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

LiDAR Surveys and Flood Mapping of Imus River

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

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LIST OF ACRONYMS AND ABBREVIATIONS

AAC	Asian Aerospace Corporation
Ab	abutment
ALTM	Airborne LiDAR Terrain Mapper
ARG	automatic rain gauge
ATQ	Antique
AWLS	Automated Water Level Sensor
BA	Bridge Approach
BM	benchmark
CAD	Computer-Aided Design
CN	Curve Number
CSRS	Chief Science Research Specialist
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
MIT	MAPUA Institute of Technology
MMS	Mobile Mapping Suite
MSL	mean sea level
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 IMUS RIVER

Enrico C. Paringit, Dr. Eng., Dr. Francis Aldrine Uy, and Engr. Fibor Tan

1.1 Background of the Phil-LIDAR 1 Program

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

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

The implementing partner university for the Phil-LiDAR 1 Program is the MAPUA Institute 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 Cavite-Batangas-Rizal-Quezon (CABARZON) Region. The university is located in the City of Manila within Metro Manila in the National Capital Region.

1.2 Overview of the Imus River Basin

The Imus River Basin is located in the province of Cavite, covering the municipalities of Silang, General Trias, Kawit, Noveleta and the cities of Tagaytay, Dasmarinas, and Imus. The DENR River Basin Control Office identified the basin to have a drainage area of 105 km2 and an estimated annual runoff of 168 million cubic meter (MCM) (RBCO, 2015).

Its main stem, Imus River, is part of the twenty-six (26) river systems in Southern Luzon Region. According to the 2015 national census of NSO, a total of 59,493 persons are residing within the immediate vicinity of the river which is distributed among fifteen (15) barangays in Imus City, and six (6) barangays in Bacoor City, in the province of Cavite. Imus City is mostly an industrial and commerical city with establishments such as real estates, manufacturing factories, commercial establishments, financial institutions, etc. It is the leading banking center of the province where this activity propagates the city's development (Source: http://imus.gov.ph/city-projects/).

One of the major problems in the Imus River Basin area is that during typhoons and heavy rainfall, water level in the river rapidly increases. Several typhoons flood the communities nearby regularly, and it is especially evident in the coastal municipalities near the river. One example was Typhoon Ondoy in 2009, which caused the city to be flooded with water. Currently, the government has provided solutions to flooding. In April 2016, DPWH started a major flood-risk management in Imus River. Dike, drainage sluice, and retarding basins in Imus City and Bacoor City areas are being constructed to prevent the reoccurrence of flooding in the lower reaches of the river during 2006 and 2013. This flooding led to thousands of affected residents in the area, as well as damage to crops, fisheries, livestock and agriculture. This project is expected to be completed by March 2019.

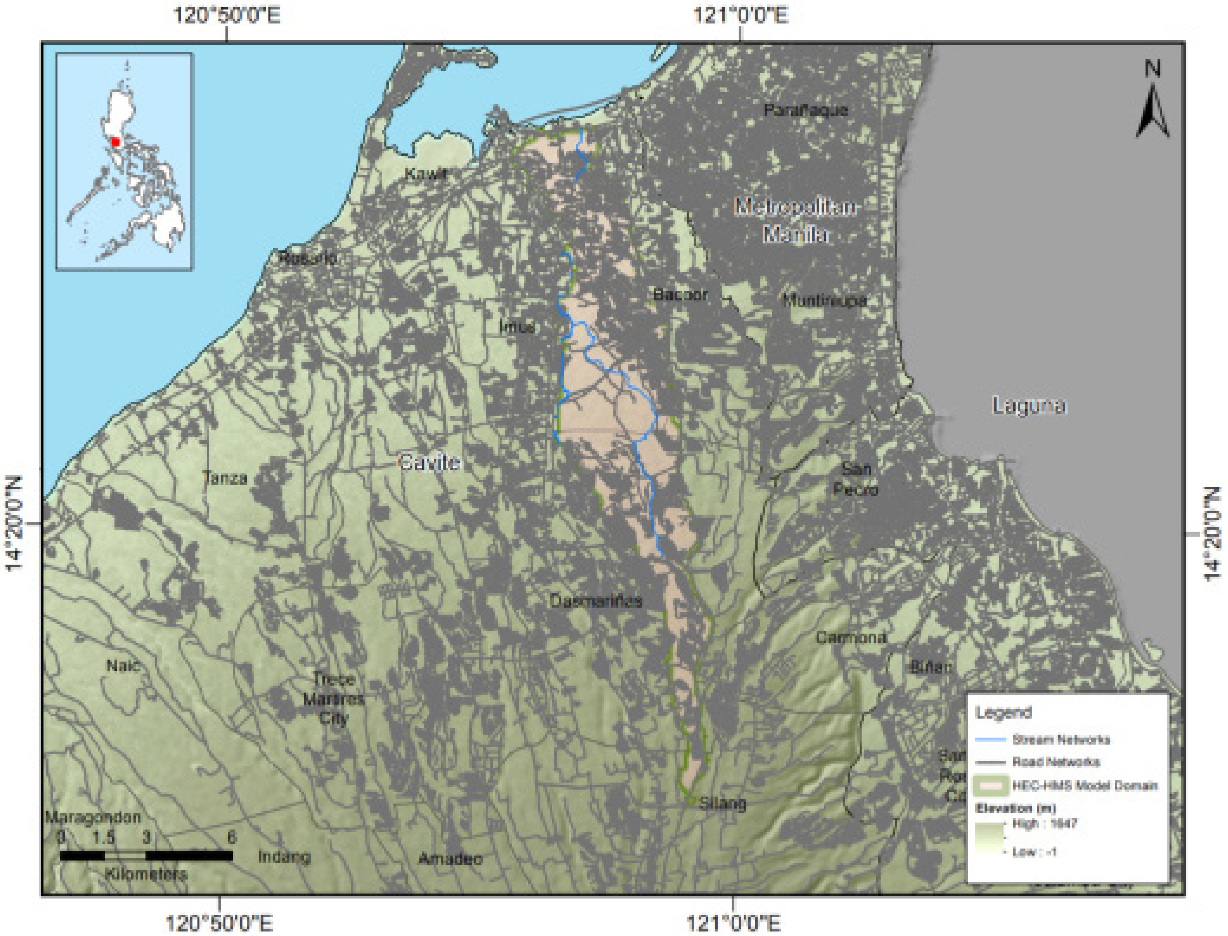

Figure 1. Map of Imus River Basin (in brown)

Meanwhile, even as flood management infrastructure were being constructed another typhoon hit the Imus River Basin. Last December 2016, Typhoon Nina, internationally known as Nock-Ten, made landfall in the Philippines and brought with it heavy rain and strong wind. The Province of Cavite was placed under Signal Number 3 by the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAG-ASA), wherein floods and landslides were to be expected during the onslaught of Nina (Source: http://www.rappler.com/nation/special-coverage/weather-alert/156614-20161226-typhoon-nina-pagasa-forecast-2am).

As a solution to the flooding, the generation of flood hazard maps incorporates LiDAR data and the hydrologic and hydraulic model of the river. Using LiDAR data with the surface elevation of an area, one can easily identify the low-lying areas prone to flooding. Through the flood hazard maps, the local government can easily determine the areas within the watershed that are prone to flooding during typhoon and heavy rainfall. These flood hazard maps are essential for planning purposes of the local government units. With proper dissemination of information about the flood inundation of a rainfall event with certain return periods, the community, especially those in low-lying and coastal areas, will be informed and aware in what to do when a typhoon or heavy rainfall occurs. Furthermore, these flood hazard maps can also be an important tool for economic purposes as these maps indicates the impeccable location or place for development projects, businesses, agriculture and livestock industry.

CHAPTER 2: LIDAR ACQUISITION IN IMUS FLOODPLAIN

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

2.1 Flight Plans

Plans were made to acquire LiDAR data within the delineated priority area for Imus Floodplain in Cavite. The mission was planned for 9 lines and ran for at most three (3) hours including take-off, landing and turning time. The flight planning parameters for Pegasus and Leica ALS80-HP LiDAR systems are found in Table 1 and Table 2, respectively. Figure 2 shows the flight plan for Imus Floodplain survey.

Table 1. Flight planning parameters for Pegasus LiDAR System.

Block Name	Flying Height (AGL)	Overlap (%)	Field of View	Pulse Repetition Frequency (PRF) (kHz)	Scan Frequency	Average Speed	Average Turn Time (Minutes)
BLK 18A	1000/1100	30	50	200	30	130	5
BLK 18B	1000	30	50	200	30	130	5
BLK 18C	1000/1100	30	50	200	30	130	5
BLK 18D	1000	30	50	200	30	130	5
BLK 18X	1200	30	50	200	30	130	5

Table 2. Flight planning parameters for Leica ALS-80 HP LiDAR System

Block Name	Flying Height (AGL)	Overlap (%)	Field of View	Pulse Repetition Frequency (PRF) (kHz)	Scan Frequency	Average Speed	Average Turn Time (Minutes)
BLK18A	1000/ 1500	30	50/45	128	30/42	130	5
BLK18B	1500	30	45	128	42	130	5

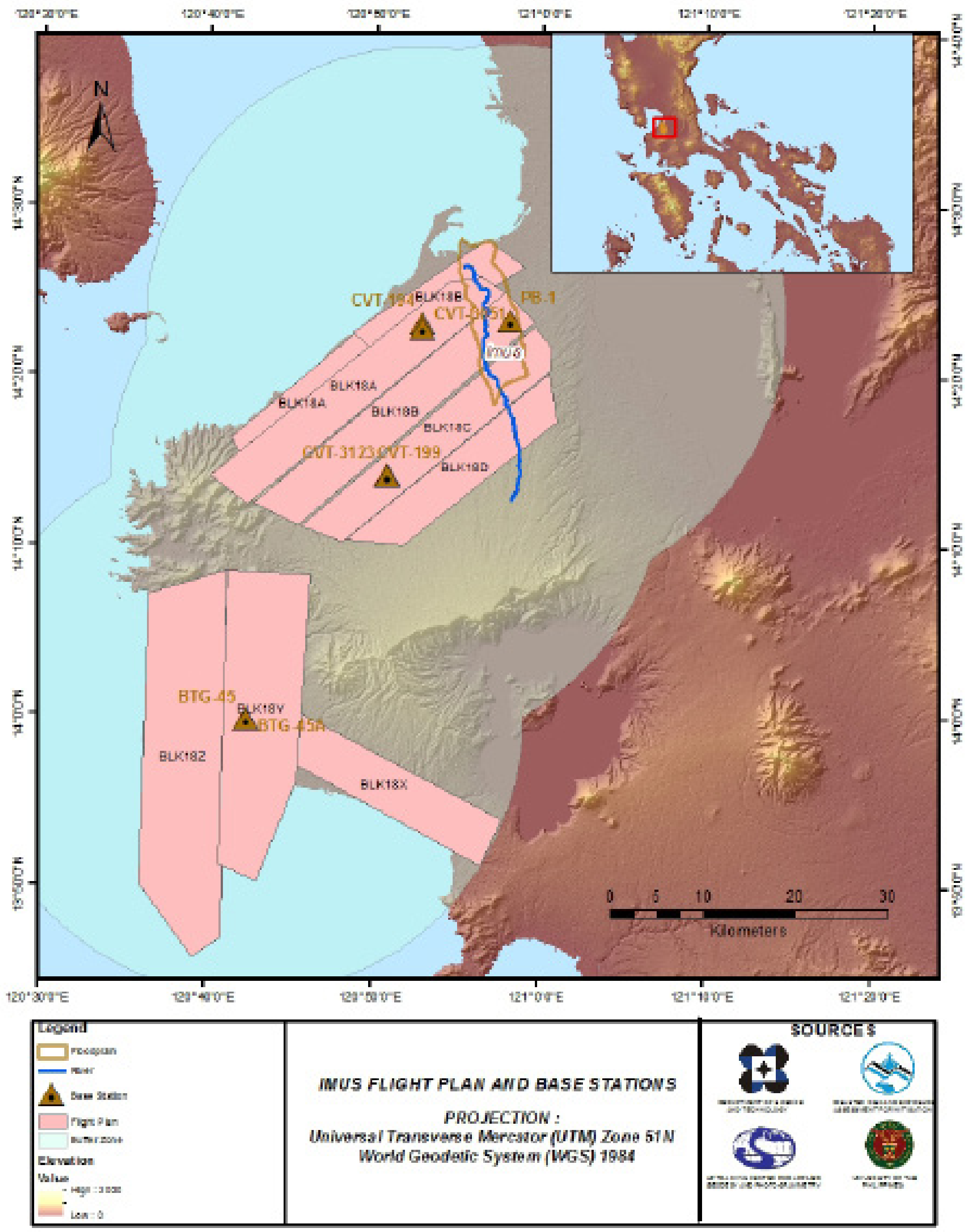


Figure 2. Flight plan and base station for Pegasus System used for Imus Floodplain

2.2 Ground Base Station

The project team was able to recover two (2) NAMRIA ground control points: CVT-194 and BTG-45 which are of second (2nd) order accuracy. The project team also established two (2) ground control points PB-1 and BTG-45A, and re-processed two (2) NAMRIA reference points CVT-3051 and CVT-3123. The certifications for the base stations are found in Annex 2 while the baseline processing reports for the re-processed ground control point and established points are found in Annex 3. These were used as base stations during flight operations for the entire duration of the survey (January 26-February 22, 2014, August 18, 2015, and May 3-6, 2016). Base stations were observed using dual frequency GPS receivers, TRIMBLE SPS 985 and TOPCON GR5. Flight plans and location of base stations used during the aerial LiDAR acquisition in Imus floodplain are shown in Figure 2. The list of team members for LiDAR data acquisition is found in Annex 4.

Figure 3 to Figure 6 show the recovered NAMRIA reference points within the area, in addition Table 3 to Table 8 show the details about the NAMRIA control stations and established points, Table 9 shows the list of all ground control points occupied during the acquisition together with the dates they are utilized during the survey.

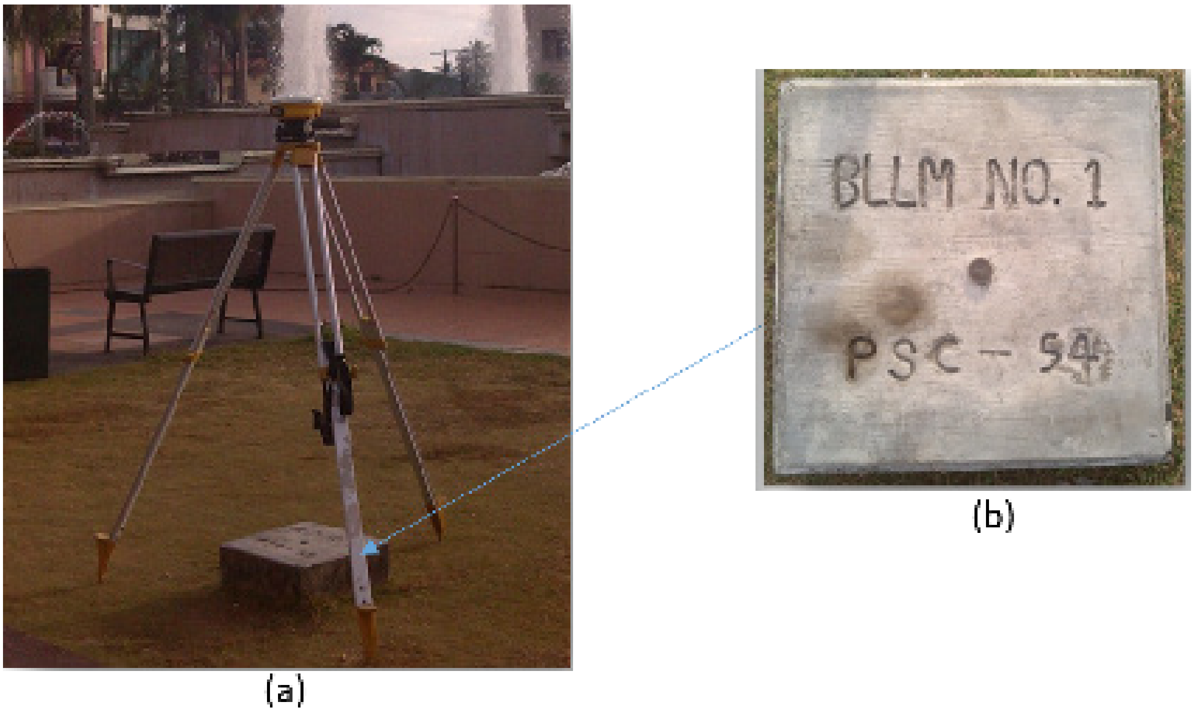
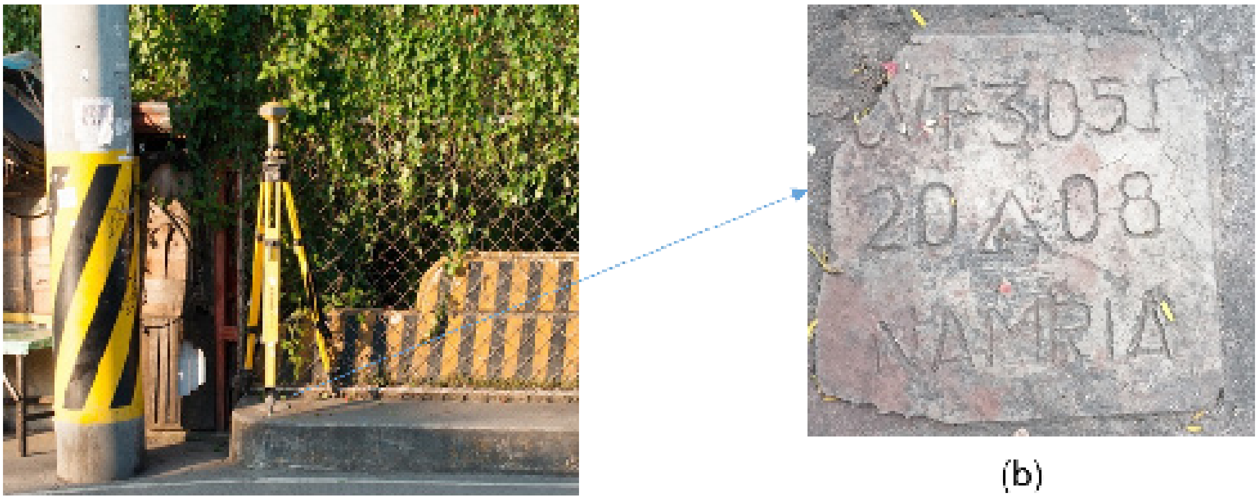


Figure 3. GPS set-up over CVT-194 (BLLM NO.1 PSC-94) near the Municipal Hall of Gen. Trias, Cavite (a) and NAMRIA reference point CVT-194 (b) as recovered by the field team.

Table 3. Details of the recovered NAMRIA horizontal control point CVT-194 used as base station for the LiDAR Acquisition.

Station Name	**CVT-194**	
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° 23’ 15.01186” North 120° 52’ 43.52184” East 18.337 meters
Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 3 PRS 92)	Easting Northing	486924.253 meters 1591045.311 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	14°23 ’9.63386” North 120° 52’ 48.43458” East 62.184 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting Northing	271265.13 meters 1591537.44 meters

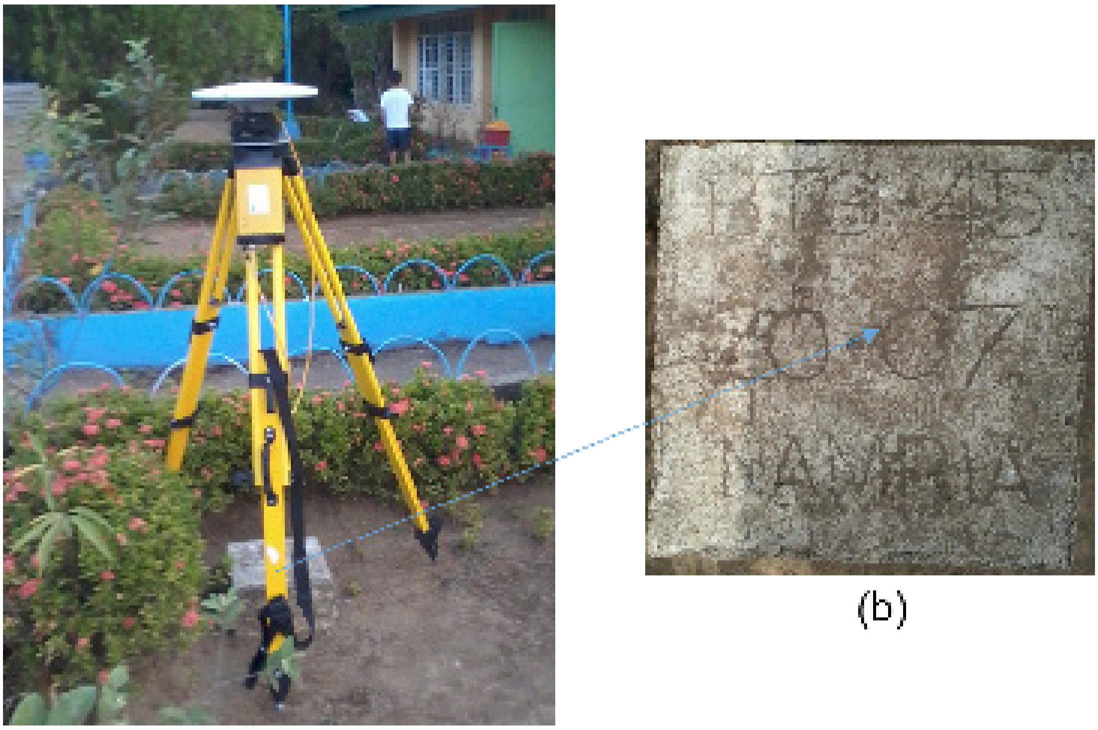


(a) (b)

Figure 4. GPS set-up over CVT-3051 in a concrete bridge leading to Manggahan, 70 m SE of Jetti Gas Station and about 250 m from Gen. Trias Poblacion (a) and NAMRIA reference point CVT-3051 (b) as recovered by the field team.

Table 4. Details of the recovered NAMRIA horizontal control point CVT-3051 with processed coordinates used as base station for the LiDAR Acquisition.

Station Name	**CVT-3051**	
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° 22’ 58.33330” North 120° 52’ 44.06059”East 21.122 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	14° 22’52.95639” North 120° 52’ 48.97372 East” 64.983 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting Northing	271276.565 meters 1591024.612 meters



(a) (b)

Figure 5. GPS set-up over BTG-45 inside Santiago De Guzman Elementary School of Brgy. Malibu, Tuy, Batangas Province (a) and NAMRIA reference point BTG-45 (b) as recovered by the field team.

Table 5. Details of the recovered NAMRIA horizontal control point BTG-45 used as base station for the LiDAR Acquisition.

Station Name	**BTG-45**	
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° 59' 52.18294" North 120° 42' 18.96476" East 48.43000 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	468159.677 meters 1547952.281 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	13° 59' 46.88216" North 120° 42' 23.91169" East 92.94300 meters

(a) (b)

Figure 6. GPS set-up over PB-1 as established in an elevated traffic island in Daang Hari Road, Imus, Cavite (a) and reference point PB-1 (b) as established by the field team.

Table 6. Details of the established horizontal control point PB-1 with processed coordinates used as base station for the LiDAR Acquisition.

Station Name	**PB-1**	
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° 23' 19.56635" North 120° 58' 04.29835"East 87.568 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	14° 23'19.56635" North 120° 58' 04.29835" East 87.568 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting Northing	280881.093 meters 1591688.776 meters

Table 8. Details of the established horizontal control point BTG-45A with processed coordinates used as base station for the LiDAR Acquisition.

Station Name	BTG-45A	
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° 59' 51.95603" North 120° 42' 18.98286 " East 49.08900 meters
Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 3 PRS 92)	Easting Northing	252126.100 meters 1548584.818 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	13° 59' 46.65526" North 120° 42' 23.92980" East 93.60200 meters

Table 9. Details of the recovered NAMRIA horizontal control point CVT-3123 with processed coordinates used as base station for the LiDAR Acquisition.

Station Name	CVT-3123	
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° 14' 15.59521" North 120° 50' 41.86474" East 167.527 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	14° 14'10.24962" North 120° 50' 46.79435" East 211.713 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting Northing	267465.517 meters 1574990.072 meters

Table 7. Ground control points used during LiDAR data acquisition

Date Surveyed	Flight Number	Mission Name	Ground Control Points
26 January 2014	1031P	1BLK18C026A	PB-1 and CVT-194
28 February 2014	1039P	1BLK18B028A	PB-1 and CVT-194
3 February 2014	1063P	1BLK18D034A	PB-1 and CVT-194
22 February 2014	1139P	1BLK18X53A	BTG-45 and BTG-45A
18 August 2015	3309P	1BLK18AsS230A	CVT-199 and CVT-3051
3 May 2016	10136L	4BLK18A124A	CVT-199 and CVT-3123
6 May 2016	10142L	4BLK18AB127A	CVT-199 and CVT-3123

2.3 Flight Missions

Seven (7) missions were conducted to complete the LiDAR Data Acquisition in Imus Floodplain, for a total of twenty-four hours and one minute (24+01) of flying time for RP-C9022 and RP-C9522. All missions were acquired using the Pegasus and Leica ALS-80 HP LiDAR systems. Table 10 shows the total area of actual coverage and the corresponding flying hours per mission, while Table 11 presents the actual parameters used during the LiDAR data acquisition.

Table 10. Flight missions for LiDAR data acquisition in Imus 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
26 January 2014	1031P	124.00	123.10	5.43	117.67	NA	3	17
3 February 2014	1063P	601.14	33.69	NA	33.69	348	2	59
22 February 2014	1139P	601.14	269.45	NA	269.45	474	3	56
28 February 2014	1039P	601.14	190.01	26.42	163.59	NA	3	17
18 August 2015	3309P	347.2	113.87	8.00	105.87	NA	3	16
3 May 2016	10136L	88.06	77.01	NA	77.01	679	3	18
6 May 2016	10142L	166.75	89.73	9.08	80.65	506	3	58
TOTAL		2529.43	896.86	48.93	847.93	2007	24	1

Table 11. Actual parameters used during LiDAR data acquisition.

Flight Number	**Flying Height (AGL)**	**Overlap (%)**	**Field of View (θ)**	**Pulse Repetition Frequency (PRF) (kHz)**	**Scan Frequency (Hz)**	**Average Speed (kts)**	**Average Turn Time (Minutes)**
1031P	1000	30	50	200	30	130	5
1063P	1000	30	50	200	30	130	5
1139P	1200	30	50	200	30	130	5
1039P	1000	30	50	200	30	130	5
3309P	1100	30	50	200	30	130	5
10136L	1000	30	50	200	32	130	5
10142L	1500	30	45	128	42	130	5

2.4 Survey Coverage

Imus Floodplain is situated within the municipalities of Cavite. The city of Trece Martires in Cavite is mostly covered during the survey. The list of municipalities and cities surveyed with at least one (1) square kilometer coverage, is shown in Table 12. The actual coverage of the LiDAR acquisition for Imus floodplain is presented in Figure 7.

Table 12. List of municipalities and cities surveyed in Imus Floodplain LiDAR survey.

Province	Municipality/City	Area of Municipality/City (km2)	Total Area Surveyed (km2)	Percentage of Area Surveyed
Batangas	Calaca	117.85	53.98	45.80%
	Lemery	82.32	29.28	35.57%
	Balayan	94.45	27.77	29.41%
	Tuy	92.55	17.92	19.36%
	Lian	91.27	16.49	18.07%
	Agoncillo	39.54	1.41	3.57%
	Nasugbu	266.83	5.52	2.07%
Cavite	Trece Martires City	44.35	44.20	99.64%
	Naic	76.11	70.51	92.65%
	General Trias	85.98	75.96	88.35%
	Dasmariñas	84.01	66.75	79.45%
	Tanza	71.41	48.38	67.75%
	Imus	56.81	37.10	65.32%
	Maragondon	147.39	88.38	59.96%
	General Emilio Aguinaldo	39.39	23.18	58.86%
	Amadeo	45.90	24.21	52.75%
	Rosario	4.89	2.54	51.92%
	Magallanes	69.07	32.36	46.85%
	Bacoor	47.43	18.16	38.29%
	Indang	88.65	26.57	29.98%
	Ternate	44.52	12.72	28.57%
	Noveleta	5.72	1.20	21.03%
	Silang	153.10	1.98	1.29%
Laguna	San Pedro	21.41	2.73	12.76%
NCR	Muntinlupa	38.52	7.28	18.88%
	Las Piñas	33.19	3.90	11.74%
Total		1942.66	740.48	41.53%

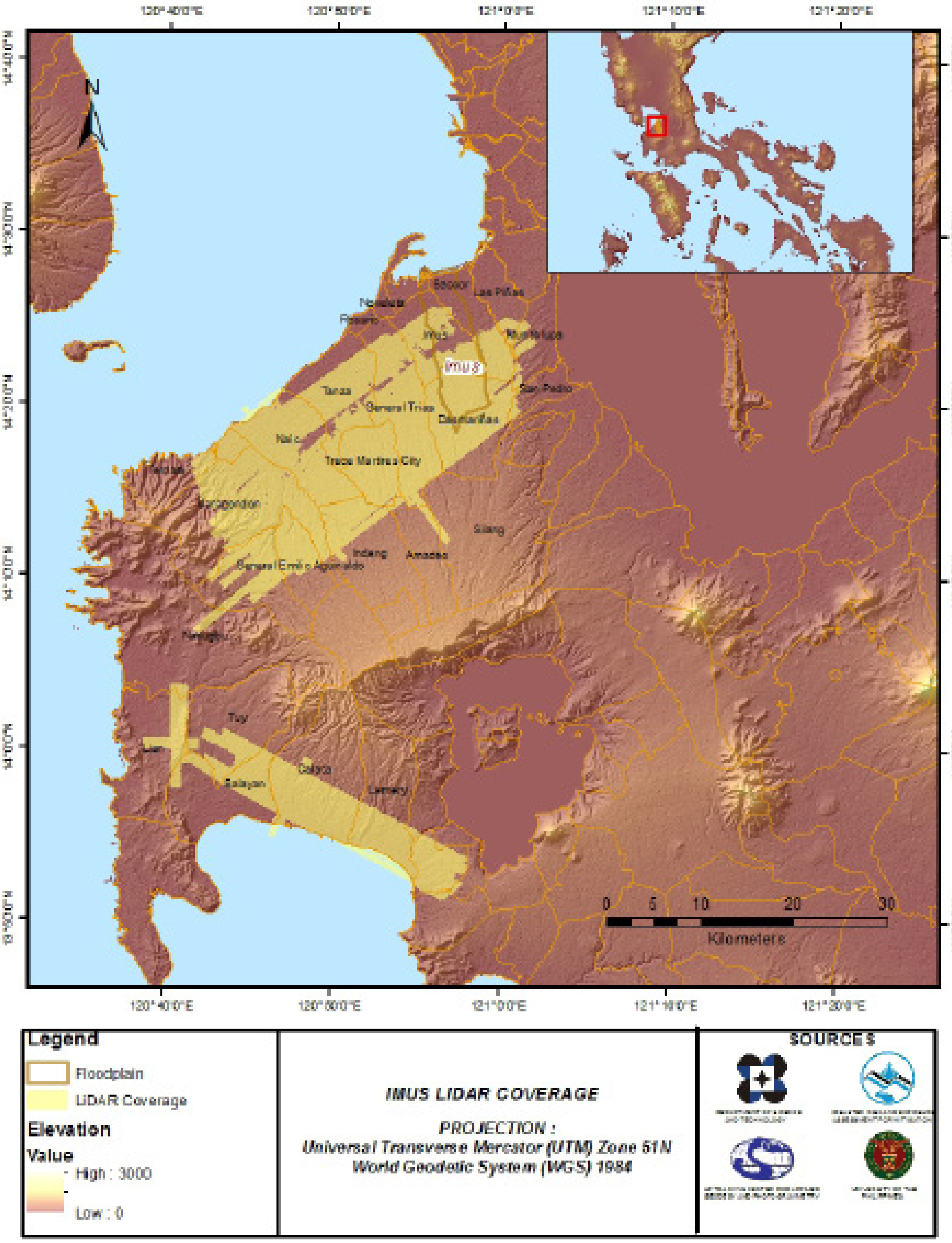


Figure 7. Actual LiDAR survey coverage for Imus Floodplain.

CHAPTER 3: LIDAR DATA PROCESSING FOR IMUS FLOODPLAIN

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

3.1 Overview of LiDAR Data Pre-Processing

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

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

These processes are summarized in the flowchart shown in Figure 9.

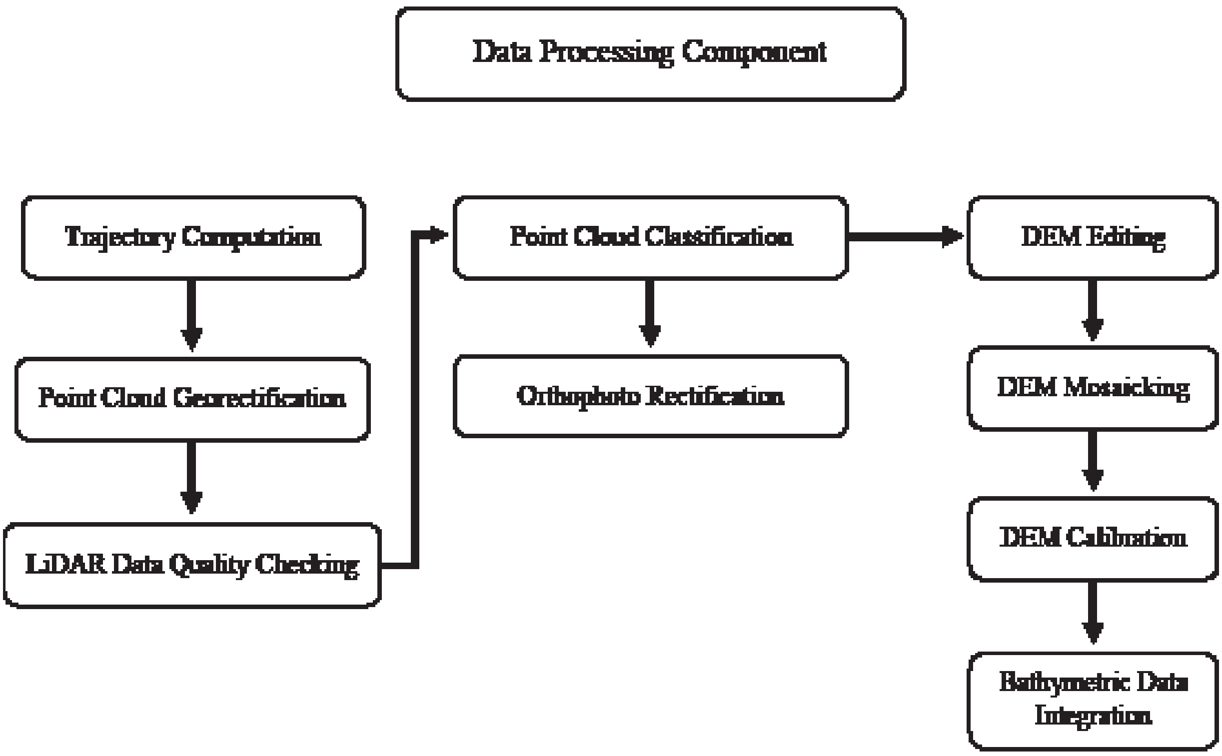


Figure 8. Schematic Diagram for Data Pre-Processing Component

3.2 Transmittal of Acquired LiDAR Data

Data transfer sheets for all the LiDAR missions for Imus floodplain can be found in Annex 5. Missions flown during the first survey conducted on January 2014 used the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.) Pegasus system while missions acquired during the second survey on August 2015 were flown using the same system over Imus, Cavite. The third survey, which was done on May 2016, the fourth survey, on July 2016 and the last survey, on January 2017, were all done using the Leica system.

The Data Acquisition Component (DAC) transferred a total of 87.56 Gigabytes of Range data, 986.08 Megabytes of POS data, 53.87 Megabytes of GPS base station data, and 67.54 Gigabytes of raw image data to the data server from February 2014 up to September 11, 2015 for Optech LiDAR system while a total of 27.7 Gigabytes of RawLaser data, 1.48 Gigabytes of GNSSIMU data, 233.59 Megabytes of base station data and 88.76 Gigabytes of RCD30 raw image data were transferred on February 13, 2017 for Leica LiDAR system. The Data Pre-processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for Imus was fully transferred on February 13, 2017, as indicated on the Data Transfer Sheets for Imus floodplain.

3.3 Trajectory Computation

The Smoothed Performance Metrics of the computed trajectory for flight 1027P, one of the Imus flights, which is the North, East, and Down position RMSE values are shown in Figure 9. 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 January 25, 2014 00:00AM. The y-axis is the RMSE value for that particular position.

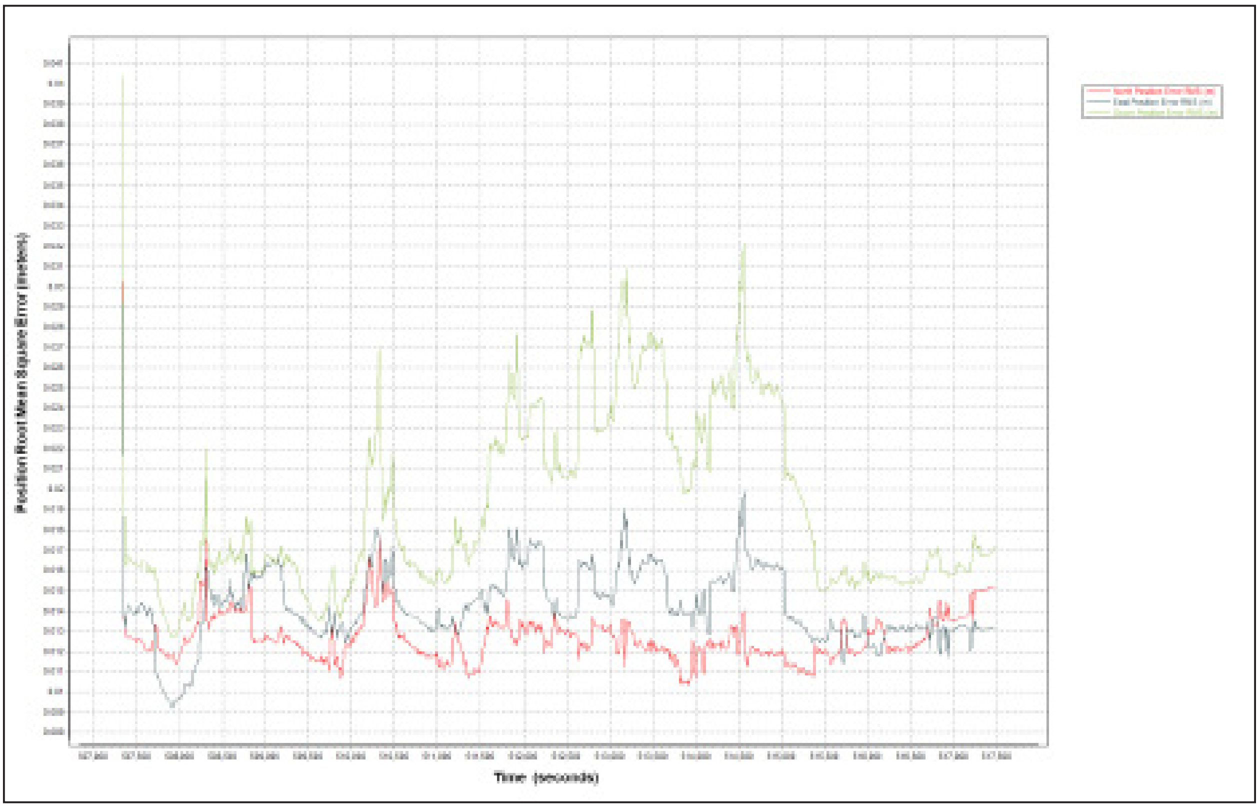


Figure 9. Smoothed Performance Metrics of Imus Flight 1027P.

The time of flight was from 507250 seconds to 517500 seconds, which corresponds to morning of January 25, 2014. The initial spike that is seen on the data corresponds to the time that the aircraft was getting into position to start the acquisition, and the POS system starts computing for the position and orientation of the aircraft. Redundant measurements from the POS system quickly minimized the RMSE value of the positions. The periodic increase in RMSE values from an otherwise smoothly curving RMSE values correspond to the turn-around period of the aircraft, when the aircraft makes a turn to start a new flight line. Figure 9 shows that the North position RMSE peaks at 1.76 centimeters, the East position RMSE peaks at 1.98 centimeters, and the Down position RMSE peaks at 3.22 centimeters, which are within the prescribed accuracies described in the methodology.

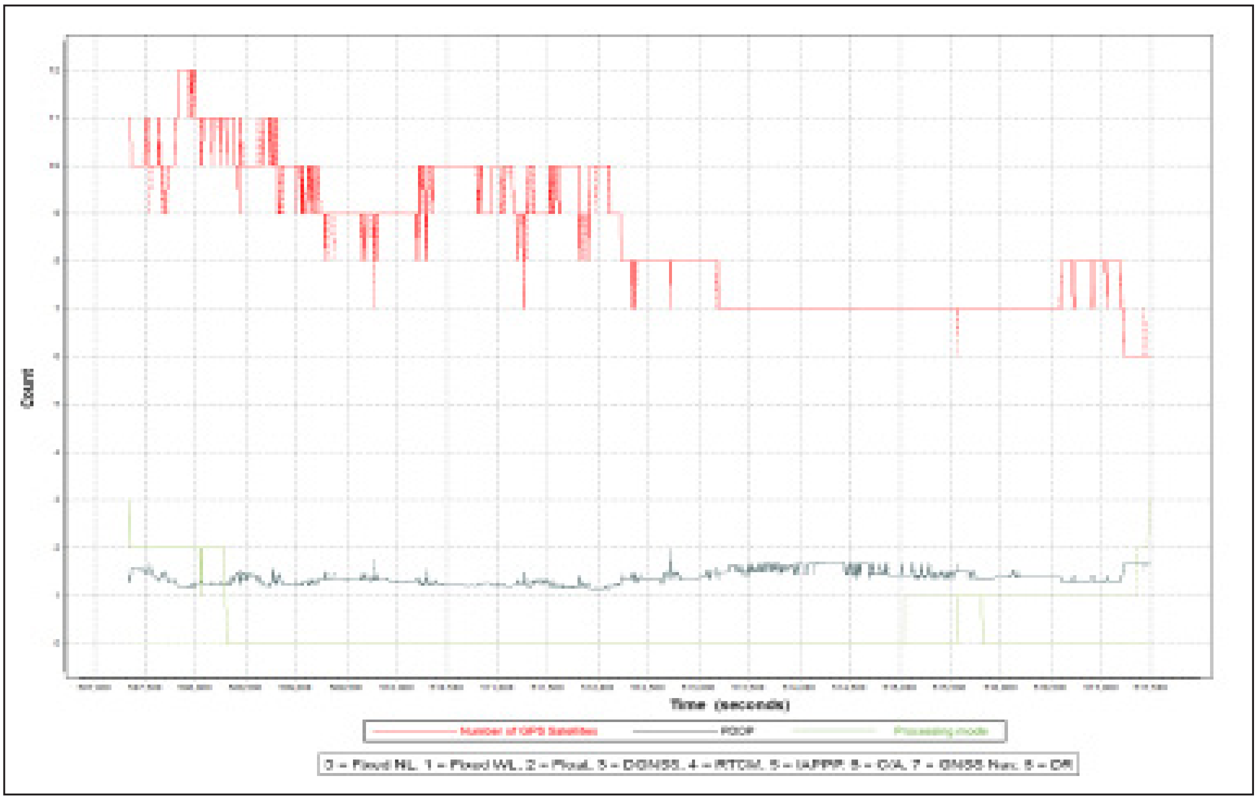


Figure 10. Solution Status Parameters of Imus Flight 1027P.

The Solution Status parameters of flight 1027P, one of the Imus flights, which are the number of GPS satellites, Positional Dilution of Precision (PDOP), and the GPS processing mode used, are shown in Figure 10. The graphs indicate that the number of satellites during the acquisition did not go down to 6. Majority of the time, the number of satellites tracked was between 6 and 10. The PDOP value also did not go above the value of 3, which indicates optimal GPS geometry. The processing mode stayed at the value of 0 for majority of the survey with some peaks up to 1 attributed to the turns performed by the aircraft. The value of 0 corresponds to a Fixed, Narrow-Lane mode, which is the optimum carrier-cycle integer ambiguity resolution technique available for POSPAC MMS. All of the parameters adhered to the accuracy requirements for optimal trajectory solutions, as indicated in the methodology. The computed best estimated trajectory for all Imus flights is shown in Figure 11.

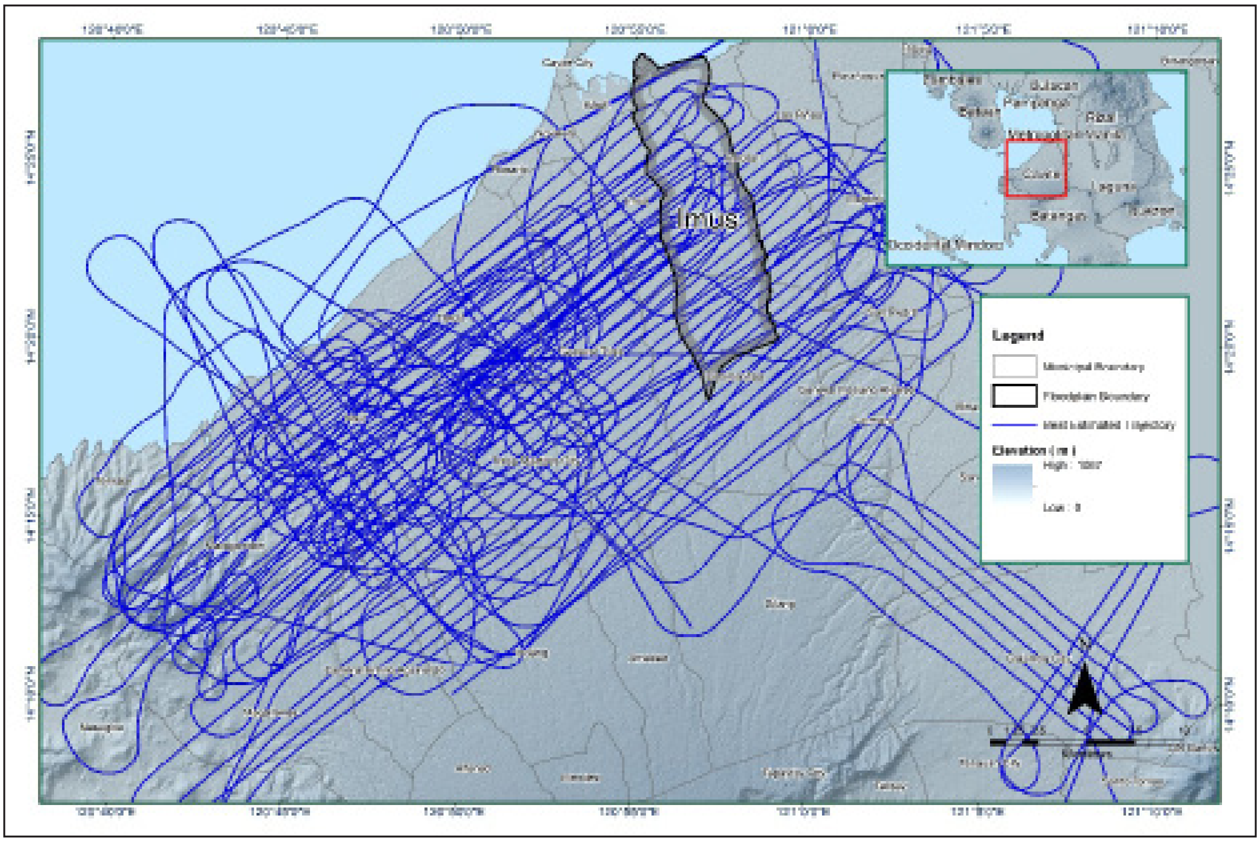


Figure 11. Best Estimated Trajectory for Imus Floodplain.

3.4 LiDAR Point Cloud Computation

The produced LAS data contains 74 flight lines, with each flight line containing two channels, since the Pegasus and Leica systems both contain two. The summary of the self-calibration results obtained from LiDAR processing in LiDAR Mapping Suite (LMS) software for all flights over Imus floodplain are given in Table 13.

Table 13. Self-Calibration Results values for Imus flights.

Parameter	Acceptable Value	Value
Boresight Correction stdev	(<0.001degrees)	0.000453
IMU Attitude Correction Roll and Pitch Corrections stdev	(<0.001degrees)	0.000946
GPS Position Z-correction stdev	(<0.01meters)	0.0019

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

3.5 LiDAR Data Quality Checking

The boundary of the processed LiDAR data on top of a SAR Elevation Data over Imus Floodplain is shown in Figure 12. The map shows gaps in the LiDAR coverage that are attributed to cloud coverage.

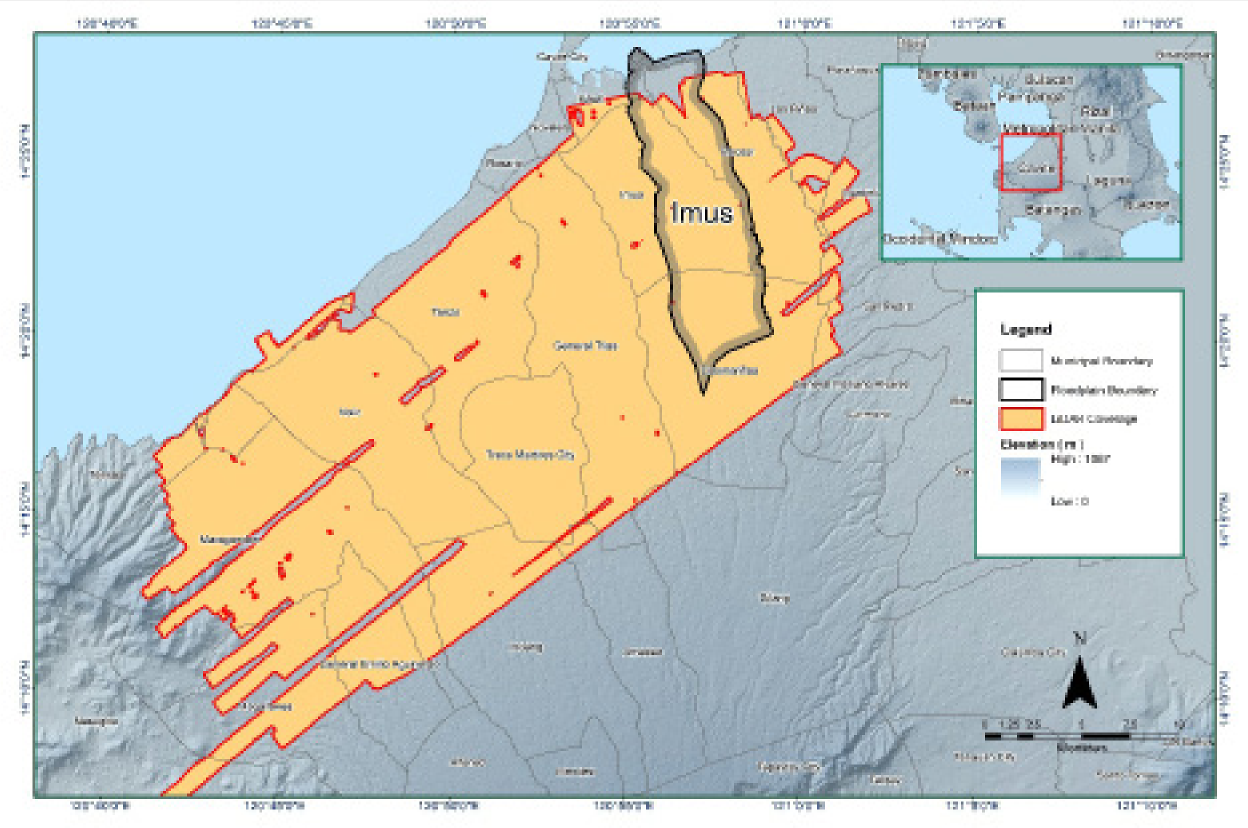


Figure 12. Boundary of the processed LiDAR data over Imus Floodplain

The total area covered by the Imus missions is 838.05 sq.km that is comprised of ten (10) flight acquisitions grouped and merged into ten (10) blocks as shown in Table 14.

Table 14. List of LiDAR blocks for Imus Floodplain.

LiDAR Blocks	Flight Numbers	Area (sq. km)
CALABARZON_Blk18B_supplement	3309P	106.91
CALABARZON_reflights_Blk18A	10136L	149.85
	10142L	
CALABARZON_reflights_Blk18B_supplement1	10321L	5.66
CALABARZON_reflights_Blk18B_supplement3	10321L	9.47
CALABARZON_reflights_Blk18B_supplement4	10321L	8.74
CALABARZON_reflights_Blk18B_supplement5	10197L	2.01
Cavite_Blk18AB	1023P	127.12
	1027P	
Cavite_Blk18C	1031P	117.91
Cavite_Blk18C_additional	1031P	210.76
	1063P	
Cavite_Blk18A_supplement2	1139P	99.62
TOTAL		838.05 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 13. Since the Pegasus and Leica systems both employ two channels, we would expect an average value of 2 (blue) for areas where there is limited overlap, and a value of 3 (yellow) or more (red) for areas with three or more overlapping flight lines.

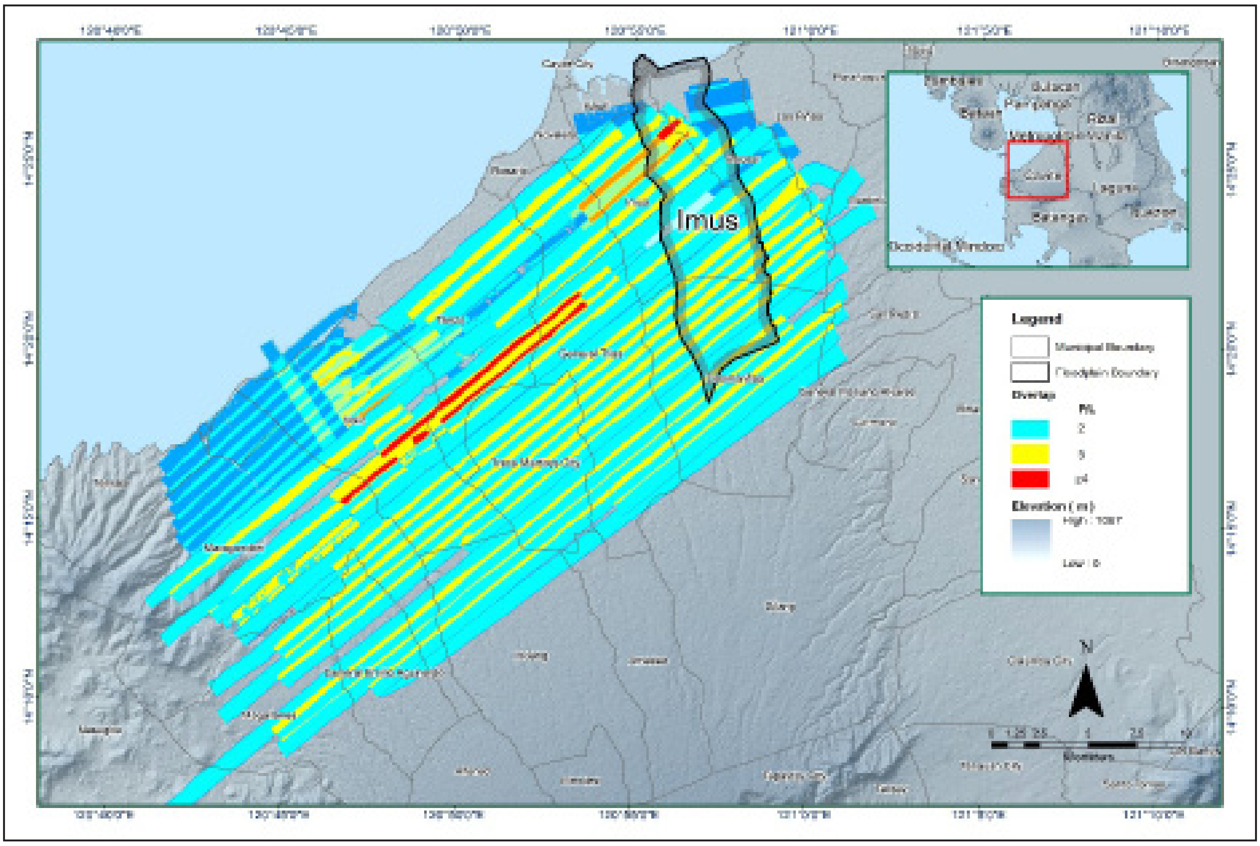


Figure 13. Image of data overlap for Imus Floodplain.

The overlap statistics per block for the Imus 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 28.57% and 51.19% 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 14. It was determined that all LiDAR data for Imus floodplain satisfy the point density requirement, and the average density for the entire survey area is 2.23 points per square meter.

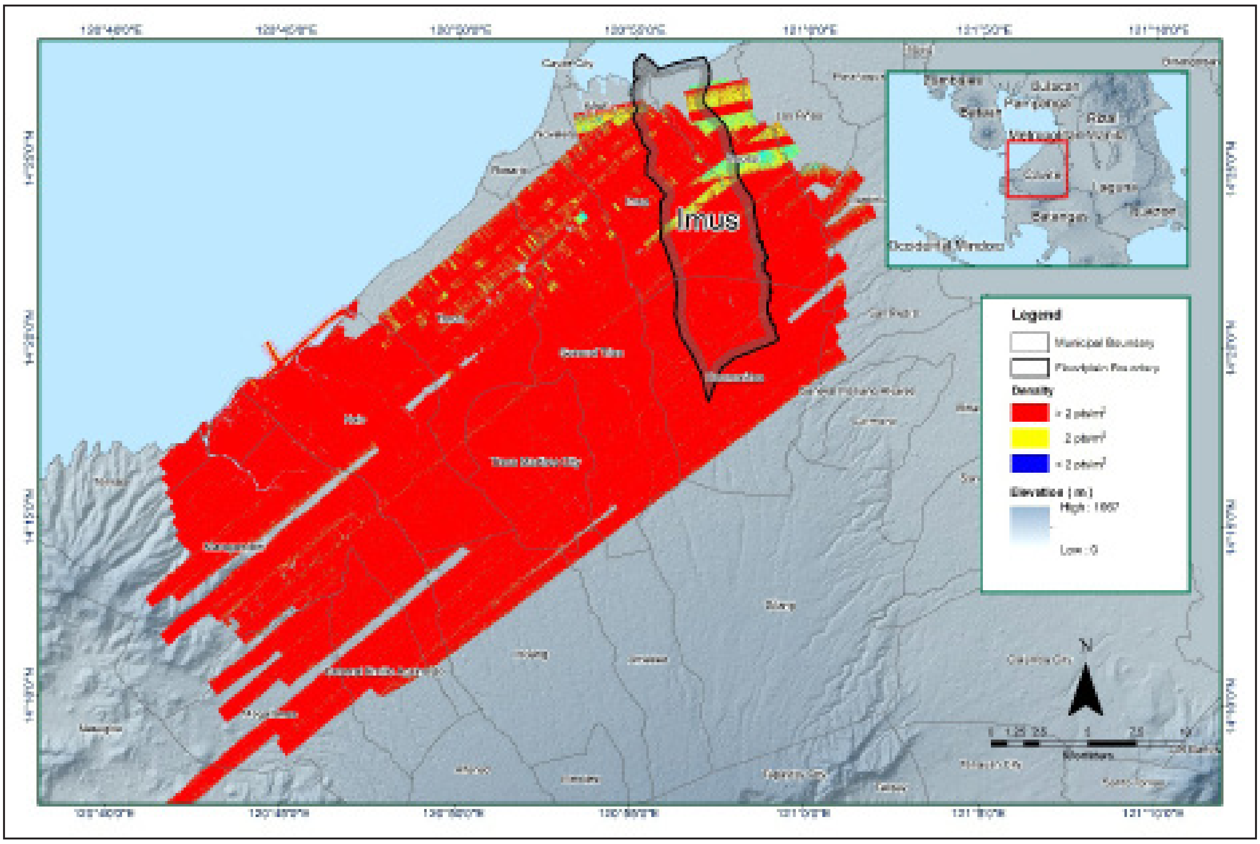


Figure 14. Pulse density map of merged LiDAR data for Imus Floodplain.

The elevation difference between overlaps of adjacent flight lines is shown in Figure 15. 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.

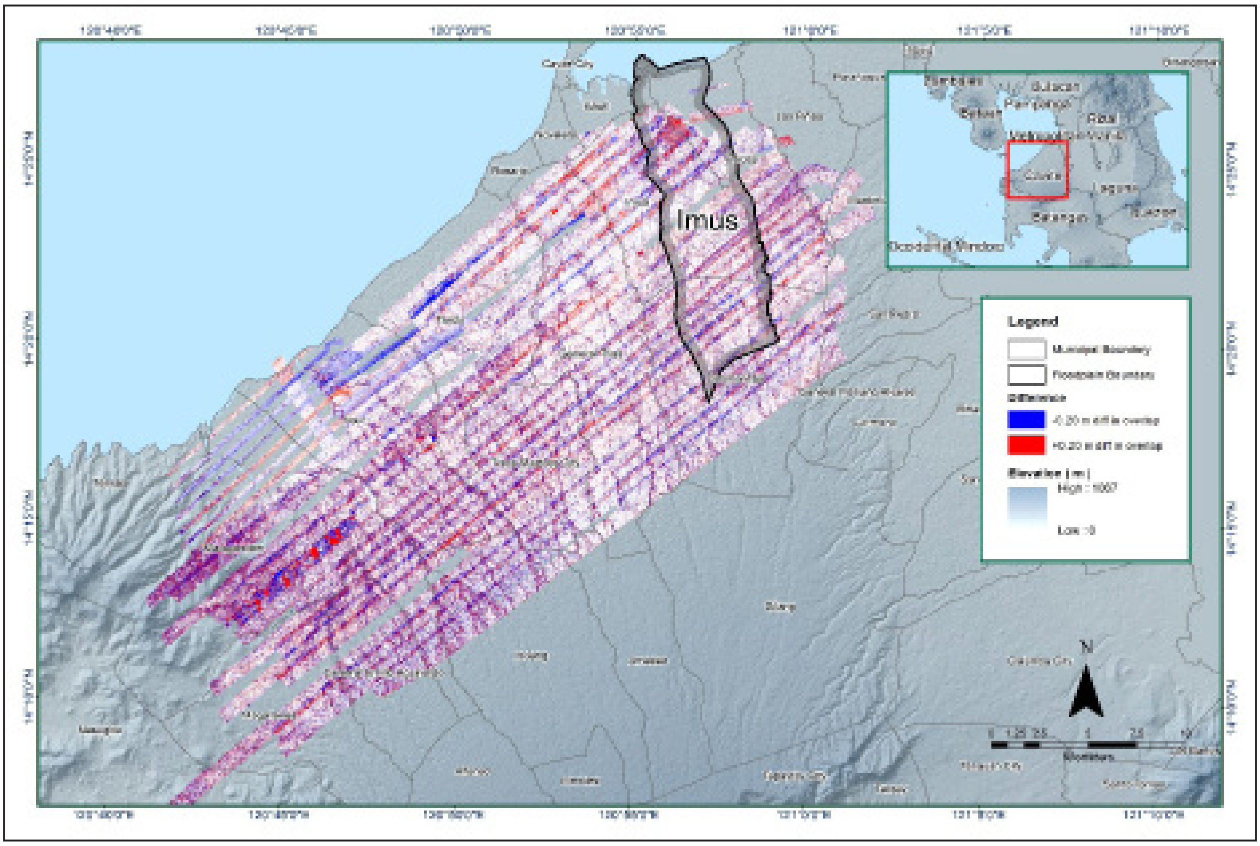


Figure 15. Elevation difference map between flight lines for Imus Floodplain.

A screen capture of the processed LAS data from Imus flight 1027P loaded in QT Modeler is shown in Figure 16. The upper left image shows the elevations of the points from two overlapping flight strips traversed by the profile, illustrated by a dashed yellow line. The x-axis corresponds to the length of the profile. It is evident that there are differences in elevation, but the differences do not exceed the 20-centimeter mark. This profiling was repeated until the quality of the LiDAR data becomes satisfactory. No reprocessing was done for this LiDAR dataset.

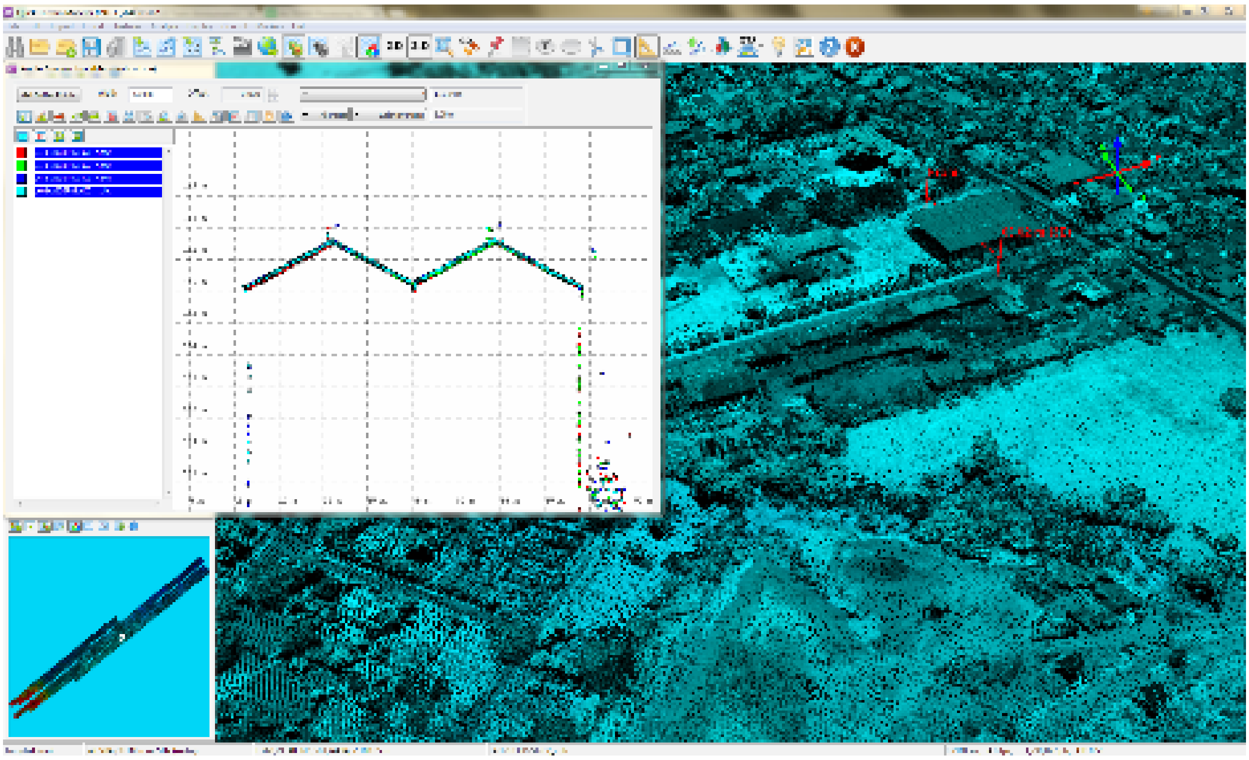


Figure 16. Quality checking for Imus flight 1027P using the Profile Tool of QT Modeler.

3.6 LiDAR Point Cloud Classification and Rasterization

Table 15. Imus classification results in TerraScan.

Pertinent Class	Total Number of Points
Ground	1,042,551,229
Low Vegetation	796,670,929
Medium Vegetation	889,186,193
High Vegetation	731,269,771
Building	254,082,365

The tile system that TerraScan employed for the LiDAR data and the final classification image for a block in Imus floodplain is shown in Figure 17. A total of 1,306 1km by 1km tiles were produced. The number of points classified to the pertinent categories is illustrated in Table 15. The point cloud has a maximum and minimum height of 805.73 meters and 44.59 meters respectively.

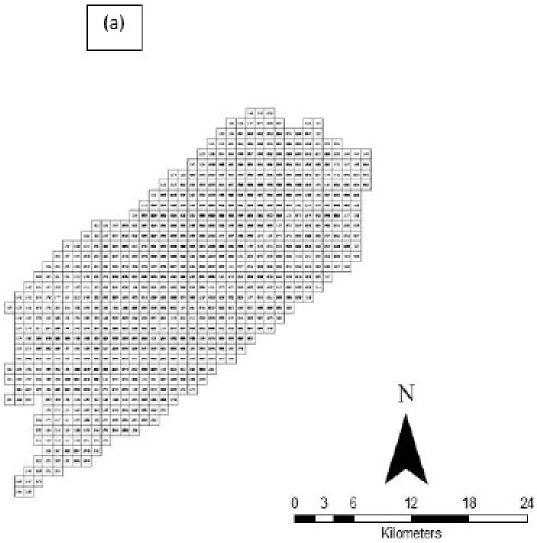


Figure 17. Tiles for Imus Floodplain (a) and classification results (b) in TerraScan.

An isometric view of an area before and after running the classification routines is shown in Figure 18. 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.

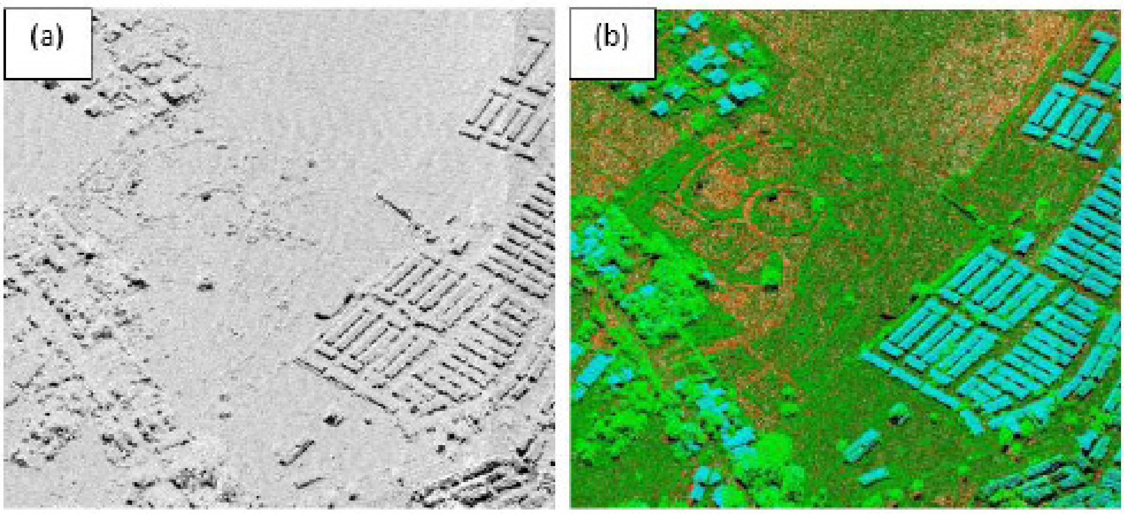


Figure 18. Point cloud before (a) and after (b) classification.

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 19. It shows that DTMs are the representation of the bare earth while on the DSMs, all features are present such as buildings and vegetation.

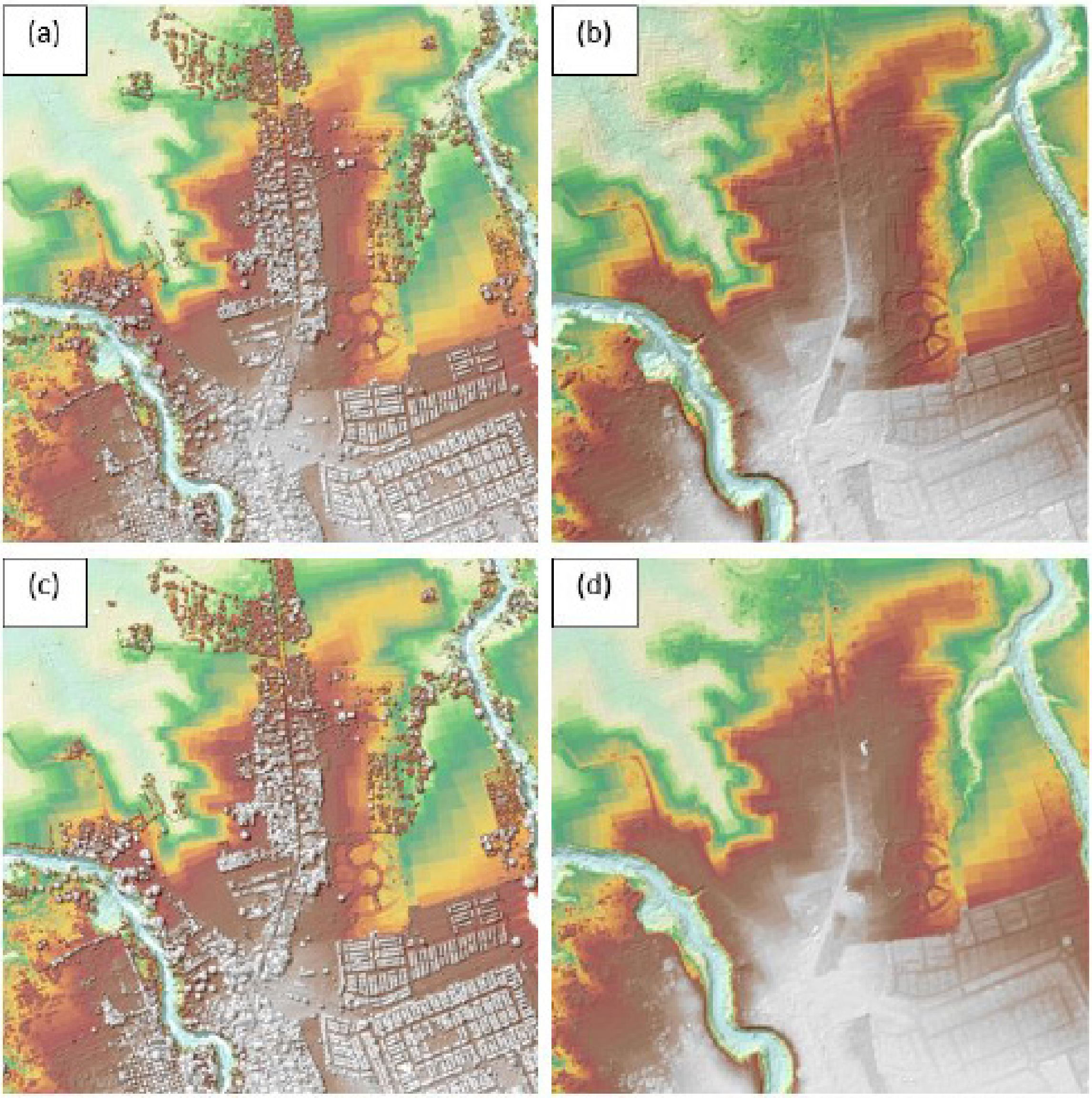


Figure 19. The production of last return DSM (a) and DTM (b), first return DSM (c) and secondary DTM (d) in some portion of Imus Floodplain.

3.7 LiDAR Image Processing and Orthophotograph Rectification

The 276 1km by 1km tiles area covered by Imus floodplain is shown in Figure 20. After tie point selection to fix photo misalignments, color points were added to smoothen out visual inconsistencies along the seamlines where photos overlap. The Imus floodplain has a total of 179.65 sq.km orthophotogaph coverage comprised of 1,203 images. A zoomed in version of sample orthophotographs named in reference to its tile number is shown in Figure 21.

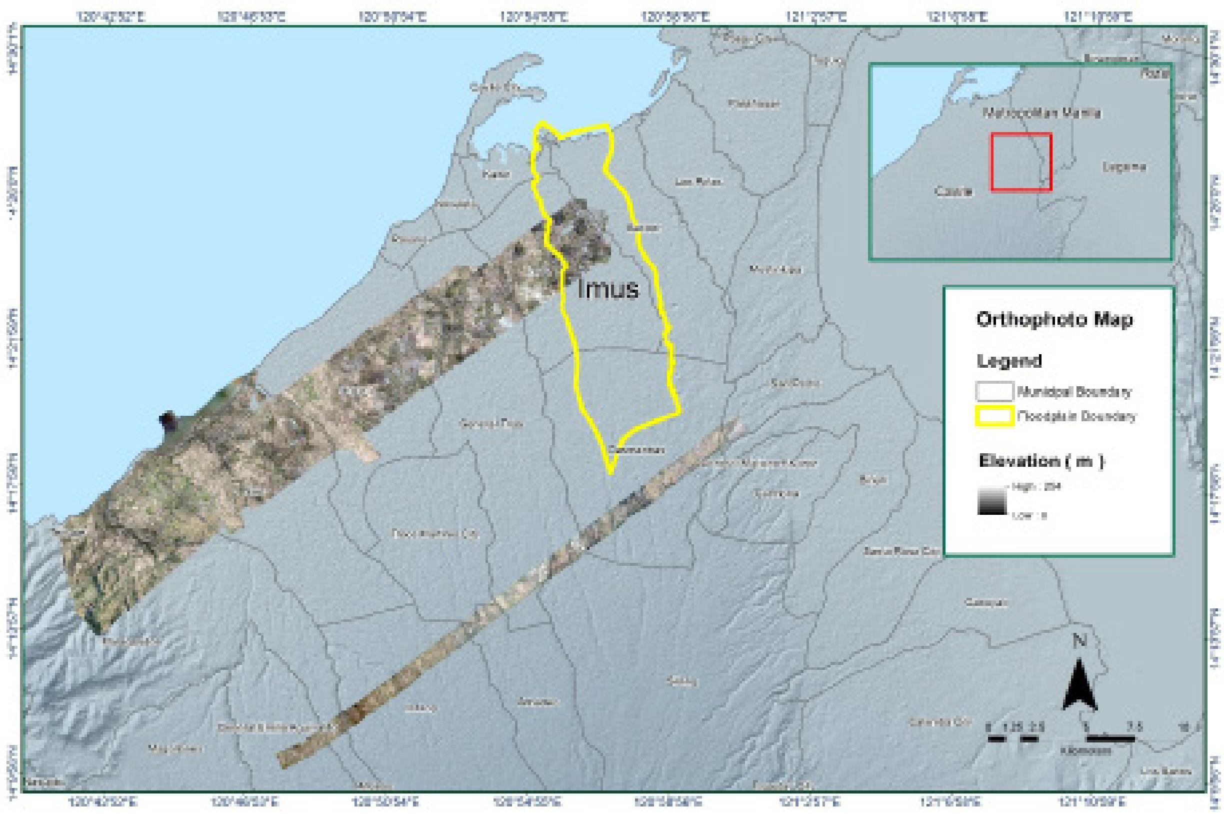


Figure 20. Imus Floodplain with available orthophotographs.

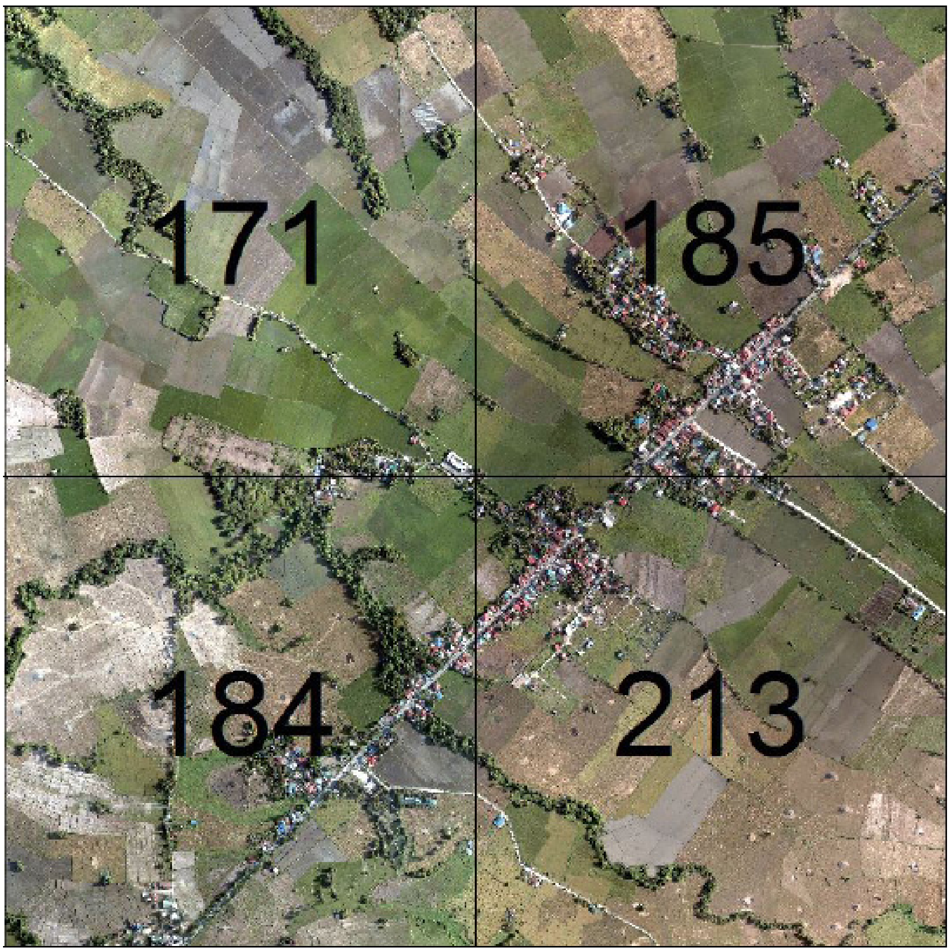


Figure 21. Sample orthophotograph tiles for Imus Floodplain.

3.8 DEM Editing and Hydro-Correction

Ten (10) mission blocks were processed for Imus flood plain. These blocks are composed of CALABARZON, CALABARZON_reflights and Cavite blocks with a total area of 838.05 square kilometers. Table 16 shows the name and corresponding area of each block in square kilometers.

Table 16. LiDAR blocks with its corresponding area.

LiDAR Blocks	Area (sq.km)
CALABARZON_Blk18B_supplement	106.91
CALABARZON_reflights_Blk18A	149.85
CALABARZON_reflights_Blk18B_supplement1	5.66
CALABARZON_reflights_Blk18B_supplement3	9.47
CALABARZON_reflights_Blk18B_supplement4	8.74
CALABARZON_reflights_Blk18B_supplement5	2.01
Cavite_Blk18AB	127.12
Cavite_Blk18C	117.91
Cavite_Blk18C_additional	210.76
Cavite_Blk18A_supplement2	99.62
TOTAL	838.05 sq.km

Portions of DTM before and after manual editing are shown in Figure 22. The bridge (Figure 22a) is also considered to be an impedance to the flow of water along the river and has to be removed (Figure 22b) in order to hydrologically correct the river. The paddy field (Figure 22c) has been misclassified and removed during classification process and has to be retrieved to complete the surface (Figure 22d) to allow the correct flow of water. Another example is a building that is still present in the DTM after classification (Figure 22e) and has to be removed through manual editing (Figure 22f).

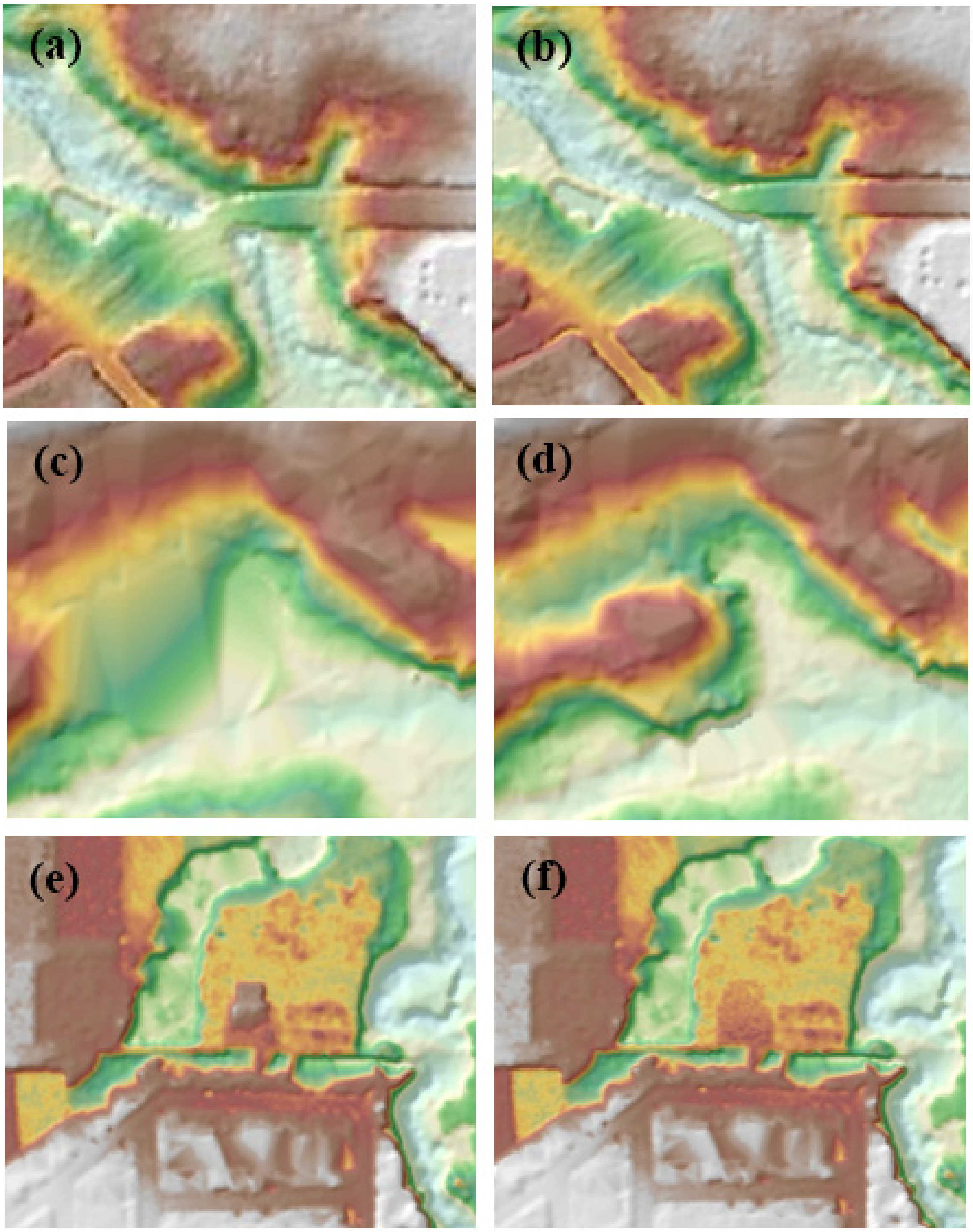


Figure 22. Portions in the DTM of Imus Floodplain – a bridge before (a) and after (b) manual editing; a ridge before (c) and after (d) data retrieval; and a building before (e) and after (f) manual editing.

3.9 Mosaicking of Blocks

No assumed reference block was used in mosaicking because the identified reference for shifting was an existing calibrated Calabarzon DEM overlapping with the blocks to be mosaicked. Table 17 shows the shift values applied to each LiDAR block during mosaicking.

Mosaicked LiDAR DTM for Imus floodplain is shown in Figure 23. It can be seen that the entire Imus floodplain is 100% covered by LiDAR data.

Table 17. Shift Values of each LiDAR Block of Imus Floodplain

Mission Blocks	Shift Values (meters)		
	x	y	z
CALABARZON_Blk18B_supplement	0.00	0.00	0.00
CALABARZON_reflights_Blk18A	-2.81	1.41	0.55
CALABARZON_reflights_Blk18B_supplement1	-1.25	0.55	0.05
CALABARZON_reflights_Blk18B_supplement3	0.00	0.00	0.00
CALABARZON_reflights_Blk18B_supplement4	-1.84	1.76	0.15
CALABARZON_reflights_Blk18B_supplement5	-1.52	-0.01	0.20
Cavite_Blk18AB	-1.80	1.13	-0.50
Cavite_Blk18C	-1.84	-1.54	-0.45
Cavite_Blk18C_additional	-1.81	1.32	-0.50
Cavite_Blk18A_supplement2	-2.31	1.34	0.00

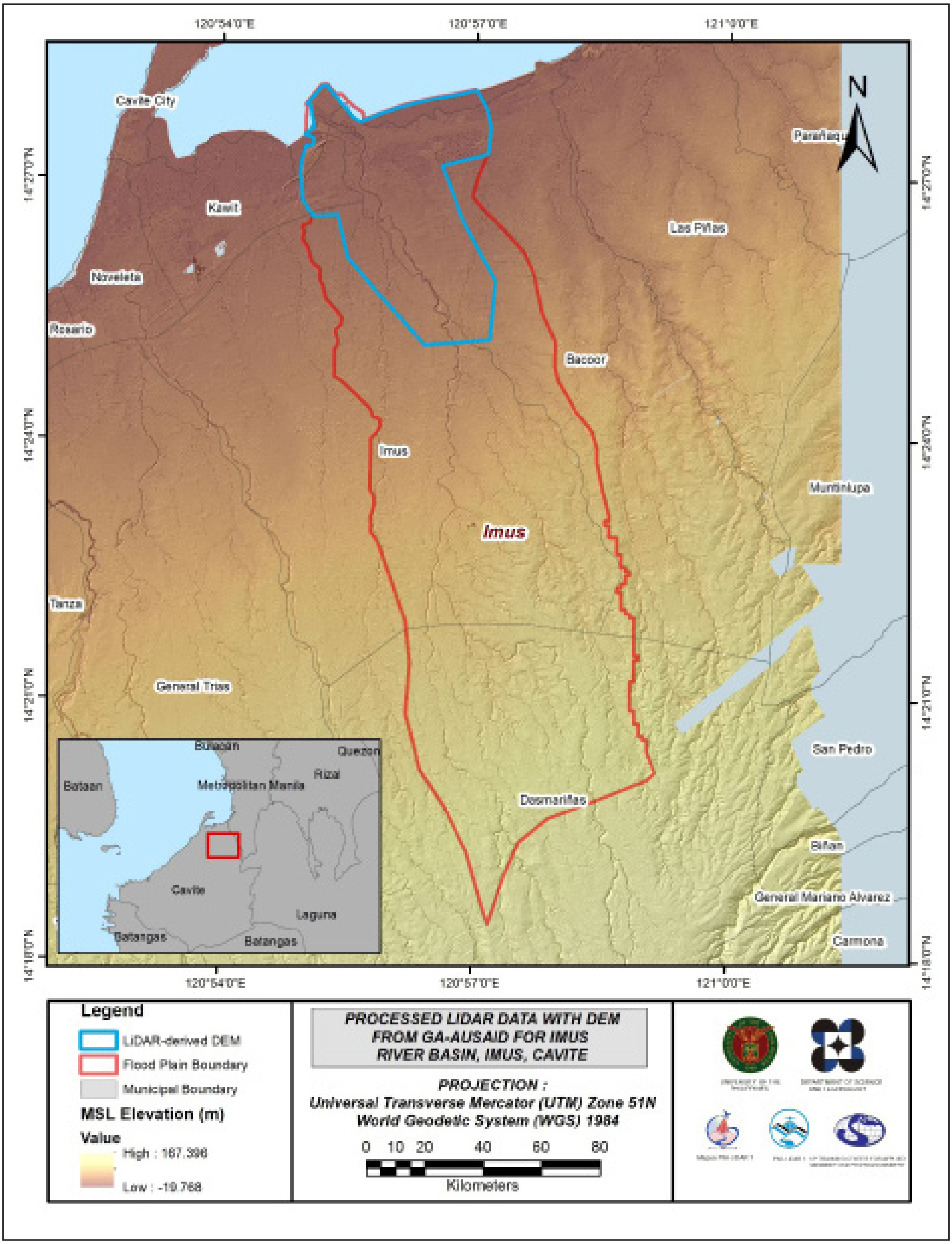


Figure 23. Map of Processed LiDAR Data for Imus Floodplain.

3.10 Calibration and Validation of Mosaicked LiDAR Digital Elevation Model

The extent of the validation survey done by the Data Validation and Bathymetry Component (DVBC) in Imus to collect points with which the LiDAR dataset is validated is shown in Figure 24. A total of 24,251 survey points were gathered for all the flood plains within the provinces of CALABARZON wherein the Imus 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 25. 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 18 shows the statistical values of the compared elevation values between the LiDAR data and calibration data.

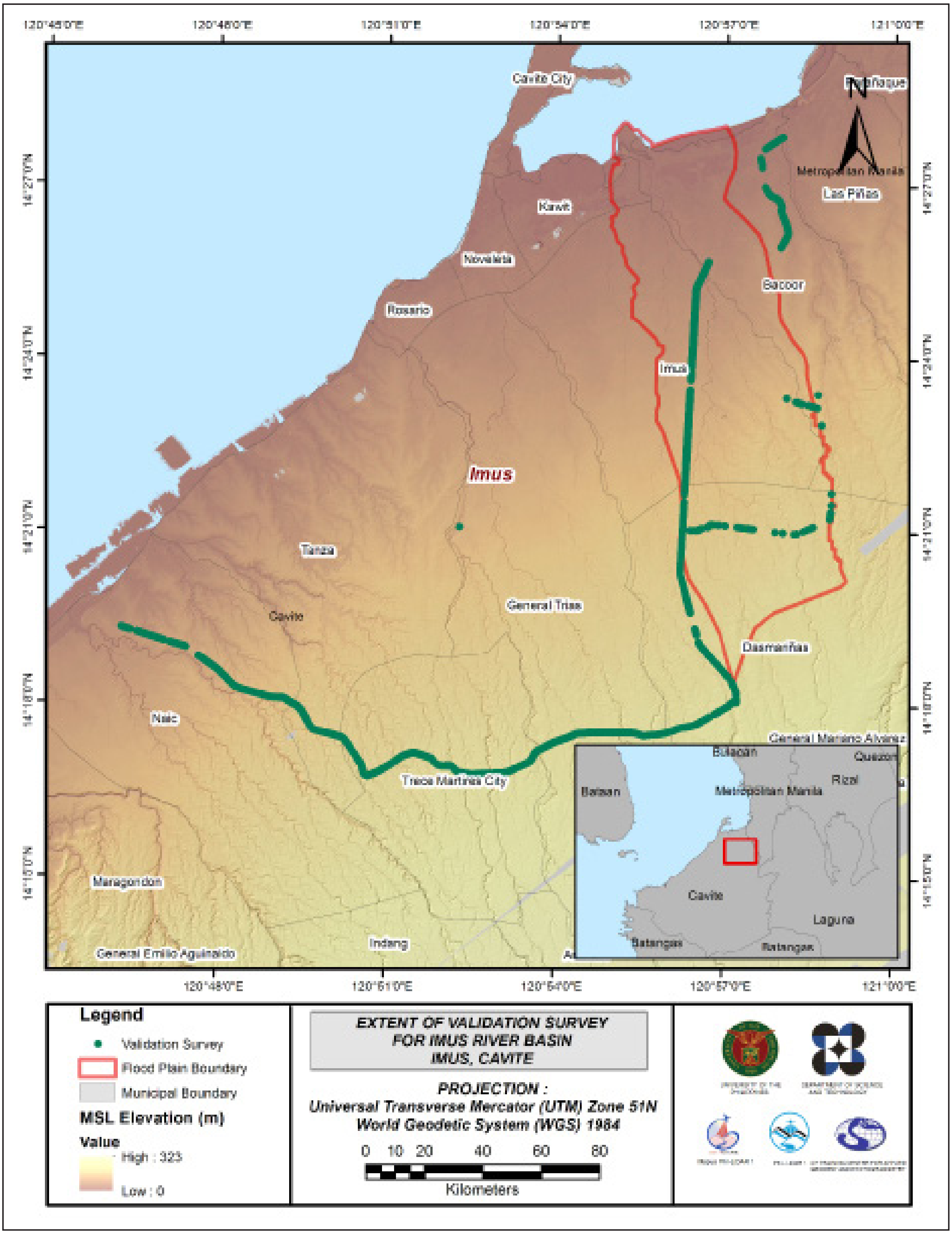


Figure 24. Map of Imus Flood Plain with validation survey points in green.

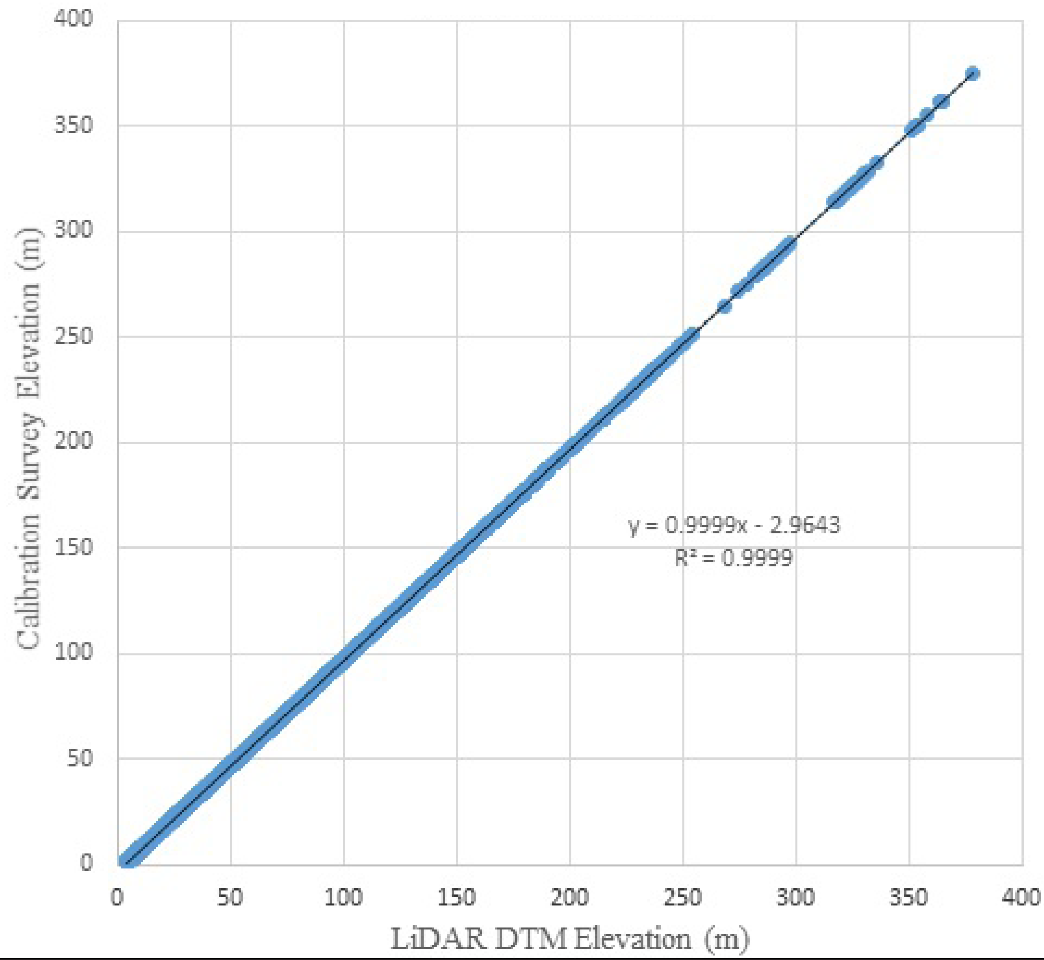


Figure 25. Correlation plot between calibration survey points and LiDAR data.

Table 18. 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 that are near Imus flood plain, resulting to 362 points, were used for the validation of calibrated Imus 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 26. The computed RMSE between the calibrated LiDAR DTM and validation elevation values is 0.20 meters with a standard deviation of 0.15 meters, as shown in Table 19.

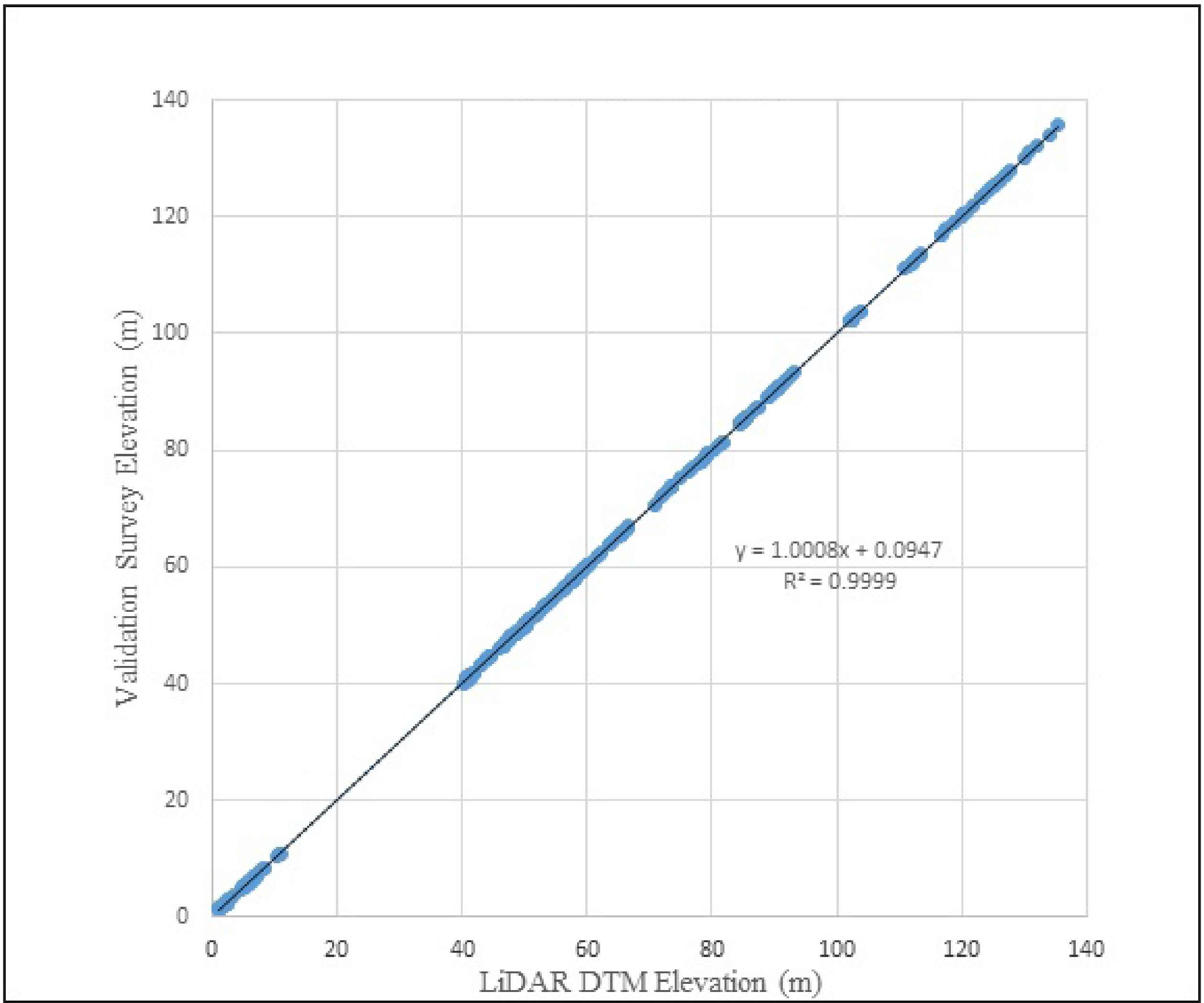


Figure 26. Correlation plot between validation survey points and LiDAR data.

Table 19. Validation Statistical Measures.

Validation Statistical Measures	Value (meters)
RMSE	0.20
Standard Deviation	0.15
Average	0.14
Minimum	-0.44
Maximum	0.31

3.11 Integration of Bathymetric Data into the LiDAR Digital Terrain Model

For bathy integration, the centerline and zigzag data were available for Imus with 9023 bathymetric survey points. The resulting raster surface produced was done by Inverse Distance Weighted (IDW) interpolation and Kernel Interpolation (with Barriers) methods. After burning the bathymetric data to the calibrated DTM, assessment of the interpolated surface is represented by the computed RMSE value of 0.31 meters. The extent of the bathymetric survey done by the Data Validation and Bathymetry Component (DVBC) in Imus integrated with the processed LiDAR DEM is shown in Figure 27.

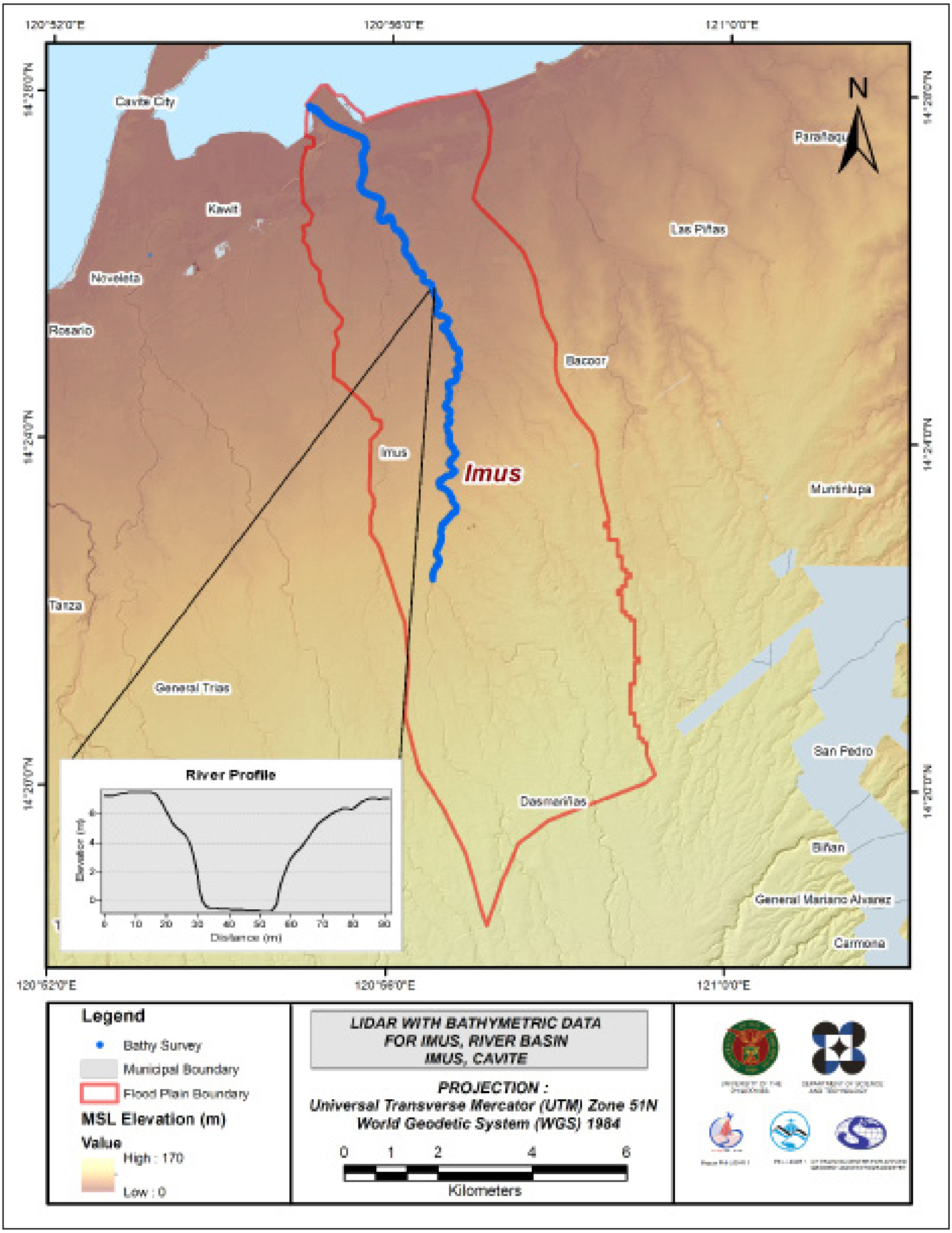


Figure 27. Map of Imus Floodplain with bathymetric survey points shown in blue.

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

Imus floodplain, including its 200 m buffer, has a total area of 79.90 sq km. For this area, a total of 5.0 sq km, corresponding to a total of 4759 building features, are considered for QC. Figure 28 shows the QC blocks for Imus floodplain.

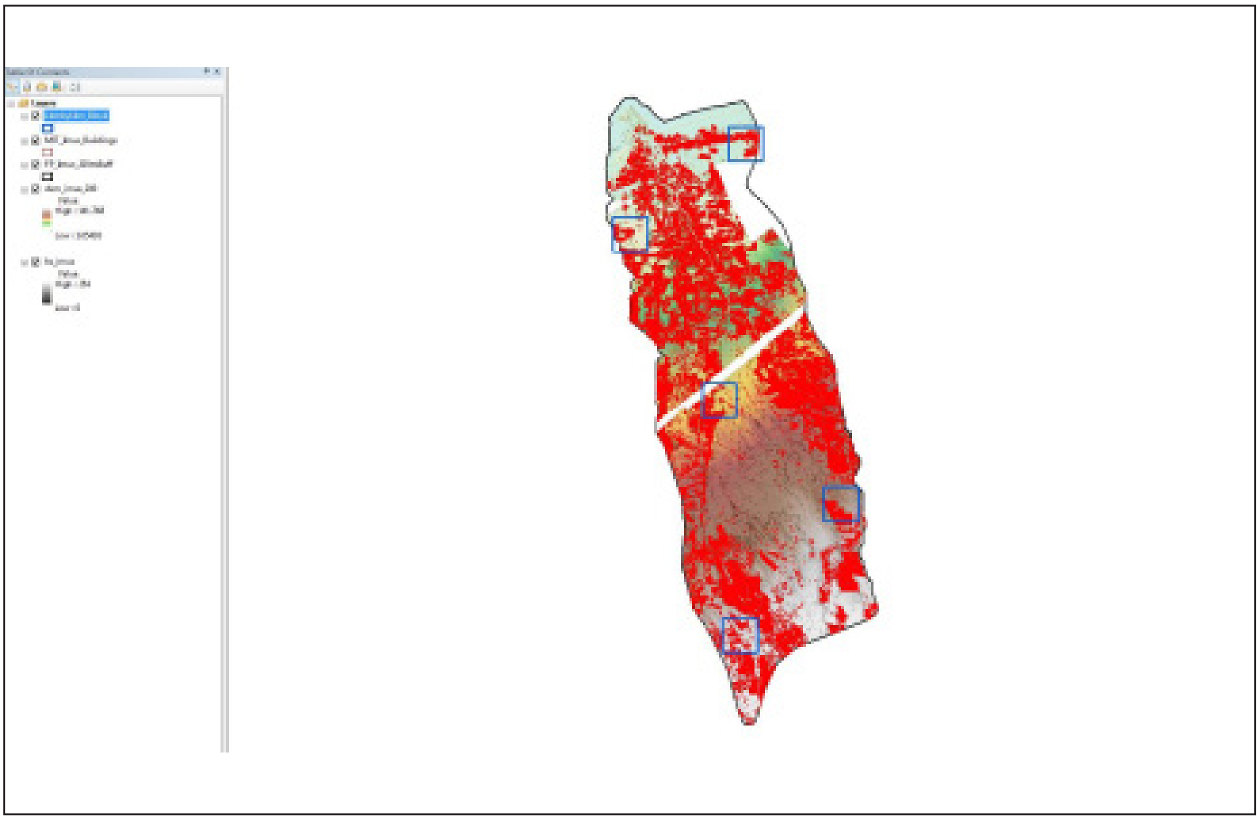


Figure 28. QC blocks for Imus building features.

Quality checking of Imus building features resulted in the ratings shown in Table 20

Table 20. Quality Checking Ratings for Imus Building Features.

FLOODPLAIN	COMPLETENESS	CORRECTNESS	QUALITY	REMARKS
Imus	99.87	98.94	95.40	PASSED

3.12.2 Height Extraction

Height extraction was done for 105,772 building features in Imus floodplain. Of these building features, none was filtered out after height extraction, resulting to 105,722 buildings with height attributes. The lowest building height is at 2.00 m, while the highest building is at 13.31 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 21 summarizes the number of building features per type. On the other hand, Table 22 shows the total length of each road type, while Table 23 shows the number of water features extracted per type.

Table 21. Building Features Extracted for Imus Floodplain.

Facility Type	No. of Features
Residential	103,837
School	612
Market	105
Agricultural/Agro-Industrial Facilities	2
Medical Institutions	64
Barangay Hall	96
Military Institution	0
Sports Center/Gymnasium/Covered Court	58
Telecommunication Facilities	0
Transport Terminal	3
Warehouse	32
Power Plant/Substation	0
NGO/CSO Offices	0
Police Station	3
Water Supply/Sewerage	17
Religious Institutions	100
Bank	6
Factory	236
Gas Station	76
Fire Station	0
Other Government Offices	34
Other Commercial Establishments	441
Total	**105,722**

Table 22. Length of Extracted Roads for Imus Floodplain.

Floodplain	Road Network Length (km)					Total
	Barangay Road	City/Municipal Road	Provincial Road	National Road	Others	
Imus	883.75	62.57	32.13	0	0.00	978.46

Table 23. Number of Extracted Water Bodies for Imus Floodplain.

Floodplain	Water Body Type						Total
	Rivers/Streams	Lakes/Ponds	Sea	Dam	Fish Pen	Others	
Imus	11	140	1	0	0	0	152

A total of 101 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 29 shows the Digital Surface Model (DSM) of Imus floodplain overlaid with its ground features.

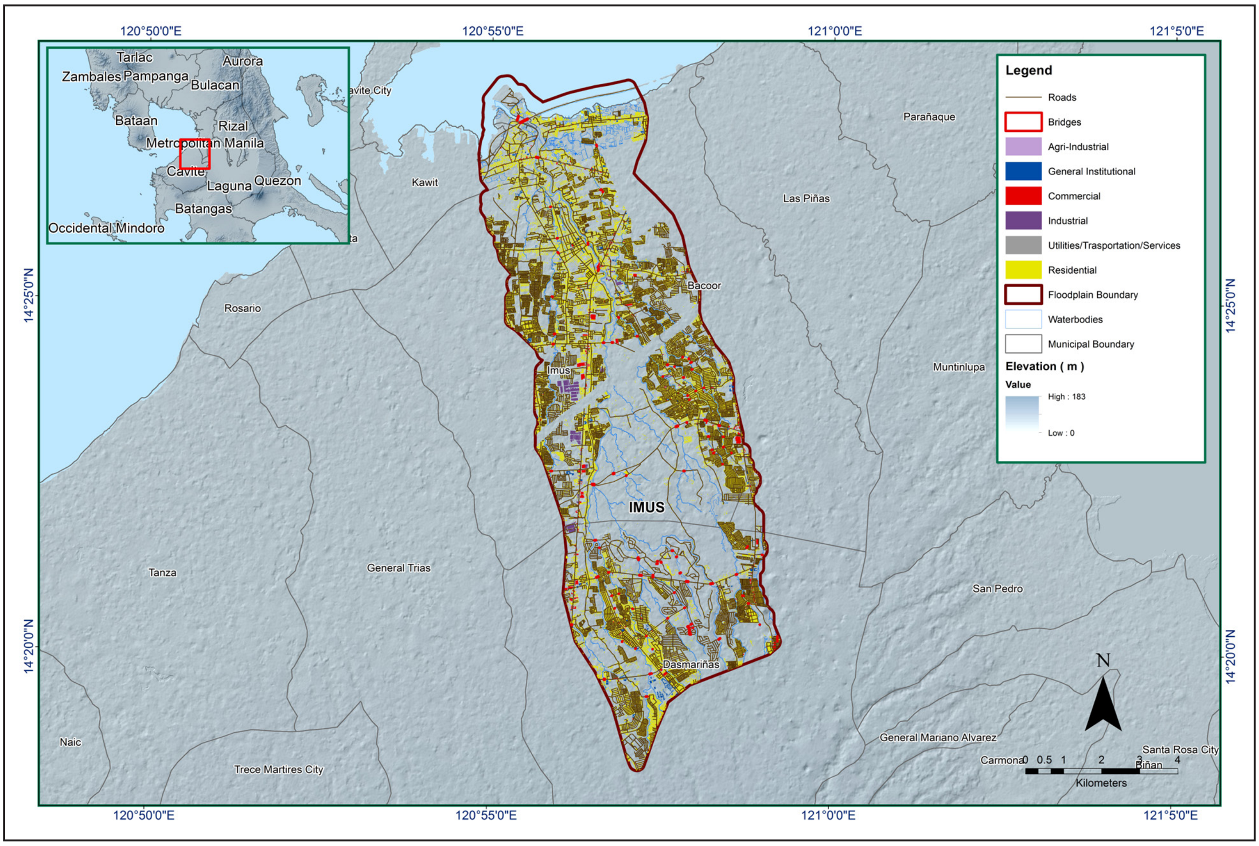


Figure 29. Extracted features for Imus Floodplain.

CHAPTER 4: DATA VALIDATION SURVEY AND MEASUREMENTS IN THE IMUS RIVER BASIN

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

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

4.1 Basin Overview

The Data Validation and Bathymetry Component (DVBC) conducted a field survey in Imus River on September 13 to September 25, 2015 in partnership with the MAPUA Institute of Technology. The survey covered the bathymetric; as-built and cross-section of Daang Hari Bridge in Brgy. Anabu II-A, Imus City; and LiDAR Validation surveys in Imus River. The bathymetric survey was conducted using an OHMEX™ single beam echo sounder to determine the depth of the river while a Trimble® SPS 882 rover GPS gathered the coordinates and elevation values of the survey points. (Figure 30).

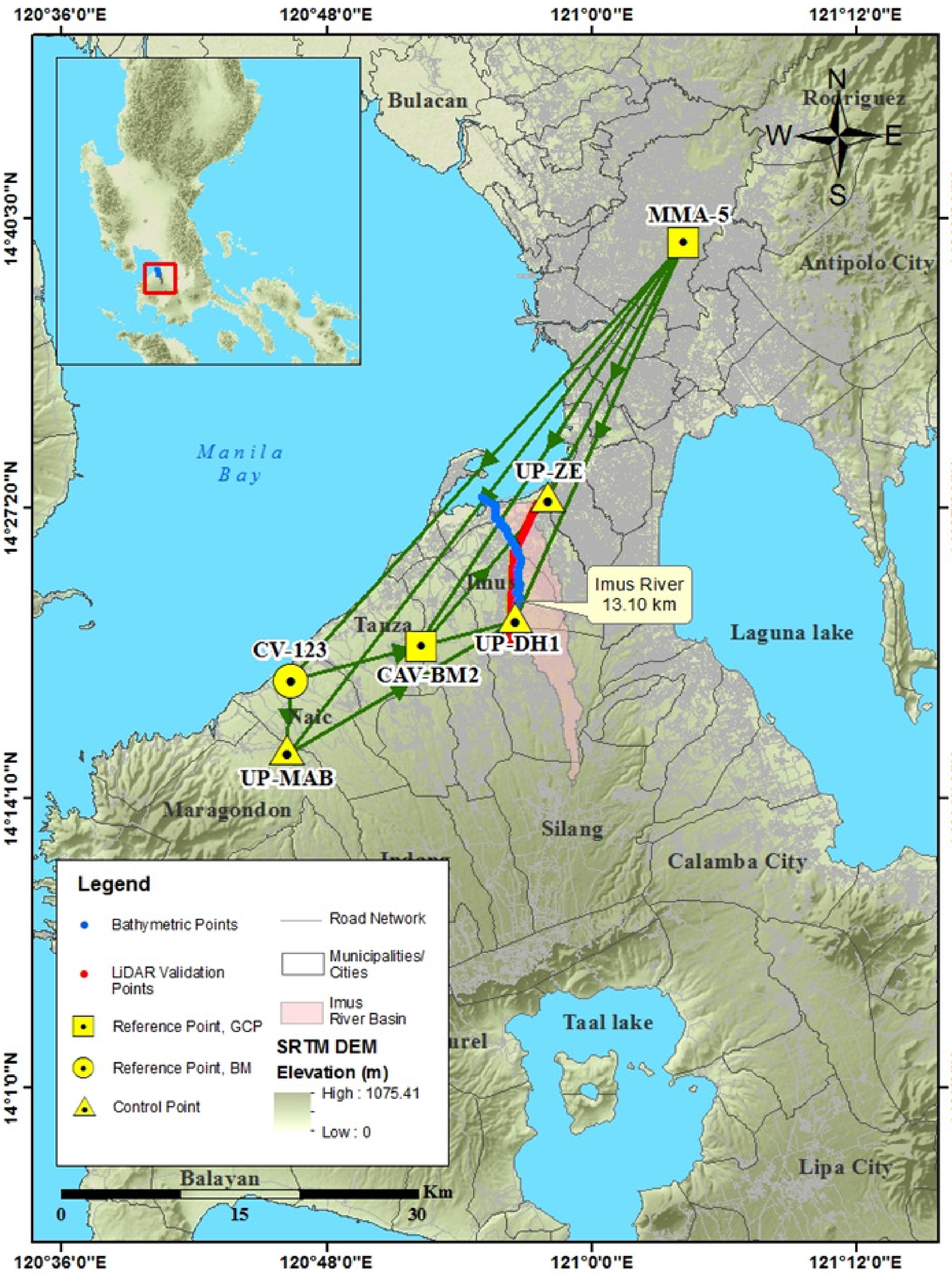


Figure 30. Imus River Survey Extent

4.2 Control Survey

The GNSS network used for Imus River Basin is composed of three (3) loops established on September 15, 2015 occupying the following reference points: MMA-5, a first order GCP in University of the Philippines, Diliman, Quezon City; and CV-123, a first order BM, located in front of Iglesia ni Cristo church, Brgy. Amaya, Municipality of Naic, Cavite.
Four control points were established along the approach of the bridges namely; UP-DH1, at Daang Hari Bridge in Brgy. Anabu II-A, Municipality of Imus, Cavite; UP-MAB, located at Mabacao Bridge, Brgy. Bucal IV B, Municipality of Maragondon, Cavite; UP-ZE at the right side of Zapote bridge, Brgy. Zapote, Basa I, Las Piñas City; and CAV-BM2, at Canas bridge, Brgy. Tapia, Municipality of General Trias, Cavite was also occupied to use as marker during the survey.

The summary of reference and control points and its location is summarized in Table 24 while GNSS network established is illustrated in Figure 31.

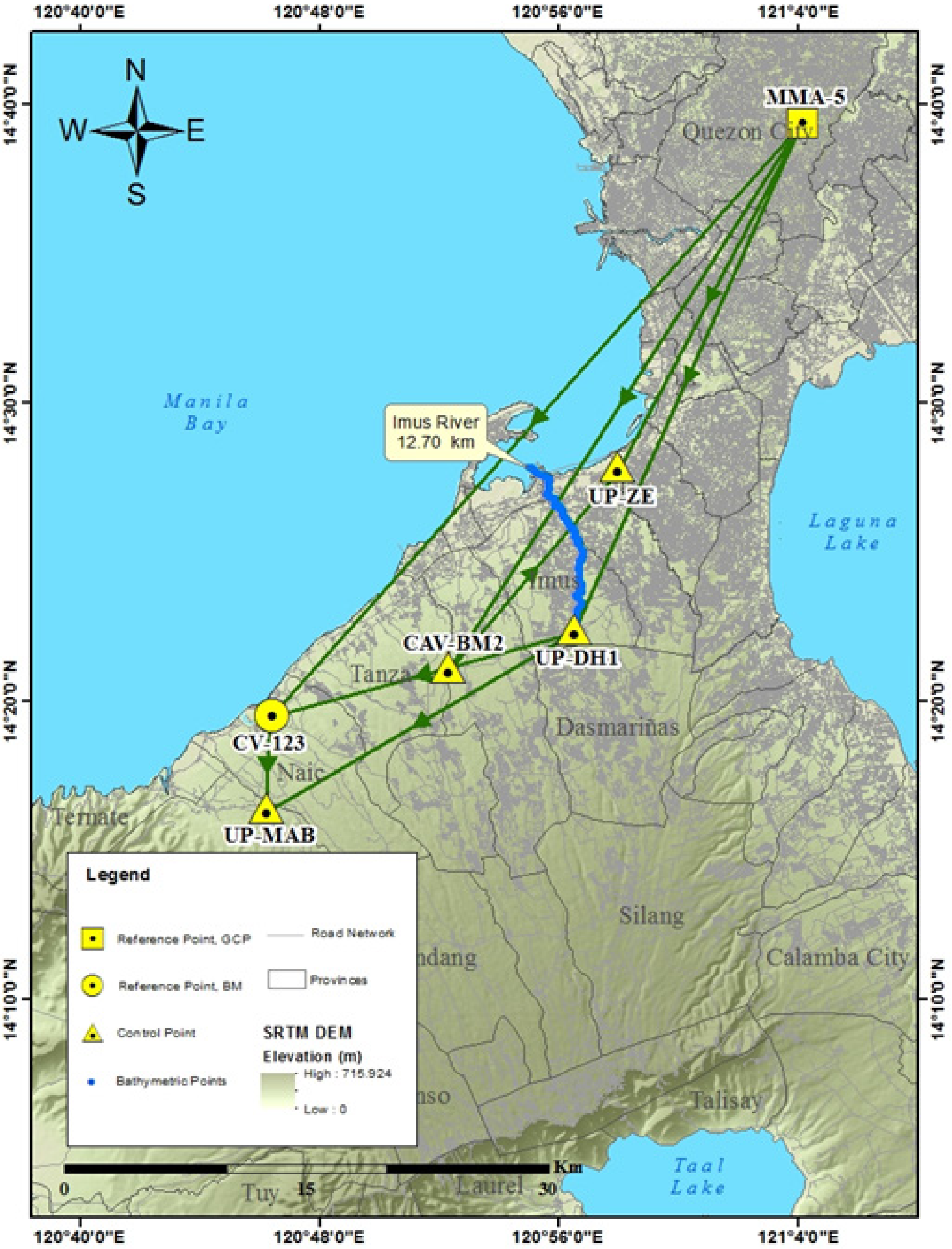


Figure 31. GNSS Network of Imus River field survey

Table 24. List of Reference and Control Points occupied for Imus River Survey (Source: NAMRIA, UP-TCAGP)

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)				
		Latitude	Longitude	Ellipsoidal Height (Meter)	Elevation in MSL (Meter)	Date Established
MMA-5	2nd Order, GCP	14°39'22.97451"	121°04'11.14940"	133.379	-	1956
CV-123	1st Order, BM	-	-	52.071	9.314	2008
CAV-BM2	UP Established	-	-	-	-	Sept. 15, 2015
UP-DH1	UP Established	-	-	-	-	Sept. 15, 2015
UP-MAB	UP Established	-	-	-	-	Sept. 17, 2015
UP-ZE	UP Established	-	-	-	-	Sept. 17, 2015

The GNSS set ups made in the location of the reference and control points are exhibited in Figure 32 to Figure 35.

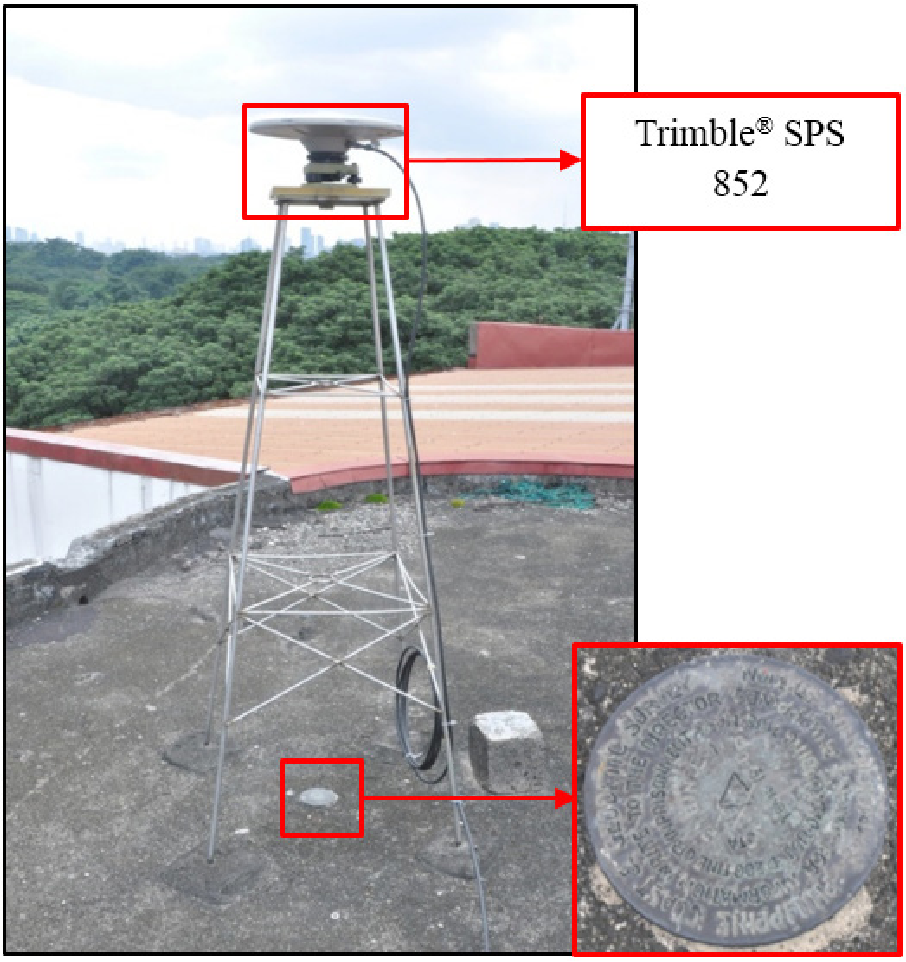


Figure 32. Trimble® SPS 852 setup at MMA-5 located at Melchor Hall, University of the Philippines, Diliman, Quezon City

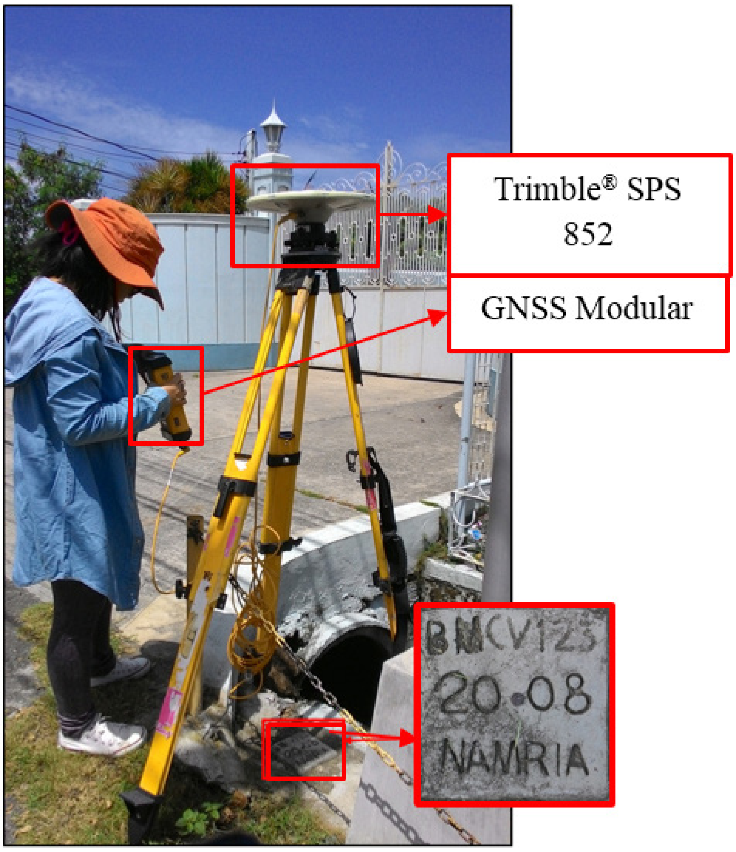


Figure 33. GNSS base setup of Trimble® SPS 852 at CV-123, located in front of the Iglesia ni Cristo chapel, Municipality of Naic, Cavite

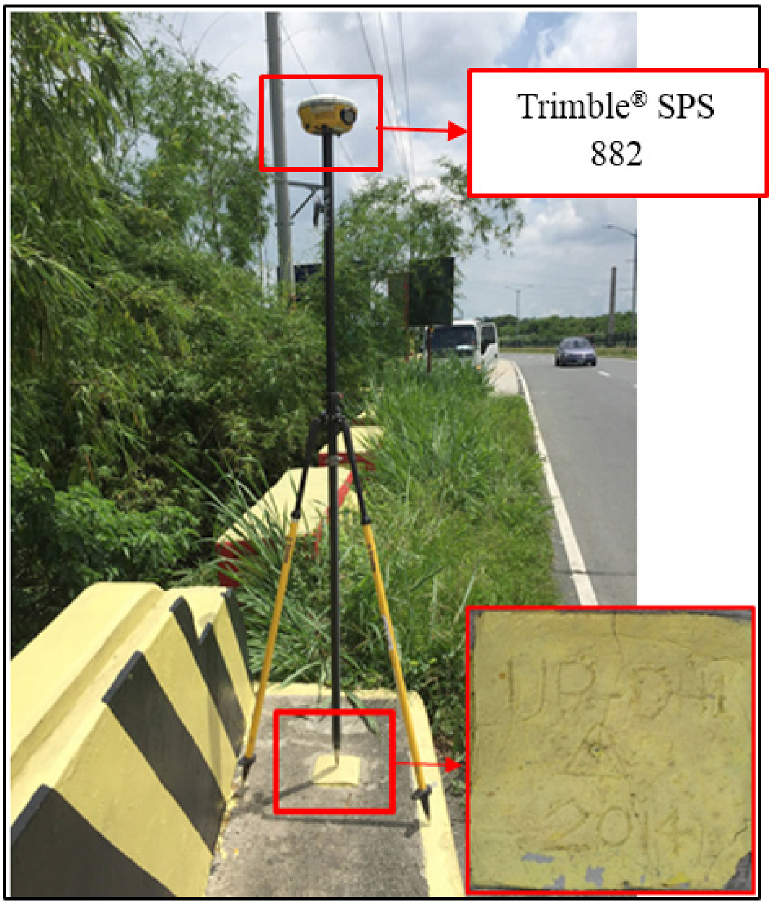


Figure 34. Trimble® SPS 882 setup at UP-DH1 located in Daang Hari Bridge, Brgy. Anabu II-A, Municipality of Imus, Cavite

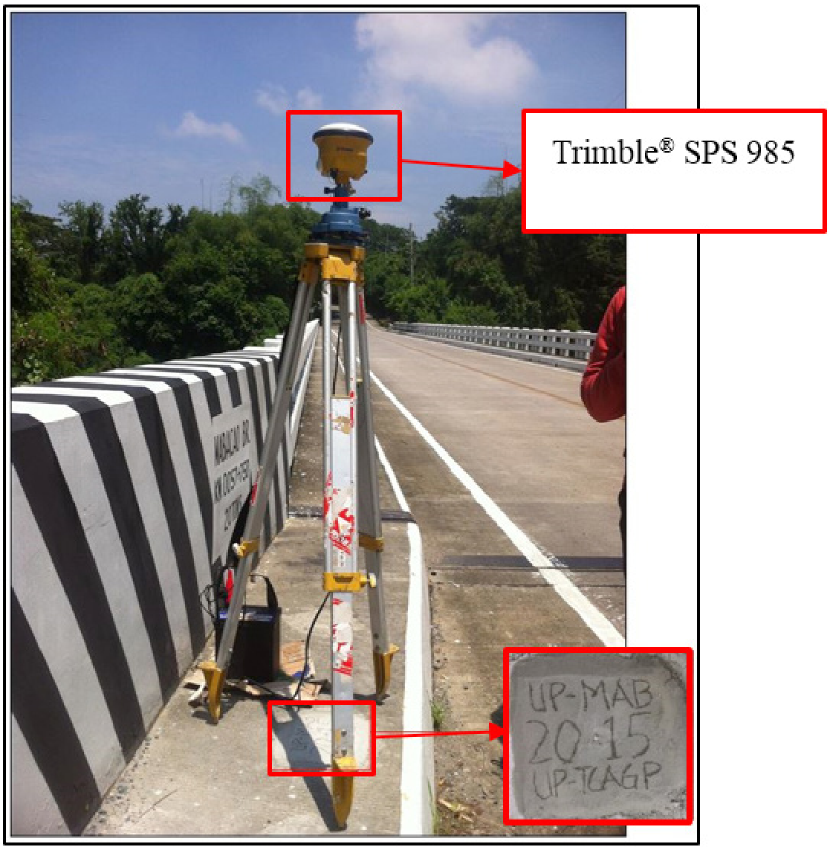


Figure 35. Trimble® SPS 985 setup at UP-MAB located at the approach of Mabacao Bridge, Brgy. Bucal IV B, Municipality of Maragondon, Cavite

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 +/-20cm and +/-10cm 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 Imus River Basin is summarized in Table 25 generated by TBC software.

Table 25. Baseline Processing Summary Report for Imus River Basin Static Survey

Observation	Date of Observation	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	Height (Meter)
CV-123---UP-MAB	09-15-2015	Fixed	0.005	0.022	182°55'06"	5730.614	19.916
CV-123---UP-MAB	09-15-2015	Fixed	0.005	0.012	182°55'05"	5730.599	19.913
UP-DH1---UP-MAB	09-15-2015	Fixed	0.088	0.108	239°06'21"	21662.35	-9.875
UP-DH1---CV-123	09-15-2015	Fixed	0.006	0.034	253°33'16"	19073.15	-29.7
CAV-BM2---UP-ZE	09-17-2015	Fixed	0.005	0.022	39°14'40"	16153.02	-24.213
MMA-5---UP-DH1	09-15-2015	Fixed	0.006	0.014	203°41'56"	34213.76	-51.591
MMA-5---CV-123	09-15-2015	Fixed	0.023	0.021	221°06'52"	48736.51	-81.313
MMA-5---CV-123	09-15-2015	Fixed	0.023	0.025	221°06'52"	48736.48	-81.311
MMA-5---UP-ZE	09-17-2015	Fixed	0.005	0.018	207°38'44"	24003.52	-85.42
MMA-5—CAVBM2	09-17-2015	Fixed	0.004	0.014	212°19'39"	39957.2	-61.233

As shown in Table 25, a total of 10 baselines were processed with reference point MMA-5 held fixed for coordinate values; and CV-123 fixed for elevation values. All of them passed the required accuracy set

4.4 Network Adjustment

After the baseline processing procedure, network adjustment is performed using TBC. Looking at the Adjusted Grid Coordinates (Table 27) 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:

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

Where:

xe is the Easting Error,
yeis the Northing Error, and
zeis the Elevation Error

for each control point. See the Network Adjustment Report shown in Table 26 to Table 28 for the complete details.

The six (6) control points, MMA-5, CV-123, CAV-BM2, UP-DH1, UP-MAB, and UP-ZE were occupied and observed simultaneously to form a GNSS loop. Coordinates of MMA-5 and elevation values of CV-123 were held fixed during the processing of the control points as presented in Table 26. Through these reference points, the coordinates and elevation of the unknown control points will be computed.

Table 26. Control Point Constraints

Point ID	Type	East σ (Meter)	North σ (Meter)	Height σ (Meter)	Elevation σ (Meter)
CV-123	Grid				Fixed
MMA-5	Global	Fixed	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 27. All fixed control points have no values for grid and elevation errors.

Table 27. Adjusted Grid Coordinates

Point ID	Easting	Easting Error (Meter)	Northing (Meter)	Northing Error (Meter)	Elevation (Meter)	Elevation Error (Meter)	Constraint
MMA-5	292122.994	?	1621207.085	?	89.331	0.047	LL
CV-123	259759.978	0.023	1584752.533	0.010	9.314	?	e
CAV-BM2	270467.286	0.011	1587618.081	0.007	29.230	0.068	
UP-DH1	278104.989	0.018	1589990.469	0.007	38.572	0.055	
UP-MAB	259413.172	0.025	1579030.620	0.013	29.050	0.040	
UP-ZE	280803.732	0.012	1600035.582	0.009	4.798	0.076	

With the mentioned equation, $\sqrt{((x_e)^2 + (y_e)^2)}$ <20cm and $z_e < 10\ cm$ for horizontal and for the vertical, respectively; the computation for the accuracy are as follows:

a. MMA-5

horizontal accuracy	=	Fixed
vertical accuracy	=	4.7 cm < 10 cm

b. CV-123

horizontal accuracy	=	$\sqrt{((2.3)^2 + (1.0)^2)}$
	=	2.51 cm < 20 cm
vertical accuracy	=	Fixed

c. CAV-BM2

horizontal accuracy	=	$\sqrt{((1.1)^2 + (0.7)^2)}$
	=	1.30cm < 20 cm
vertical accuracy	=	6.8 cm < 10 cm

d. UP-DH 1

horizontal accuracy	=	$\sqrt{((1.8)^2 + (0.7)^2)}$
	=	$\sqrt{((3.24 + 0.49)}$
	=	1.93 cm < 20 cm
vertical accuracy	=	5.5 cm < 10 cm

e. UP-MAB

horizontal accuracy	=	$\sqrt{((2.5)^2 + (1.3)^2)}$
	=	2.82 cm < 20 cm
vertical accuracy	=	4.0 cm < 10 cm

f. UP-ZE

horizontal accuracy	=	$\sqrt{((1.2)^2 + (0.9)^2)}$
	=	$\sqrt{(1.44 + 0.81)}$
	=	1.5 cm < 20 cm
vertical accuracy	=	7.6 cm < 10 cm

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

Table 28. Adjusted Geodetic Coordinates

Point ID	Latitude	Longitude	Height (Meter)	Height Error (Meter)	Constraint
MMA-5	N14°39'22.97451"	E121°04'11.14940"	133.379	0.047	LL
CV-123	N14°19'27.61225"	E120°46'21.72442"	52.071	?	e
CAV-BM2	N14°21'04.09862"	E120°52'18.03337"	72.153	0.068	
UP-DH1	N14°22'23.52073"	E120°56'32.16087"	81.814	0.055	
UP-MAB	N14°16'21.39512"	E120°46'11.99131"	71.979	0.040	
UP-ZE	N14°27'51.06089"	E120°57'59.25259"	47.954	0.076	

The corresponding geodetic coordinates of the observed points are within the required accuracy as shown in Table 28. 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 29.

Table 29. Reference and control points used and its location (Source: NAMRIA, UP-TCAGP)

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)			UTM ZONE 51 N		
		Latitude	Longitude	Ellipsoidal Height (m)	Northing	Easting	BM Ortho
MMA-5	2nd Order, GCP	14°39'22.97451"	121°04'11.14940"	133.379	1621207.085	292122.994	89.331
CV-123	1st Order, BM	14°19'27.61225"	120°46'21.72442"	52.071	1584752.533	259759.978	9.314
CAV-BM2	UP Established	14°21'04.09862"	120°52'18.03337"	72.153	1587618.081	270467.286	29.230
UP-DH1	UP Established	14°22'23.52073"	120°56'32.16087"	81.814	1589990.469	278104.989	38.572
UP-MAB	UP Established	14°16'21.39512"	120°46'11.99131"	71.979	1579030.620	259413.172	29.050
UP-ZE	UP Established	14°27'51.06089"	120°57'59.25259"	47.954	1600035.582	280803.732	4.798

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

Cross-section and as-built survey were conducted on September 16, 2015 at the upstream side of Daang Hari Bridge in Brgy. Anabu II-A, Imus City as shown in Figure 36. A Trimble® SPS 882 in PPK survey technique at the upstream side of the bridge as shown in Figure 37.

Figure 36. Imus Bridge facing upstream

Figure 37. Bridge As-Built Survey using PPK Technique.

The cross-sectional line of Daang Hari Bridge is about 103.3 meters with eighteen (18) cross-sectional points using the control point UP-DH1 as the GNSS base station. The location map, cross-section diagram, and the bridge data form are illustrated in Figure 38 to Figure 40.

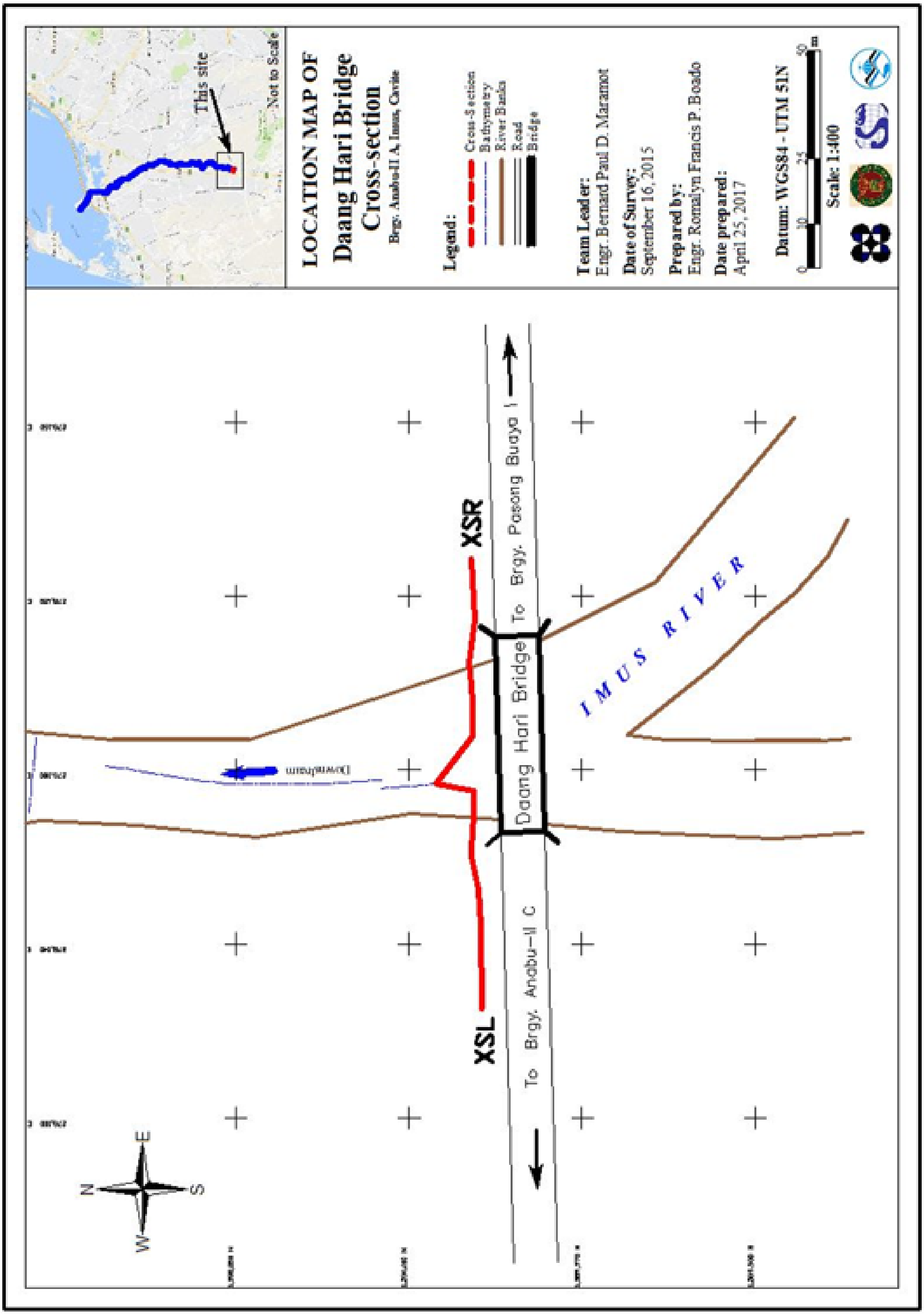


Figure 38. Location map of Daang Hari Bridge cross-section

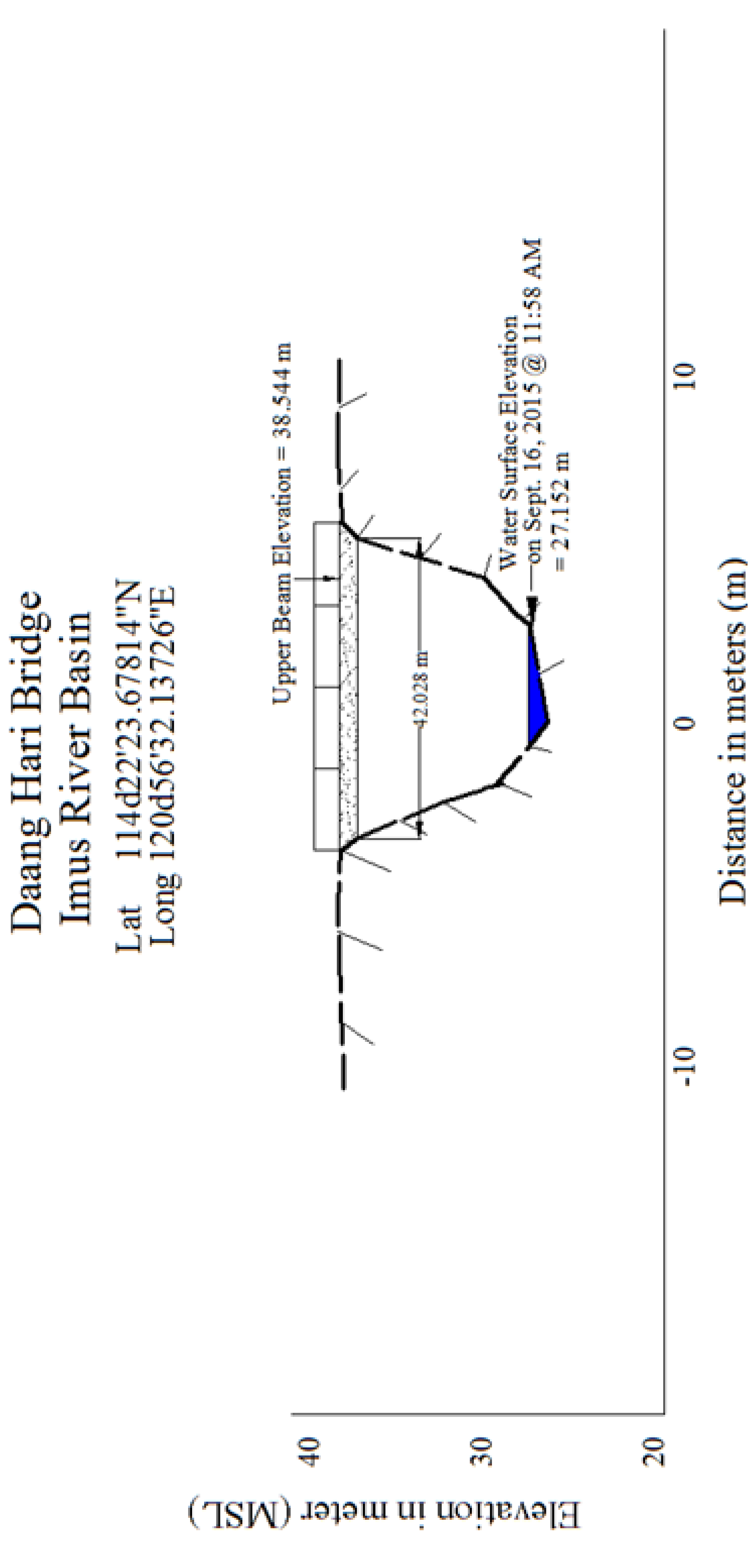
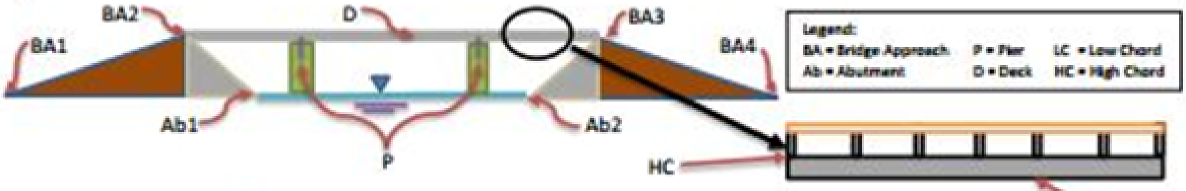


Figure 39. Daang Hari Bridge cross-section diagram

Bridge Data Form

Bridge Name: Daang Hari Bridge	**Date:** September 16, 2015
River Name: Imus River	**Time:** 11:09 A.M.
Location (Brgy, City, Region): Brgy Anabu-II A, Imus, Cavite	
Survey Team: Team Bernard	
Flow condition: low (normal) high	**Weather Condition:** (fair) rainy
Latitude: 14d22'23.67814"	**Longitude:** 120d56'32.13726"



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

Elevation: 38.544 **Width:** 7.84 **Span (BA3-BA2):** 44.906

	Station	High Chord Elevation	Low Chord Elevation
1		38.45	38.26
2			
3			
4			
5			

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

	Station(Distance from BA1)	Elevation		Station(Distance from BA1)	Elevation
BA1	0	37.865	BA3	79.770	38.519
BA2	34.864	38.45	BA4	103.3344	38.147

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

	Station (Distance from BA1)	Elevation
Ab1	35.1877	38.045
Ab2	77.130	37.074

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

Shape: ______ **Number of Piers:** 0 **Height of column footing:** ______

	Station (Distance from BA1)	Elevation	Pier Width
Pier 1			
Pier 2			
Pier 3			
Pier 4			
Pier 5			
Pier 6			

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

Figure 40. Bridge as-built form of Daang Hari Bridge

Water surface elevation of Imus River was determined using Trimble® SPS 882 in PPK mode technique on September 16, 2015 at 11:58 PM with a value of 27.152 m in MSL as shown in Figure 39. The water surface elevation was translated onto marking the bridge's pier using a digital level, illustrated in Figure 41. The marked pier shall serve as reference for flow data gathering and depth gauge deployment by the accompanying HEI, Mapua Institute, who is responsible for Imus River.

Figure 41. Water level markings on the side of the pier in Daang Hari Bridge

4.6 Validation Points Acquisition Survey

Validation points acquisition survey was conducted on September 20, 2015 using a survey-grade GNSS Rover receiver, Trimble® SPS 882, mounted on a pole which was attached in front of the vehicle as shown in Figure 42. It was secured with a cable tie to ensure that it is horizontally and vertically balanced. The antenna height of 2.36 meters was measured from the ground up to the bottom of notch of the GNSS Rover receiver.

Figure 42. Validation points acquisition survey set up for Imus River Basin

The conducted survey on September 20, 2015 started from Brgy. Zapote IV, Bacoor City, Cavite going south to Brgy. Salitran IV, Dasmariñas, Cavite. A total of 2,440 ground validation points were acquired with an approximate length of 14.86 km using UP-DH 1 as the GNSS base station, as shown in the map in Figure 43.

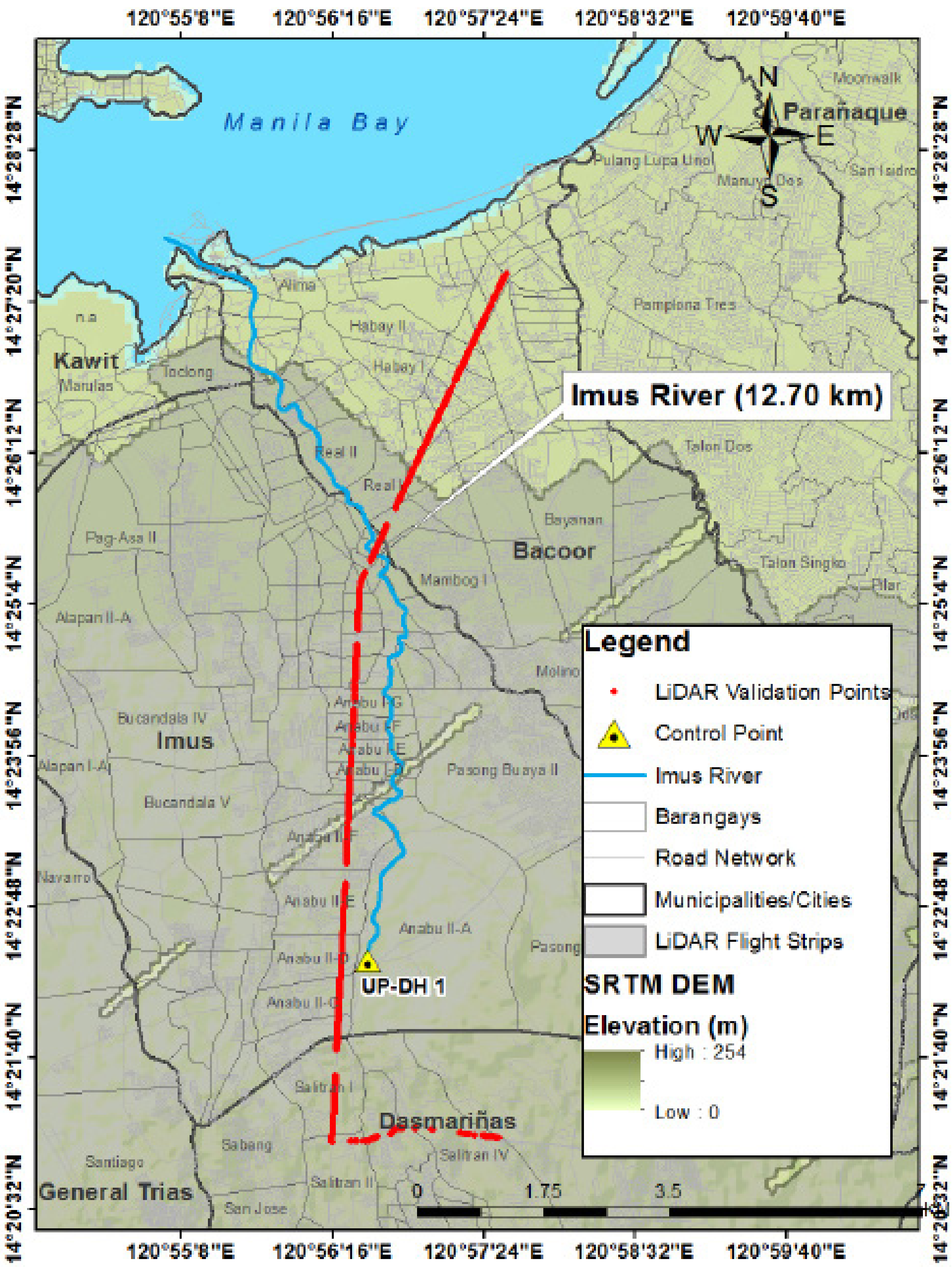


Figure 43. LiDAR validation points acquisition survey for Imus River Basin

4.7 Bathymetric Survey

Bathymetric survey was executed on September 16, 2015 using Trimble® SPS 882 in GNSS PPK survey technique in continuous topo mode as illustrated in Figure 44. The survey started in Brgy. Palico III, Imus City, Cavite, with coordinates 14°25'31.85031"N, 120°56'32.45009"E; and, ended at the mouth of the river in Brgy. Sineguelasan, Bacoor City, Cavite with coordinates 14°27'50.13509"N, 120°55'01.26006"E.

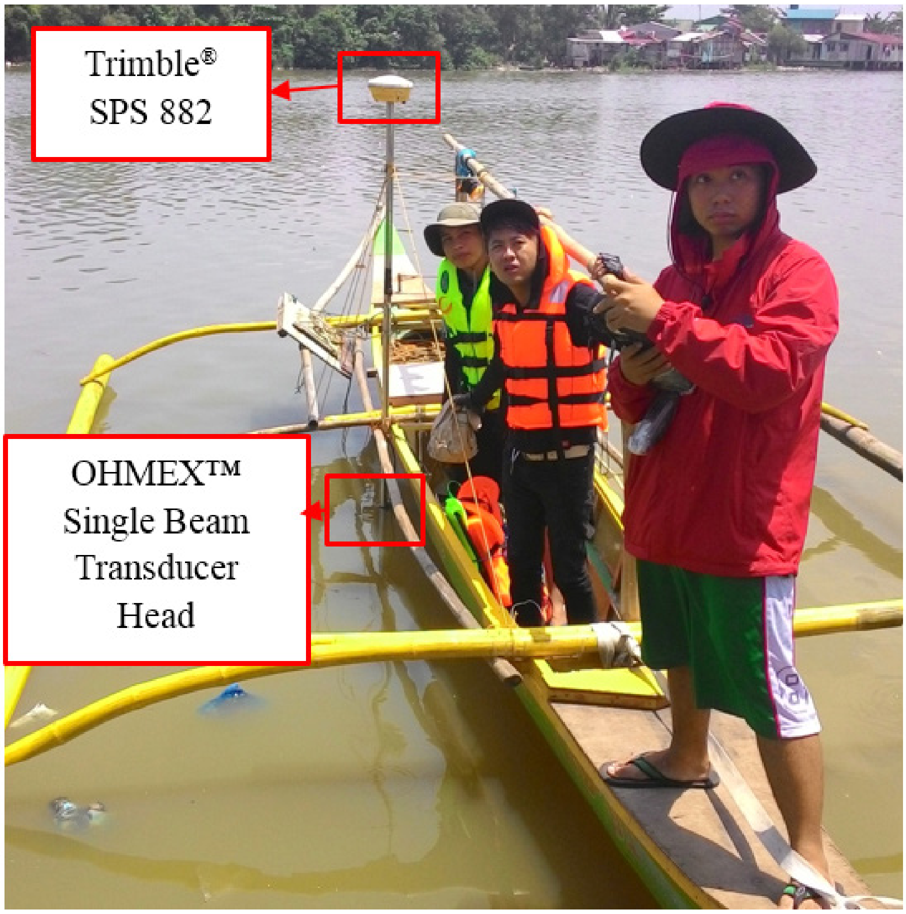


Figure 44. Bathymetric survey in Imus River

Manual Bathymetric survey on the other hand was also executed on September 20, 21, and 22, 2015 using Trimble® SPS 882 in GNSS PPK survey technique in continuous topo mode as illustrated in Figure 45. The survey started in the upstream in Brgy. Anabu II-A, Imus City, Cavite with coordinates 14°22'23.94297"N, 120°56'31.21804"E traversing down the river by foot and ended at the starting point of bathymetric survey using boat in Brgy. Palico II. The control point UP-DH1 was used as GNSS base station all throughout the entire survey.

Figure 45. Manual Bathymetric Survey in Imus River in Brgy. Anabu, Imus

The bathymetric survey for Imus River gathered a total of 8,873 points covering 12.70 km of the river traversing Barangay Anabu II-1, Imus City down to the mouth of the river in Brgy. Sineguelasan, Bacoor City, also in Cavite, as shown in Figure 46.

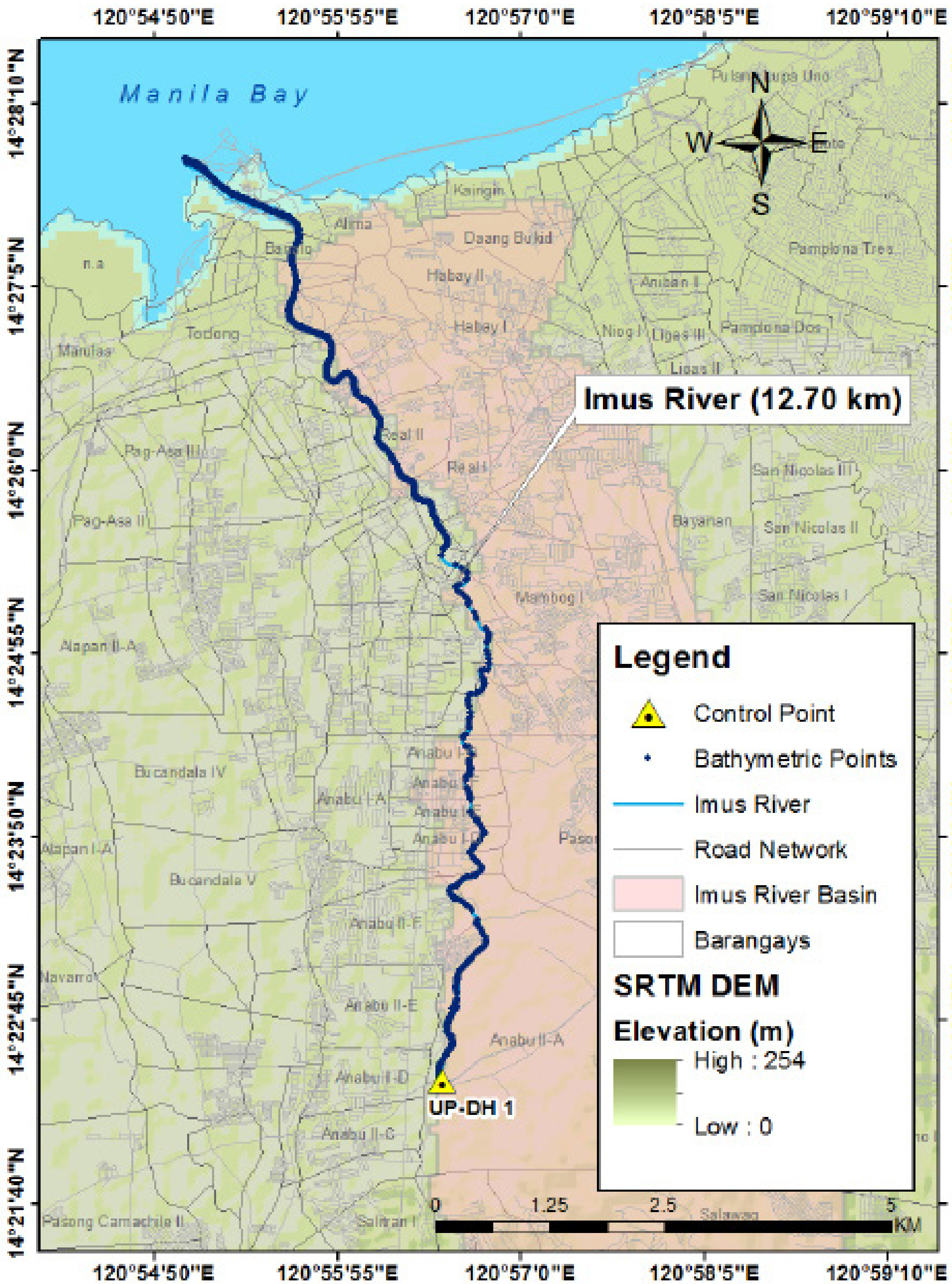


Figure 46. Bathymetric points gathered from Imus River

A CAD drawing was also produced to illustrate the riverbed profile of Macalelon River. As shown in Figure 51, the highest and lowest elevation has a 6.722-m difference for Macalelon River. The highest elevation observed was –1.5 m below MSL located at the middle part of Macalelon river; while the lowest was –8.22 m below MSL located in the downstream portion of the river.

A CAD drawing was also produced to illustrate the riverbed profile of Imus River. As shown in Figure 47, the highest and lowest elevation has a 30.733-m in MSL difference. The highest elevation observed was 35.696 m above MSL located upstream; while the lowest was -4.963 m below MSL located in the downstream part.

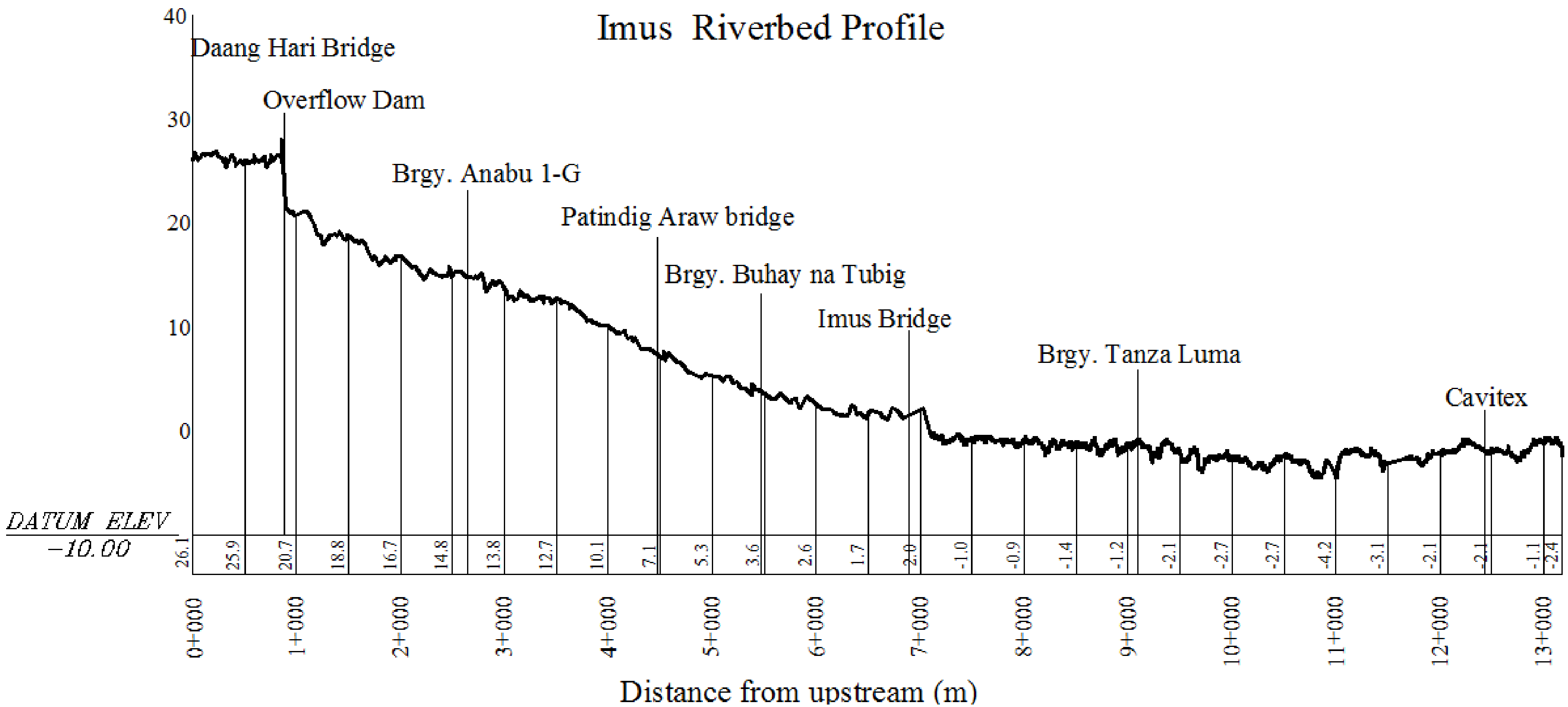


Figure 47. Imus riverbed profile

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, Pauline Racoma

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

5.1 Data used in Hydrologic Modeling

5.1.1 Hydrometry and Rating Curves

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

5.1.2 Precipitation

Precipitation data was taken from one automatic rain gauge (ARG) installed by the Department of Science and Technology – Advanced Science and Technology Institute (DOST-ASTI). The location of the ARG used in the model is located at Dasmarinas, Cavite. The location of the rain gauge is shown in Figure 48.

The total rain from Dasmarinas rain gauge is 9.2 mm. It peaked to 2.4 mm on September 14, 2016, 15:45. The lag time between the peak rainfall and discharge is 5 hours, as shown in Figure 51.

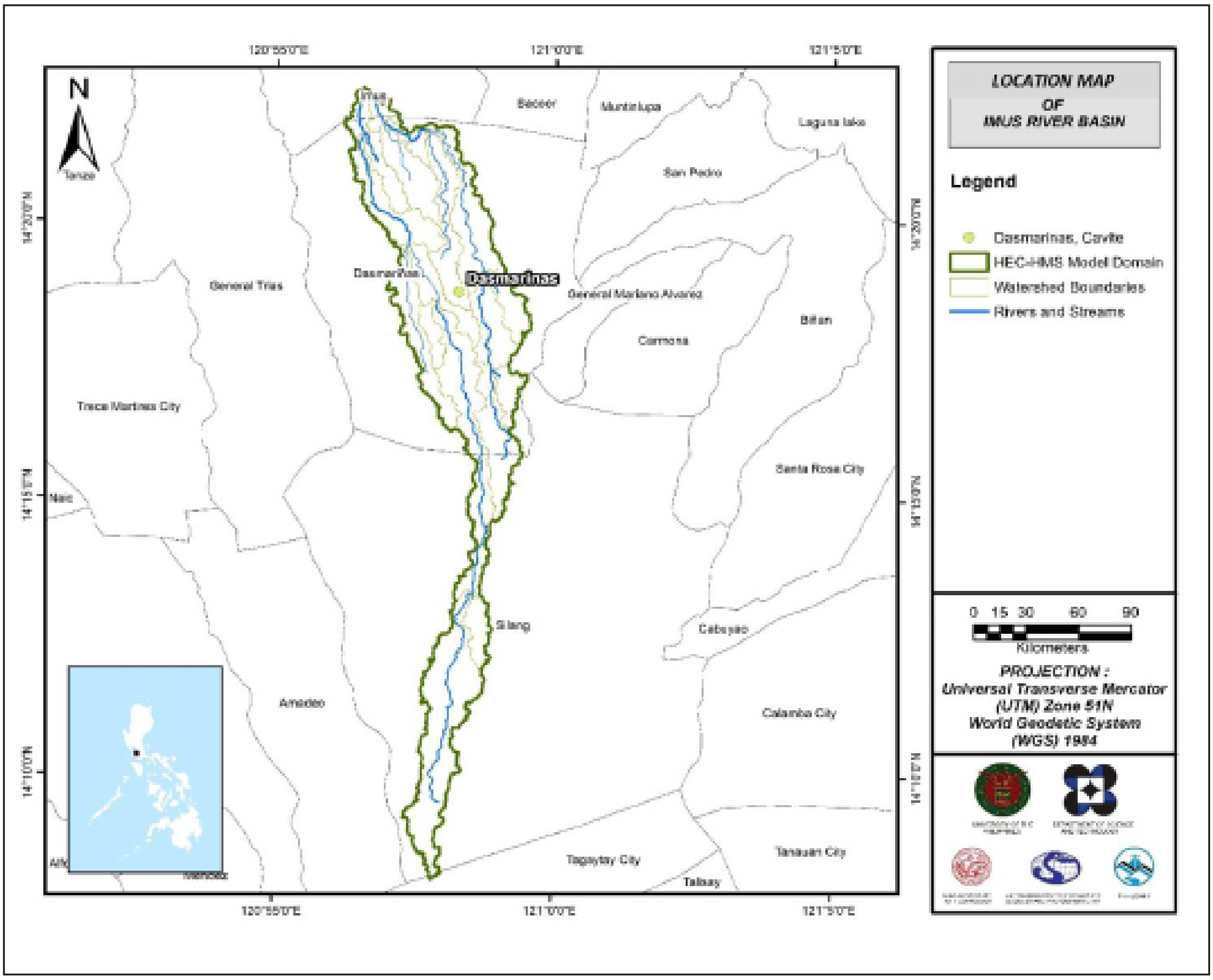


Figure 48. Location map of Dasmarinas rain gauge used for the calibration of the Imus HEC-HMS model

5.1.3 Rating Curves and River Outflow

A rating curve was developed at Daang Hari Bridge, Imus, Cavite (14°22'23.61"N, 120°56'31.54"E). It gives the relationship between the observed water levels and outflow of the watershed at this location. It is expressed in the form of the following equation:

Q=anh

where,	Q	:	discharge (m3/s),
	h	:	gauge height, and
	a and n	:	constants.

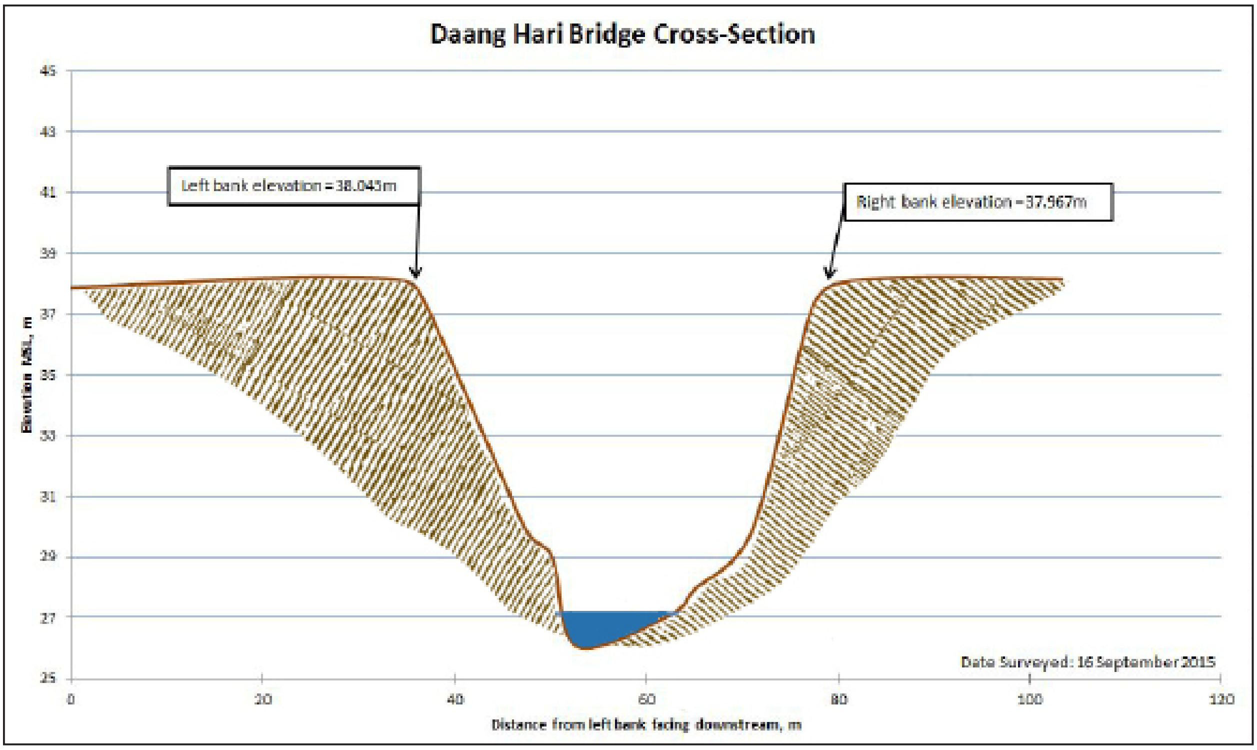


Figure 49. Cross-Section Plot of Imus Bridge

For Daang Hari Bridge, the rating curve is expressed y = 7E-286e23.227x as shown in Figure 50.

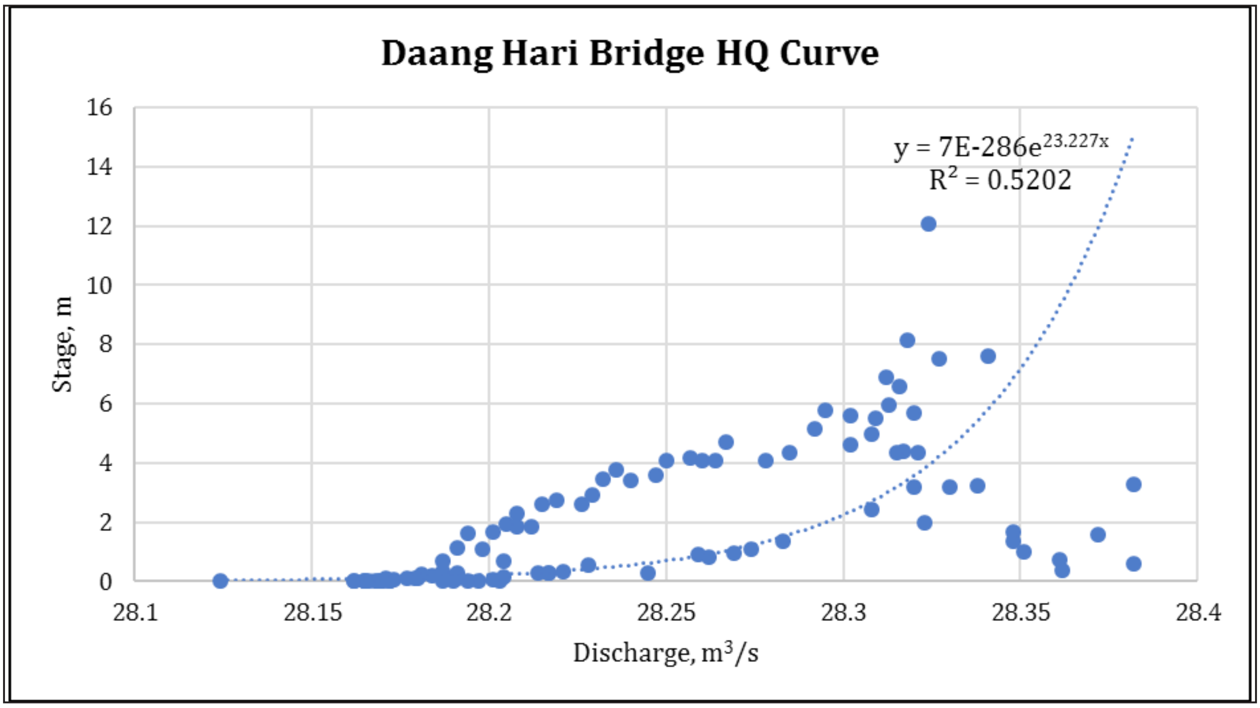


Figure 50. Rating curve at Daang Hari Bridge, Imus, Cavite

This rating curve equation was used to compute the river outflow at Daang Hari Bridge for the calibration of the HEC-HMS model shown in Figure 51. Peak discharge is 12.06 cms at 20:45, September 14, 2016.

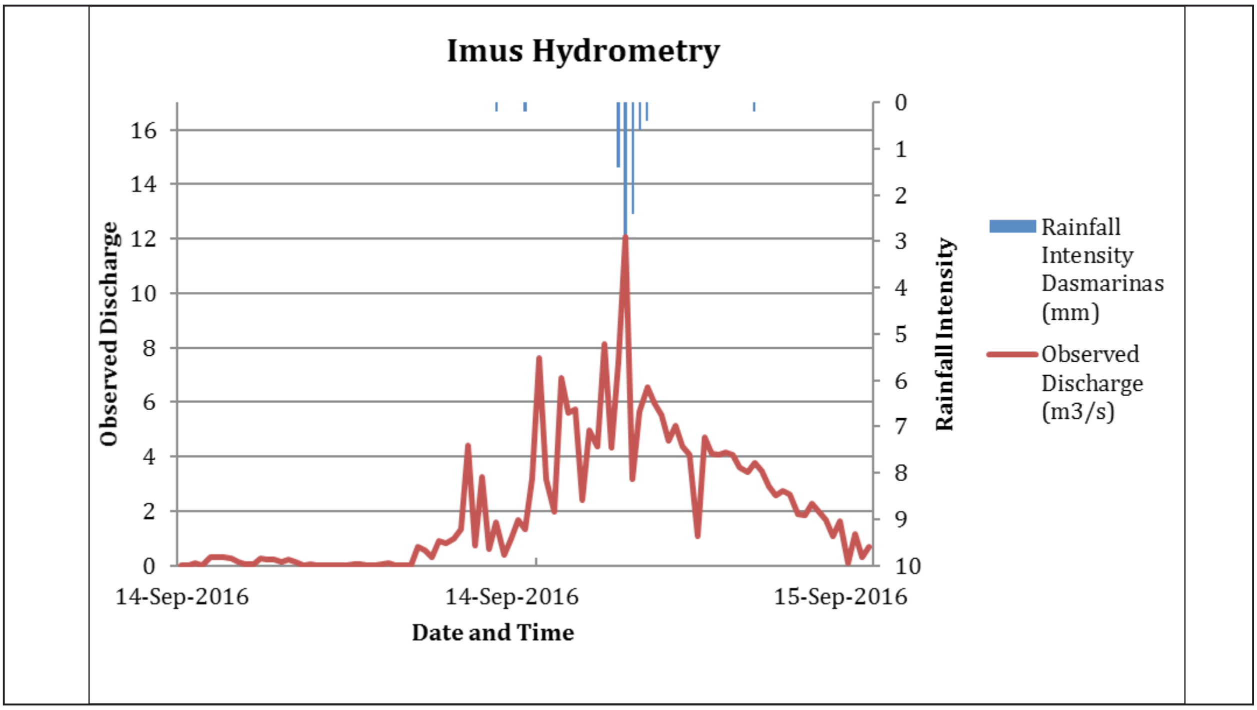


Figure 51. Rainflow and outflow data at Imus River used for modeling

5.2 RIDF Station

The Philippines Atmospheric Geophysical and Astronomical Services Administration (PAGASA) computed Rainfall Intensity Duration Frequency (RIDF) values for the Sangley Point Rain Gauge. The RIDF rainfall amount for 24 hours was converted to a synthetic storm by interpolating and re-arranging the value in such a way certain peak value will be attained at a certain time. This station chosen based on its proximity to the Imus watershed. The extreme values for this watershed were computed based on a 26-year record, as shown in Table 30.

Table 30. RIDF values for Infanta 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	20.3	30	36.6	46.4	63.2	74.6	96.6	119.6	147.9
5	28.3	41.8	50.8	64.6	89.8	106.8	140.3	174	209.4
10	33.6	49.7	60.2	76.7	107.3	128.2	169.2	210	250.1
15	36.6	54.1	65.5	83.5	117.2	140.3	185.6	230.3	273.1
20	38.7	57.2	69.2	88.3	124.2	148.7	197	244.6	289.1
25	40.3	59.6	72.1	91.9	129.5	155.2	205.8	255.5	301.5
50	45.3	66.9	80.9	103.3	146	175.2	233	289.3	339.7
100	50.3	74.2	89.7	114.5	162.3	195.1	259.9	322.8	377.6

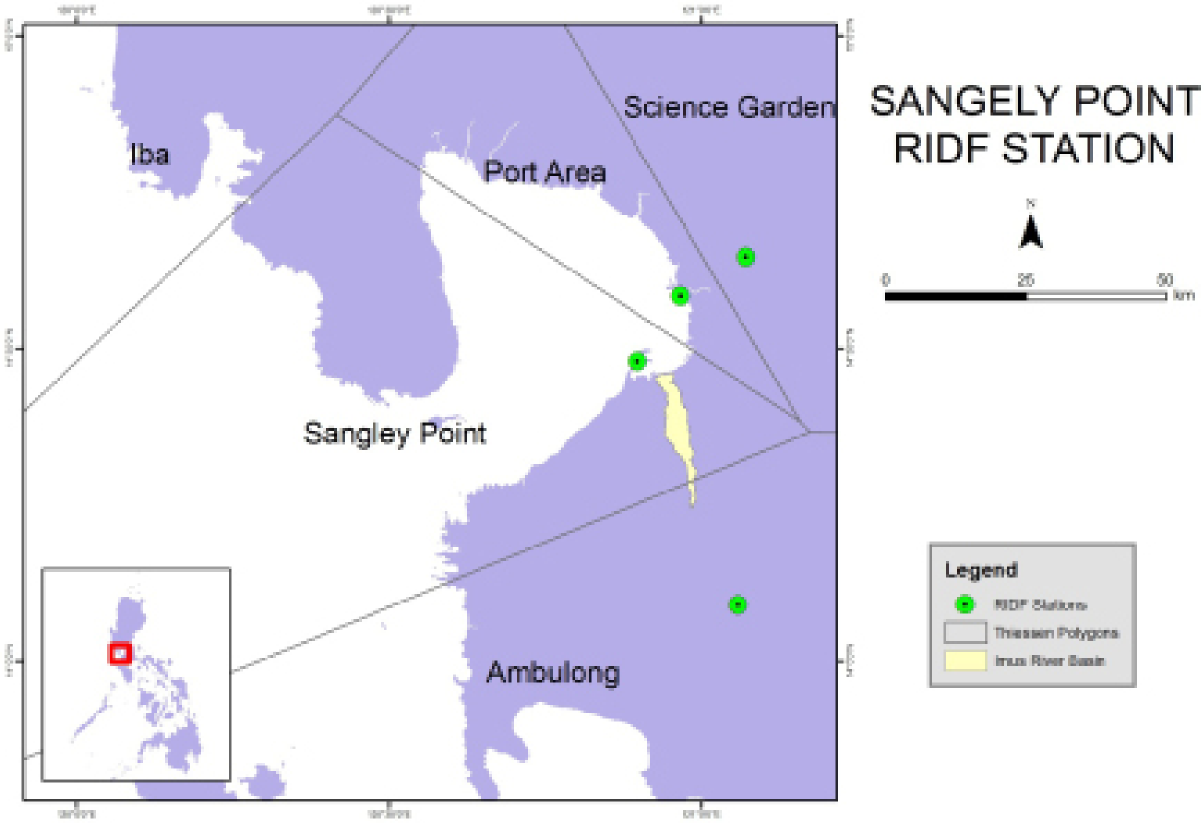


Figure 52. Sangley Point RIDF location relative to Imus River Basin

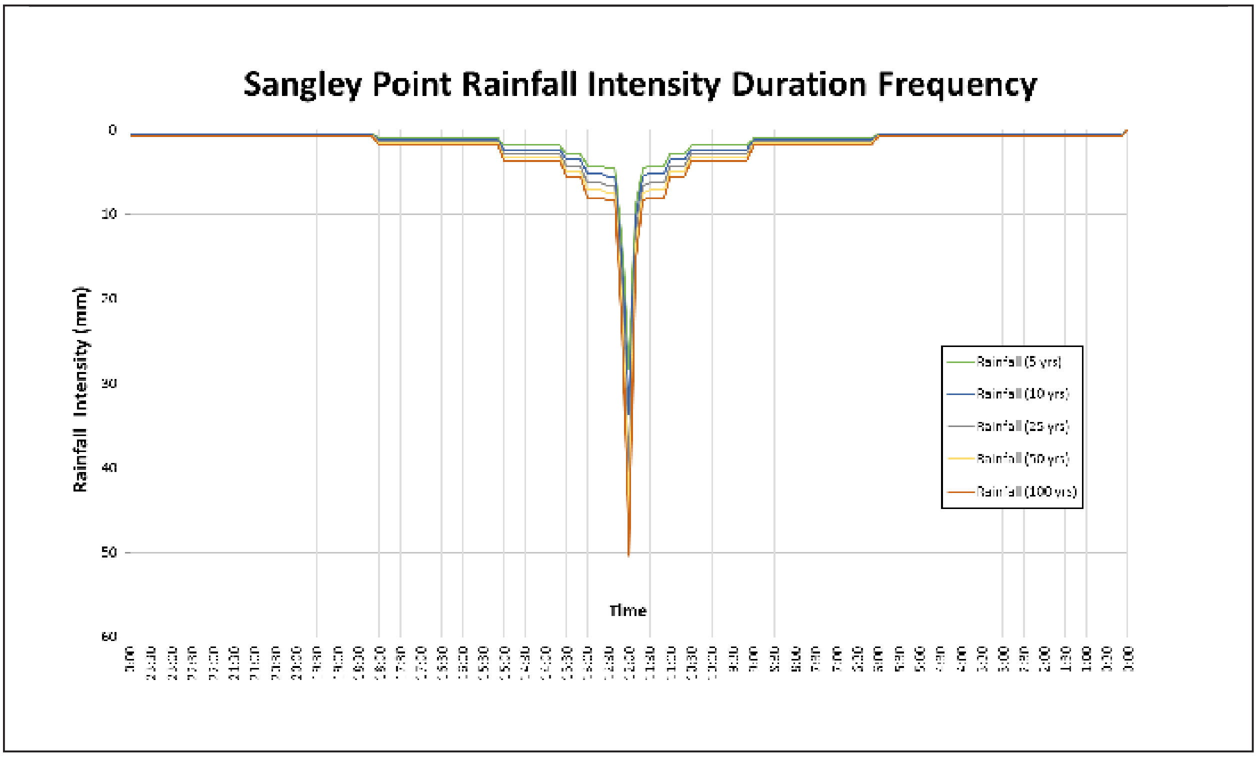


Figure 53. Synthetic storm generated for a 24-hr period rainfall for various return periods.

5.3 HMS Model

The soil dataset was generated before 2004 from the Bureau of Soil and Water Management (BSWM) 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 Imus River Basin are shown in Figure 54 and Figure 55, respectively.

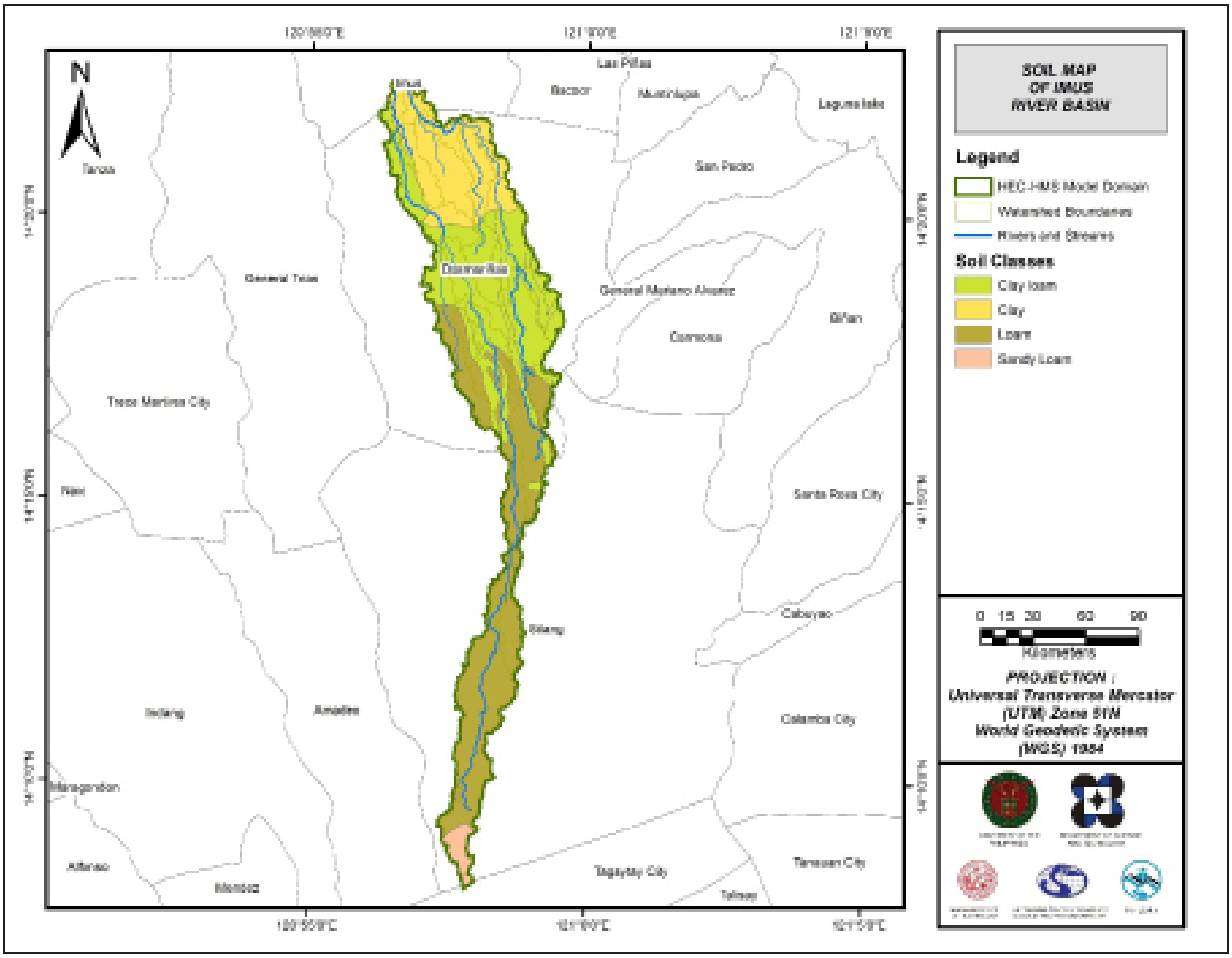


Figure 54. Soil map of the Imus River Basin

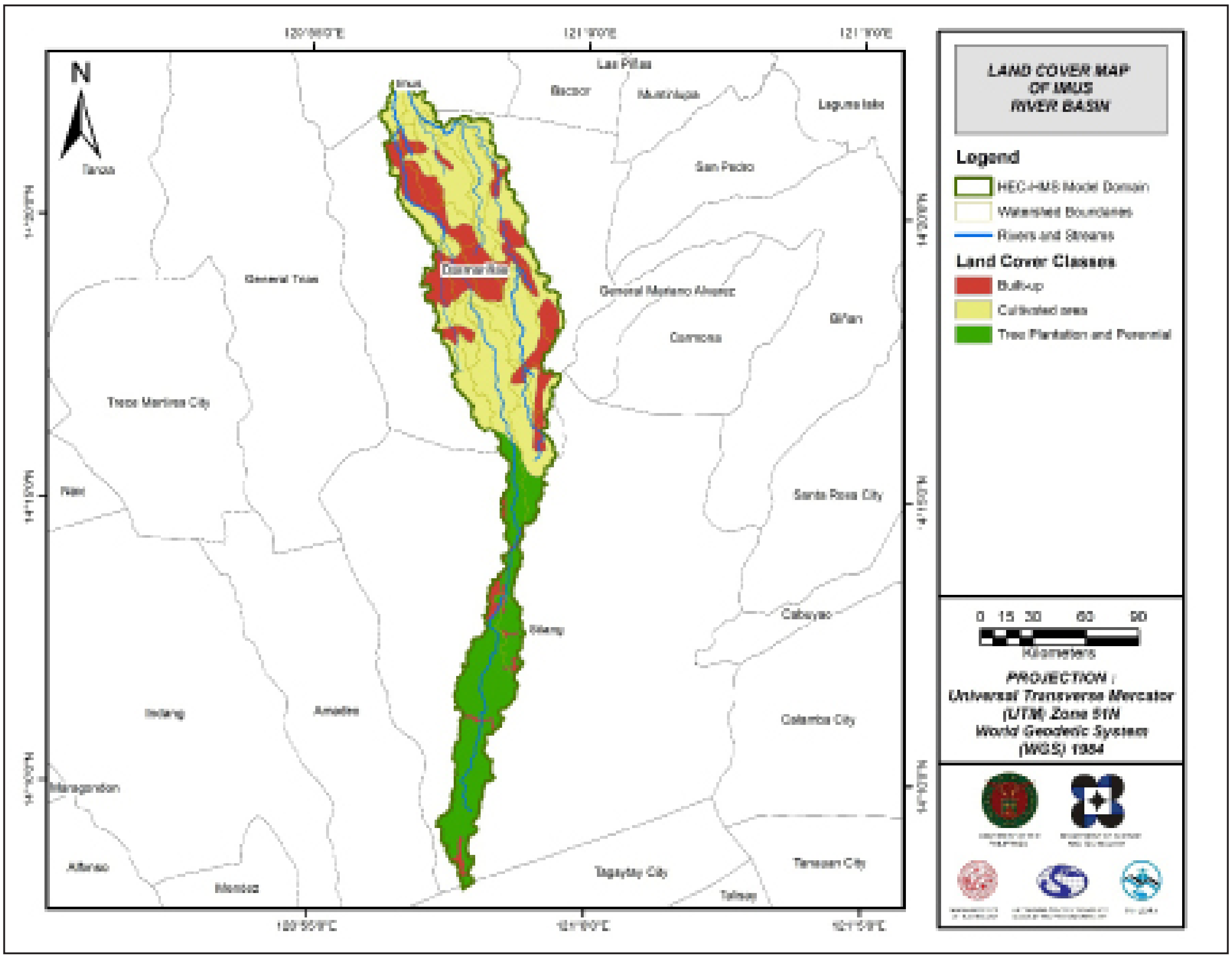


Figure 55. Land cover map of Imus River Basin

For Imus river basin, four (4) soil classes were identified. These are clay loam, clay, loam and sandy loam. Moreover, three (3) land cover classes were identified. These are built-up, cultivated area and tree plantation and perennial.

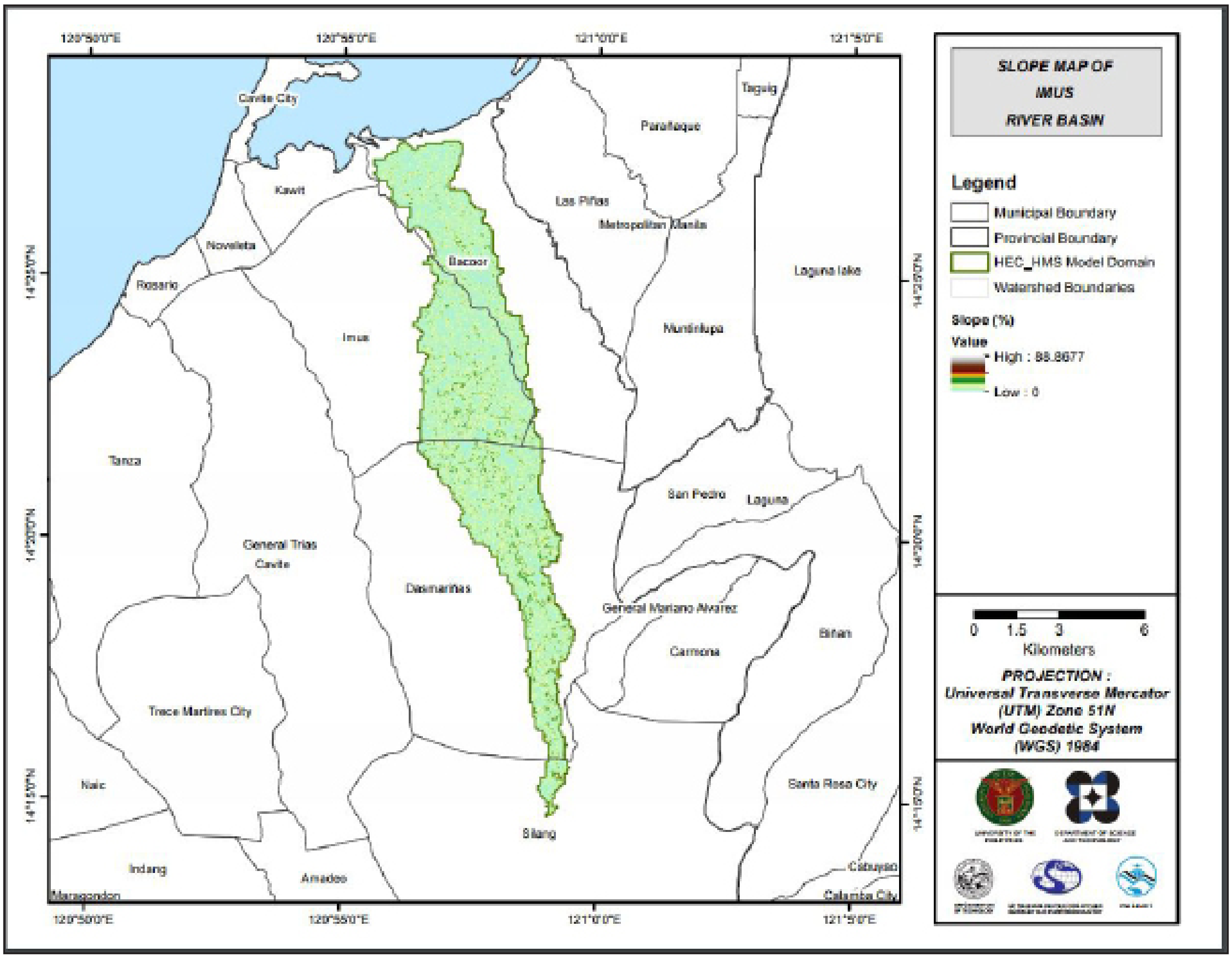


Figure 56. Slope map of Imus River Basin

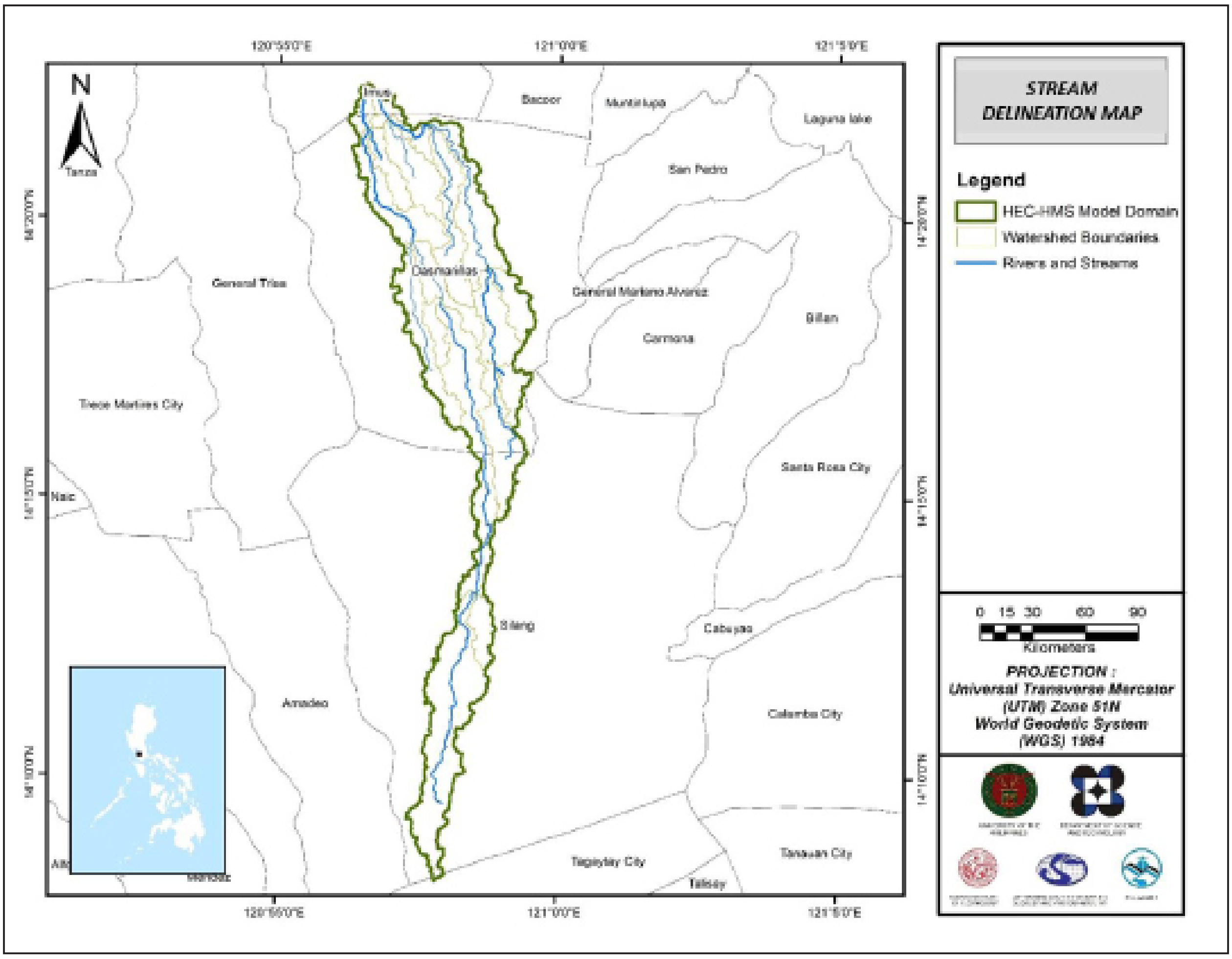


Figure 57. Stream delineation map of Imus River Basin

Using the SAR-based DEM, the Imus basin was delineated and further subdivided into subbasin. The Imus basin model consists of 18 sub basins, 9 reaches, and 9 junctions as shown in Figure 58. The main outlet is at the northernmost west tip of the watershed (W210). Finally, it was calibrated using depth gauge installed in Daang Hari Bridge.

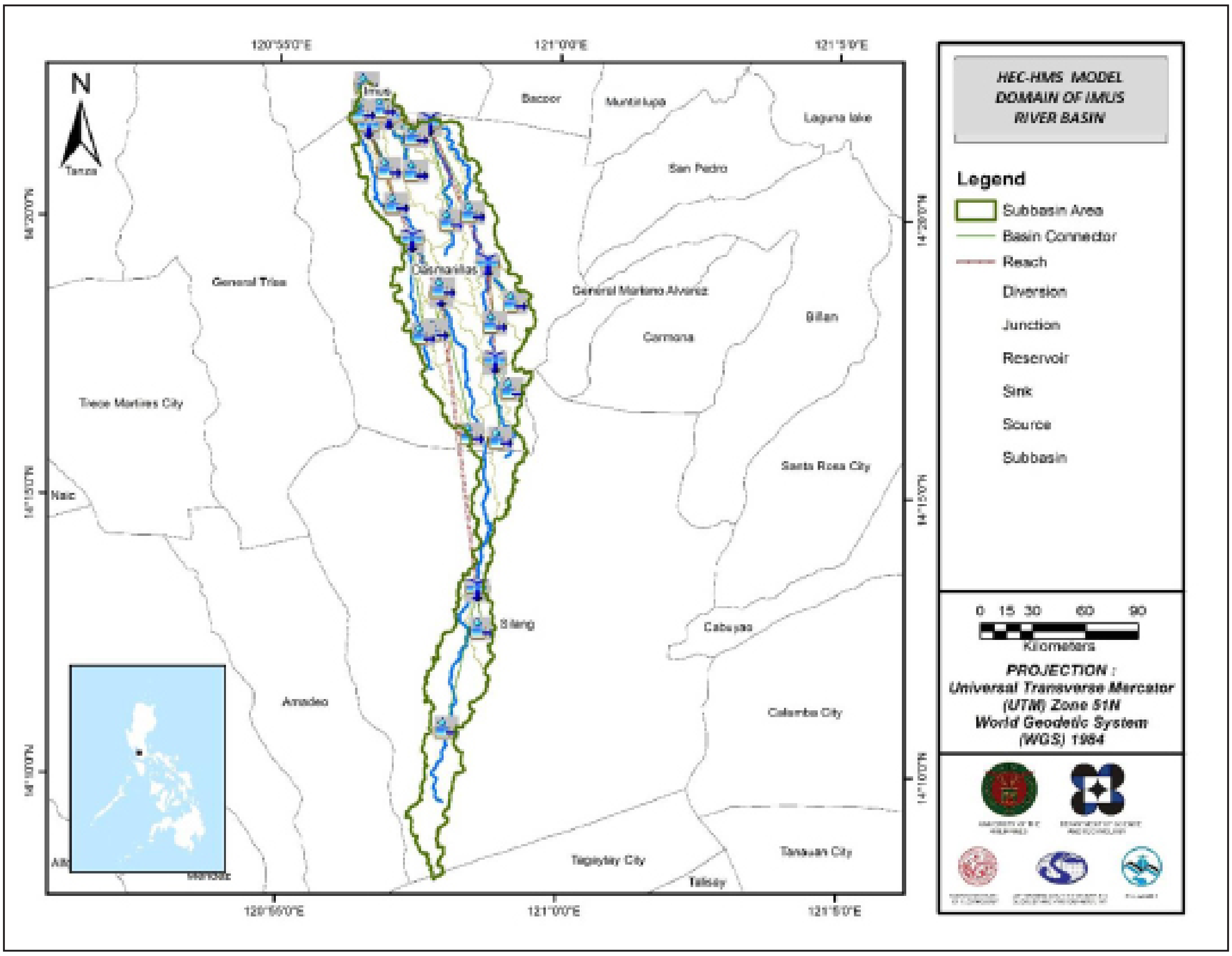


Figure 58. HEC-HMS generated Imus River Basin Model.

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. This is illustrated in Figure 59.

Figure 59. River cross-section of Imus 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 south of the model to the north, following the main channel. As such, boundary elements in those particular regions of the model are assigned as inflow and outflow elements respectively.

Figure 60. 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 115.99292 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 m2/s.

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 81636384.00 m2.

There is a total of 111514881.82 m3 of water entering the model. Of this amount, 37922850.08 m3 is due to rainfall while 73592031.73 m3 is inflow from other areas outside the model. 16304948.00 m3 of this water is lost to infiltration and interception, while 16771999.99 m3 is stored by the flood plain. The rest, amounting up to 78437951.13 m3, is outflow.

5.6 Results of HMS Calibration

After calibrating the Imus HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 67 shows the comparison between the two discharge data.

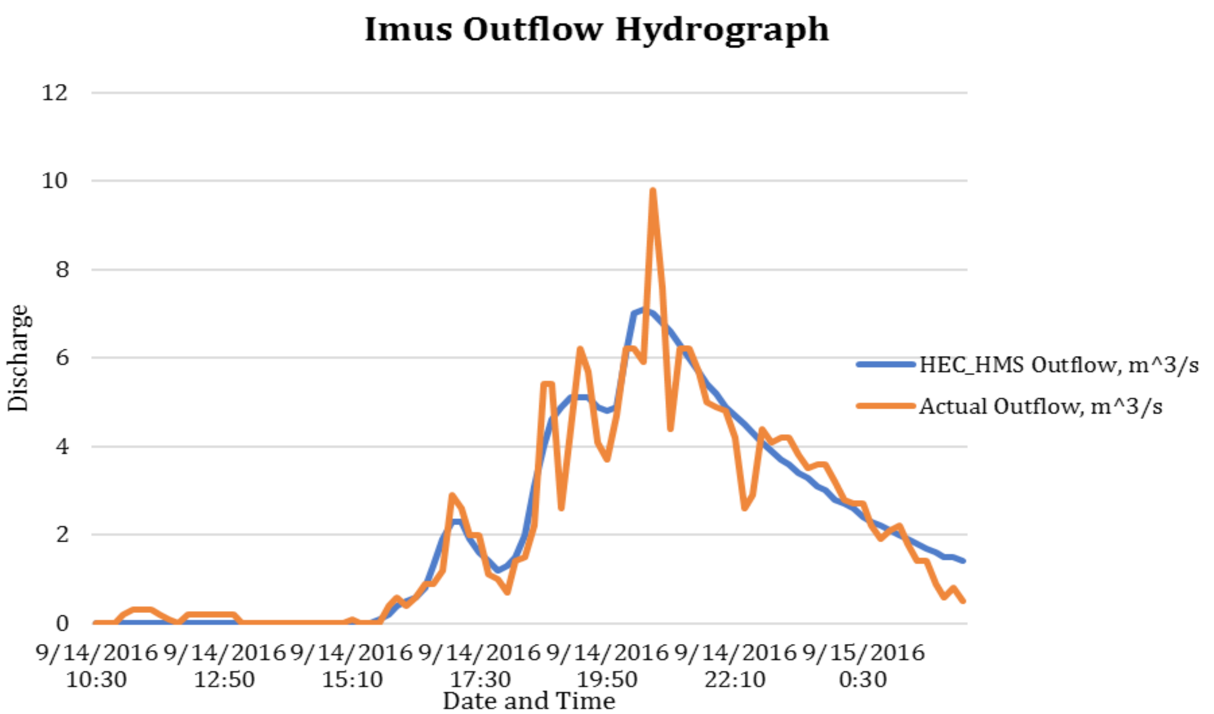


Figure 61. Outflow Hydrograph of Macalelon produced by the HEC-HMS model compared with observed outflow.

Enumerated in Table 31 are the adjusted ranges of values of the parameters used in calibrating the model.

Table 31. Range of Calibrated Values for Imus

Hydrologic Element	Calculation Type	Method	Parameter	Range of Calibrated Values
Basin	Loss	SCS Curve number	Initial Abstraction (mm)	0.73 – 9.21
			Curve Number	60.038 - 99
	Transform	Clark Unit Hydrograph	Time of Concentration (hr)	0.31 – 30.55
			Storage Coefficient (hr)	0.26 – 10.20
	Baseflow	Recession	Recession Constant	0.026 – 0.05
			Ratio to Peak	0.045 – 0.05
Reach	Routing	Muskingum-Cunge	Manning's Coefficient	0.014 – 0.74

Initial abstraction defines the amount of precipitation that must fall before surface runoff. The magnitude of the outflow hydrograph increases as initial abstraction decreases. The range of values from 0.73mm to 9.21mm means that there is a minimal amount of infiltration or rainfall interception by vegetation.

Curve number is the estimate of the precipitation excess of soil cover, land use, and antecedent moisture. The magnitude of the outflow hydrograph increases as curve number increases. The range of 60.038 to 99 for curve number is advisable for Philippine watersheds depending on the soil and land cover of the area (M. Horritt, personal communication, 2012). For Imus, four soil classes were identified. These are clay loam, clay, loam and sandy loam. Moreover, three land cover classes were identified. These are built-up, cultivated area and tree plantation and perennial.

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 0.26 hours to 30.55 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 ranges from 0.026 and 0.05 while the Ratio to Peak ranges from 0.045 to 0.05. The receding limb of the outflow hydrograph could be interpreted as likely to quickly return to its original discharge after an event.

Manning's roughness coefficient of 0.014 to 0.74 corresponds to the common roughness in Imus watershed (Brunner, 2010).

Table 32. Summary of the Efficiency Test of Imus HMS Model

Accuracy measure	Value
RMSE	0.7
r2	0.94
NSE	1.00
PBIAS	-2.57
RSR	0.03

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was computed as 0.7 (m3/s).

The Pearson correlation coefficient (r2) assesses the strength of the linear relationship between the observations and the model. This value being close to 1 corresponds to an almost perfect match of the observed discharge and the resulting discharge from the HEC HMS model. Here, it measured 0.940805.

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 1.

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 -2.57.

The Observation Standard Deviation Ratio, RSR, is an error index. A perfect model attains a value of 0 when the error in the units of the valuable a quantified. The model has an RSR value of 0.03.

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

5.7.1 Hydrograph using the Rainfall Runoff Model

The summary graph (Figure 62) shows the Imus outflow using the Sangley Point 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.

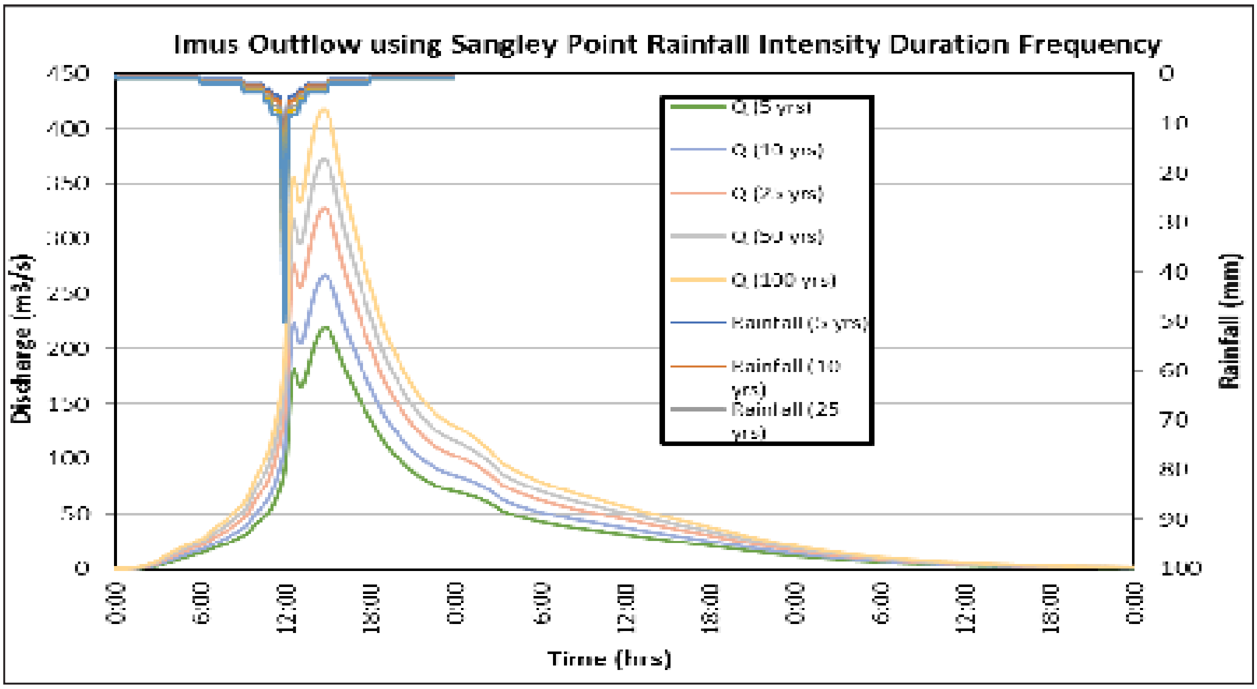


Figure 62. Outflow hydrograph at Imus Station generated using Sangley Point RIDF simulated in HEC-HMS

A summary of the total precipitation, peak rainfall, peak outflow and time to peak of the Imus discharge using the Sangley Point Rainfall Intensity-Duration-Frequency curves (RIDF) in five different return periods is shown in Table 33.

Table 33. Peak values of the Imus HECHMS Model outflow using the Alabat RIDF

RIDF Period	Total Precipitation (mm)	Peak rainfall (mm)	Peak outflow (m 3/s)	Time to Peak
5-Year	209.4	28.3	218.8	14 hours, 50 minutes
10-Year	250.1	33.6	266.6	14 hours, 50 minutes
25-Year	301.5	40.3	327.4	14 hours, 50 minutes
50-Year	339.7	45.3	372.8	14 hours, 50 minutes
100-Year	377.6	50.3	417.9	14 hours, 50 minutes

5.8 River Analysis Model Simulation

The HEC-RAS Flood Model produced a simulated water level at every cross-section for every time step for every flood simulation created. The resulting model will be used in determining the flooded areas within the model. The simulated model will be an integral part in determining real-time flood inundation extent of the river after it has been automated and uploaded on the DREAM website. The sample generated map of Imus River using the calibrated HMS event flow with 50-year rain return scenario is shown in Figure 63.

Figure 63. Sample output of Imus RAS Model

5.9 Flood Hazard and Flow Depth Map

The resulting hazard and flow depth maps have a 10m resolution. Figure 64 to Figure 69 shows the 5-, 25-, and 100-year rain return scenarios of the Imus floodplain. Table 34 shows the municipalities affected in Imus Floodplain.

Table 34. Municipalities affected in Imus Floodplain

City / Municipality	Total Area	Area Flooded	% Flooded
Bacoor	47.43	16.74	35.30%
Dasmariñas	84.01	34.98	41.64%
Imus	56.81	35.73	62.89%
Kawit	9.47	1.21	12.83%

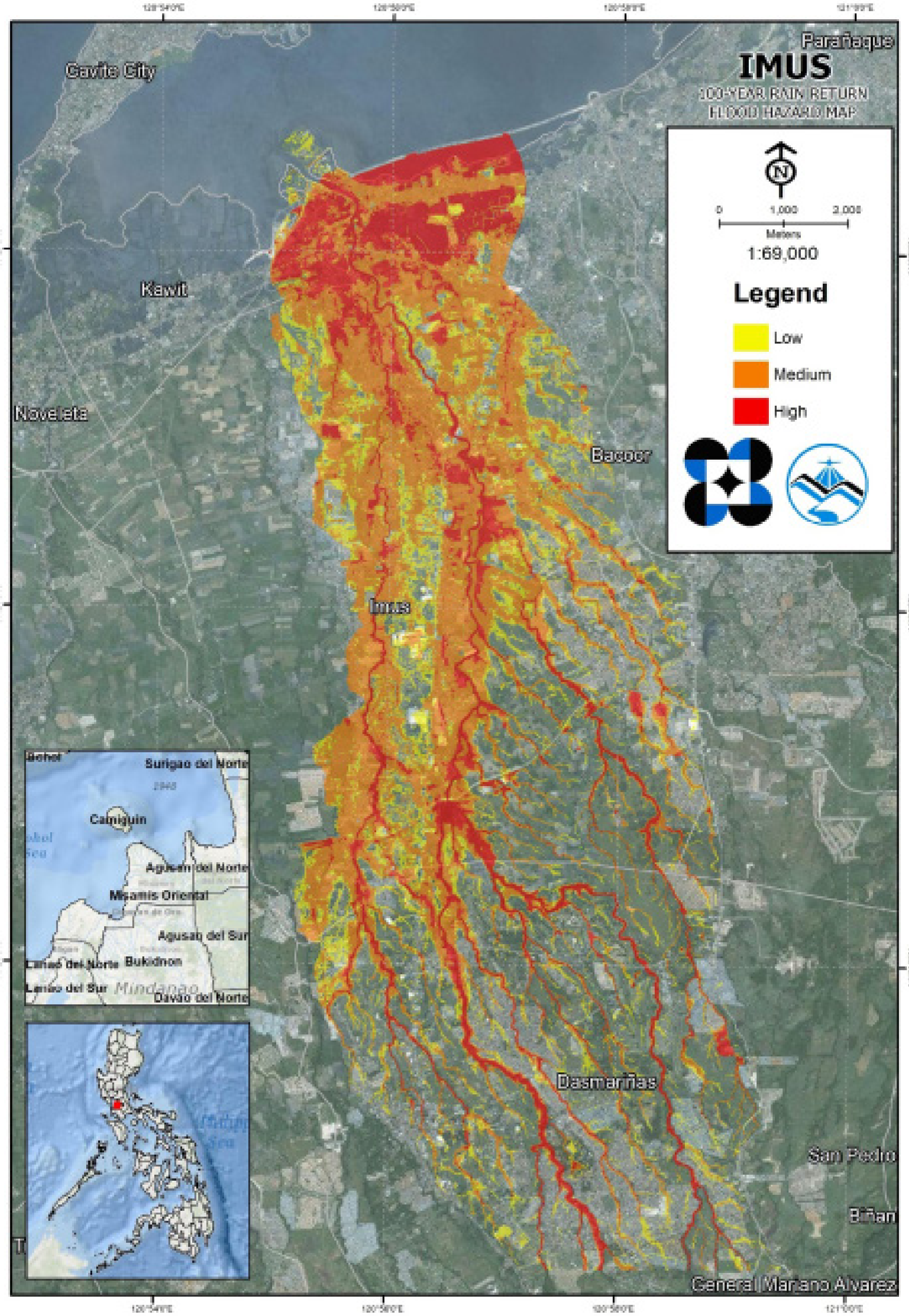


Figure 64. 100-year Flood Hazard Map for Imus Floodplain overlaid on Google Earth imagery

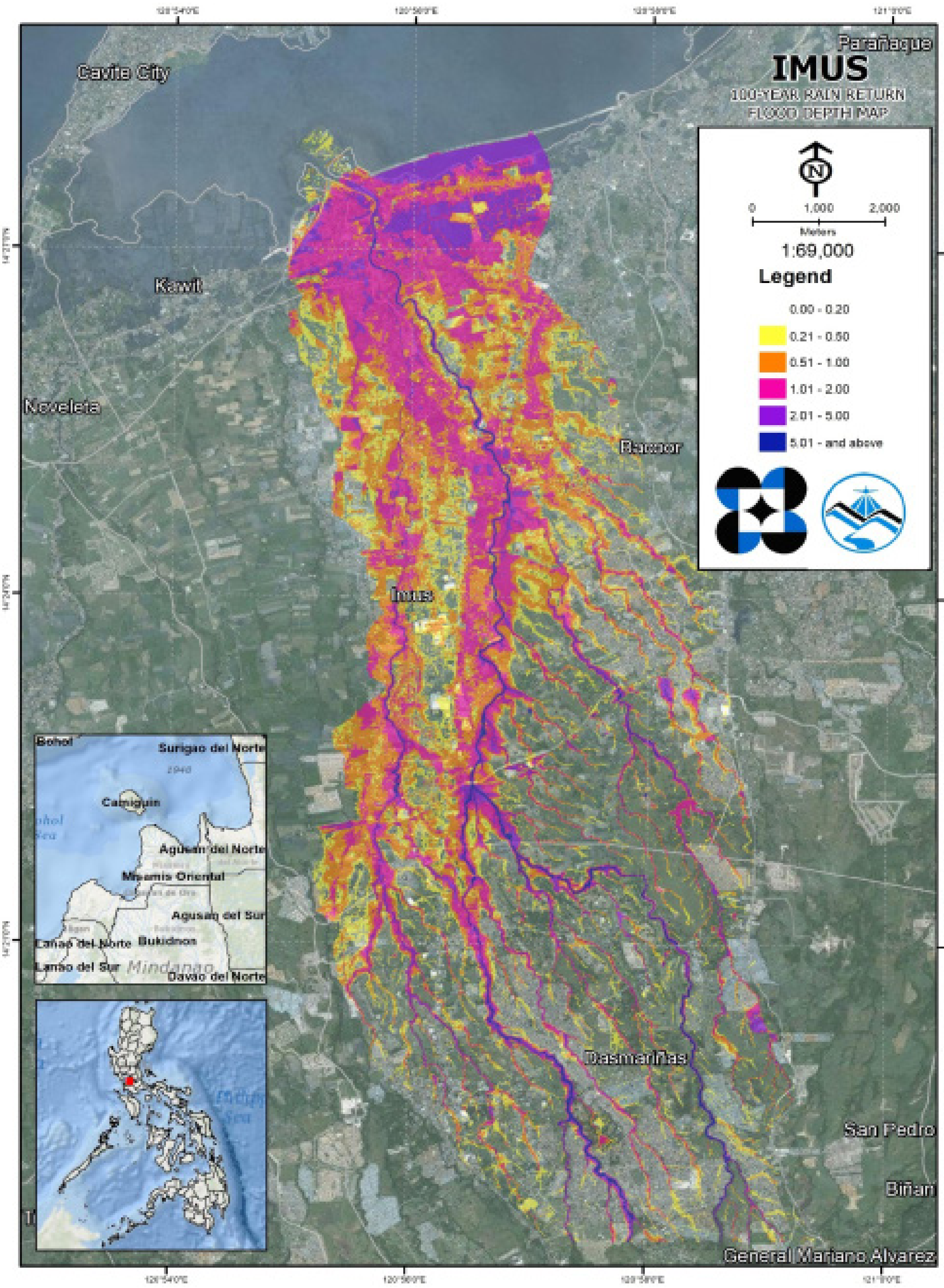


Figure 65. 100-year Flow Depth Map for Imus Floodplain overlaid on Google Earth imagery

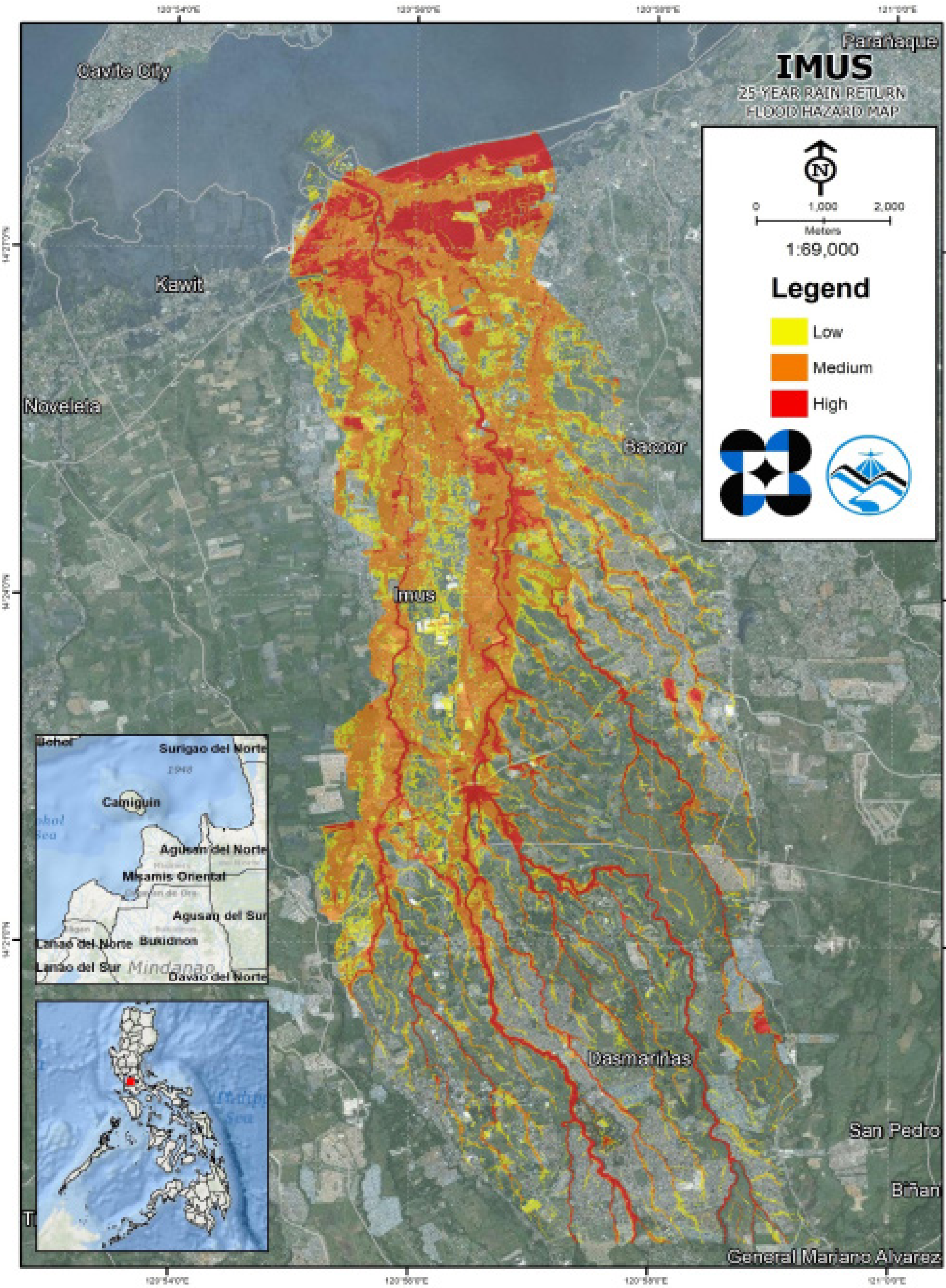


Figure 66. 25-year Flood Hazard Map for Imus Floodplain overlaid on Google Earth imagery

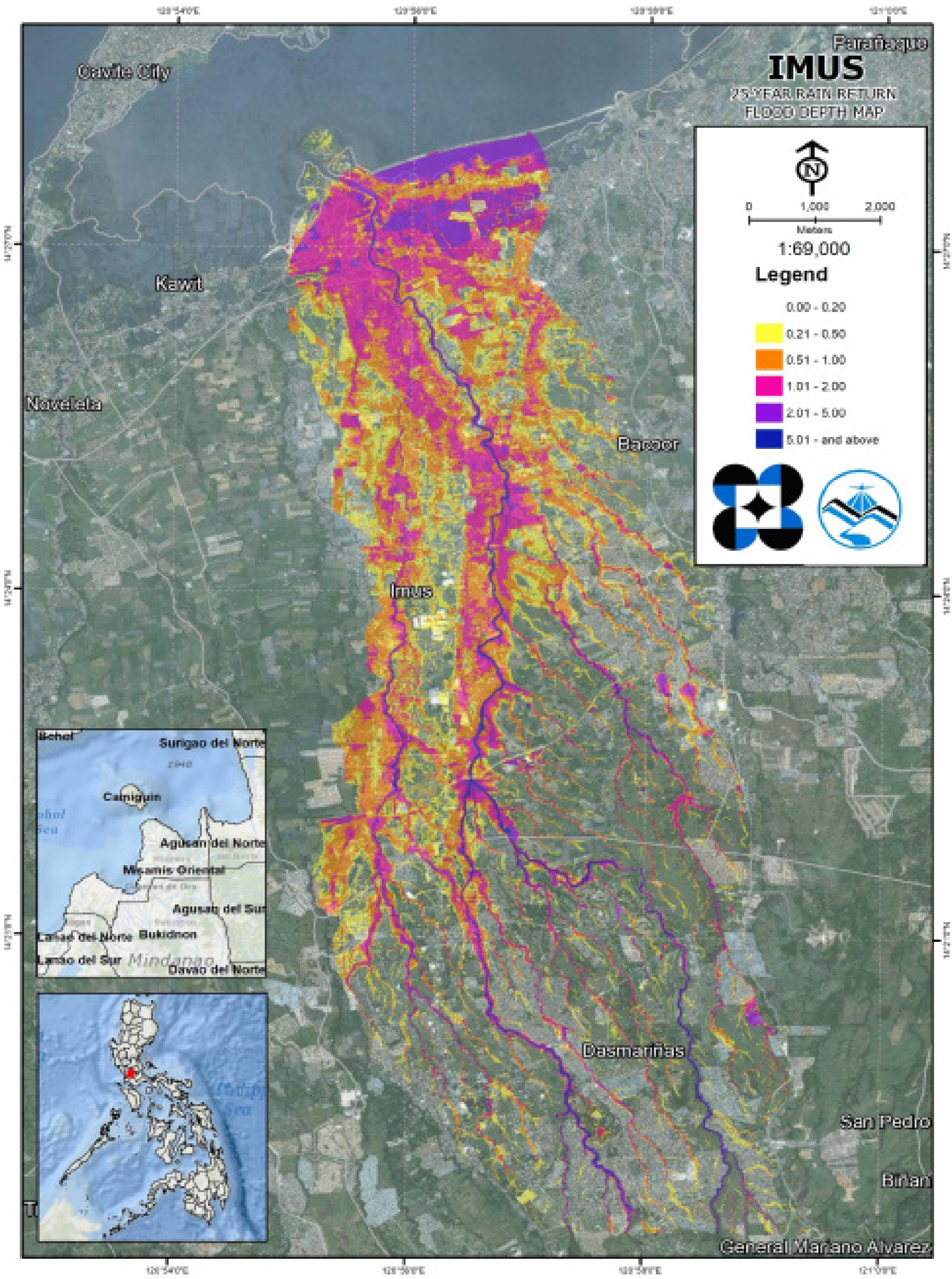


Figure 67. 25-year Flow Depth Map for Imus Floodplain overlaid on Google Earth imagery

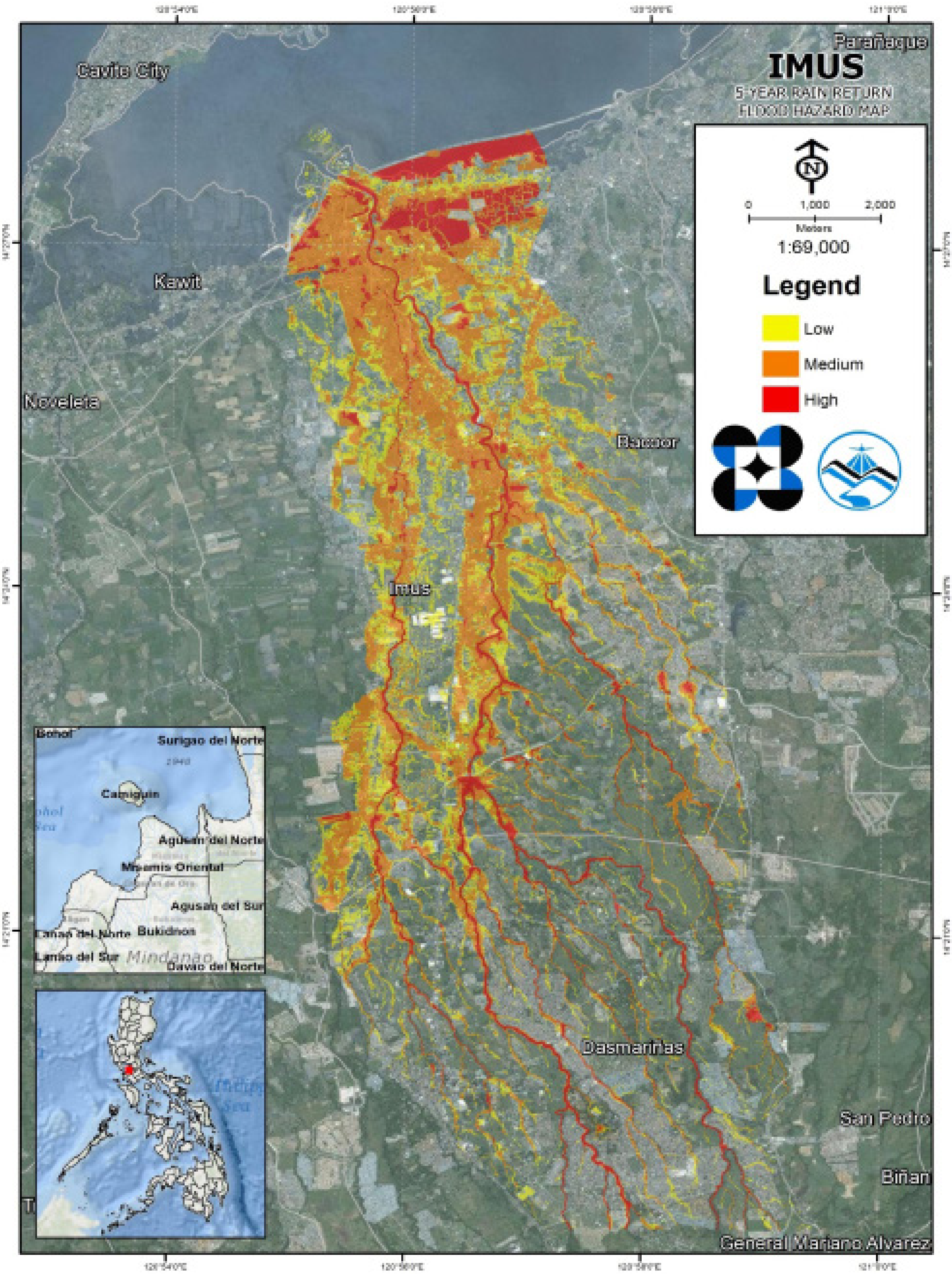


Figure 68. 5-year Flood Hazard Map for Imus Floodplain overlaid on Google Earth imagery

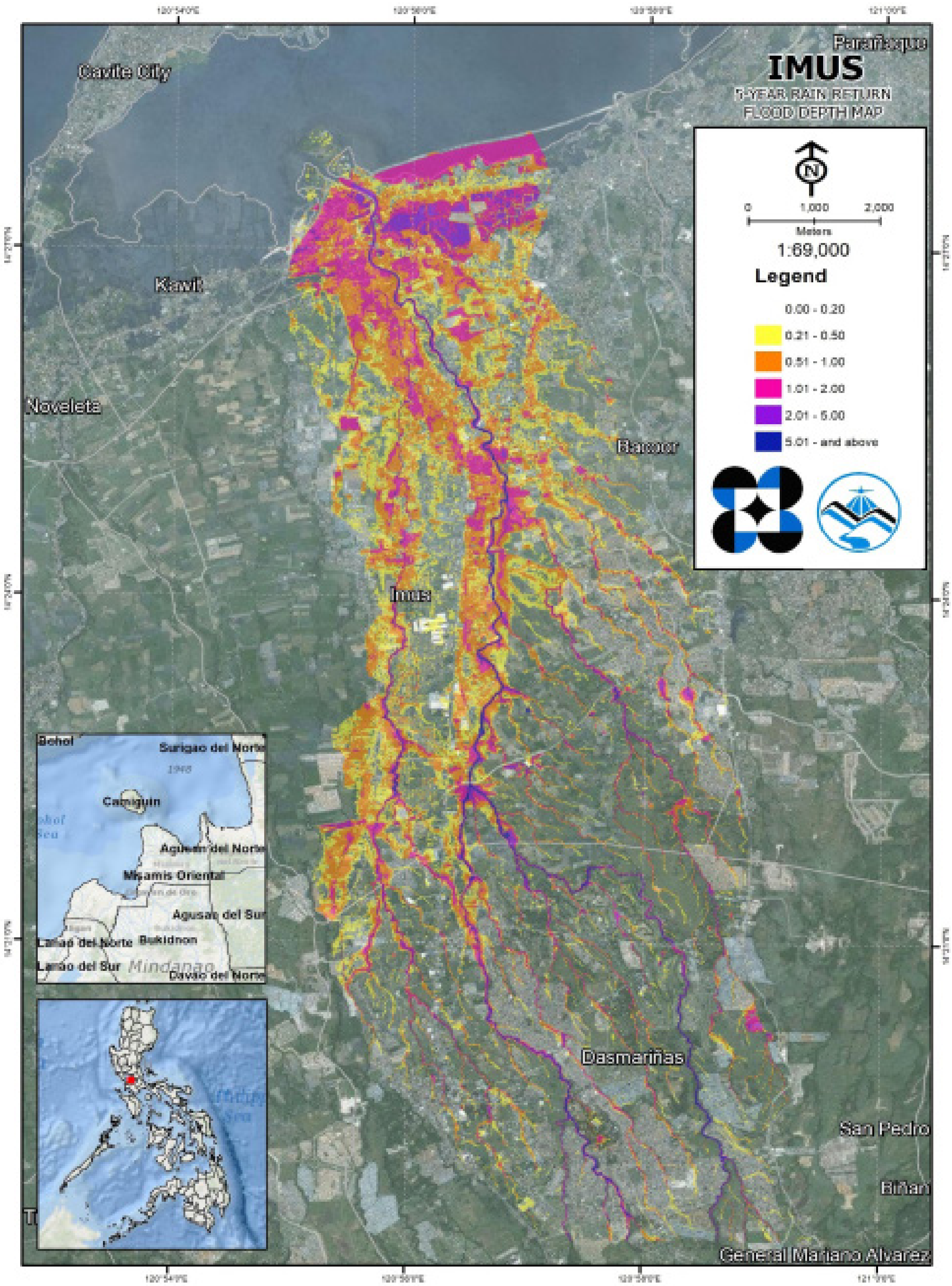


Figure 69. 5-year Flood Depth Map for Imus Floodplain overlaid on Google Earth imagery

5.10 Inventory of Areas Exposed to Flooding

Affected barangays in Imus river basin, grouped by municipality, are listed below. For the said basin, four (4) municipalities consisting of 196 barangays are expected to experience flooding when subjected to 5-, 25-, and 100-yr rainfall return period.

For the 5-year return period, 16.16% of the municipality of Bacoor with an area of 47.43 sq. km. will experience flood levels of less than 0.20 meters. 6.85% of the area will experience flood levels of 0.21 to 0.50 meters while 6.82%, 3.95%, 1.44%, 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 Table 35 to Table 38 and shown in Figure 70 to Figure 73 are the affected areas in square kilometers by flood depth per barangay.

Table 35. Affected Areas in Bacoor, Cavite during 5-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Bacoor (in sq. km)									
	Alima	Banalo	Bayanan	Campo Santo	Daang Bukid	Digman	Dulong Bayan	Habay I	Habay II	Kaingin
0.03-0.20	0.033	0.0083	0.0055	0.023	0.088	0.035	0.013	0.17	0.2	0.14
0.21-0.50	0.066	0.02	0.001	0.064	0.041	0.051	0.051	0.18	0.11	0.088
0.51-1.00	0.11	0.084	0.00056	0.067	0.099	0.016	0.13	0.17	0.14	0.073
1.01-2.00	0.13	0.098	0	0.075	0.22	0.0002	0.14	0.028	0.16	0.042
2.01-5.00	0.05	0.092	0	0.014	0.097	0	0.062	0.013	0.14	0.00068
> 5.00	0	0	0	0	0	0	0	0	0	0

Table 36. Affected Areas in Bacoor, Cavite during 5-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Bacoor (in sq. km)									
	Mabolo I	Mabolo II	Mabolo III	Maliksi I	Maliksi II	Mambog I	Mambog II	Mambog III	Mambog IV	Mambog V
0.03-0.20	0.019	0.013	0.0058	0.079	0.01	0.65	0.76	0.69	0.28	0.17
0.21-0.50	0.043	0.038	0.0045	0.026	0.0056	0.51	0.14	0.13	0.12	0.088
0.51-1.00	0.19	0.069	0.035	0.053	0.0023	0.33	0.054	0.035	0.08	0.065
1.01-2.00	0.14	0.056	0.046	0.048	0.0047	0.085	0.0069	0.011	0.0014	0.0036
2.01-5.00	0.045	0.011	0.044	0.0082	0	0.0025	0	0.0004	0	0
> 5.00	0.004	0.00073	0	0	0	0	0	0	0	0

Table 37. Affected Areas in Bacoor, Cavite during 5-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Bacoor (in sq. km)								
	Molino II	Molino III	Molino IV	Molino V	P.F. Espiritu I	P.F. Espiritu II	P.F. Espiritu III	P.F. Espiritu IV	P.F. Espiritu V
0.03-0.20	0.52	0.26	0.04	0.78	0.13	0.14	0.13	0.054	0.022
0.21-0.50	0.033	0.02	0.0045	0.16	0.064	0.076	0.055	0.046	0.046
0.51-1.00	0.021	0.0053	0	0.083	0.033	0.075	0.025	0.057	0.065
1.01-2.00	0.01	0.0043	0	0.028	0.0026	0.0096	0.0028	0.021	0.013
2.01-5.00	0.0013	0.0001	0	0.0026	0	0	0	0	0.0001
> 5.00	0	0	0	0	0	0	0	0	0

Table 38. Affected Areas in Bacoor, Cavite during 5-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Bacoor (in sq. km)								
	Queens Row East	Real I	Real II	Salinas I	Salinas II	Salinas III	Salinas IV	Sineguelasan	Tabing Dagat
0.03-0.20	1.16	0.28	0.3	0.0077	0.0073	0.035	0.1	0.27	0.038
0.21-0.50	0.1	0.35	0.18	0.053	0.025	0.056	0.1	0.094	0.0092
0.51-1.00	0.066	0.3	0.19	0.098	0.13	0.047	0.12	0.11	0.0083
1.01-2.00	0.037	0.086	0.14	0.075	0.04	0.019	0.027	0.046	0.015
2.01-5.00	0.014	0.0067	0.022	0.0012	0.0085	0.016	0	0.029	0
> 5.00	0	0.0064	0.013	0.00088	0.0041	0.0071	0	0	0

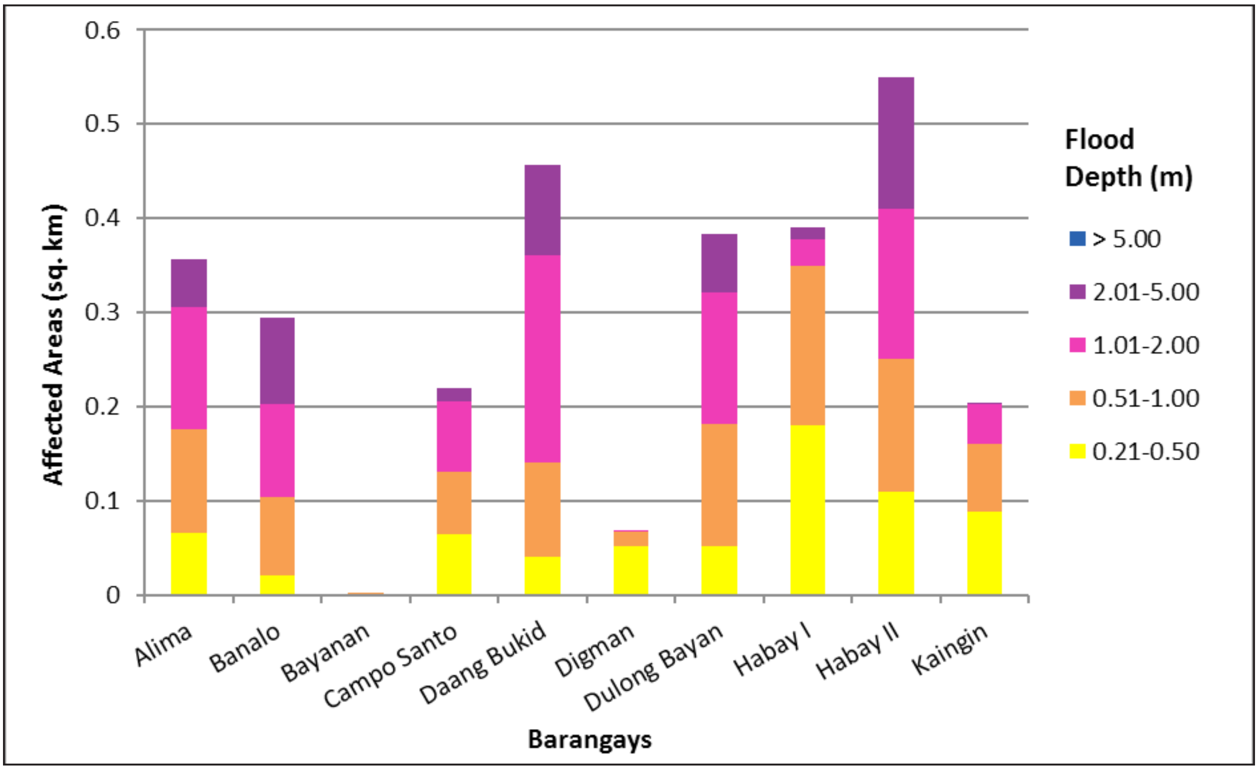


Figure 70. Affected Areas in Bacoor, Cavite during 5-year Rainfall Return Period

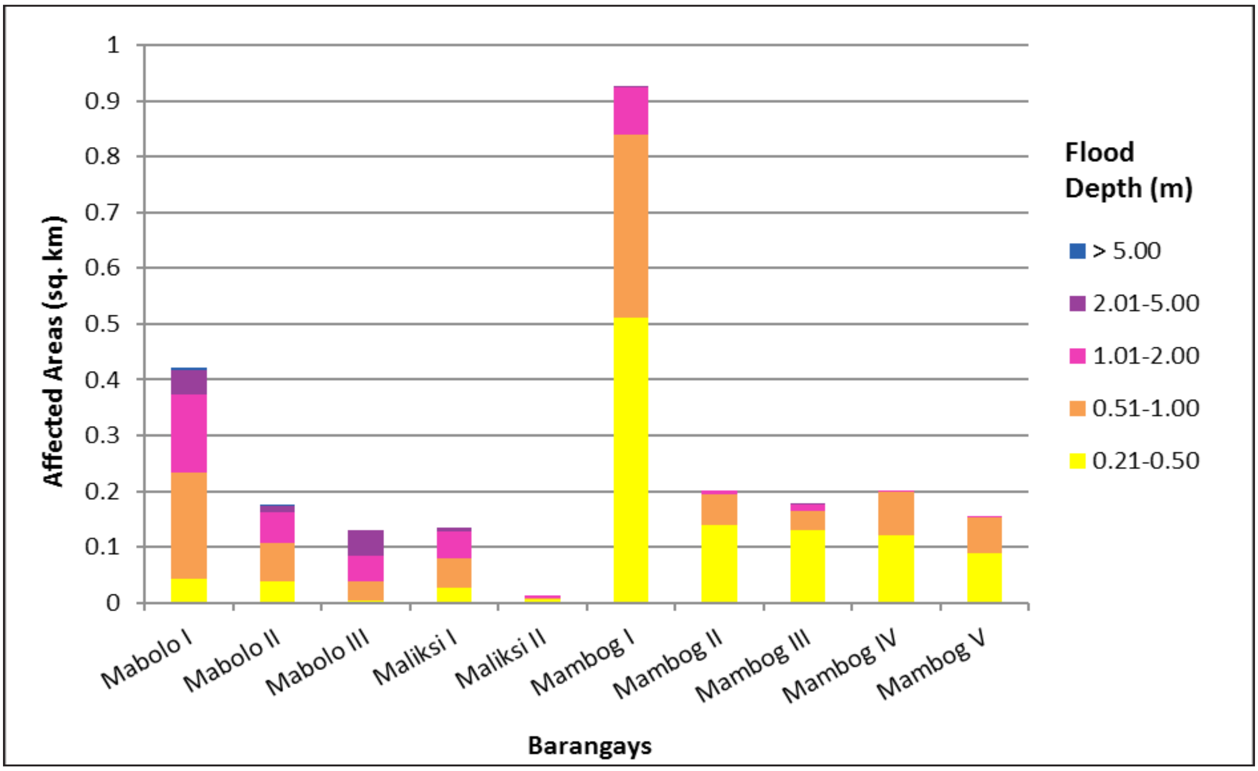


Figure 71. Affected Areas in Bacoor, Cavite during 5-year Rainfall Return Period

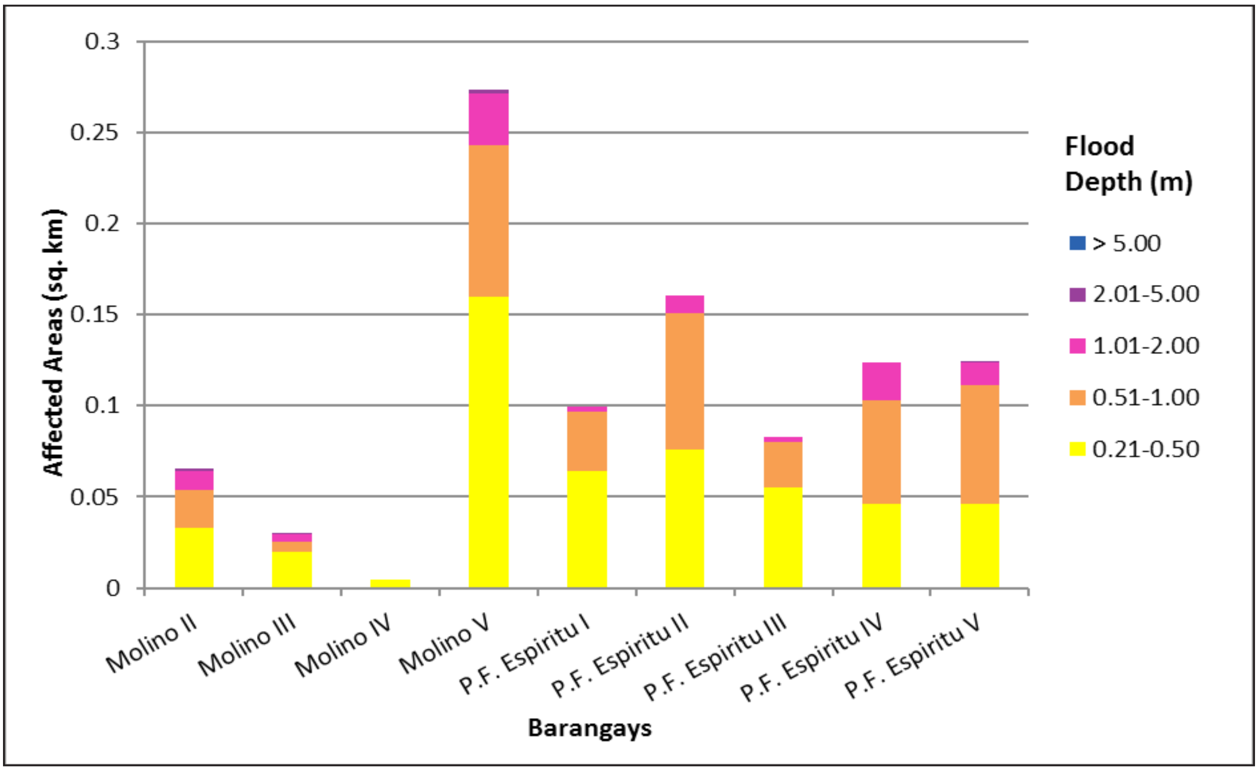


Figure 72. Affected Areas in Bacoor, Cavite during 5-year Rainfall Return Period

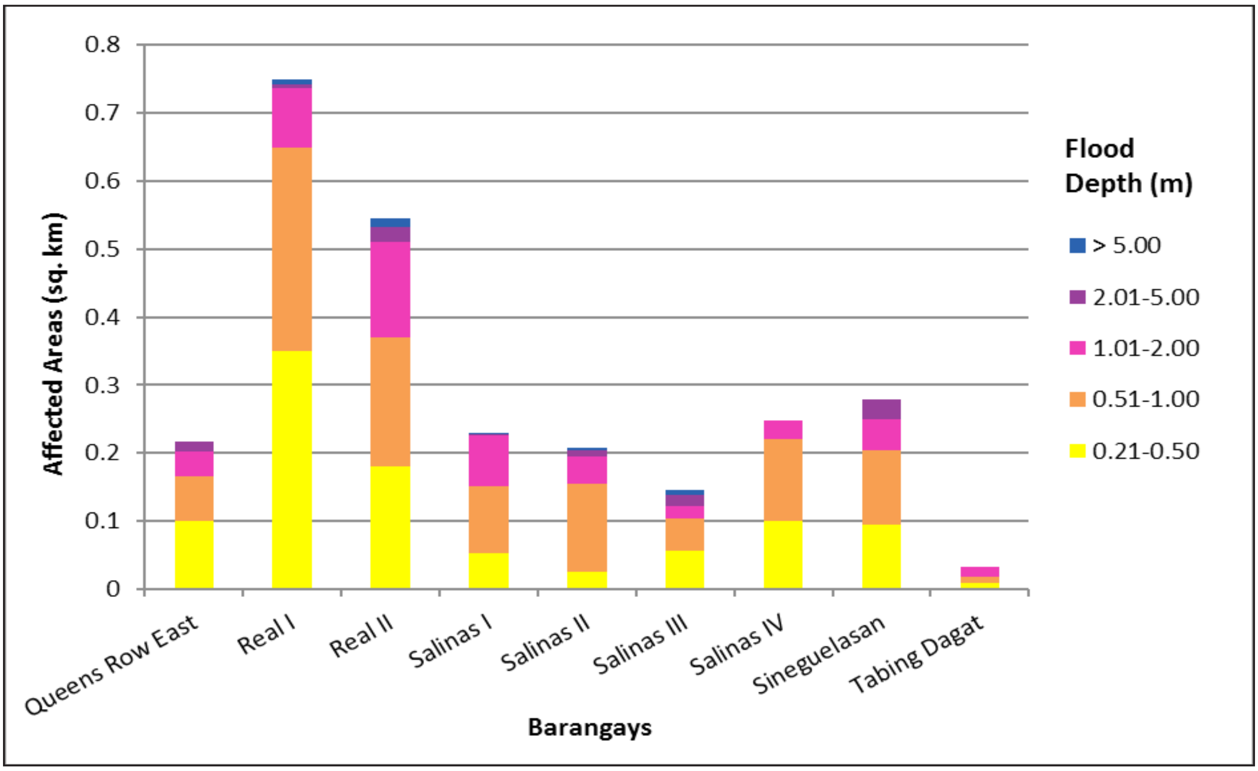


Figure 73. Affected Areas in Bacoor, Cavite during 5-year Rainfall Return Period

For the 5-year return period, 34.93% of the municipality of Dasmariñas with an area of 84.01 sq. km. will experience flood levels of less than 0.20 meters. 2.82% of the area will experience flood levels of 0.21 to 0.50 meters while 1.69%, 1.21%, 0.70%, and 0.26% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 39 to Table 44 and shown in Figure 74 to Figure 79 are the affected areas in square kilometers by flood depth per barangay.

Table 39. Affected Areas in Dasmariñas, Cavite during 5-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Dasmariñas (in sq. km)										
	Burol	Burol I	Burol II	Burol III	Datu Esmael	Emmanuel Bergado I	Emmanuel Bergado II	Fatima I	Fatima II	Fatima III	Luzviminda I
0.03-0.20	2.07	0.17	0.13	0.3	0.19	0.066	0.046	0.086	0.11	0.21	0.096
0.21-0.50	0.16	0.0057	0.016	0.014	0.0072	0.0019	0.001	0.0034	0.00017	0.018	0.0027
0.51-1.00	0.093	0.0059	0.0048	0.013	0.0058	0.0029	0.0014	0.0012	0	0.012	0.0024
1.01-2.00	0.05	0.0067	0.0066	0.0095	0.0086	0.0039	0.0034	0.00094	0	0.0039	0.00058
2.01-5.00	0.026	0.0073	0.0021	0.005	0.0099	0.0054	0.0052	0.000032	0	0.0016	0.0001
> 5.00	0.0042	0.011	0.0033	0	0.0069	0.0088	0.0065	0	0	0.000073	0

Table 40. Affected Areas in Dasmariñas, Cavite during 5-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Dasmariñas (in sq. km)										
	Luzviminda II	Paliparan II	Paliparan III	Sabang	Saint Peter I	Saint Peter II	Salawag	Salitran I	Salitran II	Salitran III	Salitran IV
0.03-0.20	0.3	0.58	2.24	0.87	0.033	0.072	9.19	0.8	1.11	0.47	2.57
0.21-0.50	0.027	0.035	0.15	0.31	0.0012	0.0025	0.47	0.18	0.078	0.12	0.22
0.51-1.00	0.011	0.016	0.044	0.16	0.0017	0.0034	0.29	0.13	0.046	0.16	0.13
1.01-2.00	0.0014	0.014	0.028	0.1	0.00072	0.0057	0.27	0.071	0.031	0.095	0.1
2.01-5.00	0	0.01	0.031	0.037	0.0023	0.0065	0.2	0.011	0.0099	0.035	0.047
> 5.00	0	0.0022	0.037	0	0.00083	0.0023	0.075	0.0002	0.0001	0.0086	0.0083

Table 41. Affected Areas in Dasmariñas, Cavite during 5-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Dasmariñas (in sq. km)										
	Sampaloc IV	San Agustin I	San Agustin II	San Agustin III	San Andres I	San Andres II	San Antonio de Padua I	San Antonio de Padua II	San Dionisio	San Esteban	San Francisco I
0.03-0.20	0.15	0.74	0.84	0.17	0.015	0.025	0.027	0.061	0.27	0.086	0.044
0.21-0.50	0.011	0.058	0.07	0.017	0.0016	0.0016	0.0011	0.0012	0.016	0.0069	0.00096
0.51-1.00	0.0005	0.014	0.026	0.011	0.0021	0.0013	0.00098	0.00071	0.016	0.0029	0.0012
1.01-2.00	0.00089	0.006	0.0099	0.0049	0.0027	0.0014	0.00042	0.00094	0.015	0.002	0.0012
2.01-5.00	0.0016	0.0061	0.0014	0.0003	0	0	0.0019	0.002	0.012	0.0007	0.0003
> 5.00	0.0013	0.0023	2.3E-06	0	0	0	0.0003	0.00072	0	0	0

Table 42. Affected Areas in Dasmariñas, Cavite during 5-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Dasmariñas (in sq. km)										
	San Francisco II	San Isidro Labrador I	San Isidro Labrador II	San Jose	San Juan	San Lorenzo Ruiz I	San Lorenzo Ruiz II	San Luis I	San Luis II	San Manuel I	San Manuel II
0.03-0.20	0.026	0.17	0.066	1.1	0.16	0.038	0.051	0.3	0.19	0.047	0.035
0.21-0.50	0.00095	0.012	0.0064	0.097	0.016	0.00065	0.00014	0.0056	0.0068	0.0042	0.0029
0.51-1.00	0	0.011	0.0036	0.043	0.0018	0	0.0006	0.0095	0.011	0.0021	0.0045
1.01-2.00	0	0.0072	0.0032	0.022	0.0019	0	0.00068	0.0047	0.016	0.0036	0.012
2.01-5.00	0	0.0013	0.0001	0.0026	0.00085	0	0.0028	0.0062	0.023	0.0041	0.02
> 5.00	0	0	0	0	0	0	0	0.0007	0.015	0.0026	0.0019

Table 43. Affected Areas in Dasmariñas, Cavite during 5-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Dasmariñas (in sq. km)										
	San Mateo	San Miguel	San Miguel II	San Nicolas I	San Nicolas II	San Roque	San Simon	Santa Cristina I	Santa Cristina II	Santa Cruz I	Santa Cruz II
0.03-0.20	0.11	0.065	0.038	0.21	0.53	0.015	0.077	0.034	0.036	0.17	0.094
0.21-0.50	0.0068	0.0041	0.0035	0.021	0.04	0.000039	0.0039	0.0024	0.0018	0.0052	0.0013
0.51-1.00	0.0076	0.0067	0.00025	0.0034	0.018	0	0.0026	0.003	0.0014	0.0024	0.0017
1.01-2.00	0.0046	0.0083	0	0.003	0.008	0	0.0023	0.0041	0.0014	0.0026	0.0024
2.01-5.00	0.0006	0.013	0	0.0006	0.002	0	0	0.0023	0.00021	0.0045	0.0057
> 5.00	0	0.0056	0	0	0.000058	0	0	0	0	0.0028	0.0006

Table 44. Affected Areas in Dasmariñas, Cavite during 5-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Dasmariñas (in sq. km)									
	Santa Fe	Santa Lucia	Santa Maria	Santo Cristo	Santo Niño I	Santo Niño II	Zone I	Zone I-B	Zone II	Zone IV
0.03-0.20	0.024	0.25	0.054	0.11	0.091	0.031	0.11	0.65	0.035	0.29
0.21-0.50	0.004	0.012	0.002	0.016	0.0057	0.0032	0.0073	0.041	0.00011	0.027
0.51-1.00	0.0028	0.0085	0.0024	0.006	0.0032	0.0033	0.00078	0.03	0	0.016
1.01-2.00	0.0031	0.0025	0.0055	0.00089	0.0044	0.002	0	0.026	0	0.007
2.01-5.00	0	0.000014	0.0088	0	0.0037	0.0007	0	0.0075	0	0.00015
> 5.00	0	0	0.012	0	0	0	0	0	0	0

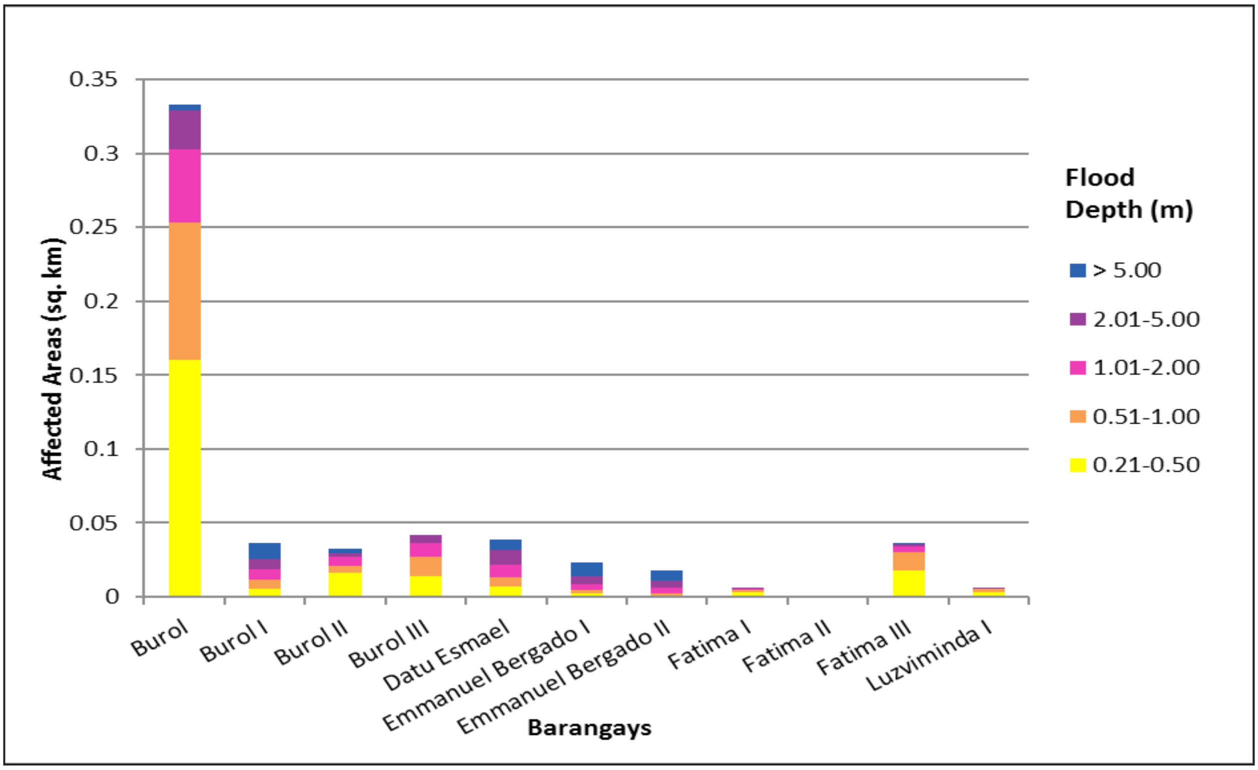


Figure 74. Affected Areas in Dasmariñas, Cavite during 5-year Rainfall Return Period

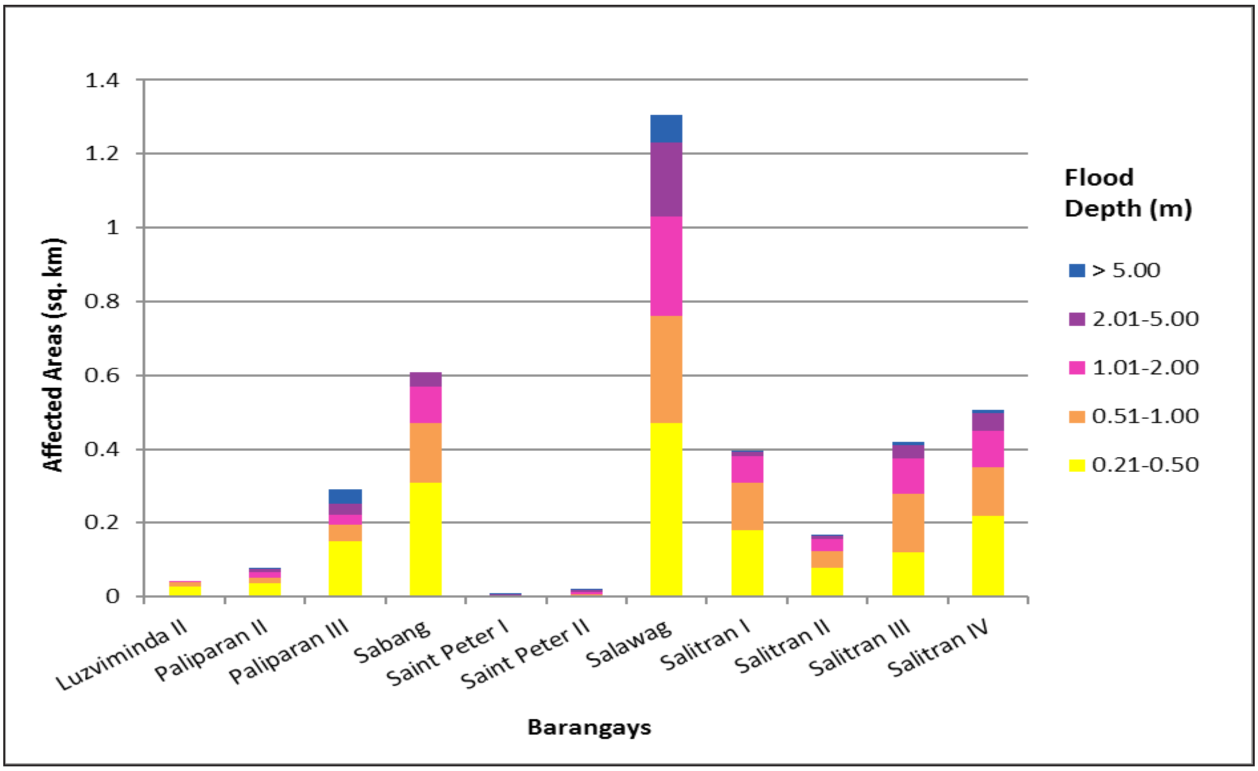


Figure 75. Affected Areas in Dasmariñas, Cavite during 5-year Rainfall Return Period

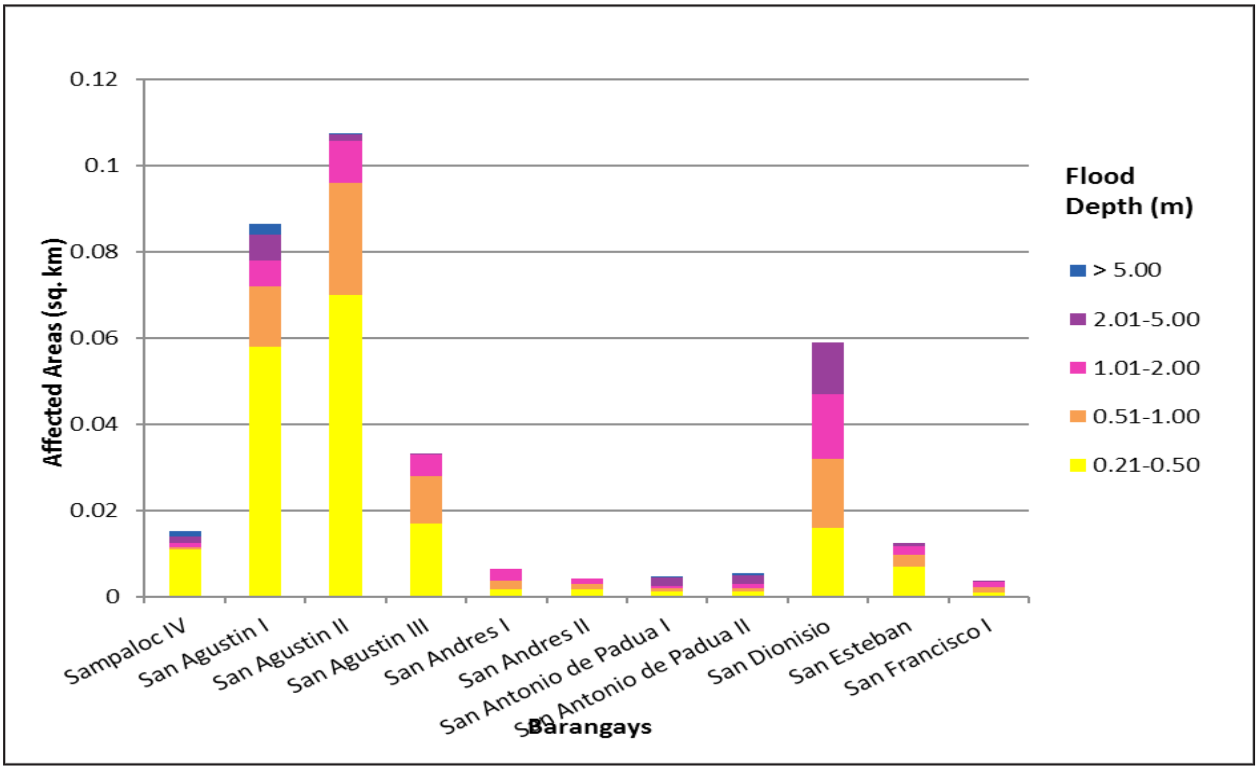


Figure 76. Affected Areas in Dasmariñas, Cavite during 5-year Rainfall Return Period

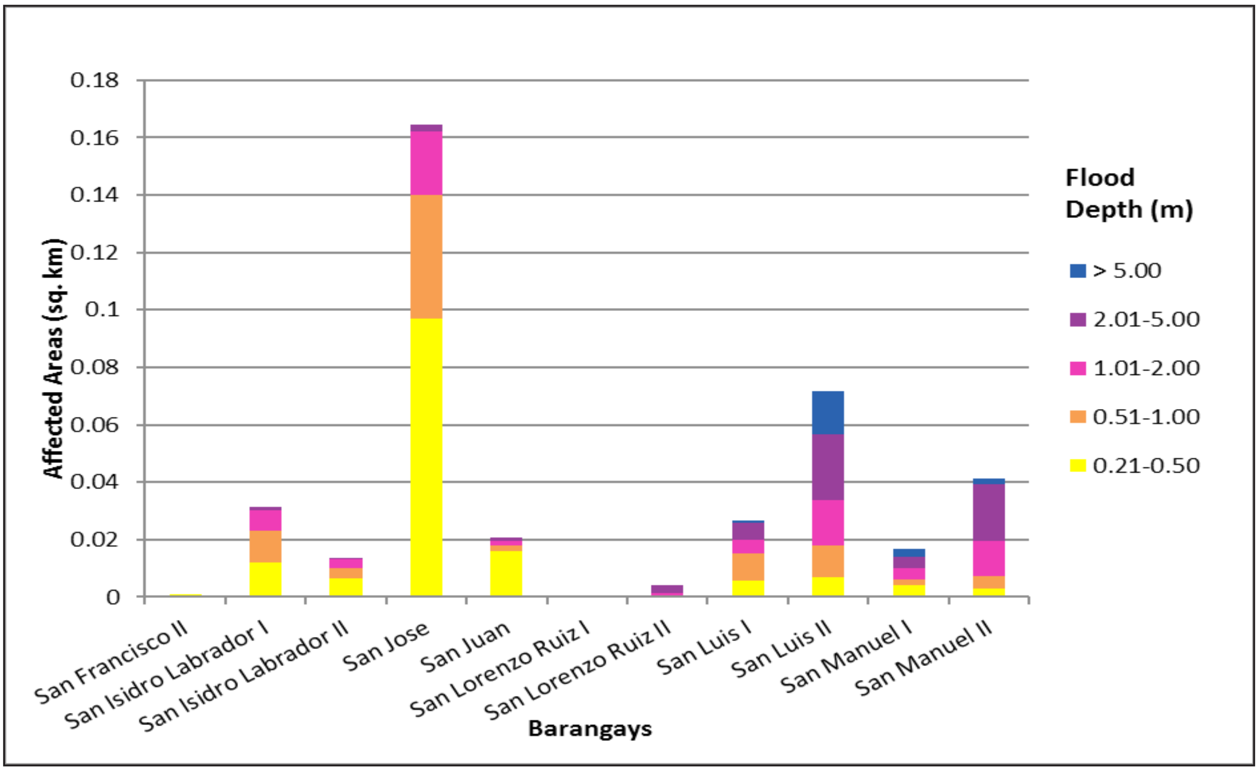


Figure 77. Affected Areas in Dasmariñas, Cavite during 5-year Rainfall Return Period

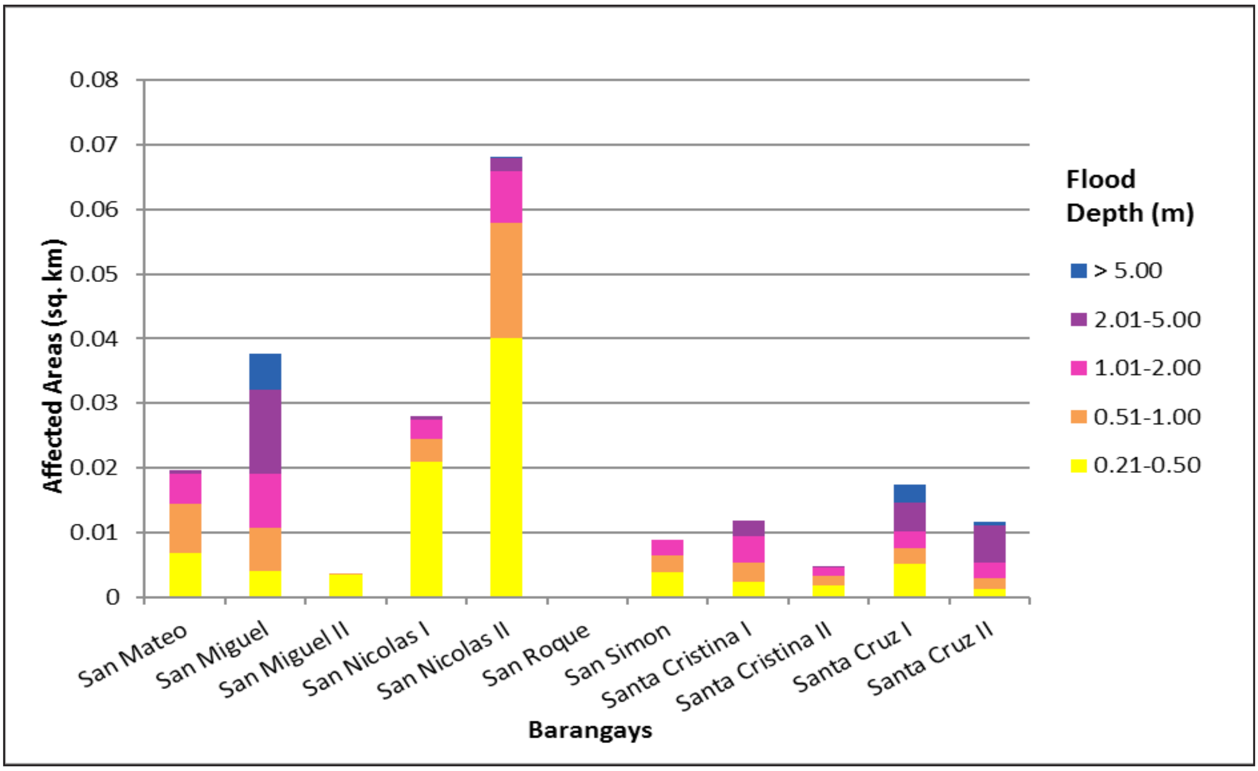


Figure 78. Affected Areas in Dasmariñas, Cavite during 5-year Rainfall Return Period

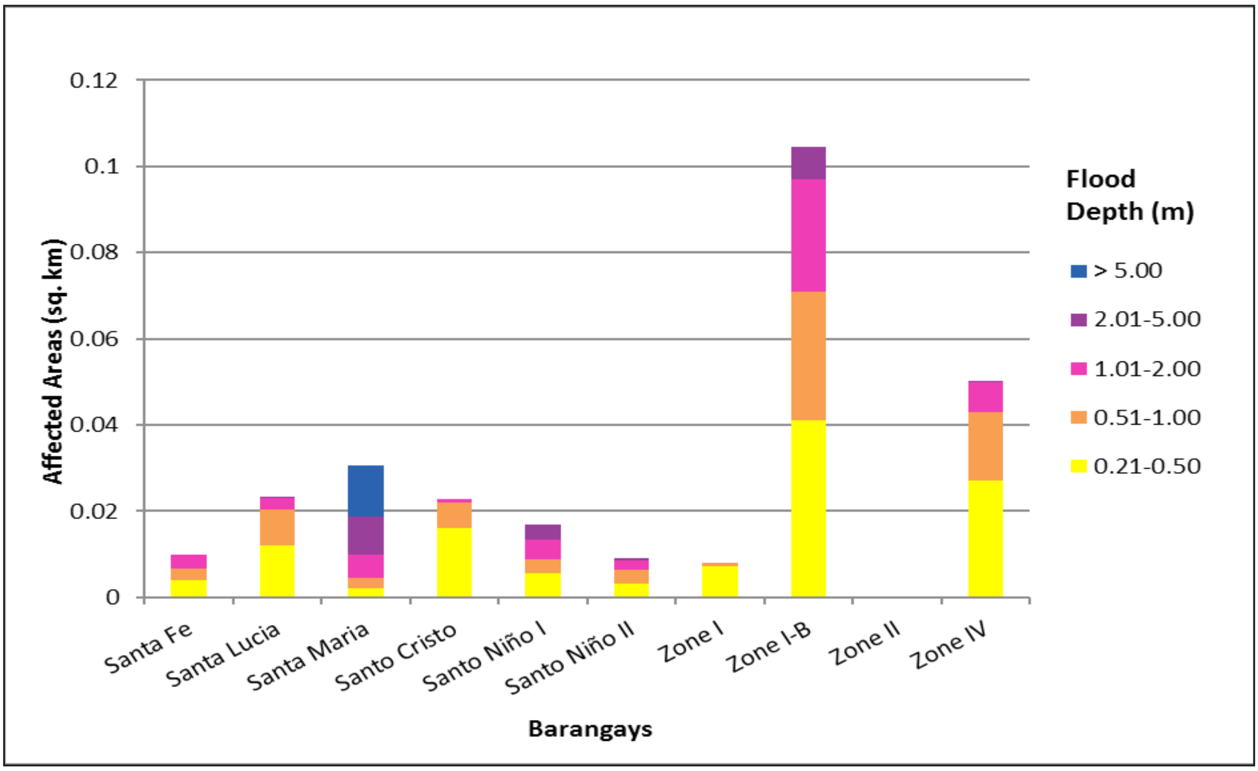


Figure 79. Affected Areas in Dasmariñas, Cavite during 5-year Rainfall Return Period

For the 5-year return period, 31.95% of the municipality of Imus with an area of 56.81 sq. km. will experience flood levels of less than 0.20 meters. 12.19% of the area will experience flood levels of 0.21 to 0.50 meters while 12.48%, 4.71%, 1.08%, and 0.41% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 45 to Table 52 and shown in Figure 80 to Figure 87 are the affected areas in square kilometers by flood depth per barangay.

Table 45. Affected Areas in Imus, Cavite during 5-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)										
	Anabu I-A	Anabu I-B	Anabu I-C	Anabu I-D	Anabu I-E	Anabu I-F	Anabu I-G	Anabu II-A	Anabu II-B	Anabu II-C	Anabu II-D
0.03-0.20	0.44	0.16	0.074	0.086	0.12	0.13	0.17	4.03	0.25	0.35	0.32
0.21-0.50	0.32	0.1	0.069	0.069	0.083	0.099	0.084	0.63	0.12	0.21	0.19
0.51-1.00	0.22	0.055	0.082	0.13	0.17	0.11	0.13	0.64	0.11	0.13	0.17
1.01-2.00	0.066	0.015	0.03	0.029	0.027	0.026	0.044	0.36	0.045	0.067	0.052
2.01-5.00	0.015	0.012	0.0045	0.01	0.0032	0.0042	0.0089	0.18	0.01	0.017	0.021
> 5.00	0.000065	0.0001	0.0057	0.005	0.007	0.0068	0.0072	0.1	0	0	0.012

Table 46. Affected Areas in Imus, Cavite during 5-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)										
	Anabu II-E	Anabu II-F	Bagong Silang	Bayan Luma I	Bayan Luma II	Bayan Luma III	Bayan Luma IV	Bayan Luma IX	Bayan Luma V	Bayan Luma VI	Bayan Luma VII
0.03-0.20	0.47	0.64	0.086	0.0098	0.02	0.011	0.064	0.045	0.022	0.022	0.11
0.21-0.50	0.3	0.31	0.018	0.017	0.026	0.04	0.051	0.061	0.035	0.027	0.055
0.51-1.00	0.25	0.27	0.03	0.049	0.048	0.091	0.025	0.023	0.03	0.03	0.014
1.01-2.00	0.067	0.065	0.028	0.032	0.026	0.03	0	0.0021	0.0025	0.0097	0
2.01-5.00	0.026	0.022	0	0.0049	0.0053	0.006	0	0	0	0	0
> 5.00	0.0039	0.0098	0	0.0005	0	0	0	0	0	0	0

Table 47. Affected Areas in Imus, Cavite during 5-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)										
	Bayan Luma VIII	Bucandala I	Bucandala II	Bucandala III	Bucandala V	Buhay na Tubig	Carsadang Bago I	Carsadang Bago II	Magdalo	Maharlika	Malagasang I-B
0.03-0.20	0.15	0.17	0.045	0.2	0.016	0.098	0.3	0.42	0.071	0.017	0.0056
0.21-0.50	0.076	0.18	0.053	0.093	0.099	0.022	0.38	0.24	0.023	0.021	0.014
0.51-1.00	0.0087	0.2	0.017	0.047	0.11	0.03	0.17	0.071	0.043	0.043	0.0028
1.01-2.00	0	0.062	0.00094	0	0.0051	0.032	0.077	0.013	0.011	0.048	0
2.01-5.00	0	0.0011	0	0	0.00021	0	0.0018	0	0	0.012	0
> 5.00	0	0	0	0	0.000035	0	0	0	0	0.0064	0

Table 48. Affected Areas in Imus, Cavite during 5-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)										
	Mala-gasang I-C	Mala-gasang I-D	Mala-gasang I-E	Mala-gasang I-F	Mala-gasang I-G	Mala-gasang II-C	Mala-gasang II-D	Mala-gasang II-E	Mala-gasang II-F	Mala-gasang II-G	Mariano Espeleta I
0.03-0.20	0.0022	0.0021	0.0052	0.034	0.063	0.09	0.051	0.029	0.22	0.063	0.022
0.21-0.50	0.0018	0.0025	0.017	0.13	0.14	0.071	0.048	0.12	0.087	0.1	0.017
0.51-1.00	0	0.0008	0.018	0.17	0.15	0.069	0.026	0.26	0.049	0.13	0.048
1.01-2.00	0	0	0.0021	0.0086	0.004	0.022	0.00021	0.049	0.015	0.013	0.038
2.01-5.00	0	0	0	0.0011	0	0.0074	0	0.0056	0.0023	0	0
> 5.00	0	0	0	0.00041	0	0	0	0	0	0	0

Table 49. Affected Areas in Imus, Cavite during 5-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)										
	Mariano Espeleta II	Mariano Espeleta III	Medicion I-A	Medicion I-B	Medicion I-C	Medicion I-D	Medicion II-B	Medicion II-C	Medicion II-D	Medicion II-E	Medicion II-F
0.03-0.20	0.0011	0.0029	0.049	0.054	0.02	0.03	0.0007	0.071	0.029	0.054	0.11
0.21-0.50	0.0072	0.029	0.0059	0.015	0.026	0.0075	0.0017	0.024	0.023	0.02	0.023
0.51-1.00	0.034	0.039	0.0047	0.0083	0.018	0.035	0.0019	0.011	0.014	0.0059	0.0014
1.01-2.00	0.045	0.019	0.0013	0.0028	0.000029	0.015	0	0	0.013	0	0
2.01-5.00	0	0.0042	0	0	0	0	0	0	0	0	0
> 5.00	0	0.0049	0	0	0	0	0	0	0	0	0

Table 50. Affected Areas in Imus, Cavite during 5-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)									
	Pag-Asa III	Palico I	Palico II	Palico III	Palico IV	Pasong Buaya I	Pasong Buaya II	Pinag-buklod	Poblacion I-A	Poblacion I-B
0.03-0.20	0.11	0.044	0.0073	0.028	0.018	3.72	3.36	0.017	0.02	0.0028
0.21-0.50	0.041	0.016	0.013	0.014	0.019	0.27	0.65	0.031	0.047	0.01
0.51-1.00	0.0076	0.0054	0.0074	0.019	0.007	0.24	0.37	0.096	0.081	0.05
1.01-2.00	0	0.0034	0.0064	0.0053	0.0004	0.16	0.13	0.049	0.002	0.01
2.01-5.00	0	0.0066	0.0055	0.0085	0	0.069	0.07	0.0056	0	0
> 5.00	0	0.0069	0.0052	0.0083	0	0.0025	0.0042	0.0083	0	0

Table 51. Affected Areas in Imus, Cavite during 5-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)									
	Poblacion I-C	Poblacion II-A	Poblacion II-B	Poblacion III-A	Poblacion III-B	Poblacion IV-A	Poblacion IV-B	Poblacion IV-C	Poblacion IV-D	Tanzang Luma I
0.03-0.20	0.0013	0.0033	0.0057	0.027	0.025	0.052	0.0018	0.037	0.0089	0.29
0.21-0.50	0.011	0.013	0.011	0.048	0.042	0.12	0.015	0.081	0.035	0.093
0.51-1.00	0.058	0.05	0.03	0.12	0.031	0.082	0.014	0.078	0.14	0.055
1.01-2.00	0.006	0.0093	0.0025	0.048	0.018	0.019	0.025	0.016	0.051	0.0013
2.01-5.00	0	0	0	0.0065	0.0029	0.0053	0.00031	0	0	0
> 5.00	0	0	0	0	0	0	0	0	0	0

Table 52. Affected Areas in Imus, Cavite during 5-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)									
	Tanzang Luma II	Tanzang Luma III	Tanzang Luma IV	Tanzang Luma V	Tanzang Luma VI	Toclong I-A	Toclong I-B	Toclong I-C	Toclong II-A	Toclong II-B
0.03-0.20	0.049	0.07	0.0029	0.0035	0.092	0.0003	0.0015	0.0018	0.0057	0.017
0.21-0.50	0.037	0.032	0.024	0.015	0.079	0.0054	0.014	0.013	0.01	0.084
0.51-1.00	0.043	0.057	0.08	0.1	0.057	0.05	0.1	0.13	0.12	0.17
1.01-2.00	0.025	0.071	0.031	0.1	0.023	0.063	0.069	0.052	0.078	0.08
2.01-5.00	0.0037	0.012	0.011	0.011	0.001	0.0019	0.002	0.004	0	0
> 5.00	0	0.0041	0.0069	0.018	0.0015	0	0	0	0	0

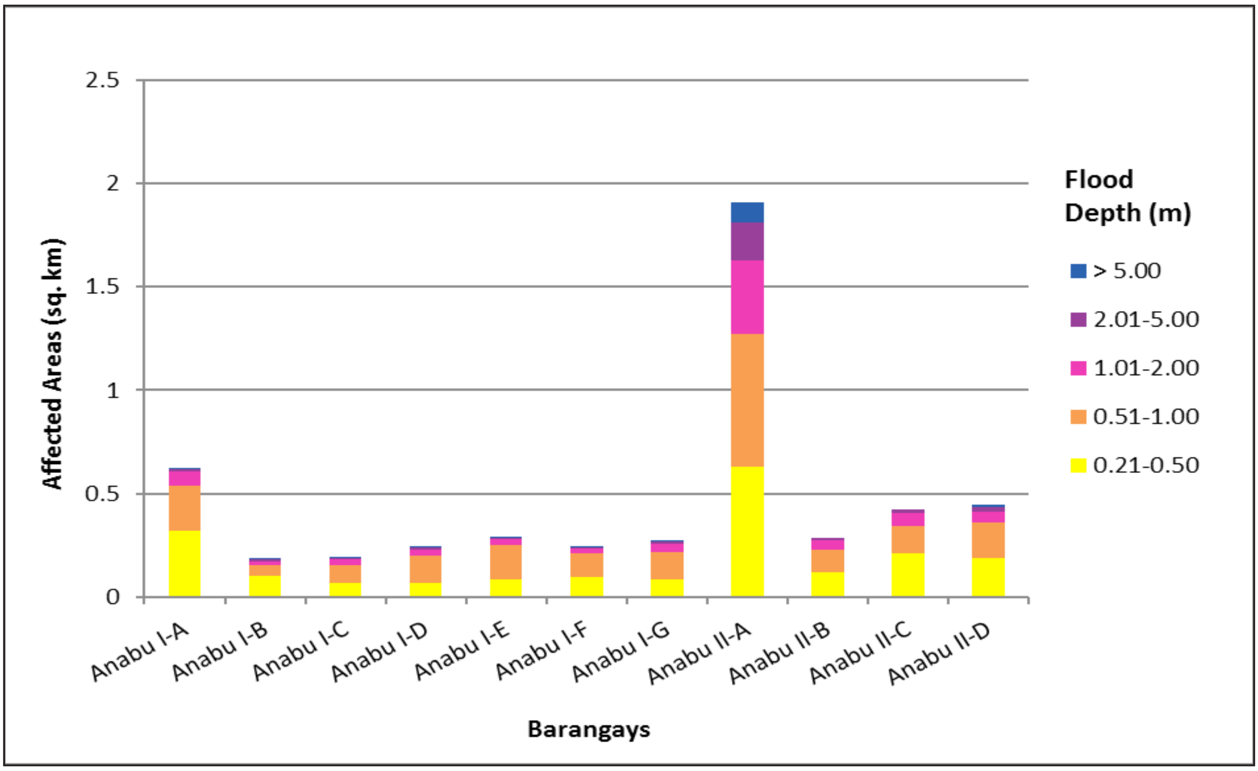


Figure 80. Affected Areas in Dasmariñas, Cavite during 5-year Rainfall Return Period

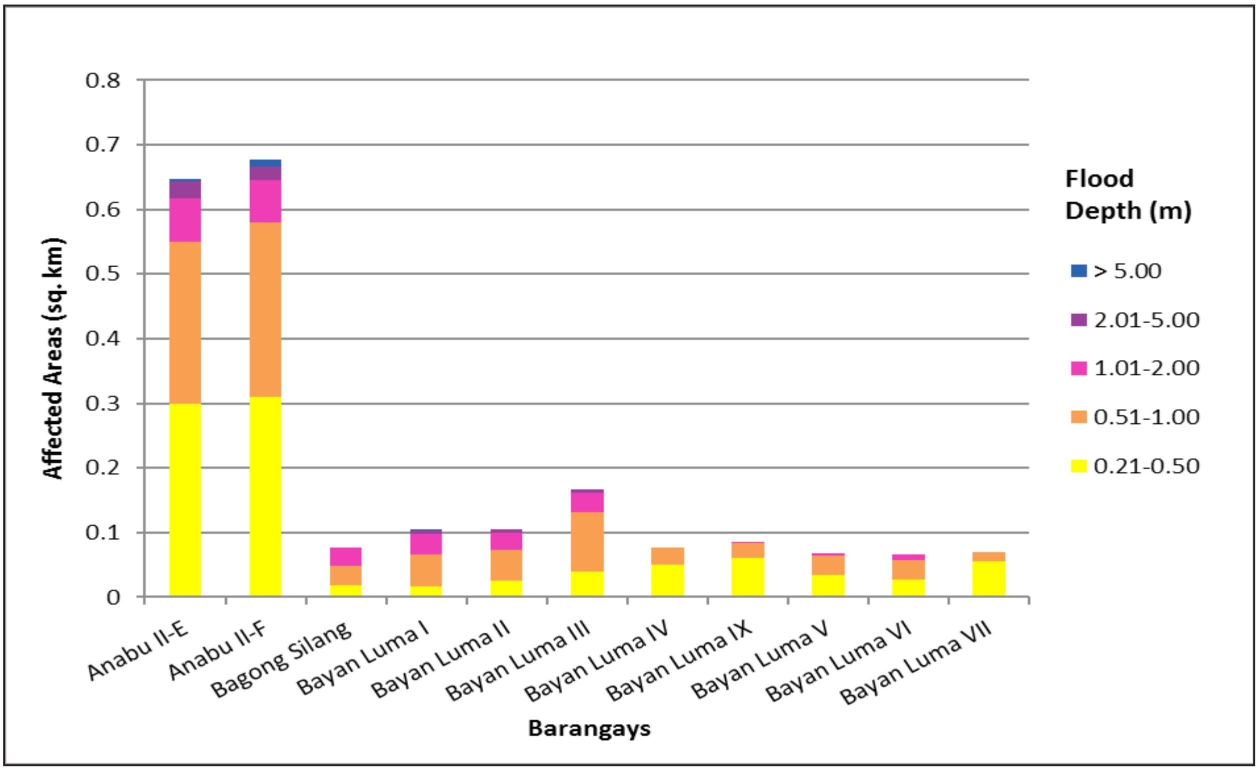


Figure 81. Affected Areas in Dasmariñas, Cavite during 5-year Rainfall Return Period

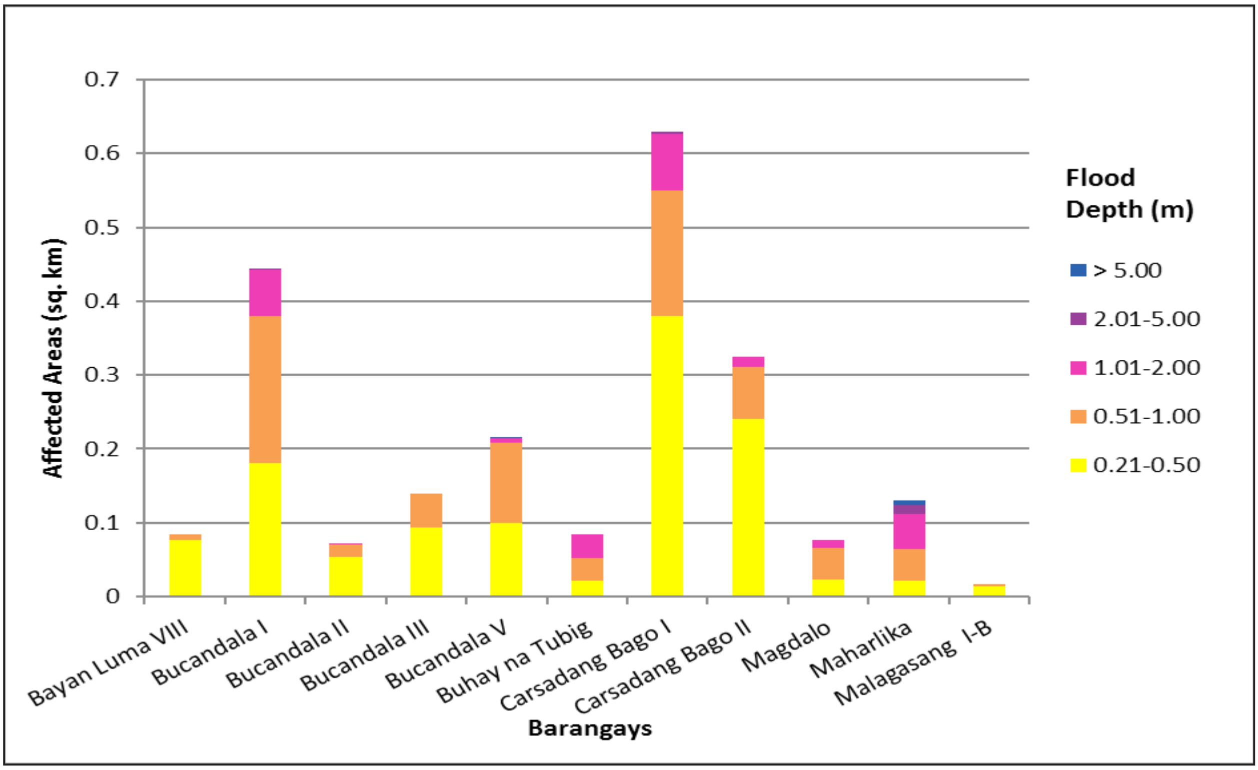


Figure 82. Affected Areas in Dasmariñas, Cavite during 5-year Rainfall Return Period

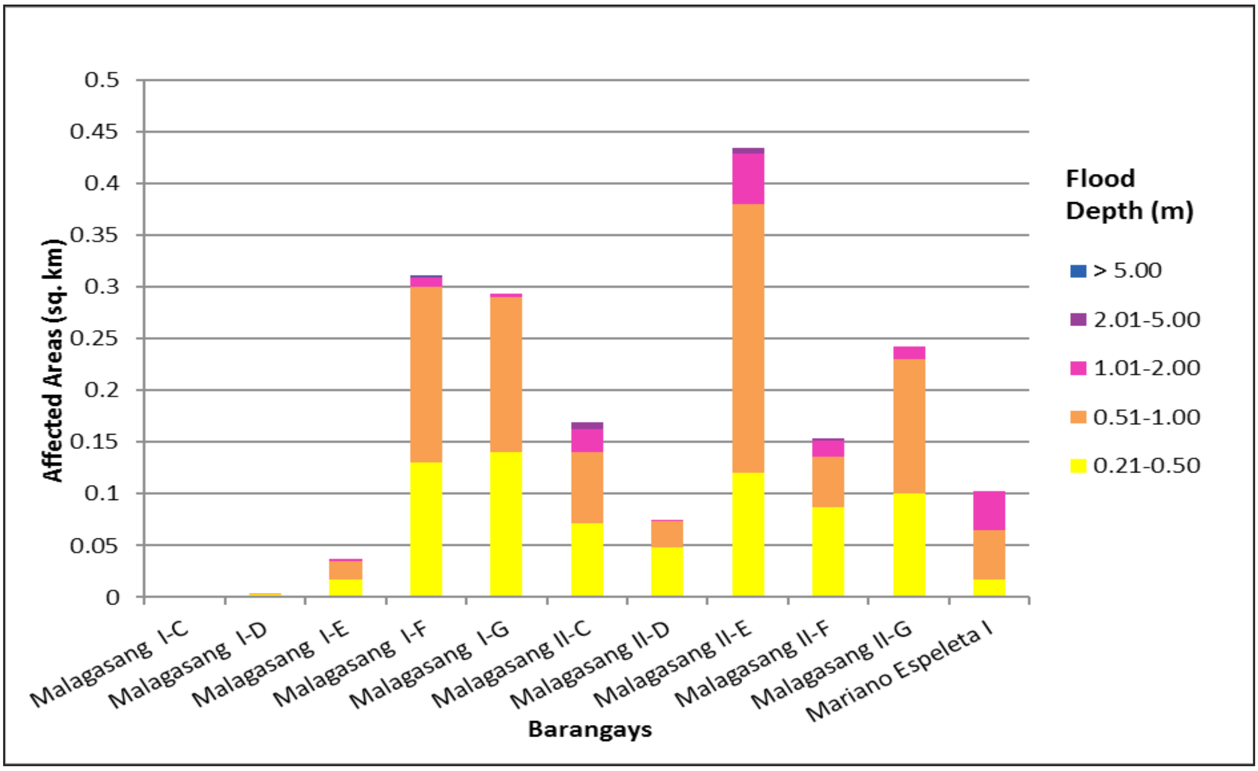


Figure 83. Affected Areas in Dasmariñas, Cavite during 5-year Rainfall Return Period

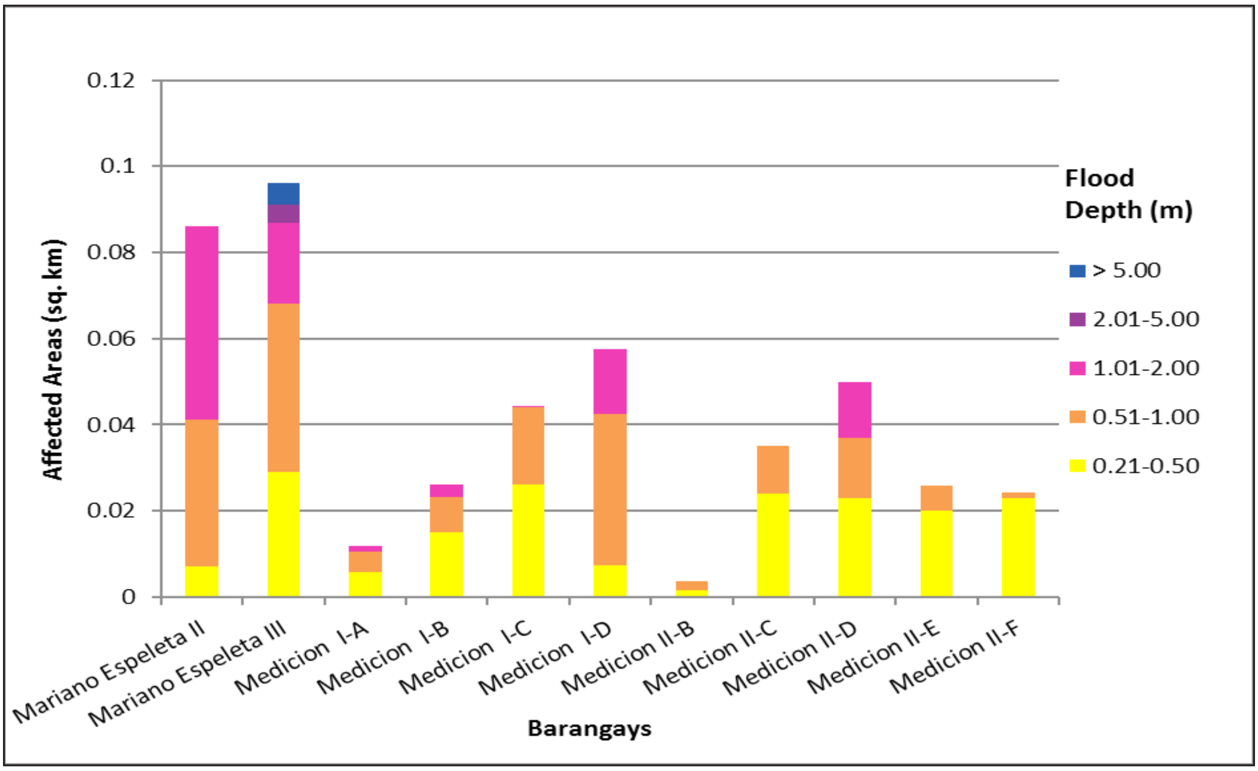


Figure 84. Affected Areas in Dasmariñas, Cavite during 5-year Rainfall Return Period

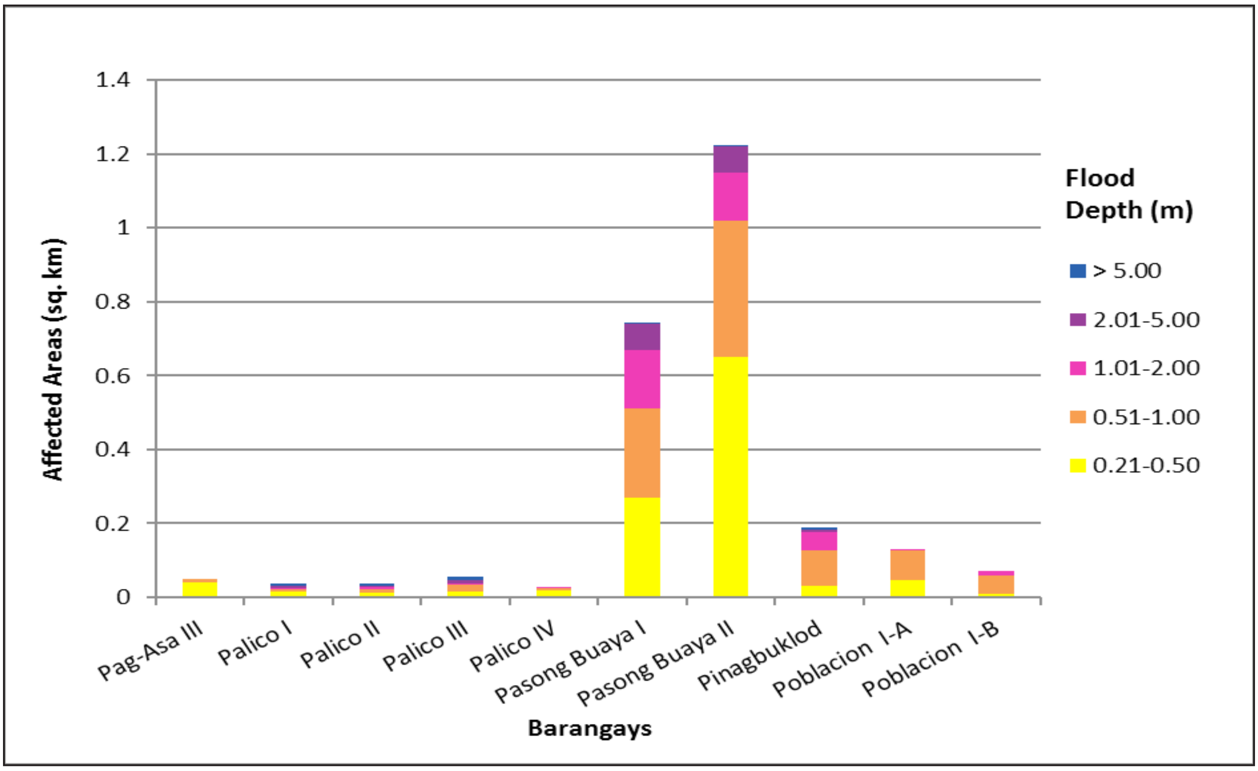


Figure 85. Affected Areas in Dasmariñas, Cavite during 5-year Rainfall Return Period

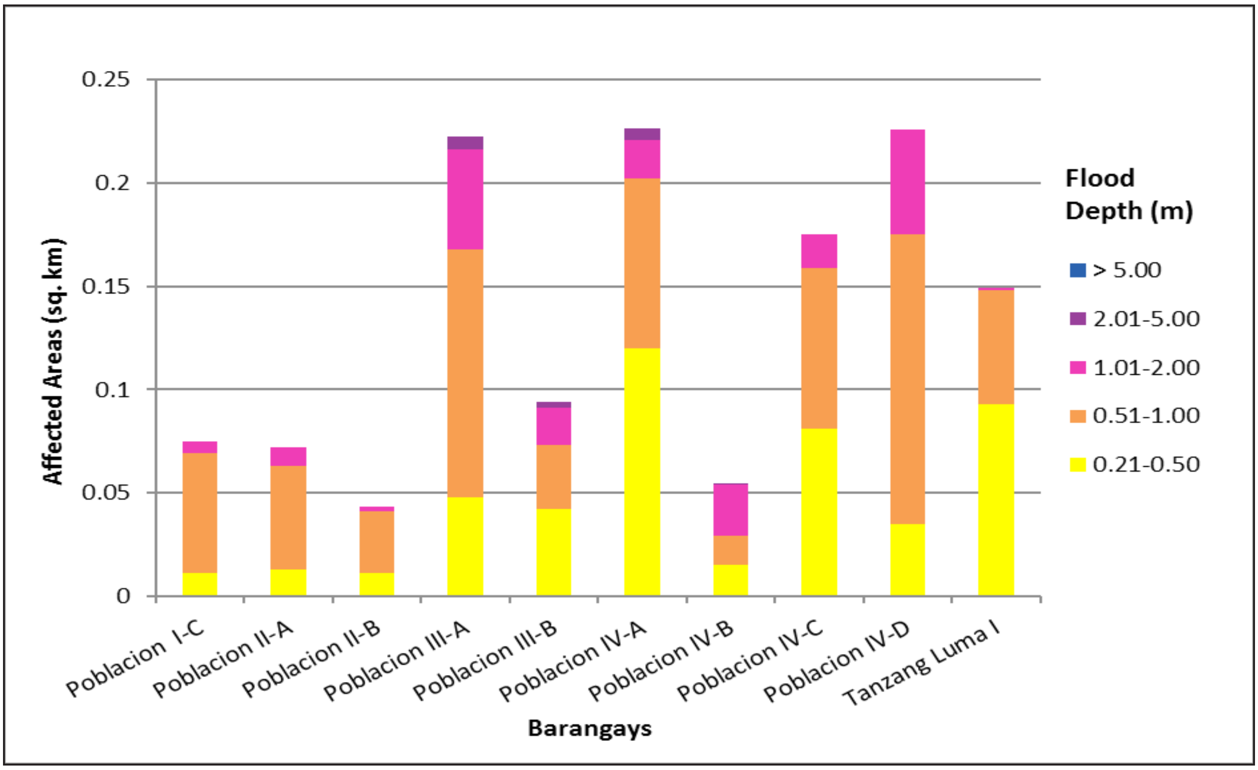


Figure 86. Affected Areas in Dasmariñas, Cavite during 5-year Rainfall Return Period

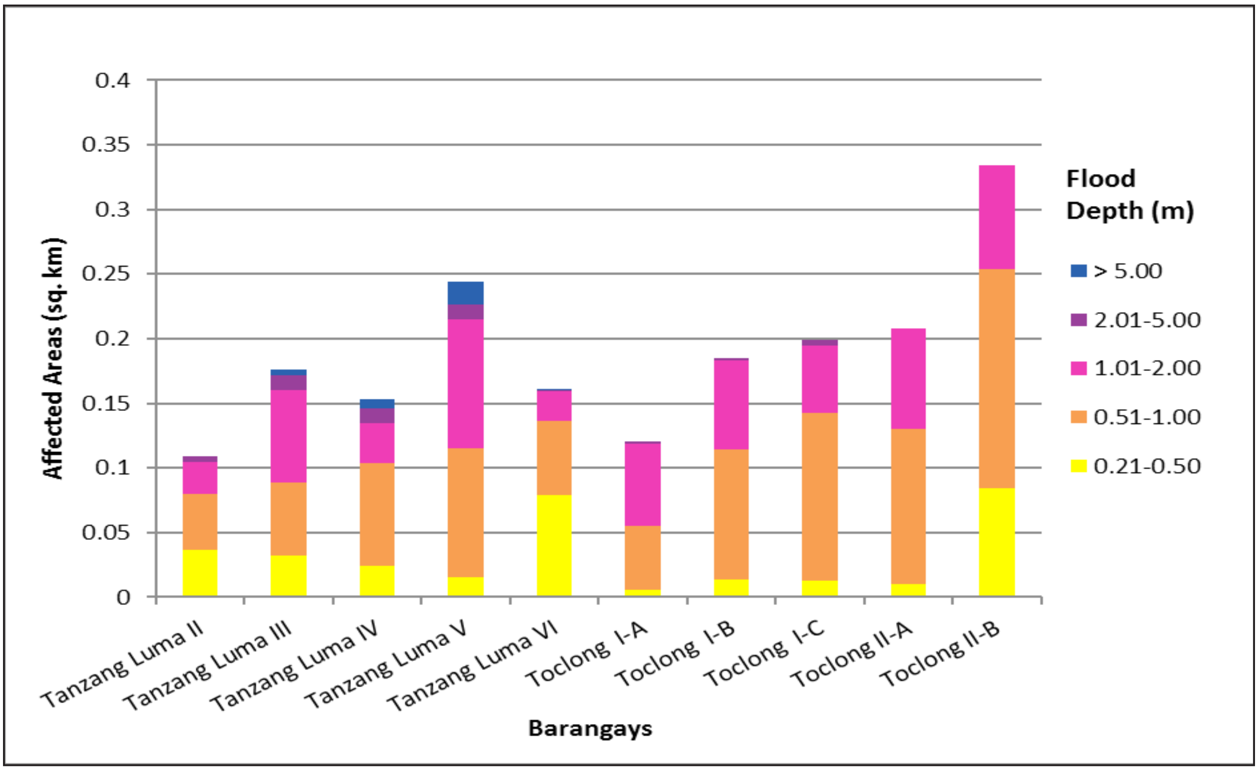


Figure 87. Affected Areas in Dasmariñas, Cavite during 5-year Rainfall Return Period

For the 5-year return period, 1.92% of the municipality of Kawit with an area of 9.47 sq. km. will experience flood levels of less than 0.20 meters. 0.83% of the area will experience flood levels of 0.21 to 0.50 meters while 3.40%, 6.39%, and 0.31% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and 2.01 to 5 meters, respectively. Listed in Table 53 and shown in Figure 88 are the affected areas in square kilometers by flood depth per barangay.

Table 53. Affected Areas in Kawit, Cavite during 5-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Kawit (in sq. km)							
	Balsahan -Bisita	Binakayan -Aplaya	Binakayan -Kanluran	Congbalay -Legaspi	Manggahan -Lawin	Pulvorista	Samala -Marquez	Toclong
0.03-0.20	0.022	0.048	0.0001	0.015	0.019	0.0001	0.0002	0.077
0.21-0.50	0.004	0.013	0.0019	0.0022	0.01	0.00058	0.0017	0.045
0.51-1.00	0.0055	0.0047	0.052	0.0043	0.0084	0.0058	0.041	0.2
1.01-2.00	0.0053	0.0055	0.025	0.0087	0.069	0.1	0.072	0.32
2.01-5.00	0.0033	0.0001	0	0	0.011	0	0.0033	0.012
> 5.00	0	0	0	0	0	0	0	0

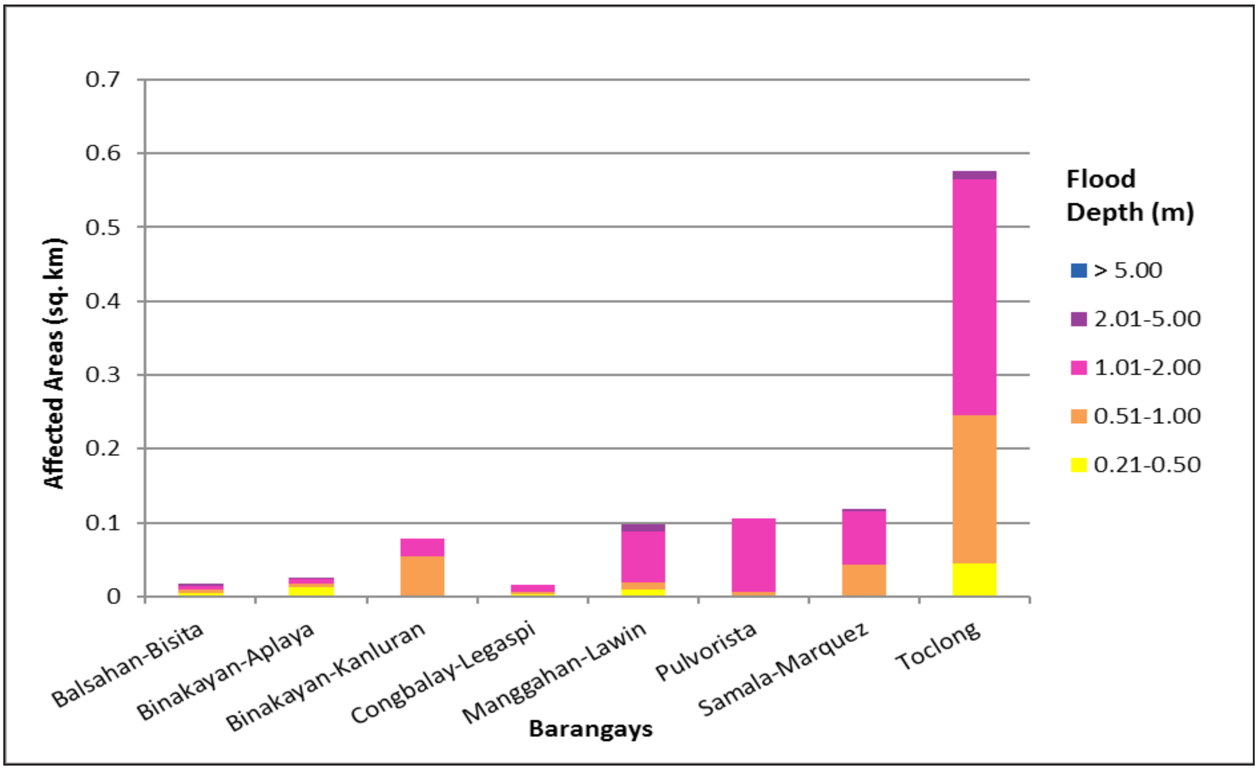


Figure 88. Affected Areas in Dasmariñas, Cavite during 5-year Rainfall Return Period

For the 25-year return period, 11.92% of the municipality of Bacoor with an area of 47.43 sq. km. will experience flood levels of less than 0.20 meters. 5.70% of the area will experience flood levels of 0.21 to 0.50 meters while 8.22%, 6.69%, 2.62%, 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 Table 54 to Table 57 and shown in Figure 89 to Figure 92 are the affected areas in square kilometers by flood depth per barangay.

Table 54. Affected Areas in Bacoor, Cavite during 25-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Bacoor (in sq. km)									
	Alima	Banalo	Bayanan	Campo Santo	Daang Bukid	Digman	Dulong Bayan	Habay I	Habay II	Kaingin
0.03-0.20	0.0014	0.0024	0.005	0.0024	0.049	0.0042	0	0.067	0.077	0.035
0.21-0.50	0.017	0.004	0.0014	0.013	0.025	0.021	0.0041	0.11	0.1	0.056
0.51-1.00	0.11	0.041	0.0007	0.1	0.065	0.065	0.085	0.25	0.15	0.12
1.01-2.00	0.12	0.14	0.000064	0.056	0.21	0.013	0.19	0.13	0.18	0.096
2.01-5.00	0.14	0.12	0	0.068	0.2	0	0.11	0.016	0.23	0.028
> 5.00	0	0.0006	0	0	0	0	0	0	0	0

Table 55. Affected Areas in Bacoor, Cavite during 25-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Bacoor (in sq. km)									
	Mabolo I	Mabolo II	Mabolo III	Maliksi I	Maliksi II	Mambog I	Mambog II	Mambog III	Mambog IV	Mambog V
0.03-0.20	0.0035	0.001	0.0028	0.022	0.00095	0.38	0.69	0.62	0.19	0.11
0.21-0.50	0.0079	0.0046	0.0017	0.032	0.00057	0.44	0.16	0.16	0.11	0.085
0.51-1.00	0.086	0.054	0.0076	0.042	0.011	0.55	0.087	0.064	0.15	0.098
1.01-2.00	0.28	0.11	0.066	0.072	0.0057	0.2	0.013	0.015	0.03	0.035
2.01-5.00	0.053	0.018	0.056	0.044	0.0042	0.0077	0.0001	0.0012	0	0
> 5.00	0.0094	0.00083	0	0	0	0	0	0	0	0

Table 56. Affected Areas in Bacoor, Cavite during 25-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Bacoor (in sq. km)								
	Molino II	Molino III	Molino IV	Molino V	P.F. Espiritu I	P.F. Espiritu II	P.F. Espiritu III	P.F. Espiritu IV	P.F. Espiritu V
0.03-0.20	0.51	0.24	0.038	0.66	0.095	0.057	0.071	0.017	0.0077
0.21-0.50	0.041	0.03	0.0064	0.19	0.075	0.069	0.069	0.031	0.013
0.51-1.00	0.027	0.006	0.0001	0.14	0.05	0.11	0.058	0.072	0.08
1.01-2.00	0.014	0.0064	0	0.055	0.014	0.067	0.01	0.058	0.045
2.01-5.00	0.0021	0.0001	0	0.005	0	0.00098	0	0.00052	0.0009
> 5.00	0	0	0	0	0	0	0	0	0

Table 57. Affected Areas in Bacoor, Cavite during 25-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Bacoor (in sq. km)								
	Queens Row East	Real I	Real II	Salinas I	Salinas II	Salinas III	Salinas IV	Sineguelasan	Tabing Dagat
0.03-0.20	1.09	0.13	0.2	0.00075	0.0017	0.017	0.053	0.2	0.00047
0.21-0.50	0.13	0.3	0.19	0.014	0.0083	0.039	0.093	0.049	0.0021
0.51-1.00	0.09	0.4	0.23	0.087	0.07	0.061	0.13	0.12	0.033
1.01-2.00	0.054	0.18	0.19	0.13	0.12	0.038	0.081	0.13	0.02
2.01-5.00	0.02	0.0076	0.024	0.0012	0.01	0.018	0	0.043	0.015
> 5.00	0	0.0069	0.014	0.00096	0.0056	0.0083	0	0	0

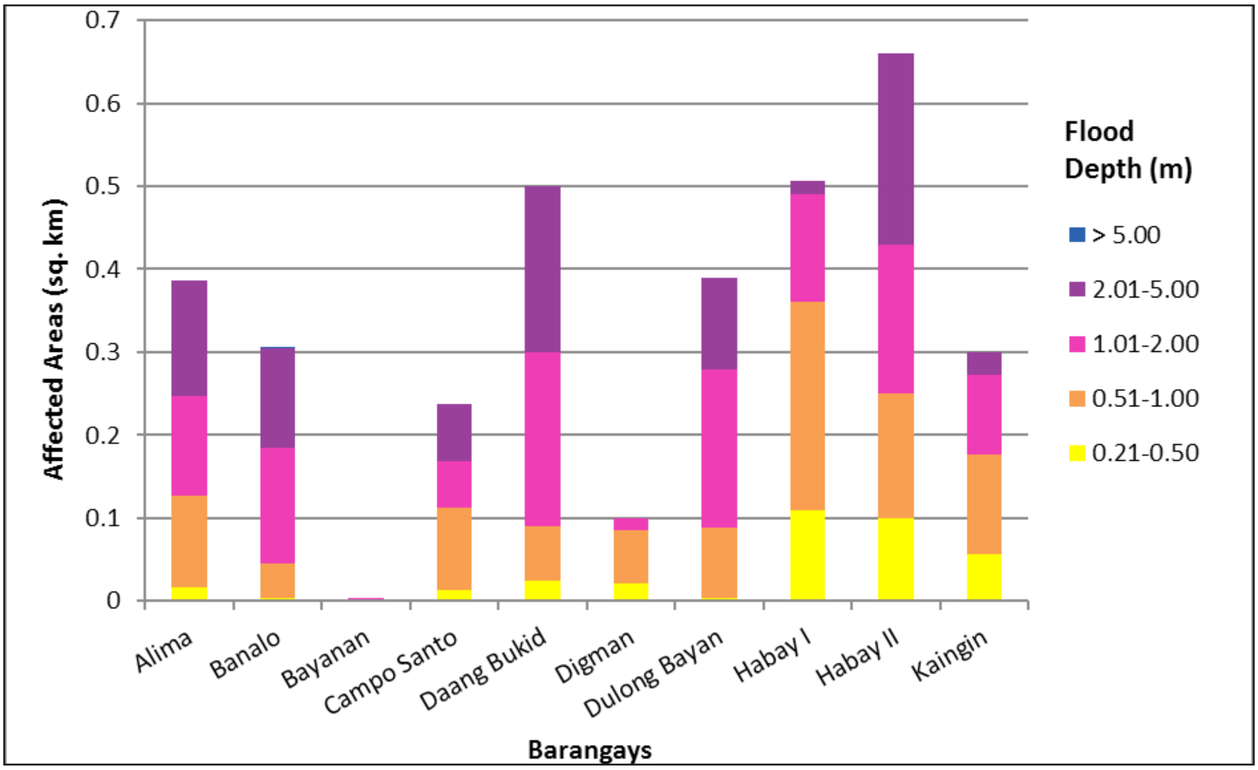


Figure 89. Affected Areas in Bacoor, Cavite during 25-year Rainfall Return Period

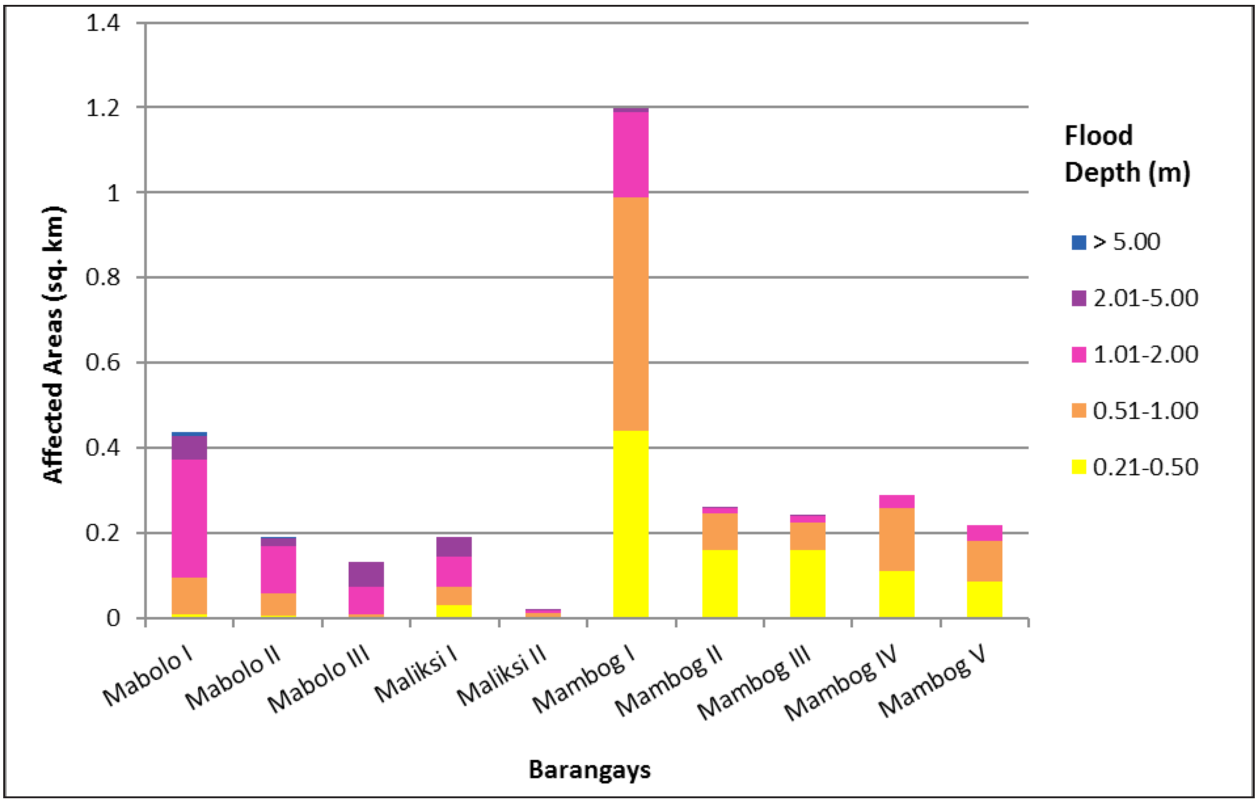


Figure 90. Affected Areas in Bacoor, Cavite during 25-year Rainfall Return Period

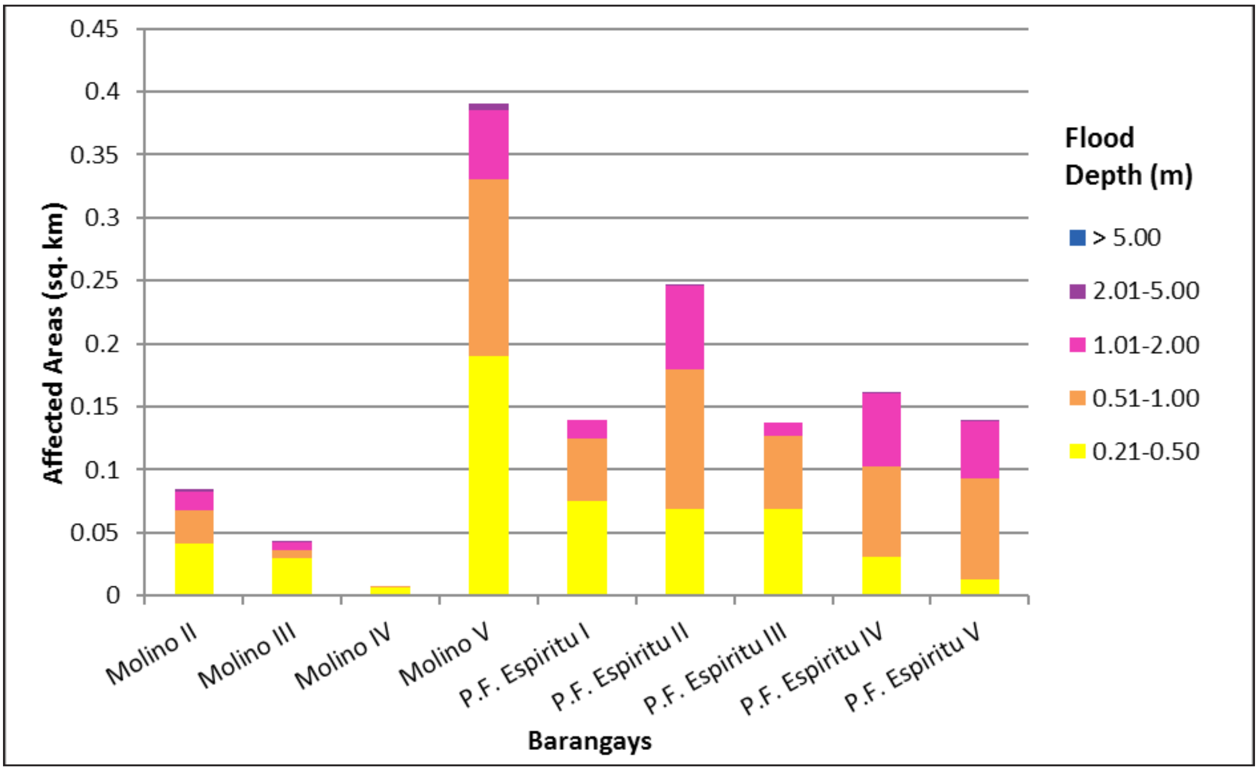


Figure 91. Affected Areas in Bacoor, Cavite during 25-year Rainfall Return Period

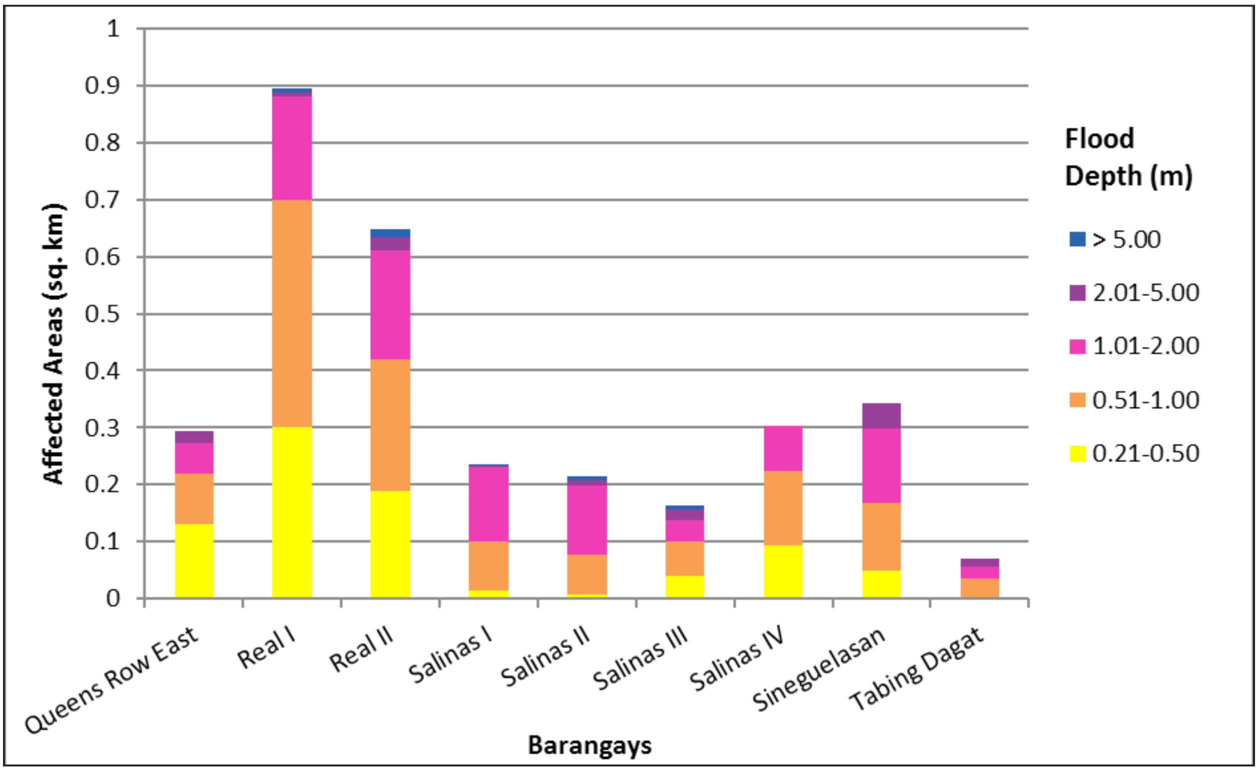


Figure 92. Affected Areas in Bacoor, Cavite during 25-year Rainfall Return Period

For the 25-year return period, 32.50% of the municipality of Dasmariñas with an area of 84.01 sq. km. will experience flood levels of less than 0.20 meters. 3.56% of the area will experience flood levels of 0.21 to 0.50 meters while 2.25%, 1.78%, 1.15%, and 0.41% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 58 to Table 63 and shown in Figure 93 to Figure 98 are the affected areas in square kilometers by flood depth per barangay.

Table 58. Affected Areas in Dasmariñas, Cavite during 25-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Dasmariñas (in sq. km)										
	Burol	Burol I	Burol II	Burol III	Datu Esmael	Emmanuel Bergado I	Emmanuel Bergado II	Fatima I	Fatima II	Fatima III	Luzviminda I
0.03-0.20	1.96	0.16	0.12	0.28	0.16	0.057	0.037	0.083	0.11	0.2	0.093
0.21-0.50	0.19	0.0053	0.02	0.019	0.0085	0.0025	0.0025	0.005	0.00017	0.02	0.0041
0.51-1.00	0.12	0.0069	0.0057	0.015	0.0088	0.0046	0.0023	0.0017	0	0.016	0.0029
1.01-2.00	0.076	0.014	0.009	0.014	0.013	0.0049	0.0045	0.0016	0	0.0056	0.0011
2.01-5.00	0.049	0.013	0.0039	0.0077	0.017	0.0082	0.0082	0.00013	0	0.0035	0.0001
> 5.00	0.0083	0.015	0.0042	0	0.013	0.011	0.0086	7.7E-06	0	0.00023	0

Table 59. Affected Areas in Dasmariñas, Cavite during 25-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Dasmariñas (in sq. km)										
	Luzviminda II	Paliparan II	Paliparan III	Sabang	Saint Peter I	Saint Peter II	Salawag	Salitran I	Salitran II	Salitran III	Salitran IV
0.03-0.20	0.29	0.56	2.13	0.64	0.028	0.061	8.68	0.65	1.04	0.38	2.38
0.21-0.50	0.036	0.046	0.22	0.35	0.0016	0.0061	0.63	0.22	0.11	0.098	0.27
0.51-1.00	0.014	0.019	0.059	0.25	0.0026	0.0052	0.39	0.18	0.065	0.18	0.19
1.01-2.00	0.0033	0.018	0.035	0.17	0.0035	0.0063	0.36	0.11	0.035	0.18	0.15
2.01-5.00	0	0.014	0.042	0.066	0.0026	0.01	0.32	0.028	0.024	0.054	0.076
> 5.00	0	0.0048	0.048	0.0001	0.0013	0.0034	0.13	0.0002	0.0008	0.012	0.01

Table 60. Affected Areas in Dasmariñas, Cavite during 25-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Dasmariñas (in sq. km)										
	Sampaloc IV	San Agustin I	San Agustin II	San Agustin III	San Andres I	San Andres II	San Antonio de Padua I	San Antonio de Padua II	San Dionisio	San Esteban	San Francisco I
0.03-0.20	0.15	0.7	0.8	0.16	0.014	0.024	0.026	0.059	0.25	0.079	0.043
0.21-0.50	0.018	0.086	0.099	0.023	0.0018	0.00064	0.001	0.0024	0.017	0.0095	0.0011
0.51-1.00	0.0013	0.021	0.036	0.013	0.0022	0.0021	0.00067	0.0005	0.016	0.0044	0.0009
1.01-2.00	0.0004	0.0077	0.014	0.0074	0.0034	0.0021	0.0011	0.0016	0.02	0.0036	0.0017
2.01-5.00	0.0022	0.0079	0.0025	0.0006	0.0004	0.00031	0.002	0.0022	0.017	0.0018	0.0008
> 5.00	0.0015	0.0031	2.3E-06	0	0	0	0.00065	0.0012	0	0	0

Table 61. Affected Areas in Dasmariñas, Cavite during 25-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Dasmariñas (in sq. km)										
	San Francisco II	San Isidro Labrador I	San Isidro Labrador II	San Jose	San Juan	San Lorenzo Ruiz I	San Lorenzo Ruiz II	San Luis I	San Luis II	San Manuel I	San Manuel II
0.03-0.20	0.025	0.16	0.061	1.05	0.15	0.037	0.05	0.29	0.16	0.041	0.023
0.21-0.50	0.0015	0.013	0.0092	0.12	0.023	0.0014	0.00036	0.0085	0.0072	0.0066	0.0038
0.51-1.00	0	0.013	0.0047	0.06	0.0026	0	0.00042	0.0093	0.01	0.0026	0.0055
1.01-2.00	0	0.012	0.0041	0.032	0.002	0	0.0009	0.0099	0.019	0.0028	0.01
2.01-5.00	0	0.0028	0.0001	0.0098	0.0022	0	0.0033	0.006	0.038	0.0065	0.026
> 5.00	0	0	0	0	0	0	8.6E-06	0.0023	0.023	0.0038	0.0067

Table 62. Affected Areas in Dasmariñas, Cavite during 25-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Dasmariñas (in sq. km)										
	San Mateo	San Miguel	San Miguel II	San Nicolas I	San Nicolas II	San Roque	San Simon	Santa Cristina I	Santa Cristina II	Santa Cruz I	Santa Cruz II
0.03-0.20	0.1	0.051	0.035	0.2	0.51	0.015	0.074	0.03	0.034	0.16	0.092
0.21-0.50	0.0061	0.0047	0.0043	0.029	0.052	0.000069	0.005	0.0043	0.0029	0.01	0.0018
0.51-1.00	0.008	0.0066	0.002	0.0042	0.023	0	0.0037	0.0027	0.0019	0.0023	0.001
1.01-2.00	0.0075	0.011	0.00004	0.004	0.013	0	0.0034	0.0047	0.0017	0.0038	0.0029
2.01-5.00	0.0013	0.019	0	0.0008	0.0017	0	0	0.0044	0.00084	0.0067	0.0059
> 5.00	0	0.01	0	0	0.00078	0	0	0	0	0.0042	0.0019

Table 63. Affected Areas in Dasmariñas, Cavite during 25-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Dasmariñas (in sq. km)									
	Santa Fe	Santa Lucia	Santa Maria	Santo Cristo	Santo Niño I	Santo Niño II	Zone I	Zone I-B	Zone II	Zone IV
0.03-0.20	0.021	0.23	0.04	0.1	0.086	0.029	0.11	0.62	0.035	0.28
0.21-0.50	0.0042	0.018	0.0044	0.021	0.0068	0.0036	0.011	0.051	0.00021	0.034
0.51-1.00	0.004	0.01	0.0037	0.0069	0.0048	0.0031	0.00093	0.036	0	0.018
1.01-2.00	0.0041	0.0083	0.007	0.0026	0.0038	0.0037	0	0.028	0	0.013
2.01-5.00	0	0.00071	0.013	0	0.0068	0.001	0	0.02	0	0.00064
> 5.00	0	0	0.017	0	0	0	0	0	0	0

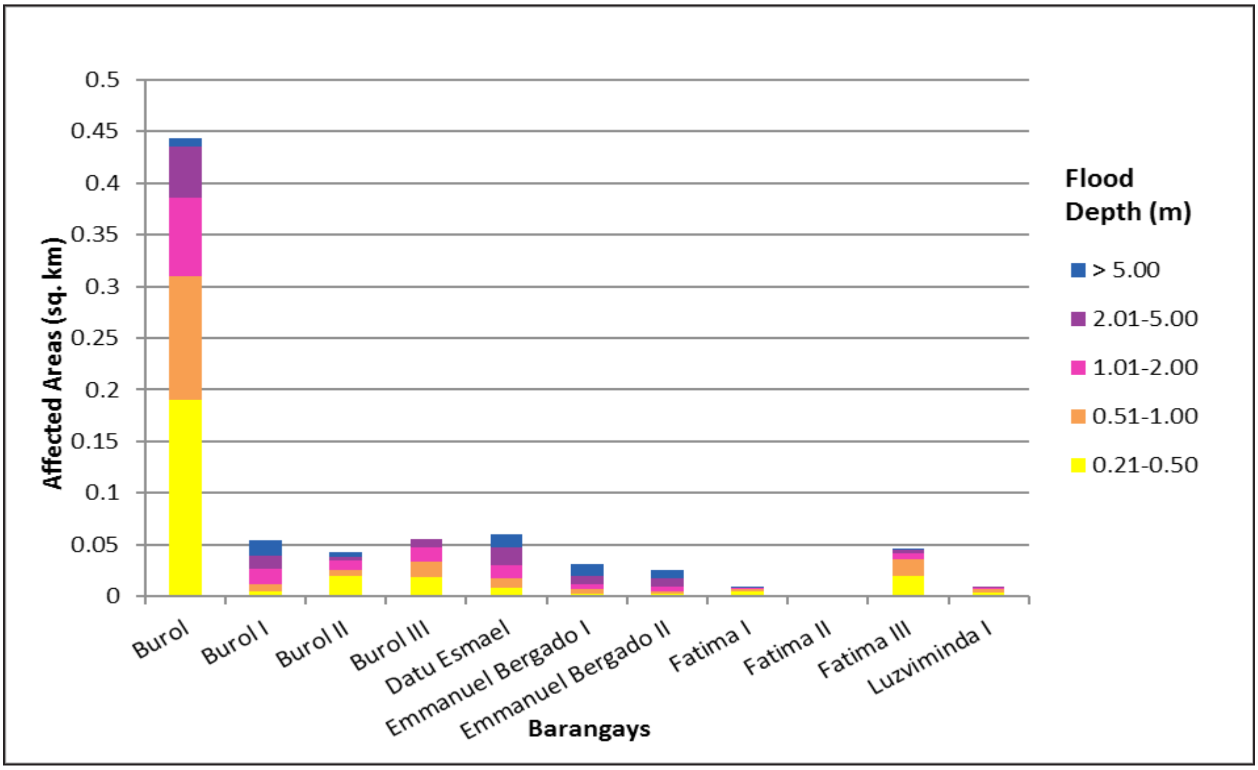


Figure 93. Affected Areas in Dasmariñas, Cavite during 25-year Rainfall Return Period

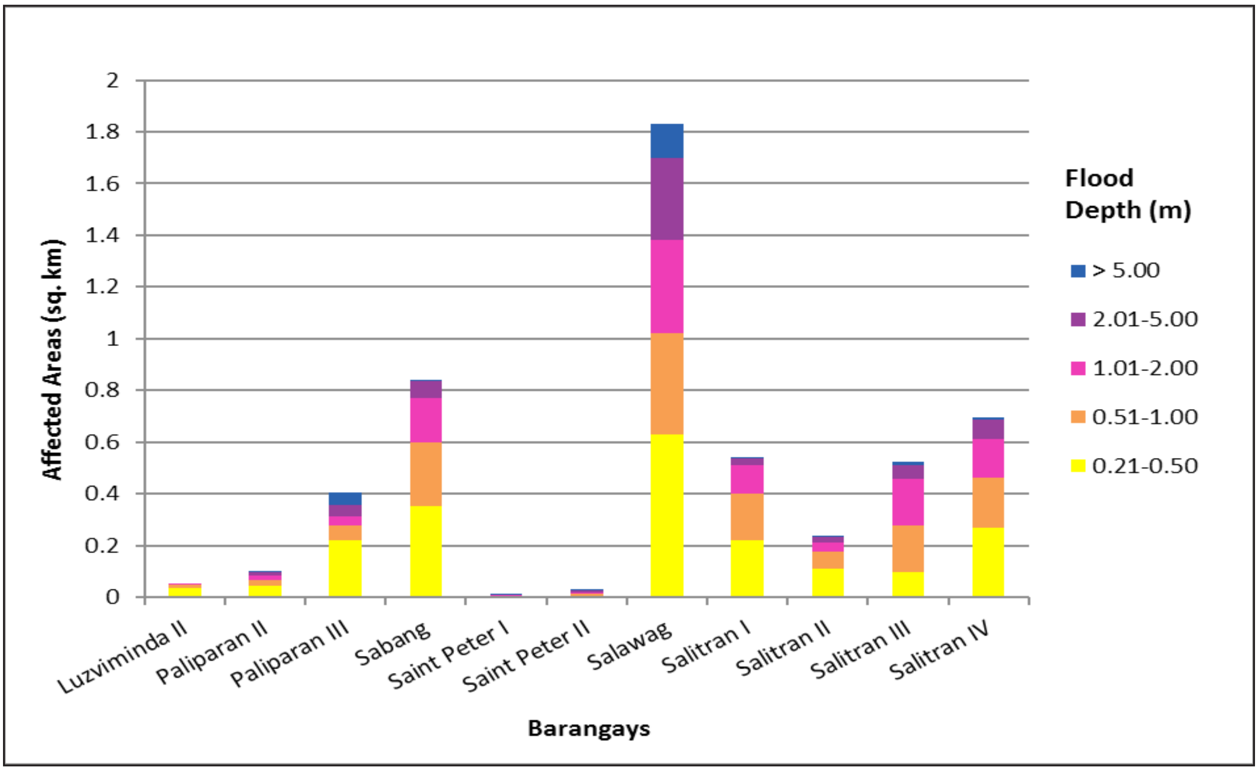


Figure 94. Affected Areas in Dasmariñas, Cavite during 25-year Rainfall Return Period

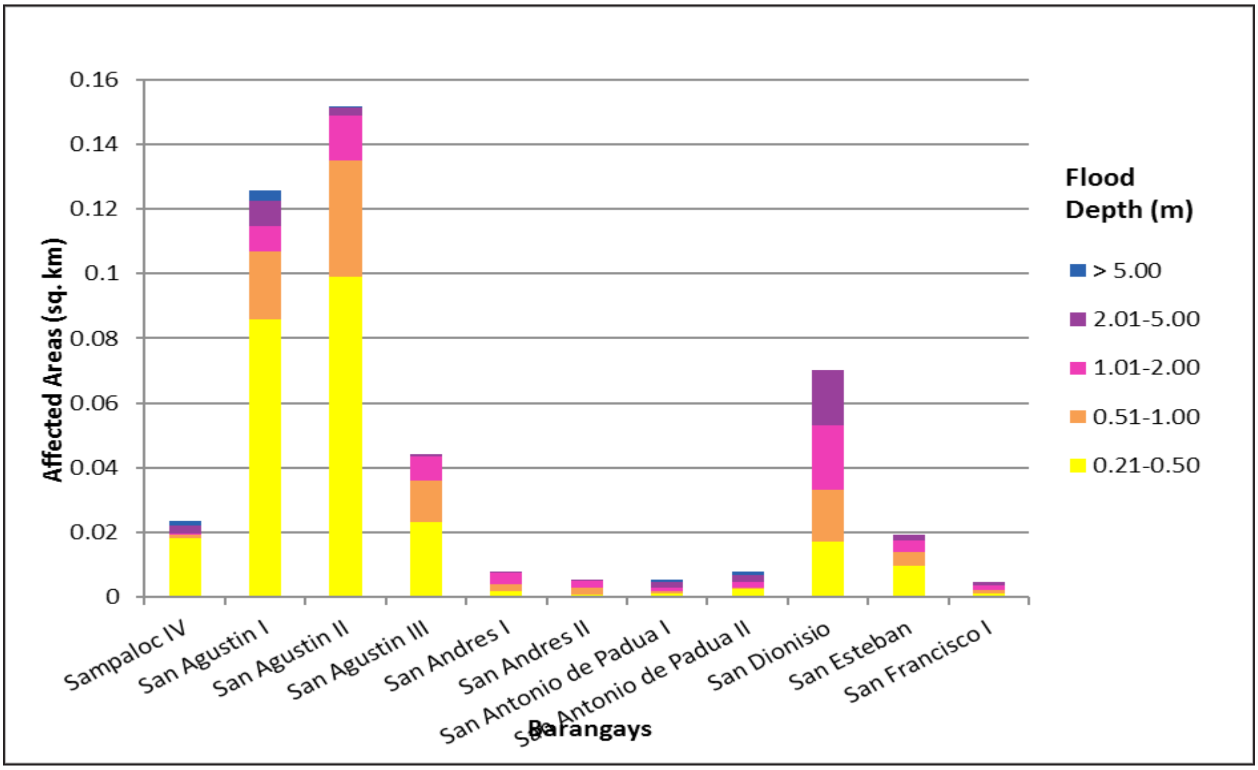


Figure 95. Affected Areas in Dasmariñas, Cavite during 25-year Rainfall Return Period

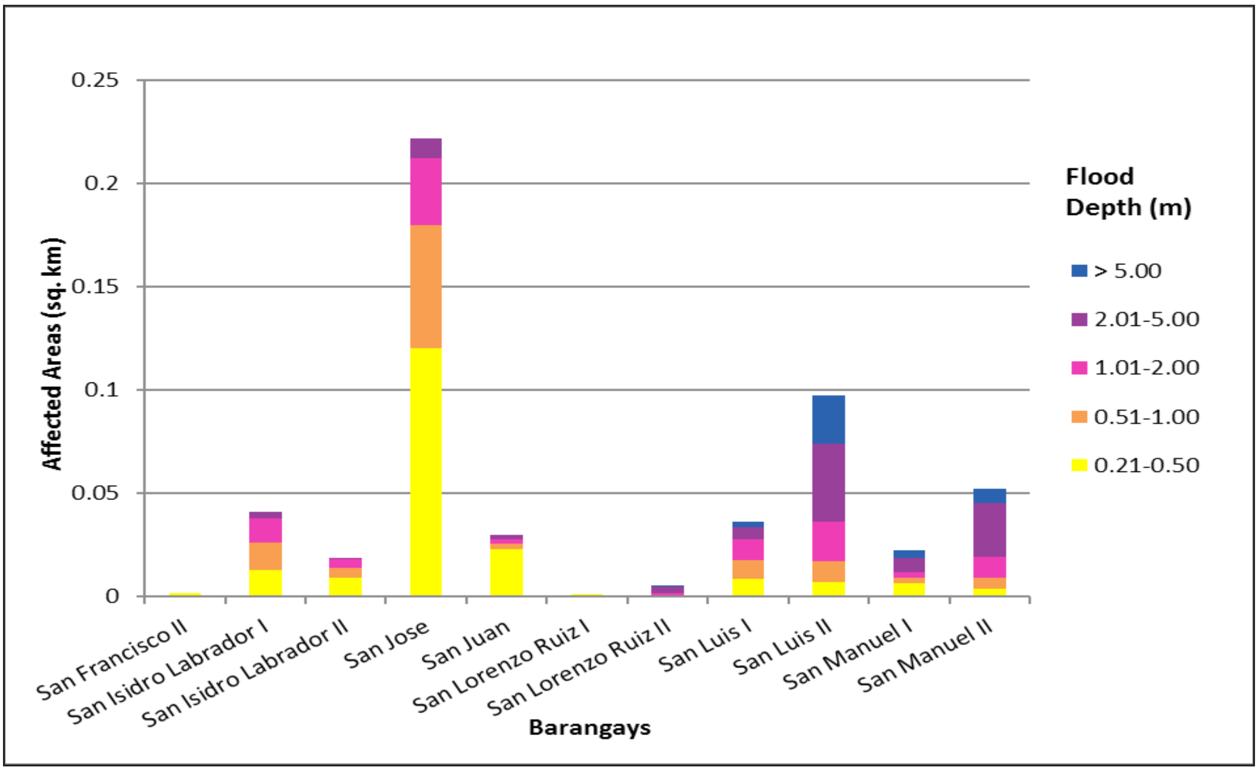


Figure 96. Affected Areas in Dasmariñas, Cavite during 25-year Rainfall Return Period

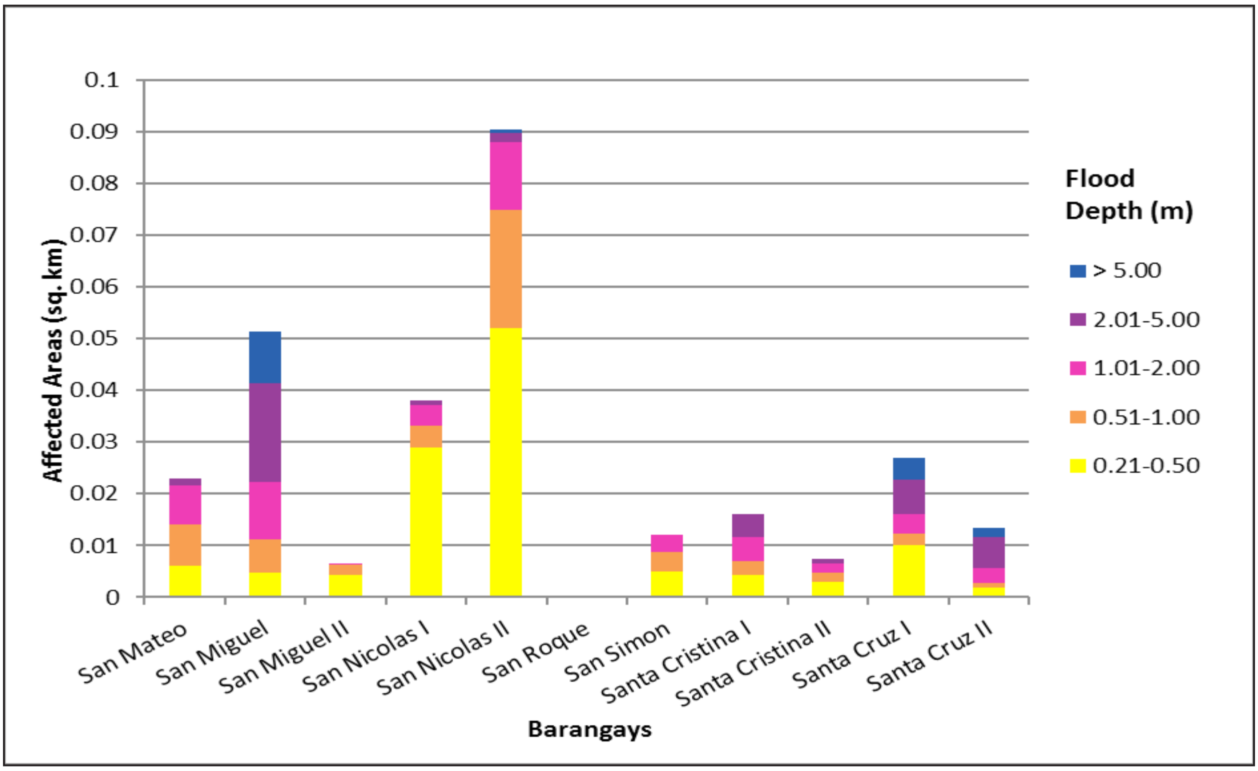


Figure 97. Affected Areas in Dasmariñas, Cavite during 25-year Rainfall Return Period

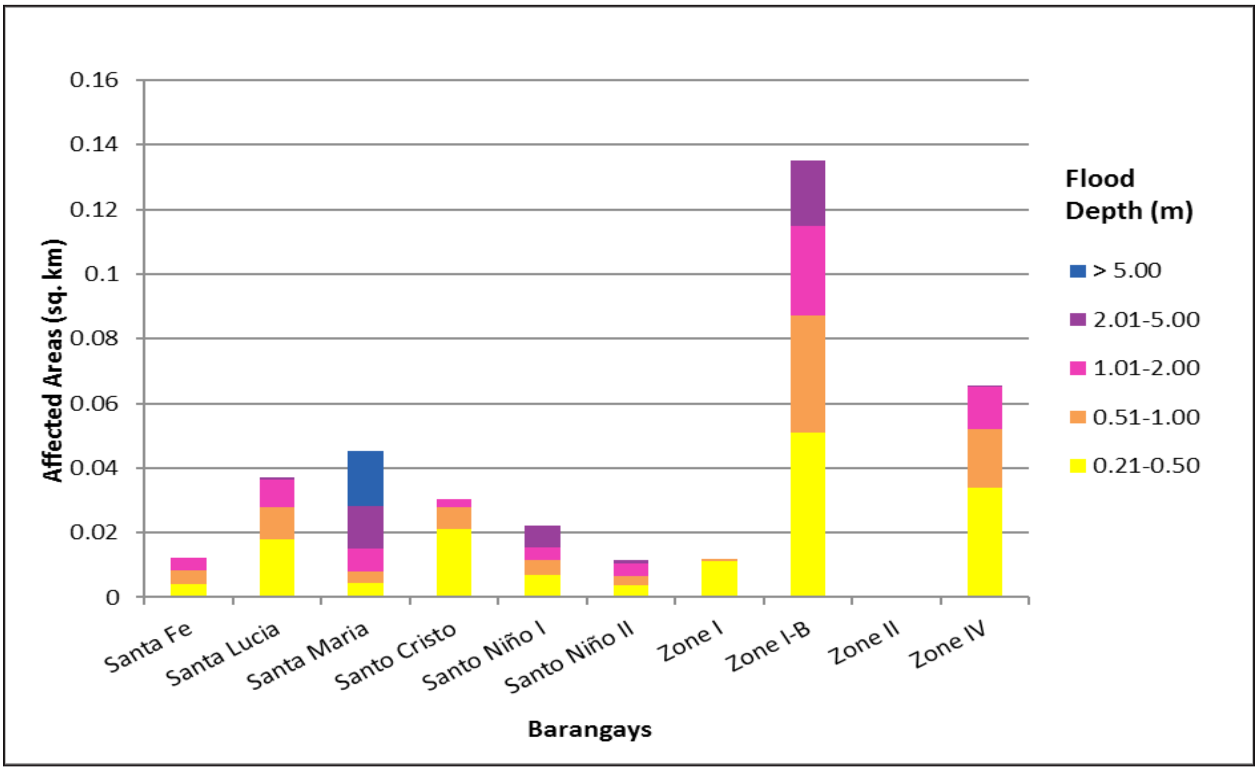


Figure 98. Affected Areas in Dasmariñas, Cavite during 25-year Rainfall Return Period

For the 25-year return period, 24.55% of the municipality of Imus with an area of 56.81 sq. km. will experience flood levels of less than 0.20 meters. 10.99% of the area will experience flood levels of 0.21 to 0.50 meters while 15.34%, 9.86%, 1.62%, and 0.50% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 64 to Table 71 and shown in Figure 99 to Figure 106 are the affected areas in square kilometers by flood depth per barangay.

Table 64. Affected Areas in Imus, Cavite during 25-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)										
	Anabu I-A	Anabu I-B	Anabu I-C	Anabu I-D	Anabu I-E	Anabu I-F	Anabu I-G	Anabu II-A	Anabu II-B	Anabu II-C	Anabu II-D
0.03-0.20	0.26	0.082	0.033	0.047	0.066	0.089	0.12	3.53	0.18	0.19	0.22
0.21-0.50	0.32	0.082	0.059	0.053	0.08	0.064	0.064	0.58	0.11	0.24	0.16
0.51-1.00	0.32	0.12	0.095	0.12	0.18	0.15	0.12	0.8	0.14	0.21	0.24
1.01-2.00	0.14	0.04	0.067	0.083	0.077	0.068	0.12	0.66	0.09	0.098	0.11
2.01-5.00	0.019	0.014	0.0059	0.014	0.0034	0.0043	0.012	0.25	0.021	0.026	0.026
> 5.00	0.00045	0.00041	0.0059	0.0054	0.0071	0.0076	0.0078	0.12	0	0.0001	0.015

Table 65. Affected Areas in Imus, Cavite during 25-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)										
	Anabu II-E	Anabu II-F	Bagong Silang	Bayan Luma I	Bayan Luma II	Bayan Luma III	Bayan Luma IV	Bayan Luma IX	Bayan Luma V	Bayan Luma VI	Bayan Luma VII
0.03-0.20	0.28	0.4	0.058	0.0056	0.007	0.0035	0.023	0.0092	0.0074	0.0097	0.057
0.21-0.50	0.27	0.28	0.035	0.0079	0.021	0.016	0.046	0.036	0.023	0.024	0.092
0.51-1.00	0.33	0.39	0.019	0.046	0.037	0.09	0.067	0.076	0.044	0.033	0.03
1.01-2.00	0.21	0.21	0.049	0.046	0.05	0.061	0.0025	0.0091	0.016	0.022	0.0015
2.01-5.00	0.029	0.025	0.0002	0.0066	0.0091	0.0074	0	0	0	0	0
> 5.00	0.0069	0.012	0	0.0006	0	0	0	0	0	0	0

Table 66. Affected Areas in Imus, Cavite during 25-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)										
	Bayan Luma VIII	Bucandala I	Bucandala II	Bucandala III	Bucandala V	Buhay na Tubig	Carsadang Bago I	Carsadang Bago II	Magdalo	Maharlika	Malagasang I-B
0.03-0.20	0.07	0.092	0.009	0.14	0.0043	0.06	0.11	0.26	0.05	0.0075	0.0024
0.21-0.50	0.11	0.15	0.054	0.11	0.033	0.043	0.36	0.26	0.032	0.0099	0.014
0.51-1.00	0.053	0.25	0.049	0.087	0.16	0.025	0.34	0.18	0.032	0.037	0.0065
1.01-2.00	0.0001	0.13	0.0045	0.0041	0.038	0.054	0.11	0.037	0.034	0.068	0
2.01-5.00	0	0.0031	0	0	0.00049	0	0.009	0.0001	0	0.017	0
> 5.00	0	0	0	0	0.000054	0	0	0	0	0.0068	0

Table 67. Affected Areas in Imus, Cavite during 25-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)										
	Mala-gasang I-C	Mala-gasang I-D	Mala-gasang I-E	Mala-gasang I-F	Mala-gasang I-G	Mala-gasang II-C	Mala-gasang II-D	Mala-gasang II-E	Mala-gasang II-F	Mala-gasang II-G	Mariano Espeleta I
0.03-0.20	0.00058	0.00098	0.00049	0.0066	0.015	0.08	0.042	0.014	0.16	0.0071	0.011
0.21-0.50	0.003	0.0025	0.005	0.063	0.087	0.067	0.051	0.088	0.1	0.078	0.014
0.51-1.00	0.00041	0.0019	0.027	0.19	0.23	0.08	0.033	0.28	0.082	0.18	0.036
1.01-2.00	0	0	0.011	0.082	0.024	0.024	0.00061	0.079	0.02	0.035	0.059
2.01-5.00	0	0	0	0.0011	0	0.0091	0	0.0061	0.0054	0	0.006
> 5.00	0	0	0	0.00054	0	0	0	0	0	0	0

Table 68. Affected Areas in Imus, Cavite during 25-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)										
	Mariano Espeleta II	Mariano Espeleta III	Medicion I-A	Medicion I-B	Medicion I-C	Medicion I-D	Medicion II-B	Medicion II-C	Medicion II-D	Medicion II-E	Medicion II-F
0.03-0.20	0	0.00063	0.016	0.024	0.0095	0.017	0	0.03	0.0061	0.017	0.087
0.21-0.50	0.002	0.0047	0.026	0.032	0.017	0.011	0.0004	0.043	0.019	0.031	0.042
0.51-1.00	0.02	0.055	0.012	0.016	0.028	0.011	0.003	0.029	0.028	0.028	0.0055
1.01-2.00	0.066	0.028	0.0055	0.0082	0.011	0.051	0.001	0.0036	0.022	0.004	0
2.01-5.00	0.0001	0.0058	0	0	0	0.0001	0	0	0.0038	0	0
> 5.00	0	0.005	0	0	0	0	0	0	0	0	0

Table 69. Affected Areas in Imus, Cavite during 25-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)									
	Pag-Asa III	Palico I	Palico II	Palico III	Palico IV	Pasong Buaya I	Pasong Buaya II	Pinag-buklod	Poblacion I-A	Poblacion I-B
0.03-0.20	0.067	0.024	0.00097	0.02	0.0063	3.5	2.92	0.011	0.0037	0
0.21-0.50	0.054	0.025	0.0096	0.0095	0.018	0.29	0.72	0.006	0.022	0.0036
0.51-1.00	0.03	0.014	0.014	0.023	0.018	0.27	0.6	0.064	0.087	0.034
1.01-2.00	0.0026	0.0044	0.0076	0.012	0.0025	0.27	0.23	0.11	0.038	0.036
2.01-5.00	0	0.0067	0.007	0.0091	0	0.12	0.1	0.0077	0	0
> 5.00	0	0.0074	0.0056	0.0088	0	0.0099	0.0071	0.0087	0	0

Table 70. Affected Areas in Imus, Cavite during 25-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)									
	Poblacion I-C	Poblacion II-A	Poblacion II-B	Poblacion III-A	Poblacion III-B	Poblacion IV-A	Poblacion IV-B	Poblacion IV-C	Poblacion IV-D	Tanzang Luma I
0.03-0.20	0	0.00038	0.00071	0.011	0.014	0.017	0.0002	0.0086	0.0021	0.23
0.21-0.50	0.0014	0.003	0.0061	0.027	0.021	0.092	0.0036	0.035	0.0065	0.092
0.51-1.00	0.04	0.034	0.024	0.083	0.057	0.14	0.022	0.13	0.098	0.11
1.01-2.00	0.035	0.037	0.019	0.12	0.022	0.025	0.03	0.039	0.13	0.0091
2.01-5.00	0	0.00039	0	0.0092	0.0037	0.0064	0.00047	0	0	0
> 5.00	0	0	0	0	0	0	0	0	0	0

Table 71. Affected Areas in Imus, Cavite during 25-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)									
	Tanzang Luma II	Tanzang Luma III	Tanzang Luma IV	Tanzang Luma V	Tanzang Luma VI	Toclong I-A	Toclong I-B	Toclong I-C	Toclong II-A	Toclong II-B
0.03-0.20	0.016	0.026	0.000076	0.0013	0.04	0	0.0002	0	0	0.0002
0.21-0.50	0.047	0.044	0.001	0.002	0.06	0.0003	0.0016	0.0018	0.0045	0.011
0.51-1.00	0.042	0.041	0.057	0.046	0.11	0.011	0.04	0.055	0.027	0.14
1.01-2.00	0.048	0.11	0.073	0.16	0.036	0.11	0.14	0.14	0.18	0.18
2.01-5.00	0.0054	0.021	0.016	0.025	0.006	0.0043	0.003	0.0078	0.0065	0.014
> 5.00	0	0.0045	0.0082	0.019	0.0017	0	0	0	0	0

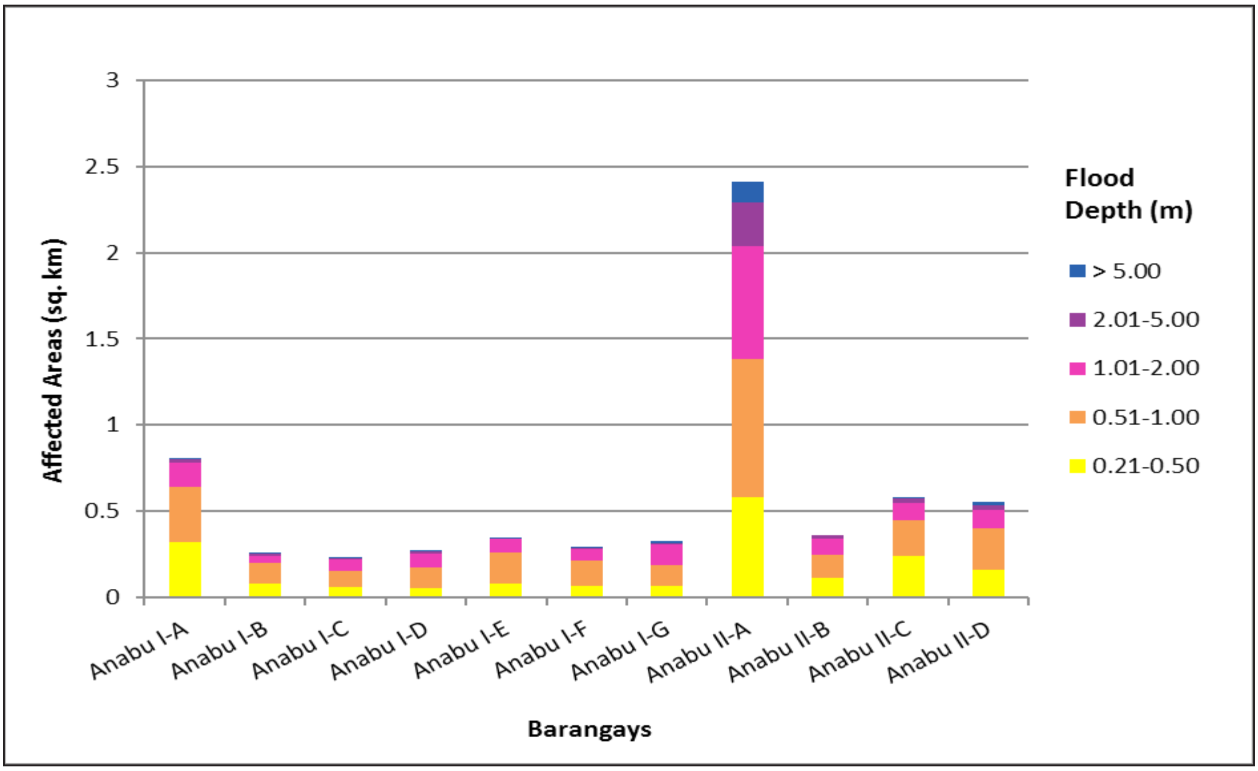


Figure 99. Affected Areas in Imus, Cavite during 25-year Rainfall Return Period

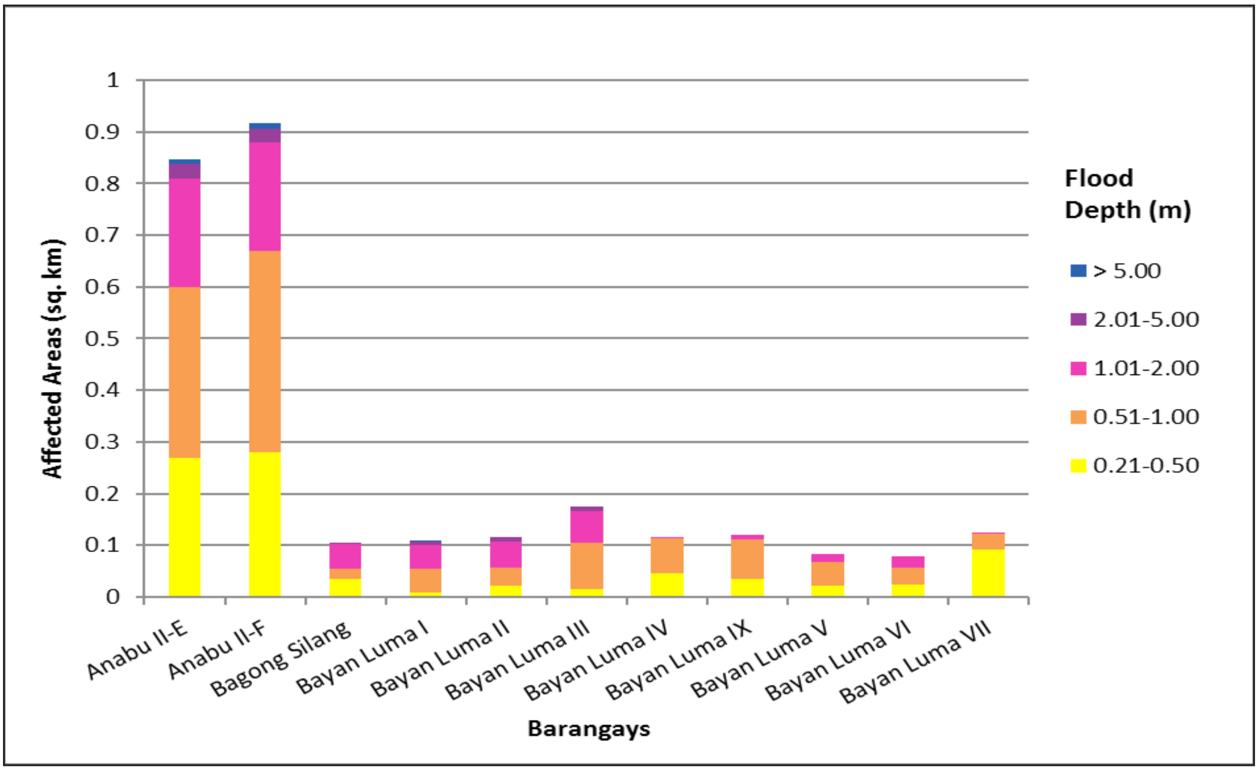


Figure 100. Affected Areas in Imus, Cavite during 25-year Rainfall Return Period

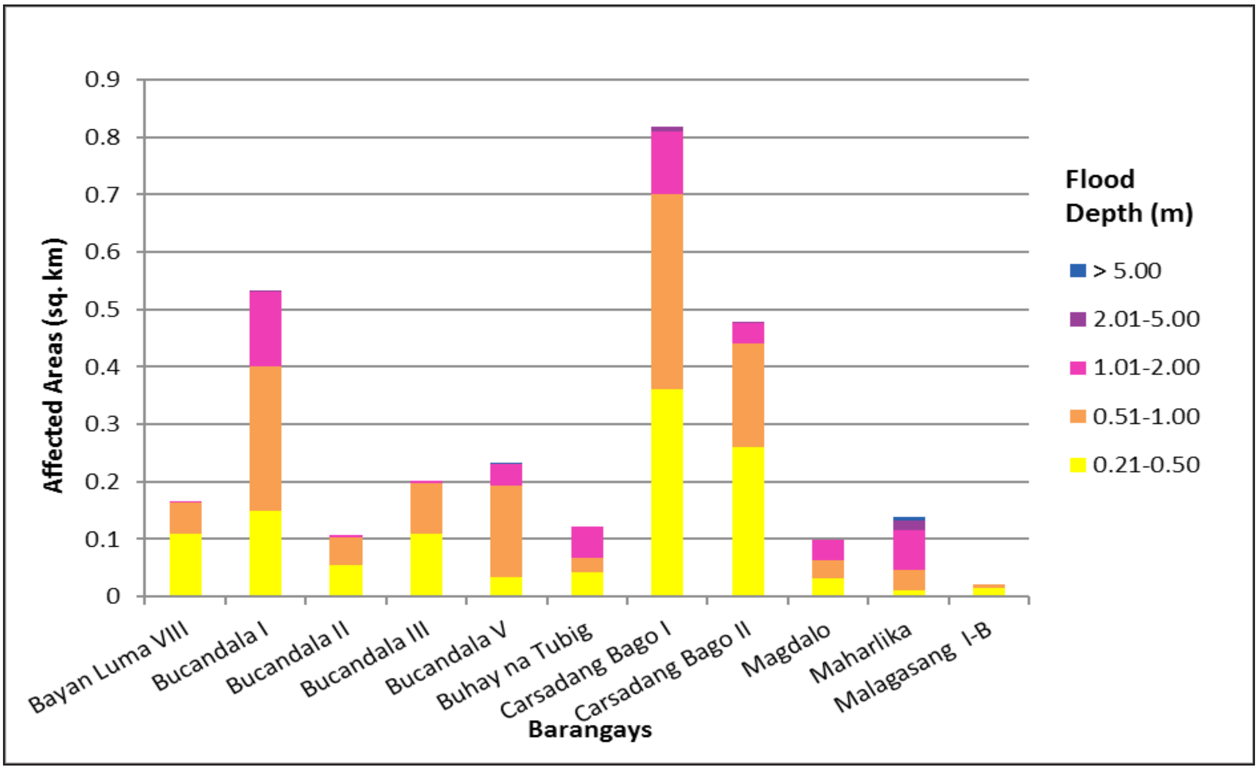


Figure 101. Affected Areas in Imus, Cavite during 25-year Rainfall Return Period

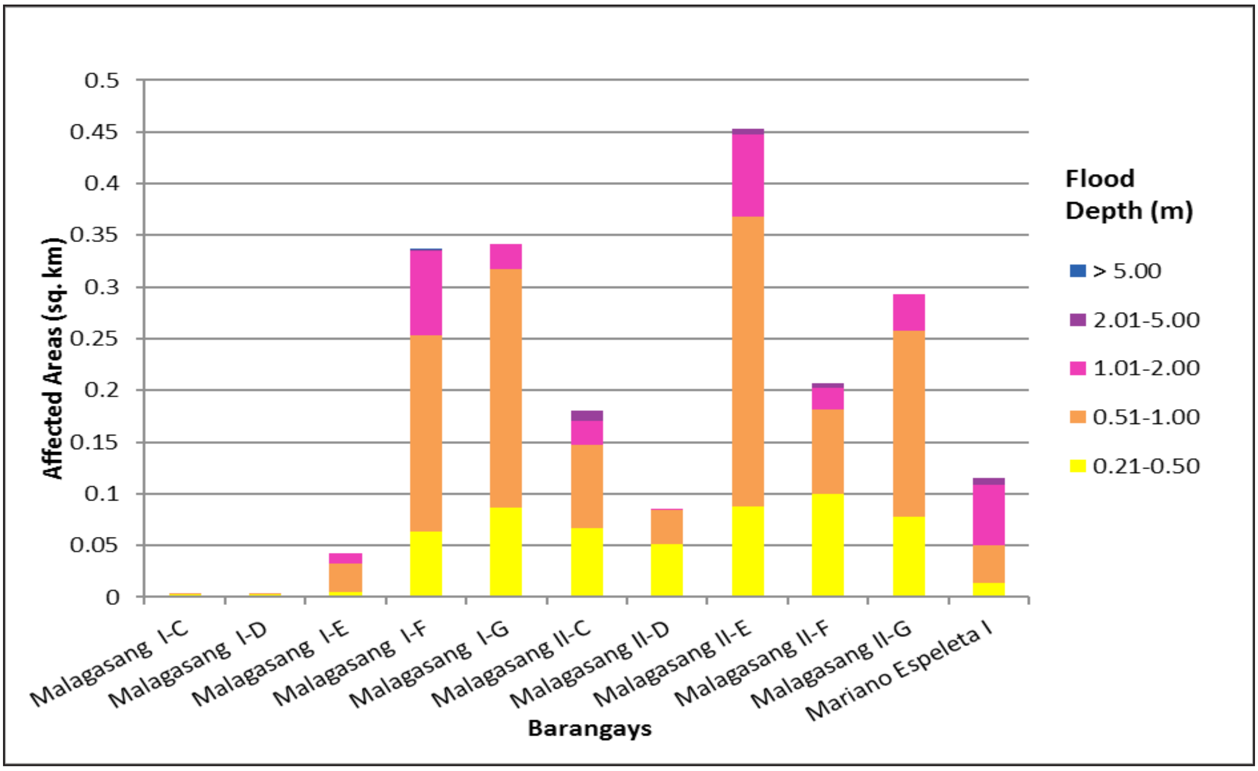


Figure 102. Affected Areas in Imus, Cavite during 25-year Rainfall Return Period

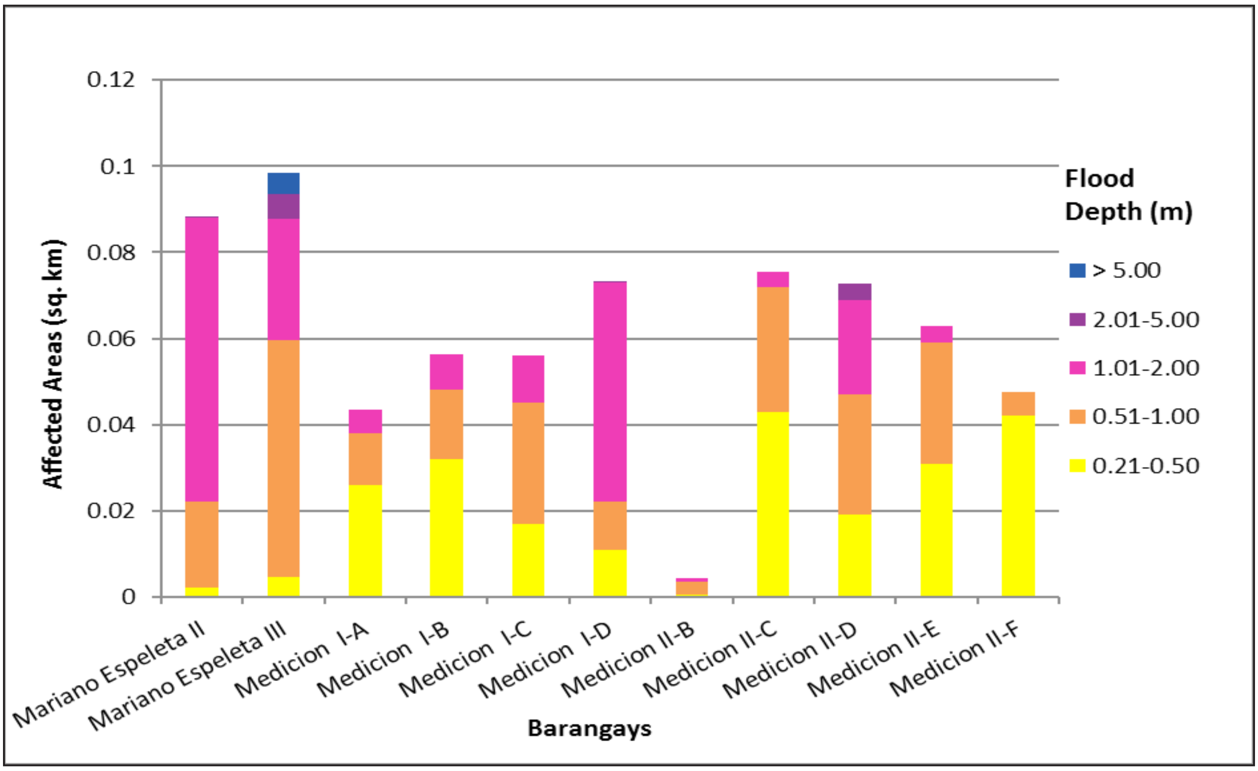


Figure 103. Affected Areas in Imus, Cavite during 25-year Rainfall Return Period

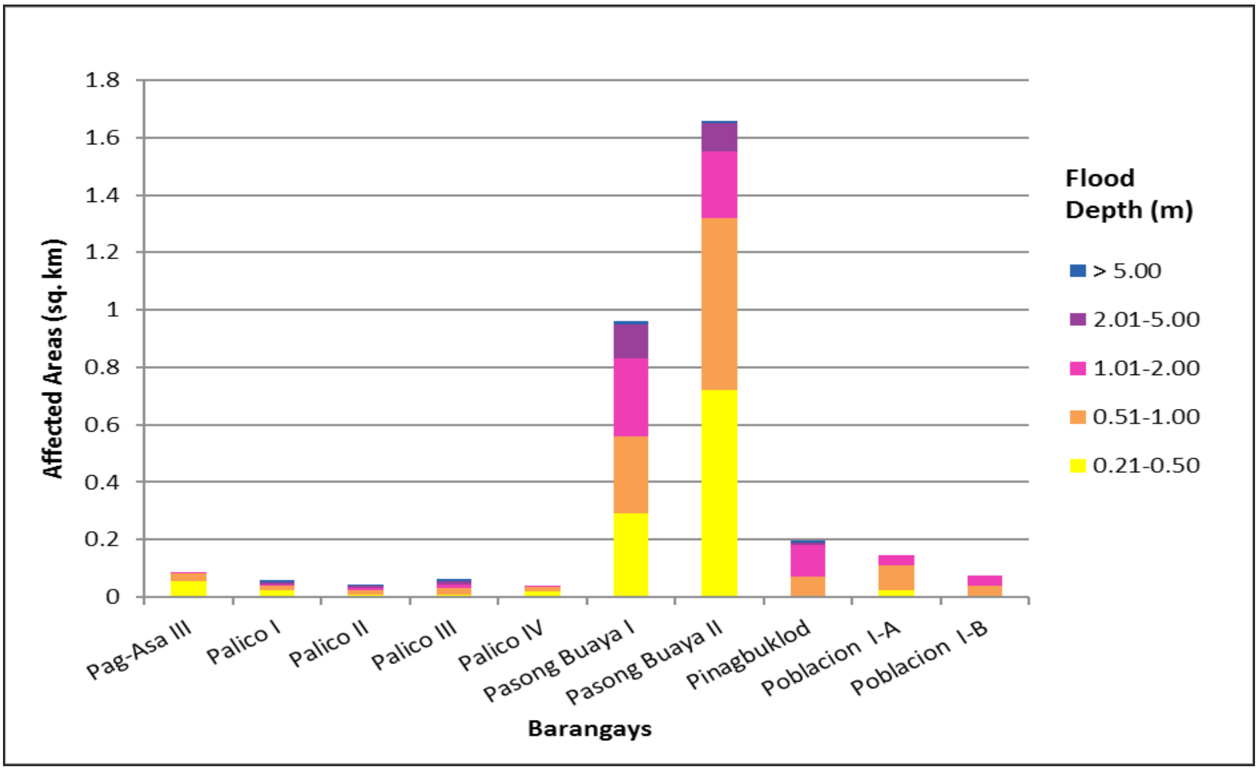


Figure 104. Affected Areas in Imus, Cavite during 25-year Rainfall Return Period

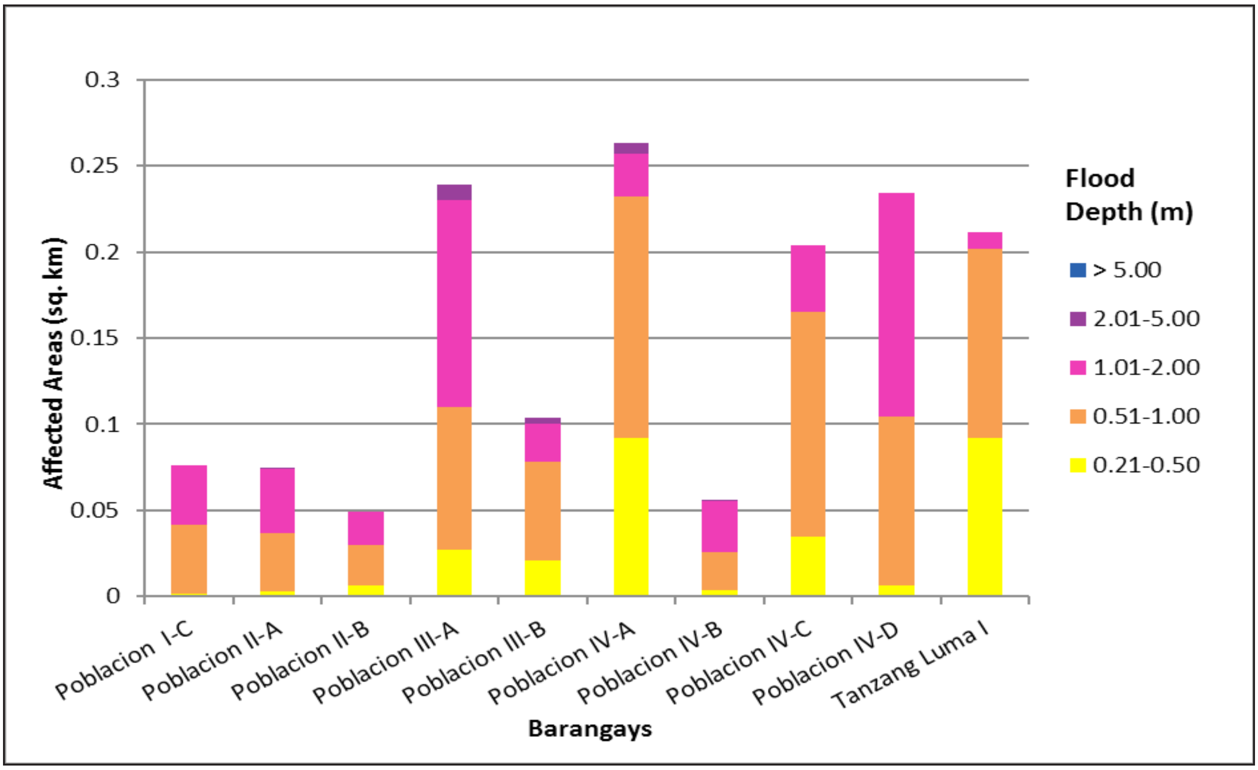


Figure 105. Affected Areas in Imus, Cavite during 25-year Rainfall Return Period

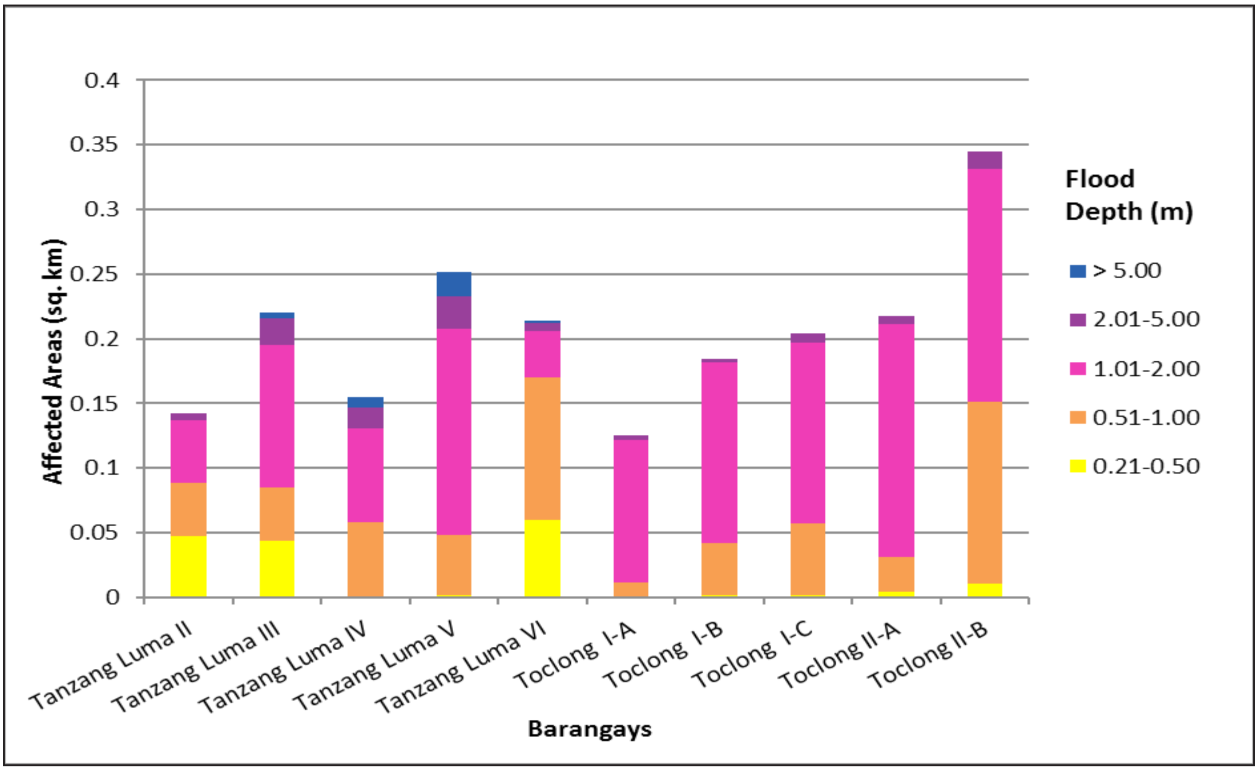


Figure 106. Affected Areas in Imus, Cavite during 25-year Rainfall Return Period

For the 25-year return period, 1.10% of the municipality of Kawit with an area of 9.47 sq. km. will experience flood levels of less than 0.20 meters. 0.71% of the area will experience flood levels of 0.21 to 0.50 meters while 1.35%, 8.34%, and 1.35% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and 2.01 to 5 meters, respectively. Listed in Table 72 and shown in Figure 107 are the affected areas in square kilometers by flood depth per barangay.

Table 72. Affected Areas in Kawit, Cavite during 25-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Kawit (in sq. km)							
	Balsahan -Bisita	Binakayan -Aplaya	Binakayan -Kanluran	Congbalay -Legaspi	Manggahan -Lawin	Pulvorista	Samala -Marquez	Toclong
0.03-0.20	0.017	0.038	0	0.0085	0.0067	0	0	0.034
0.21-0.50	0.0038	0.018	0	0.0039	0.0064	0	0.0001	0.035
0.51-1.00	0.0071	0.0075	0.006	0.0033	0.018	0.0014	0.0039	0.081
1.01-2.00	0.0076	0.0054	0.073	0.0078	0.046	0.1	0.11	0.44
2.01-5.00	0.005	0.003	0	0.0067	0.04	0.0044	0.0088	0.06
> 5.00	0	0	0	0	0	0	0	0

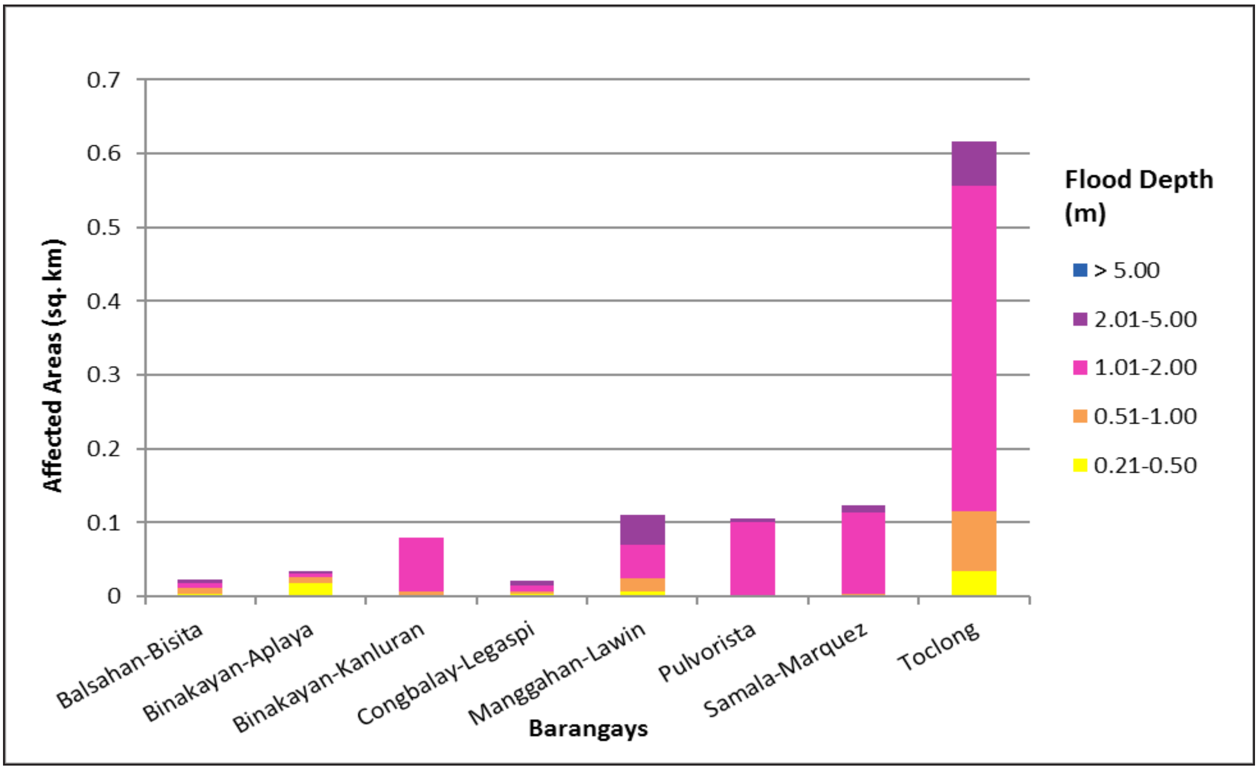


Figure 107. Affected Areas in Kawit, Cavite during 25-year Rainfall Return Period

For the 100-year return period, 10.15% of the municipality of Bacoor with an area of 47.43 sq. km. will experience flood levels of less than 0.20 meters. 4.92% of the area will experience flood levels of 0.21 to 0.50 meters while 7.69%, 9.00%, 3.42%, 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 Table 73 to Table 76 and shown in Figure 108 to Figure 111 are the affected areas in square kilometers by flood depth per barangay.

Table 73. Affected Areas in Bacoor, Cavite during 100-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Bacoor (in sq. km)									
	Alima	Banalo	Bayanan	Campo Santo	Daang Bukid	Digman	Dulong Bayan	Habay I	Habay II	Kaingin
0.03-0.20	0	0.00061	0.0045	0.0013	0.0052	0	0	0.042	0.034	0.013
0.21-0.50	0.0019	0.0022	0.0019	0.00048	0.042	0.0044	0	0.055	0.054	0.015
0.51-1.00	0.049	0.016	0.00081	0.058	0.045	0.053	0.023	0.23	0.19	0.098
1.01-2.00	0.18	0.15	0.000064	0.1	0.19	0.044	0.22	0.21	0.2	0.15
2.01-5.00	0.16	0.13	0	0.081	0.26	0.001	0.15	0.026	0.27	0.063
> 5.00	0	0.0018	0	0	0	0	0	0	0	0

Table 74. Affected Areas in Bacoor, Cavite during 100-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Bacoor (in sq. km)									
	Mabolo I	Mabolo II	Mabolo III	Maliksi I	Maliksi II	Mambog I	Mambog II	Mambog III	Mambog IV	Mambog V
0.03-0.20	0.0029	0.0008	0.0017	0.0014	0	0.27	0.65	0.57	0.15	0.071
0.21-0.50	0.0011	0.0003	0.0012	0.013	0.00062	0.37	0.18	0.19	0.095	0.087
0.51-1.00	0.037	0.024	0.0043	0.045	0.0007	0.63	0.11	0.084	0.15	0.11
1.01-2.00	0.31	0.13	0.063	0.057	0.014	0.31	0.021	0.02	0.089	0.06
2.01-5.00	0.072	0.034	0.064	0.097	0.0068	0.013	0.0001	0.0017	0	0.0002
> 5.00	0.012	0.00093	0	0	0	0	0	0	0	0

Table 75. Affected Areas in Bacoor, Cavite during 100-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Bacoor (in sq. km)								
	Molino II	Molino III	Molino IV	Molino V	P.F. Espiritu I	P.F. Espiritu II	P.F. Espiritu III	P.F. Espiritu IV	P.F. Espiritu V
0.03-0.20	0.49	0.23	0.036	0.6	0.068	0.035	0.043	0.0073	0.0044
0.21-0.50	0.043	0.039	0.0078	0.21	0.082	0.041	0.061	0.02	0.0079
0.51-1.00	0.03	0.0072	0.00038	0.16	0.055	0.11	0.086	0.063	0.051
1.01-2.00	0.019	0.0075	0	0.08	0.028	0.11	0.019	0.086	0.08
2.01-5.00	0.0032	0.0001	0	0.0068	0	0.0026	0	0.0014	0.0024
> 5.00	0	0	0	0	0	0	0	0	0

Table 76. Affected Areas in Bacoor, Cavite during 100-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Bacoor (in sq. km)								
	Queens Row East	Real I	Real II	Salinas I	Salinas II	Salinas III	Salinas IV	Sineguelasan	Tabing Dagat
0.03-0.20	1.04	0.076	0.14	0	0.00078	0.0065	0.03	0.19	0
0.21-0.50	0.15	0.22	0.19	0.0016	0.0036	0.033	0.063	0.045	0.00023
0.51-1.00	0.1	0.47	0.24	0.04	0.028	0.062	0.11	0.07	0.0058
1.01-2.00	0.069	0.24	0.23	0.19	0.16	0.049	0.15	0.19	0.045
2.01-5.00	0.025	0.013	0.028	0.0079	0.013	0.019	0.00098	0.052	0.019
> 5.00	0	0.0071	0.015	0.00096	0.0061	0.0092	0	0.0004	0

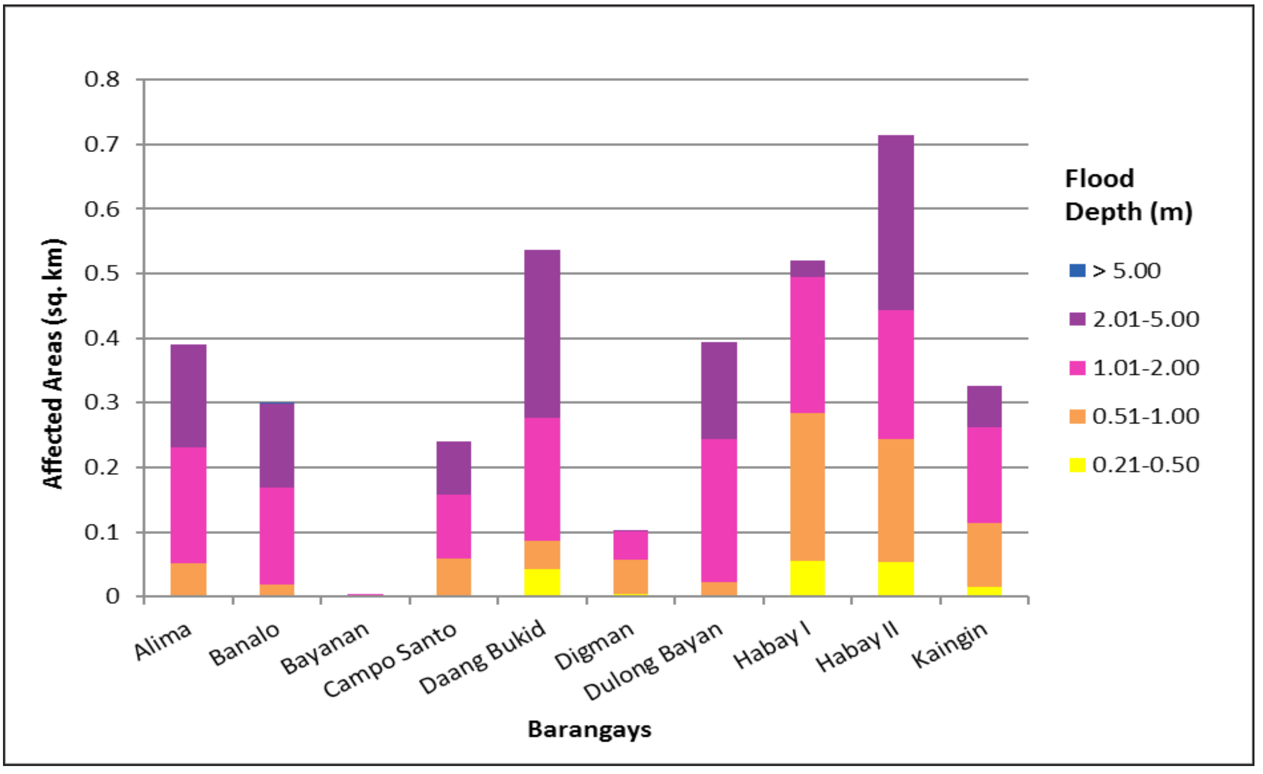


Figure 108. Affected Areas in Bacoor, Cavite during 100-year Rainfall Return Period

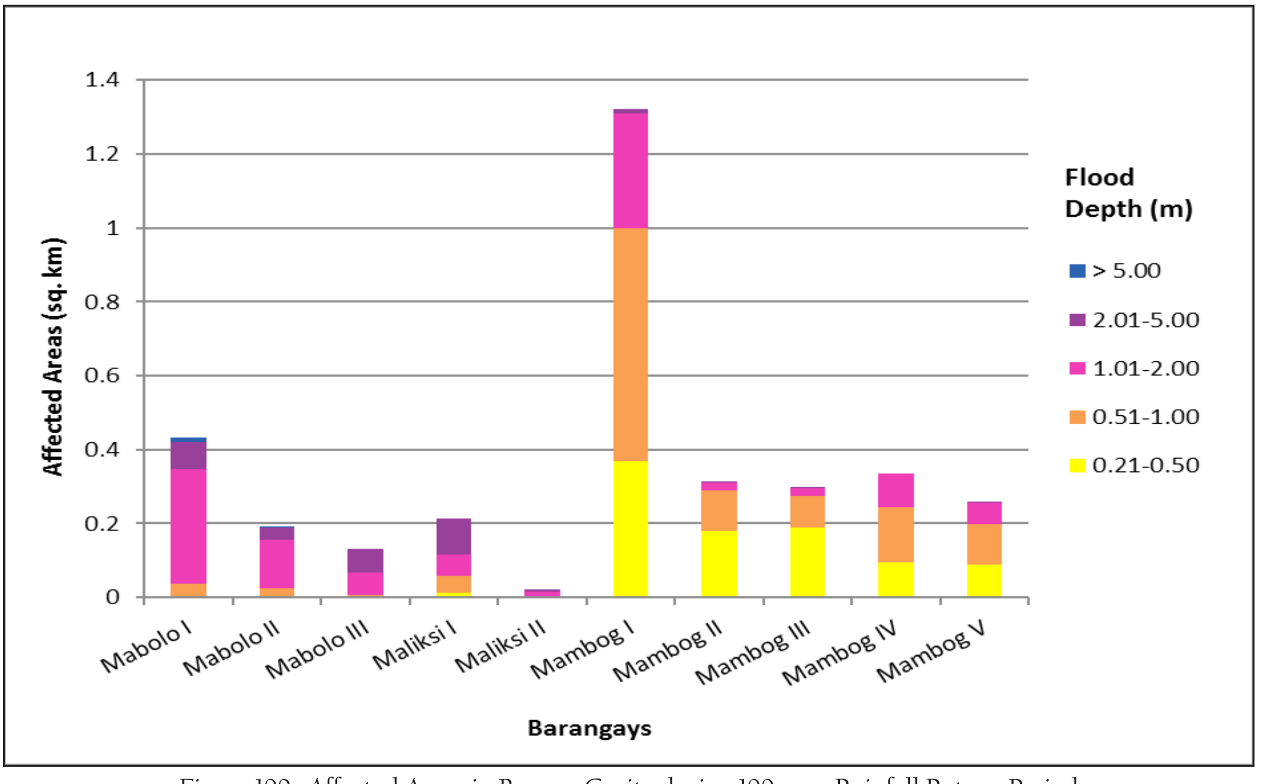


Figure 109. Affected Areas in Bacoor, Cavite during 100-year Rainfall Return Period

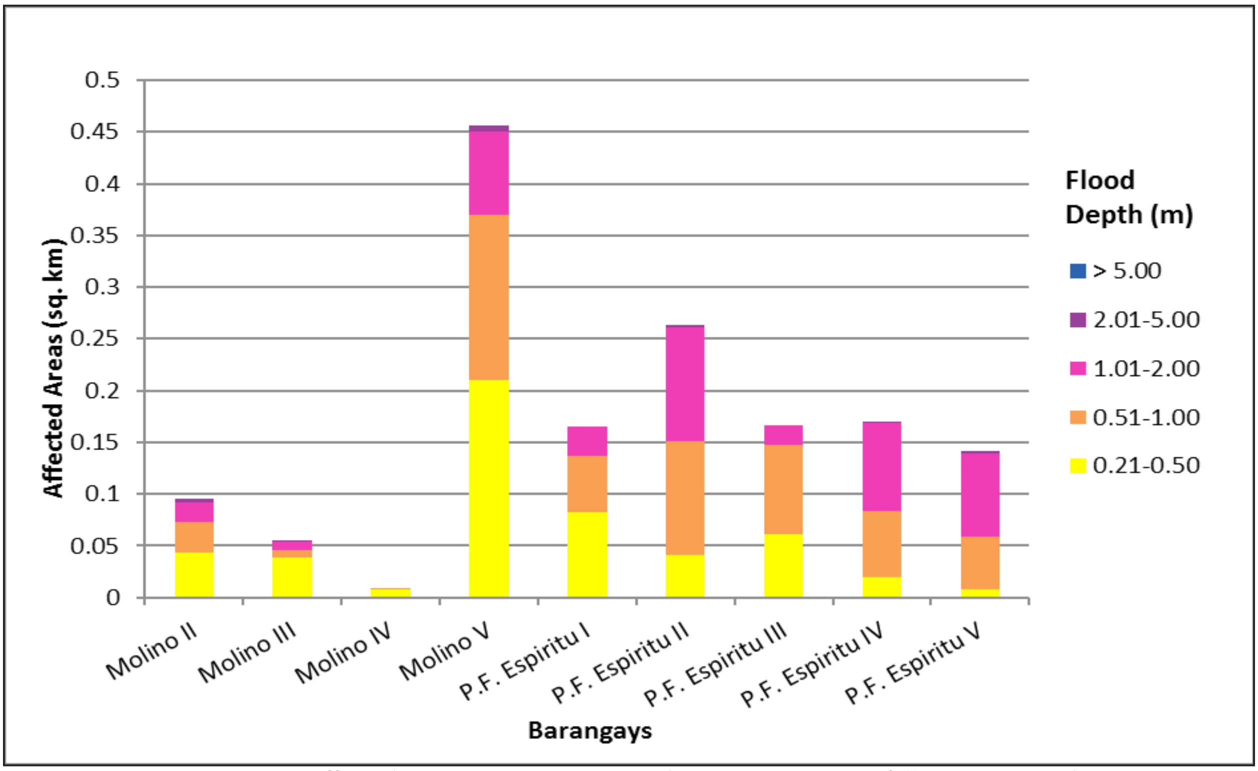


Figure 110. Affected Areas in Bacoor, Cavite during 100-year Rainfall Return Period

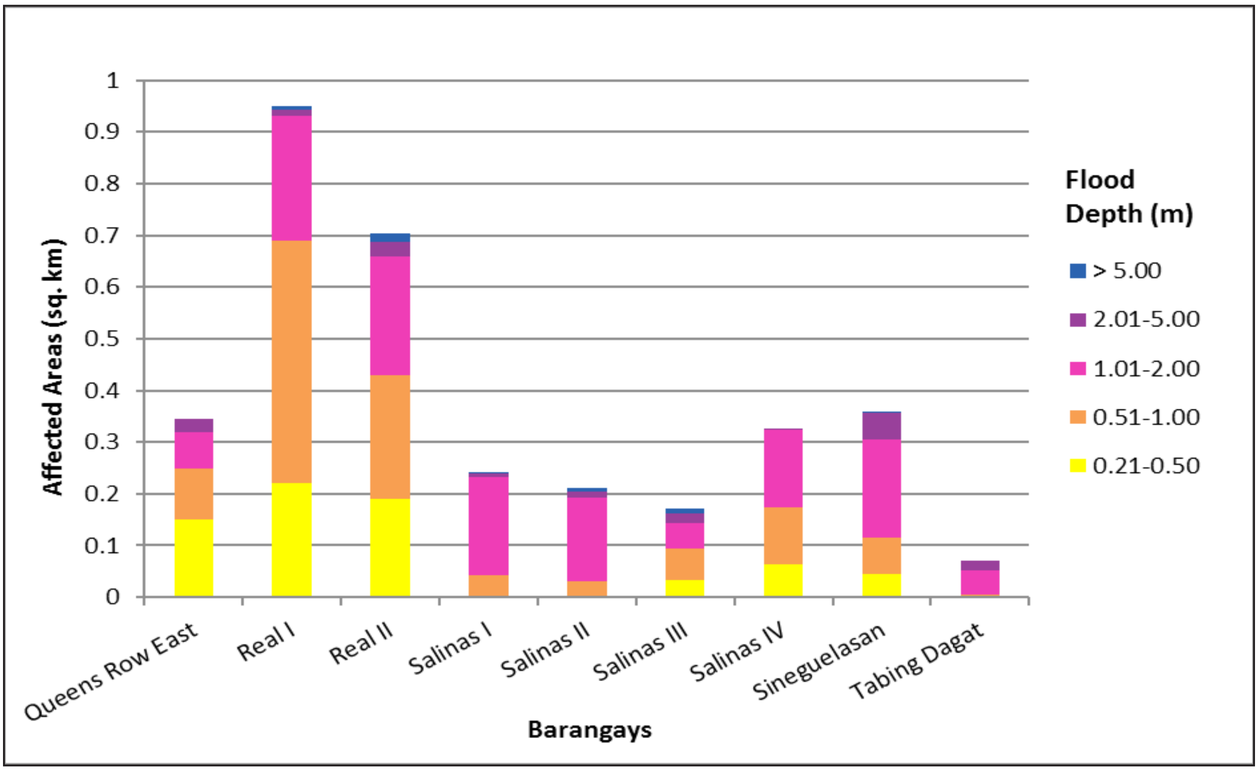


Figure 111. Affected Areas in Bacoor, Cavite during 100-year Rainfall Return Period

For the 100-year return period, 30.73% of the municipality of Dasmariñas with an area of 84.01 sq. km. will experience flood levels of less than 0.20 meters. 4.13% of the area will experience flood levels of 0.21 to 0.50 meters while 2.54%, 2.25%, 1.48%, and 0.51% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 77 to Table 82 and Figure 112 to Figure 117 shown in are the affected areas in square kilometers by flood depth per barangay.

Table 77. Affected Areas in Dasmariñas, Cavite during 100-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Dasmariñas (in sq. km)										
	Burol	Burol I	Burol II	Burol III	Datu Esmael	Emmanuel Bergado I	Emmanuel Bergado II	Fatima I	Fatima II	Fatima III	Luzviminda I
0.03-0.20	1.86	0.14	0.11	0.27	0.15	0.049	0.028	0.081	0.11	0.19	0.092
0.21-0.50	0.21	0.007	0.024	0.026	0.0075	0.004	0.0028	0.0066	0.00048	0.02	0.0039
0.51-1.00	0.14	0.0089	0.0083	0.015	0.0092	0.0039	0.0033	0.0017	0	0.019	0.0037
1.01-2.00	0.1	0.013	0.0089	0.017	0.016	0.0076	0.0059	0.0019	0	0.0074	0.0017
2.01-5.00	0.072	0.021	0.0048	0.0099	0.023	0.011	0.012	0.00032	0	0.0062	0.0001
> 5.00	0.013	0.017	0.0055	0	0.016	0.013	0.011	0.000032	0	0.00055	0

Table 78. Affected Areas in Dasmariñas, Cavite during 100-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Dasmariñas (in sq. km)										
	Luzvi-minda II	Pali-paran II	Pali-paran III	Sabang	Saint Peter I	Saint Peter II	Salawag	Salitran I	Salitran II	Salitran III	Salitran IV
0.03-0.20	0.28	0.54	2.04	0.58	0.024	0.033	8.34	0.53	1	0.31	2.24
0.21-0.50	0.041	0.053	0.27	0.34	0.0016	0.023	0.74	0.25	0.13	0.093	0.33
0.51-1.00	0.017	0.02	0.077	0.26	0.0027	0.0092	0.46	0.21	0.081	0.15	0.21
1.01-2.00	0.0054	0.02	0.04	0.22	0.005	0.0093	0.43	0.17	0.047	0.25	0.18
2.01-5.00	0.0002	0.018	0.048	0.08	0.0045	0.014	0.39	0.04	0.03	0.078	0.099
> 5.00	0	0.0057	0.062	0.0002	0.0018	0.0045	0.15	0.0002	0.0013	0.014	0.011

Table 79. Affected Areas in Dasmariñas, Cavite during 100-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Dasmariñas (in sq. km)										
	Sampaloc IV	San Agustin I	San Agustin II	San Agustin III	San Andres I	San Andres II	San Antonio de Padua I	San Antonio de Padua II	San Dionisio	San Esteban	San Francisco I
0.03-0.20	0.14	0.67	0.76	0.15	0.012	0.024	0.026	0.056	0.25	0.071	0.042
0.21-0.50	0.024	0.1	0.12	0.027	0.0021	0.00079	0.0011	0.0035	0.017	0.015	0.0015
0.51-1.00	0.0015	0.027	0.044	0.016	0.0025	0.0013	0.0009	0.0015	0.017	0.0053	0.0011
1.01-2.00	0.00068	0.012	0.018	0.0089	0.0036	0.0025	0.00058	0.0015	0.023	0.0042	0.0018
2.01-5.00	0.0019	0.0094	0.0033	0.0012	0.0011	0.0011	0.0025	0.0026	0.02	0.0025	0.0011
> 5.00	0.0019	0.0037	0.0003	0	0	0	0.00095	0.0016	0	0	0

Table 80. Affected Areas in Dasmariñas, Cavite during 100-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Dasmariñas (in sq. km)										
	San Francisco II	San Isidro Labrador I	San Isidro Labrador II	San Jose	San Juan	San Lorenzo Ruiz I	San Lorenzo Ruiz II	San Luis I	San Luis II	San Manuel I	San Manuel II
0.03-0.20	0.024	0.15	0.057	1.01	0.14	0.036	0.049	0.28	0.14	0.022	0.011
0.21-0.50	0.0024	0.019	0.012	0.13	0.028	0.003	0.001	0.01	0.0079	0.018	0.0035
0.51-1.00	0.000041	0.014	0.0048	0.074	0.0034	0	0.0003	0.0088	0.0091	0.0062	0.0098
1.01-2.00	0	0.014	0.0048	0.038	0.0027	0	0.00092	0.013	0.02	0.0043	0.011
2.01-5.00	0	0.0045	0.0003	0.014	0.0027	0	0.0035	0.0087	0.051	0.0077	0.03
> 5.00	0	0	0	0.0001	0	0	0.0003	0.003	0.032	0.0051	0.011

Table 81. Affected Areas in Dasmariñas, Cavite during 100-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Dasmariñas (in sq. km)										
	San Mateo	San Miguel	San Miguel II	San Nicolas I	San Nicolas II	San Roque	San Simon	Santa Cristina I	Santa Cristina II	Santa Cruz I	Santa Cruz II
0.03-0.20	0.1	0.037	0.032	0.19	0.49	0.015	0.072	0.027	0.032	0.15	0.09
0.21-0.50	0.0079	0.0059	0.0043	0.036	0.062	0.0004	0.0058	0.005	0.0032	0.015	0.0023
0.51-1.00	0.0082	0.0083	0.0031	0.0057	0.028	0	0.0039	0.0038	0.0026	0.0034	0.0014
1.01-2.00	0.0094	0.014	0.0023	0.0049	0.017	0	0.0039	0.0053	0.0024	0.0043	0.0025
2.01-5.00	0.0018	0.025	0.000015	0.0011	0.0018	0	0.00063	0.0053	0.001	0.0086	0.0063
> 5.00	0	0.013	0	0	0.0011	0	0	0	0	0.0055	0.0029

Table 82. Affected Areas in Dasmariñas, Cavite during 100-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Dasmariñas (in sq. km)									
	Santa Fe	Santa Lucia	Santa Maria	Santo Cristo	Santo Niño I	Santo Niño II	Zone I	Zone I-B	Zone II	Zone IV
0.03-0.20	0.02	0.21	0.023	0.1	0.08	0.027	0.11	0.59	0.034	0.27
0.21-0.50	0.0043	0.031	0.0063	0.023	0.011	0.0036	0.013	0.06	0.00041	0.037
0.51-1.00	0.0042	0.013	0.0072	0.0089	0.0047	0.0036	0.0015	0.04	8.1E-06	0.024
1.01-2.00	0.0052	0.012	0.0091	0.0034	0.0052	0.0038	0	0.03	0	0.015
2.01-5.00	0	0.0011	0.018	0	0.0079	0.0016	0	0.029	0	0.0012
> 5.00	0	0	0.021	0	0	0	0	0	0	0

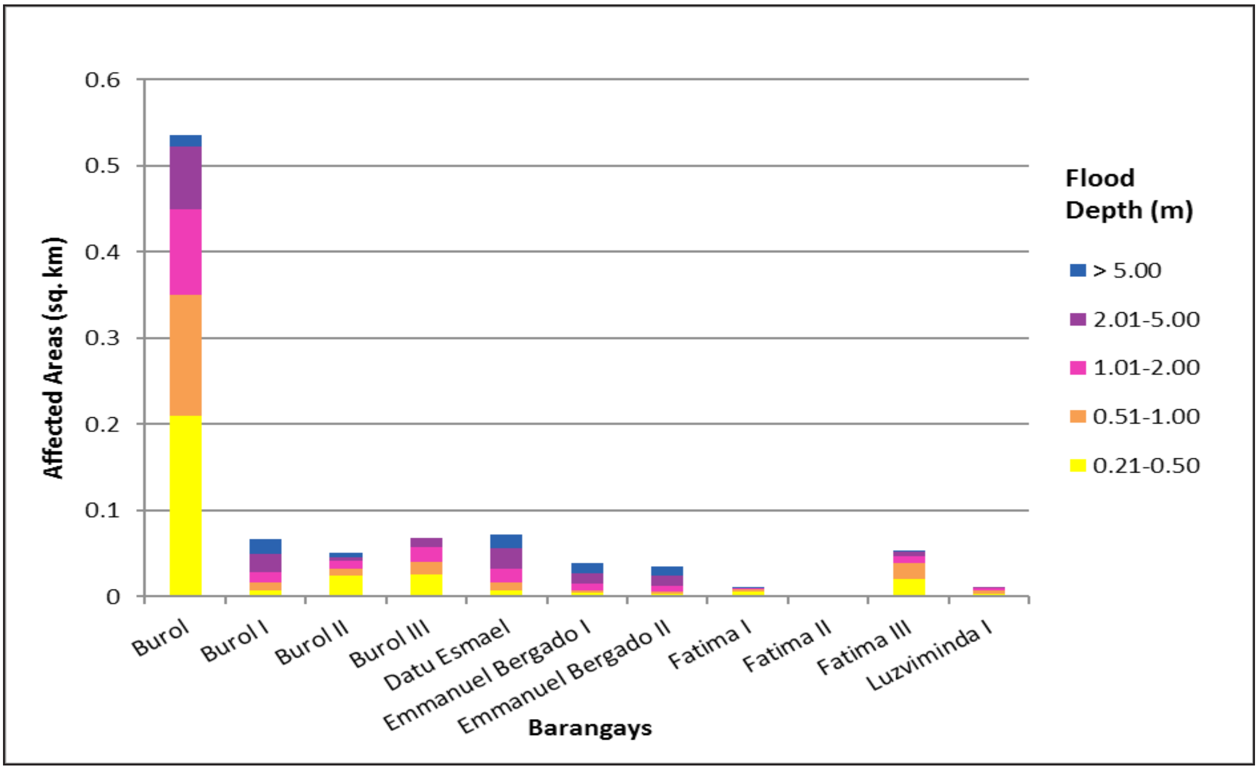


Figure 112. Affected Areas in Dasmariñas, Cavite during 100-year Rainfall Return Period

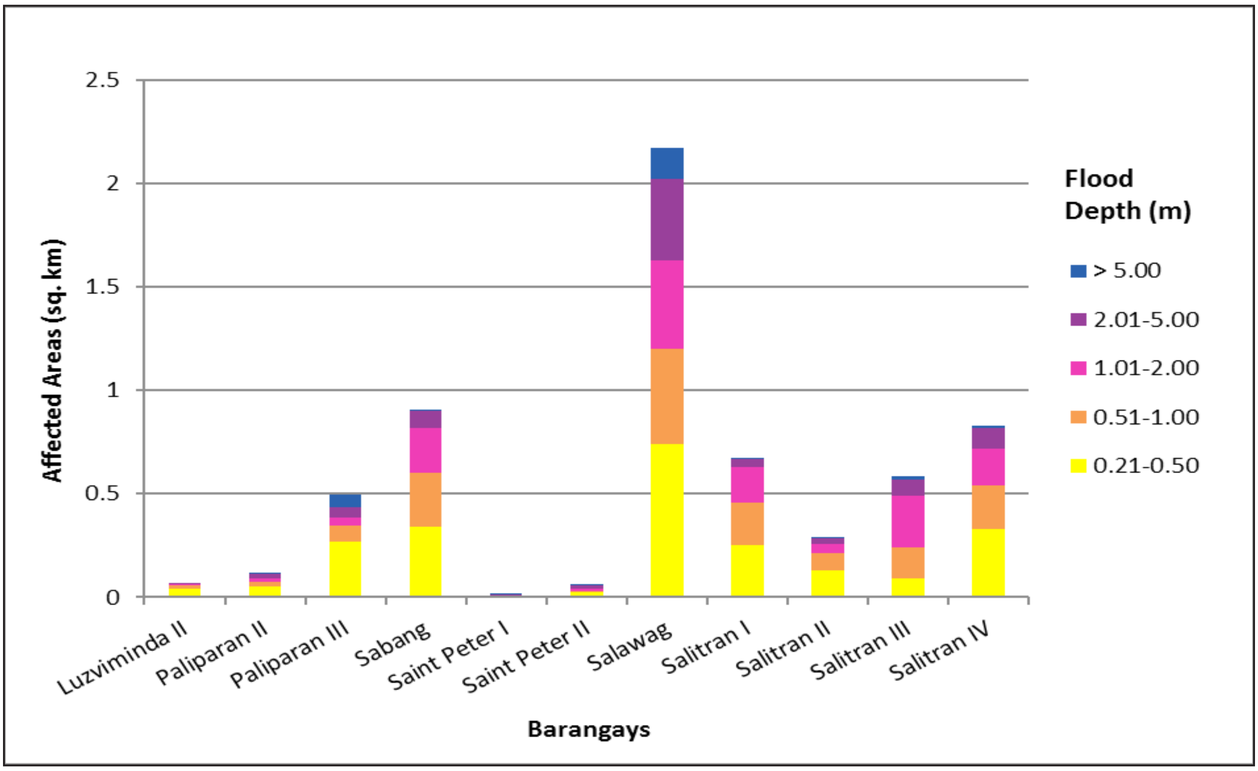


Figure 113. Affected Areas in Dasmariñas, Cavite during 100-year Rainfall Return Period

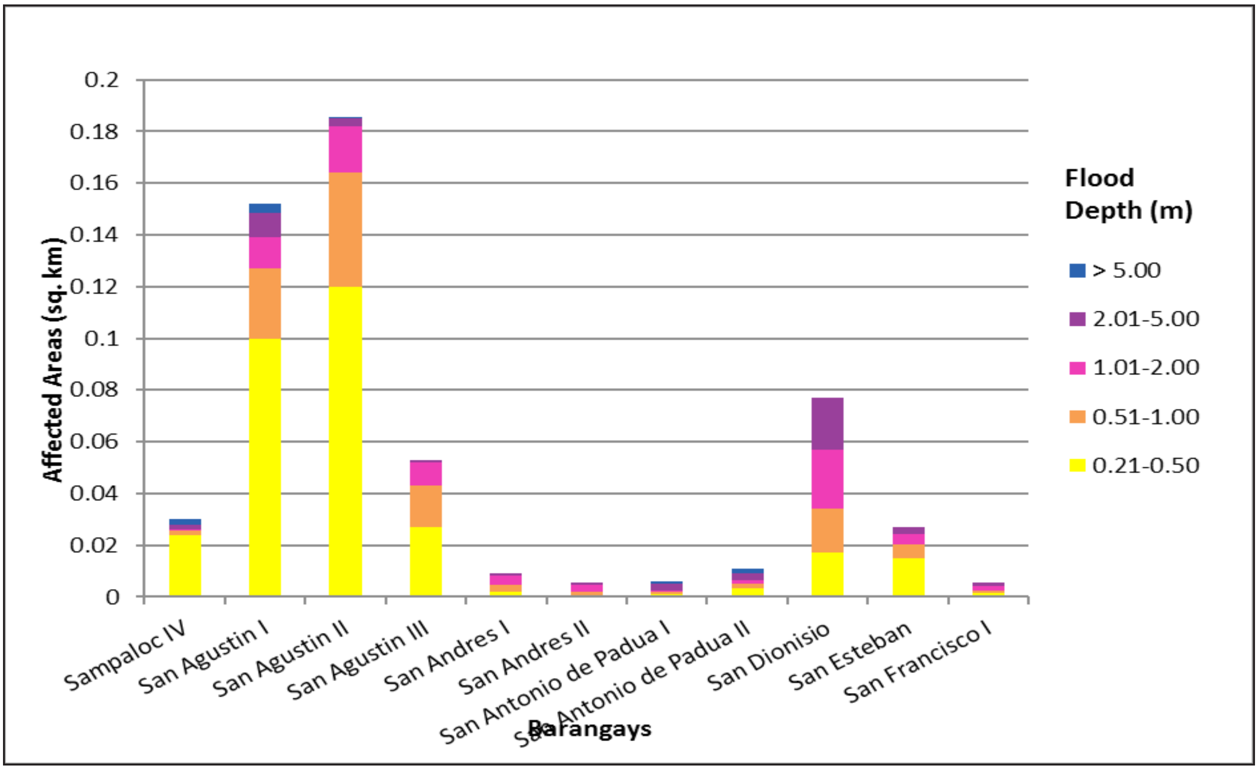


Figure 114. Affected Areas in Dasmariñas, Cavite during 100-year Rainfall Return Period

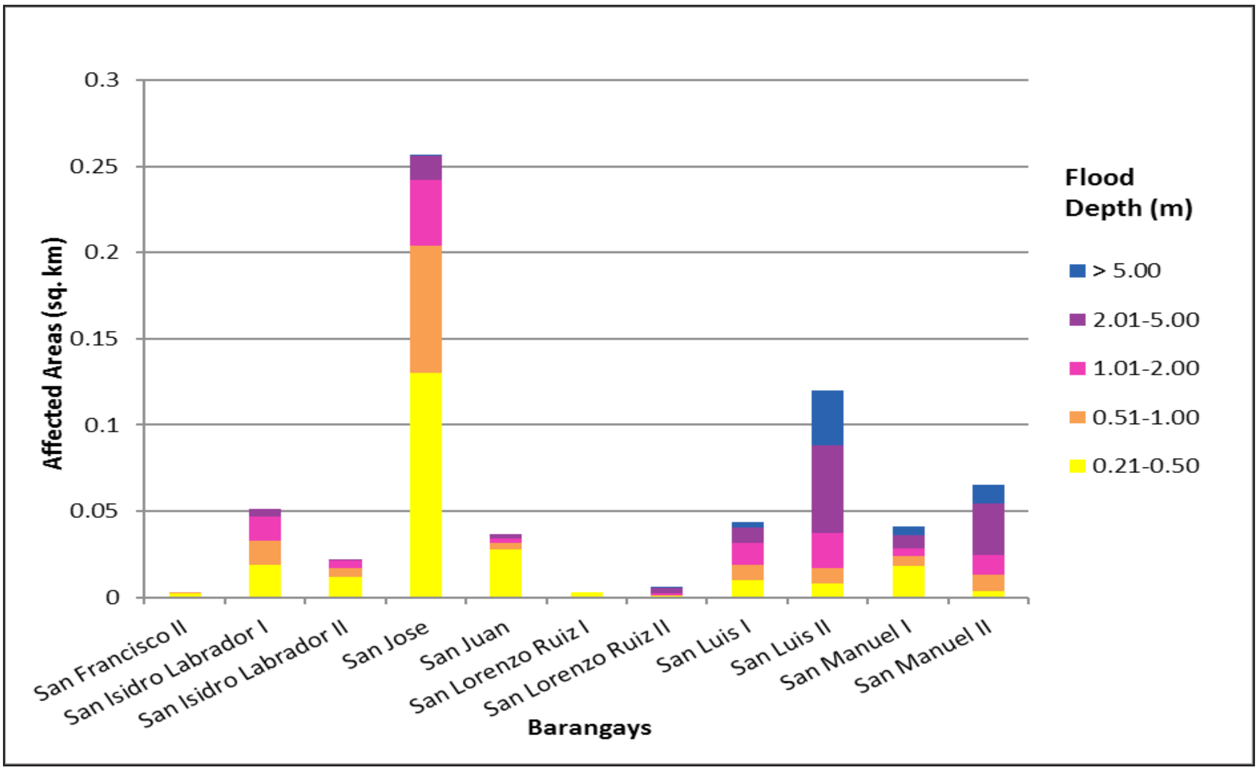


Figure 115. Affected Areas in Dasmariñas, Cavite during 100-year Rainfall Return Period

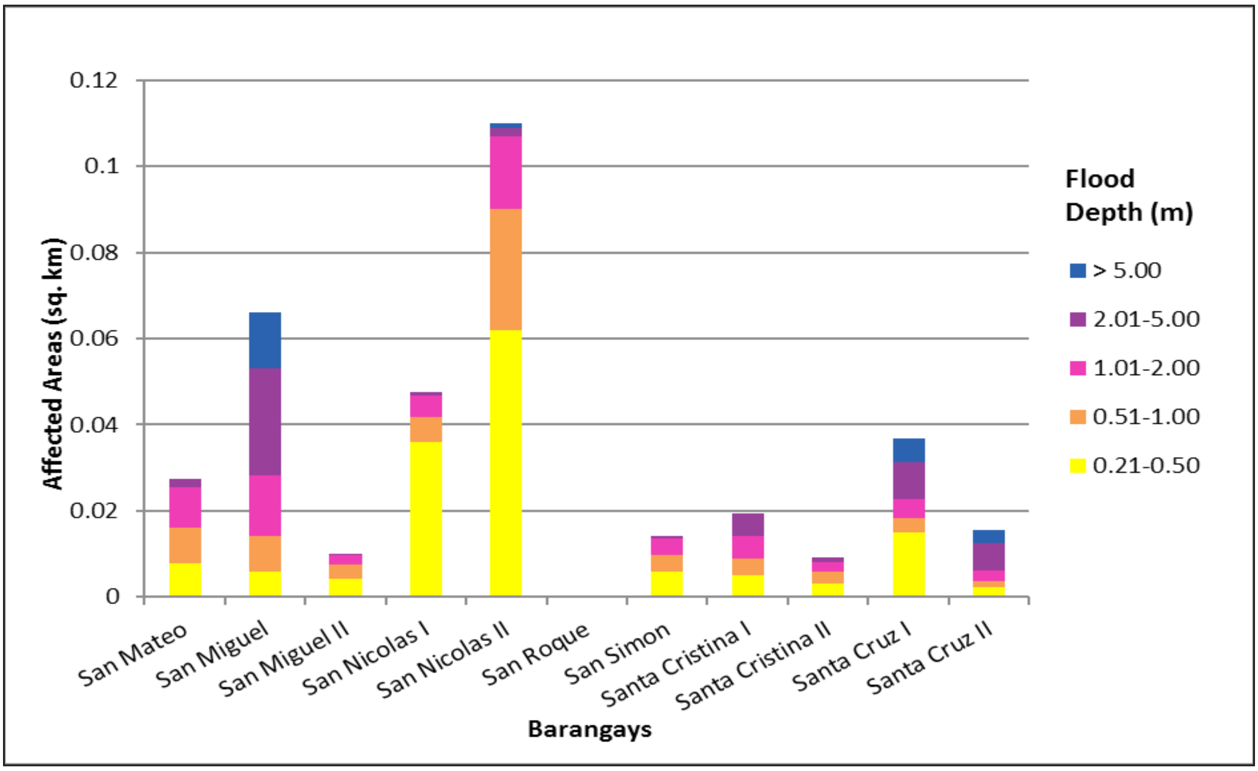


Figure 116. Affected Areas in Dasmariñas, Cavite during 100-year Rainfall Return Period

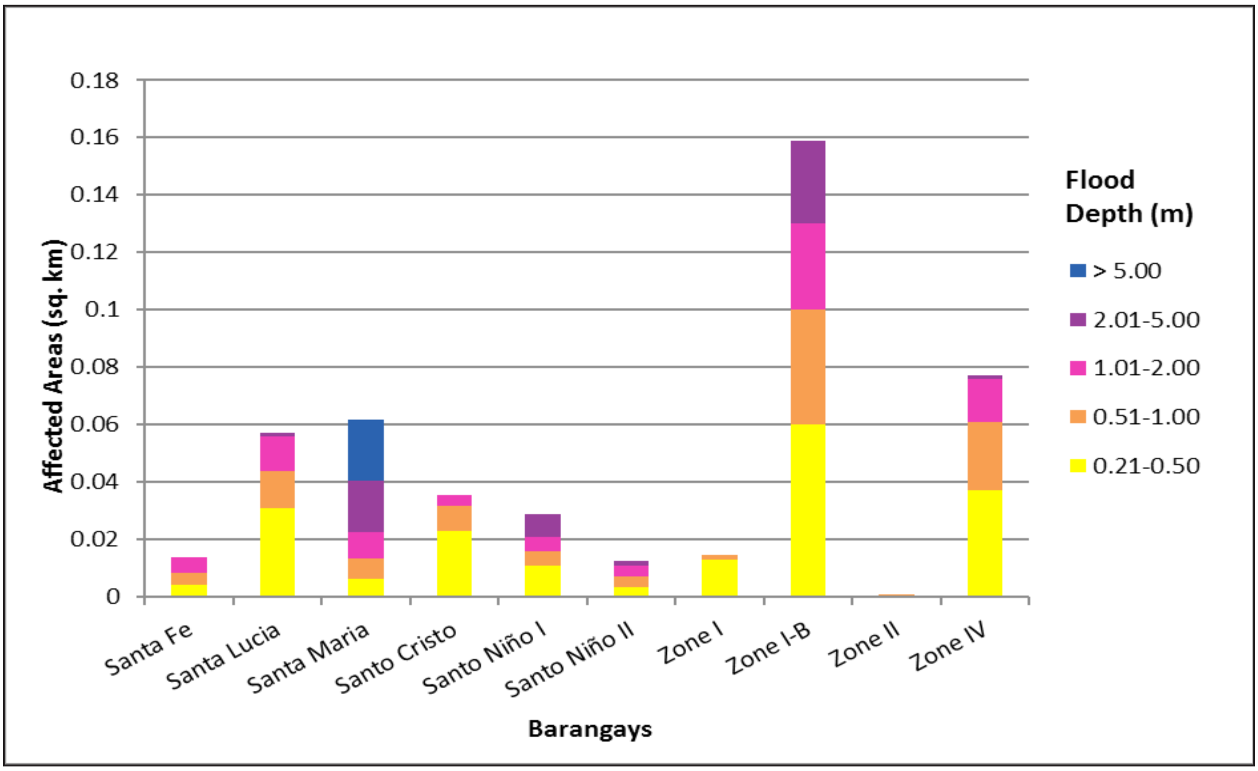


Figure 117. Affected Areas in Dasmariñas, Cavite during 100-year Rainfall Return Period

For the 100-year return period, 21.23% of the municipality of Imus with an area of 56.81 sq. km. will experience flood levels of less than 0.20 meters. 9.68% of the area will experience flood levels of 0.21 to 0.50 meters while 15.98%, 13.21%, 2.24%, and 0.55% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 83 to Table 90 and shown in Figure 118 to Figure 125 are the affected areas in square kilometers by flood depth per barangay.

Table 83. Affected Areas in Imus, Cavite during 100-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)										
	Anabu I-A	Anabu I-B	Anabu I-C	Anabu I-D	Anabu I-E	Anabu I-F	Anabu I-G	Anabu II-A	Anabu II-B	Anabu II-C	Anabu II-D
0.03-0.20	0.17	0.058	0.021	0.031	0.048	0.075	0.098	3.25	0.13	0.12	0.14
0.21-0.50	0.27	0.054	0.043	0.049	0.068	0.052	0.078	0.54	0.1	0.21	0.14
0.51-1.00	0.4	0.14	0.097	0.11	0.15	0.13	0.096	0.81	0.15	0.28	0.24
1.01-2.00	0.21	0.067	0.089	0.12	0.13	0.11	0.15	0.86	0.12	0.13	0.2
2.01-5.00	0.022	0.015	0.0098	0.015	0.0033	0.0061	0.017	0.35	0.027	0.033	0.029
> 5.00	0.00075	0.0009	0.0059	0.0055	0.0073	0.0077	0.0085	0.13	0	0.0002	0.016

Table 84. Affected Areas in Imus, Cavite during 100-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)										
	Anabu II-E	Anabu II-F	Bagong Silang	Bayan Luma I	Bayan Luma II	Bayan Luma III	Bayan Luma IV	Bayan Luma IX	Bayan Luma V	Bayan Luma VI	Bayan Luma VII
0.03-0.20	0.19	0.3	0.041	0.0041	0.0032	0.0025	0.012	0.0014	0.0026	0.006	0.029
0.21-0.50	0.24	0.25	0.043	0.0051	0.015	0.0082	0.036	0.019	0.014	0.02	0.089
0.51-1.00	0.34	0.41	0.023	0.04	0.036	0.076	0.077	0.081	0.048	0.033	0.058
1.01-2.00	0.31	0.32	0.052	0.055	0.058	0.082	0.014	0.029	0.025	0.03	0.0054
2.01-5.00	0.034	0.027	0.0029	0.0085	0.012	0.0087	0	0	0	0	0
> 5.00	0.008	0.013	0	0.0007	0	0	0	0	0	0	0

Table 85. Affected Areas in Imus, Cavite during 100-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)										
	Bayan Luma VIII	Bucandala I	Bucandala II	Bucandala III	Bucandala V	Buhay na Tubig	Carsadang Bago I	Carsadang Bago II	Magdalo	Maharlika	Malagasang I-B
0.03-0.20	0.025	0.065	0.0036	0.12	0.0023	0.049	0.068	0.21	0.036	0.0042	0.0016
0.21-0.50	0.1	0.12	0.021	0.1	0.014	0.044	0.29	0.25	0.04	0.0073	0.011
0.51-1.00	0.1	0.25	0.084	0.1	0.15	0.03	0.43	0.22	0.027	0.031	0.01
1.01-2.00	0.0027	0.18	0.0084	0.013	0.07	0.06	0.13	0.053	0.045	0.074	0
2.01-5.00	0	0.0053	0	0	0.00069	0.0001	0.013	0.0016	0	0.023	0
> 5.00	0	0	0	0	0.000054	0	0	0	0	0.0071	0

Table 86. Affected Areas in Imus, Cavite during 100-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)										
	Mala-gasang I-C	Mala-gasang I-D	Mala-gasang I-E	Mala-gasang I-F	Mala-gasang I-G	Mala-gasang II-C	Mala-gasang II-D	Mala-gasang II-E	Mala-gasang II-F	Mala-gasang II-G	Mariano Espeleta I
0.03-0.20	0.00048	0.0004	0.00019	0.0027	0.0069	0.075	0.033	0.0076	0.13	0.0024	0.0061
0.21-0.50	0.0025	0.0025	0.0013	0.04	0.051	0.064	0.057	0.069	0.11	0.037	0.012
0.51-1.00	0.00099	0.0025	0.026	0.17	0.25	0.084	0.034	0.28	0.096	0.19	0.027
1.01-2.00	0	0	0.015	0.13	0.051	0.026	0.0015	0.1	0.03	0.073	0.067
2.01-5.00	0	0	0	0.0013	0	0.01	0	0.007	0.008	0	0.013
> 5.00	0	0	0	0.00054	0	0	0	0	0	0	0

Table 87. Affected Areas in Imus, Cavite during 100-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)										
	Mariano Espeleta II	Mariano Espeleta III	Medicion I-A	Medicion I-B	Medicion I-C	Medicion I-D	Medicion II-B	Medicion II-C	Medicion II-D	Medicion II-E	Medicion II-F
0.03-0.20	0	0.00033	0.0076	0.011	0.0059	0.0053	0	0.013	0.0011	0.003	0.046
0.21-0.50	0.0006	0.0026	0.021	0.034	0.011	0.017	0	0.032	0.01	0.02	0.054
0.51-1.00	0.013	0.046	0.023	0.025	0.032	0.01	0.002	0.048	0.031	0.041	0.034
1.01-2.00	0.073	0.038	0.0084	0.011	0.016	0.053	0.0024	0.014	0.029	0.016	0.001
2.01-5.00	0.0007	0.0071	0.00027	0.00027	0	0.0028	0	0	0.0073	0	0
> 5.00	0	0.0052	0	0	0	0	0	0	0	0	0

Table 88. Affected Areas in Imus, Cavite during 100-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)									
	Pag-Asa III	Palico I	Palico II	Palico III	Palico IV	Pasong Buaya I	Pasong Buaya II	Pinag-buklod	Poblacion I-A	Poblacion I-B
0.03-0.20	0.046	0.013	0.00032	0.018	0.0044	3.36	2.67	0.0082	0.00061	0
0.21-0.50	0.066	0.025	0.0061	0.0071	0.013	0.31	0.7	0.0055	0.011	0.0001
0.51-1.00	0.031	0.023	0.016	0.021	0.022	0.3	0.74	0.04	0.073	0.023
1.01-2.00	0.011	0.0061	0.0091	0.017	0.0053	0.31	0.34	0.13	0.066	0.05
2.01-5.00	0	0.0065	0.0076	0.0098	0	0.17	0.13	0.0089	0	0
> 5.00	0	0.0075	0.0056	0.0089	0	0.018	0.012	0.0092	0	0

Table 89. Affected Areas in Imus, Cavite during 100-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)									
	Poblacion I-C	Poblacion II-A	Poblacion II-B	Poblacion III-A	Poblacion III-B	Poblacion IV-A	Poblacion IV-B	Poblacion IV-C	Poblacion IV-D	Tanzang Luma I
0.03-0.20	0	0.0001	0.000029	0.006	0.0072	0.01	0	0.0024	0.0004	0.19
0.21-0.50	3.8E-08	0.00061	0.0033	0.02	0.019	0.063	0.0018	0.019	0.005	0.11
0.51-1.00	0.017	0.017	0.015	0.061	0.061	0.17	0.02	0.13	0.053	0.12
1.01-2.00	0.06	0.056	0.031	0.15	0.026	0.035	0.031	0.064	0.18	0.026
2.01-5.00	0.0001	0.0014	0	0.012	0.0046	0.007	0.0035	0.0013	0.0001	0.0001
> 5.00	0	0	0	0	0	0	0	0	0	0

Table 90. Affected Areas in Imus, Cavite during 100-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Imus (in sq. km)									
	Tanzang Luma II	Tanzang Luma III	Tanzang Luma IV	Tanzang Luma V	Tanzang Luma VI	Toclong I-A	Toclong I-B	Toclong I-C	Toclong II-A	Toclong II-B
0.03-0.20	0.0056	0.015	0	0.00019	0.029	0	0	0	0	0
0.21-0.50	0.042	0.036	0.000076	0.0023	0.043	0	0.0004	0.000042	0.00034	0.0019
0.51-1.00	0.046	0.045	0.027	0.02	0.12	0.0044	0.015	0.021	0.011	0.095
1.01-2.00	0.058	0.11	0.1	0.17	0.053	0.11	0.17	0.17	0.18	0.22
2.01-5.00	0.0086	0.037	0.02	0.04	0.0089	0.0062	0.0039	0.013	0.025	0.025
> 5.00	0	0.0046	0.0086	0.019	0.0017	0	0	0	0	0

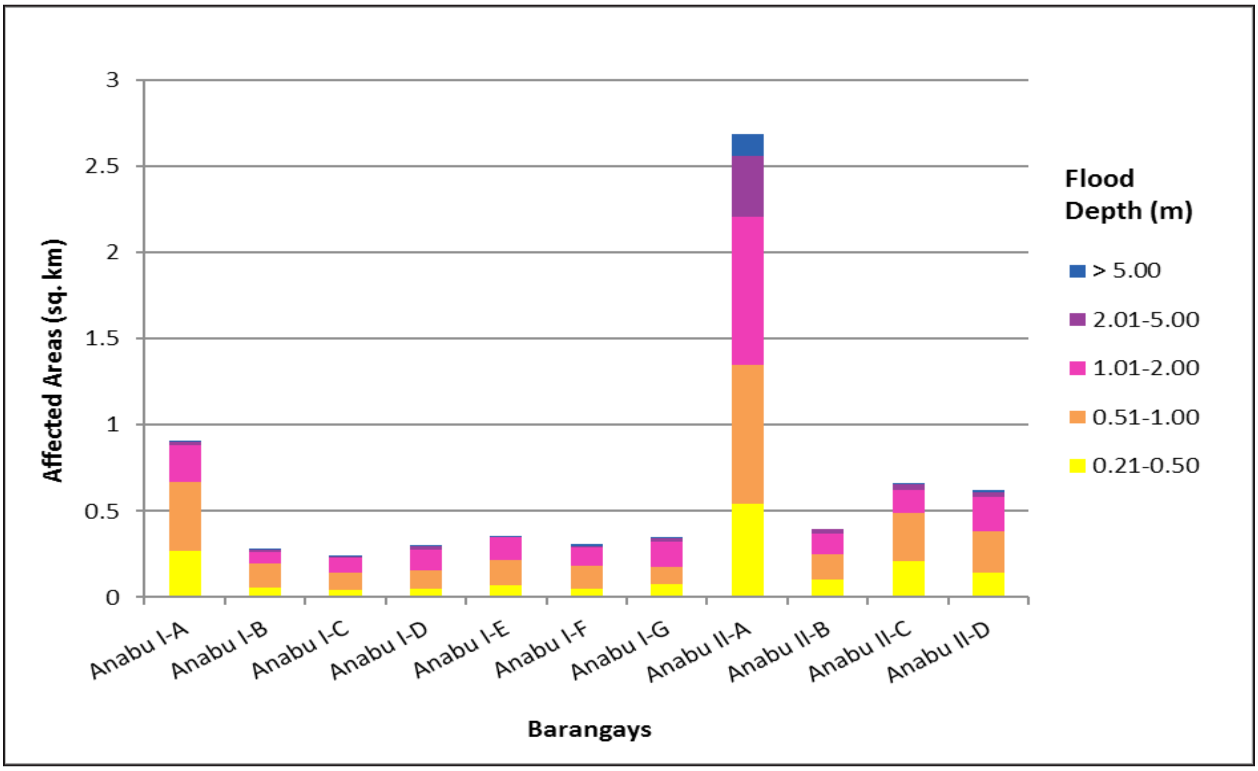


Figure 118. Affected Areas in Dasmariñas, Cavite during 100-year Rainfall Return Period

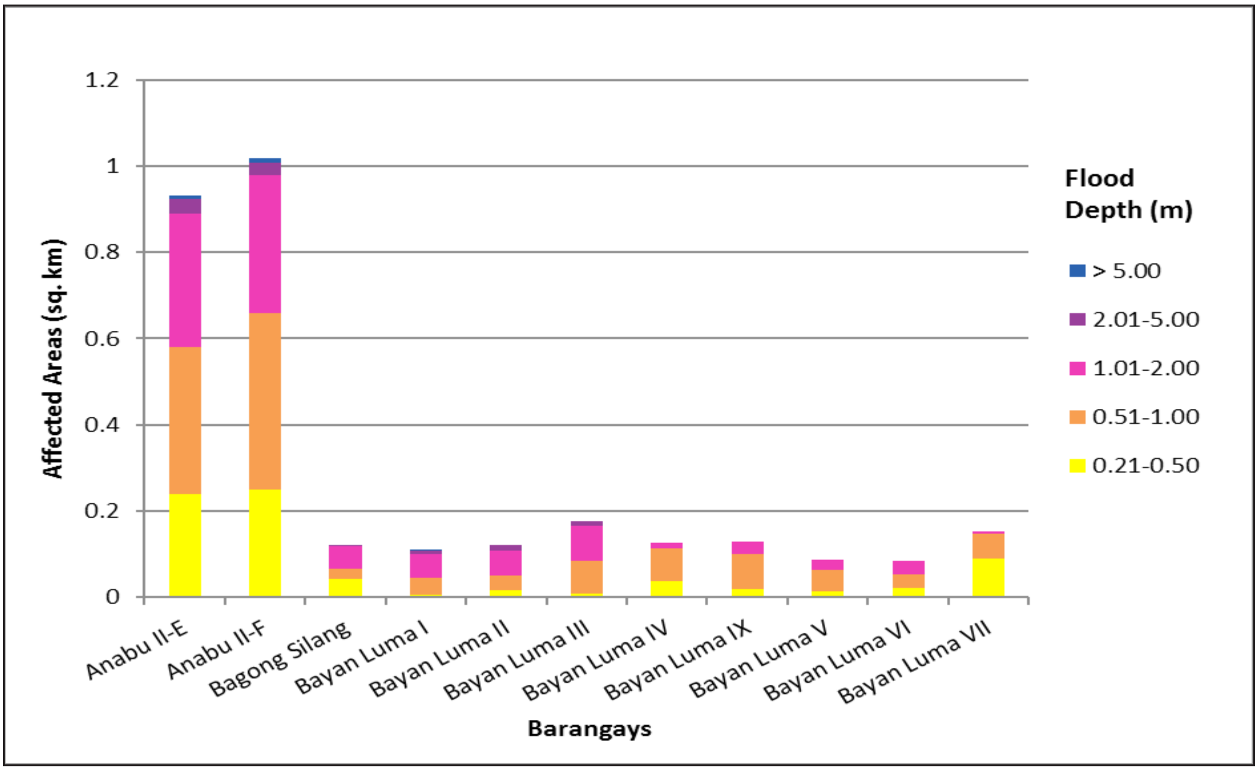


Figure 119. Affected Areas in Dasmariñas, Cavite during 100-year Rainfall Return Period

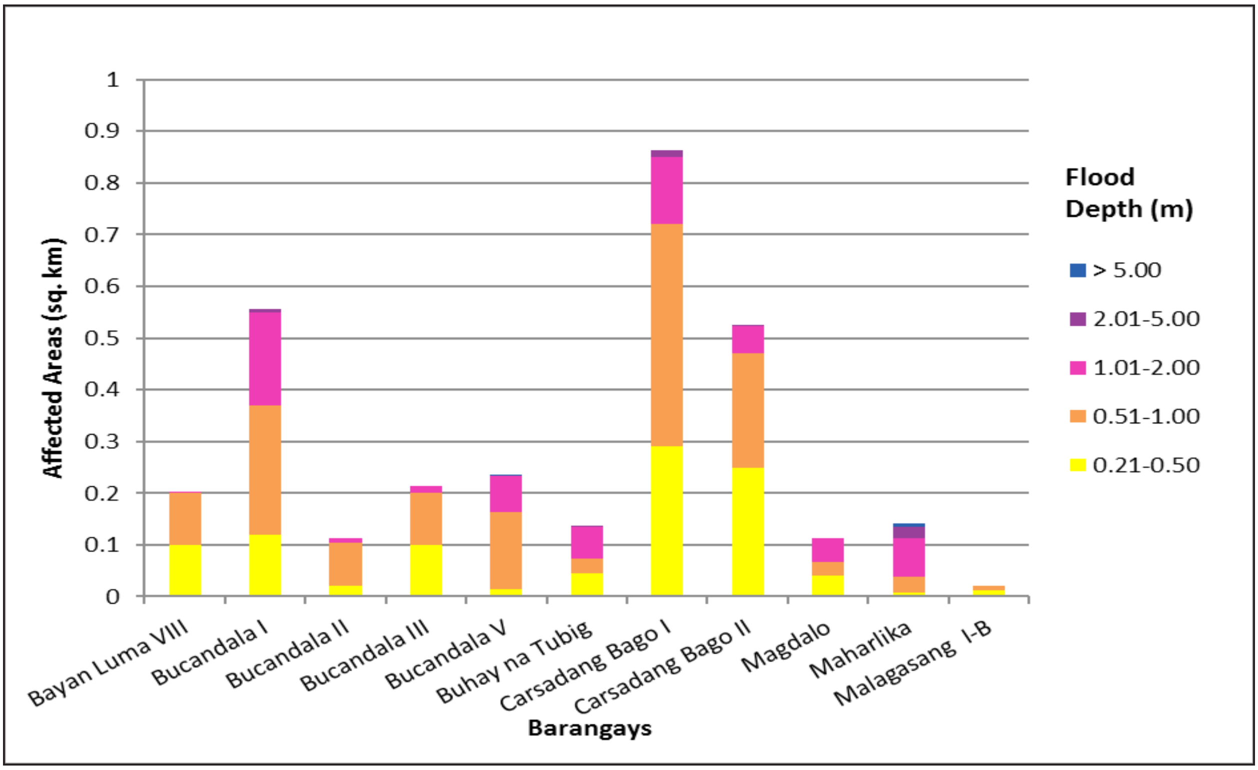


Figure 120. Affected Areas in Dasmariñas, Cavite during 100-year Rainfall Return Period

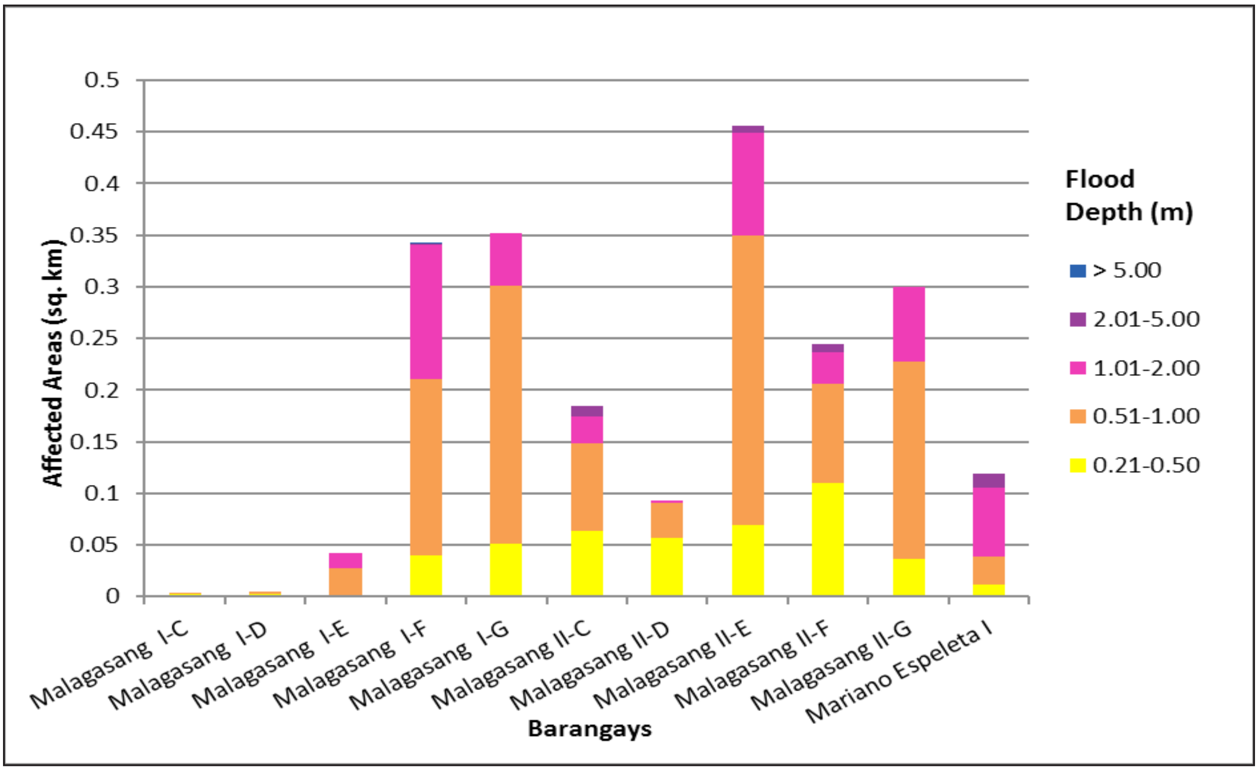


Figure 121. Affected Areas in Dasmariñas, Cavite during 100-year Rainfall Return Period

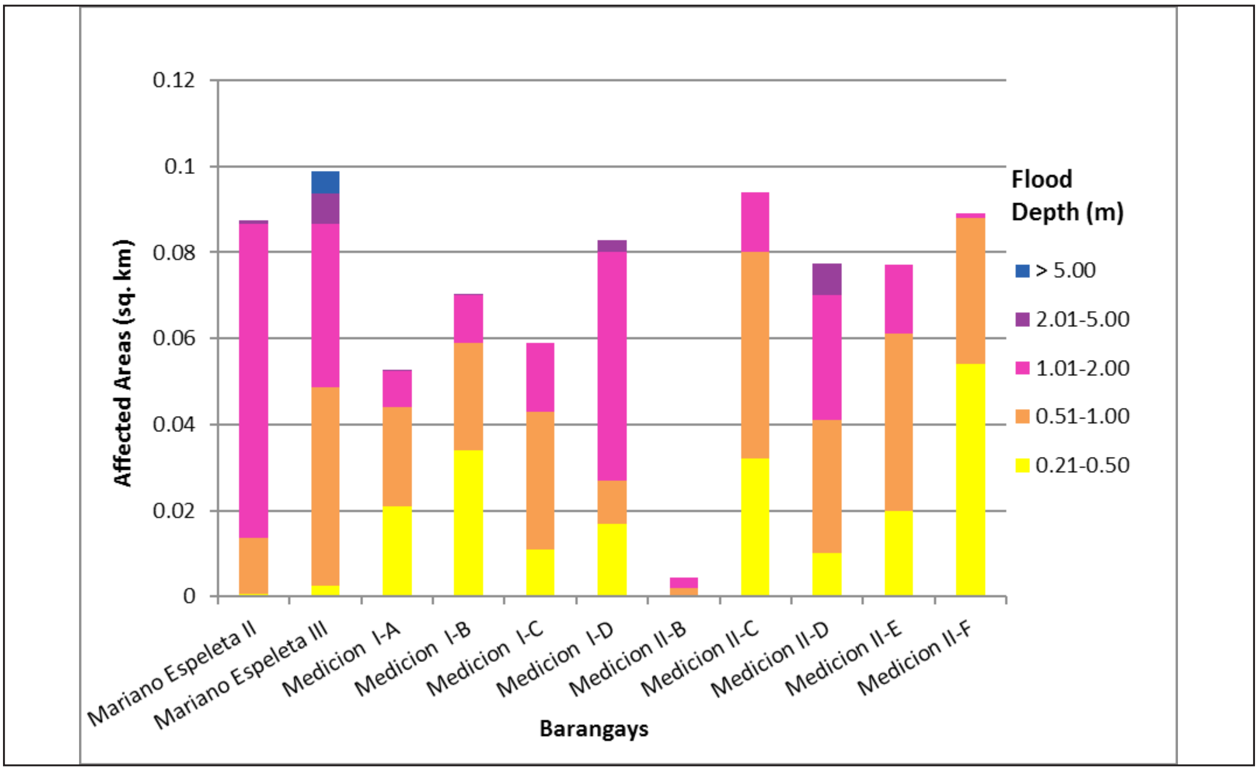


Figure 122. Affected Areas in Dasmariñas, Cavite during 100-year Rainfall Return Period

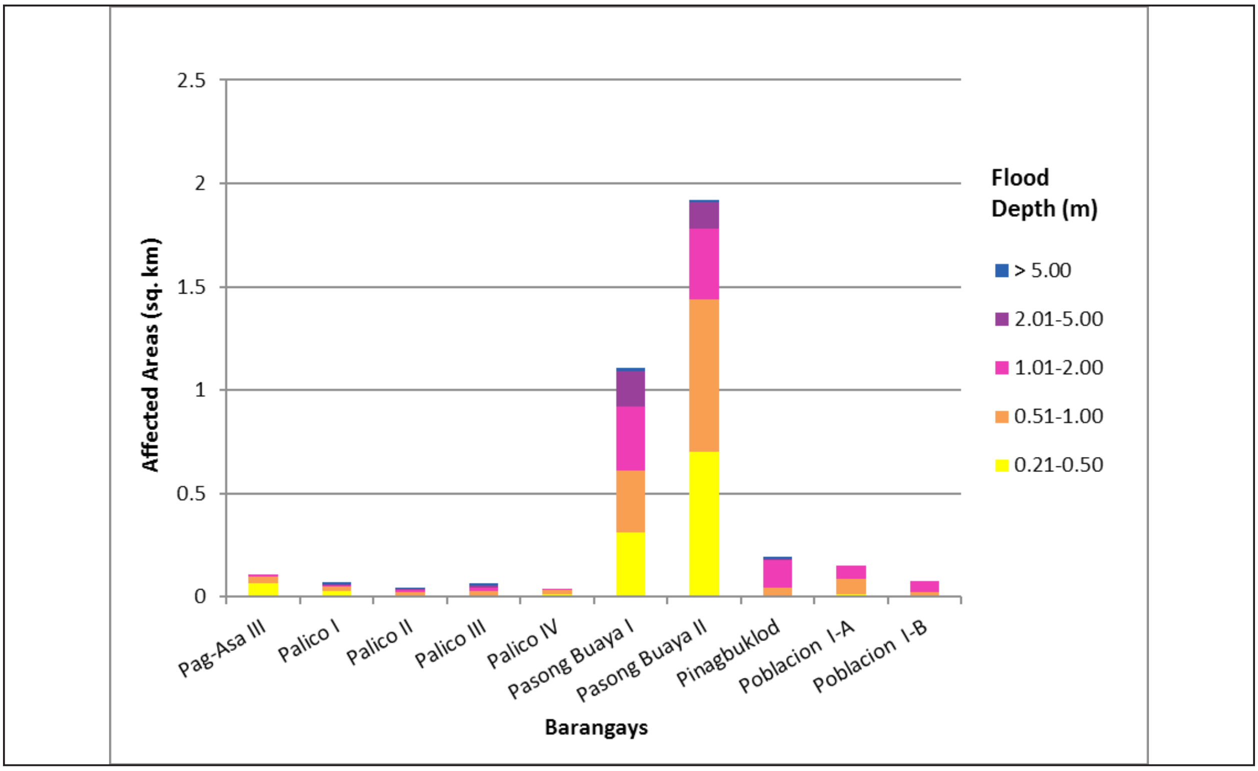


Figure 123. Affected Areas in Dasmariñas, Cavite during 100-year Rainfall Return Period

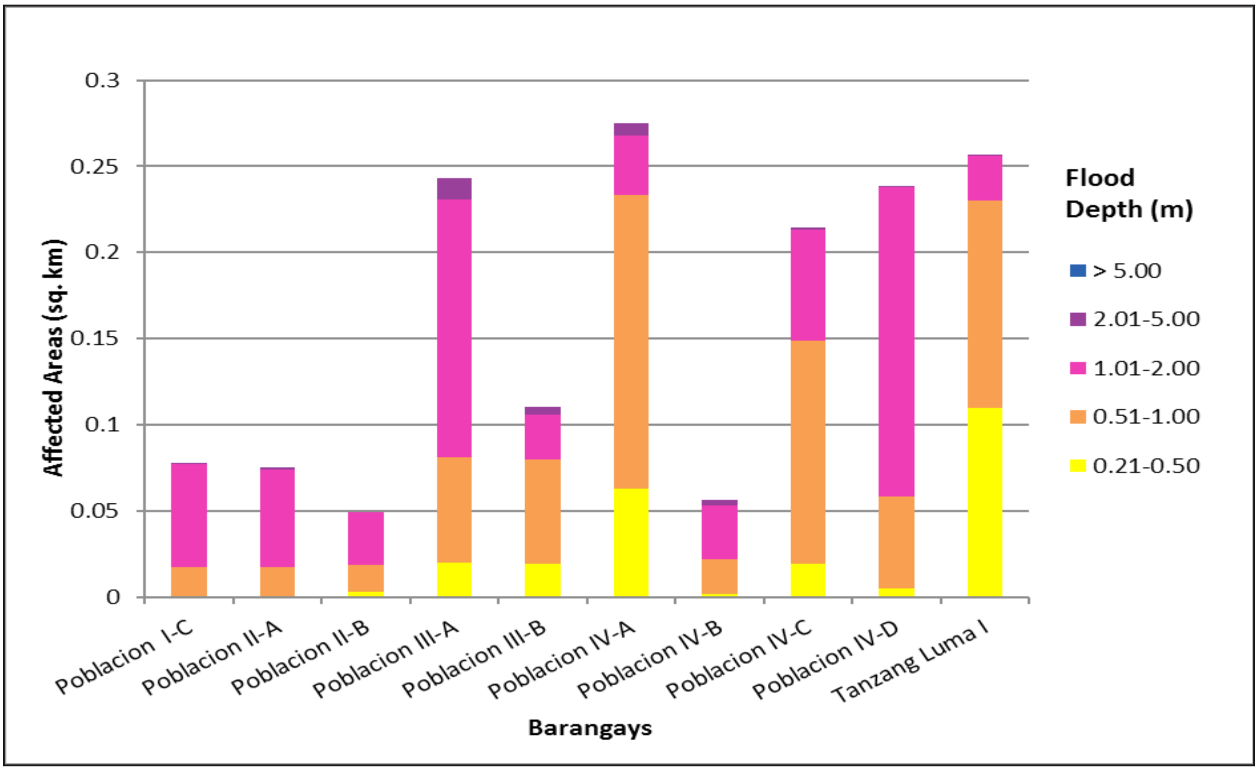


Figure 124. Affected Areas in Dasmariñas, Cavite during 100-year Rainfall Return Period

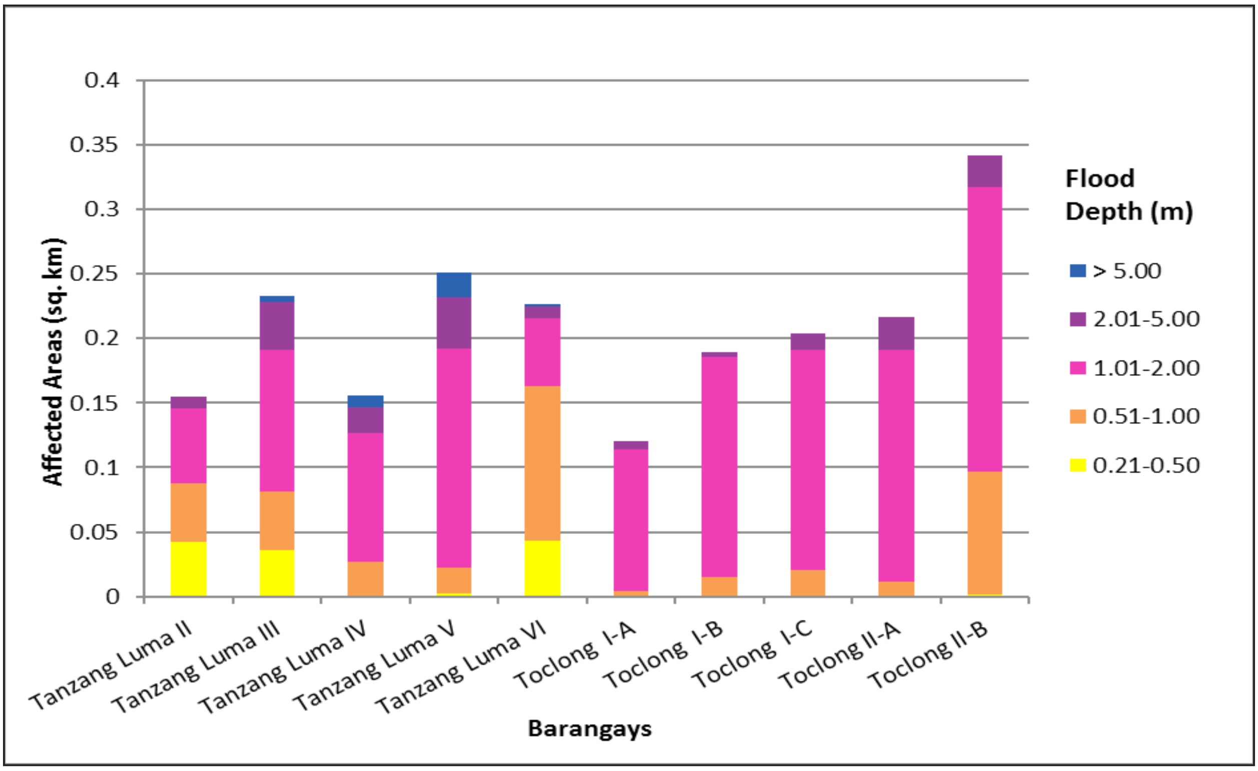


Figure 125. Affected Areas in Dasmariñas, Cavite during 100-year Rainfall Return Period

For the 100-year return period, 0.76% of the municipality of Kawit with an area of 9.47 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 1.06%, 7.78%, and 2.64% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and 2.01 to 5 meters, respectively. Listed Table 91 and shown in Figure 126 are the affected areas in square kilometers by flood depth per barangay.

Table 91. Affected Areas in Kawit, Cavite during 100-year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Kawit (in sq. km)							
	Balsahan -Bisita	Binakayan -Aplaya	Binakayan -Kanluran	Congbalay -Legaspi	Manggahan -Lawin	Pulvorista	Samala -Marquez	Toclong
0.03-0.20	0.015	0.031	0	0.0056	0.0051	0	0	0.015
0.21-0.50	0.0018	0.019	0	0.0045	0.0028	0	0	0.028
0.51-1.00	0.0068	0.01	0.00063	0.0044	0.019	0.00078	0.00067	0.058
1.01-2.00	0.0089	0.007	0.078	0.0072	0.03	0.096	0.1	0.41
2.01-5.00	0.007	0.0042	0	0.0085	0.061	0.013	0.016	0.14
> 5.00	0	0	0	0	0	0	0	0

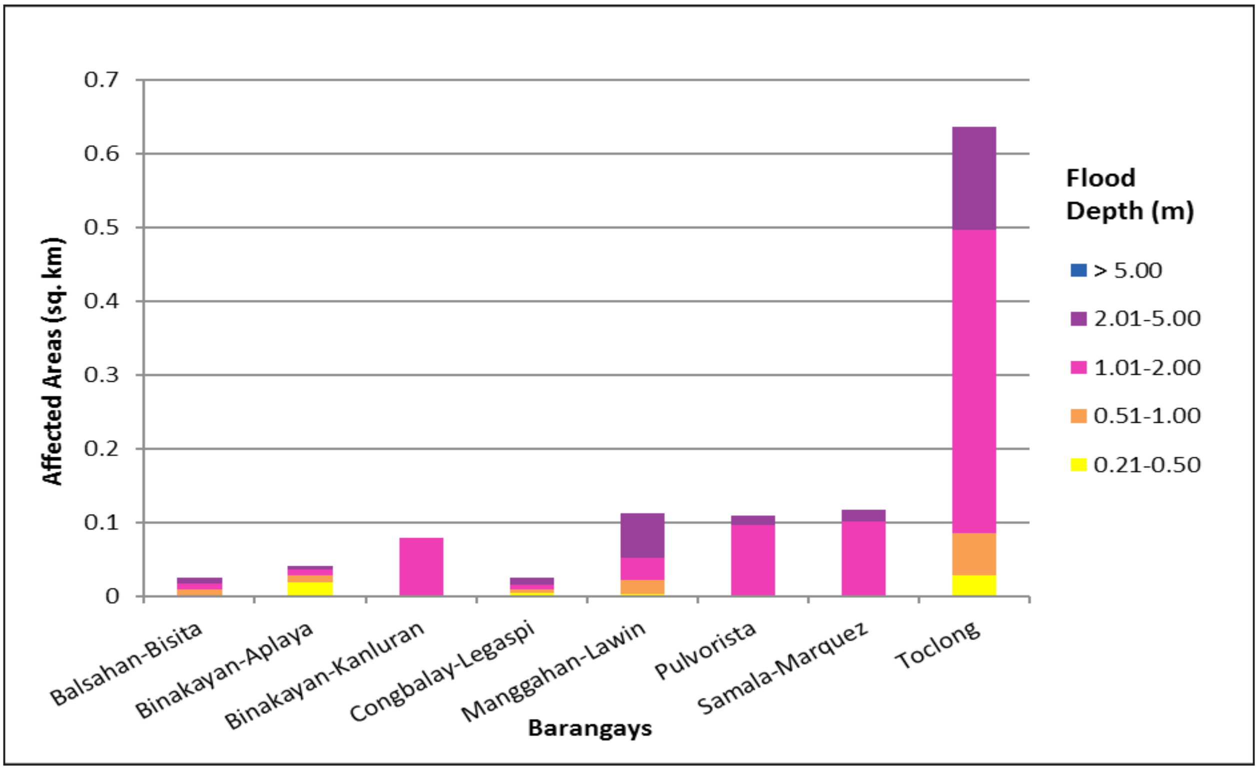


Figure 126. Affected Areas in Dasmariñas, Cavite during 100-year Rainfall Return Period

Among the barangays in the municipality of Bacoor in Cavite, Mambog I is projected to have the highest percentage of area that will experience flood levels at 3.36%. Meanwhile, Queens Row East posted the second highest percentage of area that may be affected by flood depths at 2.92%.

Among the barangays in the municipality of Dasmariñas in Cavite, Salawag is projected to have the highest percentage of area that will experience flood levels at 22.16%. Meanwhile, Salitran IV posted the second highest percentage of area that may be affected by flood depths at 6.47%.
Among the barangays in the municipality of Imus in Cavite, Anabu II-A is projected to have the highest percentage of area that will experience flood levels at 12.52%. Meanwhile, Pasong Buaya II posted the second highest percentage of area that may be affected by flood depths at 9.68%.

Among the barangays in the municipality of Kawit in Cavite, Toclong is projected to have the highest percentage of area that will experience flood levels at 1.37%. Meanwhile, Manggahan-Lawin posted the second highest percentage of area that may be affected by flood depths at 0.25%.

Moreover, the generated flood hazard maps for the Imus 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 92. 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	12.90	12.24	11.61
Medium	16.66	22.59	24.67
High	5.07	8.12	10.94
TOTAL	**34.63**	**42.95**	**47.22**

Of the 160 identified educational institutions in Imus Floodplain, thirty-four (34) schools were discovered exposed to low-level flooding while thirty-nine (39) schools were found exposed to medium-level flooding, both during the 5-year scenario. In the same scenario, four (4) schools were discovered exposed to high-level flooding.

For the 25-year scenario, twenty-three (23) schools were discovered exposed to Low-level flooding while sixty-two (62) schools were found exposed to medium-level flooding. In the same scenario, nine (9) schools were discovered exposed to High-level flooding.

For the 100-year scenario, nineteen (19) schools were discovered exposed to Low-level flooding while sixty-six (66) schools were found exposed to medium-level flooding. In the same scenario, fifteen (15) schools were discovered exposed to high-level flooding. The list of educational institutions affected by flooding are found in Annex 12.

Of the 51 identified medical institutions in Imus Floodplain, twelve (12) medical institutions were discovered exposed to low-level flooding while fifteen (15) medical institutions were found exposed to medium-level flooding, both during the 5-year scenario.

For the 25-year scenario, ten (10) medical institutions were discovered exposed to low-level flooding while twenty-one (21) medical institutions were found exposed to medium-level flooding. In the same scenario, four (4) medical institutions were discovered exposed to high-level flooding.

For the 100-year scenario, seven (7) medical institutions were discovered exposed to low-level flooding while twenty-three (23) medical institutions were found exposed to medium-level flooding. In the same scenario, six (6) medical institutions were discovered exposed to high-level flooding. The list of medical or health institutions affected by flooding are found in Annex 13.

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, obtaining maps or situation reports about the past flooding events and through interview with some residents who have knowledge of or have had experienced flooding in a particular area.

After which, the actual data from the field was compared to the simulated data to assess the accuracy of the Flood Depth Maps produced and to improve on what is needed. The points in the flood map versus its corresponding validation depths are shown in Figure 128.

The flood validation consisted of ____ points randomly selected all over the Imus floodplain (Figure 127). Comparing it with the flood depth map of the nearest storm event, the map has an RMSE value of ____m. Table 93 shows a contingency matrix of the comparison.

Figure 127. Validation points for 5-year Flood Depth Map of Imus Floodplain

Figure 128. Flood map depth vs. actual flood depth

Table 93. Actual flood vs simulated flood depth at different levels in the Imus River Basin.

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							
0.21-0.50							
0.51-1.00							
1.01-2.00							
2.01-5.00							
> 5.00							
Total							

Table 94. Summary of the Accuracy Assessment in the Imus River Basin Survey

	No. of Points	%
Correct		
Overestimated		
Underestimated		
Total		

REFERENCES

Ang M.C., 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.C., Lagmay, A.F., 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.J.S., Paringit E.C., et al. 2014. DREAM Data Aquisition 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. Optech Technical Specification of the Pegasus Sensor

1. PEGASUS SENSOR

Figure A-1.1 Pegasus Sensor

2. PARAMETERS AND SPECIFICATIONS OF THE PEGASUS SENSOR

Table A-1.1 Parameters and Specifications of the Pegasus Sensor

Parameter	Specification
Operational envelope (1,2,3,4)	150-5000 m AGL, nominal
Laser wavelength	1064 nm
Horizontal accuracy (2)	1/5,500 x altitude, 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

3. LEICA Geosystems ALS80-HP

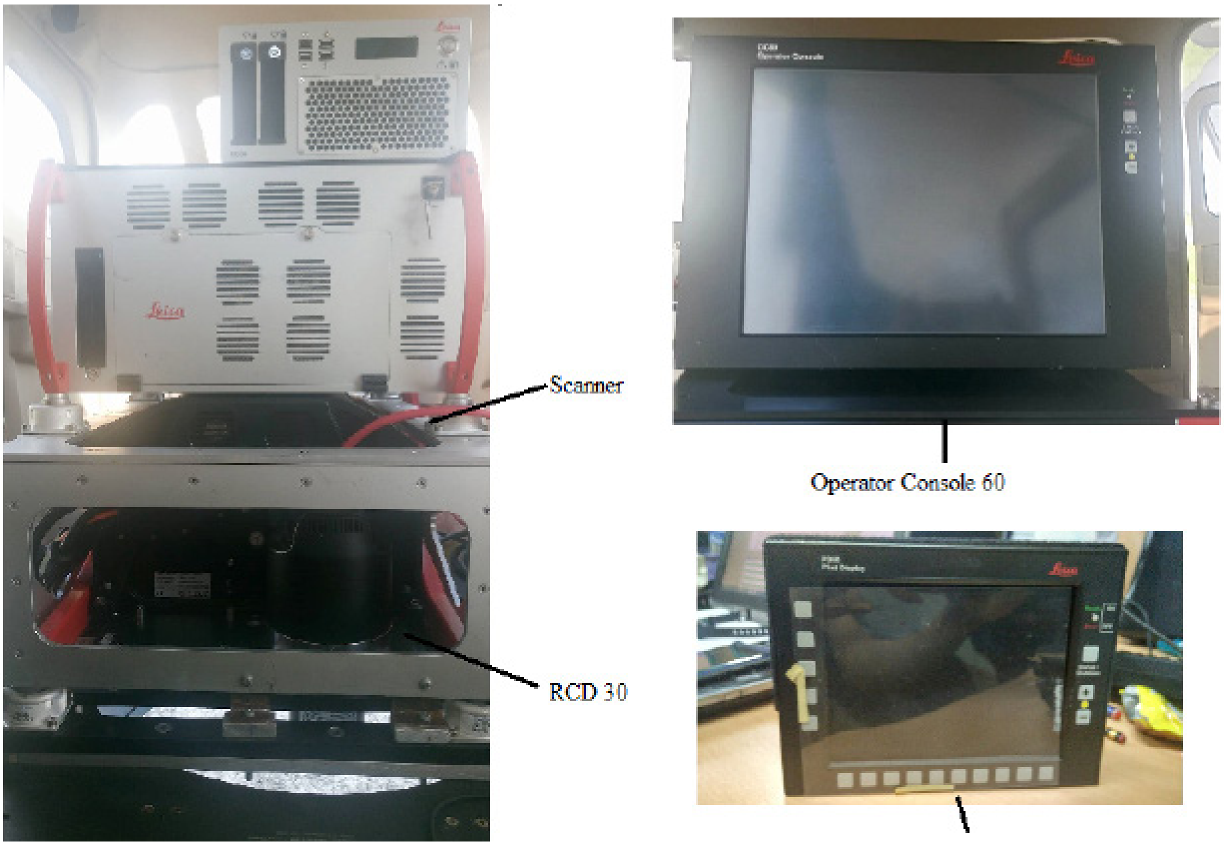


Figure A-1.1 LEICA Geosystems ALS80-HP Sensor

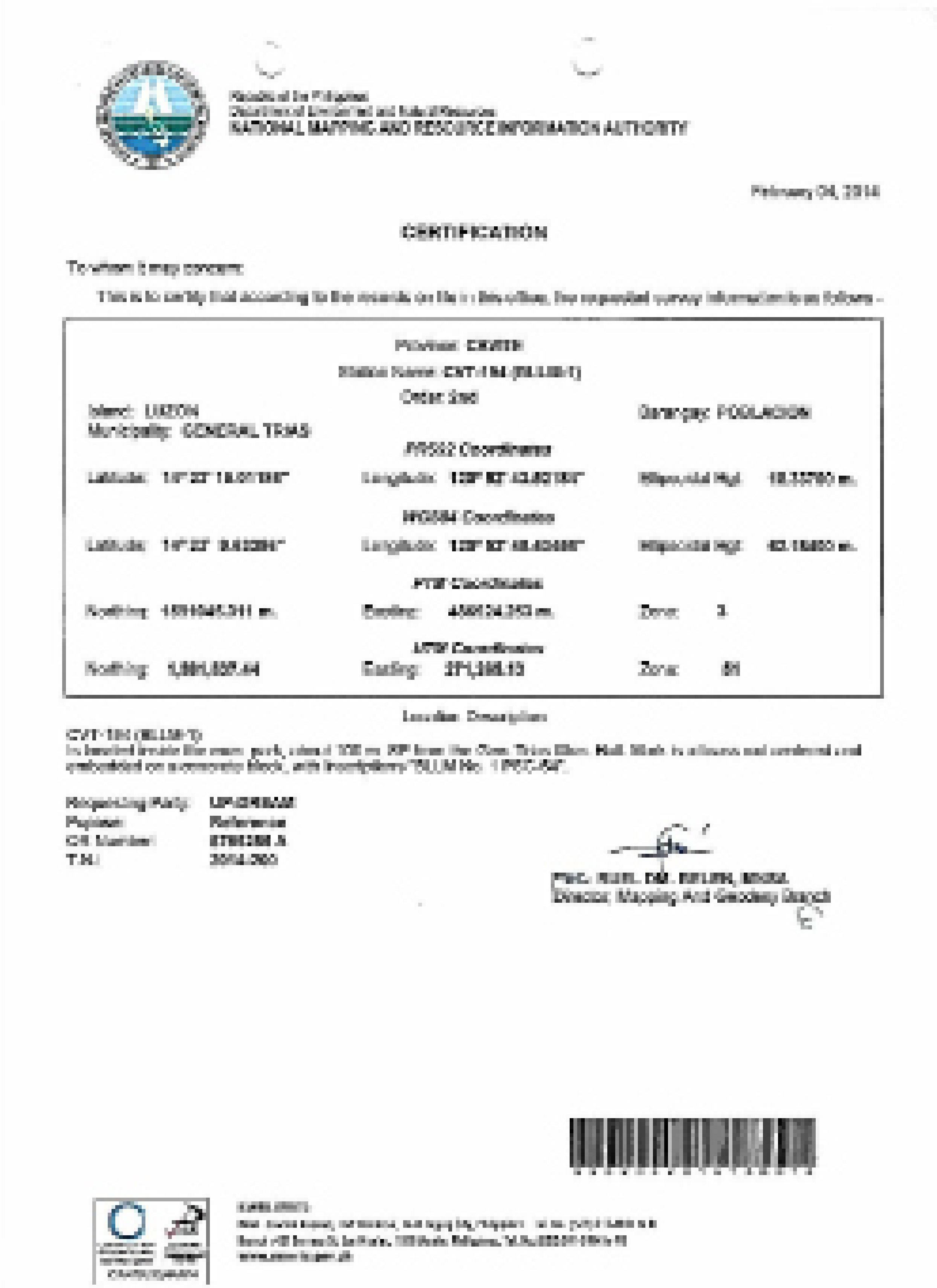
4. PARAMETERS AND SPECIFICATIONS OF THE LEICA SENSOR

Table A-1.2 Parameters and Specifications of the Leica Sensor

Parameter	Specification
Operational altitude	100 to 3500 m max AGL
Maximum measurement rate	1000 kHz
Maximum scan rate	200 Hz for sine; 158 for triangle;120 for raster
Field of view (degrees, full angle, user-adjustable)	0 to 72
Roll Stabilization(automatic adaptive, degrees)	72 – active FOV
Number of returns	unlimited
Number of intensity measurements	3(first, second and third)
Data Storage	ALS80: removable SSD hard disk (800GB each volume)
Power Consumption	922 W @ 22.0-30.3 VDC
Dimensions and weight	Scanner:37 W x 68 L x 26 H cm; 47 kg; Control Electronics: 45 W x 47 D x 25 H cm; 33 kg
Operating temperature	0-40˚C

Annex 2. NAMRIA Certificates of Reference Points Used

1. CVT-194



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: CAVITE

Station Name: CVT-194 [illegible]

Order: 2nd

Island: LUZON

Municipality: GENERAL TRIAS

Barangay: POBLACION

PRS92 Coordinates

Latitude: [illegible] Longitude: [illegible] Ellipsoidal Hgt: [illegible]

WGS84 Coordinates

Latitude: [illegible] Longitude: [illegible] Ellipsoidal Hgt: [illegible]

PTM Coordinates

Northing: [illegible] Easting: [illegible] Zone: 3

UTM Coordinates

Northing: [illegible] Easting: [illegible] Zone: 51

Location Description

[illegible]

Requesting Party: UP-DREAM

Purpose: Reference

OR Number: [illegible]

T.N.: [illegible]

Director, Mapping And Geodesy Branch

Figure A-2.1 CVT-194

2. BTG-45

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

March 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: **BATANGAS**
Station Name: **BTG-45**
Order: **2nd**

Island: **LUZON**
Municipality: **TUY**
Barangay: **MALIBU**

PRS92 Coordinates

Latitude: **13° 59' 52.18294"**	Longitude: **120° 42' 18.96476"**	Ellipsoidal Hgt: **48.43000 m.**

WGS84 Coordinates

Latitude: **13° 59' 46.88216"**	Longitude: **120° 42' 23.91169"**	Ellipsoidal Hgt: **92.94300 m.**

PTM Coordinates

Northing: **1547952.281 m.**	Easting: **468159.677 m.**	Zone: **3**

UTM Coordinates

Northing: **1,548,591.80**	Easting: **252,126.62**	Zone: **51**

Location Description

BTG-45
From Tuy Town Proper, travel S on the road going to Balayan, then turn right to the road going to Brgy. Malibu. Station is located on the NW side of a fenced garden and about 10 m. W of the school bldg. of Santiago De Guzman Elem. School. Mark is the head of a 4 in. copper nail centered and embedded on a 30 cm. x 30 cm. concrete block, with inscriptions "BTG-45 2007 NAMRIA".

Requesting Party: **UP-DREAM**
Pupose: **Reference**
OR Number: **8796470 A**
T.N.: **2014-444**

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

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

Figure A-2.2 BTG-45

Annex 3. Baseline Processing Report of Reference Points Used

1. CVT-3051

Project Information		Coordinate System	
Name:		Name:	UTM
Size:		Datum:	PRS 92
Modified:	10/12/2012 4:40:11 PM (UTC:-6)	Zone:	51 North (123E)
Time zone:	Mountain Standard Time	Geoid:	EGMPH
Reference number:		Vertical datum:	
Description:			

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
CVT-199 --- CVT-3051 (B1)	CVT-199	CVT-3051	Fixed	0.073	0.128	12°58'47"	10463.417	-145.079

Acceptance Summary

Processed	Passed	Flag	Fail
1	0	1	0

CVT-199 - CVT-3051 (3:06:13 PM-4:03:02 PM) (S1)

Baseline observation:	CVT-199 --- CVT-3051 (B1)
Processed:	9/2/2015 11:27:19 AM
Solution type:	Fixed
Frequency used:	Dual Frequency (L1, L2)
Horizontal precision:	0.073 m
Vertical precision:	0.128 m
RMS:	0.006 m
Maximum PDOP:	9.772
Ephemeris used:	Broadcast
Antenna model:	Trimble Relative
Processing start time:	9/1/2015 3:06:41 PM (Local: UTC+8hr)
Processing stop time:	9/1/2015 4:03:02 PM (Local: UTC+8hr)
Processing duration:	00:56:21
Processing interval:	1 second

1

Figure A-3.1 Baseline Processing Report - A

Vector Components (Mark to Mark)

From:	CVT-199				
Grid		Local		Global	
Easting	267428.741 m	Latitude	N14°14'16.32329"	Latitude	N14°14'10.97763"
Northing	1575012.795 m	Longitude	E120°50'40.63536"	Longitude	E120°50'45.56096"
Elevation	167.120 m	Height	166.201 m	Height	210.386 m

To:	CVT-3051				
Grid		Local		Global	
Easting	271276.565 m	Latitude	N14°22'58.33330"	Latitude	N14°22'52.95639"
Northing	1591024.612 m	Longitude	E120°52'44.06059"	Longitude	E120°52'48.97372"
Elevation	22.137 m	Height	21.122 m	Height	64.983 m

Vector					
ΔEasting	3847.824 m	NS Fwd Azimuth	12°58'47"	ΔX	-1068.623 m
ΔNorthing	16011.817 m	Ellipsoid Dist.	16463.417 m	ΔY	-5421.802 m
ΔElevation	-144.982 m	ΔHeight	-145.079 m	ΔZ	15509.176 m

Standard Errors

Vector errors:					
σ ΔEasting	0.029 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.036 m
σ ΔNorthing	0.020 m	σ Ellipsoid Dist.	0.019 m	σ ΔY	0.058 m
σ ΔElevation	0.065 m	σ ΔHeight	0.065 m	σ ΔZ	0.029 m

Aposteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.0012710639		
Y	-0.0011111494	0.0033830758	
Z	-0.0004897536	0.0012701754	0.0008644866

Figure A-3.2 Baseline Processing Report - B

2. CVT-3123

Project information		Coordinate System	
Name:	I:\Doc\DAC\2016\Fieldwork\Baseline Processing Requests\QZ-352 vs QZN-62 + CVT-3123 vs CVT-199.vce	Name:	UTM
Size:	665 KB	Datum:	PRS 92
Modified:	6/7/2016 9:10:46 PM (UTC:8)	Zone:	51 North (123E)
Time zone:	Taipei Standard Time	Geoid:	EGMPH
Reference number:		Vertical datum:	
Description:			

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
CVT-199 --- CVT-3123 (B3)	CVT-199	CVT-3123	Fixed	0.001	0.001	121°10'48"	43.218	1.326
CVT-3123 --- CVT-199 (B4)	CVT-199	CVT-3123	Fixed	0.002	0.003	121°11'34"	43.216	1.383

Acceptance Summary

Processed	Passed	Flag	Fail
2	2	0	0

CVT-199 - CVT-3123 (6:10:41 AM-2:38:11 PM) (S3)

Baseline observation:	CVT-199 --- CVT-3123 (B3)
Processed:	6/7/2016 9:18:19 PM
Solution type:	Fixed
Frequency used:	Dual Frequency (L1, L2)
Horizontal precision:	0.001 m
Vertical precision:	0.001 m
RMS:	0.001 m
Maximum PDOP:	6.311
Ephemeris used:	Broadcast
Antenna model:	NGS Absolute
Processing start time:	5/3/2016 6:11:22 AM (Local: UTC+8hr)
Processing stop time:	5/3/2016 2:38:11 PM (Local: UTC+8hr)
Processing duration:	08:26:49
Processing interval:	1 second

Figure A-3.3 Baseline Processing Report - C

Vector Components (Mark to Mark)

From:	CVT-199				
Grid		Local		Global	
Easting	267428.741 m	Latitude	N14°14'16.32329"	Latitude	N14°14'10.97763"
Northing	1575012.795 m	Longitude	E120°50'40.63536"	Longitude	E120°50'45.56096"
Elevation	167.120 m	Height	166.201 m	Height	210.386 m

To:	CVT-3123				
Grid		Local		Global	
Easting	267465.517 m	Latitude	N14°14'15.59521"	Latitude	N14°14'10.24962"
Northing	1574990.072 m	Longitude	E120°50'41.86874"	Longitude	E120°50'46.79435"
Elevation	168.445 m	Height	167.527 m	Height	211.713 m

Vector					
ΔEasting	36.776 m	NS Fwd Azimuth	121°10'48"	ΔX	-35.227 m
ΔNorthing	-22.723 m	Ellipsoid Dist.	43.218 m	ΔY	-13.131 m
ΔElevation	1.325 m	ΔHeight	1.326 m	ΔZ	-21.362 m

Standard Errors

Vector errors:					
σ ΔEasting	0.000 m	σ NS fwd Azimuth	0°00'01"	σ ΔX	0.000 m
σ ΔNorthing	0.000 m	σ Ellipsoid Dist.	0.000 m	σ ΔY	0.001 m
σ ΔElevation	0.001 m	σ ΔHeight	0.001 m	σ ΔZ	0.000 m

Aposteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.0000001903		
Y	-0.0000001733	0.0000004088	
Z	-0.0000000653	0.0000001166	0.0000001007

Figure A-3.4 Baseline Processing Report - D

3. PB-1

Project information		Coordinate System	
Name:		Name:	UTM
Size:		Datum:	WGS 1984
Modified:	10/12/2012 4:40:11 PM (UTC:-6)	Zone:	51 North (123E)
Time zone:	Mountain Standard Time	Geoid:	EGMPH
Reference number:		Vertical datum:	
Description:			

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
PB-1 --- CVT-194 (B1)	CVT-194	PB-1	Fixed	0.004	0.017	58°08'29"	9467.724	25.364

Acceptance Summary

Processed	Passed	Flag	Fail
1	1	0	0

PB-1 - CVT-194 (4:15:24 AM-8:06:34 AM) (S1)

Baseline observation:	PB-1 --- CVT-194 (B1)
Processed:	2/4/2014 9:50:26 PM
Solution type:	Fixed
Frequency used:	Dual Frequency (L1, L2)
Horizontal precision:	0.004 m
Vertical precision:	0.017 m
RMS:	0.005 m
Maximum PDOP:	2.254
Ephemeris used:	Broadcast
Antenna model:	NGS Absolute
Processing start time:	2/3/2014 4:15:24 AM (Local: UTC+8hr)
Processing stop time:	2/3/2014 8:06:34 AM (Local: UTC+8hr)
Processing duration:	03:51:10
Processing interval:	5 seconds

Figure A-3.5 Baseline Processing Report - E

Vector Components (Mark to Mark)

From:	CVT-194				
Grid		Local		Global	
Easting	271413.844 m	Latitude	N14°23'09.63386"	Latitude	N14°23'09.63386"
Northing	1591468.703 m	Longitude	E120°52'48.43458"	Longitude	E120°52'48.43458"
Elevation	19.356 m	Height	62.184 m	Height	62.184 m

To:	PB-1				
Grid		Local		Global	
Easting	280881.093 m	Latitude	N14°23'19.56835"	Latitude	N14°23'19.56835"
Northing	1591688.776 m	Longitude	E120°58'04.29835"	Longitude	E120°58'04.29835"
Elevation	44.199 m	Height	87.568 m	Height	87.568 m

Vector					
ΔEasting	9467.249 m	NS Fwd Azimuth	88°08'29"	ΔX	-8091.412 m
ΔNorthing	220.073 m	Ellipsoid Dist.	9467.724 m	ΔY	-4906.972 m
ΔElevation	24.843 m	ΔHeight	25.384 m	ΔZ	302.003 m

Standard Errors

Vector errors:					
σ ΔEasting	0.001 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.004 m
σ ΔNorthing	0.001 m	σ Ellipsoid Dist.	0.001 m	σ ΔY	0.007 m
σ ΔElevation	0.009 m	σ ΔHeight	0.009 m	σ ΔZ	0.003 m

Aposteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.0000191800		
Y	-0.0000293083	0.0000523957	
Z	-0.0000093650	0.0000161874	0.0000064708

Figure A-3.6 Baseline Processing Report - F

4. BTG-45A

Project Information		Coordinate System	
Name:		Name:	UTM
Size:		Datum:	PRS 92
Modified:	10/12/2012 4:40:11 PM (UTC:-6)	Zone:	51 North (123E)
Time zone:	Mountain Standard Time	Geoid:	EGMPH
Reference number:		Vertical datum:	
Description:			

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
BTG-45 --- BTG-45A (B1)	BTG-45	BTG-45A	Fixed	0.001	0.001	175°32'41"	6.995	0.659

Acceptance Summary

Processed	Passed	Flag	Fail
1	1	0	0

BTG-45 - BTG-45A (7:15:33 AM-11:52:39 AM) (S1)

Baseline observation:	BTG-45 --- BTG-45A (B1)
Processed:	9/2/2015 11:37:56 AM
Solution type:	Fixed
Frequency used:	Dual Frequency (L1, L2)
Horizontal precision:	0.001 m
Vertical precision:	0.001 m
RMS:	0.000 m
Maximum PDOP:	2.331
Ephemeris used:	Broadcast
Antenna model:	Trimble Relative
Processing start time:	9/1/2015 7:15:33 AM (Local: UTC+8hr)
Processing stop time:	9/1/2015 11:52:39 AM (Local: UTC+8hr)
Processing duration:	04:37:06
Processing interval:	1 second

Figure A-3.7 Baseline Processing Report - G

Vector Components (Mark to Mark)

From:	BTG-45				
Grid		Local		Global	
Easting	252125.624 m	Latitude	N13°59'52.18294"	Latitude	N13°59'46.88216"
Northing	1548591.799 m	Longitude	E120°42'18.96476"	Longitude	E120°42'23.91169"
Elevation	49.818 m	Height	48.430 m	Height	92.943 m

To:	BTG-45A				
Grid		Local		Global	
Easting	252126.100 m	Latitude	N13°59'51.95603"	Latitude	N13°59'46.65526"
Northing	1548584.818 m	Longitude	E120°42'18.98286"	Longitude	E120°42'23.92980"
Elevation	50.478 m	Height	49.089 m	Height	93.602 m

Vector					
ΔEasting	0.476 m	NS Fwd Azimuth	175°32'41"	ΔX	-1.655 m
ΔNorthing	-6.981 m	Ellipsoid Dist.	6.995 m	ΔY	1.723 m
ΔElevation	0.659 m	ΔHeight	0.659 m	ΔZ	-6.607 m

Standard Errors

Vector errors:					
σ ΔEasting	0.000 m	σ NS fwd Azimuth	0°00'12"	σ ΔX	0.001 m
σ ΔNorthing	0.000 m	σ Ellipsoid Dist.	0.000 m	σ ΔY	0.001 m
σ ΔElevation	0.001 m	σ ΔHeight	0.001 m	σ ΔZ	0.000 m

Aposteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.0000002866		
Y	-0.0000001658	0.0000003931	
Z	-0.0000000756	0.0000000861	0.0000001315

Figure A-3.8 Baseline Processing Report - H

Annex 4. The LiDAR Survey Team Composition

Table A-4.1 LiDAR Survey Team Composition

Data Acquisition Component Sub -Team	Designation	Name	Agency / Affiliation
Program Leader	Program Leader –I	ENRICO C. PARINGIT, D. Eng.	UP TCAGP
Data Acquisition Component Leader	Data Component Project Leader –I	ENGR. CZAR JAKIRI S. SARMIENTO	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
	Supervising Science Research Specialist (Supervising SRS)	LOVELY GRACIA ACUNA	UP TCAGP
		ENGR. LOVELYN ASUNCION	UP TCAGP
		ENGR. GEROME HIPOLITO	UP TCAGP

FIELD TEAM

LiDAR Operation	Senior Science Research Specialist (SSRS)	JASMINE ALVIAR	UP TCAGP
		AUBREY MATIRA	UP TCAGP
	Research Associate	ENGR. LARAH PARAGAS	UP TCAGP
		PAULINE JOANNE ARCEO	UP TCAGP
		MARY CATHERINE ELIZABETH BALIGUAS	UP TCAGP
		JONALYN GONZALES	UP TCAGP
		FAITH JOY SABLE	UP TCAGP
		KRISTINE JOY ANDAYA	UP TCAGP
Ground Survey, Data Download and Transfer	Research Associate	ENGR. RENAN PUNTO	UP TCAGP
		MA. VERLINA TONGA	UP TCAGP
		ENGR. KENNETH QUISADO	UP TCAGP
LiDAR Operation/ Ground Survey	Research Associate	ENGR. RENAN PUNTO	UP TCAGP
		ENGR. DAN ALDOVINO	UP TCAGP
LiDAR Operation	Airborne Security	SSG. RAYMUND DOMINE	PHILIPPINE AIR FORCE (PAF)
		TSG. CEBU	
LiDAR Operation	Pilot	CAPT. MARK TANGONAN	ASIAN AEROSPACE CORP (AAC)
		CAPT. RAUL SAMAR	
		CAPT. FRANCO PEPITO	
		CAPT. CAESAR ALFONSO II	
		CAPT. DANTHONY LOGRONIO	
		CAPT. CEDRIC DE ASIS	

Annex 5. Data Transfer Sheet For Imus Floodplain

DATA TRANSFER SHEET - Calabarzon
29-02-2016

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(KB)	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	
2014-02-22	1139	1BLK18X53A	Pegasus	2.2 GB	701.22 KB	8.88 MB	238.21 MB	29.34 GB	N/A	21.07 GB	0 B	6.72 MB	133 B	0 B	0 B	1139	Z:\DAC\RAWDATA\1139P

Received from

Name [illegible] group
Position
Signature

Received by

Name AC Bongat c-group DPPC
Position SSRC
Signature 2/29/16

Table A-5.1 Data Transfer Sheet for Imus Floodplain - A

DATA TRANSFER SHEET - Calabarzon
28-02-2016

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(KB)	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	
2014-01-28	1039	1BLK18B028A	Pegasus	2.07 GB	76.74 KB	11.84 MB	185.31 MB	0 B	N/A	19.11 GB	0 B	7.43 MB	141 B	242 B	0 B	1039	Z:\DAC\RAWDATA\1039P
2014-01-25	1027	1BLK18A025A	Pegasus	1.51 GB	718 B	7.32 MB	194.22 MB	7.11 GB	83.96 KB	14.35 GB	0 B	6.71 MB	112 B	718 B	105.58 KB	1027	Z:\DAC\RAWDATA\1027P
2014-01-24	1023	1BLK18B024A	Pegasus	966.82 MB	245 B	5.76 MB	52.67 MB	11.89 GB	2.68 KB	9.28 GB	39.8 GB	8.04 MB	109 B	245 B	33.37 KB	1023	Z:\DAC\RAWDATA\1023P
2014-01-26	1031	1BLK18C026A	Pegasus	1.53 GB	513.87 KB	7.24 MB	185.43 MB	0 B	N/A	14.75 GB	0 B	8.04 MB	110 B	62 B	0 B	1031	Z:\DAC\RAWDATA\1031P
2014-01-29	1043	1BLK18AS029A	Pegasus	0 B	1.16 GB	7.05 MB	251.66 MB	0 B	N/A	6.13 GB	0 B	6.79 MB	141 B	245 B	0 B	1043	Z:\DAC\RAWDATA\1043P

Received from

Name R. Punto group
Position
Signature

Received by

Name A. Bongat group DPPC SSPS
Position SSPS
Signature 2/28/16

Table A-5.2 Data Transfer Sheet for Imus Floodplain - B

DATA TRANSFER SHEET - Calabarzon
28-02-2016

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(KB)	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	
2014-02-15	1111	1BLK18QR546A	Pegasus	1.39 GB	71.57 KB	7.97 MB	194.4 MB	18.72 GB	N/A	14.73 GB	0 B	10.94 MB	215 B	359 B	0 B	1111	Z:\DAC\RAWDATA\1111P
2014-02-05	1071	1BLK18I036A	Pegasus	1.62 GB	95.86 KB	6.73 MB	157.44 MB	16.02 GB	N/A	15.4 GB	0 B	2.5 MB	193 B	411 B	0 B	1071	Z:\DAC\RAWDATA\1071P
2014-02-02	1059	1BLK18F033A	Pegasus	1.04 GB	421 B	6.75 MB	167.09 MB	11.73 GB	N/A	10.15 GB	0 B	6 MB	201 B	421 B	133.98 KB	1059	Z:\DAC\RAWDATA\1059P
2014-01-31	1051	1BLK18E031A	Aquarius	2.56 GB	1.06 MB	14.17 MB	379.85 MB	14.49 GB	N/A	13.37 GB	0 B	4.66 MB	217 B	604 B	0 B	1051	Z:\DAC\RAWDATA\1051P
2014-02-03	1063	1BLK18D034A	Pegasus	1.18 GB	29.61 KB	6.01 MB	144.55 MB	19.2 GB	N/A	18.52 GB	0 B	5.90 MB	191 B	321 B	0 B	1063	Z:\DAC\RAWDATA\1063P

Received from

Name R. [illegible] group
Position
Signature [signature]

Received by

Name AC Bongat c-group PPPC
Position CCPS
Signature [signature] 2/28/14

Table A-5.3 Data Transfer Sheet for Imus Floodplain - C

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	766	6.60	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	7.87	1KB	1KB	1	na	Z:\DAC\RAW DATA
4-Sep	3377P	1BLK18JS247A	Pegasus	129	777	8.1	190	na	na	13.4	na	6.43	1KB	1KB	61.4	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

Received by

Name AC Bongat 9/11/15

Table A-5.4 Data Transfer Sheet for Imus Floodplain - D

DATA TRANSFER SHEET
CALABARZON 6/7/2016

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

DATE	FLIGHT NO.	MISSION NAME	SENSOR	KML (swath)	Gnssimu	LogFiles	TestData	RawLaser	RawTDC	RawWFD	WebCam	RCD30 RAW IMAGES	BASE STATION(S)	Base Info (.txt)	SERVER LOCATION
3-May-16	10136L	4BLK18BB124A	ALS 80	51	463	136	41.7	6.50/3.92	4.64/2.08	NA	275/182	43.4	103	1KB	Z:\DAC\RAW DATA
6-May-16	10142L	4BLK18AB127A	ALS 80	195	506	151	40.4	9.28	6.39	NA	359	33.4	97	1KB	Z:\DAC\RAW DATA
7-May-16	10144L	4BLKAB5128A	ALS 80	68	406	115	93.6	3.59	2.3	NA	152	12.9	155	1KB	Z:\DAC\RAW DATA

Received from

Name [illegible]
Position RA
Signature [illegible]

Received by

Name [illegible]
Position SSRS
Signature [illegible] 6/20/16

Table A-5.5 Data Transfer Sheet for Imus Floodplain - E

Annex 6. Flight Logs

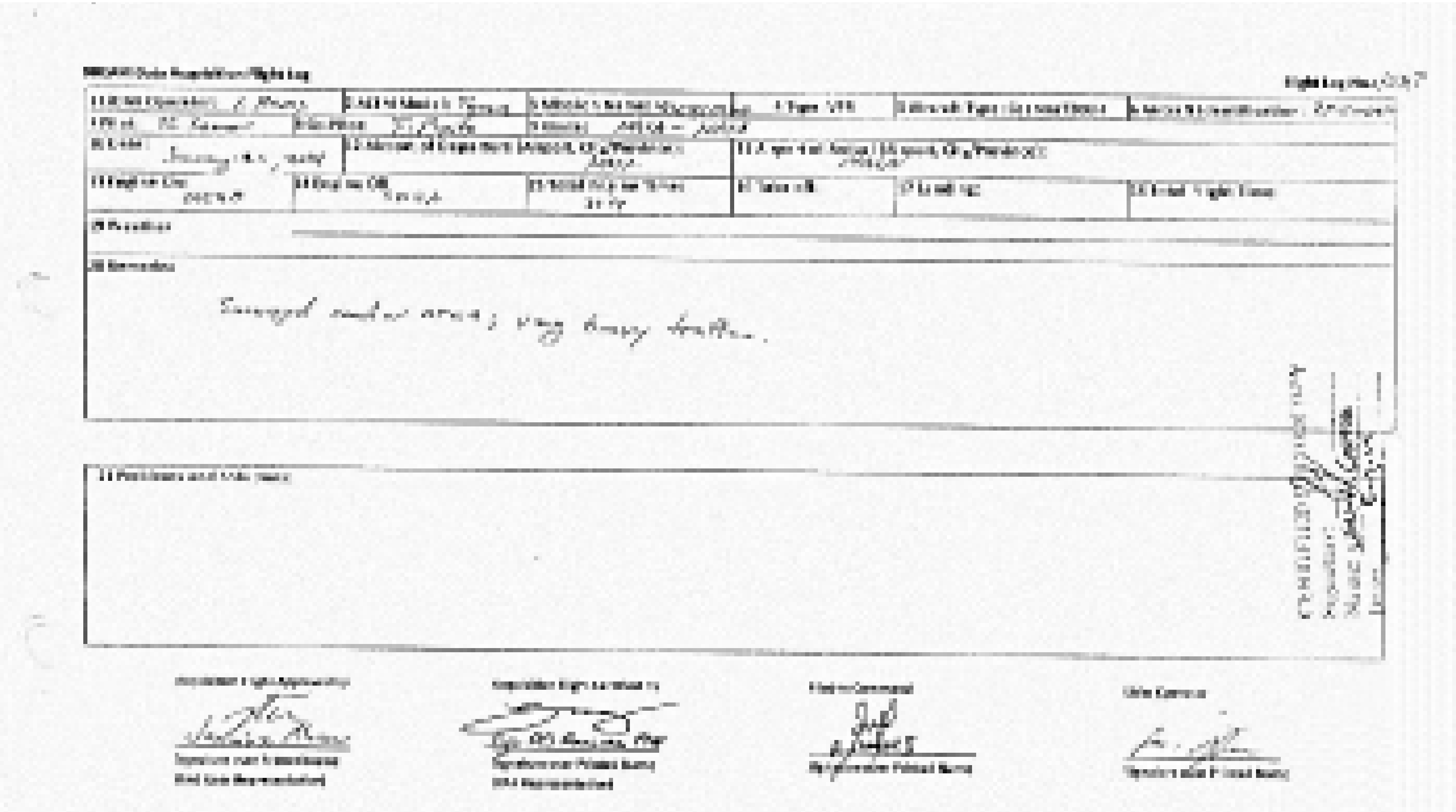


Table A-6.1 Flight Log for Mission 1031P

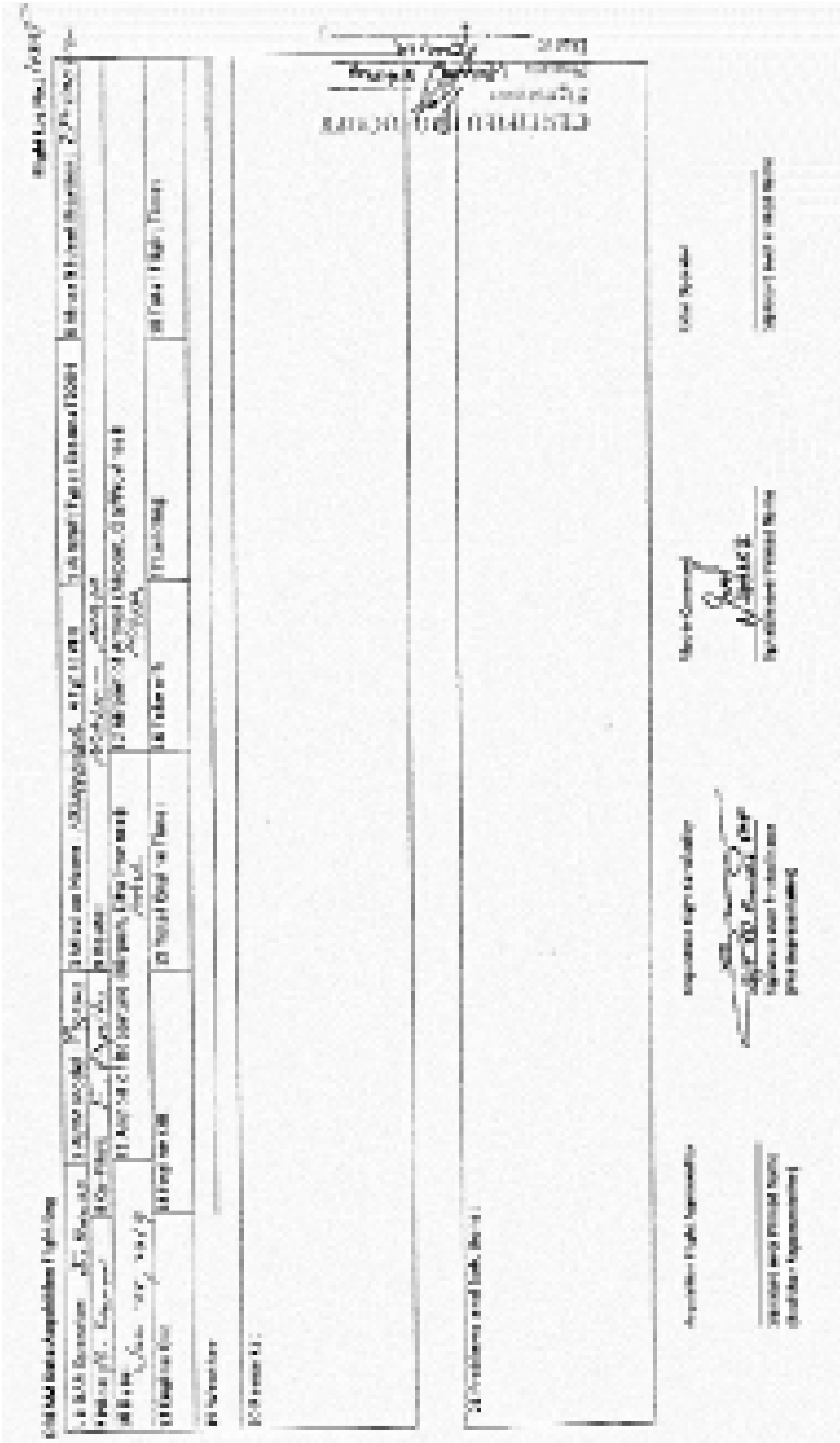


Table A-6.2 Flight Log for Mission 1039P

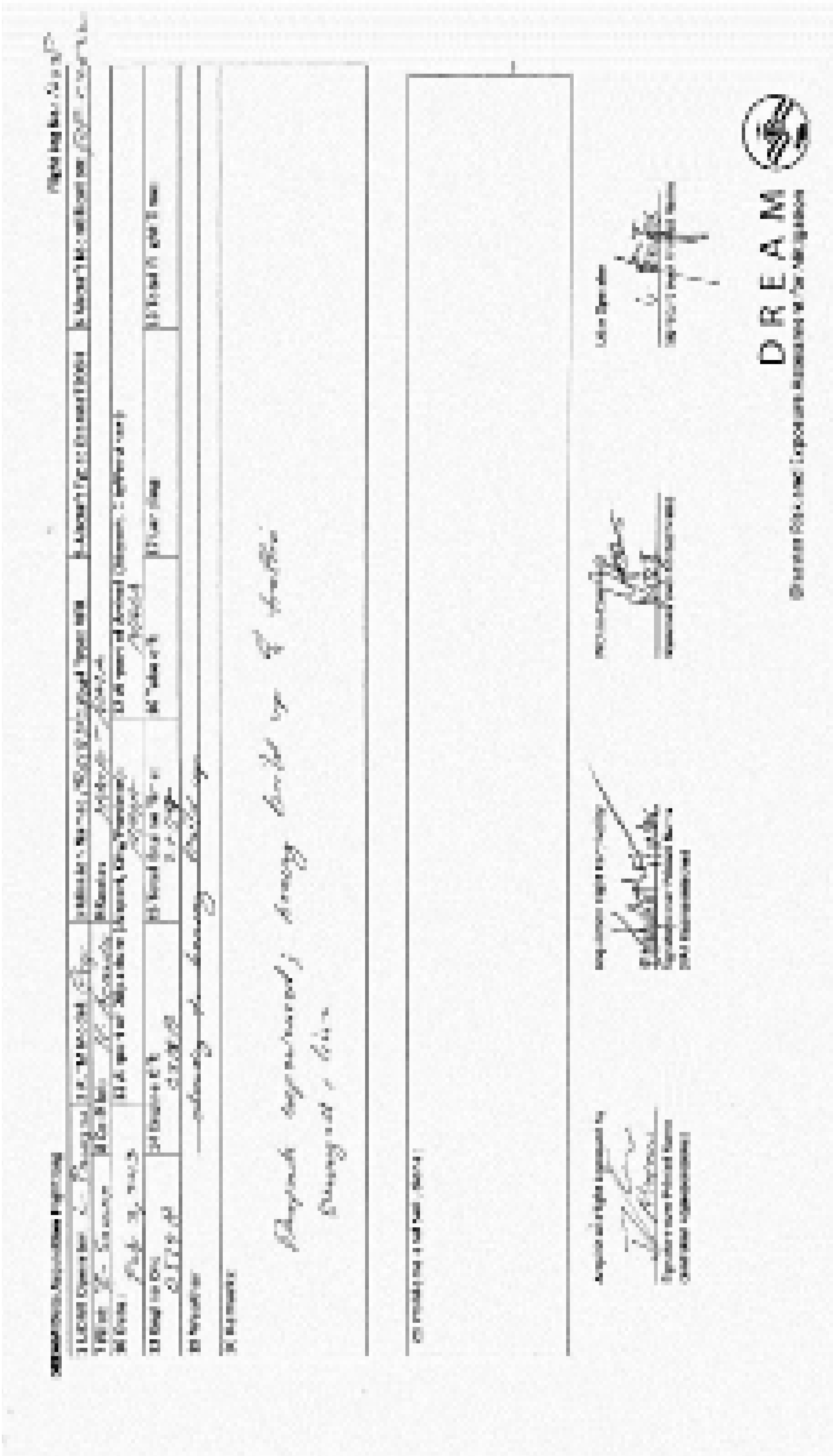


Table A-6.3 Flight Log for Mission 1063P

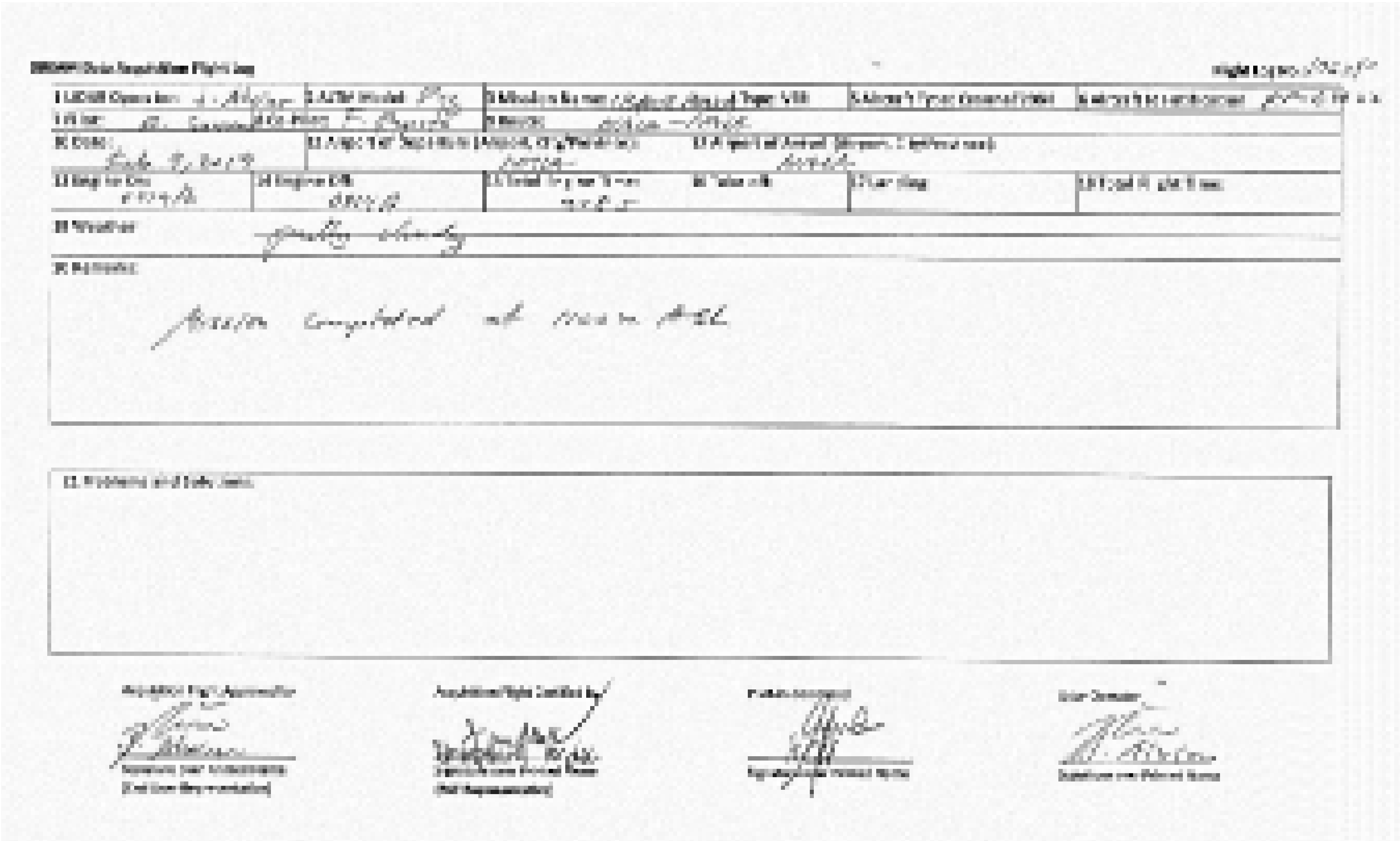


Table A-6.4 Flight Log for Mission 1139P

Data Acquisition Flight Log

Flight Log No.: 3309P

1 LiDAR Operator: KJ ANDAYA	2 ALTM Model: PEGASUS	3 Mission Name: 1BLK18AeS230A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9022
7 Pilot: M. Tangonan	8 Co-Pilot: J. Joya	9 Route: NAIA - NAIA			
10 Date: AUG 18, 2015	12 Airport of Departure (Airport, City/Province): NAIA		12 Airport of Arrival (Airport, City/Province): NAIA		
13 Engine On: 0637H	14 Engine Off: 0953 H	15 Total Engine Time: 3+16	16 Take off: 0642 H	17 Landing: 0948H	18 Total Flight Time: 3+06
19 Weather: partly cloudy					

20 Flight Classification

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

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

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

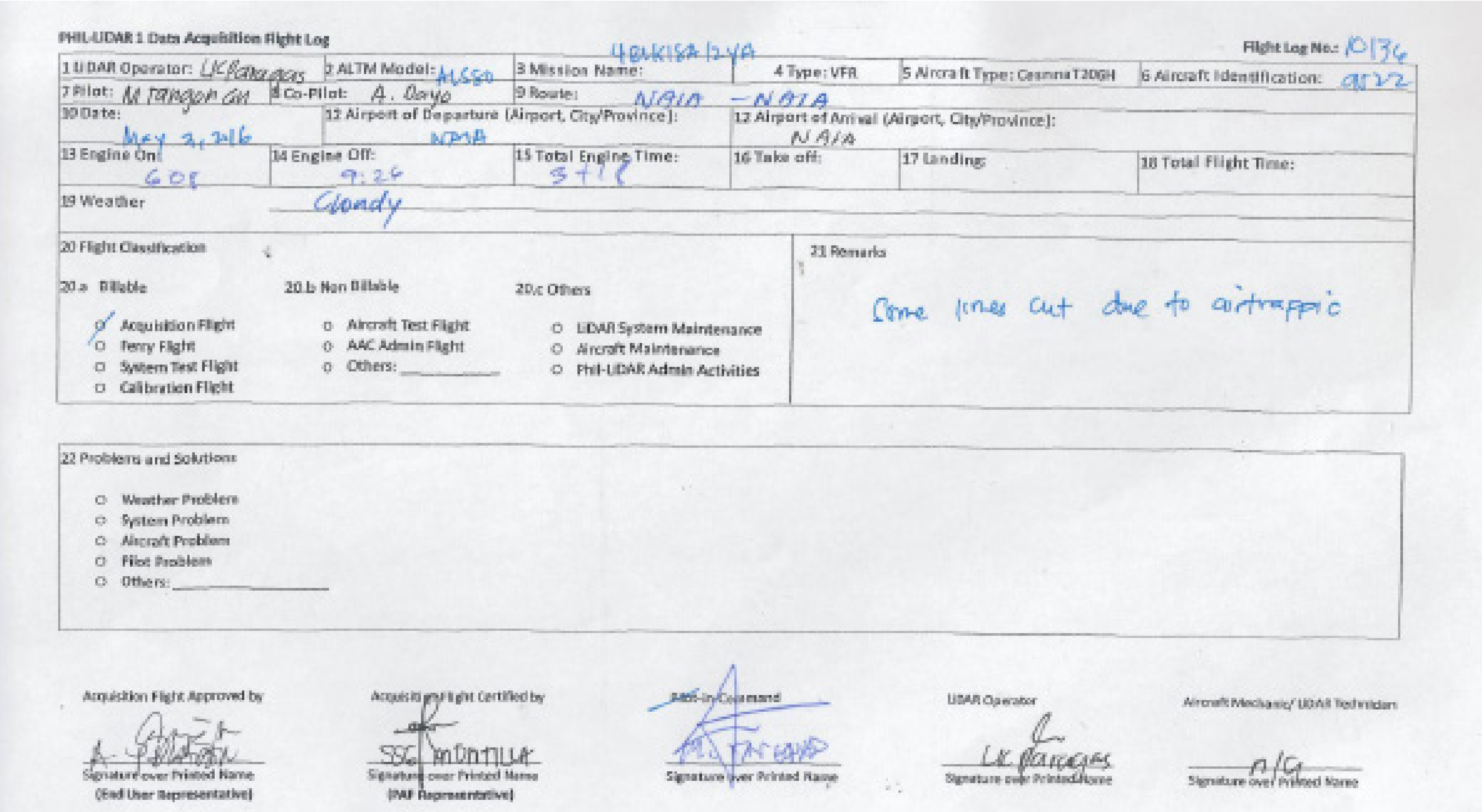
21 Remarks

Successful

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/ Technician
J. Alviar	LEE JAY PUNZALAN	M.L. TANGONAN	KJ ANDAYA	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

Table A-6.5 Flight Log for Mission 3309P



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 10136

1 LIDAR Operator: LK Paragas	2 ALTM Model: AL S80	3 Mission Name: 4BLK18A124A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 9722
7 Pilot: M Tangonan GH	8 Co-Pilot: A. Oaya	9 Route: NAIA - NAIA			
10 Date: May 3, 2016	12 Airport of Departure (Airport, City/Province): NAIA		12 Airport of Arrival (Airport, City/Province): NAIA		
13 Engine On: 608	14 Engine Off: 9:26	15 Total Engine Time: 3+18	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Cloudy					

20 Flight Classification

20.a Billable
- ✓ Acquisition Flight
- o Ferry Flight
- o System Test Flight
- o Calibration Flight

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

20.c Others
- o LIDAR System Maintenance
- o Aircraft Maintenance
- o Phil-LIDAR Admin Activities

21 Remarks

Some lines cut due to air traffic

22 Problems and Solutions
- o Weather Problem
- o System Problem
- o Aircraft Problem
- o Pilot Problem
- o Others: ____________

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	LIDAR Operator	Aircraft Mechanic/ LIDAR Technician
A. Pillarbtin	SSG. Mantilla	M. Tangonan	LK Paragas	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

Table A-6.6 Flight Log for Mission 10136L

PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 10144

1 LiDAR Operator: J Gonzales	2 ALTM Model: Aq 550	3 Mission Name: 4BLK18A...	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9522
7 Pilot: M Tangonan	8 Co-Pilot: N Adawin	9 Route: NAIA - NAIA			
10 Date: May 07, 2016	12 Airport of Departure (Airport, City/Province): NAIA		12 Airport of Arrival (Airport, City/Province): NAIA		
13 Engine On: 6:27	14 Engine Off: 9:55	15 Total Engine Time: 3+28	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Fair					

20 Flight Classification

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

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

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

21 Remarks

Covered some lines of Blk 18A (Cavite Approach)

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]	SSG [illegible]ANTILLA	M. C. TANGONAN	[signature] J GONZALES	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

Table A-6.7 Flight Log for Mission 10144L

Annex 7. Flight Status

FLIGHT STATUS REPORT
CALABARZON
(January 26-February 22, 2014, August 18, 2015, May 7, 2016 and June 16, 2016)

Table A-7.1 Flight Status Report

FLIGHT NO	AREA	MISSION	OPERATOR	DATE FLOWN	REMARKS
1031P	BLK 18CD	1BLK18C026A	I.Roxas	26 Jan 2014	Acquired data at 1000m, broken lines and irregular survey pattern due to very heavy traffic and tower restrictions
1039P	BLK 18BC	1BLK18B028A	I.Roxas	28 Jan 2014	Data acquired at 1000m AGL
1063P	BLK 18D	1BLK18D034A	L. Paragas	3 Feb 2014	Dropouts experienced, heavy build up and traffic, surveyed 1 line
1139P	BLK 18X & (ABCY)s	1BLK18X53A	J. Alviar	22 Feb 2014	Surveyed gaps in southern Cavite, voids in BLK 18Z and covered BLK 18X at 1200m flying height
3309P	BLK 18AsS	1BLK18AsS230A	KJ ANDAYA	18 Aug 2015	Voids due to low cloud cover, lines cut due to air traffic Without Digitizer and Camera
10136L	BLK18A	4BLK18B124A	LK Paragas	3 May 2016	Covered some lines of Blk 18 A
10142L	BLK18 AB	4BLK18AB127A	LK Paragas	6 May 2016	Covered some lines of Blk 18 AB

LAS BOUNDARIES PER FLIGHT

Flight No. : 1031P
Area: BLK 18BC
Mission Name: 1BLK18B028A

LAS

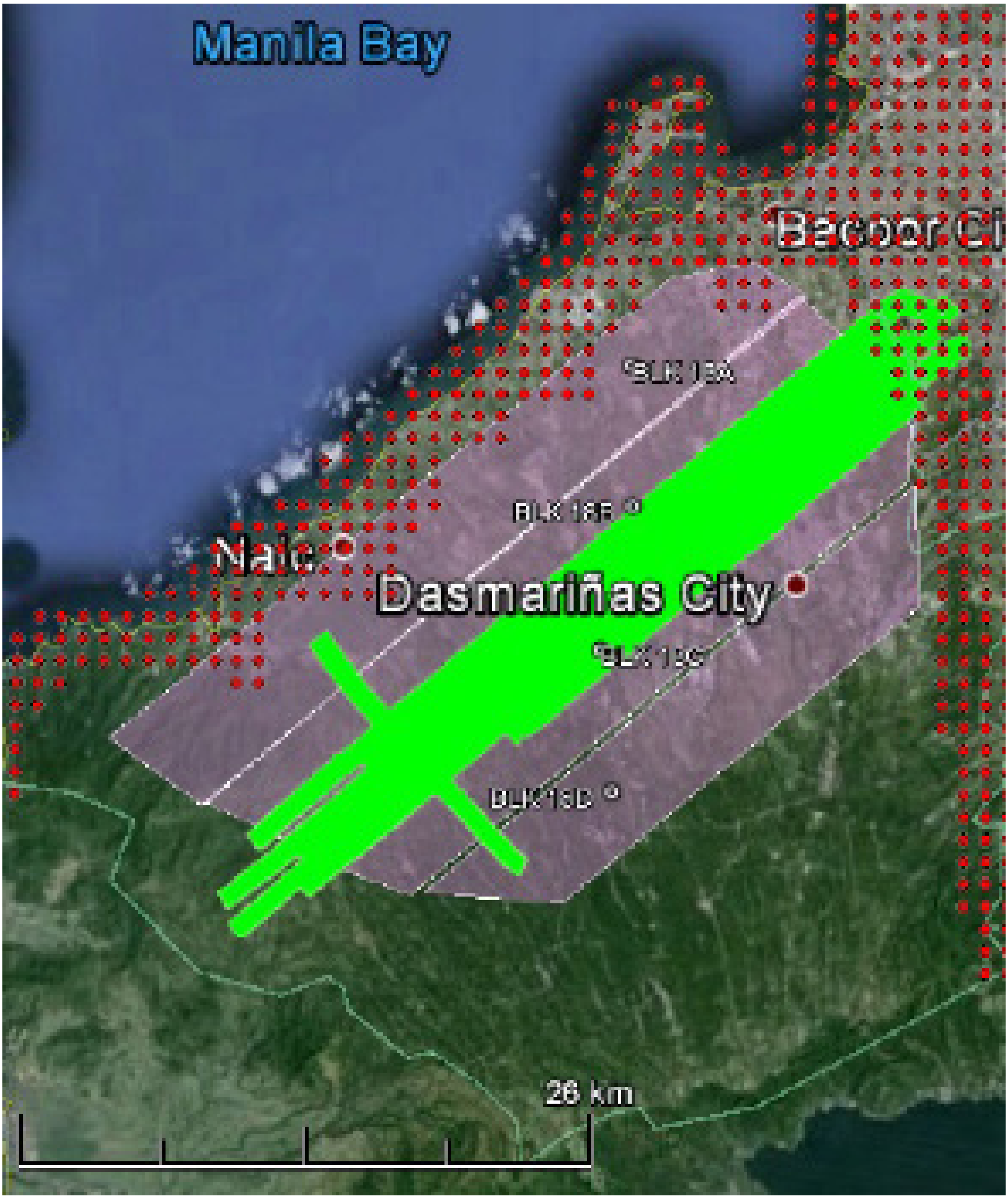


Figure A-7.1 Swath for Flight No. 1031P

Flight No. : 1039P
Area: BLK 18BC
Mission Name: 1BLK18B028A

LAS

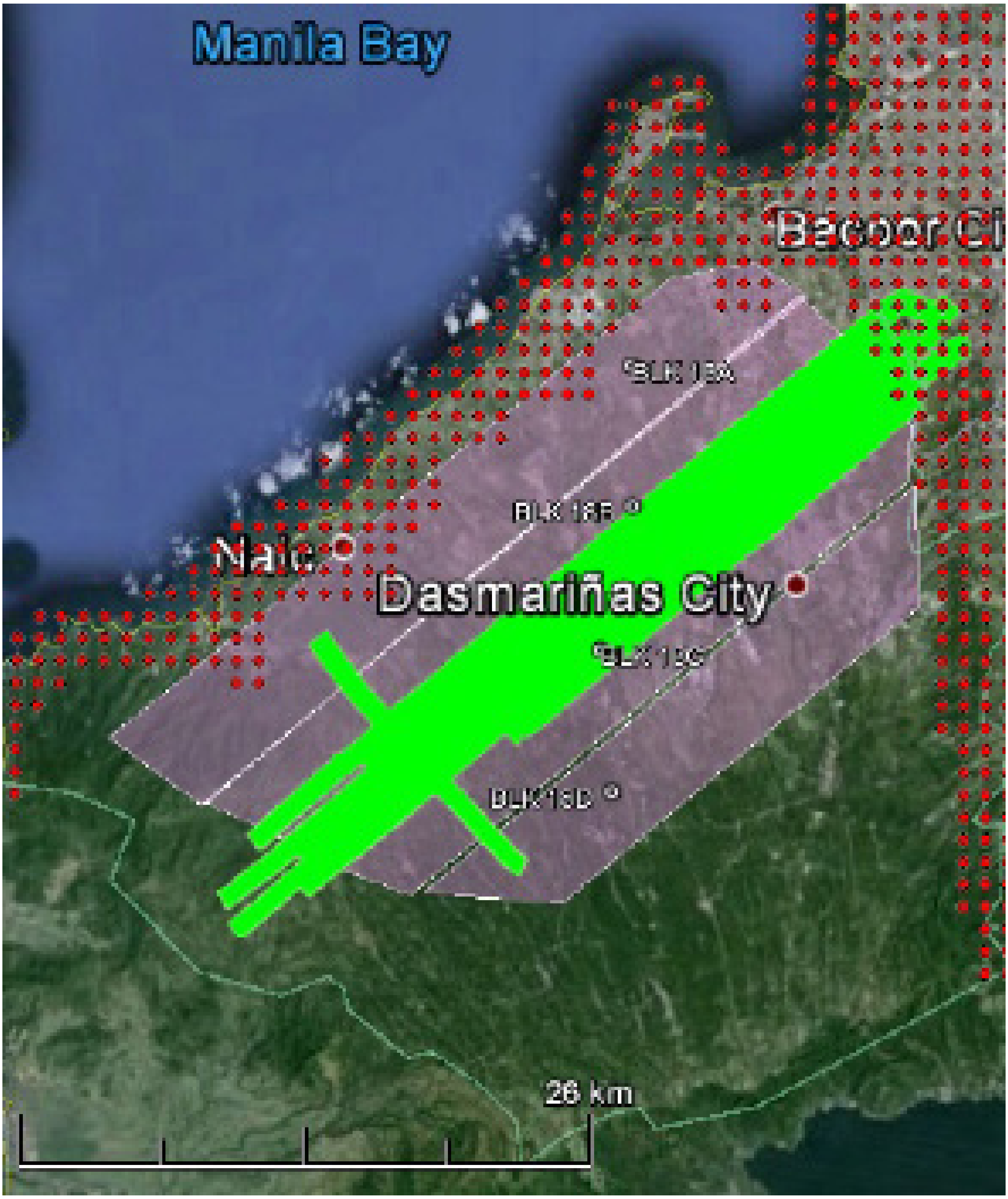


Figure A-7.2 Swath for Flight No. 1039P

Flight No. : 1063P
Area: BLK 18D
Mission Name: 1BLK18D034A

LAS

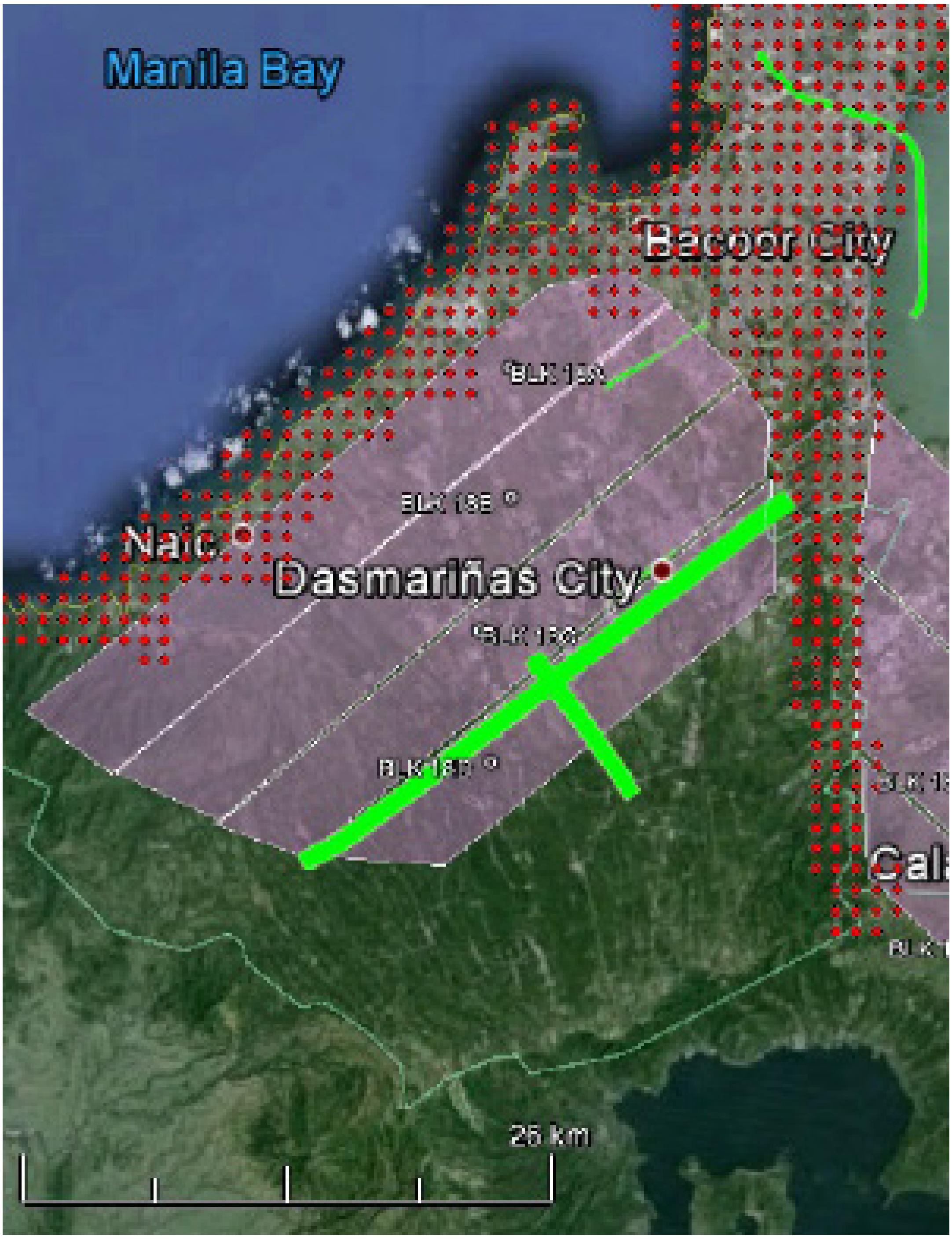


Figure A-7.3 Swath for Flight No. 1063P

Flight No. :	1139P (renamed from 1137P)
Area:	BLK 18X & (ABCY)s
Mission Name:	1BLK18S53A

LAS

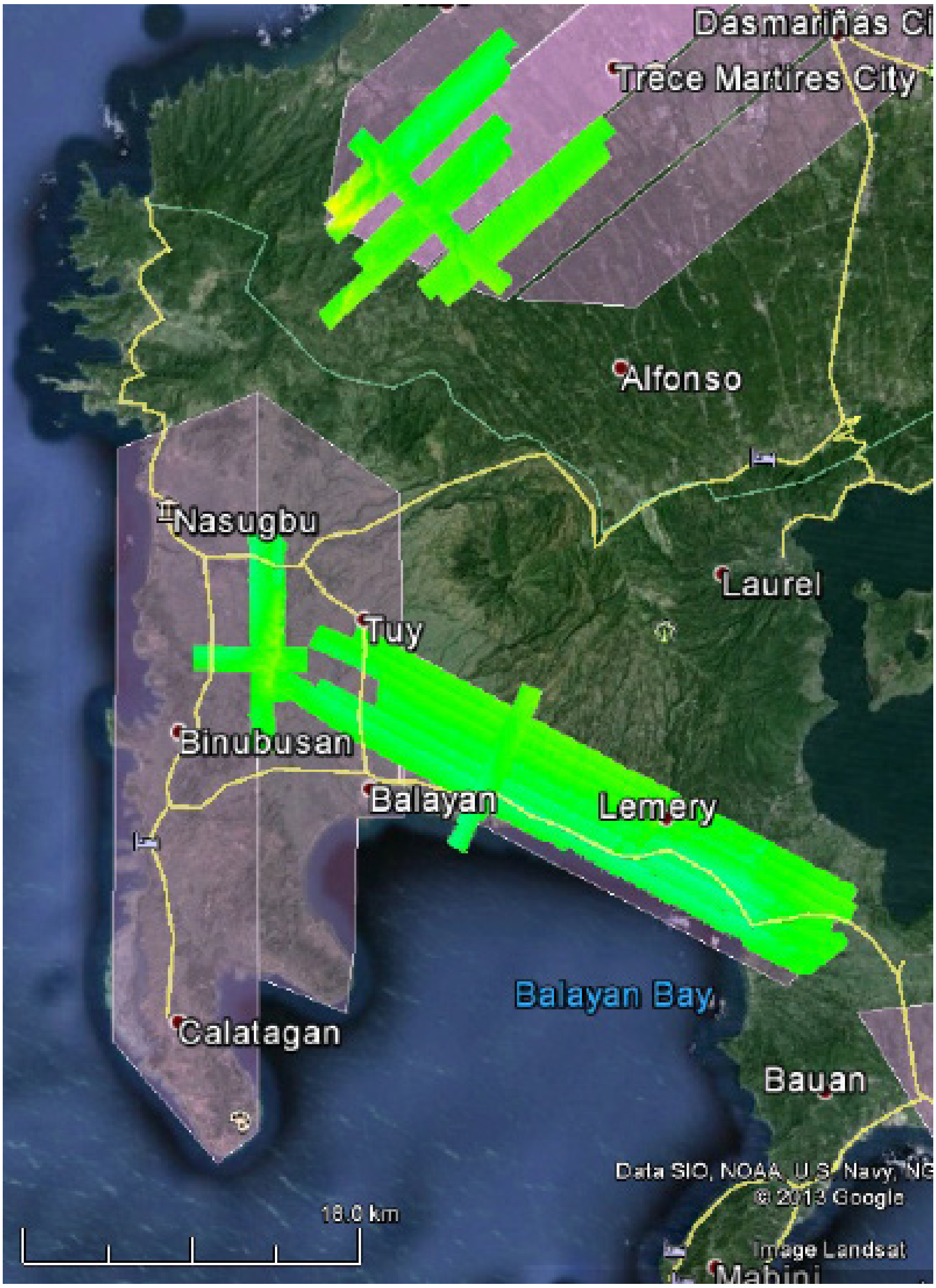


Figure A-7.4 Swath for Flight No. 1139P (renamed from 1137P)

Flight No. : 3309P
Area: BLK 18
Mission Name: 1BLK18AsS230A

LAS

Figure A-7.5 Swath for Flight No. 3309P

FLIGHT NO.: 10136L
AREA: BLK18A
MISSION NAME: 2BLK18A124A

SWATH

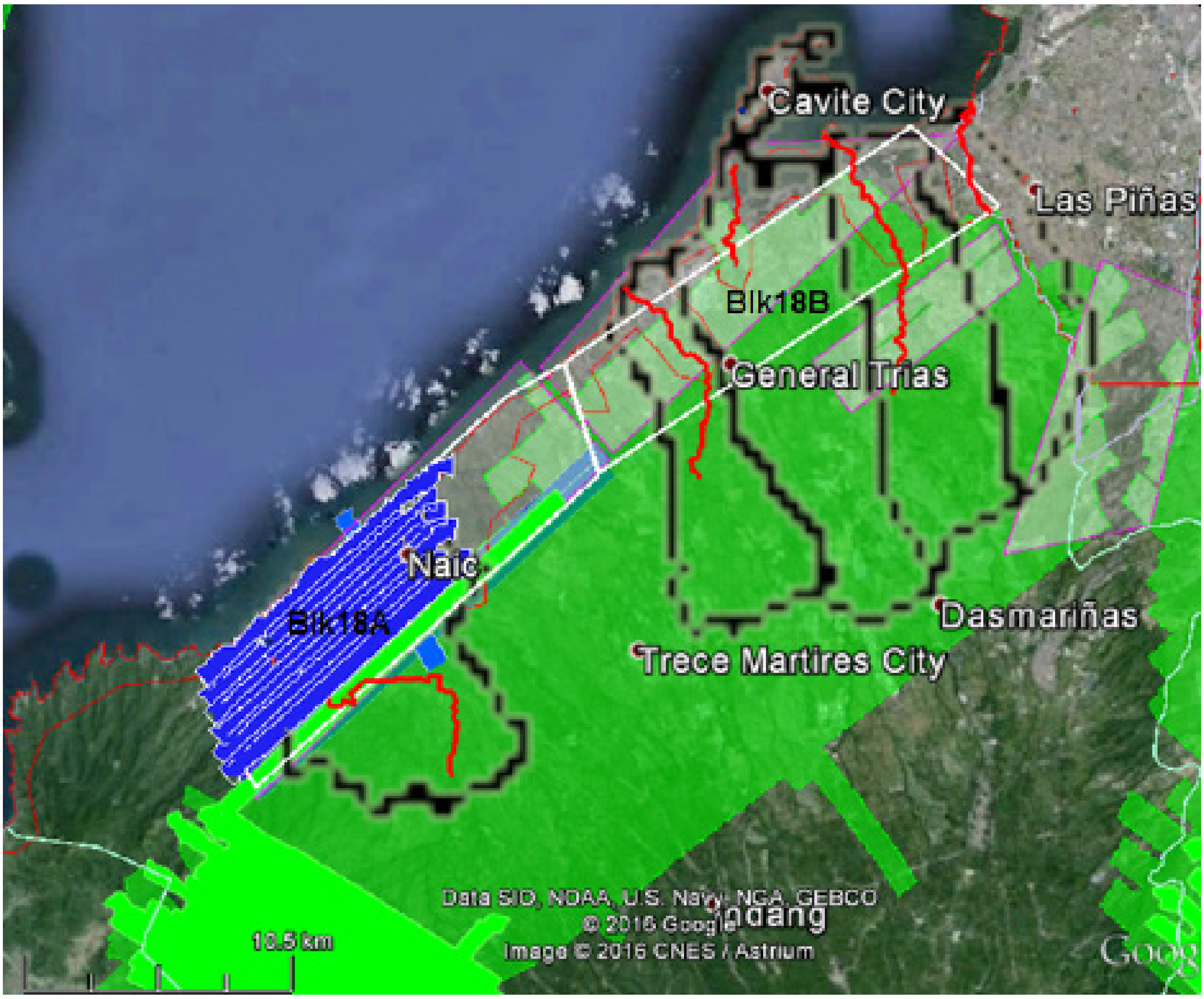


Figure A-7.6 Swath for Flight No. 10136L

FLIGHT NO.:	10142L
AREA:	BLK18AB
MISSION NAME:	4BLK18AB127A

SWATH

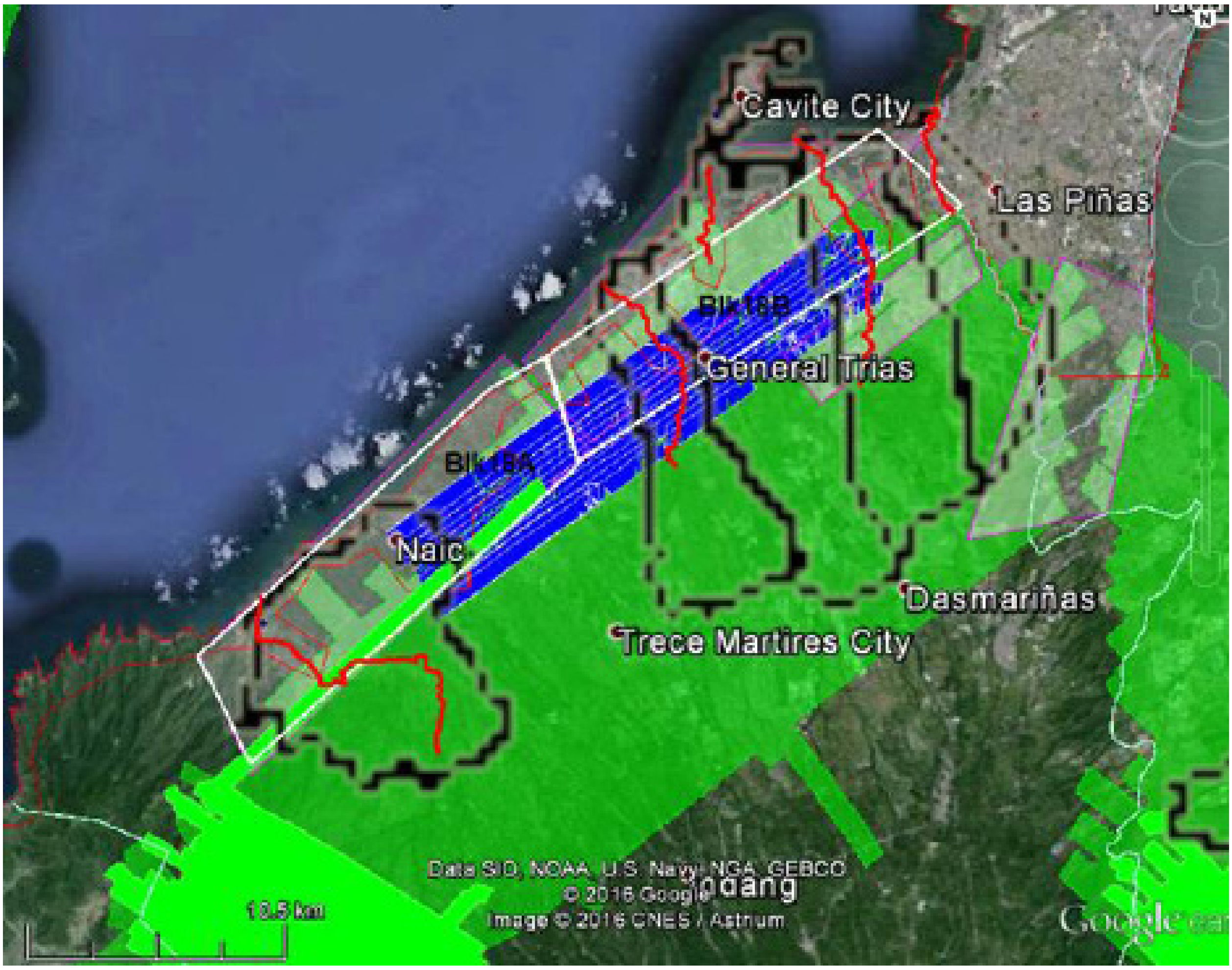


Figure A-7.7 Swath for Flight No. 10142L

Annex 8. Mission Summary Reports

Table A-8.1 Mission Summary Report for Blk18B_supplement

Flight Area	CALABARZON
Mission Name	Blk18B_supplement
Inclusive Flights	3309P
Range data size	11.9GB
POS	202 MB
Image	N/A
Transfer date	09/11/2015
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)	2.3
RMSE for East Position (<4.0 cm)	2.9
RMSE for Down Position (<8.0 cm)	2.9
Boresight correction stdev (<0.001deg)	0.000273
IMU attitude correction stdev (<0.001deg)	0.000737
GPS position stdev (<0.01m)	0.0103
Minimum % overlap (>25)	43.55%
Ave point cloud density per sq.m. (>2.0)	2.82
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	171
Maximum Height	426.11 m
Minimum Height	57.0 m
Classification (# of points)	
Ground	95,328,099
Low vegetation	65,505,303
Medium vegetation	120,204,321
High vegetation	132,825,937
Building	23,238,819
Orthophoto	No
Processed by	Engr. Analyn Naldo, Aljon Rie Araneta, Jovy Ann Narisma

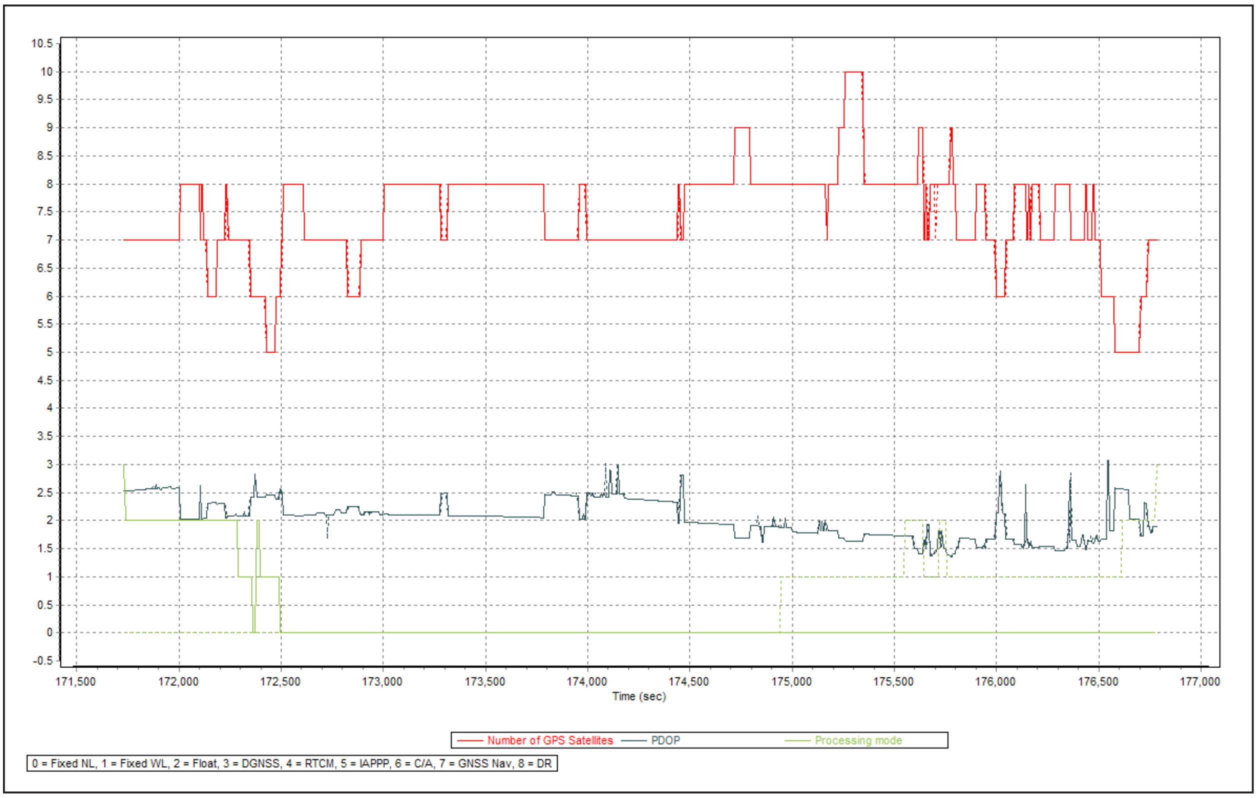


Figure A-8.1. Solution Status

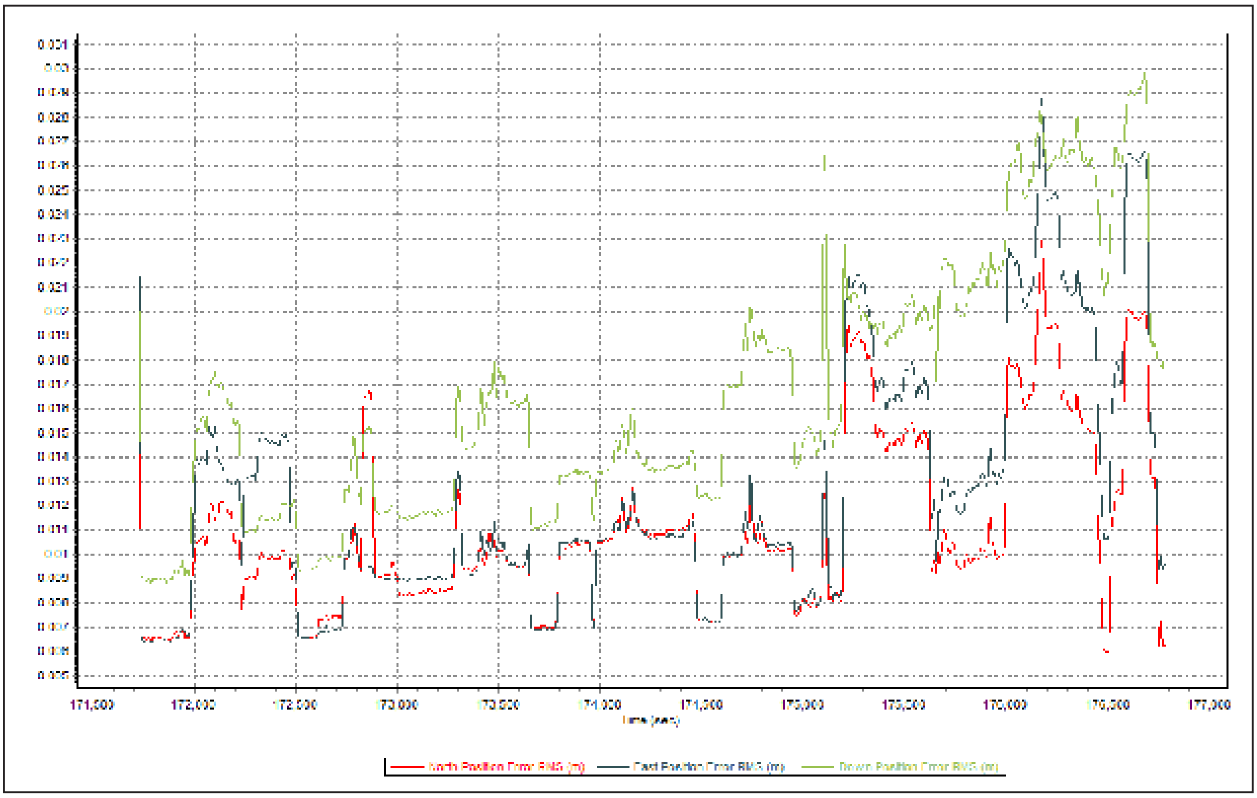


Figure A-8.2. Smoothed Performance Metric Parameters

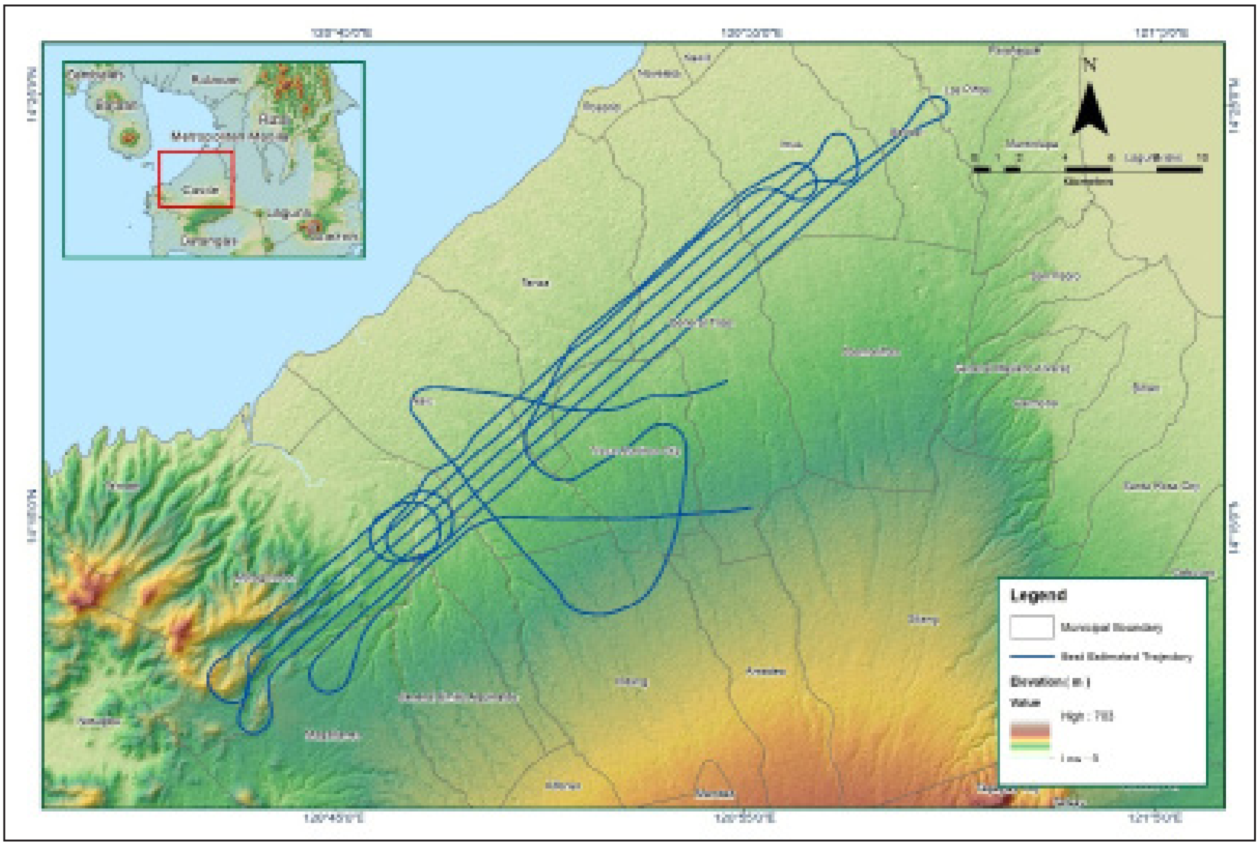


Figure A-8.3. Best Estimated Trajectory

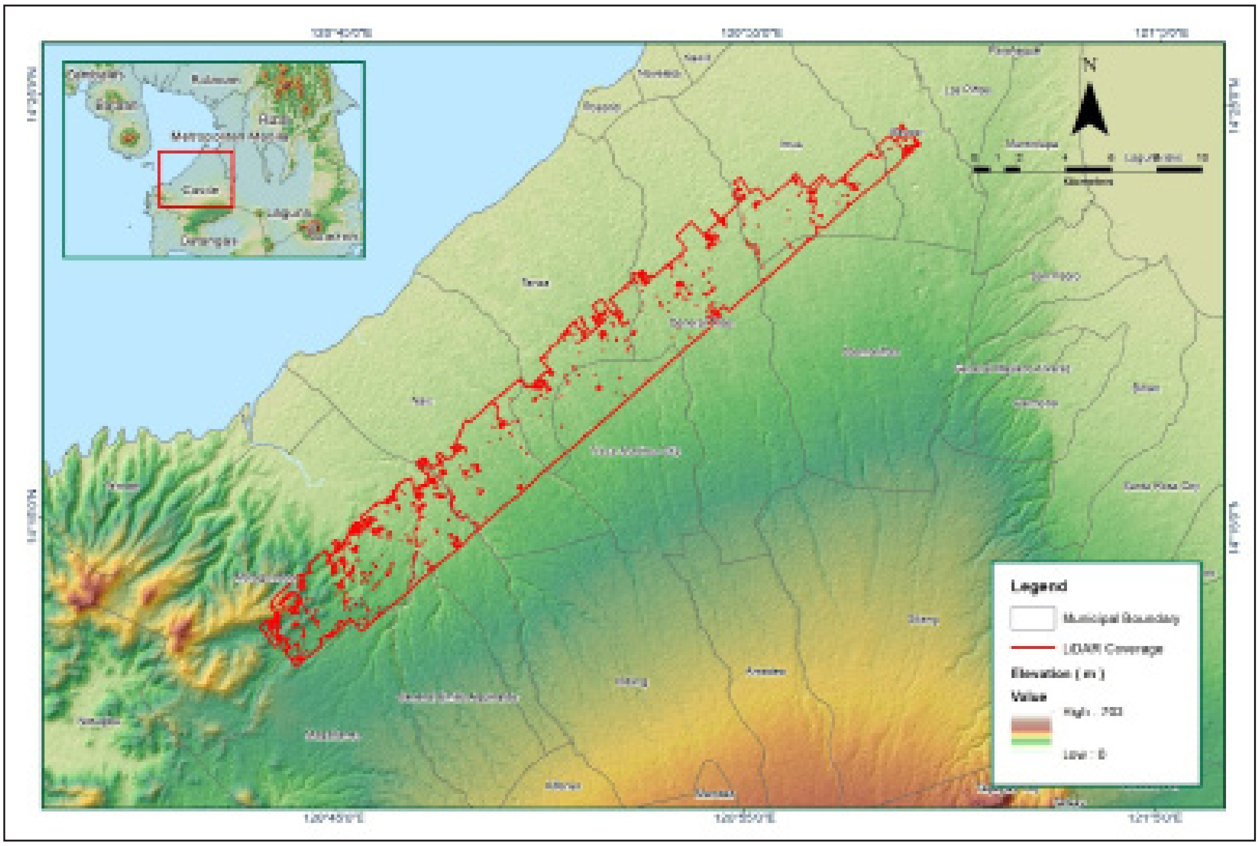


Figure A-8.4. Coverage of LiDAR data

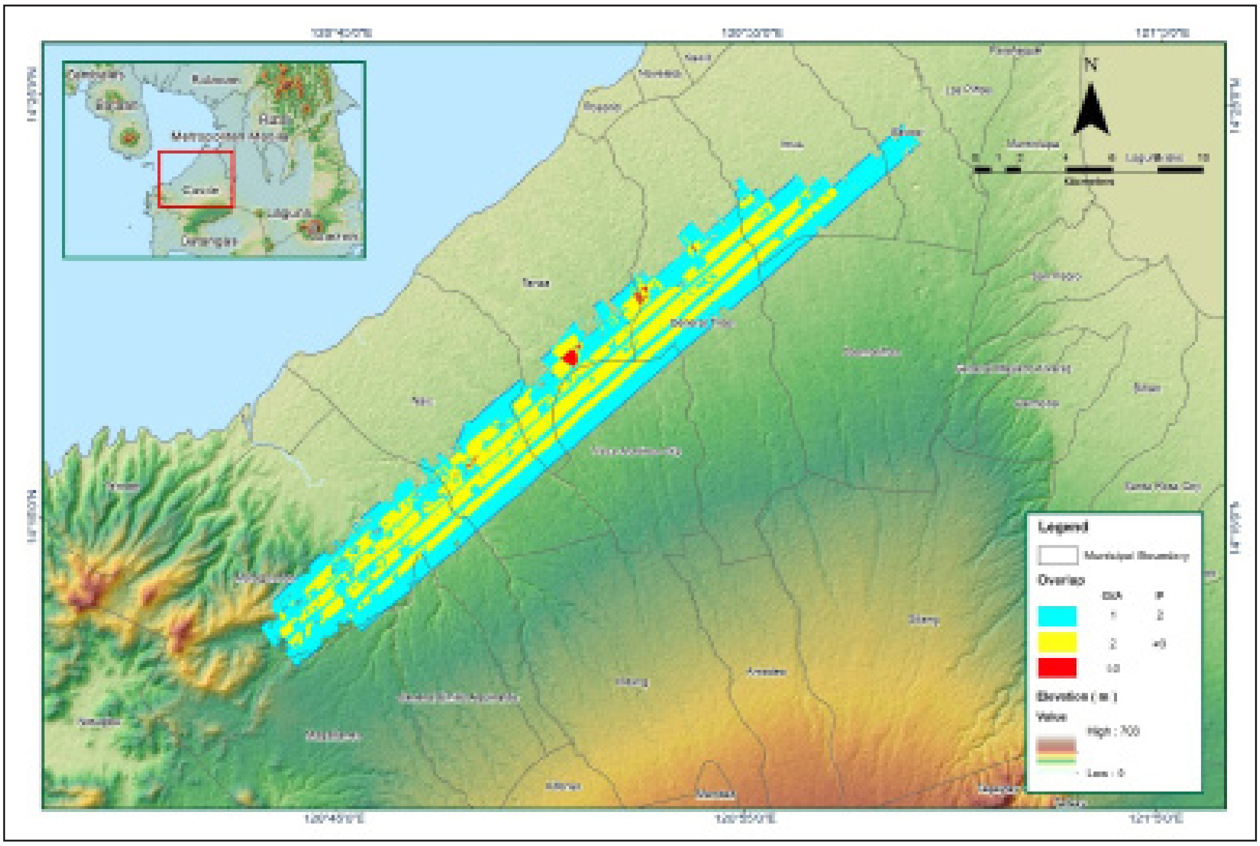


Figure A-8.5. Image of data overlap

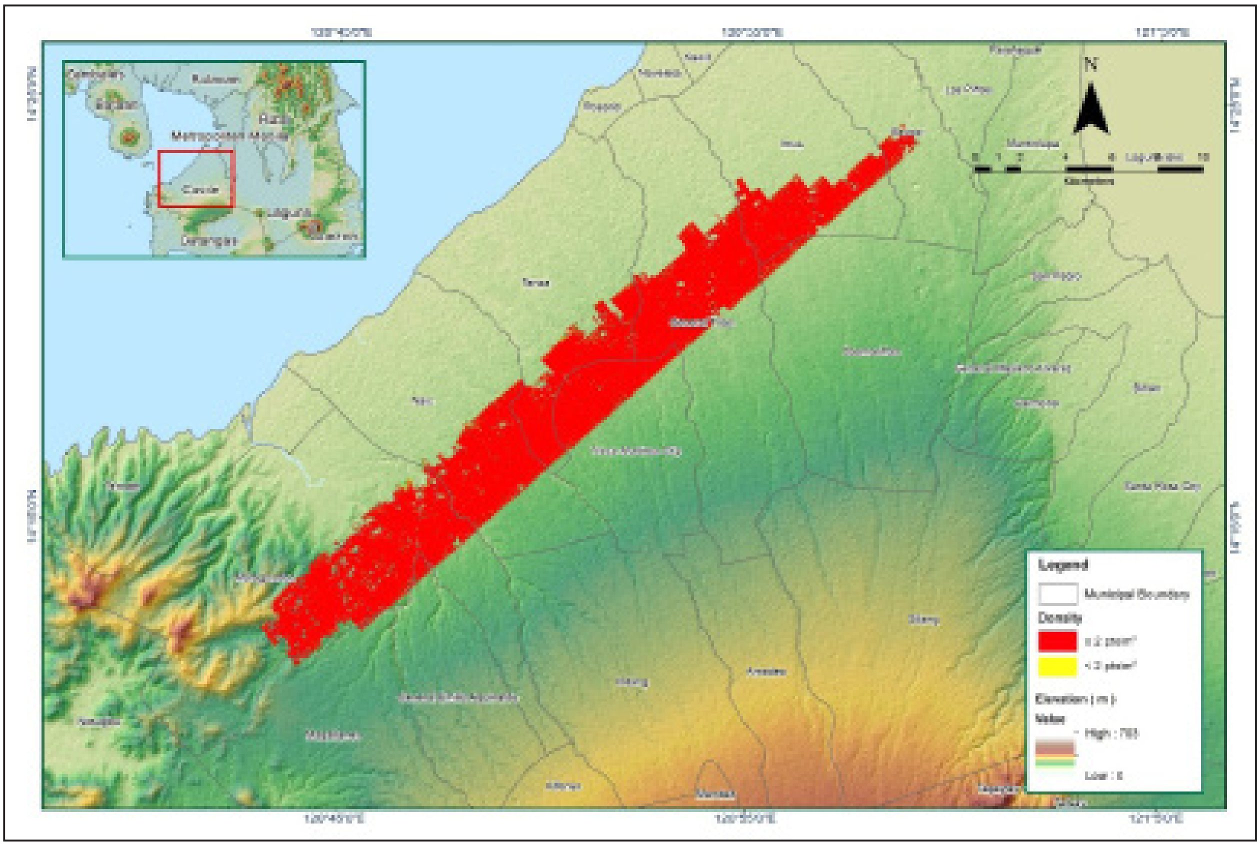


Figure A-8.6. Density map of merged LiDAR data

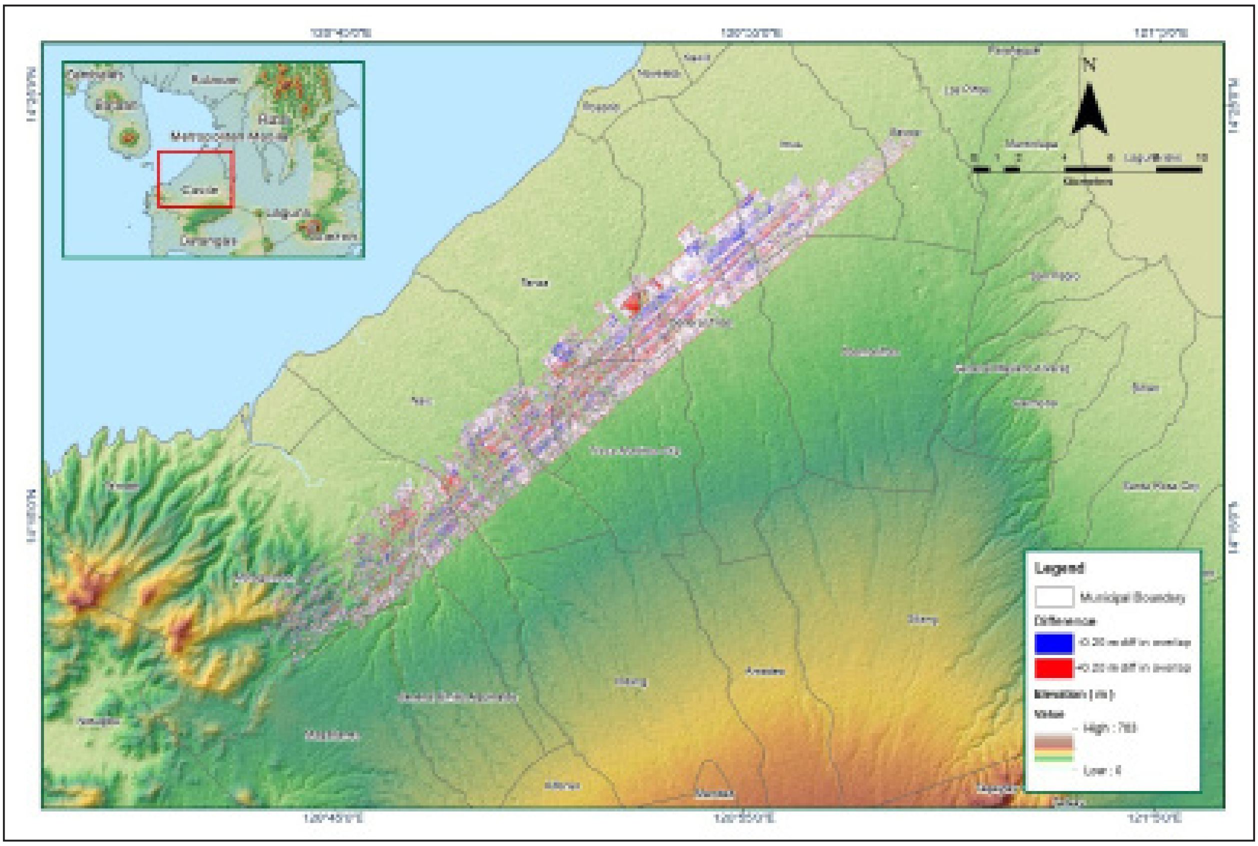


Figure A-8.7. Elevation difference between flight lines

Table A-8.2 Mission Summary Report for Blk18A

Flight Area	Calabarzon Reflights
Mission Name	Blk18A
Inclusive Flights	10136L, 10142L
RawLaser	19.79 GB
GnssImu	969 MB
Image	76.8 GB
Transfer date	6/20/2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Combined Separation (-0.1 up to 0.1)	Yes
Estimated Position Accuracy (in cm)	
Estimated Standard Devation for North Position (<4.0 cm)	0.65
Estimated Standard Devation for East Position (<4.0 cm)	0.80
Estimated Standard Devation for Height Position (<8.0 cm)	1.80
Minimum % overlap (>25)	47.33%
Ave point cloud density per sq.m. (>2.0)	3.22
Elevation difference between strips (<0.20 m)	
Number of 1km x 1km blocks	215
Maximum Height	354.74 m
Minimum Height	44.59 m
Classification (# of points)	
Ground	258,626,866
Low vegetation	250,593,109
Medium vegetation	204,765,100
High vegetation	216,443,750
Building	62,593,079
Orthophoto	Yes
Processed by	Engr. Regis Guhiting, Engr. Melanie Hingpit, Kathryn Claudyn Zarate

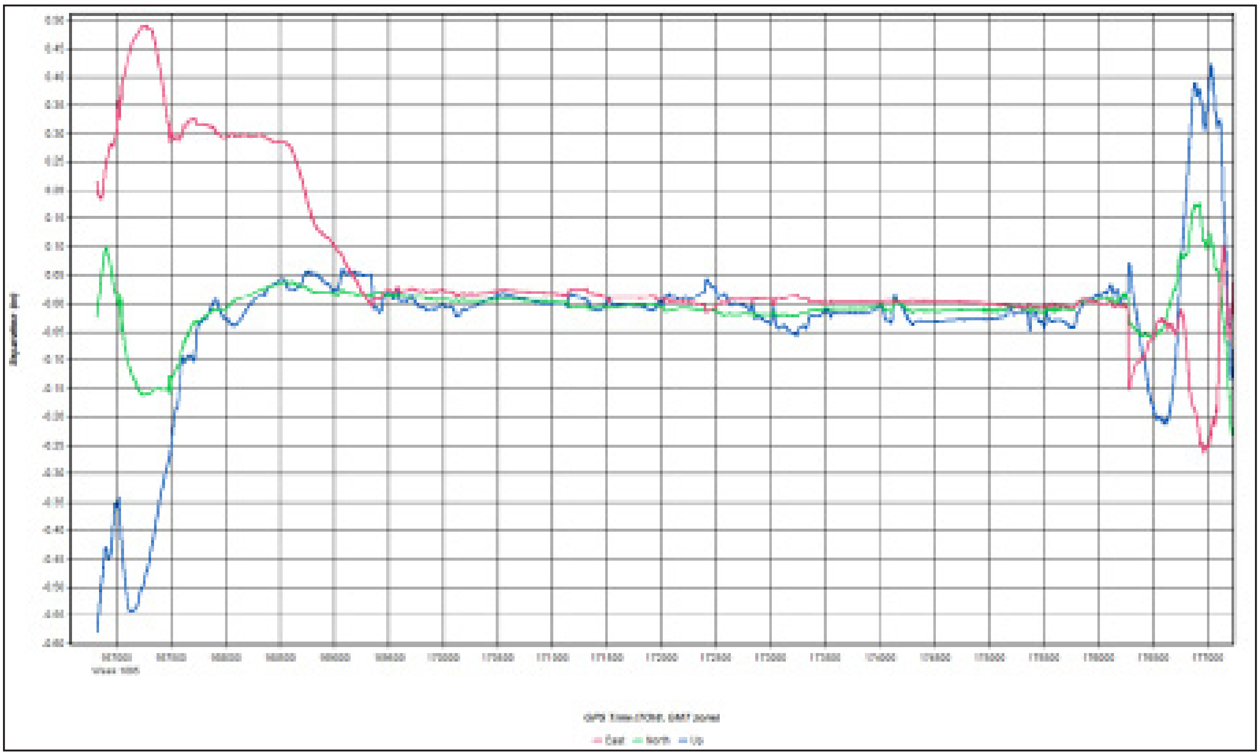


Figure A-8.8. Combined Separation

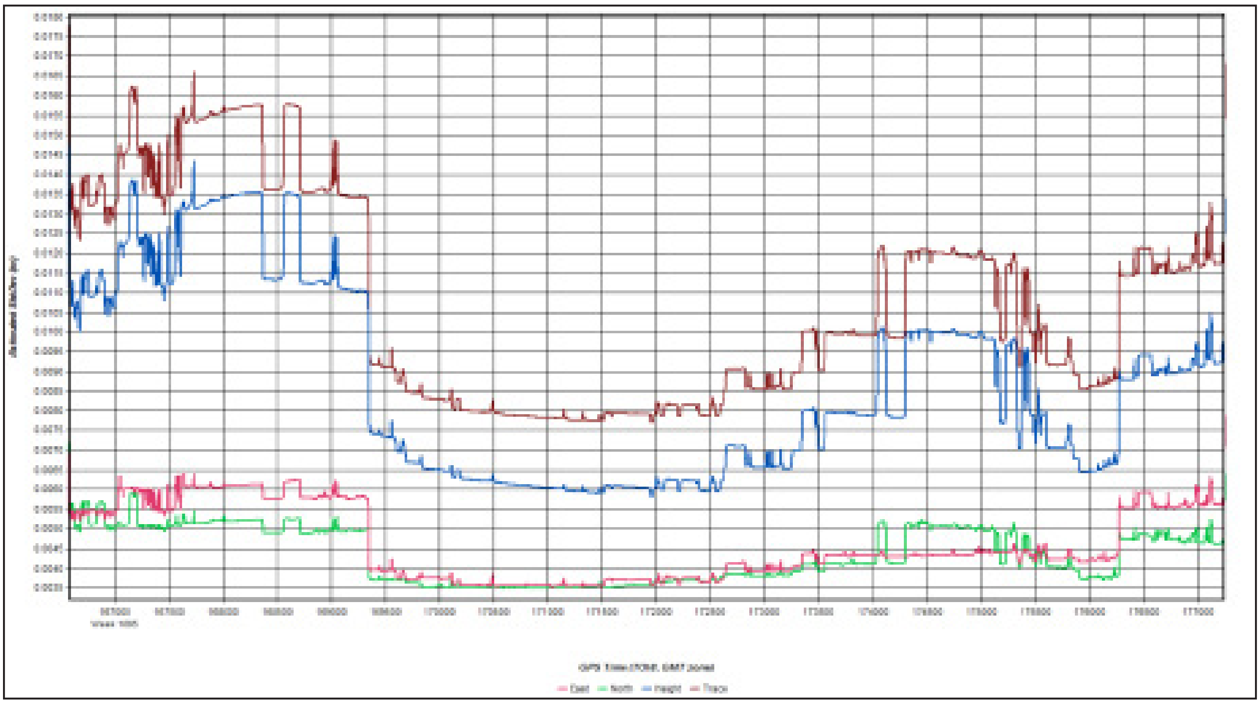


Figure A-8.9. Estimated Position of Accuracy

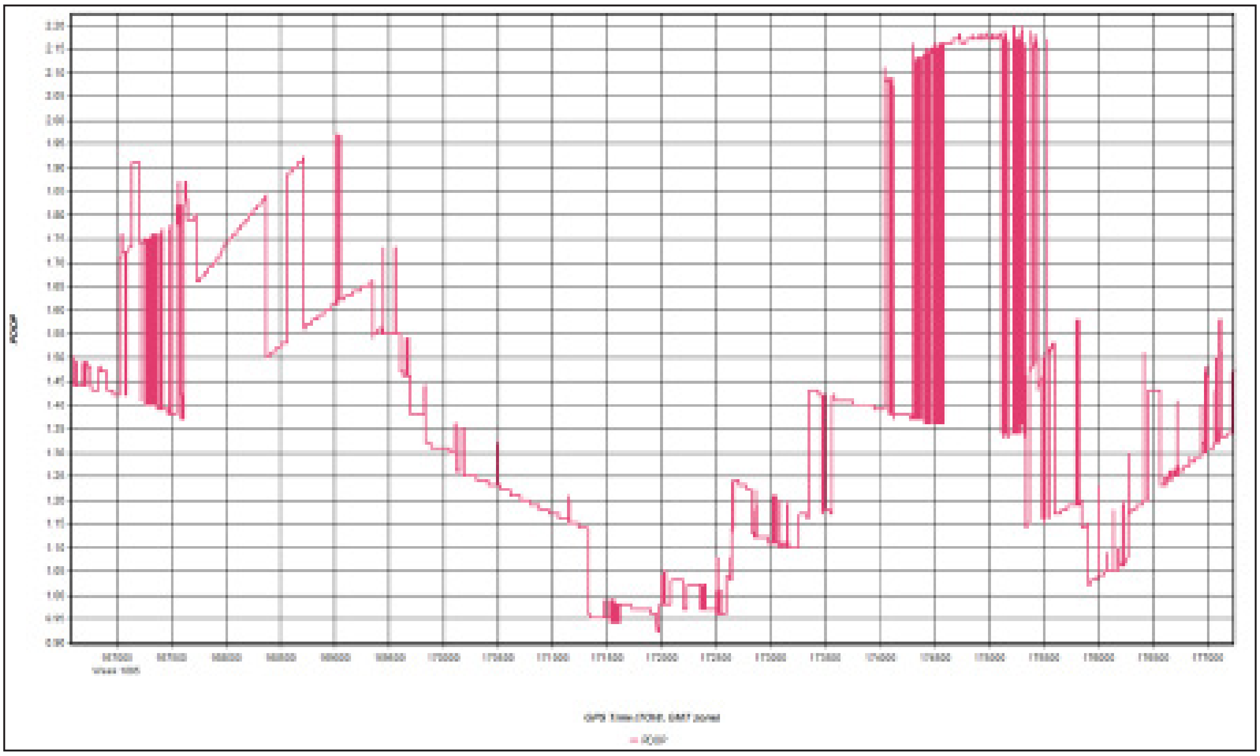


Figure A-8.10. PDOP

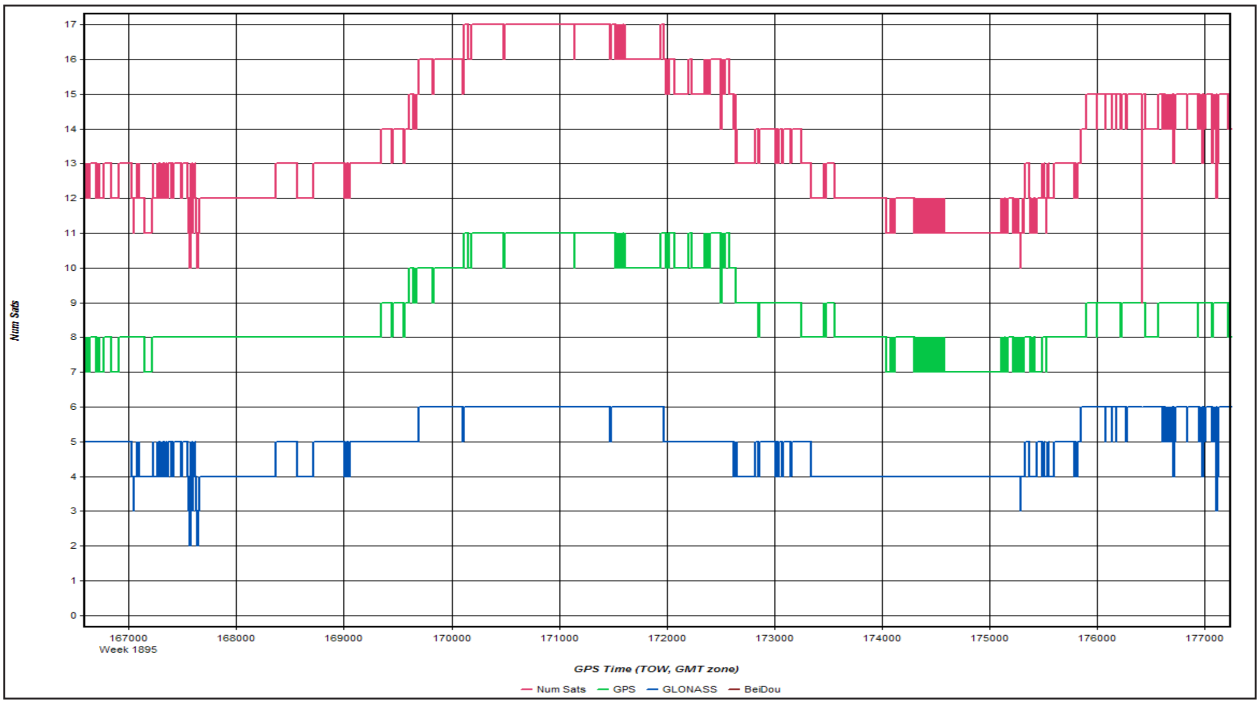


Figure A-8.11. Number of Satellites

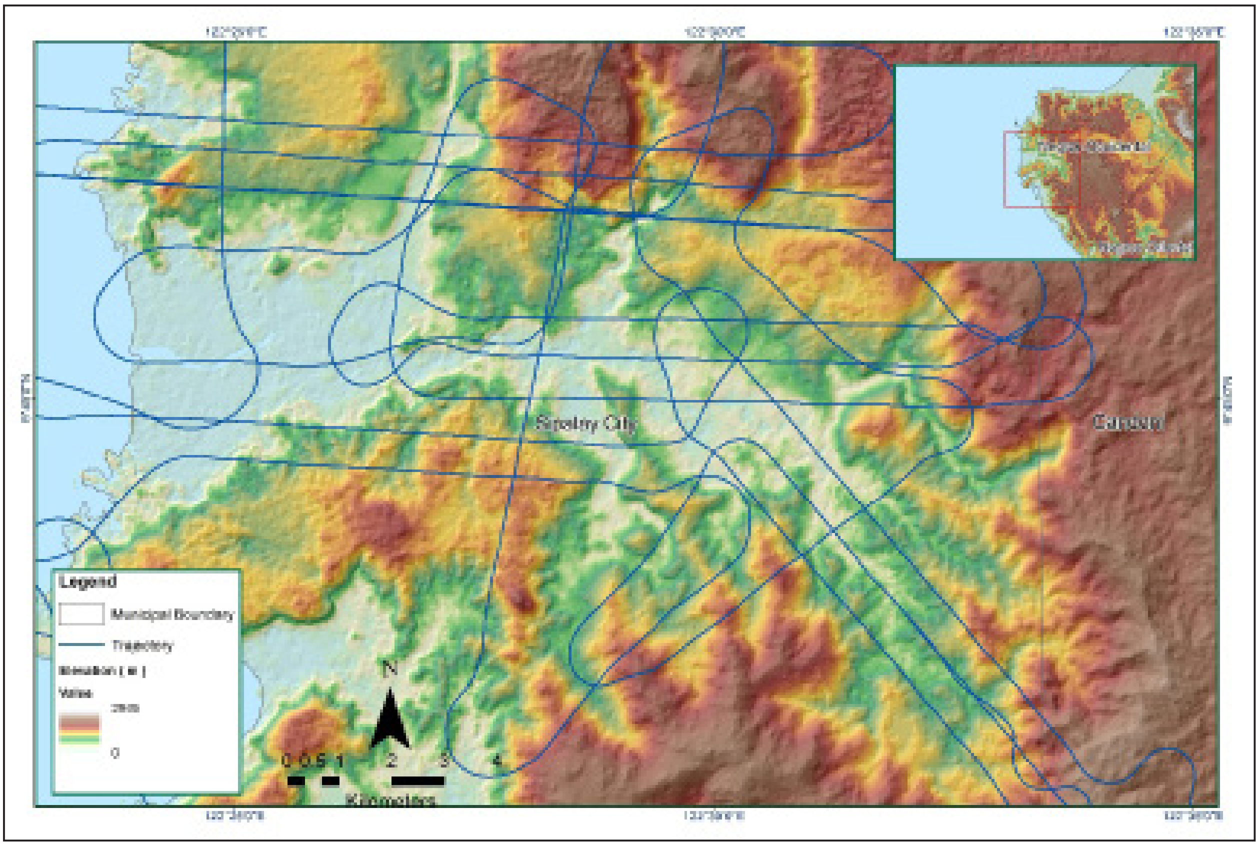


Figure A-8.10. Best Estimated Trajectory

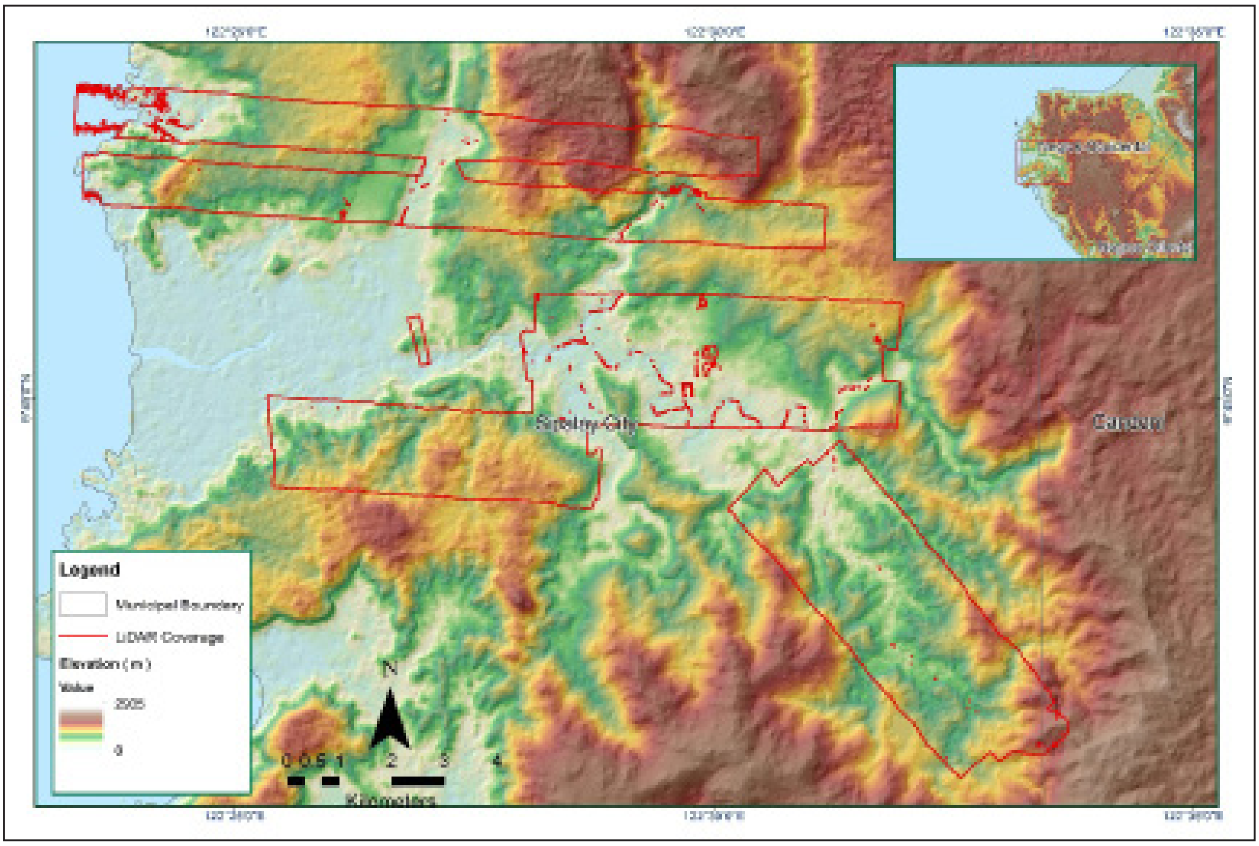


Figure A-8.11. Coverage of LiDAR data

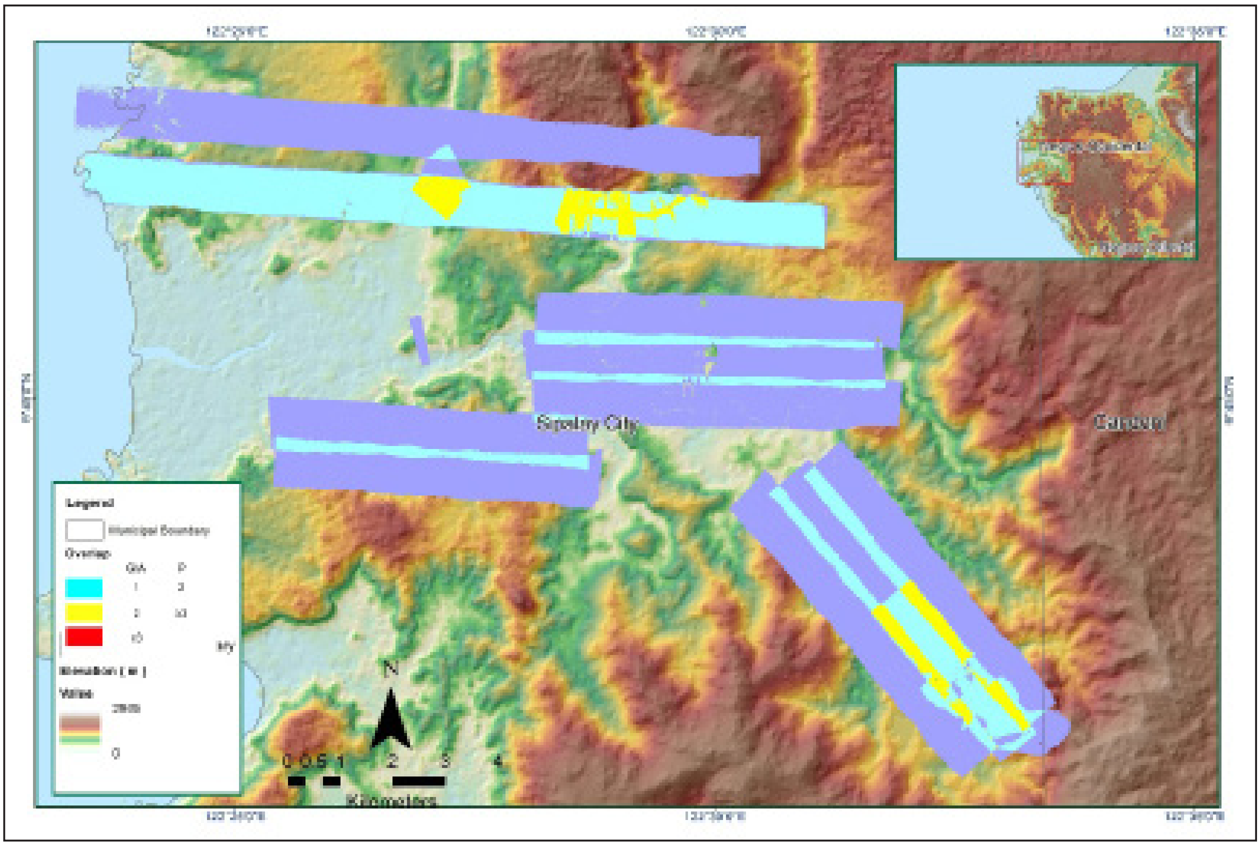


Figure A-8.12. Image of data overlap

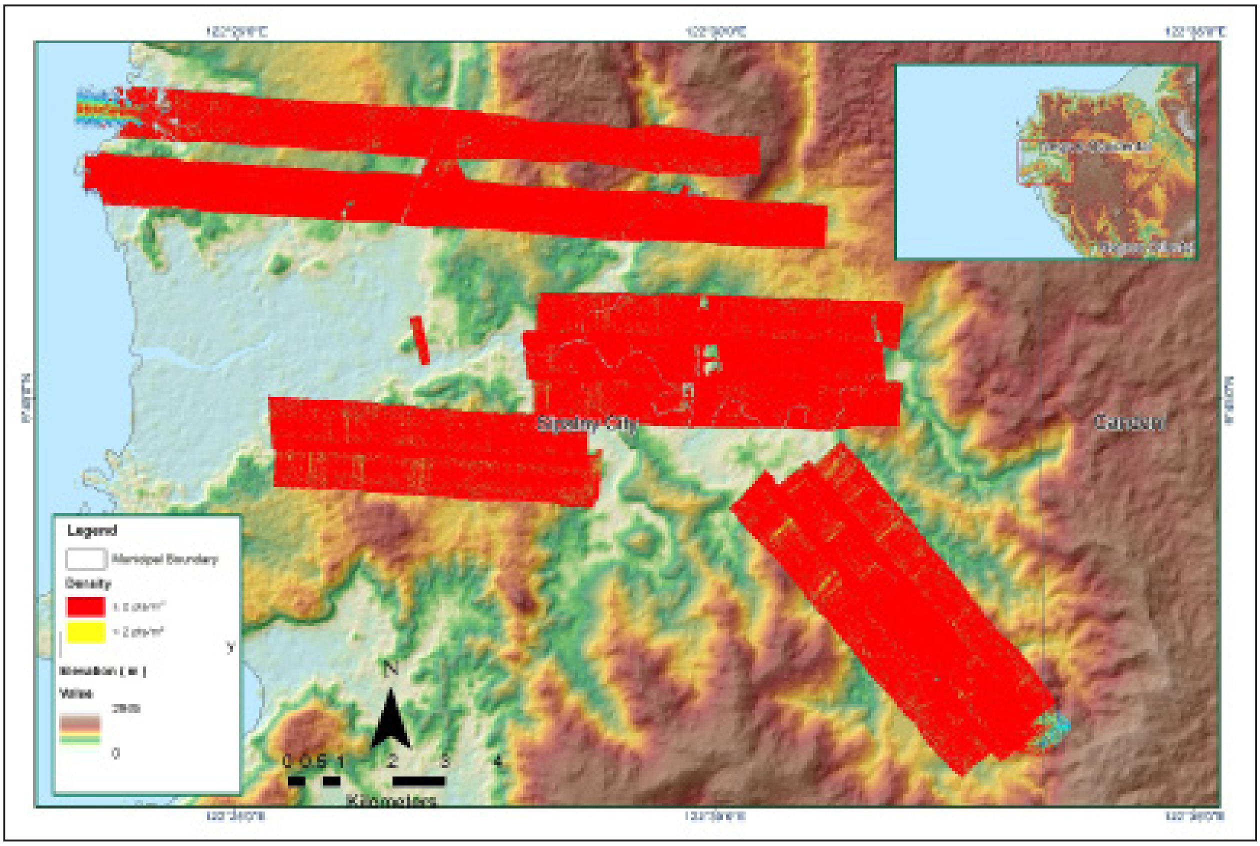


Figure A-8.13. Density map of merged LiDAR data

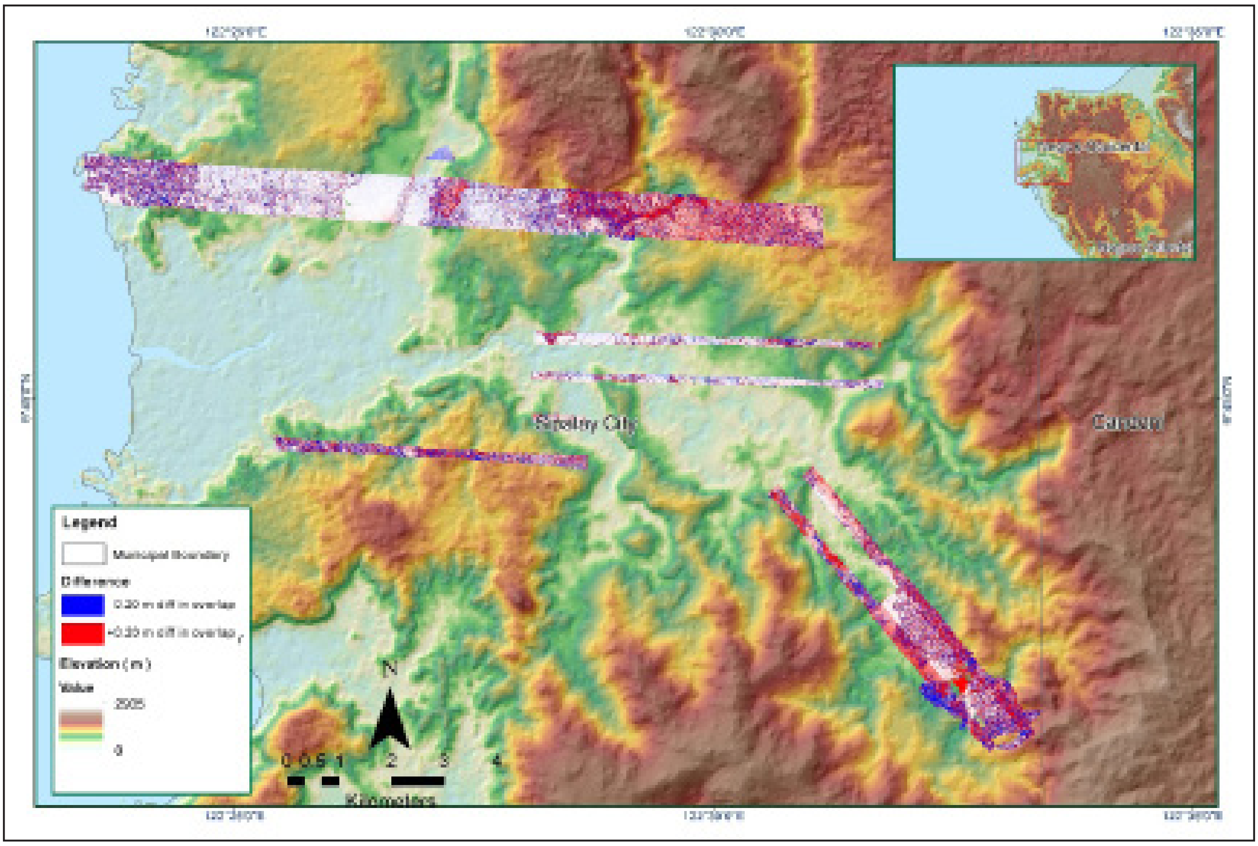


Figure A-8.14. Elevation difference between flight lines

Table A-8.3 Mission Summary Report for Blk18B_Supplement3

Flight Area	Calabarzon Reflights
Mission Name	Blk18B_Supplement3
Inclusive Flights	10321L
RawLaser	6.16 GB
GnssImu	329 MB
Image	7.32 GB
Transfer date	2/13/2017
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	No
Baseline Length (<30km)	Yes
Combined Separation (-0.1 up to 0.1)	No
Estimated Position Accuracy (in cm)	
Estimated Standard Devation for North Position (<4.0 cm)	2.7
Estimated Standard Devation for East Position (<4.0 cm)	3.2
Estimated Standard Devation for Height Position (<8.0 cm)	3.5
Minimum % overlap (>25)	22.01%
Ave point cloud density per sq.m. (>2.0)	1.20
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	18
Maximum Height	103.706 m
Minimum Height	45.009 m
Classification (# of points)	
Ground	5,339,022
Low vegetation	1,903,203
Medium vegetation	3,104,416
High vegetation	4,768,776
Building	5,270,108
Orthophoto	No
Processed by	Engr. Regis Guhiting, Engr. Harmond Santos, Engr. Gladys Mae Apat

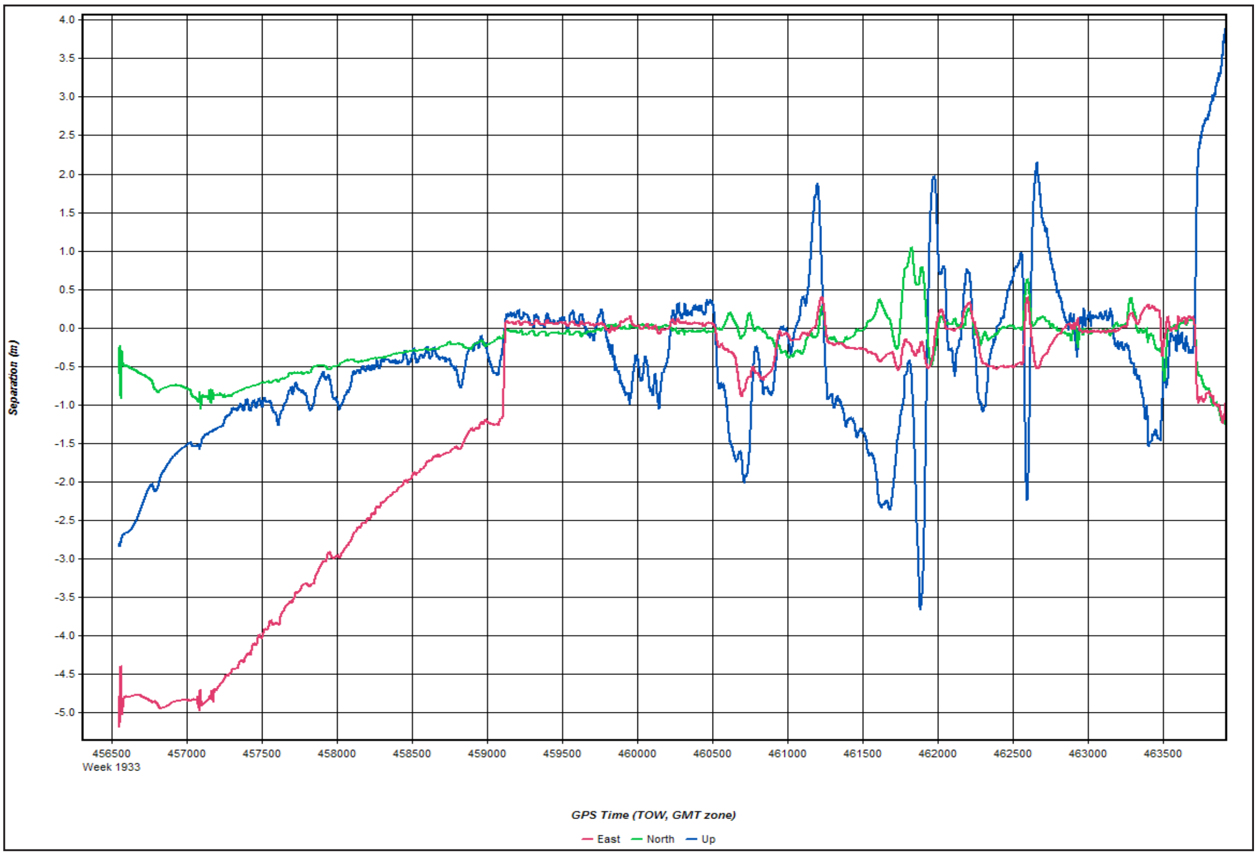


Figure A-8.15. Combined Separation

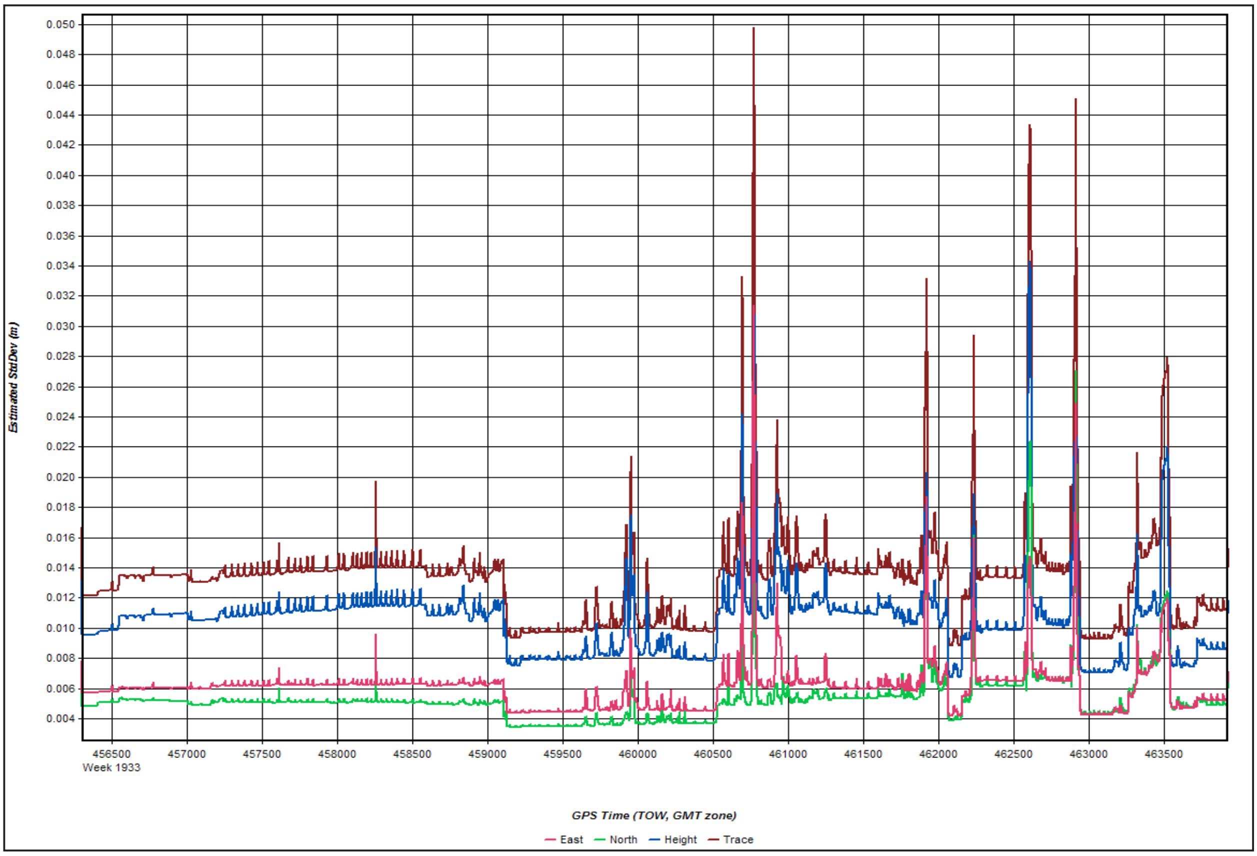


Figure A-8.16. Estimated Position of Accuracy

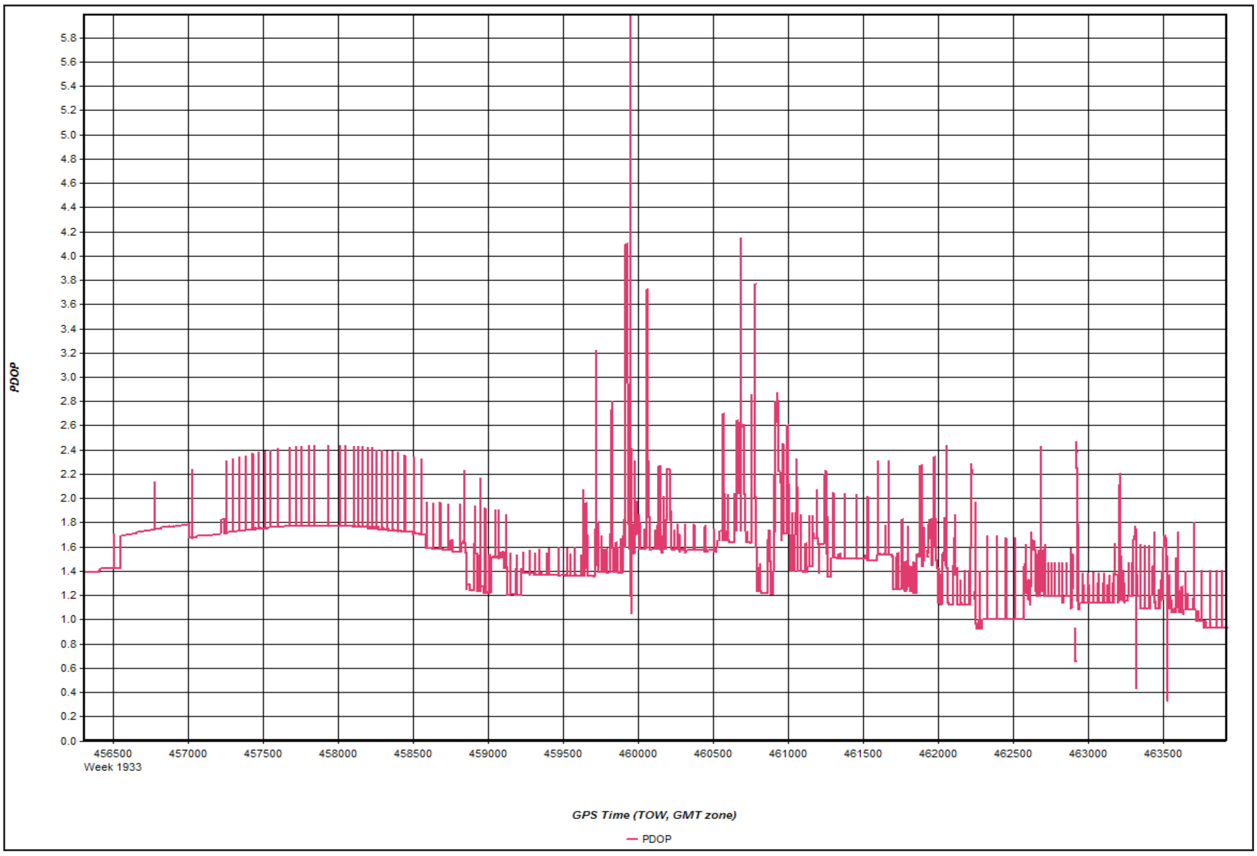


Figure A-8.15. PDOP

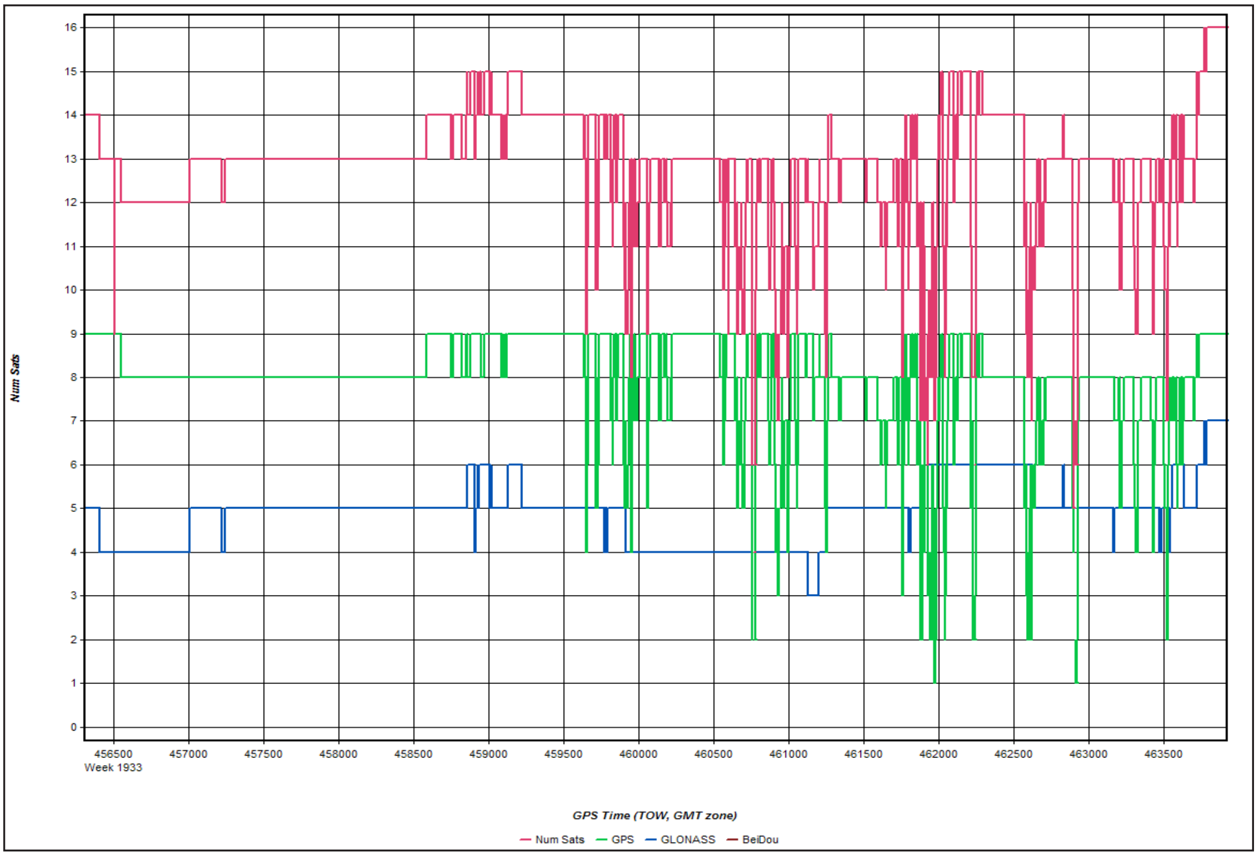


Figure A-8.16. Number of Satellites

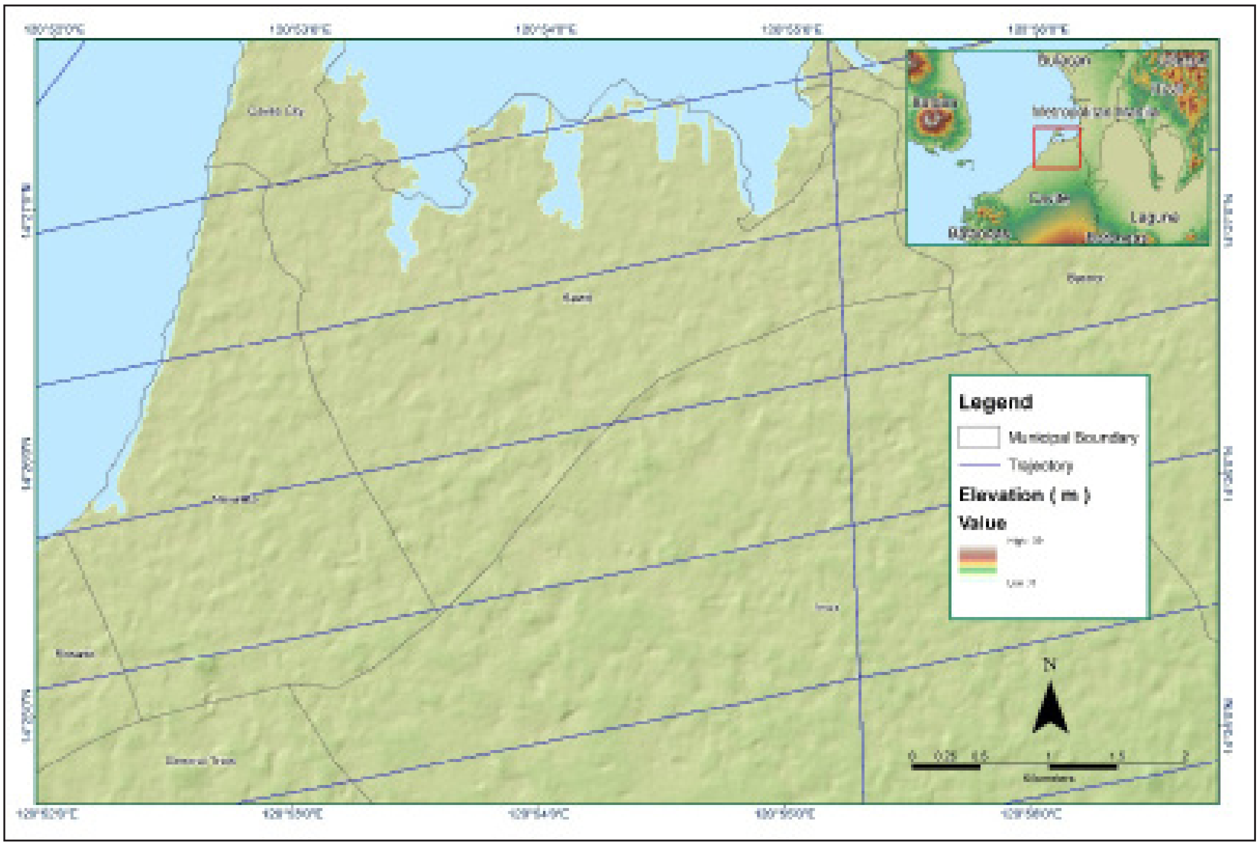


Figure A-8.17. Best Estimated Trajectory

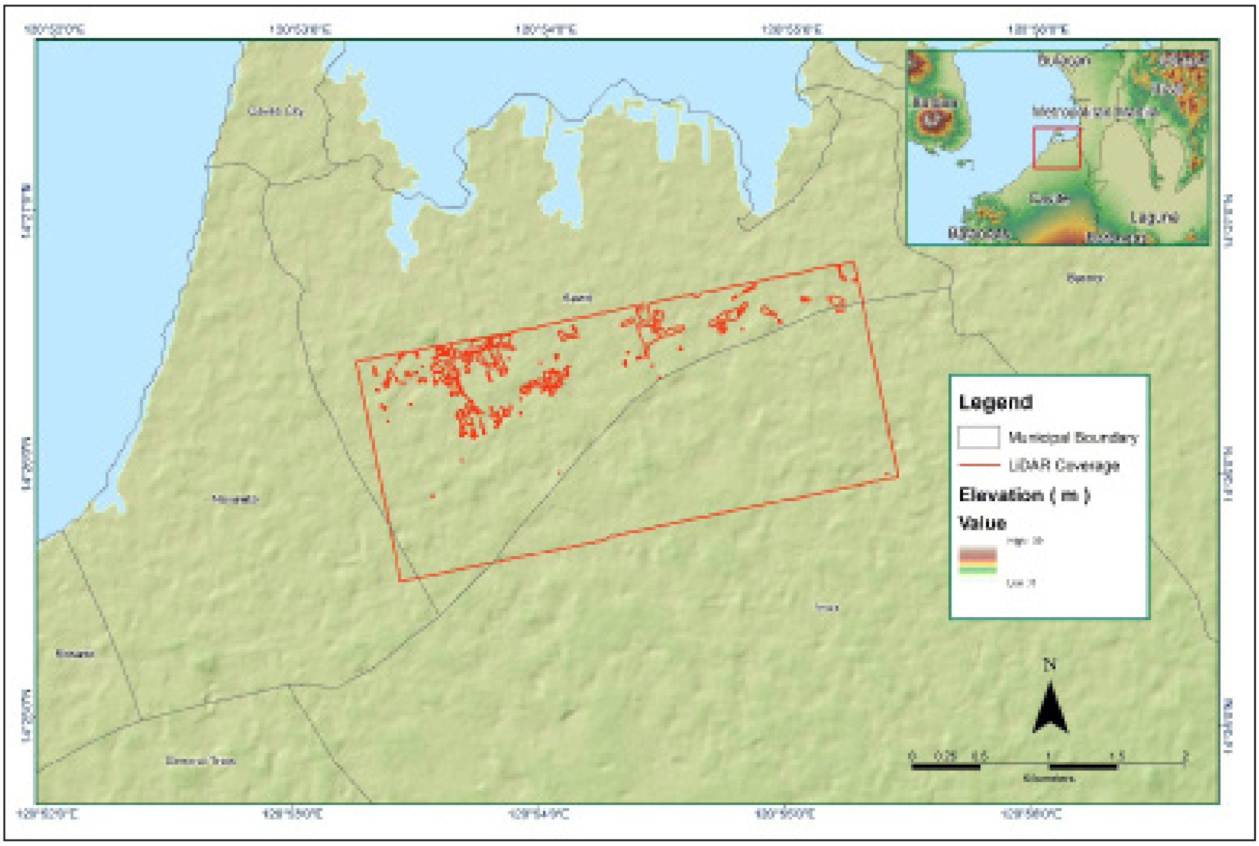


Figure A-8.18. Coverage of LiDAR data

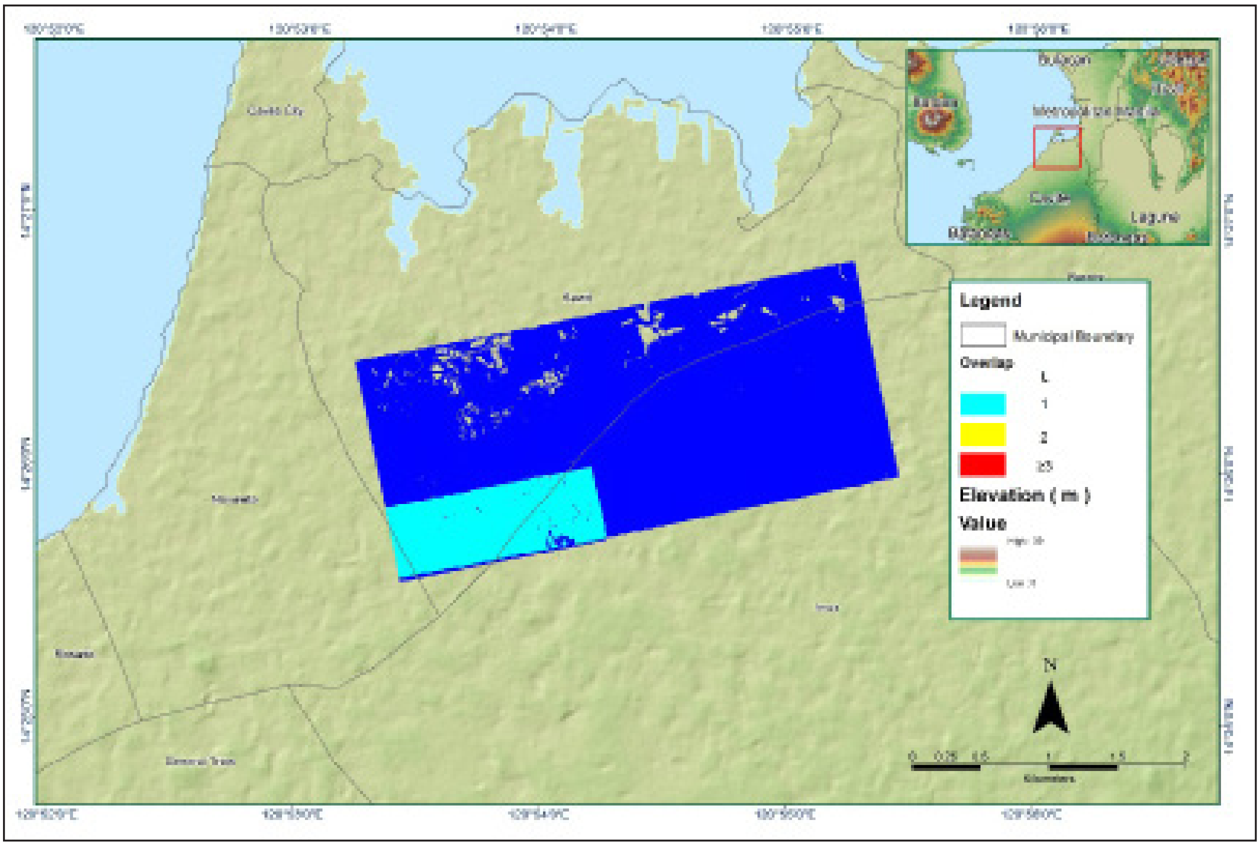


Figure A-8.19. Image of data overlap

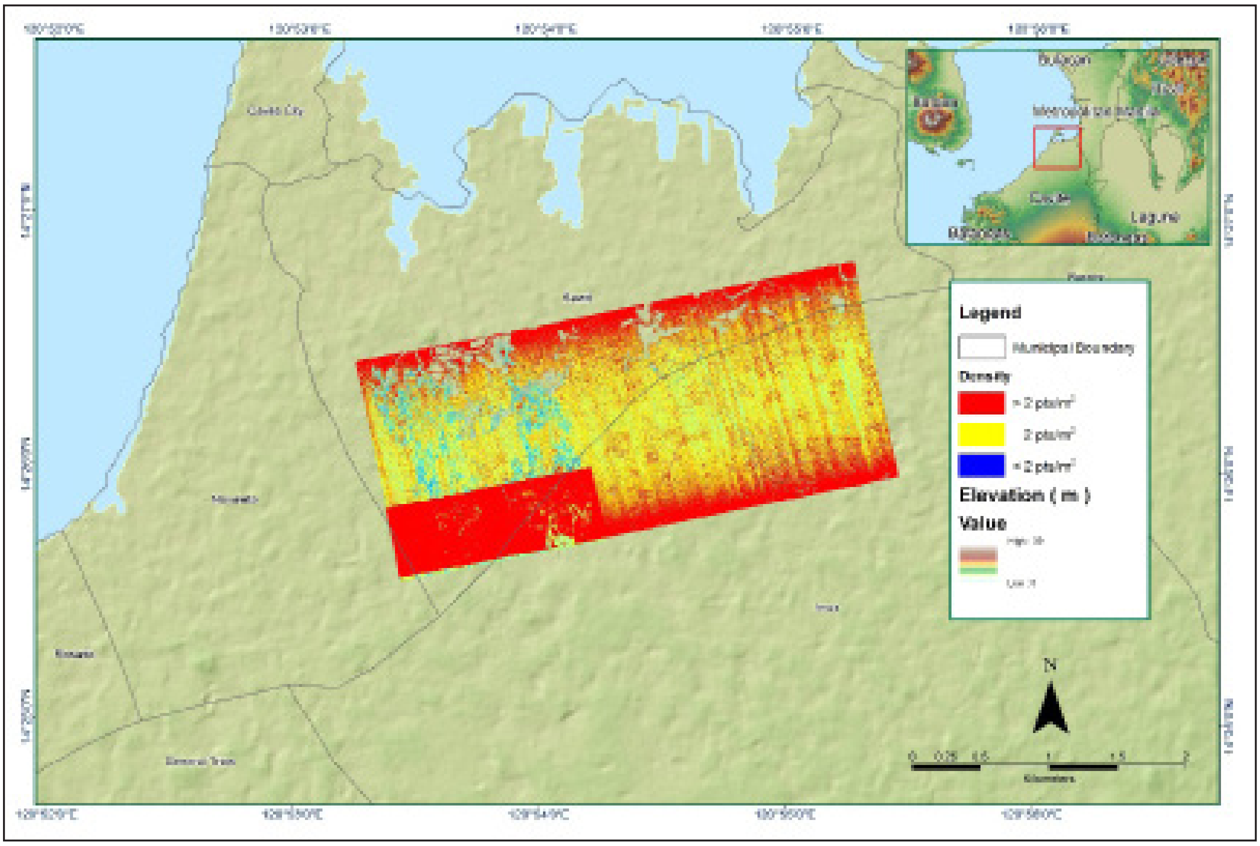


Figure A-8.20. Density map of merged LiDAR data

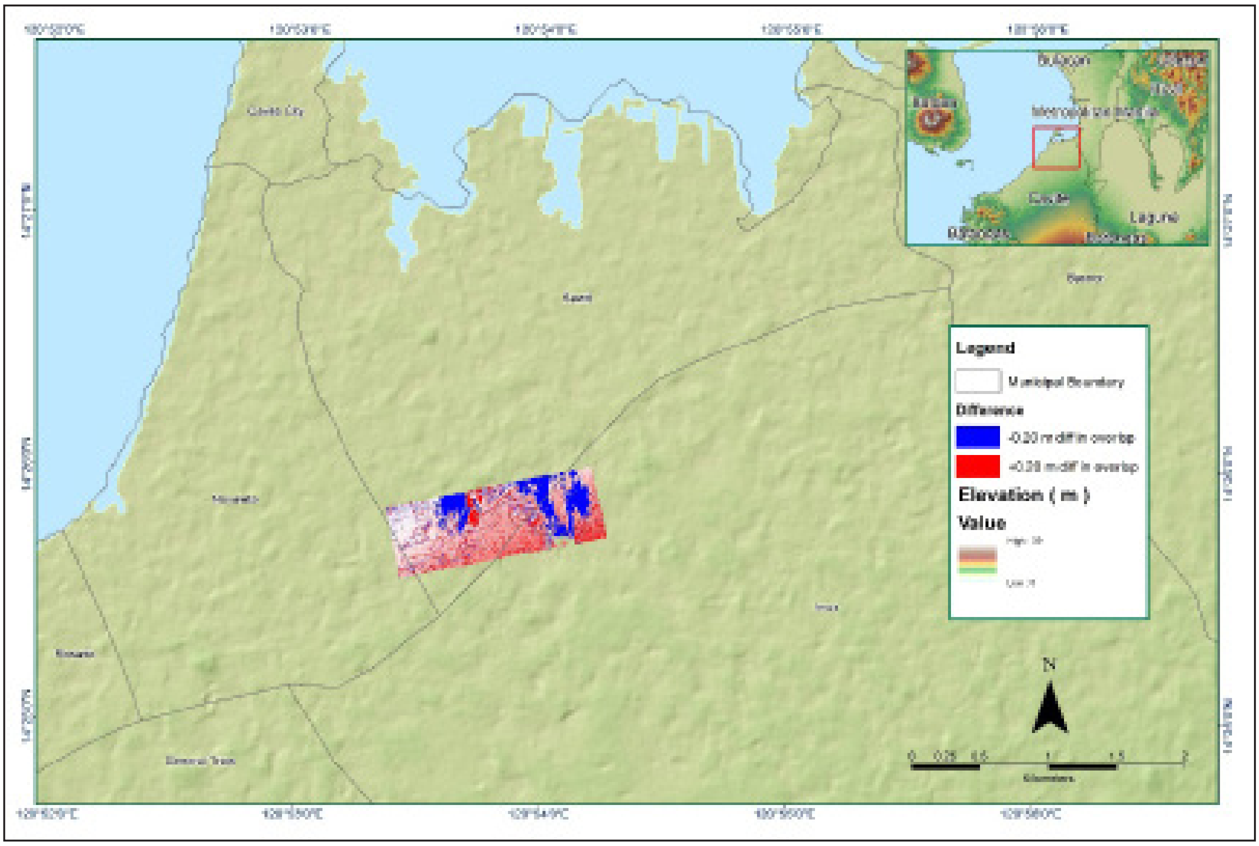


Figure A-8.21. Elevation difference between flight lines

Table A-8.4 Mission Summary Report for Blk18B_Supplement3

Flight Area	Calabarzon Reflights
Mission Name	Blk18B_Supplement3
Inclusive Flights	10321L
RawLaser	6.16 GB
GnssImu	329 MB
Image	7.32 GB
Transfer date	2/13/2017
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	No
Baseline Length (<30km)	Yes
Combined Separation (-0.1 up to 0.1)	No
Estimated Position Accuracy (in cm)	
Estimated Standard Devation for North Position (<4.0 cm)	2.7
Estimated Standard Devation for East Position (<4.0 cm)	3.2
Estimated Standard Devation for Height Position (<8.0 cm)	3.5
Minimum % overlap (>25)	22.01%
Ave point cloud density per sq.m. (>2.0)	1.20
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	18
Maximum Height	103.706 m
Minimum Height	45.009 m
Classification (# of points)	
Ground	5,339,022
Low vegetation	1,903,203
Medium vegetation	3,104,416
High vegetation	4,768,776
Building	5,270,108
Orthophoto	No
Processed by	Engr. Regis Guhiting, Engr. Harmond Santos, Engr. Gladys Mae Apat

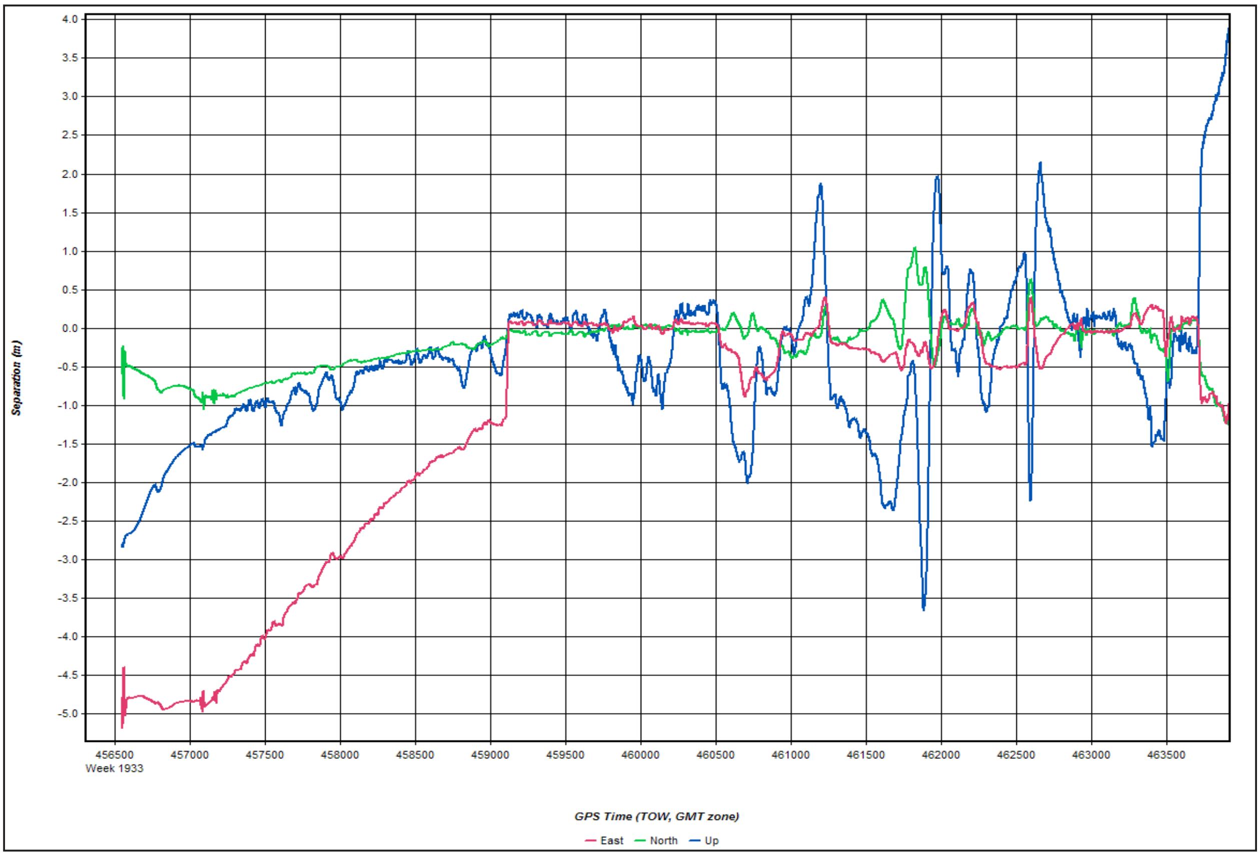


Figure A-8.22. Combined Separation

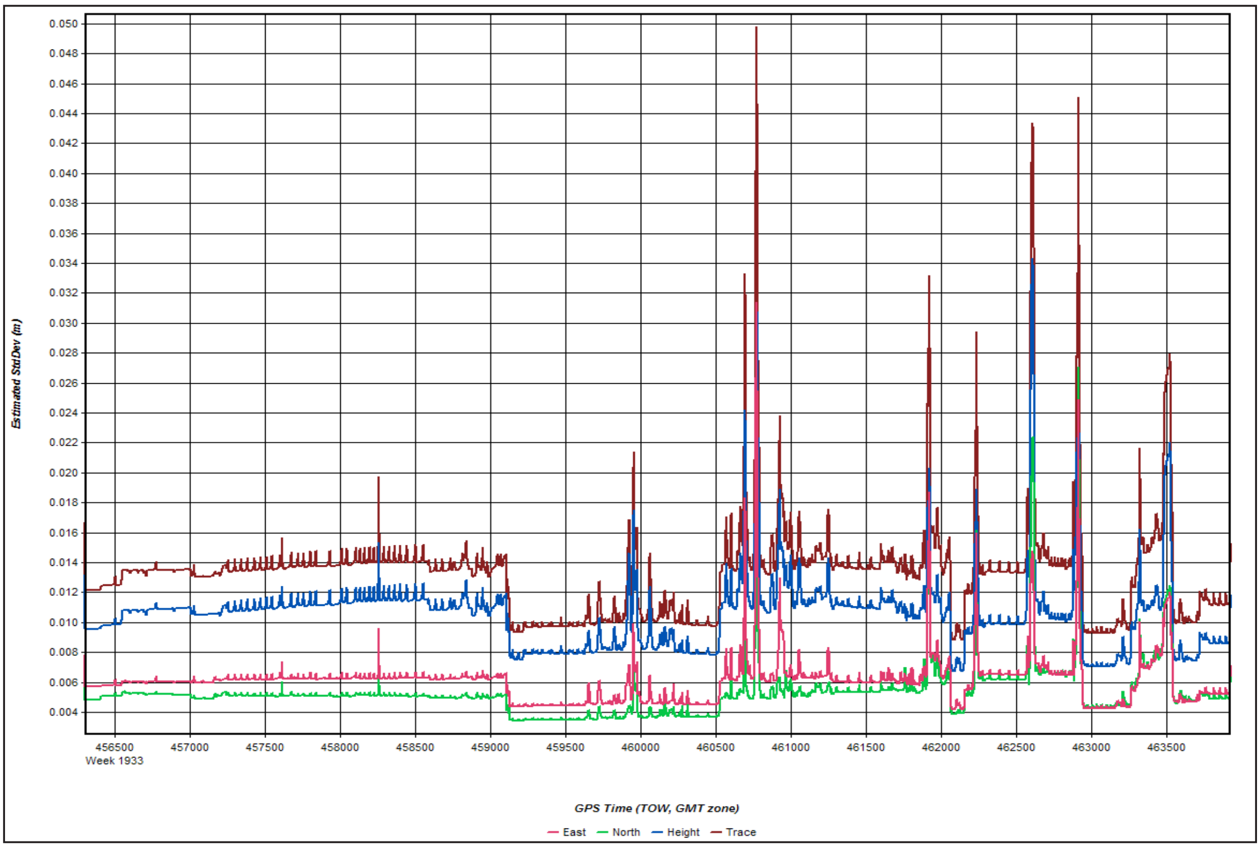


Figure A-8.23. Estimated Position of Accuracy

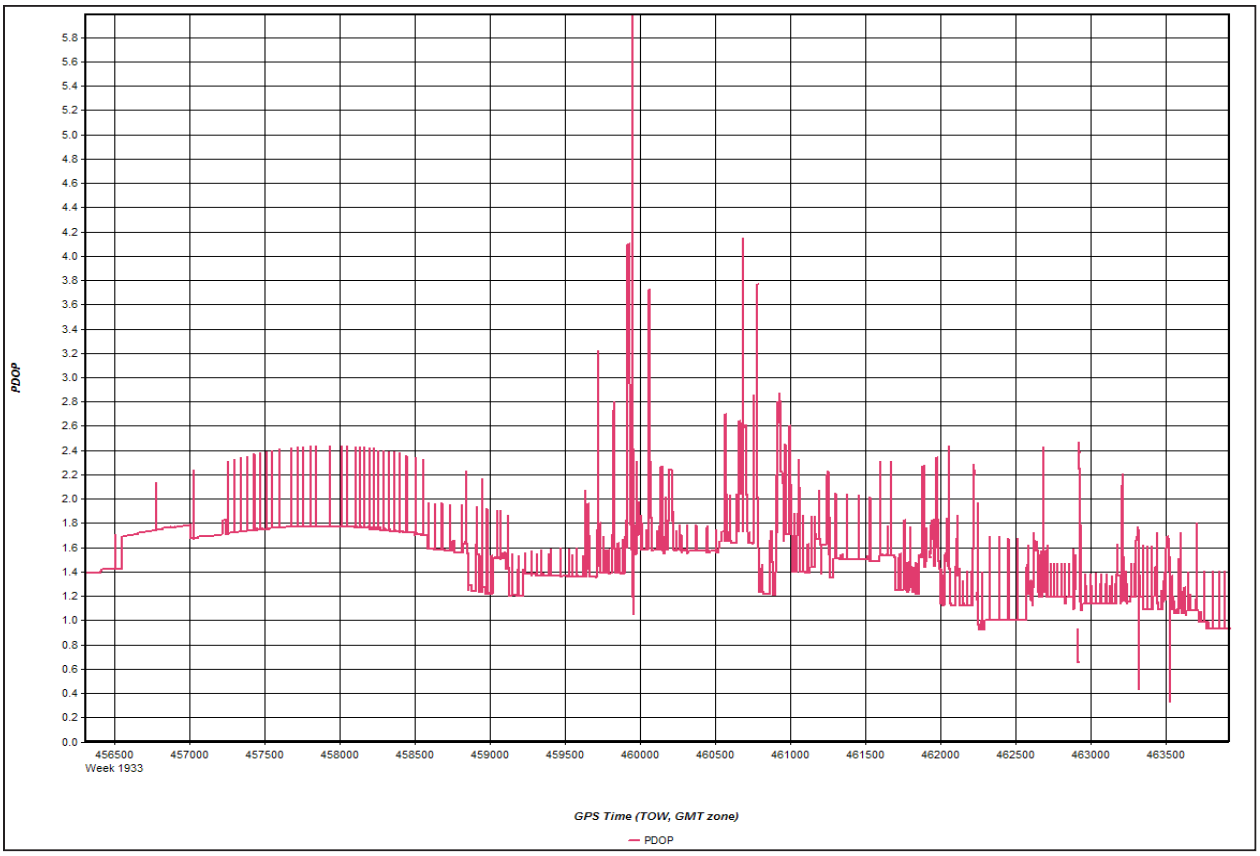


Figure A-8.22. PDOP

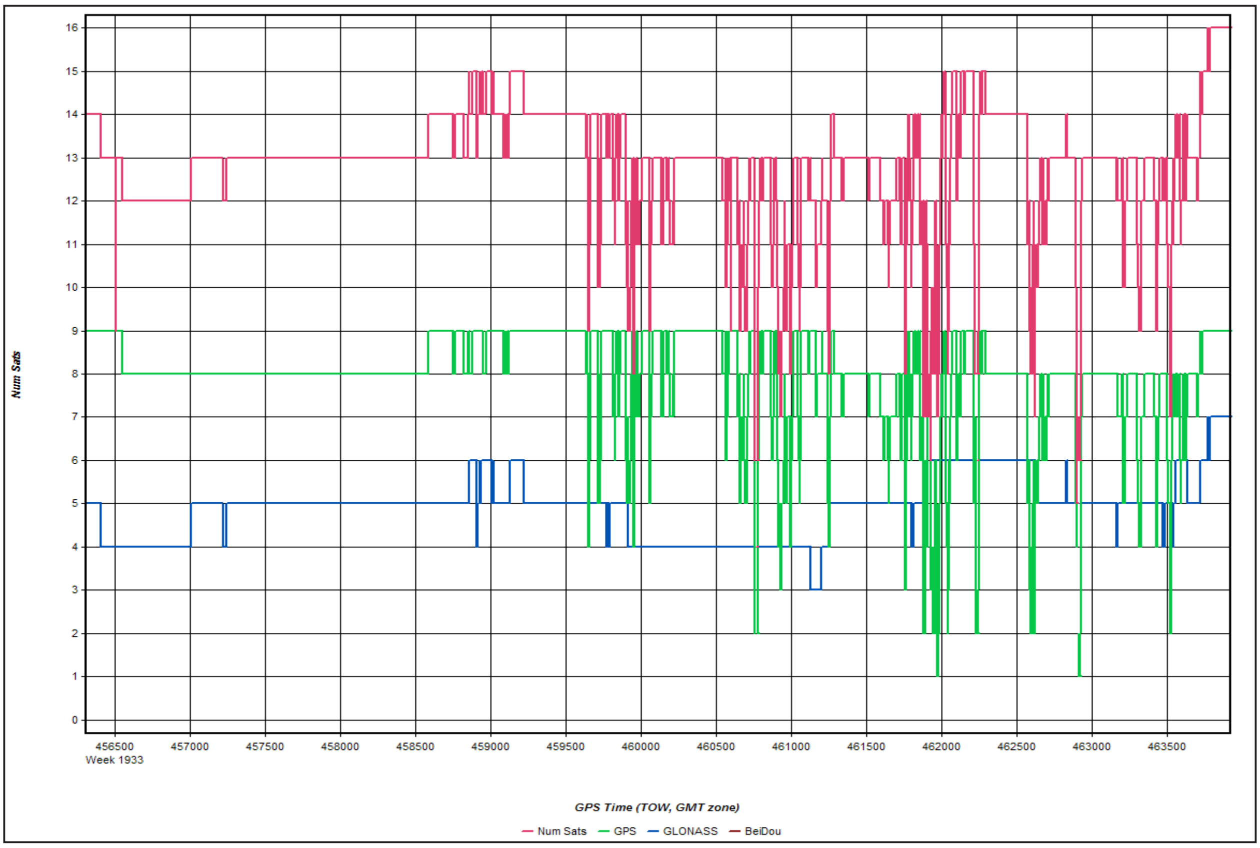


Figure A-8.23. Number of Satellites

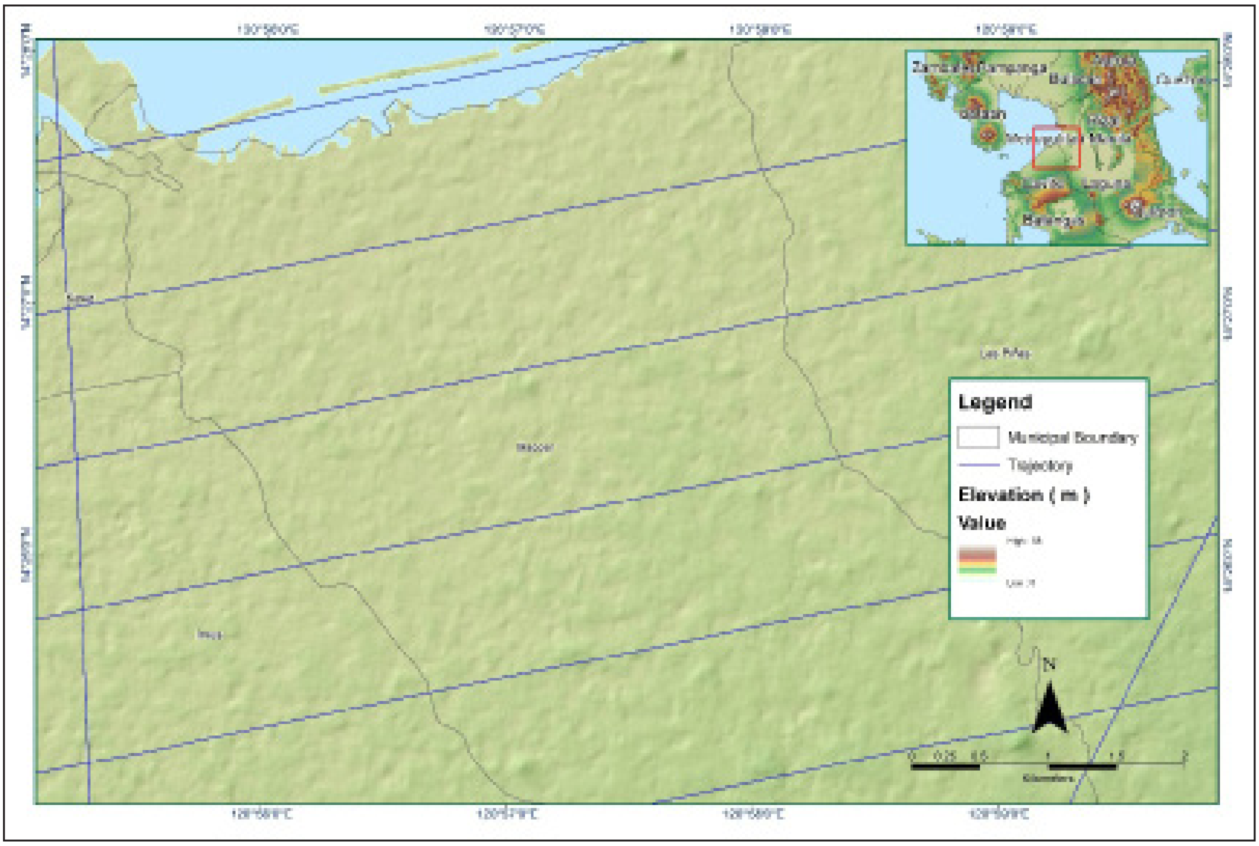


Figure A-8.24. Best Estimated Trajectory

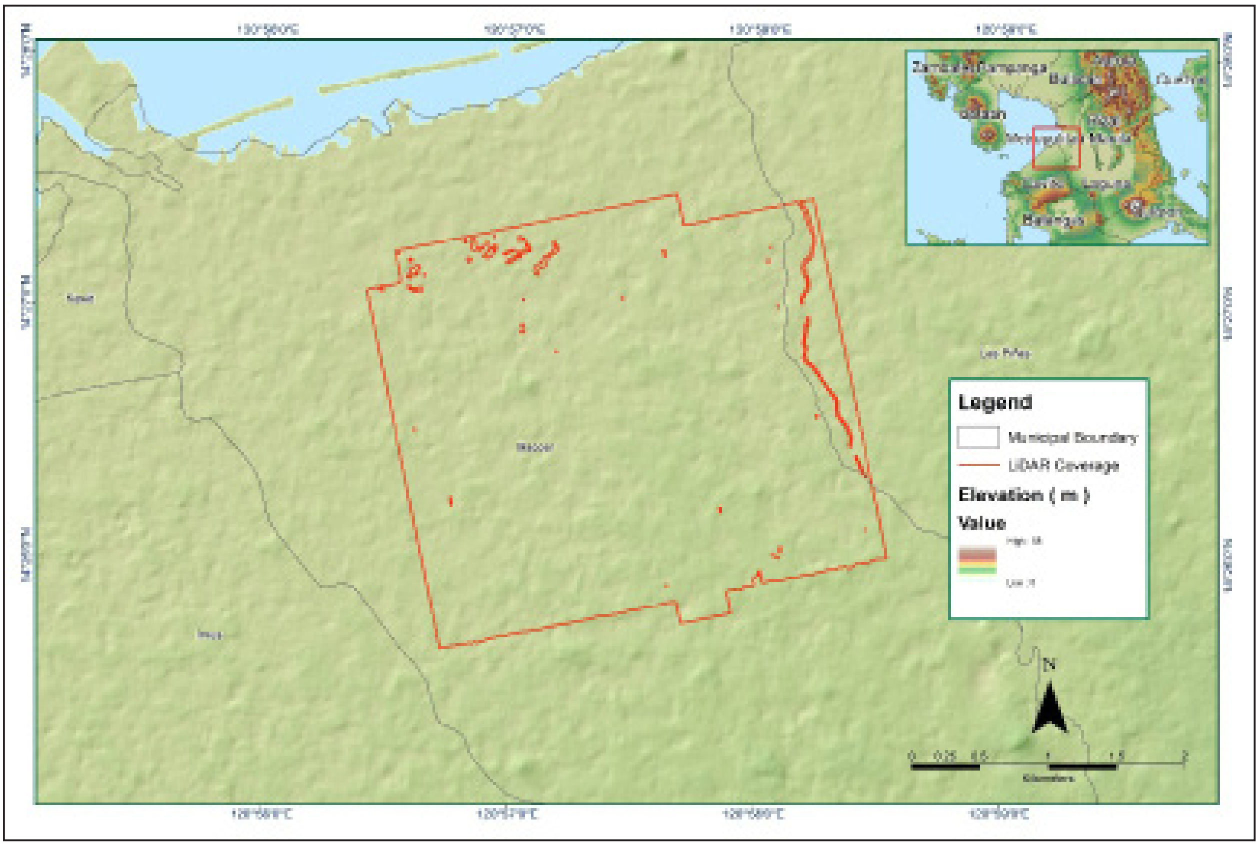


Figure A-8.25. Coverage of LiDAR data

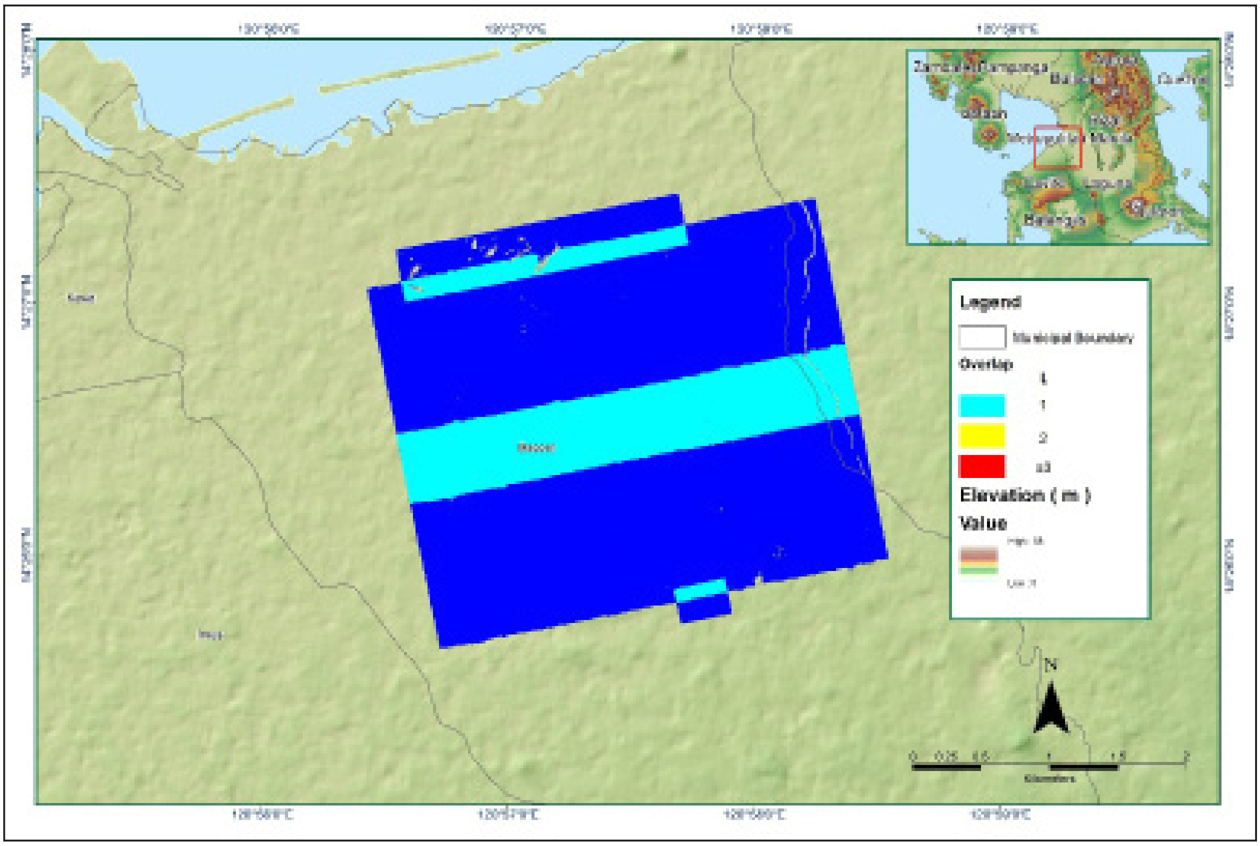


Figure A-8.26. Image of data overlap

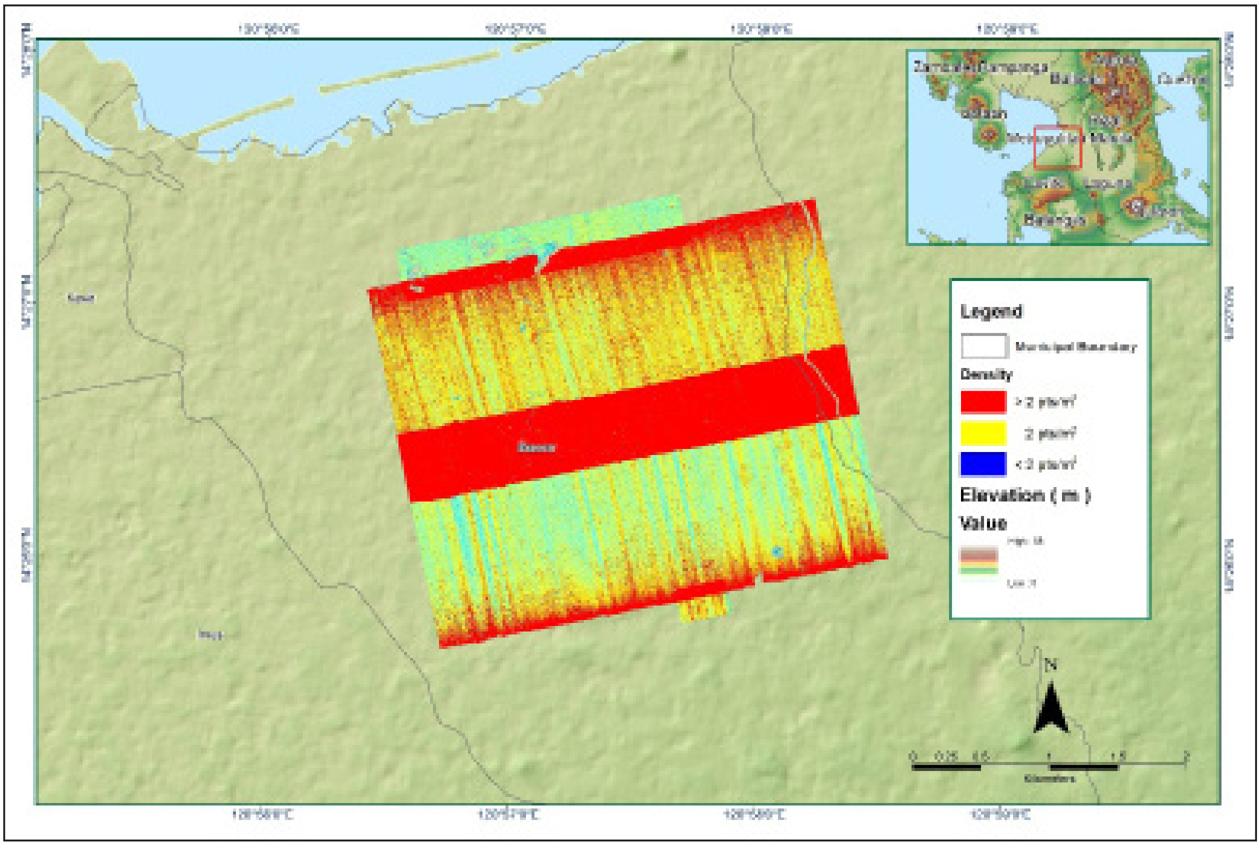


Figure A-8.27. Density map of merged LiDAR data

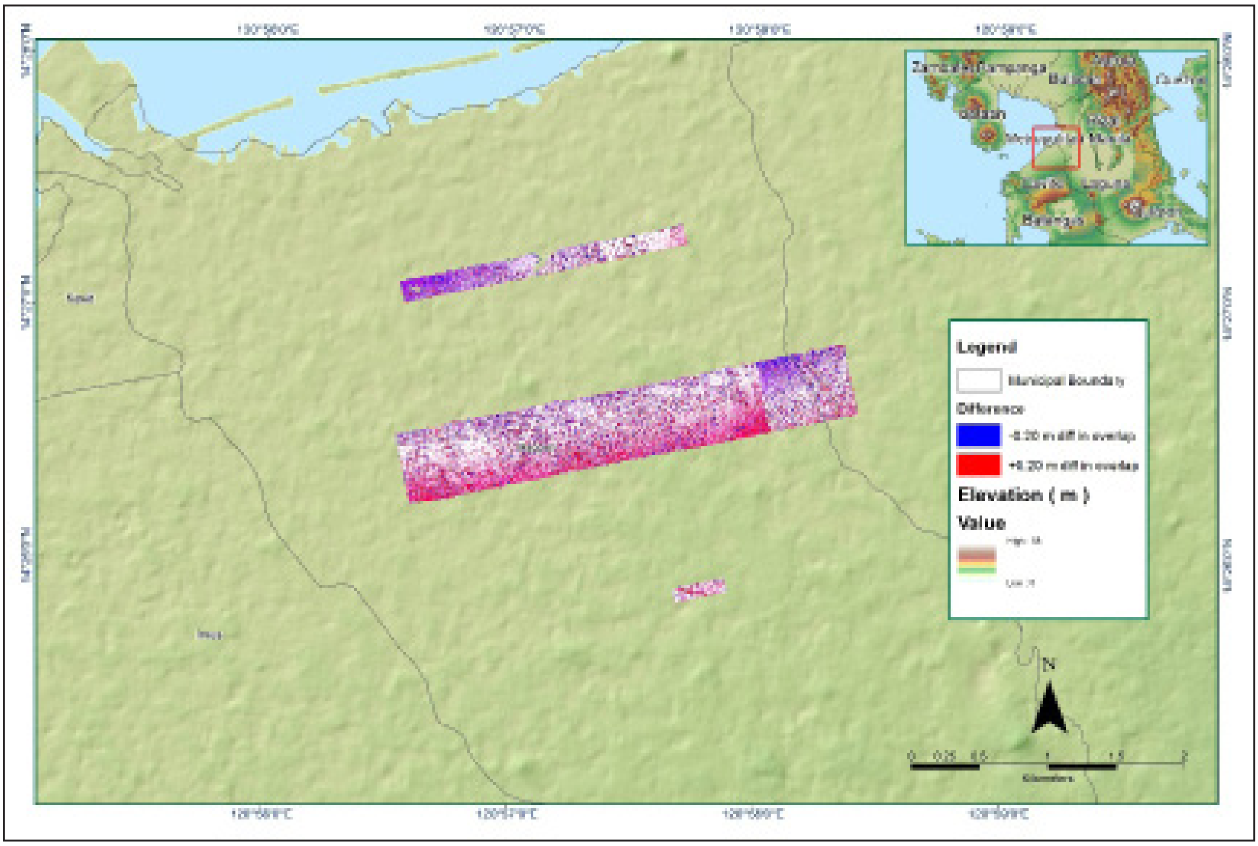


Figure A-8.28. Elevation difference between flight lines

Table A-8.5 Mission Summary Report for Blk18B_Supplement4

Flight Area	Calabarzon Reflights
Mission Name	Blk18B_Supplement4
Inclusive Flights	10321L
RawLaser	6.16 GB
GnssImu	329 MB
Image	7.32 GB
Transfer date	2/13/2017
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	No
Baseline Length (<30km)	Yes
Combined Separation (-0.1 up to 0.1)	No
Estimated Position Accuracy (in cm)	
Estimated Standard Devation for North Position (<4.0 cm)	2.7
Estimated Standard Devation for East Position (<4.0 cm)	3.2
Estimated Standard Devation for Height Position (<8.0 cm)	3.5
Minimum % overlap (>25)	17.67%
Ave point cloud density per sq.m. (>2.0)	1.10
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	21
Maximum Height	98.84 m
Minimum Height	51.17 m
Classification (# of points)	
Ground	5,441,059
Low vegetation	2,034,291
Medium vegetation	2,580,434
High vegetation	4,410,883
Building	2,943,179
Orthophoto	No
Processed by	Engr. Regis Guhiting, Engr. Harmond Santos, Engr. Gladys Mae Apat

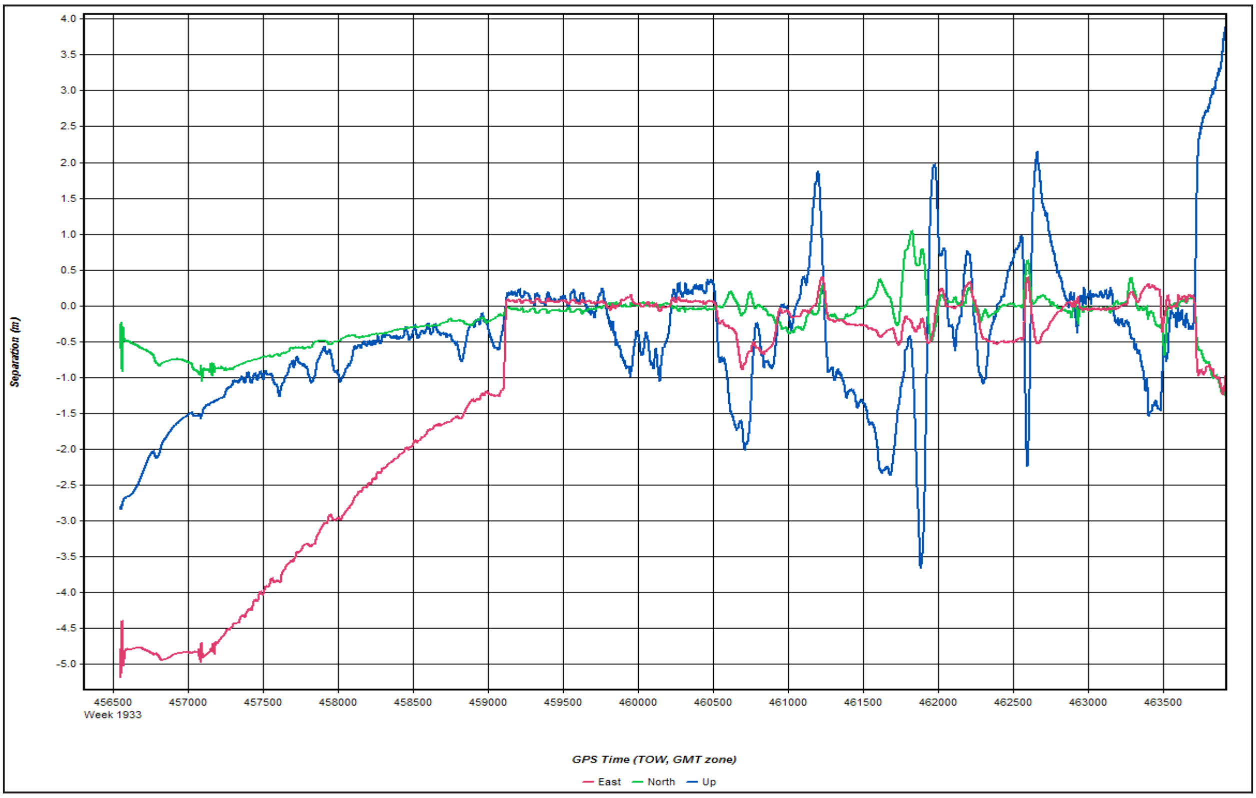


Figure A-8.1. Combined Separation

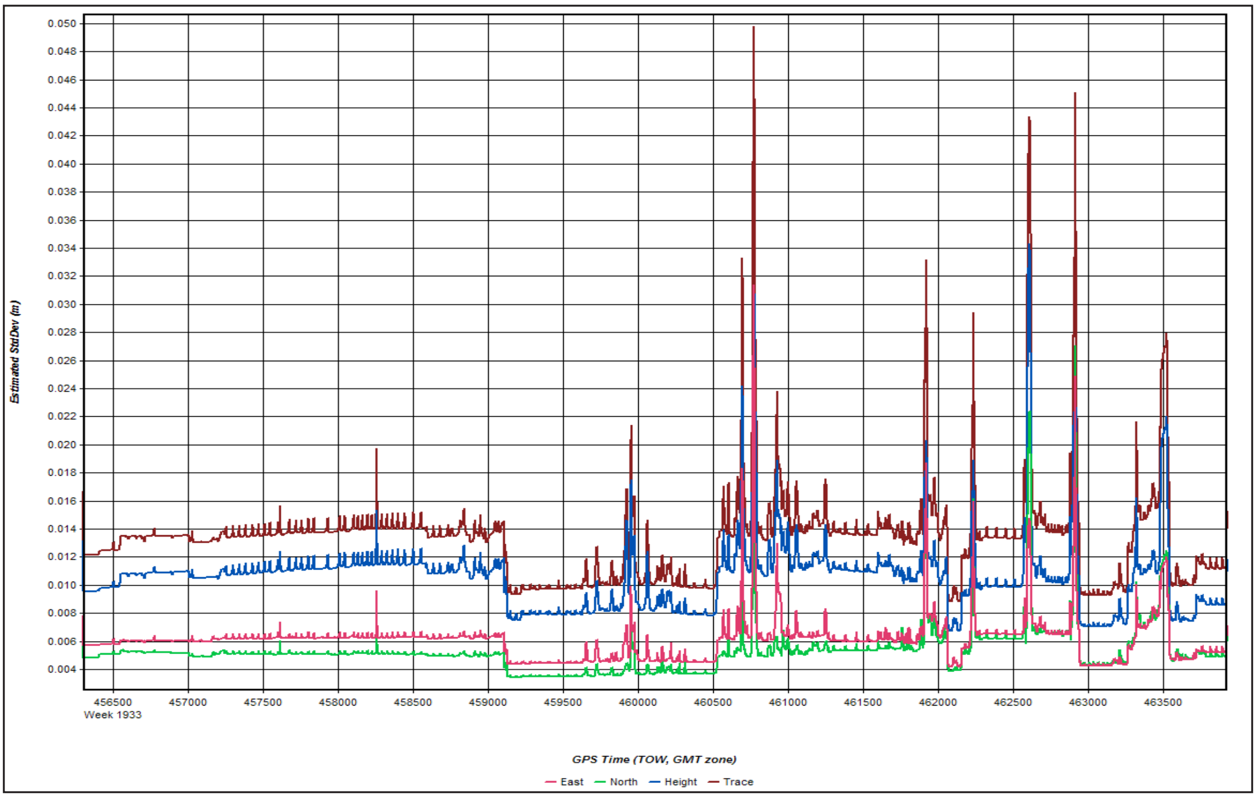


Figure A-8.2. Estimated Position of Accuracy

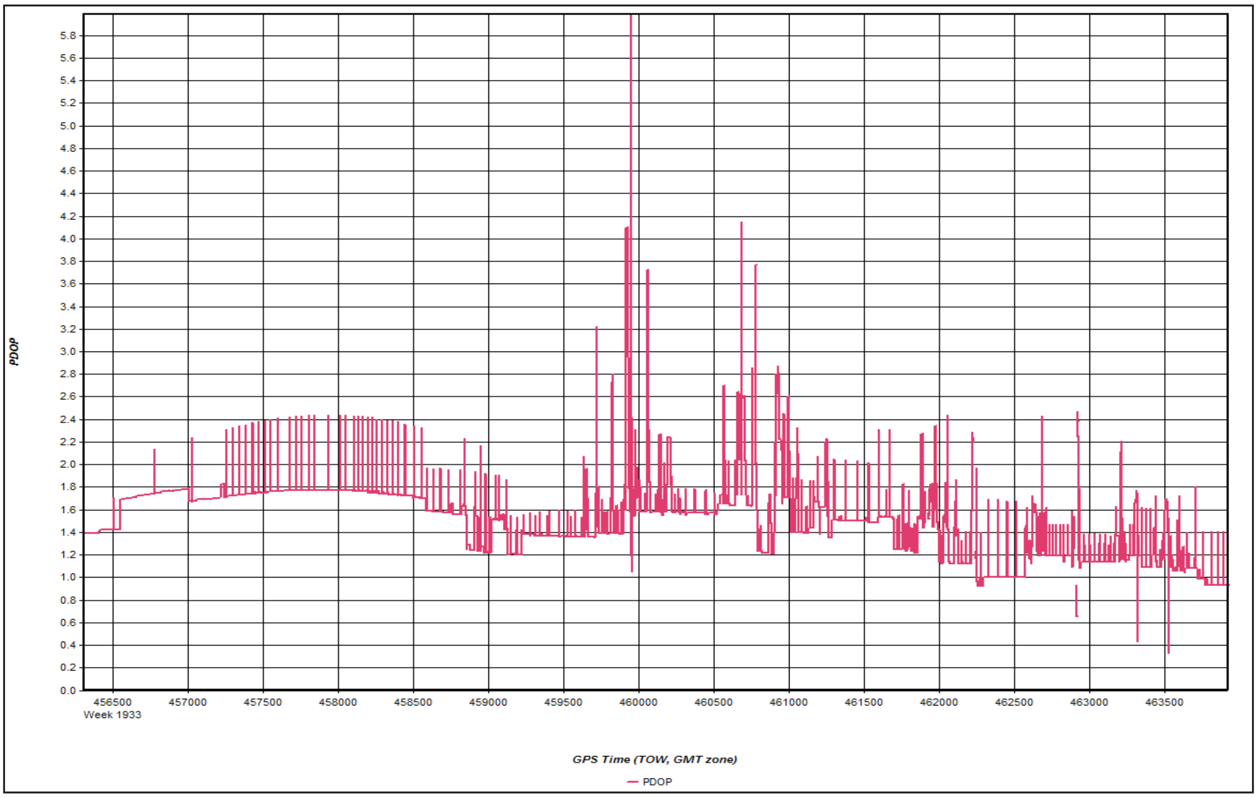


Figure A-8.1. PDOP

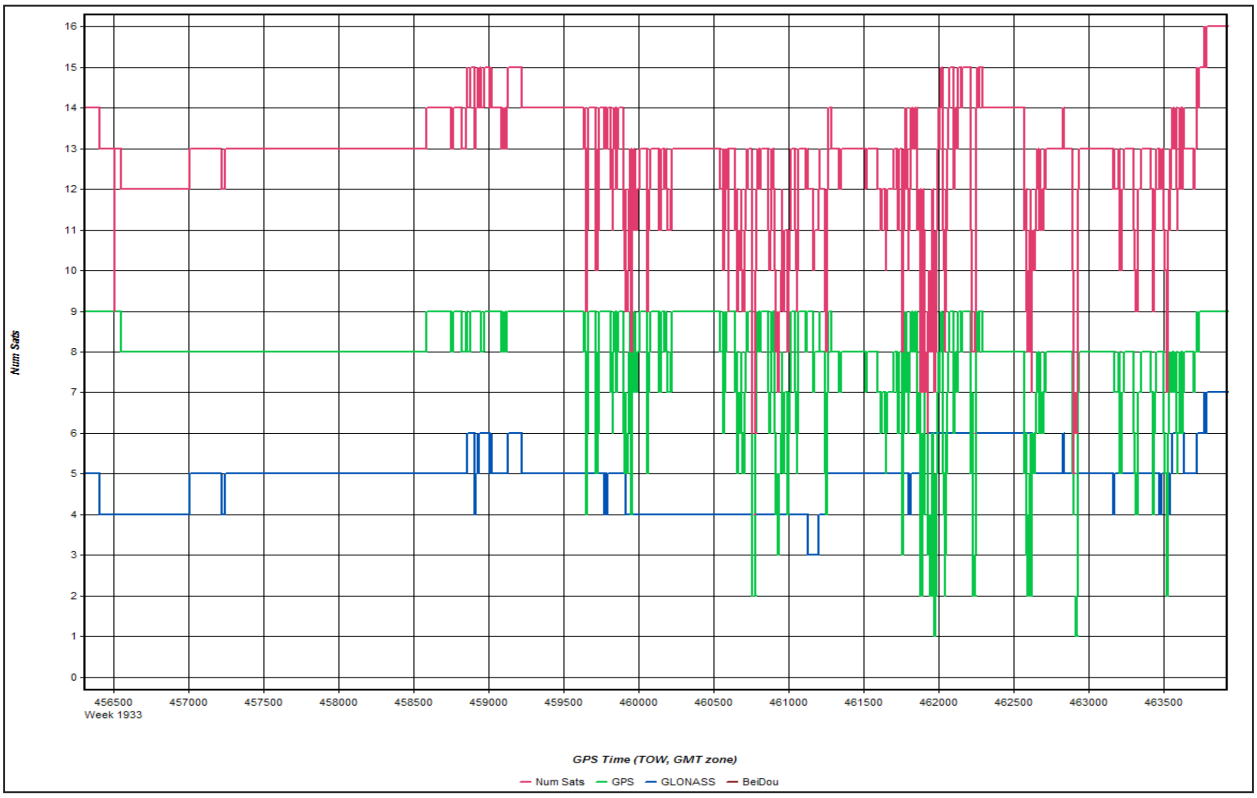


Figure A-8.2. Number of Satellites

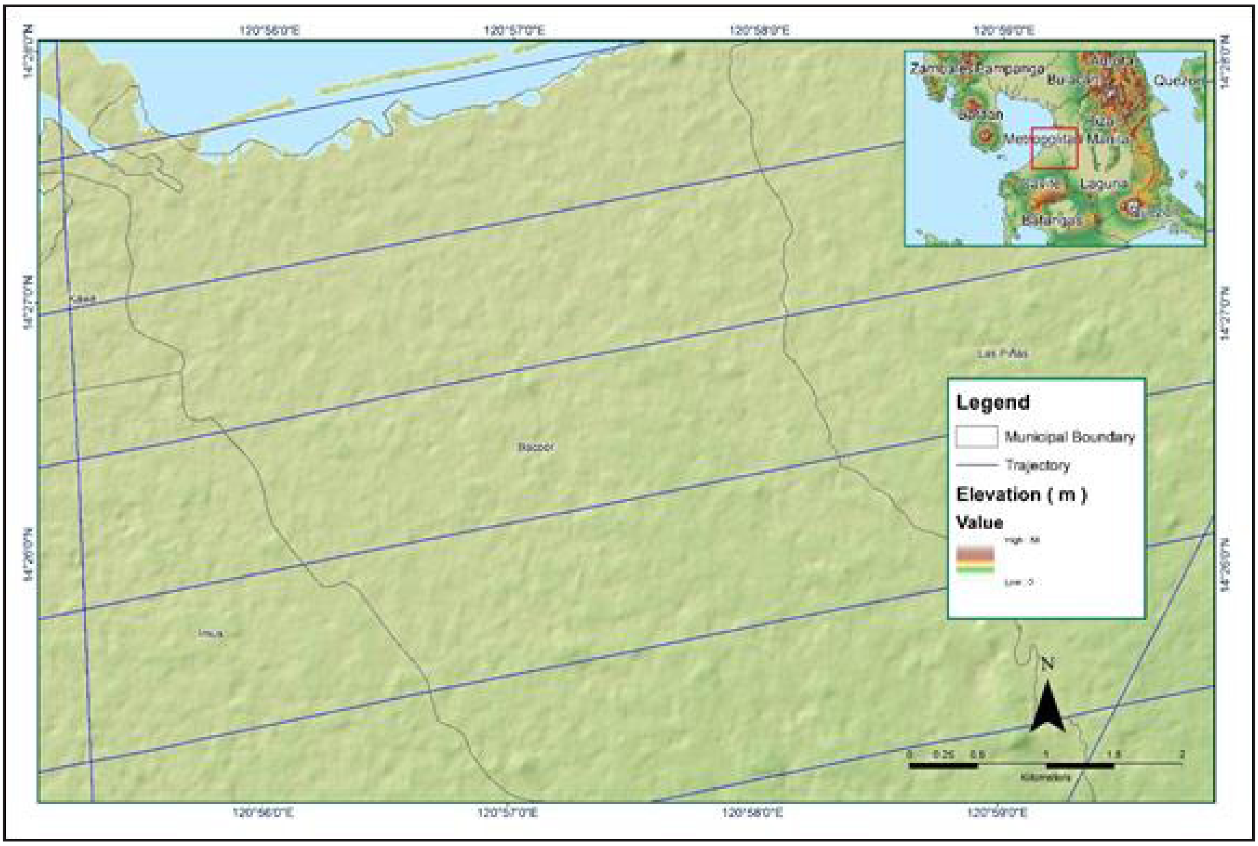


Figure A-8.3. Best Estimated Trajectory

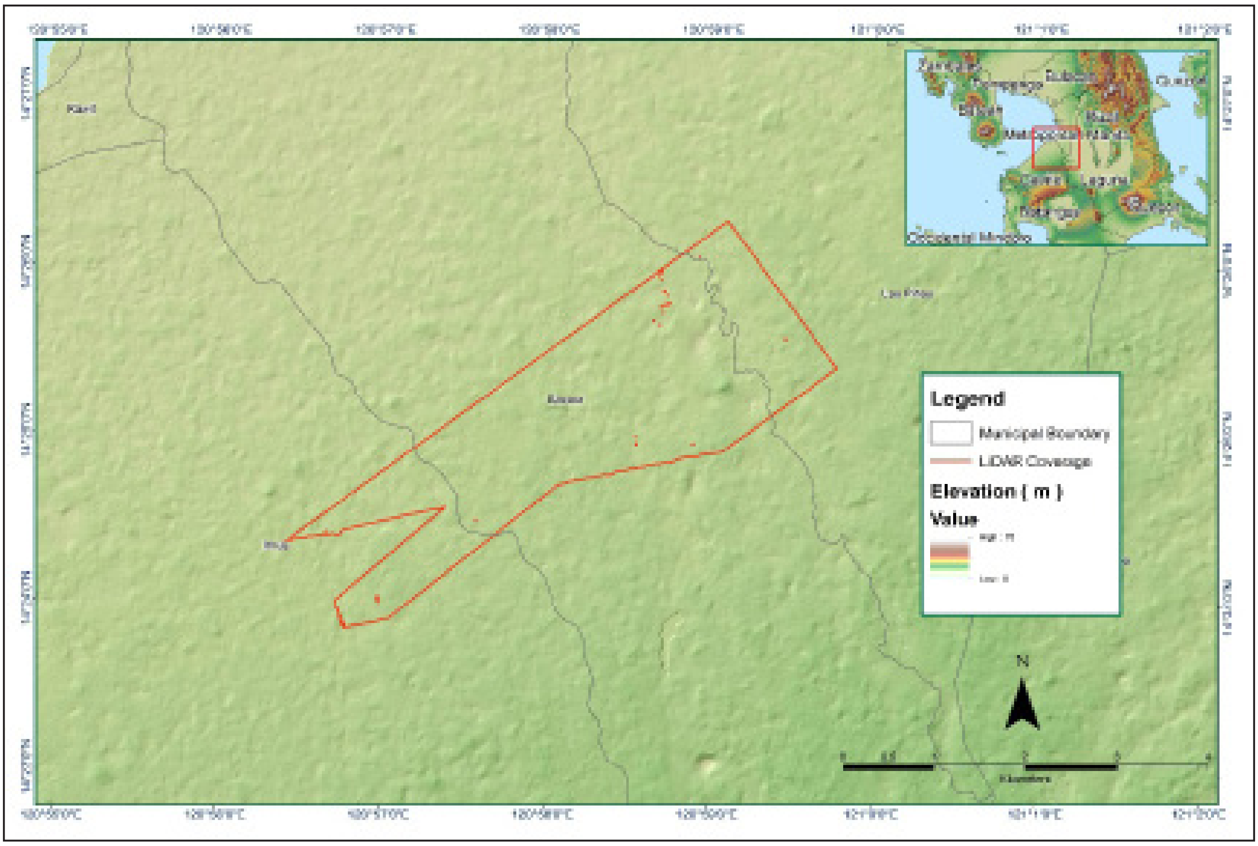


Figure A-8.4. Coverage of LiDAR data

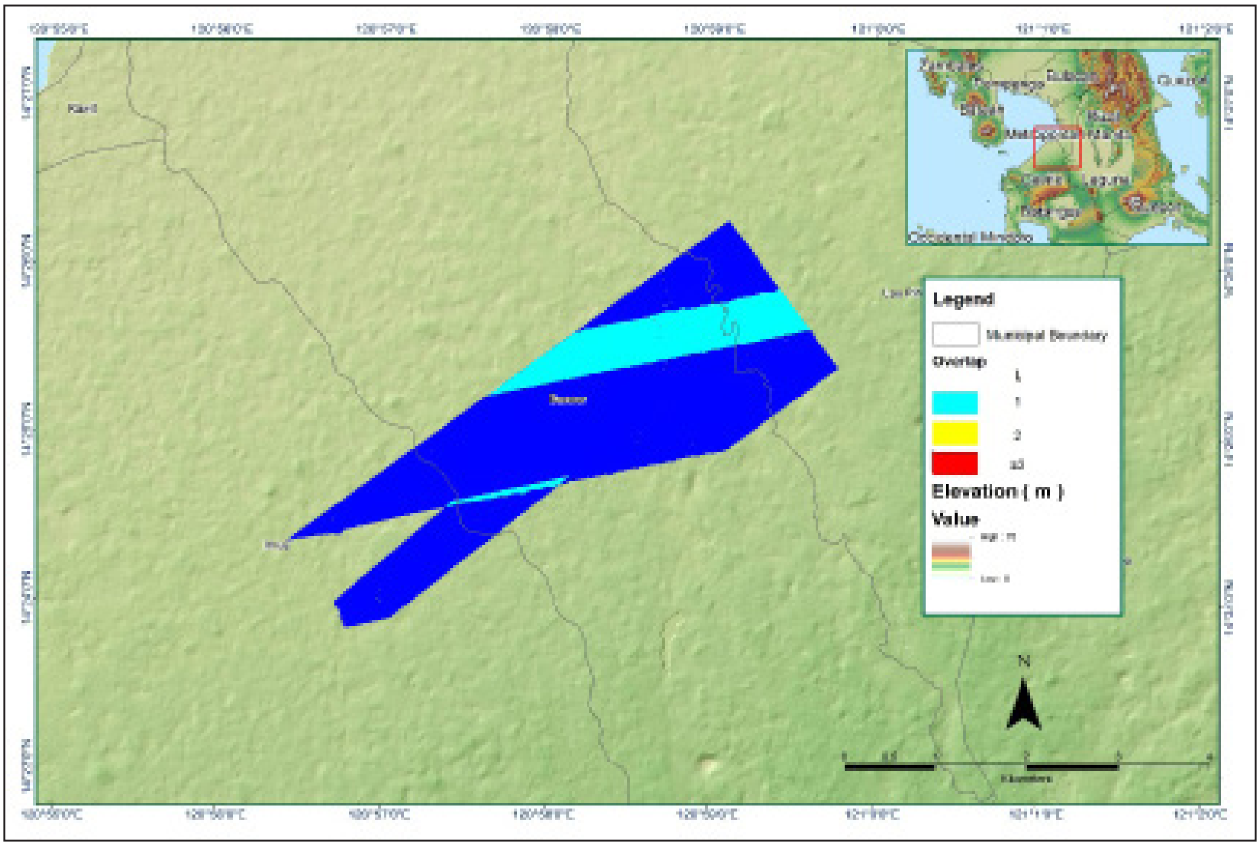


Figure A-8.5. Image of data overlap

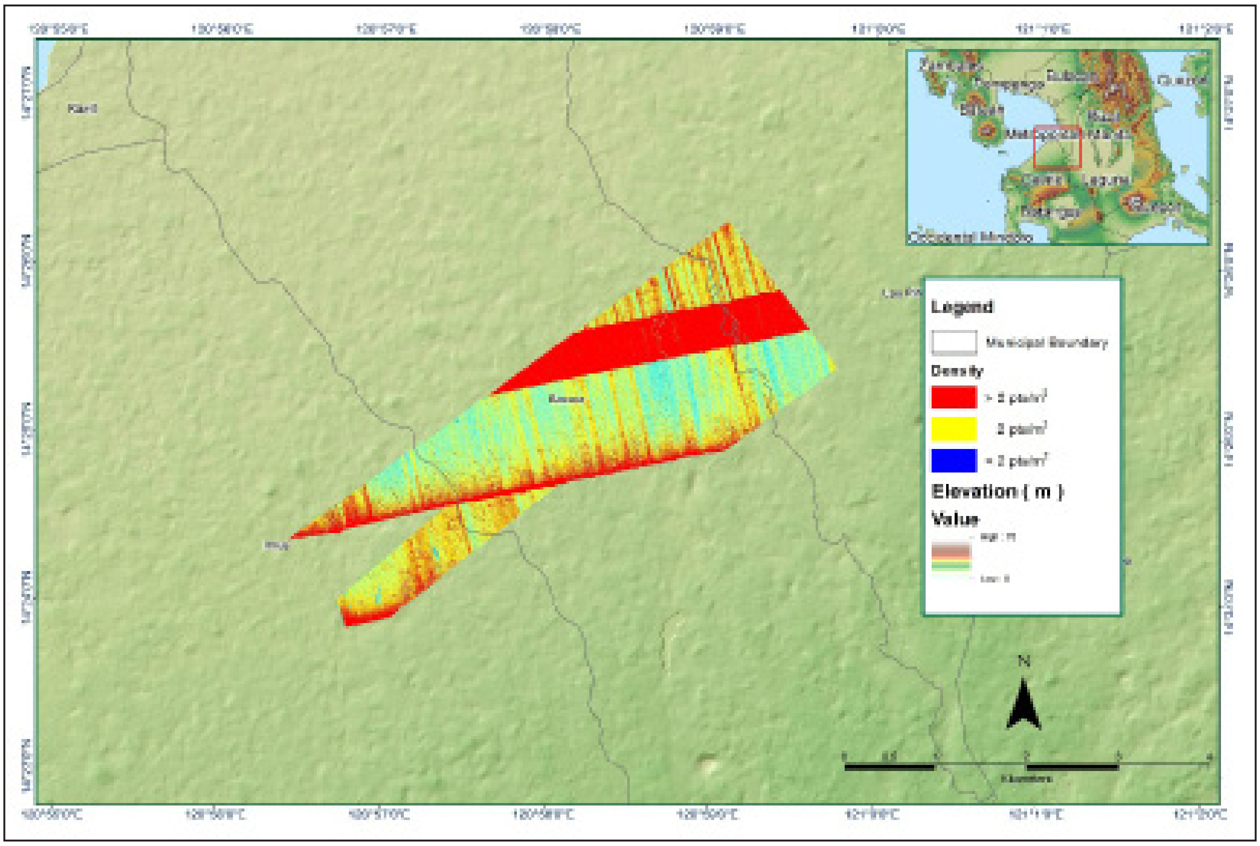


Figure A-8.6. Density map of merged LiDAR data

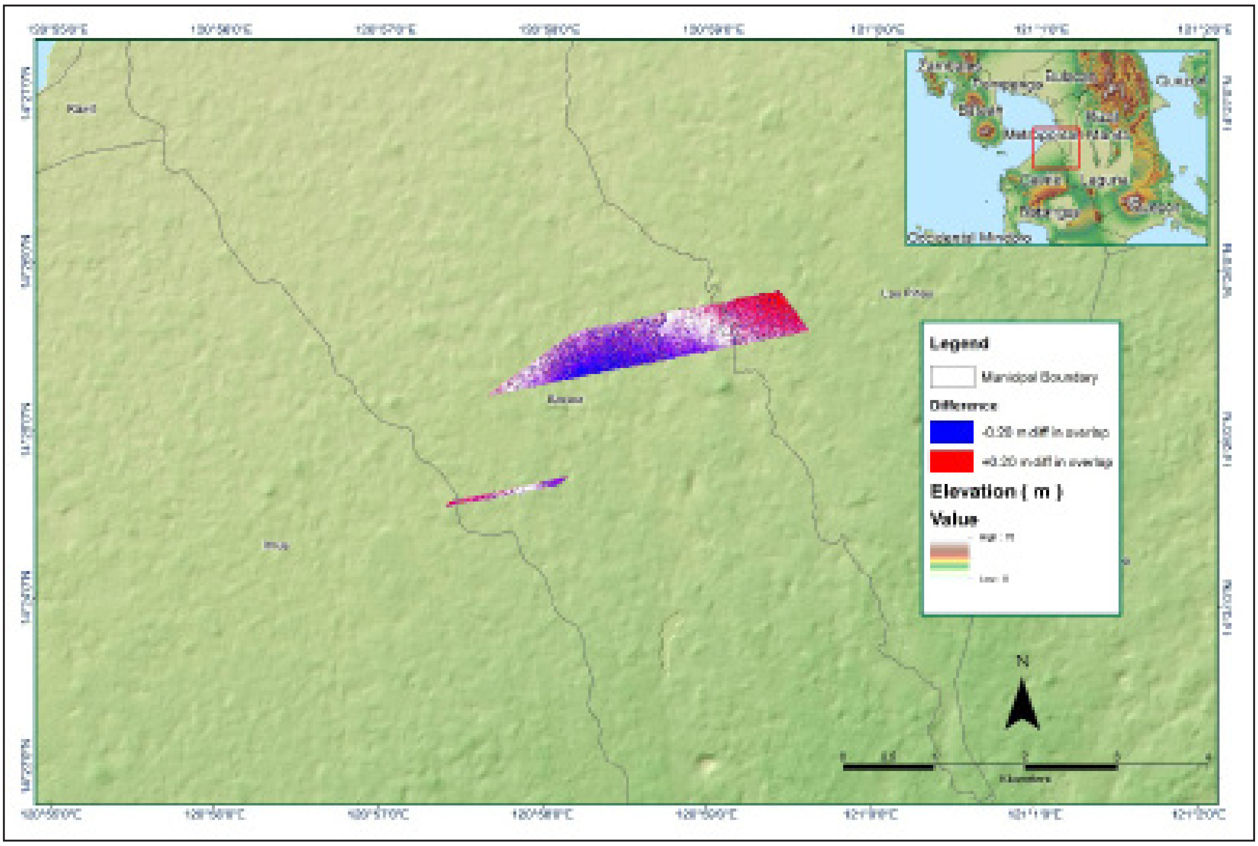


Figure A-8.7. Elevation difference between flight lines

Table A-8.6 Mission Summary Report for Blk18B_Supplement5

Flight Area	Calabarzon Reflights
Mission Name	Blk18B_Supplement5
Inclusive Flights	10321L
RawLaser	6.16 GB
GnssImu	329 MB
Image	7.32 GB
Transfer date	2/13/2017
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	No
Baseline Length (<30km)	Yes
Combined Separation (-0.1 up to 0.1)	No
Estimated Position Accuracy (in cm)	
Estimated Standard Devation for North Position (<4.0 cm)	2.7
Estimated Standard Devation for East Position (<4.0 cm)	3.2
Estimated Standard Devation for Height Position (<8.0 cm)	3.5
Minimum % overlap (>25)	NA
Ave point cloud density per sq.m. (>2.0)	0.90
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	10
Maximum Height	121.96
Minimum Height	58.37
Classification (# of points)	
Ground	1296700
Low vegetation	380063
Medium vegetation	479130
High vegetation	703766
Building	476095
Orthophoto	Yes
Processed by	Engr. Regis Guhiting, Engr. Harmond Santos, Engr. Gladys Mae Apat

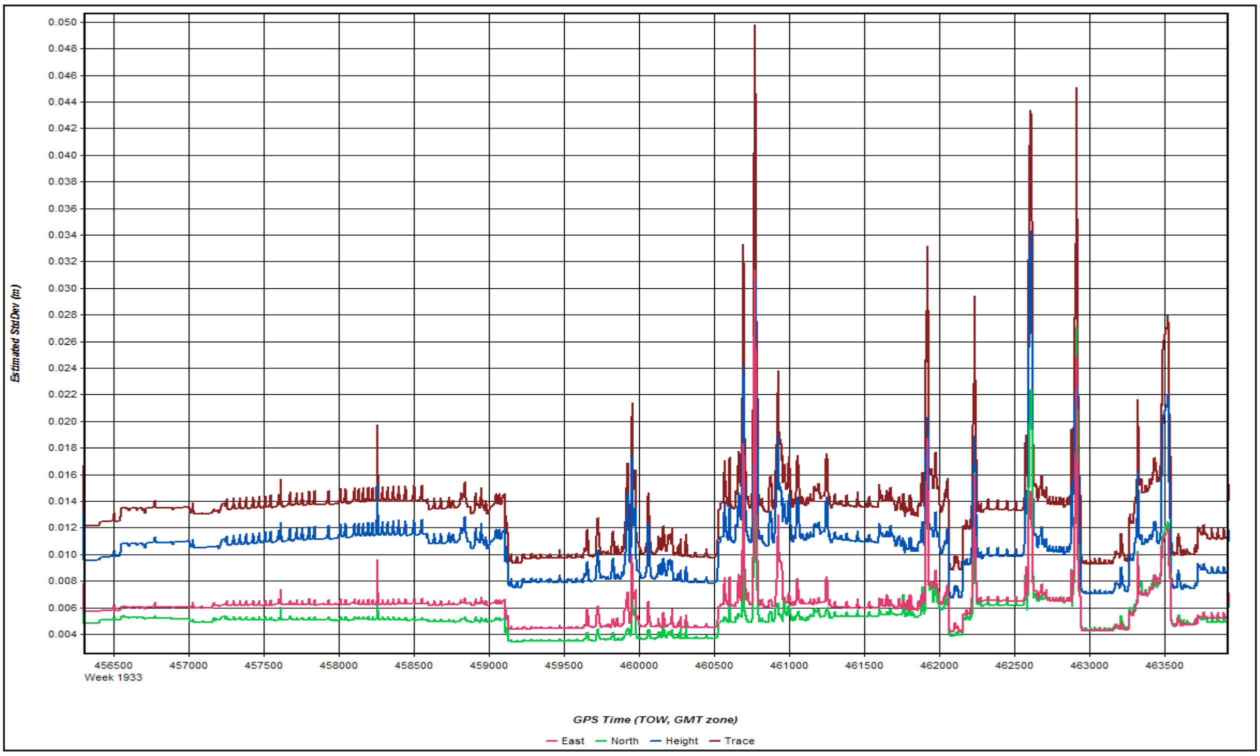


Figure A-8.8. Combined Separation

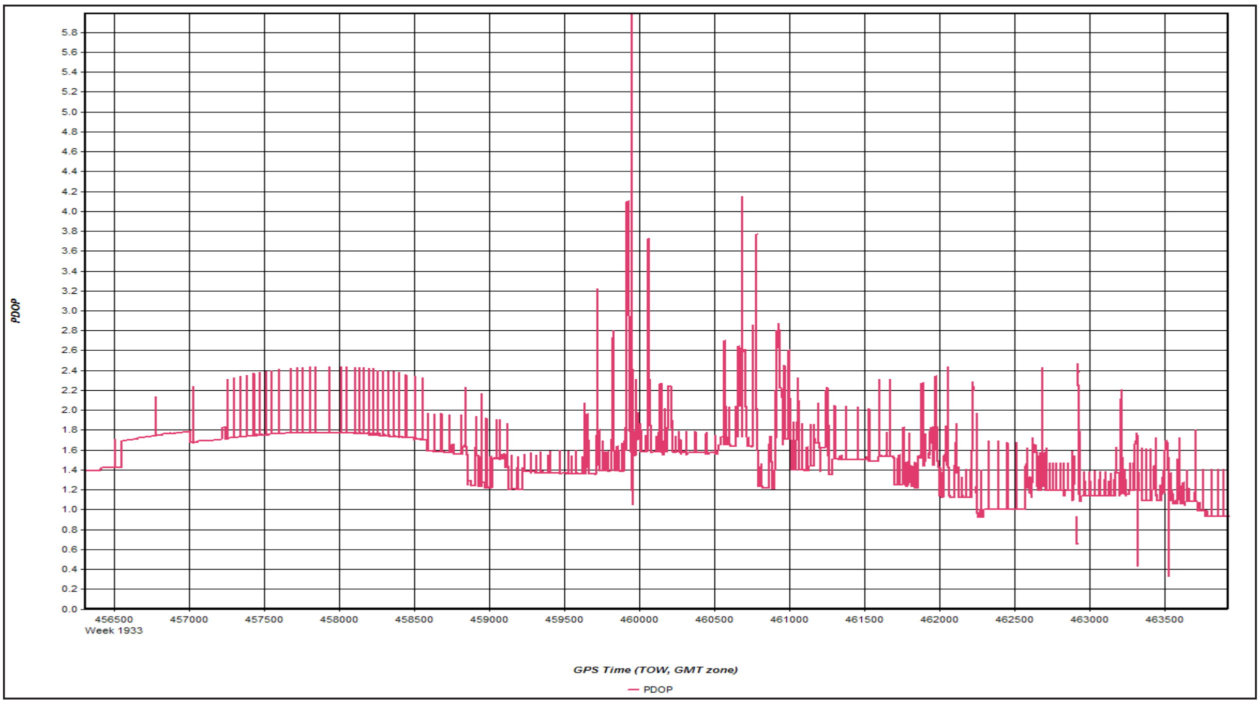


Figure A-8.9. Estimated Position of Accuracy

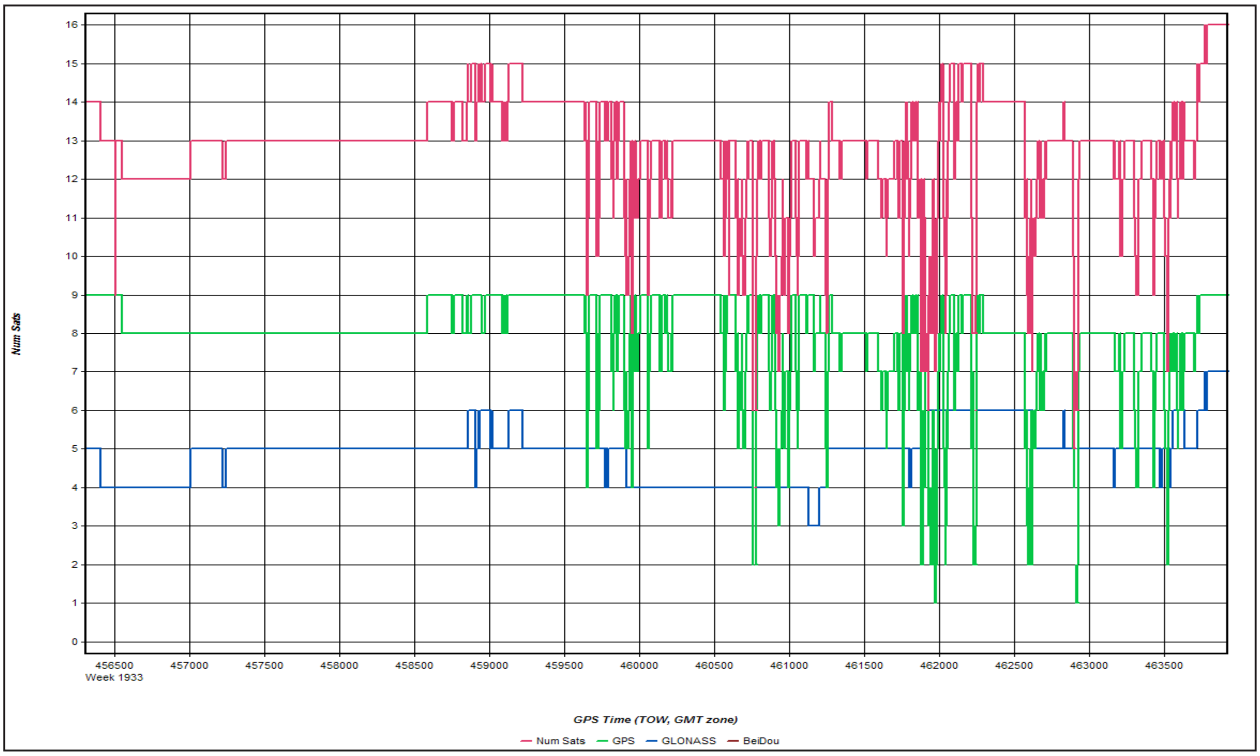


Figure A-8.8. PDOP

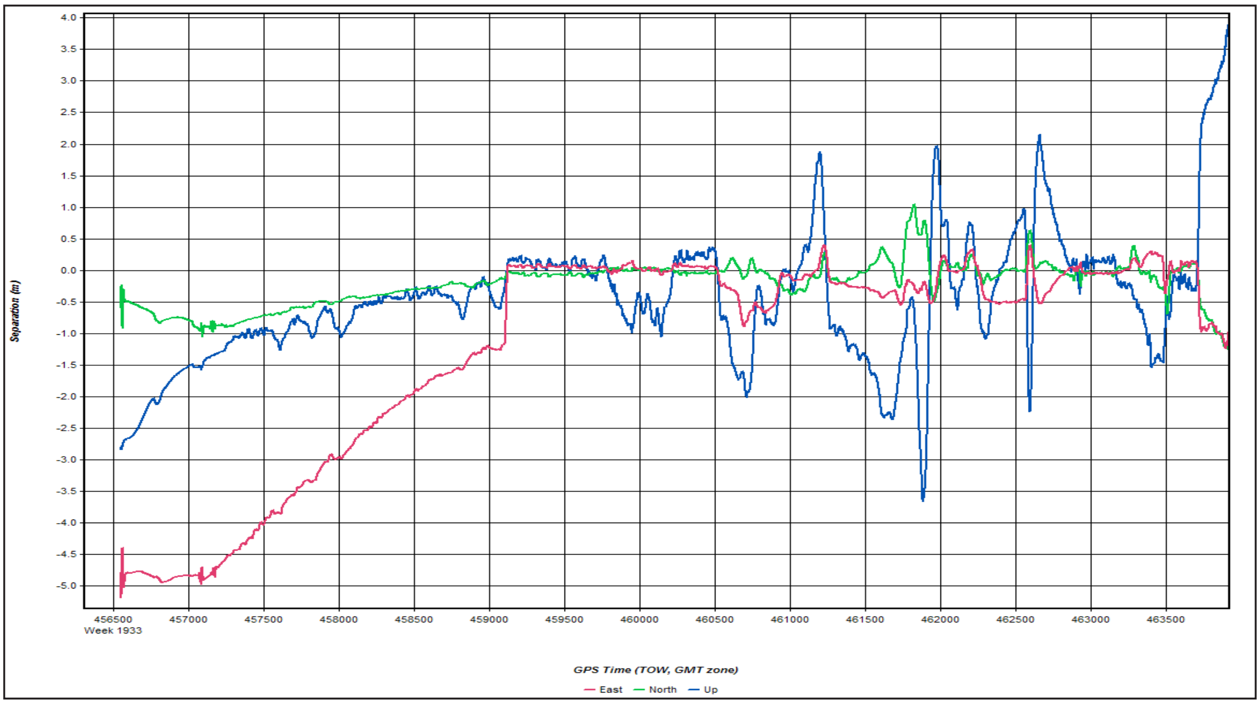


Figure A-8.9. Number of Satellites

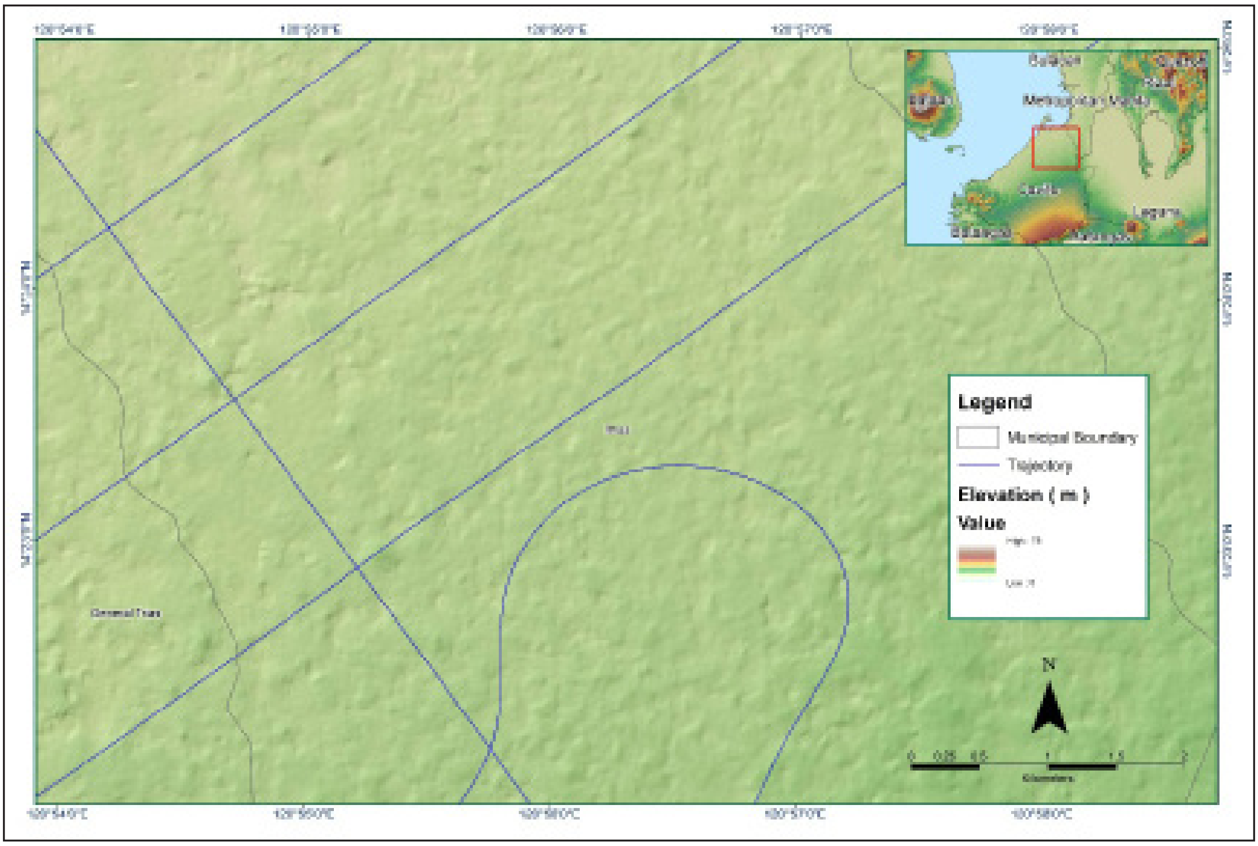


Figure A-8.10. Best Estimated Trajectory

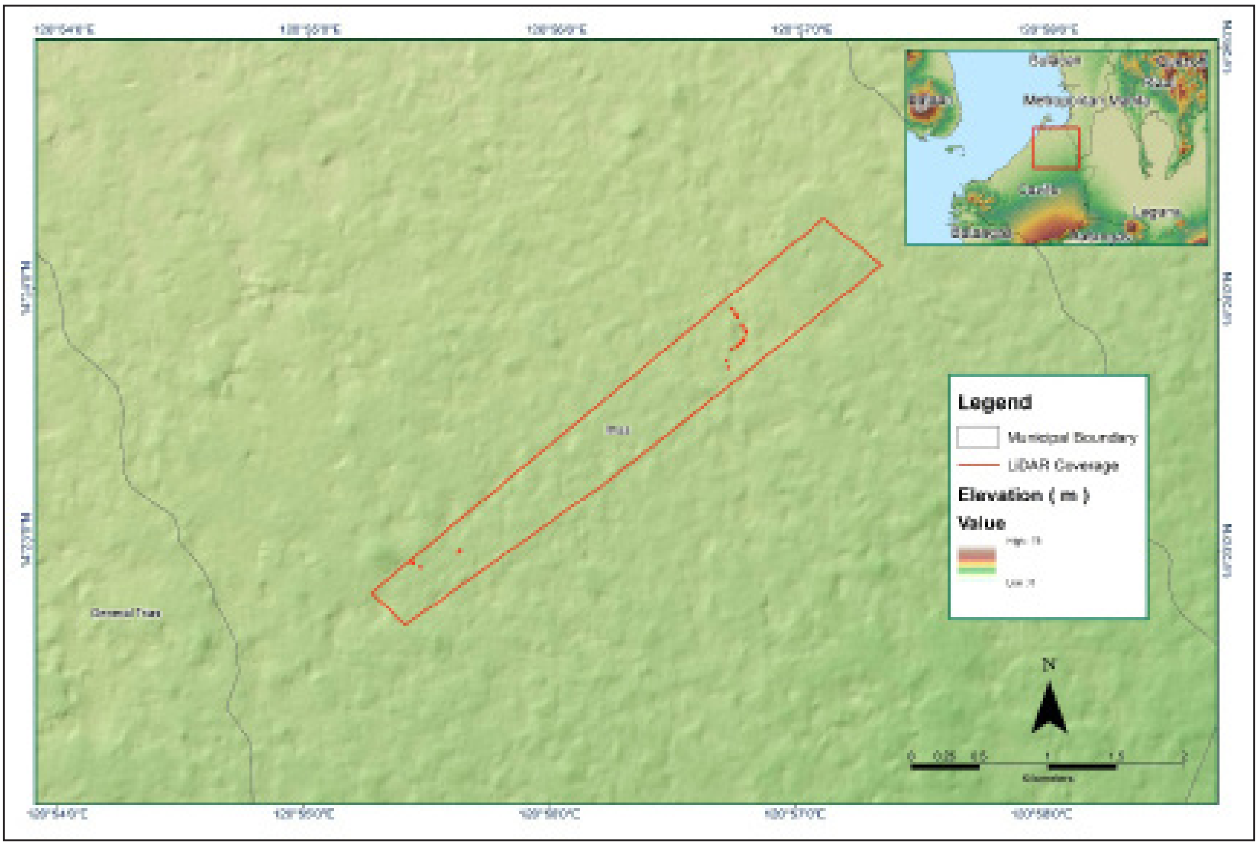


Figure A-8.11. Coverage of LiDAR data

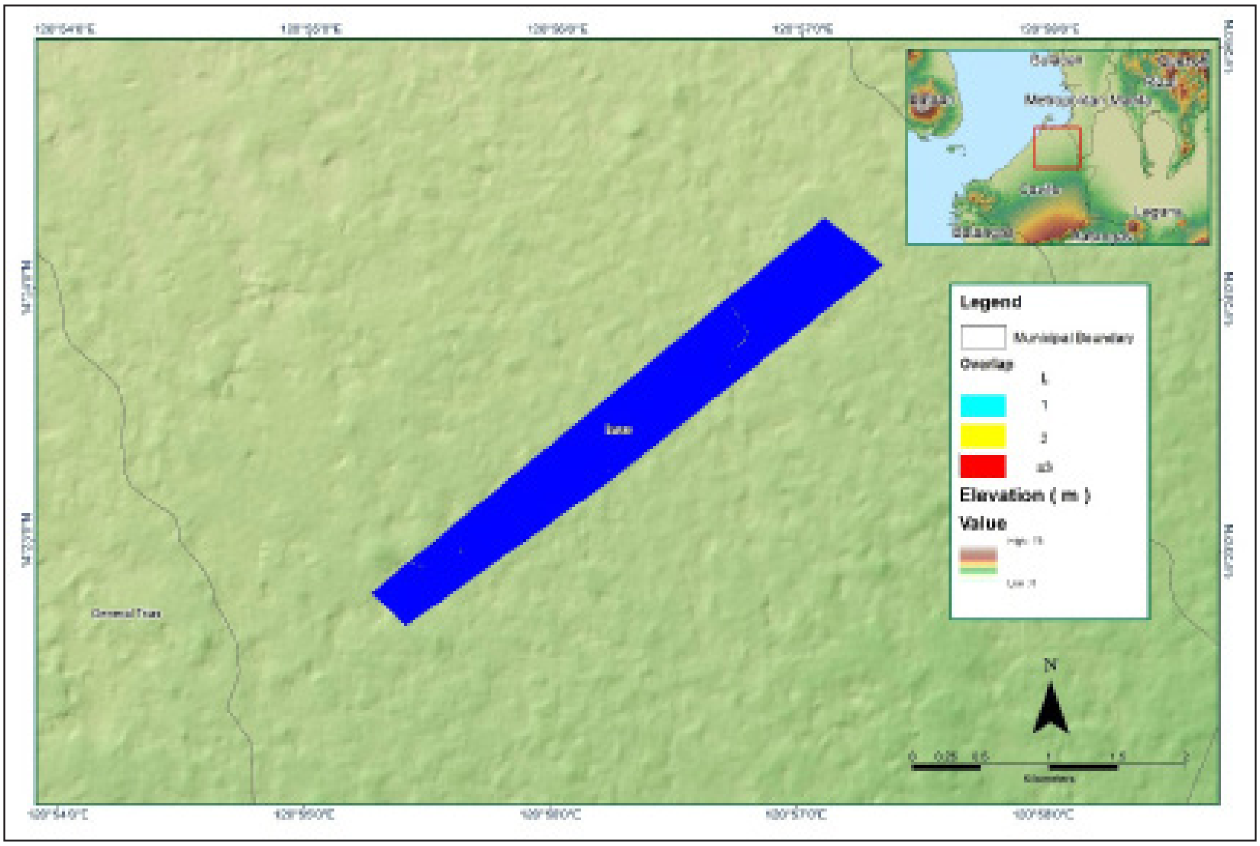


Figure A-8.12. Image of data overlap

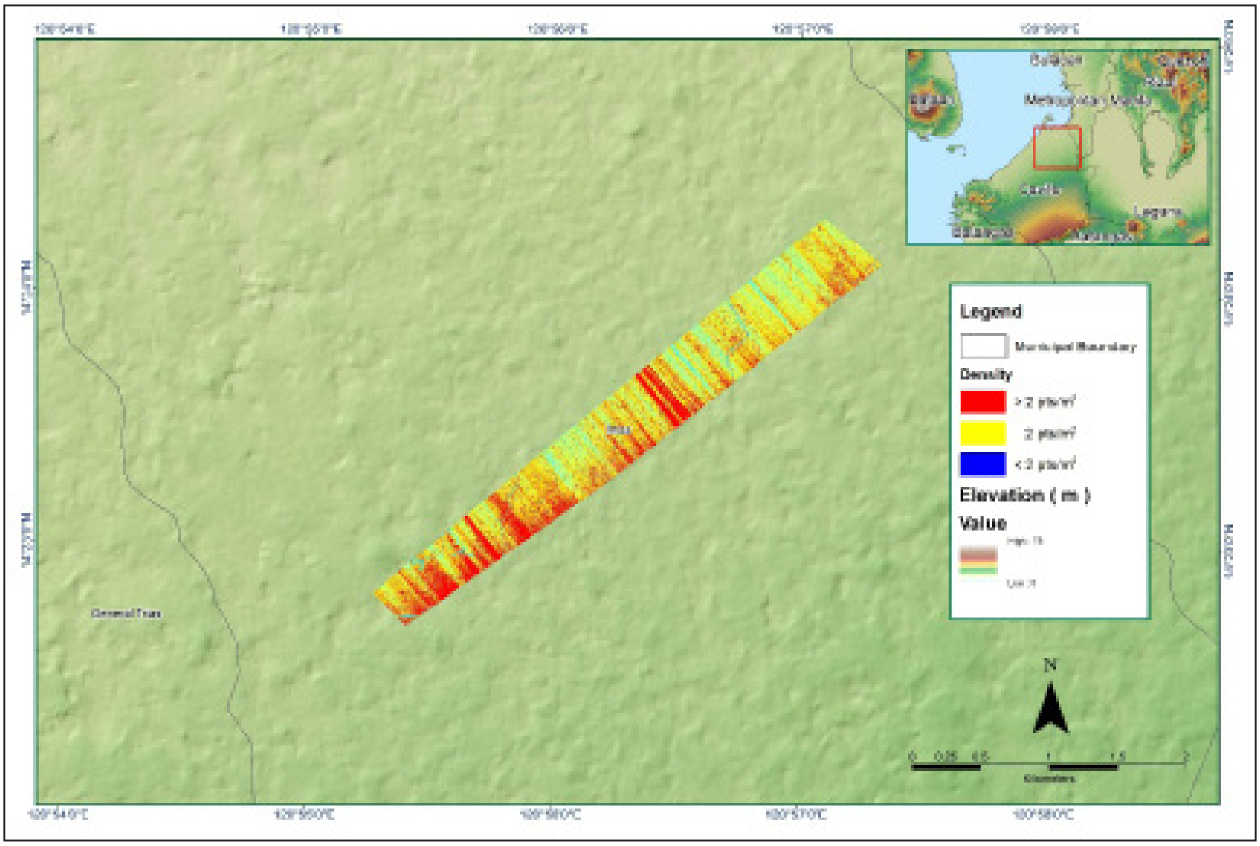


Figure A-8.13. Density map of merged LiDAR data

Table A-8.7 Mission Summary Report for Blk18A_supplement2

Flight Area	CALABARZON
Mission Name	Blk18A_supplement2
Inclusive Flights	1141P (formerly 1139P)
Range data size	15.4 GB
POS	219 MB
Image	24 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)	1.5
RMSE for Down Position (<8.0 cm)	3.6
Boresight correction stdev (<0.001deg)	0.000426
IMU attitude correction stdev (<0.001deg)	0.001019
GPS position stdev (<0.01m)	0.0155
Minimum % overlap (>25)	35.84%
Ave point cloud density per sq.m. (>2.0)	1.90
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	140
Maximum Height	133.73 m
Minimum Height	45.56 m
	133.73 m
Classification (# of points)	
Ground	104,162,308
Low vegetation	84,606,924
Medium vegetation	52,451,573
High vegetation	28,217,832
Building	1,102,474
Orthophoto	No
Processed by	Engr. Jennifer Saguran, Engr. Melanie Hingpit, Engr. Jeffrey Delica

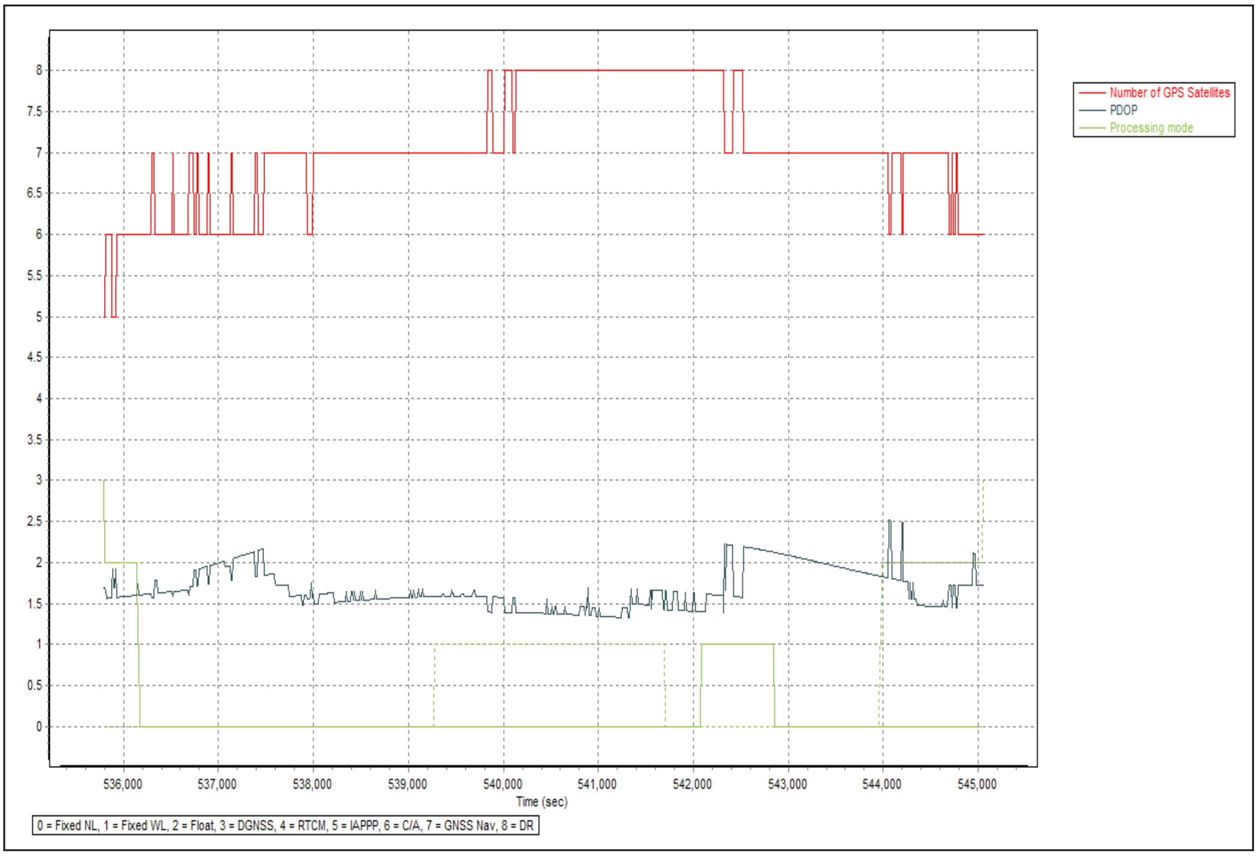


Figure A-8.15. Solution Status

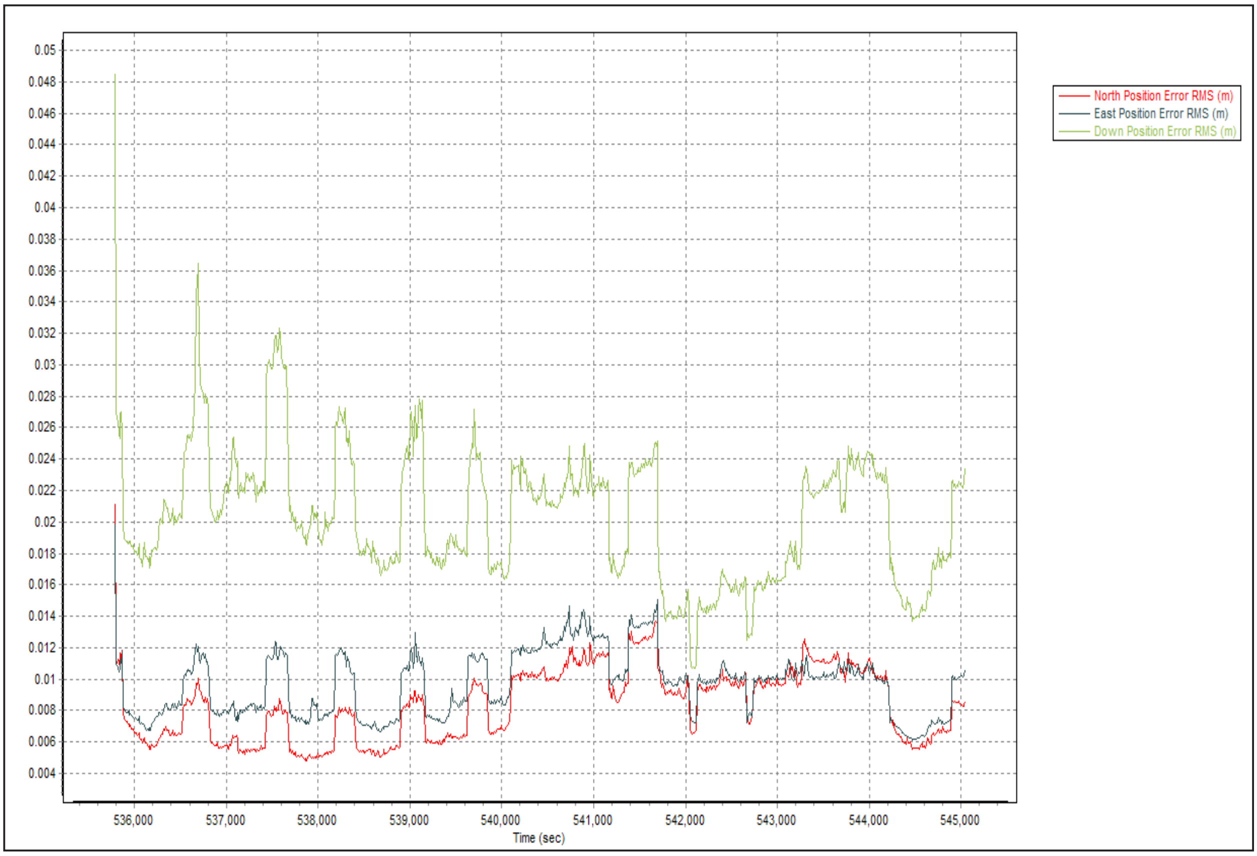


Figure A-8.16. Smoothed Performance Metric Parameters

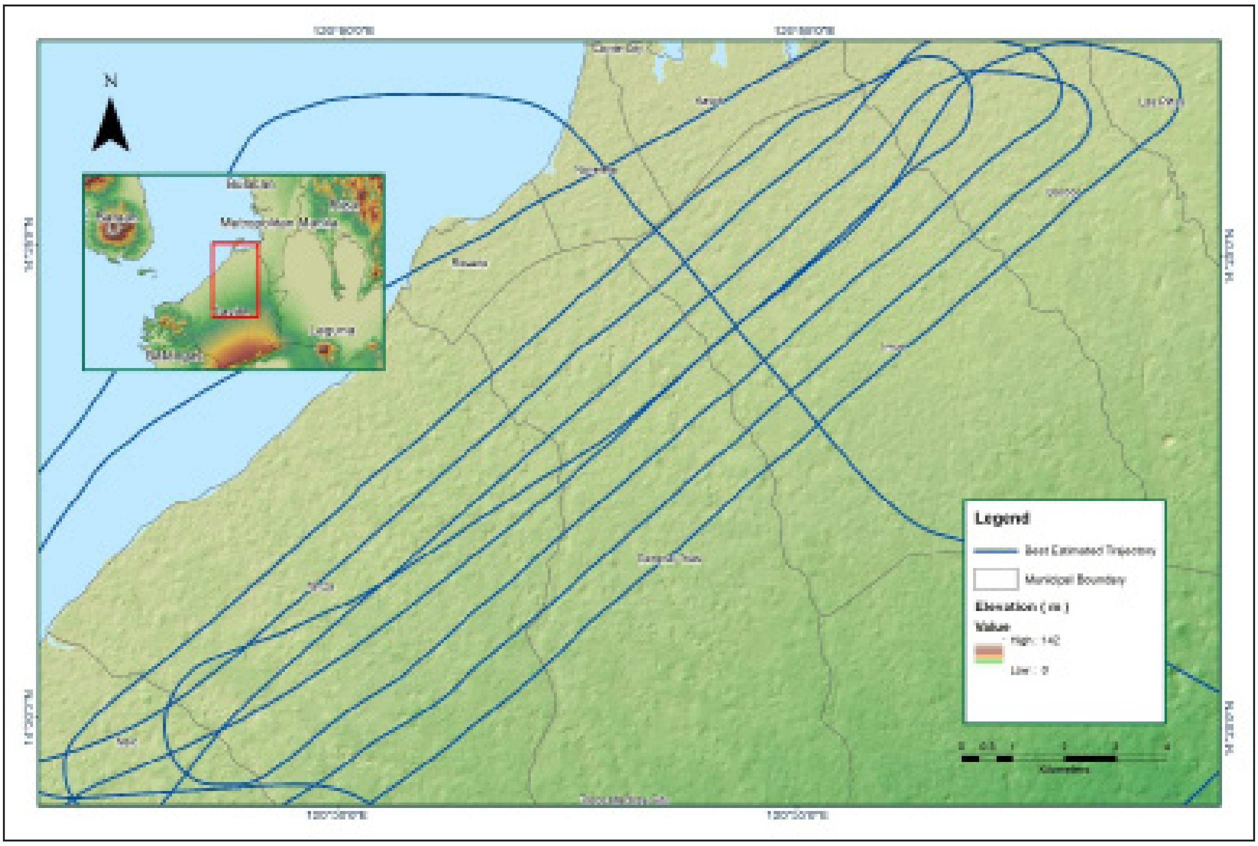


Figure A-8.17. Best Estimated Trajectory

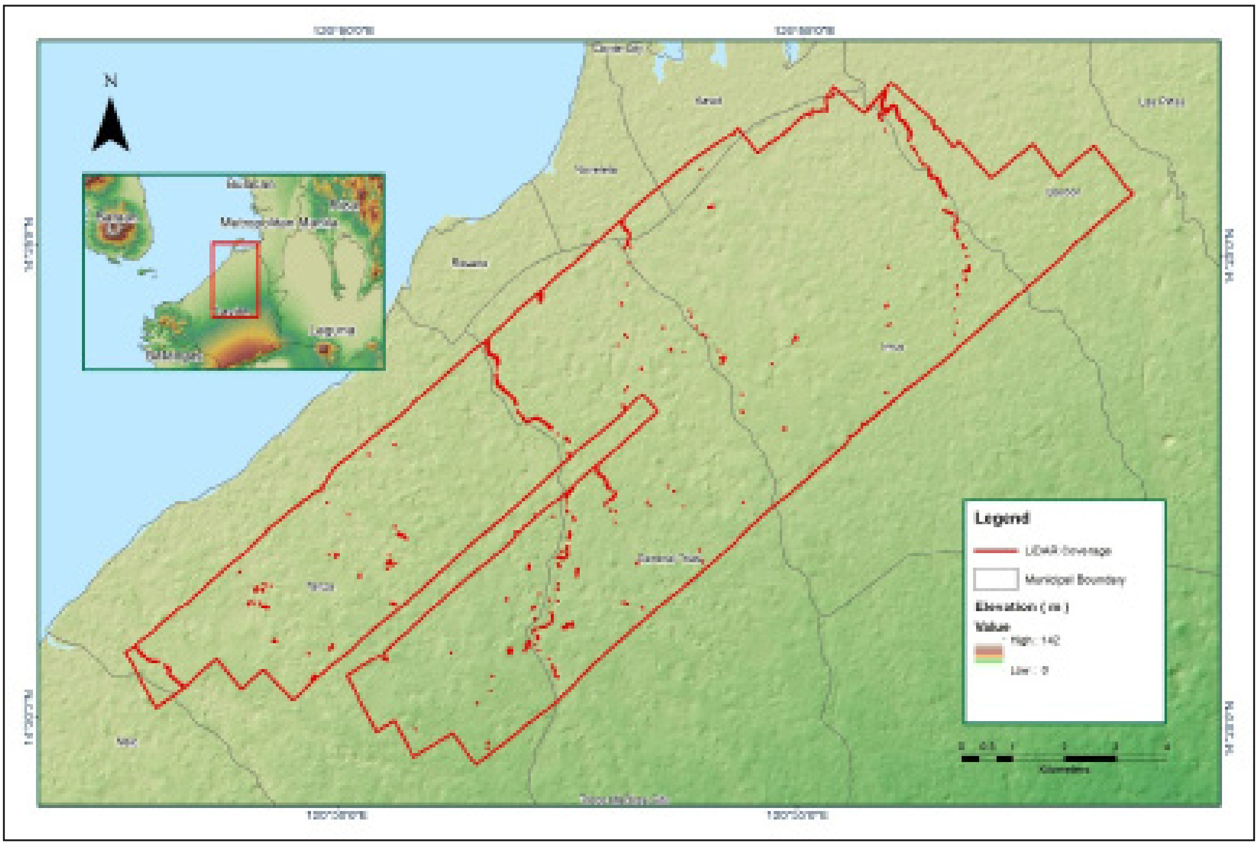


Figure A-8.18. Coverage of LiDAR data

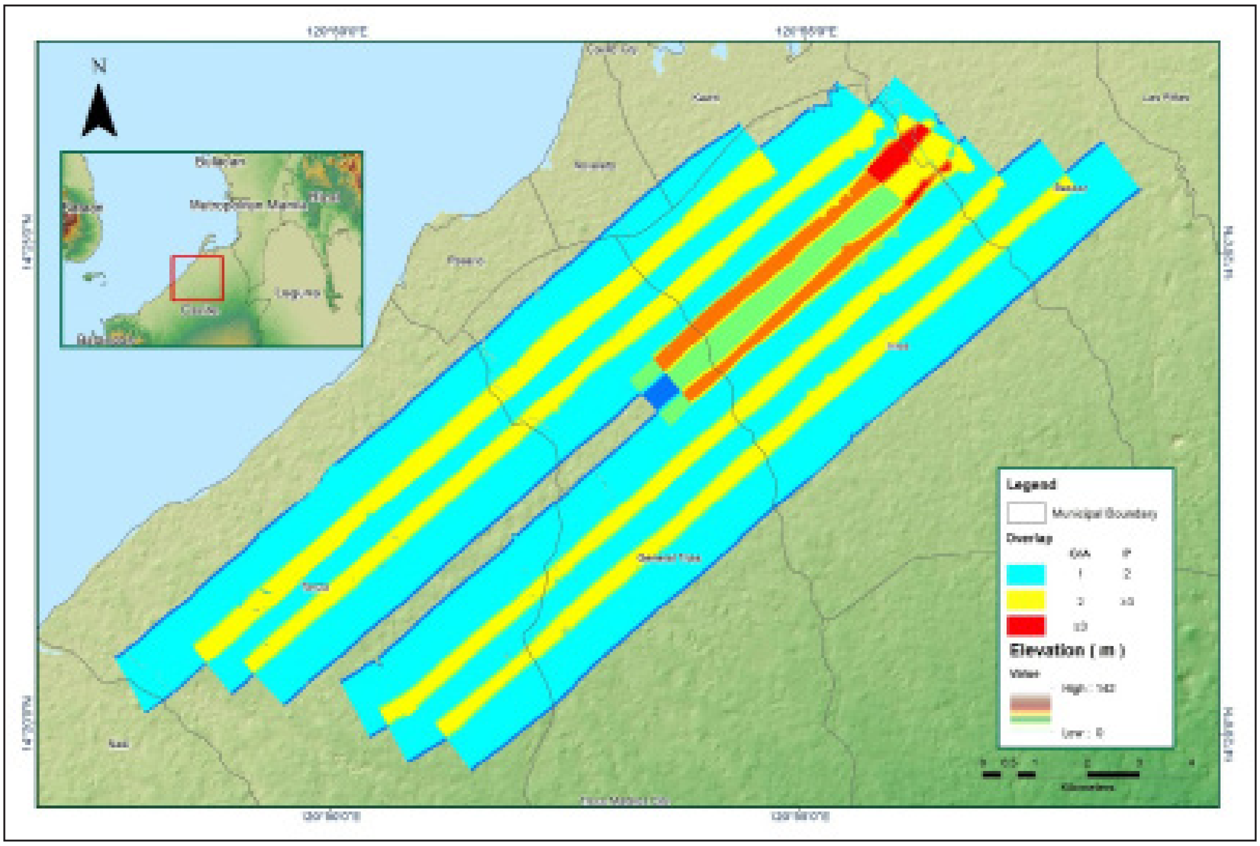


Figure A-8.19. Image of data overlap

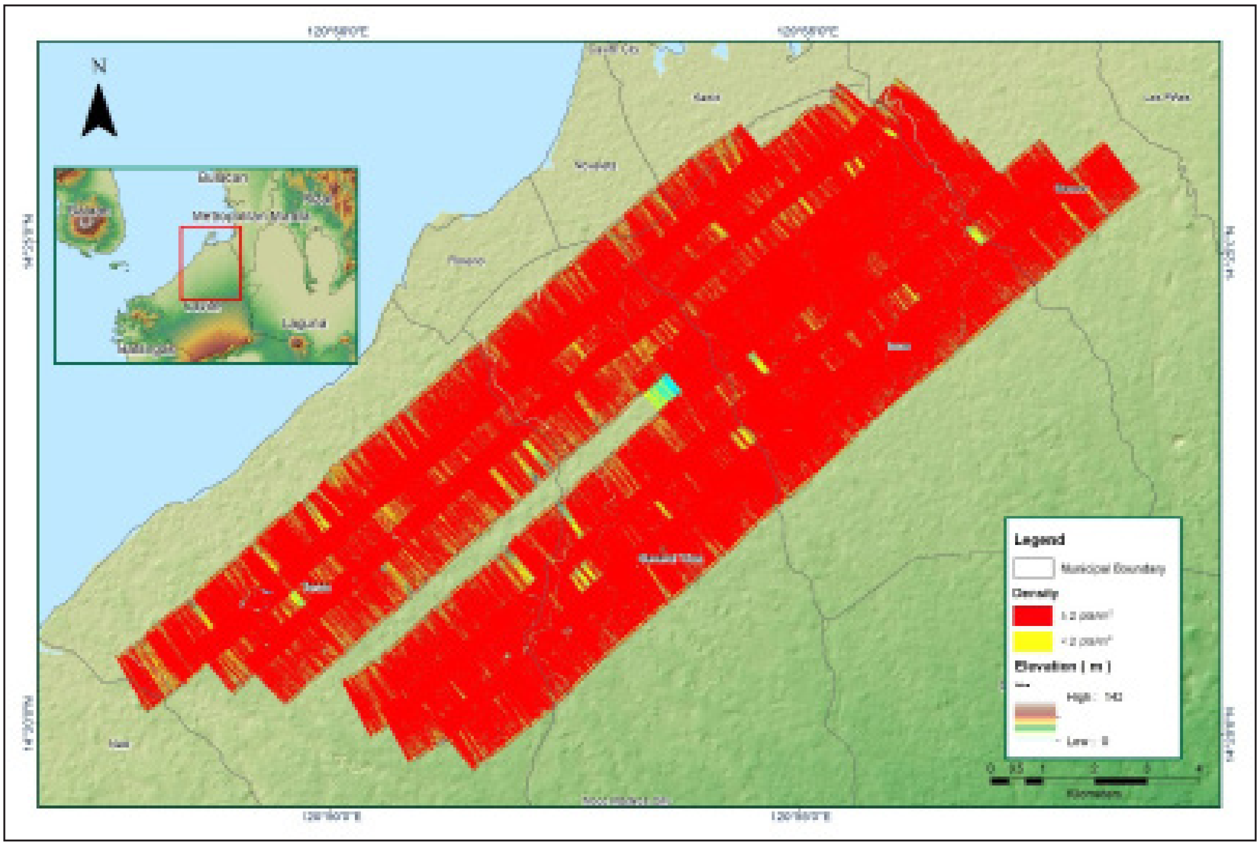


Figure A-8.20. Density map of merged LiDAR data

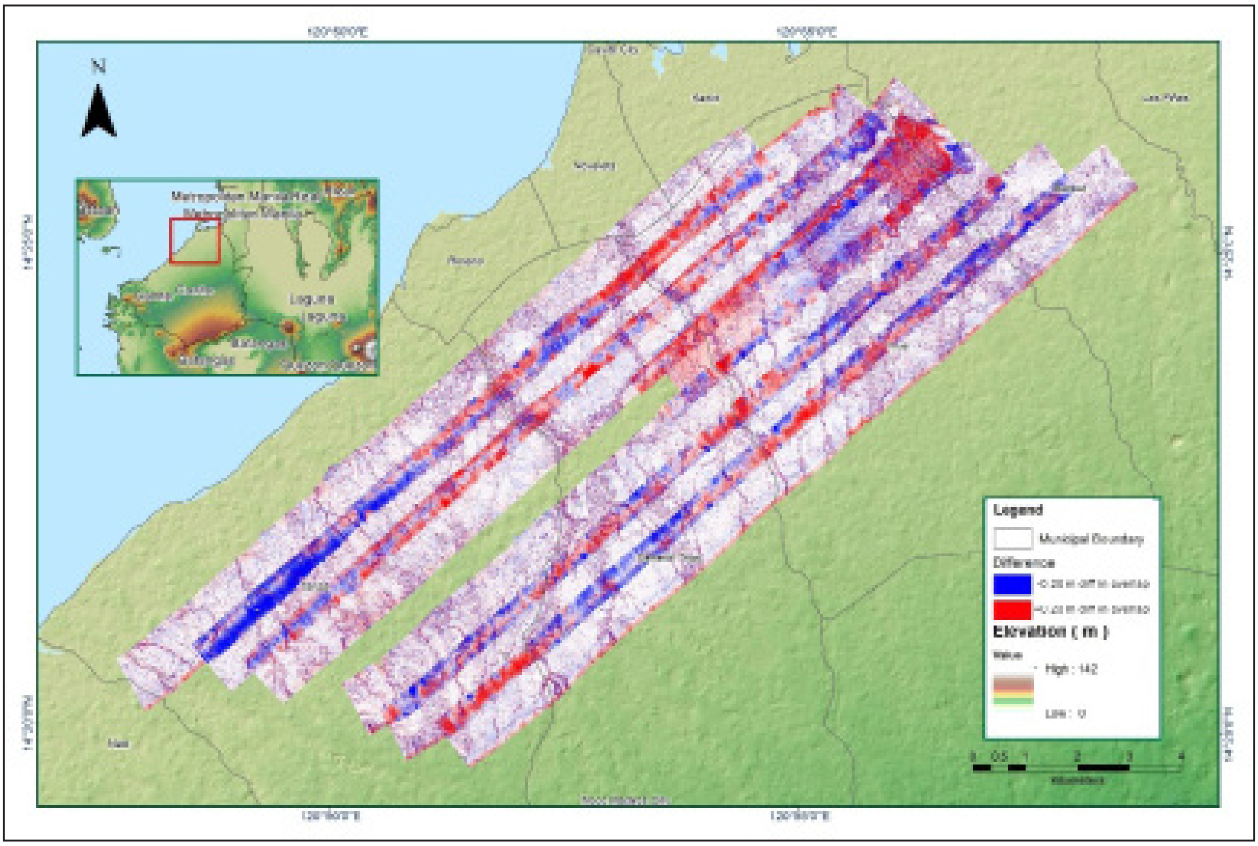


Figure A-8.21. Elevation difference between flight lines

Table A-8.8 Mission Summary Report for Blk18AB

Flight Area	CALABARZON
Mission Name	Blk18AB
Inclusive Flights	1031P, 1027P
Range data size	29.0 GB
POS	379 MB
Image	7.11 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)	1.8
RMSE for East Position (<4.0 cm)	2.0
RMSE for Down Position (<8.0 cm)	3.2
Boresight correction stdev (<0.001deg)	0.000453
IMU attitude correction stdev (<0.001deg)	0.005473
GPS position stdev (<0.01m)	0.0019
Minimum % overlap (>25)	28.57%
Ave point cloud density per sq.m. (>2.0)	3.24
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	204
Maximum Height	45.76 m
Minimum Height	603.46 m
Classification (# of points)	
Ground	175,046,421
Low vegetation	131,824,752
Medium vegetation	148,659,196
High vegetation	95,993,464
Building	30,587,801
Orthophoto	No
Processed by	Engr. Angelo Carlo Bongat, Celina Rosete, Engr. Gladys Mae Apat

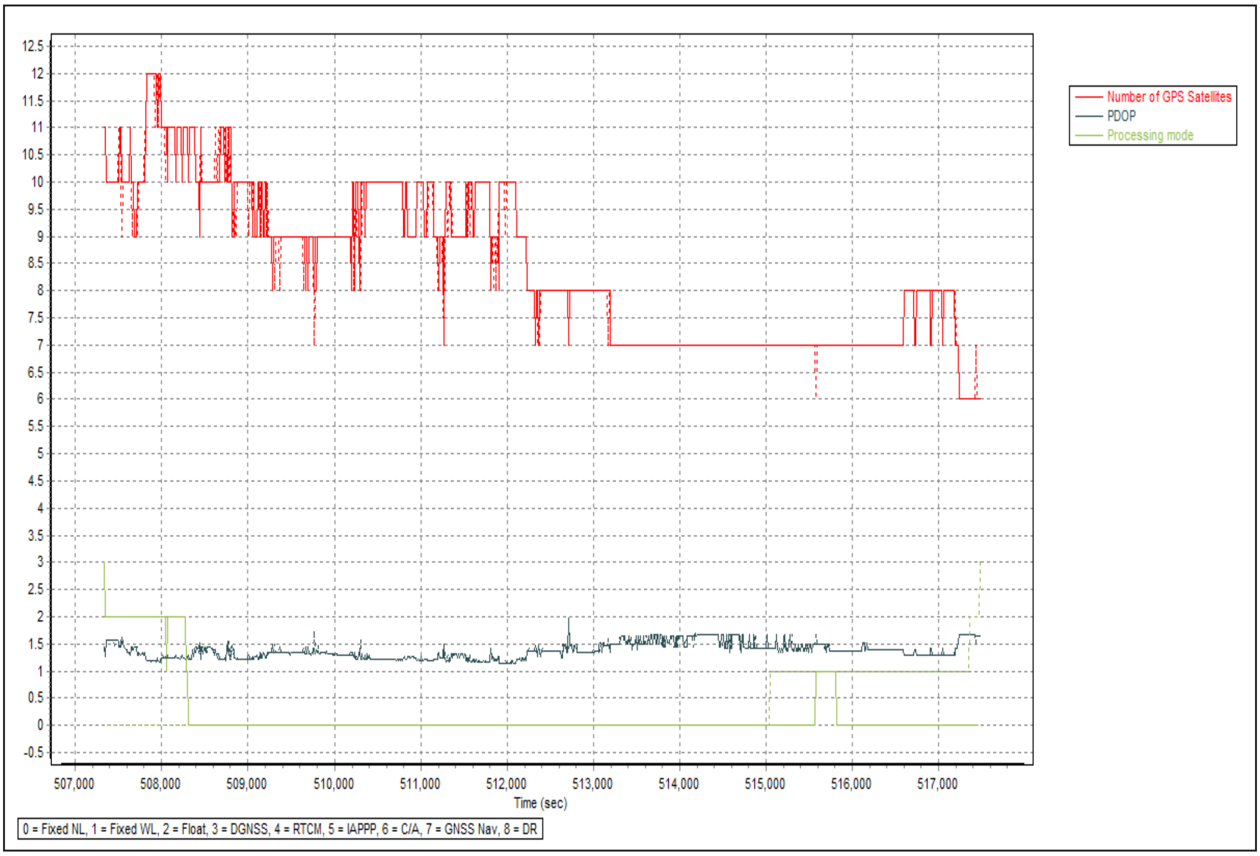


Figure A-8.22. Solution Status

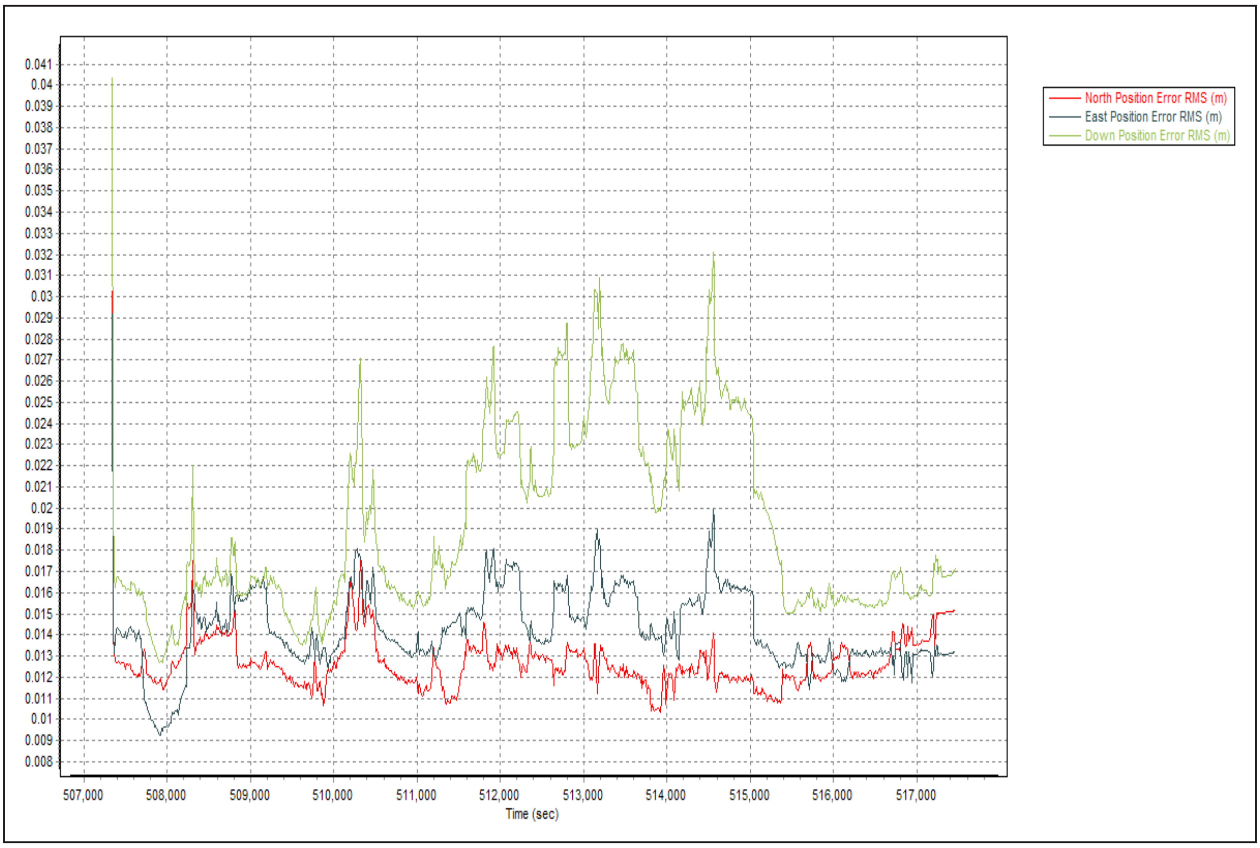


Figure A-8.23. Smoothed Performance Metric Parameters

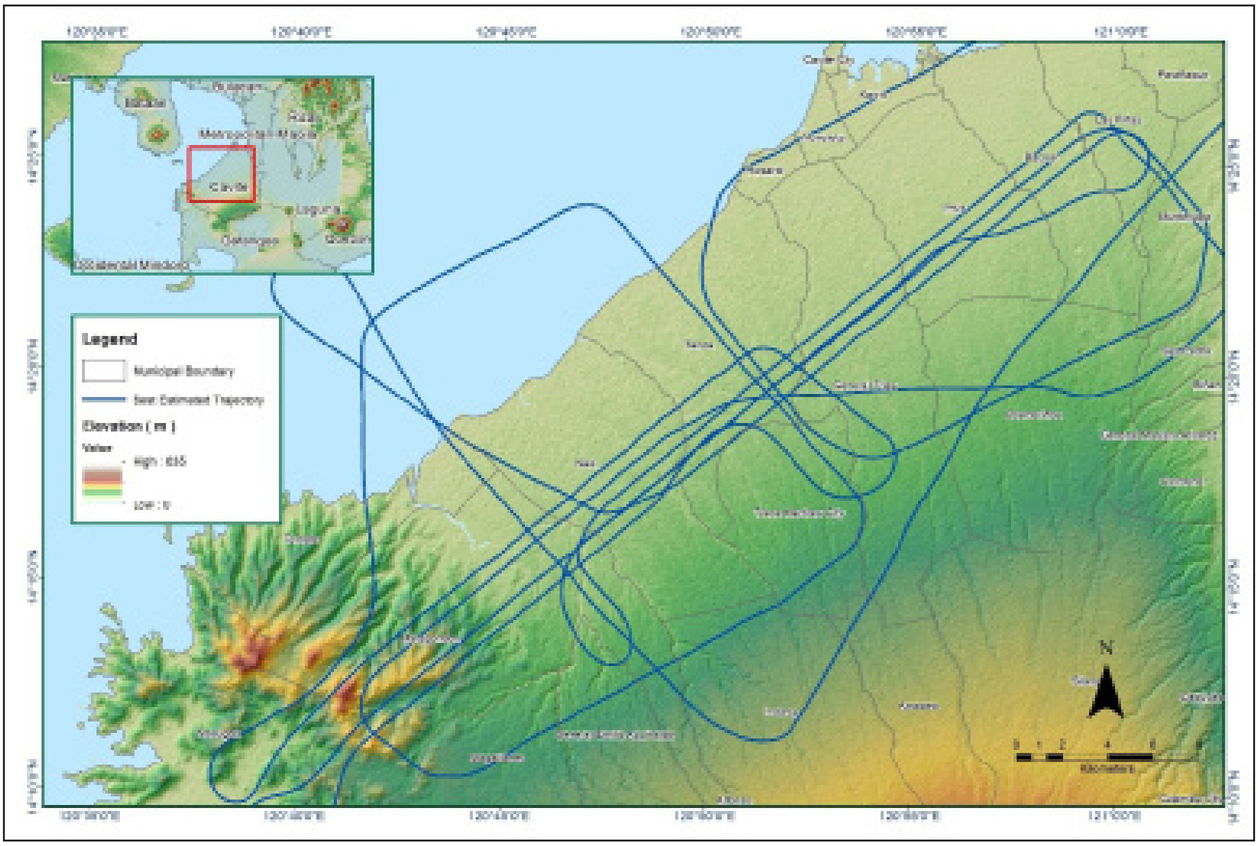


Figure A-8.24. Best Estimated Trajectory

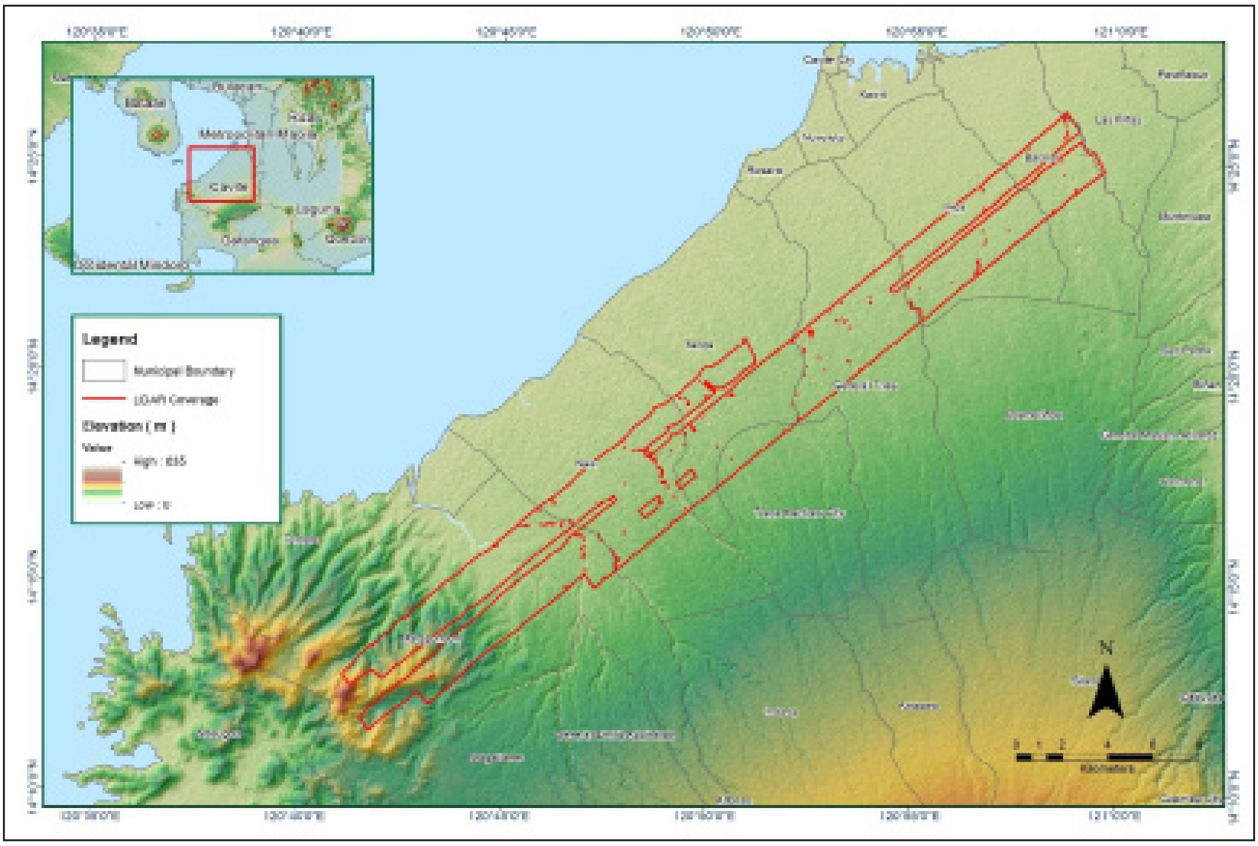


Figure A-8.25. Coverage of LiDAR data

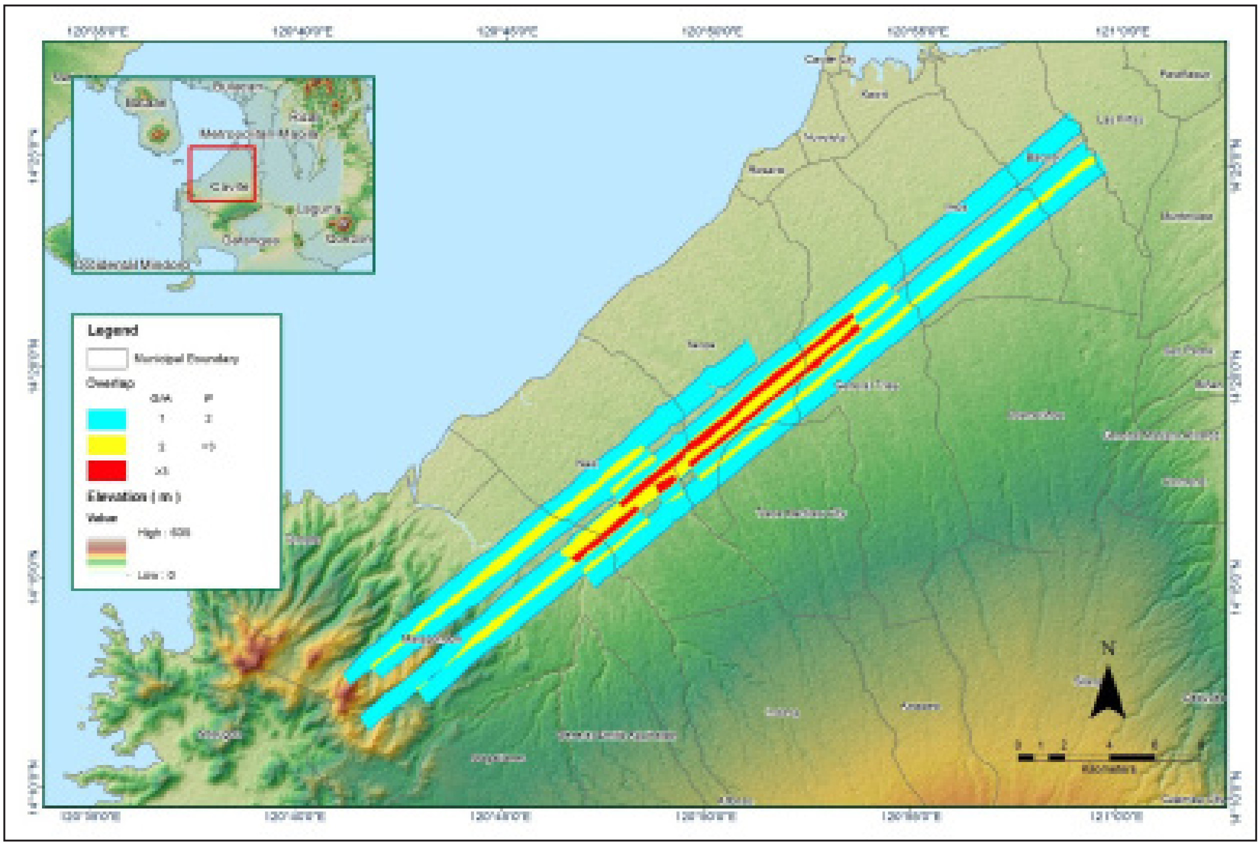


Figure A-8.26. Image of data overlap

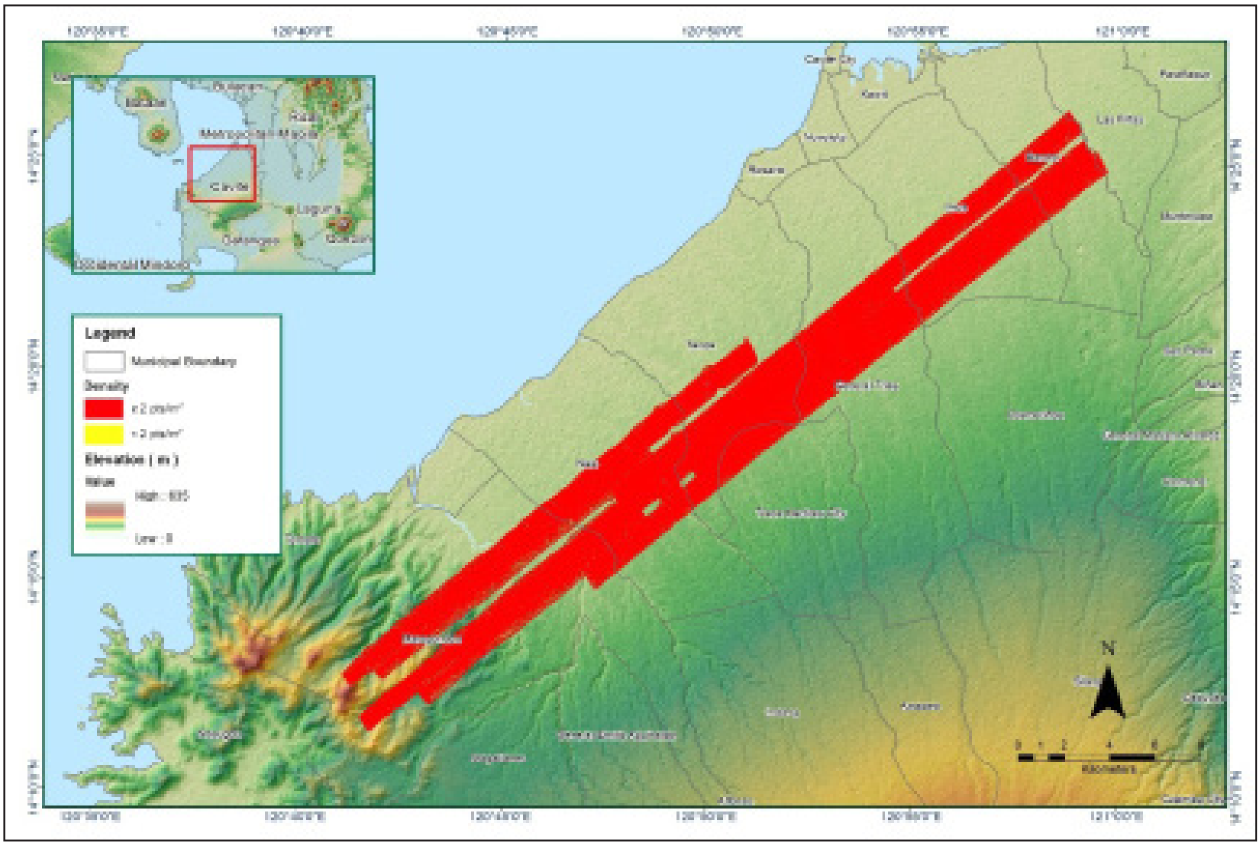


Figure A-8.27. Density map of merged LiDAR data

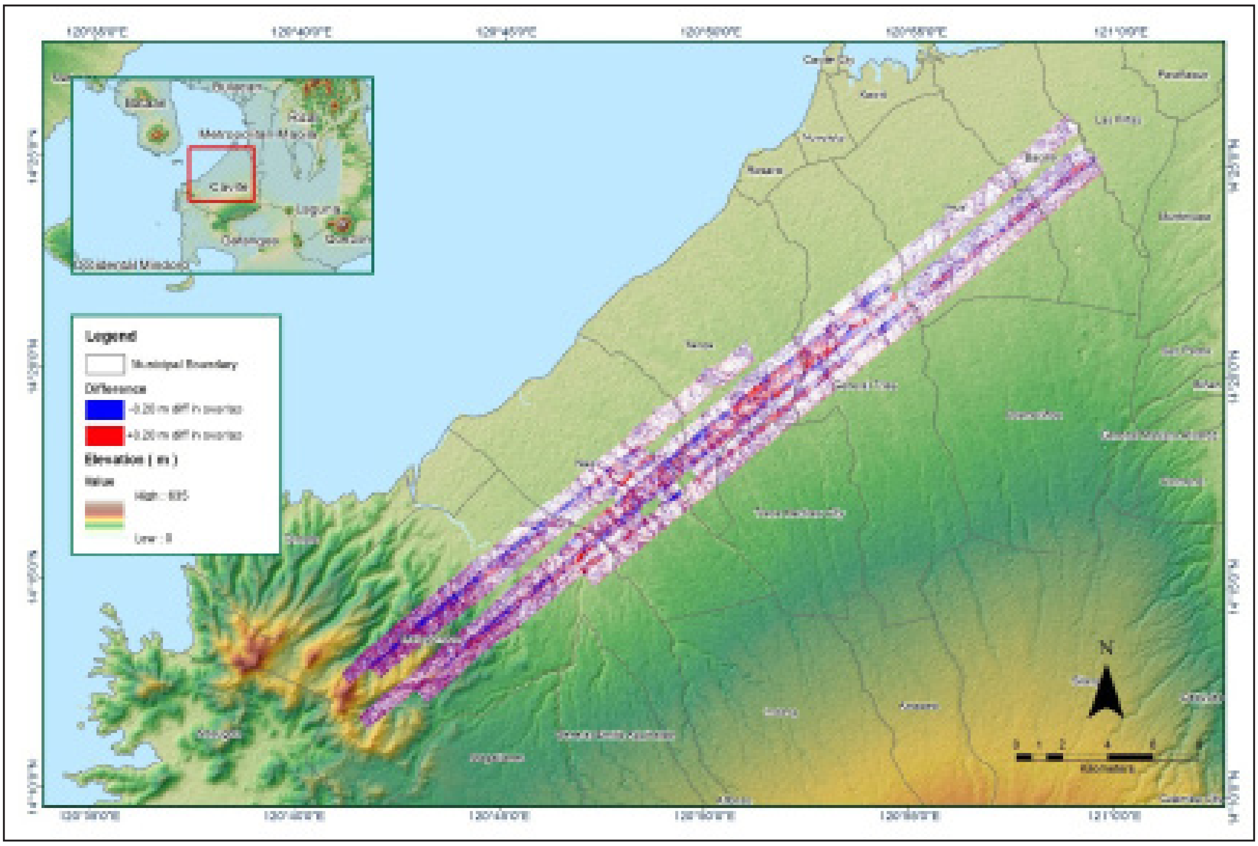


Figure A-8.28. Elevation difference between flight lines

Table A-8.9 Mission Summary Report for Blk18C

Flight Area	CALABARZON
Mission Name	Blk18C
Inclusive Flights	1031P
Range data size	14.7 GB
POS	185 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)	1.0
RMSE for East Position (<4.0 cm)	1.4
RMSE for Down Position (<8.0 cm)	2.4
Boresight correction stdev (<0.001deg)	0.000355
IMU attitude correction stdev (<0.001deg)	0.000702
GPS position stdev (<0.01m)	0.0113
Minimum % overlap (>25)	22.90%
Ave point cloud density per sq.m. (>2.0)	3.27
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	186
Maximum Height	404.02 m
Minimum Height	91.28 m
Classification (# of points)	
Ground	141,951,450
Low vegetation	94,479,716
Medium vegetation	142,100,182
High vegetation	100,785,000
Building	35,277,797
Orthophoto	Yes
Processed by	Engr. Kenneth Solidum, Engr. Christy Lubiano, Engr. Jeffrey Delica

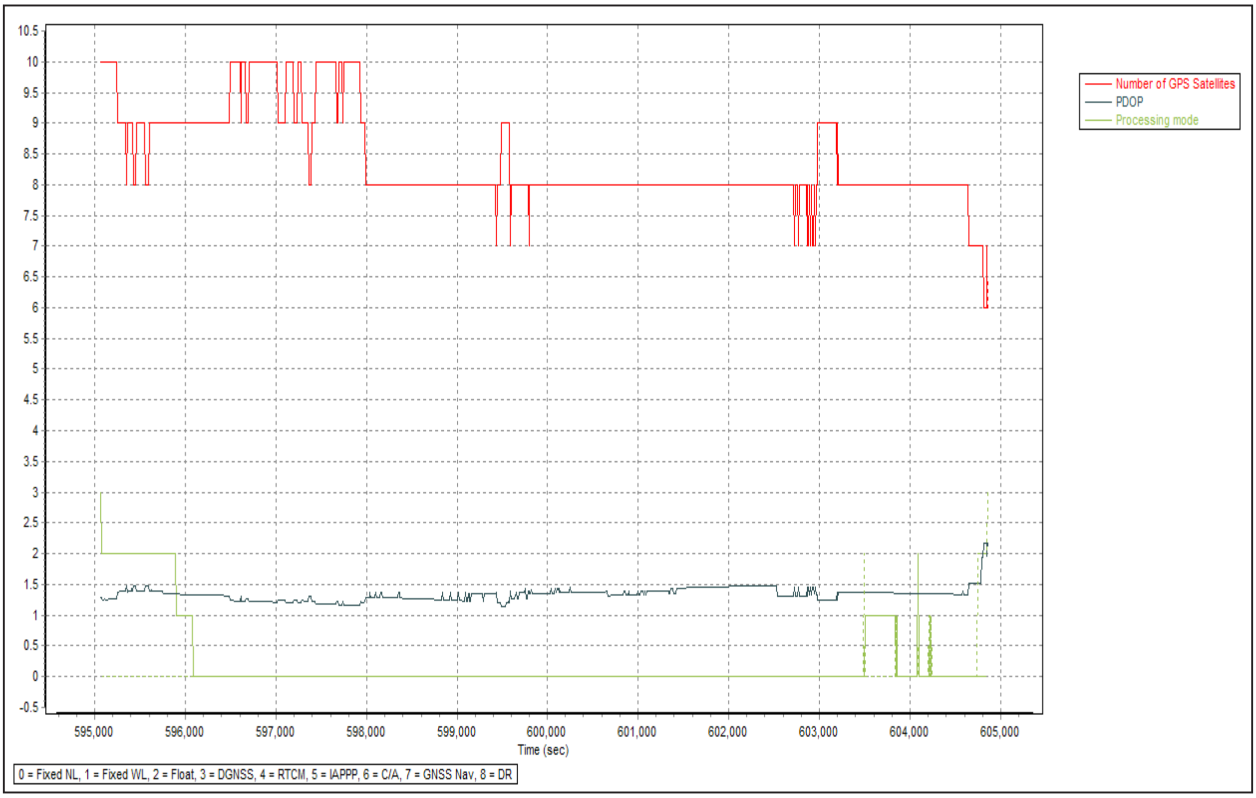


Figure A-8.1. Solution Status

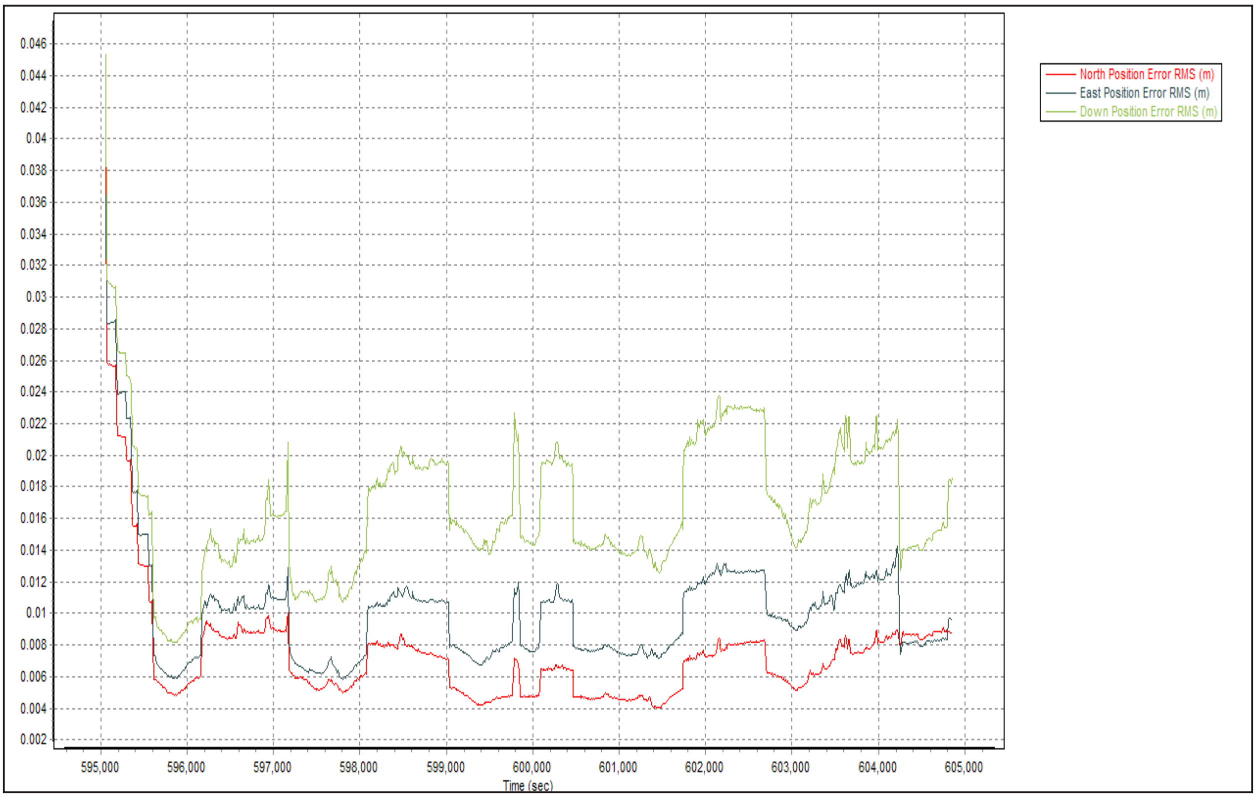


Figure A-8.2. Smoothed Performance Metric Parameters

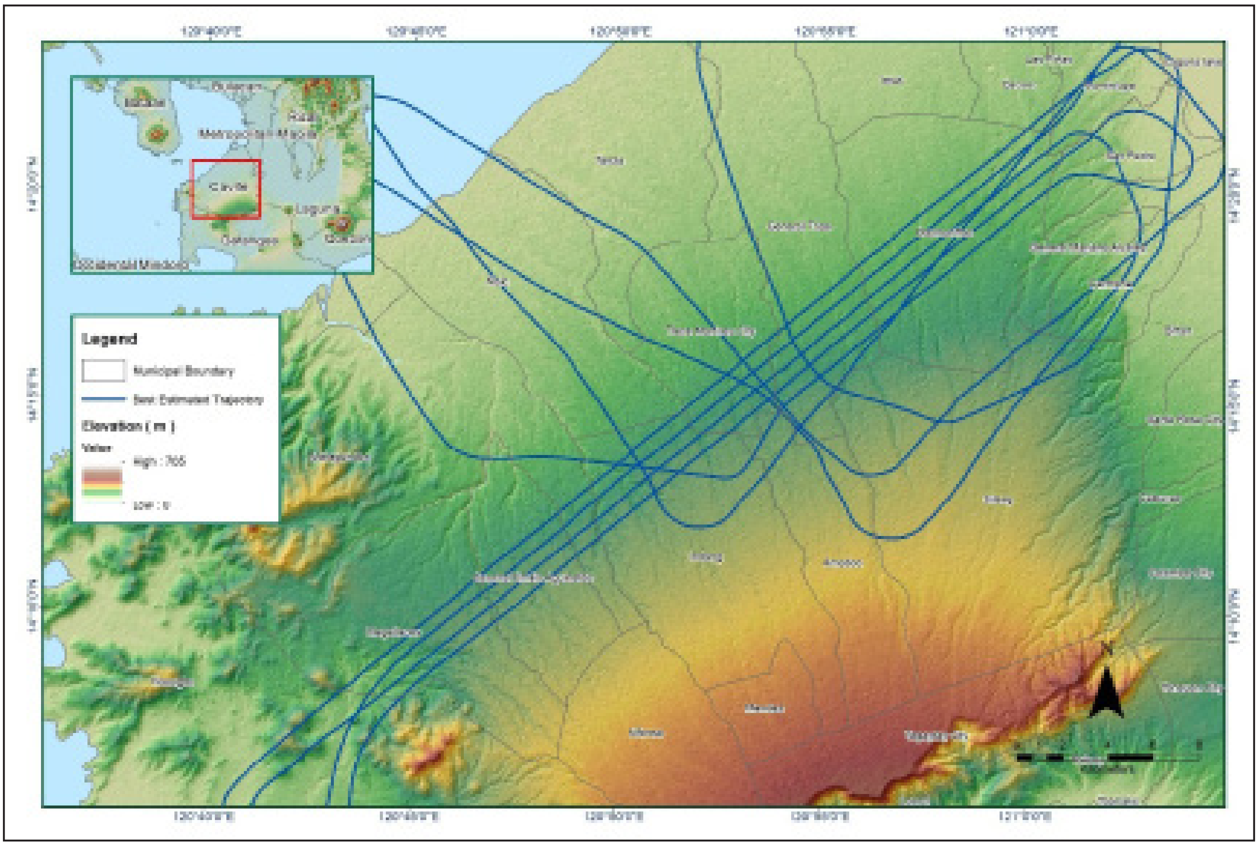


Figure A-8.3. Best Estimated Trajectory

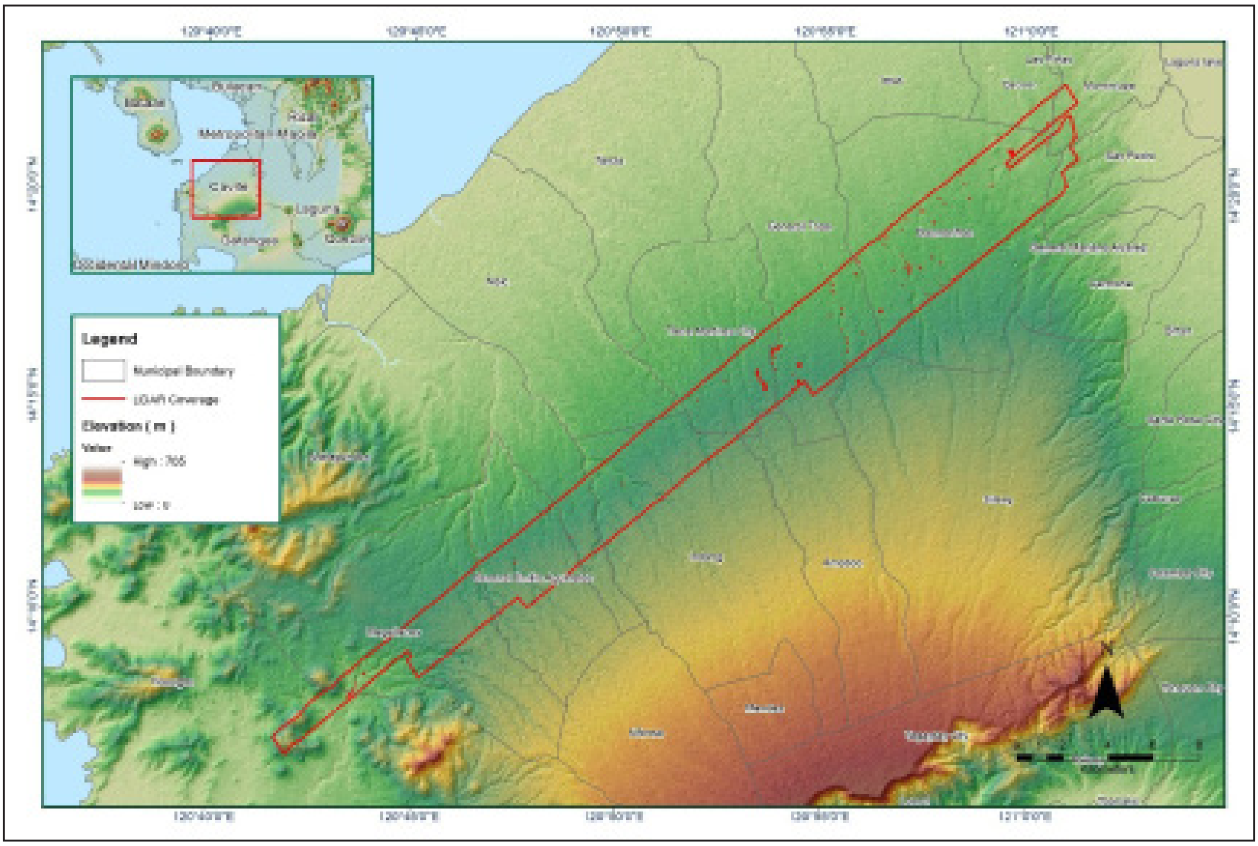


Figure A-8.4. Coverage of LiDAR data

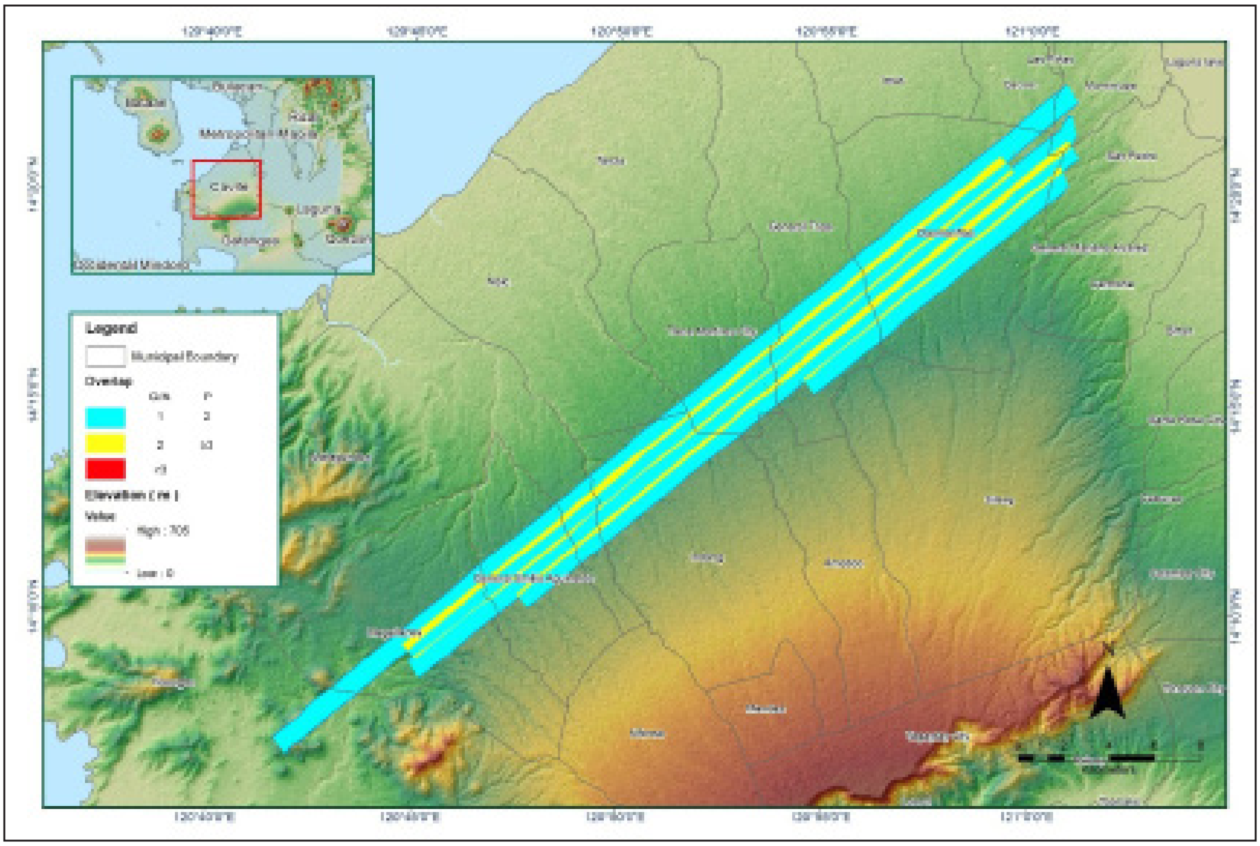


Figure A-8.5. Image of data overlap

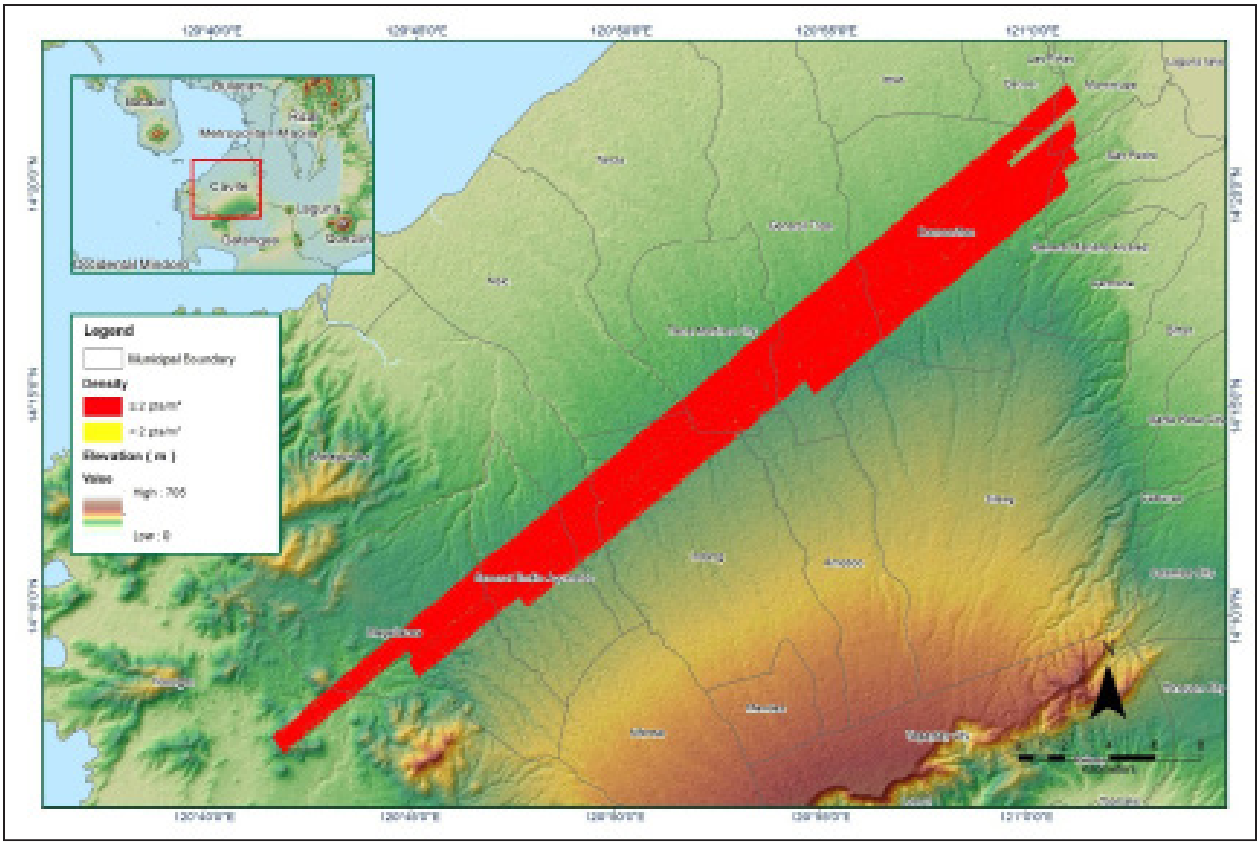


Figure A-8.6. Density map of merged LiDAR data

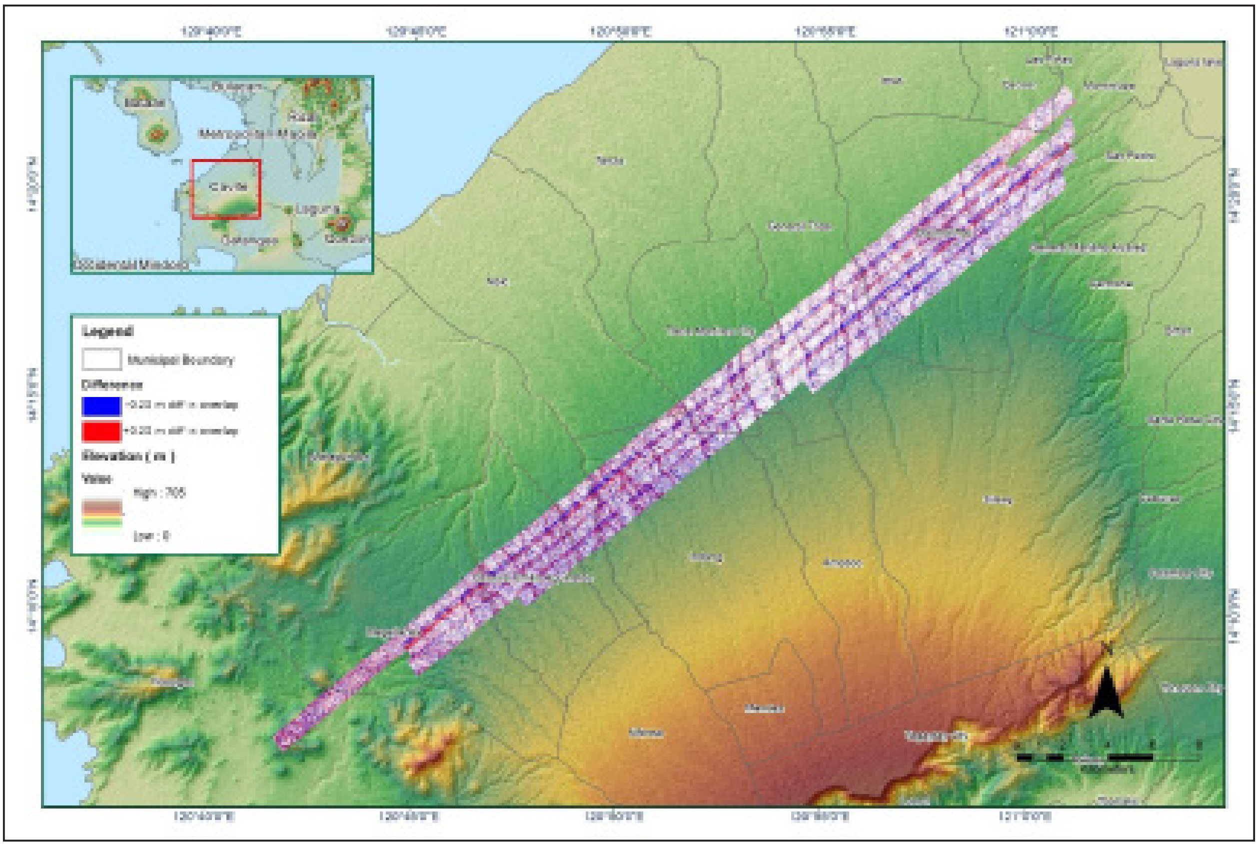


Figure A-8.7. Elevation difference between flight lines

Table A-8.10 Mission Summary Report for Blk18C_additional

Flight Area	CALABARZON
Mission Name	Blk18C_additional
Inclusive Flights	1031P; 1063P
Range data size	33.2 GB
POS	329 MB
Image	19.2 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)	1.5
RMSE for East Position (<4.0 cm)	1.9
RMSE for Down Position (<8.0 cm)	3.2
Boresight correction stdev (<0.001deg)	0.000508
IMU attitude correction stdev (<0.001deg)	0.001492
GPS position stdev (<0.01m)	0.0092
Minimum % overlap (>25)	29.92%
Ave point cloud density per sq.m. (>2.0)	2.78
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	327
Maximum Height	460.70 m
Minimum Height	60.39 m
Classification (# of points)	
Ground	187,497,140
Low vegetation	163,676,822
Medium vegetation	212,619,439
High vegetation	144,490,617
Building	59,922,956
Orthophoto	Yes
Processed by	Engr. Kenneth Solidum, Engr. Merven Matthew Natino, Marie Joyce Ilagan

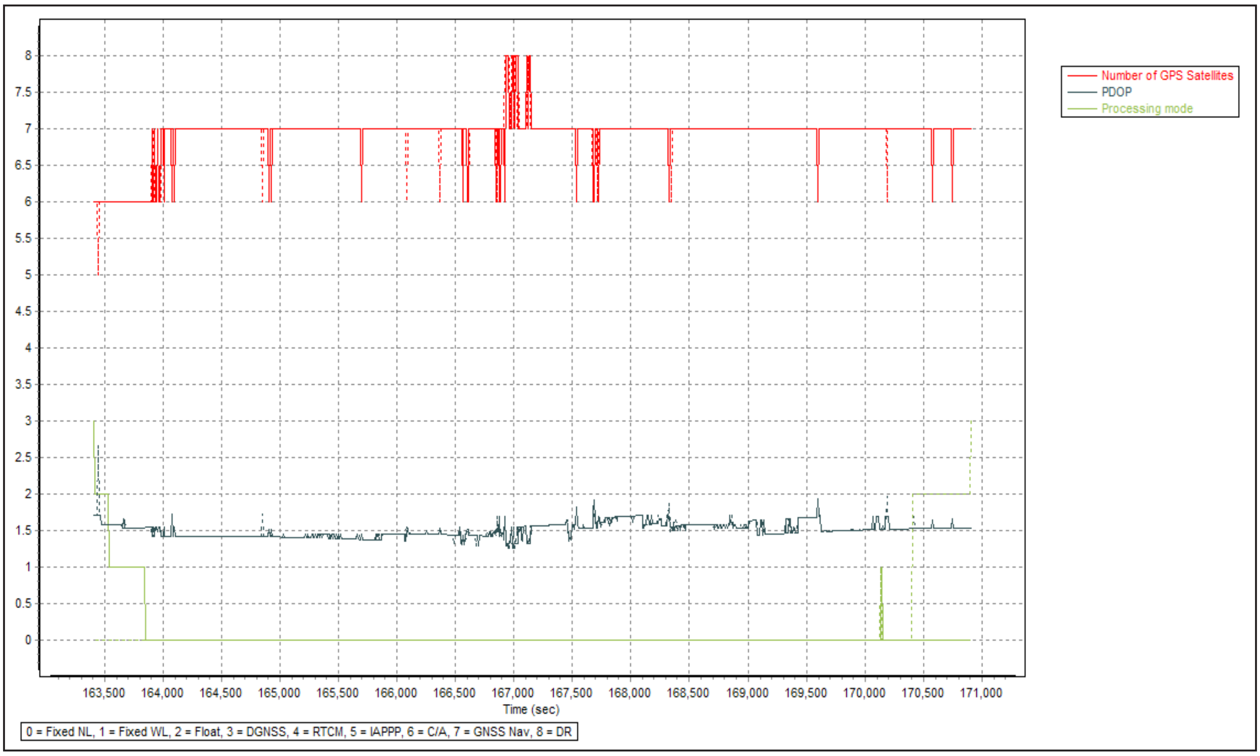


Figure A-8.8. Solution Status

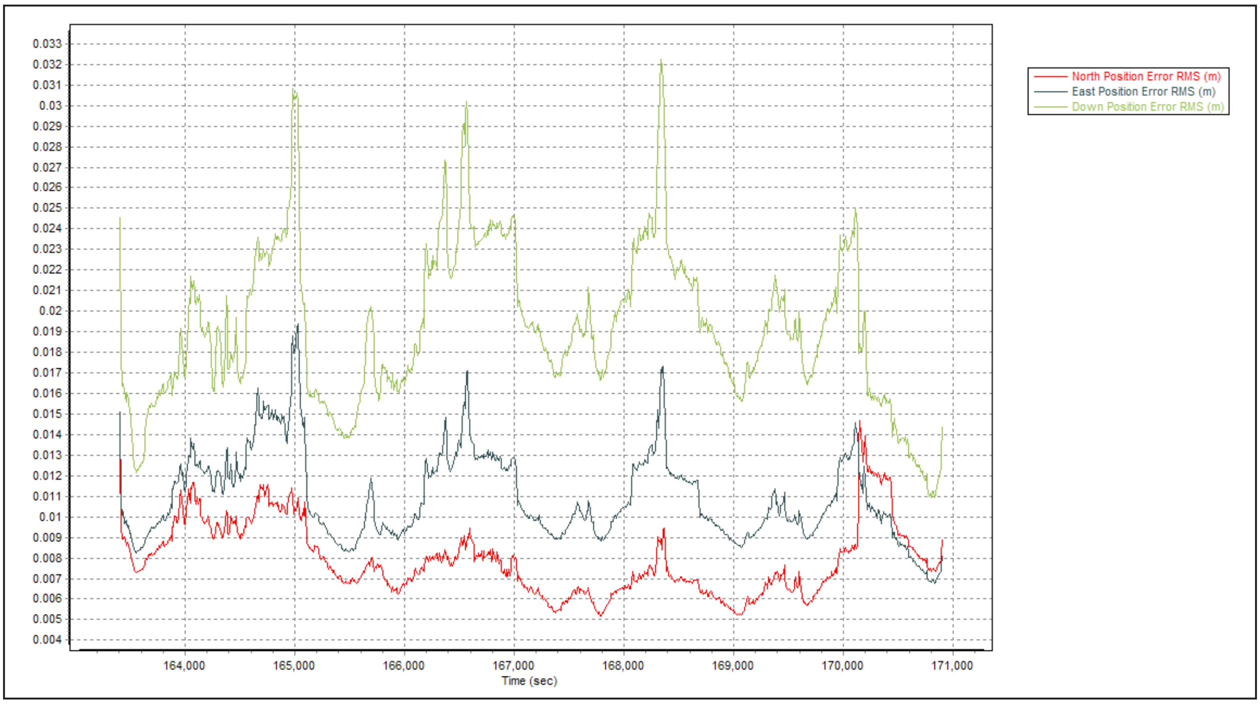


Figure A-8.9. Smoothed Performance Metric Parameters

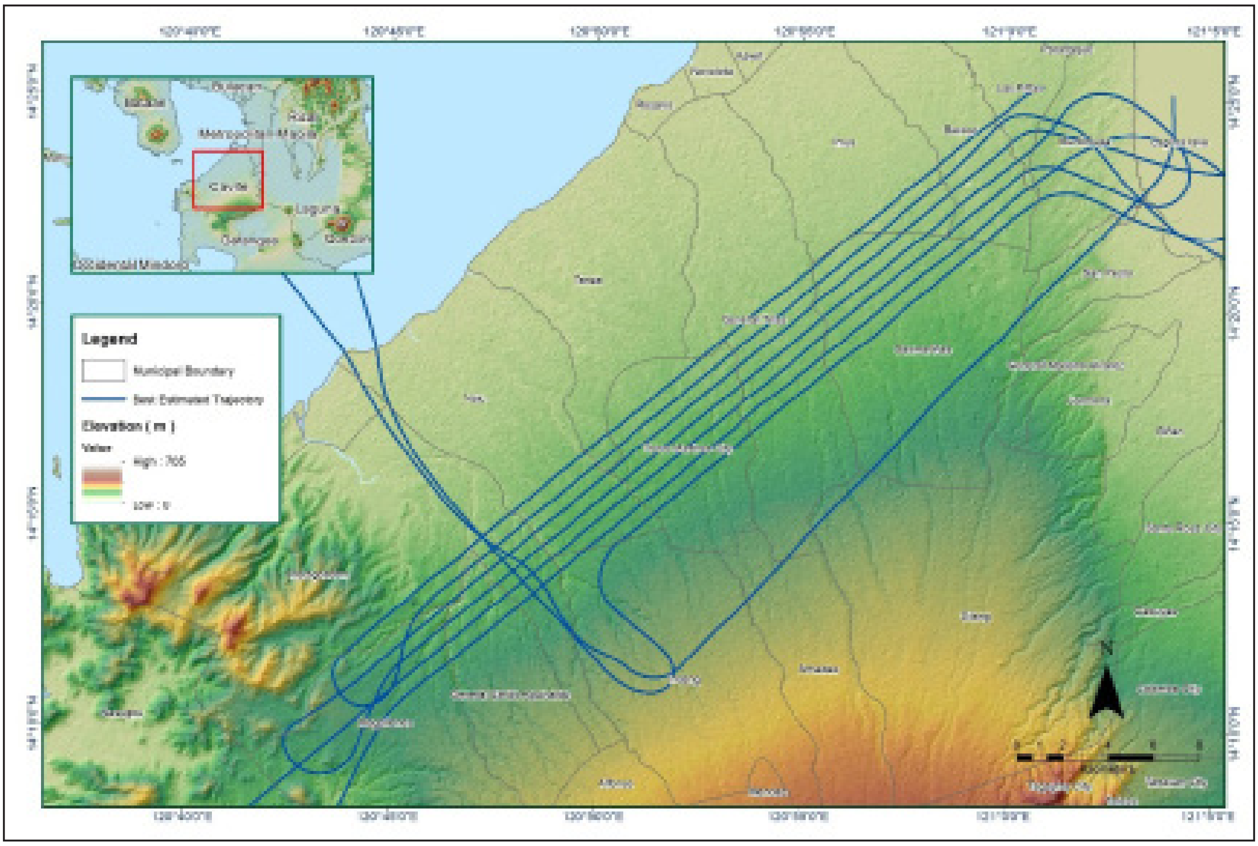


Figure A-8.10. Best Estimated Trajectory

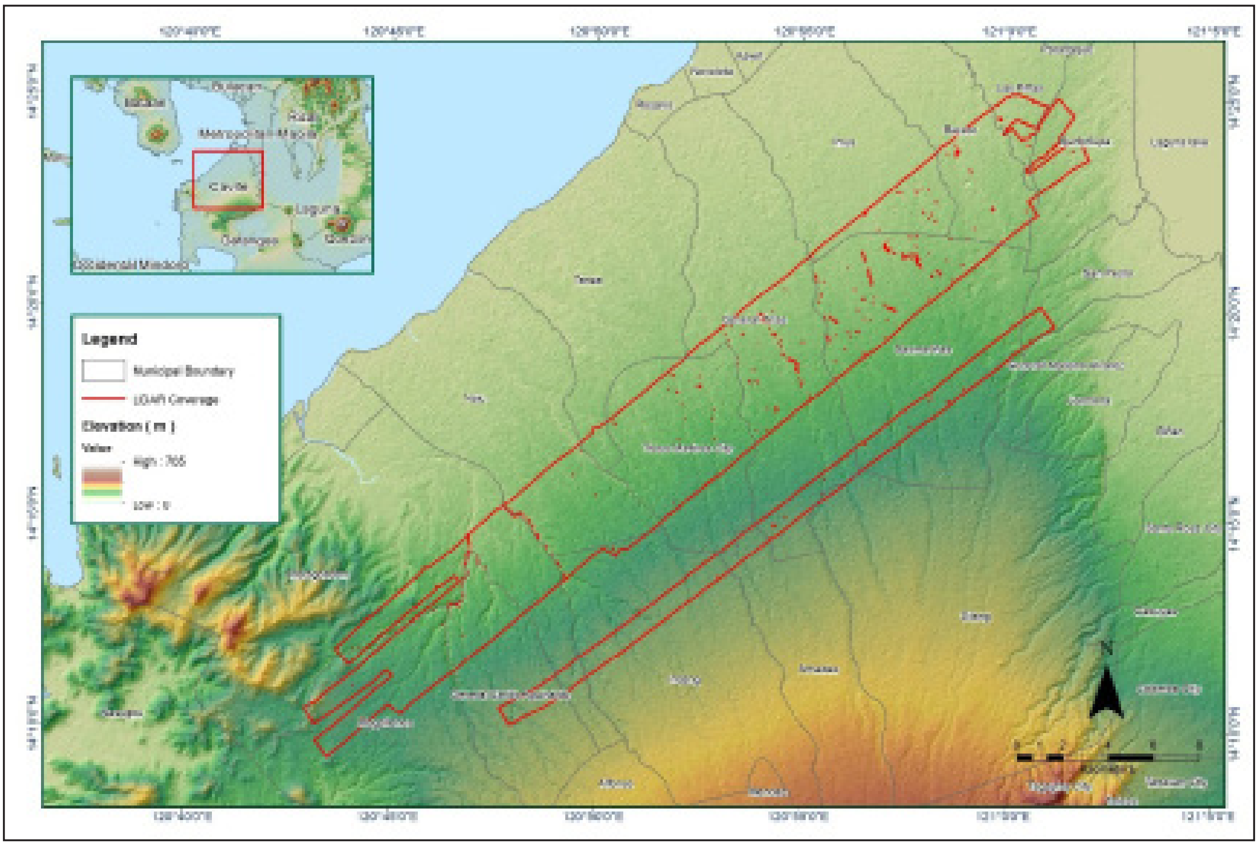


Figure A-8.11. Coverage of LiDAR data

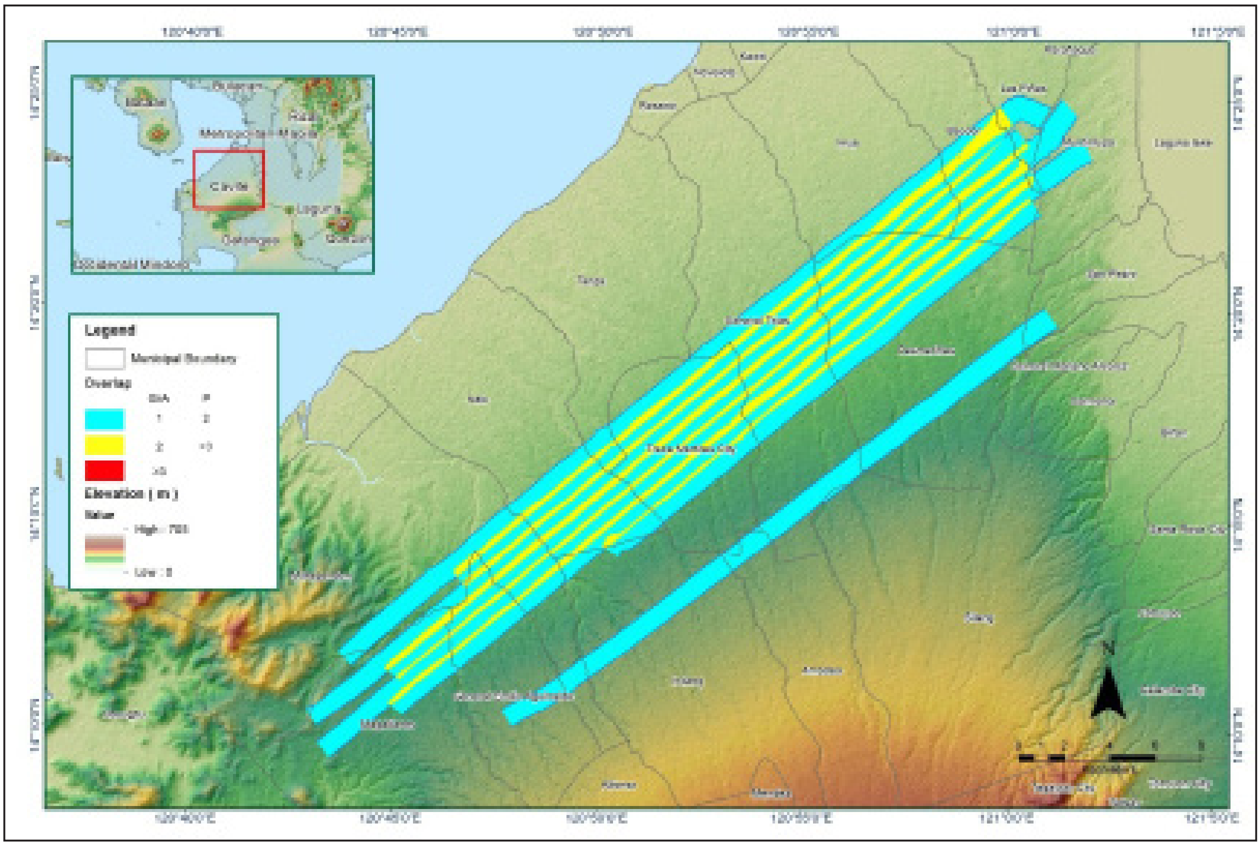


Figure A-8.12. Image of data overlap

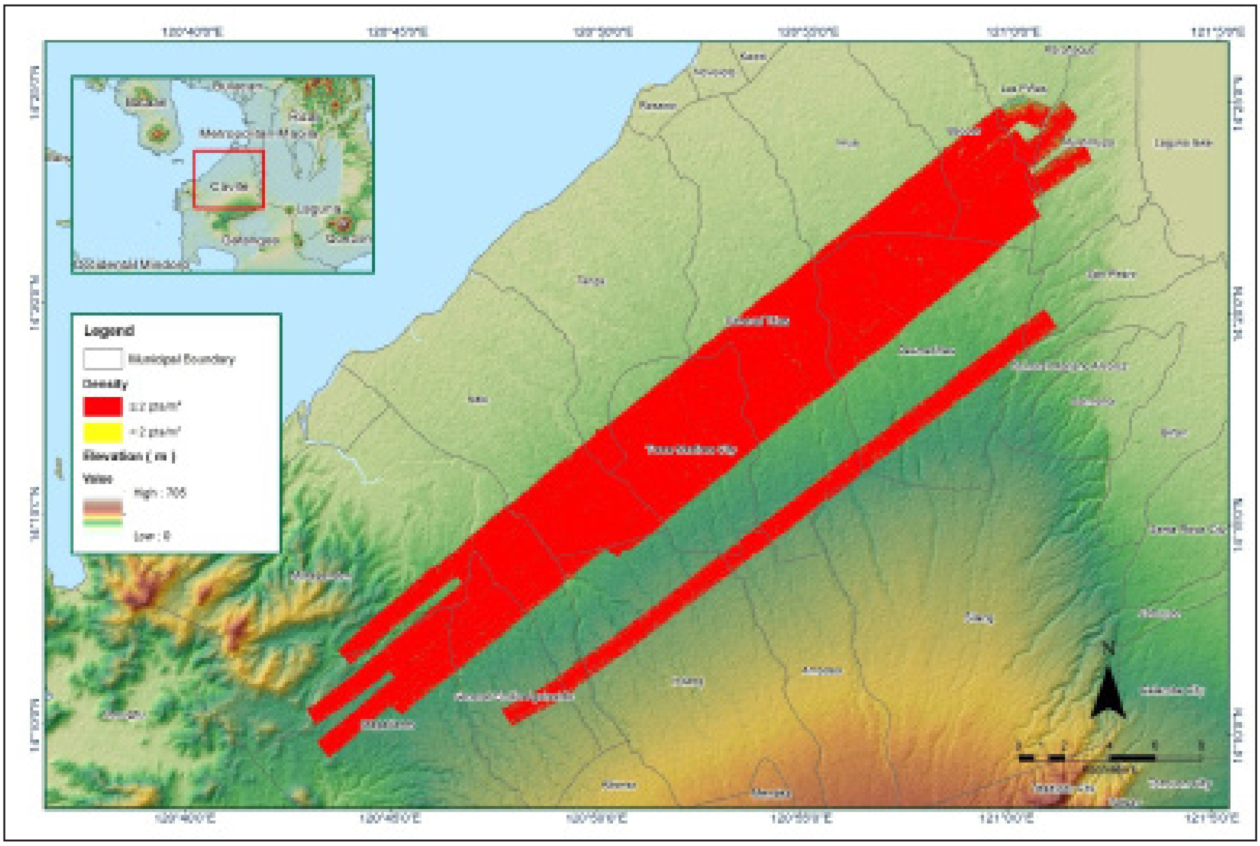


Figure A-8.13. Density map of merged LiDAR data

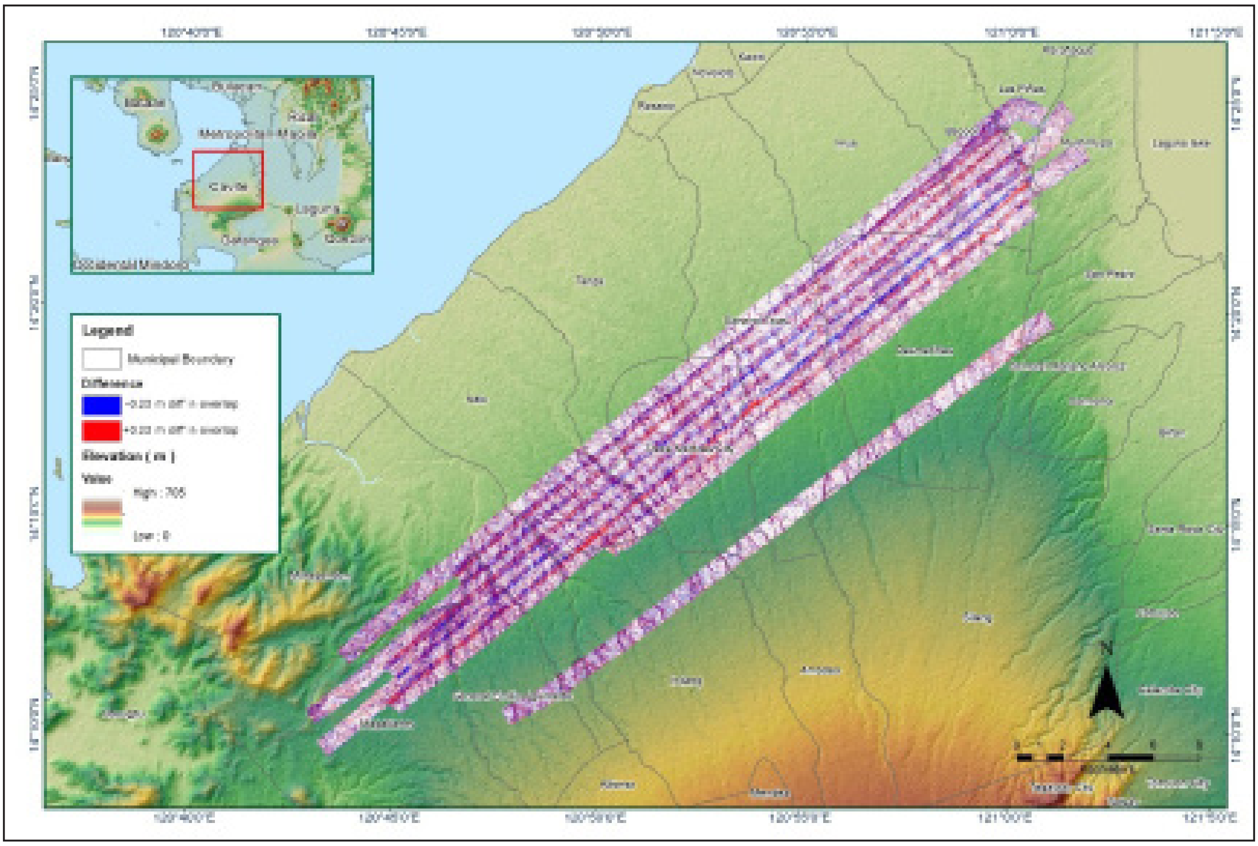


Figure A-8.14. Elevation difference between flight lines

Annex 9. Imus Model Basin Parameters

Table A-9.1 Imus Model Basin Parameters

Sub-basin	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
W380	5.1922	82.368	0	4.3318	3.0937	Discharge	0	0.05	Ratio to Peak	0.05
W370	5.5584	79.095	0	12.501	10.201	Discharge	0	0.05	Ratio to Peak	0.05
W360	1.2773	99	0	2.4762	2.2603	Discharge	0	0.05	Ratio to Peak	0.05
W350	5.2938	99	0	1.9461	3.8678	Discharge	0	0.05	Ratio to Peak	0.05
W340	9.2112	99	0	30.551	7.3666	Discharge	0	0.05	Ratio to Peak	0.05
W330	1.3138	99	0	1.7546	2.078	Discharge	0	0.05	Ratio to Peak	0.05
W320	1.0359	99	0	3.739	2.5033	Discharge	0	0.05	Ratio to Peak	0.05
W310	1.4441	99	0	2.1065	3.1147	Discharge	0	0.05	Ratio to Peak	0.05
W300	0.83785	89.907	0	2.7528	1.6315	Discharge	0	0.05	Ratio to Peak	0.05
W290	1.659	99	0	2.6727	2.1477	Discharge	0	0.05	Ratio to Peak	0.05
W280	0.86581	99	0	2.7499	2.2582	Discharge	0	0.05	Ratio to Peak	0.05
W270	1.205	79.395	0	0.77722	0.25918	Discharge	0	0.046118	Ratio to Peak	0.046118
W260	1.0544	94.105	0	0.31272	0.51276	Discharge	0	0.02646	Ratio to Peak	0.04954
W250	0.87916	60.038	0	2.832	3.5524	Discharge	0	0.05	Ratio to Peak	0.05
W240	1.4871	93.863	0	0.32016	0.37479	Discharge	0	0.046118	Ratio to Peak	0.049531
W230	0.72678	98.249	0	2.6286	2.2549	Discharge	0	0.05	Ratio to Peak	0.05
W220	1.0612	85.937	0	0.6532	0.5068	Discharge	0	0.046118	Ratio to Peak	0.047288
W210	1.0894	86.872	0	0.87505	0.43534	Discharge	0	0.045196	Ratio to Peak	0.045196

Annex 10. Imus Model Reach Parameters

Table A-10.1 Imus Model Reach Parameters

Reach Number	Muskingum Cunge Channel Routing						
	Time Step method	Length	Slope	Manning's n	Shape	Width	Side Slope
R10	Automatic Fixed Interval	37.071	0.026975	0.73993	Trapezoid	45	1
R20	Automatic Fixed Interval	1445.1	0.011072	0.089635	Trapezoid	45	1
R30	Automatic Fixed Interval	1637.1	0.006108	0.05777	Trapezoid	45	1
R40	Automatic Fixed Interval	1950.7	0.004101	0.050187	Trapezoid	45	1
R70	Automatic Fixed Interval	5158	0.008337	0.044827	Trapezoid	45	1
R90	Automatic Fixed Interval	6902.8	0.15433	0.013753	Trapezoid	45	1
R110	Automatic Fixed Interval	2540.5	0.40862	0.086487	Trapezoid	45	1
R130	Automatic Fixed Interval	3825.3	0.014065	0.034552	Trapezoid	45	1
R170	Automatic Fixed Interval	11311	0.01747	0.02	Trapezoid	45	1

Annex 11. Imus Field Validation Data

Table A-11.1 Imus Field Validation Data

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return /Scenario
	Lat	Long					

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return /Scenario
	Lat	Long					

Annex 12. Educational Institutions Affected in Imus Floodplain

Table A-12.1 Educational Institutions in Bacoor, Cavite Affected by Flooding in the Imus Floodplain

Cavite				
Bacoor				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
BACOOR EVANGELICAL SCHOOL	Alima	Medium	Medium	Medium
RUTHER E. ESCONDE SCHOOL OF MULTIPLE INTELLIGENCES	Alima	Low	Medium	Medium
ST. PEREGRINE INSTITUTE	Banalo	Medium	Medium	Medium
BACOOR COMPUTER CENTER	Campo Santo	Low	Medium	Medium
BACOOR ELEMENTARY SCHOOL	Campo Santo	Medium	Medium	Medium
POBLACION ELEMENTARY SCHOOL	Campo Santo	Low	Medium	Medium
RUTHER E. ESCONDE SCHOOL OF MULTIPLE INTELLIGENCES	Campo Santo	Low	Medium	Medium
ST. MICHAEL'S INSTITUTE	Campo Santo		Low	Medium
DAY CARE CENTER	Daang Bukid	Low	Medium	Medium
BACOOR PAROCHIAL SCHOOL OF ST. MICHAEL	Digman		Medium	Medium
ST. MICHAEL'S INSTITUTE	Digman			Low
TABING DAGAT DAY CARE CENTER	Digman	Low	Medium	Medium
THE PRECIOUS JEWELS MONTESSORI SCHOOL	Digman	Low	Medium	Medium
DULONG BAYAN ELEMENTARY SCHOOL	Dulong Bayan	Medium	High	High
RUTHER E. ESCONDE SCHOOL OF MULTIPLE INTELLIGENCES	Dulong Bayan	Medium	Medium	Medium
RUTHER E. ESONCDE SCHOOL OF MULTIPLE INTELLIGENCES	Dulong Bayan	Medium	Medium	High
HABAY ELEMENTARY SCHOOL	Habay I	Medium	Medium	High
ISHRM	Habay I		Low	Medium
ROCHEPOL ACADEMY	Habay I	Low	Medium	Medium
ST. MICHAEL SCHOOL	Habay II	Low	Medium	Medium
BACOOR PAROCHIAL SCHOOL OF ST. MICHAEL	Kaingin	Low	Medium	Medium
DIGMAN ELEMENTARY SCHOOL	Kaingin	Low	Medium	High
ERIKA MOHR ACADEMY	Kaingin	Low	Medium	Medium
ESCUELA LA MADRID OF CAVITE	Mabolo I	Medium	High	High
MARIA CORINNE COLLEGE	Mabolo I	Medium	Medium	Medium
OUR LADY OF FATIMA ACADEMY OF BINAKAYAN	Mabolo I	Medium	High	High
MALIKSI ELEMENTARY SCHOOL	Maliksi II	Low	Medium	Medium
KING JAMES ACADEMY	Mambog I		Low	Medium
MACASA LEARNING CENTER	Mambog I		Low	Low
BAHAY BULILIT	Mambog II	Low	Low	Low
MAMBOG ELEMENTARY SCHOOL	Mambog II			
MARVELOUS FAITH ACADEMY	Mambog II		Low	Low
JESUS GOOD SHEPHERD SCHOOL	Mambog V	Low	Low	Medium
UNIVERSITY OF PERPETUAL HELP SYSTEM DALTA	Molino IV			
DAY CARE CENTER	P.F. Espiritu III	Low	Low	Low

Cavite				
Bacoor				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
ACTEC	P.F. Espiritu IV		Medium	Medium
HARRELL HORNE INTEGRATED SCHOOL	Queens Row East	Low	Low	Low
SAINT JEROME EMILIANI INSTITUTE	Queens Row East			
SAINT MICHAEL SCHOOL OF CAVITE	Queens Row East			
SAINT THOMAS MORE SCHOOL	Queens Row East			
UNIVERSITY OF PERPETUAL HELP SYSTEM DALTA	Queens Row East			
BRETON SCHOOL	Real I	Medium	Medium	Medium
ISHRM	Real I		Medium	Medium
JESUS GOOD SHEPHERD SCHOOL	Real I	Medium	Medium	Medium
LA CAMELLA SCHOOL	Real I	Low	Low	Medium
MILLENIUM CHRISTIAN SCHOOL	Real I	Low	Medium	Medium
BACOOR NATINAL HIGH SCHOOL	Real II	Low	Low	Low
OUR LADY OF THE PILLAR CATHOLIC SCHOOL	Real II			Low
REAL ELEMENTARY SCHOOL	Real II			
SALINAS I ELEMENTARY SCHOOL	Real II			Low
DAY CARE CENTER	Salinas II	High	High	High
SALINAS I ELEMENTARY SCHOOL	Salinas III	Low	Low	Low
SALINAS I ELEMENTARY SCHOOL	Salinas IV			Low
BACOOR NATIONAL HIGH SCHOOL	Tabing Dagat		Medium	Medium
BACOOR PARISH SCHOOL	Tabing Dagat		Medium	Medium

Table A-12.2 Educational Institutions in Dasmariñas, Cavite Affected by Flooding in the Imus Floodplain

Cavite				
Dasmariñas				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
ASIAN TRINITY SCHOOL	Burol			
COLEGIO DE LA ESTRELLA	Burol			
DAY CARE CENTER	Burol			
EMILIO AGUINALDO COLLEGE	Burol			
ST. NICHOLAS DE MAYRA SCHOOL	Burol			
DASMARIAGAS (DBB) ELEMENTARY SCHOOL	Burol I			
DASMARIL AS (DBB) ELEMENTARY SCHOOL	Burol I			
DE LA SALLE UNIVERSITY	Burol I			
DASMARI	Burol II		Low	Low
DASMARIL AS (DBB) ELEMENTARY SCHOOL	Burol II	Low	Medium	Medium
DE LA SALLE UNIVERSITY	Burol II			
CORINTHIAN INSTITUTE OF CAVITE	Burol III			
DASMARI	Burol III			
DASMARIL AS (DBB) ELEMENTARY SCHOOL	Burol III			

Cavite				
Dasmariñas				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
BREESE CHRISTIAN ACADEMY OF DASMARI	Emmanuel Bergado I			
BREESE CHRISTIAN ACADEMY OF DASMARI	Emmanuel Bergado II			
ANGEL OF PEACE LEARNING CENTER	Salawag			
ANGEL OF THE BLESSED CHRISTIAN SCHOOL	Salawag			
BEULAH LAND INTEGRATED SCIENCE SCHOOL	Salawag			
DANHILL ACADEMY	Salawag			
FIDES SALDE SCHOOL	Salawag			
GRACE HORIZON SCHOOL	Salawag			
ICC SALAWAG	Salawag			
JESUS THE HEART OF GOD CHRISTIAN ACADEMY	Salawag			
MIDLAND SCHOOL OF CAVITE	Salawag			
OXFORDIAN COLLEGES	Salawag			
SALAWAG DAY CARE CENTER	Salawag			
SALAWAG ELEMENTARY SCHOOL	Salawag			
SALAWAG MERRYHILLS SCHOOL	Salawag			
SONS OF HOLY MARY IMMACULATE MONTESSORI	Salawag			
ST. ANTHONY MONTESSORI INTEGRATED SCHOOL	Salawag			
ST. JOHN FISHER SCHOOL	Salawag			
ST. LAZARO SCHOOL	Salawag			
BLESSED MARY ACADEMY	Salitran II			
CORNERSTONE INTERNATIONAL COLLEGE	Salitran II		Low	Low
IMMACULATE CONCEPTION ACADEMY	Salitran II			
SALITRAN ELEMENTARY SCHOOL	Salitran II			Low
DIVINE COLLEGE SCHOOL	Salitran III	Medium	Medium	Medium
GLENRIDGE'S SCHOOL	Salitran III		Low	Medium
HOLY BLESSING MONTESSORI INTERNATIONAL SCHOOL	Salitran III	Medium	Medium	Medium
DAYCARE CENTER	Salitran IV			
GOLDEN WISDOM SCHOOL	Salitran IV			
ST. BEATRIZ ACADEMY	Salitran IV			
WARNER CHRISTIAN ACADEMY	Salitran IV			
MAGSAYSAY INSITUTE OF SHIPPING	San Agustin I			
CONGRESSIONAL NATIONAL HIGH SCHOOL	San Agustin II			
BREESE CHRISTIAN ACADEMY OF DASMARI	San Antonio de Padua I			
DAY CARE CENTER	San Dionisio			
DR. JOSE P. RIZAL ELEMENTARY SCHOOL	San Dionisio			
DAY CARE CENTER	San Isidro Labrador I			
DASMARIE AS NORTH NATIONAL HIGH SCHOOL	San Juan			

Cavite				
Dasmariñas				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
DASMARIESAS NORTH NATIONAL HIGH SCHOOL	San Juan			
DAY CARE CENTER	San Juan	Low	Low	Low
JESUS SON OF MARY ACADEMY	San Manuel II	High	High	High
SAN MIGUEL ELEMENTARY SCHOOL	Santa Lucia			
DE LA SALLE UNIVERSITY	Santa Maria		Low	High
DR. JOSE P. RIZAL ELEMENTARY SCHOOL	Santo Cristo			

Table A-12.3 Educational Institutions in Imus, Cavite Affected by Flooding in the Imus Floodplain

Cavite				
Imus				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
TIERRA SANTA MONTESSORI INC.	Anabu I-D	Medium	Medium	Medium
TIERRA SANTA MONTESSORI INC.	Anabu I-E	Medium	Medium	Medium
PASONG SANTOL ELEMENTARY SCHOOL	Anabu II-A	Medium	Medium	Medium
ELIZABETH SETON SCHOOL-SOUTH	Anabu II-D	Medium	Medium	Medium
INTERNATIONA BRITISH ACADEMY	Anabu II-D	Low	Medium	Medium
STRAIGHT A'S TUTORIAL CENTER	Anabu II-D	Low	Low	Medium
ACADEMIA PRIMERA SCHOOL	Anabu II-E		Low	Low
ANABU 2 ELEMENTARY SCHOOL	Anabu II-F		Low	Medium
UCCP ANABU CHRISTIAN SCHOOL	Anabu II-F	Low	Medium	Medium
UNIDA CHRISTIAN COLLEGES	Anabu II-F	Low	Low	Medium
BAYAN LUMA I ELEMENTARY SCHOOL	Bayan Luma V	Medium	Medium	Medium
ABBEY DE SAINT AUGUSTINE SCHOOL	Bucandala V	Low	Medium	Medium
CARSADANG BAGO ELEMENTARY SCHOOL	Carsadang Bago II		Low	Low
MALAGASANG 1 ELEMENTARY SCHOOL	Malagasang I-E	Low	Medium	Medium
MONTESSORI SCHOOL	Malagasang I-G	Low	Medium	Medium
GOV. D. M. CAMERINO ELEMENTARY SCHOOL	Medicion II-E	Low	Medium	Medium
OUR LADY OF THE PILLAR CATHOLIC SCHOOL	Palico I			Low
DAY CARE CENTER	Palico II	Medium	Medium	Medium
ACADEMIA DE JULIA VICTORIA	Pasong Buaya II			
BUHAY NA TUBIG ELEMENTARY SCHOOL	Pasong Buaya II			
DAY CARE CENTER	Pasong Buaya II	Medium	Medium	Medium
GENERAL LICERIO TOPACIO NATIONAL HIGH SCHOOL	Pasong Buaya II			
MAHARLIKA ELEMENTARY SCHOOL	Pasong Buaya II			
PASONG BUAYA 2 ELEMENTARY SCHOOL	Pasong Buaya II			
SAINT FRANCIS INSTITUTE LEARNING AND BUSINESS HS	Pasong Buaya II			
SV MONTESSORI	Pasong Buaya II	Low	Low	Low

Cavite				
Imus				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
DEL PILAR ACADEMY	Poblacion I-A	Medium	Medium	Medium
OUR LADY OF THE PILLAR CATHOLIC SCHOOL	Poblacion II-B	Medium	Medium	Medium
BENEDICTINE INSTITUTE OF LEARNING	Poblacion III-A	Medium	Medium	Medium
ST. HILARY SCHOOL	Poblacion III-A	Medium	Medium	Medium
IMUS INSTITUTE - DIMASALANG CAMPUS	Poblacion IV-A	Medium	Medium	Medium
CAYETANO TOPACIO ELEMENTARY SCHOOL	Poblacion IV-B	Medium	High	High
IMUS INSTITUTE - DIMASALANG CAMPUS	Poblacion IV-B	Low	Medium	Medium
CAYETANO TOPACIO ELEMENTARY SCHOOL	Poblacion IV-C	High	High	High
IMUS LUMBER & HARDWARE	Poblacion IV-C	Medium	Medium	High
QUEEN OF ANGELS LEARNING CENTER	Tanzang Luma VI	Medium	Medium	Medium
TOCLONG 1-C ELEMENTARY SCHOOL	Toclong I-B	Medium	Medium	Medium
ST. HILARY SCHOOL	Toclong I-C	Medium	Medium	Medium
GOD'S VISION CHRISTIAN SCHOOL	Toclong II-A	Medium	Medium	Medium
GOV. D. M. CAMERINO ELEMENTARY SCHOOL	Toclong II-A	Medium	Medium	Medium
DAY CARE CENTER	Toclong II-B	Medium	High	High
LIGHTHOUSE SCIENCE HIGH SCHOOL	Toclong II-B	Low	Medium	Medium
ST. HILARY SCHOOL	Toclong II-B	Medium	Medium	Medium

Table A-12.4 Educational Institutions in Kawit, Cavite Affected by Flooding in the Imus Floodplain

Cavite				
Kawit				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
BINAKAYAN ELEMENTARY SCHOOL	Binakayan-Kanluran	Medium	Medium	Medium
DAY CARE CENTER	Manggahan-Lawin	High	High	High
BINAKAYAN ELEMENTARY SCHOOL	Samala-Marquez	Medium	Medium	Medium
BINAKAYAN ELEMENTARY SCHOOL	Toclong	Medium	Medium	High
TRAMO ELEMENTARY SCHOOL	Toclong	Medium	Medium	Medium

Annex 13. Health Institutions Affected in Imus Floodplain

Table A-13.1 Health Institutions in Bacoor, Cavite Affected by Flooding in the Imus Floodplain

Cavite				
Bacoor				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
CRISOSTOMO GENERAL HOSPITAL	Dulong Bayan	Medium	Medium	Medium
ANIMAL CLINIC	Habay I	Low	Medium	Medium
ST. CLAIR MATERNITY AND PEDIATRIC CLINIC	Habay I		Low	Medium
DENTAL CLINIC	Kaingin		Medium	Medium
MNS CLINIC	Kaingin		Medium	Medium
OB-GYN CLINIC	Maliksi I	Medium	Medium	High
HOSPITAL	Mambog I			
IMUS MEDICAL CENTER	Mambog I		Low	Low
METRO SOUTH MEDICAL CENTER	Molino II			
IMUS FAMILY HOSPITAL	Real I	Low	Medium	Medium
HEALTH CENTER	Salinas III	Low	Low	Medium

Table A-13.2 Health Institutions in Dasmariñas, Cavite Affected by Flooding in the Imus Floodplain

Cavite				
Dasmariñas				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
WELLCARE CLINIC AND LABORATORY	Burol			
DENTAL CLINIC	Salawag			
OPTICAL CLINIC	Salawag			
PARANAQUE ULTRASOUND DIAGNOSTIC CENTER, INC.	Salawag			
THE GENERICS PHARMACY	Salawag	Low	Low	Low
VIRATA MEDICAL CLINIC	Salawag			
MULTISPECIALTY AND DIAGNOSTIC CENTER	Salitran II			
HEALTH CENTER	Salitran III		Low	Low
ST. PAUL HOSPITAL	San Andres II			
BAHAY PAANAKAN	San Dionisio			
ST. PAUL HOSPITAL	San Francisco I			
DENTAL CLINIC	San Juan			
ST. PAUL HOSPITAL	Santa Cristina II			
OPTICAL	Santa Cruz I		Low	Low
RENTOSA MATERNITY AND LYING-IN CLINIC	Santo Niño I			

Table A-13.3 Health Institutions in Imus, Cavite Affected by Flooding in the Imus Floodplain

Cavite				
Imus				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
OUR LADY OF GUADALUPE HOSPITAL	Anabu I-A	Low	Low	Medium
ASIA MEDIC	Anabu II-D			Low
DENTAL CLINIC	Anabu II-F	Low	Low	Medium
DENTAL CLINIC	Bayan Luma IX	Low	Medium	Medium
OUR LADY OF THE PILLAR MEDICAL CENTER	Bayan Luma IX	Low	Medium	Medium
DENTAL CLINIC	Bayan Luma VI		Low	Low
DENTAL CLINIC	Bayan Luma VII		Low	Low
ORTHODENTAL CLINIC	Maharlika	Medium	Medium	Medium
OUR LADY OF THE PILLAR MEDICAL CENTER	Mariano Espeleta I	Low	Medium	Medium
E.B. ARGUELLES PHARMACY & GENERAL MERCHANDISE	Mariano Espeleta II	Medium	Medium	Medium
OUR LADY OF THE PILLAR MEDICAL CENTER	Mariano Espeleta II	Low	Medium	Medium
HEALTH CENTER	Medicion II-D	Low	Medium	Medium
HEALTH CENTER	Medicion II-E			
ORTHODENTAL CLINIC	Palico III	Medium	Medium	Medium
DENTAL CLINIC	Poblacion I-A	Medium	Medium	Medium
ASSISI VETERINARIAN CLINIC	Poblacion I-C	Medium	Medium	Medium
HEALTH CENTER	Poblacion II-B	Medium	Medium	Medium
VIRATA MEDICAL CLINCI	Poblacion III-B	Medium	High	High
SAGRADA FAMILIA MEDICAL CLINIC	Poblacion IV-B	Medium	High	High
VIRATA MEDICAL CLINIC	Poblacion IV-B	Medium	Medium	Medium
MEDS	Toclong I-C	Medium	Medium	Medium
VELARDE HEALTH CENTER	Toclong II-B	Low	Medium	Medium

Table A-13.4 Health Institutions in Kawit, Cavite Affected by Flooding in the Imus Floodplain

Cavite				
Kawit				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
HEALTH CENTER	Manggahan-Lawin	Medium	High	High
HEALTH 88	Toclong	Medium	Medium	High
SURGEON CLINIC	Toclong	Medium	High	High