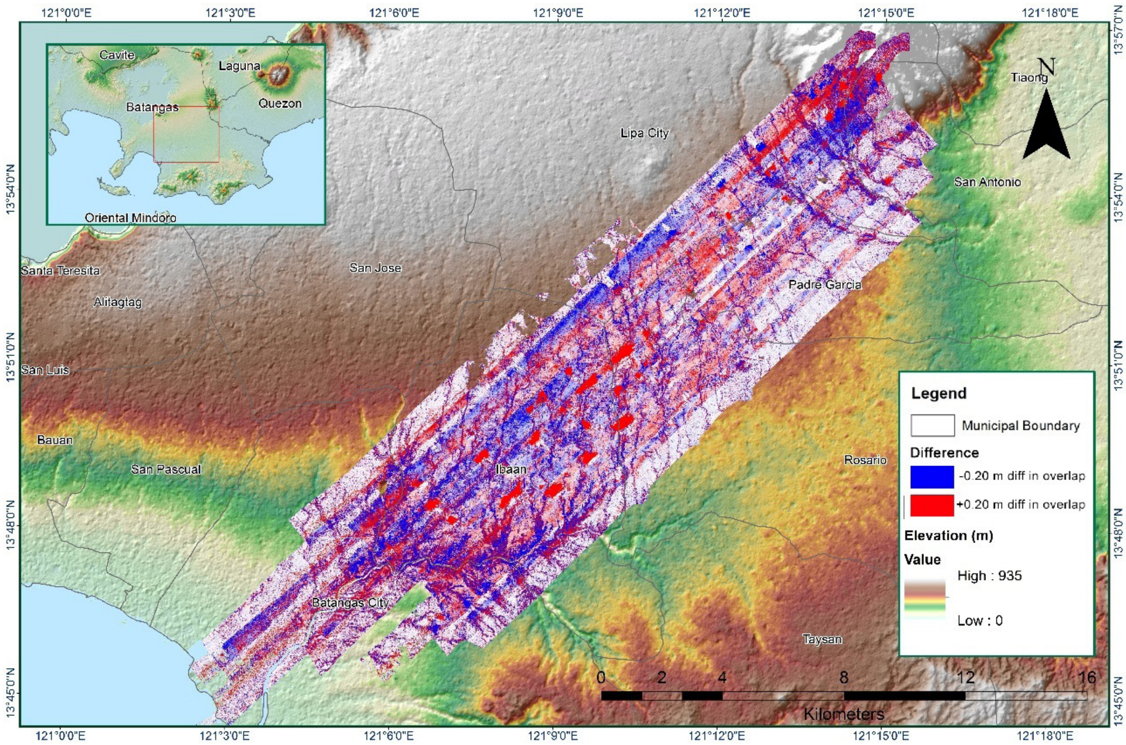


Figure 1.9.7. Elevation difference between flight lines

Flight Area	**CALABARZON**
Mission Name	**Blk18T**
Inclusive Flights	1105P
Range data size	22.2 GB
POS	219 MB
Image	N/A
Transfer date	04/23/2014
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)	1.7
RMSE for East Position (<4.0 cm)	1.7
RMSE for Down Position (<8.0 cm)	4.0
Boresight correction stdev (<0.001deg)	0.000443
IMU attitude correction stdev (<0.001deg)	0.001044
GPS position stdev (<0.01m)	0.0025
Minimum % overlap (>25)	33.79%
Ave point cloud density per sq.m. (>2.0)	2.05
Elevation difference between strips (<0.20 m)	Yess
Number of 1km x 1km blocks	339
Maximum Height	517.47 m
Minimum Height	48.70 m
Classification (# of points)	
Ground	196,485,951
Low vegetation	185,130,359
Medium vegetation	161,015,365
High vegetation	284,515,283
Building	11,560,170
Orthophoto	No
Processed by	Engr. Angelo Carlo Bongat, Celina Rosete, Engr. Jeffrey Delica

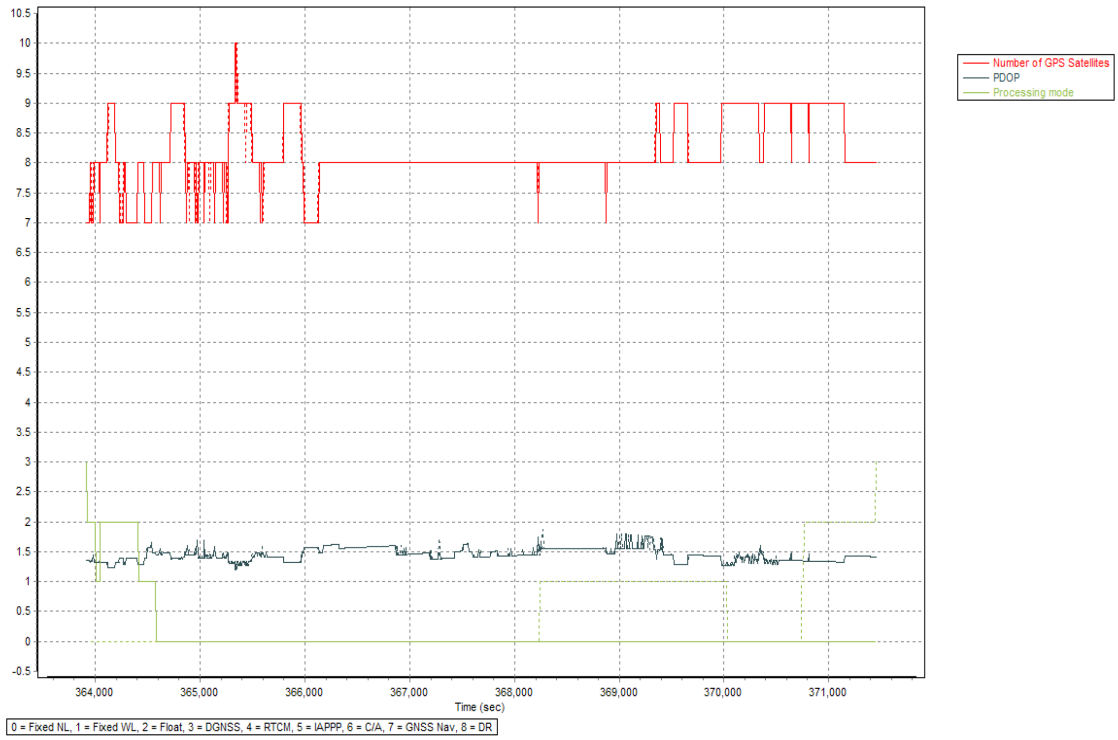


Figure 1.10.1. Solution Status

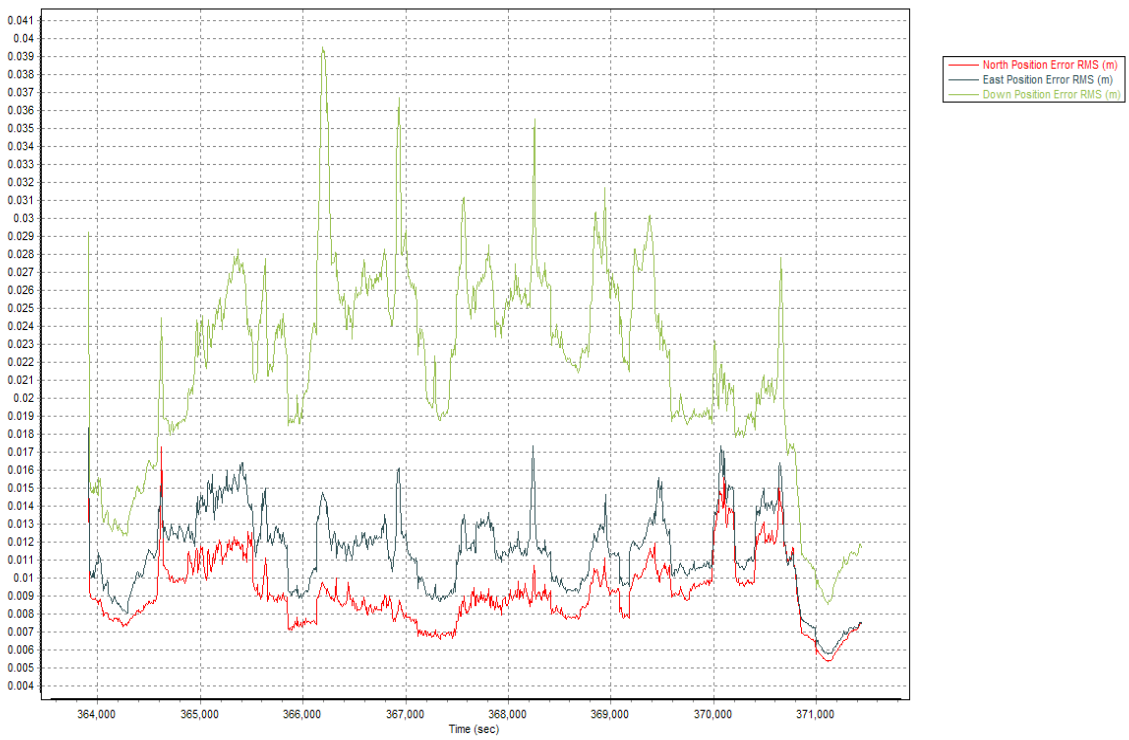


Figure 1.10.2. Smoothed Performance Metrics Parameters

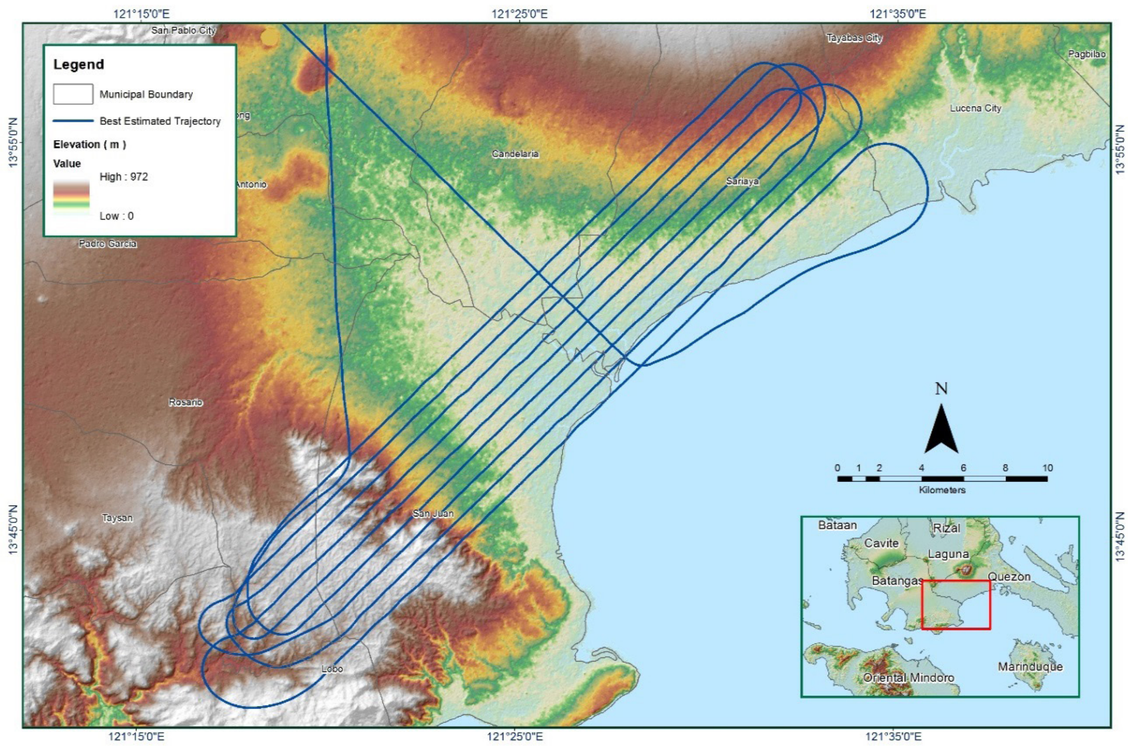


Figure 1.10.3. Best Estimated Trajectory

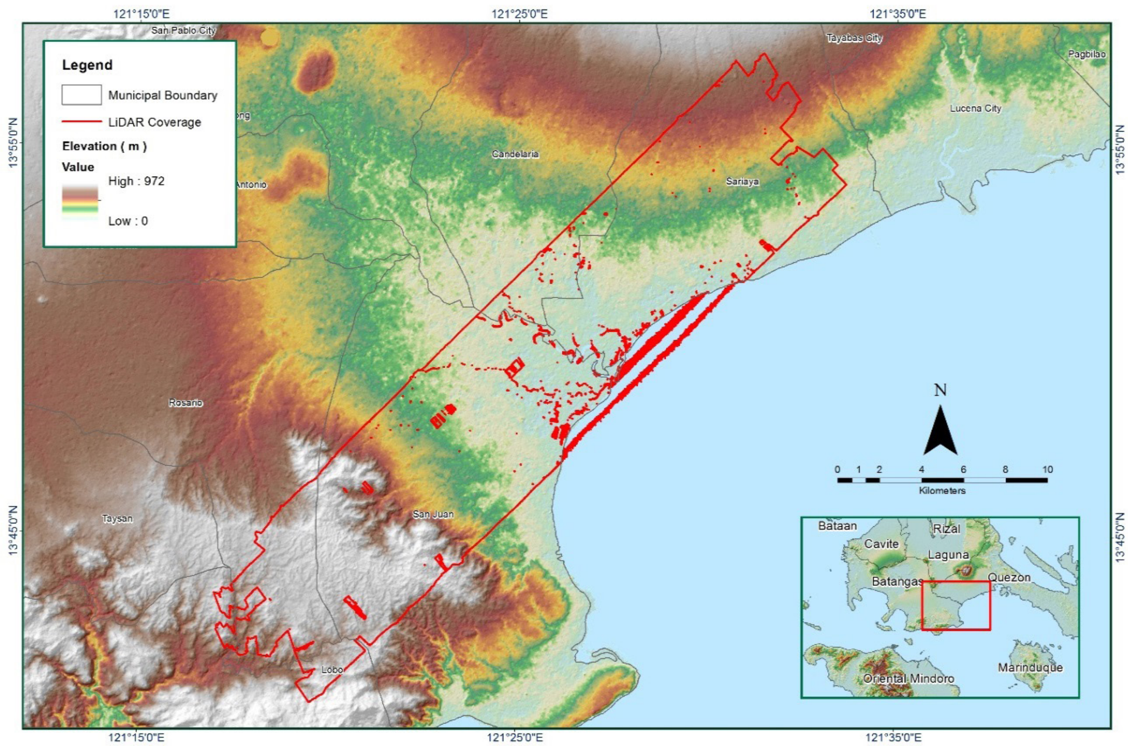


Figure 1.10.4. Coverage of LiDAR data

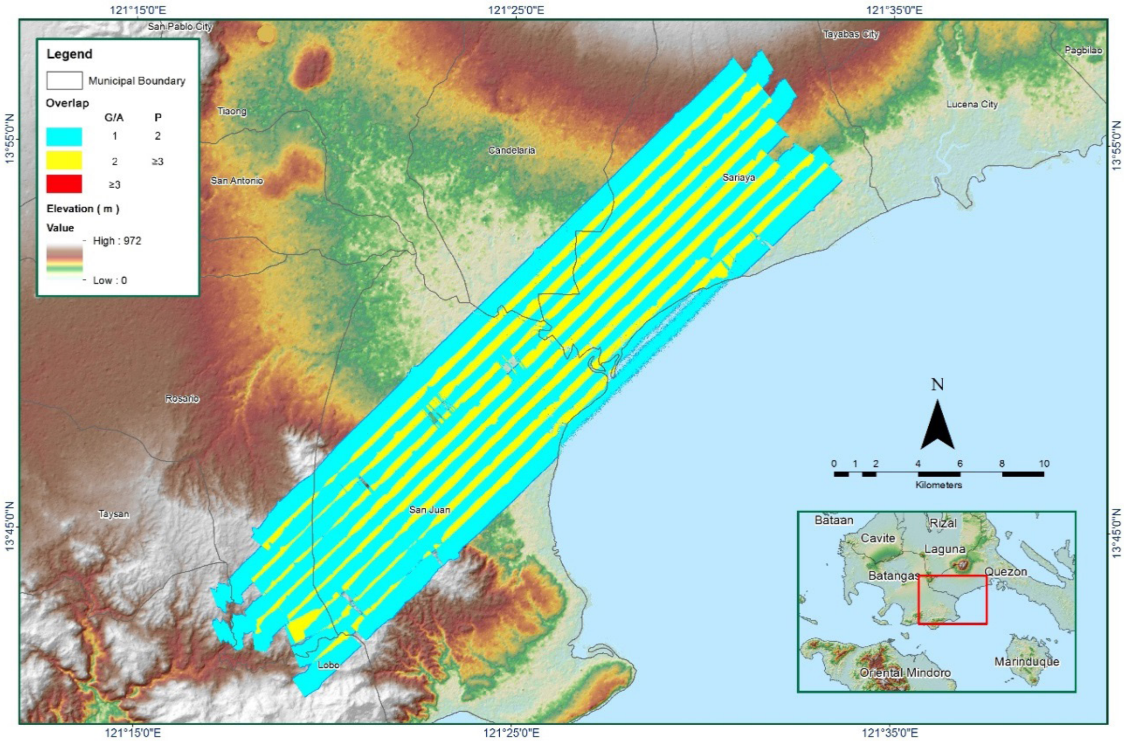


Figure 1.10.5. Image of data overlap

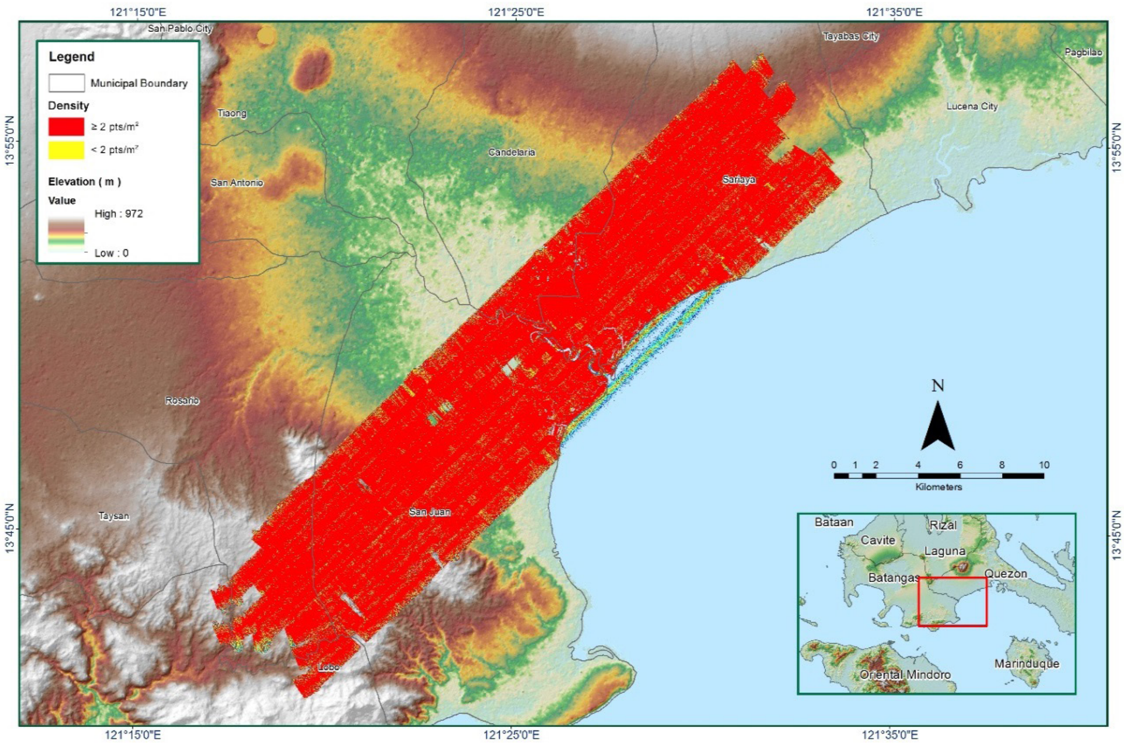


Figure 1.10.6. Density map of merged LiDAR data

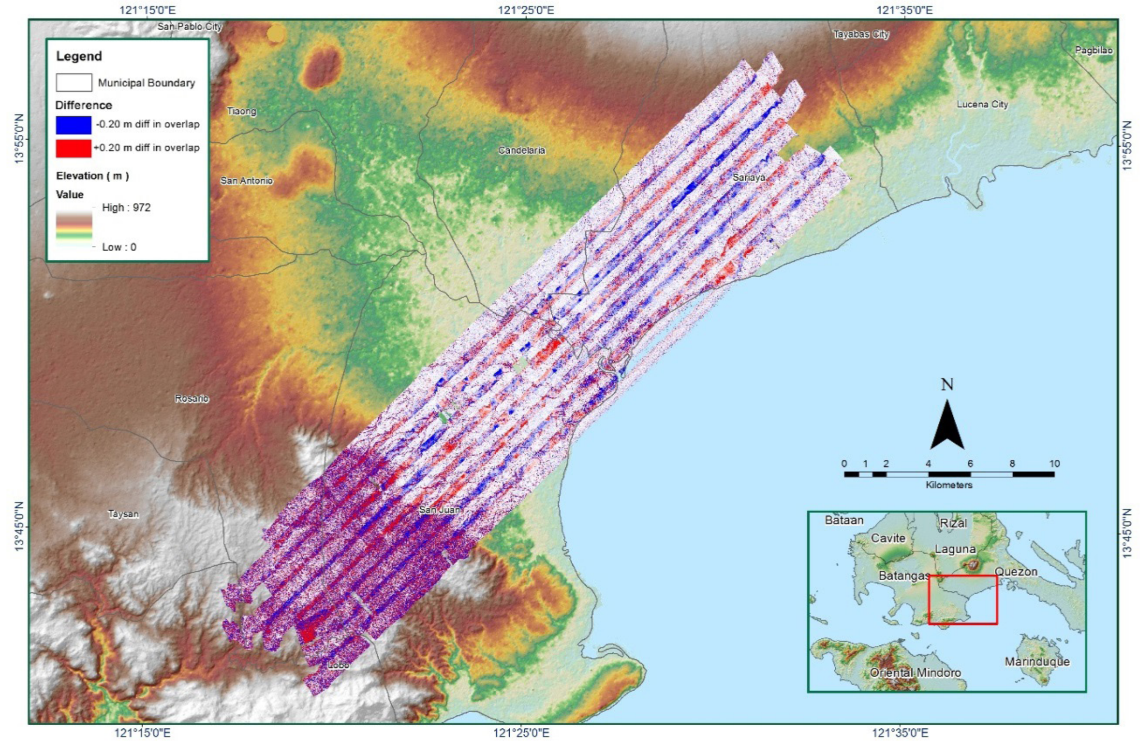


Figure 1.10.7. Elevation difference between flight lines

Flight Area	CALABARZON
Mission Name	**Blk18U_supplement**
Inclusive Flights	1109P
Range data size	15.9 GB
POS	183 MB
Image	N/A
Transfer date	04/23/2014
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)	1.4
RMSE for East Position (<4.0 cm)	2.2
RMSE for Down Position (<8.0 cm)	4.0
Boresight correction stdev (<0.001deg)	0.000377
IMU attitude correction stdev (<0.001deg)	0.000547
GPS position stdev (<0.01m)	0.0016
Minimum % overlap (>25)	32.26%
Ave point cloud density per sq.m. (>2.0)	1.93
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	245
Maximum Height	504.30 m
Minimum Height	49.31 m
Classification (# of points)	
Ground	137,187,219
Low vegetation	134,794,804
Medium vegetation	120,998,488
High vegetation	169,074,924
Building	9,822,052
Orthophoto	No
Processed by	Engr. Angelo Carlo Bongat, Engr. Abigail Joy Ching, Jovy Ann Narisma

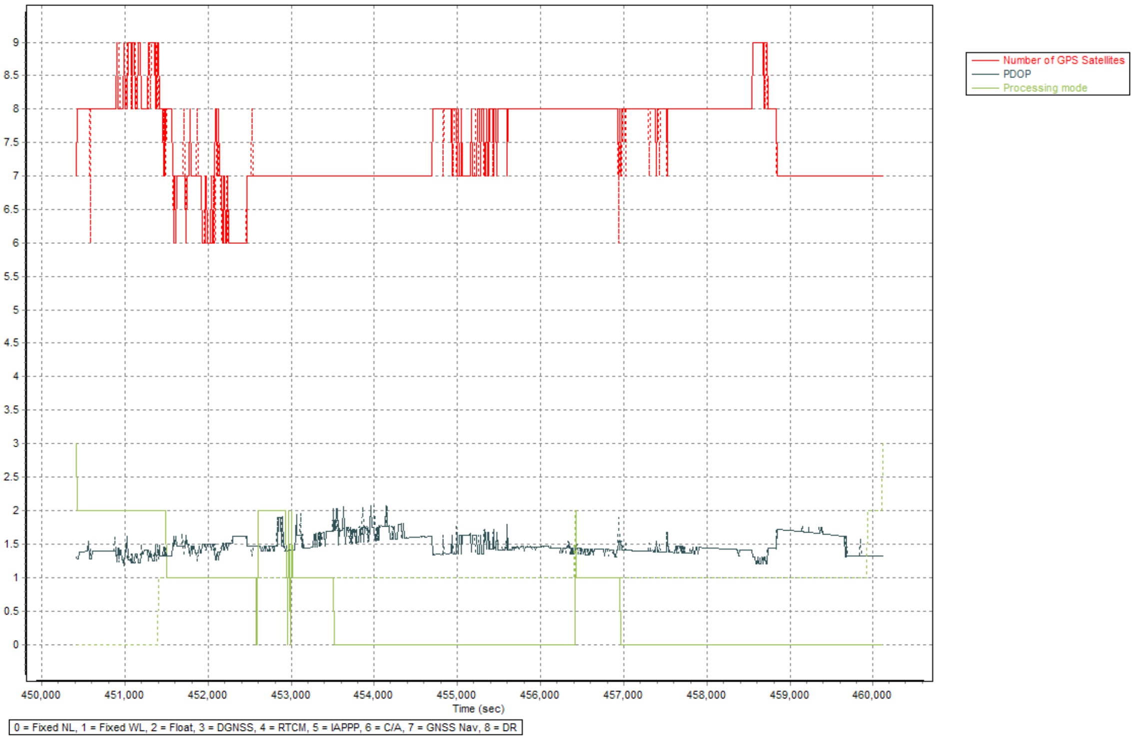


Figure 1.11.1. Solution Status

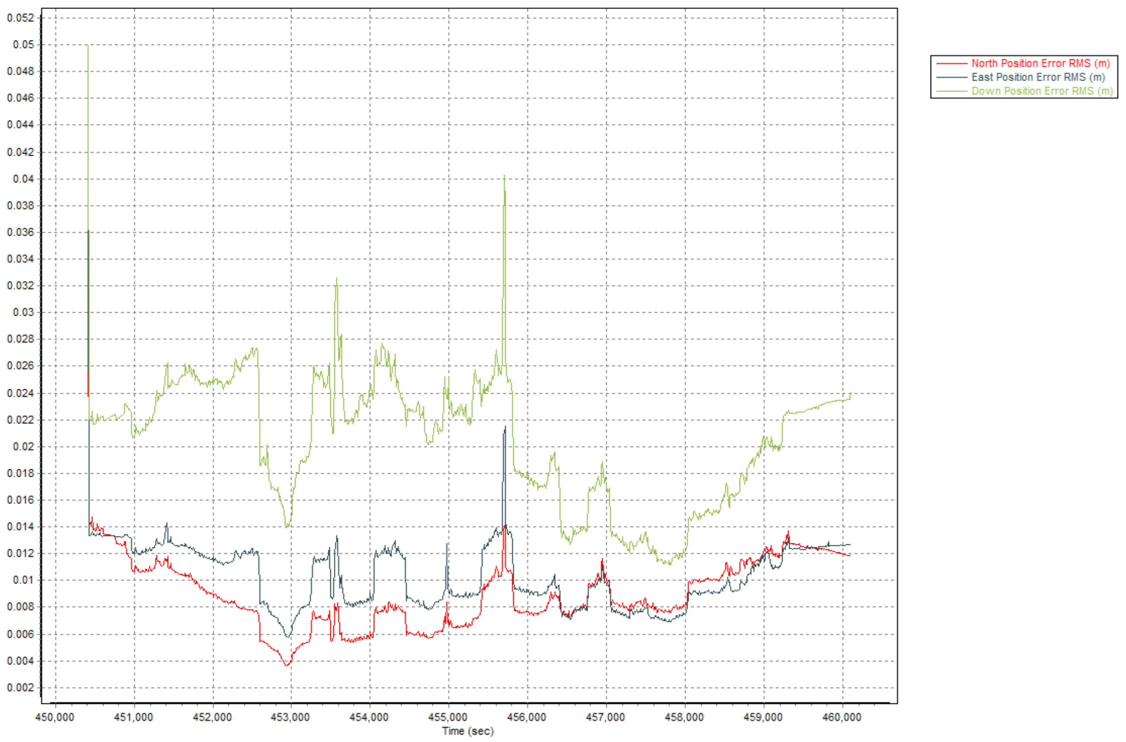


Figure 1.11.2. Smoothed Performance Metrics Parameters

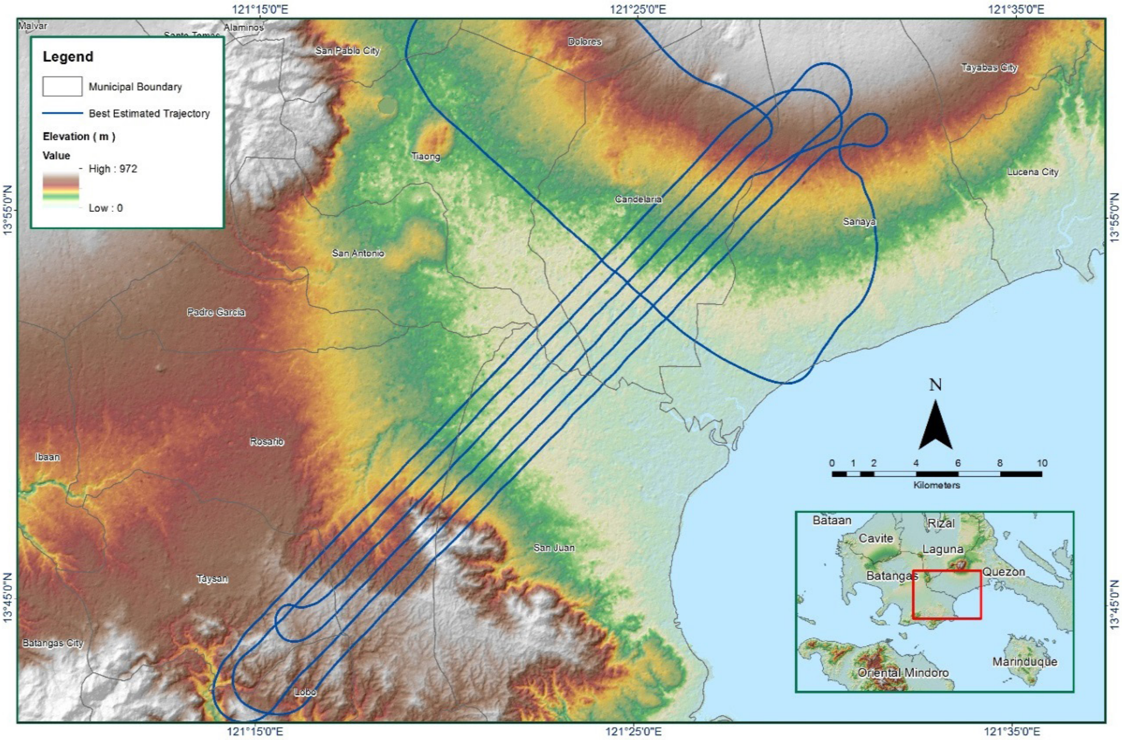


Figure 1.11.3. Best Estimated Trajectory

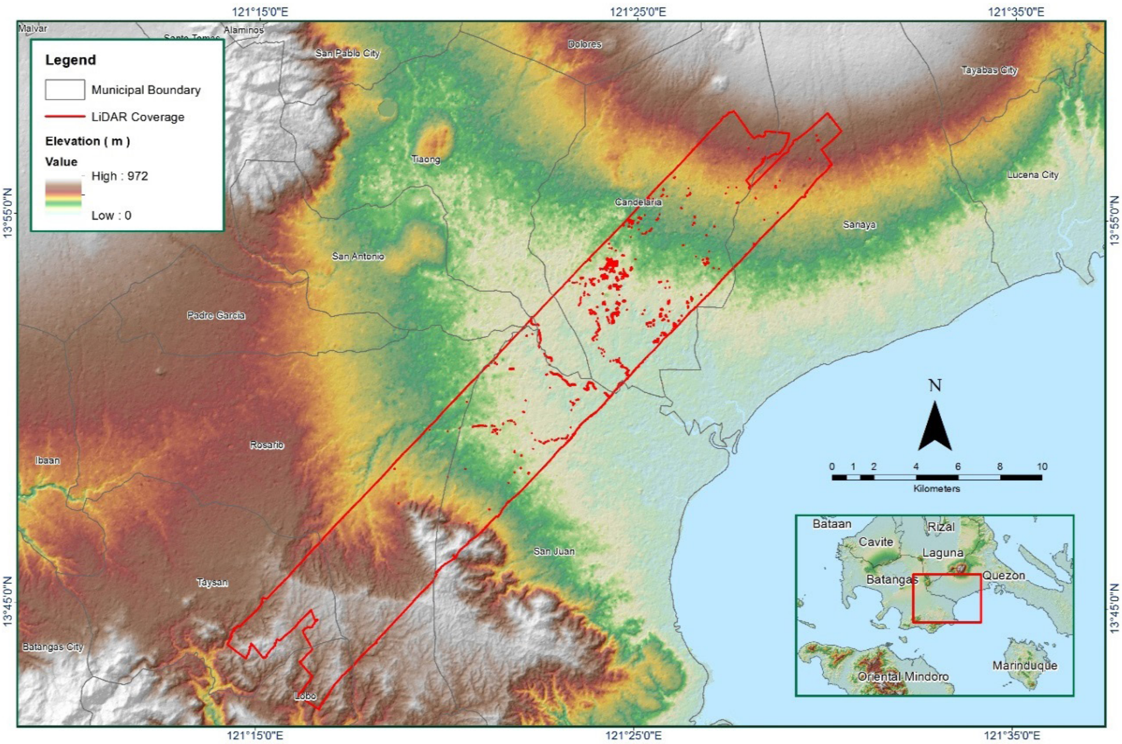


Figure 1.11.4. Coverage of LiDAR data

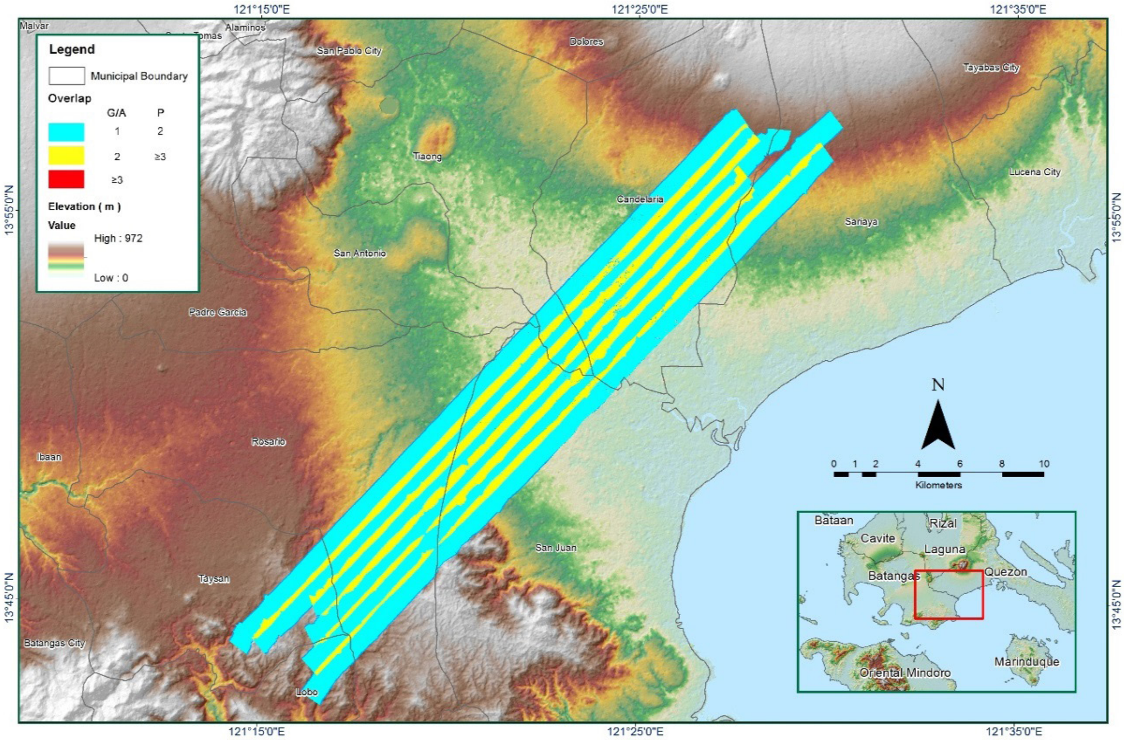


Figure 1.11.5. Image of data overlap

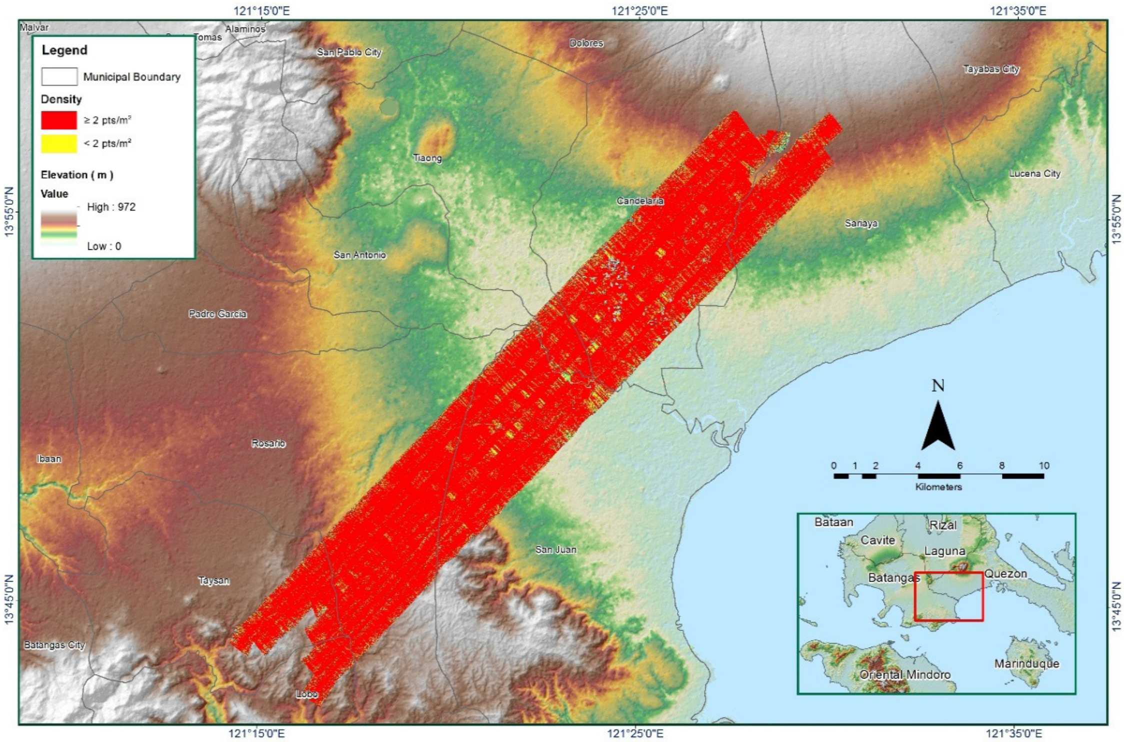


Figure 1.11.6. Density map of merged LiDAR data

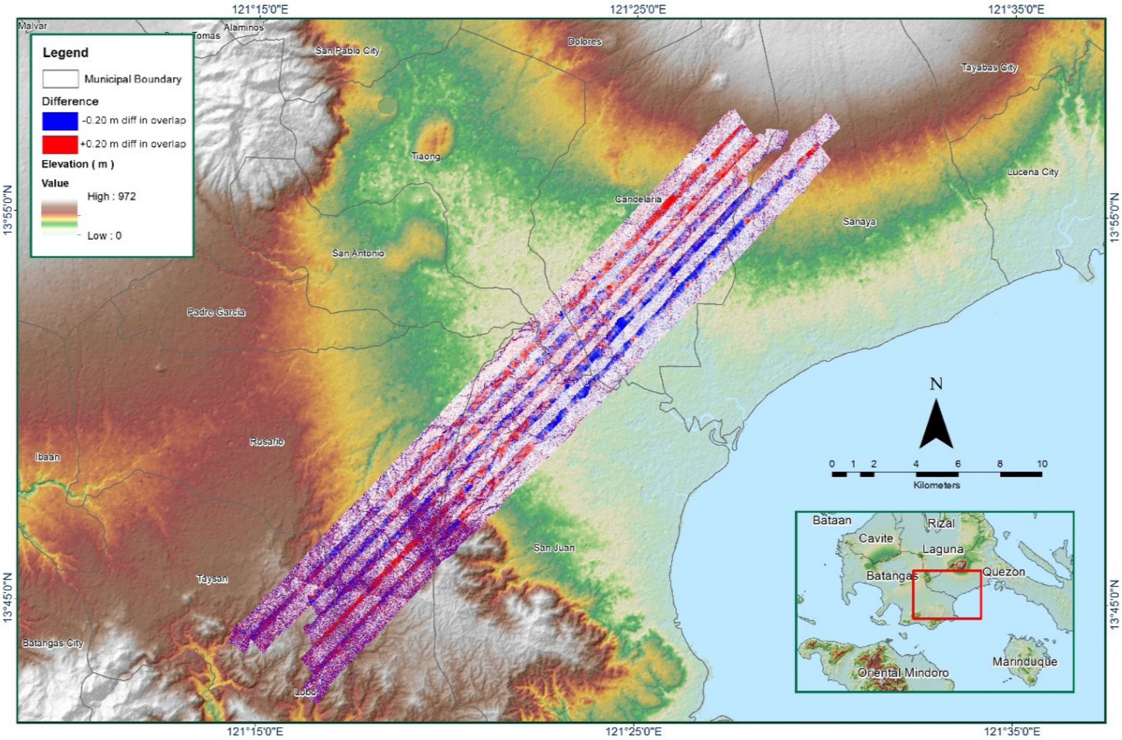


Figure 1.11.7. Elevation difference between flight lines

Flight Area	CALABARZON
Mission Name	**Blk18U**
Inclusive Flights	1095P; 1099P
Range data size	35.6 GB
POS	469 MB
Image	96.9 MB
Transfer date	04/23/2014
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)	1.6
RMSE for East Position (<4.0 cm)	2.7
RMSE for Down Position (<8.0 cm)	4.5
Boresight correction stdev (<0.001deg)	0.000440
IMU attitude correction stdev (<0.001deg)	0.001048
GPS position stdev (<0.01m)	0.0020
Minimum % overlap (>25)	28.21%
Ave point cloud density per sq.m. (>2.0)	2.36
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	418
Maximum Height	1240.04 m
Minimum Height	48.96 m
Classification (# of points)	
Ground	210,036,267
Low vegetation	216,673,271
Medium vegetation	165,265,018
High vegetation	231,122,835
Building	15,950,043
Orthophoto	No
Processed by	Victoria Maria Rejuso, Engr. Charmaine Cruz, Jovy Ann Narisma

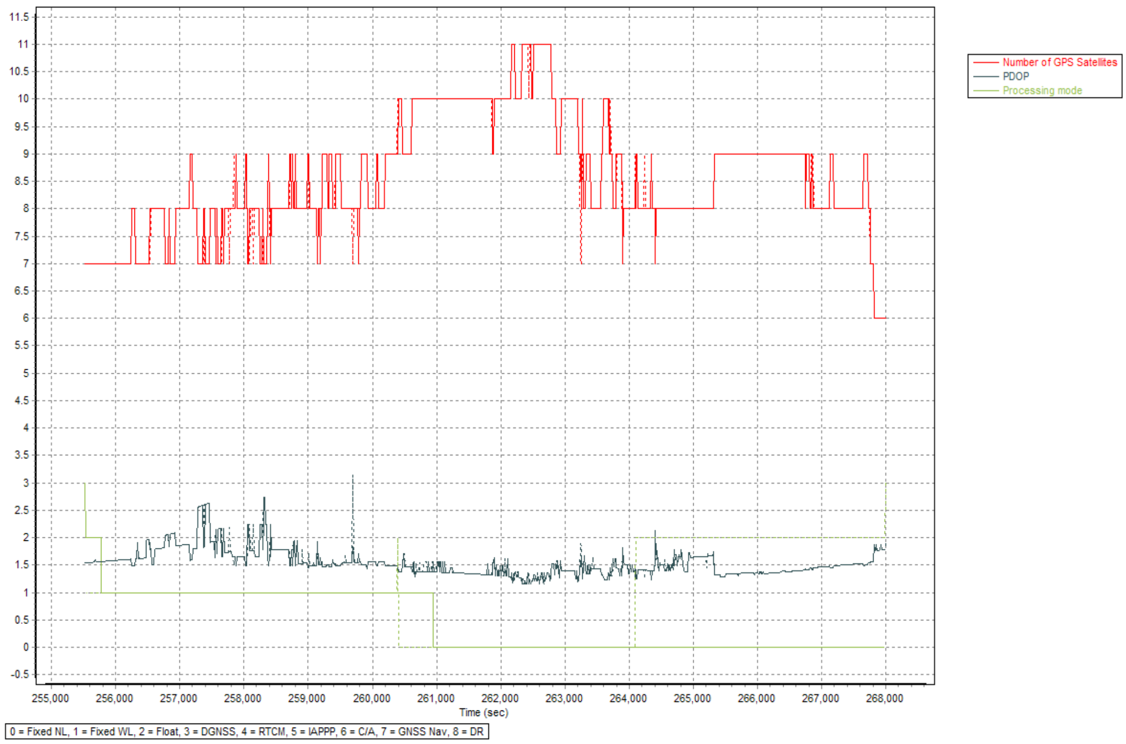


Figure 1.12.1. Solution Status

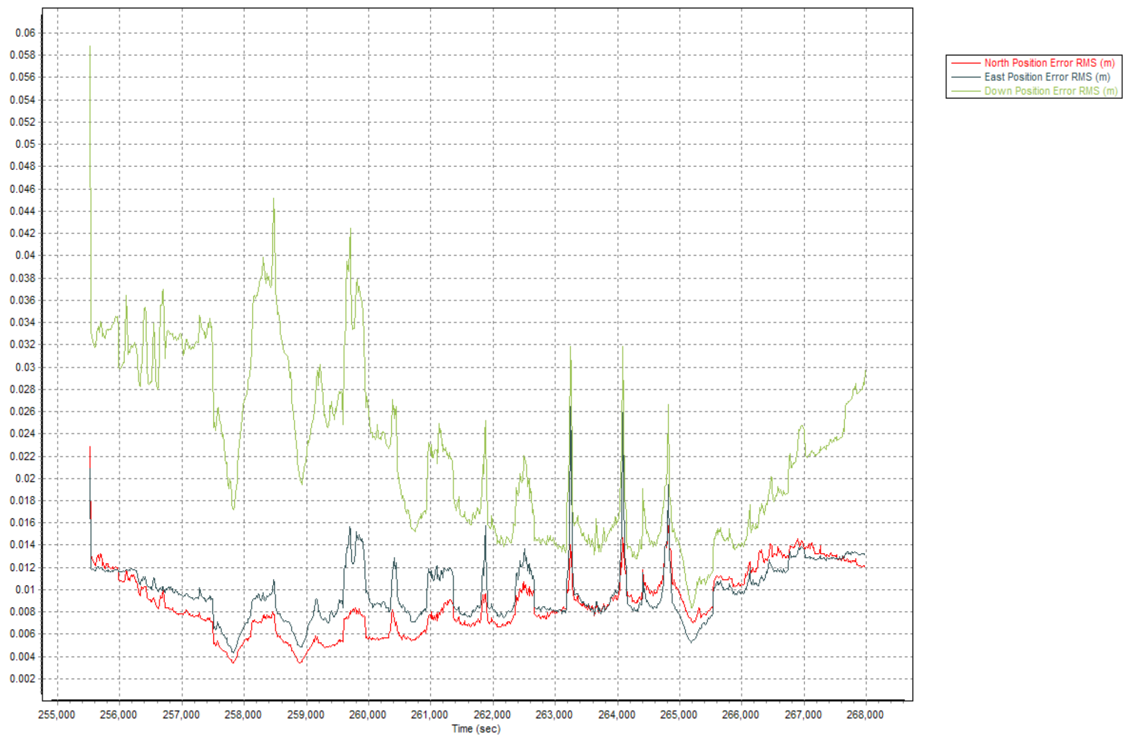


Figure 1.12.2. Smoothed Performance Metrics Parameters

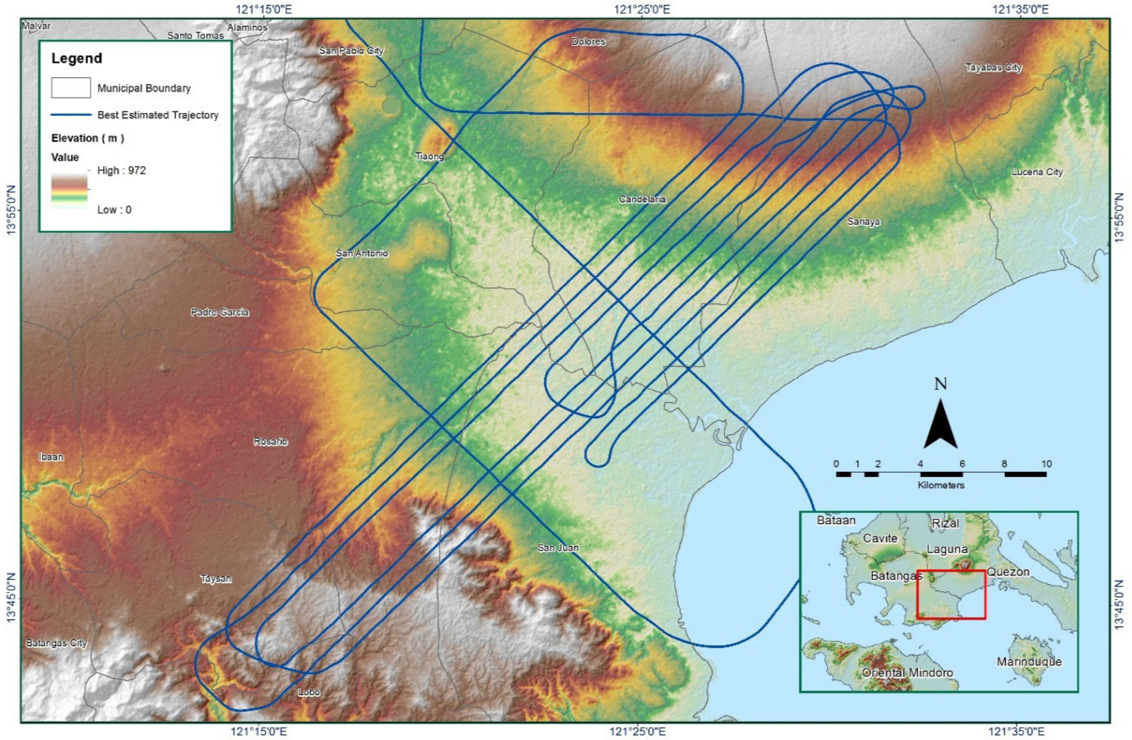


Figure 1.12.3. Best Estimated Trajectory

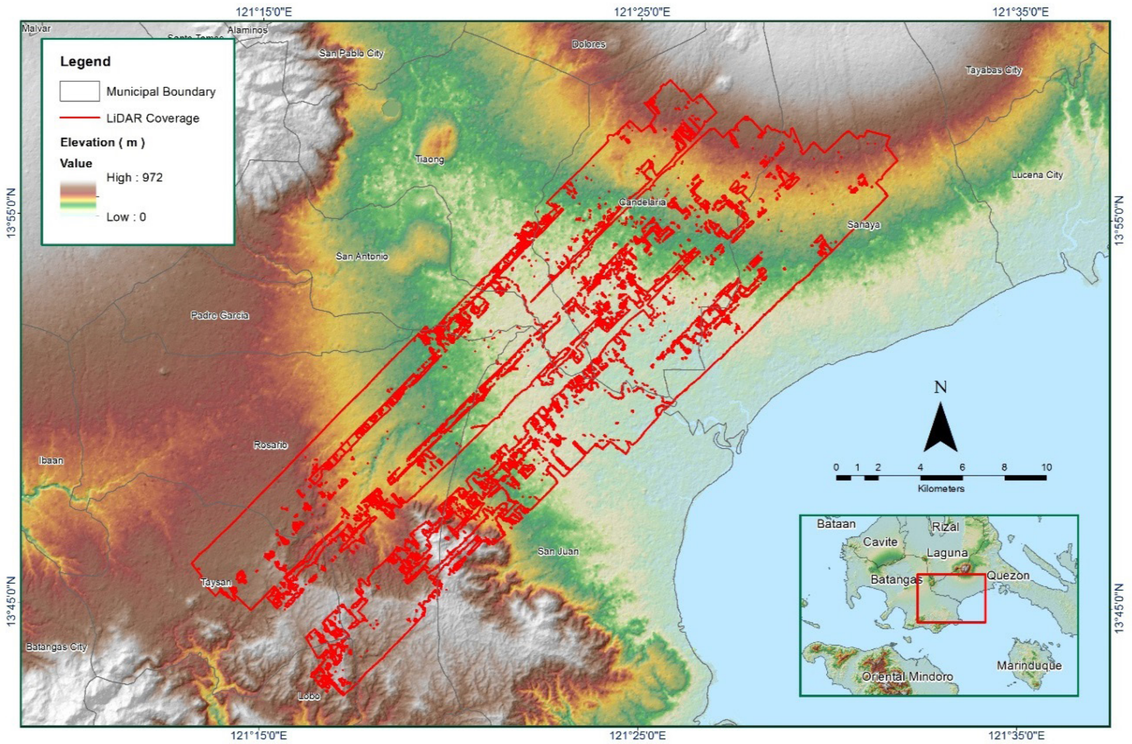


Figure 1.12.4. Coverage of LiDAR data

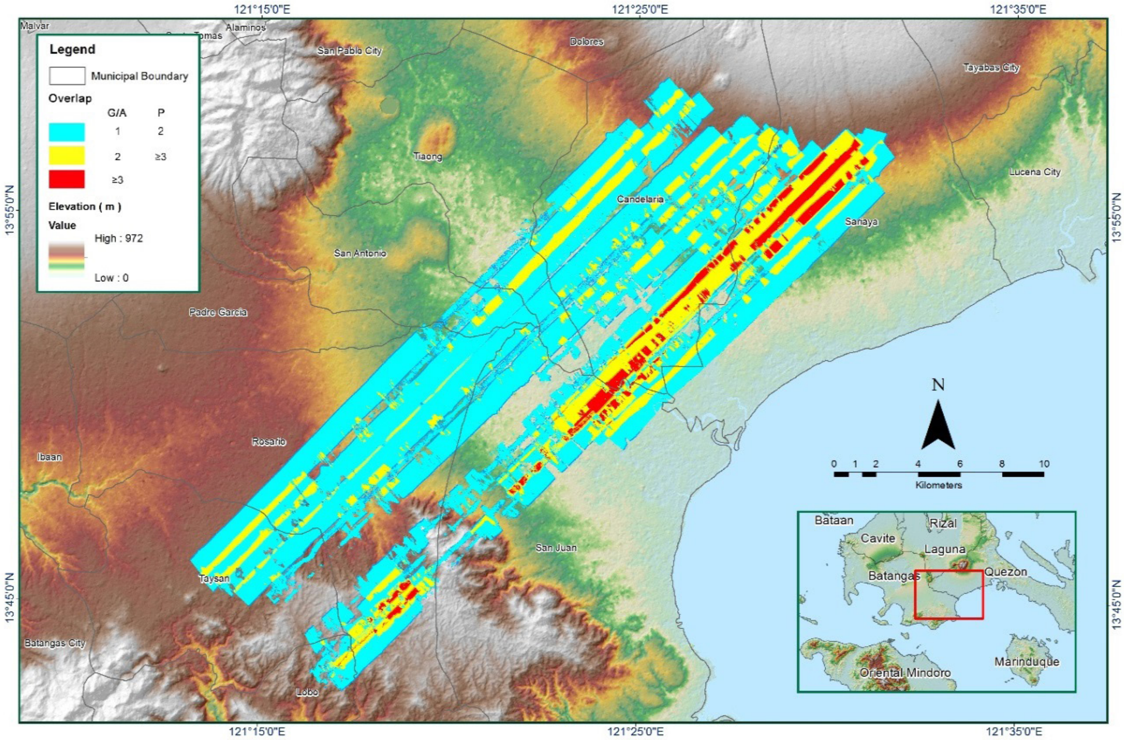


Figure 1.12.5. Image of data overlap

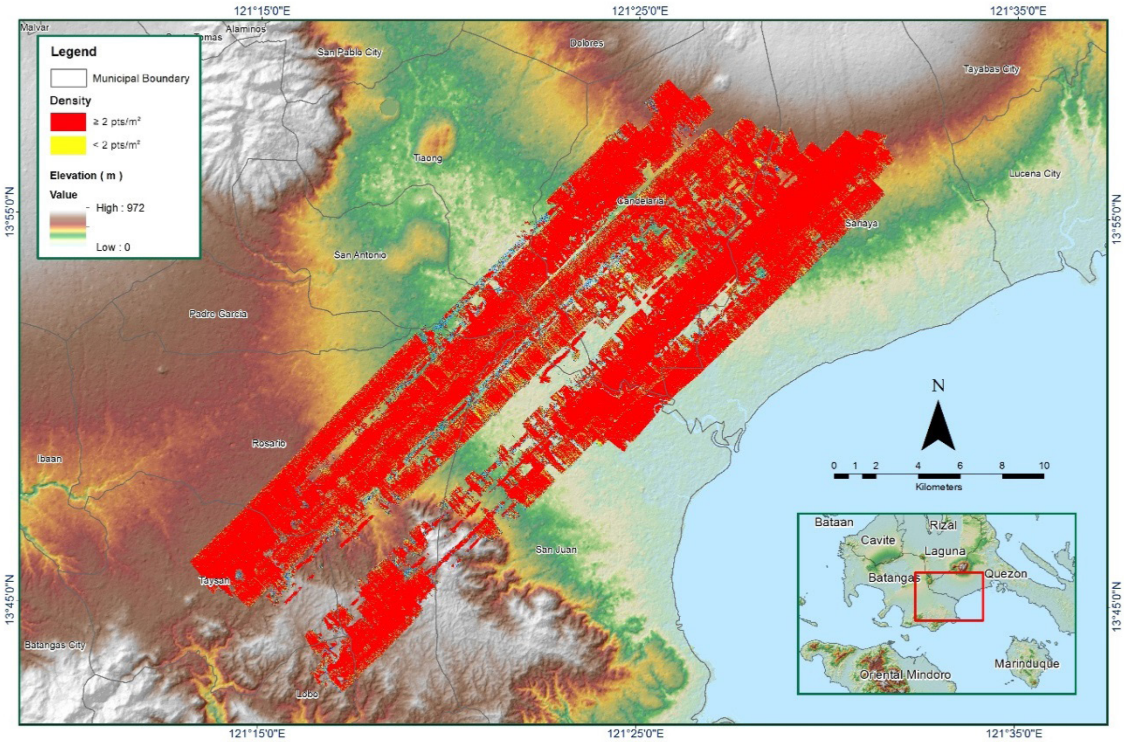


Figure 1.12.6. Density map of merged LiDAR data

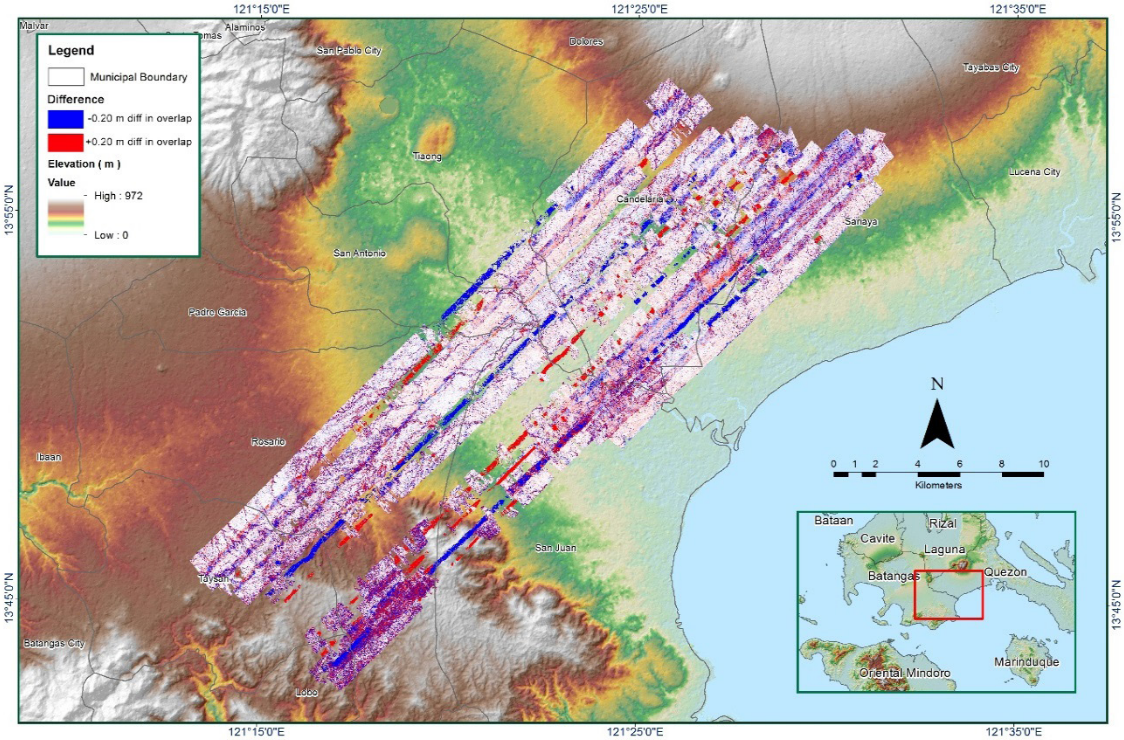


Figure 1.12.7. Elevation difference between flight lines

Flight Area	CALABARZON
Mission Name	**Blk18VW_supplement**
Inclusive Flights	1103P
Range data size	19.8 GB
POS	221 MB
Image	N/A
Transfer date	04/23/2014
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)	0.9
RMSE for East Position (<4.0 cm)	1.4
RMSE for Down Position (<8.0 cm)	5.5
Boresight correction stdev (<0.001deg)	0.000547
IMU attitude correction stdev (<0.001deg)	0.001657
GPS position stdev (<0.01m)	0.0086
Minimum % overlap (>25)	34.32%
Ave point cloud density per sq.m. (>2.0)	2.15
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	305
Maximum Height	712.23 m
Minimum Height	59.56 m
Classification (# of points)	
Ground	171,488,434
Low vegetation	168,868,841
Medium vegetation	161,212,850
High vegetation	246,176,725
Building	12,644,487
Orthophoto	No
Processed by	Engr. Kenneth Solidum, Engr. Christy Lubiano, Ailyn Biñas

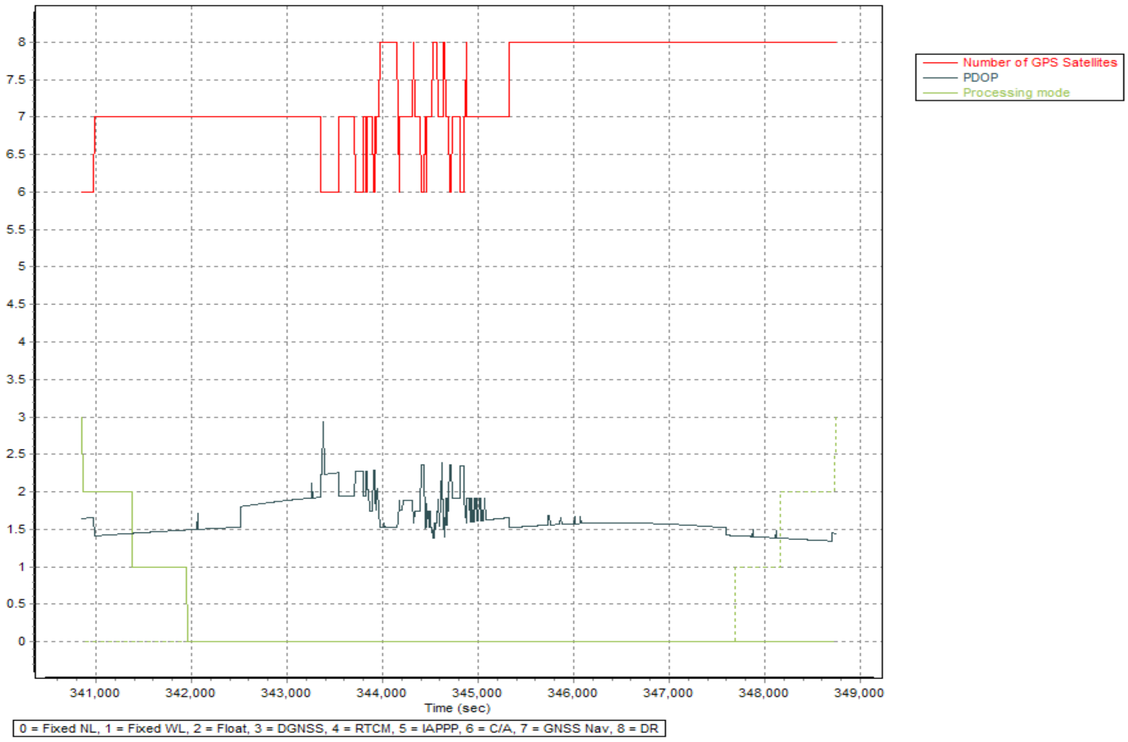


Figure 1.13.1. Solution Status

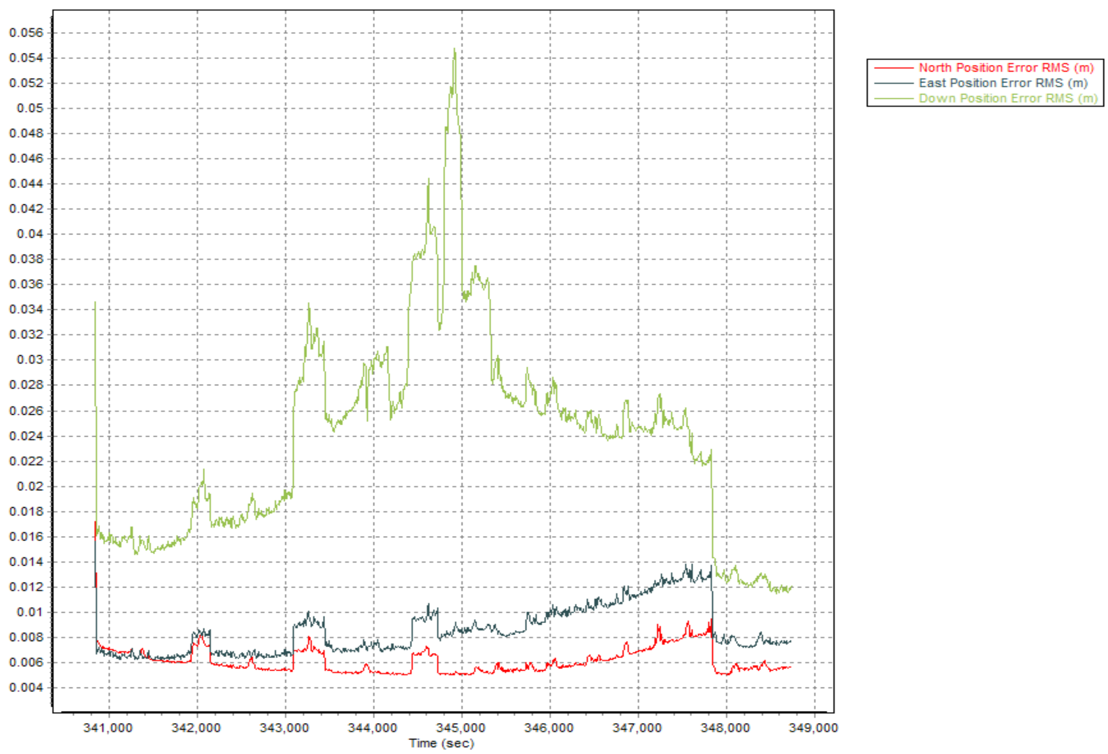


Figure 1.13.2. Smoothed Performance Metrics Parameters

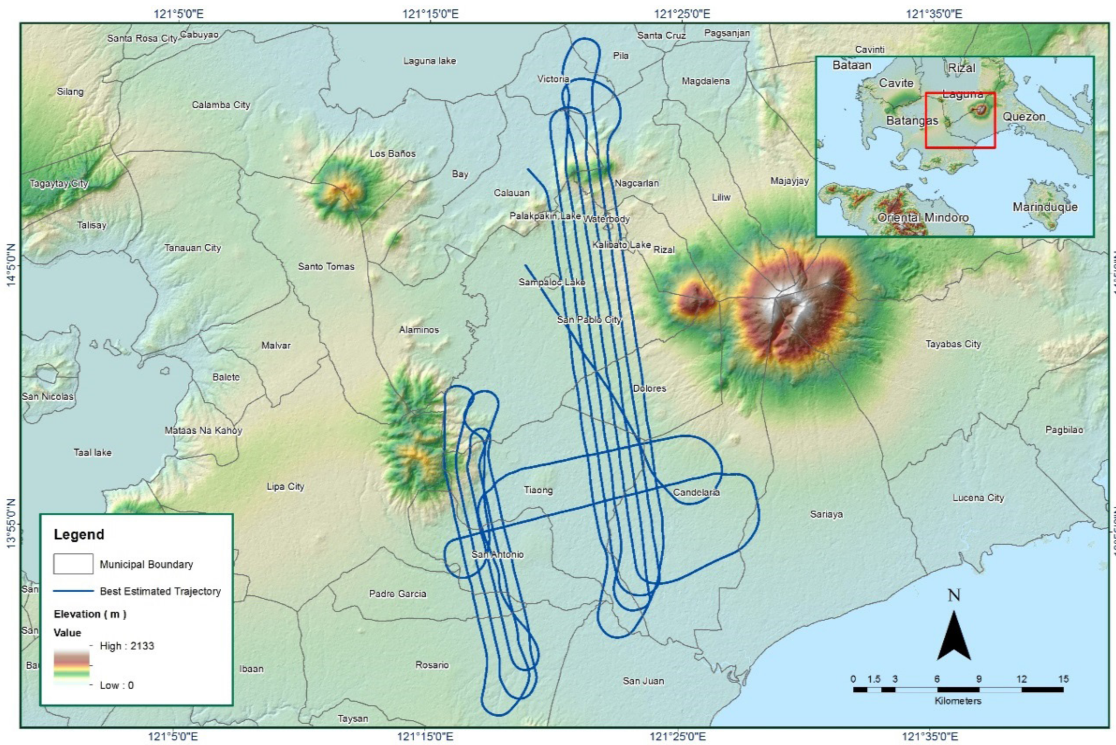


Figure 1.13.3. Best Estimated Trajectory

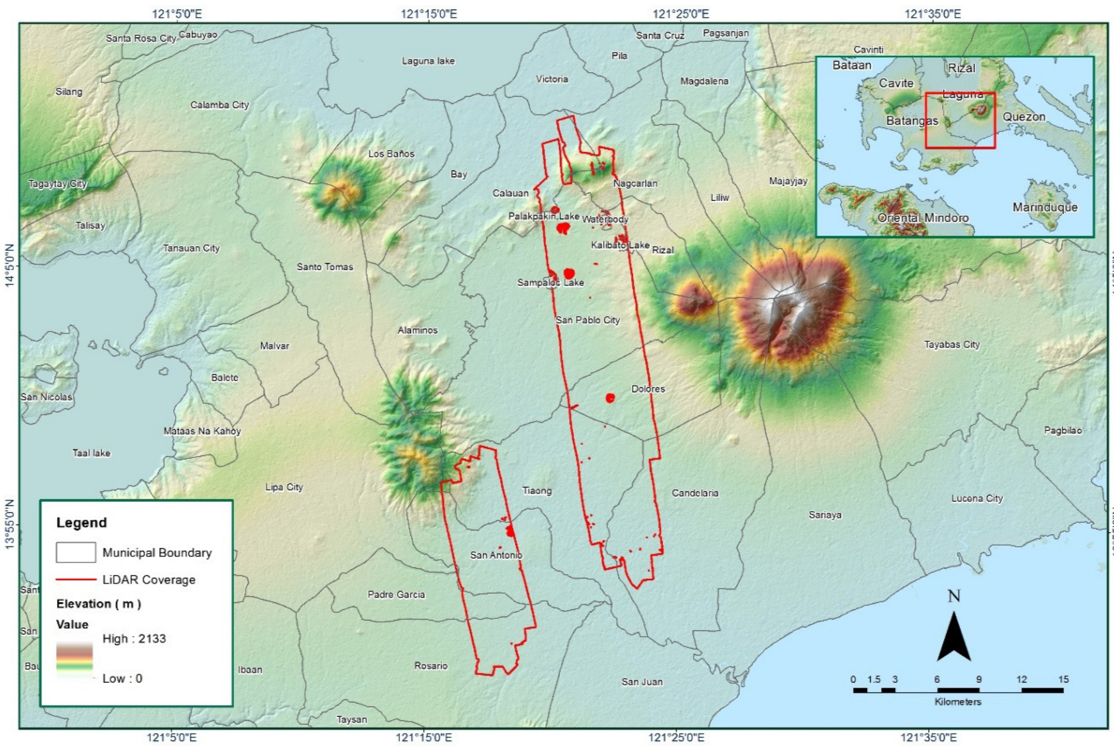


Figure 1.13.4. Coverage of LiDAR data

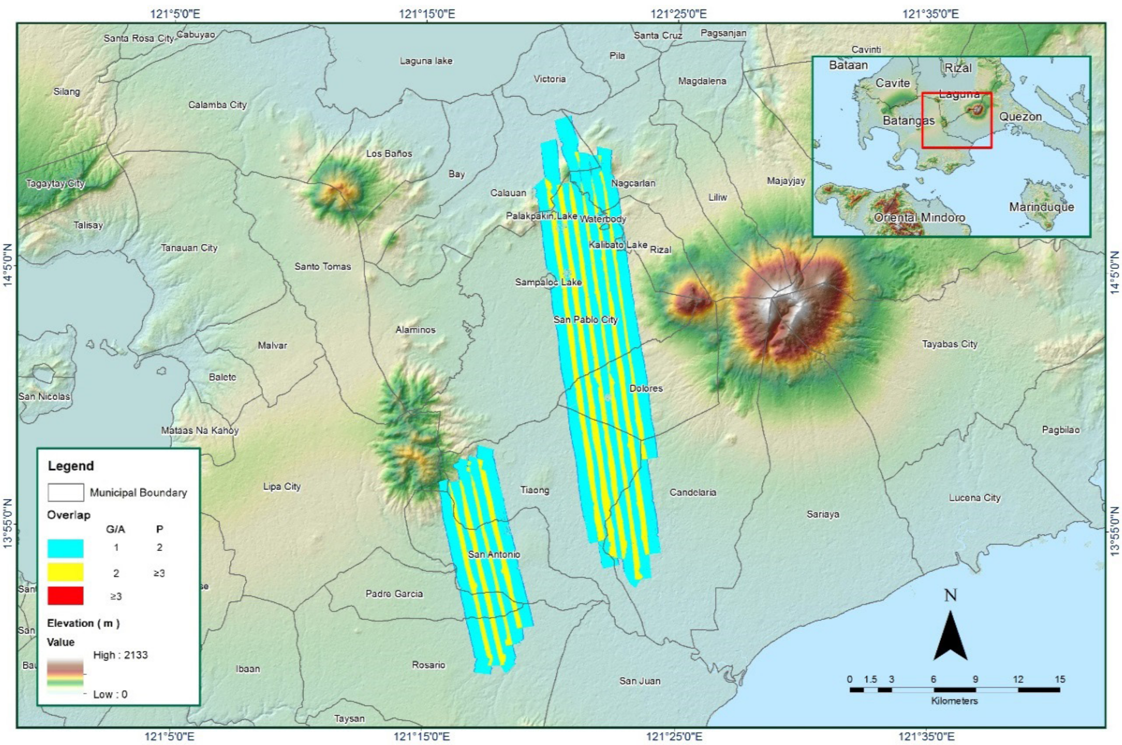


Figure 1.13.5. Image of data overlap

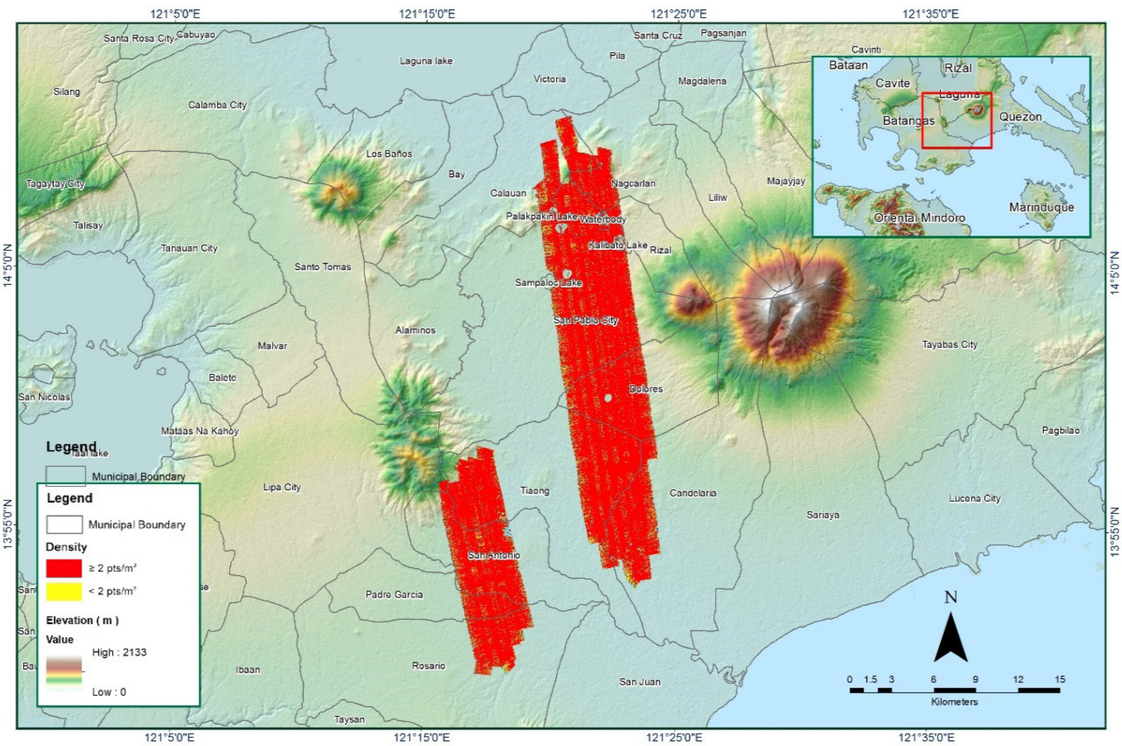


Figure 1.13.6. Density map of merged LiDAR data

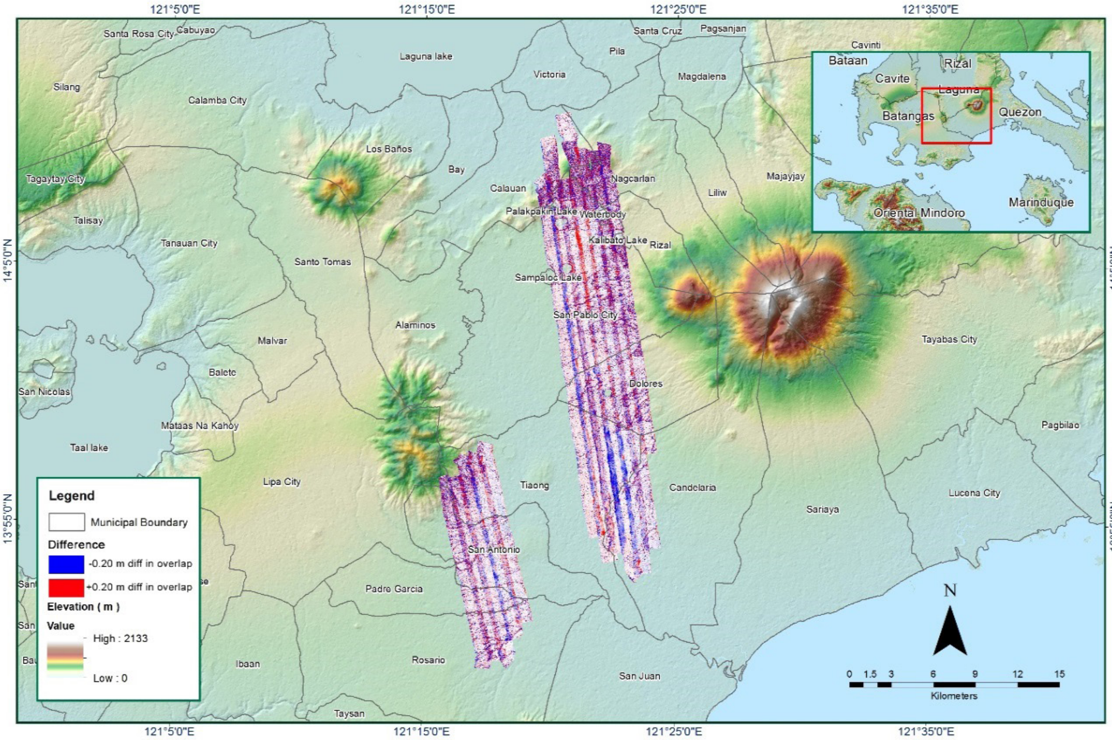


Figure 1.13.7. Elevation difference between flight lines

Flight Area	CALABARZON
Mission Name	**Blk18W**
Inclusive Flights	1091P
Range data size	20.2 GB
POS	171 MB
Image	32.7 GB
Transfer date	04/23/2014
Solution Status	
Number of Satellites (>6)	No
PDOP (<3)	No
Baseline Length (<30km)	Yes
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.2
RMSE for East Position (<4.0 cm)	1.4
RMSE for Down Position (<8.0 cm)	3.7
Boresight correction stdev (<0.001deg)	0.000300
IMU attitude correction stdev (<0.001deg)	0.000519
GPS position stdev (<0.01m)	0.0020
Minimum % overlap (>25)	44.87%
Ave point cloud density per sq.m. (>2.0)	2.22
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	305
Maximum Height	540.55 m
Minimum Height	53.13 m
Classification (# of points)	
Ground	199,914,206
Low vegetation	203,235,338
Medium vegetation	155,157,978
High vegetation	200,761,579
Building	25,340,833
Orthophoto	Yes
Processed by	Engr. Irish Cortez, Engr. Christy Lubiano, Engr. Gladys Mae Apat

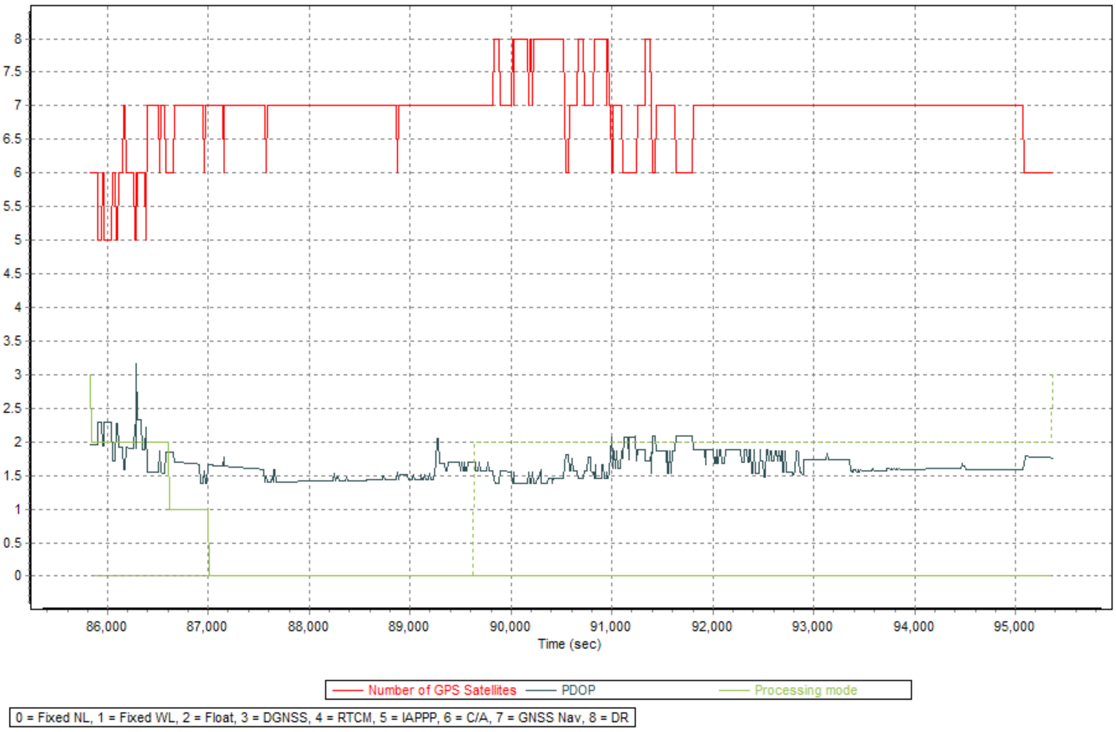


Figure 1.14.1. Solution Status

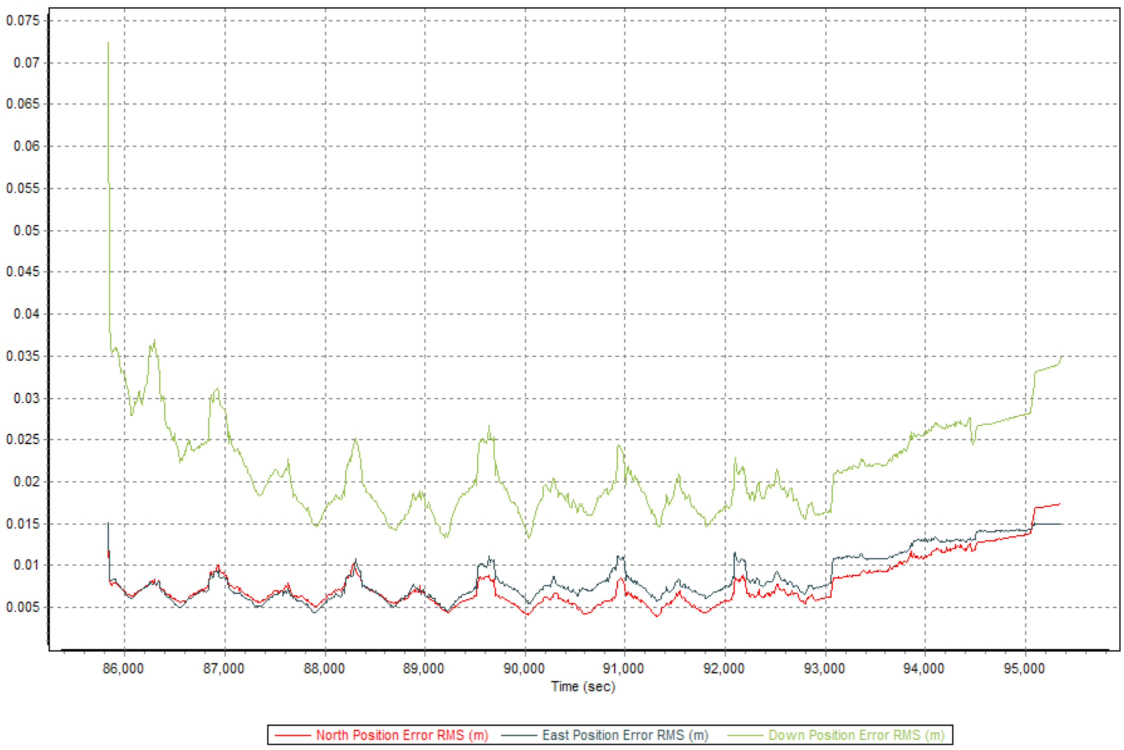


Figure 1.14.2. Smoothed Performance Metrics Parameters

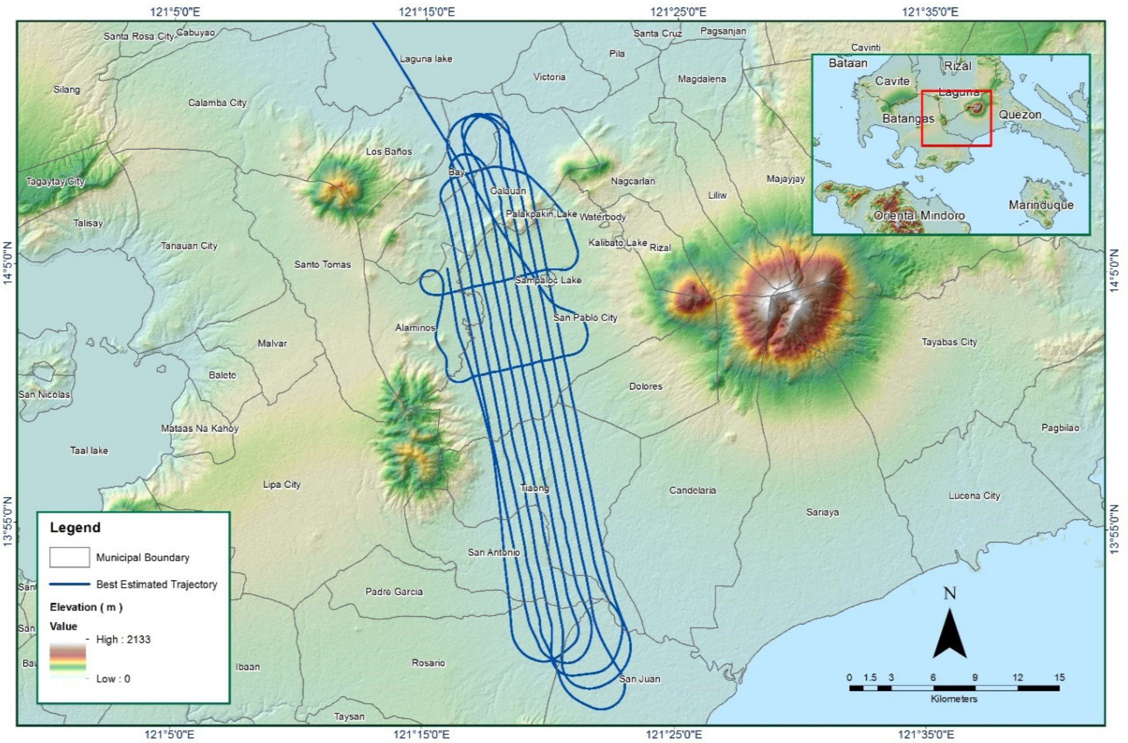


Figure 1.14.3. Best Estimated Trajectory

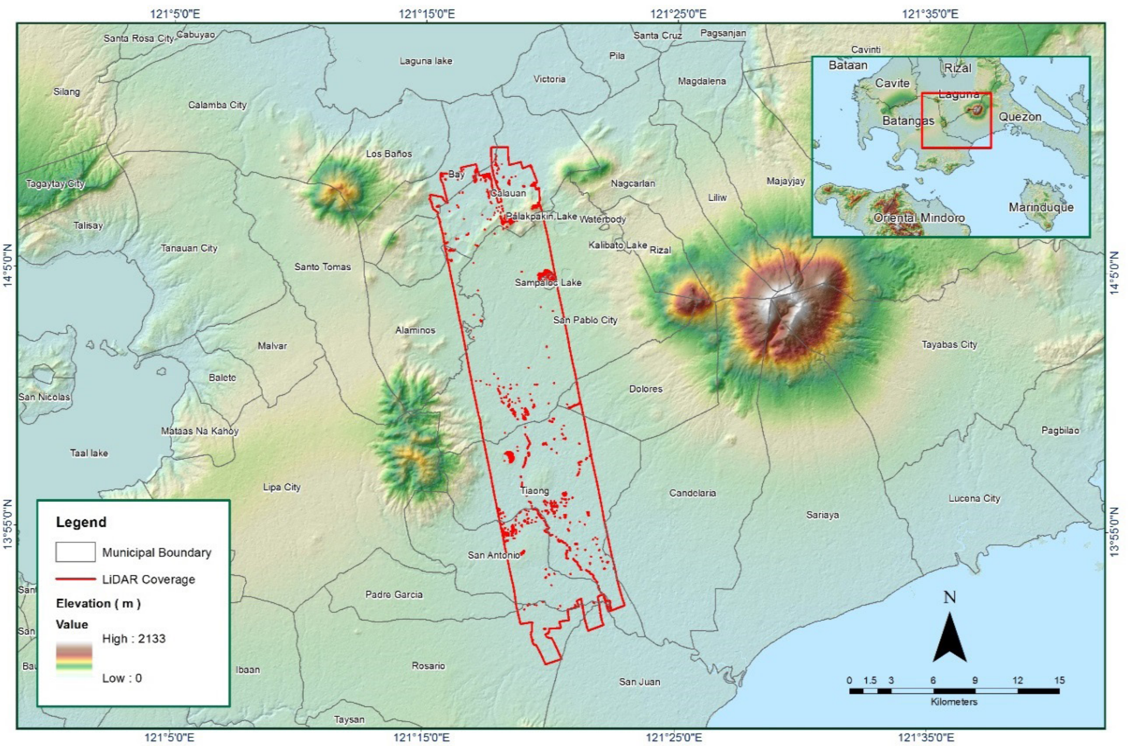


Figure 1.14.4. Coverage of LiDAR data

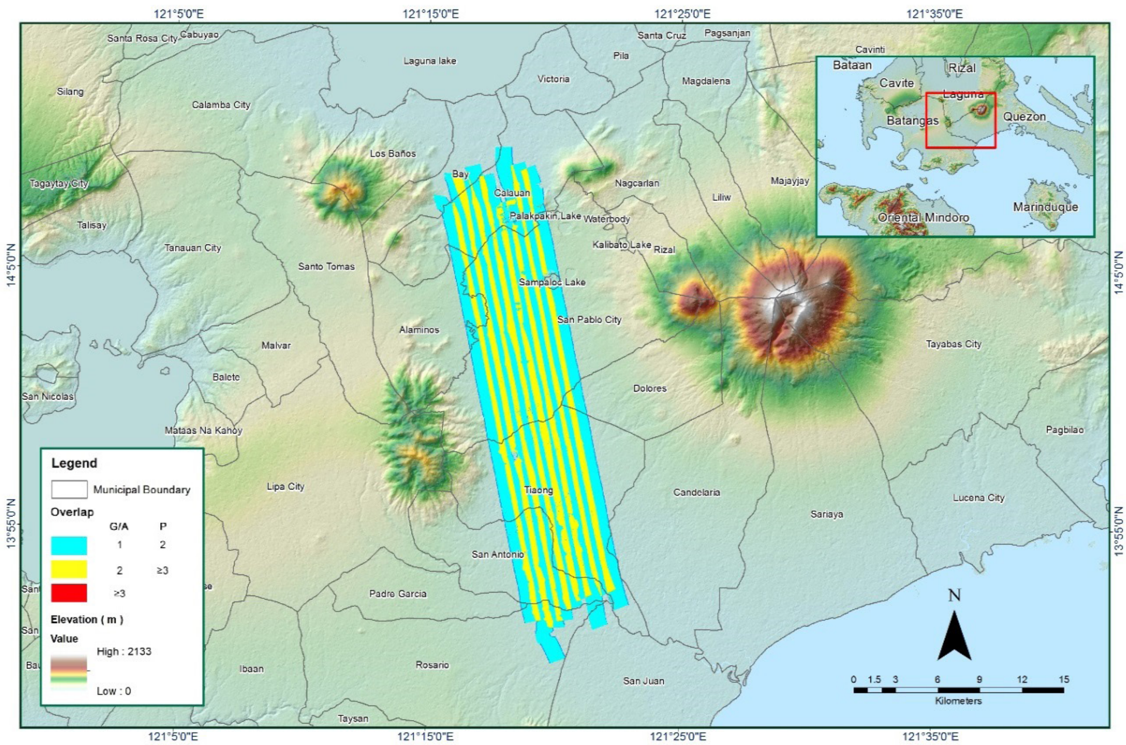


Figure 1.14.5. Image of data overlap

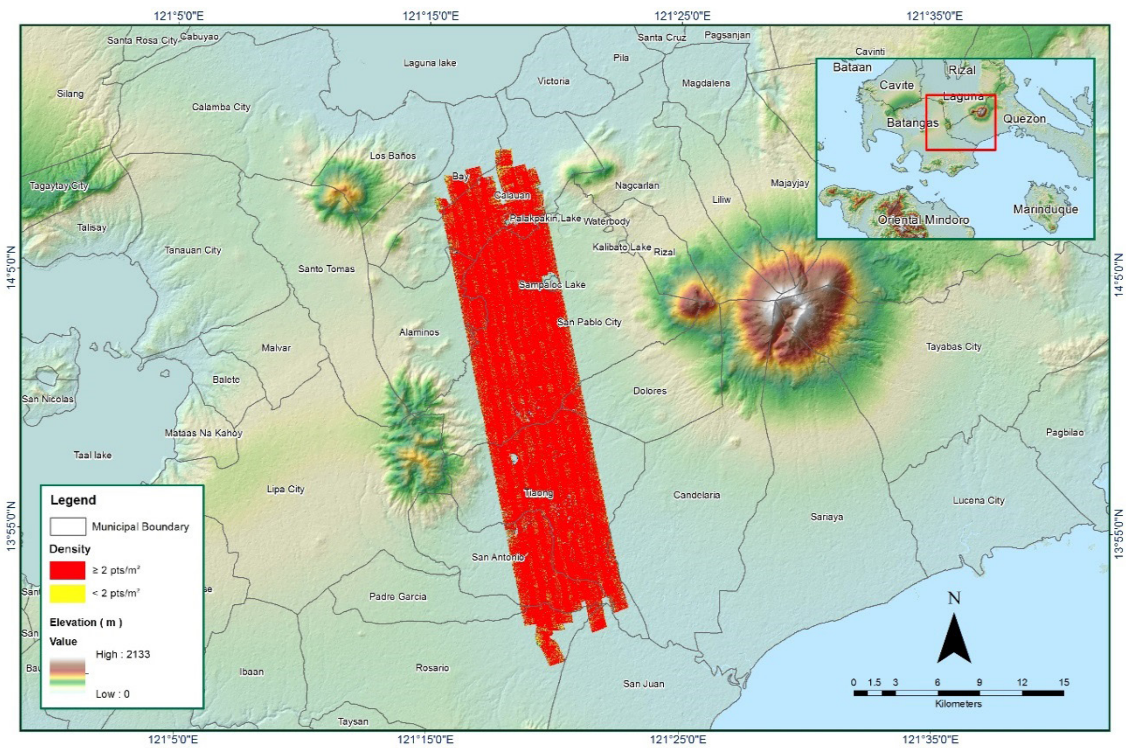


Figure 1.14.6. Density map of merged LiDAR data

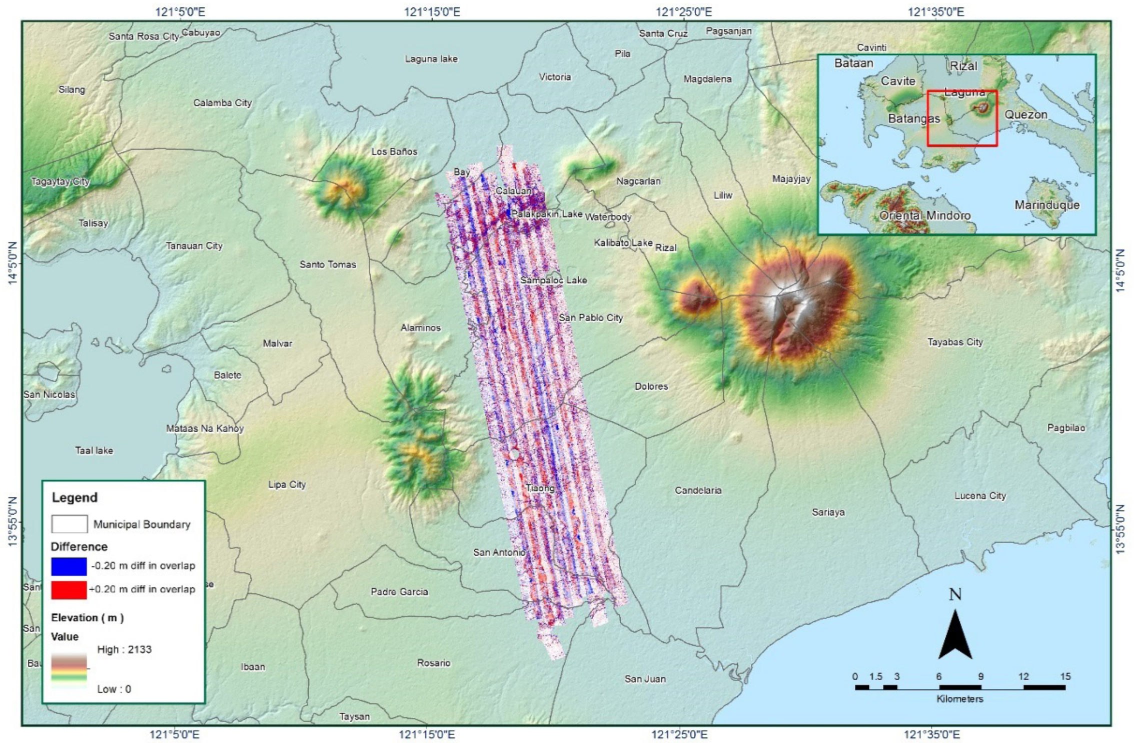


Figure 1.14.7. Elevation difference between flight lines

Flight Area	CALABARZON
Mission Name	**Blk18EFG_supplement**
Inclusive Flights	1111P
Range data size	14.7 GB
POS	194 MB
Image	19.7 GB
Transfer date	04/23/2014
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)	1.4
RMSE for East Position (<4.0 cm)	1.4
RMSE for Down Position (<8.0 cm)	3.1
Boresight correction stdev (<0.001deg)	0.000576
IMU attitude correction stdev (<0.001deg)	0.030256
GPS position stdev (<0.01m)	0.0233
Minimum % overlap (>25)	24.19%
Ave point cloud density per sq.m. (>2.0)	1.83
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	256
Maximum Height	577.15 m
Minimum Height	48.27 m
Classification (# of points)	
Ground	222,961,135
Low vegetation	368,839,290
Medium vegetation	326,022,186
High vegetation	411,722,251
Building	50,368,864
Orthophoto	Yes
Processed by	Engr. Jennifer Saguran, Engr. Chelou Prado, Engr. John Dill Macapagal

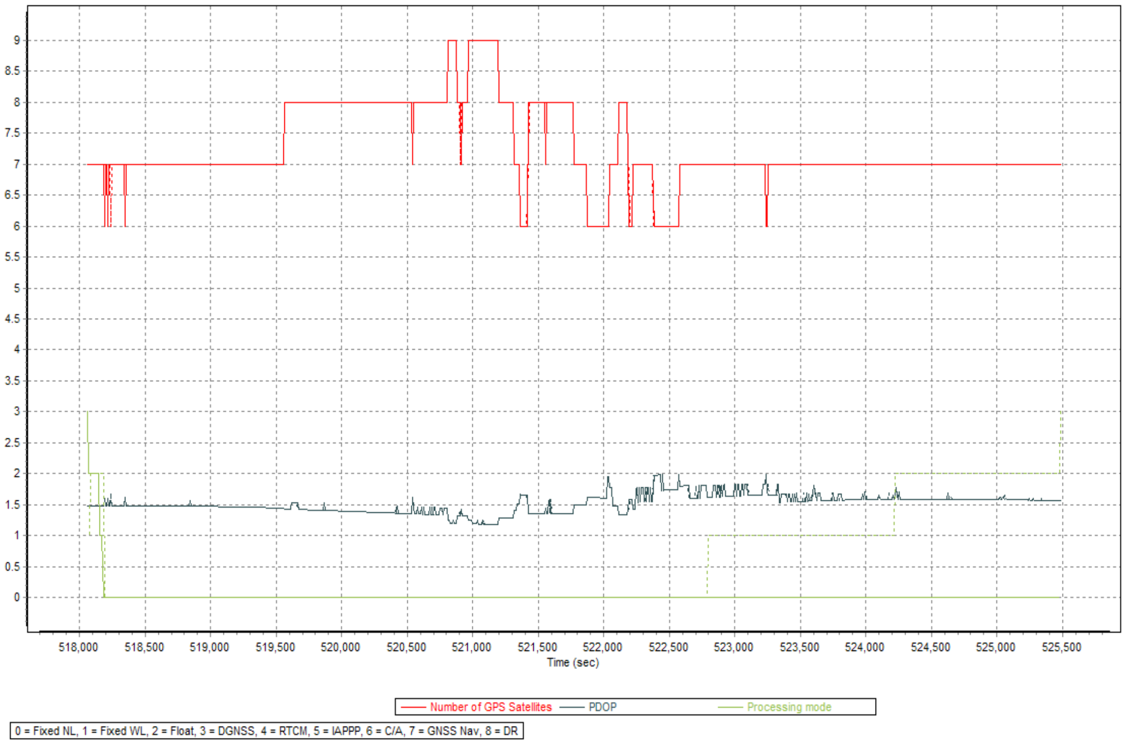


Figure 1.15.1. Solution Status

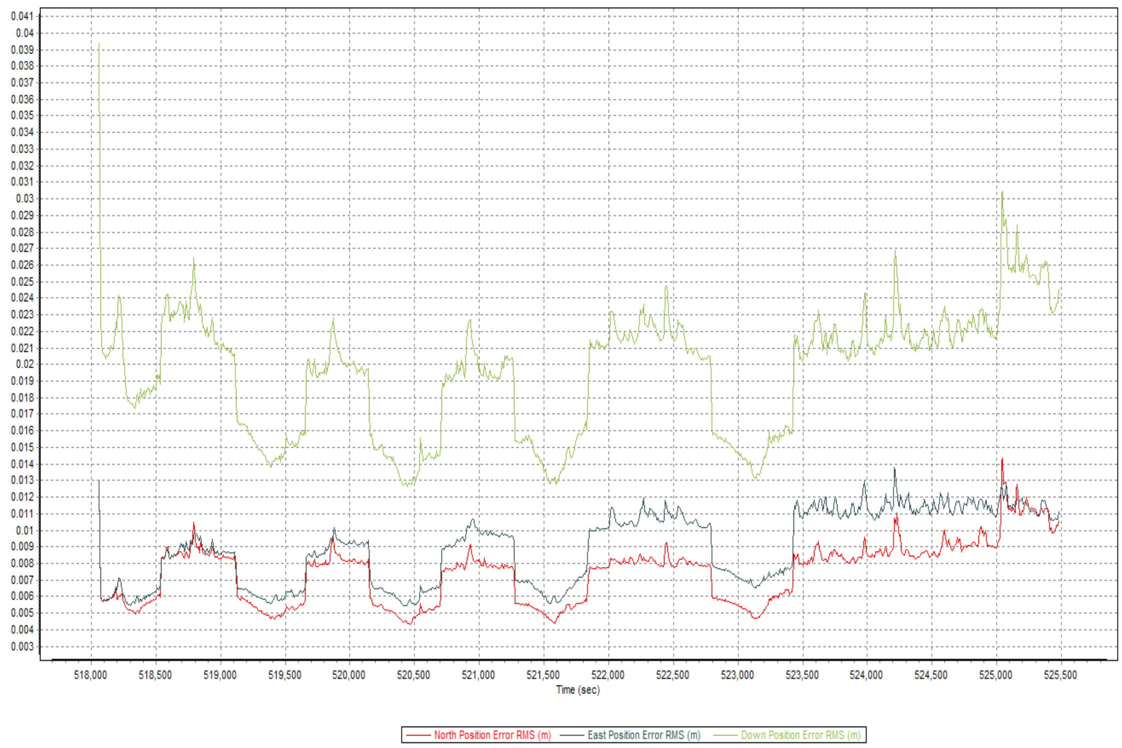


Figure 1.15.2. Smoothed Performance Metrics Parameters

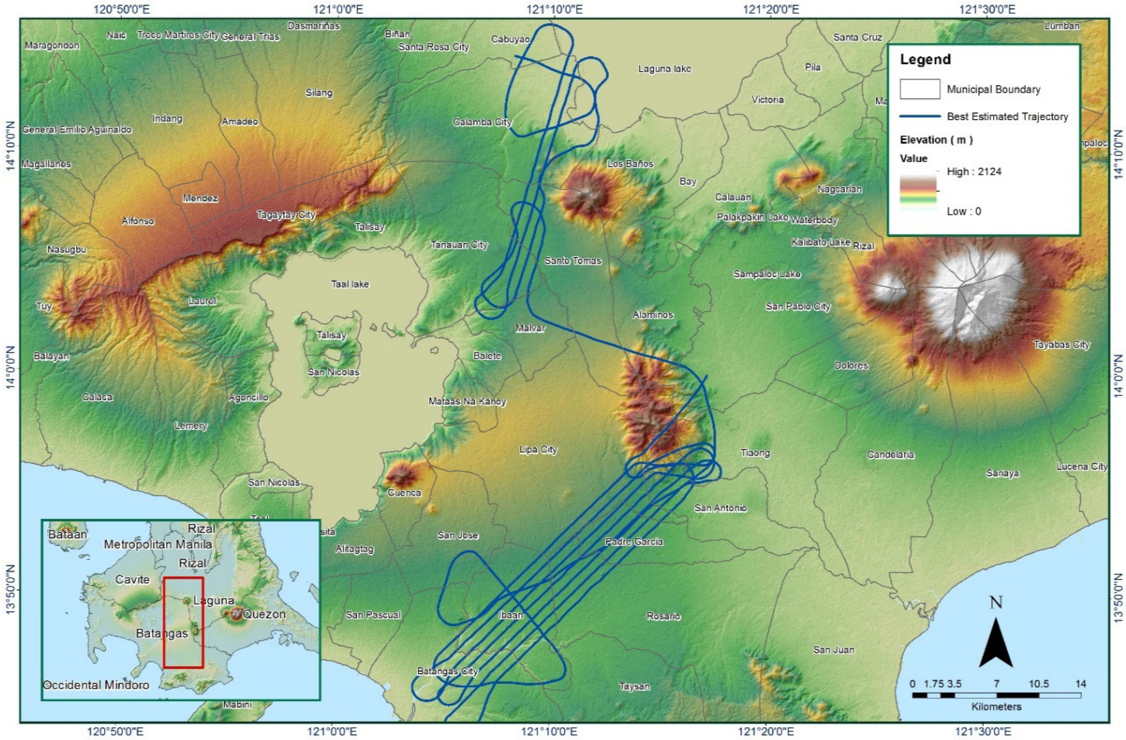


Figure 1.15.3. Best Estimated Trajectory

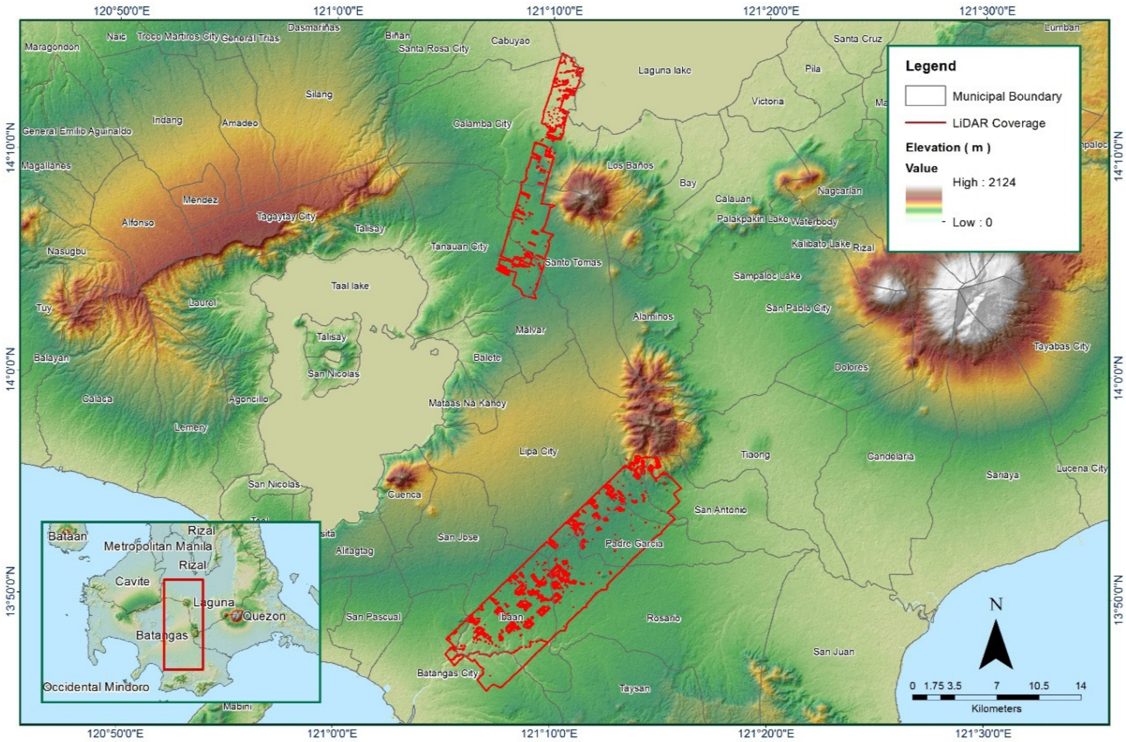


Figure 1.15.4. Coverage of LiDAR data

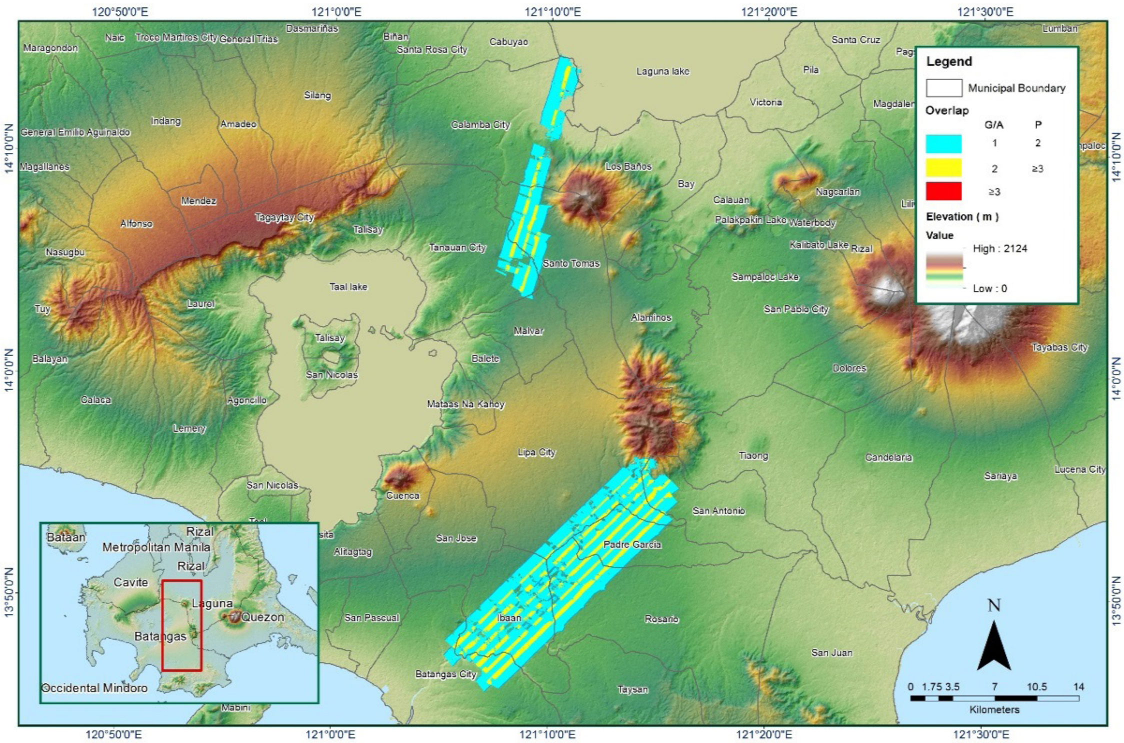


Figure 1.15.5. Image of data overlap

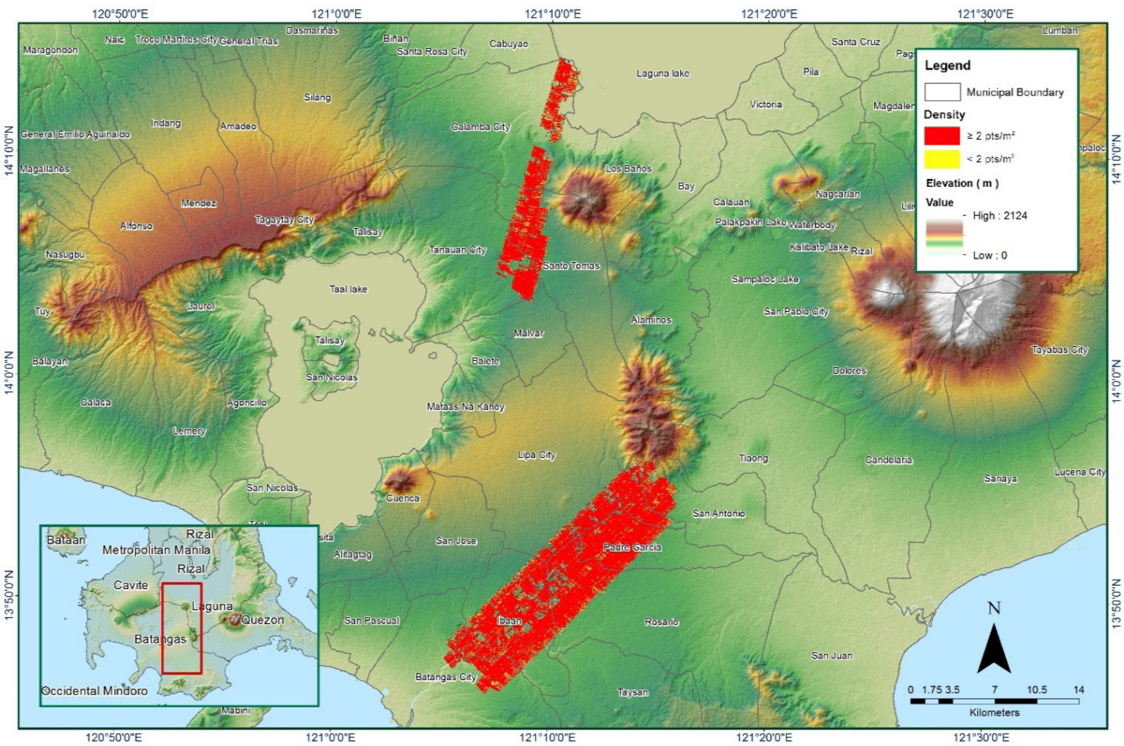


Figure 1.15.6. Density map of merged LiDAR data

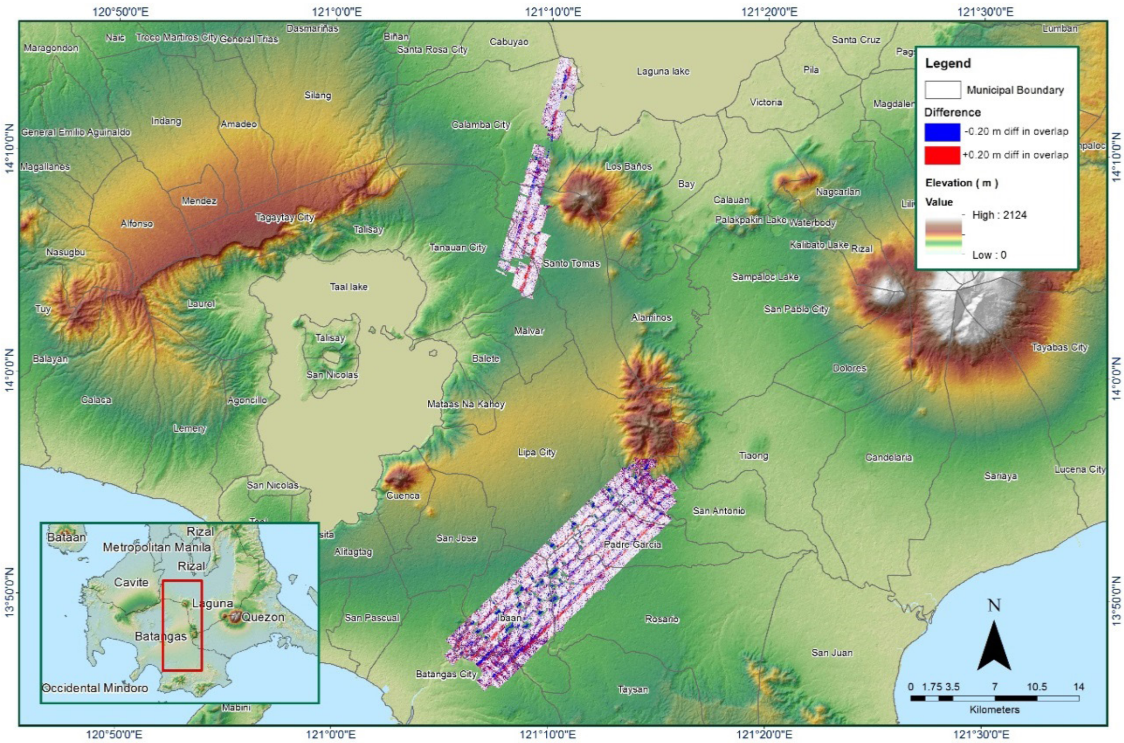


Figure 1.15.7. Elevation difference between flight lines

Annex 9. Malaking Ilog 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)	Recession Constant	Threshold Type	Ratio to Peak
W1000	15.533	43.12995	0	0.13054	0.01667	Discharge	0.001811	1.00E-05	Ratio to Peak	0.00015
W1010	30.347	40.51825	0	3.7209	0.80906	Discharge	0.000232	1.00E-05	Ratio to Peak	0.00015
W1020	42.642	42.40323	0	0.096789	0.035236	Discharge	0.008015	1.00E-05	Ratio to Peak	0.00015
W1030	70.044	43.05	0	0.096789	0.033998	Discharge	0.010876	1.00E-05	Ratio to Peak	0.00015
W1040	83.529	49.01243	0	0.27044	0.021831	Discharge	0.013173	1.00E-05	Ratio to Peak	0.00015
W1050	47.22	29.27708	0	1.0304	0.032998	Discharge	0.010592	1.00E-05	Ratio to Peak	0.00015
W1060	69.801	43.05	0	0.096789	0.01667	Discharge	0.015576	1.00E-05	Ratio to Peak	0.00015
W1070	44.8	38.93873	0	0.30415	0.017817	Discharge	0.001814	1.00E-05	Ratio to Peak	0.00015
W1080	64.653	43.05	0	0.19696	0.74739	Discharge	0.000208	1.00E-05	Ratio to Peak	0.00015
W1090	64.653	43.05	0	0.19696	0.53381	Discharge	0.000129	1.00E-05	Ratio to Peak	0.00015
W1100	64.653	43.05	0	0.21446	0.54123	Discharge	6.86E-05	1.00E-05	Ratio to Peak	0.00015
W1110	64.654	43.05	0	0.32668	0.033998	Discharge	0.006816	1.00E-05	Ratio to Peak	0.00015
W1120	26.293	42.5785	0	0.096789	0.028297	Discharge	0.007564	1.00E-05	Ratio to Peak	0.00015
W1130	97.936	43.05	0	0.21342	0.01667	Discharge	0.006967	1.00E-05	Ratio to Peak	0.00015
W1140	51.338	48.44048	0	0.30854	0.033688	Discharge	0.006012	1.00E-05	Ratio to Peak	0.00015
W1150	44.599	40.51825	0	0.096789	0.034031	Discharge	0.013843	1.00E-05	Ratio to Peak	0.00015
W1160	19.436	40.51825	0	0.57712	0.01667	Discharge	0.001038	1.00E-05	Ratio to Peak	0.00015
W1170	18.527	42.5867	0	0.096789	0.029049	Discharge	0.007967	1.00E-05	Ratio to Peak	0.00015
W1180	13.711	41.34543	0	0.096789	0.037255	Discharge	0.007153	1.00E-05	Ratio to Peak	0.00015
W1190	20.407	42.59285	0	0.092953	0.052207	Discharge	0.016139	1.00E-05	Ratio to Peak	0.00015
W1200	111.34	43.26525	0	0.32013	0.022406	Discharge	0.008999	1.00E-05	Ratio to Peak	0.00015

W1210	67.062	43.05	0	0.14442	0.051247	Discharge	0.010412	1.00E-05	Ratio to Peak	0.00015
W1220	8.7976	37.21058	0	0.096789	0.043717	Discharge	0.011592	1.00E-05	Ratio to Peak	0.00015
W1230	57.25	43.04898	0	0.29046	0.02114	Discharge	0.006856	1.00E-05	Ratio to Peak	0.00015
W1240	81.488	43.05	0	0.294	0.039423	Discharge	0.017715	1.00E-05	Ratio to Peak	0.00015
W1250	47.228	42.46575	0	0.28166	0.039866	Discharge	0.008926	1.00E-05	Ratio to Peak	0.00015
W1260	32.239	37.21058	0	0.096789	0.036806	Discharge	0.002368	1.00E-05	Ratio to Peak	0.00015
W1270	49.466	40.51825	0	1.1017	0.58341	Discharge	0.038583	1.00E-05	Ratio to Peak	0.00015
W1280	75.059	43.05	0	0.096789	0.028592	Discharge	0.009286	1.00E-05	Ratio to Peak	0.00015
W1290	67.502	43.05	0	0.096789	0.01667	Discharge	0.002104	1.00E-05	Ratio to Peak	0.00015
W1300	137.59	43.05	0	0.096789	0.31837	Discharge	0.000499	1.00E-05	Ratio to Peak	0.00015
W1310	29.745	42.46985	0	0.096789	0.038767	Discharge	0.021406	1.00E-05	Ratio to Peak	0.00015
W1320	51.367	41.34543	0	0.096789	0.026189	Discharge	0.007077	1.00E-05	Ratio to Peak	0.00015
W1330	160.18	43.05	0	0.096789	0.060922	Discharge	0.008235	1.00E-05	Ratio to Peak	0.00015
W1340	212.04	43.05	0	0.096789	0.027362	Discharge	0.002841	1.00E-05	Ratio to Peak	0.00015
W1350	108.08	43.05	0	0.096789	0.019839	Discharge	0.002799	1.00E-05	Ratio to Peak	0.00015
W1360	77.497	43.05	0	0.096789	3.5199	Discharge	0.011889	1.00E-05	Ratio to Peak	0.00015
W1370	39.944	37.9701	0	0.096789	0.034085	Discharge	0.007532	1.00E-05	Ratio to Peak	0.00015
W1380	236.89	43.05	0	0.096789	0.028205	Discharge	0.001288	1.00E-05	Ratio to Peak	0.00015
W1400	163.01	43.05	0	0.096789	0.027716	Discharge	0.004864	1.00E-05	Ratio to Peak	0.00015
W720	147.47	43.05	0	0.096789	4.5835	Discharge	0.017024	1.00E-05	Ratio to Peak	0.00015
W730	350.12	43.05	0	0.32667	0.01667	Discharge	0.010576	1.00E-05	Ratio to Peak	0.00015
W740	112.62	43.05	0	0.096789	0.058883	Discharge	0.009116	1.00E-05	Ratio to Peak	0.00015
W750	89.4	43.05	0	0.14228	0.033236	Discharge	0.002138	1.00E-05	Ratio to Peak	0.00015
W760	500	43.05	0	0.4778	0.052461	Discharge	0.011681	1.00E-05	Ratio to Peak	0.00015
W770	76.093	43.05	0	0.14228	0.056316	Discharge	0.02163	1.00E-05	Ratio to Peak	0.00015
W780	105.2	43.05	0	0.096789	0.055093	Discharge	0.007299	1.00E-05	Ratio to Peak	0.00015
W790	64.472	29.26478	0	0.28244	0.16979	Discharge	0.010455	1.00E-05	Ratio to Peak	0.00015
W800	17.096	41.84768	0	0.096789	0.044365	Discharge	0.012247	1.00E-05	Ratio to Peak	0.00015
W810	203.89	43.05	0	0.096789	0.064861	Discharge	0.029147	1.00E-05	Ratio to Peak	0.00015

W820	45.604	28.90705	0	0.096789	0.021972	Discharge	0.007345	1.00E-05	Ratio to Peak	0.00015
W830	113.69	43.05	0	0.14228	0.068905	Discharge	0.00996	1.00E-05	Ratio to Peak	0.00015
W840	139.13	43.05	0	0.096789	3.5573	Discharge	0.01988	1.00E-05	Ratio to Peak	0.00015
W850	101.88	43.05	0	0.14228	0.03444	Discharge	0.016957	1.00E-05	Ratio to Peak	0.00015
W860	147.3	43.05	0	0.20915	0.056372	Discharge	0.007195	1.00E-05	Ratio to Peak	0.00015
W870	27.187	49.5075	0	0.096789	0.017163	Discharge	0.000281	1.00E-05	Ratio to Peak	0.00015
W880	28.457	43.05	0	0.096789	0.041665	Discharge	0.009472	1.00E-05	Ratio to Peak	0.00015
W890	26.932	43.05	0	0.096789	0.025047	Discharge	0.029371	1.00E-05	Ratio to Peak	0.00015
W900	25.183	43.05	0	0.096789	0.01667	Discharge	0.001132	1.00E-05	Ratio to Peak	0.00015
W910	71.045	43.05	0	0.096789	3.5172	Discharge	0.015949	1.00E-05	Ratio to Peak	0.00015
W920	66.59	43.05	0	0.096789	0.023273	Discharge	0.003321	1.00E-05	Ratio to Peak	0.00015
W930	500	43.26525	0	0.4802	0.01667	Discharge	0.008904	1.00E-05	Ratio to Peak	0.00015
W940	500	43.05	0	0.21342	0.048171	Discharge	0.007301	1.00E-05	Ratio to Peak	0.00015
W950	64.232	43.05	0	0.48246	0.45016	Discharge	0.000323	1.00E-05	Ratio to Peak	0.00015
W960	99.631	43.05	0	0.096789	0.047534	Discharge	0.006856	1.00E-05	Ratio to Peak	0.00015
W970	42.169	42.189	0	0.43394	0.019106	Discharge	0.007312	1.00E-05	Ratio to Peak	0.00015
W980	26.001	28.98085	0	0.096789	0.026216	Discharge	0.008649	1.00E-05	Ratio to Peak	0.00015
W990	65.971	43.26525	0	0.096789	0.027969	Discharge	0.006776	1.00E-05	Ratio to Peak	0.00015

ANNEX 10. Malaking Ilog Model Reach Parameters

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
R100	Automatic Fixed Interval	7023.8	0.005407	0.0001	Trapezoid	50	1
R120	Automatic Fixed Interval	1129.7	0.004809	0.0001	Trapezoid	50	1
R150	Automatic Fixed Interval	1429.5	0.001231	0.0001	Trapezoid	50	1
R170	Automatic Fixed Interval	4021.7	0.00276	0.000156	Trapezoid	50	1
R180	Automatic Fixed Interval	2132.3	0.004472	0.000327	Trapezoid	50	1
R250	Automatic Fixed Interval	1029.8	0.001252	0.001338	Trapezoid	50	1
R260	Automatic Fixed Interval	1817.2	0.006844	0.003832	Trapezoid	50	1
R270	Automatic Fixed Interval	1045	0.002302	0.003316	Trapezoid	50	1
R290	Automatic Fixed Interval	4801.7	0.0004	0.001113	Trapezoid	50	1
R30	Automatic Fixed Interval	2796.9	0.003617	0.0001	Trapezoid	50	1
R310	Automatic Fixed Interval	1015	0.001386	0.004077	Trapezoid	50	1
R320	Automatic Fixed Interval	7787	0.004016	0.0001	Trapezoid	50	1
R340	Automatic Fixed Interval	345.27	0.011609	0.0001	Trapezoid	50	1
R350	Automatic Fixed Interval	1101.2	0.003986	0.0001	Trapezoid	50	1
R360	Automatic Fixed Interval	589.41	0.002575	0.0001	Trapezoid	50	1
R420	Automatic Fixed Interval	8357.1	0.016696	0.0001	Trapezoid	50	1
R440	Automatic Fixed Interval	3942	0.004753	0.0001	Trapezoid	50	1
R450	Automatic Fixed Interval	1842.4	0.016733	0.003155	Trapezoid	50	1
R480	Automatic Fixed Interval	6734.5	0.003664	0.000492	Trapezoid	50	1
R500	Automatic Fixed Interval	6727.4	0.003511	0.0096	Trapezoid	50	1
R510	Automatic Fixed Interval	5457.3	0.003281	0.001807	Trapezoid	50	1
R520	Automatic Fixed Interval	9442.5	0.011964	0.000238	Trapezoid	50	1
R530	Automatic Fixed Interval	8867.9	0.000941	0.001077	Trapezoid	50	1
R540	Automatic Fixed Interval	2466.2	0.001004	0.000477	Trapezoid	50	1
R560	Automatic Fixed Interval	1663.7	0.007643	0.00351	Trapezoid	50	1
R580	Automatic Fixed Interval	5228.7	0.00162	0.0001	Trapezoid	50	1
R610	Automatic Fixed Interval	2878.8	0.001198	0.0001	Trapezoid	50	1
R630	Automatic Fixed Interval	6681.8	0.004923	0.0001	Trapezoid	50	1
R640	Automatic Fixed Interval	6115.1	0.0004	0.002476	Trapezoid	50	1
R650	Automatic Fixed Interval	3985.8	0.000803	0.0001	Trapezoid	50	1
R660	Automatic Fixed Interval	3797.6	0.001172	0.0001	Trapezoid	50	1
R680	Automatic Fixed Interval	2578.8	0.000882	0.0001	Trapezoid	50	1
R80	Automatic Fixed Interval	2436.1	0.004868	0.0001	Trapezoid	50	1
R90	Automatic Fixed Interval	2624.5	0.003819	0.003285	Trapezoid	50	1

ANNEX 11. Malaking Ilog Field Validation Points

Point Number	Validation Coordinates		Model Var (m)	Valida-tion Points (m)	Error	Event/Date	Rain Return/ Scenario
	Latitude	Longitude					
1	13.815629	121.351051	0	0.03	-0.030	Glenda/July 15,2014	5-Year
2	13.818666	121.350964	0	0.18	-0.180	Glenda/July 15,2014	5-Year
3	13.819568	121.350922	0	0.04	-0.040	Glenda/July 15,2014	5-Year
4	13.819772	121.351641	0	0.03	-0.030	Glenda/July 15,2014	5-Year
5	13.819784	121.352105	0	0.03	-0.030	Glenda/July 15,2014	5-Year
6	13.819811	121.352452	0	0.03	-0.030	Glenda/July 15,2014	5-Year
7	13.819951	121.350921	0	0.04	-0.040	Glenda/July 15,2014	5-Year
8	13.820201	121.352666	0	0.04	-0.040	Glenda/July 15,2014	5-Year
9	13.820887	121.352658	0	0.07	-0.070	Glenda/July 15,2014	5-Year
10	13.821424	121.37372	0	0.03	-0.030	Glenda/July 15,2014	5-Year
11	13.821934	121.353678	0	0.03	-0.030	Glenda/July 15,2014	5-Year
12	13.821957	121.37368	0	0.04	-0.040	Glenda/July 15,2014	5-Year
13	13.822118	121.35072	0	0.37	-0.370	Glenda/July 15,2014	5-Year
14	13.822788	121.35374	0.25	0.03	0.220	Glenda/July 15,2014	5-Year
15	13.82306	121.353685	0	0.03	-0.030	Glenda/July 15,2014	5-Year
16	13.823066	121.350795	0	1.67	-1.670	Glenda/July 15,2014	5-Year
17	13.823246	121.353645	1	0.03	0.970	Glenda/July 15,2014	5-Year
18	13.823482	121.386243	0	0.93	-0.930	Glenda/July 15,2014	5-Year
19	13.823524	121.353702	5	0.03	4.970	Glenda/July 15,2014	5-Year
20	13.823743	121.387004	0	1.34	-1.340	Glenda/July 15,2014	5-Year
21	13.823794	121.388011	2	2.5	-0.500	Glenda/July 15,2014	5-Year
22	13.823866	121.388059	0.5	2.73	-2.230	Glenda/July 15,2014	5-Year
24	13.82407	121.353753	0	0.11	-0.110	Glenda/July 15,2014	5-Year
27	13.825132	121.387687	0.2	0.94	-0.740	Glenda/July 15,2014	5-Year
28	13.825491	121.350863	0	0.04	-0.040	Glenda/July 15,2014	5-Year
29	13.825663	121.390344	0.2	0.06	0.140	Glenda/July 15,2014	5-Year
30	13.825671	121.388996	0.2	0.48	-0.280	Glenda/July 15,2014	5-Year
31	13.825708	121.389275	0.2	0.28	-0.080	Glenda/July 15,2014	5-Year
32	13.825749	121.38862	0.2	0.68	-0.480	Glenda/July 15,2014	5-Year
33	13.825792	121.387571	0.2	0.87	-0.670	Glenda/July 15,2014	5-Year
34	13.825796	121.387757	0.2	0.86	-0.660	Glenda/July 15,2014	5-Year
35	13.825962	121.386891	0.2	0.83	-0.630	Glenda/July 15,2014	5-Year
36	13.82612	121.350913	0	0.27	-0.270	Glenda/July 15,2014	5-Year
37	13.826183	121.385682	0.2	0.62	-0.420	Glenda/July 15,2014	5-Year
38	13.826205	121.373337	0	0.18	-0.180	Glenda/July 15,2014	5-Year
39	13.826249	121.354814	0	0.75	-0.750	Glenda/July 15,2014	5-Year
40	13.82633	121.350944	0	0.28	-0.280	Glenda/July 15,2014	5-Year
41	13.826349	121.384862	0.2	0.52	-0.320	Glenda/July 15,2014	5-Year
42	13.826379	121.354628	0.5	0.65	-0.150	Glenda/July 15,2014	5-Year
43	13.826436	121.354327	0.5	1.1900001	-0.690	Glenda/July 15,2014	5-Year

44	13.826486	121.354001	0.7	1.51	-0.810	Glenda/July 15,2014	5-Year
45	13.826499	121.354121	0.5	0.94	-0.440	Glenda/July 15,2014	5-Year
46	13.82661	121.383514	0	0.53	-0.530	Glenda/July 15,2014	5-Year
47	13.82663	121.353823	2	1.39	0.610	Glenda/July 15,2014	5-Year
54	13.827031	121.378662	0	1.0599999	-1.060	Glenda/July 15,2014	5-Year
55	13.827035	121.38192	0	0.68	-0.680	Glenda/July 15,2014	5-Year
57	13.827077	121.381107	0.2	0.73	-0.530	Glenda/July 15,2014	5-Year
59	13.827127	121.373234	0	0.14	-0.140	Glenda/July 15,2014	5-Year
60	13.827153	121.378664	0	1.03	-1.030	Glenda/July 15,2014	5-Year
61	13.827533	121.378652	0	0.89	-0.890	Glenda/July 15,2014	5-Year
62	13.827676	121.373207	0	0.05	-0.050	Glenda/July 15,2014	5-Year
63	13.827953	121.376542	0	0.07	-0.070	Glenda/July 15,2014	5-Year
64	13.828214	121.351071	0	0.03	-0.030	Glenda/July 15,2014	5-Year
65	13.828255	121.374552	0	0.05	-0.050	Glenda/July 15,2014	5-Year
66	13.828308	121.343248	0	0.04	-0.040	Glenda/July 15,2014	5-Year
67	13.828347	121.345462	0	0.03	-0.030	Glenda/July 15,2014	5-Year
68	13.828373	121.347103	0	0.03	-0.030	Glenda/July 15,2014	5-Year
69	13.828386	121.347595	0	0.04	-0.040	Glenda/July 15,2014	5-Year
70	13.828403	121.351654	0	0.03	-0.030	Glenda/July 15,2014	5-Year
71	13.828406	121.348557	0	0.05	-0.050	Glenda/July 15,2014	5-Year
72	13.828429	121.350471	0	0.04	-0.040	Glenda/July 15,2014	5-Year
73	13.82844	121.350985	0	0.04	-0.040	Glenda/July 15,2014	5-Year
74	13.82844	121.352464	0	0.04	-0.040	Glenda/July 15,2014	5-Year
75	13.828454	121.351868	0	0.04	-0.040	Glenda/July 15,2014	5-Year
76	13.828484	121.372486	0	0.06	-0.060	Glenda/July 15,2014	5-Year
77	13.828569	121.371867	0	0.18	-0.180	Glenda/July 15,2014	5-Year
78	13.828673	121.371022	0	0.39	-0.390	Glenda/July 15,2014	5-Year
79	13.828753	121.370345	0	0.08	-0.080	Glenda/July 15,2014	5-Year
80	13.828807	121.354798	0	0.22	-0.220	Glenda/July 15,2014	5-Year
82	13.828899	121.36909	0	0.07	-0.070	Glenda/July 15,2014	5-Year
84	13.829108	121.363331	0	0.45	-0.450	Glenda/July 15,2014	5-Year
85	13.829125	121.390567	0.25	0.5	-0.250	Glenda/July 15,2014	5-Year
86	13.82958	121.359411	0	1.14	-1.140	Glenda/July 15,2014	5-Year
87	13.829611	121.39056	0	0.62	-0.620	Glenda/July 15,2014	5-Year
88	13.829665	121.363726	0	0.51	-0.510	Glenda/July 15,2014	5-Year
92	13.83025	121.39048	0.2	0.73	-0.530	Glenda/July 15,2014	5-Year
93	13.830489	121.389956	0	0.79	-0.790	Glenda/July 15,2014	5-Year
94	13.830516	121.39034	0.2	0.77	-0.570	Glenda/July 15,2014	5-Year
95	13.830592	121.389983	0	0.8	-0.800	Glenda/July 15,2014	5-Year
96	13.830681	121.390632	0	0.77	-0.770	Glenda/July 15,2014	5-Year
97	13.831093	121.390075	0	0.78	-0.780	Glenda/July 15,2014	5-Year
98	13.831279	121.390125	0	0.75	-0.750	Glenda/July 15,2014	5-Year
99	13.831313	121.368129	0	0.04	-0.040	Glenda/July 15,2014	5-Year
100	13.831535	121.390423	0.2	0.68	-0.480	Glenda/July 15,2014	5-Year
101	13.831762	121.390416	0	0.64	-0.640	Glenda/July 15,2014	5-Year
102	13.831796	121.368105	0	0.06	-0.060	Glenda/July 15,2014	5-Year

103	13.832292	121.390351	0.2	0.6	-0.400	Glenda/July 15,2014	5-Year
104	13.832482	121.389959	0.2	0.67	-0.470	Glenda/July 15,2014	5-Year
105	13.832517	121.380969	0	0.31	-0.310	Glenda/July 15,2014	5-Year
106	13.833022	121.389572	0.2	0.74	-0.540	Glenda/July 15,2014	5-Year
107	13.833043	121.368041	0	0.07	-0.070	Glenda/July 15,2014	5-Year
108	13.833457	121.389716	0.2	0.72	-0.520	Glenda/July 15,2014	5-Year
109	13.833596	121.390127	1	0.55	0.450	Glenda/July 15,2014	5-Year
110	13.833711	121.380809	0	0.12	-0.120	Glenda/July 15,2014	5-Year
111	13.833845	121.389913	1	0.68	0.320	Glenda/July 15,2014	5-Year
112	13.833926	121.390325	1	0.35	0.650	Glenda/July 15,2014	5-Year
113	13.834127	121.390469	1	0.14	0.860	Glenda/July 15,2014	5-Year
114	13.834337	121.390594	1	0.1	0.900	Glenda/July 15,2014	5-Year
115	13.834579	121.390744	1	0.14	0.860	Glenda/July 15,2014	5-Year
116	13.835106	121.390515	1	0.54	0.460	Glenda/July 15,2014	5-Year
117	13.83525	121.390314	1	0.73	0.270	Glenda/July 15,2014	5-Year
118	13.835341	121.390202	1	0.8	0.200	Glenda/July 15,2014	5-Year
119	13.835938	121.380492	0.6	0.07	0.530	Glenda/July 15,2014	5-Year
120	13.836009	121.380982	0.5	0.16	0.340	Glenda/July 15,2014	5-Year
121	13.83603	121.380894	0.5	0.13	0.370	Glenda/July 15,2014	5-Year
122	13.836055	121.381025	0.5	0.22	0.280	Glenda/July 15,2014	5-Year
123	13.837688	121.367971	0	0.06	-0.060	Glenda/July 15,2014	5-Year
124	13.842811	121.367988	0	0.03	-0.030	Glenda/July 15,2014	5-Year
125	13.847722	121.367984	0	0.04	-0.040	Glenda/July 15,2014	5-Year
126	13.851896	121.367972	0	0.06	-0.060	Glenda/July 15,2014	5-Year
128	13.853616	121.376168	1	0.59	0.410	Glenda/July 15,2014	5-Year
130	13.853803	121.371052	0	0.03	-0.030	Glenda/July 15,2014	5-Year
132	13.853862	121.367947	0	0.03	-0.030	Glenda/July 15,2014	5-Year
133	13.854109	121.367966	0	0.03	-0.030	Glenda/July 15,2014	5-Year
136	13.856143	121.367953	0	0.06	-0.060	Glenda/July 15,2014	5-Year
137	13.857571	121.367964	0	0.37	-0.370	Glenda/July 15,2014	5-Year
138	13.857956	121.367946	0	0.27	-0.270	Glenda/July 15,2014	5-Year
139	13.86104	121.25656	0.65	0.03	0.620	Glenda/July 15,2014	5-Year
140	13.8624	121.367428	0.7	0.37	0.330	Glenda/July 15,2014	5-Year
141	13.863632	121.367899	0.7	0.7	0.000	Glenda/July 15,2014	5-Year
142	13.86368	121.368398	0.7	0.79	-0.090	Glenda/July 15,2014	5-Year
143	13.863717	121.368805	1	0.69	0.310	Glenda/July 15,2014	5-Year
144	13.863854	121.370301	1	1.4299999	-0.430	Glenda/July 15,2014	5-Year
145	13.863915	121.371008	0.7	1.46	-0.760	Glenda/July 15,2014	5-Year
147	13.863974	121.371713	0.7	1.6900001	-0.990	Glenda/July 15,2014	5-Year
148	13.864009	121.374031	1	0.4	0.600	Glenda/July 15,2014	5-Year
149	13.86418	121.25773	0.5	1.47	-0.970	Glenda/July 15,2014	5-Year
151	13.86932	121.25963	0.5	0.03	0.470	Glenda/July 15,2014	5-Year
152	13.87255	121.26081	1	0.04	0.960	Glenda/July 15,2014	5-Year
153	13.87369	121.24921	1	0.03	0.970	Glenda/July 15,2014	5-Year
154	13.87593	121.26221	0.5	0.03	0.470	Glenda/July 15,2014	5-Year
156	13.8827	121.26453	0.25	0.03	0.220	Glenda/July 15,2014	5-Year

158	13.88965	121.29109	0.8	0.03	0.770	Glenda/July 15,2014	5-Year
159	13.8904	121.29361	1	0.03	0.970	Glenda/July 15,2014	5-Year
160	13.89377	121.26835	1	0.03	0.970	Glenda/July 15,2014	5-Year
161	13.90193	121.28825	0.25	0.06	0.190	Glenda/July 15,2014	5-Year
162	13.9022	121.27077	0.25	0.21	0.040	Glenda/July 15,2014	5-Year
163	13.90289	121.2913	0.25	0.1	0.150	Glenda/July 15,2014	5-Year
164	13.90352	121.32188	1.5	0.56	0.940	Glenda/July 15,2014	5-Year
166	13.9052	121.29776	0.5	1.61	-1.110	Glenda/July 15,2014	5-Year
167	13.90526	121.28648	0.75	0.17	0.580	Glenda/July 15,2014	5-Year
168	13.90565	121.27159	1	0.06	0.940	Glenda/July 15,2014	5-Year
169	13.9057	121.29936	5	4.6300001	0.370	Glenda/July 15,2014	5-Year
170	13.906787	121.30279	1.5	0.04	1.460	Glenda/July 15,2014	5-Year
171	13.90772	121.30467	1	0.03	0.970	Glenda/July 15,2014	5-Year
172	13.90787	121.31908	0.5	0.03	0.470	Glenda/July 15,2014	5-Year
173	13.9091	121.30938	0.55	0.08	0.470	Glenda/July 15,2014	5-Year
174	13.91138	121.27328	0.7	0.07	0.630	Glenda/July 15,2014	5-Year
175	13.91231	121.28879	0.3	0.03	0.270	Glenda/July 15,2014	5-Year
176	13.91418	121.27453	3	0.03	2.970	Glenda/July 15,2014	5-Year
177	13.91449	121.3324	5	0.03	4.970	Glenda/July 15,2014	5-Year
178	13.91494	121.28972	1	0.03	0.970	Glenda/July 15,2014	5-Year
180	13.91905	121.29097	2	0.03	1.970	Glenda/July 15,2014	5-Year
181	13.92371	121.28004	1	0.26	0.740	Glenda/July 15,2014	5-Year
182	13.92482	121.29259	0.2	0.46	-0.260	Glenda/July 15,2014	5-Year
186	13.93119	121.28395	1	0.48	0.520	Glenda/July 15,2014	5-Year
187	13.93149	121.28432	0.2	0.24	-0.040	Glenda/July 15,2014	5-Year
188	13.93319	121.32854	5	4.3899999	0.610	Glenda/July 15,2014	5-Year
189	13.93414	121.28594	0	0.05	-0.050	Glenda/July 15,2014	5-Year
190	13.93419	121.29233	0.5	0.1	0.400	Glenda/July 15,2014	5-Year
191	13.94016	121.29231	1.5	0.53	0.970	Glenda/July 15,2014	5-Year
192	13.94168	121.2876	0.3	0.14	0.160	Glenda/July 15,2014	5-Year
193	13.9423	121.29237	0.25	0.52	-0.270	Glenda/July 15,2014	5-Year
194	13.94829	121.29349	0.25	0.34	-0.090	Glenda/July 15,2014	5-Year
195	13.9483	121.28889	0.3	0.07	0.230	Glenda/July 15,2014	5-Year
196	13.95064	121.29401	2	0.03	1.970	Glenda/July 15,2014	5-Year
197	13.95109	121.28954	0.15	0.07	0.080	Glenda/July 15,2014	5-Year
198	13.95284	121.29446	0.6	0.25	0.350	Glenda/July 15,2014	5-Year
200	13.95407	121.29557	0.4	0.43	-0.030	Glenda/July 15,2014	5-Year
202	13.95758	121.29068	0.75	0.58	0.170	Glenda/July 15,2014	5-Year
203	13.95925	121.38931	0.7	0.49	0.210	Glenda/July 15,2014	5-Year
204	13.95974	121.2908	1	0.03	0.970	Glenda/July 15,2014	5-Year
205	13.96207	121.30392	0.25	0.25	0.000	Glenda/July 15,2014	5-Year
206	13.96576	121.30386	0.3	0.23	0.070	Glenda/July 15,2014	5-Year
207	13.96667	121.29196	0.2	0.05	0.150	Glenda/July 15,2014	5-Year
208	13.96745	121.38317	0.5	0.77	-0.270	Glenda/July 15,2014	5-Year
209	13.96889	121.30289	0.5	0.15	0.350	Glenda/July 15,2014	5-Year
210	13.9704	121.29238	0	0.03	-0.030	Glenda/July 15,2014	5-Year

212	13.97456	121.2912	0.25	0.08	0.170	Glenda/July 15,2014	5-Year
213	13.9752	121.30128	0.5	0.38	0.120	Glenda/July 15,2014	5-Year
214	13.97805	121.30038	0.5	0.06	0.440	Glenda/July 15,2014	5-Year
216	13.97998	121.28957	0.6	0.03	0.570	Glenda/July 15,2014	5-Year
217	13.98511	121.29865	0.2	0.04	0.160	Glenda/July 15,2014	5-Year
218	13.98625	121.28738	0	0.03	-0.030	Glenda/July 15,2014	5-Year
219	13.98883	121.29761	0.2	0.42	-0.220	Glenda/July 15,2014	5-Year
220	13.98929	121.37126	2	0.08	1.920	Glenda/July 15,2014	5-Year
221	13.99181	121.30511	4	3.8599999	0.140	Glenda/July 15,2014	5-Year
222	13.99424	121.28478	0.7	0.08	0.620	Glenda/July 15,2014	5-Year
224	14.0034	121.28172	0	0.03	-0.030	Glenda/July 15,2014	5-Year
225	14.01478	121.29641	5	1.0700001	3.930	Glenda/July 15,2014	5-Year
226	14.01589	121.34851	0	0.03	-0.030	Glenda/July 15,2014	5-Year
227	14.01592	121.27757	0.5	0.12	0.380	Glenda/July 15,2014	5-Year
228	14.01699	121.28328	0	0.03	-0.030	Glenda/July 15,2014	5-Year
229	14.02555	121.27867	0	0.03	-0.030	Glenda/July 15,2014	5-Year
230	14.02568	121.27436	0.5	0.11	0.390	Glenda/July 15,2014	5-Year
231	14.03515	121.27365	0	0.05	-0.050	Glenda/July 15,2014	5-Year
232	14.04414	121.344	0.3	0.03	0.270	Glenda/July 15,2014	5-Year
233	14.04414	121.34406	0.2	0.03	0.170	Glenda/July 15,2014	5-Year
234	14.04429	121.26898	0.25	0.25	0.000	Glenda/July 15,2014	5-Year
235	14.04783	121.26771	0.2	0.07	0.130	Glenda/July 15,2014	5-Year
236	14.05008	121.34033	0.2	0.11	0.090	Glenda/July 15,2014	5-Year

ANNEX 12. Educational Institutions Affected in Malaking Ilog Floodplain

Laguna				
Alaminos				
Barangay	Building	Rainfall Scenario		
		5-year	25-year	100-year
San Benito	San Benito Elementary School	None	None	None
San Gregorio	San Gregorio Elementary School	None	None	None
San Miguel	San Miguel Elementary School	None	None	None
San Roque	Day Care Center	Low	Low	Low
San Roque	San Roque Elementary School	None	None	None
San Pablo City				
Barangay	Building	Rainfall Scenario		
		5-year	25-year	100-year
Bagong Bayan II-A	Paaralang Pag-Ibig at Pag-Asa	None	None	None
Bagong Pook VI-C	Bagong Pook Elementary School	Low	Low	Medium
Bagong Pook VI-C	Capellan Institute of Technology	None	None	None
Bagong Pook VI-C	Col. Lauro D. Dizon Memorial National High School	None	None	None
Bagong Pook VI-C	Day Care Center	None	None	None
Bagong Pook VI-C	Fule Almeda Elementary School	None	None	None
Bagong Pook VI-C	Hope Zoel School	None	None	None
Bagong Pook VI-C	San Pablo Central School	None	None	None
Barangay I-A	San Roque Elementary School	None	None	None
Barangay I-B	Espiritu Junk Shop	None	None	None
Barangay I-B	San Roque Elementary School	None	None	None
Barangay II-A	Ambray Elementary School	Low	Low	Low
Barangay II-A	Bagong Bayan Elementary School	None	None	None
Barangay II-A	Espiritu Junk Shop	None	None	None
Barangay II-B	ALS Community Learning Center	None	None	None
Barangay II-B	Day Care Center	None	None	None
Barangay II-D	Day Care Center	None	None	None
Barangay II-D	First Evangelista Learning Center	None	None	None
Barangay II-D	Mababang Paaralan ng San Anton	None	None	None
Barangay II-D	Maranatha Christian Academy	None	None	None
Barangay II-F	Day Care Center	None	None	None
Barangay III-B	Learner's Academy	None	None	None
Barangay III-B	San Pablo Colleges	None	None	None
Barangay III-C	Santo Cristo Elementary School	None	None	None
Barangay III-D	Paaralang Elementarya ng Platon	None	None	None
Barangay III-D	Santo Cristo Elementary School	None	Low	Low
Barangay IV-A	Day Care Center	None	None	None
Barangay IV-A	Paaralang Elementarya ng Platon	Low	Low	Low
Barangay IV-B	Learner's Academy	Low	Low	Low
Barangay IV-B	Liceo de San Pablo	None	None	None
Barangay IV-B	San Pablo Colleges	Low	Low	Low

Barangay IV-B	Ultimart	None	None	None
Barangay IV-C	Liceo de San Pablo	None	None	None
Barangay IV-C	Ultimart	None	None	None
Barangay VI-A	Dreams Diving Academy	Low	Low	Medium
Barangay VI-A	St. Joseph School	Medium	Medium	Medium
Barangay VI-B	Col. Lauro D. Dizon Memorial National High School	None	None	None
Barangay VI-B	Fule Almeda Elementary School	None	None	None
Barangay VI-B	ODC Academy	None	None	None
Barangay VI-B	San Pablo Central School	None	None	None
Barangay VI-D	Day Care Center	None	None	None
Barangay VI-D	Dreams Diving Academy	Low	Low	Low
Barangay VI-E	CM Azcarate Elementary School	None	None	None
Barangay VI-E	Col. Lauro D. Dizon Memorial National High School	None	None	None
Barangay VI-E	Mayden Learning School	None	None	None
Barangay VI-E	San Pablo National High School	None	None	None
Barangay VII-C	Ultimart	Low	Low	Low
Barangay VII-D	San Pablo Colleges	None	Low	Low
Barangay VII-D	Ultimart	None	None	None
Barangay VII-E	Mababang Paaralan ng San Anton	None	None	None
Bautista	De Mesa Elementary School	None	None	None
Bautista	Fernando A. Quisumbing Elementary School	Medium	Medium	Medium
Del Remedio	Del Remedio Elementary School	None	None	None
Del Remedio	King Solomon Academy	None	None	None
Del Remedio	Laguna State Polytechnic University	None	None	None
Del Remedio	Saint Benilde College of Science and Technology	None	None	None
San Antonio 2	Day Care Center	None	None	None
San Antonio 2	San Antonio II Elementary School	None	None	None
San Bartolome	Banaad Elementary School	Low	Low	Low
San Crispin	San Cripsin Elementary School	None	None	None
San Francisco	Don Enrique Bautista Elementary School	Low	Low	Low
San Francisco	Nino Jesus Science Oriented Montessori	None	None	None
San Gabriel	San Gabriel Elementary School	None	None	None
San Gabriel	San Miguel High School	Medium	Medium	Medium
San Gabriel	VYP-MSC-Institute of Technology	None	None	None
San Gregorio	San Gregorio Elementary School	None	Low	Low
San Isidro	San Isidro Barangay High School	Medium	Medium	Medium
San Isidro	San Isidro Elementary School	None	None	None
San Joaquin	San Joaquin Elementary School	None	Low	Low
San Joaquin	Santa Ana Elementary School	Medium	Medium	Medium
San Juan	San Juan Elementary School	None	None	None
San Juan	San Juan Learning Center	None	None	None

San Lucas 1	CM Azcarate Elementary School	Low	Low	Low
San Lucas 1	Infant Jesus Montessori Center	None	None	None
San Lucas 1	King Solomon Academy	None	None	None
San Lucas 1	Melrose School	None	None	None
San Marcos	Day Care Center	None	None	None
San Marcos	San Juan Elementary School	None	None	None
San Marcos	Santa Maria Magdalena Elementary School	None	None	None
San Nicolas	Santa Monica	None	Low	Low
San Rafael	Santa Monica	Low	Low	Low
San Roque	Day Care Center	None	None	None
San Roque	Santa Monica Elementary School	None	Low	Low
San Vicente	Santa Cruz Elementary School	None	None	None
Santa Ana	San Antonio I Elementary School	None	Low	Low
Santa Ana	San Vicente Elementary School	Low	Low	Low
Santa Ana	Santa Ana Elementary School	Medium	Medium	Medium
Santa Felomina	Day Care Center	Low	Low	Low
Santa Felomina	Santo Felomina Integrated School	Low	Low	Low
Santa Monica	Day Care Center	None	None	Low
Santa Monica	Santa Monica Elementary School	None	Low	Low
Santa Veronica	Santa Veronica Elementary School	None	None	None
Santiago I	Paaralang Elementarya ng Santiago I	Low	Low	Low
Santiago I	San Bartolome National High School	None	Low	Low
Santiago II	Day Care Center	None	None	None
Santisimo Rosario	Santisimo Rosario Elementary School	None	None	None
Santisimo Rosario	Santisimo Rosario National High School	Low	Medium	Medium
Soledad	Santa Maria Elementary School	Low	Low	Low
Soledad	Soledad Elementary School	None	None	None

Quezon				
Candelaria				
Barangay	Building	Rainfall Scenario		
		5-year	25-year	100-year
Buenavista East	Buenavista West Daycare Center	Low	Low	Low
Buenavista East	Buenavista West Elementary School	Medium	Medium	Medium
Buenavista West	Buenavista East Daycare Center	None	None	None
Buenavista West	Buenavista East Elementary School	None	None	Low
Bukal Norte	Bukal Norte Elementary School	None	None	None
Bukal Norte	Hilirang Buli Day Care Center	None	None	None
Bukal Sur	Bukal Norte Daycare Center	None	None	None
Bukal Sur	Bukal Sur Daycare	Low	Low	Medium
Bukal Sur	Bukal Sur Daycare Center	None	None	None
Bukal Sur	Bukal Sur Elementary School	Low	Low	Medium
Bukal Sur	Bukal Sur National High School	None	None	None
Bukal Sur	Newton Science School Inc.	None	None	None
Kinatihan I	Kinatihan I Daycare Center	Low	Low	Low

Kinatihan I	Kinatihan I Elementary School	Low	Low	Low
Kinatihan II	Kinatihan II Elementary School	Low	Medium	Medium
Malabanban Sur	Malabanan Sur Elementary School	None	None	None
Mangilag Sur	Concepcion Palasan Daycare Center	Low	Low	Low
Mangilag Sur	Mangilag Sur Elementary School	None	None	None
Mangilag Sur	Tesda Learning Center	None	None	None
Masalukot I	Grabsum School	Low	Low	Medium
Masalukot I	Masalukot I Daycare	None	Low	Low
Masalukot I	Masalukot II Elementary School	None	None	None
Masalukot II	Masalukot II Elementary School	None	None	None
Masin Norte	Lady Mediatrix Institute	Medium	Medium	Medium
Masin Sur	Lady Mediatrix Institute	None	None	None
Masin Sur	Masin Norte Elementary School	None	None	None
Pahinga Norte	Pahinga Norte Daycare Center	None	None	None
Pahinga Norte	Pahinga Norte Elementary School	None	None	None
Pahinga Sur	Dolores Macasaet National High School	Low	Medium	Medium
Pahinga Sur	Pahinga Sur Elementary School	None	None	None
Poblacion	Grabsum School Inc.	Low	Low	Low
Poblacion	Masalukot I Elementary School	Low	Low	Medium
Poblacion	Tayabas Western Academy	None	None	None
San Andres	San Andres Daycare Center	None	None	None
San Andres	San Andres Elementary School	None	None	None
San Andres	Tulo Tulo Daycare Center	None	Low	Low
San Andres	Tulo Tulo Elementary School	Low	Medium	Medium
San Isidro	Kinatihan II Daycare Center	None	None	None
San Isidro	San Isidro Elementary School	None	Low	Low
Santa Catalina Norte	Sta. Catalina Norte Day Care Center	None	None	None
Santa Catalina Norte	Sta. Catalina Norte Elementary School	Low	Low	Low
Santa Catalina Sur	Sta. Catalina Central School	None	Low	Medium
Santa Catalina Sur	Sta. Catalina Sur National High School	None	Low	Medium
Santa Catalina Sur	Tulo Tulo Elementary School	Low	Low	Medium
Dolores				
Barangay	Building	Rainfall Scenario		
		5-year	25-year	100-year
Bungoy	Bungoy Elementary School	None	None	None
Bungoy	Daycare Center	None	None	None
Putol	Putol Elementary School	None	Low	Low
San Antonio				
Barangay	Building	Rainfall Scenario		
		5-year	25-year	100-year
Arawan	Bahay Tuluyan Children Center	None	None	None
Balat Atis	Balat-atis Daycare Center	None	None	None
Briones	Callejon Elementary School	None	None	None
Corazon	Corazon Barangay Hall	None	None	None
Corazon	Corazon Daycare Center	None	None	None

Loob	Bixby Knolls Preparatory Academy	None	None	None
Loob	Loob Elementary School	None	None	None
Magsaysay	Briones Elementary School	None	None	None
Matipunso	Paaralang Elementarya ng Matipunso	None	None	None
Niing	Niing Daycare Center	None	None	None
Niing	Niing Elementary School	None	None	None
Poblacion	Manuel S. Enverga Institute Foundation Inc.	Low	Low	Low
Poblacion	San Antonio Central Elementary School	Low	Low	Low
Poblacion	School	None	None	None
Pulo	Pulo Daycare Center	Low	None	None
Pury	Pury Elementary School	Low	Low	Low
Sampaguita	San Antonio National High School	None	None	Low
Sampaguita	St. Vincent Liem Dela Paz Prep. Sch. Inc.	None	None	Low
San Jose	Day Care Center	None	Low	Low
Sinturisan	Sinturisan Daycare Center	None	None	None
Sinturisan	Sinturisan Elementary School	None	None	None

Sariaya				
Barangay	Building	Rainfall Scenario		
		5-year	25-year	100-year
Bignay 2	Bignay 2 National High School	None	None	None
Bignay 2	Bignay Elementary School	None	None	None
Bignay 2	Bignay I Daycare Center	None	Low	Low
Bignay 2	Bignay I Elementary School	None	None	Low
Bignay 2	Jesus Flock Academy	None	None	None
Concepcion Palasan	Concepcion Ibaba Elementary School	Low	Low	Low
Concepcion Palasan	Lacopia Daycare Center	None	None	None
Manggalang-Bantilan	Kiling Elementary School	None	None	Low
Manggalang-Bantilan	Tipas National High School	None	None	None
Manggalang 1	Manggalang 1 Elementary School	None	None	None
Montecillo	Montecillo Elementary School	None	None	None

Sariaya				
Barangay	Building	Rainfall Scenario		
		5-year	25-year	100-year
Aquino	San Pedro Elementary School	None	None	None
Ayusan I	Ayusan I Elementary School	None	None	None
Barangay II	Recto Memorial National High School	None	None	Medium
Barangay II	Tiaong Elementary School	None	Medium	Medium
Barangay III	Brgy. III Daycare Center	None	Medium	Medium
Barangay III	Chapel	None	None	None
Barangay III	Learning Center	None	Low	Low
Barangay III	Tiaong East Elementary School	None	None	None
Barangay IV	Asian Institute of Technology and Education	None	None	None
Behia	Behia Elementary School	None	None	None

Bukal	Bukal Daycare Center	None	Low	Low
Bukal	Bukal Elementary School	None	None	None
Bula	Brgy. Bulakin Elementary School	Medium	Medium	High
Bula	Bulakin Elementary School	Medium	High	High
Cabatang	Cabatang Elementary School	Low	Low	Low
Cabay	Cabay Daycare Center	None	None	None
Cabay	Cabay Elementary School	Low	Medium	Medium
Cabay	San Juan Daycare Center	None	None	None
Cabay	San Juan Elementary School	None	Low	Low
Del Rosario	Del Resario Daycare	None	None	Low
Del Rosario	Del Rosario Daycare	None	None	Medium
Del Rosario	Del Rosario Elementary School	Low	Low	Medium
Lagalag	Escuela De Immaculada Elem School	Medium	Medium	Medium
Lagalag	Lagala Elementary School	None	None	None
Lagalag	Lagalag Daycare Center	None	None	None
Lagalag	Palagaran Elementary School	None	None	None
Lusacan	Anastacia Daycare Center	None	Low	Low
Lusacan	Anastacia Elementary School	None	Low	Low
Lusacan	Don Ysidro Memorial School	Low	Low	Low
Lusacan	Lusacan Daycare Center	None	None	None
Lusacan	Lusacan Elementary School	Low	None	None
Lusacan	Lusacan National High School	None	None	None
Lusacan	RIverside Daycare Center	Low	Low	Low
Lusacan	Southside Integrated School	None	None	None
Lusacan	St. Francis Academy	None	Low	Low
Lusacan	Talisay National High School	Low	Low	Low
Paiisa	Paiisa Elementary School	None	None	Low
Paiisa	Paiisa National High School	Low	Low	Low
Quipot	Quipot Elementary School	None	None	None
Quipot	San Agustin Elementary School	None	None	None
Quipot	Tiaong Christian Academy	Low	Low	Low
San Francisco	San Francisco Elementary School	None	None	None
San Jose	San Jose Elementary School	None	Medium	Medium
San Pedro	Daycare Center	Low	Medium	Medium
Tagbakin	Tagbakin Elementary School	None	None	None
Tamisian	Gloria Umali National High School	None	Low	Low

ANNEX 13. Medical Institutions Affected in Malaking Ilog Floodplain

Laguna				
San Pablo City				
Barangay	Building	Rainfall Scenario		
		5-year	25-year	100-year
Bagong Pook VI-C	Exconde Heart & Medical Clinic	Low	Low	Low
Bagong Pook VI-C	Jumawan Ob-Gyne Clinic	None	None	None
Barangay II-D	ENT Michael Muere Rosanes, M.D.	None	None	None
Barangay II-D	Lee-Muere Dentista	None	None	None
Barangay II-D	Muere-Santos Eye Specialist Clinic	None	None	None
Barangay III-B	Dental Clinic	None	None	None
Barangay III-D	Health Center	None	None	None
Barangay IV-C	Oro Optical	None	None	None
Barangay IV-C	Rose Lying in Clinic & Family Planning	None	None	None
Barangay V-B	Brion Deveza Optical Clinic	None	None	None
Barangay V-B	J.A. Penaloza Ortho Dental Clinic	None	None	None
Barangay V-B	Penalosa Dental Clinic	None	None	None
Barangay V-D	Oro Optical	Low	Low	Low
Barangay VI-B	Dermaholic	None	None	None
Barangay VI-B	Immaculate Conception Hospital	None	None	None
Barangay VI-B	Jumawan Ob-Gyne Clinic	None	Low	Low
Barangay VII-D	Dental Clinic	Low	Low	Medium
Del Remedio	Clinic	None	None	None
San Joaquin	Health Center	None	None	None
San Roque	SPC Medical Center	None	None	None
Santa Maria	Santa Maria BEmONC Facility	None	Low	Low
Santisimo Rosario	Magtibay Ortho-Dental Clinic	None	None	Low

Quezon				
Candelaria				
Barangay	Building	Rainfall Scenario		
		5-year	25-year	100-year
Buenavista East	Buenavista West Health Center	Low	Low	Low
Kinatihan I	Kinatihan I Health Center	Low	Low	Low
Kinatihan II	Kinatihan I Health Center	None	None	None
Mangilag Sur	United Candelaria Doctor Hospital	None	None	None
Masin Norte	Masin Norte Health Center	Low	Low	Low
Masin Sur	Adult & Pediatric Clinic	None	None	None
Pahinga Sur	Pahinga Norte Lying in Clinic	None	None	None
Pahinga Sur	Pahinga Sur Health Center	Low	Low	Medium
Poblacion	Southstar Drug	None	Low	Low
San Andres	San Andres Health Center	None	None	None
Santa Catalina Norte	Sta. Catalina Norte Health Center	None	None	None
Dolores				

Barangay	Building	Rainfall Scenario		
		5-year	25-year	100-year
Bungoy	Health Center	None	None	None
Putol	Health Center	None	None	None
San Antonio				
Barangay	Building	Rainfall Scenario		
		5-year	25-year	100-year
Corazon	Corazon Clinic	None	None	None
Corazon	Corazon Health Center	Medium	Medium	Medium
Niing	Clinic	None	None	None
Poblacion	Clinic	None	None	None
Poblacion	Dental Clinic	Low	Low	Low
San Jose	Maternity Clinic	Low	Medium	Medium
Sariaya				
Barangay	Building	Rainfall Scenario		
		5-year	25-year	100-year
Bignay 2	Bignay 2 Health Center	None	None	None
Manggalang-Bantilan	Kiling Health Center	None	None	Low
Sariaya				
Barangay	Building	Rainfall Scenario		
		5-year	25-year	100-year
Ayusan I	Health Center	None	None	None
Barangay III	Ilia Hospital	None	None	None
Barangay IV	Amazing Grace OB-GYN Ultrasound Clinic	None	None	None
Behia	Behia Health Center	None	None	None
Bukal	Health Center	None	Low	Low
Cabatang	Cabatang Health Center	None	None	None
Cabay	Cabay Health Center	Medium	Medium	Medium
Lusacan	Anastacia Health Center	None	Low	Low
Lusacan	Lusacan Health Center	None	None	None
Paiisa	Paiisa Health Center	Low	Low	Low
Quipot	Quipot Health Center	None	None	None