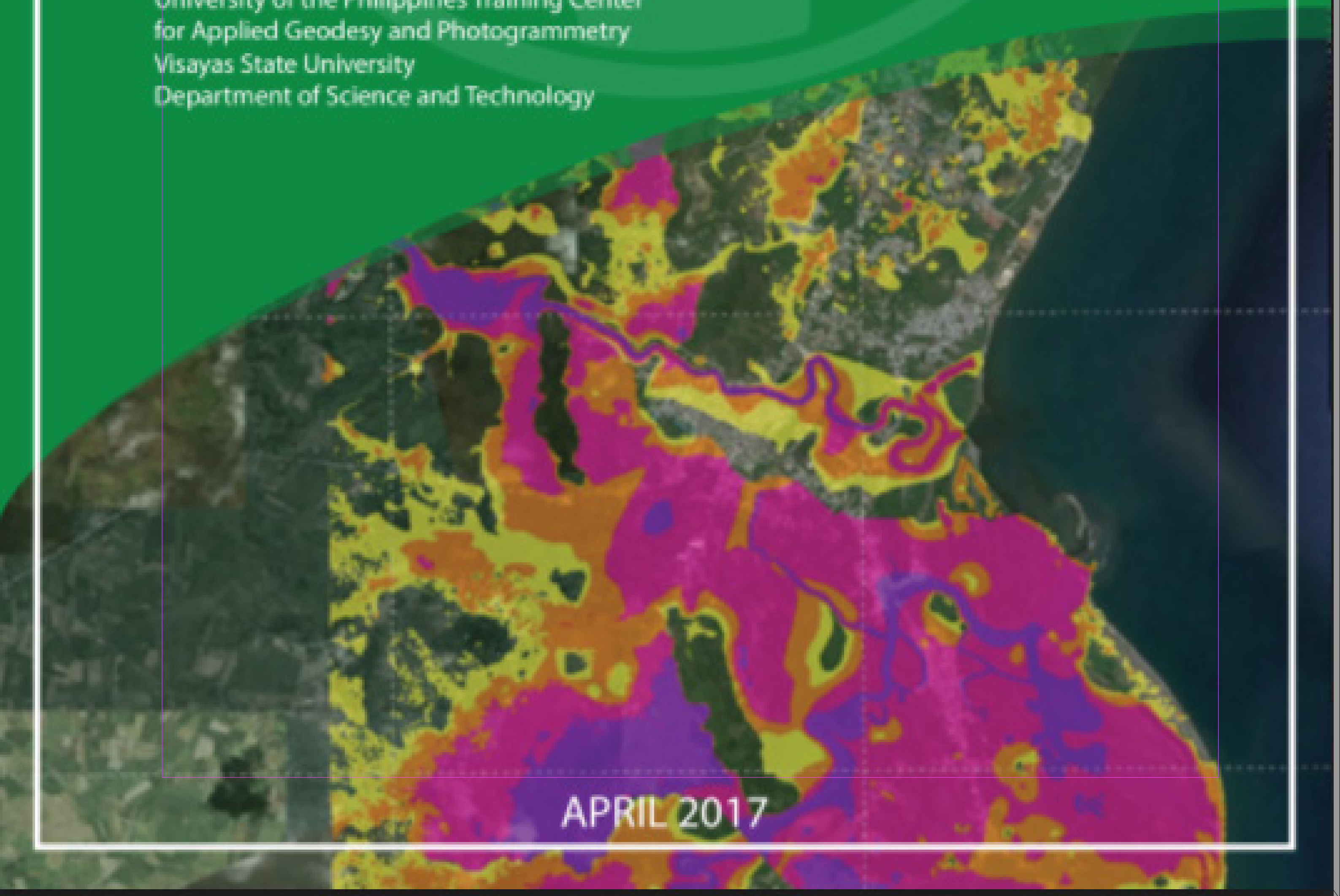
Hazard Mapping of the Philippines Using LIDAR ( Phil-LIDAR 1 )

# LiDAR Surveys and Flood Mapping of Palo River

University of the Philippines Training Center for Applied Geodesy and Photogrammetry
Visayas State University
Department of Science and Technology



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For questions/queries regarding this report, contact:

Engr. Florentino Morales, Jr.
Project Leader, PHIL-LiDAR 1 Program
Visayas State University
Baybay, Leyte, Philippines 6521
ffmorales_jr@yahoo.com

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

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

# CHAPTER 1: OVERVIEW OF THE PROGRAM AND PALO RIVER

Engr. Florentino Morales, Jr., and Enrico C. Paringit, Dr. Eng.

## 1.1 Background of the Phil-LIDAR 1 Program

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

The program was also 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 titled 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 the Visayas State University (VSU). VSU 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 12 river basins in the Leyte Province (LiDAR covered area, you may leave this blank) . The university is located in Cebu City in the province of Cebu.

## 1.2 Overview of the Palo River Basin

Palo River Basin covers portions of the Municipalities of Santa Fe, Palo, Alangalang, Pastrama, Dagami, Jaro, Buaren, and Ormoc City in Leyte. The DENR-RCBO identified it as one of the 140 critical watersheds in the Philippines, having a drainage area of 259 km2 and an estimated 492 million cubic meter annual run-off.

Its main stem, Palo River, passes along the Municipality of Santa Fe down to the Municipality of Palo. It is part of the 12 river systems in Leyte Province. An estimated population of 29,443 people resides in the immediate vicinity of the river which is distributed among the 12 barangays, namely: Baras, Buri, Guindapunan, Arado, San Fernando, Cavite West, San Miguel, Salvacion, Cavite East, Santa Cruz, Naga-Naga, and Cogon (NSO, 2010). The river is rich in mineral resources such as copper. On November 8, 2013, flooding caused by Super Typhoon Yolanda left 1,381 casualties in the vicinity of Palo, Leyte. A flood event before Super Typhoon Yolanda was on 16 March 2011 which affected 32 barangays in Palo.

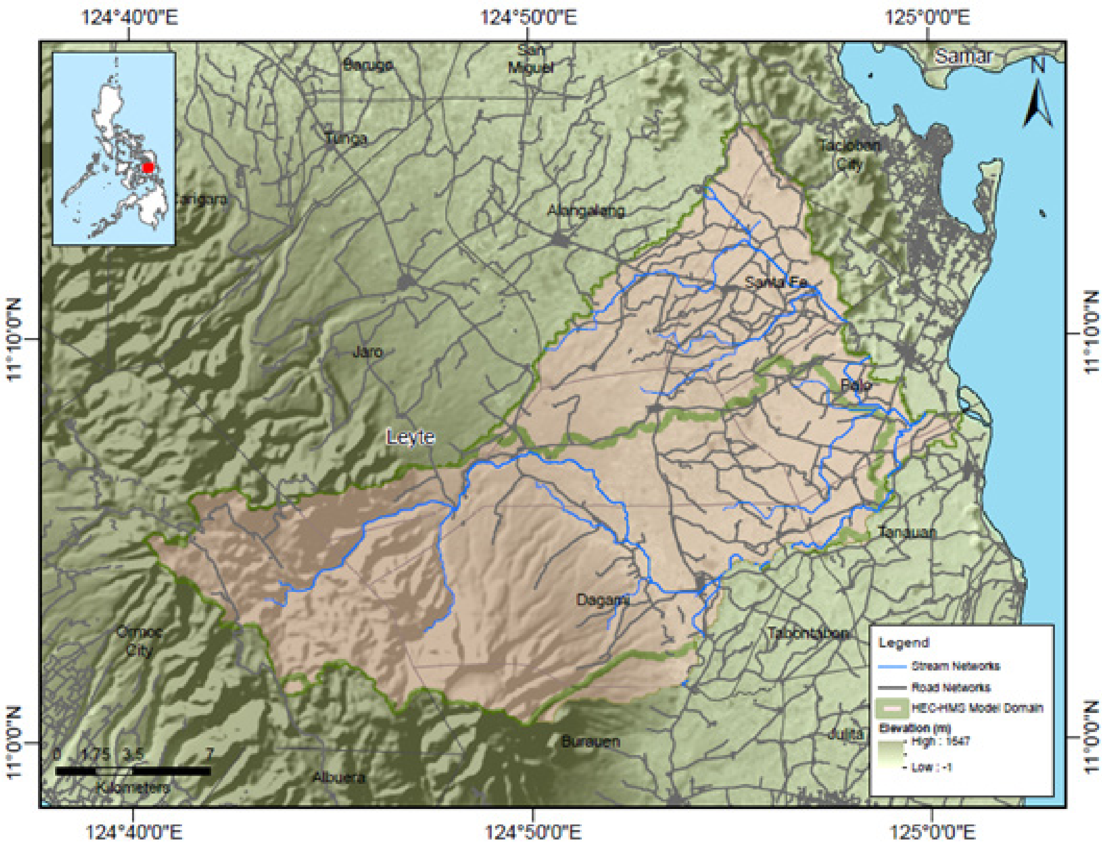



Figure 1. Map of the Palo River Basin

# CHAPTER 2: LIDAR DATA ACQUISITION OF THE PALO FLOODPLAIN

Engr. Louie P. Balicanta, Engr. Christopher Cruz, Lovely Gracia Acuña, Engr. Gerome Hipolito, Engr. Grace B. Sinadjan, Ms. Jonalyn S. Gonzales

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

## 2.1 Flight Plans

Plans were made to acquire LiDAR data within the delineated priority area for Palo Floodplain in Leyte and Samar. These missions were planned for 13 lines that run for at most three and a half (3.5) hours including take-off, landing, and turning time. The flight planning parameters for Aquarius and Gemini LiDAR systems are found in Table 1 and Table 2. Figure 2 and Figure 3 show the flight plan for Palo Floodplain survey using the Aquarius and Gemini sensors, respectively.

Table 1. Flight planning parameters for Aquarius LiDAR system.

| Block Name | Flying Height (m AGL) | Overlap (%) | Field of View (θ) | Pulse Repetition Frequency (PRF) (kHz) | Scan Frequency (Hz) | Average Speed (kts) | Average Turn Time (Minutes) |
|---|---|---|---|---|---|---|---|
| BLK34F | 600 | 30 | 36 | 50 | 50 | 120 | 5 |
| BLK33A | | | | | | | |
| BLK34D | 600 | 30 | 36 | 50 | 50 | 120 | 5 |
| BLK33E | 600 | 30 | 36 | 50 | 50 | 120 | 5 |
| BLK33H | 600 | 30 | 36 | 70 | 50 | 120 | 5 |

Table 2. Flight planning parameters for Gemini LiDAR system.

| Block Name | Flying Height (m AGL) | Overlap (%) | Field of View (θ) | Pulse Repetition Frequency (PRF) (kHz) | Scan Frequency (Hz) | Average Speed (kts) | Average Turn Time (Minutes) |
|---|---|---|---|---|---|---|---|
| BLK34A | 1200/600/850 | 30 | 34/50/40 | 100 | 50/40 | 120 | 5 |
| BLK34D | 1200/600 | 30 | 34/50 | 100 | 50/40 | 120 | 5 |
| BLK34E | 1200/600 | 30 | 34/50 | 100 | 50/40 | 120 | 5 |
| BLK34G | 1200/600/850 | 30 | 34/50/40 | 100 | 50/40 | 120 | 5 |
| BLK34B | 850 | 30 | 40 | 100 | 50 | 120 | 5 |
| BLK34C | 850/600 | 30 | 40/50 | 100 | 50/40 | 120 | 5 |

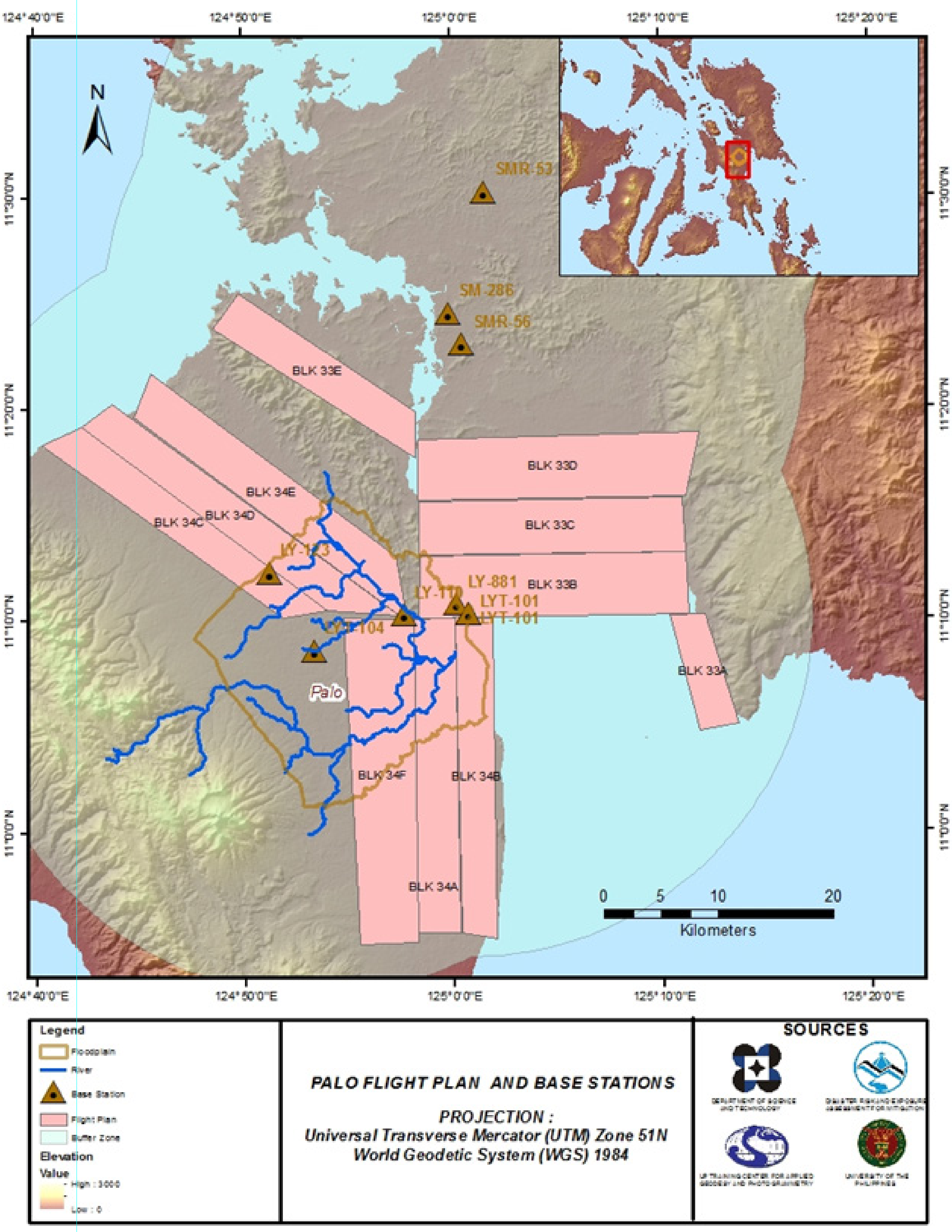



Figure 2. Flight plan and base stations for Palo Floodplain using the Aquarius sensor.

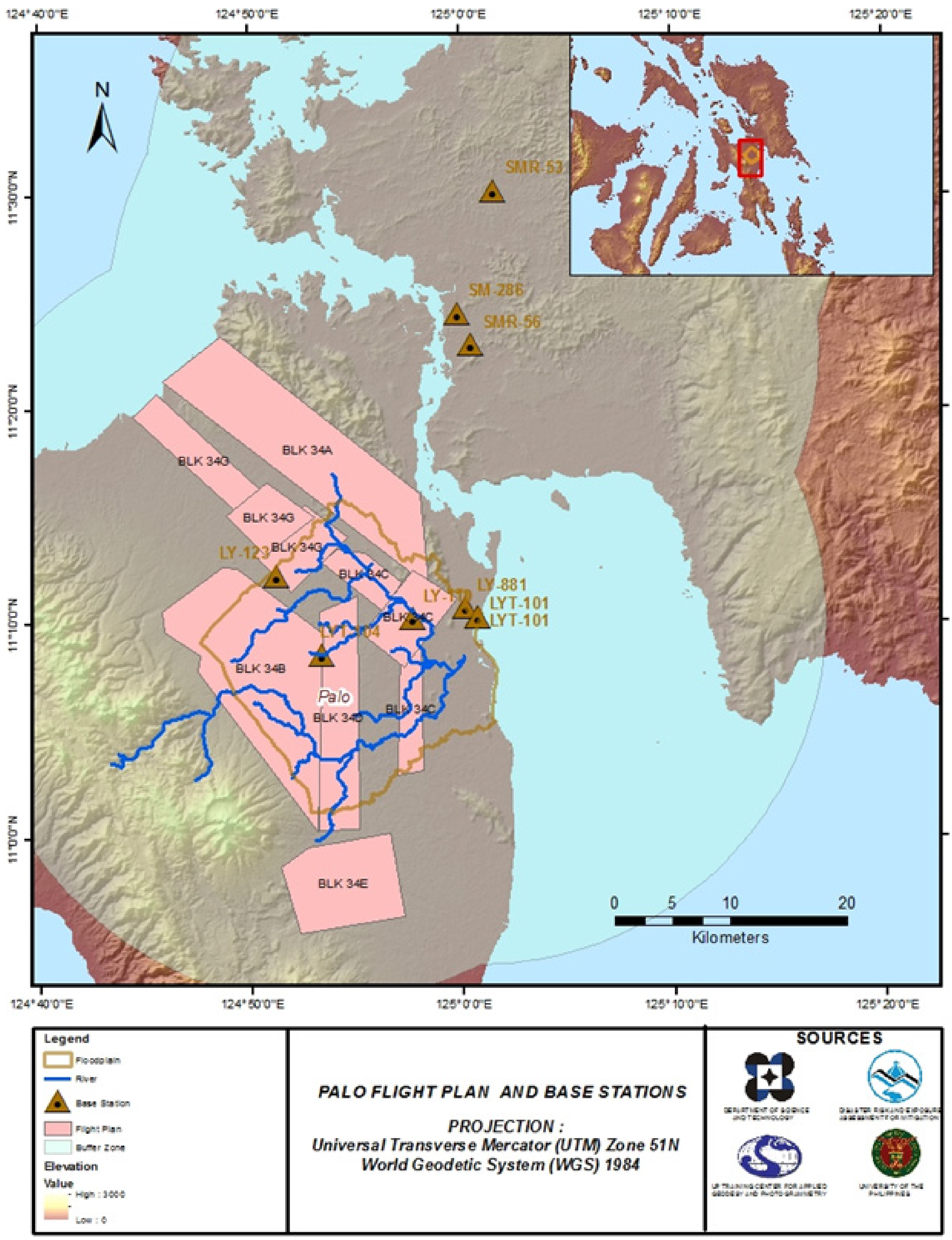



Figure 3. Flight plan and base stations for Palo Floodplain using the Gemini sensor

## 2.2 Ground Base Stations

The project team was able to recover three NAMRIA reference points: LYT-101, SMR-56, and SMR-53, which are of second-order accuracy. The project team also reprocessed four NAMRIA benchmarks LY-881, SM-286, LY-123, and LY-110, and one NAMRIA horizontal point, LYT-104. The certifications for the base stations are found in ANNEX 2 while the baseline processing report for the reprocessed points is found in ANNEX 3. These points were used as base stations during flight operations for the entire duration of the survey (January 24-30, 2014, April 20-22, 2014, May 14, 2014, and January 22-24, 2016). Base stations were observed using dual frequency GPS receivers, TRIMBLE SPS R8, TRIMBLE SPS 852, and TRIMBLE SPS 985. Flight plans and location of base stations used during the aerial LiDAR acquisition in Palo Floodplain are shown in Figure 2 and Figure 3.

Figure 4 to Figure 9 show the recovered NAMRIA reference points within the area. In addition, Table 3 to Table 11 show the details about the NAMRIA control stations while Table 12 shows the list of all ground control points occupied during the acquisition together with the dates they were utilized during the survey.

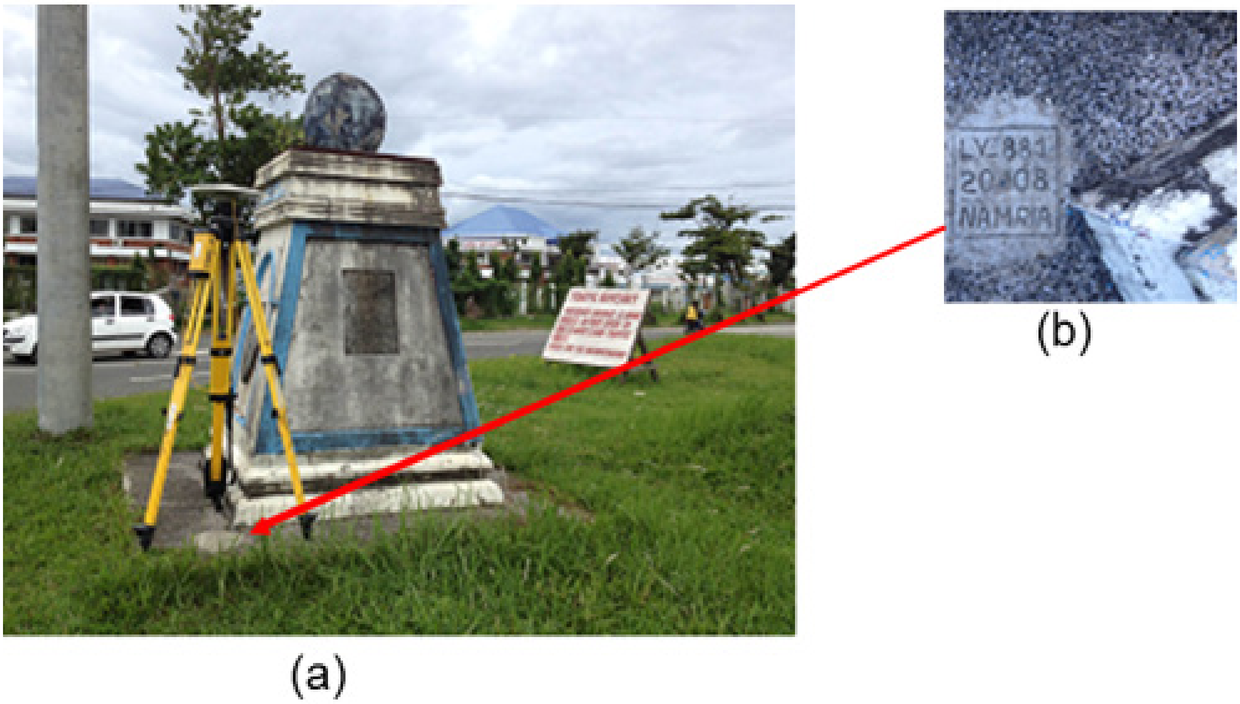



Figure 4. GPS set-up over LY-881 at the concrete foundation of Governor Center Welcome sign at the junction of the road going to Ormoc, Samar, Tacloban and MacArthur Landing Memorial Park in Brgy. Pawing, Palo, Leyte (a) and NAMRIA reference point LY-881 (b) as recovered by the field team.

Table 3. Details of the reprocessed NAMRIA Benchmark LY-881 used as base station for the LiDAR acquisition.

| | | |
|---|---|---|
| Station Name | LY-881 | |
| Order of Accuracy | $2^{nd}$ Order | |
| Relative Error (horizontal positioning) | 1: 50, 000 | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude | 11° 10’ 49.44332” North |
| | Longitude | 125° 00’ 04.69148” East |
| | Ellipsoidal Height | 5.992 meters |
| Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92) | Easting | 718540.093 meters |
| | Northing | 1236589.610 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude | 11° 10’ 45.19188” North |
| | Longitude | 125° 00’ 09.85261” East |
| | Ellipsoidal Height | 68.386 meters |

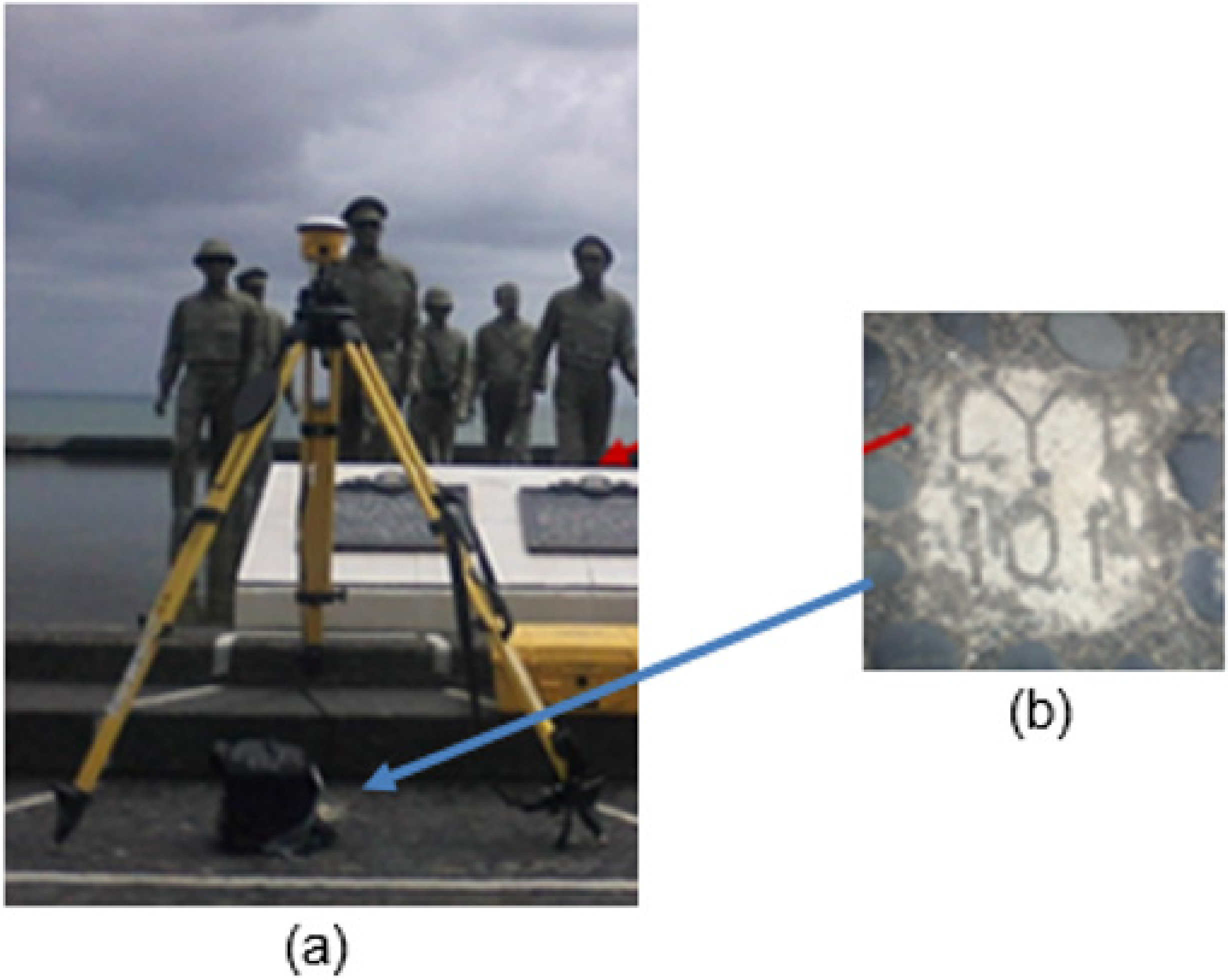



Figure 5. GPS set-up over LYT-101 situated within the premises of MacArthur's Landing Memorial Park, Palo, Leyte (a) and NAMRIA reference point LYT-101 (b) as recovered by the field team.

Table 4. Details of the recovered NAMRIA horizontal control point LYT-101 used as base station for the LiDAR Acquisition.

| | | |
|---|---|---|
| Station Name | LY-881 | |
| Order of Accuracy | 2nd Order | |
| Relative Error (horizontal positioning) | 1: 50, 000 | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude | 11° 10' 49.44332" North |
| | Longitude | 125° 00' 04.69148" East |
| | Ellipsoidal Height | 5.992 meters |
| Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92) | Easting | 718540.093 meters |
| | Northing | 1236589.610 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude | 11° 10' 45.19188" North |
| | Longitude | 125° 00' 09.85261" East |
| | Ellipsoidal Height | 68.386 meters |

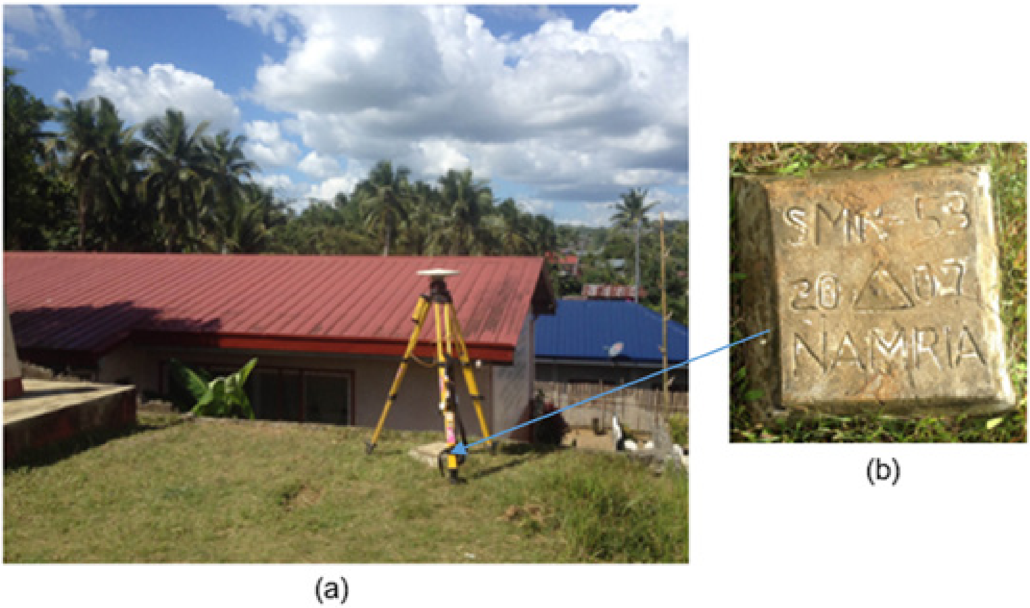



Figure 6. GPS set-up over SMR-53 located near the school building flag pole of San Isidro Elementary, Brgy. San Isidro, Santa Rita (a) and NAMRIA reference point SMR-53 (b) as recovered by the field team.

Table 5. Details of the recovered NAMRIA horizontal control point SMR-53 used as base station for the LiDAR acquisition.

| | | |
|---|---|---|
| Station Name | SMR-53 | |
| Order of Accuracy | 2nd | |
| Relative Error (horizontal positioning) | 1:50,000 | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude | 11° 30' 17.85657" North |
| | Longitude | 125° 1' 29.837339" East |
| | Ellipsoidal Height | 26.13400 meters |
| Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92) | Easting | 502722.403 meters |
| | Northing | 1272180.079 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude | 11° 30' 13.52495" North |
| | Longitude | 125° 1' 34.96980" East |
| | Ellipsoidal Height | 87.78700 meters |
| Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992) | Easting | 720874.14 meters |
| | Northing | 1272513.40 meters |

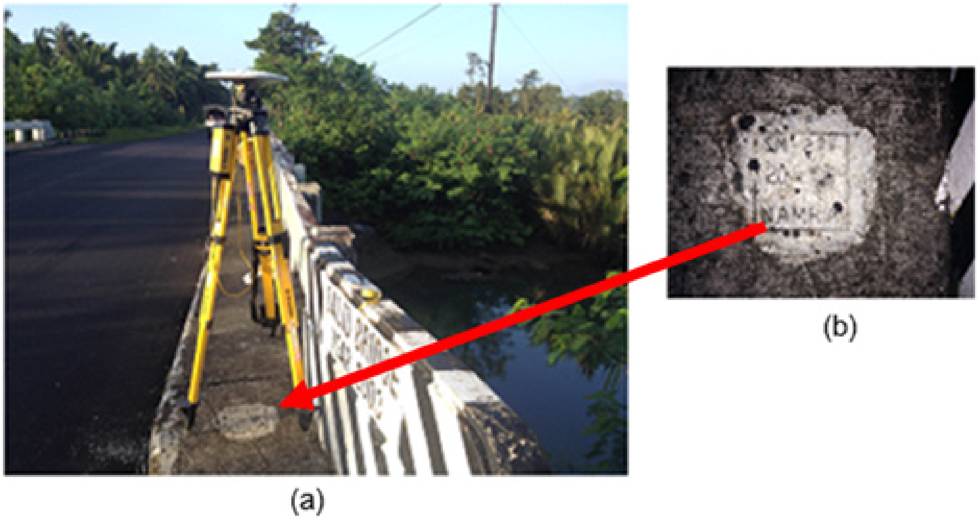



Figure 7. GPS set-up over SM-286 at Dalid Bridge along National Highway in Brgy. San Pascual, Sta. Rita, Samar (a) and NAMRIA reference point SM-286 (b) as recovered by the field team

Table 6. Details of the reprocessed NAMRIA Benchmark SM-286 used as base station for LiDAr acquisition.

| | | |
|---|---|---|
| Station Name | LYT-101 | |
| Order of Accuracy | 2nd | |
| Relative Error (horizontal positioning) | 1:50,000 | |
| Geographic Coordinates | Latitude | 11° 30’ 17.85657” North |
| | Longitude | 125° 1’ 29.837339” East |
| | Ellipsoidal Height | 26.13400 meters |
| Philippine Reference of 1992 Datum (PRS 92) | Latitude | 502722.403 meters |
| | | 1272180.079 meters |
| Longitude | Latitude | 11° 30’ 13.52495” North |
| | Longitude | 125° 1’ 34.96980” East |
| | Ellipsoidal Height | 87.78700 meters |


(a) (b)

Figure 8. GPS set-up over SMR-56 located inside Cabacungan Elementary School in Brgy. Cabacungan, Sta. Rita, Samar (a) and NAMRIA reference point SMR-56 (b) as recovered by the field team.

Table 7. Details of the recovered NAMRIA horizontal control point SMR-56 used as base station for the LiDAR acquisition

| | | |
|---|---|---|
| Station Name | SMR-53 | |
| Order of Accuracy | 2nd | |
| Relative Error (horizontal positioning) | 1:50,000 | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude | 11° 30’ 17.85657” North<br>125° 1’ 29.837339” East<br>26.13400 meters |
| Longitude | Latitude | 502722.403 meters<br>1272180.079 meters |
| Ellipsoidal Height | 11o 30’ 17.85657” North | 11° 30’ 13.52495” North<br>125° 1’ 34.96980” East<br>87.78700 meters |

(a) (b)

Figure 9. GPS set-up over LYT-104 located and re-established along rice paddy trail, approximately 90 meters from the centerline, east side of Pastrana-Santa Fe Road, District IV, Pastrana, Leyte (a) and NAMRIA reference point LYT-104 (b) as recovered by the field team.

Table 8. Details of the recovered NAMRIA horizontal control point LYT-104 with processed coordinates used as base station for the LiDAR acquisition.

| | | |
|---|---|---|
| Station Name | LYT-104 | |
| 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 | 11°08’38.92234” North<br>124° 53’ 13.52786” East<br>33.659 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Easting<br>Northing<br>Ellipsoidal Height | 11°08’34.67033” North<br>124° 53’ 18.69323” East<br>95.861 meters |
| Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992) | Latitude<br>Longitude | 706089.510m<br>1232496.838 |

Table 9. Details of the reprocessed NAMRIA Benchmark LY-123 used as base station for LiDAR acquisition

| | | |
|---|---|---|
| Station Name | LY-123 | |
| 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 | 11° 12’ 20.91223” North<br>124° 51’ 06.13717” East<br>34.930 meters |
| Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92) | Easting<br>Northing | 702180.961 meters<br>1239293.641 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude<br>Longitude<br>Ellipsoidal Height | 11° 12’ 16.64155” North<br>124° 51’ 11.29744” East<br>96.895 meters |

Table 10. Details of the reprocessed NAMRIA Benchmark LY-110 used as base station for LiDAR acquisition.

| | | |
|---|---|---|
| Station Name | LY-110 | |
| 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 | 11° 10' 19.48389" North<br>124° 57' 32.98736" East<br>12.819 meters |
| Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92) | Easting<br>Northing | 713942.863 meters<br>1235638.117 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude<br>Longitude<br>Ellipsoidal Height | 11° 10' 15.23095" North<br>124° 57' 38.14961" East<br>76.647 meters |

Table 11. Ground control points used during LiDAR data acquisition.

| Date Surveyed | Flight Number | Mission Name | Ground Control Points |
|---|---|---|---|
| 24 Jan 2014 | 1016A | 3BLK33A024A | LYT-101 |
| 24 Jan 2014 | 1018A | 3BLK33A024B | LYT-101 |
| 25 Jan 2014 | 1020A | 3BLK33B025A | LYT-101 |
| 26 Jan 2014 | 1024A | 3BLK33AS34A026A | LYT-101 |
| 26 Jan 2014 | 1026A | 3BLK34AS026A | LYT-101 |
| 27 Jan 2014 | 1028A | 3BLK 34ABS027A | LYT-101 |
| 29 Jan 2014 | 1036A | 3BLK33DS0929A | LYT-101 |
| 30 Jan 2014 | 1040A | | LYT-101 |
| 20 April 2014 | 1358A | 3BLK34F110A | LY-881 and LYT-101 |
| 20 April 2014 | 1360A | 3BLK34FS110B | LY-881 and SMR-53 |
| 22 April 2014 | 1366A | 3BLK34E112A | SM-286 and SMR-56 |
| 14 May 2014 | 1454A | 3BLK34D134A | LY-123 and SMR-56 |
| 14 May 2014 | 1456A | 3BLK34D134B | LY-123 and SMR-56 |
| 22 Jan 2016 | 3765G | 2BLK34AD022A | LY-110 and LYT-104 |
| 22 Jan 2016 | 3767G | 2BLK34AG022B | LY-110 and LYT 104 |
| 23 Jan 2016 | 3769G | 2BLK34ADEG023A | LY-110 and LYT-104 |
| 23 Jan 2016 | 3771G | 2BLK34BCG023B | LY-110 and LYT-104 |
| 24 Jan 2016 | 3773G | 2BLK34CG024A | LY-110 and LYT-104 |

## 2.3 Flight Missions

Eighteen missions were conducted to complete the LiDAR data acquisition in Palo Floodplain, for a total of sixty-six hours and five minutes (66+5) of flying time for RP-C9122 and RP-C9022. All missions were acquired using the Aquarius and Gemini LiDAR systems. Table 12 shows the total area of actual coverage and the corresponding flying hours per mission, while Table 13 presents the actual parameters used during the LiDAR data acquisition.

Table 12. Flight missions for LiDAR data acquisition in Palo 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 |
| 24 Jan 2014 | 1016A | 195.58 | 107.33 | 12.28 | 95.05 | 661 | 3 | 0 |
| 24 Jan 2014 | 1018A | 129.99 | 107.33 | 12.28 | 95.05 | NA | 1 | 54 |
| 25 Jan 2014 | 1020A | 156.71 | 193.60 | 12.75 | 180.85 | 963 | 4 | 6 |
| 26 Jan 2014 | 1024A | 251.35 | 146.11 | 24.28 | 121.83 | 857 | 4 | 17 |
| 26 Jan 2014 | 1026A | 286.61 | 102.51 | 10.18 | 92.33 | 857 | 2 | 47 |
| 27 Jan 2014 | 1028A | 315.51 | 199.77 | 64.45 | 135.32 | 1564 | 4 | 25 |
| 29 Jan 2014 | 1036A | 32.79 | 48.19 | NA | 48.19 | 397 | 2 | 11 |
| 30 Jan 2014 | 1040A | 33.95 | 58.61 | 3.38 | 55.23 | 592 | 3 | 41 |
| 20 April 2014 | 1358A | 145.52 | 121.30 | 57.46 | 63.84 | 1194 | 4 | 11 |
| 20 April 2014 | 1360A | 145.52 | 71.46 | 40.76 | 30.7 | 670 | 3 | 23 |
| 22 April 2014 | 1366A | 103.86 | 120.79 | 42.87 | 77.92 | 1346 | 4 | 29 |
| 14 May 2014 | 1454A | 147.57 | 220.81 | 74.50 | 146.31 | 1269 | 4 | 29 |
| 14 May 2014 | 1456A | 82.68 | 97.85 | 21.76 | 76.09 | 998 | 3 | 41 |
| 22 Jan 2016 | 3765G | 673.17 | 180.53 | 83.94 | 96.59 | NA | 4 | 11 |
| 22 Jan 2016 | 3767G | 1390.56 | 148.01 | 18.65 | 129.36 | NA | 3 | 23 |
| 23 Jan 2016 | 3769G | 673.17 | 171.76 | 79.68 | 92.08 | NA | 3 | 23 |
| 23 Jan 2016 | 3771G | 1390.56 | 150.85 | 107.08 | 43.77 | NA | 4 | 23 |
| 24 Jan 2016 | 3773G | 676.64 | 101.92 | 69.17 | 32.75 | NA | 4 | 11 |
| TOTAL | | 6831.74 | 2348.73 | 735.47 | 1613.26 | 11368 | 66 | 5 |

Table 13. Actual parameters used during LiDAR data acquisition

| Date Surveyed | Flight Number | Flying Height (AGL) (m) | Overlap (%) | Max. Field of View | Scan Frequency | Speed of Plane (Kts) |
|---|---|---|---|---|---|---|
| 24 Jan 2014 | 1016A | 600 | 40 | 50 | 40 | 120 |
| 24 Jan 2014 | 1018A | 600 | 40 | 50 | 40 | 120 |
| 24 Jan 2014 | 1020A | 600 | 40 | 50 | 40 | 120 |
| 25 Jan 2014 | 1024A | 600 | 40 | 50 | 40 | 120 |
| 26 Jan 2014 | 1026A | 600 | 40 | 50 | 40 | 120 |
| 26 Jan 2014 | 1028A | 600 | 40 | 50 | 40 | 120 |
| 27 Jan 2014 | 1036A | 600 | 40 | 50 | 40 | 120 |
| 29 Jan 2014 | 1040A | 600 | 35 | 40 | 40 | 120 |
| 30 Jan 2014 | 1358A | 600 | 30 | 36 | 50 | 120 |
| 20 April 2014 | 1360A | 600 | 30 | 36 | 50 | 120 |
| 20 April 2014 | 1366A | 600 | 40 | 36 | 50 | 120 |
| 22 April 2014 | 1454A | 600 | 40 | 36 | 50 | 120 |
| 14 May 2014 | 1456A | 600 | 40 | 36 | 50 | 120 |
| 14 May 2014 | 3765G | 1100 | 30 | 34 | 50 | 120 |
| 22 Jan 2016 | 3767G | 850 | 30 | 40 | 50 | 120 |
| 22 Jan 2016 | 3769G | 1100 | 30 | 34 | 50 | 120 |
| 23 Jan 2016 | 3771G | 850 | 30 | 40 | 50 | 120 |
| 23 Jan 2016 | 3773G | 600 | 30 | 50 | 40 | 120 |

## 2.4 Survey Coverage

Palo Floodplain is situated within the municipalities of Leyte and Samar with most of the Floodplain located in Leyte. The municipalities of Alangalang, Barugo, Julita, and Tabontabon 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 14. The actual coverage of the LiDAR acquisition for Palo Floodplain is presented in Figure 10.

Table 14. List of municipalities/cities surveyed during Palo Floodplain LiDAR survey

| Province | Municipality/City | Area of Municipality/City | Total Area Surveyed | Percentage of Area Surveyed |
|---|---|---|---|---|
| Leyte | Alangalang | 145.45 | 145.45 | 100% |
| | Barugo | 81.25 | 81.25 | 100% |
| | Julita | 57.17 | 57.17 | 100% |
| | Tabontabon | 20.46 | 20.46 | 100% |
| | Santa Fe | 57.15 | 57.11 | 99.94% |
| | Palo | 65.33 | 64.89 | 99.32% |
| | Tolosa | 28.17 | 27.53 | 97.72% |
| | San Miguel | 103.86 | 100.88 | 97.12% |
| | Tanauan | 62.78 | 60.94 | 97.07% |
| | Dulag | 63.65 | 59.86 | 94.05% |
| | Pastrana | 79.17 | 68.07 | 85.98% |
| | Tacloban City | 118.46 | 74.08 | 62.54% |
| | Dagami | 134.08 | 77.81 | 58.03% |
| | Tunga | 17.36 | 9.76 | 56.23% |
| | Burauen | 205.31 | 69.17 | 33.69% |
| | Jaro | 190.65 | 69.13 | 36.26% |
| | Carigara | 116.61 | 13.07 | 11.21% |
| | La paz | 136.02 | 14.74 | 10.84% |
| | Babatngon | 136.57 | 8.05 | 5.89% |
| | Mayorga | 39.45 | 2.03 | 5.14% |
| Samar | Marabut | 148.82 | 40.02 | 26.89% |
| Total | | 2007.77 | 1121.47 | 65.62% |

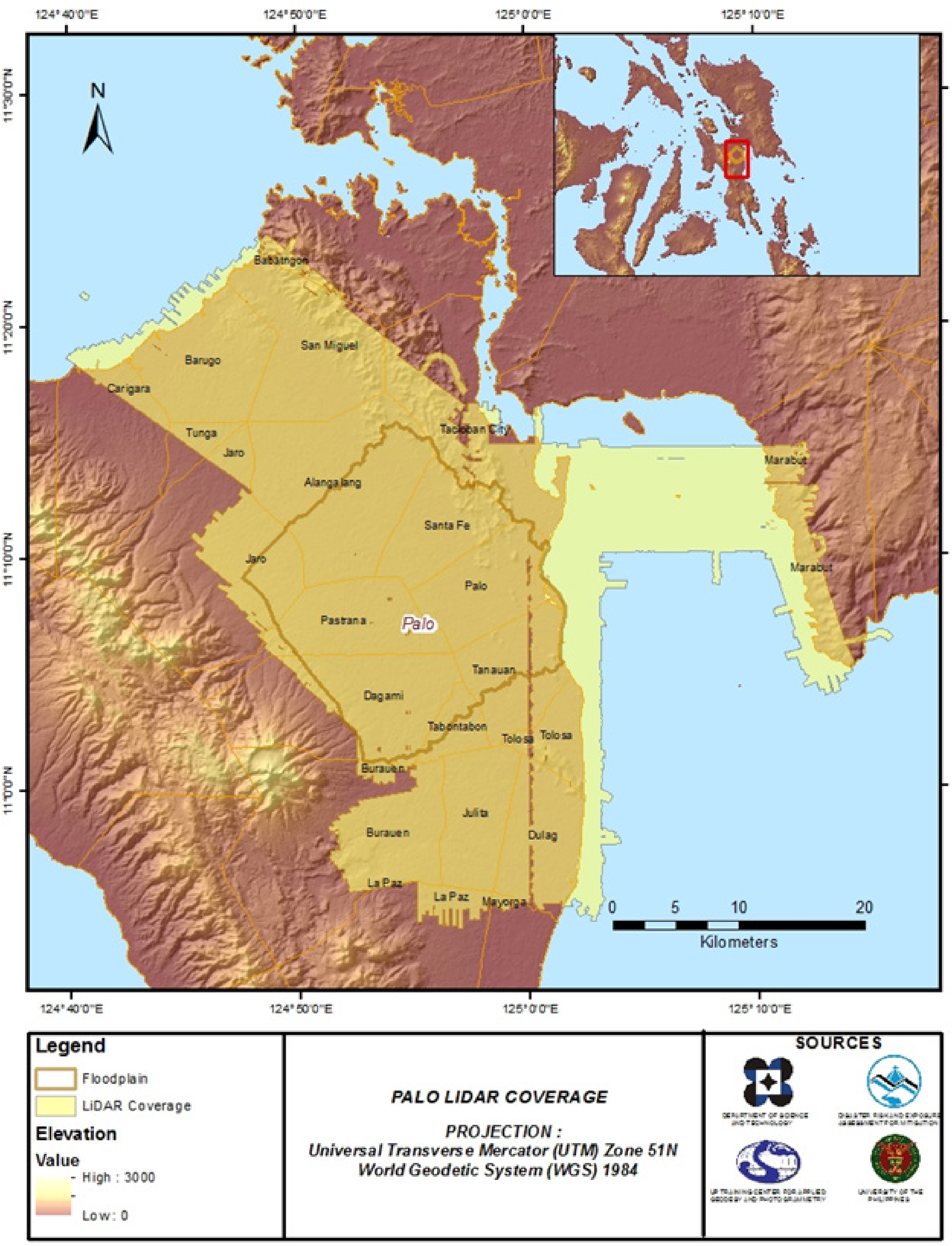



Figure 10. Actual LiDAR data acquisition for Palo Floodplain

# CHAPTER 3: LIDAR DATA PROCESSING OF THE PALO FLOODPLAIN

Engr. Ma. Ailyn L. Olanda, Engr. Jovelle Anjeanette S. Canlas, Jovy Anne S. Narisma

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 were 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 was done in order to obtain the exact location of the LiDAR sensor when the laser was shot. Point cloud georectification was 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 were the minimum point density, vertical and horizontal accuracies, were met. The point clouds were 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 were calibrated. Portions of the river that were barely penetrated by the LiDAR system were replaced by the actual river geometry measured from the field by the Data Validation and Bathymetry Component. LiDAR acquired temporally were then mosaicked to completely cover the target river systems in the Philippines. Orthorectification of images acquired simultaneously with the LiDAR data was done through the help of the georectified point clouds and the metadata containing the time the image was captured.

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

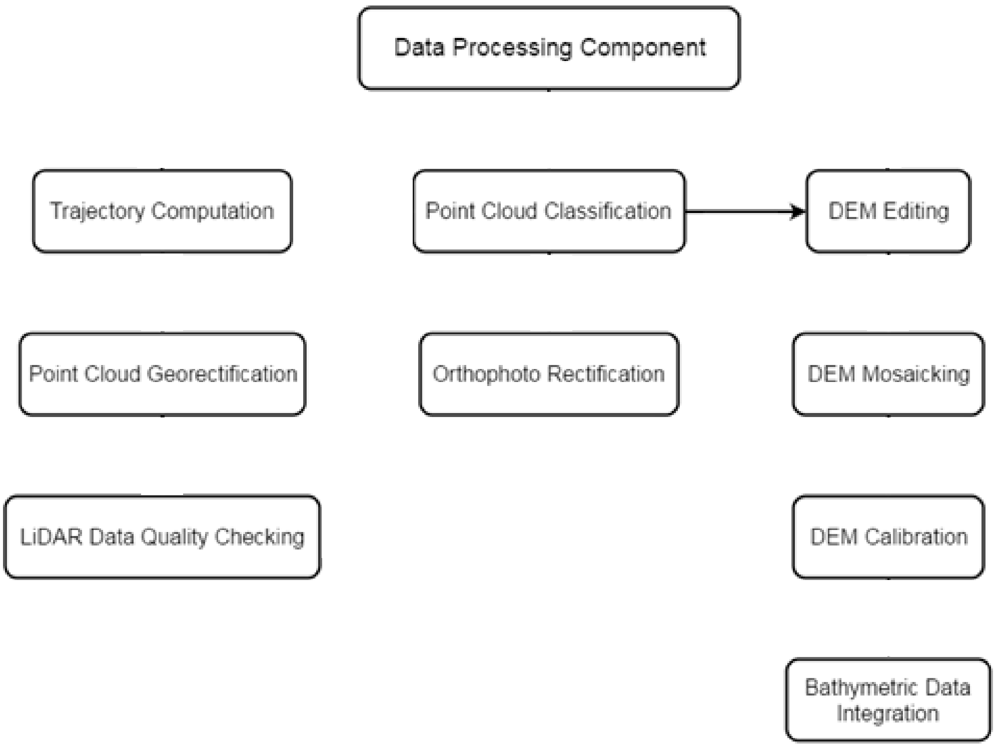



Figure 11. Schematic diagram for data pre-processing component.

## 3.2 Transmittal of Acquired LiDAR Data

Data transfer sheets for all the LiDAR missions for Palo Floodplain can be found in ANNEX 5. Missions flown over eastern Leyte during the first and second surveys conducted on January 2014 and April 2014, respectively, used the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.) Aquarius system while missions acquired during the third survey on January 2016 were flown using the Gemini system. The Data Acquisition Component (DAC) transferred a total of 256.08 Gigabytes of Range data, 3.68 Gigabytes of POS data, 195.36 Megabytes of GPS base station data, and 638.80 Gigabytes of raw image data to the data server on February 3, 2014 for the first survey, on May 22, 2014 for the second survey, and on February 11, 2016 for the third survey. The Data Pre-Processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for Palo was fully transferred on February 11, 2016, as indicated on the data transfer sheets for Palo Floodplain.

## 3.3 Trajectory Computation

The Smoothed Performance Metrics of the computed trajectory for flight 1020A, one of the Palo flights, which is the North, East, and Down position RMSE values are shown in Figure 12. The x-axis corresponds to the time of flight, which is measured by the number of seconds from the midnight of the start of the GPS week, which on that week fell on January 25, 2014 00:00AM. The y-axis is the RMSE value for that particular position.

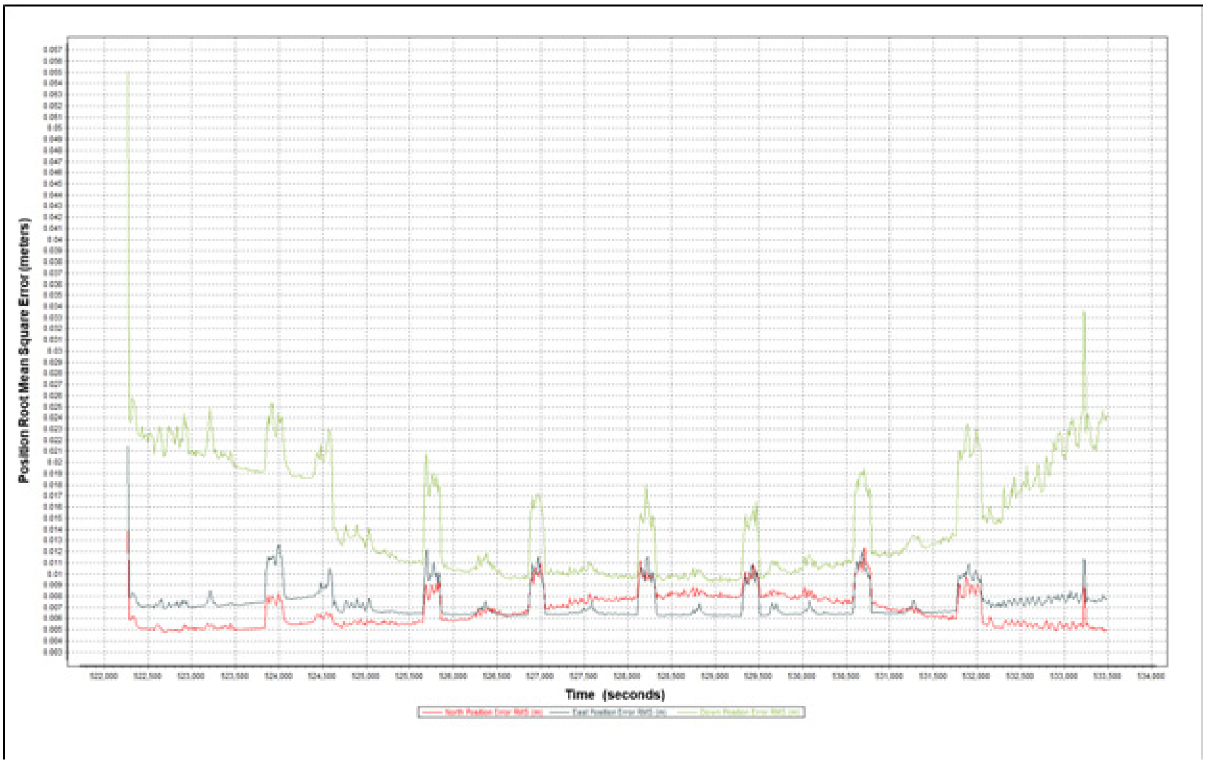



Figure 12. Smoothed Performance Metrics of Palo Flight 1020A.

The time of flight was from 522,000 seconds to 533,500 seconds, which corresponds to morning of January 25, 2014. The initial spike that is seen on the data corresponds to the time that the aircraft was getting into position to start the acquisition, and the POS system started computing for the position and orientation of the aircraft. Redundant measurements from the POS system quickly minimized the RMSE value of the positions. The periodic increase in RMSE values from an otherwise smoothly curving RMSE values correspond to the turn-around period of the aircraft, when the aircraft makes a turn to start a new flight line. Figure 12 shows that the North position RMSE peaks at 1.25 centimeters, the East position RMSE peaks at 1.30 centimeters, and the Down position RMSE peaks at 3.35 centimeters, which are within the prescribed accuracies described in the methodology.

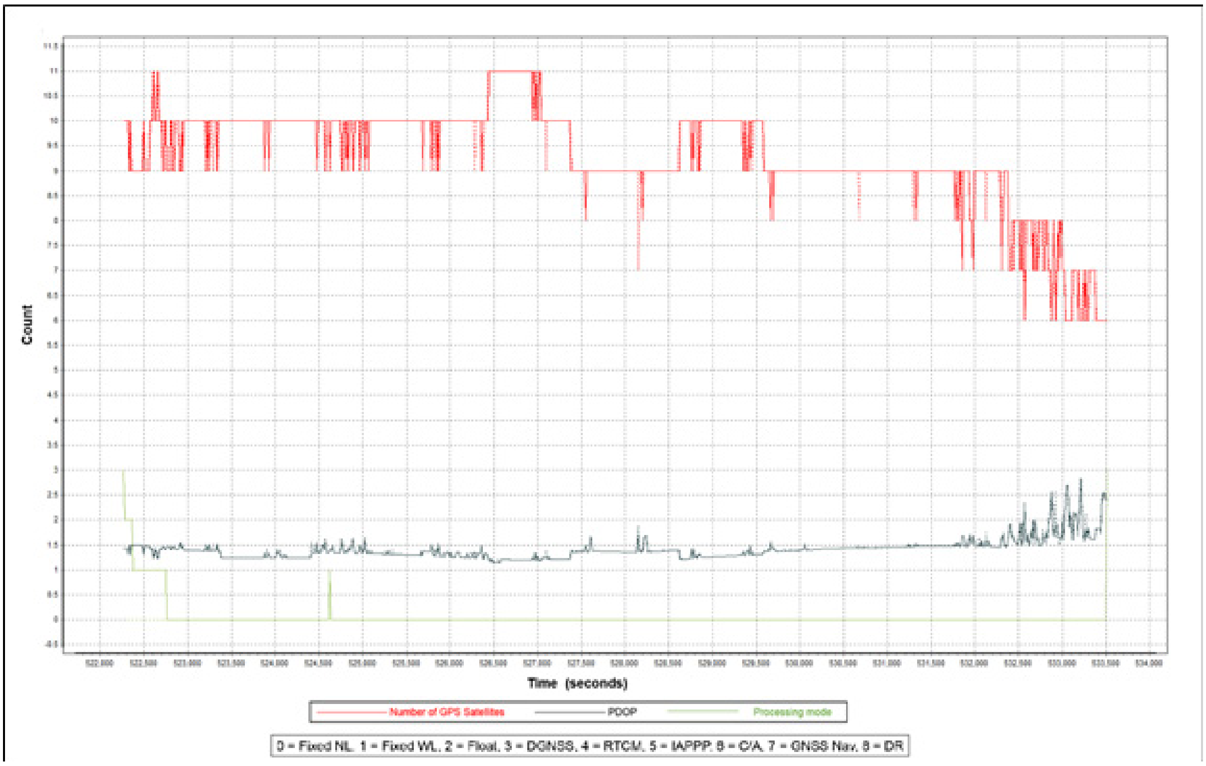



Figure 13. Solution Status Parameters of Palo Flight 1020A.

The Solution Status parameters of flight 1020A, one of the Palo flights, which indicate the number of GPS satellites, Positional Dilution of Precision (PDOP), and the GPS processing mode used, are shown in Figure 13. The graphs indicate that the number of satellites during the acquisition did not go down to 6. Most of the time, the number of satellites tracked was between 6 and 11. The PDOP value also 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 Palo flights is shown in Figure 14.

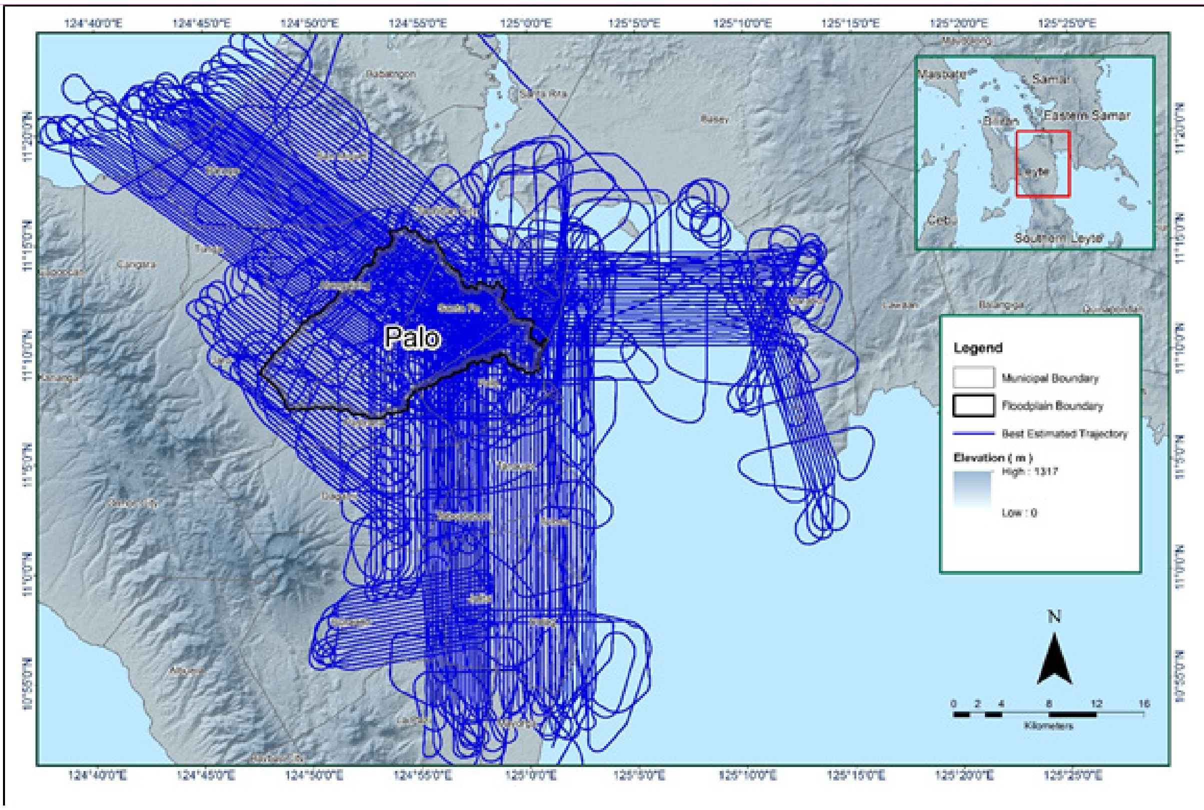



Figure 14. Best estimated trajectory of LiDAR missions conducted over the Palo Floodplain.

## 3.4 LiDAR Point Cloud Computation

The produced LAS data contains 492 flight lines, with each flight line containing one channel, since the Gemini and Aquarius systems both contain one channel only. The summary of the self-calibration results obtained from LiDAR processing in LiDAR Mapping Suite (LMS) software for all flights over Palo Floodplain are given in Table 15.

Table 15. Self-calibration results values for Palo flights.

| Parameter | Computed Value |
|---|---|
| Boresight Correction stdev (<0.001degrees) | 0.000620 |
| IMU Attitude Correction Roll and Pitch Corrections stdev (<0.001degrees) | 0.000999 |
| GPS Position Z-correction stdev (<0.01meters) | 0.0071 |

The optimum accuracy was obtained for all Palo flights based on the computed standard deviations of the corrections of the orientation parameters. Standard deviation values for individual blocks are available in ANNEX 8.

## 3.5 LiDAR Data Quality Checking

The boundary of the processed LiDAR data is shown in Figure 15. The map shows gaps in the LiDAR coverage that are attributed to cloud coverage.

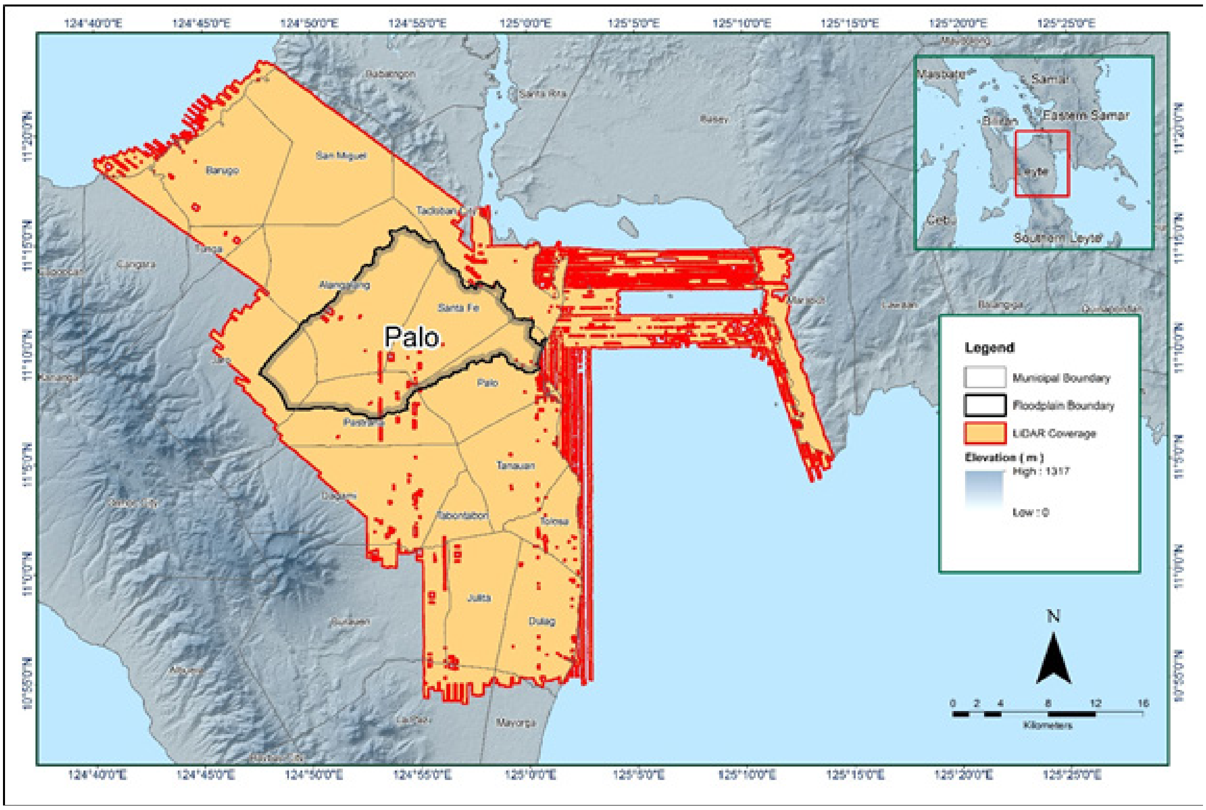



Figure 15. Boundary of the processed LiDAR data on top of a SAR Elevation Data over Palo Floodplain.

The total area covered by the Palo missions is 1478.12 sq.km comprised of 17 flight acquisitions grouped and merged into 17 blocks as shown in Table 16.

Table 16. List of LiDAR blocks for Palo Floodplain.

| LiDAR Blocks | Flight Numbers | Area (sq km.) |
|---|---|---|
| Leyte_Blk34C | 3771G<br>3773G | 145.82 |
| Leyte_Blk34D | 3767G<br>3773G | 84.81 |
| Leyte_Blk34E | 3765G<br>3767G | 170.21 |
| Leyte_Blk34G_additional2 | 3773G | 20.02 |
| Leyte_Blk34G_supplement | 3771G<br>3773G | 54.24 |
| Leyte_Blk34I | 3769G | 50.78 |
| Leyte_Blk34J | 3765G | 62.39 |
| Samar_Leyte_Blk34C | 1456A | 94.98 |
| Samar_Leyte_Blk34D | 1454A | 100.89 |
| Samar_Leyte_Blk34E | 1366A | 113.91 |
| Samar_Leyte_Blk34F | 1358A<br>1360A | 165.93 |
| Tacloban_1016A | 1016A | 26.27 |
| Tacloban_1018A | 1018A | 14.56 |
| Tacloban_1020A | 1020A | 65.17 |
| Tacloban_1024A | 1024A | 43.52 |
| Tacloban_1026A | 1026A<br>1028A | 232.71 |
| Tacloban_1040A | 1040A | 31.91 |
| TOTAL | | 1478.12 sq km. |

The overlap data for the merged LiDAR blocks, showing the number of channels that pass through a particular location, is shown in Figure 16. Since the Gemini and Aquarius systems both employ one channel, an average value of 1 (blue) would be expected for areas where there is limited overlap, and a value of 2 (yellow) or more (red) for areas with three or more overlapping flight lines.

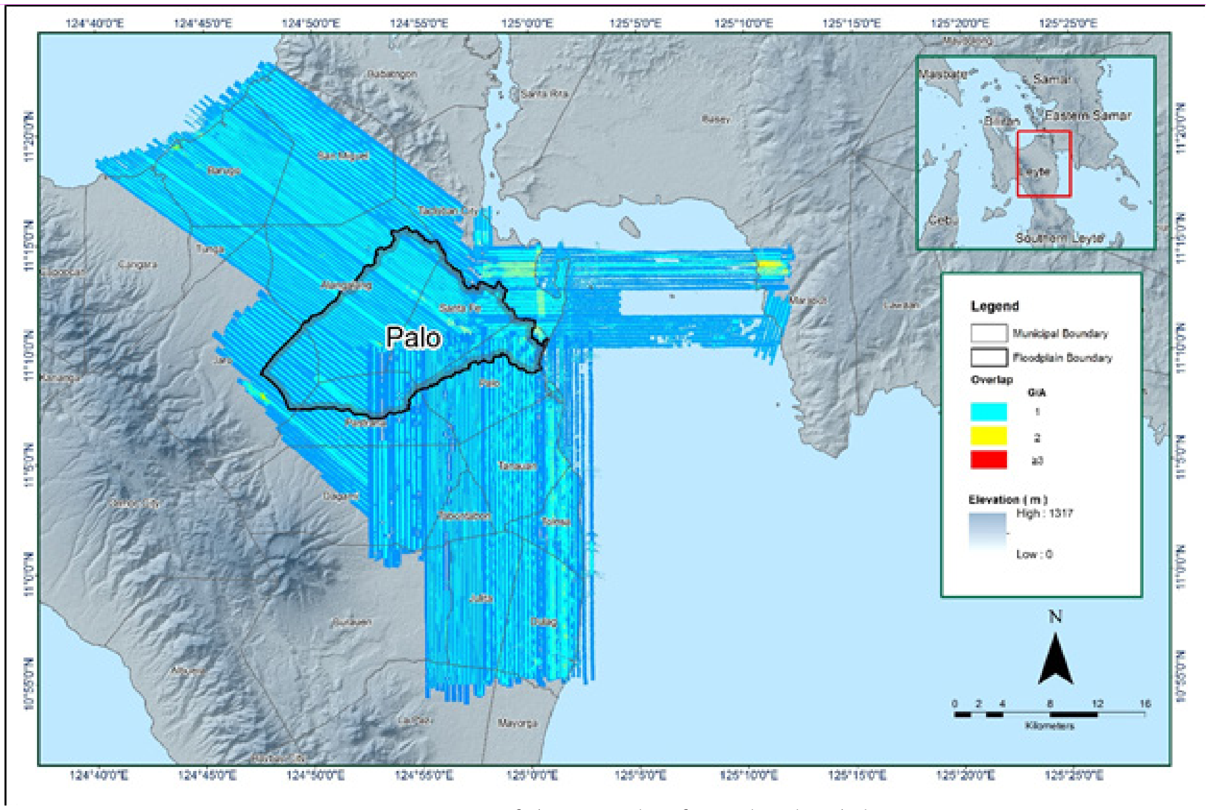



Figure 16. Image of data overlap for Palo Floodplain.

The overlap statistics per block for the Palo Floodplain can be found in Annex 8. One pixel corresponds to 25.0 square meters on the ground. For this area, the minimum and maximum percent overlaps are 27.64% and 53.44%, respectively, which passed the 25% requirement.

The density map for the merged LiDAR data, with the red parts showing the portions of the data that satisfy the 2 points per square meter criterion is shown in Figure 17. It was determined that all LiDAR data for Palo floodplain satisfy the point density requirement, and the average density for the entire survey area is 3.11 points per square meter.

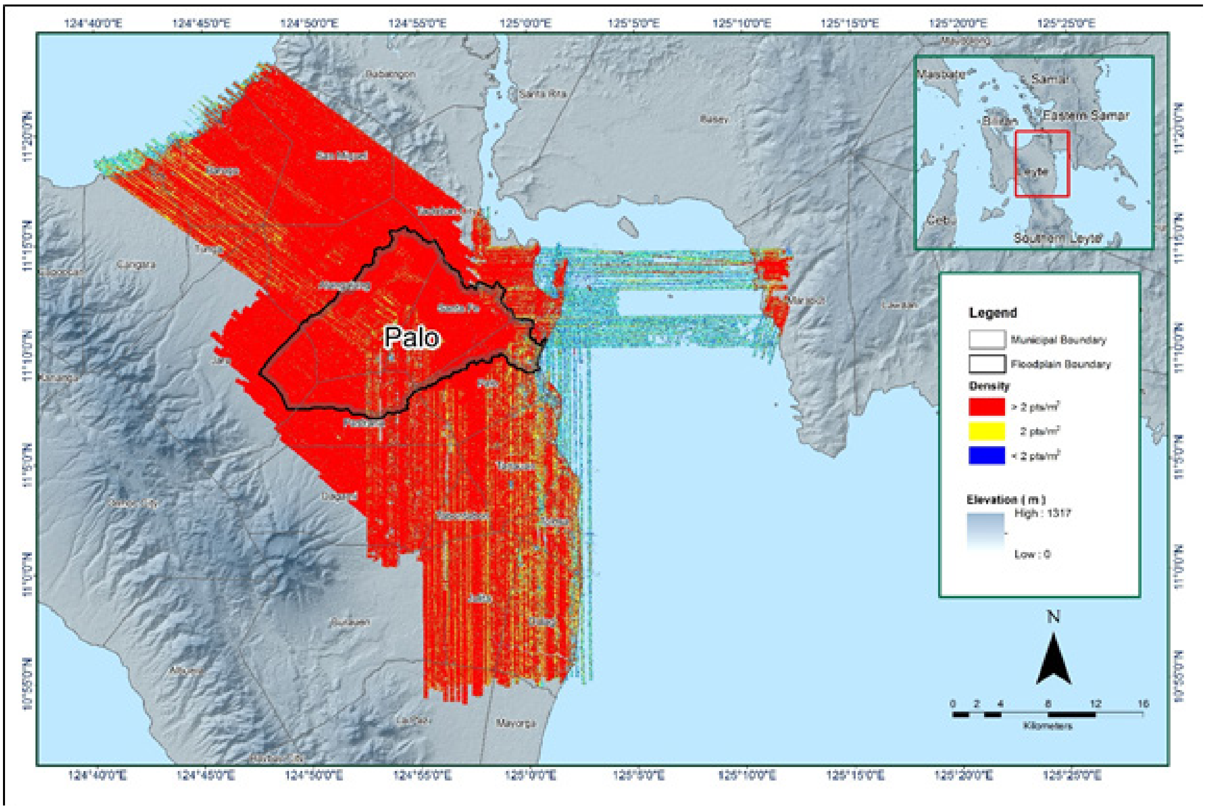



Figure 17. Pulse density map of merged LiDAR data for Palo Floodplain.

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

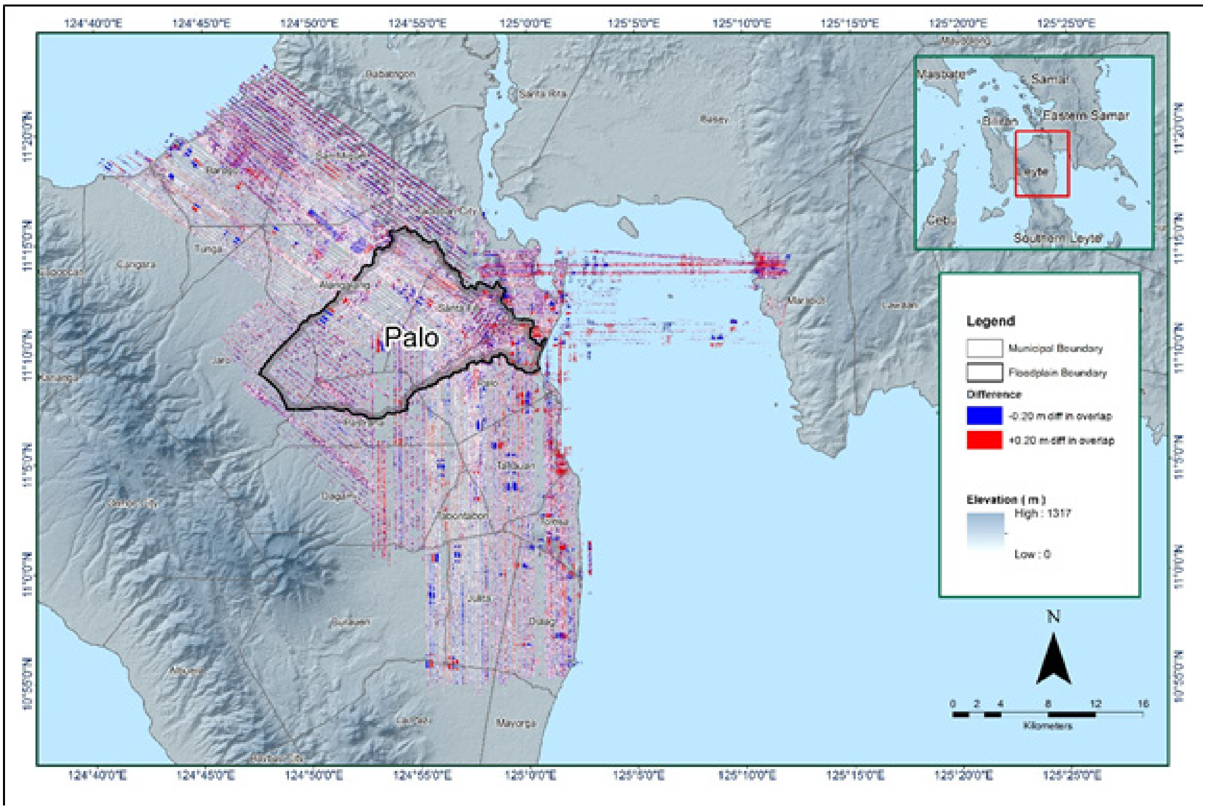



Figure 18. Map of elevation difference between flight lines for Palo Floodplain.

A screen capture of the processed LAS data from Palo flight 1020A loaded in QT Modeler is shown in Figure 19. The upper left image shows the elevations of the points from two overlapping flight strips traversed by the profile, illustrated by a dashed yellow line. The x-axis corresponds to the length of the profile. It is evident that there are differences in elevation, but the differences do not exceed the 20-centimeter mark. This profiling was repeated until the quality of the LiDAR data becomes satisfactory. No reprocessing was done for this LiDAR dataset.

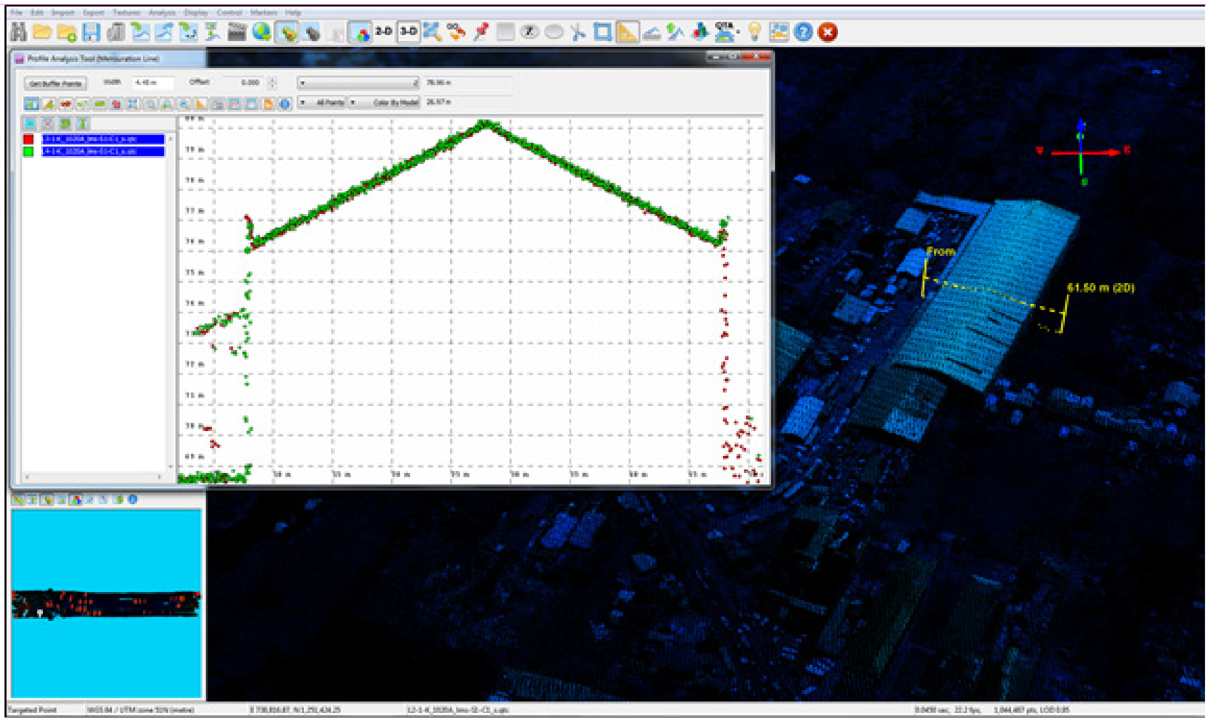


Figure 19. Quality checking for Palo flight 1020A using the Profile Tool of QT Modeler.

## 3.6 LiDAR Point Cloud Classification and Rasterization

Table 17. Palo classification results in TerraScan.

| Pertinent Class | Total Number of Points |
|---|---|
| Ground | 737,656,757 |
| Low Vegetation | 816,494,587 |
| Medium Vegetation | 1,551,393,038 |
| High Vegetation | 659,666,680 |
| Building | 24,196,664 |

The tile system that TerraScan employed for the LiDAR data and the final classification image for a block in Palo Floodplain is shown in Figure 20. A total of 2,122 1 km-by-1 km tiles were produced. The number of points classified to the pertinent categories is illustrated in Table 17. The point cloud has a maximum and minimum height of 491.90 meters and 34.19 meters.

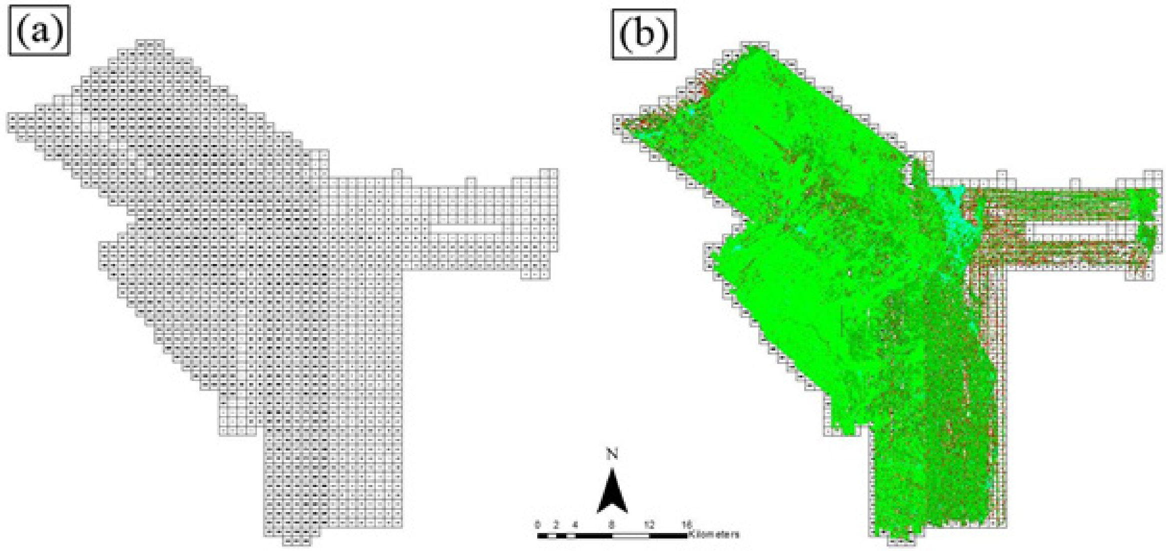



Figure 20. Tiles for Palo Floodplain (a) and classification results (b) in TerraScan.

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

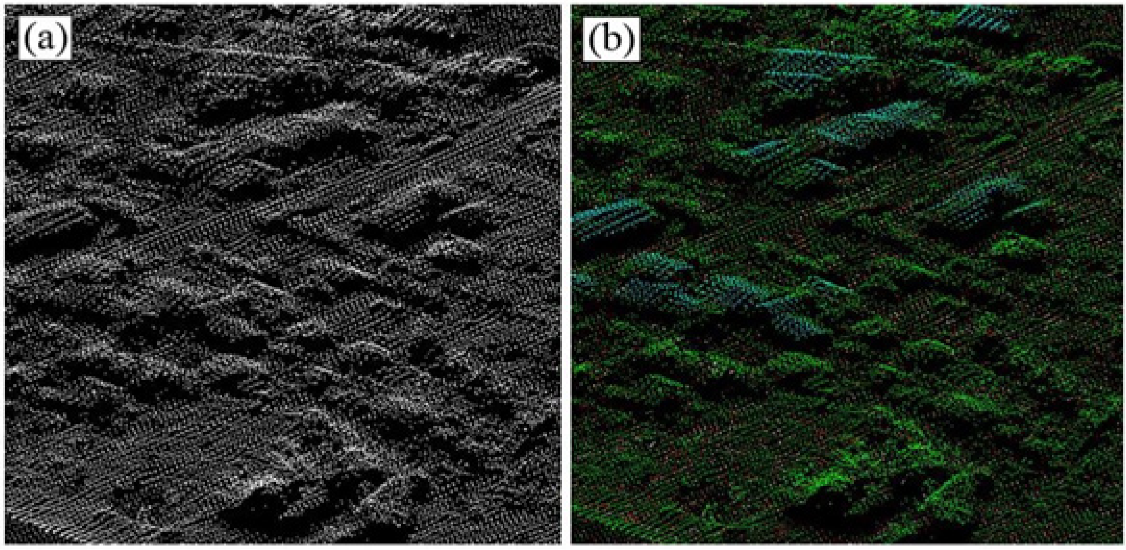



Figure 21. Point cloud before (a) and after (b) classification.

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

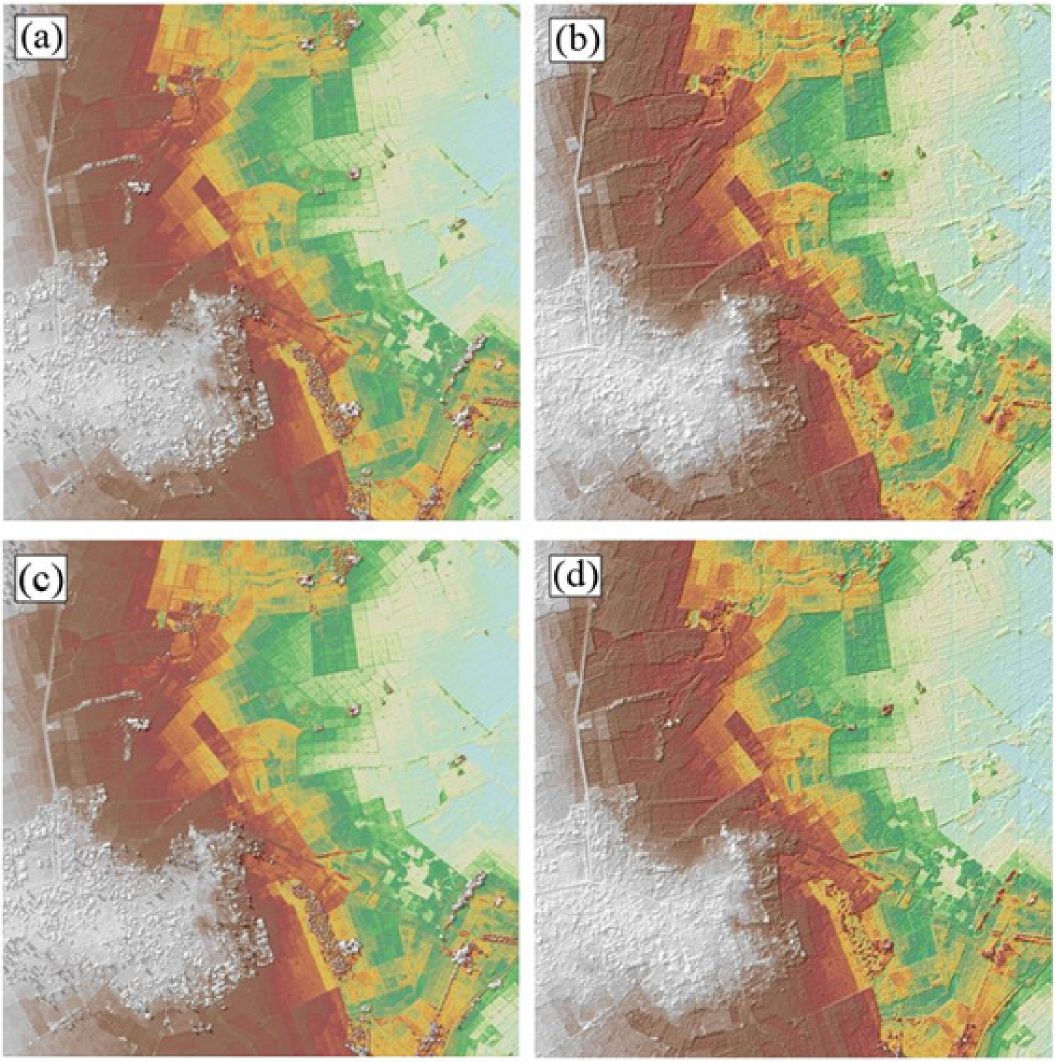



Figure 22. The production of last return DSM (a) and DTM (b); first return DSM (c) and secondary DTM (d) in some portion of Palo Floodplain.

## 3.7 LiDAR Image Processing and Orthophotograph Rectification

The 1,214 1 km-by-1 km tiles area covered by Palo Floodplain is shown in Figure 23. After tie point selection to fix photo misalignments, color points were added to smoothen out visual inconsistencies along the seamlines where photos overlap. The Palo Floodplain attained a total of 841.36 sq km in orthophotogaph coverage comprised of 9,116 images. A zoomed in version of sample orthophotographs named in reference to its tile number is shown in Figure 24.

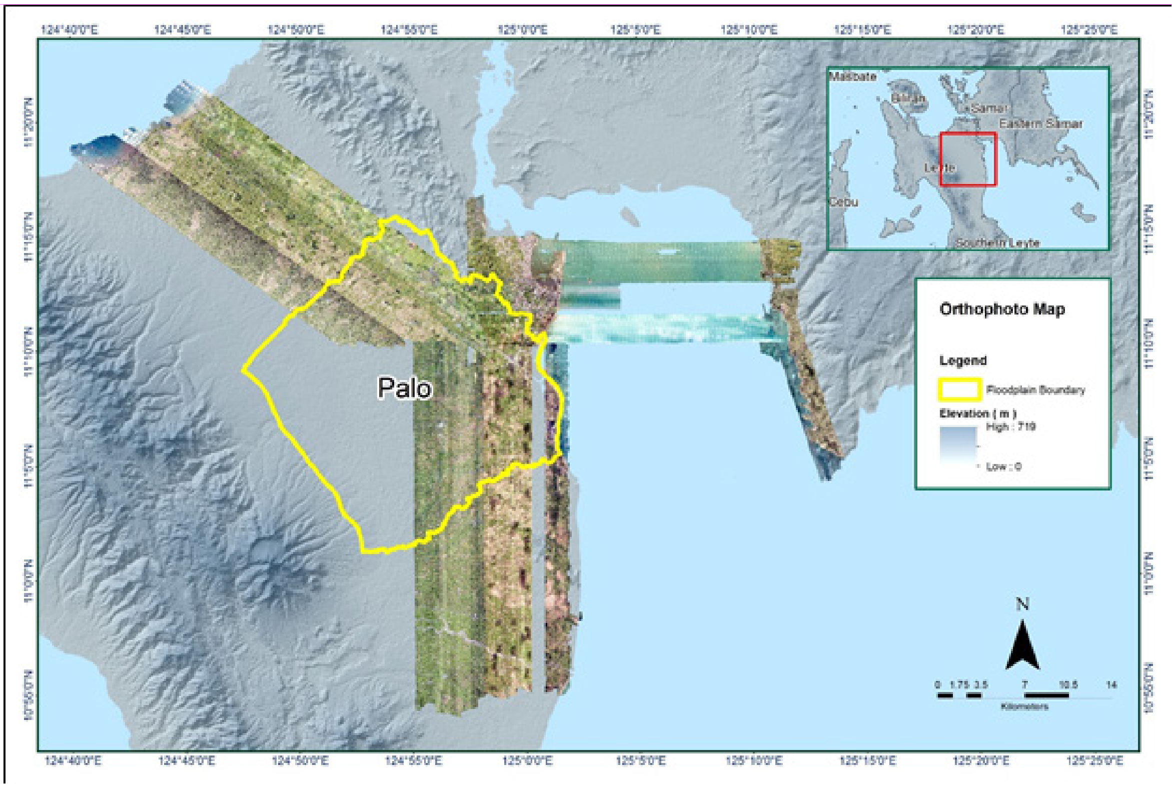



Figure 23. Palo Floodplain with available orthophotographs.


Figure 24. Sample orthophotograph tiles for Palo Floodplain.

## 3.8 DEM Editing and Hydro-Correction

Seventeen mission blocks were processed for Palo Floodplain. These blocks are composed of SamarLeyte and Leyte blocks with a total area of 1,478.12 square kilometers. Table 18 shows the name and corresponding area of each block in square kilometers.

Table 18. LiDAR blocks with its corresponding area.

| LiDAR Blocks | Area (sq km) |
|---|---|
| Leyte_Blk34C | 145.82 |
| Leyte_Blk34D | 84.81 |
| Leyte_Blk34E | 170.21 |
| Leyte_Blk34G_additional2 | 20.02 |
| Leyte_Blk34G_supplement | 54.24 |
| Leyte_Blk34I | 50.78 |
| Leyte_Blk34J | 62.39 |
| Samar_Leyte_Blk34C | 94.98 |
| Samar_Leyte_Blk34D | 100.89 |
| Samar_Leyte_Blk34E | 113.91 |
| Samar_Leyte_Blk34F | 165.93 |
| Tacloban_Blk1016A | 26.27 |
| Tacloban_Blk1018A | 14.56 |
| Tacloban_Blk1020A | 65.17 |
| Tacloban_Blk1024A | 43.52 |
| Tacloban_Blk1026A | 232.71 |
| Tacloban_Blk1040A | 31.91 |
| TOTAL | 1478.12 sq km. |

Portions of DTM before and after manual editing are shown in Figure 25. The bridge (Figure 25a) is considered to be an impedance to the flow of water along the river and has to be removed (Figure 25b) in order to hydrologically correct the river. The fishpond embankments (Figure 25c) have been misclassified and removed during classification process and have to be retrieved to complete the surface (Figure 25d) to allow the correct flow of water.

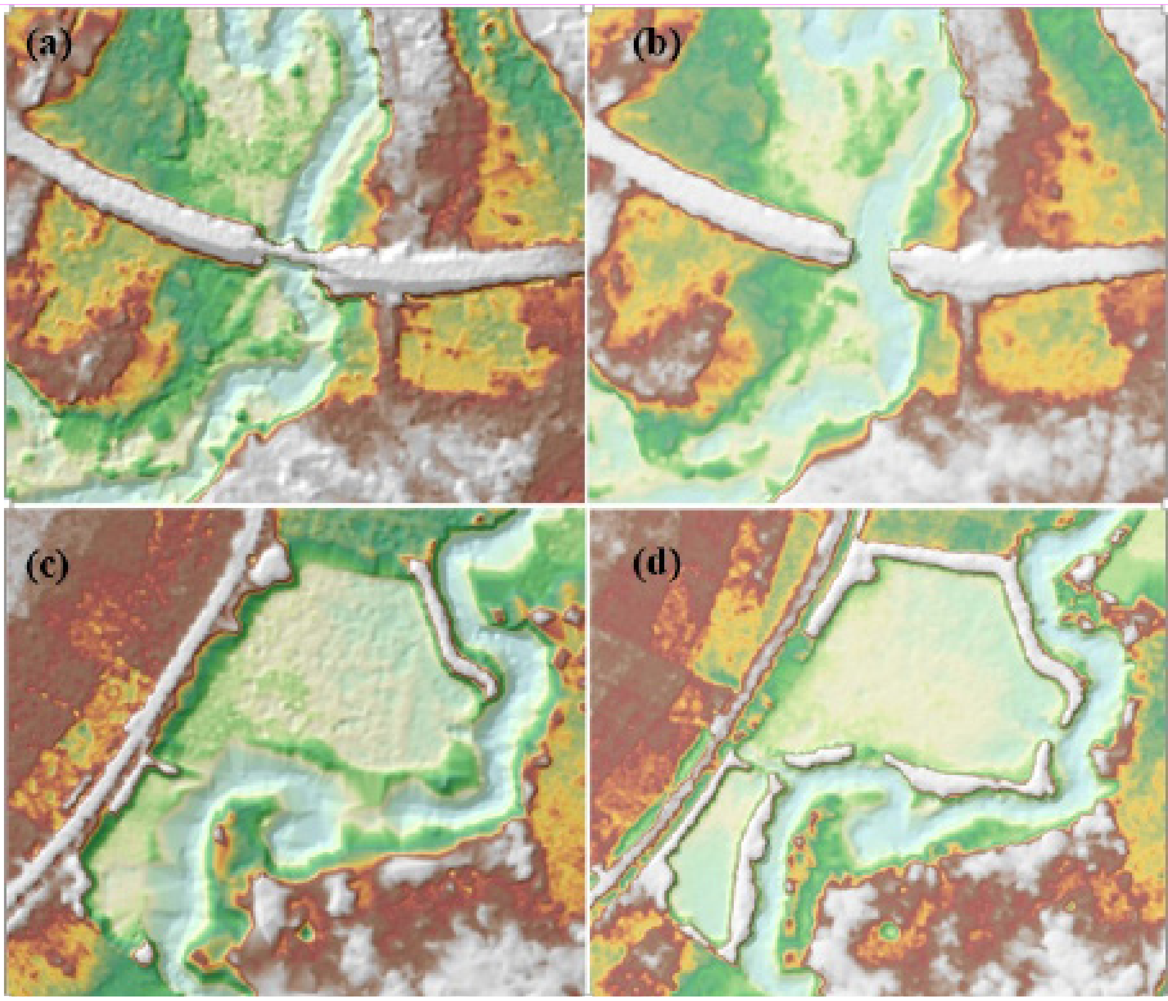



Figure 25. Portions in the DTM of Palo Floodplain—a bridge before (a) and after (b) manual editing; and a fish pond before (c) and after (d) data retrieval.

## 3.9 Mosaicking of Blocks

No assumed reference block was used in mosaicking because the identified reference for shifting was an existing calibrated Tacloban DEM overlapping with the blocks to be mosaicked. Table 19 shows the shift values applied to each LiDAR block during mosaicking.

Mosaicked LiDAR DTM for Palo Floodplain is shown in Figure 26. It can be seen that the entire Palo Floodplain is 99.13% covered by LiDAR data.

Table 19. Shift values of each LiDAR Block of Palo Floodplain.

| Mission Blocks | Shift Values (meters) | | |
|---|---|---|---|
| | x | y | z |
| SamarLeyte_Blk34F | 0.00 | 1.00 | -1.01 |
| SamarLeyte_Blk34C | 0.00 | 0.00 | -0.67 |
| SamarLeyte_Blk34D | 0.00 | 0.00 | -0.59 |
| SamarLeyte_Blk34E | 0.00 | 0.00 | -0.59 |
| Leyte_Blk34J | 0.00 | -1.00 | -1.04 |
| Leyte_Blk34I | 0.00 | 0.00 | -0.79 |
| Leyte_Blk34G_ supplement | 0.00 | 0.00 | -20.90 |
| Leyte_Blk34C | 0.00 | -1.00 | -1.13 |
| Leyte_Blk34D | 0.00 | 0.00 | 0.48 |
| Leyte_Blk34G_ additional2 | -1.00 | -2.00 | -21.05 |
| Leyte_Blk34E | 0.00 | 0.00 | -1.22 |
| Tacloban_Blk1026A | 0.00 | 0.00 | 0.00 |
| Tacloban_Blk1024A | 0.00 | 0.00 | 0.00 |
| Tacloban_Blk1016A | 0.00 | 0.00 | 0.00 |
| Tacloban_Blk1040A | 0.00 | 0.00 | 0.00 |
| Tacloban_Blk1018A | 0.00 | 0.00 | 0.00 |
| Tacloban_Blk1020A | 0.00 | 0.00 | 0.00 |

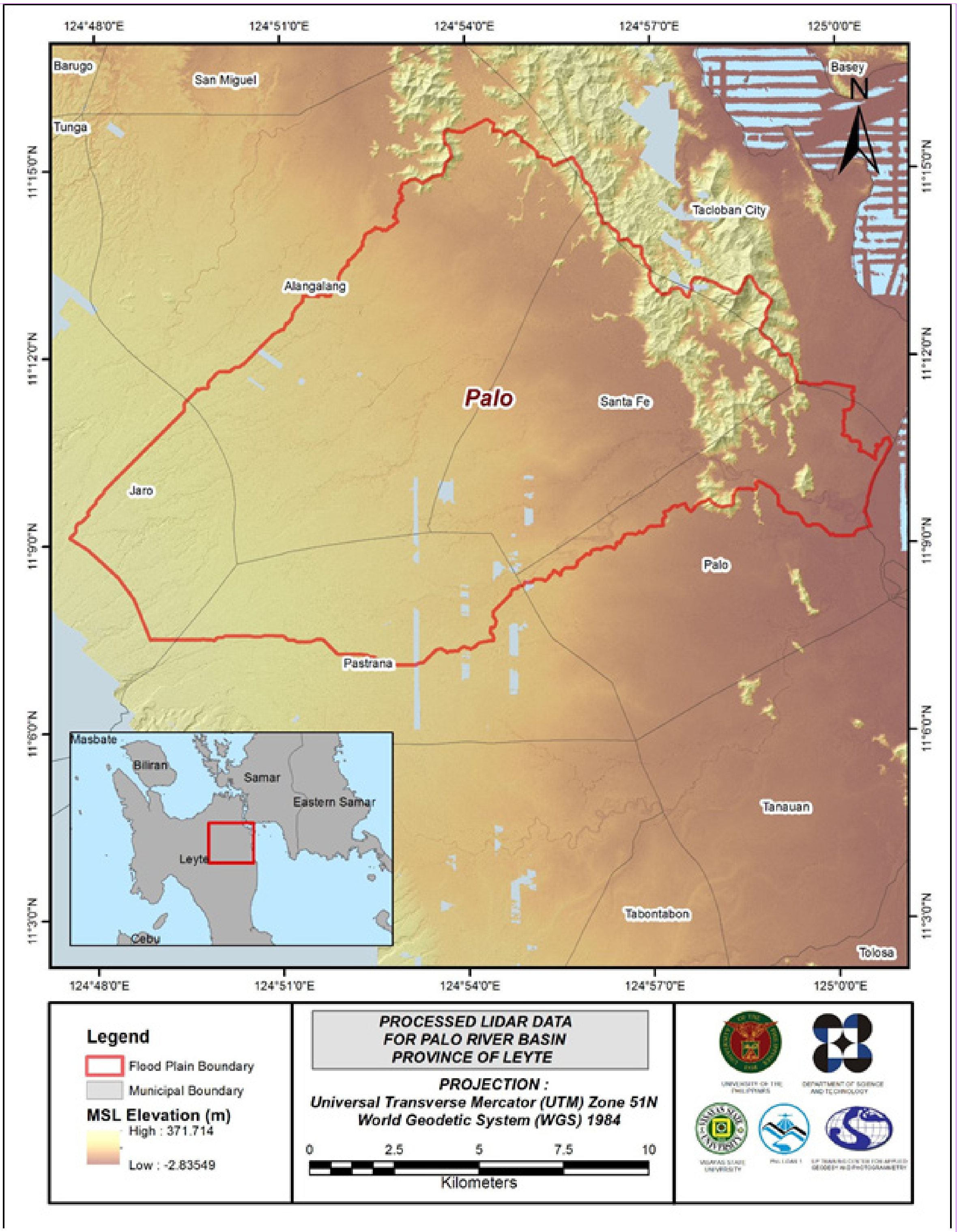



Figure 26. Map of processed LiDAR data for Palo Floodplain.

## 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 Palo to collect points with which the LiDAR dataset was validated is shown in Figure 27. A total of 3,471 survey points were gathered for the Palo Floodplain. However, the point dataset was not used for the calibration of the LiDAR data for Palo because during the mosaicking process, each LiDAR block was referred to the calibrated Tacloban DEM. Therefore, the mosaicked DEM of Palo can already be considered as a calibrated DEM.

A good correlation between the uncalibrated Tacloban LiDAR DTM and ground survey elevation values is shown in Figure 28. Statistical values were computed from extracted LiDAR values using the selected points to assess the quality of data and obtain the value for vertical adjustment. The computed height difference between the LiDAR DTM and calibration points is 0.14 meters with a standard deviation of 0.13 meters. Calibration of Tacloban LiDAR data was done by subtracting the height difference value, 0.14 meters, to Tacloban mosaicked LiDAR data. Table 20 shows the statistical values of the compared elevation values between Tacloban LiDAR data and calibration data. These values are also applicable to the Palo DEM.

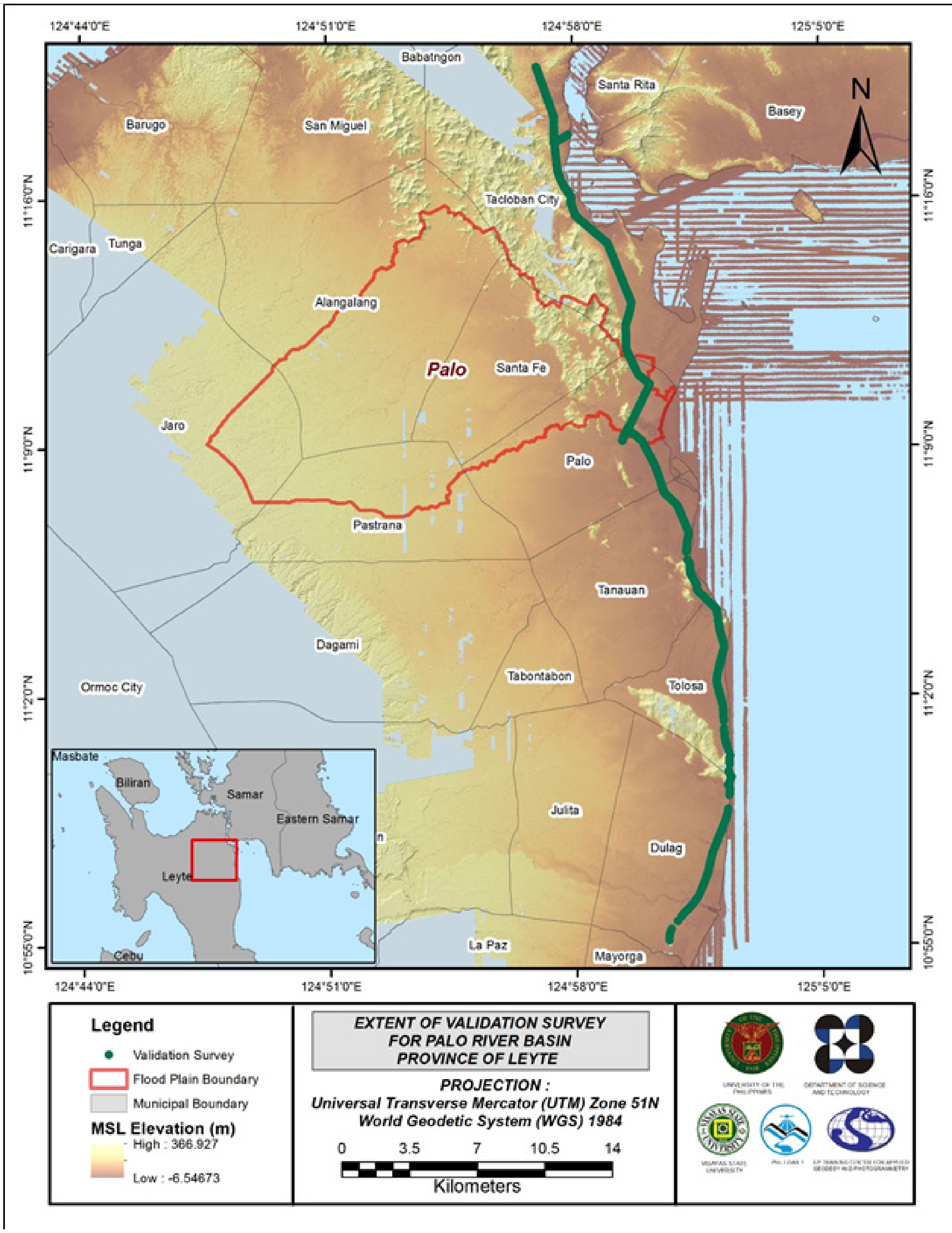



Figure 27. Map of Palo Floodplain with validation survey points in green.

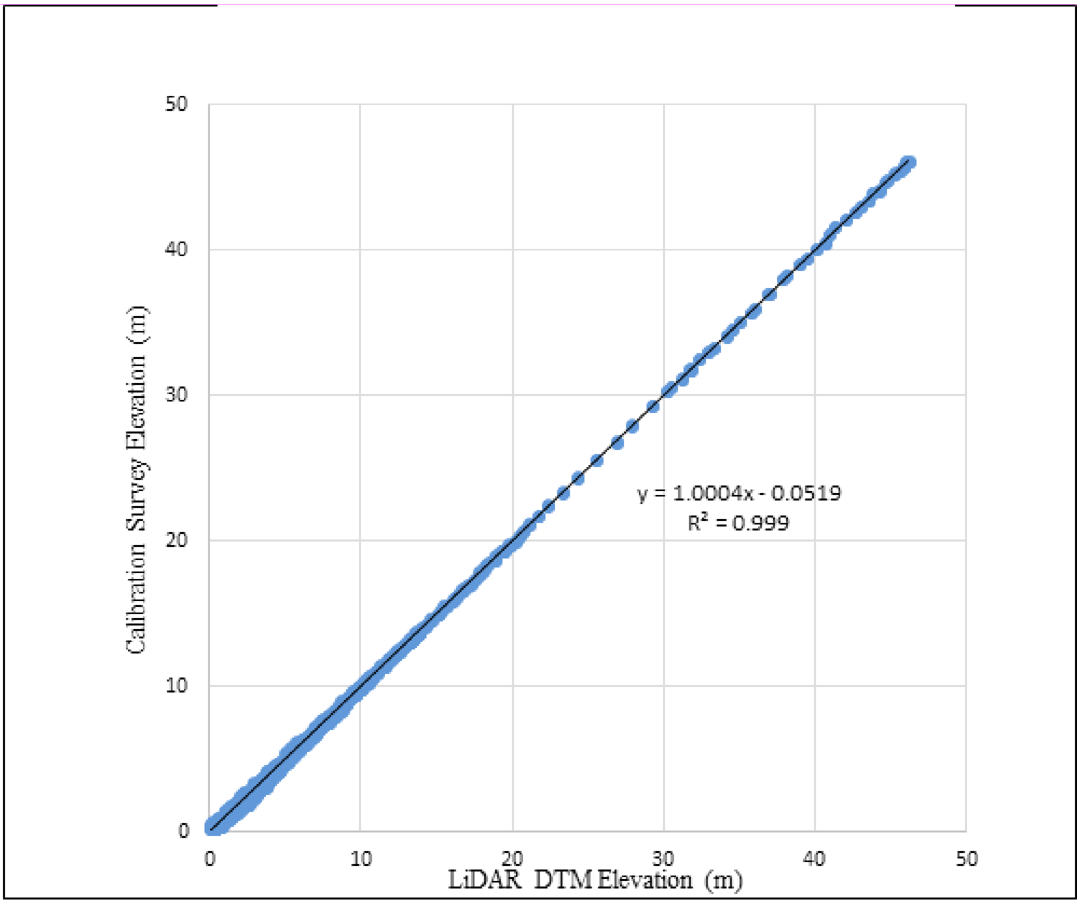



Figure 28. Correlation plot between calibration survey points and LiDAR data.

Table 20. Calibration statistical measures.

| Calibration Statistical Measures | Value (meters) |
|---|---|
| Height Difference | 0.14 |
| Standard Deviation | 0.13 |
| Average | -0.05 |
| Minimum | -0.65 |
| Maximum | 0.50 |

All survey points were used for the validation of the calibrated Palo DTM. A good correlation between the calibrated mosaicked LiDAR elevation values and the ground survey elevation, which reflects the quality of the LiDAR DTM, is shown in Figure 29. The computed RMSE between the calibrated LiDAR DTM and validation elevation values is 0.13 meters with a standard deviation of 0.09 meters, as shown in Table 21.

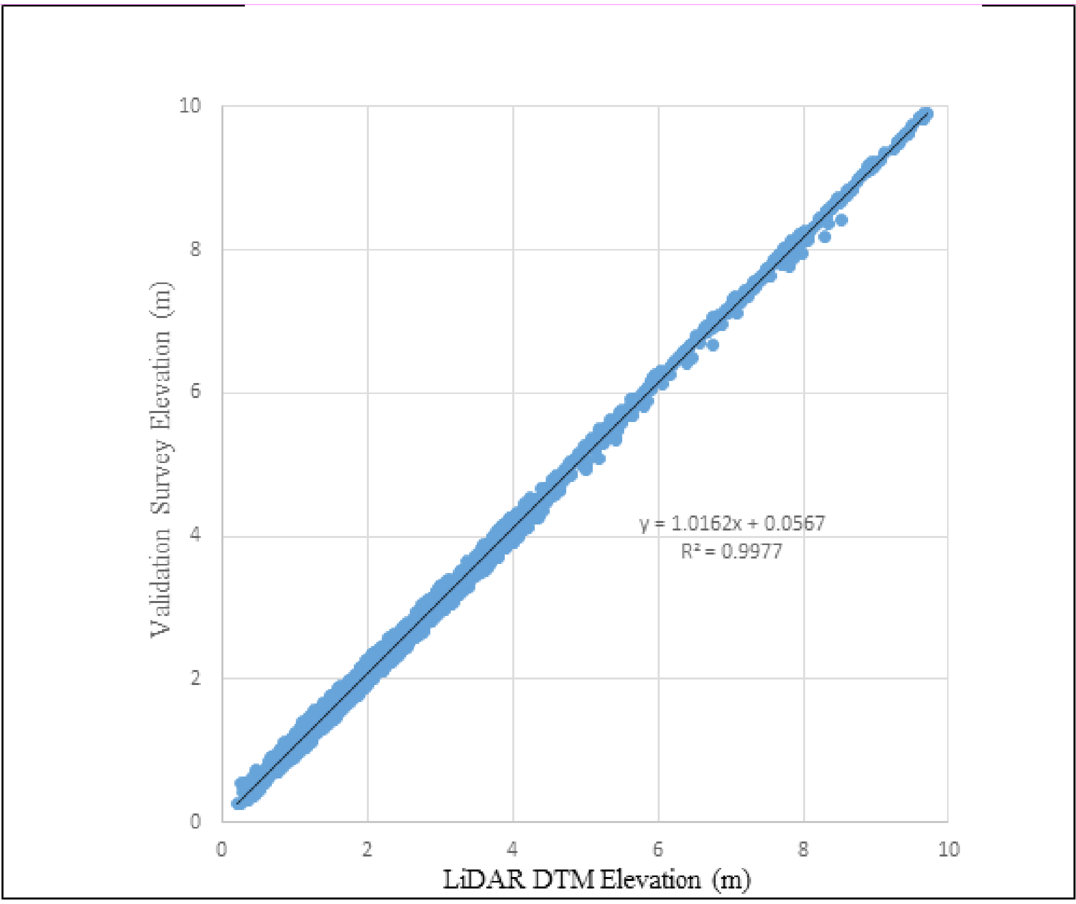



Figure 29. Correlation plot between validation survey points and LiDAR data.

Table 21. Validation statistical measures.

| Validation Statistical Measures | Value (meters) |
| --- | --- |
| RMSE | 0.13 |
| Standard Deviation | 0.09 |
| Average | 0.11 |
| Minimum | -0.10 |
| Maximum | 0.30 |

## 3.11 Integration of Bathymetric Data into the LiDAR Digital Terrain Model

For bathy integration, only centerline data was available for Palo with 587 bathymetric survey points. The resulting raster surface produced was done by Inverse Distance Weighted (IDW) interpolation method. After burning the bathymetric data to the calibrated DTM, assessment of the interpolated surface is represented by the computed RMSE value of 0.67 meters. The extent of the bathymetric survey done by the Data Validation and Bathymetry Component (DVBC) in Palo integrated with the processed LiDAR DEM is shown in Figure 30.

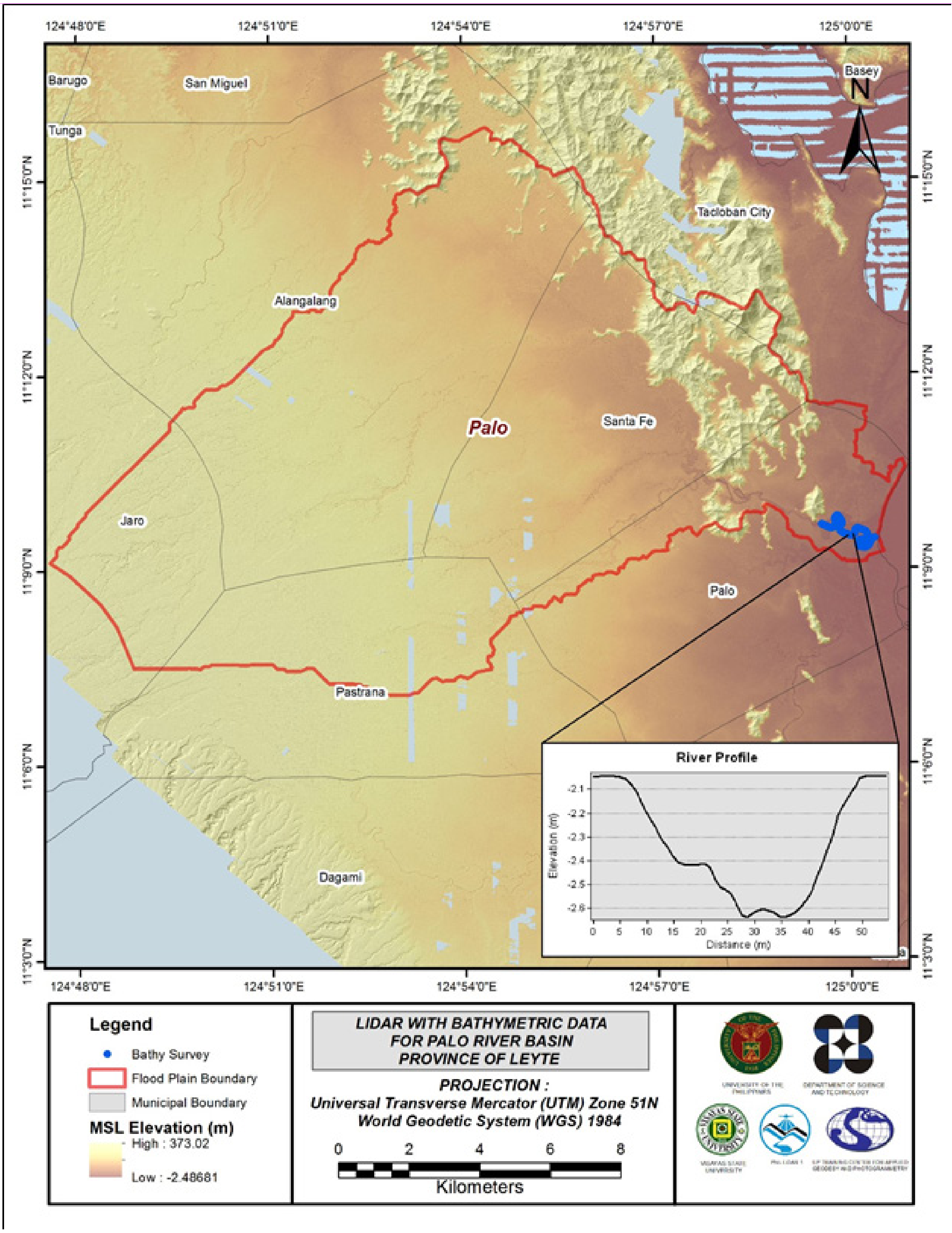



Figure 30. Map of Palo Floodplain with bathymetric survey points shown in blue.

## 3.12 Feature Extraction

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

### 3.12.1 Quality Checking of Digitized Features' Boundary

Palo Floodplain, including its 200 m buffer, has a total area of 421.61 sq km. For this area, a total of 5.0 sq km, corresponding to a total of 4731 building features, are considered for QC. Figure 31 shows the QC blocks for Palo Floodplain.

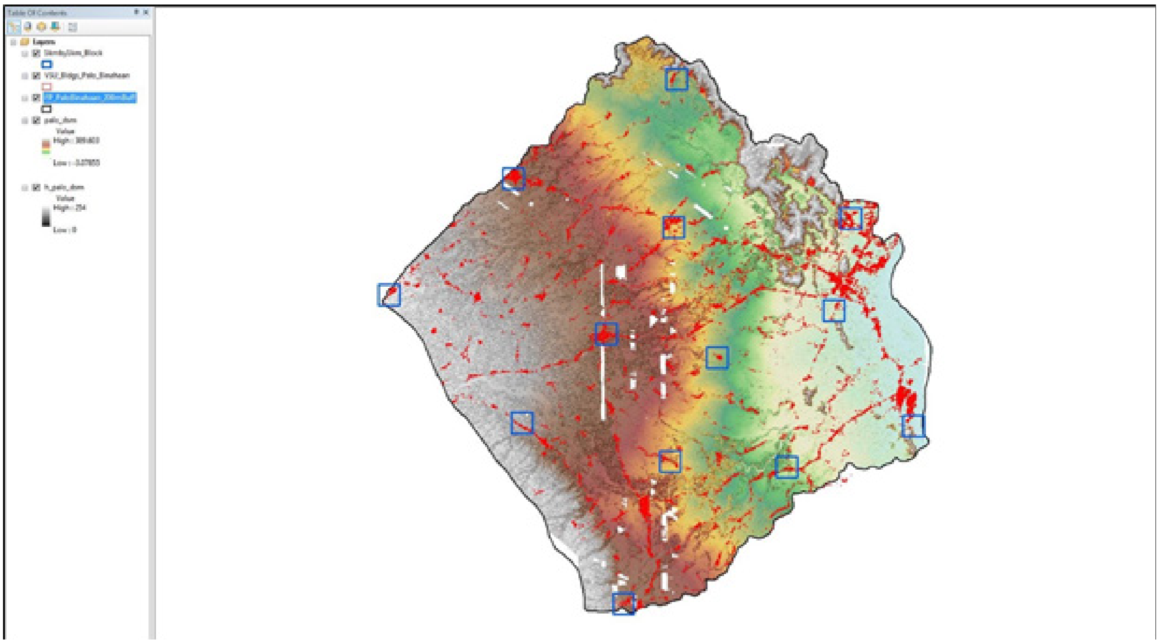


Figure 31. Blocks (in blue) of Palo building features subjected to QC.

Quality checking of Palo building features resulted in the ratings shown in Table 22.

Table 22. Quality checking ratings for Palo building features.

| Floodplain | Completeness | Correctness | Quality | Remarks |
|---|---|---|---|---|
| Palo | 94.61 | 94.61 | 80.89 | Passed |

### 3.12.2 Height Extraction

Height extraction was done for 22,789 building features in Palo Floodplain. Of these building features, 410 were filtered out after height extraction, resulting in 22,379 buildings with height attributes. The lowest building height is at 2.00 m, while the highest building is at 11.06 m.

### 3.12.3 Feature Attribution

The digitized features were marked and coded in the field using handheld GPS receivers. The attributes of non-residential buildings were first identified; all other buildings were then coded as residential. An nDSM was generated using the LiDAR DEMs to extract the heights of the buildings. A minimum height of 2 meters was used to filter out the terrain features that were digitized as buildings. Buildings that were not yet constructed during the time of LiDAR acquisition were noted as new buildings in the attribute table.

Table 23 summarizes the number of building features per type. On the other hand, Table 24 illustrates the total length of each road type, while Table 25 shows the number of water features extracted per type.

Table 23. Building features extracted for Palo Floodplain.

| Facility Type | No. of Features |
|---|---|
| Residential | 20,730 |
| School | 568 |
| Market | 32 |
| Agricultural/Agro-Industrial Facilities | 62 |
| Medical Institutions | 34 |
| Barangay Hall | 85 |
| Military Institution | 0 |
| Sports Center/Gymnasium/Covered Court | 17 |
| Telecommunication Facilities | 5 |
| Transport Terminal | 0 |
| Warehouse | 22 |
| Power Plant/Substation | 1 |
| NGO/CSO Offices | 5 |
| Police Station | 61 |
| Water Supply/Sewerage | 0 |
| Religious Institutions | 140 |
| Bank | 2 |
| Factory | 0 |
| Gas Station | 19 |
| Fire Station | 3 |
| Other Government Offices | 162 |
| Other Commercial Establishments | 414 |
| Abandoned Buildings | 17 |
| Total | 22,379 |

Table 24. Total length of extracted roads for Palo Floodplain.

| Floodplain | Road Network Length (km) | | | | | Total |
|---|---|---|---|---|---|---|
| | Barangay Road | City/ Municipal Road | Provincial Road | National Road | Others | |
| Palo | 289.89 | 86.58 | 0 | 31.22 | 0 | 407.69 |

Table 25. Number of extracted water bodies for Palo Floodplain.

| Floodplain | Water Body Type | | | | | Total |
|---|---|---|---|---|---|---|
| | Rivers/ Streams | Lakes/Ponds | Sea | Dam | Fish Pen | |
| Palo | 220 | 0 | 0 | 9 | 0 | 229 |

A total of 132 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 these output features comprise the flood hazard exposure database for the floodplain. This completes the feature extraction phase of the project.

Figure 32 shows the Digital Surface Model (DSM) of Palo Floodplain overlaid with its ground features.

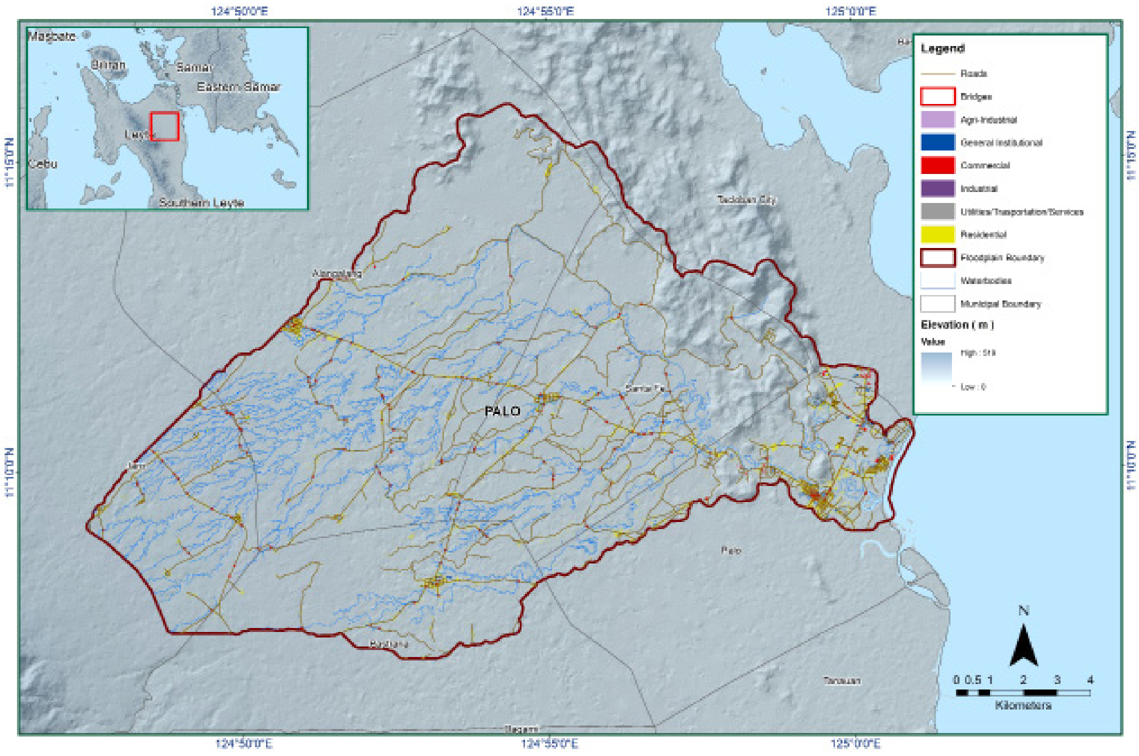



Figure 32. Extracted features for Palo Floodplain.

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

*Engr. Louie P. Balicanta, Engr. Joemarie S. Caballero, Ms. Patrizcia Mae. P. dela Cruz, Engr. Kristine Ailene B. Borromeo Engr. Mark Lester D. Rojas, Geol. Anthony Felix J. Abogado, Engr. Caren Joy S. Ordoña*

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 DVBC conducted three field surveys in Palo River. The initial fieldwork conducted was from January 8 to 20, 2014 which involved acquisition of ground validation points of about 45.847 km from Tacloban City, passing through the Municipalities of Palo, Tanauan, Tolosa, and Dulag. The second fieldwork was from September 10 to 24, 2014 with the following scope of work: control survey for the establishment of a control point; cross-section and bridge as-built of Bernard Reed Bridge. The third fieldwork was conducted frrom January 6 to 20, 2015 with the following scope of work: bathymetric survey from Brgy. San Miguel down to its mouth in Brgy. Salvacion, Leyte with an estimated length of 3.574 km and acquisition of validation points for Aquarius LIDAR.

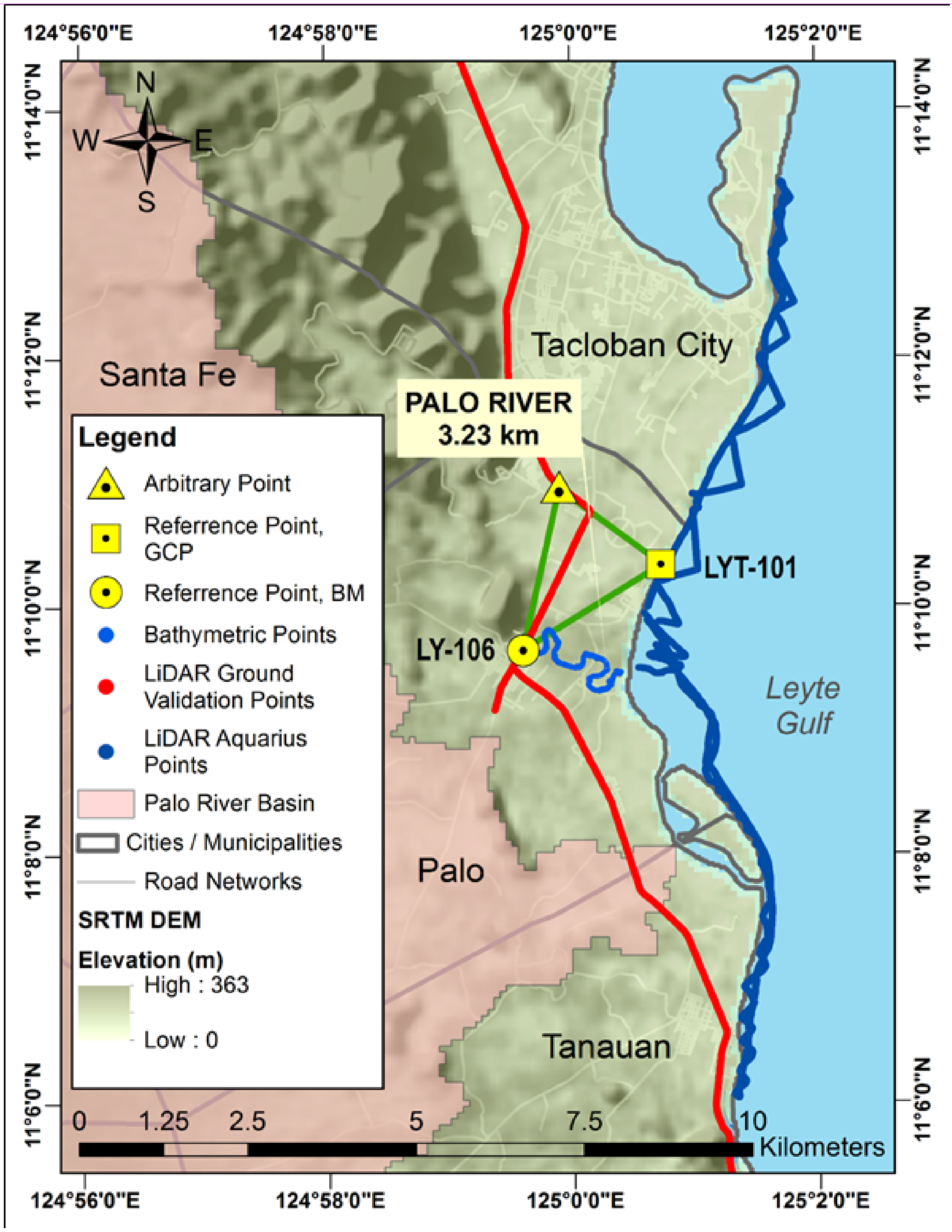



Figure 33. Extent of the bathymetric survey (in blue) in Palo River and the LiDAR data validation survey (in red)

## 4.2 Control Survey

The GNSS network used for Palo River Basin is composed of three loops established on September 18 to 20, 2014 occupying the following reference points: LYT-101, a second-order GCP, in Brgy. Candahog, Municipality of Palo; and LY-106, a second-order GCP, in Brgy. Luntad, Municipality of Palo.

Three control points were established at the approach of bridges namely: UP-DAG at Daguitan Bridge, in Brgy. Fatima, Municipality of Dulag; UP-O at Ormoc Merida Bridge, in Brgy. Liloan, Ormoc City; and UP-STN at Calay-calay Bridge, in Brgy. Caraycaray, Municipality of San Miguel. Two arbitrary points were also observed to complete the network. AP1 and AP2 are located at the corner of Maharlika Highway and an unnamed street going to Campetic Road, in Brgy. Campetik, Municipality of Palo and inside Burauen Church Plaza, Julita Burauen Road corner Burauen – Dagami Road, Brgy. Poblacion VII, Municipality of Burauen, Province of Leyte, respectively.

The summary of reference and control points and its location is summarized in Table 26 while GNSS network established is illustrated in Figure 34.

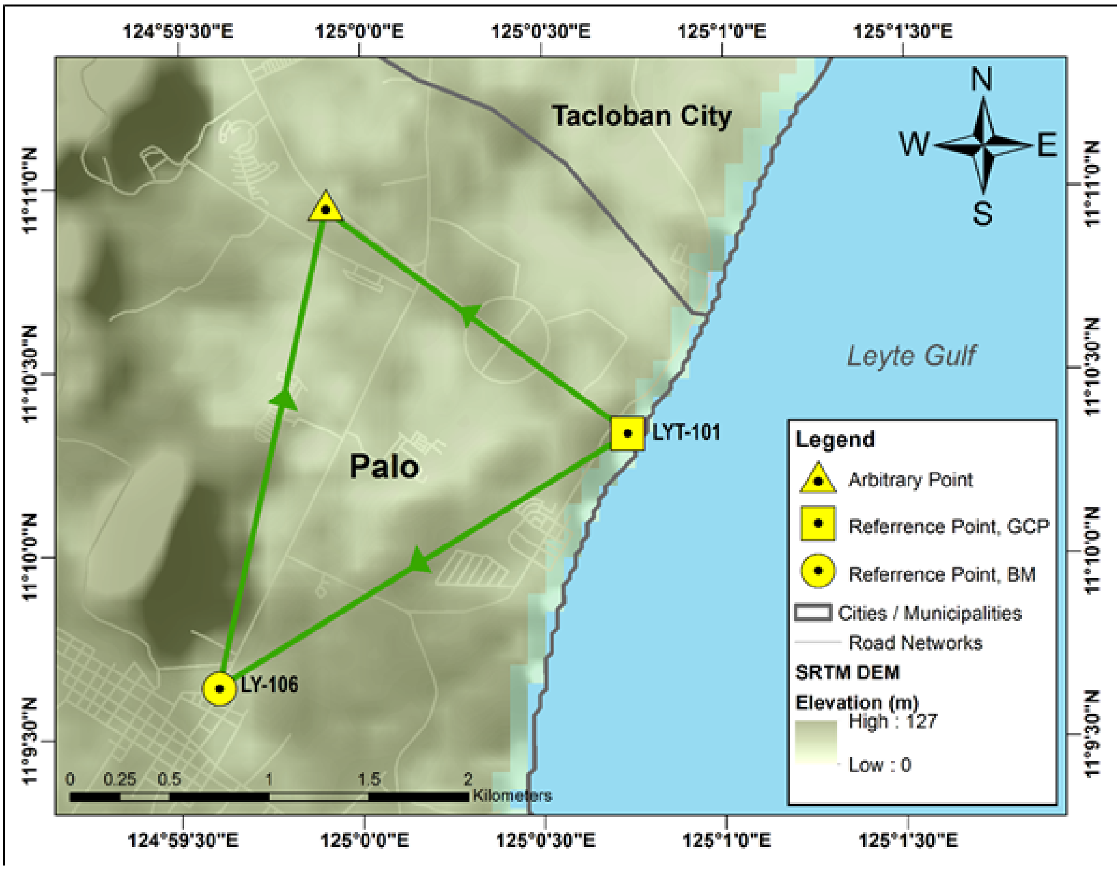



Figure 34. GNSS Network in Palo River field survey

Table 26. List of references and control points used during the survey in Leyte (Source: NAMRIA and UP-TCAGP)

| Control Point | Order of Accuracy | Geographic Coordinates (WGS 84) | | | | |
|---|---|---|---|---|---|---|
| | | Latitude | Longitude | Ellipsoidal Height (m) | MSL Elevation (m) | Date Established |
| LYT-101 | 2nd order, GCP | 11°10'19.64869" N | 125°00'43.78230" E | 69.228 | - | 09-20-2014 |
| LY-106 | 1st order, BM | - | - | 68.051 | 4.028 | 2007 |
| UP-DAG | UP Established | - | - | - | - | 09-20-2014 |
| UP-O | UP Established | - | - | - | - | 09-19-2014 |
| UP-STN | UP Established | - | - | - | - | 09-11-2014 |
| AP1 | Arbitrary | - | - | - | - | 09-18-2014 |
| AP2 | Arbitrary | - | - | - | - | 09-20-2014 |

The GNSS set-up made in the location of the reference and control points are shown in Figure 35 to Figure 40.


Figure 35. GNSS base set-up, Trimble® SPS 852, at LYT-101, located at the General McArthur Shrine in Brgy. Candahog, Municipality of Palo, Leyte


Figure 36. GNSS base set-up, Trimble® SPS 985, at LY-106, located at the approach of Bernard Reed Bridge along Maharlika Highway , Brgy. Luntad, Municipality of Palo, Leyte


Figure 37. Trimble® SPS 985 GNSS set-up at UP-ABG in Cadacan Bridge, Abuyog, Leyte


Figure 38. GNSS receiver set-up, Trimble® SPS 985, at UP DAG, an established control point, located at the bridge approach of the Daguitan Bridge along Maharlika Highway in Brgy. Fatima, Municipality of Dulag, Province of Leyte


Figure 39. GNSS receiver set-up, Trimble® SPS 985, at UP-O, an established control point, located at the bridge approach of the Ormoc Merida Bridge along Ormoc-Merida-Isabel-Palompon Road in Brgy. Liloan, City of Ormoc, Province of Leyte


Figure 40. GNSS base set-up, Trimble® SPS 852, at UP-STN, an established control point, located at Calaycalay Bridge approach in Brgy. Brgy. Poblacion Zone 12, City of Baybay, Leyte

## 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 Palo River Basin is summarized in Table 27 generated by TBC software.

Table 27. Baseline processing report for Palo River Basin static survey

| Observation | Date of Observation | Solution Type | H.Prec. (Meter) | V.Prec. (Meter) | Geodetic Az. | Ellipsoid Dist. (Meter) |
|---|---|---|---|---|---|---|
| UP-STN --- UP-O (B2) | 09-19-2014 | Fixed | 0.003 | 0.013 | 219°39'13” | 45132.753 |
| LY-106 --- AP1 (B4) | 09-18-2014 | Fixed | 0.003 | 0.012 | 12°44'49" | 2489.516 |
| LY-106 --- UP-STN (B11) | 09-18-2014 | Fixed | 0.005 | 0.042 | 317°02'38" | 29477.609 |
| LYT-101 --- UP-O (B1) | 09-19-2014 | Fixed | 0.005 | 0.013 | 254°12'03" | 52970.388 |
| LYT-101 --- AP1 (B6) | 09-18-2014 | Fixed | 0.002 | 0.003 | 307°32'43" | 1903.266 |
| LYT-101 --- UP-STN (B10) | 09-18-2014 | Fixed | 0.005 | 0.039 | 312°31'18" | 30045.665 |
| LYT-101 --- UP-STN (B3) | 09-18-2014 | Fixed | 0.003 | 0.011 | 312°31'18" | 30045.649 |
| LYT-101 --- LY-106 (B7) | 09-20-2014 | Fixed | 0.003 | 0.016 | 238°21'43" | 2417.850 |
| LYT-101 --- LY-106 (B5) | 09-20-2014 | Fixed | 0.002 | 0.004 | 238°21'42" | 2417.858 |
| LYT-101 --- UPDAG (B13) | 09-20-2014 | Fixed | 0.004 | 0.011 | 177°43'46" | 26154.013 |
| LYT-101 --- AP2 (B12) | 09-20-2014 | Fixed | 0.003 | 0.012 | 210°46'11" | 25458.032 |
| UP-DAG --- AP2 (B14) | 09-20-2014 | Fixed | 0.004 | 0.014 | 286°51'16" | 14691.113 |

As shown in Table 27, a total of 12 baselines were processed with reference points LYT-101 and LY-106 held fixed for grid and elevation values, respectively. All of them passed the required accuracy.

## 4.4 Network Adjustment

After the baseline processing procedure, network adjustment was performed using TBC. Looking at the Adjusted Grid Coordinates (Table 29) of the TBC-generated Network Adjustment Report, it is observed that the square root of the sum of the squares of x and y must be less than 20 cm and z less than 10 cm or in equation form:

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

Where:

xe is the Easting Error,

ye is the Northing Error, and

ze is the Elevation Error

for each control point. See the Network Adjustment Report shown in Table 28 to Table 30 for the complete details.

The seven control points, LYT-101, LY-106, UP-DAG, UP-O, UP-STN, and two arbitrary points were occupied and observed simultaneously to form a GNSS loop. The coordinates of point LYT-101 and elevation value of LY-106 were held fixed during the processing of the control points as presented in Table 28. Through these reference points, the coordinates and elevation of the unknown control points were computed.

Table 28. Control point constraints

| Point ID | Type | East σ (Meter | North σ (Meter) | Height σ (Meter) | Elevation σ (Meter) |
|---|---|---|---|---|---|
| LYT-101 | Local | Fixed | Fixed | | |
| LY-106 | Grid | | | | Fixed |
| Fixed = 0.000001(Meter) | | | | | |

The list of adjusted grid coordinates, i.e., Northing, Easting, Elevation, and computed standard errors of the control points in the network, is indicated in Table 29. The fixed control points LYT-101 has no values for grid errors; and LY-106, for elevation error.

Table 29. Adjusted grid coordinates

| Point ID | Easting (Meter) | Easting Error (Meter) | Northing (Meter) | Northing Error (Meter) | Elevation (Meter) | Elevation Error (Meter) | Constraint |
|---|---|---|---|---|---|---|---|
| LYT-101 | 1235759.250 | ? | 719729.823 | ? | 5.141 | 0.040 | LL |
| LY-106 | 1234476.732 | 0.007 | 717679.601 | 0.006 | 4.028 | ? | e |
| UP-DAG | 1209628.100 | 0.013 | 720942.270 | 0.009 | 5.993 | 0.077 | e |
| UP-O | 1220991.402 | 0.014 | 668855.819 | 0.010 | 8.719 | 0.076 | |
| UP-STN | 1255916.567 | 0.009 | 697443.625 | 0.007 | 8.835 | 0.070 | |
| AP1 | 1236908.994 | 0.007 | 718212.616 | 0.007 | 4.834 | 0.051 | |
| AP2 | 1213793.946 | 0.012 | 706851.618 | 0.010 | 56.317 | 0.079 | |

The network is fixed at reference points LYT-101 with known coordinates and LY-106 with known elevation. With the mentioned equation, $\sqrt{((x_e)^2+(y_e)^2)}<20cm$ for horizontal and $z_e<10$ cm for the vertical; the computation for the accuracy are as follows:

LYT-101
horizontal accuracy = Fixed
vertical accuracy = 4.0 cm < 10 cm

LY-106
horizontal accuracy = $\sqrt{((0.7)^2 + (0.6)^2)}$
= $\sqrt{(0.49 + 0.36)}$
= 0.92 cm < 20 cm
vertical accuracy = Fixed

UP-DAG
horizontal accuracy = $\sqrt{((1.3)^2 + (0.9)^2)}$
= $\sqrt{(1.69 + 0.81)}$
= 1.58 cm < 20 cm
vertical accuracy = 7.70 cm < 10 cm

UP-O
horizontal accuracy = $\sqrt{((1.40)^2 + (1.10)^2)}$
= $\sqrt{(1.96 + 1.21)}$
= 1.78 cm < 20 cm
vertical accuracy = 7.60 cm < 10 cm

UP-STN

horizontal accuracy = $\sqrt{((0.90)^2 + (0.70)^2}$
= $\sqrt{(0.81 + 0.49)}$
= 1.14 cm < 20 cm

vertical accuracy = 7.0 cm < 10 cm

AP1

horizontal accuracy = $\sqrt{((0.70)^2 + (0.70)^2}$
= $\sqrt{(0.49 + 0.49)}$
= 0.98 cm < 20 cm

vertical accuracy = 5.10 cm < 10 cm

AP2

horizontal accuracy = $\sqrt{((1.20)^2 + (1.0)^2}$
= $\sqrt{(1.44 + 1.0)}$
= 1.56 cm < 20 cm

vertical accuracy = 7.9 cm < 10 cm

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

Table 30. Adjusted geodetic coordinates

| Point ID | Latitude | Longitude | Ellipsoidal Height (Meter) | Height Error (Meter) | Constraint |
|---|---|---|---|---|---|
| LY-106 | N11°09'38.36982" | E124°59'35.93684" | 68.051 | ? | e |
| UP-DAG | N10°56'09.12671" | E125°01'17.90763" | 70.609 | 0.077 | |
| UP-O | N11°02'28.97646" | E124°32'44.58922" | 71.626 | 0.076 | |
| UP-STN | N11°21'20.28504" | E124°48'33.44650" | 71.793 | 0.070 | |
| AP1 | N11°10'57.39411" | E124°59'54.04241" | 68.821 | 0.051 | |
| AP2 | N10°58'27.65859" | E124°53'34.80074" | 120.385 | 0.079 | |

The corresponding geodetic coordinates of the observed points are within the required accuracy as shown in Table 30. Based on the result of the computation, the accuracy conditions are satisfied; hence, the required accuracy for the program was met.

The summary of reference and control points used is indicated in Table 31.

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

| Control Point | Order of Accuracy | Geographic Coordinates (WGS 84) | | | UTM ZONE 51 N | | |
|---|---|---|---|---|---|---|---|
| | | Latitude | Longitude | Ellipsoidal Height (m) | Northing (m) | Easting (m) | BM Ortho (m) |
| LYT-101 | 2nd Order, GCP | 11°10'19.64869" | 125°00'43.78230" | 69.228 | 1235759.250 | 719729.823 | 5.141 |
| LY-106 | 1st order, BM | 11°09'38.36982" | 124°59'35.93684" | 68.051 | 1234476.732 | 717679.601 | 4.028 |
| UP-DAG | UP Established | 10°56'09.12671" | 125°01'17.90763" | 70.609 | 1209628.100 | 720942.270 | 5.993 |
| UP-O | UP Established | 11°02'28.97646" | 124°32'44.58922" | 71.626 | 1220991.402 | 668855.819 | 8.719 |
| UP-STN | UP Established | 11°21'20.28504" | 124°48'33.44650" | 71.793 | 1255916.567 | 697443.625 | 8.835 |
| AP1 | Arbitrary Point | 11°10'57.39411" | 124°59'54.04241" | 68.821 | 1236908.994 | 718212.616 | 4.834 |
| AP2 | Arbitrary Point | 10°58'27.65859" | 124°53'34.80074" | 120.385 | 1213793.946 | 706851.618 | 56.317 |

## 4.5 Cross-section and Bridge As-Built Survey

Cross-section and as-built survey were conducted on September 14, 2014 along downstream side of Bernard Reed Bridge in Municipality of Palo, Leyte using a GNSS receiver, Trimble® SPS 882, in PPK survey technique as exhibited in Figure 41. The control point LY-106 was used as the GNSS base station for the survey.


Figure 41. Cross-section survey using Trimble® SPS 882 – (A) bridge approach and (B) bridge deck of Bernard Reed Bridge, Palo, Leyte

The cross-sectional line for Bernard Reed Bridge is about 59.69 m with a total of 23 points. The summary of gathered cross-section location map and diagram are shown in Figure 42 and Figure 43, while the as-built bridge data form is shown in to Figure 44.

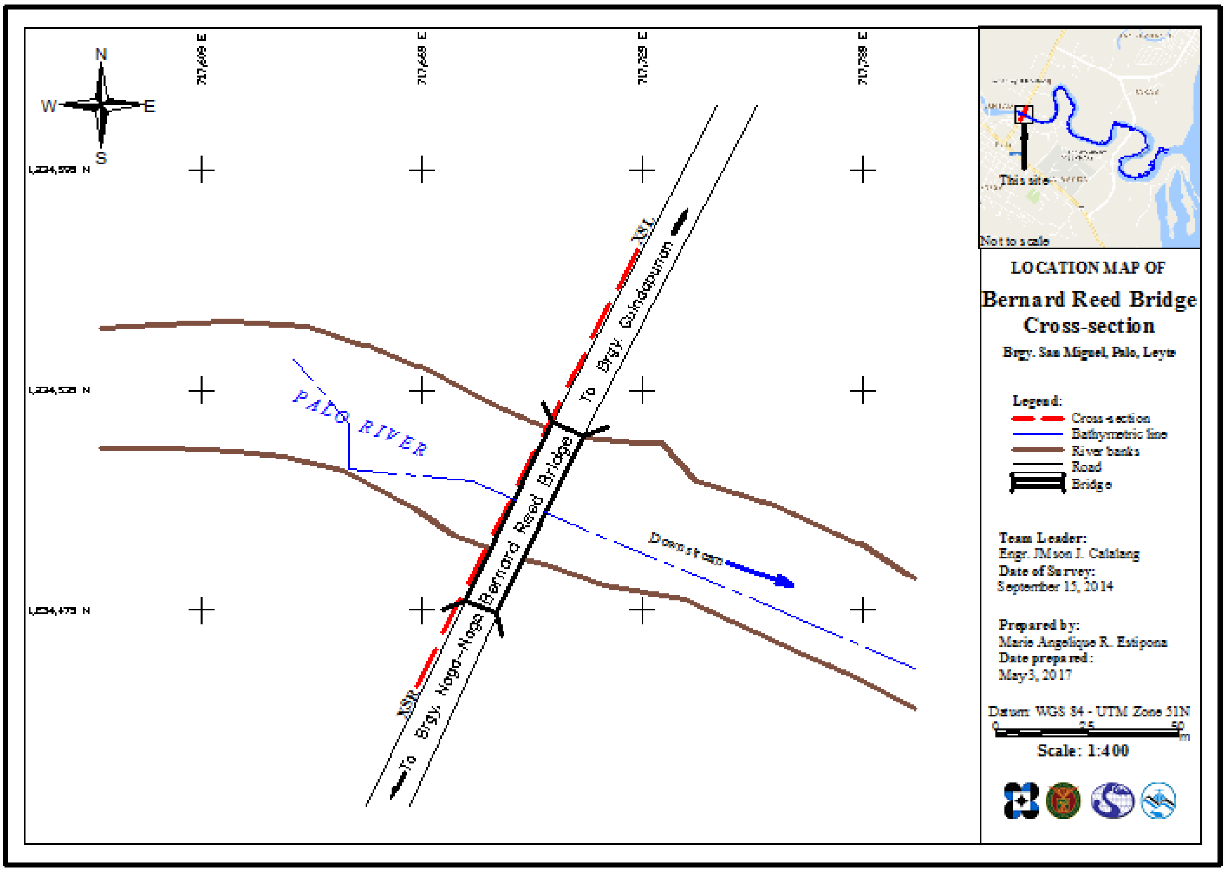



Figure 42. Bernard Reed bridge cross-section location map

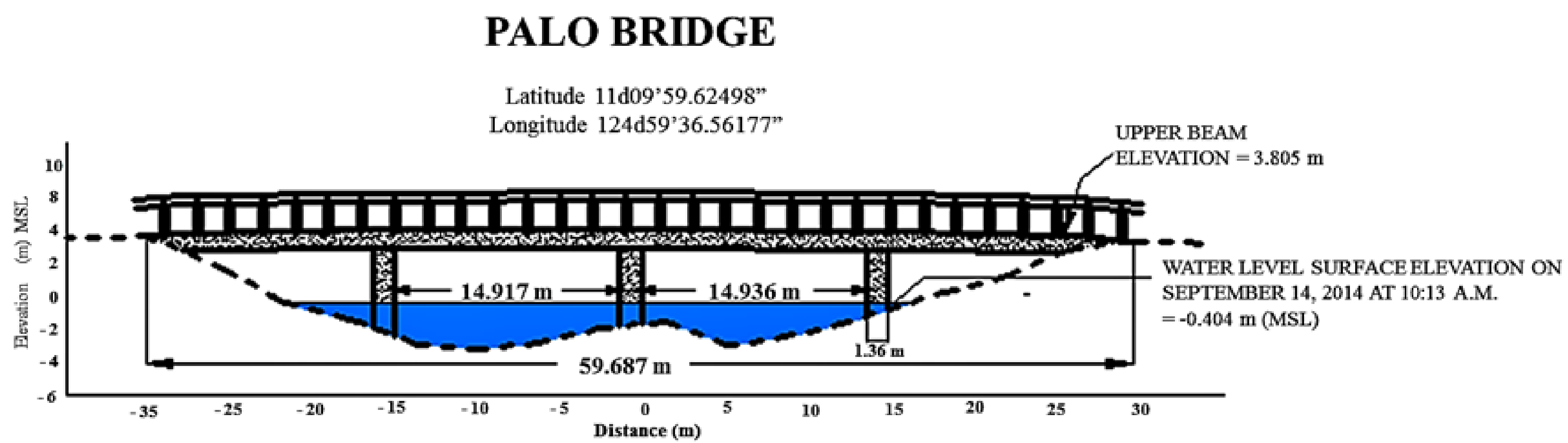



Figure 43. Palo (Bernard Reed) Bridge cross-section diagram

**Bridge Data Form**

**Bridge Name:** Bernard Reed Bridge **Date:** September 15, 2014

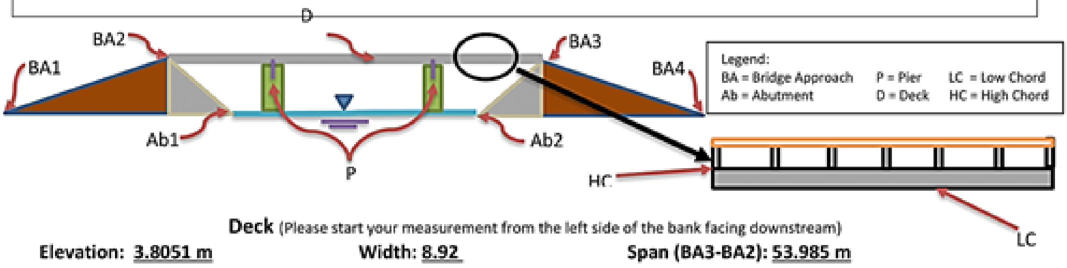
**River Name:** PALO RIVER **Time:** 10:20 AM

**Location (Brgy, City, Region):** Palo, Leyte

**Survey Team:** Team JMson Calalang and FMC- Jonard Apilado

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

**Latitude:** 11°09'39.62498"N **Longitude:** 124°59'36.56177" E




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

**Elevation:** 3.8051 m **Width:** 8.92 **Span (BA3-BA2):** 53.985 m

| | Station | High Chord Elevation | Low Chord Elevation |
|---|---|---|---|
| 1 | 52.517 | 4.203 | 3.083 |
| 2 | 64.642 | 4.352 | 3.232 |
| 3 | 79.561 | 4.414 | 3.294 |
| 4 | 94.497 | 4.280 | 3.160 |
| 5 | 106.502 | 4.069 | 2.949 |

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

| | Station(Distance from BA1) | Elevation | | Station(Distance from BA1) | Elevation |
|---|---|---|---|---|---|
| BA1 | 0 | 3.48 | BA3 | 106.502 | 4.069 |
| BA2 | 52.517 | 4.20 | BA4 | | |

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

| | Station (Distance from BA1) | Elevation |
|---|---|---|
| Ab1 | 57.981 | 0.133 |
| Ab2 | 97.156 | 0.141 |

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

**Shape:** Non-Uniform **Number of Piers:** three (3) **Height of column footing:** n/a

| | Station (Distance from BA1) | Elevation | Pier Width |
|---|---|---|---|
| Pier 1 | 64.642 | -2.953 | 0.64-1.36 |
| Pier 2 | 79.561 | -1.582 | 0.64-1.36 |
| Pier 3 | 94.497 | 0.196 | 0.64-1.36 |
| Pier 7 | 367.72 | 11.71 | 1.142 |

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

Figure 44. Palo (Bernard Reed) Bridge data form

## 4.6 Validation Points Acquisition Survey

Validation points acquisition survey was conducted on January 9, 2015 using a survey-grade GNSS Rover receiver mounted on a pole which was tied in front of the vehicle. It was secured with cable ties to ensure that it was horizontally and vertically balanced as shown in Figure 45. The antenna height was 1.33 meters which was measured from the ground up to the bottom of the notch of the GNSS Rover receiver. The survey was conducted using RTK and PPK technique on a continuous topography mode.

The ground validation started from Brgy. 101, Palo and traversed major roads going to Brgy. Salvacion, Dulag. The reference point LYT-101 was occupied as the GNSS base station for the survey.


Figure 45. Trimble® SPS 882 and RTK antenna set-up in a van for LiDAR validation survey

The survey acquired 4,826 ground validation points with an approximate length of 45.8 km, as shown in the map in Figure 46.

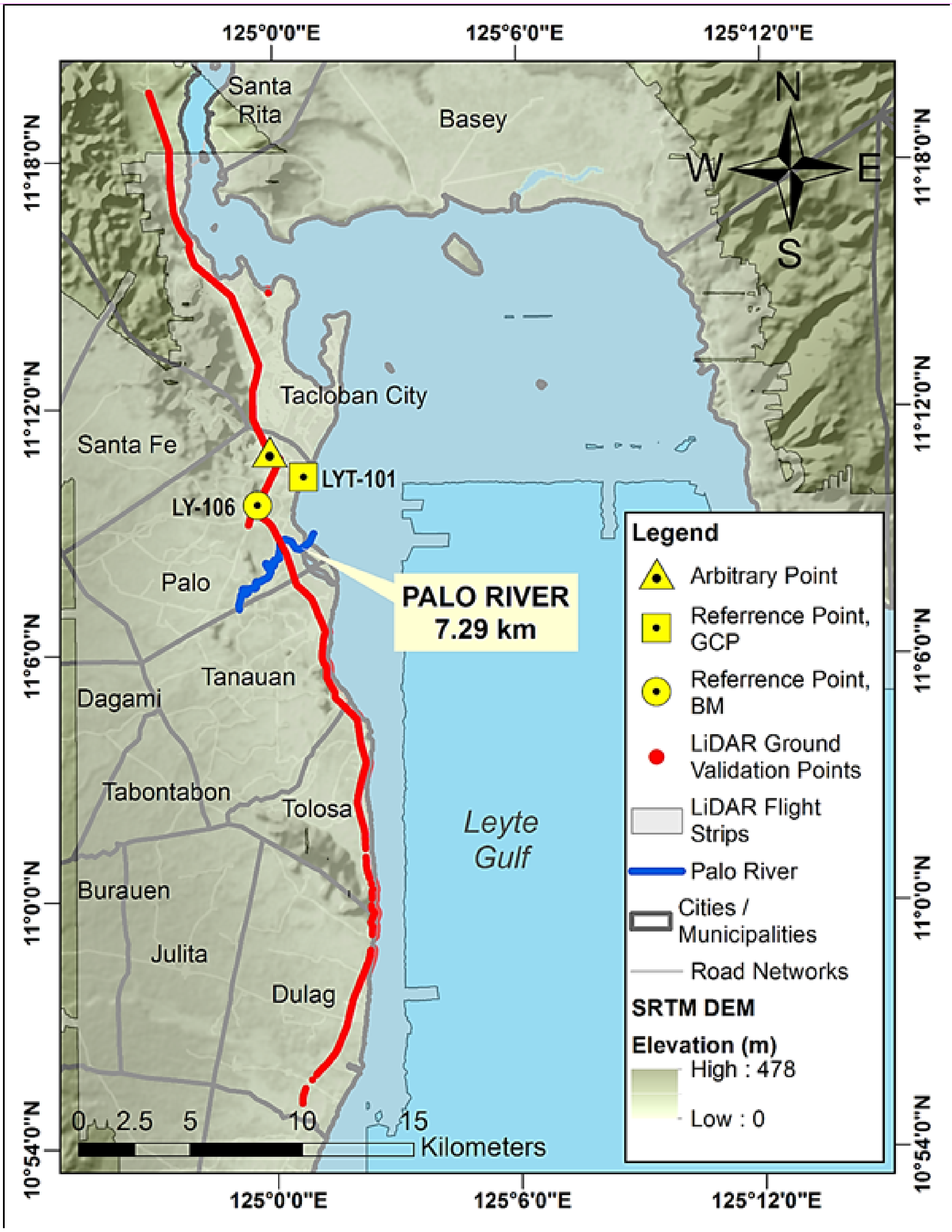



Figure 46. Validation points acquisition survey along Palo, Leyte

In addition to ground validation survey, LiDAR Aquarius validation survey was done on January 10, 2015 along the coastal areas of Tacloban City and the Municipalities of Palo and Tanauan. A boat was rented with installed OHMEX™ Single Beam Echo Sounder with a mounted Trimble® SPS 882 GNSS receiver as shown in Figure 47.

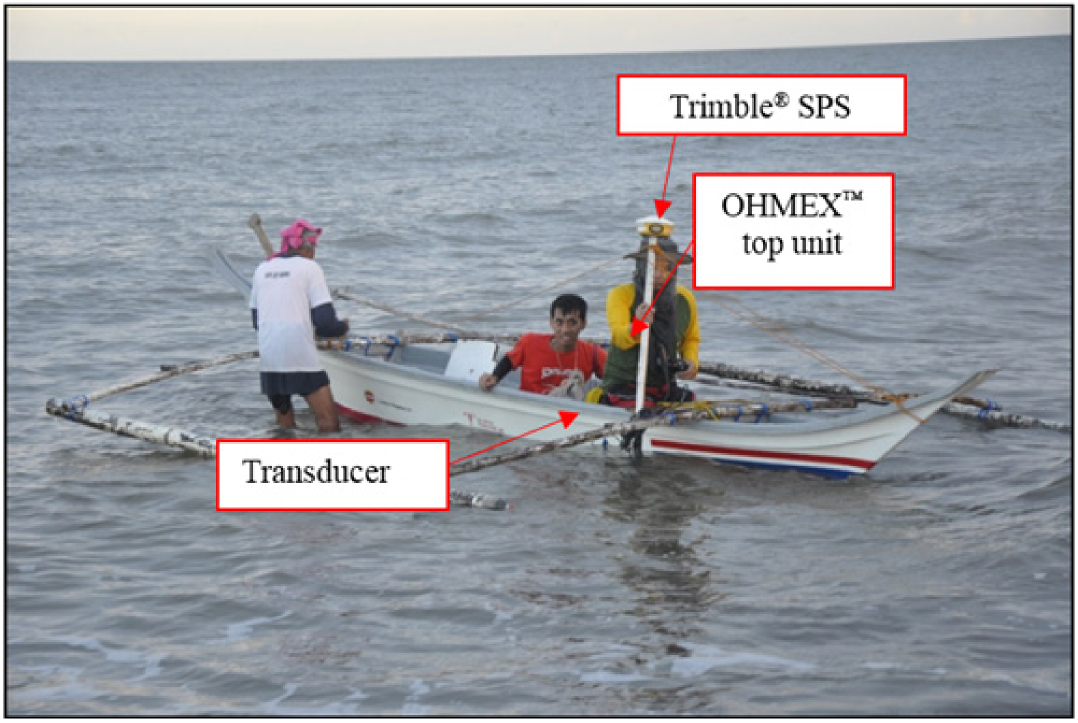



Figure 47. LiDAR Aquarius validation survey set-up

A total of 16,432 points were acquired with an approximate length of 21 km occupying LYT-101 as the GNSS base station as shown in Figure 48.

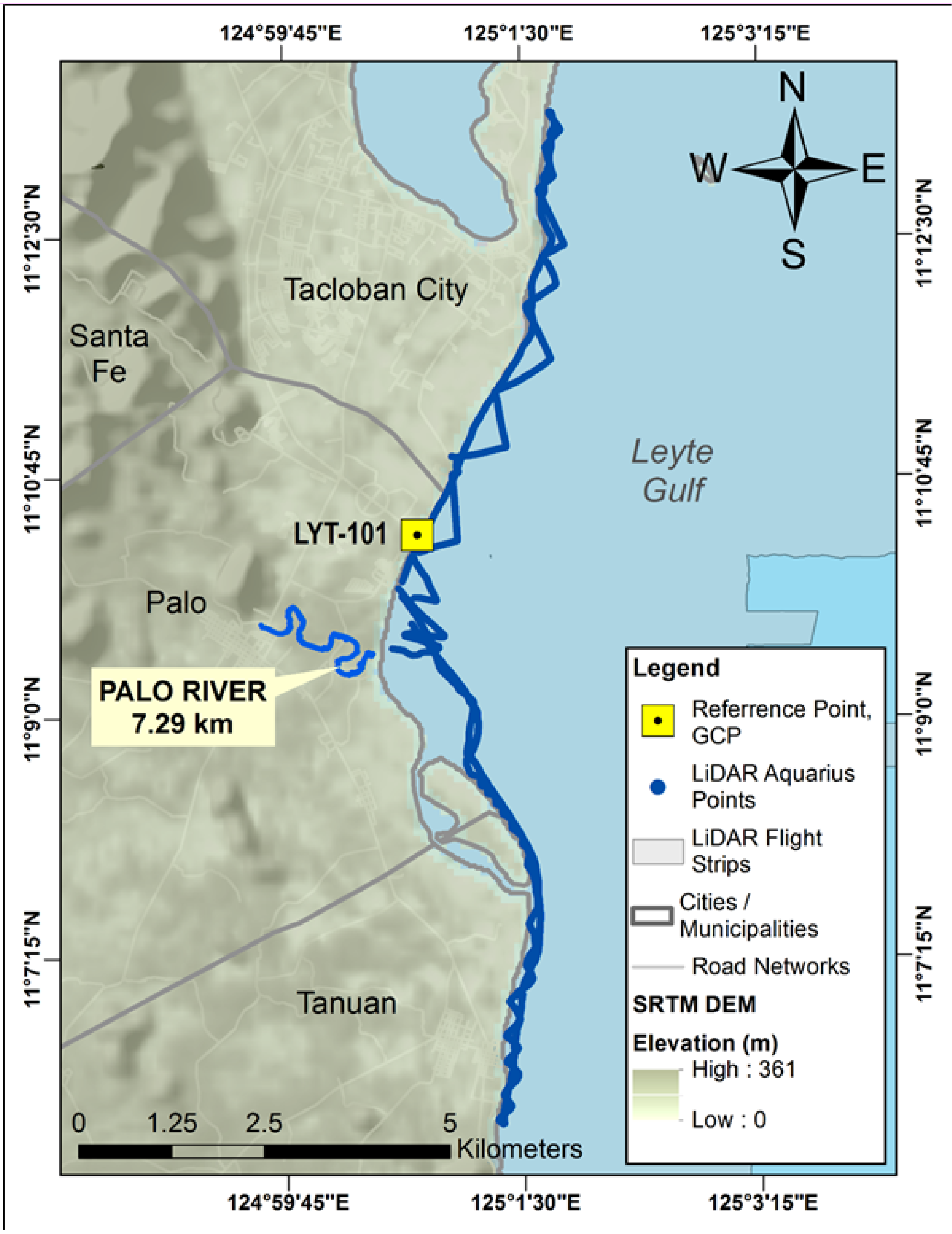



Figure 48. LiDAR Aquarius validation survey along the coast of Tacloban City, and the Municipalities of Palo and Tanauan

## 4.7 River Bathymetric Survey

Bathymetric survey was done on January 8, 2015 using an OHMEX™ Single Beam Echo Sounder with a mounted Trimble® SPS 882 GNSS receiver in PPK survey technique attached on a rented boat as shown in Figure 49. The survey started in the upstream part of Palo River in Brgy. San Miguel, Municipality of Palo with coordinates 11˚09'40.54396" 124˚59'34.49898", down to the mouth of the river in Brgy. Salvacion, Palo with coordinates 11˚09'27.72233" 125˚00'23.96538".


Figure 49. Bathymetric survey using an OHMEX™ Single Beam Echo Sounder with a mounted Trimble® SPS 882

The survey acquired 966 points with an approximate length of 3.57 km occupying LY-106 as the GNSS base station as shown in Figure 50.

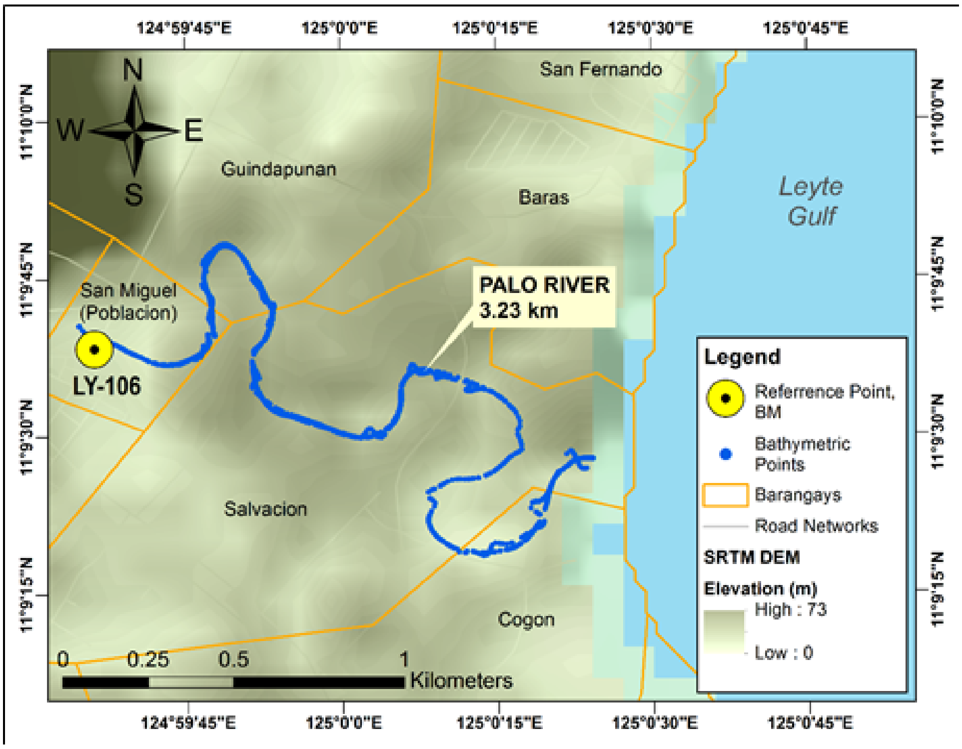



Figure 50. Bathymetric points gathered in Palo River

A CAD drawing was also produced to illustrate the Palo riverbed profile. As shown in Figure 51, the highest elevation observed was -0.943 m in MSL located in Brgy. San Miguel and the lowest elevation observed was -4.247 m below MSL located in Brgy. Cogon.

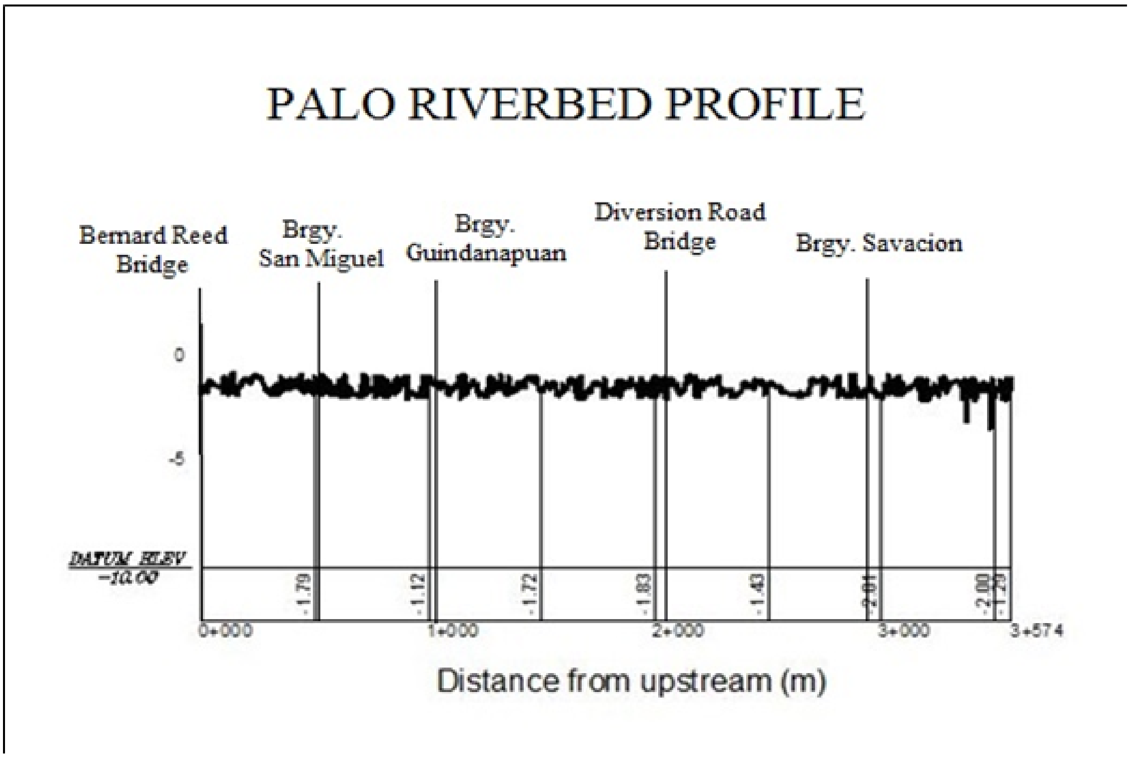



Figure 51. Riverbed profile of Palo River

# CHAPTER 5: FLOOD MODELING AND MAPPING

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

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

Rainfall, water level, and flow in a certain period of time, which may affect the hydrologic cycle of the river basin, were monitored, collected, and analyzed.

### 5.1.2 Precipitation

Precipitation data was taken from an automatic rain gauge (ARG) installed by the Department of Science and Technology – Advanced Science and Technology Institute (DOST-ASTI) and named as Sta Fe ARG. The location of the rain gauge is seen in Figure 52.

The total precipitation for this event in Sta. Fe ARG is 84.5 mm. It peaked to 8.67 mm on July 29, 2016 at 4:30 am. The lag time between the peak rainfall and discharge is 28 hours.

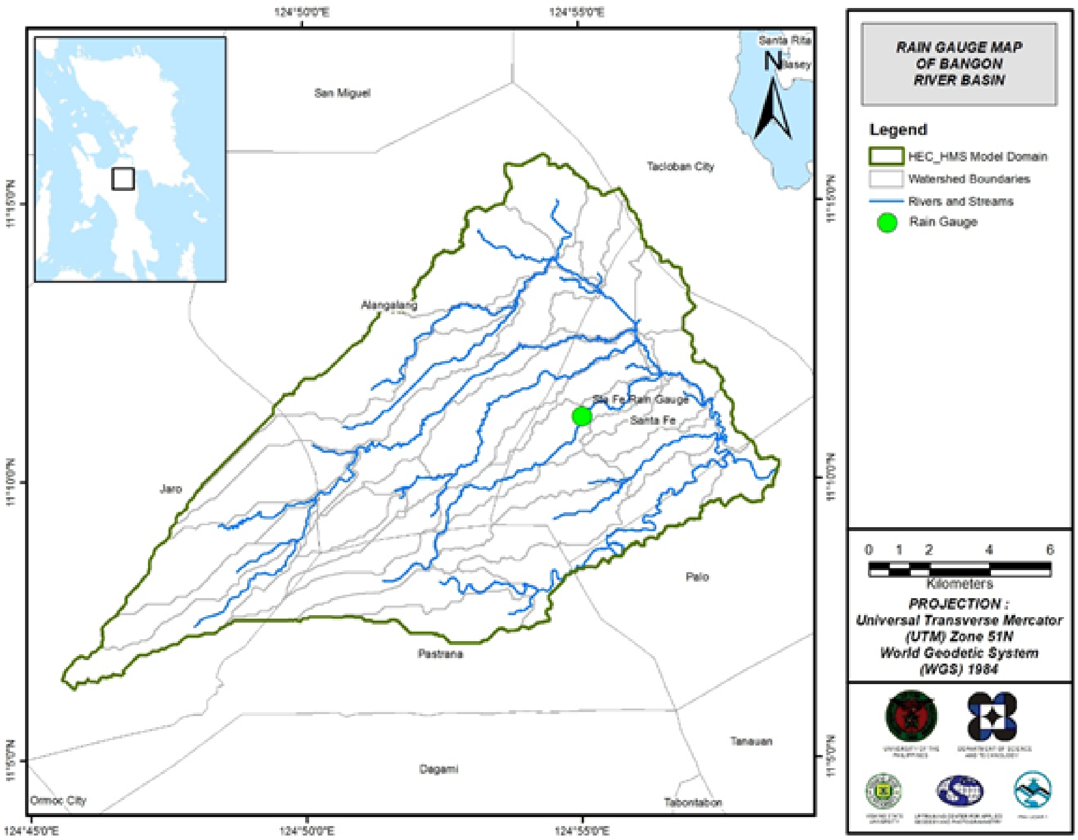



Figure 52. The location map of Palo HEC-HMS model used for calibration

### 5.1.3 Rating Curves and River Outflow

A rating curve was developed at San Jose Hanging Bridge, San Jose, Palo, Leyte (11°10'9.04"N, 124°58'34.28"E). It gives the relationship between the observed water levels and outflow of the watershed at this location.

For San Jose Hanging Bridge, the rating curve is expressed as Q = 0.029e3.2605h as shown in Figure 54.

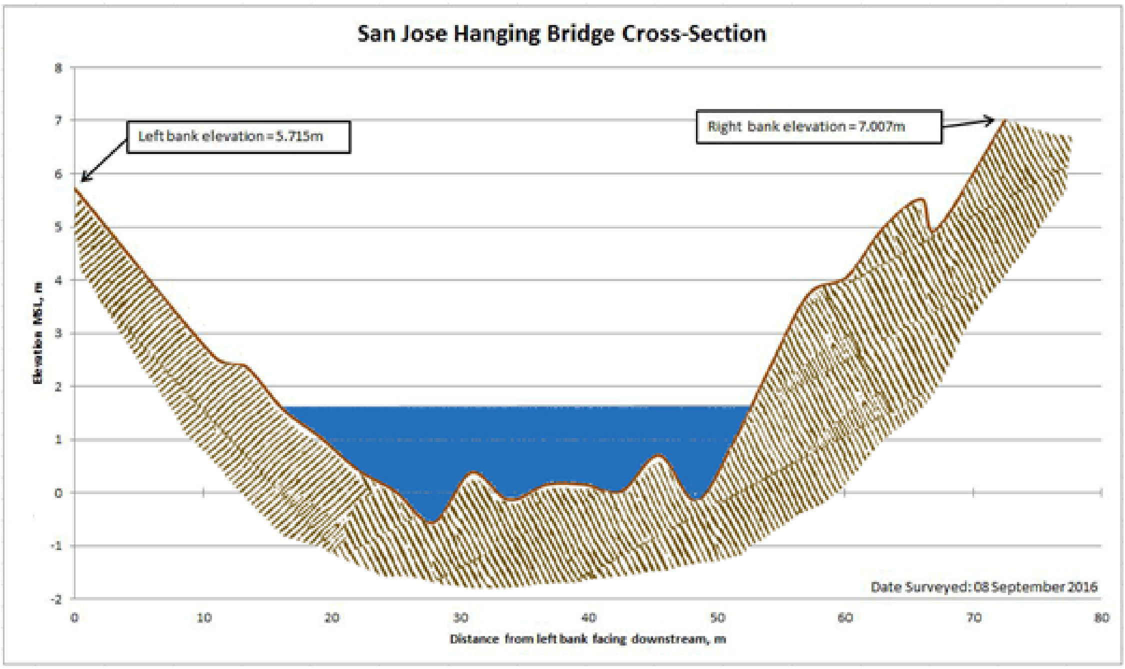



Figure 53. Cross-section plot of San Jose Hanging Bridge

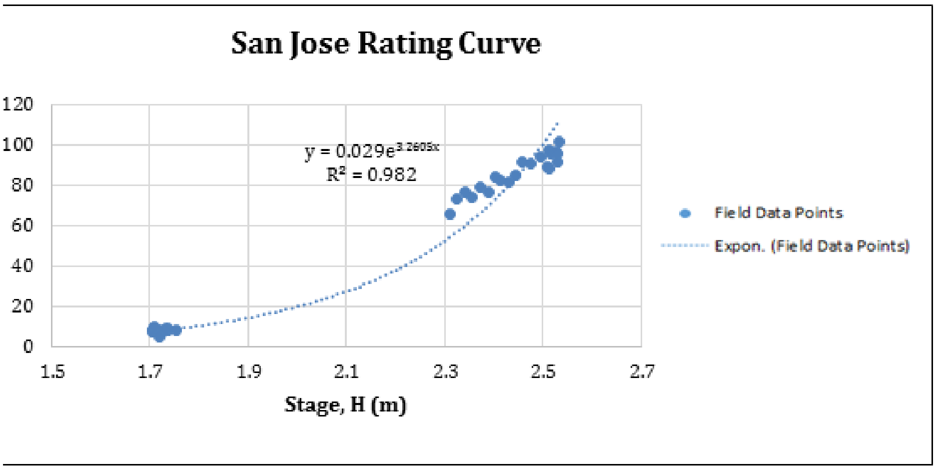



Figure 54. Rating curve at San Jose Hanging Bridge

This rating curve equation was used to compute the river outflow at San Jose Hanging Bridge for the calibration of the HEC-HMS model shown in Figure 55. River outflow gathered during typhoon Carina was used to calibrate the HEC-HMS model. This was recorded on July 29-30, 2016.

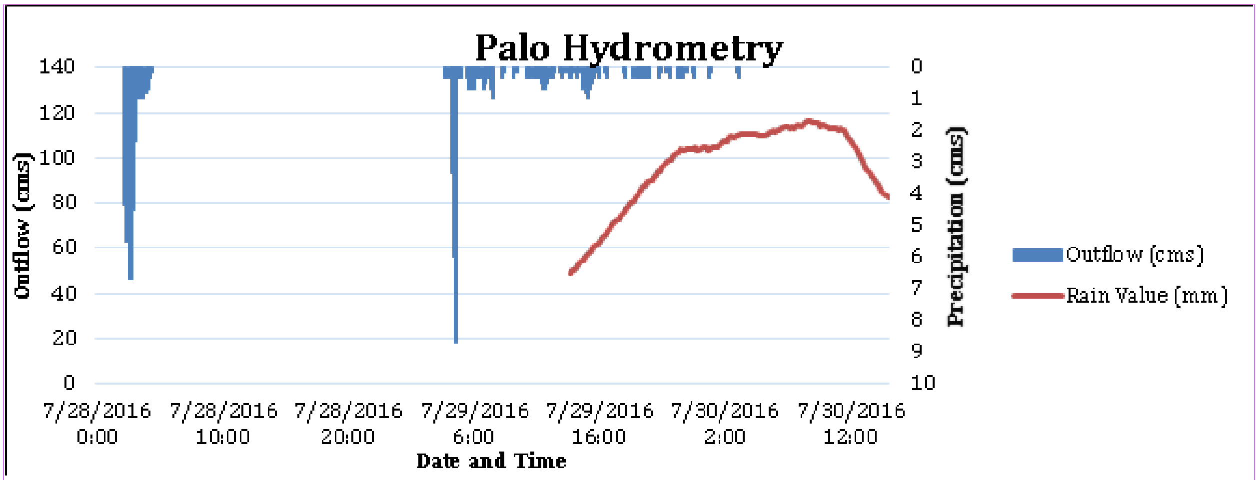



Figure 55. Rainfall and outflow data at San Jose Hanging Bridge used for modeling.

## 5.2 RIDF Station

The Philippines Atmospheric Geophysical and Astronomical Services Administration (PAGASA) computed Rainfall Intensity Duration Frequency (RIDF) values for the Tacloban Rain Gauge. The RIDF rainfall amount for 24 hours was converted to a synthetic storm by interpolating and re-arranging the value in such a way certain peak value would be attained at a certain time. This station was chosen based on its proximity to Palo watershed. The extreme values for this watershed were computed based on a 59-year record.

Table 32. RIDF values for Tacloban Rain Gauge computed by PAGASA

| COMPUTED EXTREME VALUES (in mm) OF PRECIPITATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| T (yrs) | 10 mins | 20 mins | 30 mins | 1 hr | 2 hrs | 3 hrs | 6 hrs | 12 hrs | 24 hrs |
| 2 | 17.8 | 26.9 | 33.6 | 42.8 | 59.7 | 70.5 | 87.2 | 104 | 120.6 |
| 5 | 24.3 | 36.7 | 45.7 | 57.4 | 80.7 | 95.2 | 117.9 | 140.6 | 161.4 |
| 10 | 28.5 | 43.2 | 53.7 | 67.1 | 94.6 | 111.5 | 138.2 | 164.9 | 188.4 |
| 15 | 30.9 | 46.8 | 58.3 | 72.5 | 102.5 | 120.7 | 149.6 | 178.6 | 203.7 |
| 20 | 32.6 | 49.4 | 61.4 | 76.3 | 108 | 127.1 | 157.7 | 188.1 | 214.3 |
| 25 | 33.9 | 51.4 | 63.9 | 79.3 | 112.2 | 132.1 | 163.8 | 195.5 | 222.6 |
| 50 | 37.9 | 57.5 | 71.4 | 88.3 | 125.2 | 147.4 | 182.9 | 218.2 | 247.9 |
| 100 | 41.8 | 63.5 | 78.9 | 97.3 | 138.2 | 162.5 | 201.8 | 240.8 | 273 |

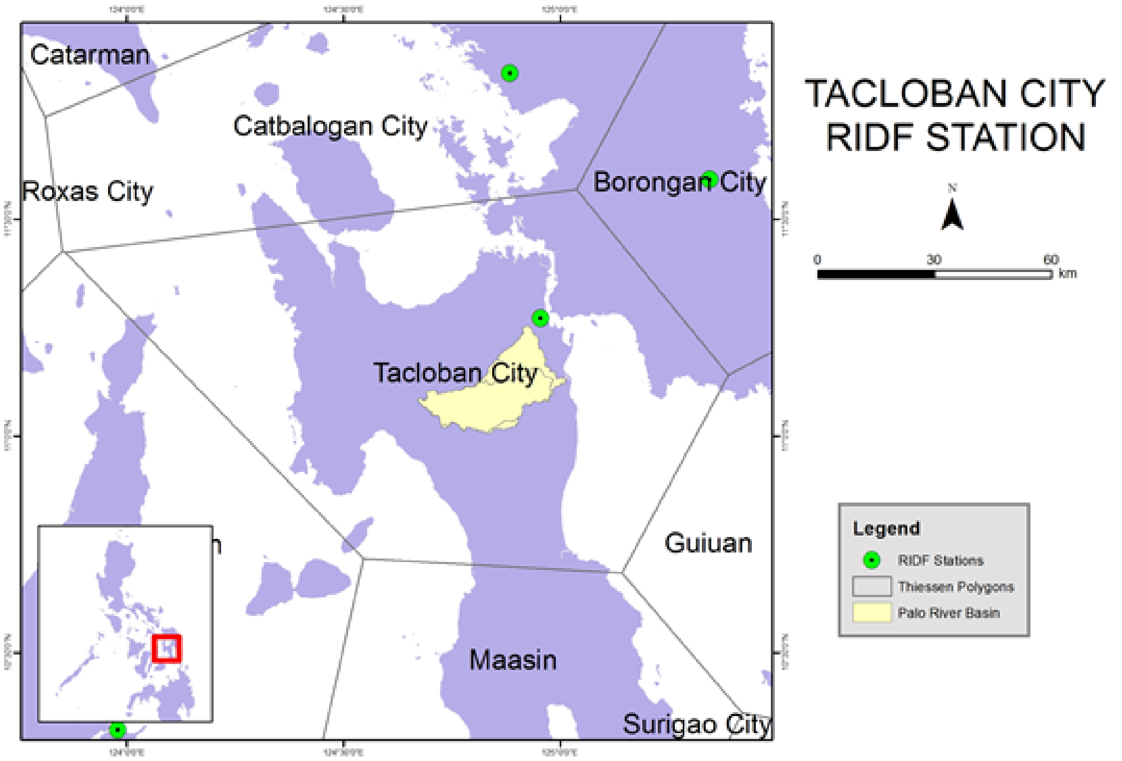



Figure 56. Location of Tacloban RIDF station relative to Palo River Basin

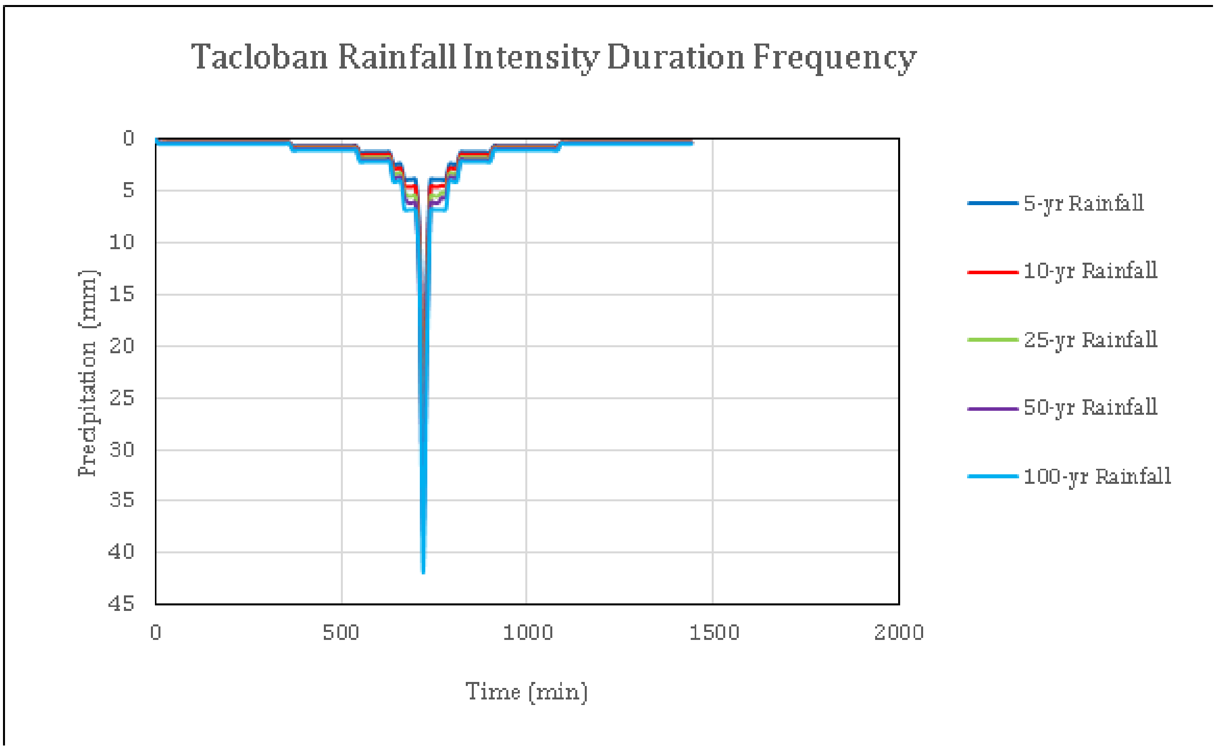



Figure 57. Synthetic storm generated for a 24-hour period rainfall for various return periods

## 5.3 HMS Model

The soil dataset was taken from and generated by the Bureau of Soils and Water Management (BSWM) under the Department of Agriculture. The land cover shape file is from the National Mapping and Resource information Authority (NAMRIA). The soil and land cover of the Palo River Basin are shown in Figure 58 and Figure 59, respectively.

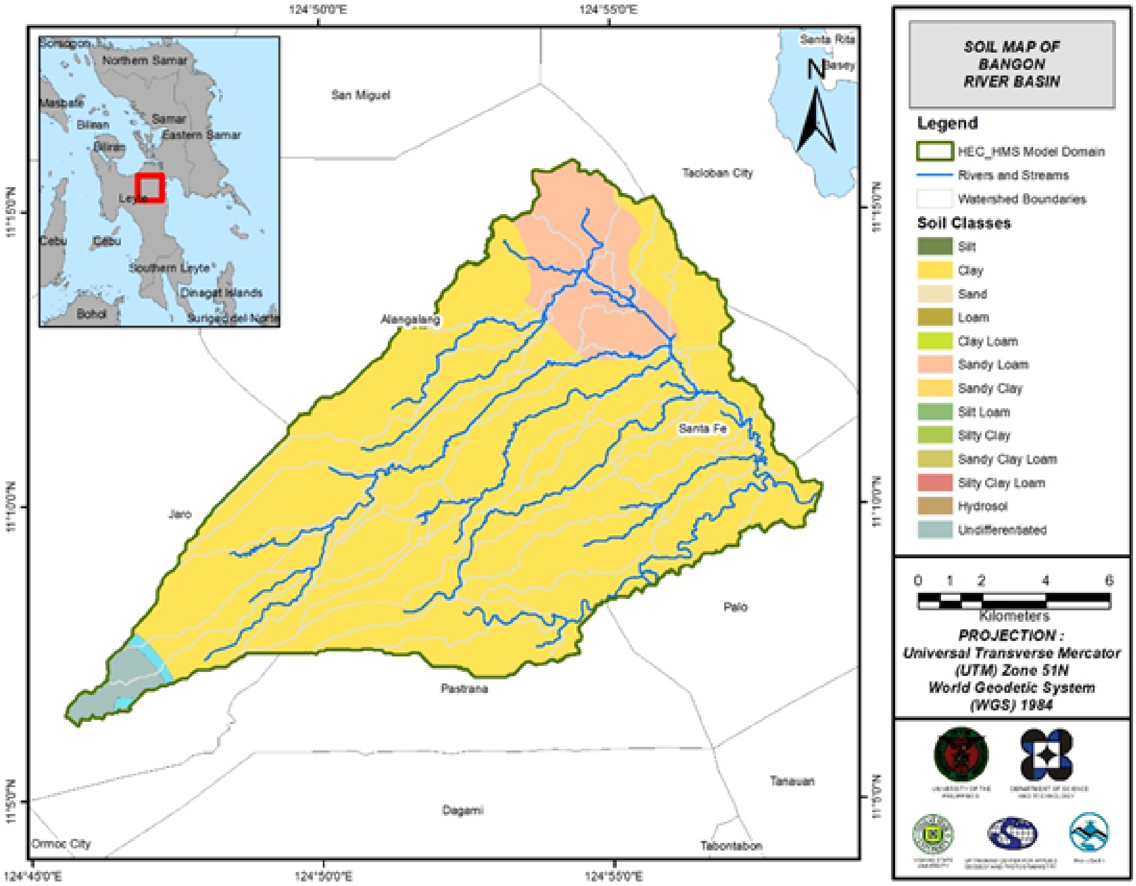



Figure 58. Soil map of Palo River Basin

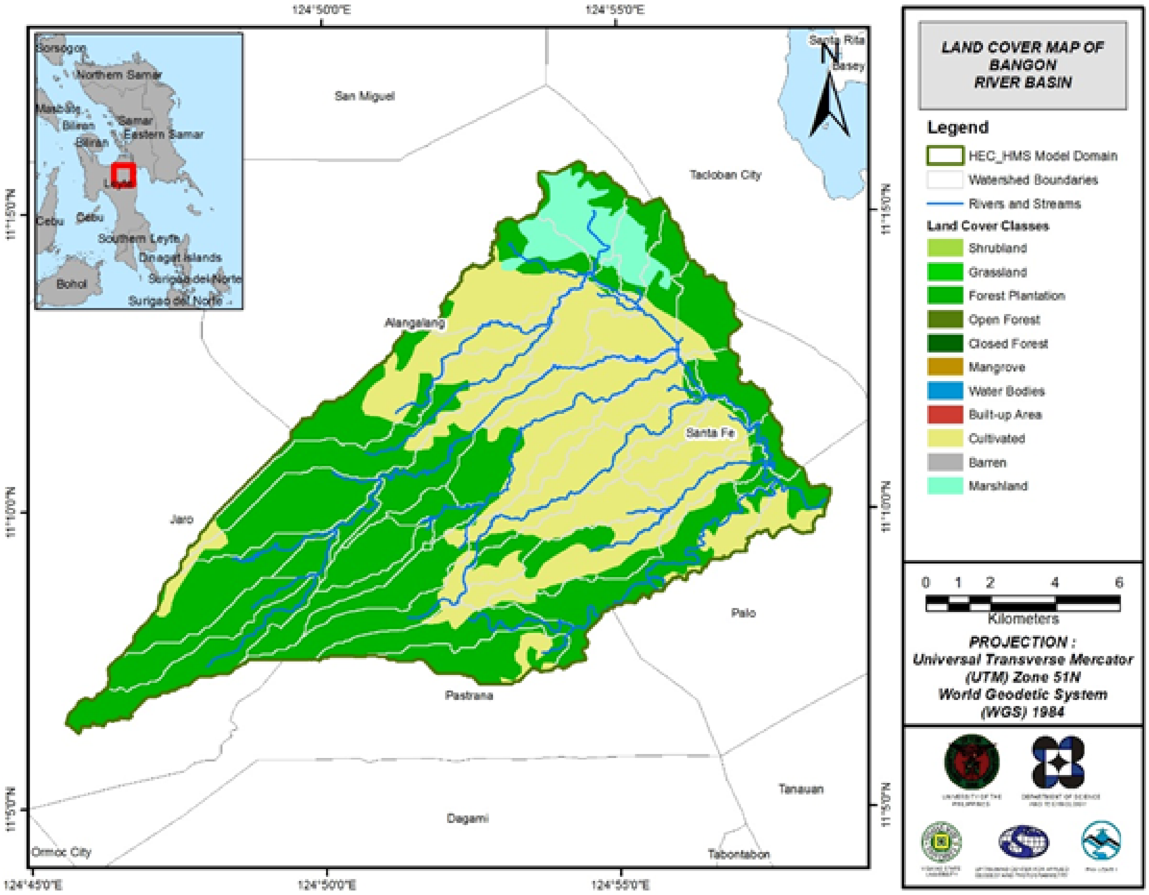



Figure 59. Land cover map of Palo River Basin (Source: NAMRIA)

Using the SAR-based DEM, the Palo basin was delineated and further subdivided into subbasins. The model consists of 41 subbasins, 20 reaches, and 20 junctions as shown in Figure 60. The main outlet is at San Jose Hanging Bridge.

For Palo, the soil classes identified were clay, sandy loam, and undifferentiated. The land cover types identified were marshland, forest plantation, and cultivated.

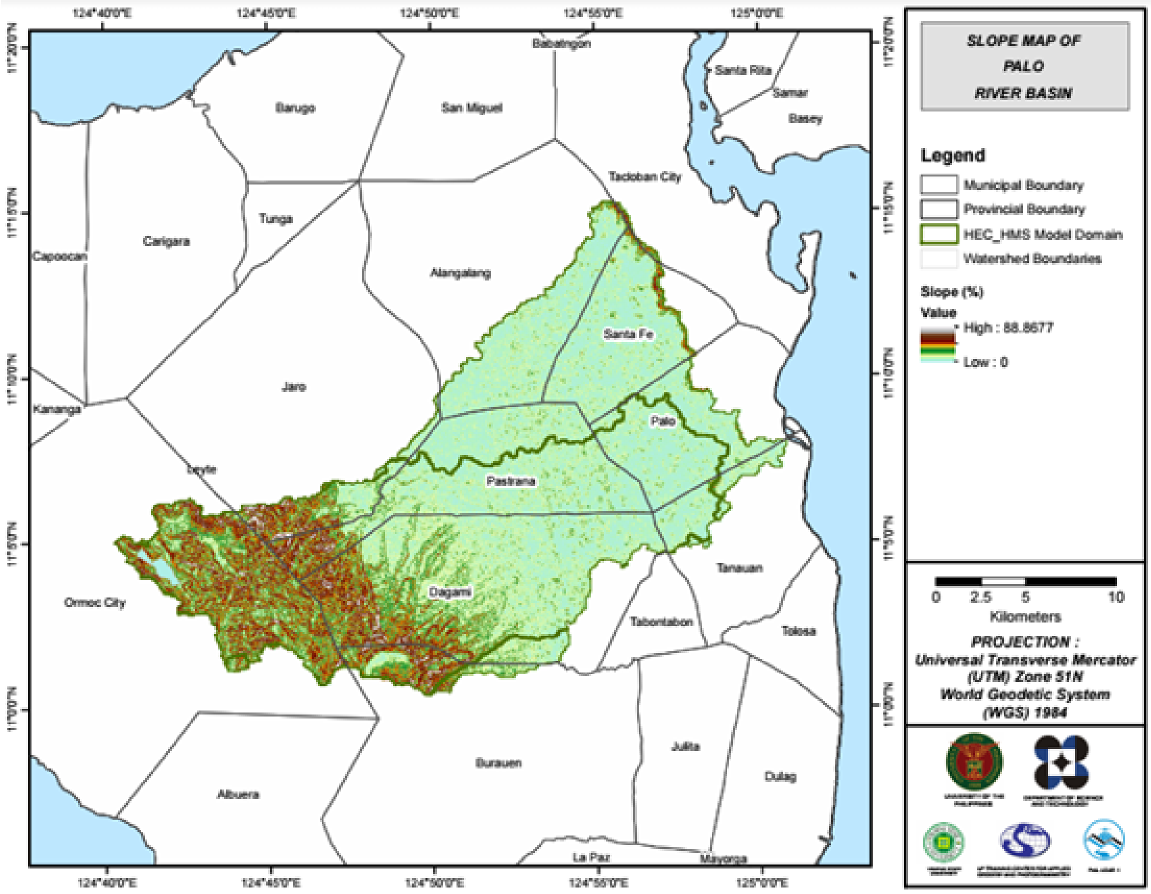



Figure 60. Slope map of the Palo River Basin

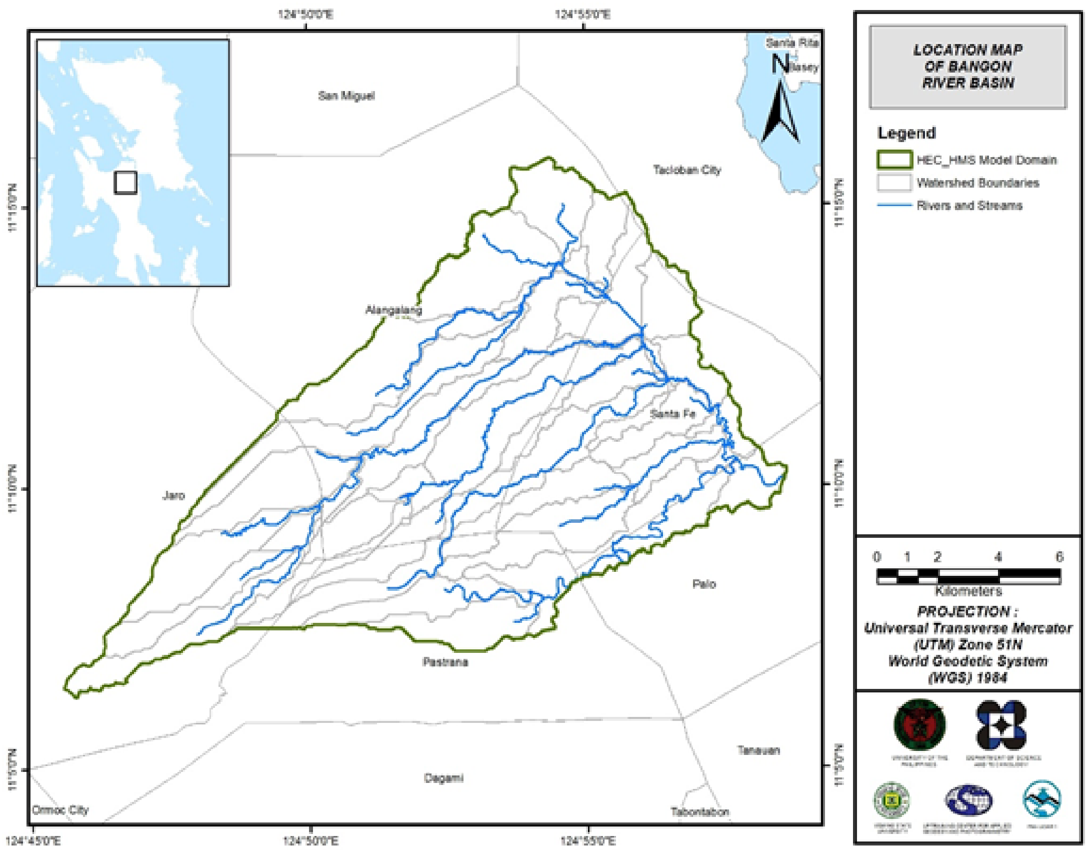



Figure 61. Stream delineation map of the Palo River Basin

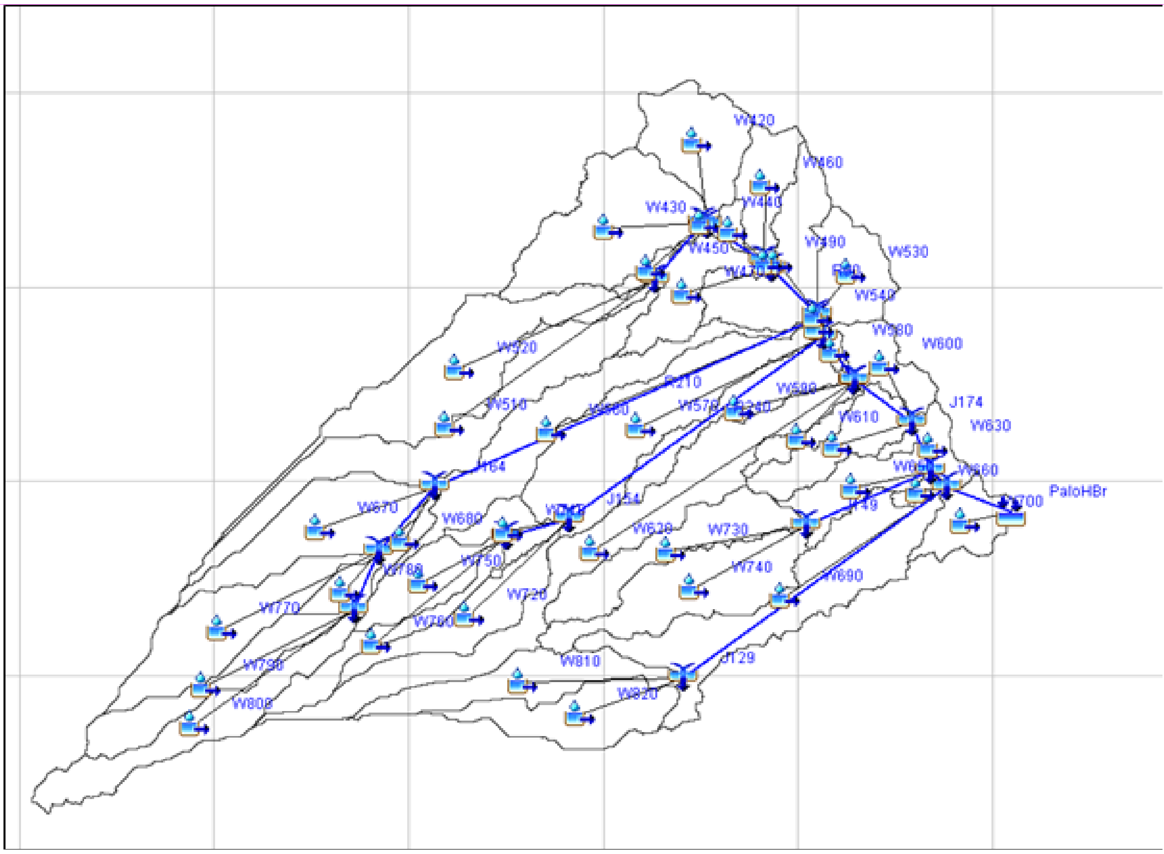



Figure 62. The Palo River Basin model generated using HEC-HMS

## 5.4 Cross-section Data

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

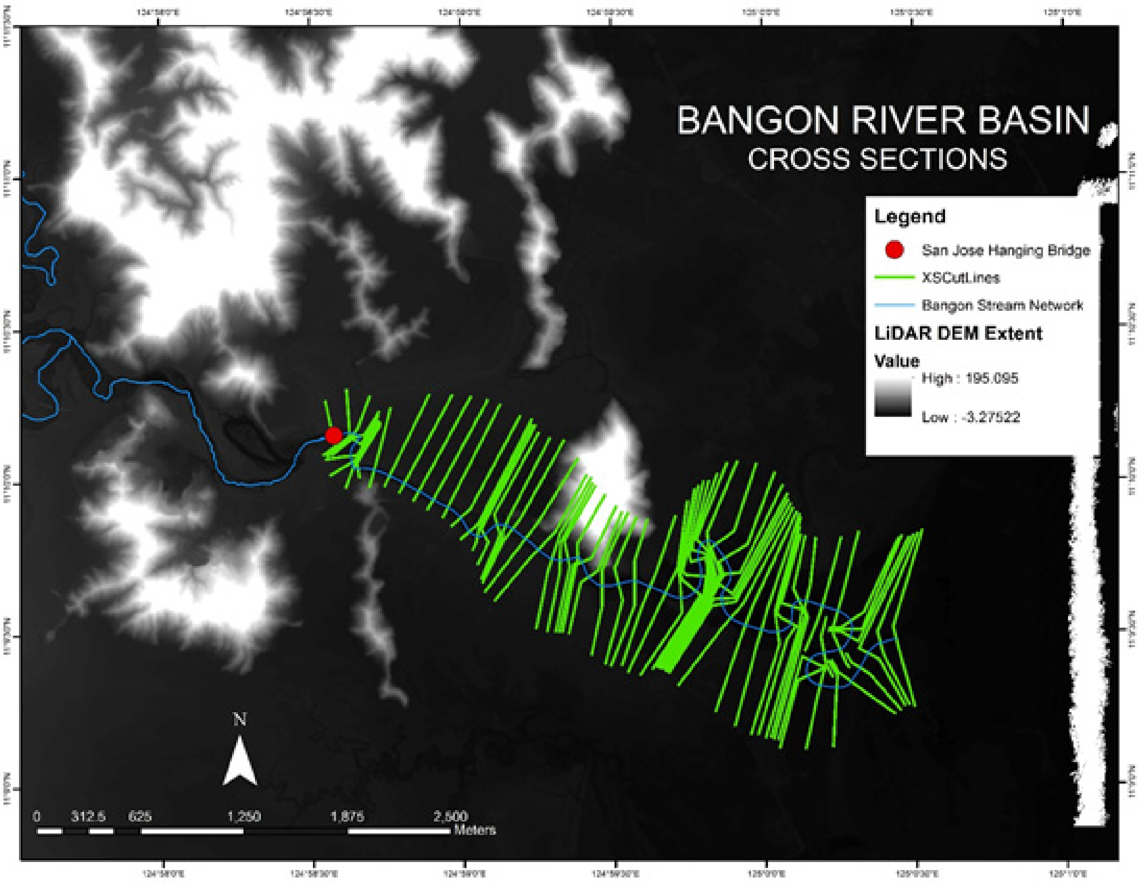



Figure 63. River cross-section of Palo River generated through ArcMap HEC GeoRAS tool.

## 5.5 Flo 2D Model

The automated modeling process allowed 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 was divided into square grid elements, 10 meter by 10 meter in size. Each element was assigned a unique grid element number which served as its identifier, then attributed with the parameters required for modeling such as x-and y-coordinate of centroid, names of adjacent grid elements, Manning coefficient of roughness, infiltration, and elevation value. The elements were 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 would generally flow from the west of the model to the east, following the main channel. As such, boundary elements in those particular regions of the model were assigned as inflow and outflow elements, respectively.

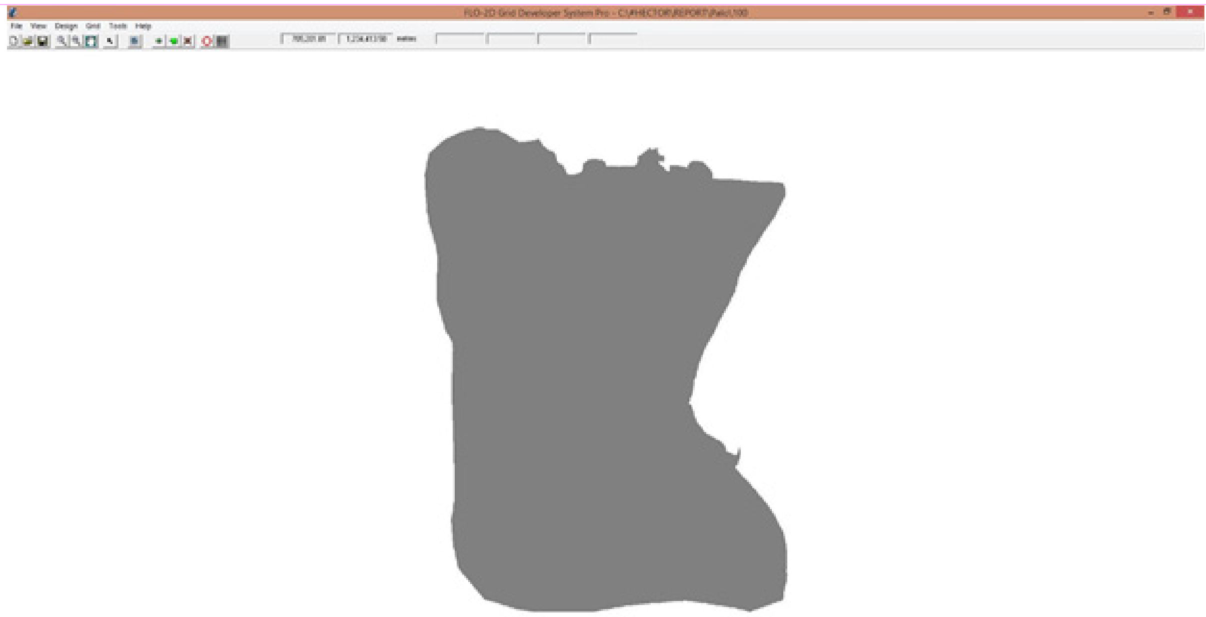


Figure 64. Screenshot of subcatchment with the computational area to be modeled in FLO-2D GDS Pro.

The simulation was then run through FLO-2D GDS Pro. This particular model had a computer run time of 43.08716 hours. After the simulation, FLO-2D Mapper Pro was 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) was set at 0.2 m while the minimum vh (Product of maximum velocity (v) times maximum depth (h)) is set at 0 m2/s. The generated hazard maps for Palo are in Figure 72, Figure 74, and Figure 76.

The creation of a flood hazard map from the model also automatically created a flow depth map depicting the maximum amount of inundation for every grid element. The legend used by default in Flo-2D Mapper was not a good representation of the range of flood inundation values, so a different legend was used for the layout. In this particular model, the inundated parts covered a maximum land area of 57,070,700.00 m2. The generated flood depth maps for Palo are in Figure 73, Figure 75, and Figure 77.

There is a total of 30,252,978.23 m3 of water entering the model. Of this amount, 15,537,038.38 m3 is due to rainfall while 14,715,939.85 m3 is inflow from other areas outside the model. Moreover, 8,438,570.00 m3 of this water is lost to infiltration and interception, while 19,552,993.99 m3 is stored by the floodplain. The rest, amounting up to 2,261413.84 m3, is outflow.

## 5.6 Results of HMS Calibration

After calibrating the Palo HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 12 shows the comparison between the two discharge data.

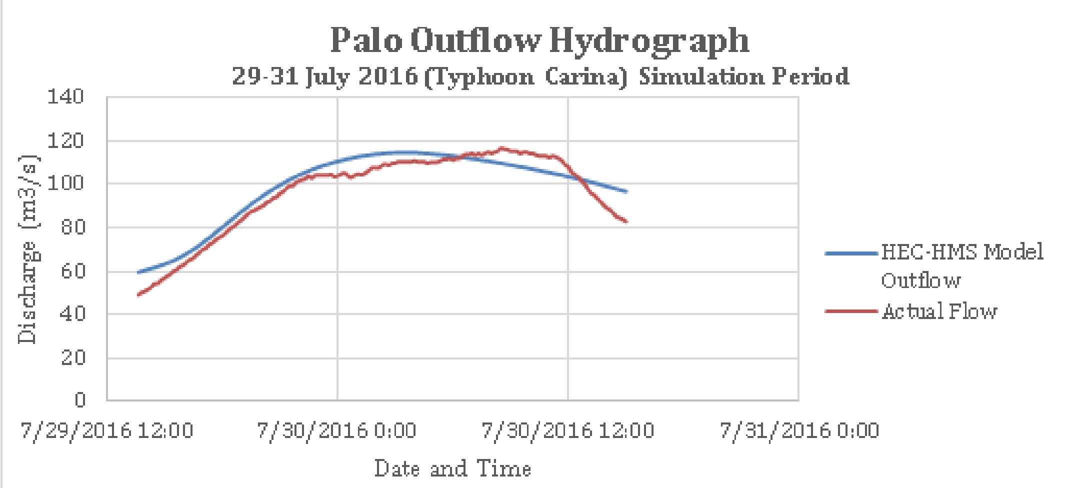



Figure 65. Outflow hydrograph of San Jose Hanging Bridge generated in HEC-HMS model compared with observed outflow.

Enumerated in Table 33 are the adjusted ranges of values of the parameters used in calibrating the model.

Table 33. Range of Calibrated Values for Palo.

| Basin/Reach Characteristic | Method | Parameter | Range of Calibrated Values |
|---|---|---|---|
| Loss | SCS Curve number | Initial Abstraction (mm) | 0.06 - 0.62 |
| | | Curve Number | 99 |
| Transform | Clark Unit Hydrograph | Time of Concentration (hr) | 1- 66 |
| | | Storage Coefficient (hr) | 0.05 - 2.17 |
| Baseflow | Recession | Recession Constant | 1 |
| | | Ratio to Peak | 0.01 |
| Routing | Muskingum-Cunge | Slope | 0.0002 - 0.02 |
| | | Manning's n | 0.04 |

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 0.06 mm to 0.62 mm means that there is minimal amount of infiltration or rainfall interception by vegetation.

Curve number is the estimate of the precipitation excess of soil cover, land use, and antecedent moisture. The magnitude of the outflow hydrograph increases as curve number increases. The value of 99 for curve number is at the highest value for Philippine watersheds depending on the soil and land cover of the area.

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 1 hours to 66 hours determines the reaction time of the model with respect to the rainfall. The peak magnitude of the hydrograph also decreases when these parameters are increased.

Recession constant is the rate at which baseflow recedes between storm events and ratio to peak is the ratio of the baseflow discharge to the peak discharge. Recession constant of 1 indicates that the basin is unlikely to quickly go back to its original discharge and will instead be higher. Ratio to peak of 0.01 indicates a steeper receding limb of the outflow hydrograph.

Manning's roughness coefficient of 0.04 corresponds to the common roughness of Palo watershed, which is determined to be cultivated with mature field crops (Brunner, 2010).

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

| | |
|---|---|
| r2 | 0.982 |
| NSE | 0.91 |
| PBIAS | -2.77 |
| RSR | 0.31 |

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It computed as 2.8 (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 0.982.

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 0.91.

A positive Percent Bias (PBIAS) indicates a model's propensity towards under-prediction. Negative values indicate bias towards over-prediction. Again, the optimal value is 0. In the model, the PBIAS is -2.77.

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 0.31.

## 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 66) shows the Palo outflow using the Tacloban RIDF in five different return periods (5-year, 10-year, 25-year, 50-year, and 100-year rainfall time series) based on the PAGASA data. The simulation results reveal significant increase in outflow magnitude as the rainfall intensity increases for a range of durations and return periods.

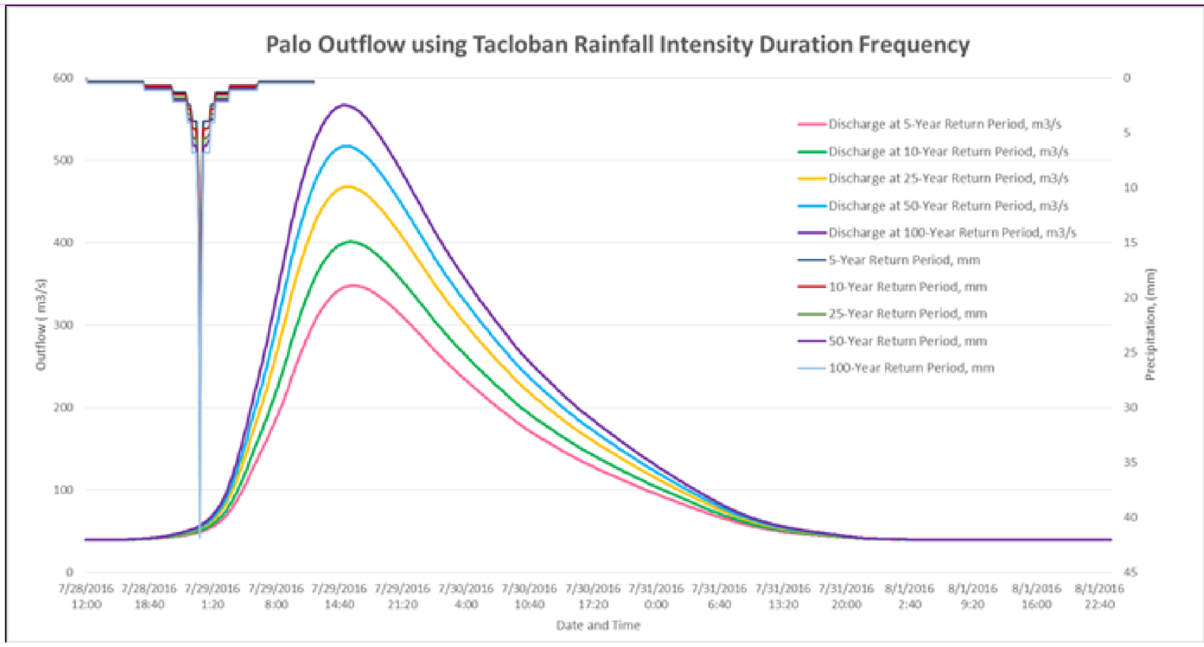



Figure 66. Outflow hydrograph at Palo Station generated using Tacloban RIDF simulated in HEC-HMS

A summary of the total precipitation, peak rainfall, peak outflow, and time to peak of Palo discharge using the Tacloban RIDF in five different return periods is shown in Table 35.

Table 35. Peak values of the Palo HEC-HMS Model outflow using the Tacloban RIDF.

| RIDF Period | Total Precipitation (mm) | Peak rainfall (mm) | Peak outflow (m3/s) | Time to Peak |
|---|---|---|---|---|
| 5-Year | 161.4 | 24.3 | 348.1 | 16 hours, 10 minutes |
| 10-Year | 188.4 | 28.5 | 401.2 | 15 hours, 50 minutes |
| 25-Year | 222.6 | 33.9 | 468.4 | 15 hours, 30 minutes |
| 50-Year | 247.9 | 37.9 | 517.6 | 15 hours, 20 minutes |

### 5.7.2 Discharge Data Using Dr. Horritts's Recommended Hydrologic Method

The river discharges entering the floodplain are shown in Figure 67 to Figure 70 and the peak values are summarized in Table 36 to Table 39.

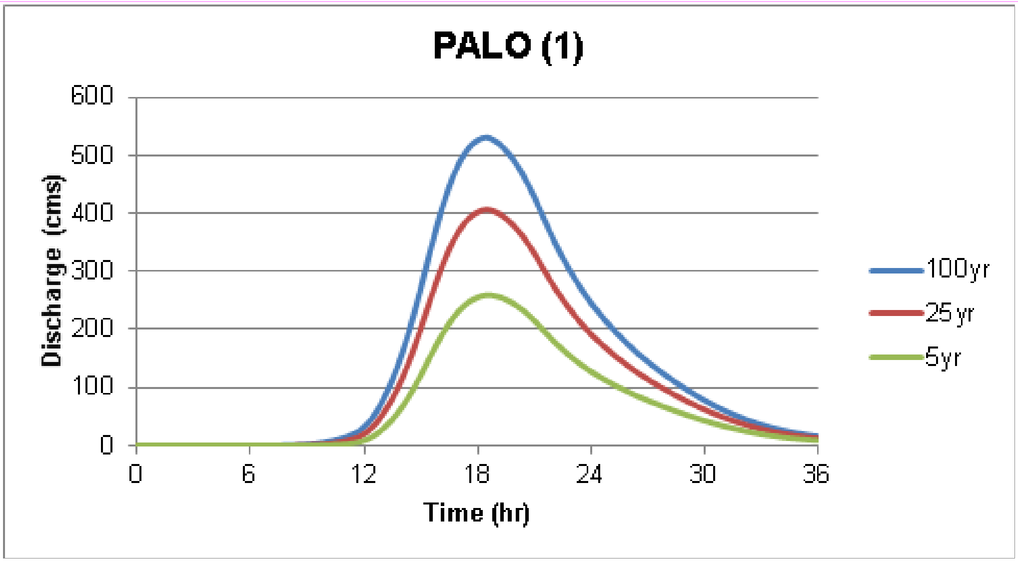



Figure 67. Palo river (1) generated discharge using 5-, 25-, and 100-year Tacloban City RIDF in HEC-HMS.

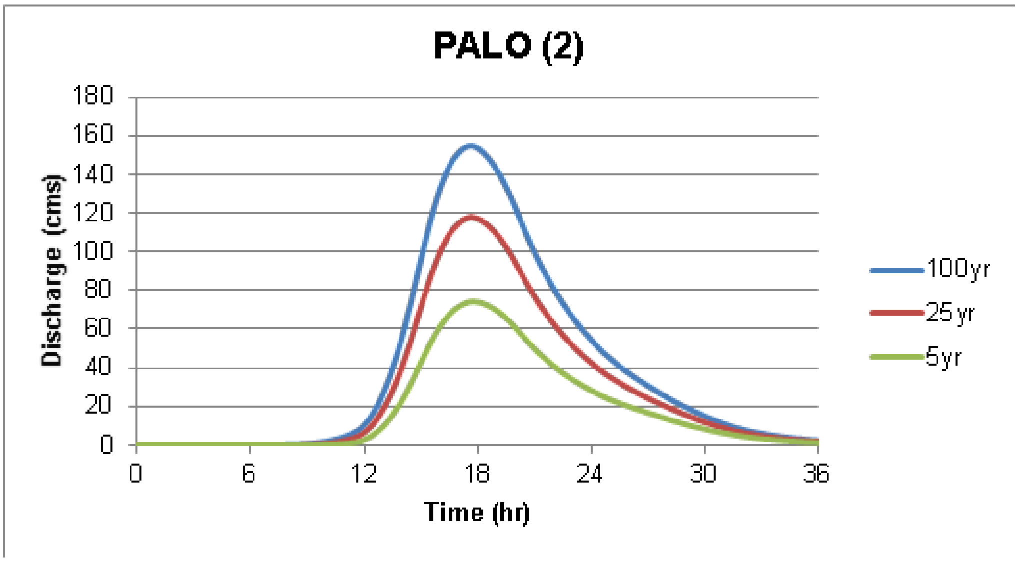



Figure 68. Palo river (2) generated discharge using 5-, 25-, and 100-year Tacloban City RIDF in HEC-HMS

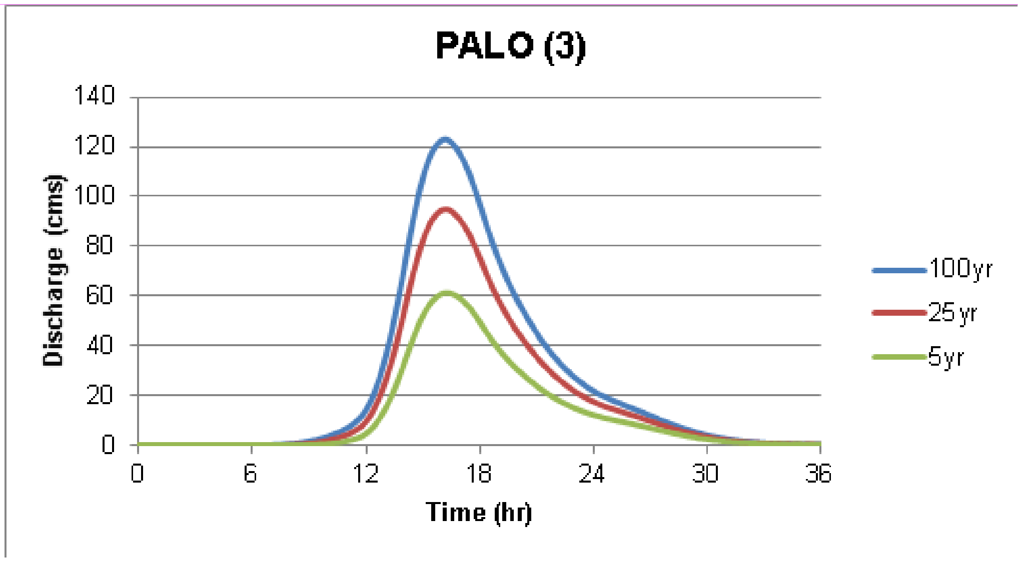



Figure 69. Palo river (3) generated discharge using 5-, 25-, and 100-year Tacloban City RIDF in HEC-HMS

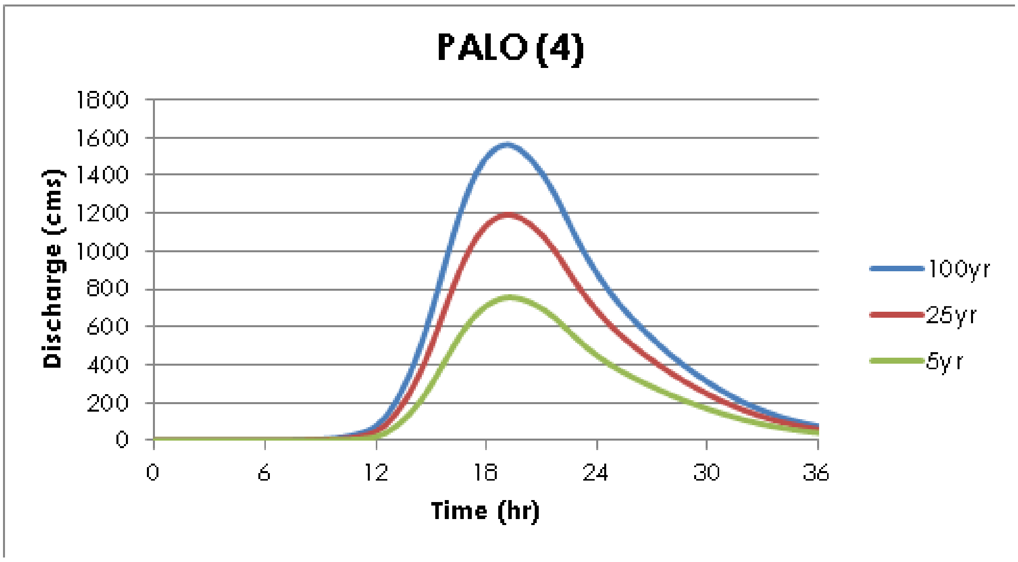



Figure 70. Palo river (4) generated discharge using 5-, 25-, and 100-year Tacloban City RIDF in HEC-HMS

Table 36. Summary of Palo River (1) discharge generated in HEC-HMS

| RIDF Period | Peak discharge (cms) | Time-to-peak |
|---|---|---|
| 100-Year | 530.6 | 18 hours, 30 minutes |
| 25-Year | 406.7 | 18 hours, 30 minutes |
| 5-Year | 259.5 | 18 hours, 30 minutes |

Table 37. Summary of Palo River (2) discharge generated in HEC-HMS

| RIDF Period | Peak discharge (cms) | Time-to-peak |
|---|---|---|
| 100-Year | 154.9 | 17 hours, 40 minutes |
| 25-Year | 118.0 | 17 hours, 40 minutes |
| 5-Year | 74.3 | 17 hours, 40 minutes |

Table 38. Summary of Palo River (3) discharge generated in HEC-HMS

| RIDF Period | Peak discharge (cms) | Time-to-peak |
|---|---|---|
| 100-Year | 123.1 | 16 hours, 10 minutes |
| 25-Year | 94.9 | 16 hours, 10 minutes |
| 5-Year | 61.3 | 16 hours, 10 minutes |

Table 39. Summary of Palo River (4) discharge generated in HEC-HMS

| RIDF Period | Peak discharge (cms) | Time-to-peak |
|---|---|---|
| 100-Year | 1182.7 | 19 hours |
| 25-Year | 904.7 | 19 hours |
| 5-Year | 575.9 | 19 hours |

The comparison of the discharge results using Dr. Horritt's recommended hydrological method against the bankful and specific discharge estimates is shown in Table 40.

Table 40. Validation of river discharge estimates.

| Discharge Point | $Q_{MED(SCS)}$, cms | $Q_{BANKFUL}$, cms | $Q_{MED(SPEC)}$, cms | VALIDATION | |
|---|---|---|---|---|---|
| | | | | Bankful Discharge | Specific Discharge |
| Palo (1) | 228.360 | 34.716 | 235.941 | Fail | Pass |
| Palo (2) | 65.384 | 8.084 | 97.480 | Fail | Pass |
| Palo (3) | 53.944 | 73.860 | 67.640 | Pass | Pass |
| Palo (4) | 665.016 | 505.928 | 116.846 | Pass | Fail |

## 5.8 River Analysis Model Simulation

The HEC-RAS flood model produced a simulated water level at every cross-section for every time step for every flood simulation created. The resulting model was 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 VSU-FMC base flow was calibrated. The sample generated map of Palo River using the calibrated HMS base flow is shown in Figure 71.

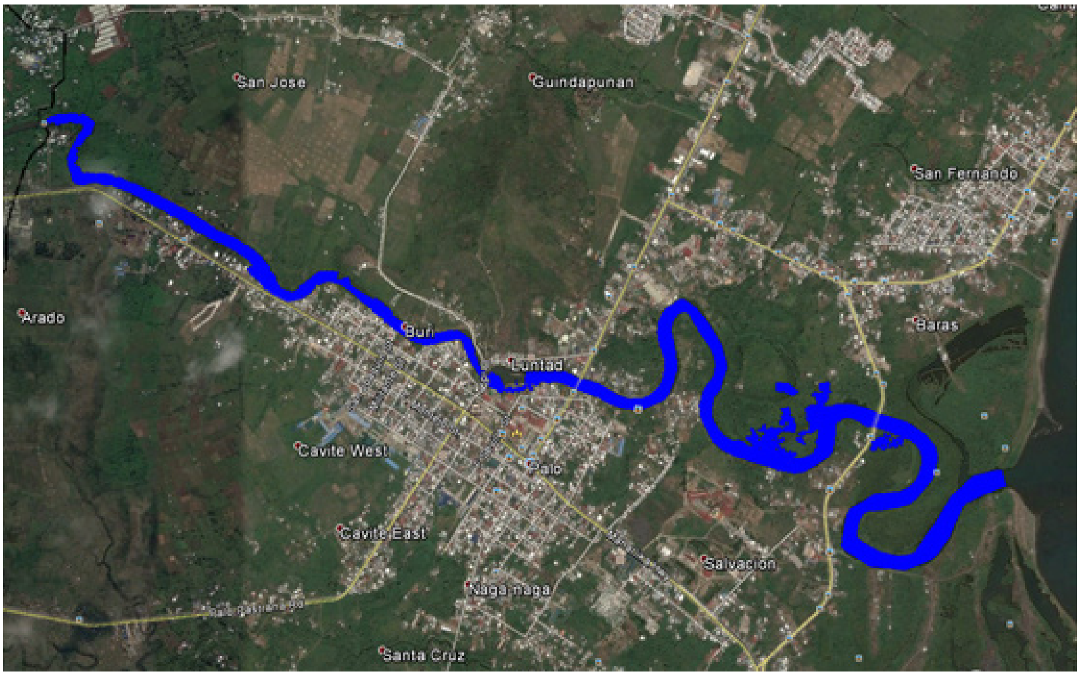



Figure 71. Sample output Palo RAS Model

## 5.9 Flood Hazard and Flow Depth

The resulting hazard and flow depth maps have a 10 m resolution. Figure 72 to Figure 77 show the 100-, 25-, and 5-year rain return scenarios of the Palo Floodplain.

The floodplain, with an area of 65.19 sq km., covers Tacloban City and three municipalities namely Palo, Santa Fe, and Tanauan. Table 41 shows the percentage of area affected by flooding per municipality.

Table 41. Municipalities affected in Palo Floodplain

| City / Municipality | Total Area | Area Flooded | % Flooded |
|---|---|---|---|
| Palo | 65.34 | 38.03 | 58% |
| Santa Fe | 57.14 | 10.33 | 18% |
| Tacloban City | 118.46 | 11.04 | 9% |
| Tanauan | 62.78 | 4.86 | 8% |

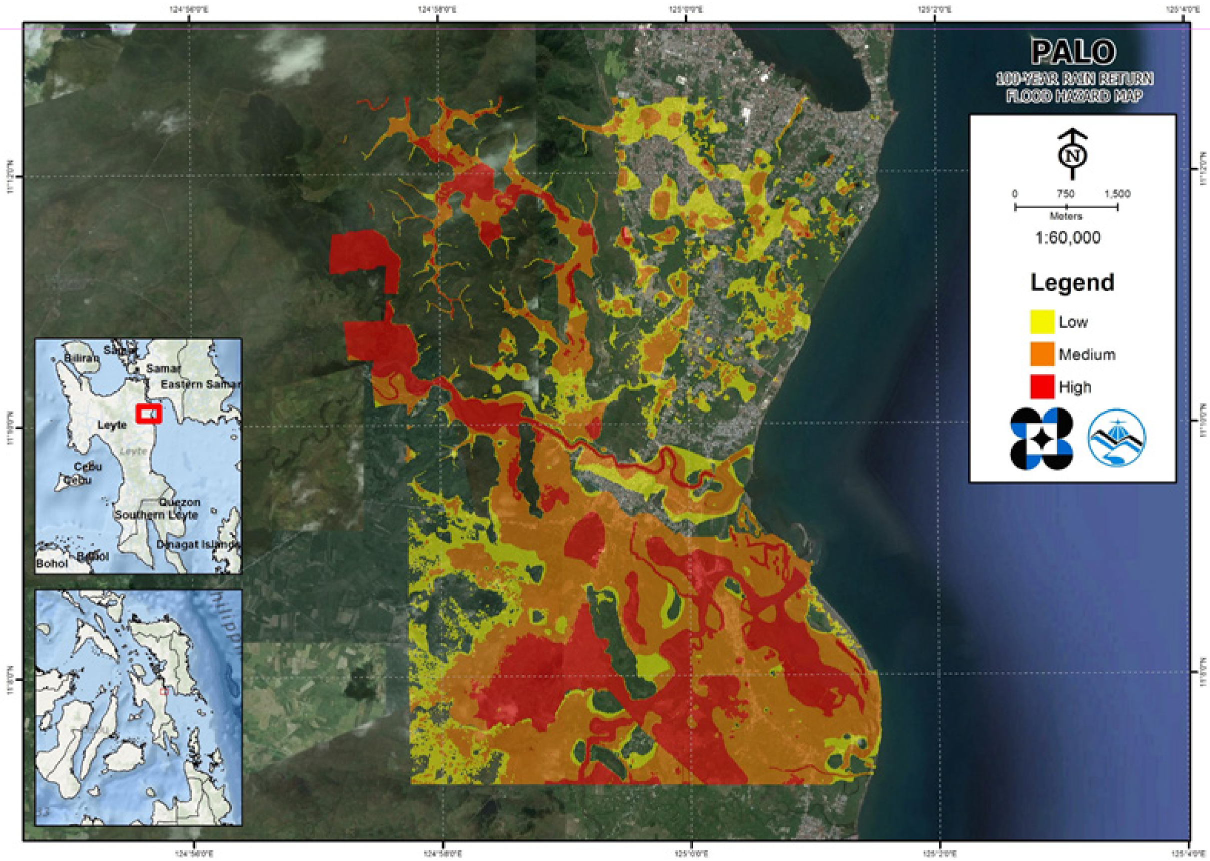



Figure 72. 100-year flood hazard map for Palo Floodplain overlaid on Google Earth imagery.

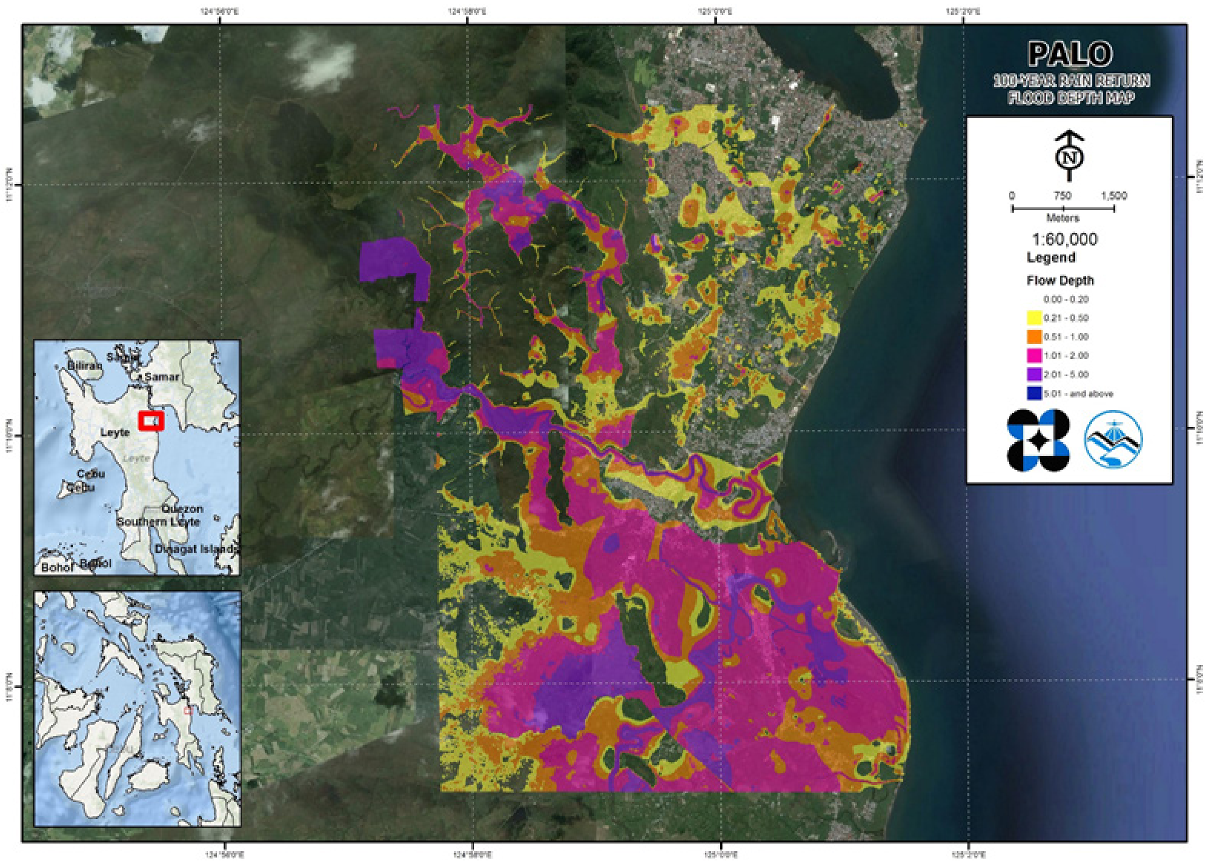



Figure 73. 100-year flow depth map for Palo Floodplain overlaid on Google Earth imagery.

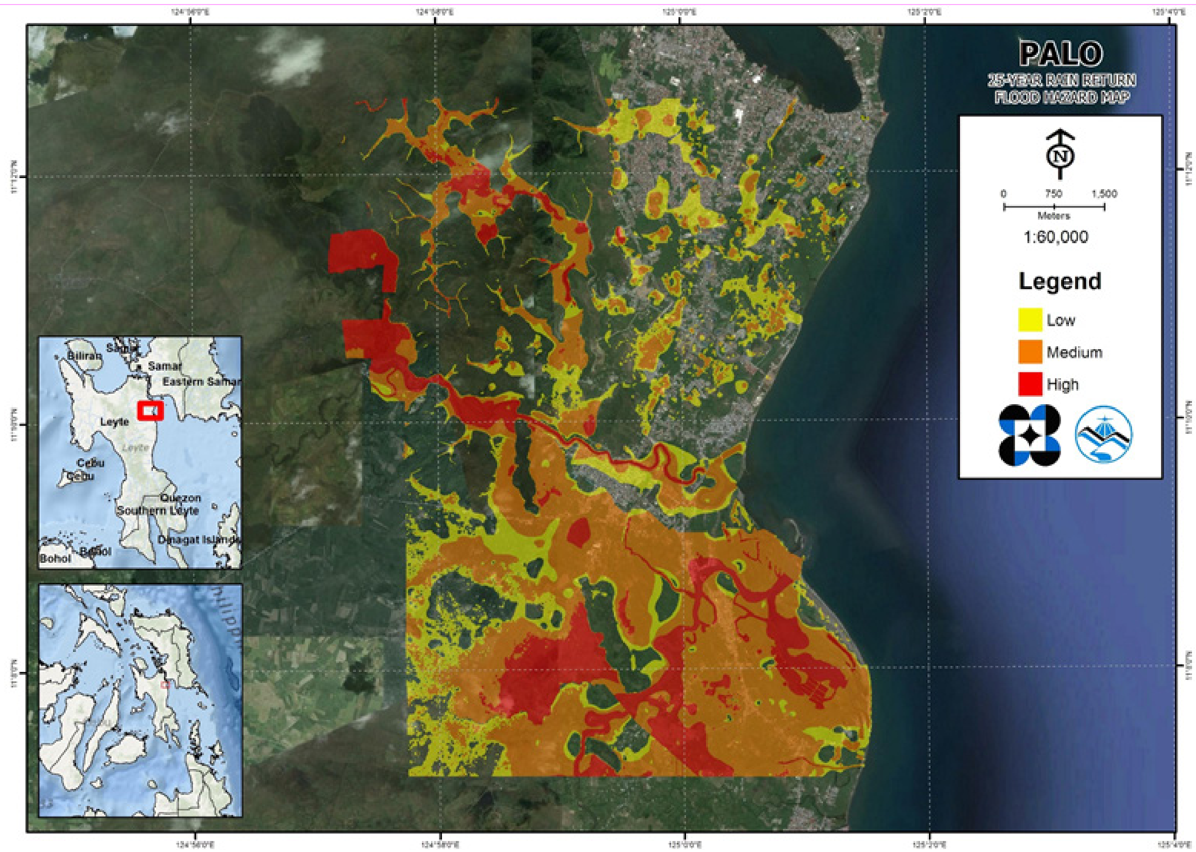



Figure 74. 25-year flood hazard map for Palo Floodplain overlaid on Google Earth imagery.

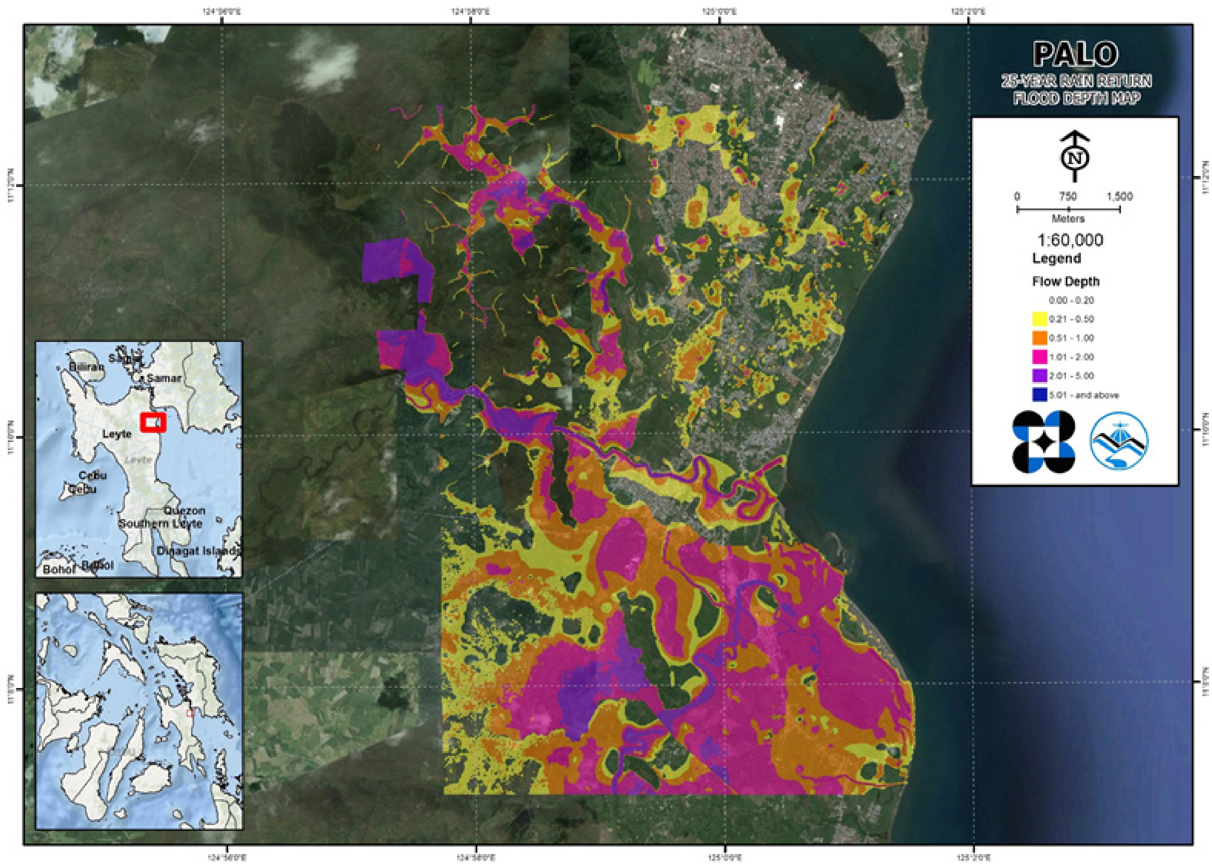



Figure 75. 25-year flow depth map for Palo Floodplain overlaid on Google Earth imagery.

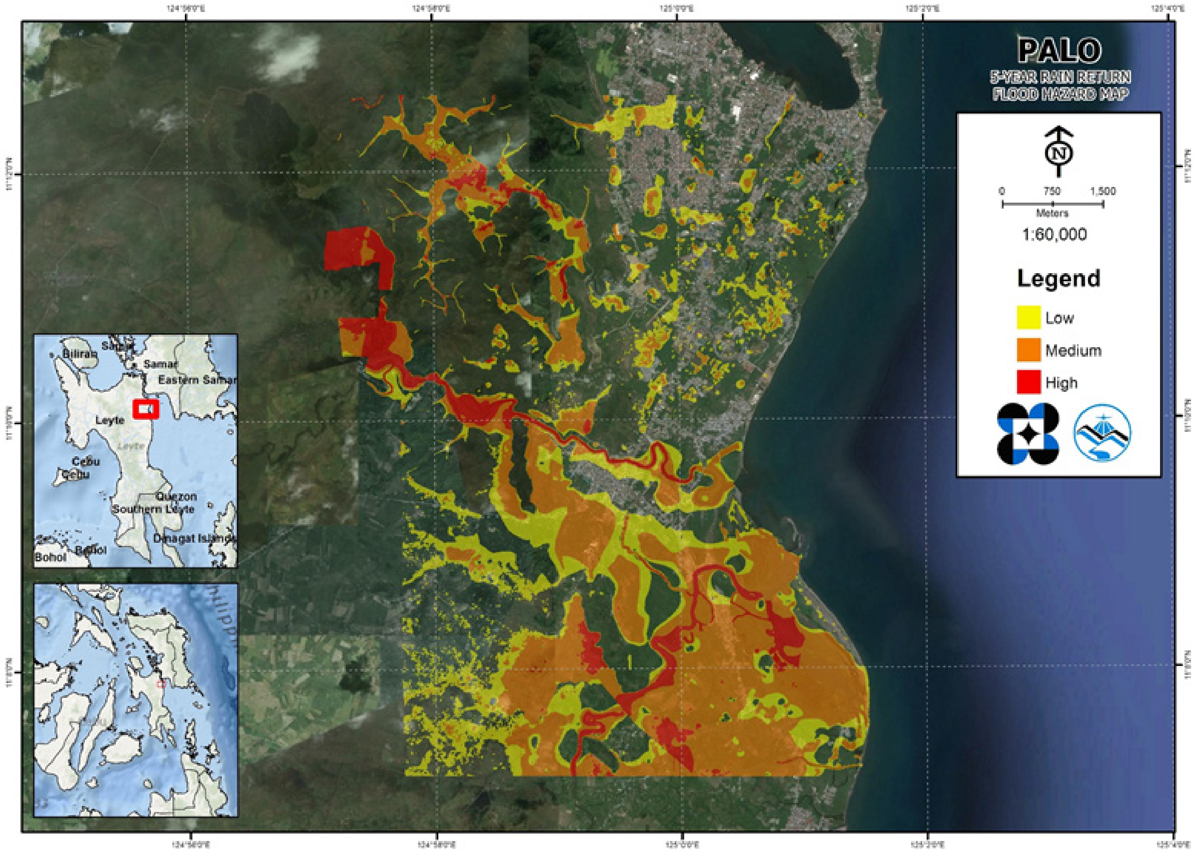



Figure 76. 5-year flood hazard map for Palo Floodplain overlaid on Google Earth imagery.

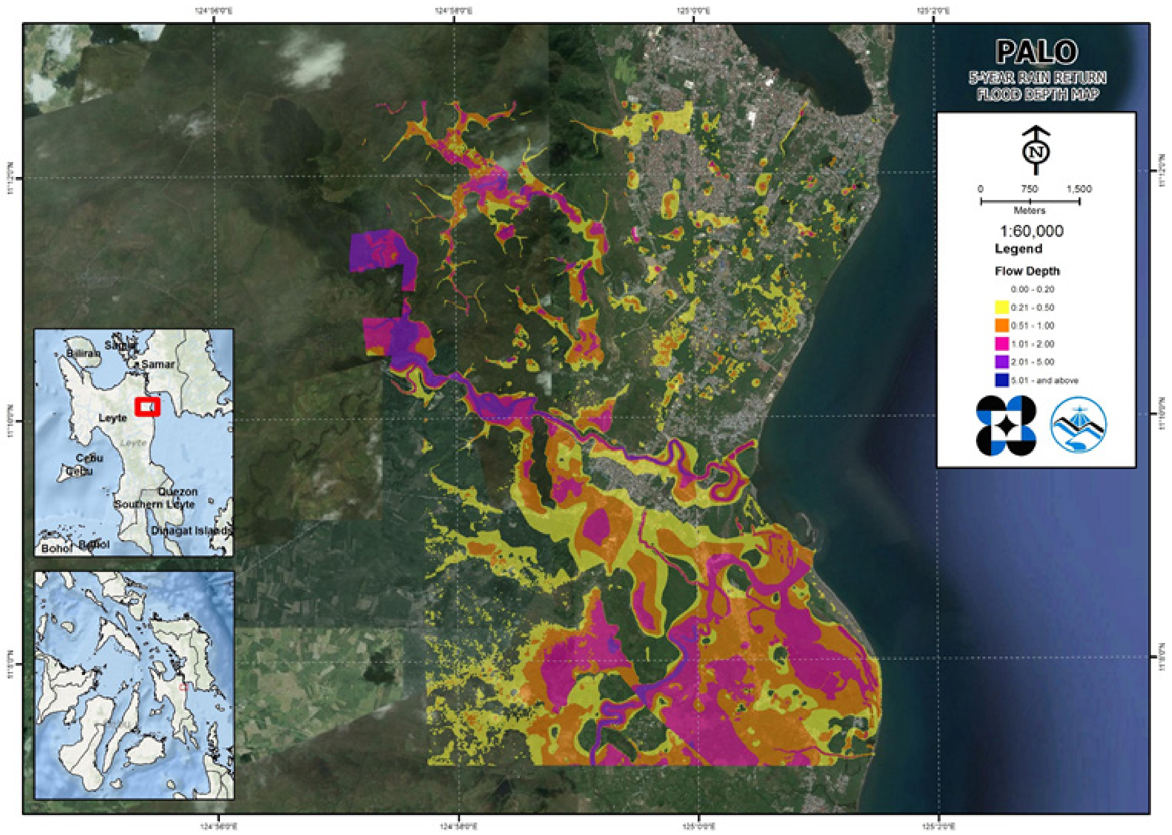



Figure 77. 5-year flow depth map for Palo Floodplain overlaid on Google Earth imagery.

## 5.10 Inventory of Areas Exposed to Flooding

Affected barangays in Palo river basin, grouped by municipality, are listed below. For the said basin, four municipalities consisting of 52 barangays are expected to experience flooding when subjected to a 5-year rainfall return period.

For the 5-year return period, 32.09% of the municipality of Palo with an area of 65.34 sq km will experience flood levels of less 0.20 meters; 10.5% of the area will experience flood levels of 0.21 to 0.50 meters; while 9.09%, 5.64% and 0.99% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively. Listed in Table 42 to Table 44 are the affected areas in square kilometers by flood depth per barangay.

Table 42. Affected areas in Palo, Leyte during a 5-year rainfall return period.

| PALO BASIN | | Affected Barangays in Palo | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Arado | Baras | Barayong | Buri | Cabarasan Guti | Campetik | Candahug | Cangumbang | Canhidoc |
| Affected Area (sq km.) | **0.03-0.20** | 1.12 | 0.44 | 1.48 | 0.11 | 0.52 | 1.79 | 0.67 | 0.85 | 1.29 |
| | **0.21-0.50** | 0.28 | 0.033 | 0.24 | 0.037 | 0.19 | 0.28 | 0.059 | 0.97 | 0.41 |
| | **0.51-1.00** | 0.39 | 0.022 | 0.37 | 0.024 | 0.41 | 0.048 | 0.012 | 0.56 | 0.065 |
| | **1.01-2.00** | 0.3 | 0.03 | 0.13 | 0.037 | 0.13 | 0.015 | 0.00099 | 0.69 | 0 |
| | **2.01-5.00** | 0.2 | 0 | 0.0078 | 0.006 | 0.13 | 0 | 0 | 0.024 | 0 |
| | **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 43. Affected areas in Palo, Leyte during a 5-year rainfall return period

| PALO BASIN | | Affected Barangays in Palo | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Capirawan | Cavite East | Cavite West | Cogon | Gacao | Guindapunan | Libertad | Luntad | Naga-Naga |
| Affected Area (sq km.) | **0.03-0.20** | 0.4 | 0.11 | 0.14 | 0.4 | 0.79 | 2.27 | 1.29 | 0.11 | 0.15 |
| | **0.21-0.50** | 0.21 | 0.018 | 0.063 | 0.38 | 0.33 | 0.33 | 0.14 | 0.016 | 0.05 |
| | **0.51-1.00** | 0.005 | 0.054 | 0.094 | 0.29 | 0.21 | 0.12 | 0.058 | 0.0066 | 0.042 |
| | **1.01-2.00** | 0 | 0.0021 | 0.043 | 0.047 | 0.057 | 0.018 | 0.07 | 0.0035 | 0 |
| | **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0.019 | 0.1 | 0.012 | 0 |
| | **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 44. Affected areas in Palo, Leyte during a 5-year rainfall return period.

| PALO BASIN | | Affected Barangays in Palo | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Pawing | Salvacion | San Antonio | San Fernando | San Isidro | San Joaquin | San Jose | San Miguel | Santa Cruz | Tacuranga |
| Affected Area (sq km.) | **0.03-0.20** | 0.61 | 0.53 | 0.17 | 0.54 | 1.63 | 2.54 | 0.49 | 0.047 | 0.051 | 0.43 |
| | **0.21-0.50** | 0.15 | 0.3 | 0.13 | 0.035 | 0.36 | 1.2 | 0.092 | 0.08 | 0.033 | 0.44 |
| | **0.51-1.00** | 0.026 | 0.24 | 0.13 | 0.0091 | 0.05 | 2.46 | 0.026 | 0.023 | 0.08 | 0.1 |
| | **1.01-2.00** | 0 | 0.15 | 0.00043 | 0 | 0.0083 | 1.9 | 0.013 | 0.01 | 0.0047 | 0.021 |
| | **2.01-5.00** | 0 | 0.016 | 0 | 0 | 0 | 0.11 | 0 | 0.025 | 0 | 0 |
| | **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

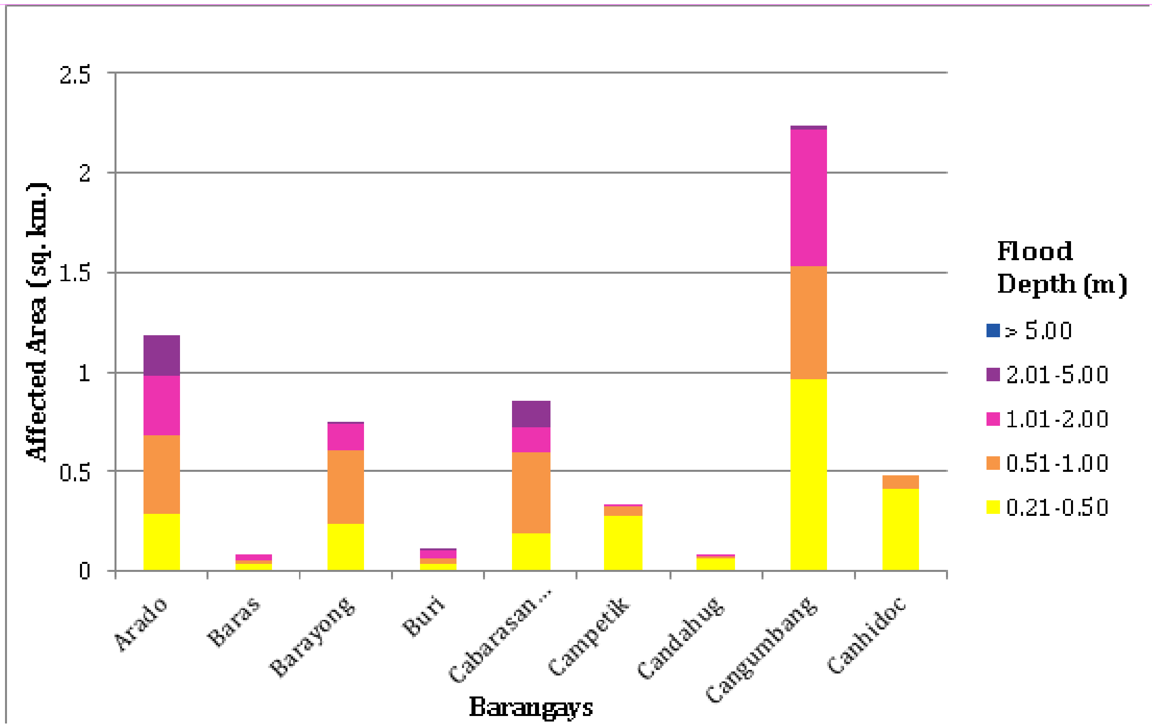



Figure 78. Affected areas in Palo, Leyte during a 5-year rainfall return period.

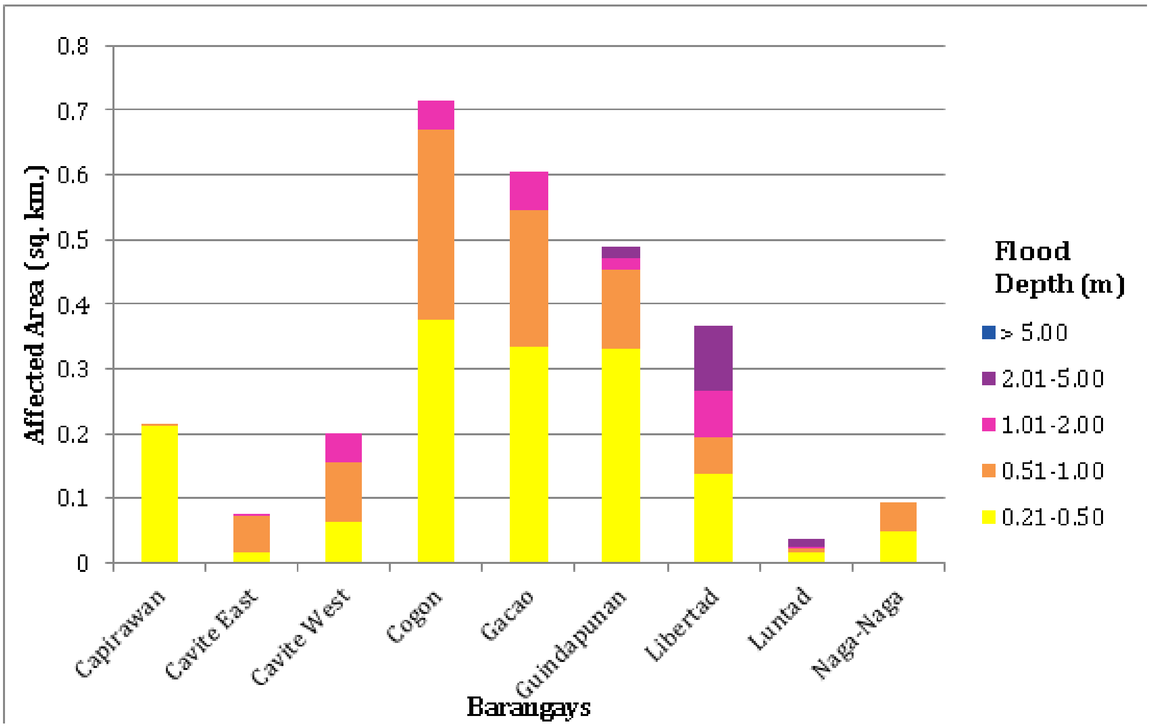



Figure 79. Affected areas in Palo, Leyte during a 5-year rainfall return period.

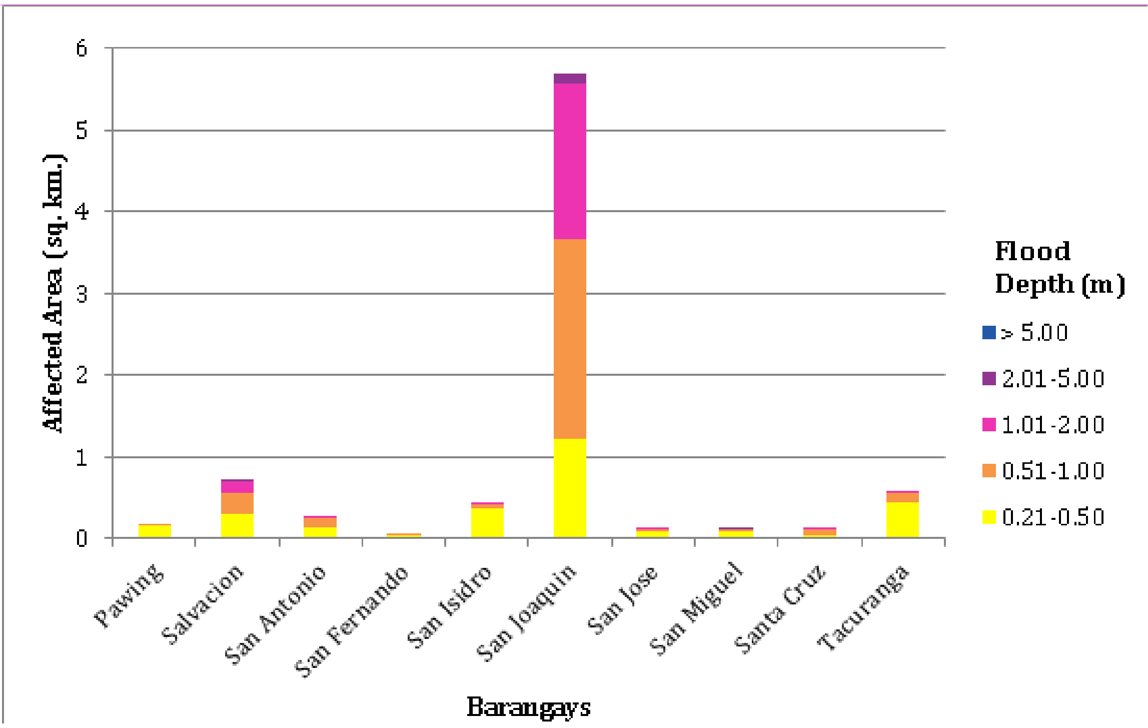



Figure 80. Affected areas in Palo, Leyte during a 5-year rainfall return period.

For the municipality of Santa Fe with an area of 57.14 sq km, 12.51% will experience flood levels of less 0.20 meters; 0.95% of the area will experience flood levels of 0.21 to 0.50 meters; while 1.46%, 1.83%, and 1.33% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively.

Table 45. Affected areas in Santa Fe, Leyte during a 5-year rainfall return period.

| PALO BASIN | | Affected Barangays in Santa Fe | | |
|---|---|---|---|---|
| | | **Badiangay** | **Milagrosa** | San Miguelay |
| **Affected Area (sq km.)** | **0.03-0.20** | 5.97 | 0.026 | 1.15 |
| | **0.21-0.50** | 0.44 | 0.035 | 0.068 |
| | **0.51-1.00** | 0.6 | 0.057 | 0.18 |
| | **1.01-2.00** | 0.76 | 0.22 | 0.068 |
| | **2.01-5.00** | 0.55 | 0.21 | 0.0017 |
| | **> 5.00** | 0 | 0 | 0 |

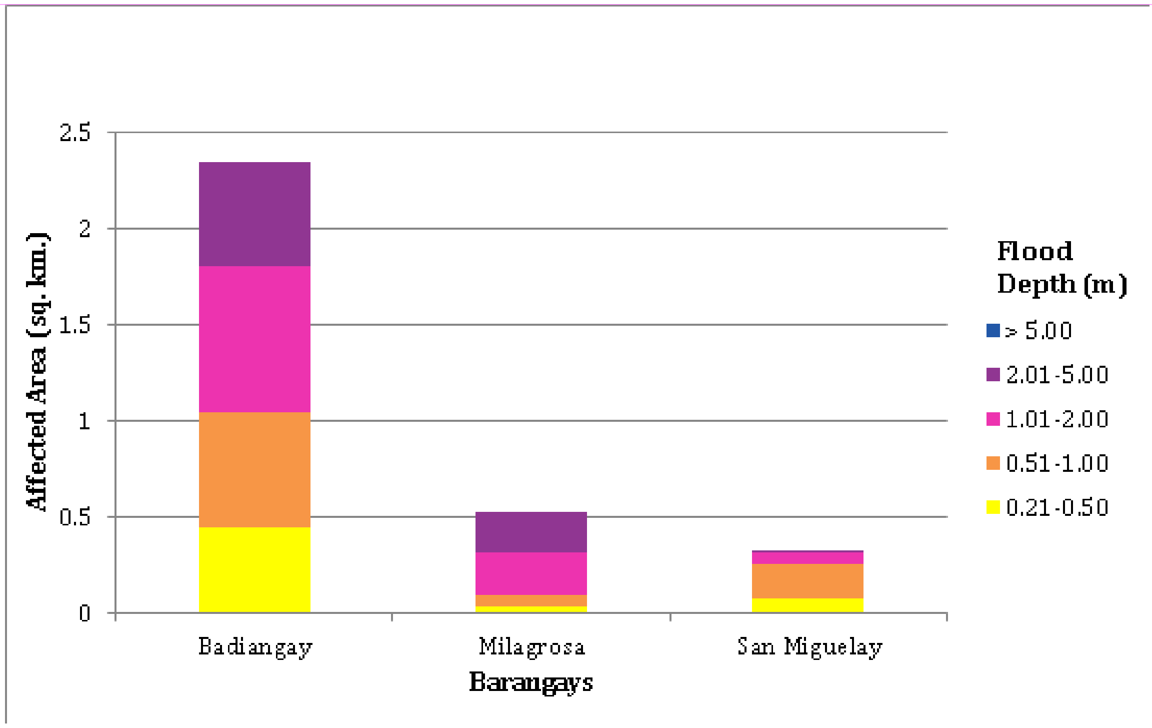



Figure 81. Affected areas in Santa Fe, Leyte during a 5-year rainfall return period.

For the city of Tacloban with an area of 118.46 sq km, 7.94% will experience flood levels of less 0.20 meters; 1.05% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.28%, 0.04%, and 0.0004% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more that 2 meters, respectively. Listed in Table 46 and Table 47 are the affected areas in square kilometers by flood depth per barangay.

Table 46. Affected areas in Tacloban City, Leyte during a 5-year rainfall return period.

| PALO BASIN | | Affected Barangays in Tacloban City | | | | | |
|---|---|---|---|---|---|---|---|
| | | Brgy 78 | Brgy 79 | Brgy 80 | Brgy 81 | Brgy 82 | Brgy 87 |
| Affected Area (sq km.) | **0.03-0.20** | 0.4 | 0.39 | 0.55 | 0.27 | 0.37 | 0.2 |
| | **0.21-0.50** | 0.0035 | 0.024 | 0.042 | 0.012 | 0.12 | 0.0015 |
| | **0.51-1.00** | 0 | 0.0058 | 0.02 | 0.0036 | 0.021 | 0 |
| | **1.01-2.00** | 0 | 0.0000071 | 0.0097 | 0.00037 | 0.0031 | 0 |
| | **2.01-5.00** | 0 | 0 | 0 | 0 | 0 | 0 |
| | **> 5.00** | 0 | 0 | 0 | 0 | 0 | 0 |

Table 47. Affected areas in Tacloban City, Leyte during a 5-year rainfall return period.

| PALO BASIN | | Affected Barangays in Tacloban City | | | | |
|---|---|---|---|---|---|---|
| | | Brgy 88 | Brgy 89 | Brgy 90 | Brgy 95 | Brgy 96 |
| Affected Area (sq km.) | **0.03-0.20** | 0.55 | 2.24 | 1.25 | 1.97 | 1.21 |
| | **0.21-0.50** | 0.017 | 0.3 | 0.16 | 0.26 | 0.31 |
| | **0.51-1.00** | 0.0055 | 0.074 | 0.044 | 0.1 | 0.062 |
| | **1.01-2.00** | 0.003 | 0.012 | 0.005 | 0.013 | 0.0057 |
| | **2.01-5.00** | 0 | 0 | 0 | 0.0005 | 0 |
| | **> 5.00** | 0 | 0 | 0 | 0 | 0 |

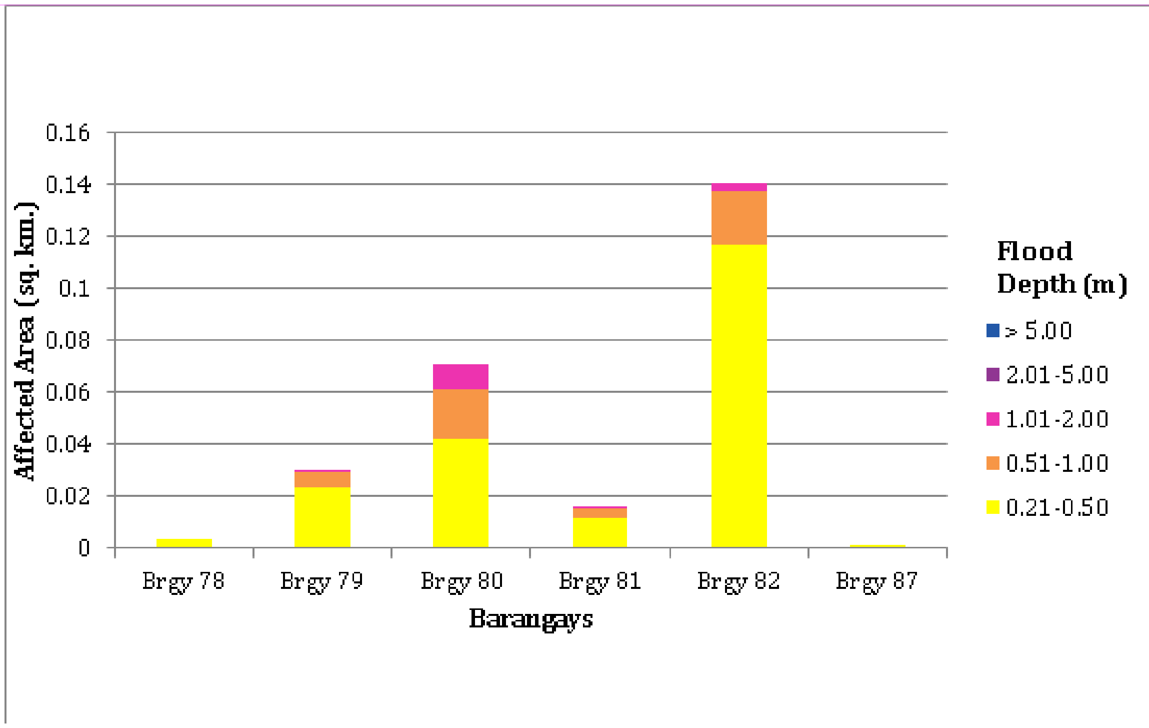



Figure 82. Affected areas in Tacloban City, Leyte during a 5-year rainfall return period.

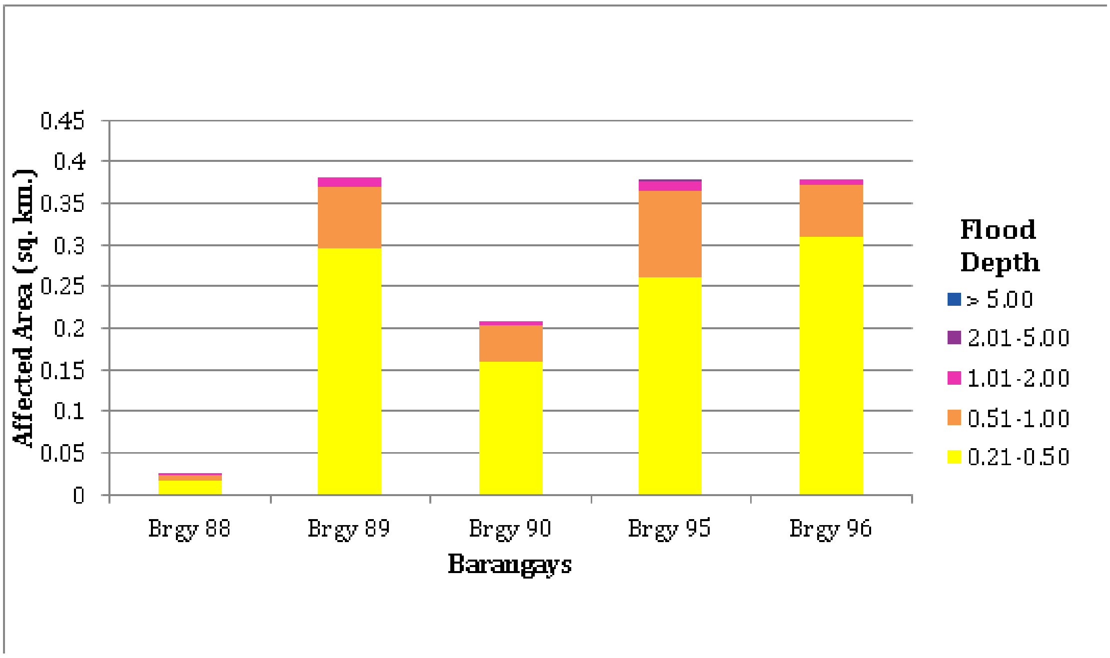



Figure 83. Affected areas in Tacloban City, Leyte during a 5-year rainfall return period.

For the municipality of Tanauan with an area of 62.78 sq km, 1.02% will experience flood levels of less 0.20 meters; 1.23% of the area will experience flood levels of 0.21 to 0.50 meters; while 3.21%, 2.28%, and 0.02% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively. Listed in Table 48 and Table 49 are the affected areas in square kilometers by flood depth per barangay.

Table 48. Affected areas in Tanauan, Leyte during a 5-year rainfall return period

| PALO BASIN | | Affected Barangays in Tanauan | | | | |
|---|---|---|---|---|---|---|
| | | Atipolo | Balud | Baras | Calogcog | Camire |
| Affected Area (sq km.) | 0.03-0.20 | 0.0004 | 0.17 | 0 | 0.25 | 0.01 |
| | 0.21-0.50 | 0.0039 | 0.084 | 0.013 | 0.28 | 0.064 |
| | 0.51-1.00 | 0.3 | 0.19 | 0.16 | 0.12 | 0.38 |
| | 1.01-2.00 | 0.06 | 0.21 | 0.45 | 0.0044 | 0.25 |
| | 2.01-5.00 | 0 | 0.01 | 0 | 0 | 0 |
| | > 5.00 | 0 | 0 | 0 | 0 | 0 |

Table 49. Affected areas in Tanauan, Leyte during a 5-year rainfall return period.

| PALO BASIN | | Affected Barangays in Tanauan | | | | |
|---|---|---|---|---|---|---|
| | | Magay | Mohon | San Roque | Santa Cruz | Solano |
| Affected Area (sq km.) | 0.03-0.20 | 0.072 | 0.018 | 0.033 | 0.082 | 0.0011 |
| | 0.21-0.50 | 0.06 | 0.18 | 0.0035 | 0.068 | 0.016 |
| | 0.51-1.00 | 0.055 | 0.22 | 0.0034 | 0.56 | 0.028 |
| | 1.01-2.00 | 0.015 | 0.041 | 0 | 0.4 | 0.0073 |
| | 2.01-5.00 | 0 | 0 | 0 | 0 | 0 |
| | > 5.00 | 0 | 0 | 0 | 0 | 0 |

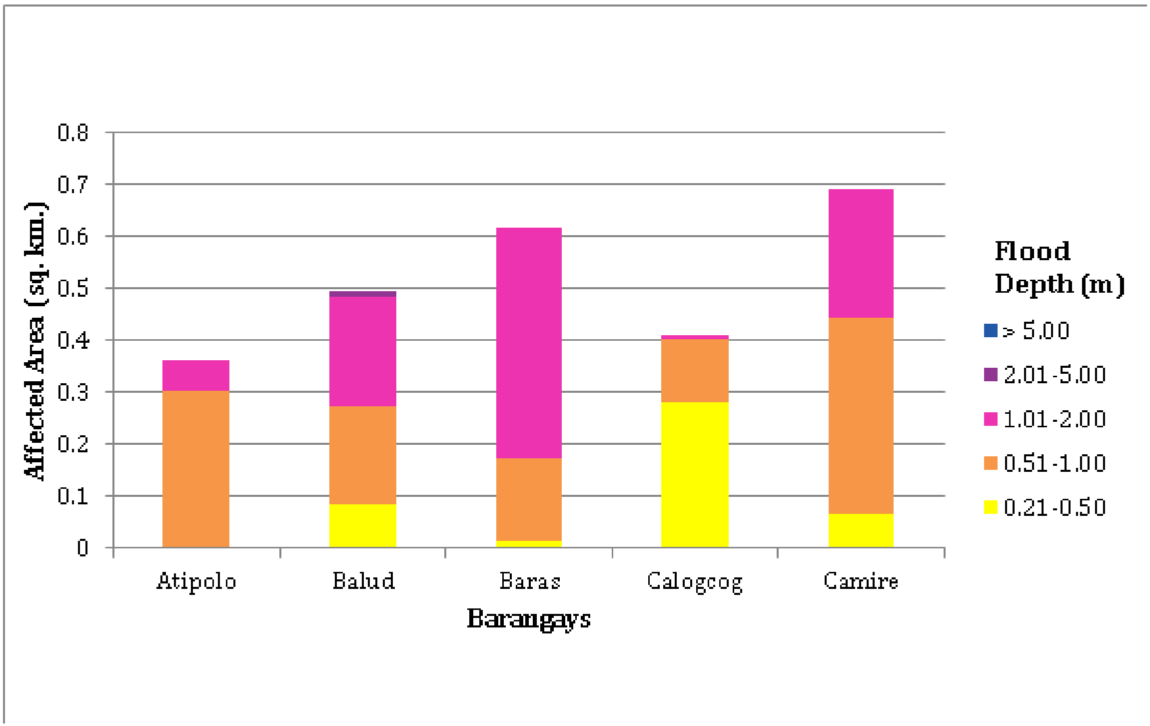



Figure 84. Affected areas in Tanauan, Leyte during a 5-year rainfall return period.

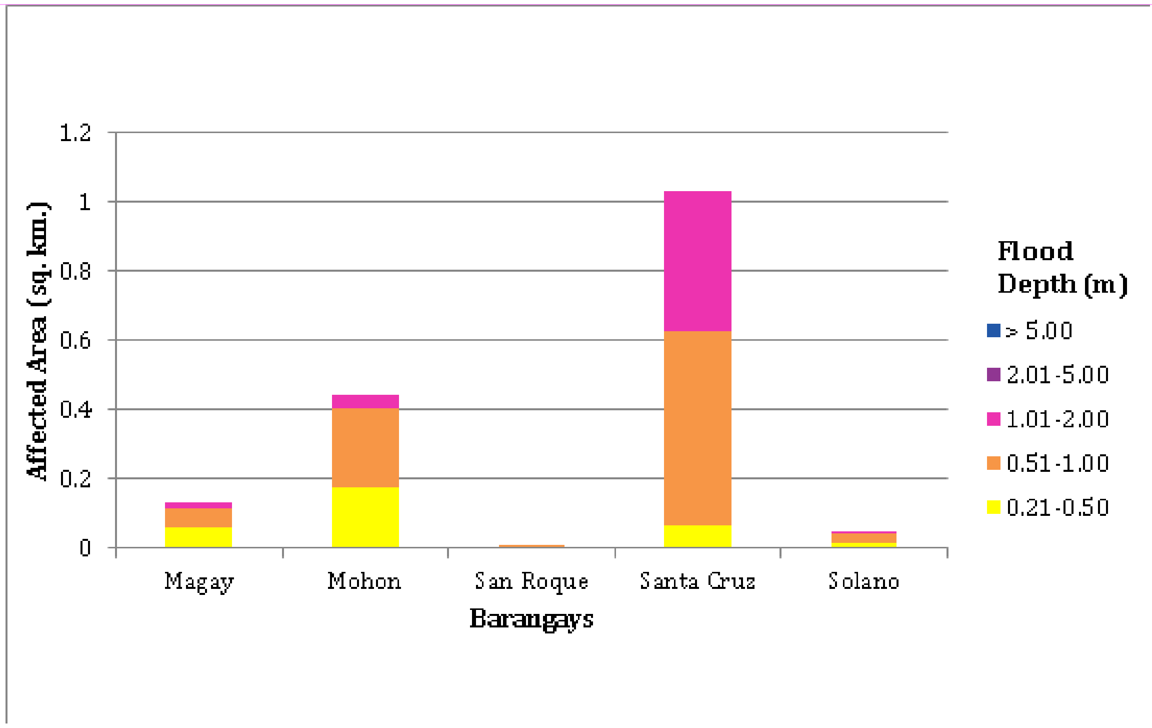



Figure 85. Affected areas in Tanauan, Leyte during a 5-year rainfall return period.

For the 25-year return period, 23.75% of the municipality of Palo with an area of 65.34 sq km will experience flood levels of less 0.20 meters; 9.81% of the area will experience flood levels of 0.21 to 0.50 meters; while 10.93%, 10.844% and 3.03% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively. Listed in Table 50 to Table 52 are the affected areas in square kilometers by flood depth per barangay.

Table 50. Affected areas in Palo, Leyte during a 25-year rainfall return period.

| PALO BASIN | | Affected Barangays in Palo | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Arado | Baras | Barayong | Buri | Cabarasan Guti | Campetik | Candahug | Cangumbang | Canhidoc |
| Affected Area (sq km.) | 0.03-0.20 | 0.97 | 0.42 | 1.35 | 0.11 | 0.38 | 1.61 | 0.63 | 0.42 | 0.37 |
| | 0.21-0.50 | 0.23 | 0.044 | 0.2 | 0.029 | 0.099 | 0.35 | 0.091 | 0.69 | 0.53 |
| | 0.51-1.00 | 0.41 | 0.024 | 0.34 | 0.031 | 0.3 | 0.15 | 0.02 | 0.5 | 0.47 |
| | 1.01-2.00 | 0.43 | 0.034 | 0.3 | 0.035 | 0.41 | 0.012 | 0.0022 | 0.76 | 0.38 |
| | 2.01-5.00 | 0.26 | 0 | 0.035 | 0.013 | 0.18 | 0.0098 | 0 | 0.74 | 0.00026 |
| | > 5.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 51. Affected areas in Palo, Leyte during a 25-year rainfall return period.

| PALO BASIN | | Affected Barangays in Palo | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Capirawan | Cavite East | Cavite West | Cogon | Gacao | Guinda-punan | Libertad | Luntad | Naga-Naga |
| Affected Area (sq km.) | 0.03-0.20 | 0.21 | 0.083 | 0.11 | 0.29 | 0.33 | 2.09 | 1.18 | 0.1 | 0.12 |
| | 0.21-0.50 | 0.29 | 0.029 | 0.058 | 0.097 | 0.39 | 0.4 | 0.11 | 0.013 | 0.041 |
| | 0.51-1.00 | 0.12 | 0.06 | 0.1 | 0.28 | 0.51 | 0.23 | 0.15 | 0.012 | 0.064 |
| | 1.01-2.00 | 0.0072 | 0.0083 | 0.071 | 0.45 | 0.16 | 0.032 | 0.08 | 0.0037 | 0.014 |
| | 2.01-5.00 | 0 | 0 | 0 | 0 | 0 | 0.019 | 0.14 | 0.012 | 0 |
| | > 5.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 52. Affected areas in Palo, Leyte during a 25-year rainfall return period

| PALO BASIN | | Affected Barangays in Palo | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Pawing | Salvacion | San Anto-nio | San Fernando | San Isidro | San Joaquin | San Jose | San Miguel | Santa Cruz | Tacuranga |
| Affected Area (sq km.) | 0.03-0.20 | 0.53 | 0.42 | 0.074 | 0.51 | 1.29 | 1.39 | 0.29 | 0.039 | 0.027 | 0.18 |
| | 0.21-0.50 | 0.21 | 0.24 | 0.07 | 0.065 | 0.55 | 0.87 | 0.25 | 0.07 | 0.027 | 0.35 |
| | 0.51-1.00 | 0.056 | 0.39 | 0.19 | 0.015 | 0.18 | 2 | 0.059 | 0.04 | 0.05 | 0.39 |
| | 1.01-2.00 | 0.0001 | 0.18 | 0.1 | 0 | 0.024 | 3.42 | 0.022 | 0.011 | 0.067 | 0.066 |
| | 2.01-5.00 | 0 | 0.022 | 0 | 0 | 0 | 0.52 | 0 | 0.026 | 0 | 0 |
| | > 5.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

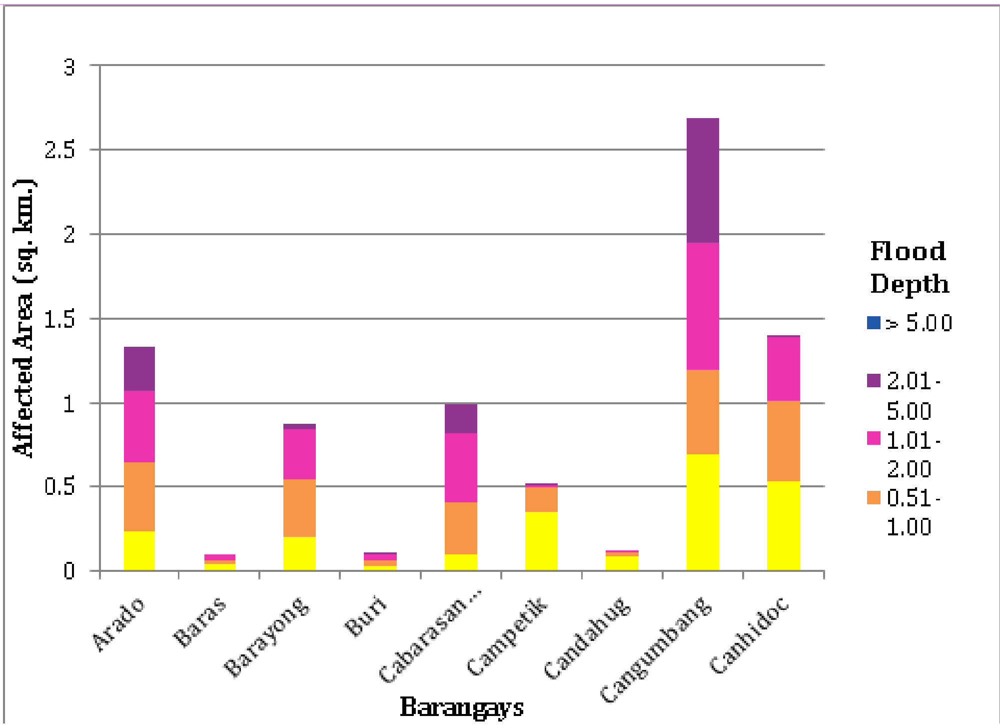



Figure 86. Affected areas in Palo, Leyte during a 25-year rainfall return period.

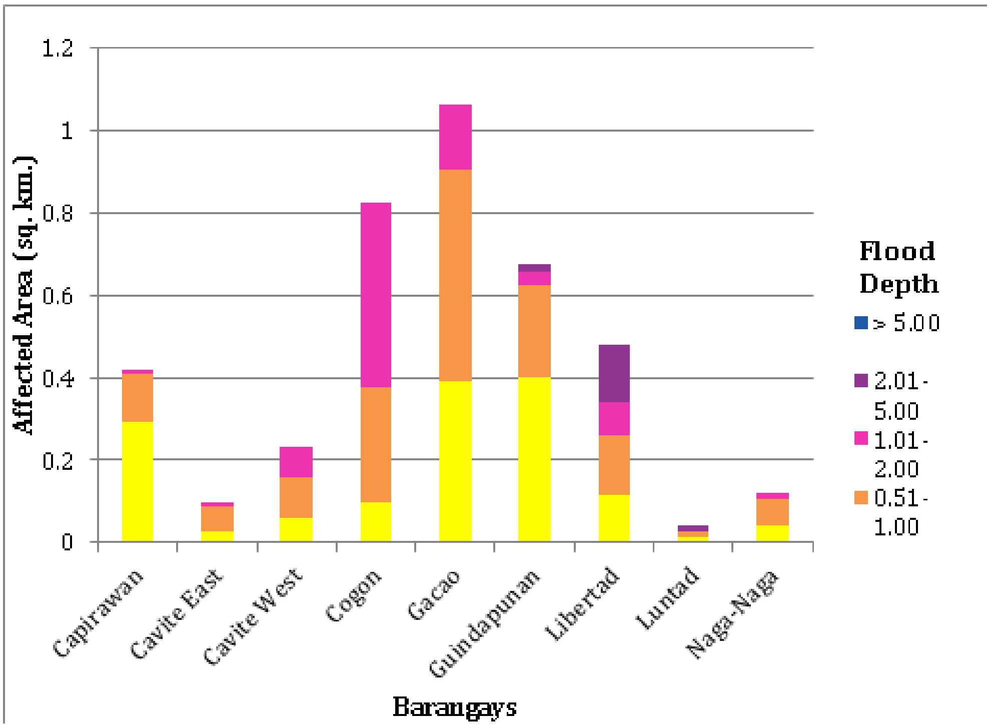



Figure 87. Affected areas in Palo, Leyte during a 25-year rainfall return period.

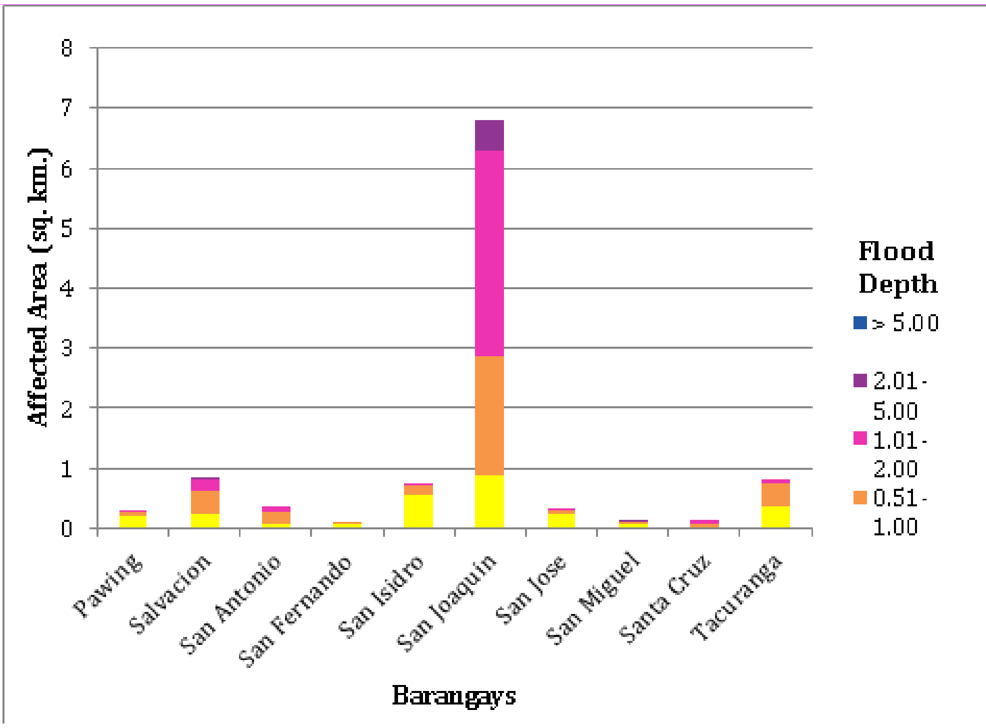



Figure 88. Affected areas in Palo, Leyte during a 25-year rainfall return period.

For the municipality of Santa Fe with an area of 57.14 sq km, 12.08% will experience flood levels of less 0.20 meters; 0.61% of the area will experience flood levels of 0.21 to 0.50 meters; while 1.29%, 2.06%, and 2.04% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively.

Table 53. Affected areas in Santa Fe, Leyte during a 25-year rainfall return period.

| **PALO BASIN** | | **Affected Barangays in Santa Fe** | | |
|---|---|---|---|---|
| | | **Badiangay** | **Milagrosa** | San Miguelay |
| **Affected Area (sq km.)** | **0.03-0.20** | 5.77 | 0.0011 | 1.13 |
| | **0.21-0.50** | 0.29 | 0.0094 | 0.047 |
| | **0.51-1.00** | 0.54 | 0.052 | 0.15 |
| | **1.01-2.00** | 0.87 | 0.18 | 0.13 |
| | **2.01-5.00** | 0.85 | 0.31 | 0.011 |
| | **> 5.00** | 0.0001 | 0.0001 | 0 |

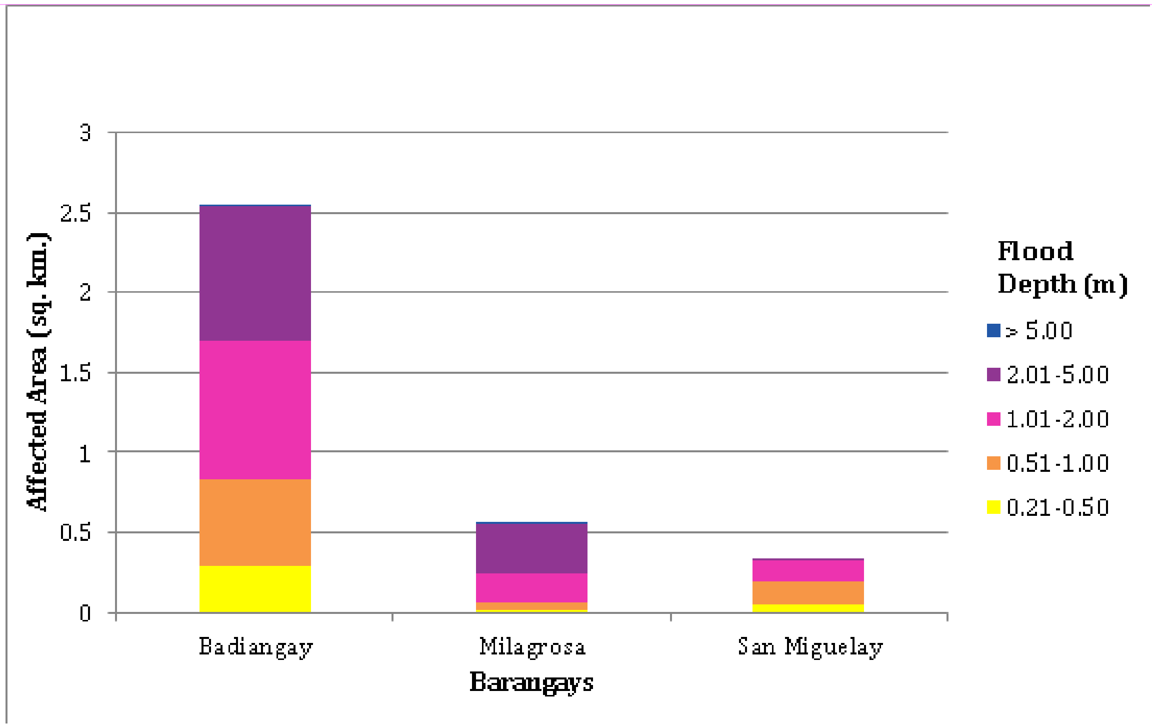



Figure 89. Affected areas in Santa Fe, Leyte during a 25-year rainfall return period.

For the city of Tacloban with an area of 118.46 sq km, 7.15% will experience flood levels of less 0.20 meters; 1.58% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.52%, 0.072%, and 0.0044% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively. Listed in Table 54 and Table 55 are the affected areas in square kilometers by flood depth per barangay.

Table 54. Affected areas in Tacloban City, Leyte during a 25-year rainfall return period.

| PALO BASIN | | Affected Barangays in Tacloban City | | | | | |
|---|---|---|---|---|---|---|---|
| | | Brgy 78 | Brgy 79 | Brgy 80 | Brgy 81 | Brgy 82 | Brgy 87 |
| Affected Area (sq km.) | 0.03-0.20 | 0.4 | 0.37 | 0.43 | 0.24 | 0.31 | 0.2 |
| | 0.21-0.50 | 0.0046 | 0.037 | 0.16 | 0.035 | 0.15 | 0.0018 |
| | 0.51-1.00 | 0.00077 | 0.014 | 0.028 | 0.0072 | 0.048 | 0 |
| | 1.01-2.00 | 0 | 0.00013 | 0.012 | 0.00093 | 0.0041 | 0 |
| | 2.01-5.00 | 0 | 0 | 0 | 0 | 0 | 0 |
| | > 5.00 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 55. Affected areas in Tacloban City, Leyte during a 25-year rainfall return period.

| PALO BASIN | | Affected Barangays in Tacloban City | | | | |
|---|---|---|---|---|---|---|
| | | Brgy 88 | Brgy 89 | Brgy 90 | Brgy 95 | Brgy 96 |
| Affected Area (sq km.) | 0.03-0.20 | 0.55 | 2.05 | 1.07 | 1.88 | 0.99 |
| | 0.21-0.50 | 0.014 | 0.41 | 0.3 | 0.3 | 0.46 |
| | 0.51-1.00 | 0.013 | 0.15 | 0.083 | 0.14 | 0.13 |
| | 1.01-2.00 | 0.0031 | 0.022 | 0.012 | 0.021 | 0.011 |
| | 2.01-5.00 | 0 | 0 | 0 | 0.0052 | 0 |
| | > 5.00 | 0 | 0 | 0 | 0 | 0 |

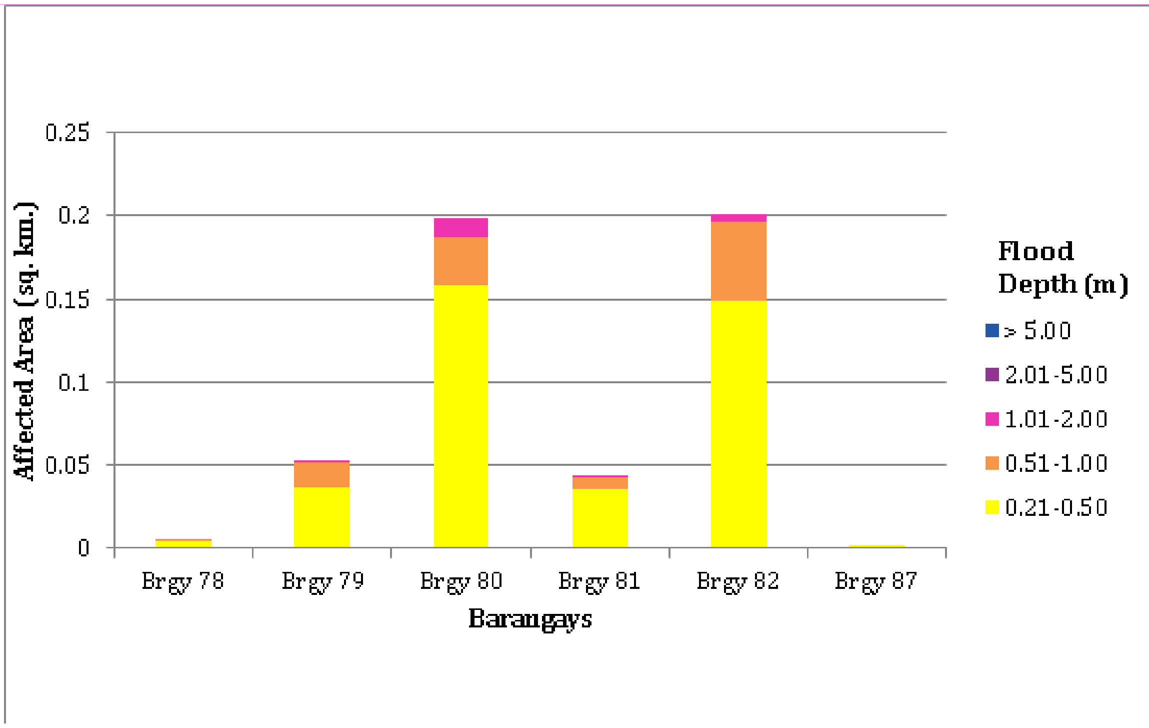



Figure 90. Affected areas in Tacloban City, Leyte during a 25-year rainfall return period.

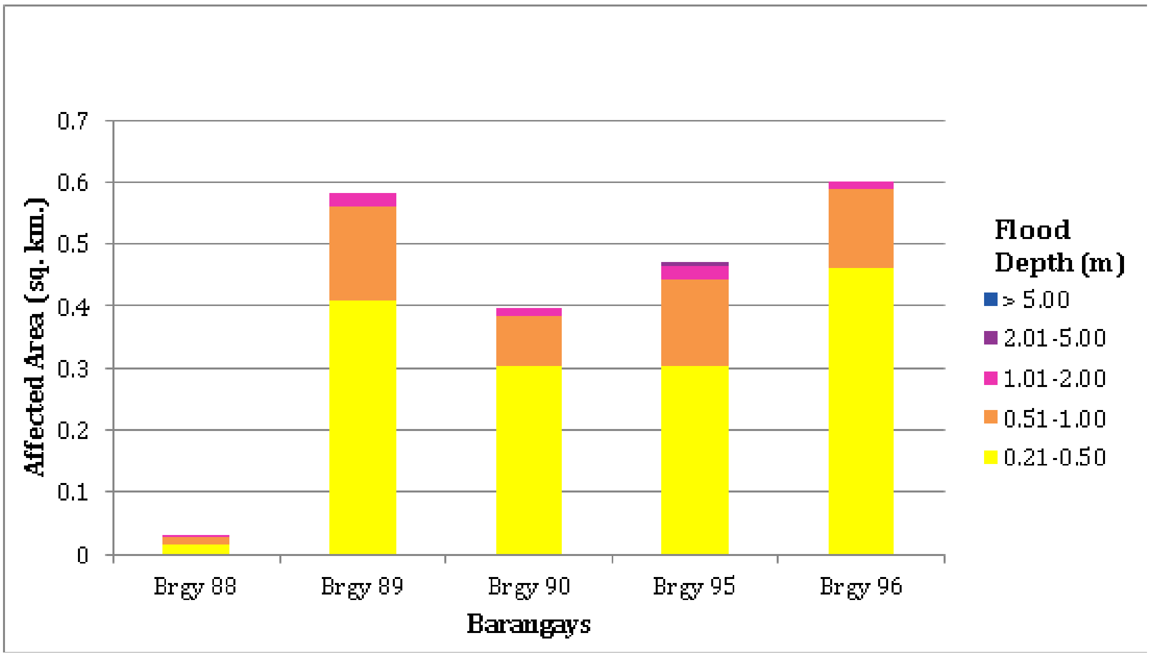



Figure 91. Affected areas in Tacloban City, Leyte during a 25-year rainfall return period.

For the municipality of Tanauan with an area of 62.78 sq km, 0.64% will experience flood levels of less 0.20 meters; 0.67% of the area will experience flood levels of 0.21 to 0.50 meters; while 2.83%, 3.41%, and 0.23% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively. Listed in Table 56 and Table 57 are the affected areas in square kilometers by flood depth per barangay.

Table 56. Affected areas in Tanauan, Leyte during a 25-year rainfall return period.

| PALO BASIN | | Affected Barangays in Tanauan | | | | |
|---|---|---|---|---|---|---|
| | | Atipolo | Balud | Baras | Calogcog | Camire |
| Affected Area (sq km.) | 0.03-0.20 | 0 | 0.089 | 0 | 0.15 | 0.0046 |
| | 0.21-0.50 | 0.0016 | 0.074 | 0.00081 | 0.21 | 0.0068 |
| | 0.51-1.00 | 0.24 | 0.13 | 0.092 | 0.29 | 0.33 |
| | 1.01-2.00 | 0.13 | 0.29 | 0.51 | 0.01 | 0.33 |
| | 2.01-5.00 | 0 | 0.089 | 0.02 | 0 | 0.033 |
| | > 5.00 | 0 | 0 | 0 | 0 | 0 |

Table 57. Affected areas in Tanauan, Leyte during a 25-year rainfall return period.

| PALO BASIN | | Affected Barangays in Tanauan | | | | |
|---|---|---|---|---|---|---|
| | | Magay | Mohon | San Roque | Santa Cruz | Solano |
| Affected Area (sq km.) | 0.03-0.20 | 0.055 | 0.0029 | 0.033 | 0.066 | 0.0006 |
| | 0.21-0.50 | 0.037 | 0.038 | 0.0039 | 0.033 | 0.008 |
| | 0.51-1.00 | 0.09 | 0.31 | 0.0035 | 0.27 | 0.03 |
| | 1.01-2.00 | 0.019 | 0.11 | 0 | 0.74 | 0.014 |
| | 2.01-5.00 | 0 | 0 | 0 | 0 | 0 |
| | > 5.00 | 0 | 0 | 0 | 0 | 0 |

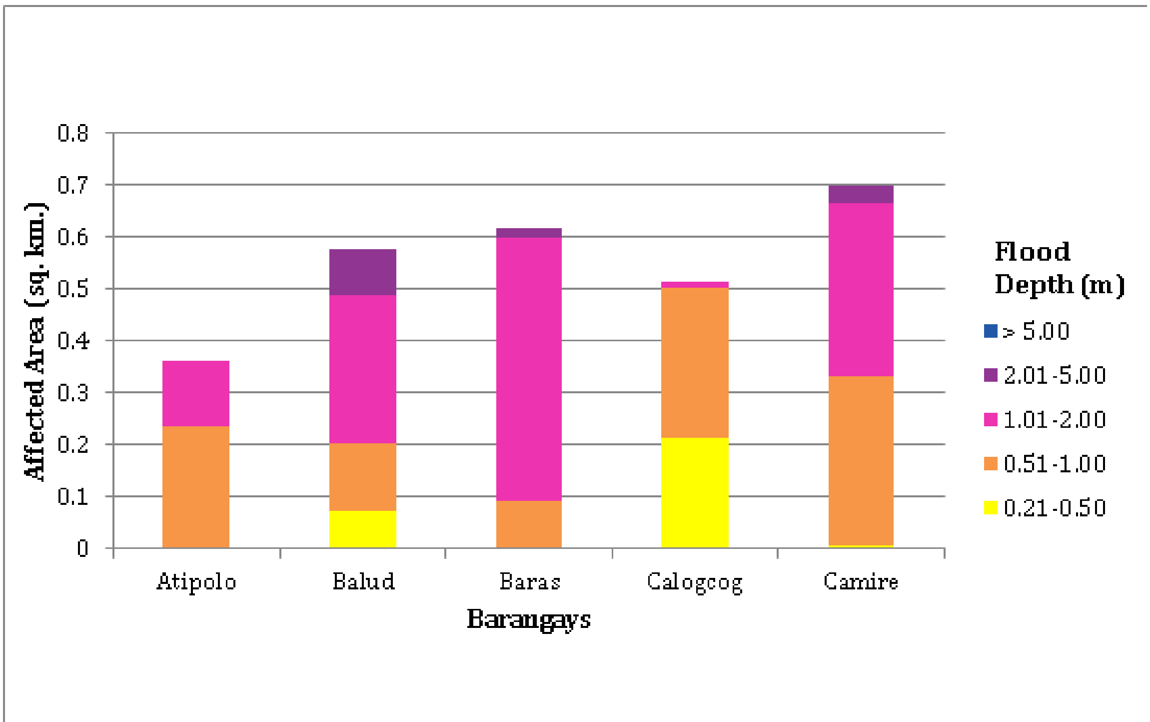



Figure 92. Affected areas in Tanauan, Leyte during a 25-year rainfall return period.

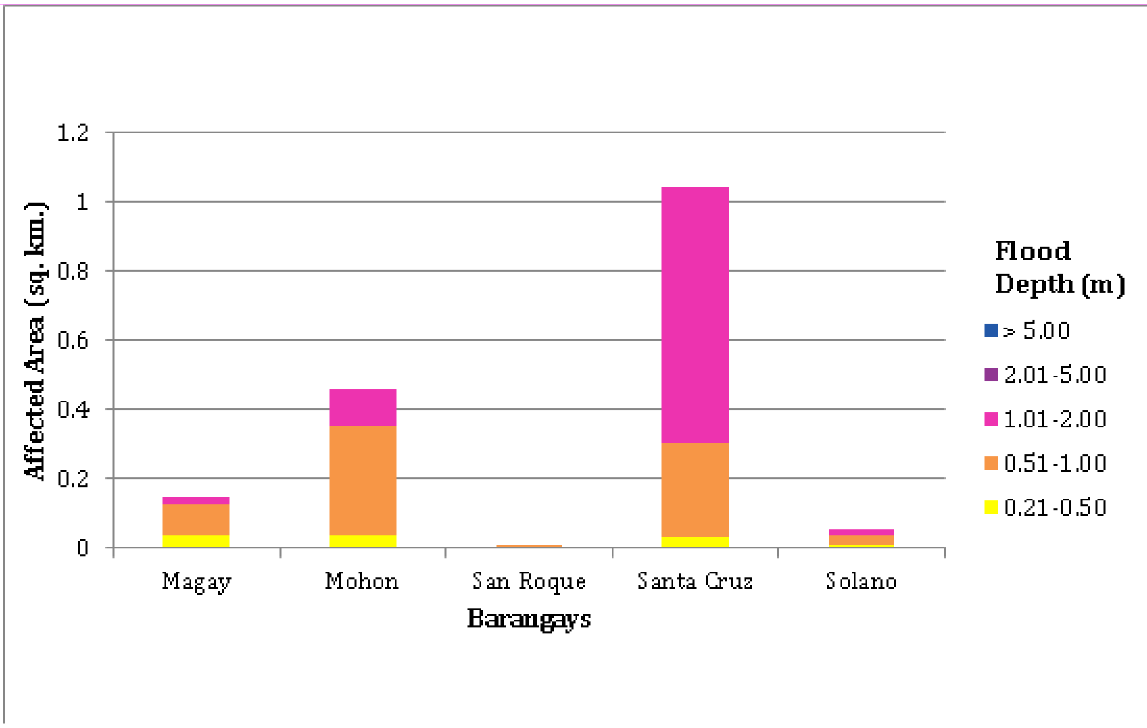



Figure 93. Affected areas in Tanauan, Leyte during a 25-year rainfall return period.

For the 100-year return period, 14.93% of the municipality of Palo with an area of 65.34 sq km will experience flood levels of less 0.20 meters; 7.01% of the area will experience flood levels of 0.21 to 0.50 meters; while 7.30%, 11.70% and 4.46% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively. Listed in Table 58 to Table 60 are the affected areas in square kilometers by flood depth per barangay.

Table 58. Affected areas in Palo, Leyte during a 100-year rainfall return period.

| PALO BASIN | | Affected Barangays in Palo | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Arado | Baras | Barayong | Buri | CabarasanGuti | Campetik | Candahug | Cangumbang | Canhidoc |
| Affected Area (sq km.) | 0.03-0.20 | 0.82 | 0.41 | 1.3 | 0.11 | 0.34 | 1.47 | 0.6 | 0.26 | 0.45 |
| | 0.21-0.50 | 0.23 | 0.054 | 0.17 | 0.015 | 0.097 | 0.39 | 0.11 | 0.64 | 0.4 |
| | 0.51-1.00 | 0.38 | 0.027 | 0.29 | 0.043 | 0.26 | 0.25 | 0.029 | 0.56 | 0.24 |
| | 1.01-2.00 | 0.53 | 0.035 | 0.42 | 0.035 | 0.47 | 0.016 | 0.003 | 0.46 | 0.62 |
| | 2.01-5.00 | 0.34 | 0 | 0.043 | 0.018 | 0.2 | 0.011 | 0 | 1.18 | 0.04 |
| | > 5.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 59. Affected areas in Palo, Leyte during a 100-year rainfall return period.

| PALO BASIN | | Affected Barangays in Palo | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Capirawan | Cavite East | Cavite West | Cogon | Gacao | Guindapunan | Libertad | Luntad | Naga-Naga |
| Affected Area (sq km.) | 0.03-0.20 | 0.16 | 0.061 | 0.09 | 0.26 | 0.48 | 1.95 | 1.13 | 0.1 | 0.11 |
| | 0.21-0.50 | 0.27 | 0.038 | 0.063 | 0.063 | 0.33 | 0.46 | 0.072 | 0.012 | 0.054 |
| | 0.51-1.00 | 0.15 | 0.025 | 0.083 | 0.12 | 0.39 | 0.29 | 0.12 | 0.015 | 0.01 |
| | 1.01-2.00 | 0.043 | 0.057 | 0.11 | 0.65 | 0.2 | 0.044 | 0.17 | 0.0037 | 0.071 |
| | 2.01-5.00 | 0 | 0 | 0.0001 | 0.027 | 0 | 0.02 | 0.16 | 0.013 | 0 |
| | > 5.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0004 | 0 | 0 |

Table 60. Affected areas in Palo, Leyte during a 100-year rainfall return period.

| PALO BASIN | | Affected Barangays in Palo | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Pawing | Salvacion | San Antonio | San Fernando | San Isidro | San Joaquin | San Jose | San Miguel | Santa Cruz | Tacuranga |
| Affected Area (sq km.) | 0.03-0.20 | 0.49 | 0.35 | 0.059 | 0.46 | 1.23 | 0.91 | 0.23 | 0.034 | 0.023 | 0.21 |
| | 0.21-0.50 | 0.23 | 0.24 | 0.046 | 0.1 | 0.58 | 0.66 | 0.27 | 0.063 | 0.014 | 0.26 |
| | 0.51-1.00 | 0.078 | 0.34 | 0.13 | 0.021 | 0.15 | 1.4 | 0.093 | 0.051 | 0.03 | 0.4 |
| | 1.01-2.00 | 0.0001 | 0.29 | 0.2 | 0.0001 | 0.084 | 4.22 | 0.026 | 0.012 | 0.1 | 0.13 |
| | 2.01-5.00 | 0 | 0.029 | 0 | 0 | 0 | 1.03 | 0.0004 | 0.026 | 0 | 0.002 |
| | > 5.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

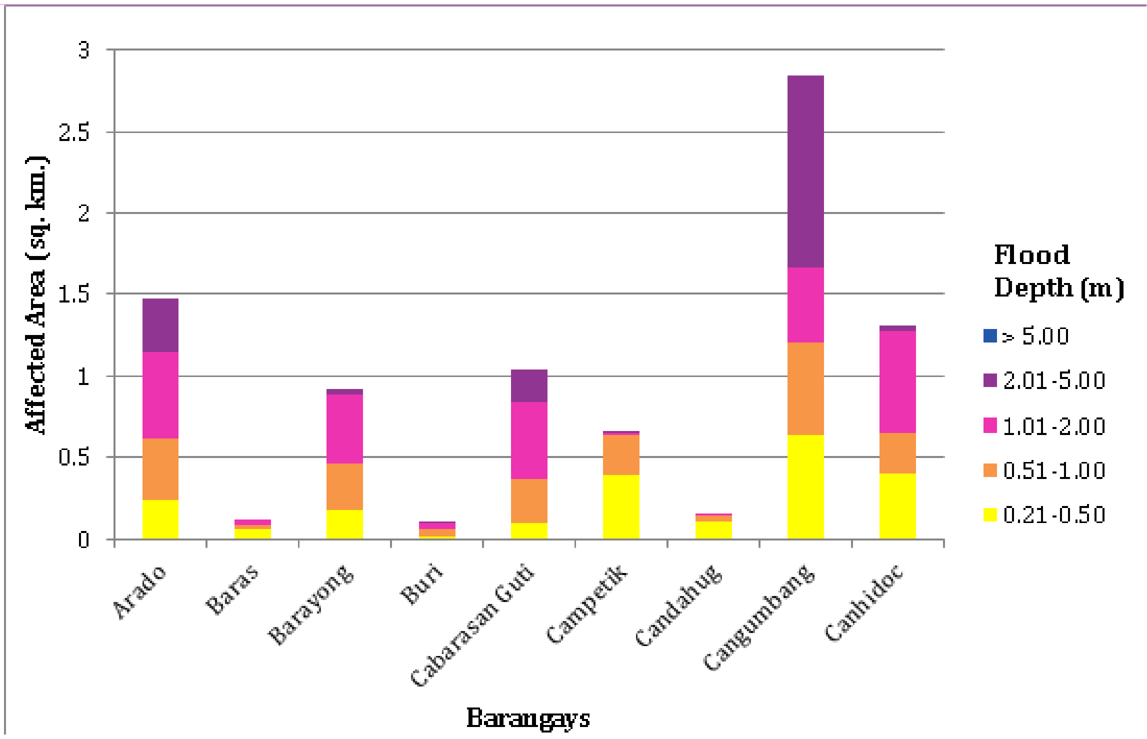



Figure 94. Affected areas in Palo, Leyte during a 100-year rainfall return period

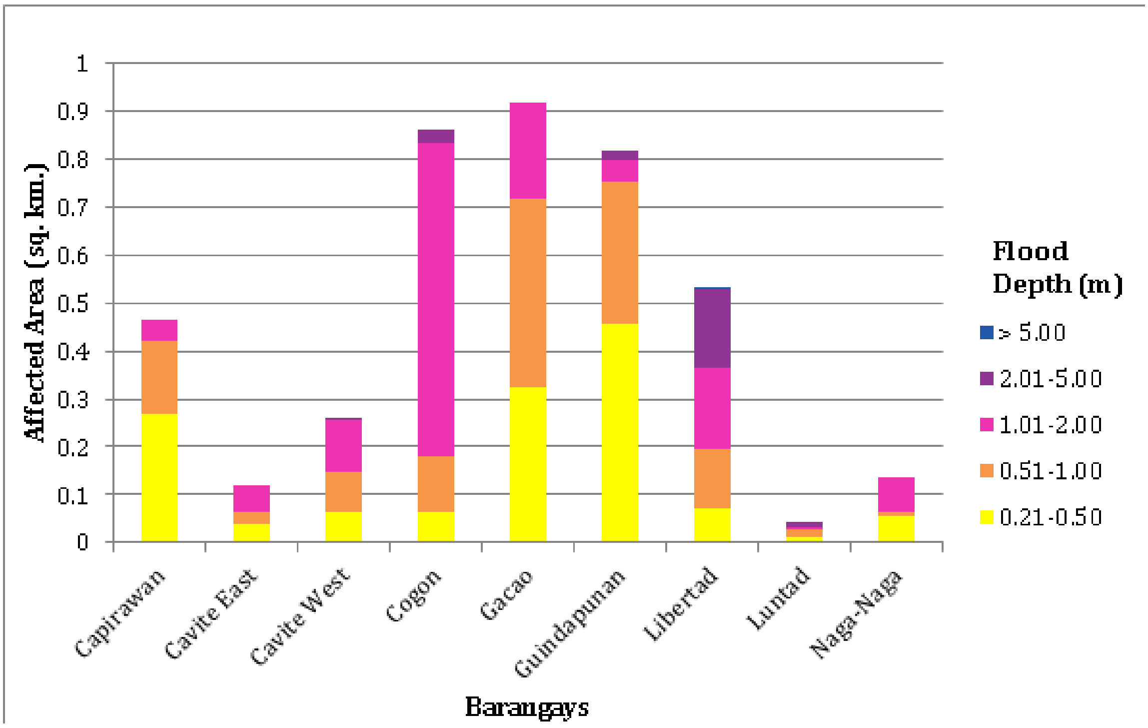



Figure 95. Affected areas in Palo, Leyte during a 100-year rainfall return period.

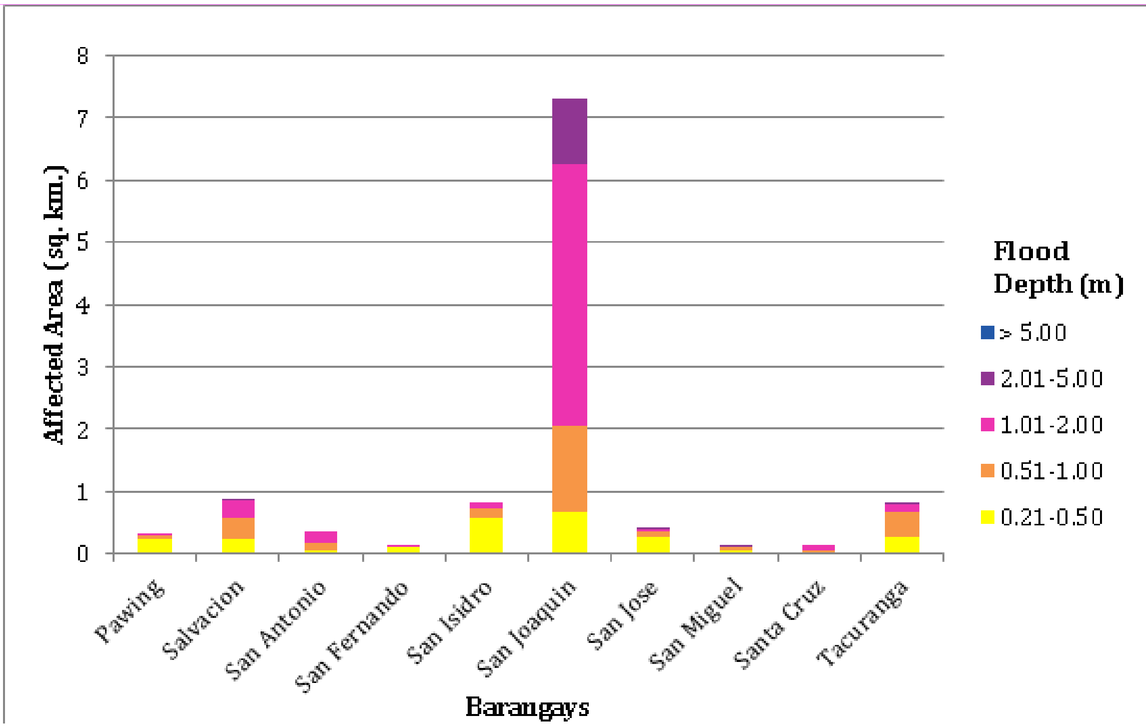



Figure 96. Affected areas in Palo, Leyte during a 100-year rainfall return period.

For the municipality of Santa Fe with an area of 57.14 sq km, 11.91% will experience flood levels of less 0.20 meters; 0.51% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.94%, 2.04%, and 2.67% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively.

Table 61. Affected areas in Santa Fe, Leyte during a 100-year rainfall return period.

| PALO BASIN | | Affected Barangays in Santa Fe | | |
|---|---|---|---|---|
| | | **Badiangay** | **Milagrosa** | San Miguelay |
| Affected Area (sq km.) | **0.03-0.20** | 5.69 | 0.00059 | 1.12 |
| | **0.21-0.50** | 0.25 | 0.00013 | 0.041 |
| | **0.51-1.00** | 0.41 | 0.014 | 0.12 |
| | **1.01-2.00** | 0.88 | 0.11 | 0.18 |
| | **2.01-5.00** | 1.09 | 0.42 | 0.015 |
| | **> 5.00** | 0.0015 | 0.014 | 0 |

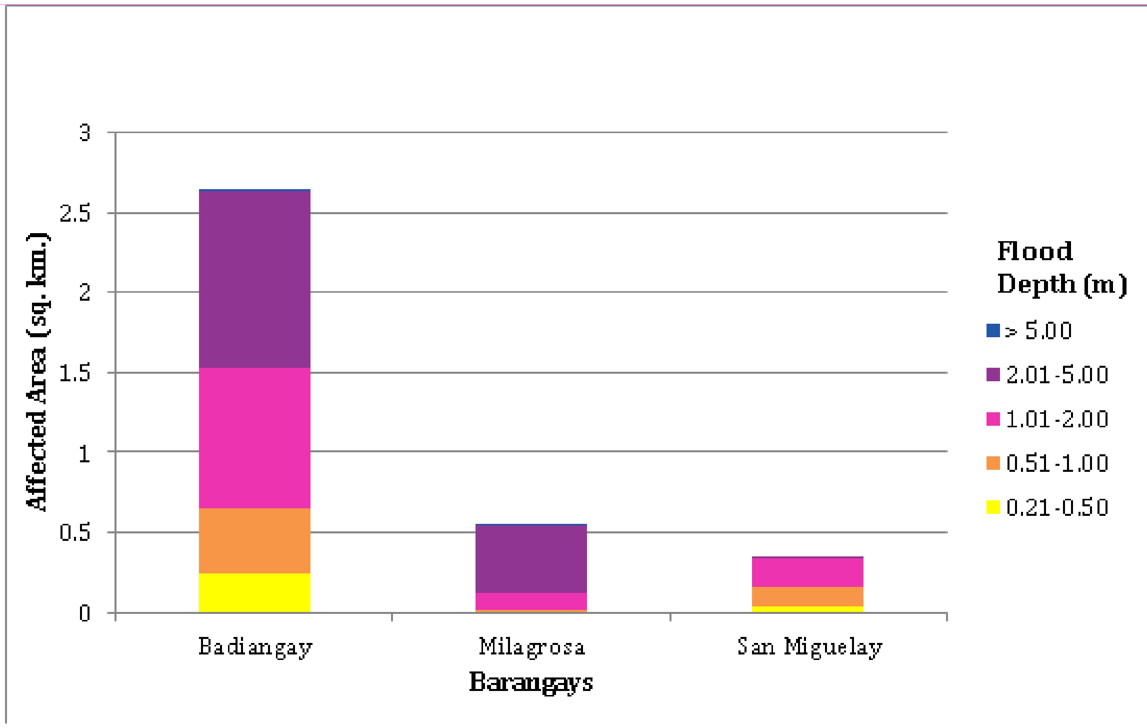



Figure 97. Affected areas in Santa Fe, Leyte during 100-year rainfall return period.

For the city of Tacloban with an area of 118.46 sq km, 6.5% will experience flood levels of less 0.20 meters; 1.94% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.79%, 0.10%, and 0.005% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively. Listed in Table 62 and Table 63 are the affected areas in square kilometers by flood depth per barangay.

Table 62. Affected areas in Tacloban City, Leyte during a 100-year rainfall return period.

| PALO BASIN | | Affected Barangays in Tacloban City | | | | | |
|---|---|---|---|---|---|---|---|
| | | Brgy 78 | Brgy 79 | Brgy 80 | Brgy 81 | Brgy 82 | Brgy 87 |
| Affected Area (sq km.) | 0.03-0.20 | 0.4 | 0.3 | 0.35 | 0.18 | 0.28 | 0.2 |
| | 0.21-0.50 | 0.0064 | 0.092 | 0.23 | 0.089 | 0.14 | 0.0022 |
| | 0.51-1.00 | 0.0015 | 0.027 | 0.037 | 0.014 | 0.081 | 0 |
| | 1.01-2.00 | 0 | 0.0012 | 0.013 | 0.0016 | 0.006 | 0 |
| | 2.01-5.00 | 0 | 0 | 0 | 0 | 0 | 0 |
| | > 5.00 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 63. Affected areas in Tacloban City, Leyte during a 100-year rainfall return period.

| PALO BASIN | | Affected Barangays in Tacloban City | | | | |
|---|---|---|---|---|---|---|
| | | Brgy 88 | Brgy 89 | Brgy 90 | Brgy 95 | Brgy 96 |
| Affected Area (sq km.) | 0.03-0.20 | 0.54 | 1.9 | 0.91 | 1.8 | 0.84 |
| | 0.21-0.50 | 0.016 | 0.47 | 0.39 | 0.33 | 0.54 |
| | 0.51-1.00 | 0.014 | 0.23 | 0.15 | 0.18 | 0.19 |
| | 1.01-2.00 | 0.0034 | 0.03 | 0.018 | 0.031 | 0.016 |
| | 2.01-5.00 | 0 | 0 | 0 | 0.0062 | 0 |
| | > 5.00 | 0 | 0 | 0 | 0 | 0 |

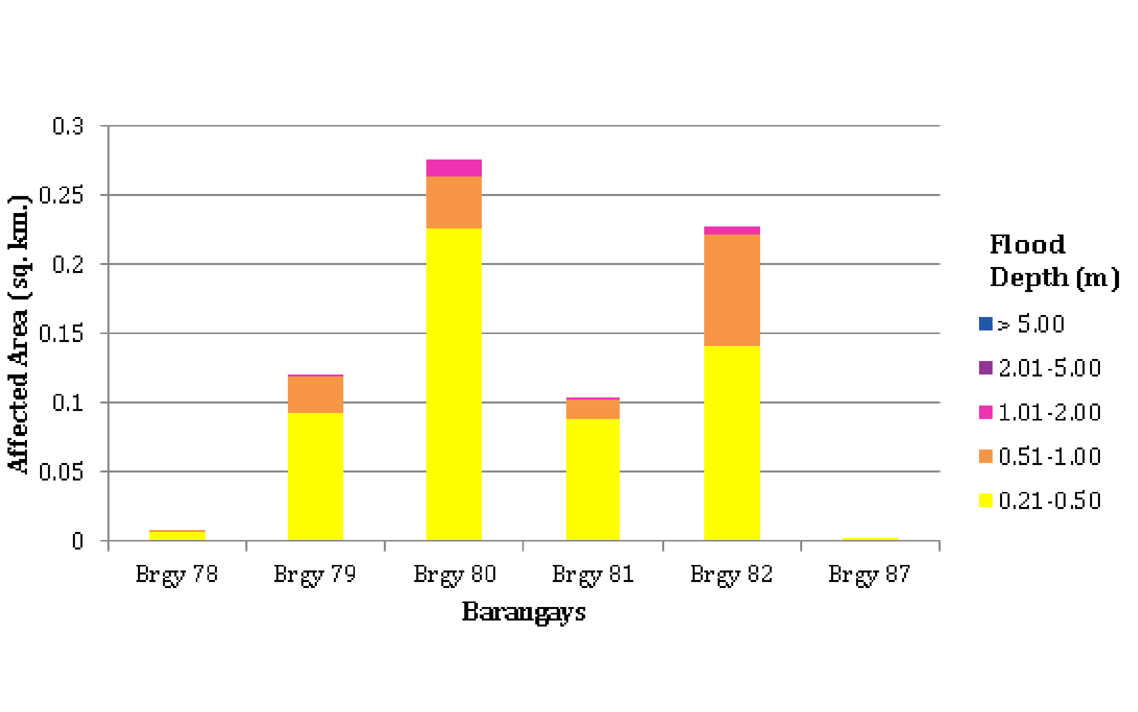



Figure 98. Affected areas in Tacloban City, Leyte during a 100-year rainfall return period.

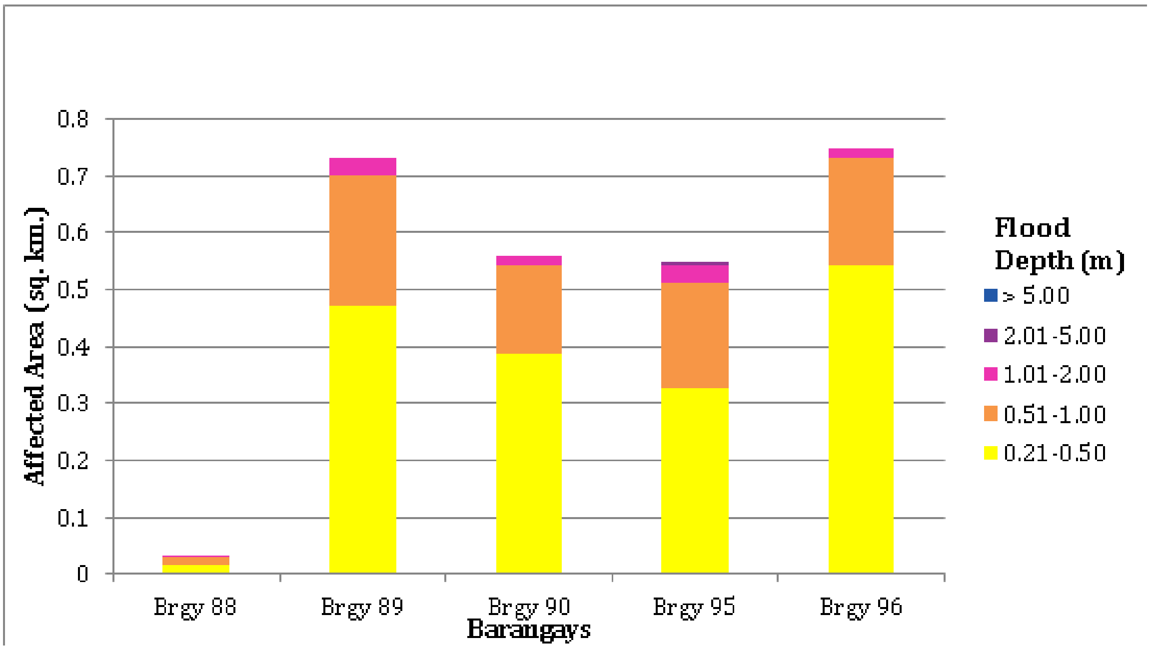



Figure 99. Affected areas in Tacloban City, Leyte during a 100-year rainfall return period.

For the municipality of Tanauan with an area of 62.78 sq km, 0.49% will experience flood levels of less 0.20 meters; 0.52% of the area will experience flood levels of 0.21 to 0.50 meters; while 1.92%, 4.25%, and 0.58% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively. Listed in Table 64 and Table 65 are the affected areas in square kilometers by flood depth per barangay.

Table 64. Affected areas in Tanauan, Leyte during a 100-year rainfall return period.

| PALO BASIN | | Affected Barangays in Tanauan | | | | |
|---|---|---|---|---|---|---|
| | | Atipolo | Balud | Baras | Calogcog | Camire |
| Affected Area (sq km.) | 0.03-0.20 | 0 | 0.066 | 0 | 0.11 | 0.0024 |
| | 0.21-0.50 | 0 | 0.072 | 0 | 0.16 | 0.0046 |
| | 0.51-1.00 | 0.069 | 0.13 | 0.046 | 0.35 | 0.13 |
| | 1.01-2.00 | 0.29 | 0.25 | 0.5 | 0.038 | 0.48 |
| | 2.01-5.00 | 0.0007 | 0.15 | 0.073 | 0 | 0.078 |
| | > 5.00 | 0 | 0 | 0 | 0 | 0 |

Table 65. Affected areas in Tanauan, Leyte during a 100-year rainfall return period.

| PALO BASIN | | Affected Barangays in Tanauan | | | | |
|---|---|---|---|---|---|---|
| | | Magay | Mohon | San Roque | Santa Cruz | Solano |
| Affected Area (sq km.) | 0.03-0.20 | 0.044 | 0.0012 | 0.032 | 0.047 | 0.00033 |
| | 0.21-0.50 | 0.038 | 0.0065 | 0.0045 | 0.04 | 0.0032 |
| | 0.51-1.00 | 0.098 | 0.23 | 0.0032 | 0.12 | 0.027 |
| | 1.01-2.00 | 0.023 | 0.2 | 0.0006 | 0.86 | 0.022 |
| | 2.01-5.00 | 0 | 0.024 | 0 | 0.04 | 0 |
| | > 5.00 | 0 | 0 | 0 | 0 | 0 |

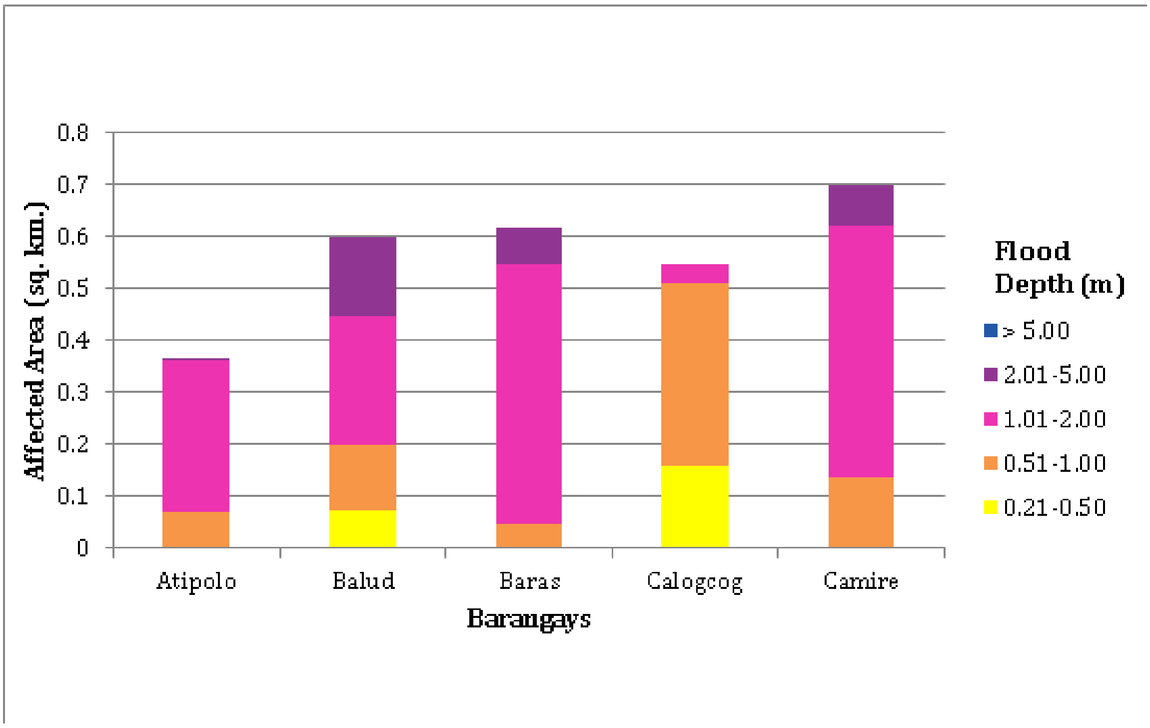



Figure 100. Affected areas in Tanauan, Leyte during a 100-year rainfall return period.

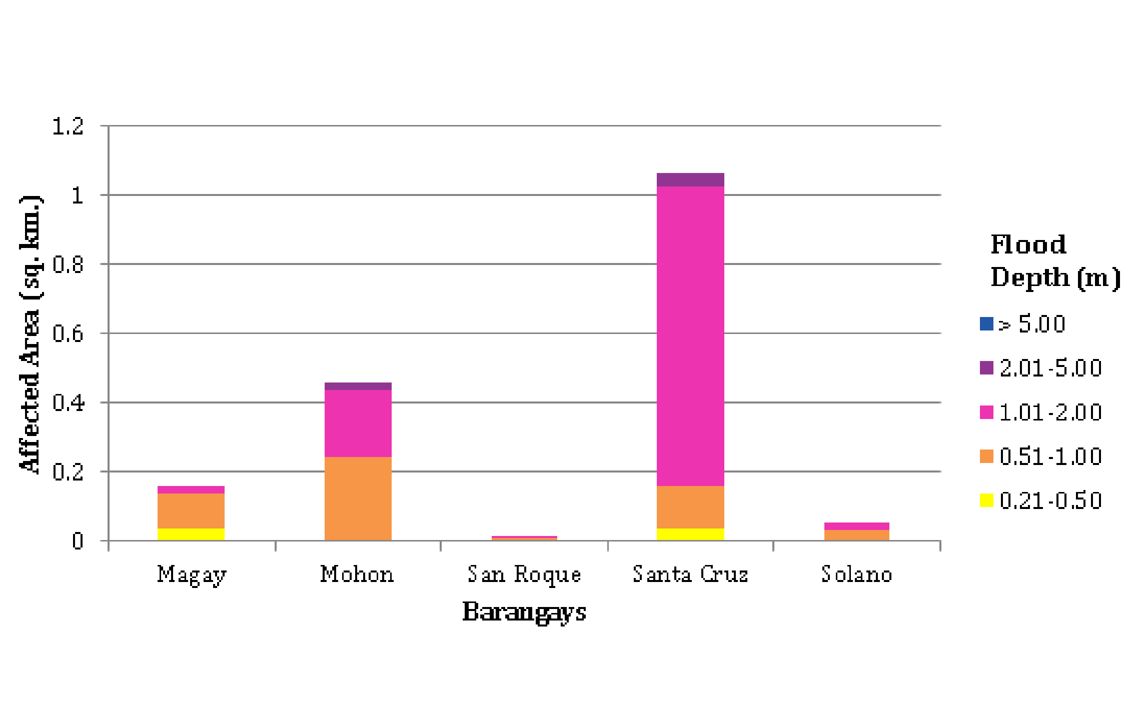



Figure 101. Affected areas in Tanauan, Leyte during a 100-year rainfall return period.

Among the barangays in the municipality of Palo, San Joaquin is projected to have the highest percentage of area that will experience flood levels at 12.56%. Meanwhile, Cangumbang posted the second highest percentage of area that may be affected by flood depths at 4.73%.

Among the barangays in the municipality of Santa Fe, Badiangay is projected to have the highest percentage of area that will experience flood levels at 14.55%. Meanwhile, San Miguelay posted the second highest percentage of area that may be affected by flood depths at 2.57%.

Among the barangays in the city of Tacloban, Barangay 89 is projected to have the highest percentage of area that will experience flood levels of at 2.217%. Meanwhile, Barangay 95 posted the second highest percentage of area that may be affected by flood depths of at 1.98%.

Among the barangays in the municipality of Tanauan, Santa Cruz is projected to have the highest percentage of area that will experience flood levels at 1.77%. Meanwhile, Camire posted the second highest percentage of area that may be affected by flood depths of at 1.12%.

Moreover, the generated flood hazard maps for the Palo 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 66. Area covered by each warning level with respect to the rainfall scenario.

| Warning Level | Area Covered in sq km | | |
|---|---|---|---|
| | 5 year | 25 year | 100 year |
| Low | 3.66 | 9.19 | 8.91 |
| Medium | 0 | 17.79 | 17.05 |
| High | 0 | 7.25 | 10.38 |

Of the 45 identified educational institutions in Palo Floodplain, 4 schools were assessed to be exposed to low-level flooding in a 5-year scenario. In the 25-year scenario, 7 schools were assessed to be exposed to low-level flooding, 12 to medium-level flooding, and 1 to high-level flooding. In the 100-year scenario, 11 schools were assessed for low-level flooding and 13 for medium-level flooding. See ANNEX 12 for a detailed enumeration of schools inside Palo Floodplain.

Of the 15 identified health institutions in Palo Floodplain, 2 were assessed to be exposed to low-level flooding in a 5-year scenario. In the 25-year scenario, 2 were assessed to be exposed to low-level flooding, 6 to medium-level flooding, and 1 to high-level flooding. For the 100-year scenario, 2 schools were assessed for low-level flooding and 6 for medium-level flooding, and 1 for high-level flooding. See ANNEX 13 for a detailed enumeration of health institutions inside Palo Floodplain.

## 5.11 Flood Validation

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

From the flood depth maps produced by Phil-LiDAR 1 Program, multiple points representing the different flood depths for different scenarios were identified for validation.

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

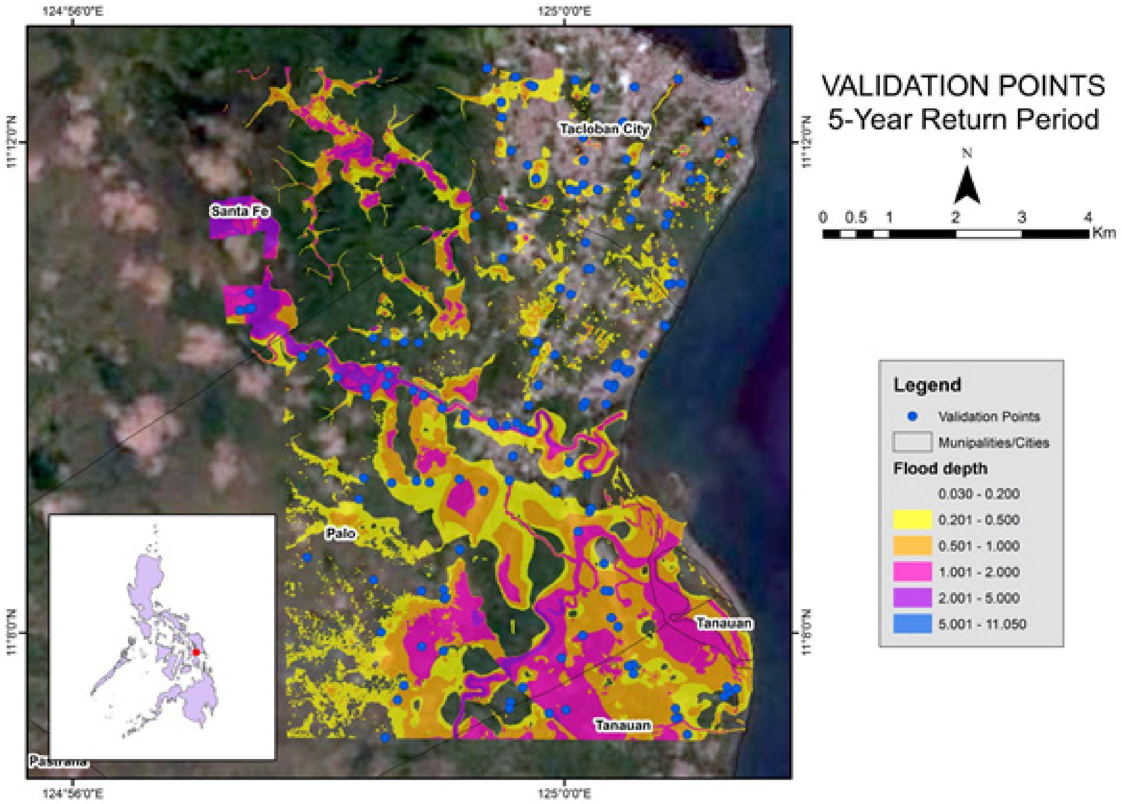



Figure 102. Validation points for 5-year flood depth map of Palo Floodplain.

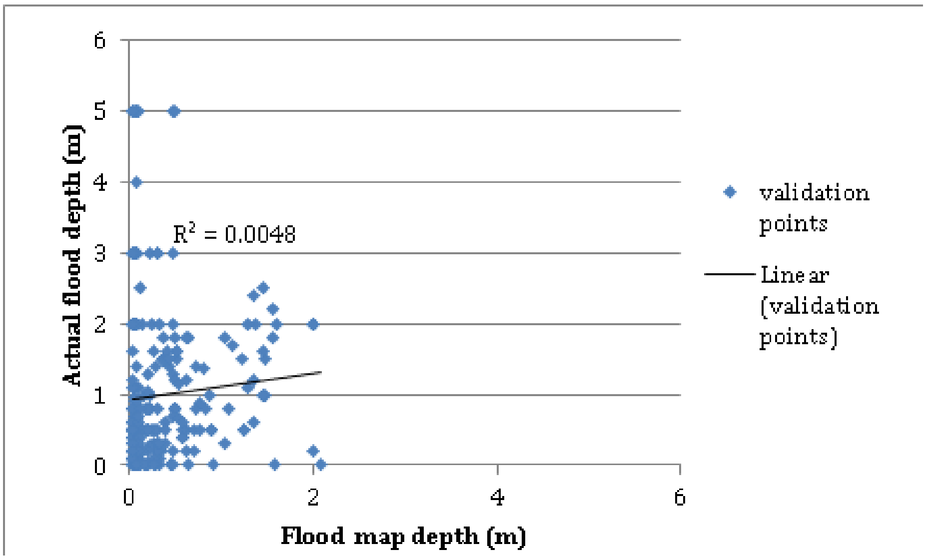



Figure 103. Flood map depth vs. actual flood depth.

Table 67. Actual flood depth vs. simulated flood depth in Palo.

| PALO BASIN | | Modeled Flood Depth (m) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0-0.20 | 0.21-0.50 | 0.51-1.00 | 1.01-2.00 | 2.01-5.00 | > 5.00 | Total |
| Actual Flood Depth (m) | 0-0.20 | 41 | 16 | 4 | 2 | 1 | 0 | 64 |
| | 0.21-0.50 | 49 | 14 | 7 | 3 | 0 | 0 | 73 |
| | 0.51-1.00 | 21 | 9 | 6 | 5 | 0 | 0 | 41 |
| | 1.01-2.00 | 19 | 16 | 9 | 13 | 0 | 0 | 57 |
| | 2.01-5.00 | 19 | 6 | 0 | 3 | 0 | 0 | 28 |
| | > 5.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Total | 149 | 61 | 26 | 26 | 1 | 0 | 263 |

The overall accuracy generated by the flood model is estimated at 28.14%, with 74 points correctly matching the actual flood depths. In addition, there were 98 points estimated one level above and below the correct flood depths while there were 44 points and 47 points estimated two levels above and below, and three or more levels above and below the correct flood. A total of 38 points were overestimated while a total of 151 points were underestimated in the modeled flood depths of Palo.

Table 68. Summary of accuracy assessment in Palo.

| | No. of Points | % |
|---|---|---|
| Correct | 74 | **28.14** |
| Overestimated | 38 | 14.45 |
| Underestimated | 151 | 57.41 |
| Total | 263 | 100 |

# REFERENCES

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

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

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.

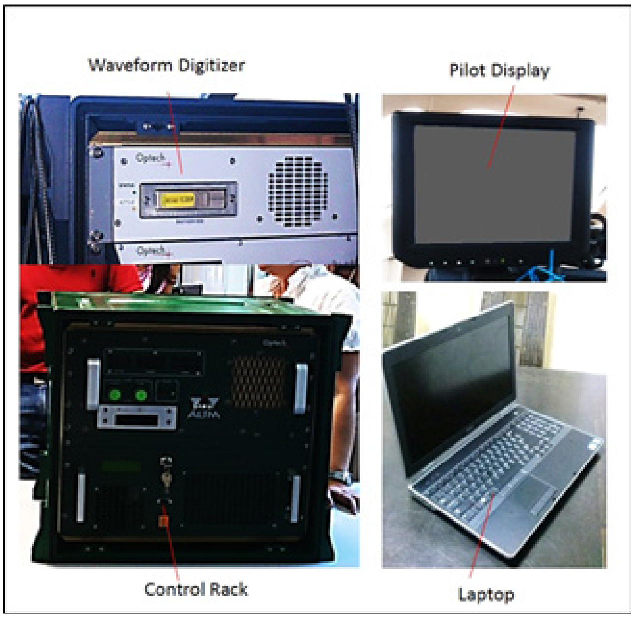
Sarmiento C., Paringit E.C., et al. 2014. DREAM Data Acquisition Component Manual. Quezon City, Philippines: UP Training Center for Applied Geodesy and Photogrammetry.

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 Palo Floodplain Survey.

1. Aquarius




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

2. Gemini


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

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

LYT-101

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

January 20, 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: **LEYTE**
Station Name: **LYT-101**
Order: **2nd**

Island: **VISAYAS**
Municipality: **PALO**
Barangay:

*PRS92 Coordinates*

Latitude: **11° 10' 23.89707"** Longitude: **125° 0' 38.62071"** Ellipsoidal Hgt: **6.58600 m.**

*WGS84 Coordinates*

Latitude: **11° 10' 19.64869"** Longitude: **125° 0' 43.78230"** Ellipsoidal Hgt: **69.02100 m.**

*PTM Coordinates*

Northing: **1235497.253 m.** Easting: **501171.719 m.** Zone: **5**

*UTM Coordinates*

Northing: **1,235,811.61** Easting: **719,575.03** Zone: **51**

Location Description

LYT-101
Station is located in the province of Leyte, municipality of Palo. From Tacloban City travel SE to McArthur Park. The point is located infront of Gen. Douglas McArthur Shrine and is approximately 10 m away and adjacent to center of lower step. Station mark is a concrete nail on center of a 20 x 20 cm. cement putty on the concrete ground.

Requesting Party: **UP-DREAM**
Pupose: **Reference**
OR Number: **8795097 A**
T.N.: **2014-94**

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

9 9 0 1 2 0 2 0 1 4 1 4 3 7 3 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

SMR-53

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

April 23, 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: **SAMAR (WESTERN SAMAR)**
Station Name: **SMR-53**
Order: **2nd**

| | | |
|---|---|---|
| Island: **VISAYAS** | | Barangay: **SAN ISIDRO** |
| Municipality: **SANTA RITA** | | |
| | ***PRS92 Coordinates*** | |
| Latitude: **11° 30' 17.85657"** | Longitude: **125° 1' 29.83739"** | Ellipsoidal Hgt: **26.13400 m.** |
| | ***WGS84 Coordinates*** | |
| Latitude: **11° 30' 13.52495"** | Longitude: **125° 1' 34.96980"** | Ellipsoidal Hgt: **87.78700 m.** |
| | ***PTM Coordinates*** | |
| Northing: **1272180.079 m.** | Easting: **502722.403 m.** | Zone: **5** |
| | ***UTM Coordinates*** | |
| Northing: **1,272,513.40** | Easting: **720,874.14** | Zone: **51** |

Location Description

SMR-53
From Tacloban City Proper, travel about 45 km. north going to Brgy. San.Isidro. The NAMRIA monument was located about 15 m. west inside the San Isidro Elementary School, and almost near at the school building and flag pole about 5 m. north. Mark is the head of a 4" copper nail flushed in a cement block embedded in the ground with inscriptions "SMR-53; 2007; NAMRIA."

Requesting Party: **Engr. Christopher Cruz/ UP-DREAM**
Pupose: **Reference**
OR Number: **8796021 A**
T.N.: **2014-920**

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

9904232014154927

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

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

ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

SMR-56

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

April 23, 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: **SAMAR (WESTERN SAMAR)**
Station Name: **SMR-56**
Order: **2nd**

Island: **VISAYAS**
Municipality: **SANTA RITA**
Barangay: **CABACUNGAN**

| | | |
|---|---|---|
| | ***PRS92 Coordinates*** | |
| Latitude: **11° 23' 6.52702"** | Longitude: **125° 0' 23.99607"** | Ellipsoidal Hgt: **11.82200 m.** |
| | ***WGS84 Coordinates*** | |
| Latitude: **11° 23' 2.22413"** | Longitude: **125° 0' 29.13917"** | Ellipsoidal Hgt: **73.72700 m.** |
| | ***PTM Coordinates*** | |
| Northing: **1258927.861 m.** | Easting: **500727.475 m.** | Zone: **5** |
| | ***UTM Coordinates*** | |
| Northing: **1,259,244.38** | Easting: **718,970.61** | Zone: **51** |

Location Description

SMR-56
From Tacloban City, travel about 15 km. north going to Brgy. Cabacungan. Before reaching the of Sta. Rita town proper Western Samar. The monument was established at the Brgy. Cabacungan Elementary School, at the side of the road, 20 m. east fronting school's entrance gate, 50 m. northeast from Waiting Shed about , and 3 m. east along the side the of pathway. Mark is the head of a 4" copper nail flushed in a 30X30 cm. cement block embedded in the ground protruding about 20 cm., with inscriptions "SMR-56; 2007; NAMRIA."

Requesting Party: **Engr. Christopher Cruz/ UP-DREAM**
Pupose: **Reference**
OR Number: **8796021 A**
T.N.: **2014-919**

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

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

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

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Branch : 421 Barraca St. San Nicolas, 1010 Manila, Philippines, Tel. No. (632) 241-3494 to 98
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ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

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

LY-881

LY-881 - LYT-101 (1:48:33 PM-5:01:31 PM) (S1)

| | |
|---|---|
| Baseline observation: | LY-881 --- LYT-101 (B1) |
| Processed: | 6/10/2014 4:31:22 PM |
| Solution type: | Fixed |
| Frequency used: | Dual Frequency (L1, L2) |
| Horizontal precision: | 0.002 m |
| Vertical precision: | 0.003 m |
| RMS: | 0.000 m |
| Maximum PDOP: | 6.041 |
| Ephemeris used: | Broadcast |
| Antenna model: | Trimble Relative |
| Processing start time: | 5/6/2014 1:48:59 PM (Local: UTC+8hr) |
| Processing stop time: | 5/6/2014 5:01:31 PM (Local: UTC+8hr) |
| Processing duration: | 03:12:32 |
| Processing interval: | 1 second |

Vector Components (Mark to Mark)

| From: | LYT-101 | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 719575.001 m | Latitude | N11°10'23.89752" | Latitude | N11°10'19.64869" |
| Northing | 1235811.576 m | Longitude | E125°00'38.62063" | Longitude | E125°00'43.78230" |
| Elevation | 4.934 m | Height | 6.587 m | Height | 69.021 m |

| To: | LY-881 | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 718540.093 m | Latitude | N11°10'49.44332" | Latitude | N11°10'45.19188" |
| Northing | 1236589.610 m | Longitude | E125°00'04.69148" | Longitude | E125°00'09.85261" |
| Elevation | 4.367 m | Height | 5.992 m | Height | 68.386 m |

| Vector | | | | | |
|---|---|---|---|---|---|
| ΔEasting | -1034.909 m | NS Fwd Azimuth | 307°19'31" | ΔX | 930.803 m |
| ΔNorthing | 778.034 m | Ellipsoid Dist. | 1294.498 m | ΔY | 465.453 m |
| ΔElevation | -0.567 m | ΔHeight | -0.594 m | ΔZ | 769.860 m |

Standard Errors

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

SM-286

## SMR-56 - SM-286 (6:40:03 AM-5:37:41 PM) (S1)

| | |
|---|---|
| Baseline observation: | SMR-56 --- SM-286 (B1) |
| Processed: | 6/10/2014 6:11:29 PM |
| Solution type: | Fixed |
| Frequency used: | Dual Frequency (L1, L2) |
| Horizontal precision: | 0.003 m |
| Vertical precision: | 0.007 m |
| RMS: | 0.002 m |
| Maximum PDOP: | 3.152 |
| Ephemeris used: | Broadcast |
| Antenna model: | Trimble Relative |
| Processing start time: | 5/10/2014 6:40:03 AM (Local: UTC+8hr) |
| Processing stop time: | 5/10/2014 5:37:41 PM (Local: UTC+8hr) |
| Processing duration: | 10:57:38 |
| Processing interval: | 1 second |

### Vector Components (Mark to Mark)

| From: | SMR-56 | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 718970.608 m | Latitude | N11°23'06.52702" | Latitude | N11°23'02.22413" |
| Northing | 1259244.377 m | Longitude | E125°00'23.99607" | Longitude | E125°00'29.13917" |
| Elevation | 10.345 m | Height | 11.822 m | Height | 73.727 m |

| To: | SM-286 | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 717715.151 m | Latitude | N11°24'35.12654" | Latitude | N11°24'30.81645" |
| Northing | 1261958.537 m | Longitude | E124°59'43.21142" | Longitude | E124°59'48.35248" |
| Elevation | 3.975 m | Height | 5.416 m | Height | 67.232 m |

| Vector | | | | | |
|---|---|---|---|---|---|
| ΔEasting | -1255.457 m | NS Fwd Azimuth | 335°34'24" | ΔX | 1325.060 m |
| ΔNorthing | 2714.160 m | Ellipsoid Dist. | 2989.890 m | ΔY | 263.463 m |
| ΔElevation | -6.370 m | ΔHeight | -6.407 m | ΔZ | 2667.263 m |

### Standard Errors

| Vector errors: | | | | | |
|---|---|---|---|---|---|
| σ ΔEasting | 0.001 m | σ NS fwd Azimuth | 0°00'00" | σ ΔX | 0.002 m |
| σ ΔNorthing | 0.000 m | σ Ellipsoid Dist. | 0.001 m | σ ΔY | 0.003 m |
| σ ΔElevation | 0.003 m | σ ΔHeight | 0.003 m | σ ΔZ | 0.001 m |

LY-123

SMR-56 - LY-123 A (7:39:33 AM-12:21:26 PM) (S1)

| | |
|---|---|
| Baseline observation: | SMR-56 --- LY-123 A (B1) |
| Processed: | 6/17/2014 11:23:48 AM |
| Solution type: | Fixed |
| Frequency used: | Dual Frequency (L1, L2) |
| Horizontal precision: | 0.003 m |
| Vertical precision: | 0.013 m |
| RMS: | 0.002 m |
| Maximum PDOP: | 2.591 |
| Ephemeris used: | Broadcast |
| Antenna model: | Trimble Relative |
| Processing start time: | 5/14/2014 7:40:11 AM (Local: UTC+8hr) |
| Processing stop time: | 5/14/2014 12:21:26 PM (Local: UTC+8hr) |
| Processing duration: | 04:41:15 |
| Processing interval: | 1 second |

Vector Components (Mark to Mark)

| From: | SMR-56 | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 718970.608 m | Latitude | N11°23'06.52702" | Latitude | N11°23'02.22413" |
| Northing | 1259244.377 m | Longitude | E125°00'23.99607" | Longitude | E125°00'29.13917" |
| Elevation | 10.345 m | Height | 11.822 m | Height | 73.727 m |

| To: | LY-123 A | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 702180.961 m | Latitude | N11°12'20.91223" | Latitude | N11°12'16.64155" |
| Northing | 1239293.641 m | Longitude | E124°51'06.13717" | Longitude | E124°51'11.29744" |
| Elevation | 33.586 m | Height | 34.930 m | Height | 96.895 m |

| Vector | | | | | |
|---|---|---|---|---|---|
| ΔEasting | -16789.647 m | NS Fwd Azimuth | 220°28'33" | ΔX | 11632.589 m |
| ΔNorthing | -19950.736 m | Ellipsoid Dist. | 26071.470 m | ΔY | 12890.711 m |
| ΔElevation | 23.241 m | ΔHeight | 23.108 m | ΔZ | -19448.320 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 | 0.006 m |
| σ ΔElevation | 0.007 m | σ ΔHeight | 0.007 m | σ ΔZ | 0.002 m |

LY-110

**Vector Components (Mark to Mark)**

| From: | LYT 104 | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 706089.510 m | Latitude | N11°08'38.92234" | Latitude | N11°08'34.67033" |
| Northing | 1232496.838 m | Longitude | E124°53'13.52786" | Longitude | E124°53'18.69323" |
| Elevation | 32.311 m | Height | 33.659 m | Height | 95.861 m |

| To: | LY 110 | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 713942.863 m | Latitude | N11°10'19.48389" | Latitude | N11°10'15.23095" |
| Northing | 1235638.117 m | Longitude | E124°57'32.98736" | Longitude | E124°57'38.14961" |
| Elevation | 12.819 m | Height | 14.336 m | Height | 76.647 m |

| Vector | | | | | |
|---|---|---|---|---|---|
| ΔEasting | 7853.353 m | NS Fwd Azimuth | 68°33'52" | ΔX | -6101.546 m |
| ΔNorthing | 3141.279 m | Ellipsoid Dist. | 8457.064 m | ΔY | -5012.598 m |
| ΔElevation | -19.492 m | ΔHeight | -19.323 m | ΔZ | 3027.816 m |

**Standard Errors**

| Vector errors: | | | | | |
|---|---|---|---|---|---|
| σ ΔEasting | 0.002 m | σ NS fwd Azimuth | 0°00'00" | σ ΔX | 0.004 m |
| σ ΔNorthing | 0.001 m | σ Ellipsoid Dist. | 0.002 m | σ ΔY | 0.005 m |
| σ ΔElevation | 0.007 m | σ ΔHeight | 0.007 m | σ ΔZ | 0.002 m |

**Aposteriori Covariance Matrix (Meter²)**

| | X | Y | Z |
|---|---|---|---|
| X | 0.0000143938 | | |
| Y | -0.0000177190 | 0.0000287509 | |
| Z | -0.0000052060 | 0.0000075812 | 0.0000037601 |

2

LYT-104

Vector Components (Mark to Mark)

| From: | SMR-53 | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 720874.133 m | Latitude | N11°30'17.85656" | Latitude | N11°30'13.52495" |
| Northing | 1272513.396 m | Longitude | E125°01'29.83738" | Longitude | E125°01'34.96980" |
| Elevation | 24.750 m | Height | 26.134 m | Height | 87.787 m |

| To: | LYT-104 | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 706089.510 m | Latitude | N11°08'38.92234" | Latitude | N11°08'34.67033" |
| Northing | 1232496.838 m | Longitude | E124°53'13.52786" | Longitude | E124°53'18.69323" |
| Elevation | 32.311 m | Height | 33.659 m | Height | 95.861 m |

| Vector | | | | | |
|---|---|---|---|---|---|
| ΔEasting | -14784.623 m | NS Fwd Azimuth | 200°40'31" | ΔX | 7839.600 m |
| ΔNorthing | -40016.558 m | Ellipsoid Dist. | 42653.401 m | ΔY | 15051.644 m |
| ΔElevation | 7.561 m | ΔHeight | 7.525 m | ΔZ | -39131.928 m |

Standard Errors

| Vector errors: | | | | | |
|---|---|---|---|---|---|
| σ ΔEasting | 0.003 m | σ NS fwd Azimuth | 0°00'00" | σ ΔX | 0.006 m |
| σ ΔNorthing | 0.002 m | σ Ellipsoid Dist. | 0.002 m | σ ΔY | 0.007 m |
| σ ΔElevation | 0.009 m | σ ΔHeight | 0.009 m | σ ΔZ | 0.002 m |

# Annex 4. The LiDAR Survey Team Composition

<table>
<tr><th>Data Acquisition Component Sub-Team</th><th>Designation</th><th>Name</th><th>Agency/ Affiliation</th></tr>
<tr><td>Program Leader</td><td>Program Leader –I</td><td>ENRICO C. PARINGIT, D. Eng.</td><td>UP-TCAGP</td></tr>
<tr><td rowspan="2">Data Acquisition Component Leader</td><td rowspan="2">Data Component Project Leader –I</td><td>ENGR. CZAR JAKIRI S. SARMIENTO</td><td>UP-TCAGP</td></tr>
<tr><td>ENGR. LOUIE P. BALICANTA</td><td>UP-TCAGP</td></tr>
<tr><td rowspan="3">Survey Supervisor</td><td>Chief Science Research Specialist (CSRS)</td><td>ENGR. CHRISTOPHER CRUZ</td><td>UP-TCAGP</td></tr>
<tr><td rowspan="2">Supervising Science Research Specialist (Supervising SRS)</td><td>LOVELY GRACIA ACUÑA</td><td>UP-TCAGP</td></tr>
<tr><td>LOVELYN ASUNCION</td><td>UP-TCAGP</td></tr>
<tr><td rowspan="3">LiDAR Operation</td><td rowspan="3">Senior Science Research Specialist (SSRS)</td><td>JULIE PEARL MARS</td><td>UP-TCAGP</td></tr>
<tr><td>ENGR. GEROME HIPOLITO</td><td></td></tr>
<tr><td>JASMINE ALVIAR</td><td>UP-TCAGP</td></tr>
<tr><td rowspan="6">LiDAR Operation</td><td rowspan="6">Research Associate (RA)</td><td>FAITH JOY SABLE</td><td>UP-TCAGP</td></tr>
<tr><td>DAN ALDOVINO</td><td>UP-TCAGP</td></tr>
<tr><td>PAULINE JOANNE ARCEO</td><td>UP-TCAGP</td></tr>
<tr><td>IRO NIEL ROXAS</td><td>UP-TCAGP</td></tr>
<tr><td>ENGR. GRACE SINADJAN</td><td>UP-TCAGP</td></tr>
<tr><td>JONATHAN ALMALVEZ</td><td>UP-TCAGP</td></tr>
<tr><td>Ground Survey</td><td>RA</td><td>JERIEL PAUL ALAMBAN, GEOL.</td><td>UP-TCAGP</td></tr>
<tr><td rowspan="6">LiDAR Operation</td><td rowspan="2">Airborne Security</td><td>SSG. RAYMUND DOMINE</td><td rowspan="2">PILIPPINE AIR FORCE (PAF)</td></tr>
<tr><td>SSG RANDY SISON</td></tr>
<tr><td rowspan="4">Pilot</td><td>CAPT. JEFFREY ALAJAR</td><td rowspan="4">ASIAN AEROSPACE CORPORATION (AAC)</td></tr>
<tr><td>CAPT. JACKSON JAVIER</td></tr>
<tr><td>CAPT. ALBERT PAUL LIM</td></tr>
<tr><td>CAPT. RANDY LAGCO</td></tr>
</table>

# Annex 5. Data Transfer Sheet for Palo Floodplain

DATA TRANSFER SHEET
Feb 3, 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 | 1016A | 3BLK33A024A | AQUARIUS | N/A | 56.5KB | 699KB | 159MB | 41.2GB | N/A | 9.96GB | 50.6GB | 14.4MB | 245B | 649B | 6.83KB | 504KB | X:\Airborne_Raw\1016A |
| Jan 24, 2014 | 1018A | 3BLK33A024B | AQUARIUS | N/A | 56.5KB | 1.41MB | 81MB | N/A | N/A | 2.63GB | 12.6GB | 14.4MB | 245B | 278B | 4.21KB | 345KB | X:\Airborne_Raw\1018A |
| Jan 25, 2014 | 1020A | 3BLK33B025A | AQUARIUS | N/A | 119KB | 1.85MB | 237MB | 67.7GB | N/A | 15.1GB | 75GB | 20.7MB | 245B | 530B | 4.2KB | 1.21KB | X:\Airborne_Raw\1020A |
| Jan 25, 2014 | 1022A | 3BLK33B025B | AQUARIUS | N/A | 819KB | 1.28MB | 242MB | 75.3GB | N/A | 18.9GB | 57.2GB | 20.7MB | 245B | 1.25KB | 4.2KB | 819KB | X:\Airborne_Raw\1022A |
| Jan 26, 2014 | 1024A | 3BLK33AS34A026A | AQUARIUS | N/A | 652KB | 1.36MB | 247MB | 55.2GB | N/A | 16.3GB | 48.1GB | 20MB | 245B | 488B | 6.72KB | 652KB | X:\Airborne_Raw\1024A |

**Received from**

Name: Larah Paragas
Position: RA
Signature:

**Received by**

Name: JOIDA PRIETO 02/03/2014
Position: SSRS
Signature:

**DATA TRANSFER SHEET**
**Feb 3, 2014**

| DATE | FLIGHT NO. | MISSION NAME | SENSOR | RAW LAS | | LOGS | POS | RAW IMAGES | MISSION LOG FILE | RANGE | DIGITIZER | BASE | | OPERATOR LOGS (OPLOG) | FLIGHT PLAN | | SERVER LOCATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Output LAS | KML (swath) | | | | | | | BASE STATION(S) | Base Info (.txt) | | Actual | KML | |
| 28-Jan-14 | 1032A | 3BLK35A028A | Aquarius | N/A | N/A | 927 KB | 54.6 MB | 24.4 GB | 246 KB | 13.7 GB | 30.1 GB | 10.8 MB | 86 BYTES | 651 BYTES | 4.09 KB | 546 KB | Y:\Airborne_Raw\1032A |
| 29-Jan-14 | 1036A | 3BLK33DS0929A | Aquarius | N/A | N/A | 541 KB | 117 MB | 27.2 GB | 201 KB | 6.12 GB | 28.7 GB | 18.2 MB | 73 BYTES | 269 BYTES | 2.86 KB | 243 KB | Y:\Airborne_Raw\1036A |
| 30-Jan-14 | 1040A | 3BLK3334V030A | Aquarius | N/A | N/A | 724 KB | 217 MB | 16.2 GB | 302 KB | 9.33 GB | 1.14 GB | 11.7 MB | 305 BYTES | 1.46 KB | 6.89 KB | 366 KB | Y:\Airborne_Raw\1040A |

**Received from**

Name Patricia alcantara

Position KA

Signature

**Received by**

Name JOIDA F. PRIETO

Position SSRS

Signature

**DATA TRANSFER SHEET**
**5/22/2014 (Leyte Ongoing)**

| 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 | |
| 4/20/2014 | 1358A | 3BLK34F110A | AQUARIUS | NA | NA | 1.17MB | 243MB | 63.3/10.7GB | 3/510/67KB | 14.1GB | NA | 12.1MB | 1KB | 1KB | 6KB | 773/12KB | Z:\Airborne_Raw\1358A |
| 4/20/2014 | 1360A | 3BLK34FS110B | AQUARIUS | NA | NA | 7.75MB | 174MB | 41.1GB | 206KB | 8.26GB | NA | 11.3MB | 1KB | 1KB | 6KB | 649/12KB | Z:\Airborne_Raw\1360A |
| 4/22/2014 | 1366A | 3BLK34E112A | AQUARIUS | NA | NA | 1.37MB | 257MB | 95.5GB | 418/1/263KB | 14.9GB | NA | 8.53MB | 1KB | 1KB | 5KB | 889/10KB | Z:\Airborne_Raw\1366P |
| 5/11/2014 | 1442A | 3BLK33GS131A | AQUARIUS | NA | NA | 5.86MB | 275MB | 108GB | 59/697/KB | 16.6GB | NA | 14.3MB | 1KB | 1KB | NA | 2652KB | Z:\Airborne_Raw\1442A |
| 5/11/2014 | 1444A | 3BLK33GSH131B | AQUARIUS | NA | NA | 2.82MB | 254MB | 79.3GB | 1/1/515/1/139KB | 15.2GB | 229GB | 14.3MB | 1KB | 1KB | 5/5KB | 2813/700KB | Z:\Airborne_Raw\1444A |
| 5/13/2014 | 1450A | 3BLK33HS133A | AQUARIUS | NA | NA | 906KB | 132MB | 34.1GB | 257KB | 6.07GB | 87.0GB | 10.5MB | 1KB | 1KB | 5KB | 1019KB | Z:\Airborne_Raw\1450A |
| 5/13/2014 | 1452A | 3BLK33HSES133B | AQUARIUS | NA | NA | 2.33MB | 233MB | 47.1GB | 1/415KB | 9.57GB | 86.8GB | 11.2MB | 1KB | 1KB | 6/10KB | 512KB | Z:\Airborne_Raw\1452A |
| 5/14/2014 | 1454A | 3BLK34D134A | AQUARIUS | NA | NA | 1.88MB | 268MB | 15.7/71.5GB | 23/102/517KB | 14.6GB | 206GB | 8.41MB | 1KB | 1KB | 5/2KB | 1522KB | Z:\Airborne_Raw\1454A |
| 5/14/2014 | 1456A | 3BLK34C134B | AQUARIUS | NA | NA | 0.98MB | 212MB | 66.6GB | 278/226KB | 11.6GB | 58.6GB | 7.92MB | 1KB | 1KB | 5KB | 641KB | Z:\Airborne_Raw\1456P |
| 5/15/2014 | 1460A | 3BLK35CD135B | AQUARIUS | NA | NA | 1.24MB | 273MB | 74.8GB | 622KB | 14.7GB | 235GB | 11.4MB | 1KB | 1KB | 5/5KB | 476/807KB | Z:\Airborne_Raw\1460A |
| 5/16/2014 | 1462A | 3BLK35DSE136A | AQUARIUS | NA | NA | 1.29MB | 275MB | 91.2GB | 685KB | 15.2GB | NA | 11.6MB | 1KB | 1KB | 5/4KB | 842KB | Z:\Airborne_Raw\1462A |
| 5/16/2014 | 1464A | 3BLK35ES136B | AQUARIUS | NA | NA | 1.20MB | 251MB | 76.9GB | 637KB | 14.0GB | NA | 11.4MB | 1KB | 1KB | 4KB | 786KB | Z:\Airborne_Raw\1464A |

**Received from**

Name: Dan Aldovino
Position: Research Associate
Signature:

**Received by**

Name: JOIDA F. PRIETO
Position: SSRS
Signature:
5/28/2014

**DATA TRANSFER SHEET**
**06/10/2014(Samar on-going)**

| DATE | FLIGHT NO. | MISSION NAME | SENSOR | RAW LAS | | LOGS(MB) | POS | RAW IMAGES/CASI | MISSION LOG FILE/CASI LOGS | RANGE | DIGITIZER | BASE STATION(S) | | OPERATOR LOGS (OPLOG) | FLIGHT PLAN | | SERVER LOCATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Output LAS | KML (swath) | | | | | | | BASE STATION(S) | Base Info (.txt) | | Actual | KML | |
| 5/15/2014 | 1458A | 3BLK35B135A | AQUARIUS | na | 730 | 2.24 | 277 | 81.7 | 593 | 13.3 | NA | 14.6 | 1KB | 1KB | 6 | 13 | Z:\Airborne_Raw\1458A |
| 5/17/2014 | 1466A | 3BLK35F137A | AQUARIUS | na | 883 | 1.29 | 284 | 94.7 | 136/563 | 16 | 181 | 7.95 | 1KB | 1KB | 4 | NA | Z:\Airborne_Raw\1466A |
| 5/19/2014 | 1474A | 3BLK35G139A | AQUARIUS | na | 1484 | 1.61 | 291 | 80.2 | 599 | 14 | 218 | 9.7 | 1KB | 1KB | 6 | NA | Z:\Airborne_Raw\1474A |
| 5/24/2014 | 1494A | 3BLK35GSH144A | AQUARIUS | na | 812/599 | 1.25 | 282 | 89.2 | 656 | 14.7 | 162 | 7.64 | 1KB | 1KB | 5 | NA | Z:\Airborne_Raw\1494A |
| 5/25/2014 | 1498A | 3BLK35HSI145A | AQUARIUS | na | 1622 | 1.7 | 282 | 88.7 | 654 | 3.23 | 9.47 | 8.04 | 1KB | 1KB | 5 | NA | Z:\Airborne_Raw\1498A |
| 5/26/2014 | 1502A | 3BLK35IS146A | AQUARIUS | na | 766 | 1.2 | 278 | 86.7 | 404 | 13.9 | 107 | 15.7 | 1KB | 1KB | 5 | NA | Z:\Airborne_Raw\1502A |
| 5/26/2014 | 1504A | 3BLK35AIS146B | AQUARIUS | na | 513/850 | 1.37 | 265 | 61.3 | 480 | 11.4 | 20.9 | 15.7 | 1KB | 1KB | 5 | NA | Z:\Airborne_Raw\1504A |
| 5/27/2014 | 1506A | 3BLK33U147A | AQUARIUS | na | 864 | 1.34 | 276 | 97.2 | 737 | 14.4 | 56.2/32.5 | 15 | 1KB | 1KB | 4 | NA | Z:\Airborne_Raw\1506A |
| 5/27/2014 | 1508A | 3BLK33UST147B | AQUARIUS | na | 249/1243 | 2 | 232 | 8.1/53.6 | 63/409 | 11.5 | NA | 15 | 1KB | 1KB | 5 | NA | Z:\Airborne_Raw\1508A |
| 5/28/2014 | 1510A | 3BLK33TSV148A | AQUARIUS | na | 815/172 | 1.61 | 269 | 114 | 534 | 18.5 | 155 | 6.85 | 1KB | 1KB | 5 | NA | Z:\Airborne_Raw\1510A |

**Received from**

Name C. JOAQUIN
Position FA
Signature

**Received by**

Name JOIDA F. PRIETO 6/10/14
Position SSRS
Signature

DATA TRANSFER SHEET
6/19/2014 (Samar - Leyte)

| 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 | |
| 30-May-14 | 1520A | 3BLK33VSS150A | Aquarius | NA | 424/602 | 1.48 | 289 | 88.5 | 748 | 14 | 164 | 10.5 | 1KB | 1KB | 4 | NA | X:\Airborne_Raw\1520A |
| 31-May-14 | 1522A | 3BLK33SS151A | Aquarius | NA | 288 | 469KB | 112 | 9.78/21 | 164/69 | 4.87 | 59.1 | 4.53 | 1KB | 1KB | 5 | NA | X:\Airborne_Raw\1522A |
| 1-Jun-14 | 1526A | 3BLK33SSR152A | Aquarius | NA | 456/784 | 1.68 | 277 | 119 | 403 | 15.5 | 204 | 8.36 | 1KB | 1KB | 6 | NA | X:\Airborne_Raw\1526A |
| 2-Jun-14 | 1530A | 3BLK33RSQ153A | Aquarius | NA | 353/605 | 1.48 | 254 | 30.9/80.2 | 555/246 | 15.6 | 165 | 7.88 | 1KB | 1KB | 3 | NA | X:\Airborne_Raw\1530A |
| 3-Jun-14 | 1534A | 3BLK33QS154A | Aquarius | NA | 1175 | 1.49 | 250 | 56.9/35.1 | 399/154 | 14.5 | 114/95.5 | 6.6 | 1KB | 1KB | 7 | NA | X:\Airborne_Raw\1534A |
| 7-Jun-14 | 1550A | 3BLK33P158A | Aquarius | NA | 657 | 1.03 | 199 | 52.9 | na | 10.8 | 149 | 7 | 1KB | 1KB | 3 | NA | X:\Airborne_Raw\1550A |
| 8-Jun-14 | 1554A | 3BLK33PSM159A | Aquarius | NA | 533/1012 | 1.78 | 257 | 99.8 | 695 | 14.5 | 27.2/59/32.2 | 16.4 | 1KB | 1KB | 3 | NA | X:\Airborne_Raw\1554A |
| 8-Jun-14 | 1556A | 3BLK33MS159B | Aquarius | NA | 982 | 1.52 | 291 | 97.2 | 477 | 15.9 | 216 | 16.4 | 1KB | 1KB | 5 | NA | X:\Airborne_Raw\1556A |
| 9-Jun-14 | 1558A | 3BLK33J160A | Aquarius | NA | 833 | 1.27 | 277 | 95.7 | 452 | 14.2 | 95.6/80.5 | 16.1 | 1KB | 1KB | 4 | NA | X:\Airborne_Raw\1558A |
| 9-Jun-14 | 1560A | 3BLK33J | Aquarius | NA | 1583 | 1.67 | 223 | 72.2 | 357 | 12.1 | 123 | 16.1 | 1KB | 1KB | 5 | NA | X:\Airborne_Raw\1560A |

Received from

Name O. JOAQUIN
Position DA
Signature

Received by

Name JOIDA PRIETO
Position SSRS
Signature

6/19/14

# Annex 6. Flight Logs for the Flight Missions

Flight Log for 1016A Mission

**DREAM Data Acquisition Flight Log** Flight Log No.: 1016

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: JC Aldovino | 2 ALTM Model: Aquarius | 3 Mission Name: 3BLK34 63A | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: RP-C9022 |
| 7 Pilot: | 8 Co-Pilot: | 9 Route: | | | |
| 10 Date: Jan 24, 2014 | 12 Airport of Departure (Airport, City/Province): Tacloban City | | 12 Airport of Arrival (Airport, City/Province): Tacloban City | | |
| 13 Engine On: 1220 | 14 Engine Off: 1520 | 15 Total Engine Time: 3+00 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather | | | | | |
| 20 Remarks: lines cut due to terrain on the east side | | | | | |

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
JEFFREY ALAJAR
Signature over Printed Name

Lidar Operator
Signature over Printed Name

Flight Log for 1018A Mission

**DREAM Data Acquisition Flight Log** — **Flight Log No.:** 1018

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: Pearl Mars | 2 ALTM Model: Aquarius | 3 Mission Name: 3BLK33A024B | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: RP-C9122 |
| 7 Pilot: | 8 Co-Pilot: | 9 Route: | | | |
| 10 Date: Jan 24, 2014 | 12 Airport of Departure (Airport, City/Province): Tacloban City | | 12 Airport of Arrival (Airport, City/Province): Tacloban City | | |
| 13 Engine On: 1550 | 14 Engine Off: 1744 | 15 Total Engine Time: 1+54 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather | | | | | |

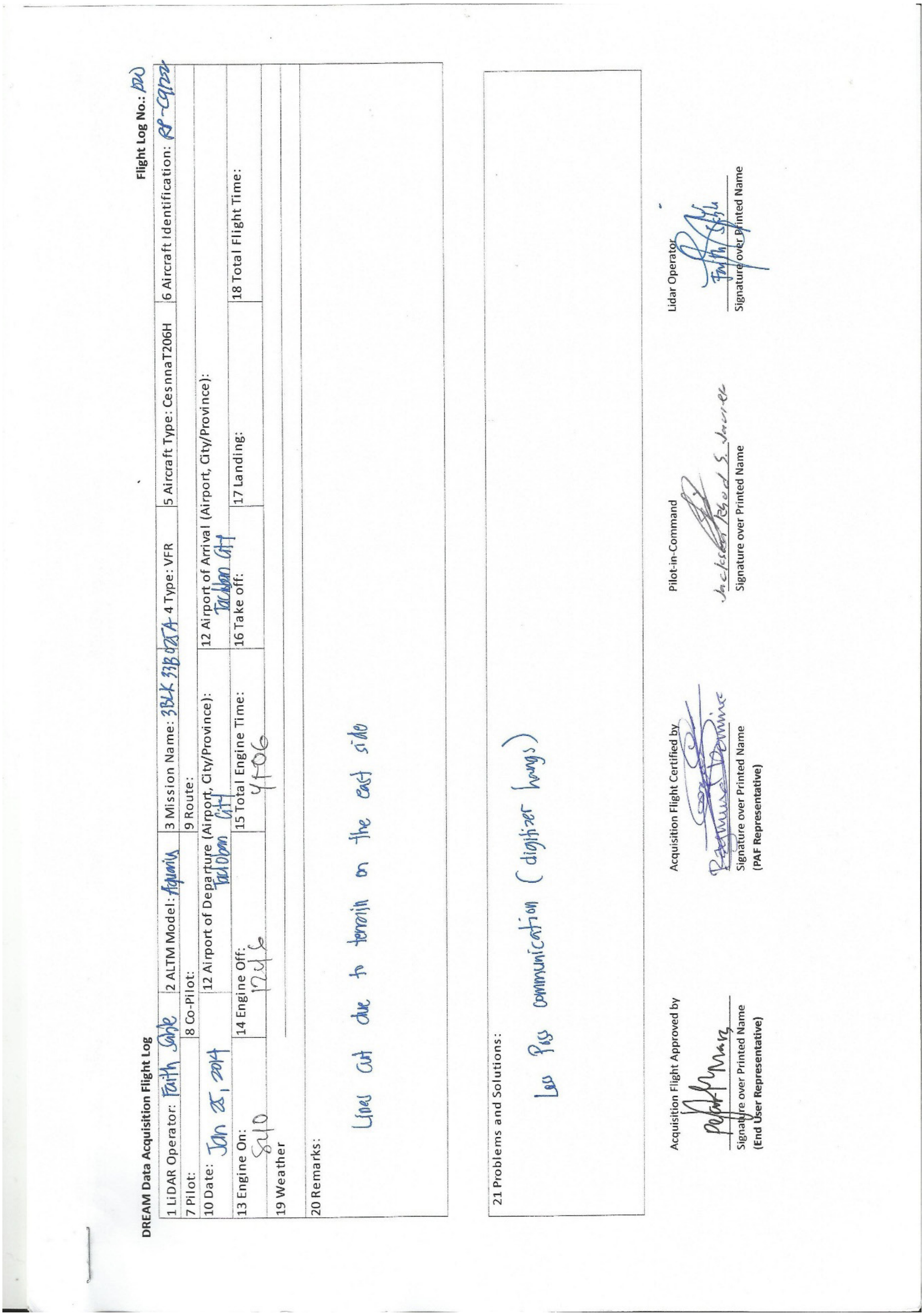
20 Remarks:

Lines cut due to terrain on the east side

21 Problems and Solutions:

| Acquisition Flight Approved by | Acquisition Flight Certified by | Pilot-in-Command | Lidar Operator |
|---|---|---|---|
| Pearl Mars | Raymund [illegible] Domin[illegible] | JEFFREY [illegible] Y ALAJAR | |
| Signature over Printed Name (End User Representative) | Signature over Printed Name (PAF Representative) | Signature over Printed Name | Signature over Printed Name |

Flight Log for 1020A Mission



**DREAM Data Acquisition Flight Log**

Flight Log No.: 1020

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: Faith Sable | 2 ALTM Model: Aquarius | 3 Mission Name: 3BLK 33B 025A | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: RP-C9122 |
| 7 Pilot: | 8 Co-Pilot: | 9 Route: | | | |
| 10 Date: Jan 25, 2014 | 12 Airport of Departure (Airport, City/Province): Tacloban City | 12 Airport of Arrival (Airport, City/Province): Tacloban City | | | |
| 13 Engine On: 810 | 14 Engine Off: 1216 | 15 Total Engine Time: 4+06 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather | | | | | |

20 Remarks:

Lines cut due to terrain on the east side

21 Problems and Solutions:

Lcs Pos communication (digitizer hangs)

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 — Faith Sable — Signature over Printed Name

Flight Log for 1024A Mission

**DREAM Data Acquisition Flight Log** **Flight Log No.:** 1024

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: Pearl Mars | 2 ALTM Model: Aquarius | 3 Mission Name: 3BLK33A534A024 | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: RP-C9122 |
| 7 Pilot: | 8 Co-Pilot: | 9 Route: | | | |
| 10 Date: Jan 26, 2014 | 12 Airport of Departure (Airport, City/Province): Tacloban City | | 12 Airport of Arrival (Airport, City/Province): Tacloban City | | |
| 13 Engine On: 925 | 14 Engine Off: 1342 | 15 Total Engine Time: 4+17 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather | | | | | |

20 Remarks:

Lines cut due to terrain on the east side

21 Problems and Solutions:

Loss Pos Communication (Digitizer Hangs)

| Acquisition Flight Approved by | Acquisition Flight Certified by | Pilot-in-Command | Lidar Operator |
|---|---|---|---|
| Pearl Mars | | Jackson Rhod S. Jarre... | |
| Signature over Printed Name (End User Representative) | Signature over Printed Name (PAF Representative) | Signature over Printed Name | Signature over Printed Name |

Flight Log for 1026A Mission

**DREAM Data Acquisition Flight Log**

**Flight Log No.:** 1026

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: Dc Aldovino | 2 ALTM Model: Aquarius | 3 Mission Name: 3BLK34A5026A | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: RP-C9122 |
| 7 Pilot: | 8 Co-Pilot: | 9 Route: | | | |
| 10 Date: Jan 26, 2014 | 12 Airport of Departure (Airport, City/Province): Tacloban City | | 12 Airport of Arrival (Airport, City/Province): Tacloban City | | |
| 13 Engine On: 1515 | 14 Engine Off: 1802 | 15 Total Engine Time: 2+47 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather | | | | | |

20 Remarks:

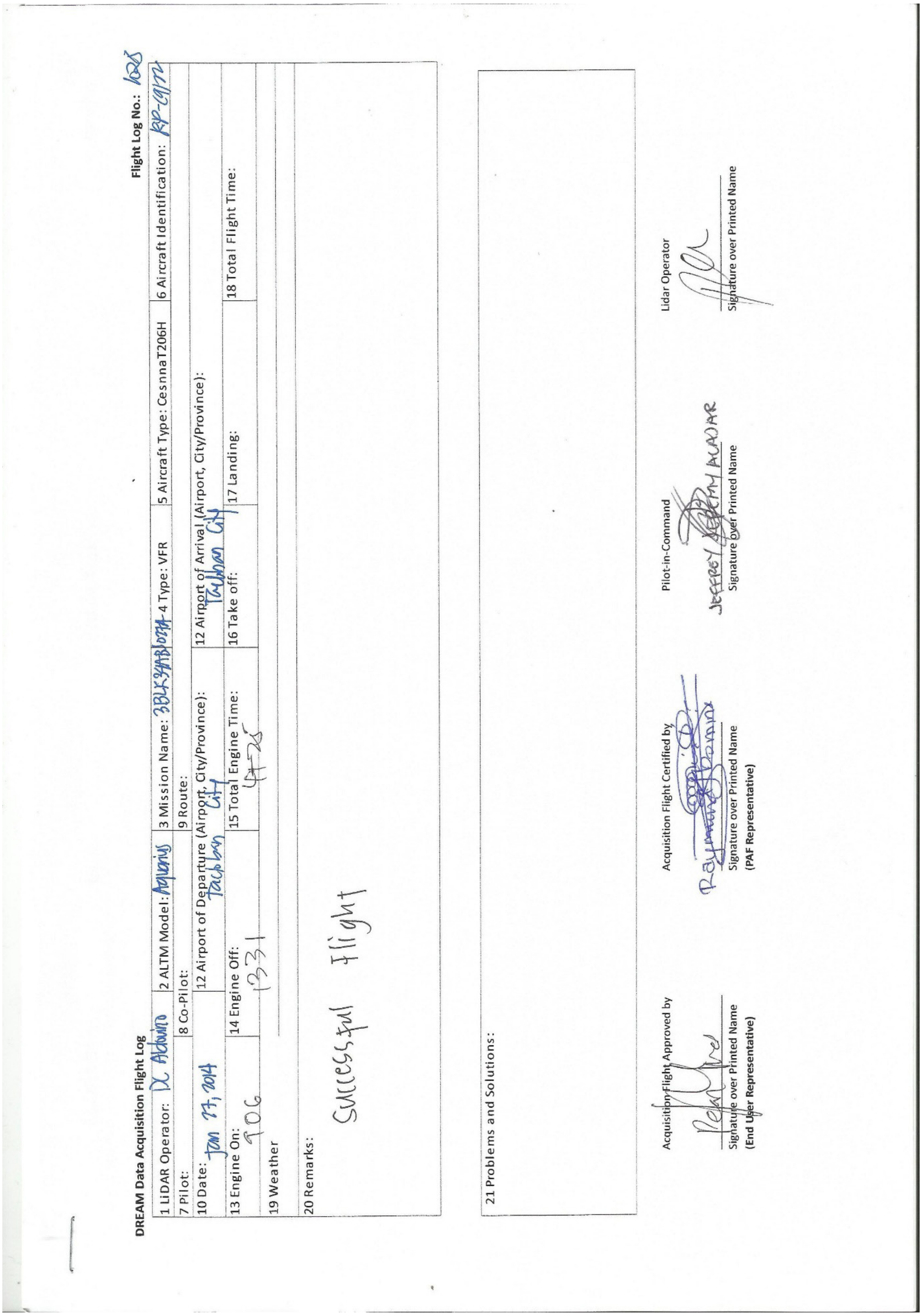
Lines cut due to terrain on the east side

21 Problems and Solutions:

Lost pos communication (digitizer hangs)

| Acquisition Flight Approved by | Acquisition Flight Certified by | Pilot-in-Command | Lidar Operator |
|---|---|---|---|
| Signature over Printed Name (End User Representative) | Signature over Printed Name (PAF Representative) | Jackson S. Javier<br>Signature over Printed Name | Signature over Printed Name |

Flight Log for 1028A Mission



**DREAM Data Acquisition Flight Log** — **Flight Log No.:** 1028

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: DC Alduino | 2 ALTM Model: Aquarius | 3 Mission Name: 3BLK34AB027A | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: RP-C9122 |
| 7 Pilot: | 8 Co-Pilot: | 9 Route: | | | |
| 10 Date: Jan 27, 2014 | 12 Airport of Departure (Airport, City/Province): Tacloban City | | 12 Airport of Arrival (Airport, City/Province): Tacloban City | | |
| 13 Engine On: 906 | 14 Engine Off: 1331 | 15 Total Engine Time: 4+25 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather | | | | | |

20 Remarks:

Successful flight

21 Problems and Solutions:

| Acquisition Flight Approved by | Acquisition Flight Certified by | Pilot-in-Command | Lidar Operator |
|---|---|---|---|
| [signature] | Raymund Dominic [signature] | JEFFREY JEREMY ALAJAR [signature] | [signature] |
| Signature over Printed Name (End User Representative) | Signature over Printed Name (PAF Representative) | Signature over Printed Name | Signature over Printed Name |

Flight Log for 1036A Mission

**DREAM Data Acquisition Flight Log**

Flight Log No.: 1036

| | | | | |
|---|---|---|---|---|
| 1 LiDAR Operator: [illegible] | 2 ALTM Model: Aquarius | 3 Mission Name: 3BLK33DS099A | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H |
| 6 Aircraft Identification: | | | | |
| 7 Pilot: | 8 Co-Pilot: | 9 Route: | | |
| 10 Date: | 12 Airport of Departure (Airport, City/Province): | 12 Airport of Arrival (Airport, City/Province): | | |
| 13 Engine On: 910 | 14 Engine Off: 1121 | 15 Total Engine Time: 2+11 | 16 Take off: | 17 Landing: |
| 18 Total Flight Time: | | | | |
| 19 Weather | | | | |

20 Remarks:

cover voids area in BLK33D & remaining lines

21 Problems and Solutions:

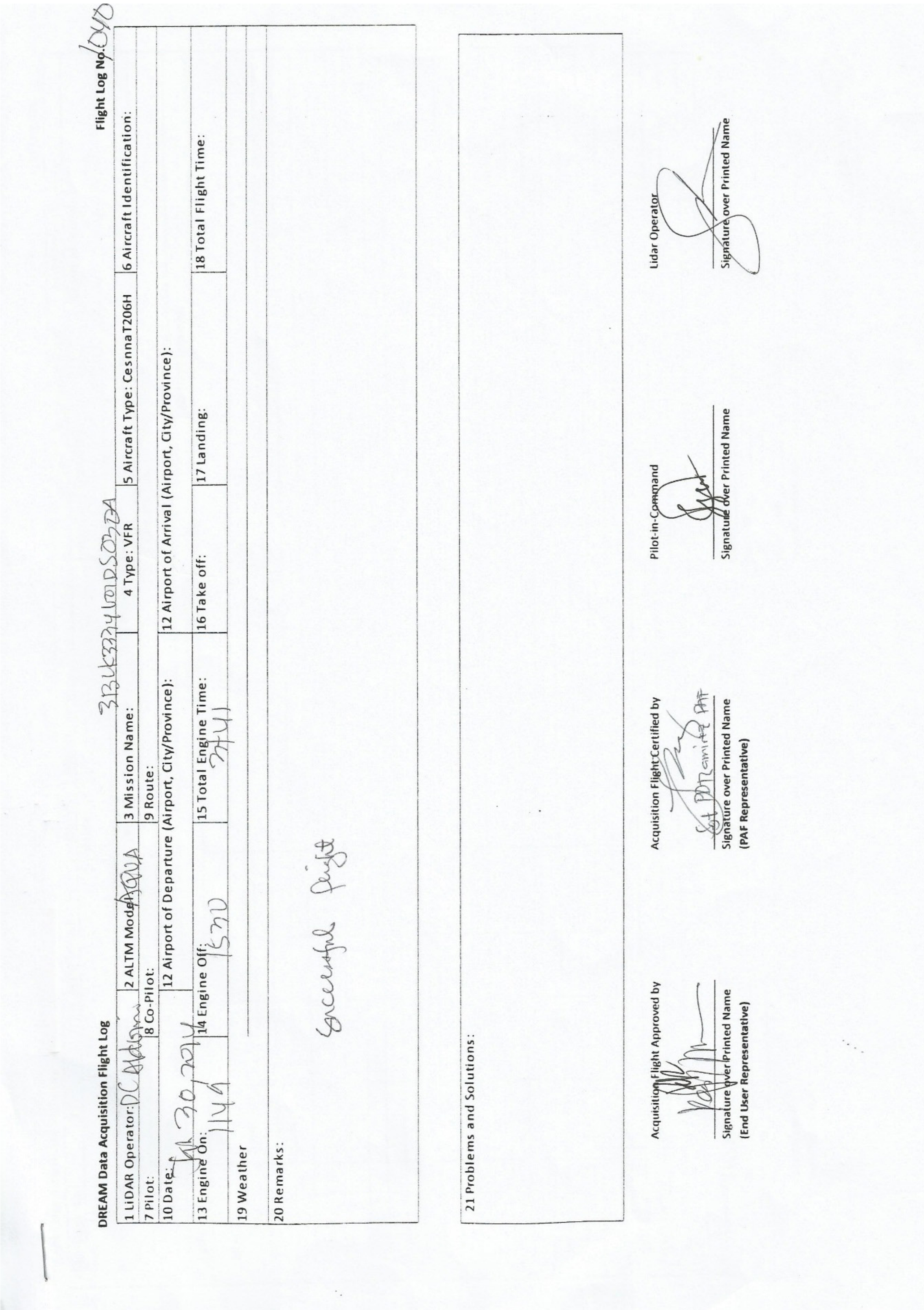
Acquisition Flight Approved by: [illegible signature]
Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by: [illegible signature]
Signature over Printed Name
(PAF Representative)

Pilot-in-Command: [illegible signature]
Signature over Printed Name

Lidar Operator: [illegible signature]
Signature over Printed Name

Flight Log for 1040A Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 1040

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: DC [illegible] | 2 ALTM Model: AQUA | 3 Mission Name: 3BLK33Y401DS023A | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: |
| 7 Pilot: | 8 Co-Pilot: | 9 Route: | | | |
| 10 Date: Jul 30, 2014 | 12 Airport of Departure (Airport, City/Province): | | 12 Airport of Arrival (Airport, City/Province): | | |
| 13 Engine On: 1149 | 14 Engine Off: 1520 | 15 Total Engine Time: 3+41 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather | | | | | |
| 20 Remarks: Successful flight | | | | | |
| 21 Problems and Solutions: | | | | | |

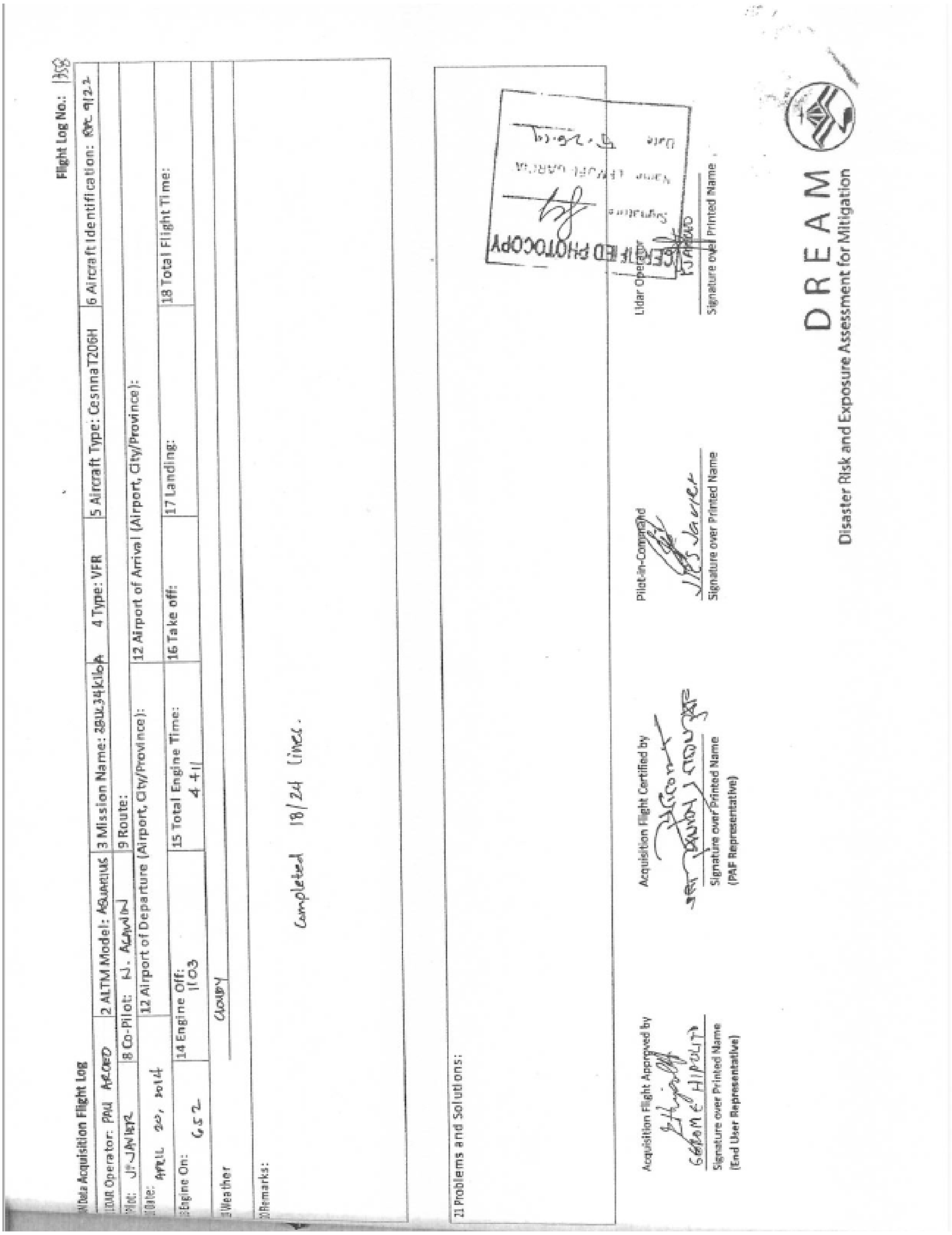
Acquisition Flight Approved by
Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by
Sgt [illegible] PAF
Signature over Printed Name
(PAF Representative)

Pilot-in-Command
Signature over Printed Name

Lidar Operator
Signature over Printed Name

Flight Log for 1358A Mission



Flight Log No.: 1358

Data Acquisition Flight Log

| | | | | | |
|---|---|---|---|---|---|
| LiDAR Operator: PAU ARCEO | 2 ALTM Model: AQUARIUS | 3 Mission Name: 2BLK34K16A | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: RPC 9122 |
| Pilot: J. JAVIER | 8 Co-Pilot: N. ACAYAN | 9 Route: | | | |
| Date: APRIL 20, 2014 | 12 Airport of Departure (Airport, City/Province): | | 12 Airport of Arrival (Airport, City/Province): | | |
| Engine On: 652 | 14 Engine Off: 1103 | 15 Total Engine Time: 4+11 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| Weather | CLOUDY | | | | |

Remarks:

Completed 18/24 lines.

21 Problems and Solutions:

CERTIFIED PHOTOCOPY
Signature
Name
Date

| | | | |
|---|---|---|---|
| Acquisition Flight Approved by | Acquisition Flight Certified by | Pilot-in-Command | Lidar Operator |
| GEROME HIPOLITO | | J. JAVIER | P. ARCEO |
| Signature over Printed Name (End User Representative) | Signature over Printed Name (PAF Representative) | Signature over Printed Name | Signature over Printed Name |

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Flight Log for 1360A Mission

Flight Log No.: 1360

**DREAM Data Acquisition Flight Log**

| | | | | | |
|---|---|---|---|---|---|
| 1 LIDAR Operator: EJ SABLE | 2 ALTM Model: Aquarius | 3 Mission Name: 2BLK54KS110B | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: RPC 9122 |
| 7 Pilot: J. JAVIER | 8 Co-Pilot: N. AGAWIN | 9 Route: | | | |
| 10 Date: APRIL 20, 2014 | 12 Airport of Departure (Airport, City/Province): | | 12 Airport of Arrival (Airport, City/Province): | | |
| 13 Engine On: 1322 | 14 Engine Off: 1645 | 15 Total Engine Time: 3+23 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather: Cloudy | | | | | |

20 Remarks:

Completed 8 lines left from the first mission.

21 Problems and Solutions:

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

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

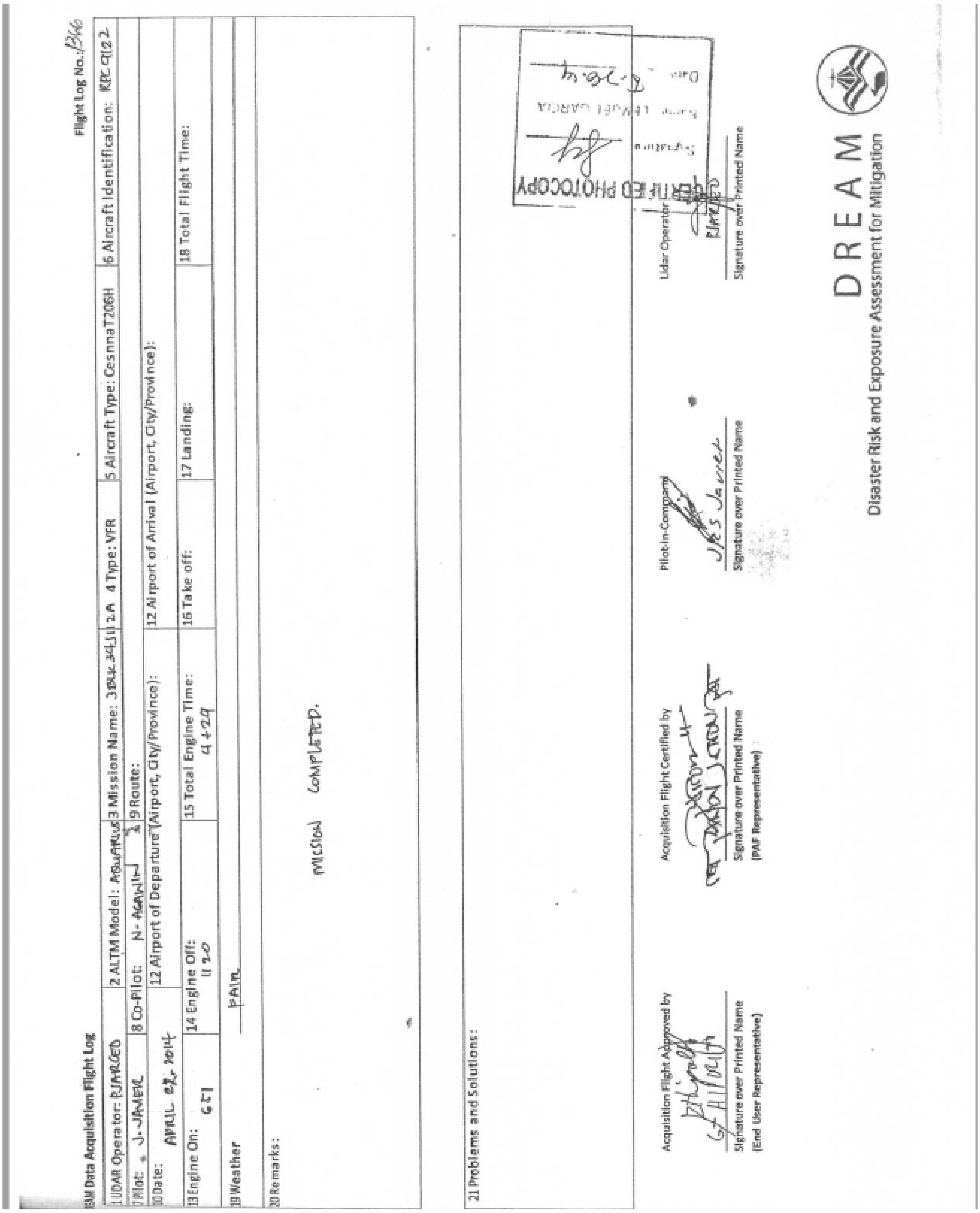
Pilot-in-Command: J. Javier — Signature over Printed Name

Lidar Operator: EJ SABLE — Signature over Printed Name

DREAM

Disaster Risk and Exposure Assessment for Mitigation

Flight Log for 1366A Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 1366

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: RJARGED | 2 ALTM Model: AQUARIUS | 3 Mission Name: 3BLK34S112A | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: RPC9122 |
| 7 Pilot: J. JAVIER | 8 Co-Pilot: N. AGAWIN | 9 Route: | | | |
| 10 Date: APRIL 22, 2014 | 12 Airport of Departure (Airport, City/Province): | | 12 Airport of Arrival (Airport, City/Province): | | |
| 13 Engine On: 651 | 14 Engine Off: 1120 | 15 Total Engine Time: 4+29 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather: FAIR | | | | | |

20 Remarks:

MISSION COMPLETED.

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 — J. Javier — Signature over Printed Name

Lidar Operator — RJARGED — Signature over Printed Name

CERTIFIED PHOTOCOPY

DREAM

Disaster Risk and Exposure Assessment for Mitigation

Flight Log for 1454A Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 1454

| | | | | | |
|---|---|---|---|---|---|
| 1 LIDAR Operator: ICD LOZAG | 2 ALTM Model: AQUA | 3 Mission Name: | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: |
| 7 Pilot: J. JAVIER | 8 Co-Pilot: N. ACAWIN | 9 Route: | | | |
| 10 Date: 14 May 2014 | 12 Airport of Departure (Airport, City/Province): | | 12 Airport of Arrival (Airport, City/Province): | | |
| 13 Engine On: 749 | 14 Engine Off: 1218 | 15 Total Engine Time: 4+29 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather | | | | | |

20 Remarks:

Completed mission over BLK34D and voids over BLK34N

21 Problems and Solutions:

Acquisition Flight Approved by

Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by

Signature over Printed Name
(PAF Representative)

Pilot-in-Command

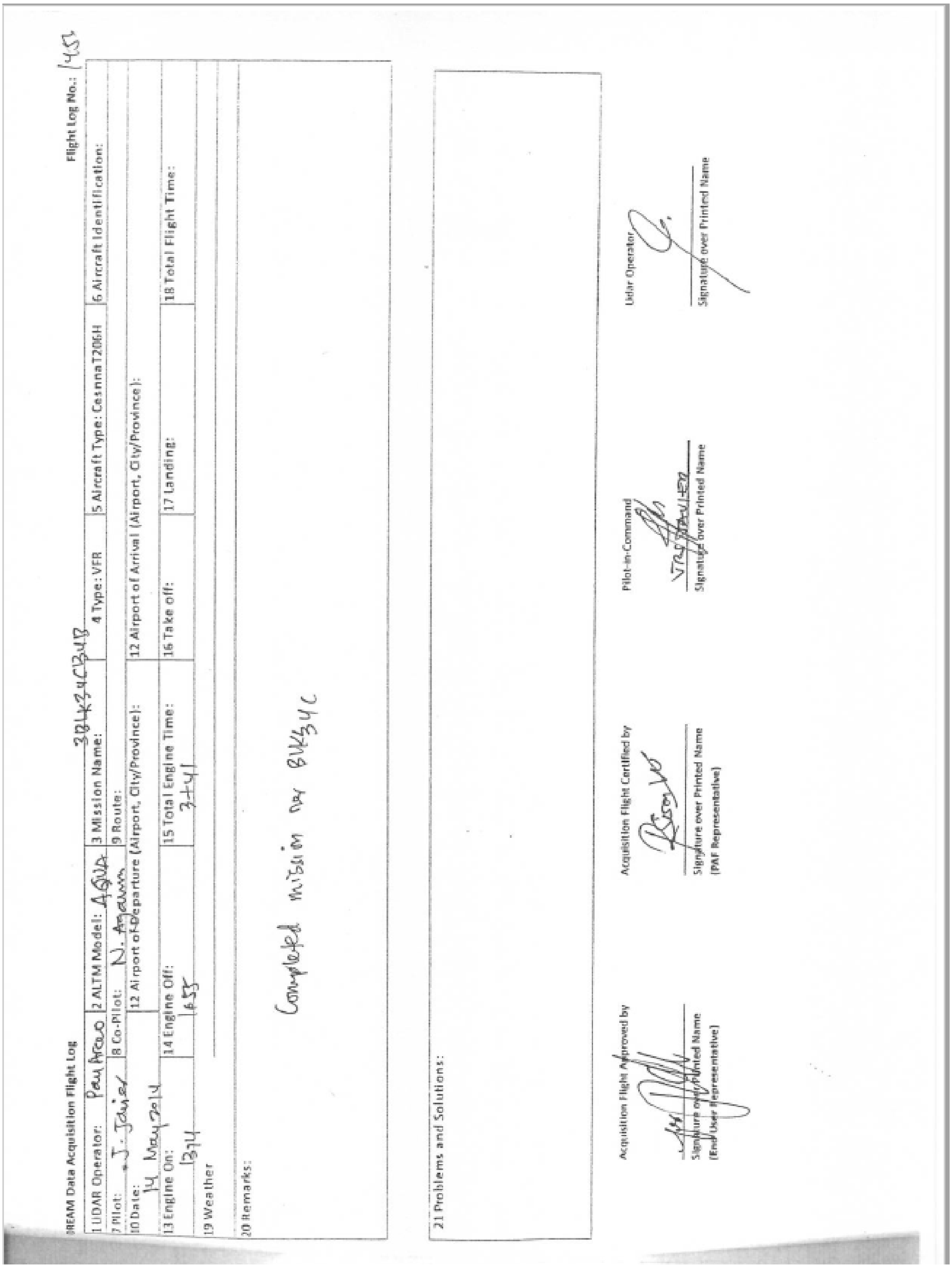
Signature over Printed Name

Lidar Operator

Signature over Printed Name

DREAM

Flight Log for 1456A Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 1456

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: Paul Arceo | 2 ALTM Model: AQUA | 3 Mission Name: 3BLK34CB4B | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: |
| 7 Pilot: J. Javier | 8 Co-Pilot: N. Aquino | 9 Route: | | | |
| 10 Date: 14 May 2014 | 12 Airport of Departure (Airport, City/Province): | | 12 Airport of Arrival (Airport, City/Province): | | |
| 13 Engine On: 1314 | 14 Engine Off: 1655 | 15 Total Engine Time: 3+41 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather | | | | | |

20 Remarks:

Completed mission for BLK34C

21 Problems and Solutions:

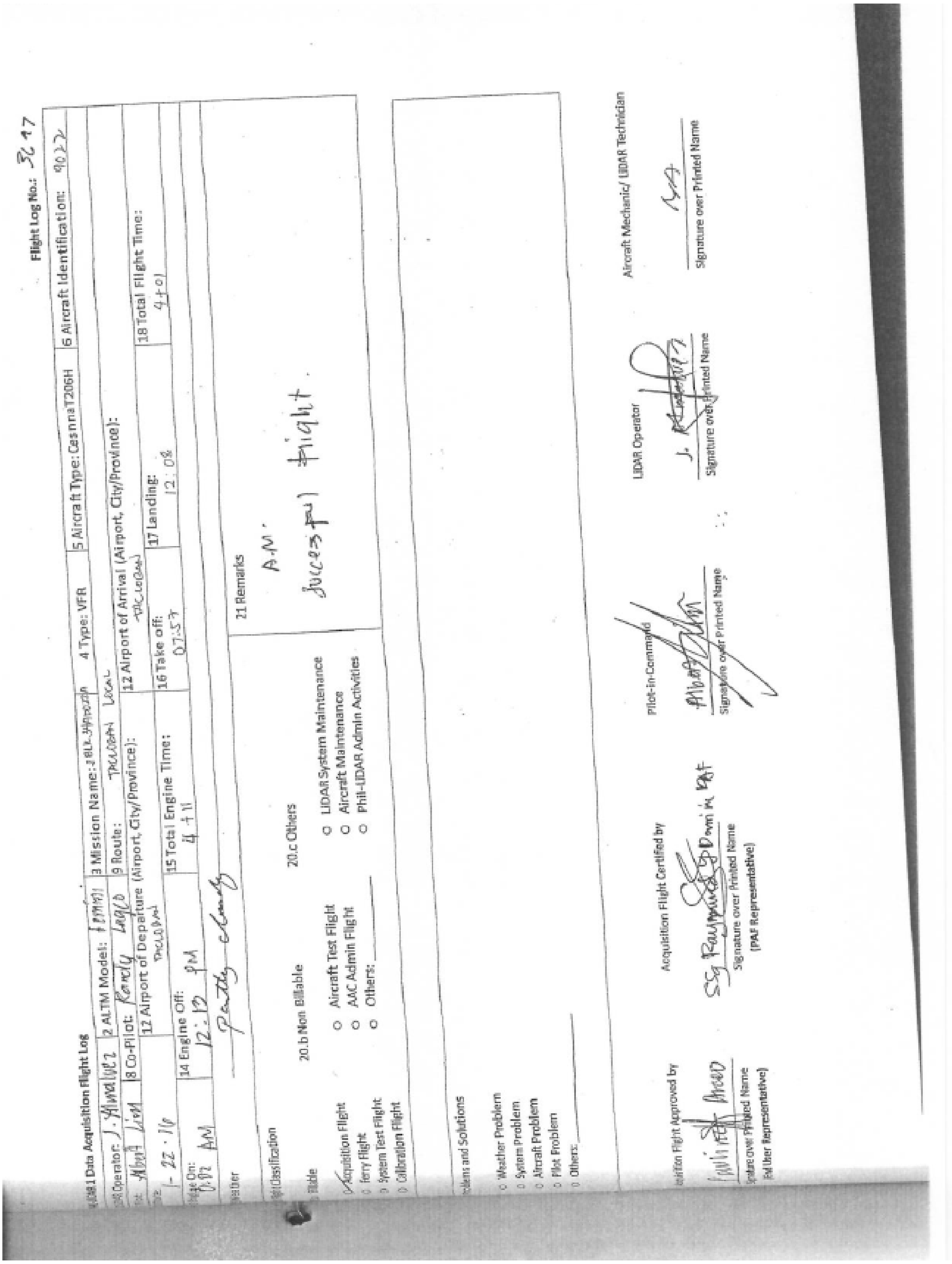
Acquisition Flight Approved by — Signature over Printed Name (End User Representative)

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

Pilot-in-Command — Signature over Printed Name

Lidar Operator — Signature over Printed Name

Flight Log for 3697 (renamed 3765G) Mission



Flight Log No.: 3697

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR 1 Data Acquisition Flight Log | | 3 Mission Name: 2BLK34H022A | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: 9022 |
| Operator: J. Almalvez | 2 ALTM Model: Pegasus | 9 Route: Tacloban Local | | | |
| Pilot: Albert Lim | 8 Co-Pilot: Randy Lagco | 12 Airport of Departure (Airport, City/Province): Tacloban | 12 Airport of Arrival (Airport, City/Province): Tacloban | | |
| Date: 1-22-16 | | | 16 Take off: 07:57 | 17 Landing: 12:08 | 18 Total Flight Time: 4+01 |
| Engine On: 8:02 AM | 14 Engine Off: 12:13 PM | 15 Total Engine Time: 4+11 | | | |
| Weather: Partly cloudy | | | | | |

Flight Classification

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

A.M.

Successful flight.

Problems and Solutions
- Weather Problem
- System Problem
- Aircraft Problem
- Pilot Problem
- Others: ______

Acquisition Flight Approved by: [signature] Signature over Printed Name (End User Representative)

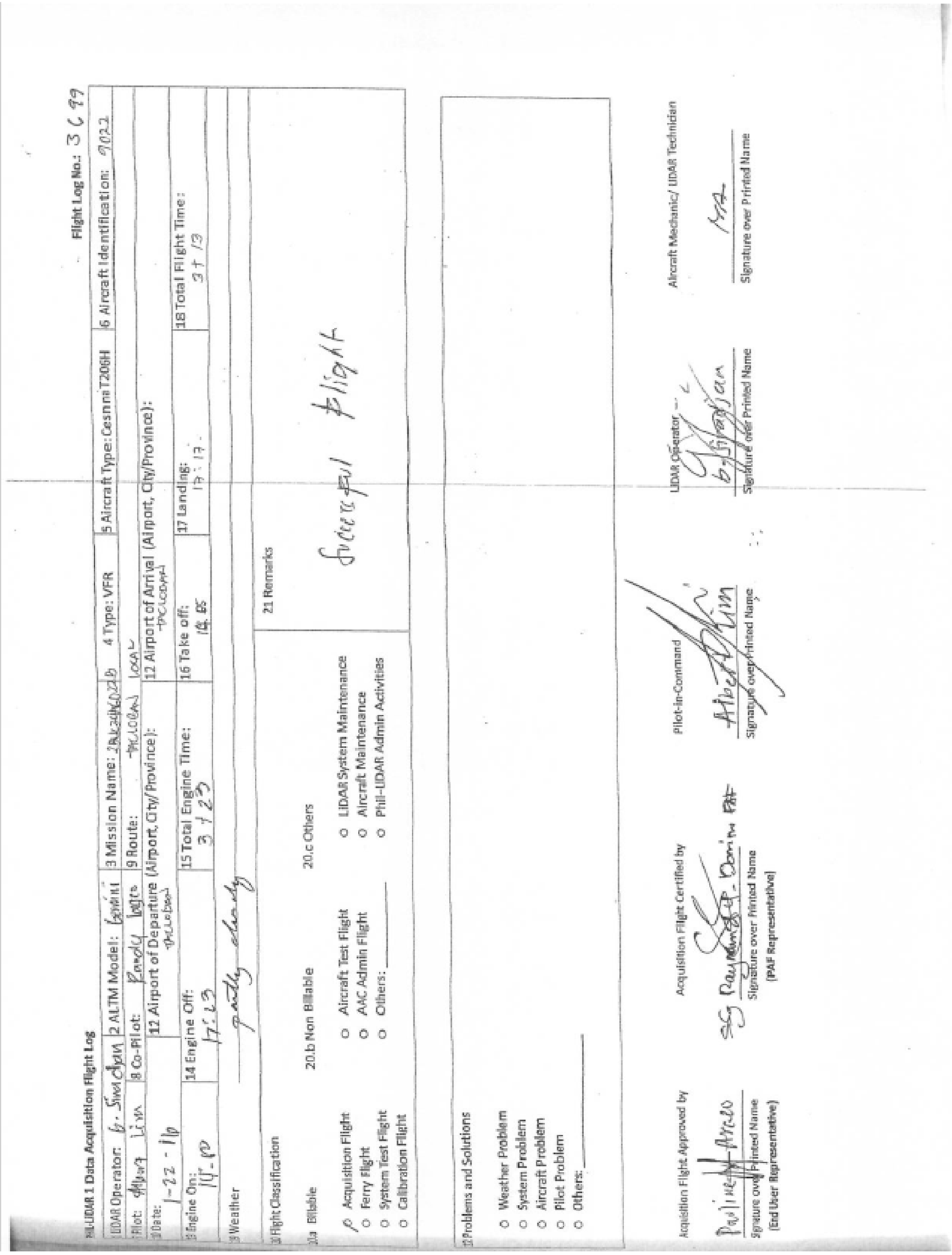
Acquisition Flight Certified by: SSg Raymund P. Domingo PAF — Signature over Printed Name (PAF Representative)

Pilot-in-Command: Albert Lim — Signature over Printed Name

LIDAR Operator: J. Almalvez — Signature over Printed Name

Aircraft Mechanic/ LIDAR Technician: [signature] Signature over Printed Name

Flight Log for 3699G (renamed 3767G) Mission



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 3699

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: G. Sinadjan | 2 ALTM Model: Gemini | 3 Mission Name: 2BLK36K022B | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: 9022 |
| 7 Pilot: Albert Lim | 8 Co-Pilot: Randy Lagco | 9 Route: Tacloban Local | | | |
| 10 Date: 1-22-16 | 12 Airport of Departure (Airport, City/Province): Tacloban | | 12 Airport of Arrival (Airport, City/Province): Tacloban | | |
| 13 Engine On: 14:00 | 14 Engine Off: 17:23 | 15 Total Engine Time: 3+23 | 16 Take off: 14:05 | 17 Landing: 17:17 | 18 Total Flight Time: 3+13 |
| 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

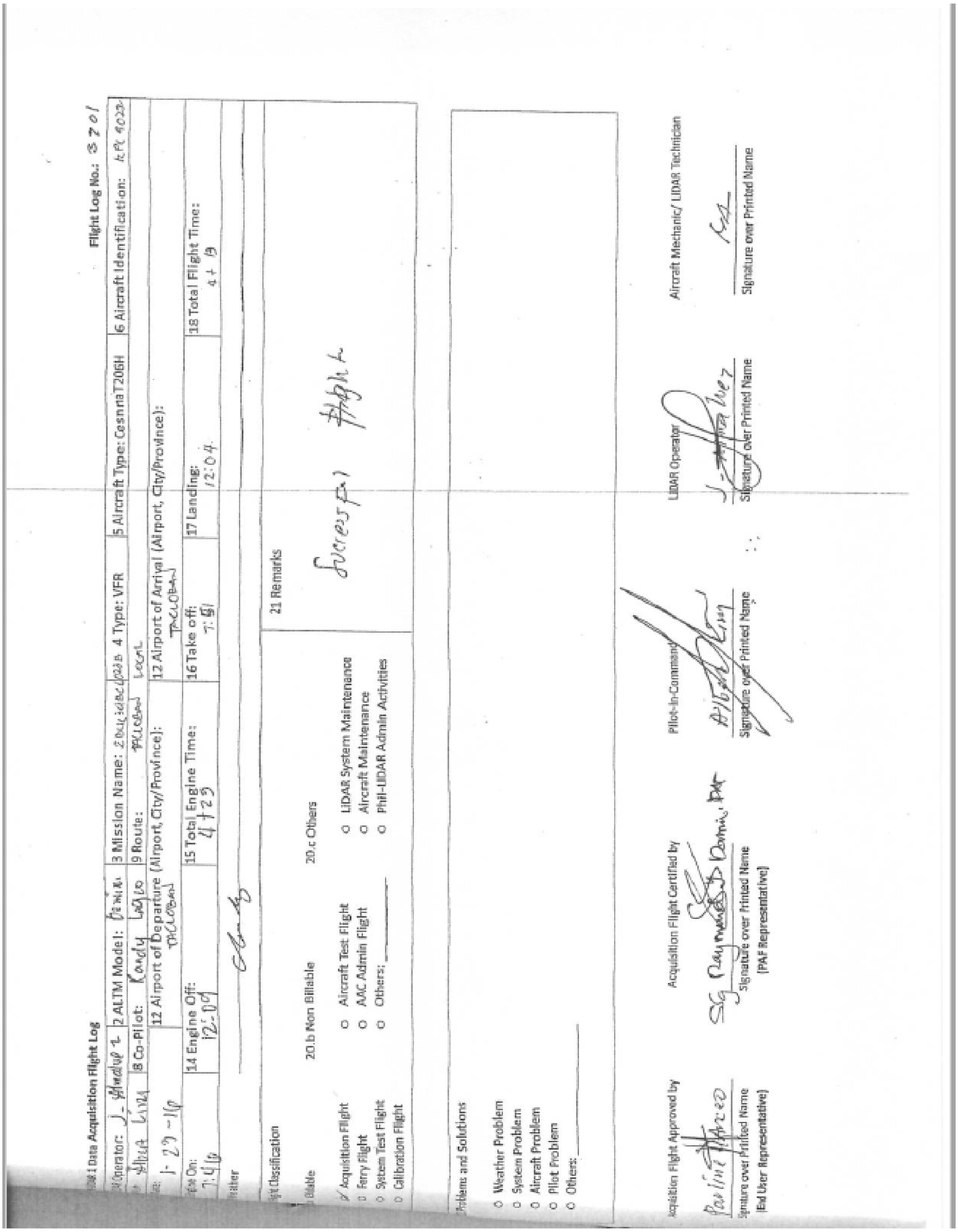
Successful flight

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

| Acquisition Flight Approved by | Acquisition Flight Certified by | Pilot-in-Command | LiDAR Operator | Aircraft Mechanic/ LiDAR Technician |
|---|---|---|---|---|
| Pauline Arceo | SSg Raymund P. Domine PAF | Albert Lim | G. Sinadjan | MA |
| Signature over Printed Name (End User Representative) | Signature over Printed Name (PAF Representative) | Signature over Printed Name | Signature over Printed Name | Signature over Printed Name |

Flight Log for 3769G Mission

Flight Log for 3701G (renamed 3771G) Mission



Data Acquisition Flight Log

Flight Log No.: 3701

| | | | | | |
|---|---|---|---|---|---|
| Operator: J. Almalvez | 2 ALTM Model: Gemini | 3 Mission Name: 2BLK30BCD028B | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: RPC 9022 |
| Albert Lim | 8 Co-Pilot: Randy Lagto | 9 Route: Tacloban Local | | | |
| Date: 1-29-16 | 12 Airport of Departure (Airport, City/Province): Tacloban | | 12 Airport of Arrival (Airport, City/Province): Tacloban | | |
| Engine On: 7:46 | 14 Engine Off: 12:09 | 15 Total Engine Time: 4+23 | 16 Take off: 7:51 | 17 Landing: 12:04 | 18 Total Flight Time: 4+13 |
| Weather | | | | | |

Flight Classification

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 flight

Problems and Solutions
- Weather Problem
- System Problem
- Aircraft Problem
- Pilot Problem
- Others: ____

Acquisition Flight Approved by: Paulin? Arceo — Signature over Printed Name (End User Representative)

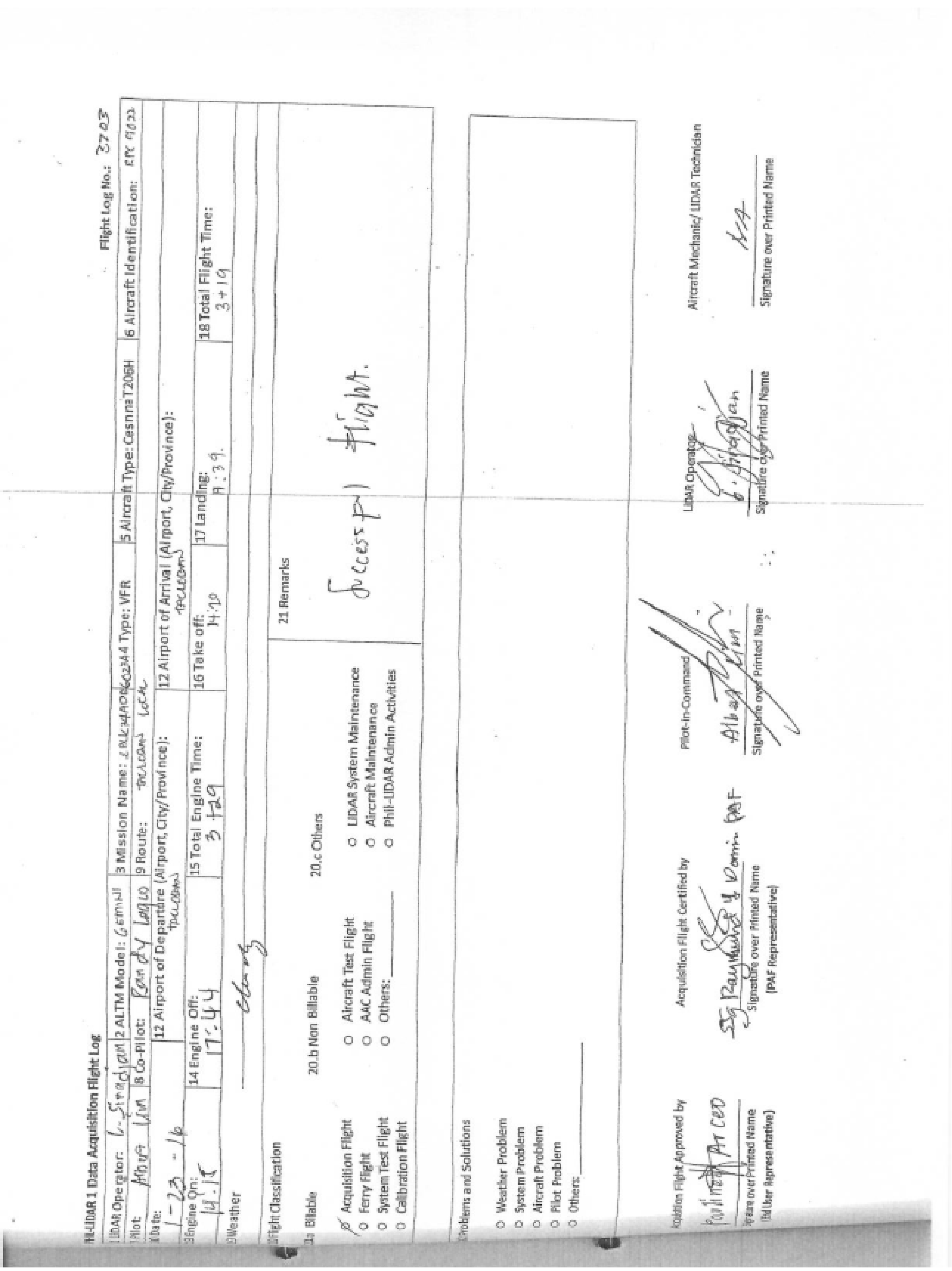
Acquisition Flight Certified by: SG Raymund D. Domin, PAF — Signature over Printed Name (PAF Representative)

Pilot-in-Command: Albert Lim — Signature over Printed Name

LiDAR Operator: J. Almalvez — Signature over Printed Name

Aircraft Mechanic/ LiDAR Technician — Signature over Printed Name

Flight Log for 3703G (renamed 3773G) Mission


PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 3703

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: L. Siradjan | 2 ALTM Model: Gemini | 3 Mission Name: 2BLK34AOE023A | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: RPC 9022 |
| 7 Pilot: Albert Lim | 8 Co-Pilot: Randy Lagco | 9 Route: Tacloban Local | | | |
| 10 Date: 1-23-16 | 12 Airport of Departure (Airport, City/Province): Tacloban | | 12 Airport of Arrival (Airport, City/Province): Tacloban | | |
| 13 Engine On: 14:15 | 14 Engine Off: 17:44 | 15 Total Engine Time: 3+29 | 16 Take off: 14:20 | 17 Landing: 17:39 | 18 Total Flight Time: 3+19 |
| 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

Successful flight.

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

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

Acquisition Flight Certified by: SSg Raymund Y Domin PAF — Signature over Printed Name (PAF Representative)

Pilot-in-Command: Albert Lim — Signature over Printed Name

LiDAR Operator: L. Siradjan — Signature over Printed Name

Aircraft Mechanic/ LiDAR Technician: N/A — Signature over Printed Name

# Annex 7. Flight Status Reports

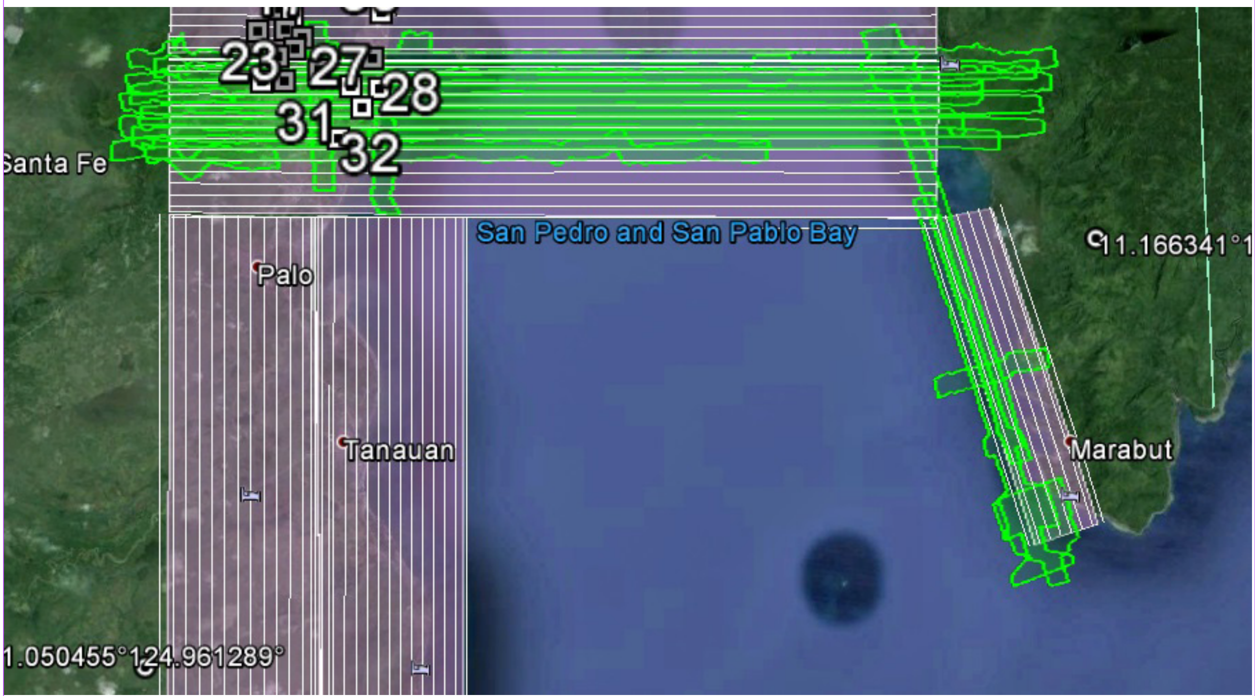
FLIGHT STATUS REPORT
CAMARINES SUR & QUEZON
(May 10-17, 2016)

| FLIGHT NO | AREA | MISSION | OPERATOR | DATE FLOWN | REMARKS |
|---|---|---|---|---|---|
| 1016A | BLK 33A AND BLK 33D | 3BLK33A024A | DC ALDOVINO | 24 Jan 14 | Lines cut due to terrain on the east side |
| 1018A | BLK 33A | 3BLK33A024B | PEARL MARS | 24 Jan 14 | Lines cut due to terrain on the east side |
| 1020A | BLK 33B | 3BLK33B025A | FAITH SABLE | 25 Jan 14 | Loss POS comm(digitizer hanged) Lines cut due to terrain on the east side |
| 1024A | BLK 33A AND BLK 34A | 3BLK33AS34A026A | PEARL MARS | 26 Jan 14 | Loss POS comm(digitizer hanged) Lines cut due to terrain on the east side |
| 1026A | BLK 34A | 3BLK34AS026A | DC ALDOVINO | 26 Jan 14 | Loss POS comm(digitizer hanged) Lines cut due to terrain on the east side |
| 1028A | BLK 34A AND BLK 34B | 3BLK 34ABS027A | DC ALDOVINO | 27 Jan 14 | Completed BLK 34A and covered some lines in BLK 34B |
| 1036A | BLK 33D | 3BLK33DS0929A | PEARL MARS | 29 Jan 14 | Remaining lines completed |
| 1040A | BLK 33 and BLK 34 voids | 3BLK3334V030A | DC ALDOVINO | 30 Jan 14 | Covered voids |
| 1358A | BLK34F | 3BLK34F110A | PJ ARCEO | 20 APR 14 | Completed 18/ 24 lines over BLK34F. |
| 1360A | BLK34F | 3BLK34FS110B | FJ SABLE | 20 APR 14 | Completed mission 8 lines left from the morning flight. |
| 1366A | BLK34E | 3BLK34E112A | PJ ARCEO | 22 APR 14 | Mission completed |
| 1454A | BLK34D BLK33E | 3BLK34D134A | IN ROXAS | 14 MAY 14 | Completed mission over BLK34D and some voids over BLK33E. |
| 1456A | BLK34D BLK33E | 3BLK34D134B | PJ ARCEO | 14 MAY 14 | Completed mission over BLK34D and voids over BLK33E. |
| 3765G | Leyte | 2BLK34AD022A | J ALMALVEZ | 22 JAN 2016 | Surveyed 7 lines at BLK34D and 10 lines at BLK34A. |
| 3767G | Leyte | 2BLK34AG022B | G SINADJAN | 22 JAN 2016 | Surveyed 7 lines at BLK34A and 16 lines at BLK34G. |
| 3769G | Leyte | 2BLK34ADEG023A | J ALMALVEZ | 23 JAN 2016 | Completed BLK34A, BLK34D and BLK 34E. Surveyed 6 lines at BLK34G. |
| 3771G | Leyte | 2BLK34BCG023B | G SINADJAN | 23 JAN 2016 | Completed BLK34B. Surveyed 10 lines at BLK34C and 4 lines at BLK34G. |
| 3773G | Leyte | 2BLK34CG024A | J ALMALVEZ | 24 JAN 2016 | Completed BLK34C and BLK34G. |

**SWATH PER FLIGHT MISSION**

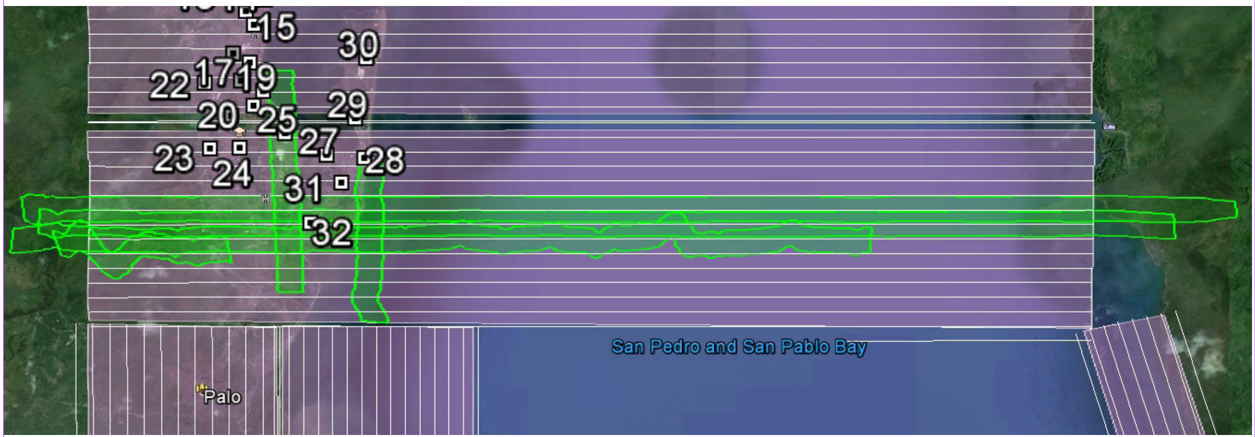
| | |
|---|---|
| Flight No. : | 1016A |
| Area: | BLK33A AND BLK 33D |
| Mission Name: | 3BLK33A024A |
| Parameters: | Alt: 600m; Scan Fz: 40; Scan angle: 25; Overlap: 40% |

**SWATH**



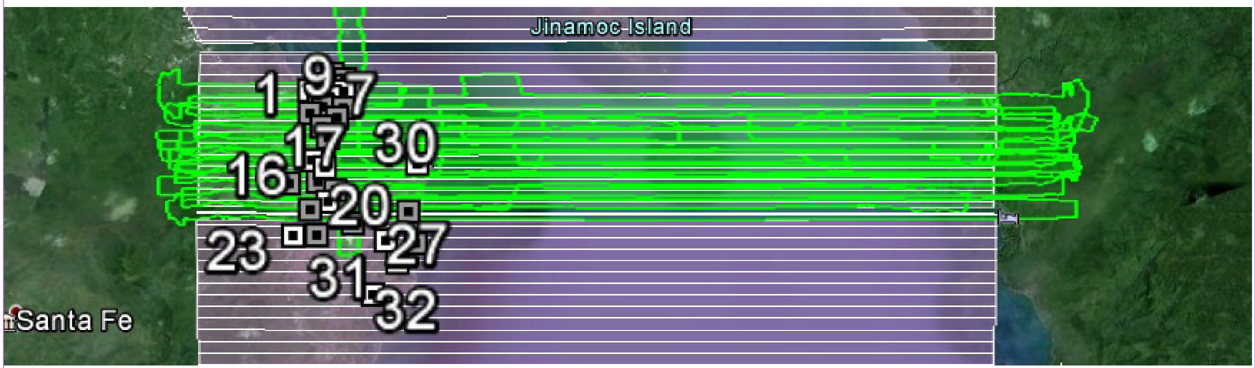
| | |
|---|---|
| Flight No. : | 1018A |
| Area: | BLK33A |
| Mission Name: | 3BLK33A024B |
| Parameters: | Alt: 600m; Scan Fz: 40; Scan angle: 25; Overlap: 40% |

**SWATH**



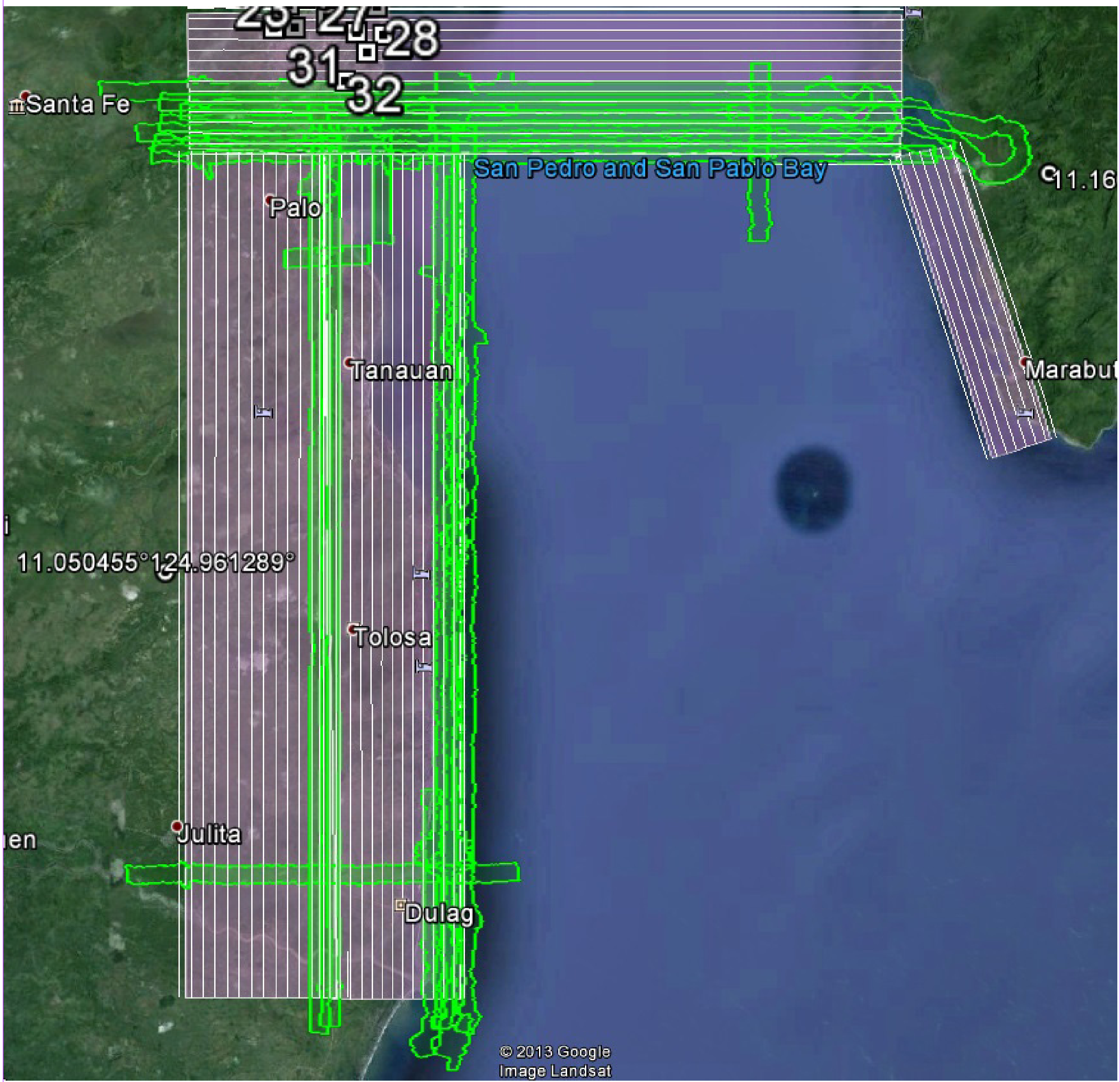
| | |
|---|---|
| Flight No. : | 1020A |
| Area: | BLK33B |
| Mission Name: | 3BLK33B025A |
| Parameters: | Alt: 600m; Scan Fz: 40; Scan angle: 25; Overlap: 40 |

**SWATH**



| | |
|---|---|
| Flight No. : | 1024A |
| Area: | BLK33B AND BLK34A |
| Mission Name: | 3BLK33AS34A026A |
| Parameters: | Alt: 600m; Scan Fz: 40; Scan ange: 25; Overlap: 40 |

**SWATH**

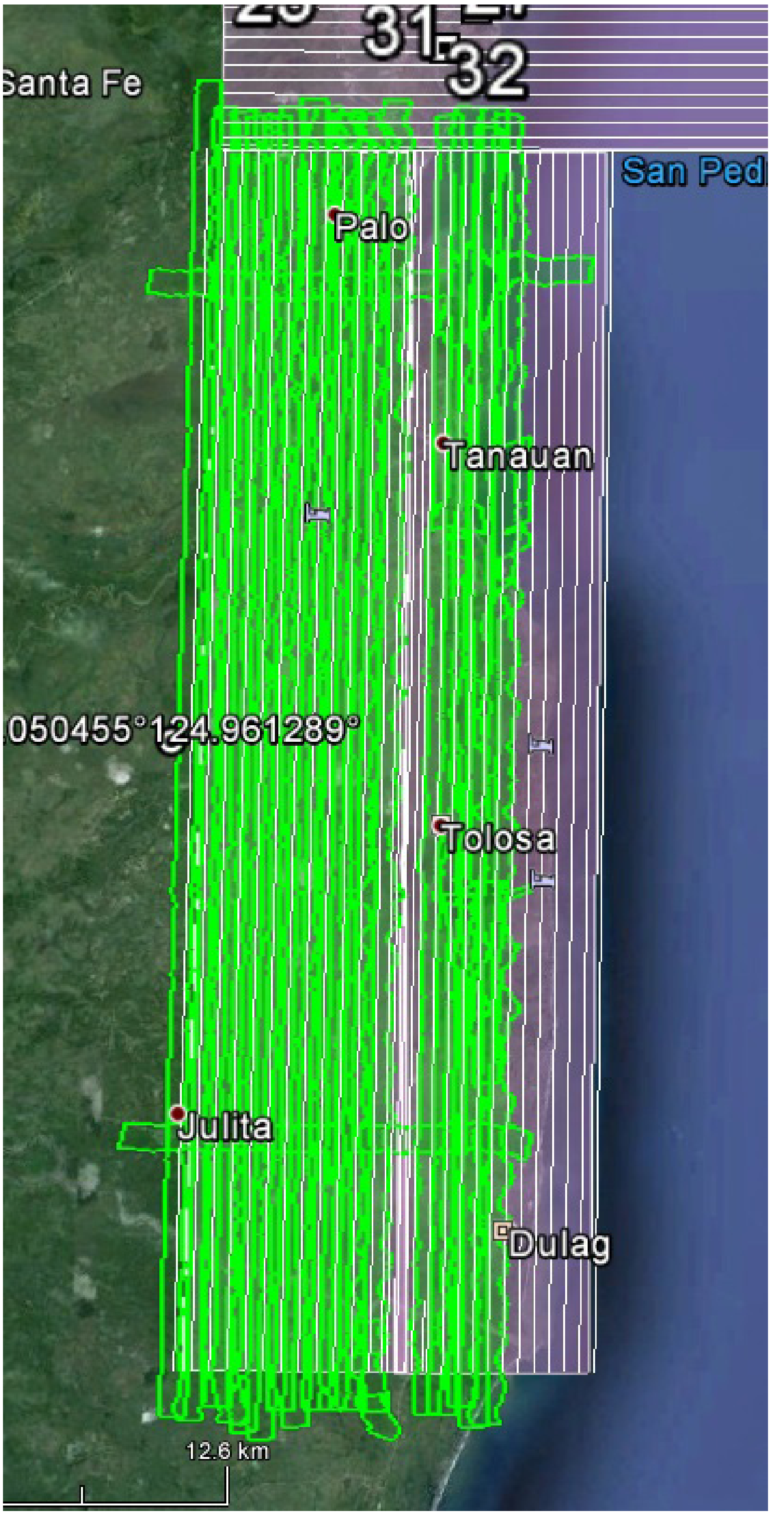


| | |
|---|---|
| Flight No. : | 1026A |
| Area: | BLK34A AND BLK 34B |
| Mission Name: | 3BLK34AS026B |
| Parameters: | Alt: 600m; Scan Fz: 40; Scan angle: 25; Overlap: 40 |

**SWATH**

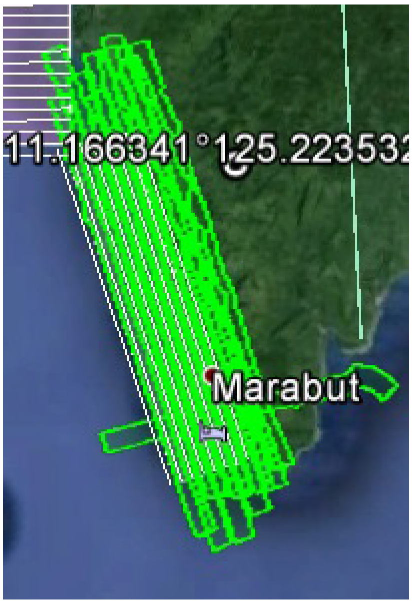
| | |
|---|---|
| Flight No. : | 1028A |
| Area: | BLK34A AND BLK34B |
| Mission Name: | 3BLK34ABS027A |
| Parameters: | Alt: 600m; Scan Fz: 40; Scan angle: 25; Overlap: 40% |

**SWATH**



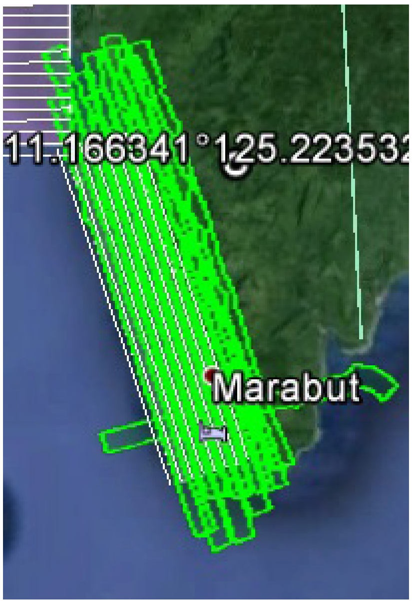
| | |
|---|---|
| Flight No. : | 1036A |
| Area: | BLK33A |
| Mission Name: | 3BLK33DS0929A |
| Parameters: | Alt: 600m; Scan Fz: 40; Scan angle: 25; Overlap: 40% |

**SWATH**



| | |
|---|---|
| Flight No. : | 1040A |
| Area: | BLK 33 and BLK 34 voids |
| Mission Name: | 3BLK3334V030A |
| Parameters: | Alt: 600m; Scan Fz: 40; Scan angle: 25; Overlap: 40% |

**SWATH**

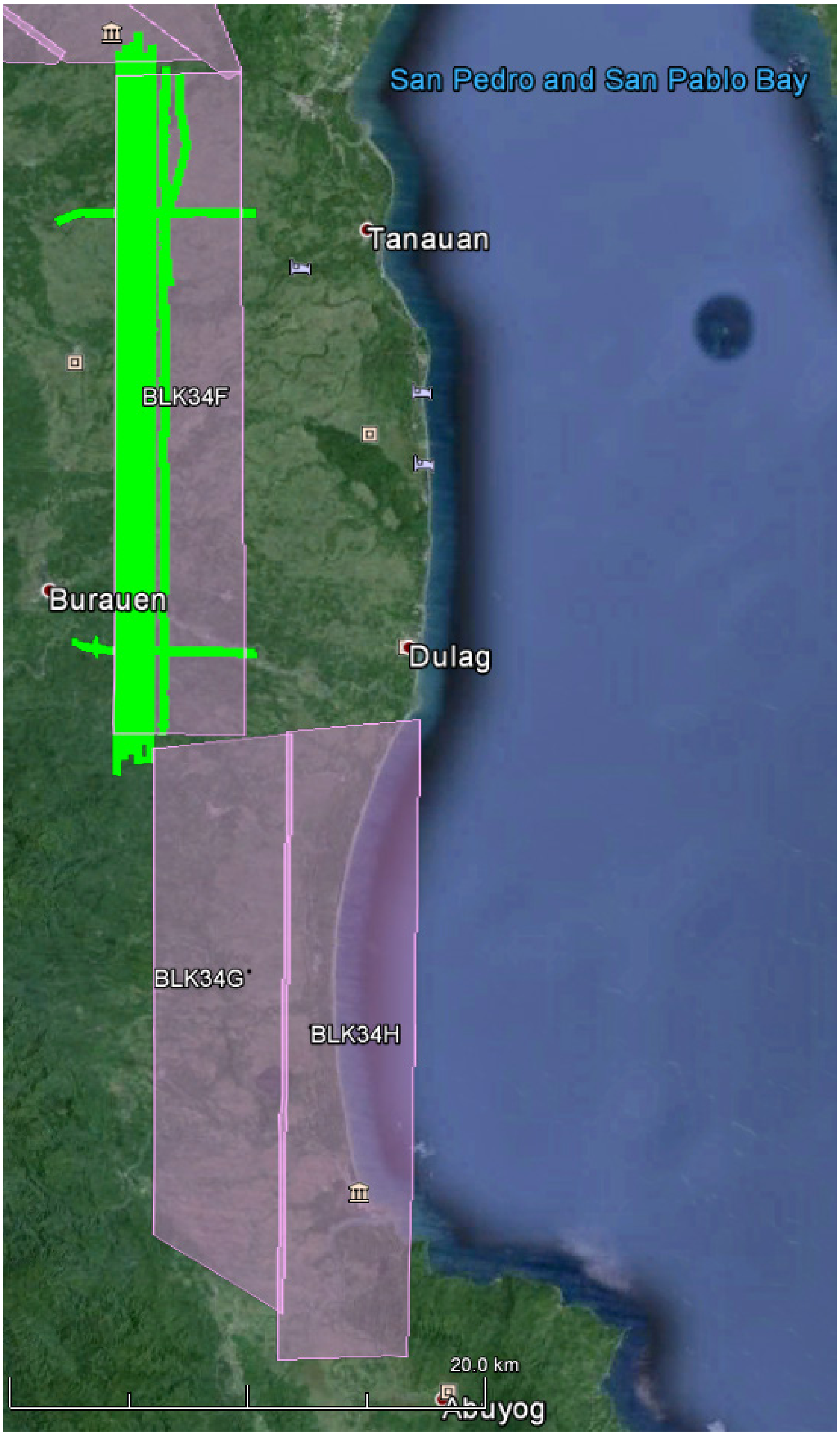


| | | | |
|---|---|---|---|
| Flight No. : | 1358A | | |
| Area: | BLK34F | | |
| Mission Name: | 3BLK34F110A | | |
| Total Area: | 122.03 sq km | | |
| Altitude: 600m | | | |
| PRF: | 50 kHz | SCF: | 50 Hz |
| Lidar FOV: | 18 deg | Sidelap: 30% | |

**SWATH**

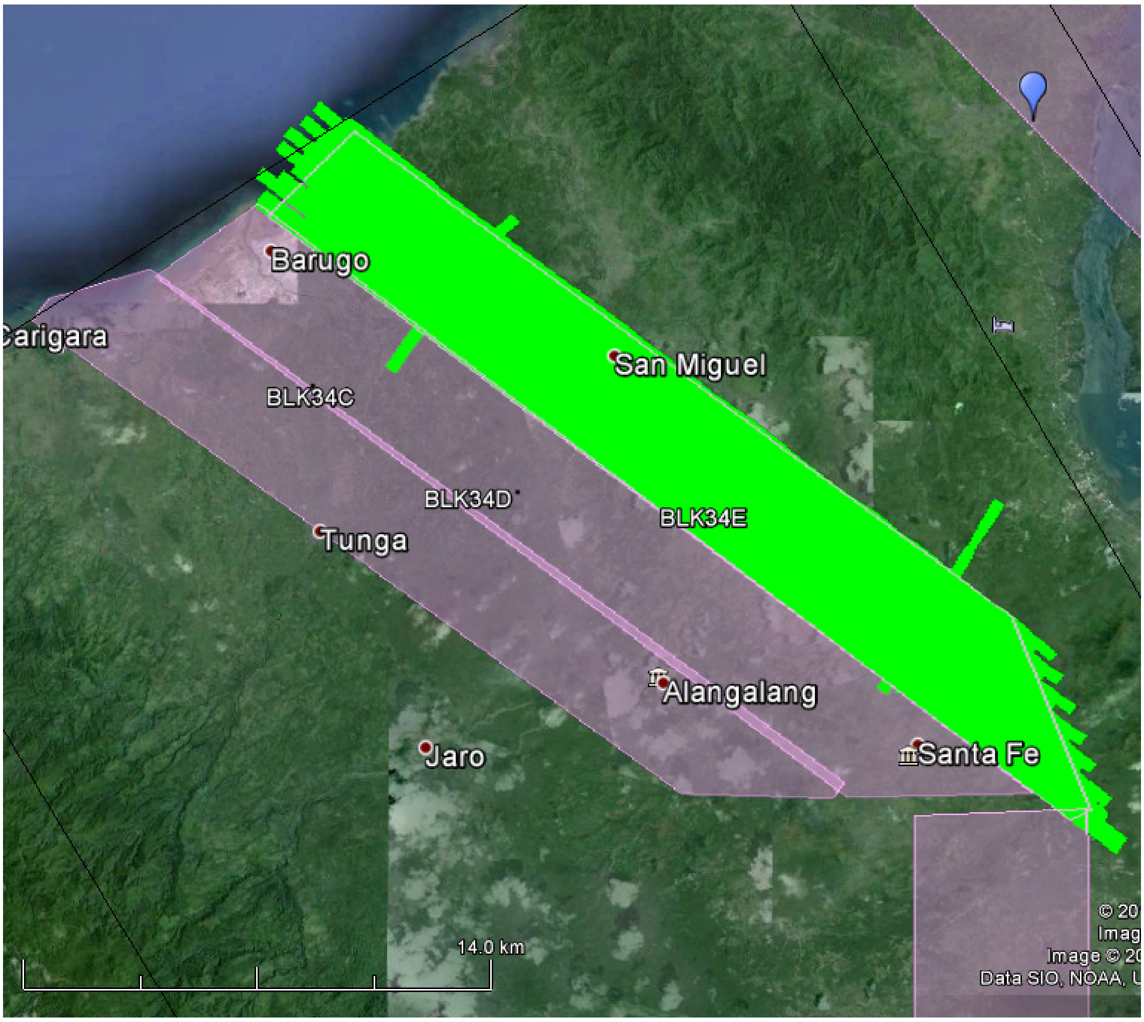
| | | | |
|---|---|---|---|
| Flight No. : | 1360A | | |
| Area: | BLK34K | | |
| Mission Name: | 3BLK34K110B | | |
| Total Area: | 74.498 sq km | | |
| Altitude: 600m | | | |
| PRF: | 50 kHz | SCF: | 50 Hz |
| Lidar FOV: | 18 deg | Sidelap: 30% | |

**SWATH**



Flight No. : 1366A
Area: BLK34E
Mission Name: 3BLK34E112A
Total Area: 121.43 sq km
Altitude: 600m
PRF: 50 kHz SCF: 50 Hz
Lidar FOV: 18 deg Sidelap: 30%

**SWATH**



Flight No. : 1454A

Area: BLK34D & BLK34E

Total Area: 138.839 sq km.

Mission Name: 3BLK34D134A

Altitude: 600m

PRF: 50 kHz SCF: 50 Hz

Lidar FOV: 18 deg Sidelap: 30%

**SWATH**

Flight No. : 1456A

Area: BLK34C

Total Area: 98.421 sq km.

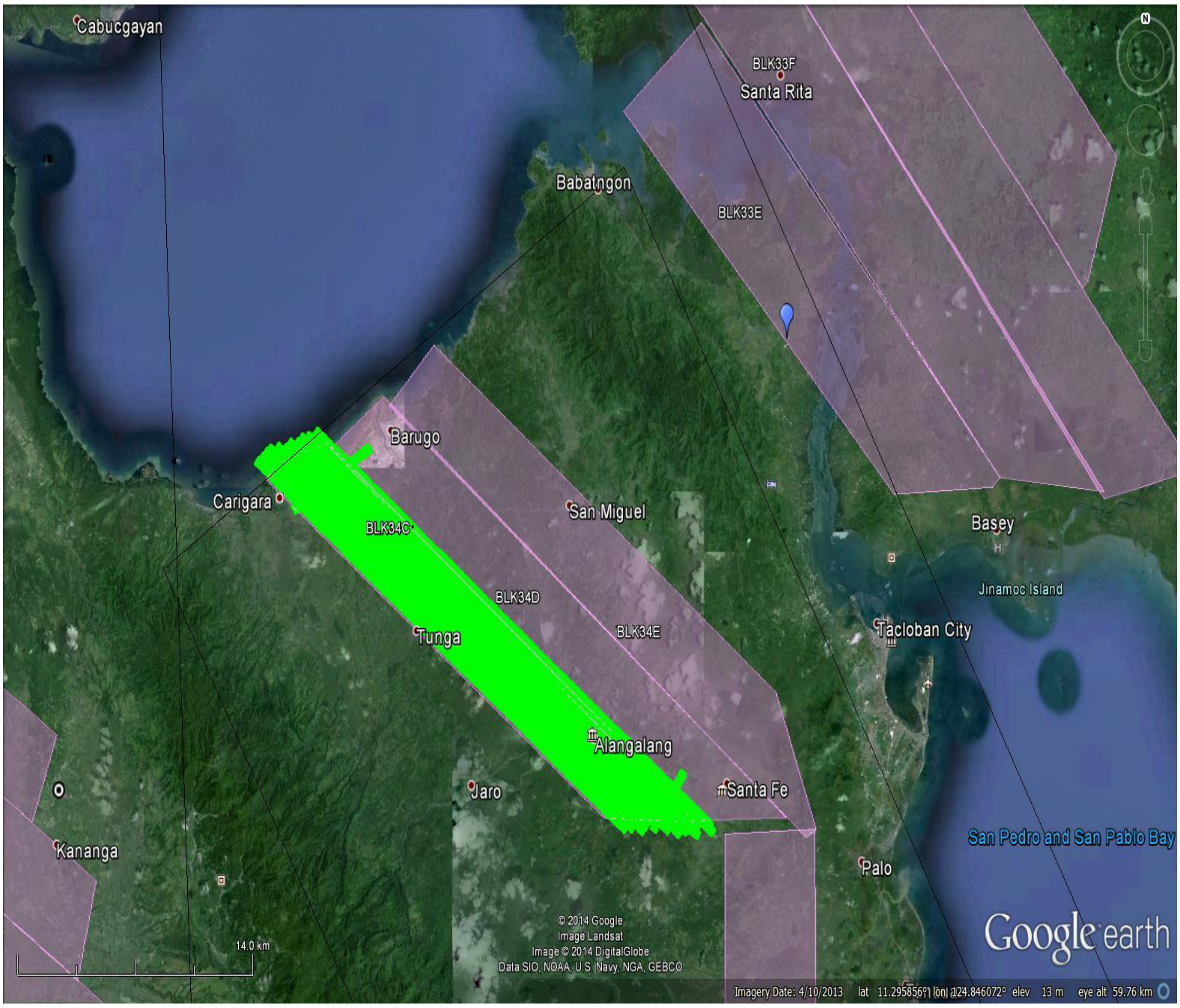
Mission Name: 3BLK34C134B

Altitude: 600m

PRF: 50 kHz SCF: 50 Hz

Lidar FOV: 18 deg Sidelap: 30%

**SWATH**



FLIGHT NO.: 3765

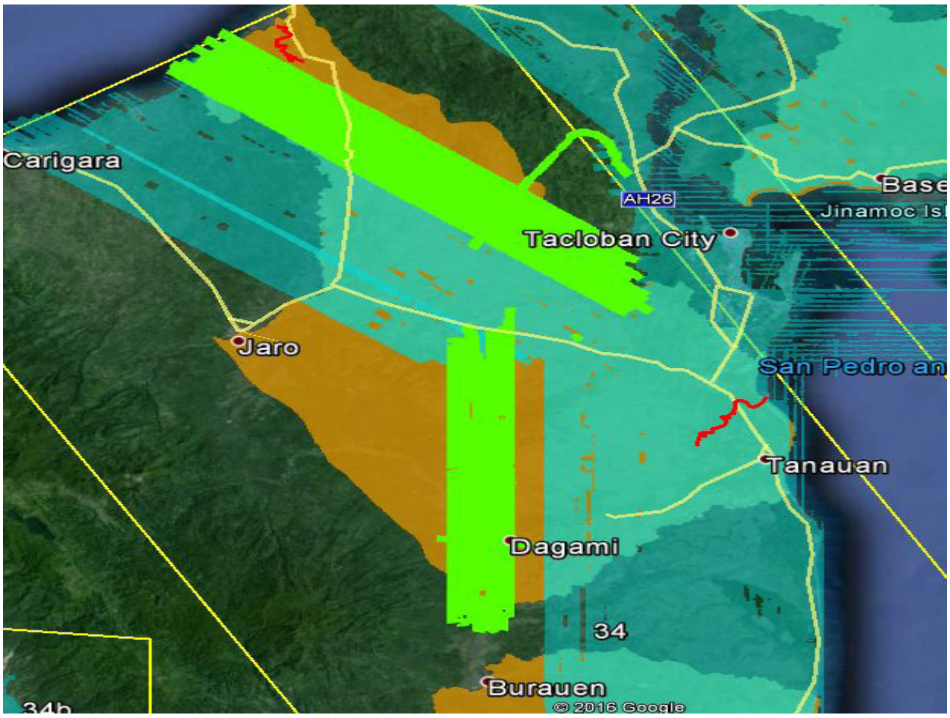
AREA: Leyte

MISSION NAME: 2BLK34AD022A

ALT: 1100m & 600m SCAN FREQ: 50 SCAN ANGLE: 17

SURVEYED AREA: 172.8

**SWATH**




| START | STOP | LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 00:33:39.345 | 00:33:51.77 | 20 | 818 | 100 | 50.00 | 17.00 | OFF | NAR | ON | OFF | 180.00 | LEYTE_New@1100LYT104.pln |
| 00:39:03.043 | 00:44:47.236 | 20 | 1212 | 100 | 50.00 | 17.00 | OFF | NAR | ON | OFF | 180.00 | LEYTE_New@1100LYT104.pln |
| 00:46:57.49 | 00:53:03.348 | 23 | 1216 | 100 | 50.00 | 17.00 | OFF | NAR | ON | OFF | 360.00 | LEYTE_New@1100LYT104.pln |
| 00:56:12.181 | 01:01:35.629 | 19 | 1207 | 100 | 50.00 | 17.00 | OFF | NAR | ON | OFF | 180.00 | LEYTE_New@1100LYT104.pln |
| 01:03:47.493 | 01:09:54.181 | 22 | 1220 | 100 | 50.00 | 17.00 | OFF | NAR | ON | OFF | 360.00 | LEYTE_New@1100LYT104.pln |
| 01:13:33.354 | 01:18:56.742 | 18 | 1203 | 100 | 50.00 | 17.00 | OFF | NAR | ON | OFF | 180.00 | LEYTE_New@1100LYT104.pln |
| 01:25:27.664 | 01:31:11.217 | 23 | 945 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 360.00 | LEYTE_New@850LYT104.pln |
| 01:37:39.524 | 01:43:47.442 | 28 | 632 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 180.00 | LEYTE_New@600LYT104.pln |
| 01:57:05.277 | 01:58:31.191 | 28 | 592 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 360.00 | LEYTE_New@600LYT104.pln |
| 02:07:24.673 | 02:15:05.335 | 71 | 691 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 307.03 | LEYTE_New@600LYT104.pln |
| 02:17:23.449 | 02:25:59.311 | 67 | 686 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 127.03 | LEYTE_New@600LYT104.pln |
| 02:31:41.644 | 02:34:33.843 | 70 | 654 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 307.03 | LEYTE_New@600LYT104.pln |
| 02:31:41.644 | 02:35:58.793 | 70 | 685 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 307.03 | LEYTE_New@600LYT104.pln |
| 02:39:50.507 | 02:47:20.039 | 70 | 672 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 307.03 | LEYTE_New@600LYT104.pln |
| 02:49:39.738 | 02:57:59.426 | 68 | 661 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 127.03 | LEYTE_New@600LYT104.pln |
| 03:00:26.88 | 03:08:07.342 | 69 | 659 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 307.03 | LEYTE_New@600LYT104.pln |
| 03:00:26.88 | 03:08:19.227 | 69 | 663 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 307.03 | LEYTE_New@600LYT104.pln |
| 03:10:15.317 | 03:18:12.774 | 72 | 675 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 127.03 | LEYTE_New@600LYT104.pln |
| 03:20:49.349 | 03:28:01.001 | 73 | 678 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 307.03 | LEYTE_New@600LYT104.pln |
| 03:30:11.401 | 03:37:48.178 | 74 | 659 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 127.03 | LEYTE_New@600LYT104.pln |
| 03:40:37.743 | 03:47:28.916 | 75 | 640 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 307.03 | LEYTE_New@600LYT104.pln |
| 03:49:24.55 | 03:56:58.098 | 76 | 658 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 127.03 | LEYTE_New@600LYT104.pln |

FLIGHT NO.: 3767

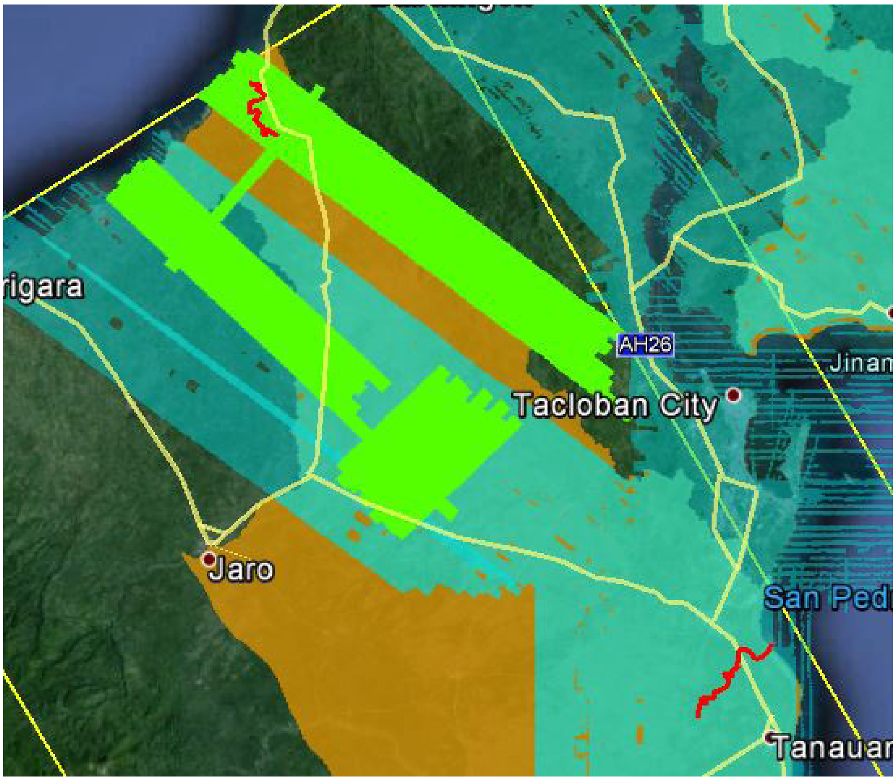
AREA: Leyte

MISSION NAME: 2BLK34AG022B

ALT: 850m SCAN FREQ: 50 SCAN ANGLE: 20

SURVEYED AREA: 144.5 km$^2$

**SWATH**




| START | STOP | LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06:25:43.612 | 06:32:32.645 | 71 | 963 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 307.03 | LEYTE_New@850.pln |
| 06:34:58.854 | 06:41:57.612 | 72 | 946 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 307.03 | LEYTE_New@850.pln |
| 06:44:15.856 | 06:50:28.824 | 73 | 956 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 127.03 | LEYTE_New@850.pln |
| 06:52:46.489 | 06:59:15.317 | 74 | 954 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 127.03 | LEYTE_New@850.pln |
| 07:01:33.721 | 07:07:19.164 | 75 | 945 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 307.03 | LEYTE_New@850.pln |
| 07:09:31.584 | 07:16:03.106 | 76 | 957 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 127.03 | LEYTE_New@850.pln |
| 07:17:57.791 | 07:23:46.924 | 77 | 918 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 307.03 | LEYTE_New@850.pln |
| 07:27:14.723 | 07:30:12.042 | 77 | 933 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 307.03 | LEYTE_New@850.pln |
| 07:36:38.11 | 07:40:31.219 | 320 | 937 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 133.03 | LEYTE_New@850.pln |
| 07:42:44.693 | 07:47:06.076 | 321 | 946 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 313.03 | LEYTE_New@850.pln |
| 07:49:10.761 | 07:53:15.534 | 322 | 949 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 313.03 | LEYTE_New@850.pln |
| 07:55:14.869 | 07:59:24.692 | 319 | 945 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 133.03 | LEYTE_New@850.pln |
| 08:01:37.732 | 08:05:33.15 | 318 | 934 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 313.03 | LEYTE_New@850.pln |
| 08:07:46.835 | 08:13:57.012 | 317 | 944 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 133.03 | LEYTE_New@850.pln |
| 08:17:02.431 | 08:19:03.081 | 333 | 940 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 45.97 | LEYTE_New@850.pln |
| 08:20:50.225 | 08:22:36.12 | 334 | 936 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 225.97 | LEYTE_New@850.pln |
| 08:24:33.629 | 08:26:41.398 | 332 | 944 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 225.97 | LEYTE_New@850.pln |
| 08:28:36.838 | 08:30:23.977 | 331 | 949 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 45.97 | LEYTE_New@850.pln |
| 08:32:26.051 | 08:34:24.806 | 330 | 963 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 45.97 | LEYTE_New@850.pln |
| 08:36:16.365 | 08:38:12.084 | 329 | 950 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 45.97 | LEYTE_New@850.pln |
| 08:40:07.734 | 08:42:15.738 | 328 | 941 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 225.97 | LEYTE_New@850.pln |
| 08:44:02.367 | 08:46:01.911 | 327 | 944 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 225.97 | LEYTE_New@850.pln |
| 08:47:52.911 | 08:50:02.565 | 326 | 961 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 45.97 | LEYTE_New@850.pln |
| 08:51:54.809 | 08:53:52.054 | 325 | 954 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 225.97 | LEYTE_New@850.pln |

FLIGHT NO.: 3769

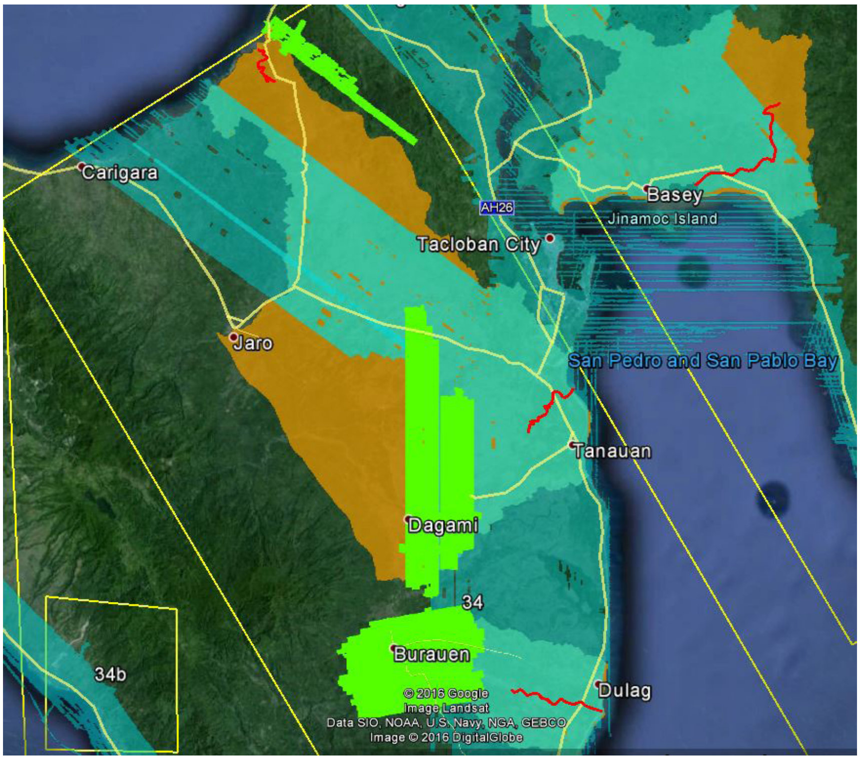
AREA: Leyte

MISSION NAME: 2BLK34ADEG023A

ALT: 1100 m & 600m SCAN FREQ: 50 SCAN ANGLE: 17

SURVEYED AREA: 167.25km$^2$

## SWATH




| START | STOP | LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 00:22:31.78 | 00:26:20.698 | 72 | 1211 | 100 | 50.00 | 17.00 | OFF | NAR | ON | OFF | 307.03 | LEYTE_New@1100LYT104.pln |
| 00:28:37.812 | 00:31:16.126 | 73 | 1193 | 100 | 50.00 | 17.00 | OFF | NAR | ON | OFF | 307.03 | LEYTE_New@1100LYT104.pln |
| 00:35:24.269 | 00:37:33.159 | 74 | 1224 | 100 | 50.00 | 17.00 | OFF | NAR | ON | OFF | 307.03 | LEYTE_New@1100LYT104.pln |
| 00:40:39.812 | 00:41:30.702 | 74 | 1207 | 100 | 50.00 | 17.00 | OFF | NAR | ON | OFF | 127.01 | LEYTE_New@1100LYT104.pln |
| 00:48:05.129 | 00:53:46.931 | 24 | 1205 | 100 | 50.00 | 17.00 | OFF | NAR | ON | OFF | 180.00 | LEYTE_New@1100LYT104.pln |
| 00:55:33.871 | 01:01:07.443 | 28 | 1208 | 100 | 50.00 | 17.00 | OFF | NAR | ON | OFF | 360.00 | LEYTE_New@1100LYT104.pln |
| 01:03:10.442 | 01:08:58.935 | 25 | 1205 | 100 | 50.00 | 17.00 | OFF | NAR | ON | OFF | 180.00 | LEYTE_New@1100LYT104.pln |
| 01:10:53.874 | 01:16:49.566 | 27 | 1212 | 100 | 50.00 | 17.00 | OFF | NAR | ON | OFF | 360.00 | LEYTE_New@1100LYT104.pln |
| 01:19:28.82 | 01:25:08.443 | 26 | 1212 | 100 | 50.00 | 17.00 | OFF | NAR | ON | OFF | 180.00 | LEYTE_New@1100LYT104.pln |
| 01:29:09.126 | 01:30:14.996 | 24 | 1192 | 100 | 50.00 | 17.00 | OFF | NAR | ON | OFF | 180.00 | LEYTE_New@1100LYT104.pln |
| 01:36:23.963 | 01:39:08.327 | 2 | 690 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 260.00 | LEYTE_New@600LYT104.pln |
| 01:40:33.271 | 01:43:43.215 | 8 | 661 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 80.00 | LEYTE_New@600LYT104.pln |
| 01:44:58.119 | 01:47:39.883 | 3 | 683 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 260.00 | LEYTE_New@600LYT104.pln |
| 01:49:25.737 | 01:52:23.296 | 7 | 695 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 80.00 | LEYTE_New@600LYT104.pln |
| 01:54:07.941 | 01:56:51.769 | 4 | 684 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 260.00 | LEYTE_New@600LYT104.pln |
| 01:58:40.714 | 02:01:44.517 | 9 | 718 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 80.00 | LEYTE_New@600LYT104.pln |
| 02:03:20.157 | 02:06:08.861 | 5 | 683 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 260.00 | LEYTE_New@600LYT104.pln |
| 02:08:12.91 | 02:11:24.969 | 10 | 679 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 80.00 | LEYTE_New@600LYT104.pln |
| 02:12:56.988 | 02:15:43.177 | 6 | 692 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 260.00 | LEYTE_New@600LYT104.pln |
| 02:17:57.036 | 02:21:14.385 | 15 | 704 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 80.00 | LEYTE_New@600LYT104.pln |
| 02:22:41.799 | 02:25:42.018 | 11 | 682 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 260.00 | LEYTE_New@600LYT104.pln |
| 02:22:41.799 | 02:25:42.018 | 11 | 681 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 260.00 | LEYTE_New@600LYT104.pln |
| 02:26:59.208 | 02:30:06.887 | 16 | 713 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 80.00 | LEYTE_New@600LYT104.pln |
| 02:31:32.886 | 02:34:31.04 | 12 | 674 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 260.00 | LEYTE_New@600LYT104.pln |
| 02:38:46.379 | 02:41:45.777 | 17 | 682 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 80.00 | LEYTE_New@600LYT104.pln |
| 02:43:14.947 | 02:46:16.721 | 13 | 683 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 260.00 | LEYTE_New@600LYT104.pln |
| 02:47:39.07 | 02:50:12.384 | 18 | 686 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 80.00 | LEYTE_New@600LYT104.pln |
| 02:51:46.069 | 02:54:51.693 | 14 | 671 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 260.00 | LEYTE_New@600LYT104.pln |
| 02:58:54.526 | 03:01:12.241 | 19 | 679 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 80.00 | LEYTE_New@600LYT104.pln |
| 03:04:38.069 | 03:06:50.924 | 19 | 702 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 80.00 | LEYTE_New@600LYT104.pln |
| 03:11:20.722 | 03:15:25.216 | 88 | 691 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 360.00 | LEYTE_New@600LYT104.pln |
| 03:16:32.95 | 03:19:39.779 | 93 | 688 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 180.00 | LEYTE_New@600LYT104.pln |
| 03:21:01.809 | 03:25:02.922 | 89 | 669 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 360.00 | LEYTE_New@600LYT104.pln |
| 03:25:59.182 | 03:29:14.811 | 92 | 692 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 180.00 | LEYTE_New@600LYT104.pln |
| 03:30:41.01 | 03:34:40.869 | 90 | 681 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 360.00 | LEYTE_New@600LYT104.pln |
| 03:36:02.318 | 03:39:28.072 | 91 | 694 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 180.00 | LEYTE_New@600LYT104.pln |
| 03:41:36.076 | 03:42:46.301 | 88 | 641 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 180.00 | LEYTE_New@600LYT104.pln |

FLIGHT NO.: 3771

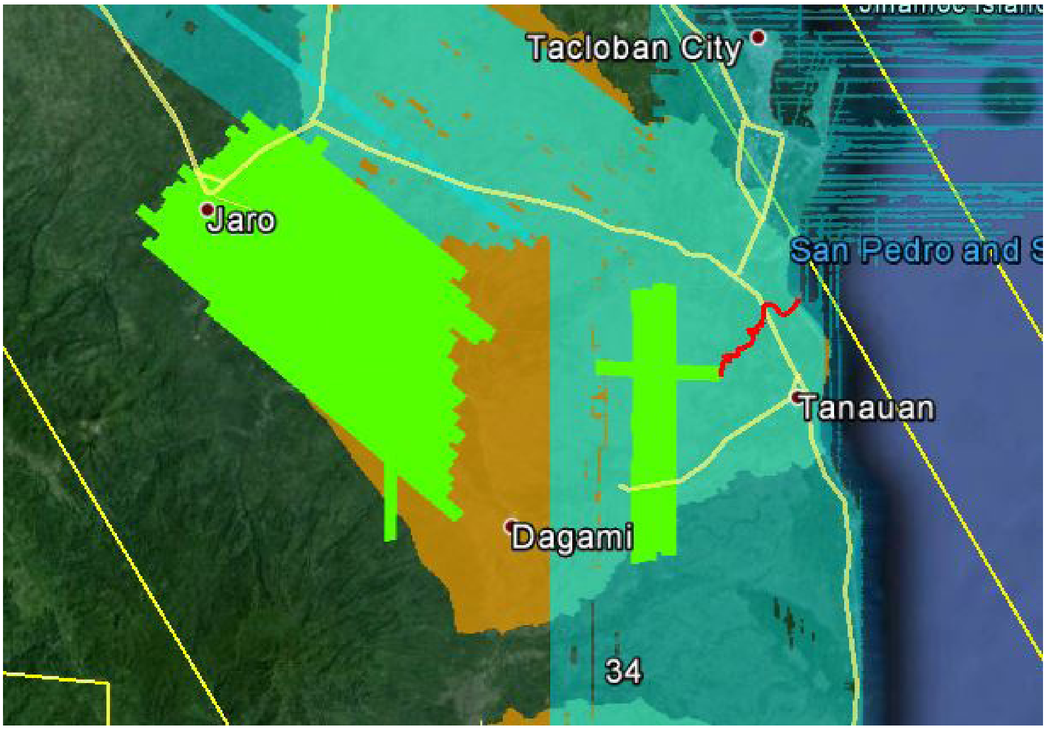
AREA: Leyte

MISSION NAME: 2BLK34BCG023B

ALT: 850 m SCAN FREQ: 50 SCAN ANGLE: 20

SURVEYED AREA: 143.4 km$^2$

**SWATH**




| START | STOP | LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06:35:50.577 | 06:39:05.031 | 92 | 957 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 133.03 | LEYTE_New@850LYT104.pln |
| 06:41:21.246 | 06:44:51.86 | 91 | 940 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 360.00 | LEYTE_New@850LYT104.pln |
| 06:47:00.754 | 06:50:13.578 | 90 | 957 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 180.00 | LEYTE_New@850LYT104.pln |
| 06:52:20.328 | 06:55:54.407 | 89 | 948 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 360.00 | LEYTE_New@850LYT104.pln |
| 06:59:06.001 | 07:01:55.615 | 43 | 946 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 308.02 | LEYTE_New@850LYT104.pln |
| 07:04:23.724 | 07:07:40.653 | 42 | 970 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 308.02 | LEYTE_New@850LYT104.pln |
| 07:09:27.792 | 07:12:48.761 | 41 | 949 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 128.02 | LEYTE_New@850LYT104.pln |
| 07:14:45.411 | 07:19:03.689 | 40 | 995 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 128.02 | LEYTE_New@850LYT104.pln |
| 07:14:45.411 | 07:19:03.689 | 40 | 998 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 128.02 | LEYTE_New@850LYT104.pln |
| 07:22:30.443 | 07:26:26.447 | 39 | 947 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 308.02 | LEYTE_New@850LYT104.pln |
| 07:29:17.041 | 07:31:04.62 | 39 | 958 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 308.02 | LEYTE_New@850LYT104.pln |
| 07:34:35.484 | 07:38:18.518 | 38 | 933 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 128.02 | LEYTE_New@850LYT104.pln |
| 07:40:19.587 | 07:44:00.311 | 37 | 940 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 308.02 | LEYTE_New@850LYT104.pln |
| 07:46:35.415 | 07:50:29.218 | 36 | 943 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 128.02 | LEYTE_New@850LYT104.pln |
| 07:53:02.767 | 07:56:56.151 | 35 | 946 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 308.02 | LEYTE_New@850LYT104.pln |
| 07:59:03.52 | 08:03:27.419 | 34 | 952 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 128.02 | LEYTE_New@850LYT104.pln |
| 08:05:49.663 | 08:09:57.871 | 60 | 949 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 310.02 | LEYTE_New@850LYT104.pln |
| 08:12:18.735 | 08:16:57.524 | 59 | 965 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 130.02 | LEYTE_New@850LYT104.pln |
| 08:19:25.488 | 08:24:05.456 | 58 | 944 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 130.02 | LEYTE_New@850LYT104.pln |
| 08:26:08.015 | 08:30:54.088 | 57 | 944 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 130.02 | LEYTE_New@850LYT104.pln |
| 08:33:10.808 | 08:37:45.911 | 56 | 951 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 310.02 | LEYTE_New@850LYT104.pln |
| 08:39:57.74 | 08:45:00.053 | 55 | 973 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 130.02 | LEYTE_New@850LYT104.pln |
| 08:46:48.528 | 08:48:48.057 | 61 | 956 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 310.02 | LEYTE_New@850LYT104.pln |
| 08:50:51.951 | 08:53:44.495 | 61 | 951 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 310.02 | LEYTE_New@850LYT104.pln |
| 08:56:35.949 | 09:01:09.127 | 54 | 917 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 310.02 | LEYTE_New@850LYT104.pln |
| 09:03:11.426 | 09:08:11.744 | 53 | 958 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 130.02 | LEYTE_New@850LYT104.pln |
| 09:10:28.919 | 09:14:22.267 | 52 | 962 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 310.02 | LEYTE_New@850LYT104.pln |
| 09:20:26.535 | 09:22:07.164 | 91 | 949 | 100 | 50.00 | 20.00 | OFF | NAR | ON | OFF | 360.00 | LEYTE_New@850LYT104.pln |

FLIGHT NO.: 3773

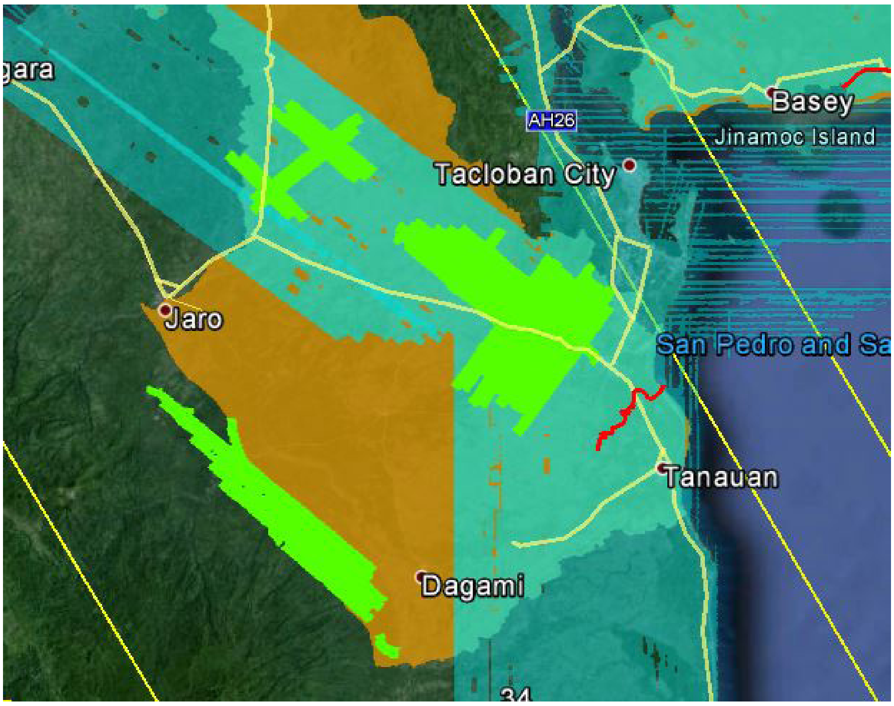
AREA: Leyte

MISSION NAME: 2BLK34CG024A

ALT: 600 m SCAN FREQ: 40 SCAN ANGLE: 25

SURVEYED AREA: 90.6 $km^2$

## SWATH




| START | STOP | LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 00:41:26.291 | 00:45:37.304 | 54 | 673 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 129.99 | leyteVOIDSnew@600.pln |
| 00:47:19.499 | 00:47:47.129 | 50 | 670 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 309.99 | leyteVOIDSnew@600.pln |
| 00:48:00.128 | 00:49:49.973 | 50 | 642 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 309.99 | leyteVOIDSnew@600.pln |
| 00:55:27.525 | 00:59:52.439 | 55 | 680 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 129.99 | leyteVOIDSnew@600.pln |
| 01:02:18.758 | 01:06:11.696 | 53 | 626 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 309.99 | leyteVOIDSnew@600.pln |
| 01:11:13.674 | 01:14:14.473 | 51 | 635 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 129.99 | leyteVOIDSnew@600.pln |
| 01:16:42.357 | 01:20:10.02 | 52 | 670 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 309.99 | leyteVOIDSnew@600.pln |
| 01:20:49.76 | 01:21:04.42 | 54 | 673 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 310.00 | leyteVOIDSnew@600.pln |
| 01:24:38.359 | 01:25:37.498 | 54 | 664 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 130.00 | leyteVOIDSnew@600.pln |
| 01:30:49.756 | 01:32:51.7 | 50 | 665 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 129.99 | leyteVOIDSnew@600.pln |
| 01:37:16.759 | 01:39:56.043 | 131 | 686 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 36.01 | leyteVOIDSnew@600.pln |
| 01:41:54.187 | 01:44:07.646 | 136 | 677 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 216.01 | leyteVOIDSnew@600.pln |
| 01:46:06.62 | 01:48:48.959 | 132 | 723 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 36.01 | leyteVOIDSnew@600.pln |
| 01:50:32.703 | 01:52:38.423 | 137 | 724 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 216.01 | leyteVOIDSnew@600.pln |
| 01:54:26.957 | 01:56:40.186 | 133 | 675 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 36.01 | leyteVOIDSnew@600.pln |
| 01:58:22.395 | 02:00:28.59 | 138 | 677 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 216.01 | leyteVOIDSnew@600.pln |
| 02:02:11.674 | 02:04:57.128 | 134 | 683 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 36.01 | leyteVOIDSnew@600.pln |
| 02:06:30.502 | 02:08:37.931 | 139 | 682 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 216.01 | leyteVOIDSnew@600.pln |
| 02:10:13.101 | 02:12:54.015 | 135 | 693 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 36.01 | leyteVOIDSnew@600.pln |
| 02:14:21.569 | 02:16:27.344 | 140 | 681 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 216.01 | leyteVOIDSnew@600.pln |
| 02:18:30.538 | 02:21:11.317 | 141 | 693 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 36.01 | leyteVOIDSnew@600.pln |
| 02:23:48.796 | 02:25:34.795 | 141 | 729 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 36.01 | leyteVOIDSnew@600.pln |
| 02:28:25.509 | 02:30:35.513 | 120 | 692 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 130.00 | leyteVOIDSnew@600.pln |
| 02:32:05.188 | 02:34:04.657 | 124 | 675 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 310.00 | leyteVOIDSnew@600.pln |
| 02:35:54.016 | 02:38:07.216 | 121 | 691 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 130.00 | leyteVOIDSnew@600.pln |
| 02:39:35.88 | 02:41:22.769 | 125 | 706 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 310.00 | leyteVOIDSnew@600.pln |
| 02:42:45.769 | 02:44:49.598 | 122 | 695 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 130.00 | leyteVOIDSnew@600.pln |
| 02:46:19.373 | 02:47:57.102 | 126 | 697 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 310.00 | leyteVOIDSnew@600.pln |
| 02:50:03.911 | 02:52:14.036 | 123 | 677 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 130.00 | leyteVOIDSnew@600.pln |
| 02:54:49.325 | 02:56:02.074 | 123 | 667 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 128.98 | leyteVOIDSnew@600.pln |
| 02:58:39.883 | 03:00:18.348 | 145 | 698 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 308.98 | leyteVOIDSnew@600.pln |
| 03:01:59.887 | 03:03:42.777 | 143 | 685 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 308.98 | leyteVOIDSnew@600.pln |
| 03:05:27.966 | 03:07:08.375 | 144 | 689 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 315.00 | leyteVOIDSnew@600.pln |
| 03:08:34.69 | 03:09:55.629 | 149 | 707 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 315.00 | leyteVOIDSnew@600.pln |
| 03:11:43.889 | 03:13:06.778 | 148 | 667 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 315.00 | leyteVOIDSnew@600.pln |
| 03:15:53.122 | 03:17:54.942 | 152 | 709 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 231.49 | leyteVOIDSnew@600.pln |
| 03:20:17.491 | 03:22:19.975 | 153 | 686 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 231.49 | leyteVOIDSnew@600.pln |
| 03:28:30.043 | 03:29:27.943 | 85 | 629 | 100 | 40.00 | 25.00 | OFF | NAR | ON | OFF | 307.01 | leyteVOIDSnew@600.pln |

# Annex 8. Mission Summary Reports

| | |
|---|---|
| Flight Area | Samar-Leyte |
| Mission Name | Blk34F |
| Inclusive Flights | 1358A, 1360A |
| Range data size | 22.36 GB |
| Base data size | 12.1 MB |
| POS | 417 MB |
| Image | 115.1 GB |
| Transfer date | May 28, 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) | 2.9 |
| RMSE for East Position (<4.0 cm) | 3.5 |
| RMSE for Down Position (<8.0 cm) | 5.5 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000685 |
| IMU attitude correction stdev (<0.001deg) | 0.002555 |
| GPS position stdev (<0.01m) | 0.0083 |
| | |
| Minimum % overlap (>25) | 43.14% |
| Ave point cloud density per sq.m. (>2.0) | 3.13 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 221 |
| Maximum Height | 268.28 m |
| Minimum Height | 66.43 m |
| | |
| *Classification (# of points)* | |
| Ground | 127,167,999 |
| Low vegetation | 167,959,671 |
| Medium vegetation | 145,772,139 |
| High vegetation | 22,065,261 |
| Building | 1,152,046 |
| Orthophoto | Yes |
| Processed by | Engr. Analyn Naldo, Engr. Aljon Rie Araneta, Jovy Narisma |

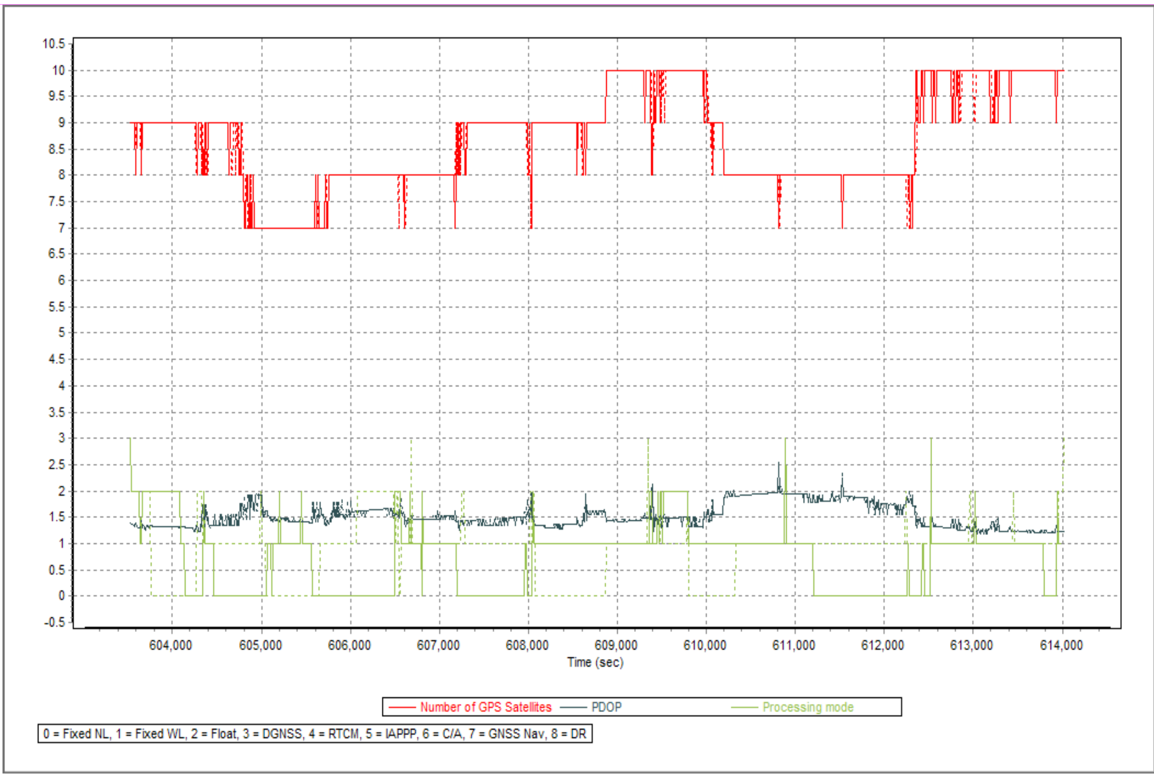



Figure A-8.1 Solution Status

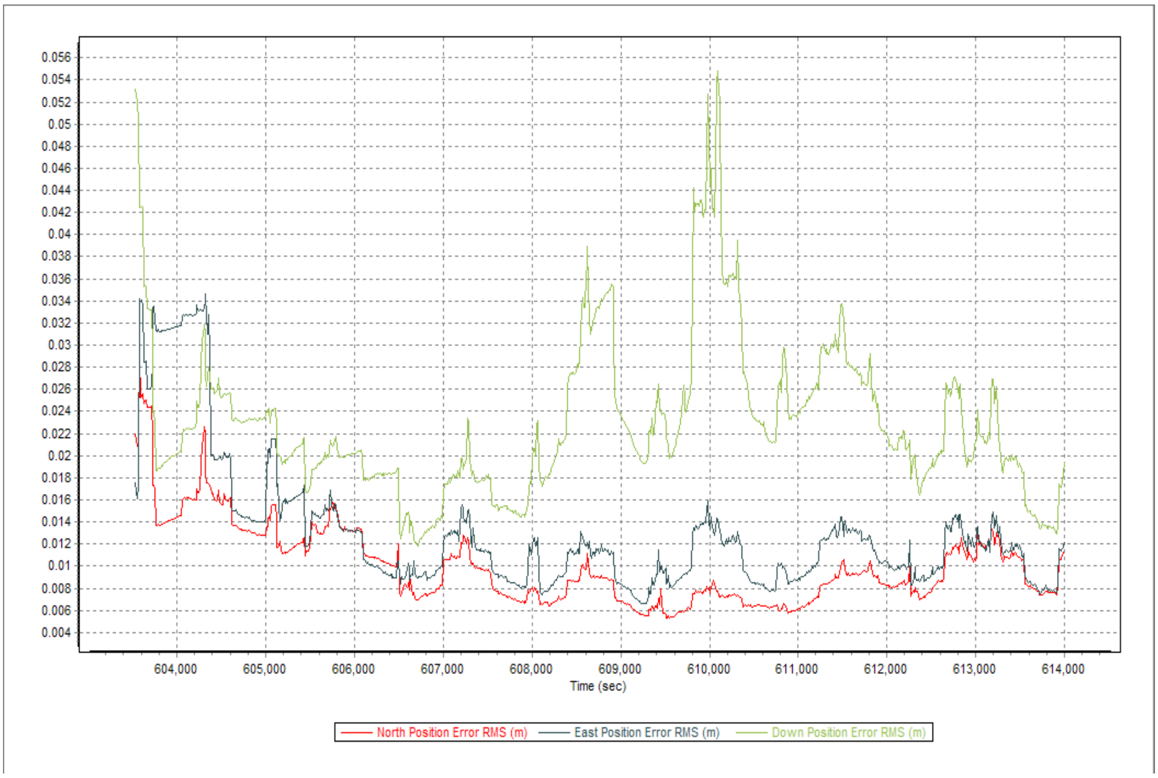



Figure A-8.2 Smoothed Performance Metric Parameters

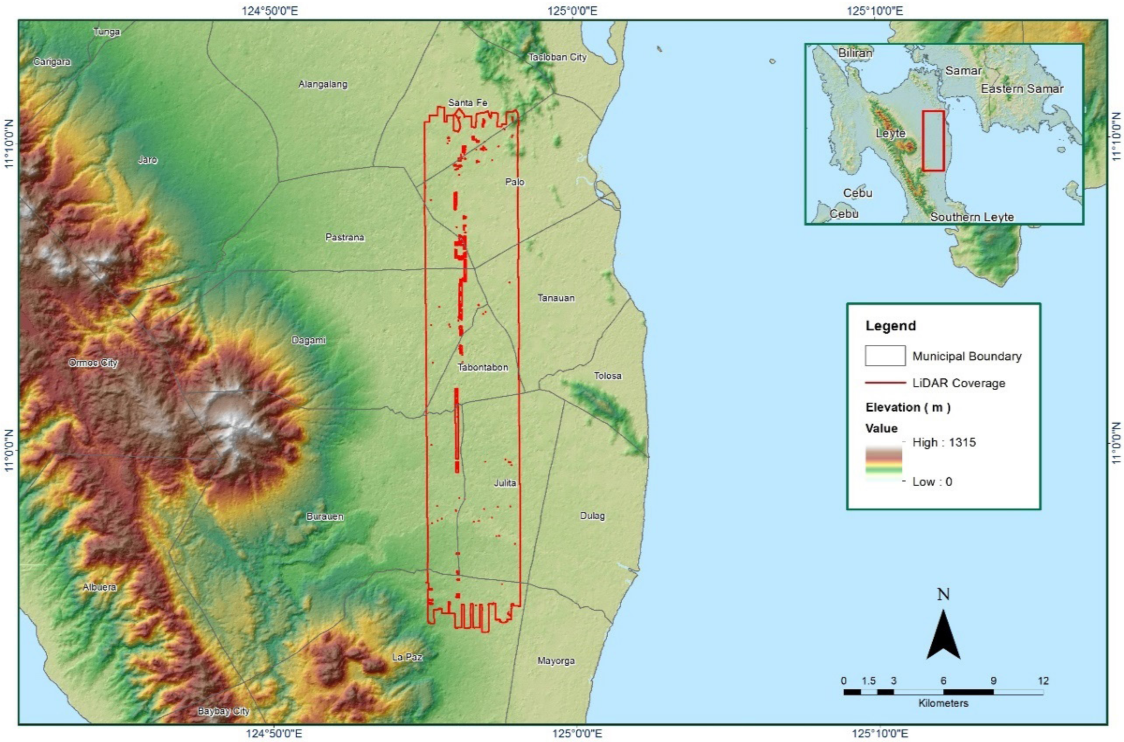



Figure A-8.3 Best Estimated Trajectory

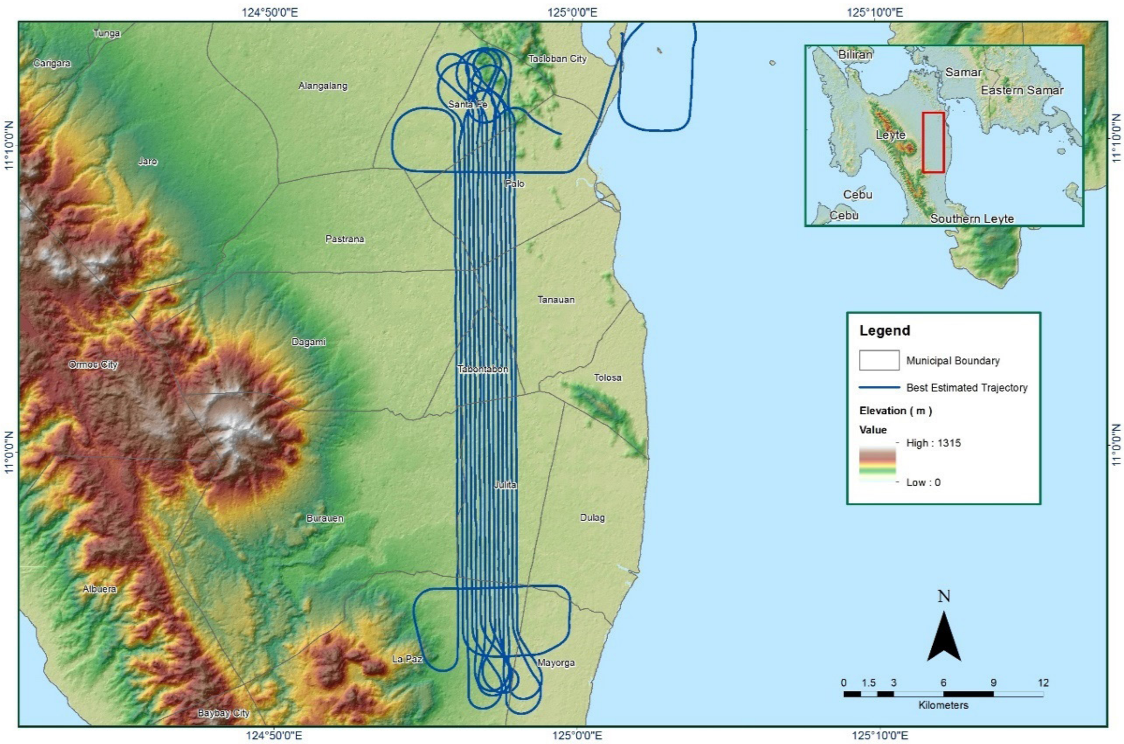



Figure A-8.4 Coverage of LiDAR data

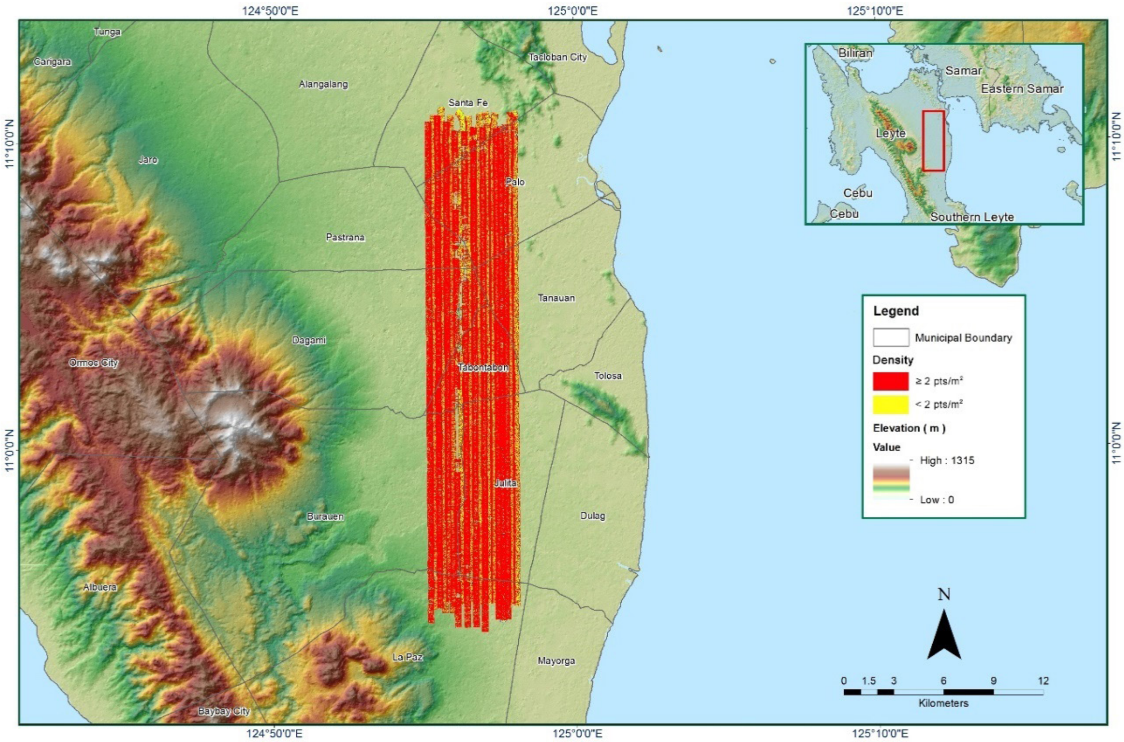



Figure A-8.5 Image of data overlap

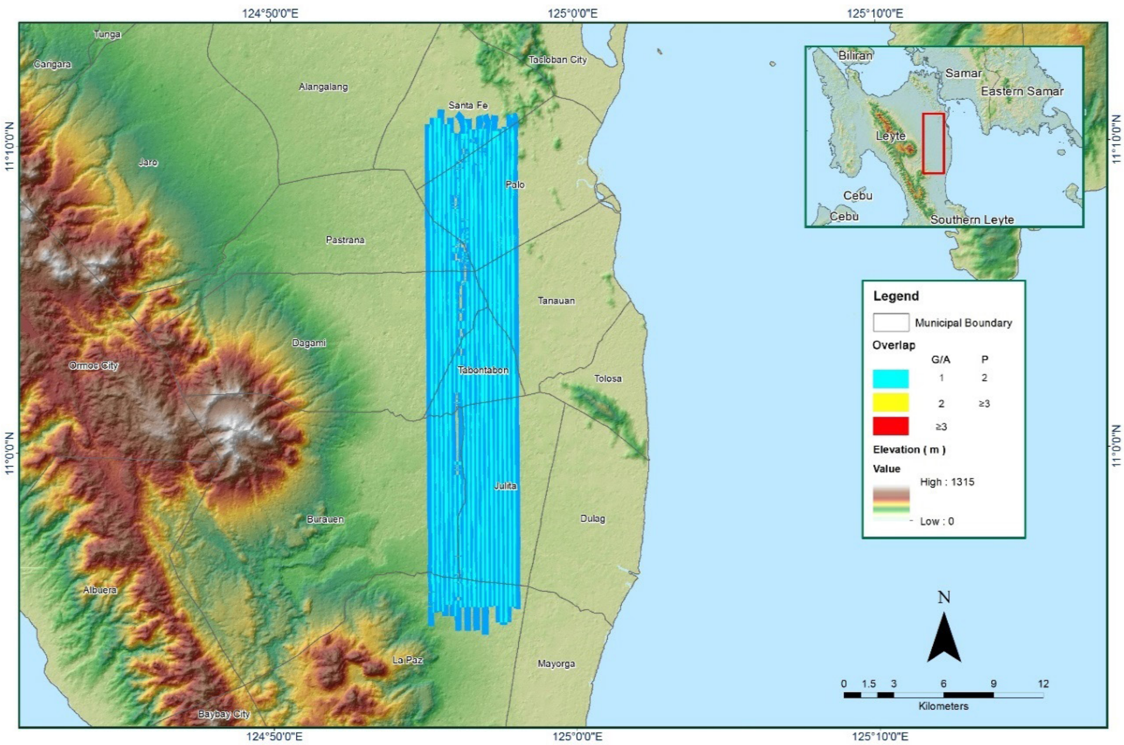



Figure A-8.6 Density map of merged LiDAR data

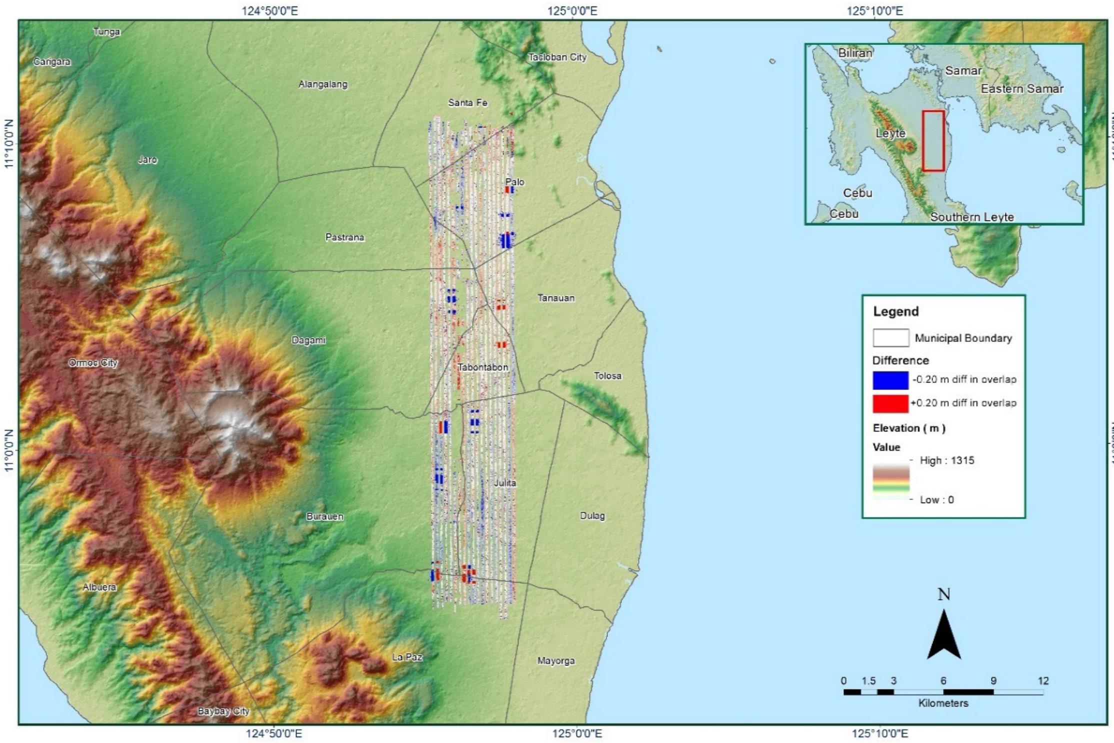



Figure A-8.7 *Elevation difference between flight lines*

| | |
|---|---|
| Flight Area | Samar-Leyte |
| Mission Name | Blk 34C |
| Inclusive Flights | 1456A |
| Range data size | 11.6 GB |
| Base data size | 7.92 MB |
| POS | 212 MB |
| Image | 66.6 GB |
| Transfer date | May 28, 2014 |
| | |
| *Solution Status* | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | Yes |
| Processing Mode (<=1) | Yes |
| | |
| *Smoothed Performance Metrics* (in cm) | |
| RMSE for North Position (<4.0 cm) | 1.3 |
| RMSE for East Position (<4.0 cm) | 1.2 |
| RMSE for Down Position (<8.0 cm) | 2.6 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000399354 |
| IMU attitude correction stdev (<0.001deg) | 0.0089118 |
| GPS position stdev (<0.01m) | 0.0169262 |
| | |
| Minimum % overlap (>25) | 40.85% |
| Ave point cloud density per sq.m. (>2.0) | 3.01 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 143 |
| Maximum Height | 151.03 m |
| Minimum Height | 59.09 m |
| | |
| *Classification (# of points)* | |
| Ground | 63,841,063 |
| Low vegetation | 73,433,267 |
| Medium vegetation | 90,859,082 |
| High vegetation | 26,640,847 |
| Building | 1,833,370 |
| Orthophoto | Yes |
| Processed by | Engr. Carlyn Ann Ibañez, Engr. Velina Angela Bemida, Engr. Gladys Mae Apat |

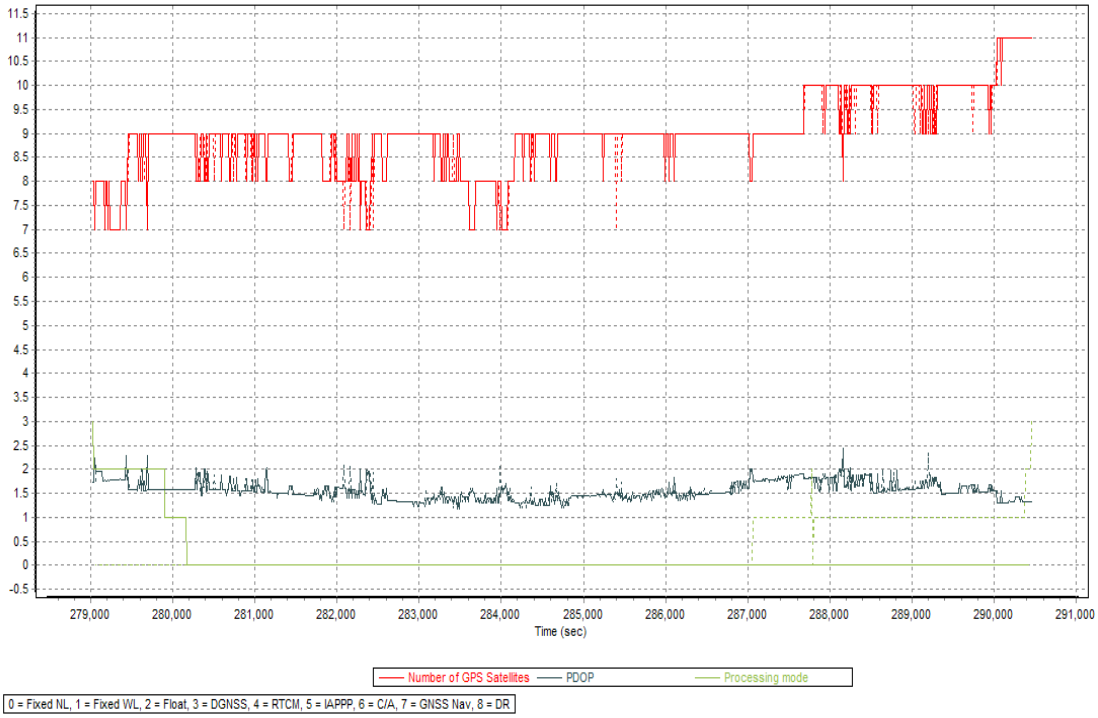



Figure A-8.8 Solution Status

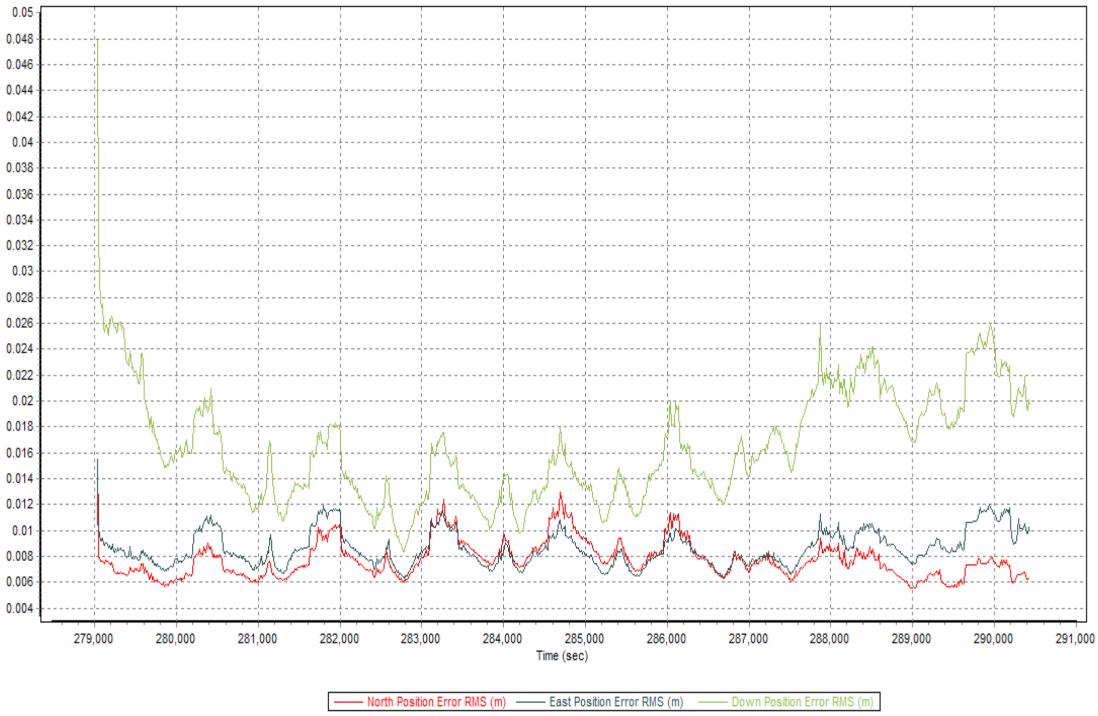



Figure A-8.9 Smoothed Performance Metric Parameters

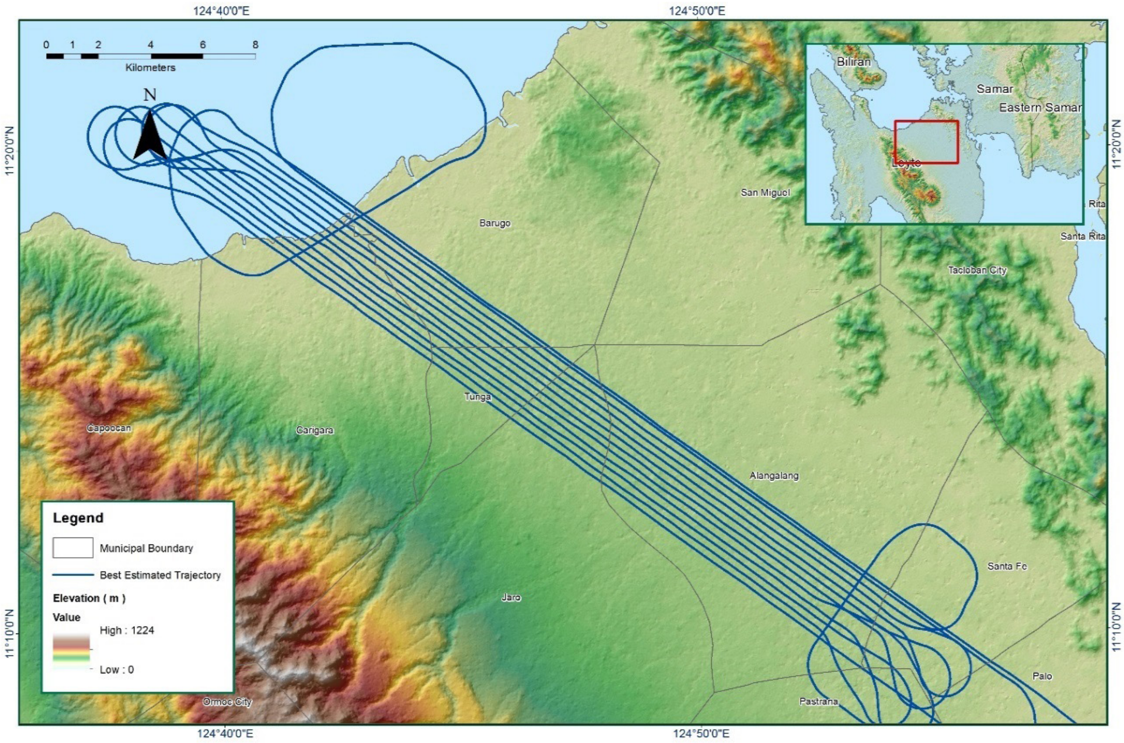



Figure A-8.10 Best Estimated Trajectory

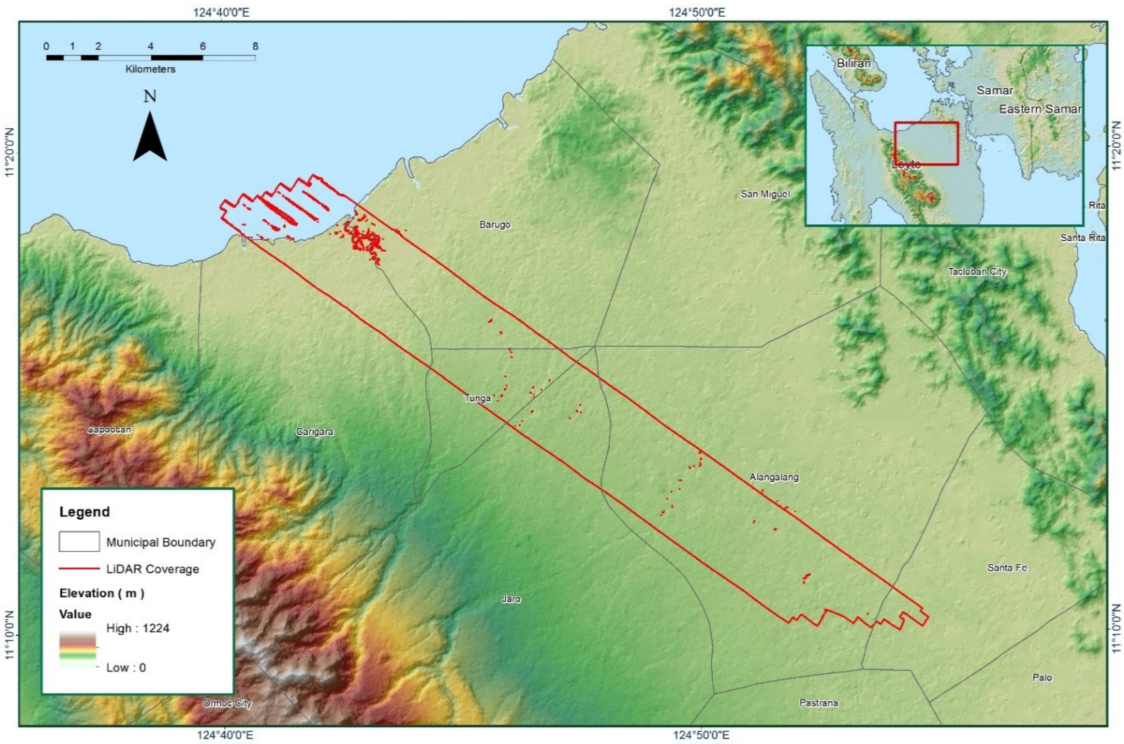



Figure A-8.11 Coverage of LiDAR data

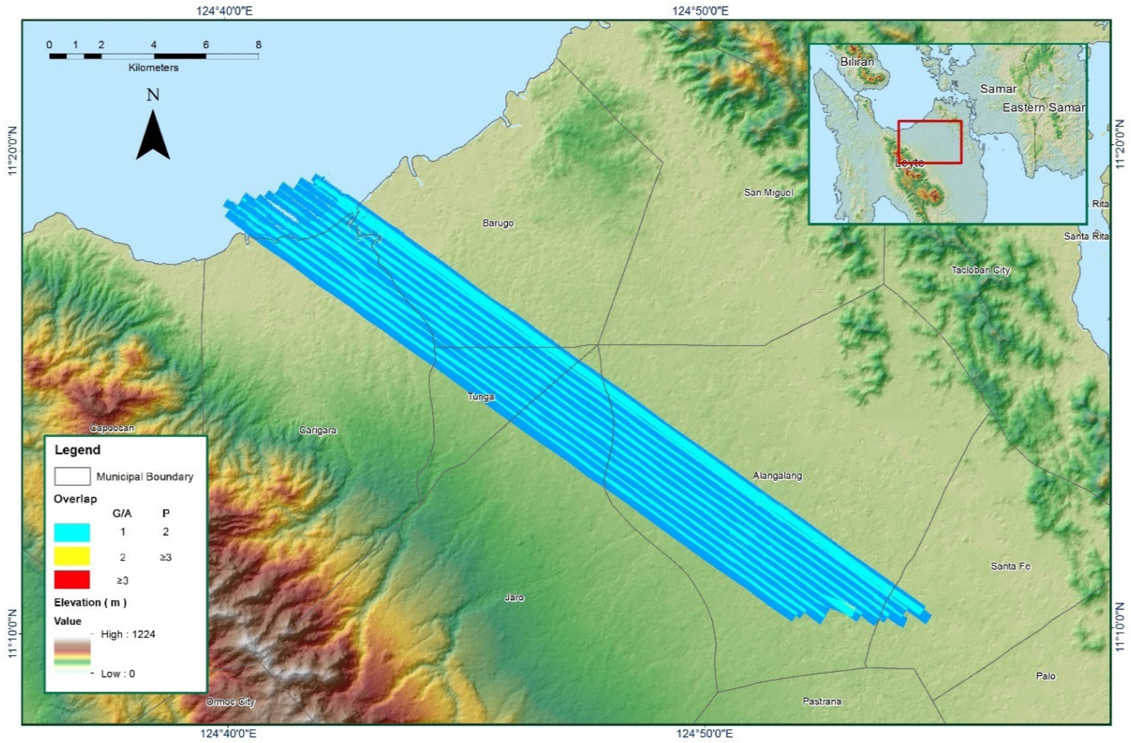



Figure A-8.12 Image of data overlap

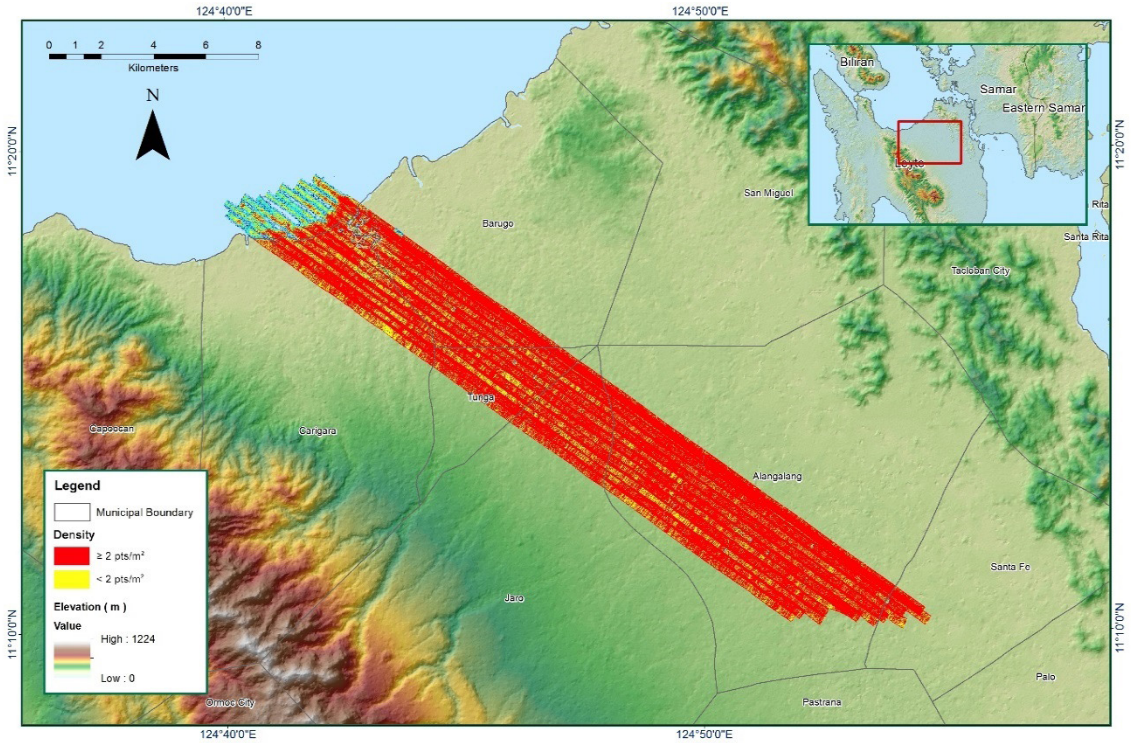



Figure A-8.13 Density map of merged LiDAR data

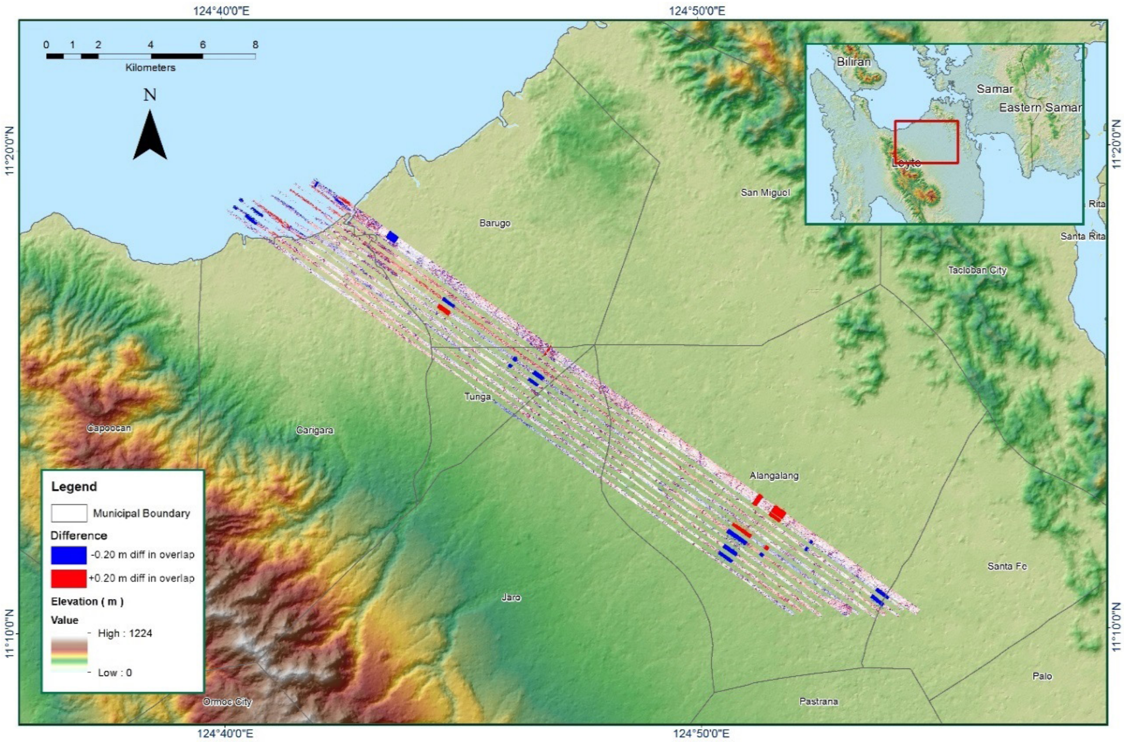



***Figure A-8.14*** *Elevation difference between flight lines*

| | |
|---|---|
| Flight Area | Samar-Leyte |
| Mission Name | Blk 34D |
| Inclusive Flights | 1454A |
| Range data size | 14.6 GB |
| Base data size | 8.41 MB |
| POS | 268 MB |
| Image | 87.2 GB |
| Transfer date | May 28, 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) | 2.2 |
| RMSE for East Position (<4.0 cm) | 1.7 |
| RMSE for Down Position (<8.0 cm) | 3.9 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000408 |
| IMU attitude correction stdev (<0.001deg) | 0.001494 |
| GPS position stdev (<0.01m) | 0.0227 |
| | |
| Minimum % overlap (>25) | 29.29% |
| Ave point cloud density per sq.m. (>2.0) | 2.73 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 149 |
| Maximum Height | 141.70 m |
| Minimum Height | 34.19 m |
| | |
| Classification (# of points) | |
| Ground | 63,755,821 |
| Low vegetation | 79,475,355 |
| Medium vegetation | 77,581,284 |
| High vegetation | 15,167,004 |
| Building | 849,062 |
| Orthophoto | Yes |
| Processed by | Victor Rejuso, Engr. Harmond Santos, Engr. Gladys Mae Apat |

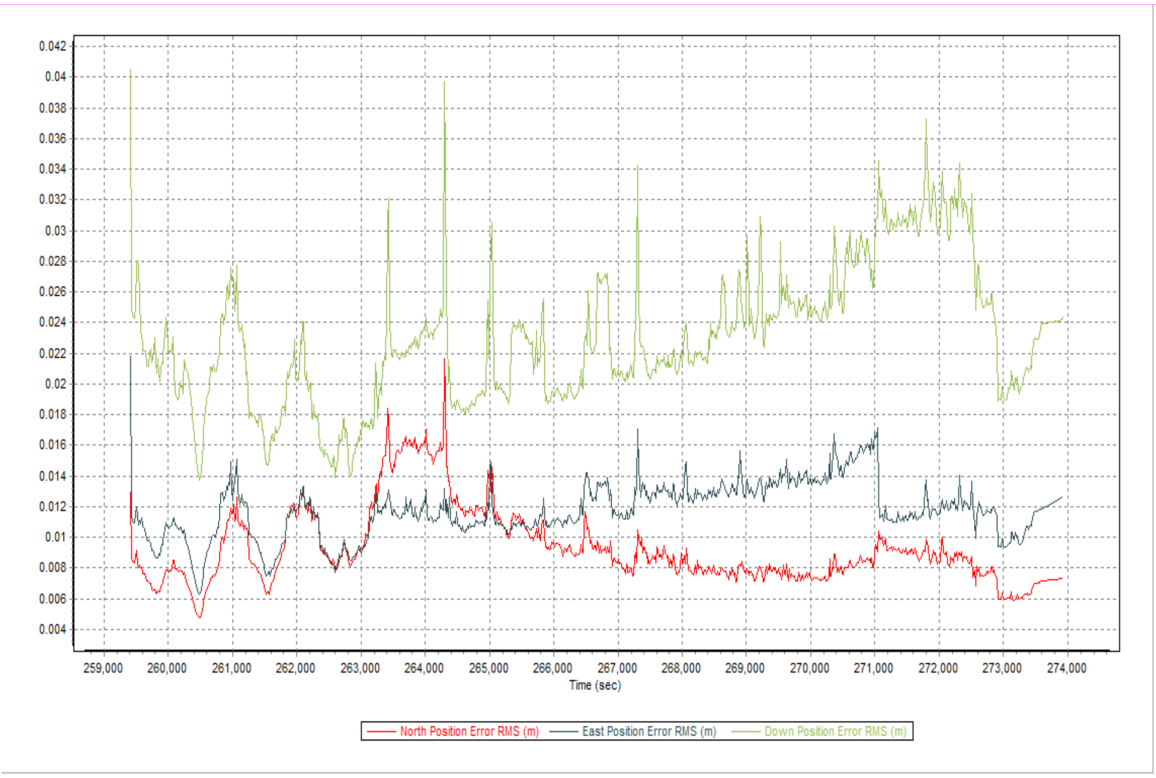



*Figure A-8.15 Solution Status*

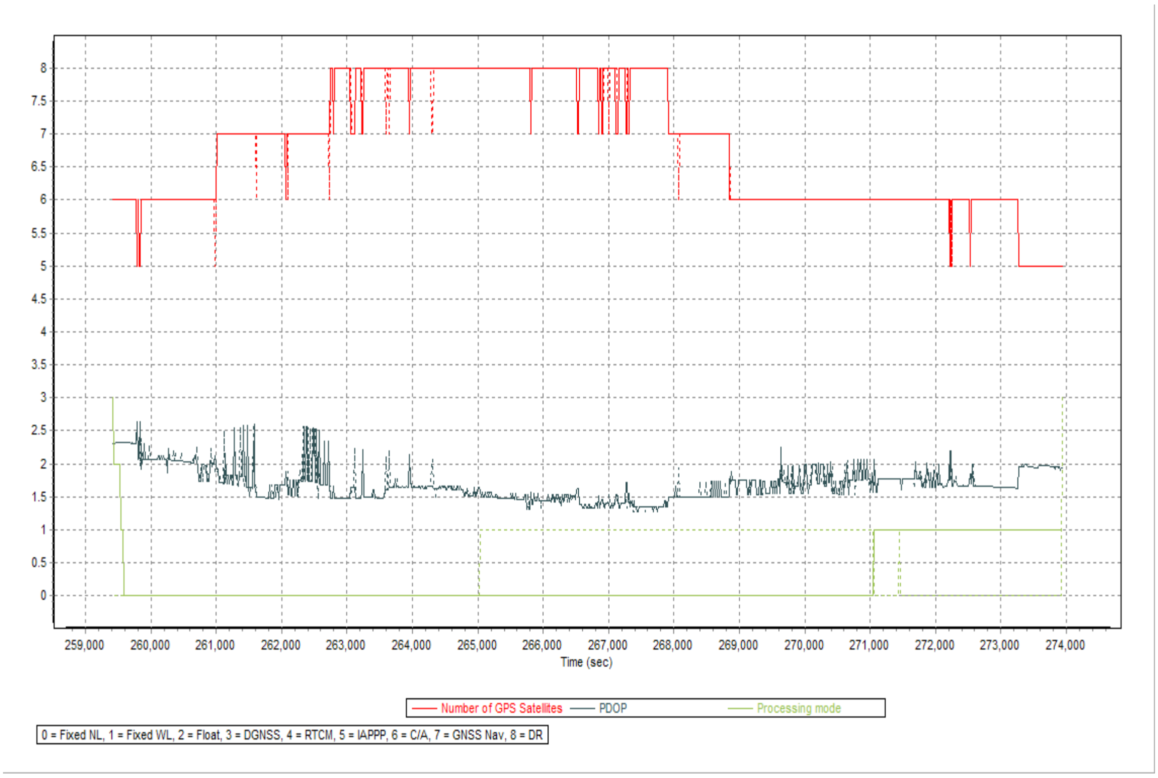



*Figure A-8.16 Smoothed Performance Metric Parameters*

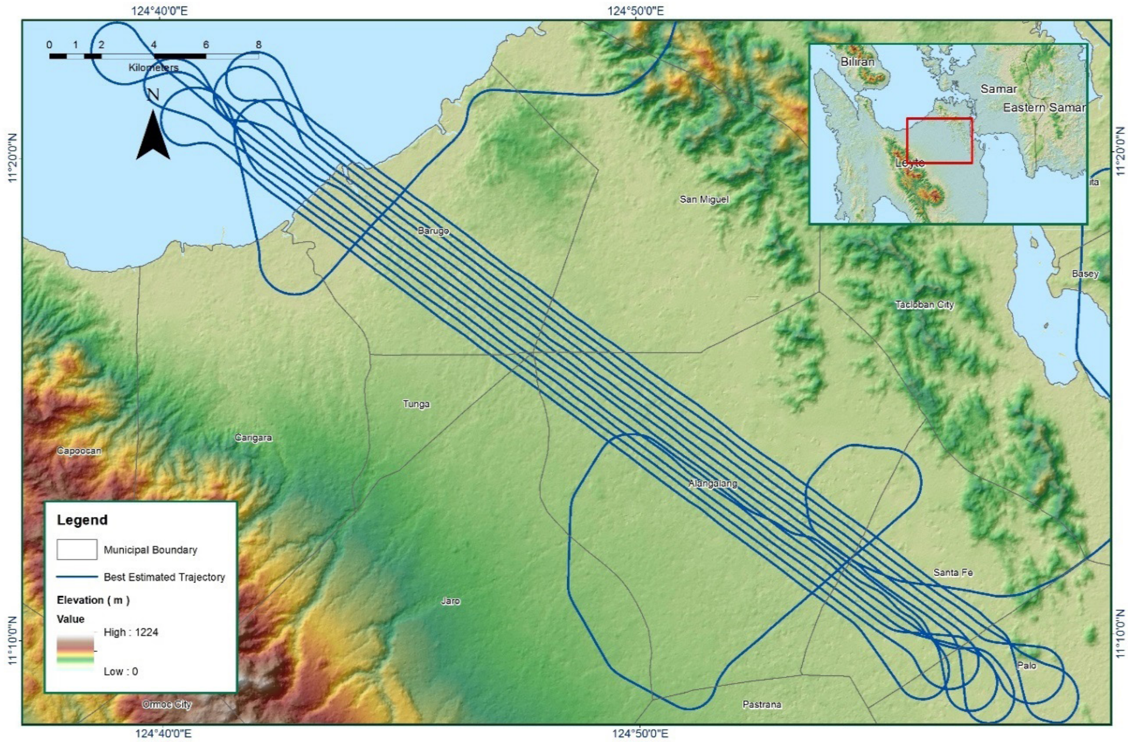



*Figure A-8.17 Best Estimated Trajectory*

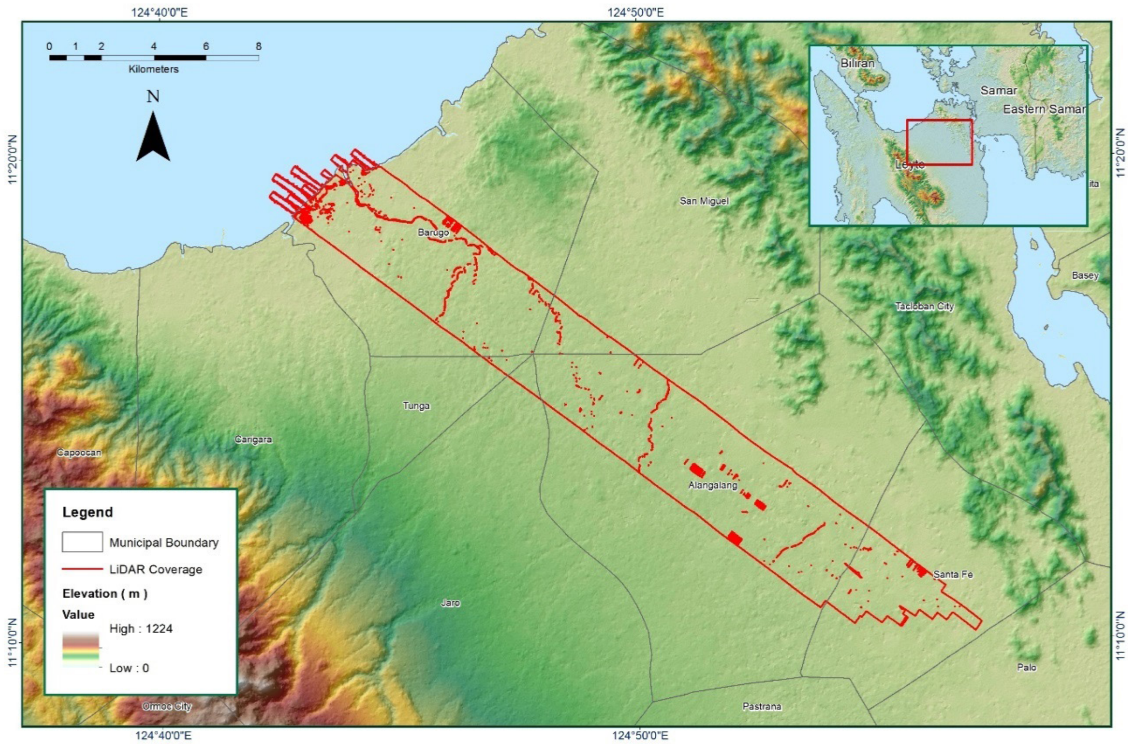



*Figure A-8.18 Coverage of LiDAR data*

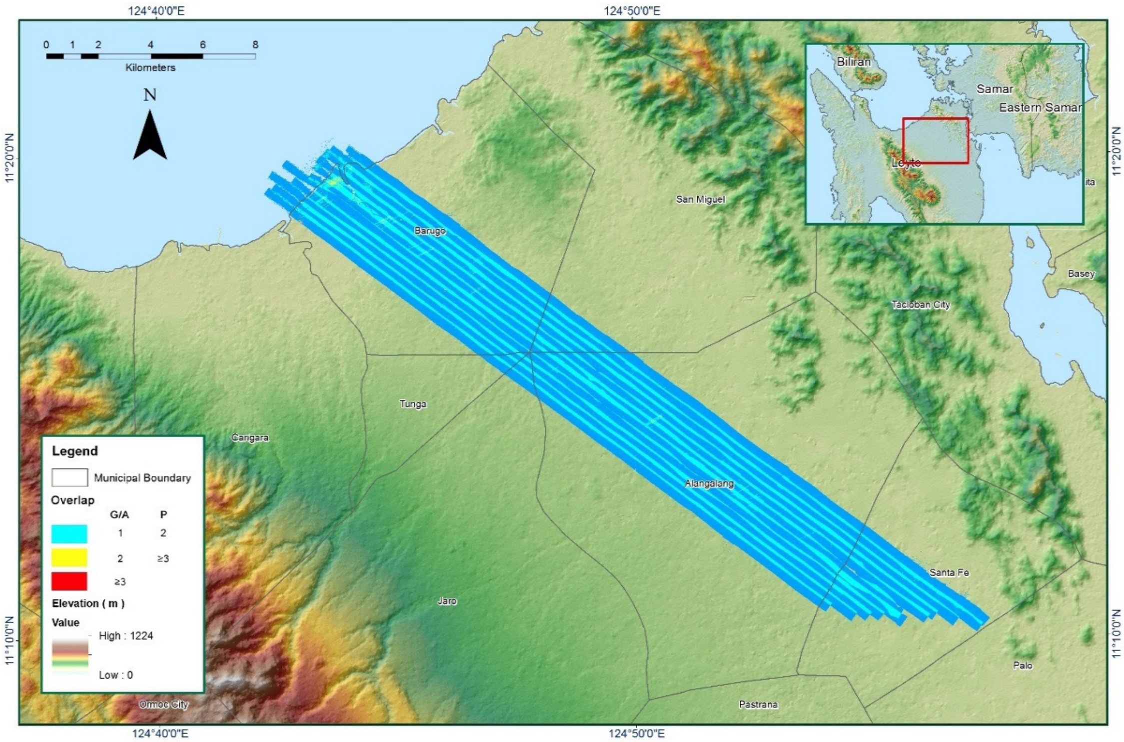



*Figure A-8.19 Image of data overlap*

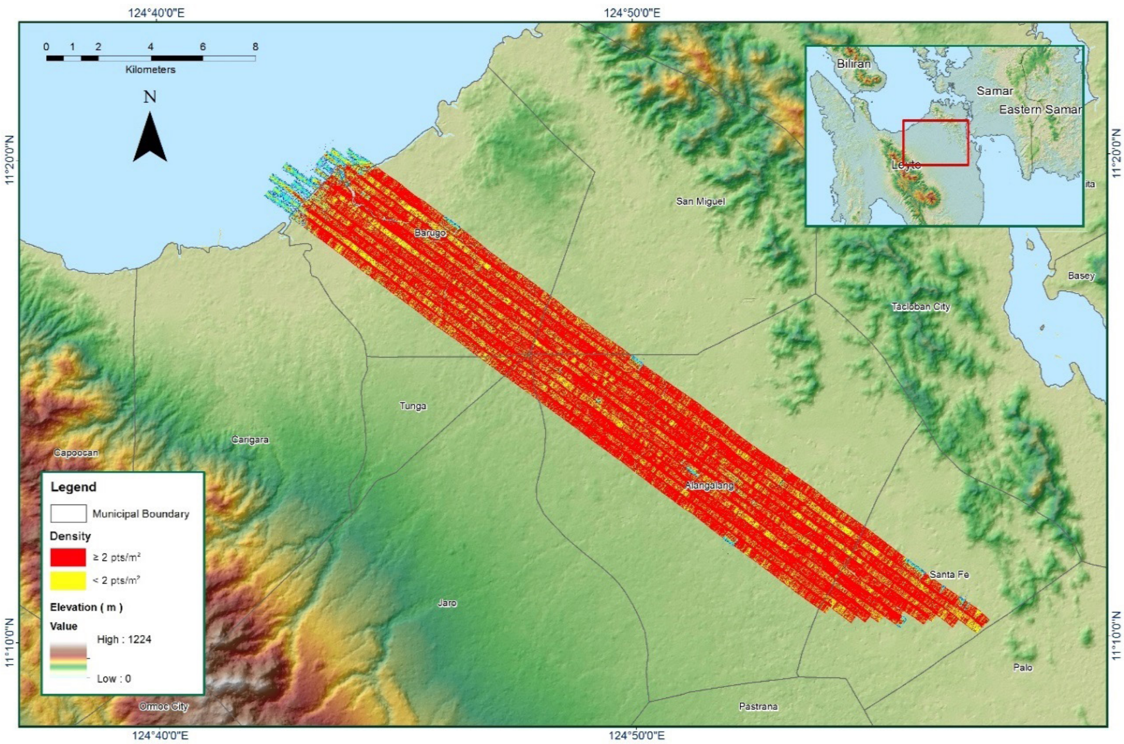



*Figure A-8.20 Density map of merged LiDAR data*

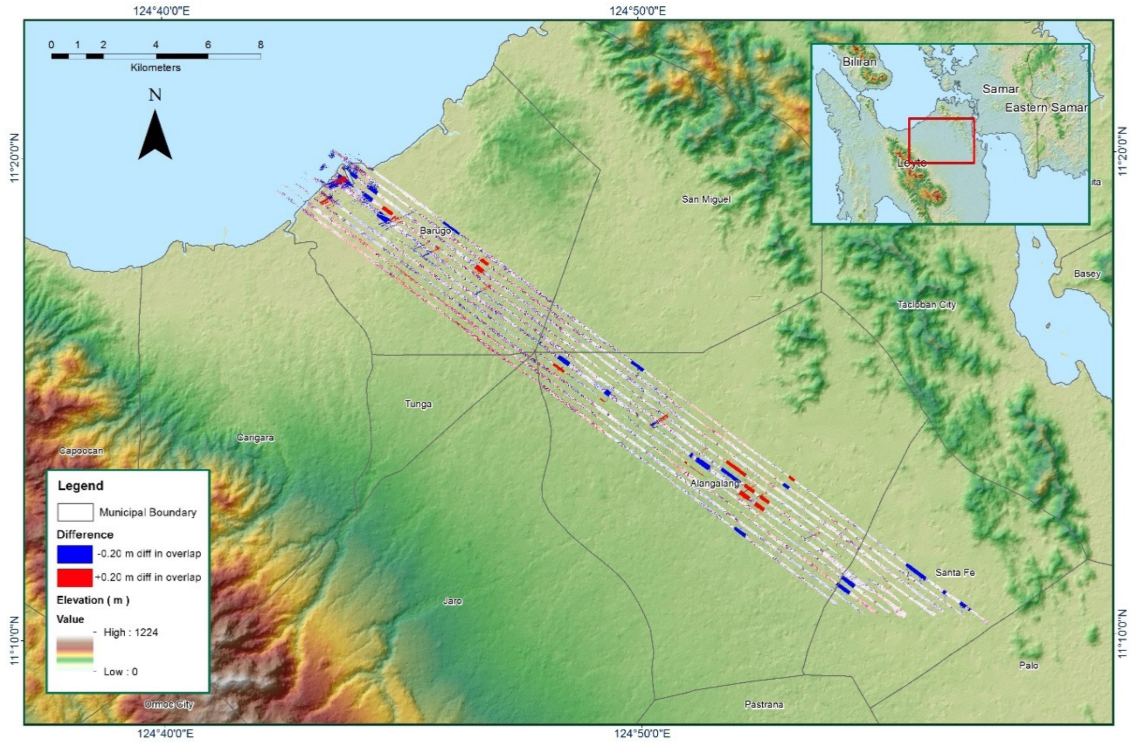



***Figure A-8.21*** *Elevation difference between flight lines*

| | |
|---|---|
| Flight Area | Samar-Leyte |
| Mission Name | Blk34E |
| Inclusive Flights | 1366A |
| Range data size | 14.9 GB |
| Base data size | 8.53 MB |
| POS | 257 MB |
| Image | 95.5 GB |
| Transfer date | May 28, 2014 |
| | |
| *Solution Status* | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | No |
| Processing Mode (<=1) | Yes |
| | |
| *Smoothed Performance Metrics* (in cm) | |
| RMSE for North Position (<4.0 cm) | 1.7 |
| RMSE for East Position (<4.0 cm) | 2.0 |
| RMSE for Down Position (<8.0 cm) | 3.8 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000518 |
| IMU attitude correction stdev (<0.001deg) | 0.026089 |
| GPS position stdev (<0.01m) | 0.0388 |
| | |
| Minimum % overlap (>25) | 53.44% |
| Ave point cloud density per sq.m. (>2.0) | 3.08 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 169 |
| Maximum Height | 313.64 m |
| Minimum Height | 59.54 m |
| | |
| *Classification (# of points)* | |
| Ground | 108,115,249 |
| Low vegetation | 76,412,876 |
| Medium vegetation | 82,519,137 |
| High vegetation | 16,810,372 |
| Building | 540,046 |
| Orthophoto | Yes |
| Processed by | Engr. Jennifer Saguran, Engr. Harmond Santos, Engr. Gladys Mae Apat |

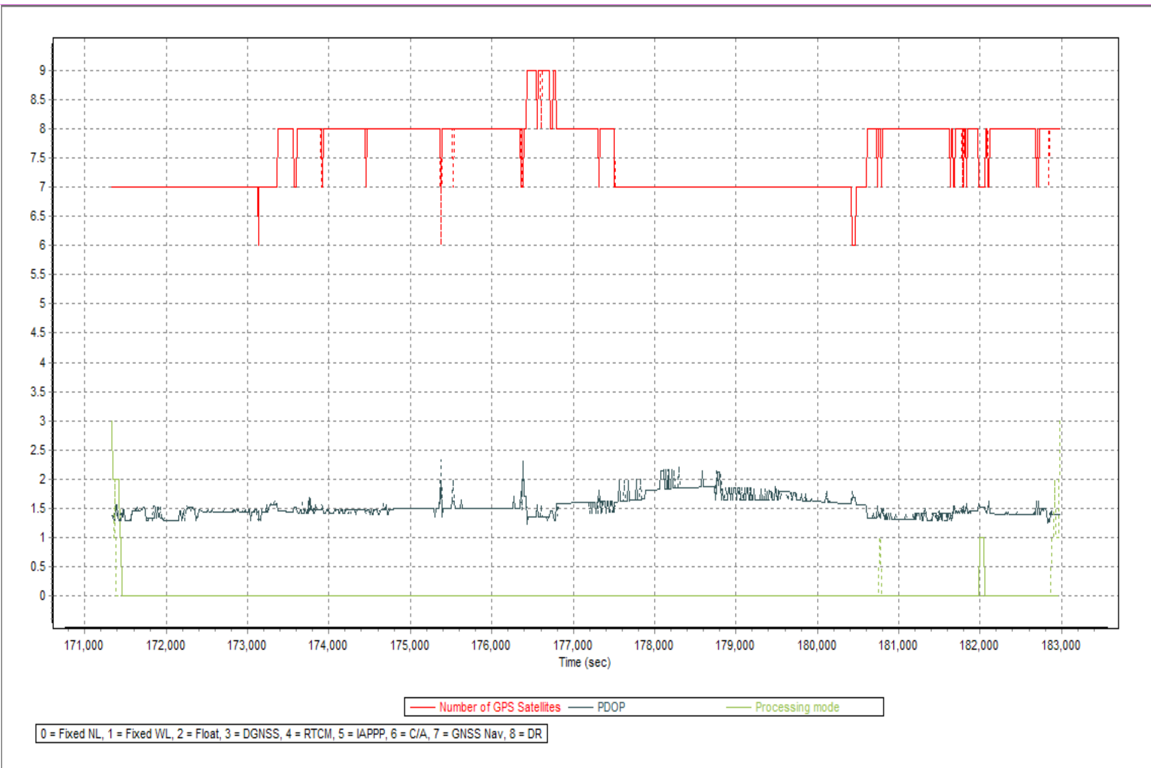



*Figure A-8.22 Solution Status*

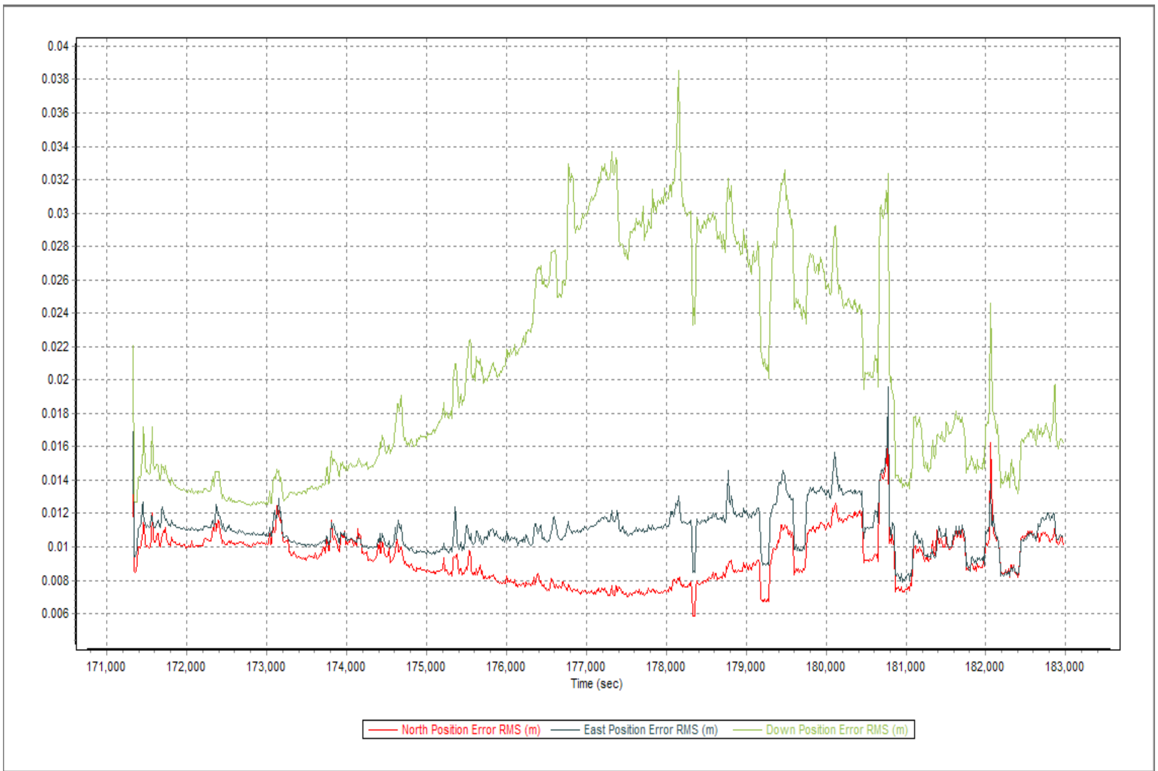



*Figure A-8.23 Smoothed Performance Metric Parameters*

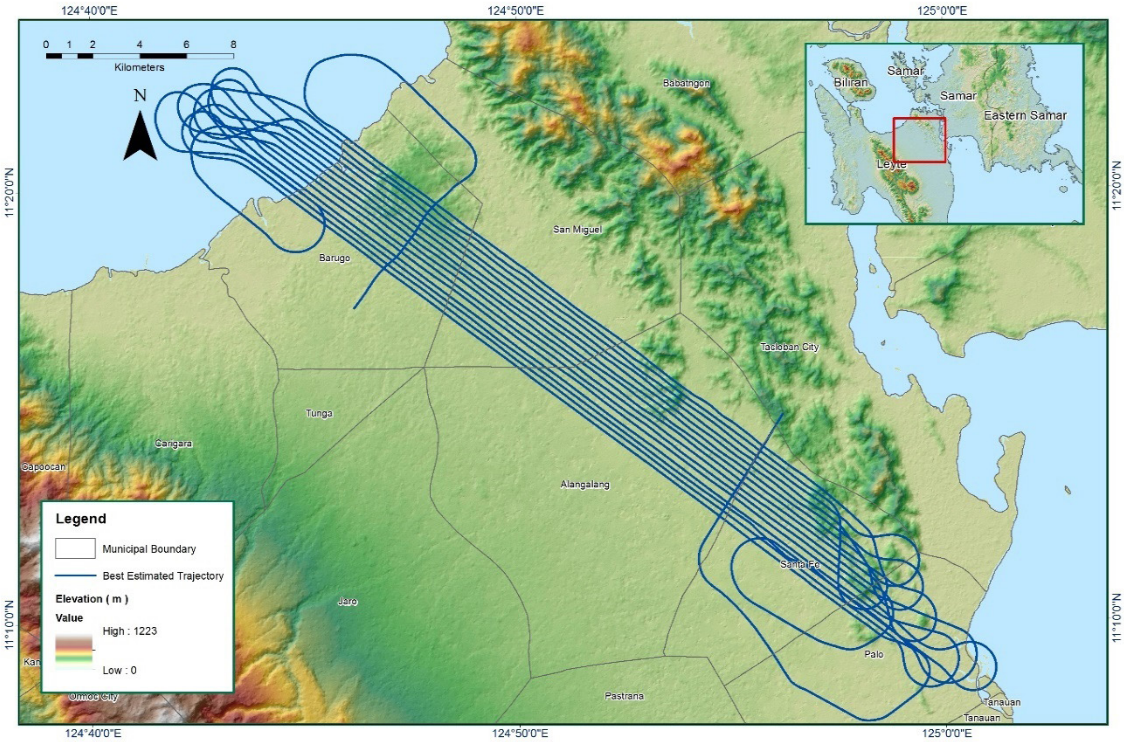



*Figure A-8.24 Best Estimated Trajectory*

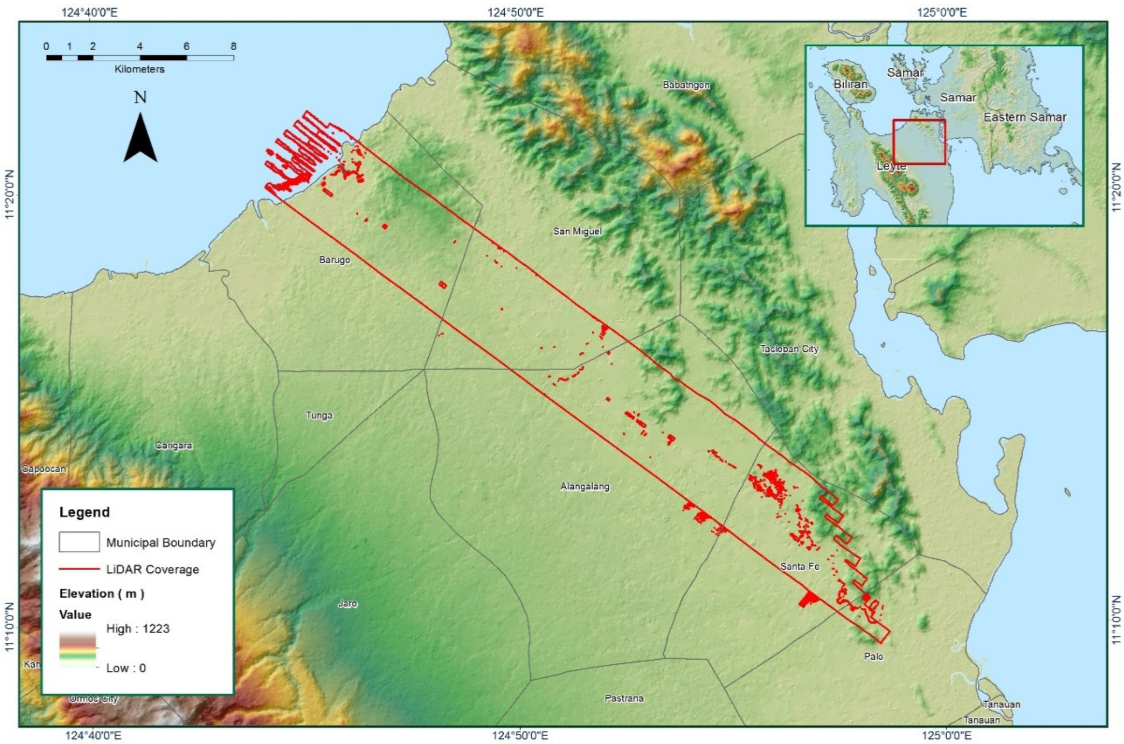



*Figure A-8.25 Coverage of LiDAR data*

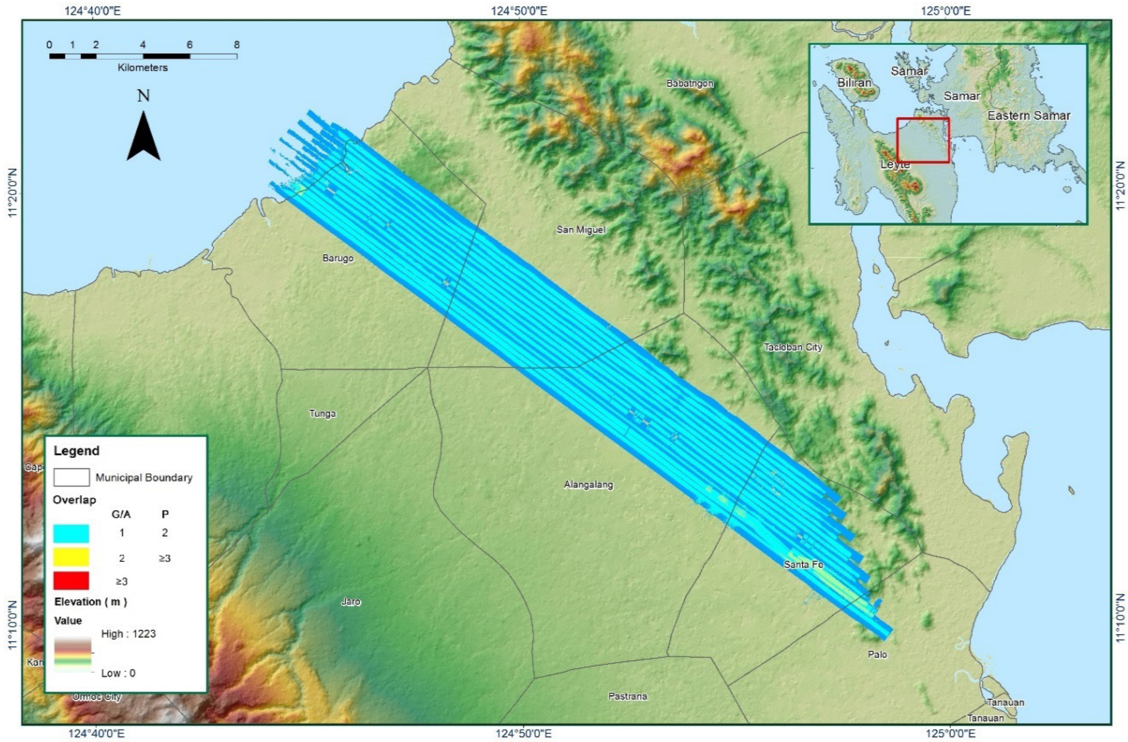



*Figure A-8.26 Image of data overlap*

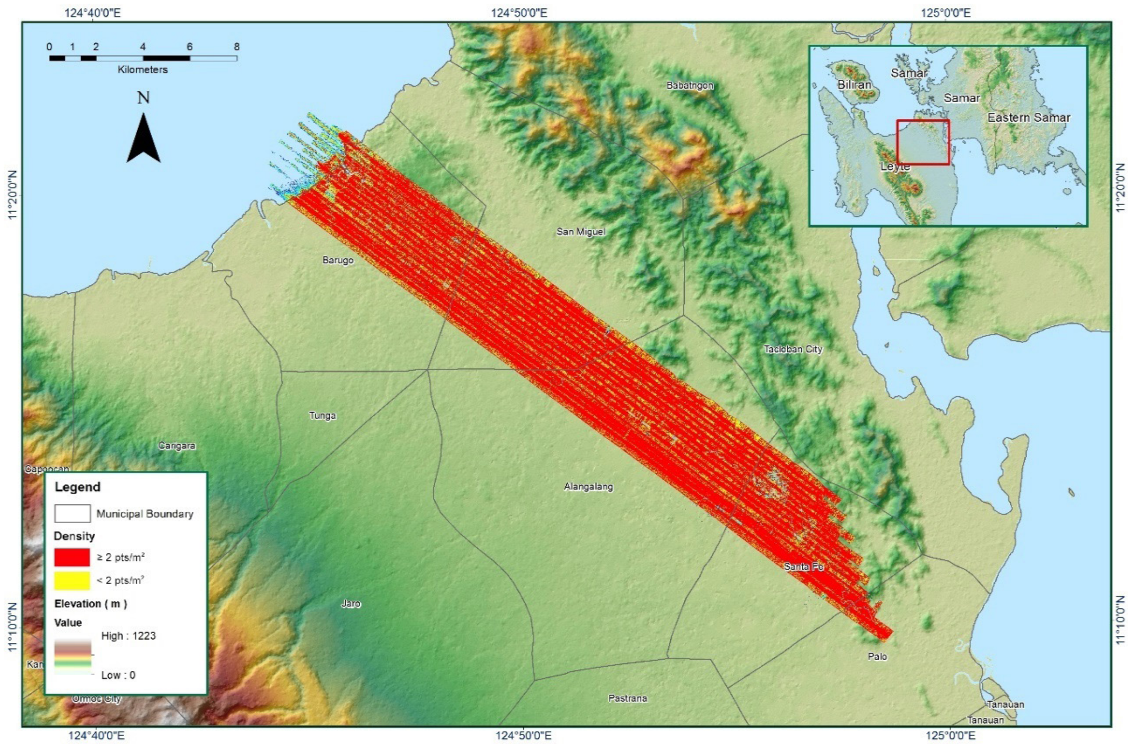



*Figure A-8.27 Density map of merged LiDAR data*

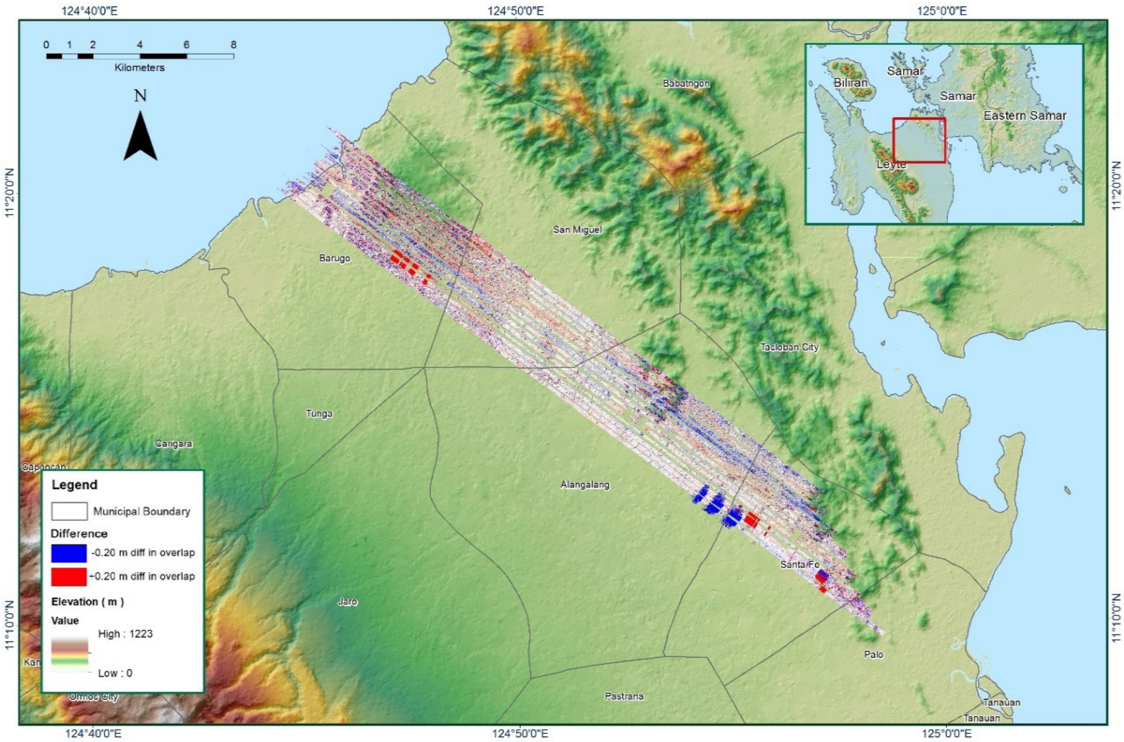



*Figure A-8.28* Elevation difference between flight lines

| | |
|---|---|
| Flight Area | Leyte |
| Mission Name | Blk34J |
| Inclusive Flights | 3765G |
| Range data size | 25.2 GB |
| Base data size | 4.38 MB |
| POS | 225 MB |
| Image | n/a |
| Transfer date | February 12, 2016 |
| | |
| *Solution Status* | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | No |
| Baseline Length (<30km) | No |
| Processing Mode (<=1) | Yes |
| | |
| *Smoothed Performance Metrics* (in cm) | |
| RMSE for North Position (<4.0 cm) | 1.7 |
| RMSE for East Position (<4.0 cm) | 1.4 |
| RMSE for Down Position (<8.0 cm) | 6.0 |
| | |
| Boresight correction stdev (<0.001deg) | 0.003377 |
| IMU attitude correction stdev (<0.001deg) | 0.001525 |
| GPS position stdev (<0.01m) | 0.0017 |
| | |
| Minimum % overlap (>25) | 27.64 |
| Ave point cloud density per sq.m. (>2.0) | 3.52 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 108 |
| Maximum Height | 246.28 m |
| Minimum Height | 78.27 m |
| | |
| *Classification (# of points)* | |
| Ground | 23,439,051 |
| Low vegetation | 27,359,793 |
| Medium vegetation | 97,600,486 |
| High vegetation | 50,609,486 |
| Building | 826,294 |
| Orthophoto | No |
| Processed by | Engr. Sheila Mae Santillan, Engr. Ma Joanne Balaga, Marie Denise Bueno |

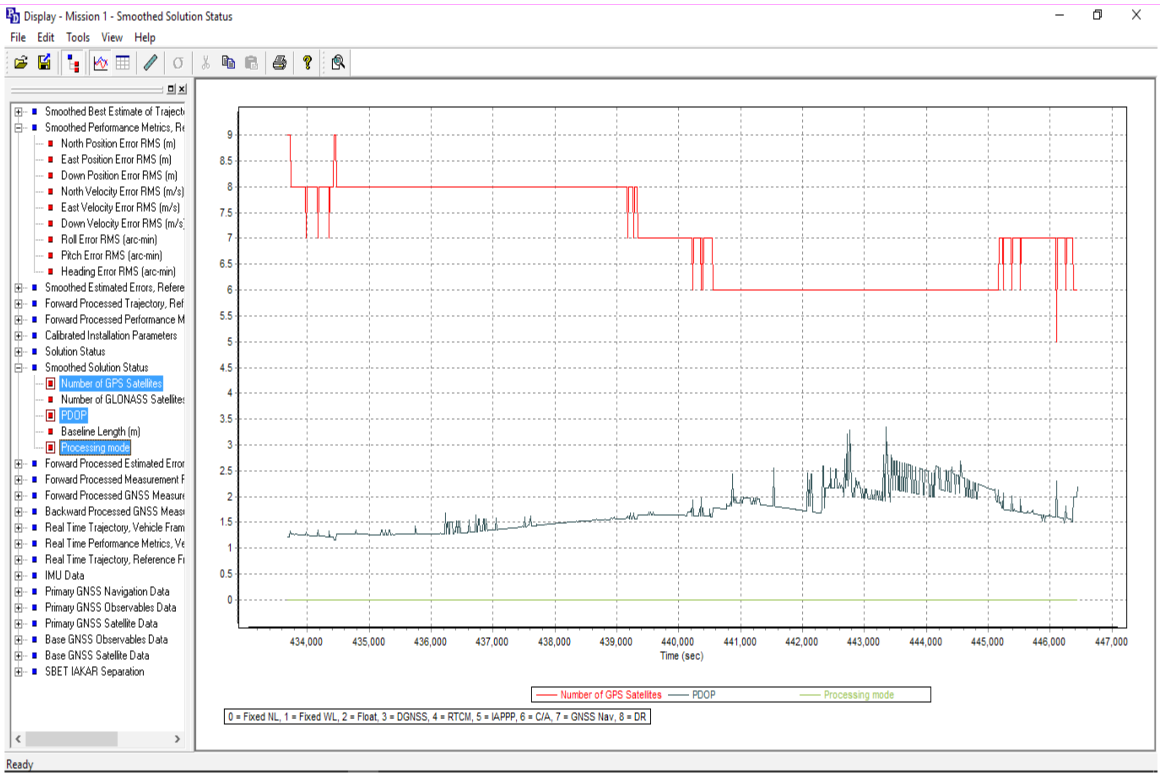



*Figure A-8.29 Solution Status*

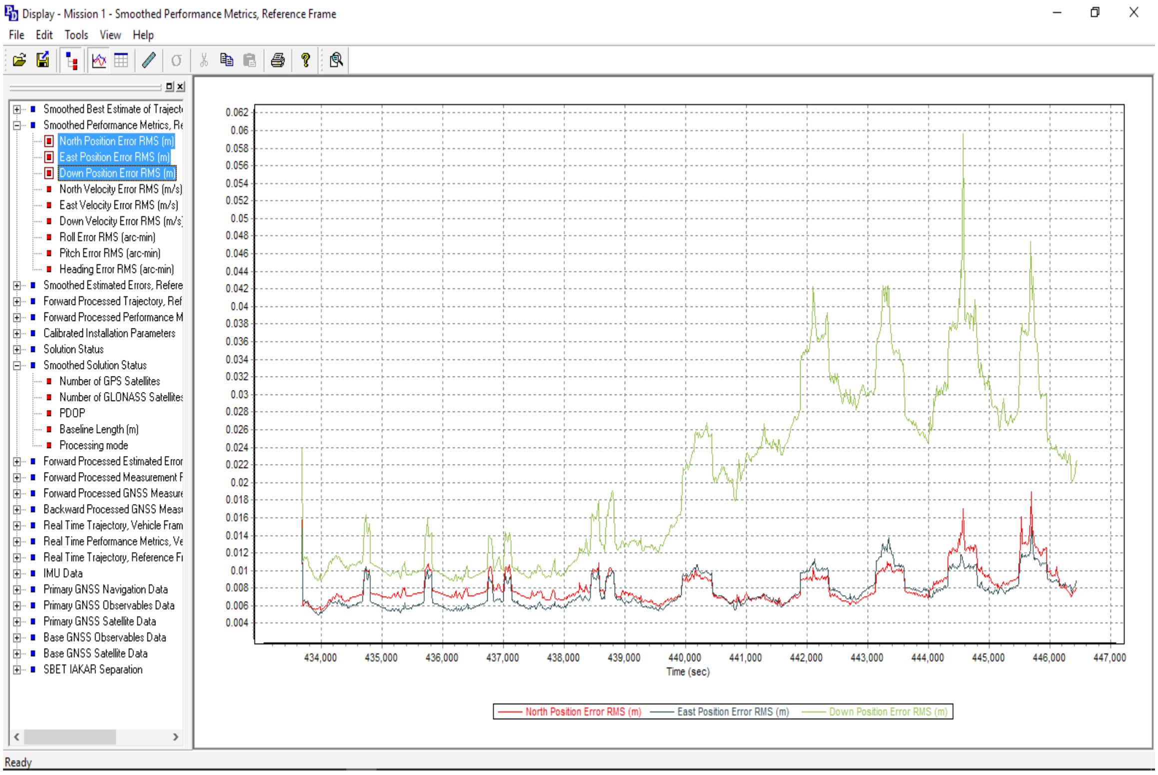



*Figure A-8.30 Smoothed Performance Metric Parameters*

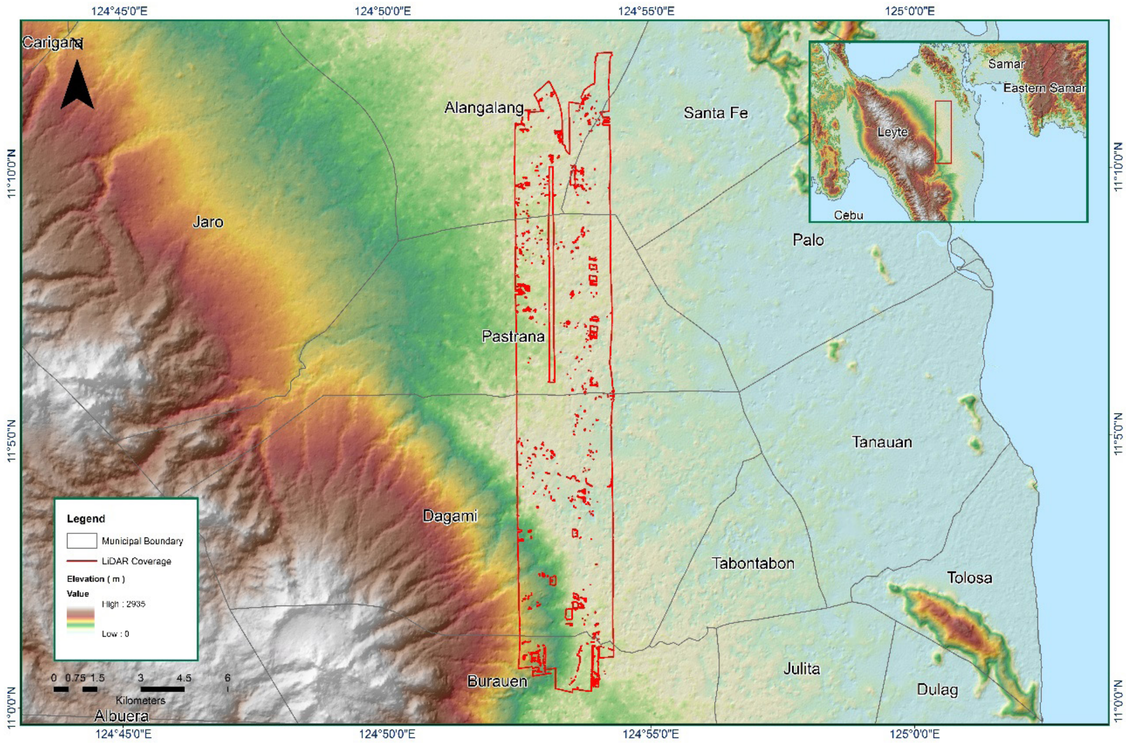



*Figure A-8.31 Best Estimated Trajectory*

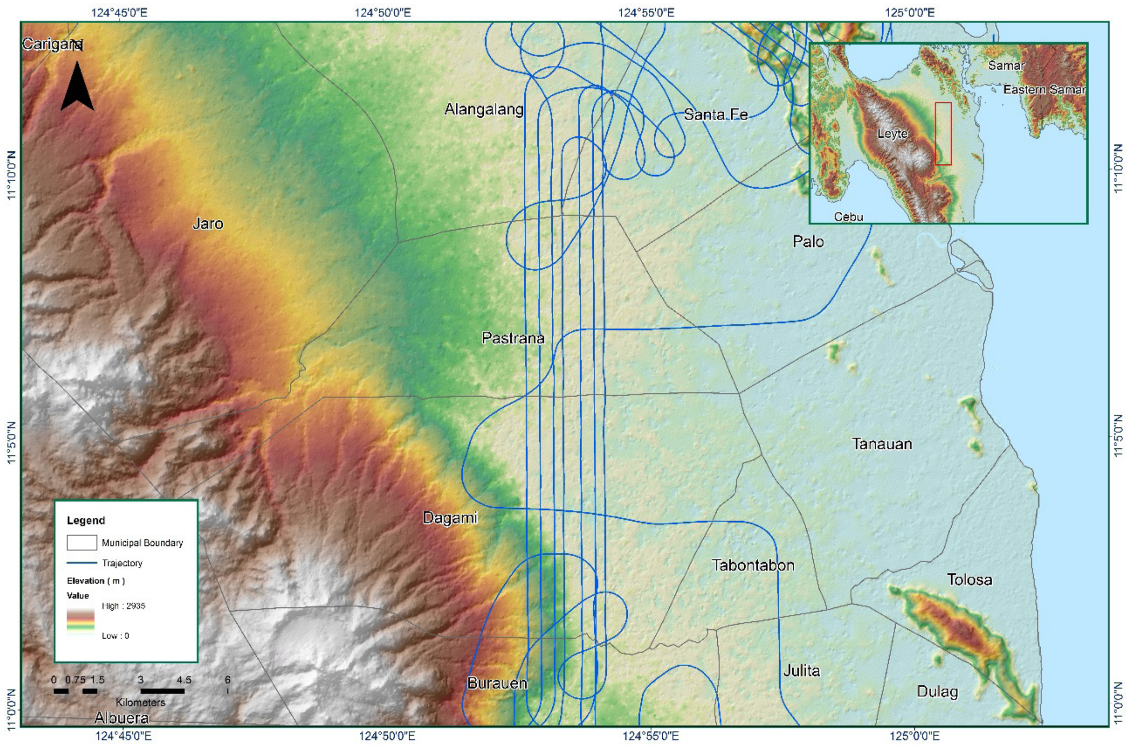



*Figure A-8.32 Coverage of LiDAR data*

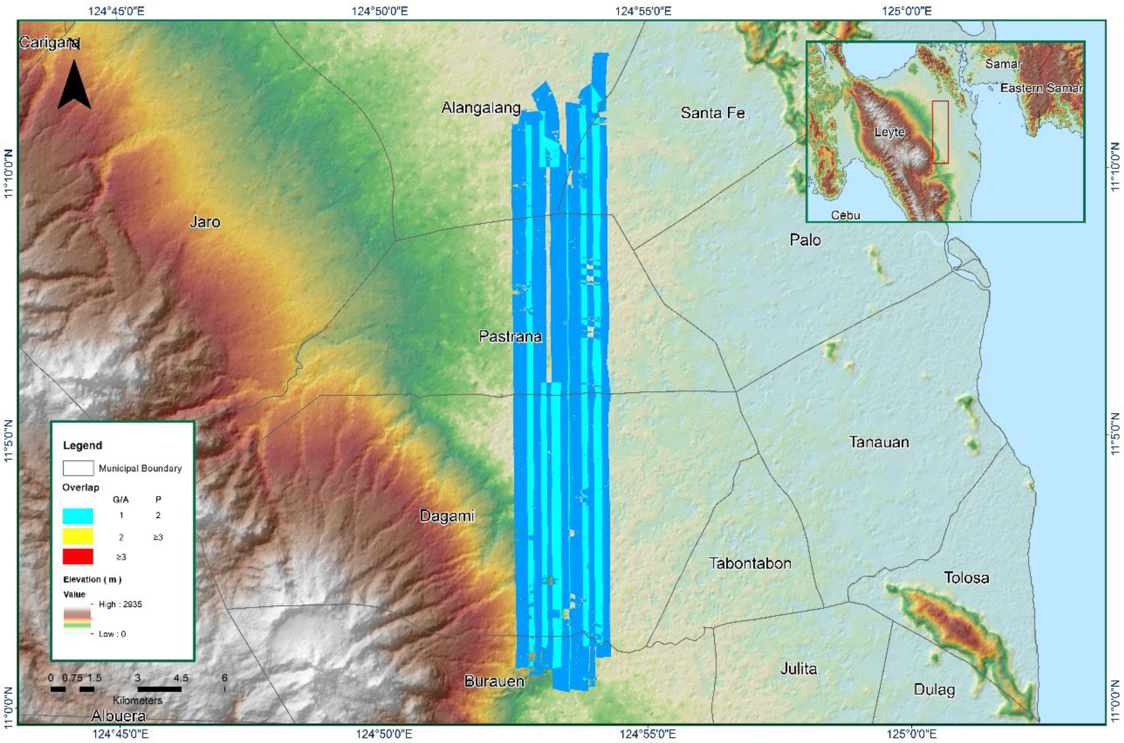



*Figure A-8.33  Image of data overlap*

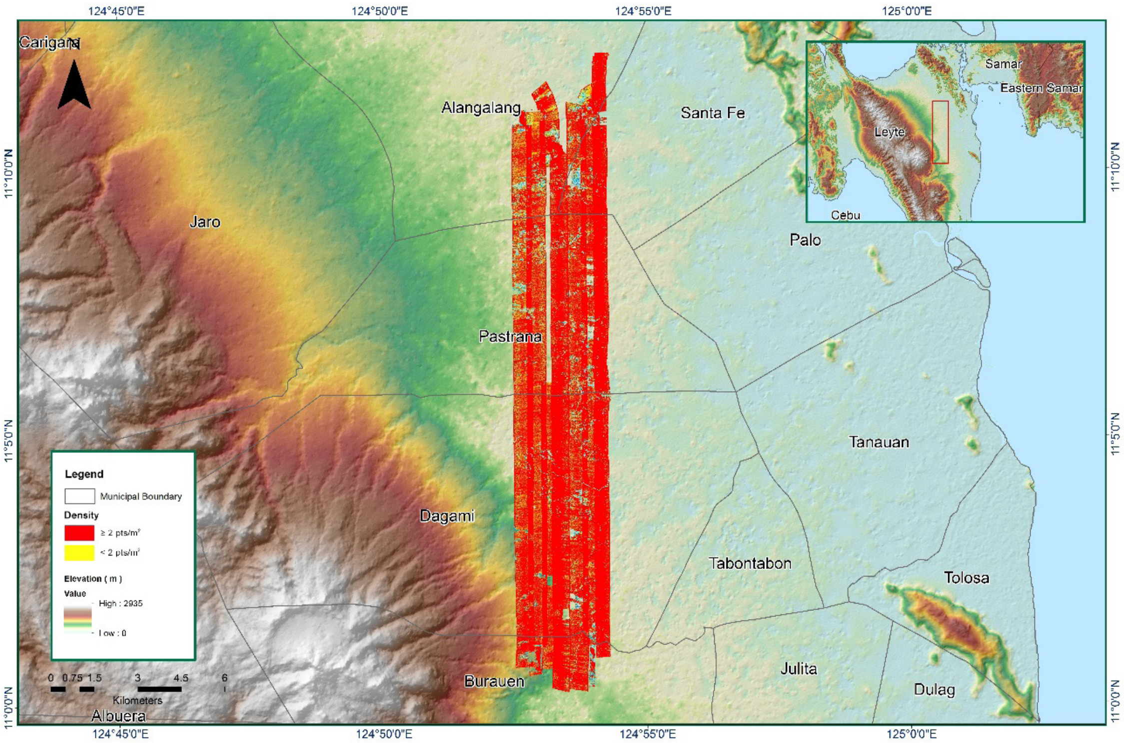



*Figure A-8.34 Density map of merged LiDAR data*

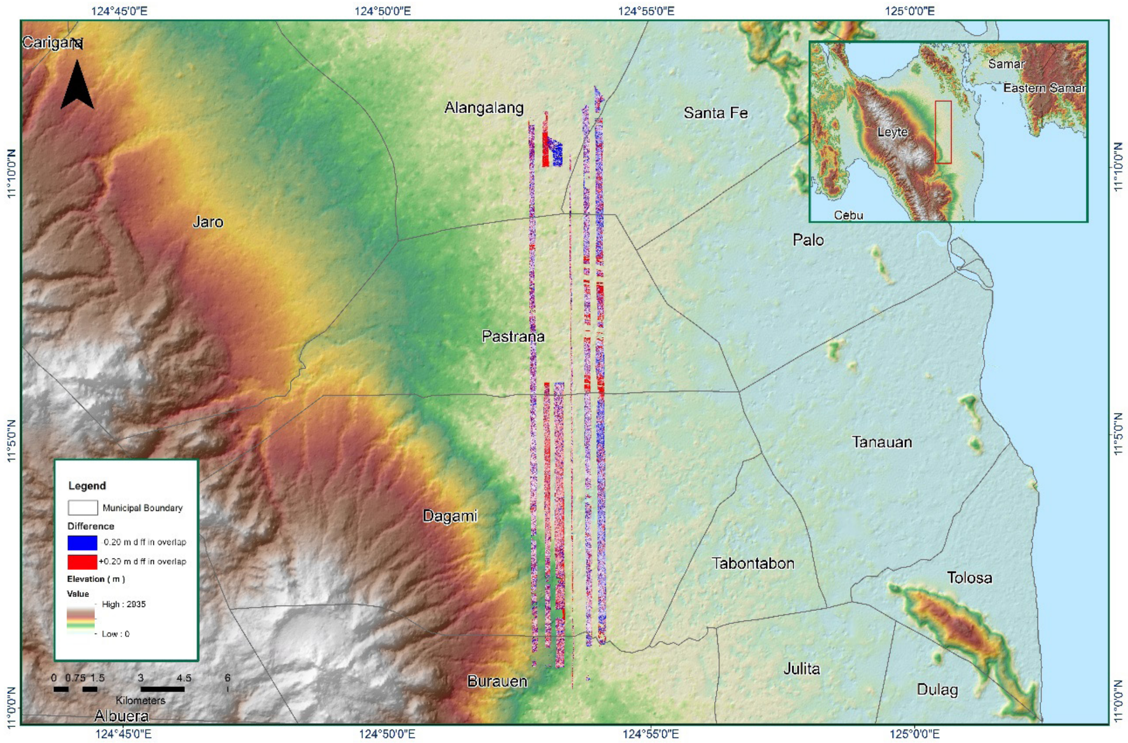



*Figure A-8.35 Elevation difference between flight lines*

| | |
|---|---|
| Flight Area | Leyte |
| Mission Name | Blk34I |
| Inclusive Flights | 3769G |
| Range data size | 23.8 GB |
| Base data size | 9.58 MB |
| POS | 260 MB |
| Image | n/a |
| Transfer date | February 12, 2016 |
| | |
| *Solution Status* | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | No |
| Processing Mode (<=1) | Yes |
| | |
| *Smoothed Performance Metrics* (in cm) | |
| RMSE for North Position (<4.0 cm) | 1.1 |
| RMSE for East Position (<4.0 cm) | 1.2 |
| RMSE for Down Position (<8.0 cm) | 3.3 |
| | |
| Boresight correction stdev (<0.001deg) | 0.003871 |
| IMU attitude correction stdev (<0.001deg) | 0.003796 |
| GPS position stdev (<0.01m) | 0.0138 |
| | |
| Minimum % overlap (>25) | 27.82 |
| Ave point cloud density per sq.m. (>2.0) | 3.21 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 86 |
| Maximum Height | 266.62 m |
| Minimum Height | 75.43 m |
| | |
| *Classification (# of points)* | |
| Ground | 20,398,103 |
| Low vegetation | 20,790,546 |
| Medium vegetation | 70,517,058 |
| High vegetation | 26,392,425 |
| Building | 302,229 |
| Orthophoto | No |
| Processed by | Engr. Kenneth Solidum, Engr. Mark Joshua Salvacion, Kathryn Claudyn Zarate |

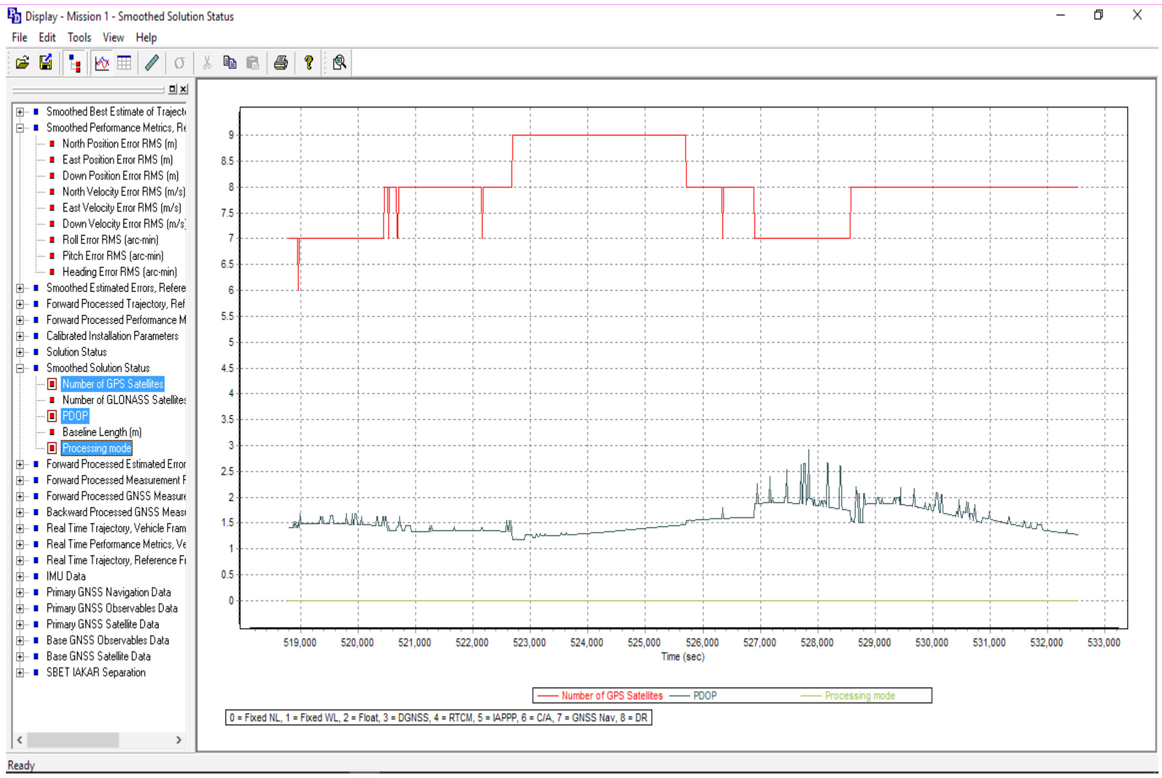


*Figure A-8.36 Solution Status*

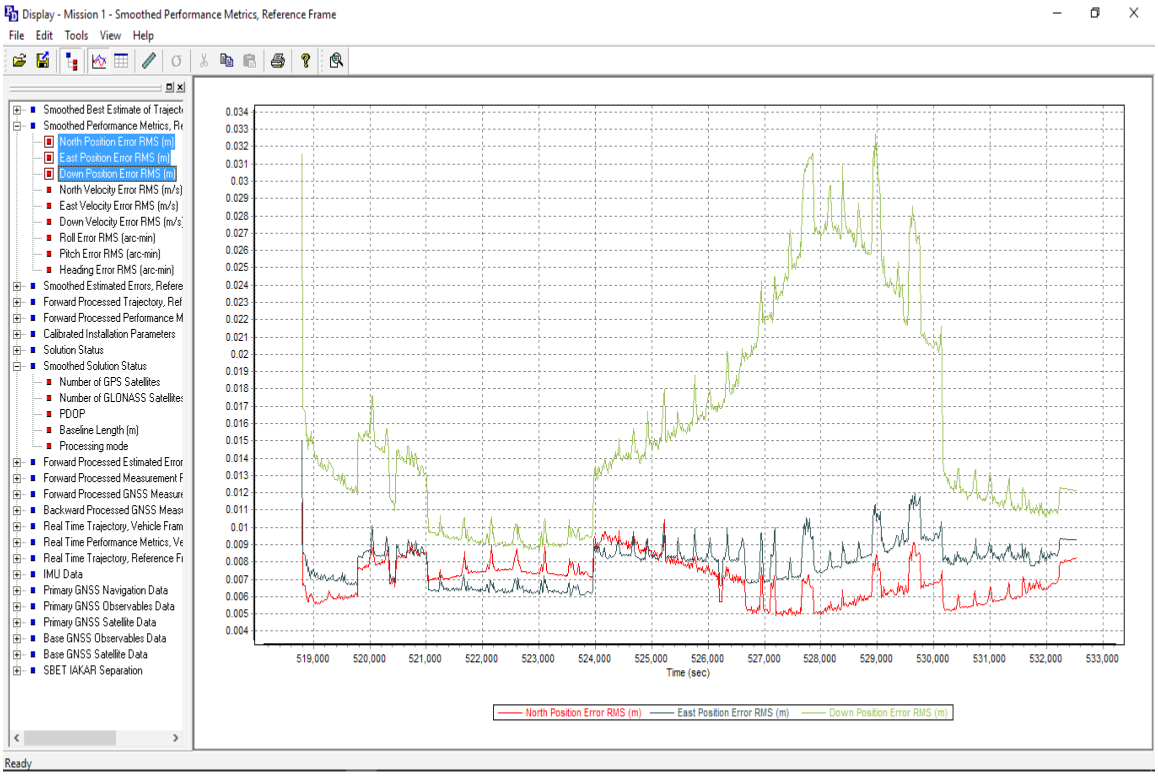


*Figure A-8.37 Smoothed Performance Metric Parameters*

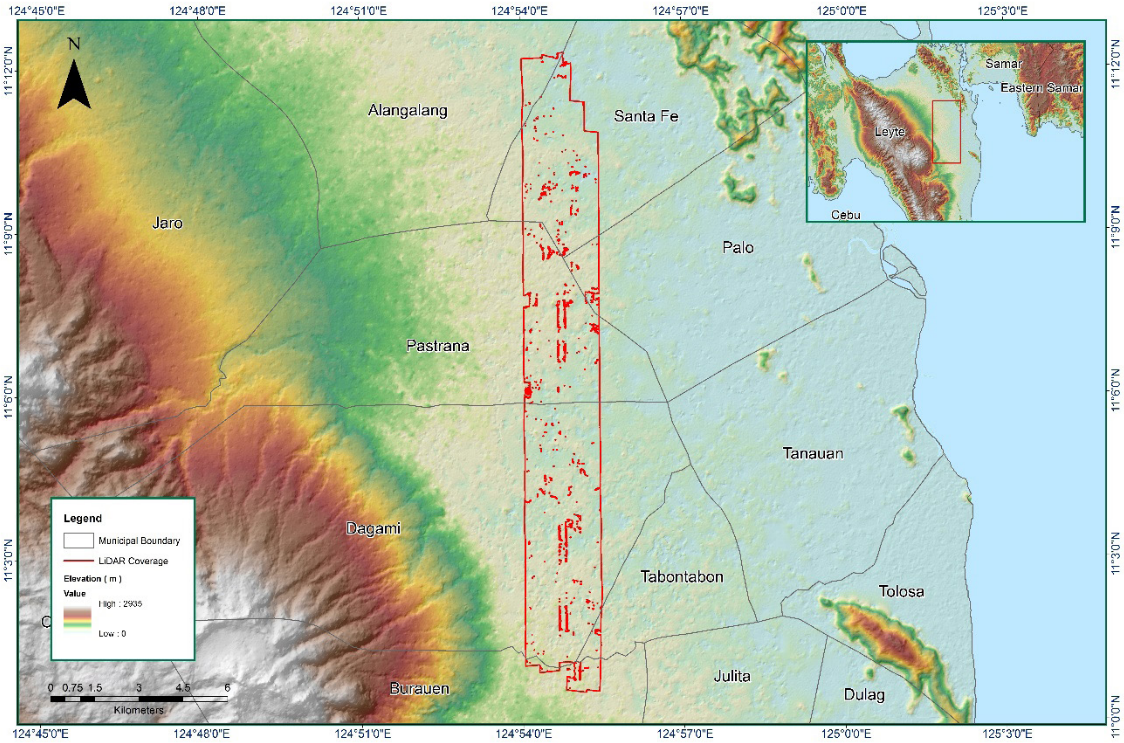



*Figure A-8.38 Best Estimated Trajectory*

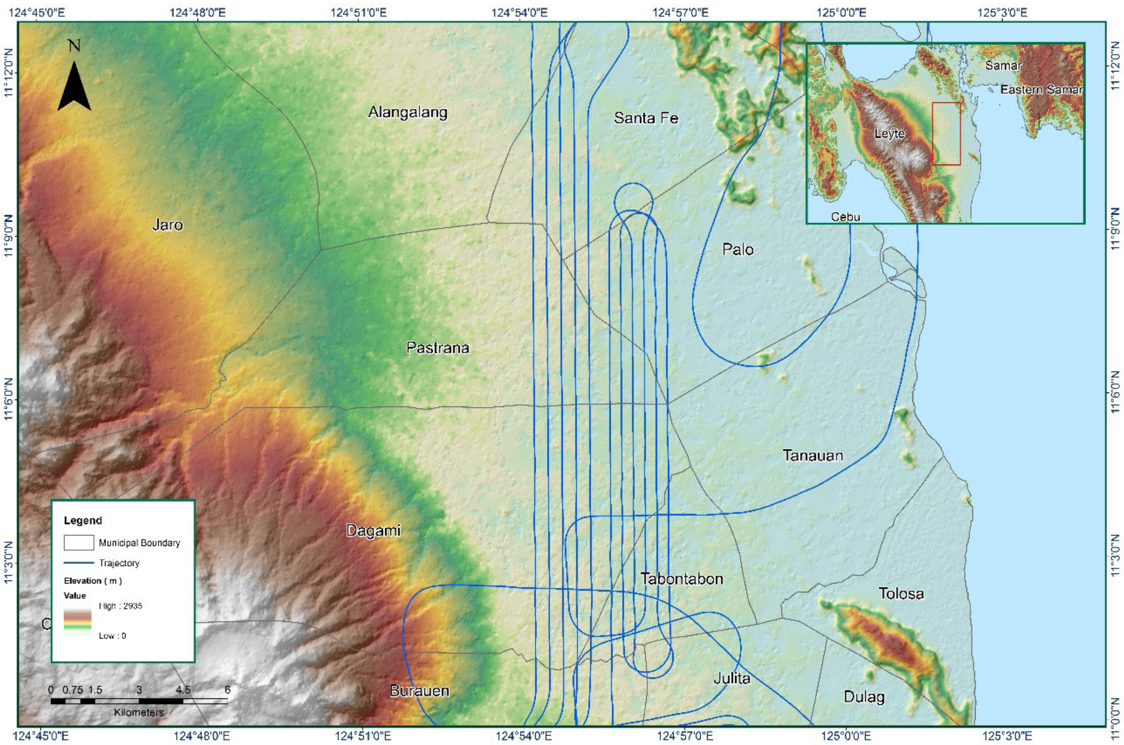



*Figure A-8.39 Coverage of LiDAR data*

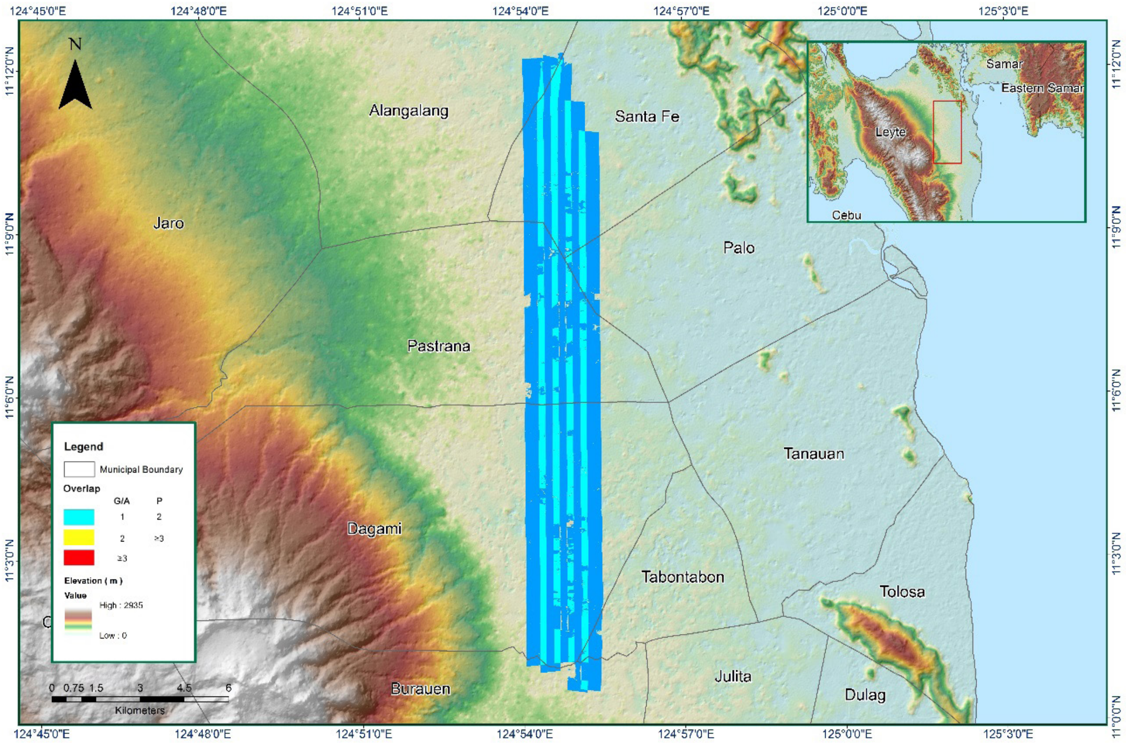



*Figure A-8.40 Image of data overlap*

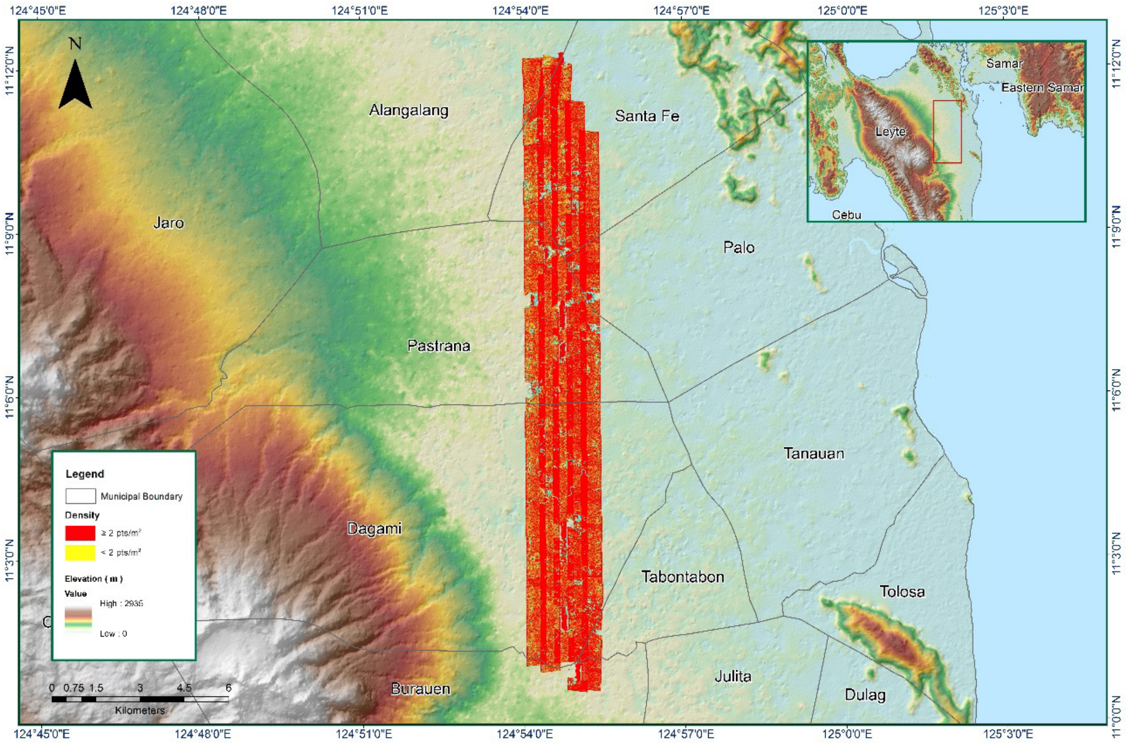



*Figure A-8.41 Density map of merged LiDAR data*

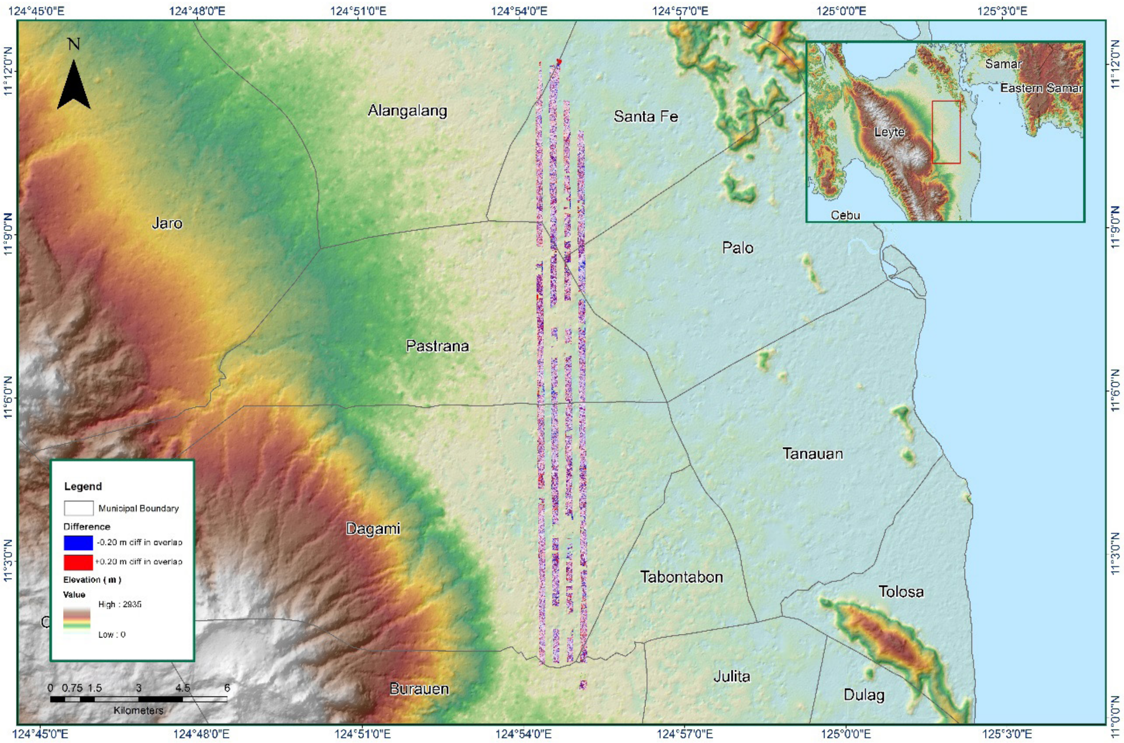



*Figure A-8.42 Elevation difference between flight lines*

| | |
|---|---|
| Flight Area | Leyte |
| Mission Name | Blk34G_Supplement |
| Inclusive Flights | 3773G |
| Range data size | 16.8 GB |
| Base data size | 4.74 MB |
| POS | 248 MB |
| Image | n/a |
| Transfer date | February 12, 2016 |
| | |
| *Solution Status* | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | No |
| Baseline Length (<30km) | Yes |
| 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) | 1.3 |
| RMSE for Down Position (<8.0 cm) | 3.0 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000314 |
| IMU attitude correction stdev (<0.001deg) | 0.000292 |
| GPS position stdev (<0.01m) | 0.0020 |
| | |
| Minimum % overlap (>25) | 38.70 |
| Ave point cloud density per sq.m. (>2.0) | 4.35 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 77 |
| Maximum Height | 331.30 m |
| Minimum Height | 84.63 m |
| | |
| *Classification (# of points)* | |
| Ground | 30,109,919 |
| Low vegetation | 49,355,383 |
| Medium vegetation | 102,195,429 |
| High vegetation | 45,790,210 |
| Building | 1,350,028 |
| Orthophoto | No |
| Processed by | Engr. Regis Guhiting, Engr. Jovelle Anjeanette Canlas, Engr. Monalyne Rabino |

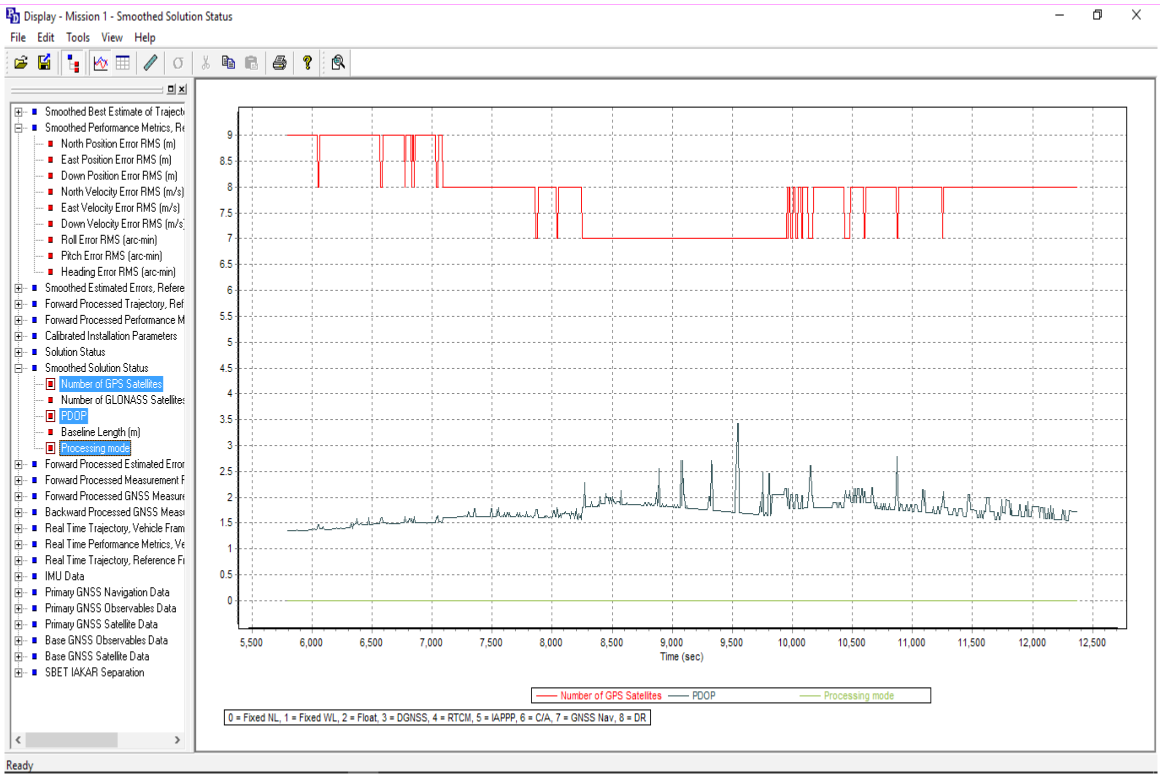



*Figure A-8.43 Solution Status*

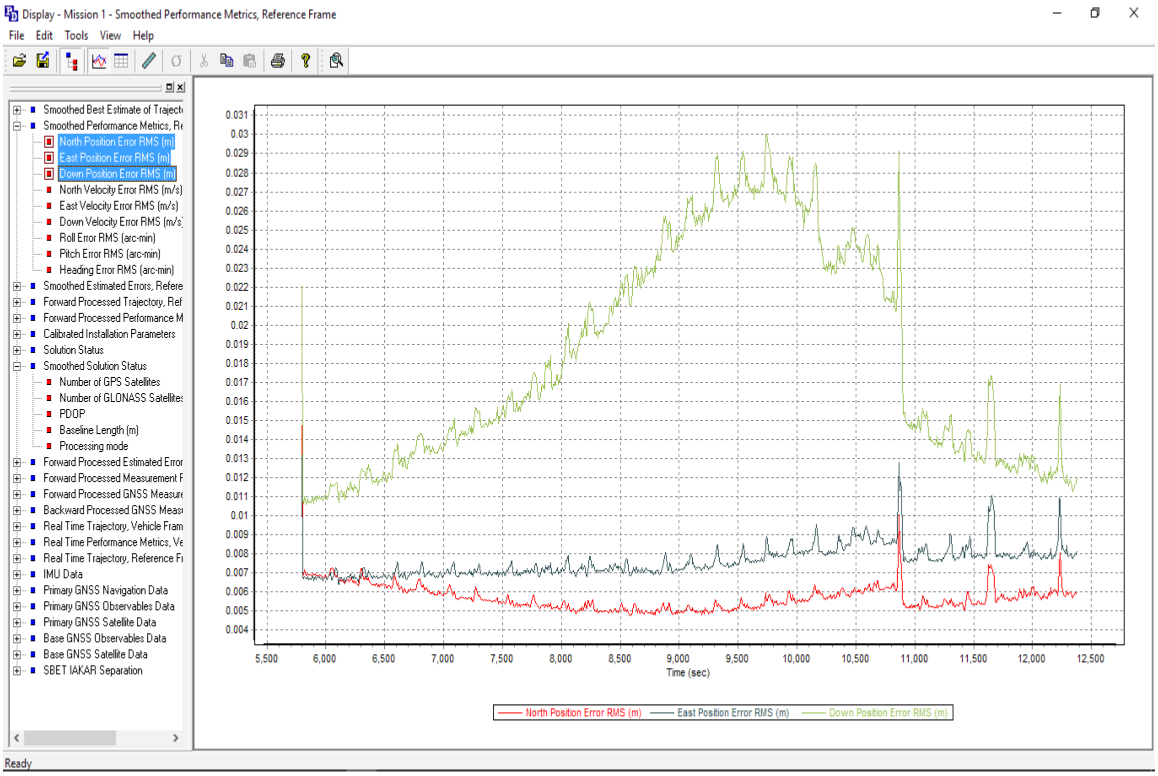



*Figure A-8.44 Smoothed Performance Metric Parameters*

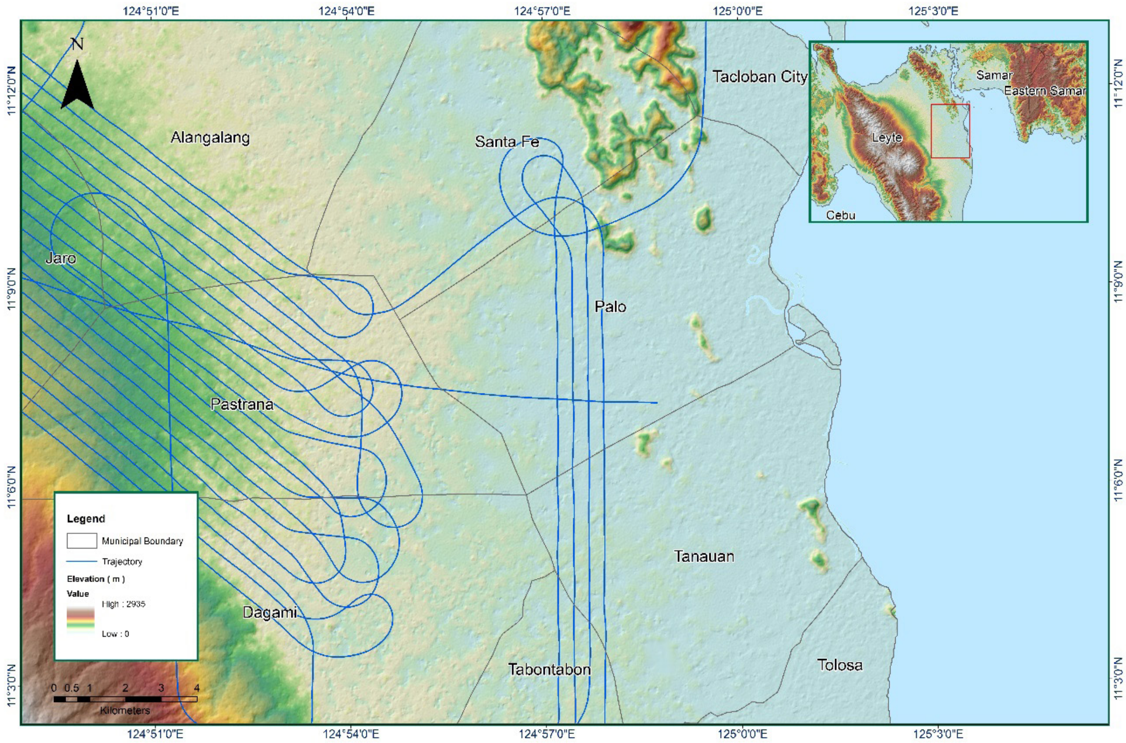



*Figure A-8.45 Best Estimated Trajectory*

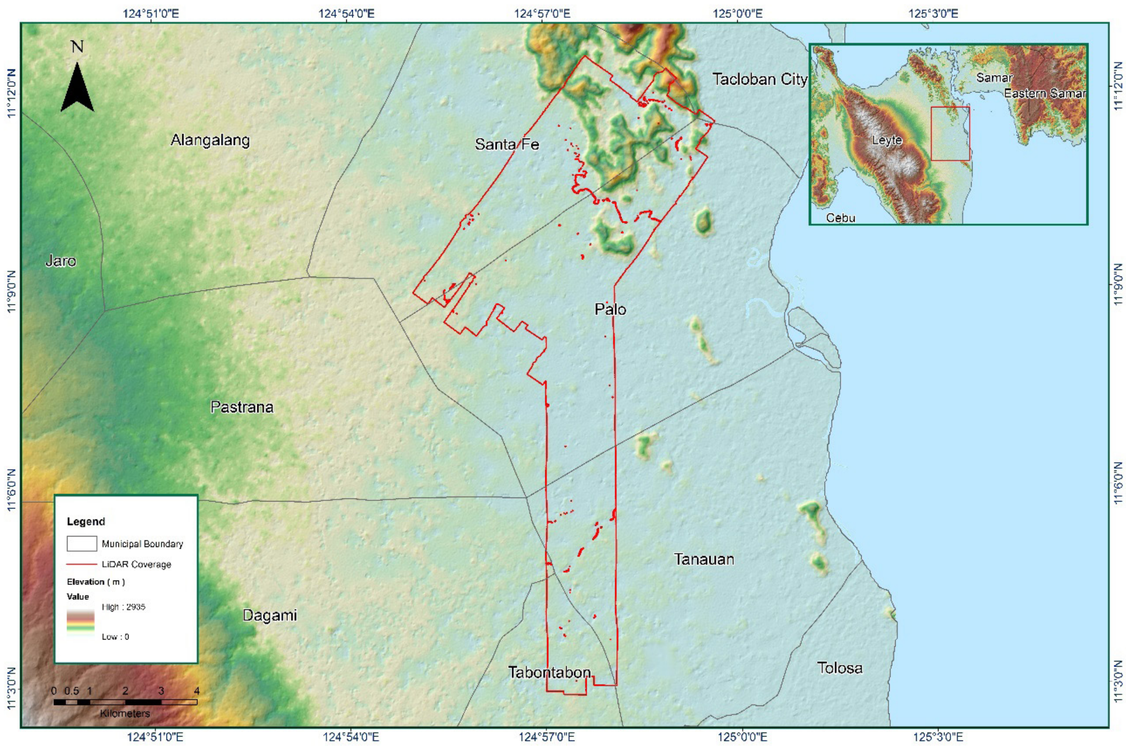



*Figure A-8.46 Coverage of LiDAR data*

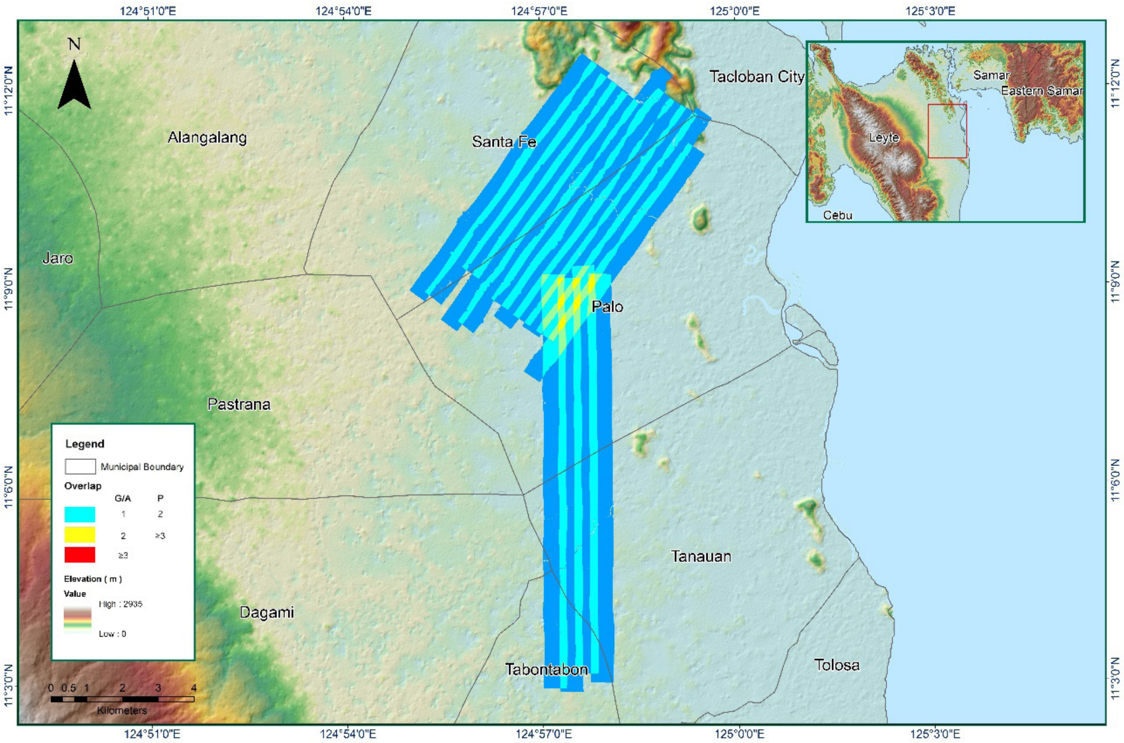



*Figure A-8.47 Image of data overlap*

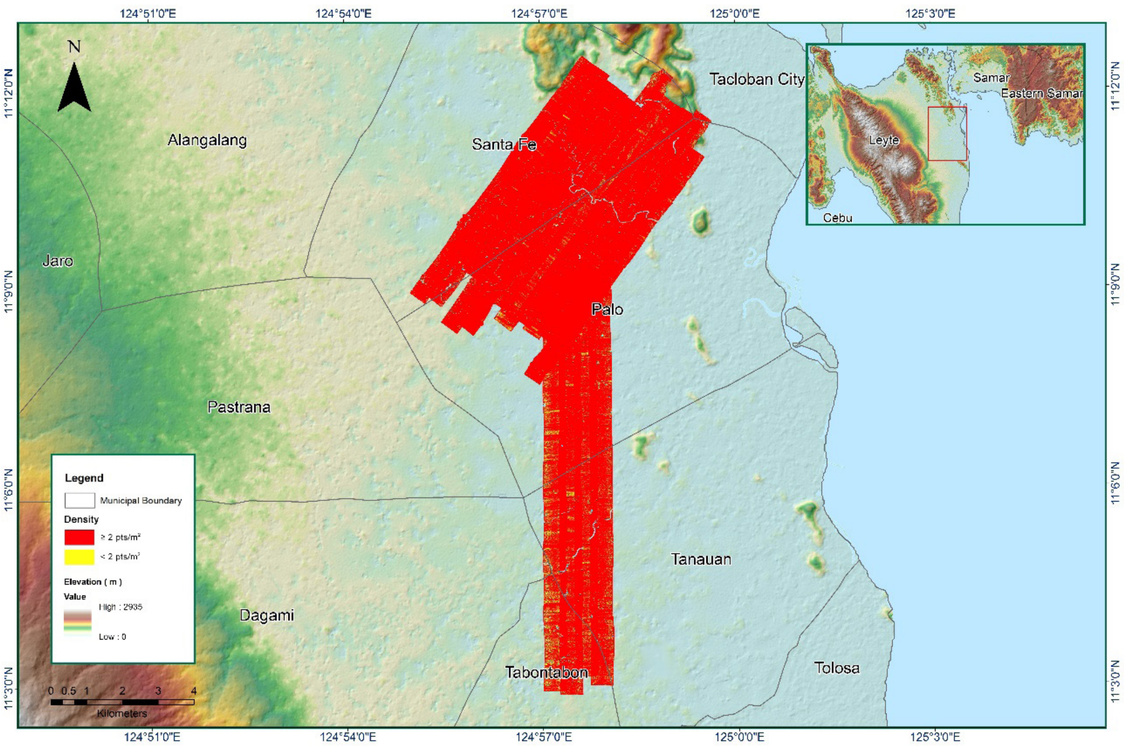



*Figure A-8.48 Density map of merged LiDAR data*

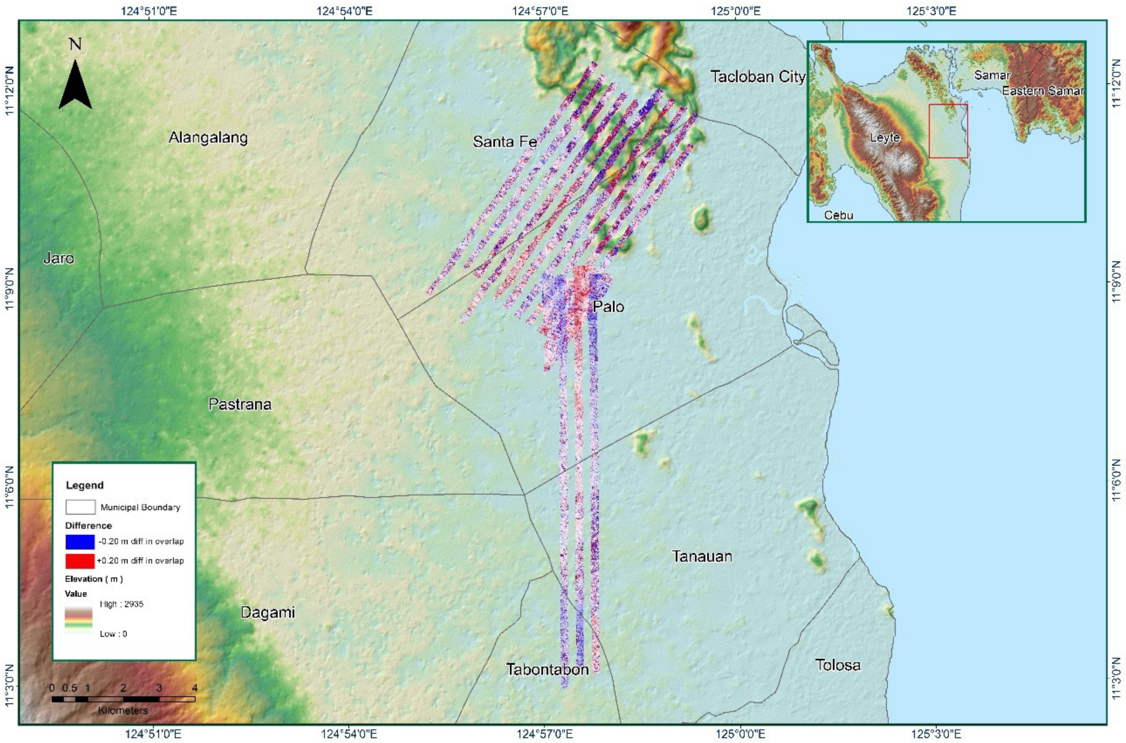



*Figure A-8.49* Elevation difference between flight lines

| | |
|---|---|
| Flight Area | Leyte |
| Mission Name | Blk34C |
| Inclusive Flights | 3773G, 3771G |
| Range data size | 37.1 GB |
| Base data size | 13.94 MB |
| POS | 460 MB |
| Image | n/a |
| Transfer date | February 12, 2016 |
| | |
| *Solution Status* | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | Yes |
| Processing Mode (<=1) | Yes |
| | |
| *Smoothed Performance Metrics* (in cm) | |
| RMSE for North Position (<4.0 cm) | 0.8 |
| RMSE for East Position (<4.0 cm) | 1.0 |
| RMSE for Down Position (<8.0 cm) | 2.8 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000620 |
| IMU attitude correction stdev (<0.001deg) | 0.004668 |
| GPS position stdev (<0.01m) | 0.0133 |
| | |
| Minimum % overlap (>25) | 35.68 |
| Ave point cloud density per sq.m. (>2.0) | 4.41 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 190 |
| Maximum Height | 293.50 m |
| Minimum Height | 85.36 m |
| | |
| *Classification (# of points)* | |
| Ground | 73,091,228 |
| Low vegetation | 68,546,439 |
| Medium vegetation | 272,398,780 |
| High vegetation | 231,908,658 |
| Building | 3,024,175 |
| Orthophoto | No |
| Processed by | Engr. Analyn Naldo, Engr. Harmond Santos, Maria Tamsyn Malabanan |

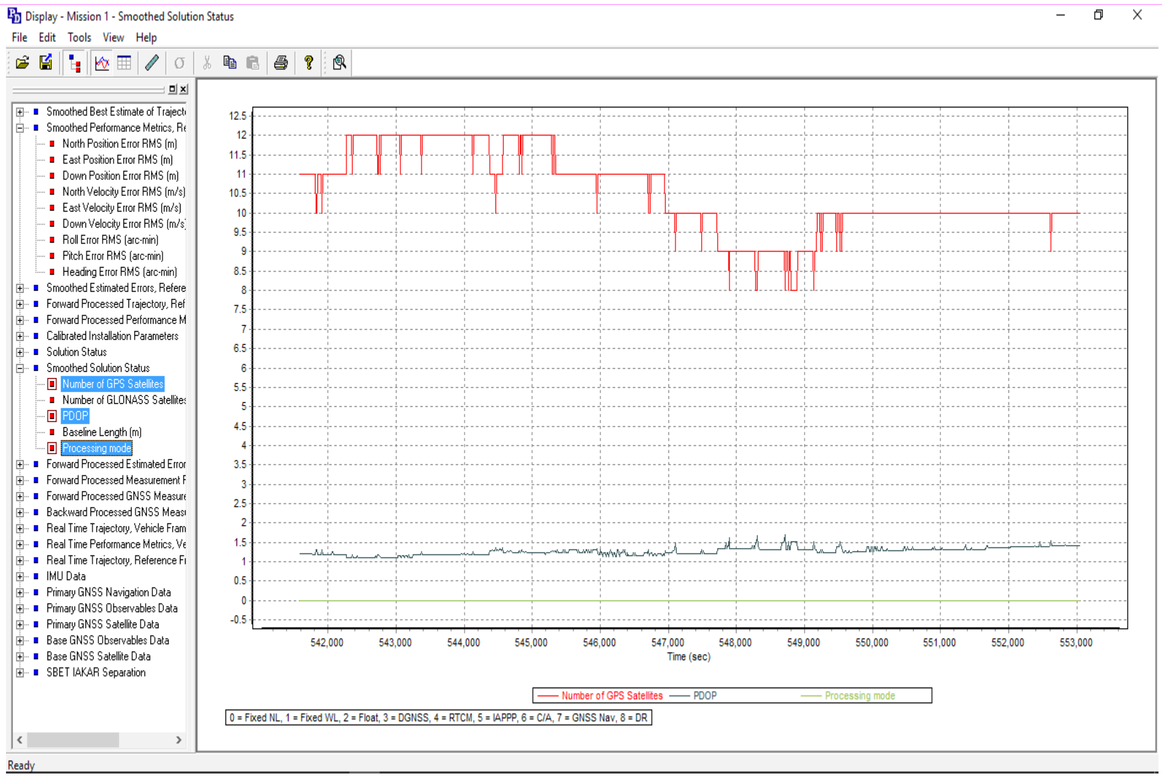



*Figure A-8.50 Solution Status*

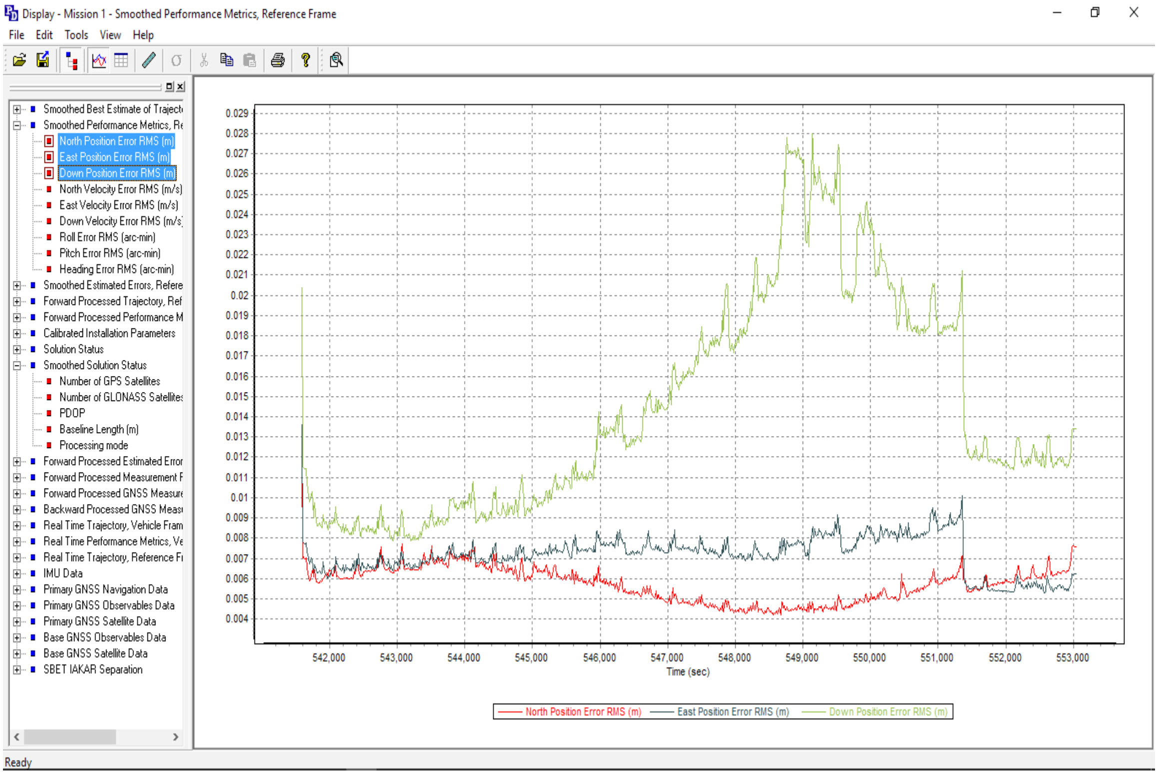



*Figure A-8.51 Smoothed Performance Metric Parameters*

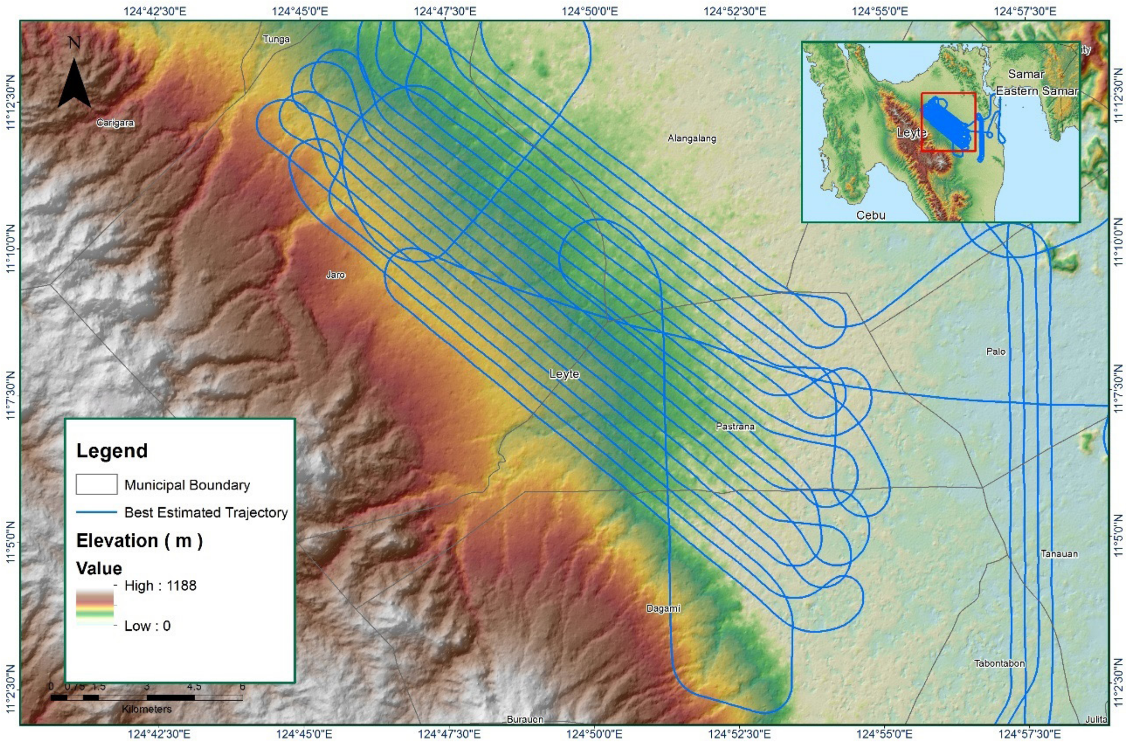



*Figure A-8.52 Best Estimated Trajectory*

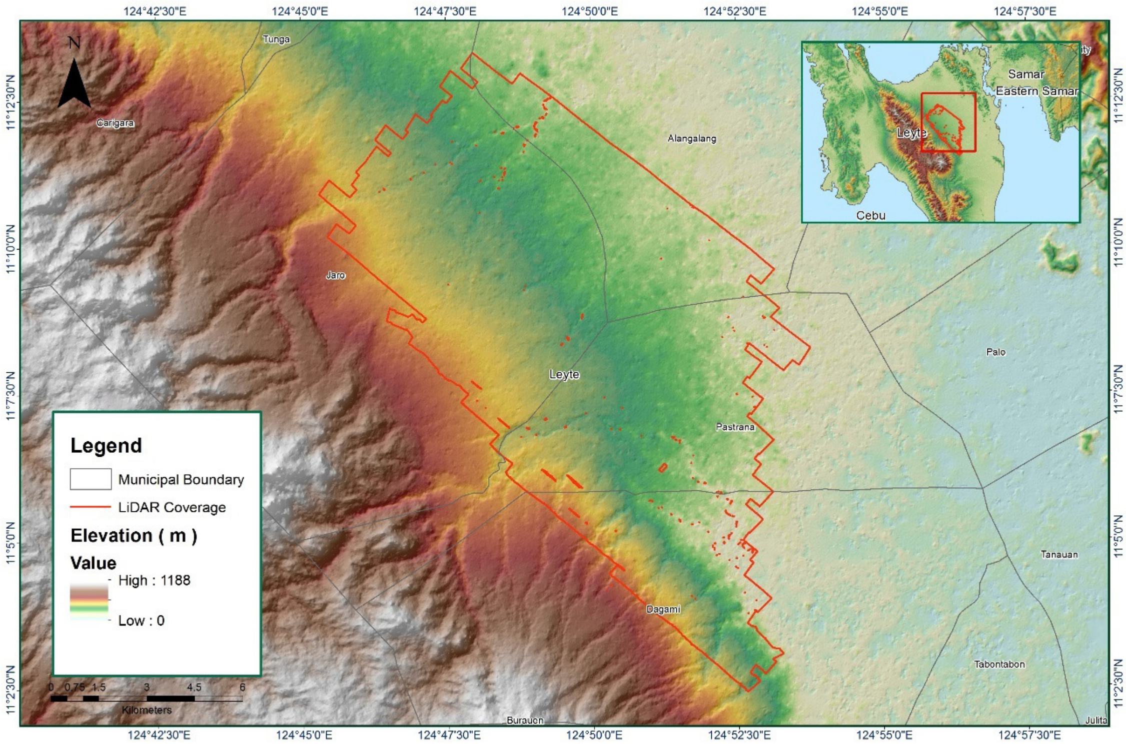



*Figure A-8.53 Coverage of LiDAR data*

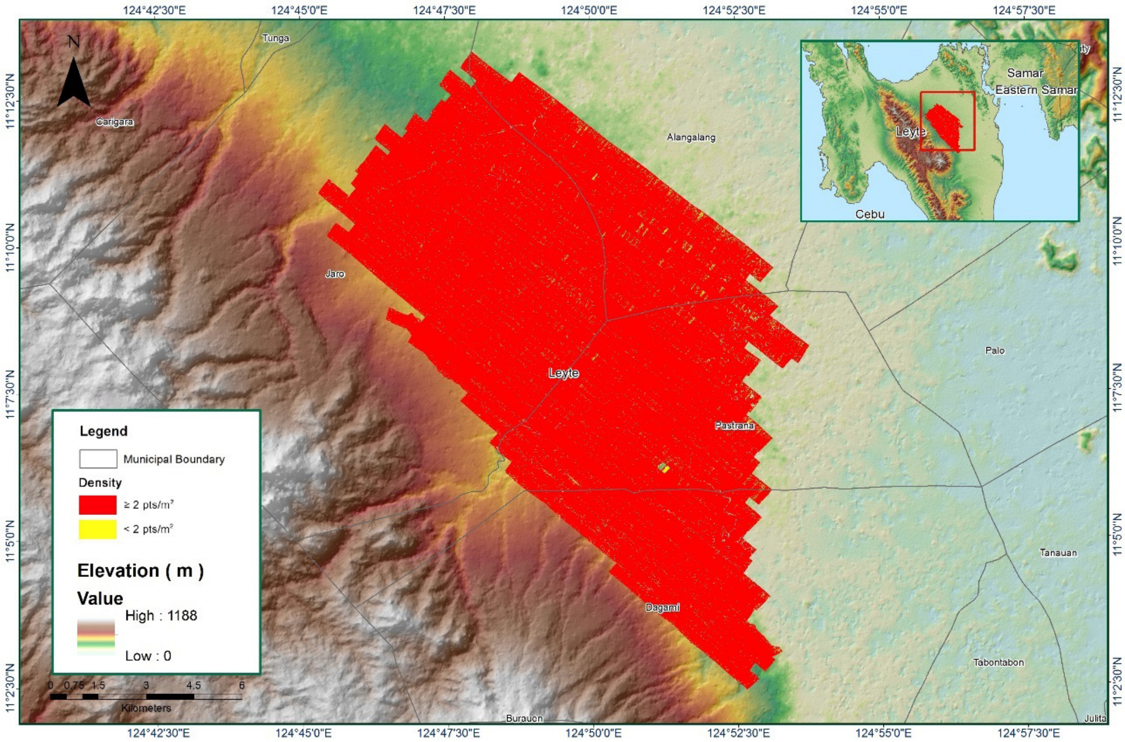



*Figure A-8.54 Image of data overlap*

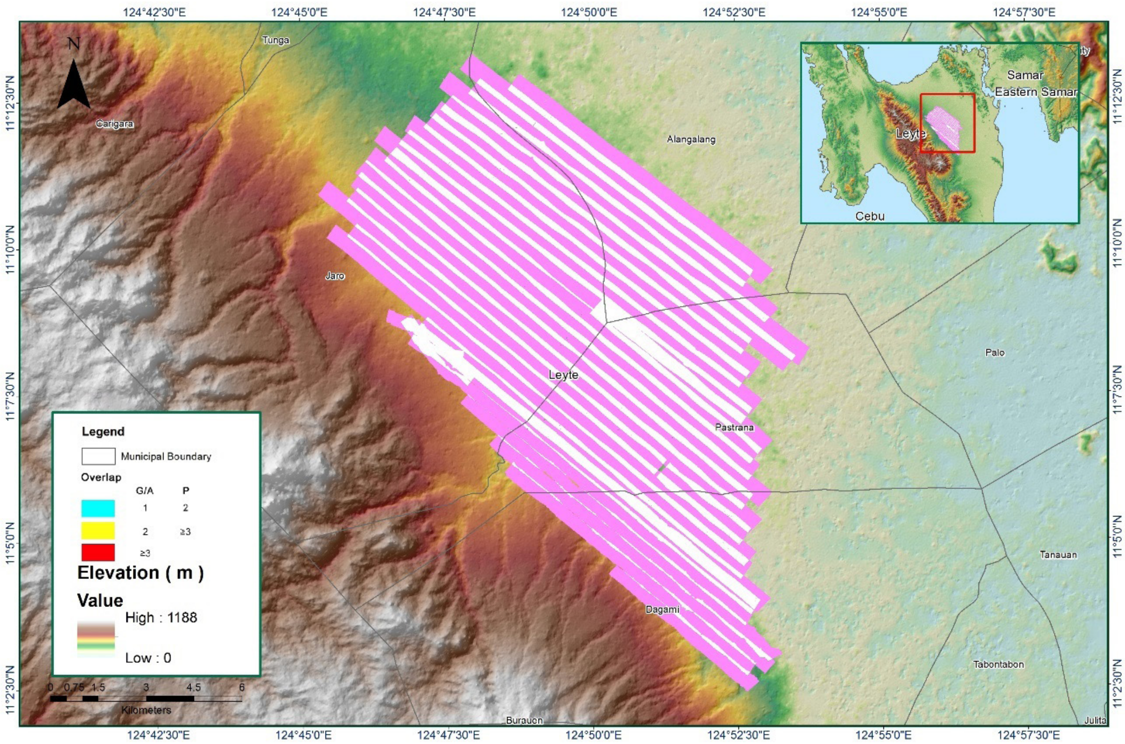



*Figure A-8.55 Density map of merged LiDAR data*

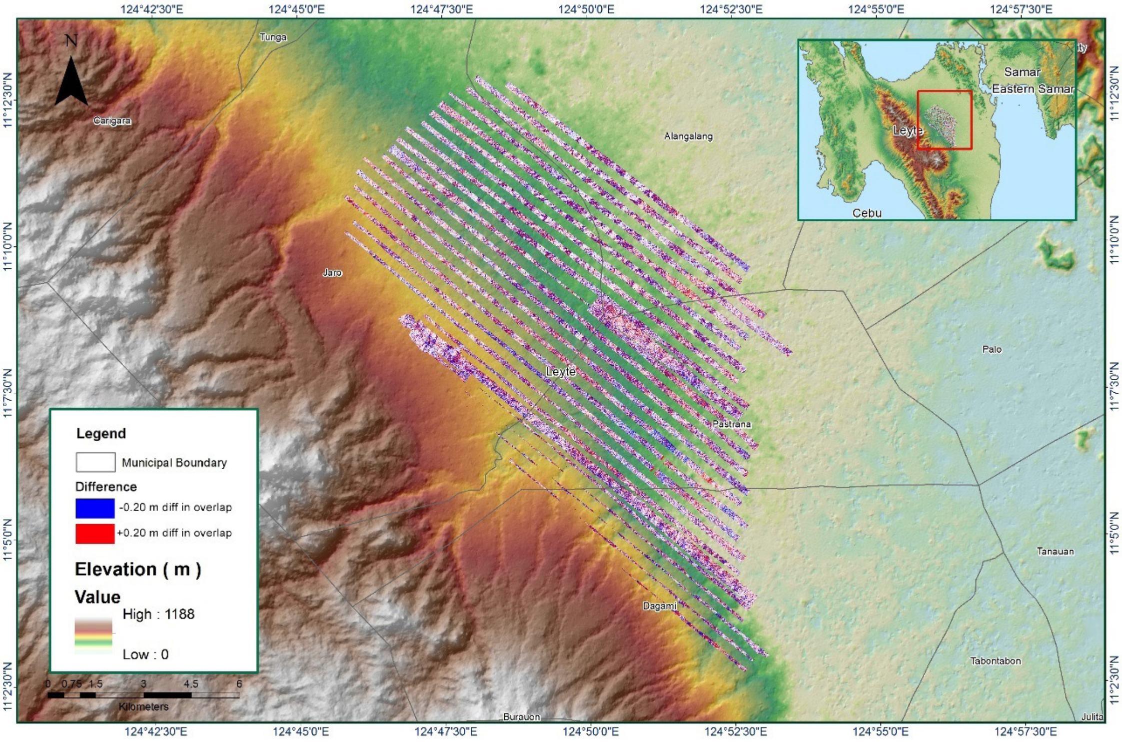



***Figure A-8.56*** *Elevation difference between flight lines*

| | |
|---|---|
| Flight Area | Leyte |
| Mission Name | Blk34D |
| Inclusive Flights | 3767G, 3773G |
| Range data size | 35.9 GB |
| Base data size | 8.14 MB |
| POS | 452 MB |
| Image | n/a |
| Transfer date | February 12, 2016 |
| | |
| *Solution Status* | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | No |
| Processing Mode (<=1) | Yes |
| | |
| *Smoothed Performance Metrics* (in cm) | |
| RMSE for North Position (<4.0 cm) | 1.0 |
| RMSE for East Position (<4.0 cm) | 1.3 |
| RMSE for Down Position (<8.0 cm) | 2.2 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000942 |
| IMU attitude correction stdev (<0.001deg) | 0.002535 |
| GPS position stdev (<0.01m) | 0.0116 |
| | |
| Minimum % overlap (>25) | 42.76 |
| Ave point cloud density per sq.m. (>2.0) | 4.23 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 126 |
| Maximum Height | 205.76 m |
| Minimum Height | 10.90 m |
| | |
| *Classification (# of points)* | |
| Ground | 37,541,051 |
| Low vegetation | 64,452,630 |
| Medium vegetation | 157,969,342 |
| High vegetation | 87,019,402 |
| Building | 1,194,655 |
| Orthophoto | No |
| Processed by | Engr. Jennifer Saguran, Engr. Ma Joanne Balaga, Jovy Narisma |

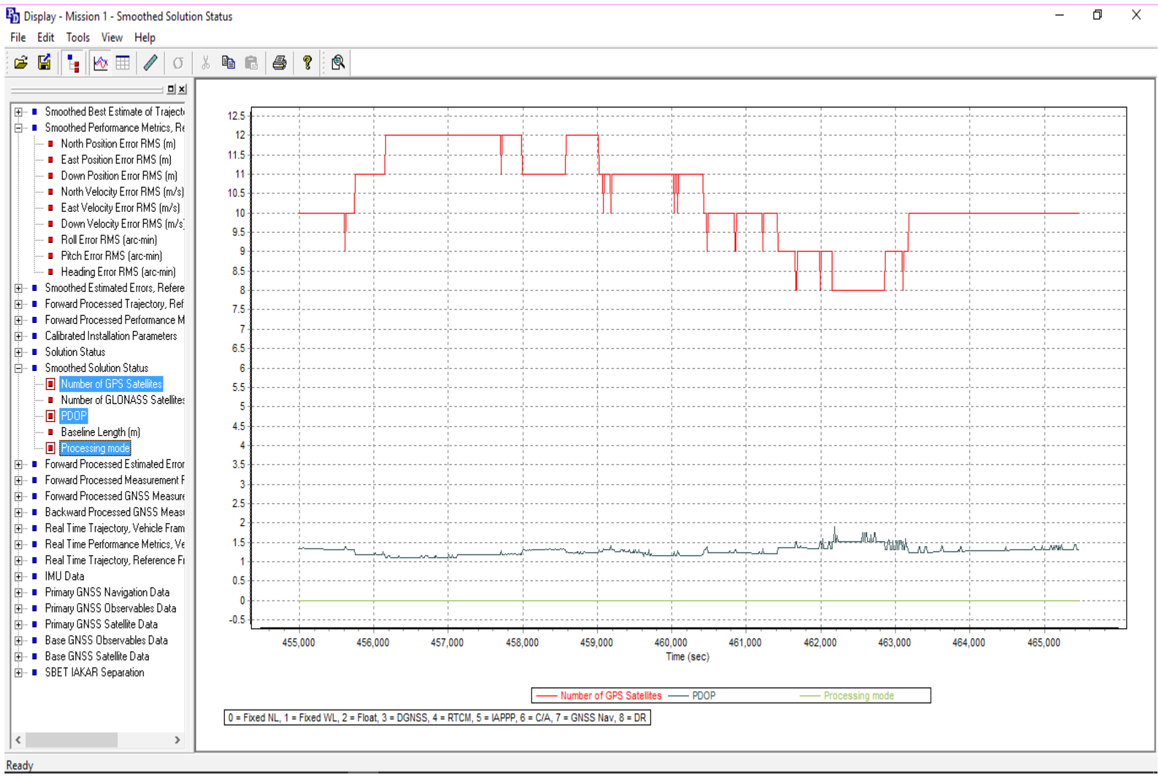



*Figure A-8.57 Solution Status*

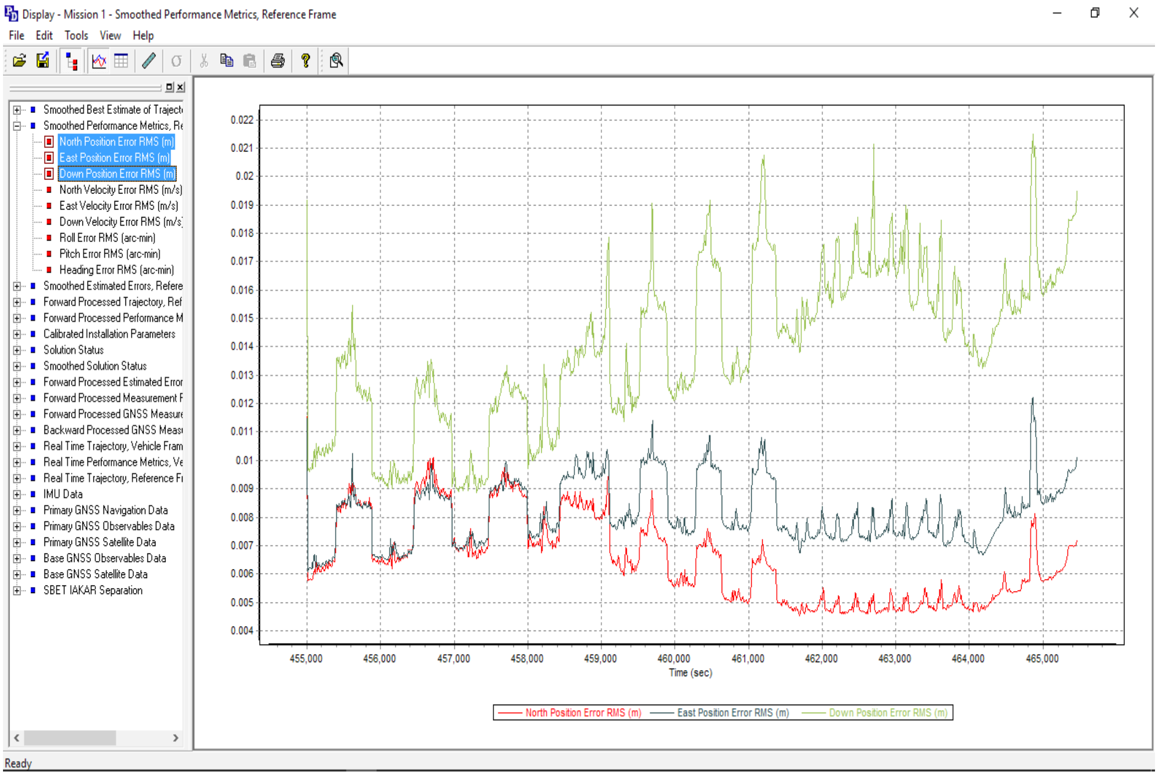



*Figure A-8.58 Smoothed Performance Metric Parameters*

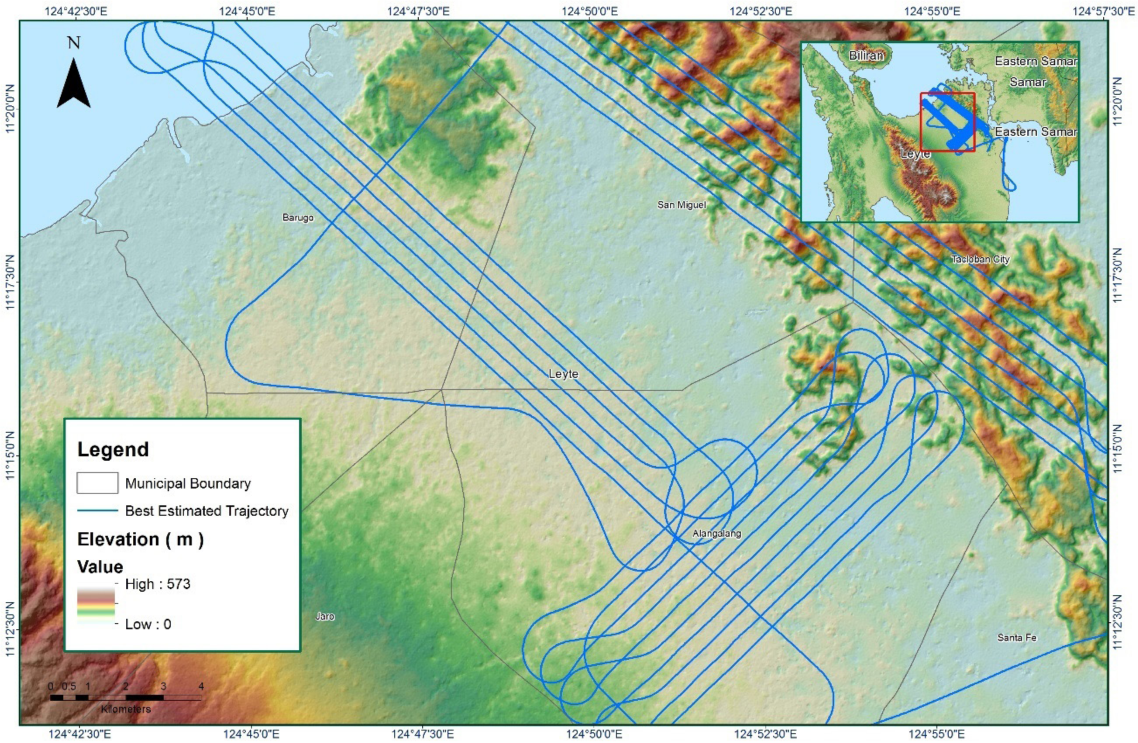



*Figure A-8.59 Best Estimated Trajectory*

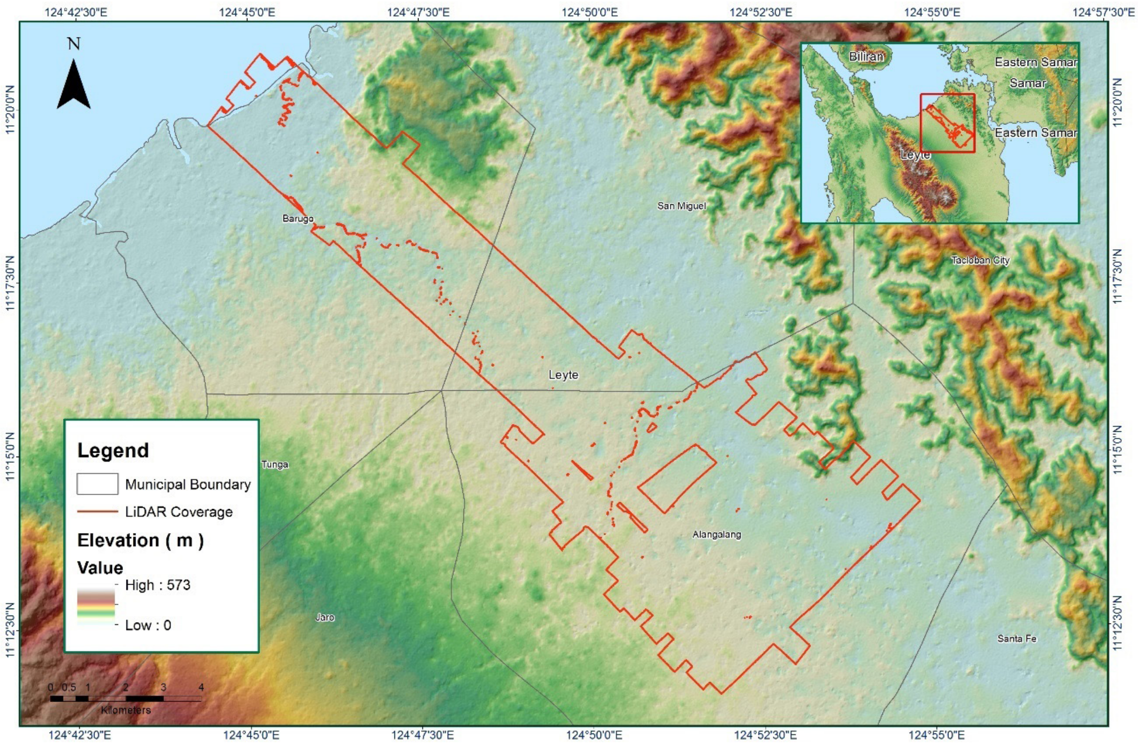



*Figure A-8.60Coverage of LiDAR data*

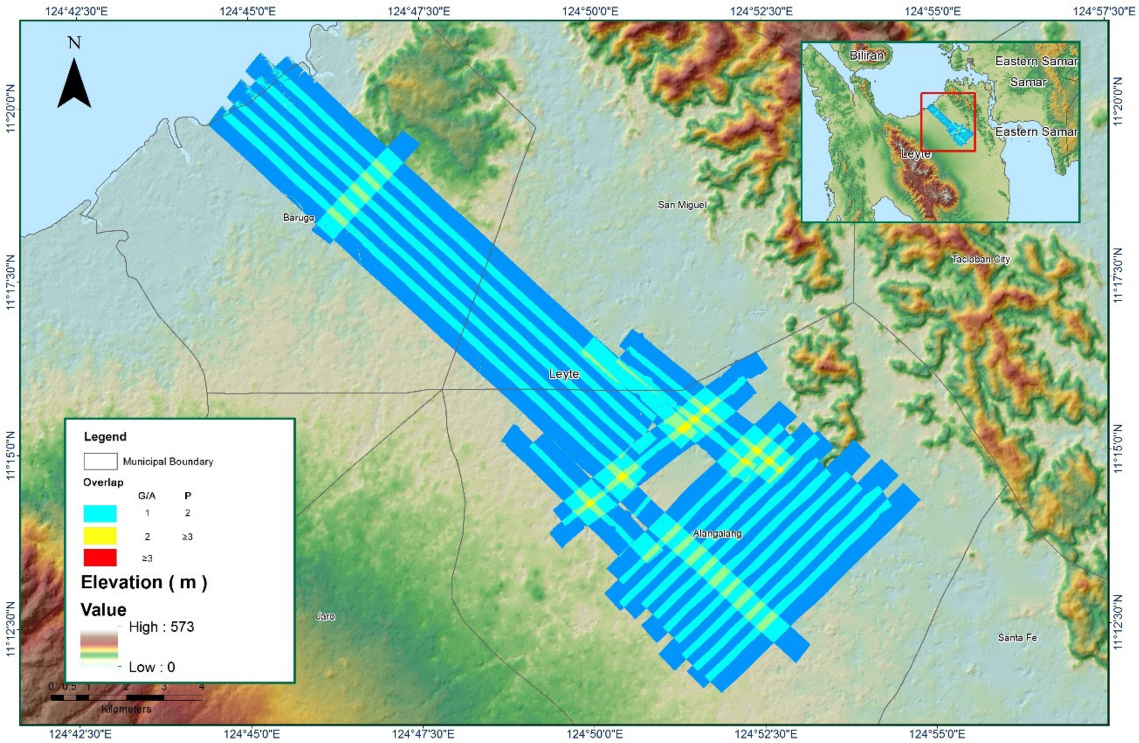



*Figure A-8.61 Image of data overlap*

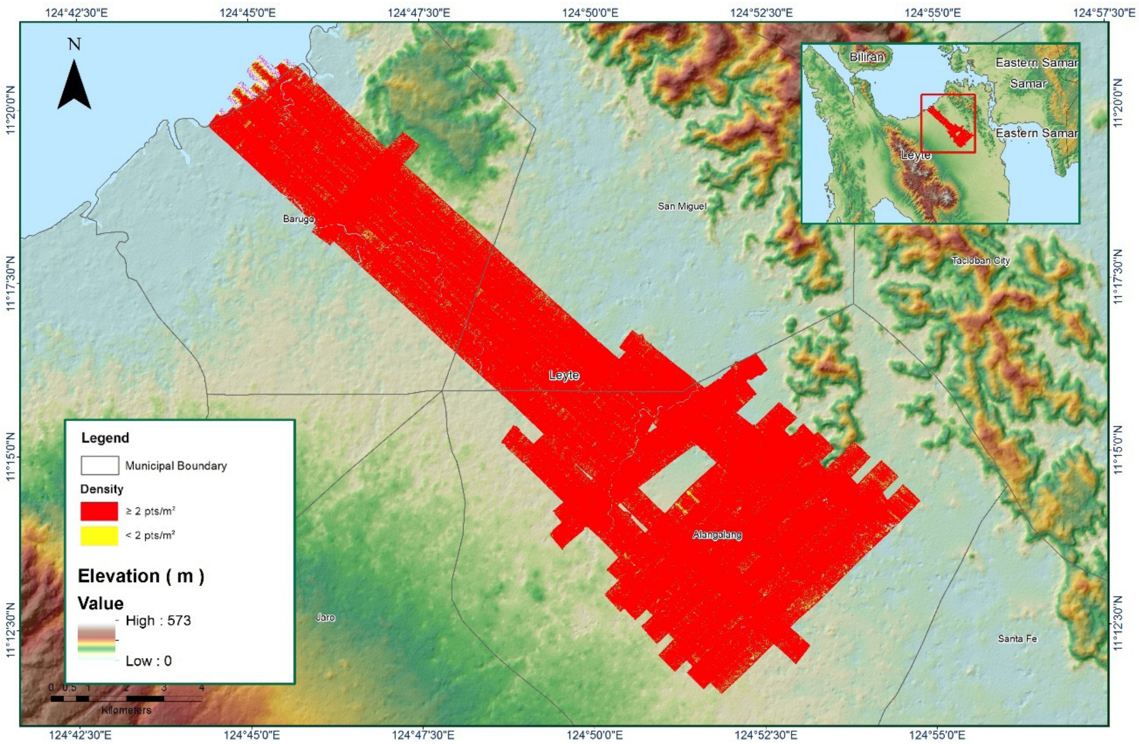



*Figure A-8.62 Density map of merged LiDAR data*

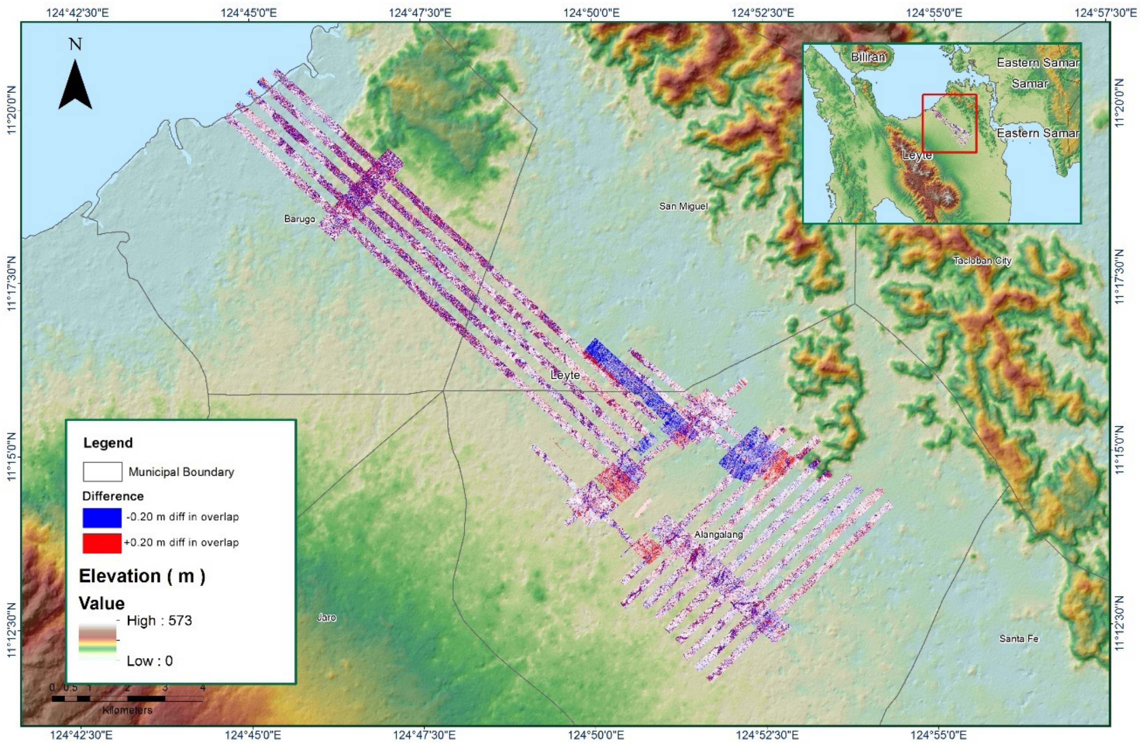



*Figure A-8.63* Elevation difference between flight lines

| | |
|---|---|
| Flight Area | Leyte |
| Mission Name | Blk34G_Additional2 |
| Inclusive Flights | 3773G |
| Range data size | 16.8 GB |
| Base data size | 4.74 MB |
| POS | 248 MB |
| Image | n/a |
| Transfer date | February 12, 2016 |
| | |
| *Solution Status* | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | No |
| Baseline Length (<30km) | Yes |
| 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) | 1.3 |
| RMSE for Down Position (<8.0 cm) | 3.0 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000314 |
| IMU attitude correction stdev (<0.001deg) | 0.000292 |
| GPS position stdev (<0.01m) | 0.0020 |
| | |
| Minimum % overlap (>25) | 33.93 |
| Ave point cloud density per sq.m. (>2.0) | 4.04 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 35 |
| Maximum Height | 170.45 |
| Minimum Height | 87.83 |
| | |
| *Classification (# of points)* | |
| Ground | 15334500 |
| Low vegetation | 24902871 |
| Medium vegetation | 30122526 |
| High vegetation | 5180576 |
| Building | 125338 |
| Orthophoto | None |
| Processed by | Engr. Regis Guhiting, Engr. Velina Angela Bemida, Engr. Gladys Mae Apat |

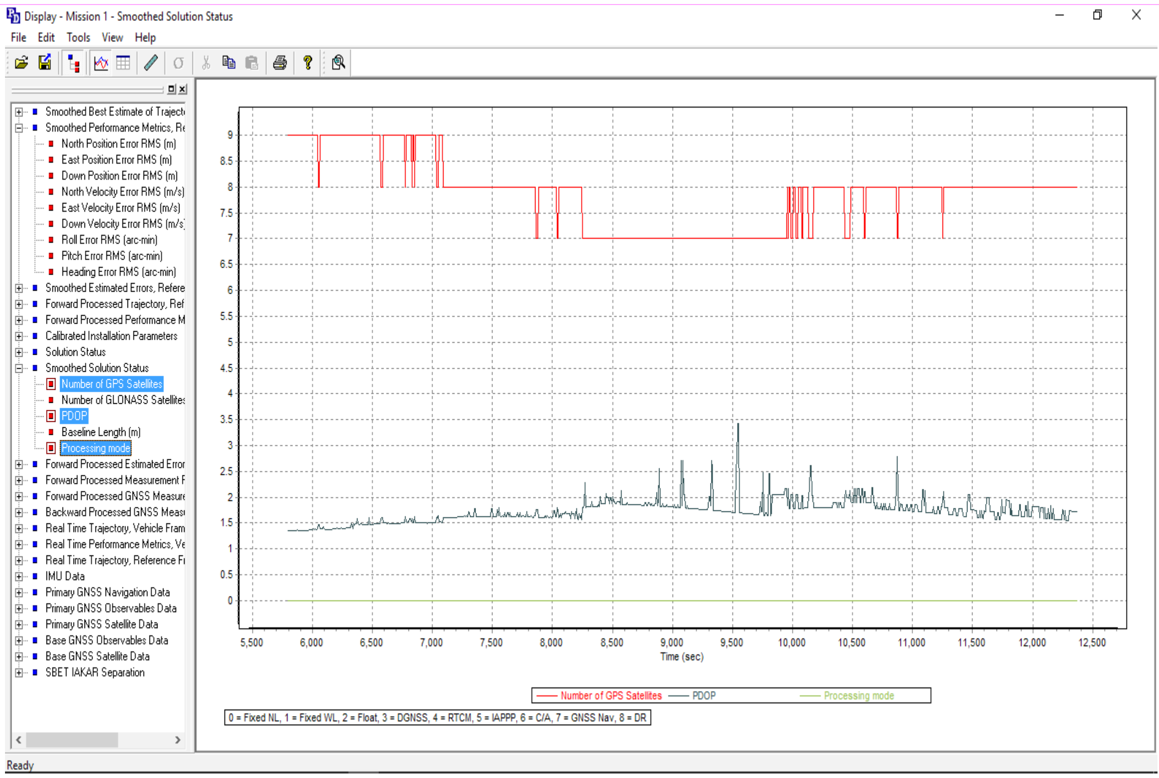



*Figure A-8.64 Solution Status*

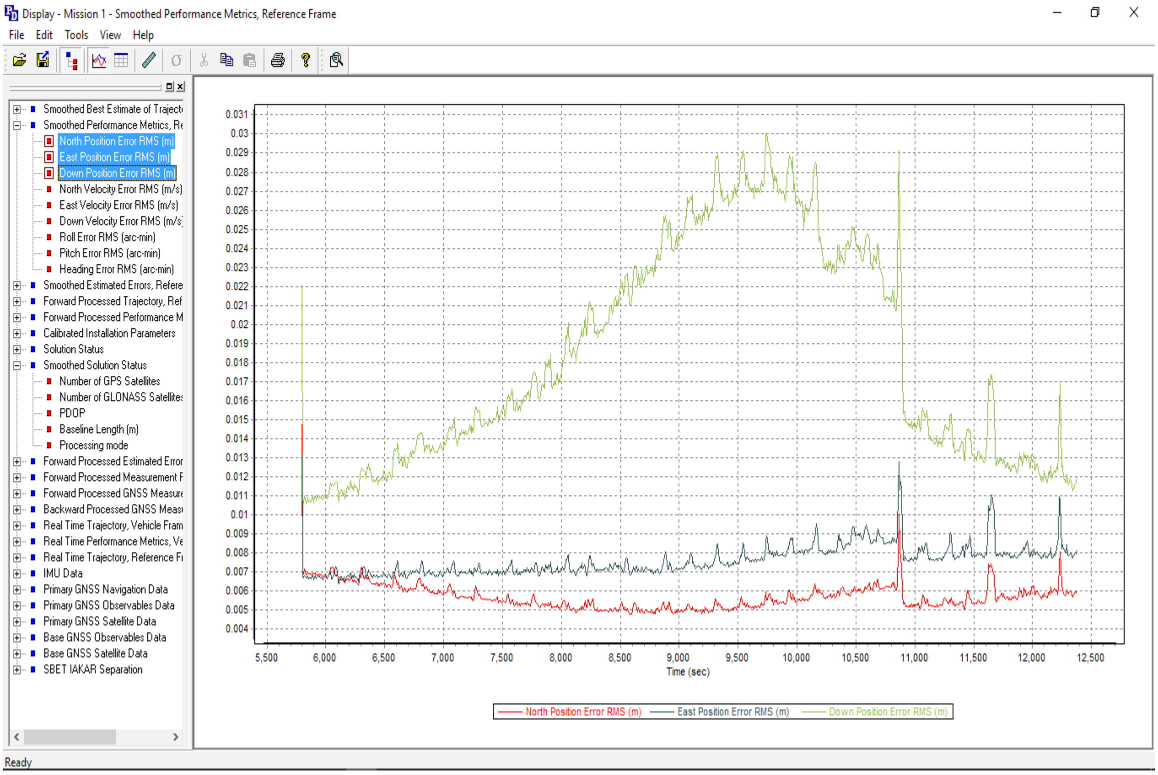



*Figure A-8.65 Smoothed Performance Metric Parameters*

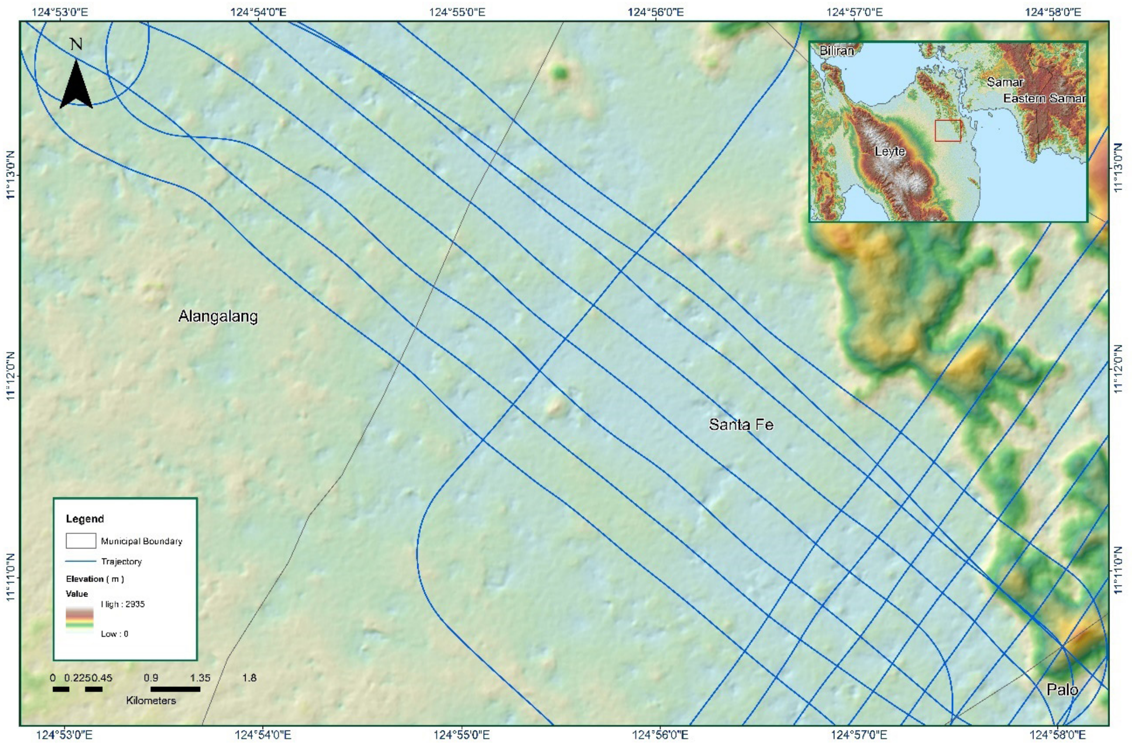



*Figure A-8.66 Best Estimated Trajectory*

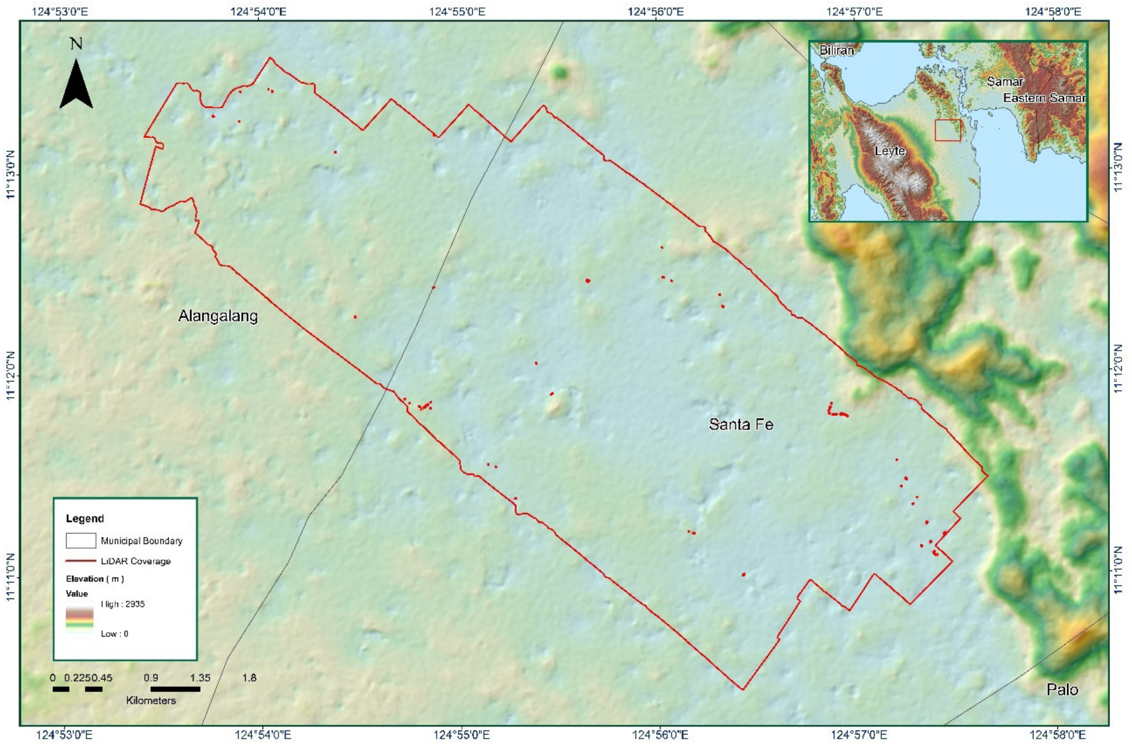



*Figure A-8.67 Coverage of LiDAR data*

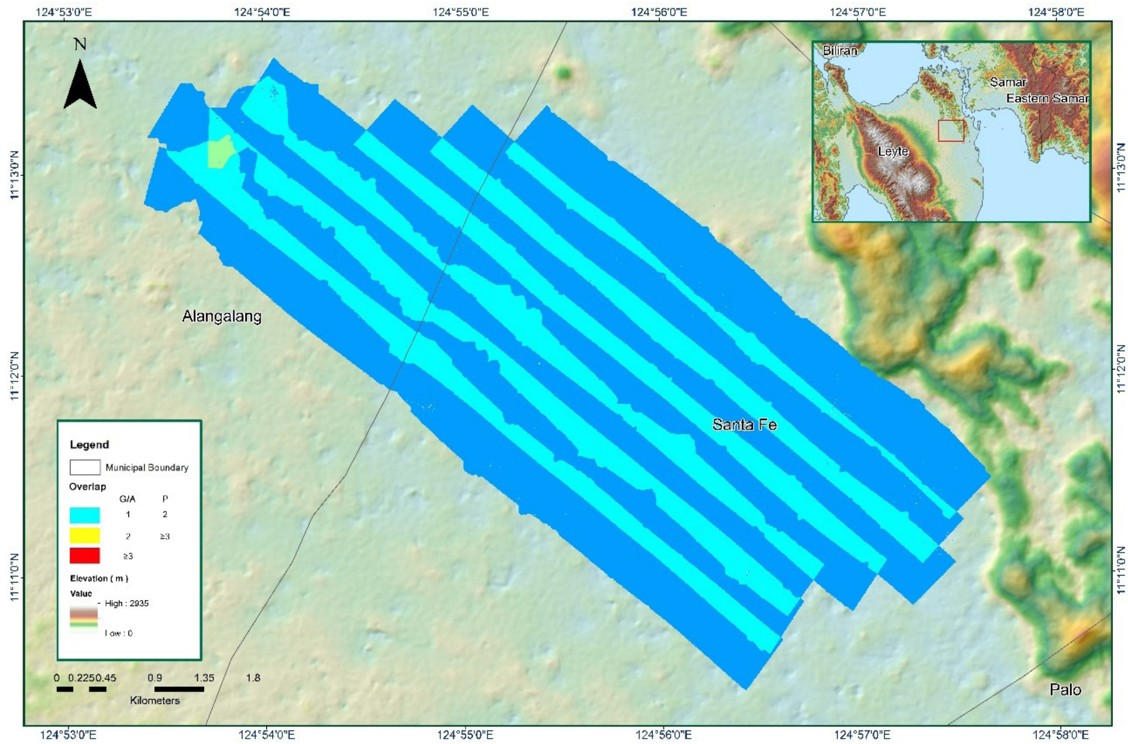



*Figure A-8.68 Image of data overlap*

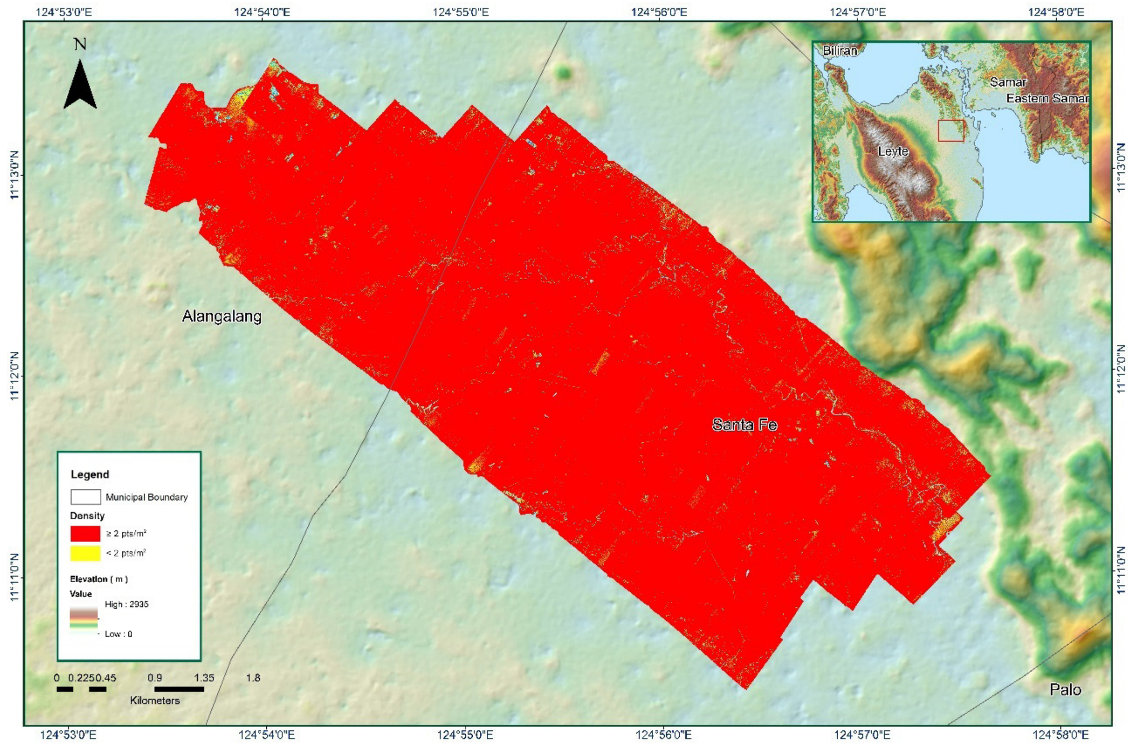



*Figure A-8.69 Density map of merged LiDAR data*

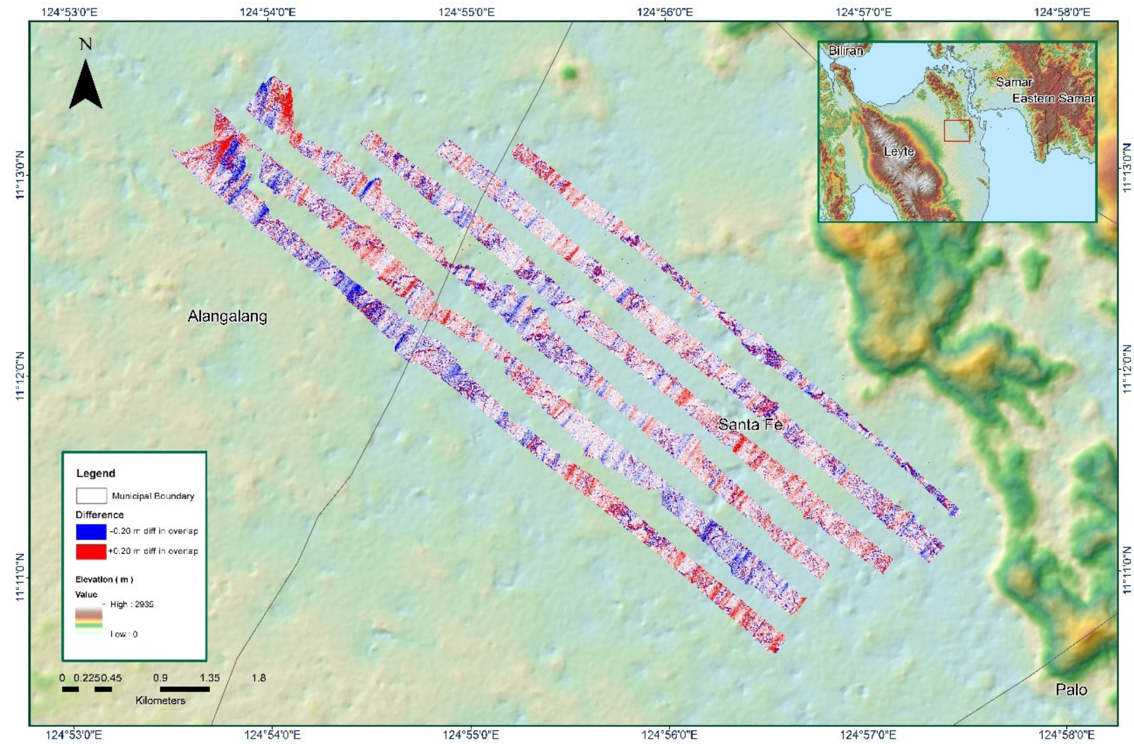



***Figure A-8.70*** *Elevation difference between flight lines*

| | |
|---|---|
| Flight Area | Leyte |
| Mission Name | Blk34E |
| Inclusive Flights | 3767G, 3765G |
| Range data size | 44.3 GB |
| Base data size | 7.78 MB |
| POS | 459 MB |
| Image | n/a |
| Transfer date | February 12, 2014 |
| | |
| *Solution Status* | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | No |
| Baseline Length (<30km) | No |
| Processing Mode (<=1) | Yes |
| | |
| *Smoothed Performance Metrics* (in cm) | |
| RMSE for North Position (<4.0 cm) | 1.9 |
| RMSE for East Position (<4.0 cm) | 1.5 |
| RMSE for Down Position (<8.0 cm) | 6.0 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000478 |
| IMU attitude correction stdev (<0.001deg) | 0.003642 |
| GPS position stdev (<0.01m) | 0.0029 |
| | |
| Minimum % overlap (>25) | 34.99 |
| Ave point cloud density per sq.m. (>2.0) | 4.65 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 93 |
| Maximum Height | 415.68 m |
| Minimum Height | 63.54 m |
| | |
| *Classification (# of points)* | |
| Ground | 35,181,518 |
| Low vegetation | 42,803,820 |
| Medium vegetation | 136,496,439 |
| High vegetation | 111,171,628 |
| Building | 2,703,347 |
| Orthophoto | No |
| Processed by | Engr. Sheila Mae Santillan, Engr. Justine Francisco, Marie Denise Bueno |

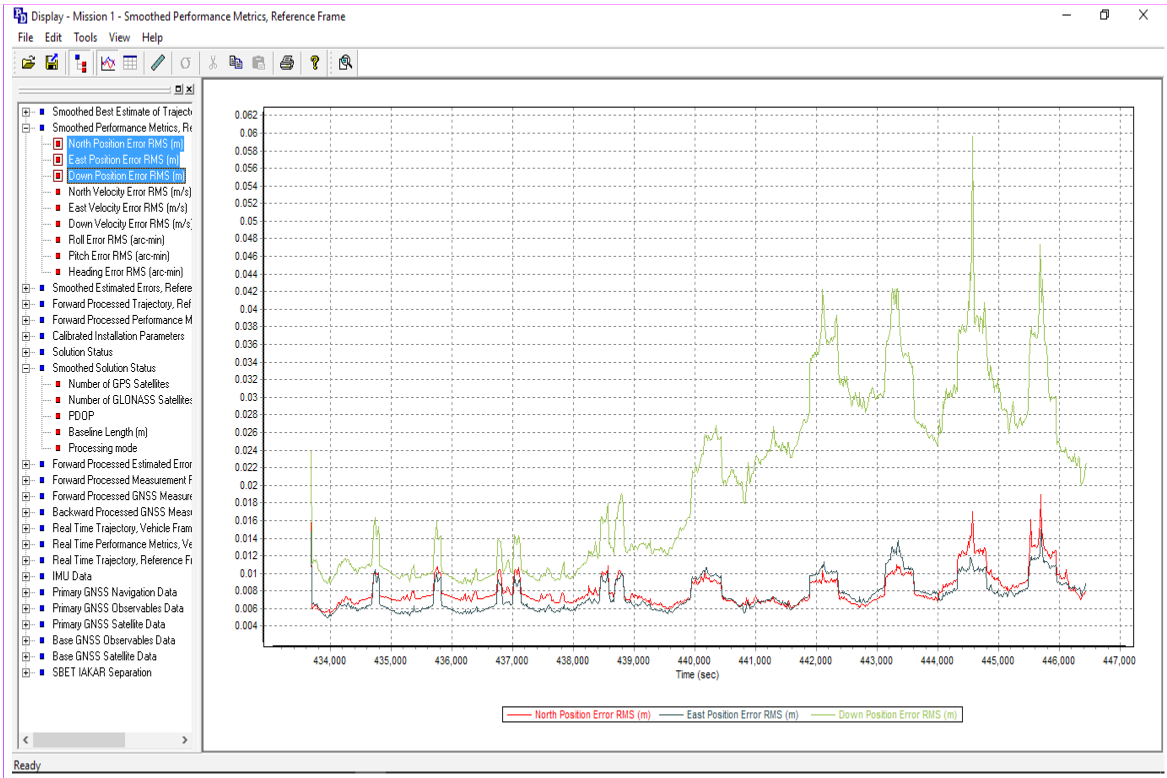



Figure A-8.71 Solution Status

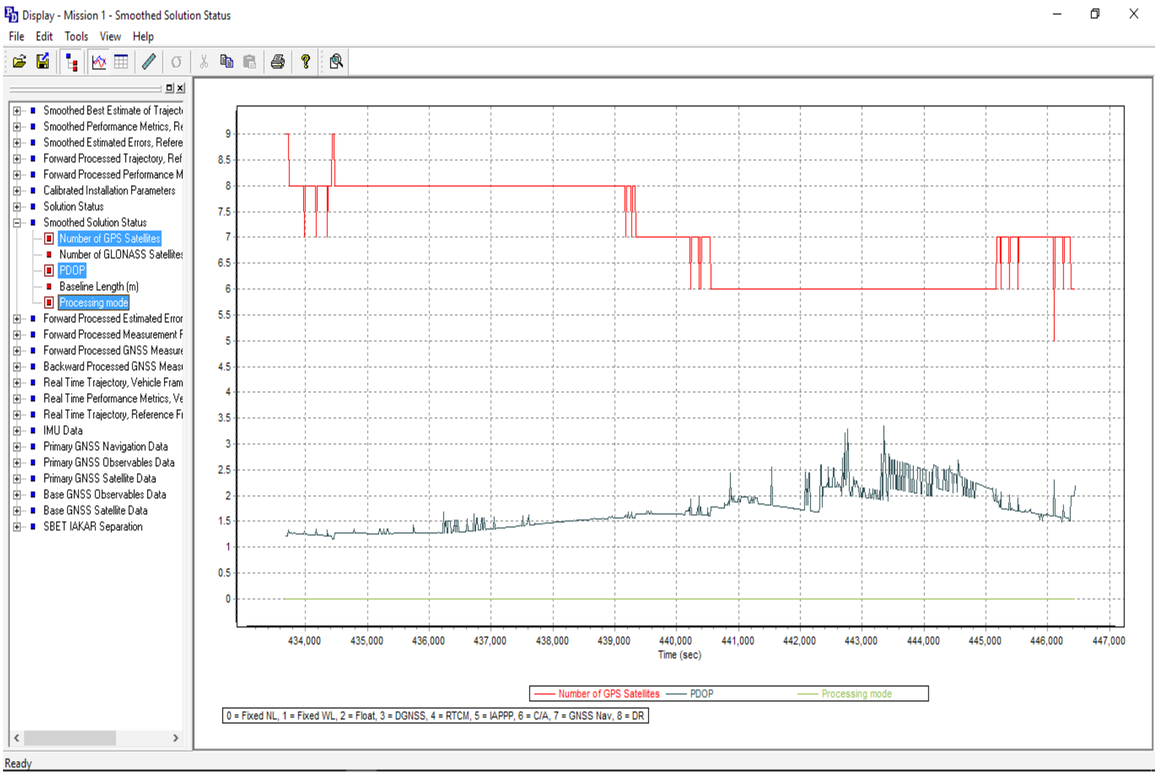



Figure A-8.72 Smoothed Performance Metric Parameters

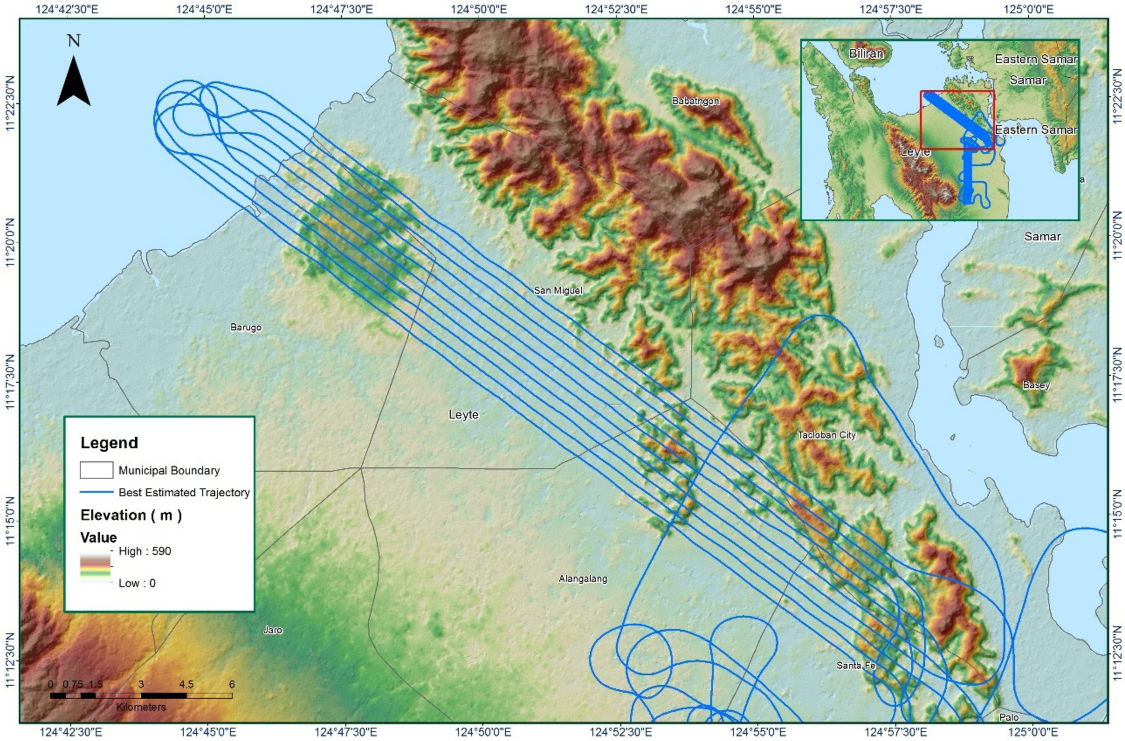



*Figure A-8.73 Best Estimated Trajectory*

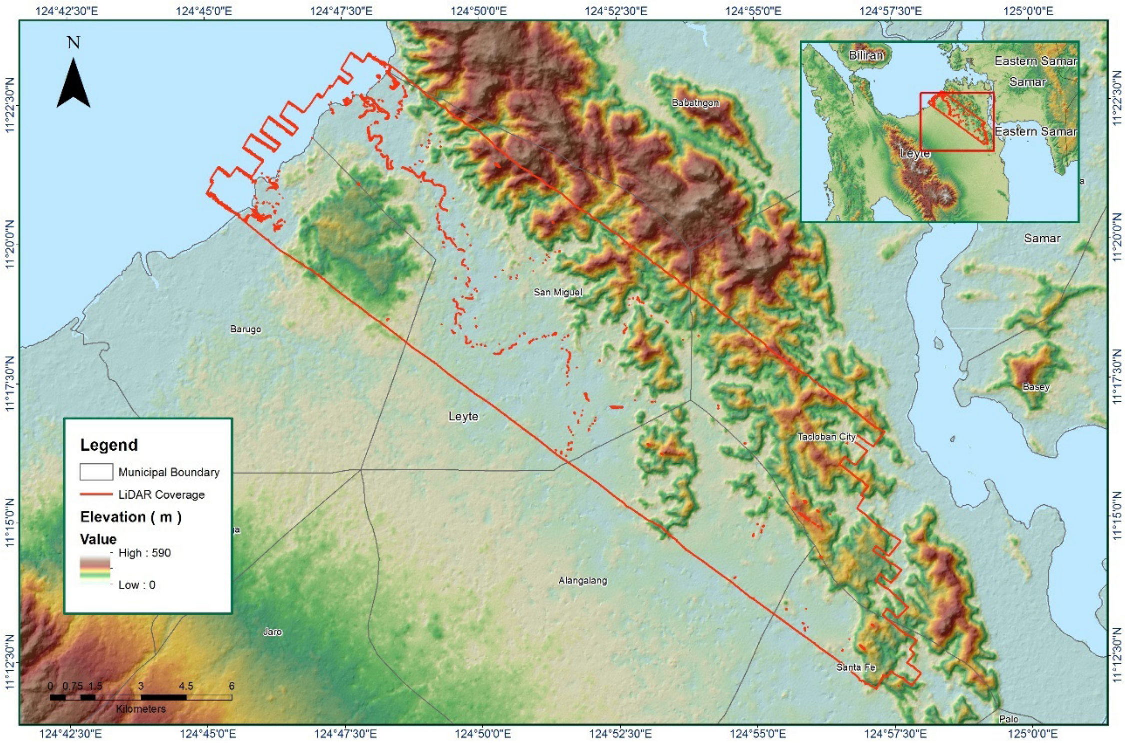



*Figure A-8.74 Coverage of LiDAR data*

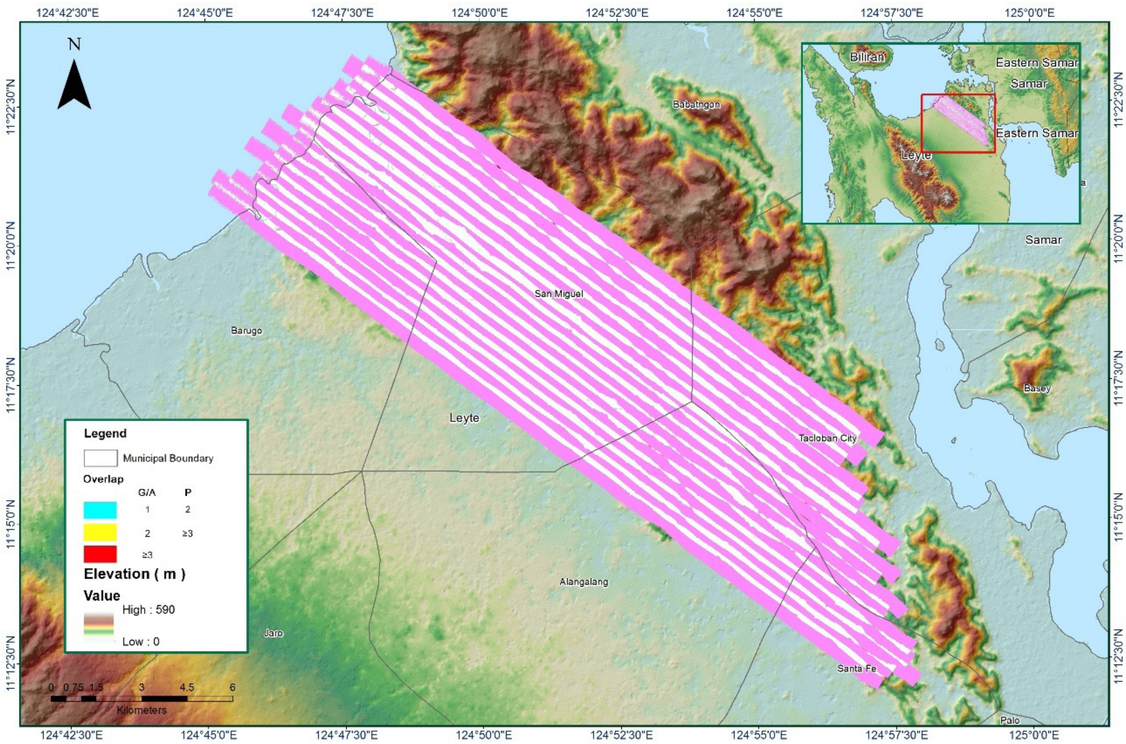



*Figure A-8.75 Image of data overlap*

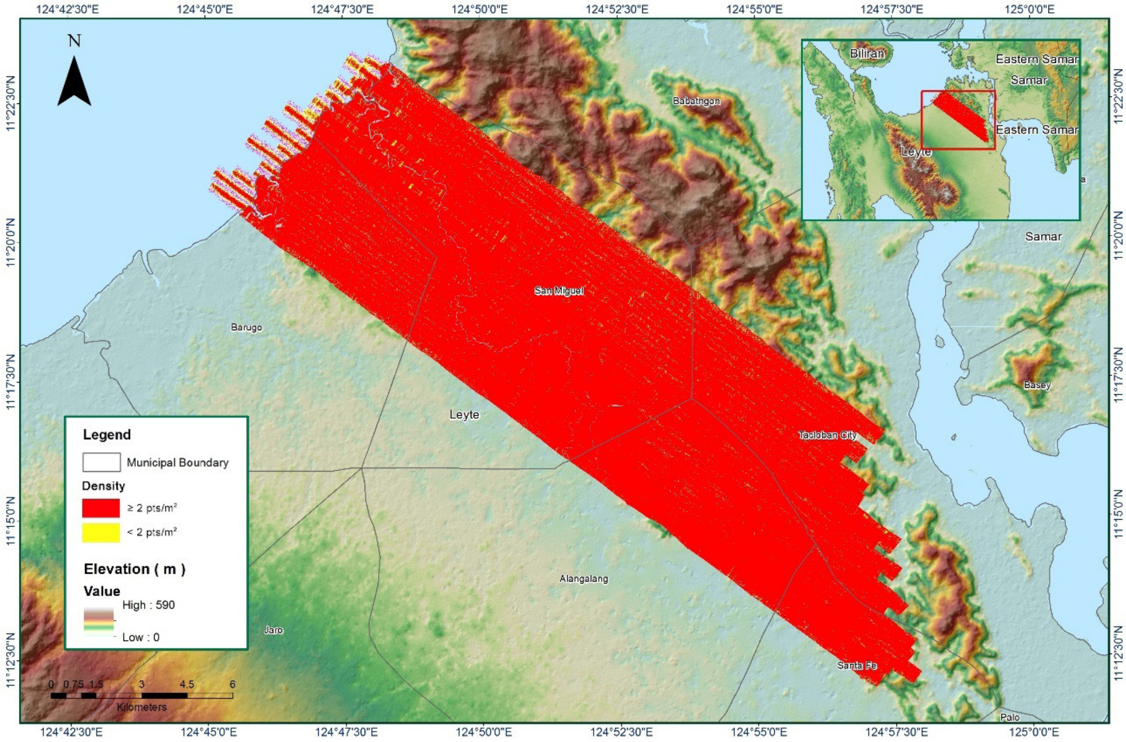



*Figure A-8.76 Density map of merged LiDAR data*

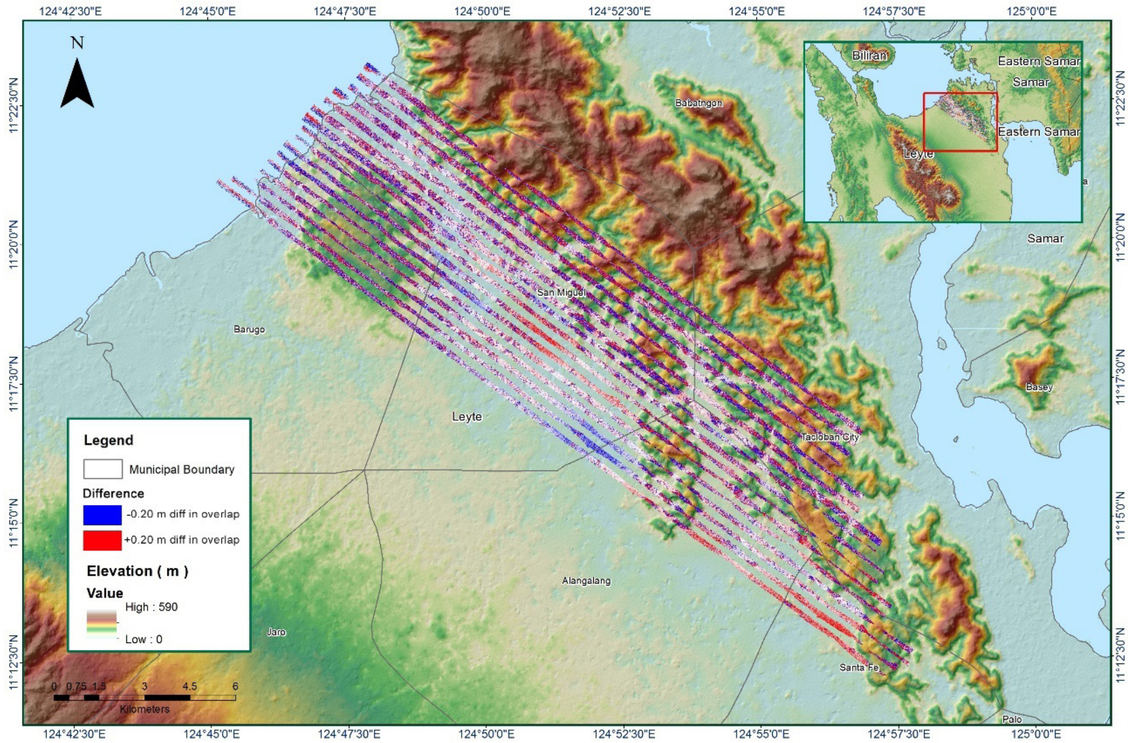



***Figure A-8.77*** *Elevation difference between flight lines*

| | |
|---|---|
| Flight Area | Tacloban |
| Mission Name | 1026A |
| Inclusive Flights | 1026A |
| Range data size | 11.6 GB |
| Base data size | 20.0 MB |
| POS | 137 MB |
| Image | 55.2 GB |
| Transfer date | February 3, 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) | 1.6 |
| RMSE for East Position (<4.0 cm) | 1.8 |
| RMSE for Down Position (<8.0 cm) | 3.1 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000559 |
| IMU attitude correction stdev (<0.001deg) | 0.007980 |
| GPS position stdev (<0.01m) | 0.0379 |
| | |
| Minimum % overlap (>25) | 42.17% |
| Ave point cloud density per sq.m. (>2.0) | 2.33 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 314 |
| Maximum Height | 386.42 m |
| Minimum Height | 42.55 m |
| | |
| *Classification (# of points)* | |
| Ground | 83,757,366 |
| Low vegetation | 78,700,823 |
| Medium vegetation | 165,907,507 |
| High vegetation | 4,928,508 |
| Building | 1,722,190 |
| Orthophoto | Yes |
| Processed by | Engr. Jennifer Saguran, Engr. Christy Lubiano, Ryan James Nicholai Dizon |

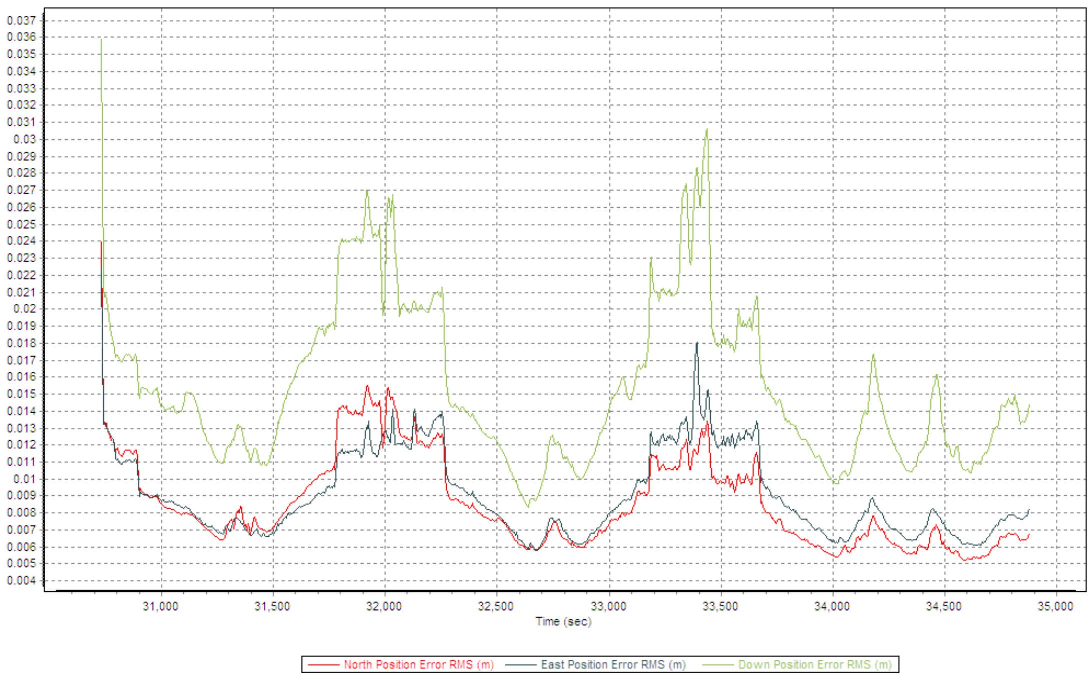



*Figure A-8.78Solution Status*

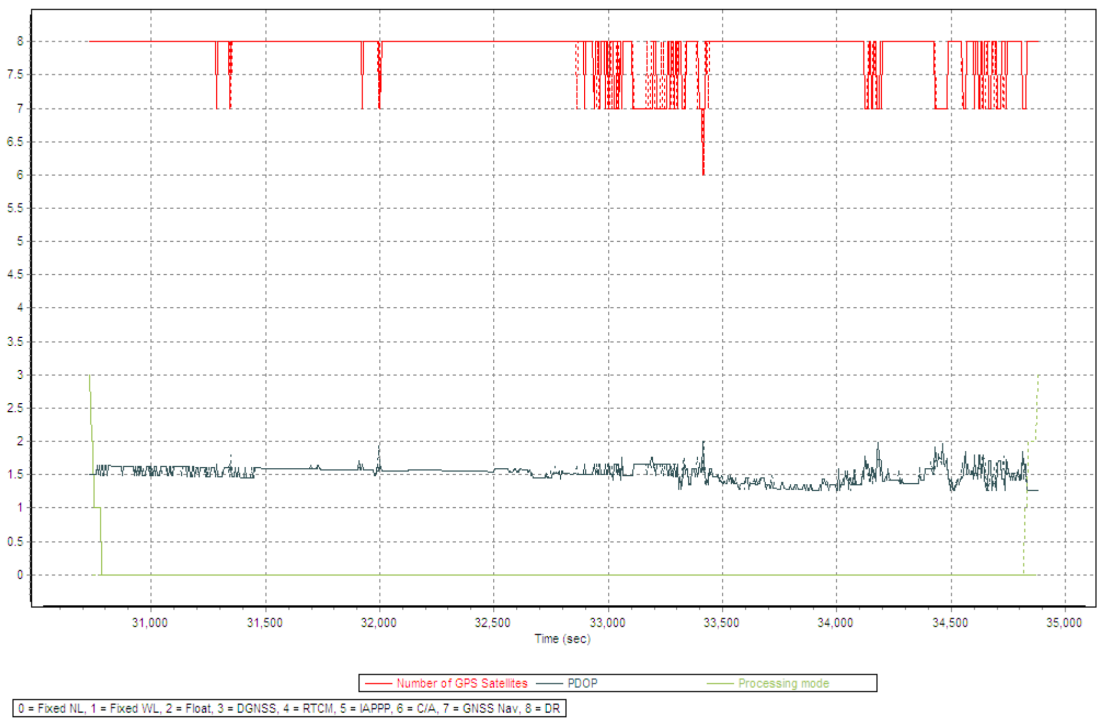



*Figure A-8.79 Smoothed Performance Metric Parameters*

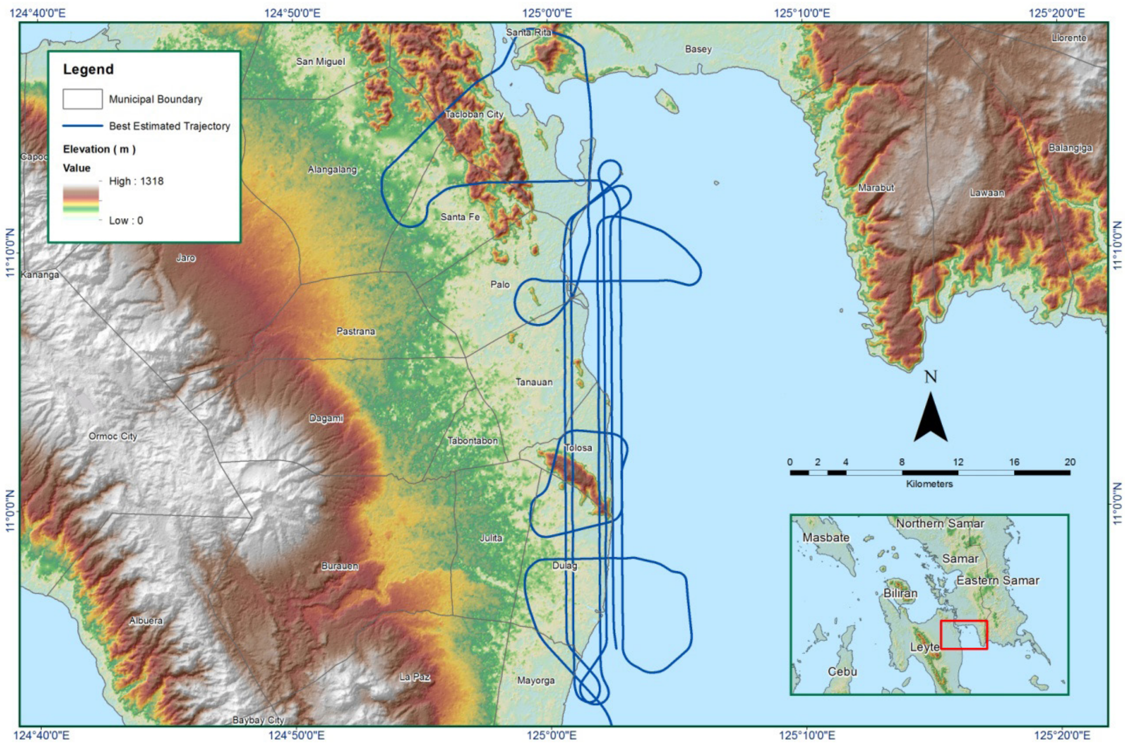



*Figure A-8.80 Best Estimated Trajectory*

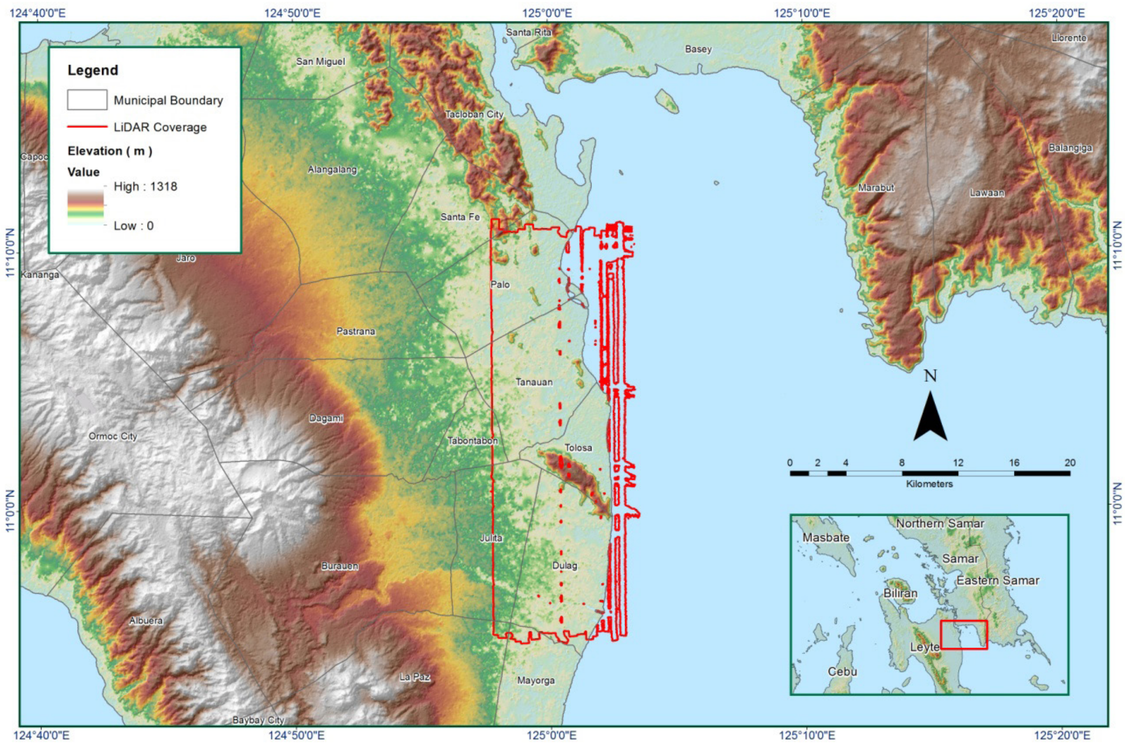



*Figure A-8.81 Coverage of LiDAR data*

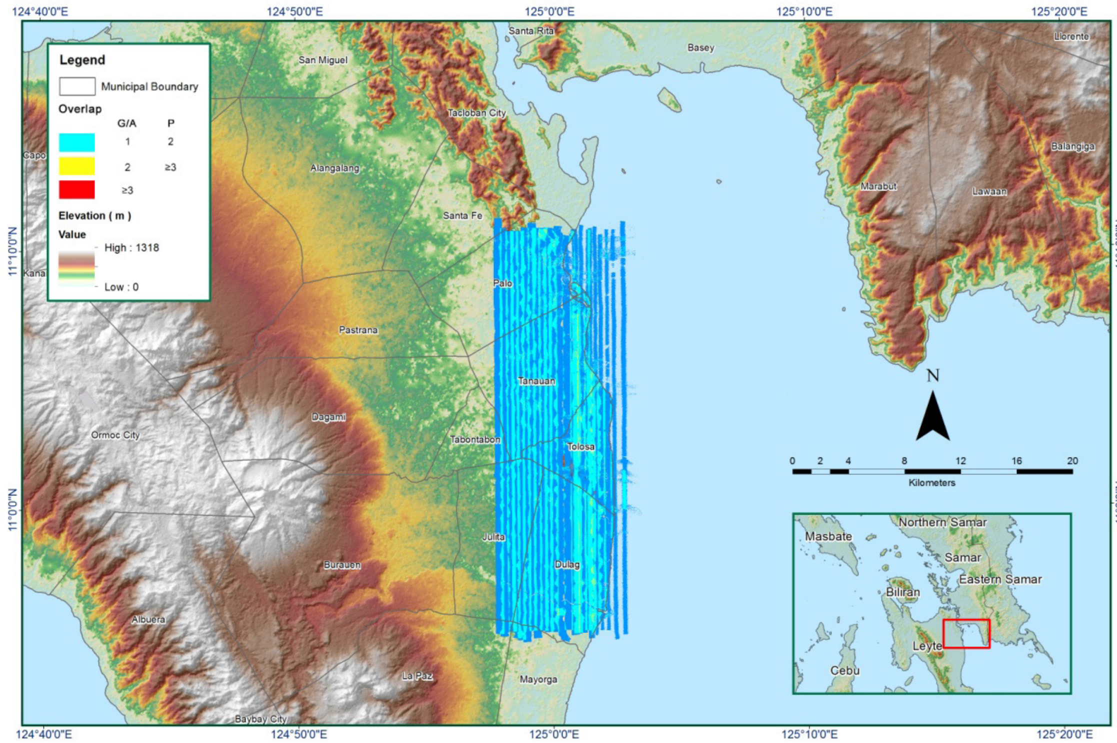



*Figure A-8.82 Image of data overlap*

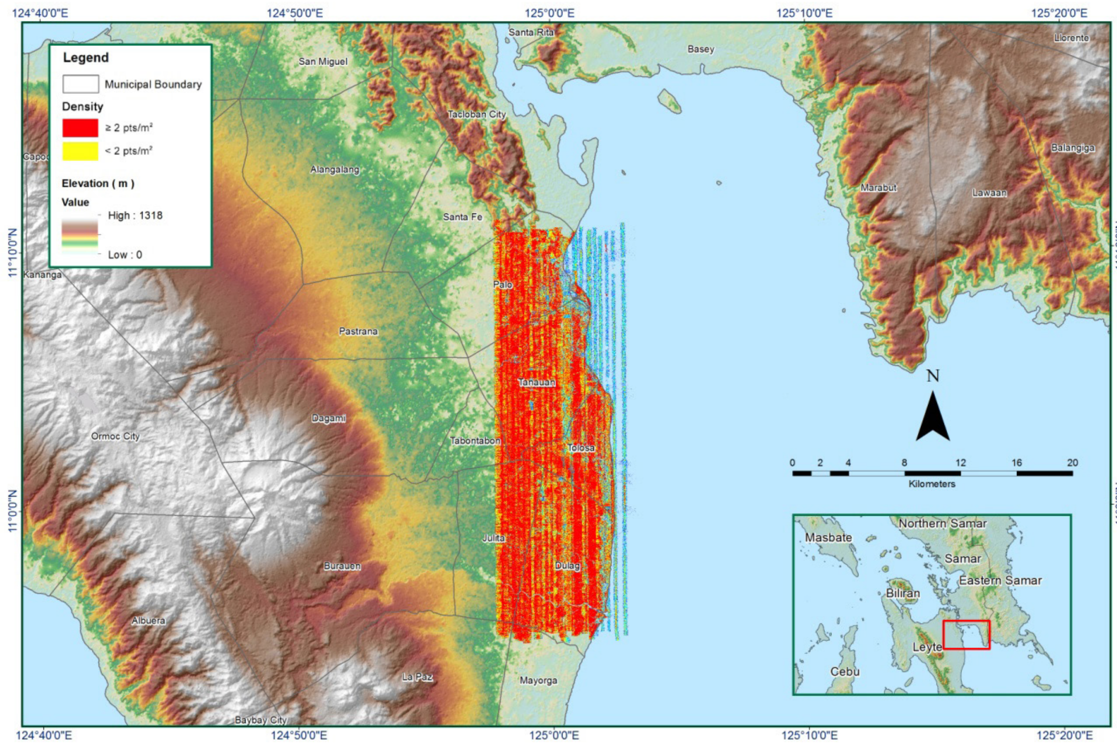



*Figure A-8.83 Density map of merged LiDAR data*

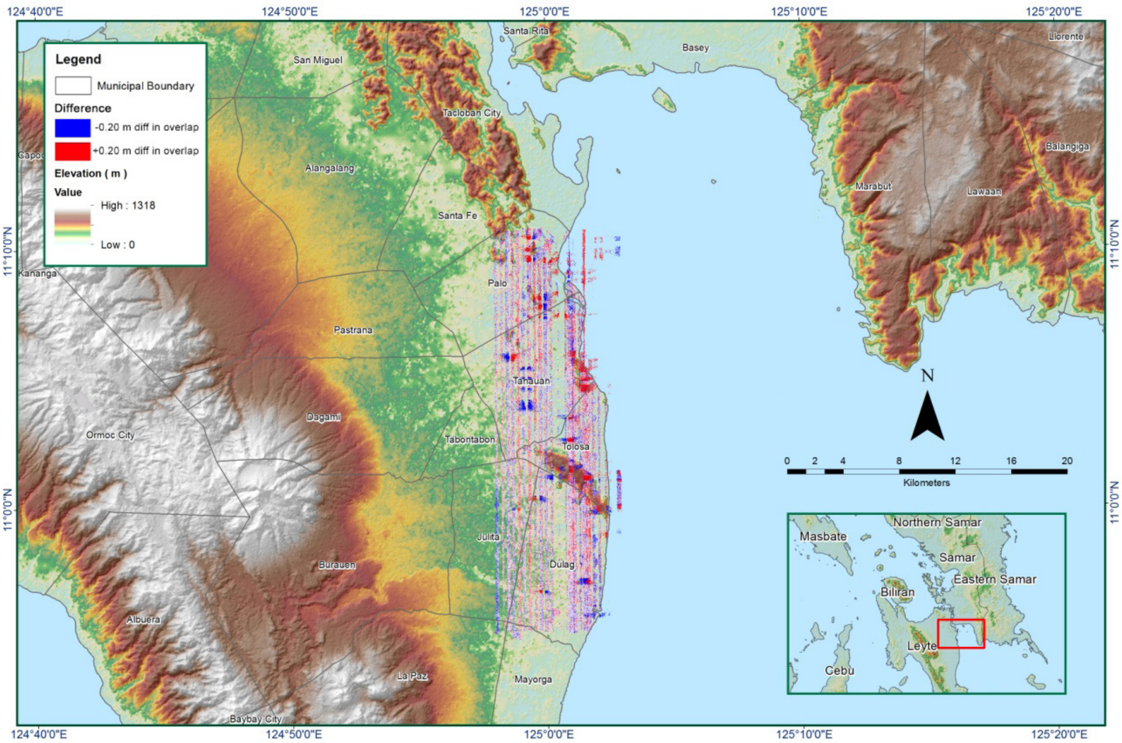



***Figure A-8.84*** *Elevation difference between flight lines*

| | |
|---|---|
| Flight Area | Tacloban |
| Mission Name | 1024A |
| Inclusive Flights | 1024A |
| Range data size | 16.3 GB |
| Base data size | 20.0 MB |
| POS | 247 MB |
| Image | 55.2 GB |
| Transfer date | February 3, 2014 |
| | |
| *Solution Status* | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | No |
| 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) | 1.5 |
| RMSE for Down Position (<8.0 cm) | 3.8 |
| | |
| Boresight correction stdev (<0.001deg) | 0.002232 |
| IMU attitude correction stdev (<0.001deg) | 0.003852 |
| GPS position stdev (<0.01m) | 0.0430 |
| | |
| Minimum % overlap (>25) | 1.78% |
| Ave point cloud density per sq.m. (>2.0) | 1.56 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 91 |
| Maximum Height | 267.05 m |
| Minimum Height | 59.03 m |
| | |
| *Classification (# of points)* | |
| Ground | 12,809,270 |
| Low vegetation | 8,880,857 |
| Medium vegetation | 21,804,521 |
| High vegetation | 1,514,514 |
| Building | 559,382 |
| Orthophoto | Yes |
| Processed by | Engr. Jennifer Saguran, Engr. Christy Lubiano, Jovy Narisma |

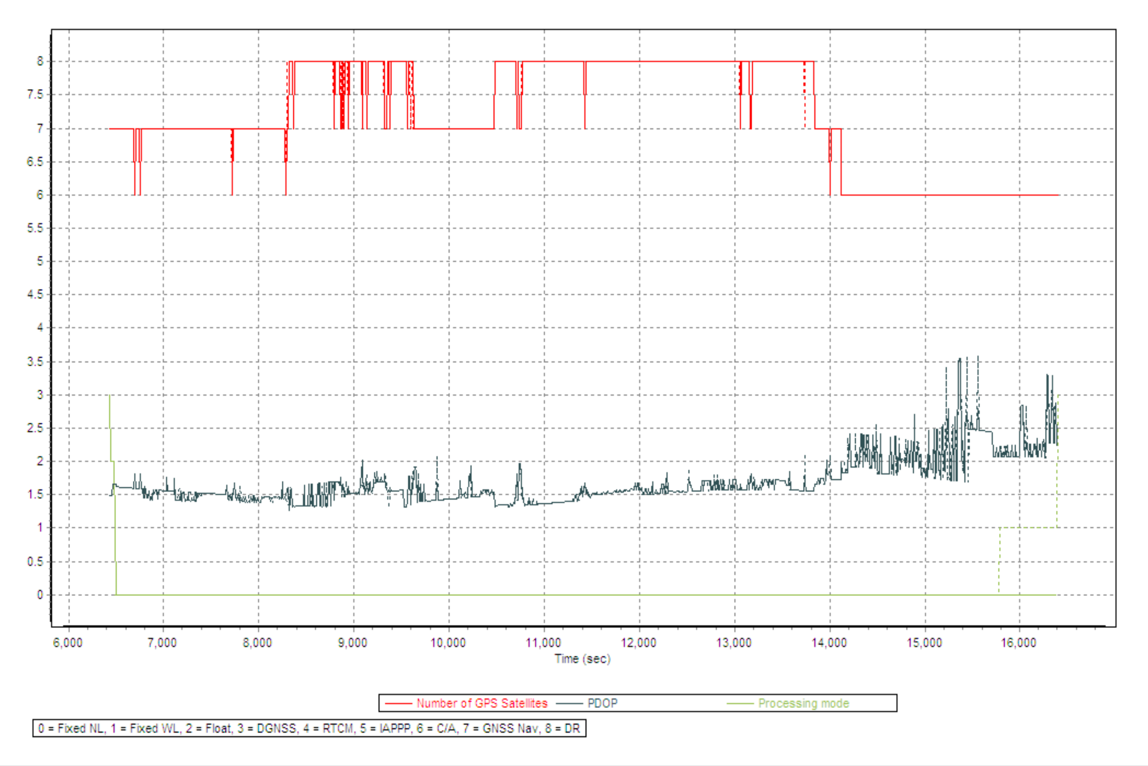



*Figure A-8.85 Solution Status*

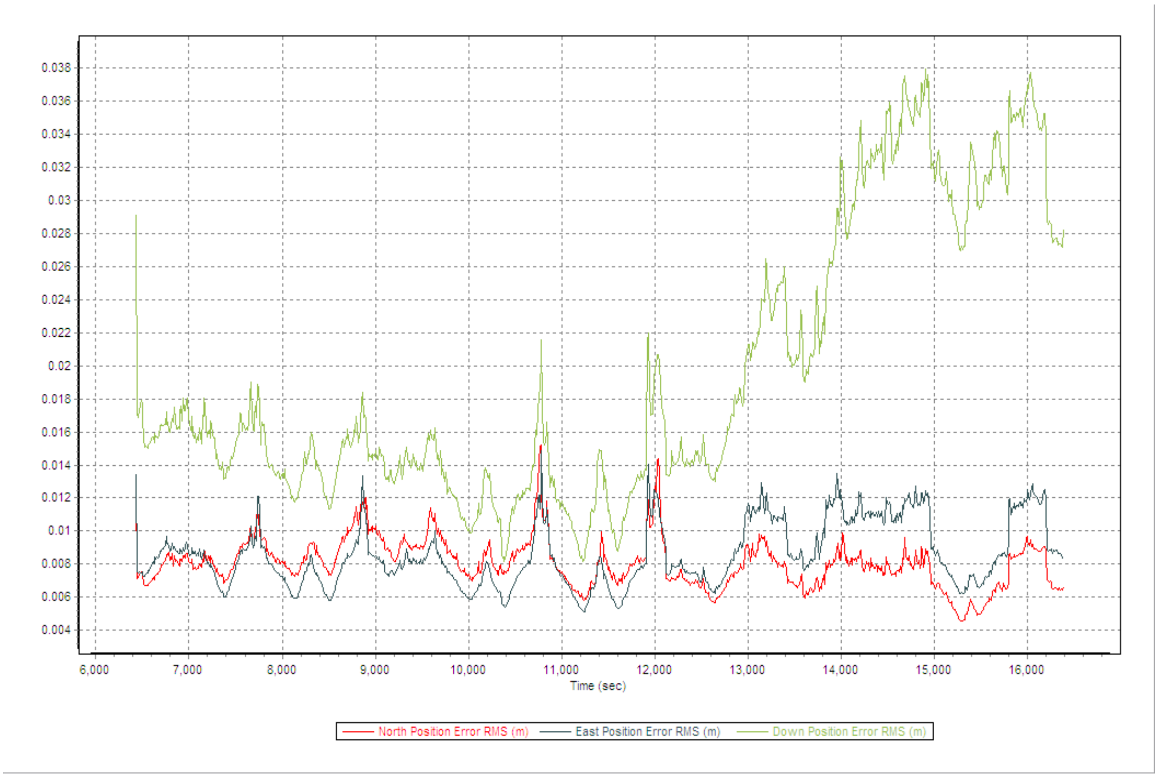



*Figure A-8.86 Smoothed Performance Metric Parameters*

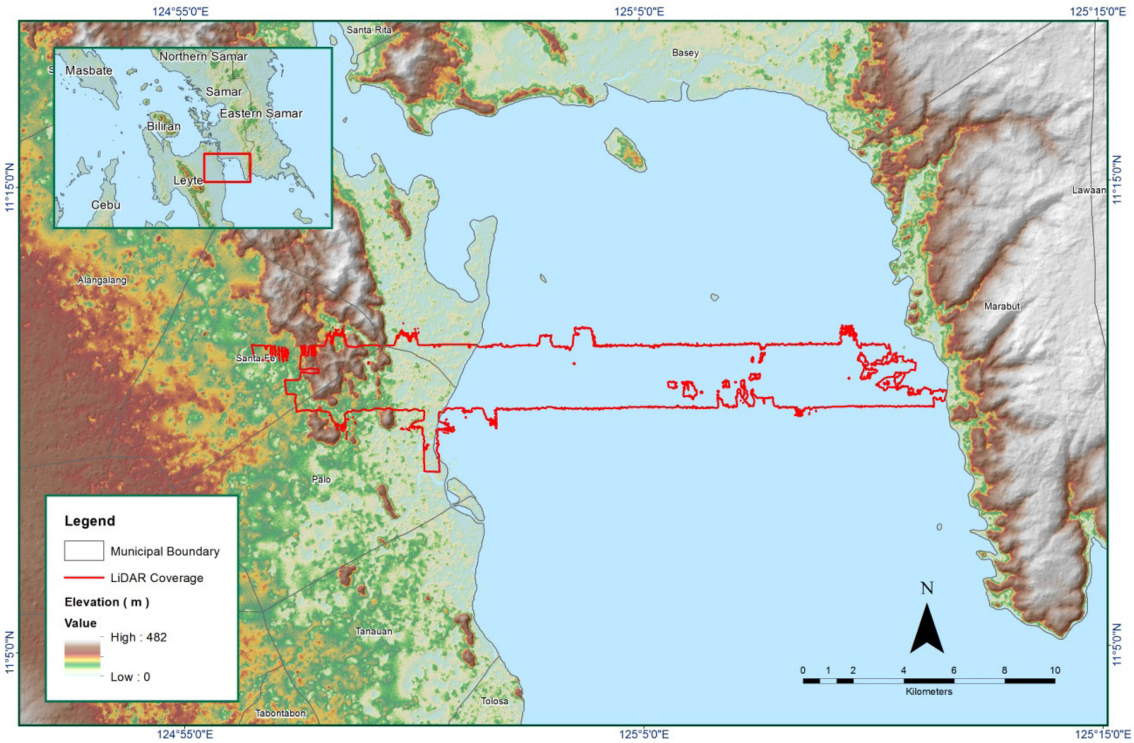



*Figure A-8.87 Best Estimated Trajectory*

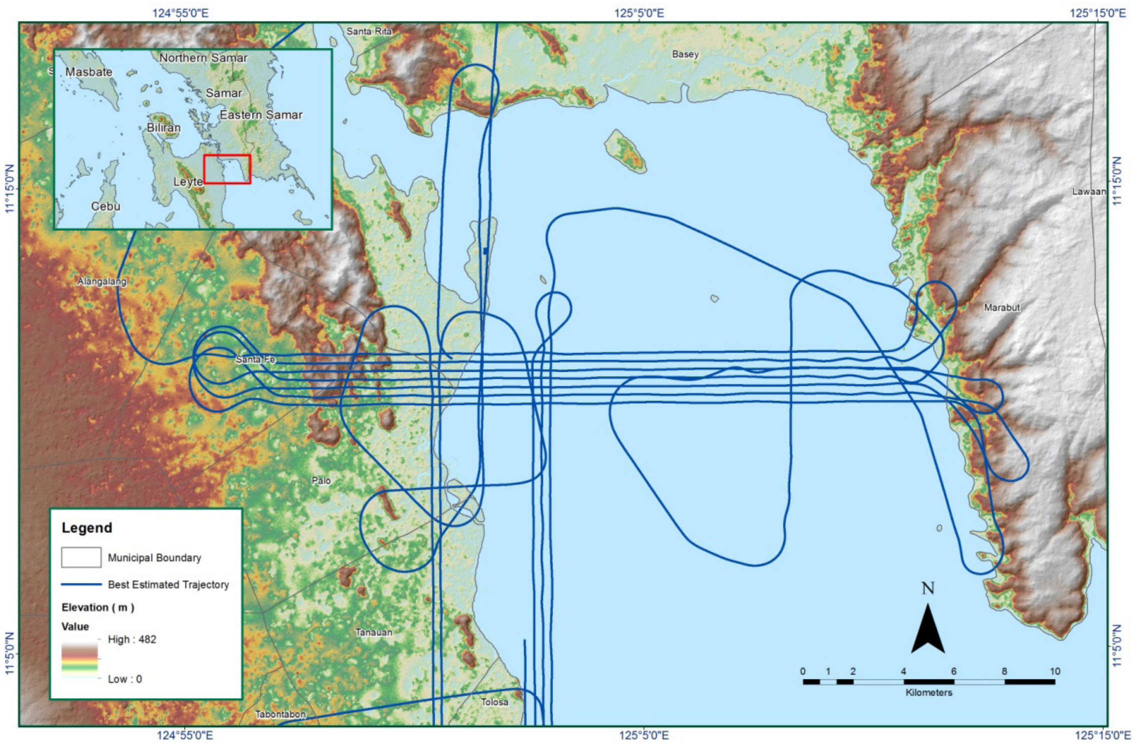



*Figure A-8.88 Coverage of LiDAR data*

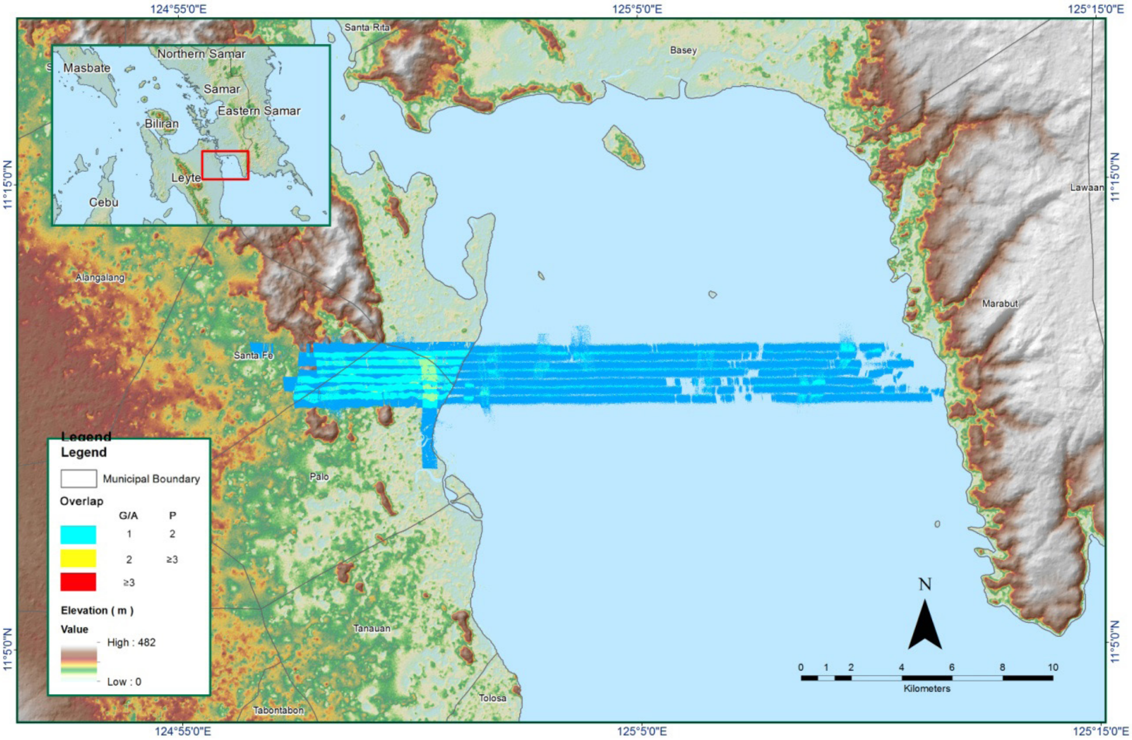



*Figure A-8.89 Image of data overlap*

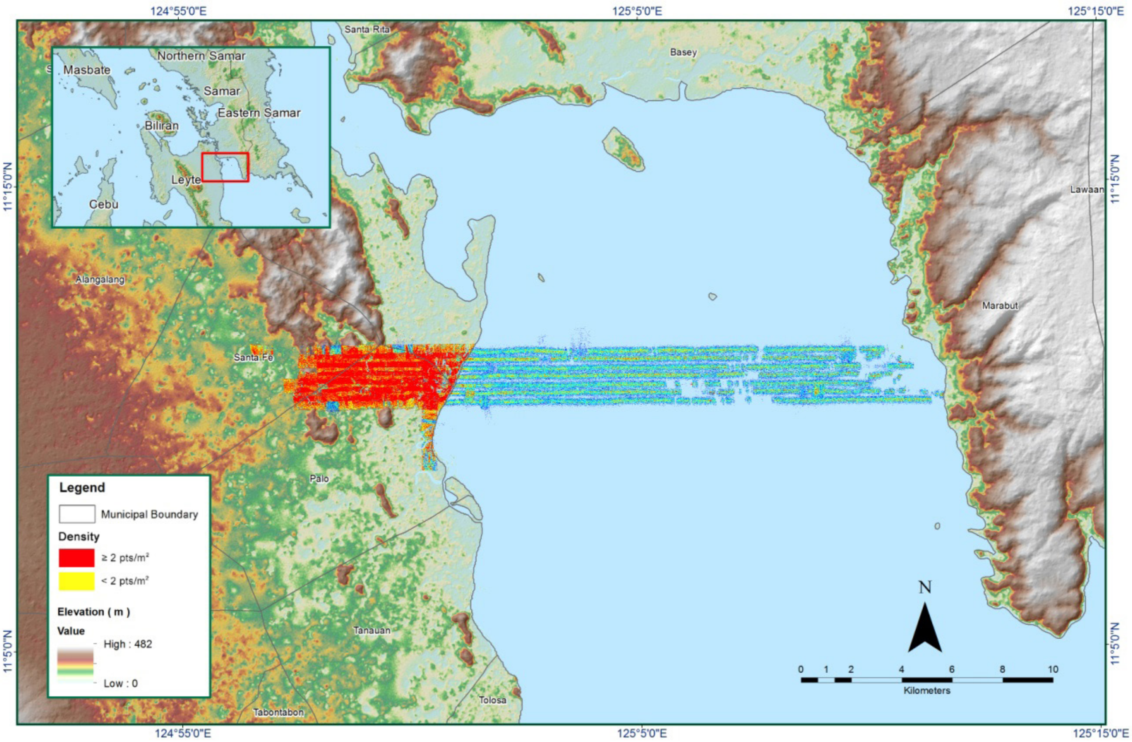



*Figure A-8.90 Density map of merged LiDAR data*

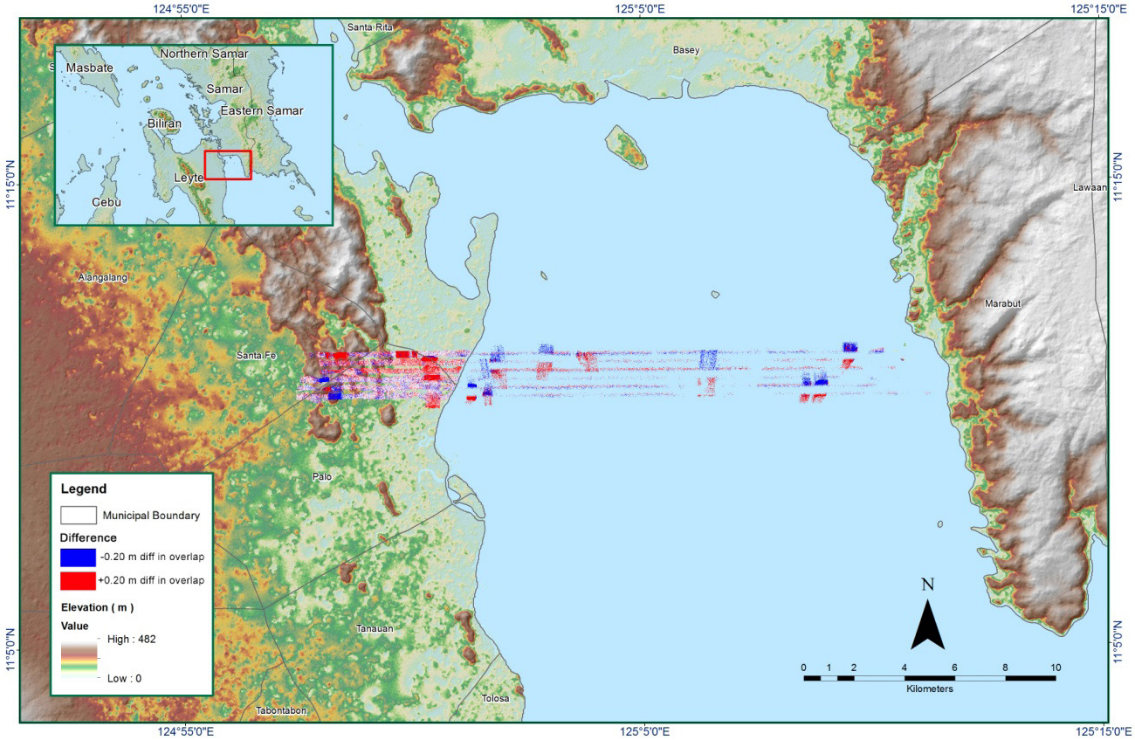



***Figure A-8.91*** *Elevation difference between flight lines*

| | |
|---|---|
| Flight Area | Tacloban |
| Mission Name | 1016A |
| Inclusive Flights | 1016A |
| Range data size | 9.96 GB |
| Base data size | 14.4 MB |
| POS | 159 MB |
| Image | 41.2 GB |
| Transfer date | February 3, 2015 |
| | |
| *Solution Status* | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | No |
| Baseline Length (<30km) | No |
| Processing Mode (<=1) | Yes |
| | |
| *Smoothed Performance Metrics* (in cm) | |
| RMSE for North Position (<4.0 cm) | 5.4 |
| RMSE for East Position (<4.0 cm) | 2.8 |
| RMSE for Down Position (<8.0 cm) | 6.8 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000560 |
| IMU attitude correction stdev (<0.001deg) | 0.001226 |
| GPS position stdev (<0.01m) | 0.0140 |
| | |
| Minimum % overlap (>25) | 36.23% |
| Ave point cloud density per sq.m. (>2.0) | 2.21 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 44 |
| Maximum Height | 403.16 m |
| Minimum Height | 54.21 m |
| | |
| *Classification (# of points)* | |
| Ground | 8,206,350 |
| Low vegetation | 6,347,280 |
| Medium vegetation | 20,067,295 |
| High vegetation | 3,485,057 |
| Building | 2,045,618 |
| Orthophoto | Yes |
| Processed by | Engr. Joida Prieto, Celina Rosete, Ailyn Biñas |

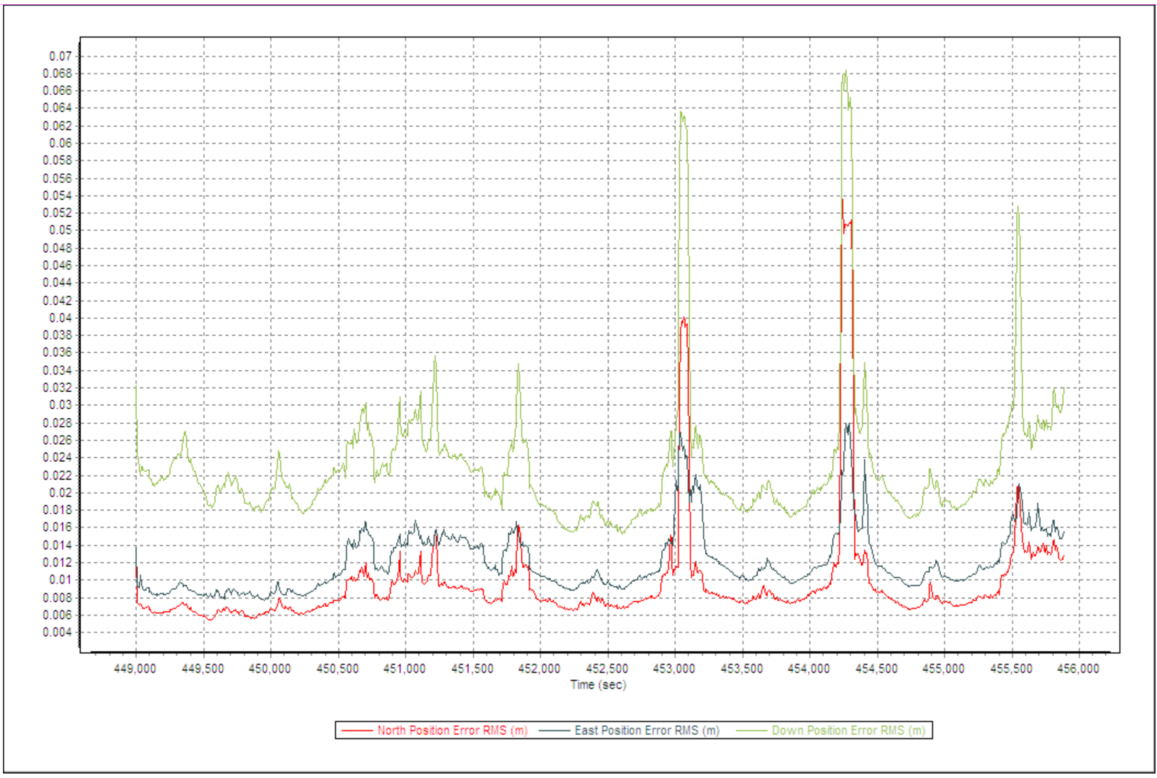



*Figure A-8.92 Solution Status*

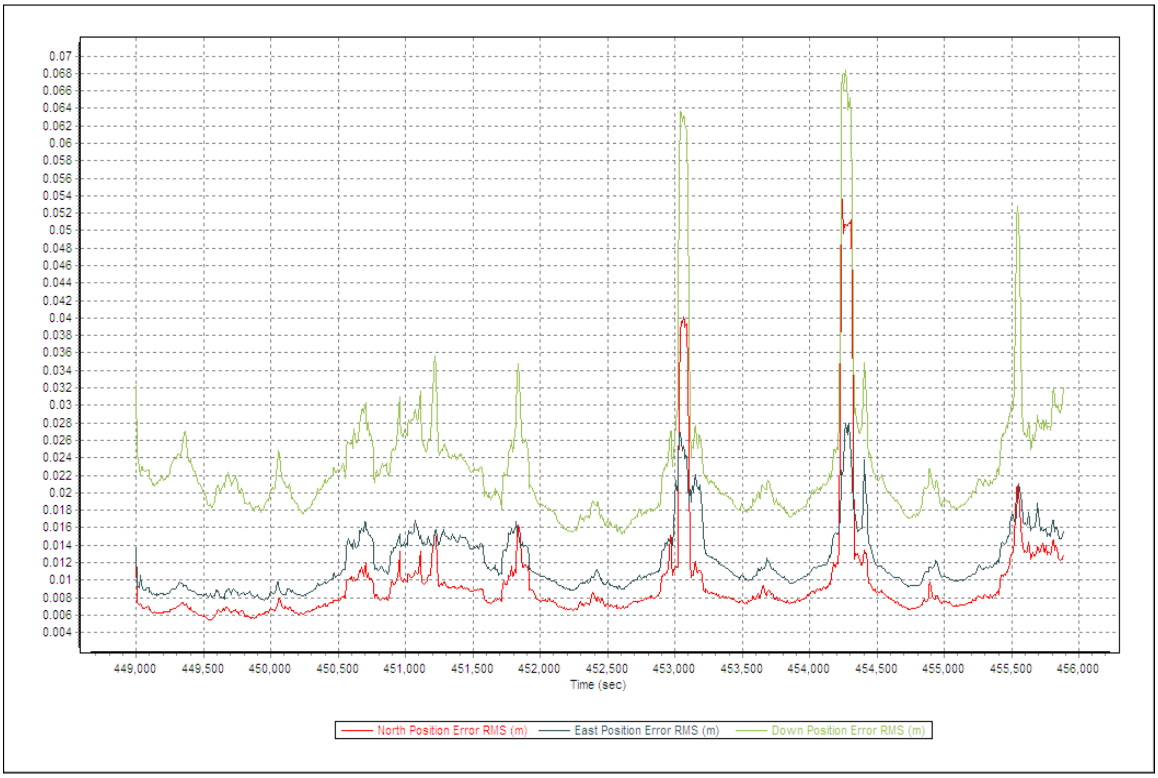



*Figure A-8.93 Smoothed Performance Metric Parameters*

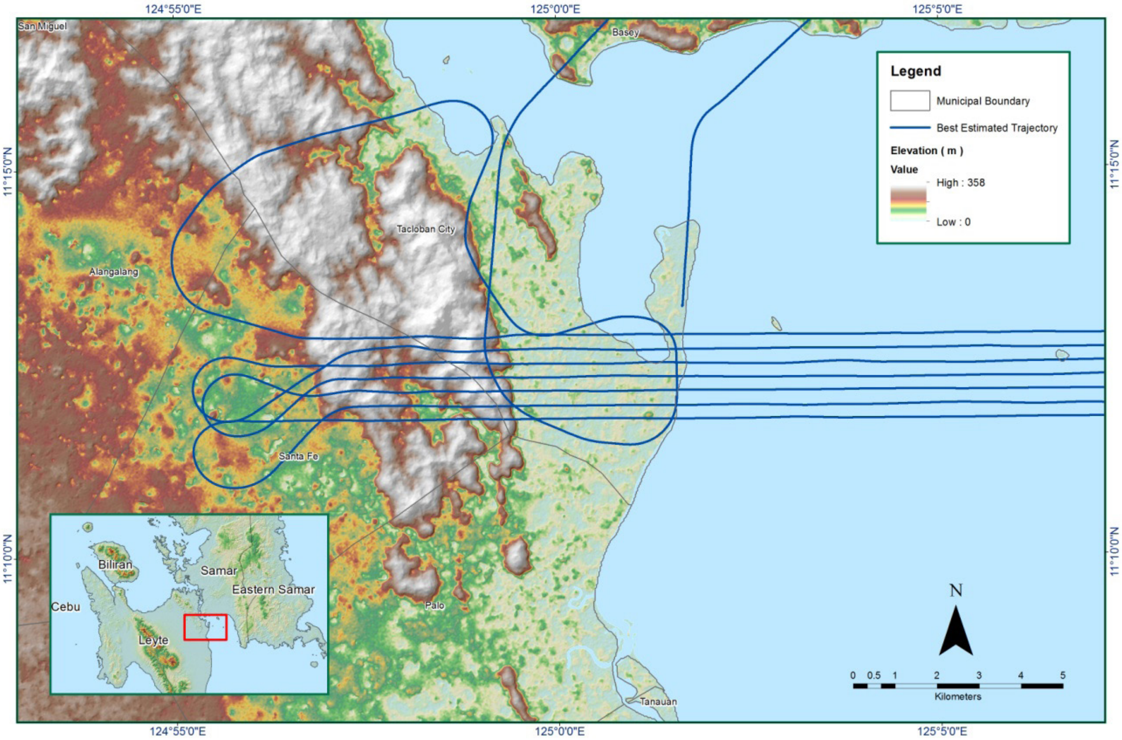



*Figure A-8.94 Best Estimated Trajectory*

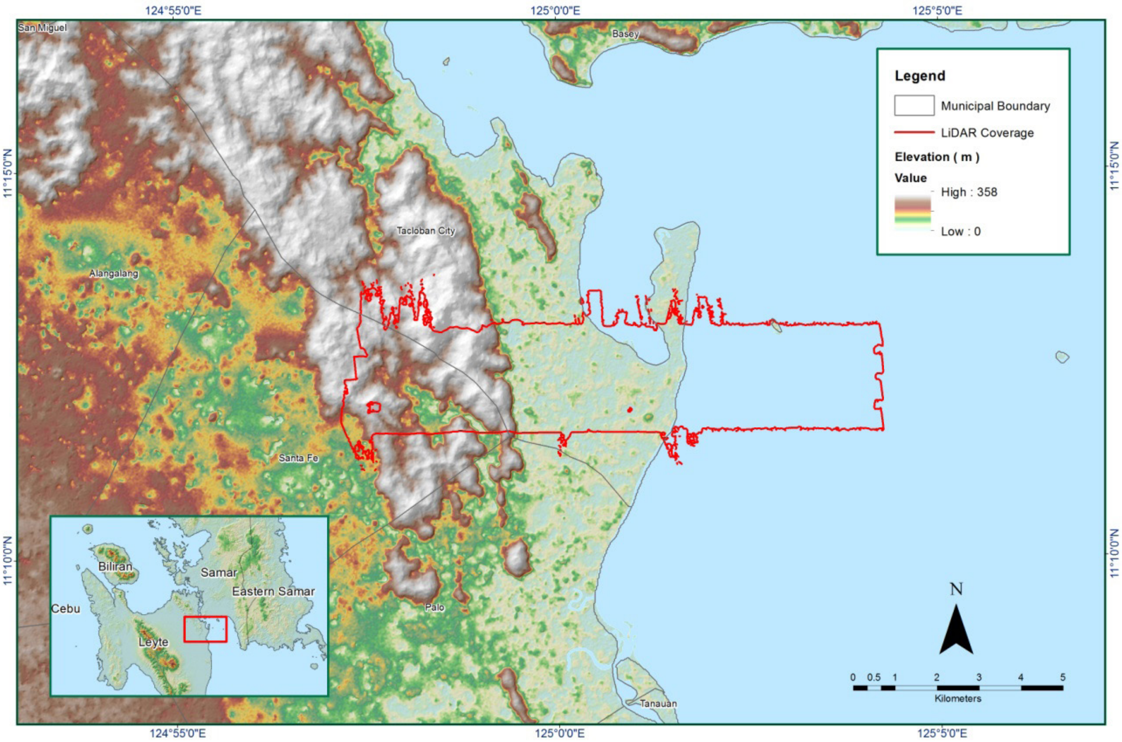



*Figure A-8.95 Coverage of LiDAR data*

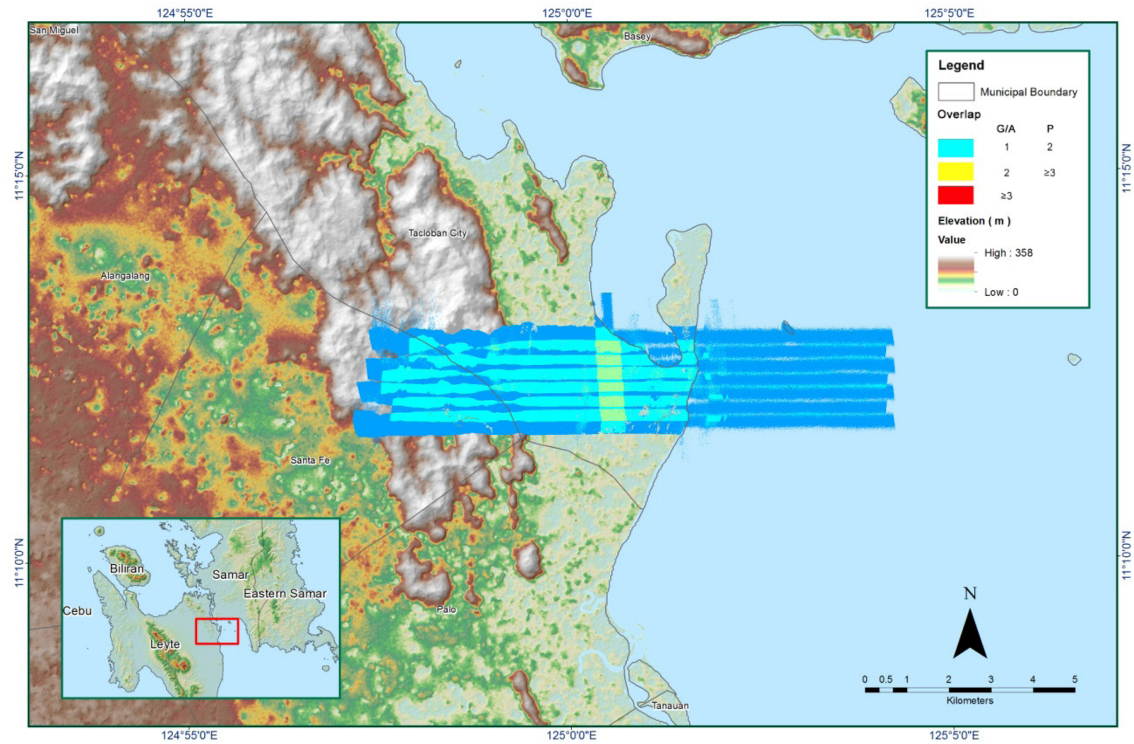



*Figure A-8.96 Image of data overlap*

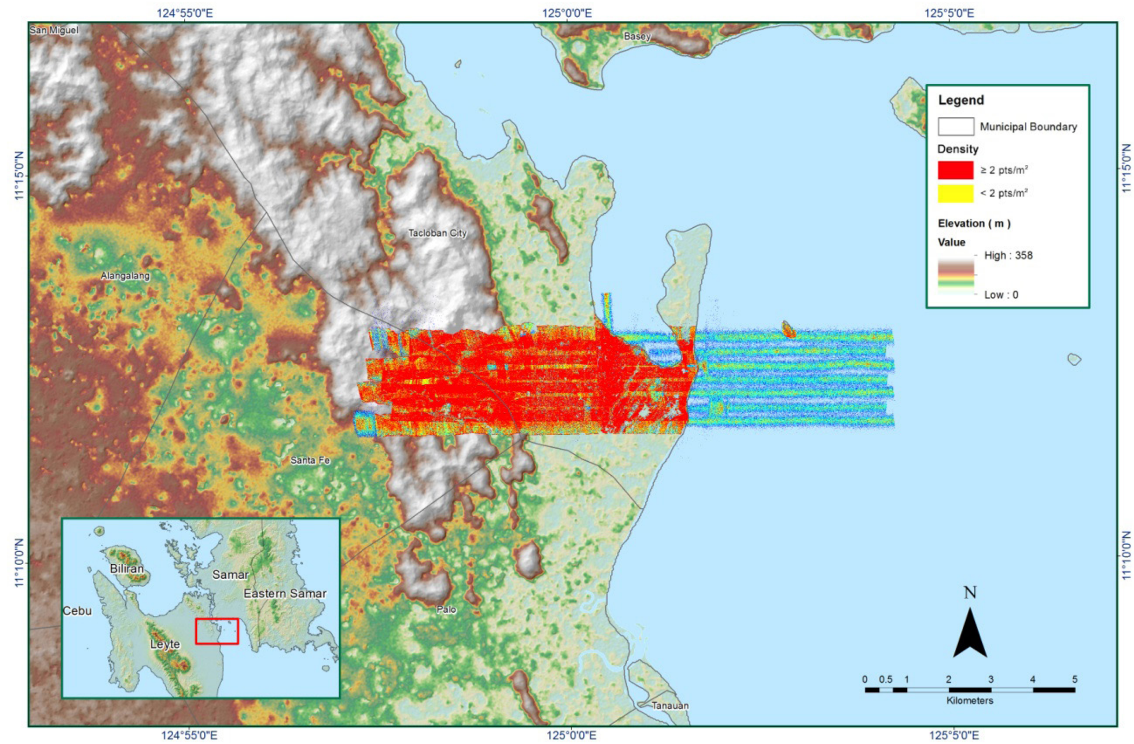



*Figure A-8.97 Density map of merged LiDAR data*

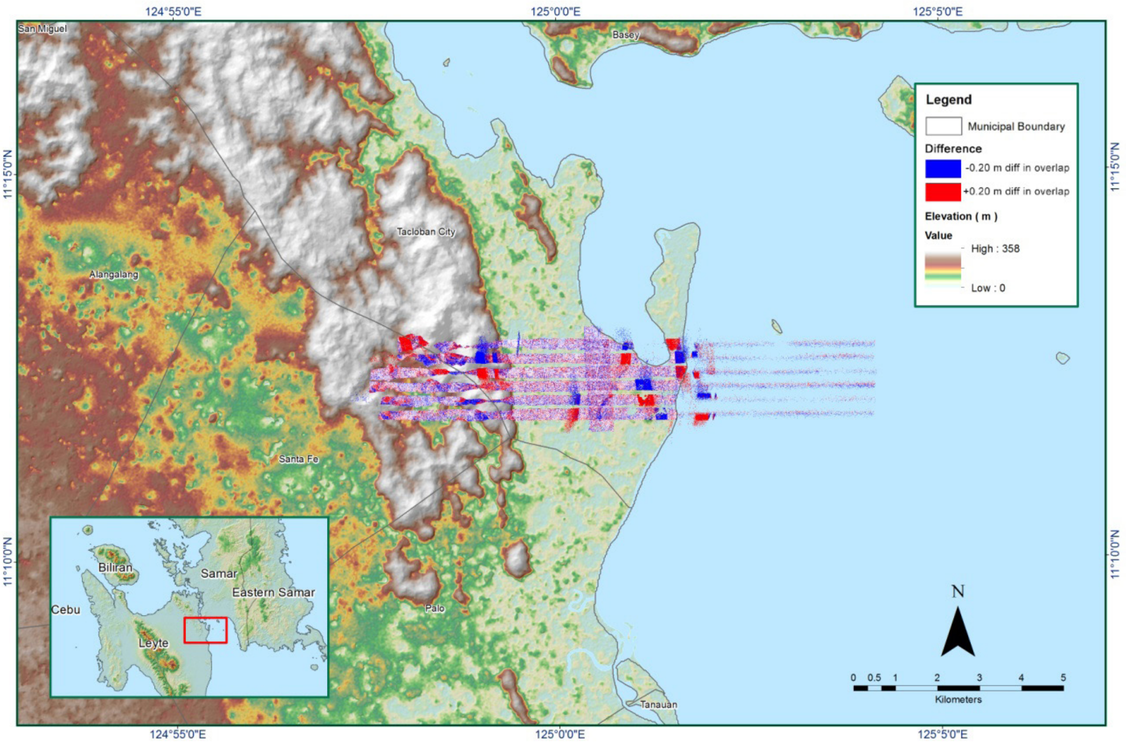



*Figure A-8.98* Elevation difference between flight lines

| | |
|---|---|
| Flight Area | Tacloban |
| Mission Name | 1040A |
| Inclusive Flights | 1040A |
| Range data size | 9.33 GB |
| Base data size | 11.7 MB |
| POS | 217 MB |
| Image | 16.2 GB |
| Transfer date | February 3, 2014 |
| | |
| *Solution Status* | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | Yes |
| Processing Mode (<=1) | Yes |
| | |
| *Smoothed Performance Metrics* (in cm) | |
| RMSE for North Position (<4.0 cm) | 1.5 |
| RMSE for East Position (<4.0 cm) | 1.8 |
| RMSE for Down Position (<8.0 cm) | 4.6 |
| | |
| Boresight correction stdev (<0.001deg) | 0.035516 |
| IMU attitude correction stdev (<0.001deg) | 0.173307 |
| GPS position stdev (<0.01m) | 0.0332 |
| | |
| Minimum % overlap (>25) | 29.93% |
| Ave point cloud density per sq.m. (>2.0) | 2.65 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 79 |
| Maximum Height | 407.51 m |
| Minimum Height | 59.98 m |
| | |
| *Classification (# of points)* | |
| Ground | 10,100,919 |
| Low vegetation | 9,632,051 |
| Medium vegetation | 27,972,442 |
| High vegetation | 3,440,624 |
| Building | 2,191,175 |
| Orthophoto | Yes |
| Processed by | Engr. Benjamin Jonah Magallon, Engr. Christy Lubiano, Jovy Narisma |

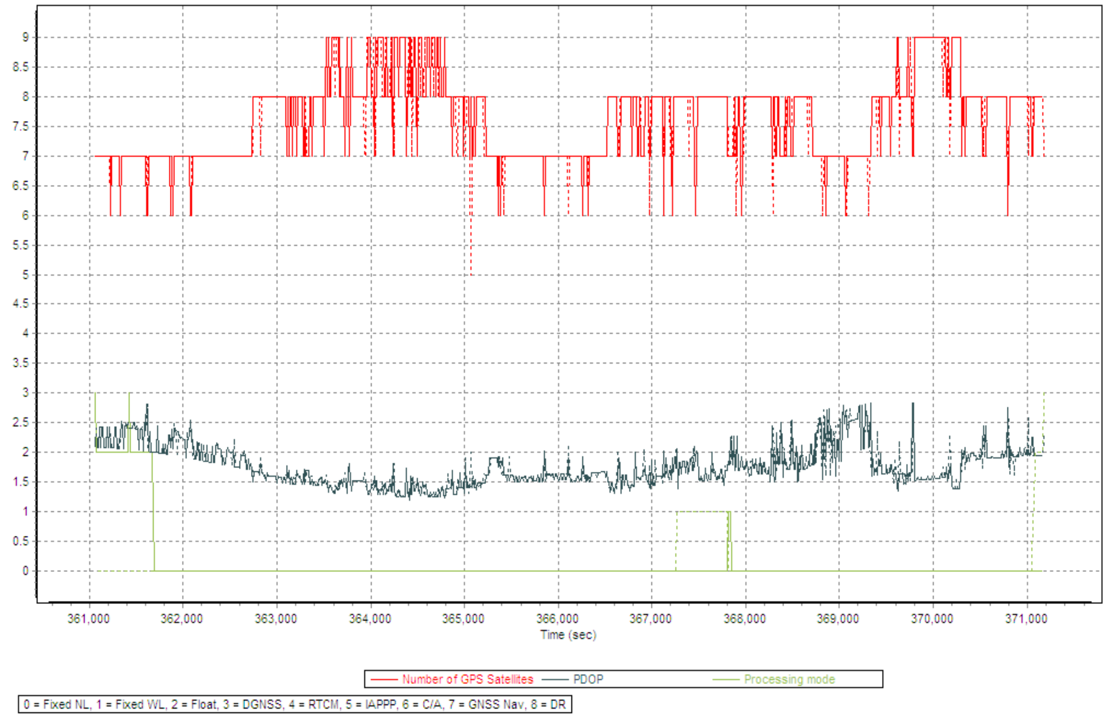



*Figure A-8.99 Solution Status*

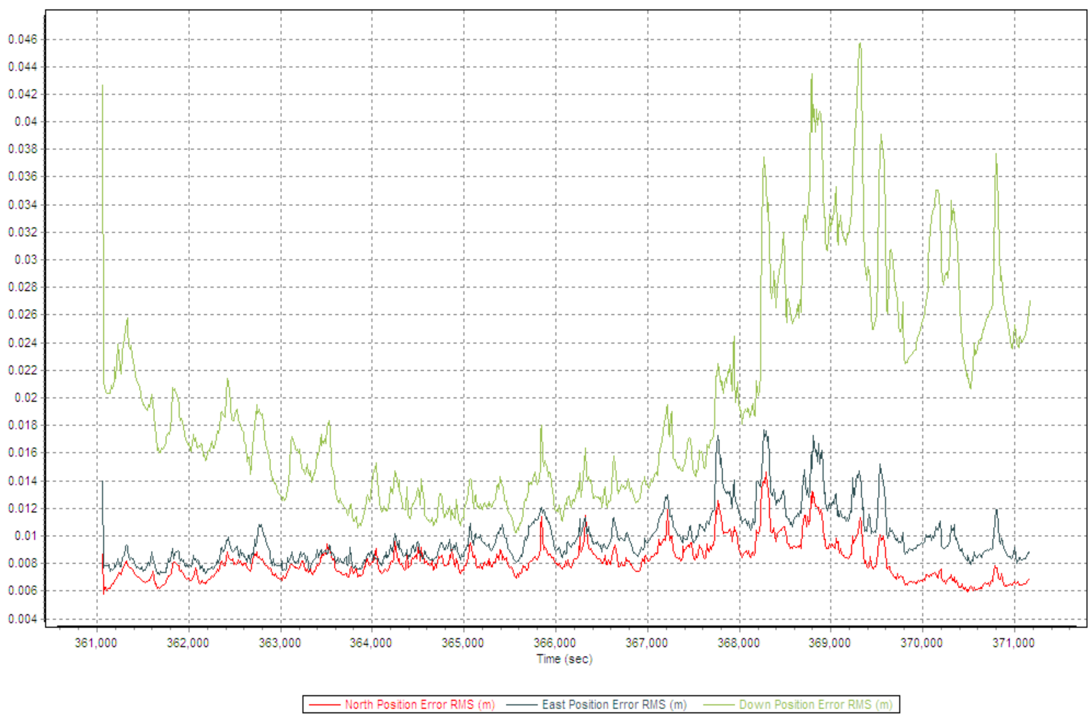



*Figure A-8.100 Smoothed Performance Metric Parameters*

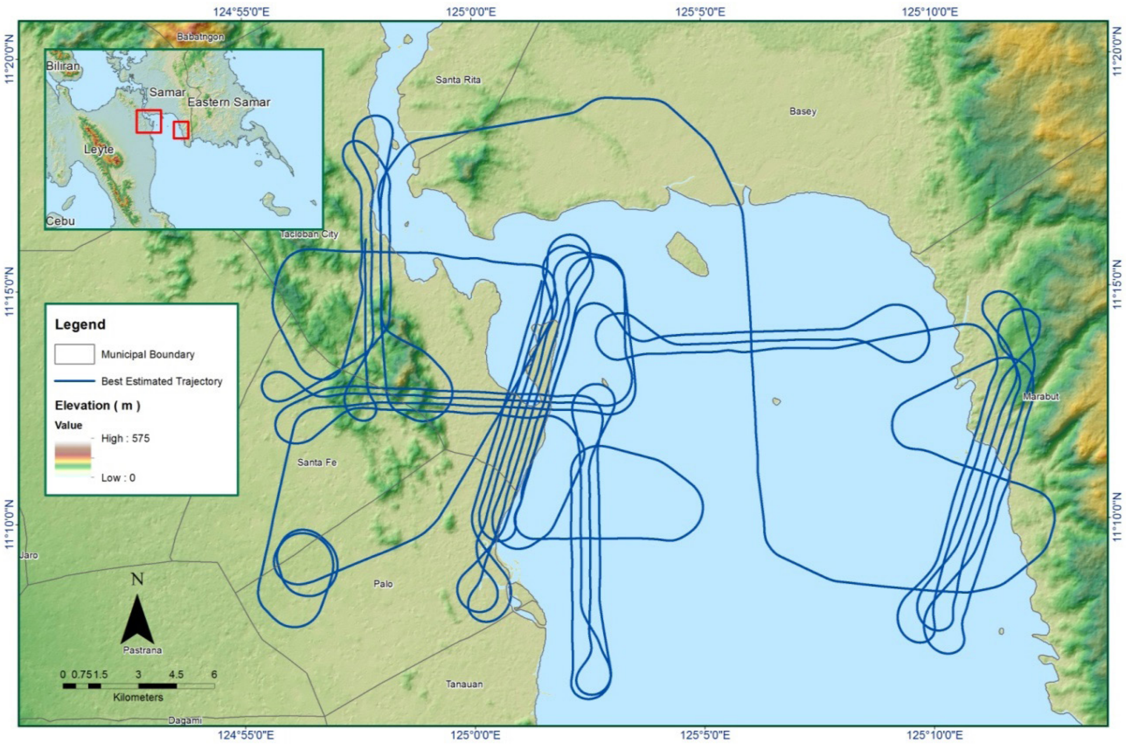



*Figure A-8.101 Best Estimated Trajectory*

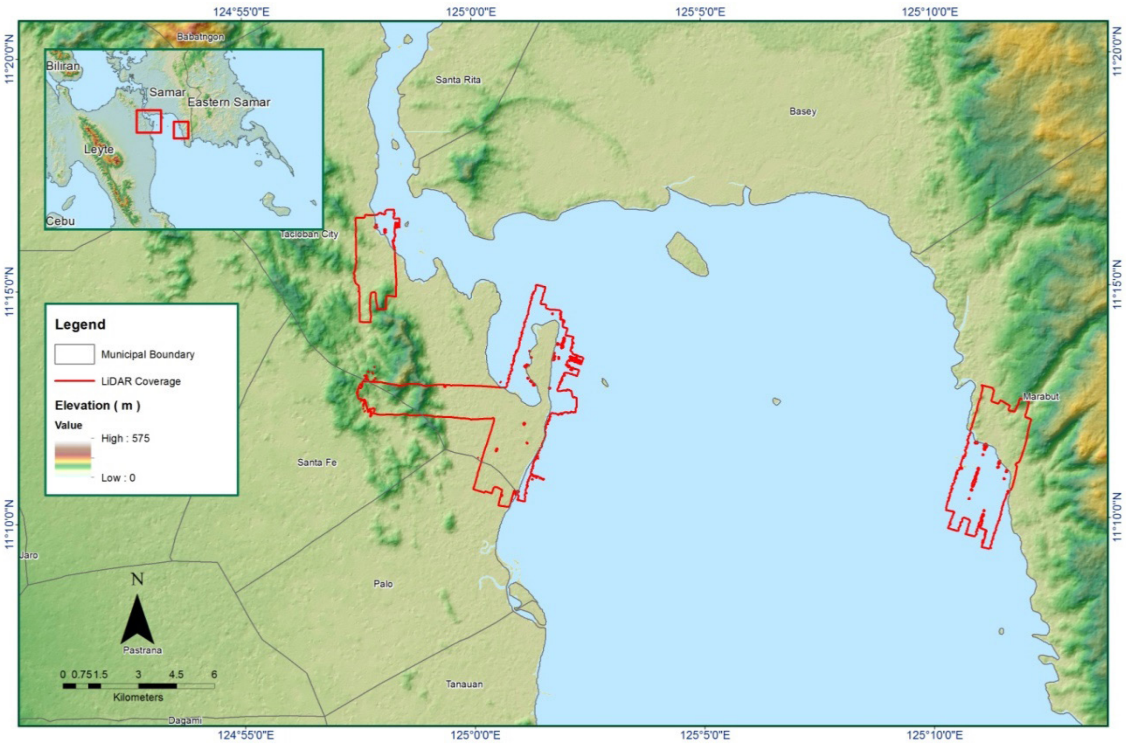



*Figure A-8.102 Coverage of LiDAR data*

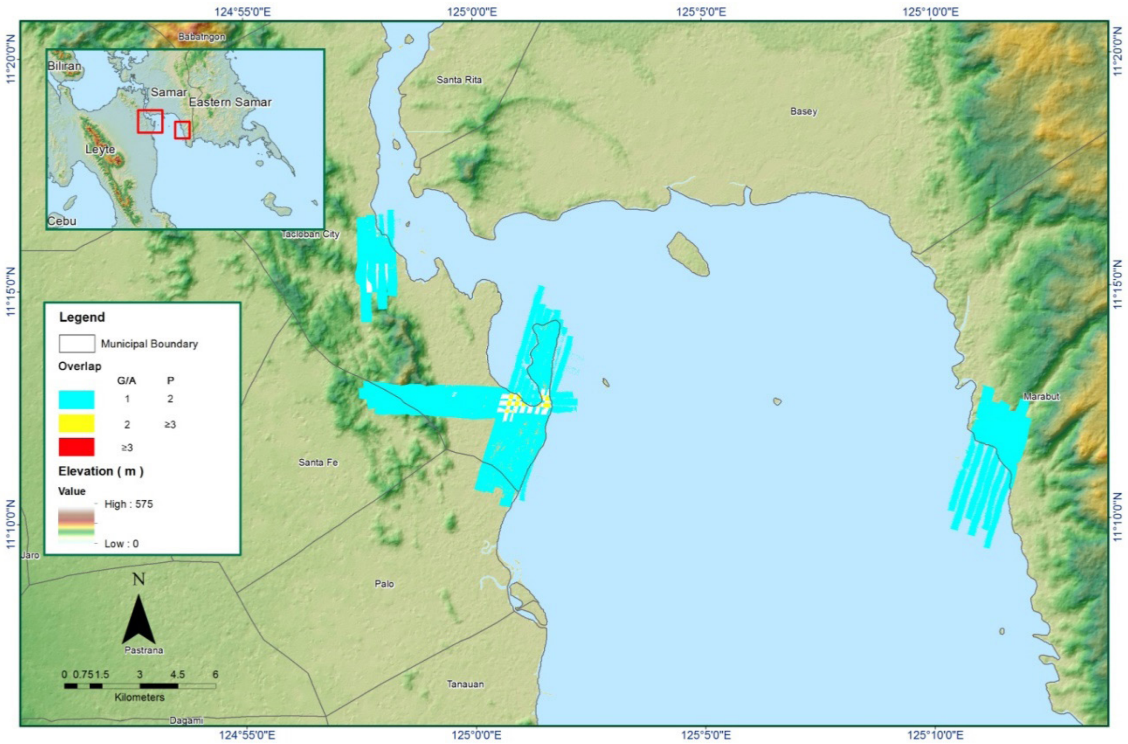



*Figure A-8.103 Image of data overlap*

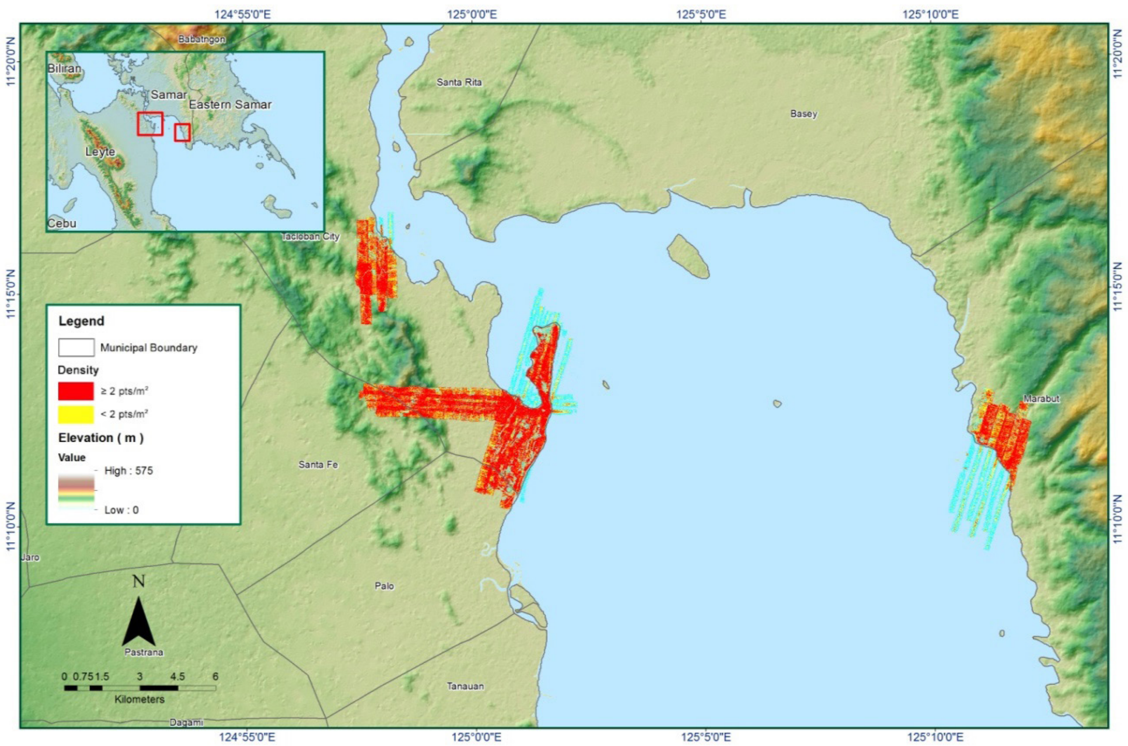



*Figure A-8.104 Density map of merged LiDAR data*

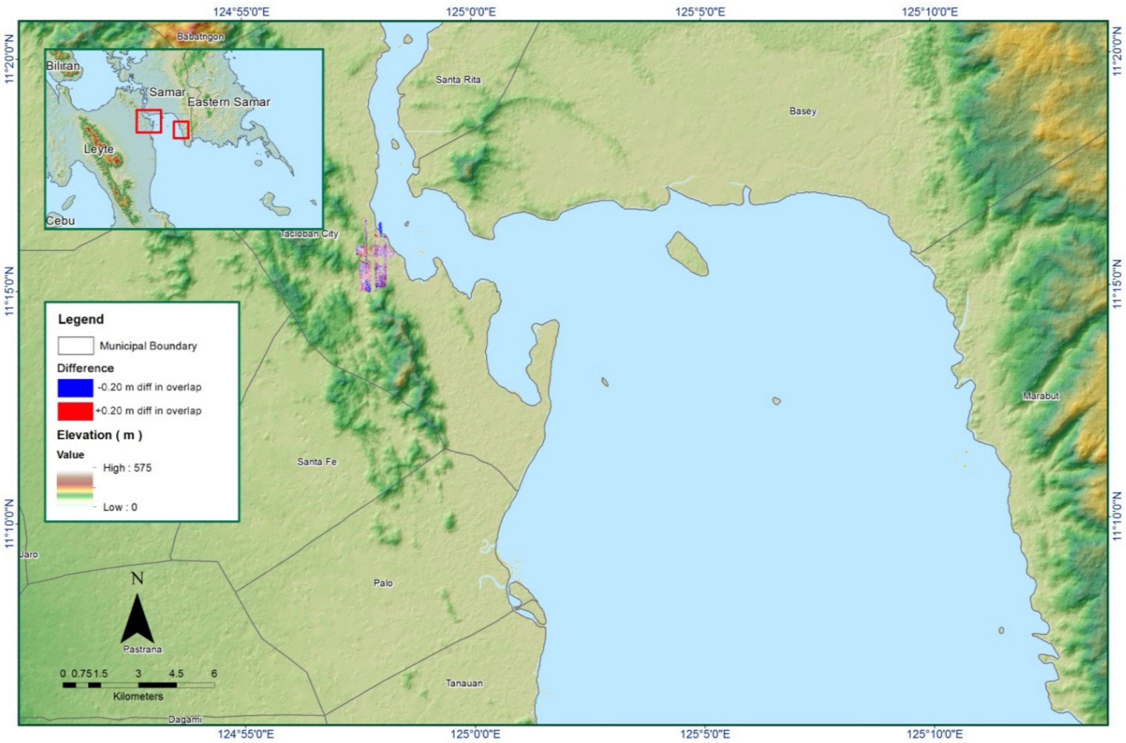



***Figure A-8.105*** *Elevation difference between flight lines*

| | |
|---|---|
| Flight Area | Tacloban |
| Mission Name | 1018A |
| Inclusive Flights | 1018A |
| Range data size | 2.63 GB |
| Base data size | 14.4 MB |
| POS | 81 MB |
| Image | N/A |
| Transfer date | February 3, 2014 |
| | |
| *Solution Status* | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | Yes |
| Processing Mode (<=1) | Yes |
| | |
| *Smoothed Performance Metrics* (in cm) | |
| RMSE for North Position (<4.0 cm) | 3.7 |
| RMSE for East Position (<4.0 cm) | 3.7 |
| RMSE for Down Position (<8.0 cm) | 4.6 |
| | |
| Boresight correction stdev (<0.001deg) | 0.007721 |
| IMU attitude correction stdev (<0.001deg) | 0.005490 |
| GPS position stdev (<0.01m) | 0.0036 |
| | |
| Minimum % overlap (>25) | 9.57% |
| Ave point cloud density per sq.m. (>2.0) | 1.46 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 55 |
| Maximum Height | 239.52 |
| Minimum Height | 1.82 |
| | |
| *Classification (# of points)* | |
| Ground | 4,390,391 |
| Low vegetation | 1,640,662 |
| Medium vegetation | 2,606,014 |
| High vegetation | 6,460,257 |
| Building | 559,780 |
| Orthophoto | Yes |
| Processed by | Engr. Angelo Carlo Bongat, Engr. Melanie Hingpit, Jovy Narisma |

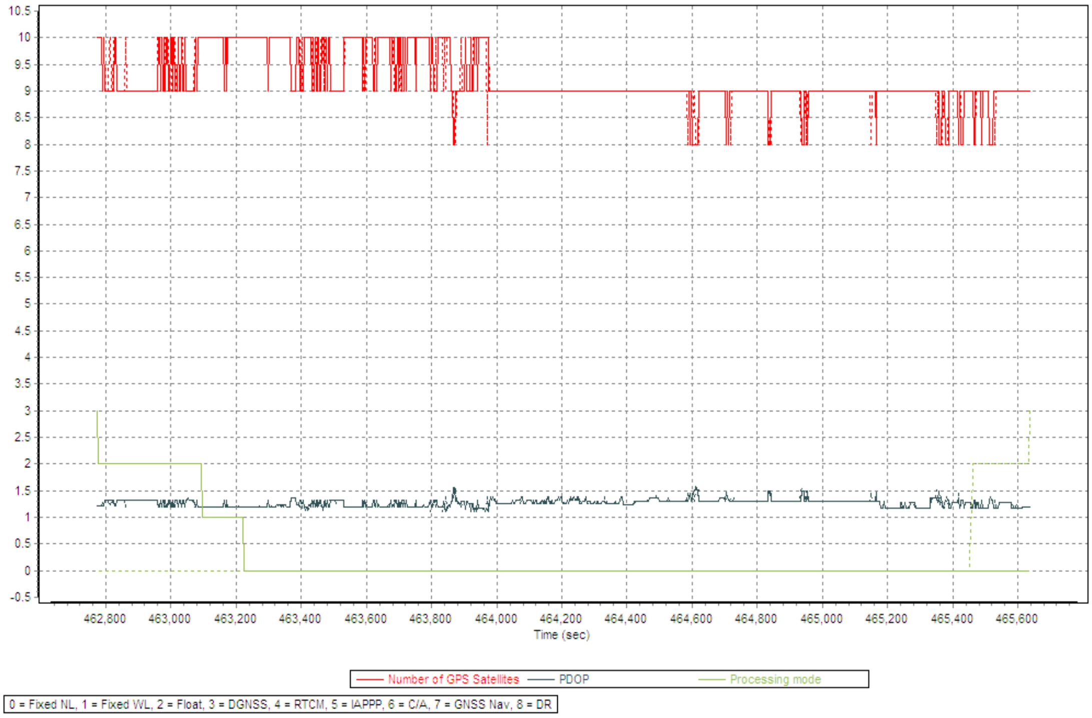



*Figure A-8.106 Solution Status*

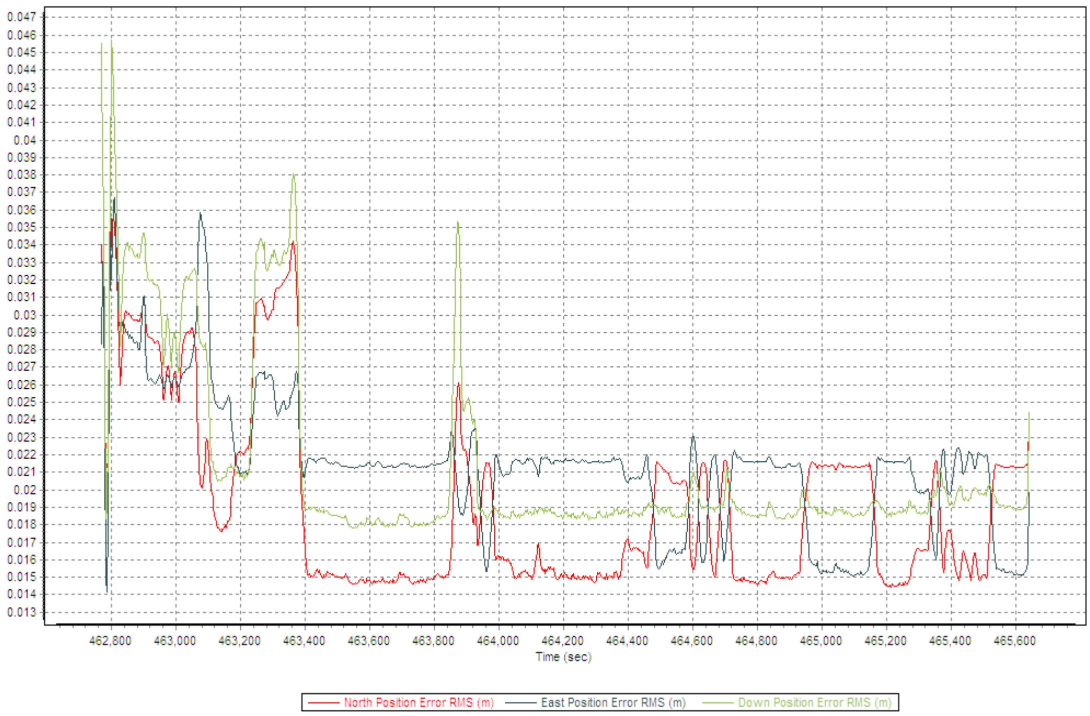



*Figure A-8.107 Smoothed Performance Metric Parameters*

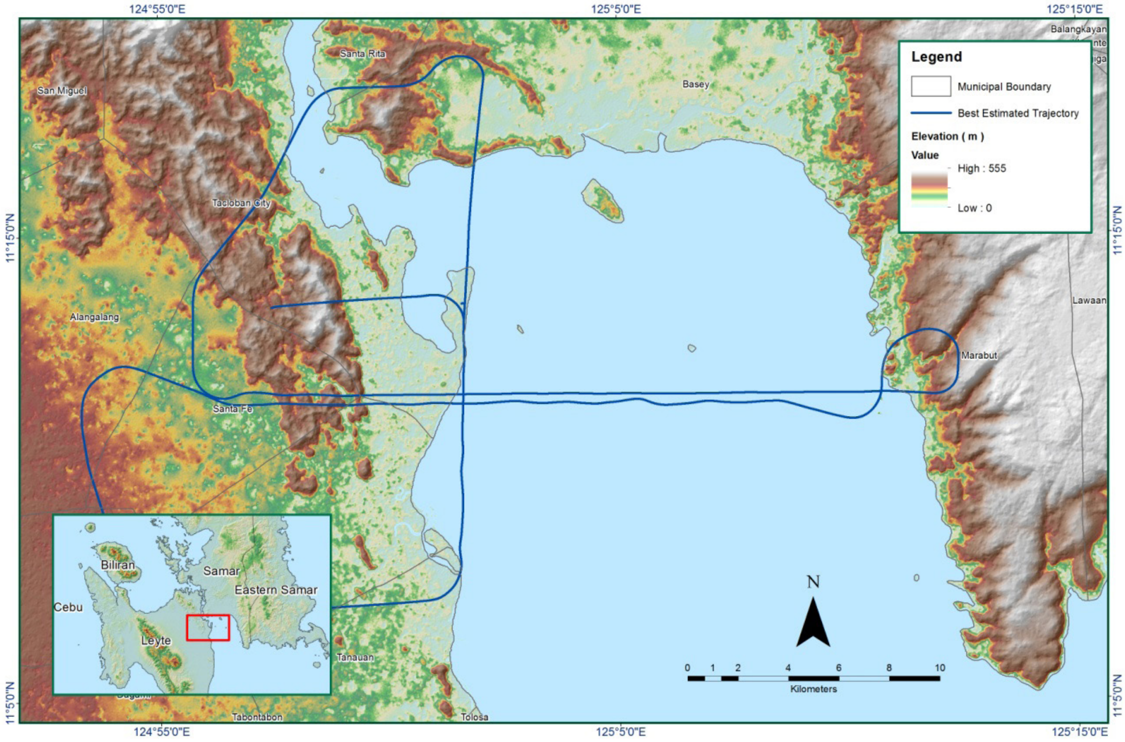



*Figure A-8.108 Best Estimated Trajectory*

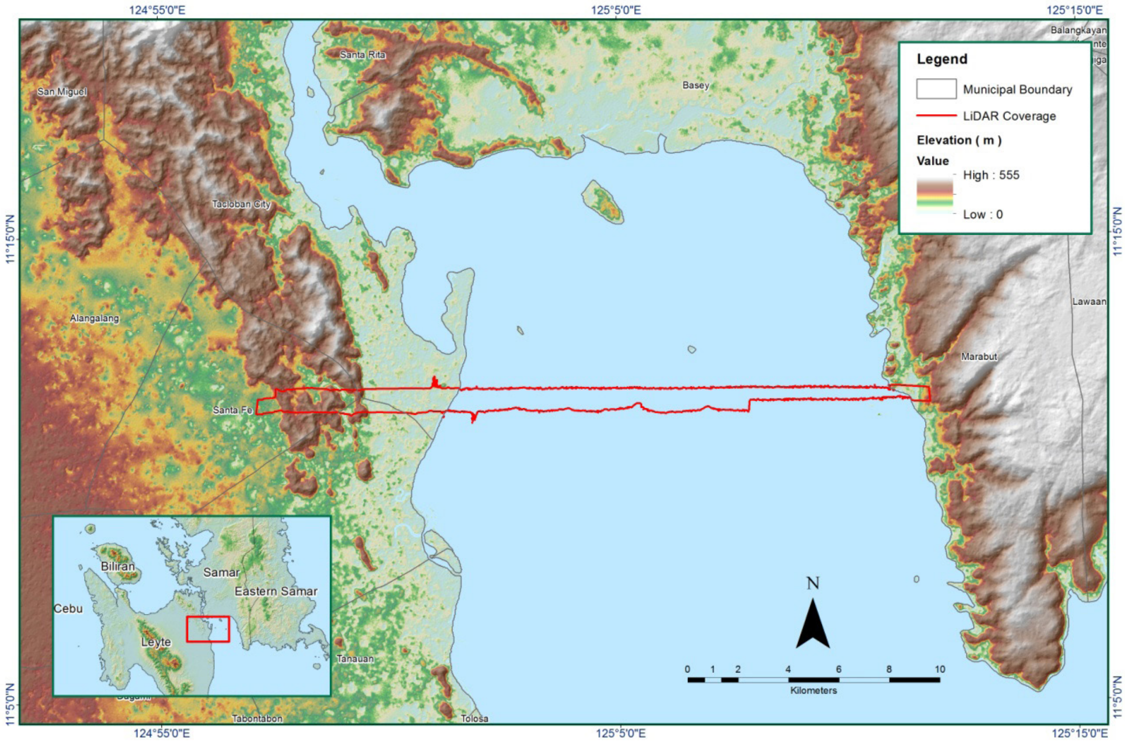



*Figure A-8.109 Coverage of LiDAR data*

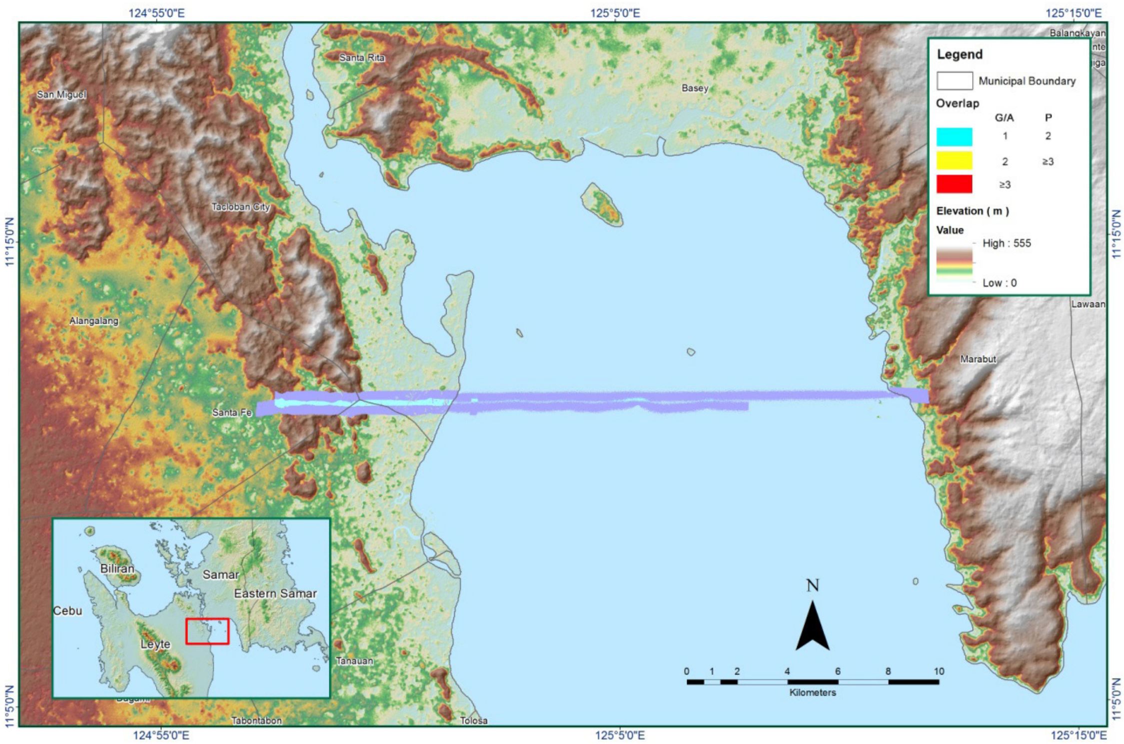



*Figure A-8.110 Image of data overlap*

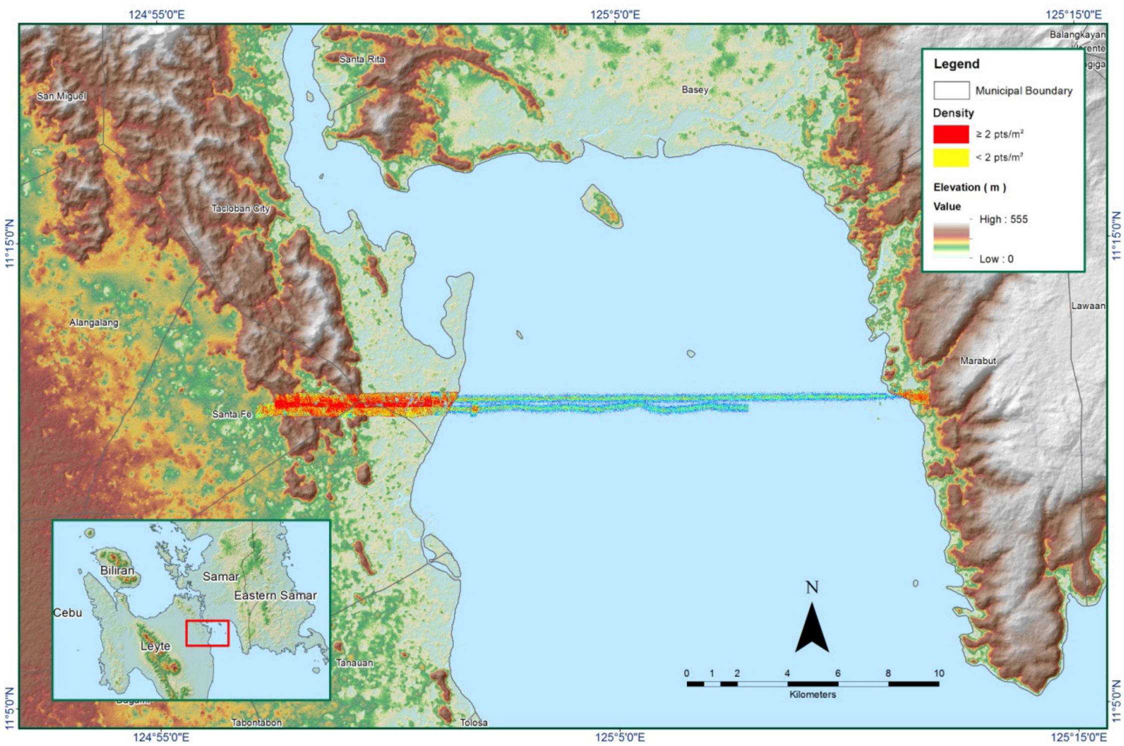



*Figure A-8.111 Density map of merged LiDAR data*

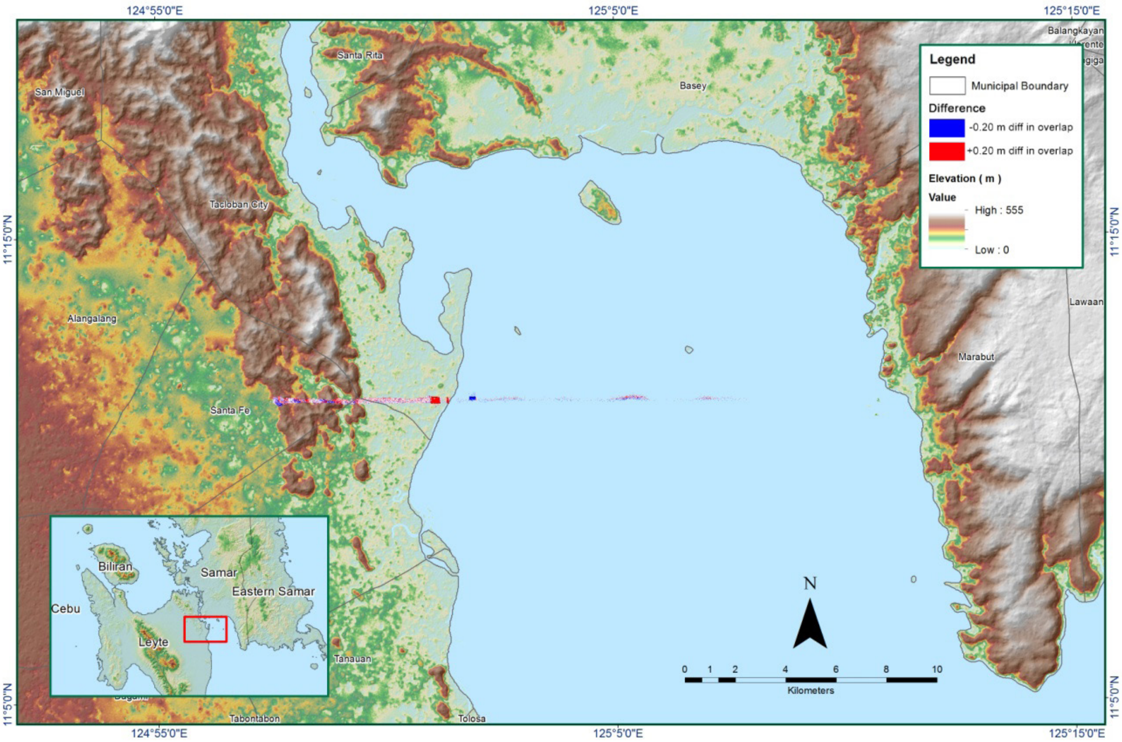



*Figure A-8.112* Elevation difference between flight lines

| | |
|---|---|
| Flight Area | Tacloban |
| Mission Name | 1020A |
| Inclusive Flights | 1020A |
| Range data size | 15.1 GB |
| Base data size | 20.7 MB |
| POS | 237 MB |
| Image | 67.7GB |
| Transfer date | February 3, 2014 |
| | |
| *Solution Status* | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | Yes |
| Processing Mode (<=1) | Yes |
| | |
| *Smoothed Performance Metrics* (in cm) | |
| RMSE for North Position (<4.0 cm) | 1.4 |
| RMSE for East Position (<4.0 cm) | 2.1 |
| RMSE for Down Position (<8.0 cm) | 5.5 |
| | |
| Boresight correction stdev (<0.001deg) | 0.004840 |
| IMU attitude correction stdev (<0.001deg) | 0.186271 |
| GPS position stdev (<0.01m) | 0.0286 |
| | |
| Minimum % overlap (>25) | 37.54% |
| Ave point cloud density per sq.m. (>2.0) | 2.07 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 142 |
| Maximum Height | 491.9 |
| Minimum Height | 41.27 |
| | |
| *Classification (# of points)* | |
| Ground | 20,416,959 |
| Low vegetation | 15,800,263 |
| Medium vegetation | 49,003,557 |
| High vegetation | 10,163,635 |
| Building | 3,217,929 |
| Orthophoto | Yes |
| Processed by | Engr. Kenneth Solidum, Engr. Christy Lubiano, Engr. Elainne Lopez |

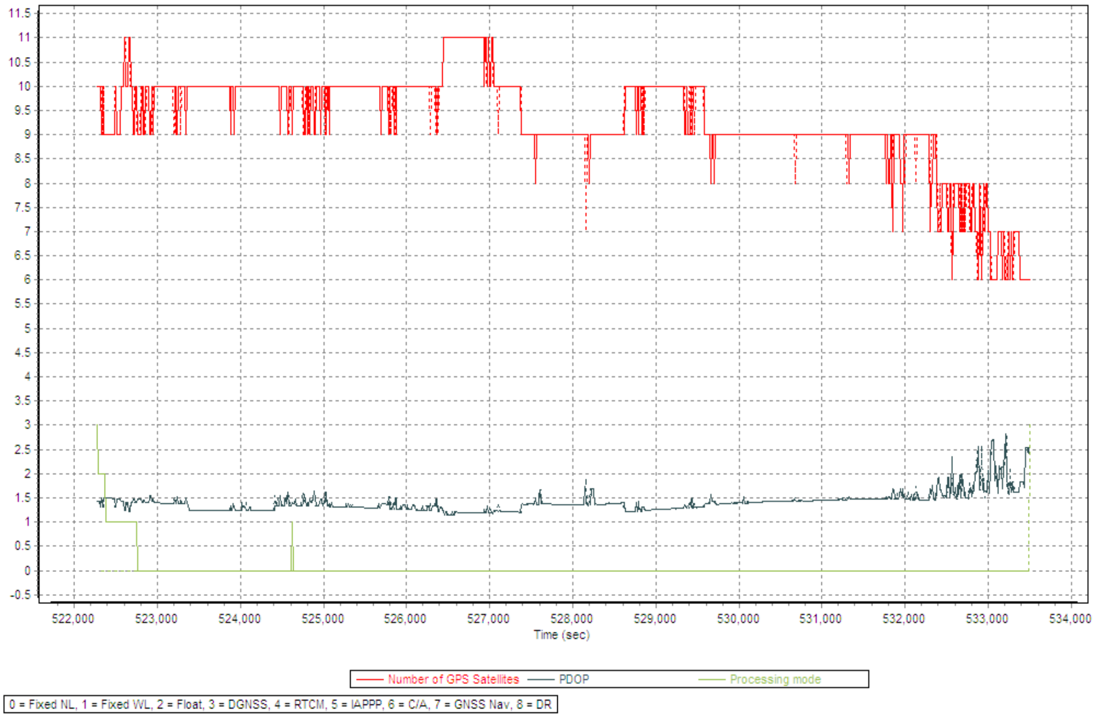



*Figure A-8.113 Solution Status*

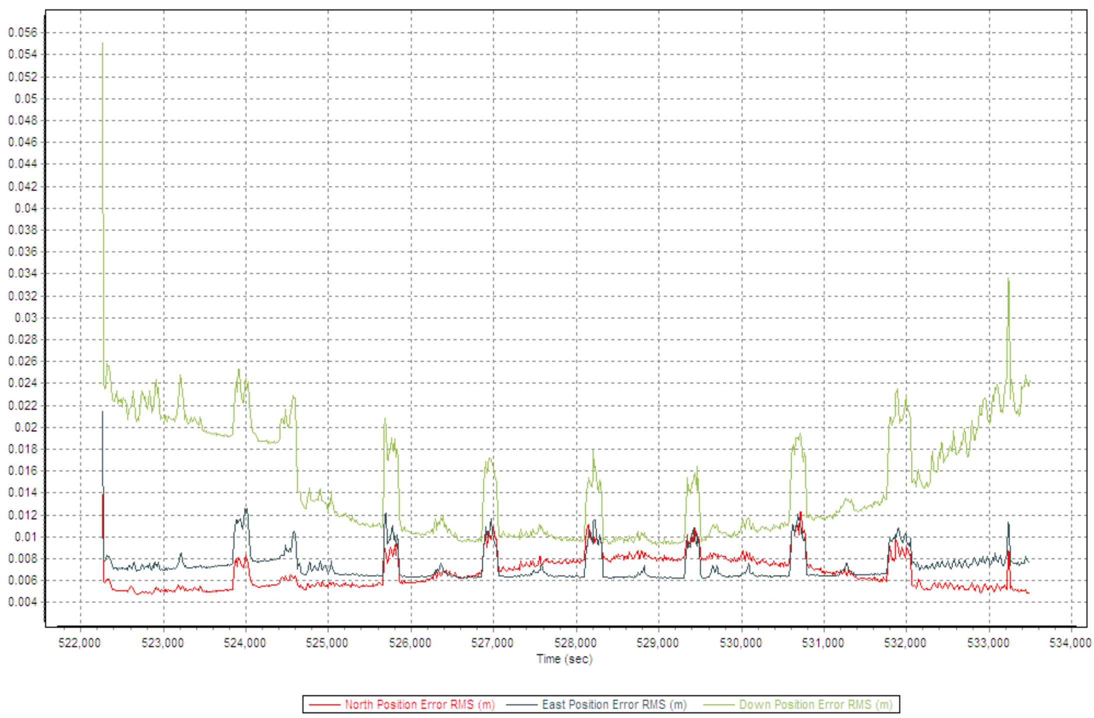



*Figure A-8.114 Smoothed Performance Metric Parameters*

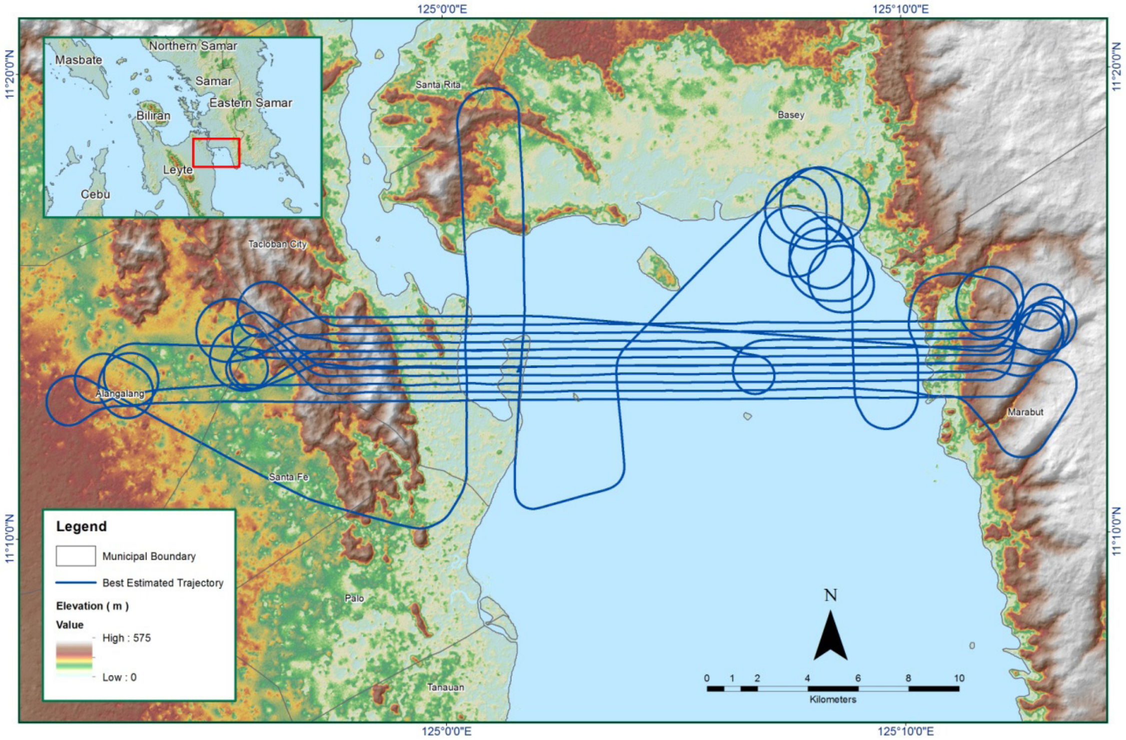



*Figure A-8.115 Best Estimated Trajectory*

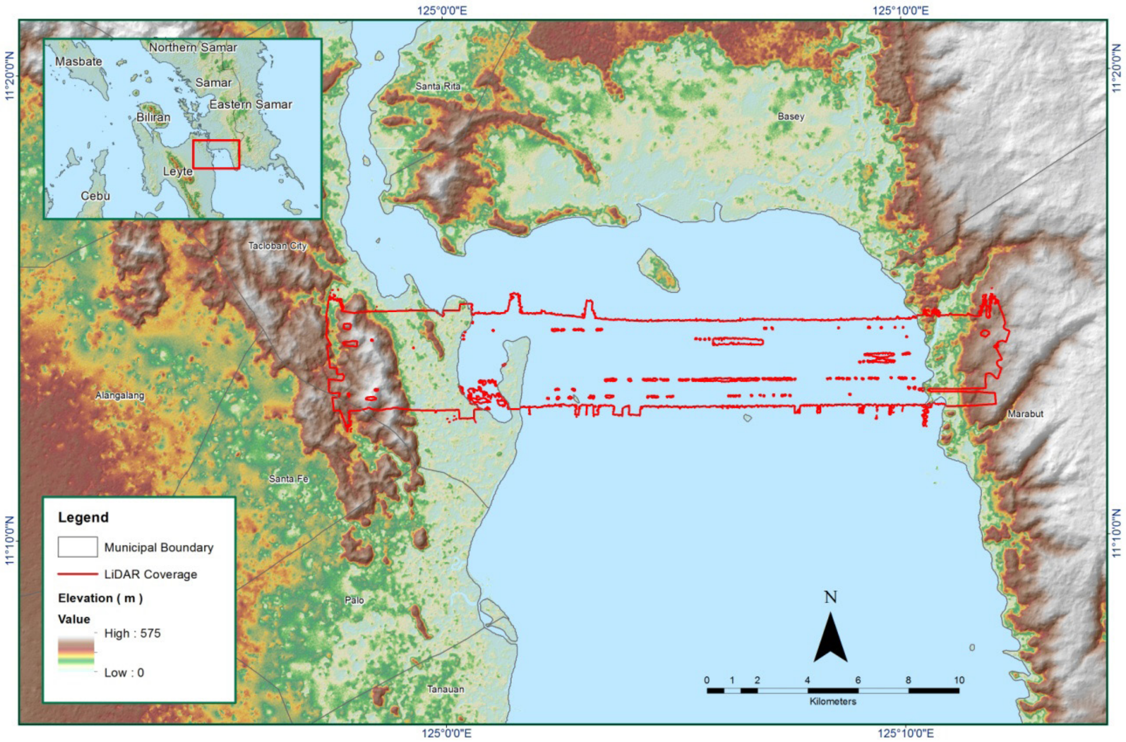



*Figure A-8.116 Coverage of LiDAR data*

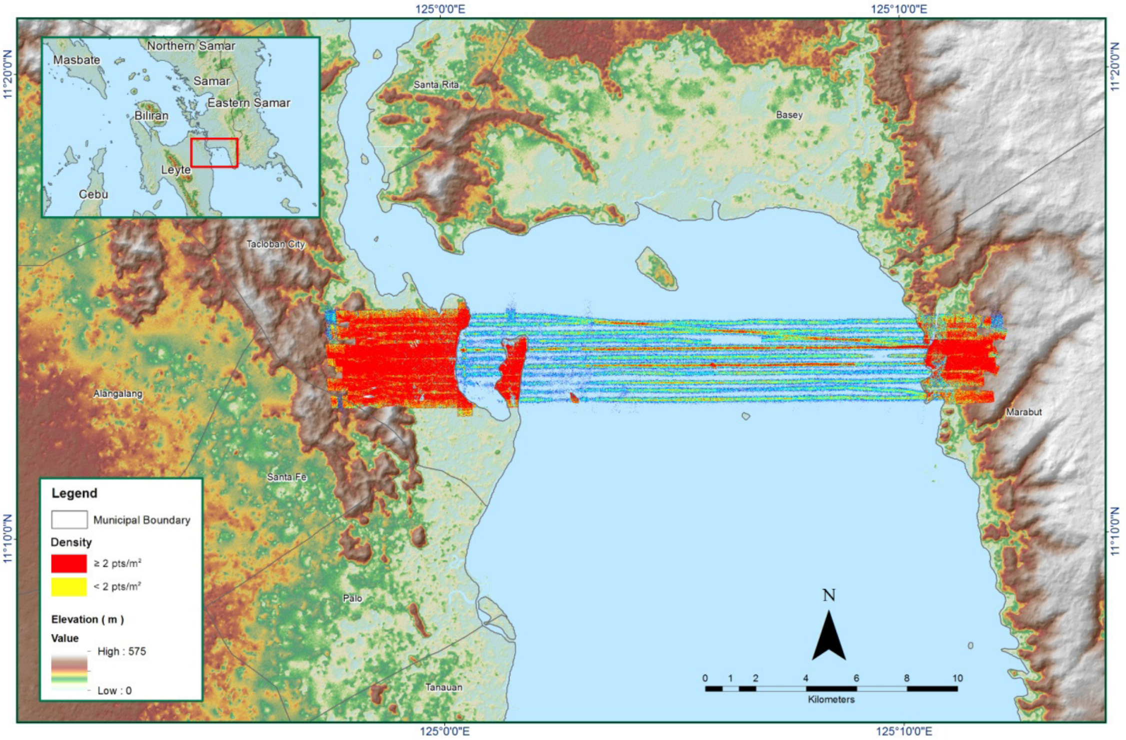



*Figure A-8.117 Image of data overlap*

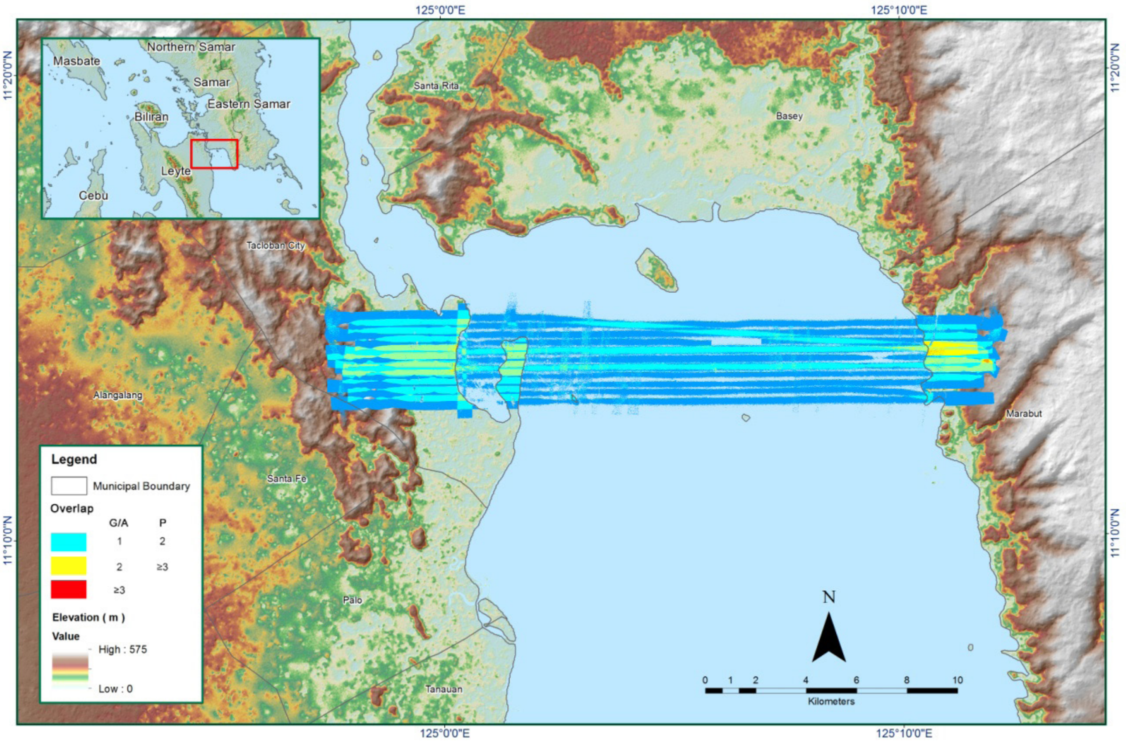



*Figure A-8.118 Density map of merged LiDAR data*

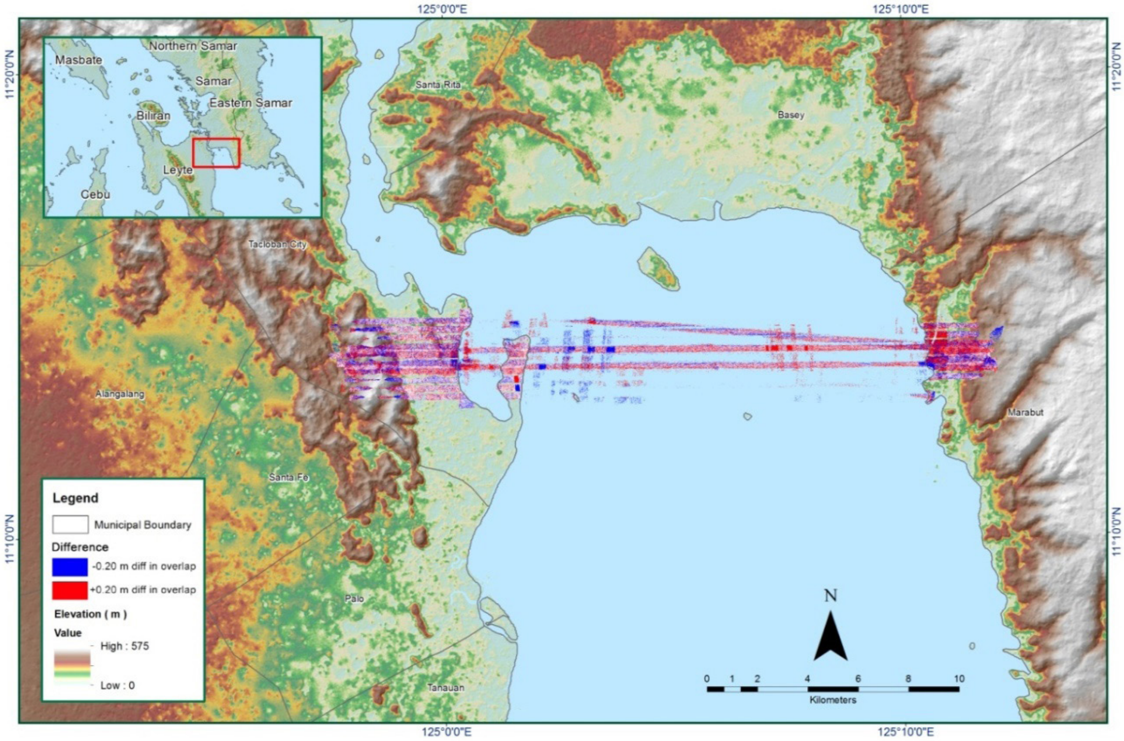



***Figure A-8.119*** *Elevation difference between flight lines*

## Annex 9. Palo Model Basin Parameters

| Basin Number | SCS Curve Number | | | Clark Unit Hydropgraph | | Recession Baseflow | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Initial Abstraction | Curve Number | Impervious | Time of Concentration | Storage Coefficient | Initial Type | Initial Discharge (m3/s) | Recession Constant | Threshold Type | Ratio to Peak |
| W820 | 0.09862 | 99 | 0 | 24.7734 | 0.8086 | Discharge | 1.13592 | 1 | Ratio to Peak | 0.01 |
| W810 | 0.09469 | 99 | 0 | 29.85934 | 0.97461 | Discharge | 1.15114 | 1 | Ratio to Peak | 0.01 |
| W800 | 0.14995 | 99 | 0 | 14.61505 | 0.47704 | Discharge | 1.33427 | 1 | Ratio to Peak | 0.01 |
| W790 | 0.13981 | 99 | 0 | 11.23064 | 0.36657 | Discharge | 1.00995 | 1 | Ratio to Peak | 0.01 |
| W780 | 0.10405 | 99 | 0 | 7.48211 | 0.24422 | Discharge | 0.31285 | 1 | Ratio to Peak | 0.01 |
| W770 | 0.09669 | 99 | 0 | 16.73068 | 0.54609 | Discharge | 1.60159 | 1 | Ratio to Peak | 0.01 |
| W760 | 0.10405 | 99 | 0 | 19.5061 | 0.63668 | Discharge | 0.65534 | 1 | Ratio to Peak | 0.01 |
| W750 | 0.10405 | 99 | 0 | 13.93521 | 0.45485 | Discharge | 0.74514 | 1 | Ratio to Peak | 0.01 |
| W740 | 0.07314 | 99 | 0 | 34.12289 | 1.11377 | Discharge | 1.65823 | 1 | Ratio to Peak | 0.01 |
| W730 | 0.07116 | 99 | 0 | 29.89572 | 0.9758 | Discharge | 1.19128 | 1 | Ratio to Peak | 0.01 |
| W720 | 0.10188 | 99 | 0 | 21.57576 | 0.70423 | Discharge | 0.93276 | 1 | Ratio to Peak | 0.01 |
| W710 | 0.10405 | 99 | 0 | 17.16975 | 0.56042 | Discharge | 0.44567 | 1 | Ratio to Peak | 0.01 |

| Basin Number | SCS Curve Number | | | Clark Unit Hydropgraph | | Recession Baseflow | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Initial Abstraction | Curve Number | Impervious | Time of Concentration | Storage Coefficient | Initial Type | Initial Discharge (m3/s) | Recession Constant | Threshold Type | Ratio to Peak |
| W700 | 0.07742 | 99 | 0 | 23.98785 | 0.78296 | Discharge | 0.59904 | 1 | Ratio to Peak | 0.01 |
| W690 | 0.08906 | 99 | 0 | 66.39008 | 2.16697 | Discharge | 2.38386 | 1 | Ratio to Peak | 0.01 |
| W680 | 0.10405 | 99 | 0 | 12.96306 | 0.42311 | Discharge | 0.21675 | 1 | Ratio to Peak | 0.01 |
| W670 | 0.09884 | 99 | 0 | 18.38707 | 0.60015 | Discharge | 1.54928 | 1 | Ratio to Peak | 0.01 |
| W660 | 0.08703 | 99 | 0 | 10.00376 | 0.32652 | Discharge | 0.11816 | 1 | Ratio to Peak | 0.01 |
| W650 | 0.06279 | 99 | 0 | 27.60182 | 0.90092 | Discharge | 0.72024 | 1 | Ratio to Peak | 0.01 |
| W640 | 0.06465 | 99 | 0 | 31.09459 | 1.01493 | Discharge | 0.82861 | 1 | Ratio to Peak | 0.01 |
| W630 | 0.06279 | 99 | 0 | 31.29493 | 1.02147 | Discharge | 0.36012 | 1 | Ratio to Peak | 0.01 |
| W620 | 0.07788 | 99 | 0 | 50.59242 | 1.65134 | Discharge | 2.7386 | 1 | Ratio to Peak | 0.01 |
| W610 | 0.06426 | 99 | 0 | 22.1663 | 0.72351 | Discharge | 0.28296 | 1 | Ratio to Peak | 0.01 |
| W600 | 0.09486 | 99 | 0 | 6.94491 | 0.22668 | Discharge | 0.59767 | 1 | Ratio to Peak | 0.01 |
| W590 | 0.06344 | 99 | 0 | 38.28229 | 1.24953 | Discharge | 0.90777 | 1 | Ratio to Peak | 0.01 |
| W580 | 0.07379 | 99 | 0 | 7.26426 | 0.23711 | Discharge | 0.09284 | 1 | Ratio to Peak | 0.01 |

| Basin Number | SCS Curve Number | | | Clark Unit Hydropgraph | | Recession Baseflow | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Initial Abstraction | Curve Number | Impervious | Time of Concentration | Storage Coefficient | Initial Type | Initial Discharge (m3/s) | Recession Constant | Threshold Type | Ratio to Peak |
| W570 | 0.07869 | 99 | 0 | 49.78548 | 1.625 | Discharge | 2.39954 | 1 | Ratio to Peak | 0.01 |
| W560 | 0.08878 | 99 | 0 | 53.83276 | 1.7571 | Discharge | 1.68921 | 1 | Ratio to Peak | 0.01 |
| W550 | 0.06279 | 99 | 0 | 1.74877 | 0.05708 | Discharge | 0.01213 | 1 | Ratio to Peak | 0.01 |
| W540 | 0.0907 | 99 | 0 | 1.46292 | 0.04775 | Discharge | 0.00228 | 1 | Ratio to Peak | 0.01 |
| W530 | 0.1557 | 99 | 0 | 6.31028 | 0.20597 | Discharge | 0.83707 | 1 | Ratio to Peak | 0.01 |
| W520 | 0.08255 | 99 | 0 | 41.67649 | 1.36032 | Discharge | 2.26923 | 1 | Ratio to Peak | 0.01 |
| W510 | 0.08869 | 99 | 0 | 37.63397 | 1.22837 | Discharge | 2.2526 | 1 | Ratio to Peak | 0.01 |
| W500 | 0.26668 | 99 | 0 | 13.4611 | 0.43937 | Discharge | 1.31727 | 1 | Ratio to Peak | 0.01 |
| W490 | 0.25223 | 99 | 0 | 1.58146 | 0.05162 | Discharge | 0.00898 | 1 | Ratio to Peak | 0.01 |
| W480 | 0.44486 | 99 | 0 | 34.38447 | 1.12231 | Discharge | 0.17896 | 1 | Ratio to Peak | 0.01 |
| W470 | 0.177 | 99 | 0 | 40.70543 | 1.32863 | Discharge | 0.80514 | 1 | Ratio to Peak | 0.01 |
| W460 | 0.25832 | 99 | 0 | 45.02823 | 1.46972 | Discharge | 0.65449 | 1 | Ratio to Peak | 0.01 |
| W450 | 0.16467 | 99 | 0 | 22.70061 | 0.74095 | Discharge | 0.12929 | 1 | Ratio to Peak | 0.01 |

| Basin Number | SCS Curve Number | | | Clark Unit Hydropgraph | | Recession Baseflow | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Initial Abstraction | Curve Number | Impervious | Time of Concentration | Storage Coefficient | Initial Type | Initial Discharge (m3/s) | Recession Constant | Threshold Type | Ratio to Peak |
| W440 | 0.62089 | 99 | 0 | 4.93177 | 0.16097 | Discharge | 0.00325 | 1 | Ratio to Peak | 0.01 |
| W430 | 0.1591 | 99 | 0 | 45.57821 | 1.48767 | Discharge | 2.06038 | 1 | Ratio to Peak | 0.01 |
| W420 | 0.28827 | 99 | 0 | 15.26662 | 0.4983 | Discharge | 1.17012 | 1 | Ratio to Peak | 0.01 |

# Annex 10. Palo Model Reach Parameters

| Reach Number | Muskingum Cunge Channel Routing | | | | | | |
|---|---|---|---|---|---|---|---|
| | Time Step Method | Length | Slope | Manning's n | Shape | Width | Side Slope |
| R10 | Automatic Fixed Interval | 199.35 | 0.000670553 | 0.04 | Trapezoid | 10 | 60 |
| R40 | Automatic Fixed Interval | 1844.7 | 0.000731987 | 0.04 | Trapezoid | 10 | 60 |
| R60 | Automatic Fixed Interval | 274.2 | 0.0002 | 0.04 | Trapezoid | 13 | 60 |
| R80 | Automatic Fixed Interval | 2369 | 0.0013517 | 0.04 | Trapezoid | 8 | 60 |
| R90 | Automatic Fixed Interval | 1638.5 | 0.0002 | 0.04 | Trapezoid | 14 | 60 |
| R110 | Automatic Fixed Interval | 106.21 | 0.0002 | 0.04 | Trapezoid | 16 | 60 |
| R120 | Automatic Fixed Interval | 543.14 | 0.0179847 | 0.04 | Trapezoid | 18 | 60 |
| R130 | Automatic Fixed Interval | 1648.4 | 0.0017266 | 0.04 | Trapezoid | 18 | 60 |
| R150 | Automatic Fixed Interval | 64.497 | 0.0179847 | 0.04 | Trapezoid | 5 | 60 |
| R170 | Automatic Fixed Interval | 2426.4 | 0.000426368 | 0.04 | Trapezoid | 20 | 60 |
| R200 | Automatic Fixed Interval | 3588.1 | 0.000233175 | 0.04 | Trapezoid | 19.5 | 60 |
| R210 | Automatic Fixed Interval | 14058 | 0.0018671 | 0.04 | Trapezoid | 13.667 | 60 |
| R220 | Automatic Fixed Interval | 1036.9 | 0.000482207 | 0.04 | Trapezoid | 24 | 60 |
| R240 | Automatic Fixed Interval | 10562 | 0.0015068 | 0.04 | Trapezoid | 10 | 60 |
| R250 | Automatic Fixed Interval | 2610.8 | 0.00080245 | 0.04 | Trapezoid | 24.8 | 60 |
| R260 | Automatic Fixed Interval | 4393.1 | 0.0011626 | 0.04 | Trapezoid | 10.333 | 60 |
| R280 | Automatic Fixed Interval | 2065.3 | 0.0033513 | 0.04 | Trapezoid | 7 | 60 |
| R310 | Automatic Fixed Interval | 3034.7 | 0.0035496 | 0.04 | Trapezoid | 13.667 | 60 |
| R350 | Automatic Fixed Interval | 1732.7 | 0.0065957 | 0.04 | Trapezoid | 12 | 60 |
| R380 | Automatic Fixed Interval | 14273 | 0.0012044 | 0.04 | Trapezoid | 12 | 60 |

# Annex 11. Palo Field Validation Points

| Point Number | Validation Coordinates | | Model Var (m) | Validation Points (m) | Error | Event/Date | Rain Return / Scenario |
|---|---|---|---|---|---|---|---|
| | Lat | Long | | | | | |
| 1 | 11.17935 | 125.000893 | 0.04 | 0 | 0.04 | Yolanda / November 2013 | 5 -Year |
| 2 | 11.180158 | 124.999386 | 0.33 | 0.1 | 0.23 | Yolanda / November 2013 | 5 -Year |
| 3 | 11.182829 | 125.003131 | 0.06 | 0.6 | -0.54 | Yolanda / November 2013 | 5 -Year |
| 4 | 11.182808 | 125.003545 | 0.06 | 2 | -1.94 | Yolanda / November 2013 | 5 -Year |
| 5 | 11.186373 | 125.002881 | 0.05 | 0.7 | -0.65 | Yolanda / November 2013 | 5 -Year |
| 6 | 11.186374 | 125.002897 | 0.05 | 0.3 | -0.25 | Ruby / December 2014 | 5 -Year |
| 7 | 11.193553 | 125.00455 | 0.27 | 0.5 | -0.23 | Yolanda / November 2013 | 5 -Year |
| 8 | 11.19359 | 125.004488 | 0.27 | 0.3 | -0.03 | 2010 | 5 -Year |
| 9 | 11.194262 | 125.002521 | 0.31 | 0.5 | -0.19 | Yolanda / November 2013 | 5 -Year |
| 10 | 11.193412 | 125.001643 | 0.17 | 0 | 0.17 | Yolanda / November 2013 | 5 -Year |
| 11 | 11.193598 | 125.000784 | 0.35 | 0.2 | 0.15 | Yolanda / November 2013 | 5 -Year |
| 12 | 11.197564 | 125.002602 | 0.05 | 1.1 | -1.05 | Yolanda / November 2013 | 5 -Year |
| 13 | 11.197564 | 125.002602 | 0.05 | 0.8 | -0.75 | Ruby / December 2014 | 5 -Year |
| 14 | 11.197564 | 125.002602 | 0.05 | 0.5 | -0.45 | Amihan / January-February 2016 | 5 -Year |
| 15 | 11.200699 | 125.002549 | 0.50 | 0.8 | -0.30 | Yolanda / November 2013 | 5 -Year |
| 16 | 11.200699 | 125.002549 | 0.50 | 0.8 | -0.30 | January 2011 | 5 -Year |
| 17 | 11.200699 | 125.002549 | 0.50 | 0.8 | -0.30 | Ruby / December 2014 | 5 -Year |
| 18 | 11.197696 | 125.008409 | 0.18 | 0.8 | -0.62 | Seniang / December 2014 | 5 -Year |
| 19 | 11.197696 | 125.008409 | 0.18 | 0.5 | -0.32 | Amihan / January-February 2016 | 5 -Year |
| 20 | 11.197696 | 125.008409 | 0.18 | 0 | 0.18 | Ruby / December 2014 | 5 -Year |
| 21 | 11.20277 | 125.007916 | 0.06 | 0.95 | -0.89 | Yolanda / November 2013 | 5 -Year |
| 22 | 11.20277 | 125.007916 | 0.06 | 0.5 | -0.44 | Amihan / January-February 2016 | 5 -Year |
| 23 | 11.20277 | 125.007916 | 0.06 | 0.5 | -0.44 | Ruby / December 2014 | 5 -Year |
| 24 | 11.20196 | 125.009871 | 0.24 | 2 | -1.76 | Yolanda / November 2013 | 5 -Year |
| 25 | 11.20196 | 125.009871 | 0.24 | 0.5 | -0.26 | Ruby / December 2014 | 5 -Year |
| 26 | 11.207533 | 125.00949 | 0.07 | 0.5 | -0.43 | Amihan / January-February 2016 | 5 -Year |
| 27 | 11.207533 | 125.00949 | 0.07 | 0 | 0.07 | Yolanda / November 2013 | 5 -Year |
| 28 | 11.207533 | 125.00949 | 0.07 | 0.65 | -0.58 | Ruby / December 2014 | 5 -Year |
| 29 | 11.20862 | 125.015388 | 0.05 | 0 | 0.05 | Yolanda / November 2013 | 5 -Year |
| 30 | 11.20862 | 125.015388 | 0.05 | 0.5 | -0.45 | Ruby / December 2014 | 5 -Year |
| 31 | 11.20862 | 125.015388 | 0.05 | 0.5 | -0.45 | Seniang / December 2014 | 5 -Year |
| 32 | 11.200107 | 125.022895 | 0.04 | 3 | -2.96 | Yolanda / November 2013 | 5 -Year |
| 33 | 11.200107 | 125.022895 | 0.04 | 0.6 | -0.56 | Seniang / December 2014 | 5 -Year |
| 34 | 11.200107 | 125.022895 | 0.04 | 0.6 | -0.56 | Ruby / December 2014 | 5 -Year |
| 35 | 11.200107 | 125.022895 | 0.04 | 0.3 | -0.26 | Amihan / January-February 2016 | 5 -Year |
| 36 | 11.202944 | 125.019436 | 0.05 | 2 | -1.95 | Yolanda / November 2013 | 5 -Year |
| 37 | 11.202944 | 125.019436 | 0.05 | 0.2 | -0.15 | Ruby / December 2014 | 5 -Year |
| 38 | 11.202944 | 125.019436 | 0.05 | 0.3 | -0.25 | Amihan / January-February 2016 | 5 -Year |
| 39 | 11.19844 | 125.021161 | 0.07 | 4 | -3.93 | Yolanda / November 2013 | 5 -Year |
| 40 | 11.19844 | 125.021161 | 0.07 | 0 | 0.07 | Ruby / December 2014 | 5 -Year |
| 41 | 11.19679 | 125.016959 | 0.05 | 2 | -1.95 | Yolanda / November 2013 | 5 -Year |

| Point Number | Validation Coordinates | | Model Var (m) | Validation Points (m) | Error | Event/Date | Rain Return / Scenario |
|---|---|---|---|---|---|---|---|
| | Lat | Long | | | | | |
| 42 | 11.19679 | 125.016959 | 0.05 | 0.2 | -0.15 | Ruby / December 2014 | 5 -Year |
| 43 | 11.194801 | 125.017175 | 0.04 | 3 | -2.96 | Yolanda / November 2013 | 5 -Year |
| 44 | 11.194801 | 125.017175 | 0.04 | 0 | 0.04 | Ruby / December 2014 | 5 -Year |
| 45 | 11.195039 | 125.018519 | 0.31 | 3 | -2.69 | Yolanda / November 2013 | 5 -Year |
| 46 | 11.195039 | 125.018519 | 0.31 | 0.2 | 0.11 | Ruby / December 2014 | 5 -Year |
| 47 | 11.195039 | 125.018519 | 0.31 | 0.2 | 0.11 | Seniang / December 2014 | 5 -Year |
| 48 | 11.195039 | 125.018519 | 0.31 | 0.3 | 0.01 | Amihan / January-February 2016 | 5 -Year |
| 49 | 11.19021 | 125.014119 | 0.03 | 2 | -1.97 | Yolanda / November 2013 | 5 -Year |
| 50 | 11.19021 | 125.014119 | 0.03 | 0.2 | -0.17 | Ruby / December 2014 | 5 -Year |
| 51 | 11.19021 | 125.014119 | 0.03 | 0.2 | -0.17 | Seniang / December 2014 | 5 -Year |
| 52 | 11.188844 | 125.013745 | 0.08 | 3 | -2.92 | Yolanda / November 2013 | 5 -Year |
| 53 | 11.188844 | 125.013745 | 0.08 | 0.3 | -0.22 | Amihan / January-February 2016 | 5 -Year |
| 54 | 11.188844 | 125.013745 | 0.08 | 0 | 0.08 | Ruby / December 2014 | 5 -Year |
| 55 | 11.189561 | 125.008909 | 0.08 | 2 | -1.92 | Yolanda / November 2013 | 5 -Year |
| 56 | 11.189561 | 125.008909 | 0.08 | 0 | 0.08 | Ruby / December 2014 | 5 -Year |
| 57 | 11.193101 | 125.009602 | 0.33 | 2 | -1.67 | Yolanda / November 2013 | 5 -Year |
| 58 | 11.193101 | 125.009602 | 0.33 | 0 | 0.33 | Ruby / December 2014 | 5 -Year |
| 59 | 11.19554 | 125.00978 | 0.21 | 1.3 | -1.09 | Yolanda / November 2013 | 5 -Year |
| 60 | 11.19554 | 125.00978 | 0.21 | 0 | 0.21 | Ruby / December 2014 | 5 -Year |
| 61 | 11.19554 | 125.00978 | 0.21 | 0 | 0.21 | Seniang / December 2014 | 5 -Year |
| 62 | 11.183715 | 125.014762 | 0.13 | 2 | -1.87 | Yolanda / November 2013 | 5 -Year |
| 63 | 11.183662 | 125.014764 | 0.13 | 0.5 | -0.37 | Ruby / December 2014 | 5 -Year |
| 64 | 11.183662 | 125.014764 | 0.13 | 0.5 | -0.37 | Seniang / December 2014 | 5 -Year |
| 65 | 11.180857 | 125.015864 | 0.10 | 0 | 0.10 | 1999/2000 | 5 -Year |
| 66 | 11.180857 | 125.015864 | 0.10 | 0 | 0.10 | Yolanda / November 2013 | 5 -Year |
| 67 | 11.180857 | 125.015864 | 0.10 | 0.5 | -0.40 | Ruby / December 2014 | 5 -Year |
| 68 | 11.180857 | 125.015864 | 0.10 | 1.1 | -1.00 | Seniang / December 2014 | 5 -Year |
| 69 | 11.180827 | 125.014584 | 0.22 | 3 | -2.78 | Yolanda / November 2013 | 5 -Year |
| 70 | 11.180827 | 125.014584 | 0.22 | 0.8 | -0.58 | Ruby / December 2014 | 5 -Year |
| 71 | 11.180827 | 125.014584 | 0.22 | 0.8 | -0.58 | Seniang / December 2014 | 5 -Year |
| 72 | 11.180827 | 125.014584 | 0.22 | 0.27 | -0.05 | Amihan / January-February 2016 | 5 -Year |
| 73 | 11.18074 | 125.014129 | 0.21 | 0.2 | 0.01 | Amihan / January-February 2016 | 5 -Year |
| 74 | 11.188562 | 124.992907 | 0.10 | 0 | 0.10 | Amihan / January-February 2016 | 5 -Year |
| 75 | 11.195079 | 124.996141 | 0.61 | 0.5 | 0.11 | Yolanda / November 2013 | 5 -Year |
| 76 | 11.195079 | 124.996141 | 0.61 | 0.2 | 0.41 | Ruby / December 2014 | 5 -Year |
| 77 | 11.196898 | 124.99505 | 0.07 | 0.5 | -0.43 | Yolanda / November 2013 | 5 -Year |
| 78 | 11.196898 | 124.99505 | 0.07 | 0 | 0.07 | Ruby / December 2014 | 5 -Year |
| 79 | 11.198839 | 124.992754 | 0.11 | 0.5 | -0.39 | Heavy Rain / May-June 2016 | 5 -Year |
| 80 | 11.203374 | 124.991501 | 0.03 | 0.5 | -0.47 | Heavy Rain / May-June 2016 | 5 -Year |
| 81 | 11.203374 | 124.991501 | 0.03 | 0.8 | -0.77 | Yolanda / November 2013 | 5 -Year |
| 82 | 11.203405 | 124.991495 | 0.03 | 0.5 | -0.47 | Ruby / December 2014 | 5 -Year |
| 83 | 11.203405 | 124.991495 | 0.03 | 0.5 | -0.47 | Seniang / December 2014 | 5 -Year |
| 84 | 11.20547 | 124.991392 | 0.28 | 0 | 0.28 | Yolanda / November 2013 | 5 -Year |

| Point Number | Validation Coordinates | | Model Var (m) | Validation Points (m) | Error | Event/Date | Rain Return / Scenario |
|---|---|---|---|---|---|---|---|
| | Lat | Long | | | | | |
| 85 | 11.20547 | 124.991392 | 0.28 | 0 | 0.28 | Ruby / December 2014 | 5 -Year |
| 86 | 11.207844 | 124.995349 | 0.70 | 0.5 | 0.20 | Ruby / December 2014 | 5 -Year |
| 87 | 11.207844 | 124.995349 | 0.70 | 0.2 | 0.50 | Seniang / December 2014 | 5 -Year |
| 88 | 11.208878 | 124.993364 | 0.08 | 0.5 | -0.42 | Amihan / January-February 2016 | 5 -Year |
| 89 | 11.208874 | 124.993389 | 0.08 | 0.5 | -0.42 | Yolanda / November 2013 | 5 -Year |
| 90 | 11.208874 | 124.993389 | 0.08 | 0.5 | -0.42 | Ruby / December 2014 | 5 -Year |
| 91 | 11.208874 | 124.993389 | 0.08 | 0.5 | -0.42 | Seniang / December 2014 | 5 -Year |
| 92 | 11.207606 | 124.995816 | 0.46 | 0 | 0.46 | Yolanda / November 2013 | 5 -Year |
| 93 | 11.207606 | 124.995816 | 0.46 | 0 | 0.46 | Ruby / December 2014 | 5 -Year |
| 94 | 11.207316 | 125.004143 | 0.04 | 0.5 | -0.46 | Yolanda / November 2013 | 5 -Year |
| 95 | 11.207316 | 125.004143 | 0.04 | 0.4 | -0.36 | Continuous rain / 2000 | 5 -Year |
| 96 | 11.208446 | 125.001458 | 0.21 | 0.8 | -0.59 | Yolanda / November 2013 | 5 -Year |
| 97 | 11.208446 | 125.001458 | 0.21 | 0.5 | -0.29 | Continuous rain / 2000 | 5 -Year |
| 98 | 11.208446 | 125.001458 | 0.21 | 0.5 | -0.29 | Ruby / December 2014 | 5 -Year |
| 99 | 11.208446 | 125.001458 | 0.21 | 0.5 | -0.29 | Amihan / January-February 2016 | 5 -Year |
| 100 | 11.210057 | 124.989483 | 0.04 | 0.2 | -0.16 | Yolanda / November 2013 | 5 -Year |
| 101 | 11.21009 | 124.989542 | 0.05 | 0.9 | -0.85 | Habagat / 2011 | 5 -Year |
| 102 | 11.18423 | 124.99169 | 0.05 | 0.2 | -0.15 | Amihan / January-February 2016 | 5 -Year |
| 103 | 11.18423 | 124.99169 | 0.05 | 0.3 | -0.25 | Ruby / December 2014 | 5 -Year |
| 104 | 11.18423 | 124.99169 | 0.05 | 0.3 | -0.25 | Seniang / December 2014 | 5 -Year |
| 105 | 11.18423 | 124.99169 | 0.05 | 0.3 | -0.25 | Habagat / 2011 | 5 -Year |
| 106 | 11.190024 | 124.987926 | 0.48 | 3 | -2.52 | Yolanda / November 2013 | 5 -Year |
| 107 | 11.190024 | 124.987926 | 0.48 | 0 | 0.48 | Ruby / December 2014 | 5 -Year |
| 108 | 11.190002 | 124.988023 | 0.03 | 0 | 0.03 | Ruby / December 2014 | 5 -Year |
| 109 | 11.190002 | 124.988023 | 0.03 | 0 | 0.03 | Yolanda / November 2013 | 5 -Year |
| 110 | 11.175195 | 125.013527 | 0.07 | 0.6 | -0.53 | Low Pressure / March 1, 2012 | 5 -Year |
| 111 | 11.175006 | 125.013687 | 0.07 | 5 | -4.93 | Yolanda / November 2013 | 5 -Year |
| 112 | 11.17124 | 125.010663 | 0.03 | 5 | -4.97 | Yolanda / November 2013 | 5 -Year |
| 113 | 11.17124 | 125.010663 | 0.03 | 0.4 | -0.37 | Ruby / December 2014 | 5 -Year |
| 114 | 11.169019 | 125.008849 | 0.04 | 0.5 | -0.46 | Ruby / December 2014 | 5 -Year |
| 115 | 11.168641 | 125.008467 | 0.06 | 3 | -2.94 | Yolanda / November 2013 | 5 -Year |
| 116 | 11.168641 | 125.008467 | 0.06 | 1.1 | -1.04 | Seniang / December 2014 | 5 -Year |
| 117 | 11.168641 | 125.008467 | 0.06 | 0.35 | -0.29 | Ruby / December 2014 | 5 -Year |
| 118 | 11.169987 | 125.007371 | 0.08 | 5 | -4.92 | Yolanda / November 2013 | 5 -Year |
| 119 | 11.169255 | 125.007915 | 0.08 | 5 | -4.92 | Yolanda / November 2013 | 5 -Year |
| 120 | 11.169255 | 125.007915 | 0.08 | 0.6 | -0.52 | Ruby / December 2014 | 5 -Year |
| 121 | 11.169855 | 125.007111 | 0.07 | 2 | -1.93 | Yolanda / November 2013 | 5 -Year |
| 122 | 11.169855 | 125.007111 | 0.07 | 0 | 0.07 | - | 5 -Year |
| 123 | 11.169378 | 125.006933 | 0.06 | 2 | -1.94 | Yolanda / November 2013 | 5 -Year |
| 124 | 11.169378 | 125.006933 | 0.06 | 0.5 | -0.44 | Seniang / December 2014 | 5 -Year |
| 125 | 11.167092 | 125.006767 | 0.07 | 3 | -2.93 | Yolanda / November 2013 | 5 -Year |
| 126 | 11.167022 | 125.006792 | 0.07 | 3 | -2.93 | Yolanda / November 2013 | 5 -Year |
| 127 | 11.167022 | 125.006792 | 0.07 | 0.3 | -0.23 | Ruby / December 2014 | 5 -Year |
| 128 | 11.166596 | 125.006578 | 0.07 | 3 | -2.93 | Yolanda / November 2013 | 5 -Year |
| 129 | 11.167077 | 125.005887 | 0.06 | 5 | -4.94 | Yolanda / November 2013 | 5 -Year |

| Point Number | Validation Coordinates | | Model Var (m) | Validation Points (m) | Error | Event/Date | Rain Return / Scenario |
|---|---|---|---|---|---|---|---|
| | Lat | Long | | | | | |
| 130 | 11.167077 | 125.005887 | 0.06 | 3 | -2.94 | Seniang / December 2014 | 5 -Year |
| 131 | 11.167077 | 125.005887 | 0.06 | 0.5 | -0.44 | Ruby / December 2014 | 5 -Year |
| 132 | 11.16443 | 125.005666 | 0.09 | 5 | -4.91 | Yolanda / November 2013 | 5 -Year |
| 133 | 11.16443 | 125.005666 | 0.09 | 0.2 | -0.11 | Ruby / December 2014 | 5 -Year |
| 134 | 11.16443 | 125.005666 | 0.09 | 0.1 | -0.01 | Seniang / December 2014 | 5 -Year |
| 135 | 11.16414 | 125.002526 | 0.07 | 1.4 | -1.33 | Yolanda / November 2013 | 5 -Year |
| 136 | 11.16414 | 125.002526 | 0.07 | 0.5 | -0.43 | Ruby / December 2014 | 5 -Year |
| 137 | 11.164661 | 125.002835 | 0.07 | 2 | -1.93 | Yolanda / November 2013 | 5 -Year |
| 138 | 11.164661 | 125.002835 | 0.07 | 0.5 | -0.43 | Seniang / December 2014 | 5 -Year |
| 139 | 11.154819 | 125.003111 | 0.48 | 0.2 | 0.28 | Seniang / December 2014 | 5 -Year |
| 140 | 11.156526 | 125.000622 | 0.30 | 3 | -2.70 | Yolanda / November 2013 | 5 -Year |
| 141 | 11.152382 | 124.998826 | 0.03 | 5 | -4.97 | Yolanda / November 2013 | 5 -Year |
| 142 | 11.152382 | 124.998826 | 0.03 | 0.5 | -0.47 | Ruby / December 2014 | 5 -Year |
| 143 | 11.157353 | 124.993016 | 0.07 | 0.2 | -0.13 | Yolanda / November 2013 | 5 -Year |
| 144 | 11.157353 | 124.993016 | 0.07 | 0.1 | -0.03 | Ruby / December 2014 | 5 -Year |
| 145 | 11.157353 | 124.993016 | 0.07 | 0.1 | -0.03 | Seniang / December 2014 | 5 -Year |
| 146 | 11.172911 | 124.996375 | 0.05 | 0 | 0.05 | - | 5 -Year |
| 147 | 11.171515 | 124.995976 | 0.23 | 1 | -0.77 | Yolanda / November 2013 | 5 -Year |
| 148 | 11.171144 | 124.998677 | 0.04 | 5 | -4.96 | Yolanda / November 2013 | 5 -Year |
| 149 | 11.171144 | 124.998677 | 0.04 | 0.5 | -0.46 | Ruby / December 2014 | 5 -Year |
| 150 | 11.171144 | 124.998677 | 0.04 | 0.5 | -0.46 | Seniang / December 2014 | 5 -Year |
| 151 | 11.167 | 124.996448 | 0.04 | 0 | 0.04 | - | 5 -Year |
| 152 | 11.16422 | 124.995166 | 0.03 | 0.1 | -0.07 | Yolanda / November 2013 | 5 -Year |
| 153 | 11.161532 | 124.990526 | 0.03 | 0.1 | -0.07 | Seniang / December 2014 | 5 -Year |
| 154 | 11.161532 | 124.990526 | 0.03 | 0.1 | -0.07 | Ruby / December 2014 | 5 -Year |
| 155 | 11.161956 | 124.990174 | 0.03 | 2 | -1.97 | Seniang / December 2014 | 5 -Year |
| 156 | 11.161956 | 124.990174 | 0.03 | 2 | -1.97 | Ruby / December 2014 | 5 -Year |
| 157 | 11.161508 | 124.992149 | 0.03 | 3 | -2.97 | Yolanda / November 2013 | 5 -Year |
| 158 | 11.161508 | 124.992149 | 0.03 | 1.6 | -1.57 | Ruby / December 2014 | 5 -Year |
| 159 | 11.161508 | 124.992149 | 0.03 | 1.1 | -1.07 | Seniang / December 2014 | 5 -Year |
| 160 | 11.16188 | 124.993533 | 0.14 | 0.5 | -0.36 | Yolanda / November 2013 | 5 -Year |
| 161 | 11.16188 | 124.993533 | 0.14 | 0.2 | -0.06 | Seniang / December 2014 | 5 -Year |
| 162 | 11.16188 | 124.993533 | 0.14 | 0.2 | -0.06 | Ruby / December 2014 | 5 -Year |
| 163 | 11.160743 | 124.995523 | 0.47 | 5 | -4.53 | Yolanda / November 2013 | 5 -Year |
| 164 | 11.160743 | 124.995523 | 0.47 | 1.3 | -0.83 | Ruby / December 2014 | 5 -Year |
| 165 | 11.160743 | 124.995523 | 0.47 | 2 | -1.53 | Seniang / December 2014 | 5 -Year |
| 166 | 11.160743 | 124.995523 | 0.47 | 0.7 | -0.23 | Nona | 5 -Year |
| 167 | 11.161127 | 124.99449 | 0.50 | 5 | -4.50 | Yolanda / November 2013 | 5 -Year |
| 168 | 11.161127 | 124.99449 | 0.50 | 1.8 | -1.30 | Ruby / December 2014 | 5 -Year |
| 169 | 11.161127 | 124.99449 | 0.50 | 1.2 | -0.70 | Seniang / December 2014 | 5 -Year |
| 170 | 11.162191 | 124.986524 | 0.58 | 0.5 | 0.08 | Seniang / December 2014 | 5 -Year |
| 171 | 11.163064 | 124.986552 | 0.87 | 1 | -0.13 | Seniang / December 2014 | 5 -Year |
| 172 | 11.163858 | 124.983407 | 1.25 | 0.5 | 0.75 | Ruby / December 2014 | 5 -Year |
| 173 | 11.163858 | 124.983407 | 1.25 | 0.5 | 0.75 | Seniang / December 2014 | 5 -Year |
| 174 | 11.165632 | 124.980886 | 0.77 | 0.5 | 0.27 | Before Yolanda / November 2013 | 5 -Year |
| 175 | 11.166273 | 124.979509 | 0.91 | 0 | 0.91 | - | 5 -Year |
| 176 | 11.169448 | 124.97504 | 0.52 | 1.5 | -0.98 | Ruby / December 2014 | 5 -Year |

| Point Number | Validation Coordinates | | Model Var (m) | Validation Points (m) | Error | Event/Date | Rain Return / Scenario |
|---|---|---|---|---|---|---|---|
| | Lat | Long | | | | | |
| 177 | 11.172776 | 124.980239 | 0.06 | 0 | 0.06 | - | 5 -Year |
| 178 | 11.172879 | 124.978285 | 0.11 | 0 | 0.11 | - | 5 -Year |
| 179 | 11.172833 | 124.975712 | 0.05 | 0.3 | -0.25 | Ruby / December 2014 | 5 -Year |
| 180 | 11.172833 | 124.975712 | 0.05 | 0.5 | -0.45 | Yolanda / November 2013 | 5 -Year |
| 181 | 11.173408 | 124.97409 | 0.15 | 0 | 0.15 | - | 5 -Year |
| 182 | 11.168384 | 124.976213 | 1.23 | 1.5 | -0.27 | Ruby / December 2014 | 5 -Year |
| 183 | 11.16704 | 124.975834 | 1.48 | 1 | 0.48 | Ruby / December 2014 | 5 -Year |
| 184 | 11.16704 | 124.975834 | 1.48 | 1.5 | -0.02 | Yolanda / November 2013 | 5 -Year |
| 185 | 11.166541 | 124.973043 | 2.09 | 0 | 2.09 | - | 5 -Year |
| 186 | 11.165584 | 124.973226 | 0.90 | 0.5 | 0.40 | Ruby / December 2014 | 5 -Year |
| 187 | 11.165584 | 124.973226 | 0.90 | 0.5 | 0.40 | Seniang / December 2014 | 5 -Year |
| 188 | 11.168074 | 124.969182 | 1.59 | 0 | 1.59 | - | 5 -Year |
| 189 | 11.171549 | 124.967141 | 0.19 | 0.5 | -0.31 | Ruby / December 2014 | 5 -Year |
| 190 | 11.171036 | 124.964422 | 0.52 | 1.6 | -1.08 | Seniang / December 2014 | 5 -Year |
| 191 | 11.171036 | 124.964422 | 0.52 | 1.6 | -1.08 | Ruby / December 2014 | 5 -Year |
| 192 | 11.170872 | 124.964444 | 0.36 | 1.5 | -1.14 | Seniang / December 2014 | 5 -Year |
| 193 | 11.170872 | 124.964444 | 0.36 | 1.5 | -1.14 | Ruby / December 2014 | 5 -Year |
| 194 | 11.177179 | 124.956013 | 1.37 | 2 | -0.63 | Seniang / December 2014 | 5 -Year |
| 195 | 11.177354 | 124.957192 | 1.46 | 1.6 | -0.14 | Seniang / December 2014 | 5 -Year |
| 196 | 11.177354 | 124.957192 | 1.46 | 1 | 0.46 | Ruby / December 2014 | 5 -Year |
| 197 | 11.177503 | 124.957552 | 2.00 | 2 | 0.00 | Ruby / December 2014 | 5 -Year |
| 198 | 11.177503 | 124.957552 | 2.00 | 2 | 0.00 | Seniang / December 2014 | 5 -Year |
| 199 | 11.177503 | 124.957552 | 2.00 | 0.2 | 1.80 | Yolanda / November 2013 | 5 -Year |
| 200 | 11.179552 | 124.957371 | 1.46 | 1 | 0.46 | Ruby / December 2014 | 5 -Year |
| 201 | 11.179552 | 124.957371 | 1.46 | 2.5 | -1.04 | Seniang / December 2014 | 5 -Year |
| 202 | 11.123073 | 125.015063 | 0.53 | 0.65 | -0.12 | Ruby / December 2014 | 5 -Year |
| 203 | 11.121831 | 125.015451 | 0.58 | 0.6 | -0.02 | Seniang / December 2014 | 5 -Year |
| 204 | 11.121736 | 125.015067 | 0.63 | 0 | 0.63 | Ruby / December 2014 | 5 -Year |
| 205 | 11.121736 | 125.015067 | 0.63 | 1.8 | -1.17 | Seniang / December 2014 | 5 -Year |
| 206 | 11.119518 | 125.016683 | 0.57 | 0.4 | 0.17 | Seniang / December 2014 | 5 -Year |
| 207 | 11.119518 | 125.016683 | 0.57 | 0.4 | 0.17 | Ruby / December 2014 | 5 -Year |
| 208 | 11.12472 | 125.02169 | 0.04 | 0.5 | -0.46 | Seniang / December 2014 | 5 -Year |
| 209 | 11.125284 | 125.022364 | 0.16 | 1 | -0.84 | Seniang / December 2014 | 5 -Year |
| 210 | 11.125751 | 125.023335 | 0.39 | 0.6 | -0.21 | Seniang / December 2014 | 5 -Year |
| 211 | 11.125751 | 125.023335 | 0.39 | 0.3 | 0.09 | Ruby / December 2014 | 5 -Year |
| 212 | 11.125971 | 125.02205 | 0.61 | 1.2 | -0.59 | Seniang / December 2014 | 5 -Year |
| 213 | 11.127793 | 125.009345 | 0.42 | 1.4 | -0.98 | Seniang / December 2014 | 5 -Year |
| 214 | 11.129036 | 125.009319 | 0.37 | 1.47 | -1.10 | Seniang / December 2014 | 5 -Year |
| 215 | 11.128825 | 125.008687 | 0.54 | 1.15 | -0.61 | Seniang / December 2014 | 5 -Year |
| 216 | 11.134181 | 125.007242 | 0.82 | 0.8 | 0.02 | Seniang / December 2014 | 5 -Year |
| 217 | 11.135378 | 125.006332 | 1.12 | 1.7 | -0.58 | Seniang / December 2014 | 5 -Year |
| 218 | 11.138991 | 125.006079 | 0.73 | 0.8 | -0.07 | Seniang / December 2014 | 5 -Year |
| 219 | 11.139071 | 125.00547 | 0.72 | 1.4 | -0.68 | Seniang / December 2014 | 5 -Year |
| 220 | 11.14276 | 125.005348 | 0.30 | 0.3 | 0.00 | Seniang / December 2014 | 5 -Year |
| 221 | 11.147131 | 125.001841 | 1.07 | 0.8 | 0.27 | Seniang / December 2014 | 5 -Year |
| 222 | 11.149789 | 125.003424 | 0.31 | 0.8 | -0.49 | Seniang / December 2014 | 5 -Year |
| 223 | 11.150286 | 125.003617 | 0.05 | 0.7 | -0.65 | Seniang / December 2014 | 5 -Year |

| Point Number | Validation Coordinates | | Model Var (m) | Validation Points (m) | Error | Event/Date | Rain Return / Scenario |
|---|---|---|---|---|---|---|---|
| | Lat | Long | | | | | |
| 224 | 11.152729 | 124.998917 | 0.03 | 0.8 | -0.77 | Seniang / December 2014 | 5 -Year |
| 225 | 11.154078 | 124.992504 | 0.26 | 0.1 | 0.16 | Seniang / December 2014 | 5 -Year |
| 226 | 11.152629 | 124.98901 | 0.77 | 0.88 | -0.11 | Seniang / December 2014 | 5 -Year |
| 227 | 11.144658 | 124.985819 | 0.04 | 0.6 | -0.56 | Seniang / December 2014 | 5 -Year |
| 228 | 11.144658 | 124.985819 | 0.04 | 0.1 | -0.06 | Ruby / December 2014 | 5 -Year |
| 229 | 11.139176 | 124.983665 | 0.04 | 1.2 | -1.16 | Seniang / December 2014 | 5 -Year |
| 230 | 11.137986 | 124.983751 | 0.29 | 1.4 | -1.11 | Seniang / December 2014 | 5 -Year |
| 231 | 11.137986 | 124.983751 | 0.29 | 0.5 | -0.21 | Yolanda / November 2013 | 5 -Year |
| 232 | 11.138166 | 124.983916 | 0.26 | 1.6 | -1.34 | Seniang / December 2014 | 5 -Year |
| 233 | 11.138166 | 124.983916 | 0.26 | 0 | 0.26 | Ruby / December 2014 | 5 -Year |
| 234 | 11.131487 | 124.980642 | 1.34 | 2.4 | -1.06 | Seniang / December 2014 | 5 -Year |
| 235 | 11.131487 | 124.980642 | 1.34 | 1.2 | 0.14 | Yolanda / November 2013 | 5 -Year |
| 236 | 11.131487 | 124.980642 | 1.34 | 0.6 | 0.74 | Ruby / December 2014 | 5 -Year |
| 237 | 11.133444 | 124.975172 | 0.19 | 1.05 | -0.86 | Seniang / December 2014 | 5 -Year |
| 238 | 11.126194 | 124.978243 | 0.41 | 1.6 | -1.19 | Seniang / December 2014 | 5 -Year |
| 239 | 11.124228 | 124.977363 | 0.62 | 1.8 | -1.18 | Seniang / December 2014 | 5 -Year |
| 240 | 11.119073 | 124.975691 | 0.08 | 0.9 | -0.82 | Seniang / December 2014 | 5 -Year |
| 241 | 11.119073 | 124.975691 | 0.08 | 0.7 | -0.62 | Ruby / December 2014 | 5 -Year |
| 242 | 11.130892 | 124.983622 | 0.11 | 2.5 | -2.39 | Seniang / December 2014 | 5 -Year |
| 243 | 11.130892 | 124.983622 | 0.11 | 0.4 | -0.29 | Yolanda / November 2013 | 5 -Year |
| 244 | 11.130892 | 124.983622 | 0.11 | 0.8 | -0.69 | Ruby / December 2014 | 5 -Year |
| 245 | 11.154232 | 124.985747 | 0.81 | 1.36 | -0.55 | Seniang / December 2014 | 5 -Year |
| 246 | 11.15376 | 124.981727 | 0.43 | 1.5 | -1.07 | Seniang / December 2014 | 5 -Year |
| 247 | 11.153976 | 124.97994 | 0.32 | 0.3 | 0.02 | Seniang / December 2014 | 5 -Year |
| 248 | 11.153717 | 124.976561 | 0.38 | 0.5 | -0.12 | Seniang / December 2014 | 5 -Year |
| 249 | 11.154375 | 124.9728 | 0.09 | 0.6 | -0.51 | Seniang / December 2014 | 5 -Year |
| 250 | 11.154375 | 124.9728 | 0.09 | 0.3 | -0.21 | Seniang / December 2014 | 5 -Year |
| 251 | 11.151513 | 124.972117 | 0.19 | 0.5 | -0.31 | Seniang / December 2014 | 5 -Year |
| 252 | 11.143602 | 124.965134 | 0.09 | 0.7 | -0.61 | Seniang / December 2014 | 5 -Year |
| 253 | 11.143602 | 124.965134 | 0.09 | 0.2 | -0.11 | Ruby / December 2014 | 5 -Year |
| 254 | 11.140522 | 124.974099 | 0.08 | 0 | 0.08 | Seniang / December 2014 | 5 -Year |
| 255 | 11.13903 | 124.980608 | 0.03 | 0.3 | -0.27 | Seniang / December 2014 | 5 -Year |
| 256 | 11.122397 | 124.997956 | 1.61 | 2 | -0.39 | Seniang / December 2014 | 5 -Year |
| 257 | 11.12288 | 125.000219 | 1.55 | 2.2 | -0.65 | Seniang / December 2014 | 5 -Year |
| 258 | 11.12288 | 125.000219 | 1.55 | 1.8 | -0.25 | Ruby / December 2014 | 5 -Year |
| 259 | 11.133005 | 125.002468 | 1.04 | 1.8 | -0.76 | Seniang / December 2014 | 5 -Year |
| 260 | 11.133005 | 125.002468 | 1.04 | 0.3 | 0.74 | Ruby / December 2014 | 5 -Year |
| 261 | 11.129941 | 124.999613 | 1.28 | 2 | -0.72 | Seniang / December 2014 | 5 -Year |
| 262 | 11.129941 | 124.999613 | 1.28 | 1.1 | 0.18 | Ruby / December 2014 | 5 -Year |
| 263 | 11.12592 | 124.994367 | 0.37 | 1.8 | -1.43 | Seniang / December 2014 | 5 -Year |
| 264 | 11.123937 | 124.992665 | 0.04 | 0.2 | -0.16 | Seniang / December 2014 | 5 -Year |
| 265 | 11.12308 | 124.992526 | 0.04 | 0.5 | -0.46 | Seniang / December 2014 | 5 -Year |

# Annex 12. Educational Institutions Affected by Flooding in Palo Floodplain

| LEYTE | | | | |
|---|---|---|---|---|
| PALO | | | | |
| Building Name | Barangay | Rainfall Scenario | | |
| | | 5-year | 25-year | 100-year |
| San Jose Elementary School | Arado | | | |
| Baras Elementary School | Baras | | | |
| Day Care Center | Baras | | | |
| San Fernando Elementary School | Baras | | | |
| Cabarasan Guti Primary School | Cabarasan Guti | | | |
| Bethel International School | Campetik | | | |
| Campetik Elementary School | Campetik | | | |
| Pawing Elementary School | Campetik | | | |
| Philippine Science High School ADMIN Building | Campetik | | | |
| Philippine Science High School Guard House | Campetik | | Low | Low |
| Philippine Science High School Room | Campetik | | | |
| St. Paul's School of Professional Studies | Campetik | | Medium | Medium |
| Cangumbang Elementary School | Cangumbang | | High | High |
| Day Care Center | Cangumbang | | High | High |
| Canhidoc Elementary School | Canhidoc | | | Low |
| Palo I Central School | Cavite East | | | |
| Palo National High School | Cavite West | | | |
| Gacao Elementary School | Gacao | | | Low |
| Caloogan Elementary School | Guindapunan | | Medium | Medium |
| Day Care Center | Guindapunan | | | |
| Guidapunan Elementary School | Guindapunan | | | |
| Leyte Academic Center | Guindapunan | | | Low |
| Zion Bible College | Guindapunan | | | Low |
| Day Care Center | Naga-Naga | | Medium | Medium |
| St. Mary Academy | Naga-Naga | | Medium | Medium |
| Philippine Science High School ADMIN Building | Pawing | | | |
| Philippine Science High School Room | Pawing | | | |
| Brgy. Salvacion Day Care Center | Salvacion | | Low | Low |
| Luntad Elementary School | Salvacion | Low | Low | Low |
| Naga-Naga Elementary School | Salvacion | | Medium | Medium |
| Sacred Heart Seminary | Salvacion | | | |
| Salvacion Elementary School | Salvacion | Low | Low | Low |
| Gacao Elementary School | San Isidro | | | Low |
| Brgy. Tacuranga, Day Care Center | San Joaquin | | Medium | Medium |
| Day Care Center | San Joaquin | | Medium | Medium |
| San Joaquin Central School | San Joaquin | | Medium | Medium |
| Tacuranga Elementary School | San Joaquin | | Medium | Medium |
| Ilawod Day Care Center | San Miguel | Low | Low | Low |

| LEYTE | | | | |
|---|---|---|---|---|
| PALO | | | | |
| Building Name | Barangay | Rainfall Scenario | | |
| | | 5-year | 25-year | 100-year |
| Luntad Elementary School | San Miguel | Low | Low | Low |
| St. Mary Academy | Santa Cruz | | Low | Medium |

| LEYTE | | | | |
|---|---|---|---|---|
| SANTA FE | | | | |
| Building Name | Barangay | Rainfall Scenario | | |
| | | 5-year | 25-year | 100-year |
| Day Care Center | Badiangay | | Medium | Medium |
| Kauswagan National High School | Badiangay | | | |
| Libertad Elementary School | Milagrosa | | High | |

| LEYTE | | | | |
|---|---|---|---|---|
| TANAUAN | | | | |
| Building Name | Barangay | Rainfall Scenario | | |
| | | 5-year | 25-year | 100-year |
| Brgy. Muhon Day Care Center | Camire | | Medium | Medium |
| Muhon Elementary School | Camire | | Medium | Medium |

# Annex 13. Health Institutions Affected by Flooding in Palo Floodplain

| LEYTE | | | | |
|---|---|---|---|---|
| PALO | | | | |
| Building Name | Barangay | Rainfall Scenario | | |
| | | 5-year | 25-year | 100-year |
| Brgy. Health Center | Arado | | | |
| Birthing Clinic | Campetik | | | |
| Cangumbang Health Center | Cangumbang | | High | High |
| Mother Bles Birthing Clinic | Cavite East | Low | Low | Low |
| Palo Maternity House | Luntad | | Medium | Medium |
| Brgy. Salvacion, Health Center | Salvacion | | Low | Low |
| C-Gen Pharma & Medical Clinic | Salvacion | | | |
| Schistosomiasis Control & Research Center | Salvacion | | | |
| Schistosomiasis Hospital | Salvacion | | | |
| 7th Angel Family Health Care & Maternity Clini | San Joaquin | | Medium | Medium |
| Brgy. Health Center | San Joaquin | | Medium | Medium |
| Brgy. Tacuranga, Health Center | San Joaquin | | Medium | Medium |
| Canhidoc Health Center | San Joaquin | | | |
| Feeding Center | San Joaquin | | Medium | Medium |
| Brgy. Health Center | Tacuranga | | | |

| LEYTE | | | | |
|---|---|---|---|---|
| SANTA FE | | | | |
| Building Name | Barangay | Rainfall Scenario | | |
| | | 5-year | 25-year | 100-year |
| Health Center | Badiangay | Low | Medium | Medium |