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

# LiDAR Surveys and Flood Mapping of Ilang-ilang River

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

APRIL 2017

Published by the UP Training Center for Applied Geodesy and Photogrammetry (TCAGP)
College of Engineering
University of the Philippines – Diliman
Quezon City
1101 PHILIPPINES

This research project is supported by the Department of Science and Technology (DOST) as part of its Grants-in-Aid Program and is to be cited as:

E. C. Paringit and F. A. Uy (eds.) (2017), LiDAR Surveys and Flood Mapping of Ilang-ilang River, Quezon City: University of the Philippines Training Center on Applied Geodesy and Photogrammetry-290pp.

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National Library of the Philippines
ISBN: 978-621-430-049-5

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| | |
|---|---|
| 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 |
| NAMRIA | National Mapping and Resource Information Authority |
| NSTC | Northern Subtropical Convergence |
| PAF | Philippine Air Force |
| PAGASA | Philippine Atmospheric Geophysical and Astronomical Services Administration |
| PDOP | Positional Dilution of Precision |
| PPK | Post-Processed Kinematic [technique] |
| PRF | Pulse Repetition Frequency |
| PTM | Philippine Transverse Mercator |
| QC | Quality Check |
| QT | Quick Terrain [Modeler] |
| RA | Research Associate |
| RIDF | Rainfall-Intensity-Duration-Frequency |
| RMSE | Root Mean Square Error |
| SAR | Synthetic Aperture Radar |
| SCS | Soil Conservation Service |
| SRTM | Shuttle Radar Topography Mission |
| SRS | Science Research Specialist |
| SSG | Special Service Group |
| TBC | Thermal Barrier Coatings |
| UP-TCAGP | University of the Philippines – Training Center for Applied Geodesy and Photogrammetry |
| UTM | Universal Transverse Mercator |
| WGS | World Geodetic System |

# CHAPTER 1: OVERVIEW OF THE PROGRAM AND ILANG-ILANG RIVER

*Enrico C. Paringit, Dr. Eng., Dr. Francis Aldrine A. 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 in 2014” or Phil-LiDAR 1, supported by the Department of Science and Technology (DOST) Grants-in-Aid (GiA) Program. The program was primarily aimed at acquiring a national elevation and resource dataset at sufficient resolution to produce information necessary to support the different phases of disaster management. Particularly, it targeted to operationalize the development of flood hazard models that would produce updated and detailed flood hazard maps for the major river systems in the country.

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

The implementing partner university for the Phil-LiDAR 1 Program is the MAPUA 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 CALABARZON and Bicol Region. The university is located in Intramuros, Manila.

## 1.2 Overview of the Ilang-ilang River Basin

Ilang-Ilang River Watershed covers the municipalities of Imus, General Trias, and Dasmarinas. Its basin has a drainage area of 82 km2 and an estimated 131 million cubic meter (MCM) annual run-off. It is identified by the River Basin Control Office (RBCO) as one of the 140 Critical Watersheds in the Philippines. It supports the Pasong Kastila Dam, Butas Marcelo Dam, San Agustin Dam and Butas Navarro Dam, all located in the province of Cavite which irrigates a total of 2,853 has of agricultural land.

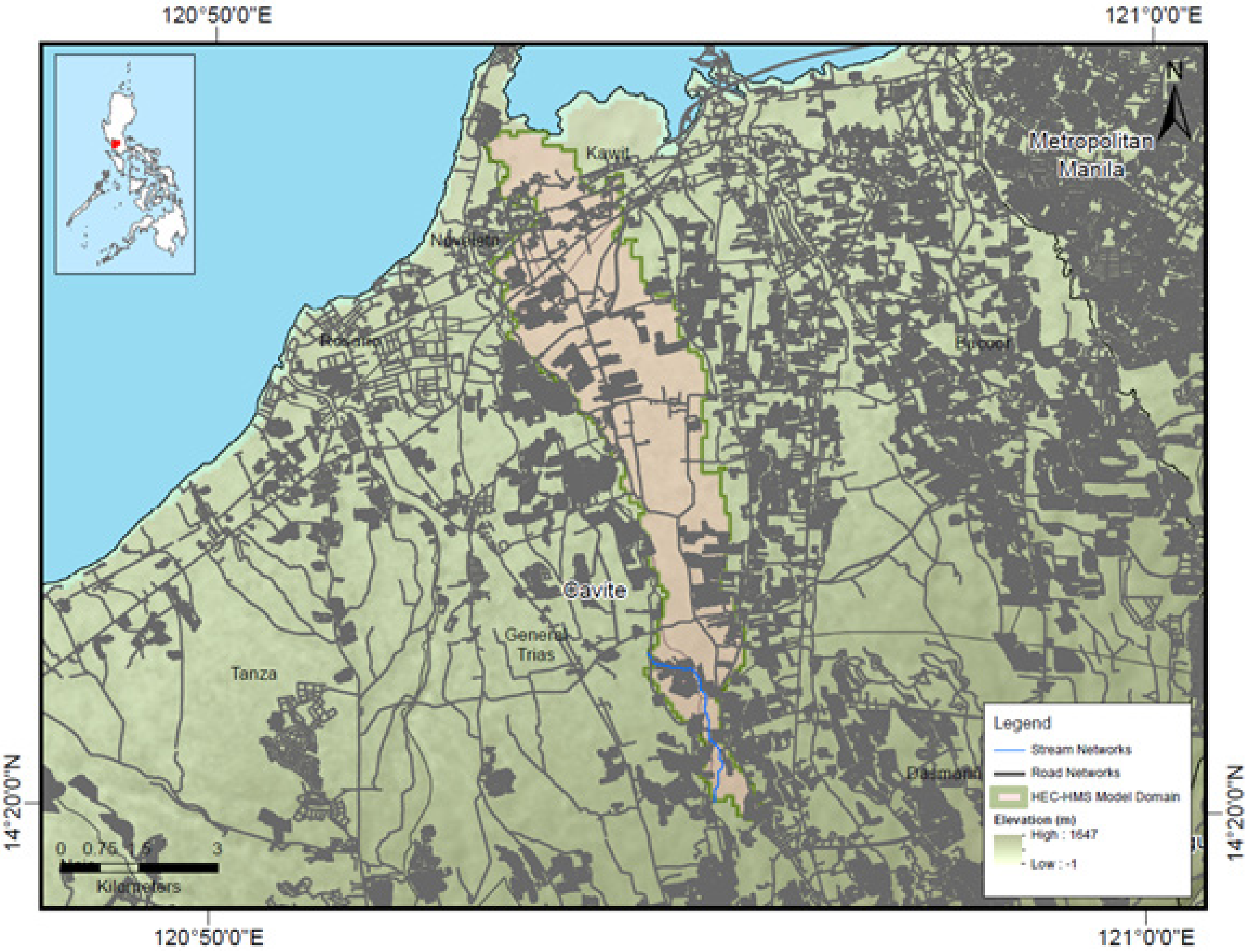

Figure 1. Map of the Ilang-ilang River Basin (in brown)

Its main stem, Ilang-Ilang River, is one of the six (6) major rivers in Cavite. Ilang-Ilang River is connected to San Juan (its point of origin) in the Municipality of San Gabriel. It meets San Juan River 4.8 kilometers from the mouth of the river. The river drains at Manila Bay. The HEI in charge of Ilang-Ilang River Basin and 23 other river basins located in Region 4 is Mapua Institue of Technology. The recent and most destructive flooding incident in Cavite was brought by Tropical Storm Maring on August 2013. Rainfall reached 475.4 mm which is more than the average monthly rainfall (457.4 mm) in Cavite. Areas in Cavite is also prone to storm surges because of the swelling of Manila Bay and Bacoor Bay.

# CHAPTER 2: LIDAR DATA ACQUISITION OF THE ILANG-ILANG 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

To initiate the LiDAR acquisition survey of the Ilang-Ilang floodplain, the Data Acquisition Component (DAC) created flight plans within the delineated priority area for Ilang-Ilang Floodplain in Cavite. These flight missions were planned for 8 lines and ran for at most three and a half hours (3.5) including take-off, landing and turning time. The flight planning parameters for Pegasus and Leica ALS-80 HP LiDAR systems are found in Table 1 and Table 2, respectively. Figure 2 shows the flight plan for Ilang-Ilang floodplain survey.

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

| Block Name | Flying Height (m AGL) | Overlap (%) | Field of view (ø) | Pulse Repetition Frequency (PRF) (kHz) | Scan Frequency (Hz) | Average Speed (kts) | Average Turn Time (Minutes) |
|---|---|---|---|---|---|---|---|
| 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 |
| BLK18 CF | 1100 | 30 | 50 | 200 | 30 | 130 | 5 |

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

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

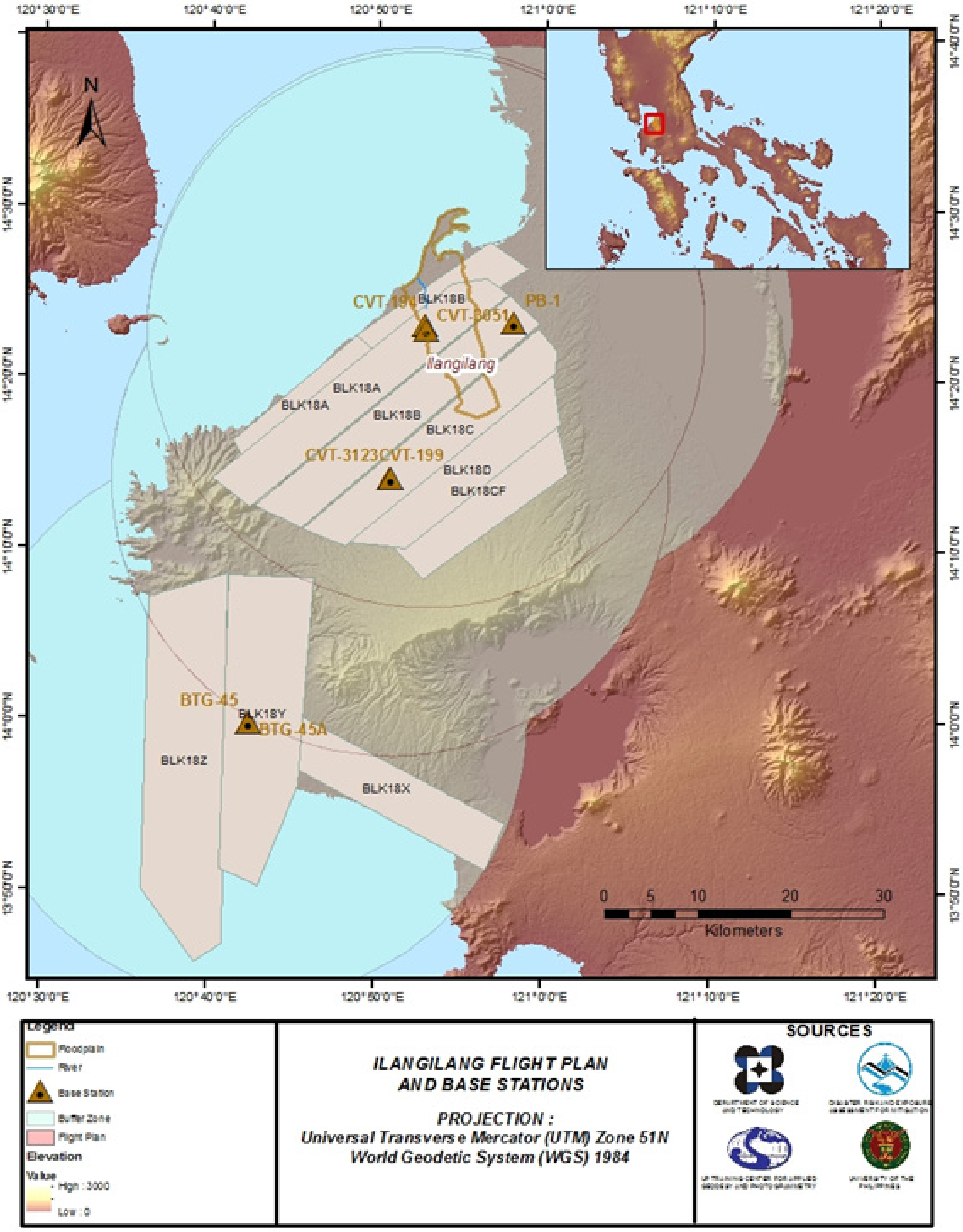


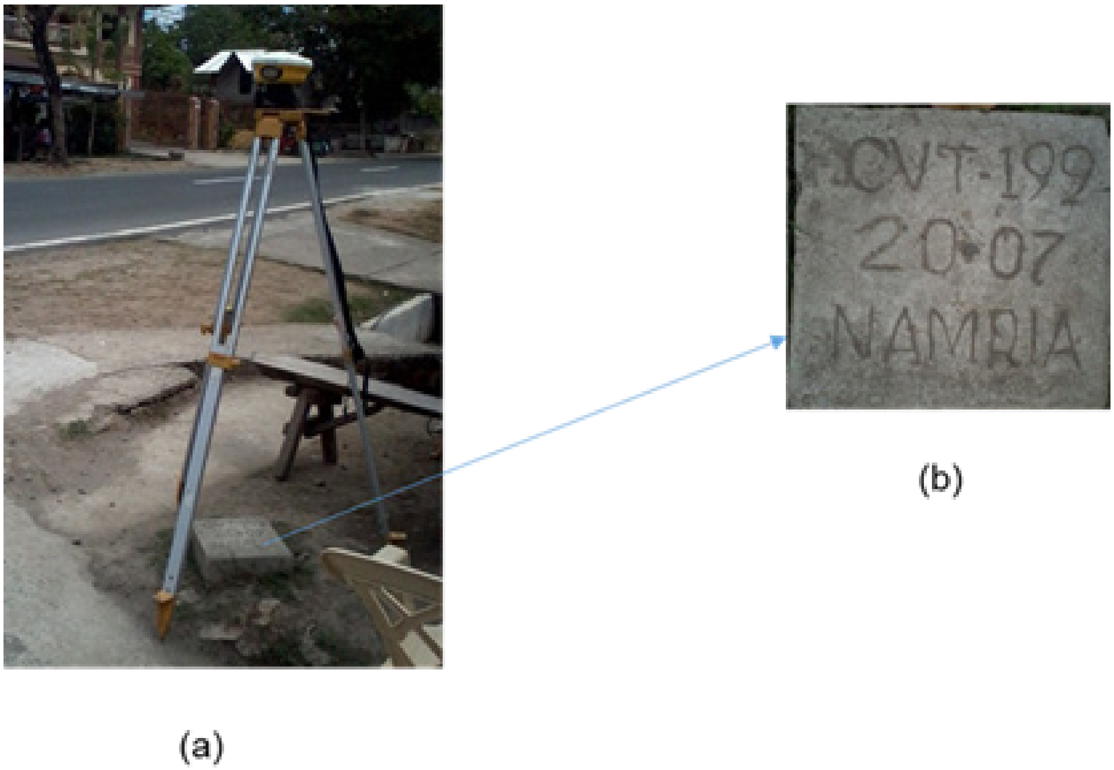
Figure 2. Flight plan and base stations for Ilang-Ilang floodplain.

## 2.2 Ground Base Stations

The project team was able to recover three (3) NAMRIA horizontal ground control points CVT-199, CVT-194, and BTG-45 which are of second (2nd) order accuracy. The project team also established four (4) ground control points PB-1, BTG- 45A, GC-1 and GC-2 and re-processed two (2) NAMRIA reference point CVT-3051 and CVT-3123.

The certifications for the base stations are found in Annex 2 while the baseline processing reports for the established control points are found in Annex 3. These were used as base stations during flight operations for the entire duration of the survey on June 9, 2014. Base stations were observed using dual frequency GPS receivers, TRIMBLE SPS 852 and SPS 985. Flight plans and location of base stations used during the aerial LiDAR acquisition in Ilang-Ilang floodplain are shown in Figure 2.

The succeeding sections depict the sets of reference points, control stations and established points, and the ground control points for the entire Ilang-Ilang Floodplain LiDAR Survey. Figure 3 to Figure 7 show the recovered NAMRIA reference points within the area of the floodplain, while Table 3 to Table 11 show the details about the following NAMRIA control stations and established points. Table 12, on the other hand, shows the list of all ground control points occupied during the acquisition together with the corresponding dates of utilization.



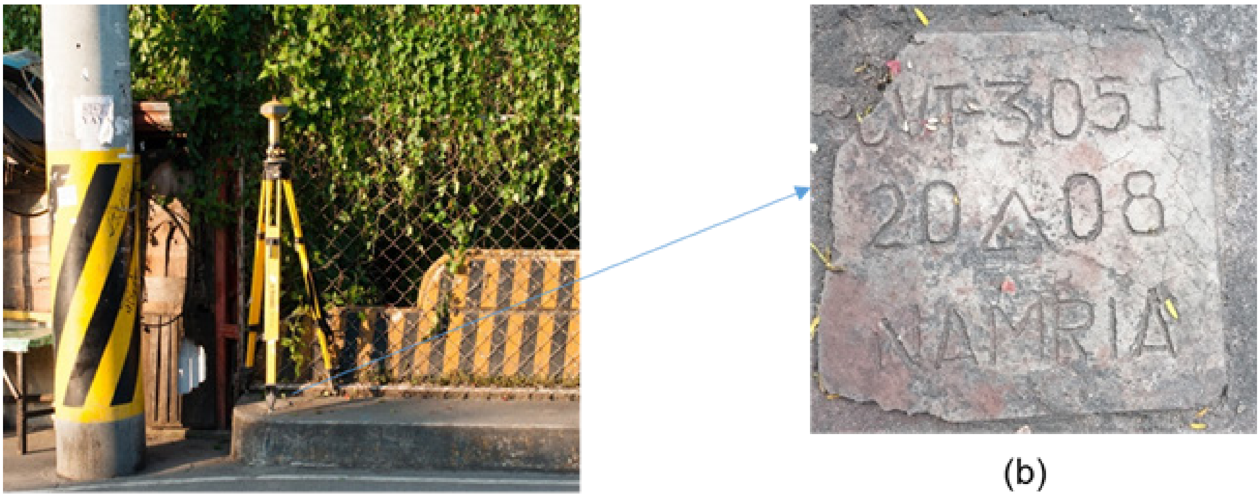
(a)

(b)

Figure 3. GPS set-up over CVT-199 found near the basketball covered court of Brgy. Calumpang Lejos (a) and NAMRIA reference point CVT-199 (b) as recovered by the field team.

Table 3. Details of the recovered NAMRIA horizontal control point CVT-199 used as base station for the LiDAR Acquisition.

| | | |
|---|---|---|
| **Station Name** | **CVT-199** | |
| **Order of Accuracy** | **2nd** | |
| **Relative Error (Horizontal positioning)** | **1:50,000** | |
| Geographic Coordinates, Philippine Reference 0f 1992 Datum (PRS 92) | Latitude<br>Longitude<br>Ellipsoidal Height | 14° 14' 16.32329" North<br>120° 50' 40.63536" East<br>166.20100 meters |
| Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92) | Easting<br>Northing | 1574493.218 meters<br>483231.789 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude<br>Longitude<br>Ellipsoidal Height | 14° 14' 10.97763" North<br>120° 50' 45.56096" East<br>210.38600 meters |
| Grid Coordinates, Philippine Transverse Mercator Zone 51 North (UTM 51N PRS 1992) | Easting<br>Northing | 267, 428.74 meters<br>1,575,012.80 meters |



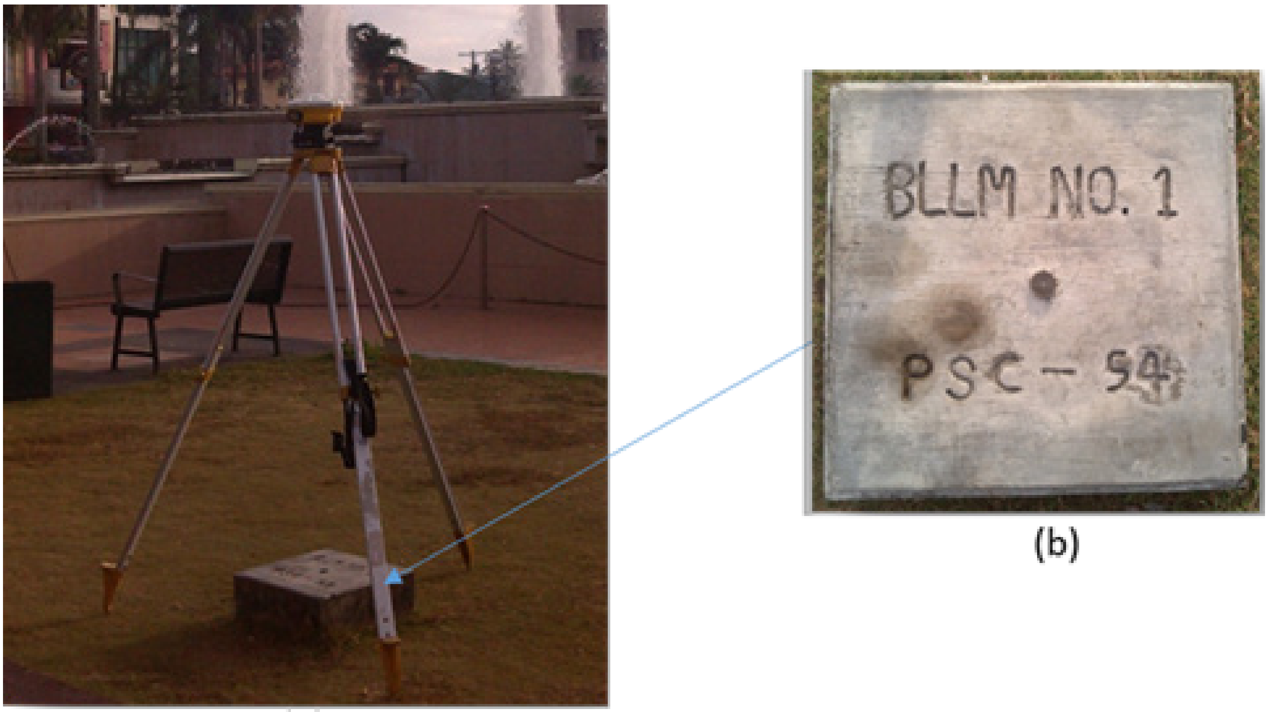
(a)

(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 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<br>Longitude<br>Ellipsoidal Height | 14° 22’ 58.33330” North<br>120° 52’ 44.06059”East<br>21.122 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude<br>Longitude<br>Ellipsoidal Height | 14° 22’52.95639” North<br>120° 52’ 48.97372 East”<br>64.983 meters |
| Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992 | Easting<br>Northing | 271276.565 meters<br>1591024.612 meters |



(a)

(b)

Figure 5. 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 5. 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 order** | |
| **Relative Error (horizontal positioning)** | **1:50,000** | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude<br>Longitude<br>Ellipsoidal Height | 14° 23’ 15.01186” North<br>120° 52’ 43.52184” East<br>18.337 meters |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Easting<br>Northing | 486924.253 meters<br>1591045.311 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude<br>Longitude<br>Ellipsoidal Height | 14°23 ’9.63386” North<br>120° 52’ 48.43458” East<br>62.184 meters |
| Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992) | Easting<br>Northing | 271265.13 meters<br>1591537.44 meters |

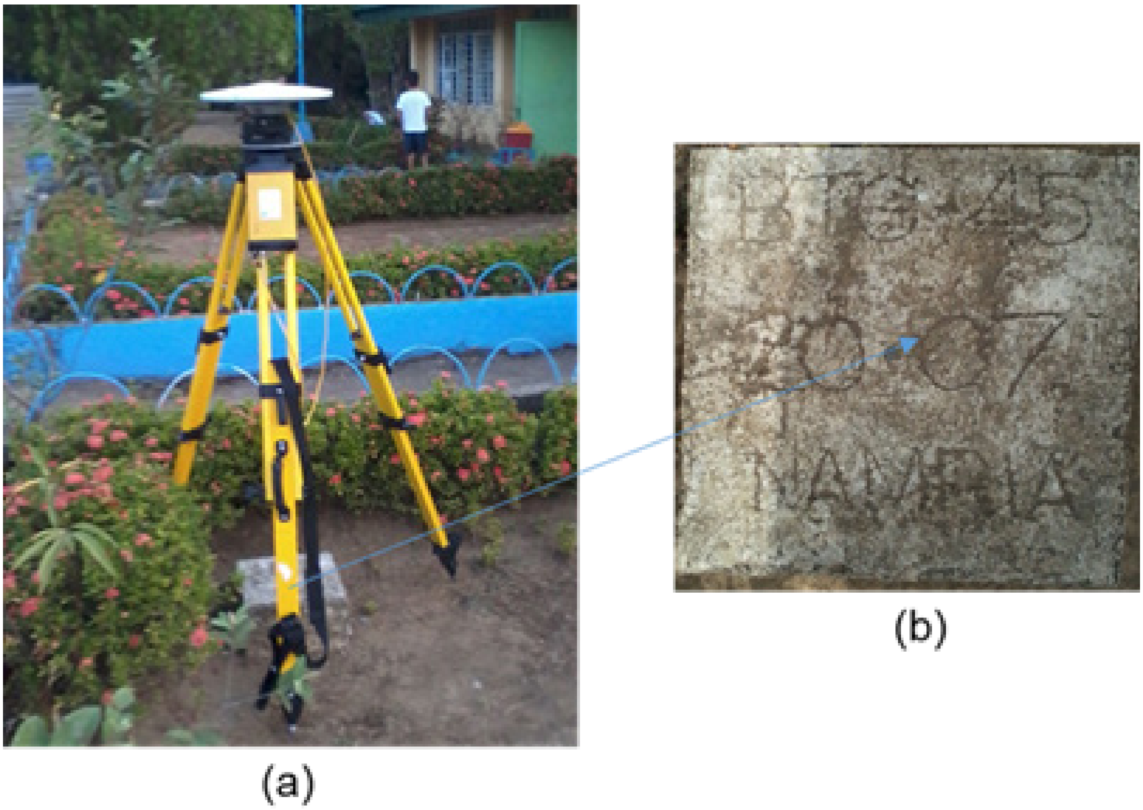


Figure 6. GPS set-up over BTG-45 inside Santiago De Guzman Elementary School of Brgy. Malibu, Tuy, Batangas Province (a) and NAMRIA reference point BTG-45 (b) as recovered by the field team.

Table 6. 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 order** | |
| **Relative Error (horizontal positioning)** | **1:50,000** | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92 | Latitude<br>Longitude<br>Ellipsoidal Height | 13° 59’ 52.18294” North<br>120° 42’ 18.96476” East<br>48.43000 meters |
| Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92) | Latitude<br>Longitude<br>Ellipsoidal Height | 468159.677 meters<br>1547952.281 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Easting<br>Northing | 13° 59’ 46.88216” North<br>120° 42’ 23.91169” East<br>92.94300 meters |

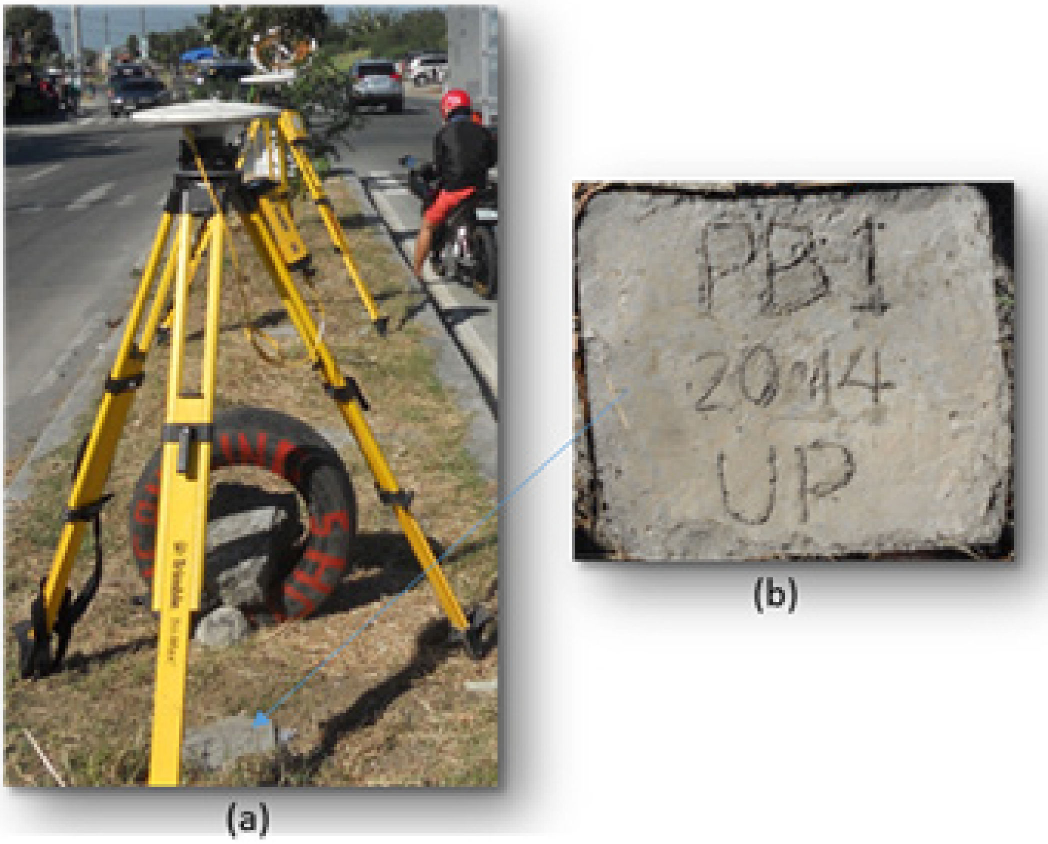


Figure 7. GPS set-up over PB-1 as established in an elevated traffic island in Daang Hari Road, Imus, Cavite (a) and reference point PB-1 (b) as established by the field team.

Table 7. 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 order** | |
| **Relative Error (horizontal positioning)** | **1:50,000** | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude<br>Longitude<br>Ellipsoidal Height | 14° 23’ 19.56635” North<br>120° 58’ 04.29835”East<br>87.568 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude<br>Longitude<br>Ellipsoidal Height | 14° 23’19.56635” North<br>120° 58’ 04.29835” East<br>87.568 meters |
| Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992) | Easting<br>Northing | 280881.093 meters<br>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 order** | |
| **Relative Error (horizontal positioning)** | **1:50,000** | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude<br>Longitude<br>Ellipsoidal Height | 13° 59’ 51.95603” North<br>120° 42’ 18.98286 ” East<br>49.08900 meters |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Easting<br>Northing | 252126.100 meters<br>1548584.818 meters |
| Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992) | Easting<br>Northing | 13° 59’ 46.65526” North<br>120° 42’ 23.92980” East<br>93.60200 meters |

Table 9. Details of the established control point GC-1 with processed coordinates used as base station for the LiDAR Acquisition.

| **Station Name** | **GC-1** | |
|---|---|---|
| **Order of Accuracy** | **2nd order** | |
| **Relative Error (horizontal positioning)** | **1:50,000** | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude<br>Longitude<br>Ellipsoidal Height | 14° 22’ 02.99339” North<br>120° 55’ 39.25400” East<br>37.855 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude<br>Longitude<br>Ellipsoidal Height | 14° 21’57.62404” North<br>120° 55’ 44.43458”East<br>81.878 meters |
| Grid Coordinates, Universal Transverse Mercator Zone 51 North<br>(UTM 51N PRS 1992) | Easting<br>Northing | 276510.990 meters<br>1589275.842 meters |

Table 10. Details of the established control point GC-2 with processed coordinates used as base station for the LiDAR Acquisition.

| | | |
|---|---|---|
| **Station Name** | **GC-2** | |
| **Order of Accuracy** | **2nd order** | |
| **Relative Error (horizontal positioning)** | **1:50,000** | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude<br>Longitude<br>Ellipsoidal Height | 14° 22’ 03.22135” North<br>120° 55’ 39.22621” East<br>38.103 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude<br>Longitude<br>Ellipsoidal Height | 14° 21’57.85198” North<br>120° 55’ 44.14039” East<br>82.125 meters |
| Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992) | Easting<br>Northing | 276510.220 meters<br>1589282.856 meters |

Table 11. 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 order** | |
| **Relative Error (horizontal positioning)** | **1:50,000** | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude<br>Longitude<br>Ellipsoidal Height | 14° 14’ 15.59521” North<br>120° 50’ 41.86474” East<br>167.527 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude<br>Longitude<br>Ellipsoidal Height | 14° 14’10.24962” North<br>120° 50’ 46.79435” East<br>211.713 meters |
| Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992) | Easting<br>Northing | 267465.517 meters<br>1574990.072 meters |

Table 12. Ground control points used during the LiDAR data acquisition.

| Date Surveyed | Flight Number | Mission Name | Ground Control Points |
|---|---|---|---|
| 27 January 2014 | 1027P | 1BLK18A025A | PB-1 and CVT-194 |
| 29 January 2014 | 1043P | 1BLK18AS029A | 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 |
| 28 February 2014 | 1039P | 1BLK18B028A | PB-1 and CVT-194 |
| 18 Aug 2015 | 3309P | 1BLK18AsS230A | CVT-3051 and CVT-199 |
| 3 May 2016 | 10136L | 4BLK18A124A | CVT-199 and CVT-3123 |
| 6 May 2016 | 10142L | 4BLK18AB127A | CVT-199 and CVT-3123 |
| 7 May 2016 | 10144L | 4BLK18ABS128A | CVT-199 and CVT-3123 |
| 16 June 2016 | 23462P | 1BLK18CFS168A | GC-1 and GC-2 |

## 2.3 Flight Missions

A total of ten (10) missions were conducted to complete the LiDAR data acquisition in Ilang-Ilang floodplain, for a total of thirty three hours and thirty three minutes (33+33) of flying time for RP-C9022 and RP-C9522. All missions were acquired using the Pegasus and Leica ALS-80 HP LiDAR systems. As shown below, the total area of actual coverage per mission and the corresponding flying hours are depicted in Table 13, while the actual parameters used during the LiDAR data acquisition are presented in Table 14.

Table 13. Flight missions for LiDAR data acquisition in Ilang-Ilang 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 |
| 27 January 2014 | 1027P | 601.14 | 127.08 | 12.18 | 114.9 | 167 | 3 | 23 |
| 29 January 2014 | 1043P | 601.14 | 64.43 | 5.54 | 58.89 | NA | 2 | 23 |
| 3 February 2014 | 1063P | 601.14 | 33.67 | NA | 33.67 | 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 | 19.76 | 170.25 | NA | 3 | 17 |
| 18 Aug 2015 | 3309P | 347.2 | 113.85 | 17.89 | 95.96 | 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 | 21.65 | 68.08 | 506 | 3 | 58 |
| 7 May 2016 | 10144L | 166.75 | 53.34 | 9.28 | 44.06 | 195 | 3 | 28 |
| 16 June 2016 | 23462P | 1480.4 | 124.32 | NA | 124.32 | NA | 3 | 35 |
| | | **5254.86** | **1142.89** | **86.3** | **1056.59** | **2369** | **33** | **33** |

Table 14. Actual parameters used during LiDAR data acquisition.

| Flight Number | Flying Height (m AGL) | Overlap (%) | FOV (θ) | PRF (khz) | Scan Frequency (Hz) | Average Speed (kts) | Average Turn Time (Minutes) |
|---|---|---|---|---|---|---|---|
| 1027P | 1000 | 30 | 50 | 200 | 30 | 130 | 5 |
| 1043P | 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 |
| 10144L | 1500 | 30 | 45 | 128 | 42 | 130 | 5 |
| 23462P | 1000 | 60 | 50 | 200 | 32 | 130 | 5 |
| 23104P | 1000/ 1200 | 30 | 50 | 200 | 30 | 130 | 5 |
| 23128P | 1000 | 30 | 50 | 200 | 30 | 130 | 5 |
| 23602P | 1200 | 30 | 50 | 200 | 30 | 130 | 5 |

## 2.4 Survey Coverage

This certain LiDAR acquisition survey covered the Ilang-Ilang floodplain (See Annex 7). It is located along the provinces of Batangas, Cavite, Laguna and Metro Manila with majority of the floodplain situated within the municipalities of Cavite. Most of the municipalities of Naic and Tanza in Cavite are fully covered during the survey. The list of municipalities and cities surveyed, with at least one (1) square kilometer coverage, is shown in Table 15. Figure 8, on the other hand, shows the actual coverage of the LiDAR acquisition for the Ilang-Ilang floodplain.

Table 15. List of municipalities and cities surveyed during Ilang-Ilang floodplain LiDAR survey.

| Province | Municipality/ City | Area of Municipality/City (km2) | Total Area Surveyed (km2) | Percentage of Area Surveyed |
|---|---|---|---|---|
| Batangas | Taal | 29.37 | 25.22 | 85.85% |
| | 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% |
| | San Luis | 42.04 | 1.61 | 3.83% |
| | Nasugbu | 266.83 | 2.10 | 0.77% |
| Cavite | Naic | 76.11 | 75.78 | 99.57% |
| | Tanza | 71.41 | 71.03 | 99.46% |
| | General Trias | 85.98 | 71.63 | 83.32% |
| | Imus | 56.81 | 44.25 | 77.89% |
| | Trece Martires City | 44.35 | 34.13 | 76.96% |
| | Indang | 88.65 | 57.81 | 65.22% |
| | Maragondon | 147.39 | 94.37 | 64.03% |
| | Dasmariñas | 84.01 | 45.88 | 54.61% |
| | Amadeo | 45.90 | 24.18 | 52.68% |
| | Rosario | 4.89 | 2.54 | 51.92% |
| | Bacoor | 47.43 | 24.16 | 50.93% |
| | General Emilio Aguinaldo | 39.39 | 16.55 | 42.03% |
| | Magallanes | 69.07 | 20.54 | 29.73% |
| | Ternate | 44.52 | 12.72 | 28.57% |
| | Silang | 154.00 | 40.74 | 26.45% |
| | Noveleta | 5.72 | 1.20 | 21.03% |
| Laguna | San Pedro | 21.41 | 1.42 | 6.62% |
| National Capital Region | Las Piñas | 33.19 | 3.97 | 11.97% |
| | | 38.52 | 5.19 | 13.46% |
| Total | | 1975.43 | 822.46 | 44.26% |

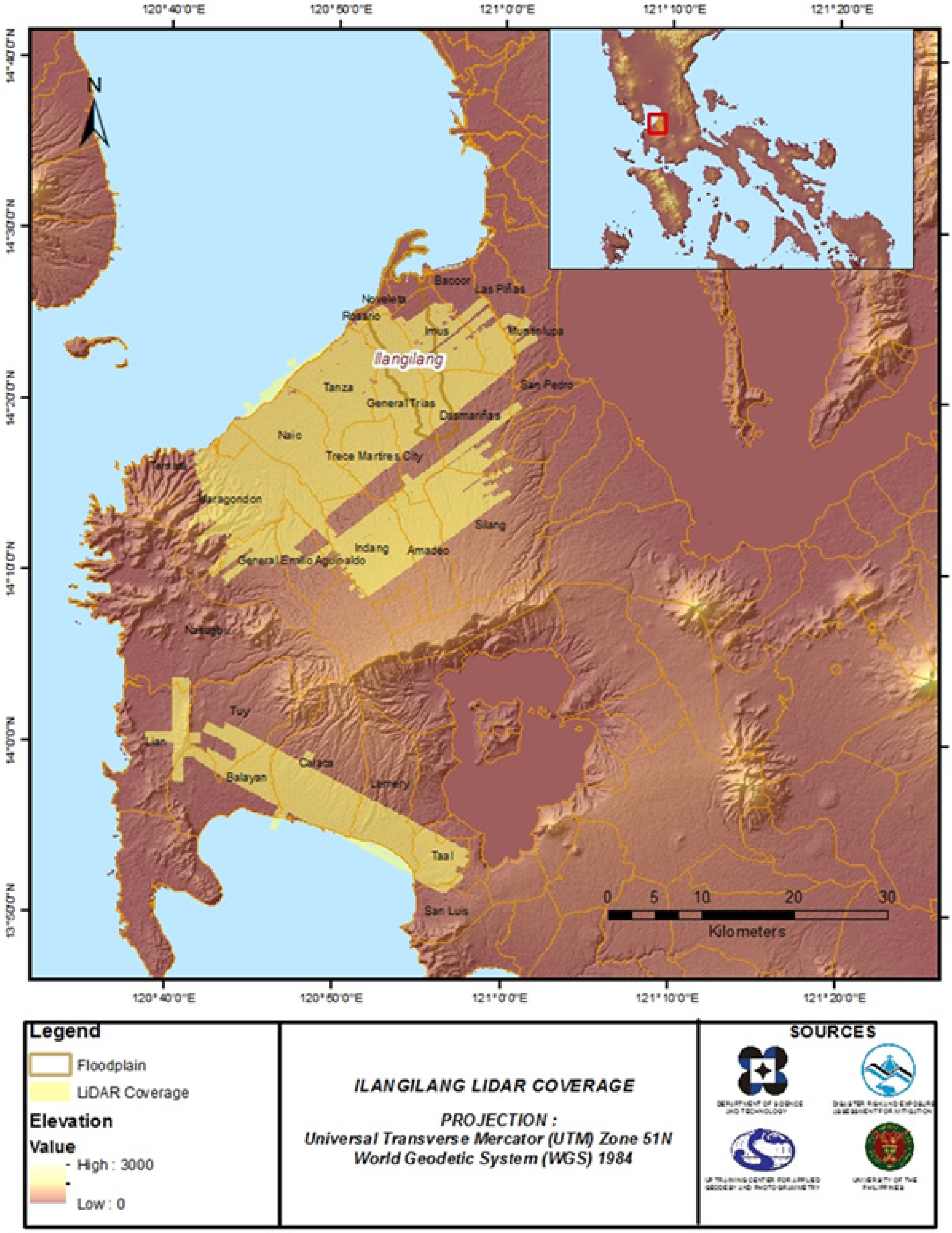


Figure 8. Actual LiDAR survey coverage for Ilang-Ilang floodplain.

# CHAPTER 3: LIDAR DATA PROCESSING FOR ILANG-ILANG 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 the LiDAR Data Pre-Processing

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

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

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

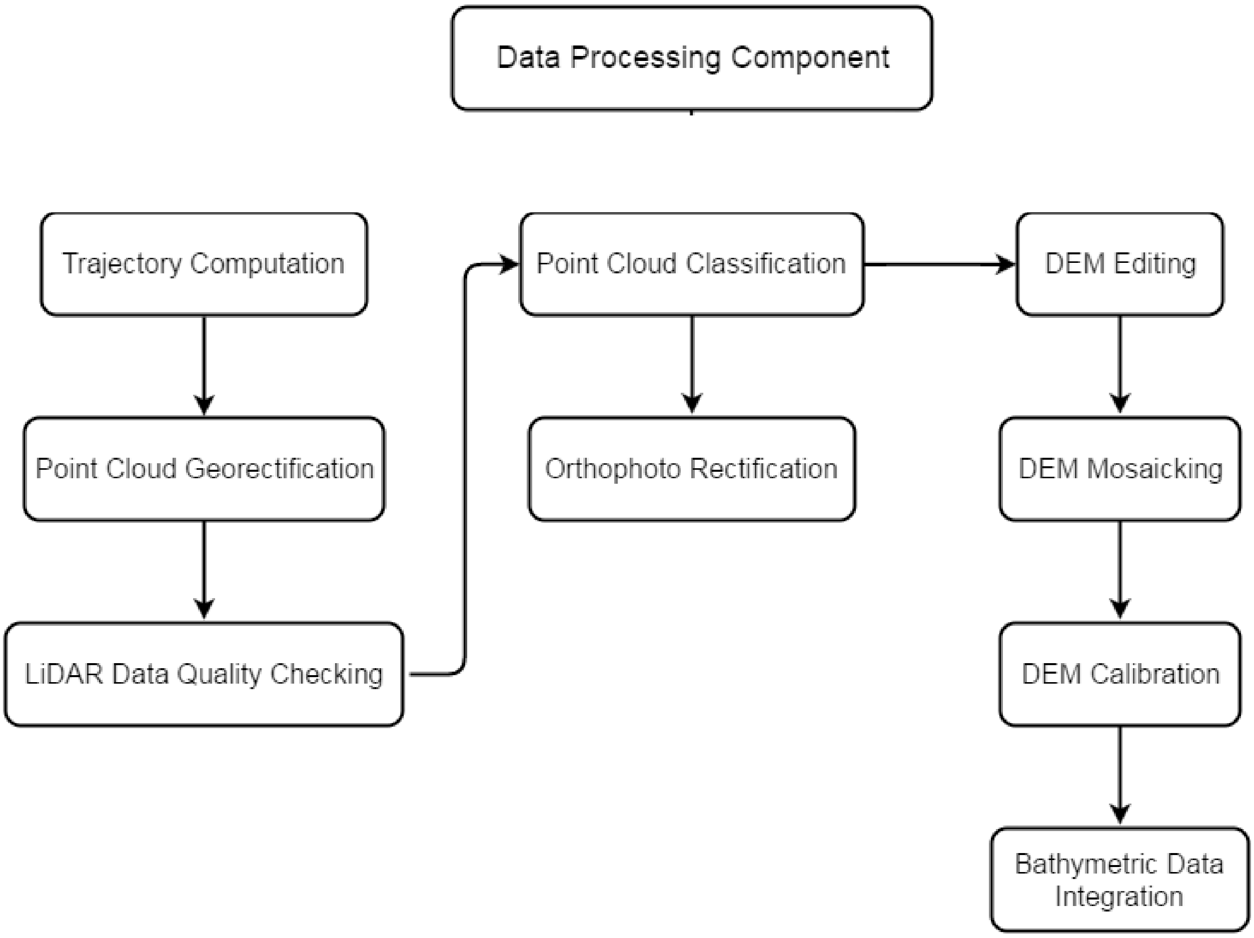


Figure 9. Schematic diagram for the data pre-processing.

## 3.2 Transmittal of Acquired LiDAR Data

Data transfer sheets for all the LiDAR missions for Ilang-Ilang floodplain can be found in Annex A-5. Data Transfer Sheets. Missions flown during the first and second survey conducted on January 2014 and August 2015 used the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.) Pegasus system and lastly, the third survey was done on May 2016 using the Leica system over CALABARZON.

The Data Acquisition Component (DAC) transferred a total of 116.78 Gigabytes of Range data, 1.44 Gigabytes of POS data, and 369.01 Megabytes of GPS base station data, and 55.65 Gigabytes of Image data to the data server from January 25, 2014 up to August 18, 2015 for Optech LiDAR systems while a total of 19.46 Gigabytes of RawLaser data, 1377 Megabytes of GNSSIMU data, 355 Megabytes of base station data and 89.7 Gigabytes of RCD30 raw image data were transferred on May 3, 2016 for Leica LiDAR system. The Data Pre-processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for Ilang-Ilang was fully transferred on July 14, 2016, as indicated on the Data Transfer Sheets for Ilang-Ilang floodplain.

## 3.3 Trajectory Computation

The Smoothed Performance Metrics of the computed trajectory for Flight 23462P, one of the Ilang-Ilang flights, which is the North, East, and Down position RMSE values are shown in Figure 10. The x-axis corresponds to the time of flight, which is measured by the number of seconds from the midnight of the start of the GPS week, which on that week fell on July 14, 2016 00:00AM. The y-axis is the RMSE value for that particular position.

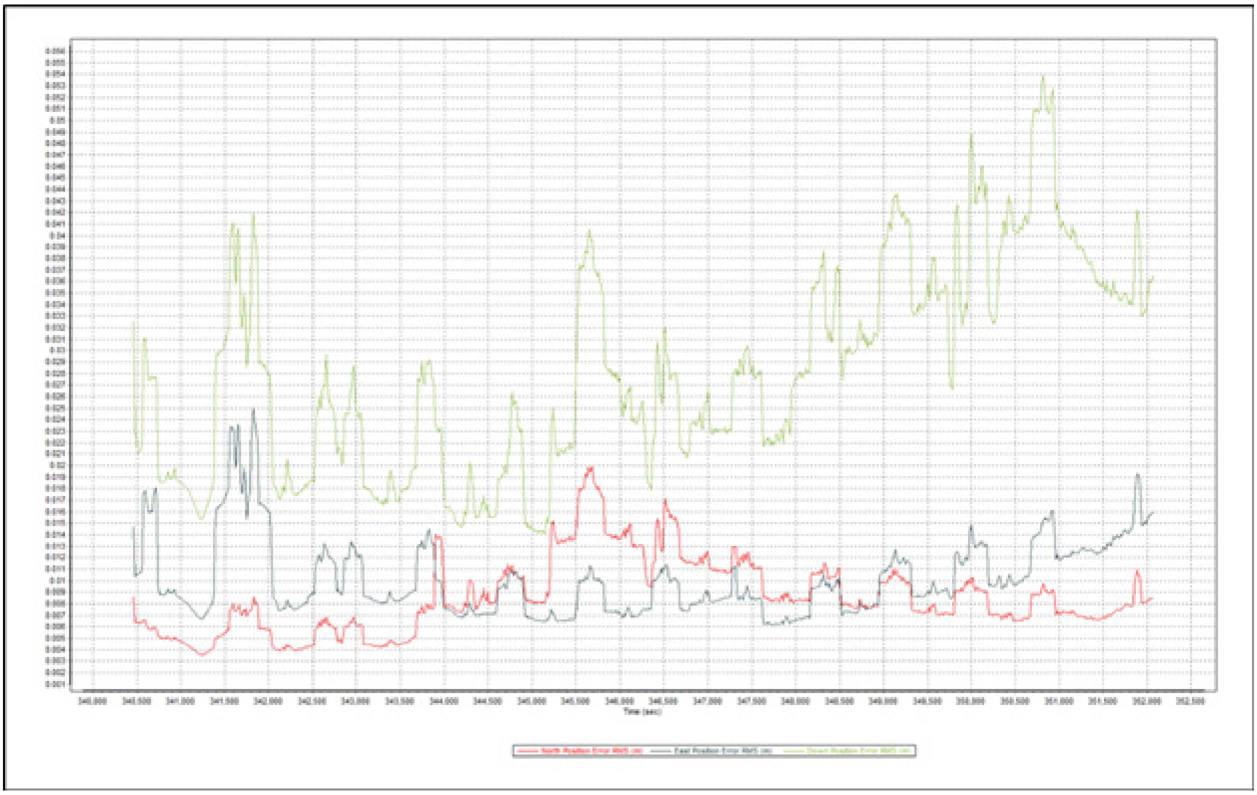


Figure 10. Smoothed Performance Metrics of Ilang-Ilang Flight 23462P.

The time of flight was from 340,000 seconds to 352,500 seconds, which corresponds to morning of July 14, 2016. The initial spike that is seen on the data corresponds to the time that the aircraft was getting into position to start the acquisition, and the POS system starts computing for the position and orientation of the aircraft.

Redundant measurements from the POS system quickly minimized the RMSE value of the positions. The periodic increase in RMSE values from an otherwise smoothly curving RMSE values correspond to the turn-around period of the aircraft, when the aircraft makes a turn to start a new flight line. Figure 10 shows that the North position RMSE peaks at 2 centimeters, the East position RMSE peaks at 2.5 centimeters, and the Down position RMSE peaks at 5.4 centimeters, which are within the prescribed accuracies described in the methodology.

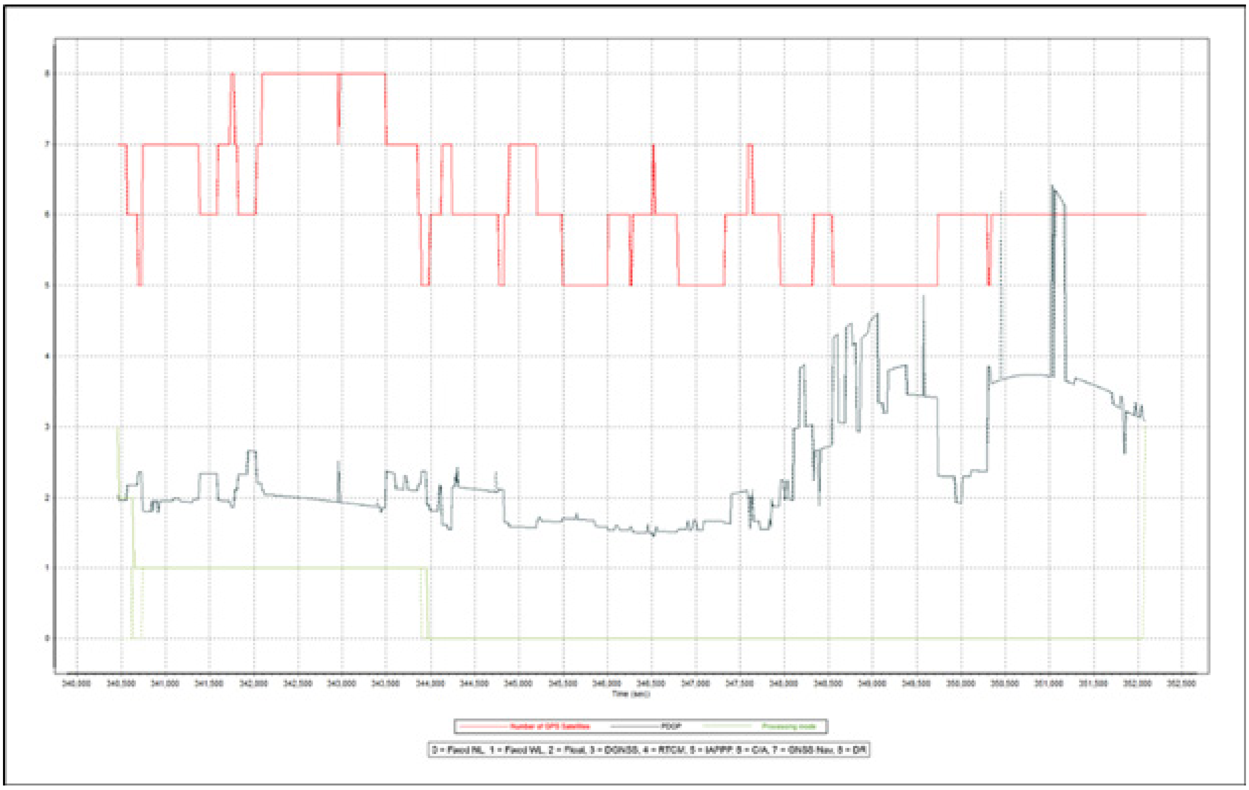


Figure 11. Solution Status Parameters of Ilang-Ilang Flight 23462P.

The Solution Status parameters, which indicate the number of GPS satellites; Positional Dilution of Precision (PDOP); and the GPS processing mode used for Ilang-Ilang Flight 23462P are shown in Figure 11. For the Solution Status parameters, the figure above signifies that the number of satellites utilized and tracked during the acquisition were between 5 and 8, not going lower than 6. Similarly, the PDOP value did not go above the value of 3, which indicates optimal GPS geometry. The processing mode remained at 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 Ilang-Ilang flights is shown in Figure 12.

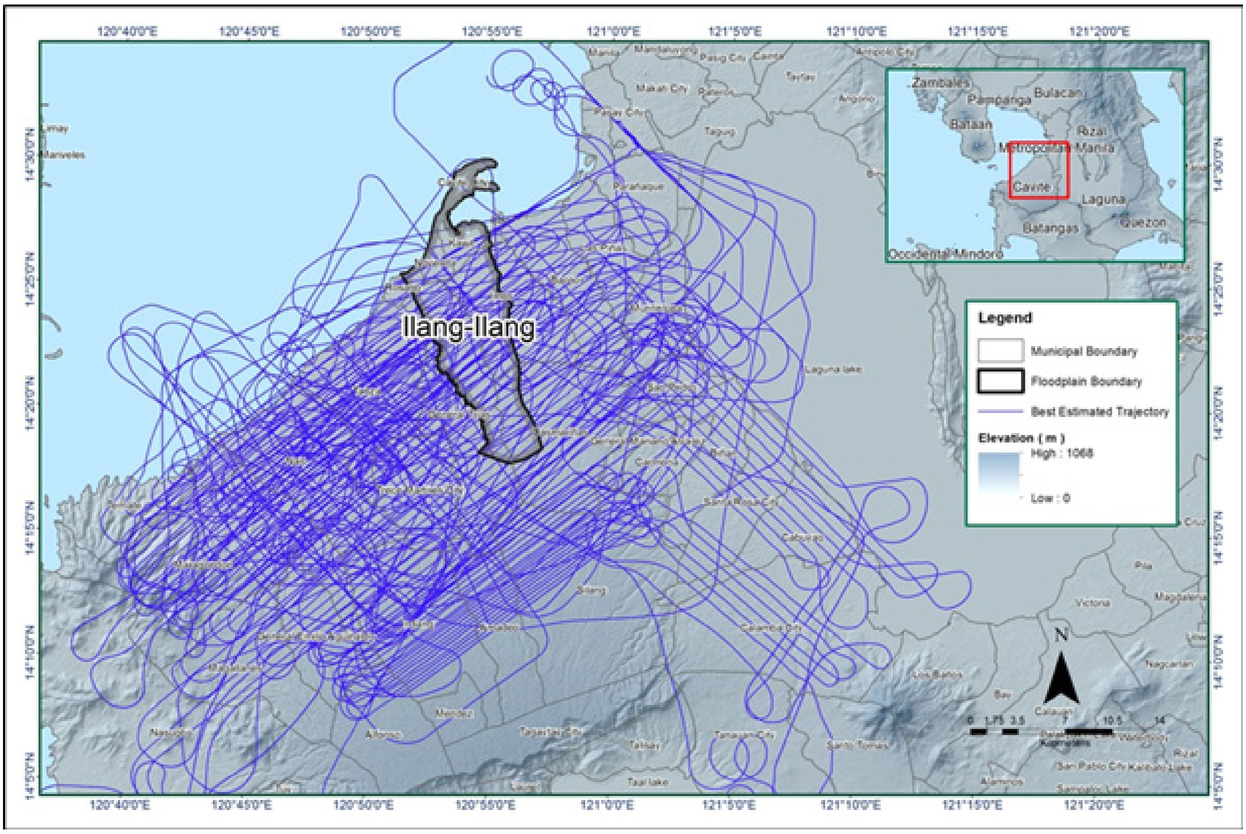


Figure 12. Best estimated trajectory of the LiDAR missions conducted over the Ilang-Ilang Floodplain.

## 3.4 LiDAR Point Cloud Computation

The produced LAS contains 115 flight lines, with each flight line containing two channels, since the Pegasus and Leica systems both employ two channels. The summary of the self-calibration results obtained from LiDAR processing in LiDAR Mapping Suite (LMS) software for all flights over Iang-Ilang floodplain are given in Table 16.

Table 16. Self-calibration Results values for Ilang-Ilang flights.

| Parameter | Acceptable Value | Computed Value |
|---|---|---|
| Boresight Correction stdev) | <0.001degrees | 0.000798 |
| IMU Attitude Correction Roll and Pitch Corrections stdev) | <0.001degrees | 0.000357 |
| GPS Position Z-correction stdev) | <0.01meters | 0.0010 |

The optimum accuracy is obtained for all Ilang-Ilang flights based on the computed standard deviations of the corrections of the orientation parameters. The standard deviation values for individual blocks are presented in the Mission Summary Reports (Annex 8).

## 3.5 LiDAR Data Quality Checking

The boundary of the processed LiDAR data is shown in Figure 13. The map shows gaps in the LiDAR coverage that are attributed to cloud coverage.

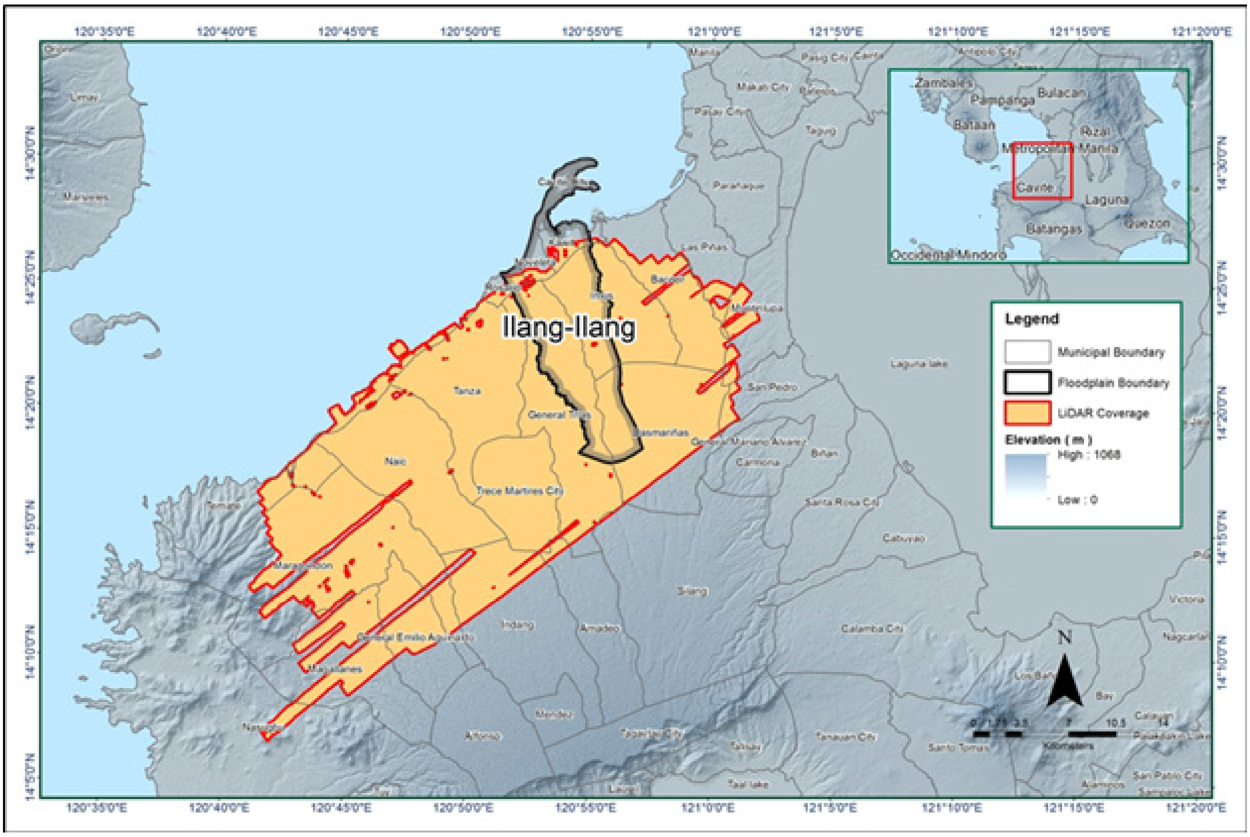


Figure 13. Boundary of the processed LiDAR data on top of the SAR Elevation Data over the Ilang-Ilang Floodplain.

A total area of 1,136.33 square kilometers (sq. kms.) were covered by the Ilang-Ilang flight missions as a result of twelve (12) flight acquisitions, which were grouped and merged into twelve (12) blocks accordingly, as portrayed in Table 17.

Table 17. List of LiDAR blocks for the Ilang-Ilang floodplain.

| **LiDAR Blocks** | **Flight Numbers** | **Area (sq. km)** |
|---|---|---|
| CALABARZON_Blk18B_supplement | 3309P | 106.91 |
| Cavite_Blk18AB | 1035P | 127.12 |
| Cavite_Blk18A_supplement | 1043P | 56.96 |
| Cavite_Blk18A_supplement2 | 1139P | 99.62 |
| Cavite_Blk18C | 1039P | 117.91 |
| Cavite_Blk18C_additional | 1039P | 210.76 |
| | 1063P | |
| Cavite_Blk18B_supplement | 1027P | 125.39 |
| CALABARZON_reflights_Blk18A | 10136L | 229.66 |
| | 10142L | |
| CALABARZON_reflights_Blk18A_supplement | 10144L | 53.33 |
| CALABARZON_reflights_Blk18B_supplement1 | 10321L | 5.66 |
| CALABARZON_reflights_Blk18B_supplement2 | 10321L | 1.00 |
| CALABARZON_reflights_Blk18B_supplement5 | 10321L | 2.01 |
| **Total** | | **1,136.33 sq.km** |

The overlap data for the merged LiDAR blocks, showing the number of channels that pass through a particular location is shown in Figure 14. Since the 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.

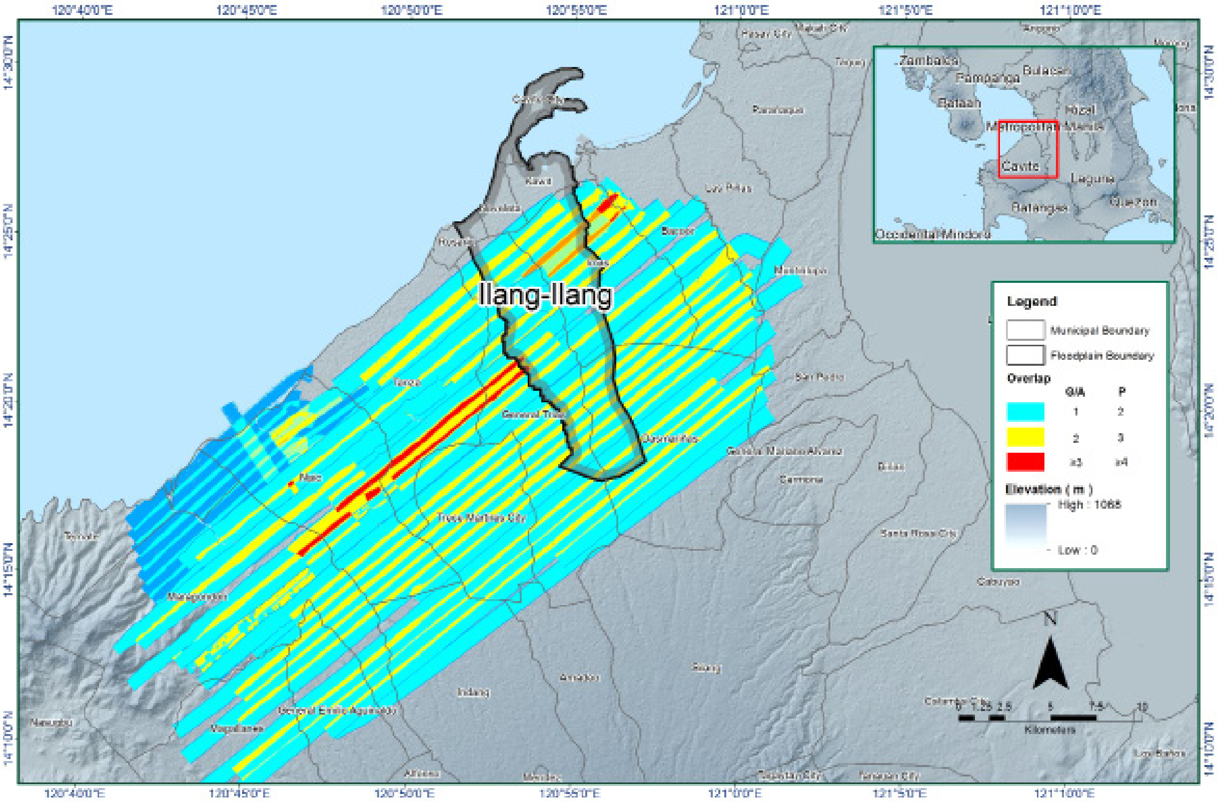


Figure 14. Image of data overlap for Ilang-Ilang floodplain.

The overlap statistics per block for the Ilang-Ilang floodplain can be found in the Mission Summary Reports (Annex 8). One pixel corresponds to 25.0 square meters on the ground. For this area, the percent overlap is 38.08% and 67.14% respectively, which passed the 25% requirement.

The pulse density map for the merged LiDAR data, with the red parts showing the portions of the data that satisfy the two (2) points per square meter criterion is shown in Figure 15. As seen in the figure below, it was determined that all LiDAR data for the Ilang-Ilang. Floodplain Survey satisfied the point density requirement, as the average density for the entire survey area is 4.81points per square meter.

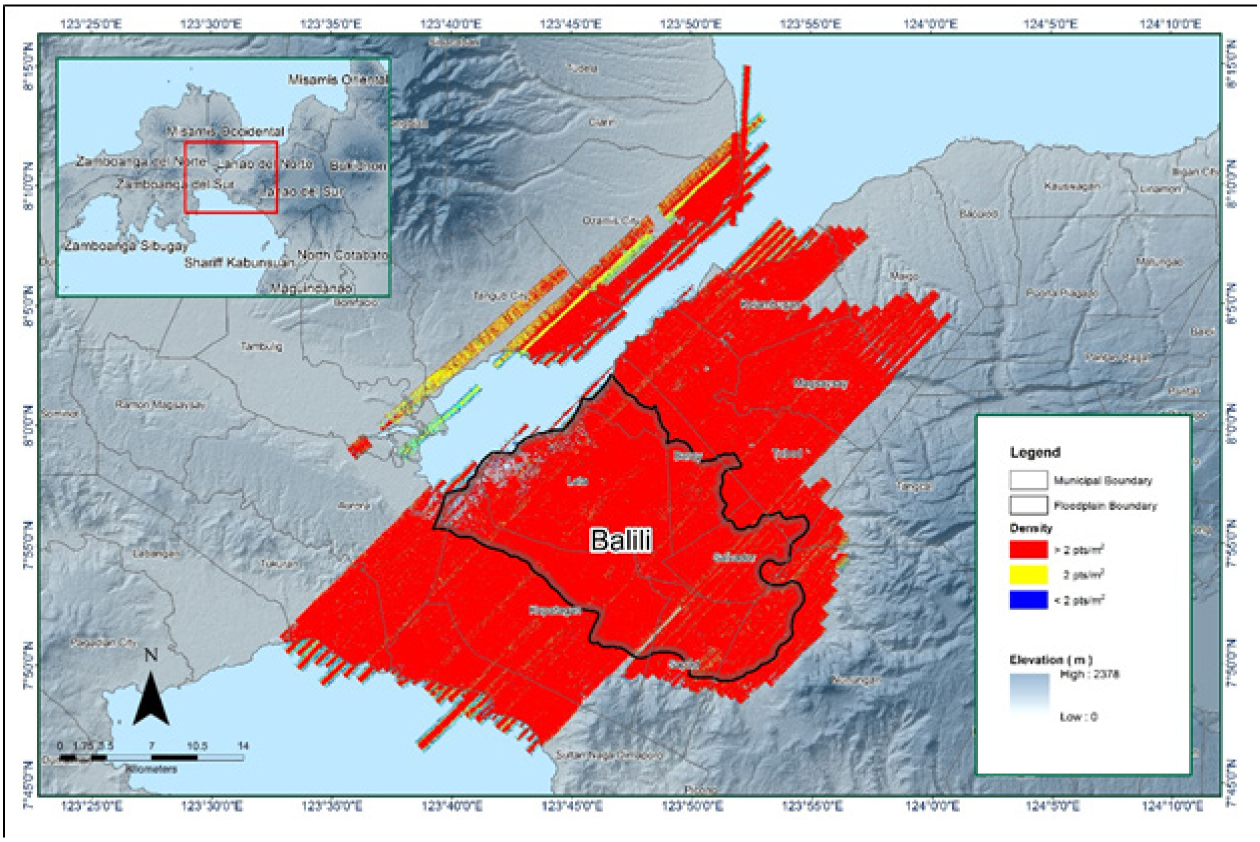


Figure 15. Pulse density map of the merged LiDAR data for Ilang-Ilang floodplain.

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

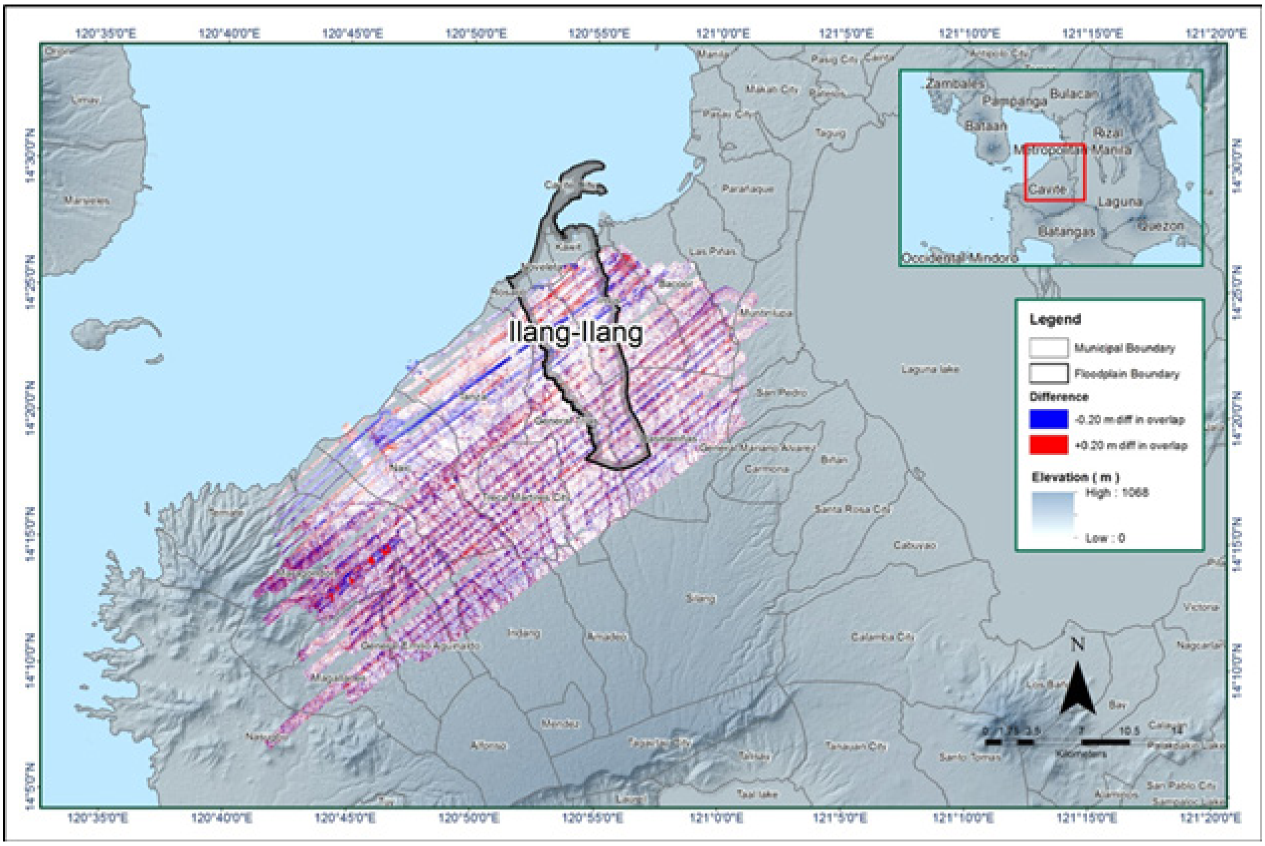


Figure 16. Elevation difference Map between flight lines for the Ilang-Ilang Floodplain Survey.

A screen capture of the processed LAS data from Ilang-Ilang flight 23462P loaded in QT Modeler is shown in Figure 17. The upper left image shows the elevations of the points from two overlapping flight strips traversed by the profile, illustrated by a dashed red line. The x-axis corresponds to the length of the profile. It is evident that there are differences in elevation, but the differences do not exceed the 20-centimeter mark. This profiling was repeated until the quality of the LiDAR data becomes satisfactory. No reprocessing was done for this LiDAR dataset.

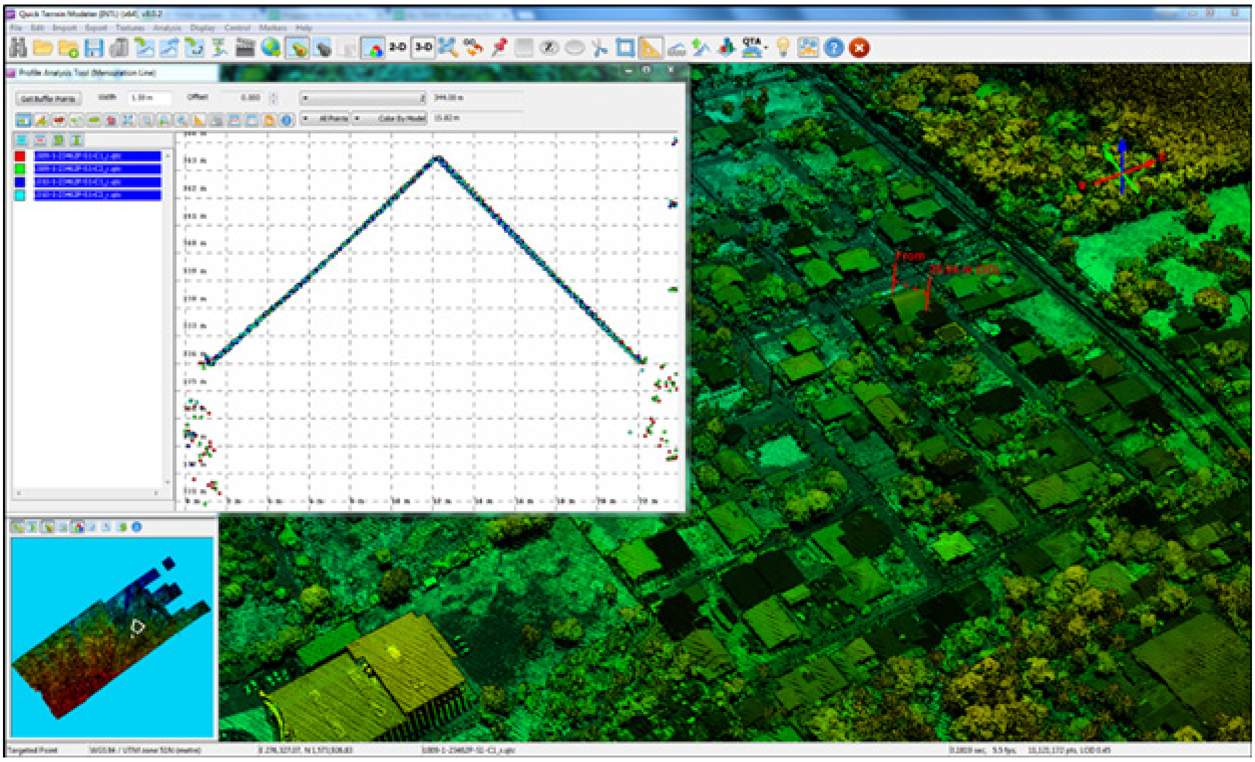


Figure 17. Quality checking for Ilang-Ilang flight 23462P using the Profile Tool of QT Modeler.

## 3.6 LiDAR Point Cloud Classification and Rasterization

Table 18. Ilang-Ilang  classification results in TerraScan.

| Pertinent Class | Total Number of Points |
|---|---|
| Ground | 1,039,448,240 |
| Low Vegetation | 838,944,668 |
| Medium Vegetation | 923,621,916 |
| High Vegetation | 738,089,176 |
| Building | 220,643,500 |

The tile system that TerraScan employed for the LiDAR data and the final classification image for a block in Ilang-Ilang floodplain is shown in Figure 18. A total of 1,346 1km by 1km tiles were produced. Correspondingly, Table 18 summarizes the number of points classified to the pertinent categories. The point cloud has a maximum and minimum height of 460.70 meters and 45.20 meters respectively.

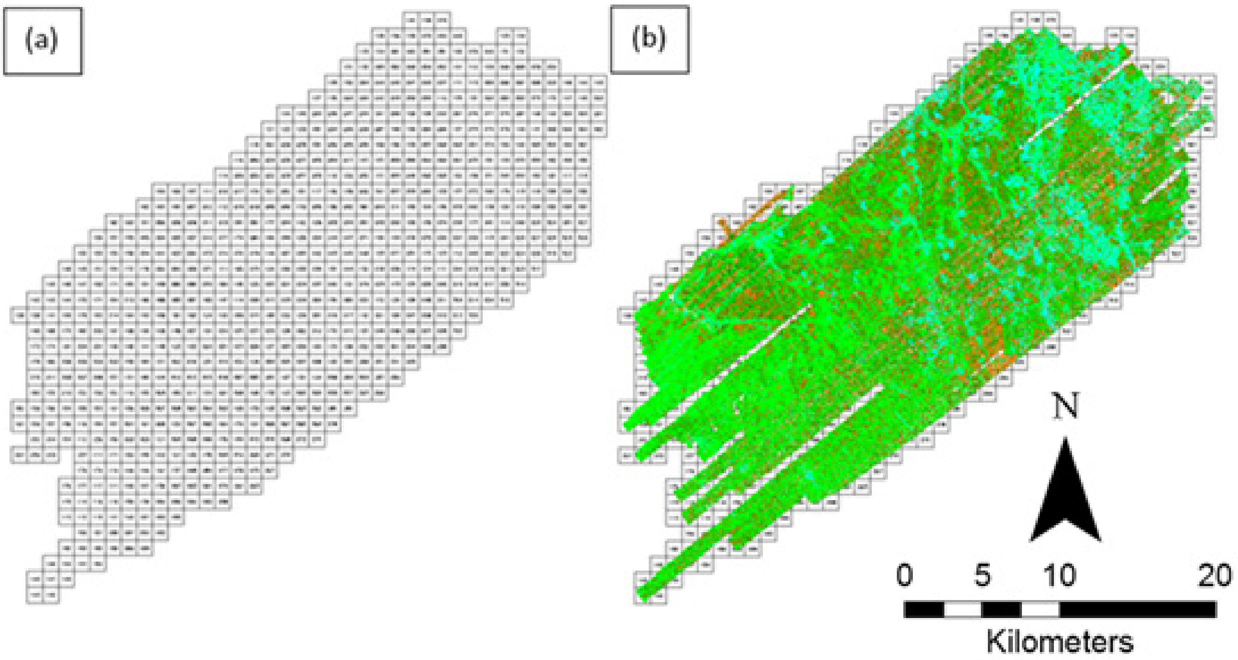


Figure 18. Tiles for Ilang-Ilang floodplain (a) and classification results (b) in TerraScan.

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

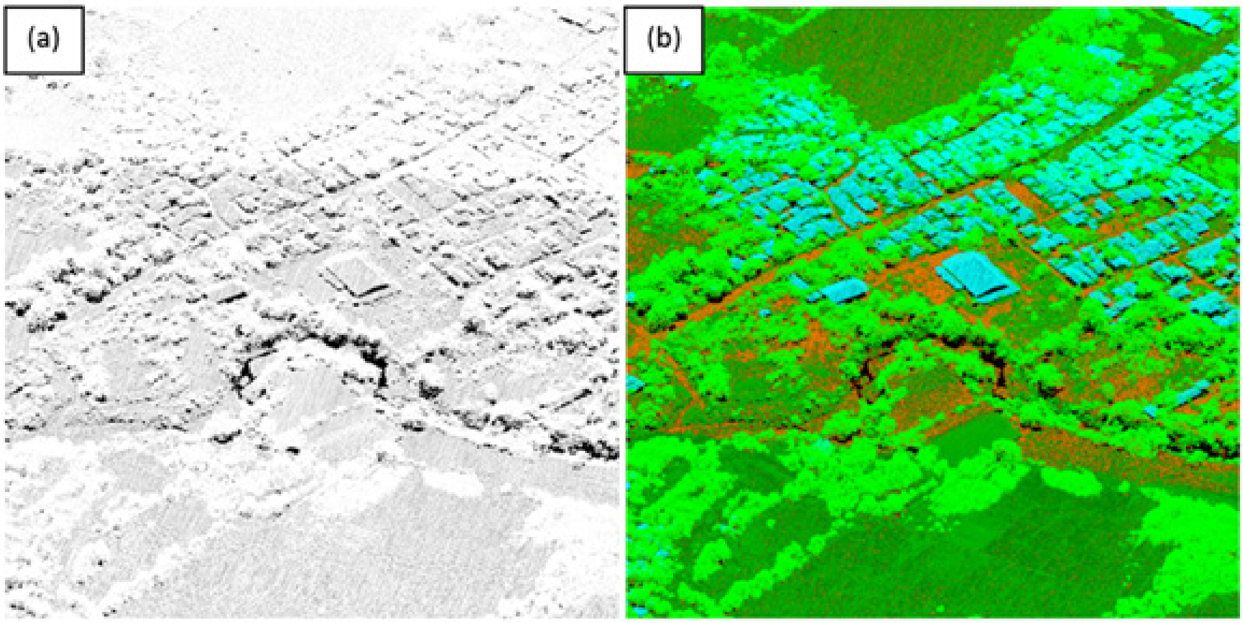


Figure 19. Point cloud before (a) and after (b) classification.

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

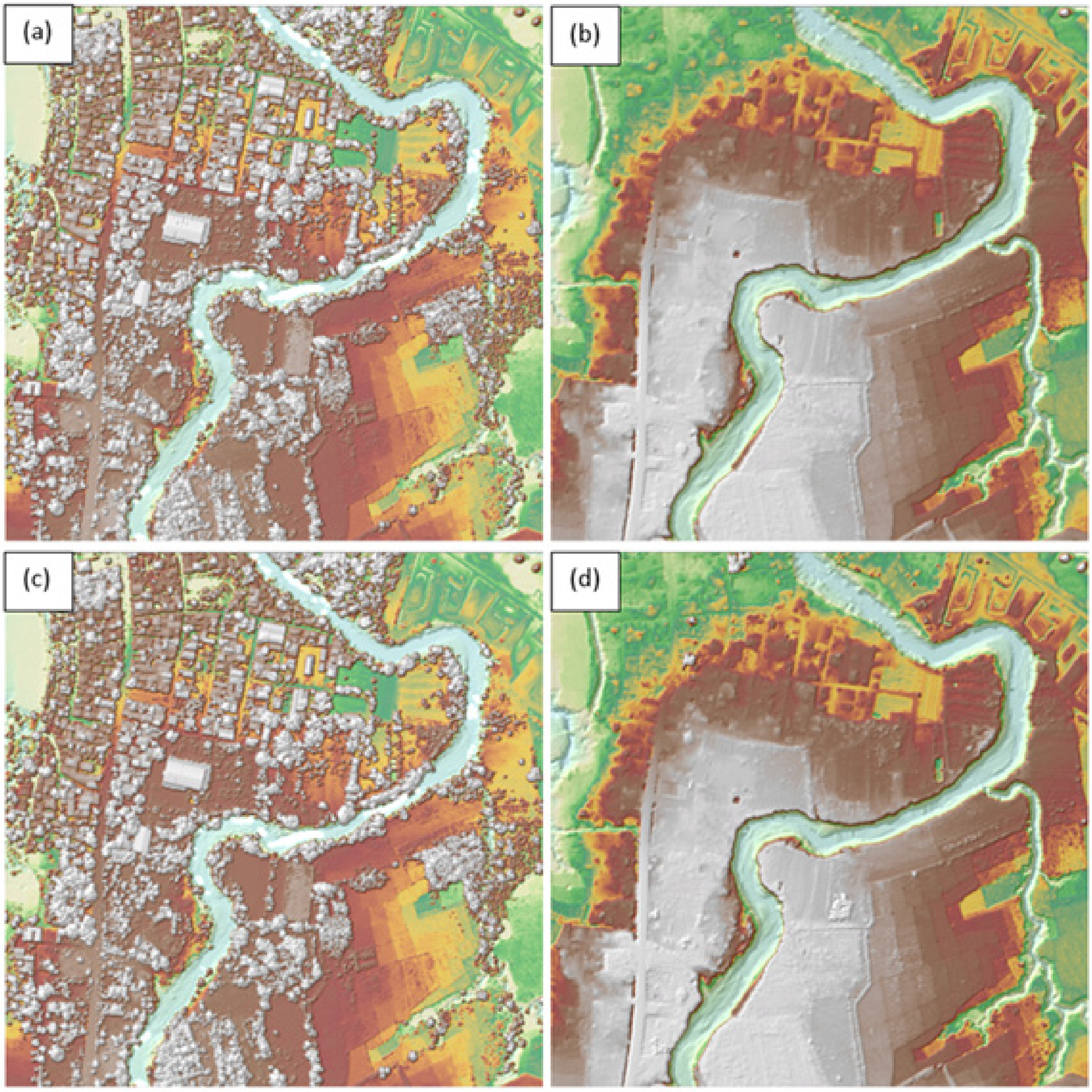


Figure 20. The production of last return DSM (a) and DTM (b), first return DSM (c) and secondary DTM (d) in some portion of Ilang-Ilang floodplain.

## 3.7 LiDAR Image Processing and Orthophotograph Rectification

The 2761km by 1km tiles area covered by Ilang-Ilang floodplain is shown in Figure 21. After tie point selection to fix photo misalignments, color points were added to smoothen out visual inconsistencies along the seamlines where photos overlap. The Ilang-Ilang 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 22.

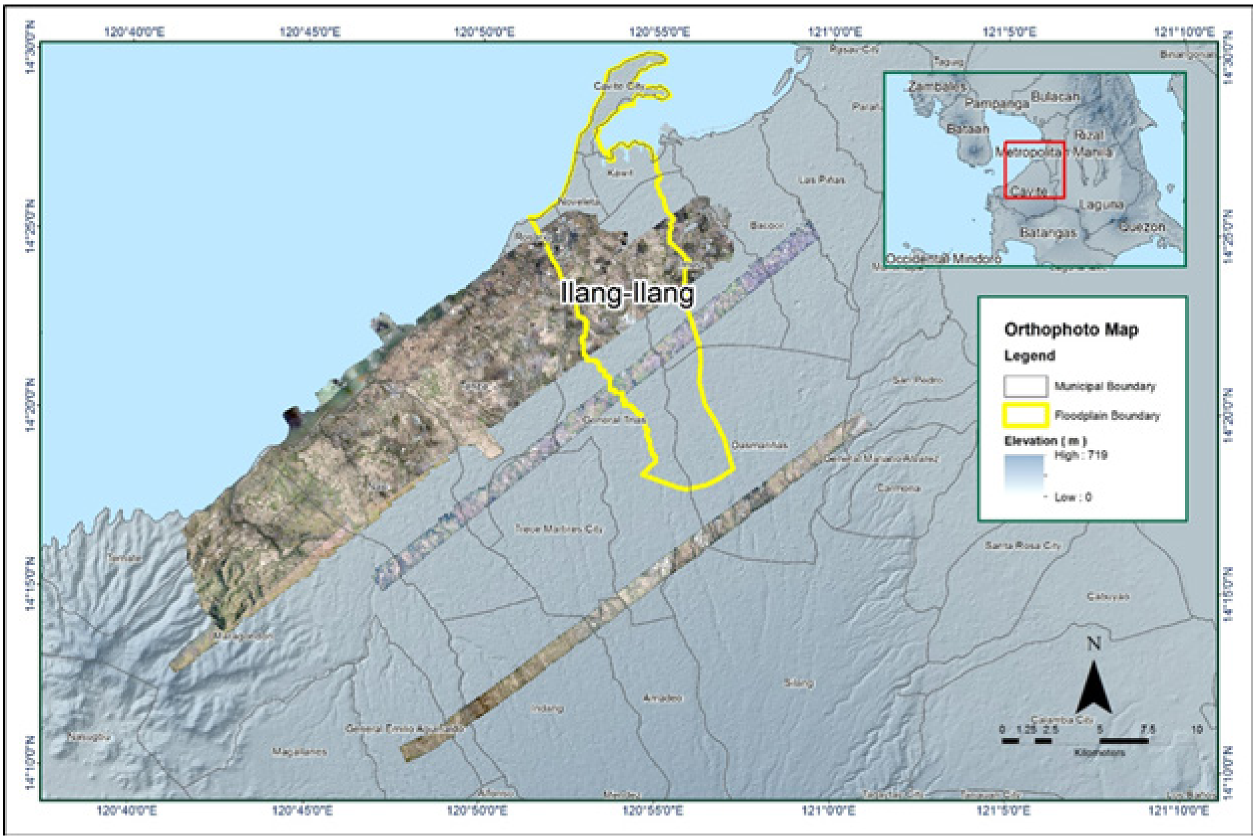


Figure 21. Ilang-Ilang floodplain with the available orthographs.

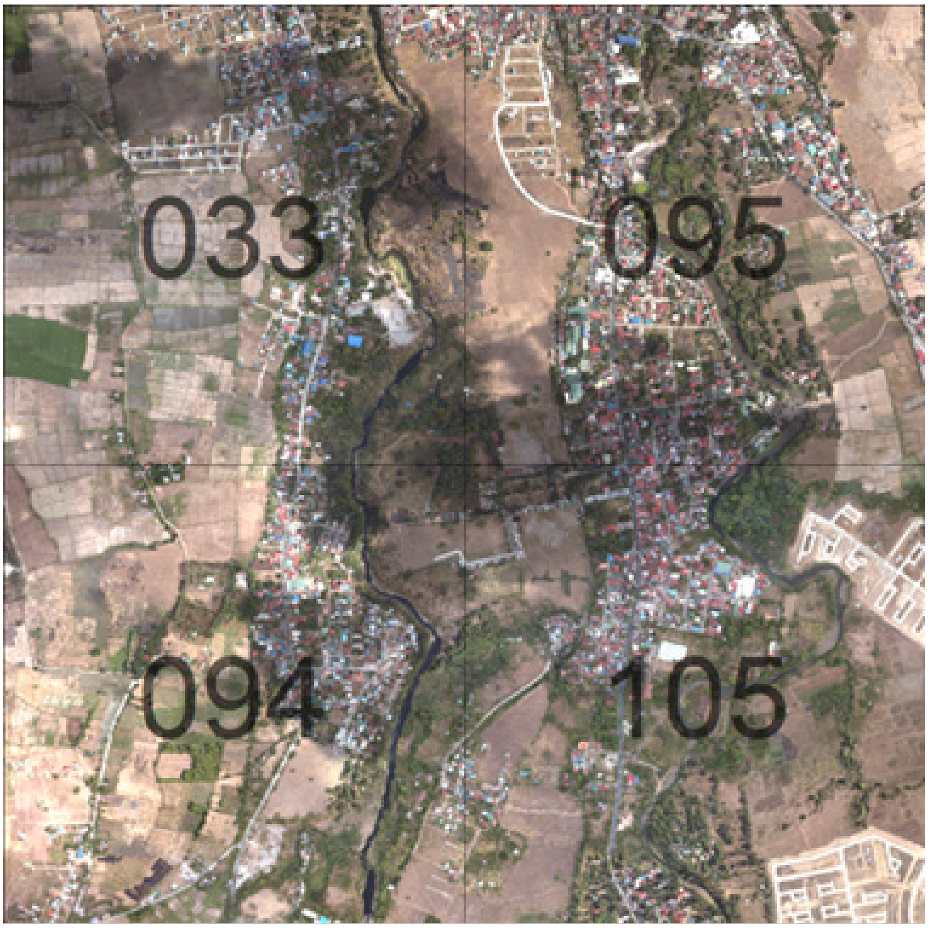


Figure 22. Sample orthophotograph tiles for Ilang-Ilang floodplain

## 3.8 DEM Editing and Hydro-Correction

Twelve (12) mission blocks were processed for Ilang-Ilang flood plain. These blocks are composed of CALABARZON blocks with a total area of 1,136.33 square kilometers. Table 19 shows the name and corresponding area of each block in square kilometers.

Table 19. LiDAR blocks with its corresponding areas.

| LiDAR Blocks | Area (sq.km) |
|---|---|
| CALABARZON_Blk18B_supplement | 106.91 |
| CALABARZON_Reflights_Blk18A_supplement | 53.33 |
| CALABARZON_Reflights_Blk18A | 229.66 |
| Cavite_Blk18A_supplement | 56.96 |
| CALABARZON_Reflights_Blk18B_supplement1 | 5.66 |
| CALABARZON_Reflights_Blk18B_supplement2 | 1.00 |
| CALABARZON_Reflights_Blk18B_supplement5 | 2.01 |
| Cavite_Blk18A_supplement2 | 99.62 |
| Cavite_Blk18AB | 127.12 |
| Cavite_Blk18C | 117.91 |
| Cavite_Blk18C_additional | 210.76 |
| Cavite_Blk18B_supplement | 125.39 |
| TOTAL | 1,136.33 sq.km |

Figure 23 shows portions of a DTM before and after manual editing. As evident in the figure, the bridge (Figure 23a) is also considered to be an impedance to the flow of water along the river and has to be removed (Figure 23b) in order to hydrologically correct the river. The paddy field (Figure 23c) has been misclassified and removed during classification process and has to be retrieved to complete the surface (Figure 23d) to allow the correct flow of water. Another example is a building that is still present in the DTM after classification (Figure 23e) and has to be removed through manual editing (Figure 23f).

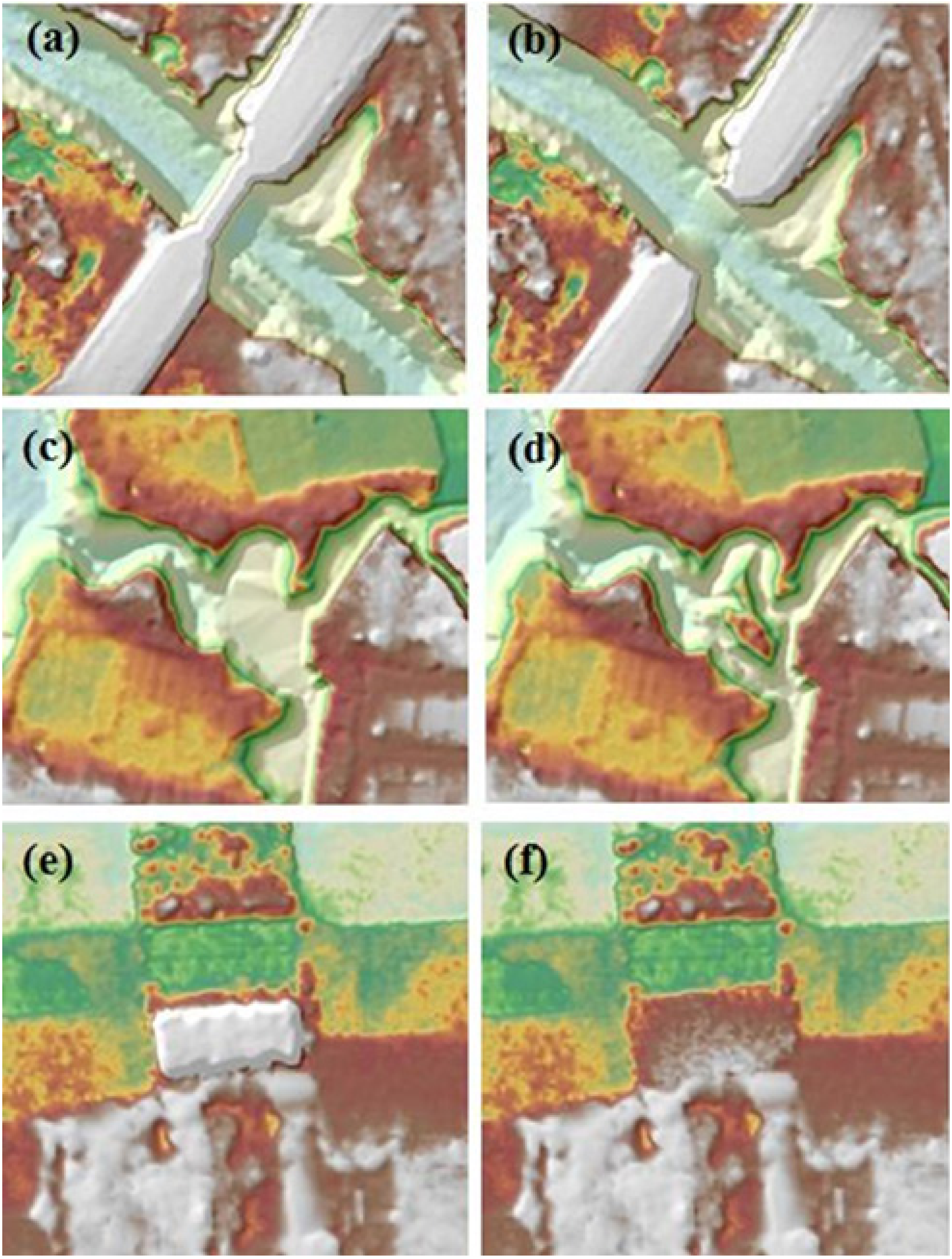


Figure 23. Portions in the DTM of Ilang-Ilang floodplain – a bridge before (a) and after (b) manual editing; a paddy field before (c) and after (d) data retrieval; and a building before (e) and after (f) manual editing.

## 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 20 shows the shift values applied to each LiDAR block during mosaicking.

Mosaicked LiDAR DTM for Ilang-Ilang Floodplain is shown in Figure 24. It can be seen that the entire Ilang-Ilang floodplain is 100% covered by LiDAR data.

Table 20. Shift values of each LiDAR block of Ilang-Ilang Floodplain.

| **Mission Blocks** | **Shift Values (meters)** | | |
|---|---|---|---|
| | **x** | **y** | **z** |
| CALABARZON_Blk18B_supplement | -1.85 | 1.08 | 0.10 |
| CALABARZON_Reflights_Blk18A_supplement | 34.04 | -20.59 | 1.40 |
| CALABARZON_Reflights_Blk18A | -2.81 | 1.41 | 0.55 |
| CALABARZON_Reflights_Blk18B_supplement1 | -1.25 | 0.55 | 0.05 |
| CALABARZON_Reflights_Blk18B_supplement2 | -3.28 | 4.06 | 0.93 |
| CALABARZON_Reflights_Blk18B_supplement5 | -1.52 | -0.01 | 0.20 |
| Cavite_Blk18A_supplement | -1.55 | 1.14 | -0.20 |
| Cavite_Blk18A_supplement2 | -2.31 | 1.34 | 0.00 |
| 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_Blk18B_supplement | -3.10 | 1.47 | -0.13 |

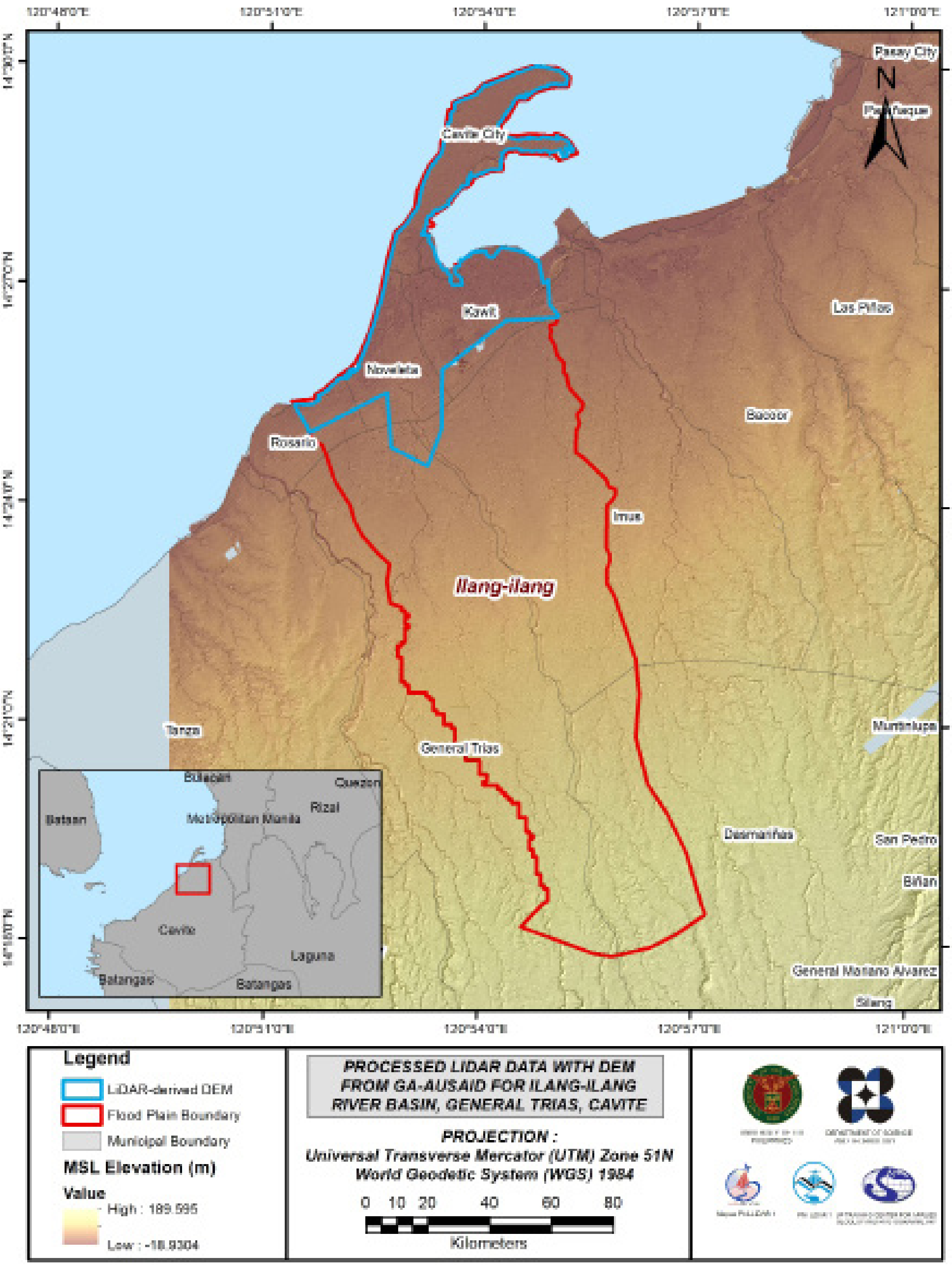


Figure 24. Map of processed LiDAR data for the Ilang-Ilang Floodplain.

## 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 Ilang-Ilang to collect points with which the LiDAR dataset is validated is shown in Figure 25. A total of 24,251 survey points were gathered for all the flood plains within the provinces of CALABARZON wherein the Ilang-Ilang floodplain is located. Random selection of 80% of the survey points, resulting to 19,401 points, was used for calibration.

A good correlation between the uncalibrated mosaicked LiDAR DTM and ground survey elevation values is shown in Figure 26. Statistical values were computed from extracted LiDAR values using the selected points to assess the quality of data and obtain the value for vertical adjustment. The computed height difference between the LiDAR DTM and calibration points is 2.97 meters with a standard deviation of 0.20 meters. Calibration of the LiDAR data was done by subtracting the height difference value, 2.97 meters, to the mosaicked LiDAR data. Table 21 shows the statistical values of the compared elevation values between the LiDAR data and calibration data.

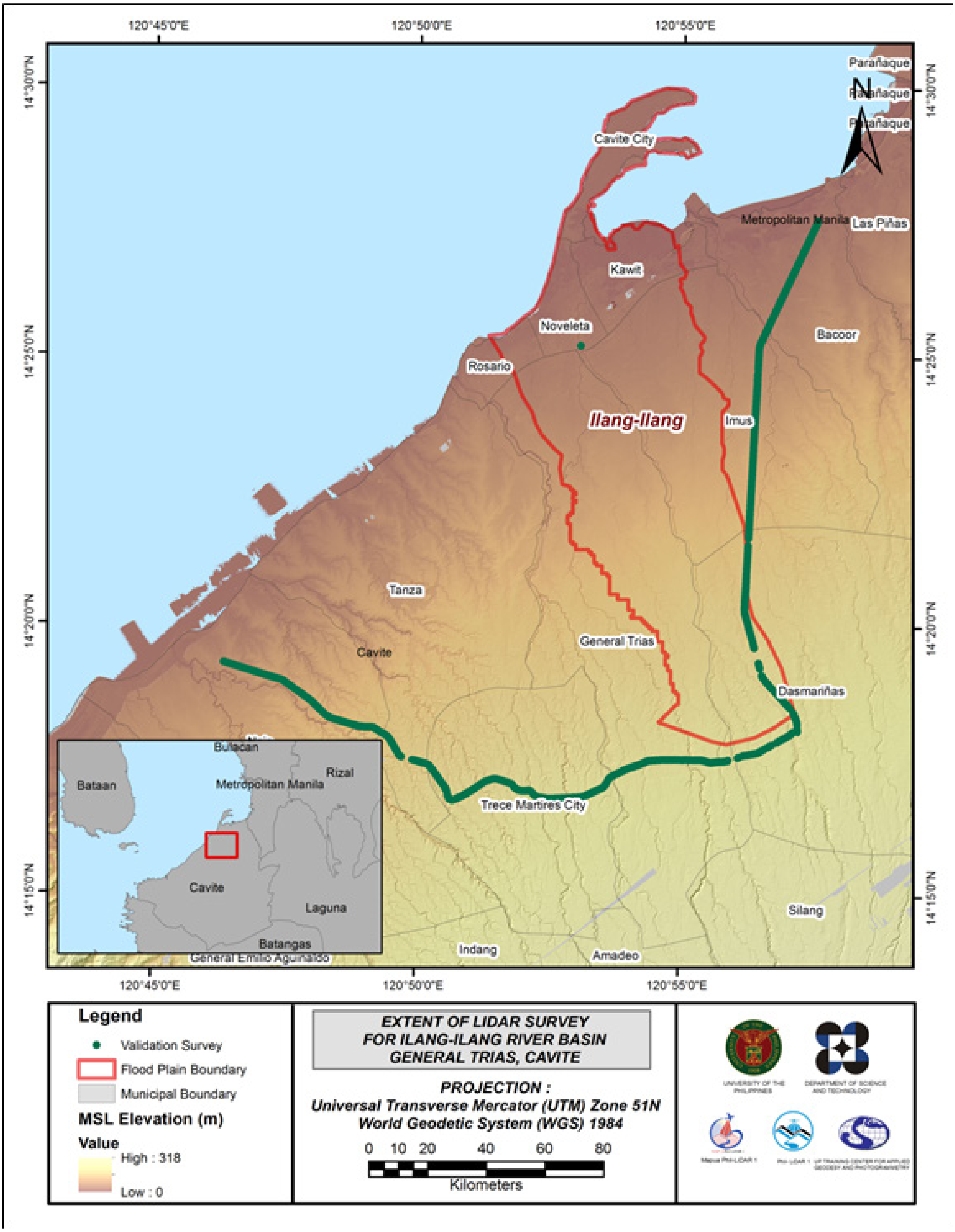


Figure 25. Map of Ilang-Ilang Floodplain with validation survey points in green.

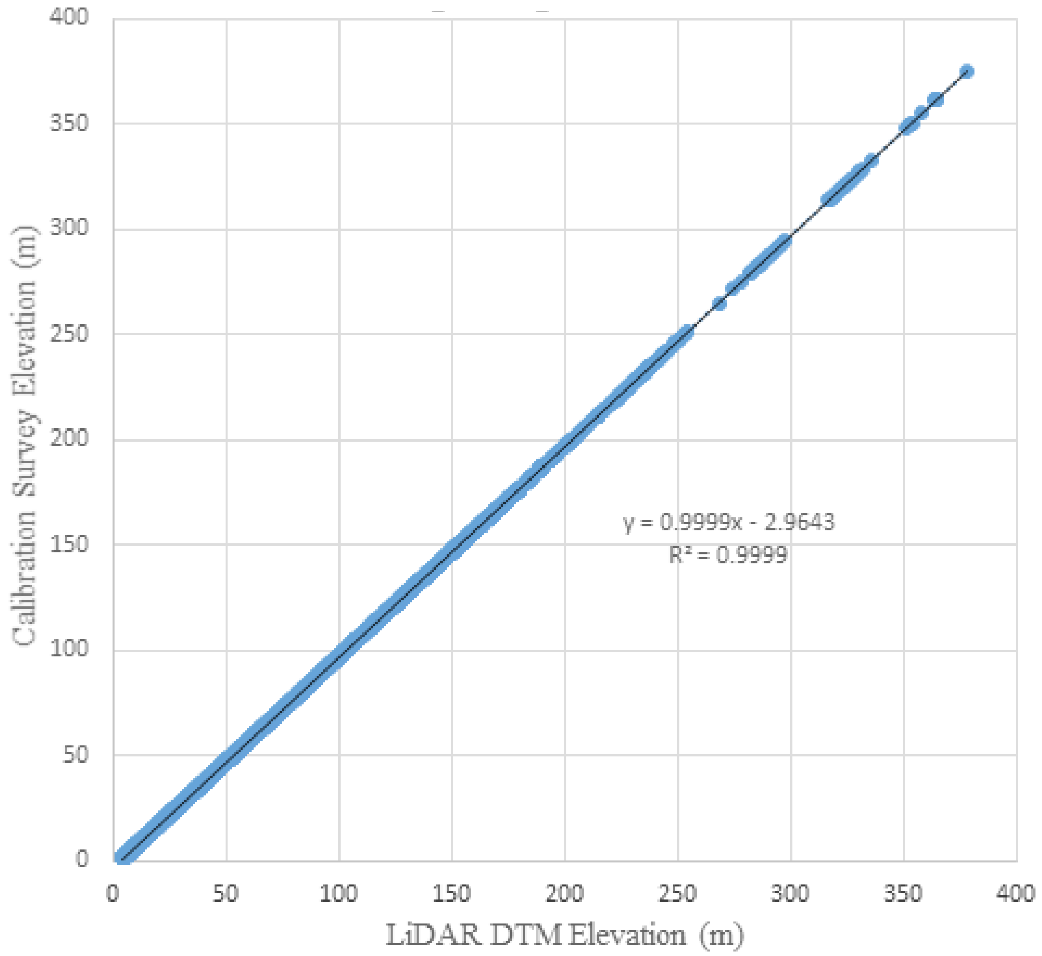


Figure 26. Correlation plot between calibration survey points and LiDAR data.

Table 21. 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 Ilang-Ilang flood plain, resulting to 362 points, were used for the validation of calibrated Ilang-Ilang DTM. A good correlation between the calibrated mosaicked LiDAR elevation values and the ground survey elevation, which reflects the quality of the LiDAR DTM, is shown in Figure 27. The computed RMSE between the calibrated LiDAR DTM and validation elevation values is 0.20 meters with a standard deviation of 0.15 meters, as shown in Table 22.

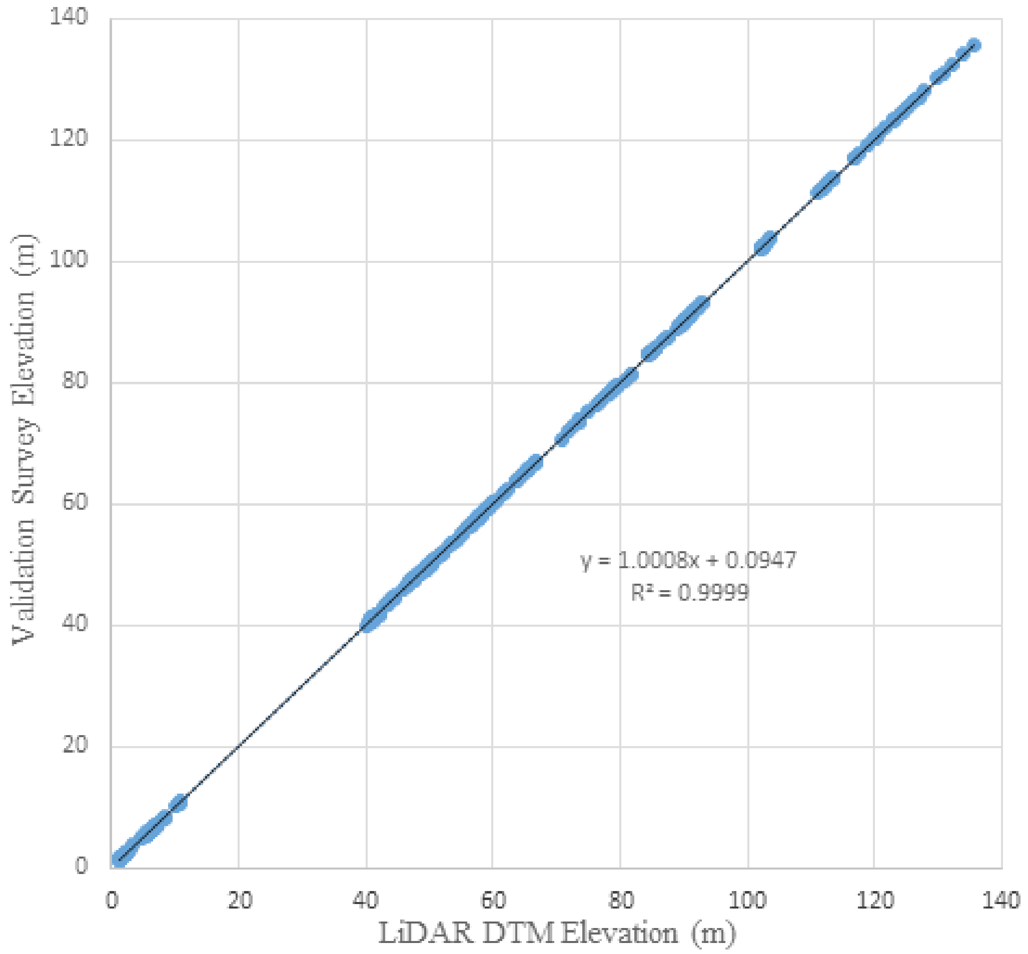


Figure 27. Correlation plot between the validation survey points and the LiDAR data.

Table 22. 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 only centerline data was available for Ilang-Ilang with 3,307 bathymetric survey points. The resulting raster surface produced was done by Inverse Distance Weighted (IDW) interpolation method. After burning the bathymetric data to the calibrated DTM, assessment of the interpolated surface is represented by the computed RMSE value of 2.09 meters. The extent of the bathymetric survey done by the Data Validation and Bathymetry Component (DVBC) in Ilang-Ilang integrated with the processed LiDAR DEM is shown in Figure 28.

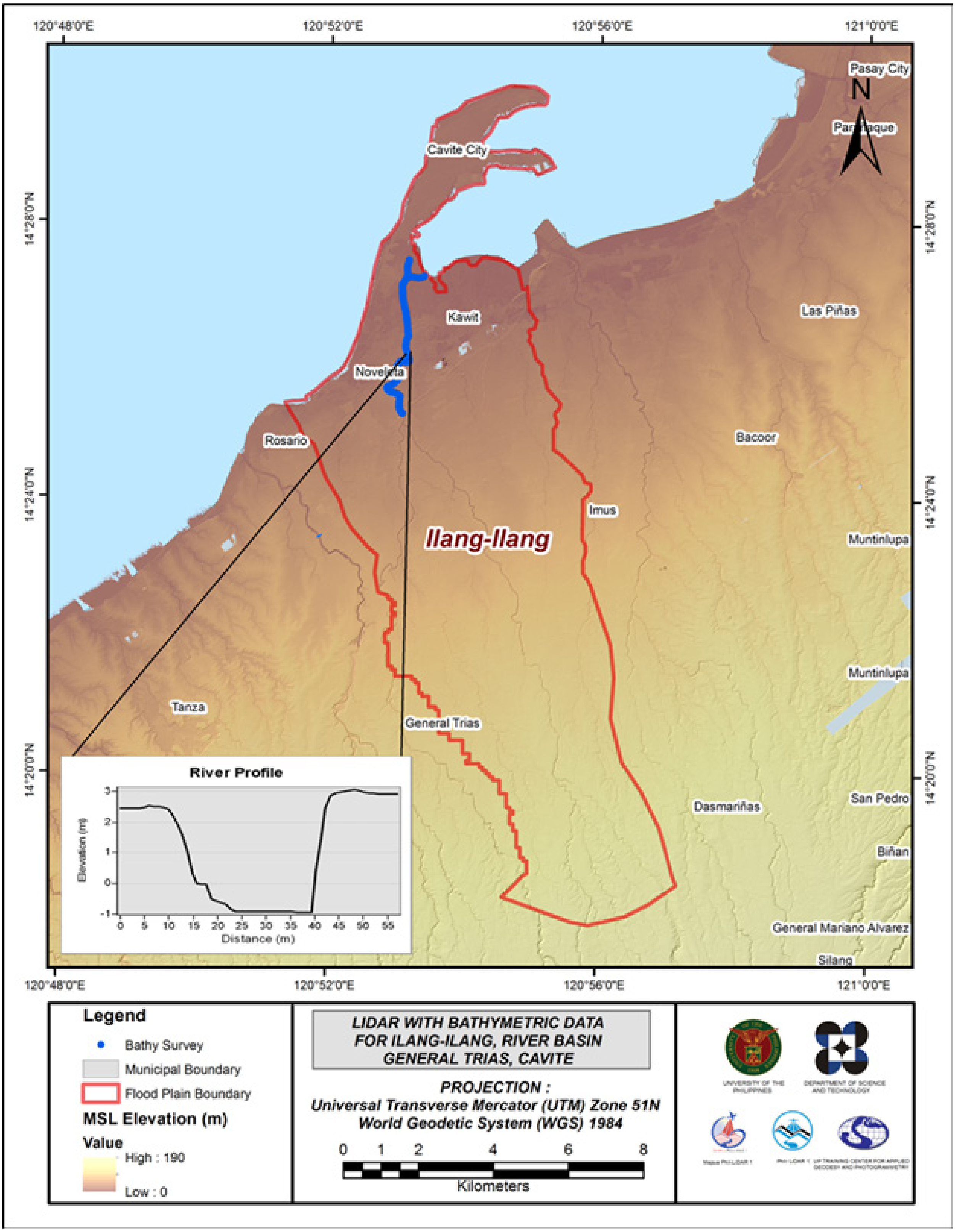


Figure 28. Map of Ilang-Ilang floodplain with bathymetric survey points in blue.

## 3.12 Feature Extraction

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

### 3.12.1 Quality Checking of Digitized Features' Boundary

Ilang-Ilang floodplain, including its 200 m buffer, has a total area of 110.36 sq km. For this area, a total of 5.0 sq km, corresponding to a total of 4,645 building features, are considered for QC. Figure 29 shows the QC blocks for Ilang-Ilang floodplain.

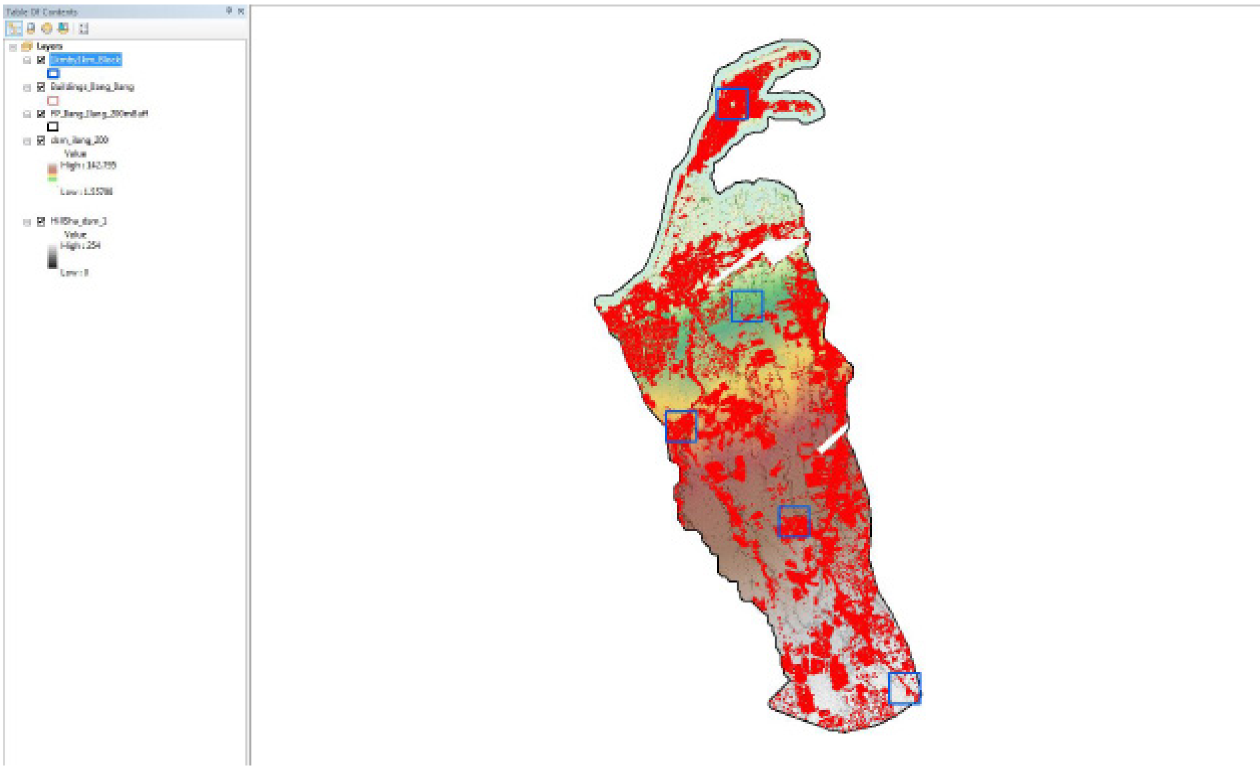


Figure 29. Block (in blue) of Ilang-Ilang building features that was subjected to QC.

Quality checking of Ilang-Ilang building features resulted in the ratings shown in Table 23.

Table 23. Details of the quality checking ratings for the building features extracted for the Ilang-Ilang River Basin

| FLOODPLAIN | COMPLETENESS | CORRECTNESS | QUALITY | REMARKS |
|---|---|---|---|---|
| Ilang-Ilang | 99.57 | 98.62 | 90.10 | PASSED |

### 3.12.2 Height Extraction

Height extraction was done for 99,096 building features in Ilang-Ilang floodplain. Of these building features, none was filtered out after height extraction, resulting to 99,096 buildings with height attributes. The lowest building height is at 2.00 m, while the highest building is at 17.21 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 24 summarizes the number of building features per type, while Table 25 shows the total length of each road type.Table 26, on the other hand, shows the number of water features extracted per type.

Table 24. Building features extracted for Ilang-Ilang Floodplain.

| Facility Type | No. of Features |
|---|---|
| Residential | 97,539 |
| School | 614 |
| Market | 99 |
| Agricultural/Agro-Industrial Facilities | 0 |
| Medical Institutions | 76 |
| Barangay Hall | 98 |
| Military Institution | 168 |
| Sports Center/Gymnasium/Covered Court | 27 |
| Telecommunication Facilities | 2 |
| Transport Terminal | 1 |
| Warehouse | 4 |
| Power Plant/Substation | 0 |
| NGO/CSO Offices | 0 |
| Police Station | 2 |
| Water Supply/Sewerage | 19 |
| Religious Institutions | 106 |
| Bank | 28 |
| Factory | 31 |
| Gas Station | 40 |
| Fire Station | 1 |
| Other Government Offices | 39 |
| Other Commercial Establishments | 202 |
| Total | 99,096 |

Table 25. Total Length of Extracted Roads for Silaga Floodplain.

| Floodplain | Road Network Length (km) | | | | | Total |
|---|---|---|---|---|---|---|
| | Barangay Road | City/Municipal Road | Provincial Road | National Road | Others | |
| Ilang-Ilang | 148.77 | 117.70 | 64.45 | 2.07 | 0.00 | 332.99 |

Table 26. Number of extracted water bodies for Silage Floodplain.

| Floodplain | Water Body Type | | | | | Total |
|---|---|---|---|---|---|---|
| | Rivers/Streams | Lakes/Ponds | Sea | Dam | Fish Pen | |
| Ilang-Ilang | 8 | 0 | 4 | 0 | 87 | 99 |

A total of 137 bridges and culverts over small channels that are part of the river network were also extracted for the floodplain.

### 3.12.4 Final Quality Checking of Extracted Features

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

Figure 30 shows the completed Digital Surface Model (DSM) of the Ilang-Ilang floodplain overlaid with its ground features.

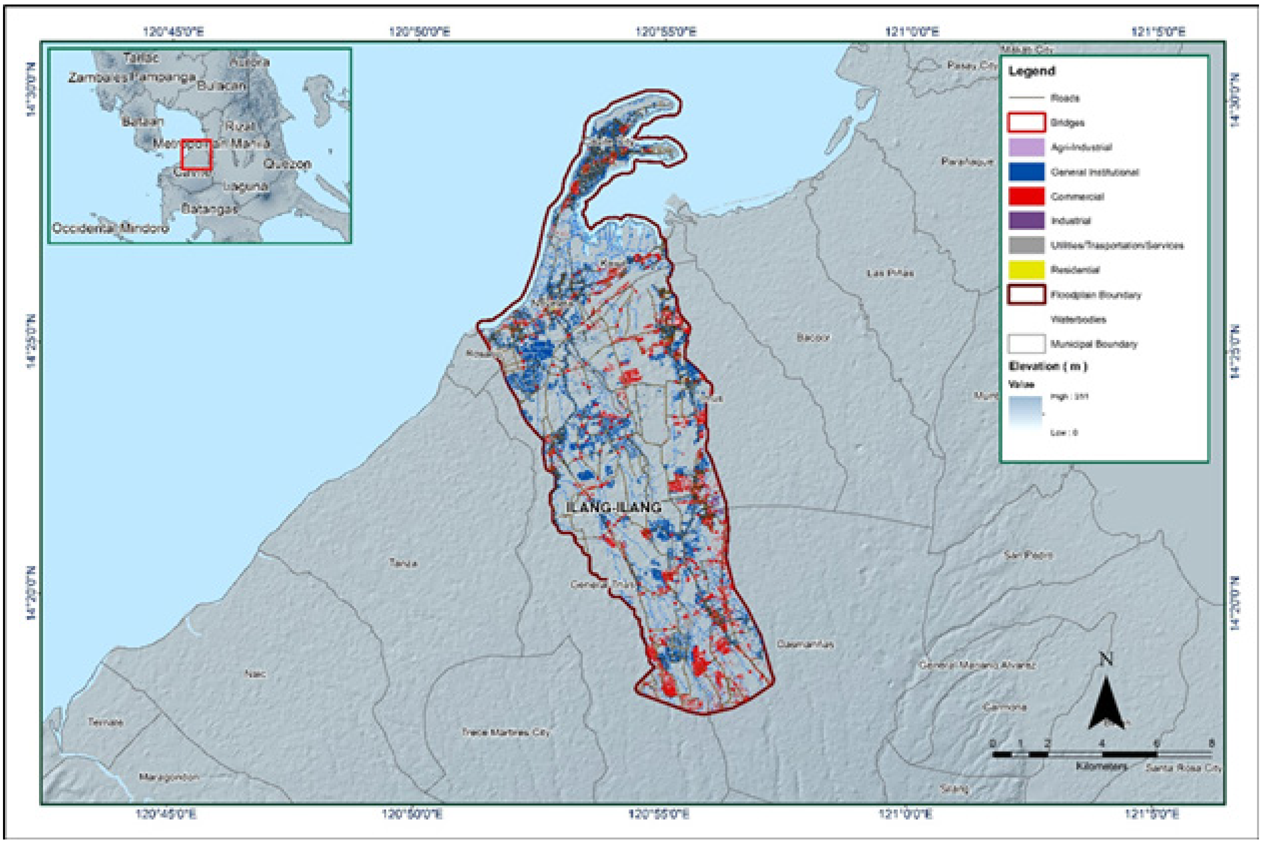


Figure 30. Extracted features of the Ilang-Ilang Floodplain.

# CHAPTER 4: LIDAR VALIDATION SURVEY AND MEASUREMENTS OF THE ILANG-ILANG RIVER BASIN

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

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

## 4.1 Summary of Activities

The Data Validation and Bathymetry Component (DVBC) conducted its field survey from February 3 to 6, 2015 for Ilang-Ilang River with the following scope of work: reconnaissance; control survey for the establishment of a control point; cross-section, bridge as-built for Ilang-Ilang Bridge in Brgy. San Antonio I, Noveleta, Cavite; ground validation data acquisition; and bathymetric survey with an estimated length of 4.5 km using Ohmex™ Single Beam Echo Sounder and GNSS PPK survey technique. The entire survey extent is illustrated in Figure 31.

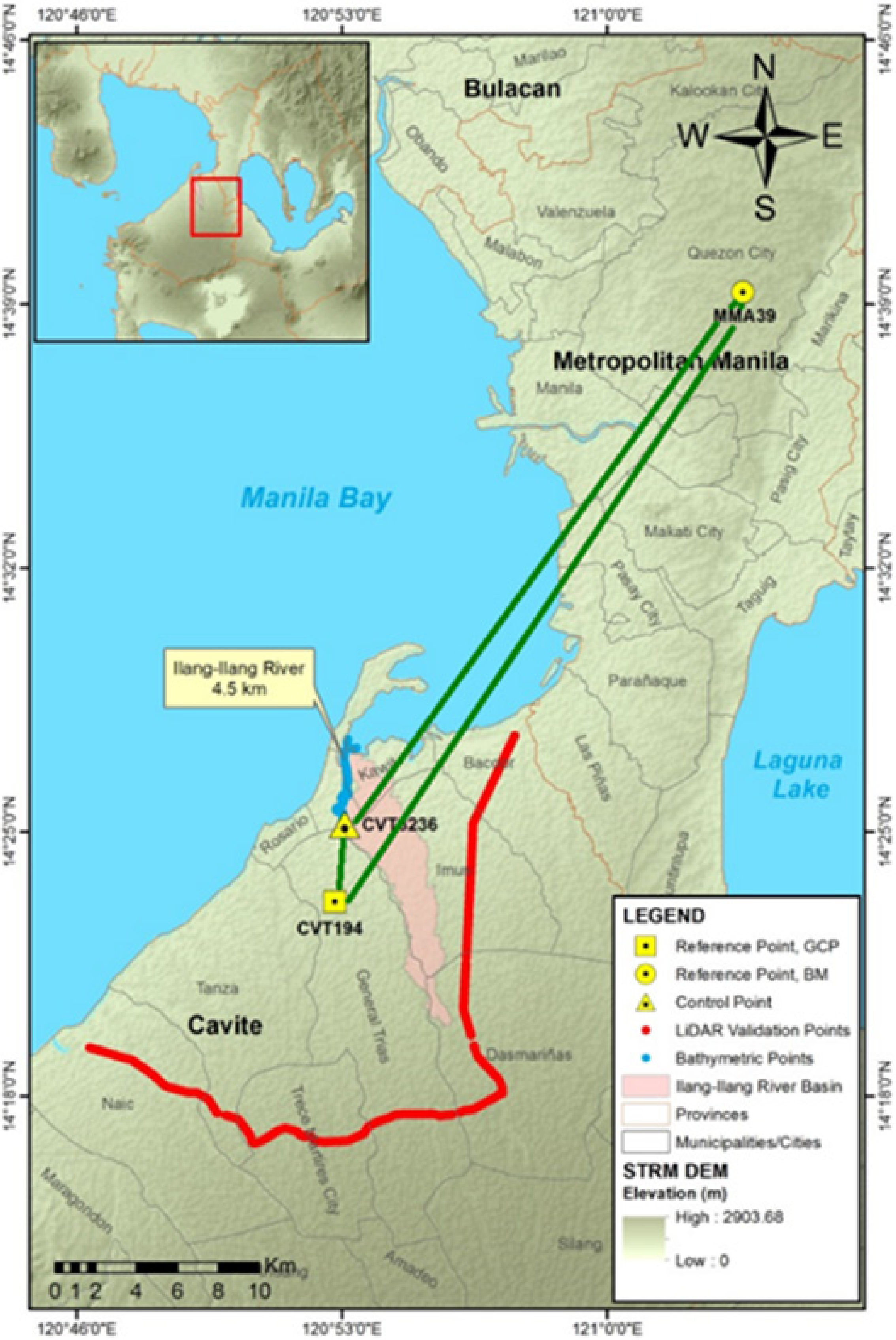


Figure 31. Ilang-Ilang River Survey Extent

## 4.2 Control Survey

The GNSS network used for Ilang-Ilang River survey is composed of four (4) loops established on December 10, 2016, occupying the following reference points: SME-18, a 2nd order NAMRIA GCP in Brgy. Canciledes, Municipality of Hernani, Eastern Samar; SMR-41, a 2nd order NAMRIA GCP in Brgy. Fatima, Municipality of Hinabangan, Samar; and, SE-172, a 1st order BM in Brgy. Nato, Municipality of Taft, Eastern Samar.

Three (3) control points were established in the area: UP-BOR located at the approach of Can-Obing Bridge in Brgy. Can-Abong, Borongan City, Eastern Samar; UP-SUL located at the approach of Ilang-Ilang Bridge in Brgy. Maramara, Municipality of Ilang-Ilang, Eastern Samar; and UP-ULO-2 located at the approach of Can-Avid Bridge in Brgy. Canteros, Municipality of Can-Avid, Eastern Samar.

Table 27 depicts the summary of reference and control points utilized, with their corresponding locations, while Figure 32 shows the GNSS network established in the Ilang-Ilang River Survey.

Table 27. List of reference and control points used during the survey in Ilang-Ilang River (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- 39 | 2nd Order GCP | 14°39'18.82950" | 121°03'34.94441" | 98.2 | 52.0289 | |
| CVT- 3236 | Used as Marker | - | - | - | - | 2-3-2015 |
| PSC-54 | Used as Marker | - | - | - | - | 2-3-2015 |

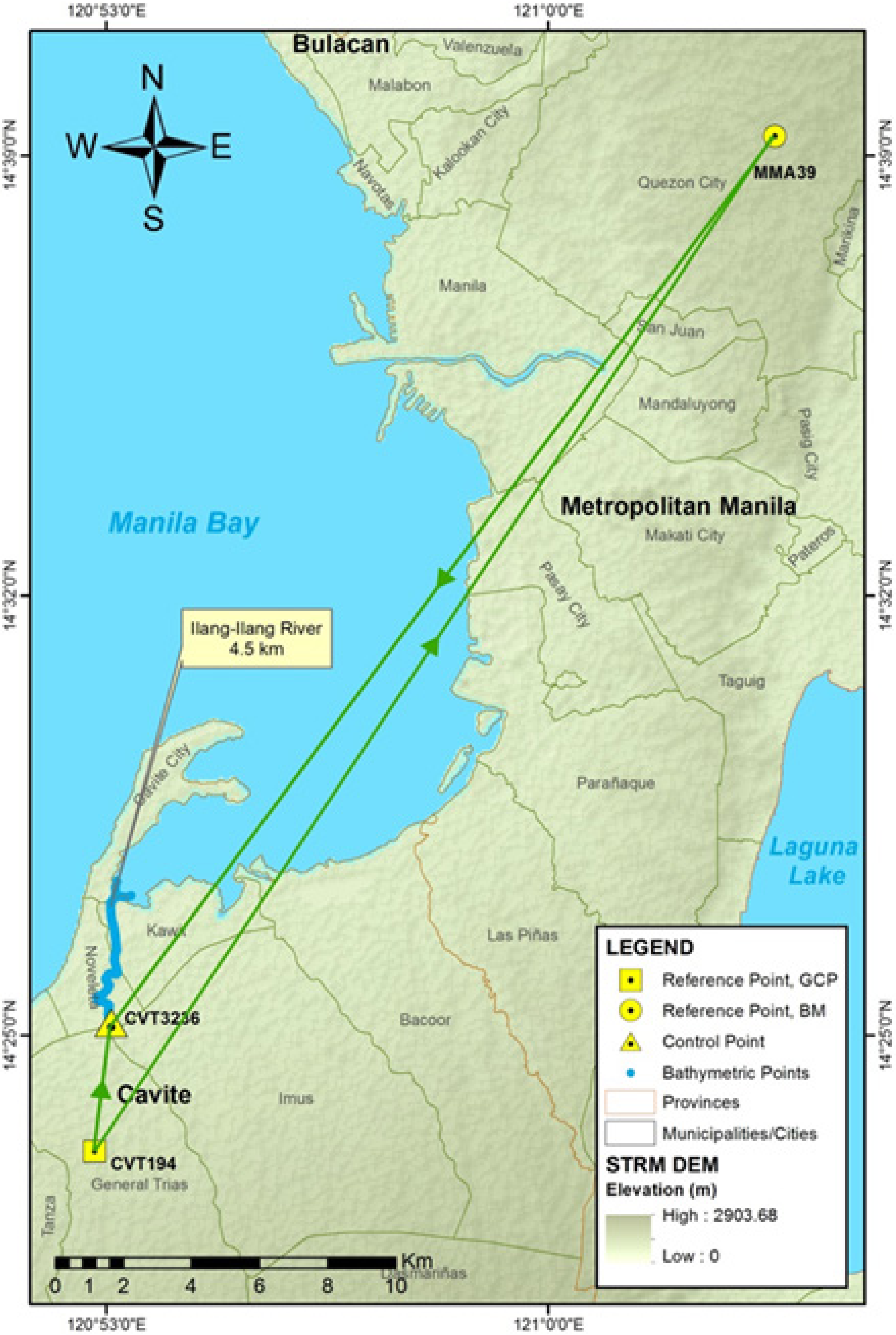


Figure 32. Ilang-Ilang River Basin Control Survey Extent.

Figure 33 to Figure 35 depict the setup of the GNSS on recovered reference points and established control points in the Ilang-Ilang River.

Figure 33. Trimble® SPS 882 at MMA-39 in UP Diliman, Quezon City

Figure 34. Trimble® SPS 852 at CVT-3236 along Ilang Ilang brigde in Brgy. San Antonio I, Noveleta, Cavite

Figure 35. Trimble® SPS 852 at PSC-54 at the town plaza in Brgy. Bagumbayan, Gen. Trias, 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 +/- 20 cm and +/- 10 cm requirement, respectively. In case where one or more baselines did not meet all of these criteria, masking was 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 Balili River Basin is summarized in Table 27 generated by TBC software.

Table 28. The Baseline processing report for the Ilang-Ilang River GNSS static observation survey.

| Observation | Date of Observation | Solution Type | H. Prec. (Meter) | V. Prec. (Meter) | Geodetic Az. | Ellipsoid Dist. (Meter) | ΔHeight (Meter) |
|---|---|---|---|---|---|---|---|
| PSC-54 --- MMA-39 (B3) | 2-3-2015 | Fixed | 0.004 | 0.014 | 7°18'02" | 3799.623 | -5.661 |
| MMA-39 --- CVT-3236 | 2-3-2015 | Fixed | 0.010 | 0.023 | 35°56'00" | 32142.850 | 40.473 |
| PSC-54 --- CVT-3236 (B1) | 2-3-2015 | Fixed | 0.006 | 0.019 | 32°59'40" | 35524.538 | 34.865 |

As shown in Table 28, a total of three (3) baselines were used in the fieldwork. The first-order GCP MMA-39 was held fixed and used as a control for the network. All control points have a fixed solution type; PSC-54 to MMA-39 has a horizontal accuracy of 0.4 cm and a vertical accuracy of 1.4 cm. The baseline MMA-39 to CVT-3236 has horizontal and vertical accuracies of 1.0 cm and 2.3 cm, respectively. Lastly, PSC-54 to CVT-3236 has a 0.6 cm horizontal precision and 1.9 cm vertical precision; it is apparent that all baselines passed the required accuracy.

## 4.4 Network Adjustment

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

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

where:

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

For complete details, see the Network Adjustment Report shown in Table 29 to Table 31.

Table 29. Constraints applied to the adjustment of the control points.

| Point ID | Type | East σ (Meter) | North σ (Meter) | Height σ (Meter) | Elevation σ (Meter) |
|---|---|---|---|---|---|
| MMA-39 | Global | Fixed | Fixed | Fixed | |
| Fixed = 0.000001(Meter) | | | | | |

Likewise, the list of adjusted grid coordinates, i.e. Northing, Easting, Elevation and computed standard errors of the control points in the network is indicated in Table 30.

Table 30. Adjusted grid coordinates for the control points used in the Ilang-Ilang River flood plain survey.

| Point ID | Easting (Meter) | Easting Error (Meter) | Northing (Meter) | Northing Error (Meter) | Elevation (Meter) | Elevation Error (Meter) | Constraint |
|---|---|---|---|---|---|---|---|
| PSC-54 | 271413.914 | 0.011 | 1591468.733 | 0.014 | 19.507 | 0.049 | |
| CVT-3236 | 271931.547 | 0.011 | 1595233.868 | 0.013 | 13.930 | 0.052 | |
| MMA-39 | 291038.456 | ? | 1621088.939 | ? | 54.253 | ? | LLh |

The results of the computation for accuracy are as follows:

a. PSC-54

horizontal accuracy = $\sqrt{((1.1)^2 + (1.4)^2}$

= $\sqrt{(1.21 + 1.96)}$

= 1.78 cm < 20 cm

vertical accuracy = 4.9 cm < 10 cm

b. CVT-3236

horizontal accuracy = $\sqrt{((1.1)^2 + (1.3)^2}$

= $\sqrt{(1.21 + 1.69)}$

= 1.70 cm < 20 cm

vertical accuracy = 5.2 cm < 10 cm

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

Table 31. Adjusted geodetic coordinates for control points used in the Ilang-Ilang River Flood Plain validation.

| Point ID | Latitude | Longitude | Ellipsoid | Height | Constraint |
|---|---|---|---|---|---|
| PSC-54 | N14°23'09.63484" | E120°52'48.43692" | 62.336 | 0.049 | |
| CVT-3236 | N14°25'12.26104" | E120°53'04.55579" | 56.662 | 0.052 | |
| MMA-39 | N14°39'18.82950" | E121°03'34.94441" | 98.200 | ? | LLh |

The corresponding geodetic coordinates of the observed points are within the required accuracy as shown in Table 31. Based on the results of the computation, the accuracy conditions are satisfied; hence, the required accuracy for the program was met. The computed coordinates of the reference and control points utilized in the Ilang-Ilang River GNSS Static Survey are seen in Table 32.

Table 32. The reference and control points utilized in the Ilang-Ilang River Static Survey, with their corresponding locations (Source: NAMRIA, UP-TCAGP)

| **Control Point** | **Order of Accuracy** | **Geographic Coordinates (WGS 84)** | | | **UTM ZONE 51 N** | | |
|---|---|---|---|---|---|---|---|
| | | **Latitude** | **Longitude** | **Ellipsoidal Height (m)** | **Northing (m)** | **Easting (m)** | **BM Ortho (m)** |
| MMA-39 | 1st | 14°39'18.82950" | 121°03'34.94441" | 98.2 | 1621088.939 | 291038.456 | 52.0289 |
| CVT-3236 | Used as Marker | 14°25'12.26104" | 120°53'04.55579" | 56.662 | 1595233.868 | 271931.547 | 11.7059 |
| PSC-54 | Used as Marker | 14°23'09.63484" | 120°52'48.43692" | 62.336 | 1591468.733 | 271413.914 | 17.2829 |

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

The bridge cross-section and as-built surveys were conducted on February 4, 2015, along the downstream side of Ilang Ilang Bridge in Brgy. San Antonio I, Noveleta, Cavite using Trimble® SPS 882 in GNSS PPK survey technique as shown in Figure 36.

Figure 36. Cross-section survey in Ilang-Ilang Bridge in Brgy. San Antonio, Noveleta, Cavite.

The location map, cross-section diagram and the accomplished bridge data form are shown in Figure 37, 38, and 39.

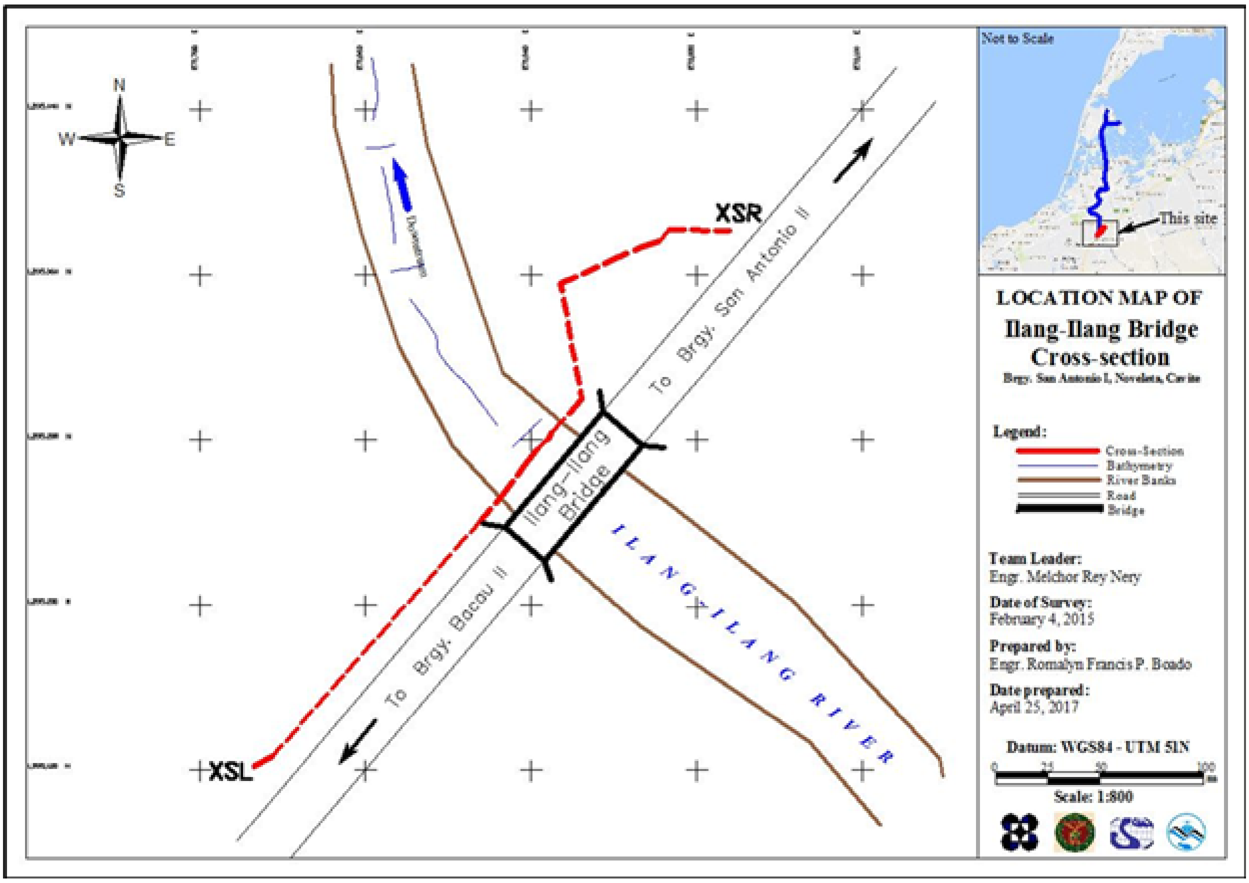


Figure 37. Location map of the Ilang-Ilang Bridge Cross Section

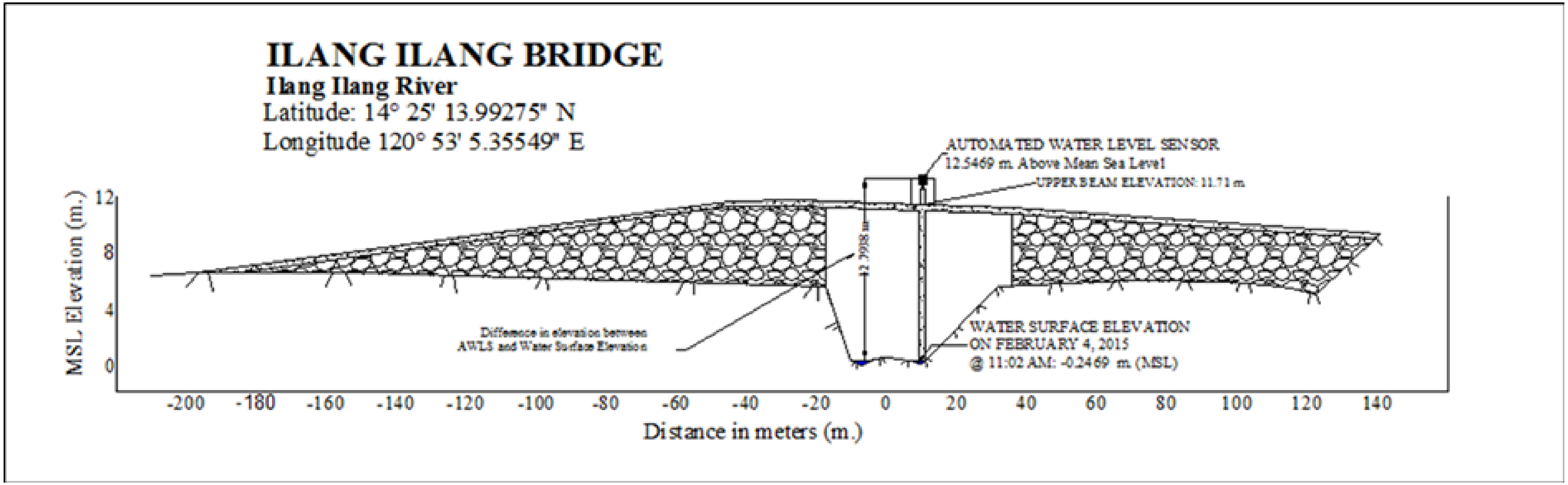
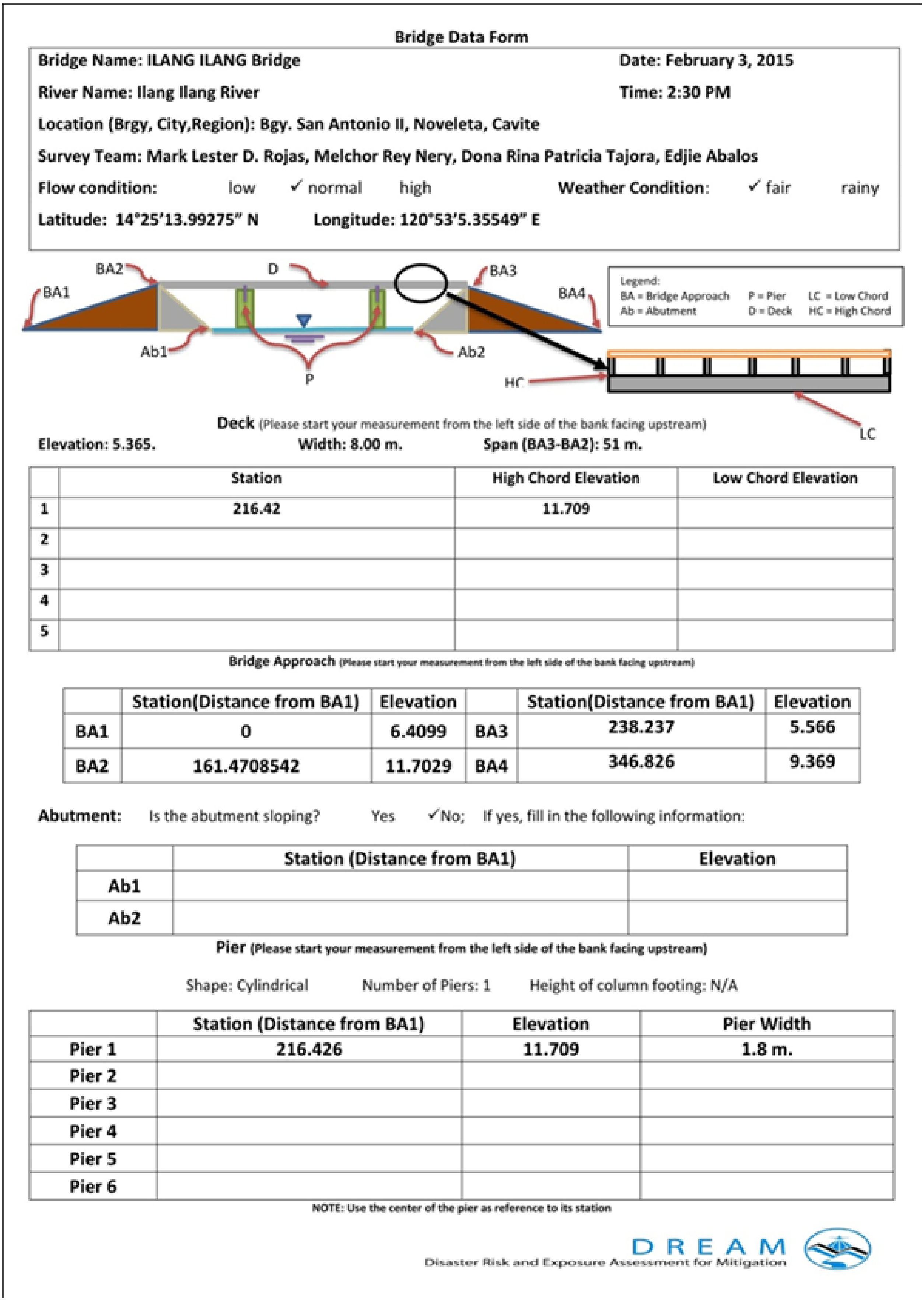


Figure 38. The Ilang-Ilang Bridge cross-section diagram.



**Bridge Data Form**

**Bridge Name: ILANG ILANG Bridge** **Date: February 3, 2015**

**River Name: Ilang Ilang River** **Time: 2:30 PM**

**Location (Brgy, City,Region): Bgy. San Antonio II, Noveleta, Cavite**

**Survey Team: Mark Lester D. Rojas, Melchor Rey Nery, Dona Rina Patricia Tajora, Edjie Abalos**

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

**Latitude: 14°25'13.99275" N** **Longitude: 120°53'5.35549" E**

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

**Elevation: 5.365.** **Width: 8.00 m.** **Span (BA3-BA2): 51 m.**

| | Station | High Chord Elevation | Low Chord Elevation |
|---|---|---|---|
| 1 | 216.42 | 11.709 | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |

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

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

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

| | Station (Distance from BA1) | Elevation |
|---|---|---|
| Ab1 | | |
| Ab2 | | |

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

Shape: Cylindrical Number of Piers: 1 Height of column footing: N/A

| | Station (Distance from BA1) | Elevation | Pier Width |
|---|---|---|---|
| Pier 1 | 216.426 | 11.709 | 1.8 m. |
| Pier 2 | | | |
| Pier 3 | | | |
| Pier 4 | | | |
| Pier 5 | | | |
| Pier 6 | | | |

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

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure 39. The Ilang-Ilang Bridge as-built survey data.

Bridge marking was done in Ilang-Ilang Bridge, San Antonio, Noveleta, Cavite using GNSS point observation and differential levelling. The elevation in MSL of a point on the ground was determined using GPS PPK survey technique. The elevation obtained on the ground was used as a reference to determine the elevation of the bridge markings on the pier of the bridge using a Topcon DL 500 digital level. The pier has an existing bridge marking which was not referred from MSL.Image of the setup for the water bridge marking using GNSS and Digital level is shown in Figure 40.

Figure 40. GNSS Observation and Digital level setup at the bank of Ilang-Ilang River.

Topcon DL 500 was used for differential levelling and Trimble® SPS 882 was used to get the reference elevation. The existing bridge marking on the pier of the bridge is shown in Figure 41.

Figure 41. Existing bridge marking and the corresponding MSL elevation.

## 4.6 Validation Points Acquisition Survey

The validation points acquisition survey was conducted on February 3, 2014 using a survey 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 steel rod and tied with cable ties to ensure that it was horizontally and vertically balanced. The antenna height of 2.10 m was measured from the ground up to the bottom of notch of the GNSS rover receiver.

Figure 42. GNSS Receiver Trimble® SPS 882 installed on a vehicle for Ground Validation Survey.

The survey covered municipalities of Bacoor, Imus, Dasmariñas, General Trias, Trece Martires, Tanza and Naic, in the province of Cavite for the entire extent validation points acquisition survey as illustrated in the map in Figure 43.

Figure 43. The extent of the LiDAR ground validation survey (in red) for Ilang-Ilang River Basin.

## 4.7 River Bathymetric Survey

A bathymetric survey was performed on February 5, 2015 using an Ohmex™ Single Beam Echo Sounder and Trimble® SPS 882 in GNSS PPK survey technique as shown in Figure 44. The survey started in Brgy. San Antonio I, Municipality of General Trias with coordinates 14°25'28.49052" 120°53'02.70645", down to the mouth of the river in Brgy. 3 Cavite City with coordinates 14°27'22.56516" 120°53'08.62131".

Figure 44. Set up of the bathymetric survey at Ilang-Ilang River using Trimble® SPS 882 in GNSS PPK survey technique.

A manual bathymetric survey was executed on February 4, 2015 using Trimble® SPS 882 in GNSS PPK survey technique. The survey only covered shallow parts in the upstream in Brgy. San Antonio I with coordinates 14°25'13.36354" 120°53'04.71909", traversed down by foot and ended at the starting point of bathymetric survey using boat.

Overall, the bathymetric survey for the Ilang-Ilang River gathered a total of 3,236 points, covering 4.5 km of the river, using the base station at CVT-3236 (Figure 45). To further illustrate this, a CAD drawing of the riverbed profile of the Silaga River was produced. The change of elevation is gradual from Brgy. San Antonio, Noveleta, Cavite down to in Brgy. Sta. Isabel, Kawit, Cavite as illustrated in Figure 46. The highest elevation observed was 0.72 m in MSL, located at the Brgy. San Antonio I, while the lowest elevation was -5.20 m below MSL, located at the Brgy. San Jose, Noveleta, Cavite.

Figure 45. The extent of the Ilang-Ilang River Bathymetry Survey.

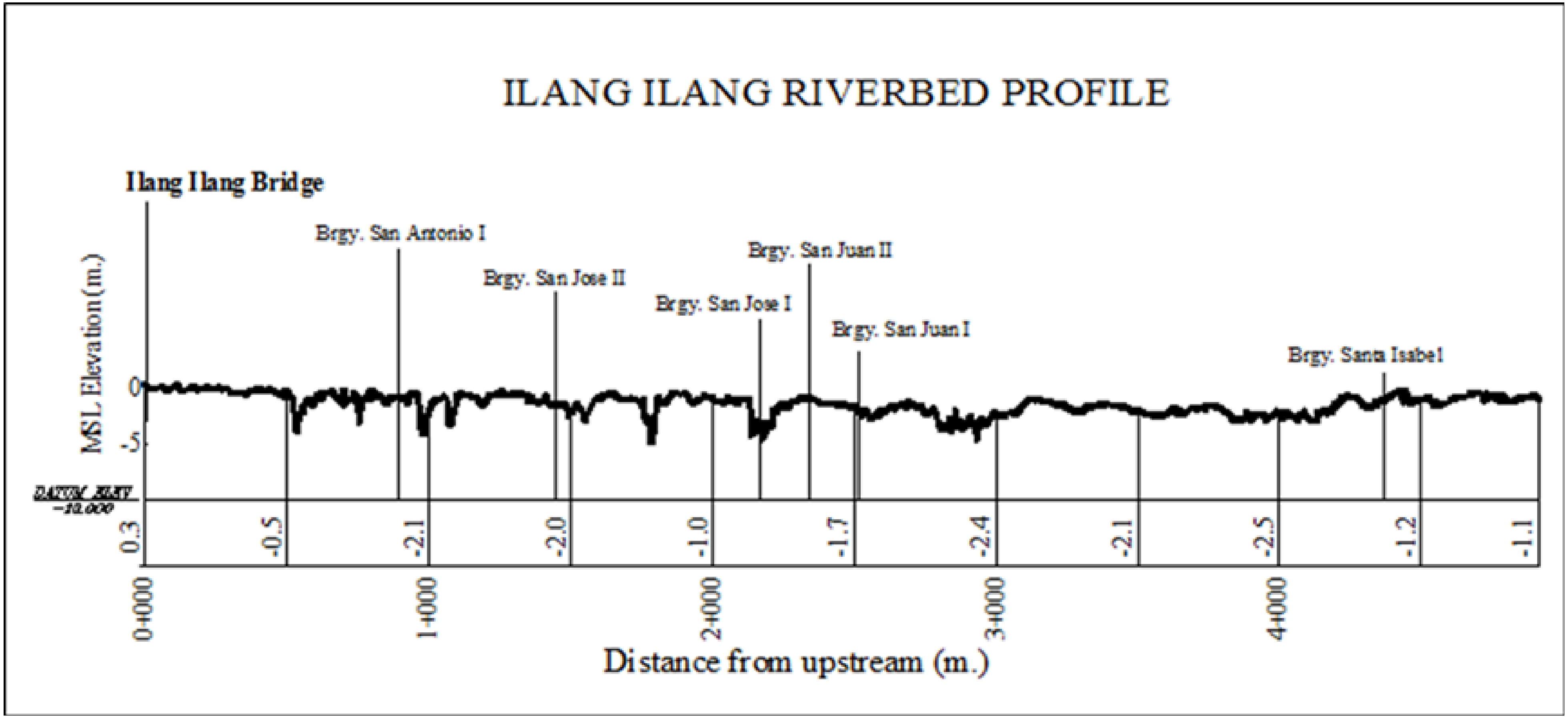


Figure 46. The Ilang-Ilang Riverbed Profile.

# 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 for Hydrologic Modeling

### 5.1.1 Hydrometry and Rating Curves

All components and data, such as rainfall, water level, and flow in a certain period of time, which may affect the hydrologic cycle of the Ilang-Ilang River Basin were monitored, collected, and analyzed.

### 5.1.2 Precipitation

Precipitation data was taken from automatic rain gauges (ARG) installed by the Department of Science and Technology – Advanced Science and Technology Institute (DOST-ASTI). The ARG was installed at GMA, Cavite as illustrated in in Figure 47.

The total precipitation from this event in GMA rain gauge was 17.2 mm with a peak rainfall rate of 4.2 mm on August 12, 2016 at 11:30 AM. The lag time between the peak rainfall and discharge is 3 hours and 15 minutes.

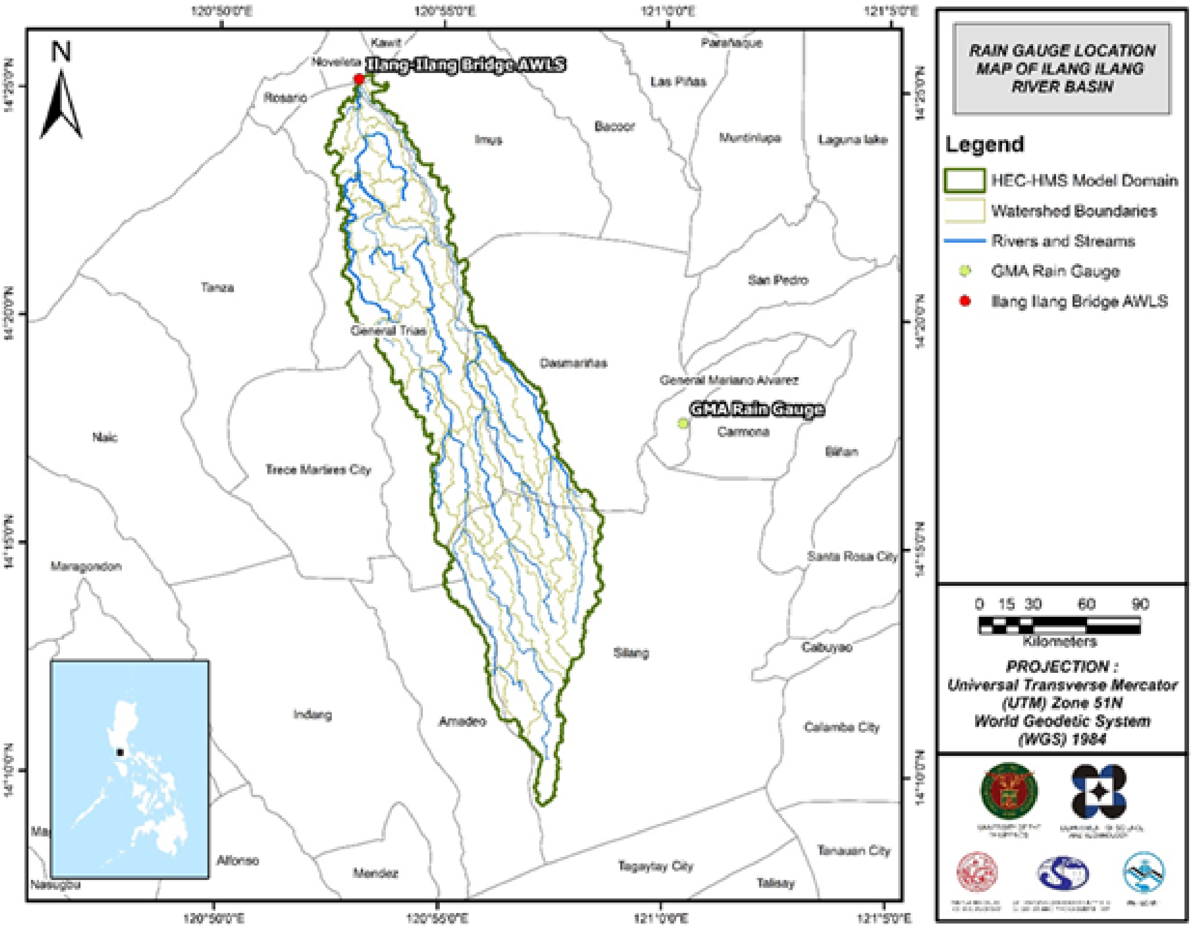


Figure 47. Location Map of the Ilang-Ilang HEC-HMS model used for calibration.

### 5.1.3 Rating Curves and River Outflow

A rating curve was developed at Ilang Ilang Bridge, Noveleta, Cavite (14°25'13.20"N, 120°53'5.54"E) to establish the relationship between the observed water levels (H) at Ilang-Ilang Bridge and outflow (Q) of the watershed at this location.

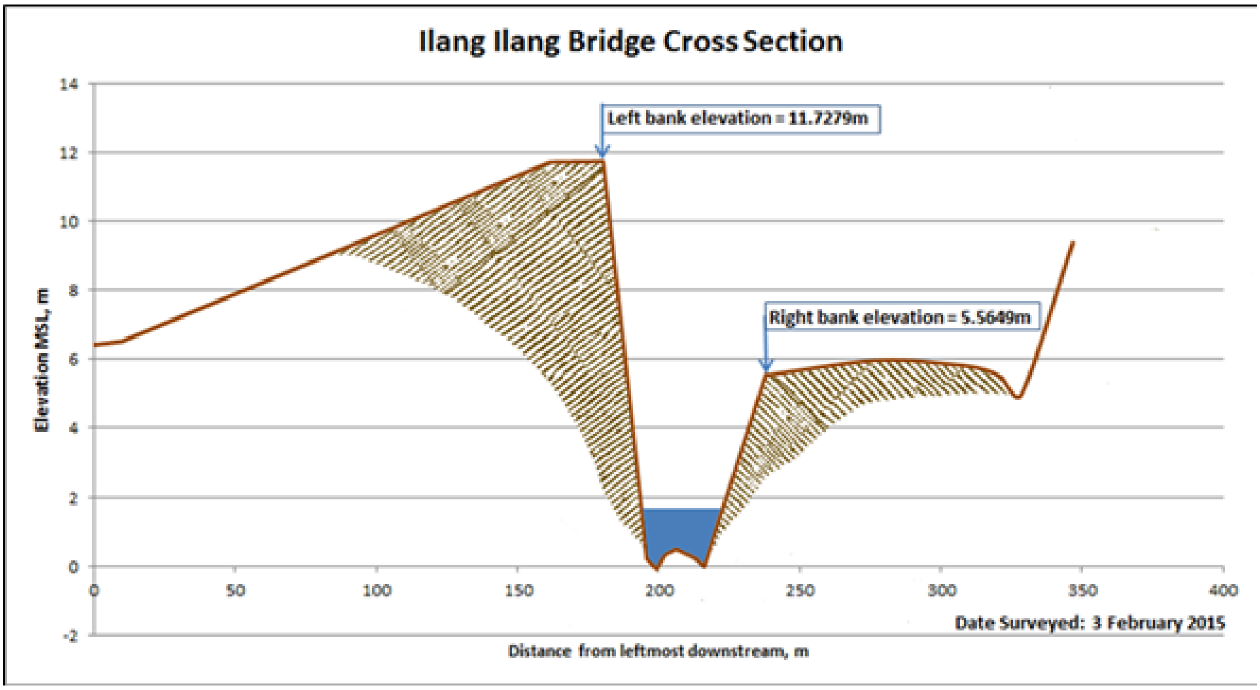


Figure 48. Cross-Section Plot of Ilang-Ilang Bridge.

For Ilang-Ilang Bridge, the rating curve is expressed as y = 0.2466e2.8775x as shown in Figure 49.

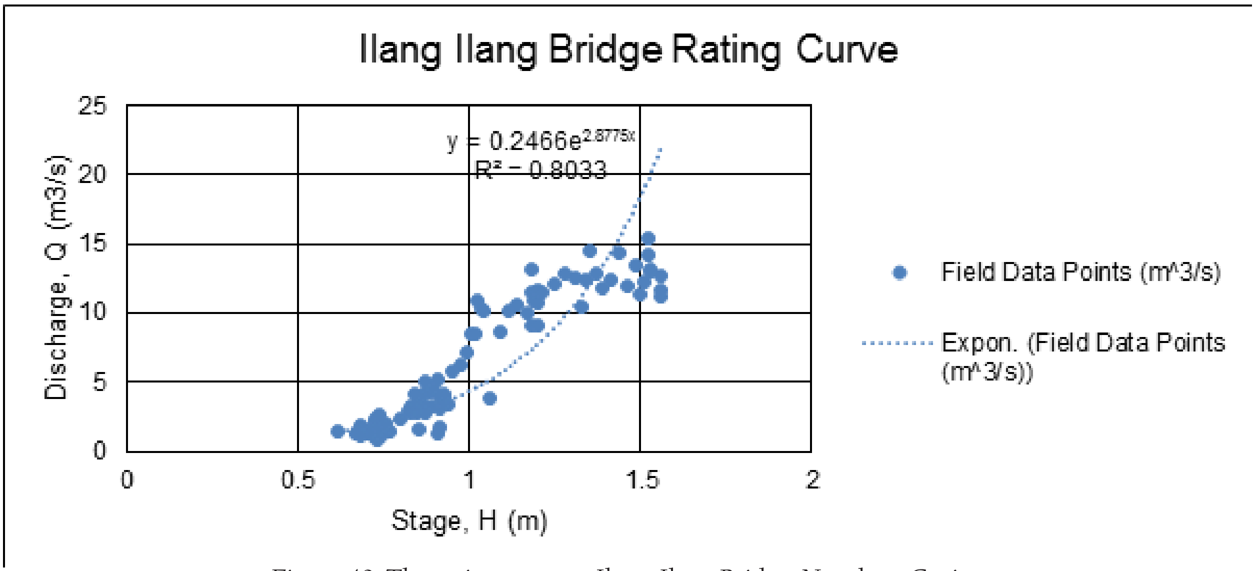


Figure 49. The rating curve at Ilang-Ilang Bridge, Noveleta, Cavite.

This rating curve equation was used to compute the river outflow at Ilang-Ilang Bridge for the calibration of the HEC-HMS model for Ilang-Ilang shown in Figure 50. The peak discharge is 15.4 m3/s at 15:20, August 12, 2016.

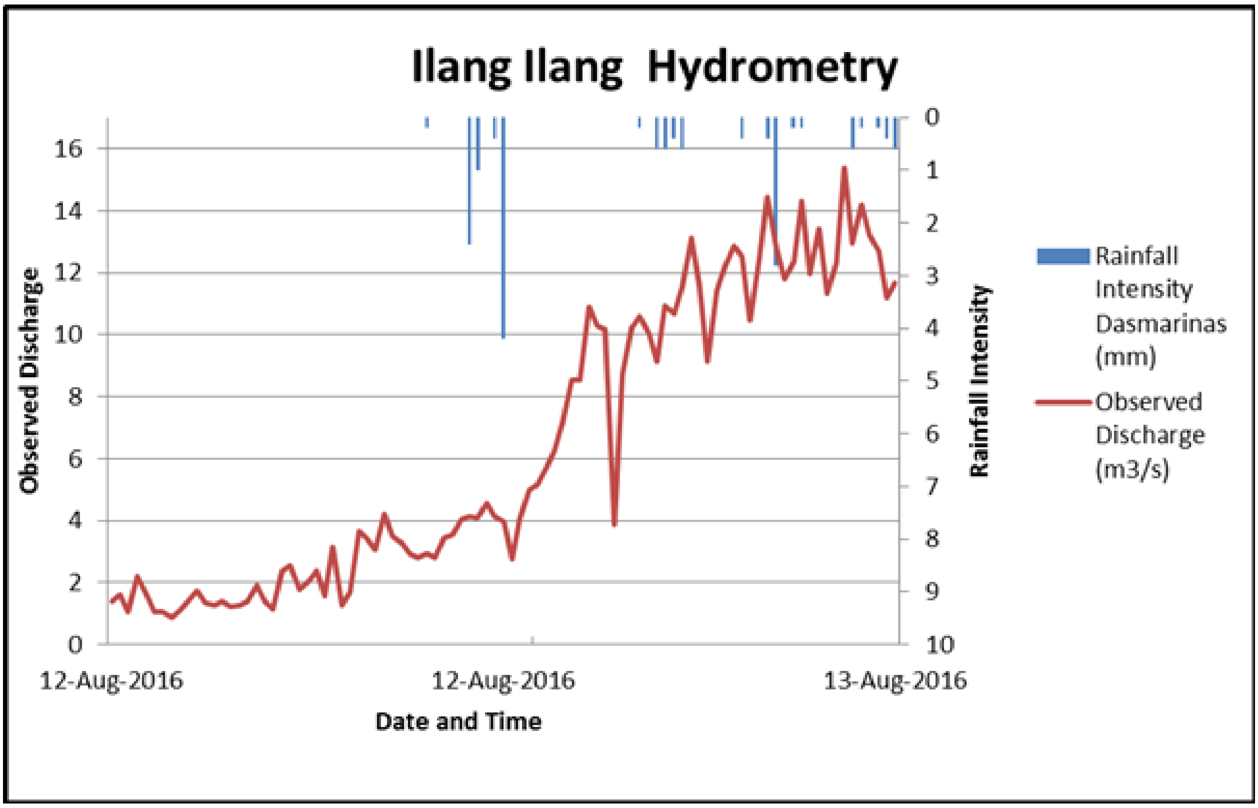


Figure 50. Rainfall and outflow data at Ilang-Ilang Bridge, which was used for modeling.

## 5.2 RIDF Station

PAGASA computed the Rainfall Intensity Duration Frequency (RIDF) values for the Sangley Point Gauge (Table 33). The RIDF rainfall amount for 24 hours was converted into a synthetic storm by interpolating and re-arranging the values in such a way that certain peak values will be attained at a certain time (Figure 52). This station was selected based on its proximity to the Ilang-Ilang watershed. The extreme values for this watershed were computed based on a 54-year record.

Table 33. RIDF values for the Ilang-Ilang River Basin based on average RIDF data of Sangley station, as computed by PAGASA.

| **COMPUTED EXTREME VALUES (in mm) OF PRECIPITATION** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **T (yrs)** | **10 mins** | **20 mins** | **30 mins** | **1 hr** | **2 hrs** | **3 hrs** | **6 hrs** | **12 hrs** | **24 hrs** |
| **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 |

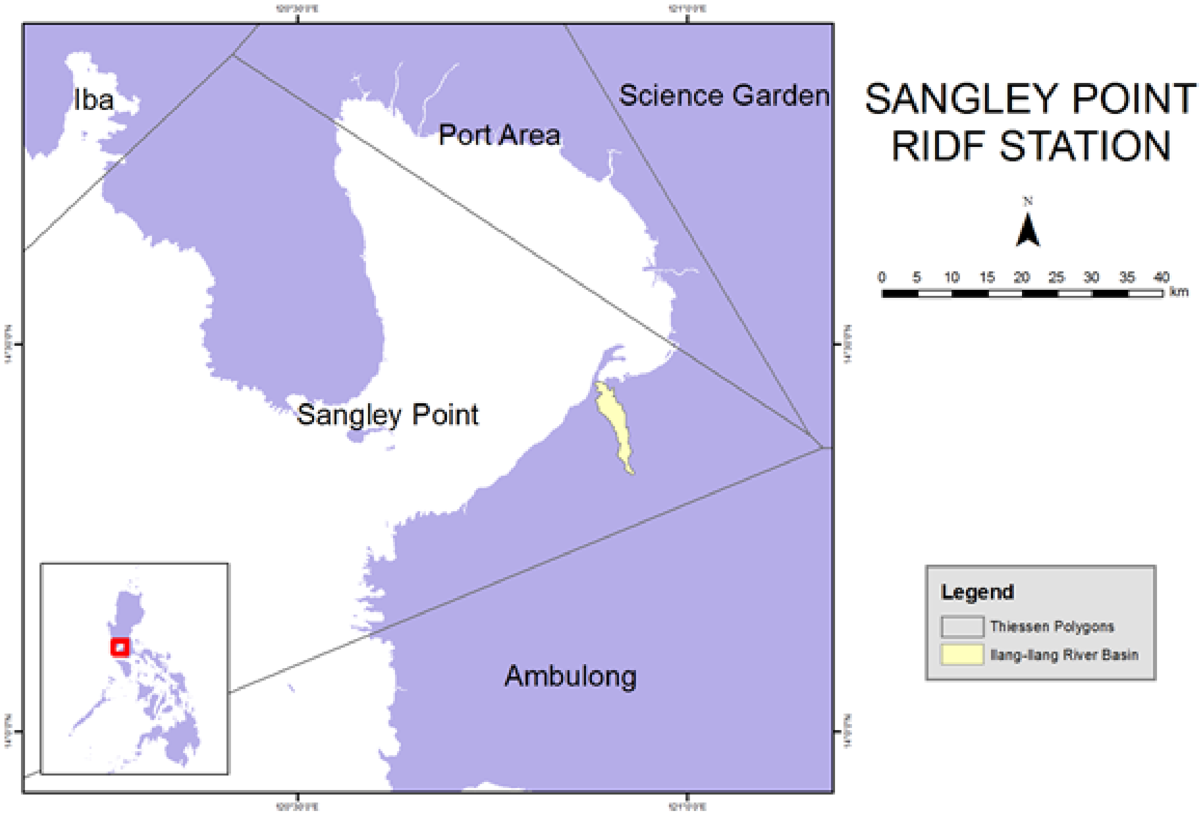


Figure 51. The location of the Sangley Point RIDF station relative to the Ilang-Ilang River Basin.

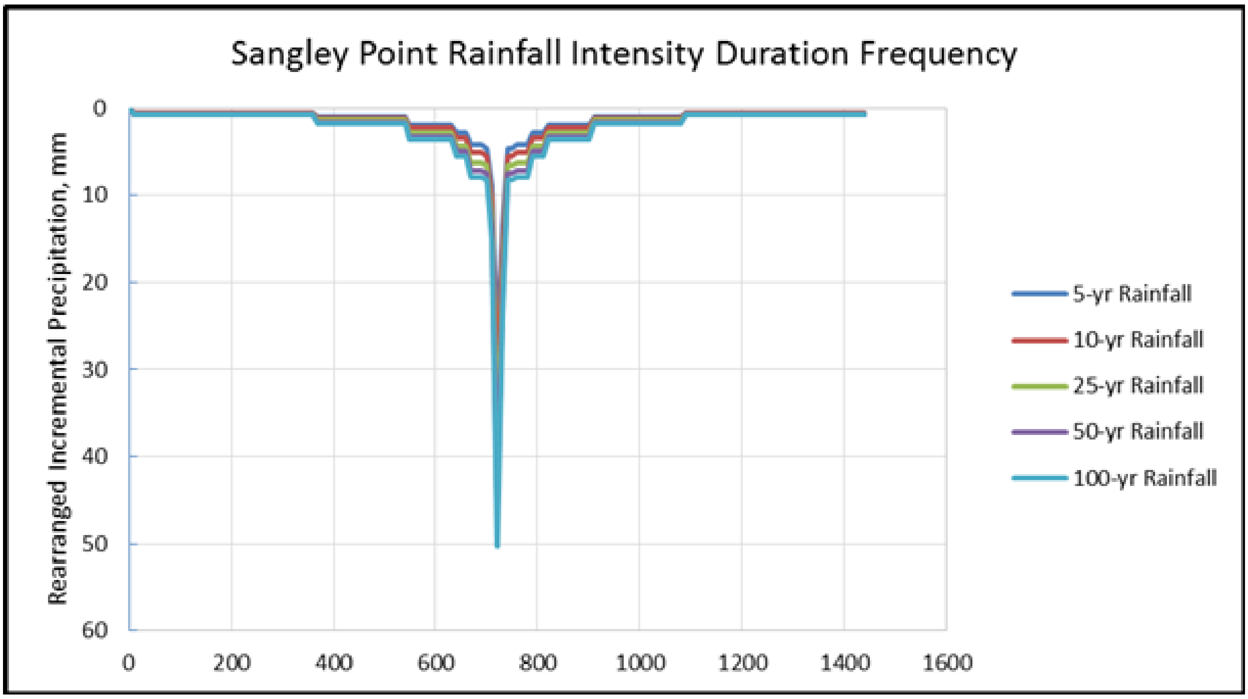


Figure 52. The synthetic storm generated for a 24-hour period rainfall for various return periods.

## 5.3 HMS Model

The soil dataset was generated before 2004 by the Bureau of Soils under the Department of Environment and Natural Resources Management (DENR). The land cover dataset is from the National Mapping and Resource information Authority (NAMRIA). The soil and land cover of the Ilang Ilang River Basin are shown in Figure 53 and Figure 54, respectively.

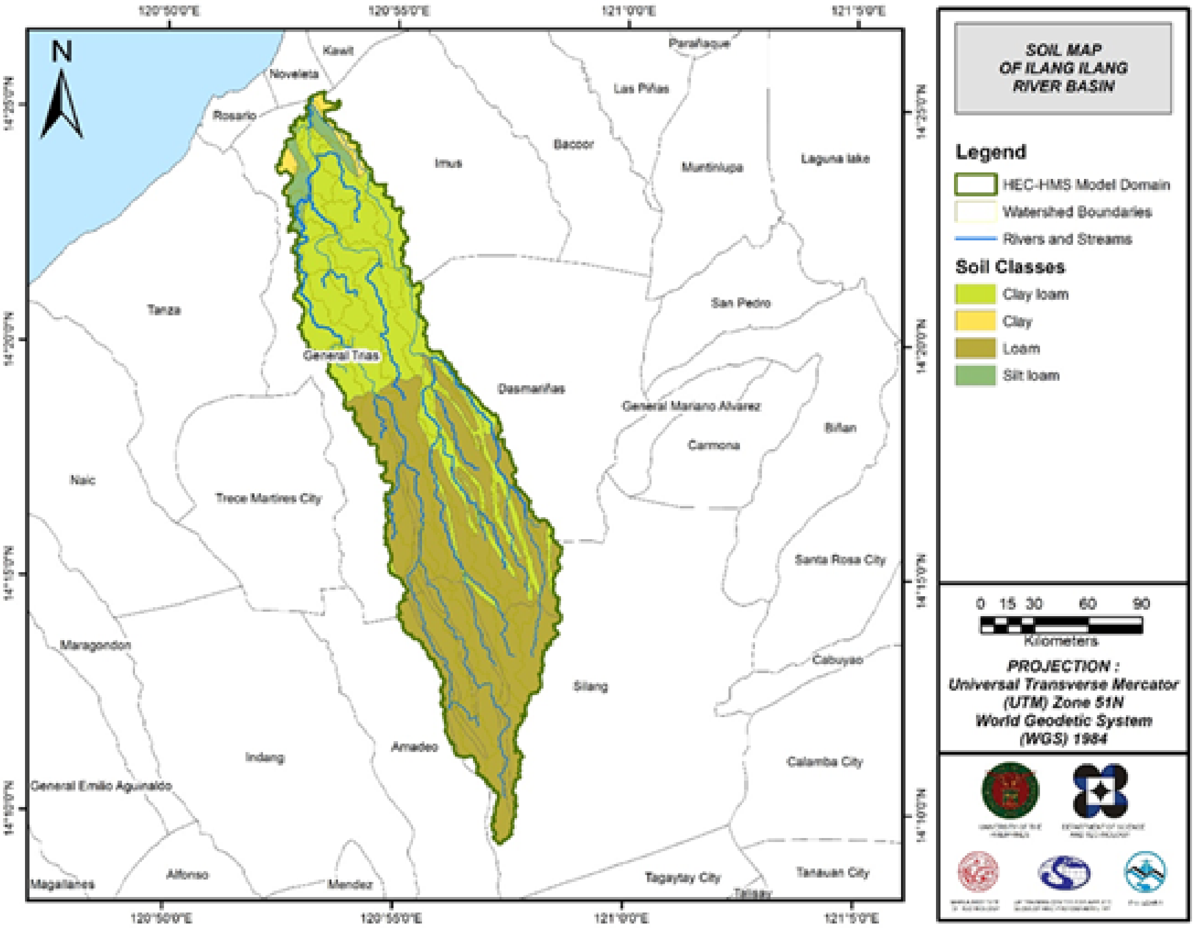


Figure 53. Soil Map of Ilang-Ilang River Basin.

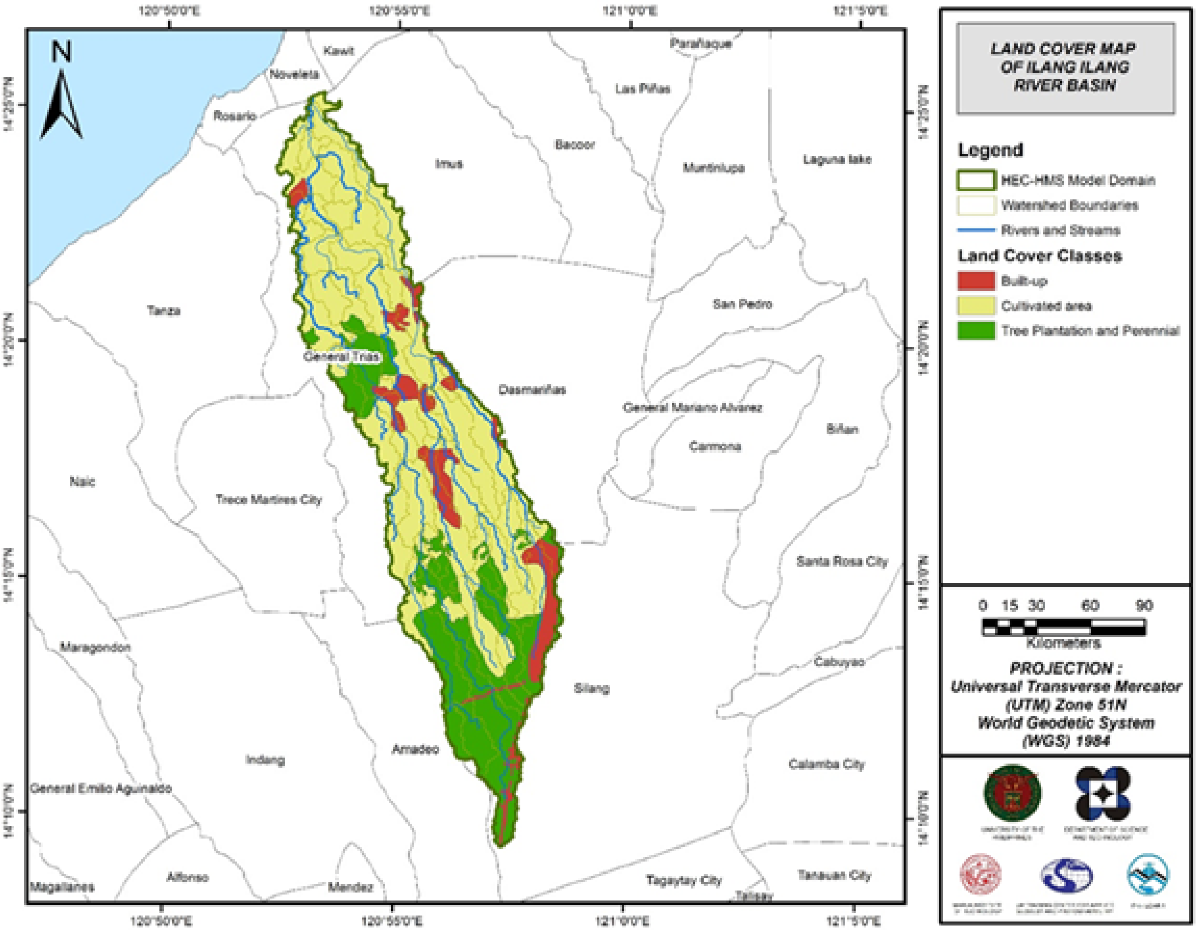


Figure 54. Land Cover Map of Ilang-Ilang River Basin.

For Ilang-Ilang, the soil classes were identified. These are clay, loam, clay loam, clay, and silt loam. Moreover, the land cover classes were identified. These are built-up, cultivated area and tree plantations

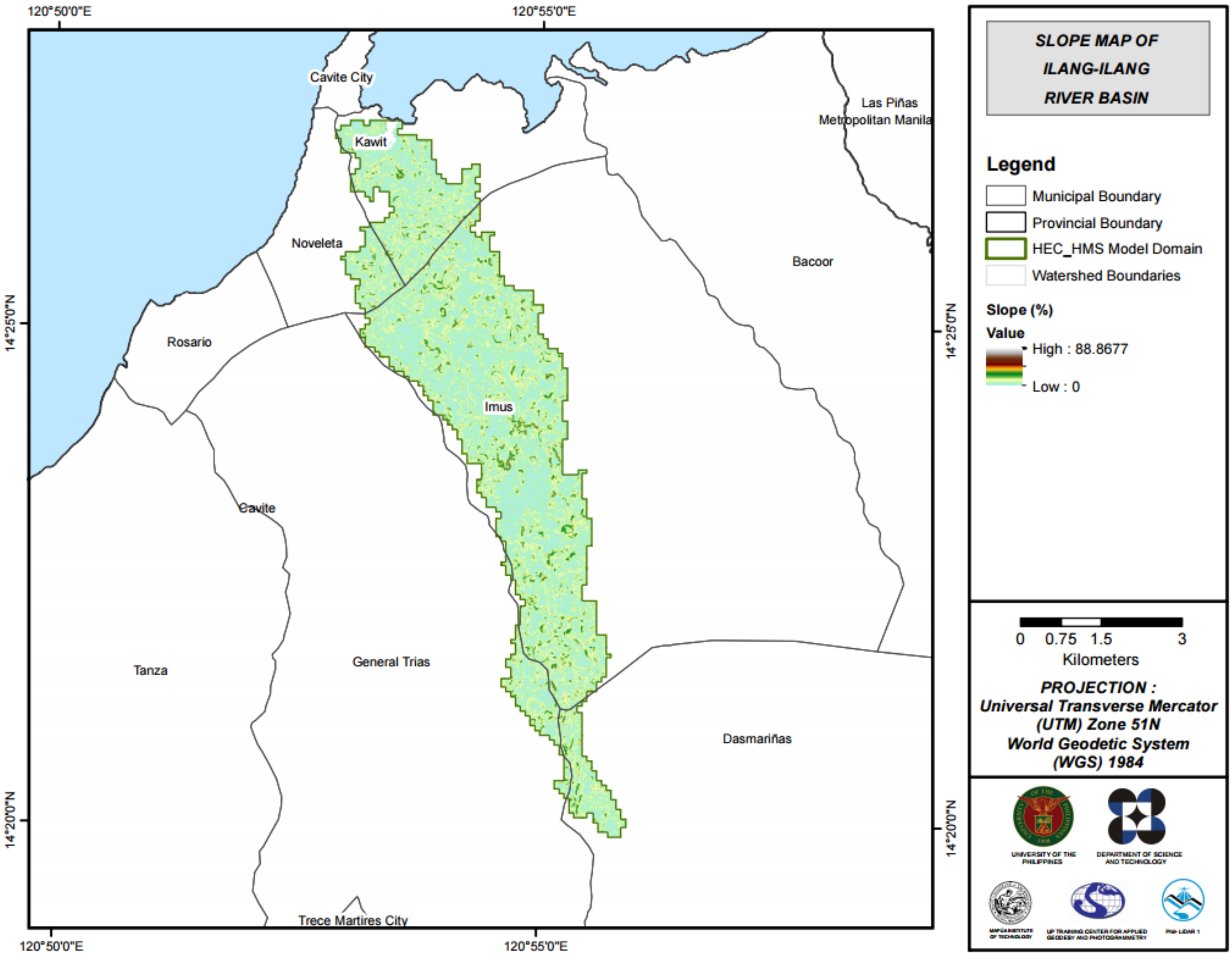


Figure 55. Slope Map of the Ilang-Ilang River Basin.

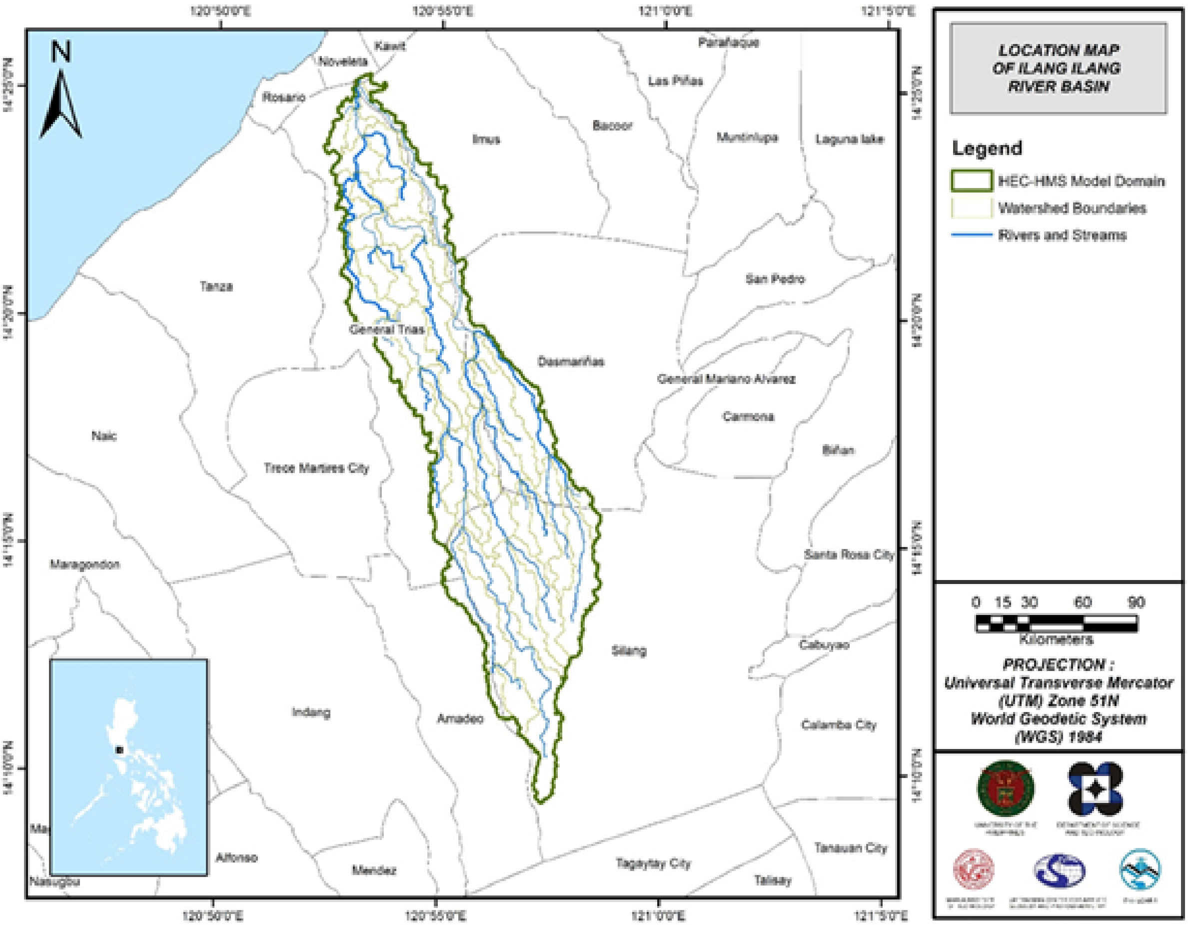


Figure 56. Stream Delineation Map of Ilang-Ilang River Basin

Using the SAR-based DEM, the Ilang Ilang basin was delineated and further subdivided into subbasins. The model consists of 45 sub basins, 22 reaches, and 22 junctions, as shown in Figure 57 (See Annex 10). The main outlet is outlet 2.

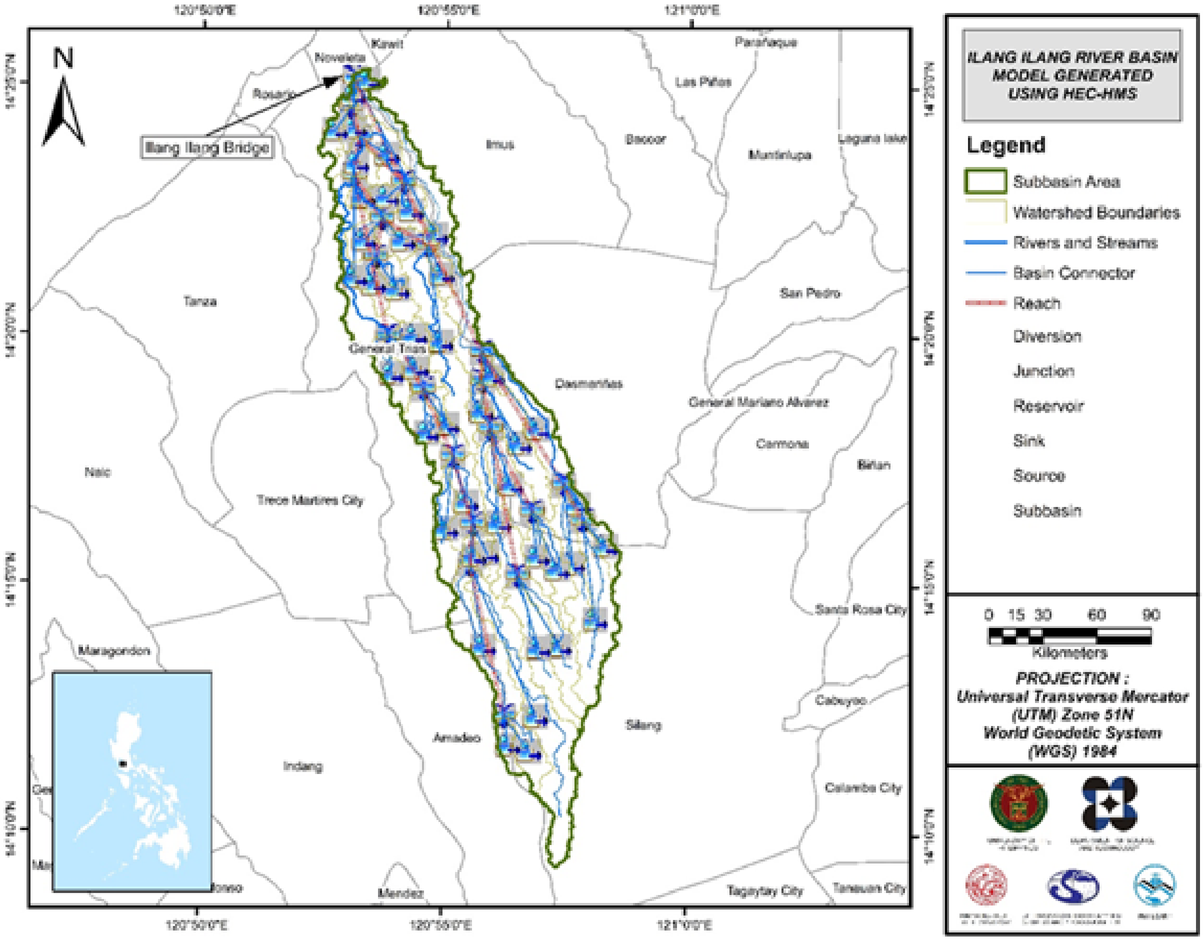


Figure 57. Ilang-Ilang river basin model generated in HEC-HMS.

## 5.4 Cross-section Data

The riverbed cross-sections of the watershed were necessary in the HEC-RAS model setup. The cross-section data for the HEC-RAS model was derived from the LiDAR DEM data, which was defined using the Arc GeoRAS tool and was post-processed in ArcGIS (Figure 58).

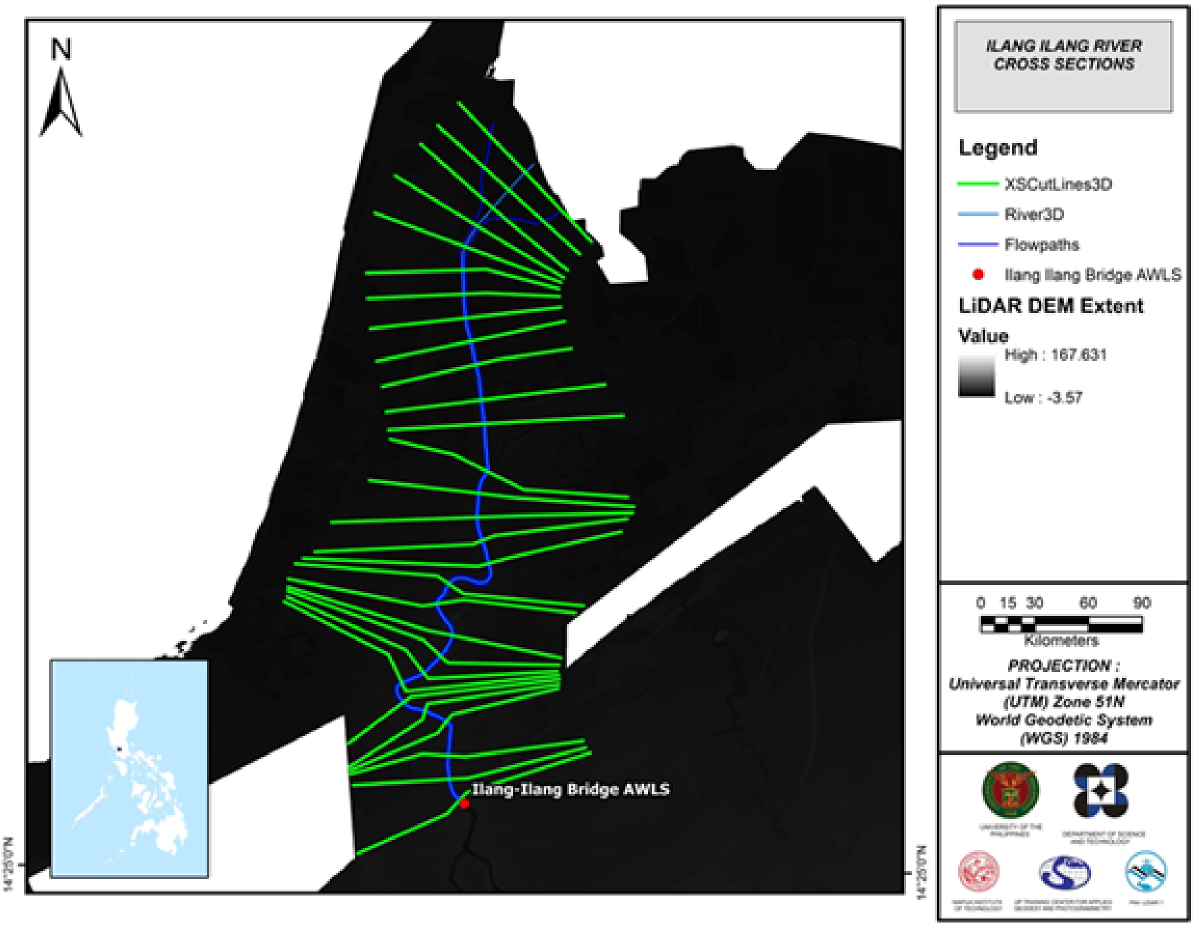


Figure 58. River cross-section of the Ilang-Ilang River through the ArcMap HEC GeoRas tool.

## 5.5 Flo 2D Model

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

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

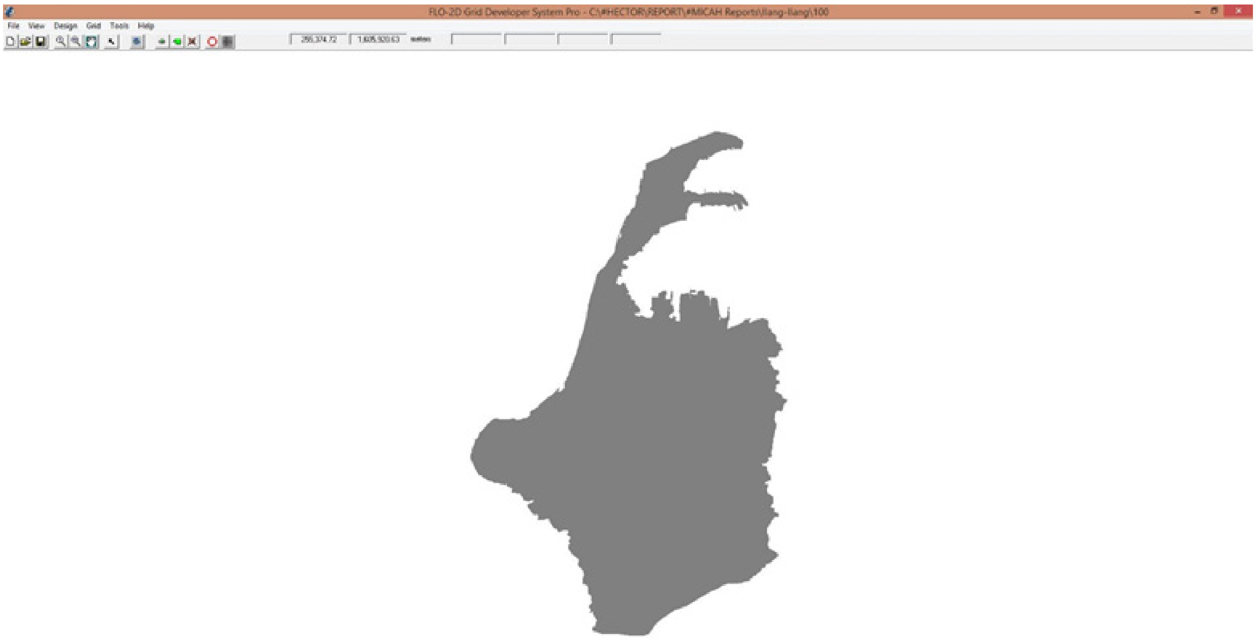


Figure 59. Generated 100-year Rain Return Hazard Map from FLO-2D Mapper

The simulation is then run through FLO-2D GDS Pro. This particular model had a computer run time of 57.88306 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.

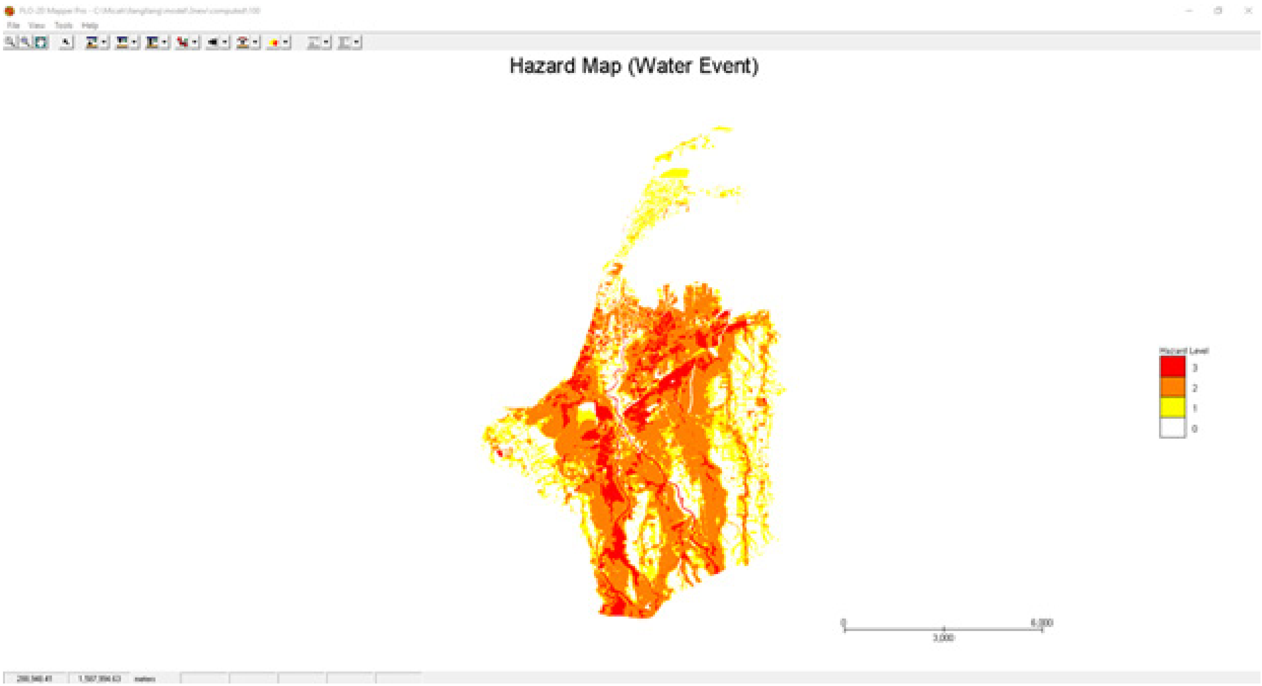


Figure 60. Generated 100-year Rain Return Hazard Map from FLO-2D Mapper

The creation of a flood hazard map from the model also automatically creates a flow depth map depicting the maximum amount of inundation for every grid element. The legend used by default in Flo-2D Mapper is not a good representation of the range of flood inundation values, so a different legend is used for the layout. In this particular model, the inundated parts cover a maximum land area of 66 116 800.00 m2.

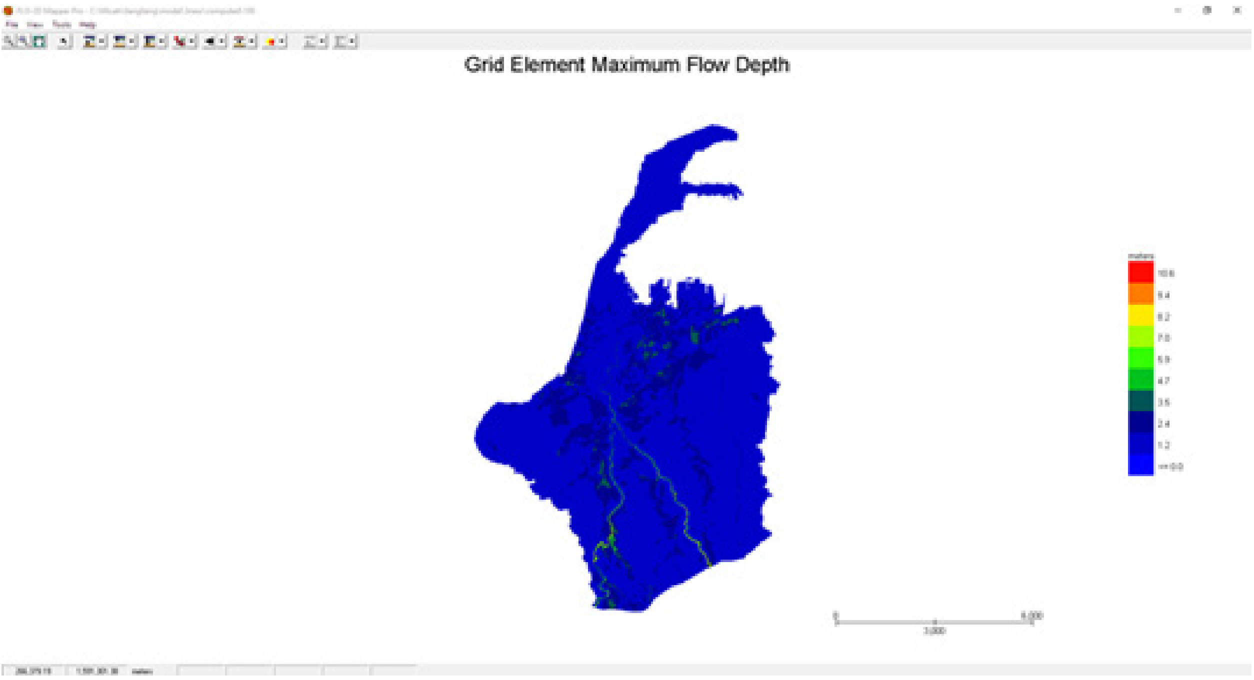


Figure 61. Generated 100-year Rain Return Flow Depth Map from FLO-2D Mapper

There is a total of 61 682 079.01 m3 of water entering the model. Of this amount, 25 353 505.42 m3 is due to rainfall while 36 328 573.59 m3 is inflow from other areas outside the model. 11 748 913.00 m3 of this water is lost to infiltration and interception, while 14 846 850.67 m3 is stored by the flood plain. The rest, amounting up to 35 086 314.17 m3, is outflow.

## 5.6 Results of HMS Calibration

After calibrating the Ilang-Ilang HEC-HMS river basin model (See Annex 9), its accuracy was measured against the observed values. Figure 61 shows the comparison between the two discharge data.

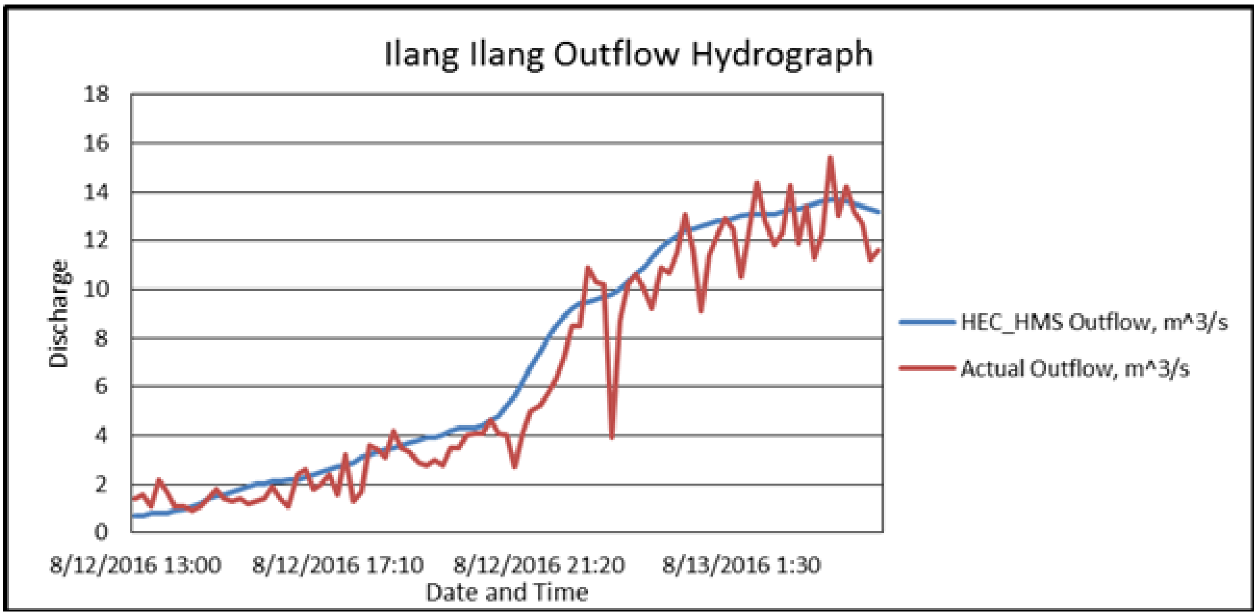


Figure 62. Outflow Hydrograph of Ilang-Ilang produced by the HEC-HMS model compared with observed outflow.

Table 34 shows the adjusted ranges of values of the parameters used in calibrating the model.

Table 34. Range of calibrated values for Ilang-Ilang River Basin

| Hydrologic Element | Calculation Type | Method | Parameter | Range of Calibrated Values |
|---|---|---|---|---|
| Basin | Loss | SCS Curve number | Initial Abstraction (mm) | 0.22 – 9.80 |
| | | | Curve Number | 46.69 - 99 |
| | Transform | Clark Unit Hydrograph | Time of Concentration (hr) | 0.21 – 8.75 |
| | | | Storage Coefficient (hr) | 0.21 – 11.22 |
| | Baseflow | Recession | Recession Constant | 0.33 – 0.75 |
| | | | Ratio to Peak | 0.015 – 0.075 |
| Reach | Routing | Muskingum-Cunge | Manning's Coefficient | 0.0015 – 0.88 |

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 0.22mm to 9.80mm means that there is minimal to average amount of infiltration or rainfall interception by vegetation.

The 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 curve numbers for the watershed's subbasins are from 46.69 to 99. For Ilang Ilang, the basin mostly consists built-up, cultivated area and tree plantations and soil consists of clay, loam, clay loam, clay, and silt loam.

The 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 0.21 hours to 11.22 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. Subbasin values for recession constant range from 0.33 to 0.75 while ratio to peak ranges from 0.015 to 0.075. These values contribute to a shallower receding limb of the outflow hydrograph.

Manning's roughness coefficient of 0.0015 to 0.88 corresponds to the common roughness in the Ilang-Ilang watershed, which describes the varied combinations of soil and land cover in the basin.

Table 35. Summary of the Efficiency Test of the Ilang-Ilang HMS Model

| Accuracy measure | Value |
|---|---|
| RMSE | 1.3 |
| r2 | 0.9443 |
| NSE | 0.92 |
| PBIAS | -8.84 |
| RSR | 0.28 |

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was identified at 1.3 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 0.9443.

The Nash-Sutcliffe (E) method was also used to assess the predictive power of the model. Here the optimal value is 1. The model attained an efficiency coefficient of 0.92.

.

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 -8.84.

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 0.28.

## 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 63) shows the Ilang Ilang 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 (PAGASA) data. The simulation results reveal significant increase in outflow magnitude as the rainfall intensity increases for a range of durations and return periods.

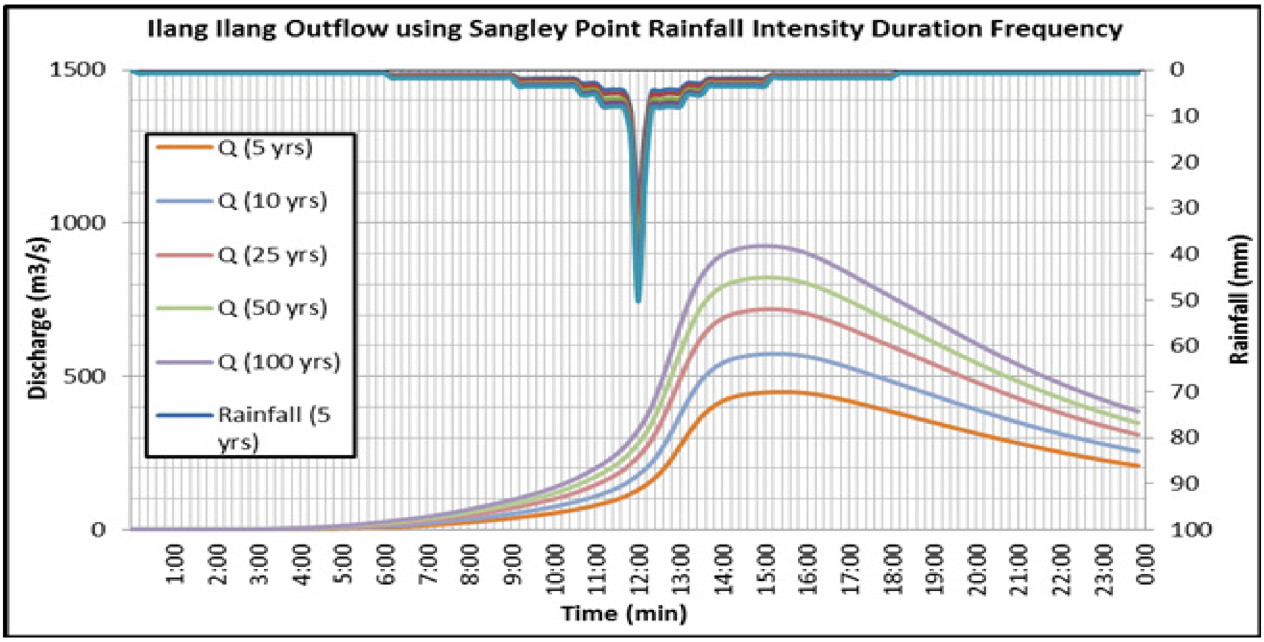


Figure 63. The Outflow hydrograph at Ilang Ilang generated using Sangley PointRIDF simulated in HEC-HMS.

A summary of the total precipitation, peak rainfall, peak outflow and time to peak of the Ilang Ilang River discharge using the Sangley Point Rainfall Intensity-Duration-Frequency curves (RIDF) in five different return periods is shown in Table 36.

Table 36. The peak values of the Ilang-Ilang HEC-HMS Model outflow using the Sangley RIDF.

| RIDF Period | Total Precipitation (mm) | Peak rainfall (mm) | Peak outflow (m 3/s) | Time to Peak |
|---|---|---|---|---|
| 5-Year | 174.0 | 28.3 | 449.5 | 15 hours, 20 minutes |
| 10-Year | 210.0 | 33.6 | 573.7 | 15 hours, 10 minutes |
| 25-Year | 255.5 | 40.3 | 719.3 | 15 hours, 10 minutes |
| 50-Year | 289.3 | 45.3 | 823.0 | 15 hours |
| 100-Year | 322.8 | 50.3 | 926.2 | 15 hours |

## 5.8 River Analysis (RAS) Model Simulation

The HEC-RAS Flood Model produced a simulated water level at every cross-section for every time step for every flood simulation created. The resulting model will be used in determining the flooded areas within the model. The simulated model will be an integral part in determining real-time flood inundation extent of the river after it has been automated and uploaded on the DREAM website. For this publication, only a sample output map river was to be shown, since only the Flood Acquisition and Validation Component (MIT-FAVC) base flow was calibrated. Figure 63 shows a generated sample map of the Ilang-Ilang River using the calibrated HMS base flow.

Figure 64. Sample output map of the Ilnag-ilang RAS Model.

## 5.9 Flow Depth and Flood Hazard

The resulting hazard and flow depth maps have a 10m resolution. Figure 65 to Figure 70 shows the 5-, 25-, and 100-year rain return scenarios of the Ilang-Ilang floodplain. shows the percentage of area affected by flooding per municipality.

Table 37. Municipalities affected in Ilang-Ilang floodplain.

| Municipality/ City | Total Area (sq.km.) | Area Flooded (sq. km.) | % Flooded |
|---|---|---|---|
| Cavite City | 11.88 | 5.95 | 50% |
| Kawit | 15.97 | 7.10 | 44% |
| Imus | 50.40 | 22.24 | 44% |
| Noveleta | 5.16 | 2.64 | 51% |
| General Trias | 87.50 | 11.01 | 13% |

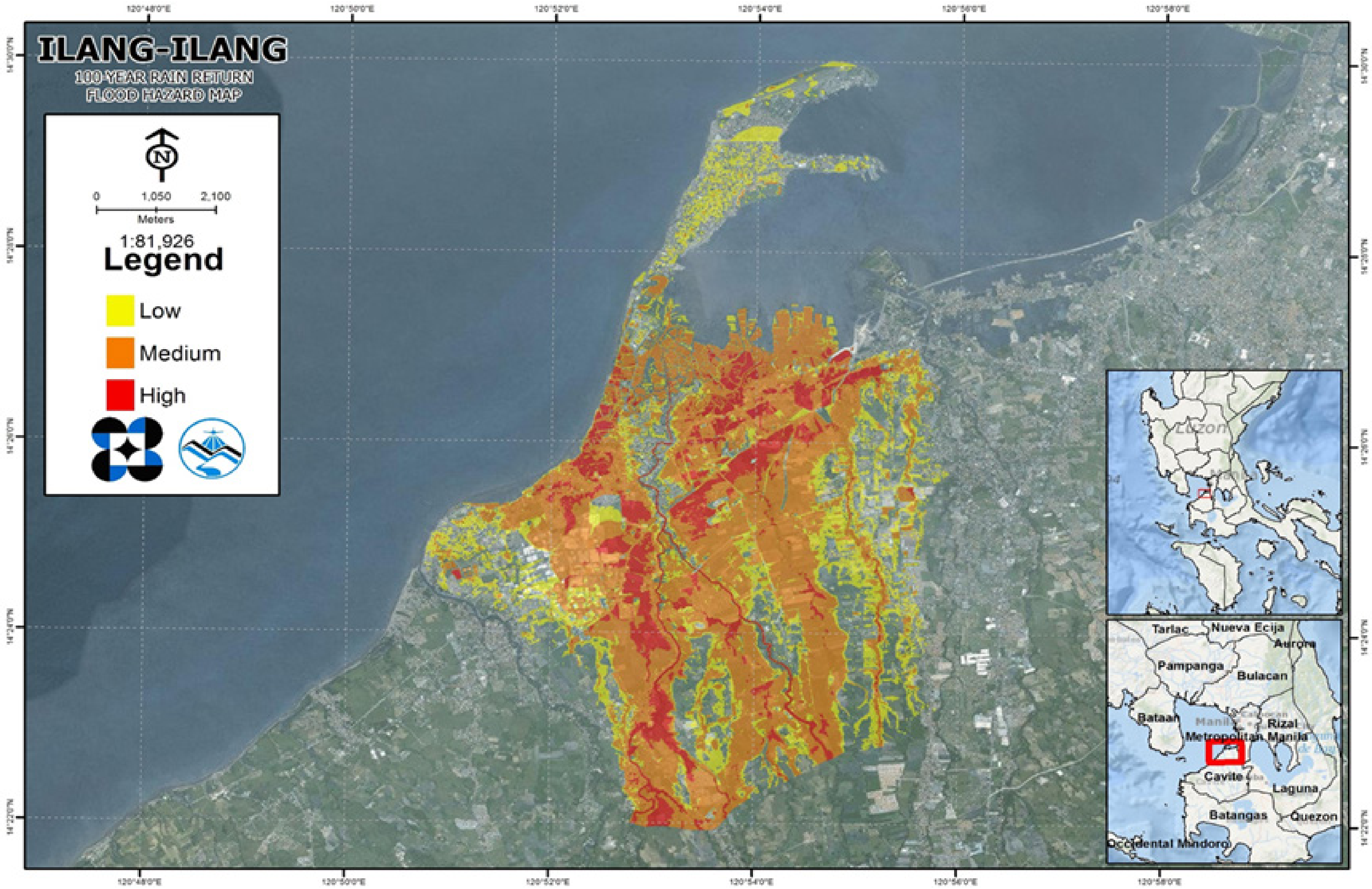


Figure 65. A 100-year Flood Hazard Map for Ilang-Ilang Floodplain overlaid on Google Earth imagery.

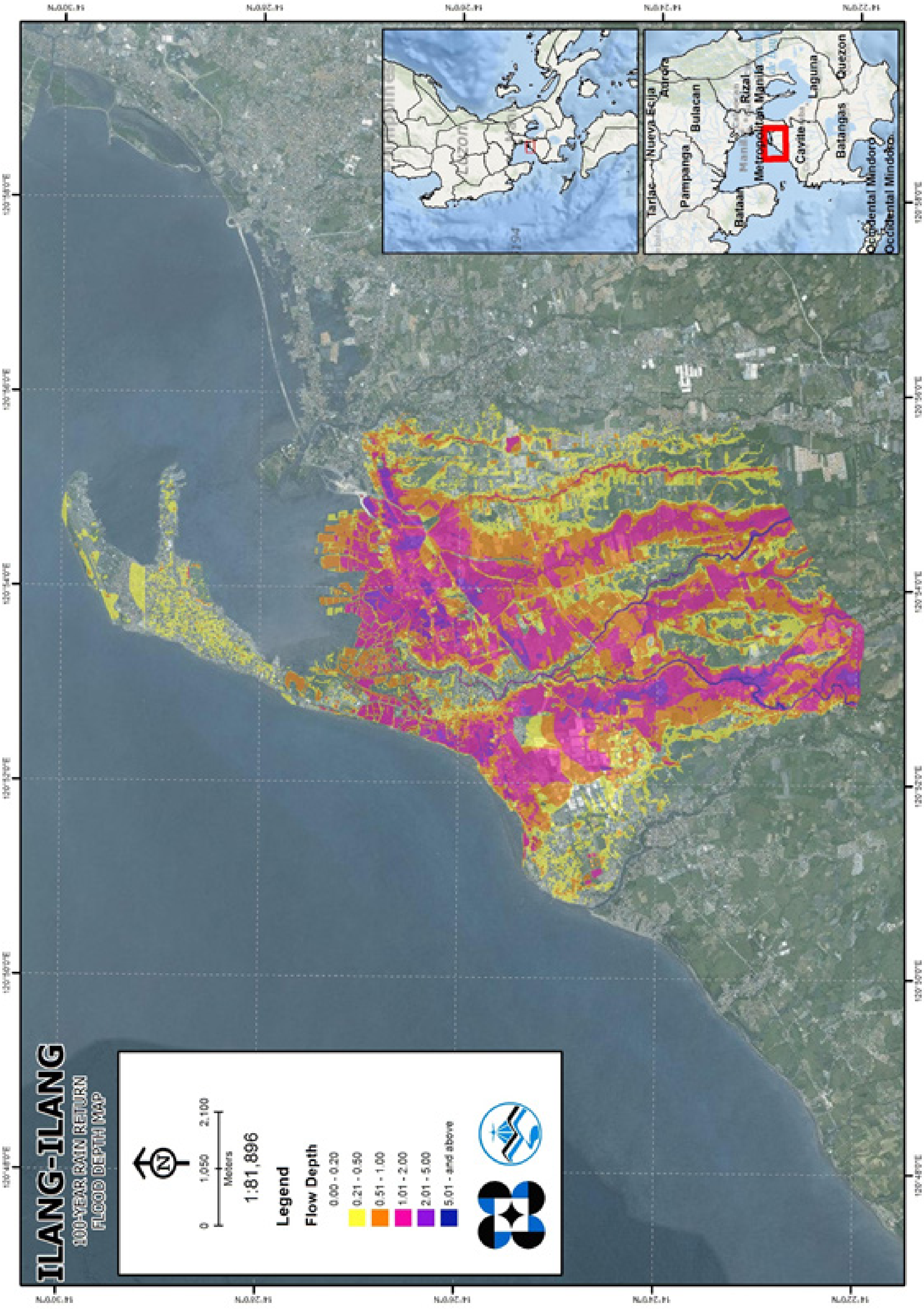


Figure 66. A 100-year Flow Depth Map for Ilang-Ilang Floodplain overlaid on Google Earth imagery.

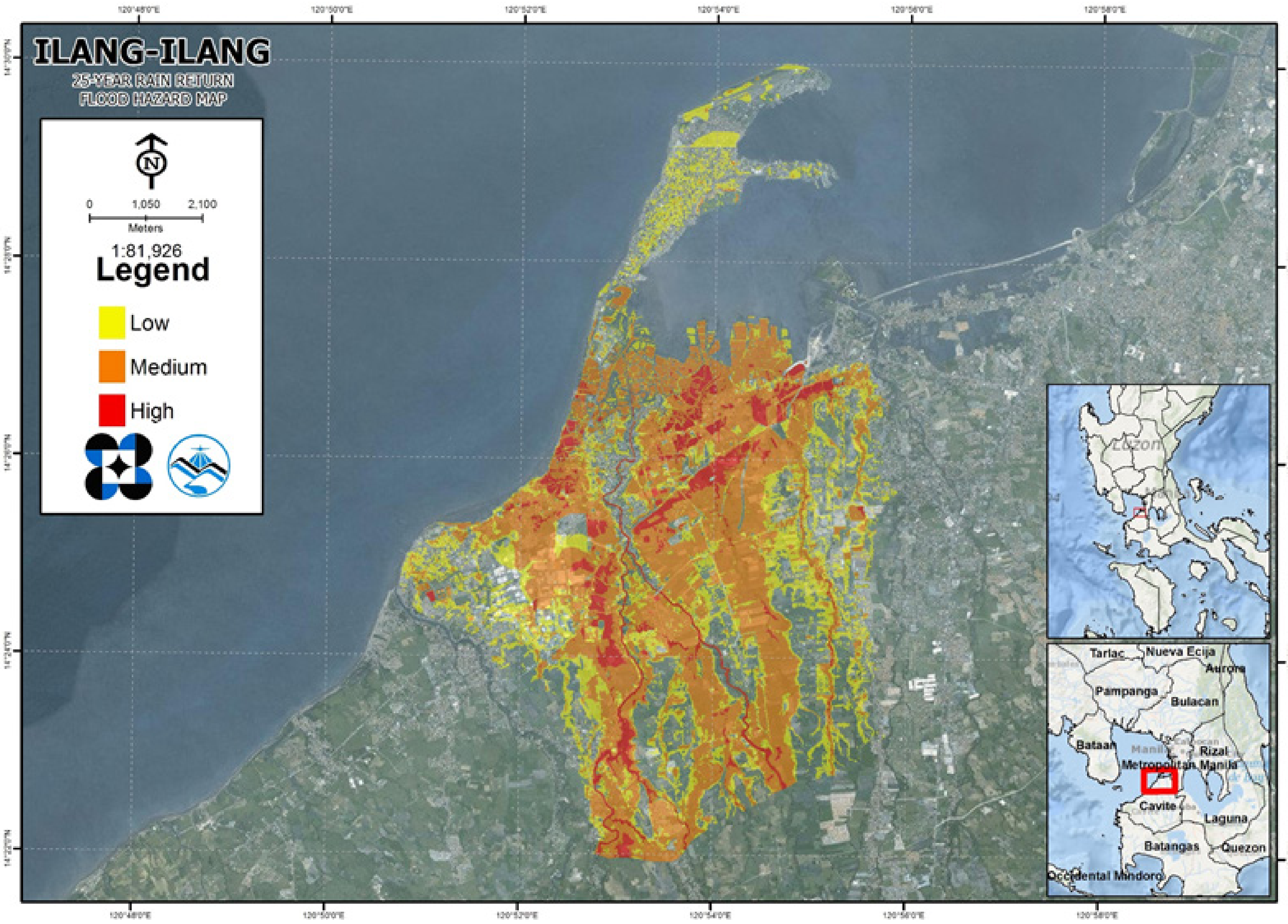


Figure 67. A 25-year Flood Hazard Map for Ilang-Ilang Floodplain overlaid on Google Earth imagery.

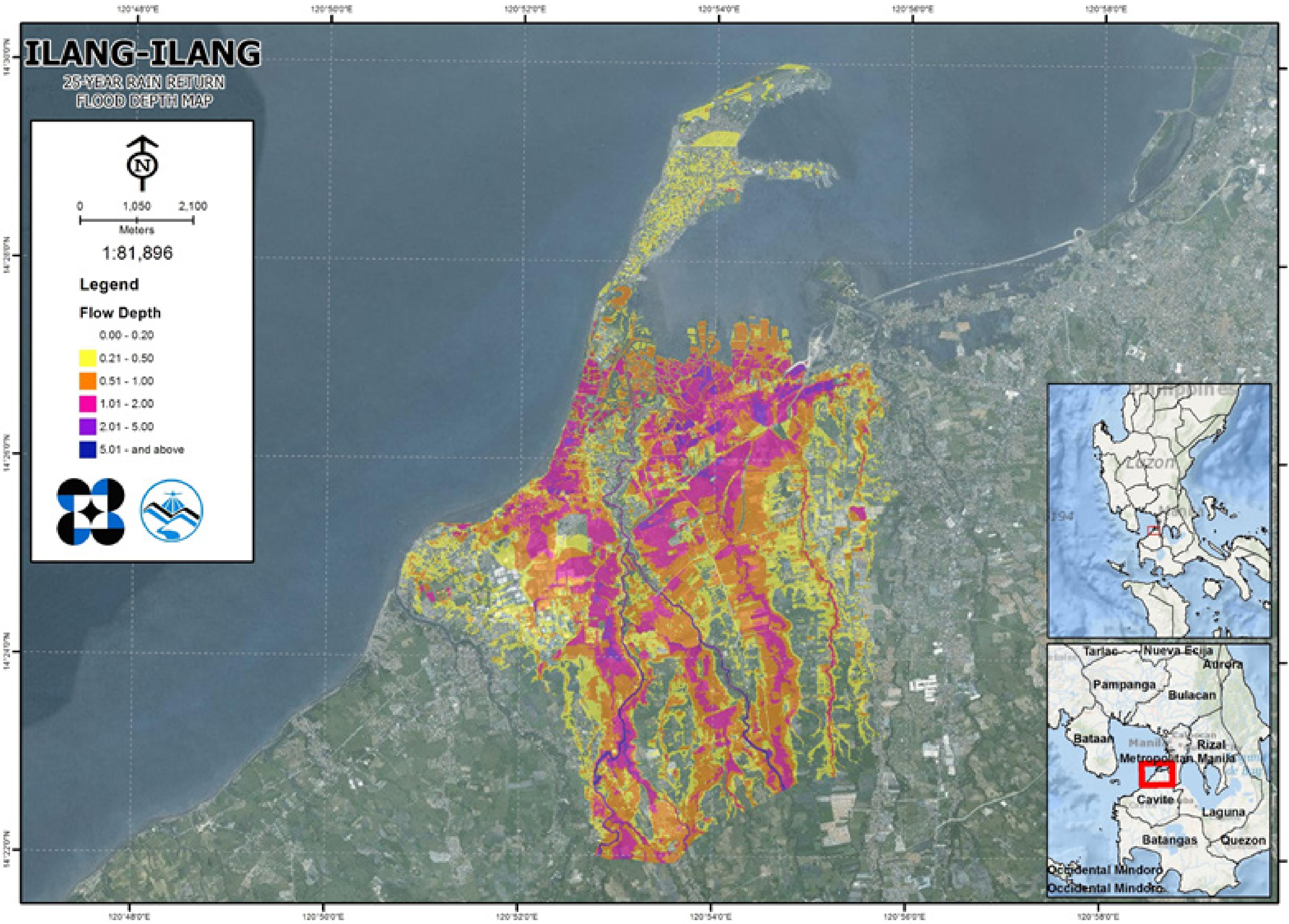


Figure 68. A 25-year Flow Depth Map for Ilang-Ilang Floodplain overlaid on Google Earth imagery.

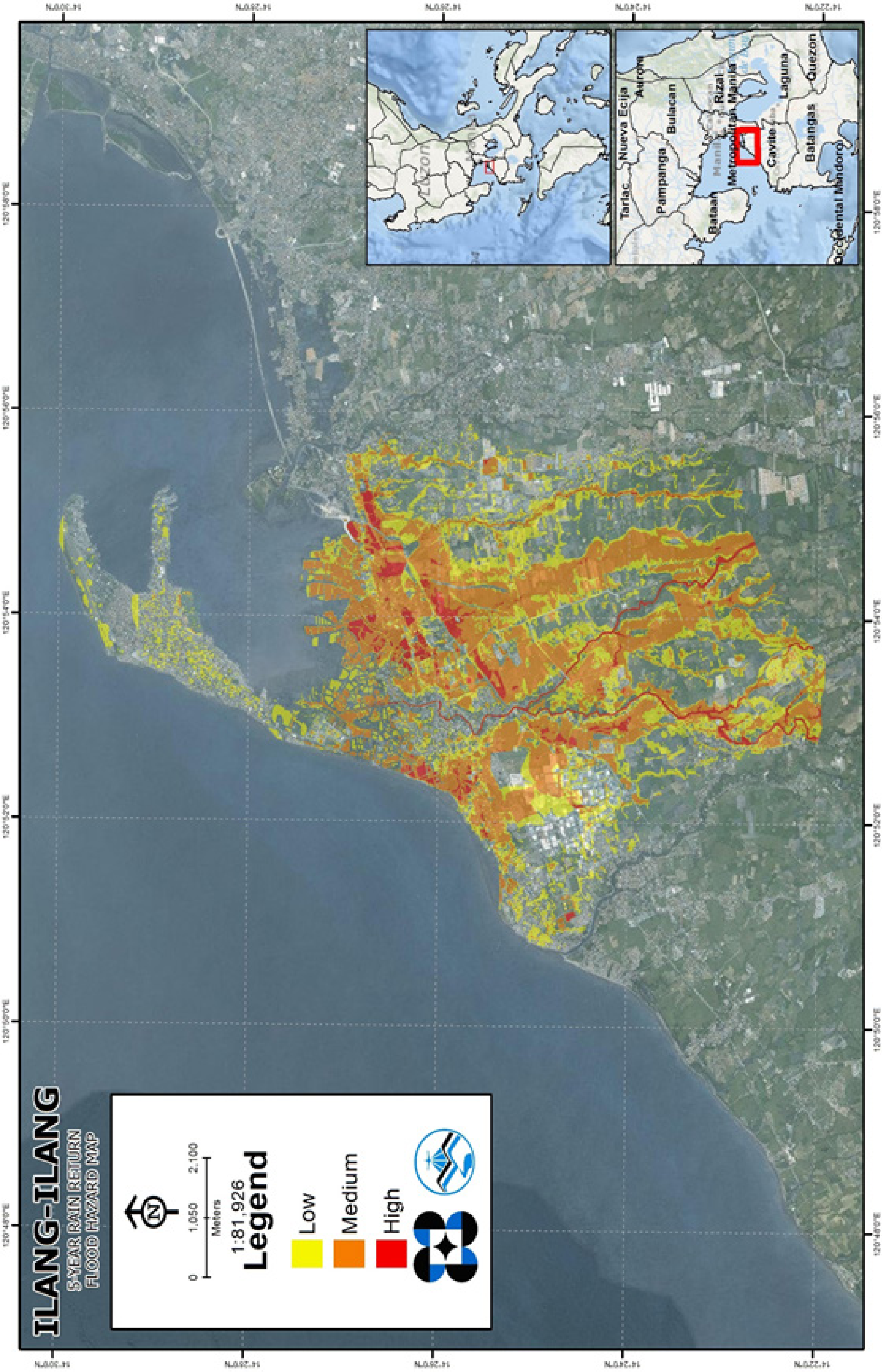


Figure 69. A 5-year Flood Hazard Map for Ilang-Ilang Floodplain overlaid on Google Earth imagery.

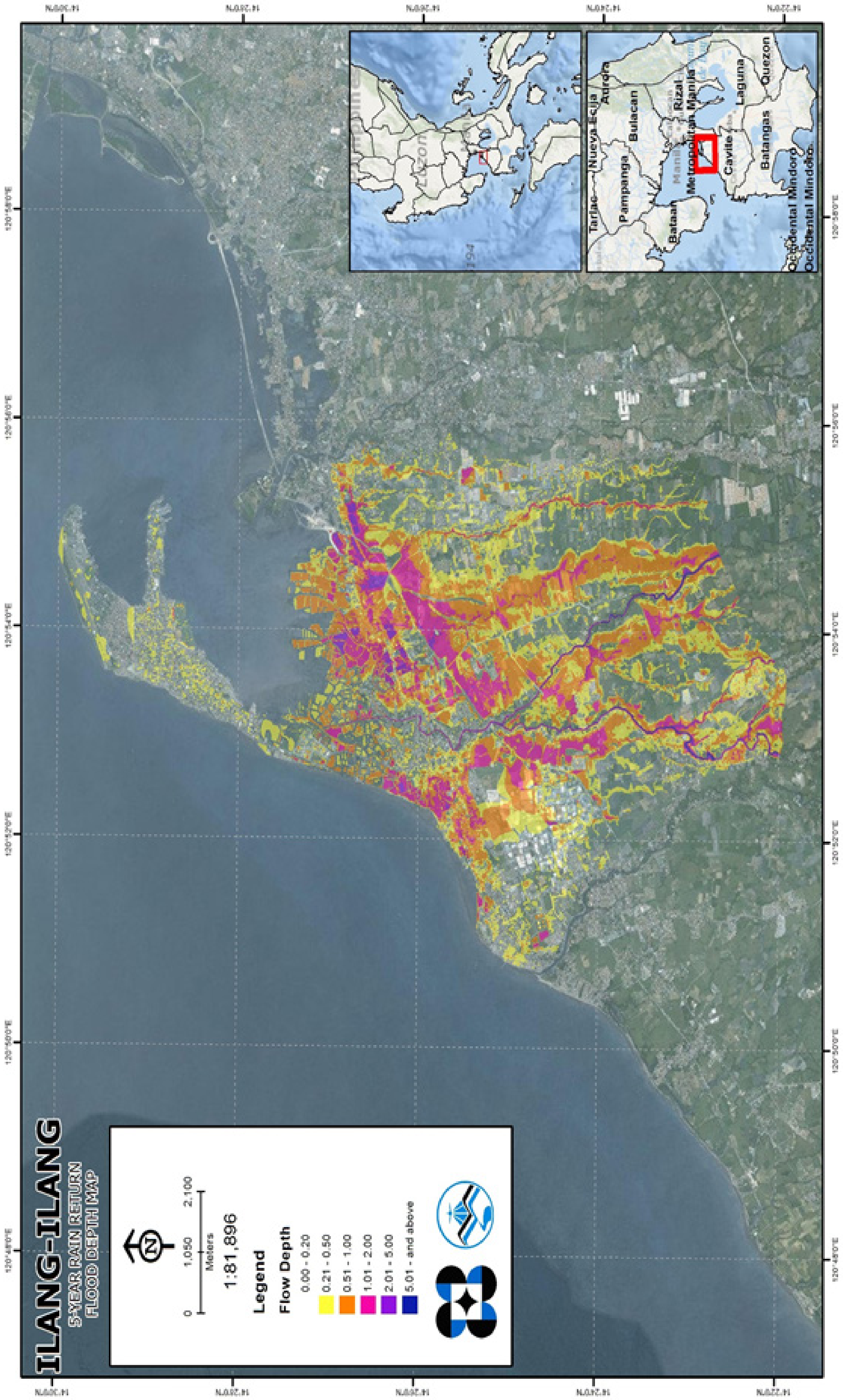


Figure 70. A 5-year Flood Depth Map for Ilang-Ilang Floodplain overlaid on Google Earth imagery.

## 5.10 Inventory of Areas Exposed to Flooding

Listed below are the barangays affected by the Ilang Ilang River Basin, grouped accordingly by municipality. For the said basin, five (5) municipalities consisting of 171 barangays are expected to experience flooding when subjected to a 5-year rainfall return period.

For the 5-year return period, 40.45% of the municipality of Cavite City with an area of 11.88 sq. km. will experience flood levels of less than 0.20 meters. 9.25% of the area will experience flood levels of 0.21 to 0.50 meters while 0.36%, 0.04%, 0.00%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the Table 38 are the affected areas in square kilometers by flood depth per barangay. Annex 12 and Annex 13 show the educational and health institutions exposed to flooding, respectively.

Table 38. Affected areas in Cavite City, Cavite during a 5-Year Rainfall Return Period

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barangay 1 | Barangay 10 | Barangay 10-A | Barangay 10-B | Barangay 11 | Barangay 12 | Barangay 13 | Barangay 14 | Barangay 15 | Barangay 16 | Barangay 17 |
| **0.03-0.20** | 0.023 | 0.06 | 0.022 | 0.038 | 0.055 | 0.017 | 0.042 | 0.038 | 0.028 | 0.077 | 0.019 |
| **0.21-0.50** | 0.0054 | 0.013 | 0.0016 | 0.0018 | 0.0027 | 0.0077 | 0.0021 | 0.0031 | 0.0076 | 0.02 | 0.014 |
| **0.51-1.00** | 0.000017 | 0.001 | 0 | 0 | 0.000012 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1.01-2.00** | 0 | 0 | 0 | 0 | 0.000003 | 0 | 0.000002 | 0 | 0 | 0 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barangay 18 | Barangay 19 | Barangay 2 | Barangay 20 | Barangay 22 | Barangay 22-A | Barangay 23 | Barangay 24 | Barangay 25 | Barangay 26 | Barangay 27 |
| **0.03-0.20** | 0.023 | 0.06 | 0.022 | 0.038 | 0.055 | 0.017 | 0.042 | 0.038 | 0.028 | 0.077 | 0.019 |
| **0.21-0.50** | 0.0054 | 0.013 | 0.0016 | 0.0018 | 0.0027 | 0.0077 | 0.0021 | 0.0031 | 0.0076 | 0.02 | 0.014 |
| **0.51-1.00** | 0.000017 | 0.001 | 0 | 0 | 0.000012 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1.01-2.00** | 0 | 0 | 0 | 0 | 0.000003 | 0 | 0.000002 | 0 | 0 | 0 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barangay 28 | Barangay 29 | Barangay 29-A | Barangay 3 | Barangay 30 | Barangay 31 | Barangay 32 | Barangay 33 | Barangay 34 | Barangay 35 | Barangay 36 |
| **0.03-0.20** | 0.023 | 0.06 | 0.022 | 0.038 | 0.055 | 0.017 | 0.042 | 0.038 | 0.028 | 0.077 | 0.019 |
| **0.21-0.50** | 0.0054 | 0.013 | 0.0016 | 0.0018 | 0.0027 | 0.0077 | 0.0021 | 0.0031 | 0.0076 | 0.02 | 0.014 |
| **0.51-1.00** | 0.000017 | 0.001 | 0 | 0 | 0.000012 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1.01-2.00** | 0 | 0 | 0 | 0 | 0.000003 | 0 | 0.000002 | 0 | 0 | 0 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barangay 36-A | Barangay 37 | Barangay 37-A | Barangay 38 | Barangay 38-A | Barangay 39 | Barangay 4 | Barangay 40 | Barangay 41 | Barangay 42 | Barangay 42-A |
| **0.03-0.20** | 0.023 | 0.06 | 0.022 | 0.038 | 0.055 | 0.017 | 0.042 | 0.038 | 0.028 | 0.077 | 0.019 |
| **0.21-0.50** | 0.0054 | 0.013 | 0.0016 | 0.0018 | 0.0027 | 0.0077 | 0.0021 | 0.0031 | 0.0076 | 0.02 | 0.014 |
| **0.51-1.00** | 0.000017 | 0.001 | 0 | 0 | 0.000012 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1.01-2.00** | 0 | 0 | 0 | 0 | 0.000003 | 0 | 0.000002 | 0 | 0 | 0 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barangay 42-B | Barangay 42-C | Barangay 43 | Barangay 44 | Barangay 45 | Barangay 45-A | Barangay 46 | Barangay 47 | Barangay 47-A | Barangay 47-B | Barangay 48 |
| **0.03-0.20** | 0.023 | 0.06 | 0.022 | 0.038 | 0.055 | 0.017 | 0.042 | 0.038 | 0.028 | 0.077 | 0.019 |
| **0.21-0.50** | 0.0054 | 0.013 | 0.0016 | 0.0018 | 0.0027 | 0.0077 | 0.0021 | 0.0031 | 0.0076 | 0.02 | 0.014 |
| **0.51-1.00** | 0.000017 | 0.001 | 0 | 0 | 0.000012 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1.01-2.00** | 0 | 0 | 0 | 0 | 0.000003 | 0 | 0.000002 | 0 | 0 | 0 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barangay 48-A | Barangay 49 | Barangay 49-A | Barangay 5 | Barangay 50 | Barangay 51 | Barangay 52 | Barangay 53 | Barangay 53-A | Barangay 53-B | Barangay 54 |
| **0.03-0.20** | 0.038 | 0.037 | 0.037 | 0.012 | 0.036 | 0.04 | 0.036 | 1.35 | 0.019 | 0.015 | 0.043 |
| **0.21-0.50** | 0.0093 | 0.0029 | 0.00019 | 0.00065 | 0 | 0 | 0 | 0.2 | 0 | 0 | 0.0087 |
| **0.51-1.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0022 | 0 | 0 | 0 |
| **1.01-2.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barangay 54-A | Barangay 55 | Barangay 56 | Barangay 57 | Barangay 58 | Barangay 58-A | Barangay 59 | Barangay 6 | Barangay 60 | Barangay 61 | Barangay 61-A |
| **0.03-0.20** | 0.013 | 0.044 | 0.045 | 0.011 | 0.007 | 0.012 | 0.045 | 0.081 | 0.028 | 0.023 | 0.02 |
| **0.21-0.50** | 0.0077 | 0.022 | 0.0096 | 0.0045 | 0.0075 | 0.005 | 0.0043 | 0.027 | 0.007 | 0.008 | 0.0021 |
| **0.51-1.00** | 0 | 0 | 0 | 0.00075 | 0.0008 | 0.0029 | 0 | 0.00048 | 0.000044 | 0 | 0 |
| **1.01-2.00** | 0 | 0 | 0 | 0 | 0 | 0.0011 | 0 | 0 | 0 | 0 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | |
|---|---|---|---|---|---|---|
| | Barangay 62 | Barangay 62-A | Barangay 62-B | Barangay 7 | Barangay 8 | Barangay 9 |
| **0.03-0.20** | 0.2 | 0.059 | 0.23 | 0.011 | 0.23 | 0.025 |
| **0.21-0.50** | 0.033 | 0.02 | 0.015 | 0.005 | 0.038 | 0.019 |
| **0.51-1.00** | 0.00044 | 0.0002 | 0 | 0 | 0.0046 | 0.0013 |
| **1.01-2.00** | 0 | 0 | 0 | 0 | 0.0022 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 |

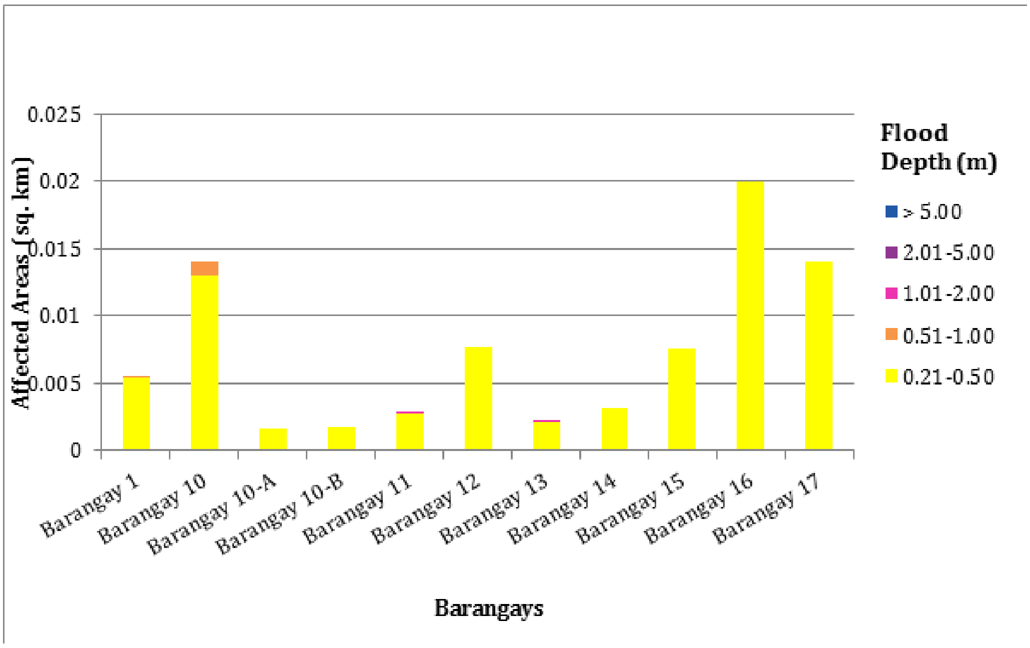


Figure 71. Affected areas in Cavite City, Cavite during a 5-Year Rainfall Return Period.

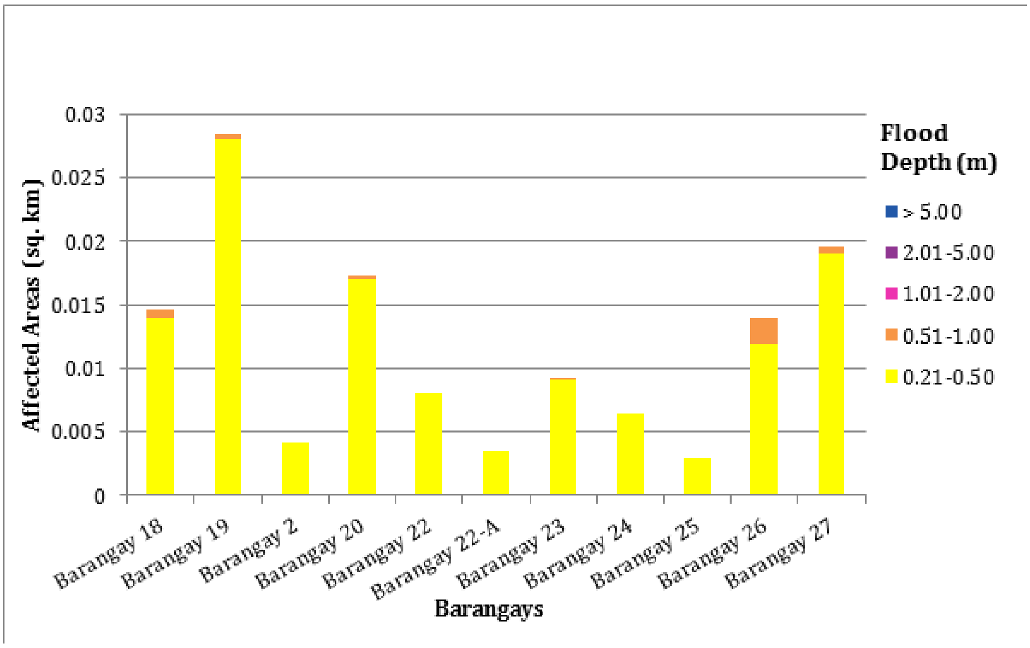


Figure 72. Affected areas in Cavite City, Cavite during a 5-Year Rainfall Return Period.

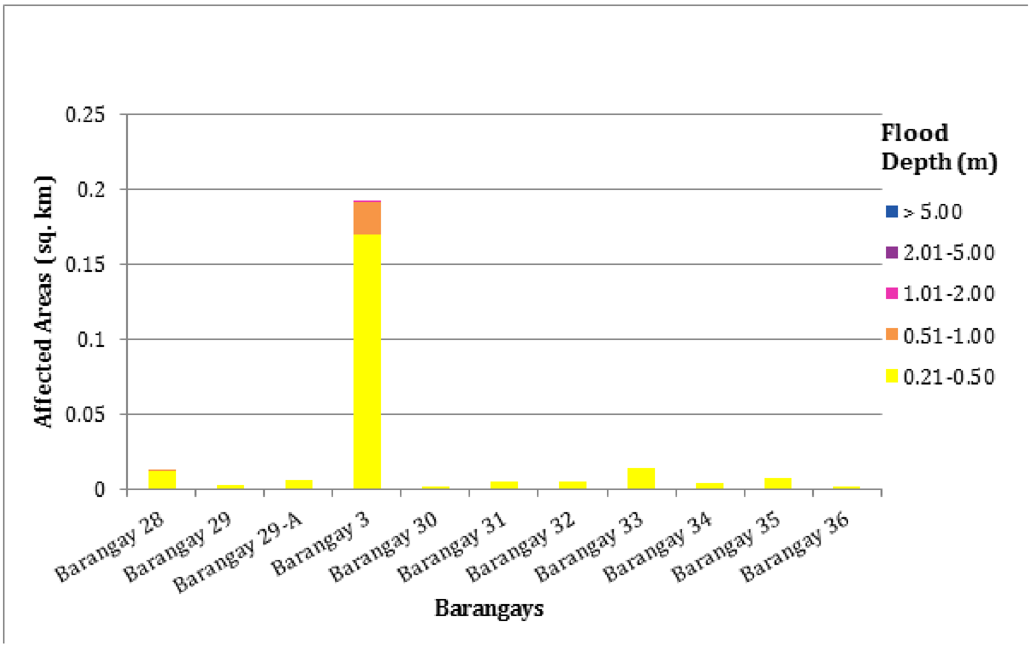


Figure 73. Affected areas in Cavite City, Cavite during a 5-Year Rainfall Return Period.

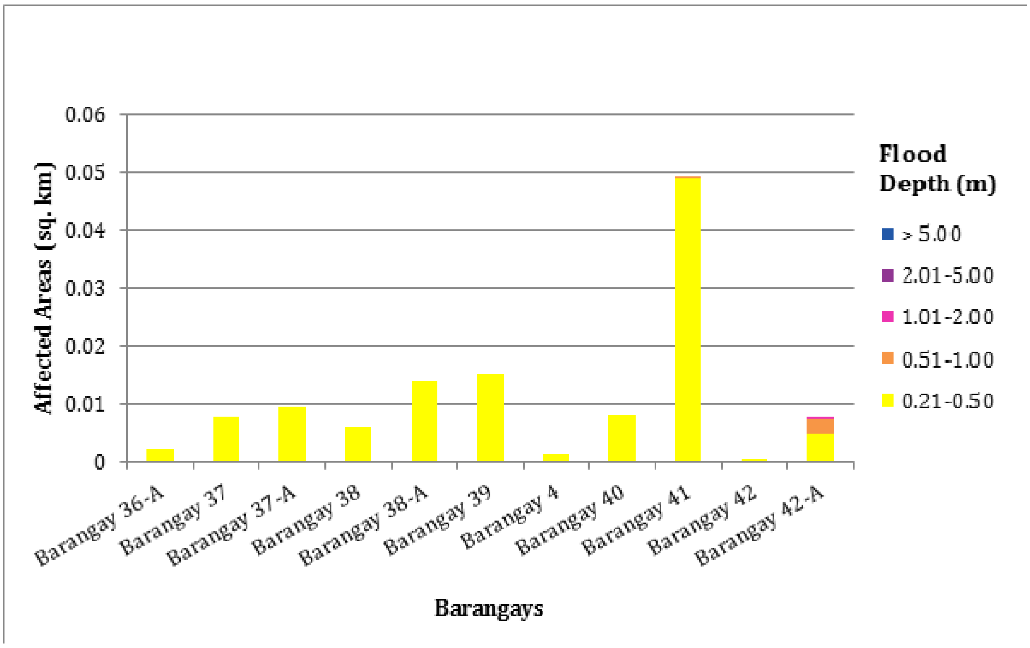


Figure 74. Affected areas in Cavite City, Cavite during a 5-Year Rainfall Return Period.

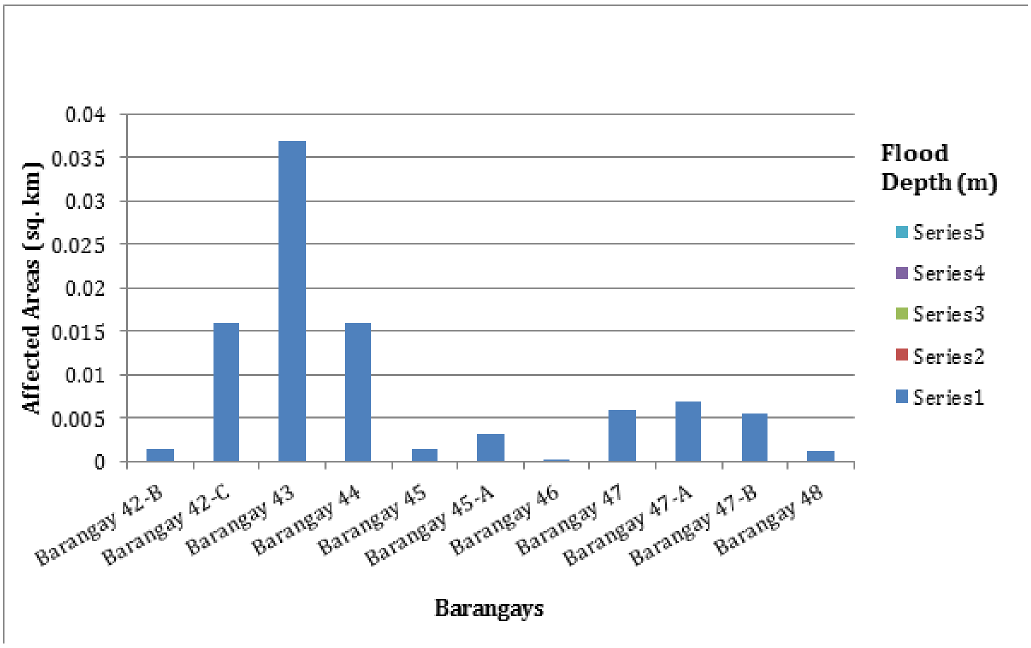


Figure 75. Affected areas in Cavite City, Cavite during a 5-Year Rainfall Return Period.

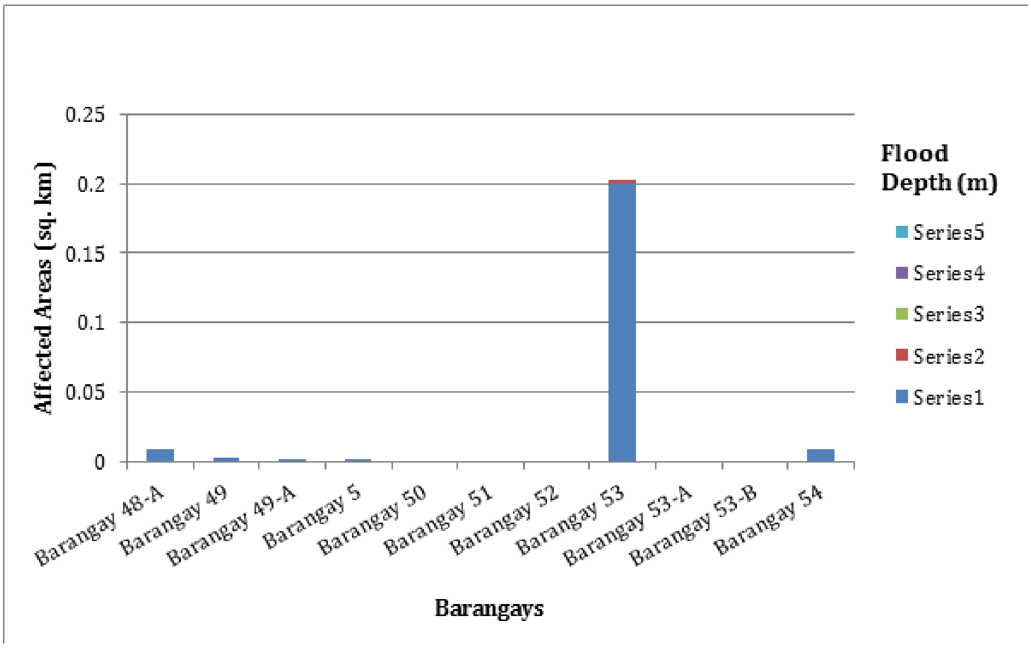


Figure 76. Affected areas in Cavite City, Cavite during a 5-Year Rainfall Return Period.

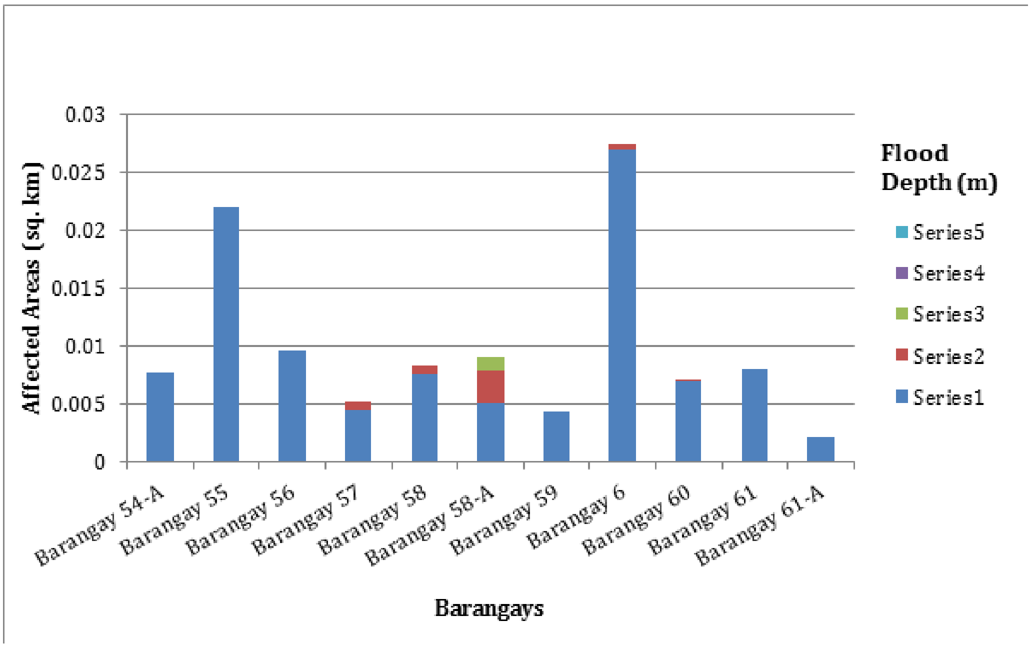


Figure 77. Affected areas in Cavite City, Cavite during a 5-Year Rainfall Return Period.

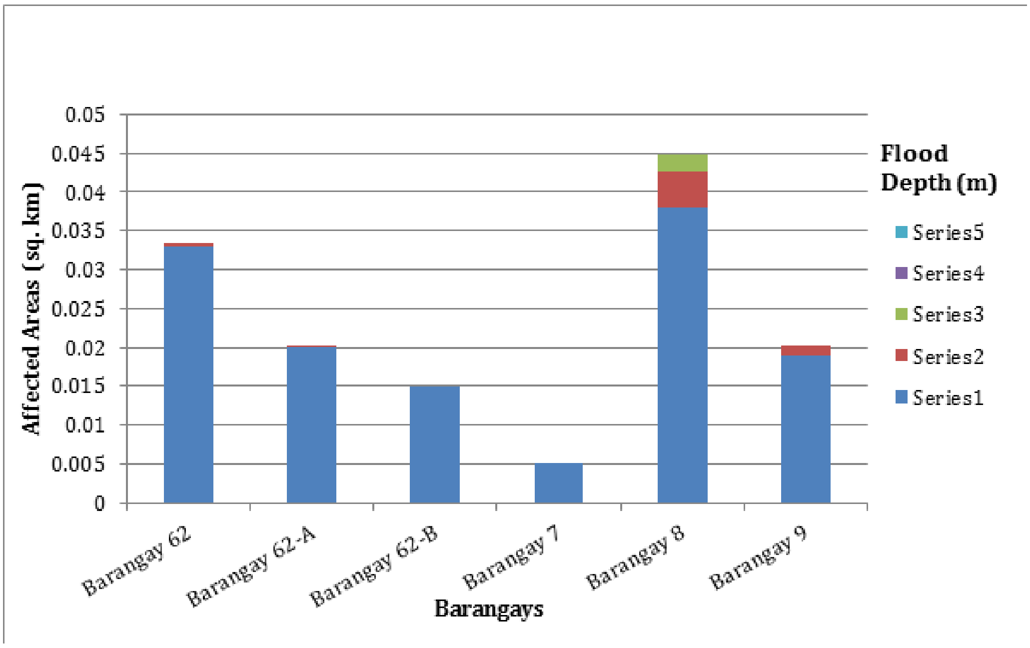


Figure 78. Affected areas in Cavite City, Cavite during a 5-Year Rainfall Return Period.

For the 5-year return period, 12.52% of the municipality of Kawit with an area of 15.97 sq. km. will experience flood levels of less than 0.20 meters. 9.33% of the area will experience flood levels of 0.21 to 0.50 meters while 12.31%, 7.91%, 2.36%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the Table 39 are the affected areas in square kilometers by flood depth per barangay.

Table 39. Affected areas in Kawit, Cavite during a 5-Year Rainfall Return Period.

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Kawit (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Balsahan-Bisita | Batong Dalig | Gahak | Kaingen | Magdalo | Marulas | Panamitan | Poblacion | Barangay 15 | Barangay 16 | Barangay 17 |
| **0.03-0.20** | 0.02 | 0.21 | 0.0086 | 0.033 | 0.088 | 0.14 | 0.12 | 0.043 | 0.028 | 0.077 | 0.019 |
| **0.21-0.50** | 0.0018 | 0.069 | 0.065 | 0.049 | 0.059 | 0.15 | 0.13 | 0.056 | 0.0076 | 0.02 | 0.014 |
| **0.51-1.00** | 0.0038 | 0.086 | 0.097 | 0.2 | 0.049 | 0.3 | 0.18 | 0.14 | 0 | 0 | 0 |
| **1.01-2.00** | 0.016 | 0.16 | 0.045 | 0.034 | 0.0097 | 0.14 | 0.12 | 0.11 | 0 | 0 | 0 |
| **2.01-5.00** | 0.016 | 0.025 | 0.046 | 0.0034 | 0.00056 | 0.046 | 0.057 | 0.058 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Kawit (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | San Sebastian | Santa Isabel | Tabon I | Tabon II | Tabon III | Toclong | Tramo-Bantayan | Wakas I | Wakas II | Barangay 26 | Barangay 27 |
| **0.03-0.20** | 0.13 | 0.81 | 0.022 | 0.029 | 0.0039 | 0.21 | 0.02 | 0.097 | 0.015 | 0.077 | 0.019 |
| **0.21-0.50** | 0.13 | 0.42 | 0.039 | 0.033 | 0.013 | 0.17 | 0.012 | 0.064 | 0.029 | 0.02 | 0.014 |
| **0.51-1.00** | 0.11 | 0.18 | 0.2 | 0.043 | 0.039 | 0.17 | 0.018 | 0.073 | 0.077 | 0 | 0 |
| **1.01-2.00** | 0.14 | 0.072 | 0.082 | 0.016 | 0.0053 | 0.13 | 0.036 | 0.038 | 0.11 | 0 | 0 |
| **2.01-5.00** | 0.0005 | 0.0029 | 0.0088 | 0.026 | 0.0016 | 0.079 | 0.0012 | 0.0016 | 0.0037 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

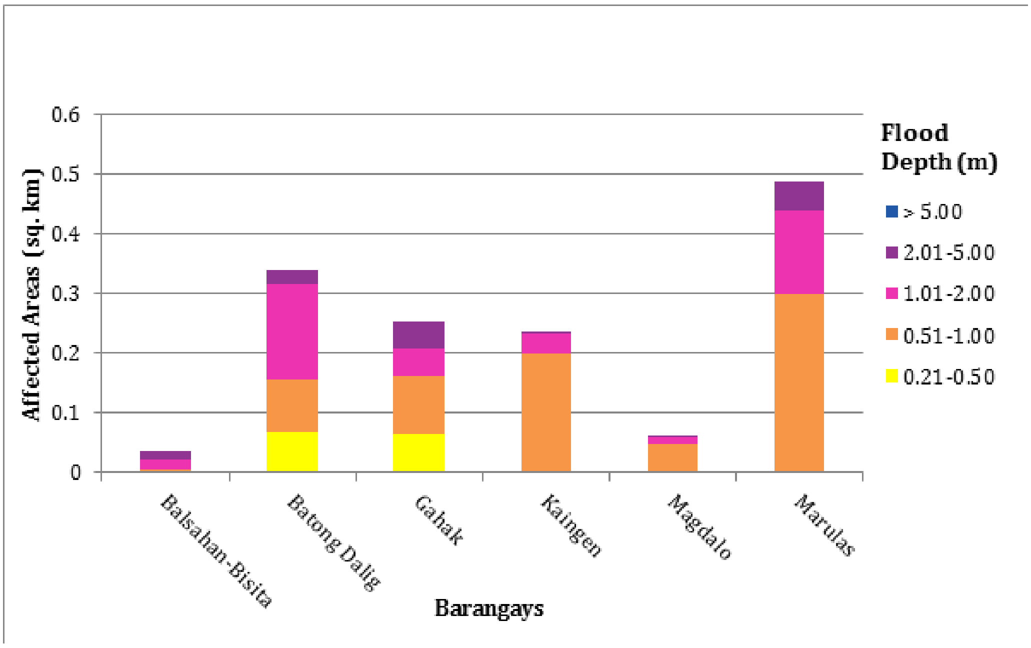


Figure 79. Affected areas in Kawit, Cavite during a 5-Year Rainfall Return Period.

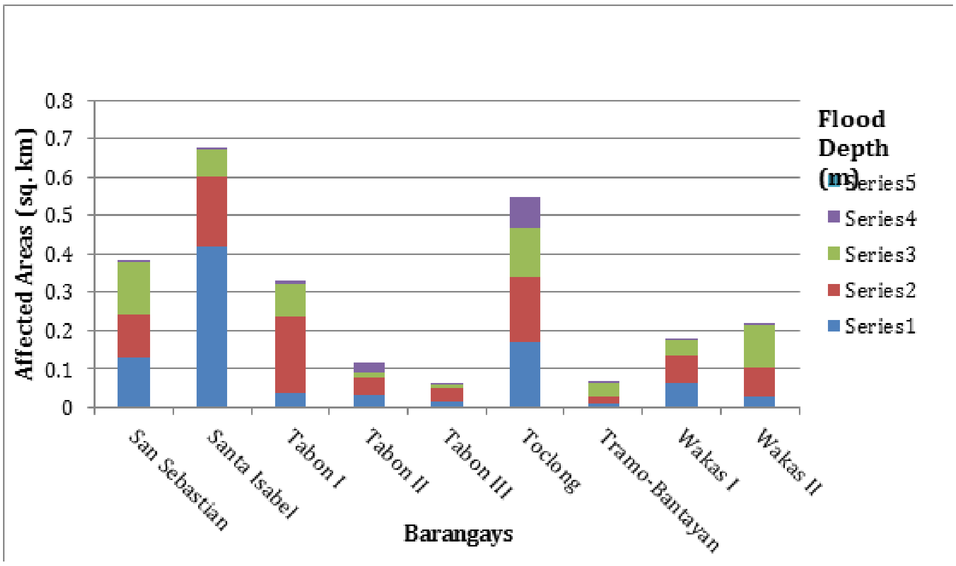


Figure 80. Affected areas in Kawit, Cavite during a 5-Year Rainfall Return Period.

For the 5-year return period, 22.29% of the municipality of Imus with an area of 50.4 sq. km. will experience flood levels of less than 0.20 meters. 10.36% of the area will experience flood levels of 0.21 to 0.50 meters while 8.61%, 2.50%, 0.24%, and 0.14% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the Table 40 are the affected areas in square kilometers by flood depth per barangay.

Table 40. Affected areas in Imus, Cavite during a 5-Year Rainfall Return Period.

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Imus (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Alapan I-A | Alapan I-B | Alapan I-C | Alapan II-A | Alapan II-B | Anabu II-F | Bucandala I | Bucandala II | Bucandala III | Bucandala IV | Barangay 17 |
| **0.03-0.20** | 0.68 | 0.43 | 0.85 | 0.76 | 0.31 | 0.023 | 0.077 | 0.24 | 0.53 | 1.3 | 0.019 |
| **0.21-0.50** | 0.46 | 0.37 | 0.5 | 0.69 | 0.3 | 0.001 | 0.012 | 0.088 | 0.13 | 0.35 | 0.014 |
| **0.51-1.00** | 0.48 | 0.38 | 0.45 | 0.63 | 0.074 | 0 | 0.001 | 0.017 | 0.016 | 0.46 | 0 |
| **1.01-2.00** | 0.029 | 0.091 | 0.13 | 0.047 | 0.029 | 0 | 0 | 0 | 0.0038 | 0.11 | 0 |
| **2.01-5.00** | 0.042 | 0.05 | 0 | 0 | 0.0007 | 0 | 0 | 0 | 0.0002 | 0.0015 | 0 |
| **> 5.00** | 0.038 | 0.013 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Imus (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bucandala V | Carsadang Bago I | Carsadang Bago II | Malagasang I-A | Malagasang I-B | Malagasang I-C | Malagasang I-D | Malagasang I-E | Malagasang I-F | Medicion I-A | Barangay 27 |
| **0.03-0.20** | 1.16 | 1.13 | 0.66 | 0.0098 | 0.12 | 0.56 | 0.23 | 0.26 | 0.039 | 0.038 | 0.019 |
| **0.21-0.50** | 0.32 | 0.24 | 0.18 | 0.038 | 0.02 | 0.098 | 0.047 | 0.029 | 0.0028 | 0.02 | 0.014 |
| **0.51-1.00** | 0.4 | 0.095 | 0.023 | 0.053 | 0.091 | 0.079 | 0.014 | 0 | 0 | 0.0026 | 0 |
| **1.01-2.00** | 0.023 | 0.036 | 0.0031 | 0.023 | 0.0021 | 0.021 | 0.0034 | 0 | 0 | 0.000093 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0.019 | 0.0014 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0.018 | 0.0012 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Imus (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Medicion I-B | Medicion I-C | Medicion I-D | Medicion II-A | Medicion II-B | Medicion II-C | Medicion II-D | Medicion II-E | Medicion II-F | Pag-Asa I | Barangay 17 |
| **0.03-0.20** | 0.058 | 0.046 | 0.041 | 0.027 | 0.032 | 0.063 | 0.059 | 0.052 | 0.11 | 0.12 | 0.019 |
| **0.21-0.50** | 0.016 | 0.012 | 0.032 | 0.037 | 0.059 | 0.038 | 0.026 | 0.022 | 0.023 | 0.27 | 0.014 |
| **0.51-1.00** | 0.004 | 0.000024 | 0.015 | 0.021 | 0.02 | 0.009 | 0.018 | 0.007 | 0.00091 | 0.55 | 0 |
| **1.01-2.00** | 0.0019 | 0 | 0.00021 | 0.027 | 0.0058 | 0 | 0.0049 | 0 | 0 | 0.46 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0.0016 | 0 | 0 | 0 | 0 | 0 | 0.0066 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Imus (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pag-Asa II | Pag-Asa III | Poblacion III-A | Poblacoin III-B | Poblacion IV-A | Toclong I-A | Toclong I-B | Toclong I-C | Toclong II-A | Toclong II-B | Barangay 17 |
| **0.03-0.20** | 0.43 | 0.37 | 0.023 | 0 | 0.02 | 0.042 | 0.0092 | 0.0043 | 0.13 | 0.19 | 0.019 |
| **0.21-0.50** | 0.37 | 0.29 | 0.0079 | 0 | 0.000097 | 0.011 | 0.00021 | 0 | 0.05 | 0.06 | 0.014 |
| **0.51-1.00** | 0.15 | 0.2 | 0.0002 | 0 | 0 | 0.00061 | 0 | 0 | 0.033 | 0.043 | 0 |
| **1.01-2.00** | 0.11 | 0.093 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0008 | 0.0054 | 0 |
| **2.01-5.00** | 0.0002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

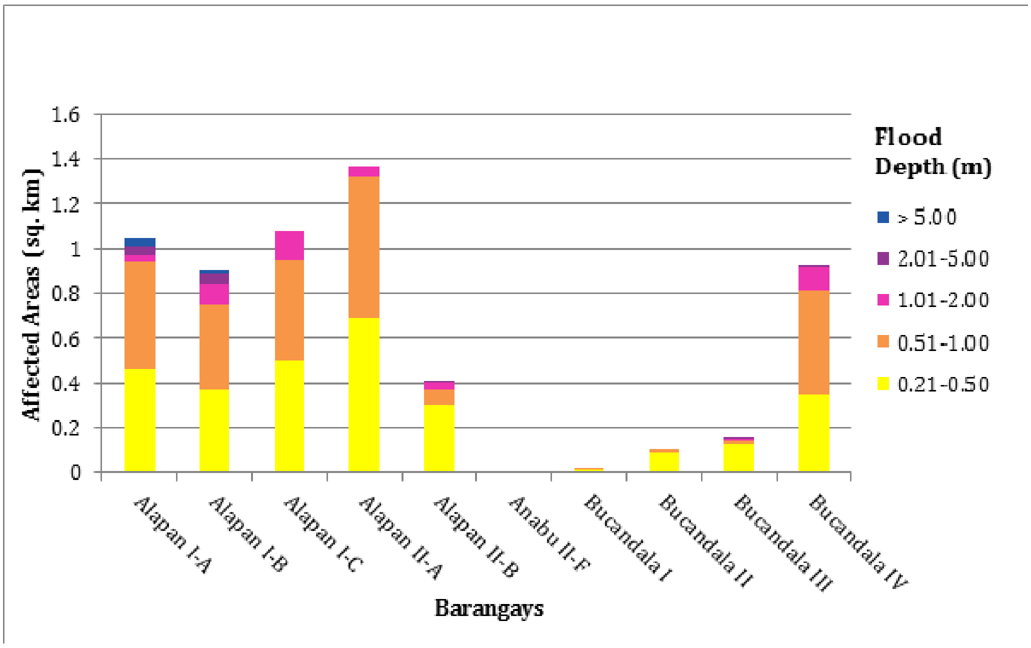


Figure 81. Affected areas in Imus, Cavite during a 5-Year Rainfall Return Period.

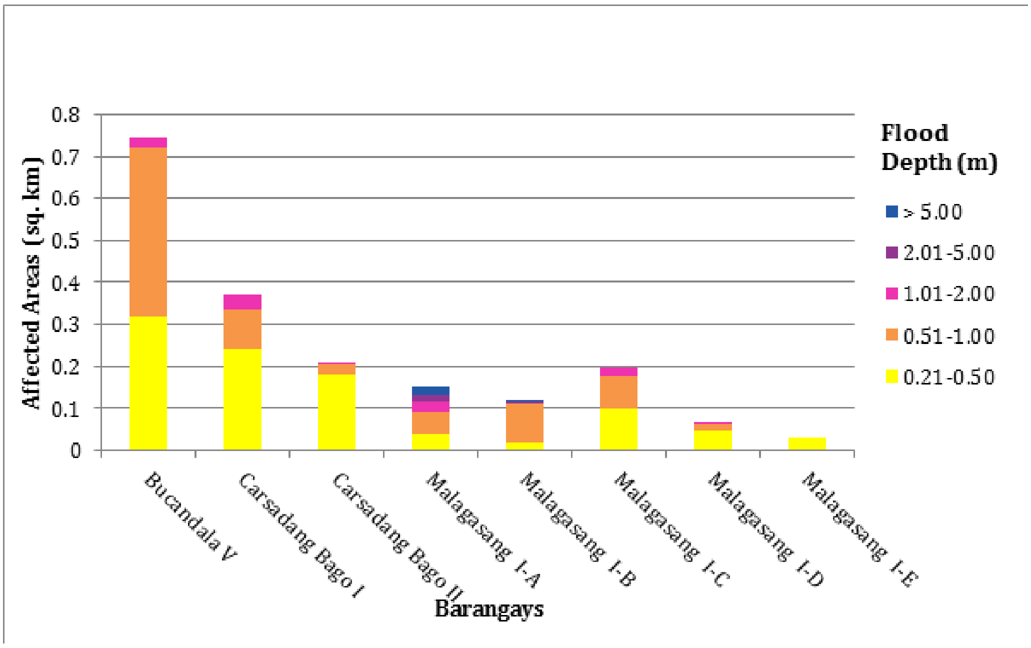


Figure 82. Affected areas in Imus, Cavite during a 5-Year Rainfall Return Period.

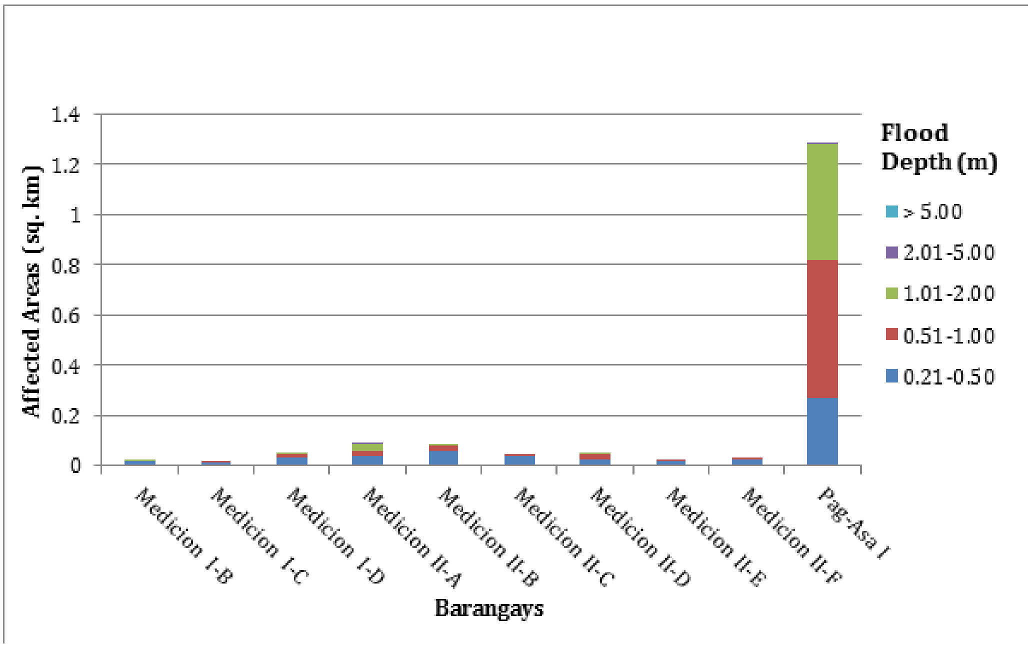


Figure 83. Affected areas in Imus, Cavite during a 5-Year Rainfall Return Period.

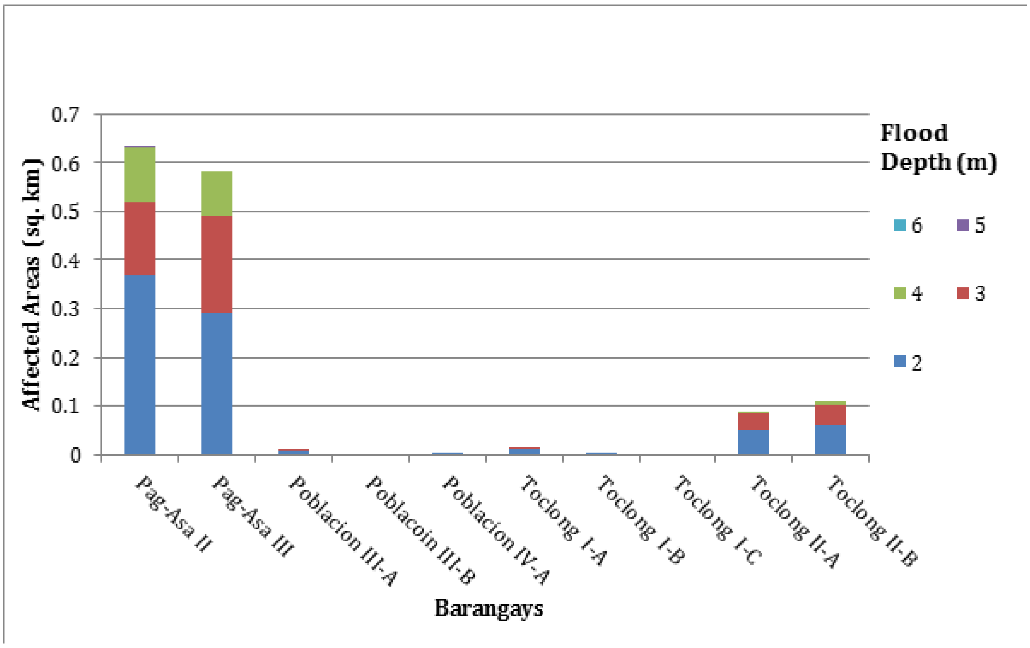


Figure 84. Affected areas in Imus, Cavite during a 5-Year Rainfall Return Period.

For the 5-year return period, 29.20% of the municipality of Noveleta with an area of 5.16 sq. km. will experience flood levels of less than 0.20 meters. 8.63% of the area will experience flood levels of 0.21 to 0.50 meters while 7.22%, 5.32%, 0.83%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the Table 41 are the affected areas in square kilometers by flood depth per barangay.

Table 41. Affected areas in Noveleta, Cavite during a 5-Year Rainfall Return Period.

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Noveleta (in sq. km.) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Magdiwang | San Antonio I | San Antonio II | San Jose I | San Jose II | San Juan I | San Juan II | San Rafael II | San Rafael IV | Santa Rosa II |
| **0.03-0.20** | 0.022 | 0.33 | 0.12 | 0.088 | 0.032 | 0.44 | 0.042 | 0.32 | 0.11 | 0.0029 |
| **0.21-0.50** | 0.00039 | 0.059 | 0.085 | 0.0066 | 0.0018 | 0.16 | 0.011 | 0.083 | 0.038 | 0.00042 |
| **0.51-1.00** | 0.00012 | 0.06 | 0.13 | 0.0035 | 0.0021 | 0.096 | 0.0005 | 0.067 | 0.013 | 0.0004 |
| **1.01-2.00** | 0.00071 | 0.075 | 0.18 | 0.0057 | 0.0053 | 0.0041 | 0.00091 | 0.0017 | 0.0003 | 0.00087 |
| **2.01-5.00** | 0.00076 | 0.02 | 0.0048 | 0.0074 | 0.0047 | 0.002 | 0.002 | 0 | 0 | 0.0012 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

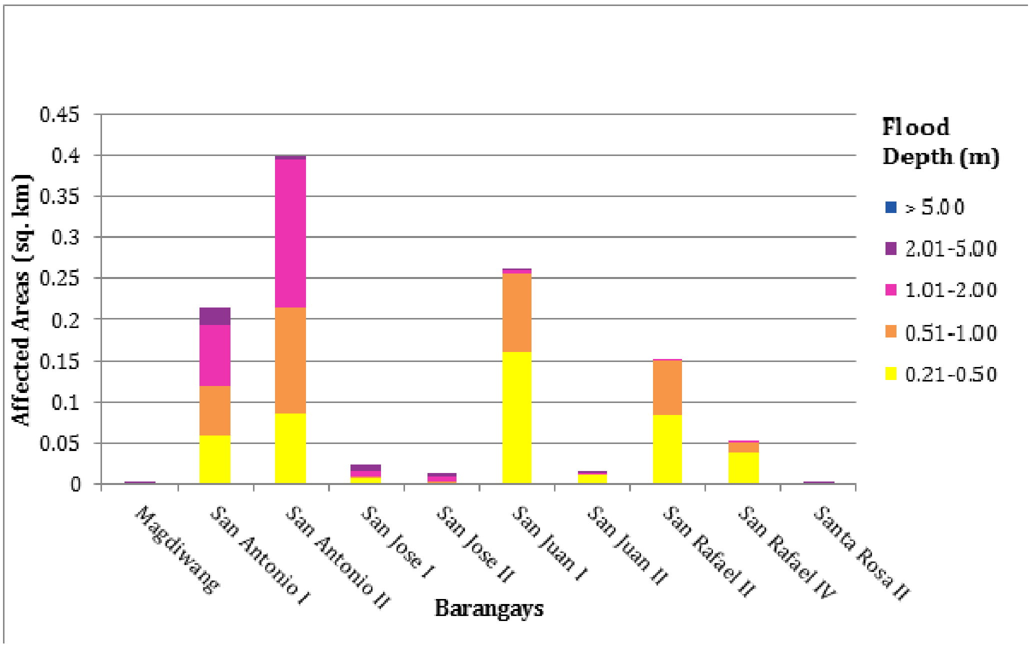


Figure 85. Affected Areas in Noveleta, Cavite during a 5-Year Rainfall Return Period.

For the 5-year return period, 6.43% of the municipality of General Trias with an area of 87.5 sq. km. will experience flood levels of less than 0.20 meters. 2.95% of the area will experience flood levels of 0.21 to 0.50 meters while 2.17%, 0.73%, 0.23%, and 0.07% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the Table 42 are the affected areas in square kilometers by flood depth per barangay.

Table 42. Affected areas in General Trias, Cavite during a 5-Year Rainfall Return Period.

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in General Trias (in sq. km.) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Arnaldo Poblacion | Bacao I | Bacao II | Bagumbayan Poblacion | Dulong Bayan Poblacion | Gov. Ferrer Poblacion | Navarro | Pasong Camachile I | Pasong Camachile II | Pinagtipunan | Prinza Poblacion | Sampalucan Poblacion |
| **0.03-0.20** | 0.043 | 0.41 | 0.21 | 0.034 | 0.04 | 0.0013 | 2.19 | 2.22 | 0.13 | 0.072 | 0.032 | 0.014 |
| **0.21-0.50** | 0.011 | 0.34 | 0.29 | 0.005 | 0.028 | 0.00032 | 1.01 | 0.55 | 0.019 | 0.048 | 0.015 | 0.0035 |
| **0.51-1.00** | 0.002 | 0.34 | 0.25 | 0.0006 | 0.0042 | 0 | 0.82 | 0.28 | 0.0032 | 0.047 | 0.00062 | 0.0001 |
| **1.01-2.00** | 0.0011 | 0.11 | 0.12 | 0 | 0.0019 | 0 | 0.2 | 0.15 | 0.0049 | 0.011 | 0 | 0 |
| **2.01-5.00** | 0.0013 | 0.033 | 0.034 | 0 | 0.0032 | 0 | 0.039 | 0.037 | 0 | 0.0078 | 0 | 0 |
| **> 5.00** | 0.0014 | 0.0063 | 0.0021 | 0 | 0.0021 | 0 | 0.021 | 0.0048 | 0 | 0.0036 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in General Trias (in sq. km.) | | |
|---|---|---|---|
| | San Gabriel Poblacion | Santa Clara | Vibora Poblacion |
| **0.03-0.20** | 0.026 | 0.17 | 0.033 |
| **0.21-0.50** | 0.024 | 0.23 | 0.01 |
| **0.51-1.00** | 0.0061 | 0.14 | 0.0078 |
| **1.01-2.00** | 0 | 0.039 | 0.002 |
| **2.01-5.00** | 0 | 0.043 | 0.00068 |
| **> 5.00** | 0 | 0.02 | 0 |

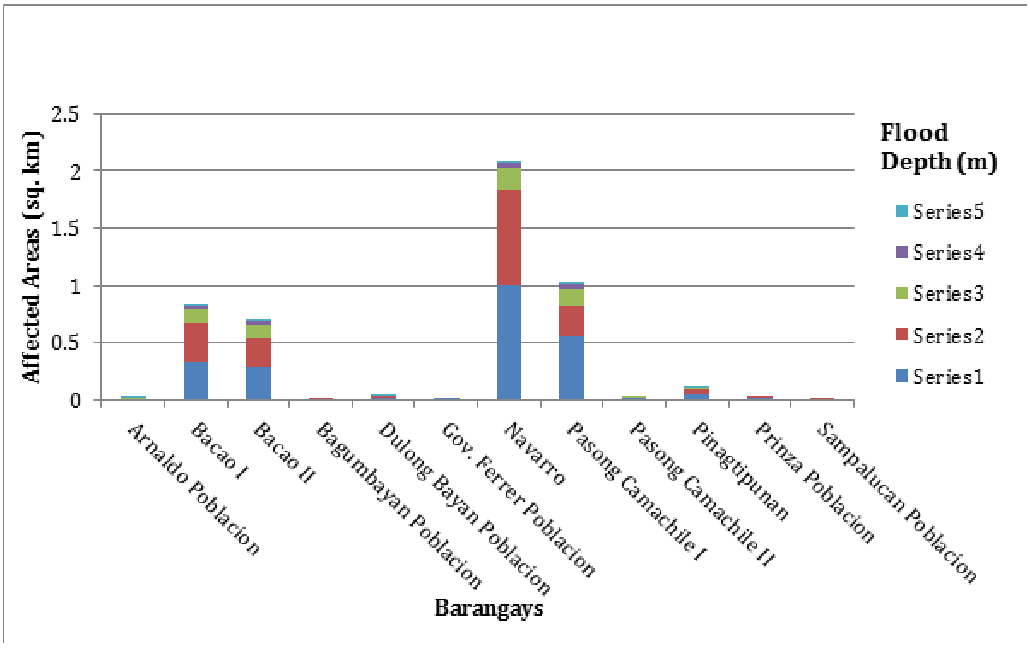


Figure 86. Affected Areas in General Trias, Cavite during a 5-Year Rainfall Return Period.

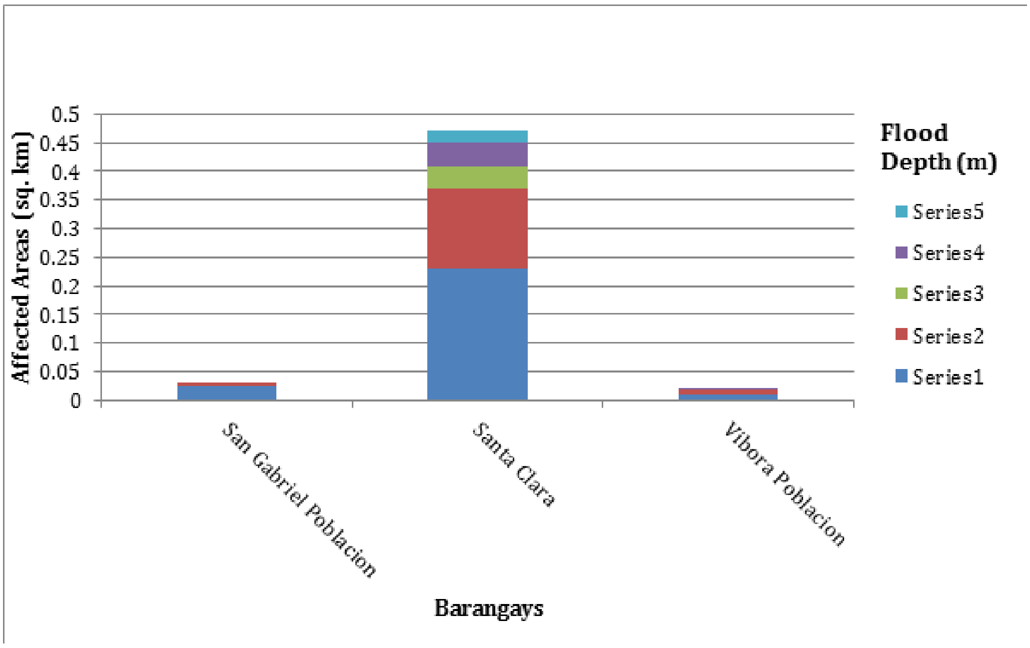


Figure 87. Affected Areas in General Trias, Cavite during a 5-Year Rainfall Return Period.

For the 25-year return period, 4.80% of the municipality of Cavite City with an area of 627.97 sq. km. will experience flood levels of less 0.20 meters. 0.16% of the area will experience flood levels of 0.21 to 0.50 meters while 0.15%, 0.21%, 0.14%, and 0.02% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 43 are the affected areas in square kilometres by flood depth per barangay.

Table 38. Affected areas in Cavite City, Cavite during a 25-Year Rainfall Return Period

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barangay 1 | Barangay 10 | Barangay 10-A | Barangay 10-B | Barangay 11 | Barangay 12 | Barangay 13 | Barangay 14 | Barangay 15 | Barangay 16 | Barangay 17 |
| **0.03-0.20** | 0.018 | 0.053 | 0.019 | 0.035 | 0.051 | 0.014 | 0.039 | 0.033 | 0.022 | 0.068 | 0.011 |
| **0.21-0.50** | 0.01 | 0.019 | 0.0041 | 0.0053 | 0.0059 | 0.011 | 0.0053 | 0.0088 | 0.013 | 0.03 | 0.022 |
| **0.51-1.00** | 0.00022 | 0.0021 | 0.0002 | 0 | 0.000068 | 0 | 0.000041 | 0 | 0.0004 | 0 | 0.000058 |
| **1.01-2.00** | 0 | 0 | 0 | 0 | 0.000015 | 0 | 0.000002 | 0 | 0 | 0 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barangay 18 | Barangay 19 | Barangay 2 | Barangay 20 | Barangay 22 | Barangay 22-A | Barangay 23 | Barangay 24 | Barangay 25 | Barangay 26 | Barangay 27 |
| **0.03-0.20** | 0.0074 | 0.025 | 0.014 | 0.0061 | 0.05 | 0.028 | 0.016 | 0.0063 | 0.0093 | 0.034 | 0.031 |
| **0.21-0.50** | 0.02 | 0.042 | 0.0059 | 0.023 | 0.015 | 0.01 | 0.019 | 0.0092 | 0.0061 | 0.015 | 0.025 |
| **0.51-1.00** | 0.0016 | 0.00094 | 0 | 0.002 | 0 | 0 | 0.00073 | 0.001 | 0 | 0.007 | 0.0028 |
| **1.01-2.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0001 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barangay 28 | Barangay 29 | Barangay 29-A | Barangay 3 | Barangay 30 | Barangay 31 | Barangay 32 | Barangay 33 | Barangay 34 | Barangay 35 | Barangay 36 |
| **0.03-0.20** | 0.0069 | 0.015 | 0.011 | 0.4 | 0.036 | 0.019 | 0.025 | 0.021 | 0.016 | 0.0078 | 0.031 |
| **0.21-0.50** | 0.017 | 0.0043 | 0.0088 | 0.12 | 0.0053 | 0.0076 | 0.016 | 0.023 | 0.0077 | 0.014 | 0.0029 |
| **0.51-1.00** | 0.00066 | 0 | 0 | 0.12 | 0 | 0 | 0.000037 | 0.00046 | 0.0002 | 0 | 0 |
| **1.01-2.00** | 0 | 0 | 0 | 0.0034 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barangay 36-A | Barangay 37 | Barangay 37-A | Barangay 38 | Barangay 38-A | Barangay 39 | Barangay 4 | Barangay 40 | Barangay 41 | Barangay 42 | Barangay 42-A |
| **0.03-0.20** | 0.0059 | 0.01 | 0.013 | 0.025 | 0.0094 | 0.019 | 0.012 | 0.0089 | 0.06 | 0.023 | 0.0083 |
| **0.21-0.50** | 0.0041 | 0.011 | 0.015 | 0.014 | 0.024 | 0.026 | 0.0034 | 0.012 | 0.074 | 0.014 | 0.005 |
| **0.51-1.00** | 0 | 0.0001 | 0 | 0 | 0 | 0.00021 | 0 | 0.0003 | 0.0026 | 0 | 0.0041 |
| **1.01-2.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0003 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barangay 42-B | Barangay 42-C | Barangay 43 | Barangay 44 | Barangay 45 | Barangay 45-A | Barangay 46 | Barangay 47 | Barangay 47-A | Barangay 47-B | Barangay 48 |
| **0.03-0.20** | 0.018 | 0.011 | 0.0035 | 0.02 | 0.0081 | 0.019 | 0.051 | 0.016 | 0.023 | 0.019 | 0.045 |
| **0.21-0.50** | 0.003 | 0.032 | 0.061 | 0.039 | 0.015 | 0.021 | 0.012 | 0.01 | 0.011 | 0.011 | 0.0036 |
| **0.51-1.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1.01-2.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barangay 48-A | Barangay 49 | Barangay 49-A | Barangay 5 | Barangay 50 | Barangay 51 | Barangay 52 | Barangay 53 | Barangay 53-A | Barangay 53-B | Barangay 54 |
| **0.03-0.20** | 0.033 | 0.036 | 0.036 | 0.011 | 0.03 | 0.04 | 0.022 | 1.26 | 0.019 | 0.0051 | 0.037 |
| **0.21-0.50** | 0.014 | 0.0044 | 0.0012 | 0.0011 | 0.0054 | 0 | 0.013 | 0.28 | 0 | 0.0097 | 0.014 |
| **0.51-1.00** | 0.0002 | 0 | 0 | 0 | 0 | 0 | 0 | 0.014 | 0 | 0 | 0 |
| **1.01-2.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barangay 54-A | Barangay 55 | Barangay 56 | Barangay 57 | Barangay 58 | Barangay 58-A | Barangay 59 | Barangay 6 | Barangay 60 | Barangay 61 | Barangay 61-A |
| **0.03-0.20** | 0.009 | 0.03 | 0.032 | 0.008 | 0.0027 | 0.004 | 0.038 | 0.069 | 0.02 | 0.022 | 0.016 |
| **0.21-0.50** | 0.011 | 0.035 | 0.022 | 0.0065 | 0.011 | 0.012 | 0.011 | 0.04 | 0.015 | 0.0091 | 0.0066 |
| **0.51-1.00** | 0 | 0 | 0 | 0.0016 | 0.0012 | 0.0024 | 0 | 0.0013 | 0.000076 | 0.0004 | 0 |
| **1.01-2.00** | 0 | 0 | 0 | 0 | 0 | 0.0019 | 0 | 0 | 0 | 0 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | |
|---|---|---|---|---|---|---|
| | Barangay 62 | Barangay 62-A | Barangay 62-B | Barangay 7 | Barangay 8 | Barangay 9 |
| **0.03-0.20** | 0.18 | 0.05 | 0.22 | 0.0082 | 0.22 | 0.014 |
| **0.21-0.50** | 0.051 | 0.028 | 0.026 | 0.0083 | 0.043 | 0.028 |
| **0.51-1.00** | 0.0016 | 0.002 | 0 | 0 | 0.0085 | 0.003 |
| **1.01-2.00** | 0 | 0 | 0 | 0 | 0.0034 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 |

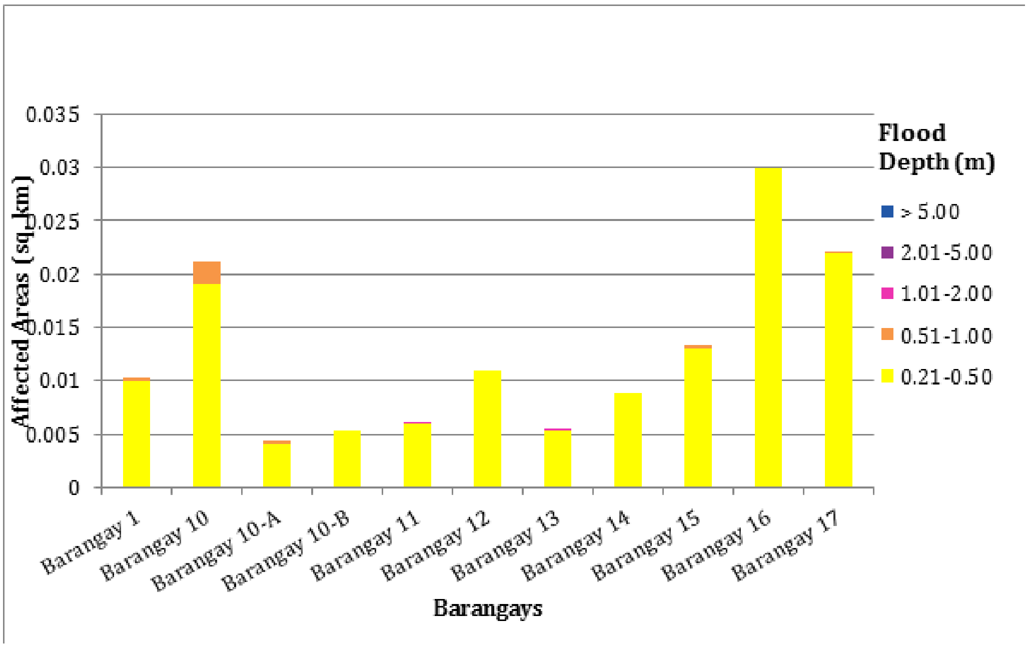


Figure 88. Affected areas in Cavite City, Cavite during a 25-Year Rainfall Return Period.

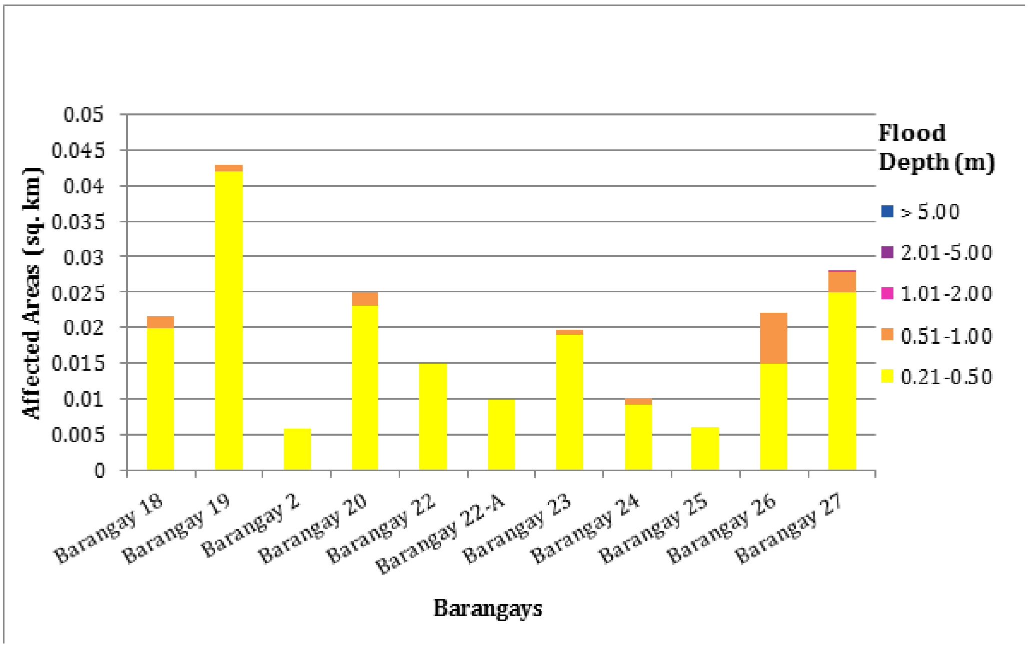


Figure 89. Affected areas in Cavite City, Cavite during a 25-Year Rainfall Return Period.

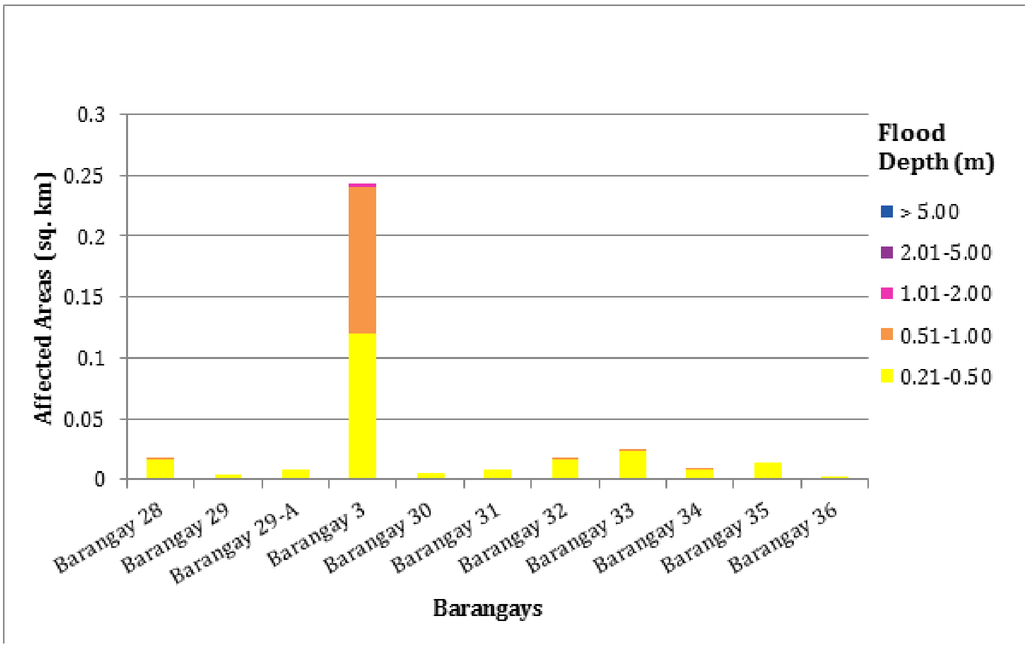


Figure 90. Affected areas in Cavite City, Cavite during a 25-Year Rainfall Return Period.

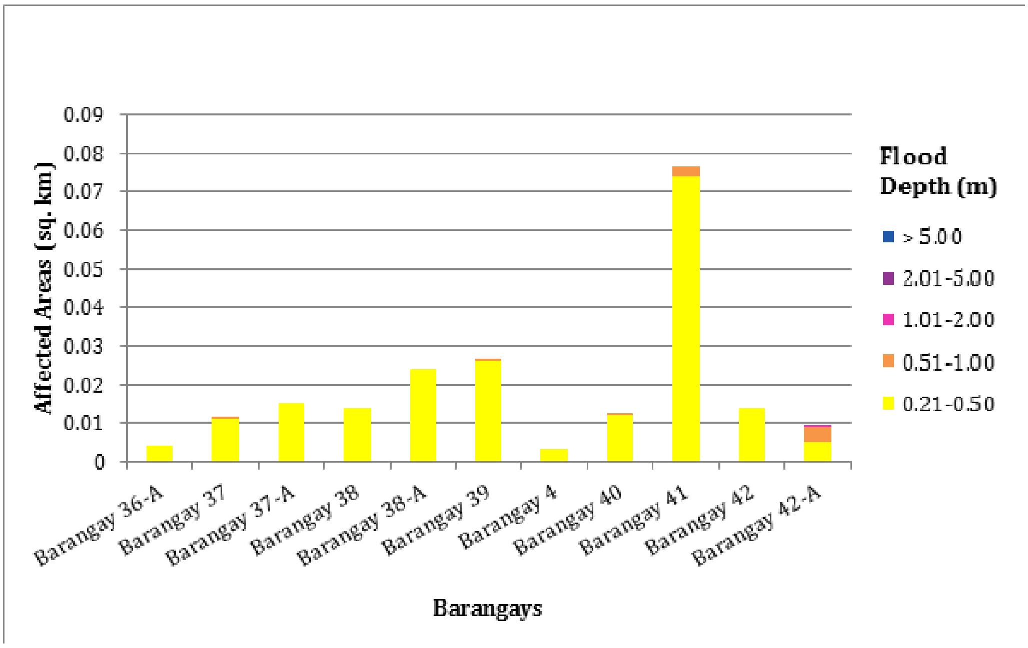


Figure 91. Affected areas in Cavite City, Cavite during a 25-Year Rainfall Return Period.

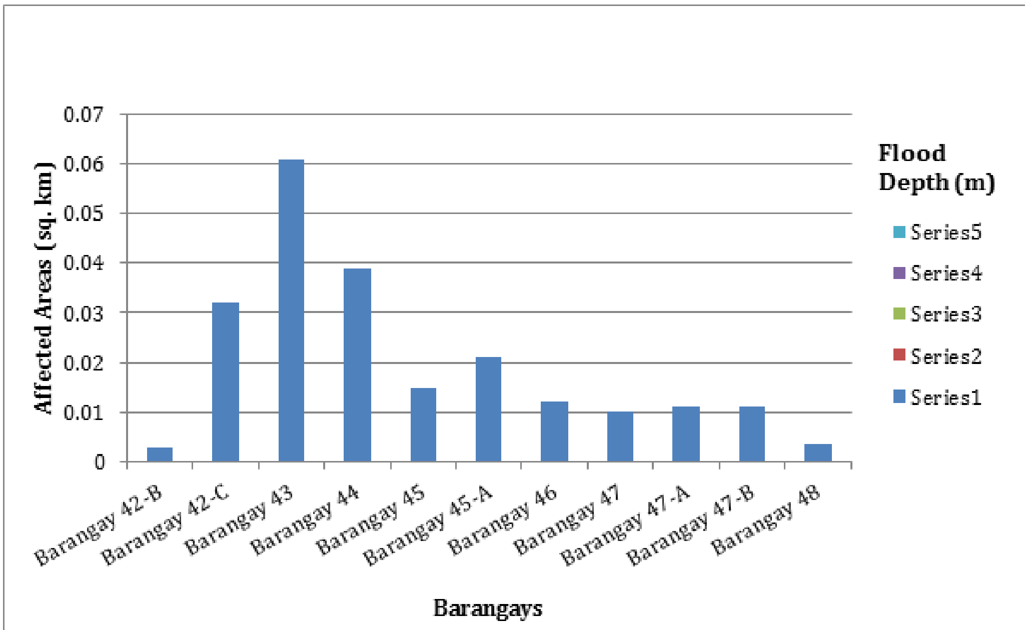


Figure 92. Affected areas in Cavite City, Cavite during a 25-Year Rainfall Return Period.

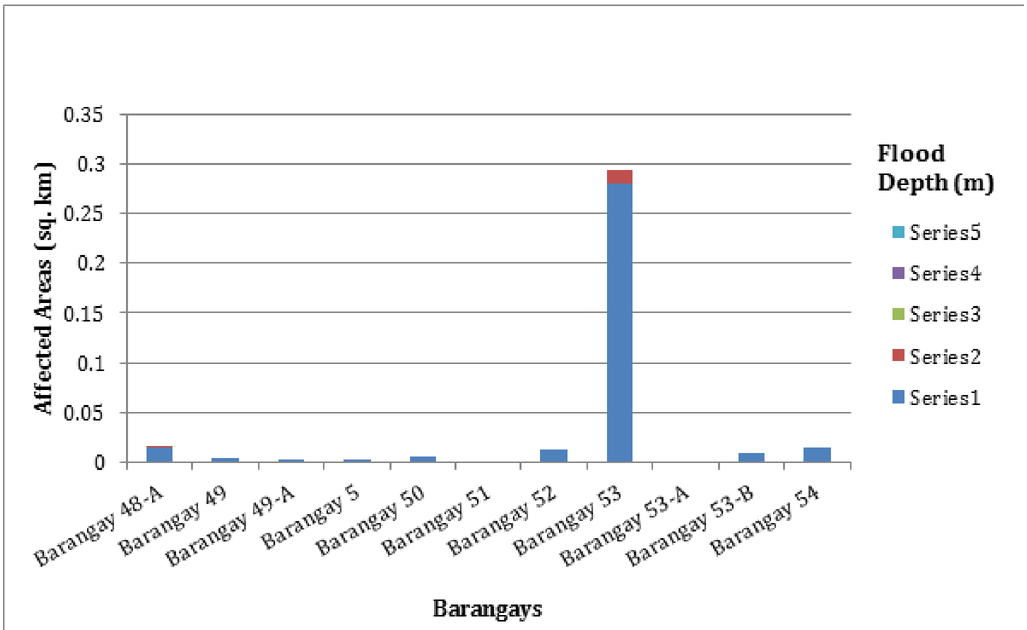


Figure 93. Affected areas in Cavite City, Cavite during a 25-Year Rainfall Return Period.

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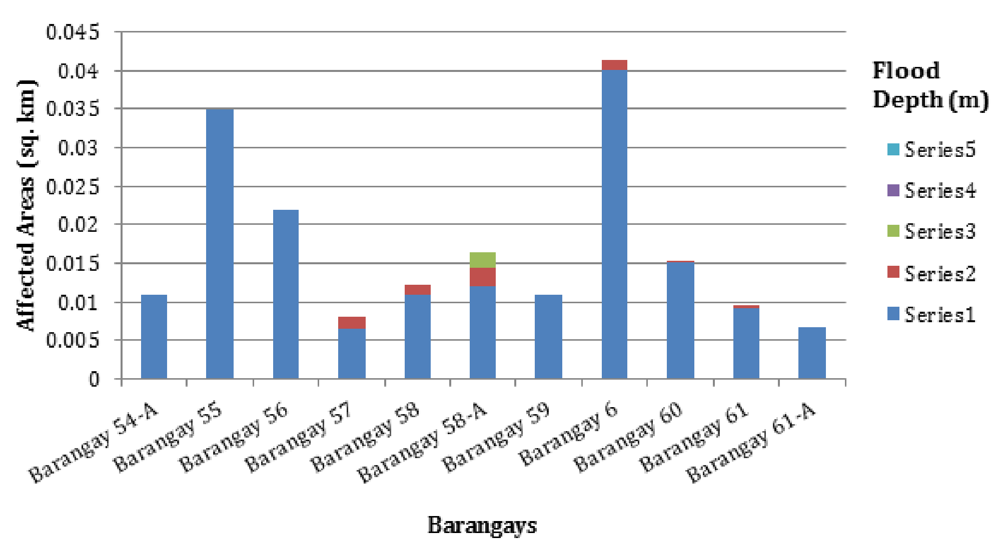


Figure 94. Affected areas in Cavite City, Cavite during a 25-Year Rainfall Return Period.

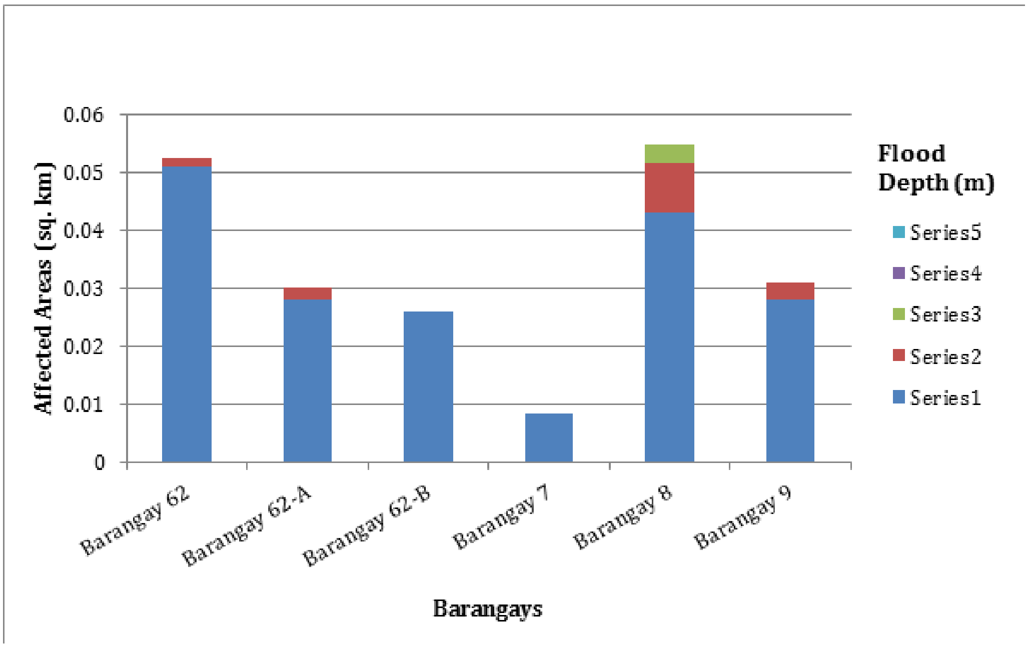


Figure 95. Affected areas in Cavite City, Cavite during a 25-Year Rainfall Return Period.

For the 25-year return period, 7.57% of the municipality of Kawit with an area of 15.97 sq. km. will experience flood levels of less than 0.20 meters. 6.77% of the area will experience flood levels of 0.21 to 0.50 meters while 13.40%, 13.38%, 3.44%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 44 are the affected areas in square kilometers by flood depth per barangay.

Table 39. Affected areas in Kawit, Cavite during a 25-Year Rainfall Return Period.

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Kawit (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Balsahan-Bisita | Batong Dalig | Gahak | Kaingen | Magdalo | Marulas | Panamitan | Poblacion | Barangay 15 | Barangay 16 | Barangay 17 |
| **0.03-0.20** | 0.019 | 0.12 | 0.00045 | 0.017 | 0.048 | 0.063 | 0.037 | 0.024 | 0.028 | 0.077 | 0.019 |
| **0.21-0.50** | 0.0007 | 0.1 | 0.0095 | 0.018 | 0.047 | 0.1 | 0.081 | 0.021 | 0.0076 | 0.02 | 0.014 |
| **0.51-1.00** | 0.0044 | 0.093 | 0.12 | 0.14 | 0.078 | 0.25 | 0.21 | 0.1 | 0 | 0 | 0 |
| **1.01-2.00** | 0.0097 | 0.17 | 0.083 | 0.15 | 0.031 | 0.31 | 0.19 | 0.18 | 0 | 0 | 0 |
| **2.01-5.00** | 0.024 | 0.058 | 0.052 | 0.0056 | 0.0015 | 0.058 | 0.09 | 0.078 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Kawit (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | San Sebastian | Santa Isabel | Tabon I | Tabon II | Tabon III | Toclong | Tramo-Bantayan | Wakas I | Wakas II | Barangay 26 | Barangay 27 |
| **0.03-0.20** | 0.035 | 0.55 | 0.0038 | 0.0029 | 0.0001 | 0.12 | 0.014 | 0.015 | 0.0012 | 0.077 | 0.019 |
| **0.21-0.50** | 0.089 | 0.27 | 0.02 | 0.017 | 0.00058 | 0.16 | 0.0073 | 0.039 | 0.0034 | 0.02 | 0.014 |
| **0.51-1.00** | 0.18 | 0.43 | 0.08 | 0.044 | 0.021 | 0.21 | 0.02 | 0.087 | 0.038 | 0 | 0 |
| **1.01-2.00** | 0.19 | 0.24 | 0.24 | 0.052 | 0.038 | 0.17 | 0.041 | 0.12 | 0.17 | 0 | 0 |
| **2.01-5.00** | 0.014 | 0.0035 | 0.014 | 0.032 | 0.0026 | 0.11 | 0.005 | 0.0076 | 0.025 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

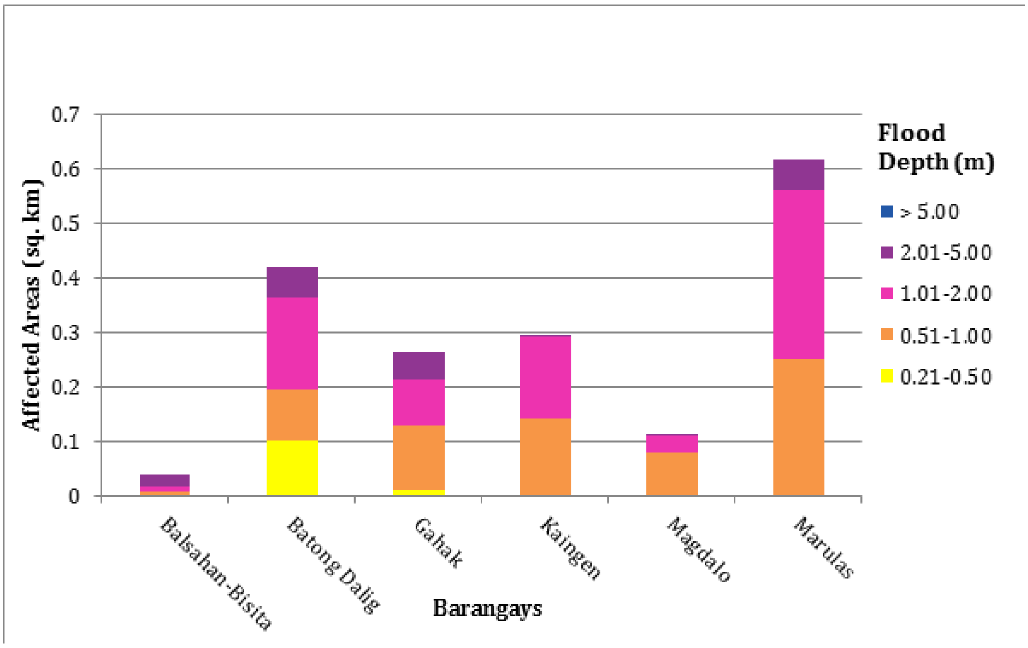


Figure 96. Affected areas in Kawit, Cavite during a 25-Year Rainfall Return Period.

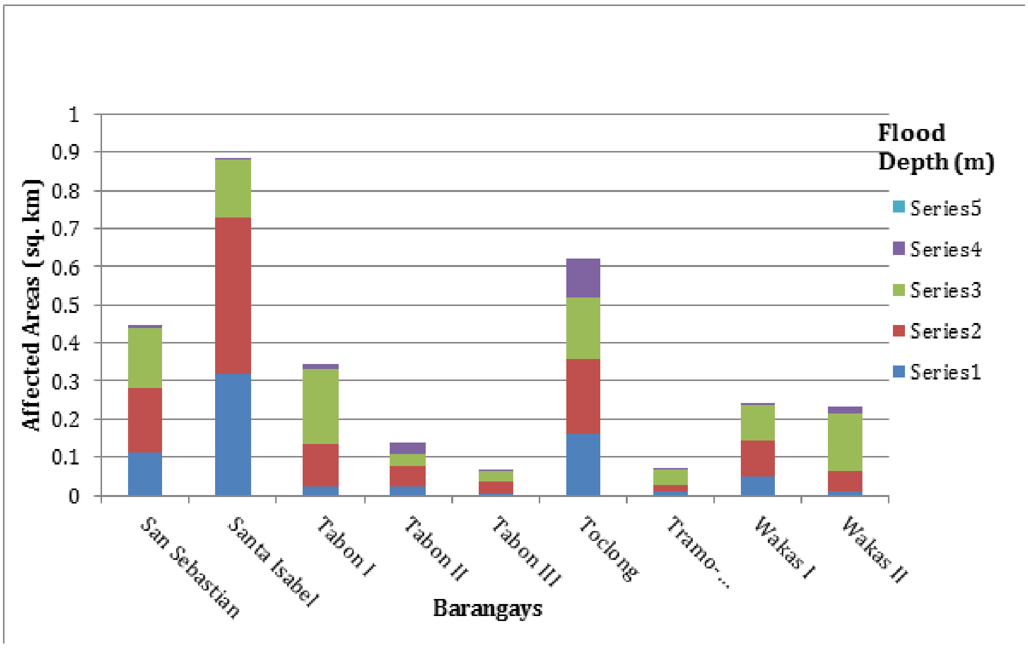


Figure 97. Affected areas in Kawit, Cavite during a 25-Year Rainfall Return Period.

For the 25-year return period, 17.00% of the municipality of Imus with an area of 50.4 sq. km. will experience flood levels of less than 0.20 meters. 10.79% of the area will experience flood levels of 0.21 to 0.50 meters while 10.61%, 5.31%, 0.29%, and 0.15% 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 are the affected areas in square kilometers by flood depth per barangay.

Table 40. Affected areas in Imus, Cavite during a 25-Year Rainfall Return Period.

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Imus (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Alapan I-A | Alapan I-B | Alapan I-C | Alapan II-A | Alapan II-B | Anabu II-F | Bucandala I | Bucandala II | Bucandala III | Bucandala IV | Barangay 17 |
| **0.03-0.20** | 0.54 | 0.34 | 0.54 | 0.43 | 0.17 | 0.022 | 0.072 | 0.19 | 0.43 | 1.02 | 0.019 |
| **0.21-0.50** | 0.33 | 0.31 | 0.56 | 0.63 | 0.37 | 0.0023 | 0.016 | 0.12 | 0.22 | 0.46 | 0.014 |
| **0.51-1.00** | 0.67 | 0.44 | 0.58 | 0.82 | 0.14 | 0 | 0.0018 | 0.031 | 0.029 | 0.36 | 0 |
| **1.01-2.00** | 0.11 | 0.17 | 0.25 | 0.24 | 0.037 | 0 | 0 | 0.0001 | 0.0056 | 0.37 | 0 |
| **2.01-5.00** | 0.042 | 0.05 | 0 | 0 | 0.0016 | 0 | 0 | 0 | 0.0005 | 0.0033 | 0 |
| **> 5.00** | 0.04 | 0.014 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Imus (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bucandala V | Carsadang Bago I | Carsadang Bago II | Malagasang I-A | Malagasang I-B | Malagasang I-C | Malagasang I-D | Malagasang I-E | Malagasang I-F | Medicion I-A | Barangay 27 |
| **0.03-0.20** | 0.98 | 0.93 | 0.55 | 0.0008 | 0.11 | 0.47 | 0.19 | 0.24 | 0.037 | 0.027 | 0.019 |
| **0.21-0.50** | 0.36 | 0.39 | 0.26 | 0.0083 | 0.016 | 0.14 | 0.082 | 0.053 | 0.0046 | 0.026 | 0.014 |
| **0.51-1.00** | 0.41 | 0.13 | 0.049 | 0.06 | 0.043 | 0.085 | 0.016 | 0 | 0 | 0.0075 | 0 |
| **1.01-2.00** | 0.16 | 0.047 | 0.0069 | 0.051 | 0.07 | 0.066 | 0.0065 | 0 | 0 | 0.00015 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0.022 | 0.0016 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0.019 | 0.0013 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Imus (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Medicion I-B | Medicion I-C | Medicion I-D | Medicion II-A | Medicion II-B | Medicion II-C | Medicion II-D | Medicion II-E | Medicion II-F | Pag-Asa I | Barangay 17 |
| **0.03-0.20** | 0.049 | 0.042 | 0.03 | 0.0081 | 0.021 | 0.049 | 0.029 | 0.04 | 0.098 | 0.067 | 0.019 |
| **0.21-0.50** | 0.022 | 0.016 | 0.031 | 0.038 | 0.039 | 0.033 | 0.04 | 0.027 | 0.033 | 0.091 | 0.014 |
| **0.51-1.00** | 0.0062 | 0.00021 | 0.026 | 0.028 | 0.045 | 0.027 | 0.031 | 0.013 | 0.0031 | 0.54 | 0 |
| **1.01-2.00** | 0.0033 | 0 | 0.001 | 0.038 | 0.011 | 0 | 0.0081 | 0 | 0 | 0.68 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0.0025 | 0 | 0 | 0 | 0 | 0 | 0.021 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Imus (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pag-Asa II | Pag-Asa III | Poblacion III-A | Poblacoin III-B | Poblacion IV-A | Toclong I-A | Toclong I-B | Toclong I-C | Toclong II-A | Toclong II-B | Barangay 17 |
| **0.03-0.20** | 0.25 | 0.26 | 0.021 | 0 | 0.02 | 0.037 | 0.009 | 0.0043 | 0.096 | 0.15 | 0.019 |
| **0.21-0.50** | 0.27 | 0.26 | 0.01 | 0 | 0.00039 | 0.014 | 0.00041 | 0 | 0.076 | 0.078 | 0.014 |
| **0.51-1.00** | 0.37 | 0.29 | 0.00039 | 0 | 0 | 0.0023 | 0 | 0 | 0.039 | 0.055 | 0 |
| **1.01-2.00** | 0.17 | 0.16 | 0 | 0 | 0 | 0.00011 | 0 | 0 | 0.0044 | 0.011 | 0 |
| **2.01-5.00** | 0.0022 | 0.0001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

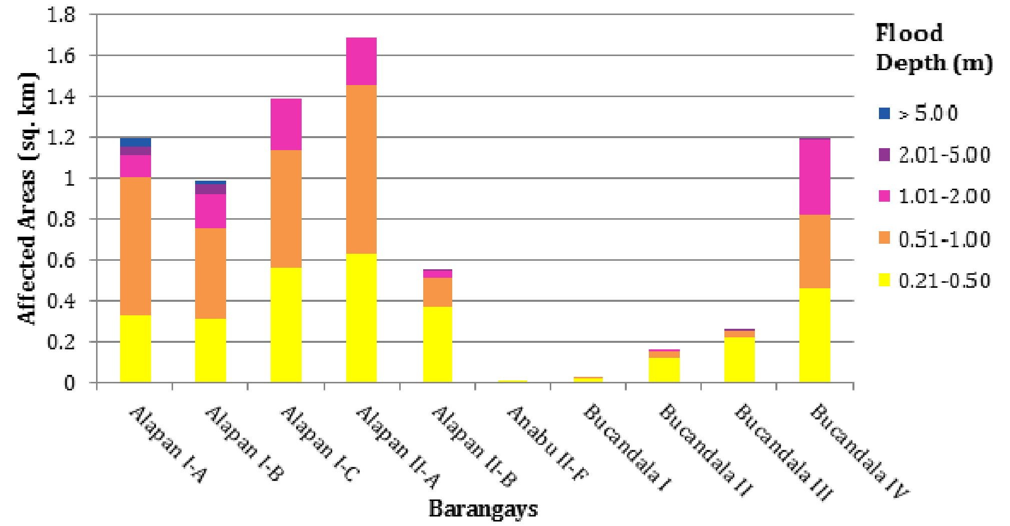


Figure 98. Affected areas in Imus, Cavite during a 25-Year Rainfall Return Period.

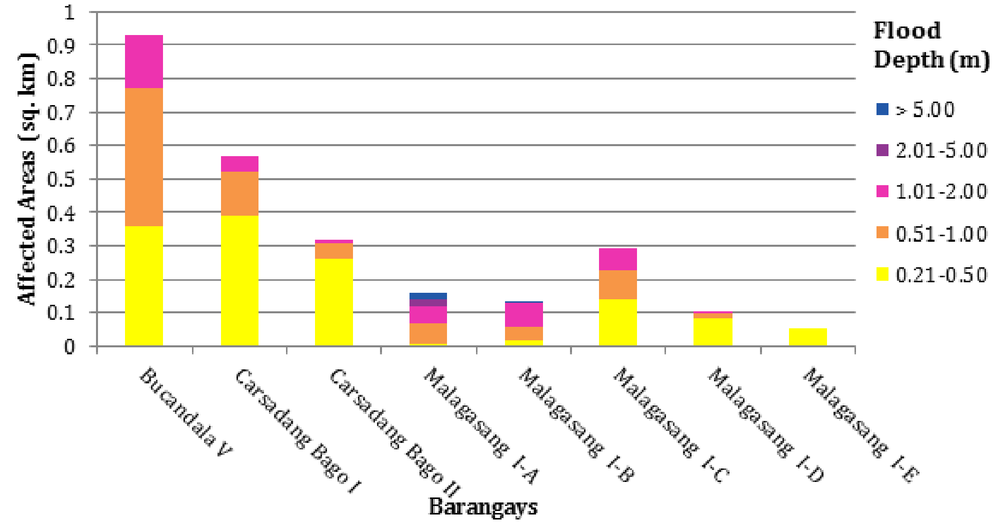


Figure 99. Affected areas in Imus, Cavite during a 25-Year Rainfall Return Period.

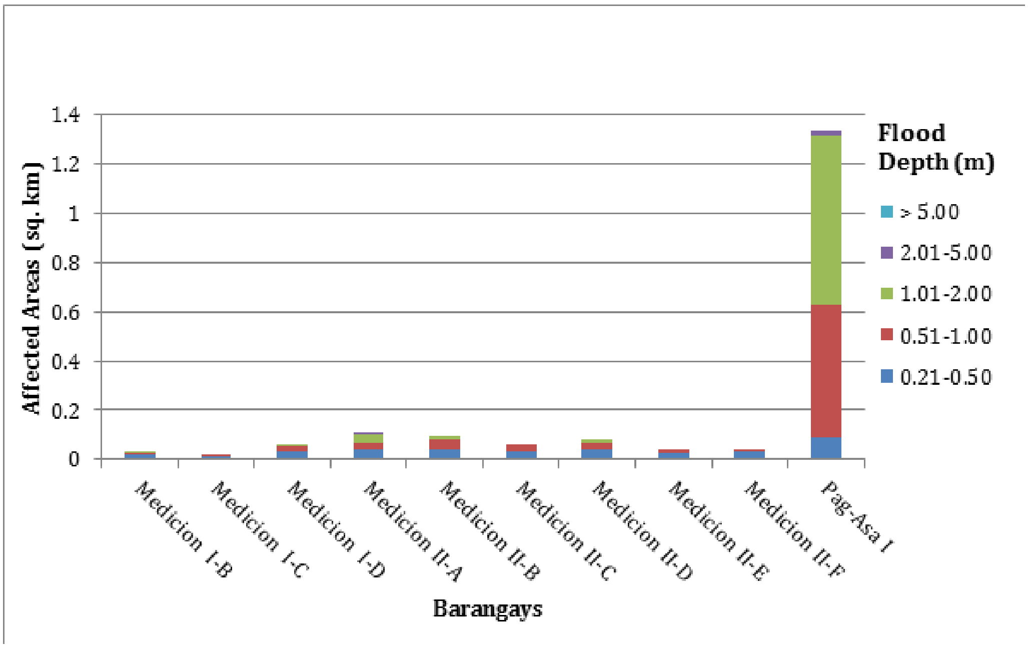


Figure 100. Affected areas in Imus, Cavite during a 25-Year Rainfall Return Period.

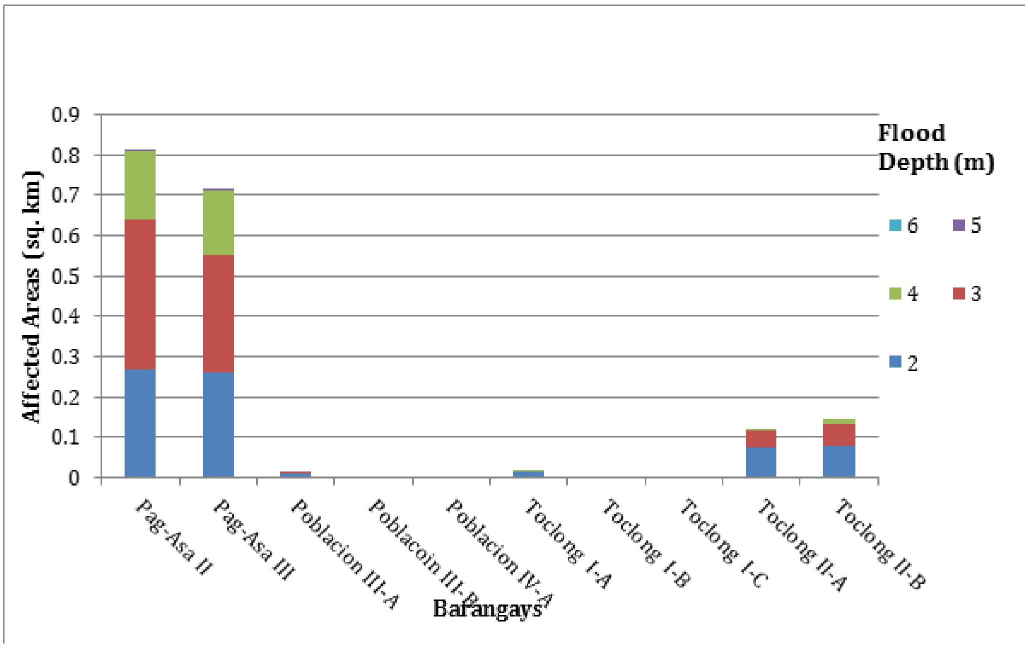


Figure 101. Affected areas in Imus, Cavite during a 25-Year Rainfall Return Period.

For the 25-year return period, 24.09% of the municipality of Noveleta with an area of 5.16 sq. km. will experience flood levels of less than 0.20 meters. 9.40% of the area will experience flood levels of 0.21 to 0.50 meters while 9.35%, 7.49%, 1.32%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 46 are the affected areas in square kilometers by flood depth per barangay.

Table 46. Affected areas in Noveleta, Cavite during a 25-Year Rainfall Return Period.

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Noveleta (in sq. k= | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Magdiwang | San Antonio I | San Antonio II | San Jose I | San Jose II | San Juan I | San Juan II | San Rafael II | San Rafael IV | Santa Rosa II |
| **0.03-0.20** | 0.022 | 0.3 | 0.073 | 0.083 | 0.032 | 0.35 | 0.037 | 0.25 | 0.093 | 0.0029 |
| **0.21-0.50** | 0.00041 | 0.077 | 0.088 | 0.01 | 0.002 | 0.17 | 0.016 | 0.097 | 0.024 | 0.00042 |
| **0.51-1.00** | 0.0002 | 0.058 | 0.12 | 0.0048 | 0.0021 | 0.16 | 0.0008 | 0.1 | 0.036 | 0.00032 |
| **1.01-2.00** | 0.00071 | 0.079 | 0.23 | 0.0053 | 0.0053 | 0.031 | 0.00091 | 0.03 | 0.0032 | 0.00094 |
| **2.01-5.00** | 0.00076 | 0.036 | 0.013 | 0.008 | 0.0049 | 0.002 | 0.002 | 0 | 0 | 0.0012 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

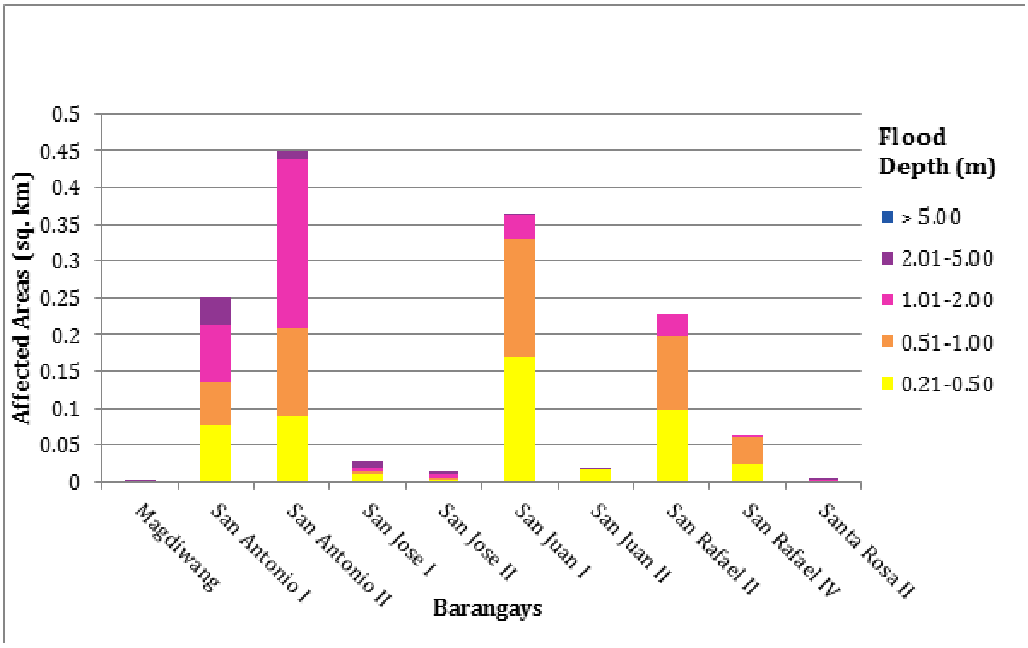


Figure 102. Affected Areas in Noveleta, Cavite during a 25-Year Rainfall Return Period.

For the 25-year return period, 5.13% of the municipality of General Trias with an area of 87.5 sq. km. will experience flood levels of less than 0.20 meters. 3.05% of the area will experience flood levels of 0.21 to 0.50 meters while 2.92%, 1.15%, 0.26%, 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 47 are the affected areas in square kilometers by flood depth per barangay.

Table 42. Affected areas in General Trias, Cavite during a 25-Year Rainfall Return Period.

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in General Trias (in sq. km.) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Arnaldo Poblacion | Bacao I | Bacao II | Bagumbayan Poblacion | Dulong Bayan Poblacion | Gov. Ferrer Poblacion | Navarro | Pasong Camachile I | Pasong Camachile II | Pinagtipunan | Prinza Poblacion | Sampalucan Poblacion | San Gabriel Poblacion | Santa Clara | Vibora Poblacion |
| **0.03-0.20** | 0.038 | 0.33 | 0.15 | 0.031 | 0.028 | 0.0012 | 1.68 | 1.89 | 0.12 | 0.041 | 0.029 | 0.013 | 0.021 | 0.09 | 0.029 |
| **0.21-0.50** | 0.015 | 0.29 | 0.24 | 0.0064 | 0.029 | 0.00039 | 1.07 | 0.68 | 0.028 | 0.06 | 0.016 | 0.0048 | 0.019 | 0.2 | 0.011 |
| **0.51-1.00** | 0.0031 | 0.42 | 0.32 | 0.0015 | 0.014 | 0.000002 | 1.09 | 0.38 | 0.0047 | 0.057 | 0.0021 | 0.0004 | 0.017 | 0.23 | 0.011 |
| **1.01-2.00** | 0.0012 | 0.16 | 0.16 | 0 | 0.0028 | 0 | 0.38 | 0.22 | 0.0051 | 0.019 | 0 | 0 | 0 | 0.057 | 0.0027 |
| **2.01-5.00** | 0.0013 | 0.037 | 0.035 | 0 | 0.0036 | 0 | 0.047 | 0.047 | 0.0006 | 0.0092 | 0 | 0 | 0 | 0.046 | 0.00072 |
| **> 5.00** | 0.0015 | 0.007 | 0.0027 | 0 | 0.0022 | 0 | 0.024 | 0.0062 | 0 | 0.0038 | 0 | 0 | 0 | 0.021 | 0 |

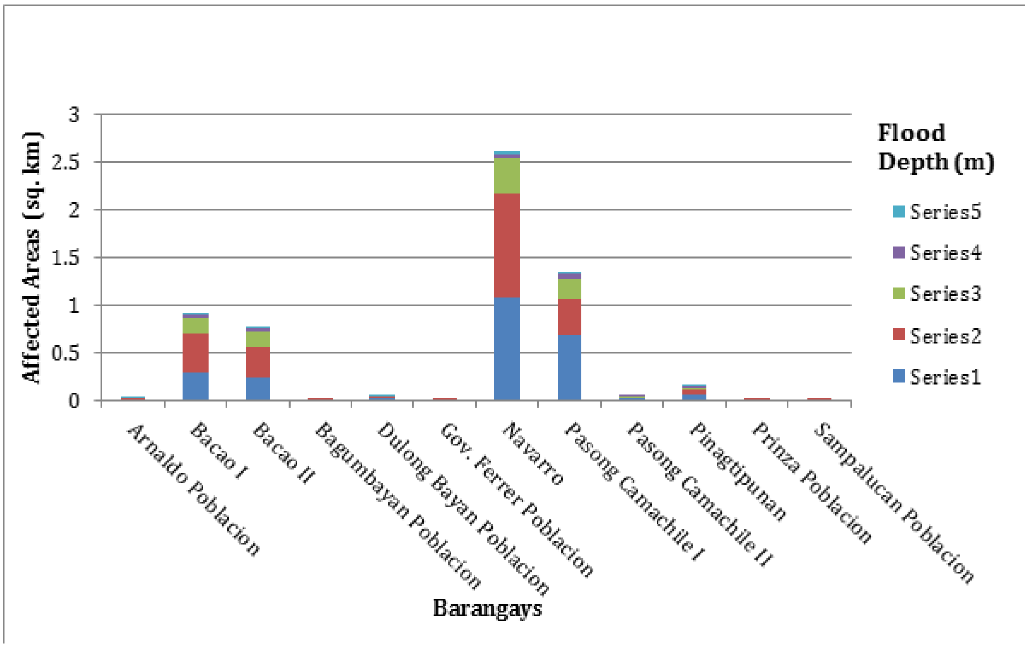


Figure 103. Affected Areas in General Trias, Cavite during a 25-Year Rainfall Return Period.

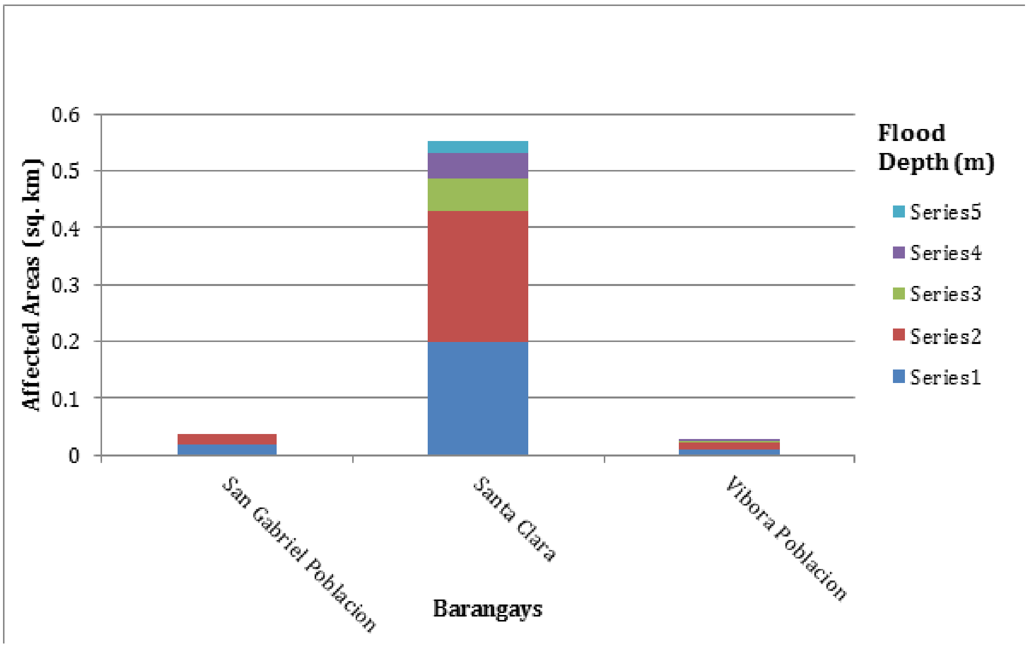


Figure 104. Affected Areas in General Trias, Cavite during a 25-Year Rainfall Return Period.

For the 100-year return period, 34.34% of the municipality of Cavite City with an area of 11.88 sq. km. will experience flood levels of less than 0.20 meters. 14.13% of the area will experience flood levels of 0.21 to 0.50 meters while 1.55%, 0.08%, 0.00%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the Table 48 are the affected areas in square kilometers by flood depth per barangay.

Table 48. Affected areas in Cavite City, Cavite during a 100-Year Rainfall Return Period

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barangay 1 | Barangay 10 | Barangay 10-A | Barangay 10-B | Barangay 11 | Barangay 12 | Barangay 13 | Barangay 14 | Barangay 15 | Barangay 16 | Barangay 17 |
| **0.03-0.20** | 0.018 | 0.053 | 0.019 | 0.035 | 0.051 | 0.014 | 0.039 | 0.033 | 0.022 | 0.068 | 0.011 |
| **0.21-0.50** | 0.01 | 0.019 | 0.0041 | 0.0053 | 0.0059 | 0.011 | 0.0053 | 0.0088 | 0.013 | 0.03 | 0.022 |
| **0.51-1.00** | 0.00022 | 0.0021 | 0.0002 | 0 | 0.000068 | 0 | 0.000041 | 0 | 0.0004 | 0 | 0.000058 |
| **1.01-2.00** | 0 | 0 | 0 | 0 | 0.000015 | 0 | 0.000002 | 0 | 0 | 0 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barangay 18 | Barangay 19 | Barangay 2 | Barangay 20 | Barangay 22 | Barangay 22-A | Barangay 23 | Barangay 24 | Barangay 25 | Barangay 26 | Barangay 27 |
| **0.03-0.20** | 0.0074 | 0.025 | 0.014 | 0.0061 | 0.05 | 0.028 | 0.016 | 0.0063 | 0.0093 | 0.034 | 0.031 |
| **0.21-0.50** | 0.02 | 0.042 | 0.0059 | 0.023 | 0.015 | 0.01 | 0.019 | 0.0092 | 0.0061 | 0.015 | 0.025 |
| **0.51-1.00** | 0.0016 | 0.00094 | 0 | 0.002 | 0 | 0 | 0.00073 | 0.001 | 0 | 0.007 | 0.0028 |
| **1.01-2.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0001 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barangay 28 | Barangay 29 | Barangay 29-A | Barangay 3 | Barangay 30 | Barangay 31 | Barangay 32 | Barangay 33 | Barangay 34 | Barangay 35 | Barangay 36 |
| **0.03-0.20** | 0.0069 | 0.015 | 0.011 | 0.4 | 0.036 | 0.019 | 0.025 | 0.021 | 0.016 | 0.0078 | 0.031 |
| **0.21-0.50** | 0.017 | 0.0043 | 0.0088 | 0.12 | 0.0053 | 0.0076 | 0.016 | 0.023 | 0.0077 | 0.014 | 0.0029 |
| **0.51-1.00** | 0.00066 | 0 | 0 | 0.12 | 0 | 0 | 0.000037 | 0.00046 | 0.0002 | 0 | 0 |
| **1.01-2.00** | 0 | 0 | 0 | 0.0034 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barangay 36-A | Barangay 37 | Barangay 37-A | Barangay 38 | Barangay 38-A | Barangay 39 | Barangay 4 | Barangay 40 | Barangay 41 | Barangay 42 | Barangay 42-A |
| **0.03-0.20** | 0.0059 | 0.01 | 0.013 | 0.025 | 0.0094 | 0.019 | 0.012 | 0.009 | 0.06 | 0.024 | 0.0083 |
| **0.21-0.50** | 0.0041 | 0.011 | 0.015 | 0.014 | 0.024 | 0.026 | 0.0033 | 0.012 | 0.074 | 0.014 | 0.005 |
| **0.51-1.00** | 0 | 0.0001 | 0 | 0 | 0 | 0.00021 | 0 | 0.0003 | 0.0026 | 0 | 0.0041 |
| **1.01-2.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0003 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barangay 42-B | Barangay 42-C | Barangay 43 | Barangay 44 | Barangay 45 | Barangay 45-A | Barangay 46 | Barangay 47 | Barangay 47-A | Barangay 47-B | Barangay 48 |
| **0.03-0.20** | 0.018 | 0.011 | 0.0035 | 0.02 | 0.0081 | 0.019 | 0.051 | 0.016 | 0.023 | 0.019 | 0.045 |
| **0.21-0.50** | 0.003 | 0.032 | 0.061 | 0.039 | 0.015 | 0.021 | 0.012 | 0.01 | 0.011 | 0.011 | 0.0036 |
| **0.51-1.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1.01-2.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barangay 48-A | Barangay 49 | Barangay 49-A | Barangay 5 | Barangay 50 | Barangay 51 | Barangay 52 | Barangay 53 | Barangay 53-A | Barangay 53-B | Barangay 54 |
| **0.03-0.20** | 0.033 | 0.036 | 0.036 | 0.011 | 0.03 | 0.04 | 0.022 | 1.26 | 0.019 | 0.0051 | 0.037 |
| **0.21-0.50** | 0.014 | 0.0044 | 0.0012 | 0.0011 | 0.0053 | 0 | 0.013 | 0.28 | 0 | 0.0097 | 0.014 |
| **0.51-1.00** | 0.0002 | 0 | 0 | 0 | 0 | 0 | 0 | 0.014 | 0 | 0 | 0 |
| **1.01-2.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barangay 54-A | Barangay 55 | Barangay 56 | Barangay 57 | Barangay 58 | Barangay 58-A | Barangay 59 | Barangay 6 | Barangay 60 | Barangay 61 | Barangay 61-A |
| **0.03-0.20** | 0.009 | 0.03 | 0.032 | 0.0081 | 0.0027 | 0.004 | 0.038 | 0.069 | 0.02 | 0.022 | 0.016 |
| **0.21-0.50** | 0.011 | 0.035 | 0.022 | 0.0064 | 0.011 | 0.012 | 0.011 | 0.04 | 0.015 | 0.0091 | 0.0066 |
| **0.51-1.00** | 0 | 0 | 0 | 0.0016 | 0.0012 | 0.0024 | 0 | 0.0013 | 0.000076 | 0.0004 | 0 |
| **1.01-2.00** | 0 | 0 | 0 | 0 | 0 | 0.0019 | 0 | 0 | 0 | 0 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Cavite City (in sq. km.) | | | | | |
|---|---|---|---|---|---|---|
| | Barangay 62 | Barangay 62-A | Barangay 62-B | Barangay 7 | Barangay 8 | Barangay 9 |
| **0.03-0.20** | 0.18 | 0.05 | 0.22 | 0.0082 | 0.22 | 0.014 |
| **0.21-0.50** | 0.051 | 0.028 | 0.026 | 0.0083 | 0.043 | 0.028 |
| **0.51-1.00** | 0.0016 | 0.002 | 0 | 0 | 0.0085 | 0.003 |
| **1.01-2.00** | 0 | 0 | 0 | 0 | 0.0034 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 |

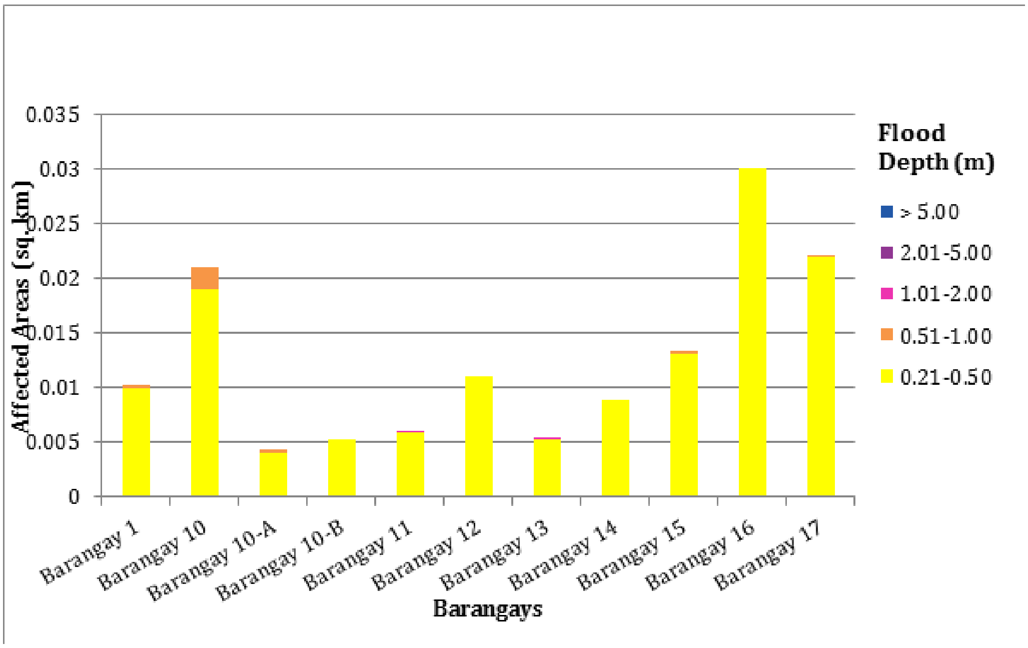


Figure 105. Affected areas in Cavite City, Cavite during a 100-Year Rainfall Return Period.

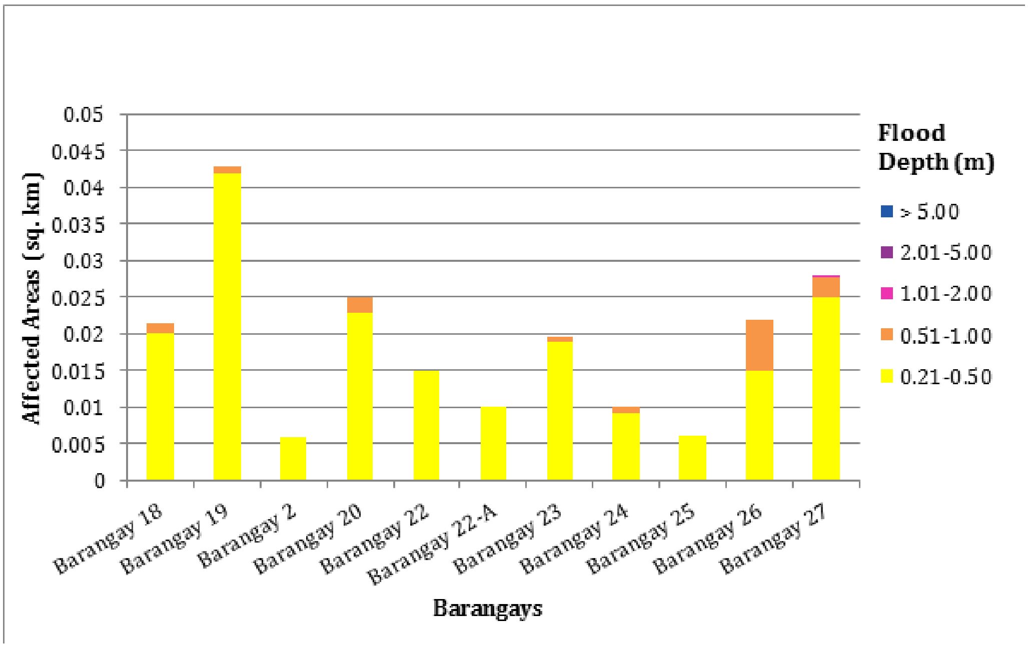


Figure 106. Affected areas in Cavite City, Cavite during a 100-Year Rainfall Return Period.

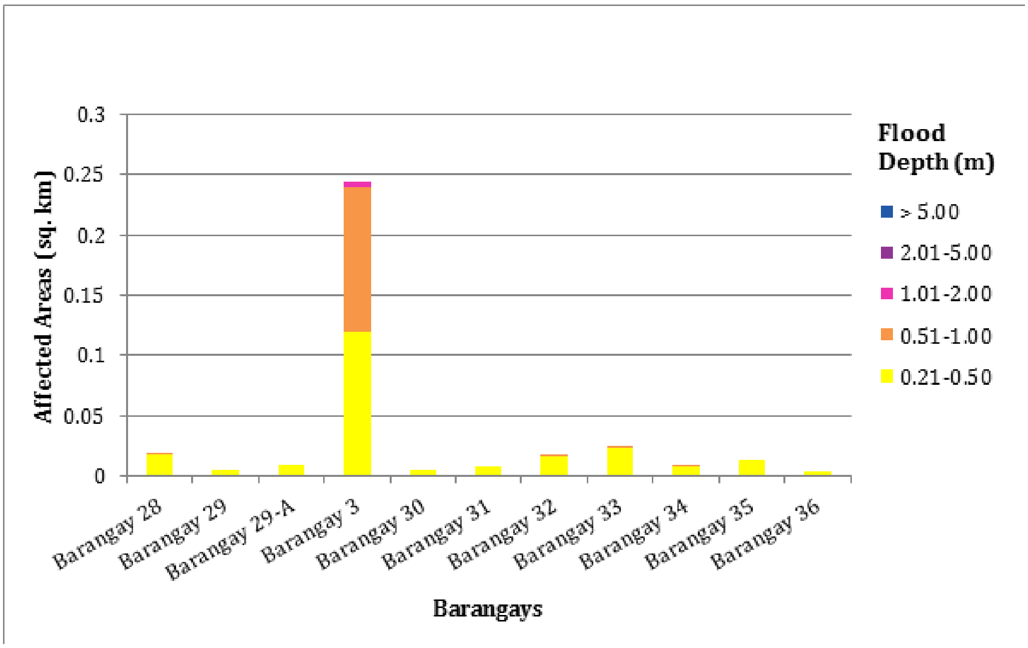


Figure 107. Affected areas in Cavite City, Cavite during a 100-Year Rainfall Return Period.

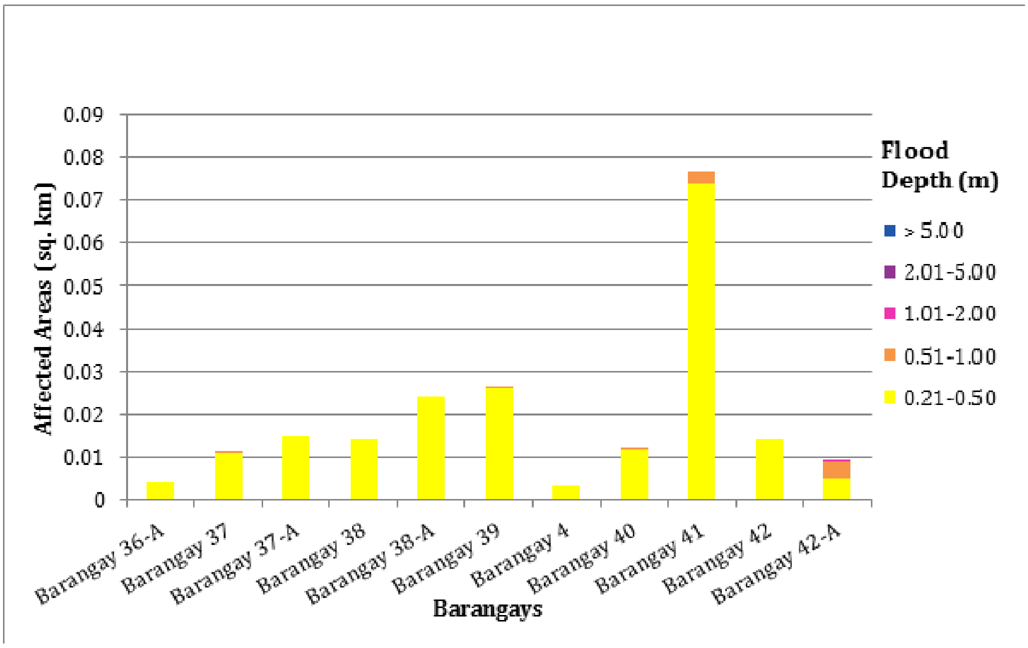


Figure 108. Affected areas in Cavite City, Cavite during a 100-Year Rainfall Return Period.

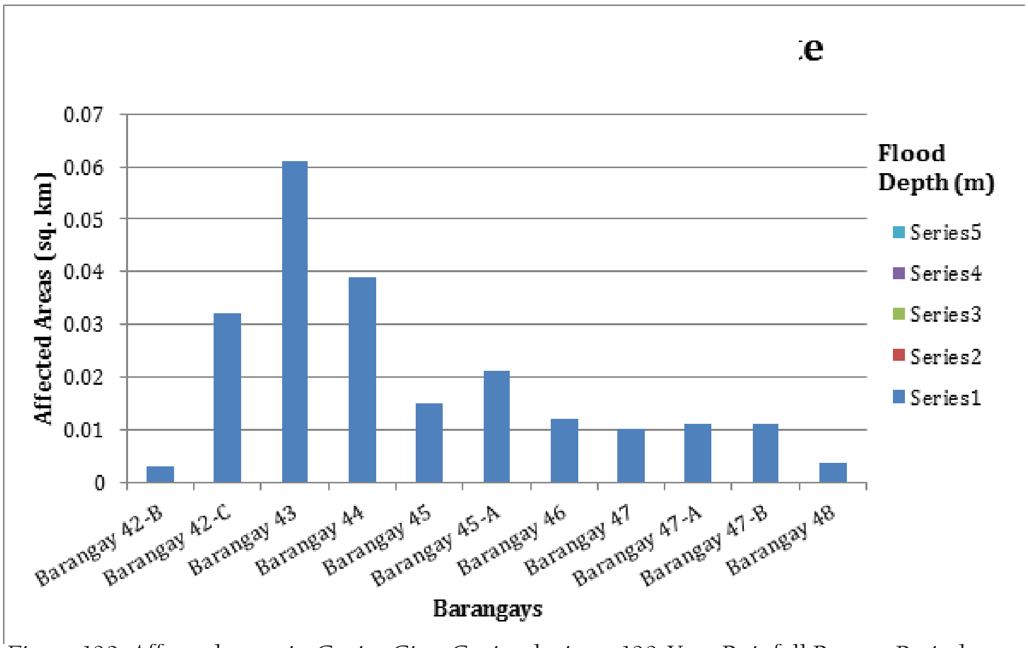


Figure 109. Affected areas in Cavite City, Cavite during a 100-Year Rainfall Return Period.

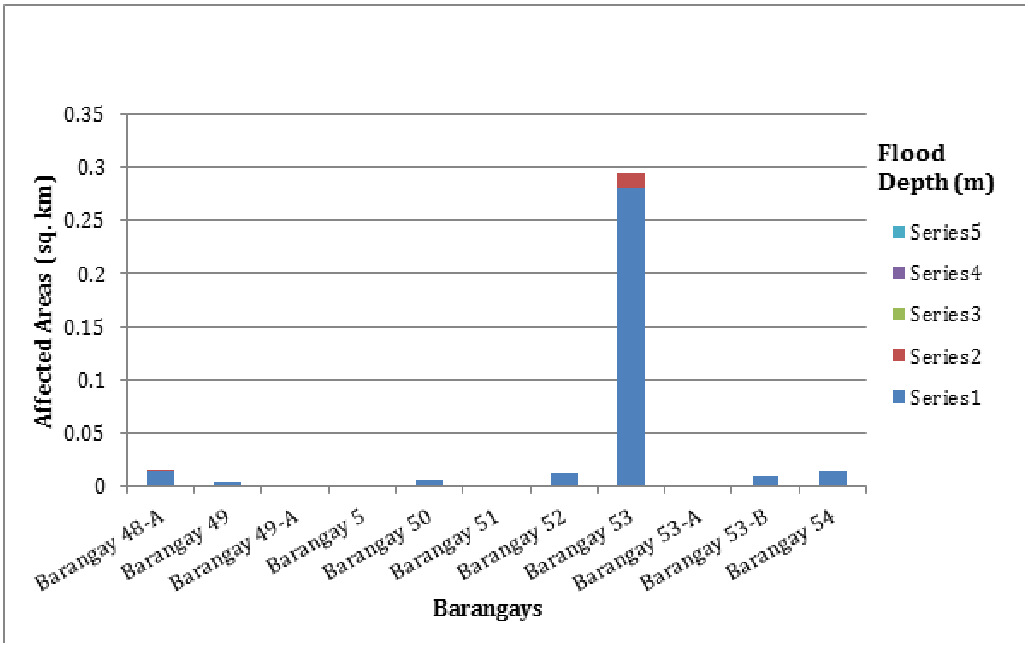


Figure 110. Affected areas in Cavite City, Cavite during a 100-Year Rainfall Return Period.

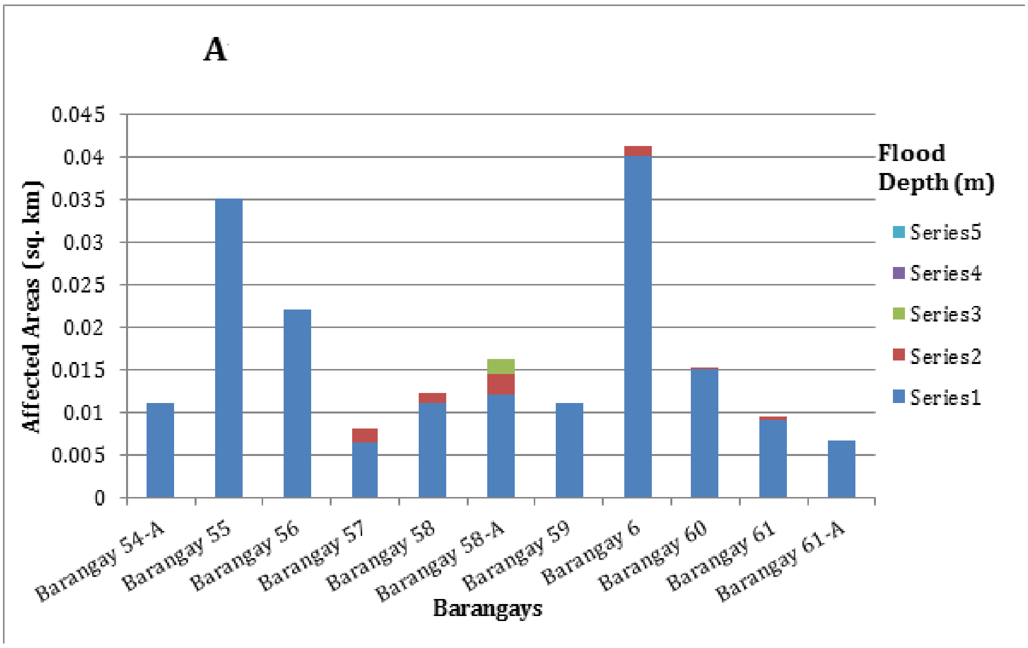


Figure 111. Affected areas in Cavite City, Cavite during a 100-Year Rainfall Return Period.

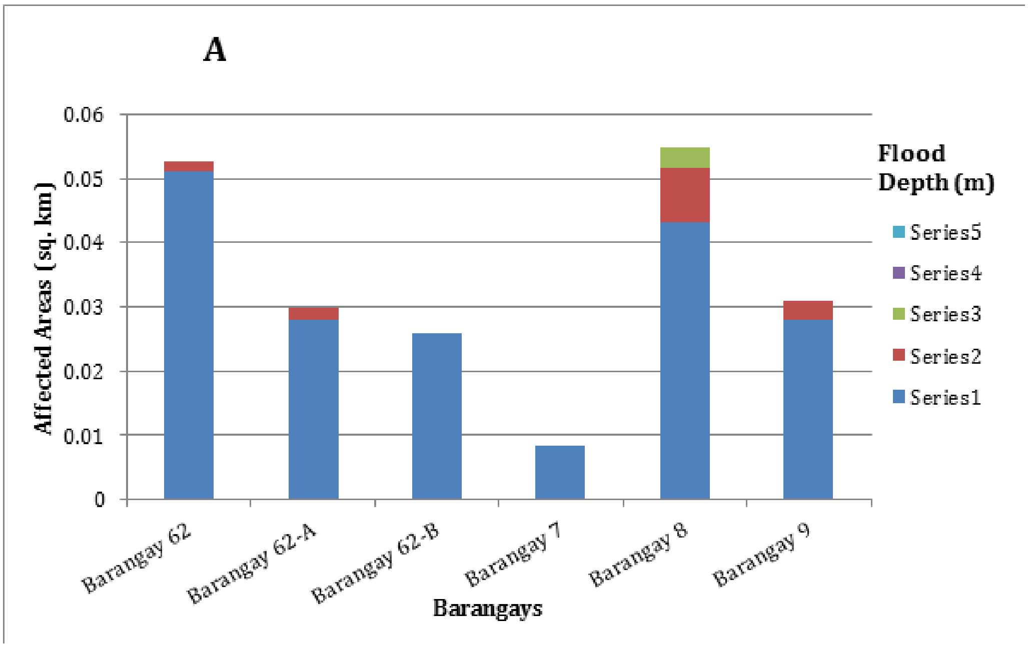


Figure 112. Affected areas in Cavite City, Cavite during a 100-Year Rainfall Return Period.

For the 100-year return period, 6.09% of the municipality of Kawit with an area of 15.97 sq. km. will experience flood levels of less than 0.20 meters. 5.51% of the area will experience flood levels of 0.21 to 0.50 meters while 12.55%, 16.41%, 4.15%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 49 are the affected areas in square kilometers by flood depth per barangay.

Table 49. Affected areas in Kawit, Cavite during a 100-Year Rainfall Return Period.

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Kawit (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Balsahan-Bisita | Batong Dalig | Gahak | Kaingen | Magdalo | Marulas | Panamitan | Poblacion | Barangay 15 | Barangay 16 | Barangay 17 |
| **0.03-0.20** | 0.019 | 0.09 | 0.00019 | 0.014 | 0.022 | 0.049 | 0.016 | 0.02 | 0.028 | 0.077 | 0.019 |
| **0.21-0.50** | 0.00066 | 0.075 | 0.0066 | 0.012 | 0.042 | 0.076 | 0.045 | 0.017 | 0.0076 | 0.02 | 0.014 |
| **0.51-1.00** | 0.0037 | 0.12 | 0.091 | 0.1 | 0.084 | 0.22 | 0.2 | 0.076 | 0 | 0 | 0 |
| **1.01-2.00** | 0.0069 | 0.17 | 0.11 | 0.19 | 0.053 | 0.37 | 0.25 | 0.21 | 0 | 0 | 0 |
| **2.01-5.00** | 0.028 | 0.094 | 0.055 | 0.0071 | 0.0038 | 0.066 | 0.11 | 0.085 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Kawit (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | San Sebastian | Santa Isabel | Tabon I | Tabon II | Tabon III | Toclong | Tramo-Bantayan | Wakas I | Wakas II | Barangay 26 | Barangay 27 |
| **0.03-0.20** | 0.035 | 0.55 | 0.0038 | 0.0029 | 0.0001 | 0.12 | 0.014 | 0.015 | 0.0012 | 0.077 | 0.019 |
| **0.21-0.50** | 0.089 | 0.27 | 0.02 | 0.017 | 0.00058 | 0.16 | 0.0073 | 0.039 | 0.0034 | 0.02 | 0.014 |
| **0.51-1.00** | 0.18 | 0.43 | 0.08 | 0.044 | 0.021 | 0.21 | 0.02 | 0.087 | 0.038 | 0 | 0 |
| **1.01-2.00** | 0.19 | 0.24 | 0.24 | 0.052 | 0.038 | 0.17 | 0.041 | 0.12 | 0.17 | 0 | 0 |
| **2.01-5.00** | 0.014 | 0.0035 | 0.014 | 0.032 | 0.0026 | 0.11 | 0.005 | 0.0076 | 0.025 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

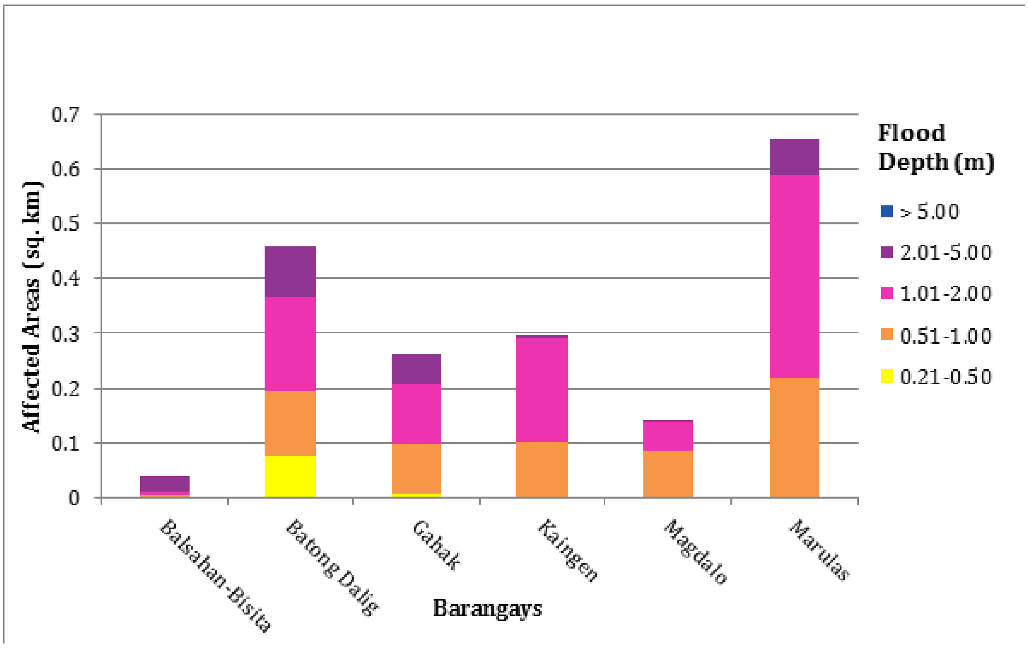


Figure 113. Affected areas in Kawit, Cavite during a 100-Year Rainfall Return Period.

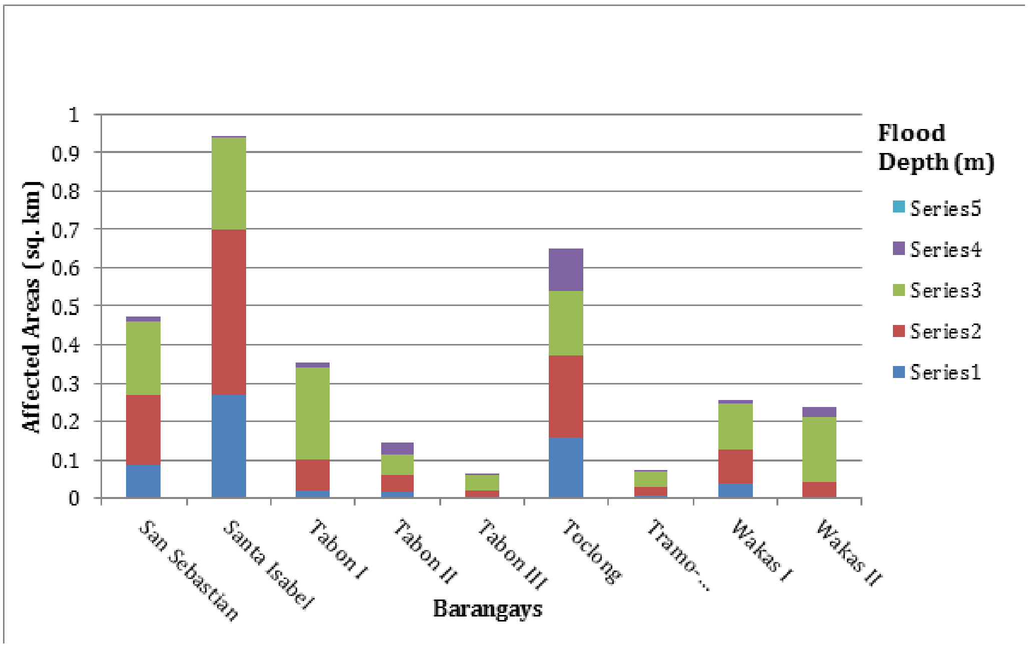


Figure 114. Affected areas in Kawit, Cavite during a 100-Year Rainfall Return Period.

For the 100-year return period, 16.12% of the municipality of Imus with an area of 50.4 sq. km. will experience flood levels of less than 0.20 meters. 10.01% of the area will experience flood levels of 0.21 to 0.50 meters while 10.34%, 7.17%, 0.36%, and 0.15% 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 50 are the affected areas in square kilometers by flood depth per barangay.

Table 50. Affected areas in Imus, Cavite during a 100-Year Rainfall Return Period.

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Imus (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Alapan I-A | Alapan I-B | Alapan I-C | Alapan II-A | Alapan II-B | Anabu II-F | | | Bucandala III | Bucandala IV | Barangay 17 |
| **0.03-0.20** | 0.49 | 0.28 | 0.39 | 0.39 | 0.17 | 0.022 | 0.072 | 0.19 | 0.43 | 0.99 | 0.019 |
| **0.21-0.50** | 0.27 | 0.25 | 0.53 | 0.55 | 0.37 | 0.0023 | 0.016 | 0.12 | 0.22 | 0.45 | 0.014 |
| **0.51-1.00** | 0.68 | 0.48 | 0.66 | 0.8 | 0.14 | 0 | 0.0018 | 0.031 | 0.029 | 0.27 | 0 |
| **1.01-2.00** | 0.21 | 0.25 | 0.35 | 0.39 | 0.037 | 0 | 0 | 0.0001 | 0.0056 | 0.5 | 0 |
| **2.01-5.00** | 0.043 | 0.052 | 0.0001 | 0 | 0.0016 | 0 | 0 | 0 | 0.0005 | 0.005 | 0 |
| **> 5.00** | 0.041 | 0.015 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Imus (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bucandala V | Carsadang Bago I | Carsadang Bago II | Malagasang I-A | Malagasang I-B | Malagasang I-C | Malagasang I-D | Malagasang I-E | Malagasang I-F | Medicion I-A | Barangay 27 |
| **0.03-0.20** | 0.96 | 0.93 | 0.55 | 0.0001 | 0.1 | 0.45 | 0.19 | 0.24 | 0.037 | 0.027 | 0.019 |
| **0.21-0.50** | 0.34 | 0.39 | 0.26 | 0.0035 | 0.016 | 0.13 | 0.081 | 0.053 | 0.0046 | 0.026 | 0.014 |
| **0.51-1.00** | 0.31 | 0.13 | 0.049 | 0.046 | 0.027 | 0.081 | 0.016 | 0 | 0 | 0.0073 | 0 |
| **1.01-2.00** | 0.29 | 0.047 | 0.0069 | 0.068 | 0.093 | 0.091 | 0.0065 | 0 | 0 | 0.00015 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0.024 | 0.0015 | 0.0033 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0.019 | 0.0014 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Imus (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Medicion I-B | Medicion I-C | Medicion I-D | Medicion II-A | Medicion II-B | Medicion II-C | Medicion II-D | Medicion II-E | Medicion II-F | Pag-Asa I | Barangay 17 |
| **0.03-0.20** | 0.049 | 0.042 | 0.031 | 0.0059 | 0.02 | 0.048 | 0.024 | 0.037 | 0.098 | 0.057 | 0.019 |
| **0.21-0.50** | 0.022 | 0.016 | 0.031 | 0.023 | 0.022 | 0.03 | 0.042 | 0.029 | 0.033 | 0.056 | 0.014 |
| **0.51-1.00** | 0.0062 | 0.00021 | 0.026 | 0.042 | 0.063 | 0.032 | 0.032 | 0.014 | 0.0031 | 0.45 | 0 |
| **1.01-2.00** | 0.0033 | 0 | 0.001 | 0.035 | 0.012 | 0 | 0.011 | 0 | 0 | 0.81 | 0 |
| **2.01-5.00** | 0 | 0 | 0 | 0.0088 | 0.0014 | 0 | 0 | 0 | 0 | 0.036 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Imus (in sq. km.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pag-Asa II | Pag-Asa III | Poblacion III-A | Poblacoin III-B | Poblacion IV-A | Toclong I-A | Toclong I-B | Toclong I-C | Toclong II-A | Toclong II-B | Barangay 17 |
| **0.03-0.20** | 0.22 | 0.25 | 0.021 | 0 | 0.02 | 0.037 | 0.009 | 0.0043 | 0.094 | 0.15 | 0.019 |
| **0.21-0.50** | 0.24 | 0.24 | 0.01 | 0 | 0.00039 | 0.014 | 0.00041 | 0 | 0.077 | 0.078 | 0.014 |
| **0.51-1.00** | 0.41 | 0.28 | 0.00039 | 0 | 0 | 0.0023 | 0 | 0 | 0.039 | 0.055 | 0 |
| **1.01-2.00** | 0.19 | 0.19 | 0 | 0 | 0 | 0.00011 | 0 | 0 | 0.0043 | 0.011 | 0 |
| **2.01-5.00** | 0.0044 | 0.0001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

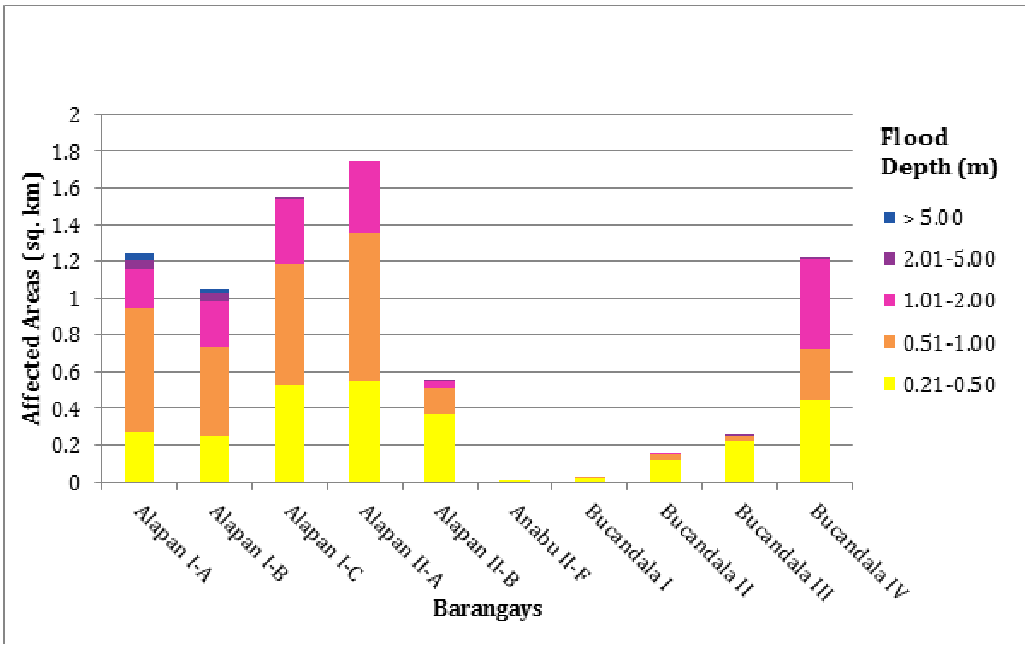


Figure 115. Affected areas in Imus, Cavite during a 100-Year Rainfall Return Period.

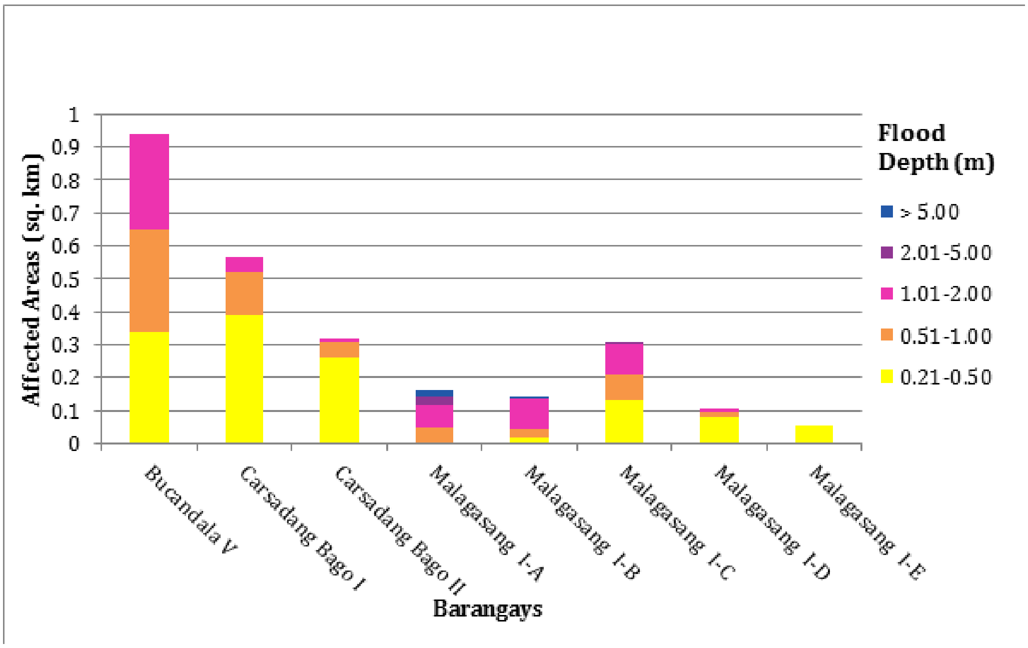


Figure 116. Affected areas in Imus, Cavite during a 100-Year Rainfall Return Period.

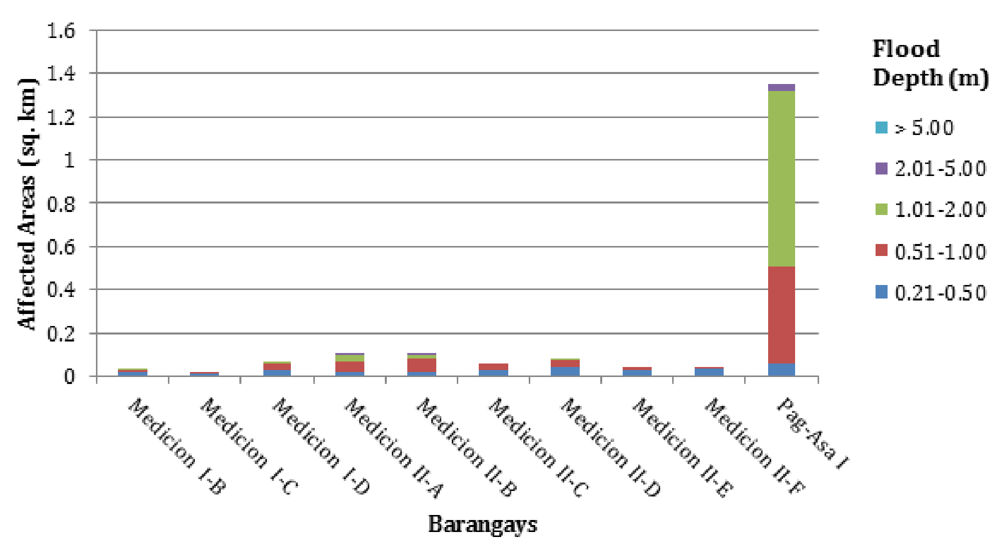


Figure 117. Affected areas in Imus, Cavite during a 100-Year Rainfall Return Period.

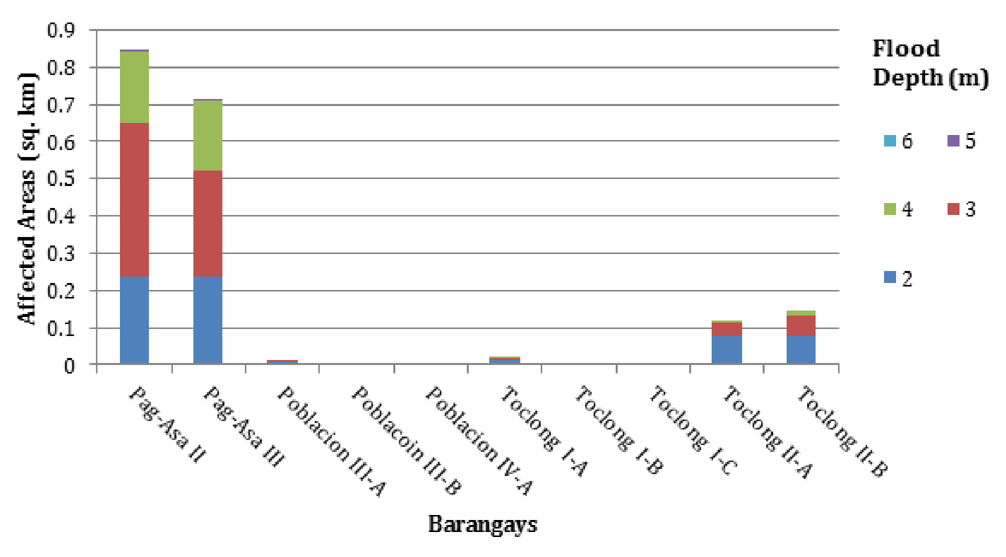


Figure 118. Affected areas in Imus, Cavite during a 100-Year Rainfall Return Period.

For the 100-year return period, 23.29% of the municipality of Noveleta with an area of 5.16 sq. km. will experience flood levels of less than 0.20 meters. 9.18% of the area will experience flood levels of 0.21 to 0.50 meters while 9.64%, 7.62%, 2.02%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 51 are the affected areas in square kilometers by flood depth per barangay.

Table 51. Affected areas in Noveleta, Cavite during a 100-Year Rainfall Return Period.

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in Noveleta (in sq. km.) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Magdiwang | San Antonio I | San Antonio II | San Jose I | San Jose II | San Juan I | San Juan II | San Rafael II | San Rafael IV | Santa Rosa II |
| **0.03-0.20** | 0.022 | 0.29 | 0.045 | 0.08 | 0.032 | 0.35 | 0.037 | 0.25 | 0.093 | 0.0029 |
| **0.21-0.50** | 0.00041 | 0.074 | 0.079 | 0.012 | 0.002 | 0.17 | 0.016 | 0.096 | 0.024 | 0.00027 |
| **0.51-1.00** | 0.0002 | 0.062 | 0.13 | 0.0057 | 0.0022 | 0.16 | 0.0008 | 0.1 | 0.036 | 0.00037 |
| **1.01-2.00** | 0.00071 | 0.076 | 0.24 | 0.0052 | 0.0052 | 0.031 | 0.00091 | 0.03 | 0.0032 | 0.001 |
| **2.01-5.00** | 0.00076 | 0.051 | 0.034 | 0.0081 | 0.005 | 0.002 | 0.002 | 0 | 0 | 0.0012 |
| **> 5.00** | 0 | 0.0001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

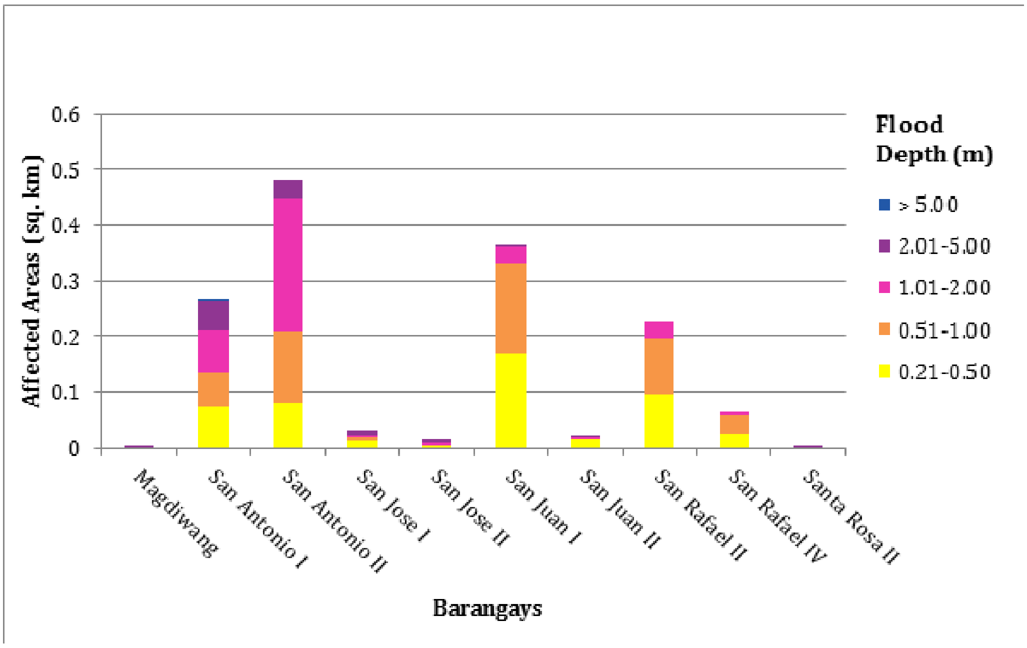


Figure 119. Affected Areas in Noveleta, Cavite during a 100-Year Rainfall Return Period.

For the 100-year return period, 5.13% of the municipality of General Trias with an area of 87.5 sq. km. will experience flood levels of less than 0.20 meters. 3.05% of the area will experience flood levels of 0.21 to 0.50 meters while 2.92%, 1.15%, 0.26%, 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 52 are the affected areas in square kilometers by flood depth per barangay.

Table 52. Affected areas in General Trias, Cavite during a 100-Year Rainfall Return Period.

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in General Trias (in sq. km.) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Arnaldo Poblacion | Bacao I | Bacao II | Bagumbayan Poblacion | Dulong Bayan Poblacion | Gov. Ferrer Poblacion | Navarro | Pasong Camachile I | Pasong Camachile II | Pinagtipunan | Prinza Poblacion | Sampalucan Poblacion |
| **0.03-0.20** | 0.036 | 0.27 | 0.12 | 0.031 | 0.025 | 0.0011 | 1.57 | 1.83 | 0.12 | 0.026 | 0.028 | 0.013 |
| **0.21-0.50** | 0.016 | 0.27 | 0.2 | 0.0065 | 0.025 | 0.00049 | 0.99 | 0.65 | 0.029 | 0.059 | 0.017 | 0.0048 |
| **0.51-1.00** | 0.0037 | 0.43 | 0.36 | 0.0015 | 0.02 | 0.000002 | 1.07 | 0.42 | 0.005 | 0.064 | 0.0027 | 0.0004 |
| **1.01-2.00** | 0.0013 | 0.22 | 0.19 | 0 | 0.0032 | 0 | 0.58 | 0.28 | 0.0045 | 0.028 | 0 | 0 |
| **2.01-5.00** | 0.0014 | 0.041 | 0.035 | 0 | 0.0036 | 0 | 0.054 | 0.054 | 0.0016 | 0.01 | 0 | 0 |
| **> 5.00** | 0.0015 | 0.0075 | 0.003 | 0 | 0.0023 | 0 | 0.025 | 0.007 | 0 | 0.0039 | 0 | 0 |

| Affected Area (sq. km.) by flood depth (m.) | Area of affected barangays in General Trias (in sq. km.) | | |
|---|---|---|---|
| | San Gabriel Poblacion | Santa Clara | Vibora Poblacion |
| **0.03-0.20** | 0.017 | 0.062 | 0.028 |
| **0.21-0.50** | 0.018 | 0.17 | 0.01 |
| **0.51-1.00** | 0.022 | 0.27 | 0.012 |
| **1.01-2.00** | 0.0001 | 0.072 | 0.0033 |
| **2.01-5.00** | 0 | 0.048 | 0.00082 |
| **> 5.00** | 0 | 0.021 | 0 |

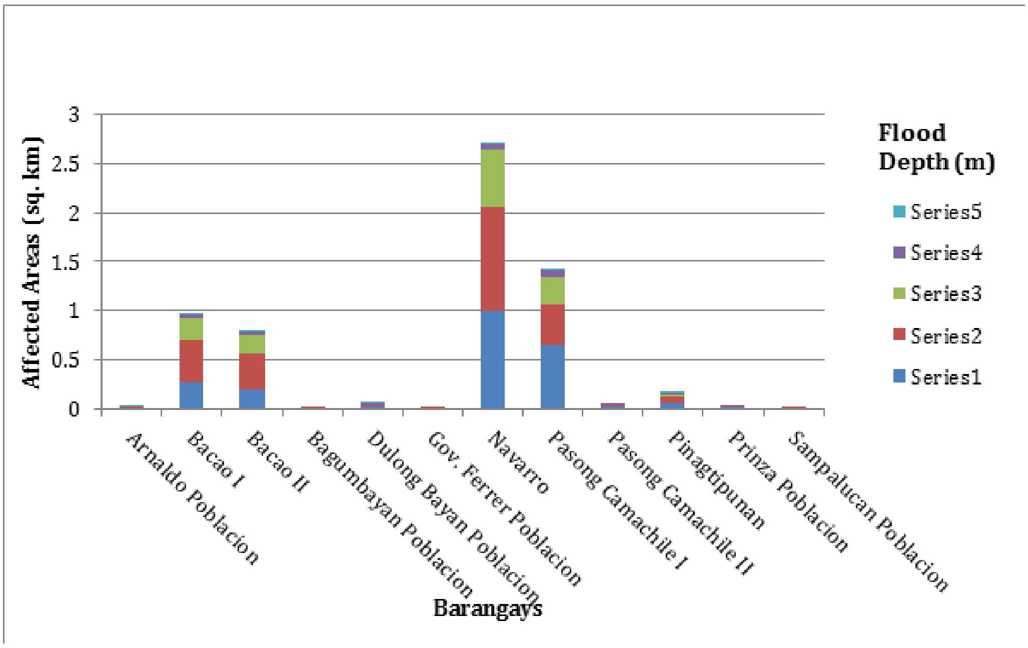


Figure 120. Affected Areas in General Trias, Cavite during a 100-Year Rainfall Return Period.

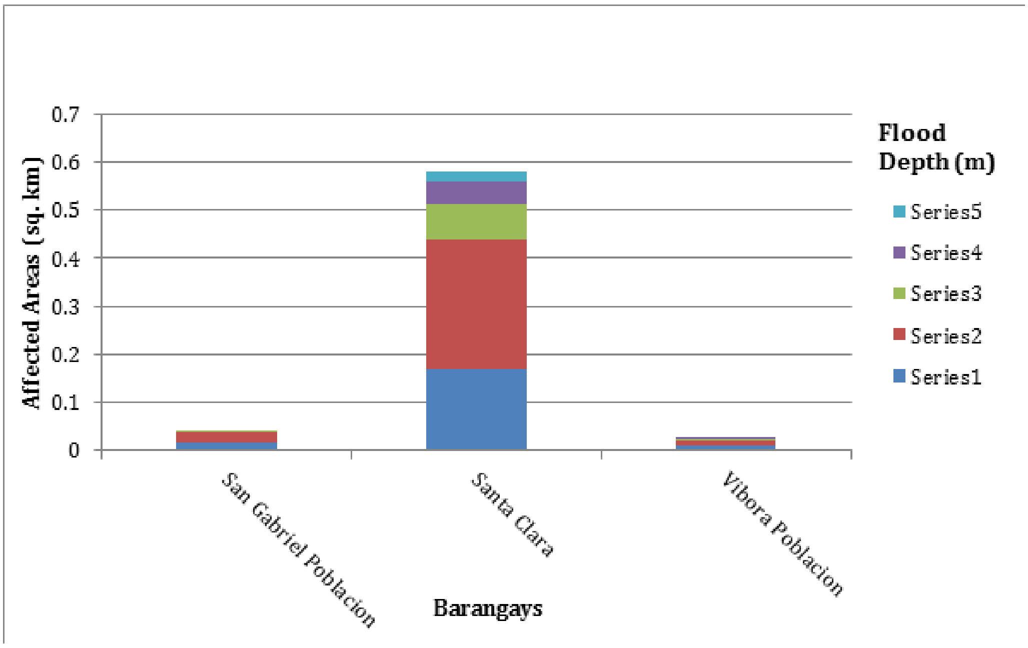


Figure 121. Affected Areas in General Trias, Cavite during a 100-Year Rainfall Return Period.

Among the barangays in the municipality of San Julian, Nena is projected to have the highest percentage of area that will experience flood levels at 0.81%. Meanwhile, Putong posted the second highest percentage of area that may be affected by flood depths at 0.41%.

Among the barangays in the municipality of Ilang-Ilang, Kandalakit is projected to have the highest percentage of area that will experience flood levels at 6.85%. Meanwhile, San Juan posted the second highest percentage of area that may be affected by flood depths at 4.84%.

Among the barangays in the municipality of Taft, Mantang is projected to have the highest percentage of area that will experience flood levels of at 0.62%. Meanwhile, Malinao posted the percentage of area that may be affected by flood depths of at 0.56%.

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

Table 53. Area 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** | 11.34 | 11.79 | 10.94 |
| **Medium** | 11.80 | 16.38 | 17.61 |
| **High** | 1.64 | 2.42 | 3.11 |
| **Total** | **24.78** | **30.59** | **31.66** |

Of the four (4) identified educational institutions in Ilang-Ilang Flood plain, two schools were discovered exposed to Medium-level flooding for the 5- and 25-year scenarios. For the 100 year scenario, these 2 schools were assessed for High level flooding.

Only one health institution was identified in Ilang-Ilang Floodplain, namely Sto Niño Health Center. The institution was assessed to be exposed to the Medium level flooding during a 5, 25, and 100 year scenario.

## 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 to the specified points identified in a river basin and will gather data regarding the actual flood level in each location. Data gathering was done through a local DRRM office to obtain maps or situation reports about the past flooding events or interview some residents with knowledge of or have had experienced flooding in a particular area.

The actual data from the field were compared to the simulated data to assess the accuracy of the Flood Depth Maps produced and to improve on the results of the flood map. The points in the flood map versus its corresponding validation depths are shown in Figure 123.

The flood validation consists of 181 points randomly selected all over the Ilang-Ilang floodplain. Comparing it with the flood depth map of the nearest storm event, the map has an RMSE value of 1.20 m. Table 54 shows a contingency matrix of the comparison. The validation points are found in Annex 11.

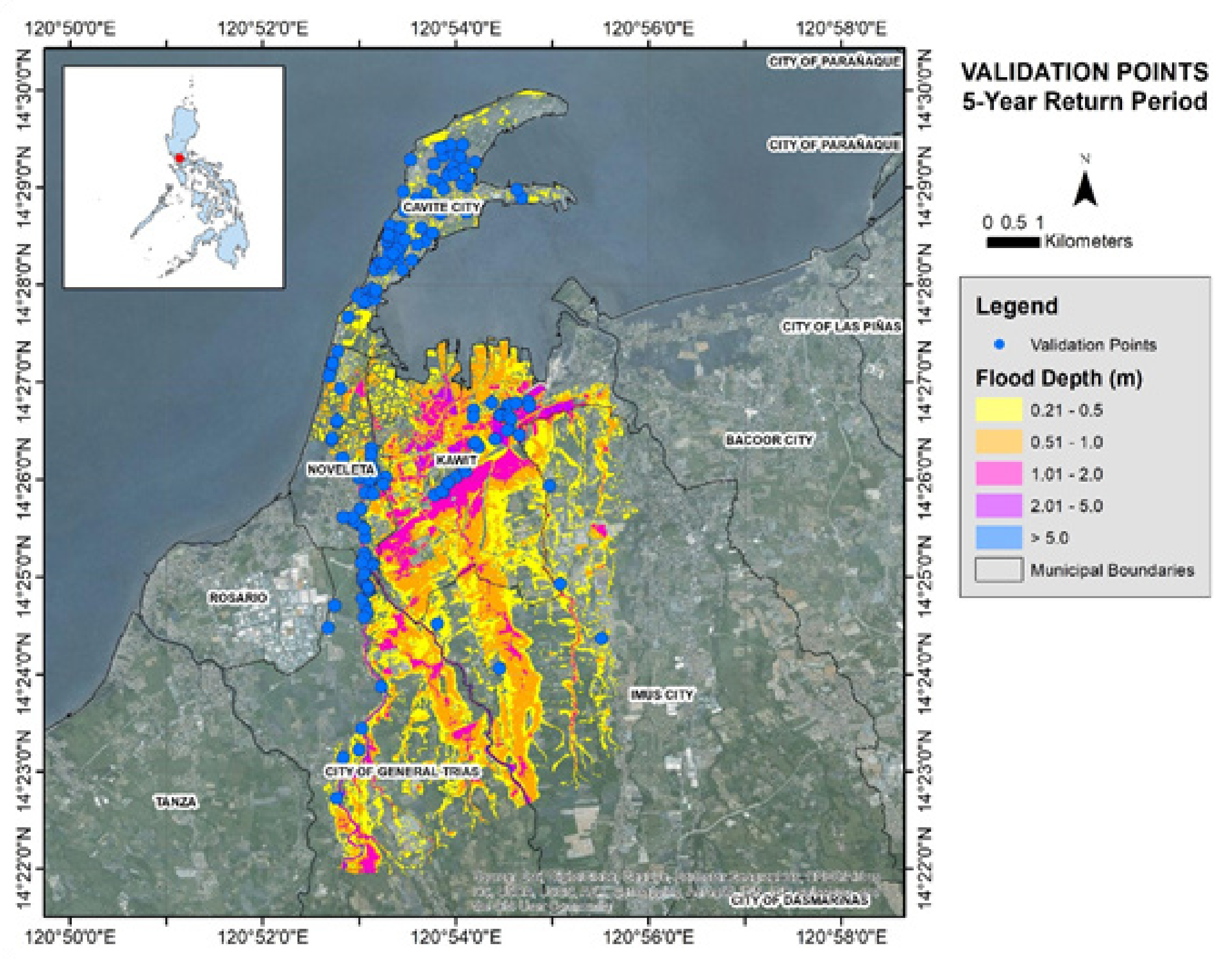


Figure 122. Validation Points for a 5-year Flood Depth Map of the Ilang-Ilang Floodplain.

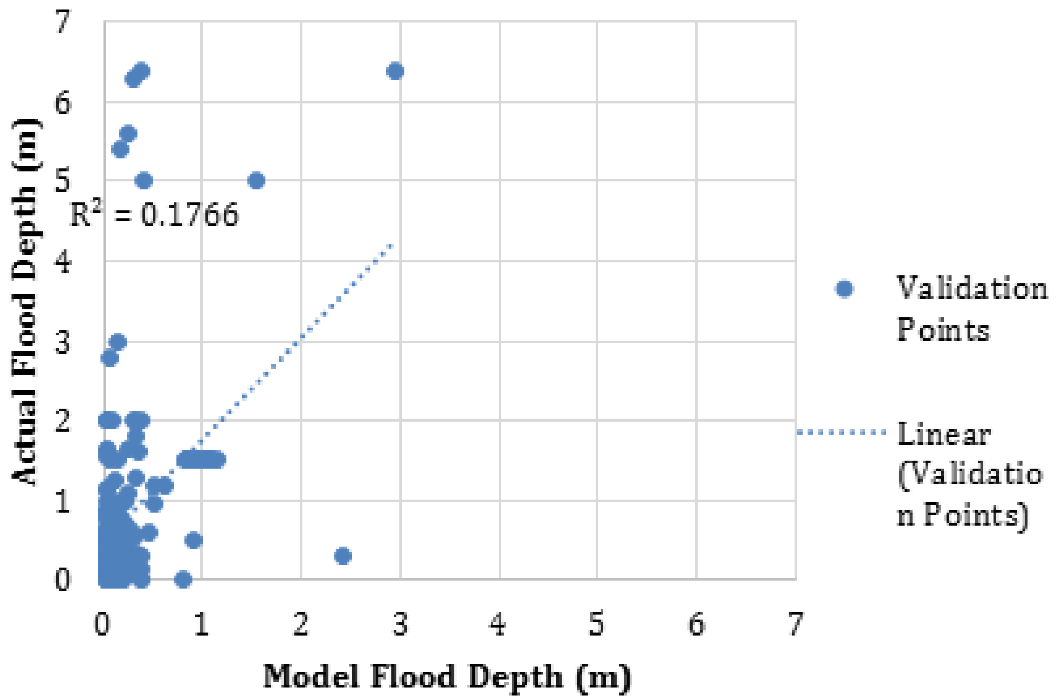


Figure 123. Flood Map depth versus Actual Flood Depth

Table 54. Actual Flood Depth versus Simulated Flood Depth at different levels in the Ilang-Ilang 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** | 49 | 8 | 1 | 0 | 0 | 0 | 58 |
| **0.21-0.50** | 34 | 11 | 1 | 0 | 1 | 0 | 47 |
| **0.51-1.00** | 21 | 7 | 1 | 0 | 0 | 0 | 29 |
| **1.01-2.00** | 12 | 8 | 11 | 6 | 0 | 0 | 37 |
| **2.01-5.00** | 2 | 1 | 0 | 1 | 0 | 0 | 4 |
| **> 5.00** | | 3 | 0 | 0 | 1 | 0 | 5 |
| | 111 | 31 | 19 | 13 | 7 | 0 | 180 |

On the whole, the overall accuracy generated by the flood model is estimated at 37.22%, with 67 points correctly matching the actual flood depths. In addition, there were 56 points estimated one level above and below the correct flood depths while there were 30 points and 20 points estimated two levels above and below, and three or more levels above and below the correct flood. A total of 4 points were overestimated while a total of 102 points were underestimated in the modelled flood depths of Ilang-Ilang. Table 55 depicts the summary of the Accuracy Assessment in the Ilang-Ilang River Basin Flood Depth Map.

Table 55. Summary of the Accuracy Assessment in the Ilang-Ilang River Basin Survey.

| | **No. of Points** | **%** |
|---|---|---|
| Correct | 37.22 | 37.22 |
| Overestimated | 6.11 | 6.11 |
| Underestimated | 56.67 | 56.67 |
| Total | 100.00 | 100.00 |

# REFERENCES

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

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

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

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

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

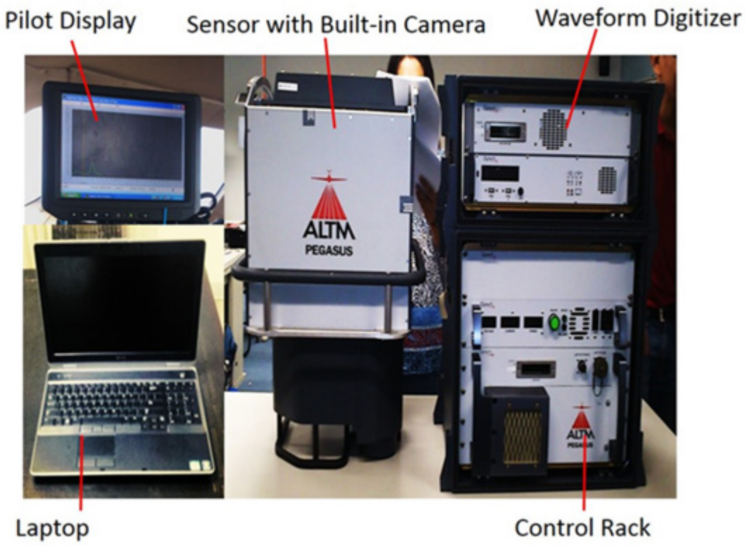
Sarmiento C., Paringit E.C., et al. 2014. DREAM Data Acquisition Component Manual. Quezon City, Philippines: UP Training Center for Applied Geodesy and Photogrammetry.

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

# ANNEXES

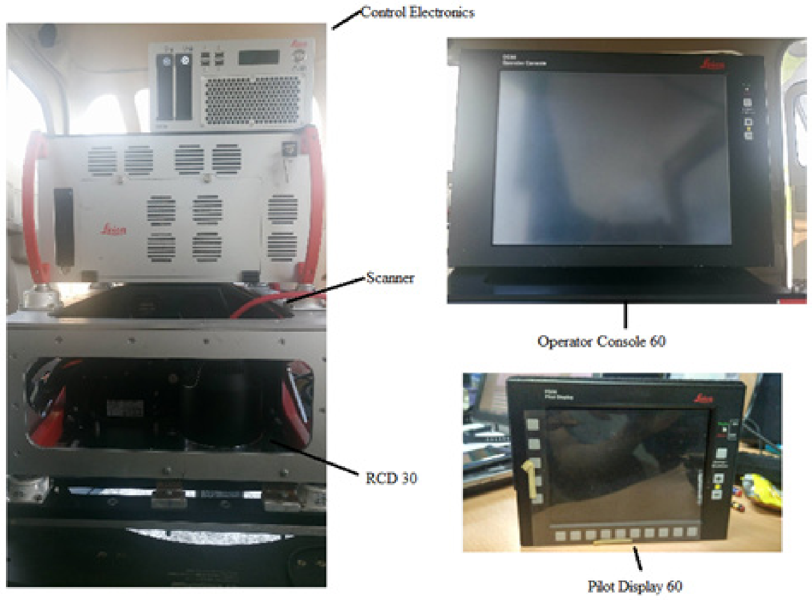
## Annex 1. Technical Specifications of the LIDAR Sensors used in the Ilang-Ilang Floodplain Survey

1. PEGASUS SENSOR



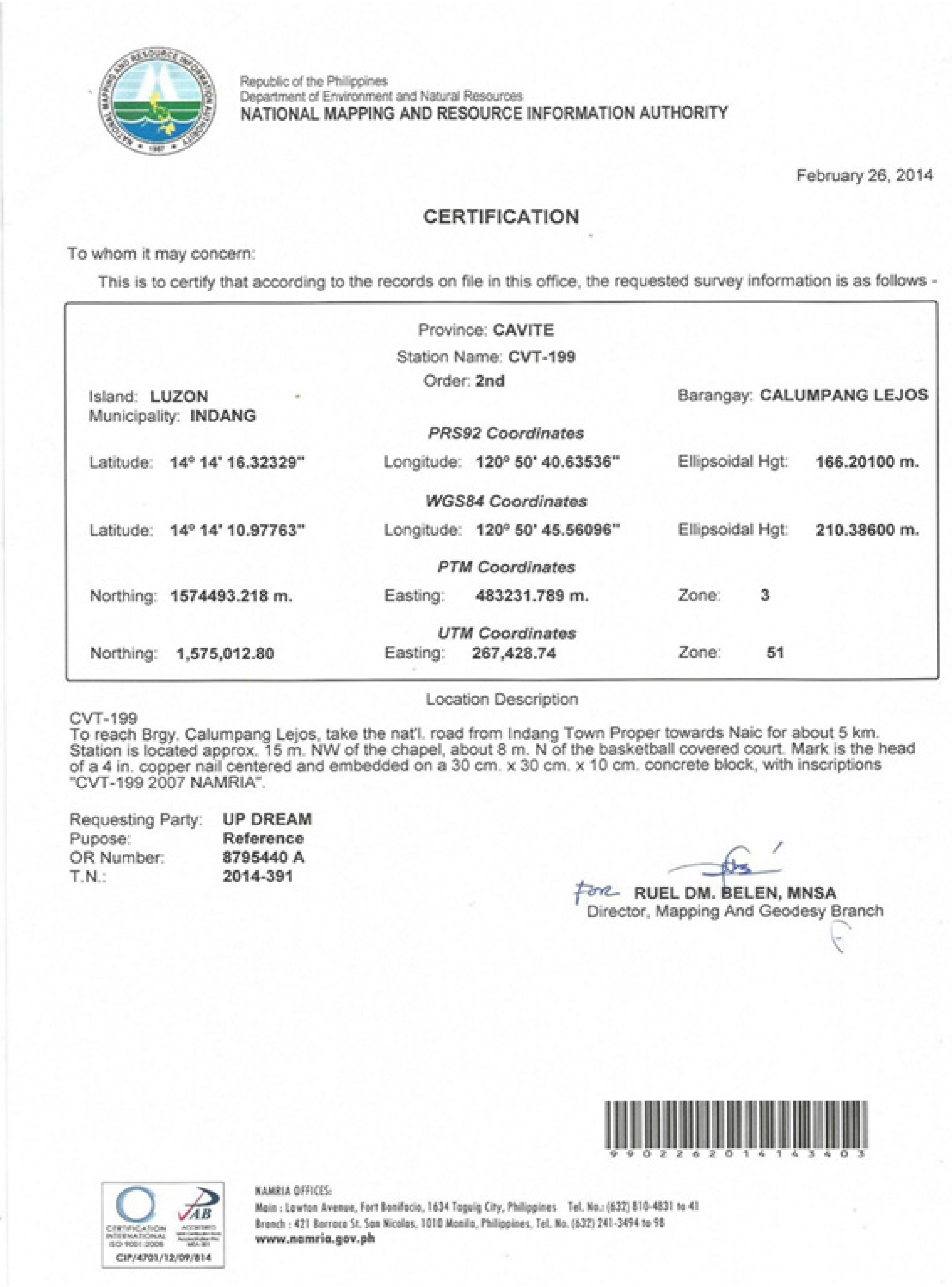
| Parameter | Specification |
|---|---|
| Parameter | Specification |
| Operational envelope (1,2,3,4) | 150-5000 m AGL, nominal |
| Laser wavelength | 1064 nm |
| Horizontal accuracy (2) | 1/5,500 x altitude, 1σ |
| Elevation accuracy (2) | < 5-20 cm, 1σ |
| Effective laser repetition rate | Programmable, 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 |

## 2. LEICA ALS80 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 Certificate of Reference Points Used in the LiDAR Survey



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

February 26, 2014

## CERTIFICATION

To whom it may concern:

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

Province: **CAVITE**
Station Name: **CVT-199**
Order: **2nd**

Island: **LUZON**
Municipality: **INDANG**
Barangay: **CALUMPANG LEJOS**

*PRS92 Coordinates*

| | | | | | |
|---|---|---|---|---|---|
| Latitude: | **14° 14' 16.32329"** | Longitude: | **120° 50' 40.63536"** | Ellipsoidal Hgt: | **166.20100 m.** |

*WGS84 Coordinates*

| | | | | | |
|---|---|---|---|---|---|
| Latitude: | **14° 14' 10.97763"** | Longitude: | **120° 50' 45.56096"** | Ellipsoidal Hgt: | **210.38600 m.** |

*PTM Coordinates*

| | | | | | |
|---|---|---|---|---|---|
| Northing: | **1574493.218 m.** | Easting: | **483231.789 m.** | Zone: | **3** |

*UTM Coordinates*

| | | | | | |
|---|---|---|---|---|---|
| Northing: | **1,575,012.80** | Easting: | **267,428.74** | Zone: | **51** |

Location Description

CVT-199
To reach Brgy. Calumpang Lejos, take the nat'l. road from Indang Town Proper towards Naic for about 5 km. Station is located approx. 15 m. NW of the chapel, about 8 m. N of the basketball covered court. Mark is the head of a 4 in. copper nail centered and embedded on a 30 cm. x 30 cm. x 10 cm. concrete block, with inscriptions "CVT-199 2007 NAMRIA".

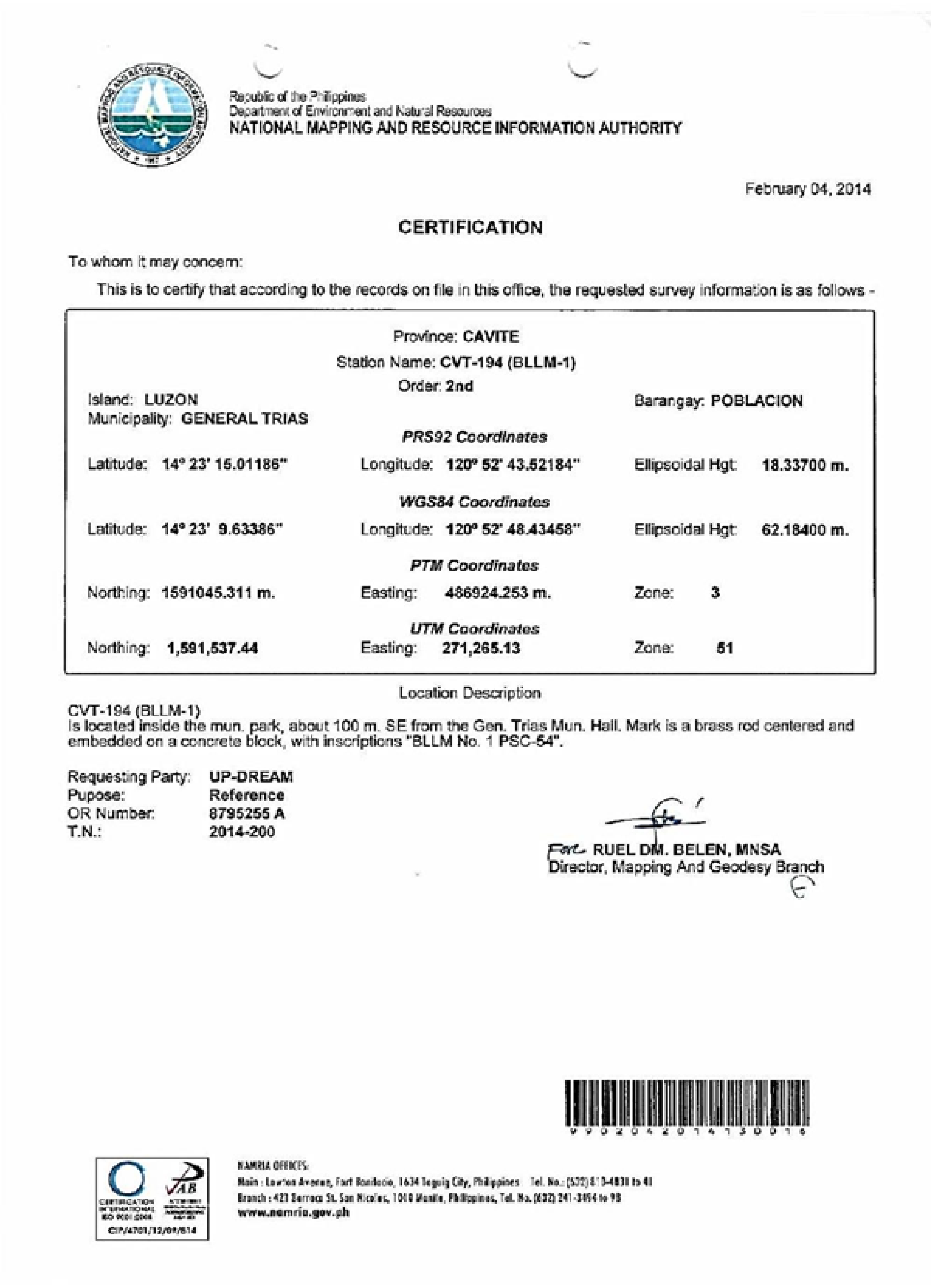
Requesting Party: **UP DREAM**
Pupose: **Reference**
OR Number: **8795440 A**
T.N.: **2014-391**

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

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

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

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



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

February 04, 2014

## CERTIFICATION

To whom it may concern:

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

Province: **CAVITE**
Station Name: **CVT-194 (BLLM-1)**
Order: **2nd**

| | | |
|---|---|---|
| Island: **LUZON** | | Barangay: **POBLACION** |
| Municipality: **GENERAL TRIAS** | | |
| | ***PRS92 Coordinates*** | |
| Latitude: **14° 23' 15.01186"** | Longitude: **120° 52' 43.52184"** | Ellipsoidal Hgt: **18.33700 m.** |
| | ***WGS84 Coordinates*** | |
| Latitude: **14° 23' 9.63386"** | Longitude: **120° 52' 48.43458"** | Ellipsoidal Hgt: **62.18400 m.** |
| | ***PTM Coordinates*** | |
| Northing: **1591045.311 m.** | Easting: **486924.253 m.** | Zone: **3** |
| | ***UTM Coordinates*** | |
| Northing: **1,591,537.44** | Easting: **271,265.13** | Zone: **51** |

Location Description

CVT-194 (BLLM-1)
Is located inside the mun. park, about 100 m. SE from the Gen. Trias Mun. Hall. Mark is a brass rod centered and embedded on a concrete block, with inscriptions "BLLM No. 1 PSC-54".

| | |
|---|---|
| Requesting Party: | **UP-DREAM** |
| Pupose: | **Reference** |
| OR Number: | **8795255 A** |
| T.N.: | **2014-200** |

For **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**

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** | | Barangay: **MALIBU** |
| Municipality: **TUY** | | |
| | *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: **252,125.62** | 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: | **8795470 A** |
| T.N.: | **2014-444** |

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

9903042014160114

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

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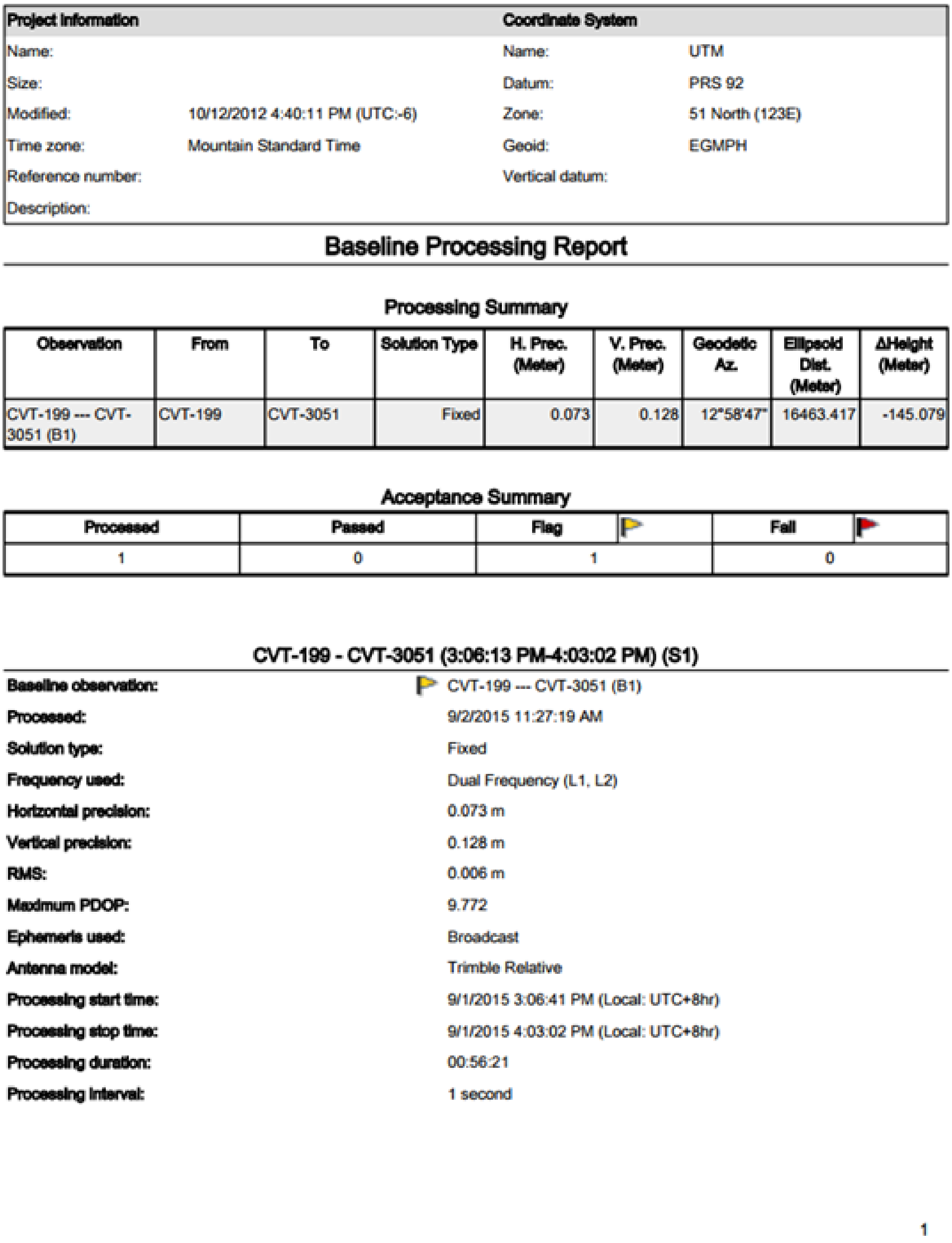
Main : Lawton Avenue, Fort Bonifacio, 1634 Taguig City, Philippines Tel. No.: (632) 810-4831 to 41
Branch : 421 Barraca St. San Nicolas, 1010 Manila, Philippines, Tel. No. (632) 241-3494 to 98
www.namria.gov.ph

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

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" | 16463.417 | -145.079 |

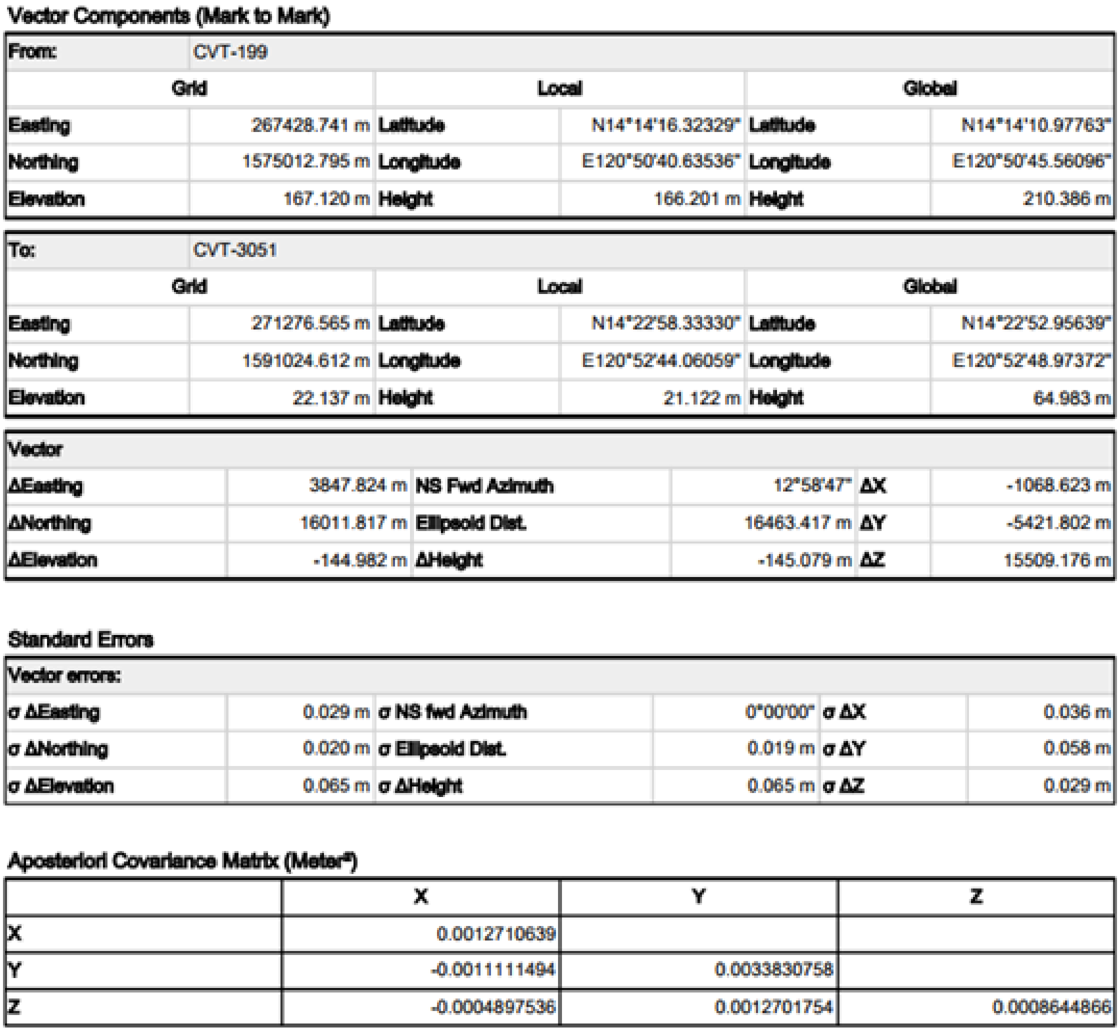
### Acceptance Summary

| 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



**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 |

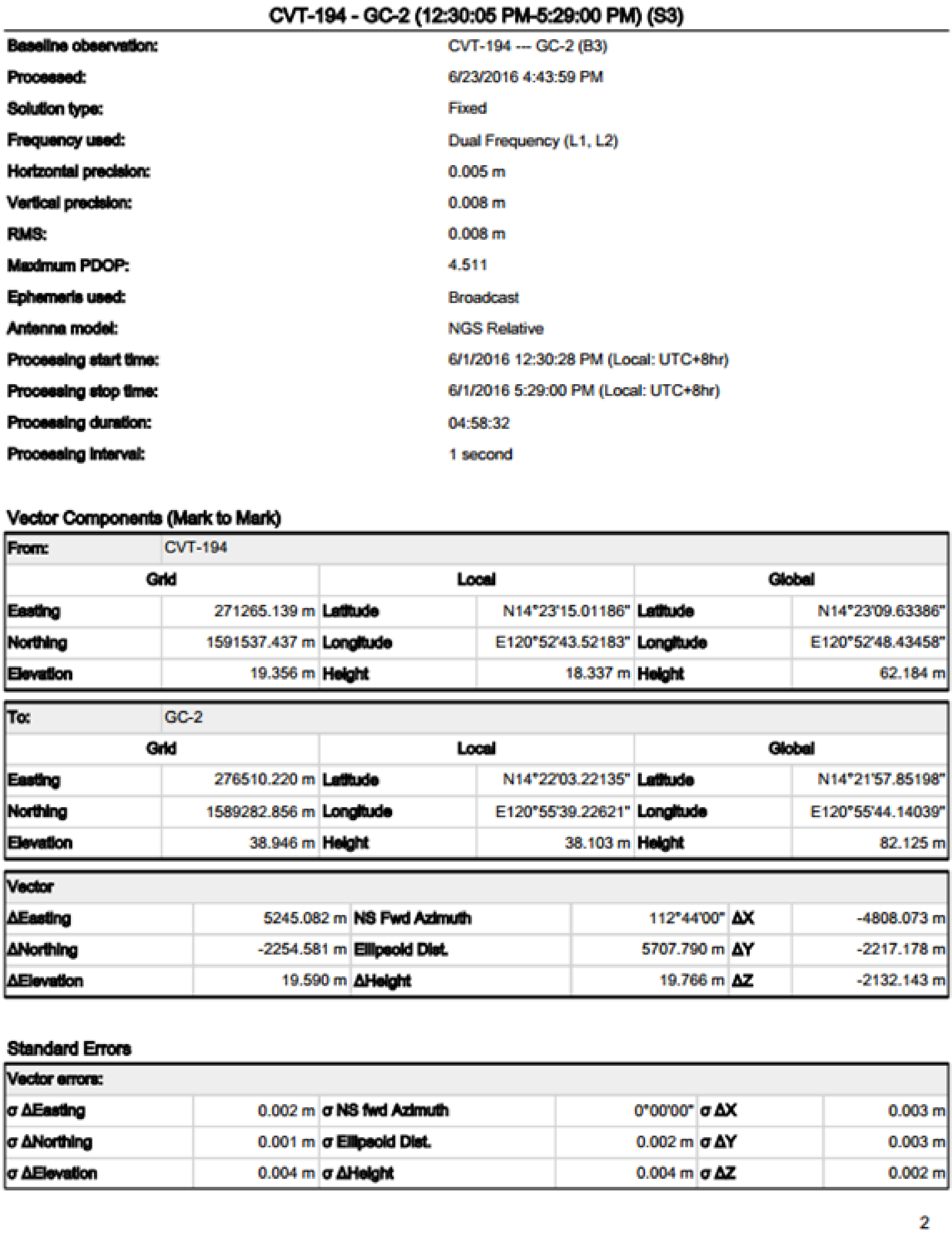
**Standard Errors**

| **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 |

2. GC-2



### CVT-194 - GC-2 (12:30:05 PM-5:29:00 PM) (S3)

| | |
|---|---|
| **Baseline observation:** | CVT-194 --- GC-2 (B3) |
| **Processed:** | 6/23/2016 4:43:59 PM |
| **Solution type:** | Fixed |
| **Frequency used:** | Dual Frequency (L1, L2) |
| **Horizontal precision:** | 0.005 m |
| **Vertical precision:** | 0.008 m |
| **RMS:** | 0.008 m |
| **Maximum PDOP:** | 4.511 |
| **Ephemeris used:** | Broadcast |
| **Antenna model:** | NGS Relative |
| **Processing start time:** | 6/1/2016 12:30:28 PM (Local: UTC+8hr) |
| **Processing stop time:** | 6/1/2016 5:29:00 PM (Local: UTC+8hr) |
| **Processing duration:** | 04:58:32 |
| **Processing interval:** | 1 second |

**Vector Components (Mark to Mark)**

| **From:** | CVT-194 | | | | |
|---|---|---|---|---|---|
| **Grid** | | **Local** | | **Global** | |
| **Easting** | 271265.139 m | **Latitude** | N14°23'15.01186" | **Latitude** | N14°23'09.63386" |
| **Northing** | 1591537.437 m | **Longitude** | E120°52'43.52183" | **Longitude** | E120°52'48.43458" |
| **Elevation** | 19.356 m | **Height** | 18.337 m | **Height** | 62.184 m |

| **To:** | GC-2 | | | | |
|---|---|---|---|---|---|
| **Grid** | | **Local** | | **Global** | |
| **Easting** | 276510.220 m | **Latitude** | N14°22'03.22135" | **Latitude** | N14°21'57.85198" |
| **Northing** | 1589282.856 m | **Longitude** | E120°55'39.22621" | **Longitude** | E120°55'44.14039" |
| **Elevation** | 38.946 m | **Height** | 38.103 m | **Height** | 82.125 m |

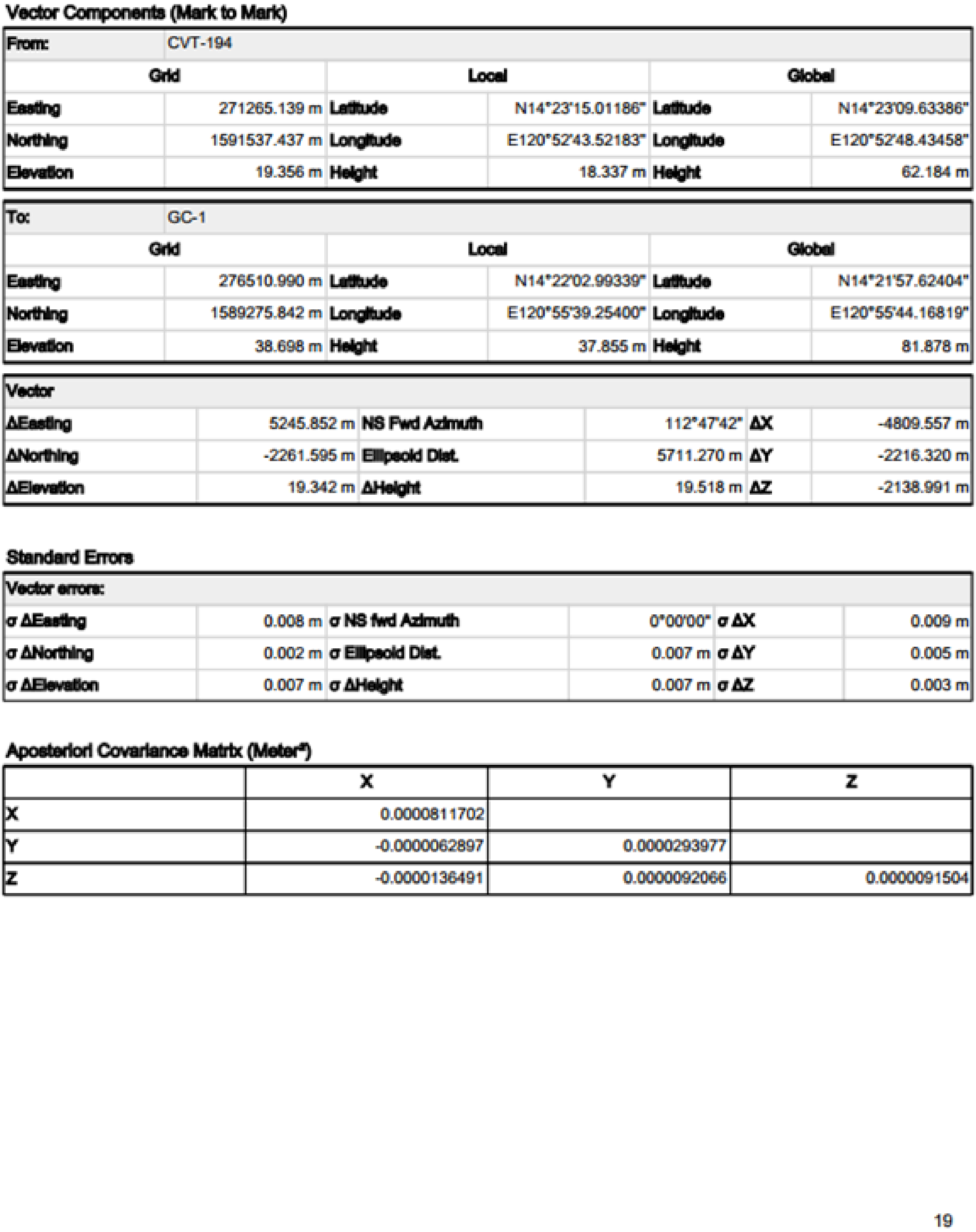
| **Vector** | | | | | |
|---|---|---|---|---|---|
| **ΔEasting** | 5245.082 m | **NS Fwd Azimuth** | 112°44'00" | **ΔX** | -4808.073 m |
| **ΔNorthing** | -2254.581 m | **Ellipsoid Dist.** | 5707.790 m | **ΔY** | -2217.178 m |
| **ΔElevation** | 19.590 m | **ΔHeight** | 19.766 m | **ΔZ** | -2132.143 m |

**Standard Errors**

| **Vector errors:** | | | | | |
|---|---|---|---|---|---|
| **σ ΔEasting** | 0.002 m | **σ NS fwd Azimuth** | 0°00'00" | **σ ΔX** | 0.003 m |
| **σ ΔNorthing** | 0.001 m | **σ Ellipsoid Dist.** | 0.002 m | **σ ΔY** | 0.003 m |
| **σ ΔElevation** | 0.004 m | **σ ΔHeight** | 0.004 m | **σ ΔZ** | 0.002 m |

2

3. GC-1



**Vector Components (Mark to Mark)**

| **From:** | CVT-194 | | | | |
|---|---|---|---|---|---|
| **Grid** | | **Local** | | **Global** | |
| **Easting** | 271265.139 m | **Latitude** | N14°23'15.01186" | **Latitude** | N14°23'09.63386" |
| **Northing** | 1591537.437 m | **Longitude** | E120°52'43.52183" | **Longitude** | E120°52'48.43458" |
| **Elevation** | 19.356 m | **Height** | 18.337 m | **Height** | 62.184 m |

| **To:** | GC-1 | | | | |
|---|---|---|---|---|---|
| **Grid** | | **Local** | | **Global** | |
| **Easting** | 276510.990 m | **Latitude** | N14°22'02.99339" | **Latitude** | N14°21'57.62404" |
| **Northing** | 1589275.842 m | **Longitude** | E120°55'39.25400" | **Longitude** | E120°55'44.16819" |
| **Elevation** | 38.698 m | **Height** | 37.855 m | **Height** | 81.878 m |

| **Vector** | | | | | |
|---|---|---|---|---|---|
| **ΔEasting** | 5245.852 m | **NS Fwd Azimuth** | 112°47'42" | **ΔX** | -4809.557 m |
| **ΔNorthing** | -2261.595 m | **Ellipsoid Dist.** | 5711.270 m | **ΔY** | -2216.320 m |
| **ΔElevation** | 19.342 m | **ΔHeight** | 19.518 m | **ΔZ** | -2138.991 m |

**Standard Errors**

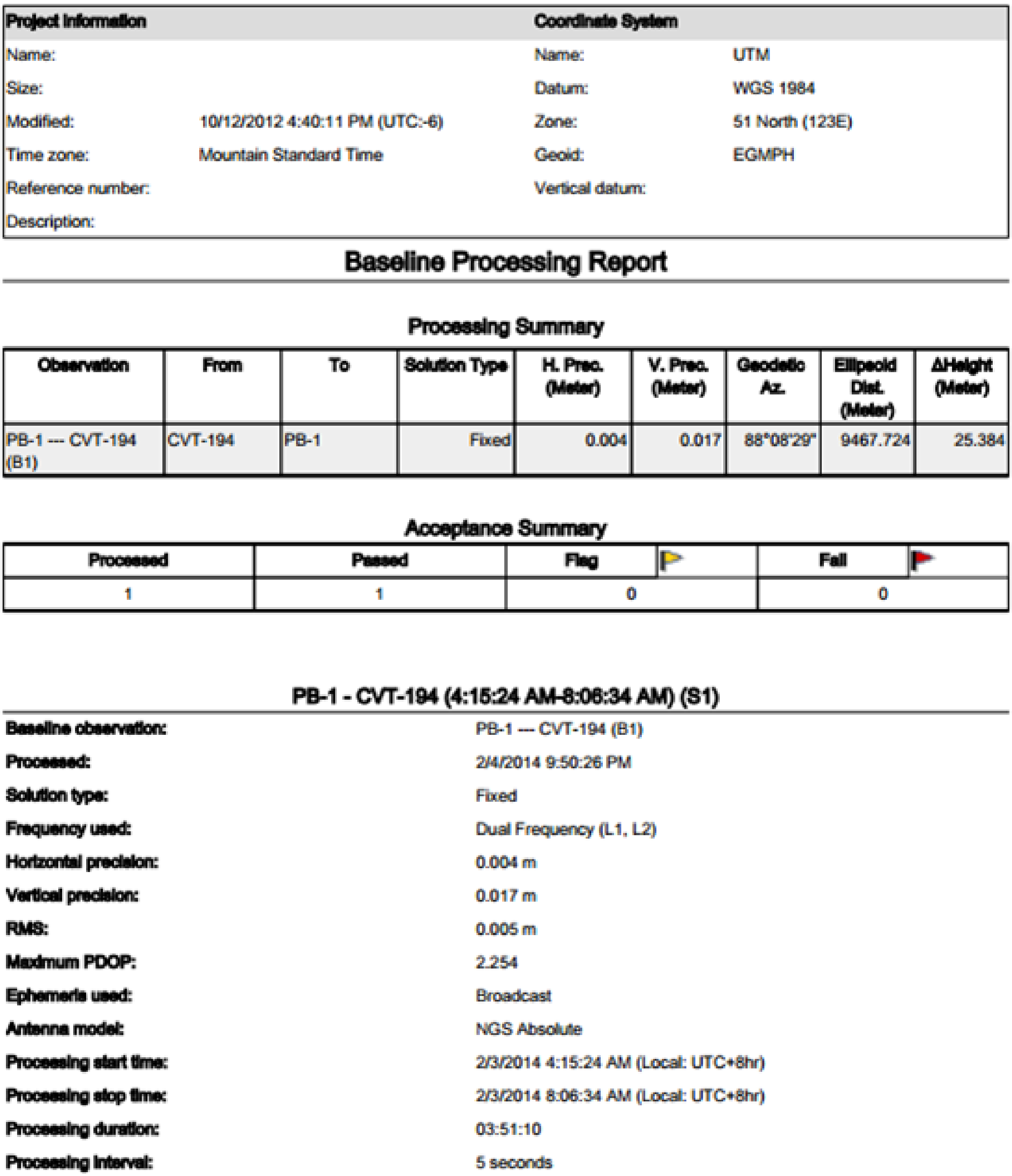
| **Vector errors:** | | | | | |
|---|---|---|---|---|---|
| **σ ΔEasting** | 0.008 m | **σ NS fwd Azimuth** | 0°00'00" | **σ ΔX** | 0.009 m |
| **σ ΔNorthing** | 0.002 m | **σ Ellipsoid Dist.** | 0.007 m | **σ ΔY** | 0.005 m |
| **σ ΔElevation** | 0.007 m | **σ ΔHeight** | 0.007 m | **σ ΔZ** | 0.003 m |

**Aposteriori Covariance Matrix (Meter²)**

| | **X** | **Y** | **Z** |
|---|---|---|---|
| **X** | 0.0000811702 | | |
| **Y** | -0.0000062897 | 0.0000293977 | |
| **Z** | -0.0000136491 | 0.0000092066 | 0.0000091504 |

19

4. 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

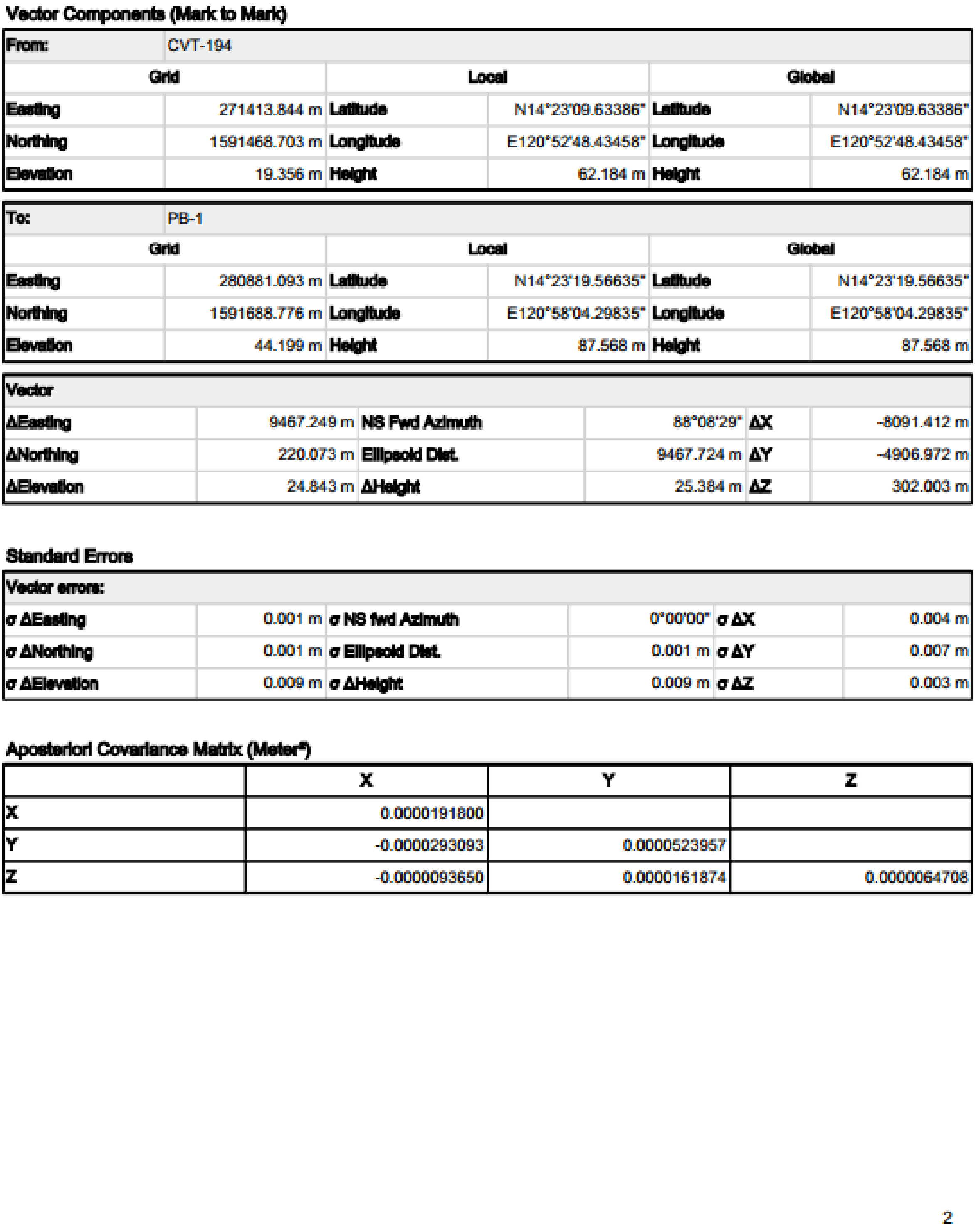
| Observation | From | To | Solution Type | H. Prec. (Meter) | V. Prec. (Meter) | Geodetic Az. | Ellipsoid Dist. (Meter) | ΔHeight (Meter) |
|---|---|---|---|---|---|---|---|---|
| PB-1 --- CVT-194 (B1) | CVT-194 | PB-1 | Fixed | 0.004 | 0.017 | 88°08'29" | 9467.724 | 25.384 |

### 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 |



**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°23'19.56635" | **Latitude** | N14°23'19.56635" |
| **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**

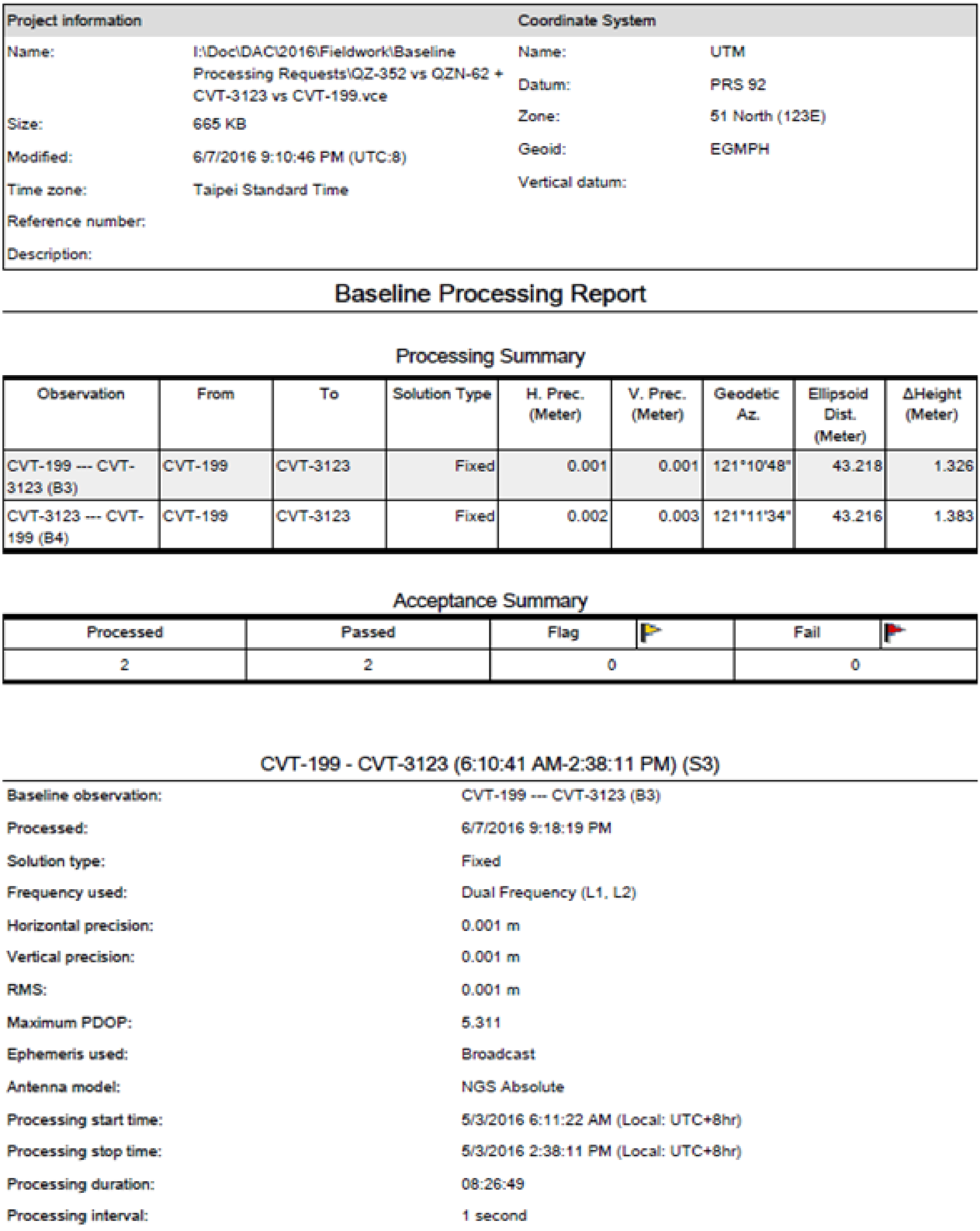
| Vector errors: | | | | | |
|---|---|---|---|---|---|
| **σ ΔEasting** | 0.001 m | **σ NS fwd Azimuth** | 0°00'00" | **σ ΔX** | 0.004 m |
| **σ ΔNorthing** | 0.001 m | **σ Ellipsoid Dist.** | 0.001 m | **σ ΔY** | 0.007 m |
| **σ ΔElevation** | 0.009 m | **σ ΔHeight** | 0.009 m | **σ ΔZ** | 0.003 m |

**Aposteriori Covariance Matrix (Meter²)**

| | X | Y | Z |
|---|---|---|---|
| **X** | 0.0000191800 | | |
| **Y** | -0.0000293093 | 0.0000523957 | |
| **Z** | -0.0000093650 | 0.0000161874 | 0.0000064708 |

2

5. 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

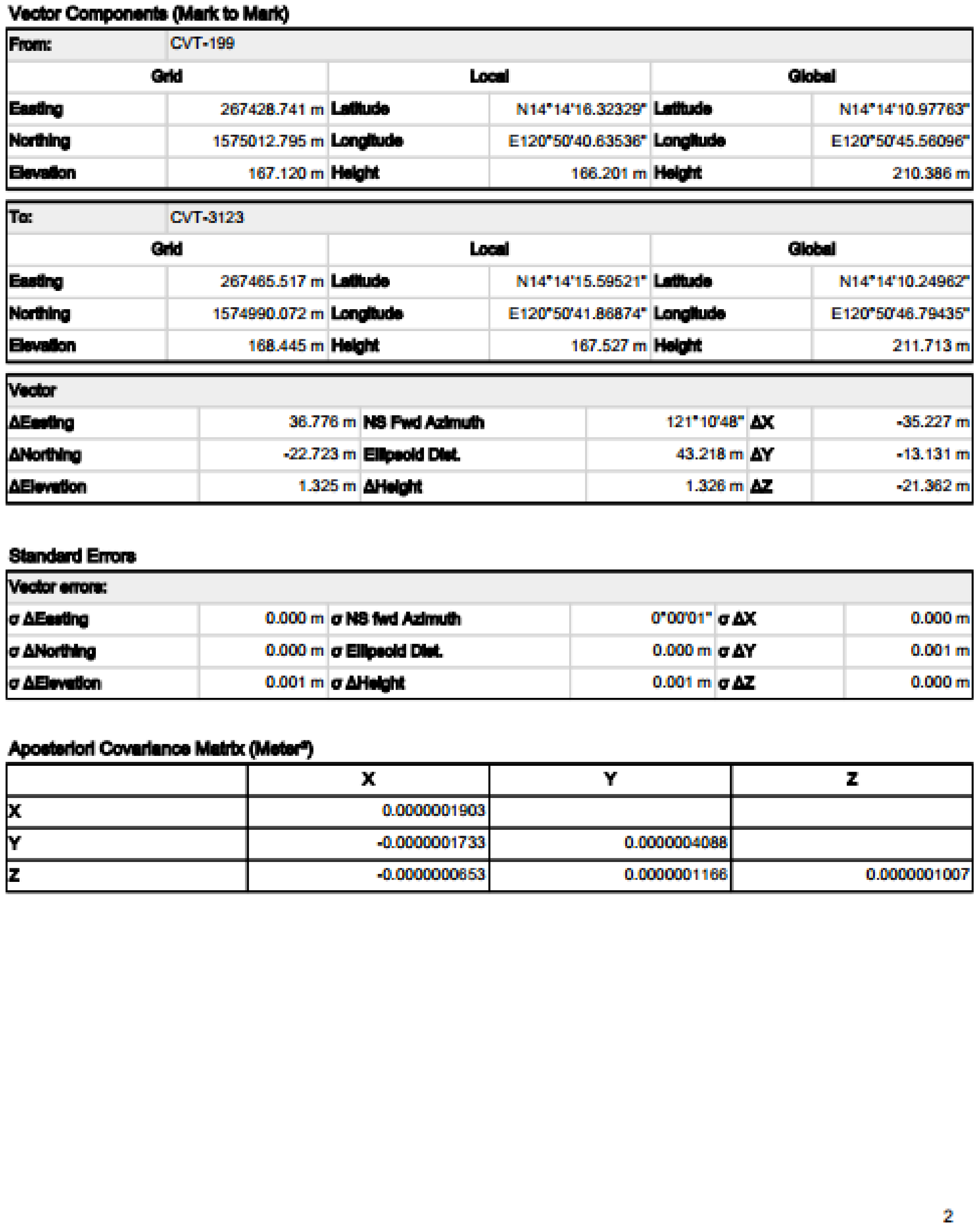
| Observation | From | To | Solution Type | H. Prec. (Meter) | V. Prec. (Meter) | Geodetic Az. | Ellipsoid Dist. (Meter) | ΔHeight (Meter) |
|---|---|---|---|---|---|---|---|---|
| CVT-199 --- CVT-3123 (B3) | CVT-199 | CVT-3123 | Fixed | 0.001 | 0.001 | 121°10'48" | 43.218 | 1.326 |
| CVT-3123 --- CVT-199 (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:** | 5.311 |
| **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 |



**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 |

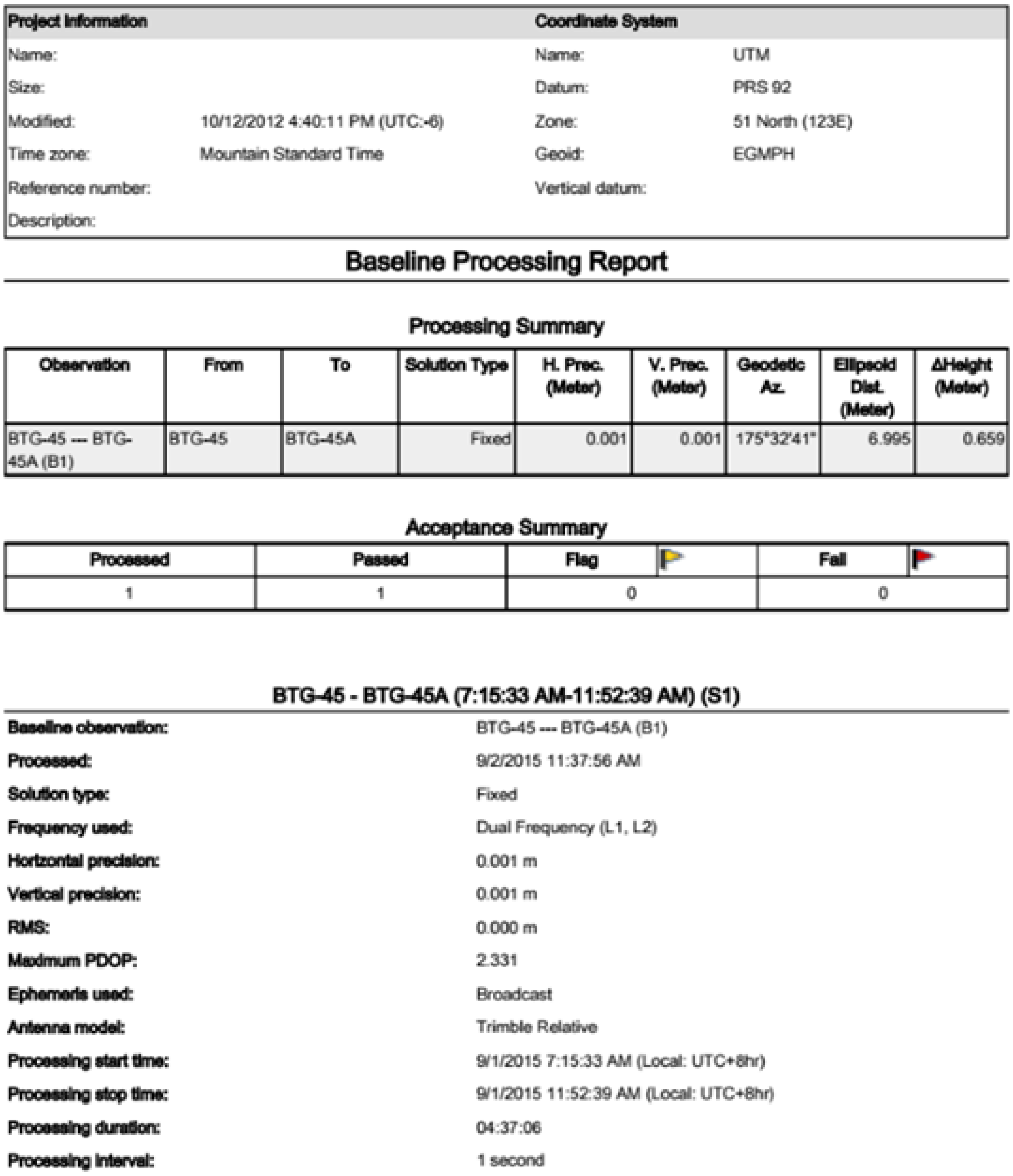
**Standard Errors**

| **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 |

6. 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

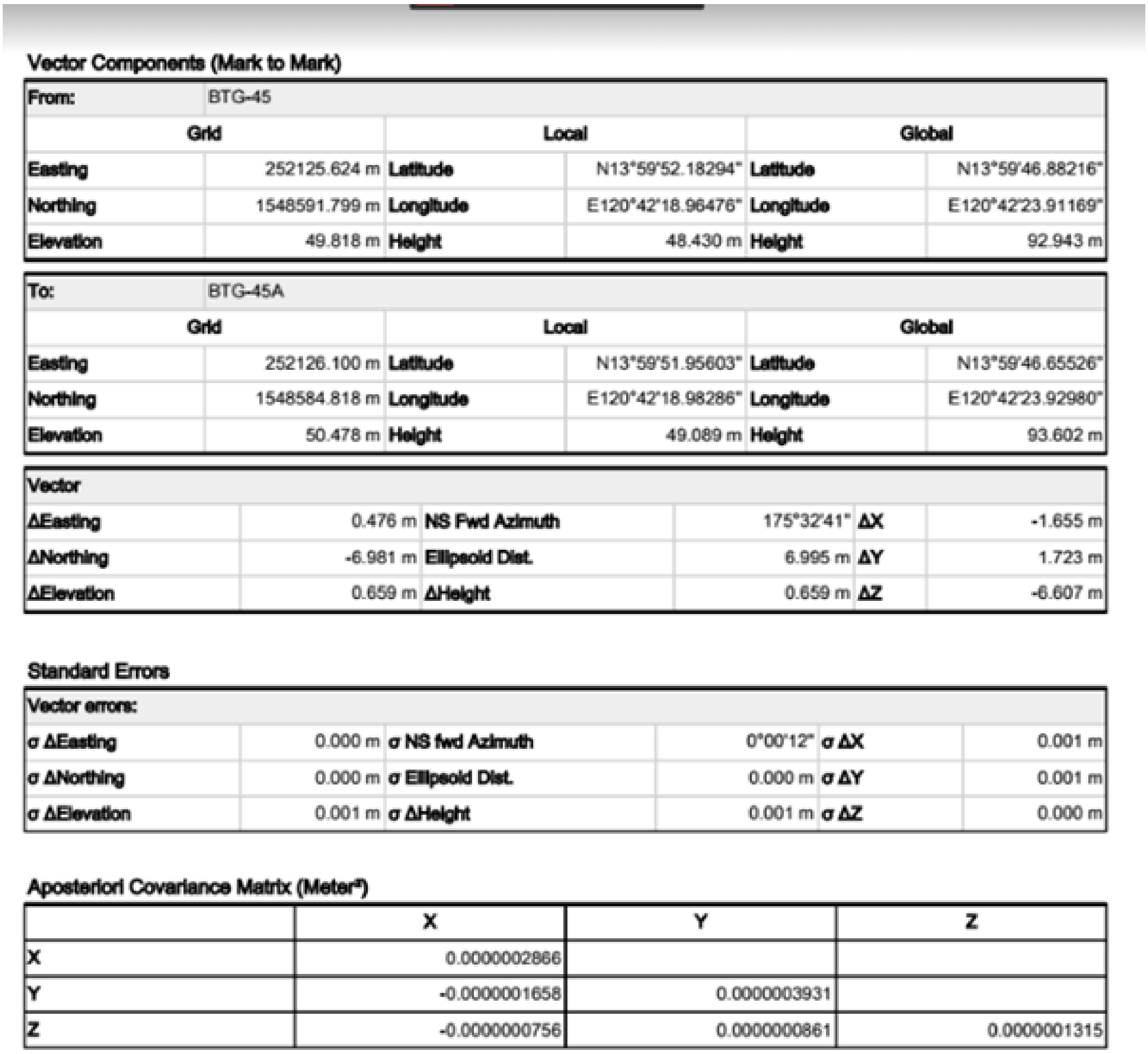
| Observation | From | To | Solution Type | H. Prec. (Meter) | V. Prec. (Meter) | Geodetic Az. | Ellipsoid Dist. (Meter) | ΔHeight (Meter) |
|---|---|---|---|---|---|---|---|---|
| BTG-45 --- BTG-45A (B1) | BTG-45 | BTG-45A | Fixed | 0.001 | 0.001 | 175°32'41" | 6.995 | 0.659 |

### 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 |



**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 (Meter$^2$)**

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

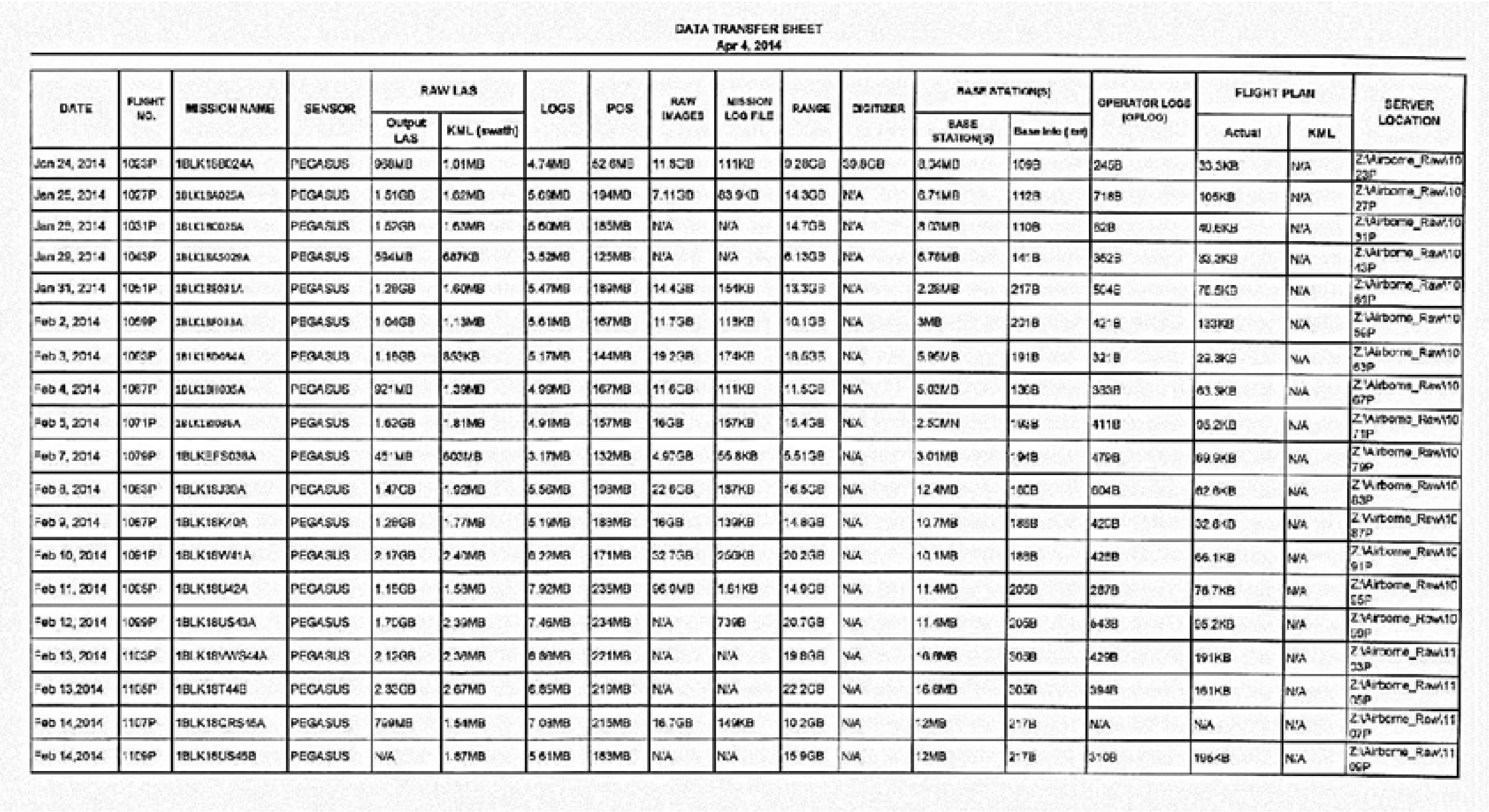
## Annex 4. The LIDAR Survey Team Composition

| **Data Acquisition Component Sub-Team** | **Designation** | **Name** | **Agency/ Affiliation** |
|---|---|---|---|
| PHIL-LIDAR 1 | Program Leader | ENRICO C. PARINGIT, D.ENG | UP-TCAGP |
| Data Acquisition Component Leader | Data Component Project Leader - I | ENGR. CZAR JAKIRI 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) | LOVELYN ASUNCION | UP-TCAGP |
| | | ENGR. LOVELYN ASUNCION | UP-TCAGP |
| | | ENGR. GEROME HIPOLITO | UP-TCAGP |

FIELD TEAM

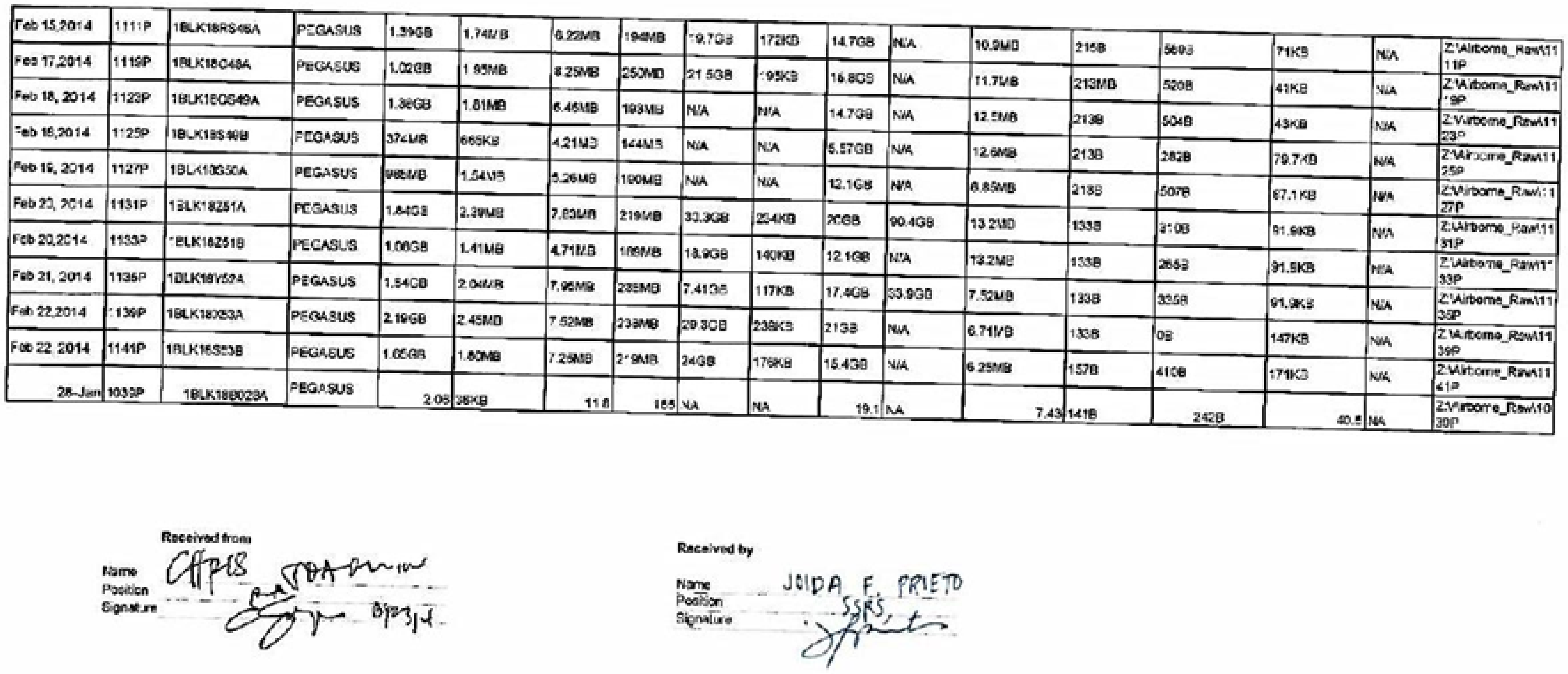
| | | | |
|---|---|---|---|
| LiDAR Operation | Senior Science Research Specialist (SSRS) | JASMINE ALVIAR | UP TCAGP |
| | | AUBREY MATIRA | UP TCAGP |
| | Research Associate (RA) | ENGR. LARAH PARAGAS | UP TCAGP |
| | | PAULINE JOANNE ARCEO | UP TCAGP |
| | | MARY CATHERINE ELIZABETH BALIGUAS | UP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

# Annex 5. Data Transfer Sheet for Ilang-Ilang Floodplain



DATA TRANSFER SHEET
Apr 4, 2014

| DATE | FLIGHT NO. | MISSION NAME | SENSOR | RAW LAS | | LOGS | POS | RAW IMAGES | MISSION LOG FILE | RANGE | DIGITIZER | BASE STATION(S) | | OPERATOR LOGS (OPLOG) | FLIGHT PLAN | | SERVER LOCATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Output LAS | KML (swath) | | | | | | | BASE STATION(S) | Base Info (.txt) | | Actual | KML | |
| Jan 24, 2014 | 1023P | 1BLK18D024A | PEGASUS | 958MB | 1.01MB | 4.74MB | 52.6MB | 11.5GB | 111KB | 9.28GB | 39.8GB | 8.34MB | 109B | 245B | 33.3KB | N/A | Z:\Airborne_Raw\1023P |
| Jan 25, 2014 | 1027P | 1BLK18A025A | PEGASUS | 1.51GB | 1.62MB | 5.69MB | 194MB | 7.11GB | 63.9KB | 14.3GB | N/A | 6.71MB | 112B | 716B | 105KB | N/A | Z:\Airborne_Raw\1027P |
| Jan 28, 2014 | 1031P | 1BLK18C028A | PEGASUS | 1.57GB | 1.63MB | 5.60MB | 185MB | N/A | N/A | 14.7GB | N/A | 8.02MB | 110B | 62B | 40.6KB | N/A | Z:\Airborne_Raw\1031P |
| Jan 29, 2014 | 1043P | 1BLK18AS029A | PEGASUS | 594MB | 687KB | 3.52MB | 125MB | N/A | N/A | 6.13GB | N/A | 6.76MB | 141B | 362B | 33.2KB | N/A | Z:\Airborne_Raw\1043P |
| Jan 31, 2014 | 1051P | 1BLK18S031A | PEGASUS | 1.29GB | 1.60MB | 5.47MB | 189MB | 14.4GB | 164KB | 13.3GB | N/A | 2.26MB | 217B | 504B | 76.5KB | N/A | Z:\Airborne_Raw\1051P |
| Feb 2, 2014 | 1059P | 1BLK18F033A | PEGASUS | 1.04GB | 1.13MB | 5.61MB | 167MB | 11.7GB | 115KB | 10.1GB | N/A | 3MB | 221B | 421B | 133KB | N/A | Z:\Airborne_Raw\1059P |
| Feb 3, 2014 | 1063P | 1BLK18D034A | PEGASUS | 1.15GB | 852KB | 5.17MB | 144MB | 19.2GB | 174KB | 18.6GB | N/A | 5.96MB | 191B | 321B | 29.3KB | N/A | Z:\Airborne_Raw\1063P |
| Feb 4, 2014 | 1067P | 1BLK18H035A | PEGASUS | 921MB | 1.39MB | 4.99MB | 167MB | 11.6GB | 111KB | 11.5GB | N/A | 5.02MB | 130B | 333B | 63.9KB | N/A | Z:\Airborne_Raw\1067P |
| Feb 5, 2014 | 1071P | 1BLK18I036A | PEGASUS | 1.62GB | 1.81MB | 4.91MB | 157MB | 16GB | 157KB | 15.4GB | N/A | 2.50MN | 194B | 411B | 95.2KB | N/A | Z:\Airborne_Raw\1071P |
| Feb 7, 2014 | 1079P | 1BLKEFS038A | PEGASUS | 451MB | 600MB | 3.17MB | 132MB | 4.97GB | 56.8KB | 5.51GB | N/A | 3.01MB | 194B | 479B | 69.9KB | N/A | Z:\Airborne_Raw\1079P |
| Feb 8, 2014 | 1083P | 1BLK18J39A | PEGASUS | 1.47GB | 1.92MB | 5.56MB | 193MB | 22.6GB | 187KB | 16.5GB | N/A | 12.4MB | 180B | 604B | 62.6KB | N/A | Z:\Airborne_Raw\1083P |
| Feb 9, 2014 | 1087P | 1BLK18K40A | PEGASUS | 1.29GB | 1.77MB | 5.19MB | 183MB | 16GB | 139KB | 14.8GB | N/A | 10.7MB | 188B | 420B | 32.6KB | N/A | Z:\Airborne_Raw\1087P |
| Feb 10, 2014 | 1091P | 1BLK18W41A | PEGASUS | 2.17GB | 2.40MB | 6.22MB | 171MB | 32.7GB | 250KB | 20.2GB | N/A | 10.1MB | 188B | 425B | 66.1KB | N/A | Z:\Airborne_Raw\1091P |
| Feb 11, 2014 | 1095P | 1BLK18U42A | PEGASUS | 1.15GB | 1.53MB | 7.92MB | 235MB | 96.0MB | 1.61KB | 14.9GB | N/A | 11.4MB | 205B | 287B | 76.7KB | N/A | Z:\Airborne_Raw\1095P |
| Feb 12, 2014 | 1099P | 1BLK18US43A | PEGASUS | 1.70GB | 2.39MB | 7.46MB | 234MB | N/A | 739B | 20.7GB | N/A | 11.4MB | 205B | 643B | 95.2KB | N/A | Z:\Airborne_Raw\1099P |
| Feb 13, 2014 | 1103P | 1BLK18VWS44A | PEGASUS | 2.12GB | 2.38MB | 6.89MB | 221MB | N/A | N/A | 19.8GB | N/A | 16.6MB | 303B | 429B | 191KB | N/A | Z:\Airborne_Raw\1103P |
| Feb 13,2014 | 1105P | 1BLK18T44B | PEGASUS | 2.32GB | 2.67MB | 6.85MB | 210MB | N/A | N/A | 22.2GB | N/A | 16.6MB | 303B | 394B | 161KB | N/A | Z:\Airborne_Raw\1105P |
| Feb 14,2014 | 1107P | 1BLK18CRS45A | PEGASUS | 799MB | 1.54MB | 7.03MB | 215MB | 16.7GB | 149KB | 10.2GB | N/A | 12MB | 217B | N/A | N/A | N/A | Z:\Airborne_Raw\1107P |
| Feb 14,2014 | 1109P | 1BLK18US45B | PEGASUS | N/A | 1.87MB | 5.61MB | 183MB | N/A | N/A | 15.9GB | N/A | 12MB | 217B | 310B | 196KB | N/A | Z:\Airborne_Raw\1109P |



| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Feb 15,2014 | 1111P | 1BLK18RS46A | PEGASUS | 1.39GB | 1.74MB | 6.22MB | 194MB | 19.7GB | 172KB | 14.7GB | N/A | 10.9MB | 215B | 569B | 71KB | N/A | Z:\Airborne_Raw\1111P |
| Feb 17,2014 | 1119P | 1BLK18C48A | PEGASUS | 1.02GB | 1.95MB | 8.25MB | 250MB | 21.5GB | 195KB | 16.8GB | N/A | 11.7MB | 213MB | 520B | 41KB | N/A | Z:\Airborne_Raw\1119P |
| Feb 18, 2014 | 1123P | 1BLK18OS49A | PEGASUS | 1.38GB | 1.81MB | 6.46MB | 193MB | N/A | N/A | 14.7GB | N/A | 12.5MB | 213B | 504B | 43KB | N/A | Z:\Airborne_Raw\1123P |
| Feb 18,2014 | 1125P | 1BLK18S49B | PEGASUS | 374MB | 665KB | 4.21MB | 144MB | N/A | N/A | 5.57GB | N/A | 12.6MB | 213B | 282B | 79.7KB | N/A | Z:\Airborne_Raw\1125P |
| Feb 19, 2014 | 1127P | 1BLK18G50A | PEGASUS | 988MB | 1.54MB | 5.26MB | 190MB | N/A | N/A | 12.1GB | N/A | 8.85MB | 213B | 507B | 67.1KB | N/A | Z:\Airborne_Raw\1127P |
| Feb 20, 2014 | 1131P | 1BLK18Z51A | PEGASUS | 1.84GB | 2.39MB | 7.83MB | 219MB | 30.3GB | 224KB | 20GB | 90.4GB | 13.2MB | 133B | 310B | 91.9KB | N/A | Z:\Airborne_Raw\1131P |
| Feb 20,2014 | 1133P | 1BLK18Z51B | PEGASUS | 1.06GB | 1.41MB | 4.71MB | 186MB | 18.9GB | 140KB | 12.1GB | N/A | 13.2MB | 133B | 265B | 91.5KB | N/A | Z:\Airborne_Raw\1133P |
| Feb 21, 2014 | 1135P | 1BLK18Y52A | PEGASUS | 1.54GB | 2.04MB | 7.96MB | 235MB | 7.41GB | 117KB | 17.4GB | 33.9GB | 7.52MB | 133B | 335B | 91.9KB | N/A | Z:\Airborne_Raw\1135P |
| Feb 22,2014 | 1139P | 1BLK18X53A | PEGASUS | 2.19GB | 2.45MB | 7.52MB | 236MB | 29.3GB | 238KB | 21GB | N/A | 6.71MB | 133B | 0B | 147KB | N/A | Z:\Airborne_Raw\1139P |
| Feb 22, 2014 | 1141P | 1BLK18S53B | PEGASUS | 1.65GB | 1.60MB | 7.29MB | 219MB | 24GB | 176KB | 15.4GB | N/A | 6.25MB | 157B | 410B | 171KB | N/A | Z:\Airborne_Raw\1141P |
| 28-Jan | 1033P | 1BLK18B028A | PEGASUS | 2.05 | 36KB | 11.8 | 165 | NA | NA | 19.1 | NA | 7.43 | 141B | 242B | 40.5 | NA | Z:\Airborne_Raw\1030P |

Received from

Name CHRIS [illegible]

Position

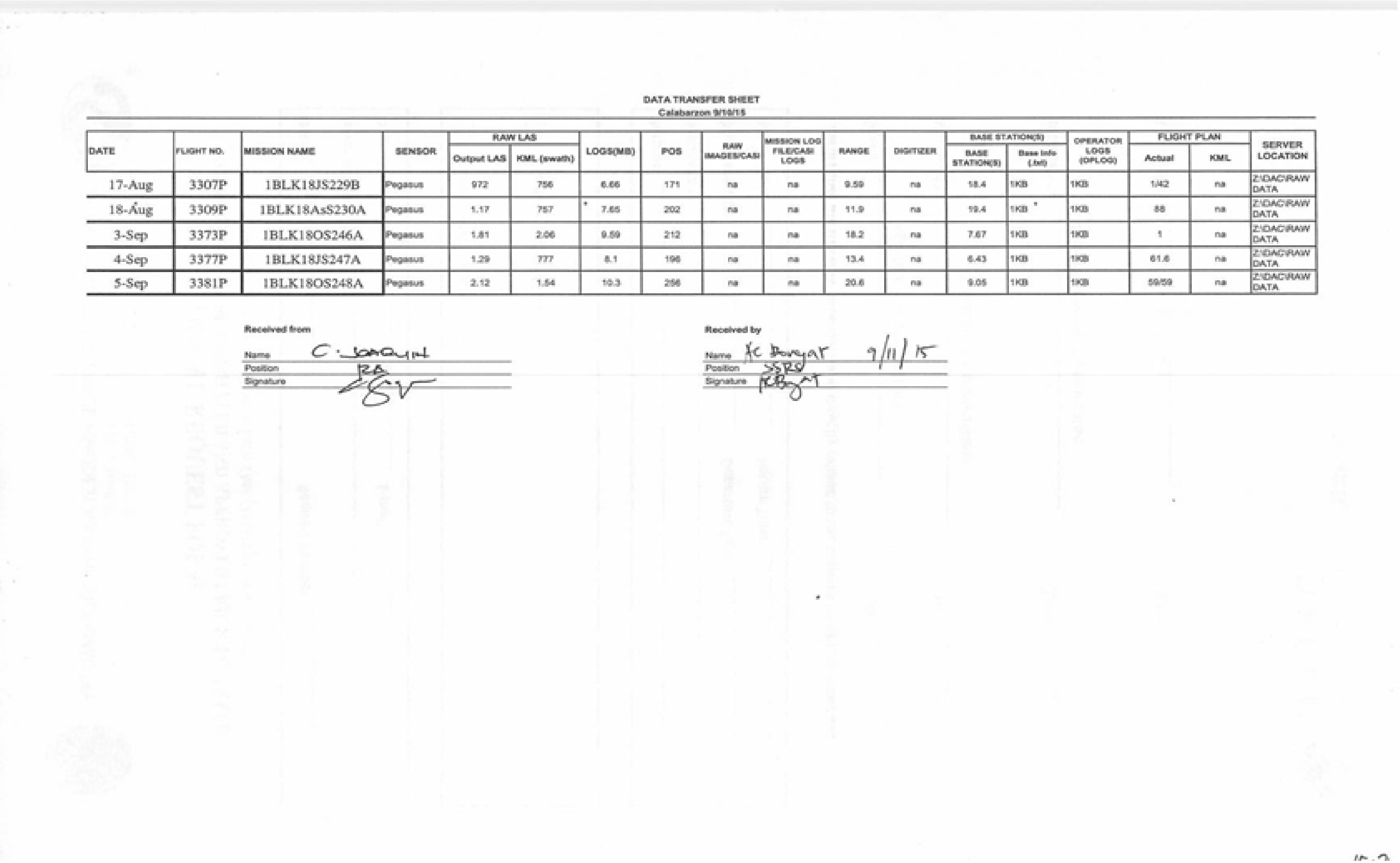
Signature 8/23/14

Received by

Name JUIDA F. PRIETO

Position SSRS

Signature



DATA TRANSFER SHEET
Calabarzon 9/10/15

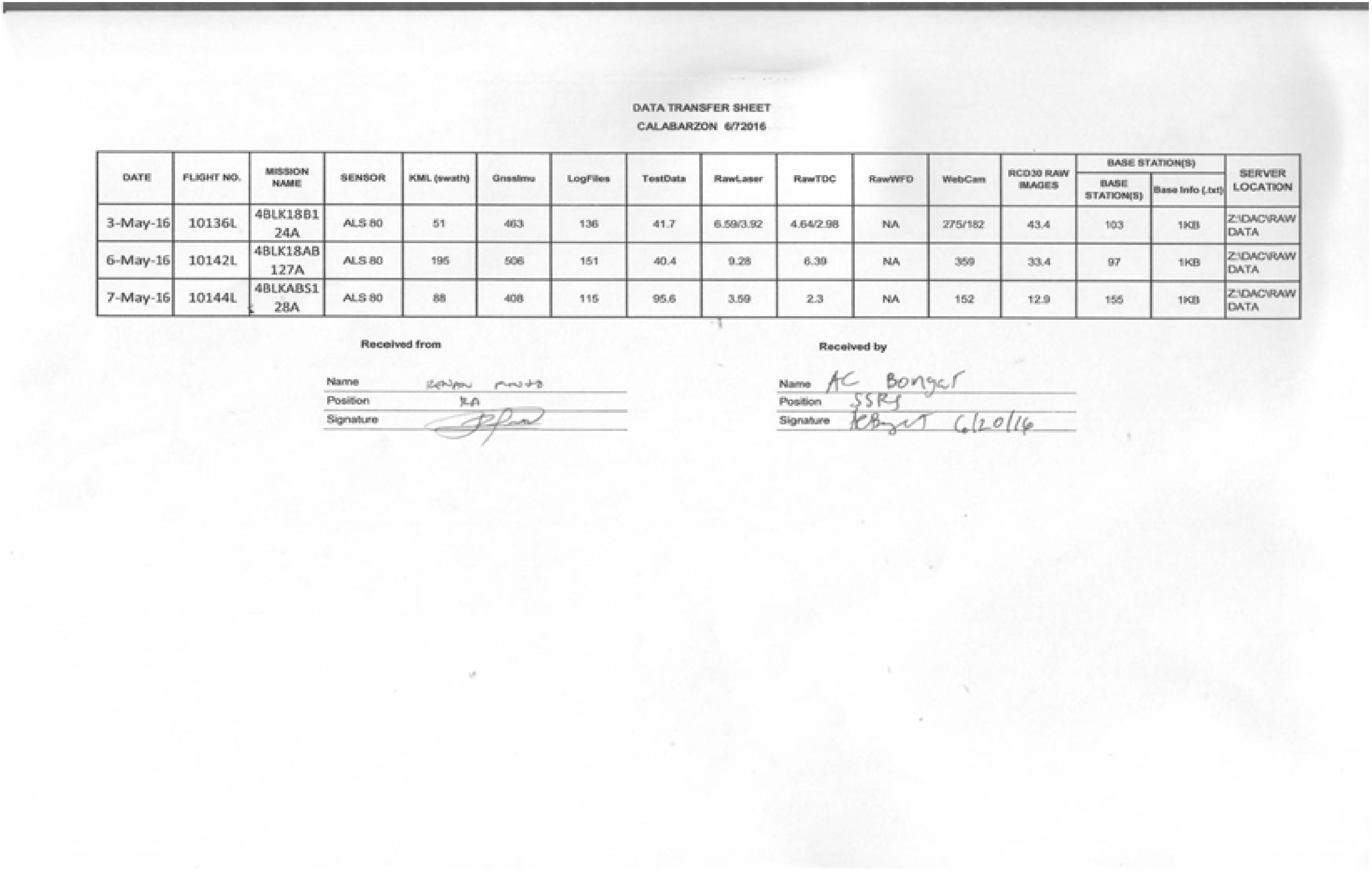
| DATE | FLIGHT NO. | MISSION NAME | SENSOR | RAW LAS | | LOGS(MB) | POS | RAW IMAGES/CASI | MISSION LOG FILE/CASI LOGS | RANGE | DIGITIZER | BASE STATION(S) | | OPERATOR LOGS (OPLOG) | FLIGHT PLAN | | SERVER LOCATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Output LAS | KML (swath) | | | | | | | BASE STATION(S) | Base Info (.txt) | | Actual | KML | |
| 17-Aug | 3307P | 1BLK18JS229B | Pegasus | 972 | 756 | 6.66 | 171 | na | na | 9.59 | na | 18.4 | 1KB | 1KB | 1/42 | na | Z:\DAC\RAW DATA |
| 18-Aug | 3309P | 1BLK18AsS230A | Pegasus | 1.17 | 757 | 7.65 | 202 | na | na | 11.9 | na | 19.4 | 1KB | 1KB | 88 | na | Z:\DAC\RAW DATA |
| 3-Sep | 3373P | 1BLK18OS246A | Pegasus | 1.81 | 2.06 | 9.59 | 212 | na | na | 18.2 | na | 7.67 | 1KB | 1KB | 1 | na | Z:\DAC\RAW DATA |
| 4-Sep | 3377P | 1BLK18JS247A | Pegasus | 1.29 | 777 | 8.1 | 196 | na | na | 13.4 | na | 6.43 | 1KB | 1KB | 61.6 | na | Z:\DAC\RAW DATA |
| 5-Sep | 3381P | 1BLK18OS248A | Pegasus | 2.12 | 1.54 | 10.3 | 256 | na | na | 20.6 | na | 9.05 | 1KB | 1KB | 59/59 | na | Z:\DAC\RAW DATA |

Received from

Name C. Joaquin
Position RA
Signature

Received by

Name KC Bongat 9/11/15
Position SSRS
Signature



DATA TRANSFER SHEET
CALABARZON 6/72016

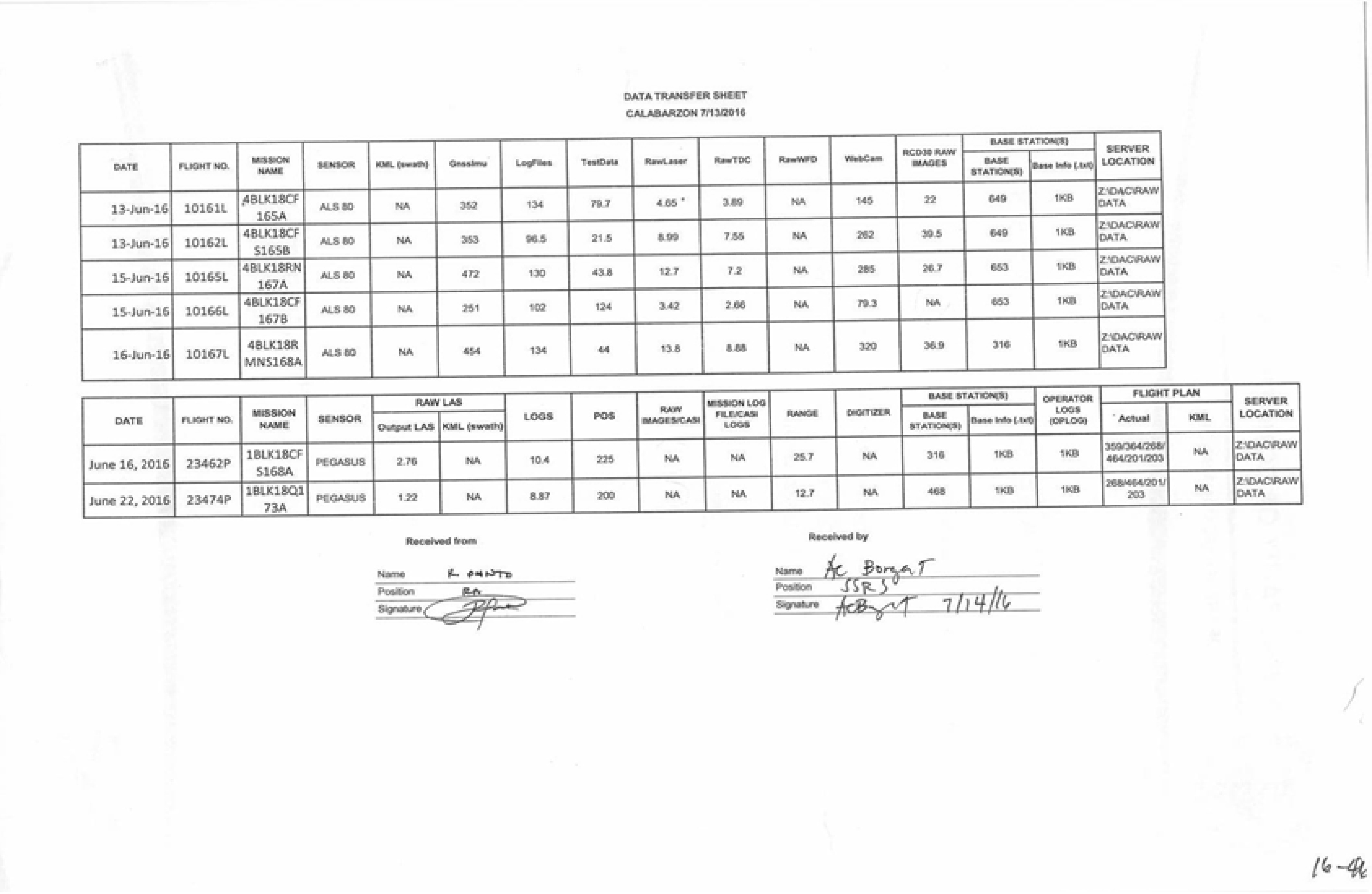
| DATE | FLIGHT NO. | MISSION NAME | SENSOR | KML (swath) | GnssImu | LogFiles | TestData | RawLaser | RawTDC | RawWFD | WebCam | RCD30 RAW IMAGES | BASE STATION(S) | | SERVER LOCATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | BASE STATION(S) | Base Info (.txt) | |
| 3-May-16 | 10136L | 4BLK18B124A | ALS 80 | 51 | 463 | 136 | 41.7 | 6.59/3.92 | 4.64/2.98 | 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 | 4BLKABS128A | ALS 80 | 88 | 408 | 115 | 95.6 | 3.59 | 2.3 | NA | 152 | 12.9 | 155 | 1KB | Z:\DAC\RAW DATA |

**Received from**

Name [illegible]
Position RA
Signature

**Received by**

Name AC Bongat
Position SSRS
Signature 6/20/16



DATA TRANSFER SHEET
CALABARZON 7/13/2016

| DATE | FLIGHT NO. | MISSION NAME | SENSOR | KML (swath) | GnssImu | LogFiles | TestData | RawLaser | RawTDC | RawWFD | WebCam | RCD30 RAW IMAGES | BASE STATION(S) | | SERVER LOCATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | BASE STATION(S) | Base Info (.txt) | |
| 13-Jun-16 | 10161L | 4BLK18CF 165A | ALS 80 | NA | 352 | 134 | 79.7 | 4.65 * | 3.89 | NA | 145 | 22 | 649 | 1KB | Z:\DAC\RAW DATA |
| 13-Jun-16 | 10162L | 4BLK18CF S165B | ALS 80 | NA | 353 | 96.5 | 21.5 | 8.99 | 7.55 | NA | 262 | 39.5 | 649 | 1KB | Z:\DAC\RAW DATA |
| 15-Jun-16 | 10165L | 4BLK18RN 167A | ALS 80 | NA | 472 | 130 | 43.8 | 12.7 | 7.2 | NA | 285 | 26.7 | 653 | 1KB | Z:\DAC\RAW DATA |
| 15-Jun-16 | 10166L | 4BLK18CF 167B | ALS 80 | NA | 251 | 102 | 124 | 3.42 | 2.66 | NA | 79.3 | NA | 653 | 1KB | Z:\DAC\RAW DATA |
| 16-Jun-16 | 10167L | 4BLK18R MNS168A | ALS 80 | NA | 454 | 134 | 44 | 13.8 | 8.88 | NA | 320 | 36.9 | 316 | 1KB | Z:\DAC\RAW DATA |

| DATE | FLIGHT NO. | MISSION NAME | SENSOR | RAW LAS | | LOGS | POS | RAW IMAGES/CASI | MISSION LOG FILE/CASI LOGS | RANGE | DIGITIZER | BASE STATION(S) | | OPERATOR LOGS (OPLOG) | FLIGHT PLAN | | SERVER LOCATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Output LAS | KML (swath) | | | | | | | BASE STATION(S) | Base Info (.txt) | | Actual | KML | |
| June 16, 2016 | 23462P | 1BLK18CF S168A | PEGASUS | 2.76 | NA | 10.4 | 225 | NA | NA | 25.7 | NA | 316 | 1KB | 1KB | 359/364/268/ 464/201/203 | NA | Z:\DAC\RAW DATA |
| June 22, 2016 | 23474P | 1BLK18Q1 73A | PEGASUS | 1.22 | NA | 8.87 | 200 | NA | NA | 12.7 | NA | 468 | 1KB | 1KB | 268/464/201/ 203 | NA | Z:\DAC\RAW DATA |

Received from

Name R. PUNTO
Position RA
Signature

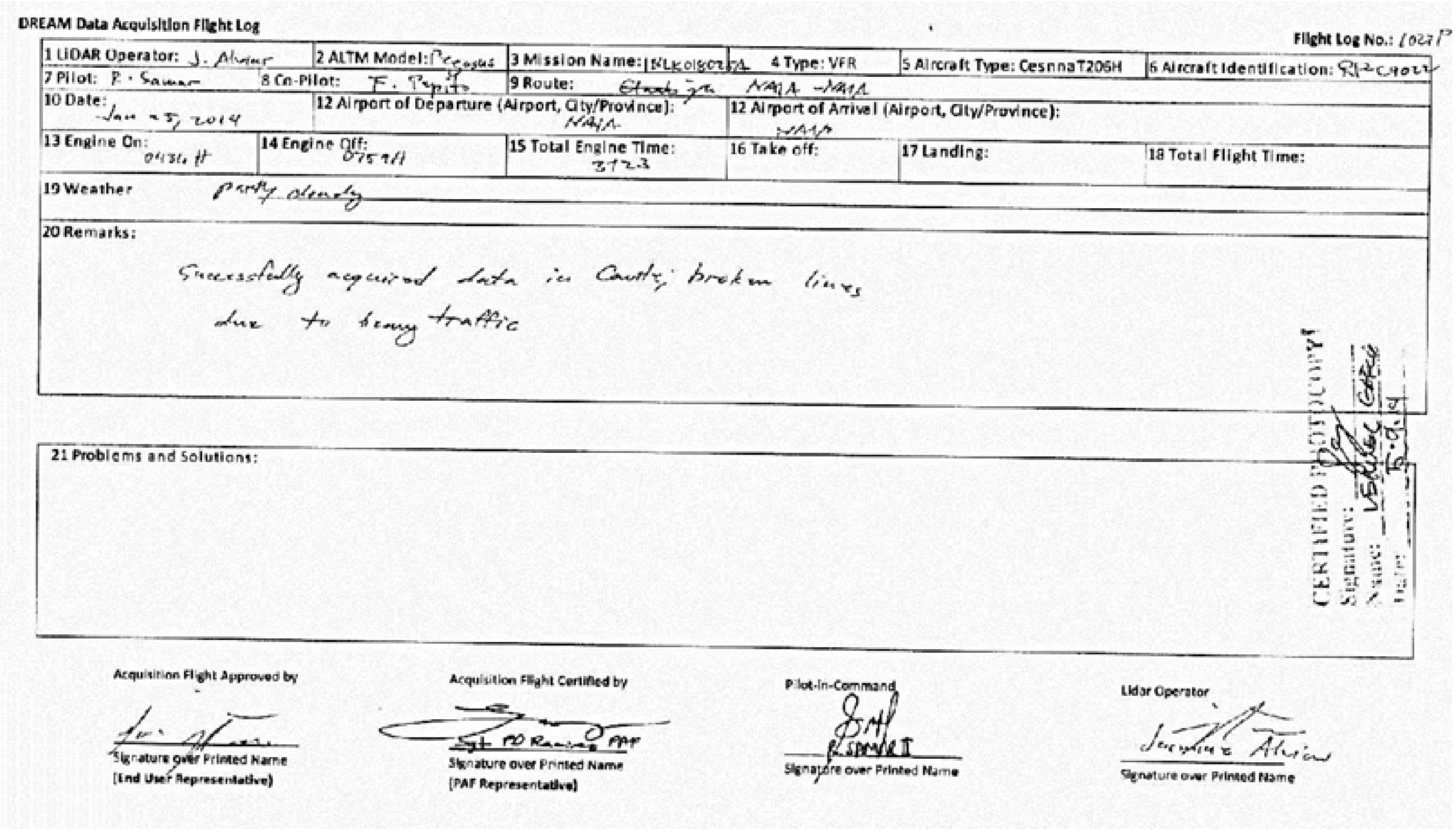
Received by

Name AC Bongat
Position SSRS
Signature ACBongat 7/14/16

16-4

# Annex 6. Flight logs for the flight missions

1. Flight Log for 1027P Mission



**DREAM Data Acquisition Flight Log**

**Flight Log No.:** 1027P

1 LiDAR Operator: J. Alviar
2 ALTM Model: Pegasus
3 Mission Name: 1BLK01SC025A
4 Type: VFR
5 Aircraft Type: CesnnaT206H
6 Aircraft Identification: RP-C9022
7 Pilot: R. Samson
8 Co-Pilot: F. Pepito
9 Route: Ilang-ilang NAIA - NAIA
10 Date: Jan 25, 2014
12 Airport of Departure (Airport, City/Province): NAIA
12 Airport of Arrival (Airport, City/Province): NAIA
13 Engine On: 0436H
14 Engine Off: 0759H
15 Total Engine Time: 3+23
16 Take off:
17 Landing:
18 Total Flight Time:
19 Weather: Partly cloudy
20 Remarks:

Successfully acquired data in Cavite; broken lines due to heavy traffic

21 Problems and Solutions:

CERTIFIED PHOTOCOPY
Signature:
Name: VSalas Cabral
Date: 5.9.14

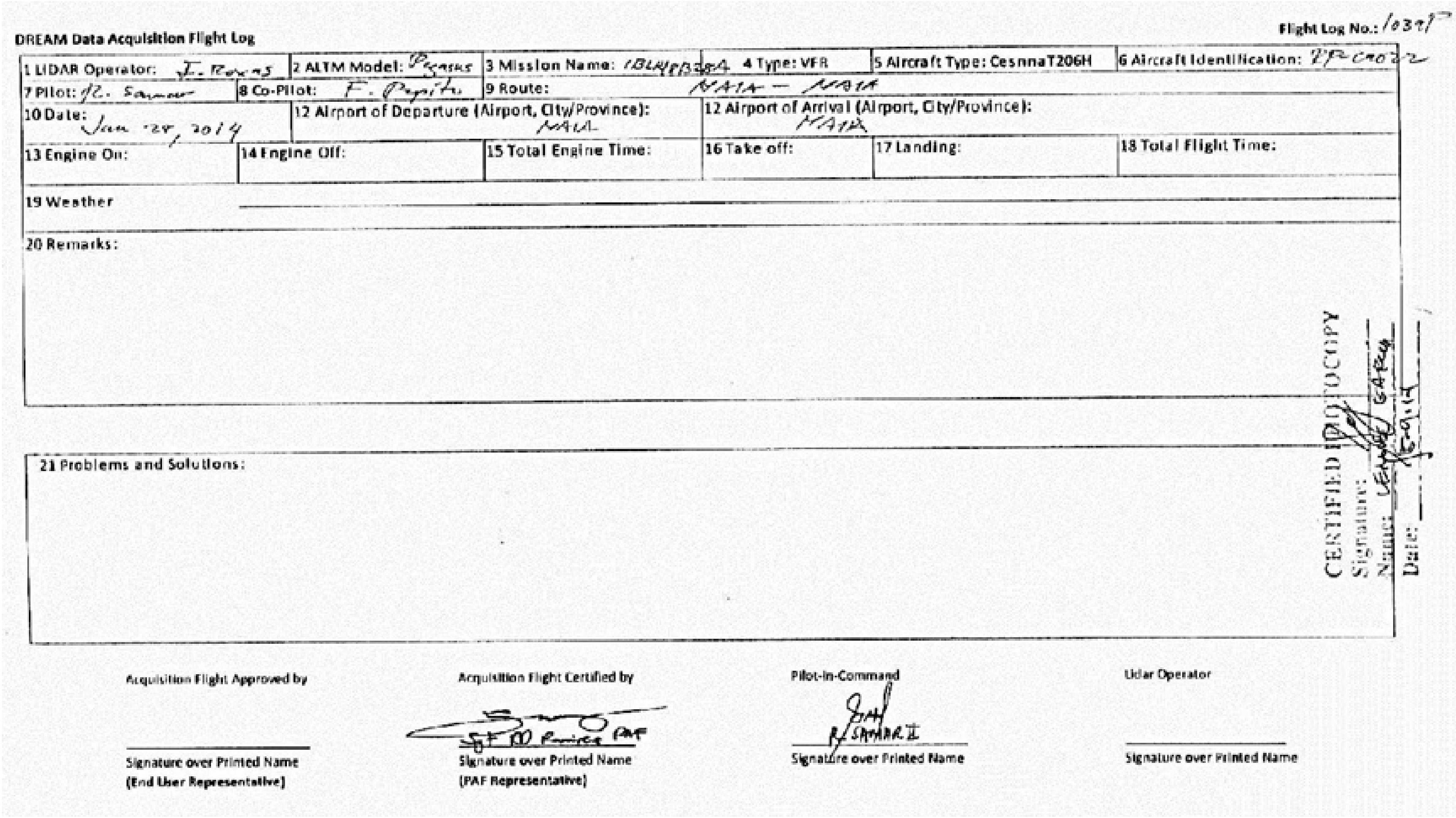
Acquisition Flight Approved by
Signature over Printed Name
(End User Representative)

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

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

Lidar Operator
Jerome Alviar
Signature over Printed Name

2. Flight Log for 1039P Mission



**DREAM Data Acquisition Flight Log**

Flight Log No.: 1039P

1 LIDAR Operator: I. Roxas
2 ALTM Model: Pegasus
3 Mission Name: 1BLK11B28A
4 Type: VFR
5 Aircraft Type: CesnnaT206H
6 Aircraft Identification: RP-C9022
7 Pilot: R. Samson
8 Co-Pilot: F. Pepito
9 Route: NAIA — NAIA
10 Date: Jan 28, 2014
12 Airport of Departure (Airport, City/Province): NAIA
12 Airport of Arrival (Airport, City/Province): NAIA
13 Engine On:
14 Engine Off:
15 Total Engine Time:
16 Take off:
17 Landing:
18 Total Flight Time:
19 Weather
20 Remarks:

21 Problems and Solutions:

CERTIFIED PHOTOCOPY
Signature:
Name:
Date:

Acquisition Flight Approved by

Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by

SgT ED Ramirez PAF
Signature over Printed Name
(PAF Representative)

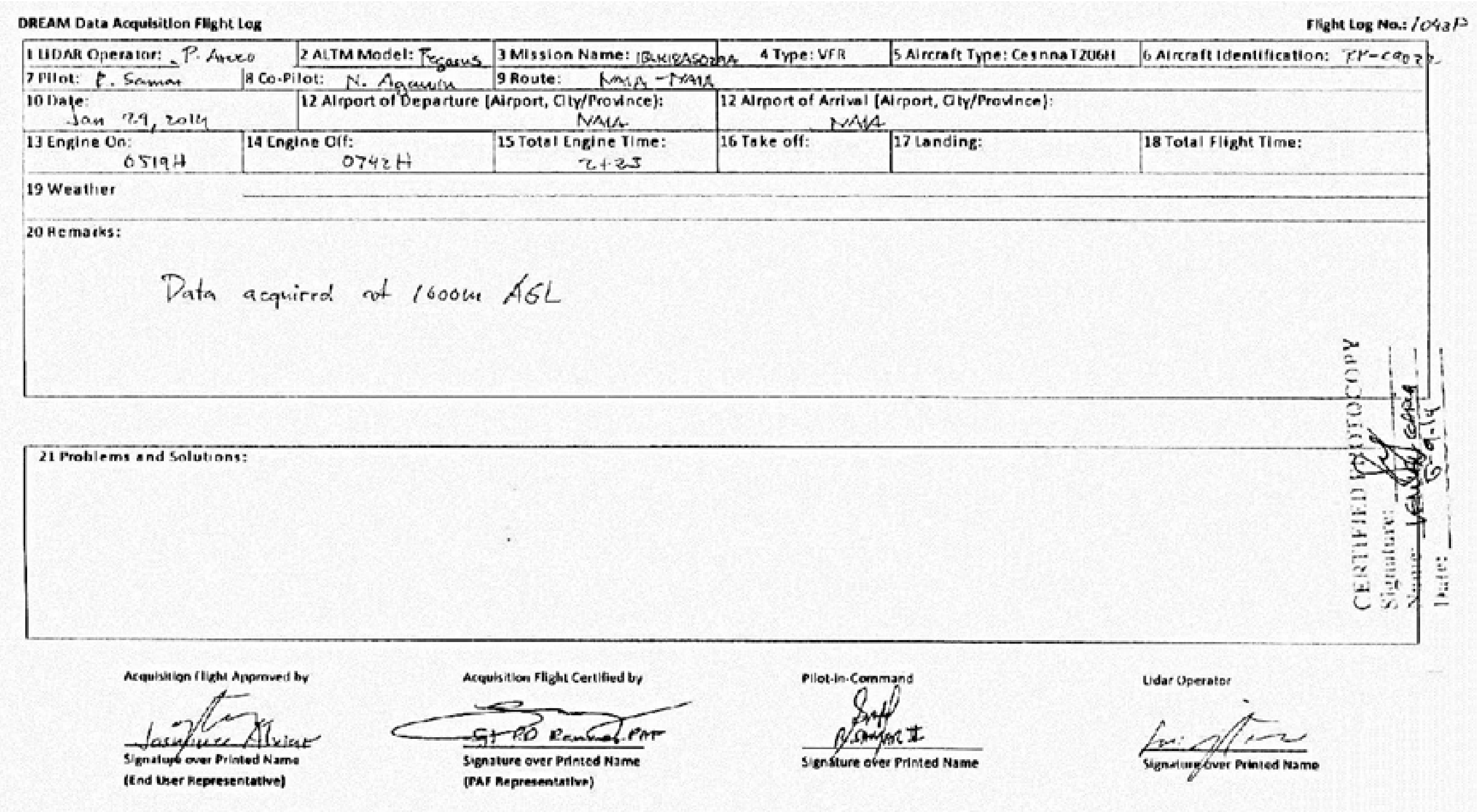
Pilot-in-Command

R SAMBAR II
Signature over Printed Name

Lidar Operator

Signature over Printed Name

3. Flight Log for 1043P Mission



**DREAM Data Acquisition Flight Log**

**Flight Log No.:** 1043P

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: P. Arceo | 2 ALTM Model: Pegasus | 3 Mission Name: 1BLK18AS029A | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: RP-C9022 |
| 7 Pilot: F. Samar | 8 Co-Pilot: N. Aguadin | 9 Route: NAIA - NAIA | | | |
| 10 Date: Jan 29, 2014 | 12 Airport of Departure (Airport, City/Province): NAIA | | 12 Airport of Arrival (Airport, City/Province): NAIA | | |
| 13 Engine On: 0519H | 14 Engine Off: 0742H | 15 Total Engine Time: 2+23 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |

19 Weather

20 Remarks:

Data acquired at 1600m AGL

21 Problems and Solutions:

CERTIFIED PHOTOCOPY
Signature:
Name:
Date: 6-9-14

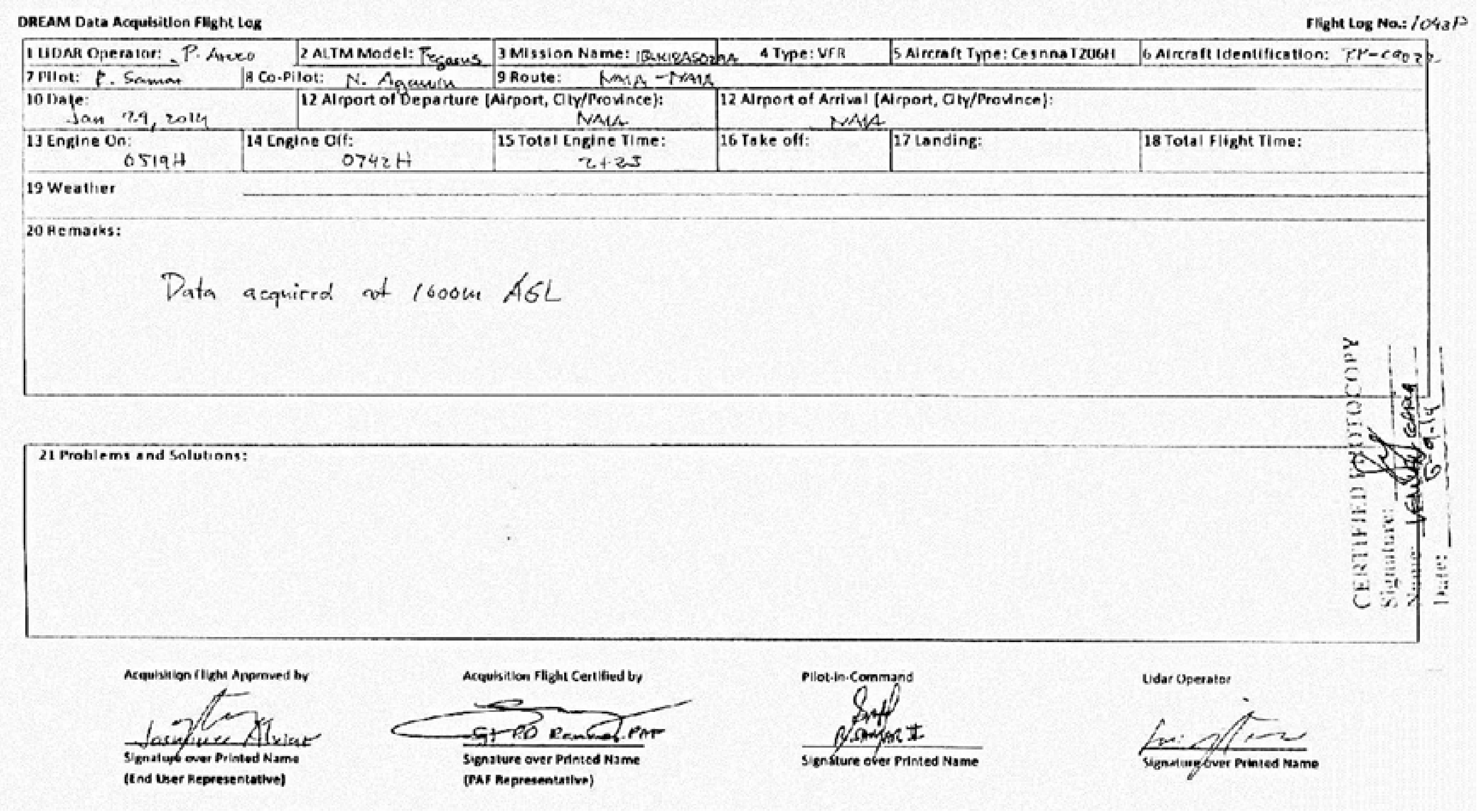
Acquisition Flight Approved by
Signature over Printed Name
(End User Representative)

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

Pilot-in-Command
Signature over Printed Name

Lidar Operator
Signature over Printed Name

4. Flight Log for 1063P Mission



**DREAM Data Acquisition Flight Log**

**Flight Log No.:** 1063P

1 LiDAR Operator: P. Arceo
2 ALTM Model: Pegasus
3 Mission Name: 1BLK18AS029A
4 Type: VFR
5 Aircraft Type: Cessna T206H
6 Aircraft Identification: RP-C9022
7 Pilot: F. Samar
8 Co-Pilot: N. Aguana
9 Route: NAIA - NAIA
10 Date: Jan 29, 2014
12 Airport of Departure (Airport, City/Province): NAIA
12 Airport of Arrival (Airport, City/Province): NAIA
13 Engine On: 0519H
14 Engine Off: 0742H
15 Total Engine Time: 2+23
16 Take off:
17 Landing:
18 Total Flight Time:
19 Weather
20 Remarks:

Data acquired at 1600m AGL

21 Problems and Solutions:

CERTIFIED PHOTOCOPY
Signature:
Name:
Date: 6-9-14

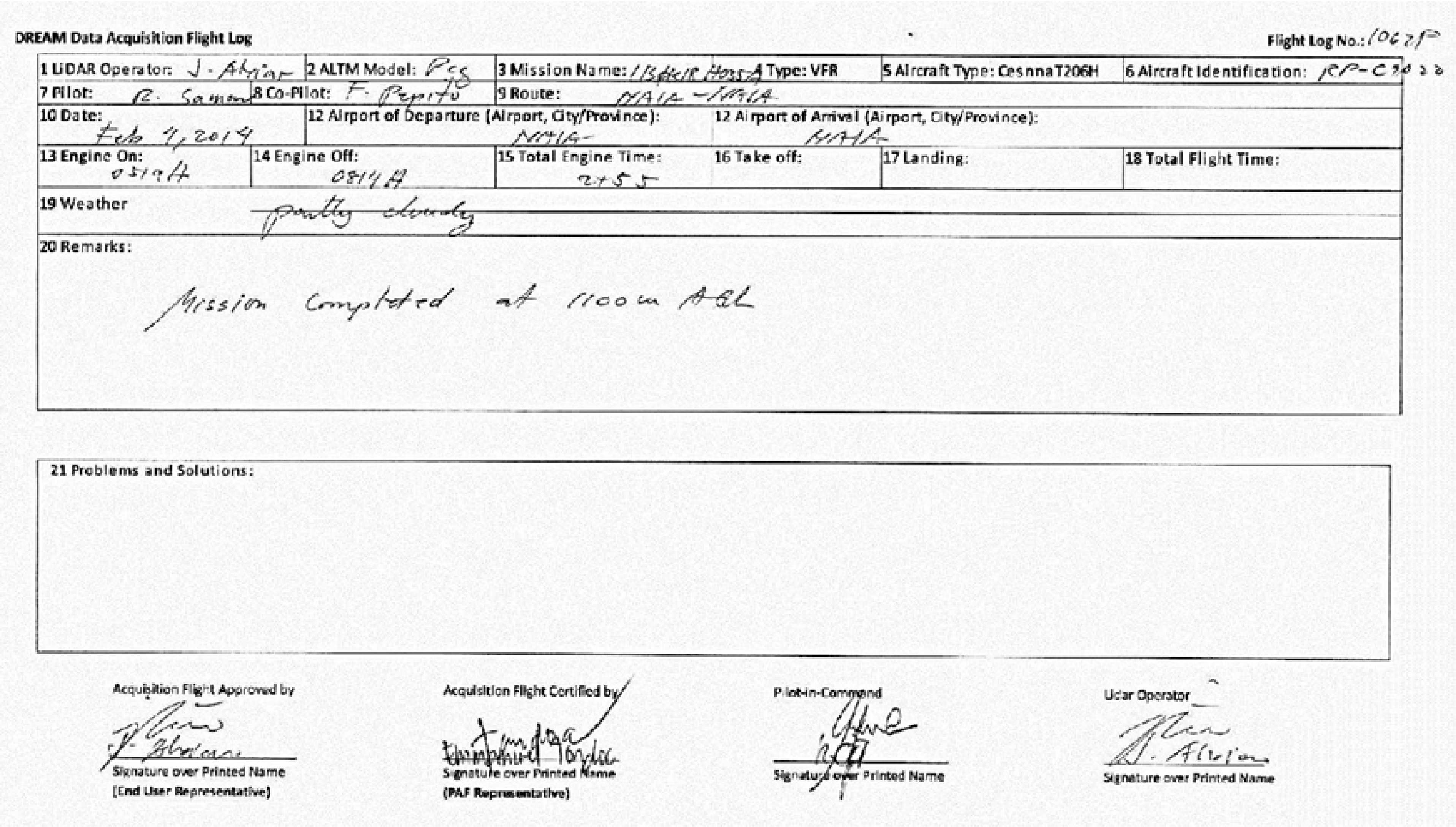
Acquisition Flight Approved by
Signature over Printed Name
(End User Representative)

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

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

Lidar Operator
Signature over Printed Name

5. Flight Log for 1139P Mission



**DREAM Data Acquisition Flight Log**

Flight Log No.: 1067P

1 LiDAR Operator: J. Alviar
2 ALTM Model: Pegasus
3 Mission Name: 1BLK18H035A
4 Type: VFR
5 Aircraft Type: CesnnaT206H
6 Aircraft Identification: RP-C9022
7 Pilot: R. Samson
8 Co-Pilot: F. Pepito
9 Route: NAIA - NAIA
10 Date: Feb 4, 2014
12 Airport of Departure (Airport, City/Province): NAIA
12 Airport of Arrival (Airport, City/Province): NAIA
13 Engine On: 0519H
14 Engine Off: 0814H
15 Total Engine Time: 2+55
16 Take off:
17 Landing:
18 Total Flight Time:
19 Weather: partly cloudy
20 Remarks:

Mission Completed at 1100m AGL

21 Problems and Solutions:

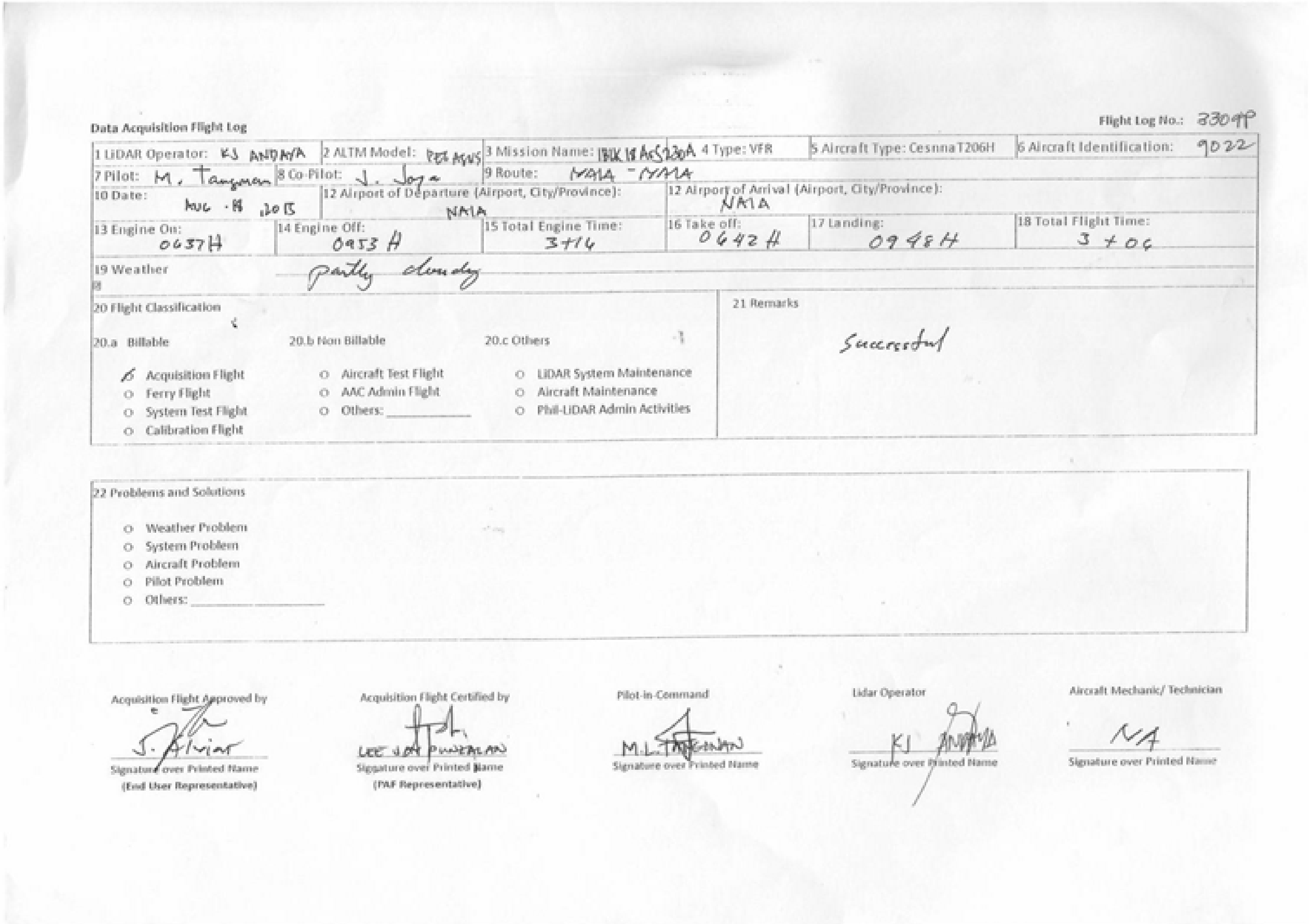
Acquisition Flight Approved by
Signature over Printed Name
(End User Representative)

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

Pilot-in-Command
Signature over Printed Name

Lidar Operator
J. Alviar
Signature over Printed Name

## 6. Flight Log for 3309P Mission



**Data Acquisition Flight Log**

**Flight Log No.:** 3309P

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: KJ ANDAYA | 2 ALTM Model: PEGASUS | 3 Mission Name: 1BLK18ACS230A | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 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: 0948 H | 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

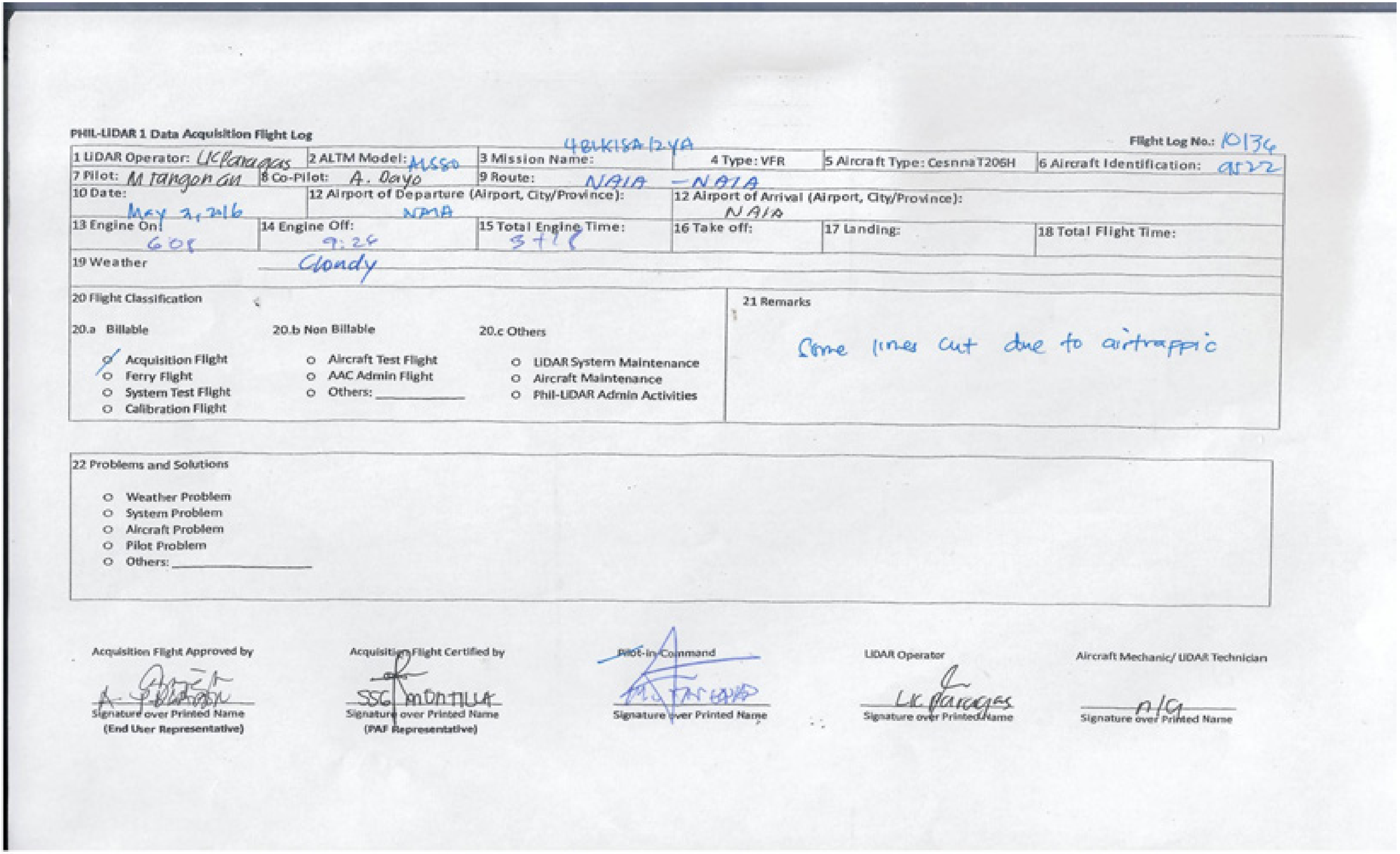
21 Remarks

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<br>(End User Representative) | Signature over Printed Name<br>(PAF Representative) | Signature over Printed Name | Signature over Printed Name | Signature over Printed Name |

7. Flight Log for 10136L Mission.



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 10136

|  |  |  |  |  |  |
|---|---|---|---|---|---|
| 1 LiDAR Operator: LK Paragas | 2 ALTM Model: AQ50 | 3 Mission Name: 4BLK18A12YA | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: 9122 |
| 7 Pilot: M Tangonan | 8 Co-Pilot: A. Dayo | 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: 6:08 | 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
- ○ 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

Some lines cut due to airtraffic

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

Acquisition Flight Approved by

Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by

SSG MONTILLA
Signature over Printed Name
(PAF Representative)

Pilot-in-Command

Signature over Printed Name

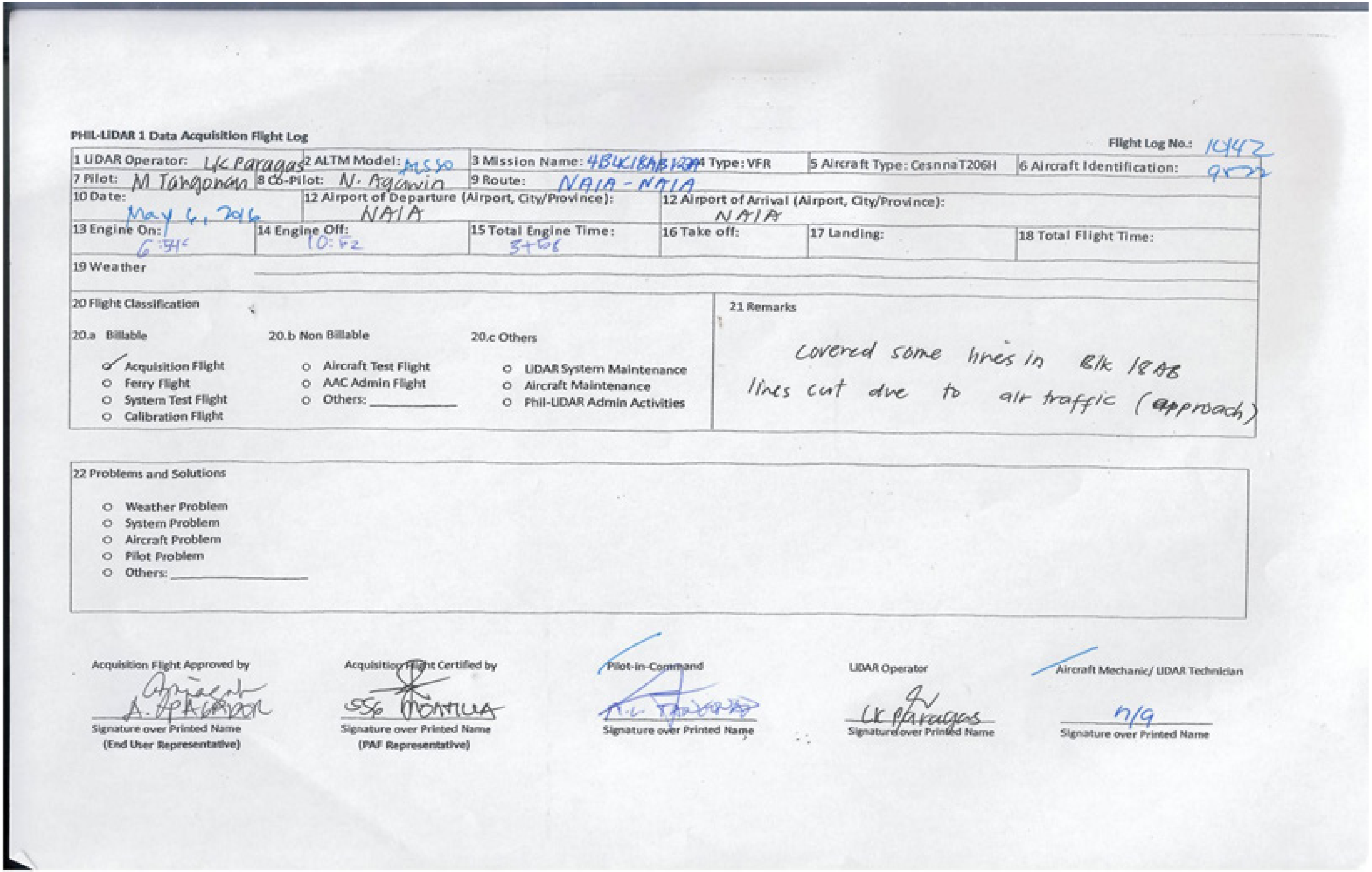
LiDAR Operator

LK Paragas
Signature over Printed Name

Aircraft Mechanic/ LiDAR Technician

N/A
Signature over Printed Name

8. Flight Log for 10142L Mission



**PHIL-LIDAR 1 Data Acquisition Flight Log**

Flight Log No.: 1042

| | | | | | |
|---|---|---|---|---|---|
| 1 LIDAR Operator: LK Paragas | 2 ALTM Model: MS50 | 3 Mission Name: 4BLK18AB127A | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: 9522 |
| 7 Pilot: M Tangonan | 8 Co-Pilot: N. Aguinin | 9 Route: NAIA - NAIA | | | |
| 10 Date: May 6, 2016 | 12 Airport of Departure (Airport, City/Province): NAIA | | 12 Airport of Arrival (Airport, City/Province): NAIA | | |
| 13 Engine On: 6:54 | 14 Engine Off: 10:52 | 15 Total Engine Time: 3+58 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather | | | | | |

20 Flight Classification

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

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

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

21 Remarks

Covered some lines in Blk 18AB lines cut due to air traffic (approach)

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

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

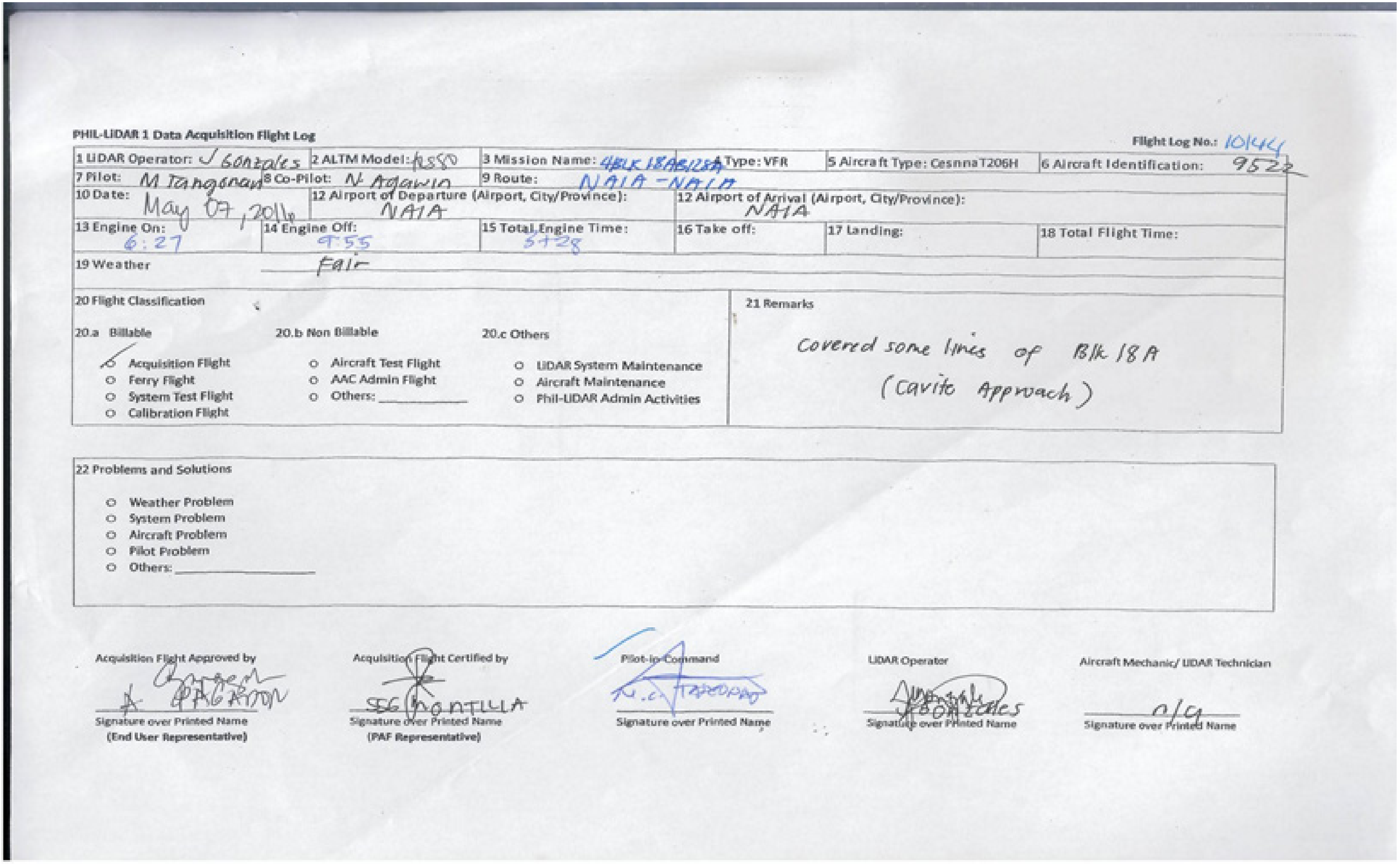
Acquisition Flight Certified by
SSg Montilla
Signature over Printed Name
(PAF Representative)

Pilot-in-Command
M.C. Tangonan
Signature over Printed Name

LIDAR Operator
LK Paragas
Signature over Printed Name

Aircraft Mechanic/ LIDAR Technician
n/a
Signature over Printed Name

9. Flight Log for 10144L Mission.



**PHIL-LIDAR 1 Data Acquisition Flight Log**

**Flight Log No.:** 10144

1 LiDAR Operator: J Gonzales
2 ALTM Model: A850
3 Mission Name: 4BLK18AS128A
4 Type: VFR
5 Aircraft Type: CesnnaT206H
6 Aircraft Identification: 9522
7 Pilot: M Tangonan
8 Co-Pilot: N Agawin
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
A. Pagaran
Signature over Printed Name
(End User Representative)

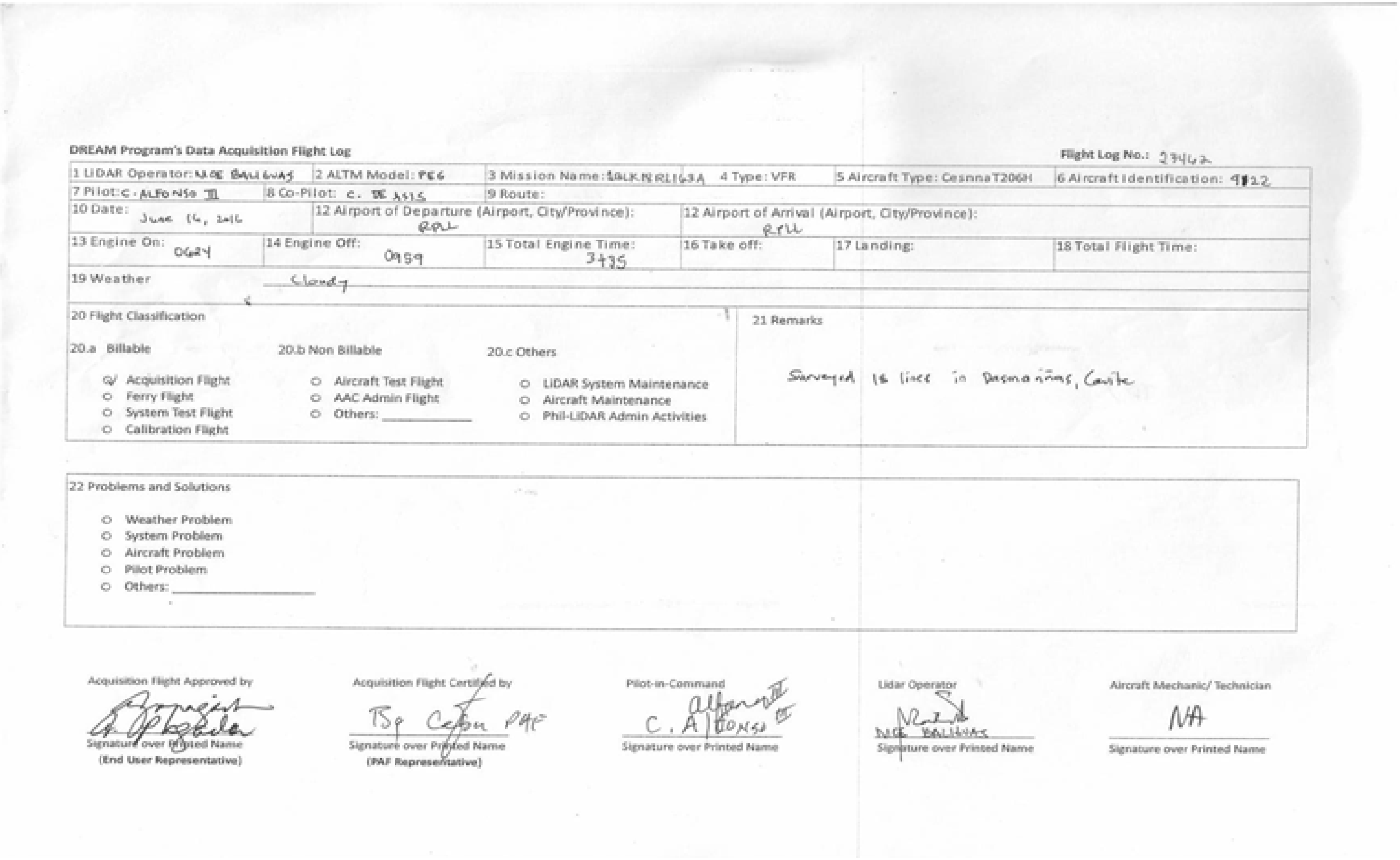
Acquisition Flight Certified by
SG Montilla
Signature over Printed Name
(PAF Representative)

Pilot-in-Command
M.C. Tangonan
Signature over Printed Name

LiDAR Operator
J Gonzales
Signature over Printed Name

Aircraft Mechanic/ LiDAR Technician
n/a
Signature over Printed Name

10. Flight Log for 23462P Mission



**DREAM Program's Data Acquisition Flight Log**

Flight Log No.: 23462

| | | | | | |
|---|---|---|---|---|---|
| 1 LIDAR Operator: NOE BALIGUAS | 2 ALTM Model: PEG | 3 Mission Name: 1BLKNRL163A | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: 9122 |
| 7 Pilot: C. ALFONSO III | 8 Co-Pilot: C. DE ASIS | 9 Route: | | | |
| 10 Date: June 16, 2016 | 12 Airport of Departure (Airport, City/Province): RPLL | | 12 Airport of Arrival (Airport, City/Province): RPLL | | |
| 13 Engine On: 0624 | 14 Engine Off: 0959 | 15 Total Engine Time: 3+35 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather: 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

Surveyed 16 lines in Dasmariñas, Cavite

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

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

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

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

Lidar Operator
NOE BALIGUAS
Signature over Printed Name

Aircraft Mechanic/ Technician
NA
Signature over Printed Name

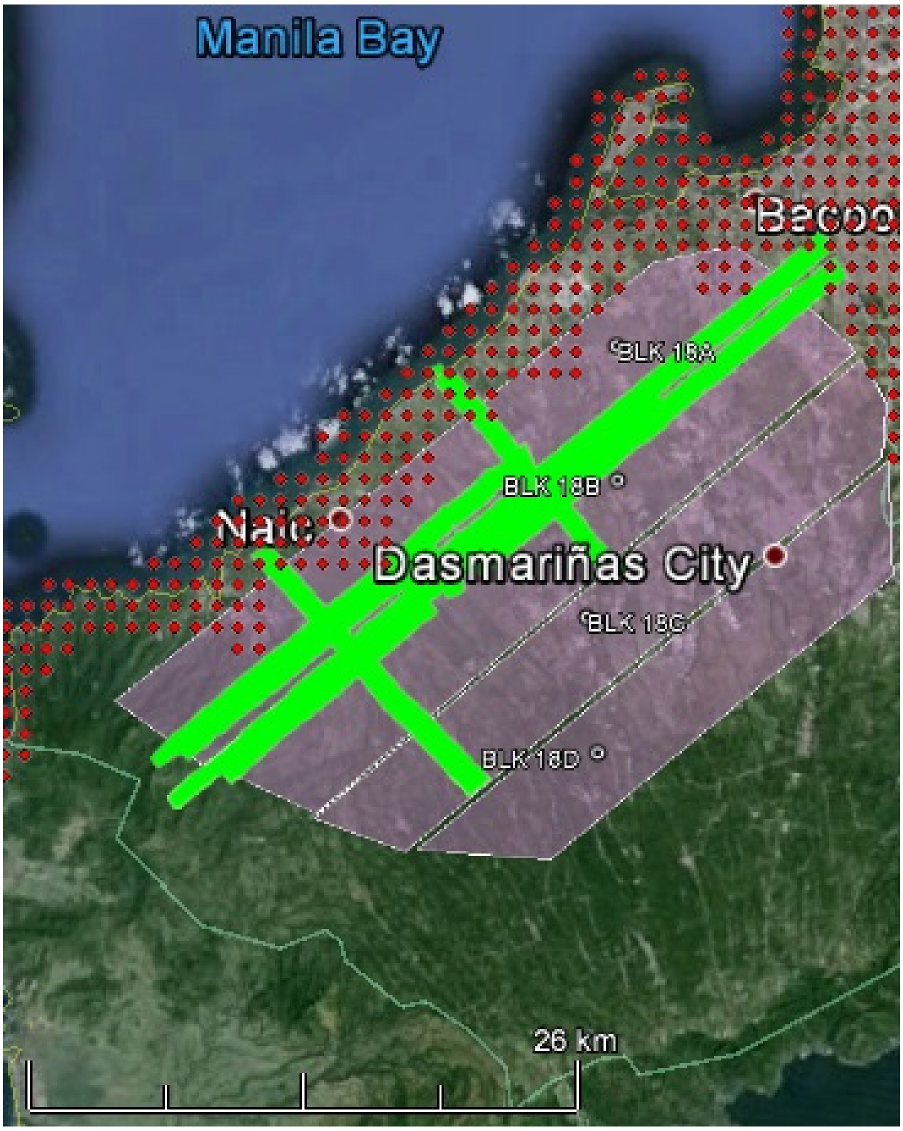
# Annex 7. Flight status reports

Ilang-Ilang Mission
January 27- February 28, 2014,
August 18, 2015 and June 16, 2016

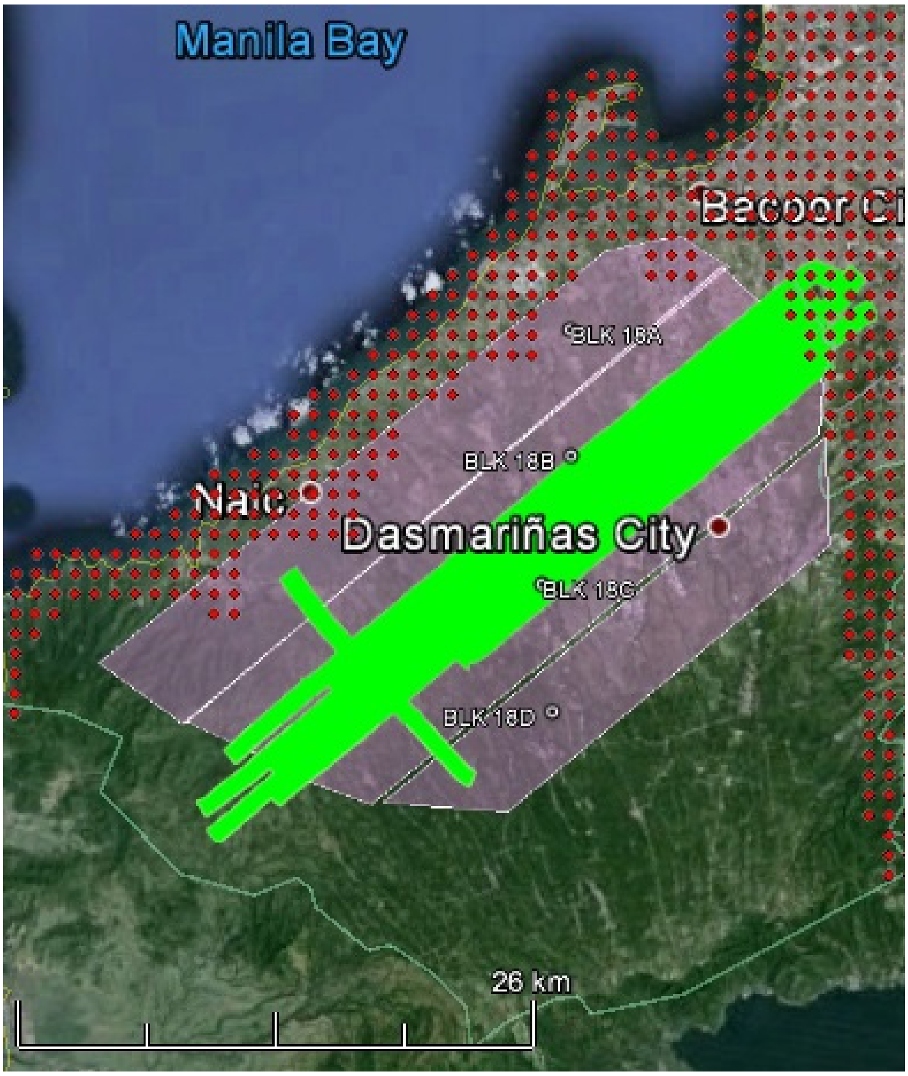
| FLIGHT NO. | AREA | MISSION | OPERATOR | DATE FLOWN | REMARKS |
|---|---|---|---|---|---|
| 1027P | BLK 18AB | 1BLK18A025A | J. Alviar | 25 Jan 2014 | Acquired data at 1000m, broken lines and irregular survey pattern due to very heavy traffic and tower restrictions |
| 1039P | BLK 18BC | 1BLK18B028A | I.Roxas | 28 Jan 2014 | Data acquired at 1000m AGL |
| 1043P | BLK 18AS | 1BLK18AS029A | P.J.Arceo | 29 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 ceiling |
| 3309P | BLK 18AsS | 1BLK18AsS230A | KJ ANDAYA | 18 AUG 2015 | Voids due to low cloud ceiling, laser off due to clouds, experienced POSAV error, 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 |
| 10144L | BLK18 AB | 4BLK18ABS128A | J. Gonzales | 7May 2016 | Covered some lines of Blk 18 AB |
| 23462P | BLK18 CF | 1BLK18CFS168A | MCE Baliguas | 16 JUN 2016 | Covered 25 lines over Dasmarinas |
| 10144L | BLK18 AB | 4BLK18ABS128A | J. Gonzales | 7May 2016 | Covered some lines of Blk 18 AB |
| 23462P | BLK18 CF | 1BLK18CFS168A | MCE Baliguas | 16 JUN 2016 | Covered 25 lines over Dasmarinas |

SWATH PER FLIGHT MISSION

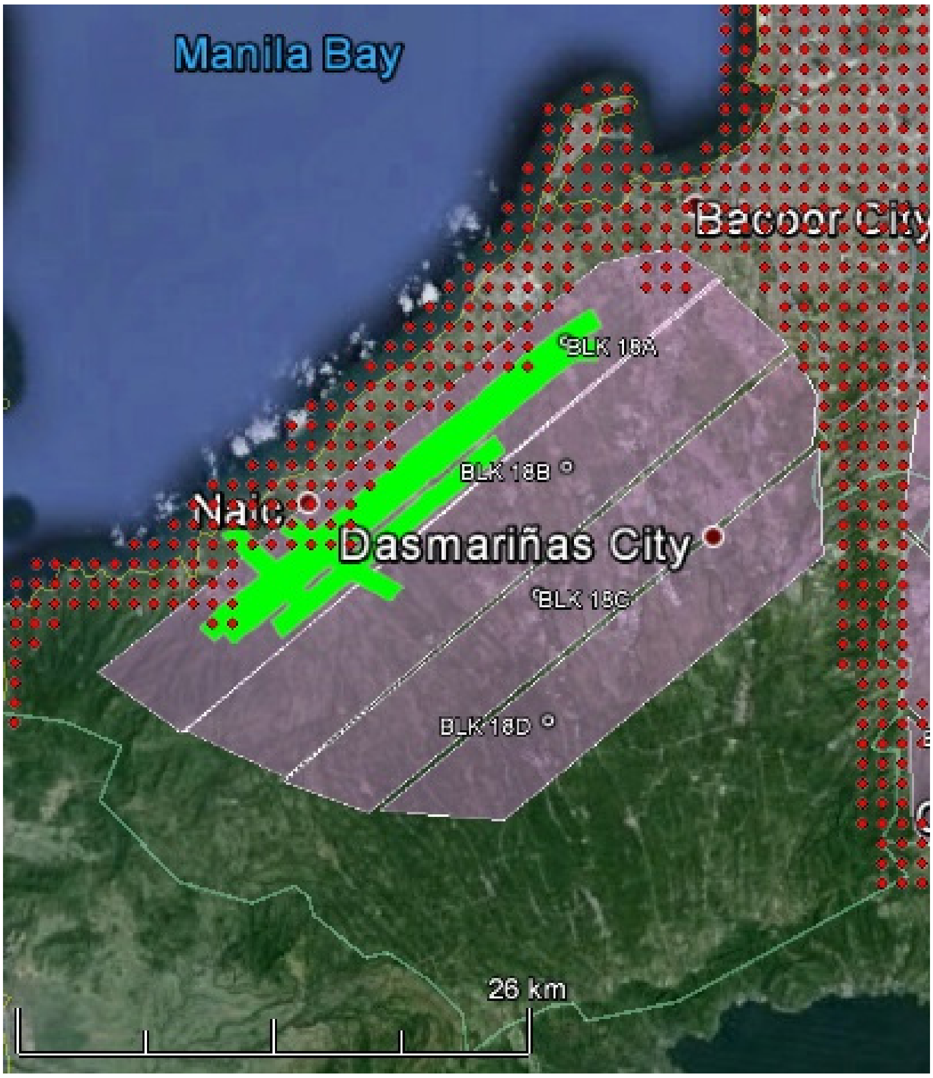
Flight No. : 1027P
Area: BLK 18AB.
Mission Name: 1BLK18B025A



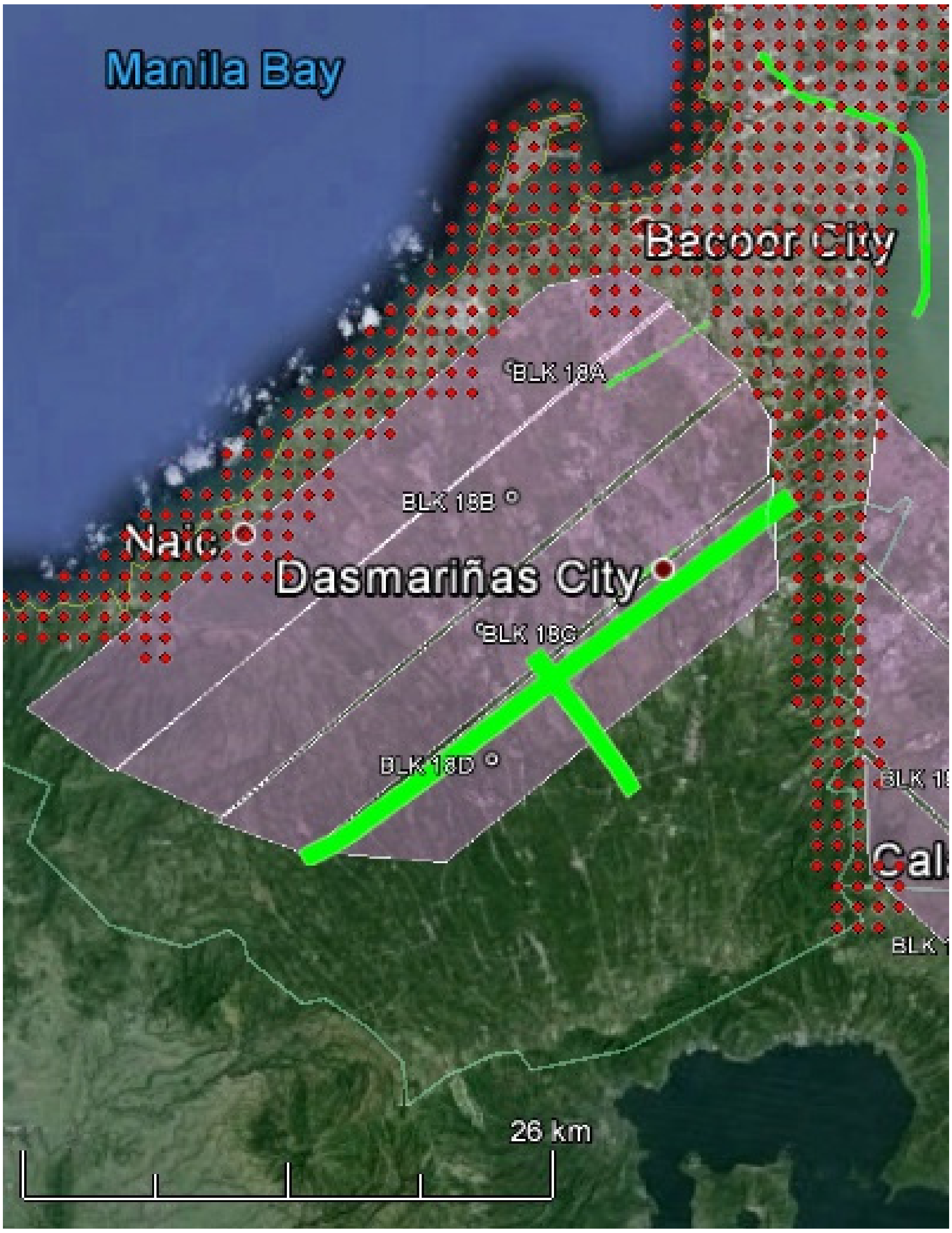
Flight No. : 1039P
Area: BLK 18BC
Mission Name: 1BLK18B028A



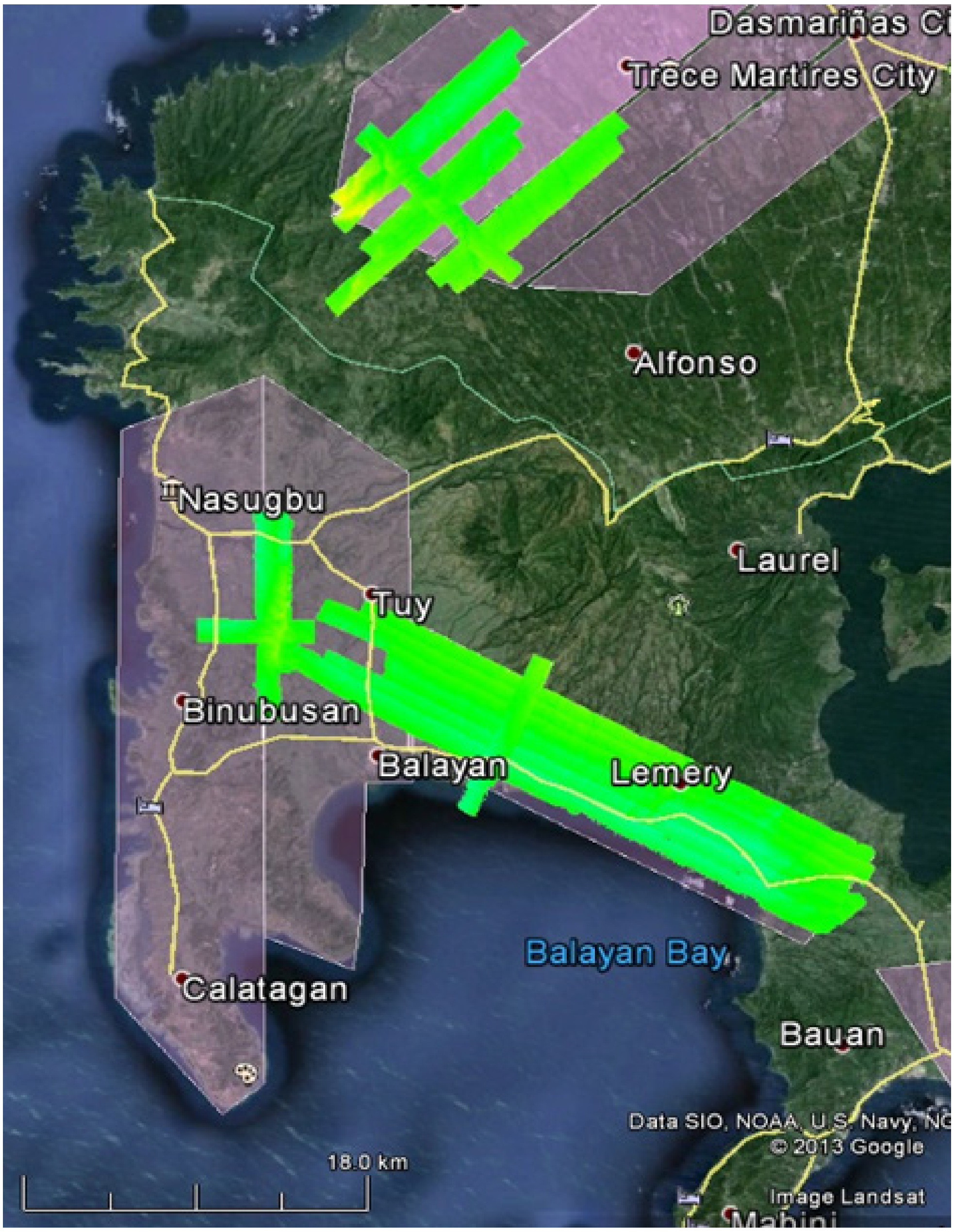
Flight No. : 1043P
Area: BLK 18AS
Mission Name: 1BLK18AS029A



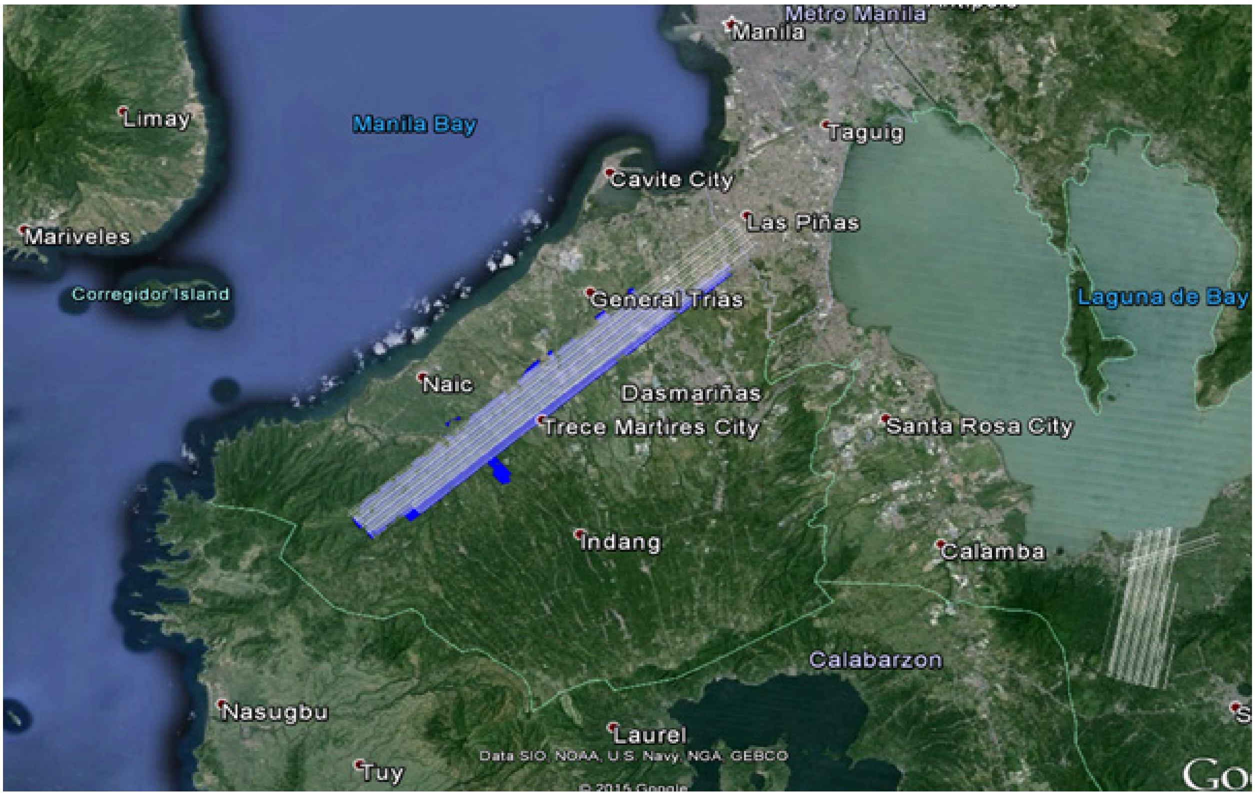
Flight No. : 1063P
Area: BLK 18D
Mission Name: 1BLK18D034A



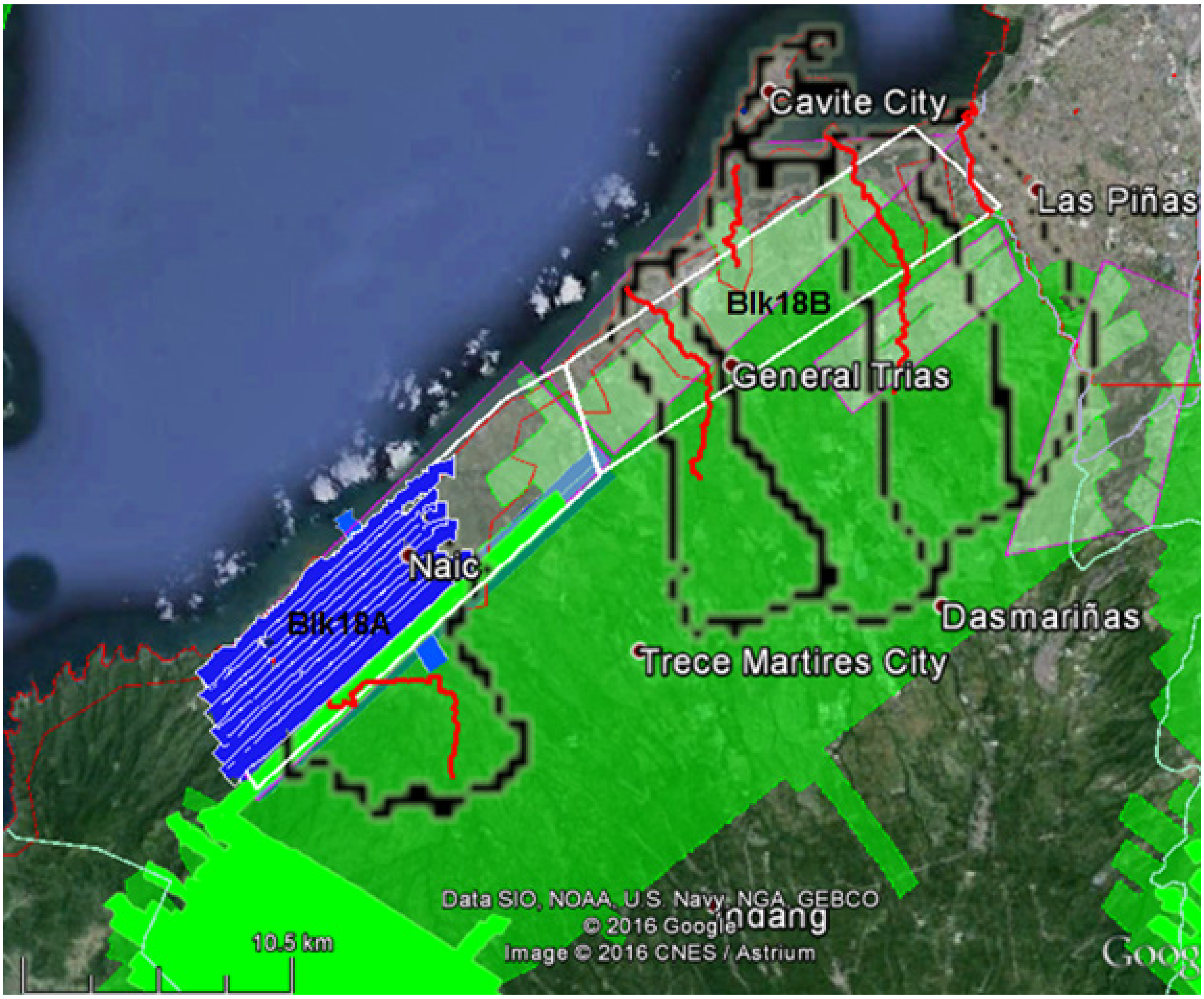
Flight No. : 1139P (renamed from 1137P)
Area: BLK 18X & (ABCY)
Mission Name: 1BLK18S53A



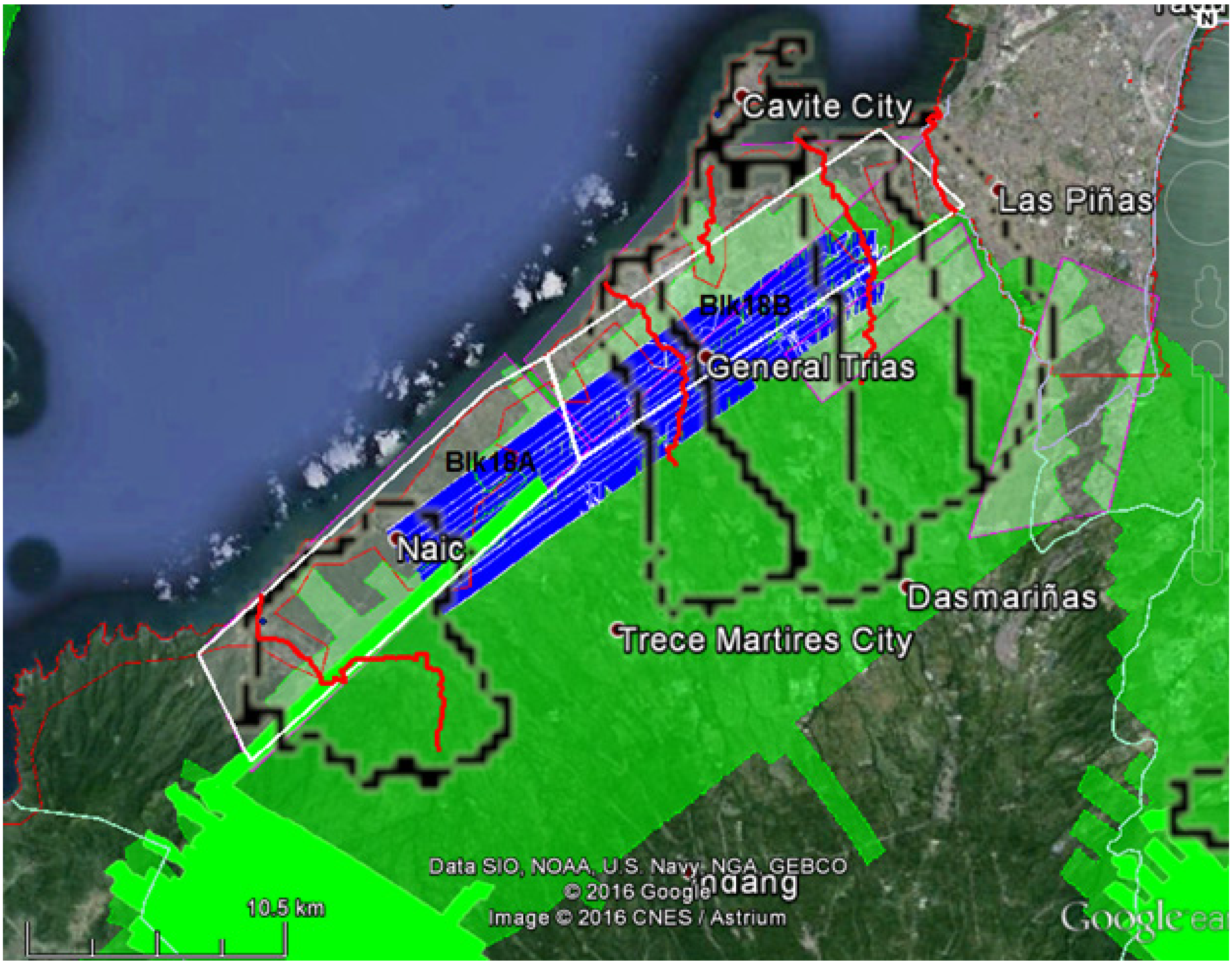
Flight No. : 3309P
Area: BLK 18ASS
Mission Name: 1BLK18AsS230A



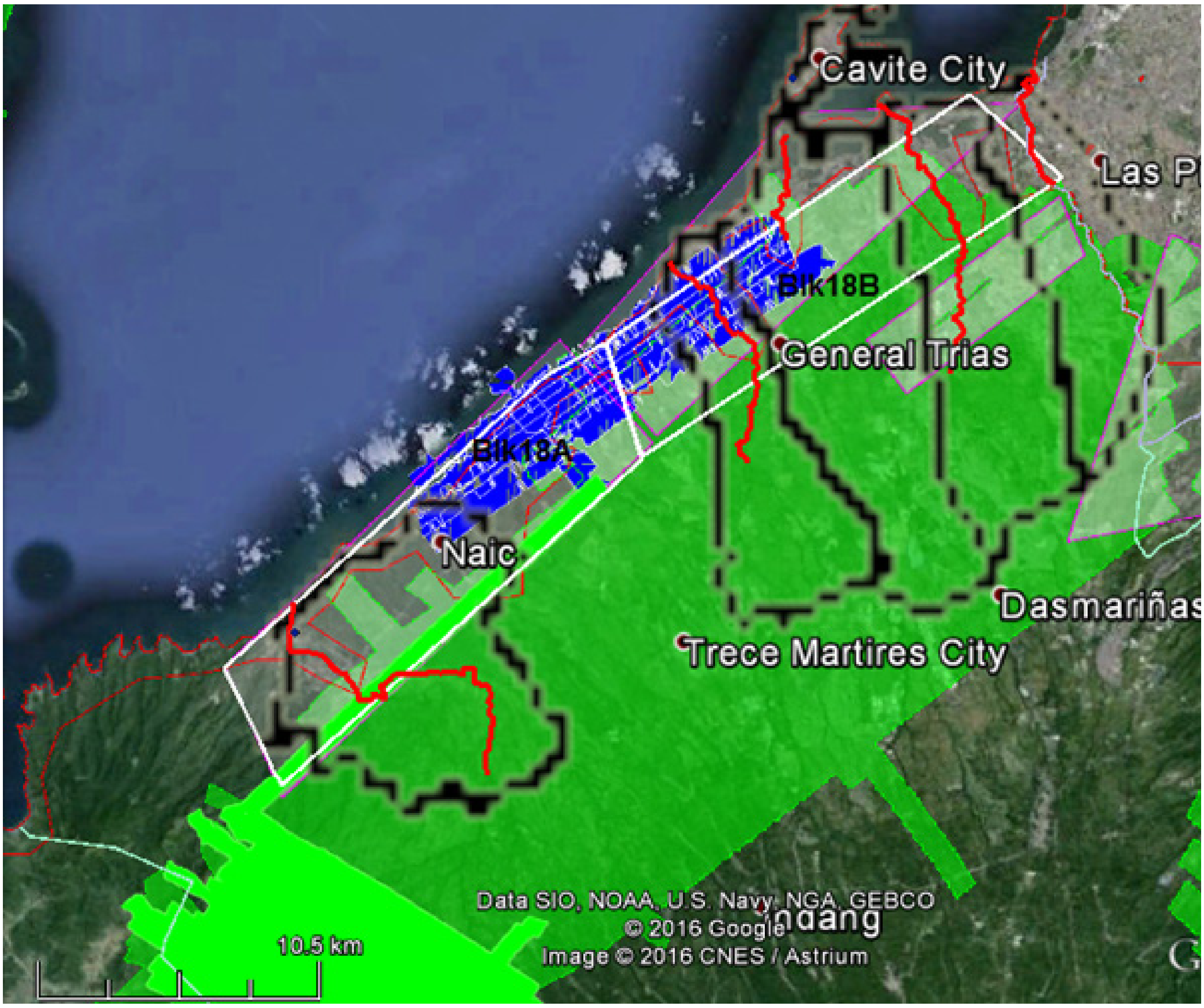
FLIGHT NO.: 10136L
AREA: BLK18A
MISSION NAME: 2BLK18A124A



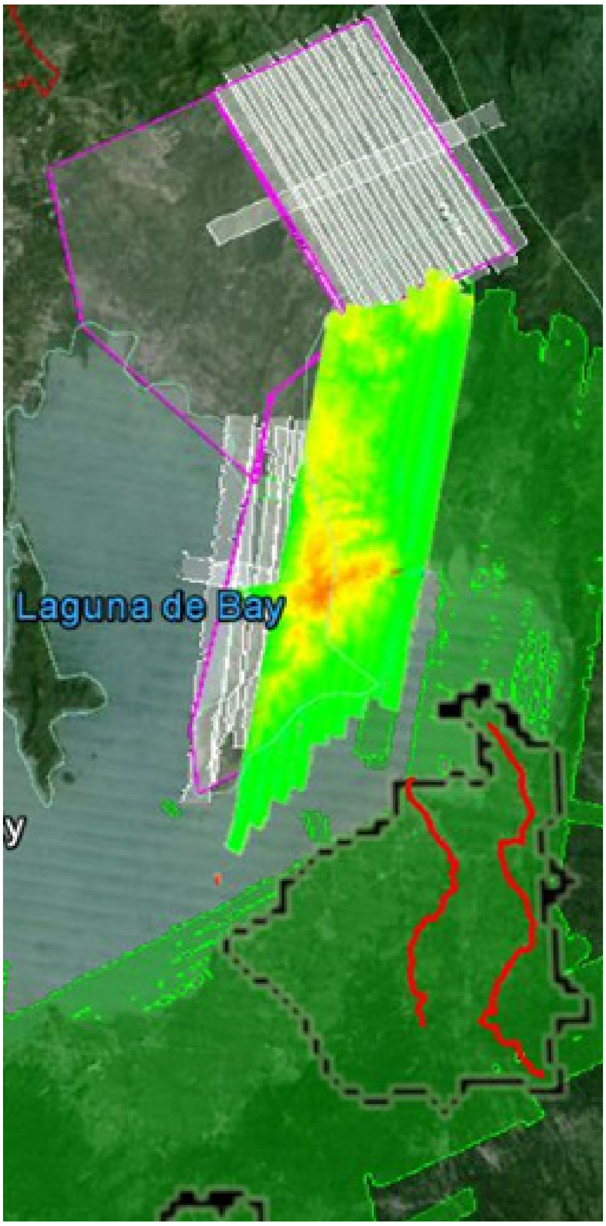
FLIGHT NO.: 10142L
AREA: BLK18AB
MISSION NAME: 4BLK18AB127A



FLIGHT NO.: 10144L
AREA: BLK18AB
MISSION NAME: 4BLK18ABS128A

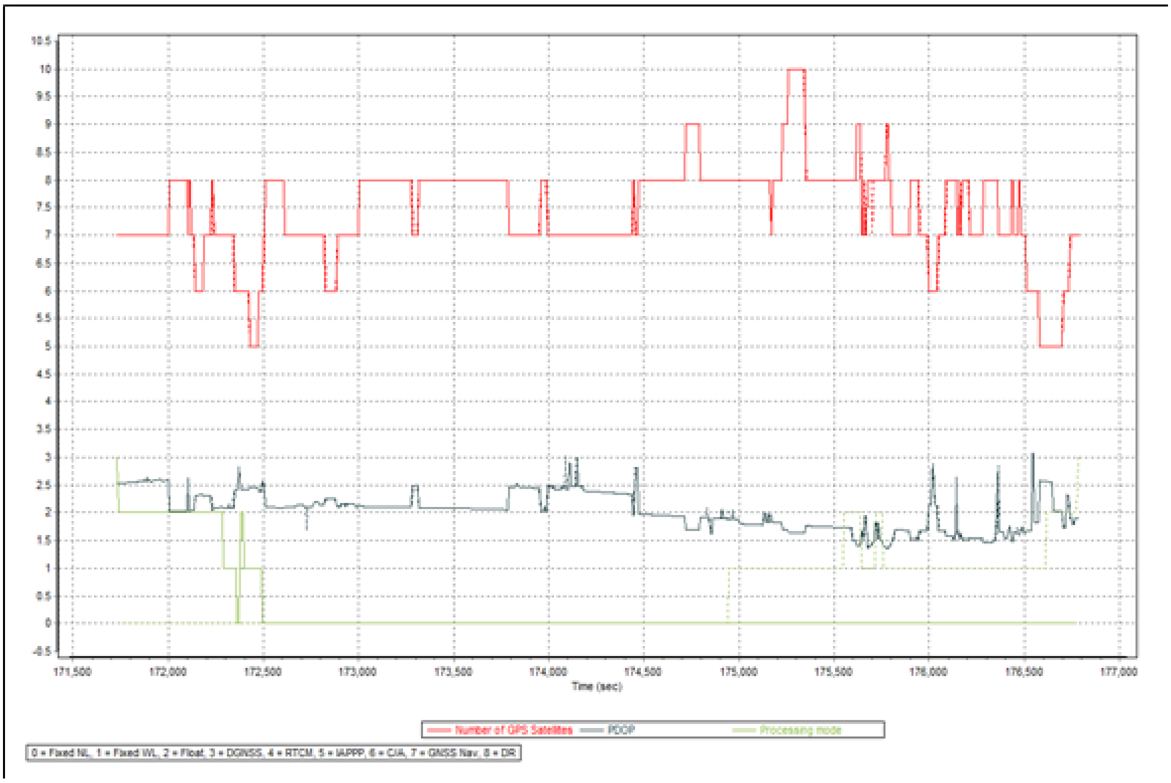


FLIGHT NO.: 23462P
AREA: BLK18RM, BLK18RN
MISSION NAME: 4BLK18RMNS168A

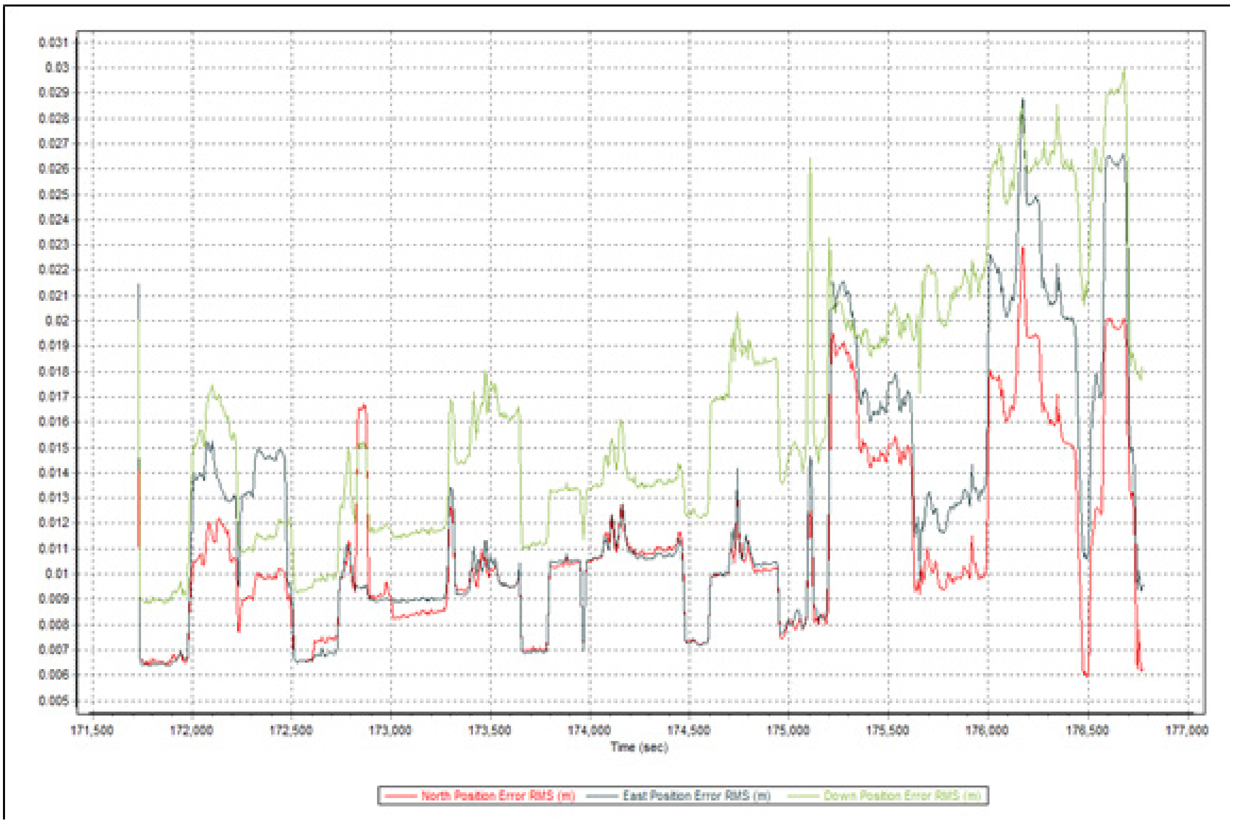


# Annex 8. Mission Summary Reports

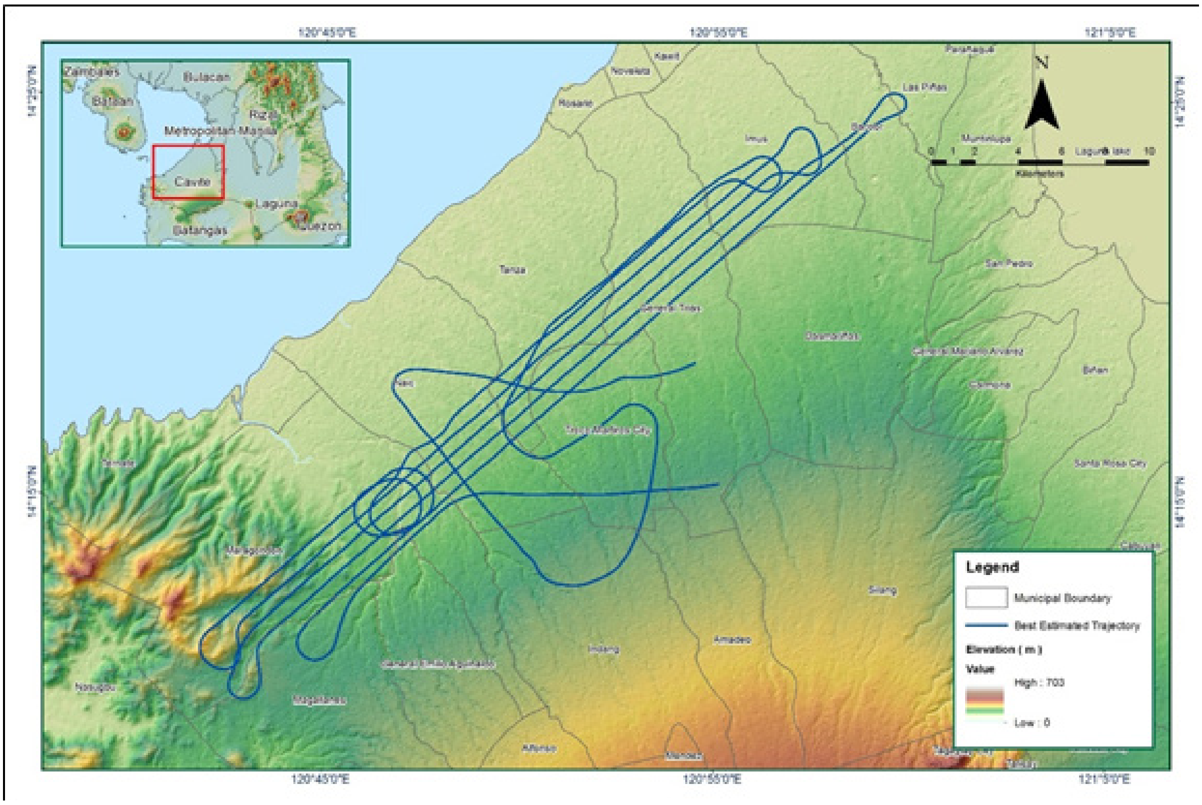
| **Flight Area** | **Pagadian** |
|---|---|
| Mission Name | Blk18B_supplement |
| Inclusive Flights | 3309P |
| Range data size | 11.9GB |
| POS data size | 202 MB |
| Base data size | 19.4 MB |
| Image | N/A |
| Transfer date | September 11, 2015 |
| | |
| Solution Status | |
| Number of Satellites (>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 Narisma |



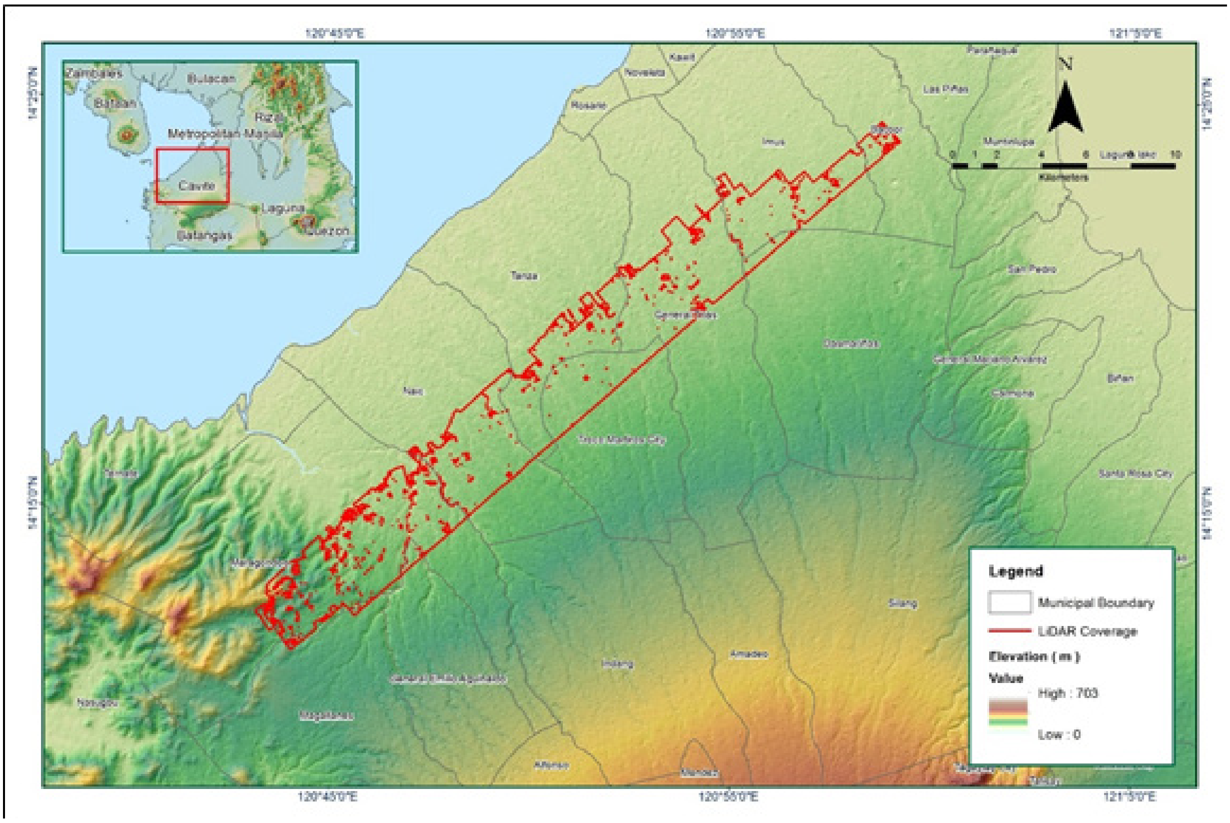
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

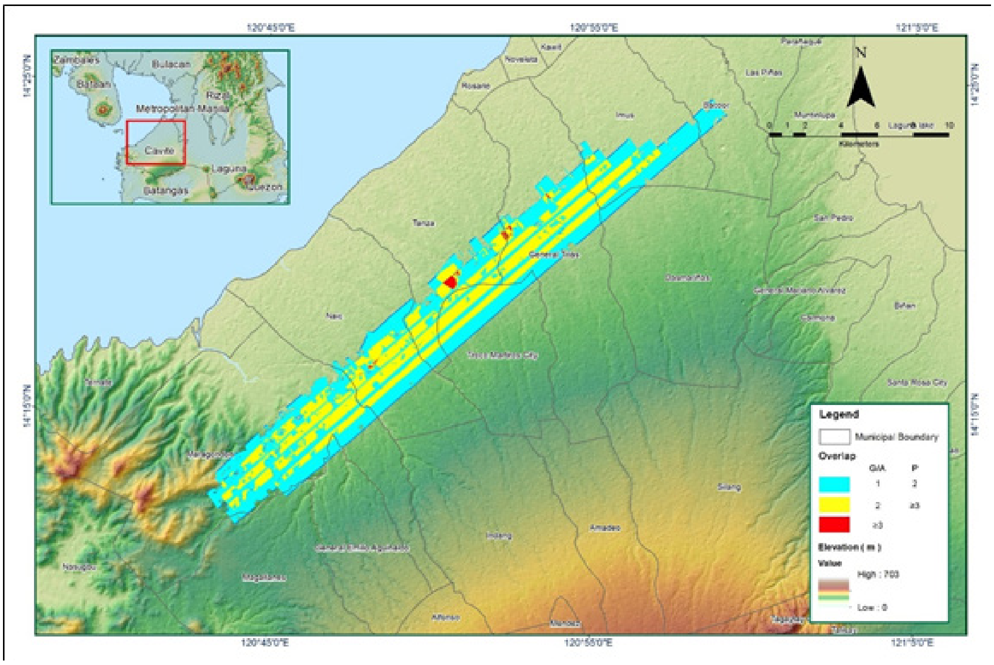
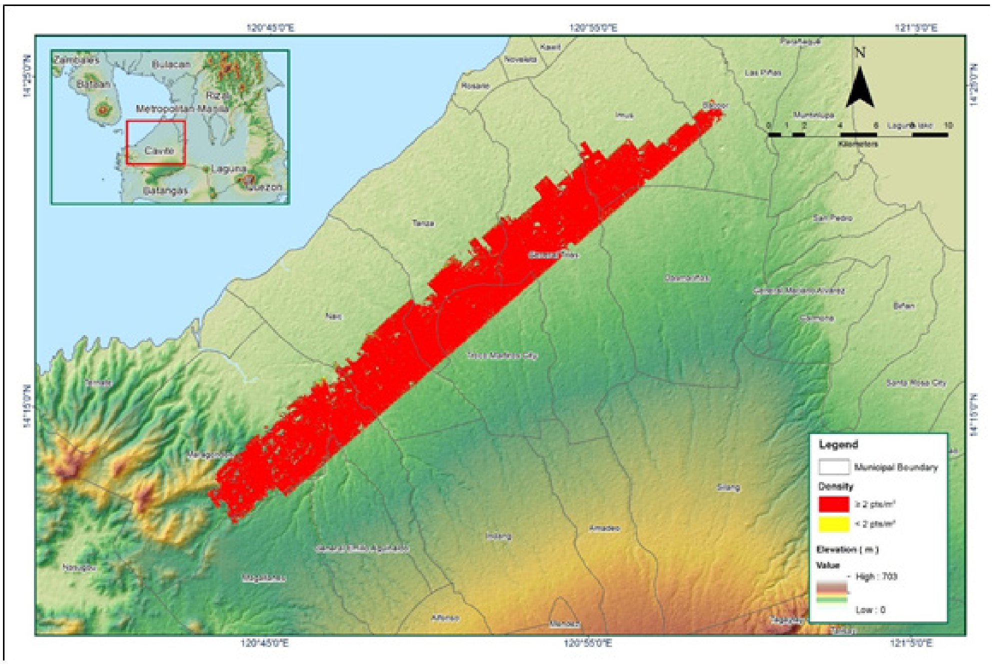
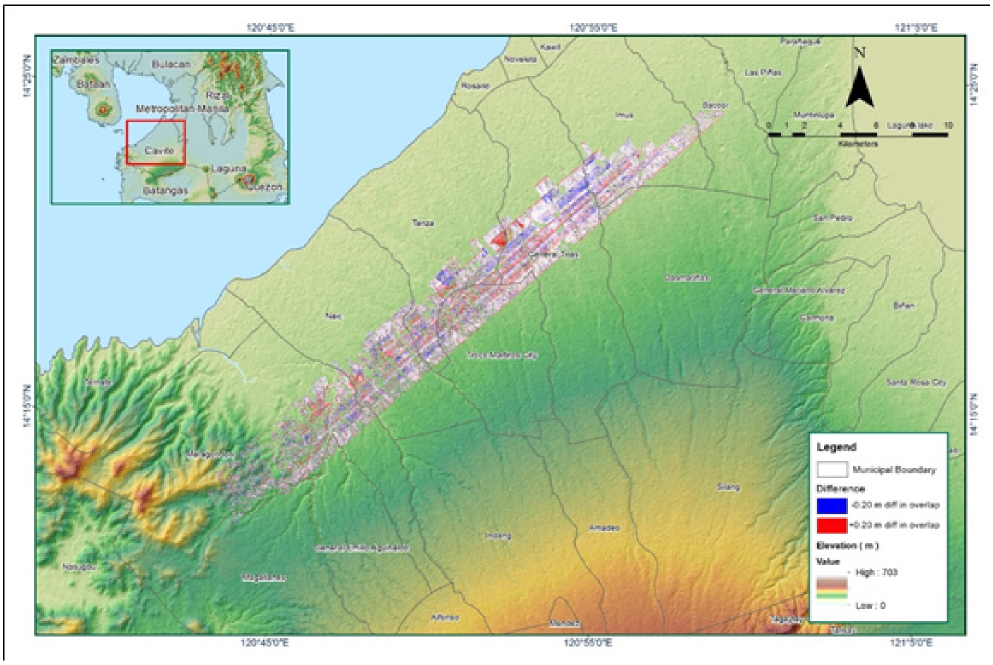


Image of Data Overlap

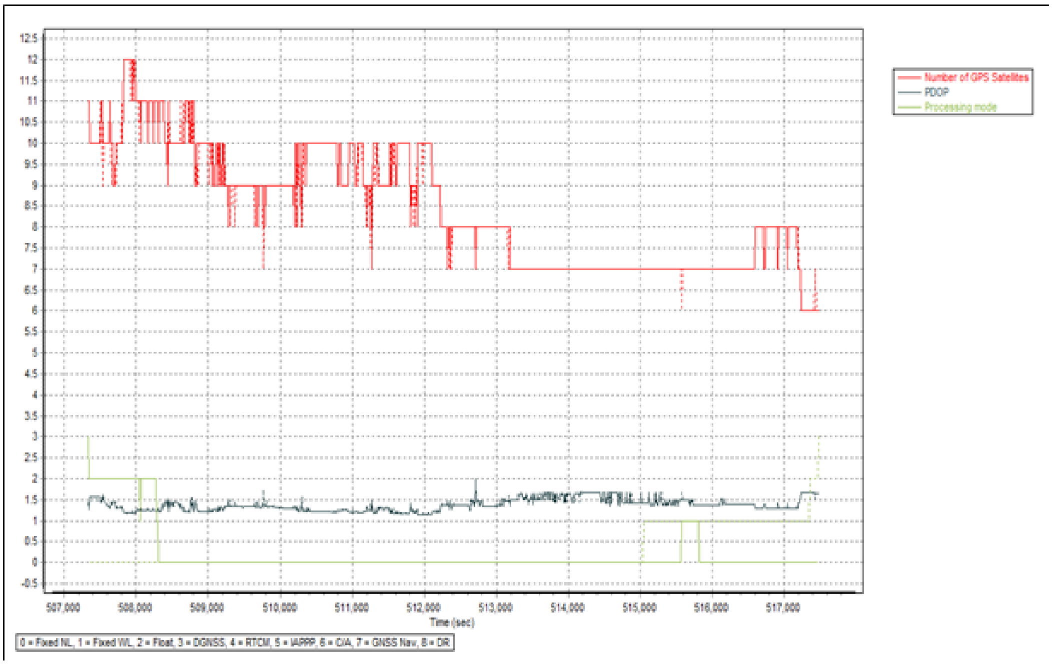


Density map of merged LiDAR data

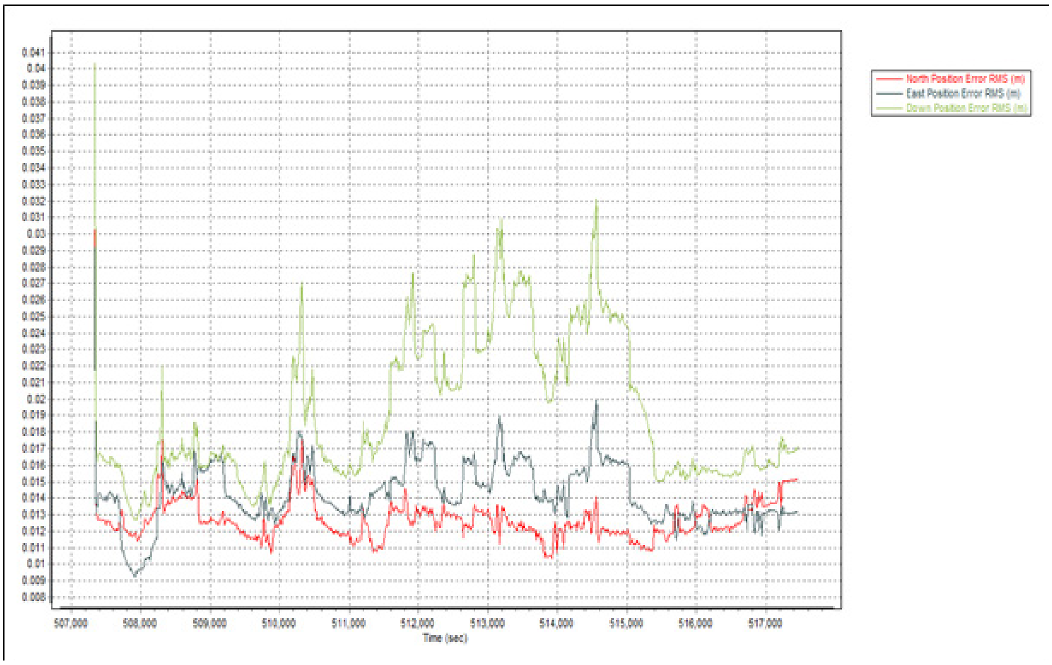


Elevation difference between flight lines

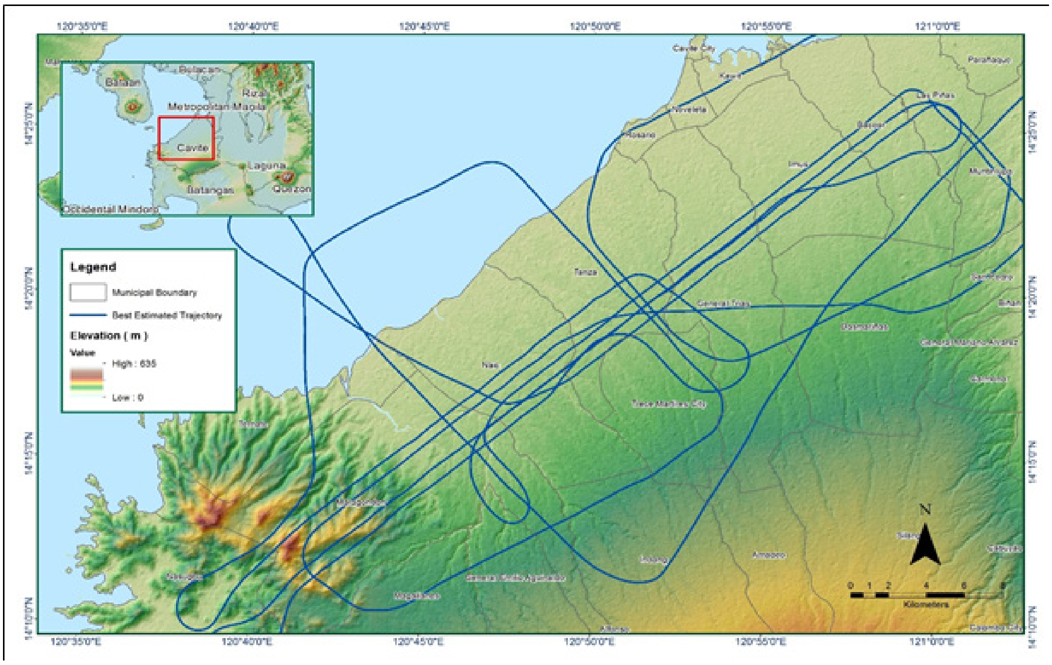
| **Flight Area** | **CALABARZON** |
|---|---|
| Mission Name | Blk18AB |
| Inclusive Flights | 1031P, 1027P |
| Range data size | 29.0 GB |
| Base data size | 14.75 MB |
| POS | 379 MB |
| Image | 7.11 GB |
| Transfer date | 04/23/2014 |
| | |
| Solution Status | |
| Number of Satellites (>6) | Yes |
| 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 |



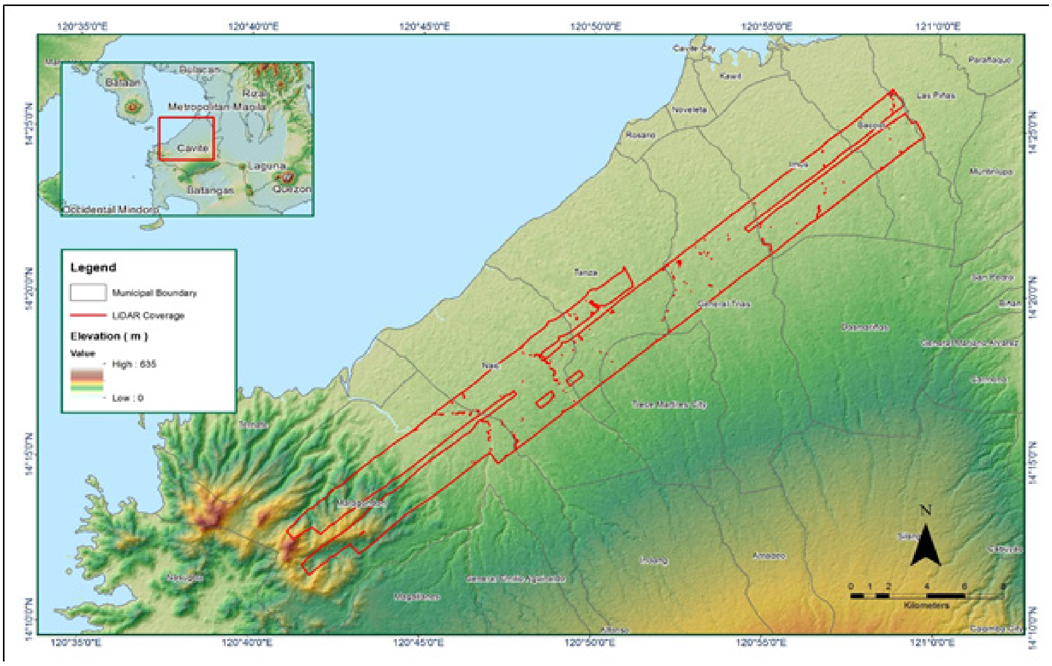
Solution Status Parameters



Smoothed Performance Metrics Parameters



Best Estimated Trajectory



Coverage of LiDAR data

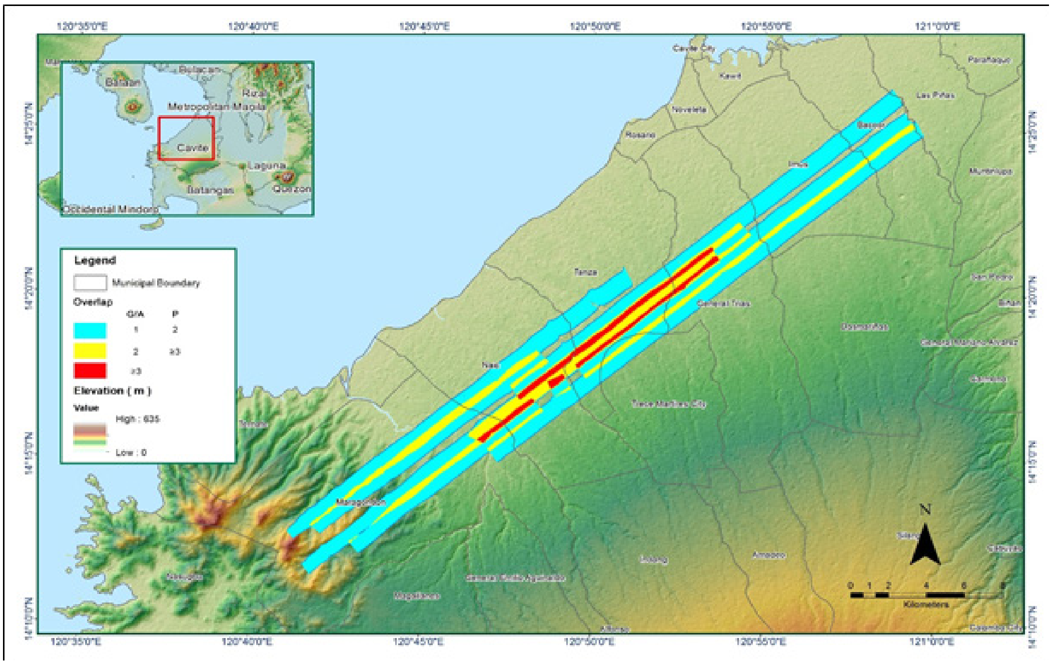
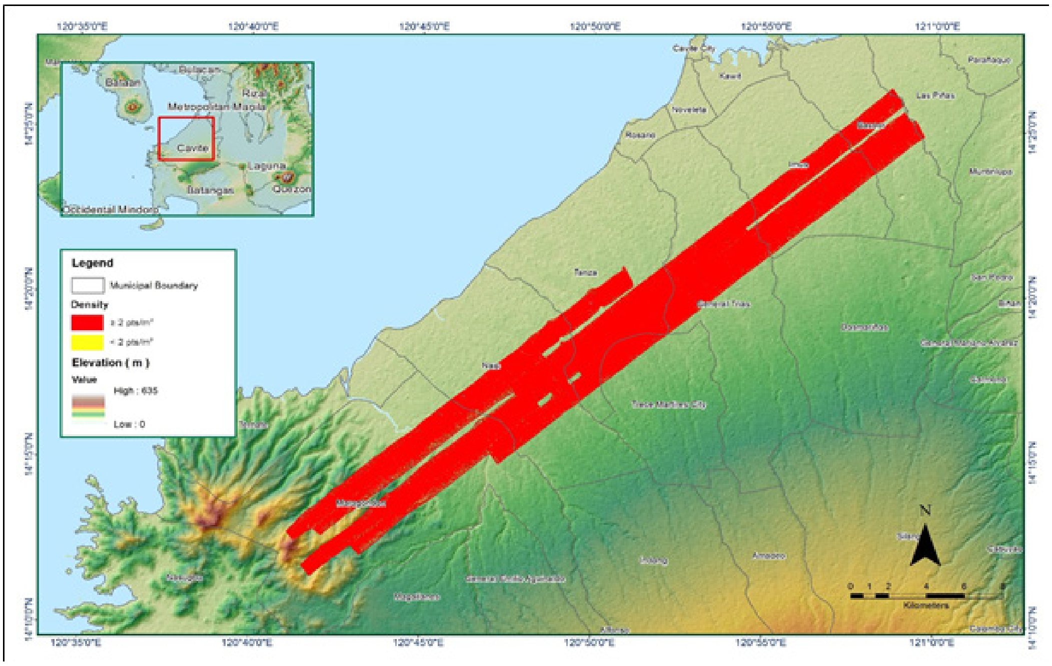
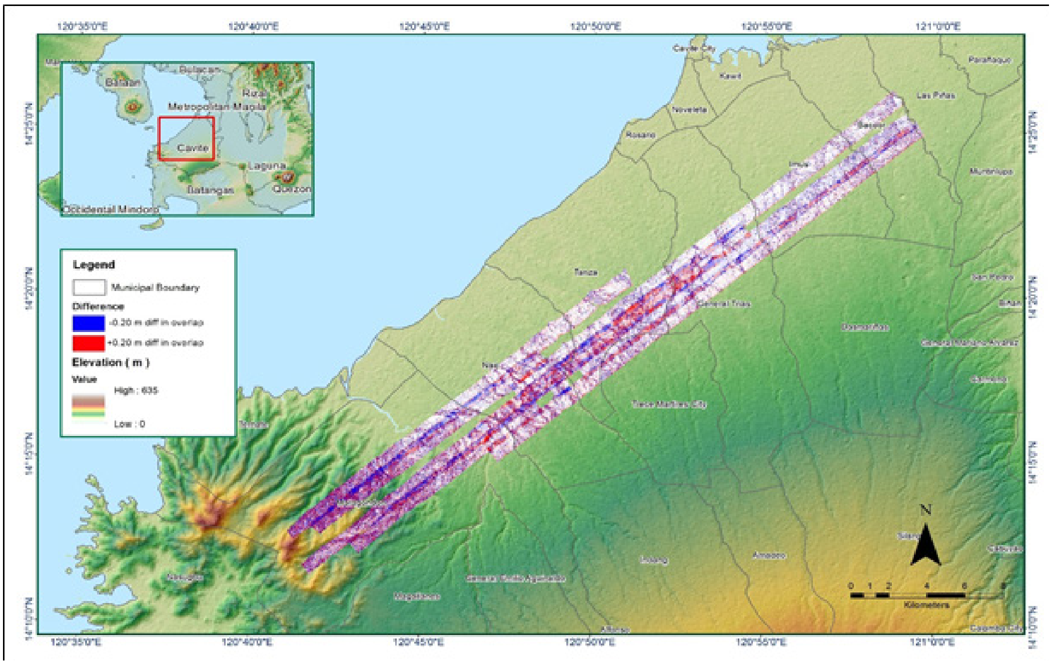


Image of Data Overlap

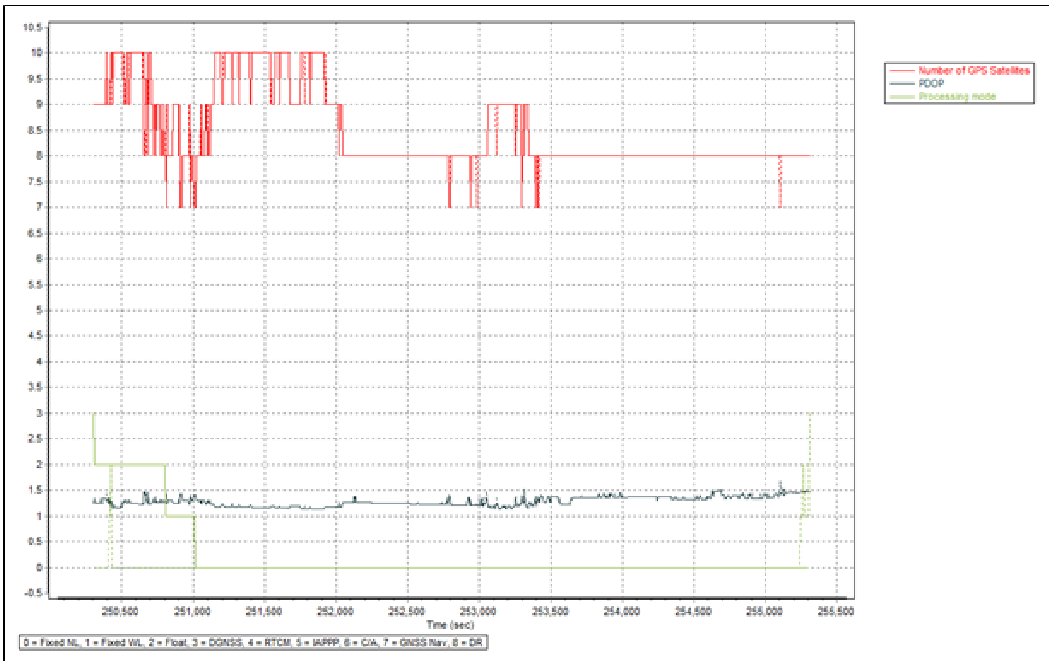


Density map of merged LiDAR data

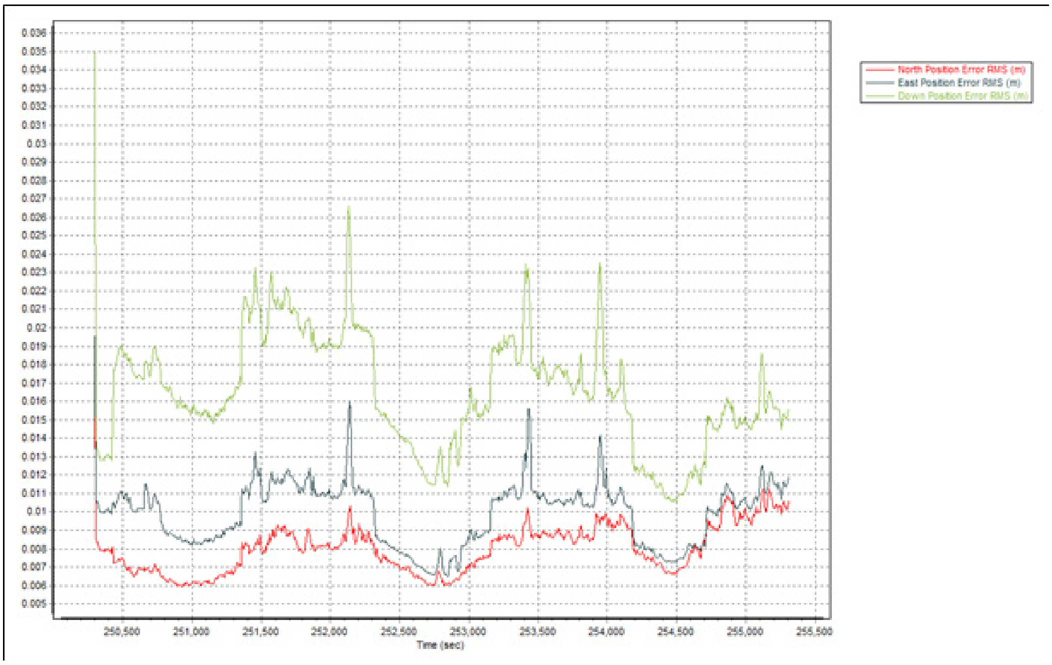


Elevation difference between flight lines

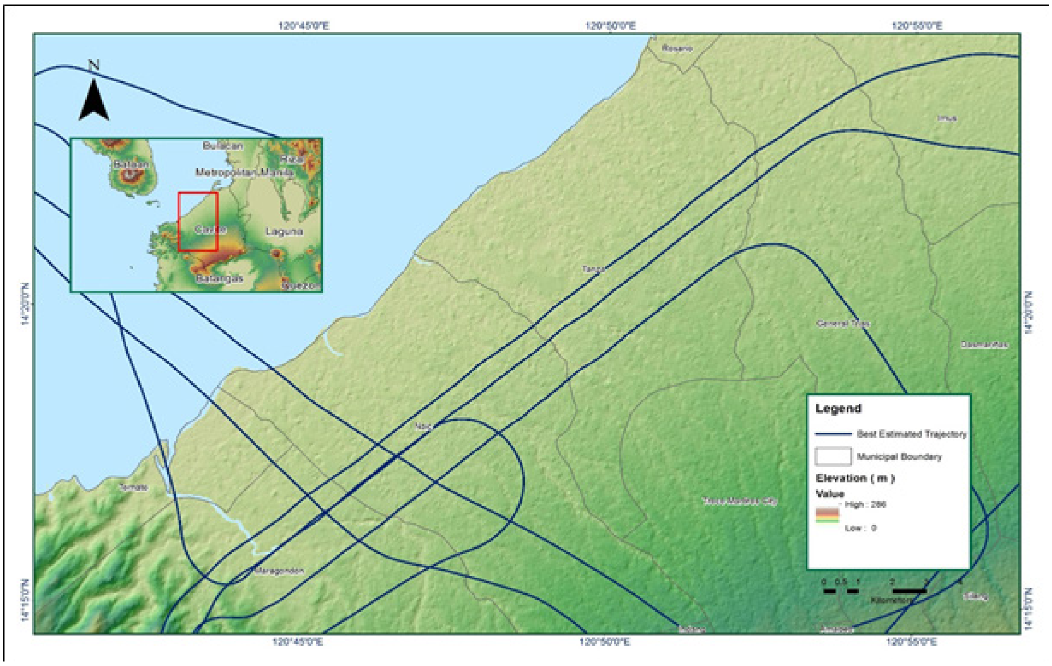
| **Flight Area** | **CALABARZON** |
|---|---|
| Mission Name | Blk18A_supplement |
| Inclusive Flights | 1043P |
| Range data size | 6.13 GB |
| Base data size | 6.79 MB |
| POS | 125 MB |
| Image | N/A |
| Transfer date | 04/23/2014 |
| | |
| Solution Status | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | No |
| Processing Mode (<=1) | No |
| | |
| Smoothed Performance Metrics (in cm) | |
| RMSE for North Position (<4.0 cm) | 1.1 |
| RMSE for East Position (<4.0 cm) | 1.6 |
| RMSE for Down Position (<8.0 cm) | 2.6 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000829 |
| IMU attitude correction stdev (<0.001deg) | 0.001021 |
| GPS position stdev (<0.01m) | 0.0013 |
| | |
| Minimum % overlap (>25) | 11.00% |
| Ave point cloud density per sq.m. (>2.0) | 2.31 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 103 |
| Maximum Height | 157.83 m |
| Minimum Height | 45.2 m |
| | |
| Classification (# of points) | |
| Ground | 76,835,956 |
| Low vegetation | 48,258,042 |
| Medium vegetation | 42,822,105 |
| High vegetation | 19,332,576 |
| Building | 7,920,574 |
| | |
| Orthophoto | No |
| Processed by | Engr. Angelo Carlo Bongat, Celina, Engr. Gladys Mae Apat |



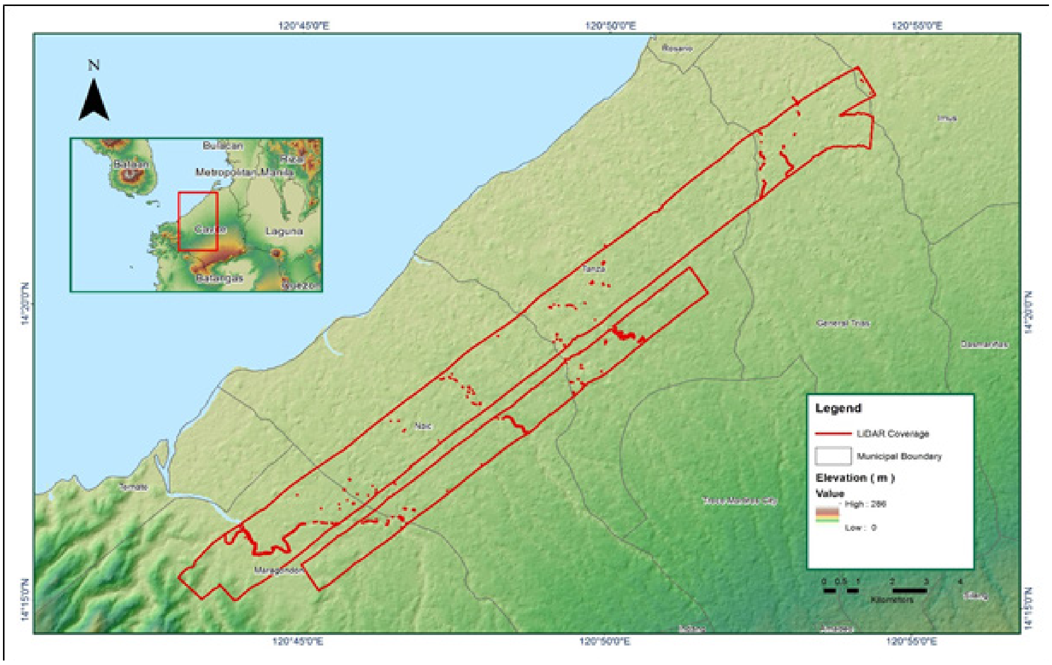
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

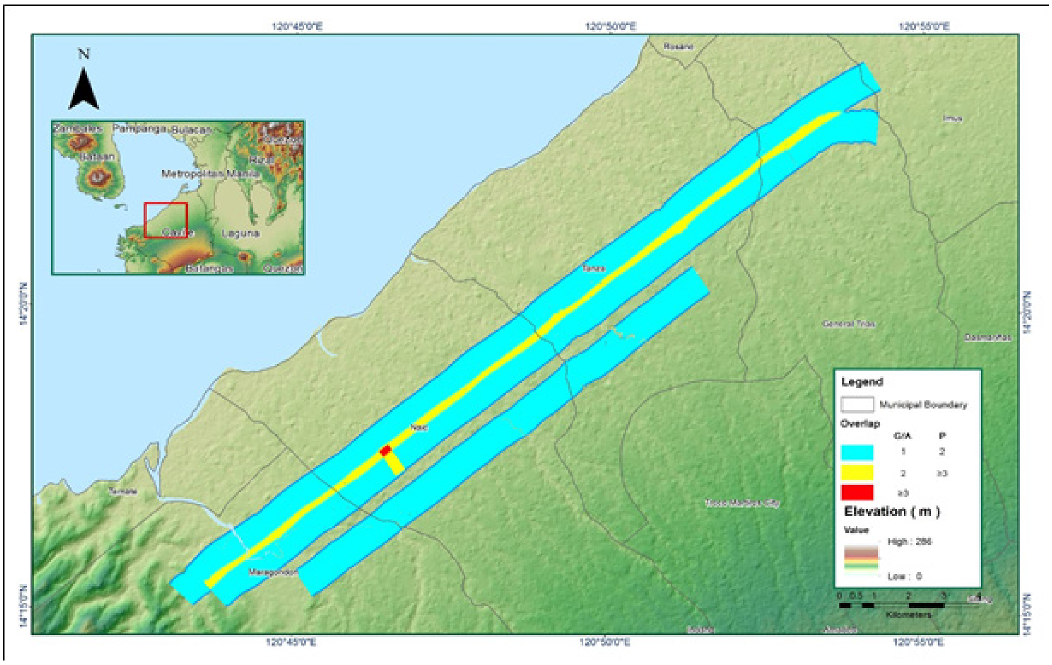
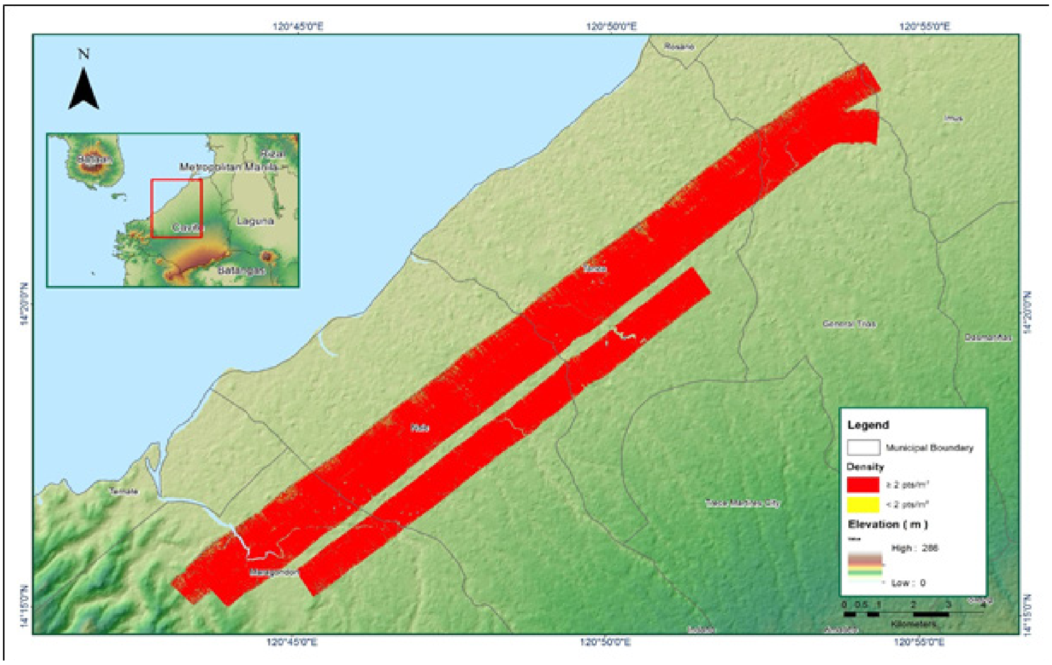
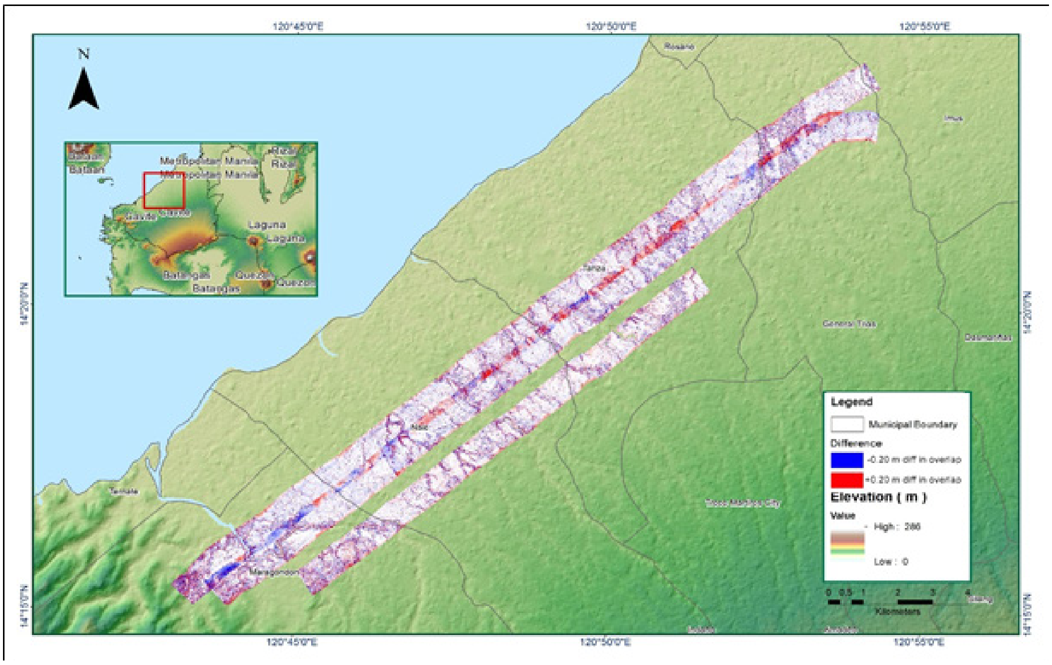


Image of Data Overlap

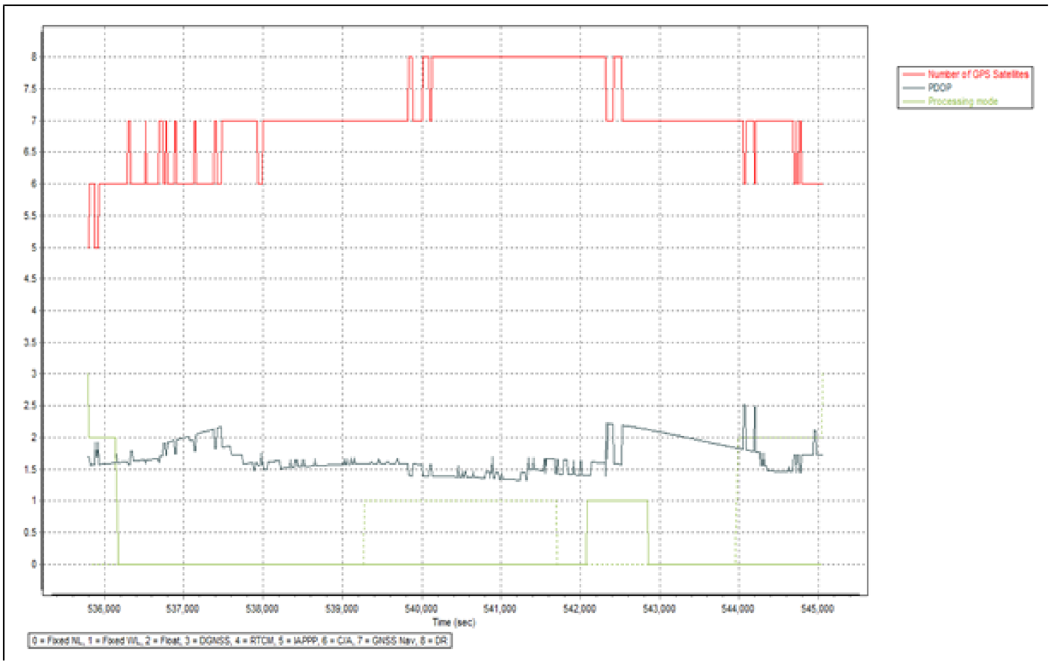


Density map of merged LiDAR data

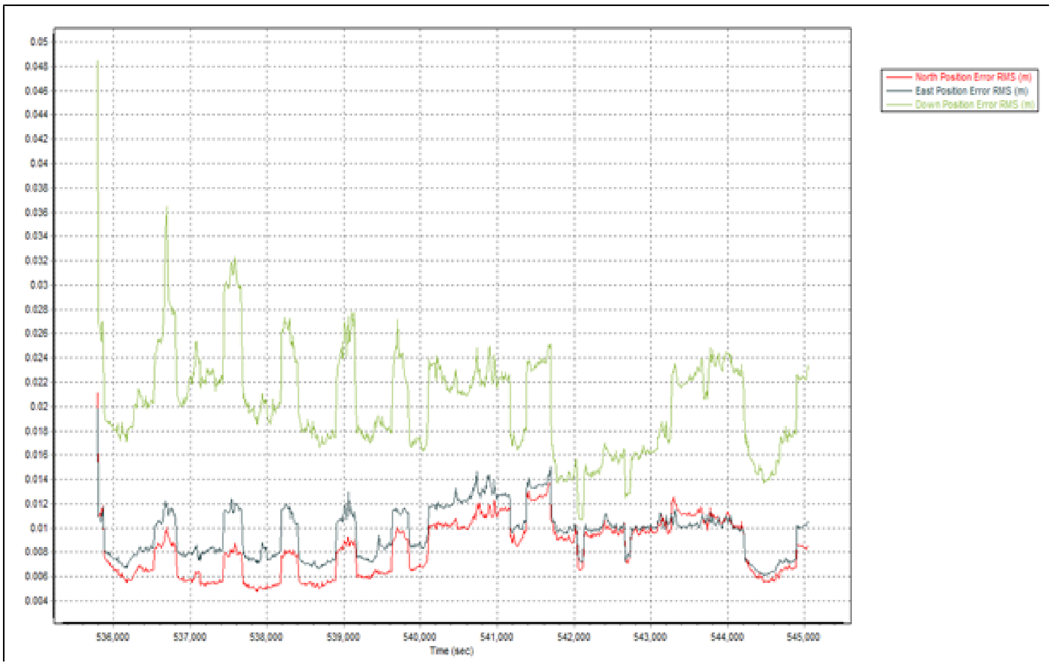


Elevation difference between flight lines

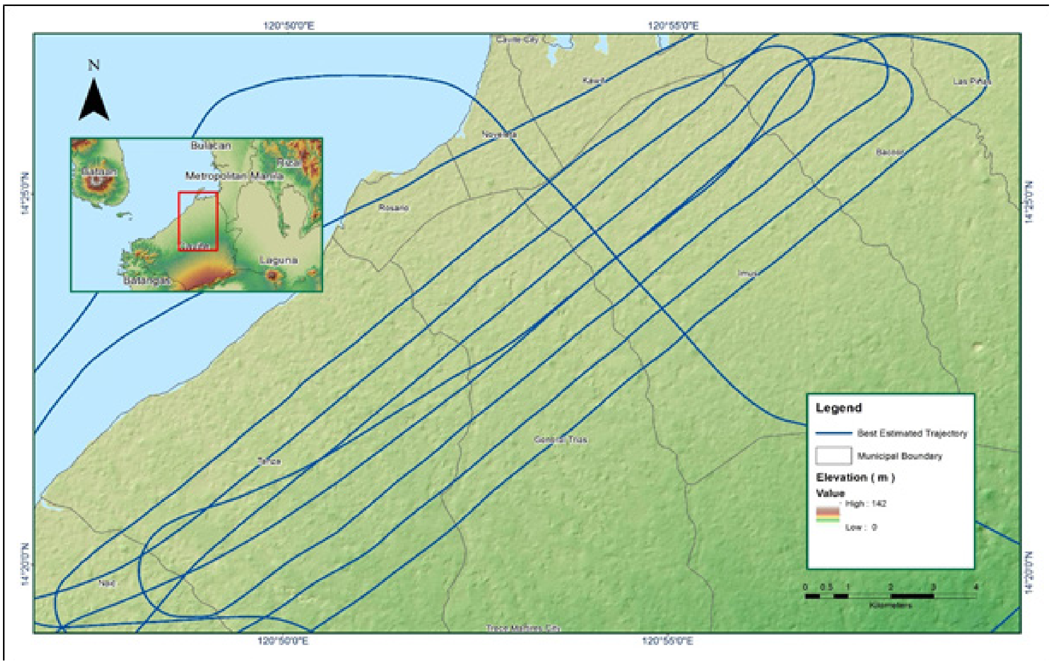
| **Flight Area** | **CALABARZON** |
|---|---|
| Mission Name | Blk18As2 |
| Inclusive Flights | 1141P (formerly 1139P) |
| Range data size | 15.4 GB |
| Base data size | 6.25 MB |
| POS | 219 MB |
| Image | 24 GB |
| Transfer date | 04/23/2014 |
| | |
| Solution Status | |
| Number of Satellites (>6) | 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 |



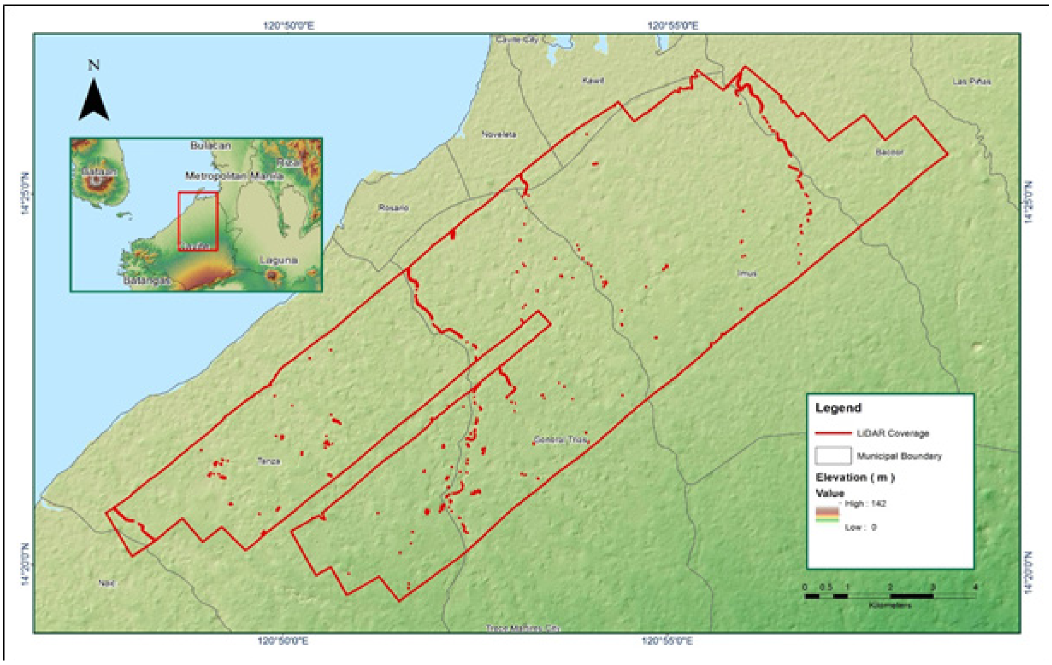
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

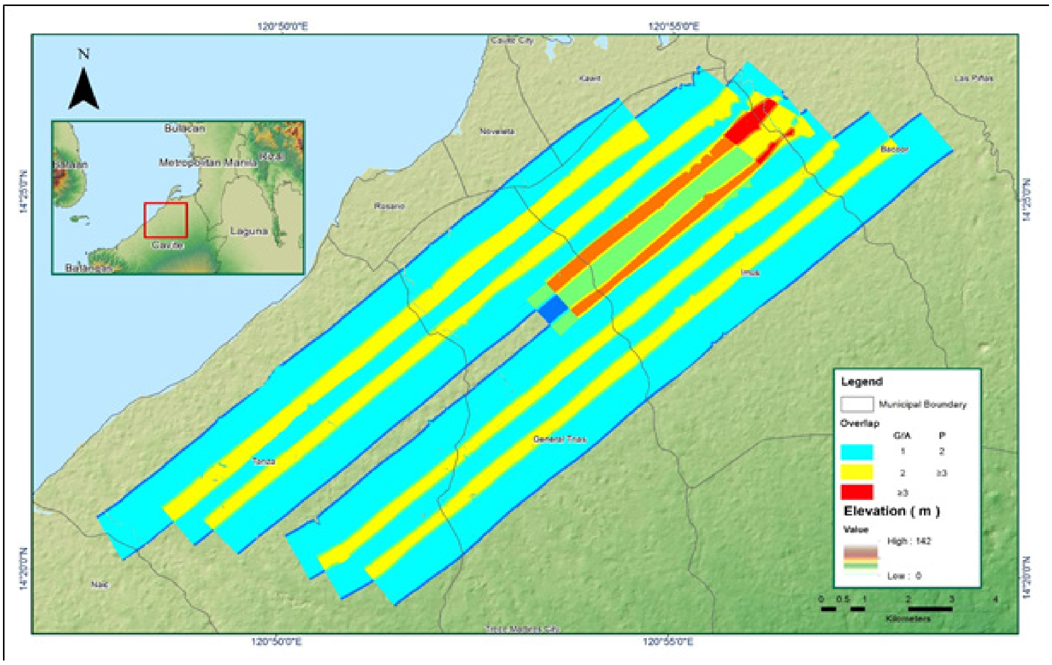
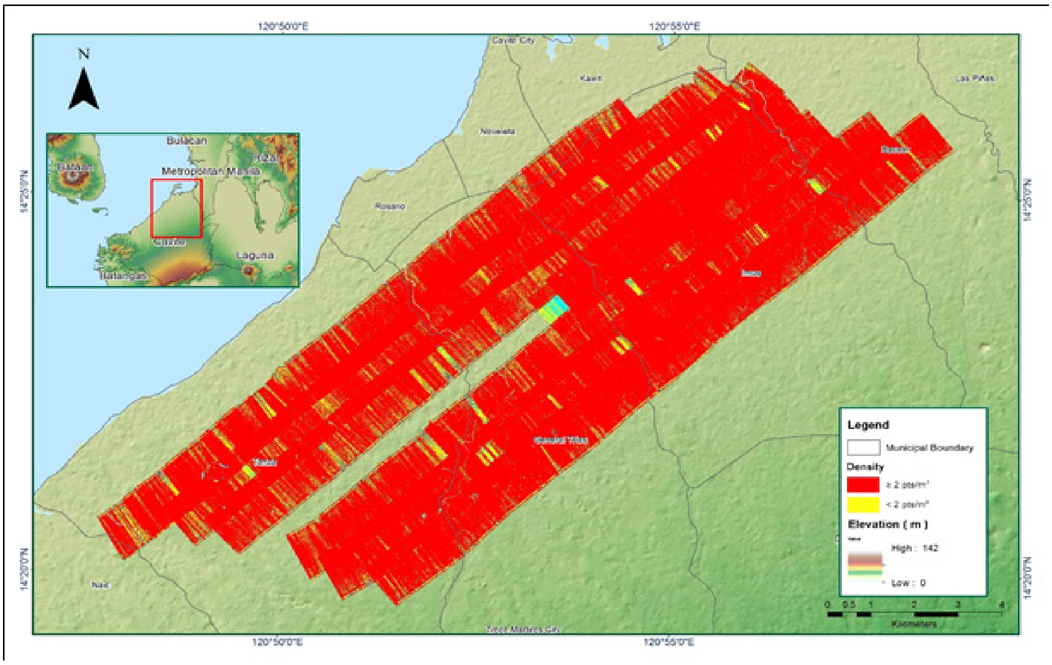
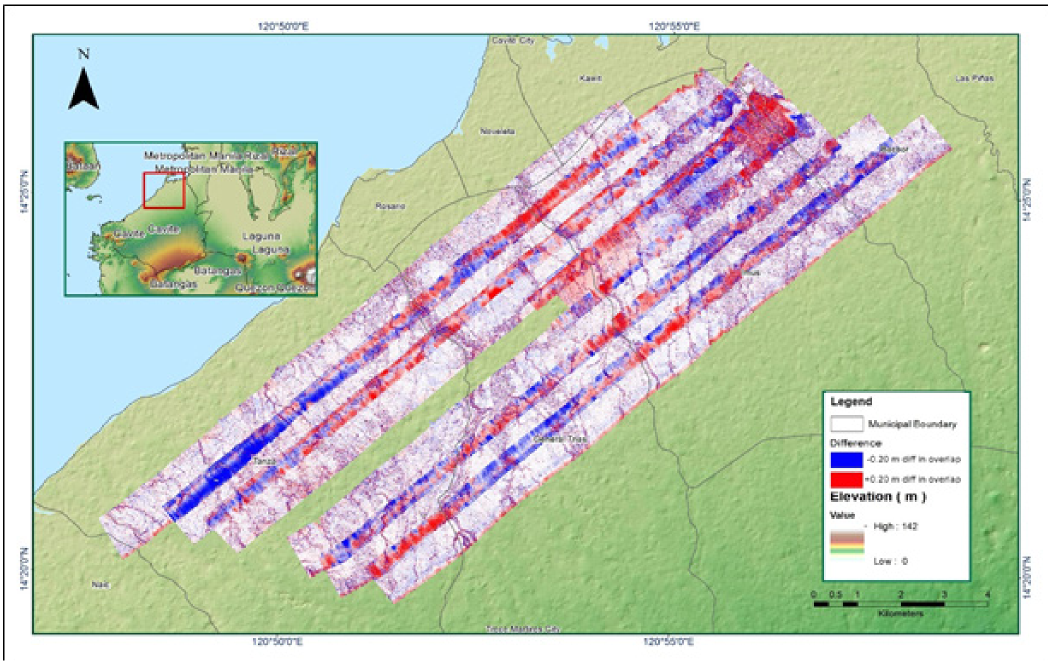


Image of Data Overlap

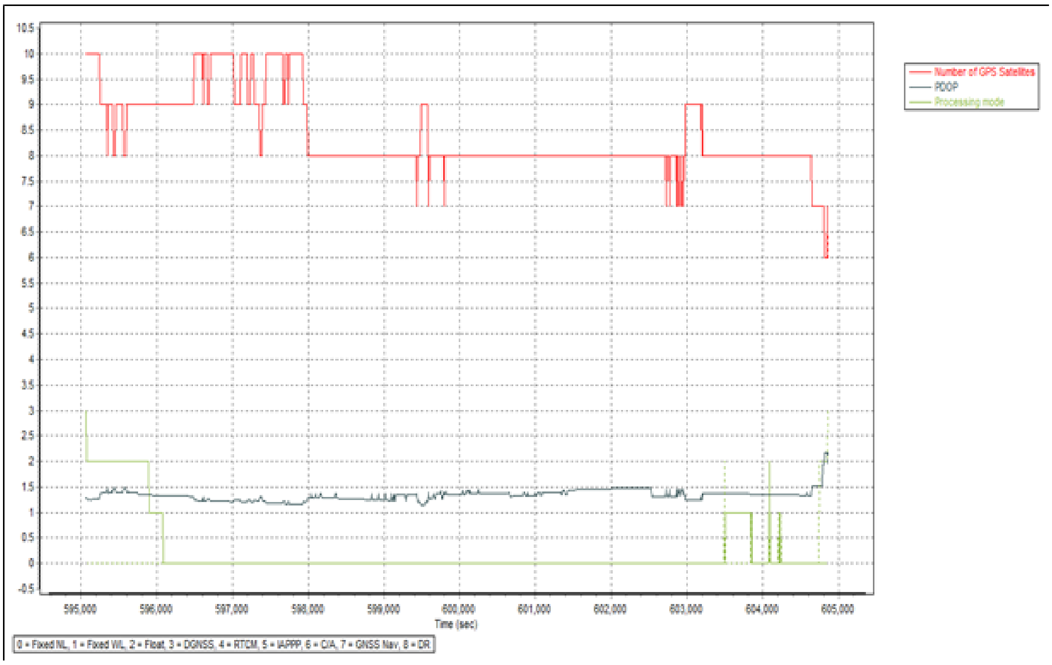


Density map of merged LiDAR data

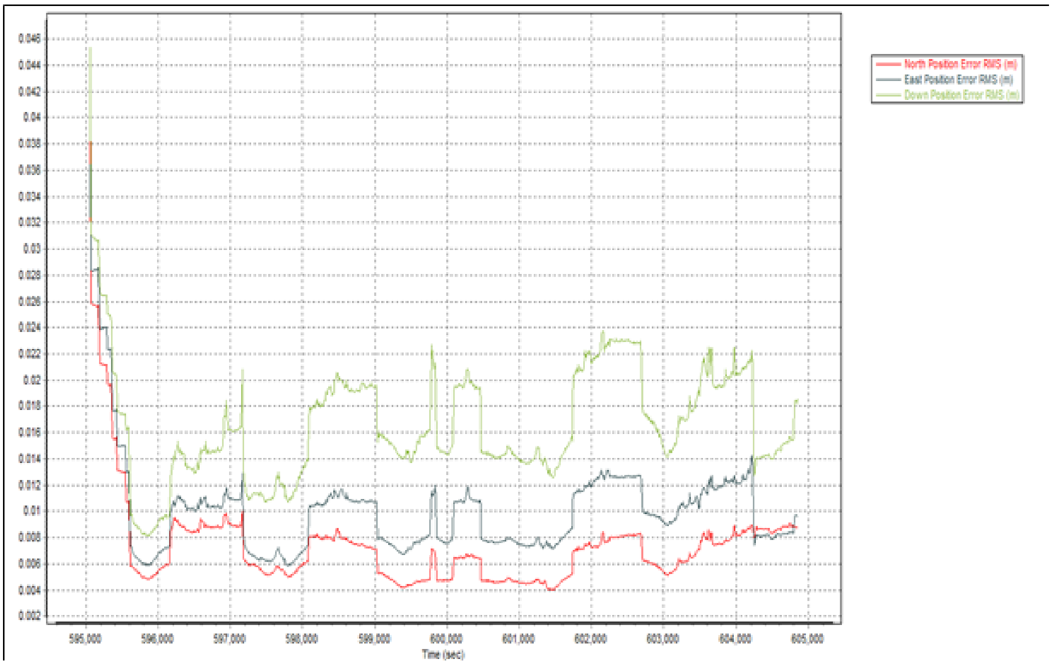


Elevation difference between flight lines

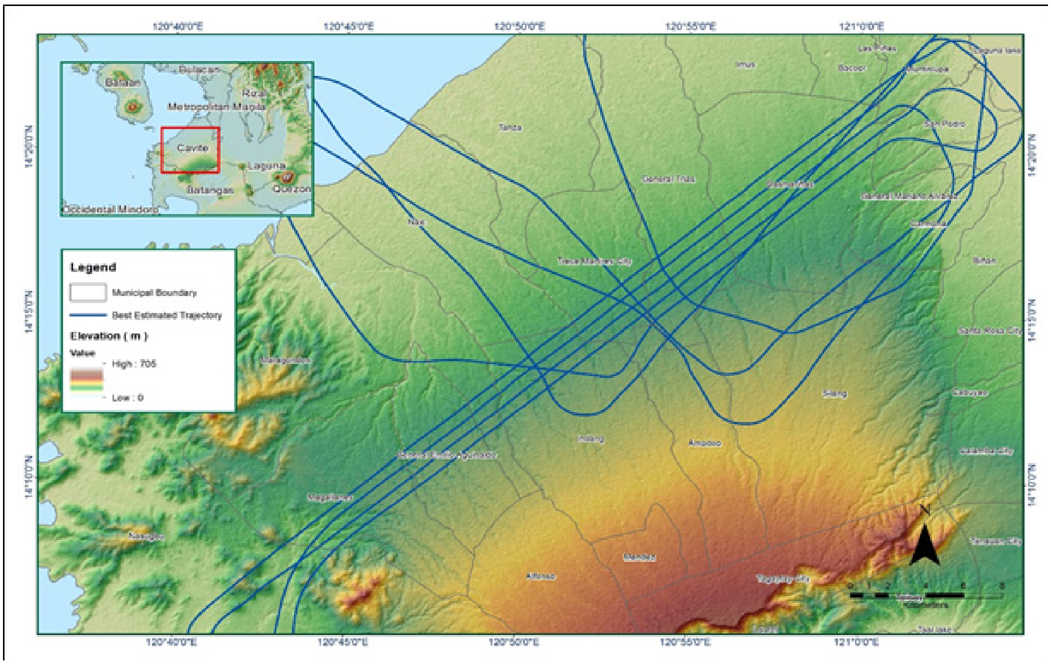
| **Flight Area** | **CALABARZON** |
|---|---|
| Mission Name | Blk18C |
| Inclusive Flights | 1031P |
| Range data size | 14.7 GB |
| Base data size | 8.04 MB |
| POS | 185 MB |
| Image | N/A |
| Transfer date | 04/23/2014 |
| | |
| Solution Status | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | 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 |



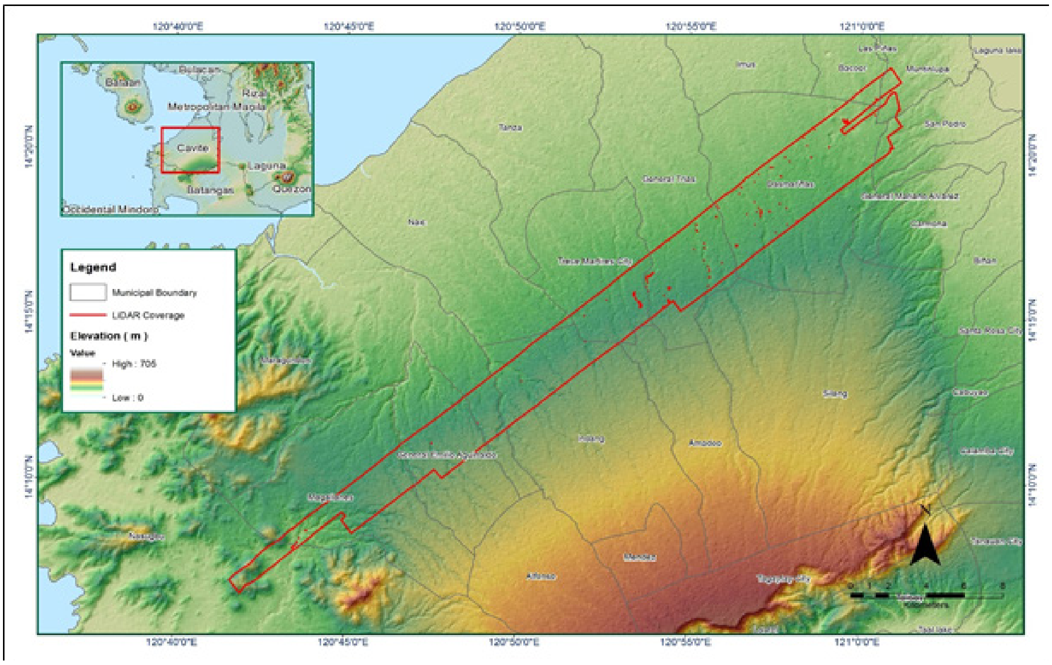
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

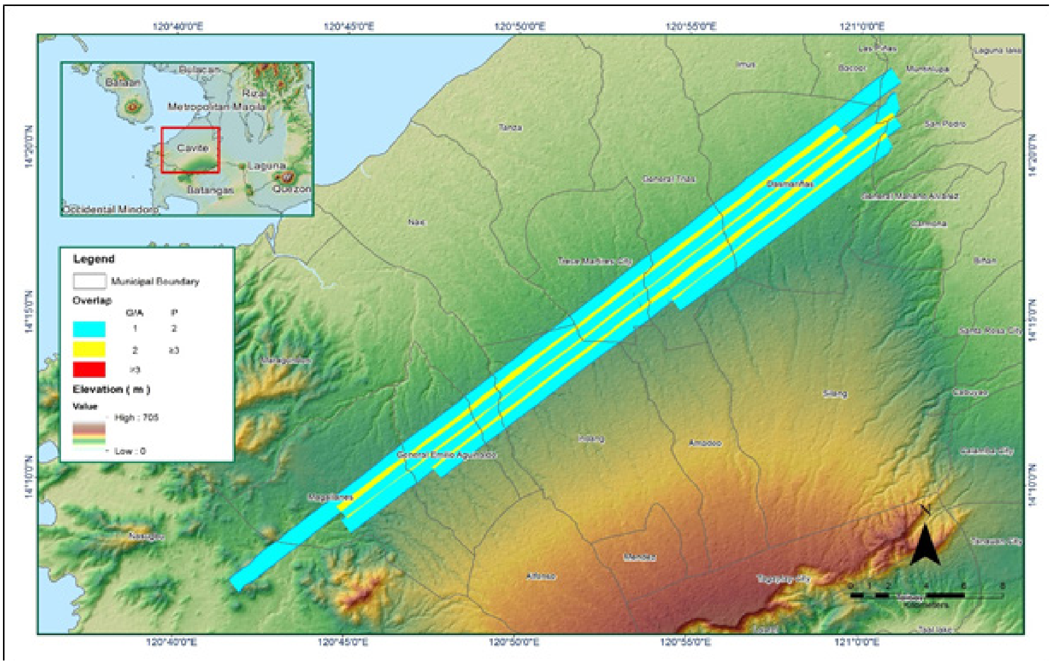
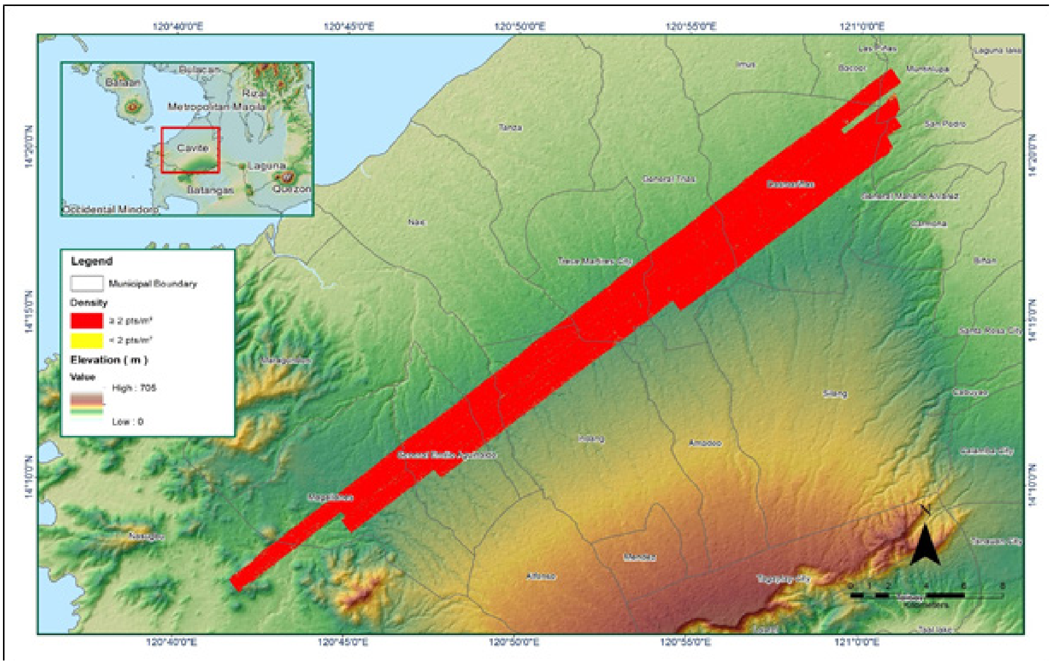
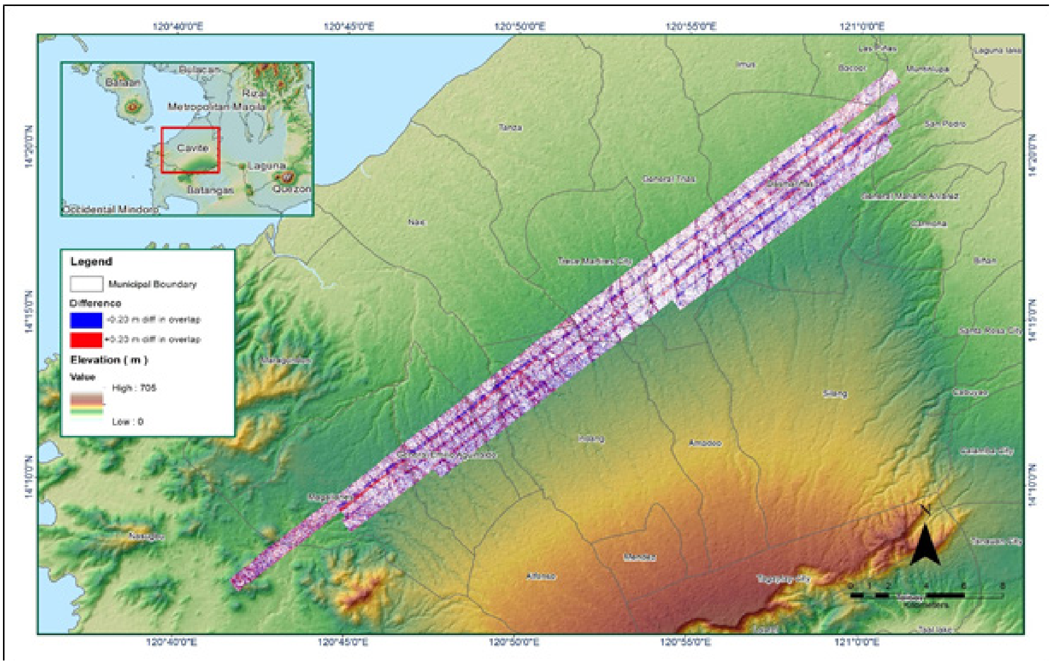


Image of Data Overlap

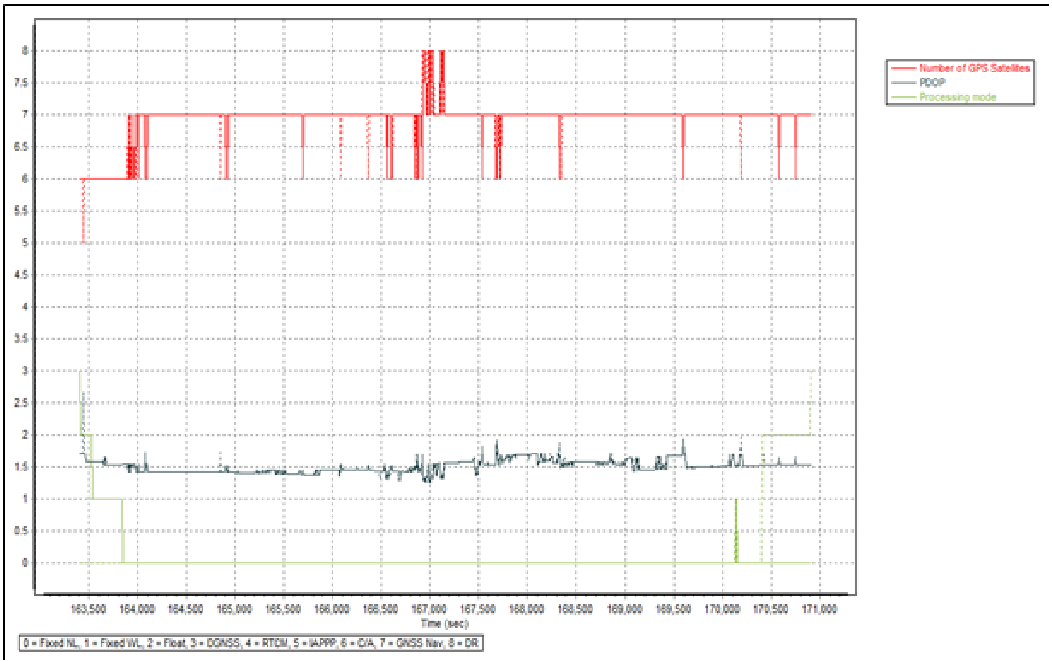


Density map of merged LiDAR data

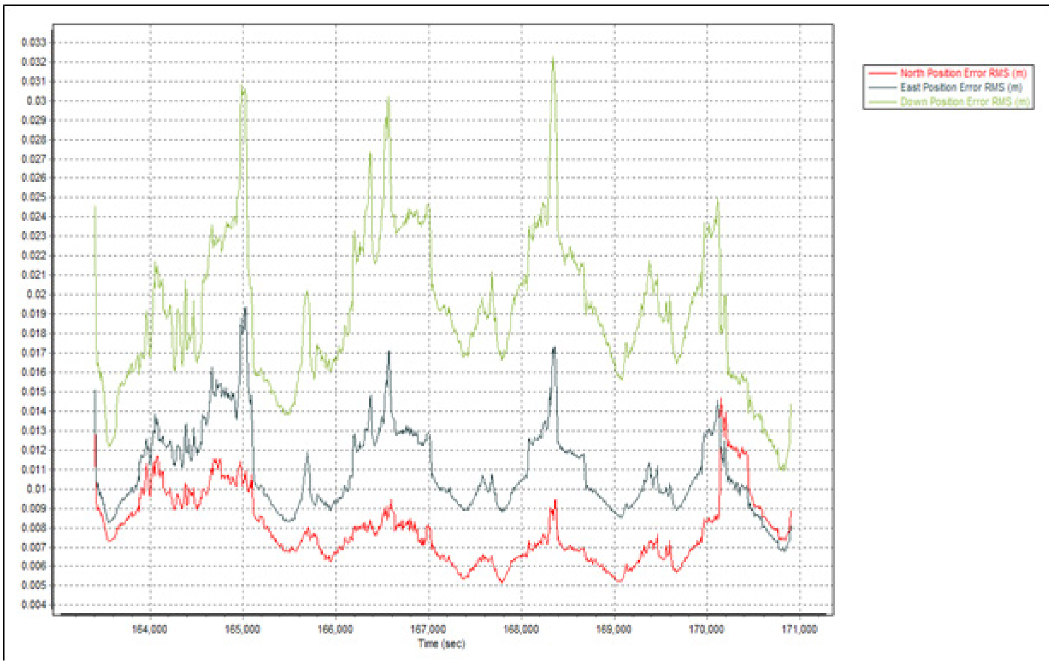


Elevation difference between flight lines

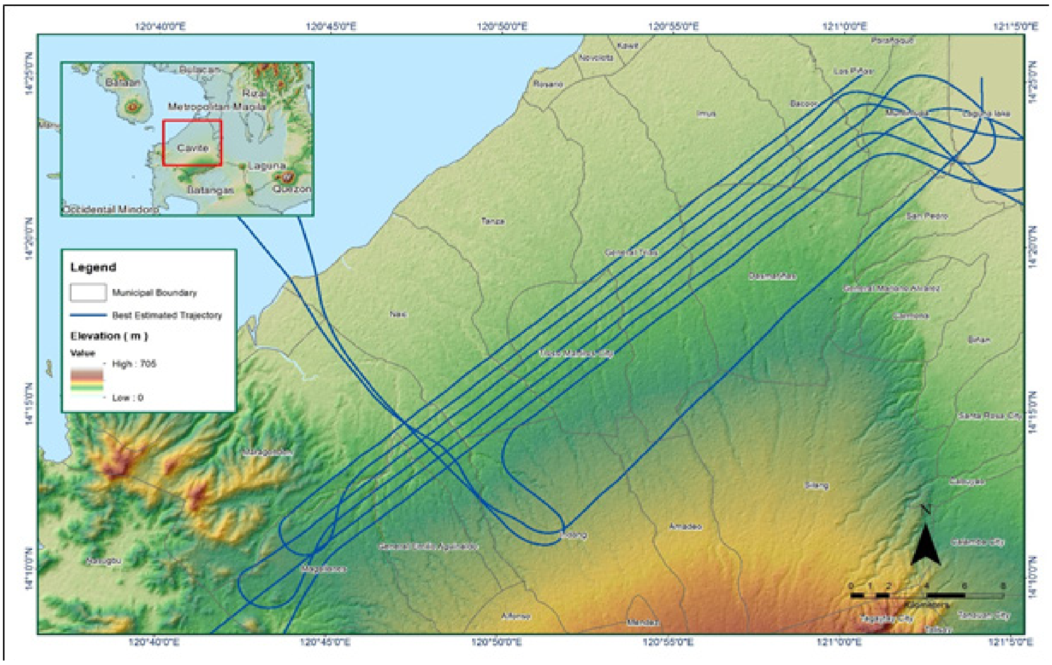
| **Flight Area** | **CALABARZON** |
|---|---|
| Mission Name | Blk18C_additional |
| Inclusive Flights | 1031P; 1063P |
| Range data size | 33.2 GB |
| Base data size | 14.00 MB |
| POS | 329 MB |
| Image | 19.2 GB |
| Transfer date | 04/23/2014 |
| | |
| Solution Status | |
| Number of Satellites (>6) | 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, Celina Rosete |



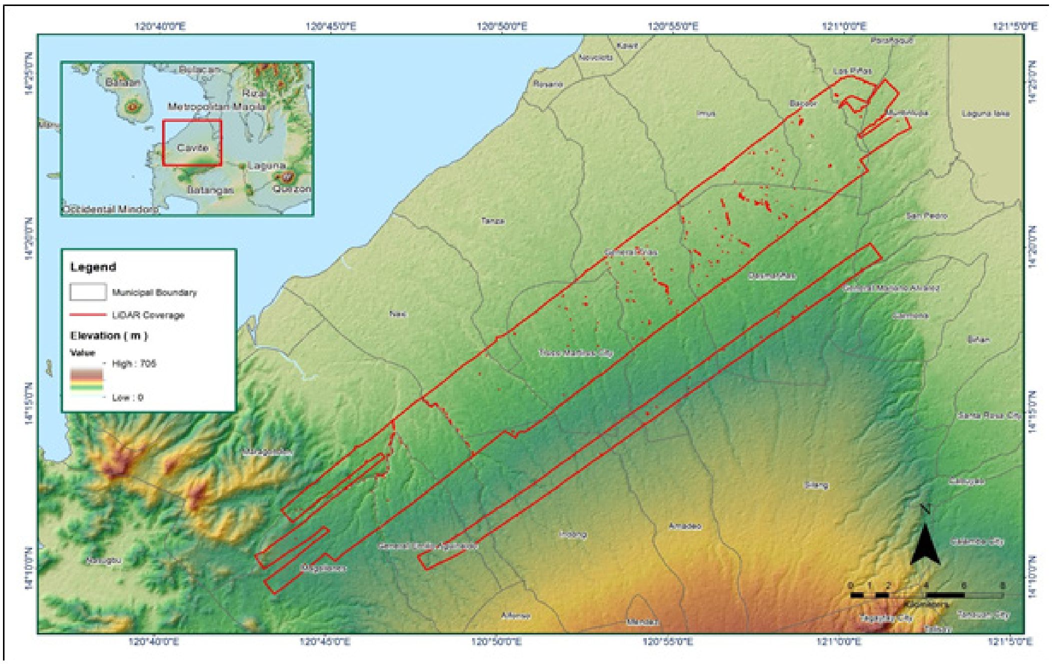
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

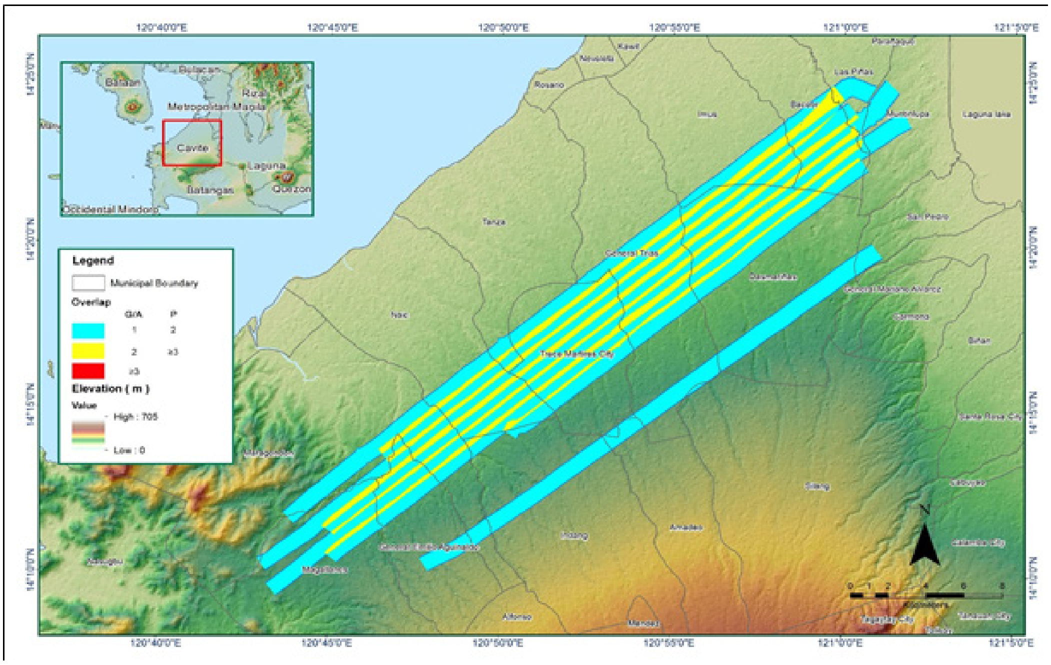
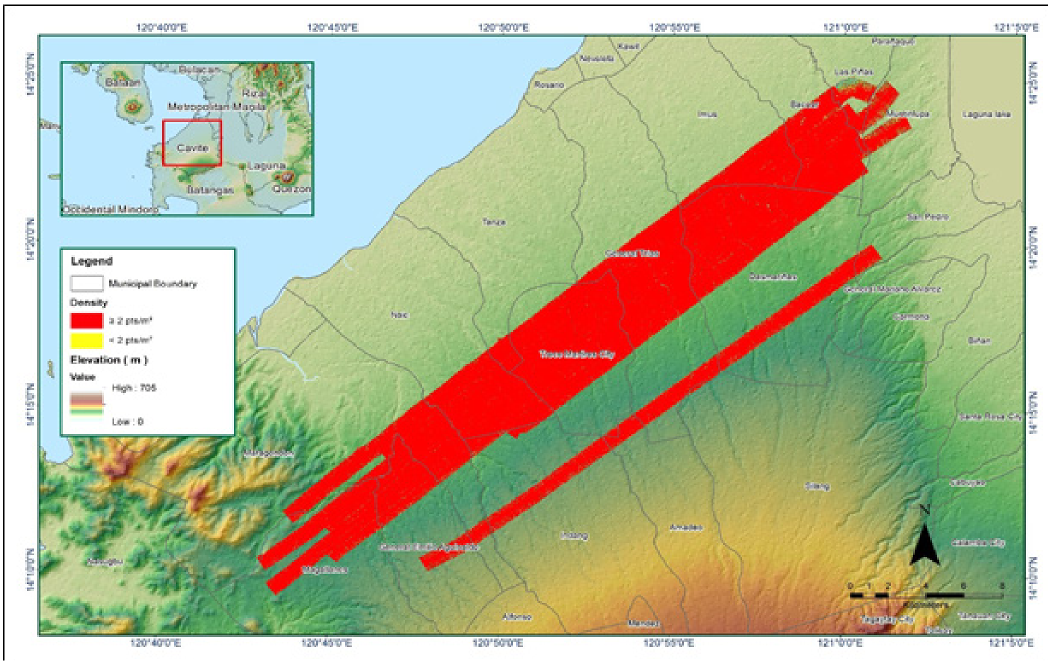
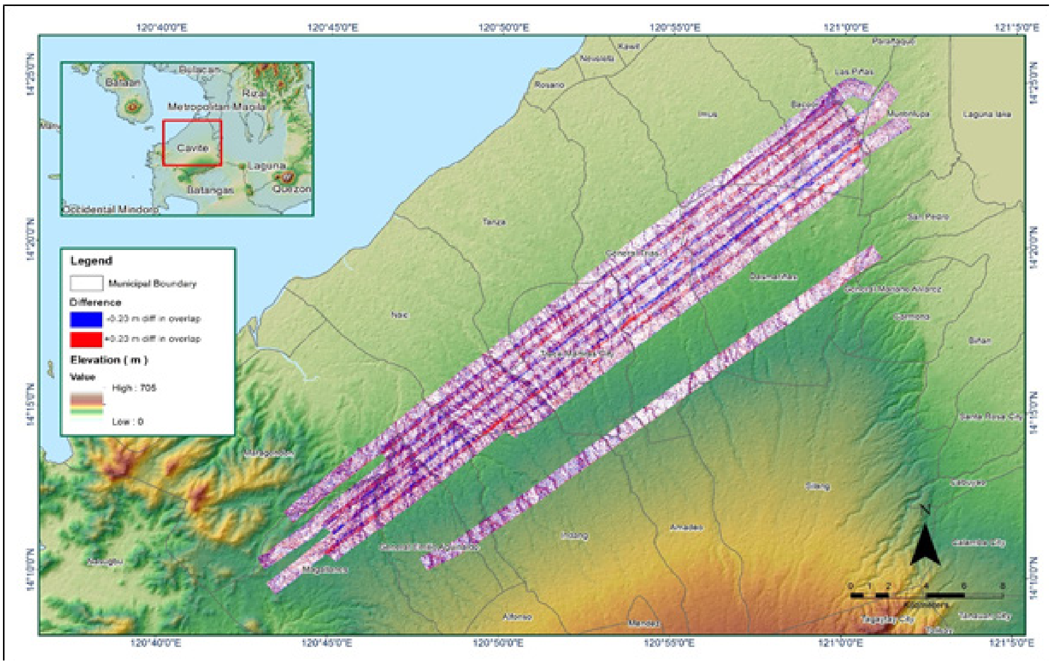


Image of Data Overlap

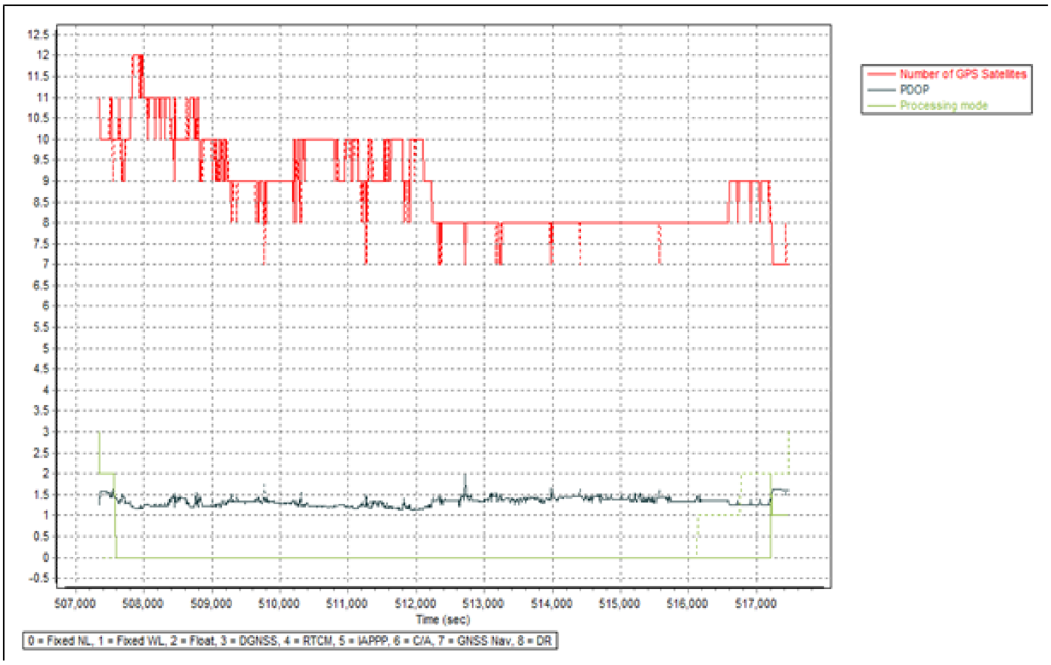


Density map of merged LiDAR data

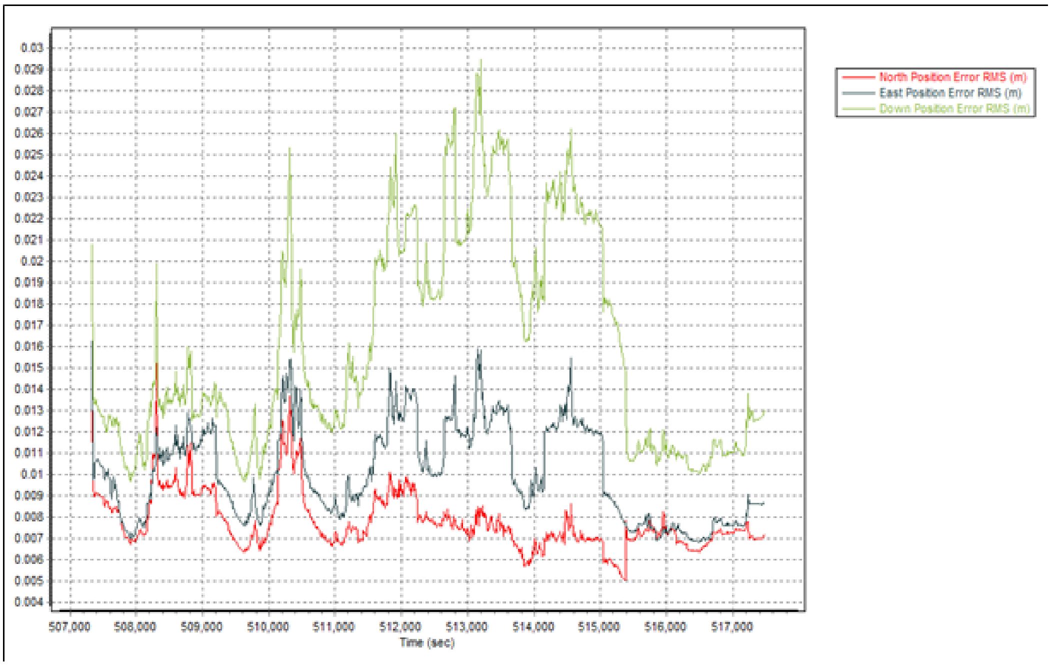


Elevation difference between flight lines

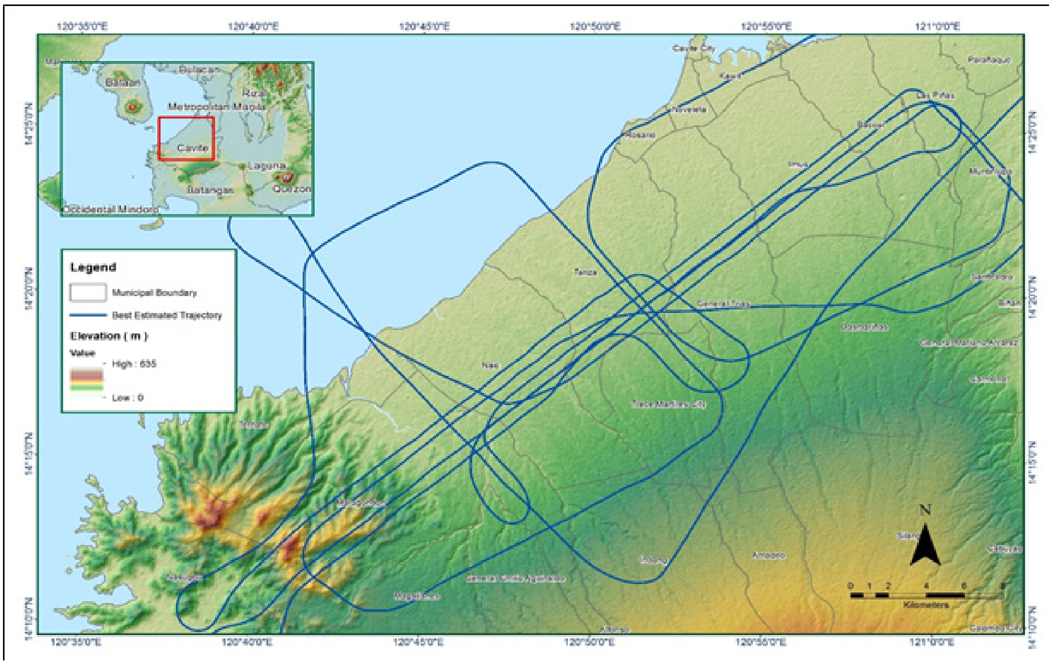
| **Flight Area** | **CALABARZON** |
|---|---|
| Mission Name | Blk18Bs |
| Inclusive Flights | 1023P; 1027P |
| Range data size | 23.58 GB |
| Base data size | 14.75 MB |
| POS | 246.6 MB |
| Image | 18.91 GB |
| Transfer date | 04/23/2014 |
| | |
| Solution Status | |
| Number of Satellites (>6) | 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) | 1.6 |
| RMSE for Down Position (<8.0 cm) | 2.9 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000547 |
| IMU attitude correction stdev (<0.001deg) | 0.001564 |
| GPS position stdev (<0.01m) | 0.0077 |
| | |
| Minimum % overlap (>25) | 28.57% |
| Ave point cloud density per sq.m. (>2.0) | 3.24 |
| Elevation difference between strips (<0.20 m) | Yessss |
| | |
| Number of 1km x 1km blocks | 202 |
| Maximum Height | 593.69 m |
| Minimum Height | 45.52 m |
| | |
| Classification (# of points) | |
| Ground | 111,841,053 |
| Low vegetation | 50,974,483 |
| Medium vegetation | 64,960,681 |
| High vegetation | 47,229,609 |
| Building | 14,200,178 |
| | |
| Orthophoto | No |
| Processed by | Engr. Benjamin Jonah Magallon, Celina Rosete, Ryan Nicholai Dizon |



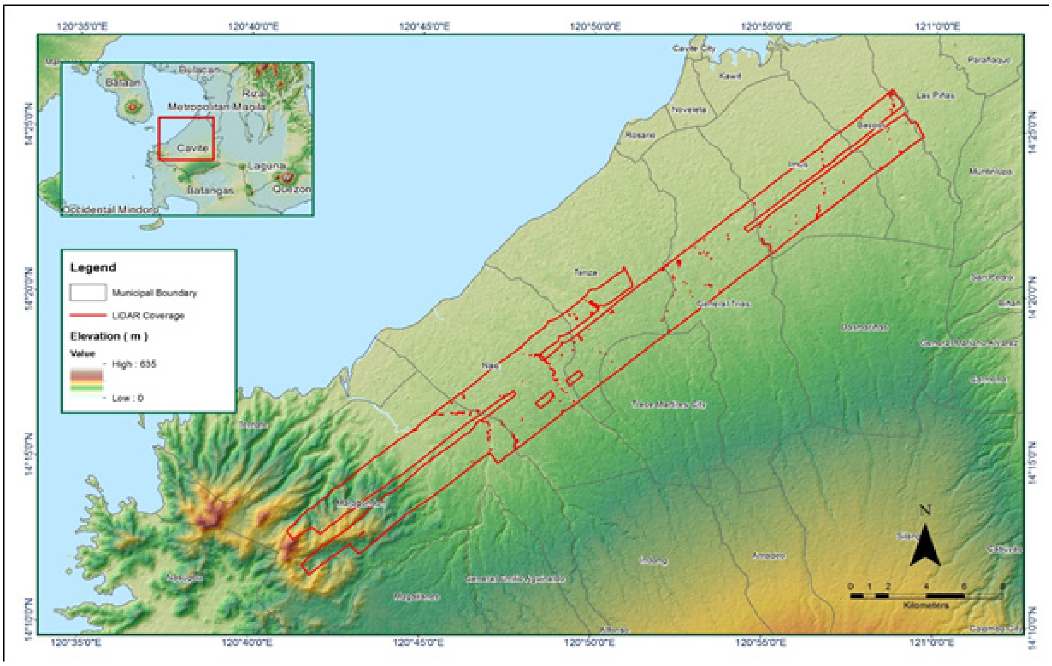
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

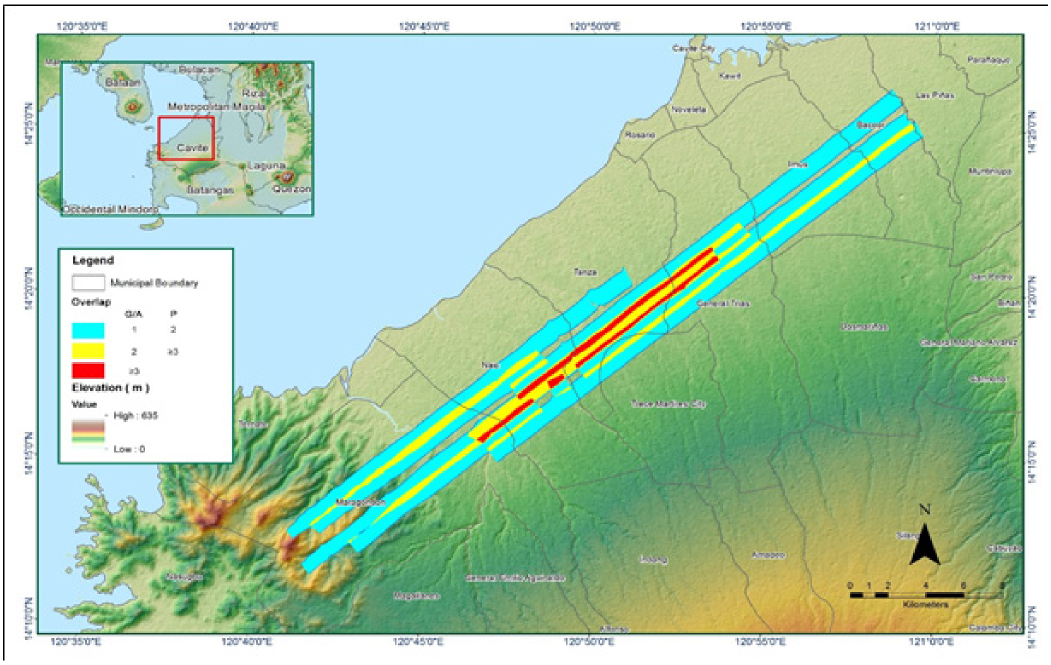
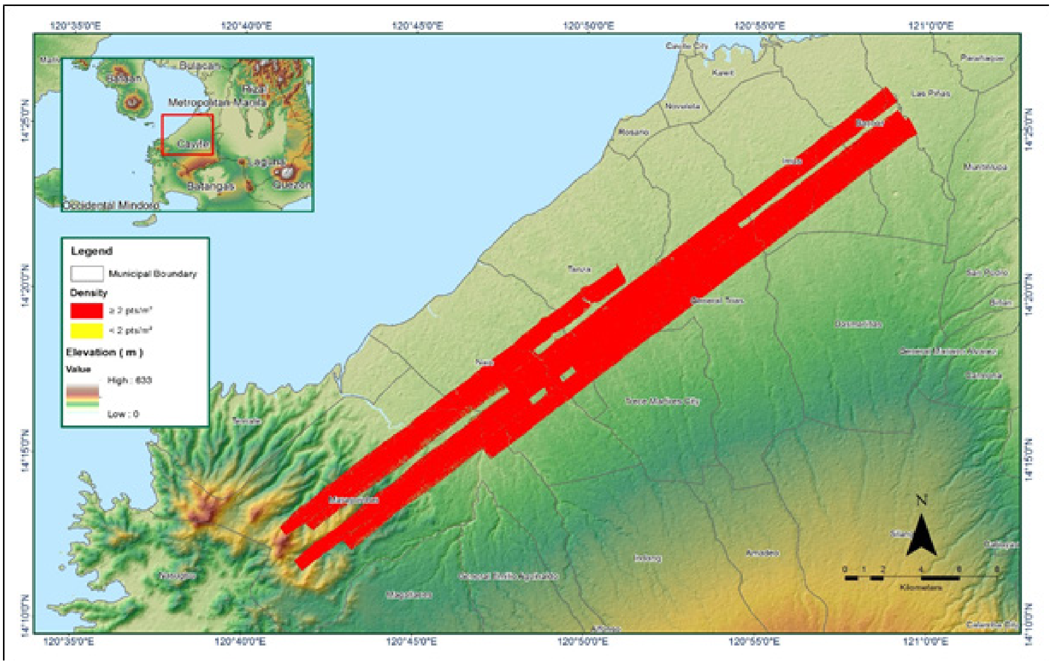
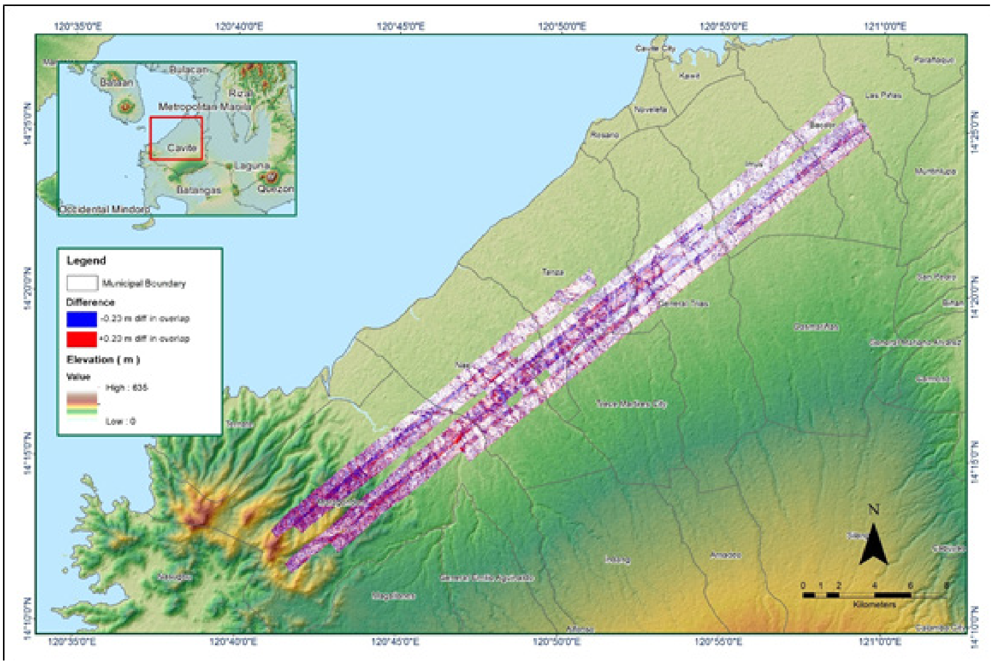


Image of Data Overlap

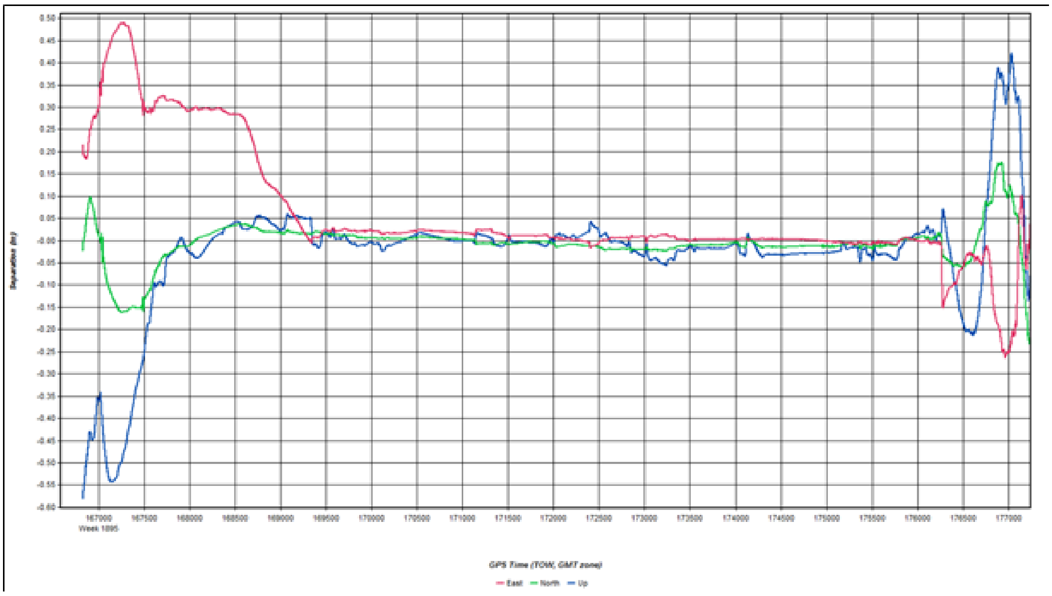


Density map of merged LiDAR data

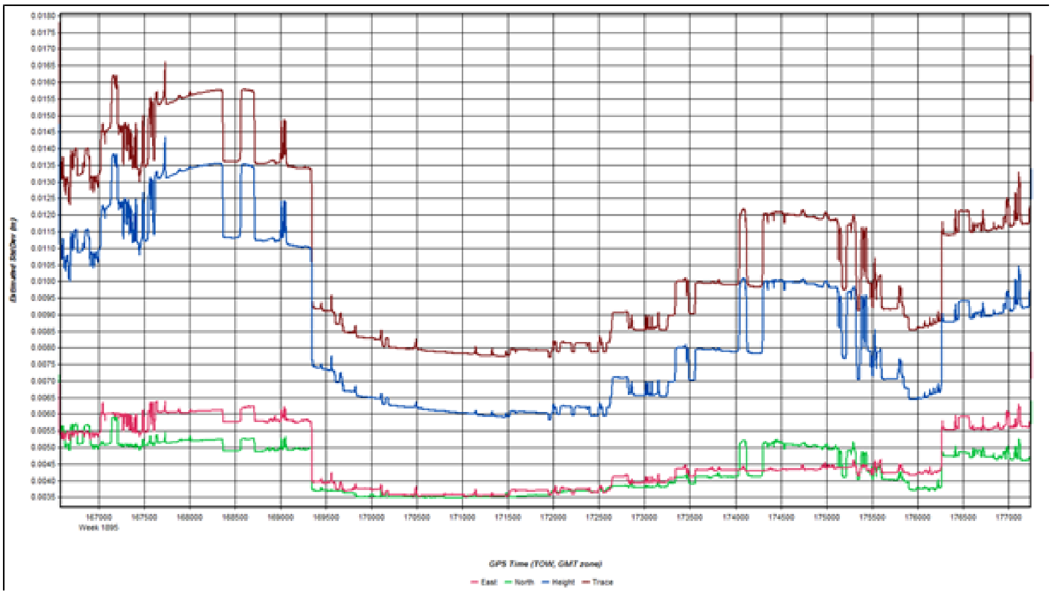


Elevation difference between flight lines

| Flight Area | Calabarzon Reflights |
|---|---|
| Mission Name | Blk18A |
| Inclusive Flights | 10136L, 10142L |
| RawLaser | 19.79 GB |
| Base data size | 200 MB |
| 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) | Yes |
| | |
| 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 Claudine Zarate |
| | |
| | |
| | |

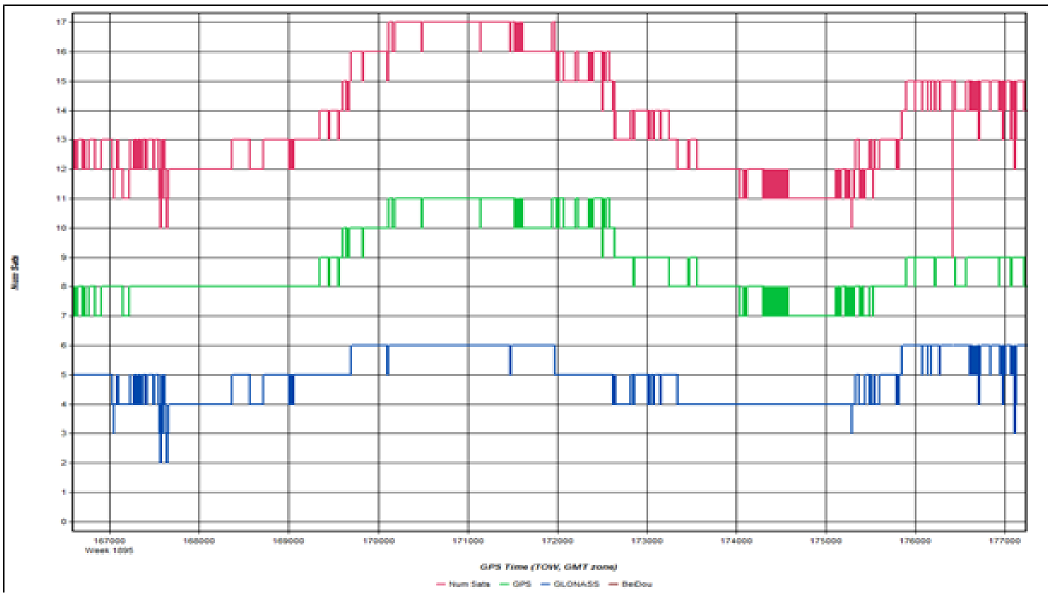


Combined Separation

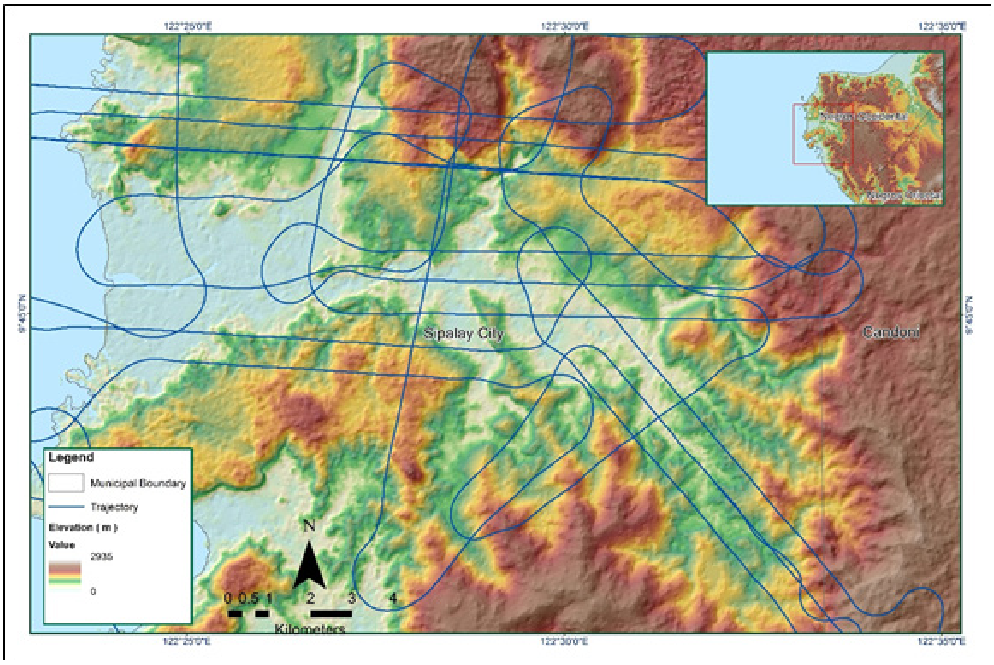


Estimated Position of Accuracy

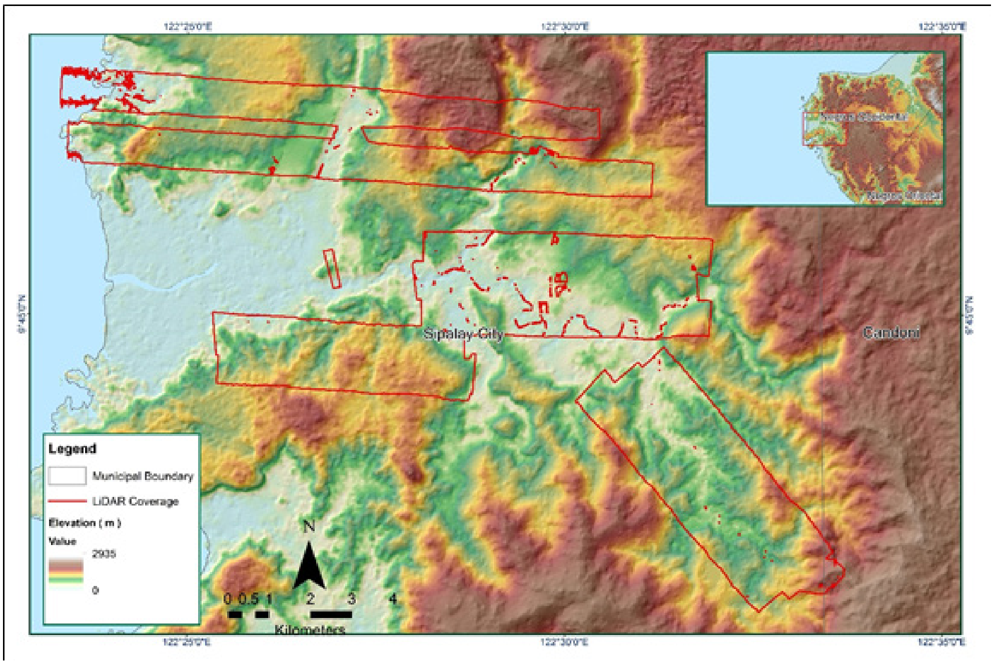
PDOP



Number of Satellites



Best Estimated Trajectory



Coverage of LiDAR data

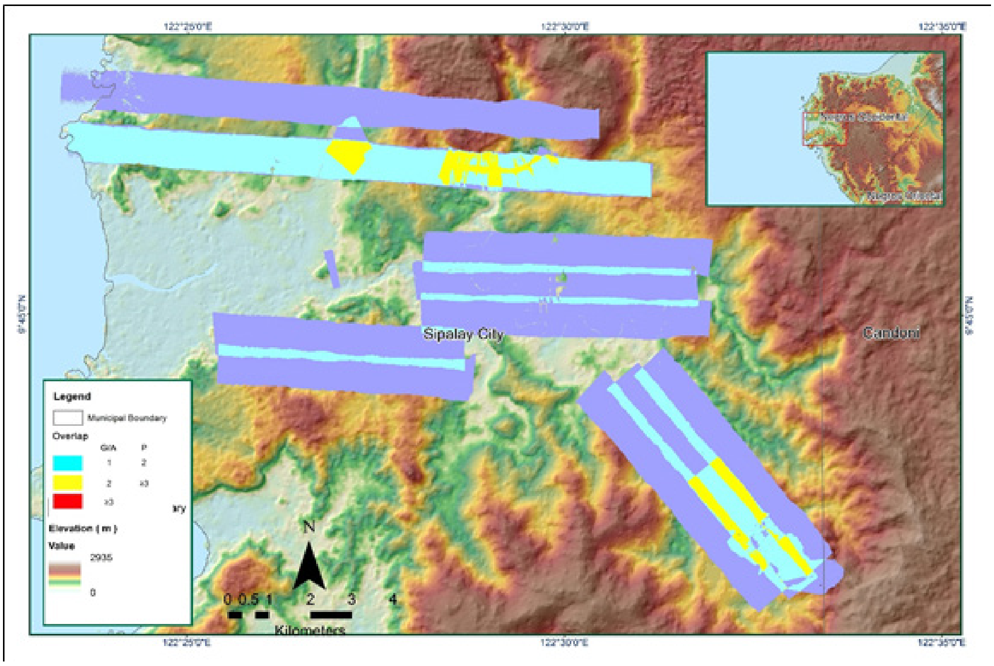
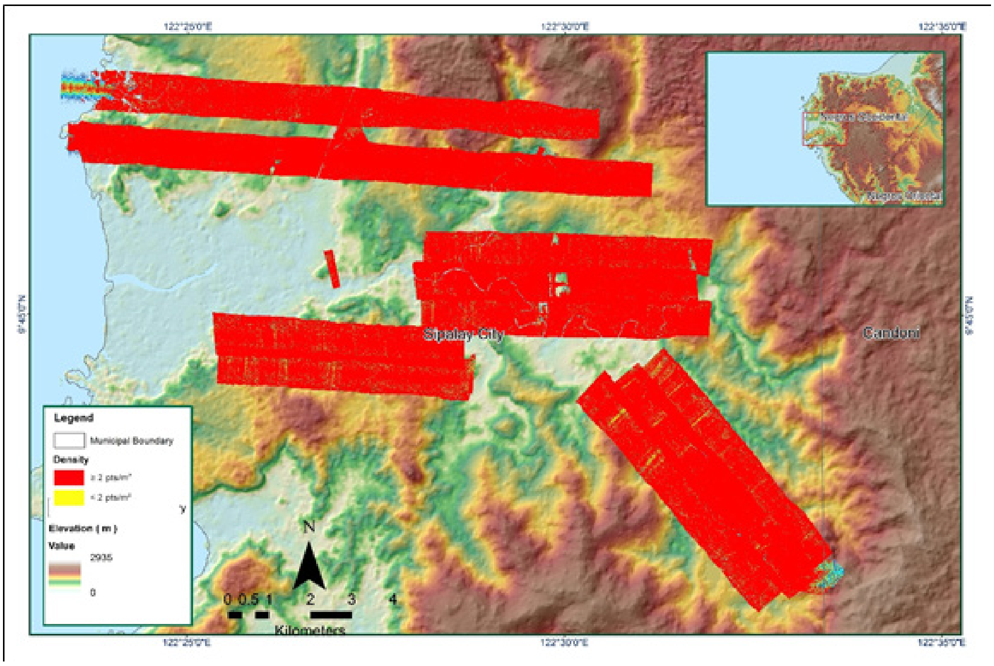
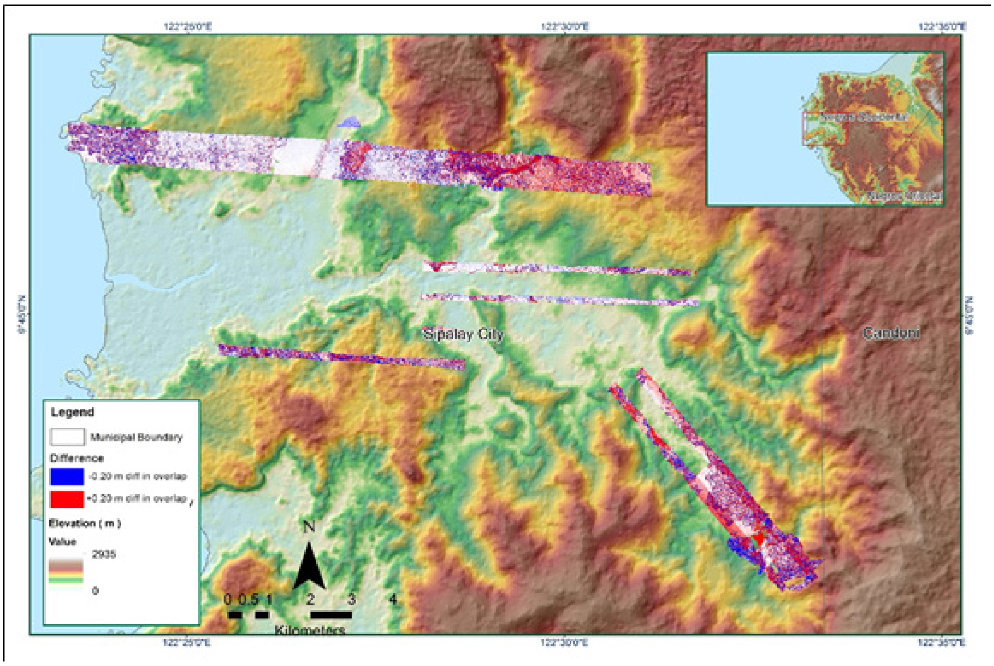


Image of Data Overlap

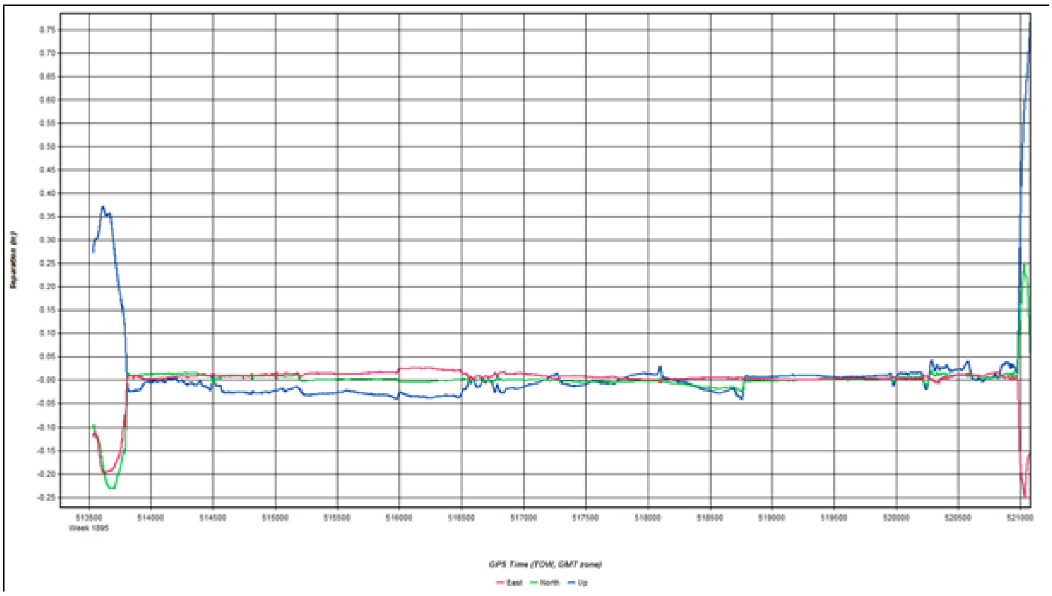


Density map of merged LiDAR data

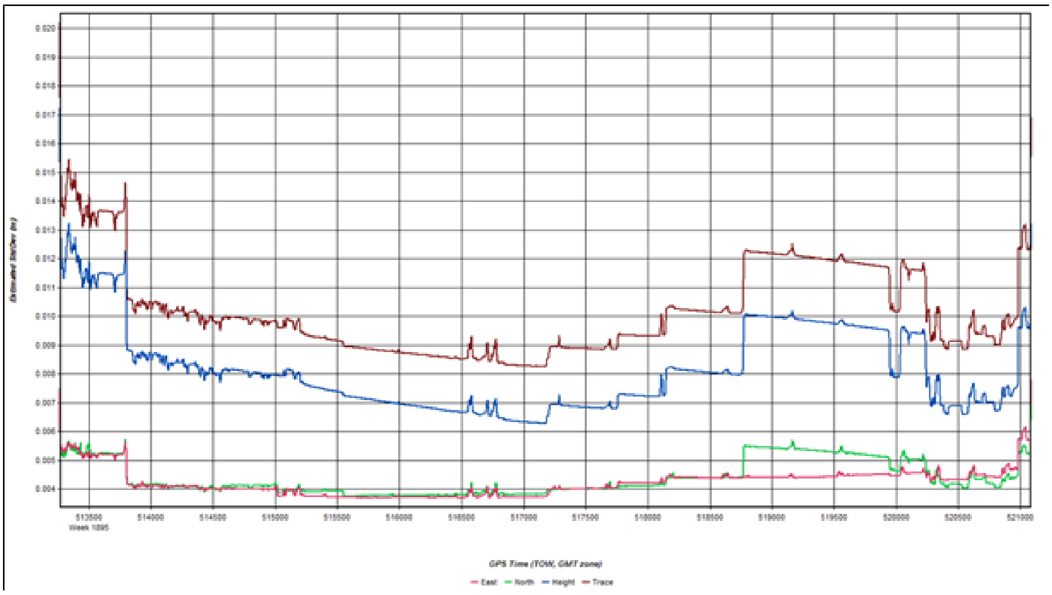


Elevation difference between flight lines

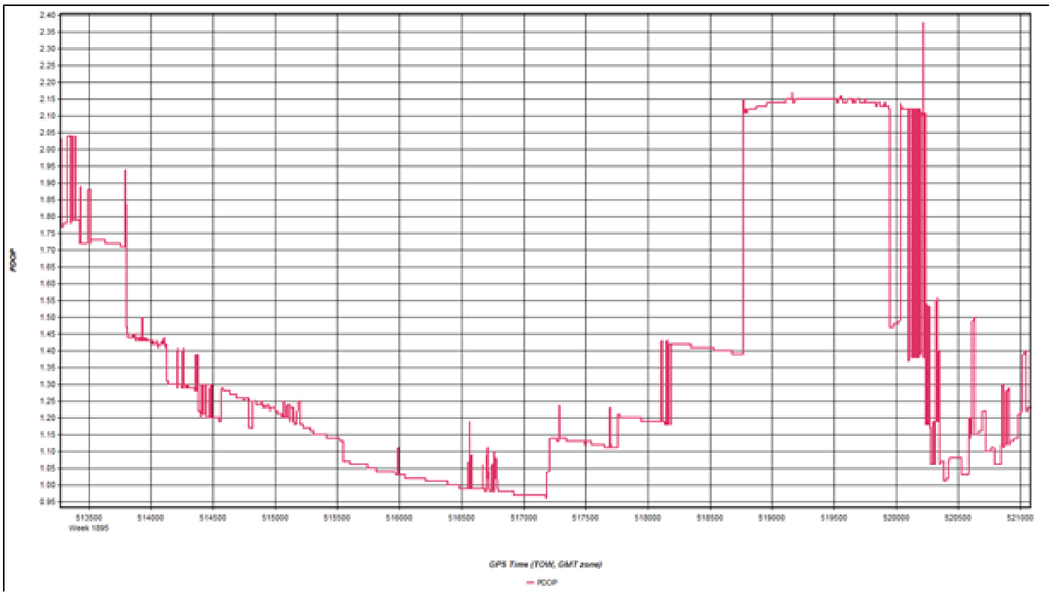
| **Flight Area** | **Calabarzon Reflights** |
|---|---|
| Mission Name | Blk18A_supplement |
| Inclusive Flights | 10144L |
| RawLaser | 3.59 GB |
| Base data size | 155 MB |
| GnssImu | 408 MB |
| Image | 12.9 GB |
| Transfer date | 6/20/2016 |
| | |
| Solution Status | |
| Number of Satellites (>6) | 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) | 0.55 |
| Estimated Standard Devation for East Position (<4.0 cm) | 0.45 |
| Estimated Standard Devation for Height Position (<8.0 cm) | 1.00 |
| | |
| | |
| Minimum % overlap (>25) | 43.07 |
| Ave point cloud density per sq.m. (>2.0) | 4.60 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 92 |
| Maximum Height | 106.83 m |
| Minimum Height | 41.14 m |
| | |
| Classification (# of points) | |
| Ground | 65,752,105 |
| Low vegetation | 34,201,252 |
| Medium vegetation | 22,488,691 |
| High vegetation | 24,727,914 |
| Building | 20,212,718 |
| | |
| Orthophoto | Yes |
| Processed by | Engr. Regis Guhiting, Engr. Melanie Hingpit, Engr. Elainne Lopez |
| | |



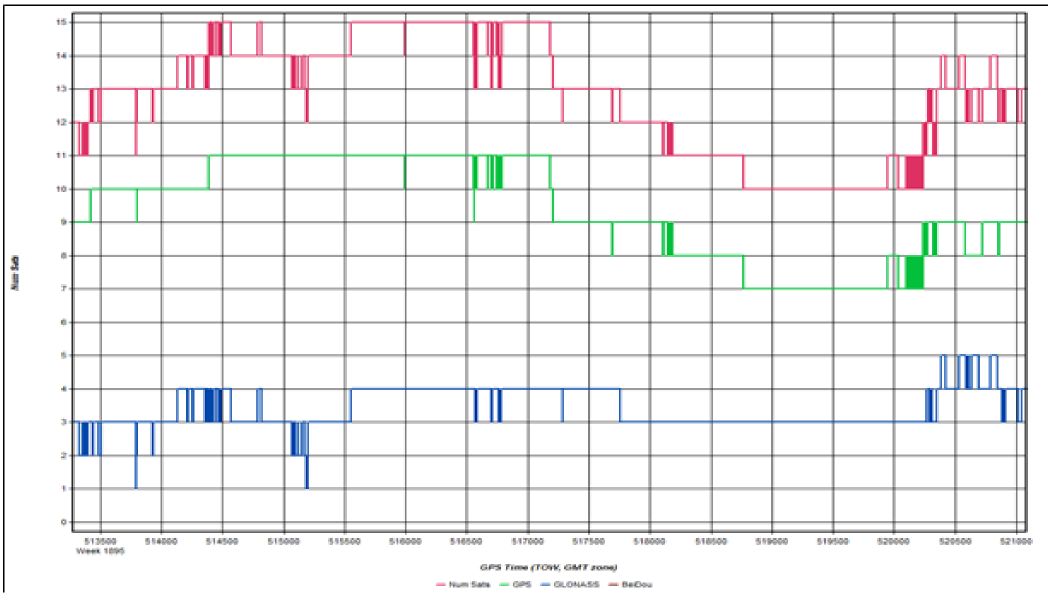
Combined Separation



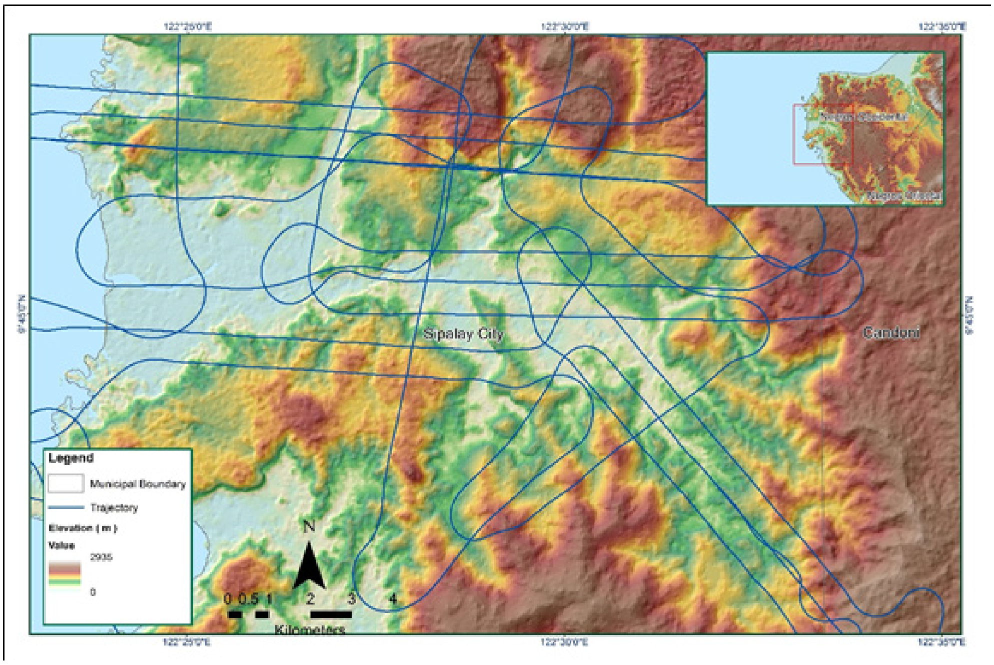
Estimated Position of Accuracy



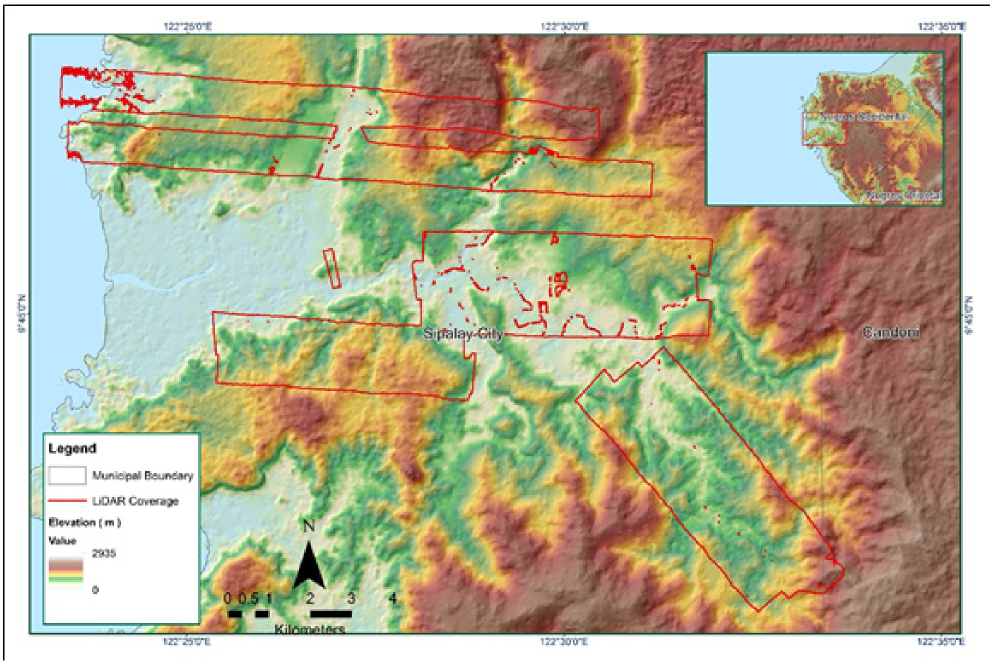
PDOP



Number of Satellites



Best Estimated Trajectory



Coverage of LiDAR data

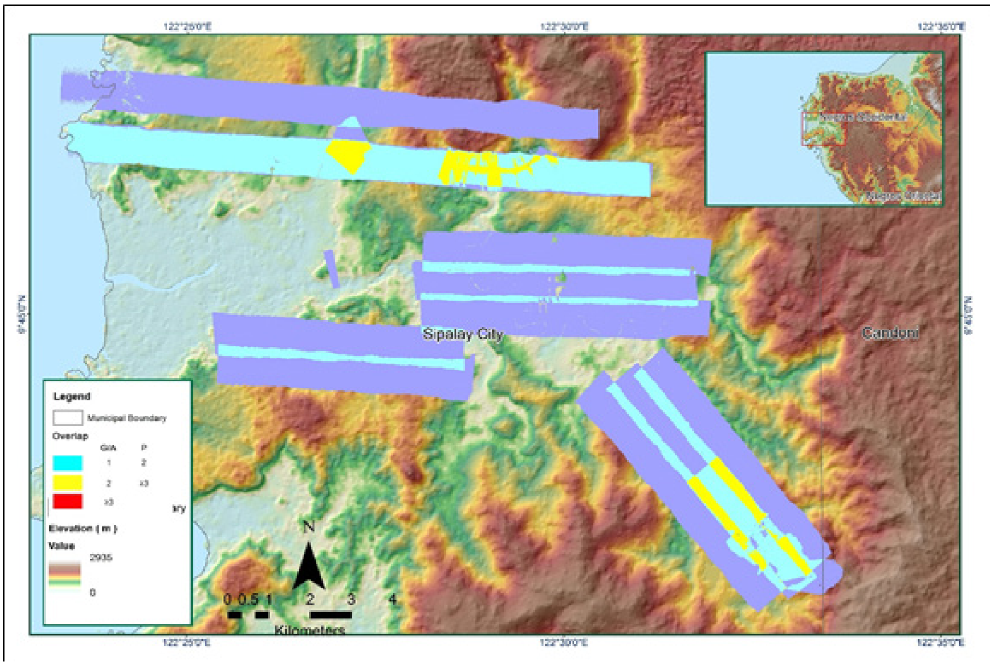
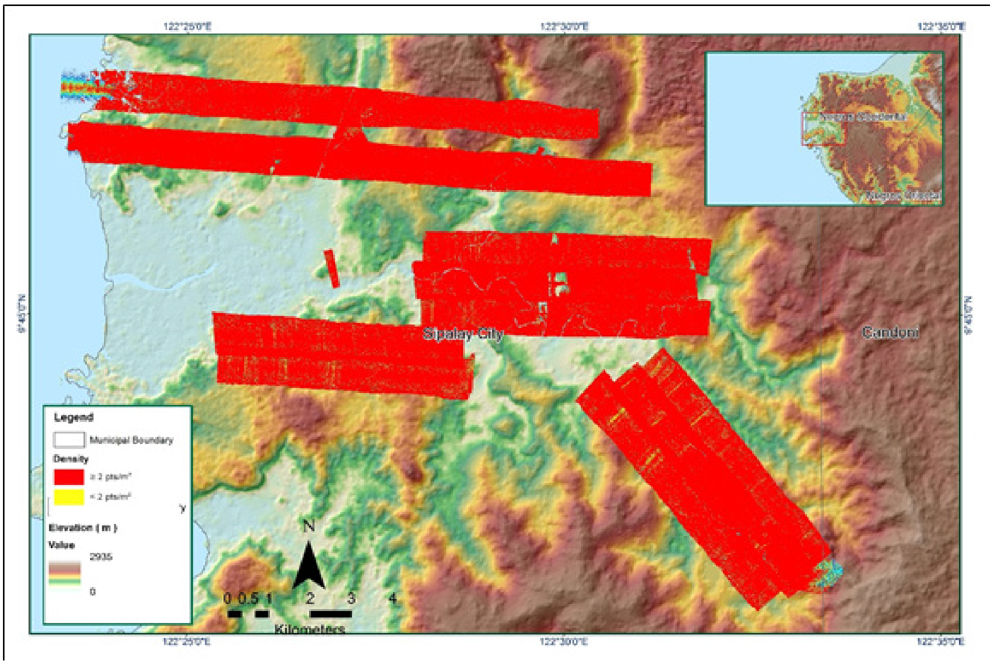
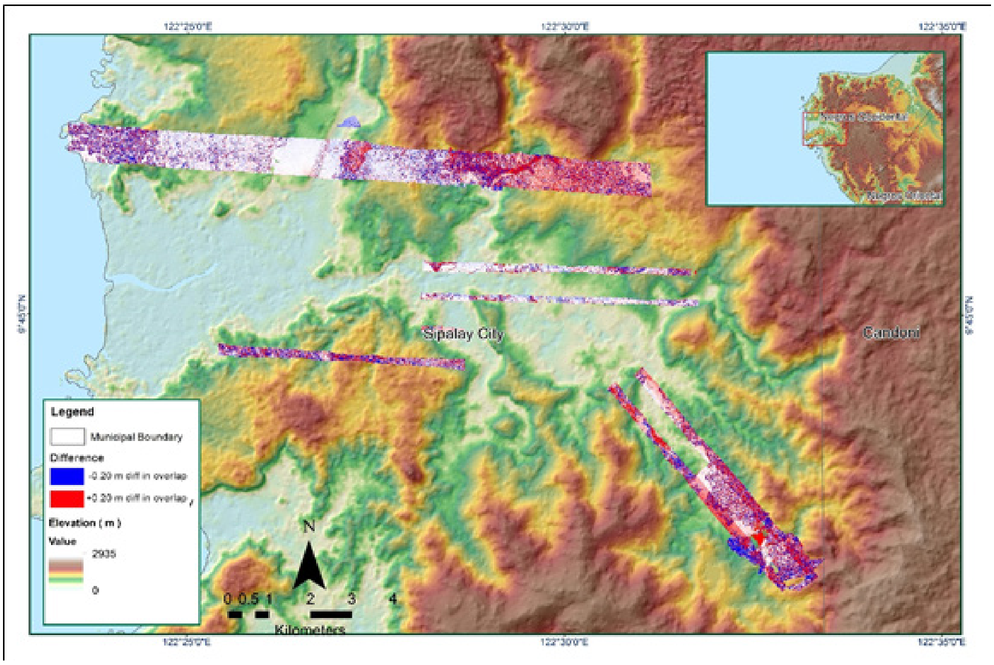


Image of Data Overlap

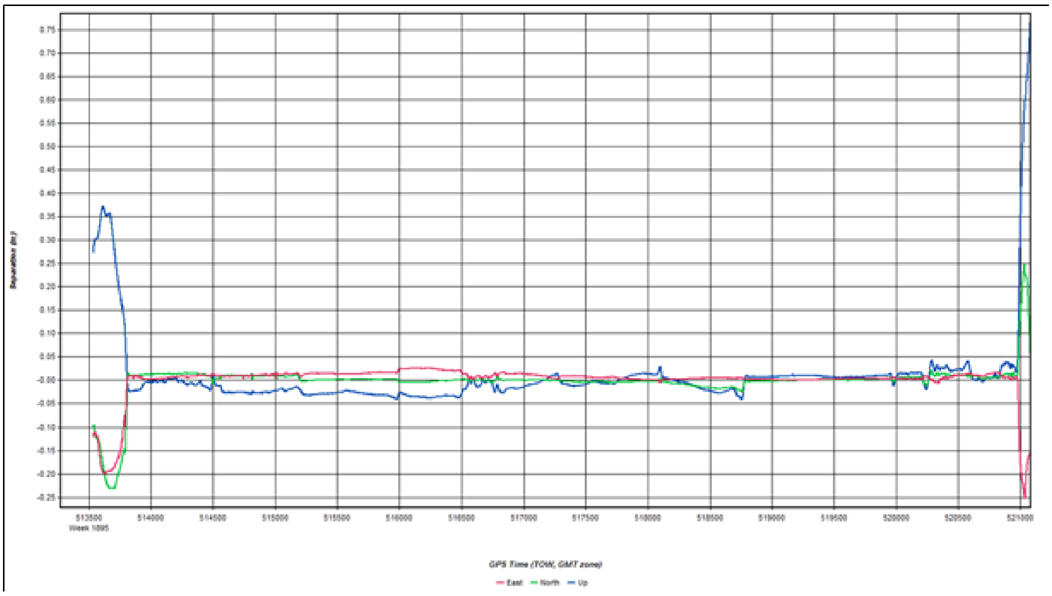


Density map of merged LiDAR data

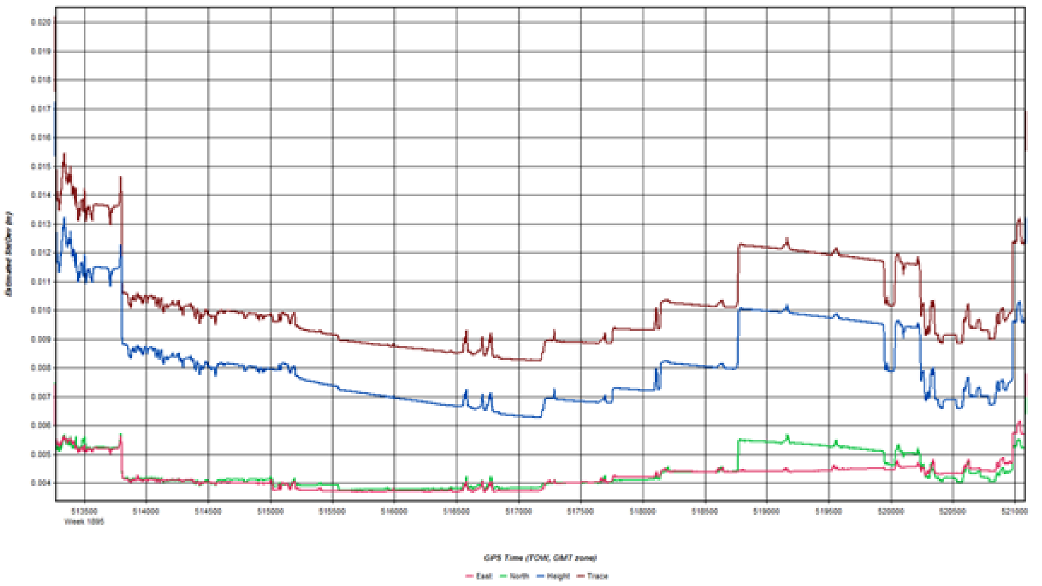


Elevation difference between flight lines

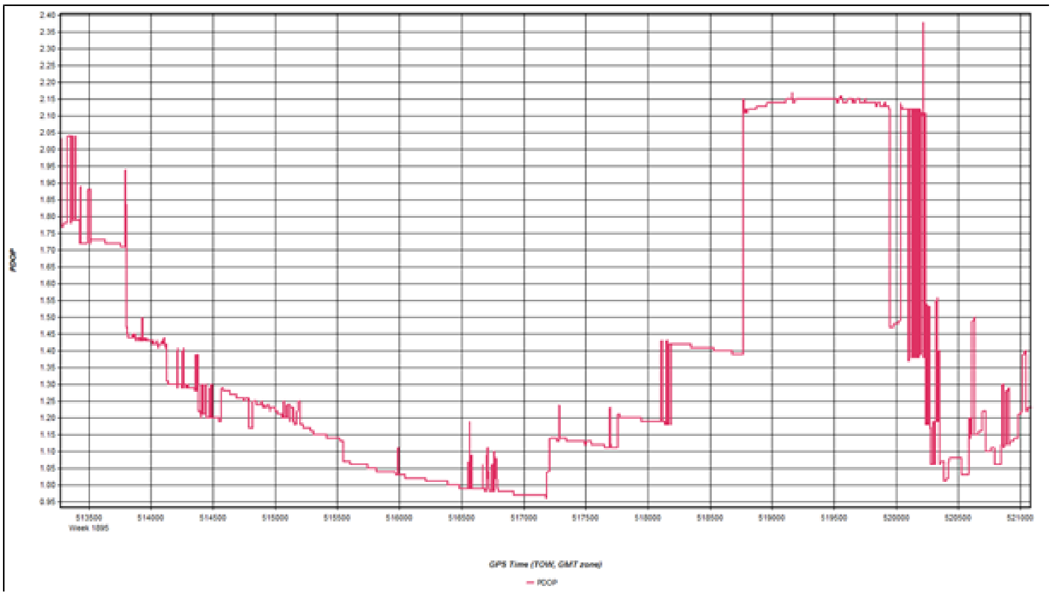
| Flight Area | Calabarzon Reflights |
|---|---|
| Mission Name | Blk18A_supplement |
| Inclusive Flights | 10144L |
| RawLaser | 3.59 GB |
| Base data size | 155 MB |
| GnssImu | 408 MB |
| Image | 12.9 GB |
| Transfer date | 6/20/2016 |
| | |
| Solution Status | |
| Number of Satellites (>6) | Yes |
| 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) | 0.55 |
| Estimated Standard Devation for East Position (<4.0 cm) | 0.45 |
| Estimated Standard Devation for Height Position (<8.0 cm) | 1.00 |
| | |
| | |
| Minimum % overlap (>25) | 43.07 |
| Ave point cloud density per sq.m. (>2.0) | 4.60 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 92 |
| Maximum Height | 106.83 m |
| Minimum Height | 41.14 m |
| | |
| Classification (# of points) | |
| Ground | 65,752,105 |
| Low vegetation | 34,201,252 |
| Medium vegetation | 22,488,691 |
| High vegetation | 24,727,914 |
| Building | 20,212,718 |
| | |
| Orthophoto | Yes |
| Processed by | Engr. Regis Guhiting, Engr. Melanie Hingpit, Engr. Elainne Lopez |
| | |
| | |
| | |



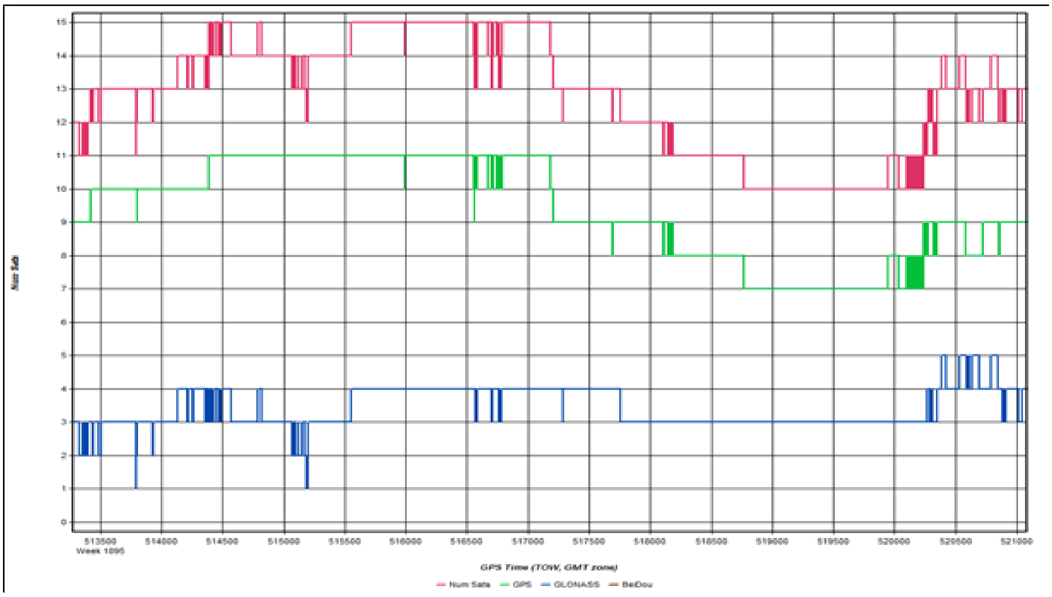
Combined Separation



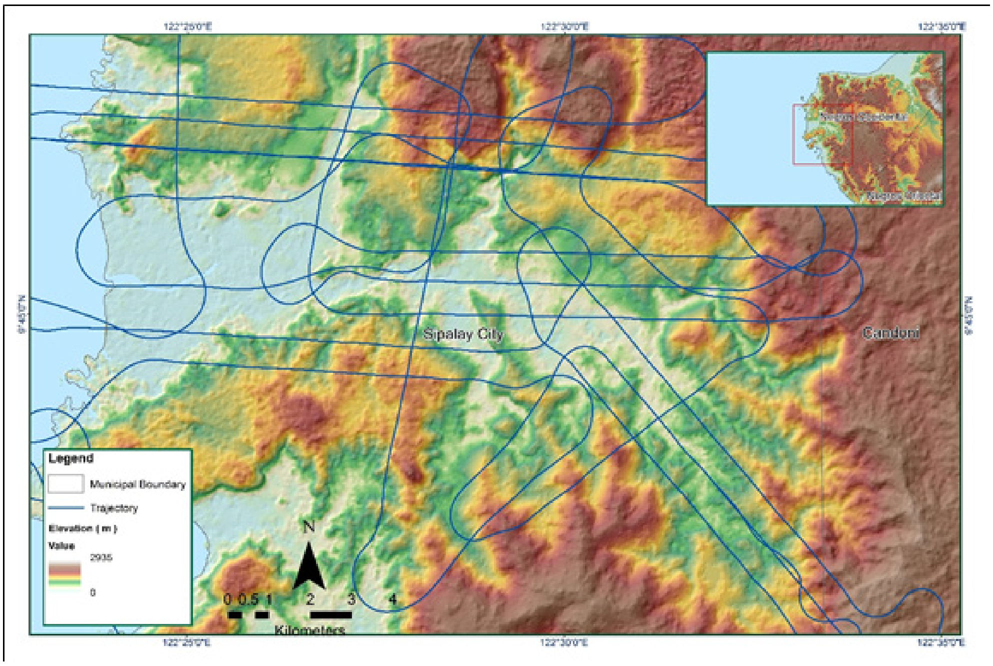
Estimated Position of Accuracy



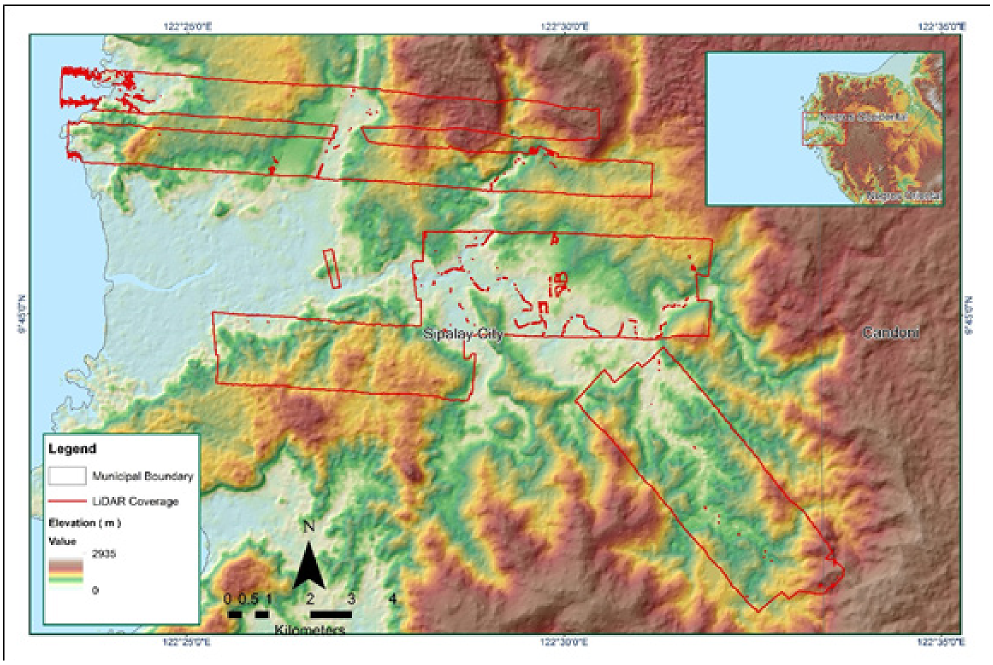
PDOP



Number of Satellites



Best Estimated Trajectory



Coverage of LiDAR data

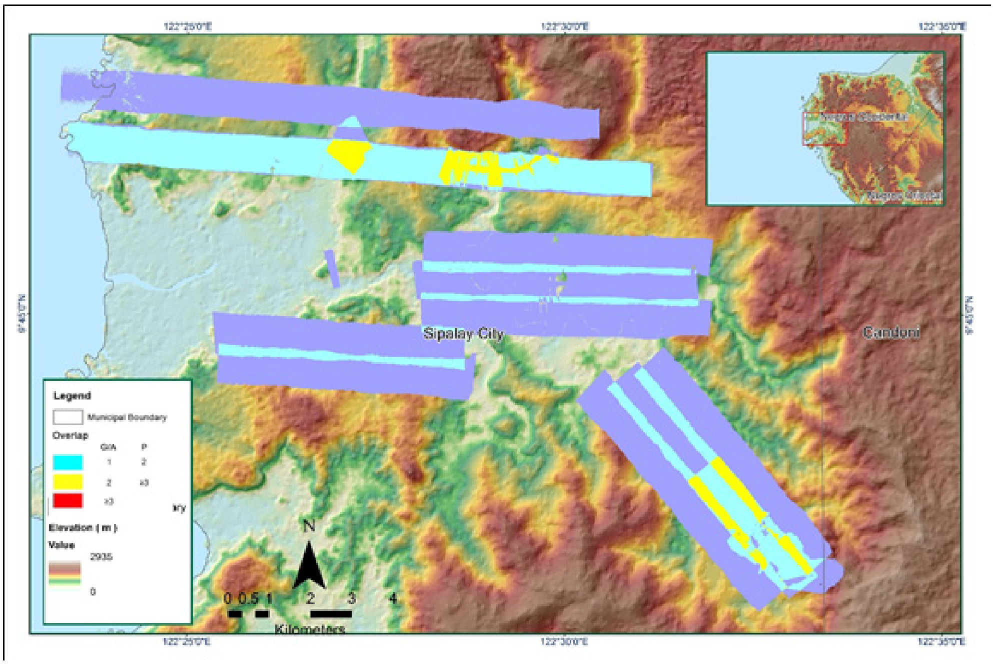
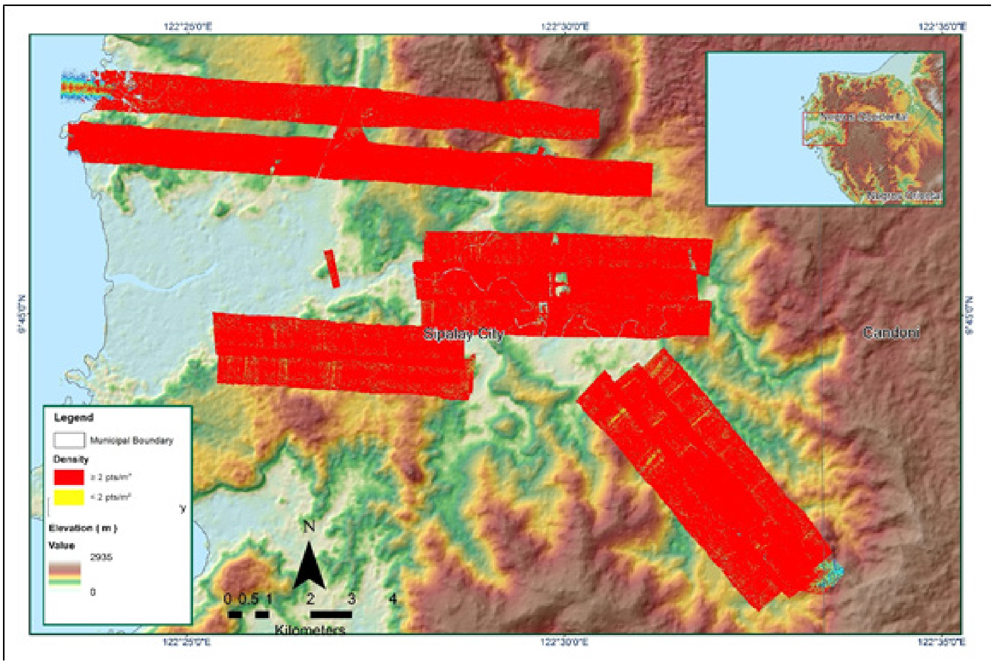
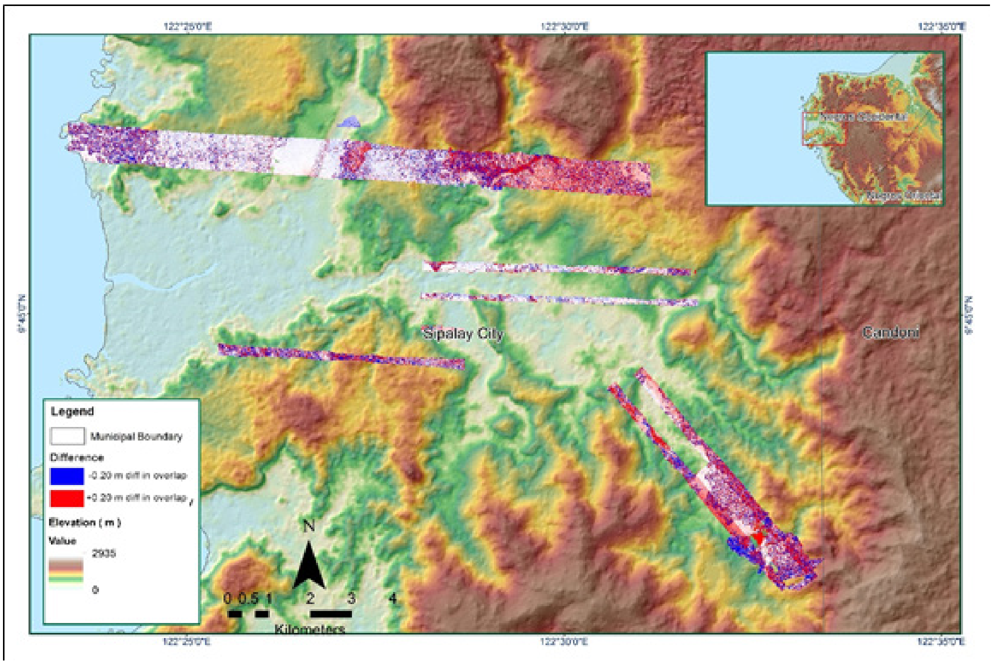


Image of Data Overlap

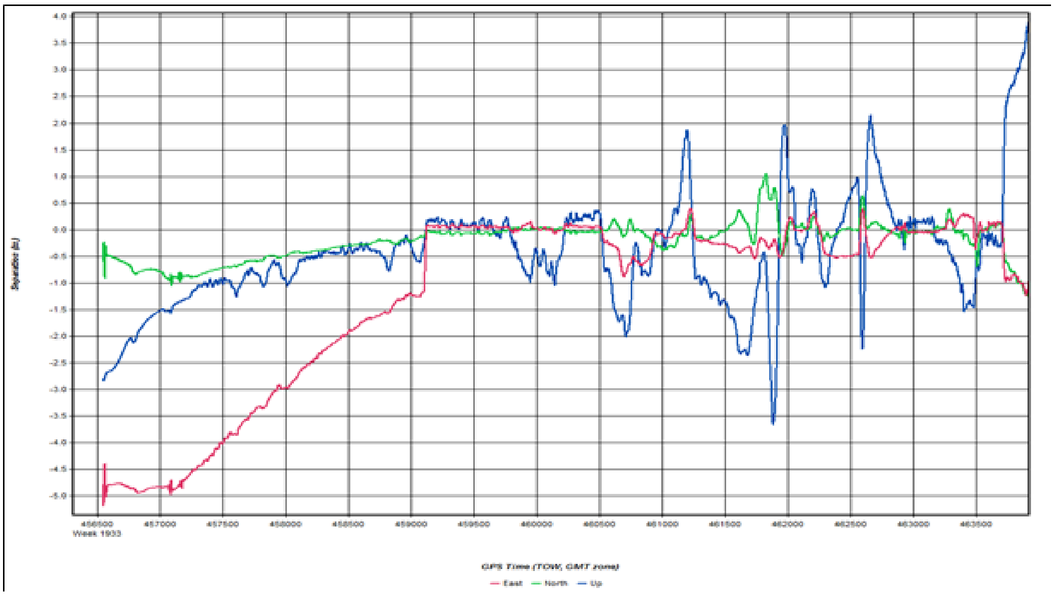


Density map of merged LiDAR data

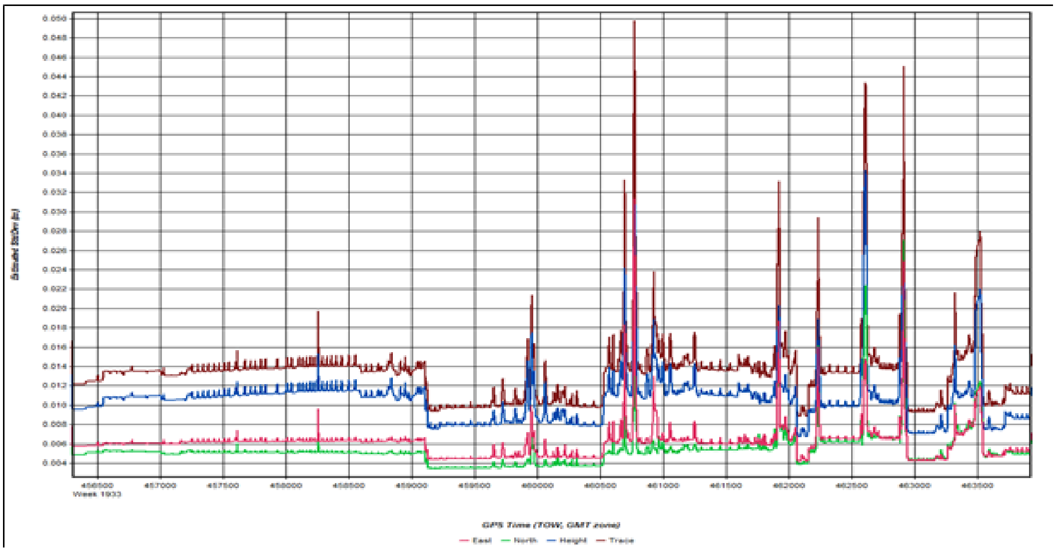


Elevation difference between flight lines

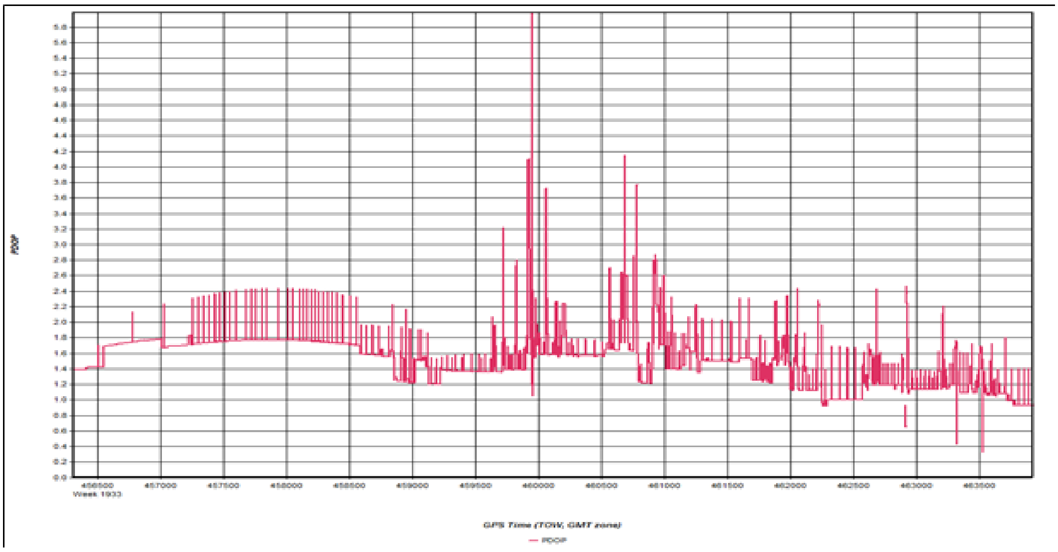
| **Flight Area** | **Calabarzon Reflights** |
|---|---|
| Mission Name | Blk18B_Supplement1 |
| Inclusive Flights | 10321L |
| RawLaser | 6.16 GB |
| GnssImu | 329 MB |
| Image | 7.32 GB |
| Transfer date | 2/13/2017 |
| | |
| Solution Status | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | No |
| 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) | 13.61 |
| Ave point cloud density per sq.m. (>2.0) | 1.22 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 14 |
| Maximum Height | 127.96 |
| Minimum Height | 3.47 |
| | |
| Classification (# of points) | |
| Ground | 3,367,084 |
| Low vegetation | 1,666,746 |
| Medium vegetation | 2,222,402 |
| High vegetation | 2,629,746 |
| Building | 1,491,047 |
| | |
| Orthophoto | Yes |
| Processed by | Engr. Regis Guhiting |
| | |
| | |
| | |



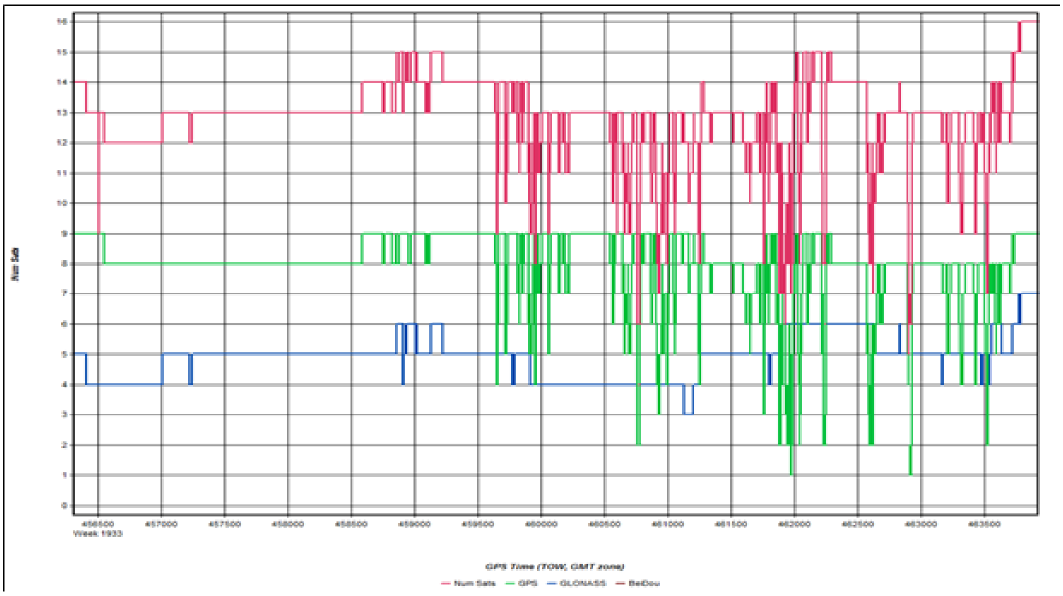
Combined Separation



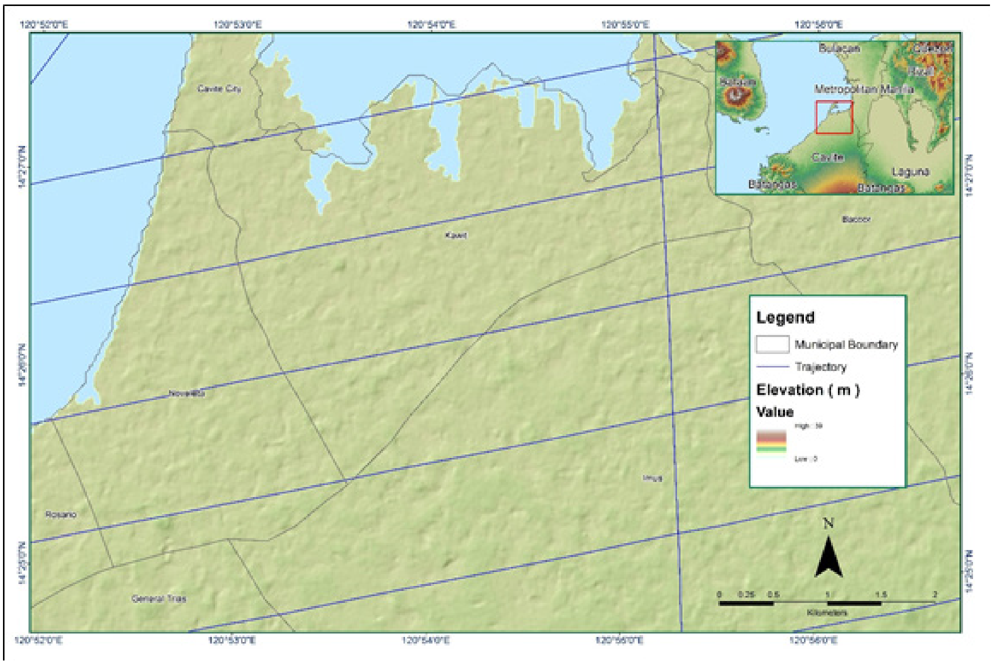
Estimated Position of Accuracy



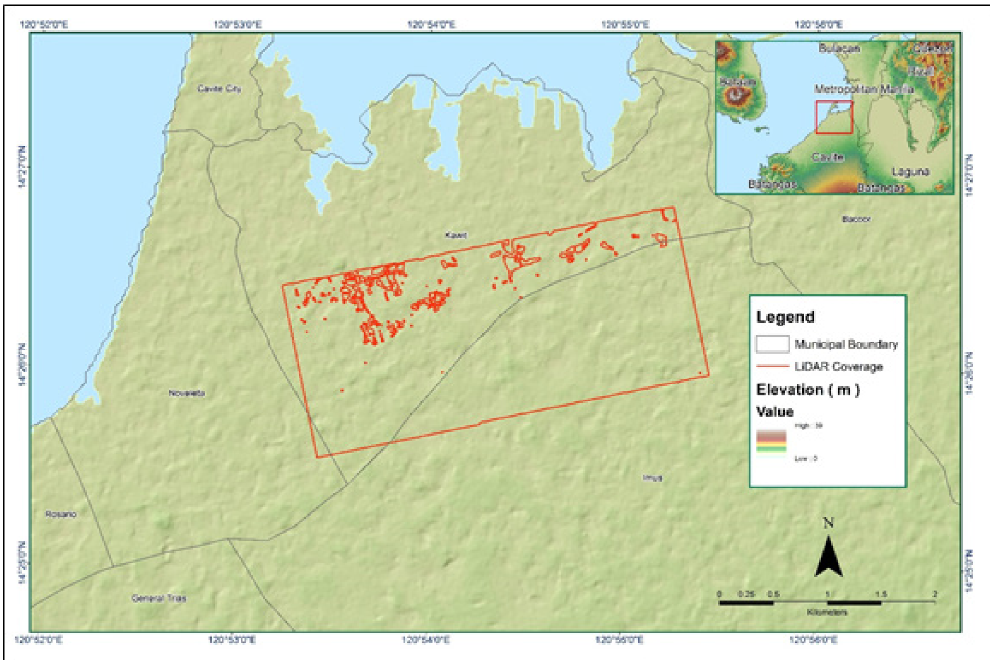
PDOP



Number of Satellites



Best Estimated Trajectory



Coverage of LiDAR data

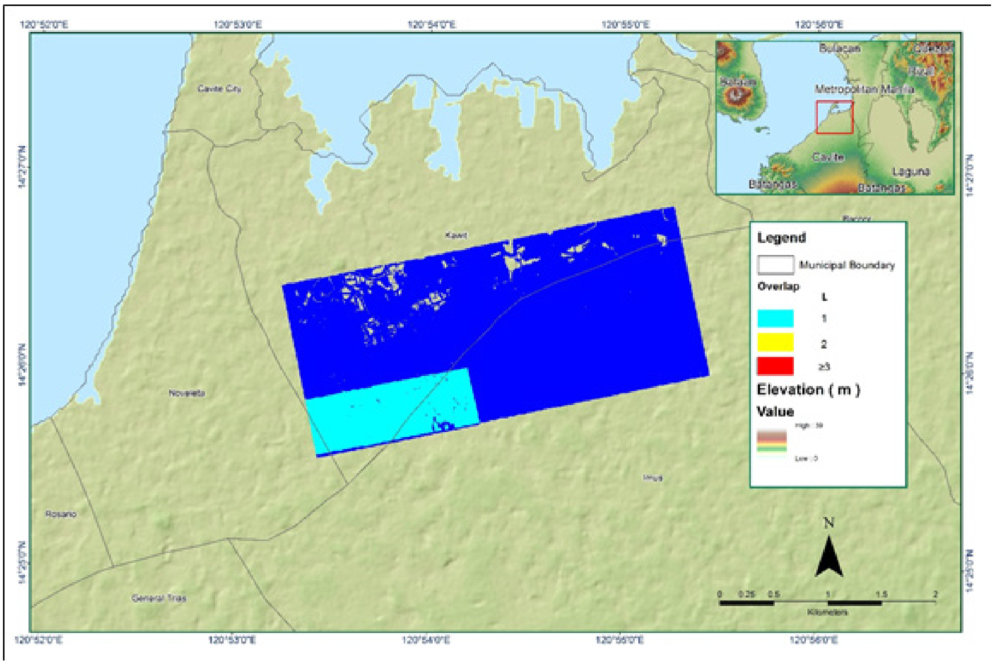
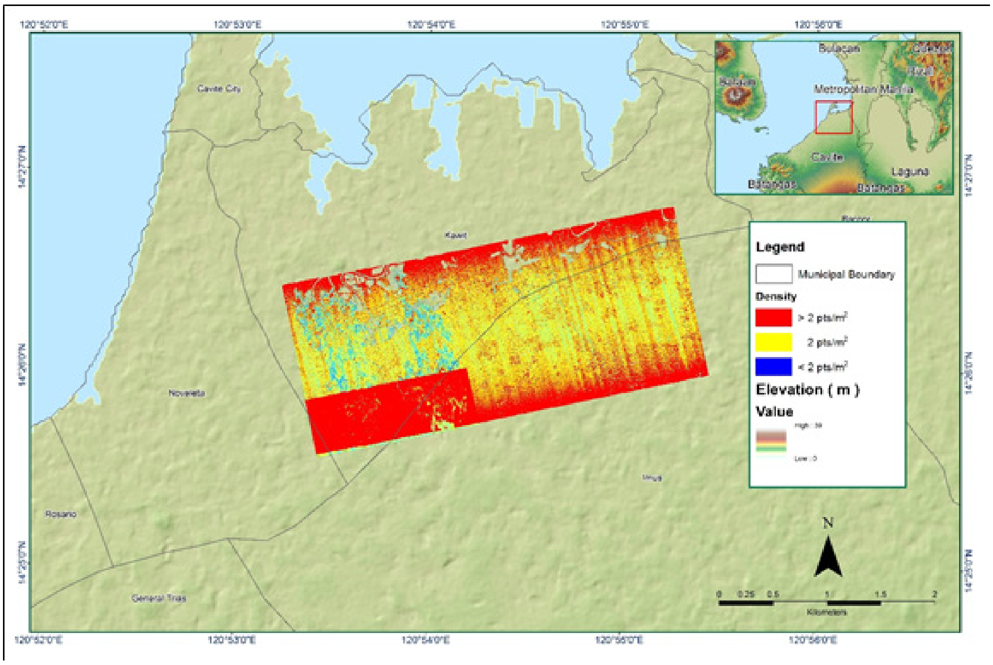
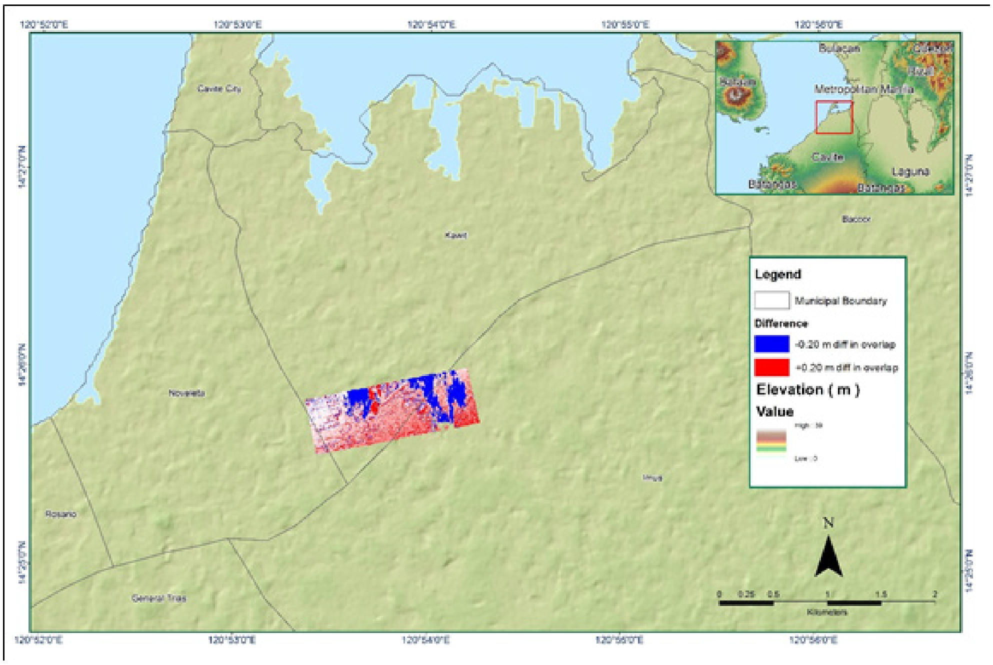


Image of Data Overlap

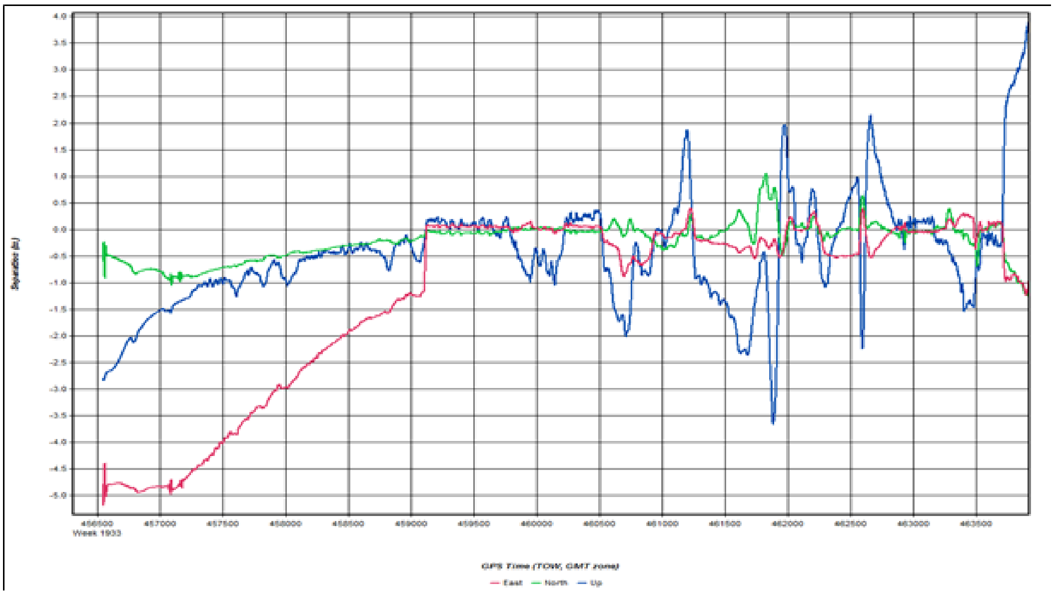


Density map of merged LiDAR data

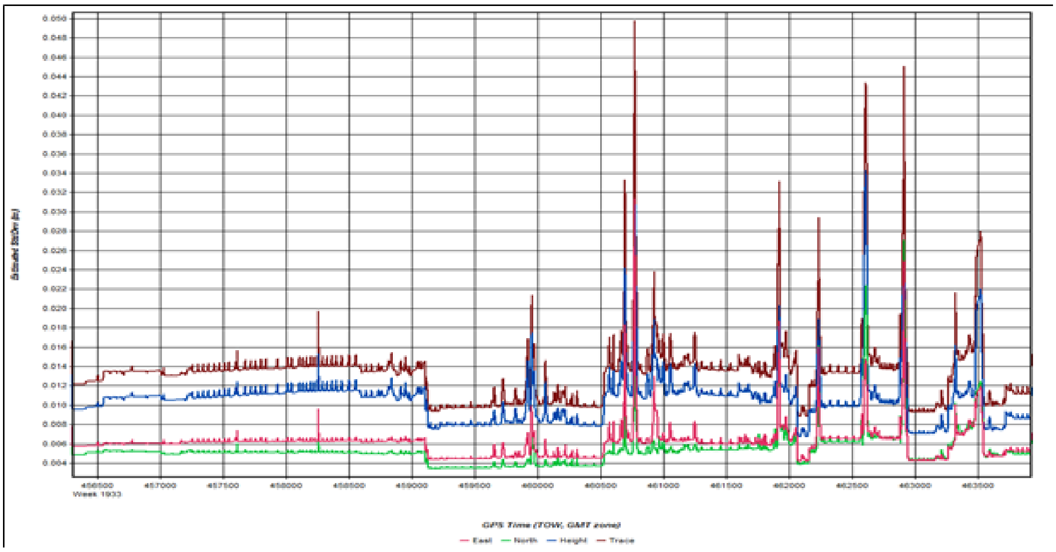


Elevation difference between flight lines

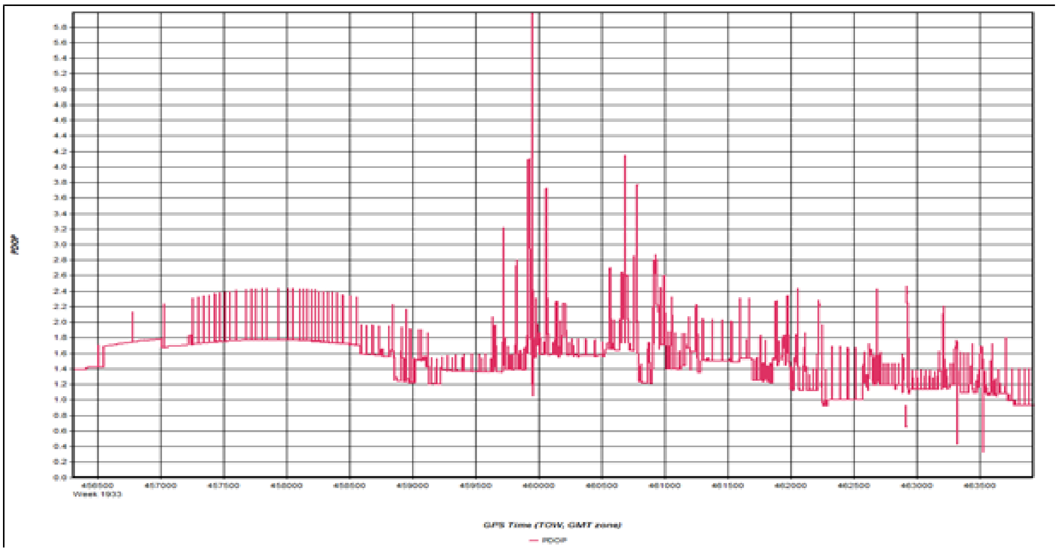
| **Flight Area** | **Calabarzon Reflights** |
|---|---|
| Mission Name | Blk18B_Supplement2 |
| Inclusive Flights | 10321L |
| RawLaser | 6.16 GB |
| GnssImu | 329 MB |
| Image | 7.32 GB |
| Transfer date | 2/13/2017 |
| | |
| Solution Status | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | No |
| 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) | 0.36 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 4 |
| Maximum Height | 80.78 |
| Minimum Height | 44.26 |
| | |
| Classification (# of points) | |
| Ground | 567,120 |
| Low vegetation | 71,493 |
| Medium vegetation | 207,551 |
| High vegetation | 367,049 |
| Building | 812,227 |
| | |
| Orthophoto | Yes |
| Processed by | Engr. Regis Guhiting, Engr. Harmond Santos, Engr. Gladys Mae Apat |
| | |
| | |
| | |
| | |



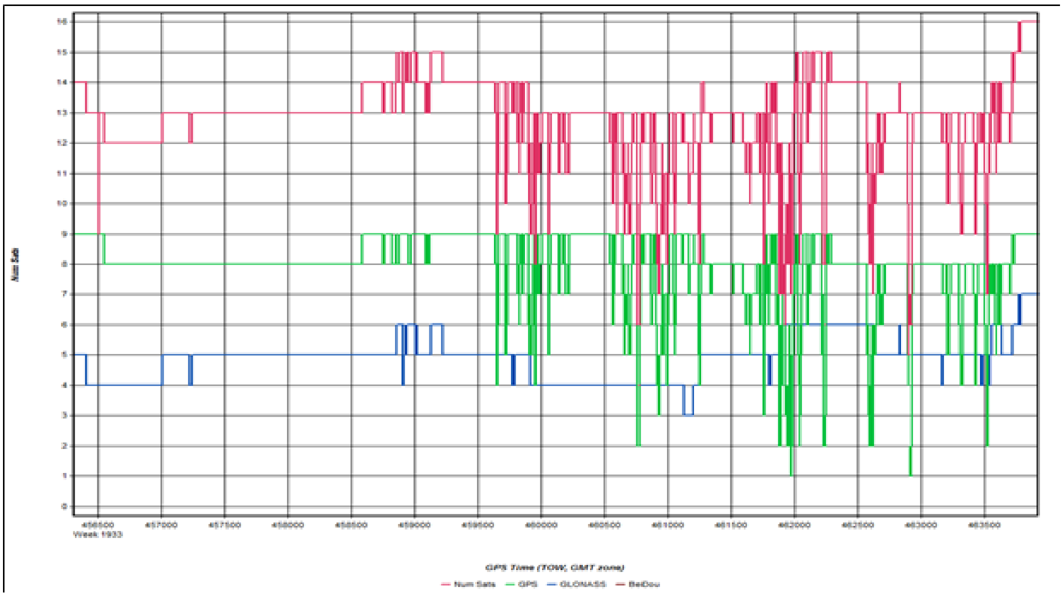
Combined Separation



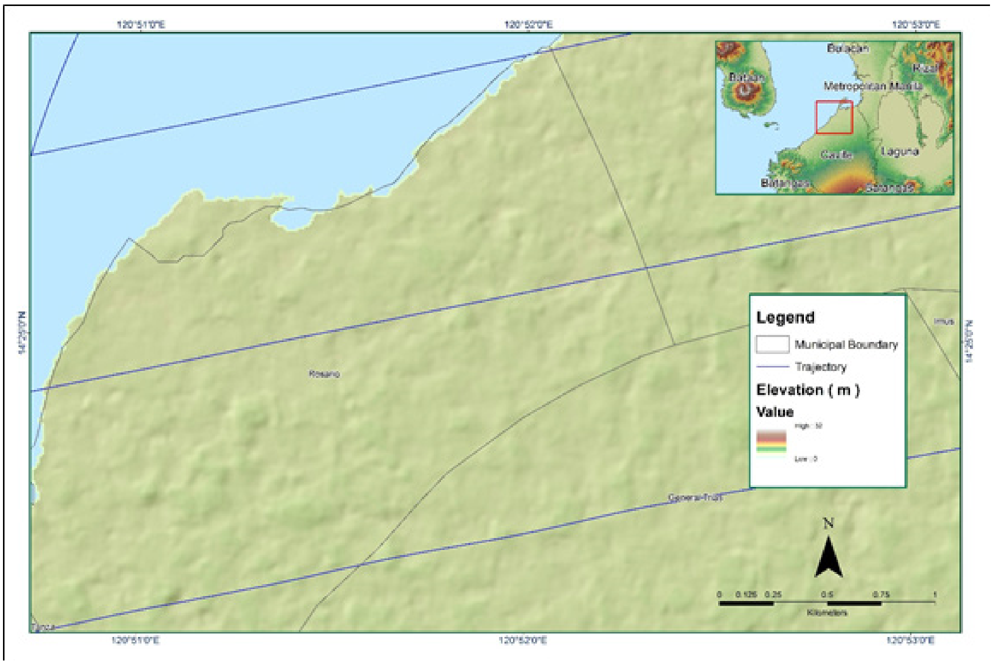
Estimated Position of Accuracy



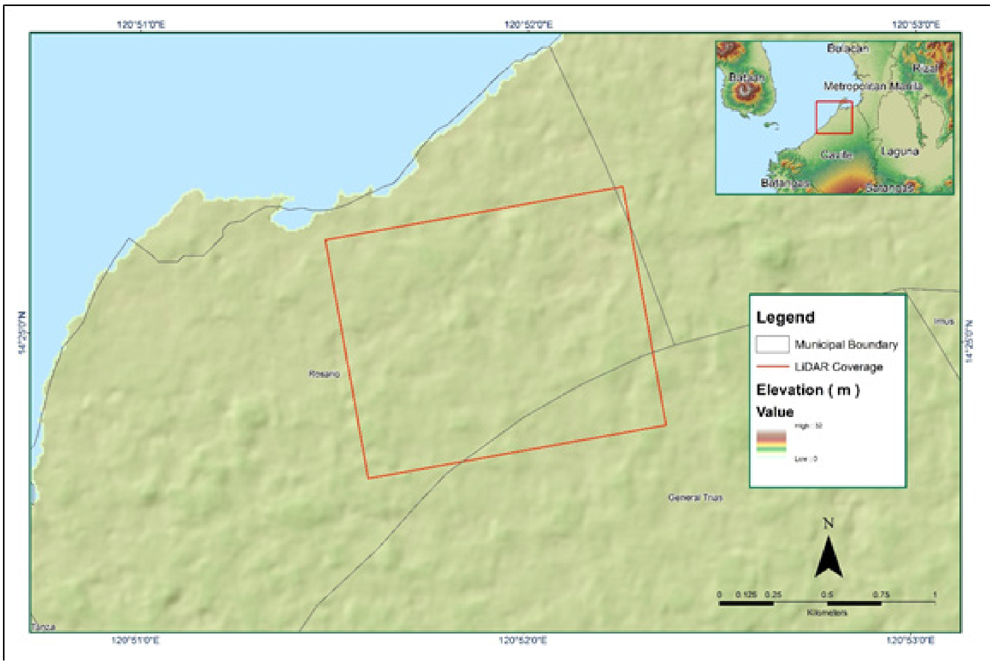
PDOP



Number of Satellites



Best Estimated Trajectory



Coverage of LiDAR data

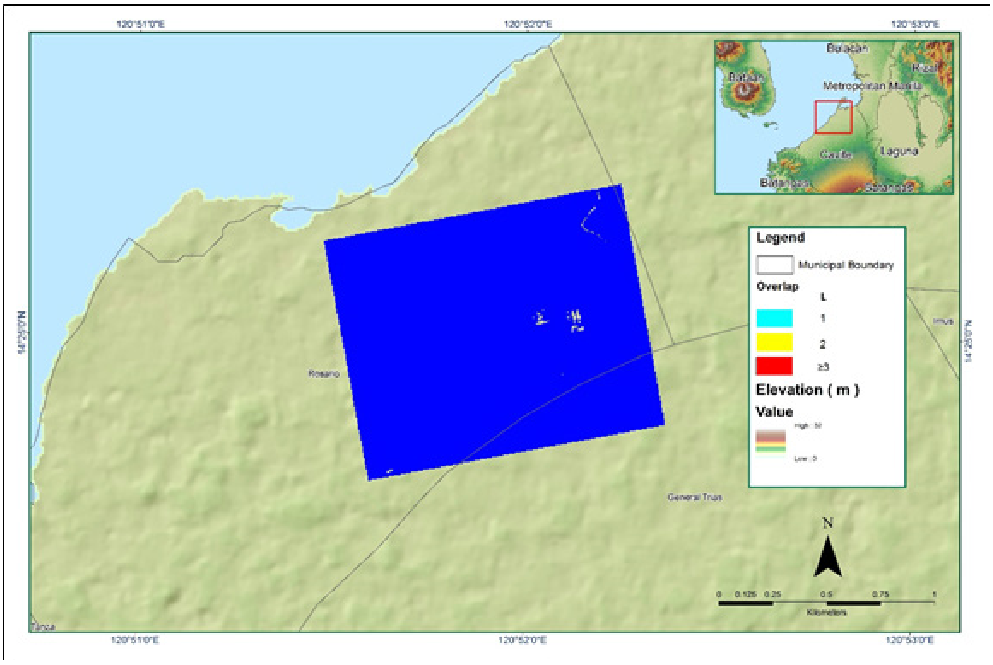
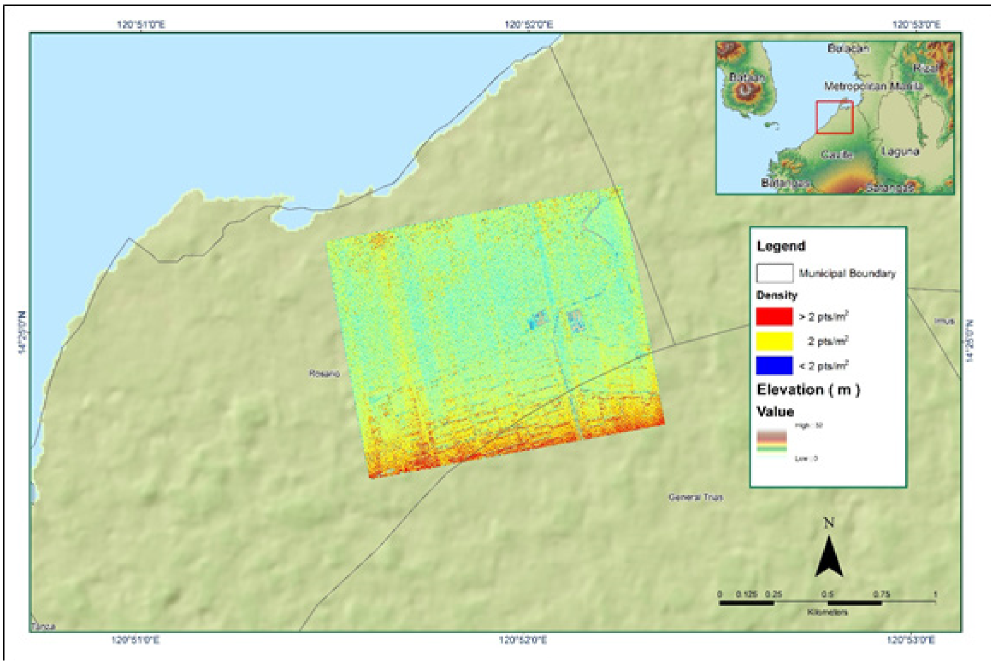
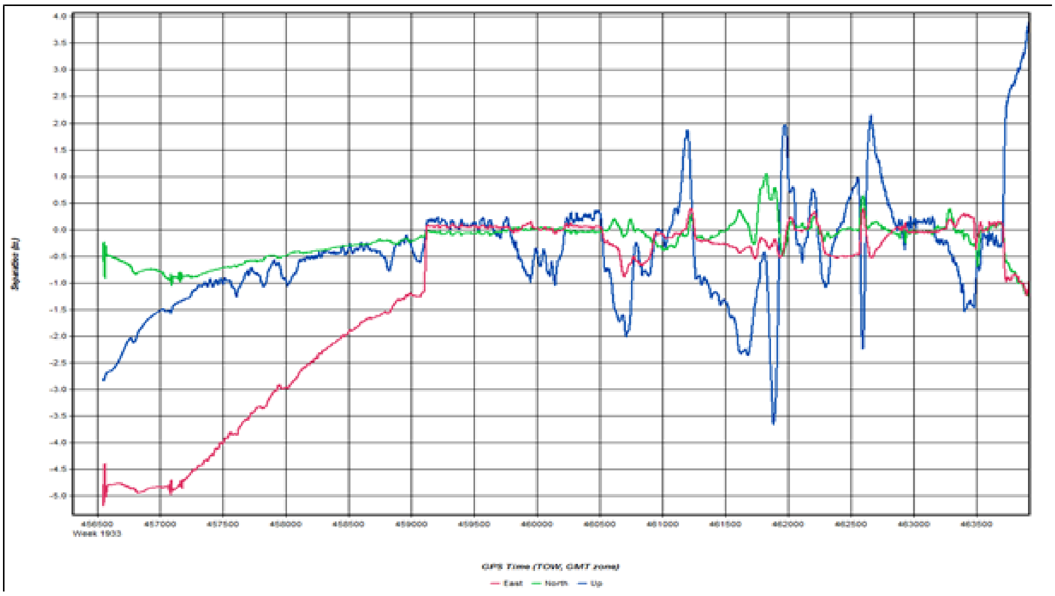


Image of Data Overlap

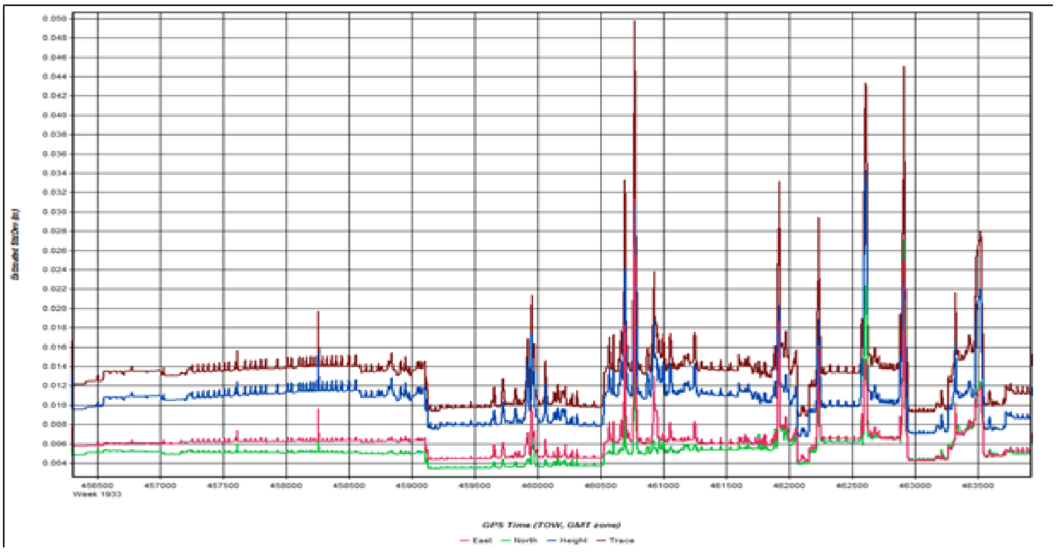


Density map of merged LiDAR data

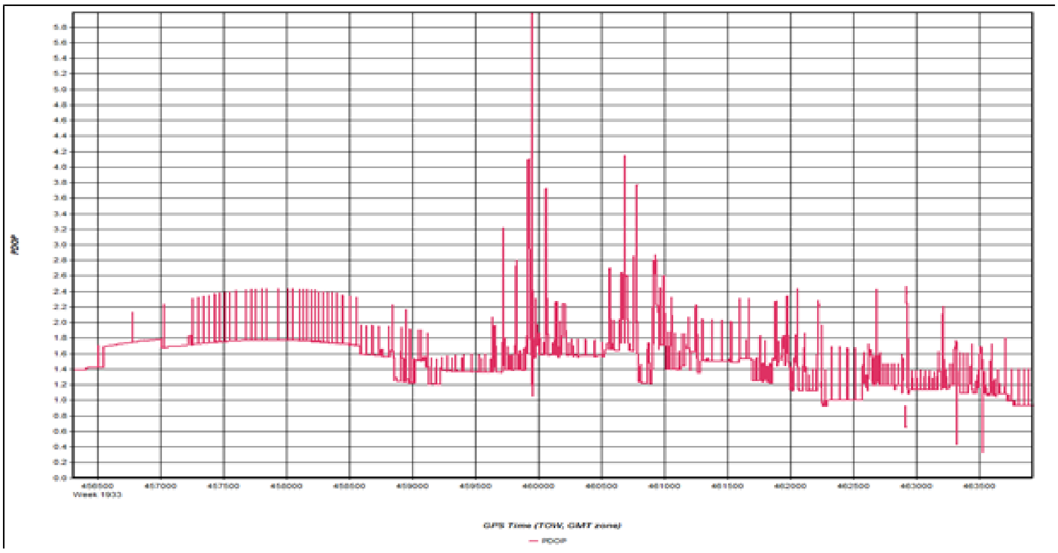
| **Flight Area** | **Calabarzon Reflights** |
|---|---|
| Mission Name | Blk18B_Supplement5 |
| Inclusive Flights | 10321L |
| RawLaser | 6.16 GB |
| GnssImu | 329 MB |
| Image | 7.32 GB |
| Transfer date | 2/13/2017 |
| | |
| Solution Status | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | No |
| 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 | 1,296,700 |
| Low vegetation | 380,063 |
| Medium vegetation | 479,130 |
| High vegetation | 703,766 |
| Building | 476,095 |
| | |
| Orthophoto | Yes |
| Processed by | Engr. Regis Guhiting, Engr. Harmond Santos, Engr. Gladys Mae Apat |
| | |
| | |
| | |
| | |



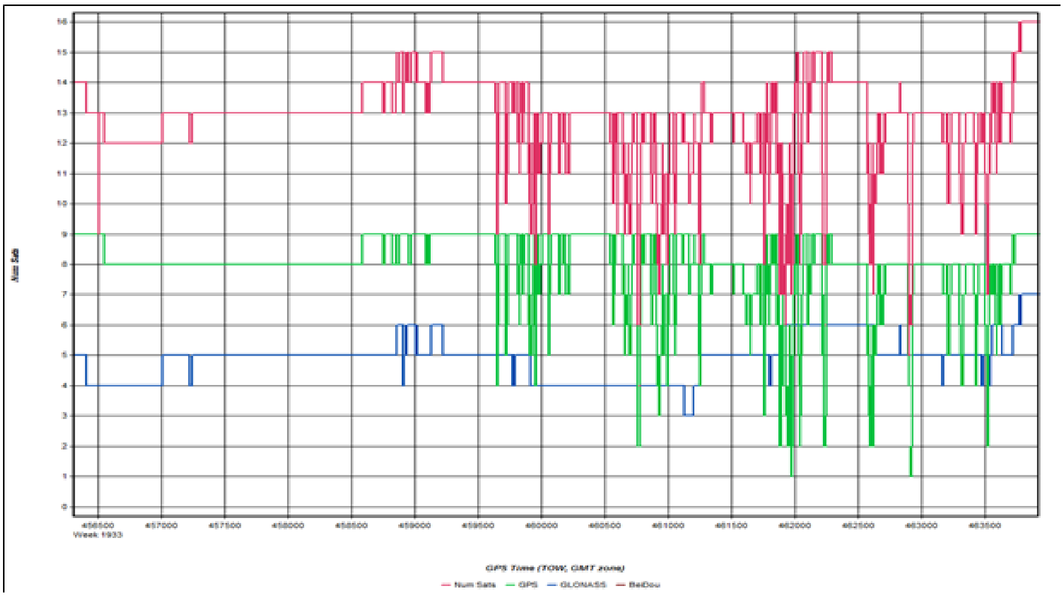
Combined Separation



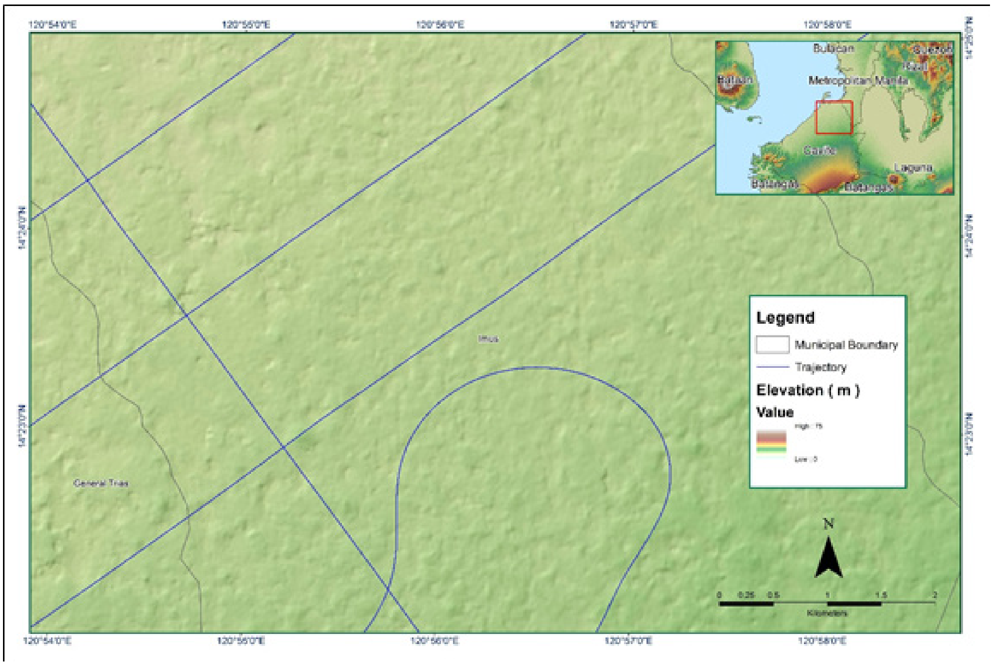
Estimated Position of Accuracy



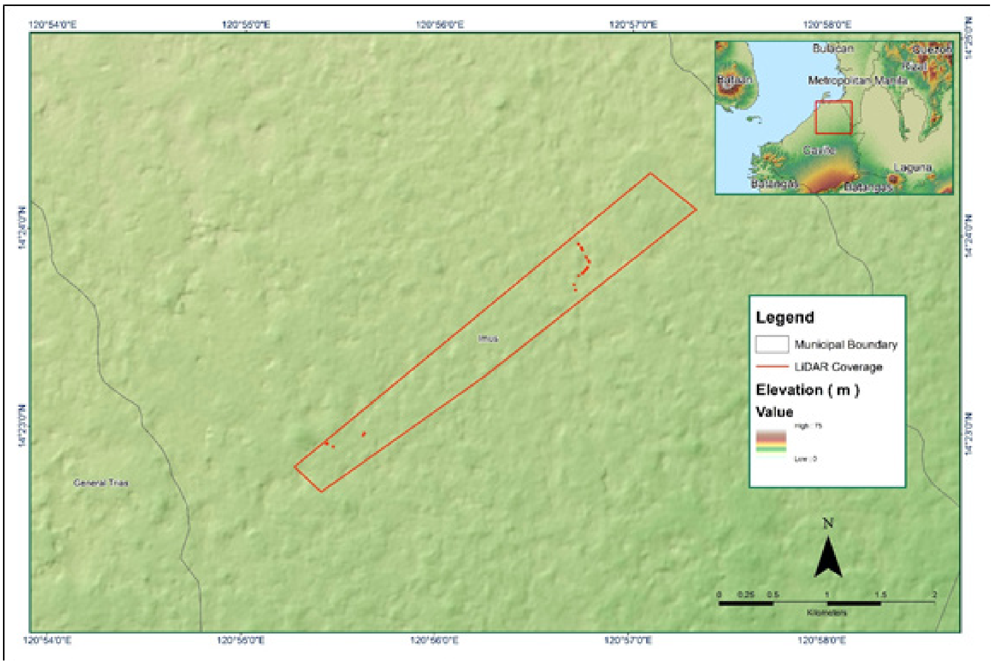
PDOP



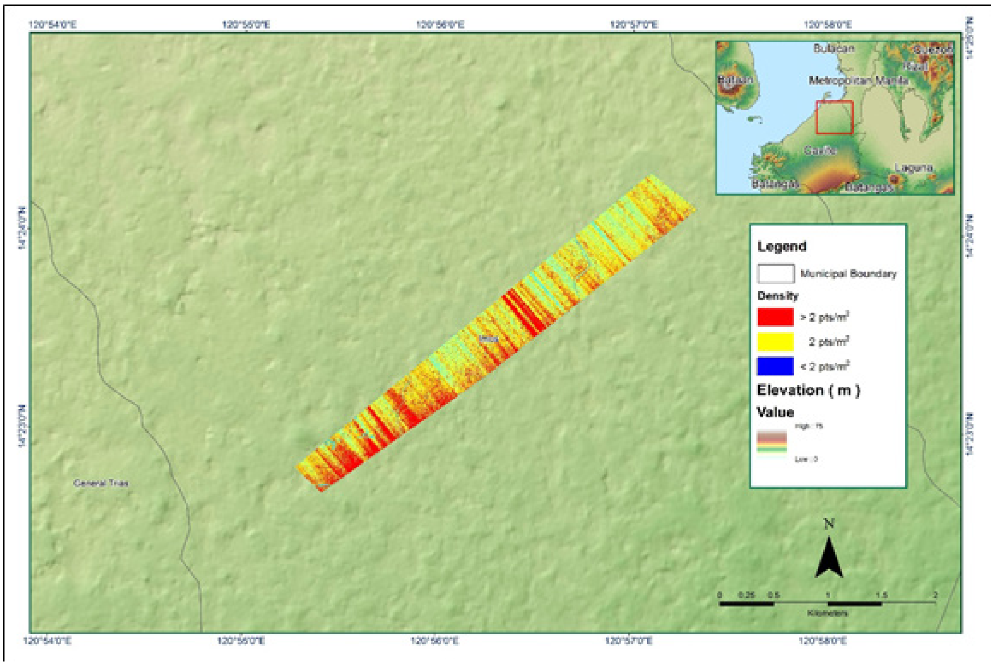
Number of Satellites



Best Estimated Trajectory



Coverage of LiDAR data



Density map of merged LiDAR data

# ANNEX 9. Ilang-Ilang Model Basin Parameters

| Basin Number | SCS Curve Number Loss | | | Clark Unit Hydrograph Transform | | Recession Baseflow | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Initial Abstraction (mm) | Curve Number | Impervious (%) | Time of Concentration (HR) | Storage Coefficient (HR) | Initial Type | Initial Discharge (M3/S) | Recession Constant | Threshold Type | Ratio to Peak |
| W460 | 9.79545 | 89.219 | 0.0 | 0.21492 | 0.31488 | Discharge | 0.0027503 | 0.33333 | Ratio to Peak | 0.05255 |
| W470 | 3.349415 | 80.263 | 0.0 | 0.227864 | 0.20757 | Discharge | 0.0011524 | 0.33333 | Ratio to Peak | |
| W480 | 6.80238 | 90.247 | 0.0 | 1.8844 | 0.64798 | Discharge | 0.0081771 | 0.33333 | Ratio to Peak | |
| W490 | 3.084365 | 84.774 | 0.0 | 0.86704 | 3.4989 | Discharge | 0.0067252 | 0.33333 | Ratio to Peak | 0.05 |
| W500 | 1.463665 | 97.098 | 0.0 | 8.7496 | 9.6975 | Discharge | 0.0541181 | 0.33333 | Ratio to Peak | 0.05 |
| W510 | 2.92809 | 90.735 | 0.0 | 0.87528 | 1.7691 | Discharge | 0.0168304 | 0.33333 | Ratio to Peak | 0.05 |
| W520 | 2.121065 | 88.341 | 0.0 | 0.607088 | 1.6892 | Discharge | 0.008338 | 0.33333 | Ratio to Peak | |
| W530 | 1.8107 | 92.831 | 0.0 | 0.93208 | 1.5902 | Discharge | 0.0340538 | 0.33333 | Ratio to Peak | 0.05 |
| W540 | 5.10986 | 91.779 | 0.0 | 1.44328 | 0.42011 | Discharge | 0.0069874 | 0.33333 | Ratio to Peak | |
| W550 | 1.613955 | 99 | 0.0 | 3.68464 | 10.603 | Discharge | 0.0067373 | 0.33333 | Ratio to Peak | 0.05 |
| W560 | 0.8618685 | 98.001 | 0.0 | 3.09944 | 3.2867 | Discharge | 0.0125249 | 0.33333 | Ratio to Peak | 0.05 |
| W570 | 2.352675 | 90.479 | 0.0 | 1.86776 | 0.68036 | Discharge | 0.0111548 | 0.33333 | Ratio to Peak | |
| W580 | 2.29311 | 93.332 | 0.0 | 0.267272 | 0.76269 | Discharge | 0.0091107 | 0.33333 | Ratio to Peak | |
| W590 | 2.315245 | 99 | 0.0 | 5.3784 | 7.2951 | Discharge | 0.0477175 | 0.33333 | Ratio to Peak | 0.05 |
| W600 | 1.486845 | 93.796 | 0.0 | 5.11544 | 3.978 | Discharge | 0.0070055 | 0.33333 | Ratio to Peak | 0.05 |
| W610 | 1.38149 | 91.926 | 0.0 | 3.29952 | 4.0162 | Discharge | 0.0120022 | 0.33333 | Ratio to Peak | 0.05 |
| W620 | 0.600305 | 99 | 0.0 | 4.46176 | 5.9141 | Discharge | 0.013822 | 0.33333 | Ratio to Peak | 0.05 |
| W630 | 3.94725 | 92.818 | 0.0 | 0.52804 | 0.47707 | Discharge | 0.008167 | 0.33333 | Ratio to Peak | |
| W640 | 4.54879 | 93.832 | 0.0 | 1.35448 | 1.2622 | Discharge | 0.0135715 | 0.33333 | Ratio to Peak | 0.05 |
| W650 | 0.711094 | 60.123 | 0.0 | 0.594776 | 0.46205 | Discharge | 0.0015284 | 0.50244 | Ratio to Peak | |

| Basin Number | SCS Curve Number Loss | | | Clark Unit Hydrograph Transform | | Recession Baseflow | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Initial Abstraction (mm) | Curve Number | Impervious (%) | Time of Concentration (HR) | Storage Coefficient (HR) | Initial Type | Initial Discharge (M3/S) | Recession Constant | Threshold Type | Ratio to Peak |
| W660 | 2.530515 | 93.594 | 0.0 | 0.440512 | 0.52146 | Discharge | 0.013491 | 0.33333 | Ratio to Peak | 0.046099 |
| W670 | 3.687615 | 94.631 | 0.0 | 5.08072 | 6.5847 | Discharge | 0.0302056 | 0.33333 | Ratio to Peak | 0.05 |
| W680 | 0.216068 | 92.08 | 0.0 | 0.9968 | 0.83342 | Discharge | 0.0054452 | 0.33333 | Ratio to Peak | |
| W690 | 2.31591 | 89.168 | 0.0 | 3.698 | 4.0162 | Discharge | 0.0084351 | 0.33333 | Ratio to Peak | 0.05 |
| W700 | 3.680775 | 92.968 | 0.0 | 1.36176 | 3.9304 | Discharge | 0.0184468 | 0.45 | Ratio to Peak | 0.05 |
| W710 | 4.58375 | 92.948 | 0.0 | 0.92864 | 1.2368 | Discharge | 0.0122222 | 0.49 | Ratio to Peak | 0.05 |
| W720 | 5.03025 | 94.622 | 0.0 | 3.92176 | 3.3687 | Discharge | 0.031193 | 0.33333 | Ratio to Peak | 0.05 |
| W730 | 3.115335 | 95.45 | 0.0 | 6.9916 | 8.82 | Discharge | 0.0159802 | 0.33333 | Ratio to Peak | 0.05 |
| W740 | 2.664465 | 99 | 0.0 | 5.7692 | 6.3444 | Discharge | 0.0186619 | 0.49 | Ratio to Peak | 0.05 |
| W750 | 3.22582 | 85.457 | 0.0 | 2.35832 | 4.2266 | Discharge | 0.0228956 | 0.49 | Ratio to Peak | 0.05 |
| W760 | 2.823115 | 88.758 | 0.0 | 3.81536 | 4.0831 | Discharge | 0.0300912 | 0.33333 | Ratio to Peak | 0.05 |
| W770 | 3.737015 | 89.078 | 0.0 | 0.520888 | 0.63416 | Discharge | 0.00452 | 0.33333 | Ratio to Peak | |
| W780 | 5.55598 | 89.354 | 0.0 | 1.50016 | 2.0391 | Discharge | 0.0116061 | 0.33333 | Ratio to Peak | 0.05 |
| W790 | 0.8073955 | 88.941 | 0.0 | 3.74496 | 4.75 | Discharge | 0.0411971 | 0.49 | Ratio to Peak | 0.05 |
| W800 | 0.3271515 | 93.551 | 0.0 | 4.16328 | 5.3168 | Discharge | 0.008255 | 0.33333 | Ratio to Peak | 0.05 |
| W810 | 2.52282 | 88.188 | 0.0 | 0.255544 | 0.46507 | Discharge | 0.005464 | 0.49 | Ratio to Peak | 0.071084 |
| W820 | 5.39581 | 95.628 | 0.0 | 0.94728 | 2.6804 | Discharge | 0.0073307 | 0.49 | Ratio to Peak | 0.05 |
| W830 | 0.99579 | 85.948 | 0.0 | 1.51472 | 3.9178 | Discharge | 0.0171437 | 0.33333 | Ratio to Peak | 0.05 |
| W840 | 2.97749 | 85.822 | 0.0 | 3.30168 | 4.0872 | Discharge | 0.017003 | 0.49 | Ratio to Peak | 0.05 |
| W850 | 4.344255 | 88.364 | 0.0 | 2.12904 | 2.6079 | Discharge | 0.0398795 | 0.5 | Ratio to Peak | 0.05 |
| W860 | 0.893817 | 96.591 | 0.0 | 7.87512 | 11.215 | Discharge | 0.0739255 | 0.575 | Ratio to Peak | 0.05 |
| W870 | 5.71976 | 46.689 | 0.0 | 1.29496 | 2.3444 | Discharge | 0.0314017 | 0.33333 | Ratio to Peak | 0.05 |
| W880 | 3.0498 | 58.532 | 0.0 | 3.0822 | 4.8855 | Discharge | 0.0256979 | 0.33333 | Ratio to Peak | 0.05 |
| W890 | 6.1245 | 93.579 | 0.0 | 1.9194 | 2.8627 | Discharge | 0.0077483 | 0.75 | Ratio to Peak | 0.05 |
| W900 | 4.8632 | 76.145 | 0.0 | 2.3595 | 3.0451 | Discharge | 0.0163694 | 0.5 | Ratio to Peak | 0.05 |

## Annex 10. Ilang Ilang Model Reach Parameters

| Reach Number | Muskingum Cunge Channel Routing | | | | | | |
|---|---|---|---|---|---|---|---|
| | Time Step Method | Length (m) | Slope | Manning's n | Shape | Width | Side Slope |
| R10 | Automatic Fixed Interval | 278.49 | 0.004 | 0.21489 | Trapezoid | 45 | 45 |
| R100 | Automatic Fixed Interval | 2832.1 | 0.36085 | 0.32939 | Trapezoid | 45 | 45 |
| R120 | Automatic Fixed Interval | 2456.5 | 0.41386 | 0.88361 | Trapezoid | 45 | 45 |
| R150 | Automatic Fixed Interval | 8927.3 | 0.0031364 | 0.0224661 | Trapezoid | 45 | 45 |
| R170 | Automatic Fixed Interval | 427.99 | 0.0140190 | 0.073667 | Trapezoid | 45 | 45 |
| R180 | Automatic Fixed Interval | 14013 | 0.0770761 | 0.0195678 | Trapezoid | 45 | 45 |
| R20 | Automatic Fixed Interval | 1283.0 | 0.0007794 | 0.12006 | Trapezoid | 45 | 45 |
| R200 | Automatic Fixed Interval | 1270.8 | 0.0052349 | 0.0050991 | Trapezoid | 45 | 45 |
| R210 | Automatic Fixed Interval | 2576.9 | 0.40089 | 0.0020341 | Trapezoid | 45 | 45 |
| R230 | Automatic Fixed Interval | 2402.1 | 0.0101930 | 0.0150236 | Trapezoid | 45 | 45 |
| R250 | Automatic Fixed Interval | 3314.2 | 0.0132675 | 0.0044526 | Trapezoid | 45 | 45 |
| R270 | Automatic Fixed Interval | 6950.1 | 0.0102578 | 0.0606979 | Trapezoid | 45 | 45 |
| R280 | Automatic Fixed Interval | 4204.3 | 0.0169461 | 0.0151842 | Trapezoid | 45 | 45 |
| R290 | Automatic Fixed Interval | 1680.2 | 0.0091833 | 0.0419209 | Trapezoid | 45 | 45 |
| R300 | Automatic Fixed Interval | 3180.1 | 0.0123744 | 0.0014773 | Trapezoid | 45 | 45 |
| R350 | Automatic Fixed Interval | 1603.6 | 0.0233076 | 0.0014821 | Trapezoid | 45 | 45 |
| R370 | Automatic Fixed Interval | 6524.0 | 0.0133162 | 0.0023142 | Trapezoid | 45 | 45 |
| R40 | Automatic Fixed Interval | 1453.7 | 0.68792 | 0.50102 | Trapezoid | 45 | 45 |
| R420 | Automatic Fixed Interval | 7032.1 | 0.0186313 | 0.0016204 | Trapezoid | 45 | 45 |
| R50 | Automatic Fixed Interval | 1743.4 | 0.56902 | 0.0573445 | Trapezoid | 45 | 45 |
| R60 | Automatic Fixed Interval | 3424.2 | 0.0061404 | 0.16473 | Trapezoid | 45 | 45 |
| R90 | Automatic Fixed Interval | 2357.6 | 0.0038174 | 0.12328 | Trapezoid | 45 | 45 |

# Annex 11. Ilang-Ilang Field Validation Points

| Point Number | Validation Coordinates (in WGS84) | | Model Var (m) | Validation Points (m) | Error | Event/Date | Rain Return / Scenario |
|---|---|---|---|---|---|---|---|
| | Lat | Long | | | | | |
| 1 | 14.410560 | 120.884749 | 0.103 | 0.5 | 0.397 | Milenyo / September 28, 2006 | 5 -Year |
| 2 | 14.411674 | 120.884279 | 0.181 | 0.5 | 0.319 | Milenyo / September 28, 2006 | 5 -Year |
| 3 | 14.412941 | 120.883892 | 0.03 | 0.5 | 0.470 | Milenyo / September 28, 2006 | 5 -Year |
| 4 | 14.417687 | 120.884427 | 0.03 | 0.5 | 0.470 | Milenyo / September 28, 2006 | 5 -Year |
| 5 | 14.409722 | 120.884174 | 0.03 | 0.5 | 0.470 | Milenyo / September 28, 2006 | 5 -Year |
| 6 | 14.414473 | 120.884967 | 0.291 | 2 | 1.709 | Milenyo / September 28, 2006 | 5 -Year |
| 7 | 14.415879 | 120.884006 | 0.375 | 2 | 1.625 | Milenyo / September 28, 2006 | 5 -Year |
| 8 | 14.416715 | 120.884041 | 0.03 | 2 | 1.970 | Milenyo / September 28, 2006 | 5 -Year |
| 9 | 14.415124 | 120.884702 | 0.034 | 2 | 1.966 | Milenyo / September 28, 2006 | 5 -Year |
| 10 | 14.414889 | 120.884871 | 0.03 | 2 | 1.970 | Milenyo / September 28, 2006 | 5 -Year |
| 11 | 14.414619 | 120.884931 | 0.092 | 2 | 1.908 | Milenyo / September 28, 2006 | 5 -Year |
| 12 | 14.415426 | 120.884404 | 0.338 | 2 | 1.662 | Milenyo / September 28, 2006 | 5 -Year |
| 13 | 14.411737 | 120.879109 | 0.16 | 5.4 | 5.240 | Milenyo / September 28, 2006 | 5 -Year |
| 14 | 14.417096 | 120.884186 | 0.245 | 5.6 | 5.355 | Milenyo / September 28, 2006 | 5 -Year |
| 15 | 14.419050 | 120.883759 | 0.395 | 5 | 4.605 | Milenyo / September 28, 2006 | 5 -Year |
| 16 | 14.407914 | 120.877951 | 1.554 | 5 | 3.446 | Milenyo / September 28, 2006 | 5 -Year |
| 17 | 14.440910 | 120.911089 | 0.303 | 6.3 | 5.997 | Milenyo / September 28, 2006 | 5 -Year |
| 18 | 14.432761 | 120.898750 | 0.385 | 6.4 | 6.015 | Milenyo / September 28, 2006 | 5 -Year |
| 19 | 14.419848 | 120.884229 | | 6.4 | 3.455 | Milenyo / September 28, 2006 | 5 -Year |
| 20 | 14.431303 | 120.897558 | 2.408 | 0.3 | -2.108 | Milenyo / September 28, 2006 | 5 -Year |
| 21 | 14.431158 | 120.897814 | 0.382 | 0.3 | -0.082 | Milenyo / September 28, 2006 | 5 -Year |
| 22 | 14.433762 | 120.900120 | 0.069 | 0.3 | 0.231 | Milenyo / September 28, 2006 | 5 -Year |
| 23 | 14.430628 | 120.896409 | 0.203 | 0.3 | 0.097 | Milenyo / September 28, 2006 | 5 -Year |
| 24 | 14.445906 | 120.908863 | 0.316 | 0.3 | -0.016 | Milenyo / September 28, 2006 | 5 -Year |
| 25 | 14.434743 | 120.901719 | 0.063 | 0.4 | 0.337 | Milenyo / September 28, 2006 | 5 -Year |
| 26 | 14.438930 | 120.903987 | 0.071 | 0.5 | 0.429 | Milenyo / September 28, 2006 | 5 -Year |
| 27 | 14.446135 | 120.909423 | 0.123 | 0.5 | 0.377 | Milenyo / September 28, 2006 | 5 -Year |
| 28 | 14.446430 | 120.910430 | 0.903 | 0.5 | -0.403 | Milenyo / September 28, 2006 | 5 -Year |
| 29 | 14.443699 | 120.909567 | 0.843 | 1.5 | 0.657 | Milenyo / September 28, 2006 | 5 -Year |
| 30 | 14.444198 | 120.909188 | 0.859 | 1.5 | 0.641 | Milenyo / September 28, 2006 | 5 -Year |
| 31 | 14.444384 | 120.907574 | | 1.5 | 0.445 | Milenyo / September 28, 2006 | 5 -Year |
| 32 | 14.444273 | 120.907798 | 0.866 | 1.5 | 0.634 | Milenyo / September 28, 2006 | 5 -Year |
| 33 | 14.444260 | 120.908136 | 1.104 | 1.5 | 0.396 | Milenyo / September 28, 2006 | 5 -Year |
| 34 | 14.446638 | 120.912541 | 1.064 | 1.5 | 0.436 | Milenyo / September 28, 2006 | 5 -Year |
| 35 | 14.445923 | 120.912761 | 1.049 | 1.5 | 0.451 | Milenyo / September 28, 2006 | 5 -Year |
| 36 | 14.435844 | 120.901333 | 0.987 | 1.5 | 0.513 | Milenyo / September 28, 2006 | 5 -Year |
| 37 | 14.436029 | 120.901148 | 0.927 | 1.5 | 0.573 | Milenyo / September 28, 2006 | 5 -Year |
| 38 | 14.435896 | 120.900939 | 0.904 | 1.5 | 0.596 | Milenyo / September 28, 2006 | 5 -Year |
| 39 | 14.439682 | 120.903375 | 0.967 | 1.5 | 0.533 | Milenyo / September 28, 2006 | 5 -Year |
| 40 | 14.439470 | 120.903114 | 1.148 | 1.5 | 0.352 | Milenyo / September 28, 2006 | 5 -Year |
| 41 | 14.440187 | 120.906795 | 0.97 | 1.5 | 0.530 | Milenyo / September 28, 2006 | 5 -Year |
| 42 | 14.441759 | 120.908971 | 0.832 | 1.5 | 0.668 | Milenyo / September 28, 2006 | 5 -Year |

| Point Number | Validation Coordinates (in WGS84) | | Model Var (m) | Validation Points (m) | Error | Event/Date | Rain Return / Scenario |
|---|---|---|---|---|---|---|---|
| | Lat | Long | | | | | |
| 43 | 14.442050 | 120.909414 | | 1.5 | 0.440 | Milenyo / September 28, 2006 | 5 -Year |
| 44 | 14.435556 | 120.901368 | 0.151 | 1.5 | 1.349 | Milenyo / September 28, 2006 | 5 -Year |
| 45 | 14.465277 | 120.884646 | 0.061 | 0 | -0.061 | Milenyo / September 28, 2006 | 5 -Year |
| 46 | 14.470518 | 120.887061 | 0.195 | 0 | -0.195 | Milenyo / September 28, 2006 | 5 -Year |
| 47 | 14.471946 | 120.889167 | 0.377 | 0 | -0.377 | Milenyo / September 28, 2006 | 5 -Year |
| 48 | 14.472730 | 120.889901 | 0.187 | 0 | -0.187 | Milenyo / September 28, 2006 | 5 -Year |
| 49 | 14.472101 | 120.890178 | 0.093 | 0 | -0.093 | Milenyo / September 28, 2006 | 5 -Year |
| 50 | 14.474737 | 120.888524 | 0.159 | 0 | -0.159 | Milenyo / September 28, 2006 | 5 -Year |
| 51 | 14.475056 | 120.888468 | 0.03 | 0 | -0.030 | Milenyo / September 28, 2006 | 5 -Year |
| 52 | 14.431762 | 120.885164 | 0.03 | 0 | -0.030 | Milenyo / September 28, 2006 | 5 -Year |
| 53 | 14.453528 | 120.878878 | 0.03 | 0 | -0.030 | Milenyo / September 28, 2006 | 5 -Year |
| 54 | 14.433678 | 120.887963 | 0.03 | 0 | -0.030 | Milenyo / September 28, 2006 | 5 -Year |
| 55 | 14.453168 | 120.878763 | 0.383 | 0 | -0.383 | Milenyo / September 28, 2006 | 5 -Year |
| 56 | 14.432489 | 120.887479 | 0.03 | 0 | -0.030 | Milenyo / September 28, 2006 | 5 -Year |
| 57 | 14.451727 | 120.878328 | 0.03 | 0 | -0.030 | Milenyo / September 28, 2006 | 5 -Year |
| 58 | 14.450968 | 120.878169 | 0.082 | 0 | -0.082 | Milenyo / September 28, 2006 | 5 -Year |
| 59 | 14.464520 | 120.885500 | 0.03 | 0 | -0.030 | Milenyo / September 28, 2006 | 5 -Year |
| 60 | 14.470344 | 120.887545 | 0.03 | 0 | -0.030 | Milenyo / September 28, 2006 | 5 -Year |
| 61 | 14.470091 | 120.888266 | 0.145 | 0 | -0.145 | Milenyo / September 28, 2006 | 5 -Year |
| 62 | 14.470109 | 120.888050 | 0.03 | 0 | -0.030 | Milenyo / September 28, 2006 | 5 -Year |
| 63 | 14.431063 | 120.884424 | 0.129 | 0 | -0.129 | Milenyo / September 28, 2006 | 5 -Year |
| 64 | 14.455333 | 120.879709 | 0.07 | 0 | -0.070 | Milenyo / September 28, 2006 | 5 -Year |
| 65 | 14.470372 | 120.887470 | 0.123 | 0.1 | -0.023 | Milenyo / September 28, 2006 | 5 -Year |
| 66 | 14.470329 | 120.886669 | 0.175 | 0.1 | -0.075 | Milenyo / September 28, 2006 | 5 -Year |
| 67 | 14.465088 | 120.883395 | 0.03 | 0.1 | 0.070 | Milenyo / September 28, 2006 | 5 -Year |
| 68 | 14.470894 | 120.892457 | 0.233 | 0.1 | -0.133 | Milenyo / September 28, 2006 | 5 -Year |
| 69 | 14.473543 | 120.893395 | 0.069 | 0.1 | 0.031 | Milenyo / September 28, 2006 | 5 -Year |
| 70 | 14.473898 | 120.888596 | 0.041 | 0.1 | 0.059 | Milenyo / September 28, 2006 | 5 -Year |
| 71 | 14.474085 | 120.888130 | 0.257 | 0.1 | -0.157 | Milenyo / September 28, 2006 | 5 -Year |
| 72 | 14.471991 | 120.888505 | 0.03 | 0.1 | 0.070 | Milenyo / September 28, 2006 | 5 -Year |
| 73 | 14.448875 | 120.880054 | 0.113 | 0.1 | -0.013 | Milenyo / September 28, 2006 | 5 -Year |
| 74 | 14.469268 | 120.886097 | 0.03 | 0.12 | 0.090 | Milenyo / September 28, 2006 | 5 -Year |
| 75 | 14.473808 | 120.890079 | 0.136 | 0.12 | -0.016 | Milenyo / September 28, 2006 | 5 -Year |
| 76 | 14.475416 | 120.890185 | 0.112 | 0.12 | 0.008 | Milenyo / September 28, 2006 | 5 -Year |
| 77 | 14.475548 | 120.896006 | 0.197 | 0.12 | -0.077 | Milenyo / September 28, 2006 | 5 -Year |
| 78 | 14.473628 | 120.888330 | 0.113 | 0.12 | 0.007 | Milenyo / September 28, 2006 | 5 -Year |
| 79 | 14.471420 | 120.888917 | 0.093 | 0.12 | 0.027 | Milenyo / September 28, 2006 | 5 -Year |
| 80 | 14.470183 | 120.887950 | 0.111 | 0.13 | 0.019 | Milenyo / September 28, 2006 | 5 -Year |
| 81 | 14.470873 | 120.890121 | 0.12 | 0.14 | 0.020 | Milenyo / September 28, 2006 | 5 -Year |
| 82 | 14.475275 | 120.895140 | 0.136 | 0.14 | 0.004 | Milenyo / September 28, 2006 | 5 -Year |
| 83 | 14.469484 | 120.886529 | 0.084 | 0.14 | 0.056 | Milenyo / September 28, 2006 | 5 -Year |
| 84 | 14.466057 | 120.885486 | 0.201 | 0.15 | -0.051 | Milenyo / September 28, 2006 | 5 -Year |
| 85 | 14.465518 | 120.884959 | 0.124 | 0.15 | 0.026 | Milenyo / September 28, 2006 | 5 -Year |
| 86 | 14.473113 | 120.890623 | 0.194 | 0.15 | -0.044 | Milenyo / September 28, 2006 | 5 -Year |

| Point Number | Validation Coordinates (in WGS84) | | Model Var (m) | Validation Points (m) | Error | Event/Date | Rain Return / Scenario |
|---|---|---|---|---|---|---|---|
| | Lat | Long | | | | | |
| 87 | 14.476426 | 120.894001 | 0.253 | 0.15 | -0.103 | Milenyo / September 28, 2006 | 5 -Year |
| 88 | 14.474025 | 120.894742 | 0.157 | 0.15 | -0.007 | Milenyo / September 28, 2006 | 5 -Year |
| 89 | 14.470358 | 120.887705 | 0.369 | 0.15 | -0.219 | Milenyo / September 28, 2006 | 5 -Year |
| 90 | 14.474694 | 120.889711 | 0.071 | 0.16 | 0.089 | Milenyo / September 28, 2006 | 5 -Year |
| 91 | 14.469256 | 120.887463 | 0.03 | 0.2 | 0.170 | Milenyo / September 28, 2006 | 5 -Year |
| 92 | 14.440111 | 120.878566 | 0.088 | 0.2 | 0.112 | Milenyo / September 28, 2006 | 5 -Year |
| 93 | 14.437069 | 120.880500 | 0.03 | 0.2 | 0.170 | Milenyo / September 28, 2006 | 5 -Year |
| 94 | 14.443122 | 120.879420 | 0.03 | 0.2 | 0.170 | Milenyo / September 28, 2006 | 5 -Year |
| 95 | 14.435604 | 120.885450 | 0.161 | 0.25 | 0.089 | Milenyo / September 28, 2006 | 5 -Year |
| 96 | 14.463563 | 120.884138 | 0.081 | 0.25 | 0.169 | Milenyo / September 28, 2006 | 5 -Year |
| 97 | 14.463851 | 120.884475 | 0.03 | 0.3 | 0.270 | Milenyo / September 28, 2006 | 5 -Year |
| 98 | 14.464211 | 120.886011 | 0.03 | 0.3 | 0.270 | Milenyo / September 28, 2006 | 5 -Year |
| 99 | 14.418696 | 120.885617 | 0.074 | 0.3 | 0.226 | Milenyo / September 28, 2006 | 5 -Year |
| 100 | 14.465385 | 120.886116 | 0.03 | 0.3 | 0.270 | Milenyo / September 28, 2006 | 5 -Year |
| 101 | 14.464614 | 120.883067 | 0.06 | 0.3 | 0.240 | Milenyo / September 28, 2006 | 5 -Year |
| 102 | 14.481509 | 120.911479 | 0.218 | 0.3 | 0.082 | Milenyo / September 28, 2006 | 5 -Year |
| 103 | 14.464919 | 120.885933 | 0.296 | 0.35 | 0.054 | Milenyo / September 28, 2006 | 5 -Year |
| 104 | 14.474387 | 120.891266 | 0.03 | 0.35 | 0.320 | Milenyo / September 28, 2006 | 5 -Year |
| 105 | 14.461103 | 120.881377 | 0.234 | 0.35 | 0.116 | Milenyo / September 28, 2006 | 5 -Year |
| 106 | 14.482932 | 120.910591 | 0.04 | 0.35 | 0.310 | Milenyo / September 28, 2006 | 5 -Year |
| 107 | 14.465765 | 120.886231 | 0.03 | 0.4 | 0.370 | Milenyo / September 28, 2006 | 5 -Year |
| 108 | 14.423408 | 120.884362 | 0.158 | 0.5 | 0.342 | Milenyo / September 28, 2006 | 5 -Year |
| 109 | 14.426444 | 120.882183 | 0.239 | 0.5 | 0.261 | Milenyo / September 28, 2006 | 5 -Year |
| 110 | 14.430862 | 120.885785 | 0.03 | 0.5 | 0.470 | Milenyo / September 28, 2006 | 5 -Year |
| 111 | 14.475157 | 120.888379 | 0.087 | 0.5 | 0.413 | Milenyo / September 28, 2006 | 5 -Year |
| 112 | 14.420286 | 120.884444 | 0.03 | 0.55 | 0.520 | Milenyo / September 28, 2006 | 5 -Year |
| 113 | 14.426062 | 120.882651 | 0.03 | 0.55 | 0.520 | Milenyo / September 28, 2006 | 5 -Year |
| 114 | 14.424869 | 120.884227 | 0.03 | 0.55 | 0.520 | Milenyo / September 28, 2006 | 5 -Year |
| 115 | 14.425232 | 120.883837 | 0.331 | 0.55 | 0.219 | Milenyo / September 28, 2006 | 5 -Year |
| 116 | 14.426845 | 120.882136 | 0.03 | 0.6 | 0.570 | Milenyo / September 28, 2006 | 5 -Year |
| 117 | 14.418885 | 120.884816 | 0.063 | 0.6 | 0.537 | Milenyo / September 28, 2006 | 5 -Year |
| 118 | 14.433646 | 120.883334 | 0.04 | 0.6 | 0.560 | Milenyo / September 28, 2006 | 5 -Year |
| 119 | 14.418902 | 120.885694 | 0.451 | 0.6 | 0.149 | Milenyo / September 28, 2006 | 5 -Year |
| 120 | 14.479058 | 120.901867 | 0.042 | 0.6 | 0.558 | Milenyo / September 28, 2006 | 5 -Year |
| 121 | 14.484956 | 120.902365 | 0.03 | 0.6 | 0.570 | Milenyo / September 28, 2006 | 5 -Year |
| 122 | 14.420727 | 120.884175 | 0.03 | 0.65 | 0.620 | Milenyo / September 28, 2006 | 5 -Year |
| 123 | 14.434962 | 120.885681 | 0.204 | 0.65 | 0.446 | Milenyo / September 28, 2006 | 5 -Year |
| 124 | 14.428266 | 120.883564 | 0.25 | 0.65 | 0.400 | Milenyo / September 28, 2006 | 5 -Year |
| 125 | 14.486506 | 120.901487 | 0.146 | 0.65 | 0.504 | Milenyo / September 28, 2006 | 5 -Year |
| 126 | 14.487690 | 120.903389 | 0.118 | 0.67 | 0.552 | Milenyo / September 28, 2006 | 5 -Year |
| 127 | 14.482985 | 120.897869 | 0.158 | 0.7 | 0.542 | Milenyo / September 28, 2006 | 5 -Year |
| 128 | 14.480420 | 120.896597 | 0.03 | 0.75 | 0.720 | Milenyo / September 28, 2006 | 5 -Year |
| 129 | 14.433462 | 120.884451 | 0.07 | 0.8 | 0.730 | Milenyo / September 28, 2006 | 5 -Year |
| 130 | 14.469239 | 120.890772 | 0.163 | 0.8 | 0.637 | Milenyo / September 28, 2006 | 5 -Year |

| Point Number | Validation Coordinates (in WGS84) | | Model Var (m) | Validation Points (m) | Error | Event/Date | Rain Return / Scenario |
|---|---|---|---|---|---|---|---|
| | Lat | Long | | | | | |
| 131 | 14.479598 | 120.895568 | 0.03 | 0.8 | 0.770 | Milenyo / September 28, 2006 | 5 -Year |
| 132 | 14.433328 | 120.885202 | 0.03 | 0.85 | 0.820 | Milenyo / September 28, 2006 | 5 -Year |
| 133 | 14.478844 | 120.897394 | 0.03 | 0.85 | 0.820 | Milenyo / September 28, 2006 | 5 -Year |
| 134 | 14.437624 | 120.885366 | 0.03 | 0.9 | 0.870 | Milenyo / September 28, 2006 | 5 -Year |
| 135 | 14.433935 | 120.885948 | 0.507 | 0.95 | 0.443 | Milenyo / September 28, 2006 | 5 -Year |
| 136 | 14.436996 | 120.901982 | 0.03 | 1 | 0.970 | Milenyo / September 28, 2006 | 5 -Year |
| 137 | 14.435915 | 120.885334 | 0.244 | 1.1 | 0.856 | Milenyo / September 28, 2006 | 5 -Year |
| 138 | 14.485580 | 120.899858 | 0.031 | 1.13 | 1.099 | Milenyo / September 28, 2006 | 5 -Year |
| 139 | 14.446449 | 120.906315 | 0.03 | 1.15 | 1.120 | Milenyo / September 28, 2006 | 5 -Year |
| 140 | 14.438579 | 120.885517 | 0.608 | 1.2 | 0.592 | Milenyo / September 28, 2006 | 5 -Year |
| 141 | 14.445236 | 120.903135 | 0.512 | 1.2 | 0.688 | Milenyo / September 28, 2006 | 5 -Year |
| 142 | 14.444008 | 120.903056 | 0.114 | 1.25 | 1.136 | Milenyo / September 28, 2006 | 5 -Year |
| 143 | 14.426841 | 120.880579 | 0.331 | 1.3 | 0.969 | Milenyo / September 28, 2006 | 5 -Year |
| 144 | 14.415414 | 120.918057 | 0.064 | 1.5 | 1.436 | Milenyo / September 28, 2006 | 5 -Year |
| 145 | 14.400959 | 120.907594 | 0.03 | 1.55 | 1.520 | Milenyo / September 28, 2006 | 5 -Year |
| 146 | 14.440341 | 120.878667 | 0.36 | 1.6 | 1.240 | Milenyo / September 28, 2006 | 5 -Year |
| 147 | 14.408581 | 120.896778 | 0.03 | 1.6 | 1.570 | Milenyo / September 28, 2006 | 5 -Year |
| 148 | 14.443471 | 120.879555 | 0.03 | 1.65 | 1.620 | Milenyo / September 28, 2006 | 5 -Year |
| 149 | 14.406144 | 120.925223 | 0.256 | 1.65 | 1.394 | Milenyo / September 28, 2006 | 5 -Year |
| 150 | 14.397844 | 120.887190 | 0.791 | 0 | -0.791 | Milenyo / September 28, 2006 | 5 -Year |
| 151 | 14.390722 | 120.883812 | 0.052 | 0.3 | 0.248 | Milenyo / September 28, 2006 | 5 -Year |
| 152 | 14.385740 | 120.880585 | 0.213 | 0.7 | 0.487 | Milenyo / September 28, 2006 | 5 -Year |
| 153 | 14.432269 | 120.916212 | 0.03 | 0 | -0.030 | Milenyo / September 28, 2006 | 5 -Year |
| 154 | 14.414177 | 120.884987 | 0.317 | 1.8 | 1.483 | Milenyo / September 28, 2006 | 5 -Year |
| 155 | 14.387116 | 120.883288 | 0.233 | 1 | 0.767 | Milenyo / September 28, 2006 | 5 -Year |
| 156 | 14.378742 | 120.879425 | 0.157 | 1 | 0.843 | Milenyo / September 28, 2006 | 5 -Year |
| 157 | 14.488130 | 120.901010 | 0.118 | 0.23 | 0.112 | Milenyo / September 28, 2006 | 5 -Year |
| 158 | 14.488864 | 120.899776 | 0.104 | 0.25 | 0.146 | Milenyo / September 28, 2006 | 5 -Year |
| 159 | 14.485710 | 120.898675 | 0.255 | 0.25 | -0.005 | Milenyo / September 28, 2006 | 5 -Year |
| 160 | 14.483926 | 120.897440 | 0.087 | 0.3 | 0.213 | Milenyo / September 28, 2006 | 5 -Year |
| 161 | 14.490662 | 120.901247 | 0.107 | 0.36 | 0.253 | Milenyo / September 28, 2006 | 5 -Year |
| 162 | 14.490314 | 120.898190 | 0.212 | 0.38 | 0.168 | Milenyo / September 28, 2006 | 5 -Year |
| 163 | 14.486858 | 120.899563 | 0.073 | 0.4 | 0.327 | Milenyo / September 28, 2006 | 5 -Year |
| 164 | 14.490661 | 120.899134 | 0.131 | 0.43 | 0.299 | Milenyo / September 28, 2006 | 5 -Year |
| 165 | 14.488553 | 120.900762 | 0.218 | 0.45 | 0.232 | Milenyo / September 28, 2006 | 5 -Year |
| 166 | 14.485332 | 120.898689 | 0.276 | 0.53 | 0.254 | Milenyo / September 28, 2006 | 5 -Year |
| 167 | 14.480692 | 120.894847 | 0.073 | 2.8 | 2.727 | Milenyo / September 28, 2006 | 5 -Year |
| 168 | 14.481304 | 120.893173 | 0.139 | 3 | 2.861 | Milenyo / September 28, 2006 | 5 -Year |
| 169 | 14.487337 | 120.896291 | 0.2 | 0.1 | -0.100 | Milenyo / September 28, 2006 | 5 -Year |
| 170 | 14.479308 | 120.891164 | 0.03 | 0.15 | 0.120 | Milenyo / September 28, 2006 | 5 -Year |
| 171 | 14.488020 | 120.892228 | 0.125 | 0.15 | 0.025 | Milenyo / September 28, 2006 | 5 -Year |
| 172 | 14.476476 | 120.890564 | 0.108 | 0.2 | 0.092 | Milenyo / September 28, 2006 | 5 -Year |
| 173 | 14.488735 | 120.897927 | 0.194 | 0.25 | 0.056 | Milenyo / September 28, 2006 | 5 -Year |
| 174 | 14.483543 | 120.901823 | 0.174 | 0.3 | 0.126 | Milenyo / September 28, 2006 | 5 -Year |

| Point Number | Validation Coordinates (in WGS84) | | Model Var (m) | Validation Points (m) | Error | Event/Date | Rain Return |
|---|---|---|---|---|---|---|---|
| | Lat | Long | | | | | |
| 175 | 14.476812 | 120.888722 | 0.334 | 0.35 | 0.016 | Milenyo / September 28, 2006 | 5 -Year |
| 176 | 14.483798 | 120.901107 | 0.089 | 0.35 | 0.261 | Milenyo / September 28, 2006 | 5 -Year |
| 177 | 14.484665 | 120.896122 | 0.072 | 0.4 | 0.328 | Milenyo / September 28, 2006 | 5 -Year |
| 178 | 14.490027 | 120.897447 | 0.03 | 0.45 | 0.420 | Milenyo / September 28, 2006 | 5 -Year |
| 179 | 14.482627 | 120.890984 | 0.287 | 0.1 | -0.187 | Milenyo / September 28, 2006 | 5 -Year |
| 180 | 14.482187 | 120.894945 | 0.068 | 0.2 | 0.132 | Milenyo / September 28, 2006 | 5 -Year |
| 148 | 14.443471 | 120.879555 | 0.03 | 1.65 | 1.620 | Milenyo / September 28, 2006 | 5 -Year |
| 149 | 14.406144 | 120.925223 | 0.256 | 1.65 | 1.394 | Milenyo / September 28, 2006 | 5 -Year |
| 150 | 14.397844 | 120.887190 | 0.791 | 0 | -0.791 | Milenyo / September 28, 2006 | 5 -Year |

# Annex 12. Educational Institutions affected by flooding in Ilang-Ilang Floodplain

| CAVITE | | | | |
|---|---|---|---|---|
| ILANG-ILANG | | | | |
| Building Name | Barangay | Rainfall Scenario | | |
| | | 5-year | 25-year | 100-year |
| Hamorawon Day Care Center | San Juan | Medium | Medium | High |
| Hamorawon Elementary School | San Juan | Medium | Medium | High |
| Sto. Niño Elementary School | Santo Niño | | | |
| Sto. Niño National High School | Santo Niño | | | |

## Annex 13. Health Institutions affected by flooding in Ilang-Ilang Floodplain

<table>
<tr><th colspan="5">CAVITE</th></tr>
<tr><th colspan="5">ILANG-ILANG</th></tr>
<tr><th rowspan="2">Building Name</th><th rowspan="2">Barangay</th><th colspan="3">Rainfall Scenario</th></tr>
<tr><th>5-year</th><th>25-year</th><th>100-year</th></tr>
<tr><td>Sto. Niño Health Center</td><td>Santo Niño</td><td>Medium</td><td>Medium</td><td>Medium</td></tr>
<tr><td>Rural Health Unit</td><td>San Juan</td><td></td><td></td><td></td></tr>
</table>