HAZARD MAPPING OF THE PHILIPPINES USING LIDAR (PHIL-LIDAR I)

LiDAR Surveys and Flood Mapping of Butadon River

University of the Philippines Training Center
for Applied Geodesy and Photogrammetry
Mindanao State University-Iligan Institute
of Technology

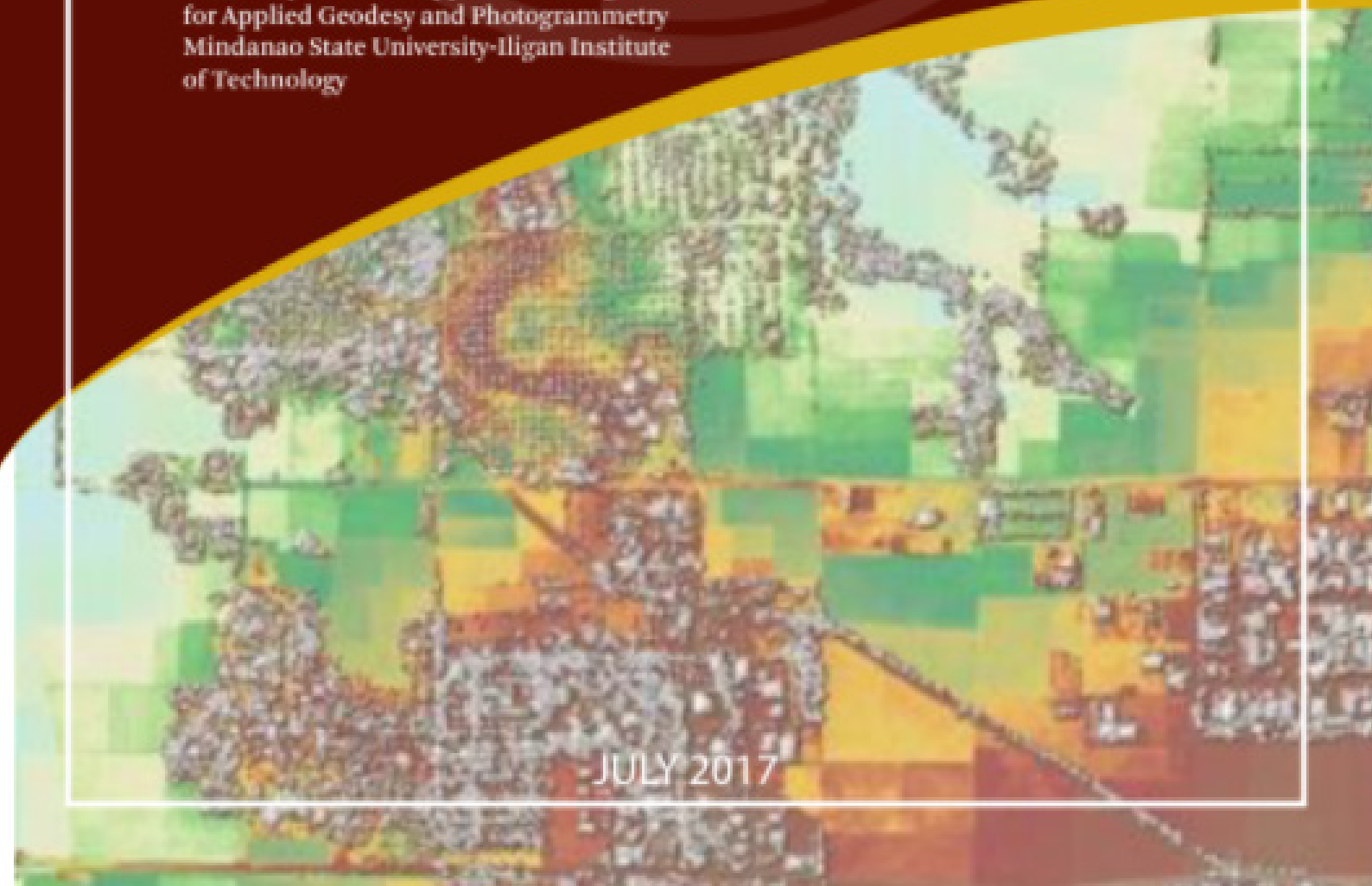

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS AND ABBREVIATIONS

AAC	Asian Aerospace Corporation
Ab	abutment
ABSD	AB Surveying and Development
ALTM	Airborne LiDAR Terrain Mapper
ARG	automatic rain gauge
AWLS	Automated Water Level Sensor
BA	Bridge Approach
BM	benchmark
BSWM	Bureau of Soils and Water Management
CAD	Computer-Aided Design
CN	Curve Number
CSRS	Chief Science Research Specialist
DA	Department of Agriculture
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
MSU-IIT	Mindanao State University – Iligan Institute of Technology
NAMRIA	National Mapping and Resource Information Authority
NSTC	Northern Subtropical Convergence
PAF	Philippine Air Force
PAGASA	Philippine Atmospheric Geophysical and Astronomical Services Administration
PDOP	Positional Dilution of Precision
PPK	Post-Processed Kinematic [technique]
PRF	Pulse Repetition Frequency
PSA	Philippine Statistics Authority
PTM	Philippine Transverse Mercator
QC	Quality Check
QT	Quick Terrain [Modeler]
RA	Research Associate
RBCO	River Basin Control Office
RIDF	Rainfall-Intensity-Duration-Frequency
RMSE	Root Mean Square Error
SAR	Synthetic Aperture Radar
SCS	Soil Conservation Service
SRTM	Shuttle Radar Topography Mission
SRS	Science Research Specialist
SSG	Special Service Group
TBC	Thermal Barrier Coatings
UP-TCAGP	University of the Philippines – Training Center for Applied Geodesy and Photogrammetry
UTM	Universal Transverse Mercator
WGS	World Geodetic System

CHAPTER 1: OVERVIEW OF THE PROGRAM AND BUTADON RIVER

Enrico C. Paringit, Dr. Eng., Dr . George Puno, and Eric Bruno

1.1 Background of the Phil-LiDAR 1 Program

The University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP-TCAGP) launched a research program entitled "Nationwide Hazard Mapping using LiDAR" or Phil-LiDAR 1, supported by the Department of Science and Technology (DOST) Grants-in-Aid (GiA) Program. The program was primarily aimed at acquiring a national elevation and resource dataset at a 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 a 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 the DOST.The methods applied in this report are thoroughly described in a separate publication entitled "Flood Mapping of Rivers in the Philippines Using Airborne LiDAR: Methods" (Paringit, et. al., 2017), available separately.

The implementing partner university for the Phil-LiDAR 1 Program is the Mindanao State University – Iligan Institute of Technology (MSU-IIT). MSU-IITis 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 sixteen (16)river basins in the Northern Mindanao Region. The university is located in IliganCity in the province of Lanao del Norte.

1.2 Overview of the ButadonRiver Basin

The Butadon River Basin is situated in Northern Mindanao,within the territory of the province of Lanao del Norte under Region X. The whole area of the delineated river basin covers the Municipalities of Kapatagan, Lala, Baroy, Salvador, Sapad, and Nunungan in Lanao del Norte. The outlet of the Butadon River Basin, where flow measurements were obtained, is located in the Municipality of Kapatagan,traversing the barangays of Lapinig, Concepcion, Butadon, Sta. Cruz, and Suso. The Butadon River Basin has a drainage area of 272.564 km^2.The basin travels 10.5 kilometers from its source to its outlet, and 21.8 kilometers from its source to its mouth at the Panguil Bay. A total of 53,418 features were extracted within the floodplain, which belong to the municipalities and cities within the flood-prone area.

The basin's main stem, the Butadon River (locally known as the Kapatagan I River), is among the sixteen (16) river systems in Northern Mindanao.The river is utilized as the fundamental waterway for navigating within the region of Kapatagan. The Butadon River begins in Sultan Naga Dimaporo and crosses down to Pulang Yuta.It then traverses Bansarvi to Butadon. The river then stretches to Sta. Cruz, Bali, and Concepcion.At this point, the Butadon waterway intersects with the Maranding waterway.Finally, the river reaches Sitio Lapus-lapus, an islet that is part of Lapinig in the Panguil Bay.

Kapatagan is one of the twenty-two (22) localities in the area of Lanao Del Norte, with a total land region of approximately 25,048.41 hectares.The area is positioned within the grid headings of 123° 42' and 123° 49' north longitude, and 7° 49' and 7° 56' east degree.It is bounded by the Municipality of Lala and the Panguil Bay in the North; the Municipalities of Baroy and Salvador in the East; the Municipality of Sapad in the southeast; the Municipality of Sultan Naga Dimaporo in the south; and the range of Zamboanga del Sur in the westand northwest.

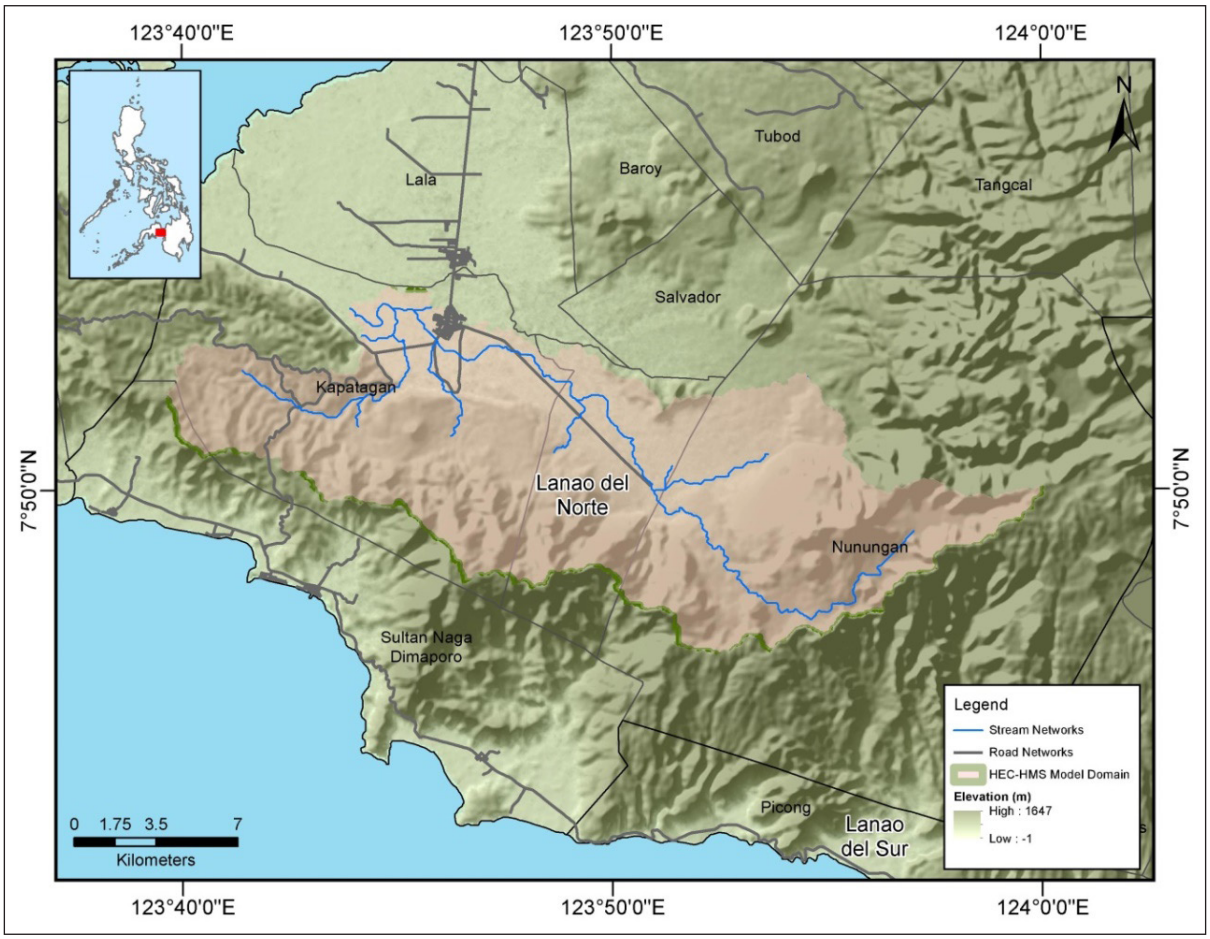

Figure 1. Location map of the Butadon River Basin (in brown)

According to the 2015 national census of the Philippine Statistics Authority (PSA), the total residents in barangays within the immediate vicinity of the Butadon River is 9,950 persons.

The economy of the province of Lanao del Norte largely relies on fishery and agriculture, which include the production of copra, rice, corn, fruits, and aquaculture products (Province of Lanao del Norte, 2017).

The region is viewed as a warm marsh, due to its most noteworthy height of just up to 300 meters above sea level. Mountains fill the regular boundaries of the region in its southern and eastern sides,shielding it from tropical storms. However, this is counteracted by the region's close proximity of the ocean, which is at level with the ground, and the valleys. As such, the area is highly exposed to flooding.

The whole Province of Lanao del Norte was placed under "readiness status" on August 6, 2015, due to the blaze surges generated by the monsoon rains, causing the deaths of579 people (or 130 families).The surges brought about flooding of three (3) streams. Three (3) barangay zones (purok) in Lapinig, Kapatagan, and Maranding were heavily impacted by the flooding. The events prompted Lanao del Norte Governor Mohammad Khalid Dimaporo to issue Provincial Disaster Risk Reduction and Management Council (PDRRMC) Advisory No. 2 to the whole territory,advising all covered localities to observe "readiness status."

Under the "readiness status,"local metropolitan and barangay Disaster Risk Reduction and Management Council (DRRMC) offices maintained 24-hour operations,focusing on their individual zones. All levels of government units and teams were requested to exhaust all means by which to alert zones(puroks) and groups that were highly-exposed to surges, particularly those that were situated along the waterways and coastlines, and those situated in low-lying ranges.

Governor Dimaporo mandated all territories with recent history of flooding to exercise twofold readiness, and to set up for clearing. Furthermore, these areas were ordered to coordinate with fisher folk, to cease them from going to the ocean until it is pronounced safe.

Under the “readiness status,” concerned organizations werecommanded to identifysafe zones,routes, and accessible vehicles for clearing operations. Additionally, the organizations educated families in the province to preparecrisis sacks with sustenance and water that can last for the following seventy-two (72) hours. (http://cnnphilippines.com).

Most recently, on January 12, 2017, the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) issued a yellow warning to the flood levels in the province of Lanao del Norte, due to continuous torrential rains that hadcaused the inundation(Catoto, 2017).

CHAPTER 2: LIDAR DATA ACQUISITION OF THE BUTADONFLOODPLAIN

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

2.1 Flight Plans

To initiate the LiDAR acquisition survey of the Butadon floodplain, the Data Acquisition Component (DAC) created flight plans within the delineated priority area for the floodplain in Zamboanga del Norte. Each flight mission hadan average of fourteen (14) lines and ran for at most four and a half (4.5) hours, including take-off, landing, and turning time. The Pegasus LiDAR system was used for the missions (See Annex 1 for the sensor specifications). The parameters used in the LiDAR system for the acquisition arefound in Table 1. Figure 2illustratesthe flight plans for the Butadon floodplain.

Table 1. Flight planning parameters for the Pegasus LiDAR system

Block Name	Flying Height (AGL)	Overlap (%)	Field of View (θ)	Pulse Repetition Frequency (PRF) (kHz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
BLK70B	1000	30	50	200	30	130	5
BLK71ABC	1200	30	50	200	30	130	5
BLK71C	1000	30	50	200	30	130	5
BLK71E	800/1100/ 1200	30	50	200	30	130	5
BLK71Es	1100	30	50	200	30	130	5
BLK71ext	1000	30	50	200	30	130	5
BLK71F	1000	30	50	200	30	130	5
BLK71G	900	30	50	200	30	130	5
BLK76A	1200	30	50	200	30	130	5
BLK 76C	1100	30	50	200	30	130	5
BLK 76D	1100/ 1200	30	50	200	30	130	5
BLK 76I	1200	30	50	200	30	130	5
BLK 76M	1000/1200	30	50	200	30	130	5

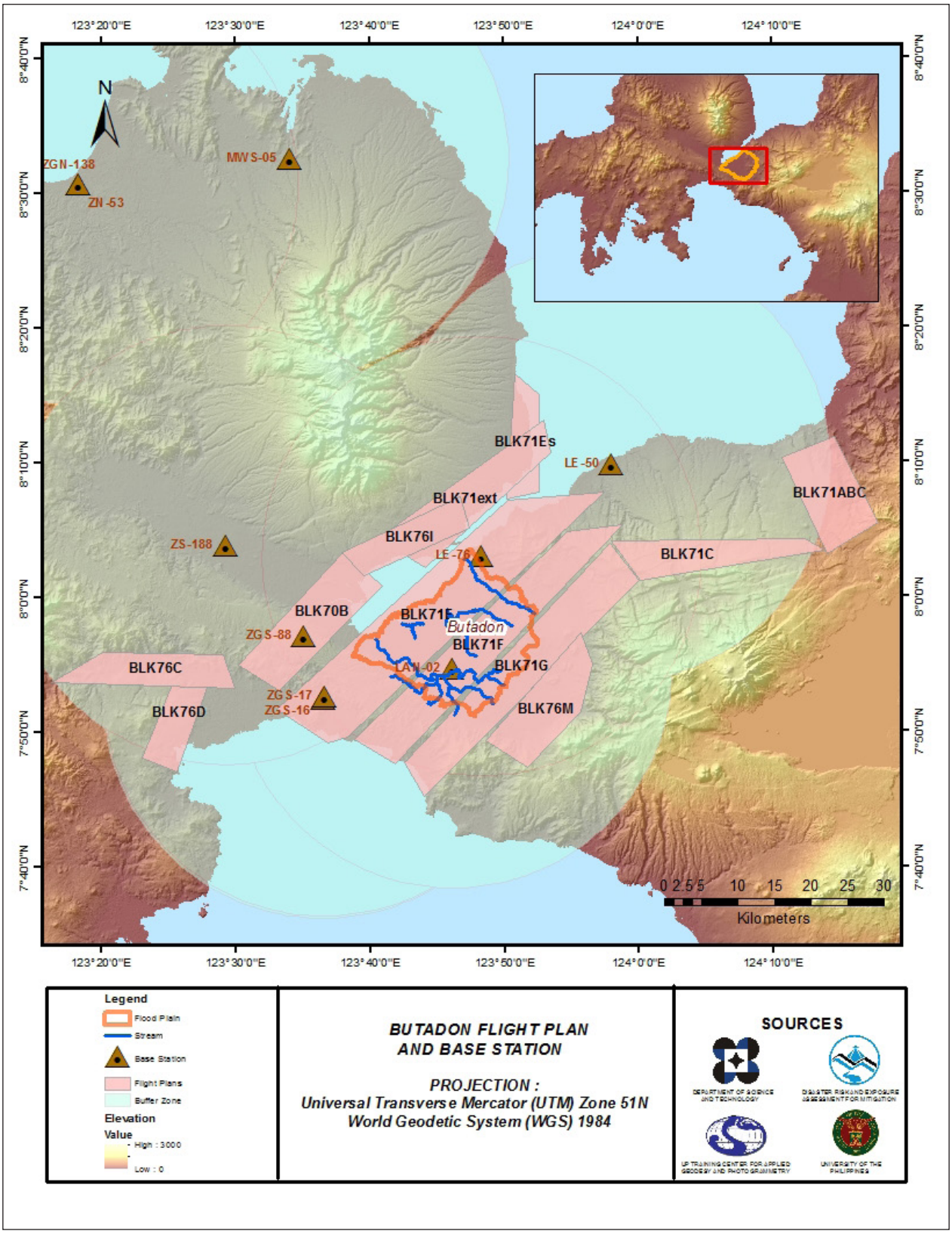


Figure 2. Flight plans and base stations used to cover the Butadon floodplain survey

2.2 Ground Base Stations

The fieldteam for this undertaking was able to recover five (5) NAMRIA ground control points: LAN-02 , ZGS-88, ZGS-16, ZGS-17, and ZGN-138, which are of second (2nd) order accuracy.Four (4) benchmark points were also recovered: ZN_53, LE-50, ZS-188, and LE-76. The certifications for the NAMRIA reference points and the baseline processing reports for the established points are found in Annexes2 and 3, respectively.

These were used as the base stations during the flight operations for the entire duration of the survey, held onMay 29-July 10, 2014; on February 4-March 4, 2016; and on November 18-December 2, 2016. The base stations were observed using dual frequency GPS receivers, TRIMBLE SPS 882, SPS 852, SPS 985, and Topcon GR-5. The flight plans and locations of the base stations used during the aerial LiDAR acquisition in the Butadon floodplain are shown in Figure 2.The composition of the full project team is given in Annex 4.

Figure 3 to Figure 11exhibitthe recovered NAMRIA control stations within the area.Table 2 to Table 10providethe details about the correspondingNAMRIA control stations and established points.Table 11listsall of the ground control points occupied during the acquisition, together with the dates of utilization.

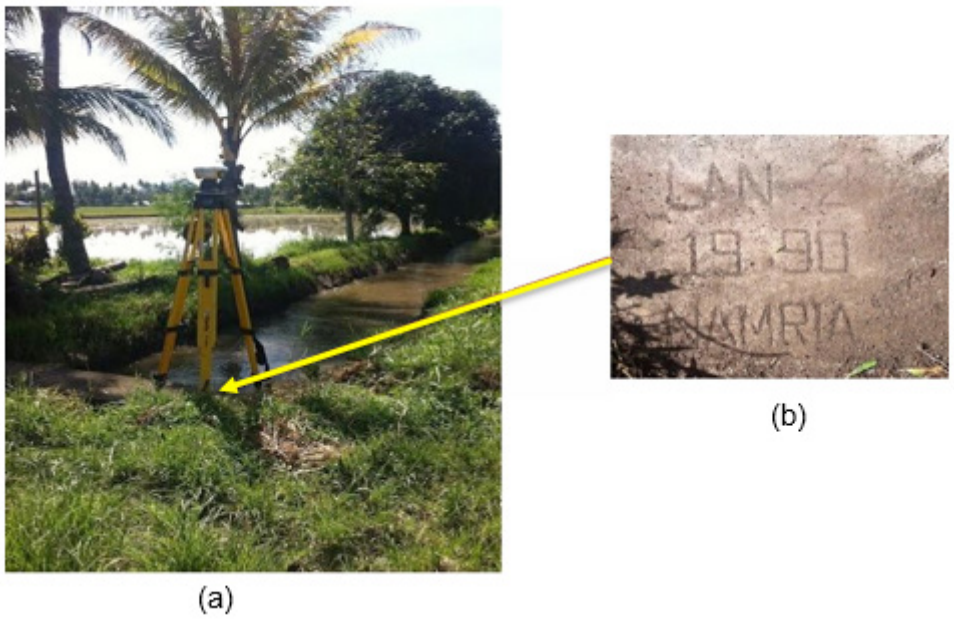


Figure 3. (a) GPS set-up over LAN-02 on top of a concrete irrigation canal water gate in Barangay Pinoyak, Lala, Lanao del Norte; and (b) NAMRIA reference point LAN-02, as recovered by the field team

Table 2. Details of the recovered NAMRIA horizontal control point LAN-02, used as a base station for the LiDAR acquisition

Station Name	LAN-02	
Order of Accuracy	1st	
Relative Error (horizontal positioning)	1 in 100,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	7°54'46.07859" North
	Longitude	123°46'0.85333" East
	Ellipsoidal Height	17.35400 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	364025.74 meters
	Northing	875110.149 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	7°54'42.56546" North
	Longitude	123°46'6.31720" East
	Ellipsoidal Height	83.92120 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting	584533.45 meters
	Northing	874680.35 meters

Figure 4. (a) GPS set-up over ZGS-88 on a center island in Puroy Saray, Aurora, Zamboanga del Sur; and (b) NAMRIA reference point ZGS-88, as recovered by the field team

Table 3. Details of the recovered NAMRIA horizontal control point ZGS-88, used as a base station for the LiDAR acquisition

Station Name	ZGS-88	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	7°57'13.25316" North
	Longitude	123°34'56.50093" East
	Ellipsoidal Height	258.34500 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	564207.26 meters
	Northing	879474.685 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	7°57'9.71271" North
	Longitude	123°35'1.96243" East
	Ellipsoidal Height	324.37300 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting	564184.79 meters
	Northing	879166.85 meters

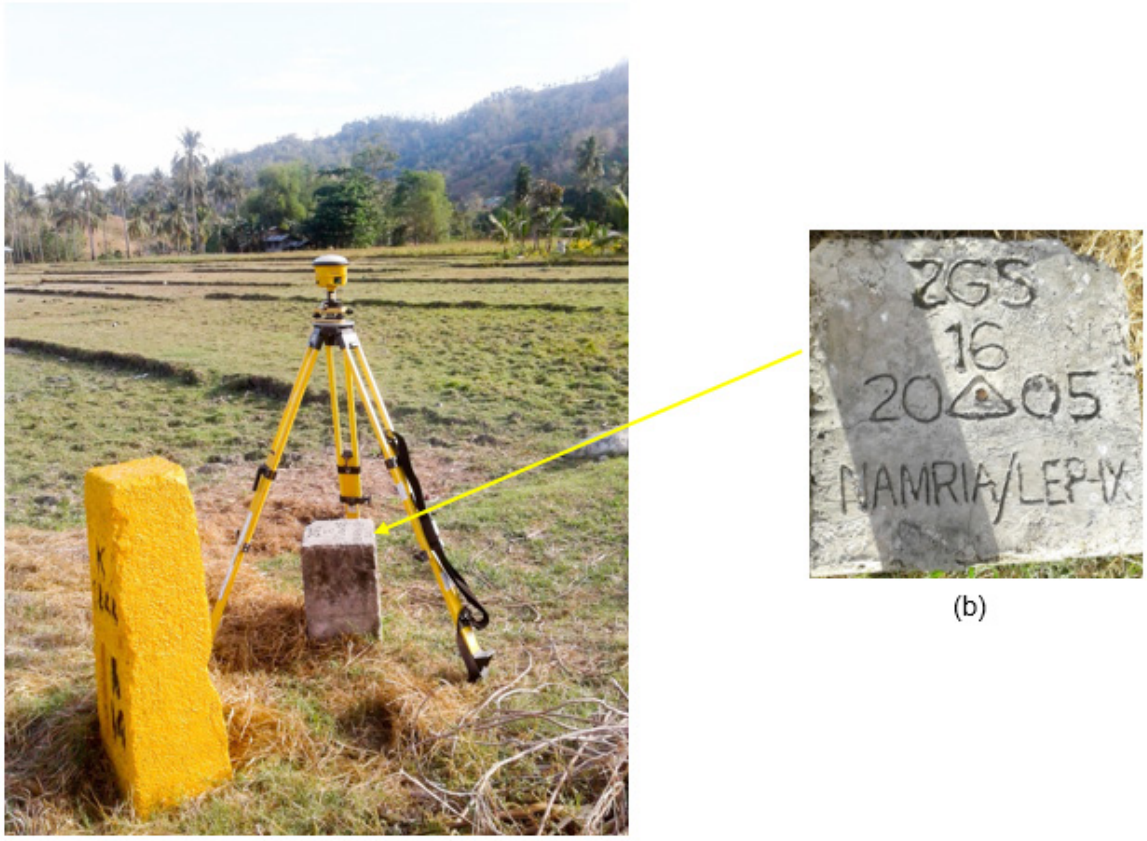


Figure 5. (a) GPS set-up over ZGS-16 in Purok Nangka, Barangay Baclay, Tukuran, Zamboanga del Sur; and (b) NAMRIA reference point ZGS-16, as recovered by the field team

Table 4. Details of the recovered NAMRIA horizontal control point ZGS-16, used as a base station for the LiDAR acquisition

Station Name	ZGS-16	
Order of Accuracy	2rd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	7° 52' 35.53106" North
	Longitude	123° 36' 23.39905" East
	Ellipsoidal Height	18.17800 meters
Grid Coordinates, Philippine Transverse Mercator Zone 4 (PTM Zone 5 PRS 92)	Easting	566881.259 meters
	Northing	8708554.959 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	7° 52' 29.01321" North
	Longitude	123° 36' 28.86762" East
	Ellipsoidal Height	84.42000 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting	566857.85 meters
	Northing	870550.15 meters

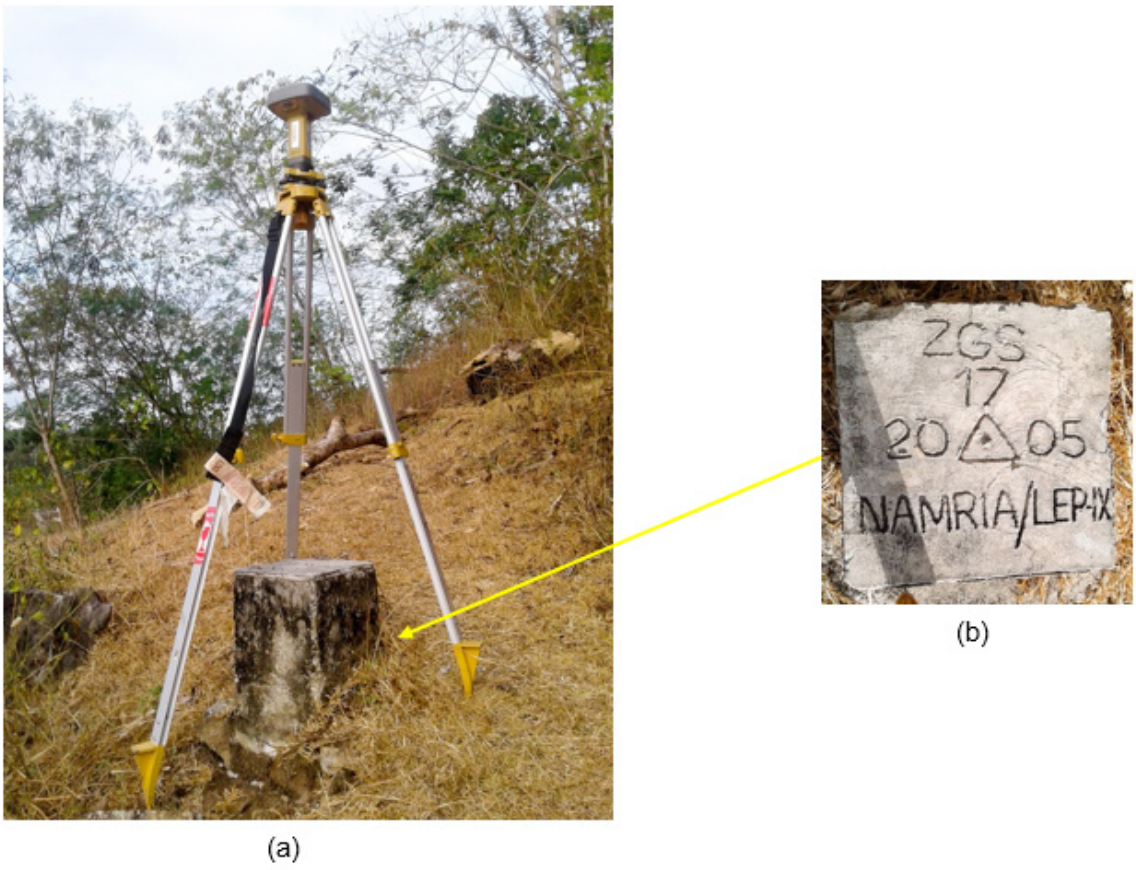


Figure 6. (a) GPS set-up over ZGS-17 in Purok Kasoy, Barangay Baclay, Tukuran, Zamboanga del Sur; and (b) NAMRIA reference point ZGS-17, as recovered by the field team

Table 5. Details of the recovered NAMRIA horizontal control point ZGS-17, used as a base station for the LiDAR acquisition

Station Name	ZGS-17	
Order of Accuracy	2rd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	7° 52' 42.71658" North
	Longitude	123° 36' 29.22049" East
	Ellipsoidal Height	29.68400 meters
Grid Coordinates, Philippine Transverse Mercator Zone 4 (PTM Zone 5 PRS 92)	Easting	567059.131 meters
	Northing	871168.108 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	7° 2' 39.19813" North
	Longitude	123° 36' 34.68878" East
	Ellipsoidal Height	95.92400 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting	567035.66 meters
	Northing	870863.18 meters

Figure 7. (a) GPS set-up over ZGN-138 in Katipinan, Zamboanga del Norte; and (b) NAMRIA reference point ZGN-138, as recovered by the field team

Table 6. Details of the recovered NAMRIA horizontal control point ZGN-138, used as a base station for the LiDAR acquisition

Station Name	ZGN-138	
Order of Accuracy	2rd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	8° 30' 40.65974"North
	Longitude	122° 18' 14.44217"East
	Ellipsoidal Height	6.715 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	533471.036 meters
	Northing	941106.14 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	8° 30' 36.94779" North
	Longitude	123° 18' 19.85548"East
	Ellipsoidal Height	70.925 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting	533459.32 meters
	Northing	940776.74 meters

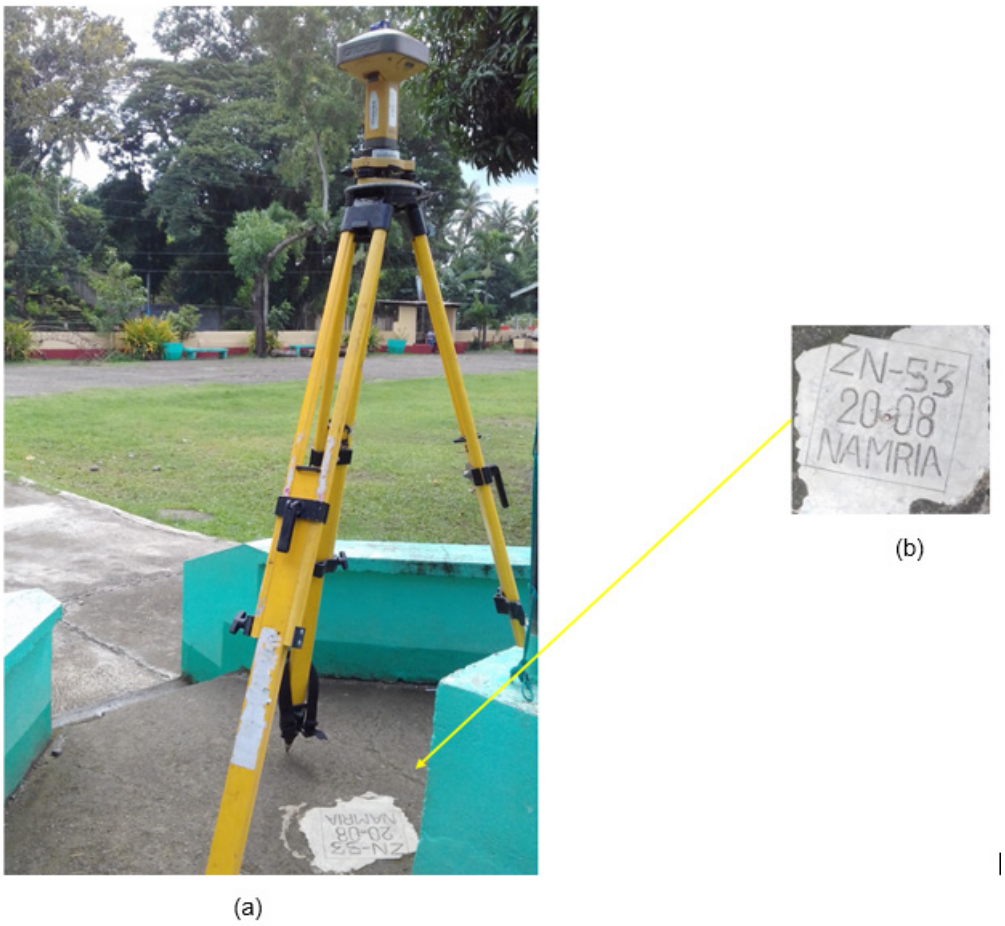
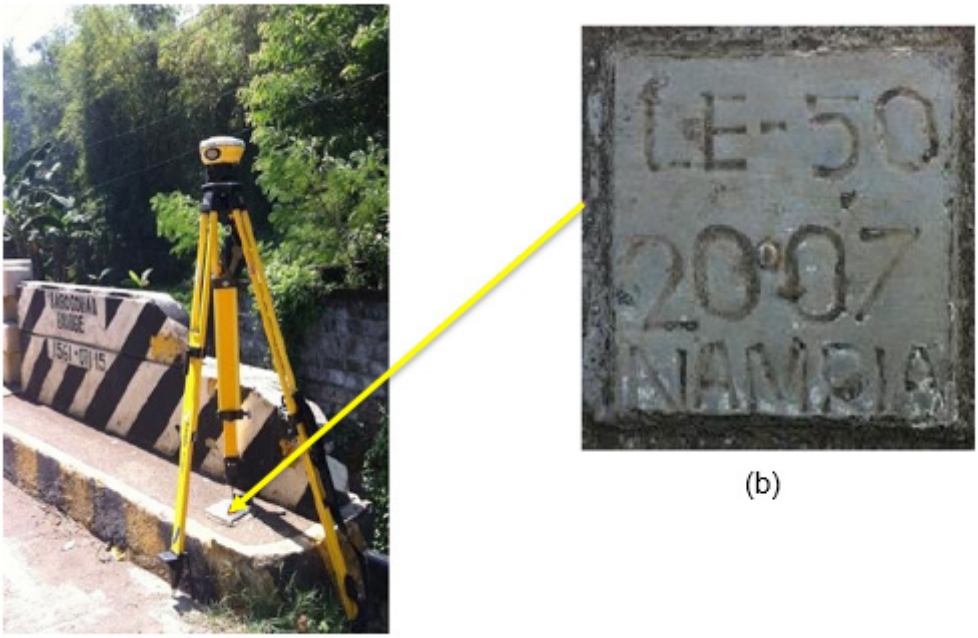


Figure 8. (a) GPS set-up over ZN-53 at Barangay Daanglungsod, Katipunan, Zamboanga del Norte; and (b) reference point ZN-53, as recovered by the field team

Table 7. Details of the benchmark ZN- 53, used as a base station for the LiDAR acquisition

Station Name	ZN-53	
Order of Accuracy (benchmark)	2nd	
Elevation (horizontal positioning)	1:50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	8°30'41.04428" North
	Longitude	123°18'14.33457" East
	Ellipsoidal Height	7.072 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	8°30'37.33230" North
	Longitude	123°18'19.74787" East
	Ellipsoidal Height	71.282 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 92)	Easting	533456.022 meters
	Northing	940788.542 meters



(a) (b)

Figure 9. (a) GPS set-up over LE-50 on the Barogohan Bridge in Maigo, Lanao del Norte; and (b) NAMRIA benchmark LE-50, as recovered by the field team

Table 8. Details of the recovered benchmark point LE-50, used as a base station for the LiDAR acquisition

Station Name	LE-50	
Order of Accuracy	1st	
Relative Error (horizontal positioning)	1 in 100,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	8°9'54.972" North
	Longitude	123°57'50.357" East
	Ellipsoidal Height	6.91 m meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	385831.49 meters
	Northing	902974.41 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	8°09'51.11024" North
	Longitude	123°57'55.36634" East
	Ellipsoidal Height	73.452 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting	606345.902 meters
	Northing	902577.426 meters

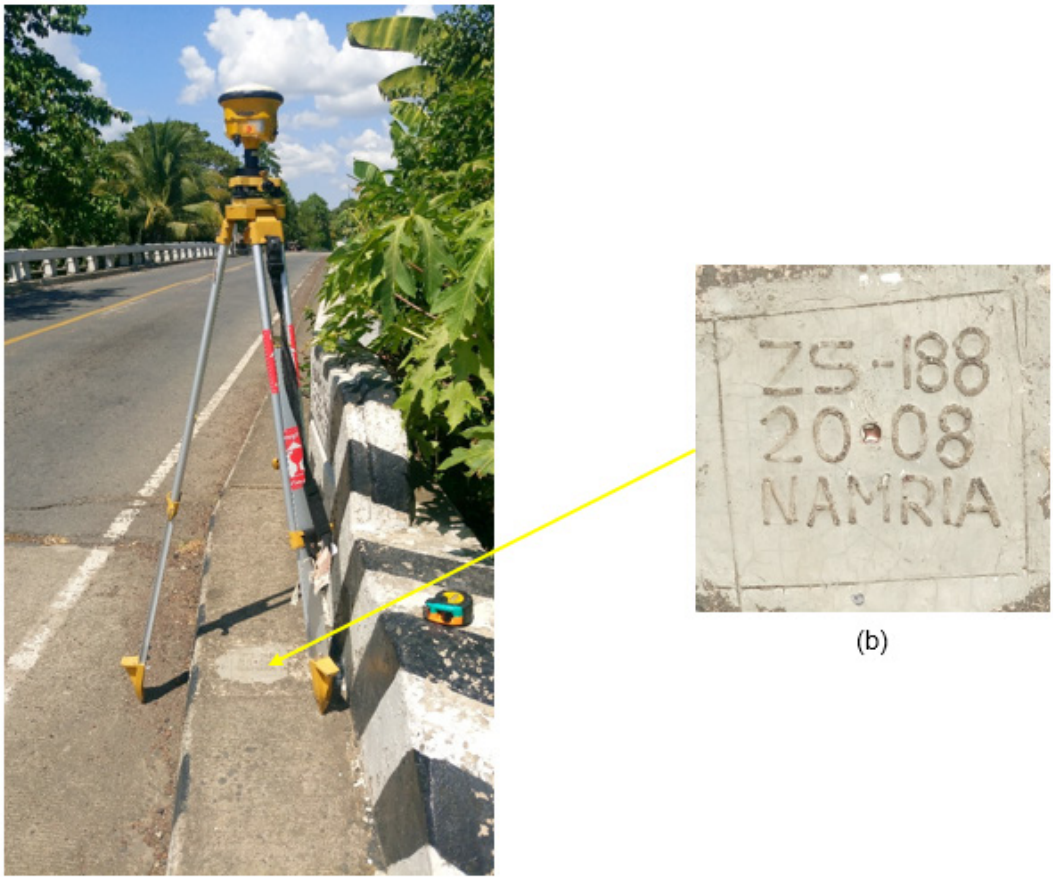


Figure 10. (a) GPS set-up over ZS-188 at the Dipolo Bridge in Barangay Licomo, Molave, Zamboanga del Sur; and (b) NAMRIA benchmark ZS-188, as recovered by the field team

Table 9. Details of the recovered NAMRIA benchmark ZS-188, used as a base station for the LiDAR acquisition

Station Name	ZS-188	
Order of Accuracy (benchmark)	1st	
Elevation (horizontal positioning)	1:100,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	8°03'56.69408" North
	Longitude	123°29'12.15500" East
	Ellipsoidal Height	19.832 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	8°03'53.11537" North
	Longitude	123°29'17.60722" East
	Ellipsoidal Height	85.400 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 92)	Easting	553627.634 meters
	Northing	891542.089 meters

Figure 11. (a) GPS set-up over LE-76 at the Bulod Bridge in Barangay Bulod, Tubod, Lanao del Norte; and (b) NAMRIA benchmark LE-76, as recovered by the field team

Table 10. Details of the recovered NAMRIA benchmark LE-76, used as a base station for the LiDAR acquisition

Station Name	LE-76	
Order of Accuracy (benchmark)	1st	
Elevation (horizontal positioning)	1:100,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	8° 03' 05.36825" North
	Longitude	123° 48' 12.37307" East
	Ellipsoidal Height	9.355 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	8° 03' 01.82183" North
	Longitude	123° 48' 17.82405" East
	Ellipsoidal Height	75.717 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 92)	Easting	588,530.790 meters
	Northing	890,021.013 meters

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

Date Surveyed	Flight Number	Mission Name	Ground Control Points
June 4, 2014	1549P	1BLK 71D155A	LAN-02 and LE-50
June 8, 2014	1565P	1BLK71B159A	LAN-02 and LE-50
June 20, 2014	1613P	1BLK71G171A	LAN-02 and LE-50
July 3, 2014	1665P	1BLK71ES184A	LAN-02 and LE-50

July 5, 2014	1673P	1BLK71ES186A	LAN-02 and ZGS-88
July 6, 2014	1677P	1BLK71S187A	LAN-02 and ZGS-88
July 8, 2014	1685P	1BLK71S189A	LAN-02 and LE-50
July 9, 2014	1689P	1BLK71S190A	LE-50 and LE-76
February 12, 2016	23084P	1BLK76JKLCs043A	ZGS-16 and ZS-188
February 13, 2016	23088P	1BLK76ILM044A	ZGS-16 and ZS-188
February 17, 2016	23104P	1BLK76DLM048A	ZGS-16 and ZS-188
February 23, 2016	23128P	1BLK70B054A	ZGS-16 and ZGS-17
December 1, 2016	23602P	1BLK76AB336A	ZGN-138 and ZN-53

2.3 Flight Missions

A total of twelve (12) flight missions were conducted to complete the LiDAR data acquisition in the Butadon floodplain, for a total of 50 hours and 20 minutes (50+20) of flying time for RP-C9022. All missions were acquired using the Pegasus system. The flight logs of the missions are provided in Annex 6. Table 12indicates the total area of actual coverage per mission and the corresponding flying hours;and Table 13 presents the actual parameters used during the LiDAR data acquisition.

Table 12. Flight missions for the LiDAR data acquisition in the Butadon floodplain

Date Surveyed	Flight Number	Flight Plan Area (km^2)	Surveyed Area (km^2)	Area Surveyed within the Floodplain (km^2)	Area Surveyed Outside the Floodplain (km^2)	No. of Images (Frames)	Flying Hours	
							Hr	Min
June 4, 2014	1549P	404.99	202.34	65.36	136.98	_	4	24
June 8, 2014	1565P	238.51	117.70	52.35	65.35	324	2	53
June 20, 2014	1613P	240.61	246.62	79.13	167.49	936	4	06
July 3, 2014	1665P	59.24	42.73	42.73	0	_	2	59
July 5, 2014	1673P	142.27	125.28	21.51	103.77	330	2	55
July 6, 2014	1677P	73.20	45.22	45.22	0	170	2	35
July 8, 2014	1685P	335.86	184.57	64.79	119.78	569	4	05
July 9, 2014	1689P	109.30	202.18	54.27	147.91	_	4	17
February 12, 2016	23084P	167.89	299.63	83.16	216.47	652	4	17
February 13, 2016	23088P	112.09	231.36	25.29	206.07	536	4	23

February 17, 2016	23104P	185.72	170.14	31.46	138.68	396	4	34
February 23, 2016	23128P	139.43	198.99	17.66	181.33	5	4	17
December 1, 2016	23602P	68.58	130.56	7.23	123.33	_	4	35
TOTAL		2277.69	2197.32	590.16	1607.16	3918	50	20

Table 13. Actual parameters used during the LiDAR data acquisition

Flight Number	Flying Height (AGL)	Overlap (%)	Field of View (θ)	Pulse Repetition Frequency (PRF) (kHz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
1549P	800	30	50	200	30	130	5
1565P	1000	30	50	200	30	130	5
1613P	900	30	50	200	30	130	5
1665P	1100	30	50	200	30	130	5
1673P	1000	30	50	200	30	130	5
1677P	1000	30	50	200	30	130	5
1685P	1000	30	50	200	30	130	5
1689P	1200	30	50	200	30	130	5
23084P	1100	30	50	200	30	130	5
23088P	1200	30	50	200	30	130	5
23104P	1000/ 1200	30	50	200	30	130	5
23128P	1000	30	50	200	30	130	5
23602P	1200	30	50	200	30	130	5

2.4 Survey Coverage

The Butadon floodplain is located in the provinces of Lanao del Norte and Zamboanga del Sur, with the floodplain situated within the municipalities of Aurora, Baroy, Kapatagan, Lala, Salvador, Sapad, and Tubod. The list of municipalities and cities surveyed,with at least one (1) square kilometer coverage, is outlinedin Table 14. The actual coverage of the LiDAR acquisition for the Butadon floodplain is presented in Figure 12. See Annex 7 for the flight status reports.

Table 14. List of municipalities and cities surveyed in the Butadon floodplain LiDAR survey

Province	Municipality/City	Area of Municipality/City (km^2)	Total Area Surveyed (km^2)	Percentage of Area Surveyed =(Total Area covered/ Area of Municipality)*100
Lanao del Norte	Baloi	65.18	18.65	29%
	Baroy	62.08	59.89	96%
	Iligan City	650.87	16.26	2%
	Kapatagan	184.77	168.01	91%
	Kolambugan	70.70	55.74	79%
	Lala	125.18	120.21	96%
	Linamon	22.21	2.29	10%
	Magsaysay	83.06	64.44	78%
	Maigo	126.36	26.13	21%
	Matungao	52.50	2.50	5%
	Nunungan	418.22	61.20	15%
	Pantao Ragat	71.36	2.55	4%
	Pantar	50.19	4.71	9%
	Poona Piagapo	88.11	3.86	4%
	Salvador	46.46	46.18	99%
	Sapad	65.13	42.90	66%
	Sultan Naga Dimaporo	143.65	54.42	38%
	Tagoloan	25.06	1.77	7%
	Tangcal	118.94	7.23	6%
	Tubod	121.94	108.14	89%
Misamis Occidental	Bonifacio	103.87	9.76	9%
	Clarin	113.99	12.37	11%
	Ozamis City	149.44	39.45	26%
	Tangub City	141.82	54.81	39%
	Tudela	108.93	3.45	3%
Zamboanga del Sur	Tambulig	142.93	27.88	20%
	Tukuran	119.01	64.90	55%
	Aurora	162.22	100.06	62%
	Dumalinao	108.64	2.51	2%
	Kumalarang	143.51	51.18	36%
	Labangan	176.44	59.97	34%
	Pagadian City	279.33	70.86	25%
	Sominot	97.75	2.19	2%
Zamboanga Sibugay	Buug	134.89	2.99	2%
Total		4574.74	1369.46	29.94%

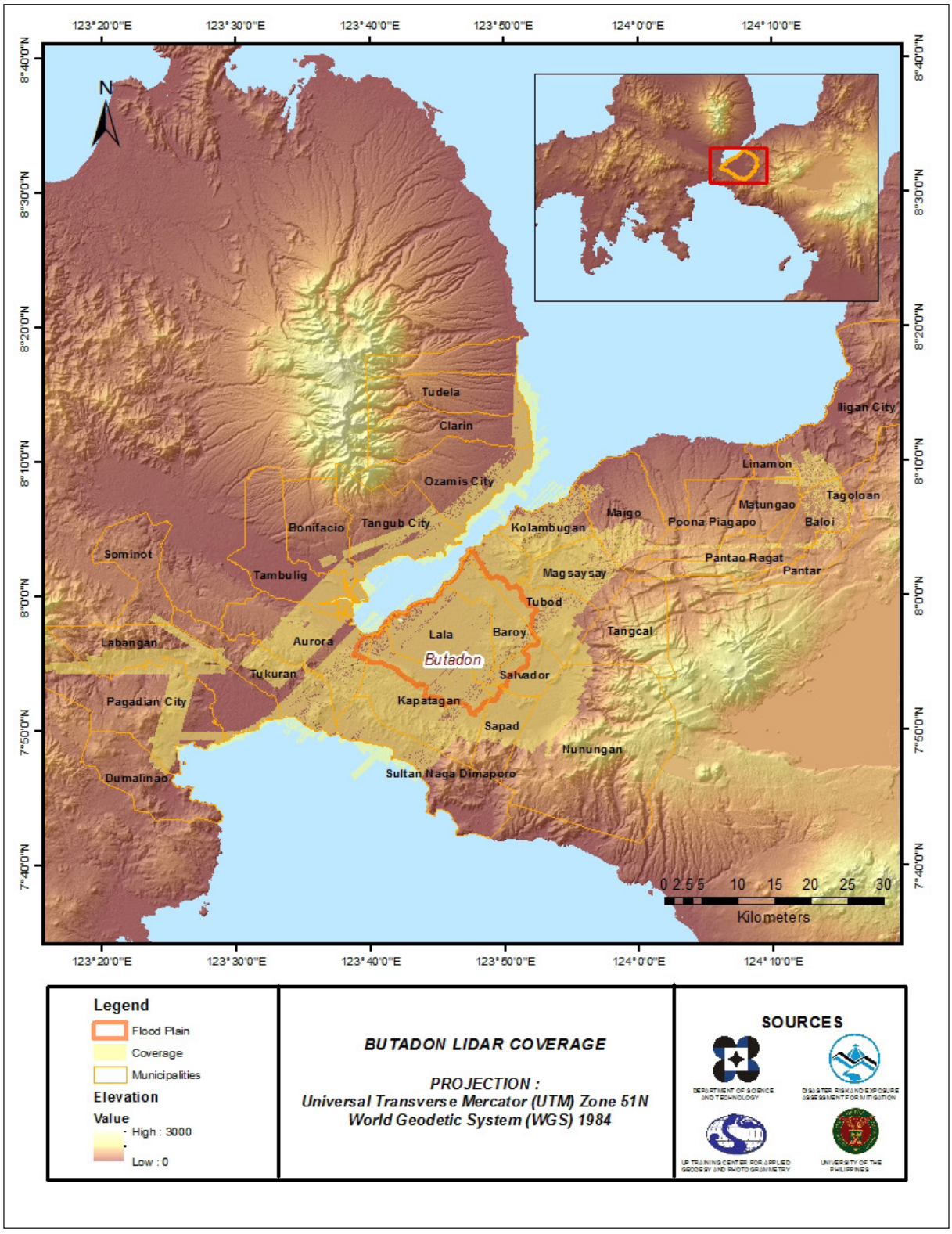


Figure 12. Actual LiDAR data acquisition for the Butadon floodplain

CHAPTER 3: LIDAR DATA PROCESSING OF THE BUTADON FLOODPLAIN

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

3.1 Overview of the LIDAR Data Pre-Processing

The data transmitted by the DAC 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 the correct position and orientation for each point acquired. The georectified LiDAR point clouds were subjected to quality checking, to ensure that the required accuracies of the program, which are the minimum point density, and the vertical and horizontal accuracies, were met. The point clouds were then categorized into various classes before generating Digital Elevation Models (DEMs), such as the Digital Terrain Model (DTM) and the Digital Surface Model (DSM).

Using the elevation of points gathered from 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 (DVBC). 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 accomplished through the help of the georectified point clouds, and the metadata containing the time the image was captured.

These processes are summarized in the diagram in Figure 13.

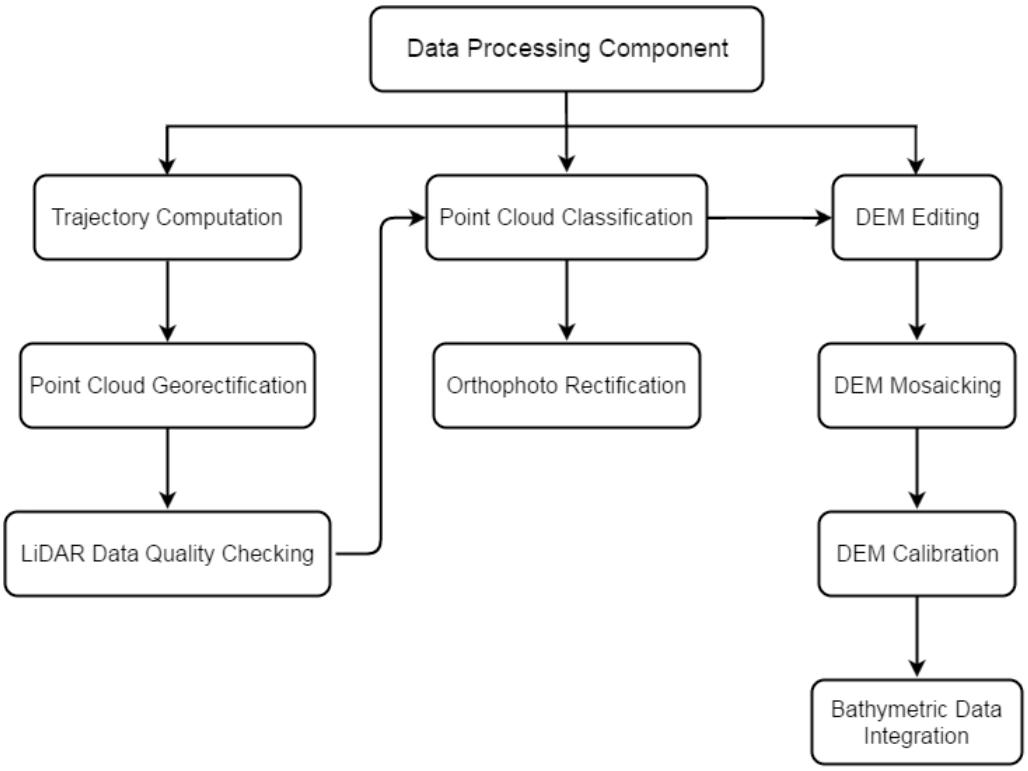

Figure 13. Schematic diagram for the Data Pre-Processing Component

3.2 Transmittal of Acquired LiDAR Data

The data transfer sheets for all the LiDAR missions for the Butadon floodplain can be found in Annex 5. The Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.)Pegasus system was used for the missions flown during the first survey conducted in June 2014,and the missions acquired during the second survey in February 2016 over Lala, Baroy, Salvador, Kapatagan, Sapad, and Nunungan in Lanao del Norte. The DAC transferred a total of 266.77 Gigabytes of Range data, 2.88 Gigabytes of POS data, 608.4 Megabytes of GPS base station data, and 254.75 Gigabytes of raw image data to the data server on June 20, 2014 for the first survey, and on March 1, 2016 for the second survey. The Data Pre-processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for Butadon was fully transferred on December 8, 2016, as indicated on the data transfer sheets for the Butadon floodplain.

3.3 Trajectory Computation

The Smoothed Performance Metric parameters of the computed trajectory for Flight 23128P, one of the Butadon flights, which are the North, East, and Down position RMSE values, are exhibited in Figure 14. 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 fell on February 26, 2016 at 00:00hrs. on that week. The y-axis represents the RMSE value for that particular position.

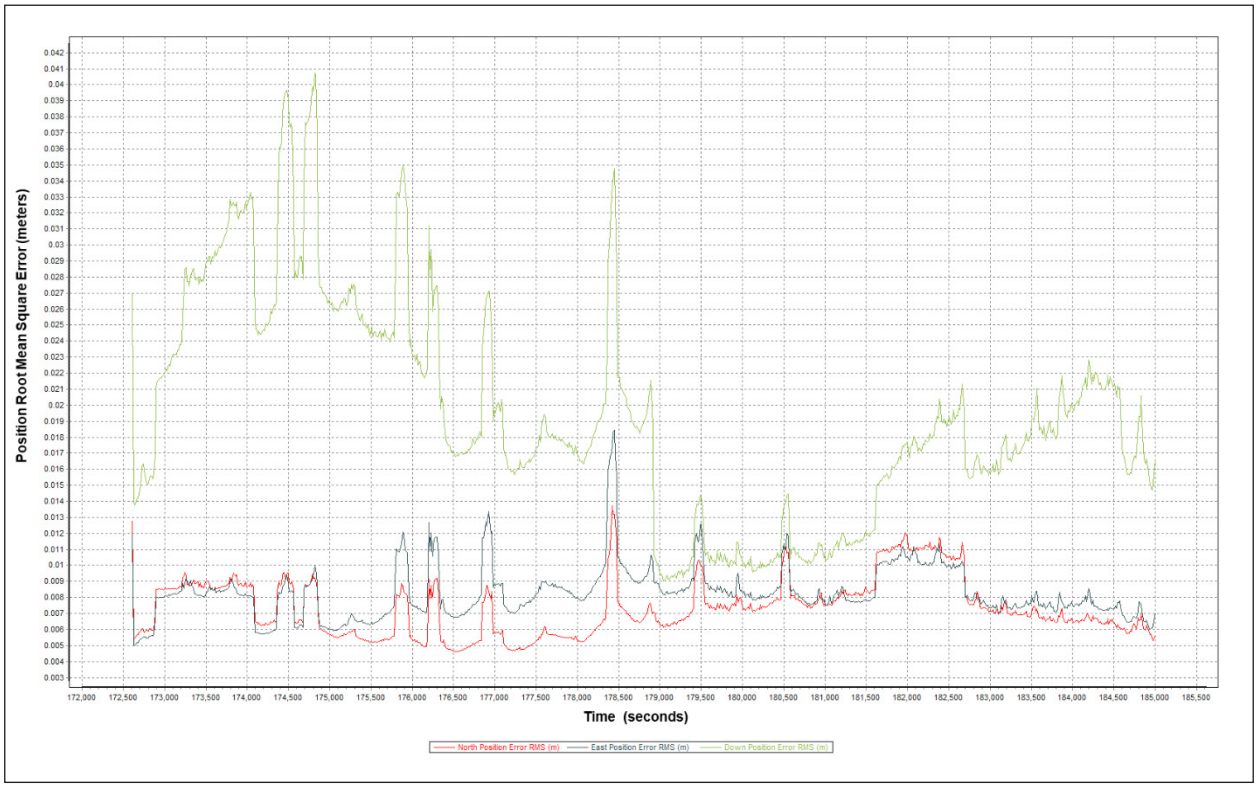

Figure 14. Smoothed Performance Metric Parameters of Butadon Flight 23128P

The time of flight was from 172,500 seconds to 185,000 seconds, which corresponds to the morning of February 26, 2016. The initial spike reflected on the data corresponds to the time that the aircraft was getting into position to start the acquisition, and the POS system was starting to compute for the position and orientation of the aircraft. Redundant measurements from the POS system quickly minimized the RMSE values of the positions. The periodic increase in RMSE values from an otherwise smoothly curving set of RMSE values corresponds to the turn-around period of the aircraft, when the aircraft makes a turn to start a new flight line. Figure 14 demonstratest hat the North position RMSE peaked at 1.40 centimeters, the East position RMSE peaked at 1. 90 centimeters, and the Down position RMSE peaked at 4.10 centimeters, which are within the prescribed accuracies described in the methodology.

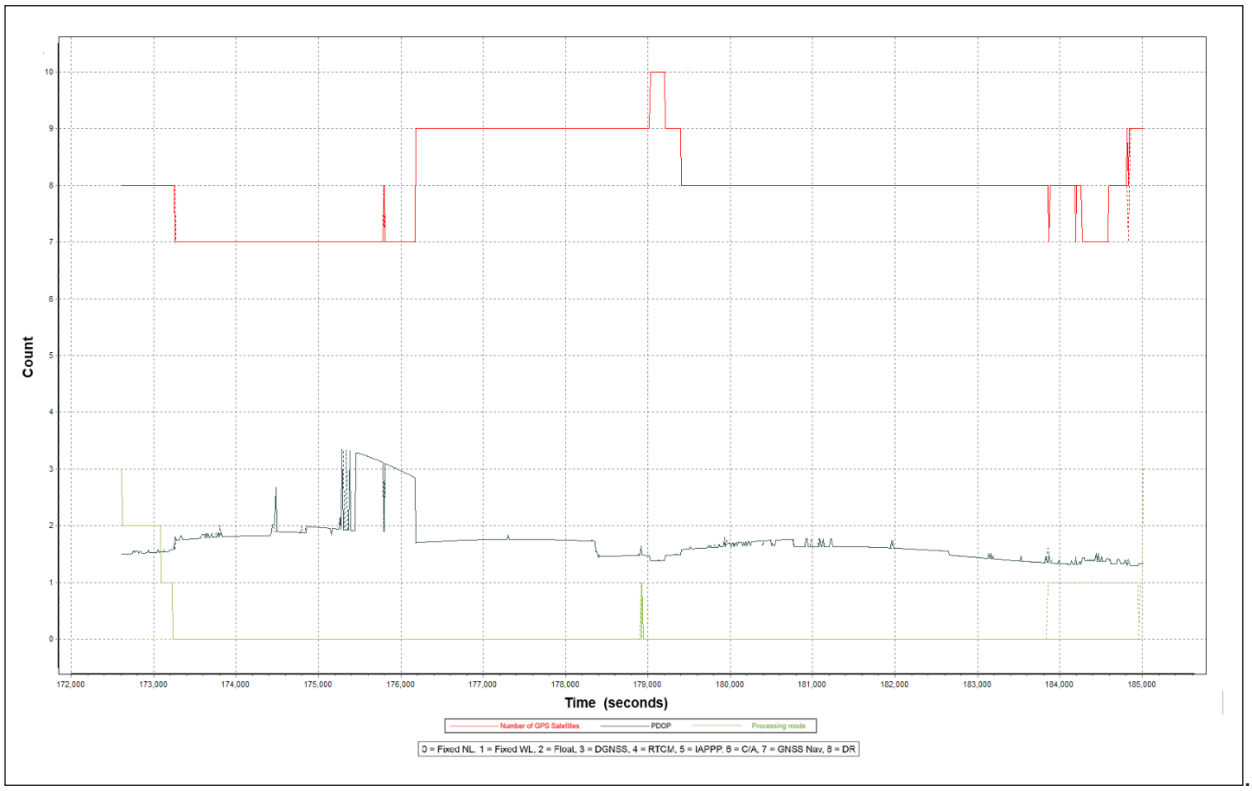

Figure 15. Solution Status Parameters of Butadon Flight 23128P

The Solution Status parameters of Flight 23128P, one of the Butadon flights, which are the number of GPS satellites, Positional Dilution of Precision (PDOP), and the GPS processing mode used, are illustrated in Figure 15. The graphs indicate that the number of satellites during the acquisition did not go down to 7. Majority of the time, the number of satellites tracked was between 7 and 10. The PDOP value also did not go above the value of 3, which indicates optimal GPS geometry. The processing mode remained at the value of 0 for majority of the survey, with some peaks to up to 1, attributed to the turns performed by the aircraft. The value of 0 represents a Fixed, Narrow-Lane mode, which is the optimum carrier-cycle integer ambiguity resolution technique available for POSPAC MMS. All of the parameters satisfied the accuracy requirements for optimal trajectory solutions, as indicated in the methodology. The computed best estimated trajectory for all Butadon flights is depictedin Figure 16.

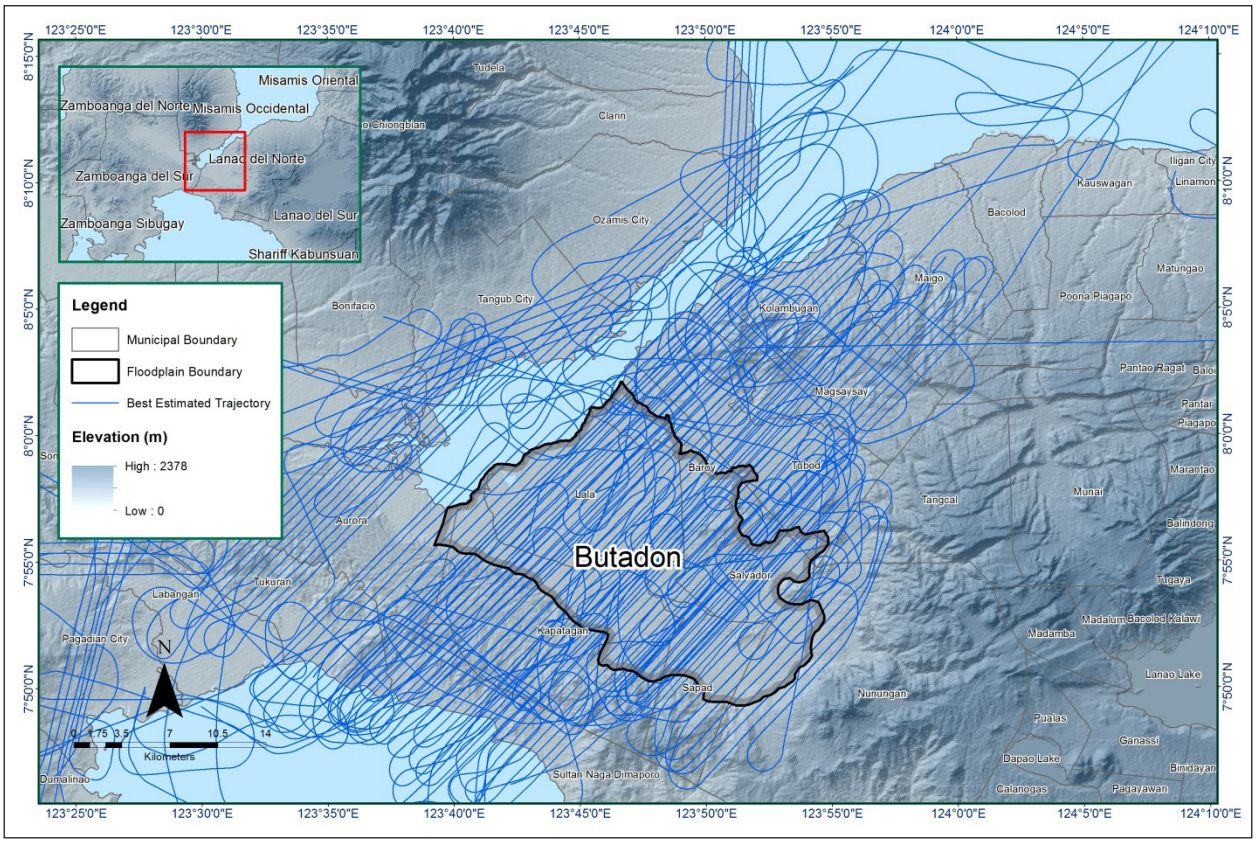

Figure 16. The best estimated trajectory conducted over the Butadon floodplain

3.4 LiDAR Point Cloud Computation

The produced LAS data contains one hundred and fifty-four (154) flight lines, with each flight line containing two(2) channels, since the Pegasus system contains two (2) channels. The summary of the self-calibration results for all flights over the Butadon floodplain, obtained through LiDAR processing in the LiDAR Mapping Suite (LMS) software,is given in Table 15.

Table 15. Self-calibration results for the Butadon flights

Parameter		Acceptable Value
Boresight Correction stdev	(<0.001degrees)	0.000128
IMU Attitude Correction Roll and Pitch Corrections stdev	(<0.001degrees)	0.000139
GPS Position Z-correction stdev	(<0.01meters)	0.0122

Optimum accuracy was obtained for all Butadon flights, based on the computed standard deviations of the corrections of the orientation parameters. The standard deviation values for the individual blocks are available in Annex 8: Mission Summary Reports.

3.5 LiDAR Data Quality Checking

The boundaries of the processed LiDAR data on top of a SAR Elevation Data over the Butadon floodplain are represented in Figure 17. The map shows gaps in the LiDAR coverage that are attributed to cloud coverage.

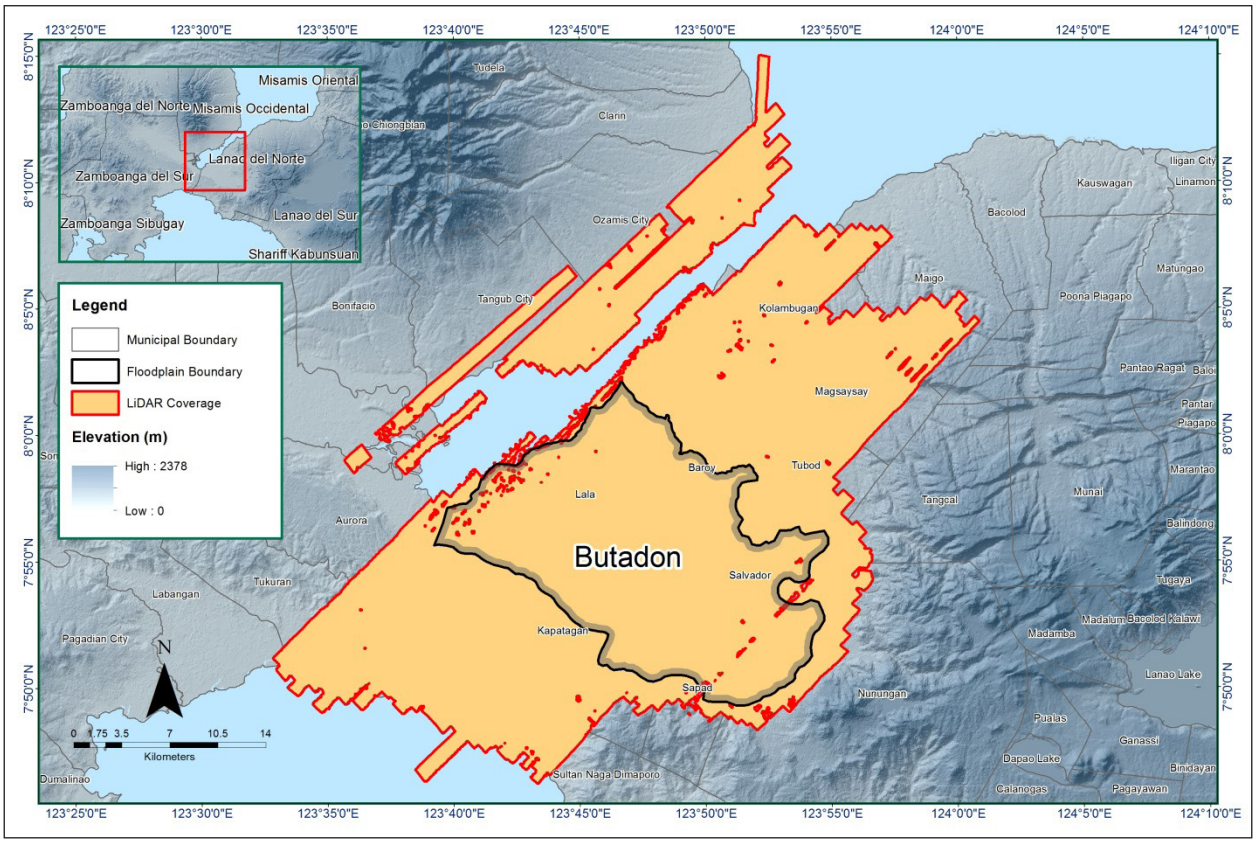

Figure 17. Boundaries of the processed LiDAR data over the Butadon floodplain

The total area covered by the Butadon missions is 1737.29 square kilometers, comprised of fourteen (14) flight acquisitions that were grouped and merged into twelve (12) blocks, as indicated in Table 16.

Table 16. List of LiDAR blocks for the Butadon floodplain

LiDAR Blocks	Flight Numbers	Area (sq.km)
Pagadian_Blk76J	23088P	37.95
Pagadian_Blk76K	23084P	182.99
Pagadian_Blk76K_additional	23104P	53.29
Pagadian_Blk76M	23128P	71.78
Pagadian_Blk76N	23088P	136.47
Pagadian_Blk76N_additional	23104P	60.44
Pagadian_Blk76N_supplement	23104P	5.30
NorthernMindanao_Blk71_extension	1665P	138.3
	1673P	
	1677P	
NorthernMindanao_Blk71E	1689P	194.58
NorthernMindanao_Blk71F	1565P	500.1
	1549P	
	1685P	
NorthernMindanao_Blk71G	1613P	282.38
Dipolog_Reflights_Blk76M	23602P	73.714
TOTAL		1,737.29 sq.km

The overlap data for the merged LiDAR blocks, showing the number of channels that pass through a particular location, is presentedin Figure 18. Since the Pegasus system employs two (2) channels, it is expected to have an average value of 2 (blue) for areas where there is limited overlap, and a value of 3 (yellow) or more (red) for areas with three or more overlapping flight lines.

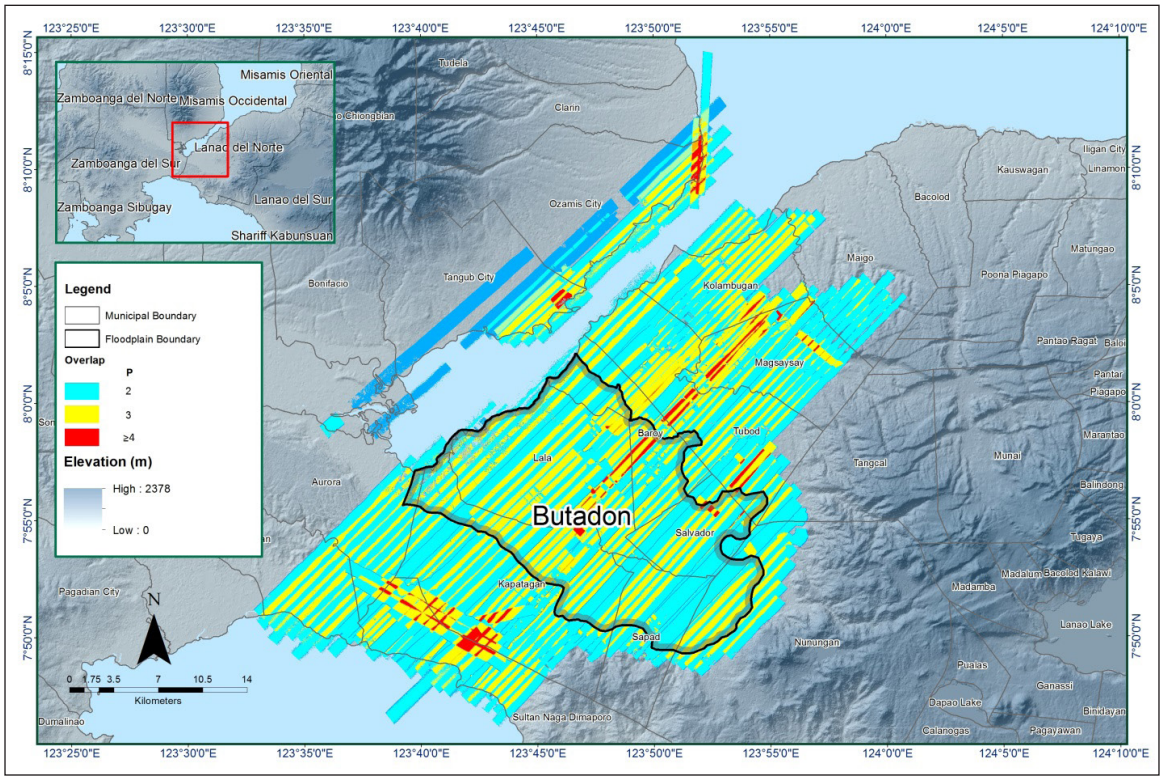

Figure 18. Image of data overlap for the Butadon floodplain

The overlap statistics per block for the Butadon floodplain can be found in Annex 8. One (1) pixel corresponds to 25.0 square meters on the ground. For this area, the minimum and maximum percent overlaps were 27.83% and 51.56%, respectively, which passed the 25% requirement.

The pulse density map for the merged LiDAR data, with the red parts showing the portions of the data that satisfy the two (2) points per square meter criterion, is presentedi n Figure 19. It was determined that all LiDAR data for the Butadon floodplain satisfy the point density requirement, and that the average density for the entire survey area is 3.32 points per square meter.

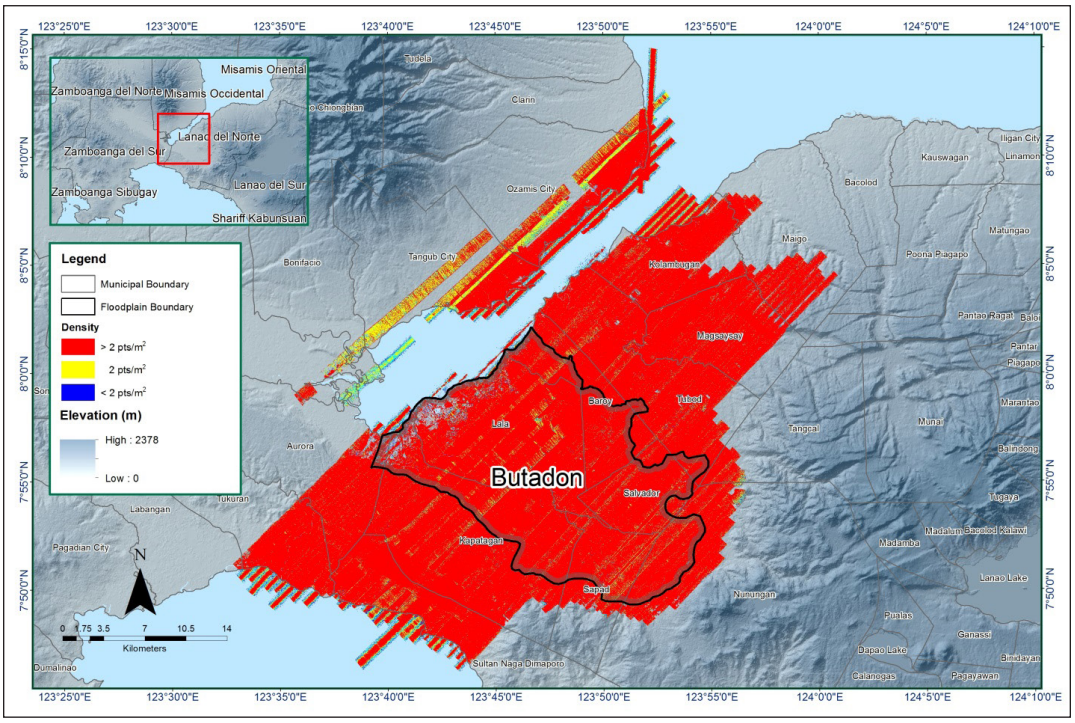

Figure 19. Pulse density map of merged LiDAR data for the Butadon floodplain

The elevation difference between overlaps of adjacent flight lines is illustrated in Figure 20. The default color range is from blue to red. Bright blue areas correspond to portions where elevations of a previous flight line, identified by its acquisition time, are higher by more than 0.20 meters relative to the elevations of its adjacent flight line. Bright red areas indicate portions where elevations of a previous flight line are lower by more than 0.20 meters relative to the elevations of its adjacent flight line. Areas with bright red or bright blue colors were investigated further using the Quick Terrain (QT) Modeler software.

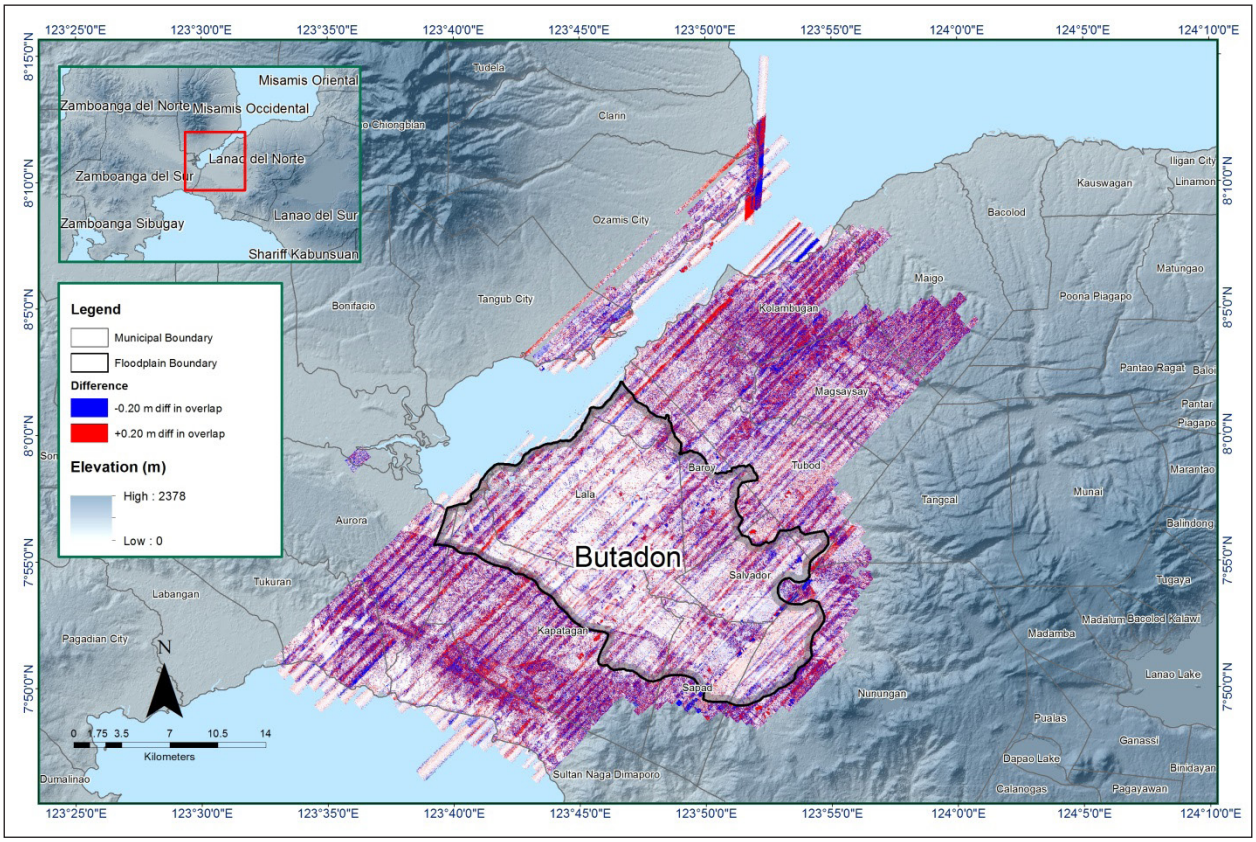

Figure 20. Elevation difference map between flight lines for the Butadon floodplain

A screen capture of the processed LAS data from a Butadon Flight 23128P loaded in the QT Modeler is shown in Figure 21. The upper left image reflects the elevations of the points from two (2) overlapping flight strips traversed by the profile, illustrated by a dashed yellow line. The x-axis represents the length of the profile. It is evident that there were differences in elevation, but the differences did not exceed the 20-centimeter mark. This profiling was repeated until the quality of the LiDAR data became satisfactory. No reprocessing was done for this LiDAR dataset.

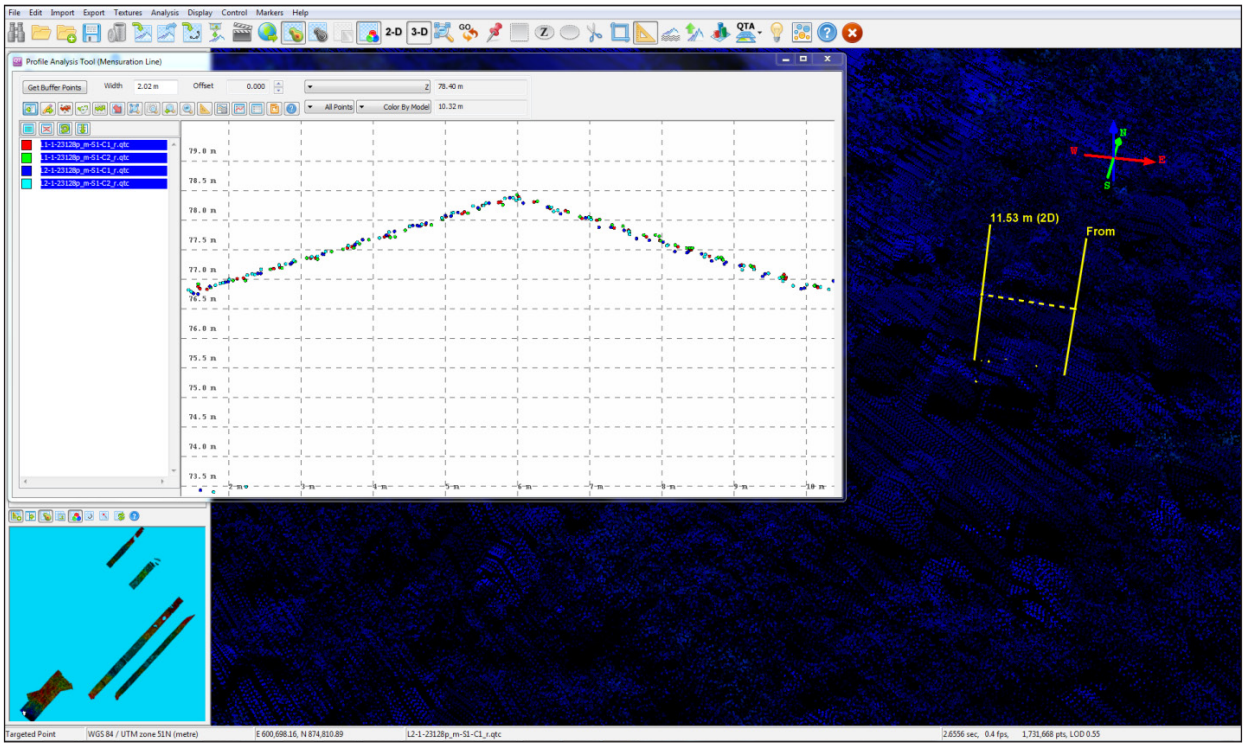

Figure 21. Quality checking for a Butadon Flight 23128P using the Profile Tool of QT Modeler

3.6 LiDAR Point Cloud Classification and Rasterization

Table 17. Butadon classification results in TerraScan

Pertinent Class	Total Number of Points
Ground	1,808,617,897
Low Vegetation	1,572,153,754
Medium Vegetation	1,928,469,461
High Vegetation	2,983,548,273
Building	68,699,481

The tile system that TerraScan employed for the LiDAR data,as well as the final classification image for a block in the Butadon floodplain,are presented in Figure 22. A total of 2,428 1km by 1km tiles were produced. The number of points classified according to the pertinent categories is illustrated in Table 17. The point cloud had a maximum and minimum height of 1,224.52 meters and 62.15 meters, respectively.

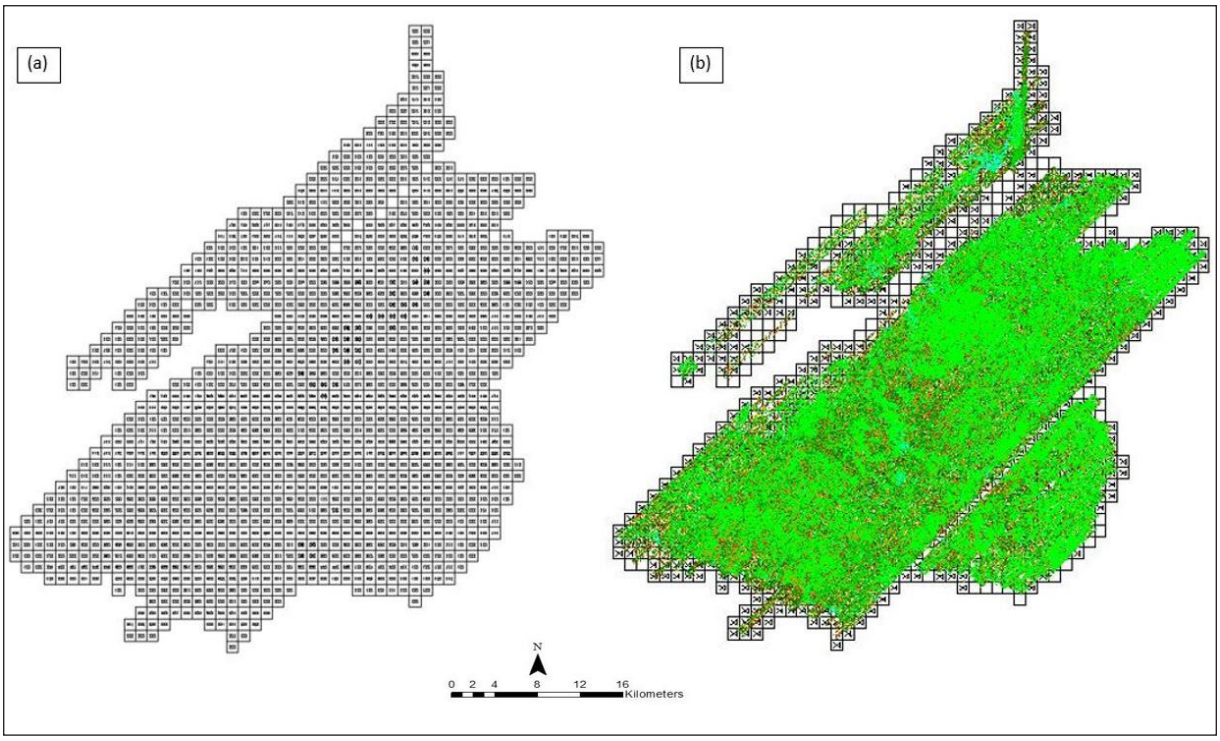

Figure 22. (a) Tiles for the Butadon floodplain; and (b) classification results in TerraScan

An isometric view of an area before and after running the classification routines is shown in Figure 23. The ground points are in orange, the vegetation is in different shades of green, and the buildings are in cyan. It is visible that the residential structures adjacent or even below canopy were classified correctly, due to the density of the LiDAR data.

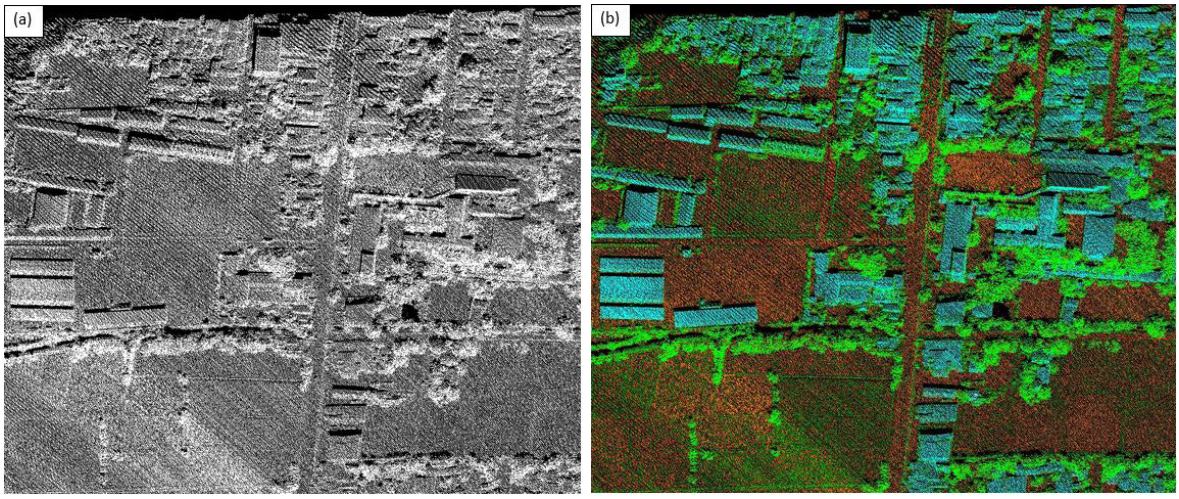

Figure 23. Point cloud (a) before and (b) after classification

The production of last return (V_ASCII) and the secondary (T_ ASCII) DTM, and the first (S_ ASCII) and last (D_ ASCII) return DSM of the area are illustrated in Figure 24, in top view display. The images convey that the DTMs are a representation of the bare earth; while the DSMs reflect all features that are present, such as buildings and vegetation.

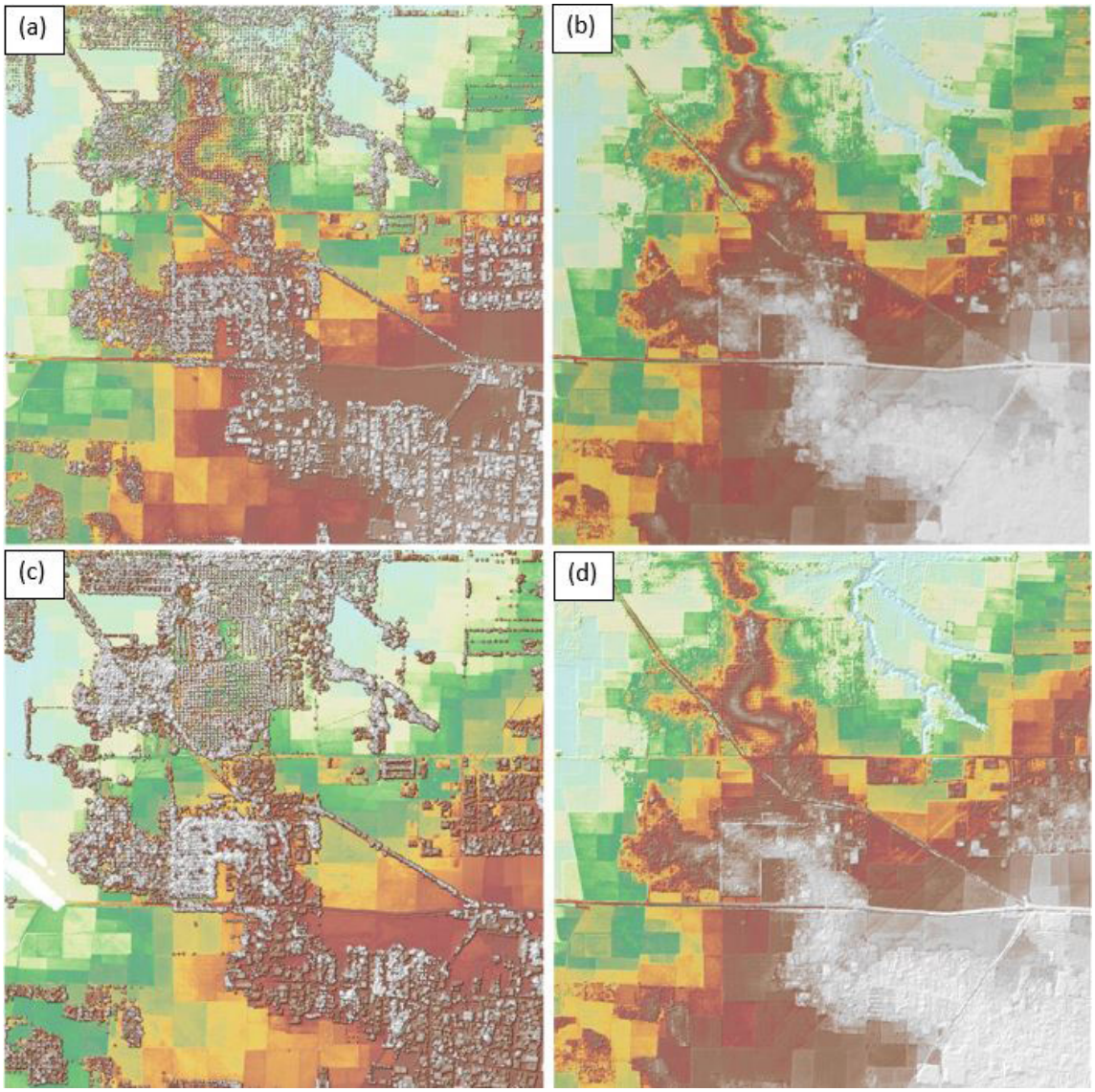

Figure 24. The (a) production of last return DSM and (b) DTM, and (c) first return DSM and (d) secondary DTM in some portion of the Butadon floodplain

3.7 LiDAR Image Processing and Orthophotograph Rectification

The 1,759 1km by 1km tiles area covered by the Butadon floodplain is illustrated in Figure 25. After employing tie point selection to fix photo misalignments, color points were added to smoothen out visual inconsistencies along the seamlines where photos overlap. The Butadon floodplain survey attained a total of 910.28 square kilometers in orthophotographic coverage, comprised of 2,828 images. Zoomed-in versions of sample orthophotographs,identified by their tile numbers,are shown in Figure 26.

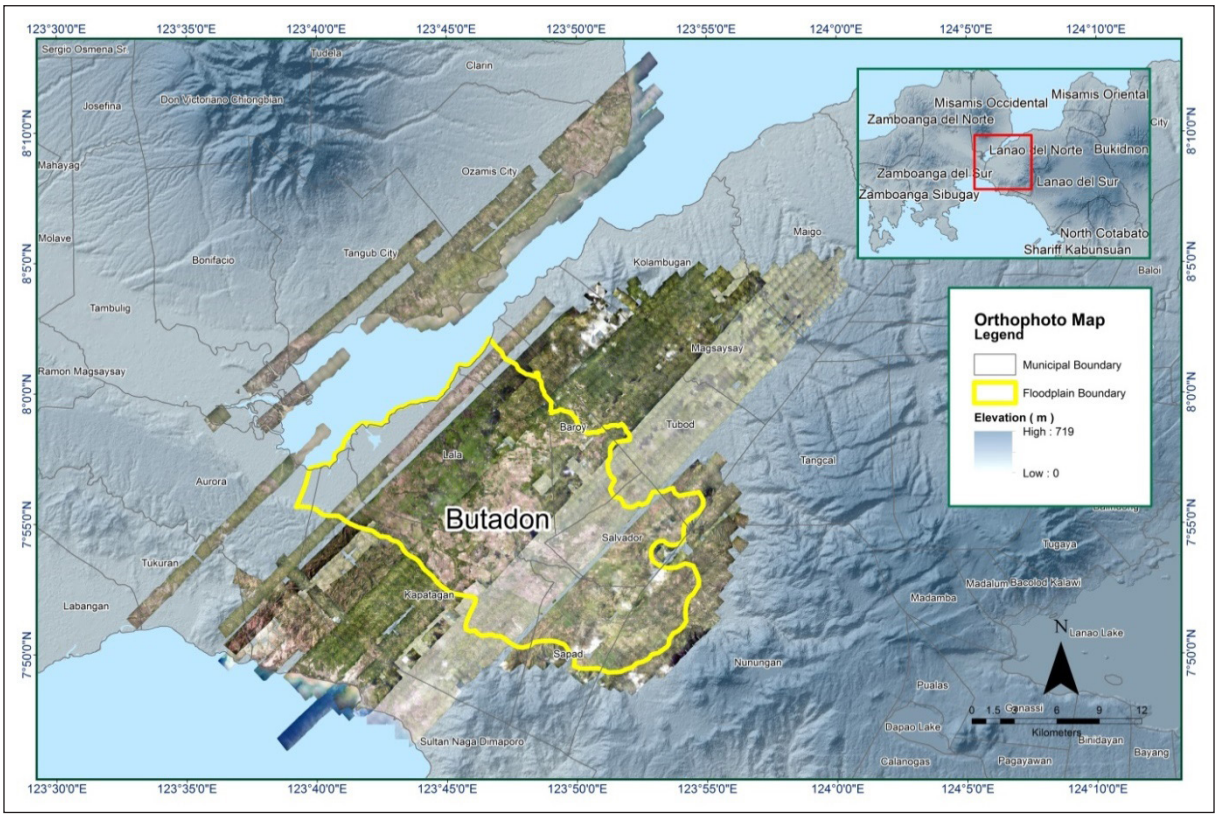

Figure 25. The Butadon floodplain with available orthophotographs

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Figure 26. Sample orthophotograph tiles for the Butadon floodplain

3.8 DEM Editing and Hydro-Correction

Twelve (12) mission blocks were processed for the Butadon floodplain. These blocks are composed of Pagadian, NorthernMindanao, and Dipolog_reflights blocks, with a total area of 1,737.29 square kilometers. Table 18 summarizes the names and corresponding areas of the blocks, in square kilometers.

Table 18. LiDAR blocks with their corresponding areas

LiDAR Blocks	Area (sq.km)
Pagadian_Blk76J	37.95
Pagadian_Blk76K	182.99
Pagadian_Blk76K_additional	53.29
Pagadian_Blk76M	71.78
Pagadian_Blk76N	136.47
Pagadian_Blk76N_additional	60.44
Pagadian_Blk76N_supplement	5.3
NorthernMindanao_Blk71_extension	138.3
NorthernMindanao_Blk71E	194.58
NorthernMindanao_Blk71F	500.1
NorthernMindanao_Blk71G	282.38
Dipolog_Reflights_Blk76M	73.714
TOTAL	1,737.29 sq.km

Portions of the DTM before and after manual editing are presented in Figure 27. The bridge (Figure 27a) was considered to be an obstruction to the flow of water along the river, and had to be removed (Figure 27b) in order to hydrologically correct the river. The river embankment (Figure 27c) was misclassified and removed during the classification process, and had to be retrieved to complete the surface (Figure 27d), in order to allow for the correct flow of water.

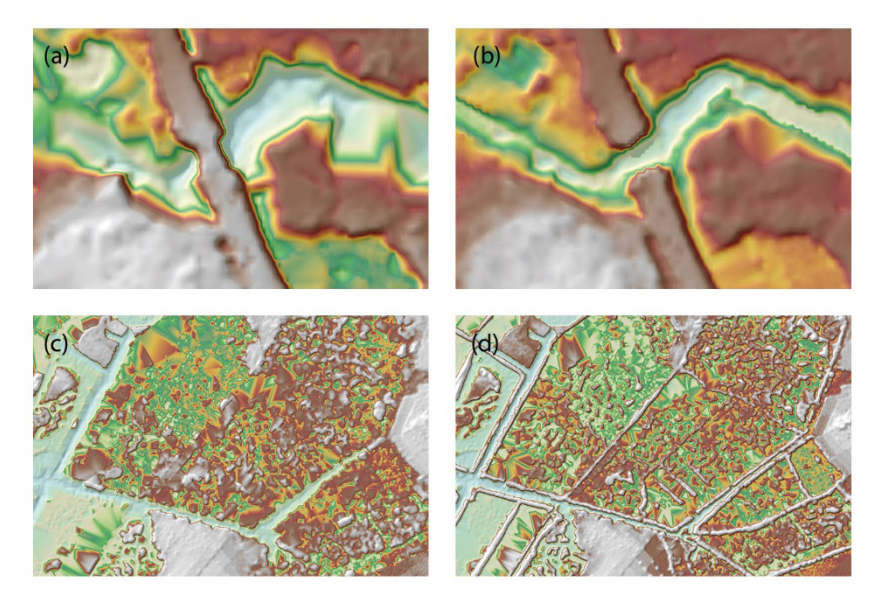


Figure 27. Portions in the DTM of the Butadon floodplain – a bridge (a) before and (b) after manual editing; a river embankment (c) before and (d) after data retrieval

3.9 Mosaicking of Blocks

The NorthernMindanao_Blk71F block was used as the reference block at the start of mosaicking, because it covers the largest area among the missions blocks.Table 19 specifies the shift values applied to each LiDAR block during the mosaicking process.

The mosaicked LiDAR DTM for the Butadon floodplain is displayed in Figure 28. The image reflects that the entire Butadon floodplain is 99.76% covered by LiDAR data.

Table 19. Shift Values of each LiDAR Block of the Butadon floodplain

Mission Blocks	Shift Values (meters)		
	x	y	z
Pagadian_Blk76J	-0.20	0.40	0.00
Pagadian_Blk76K	0.00	0.00	0.00
Pagadian_Blk76K_additional	0.00	0.00	0.00
Pagadian_Blk76M	0.00	0.00	0.00
Pagadian_Blk76N	0.00	0.00	0.00
Pagadian_Blk76N_additional	0.75	0.50	-0.45
Pagadian_Blk76N_supplement	0.05	0.05	-0.45
NorthernMindanao_Blk71_extension	0.00	0.00	0.00
NorthernMindanao_Blk71E	0.00	0.00	-0.30
NorthernMindanao_Blk71F	0.00	0.00	0.00
NorthernMindanao_Blk71G	0.00	0.00	0.00
Dipolog_Reflights_Blk76M	0.70	-0.60	-0.43

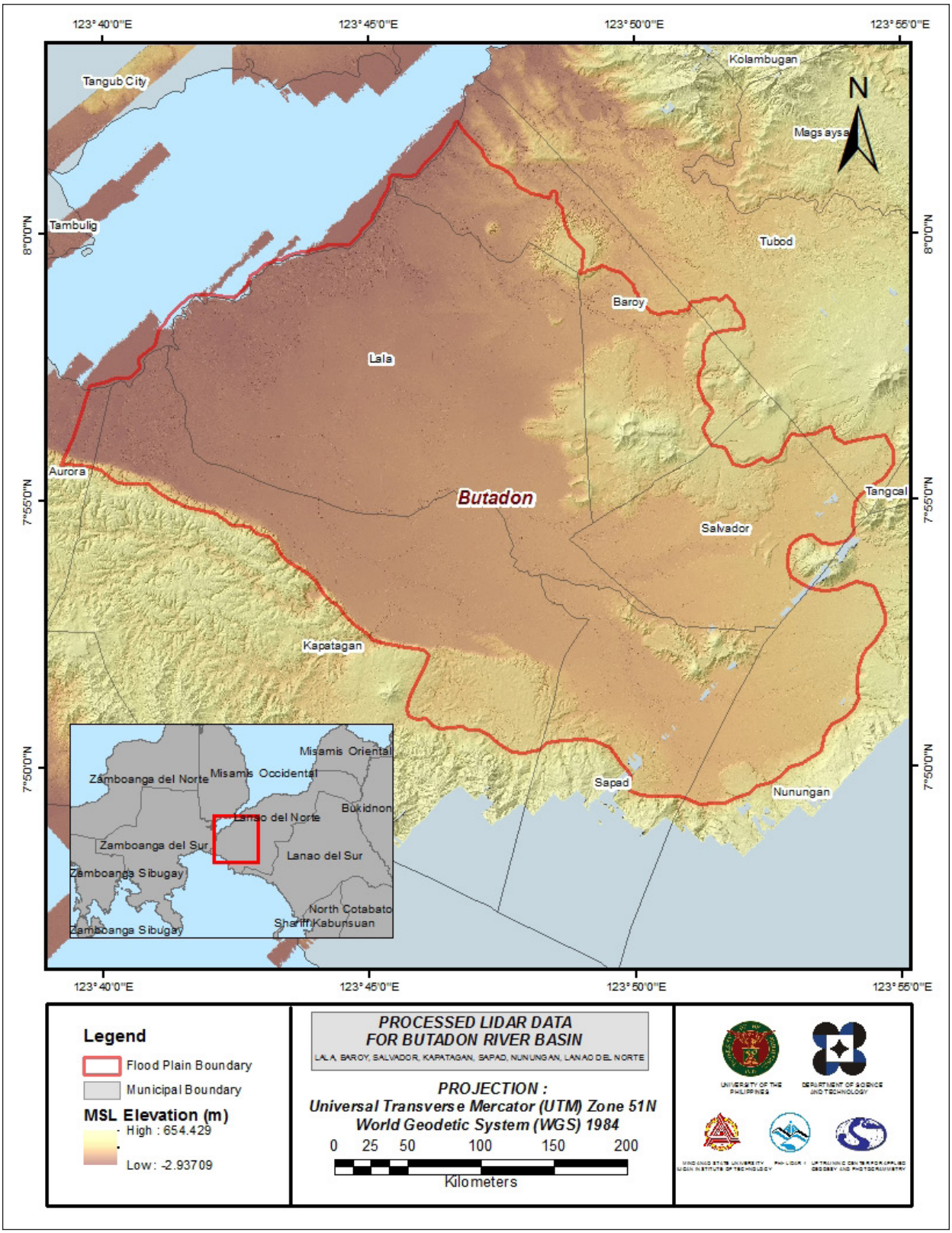


Figure 28. Map of processed LiDAR data for the Butadon floodplain

3.10 Calibration and Validation of Mosaicked LiDAR DEM

To undertake the data validation of the Mosaicked LiDAR DEMs, the DVBC conducted a validation survey along the Butadon floodplain.The extent of the validation survey done in Butadon to collect points with which the LiDAR dataset was validated is shown in Figure 29, with the validation survey points highlighted in green.

The Butadon LiDAR data were calibrated with NorthernMindanao_Blk71F as the reference block. A total of 2,003 survey points from the Butadon floodplain were used for the calibration of the Butadon DTM. Random selection of 80% of the survey points resulted in1,602 points, which were used for the calibration of the Butadon DTM. A good correlation between the uncalibrated mosaicked LiDAR elevation of values and the ground survey elevation values is reflected in Figure 30. Statistical values were computed from extracted LiDAR values using the selected points, to assess the quality of data and to obtain the values for vertical adjustment. The computed height difference between the LiDAR DTM and the calibration elevation values is 2.27 meters, with a standard deviation of 0.08 meters. Calibration of the Butadon LiDAR data was performed by adding the height difference value, 2.27 meters, to the Butadon mosaicked LiDAR data. Table 20 indicates the statistical values of the compared elevation values between the LiDAR data and the calibration data.

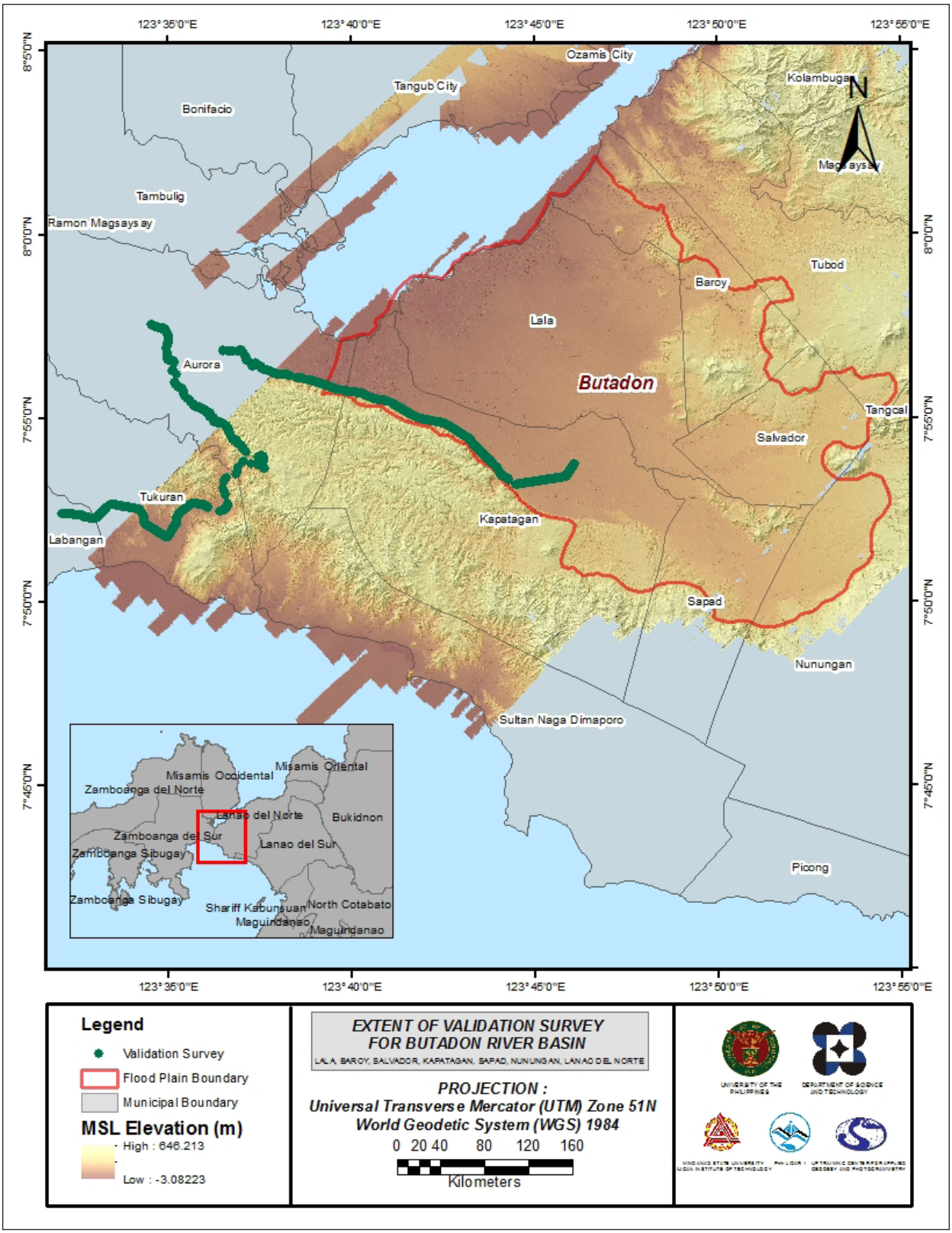


Figure 29. Map of the Butadon floodplain, with validation survey points in green

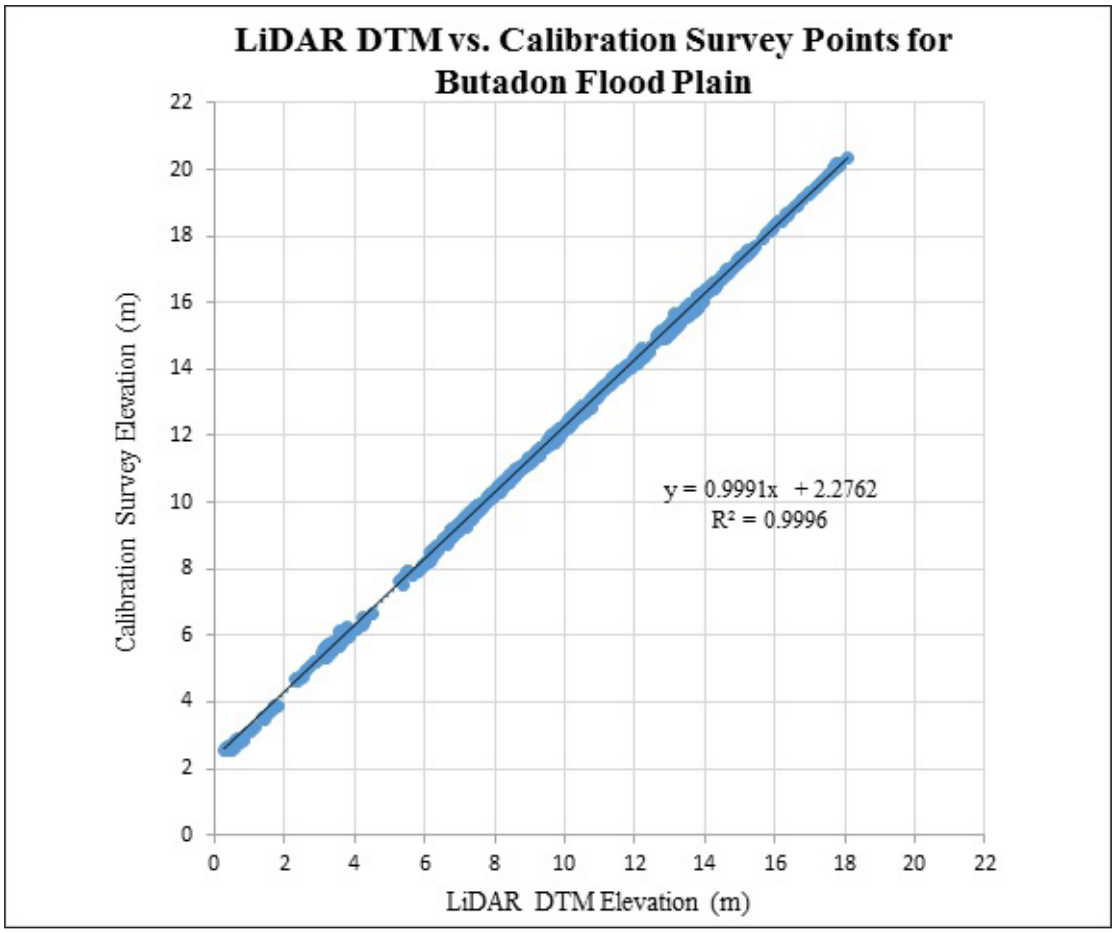


Figure 30. Correlation plot between the calibration survey points and the LiDAR data

Table 20. Calibration statistical measures

Calibration Statistical Measures	Value (meters)
Height Difference	2.27
Standard Deviation	0.08
Average	2.27
Minimum	2.06
Maximum	2.52

A total of 5,547 survey points were collected by the DVBC for the Butadon River Basin. Random selection of 20% of the total survey pointsresulted in1,110 points, which were used for the validation of the calibrated Butadon 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 reflected in Figure 31. The computed RMSE between the calibrated LiDAR DTM and validation elevation values is 0.22 meters, with a standard deviation of 0.21 meters, as shown in Table 21.

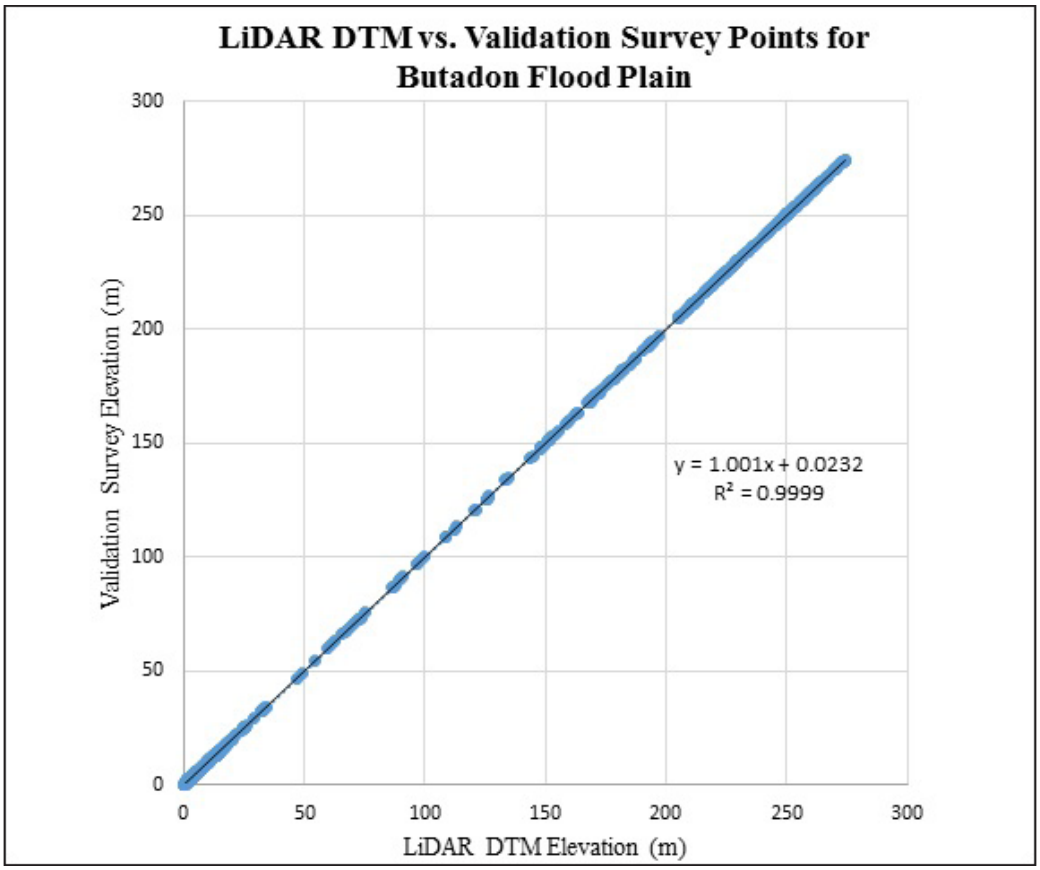


Figure 31. Correlation plot between the validation survey points and the LiDAR data

Table 21. Validation statistical measures

Validation Statistical Measures	Value (meters)
RMSE	0.22
Standard Deviation	0.21
Average	0.09
Minimum	-0.33
Maximum	0.50

3.11 Integration of Bathymetric Data into the LiDAR Digital Terrain Model

For bathy integration, centerline, zig-zag line, and cross-section data were available for Butadon, with 5,070 bathymetric survey points. The resulting raster surface produced was obtained through the Kernel interpolation method. After burning the bathymetric data to the calibrated DTM, assessment of the interpolated surface is represented by the computed RMSE value of 0.30 meters. The extent of the bathymetric survey conducted by the DVBC in the Butadon, River, integrated with the processed LiDAR DEM, is illustrated in Figure 32.

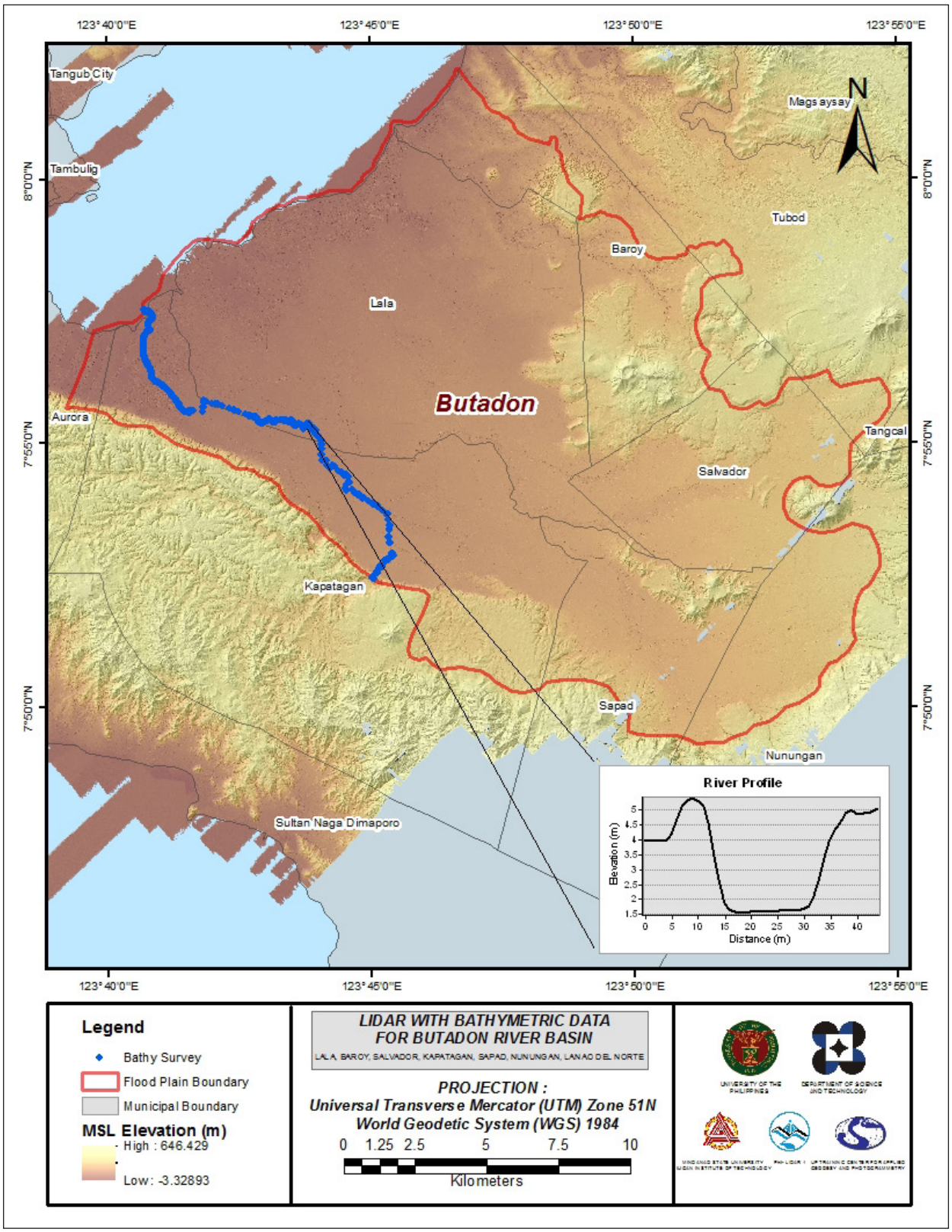


Figure 32. Map of the Butadon floodplain, with bathymetric survey points shown in blue

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 a 200-meter buffer zone. Mosaicked LiDAR DEM with a 1-meter 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 – comprised of main thoroughfares, such as highways, and municipal and barangay

roads – are essential for routing disaster response efforts. These features are represented by a network of road centerlines.

3.12.1 Quality Checking of Digitized Features' Boundary

The Butadon floodplain, including its 200-meter buffer zone, has a total area of 367.13 square kilometers. Of this area, a total of 12.00 square kilometers, corresponding to a total of 2,495 building features, were considered for quality checking (QC). Figure 33 displays the QC blocks for the Butadon floodplain.

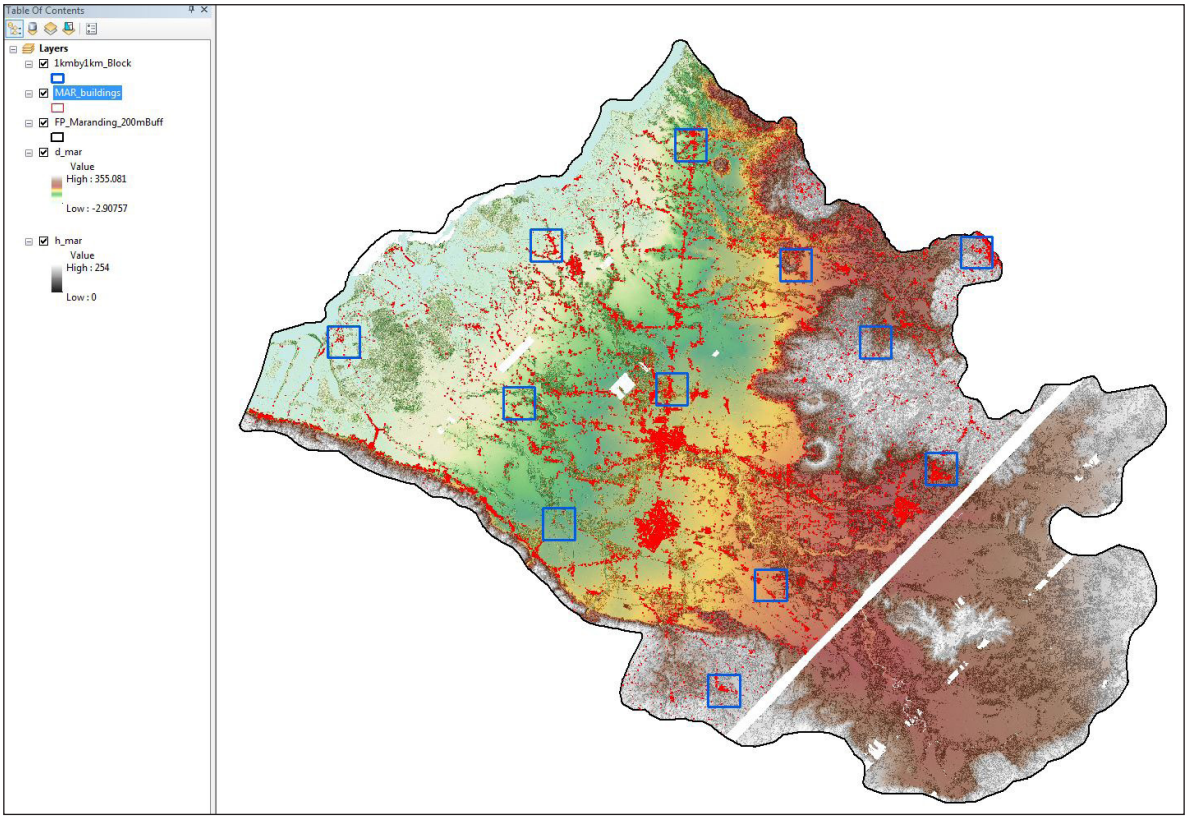


Figure 33. Blocks (in blue) of the Butadon building features that were subjected to QC

Quality checking of the Butadon building features resulted in the ratings given in Table 22.

Table 22. Quality checking ratings for the Butadon building features

FLOODPLAIN	COMPLETENESS	CORRECTNESS	QUALITY	REMARKS
Butadon	89.13	99.65	83.06	PASSED

3.12.2 Height Extraction

Height extraction was done for 53,418 building features in the Butadon floodplain. Of these building features, 1,621 were filtered out after height extraction, resulting in 51,797 buildings with height attributes. The lowest building height is at 2.00 meters, while the highest building is at 20.37meters.

3.12.3 Feature Attribution

The Butadon floodplain covers six (6) municipalities; namely, the Municipality of Lala, Municipality of Baroy, Municipality of Salvador, Municipality of Kapatagan, Municipality of Sapad, and Municipality of Nunungan. The building attribution on these municipalities was performed through the Google Earth approach. In this approach, Purok (barangay zone) representatives were requested for assistance with participatory mapping over the Google Earth software. The attributions of road, bridge, and water body features were conducted using NAMRIA maps, municipal and city records, and participatory mapping of

the municipalities and cities.

Table 23 summarizes the number of building features per type. Table 24 indicates the total length of each road type, andTable 25 providesthe number of water features extracted per type.

Table 23. Building features extracted for the Butadon floodplain

Facility Type	No. of Features
Residential	49219
School	700
Market	23
Agricultural/Agro-Industrial Facilities	365
Medical Institutions	84
Barangay Hall	87
Military Institution	38
Sports Center/Gymnasium/Covered Court	34
Telecommunication Facilities	3
Transport Terminal	4
Warehouse	167
Power Plant/Substation	1
NGO/CSO Offices	3
Police Station	5
Water Supply/Sewerage	7
Religious Institutions	298
Bank	6
Factory	2
Gas Station	13
Fire Station	3
Other Government Offices	308
Other Commercial Establishments	427
Total	51,797

Table 24. Total length of extracted roads for the Butadon floodplain

Floodplain	Road Network Length (km)					Total
	Barangay Road	City/Municipal Road	Provincial Road	National Road	Others	
Butadon	303.26	89.29	44.19	71.69	0.00	**508.43**

Table 25. Number of extracted water bodies for the Butadon floodplain

Floodplain	Water Body Type					Total
	Rivers/Streams	Lakes/Ponds	Sea	Dam	Fish Pen	
Butadon	39	0	0	3	231	273

A total of one hundred and five (105) bridges and culverts over small channels that are part of the river network were also extracted for the floodplain.

3.12.4 Final Quality Checking of Extracted Features

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

Figure 34 displays the Digital Surface Model (DSM) of the Butadon floodplain, overlaid with its ground features.

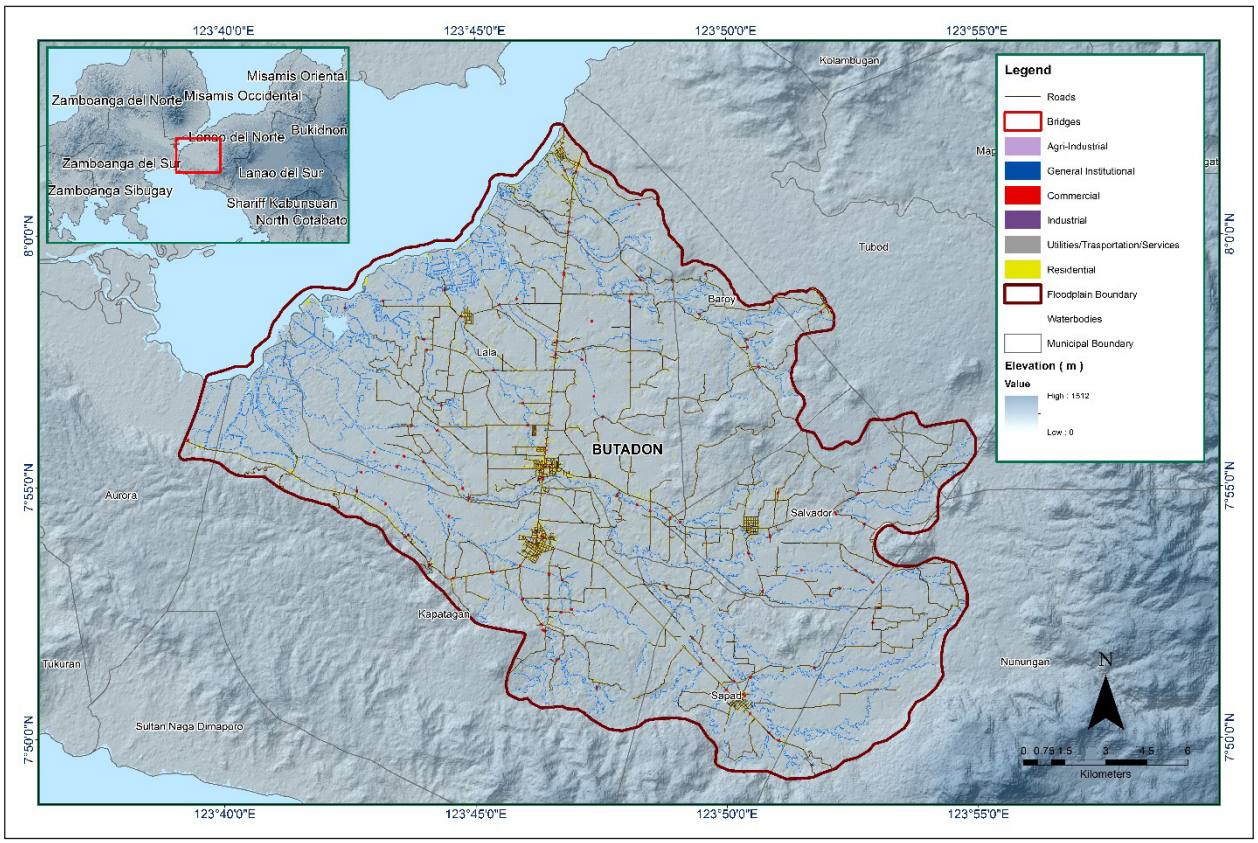


Figure 34. Extracted features for the Butadon floodplain

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

Engr. Louie P. Balicanta, Engr. Joemarie S. Caballero, Patrizcia Mae. P. dela Cruz, and Engr. Kristine Ailene B. Borromeo

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 AB Surveying and Development (ABSD) team conducted field surveys in the Butadon River on March 21, 2016 and May 11- 13, 2016.The scope of work was comprised of: (i.) initial reconnaissance; (ii.) control survey; and (iii.) cross-section and bridge as-built survey at the Butadon Bridge in Barangay Sta. Cruz, Municipality of Kapatagan, Lanao del Norte. Random checking points for the contractor's cross-section and bathymetry data were gathered by the DVBC on August 19, 2016 using a Trimble® SPS 882 GNSS in PPK survey technique. In addition to this, the validation points acquisition survey was conducted, covering the Butadon River Basin area. The entire survey extent is illustrated in Figure 35.

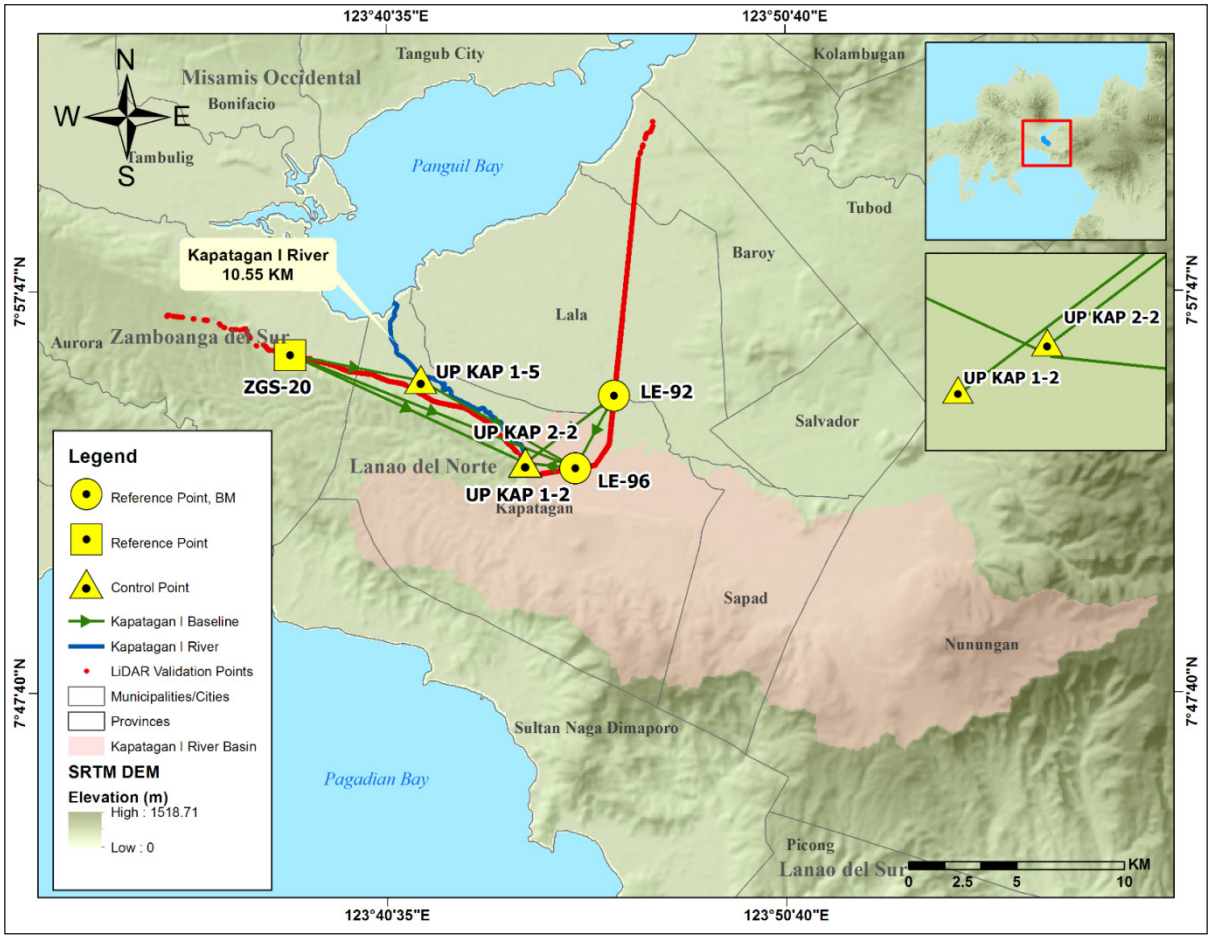


Figure 35. Extent of the bathymetric survey (in blue line) in the Butadon River and the LiDAR data validation survey (in red)

4.2 Control Survey

The GNSS network used for the Butadon River is composed of four (4) loops established on August 8 and November 2, 2016, occupying the following reference points: (i.) ZGS-20, a second-order GCP, in Barangay Anonang, Municipality of Aurora, Zamboanga del Sur; (ii.) LE-92, a first-order BM, in Barangay Maranding,

Municipality of Lala, Lanao del Norte; and (iii.) LE-96, a first-order BM, in Barangay Poblacion, Municipality of Kapatagan, Lanao del Norte.

Three (3) control points established in the area were also occupied. These are: (i.) UP_KAP 1-2, located near the approach of the Butadon Bridge in Barangay Sta. Cruz, Municipality of Kapatagan, Province of Lanao del Norte; (ii.) UP_KAP 1-5, located within a basketball court in Barangay Lapinig, Municipality of Kapatagan, Province of Lanao del Norte; and (iii.) UP_KAP 2-2, located near the approach of the Butadon Bridge in Barangay Sta. Cruz, Municipality of Kapatagan, Province of Lanao del Norte.

The summary of reference and control points and their corresponding locations is provided in Table 26; while the established GNSS network is illustrated in Figure 36.

Table 26. List of reference and control points used during the survey in the Butadon River (Source: NAMRIA, UP-TCAGP)

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)				
		Latitude	Longitude	Ellipsoid Height (m)	Elevation (MSL) (m)	Date of Establishment
ZGS-20	2nd order, GCP	7°56'10.67208"N	123°38'09.10220"E	95.136	26.596	2005
LE-92	1st order, BM	7°55'08.47442"N	123°46'19.89121"E	89.406	20.730	2007
LE-96	1st order, BM	7°53'19.07415"N	123°45'21.01225" E	85.854	17.153	2007
UP_KAP 1-2	Established	7°53'27.09042"N	123°44'05.15906"E	87.865	19.212	05-11-16
UP_KAP 1-5	Established	7°55'33.70206"N	123°41'26.70374"E	70.334	1.798	05-11-16
UP_KAP 2-2	Established	7°53'27.09071"N	123°44'05.15960"E	87.673	19.021	05-11-16

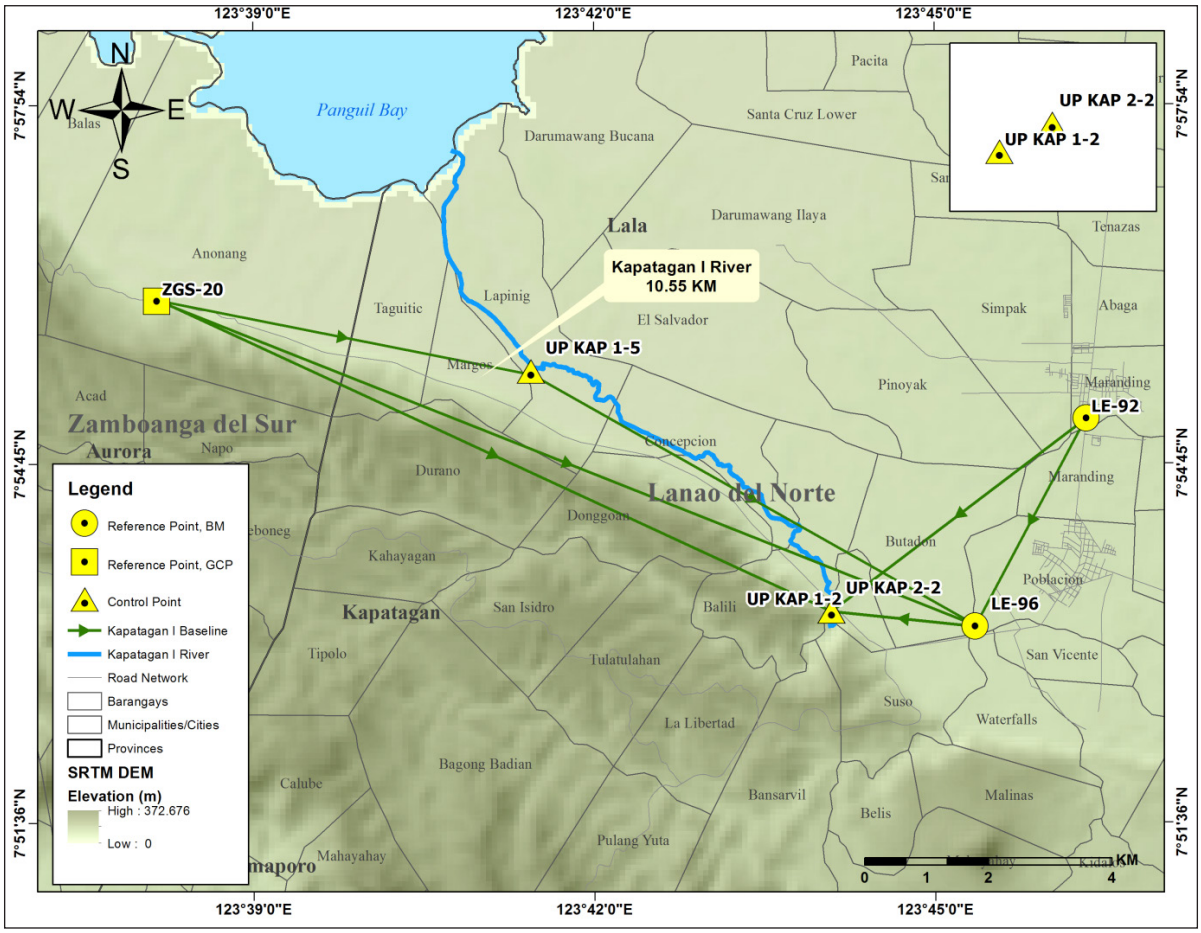


Figure 36. Butadon River Basin control survey extent

The GNSS set-ups on the recovered reference points and established control points in the Butadon River are exhibited in Figure 37 to Figure 42.

Figure 37. GNSS receiver set-up, Trimble® SPS 882 at ZGS-20, located on the side of the National Highway from Zamboanga del Sur towards Lanao del Norte in Barangay Anonang, Municipality of Aurora, Zamboanga del Sur

Figure 38. GNSS receiver set-up, Trimble® SPS 985 at LE-96, located at the approach of the Butadon Bridge in Barangay Poblacion, Municipality of Kapatagan, Lanao del Norte

Figure 39. GNSS receiver set-up, Trimble® SPS 882 at LE-92, located in Barangay Maranding, Municipality of Lala, Lanao del Norte

Figure 40. GNSS receiver set-up, Hi-Target® V30 at UP_KAP 1-5, located in a basketball court in Barangay Lapinig, Municipality of Kapatagan, Lanao del Norte

Figure 41. GNSS receiver set-up, Trimble® SPS 985 at UP_KAP 1-2, located near the approach of the Butadon Bridge in Barangay Sta. Cruz, Municipality of Kapatagan, Lanao del Norte

Figure 42. GNSS receiver set-up, Trimble® SPS 882 at UP-KAP 2-2, located near the approach of the Butadon Bridge in Barangay Sta. Cruz, Municipality of Kapatagan, Lanao del Norte

4.3 Baseline Processing

The GNSS baselines were processed simultaneously in TBC by observing that all baselines have fixed solutions, with horizontal and vertical precisions within the +/- 20-centimeter and +/- 10-centimeter requirement, respectively. In cases where one or more of the baselines did not meet all of these criteria, masking was performed. Masking is the removal of 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, a re-survey is initiated. The baseline processing results of control points in the Butadon River Basin, generated by the TBC software, are summarized in Table 27.

Table 27. Baseline processing report for the Butadon River static survey

Observation	Date of Observation	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	Height (m)
LE-92 --- UP KAP 1-2	8-18-2016	Fixed	0.005	0.024	232°57'38"	5170.225	-1.528
UP KAP 1-5 --- LE-96	8-18-2016	Fixed	0.006	0.029	119°57'00"	8283.207	15.481
LE-96 --- UP KAP 2-2	8-18-2016	Fixed	0.007	0.048	276°03'08”	2336.448	1.831
LE-96 --- UP KAP 1-2	8-18-2016	Fixed	0.014	0.072	276°03'09”	2336.467	1.877
LE-92 --- LE-96	8-18-2016	Fixed	0.012	0.055	208°13'12"	3814.139	-3.443
UP KAP 1-5 --- ZGS-20	8-18-2016	Fixed	0.003	0.019	100°37'31"	6157.763	-24.818
UP KAP 2-2 --- ZGS-20	8-18-2016	Fixed	0.005	0.029	114°44'01"	12007.875	-7.467
ZGS-20 --- LE-96	8-18-2016	Fixed	0.007	0.045	111°43'07"	14240.741	-9.312
LE-96 --- ZGS-20	8-18-2016	Fixed	0.007	0.051	111°43'07"	14240.722	-9.327

As shown inTable 27, a total of nine (9) baselines were processed, with the coordinate and ellipsoidal height values of ZGS-20 and LE-92 held fixed. All of the baselines satisfied the required accuracy.

4.4 Network Adjustment

After the baseline processing procedure, network adjustment was performed using Spectra Precision. Looking at the adjusted grid coordinates table of the Spectra Precision-generated Network Adjustment Report, it is observed that the square root of the squares of x and y must be less than 20 centimeters,and z less than 10 centimeters, orin equation form:

$$\sqrt{((x)^2 + (y)^2)} < 20\ cm \text{ and } z < 10\ cm$$

Where:

x is the Easting Error,

y is the Northing Error, and

z is the Elevation Error

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

The six (6) control points – ZGS-20, LE-92, LE-96, UP_KAP-1-2, UP_KAP-1-5, and UP_KAP-2-2 – were occupied and observed simultaneously to form a GNSS loop. The coordinates and ellipsoidal heights of ZGS-20 and LE-92 were held fixed during the processing of the control points, as presented in Table 28. Through this reference point, the coordinates and ellipsoidal height of the unknown control points were computed.

Table 28. Constraints applied to the adjustments of the control points

Point ID	Type	East σ (Meter)	North σ (Meter)	Height σ (Meter)	Elevation σ (Meter)
LE-92	Global	Fixed	Fixed	Fixed	
ZGS-20	Global	Fixed	Fixed	Fixed	
Fixed = 0.000001(Meter)					

Table 29. Adjusted grid coordinates for the control points used in the Butadon floodplain survey

Point ID	Easting (Meter)	Easting Error (Meter)	Northing (Meter)	Northing Error (Meter)	Elevation (Meter)	Elevation Error (Meter)	Constraint
ZGS-20	570083.672	?	877309.182	?	26.596	?	LLh
LE-92	585114.134	?	875424.503	?	20.730	?	LLh
LE-96	583317.383	0.019	872061.376	0.019	17.153	0.059	
UP KAP 1-2	580994.200	0.012	872303.417	0.011	19.212	0.068	
UP KAP 1-5	576135.647	0.011	876183.473	0.010	1.798	0.051	
UP KAP 2-2	580994.217	0.019	872303.426	0.019	19.021	0.077	

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

a. ZGS-20

Horizontal Accuracy = Fixed
Vertical Accuracy = Fixed

b. LE-92

Horizontal Accuracy = Fixed
Vertical Accuracy = Fixed

c. LE-96

Horizontal Accuracy = √((1.9)² + (1.9)²
= √ (3.61+ 3.61)
= 7.22 < 20 cm
Vertical Accuracy = 5.9 < 10 cm

d. UP KAP 1-2

Horizontal Accuracy = √((1.2)² + (1.1)²
= √ (1.44 + 1.21)
= 2.65 < 20 cm
Vertical Accuracy = 6.8 < 10 cm

e. UP KAP 1-5

Horizontal Accuracy = √((1.1)² + (1.0)²
= √ (1.21 + 1.0)
= 2.21 < 20 cm
Vertical Accuracy = 5.1 < 10 cm

f. UP KAP 2-2

Horizontal Accuracy = √((1.9)² + (1.9)²
= √ (3.61 + 3.61)
= 7.22 < 20 cm
Vertical Accuracy = 7.7 < 10 cm

Following the given formula, the horizontal and vertical accuracy results of the six (6) occupied control points are within the required precision.

Table 30. Adjusted geodetic coordinates for control points used in the Butadon River floodplain validation

Point ID	Latitude	Longitude	Height (Meter)	Height Error (Meter)	Constraint
LE-92	7°55'08.47442"N	123°46'19.89121"E	89.406	?	LLh
LE-96	7°53'19.07415"N	123°45'21.01225"E	85.854	0.059	
UP KAP 1-2	7°56'10.67208"N	123°38'09.10220"E	87.865	0.068	
UP KAP 1-5	7°53'27.09042"N	123°44'05.15906"E	70.334	0.051	
UP KAP 2-2	7°55'33.70206"N	123°41'26.70374"E	87.673	0.077	
ZGS-20	7°53'27.09071"N	123°44'05.15960"E	95.136	?	LLh

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

The computed coordinates of the reference and control points utilized in the Butadon River GNSS Static Survey are indicated in Table 31.

Table 31. Reference and control points used in the Butadon River Static Survey, with their corresponding locations (Source: NAMRIA, UP-TCAGP)

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)			UTM Zone 51N		
		Latitude	Longitude	Ellipsoidal Height (Meter)	Northing (m)	Easting (m)	BM Ortho (m)
LE-92	2nd Order, GCP	7°55'08.47442"N	123°46'19.89121"E	95.136	877309.182	570083.672	26.596
LE-96	1st Order, BM	7°53'19.07415"N	123°45'21.01225"E	89.406	875424.503	585114.134	20.730
ZGS-20	2nd Order, GCP	7°56'10.67208"N	123°38'09.10220"E	87.673	872303.426	580994.217	19.021
UP KAP 1-2	Established	7°53'27.09042"N	123°44'05.15906"E	85.854	872061.376	583317.383	17.153
UP KAP 1-5	Established	7°55'33.70206"N	123°41'26.70374"E	87.865	872303.417	580994.200	19.212
UP_KAP 2-2	Established	7°53'27.09071"N	123°44'05.15960"E	70.334	876183.473	576135.647	1.798

4.5 Cross-section and Bridge As-Built Survey and WaterLevel Marking

The cross-section and bridge as-built surveys were conducted on May 11, 2016 by the ABSD at the upstream side of the Butadon Bridge in Barangay Sta. Cruz, Municipality of Kapatagan, Lanao del Sur (Figure 43). A Nikon®Total Station was utilized for this survey, as depictedin Figure 44.

Figure 43. Downstream side of the Butadon Bridge

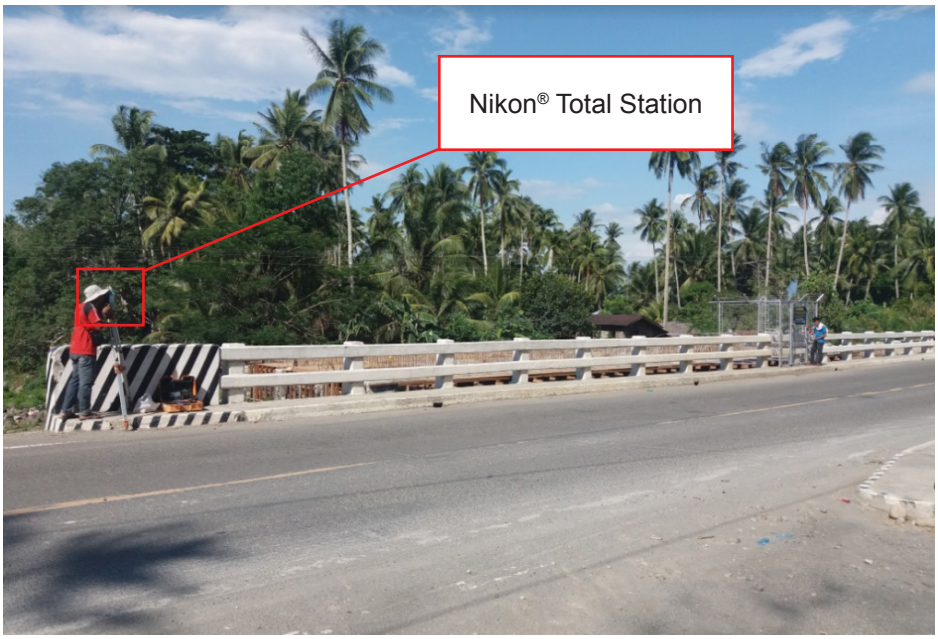


Figure 44. As-built survey of Butadon Bridge

The cross-sectional line surveyed in the Butadon Bridge is about 124.283 meterswith thirty-one (31) cross-sectional points, using the control points UP_KAP 1-1 and UP_KAP 1-2 as the GNSS base stations. The location map, cross-section diagram, and the bridge data form are presented in Figure 45to Figure 47.

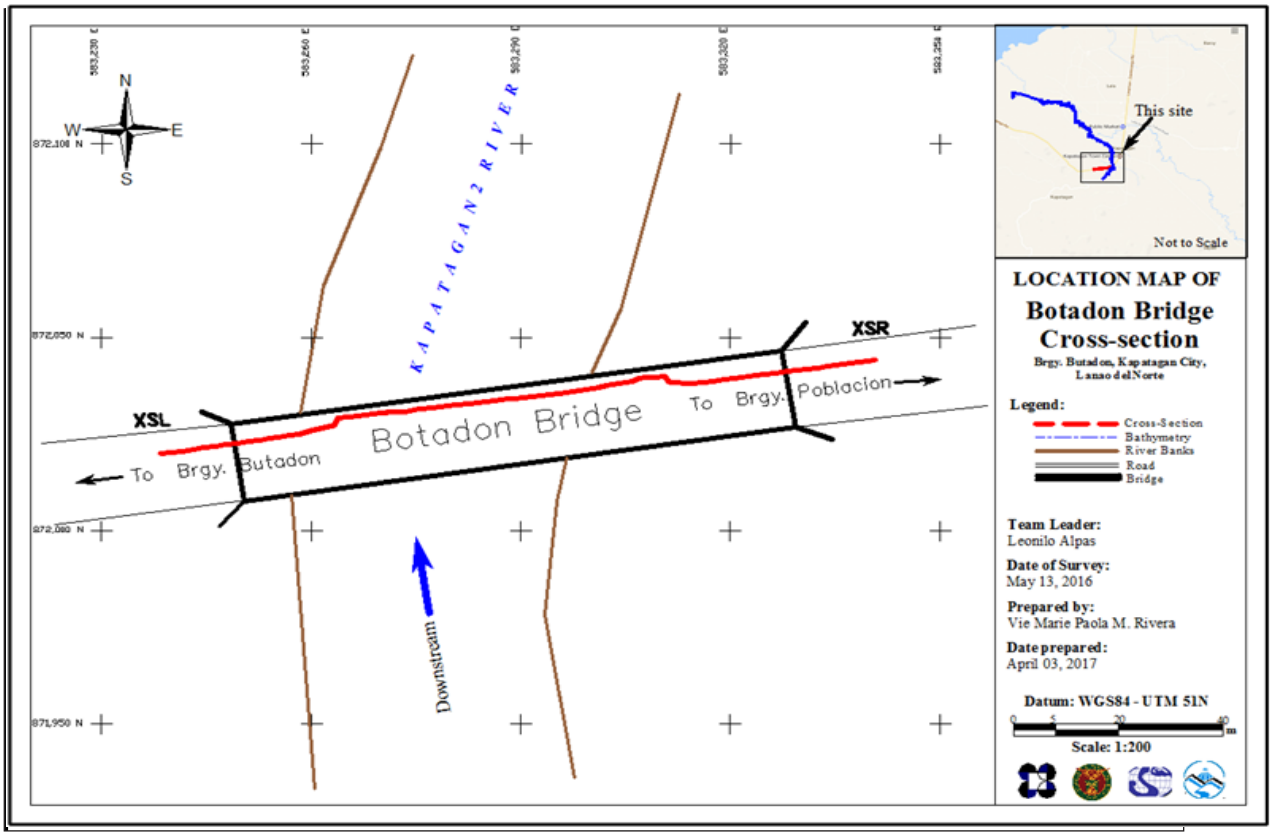


Figure 45. Butadon Bridge cross-section location map

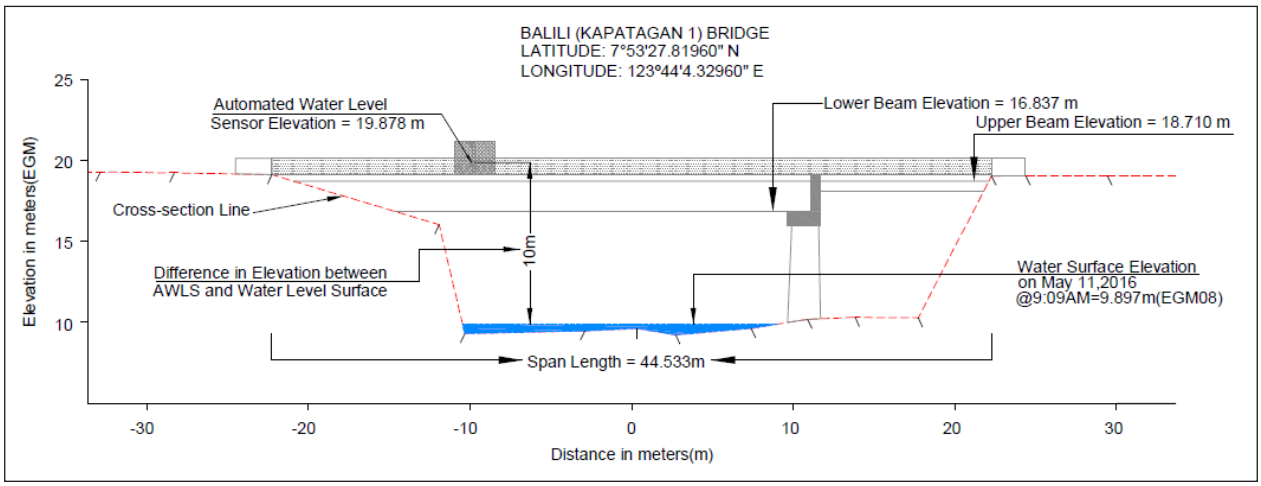
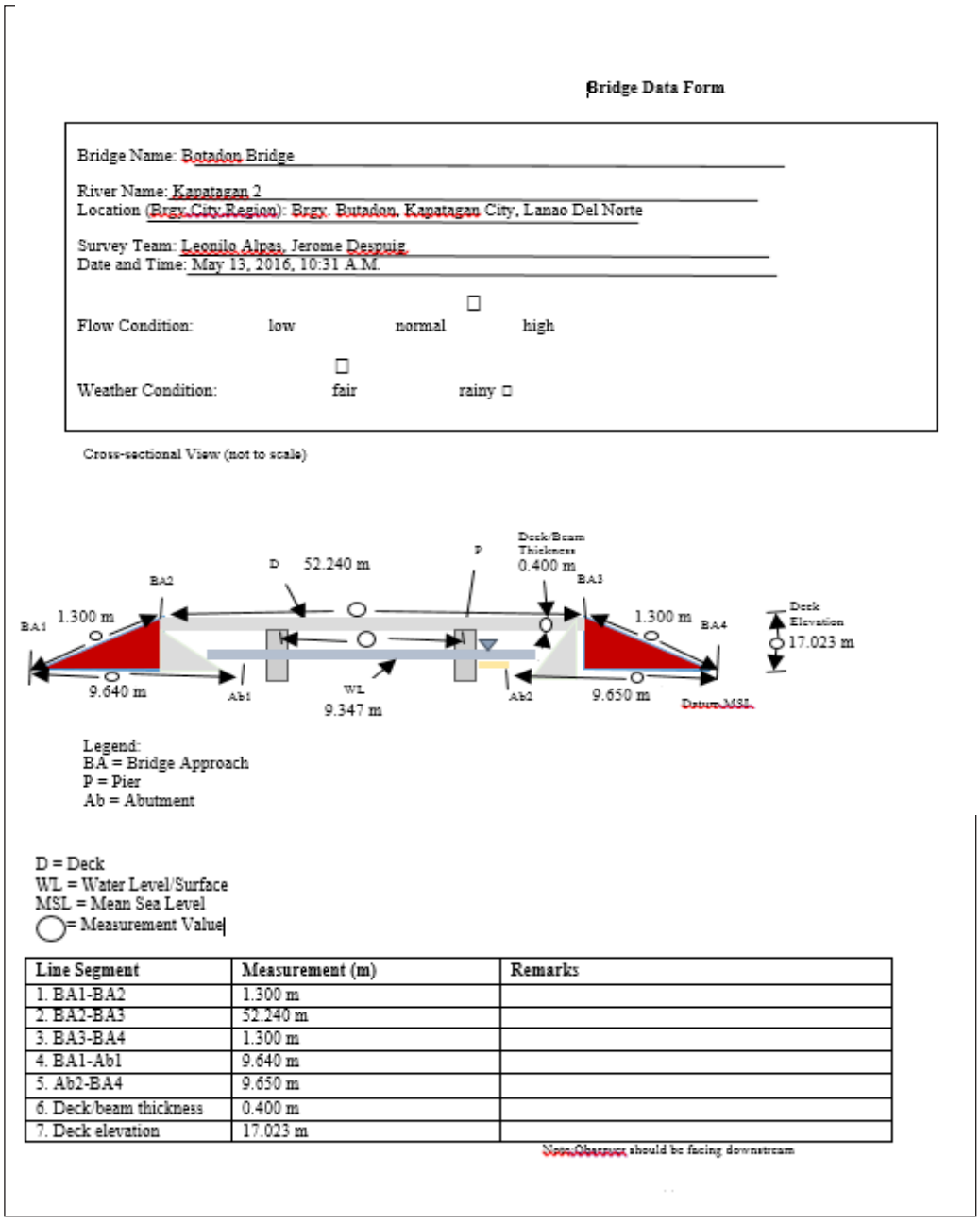


Figure 46. Butadon Bridge cross-section diagram



Bridge Data Form

Bridge Name: Botadon Bridge

River Name: Kapatagan 2
Location (Brgy,City,Region): Brgy. Butadon, Kapatagan City, Lanao Del Norte

Survey Team: Leonilo Alpas, Jerome Despuig
Date and Time: May 13, 2016, 10:31 A.M.

Flow Condition: low ☐ normal high

Weather Condition: ☐ fair rainy ☐

Cross-sectional View (not to scale)

Legend:
BA = Bridge Approach
P = Pier
Ab = Abutment

D = Deck
WL = Water Level/Surface
MSL = Mean Sea Level
◯ = Measurement Value

Line Segment	Measurement (m)	Remarks
1. BA1-BA2	1.300 m	
2. BA2-BA3	52.240 m	
3. BA3-BA4	1.300 m	
4. BA1-Ab1	9.640 m	
5. Ab2-BA4	9.650 m	
6. Deck/beam thickness	0.400 m	
7. Deck elevation	17.023 m	

Note:Observer should be facing downstream

Figure 47. Butadon Bridge data sheet

The water surface elevation of the Butadon River was determined by a Horizon® Total Station on May 11, 2016 at 9:09 hrs. at the Butadon Bridge area. A value of 9.897 meters in EGM08 was obtained, as reflected in Figure 46. This was translated into markings on the bridge's pier, as displayed in Figure 48. The markings will serve as a reference for flow data gathering and depth gauge deployment of the partner university responsible for the Butadon River, the MSU-IIT.

Figure 48. Water-level markings on the Butadon Bridge

4.6 Validation Points Acquisition Survey

The validation points acquisition survey was conducted by the DVBC onAugust 19-20, 2016 using a survey-grade GNSS Rover receiver, Trimble® SPS 882, mounted on a range pole that was attached on the side of the vehicle, as demonstrated in Figure 49. It was secured with cable ties and ropes to ensure that it was horizontally and vertically balanced. The antenna height was 2.400 meters, measured from the ground up to the bottom of the quick release of the GNSS Rover receiver. The PPK technique utilized for the conduct of the survey was set to continuous topo mode, with UP_KAP 2-2 and LE-96 occupied as the GNSS base stations.

Figure 49. Validation points acquisition survey set-up for the Butadon River

The survey started in Barangay Butadon, in the Municipality of Kapatagan, Lanao del Norte, and headed southwest along the national highway, ending in Barangay Poblacion in the Municipality of Aurora, Zamboanga del Sur on August 19, 2016. The second survey started inBarangay Sta. Cruz in theMunicipality of Kapatagan, Lanao del Norte,and traveled northeast along the national highway, ending in Barangay Sagadan in the Municipality of Tubod, Lanao del Norte. A total of 5,192 points were gathered with an approximate length of 38.360 kilometers, using UP_KAP 2-2 and LE-96 as the GNSS base stations for the entire extent of validation points acquisition survey. The scope of the survey is illustrated in the map in Figure 50.

Figure 50. Extent of the LiDAR ground validation survey of the Butadon River Basin Area

4.7 Bathymetric Survey

A bathymetric survey was executed on May 21, 2016 using a Hi-Target® echo sounder, as illustrated in Figure 51. The survey started downstream in Barangay Lapinig in the Municipality of Kapatagan, with coordinates 7° 57’ 31.34209”N, 123° 40’ 42.90492”E; and ended upstream in Barangay Lapinig in the Municipality of Kapatagan, with coordinates 7° 55’ 36.75568”N, 123° 41’ 27.01860”E.

Figure 51. Bathymetric survey of ABSD at the Butadon River using Hi-Target® echo sounder

A manual bathymetric survey was conducted on May 21, 2016 using a Hi-Target® echo sounder, as depicted in Figure 52. The survey started downstream in Barangay Lapinig in the Municipality of Kapatagan, with coordinates 7° 55' 37.17333"N, 123° 41' 38.46804"E; and ended upstream in Barangay Suso, Municipality of Kapatagan, with coordinates 7° 52' 59.74343"N,123° 43' 55.76124"E. The control points UP_KAP 1-5 and UP_KAP 1-6 were used as the GNSS base stations all throughout the survey.

Figure 52. Manual bathymetric survey of ABSD at the Butadon River, using Nikon® Total Station

Gathering of random points for the validation of ABSD's bathymetric data was performed by the DVBC on August 19, 2016, using a Trimble® SPS 882 GNSS in PPK survey technique(See Figure 53). A map displaying the DVBC bathymetric checking points is shown in Figure 55.

Linear square correlation (R^2) and RMSE analysis were performed on the two (2) datasets. The linear square coefficient range was determined to ensure that the data submitted by the contractor was within the accuracy standards of the project, which is ±20 centimeters and ±10 centimeters for horizontal and vertical accuracies, respectively. The R^2 value must be within 0.85 to 1. An R^2 approaching 1 signifies a strong correlation between the vertical (elevation values) of the two datasets. A computed R^2 value of 0.999 was obtained by comparing the data from the contractor with that from the DVBC, signifying a strong correlation between the two (2) datasets.

In addition to the Linear Square correlation, the Root Mean Square (RMSE) analysis was also performed, in order to assess the difference in elevation between the DVBC checking points and those of the contractor's. The RMSE value should only have a maximum radial distance of 5meters; and the difference in elevation within the radius of 5 meters should not be beyond 0.50 m. For the bathymetric data, a computed value of 0.220 was acquired. The computed R^2 and RMSE values are within the accuracy requirement of the program.

Figure 53. Gathering of random bathymetric points along the Butadon River

The bathymetric survey for the Butadon River gathered a total of 3,836 points covering an approximate length of 13.410 kilometers of the river, traversing Barangays Lapinig, Concepcion, Butadon, Sta. Cruz, and Suso in the Municipality of Kapatagan, Lanao del Norte (Figure 54). A CAD drawing was also produced to illustrate the riverbed profile of the Butadon River, presented in Figure 56. The profile shows that the highest and lowest elevation hada 25-meter difference. The highest elevation observed was 31 meters above MSL, located in Barangay Sta. Cruz, Kapatagan, Lanao del Norte; while the lowest was -6 meters below MSL, located in Barangay Taguitic, Kapatagan, Lanao del Norte.

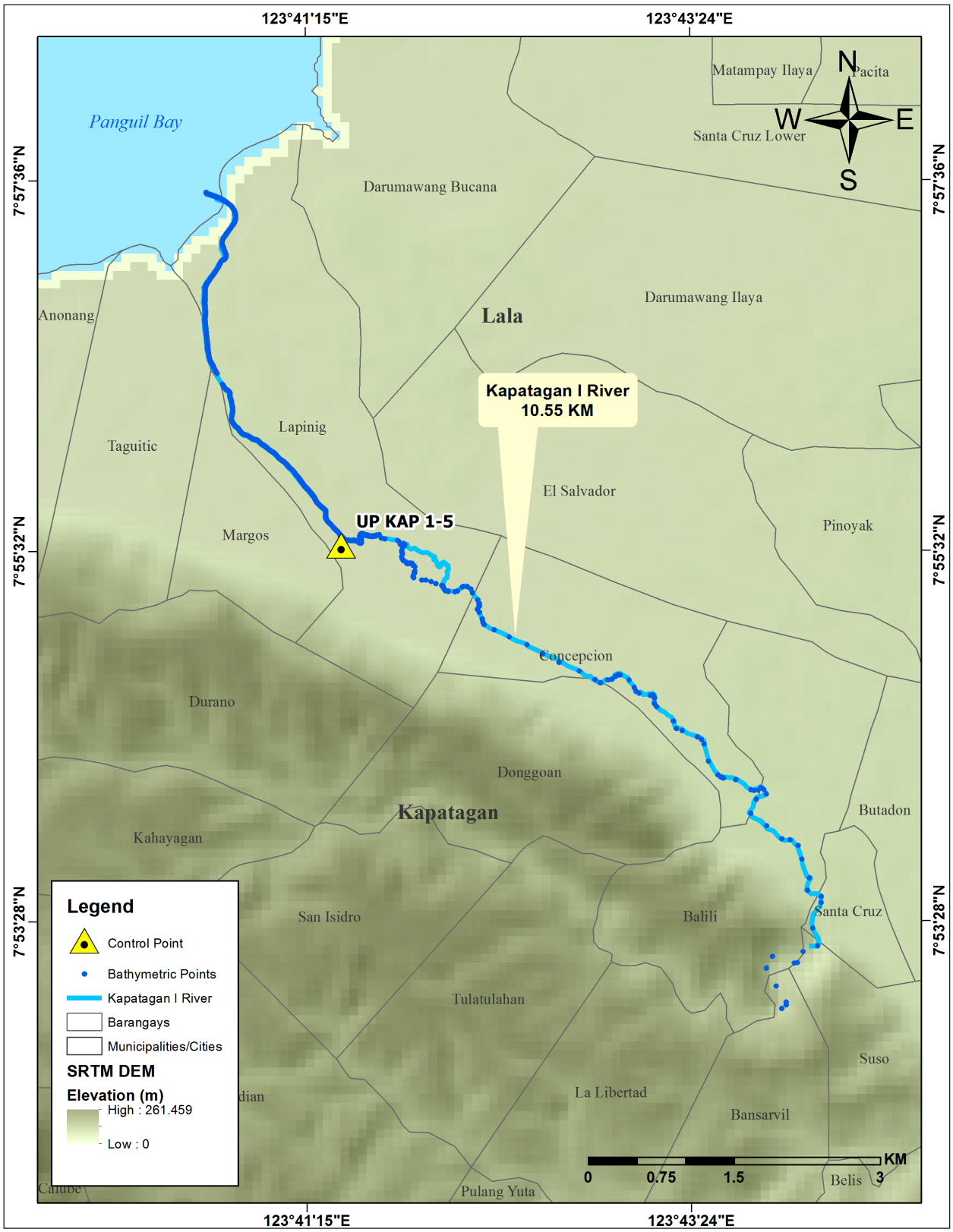


Figure 54. Extent of the bathymetric survey of the Butadon River

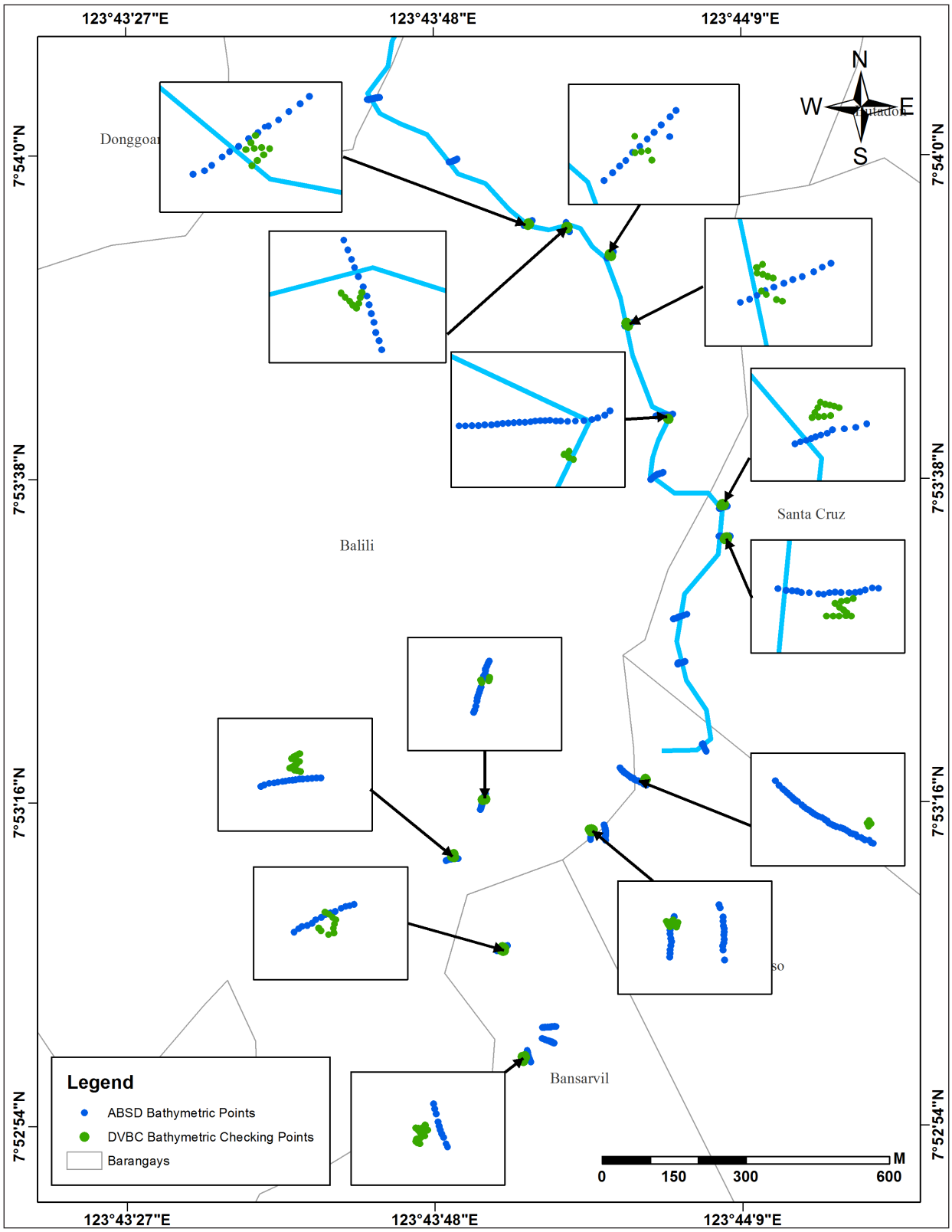


Figure 55. Quality checking points gathered along the Butadon River by the DVBC

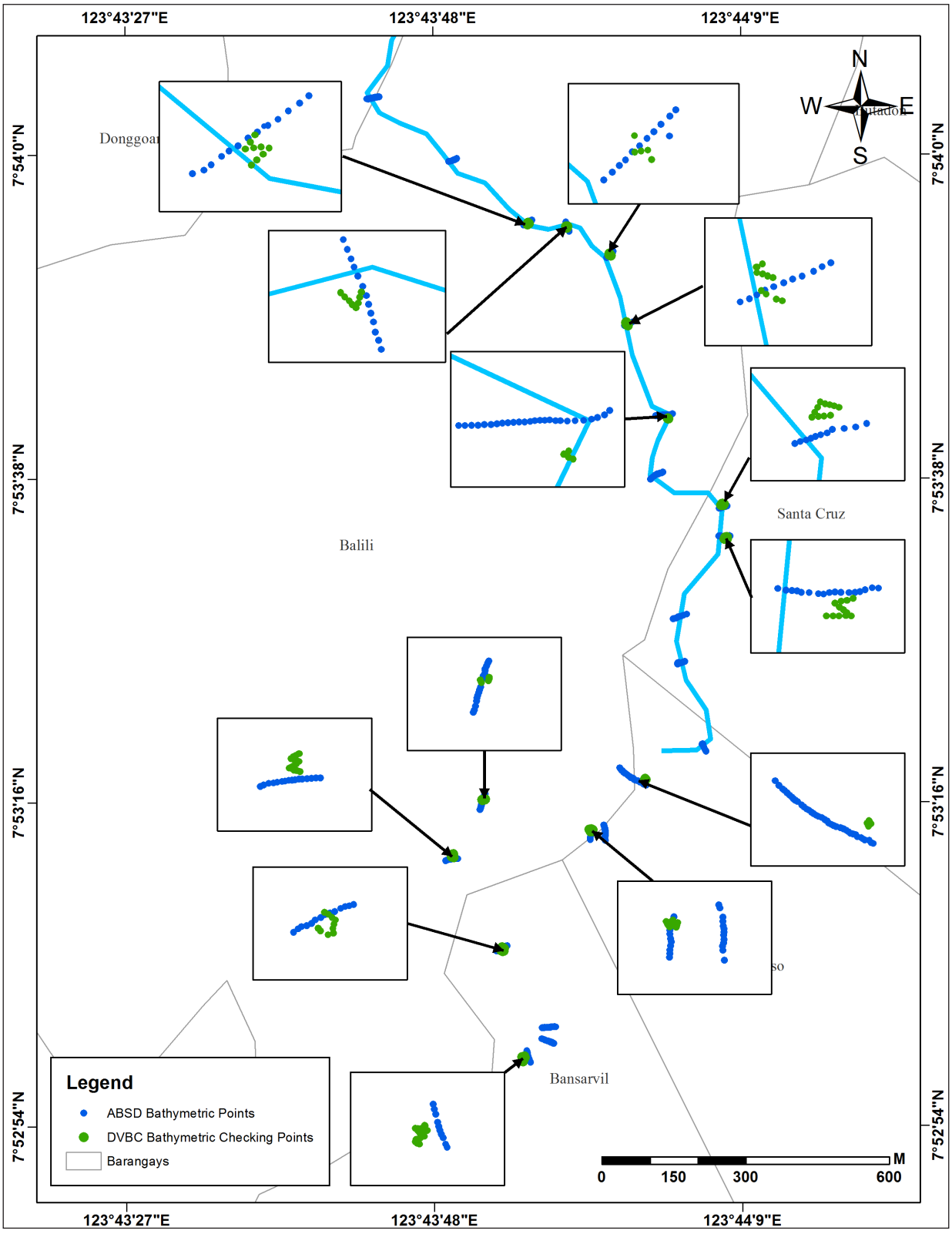


Figure 56. Quality checking points gathered along the Butadon River by the DVBC

CHAPTER 5: FLOOD MODELING AND MAPPING

Dr. Alfredo Mahar Lagmay, Christopher Uichanco, Sylvia Sueno, Marc Moises, Hale Ines, Miguel del Rosario, Kenneth Punay, and 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 are components and data that may affect the hydrologic cycle of the Butadon River Basin,were monitored, collected, and analyzed. .

5.1.2 Precipitation

Precipitation data was taken from the Portable Rain Gauge (PRG) installed upstream by the Data Validation Component (DVC) of MSU-IIT. The PRG was specifically installed in Barangay Malinas in the Municipality of Kapatagan, with coordinates 7°51'38.28"N Latitude and 123°44'20.18"E Longitude. The location of the rain gauge is shown in Figure 57.

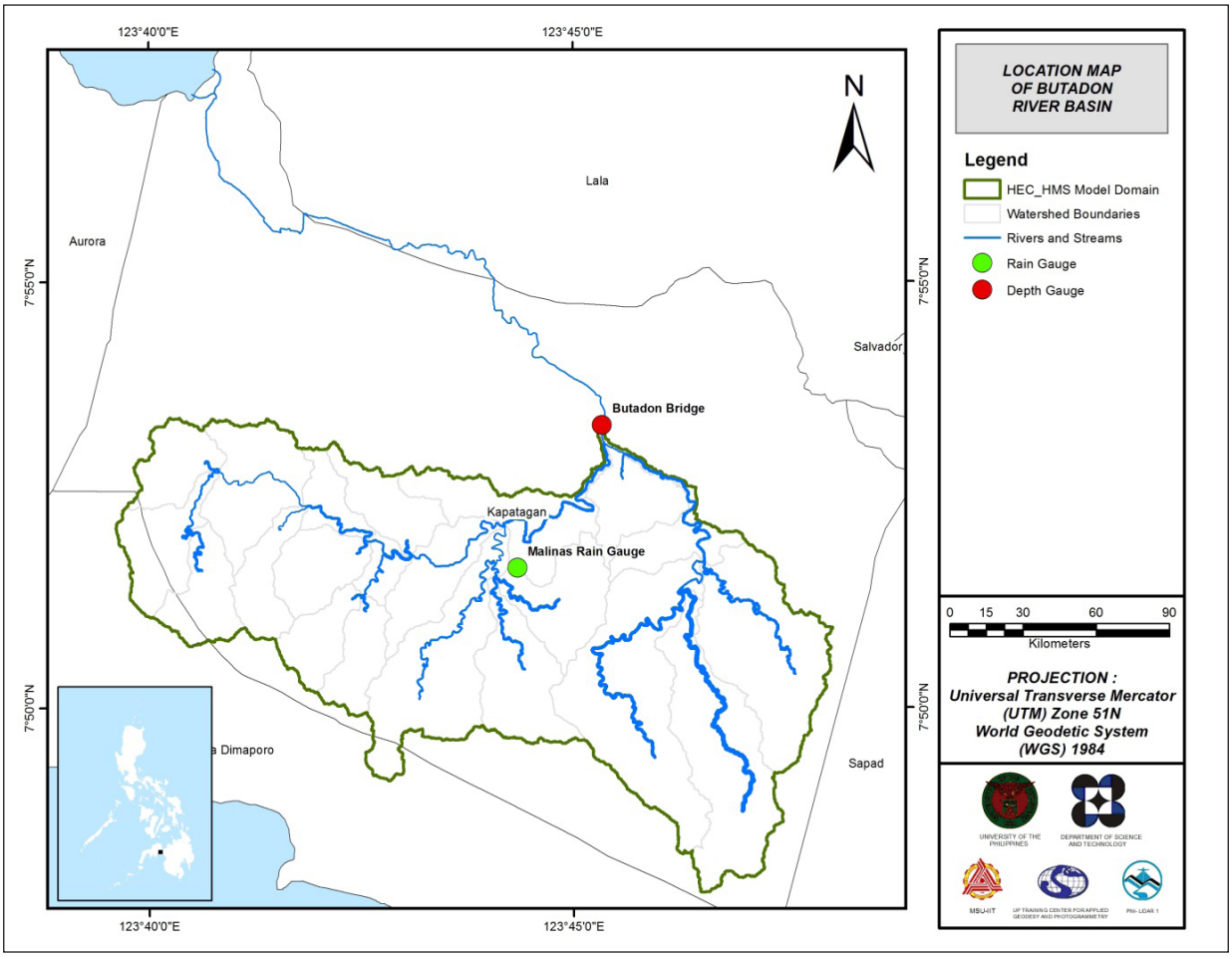


Figure 57. The location map of the Butadon HEC-HMS model, which was used for calibration

5.1.3 Rating Curves and River Outflow

A rating curve was computed at the prevailing cross-section (Figure 58) at the Butadon Bridge to establish the relationship between the observed water levels (H) and outflow (Q) at this location. The rating curve, or HQ curve, analysis is important in determining the equation to be used in establishing the Q values, with R-Squared values closer to 1. A trendline is more accurate if the R-Squared value is closer to, or at 1. For Butadon, base flow hydrometry was used.

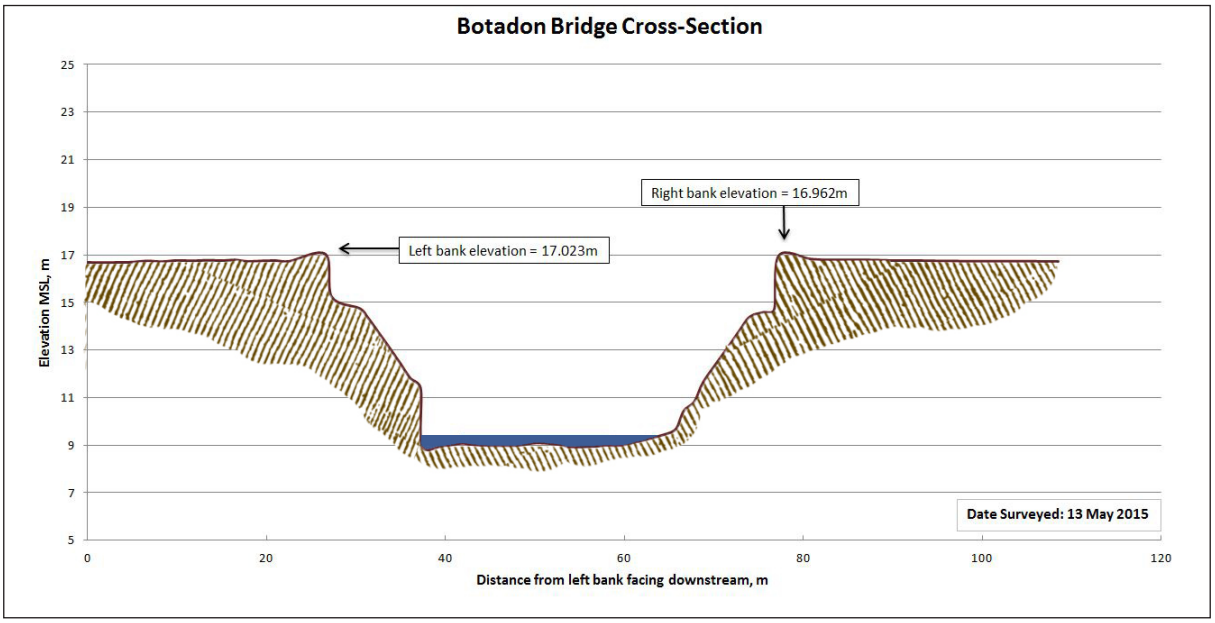


Figure 58. Cross-section plot of the Butadon Bridge

Figure 59presents the highest R-Squared value of 0.9481, compared withthe graphs using the original Q. In this case, Q boxed values with Q at bankful were plotted versus the stage.

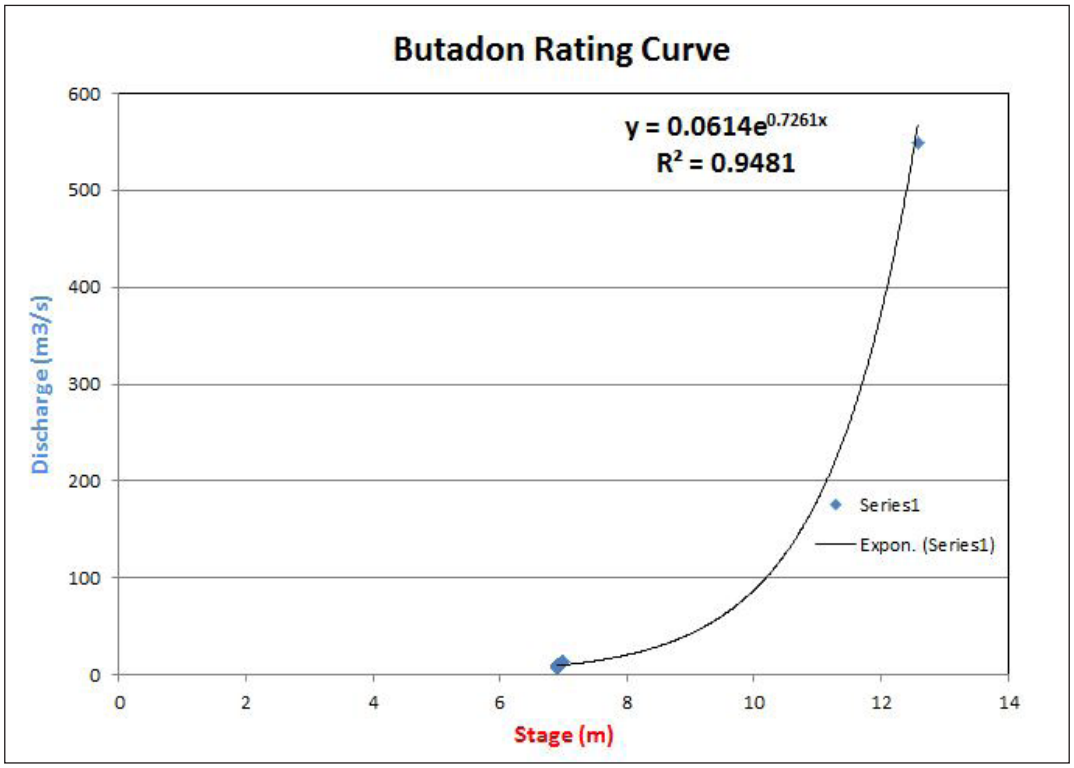


Figure 59. Rating Curve at Butadon Bridge

This rating curve equation was used to compute for the river outflow at the Butadon Bridge, for the calibration of the HEC-HMS model presented in Figure 60.

Total rainfall taken from the PRG at Malinas, Kapatagan measured 82.6 millimeters. It peaked at 10.6 millimeters on August 22, 2016 at 19:50 hrs. The lag time between the peak rainfall and discharge was five (5) hours and thirty (30_ minutes.

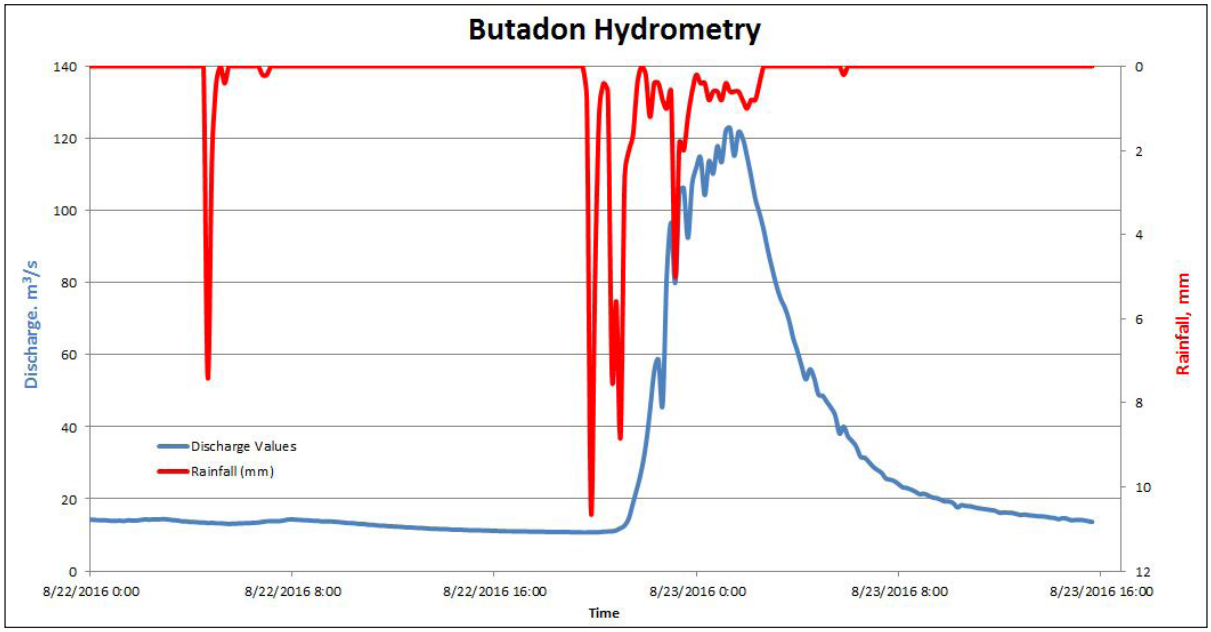


Figure 60. Rainfall and outflow data at the Butadon Bridge, which were used for modeling

5.2 RIDF Station

The Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) computed for the Rainfall Intensity Duration Frequency (RIDF) values for the Dipolog Rain Gauge (Table 32). This station was selected based on its proximity to the Butadon watershed (Figure 61). The RIDF rainfall amount for 24 hours was converted into a synthetic storm by interpolating and re-arranging the values such that certain peak values were attained at a certain time. The extreme values for this watershed were computed based on a 51-year record.

Table 32. RIDF values for the Dipolog 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	19.7	30.9	38.7	53.8	73.6	85.5	105.7	120.3	136.2
5	25.9	39.6	50.1	72.6	99.7	117.3	140.9	158.3	178.5
10	30	45.4	57.6	85.1	117	138.3	164.3	183.4	206.5
15	32.3	48.6	61.8	92.1	126.8	150.2	177.4	197.6	222.4
20	34	50.9	64.8	97.1	133.6	158.5	186.6	207.6	233.4
25	35.2	52.7	67.1	100.9	138.9	164.9	193.7	215.2	242
50	39	58.1	74.1	112.5	155.1	184.6	215.6	238.8	268.3
100	42.9	63.4	81.1	124.1	171.2	204.2	237.3	262.1	294.4

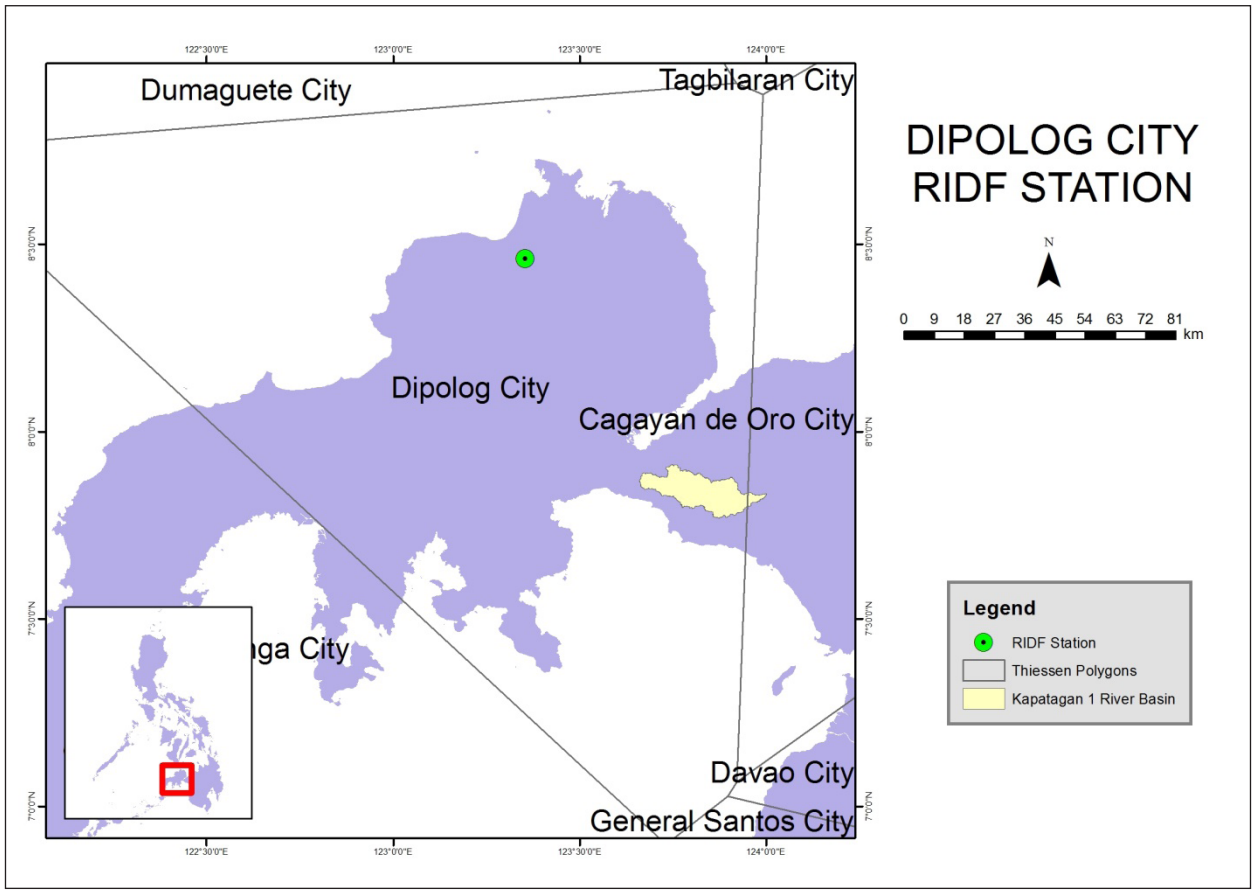


Figure 61. Location of the Dipolog RIDF station, relative to the Butadon River Basin

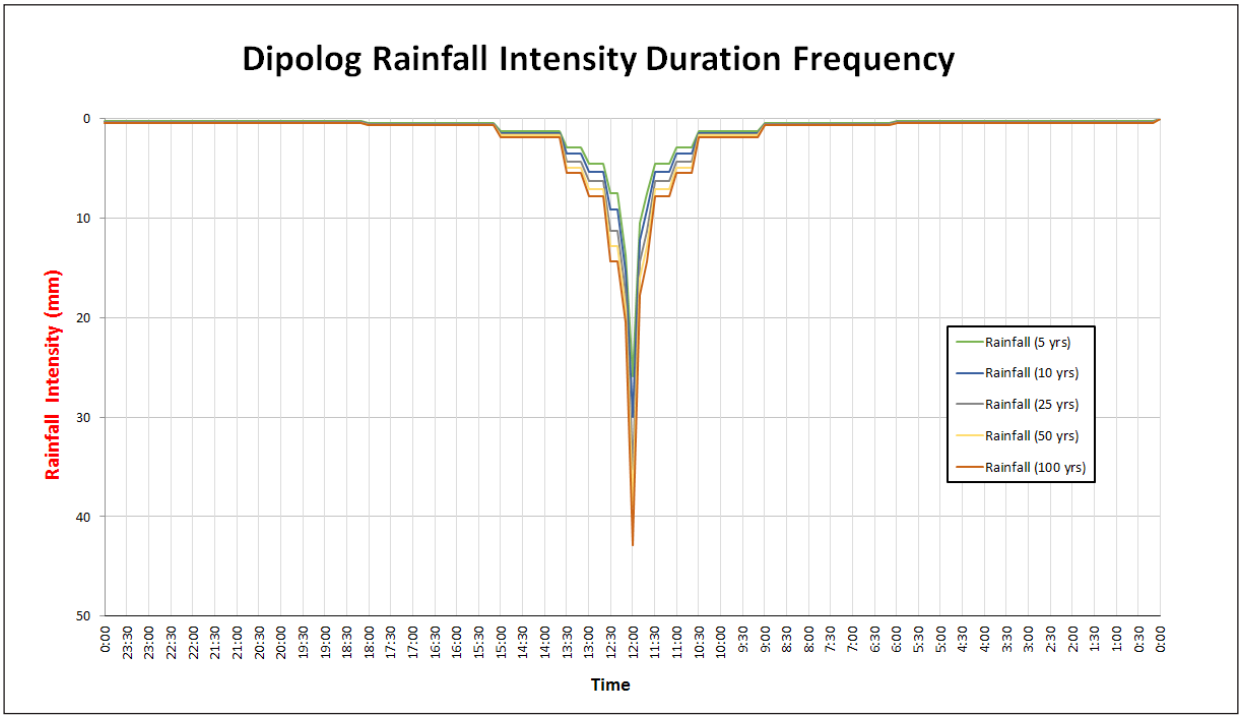


Figure 62. Synthetic storm generated from a 24-hour period rainfall, for various return periods

5.3 HMS Model

The soil texture shape shapefile was generated in 2004 from the Bureau of Soils and Water Management (BSWM) under the Department of Agriculture (DA). The soil texture map (Figure 63) of the Butadon River Basin was used as one of the factors for the estimation of the CN parameters.

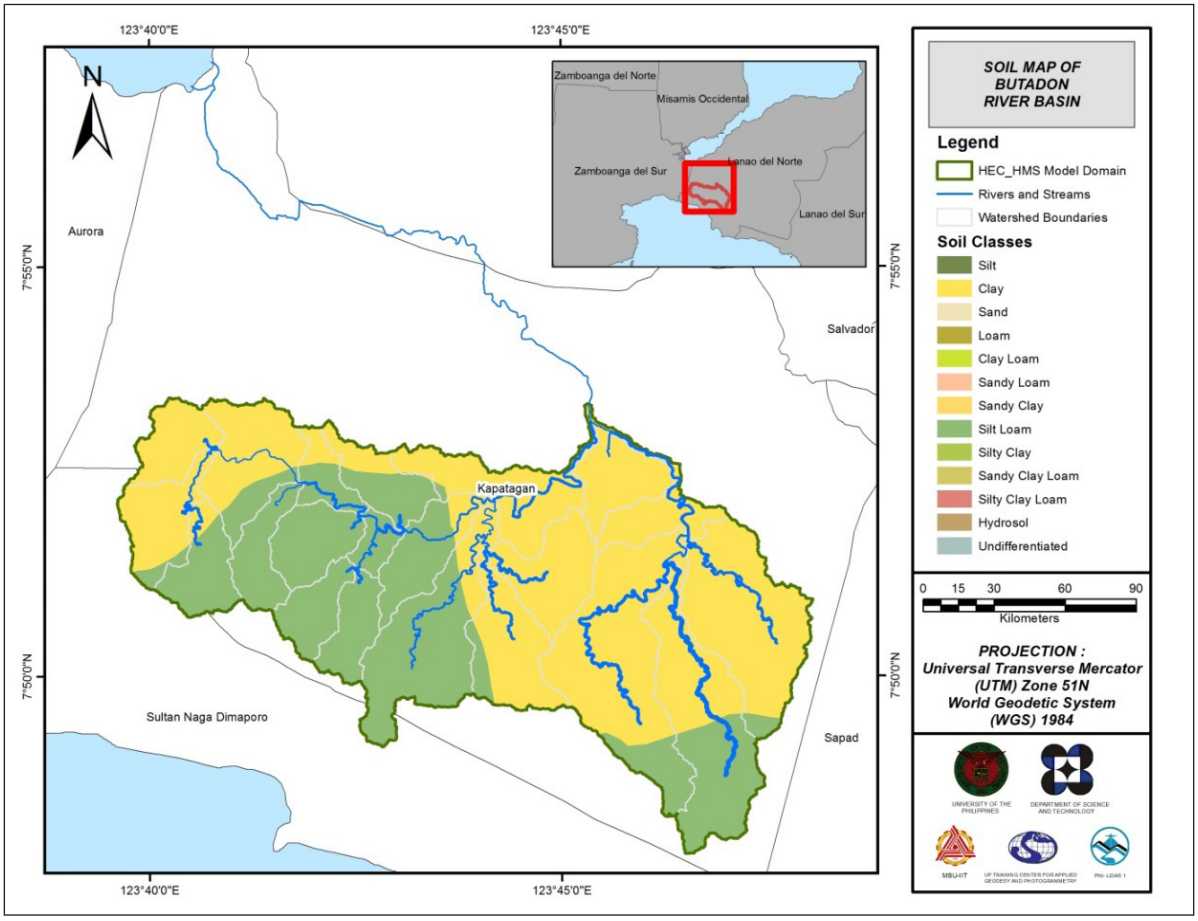


Figure 63. Soil map of the Butadon River Basin (Source: DA)

The land cover data was generated in 2003 from the National Mapping and Resource information Authority (NAMRIA). Figure 64presents the land cover inside the Butadon River Basin. The land cover map was used as another factor for the estimation of the CN and watershed lag parameters of the rainfall-runoff model.

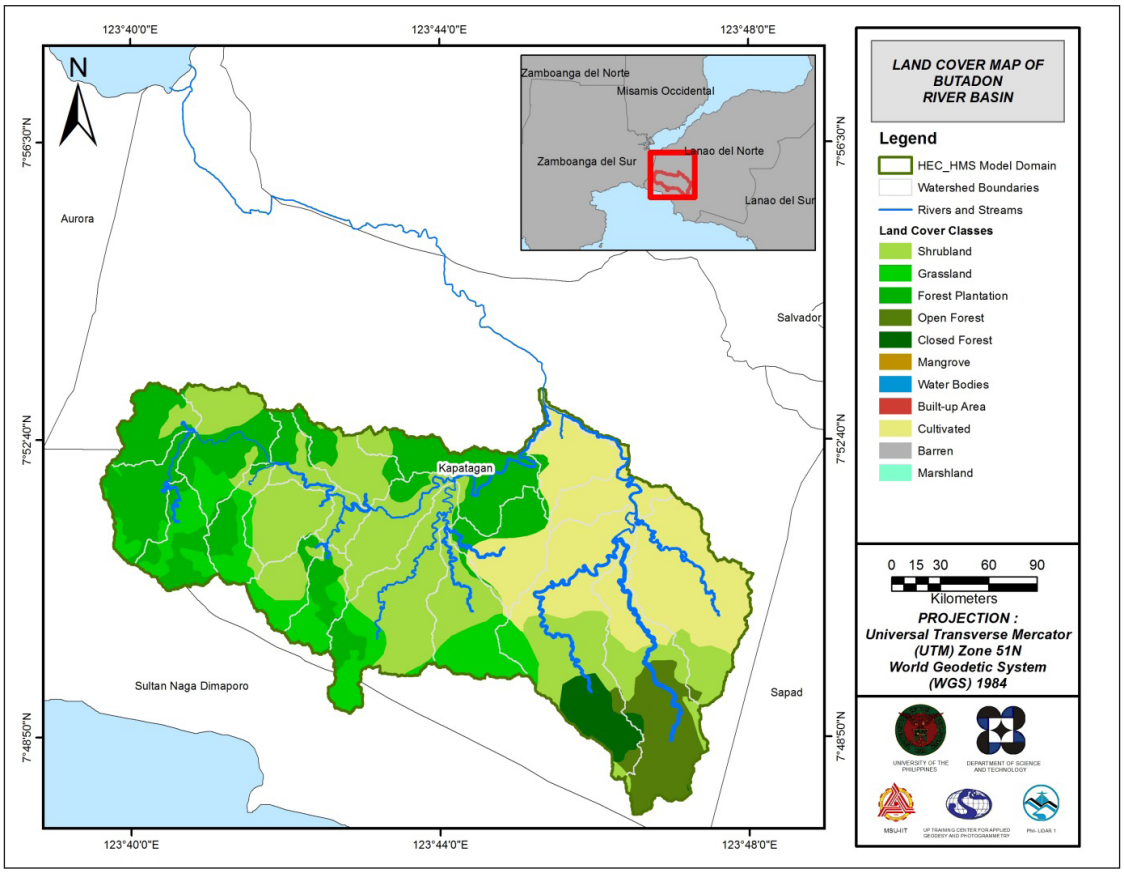


Figure 64. Land cover map of the Butadon River Basin (Source: NAMRIA)

The soil classes identified in the Butadon basin were clay and silt loam. The land cover types identified were shrublands, grasslands, forest plantations, open forests, closed forests, and cultivated land.

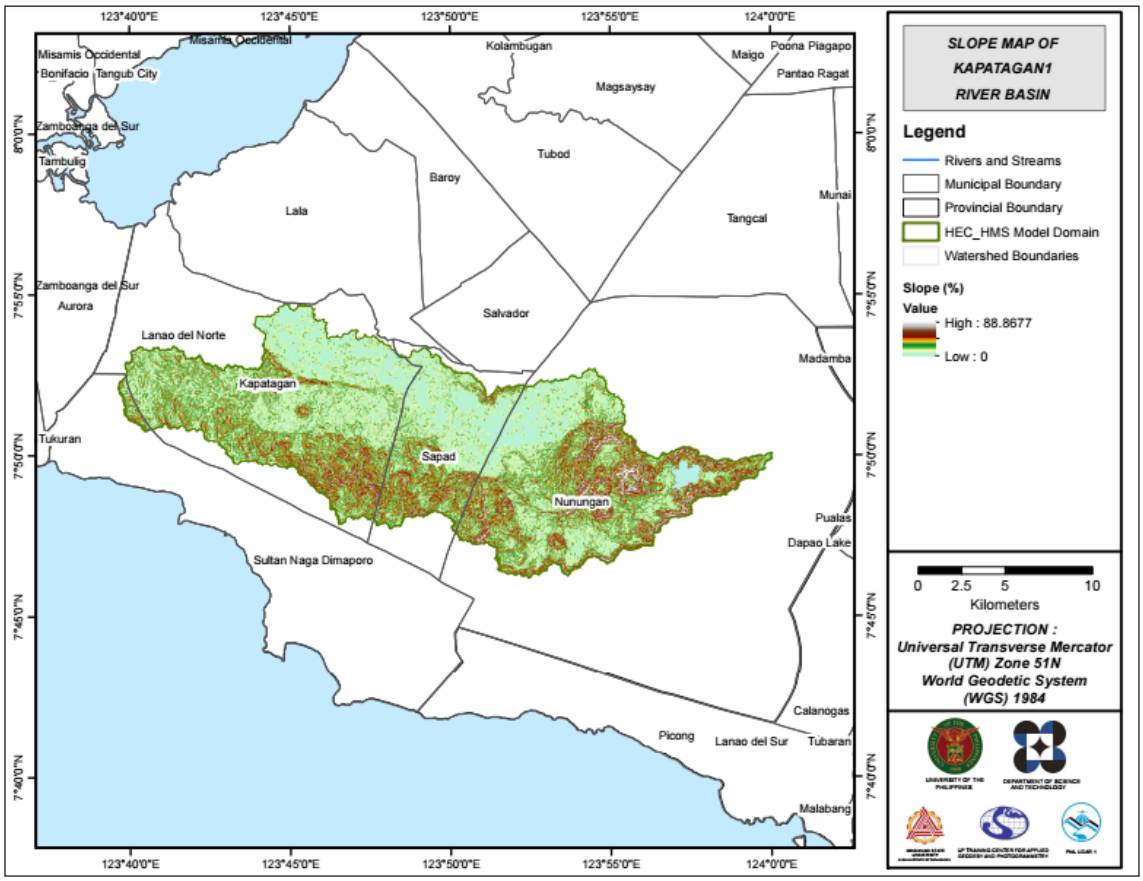


Figure 65. Slope map of the Butadon River Basin

Figure 66. Stream delineation map of the Butadon River Basin

Using the SAR-based DEM, the Butadon basin was delineated and further subdivided into sub-basins. The model consists of twenty-one (21) sub basins, fourteen (14) reaches, and fourteen (14) junctions. The main outlet is located at the Butadon Bridge in Kapatagan, Lanao del Norte. Thebasin model is illustrated in Figure 67. See Annex 10 for the Butadon Model Reach Parameters. The model was calibrated using hydrological data derived from the depth gauge and flow meter deployed at the ButadonBridge.

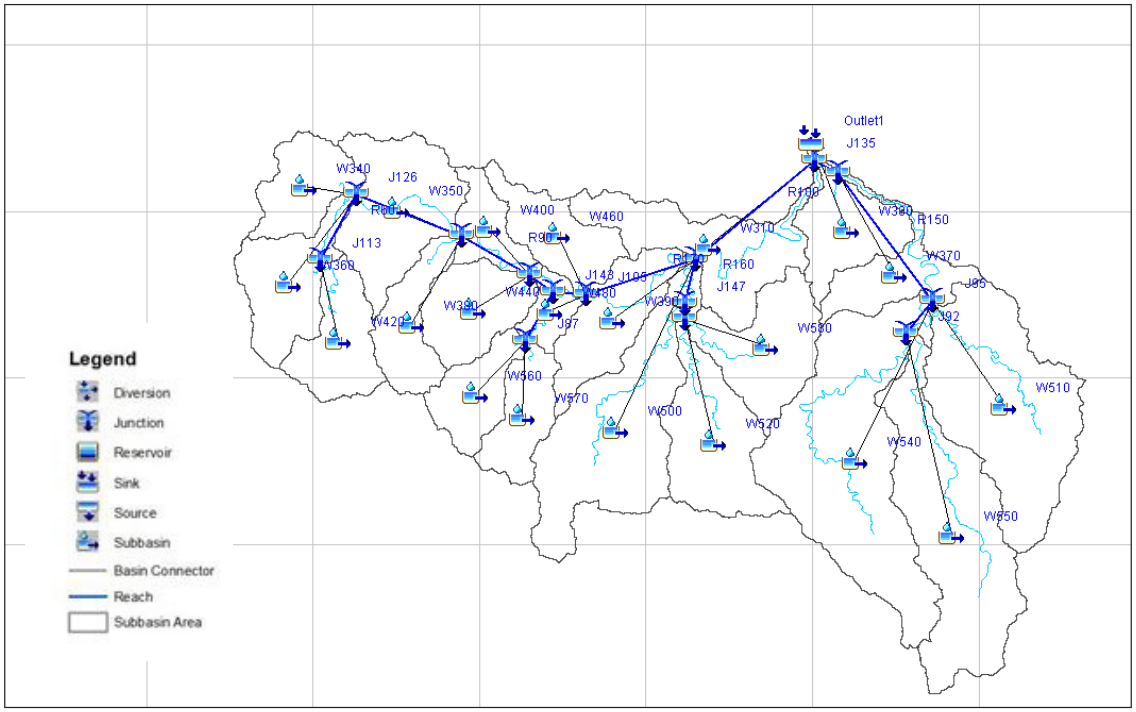


Figure 67. The Butadon hydrologic model, generated in HEC-GeoHMS

5.4 Cross-section Data

Riverbed cross-sections of the watershed were necessary in the HEC-RAS model set-up. The cross-section data for the HEC-RAS model was derived fromthe LiDAR DEM data. It was defined using the Arc GeoRAS tool and was post-processed in ArcGIS (Figure 68).

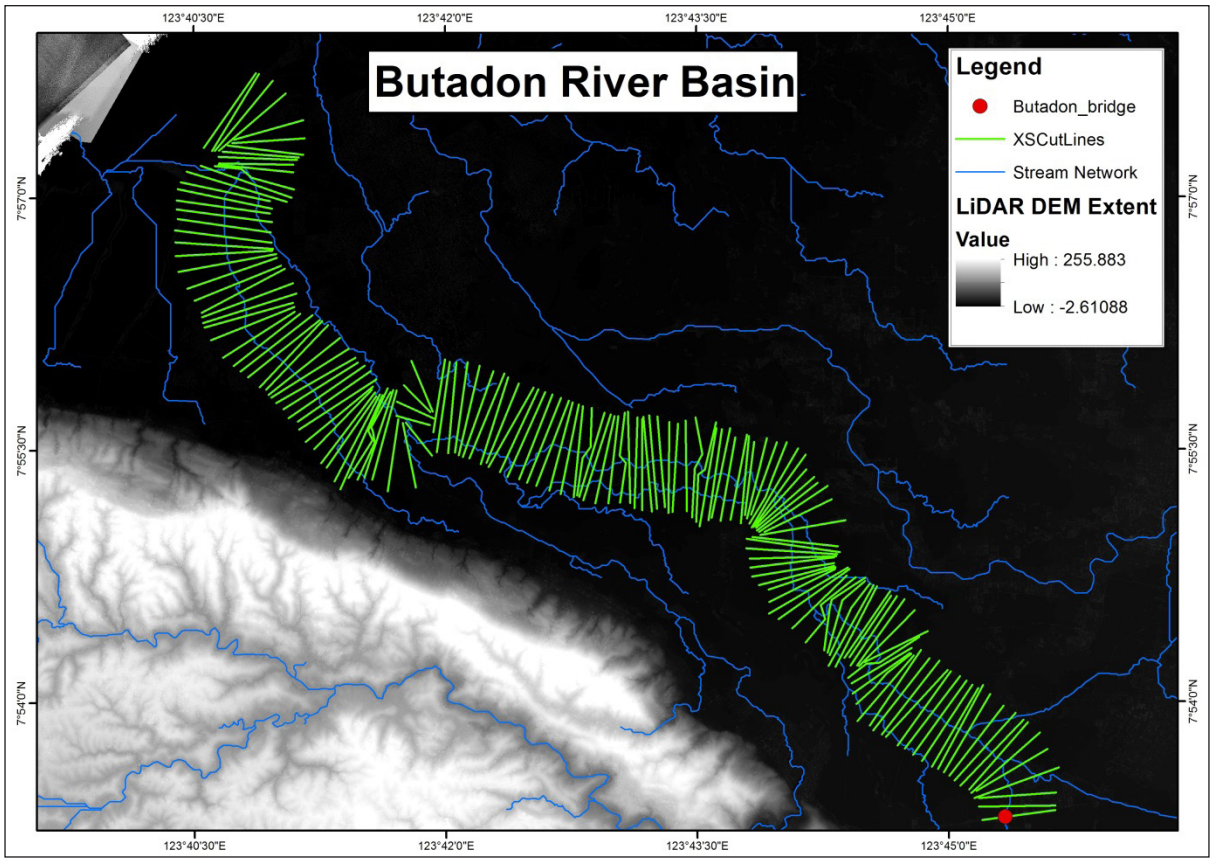


Figure 68. River cross-section of the Butadon River, generated through the ArcMap HEC GeoRAS tool

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 meters by 10 meters in size. Each element was assigned a unique grid element number, which served as its identifier. The elements were then attributed with the parameters required for modelling, such as x-and y-coordinates of centroid, names of adjacent grid elements, Manning's coefficient of roughness, infiltration, and elevation values. The elements were arranged spatially to form the model, allowing the software to simulate the flow of water across the grid elements in eight (8) directions (i.e., north, south, east, west, northeast, northwest, southeast, and southwest).

Based on the elevation and flow direction, it was determined that the water will generally flow from the southeast of the model to the northwest, following the main channel. As such, boundary elements in those particular regions of the model were assigned as inflow and outflow elements, respectively.

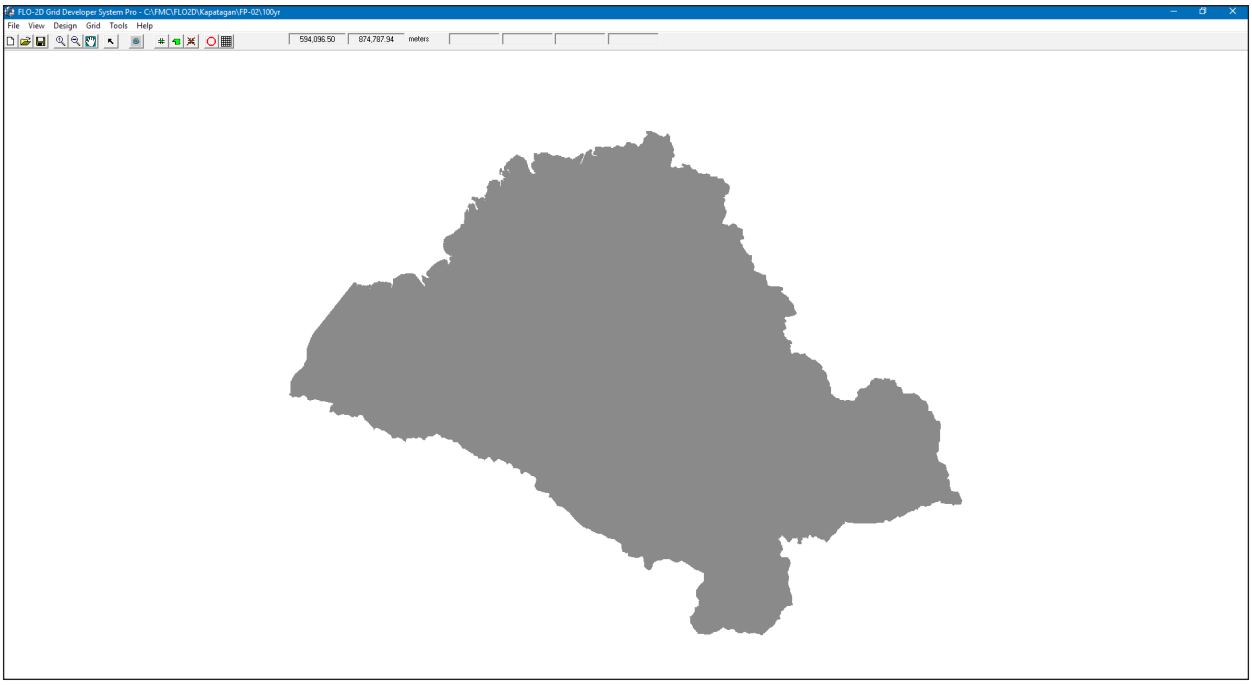


Figure 69. Screenshot of a sub-catchment with the computational area to be modeled in FLO-2D GDS Pro

The simulation wasthen run through the FLO-2D GDS Pro. This particular model had a computer run time of 159.80316 hours. After the simulation, the FLO-2D Mapper Pro wasused to transform the simulation results into spatial data that shows the flood hazard levels, as well as the extent and inundation. Assigning the appropriate flood depths and velocity values for Low, Medium, and High generatedthe flood hazard map. Most of the default values given by the FLO-2D Mapper Pro wereused, except for those in the Low hazard level. For this particular level, the minimum h (maximum depth) wasset at 0.2 meters;while the minimum vh (product of maximum velocity (v) andmaximum depth (h)) wasset at 0 m^2/s. The generated flood hazard maps for the Butadon floodplain are in Figures 73, 75, and 77.

The creation of a flood hazard map from the model also automatically generateda flow depth map, depicting the maximum amount of inundation for every grid element. The legend used by default in the Flo-2D Mapper wasnot a good representation of the range of flood inundation values; thus,a different legend wasused for the layout. In this particular model, the inundated parts cover a maximum land area of 94 394 976.00 m^2. The generated flood depth maps for the Butadon floodplain are in Figures 74, 76, and 78.

There was a total of 91,959,868.63 m^3 of water that entered the model. Of this amount, 22,901,071.12 m^3 wasdue to rainfall, while 69,058,797.52 m^3 wasinflow from other areas outside the model. 18,438 ,742.00 m^3 of this water was lost to infiltration and interception, while 55 612 620.42 m^3 wasstored by the floodplain. The rest, amounting to up to 17,908 ,551.14 m^3,was outflow.

5.6 Results of HMS Calibration

After calibrating the Butadon HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 70depicts the comparison between the two discharge data. The Butadon Model Basin Parameters are available in Annex 9.

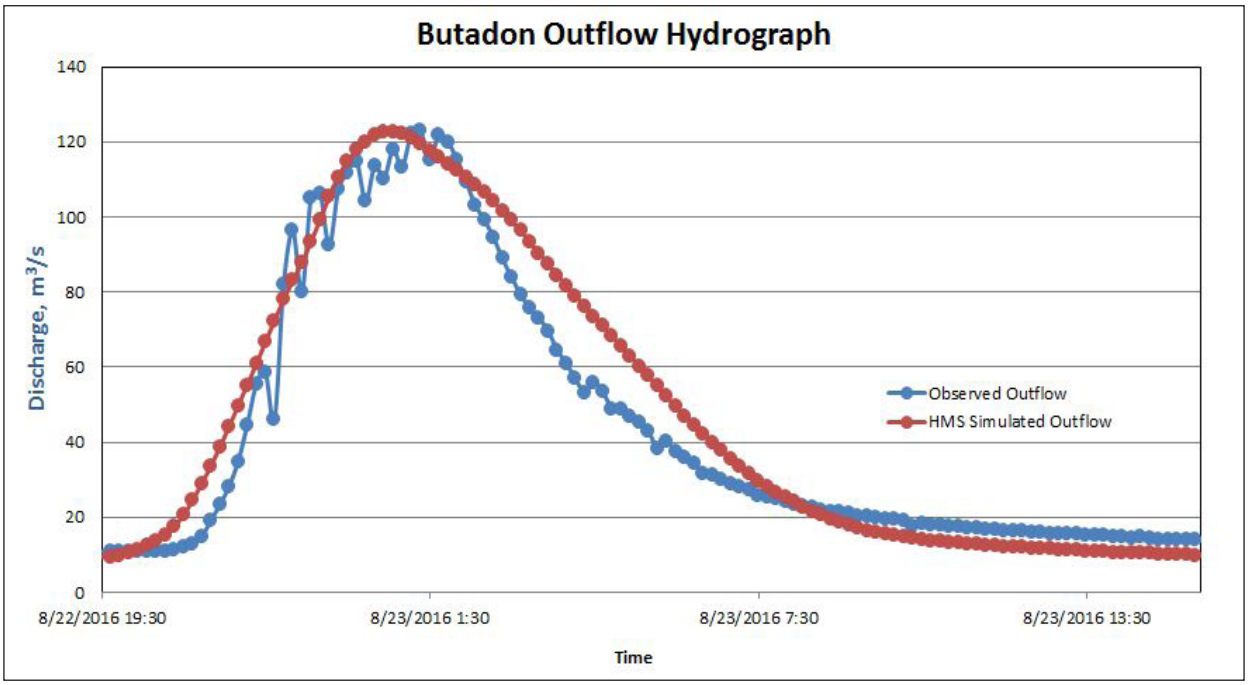


Figure 70. Outflow Hydrograph of the Butadon Bridge generated in HEC-HMS model, compared with observed outflow

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 the Butadon model

Hydrologic Element	Calculation Type	Method	Parameter	Range of Calibrated Values
Basin	Loss	SCS Curve number	Initial Abstraction (mm)	2 - 29
			Curve Number	48 - 89
	Transform	Clark Unit Hydrograph	Time of Concentration (hr)	2 - 15
			Storage Coefficient (hr)	0.1 – 2.4
	Baseflow	Recession	Recession Constant	0.07 - 1
			Ratio to Peak	0.01
Reach	Routing	Muskingum-Cunge	Manning's Coefficient	0.06

The initial abstraction defines the amount of precipitation that must fall before surface runoff. The magnitude of the outflow hydrograph increases as the initial abstraction decreases. The range of values of 2– 29 millimeters signifiesthat there is a minimal to average amount of infiltration or rainfall interception by vegetation, per sub-basin.

The curve number is the estimate of the precipitation excess of soil cover, land use, and antecedent moisture. The magnitude of the outflow hydrograph increases as the curve number increases. The range of 48 -89 for the curve number is advisable for Philippine watersheds, depending on the soil and land cover of the area (M. Horritt, personal communication, 2012). For Butadon, the basin mostly consists of shrublands, grasslands, forests, and cultivated areas; and the soil consists of clay and silt loam.

The time of concentration and the storage coefficient are the travel time and the index of temporary storage of runoff in a watershed. The range of calibrated values from 0.1 to 15 hours determines the reaction time of the model, with respect to the rainfall. The peak magnitude of the hydrograph decreases when these parameters are increased.

The recession constant is the rate at which the baseflow recedes between storm events; and ratio to peak is the ratio of the baseflow discharge to the peak discharge. A recession constant of 0.07 - 1 indicates that the sub-basins within Butadon basin bear different behaviors. A ratio to peak of 0.01 implies a steeper receding limb of the outflow hydrograph.

A Manning's roughness coefficient of 0.06 is slightly higher in comparison to the common roughness of Philippine watersheds.

Table 34. Efficiency Test of the Butadon HMS Model

RMSE	9.53
r^2	0.95
NSE	0.93
PBIAS	-7.78
RSR	0.26

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was computed as 9.53 (m^3/s).

The Pearson correlation coefficient (r^2) assesses the strength of the linear relationship between the observations and the model. A coefficient value close to 1 signifies an almost perfect match betweenthe observed discharge and the resulting discharge from the HEC HMS model. In the model, it was measured at 0.95.

The Nash-Sutcliffe (E) method was also used to assess the predictive power of the model, where the optimal value is 1. The model attained an efficiency coefficient of 0.93. A positive Percent Bias (PBIAS) indicates a model's propensity towards under-prediction. Negative values indicate a bias towards over-prediction. The optimal value is 0. In the model, the PBIAS is -7.78.

The Observation Standard Deviation Ratio(RSR) is an error index. A perfect model attains a value of 0 when the error units of the valuesare quantified. The model attained an RSR value of 0.26.

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 in Figure 71depictsthe Butadon outflow using the DipologRIDF curves in five (5) different return periods (i.e., 5-year, 10-year, 25-year, 50-year, and 100-year rainfall time series), based on the data from PAGASA. The simulation results reveal a significant increase in outflow magnitude as the rainfall intensity increases, for a range of durations and return periods.

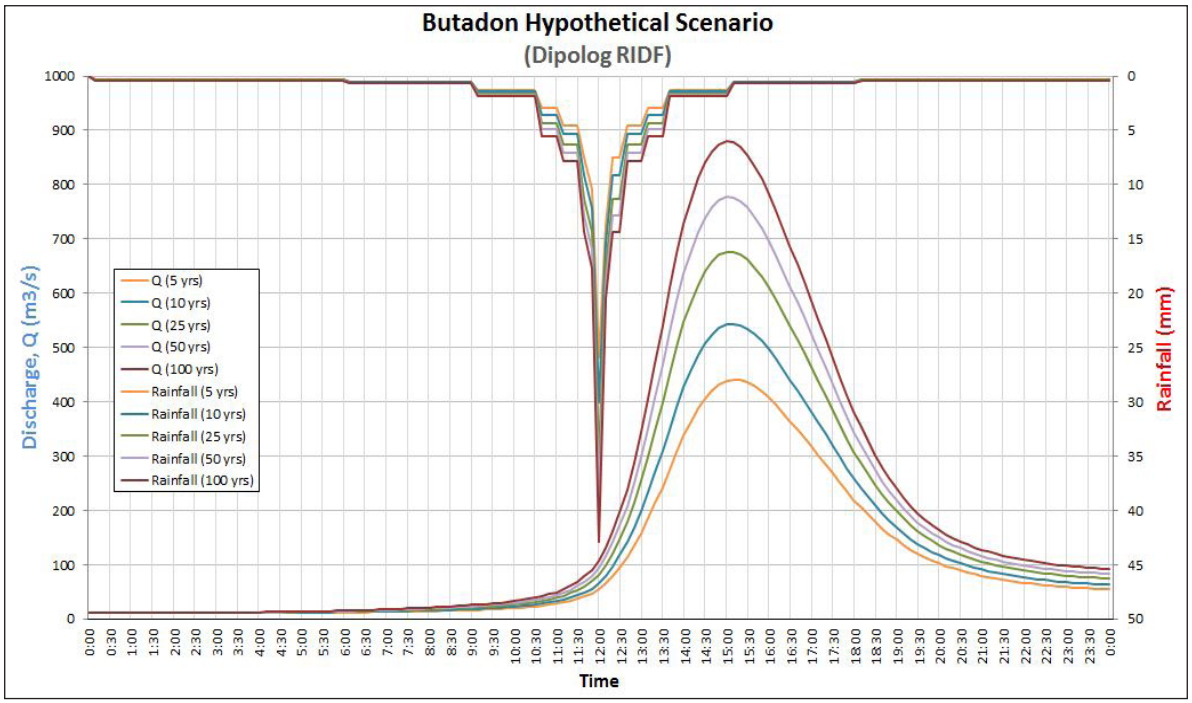


Figure 71. Outflow hydrograph at the Butadon Station, generated using the Dipolog RIDF simulated in HEC-HMS

A summary of the total precipitation, peak rainfall, peak outflow, and time to peak of the Butadon discharge using the Dipolog RIDF curves in five (5) different return periods is provided in Table 35.

Table 35. Peak values of the Butadon HEC-HMS Model outflow, using the Dipolog RIDF

RIDF Period	Total Precipitation (mm)	Peak rainfall (mm)	Peak outflow (m^3/s)	Time to Peak
5-Year	178.32	25.9	441.3	13 hours 10 mins
10-Year	206.37	30	543.6	13 hours 10 mins
25-Year	241.91	35.2	676.2	13 hours 10 mins
50-Year	268.14	39	777.7	13 hours
100-Year	294.55	42.9	880	13 hours

5.8 River Analysis (RAS) Model Simulation

The HEC-RAS flood model produced a simulated water level at every cross-section, for every time step, for every flood simulation created. The resulting model will be used in determining the flooded areas within the model. The simulated model will be an integral part in determining the real-time flood inundation extent of the river, after it has been automated and uploaded on the DREAM website. The sample generated map of the Butadon River using the calibrated HMS base flow is presentedin Figure 72.

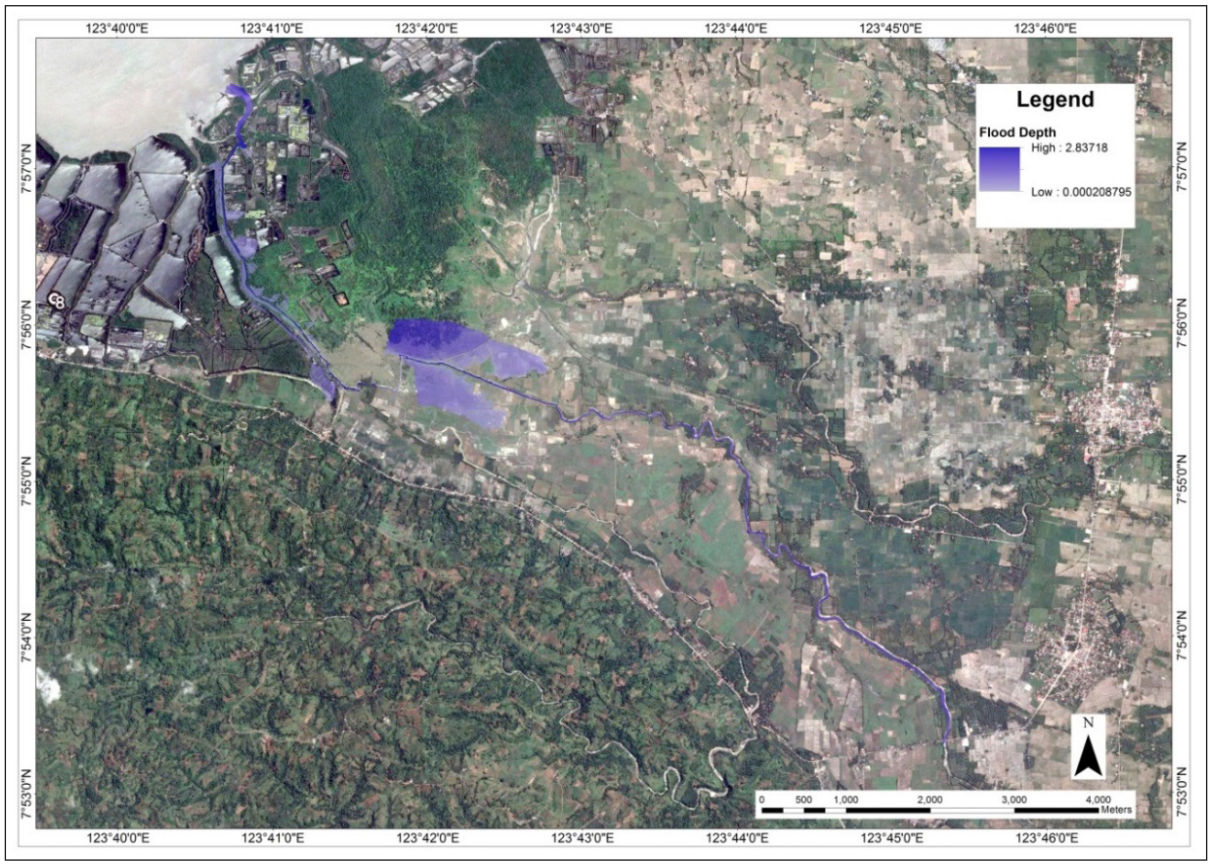


Figure 72. Sample output map of the Butadon RAS Model

5.9 Flow Depth and Flood Hazard

The resulting flood hazard and flow depth maps have a 10-meter resolution. Figure 73 to Figure 78 exhibit the 5-year, 25-year, and 100-year rain return scenarios of the Butadon floodplain.The floodplain, with an area of 218.63 square kilometers, covers seven (7) municipalities – Baroy, Kapatagan, Lala, Salvador, Sapad, Tubod, and Aurora. Table 36 specifiest he percentage of area affected by flooding per municipality.

Table 36. Municipalities affected in the Butadon floodplain

City / Municipality	Total Area (sq. km.)	Area Flooded (sq. km.)	% Flooded
Baroy	62.08	61.56	99%
Kapatagan	184.77	65.46	35%
Lala	125.18	124.31	99%
Salvador	46.46	12.02	26%
Sapad	65.13	3.39	5%
Tubod	121.95	17.64	14%
Aurora	162.23	4.92	3%

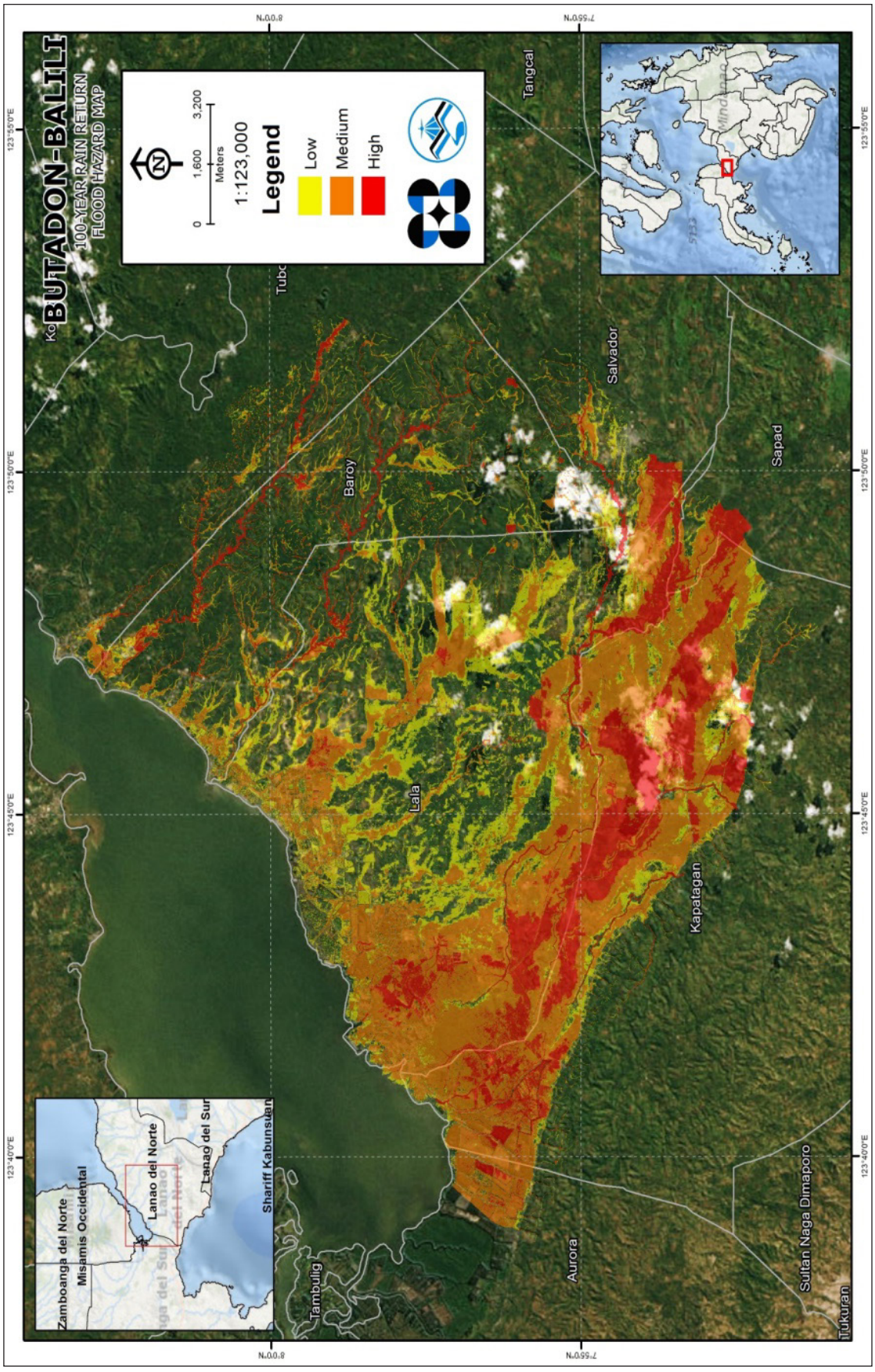


Figure 73. 100-year rain return flood hazard map for the Butadon floodplain, overlaid on Google Earth imagery

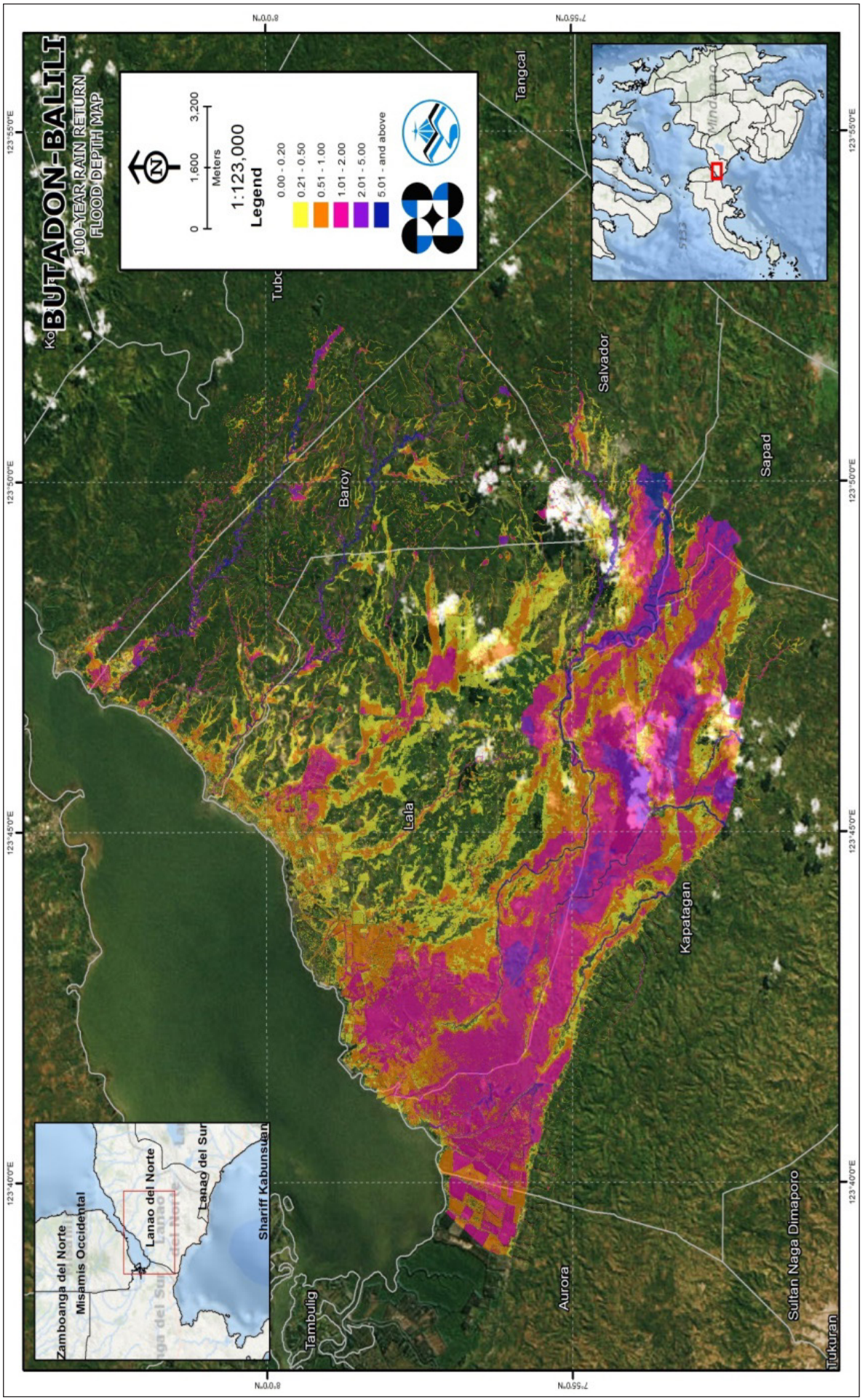


Figure 74. 100-year rain return flow depth map for the Butadon floodplain, overlaid on Google Earth imagery

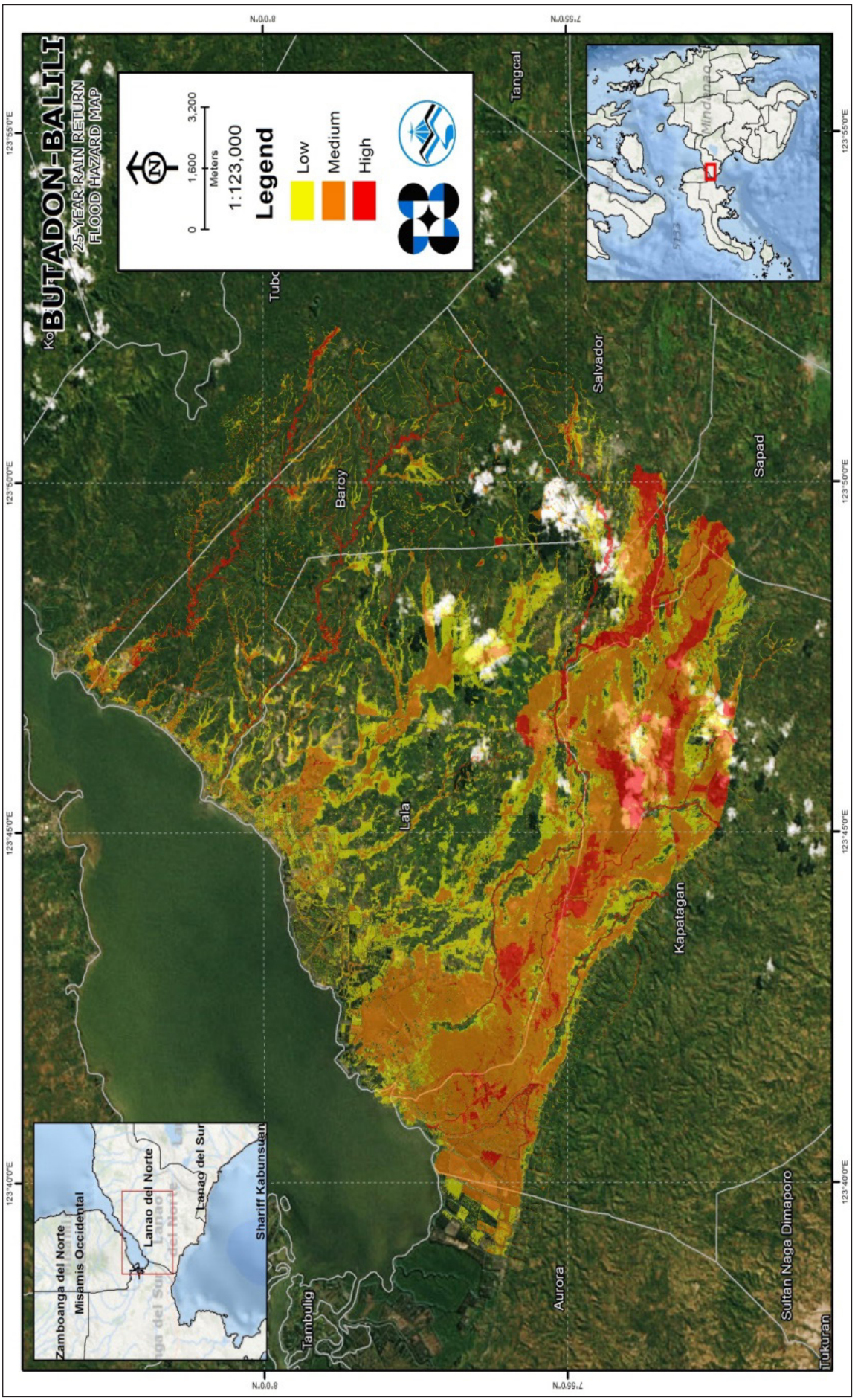


Figure 75. 25-year rain return flood hazard map for the Butadon floodplain, overlaid on Google Earth imagery

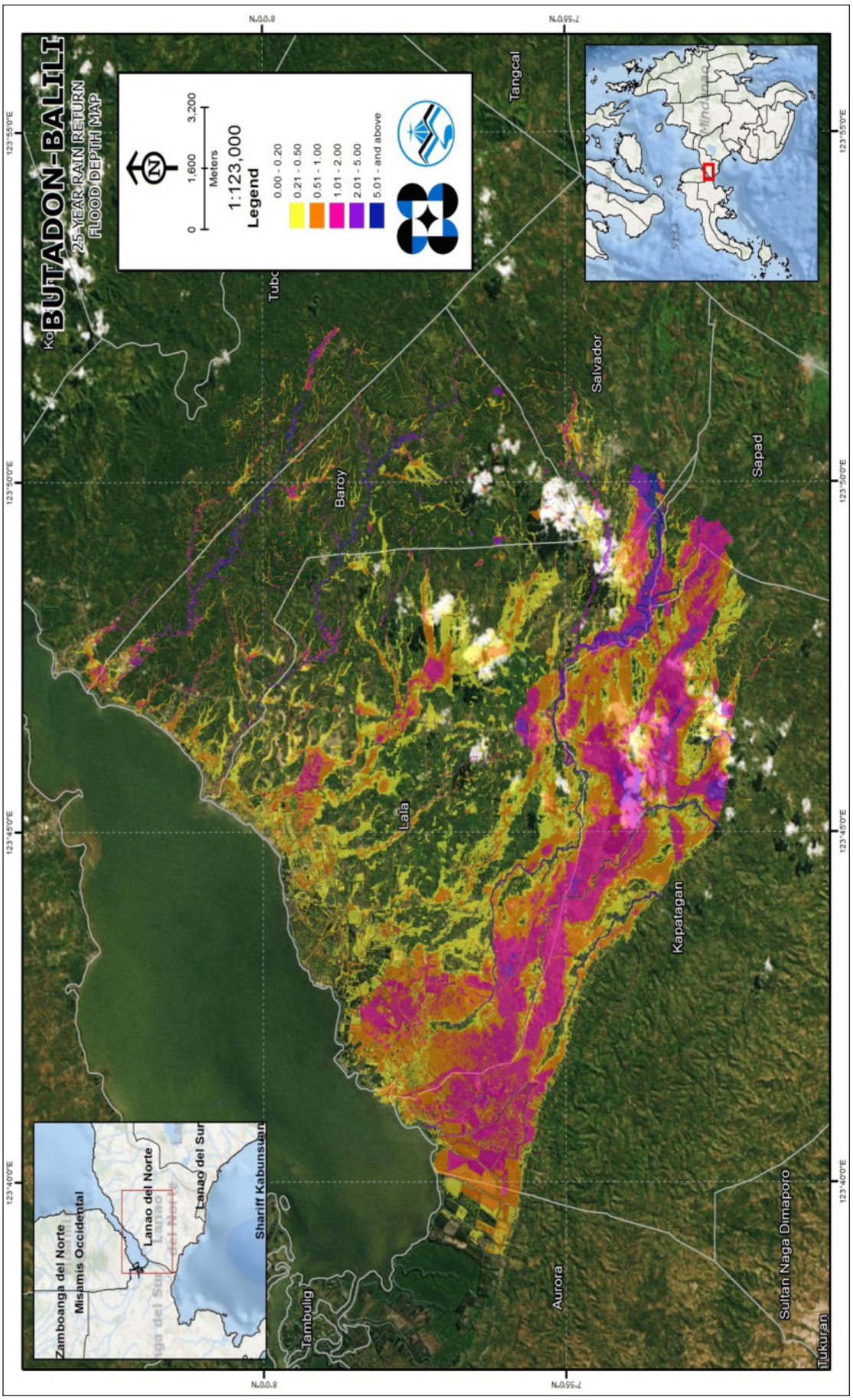


Figure 76. 25-year rain return flow depth map for the Butadon floodplain, overlaid on Google Earth imagery

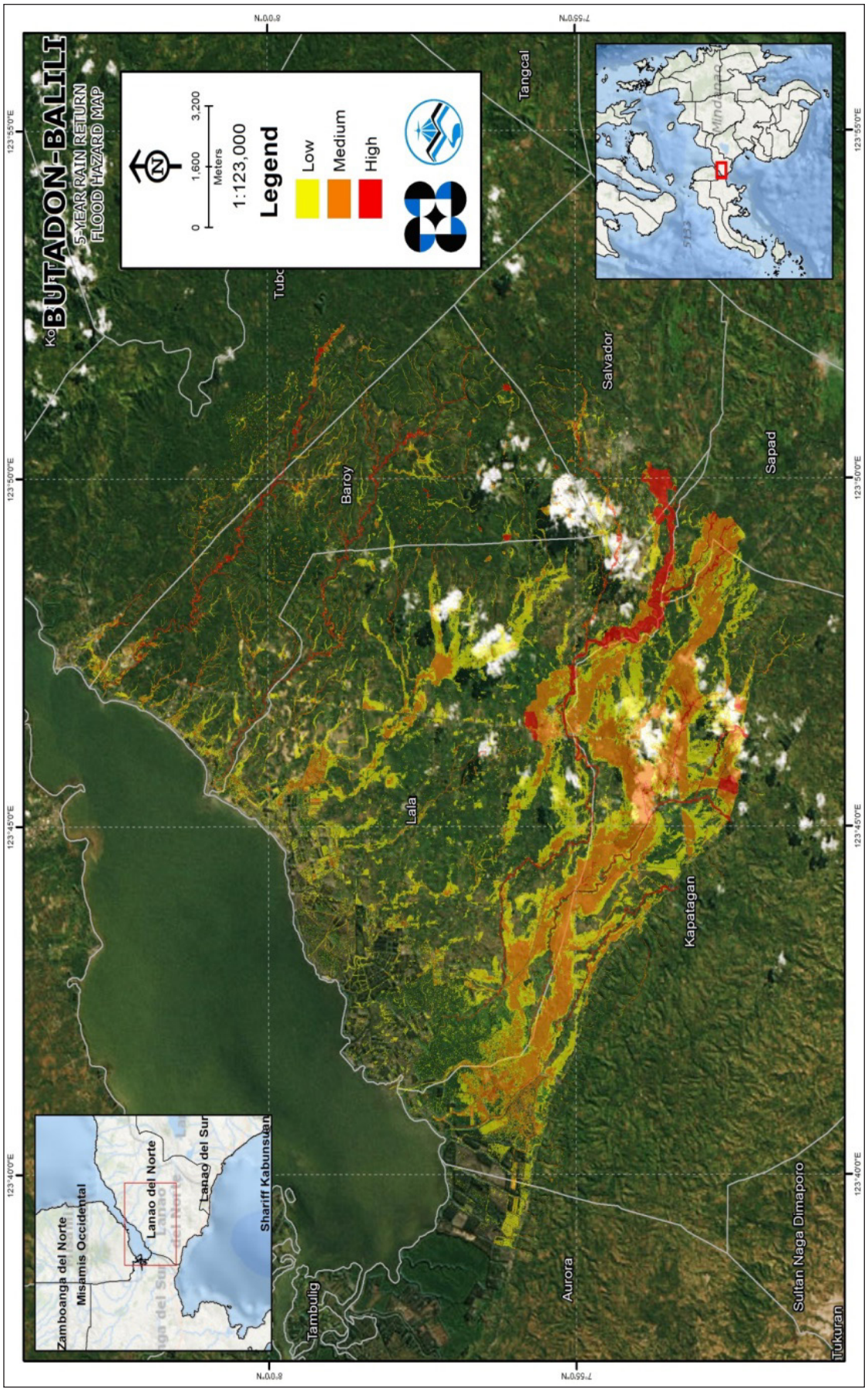


Figure 77. 5-year rain return flood hazard map for the Butadon floodplain overlaid on Google Earth imagery

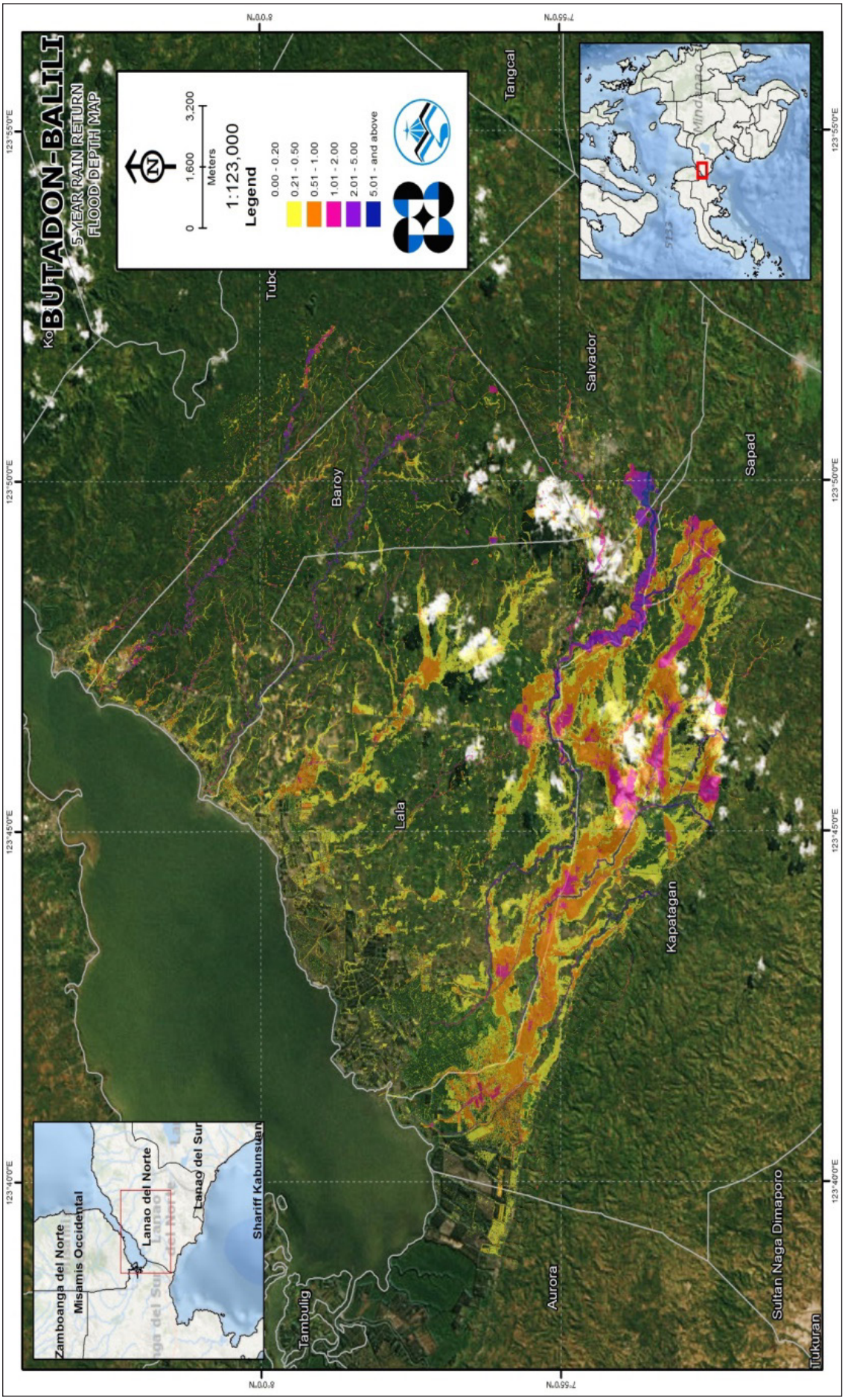


Figure 78. 5-year rain return flow depth map for the Butadon floodplain, overlaid on Google Earth imagery

5.10 Inventory of Areas Exposed to Flooding

Affected barangays in the ButadonRiver Basin, grouped by municipality, are listed below. For the said basin, seven(7) municipalities consisting of ninety-three (93) barangays are expected to experience flooding when subjected to the 5-year, 25-year, and 100-yearrainfall return periods.

For the 5-year return period, 2.61% of the Municipality of Aurora, with an area of 162.225 square kilometers, will experience flood levels of less than 0.20 meters. 0.37% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile,0.04%, 0.005%, and 0.002% 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 37 are the affected areas, in square kilometers, by flood depth per barangay.

Table 37. Affected areas in Aurora, Zamboanga del Sur during a 5-year rainfall return period

BUTADON-Butadon BASIN		Affected Barangays in Aurora
		Anonang
Affected Area (sq. km.)	0.03-0.20	4.23225
	0.21-0.50	0.607248
	0.51-1.00	0.0698
	1.01-2.00	0.0088
	2.01-5.00	0.0035
	> 5.00	0

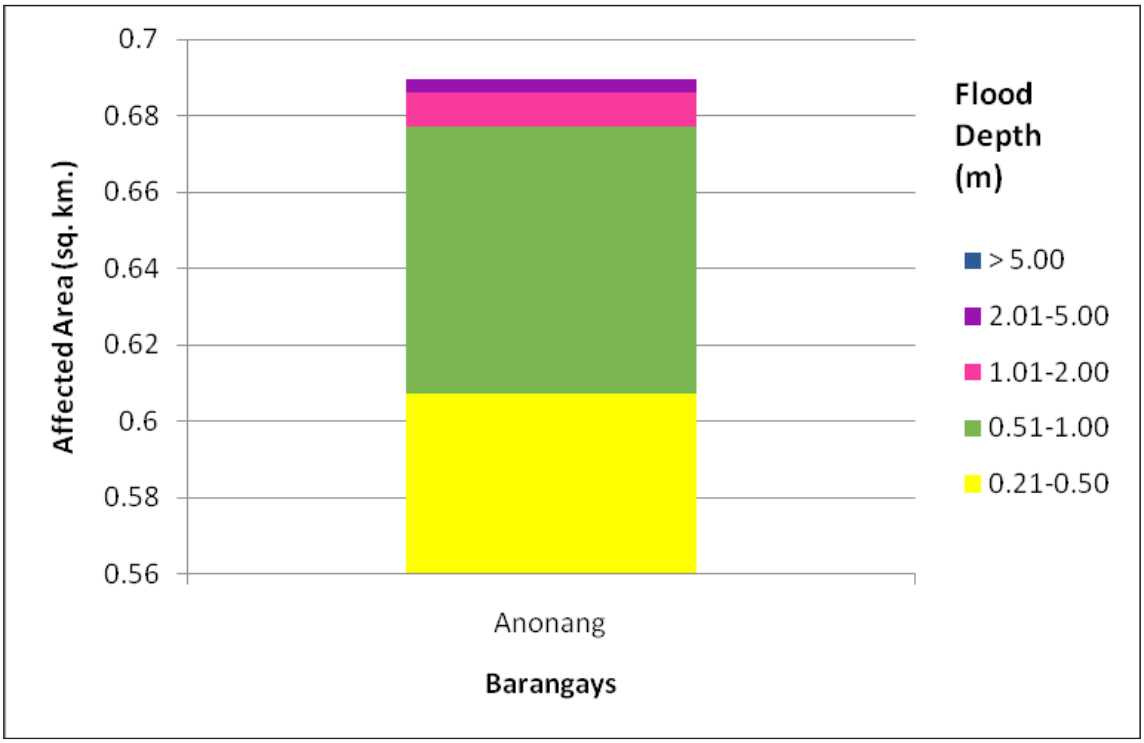


Figure 79. Affected areas in Aurora, Zamboanga del Sur during a 5-year rainfall return period

For the Municipality of Baroy, with an area of 32.08 square kilometers, 87.96% will experience flood levels of less than 0.20 meters. 5.63% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile,2.48%, 1.53%, 1.24%, and 0.42% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 38 are the affected areas, in square kilometers, by flood depth per barangay.

Table 38. Affected areas in Baroy, Lanao del Norte during a 5-year rainfall return period

BUTADON-Butadon BASIN		Affected Barangays in Baroy											
		Andil	Bagong Dawis	Baroy Daku	Bato	Cabasagan	Dalama	Libertad	Limwag	Lindongan	Maliwanag	Manan-Ao	Pange
Affected Area (sq. km.)	0.03-0.20	4.40468	1.94386	0.950785	1.92576	2.69146	1.97162	1.45446	1.33433	2.5115	3.25986	1.91386	1.93279
	0.21-0.50	0.154252	0.145173	0.197693	0.061336	0.088566	0.172662	0.248171	0.055754	0.169224	0.200007	0.133319	0.134309
	0.51-1.00	0.124492	0.052227	0.075216	0.02992	0.027664	0.029435	0.054178	0.016812	0.082561	0.077854	0.048418	0.056199
	1.01-2.00	0.102096	0.03623	0.01099	0.021333	0.013003	0.011984	0.0177	0.022	0.030489	0.063523	0.016632	0.036621
	2.01-5.00	0.094202	0.032305	0.002	0.01061	0.005211	0.009427	0.011501	0.043624	0.0075	0.095362	0.006679	0.0152
	> 5.00	0.037019	0.012545	0	0.0008	0.0002	0.001	0.000437	0.017503	0	0.058796	0	0

BUTADON-Butadon BASIN		Affected Barangays in Baroy										
		Pindolonan	Poblacion	Princesa	Rawan Point	Riverside	Sagadan	Sagadan Upper	Salong	San Juan	Tinubdan	Village
Affected Area (sq. km.)	0.03-0.20	2.43917	1.20102	3.96815	2.40521	5.30325	1.68662	1.25265	3.77664	0.394761	4.46677	1.4217
	0.21-0.50	0.13491	0.038619	0.129314	0.410837	0.196525	0.090365	0.181929	0.164645	0.047308	0.280242	0.059178
	0.51-1.00	0.048979	0.033058	0.088016	0.095156	0.108863	0.069916	0.092541	0.073617	0.027344	0.160266	0.064989
	1.01-2.00	0.032805	0.014573	0.105909	0.0371	0.099474	0.060861	0.027224	0.053561	0.005941	0.090185	0.04159
	2.01-5.00	0.023764	0.002525	0.109157	0.050339	0.096868	0.053807	0.01805	0.003547	0.000356	0.067026	0.013
	> 5.00	0	0.022378	0.037951	0.01269	0.01943	0.0074	0	0	0	0.031794	0

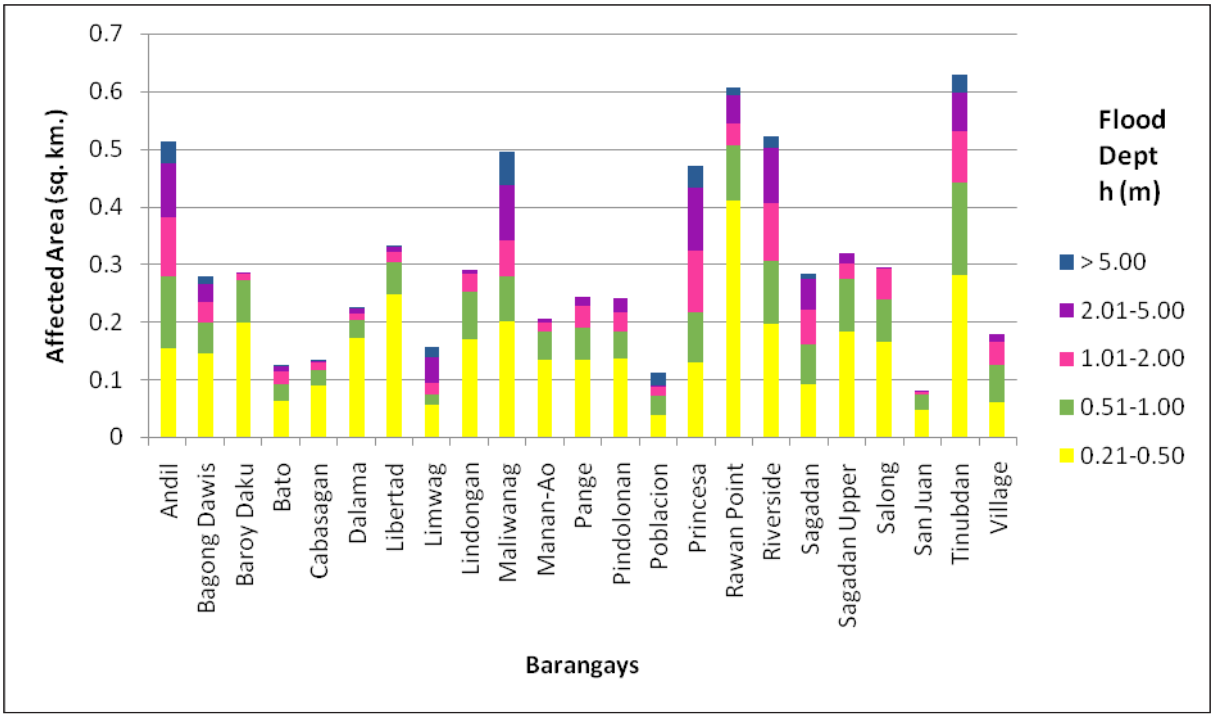


Figure 80. Affected areas in Baroy, Lanao del Norte during a 5-year rainfall return period

For the Municipality of Kapatagan, with an area of 184.77square kilometers, 18.13% will experience flood levels of less 0.20 than meters. 7.13% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile,6.20%, 1.37%, 0.31%, and 0.19% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 39 are the affected areas, in square kilometers, by flood depth per barangay.

Table 39. Affected areas in Kapatagan, Lanao del Norte during a 5-year rainfall return period

BUTADON-Butadon BASIN		Affected Barangays in Kapatagan											
		Bagong Silang	Butadon	Bansarvil	Buenavista	Butadon	Cathedral Falls	Concepcion	Curvada	De Asis	Donggoan	Durano	Lapinig
Affected Area (sq. km.)	0.03-0.20	2.60197	2.30471	0.118836	1.33323	2.11904	1.03709	1.17152	0.689962	0.896606	3.53207	0.848083	3.6352
	0.21-0.50	1.57844	0.776544	0.0022	0.081905	1.49508	0.493558	1.16122	0.222296	0.955294	0.177508	0.010343	1.63532
	0.51-1.00	1.35935	0.828453	0.000193	0.024211	1.62124	0.256007	1.2326	0.275394	0.344252	0.142344	0.003087	1.88021
	1.01-2.00	0.568179	0.210979	0.0003	0.011576	0.16262	0.109467	0.059343	0.143599	0.02297	0.031429	0.00205	0.276532
	2.01-5.00	0.088038	0.068907	0	0.002393	0.07269	0.028248	0.071894	0.029391	0.024308	0.017228	0.000407	0.063171
	> 5.00	0.007475	0.043339	0	0.0001	0.067442	0.047745	0.038302	0.004784	0	0.0004	0	0.0002

BUTADON-Butadon BASIN		Affected Barangays in Kapatagan											
		Malinas	Maranding	Margos	Poblacion	San Vicente	Santa Cruz	Santo Tomas	Suso	Taguitic	Tiacongan	Tulatulahan	Waterfalls
Affected Area (sq. km.)	0.03-0.20	0.336109	0.520039	1.40354	1.20102	0.540308	0.588903	0.229926	1.77454	3.74068	1.84231	0.053399	0.977286
	0.21-0.50	0.011628	0.650482	0.538427	0.038619	0.610971	0.369175	0.508256	0.588259	0.597039	0.187115	0	0.482734
	0.51-1.00	0.0041	1.01617	0.423782	0.033058	0.317403	0.034517	0.773081	0.207899	0.09892	0.05543	0	0.52229
	1.01-2.00	0.0002	0.336504	0.020483	0.014573	0.114874	0.003572	0.014817	0.018772	0.019797	0.020596	0	0.367235
	2.01-5.00	0	0.007241	0.003067	0.002525	0.003803	0.005429	0.013185	0.018343	0.003009	0.001307	0	0.040052
	> 5.00	0	0.020464	0.0001	0.022378	0	0.016578	0.000738	0.039113	0	0	0	0.03907

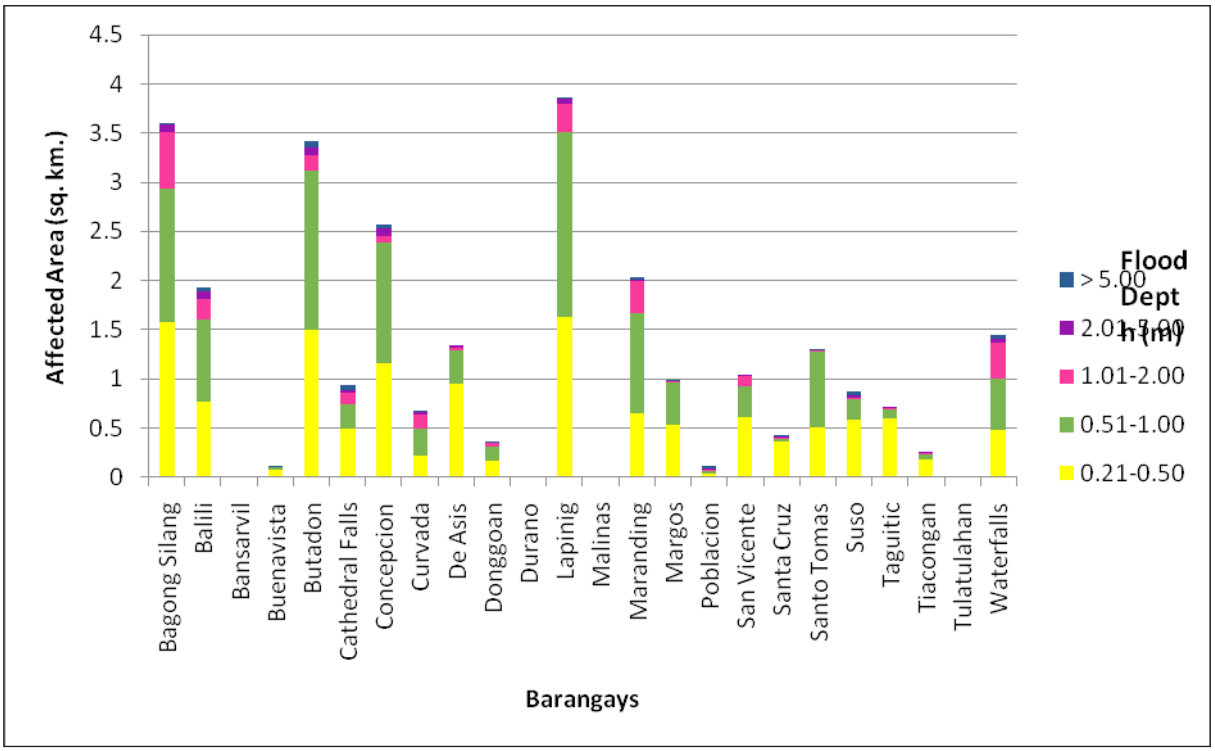


Figure 81. Affected areas in Kapatagan, Lanao del Norte during a 5-year rainfall return period

For the Municipality of Lala, with an area of 125.18square kilometers, 75.73% will experience flood levels of less than 0.20 meters. 15.03% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile,5.57%, 1.43%, 1.31%, and 0.31% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 40 are the affected areas, in square kilometers, by flood depth per barangay.

Table 40. Affected areas in Lala, Lanao del Norte during a 5-year rainfall return period

BUTADON-Butadon BASIN		Affected Barangays in Lala									
		Abaga	Andil	Cabasagan	Camalan	Darumawang Bucana	Darumawang Ilaya	El Salvador	Gumagamot	Lala Proper	Lanipao
Affected Area (sq. km.)	0.03-0.20	2.0051	4.40468	2.69146	2.90129	6.93797	8.40903	3.17868	2.66599	1.19515	1.54169
	0.21-0.50	0.186849	0.154252	0.088566	0.703452	1.00461	1.45679	2.33241	0.468779	0.210934	0.311796
	0.51-1.00	0.015355	0.124492	0.027664	0.241062	0.123578	0.217805	2.32056	0.129615	0.035978	0.082912
	1.01-2.00	0.051482	0.102096	0.013003	0.008301	0.013001	0.025511	0.325324	0.0002	0.013891	0.0012
	2.01-5.00	0.010081	0.094202	0.005211	0	0.0008	0.031236	0.165029	0	0	0
	> 5.00	0	0.037019	0.0002	0	0	0.007404	0	0	0	0

BUTADON-Butadon BASIN		Affected Barangays in Lala										
		Magpatao	Maranding	Matampay Bucana	Matampay Ilaya	Pacita	Pendolonan	Pinoyak	Raw-An	Rebe	San Isidro Lower	San Isidro Upper
Affected Area (sq. km.)	0.03-0.20	2.87387	0.520039	2.71572	1.36805	1.79739	4.80623	4.0972	1.37038	6.13423	3.89005	3.67033
	0.21-0.50	0.436569	0.650482	0.332162	0.225889	0.24538	1.03546	1.82841	0.104887	1.37439	0.421712	0.275114
	0.51-1.00	0.293539	1.01617	0.0265	0.039035	0.012931	0.081635	0.274938	0.003494	0.473929	0.048709	0.059496
	1.01-2.00	0.044382	0.336504	0	0.004135	0.0001	0.024116	0.03779	0.001578	0.321071	0.036361	0.05442
	2.01-5.00	0.0022	0.007241	0	0	0	0.0109	0.063902	0.000004	0.752258	0.000302	0.046517
	> 5.00	0	0.020464	0	0	0	0.0001	0.100346	0	0.046175	0	0.031908

BUTADON-Butadon BASIN		Affected Barangays in Lala					
		San Manuel	Santa Cruz Lower	Santa Cruz Upper	Simpak	Tenazas	Tuna-An
Affected Area (sq. km.)	0.03-0.20	3.55357	5.08506	7.26576	5.33245	2.21415	2.16931
	0.21-0.50	0.641432	0.69255	1.31312	1.3278	0.223156	0.771991
	0.51-1.00	0.188141	0.08145	0.480047	0.376883	0.037169	0.15593
	1.01-2.00	0.130907	0.003875	0.138883	0.071756	0.008628	0.02317
	2.01-5.00	0.373071	0	0.060266	0.02115	0	0.001
	> 5.00	0.088457	0	0.0411	0.018035	0	0

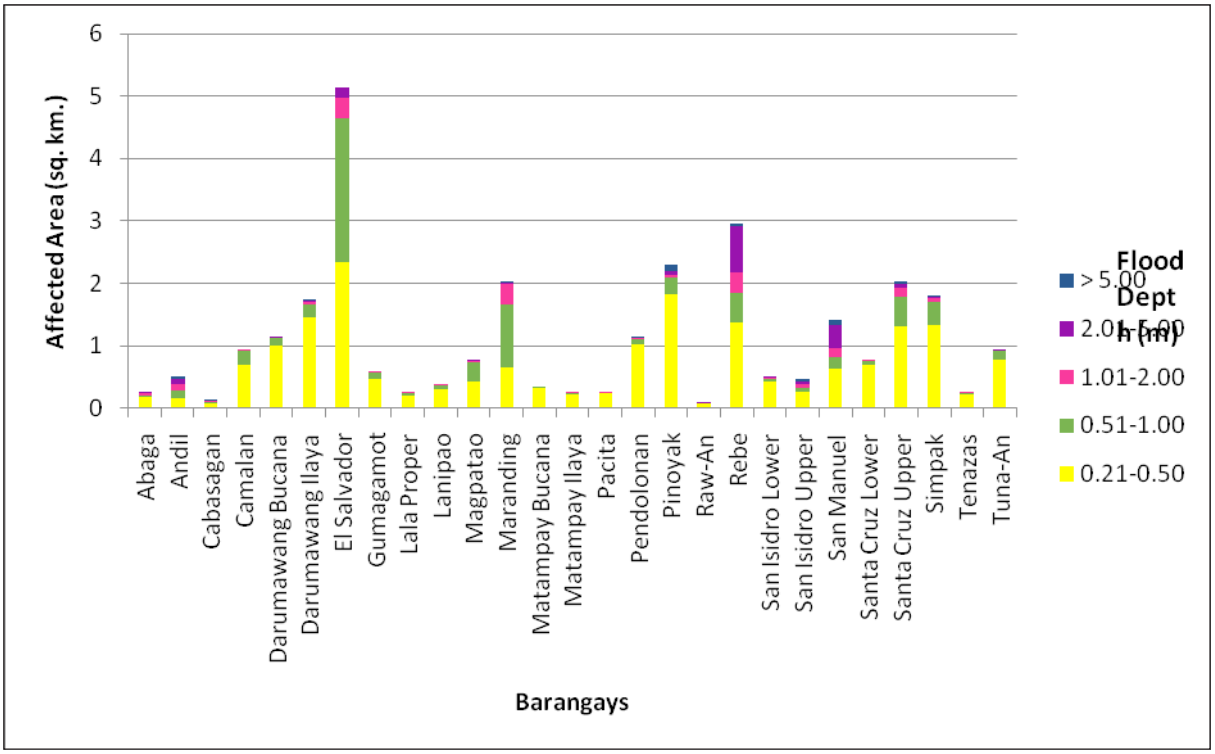


Figure 82. Affected areas in Lala, Lanao del Norte during a 5-year rainfall return period

For the Municipality of Salvador, with an area of 46.46square kilometers, 23.52% will experience flood levels of less than 0.20 meters. 1.73% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile,0.78%, 0.88%, 1.03%, and 0.39% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 41 are the affected areas, in square kilometers, by flood depth per barangay.

Table 41. Affected areas in Salvador, Lanao del Norte during a 5-year rainfall return period

BUTADON-Butadon BASIN		Affected Barangays in Salvador									
		Camp III	Curva-Miagao	Inasagan	Mabatao	Padianan	Pagayawan	Panaliwad-On	Panganta-pan	Poblacion	Sudlon
Affected Area (sq. km.)	0.03-0.20	3.10936	1.25679	1.20012	1.49208	0.155442	0.037194	1.20721	0.007839	1.20102	1.26288
	0.21-0.50	0.218019	0.165668	0.09619	0.048934	0.011049	0.002311	0.13714	0.0013	0.038619	0.084626
	0.51-1.00	0.110866	0.065867	0.010089	0.027589	0.000158	0.0002	0.062408	0	0.033058	0.051633
	1.01-2.00	0.084129	0.111241	0.0041	0.012341	0.000748	0.0001	0.117307	0	0.014573	0.062226
	2.01-5.00	0.026609	0.014868	0.0003	0.0008	0.000549	0	0.39703	0	0.002525	0.035005
	> 5.00	0.0004	0	0	0	0	0	0.160243	0	0.022378	0

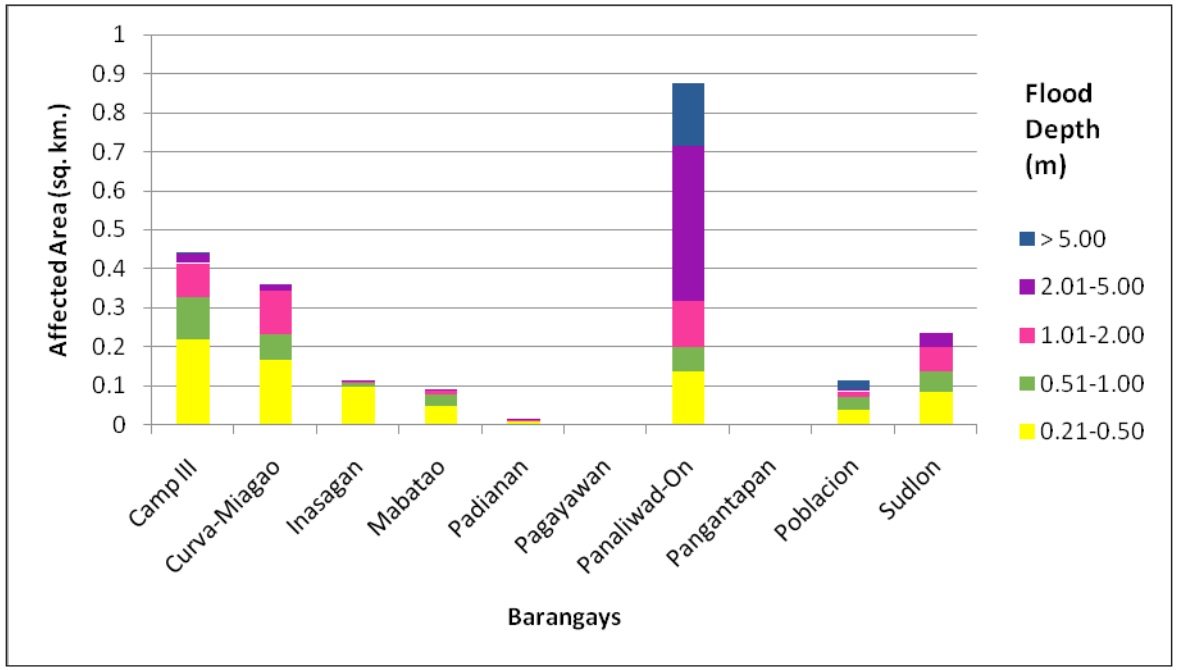


Figure 83. Affected areas in Salvador, Lanao del Norte during a 5-year rainfall return period

For the Municipality of Sapad, with an area of 65.13square kilometers, 2.15% will experience flood levels of less than 0.20 meters. 0.89% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile,1.41%, 0.46%, 0.20%, and 0.10% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 42 are the affected areas, in square kilometers, by flood depth per barangay.

Table 42. Affected areas in Sapad, Lanao del Norte during a 5-year rainfall return period

BUTADON-Butadon BASIN		Affected Barangays in Sapad			
		Mabugnao	Mapurog	Pancilan	Panoloon
Affected Area (sq. km.)	0.03-0.20	0.586253	0.754582	0.008044	0.053034
	0.21-0.50	0.075851	0.385404	0.03873	0.079508
	0.51-1.00	0.097786	0.444446	0.272681	0.10131
	1.01-2.00	0.12516	0.094381	0.049688	0.031
	2.01-5.00	0.010804	0.090596	0.023474	0.005251
	> 5.00	0.014868	0.050502	0	0

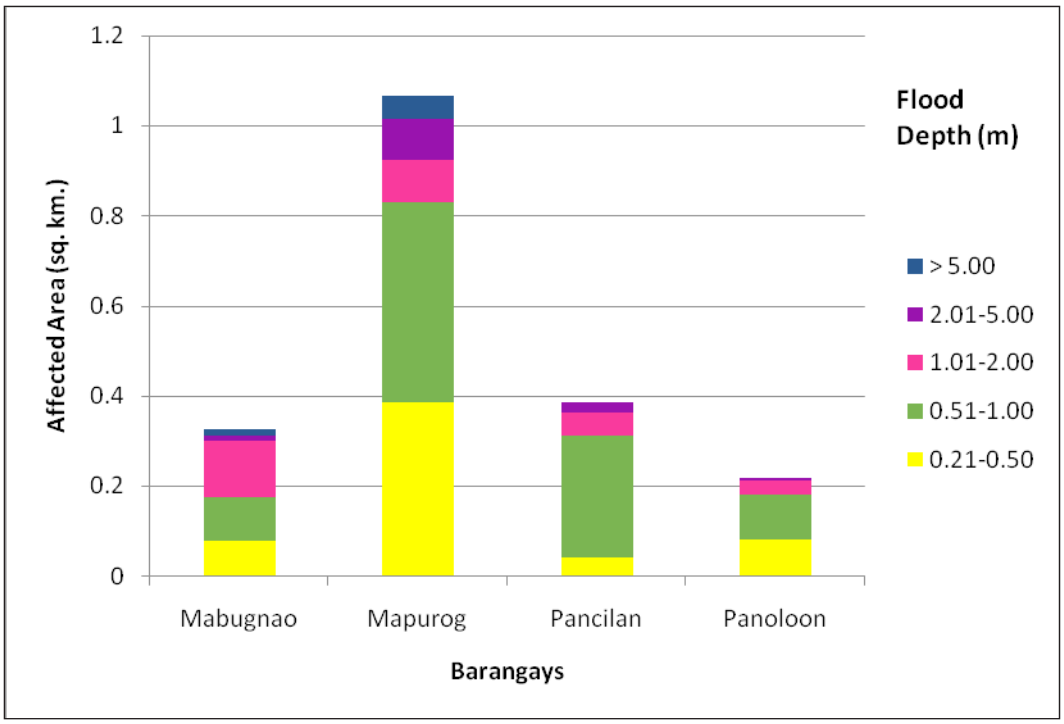


Figure 84. Affected areas in Sapad, Lanao del Norte during a 5-year rainfall return period

For the Municipality of Tubod, with an area of 121.95square kilometers, 12.74% will experience flood levels of less than 0.20 meters. 067% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile,0.46%, 0.29%, 0.15%, and 0.04% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 43 are the affected areas, in square kilometers, by flood depth per barangay.

Table 43. Affected areas in Tubod, Lanao del Norte during a 5-year rainfall return period

BUTADON-Butadon BASIN		Affected Barangays in Tubod									
		Bulod	Candis	Licapao	Malingao	Patudan	Pinpin	Poblacion	Pualas	San Antonio	Santo Niño
Affected Area (sq. km.)	0.03-0.20	0.271384	0.356899	2.89185	2.85429	1.06672	2.16465	1.20102	0.807976	1.50183	2.41784
	0.21-0.50	0.009286	0.010703	0.152622	0.174308	0.062407	0.087068	0.038619	0.039422	0.039382	0.203027
	0.51-1.00	0.007394	0.000988	0.095427	0.120329	0.030826	0.060027	0.033058	0.041976	0.065638	0.10149
	1.01-2.00	0.001638	0.000547	0.080673	0.075749	0.026712	0.036004	0.014573	0.025979	0.047821	0.048812
	2.01-5.00	0	0	0.0502	0.070755	0.011752	0.022404	0.002525	0.001363	0.023092	0.003495
	> 5.00	0	0	0	0.007285	0	0.016734	0.022378	0	0	0

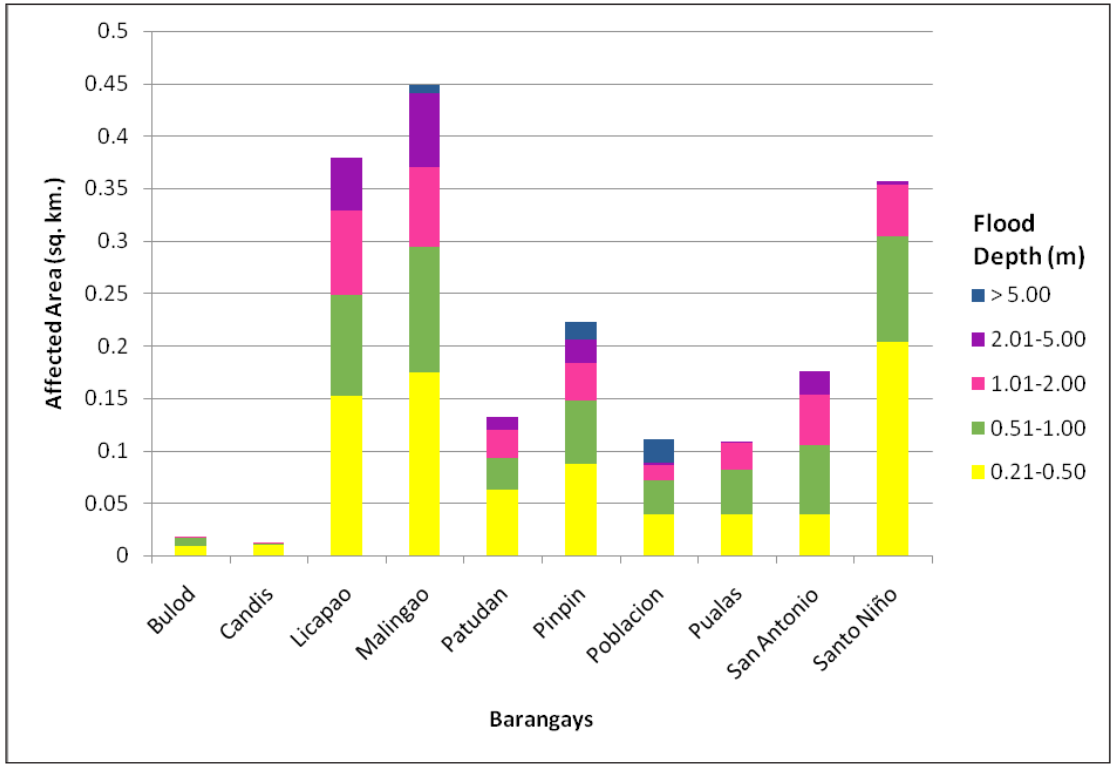


Figure 85. Affected areas in Tubod, Lanao del Norte during a 5-year rainfall return period

For the 25-year return period, 2.61% of the Municipality of Aurora, with an area of 162.225 square kilometers, will experience flood levels of less than 0.20 meters. 1.72% of the area will experience flood levels of 0.21 to 0.50 meters.Meanwhile,0.59%, 067%, 0.04%, and 0.00006% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 44 are the affected areas, in square kilometers, by flood depth per barangay.

Table 44. Affected areas in Aurora, Zamboanga del Sur during a 25-year rainfall return period

BUTADON-Butadon BASIN		Affected Barangays in Aurora
		Anonang
Affected Area (sq. km.)	0.03-0.20	2.78664
	0.21-0.50	0.965115
	0.51-1.00	1.09455
	1.01-2.00	0.070194
	2.01-5.00	0.005
	> 5.00	0.0001

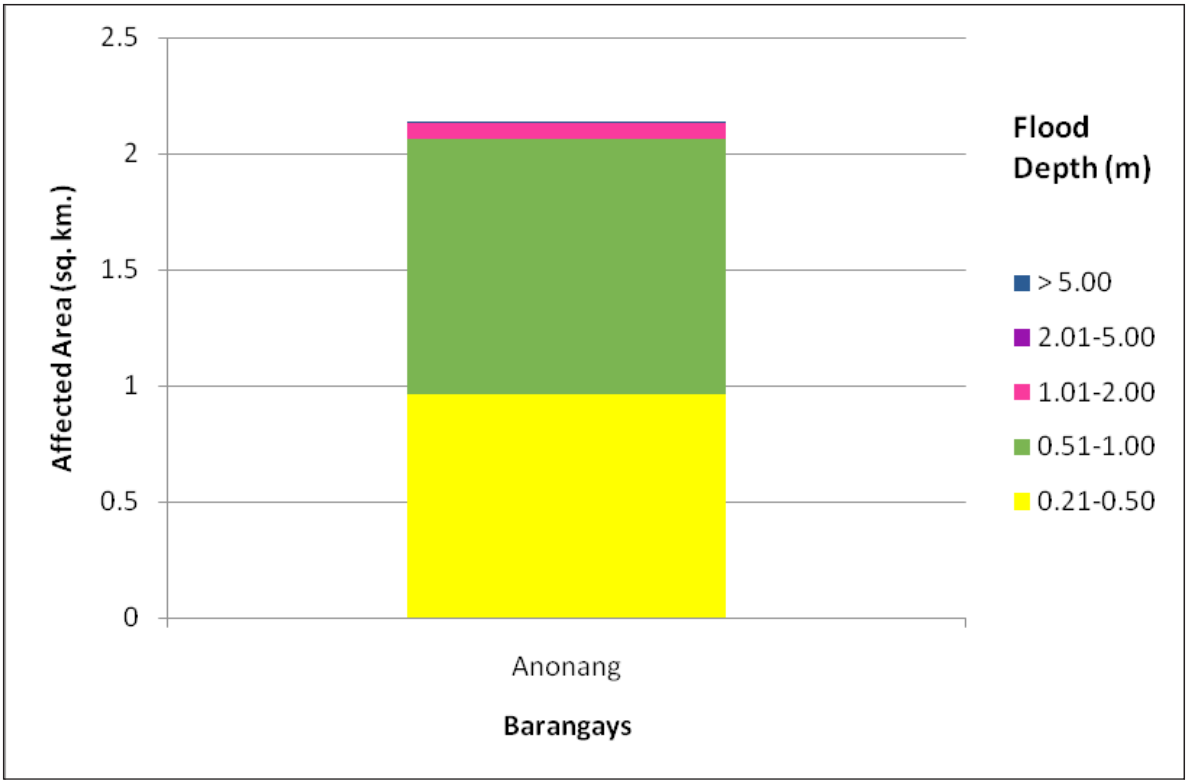


Figure 86. Affected areas in Aurora, Zamboanga del Sur during a 25-year rainfall return period

For the Municipality of Baroy, with an area of 32.08square kilometers, 82.85% will experience flood levels of less than 0.20 meters. 7.63% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile,3.90%, 2.20%, 1.88%, and 0.86% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 45 are the affected areas, in square kilometers, by flood depth per barangay.

Table 45. Affected areas in Baroy, Lanao del Norte during a 25-year rainfall return period

BUTADON-Butadon BASIN		Affected Barangays in Baroy											
		Andil	Bagong Dawis	Baroy Daku	Bato	Cabasagan	Dalama	Libertad	Limwag	Lindongan	Maliwanag	Manan-Ao	Pange
Affected Area (sq. km.)	0.03-0.20	4.26304	1.74382	0.831675	1.88203	2.62849	1.84807	1.22822	1.27297	2.40505	3.12666	1.80999	1.81
	0.21-0.50	0.182034	0.228371	0.224754	0.083227	0.127871	0.256325	0.36965	0.096025	0.197411	0.231464	0.199088	0.193487
	0.51-1.00	0.131119	0.119307	0.148235	0.039758	0.036853	0.063819	0.13796	0.016355	0.132536	0.11072	0.064725	0.092827
	1.01-2.00	0.124713	0.066959	0.028861	0.022638	0.023911	0.016984	0.032997	0.021021	0.046998	0.060243	0.035432	0.050907
	2.01-5.00	0.14161	0.046133	0.003159	0.020911	0.009515	0.010627	0.014923	0.041812	0.020379	0.120213	0.010179	0.027894
	> 5.00	0.074219	0.018344	0	0.0012	0.0006	0.0032	0.00269	0.041839	0	0.106096	0	0

BUTADON-Butadon BASIN		Affected Barangays in Baroy										
		Pindolonan	Poblacion	Princesa	Rawan Point	Riverside	Sagadan	Sagadan Upper	Salong	San Juan	Tinubdan	Village
Affected Area (sq. km.)	0.03-0.20	2.31629	1.18229	3.78414	1.89596	5.15615	1.53219	1.06921	3.68098	0.358449	4.23231	1.38177
	0.21-0.50	0.218661	0.041469	0.150333	0.719264	0.249782	0.123475	0.207234	0.196755	0.062116	0.320094	0.061013
	0.51-1.00	0.05664	0.036404	0.114746	0.274015	0.135016	0.098983	0.181649	0.099709	0.037702	0.226332	0.065006
	1.01-2.00	0.043515	0.025036	0.120811	0.058567	0.091108	0.102442	0.093021	0.052795	0.016985	0.164768	0.067629
	2.01-5.00	0.045385	0.004596	0.191985	0.050541	0.138301	0.081409	0.02128	0.042368	0.000456	0.096285	0.025041
	> 5.00	0	0.043139	0.076481	0.024887	0.054049	0.030471	0	0	0	0.056497	0

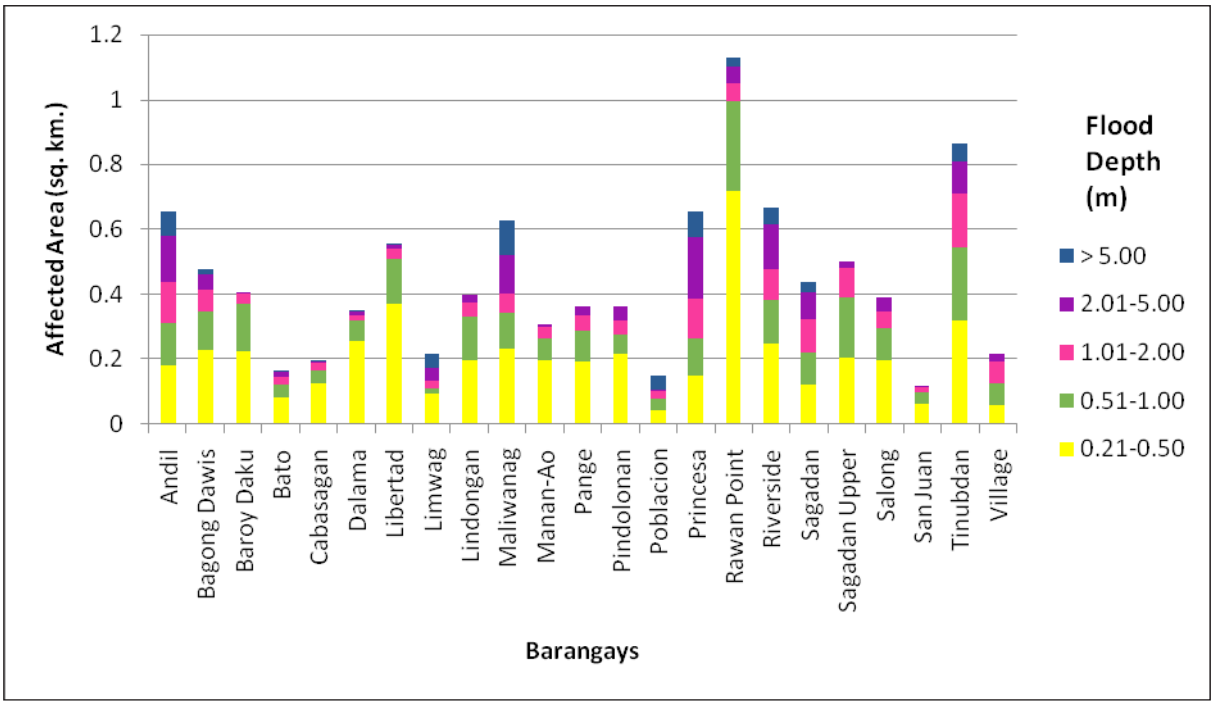


Figure 87. Affected areas in Baroy, Lanao del Norte during a 25-year rainfall return period

For the Municipality of Kapatagan, with an area of 184.77 square kilometers, 10.59% will experience flood levels of less than 0.20 meters. 4.61% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile 8.58%, 8.59%, 0.73%, and 0.25% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 46 are the affected areas, in square kilometers, by flood depth per barangay.

Table 46. Affected areas in Kapatagan, Lanao del Norte during a 25-year rainfall return period

BUTADON-Butadon BASIN		Affected Barangays in Kapatagan											
		Bagong Silang	Butadon	Bansarvil	Buenavista	Butadon	Cathedral Falls	Concepcion	Curvada	De Asis	Donggoan	Durano	Lapinig
Affected Area (sq. km.)	0.03-0.20	0.681206	1.38073	0.116857	1.28105	0.355727	0.776085	0.593858	0.111076	0.293725	3.40794	0.84211	1.37571
	0.21-0.50	1.47474	0.661879	0.003679	0.114161	0.679924	0.527673	0.686736	0.301007	0.525989	0.223136	0.013222	0.669498
	0.51-1.00	1.83158	0.777461	0.000648	0.035619	1.8505	0.380526	0.938203	0.437303	1.1486	0.190196	0.004581	2.30493
	1.01-2.00	1.86187	1.21334	0.000145	0.018588	2.48049	0.173599	1.39888	0.4612	0.255916	0.050335	0.00295	2.99481
	2.01-5.00	0.330236	0.131874	0.0002	0.003793	0.0905	0.065814	0.075886	0.041989	0.024024	0.028275	0.001	0.145178
	> 5.00	0.023814	0.067653	0	0.0002	0.088688	0.048417	0.041308	0.012852	0.003181	0.001094	0.000107	0.000493

BUTADON-Butadon BASIN		Affected Barangays in Kapatagan											
		Malinas	Maranding	Margos	Poblacion	San Vicente	Santa Cruz	Santo Tomas	Suso	Taguitic	Tiacongan	Tulatulahan	Waterfalls
Affected Area (sq. km.)	0.03-0.20	0.330121	0.157747	0.856354	1.18229	0.138445	0.349874	0.095462	1.42163	1.4019	1.68229	0.053299	0.674534
	0.21-0.50	0.015292	0.2945	0.168328	0.041469	0.425059	0.20504	0.255489	0.444515	0.270848	0.27739	0.0001	0.2334
	0.51-1.00	0.005623	0.923331	0.383526	0.036404	0.420876	0.41574	0.991873	0.514602	1.63655	0.106461	0	0.523665
	1.01-2.00	0.001	1.14239	0.967025	0.025036	0.579768	0.024119	0.182983	0.208504	1.14404	0.038314	0	0.651371
	2.01-5.00	0	0.011412	0.014067	0.004596	0.023212	0.005785	0.015658	0.02142	0.006109	0.002307	0	0.30369
	> 5.00	0	0.021522	0.0001	0.043139	0	0.017616	0.000837	0.040442	0	0	0	0.042632

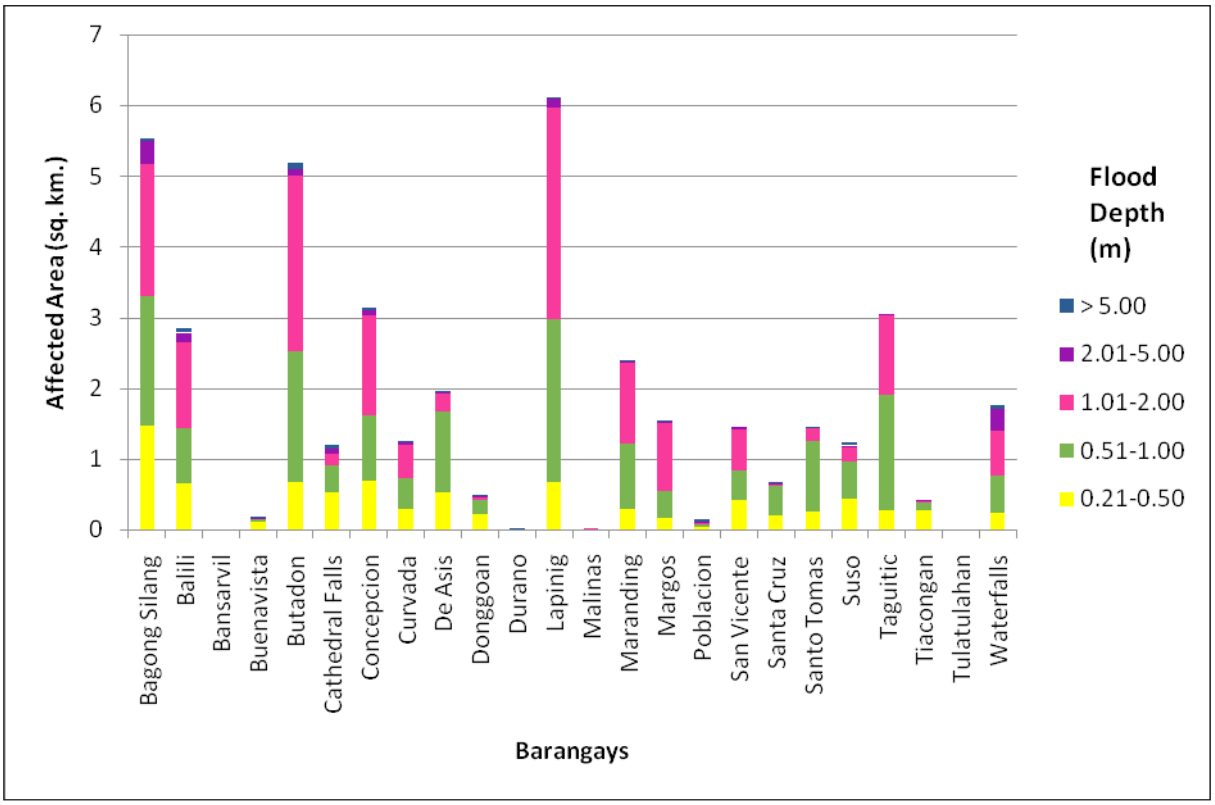


Figure 88. Affected areas in Kapatagan, Lanao del Norte during a 25-year rainfall return period

For the Municipality of Lala, with an area of 125.18 square kilometers, 52.28% will experience flood levels of less than 0.20 meters. 21.17% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile,14.95%, 8.74%, 1.79%, and 0.50% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 47 are the affected areas, in square kilometers, by flood depth per barangay.

Table 47. Affected areas in Lala, Lanao del Norte during a 25-year rainfall return period

BUTADON-Butadon BASIN		Affected Barangays in Lala										
		Abaga	Andil	Cabasagan	Camalan	Darumawang Bucana	Darumawang Ilaya	El Salvador	Gumagamot	Lala Proper	Lanipao	Magpatao
Affected Area (sq. km.)	0.03-0.20	1.79083	4.26304	2.62849	1.5455	1.56072	4.26274	0.357566	2.19321	0.925401	1.16686	2.29348
	0.21-0.50	0.379307	0.182034	0.127871	1.16126	1.45496	3.05202	0.764308	0.730402	0.404857	0.536653	0.664225
	0.51-1.00	0.033972	0.131119	0.036853	0.947524	3.34876	2.09976	2.51342	0.326966	0.100367	0.178755	0.415824
	1.01-2.00	0.028599	0.124713	0.023911	0.199816	1.71353	0.691198	4.34052	0.019361	0.024133	0.055322	0.271817
	2.01-5.00	0.036262	0.14161	0.009515	0	0.002	0.031857	0.345345	0	0.0012	0	0.005217
	> 5.00	0	0.074219	0.0006	0	0	0.010204	0.000841	0	0	0	0

BUTADON-Butadon BASIN		Affected Barangays in Lala										
		Maranding	Matampay Bucana	Matampay Ilaya	Pacita	Pendolonan	Pinoyak	Raw-An	Rebe	San Isidro Lower	San Isidro Upper	San Manuel
Affected Area (sq. km.)	0.03-0.20	0.157747	2.31232	0.954579	1.39871	3.98747	2.14318	1.23857	4.68903	3.24877	3.31729	2.30358
	0.21-0.50	0.2945	0.633382	0.555049	0.597407	1.57621	1.89517	0.220345	2.12674	0.895633	0.535997	0.876542
	0.51-1.00	0.923331	0.129876	0.121904	0.060082	0.340032	1.93157	0.021766	0.860422	0.206709	0.104144	0.697306
	1.01-2.00	1.14239	0.0001	0.00808	0.0011	0.041726	0.245252	0.003094	0.441274	0.035082	0.058576	0.511527
	2.01-5.00	0.011412	0	0	0	0.0128	0.077634	0.000083	0.867052	0.016402	0.079487	0.425045
	> 5.00	0.021522	0	0	0	0.0002	0.109788	0.000004	0.122116	0	0.044984	0.162469

BUTADON-Butadon BASIN		Affected Barangays in Lala				
		Santa Cruz Lower	Santa Cruz Upper	Simpak	Tenazas	Tuna-An
Affected Area (sq. km.)	0.03-0.20	3.07068	5.95593	4.32616	1.87531	1.47933
	0.21-0.50	1.73794	1.65553	1.88535	0.481954	1.07092
	0.51-1.00	0.726034	1.1036	0.762366	0.094939	0.491201
	1.01-2.00	0.332391	0.395766	0.125255	0.030508	0.078759
	2.01-5.00	0	0.139605	0.041248	0.0004	0.0012
	> 5.00	0	0.054174	0.018735	0	0

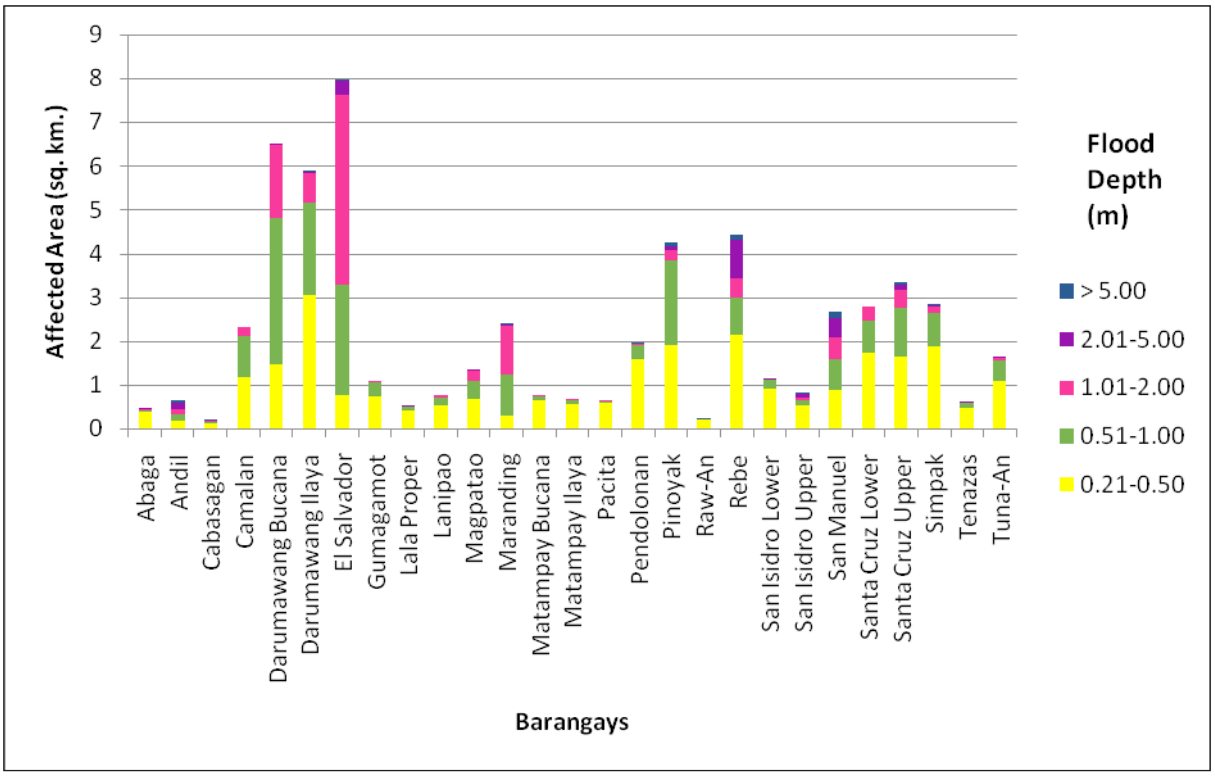


Figure 89. Affected areas in Lala, Lanao del Norte during a 25-year rainfall return period

For the Municipality of Salvador, with an area of 46.46 square kilometers, 23.52% will experience flood levels of less than 0.20 meters. 1.73% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile,0.78%, 0.88%, 1.03%, and 0.39% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 48 are the affected areas, in square kilometers, by flood depth per barangay.

Table 48. Affected areas in Salvador, Lanao del Norte during a 25-year rainfall return period

BUTADON-Butadon BASIN		Affected Barangays in Salvador									
		Camp III	Curva-Miagao	Inasagan	Mabatao	Padianan	Pagayawan	Panaliwad-On	Panganta-pan	Poblacion	Sudlon
Affected Area (sq. km.)	0.03-0.20	2.87042	0.890981	1.04467	1.45989	0.145715	0.035369	0.659671	0.006209	1.18229	1.12408
	0.21-0.50	0.321941	0.355637	0.238856	0.06436	0.020508	0.003836	0.19082	0.00293	0.041469	0.145573
	0.51-1.00	0.198428	0.123323	0.01952	0.035866	0.000369	0.0005	0.223969	0	0.036404	0.078048
	1.01-2.00	0.110469	0.090474	0.007049	0.019869	0.000664	0	0.288435	0	0.025036	0.072404
	2.01-5.00	0.047327	0.154019	0.0007	0.002657	0.00069	0.0001	0.455195	0	0.004596	0.076271
	> 5.00	0.0008	0	0	0	0	0	0.263248	0	0.043139	0

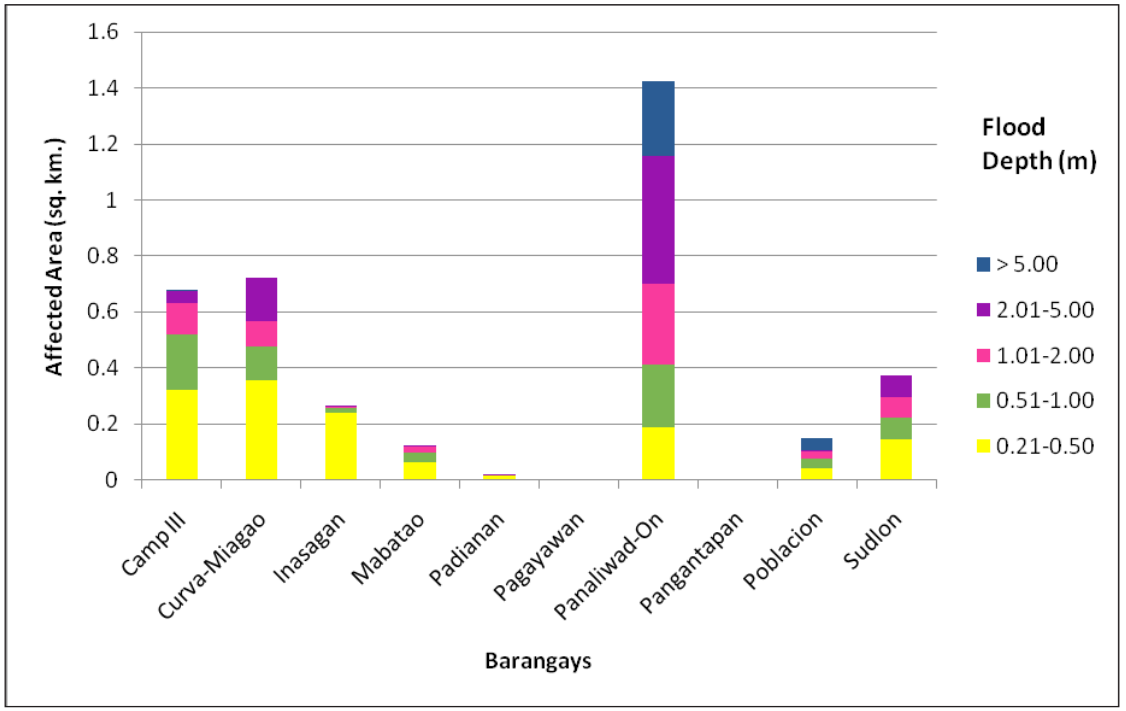


Figure 90. Affected areas in Salvador, Lanao del Norte during a 25-year rainfall return period

For the Municipality of Sapad, with an area of 65.13square kilometers, 2.15% will experience flood levels of less than 0.20 meters. 0.89% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile,1.41%, 0.46%, 0.20%, and 0.10% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 49 are the affected areas, in square kilometers, by flood depth per barangay.

Table 49. Affected areas in Sapad, Lanao del Norte during a 25-year rainfall return period

BUTADON-Butadon BASIN		Affected Barangays in Sapad			
		Mabugnao	Mapurog	Pancilan	Panoloon
Affected Area (sq. km.)	0.03-0.20	0.541182	0.389401	0	0.00968
	0.21-0.50	0.075331	0.245422	0.0003	0.02064
	0.51-1.00	0.062149	0.520633	0.013828	0.0497
	1.01-2.00	0.186013	0.470577	0.336615	0.178137
	2.01-5.00	0.030179	0.137181	0.041874	0.011947
	> 5.00	0.015868	0.056696	0	0

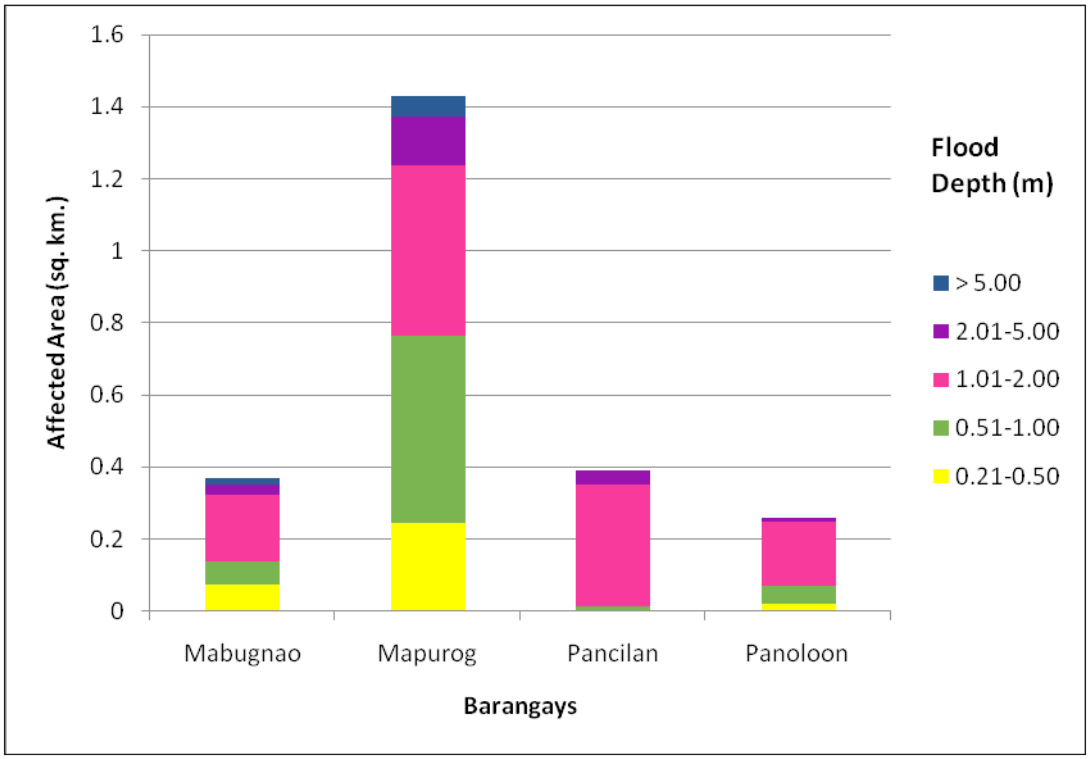


Figure 91. Affected areas in Sapad, Lanao del Norte during a 25-year rainfall return period

For the Municipality of Tubod, with an area of 121.95 square kilometers, 12.74% will experience flood levels of less than 0.20 meters. 067% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile,0.46%, 0.29%, 0.15%, and 0.04% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 50 are the affected areas, in square kilometers, by flood depth per barangay.

Table 50. Affected areas in Tubod, Lanao del Norte during a 25-year rainfall return period

BUTADON-Butadon BASIN		Affected Barangays in Tubod									
		Bulod	Candis	Licapao	Malingao	Patudan	Pinpin	Poblacion	Pualas	San Antonio	Santo Niño
Affected Area (sq. km.)	0.03-0.20	0.265069	0.351044	2.77308	2.72772	1.01946	2.08268	1.18229	0.781151	1.46984	2.25839
	0.21-0.50	0.007408	0.015558	0.17407	0.191031	0.056251	0.108491	0.041469	0.031737	0.034409	0.238741
	0.51-1.00	0.010925	0.001788	0.119079	0.143898	0.050041	0.08056	0.036404	0.045292	0.051592	0.167833
	1.01-2.00	0.0063	0.000747	0.12037	0.107287	0.041645	0.058239	0.025036	0.05002	0.084113	0.091735
	2.01-5.00	0	0	0.084175	0.07968	0.031024	0.02639	0.004596	0.008515	0.037809	0.01796
	> 5.00	0	0	0	0.053096	0	0.030533	0.043139	0	0	0

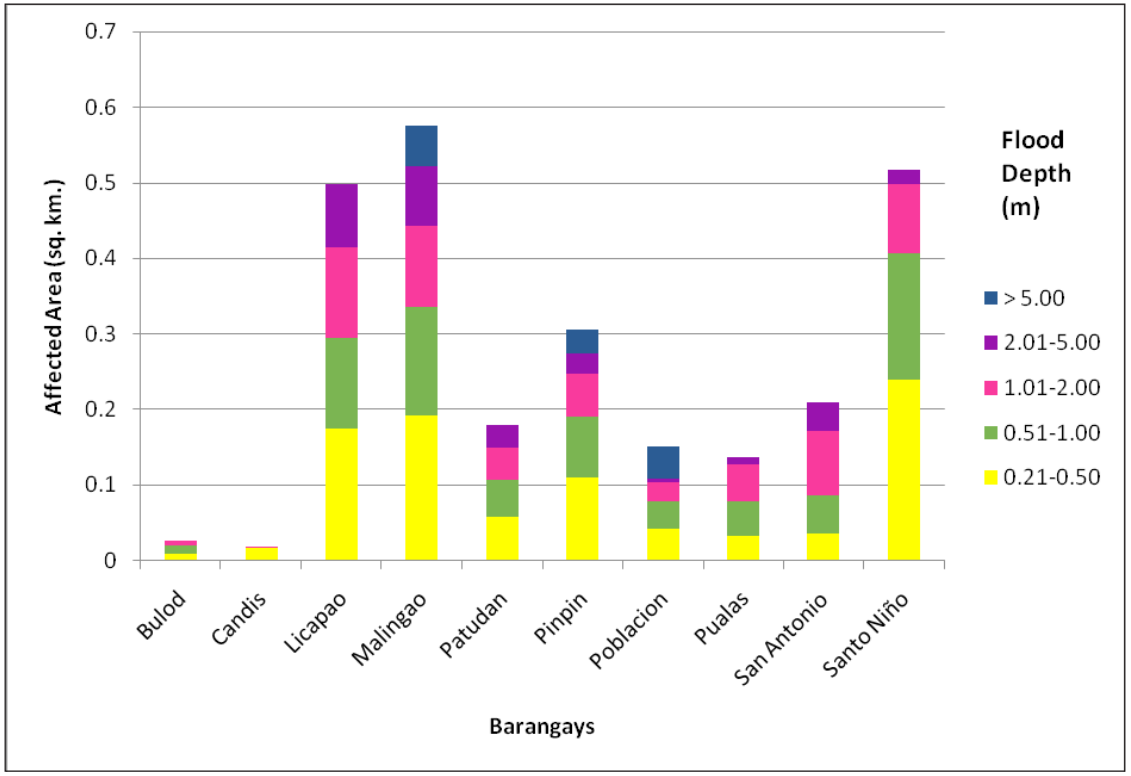


Figure 92. Affected areas in Tubod, Lanao del Norte during a 25-year rainfall return period

For the 100-yearreturn period, 1.07% of the Municipality of Aurora, with an area of 162.225square kilometers,will experience flood levels of less than 0.20 meters. 0.15% of the area will experience flood levels of 0.21 to 0.50 meters.Meanwhile,0.79%, 1.01%, 0.004%, and 0.00006% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 51 are the affected areas, in square kilometers, by flood depth per barangay.

Table 51. Affected areas in Aurora, Zamboanga del Sur during a 100-year rainfall return period

BUTADON-Butadon BASIN		Affected Barangays in Aurora
		Anonang
Affected Area (sq. km.)	0.03-0.20	1.74136
	0.21-0.50	0.244848
	0.51-1.00	1.28596
	1.01-2.00	1.64243
	2.01-5.00	0.0069
	> 5.00	0.0001

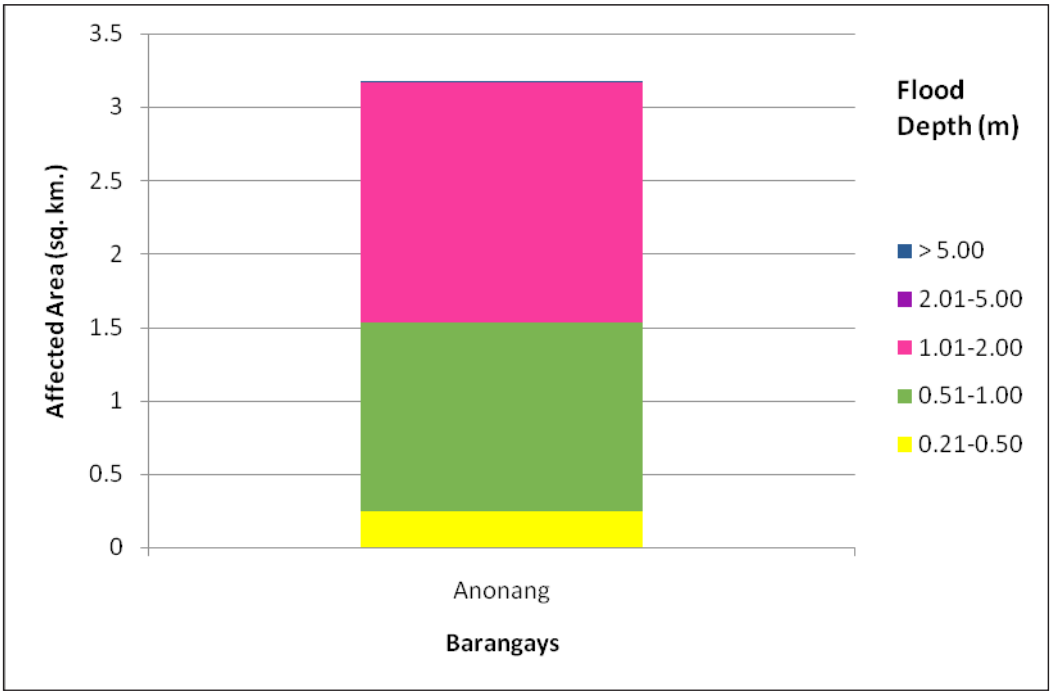


Figure 93. Affected areas in Aurora, Zamboanga del Sur during a 100-year rainfall return period

For the Municipality of Baroy, with an area of 32.08 square kilometers, 79.47% will experience flood levels of less than 0.20 meters. 8.49% of the area will experience flood levels of 0.21 to 0.50 meters.Meanwhile, 5.09%, 2.92%, 2.16%, and 1.24% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 52 are the affected areas, in square kilometers, by flood depth per barangay.

Table 52. Affected areas in Baroy, Lanao del Norte during a 100-year rainfall return period

BUTADON-Butadon BASIN		Affected Barangays in Baroy											
		Andil	Bagong Dawis	Baroy Daku	Bato	Cabasagan	Dalama	Libertad	Limwag	Lindongan	Maliwanag	Manan-Ao	Pange
Affected Area (sq. km.)	0.03-0.20	4.1699	1.568	0.771113	1.83972	2.57914	1.77467	1.1196	1.22999	2.34039	3.04292	1.73139	1.70504
	0.21-0.50	0.207506	0.288336	0.223375	0.106927	0.159096	0.293875	0.391821	0.116123	0.218244	0.242051	0.246042	0.243969
	0.51-1.00	0.140753	0.195344	0.192101	0.047805	0.042558	0.09347	0.19456	0.024153	0.110536	0.145642	0.083173	0.124488
	1.01-2.00	0.138584	0.099803	0.046137	0.029303	0.031431	0.021816	0.058074	0.021061	0.107534	0.065459	0.046281	0.064894
	2.01-5.00	0.148306	0.052666	0.003959	0.024405	0.014015	0.011995	0.017771	0.037782	0.025972	0.108467	0.013111	0.036492
	> 5.00	0.111688	0.021111	0	0.0016	0.0017	0.0039	0.004619	0.060917	0	0.150858	0.0001	0.000233

BUTADON-Butadon BASIN		Affected Barangays in Baroy										
		Pindolonan	Poblacion	Princesa	Rawan Point	Riverside	Sagadan	Sagadan Upper	Salong	San Juan	Tinubdan	Village
Affected Area (sq. km.)	0.03-0.20	2.23233	1.17049	3.6443	1.57667	5.05135	1.41586	0.994706	3.61781	0.333341	4.07544	1.3546
	0.21-0.50	0.270396	0.04118	0.175112	0.734279	0.284249	0.156986	0.202867	0.213166	0.07636	0.318038	0.061653
	0.51-1.00	0.072231	0.038491	0.139784	0.546323	0.155906	0.120933	0.20289	0.115928	0.040918	0.266236	0.065231
	1.01-2.00	0.046893	0.032336	0.142245	0.093033	0.104776	0.130509	0.145416	0.067684	0.024535	0.213938	0.080469
	2.01-5.00	0.059185	0.007295	0.225778	0.052841	0.125438	0.106807	0.026515	0.058374	0.000556	0.143673	0.038506
	> 5.00	0.0001	0.054745	0.111277	0.026987	0.102694	0.037875	0	0	0	0.078956	0

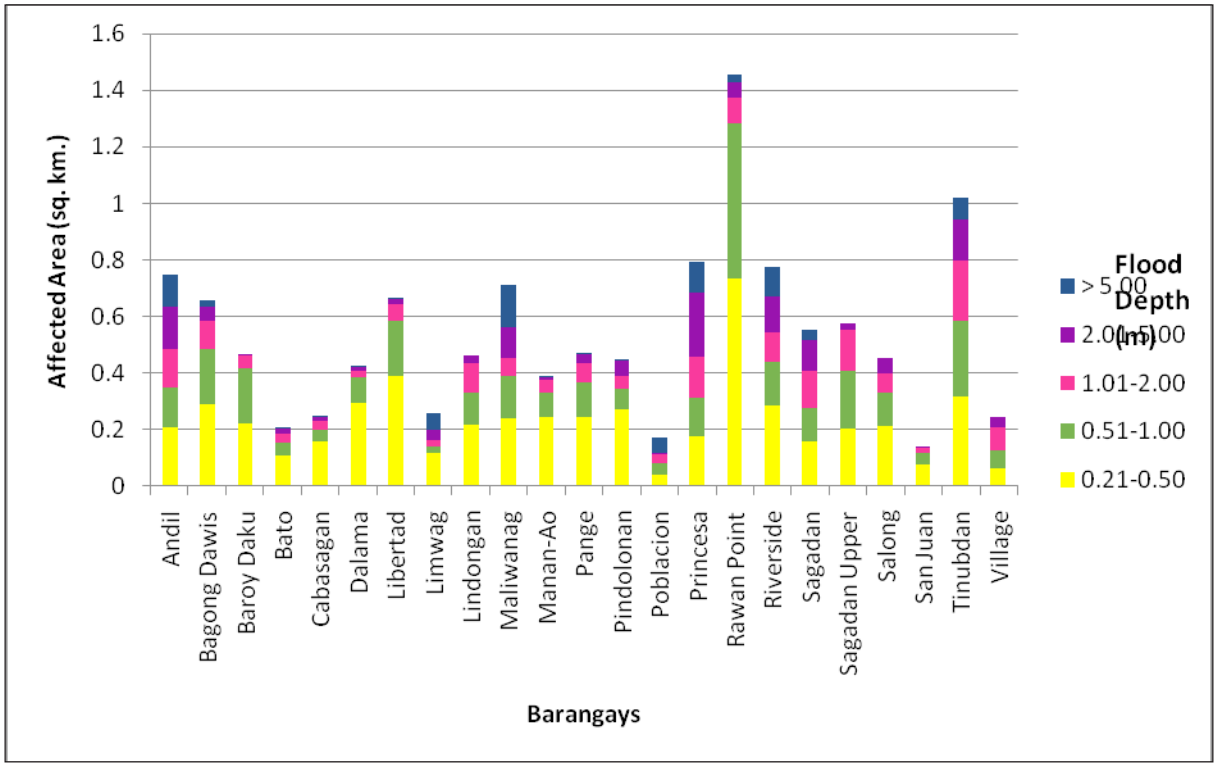


Figure 94. Affected areas in Baroy, Lanao del Norte during a 100-year rainfall return period

For the Municipality of Kapatagan, with an area of 184.77 square kilometers, 9.16% will experience flood levels of less than 0.20 meters. 3.07% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile,6.84%, 12.01%, 2.00%, and 0.28% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 53 are the affected areas, in square kilometers, by flood depth per barangay.

Table 53. Affected areas in Kapatagan, Lanao del Norte during a 100-year rainfall return period

BUTADON-Butadon BASIN		Affected Barangays in Kapatagan											
		Bagong Silang	Butadon	Bansarvil	Buenavista	Butadon	Cathedral Falls	Concepcion	Curvada	De Asis	Donggoan	Durano	Lapinig
Affected Area (sq. km.)	0.03-0.20	0.177695	1.17159	0.115609	1.24916	0.149141	0.70308	0.36793	0.03487	0.113671	3.33205	0.837806	1.05979
	0.21-0.50	0.718437	0.518964	0.004527	0.127006	0.239611	0.457581	0.559387	0.128743	0.339498	0.259939	0.015079	0.434852
	0.51-1.00	1.89178	0.656465	0.001048	0.048561	1.08274	0.455058	0.771606	0.510097	1.14222	0.206763	0.005995	1.35551
	1.01-2.00	2.53346	1.2674	0.000145	0.023088	3.44668	0.201414	1.90272	0.501248	0.624311	0.066116	0.003483	4.26509
	2.01-5.00	0.844673	0.534266	0.0002	0.005293	0.534962	0.106061	0.085513	0.17717	0.023167	0.034517	0.0015	0.374893
	> 5.00	0.037404	0.084246	0	0.0003	0.093582	0.04892	0.047708	0.013299	0.007859	0.001594	0.000107	0.000493

BUTADON-Butadon BASIN		Affected Barangays in Kapatagan											
		Malinas	Maranding	Margos	Poblacion	San Vicente	Santa Cruz	Santo Tomas	Suso	Taguitic	Tiacongan	Tulatulahan	Waterfalls
Affected Area (sq. km.)	0.03-0.20	0.327051	0.06549	0.756131	1.17049	0.079536	0.27354	0.065845	1.34642	1.28998	1.58707	0.053299	0.601919
	0.21-0.50	0.016063	0.157067	0.127838	0.04118	0.249539	0.166409	0.148655	0.351515	0.219939	0.221516	0.0001	0.166361
	0.51-1.00	0.007223	0.618916	0.235121	0.038491	0.315664	0.328403	0.763823	0.509847	0.972827	0.217067	0	0.493836
	1.01-2.00	0.0017	1.44263	1.16636	0.032336	0.795752	0.225622	0.546114	0.381208	1.95929	0.076465	0	0.719918
	2.01-5.00	0	0.243789	0.103846	0.007295	0.146459	0.005501	0.017627	0.022298	0.017406	0.004646	0	0.403994
	> 5.00	0	0.023008	0.0001	0.054745	0.00041	0.0187	0.00084	0.041365	0	0	0	0.044028

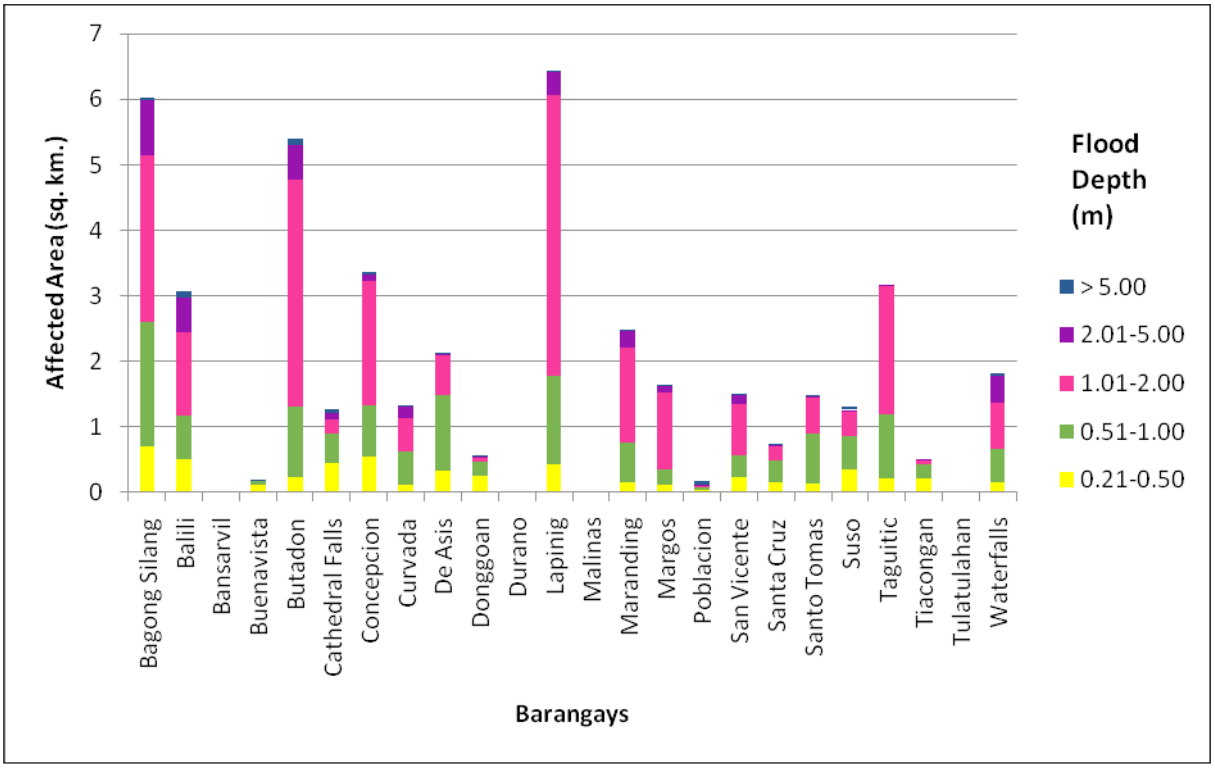


Figure 95. Affected areas in Kapatagan, Lanao del Norte during a 100-year rainfall return period

For the Municipality of Lala, with an area of 125.18 square kilometers, 41.94% will experience flood levels of less than 0.20 meters. 19.66% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile,18.02%, 16.32%, 2.83%, and 0.67% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 54 are the affected areas, in square kilometers, by flood depth per barangay.

Table 54. Affected areas in Lala, Lanao del Norte during a 100-year rainfall return period

BUTADON-Butadon BASIN		Affected Barangays in Lala										
		Abaga	Andil	Cabasagan	Camalan	Darumawang Bucana	Darumawang Ilaya	El Salvador	Gumagamot	Lala Proper	Lanipao	Magpatao
Affected Area (sq. km.)	0.03-0.20	1.62361	4.1699	2.57914	1.13091	0.54081	2.4194	0.060992	1.85725	0.772655	0.932328	2.00569
	0.21-0.50	0.520495	0.207506	0.159096	0.873563	0.664719	2.8758	0.196089	0.896586	0.457586	0.662325	0.661436
	0.51-1.00	0.058657	0.140753	0.042558	1.4193	2.52536	2.6127	1.26632	0.438446	0.185458	0.204185	0.525129
	1.01-2.00	0.020341	0.138584	0.031431	0.428048	4.31332	2.18611	5.64087	0.078854	0.037659	0.138756	0.441832
	2.01-5.00	0.045861	0.148306	0.014015	0.00228	0.03575	0.040058	1.14008	0	0.0026	0	0.016476
	> 5.00	0	0.111688	0.0017	0	0	0.013704	0.017641	0	0	0	0

BUTADON-Butadon BASIN		Affected Barangays in Lala										
		Maranding	Matampay Bucana	Matampay Ilaya	Pacita	Pendolonan	Pinoyak	Raw-An	Rebe	San Isidro Lower	San Isidro Upper	San Manuel	Santa Cruz Lower
Affected Area (sq. km.)	0.03-0.20	0.06549	1.76257	0.619675	1.19337	3.68474	1.13767	1.10252	3.72604	2.70838	3.09034	1.92167	1.69206
	0.21-0.50	0.157067	0.806143	0.489372	0.696716	1.47869	0.965526	0.310549	2.41588	1.23719	0.691314	0.779179	0.931505
	0.51-1.00	0.618916	0.44025	0.493868	0.163236	0.72698	2.56115	0.067479	1.34833	0.398999	0.149797	0.739669	1.96329
	1.01-2.00	1.44263	0.075965	0.03941	0.004212	0.050728	1.53624	0.00384	0.538904	0.037025	0.060693	0.834135	1.27893
	2.01-5.00	0.243789	0	0	0	0.0171	0.082202	0.000245	0.920395	0.023102	0.094496	0.447942	0.003856
	> 5.00	0.023008	0	0	0	0.0002	0.119802	0.000004	0.162316	0	0.054251	0.254082	0

BUTADON-Butadon BASIN		Affected Barangays in Lala			
		Santa Cruz Upper	Simpak	Tenazas	Tuna-An
Affected Area (sq. km.)	0.03-0.20	5.19777	3.75823	1.62438	1.12107
	0.21-0.50	1.83862	2.03709	0.620767	0.984099
	0.51-1.00	1.38619	1.11295	0.175264	0.798465
	1.01-2.00	0.630253	0.17744	0.061898	0.205435
	2.01-5.00	0.193204	0.05855	0.0008	0.012331
	> 5.00	0.060474	0.019635	0	0

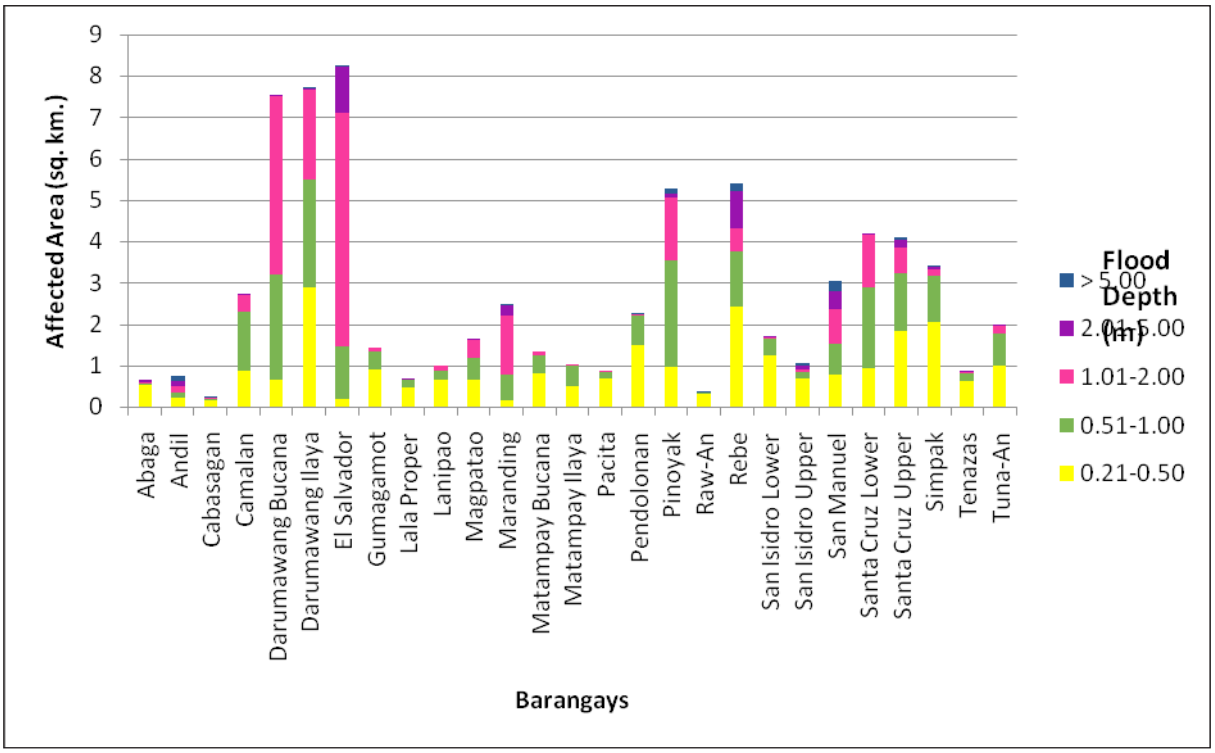


Figure 96. Affected areas in Lala, Lanao del Norte during a 100-year rainfall return period

For the Municiplity of Salvador, with an area of 46.46square kilometers, 18.28% will experience flood levels of less than 0.20 meters. 3.27% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile,2.03%, 1.97%, 1.52%, and 1.33% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 55 are the affected areas, in square kilometers, by flood depth per barangay.

Table 55. Affected areas in Salvador, Lanao del Norte during a 100-year rainfall return period

BUTADON-Butadon BASIN		Affected Barangays in Salvador									
		Camp III	Curva-Miagao	Inasagan	Mabatao	Padianan	Pagayawan	Panaliwad-On	Panganta-pan	Poblacion	Sudlon
Affected Area (sq. km.)	0.03-0.20	2.75792	0.66442	0.93799	1.44091	0.140007	0.033801	0.315921	0.000275	1.17049	1.03217
	0.21-0.50	0.337176	0.396702	0.319958	0.071357	0.026095	0.005004	0.149166	0.00067	0.04118	0.170098
	0.51-1.00	0.256625	0.184033	0.041751	0.040846	0.00039	0.0008	0.256164	0.007664	0.038491	0.117403
	1.01-2.00	0.134534	0.141723	0.009999	0.024696	0.000565	0.0001	0.499169	0.00053	0.032336	0.070893
	2.01-5.00	0.062127	0.182405	0.0011	0.004841	0.00089	0.0001	0.341783	0	0.007295	0.105807
	> 5.00	0.001	0.04515	0	0	0	0	0.519136	0	0.054745	0

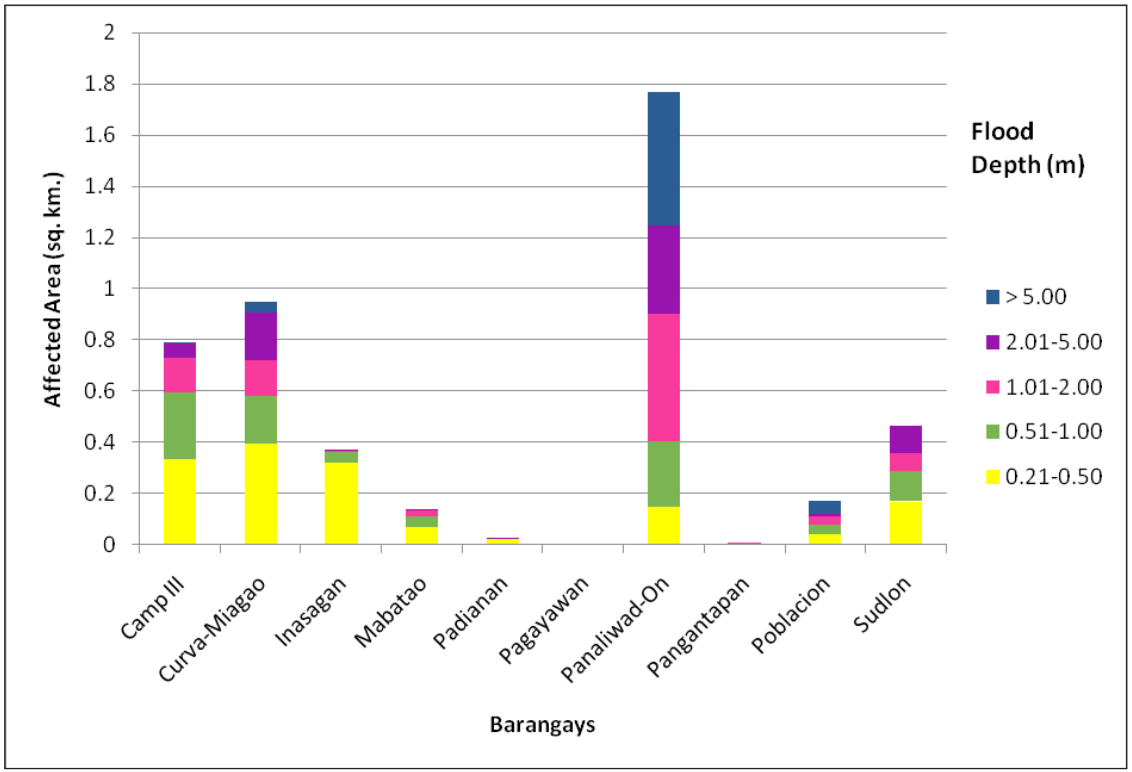


Figure 97. Affected areas in Salvador, Lanao del Norte during a 100-year rainfall return period

For the Municipality of Sapad, with an area of 65.13 square kilometers, 1.23% will experience flood levels of less than 0.20 meters. 0.34% of the area will experience flood levels of 0.21 to 0.50 meters.Meanwhile, 0.81%, 1.83%, 0.88%, and 0.13% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 56 are the affected areas, in square kilometers, by flood depth per barangay.

Table 56. Affected areas in Sapad, Lanao del Norte during a 100-year rainfall return period

BUTADON-Butadon BASIN		Affected Barangays in Sapad			
		Mabugnao	Mapurog	Pancilan	Panoloon
Affected Area (sq. km.)	0.03-0.20	0.513932	0.282155	0	0.004028
	0.21-0.50	0.078871	0.13696	0	0.005142
	0.51-1.00	0.066993	0.425635	0.000384	0.034355
	1.01-2.00	0.172747	0.722034	0.192054	0.104129
	2.01-5.00	0.061812	0.191911	0.19588	0.122449
	> 5.00	0.016368	0.061216	0.0043	0

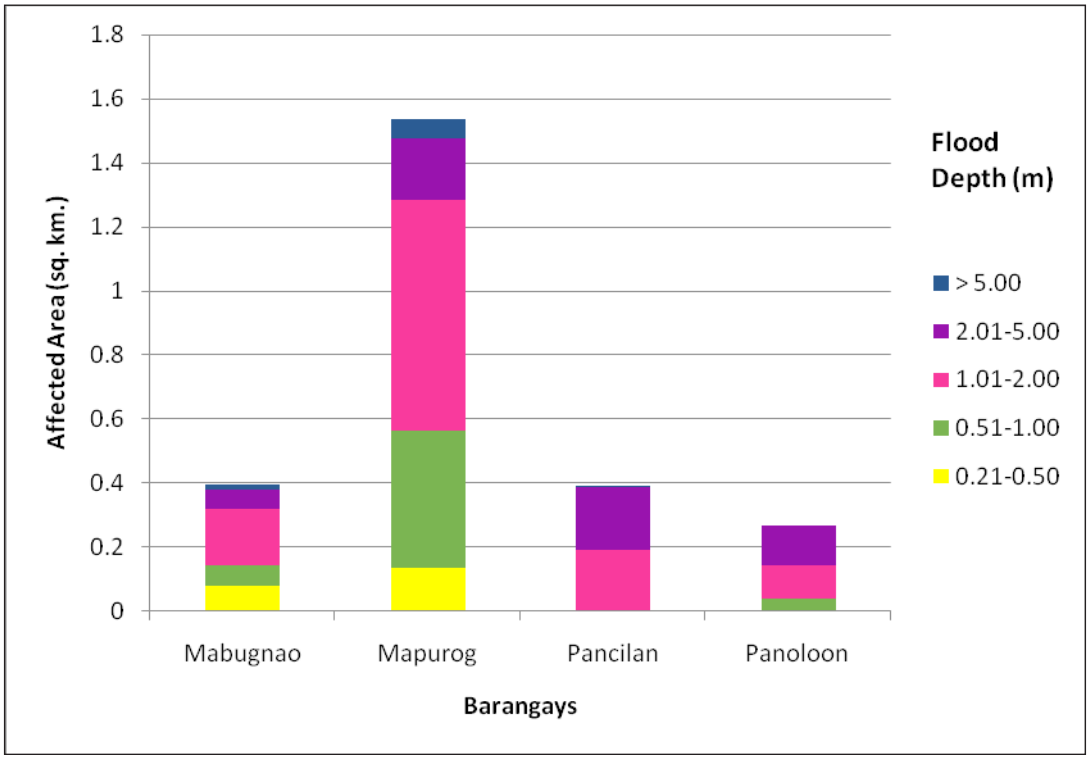


Figure 98. Affected areas in Sapad, Lanao del Norte during a 100-year rainfall return period

For the Municipality of Tubod, with an area of 121.95 square kilometers, 11.84% will experience flood levels of less than 0.20 meters. 0.82% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 0.66%, 0.59%, 0.32%, and 0.15% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 57 are the affected areas, in square kilometers, by flood depth per barangay.

Table 56. Affected areas in Tubod, Lanao del Norte during a 100-year rainfall return period

BUTADON-Butadon BASIN		Affected Barangays in Tubod									
		Bulod	Candis	Licapao	Malingao	Patudan	Pinpin	Poblacion	Pualas	San Antonio	Santo Niño
Affected Area (sq. km.)	0.03-0.20	0.261262	0.345767	2.69663	2.64028	0.991715	1.95965	1.17049	0.766122	1.45168	2.15577
	0.21-0.50	0.008352	0.019623	0.196496	0.209508	0.055078	0.157235	0.04118	0.030981	0.037499	0.243176
	0.51-1.00	0.010755	0.002811	0.122056	0.161114	0.055505	0.114205	0.038491	0.039692	0.043694	0.214537
	1.01-2.00	0.009333	0.000936	0.130131	0.131926	0.046327	0.084266	0.032336	0.064537	0.093955	0.124455
	2.01-5.00	0	0	0.124854	0.074095	0.049696	0.034042	0.007295	0.015384	0.050934	0.03672
	> 5.00	0	0	0.0006	0.085796	0.0001	0.037492	0.054745	0	0	0

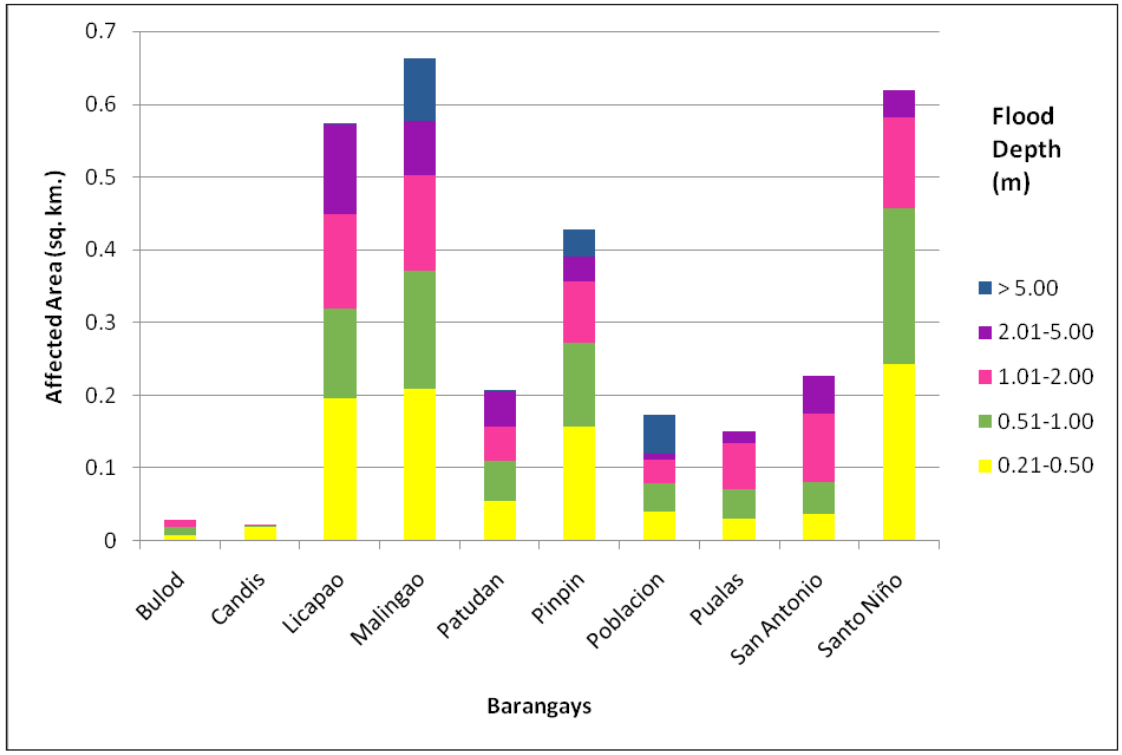


Figure 99. Affected areas in Tubod, Lanao del Norte during a 100-year rainfall return period

Among the barangays in the Municipality of Aurora, only Anonang is projected to experience flood levels, at 3.03% of its area.

Among the barangays in the Municipality of Baroy, Riverside is projected to have the highest percentage of area that will experience flood levels, at 9.38%. Meanwhile, Tinubdan posted the second highest percentage of area that may be affected by flood depths, at 8.21%.

Among the barangays in the Municipality of Kapatagan, Lapinig is projected to have the highest percentage of area that will experience flood levels, at 4.05%. Meanwhile, Bagong Silang posted the second highest percentage of area that may be affected by flood depths, at 3.36%.

Among the barangays in the Municipality of Lala, Darumawang Ilaya is projected to have the highest percentage of area that will experience flood levels, at 8.11%. Meanwhile, Santa Cruz Upper posted the second highest percentage of area that may be affected by flood depths, at 7.43%.

Among the barangays in the Municipality of Salvador, Camp III is projected to have the highest percentage of area that will experience flood levels, at 7.64%. Meanwhile, Panaliwad-On posted the second highest percentage of area that may be affected by flood depths, at 4.48%.

Among the barangays in the Municipality of Sapad, Mapurog is projected to have the highest percentage of area that will experience flood levels, at 2.79%. Meanwhile, Mabugnao posted the second highest percentage of area that may be affected by flood depths, at 1.40%.

Among the barangays in the Municipality of Tubod, Malingao is projected to have the highest percentage of area that will experience flood levels, at 2.71%. Meanwhile, Licapao posted the second highest percentage of area that may be affected by flood depths, at 2.68%.

The generated flood hazard maps for the Butadon floodplain were also used to assess the vulnerability of the educational and medical institutions in the floodplain. Using the flood depth units of PAGASA for the hazard maps – "Low", "Medium", and "High" – the affected institutions were given an individual assessment for each flood hazard scenario (5-year, 25-year, and 100-year).

Table 57. Table 58. 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	41.80	45.72	40.45
Medium	29.72	67.10	76.74
High	7.25	17.83	33.95

Of the three hundred and ninety-three (393) identified educational institutions in the Butadon floodplain, sixty-six (66) schools were assessed to be exposed to Low-level flooding during a 5-year scenario.On the other hand,sixty-one (61) schools were assessed to be exposed to Medium-level flooding, and one (1) school to High-level flooding, in the same scenario. In the 25-year scenario, eighty-six (86) schools were found to be exposed to Low-level flooding,one hundred and eight(108) schools to Medium-level flooding, and seven (7)to High-level flooding. For the 100-year scenario, sixty-five (65) schools were discovered to be exposed to Low-level flooding, and one hundred and eighteen (118) schools to Medium-level flooding. In the same scenario, twenty-eight (28) schools were projected to experience High-level flooding. See Annex 12 for a detailed enumeration of the schools within the Butadon floodplain.

Of the seventy-two (72) identified medical institutions in the Butadon floodplain, fourteen (14) were found to be exposed to Low-level flooding during a 5-year scenario; while ten (10) were assessed to be exposed to Medium-level flooding, and one (1)to High-level flooding in the same scenario. In the 25-year scenario, eleven (11) hospitals and clinics were discovered to be exposed to Low-level flooding,nineteen(19)to Medium-level flooding, and two (2)to High-level flooding. For the 100-year scenario, sixteen (16)medical establishments were projected to experience Low-level flooding. In the same scenario, twenty-one (21) institutions were assessed to be subjected to Medium-level flooding, and four(4)were found to be exposed to High-level flooding. See Annex 13 for a detailed enumeration of medical institutions within the Butadon 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. For this purpose, field personnel gathered secondary data regarding flood occurrences in the respective areas within the major river systems in the Philippines.

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

The validation personnel then went to the specified points identified in the river basin to gather data regarding the actual flood levels in each location. Data gathering was conducted through assistance from a local DRRM office to obtain maps or situation reports about the past flooding events, or through interviews with some residents with knowledge or experience of flooding in a particular area.

After which, the actual data from the field were compared with the simulated data to assess the accuracy of the flood depth maps produced, and to improve on the results of the flood map. The points in the flood map versus the corresponding validation depths are illustrated in Figure 101.

The flood validation consists of one hundred and seventeen (117) points, randomly selected all over the Butadon floodplain. The validation attained an RMSE value of 1.51. Table 59 presents a contingency matrix of the comparison. The validation points are found in Annex 11.

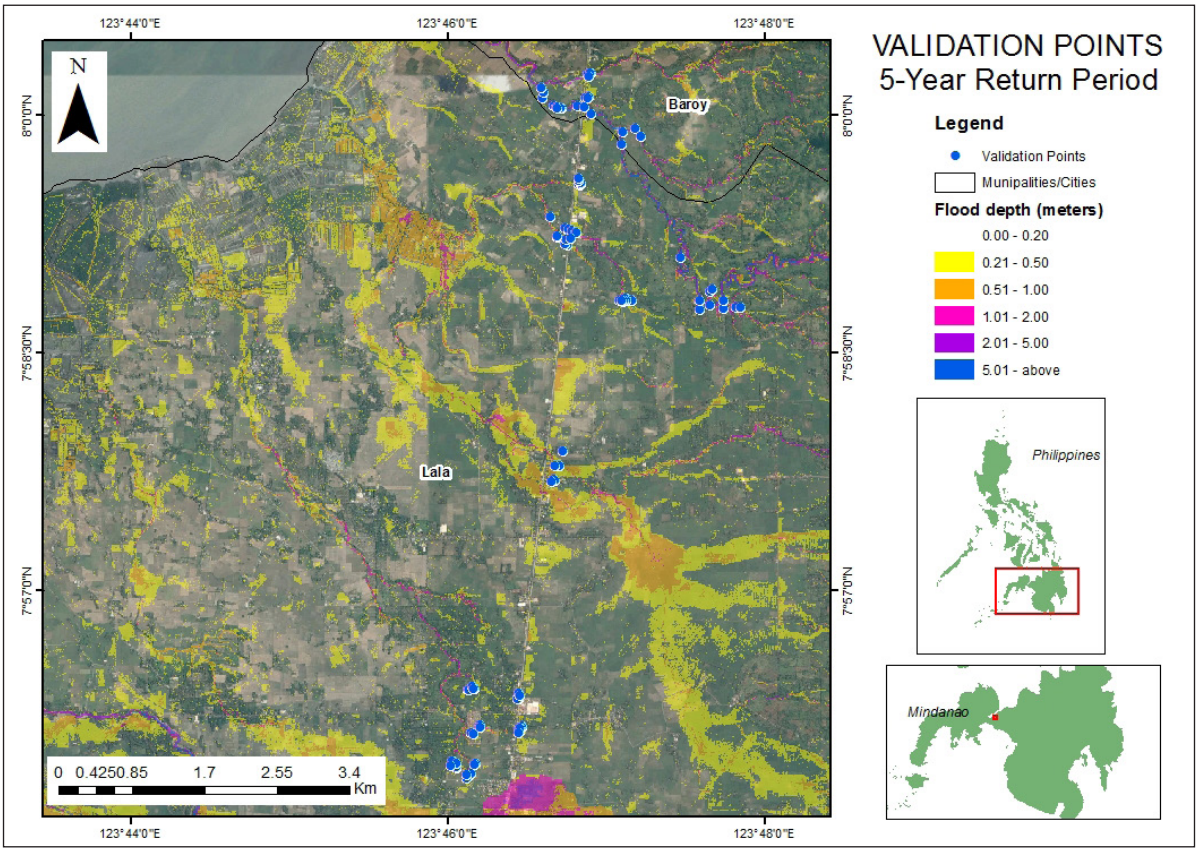


Figure 100. Validation points for a 5-year flood depth map of Butadon floodplain

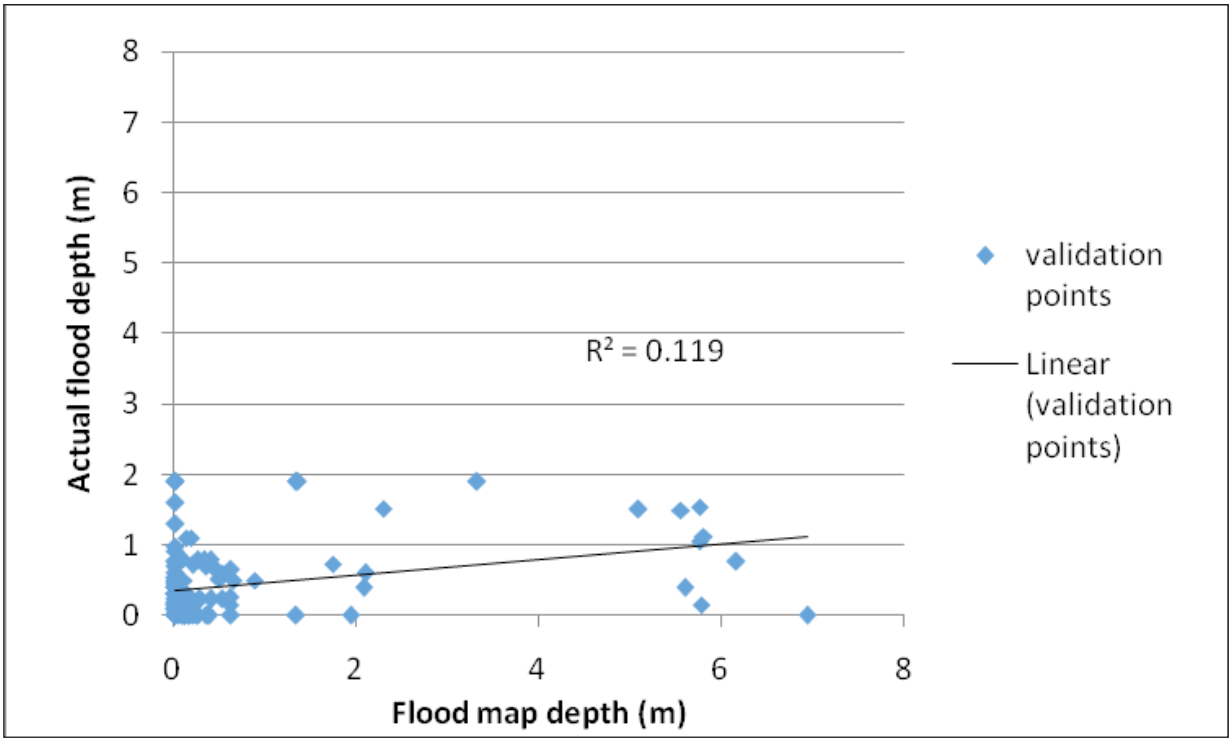


Figure 101. Flood map depth vs. actual flood depth

Table 58. Actual flood depth vs. simulated flood depth in the Butadon River Basin

BUTADON-Butadon 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	38	7	2	2	0	2	51
	0.21-0.50	20	4	4	0	1	1	30
	0.51-1.00	9	6	3	1	1	1	21
	1.01-2.00	6	0	0	2	2	5	15
	2.01-5.00	0	0	0	0	0	0	0
	> 5.00	0	0	0	0	0	0	0
	Total	73	17	9	5	4	9	117

The overall accuracy generated by the flood model is estimated at 40.17%, with forty-seven (47) points correctly matching the actual flood depths. Additionally, there were forty (40) points estimated one (1) level above and below the correct flood depths.Meanwhile, there were seventeen (17) points and thirteen (13) points estimated two (2) levels above and below, and three (3) or more levels above and below the correct flood depths, respectively. A total of twenty-nine(29) points were overestimated, while a total of forty-one (41) points were underestimated in the modeled flood depths of the Butadon floodplain.

Table 59. Summary of the Accuracy Assessment of the Butadon model

	No. of Points	%
Correct	47	**40.17**
Overestimated	29	24.79
Underestimated	41	35.04
Total	117	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.

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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.b

ANNEXES

Annex 1. Technical Specifications of the LiDAR Sensors used in the Butadon Floodplain Survey

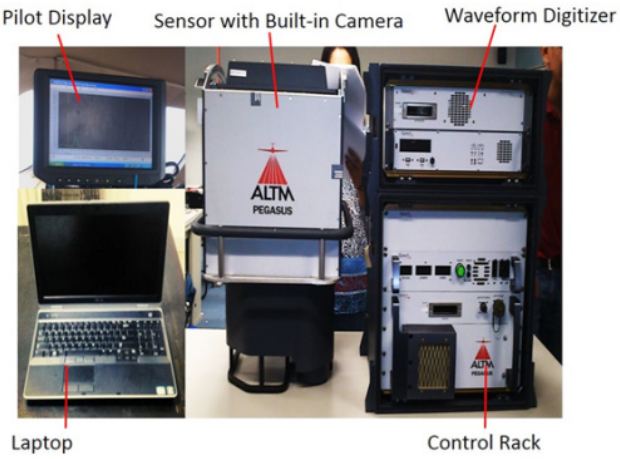

Figure A-1.1. Pegasus sensor

Table A-1.1. Technical specifications of the Pegasus sensor

Parameter	Specification
Operational envelope (1,2,3,4)	150-5000 m AGL, nominal
Laser wavelength	1064 nm
Horizontal accuracy (2)	1/5,500 x altitude, 1σ
Elevation accuracy (2)	< 5-20 cm, 1σ
Effective laser repetition rate	Programmable, 100-500 kHz
Position and orientation system	POS AV ™AP50 (OEM)
Scan width (FOV)	Programmable, 0-75 ˚
Scan frequency (5)	Programmable, 0-140 Hz (effective)
Sensor scan product	800 maximum
Beam divergence	0.25 mrad (1/e)
Roll compensation	Programmable, ±37˚ (FOV dependent)
Vertical target separation distance	<0.7 m
Range capture	Up to 4 range measurements, including 1st, 2nd, 3rd, and last returns
Intensity capture	Up to 4 intensity returns for each pulse, including last (12 bit)
Image capture	5 MP interline camera (standard); 60 MP full frame (optional)
Full waveform capture	12-bit Optech IWD-2 Intelligent Waveform Digitizer
Data storage	Removable solid state disk SSD (SATA II)
Power requirements	28 V, 800 W, 30 A
Dimensions and weight	Sensor: 630 x 540 x 450 mm; 65 kg;
	Control rack: 650 x 590 x 490 mm; 46 kg
Operating Temperature	-10°C to +35°C
Relative humidity	0-95% non-condensing

1 Target reflectivity ≥20%

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

3 Angle of incidence ≤20˚

4 Target size ≥ laser footprint5 Dependent on system configuration

Table A-1.2. Technical specifications of the D-8900 Aerial Digital Camera

Parameter	Specification
Camera Head	
Sensor type	60 Mpix full frame CCD, RGB
Sensor format (H x V)	8, 984 x 6, 732 pixels
Pixel size	6µm x 6 µm
Frame rate	1 frame/2 sec.
FMC	Electro-mechanical, driven by piezo technology (patented)
Shutter	Electro-mechanical iris mechanism 1/125 to 1/500++ sec. f-stops: 5.6, 8, 11, 16
Lenses	50 mm/70 mm/120 mm/210 mm
Filter	Color and near-infrared removable filters
Dimensions (H x W x D)	200 x 150 x 120 mm (70 mm lens)
Weight	~4.5 kg (70 mm lens)
Controller Unit	
Computer	Mini-ITX RoHS-compliant small-form-factor embedded computers with AMD TurionTM 64 X2 CPU 4 GB RAM, 4 GB flash disk local storage IEEE 1394 Firewire interface
Removable storage unit	~500 GB solid state drives, 8,000 images
Power consumption	~8 A, 168 W
Dimensions	2U full rack; 88 x 448 x 493 mm
Weight	~15 kg
Image Pre-Processing Software	
Capture One	Radiometric control and format conversion, TIFF or JPEG
Image output	8,984 x 6,732 pixels 8 or 16 bits per channel (180 MB or 360 MB per image)

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

1. ZGN-138

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

October 30, 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: **ZAMBOANGA DEL NORTE**
Station Name: **ZGN-138**
Order: **2nd**
Island: **MINDANAO** Barangay:
Municipality: **KATIPUNAN** MSL Elevation:

PRS92 Coordinates

Latitude: **8° 30' 40.65974"** Longitude: **123° 18' 14.44217"** Ellipsoidal Hgt: **6.71500 m.**

WGS84 Coordinates

Latitude: **8° 30' 36.94779"** Longitude: **123° 18' 19.85548"** Ellipsoidal Hgt: **70.92500 m.**

PTM / PRS92 Coordinates

Northing: **941106.14 m.** Easting: **533471.036 m.** Zone: **4**

UTM / PRS92 Coordinates

Northing: **940,776.74** Easting: **533,459.32** Zone: **51**

Location Description

The station is marked by an 4" copper nail with its head flushed at the center of an cement putty on a concrete open canal with inscription " ZGN-138, 2009 NAMRIA".Located at brgy. Taga katipunan zamboanga del norte. The monument is situated inside taga central school 10 meters from the main gate going north west 6 meters from the flag pole going south east.

Requesting Party: **PHIL-LIDAR I**
Purpose: **Reference**
OR Number: **8075910 I**
T.N.: **2014-2584**

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

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

CIP/4701/12/09/814

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Figure A-2.1. ZGN-138

2. ZGS-88

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

July 11, 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: **ZAMBOANGA DEL SUR**
Station Name: **ZGS-88**
Order: **2nd**

Island: **MINDANAO**
Municipality: **AURORA**
Barangay: **SAN JOSE**
MSL Elevation:

PRS92 Coordinates

Latitude: **7° 57' 13.25316"** Longitude: **123° 34' 56.50093"** Ellipsoidal Hgt: **258.34500 m.**

WGS84 Coordinates

Latitude: **7° 57' 9.71271"** Longitude: **123° 35' 1.96243"** Ellipsoidal Hgt: **324.37300 m.**

PTM / PRS92 Coordinates

Northing: **879474.685 m.** Easting: **564207.26 m.** Zone: **4**

UTM / PRS92 Coordinates

Northing: **879,166.85** Easting: **564,184.79** Zone: **51**

Location Description

ZGS-88
Is located on the S end of the W wedge-shaped island in Purok Saray, Brgy. San Jose, Aurora. It is about 500 m. N of the municipal hall, 30 m. W of the Seaoil Gasoline Station and 5 m. E of the W side of the road. Mark is the head of a 3 in. copper nail embedded and centered on a 27 cm. x 26 cm. x cement putty, with inscriptions "ZGS-88 2005 NAMRIA LEP IX".

Requesting Party: **UP TCAGP / Engr. Christopher Cruz**
Pupose: **Reference**
OR Number: **8796507 A**
T.N.: **2014-1601**

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Director, Mapping And Geodesy Branch

9907112014150154

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Figure A-2.2. ZGS-88

3. ZGS-16

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

February 10, 2016

CERTIFICATION

To whom it may concern:

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

Province: **ZAMBOANGA DEL SUR**
Station Name: **ZGS-16**
Order: **2nd**
Island: **MINDANAO** Barangay: **BACLAY**
Municipality: **TUKURAN** MSL Elevation:

PRS92 Coordinates

Latitude: **7° 52' 32.53106"** Longitude: **123° 36' 23.39905"** Ellipsoidal Hgt: **18.17800 m.**

WGS84 Coordinates

Latitude: **7° 52' 29.01321"** Longitude: **123° 36' 28.86762"** Ellipsoidal Hgt: **84.42000 m.**

PTM / PRS92 Coordinates

Northing: **870854.959 m.** Easting: **566881.259 m.** Zone: **4**

UTM / PRS92 Coordinates

Northing: **870,550.15** Easting: **566,857.85** Zone: **51**

Location Description

ZGS-16
Is located at Purok Nangka, Brgy. Baclay. It is situated 1 m. NE of Km. Post # 1644 and about 50 m. SW of the chapel, approx. 3 km. from the road junction leading to Aurora town. Mark is the head of a 3 in. concrete nail embedded and centered on a 30 cm. x 30 cm. x 58 cm. concrete monument, with inscriptions "ZGS-16 2005 NAMRIA/LEP-IX".

Requesting Party: **UP DREAM**
Purpose: **Reference**
OR Number: **8089774 I**
T.N.: **2016-0334**

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

9902102014122213

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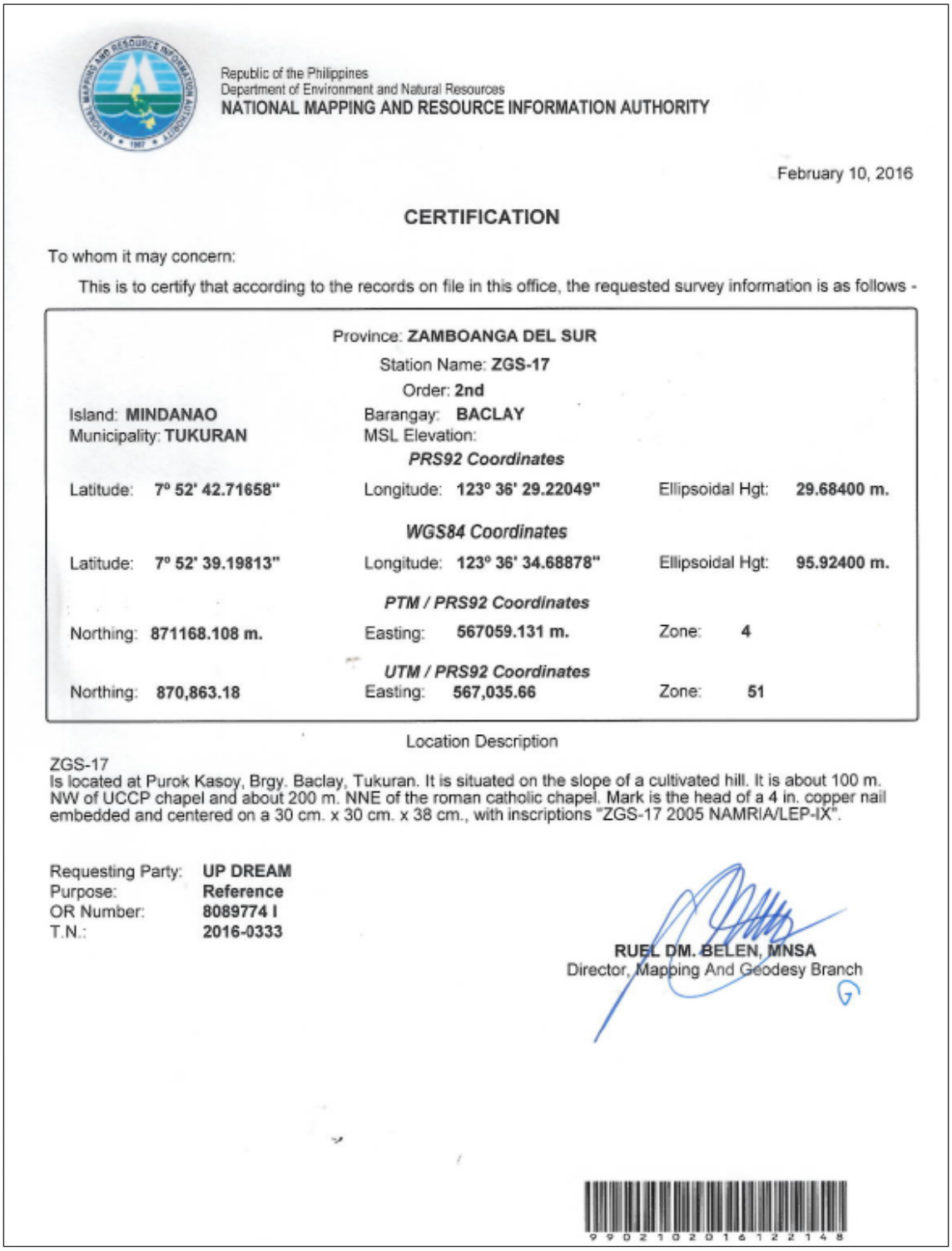
Figure A-2.3. ZGS-16

4. ZGS-17



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

February 10, 2016

CERTIFICATION

To whom it may concern:

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

Province: **ZAMBOANGA DEL SUR**
Station Name: **ZGS-17**
Order: **2nd**
Island: **MINDANAO** Barangay: **BACLAY**
Municipality: **TUKURAN** MSL Elevation:

PRS92 Coordinates

Latitude: **7° 52' 42.71658"** Longitude: **123° 36' 29.22049"** Ellipsoidal Hgt: **29.68400 m.**

WGS84 Coordinates

Latitude: **7° 52' 39.19813"** Longitude: **123° 36' 34.68878"** Ellipsoidal Hgt: **95.92400 m.**

PTM / PRS92 Coordinates

Northing: **871168.108 m.** Easting: **567059.131 m.** Zone: **4**

UTM / PRS92 Coordinates

Northing: **870,863.18** Easting: **567,035.66** Zone: **51**

Location Description

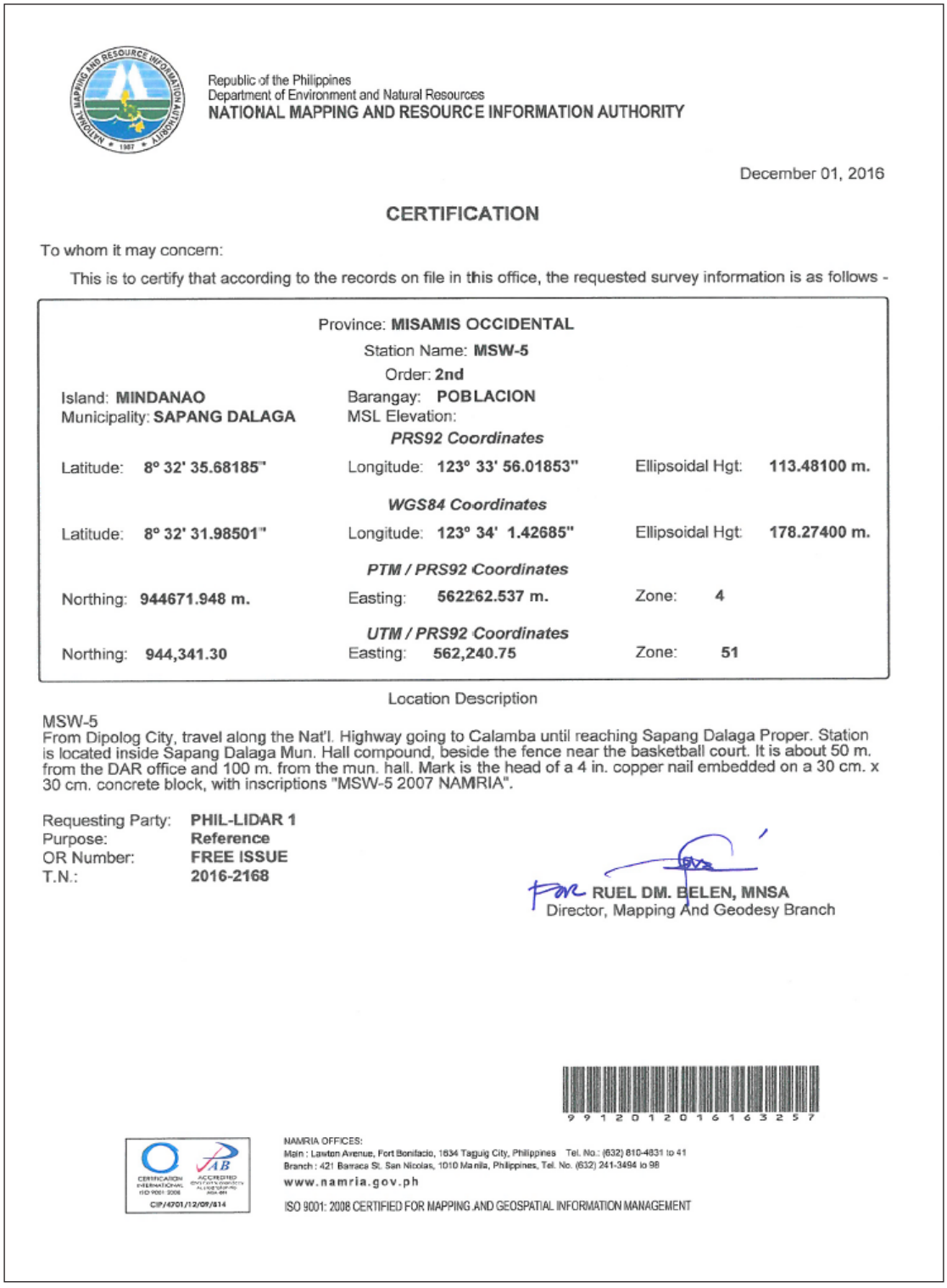
ZGS-17
Is located at Purok Kasoy, Brgy. Baclay, Tukuran. It is situated on the slope of a cultivated hill. It is about 100 m. NW of UCCP chapel and about 200 m. NNE of the roman catholic chapel. Mark is the head of a 4 in. copper nail embedded and centered on a 30 cm. x 30 cm. x 38 cm., with inscriptions "ZGS-17 2005 NAMRIA/LEP-IX".

Requesting Party: **UP DREAM**
Purpose: **Reference**
OR Number: **8089774 I**
T.N.: **2016-0333**

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

Figure A-2.4. ZGS-17

5. MSW-05



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

December 01, 2016

CERTIFICATION

To whom it may concern:

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

Province: **MISAMIS OCCIDENTAL**
Station Name: **MSW-5**
Order: **2nd**
Island: **MINDANAO** Barangay: **POBLACION**
Municipality: **SAPANG DALAGA** MSL Elevation:

PRS92 Coordinates

Latitude: **8° 32' 35.68185"** Longitude: **123° 33' 56.01853"** Ellipsoidal Hgt: **113.48100 m.**

WGS84 Coordinates

Latitude: **8° 32' 31.98501"** Longitude: **123° 34' 1.42685"** Ellipsoidal Hgt: **178.27400 m.**

PTM / PRS92 Coordinates

Northing: **944671.948 m.** Easting: **562262.537 m.** Zone: **4**

UTM / PRS92 Coordinates

Northing: **944,341.30** Easting: **562,240.75** Zone: **51**

Location Description

MSW-5
From Dipolog City, travel along the Nat'l. Highway going to Calamba until reaching Sapang Dalaga Proper. Station is located inside Sapang Dalaga Mun. Hall compound, beside the fence near the basketball court. It is about 50 m. from the DAR office and 100 m. from the mun. hall. Mark is the head of a 4 in. copper nail embedded on a 30 cm. x 30 cm. concrete block, with inscriptions "MSW-5 2007 NAMRIA".

Requesting Party: **PHIL-LIDAR 1**
Purpose: **Reference**
OR Number: **FREE ISSUE**
T.N.: **2016-2168**

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

9912012016163257

CIP/4701/12/09/814

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Figure A-2.5. MSW-05

6. ZN-53

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

October 30, 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: **ZAMBOANGA DEL NORTE**
Station Name: **ZN-53**

Island: **Mindanao**	Municipality: **KATIPUNAN**	Barangay: **DAANGLUNGSOD**
Elevation: **10.0561 +/- 0.00 m.**	Order: **1st Order**	Datum: **Mean Sea Level**
Latitude:	Longitude:	

Location Description

ZN-53
Along Dipolog Liloy National Road. The station is located at the compound of Taga Central School, near the flagpole and about 50 meters northwest of the centerline of the road. Mark is the head of a 4" copper nail set on a dsrilled hole and cemented flushed on top of 15cm x 15cm cement putty with inscription " ZN-53 2008 NAMRIA".

Requesting Party: **PHIL-LIDAR I**
Purpose: **Reference**
OR Number: **8075910 I**
T.N.: **2014-2589**

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

9910302014134448

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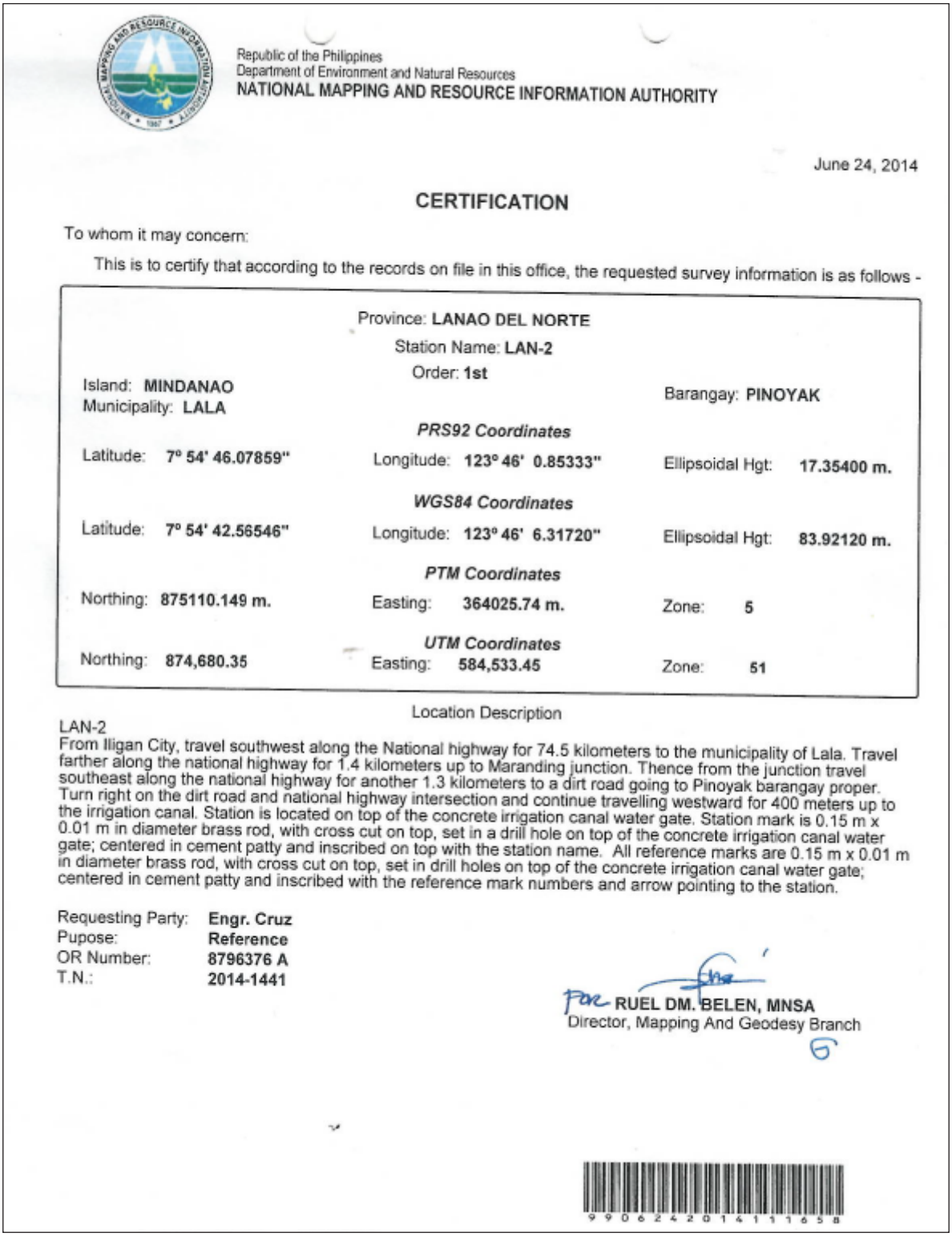
Figure A-2.6. ZN-53

7. LAN-02



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

June 24, 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: **LANAO DEL NORTE**
Station Name: **LAN-2**
Order: **1st**

Island: **MINDANAO**
Municipality: **LALA**
Barangay: **PINOYAK**

PRS92 Coordinates

Latitude: **7° 54' 46.07859"** Longitude: **123° 46' 0.85333"** Ellipsoidal Hgt: **17.35400 m.**

WGS84 Coordinates

Latitude: **7° 54' 42.56546"** Longitude: **123° 46' 6.31720"** Ellipsoidal Hgt: **83.92120 m.**

PTM Coordinates

Northing: **875110.149 m.** Easting: **364025.74 m.** Zone: **5**

UTM Coordinates

Northing: **874,680.35** Easting: **584,533.45** Zone: **51**

Location Description

LAN-2
From Iligan City, travel southwest along the National highway for 74.5 kilometers to the municipality of Lala. Travel farther along the national highway for 1.4 kilometers up to Maranding junction. Thence from the junction travel southeast along the national highway for another 1.3 kilometers to a dirt road going to Pinoyak barangay proper. Turn right on the dirt road and national highway intersection and continue travelling westward for 400 meters up to the irrigation canal. Station is located on top of the concrete irrigation canal water gate. Station mark is 0.15 m x 0.01 m in diameter brass rod, with cross cut on top, set in a drill hole on top of the concrete irrigation canal water gate; centered in cement patty and inscribed on top with the station name. All reference marks are 0.15 m x 0.01 m in diameter brass rod, with cross cut on top, set in drill holes on top of the concrete irrigation canal water gate; centered in cement patty and inscribed with the reference mark numbers and arrow pointing to the station.

Requesting Party: **Engr. Cruz**
Pupose: **Reference**
OR Number: **8796376 A**
T.N.: **2014-1441**

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

9 9 0 6 2 4 2 0 1 4 1 1 1 6 5 8

Figure A-2.7. LAN-02

7. ZN-53

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

December 09, 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: **ZAMBOANGA DEL NORTE**
Station Name: **ZN-123**

Island: **Mindanao**	Municipality: **SINDANGAN**	Barangay: **GOLEO**
Elevation: **13.1013 +/- 0.00 m.**	Order: **1st Order**	Datum: **Mean Sea Level**
Latitude:	Longitude:	

Location Description

BM ZN-123 is in the Province of Zamboanga Del Norte, Town of Sindangan, Brgy. Goleo, along the Dipolog-Sindangan National Road. The station is located west-northwest of Sindangan Bridge at KM. 1921 + 182 and about 4 meters northwest of the centerline of the road.

Mark is the head of a 4" copper nail set on a drilled hole and cemented flushed on the top of 15cm x 15cm cement putty with inscription "BM ZN-123,2009,NAMRIA".

Requesting Party: **Christopher Cruz**
Purpose: **Reference**
OR Number: **8077396 I**
T.N.: **2014-2985**

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

9912092014105708

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Figure A-2.8. ZN-53

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

1. ZN-53

Table A-3.1. ZN-53

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
zgn 138 — zn 53 am (B1)	zgn 138	zn 53 am	Fixed	0.001	0.002	344°25'59"	12.263	0.357
zgn 138 — zn 53 pm (B2)	zgn 138	zn 53 pm	Fixed	0.003	0.004	344°25'44"	12.270	0.372

Acceptance Summary

Processed	Passed	Flag	Fail
2	2	0	0

Vector Components (Mark to Mark)

From:	zgn 138				
Grid		Local		Global	
Easting	533459.321 m	Latitude	N8°30'40.65974"	Latitude	N8°30'36.94779"
Northing	940776.736 m	Longitude	E123°18'14.44217"	Longitude	E123°18'19.85548"
Elevation	5.484 m	Height	6.715 m	Height	70.925 m

To:	zn 53 am				
Grid		Local		Global	
Easting	533456.022 m	Latitude	N8°30'41.04428"	Latitude	N8°30'37.33230"
Northing	940788.542 m	Longitude	E123°18'14.33457"	Longitude	E123°18'19.74787"
Elevation	5.842 m	Height	7.072 m	Height	71.282 m

Vector					
ΔEasting	-3.299 m	NS Fwd Azimuth	344°25'59"	ΔX	3.517 m
ΔNorthing	11.806 m	Ellipsoid Dist.	12.263 m	ΔY	0.641 m
ΔElevation	0.358 m	ΔHeight	0.357 m	ΔZ	11.736 m

Standard Errors

Vector errors:					
σ ΔEasting	0.001 m	σ NS fwd Azimuth	0°00'09"	σ ΔX	0.001 m
σ ΔNorthing	0.000 m	σ Ellipsoid Dist.	0.000 m	σ ΔY	0.001 m
σ ΔElevation	0.001 m	σ ΔHeight	0.001 m	σ ΔZ	0.000 m

Aposteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.0000005629		
Y	-0.0000004033	0.0000010310	
Z	-0.0000000776	0.0000001462	0.0000001693

2. LE-50

Table A-3.2. LE-50

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

Baseline Processing Report

Processing Summary

Observation	From	To	Occupation Start Time	Occupation Stop Time	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	ΔX (Meter)	ΔY (Meter)	ΔZ (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	Δ Height (Meter)	Processing Start Time	Processing Stop Time	Satellite Available
LE50 --- LAN2 (B1)	LAN2	LE50	6/20/2014 10:05:34 AM	6/20/2014 2:59:59 PM	Fixed	0.012	0.024	-15846.890	-15348.670	27636.104	37°51'51"	35361.439	-10.469	6/20/2014 10:05:34 AM	6/20/2014 2:59:59 PM	GPS: 15 GLONASS: 13 Galileo: 0 QZSS: 0

Acceptance Summary

Processed	Passed	Flag	Fail
1	1	0	0

Vector Components (Mark to Mark)

From:	LAN2				
Grid		Local		Global	
Easting	584699.973 m	Latitude	N7°54'42.56546"	Latitude	N7°54'42.56546"
Northing	874628.035 m	Longitude	E123°46'06.31720"	Longitude	E123°46'06.31720"
Elevation	15.242 m	Height	83.921 m	Height	83.921 m

To:	LE50				
Grid		Local		Global	
Easting	606345.902 m	Latitude	N8°09'51.11024"	Latitude	N8°09'51.11024"
Northing	902577.426 m	Longitude	E123°57'55.36634"	Longitude	E123°57'55.36634"
Elevation	4.394 m	Height	73.452 m	Height	73.452 m

Vector					
ΔEasting	21645.929 m	NS Fwd Azimuth	37°51'51"	ΔX	-15847.070 m
ΔNorthing	27949.392 m	Ellipsoid Dist.	35361.439 m	ΔY	-15348.392 m
ΔElevation	-10.847 m	ΔHeight	-10.469 m	ΔZ	27636.144 m

3. LE-76

Table A-3.3. LE-76

Vector Components (Mark to Mark)

From:	LE-50				
Grid		Local		Global	
Easting	606180.417 m	Latitude	N8°09'54.67217"	Latitude	N8°09'51.11024"
Northing	902629.434 m	Longitude	E123°57'49.92699"	Longitude	E123°57'55.36834"
Elevation	4.394 m	Height	6.900 m	Height	73.452 m

To:	LE-76				
Grid		Local		Global	
Easting	588530.790 m	Latitude	N8°03'05.36825"	Latitude	N8°03'01.82183"
Northing	890021.013 m	Longitude	E123°48'12.37307"	Longitude	E123°48'17.82405"
Elevation	7.017 m	Height	9.335 m	Height	75.717 m

Vector					
ΔEasting	-17649.627 m	NS Fwd Azimuth	234°35'42"	ΔX	13688.663 m
ΔNorthing	-12608.421 m	Ellipsoid Dist.	21696.715 m	ΔY	11332.042 m
ΔElevation	2.623 m	ΔHeight	2.435 m	ΔZ	-12447.993 m

Standard Errors

Vector errors:					
σ ΔEasting	0.021 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.024 m
σ ΔNorthing	0.006 m	σ Ellipsoid Dist.	0.015 m	σ ΔY	0.034 m
σ ΔElevation	0.036 m	σ ΔHeight	0.036 m	σ ΔZ	0.009 m

Aposteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.0005606089		
Y	-0.0003223999	0.0011623638	
Z	-0.0000556148	0.0002703935	0.0000791896

4. ZS-188

Table A-3.4. ZS-188

Vector Components (Mark to Mark)

From:	ZGS-1				
Grid		**Local**		**Global**	
Easting	553699.482 m	**Latitude**	N8°04'26.98335"	**Latitude**	N8°04'23.40249"
Northing	892472.300 m	**Longitude**	E123°29'14.53868"	**Longitude**	E123°29'19.99013"
Elevation	20.051 m	**Height**	22.611 m	**Height**	88.163 m

To:	ZS-188A				
Grid		**Local**		**Global**	
Easting	553627.634 m	**Latitude**	N8°03'56.69408"	**Latitude**	N8°03'53.11537"
Northing	891542.089 m	**Longitude**	E123°29'12.15500"	**Longitude**	E123°29'17.60722"
Elevation	17.277 m	**Height**	19.832 m	**Height**	85.400 m

Vector					
ΔEasting	-71.848 m	**NS Fwd Azimuth**	184°29'06"	**ΔX**	-9.705 m
ΔNorthing	-930.211 m	**Ellipsoid Dist.**	933.322 m	**ΔY**	146.900 m
ΔElevation	-2.773 m	**ΔHeight**	-2.778 m	**ΔZ**	-921.644 m

Standard Errors

Vector errors:					
σ ΔEasting	0.004 m	**σ NS fwd Azimuth**	0°00'01"	**σ ΔX**	0.001 m
σ ΔNorthing	0.001 m	**σ Ellipsoid Dist.**	0.001 m	**σ ΔY**	0.005 m
σ ΔElevation	0.004 m	**σ ΔHeight**	0.004 m	**σ ΔZ**	0.001 m

Aposteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.0000013603		
Y	0.0000026352	0.0000296273	
Z	0.0000004069	0.0000057486	0.0000013978

Annex 4. The LiDAR Survey Team Composition

Table A-4.1.LiDAR Survey Team Composition

Data Acquisition Component Sub -Team	Designation	Name	Agency / Affiliation
PHIL-LIDAR 1	Program Leader	ENRICO C. PARINGIT, D.ENG	UP-TCAGP
Data Acquisition Component Leader	Data Component Project Leader – I	ENGR. CZAR JAKIRI SARMIENTO	UP-TCAGP
Survey Supervisor	Chief Science Research Specialist (CSRS)	ENGR. CHRISTOPHER CRUZ	UP-TCAGP
	Supervising Science Research Specialist (Supervising SRS)	LOVELY GRACIA ACUÑA	UP-TCAGP
		LOVELYN ASUNCION	UP-TCAGP
FIELD TEAM			
LiDAR Operation	Senior Science Research Specialist (SSRS)	ENGR. GEROME HIPOLITO	UP-TCAGP
	SSRS	PAULINE JOANNE ARCEO	UP-TCAGP
	Research Associate (RA)	ENGR. RENAN PUNTO	UP-TCAGP
	RA	ENGR. IRO NIEL ROXAS	UP-TCAGP
	RA	JERIEL PAUL ALAMBAN, GEOL.	UP-TCAGP
	RA	ENGR. KENNETH QUISADO	UP-TCAGP
	RA	ENGR. GRACE SINADJAN	UP-TCAGP
	RA	JONATHAN ALMALVEZ	UP-TCAGP
	RA	ENG. GEF SORIANO	UP-TCAGP
	RA	FRANK NICOLAS ILEJAY	UP-TCAGP
Ground Survey, Data Download and Transfer	RA	JASMIN DOMINGO	UP-TCAGP
	RA	MERLIN FERNANDO	UP-TCAGP
LiDAR Operation	Airborne Security	SSG. JAYCO MANZANO	PHILIPPINE AIR FORCE (PAF)
	Airborne Security	SSG. GERONIMO BALICOW III	PAF
	Airborne Security	SSG. LEEJAY PUNZALAN	PAF
	Pilot	CAPT. BRYAN DONGUINES	ASIAN AEROSPACE CORPORATION (AAC)
		CAPT. SHERWIN CESAR ALFONSO	AAC
		CAPT. ERNESTO SAYSAY JR.	AAC
		CAPT. ANTON DAYO	AAC

Annex 5. Data Transfer Sheets for the ButadonFloodplain Flights

DATA TRANSFER SHEET
06/10/2014(Northern Mindanao) ongoing

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	
5/22/2014	1497P	1BLK67B142A	PEGASUS	1.8	1342	8.61	201	31.8	221	19.1	NA	5.19	1KB	1KB	49	NA	Z:\Airborne_Raw\1497P
5/23/2014	1501P	1BLK67C143A	PEGASUS	3	1221	14.1	271	77.3	539	29.5	NA	7.61	1KB	1KB	59/56	NA	Z:\Airborne_Raw\1501P
5/24/2014	1505P	1BLK67BC144A	PEGASUS	2.25	759	10	212	46.7	340	21.8	NA	7.68	1KB	1KB	97	NA	Z:\Airborne_Raw\1505P
5/25/2014	1509P	1RDXE145A	PEGASUS	2.4	338	11.2	254	NA 31.6 22	31.6/22 NA	26.2	NA	4.96	1KB	1KB	50/43	NA	Z:\Airborne_Raw\1509P
5/27/2014	1517P	1RXE147A	PEGASUS	2.74	1497	12	235	NA	NA	27.7	NA	9.7	1KB	1KB	78/72	NA	Z:\Airborne_Raw\1517P
5/28/2014	1521P	1RXC148A	PEGASUS	2.39	490	12	252	NA	NA	28	NA	5.54	1KB	1KB	52	NA	Z:\Airborne_Raw\1521P

Received from

Name C. SORIANO
Position
Signature

Received by

Name JOIDA PRIETO
Position SSRS
Signature 6/10/2014

Figure A-5.1. Data Transfer Sheet for Butadon Floodplain – A

DATA TRANSFER SHEET
06/20/2014(Northern Mindanao)

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	
29-May-14	1525P	1RXB149A	PEGASUS	1.6	457	9.27	265	na	na	26.5	NA	9.83	1KB	1KB	40	NA	Z:\Airborne_Raw\1525P
31-May-14	1533P	1BLK67151A	PEGASUS	3.32	270	14.4	224	43.2	428	33.3	NA	8.87	1KB	1KB	47/38	NA	Z:\Airborne_Raw\1533P
2-Jun-14	1541P	1BLK71B153A	PEGASUS	4	242	0	285	19.7	139	39	674MB	12.6	1KB	1KB	47/45/40/34	NA	Z:\Airborne_Raw\1541P
3-Jun-14	1545P	1BLK71C154A	PEGASUS	4.13	2259	13	253	69.7	533	40.1	272MB	9.95	1KB	1KB	141	NA	Z:\Airborne_Raw\1545P
4-Jun-14	1549P	1BLK71D155A	PEGASUS	3.48	150	14.3	264	NA	NA	34.6	NA	11.2	1KB	1KB	54/50/45	NA	Z:\Airborne_Raw\1549P
7-Jun-14	1561P	1RXE158A	PEGASUS	NA	44	NA	187	NA	NA	22	NA	8.1	1KB	1KB	71	NA	Z:\Airborne_Raw\1561P
8-Jun-14	1565P	1BLK71B159A	PEGASUS	NA	16	5.35	168	22.1	163	13.3	NA	7.75	1KB	1KB	36	NA	Z:\Airborne_Raw\1565P

Received from

Name C. JOAQUIN
Position RA
Signature

Received by

Name JOIDA F. PRIETO
Position SSRS
Signature 6/23/2014

Figure A-5.2. Data Transfer Sheet for Butadon Floodplain – B

DATA TRANSFER SHEET

08/05/2014(Northern Mindanao - ready)

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	SHP	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	
7/3/2014	1665P	1BLK71ES184A	Pegasus	606	93	4.69	94.5	169	NA	NA	6.77	NA	6.94	1KB	1KB	35	NA	Z:\Airborne_Raw
7/5/2014	1673P	1BLK71ES186A	Pegasus	1.05	379	7.58	335	190	22.4	167	12.5	27.8	5.09	1KB	1KB	92/84	NA	Z:\Airborne_Raw
7/6/2014	1677P	1BLK71S187A	Pegasus	695	68	5.33	188	141	11.2	86	7.79	NA	4.94	1KB	1KB	130	NA	Z:\Airborne_Raw
7/8/2014	1685P	1BLK71S189A	Pegasus	2.31	515	11	578	242	37	288	22.4	47.4	4.39	1KB	1KB	184	NA	Z:\Airborne_Raw
7/8/2014	1687P	1BLK71S189B	Pegasus	749	79	4.81	176	136	NA	NA	7.47	NA	4.39	1KB	1KB	NA	NA	Z:\Airborne_Raw
7/9/2014	1689P	1BLK71S190A	Pegasus	2.56	156	12.6	740	257	NA	NA	27.1	NA	3.68	1KB	1KB	196/207	NA	Z:\Airborne_Raw
7/10/2014	1693P	1RXES191A	Pegasus	1.78	551	8.11	448	175	NA	NA	16.9	NA	4.08	1KB	1KB	53	NA	Z:\Airborne_Raw

Received from

Name TIN ANDAYA

Position RA

Signature

Received by

Name JOIDA F. PRIETO

Position SSRS

Signature

8/6/14

Figure A-5.3. Data Transfer Sheet for Butadon Floodplain – C

DATA TRANSFER SHEET
07/28/2014(Northern Mindanao - ready)

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	
6/8/2014	1565P	1BLK71B159A	Pegasus	NA	16	6.93	168	NA	NA	13.3	NA	7.75	1KB	1KB	36	NA	Z:\Airborne_Raw
6/9/2014	1569P	1BLKRXE160A	Pegasus	4.16	832	16.5	290	8.86	62	38.5	NA	10	1KB	1KB	85	NA	Z:\Airborne_Raw
6/16/2014	1597P	1BLKRXE167A	Pegasus	2.18	332	10.5	237	NA	NA	21.3	NA	7.52	1KB	1KB	68	NA	Z:\Airborne_Raw
6/19/2014	1609P	1RXS170A	Pegasus	2.16	526	11.2	259	45.3	309	22.1	NA	7.07	1KB	1KB	77/76	NA	Z:\Airborne_Raw
6/20/2014	1613P	1BLK71G171A	Pegasus	3.44	177	13.7	258	67.3	437	33.2	NA	5.92	1KB	1KB	46	NA	Z:\Airborne_Raw
6/23/2014	1625P	1BLK67BC174A	Pegasus	3.09	1112	11.7	212	60.3	415	29.4	86.6	4.97	1KB	1KB	52/56	NA	Z:\Airborne_Raw
6/24/2014	1629P	1BLKRXES175A	Pegasus	2.79	370	10.7	187	36.3	268	26.1	NA	4.45	1KB	1KB	73	NA	Z:\Airborne_Raw
6/27/2014	1641P	1BLK68A178A	Pegasus	2.94	1995	12.6	268	57.4	398	28.9	57.2	7.7	1KB	1KB	65/65/60/58	NA	Z:\Airborne_Raw
6/27/2014	1643P	1BLK67ABS178E	Pegasus	532	95	4.33	119	NA	NA	5.65	NA	7.7	1KB	1KB	48	NA	Z:\Airborne_Raw
6/28/2014	1645P	1BLK71C179A	Pegasus	2.84	NA	11.4	242	51.8	375	27.4	NA	6.25	1KB	1KB	59/68	NA	Z:\Airborne_Raw

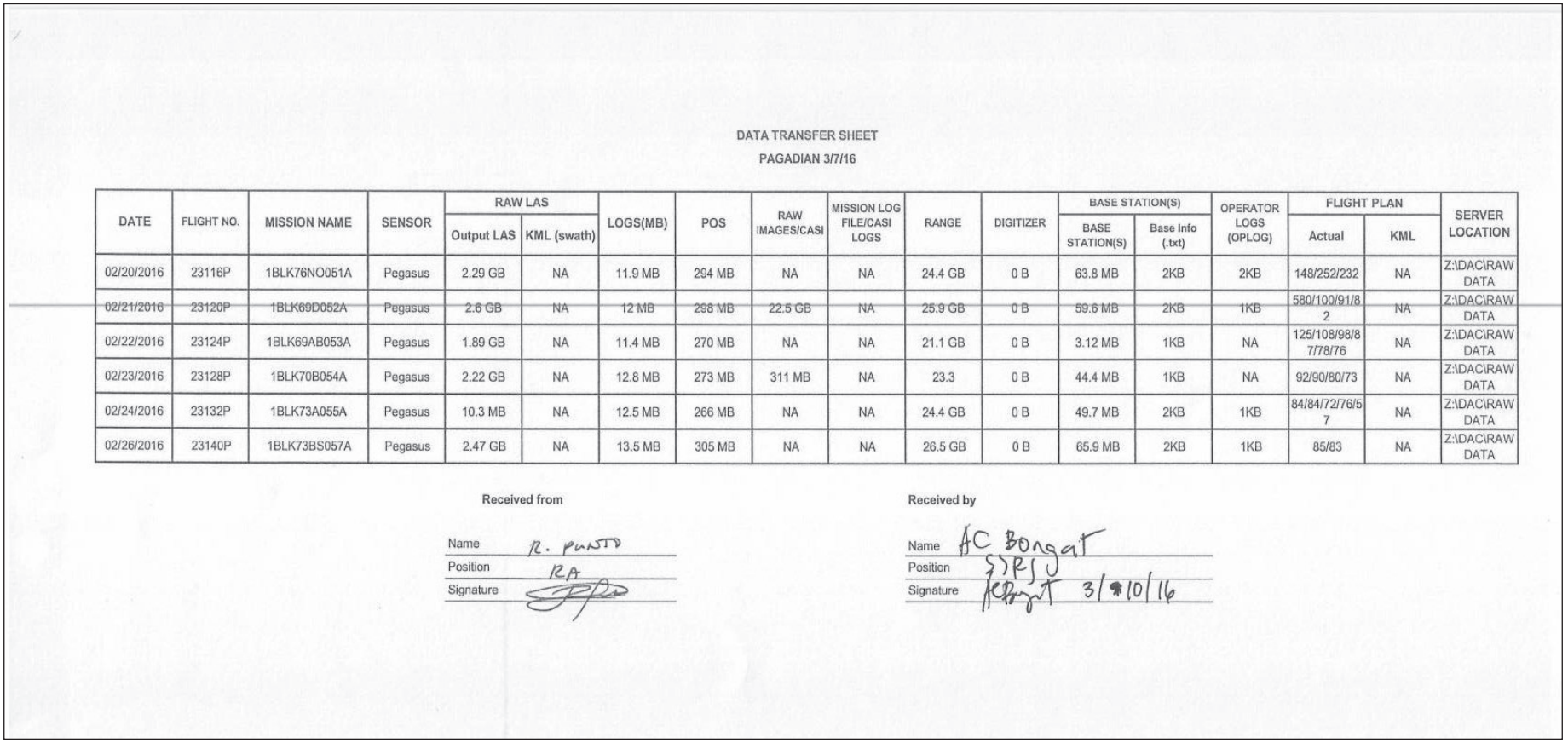
Received from

Name TIN ANDAYA
Position RA
Signature

Received by

Name JOINA PRIETO
Position SSRS
Signature 7/28/14

Figure A-5.4. Data Transfer Sheet for Butadon Floodplain – D



DATA TRANSFER SHEET

PAGADIAN 3/7/16

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	POS	RAW IMAGES/CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
02/20/2016	23116P	1BLK76NO051A	Pegasus	2.29 GB	NA	11.9 MB	294 MB	NA	NA	24.4 GB	0 B	63.8 MB	2KB	2KB	148/252/232	NA	Z:\DAC\RAW DATA
02/21/2016	23120P	1BLK69D052A	Pegasus	2.6 GB	NA	12 MB	298 MB	22.5 GB	NA	25.9 GB	0 B	59.6 MB	2KB	1KB	580/100/91/82	NA	Z:\DAC\RAW DATA
02/22/2016	23124P	1BLK69AB053A	Pegasus	1.89 GB	NA	11.4 MB	270 MB	NA	NA	21.1 GB	0 B	3.12 MB	1KB	NA	125/108/98/87/78/76	NA	Z:\DAC\RAW DATA
02/23/2016	23128P	1BLK70B054A	Pegasus	2.22 GB	NA	12.8 MB	273 MB	311 MB	NA	23.3	0 B	44.4 MB	1KB	NA	92/90/80/73	NA	Z:\DAC\RAW DATA
02/24/2016	23132P	1BLK73A055A	Pegasus	10.3 MB	NA	12.5 MB	266 MB	NA	NA	24.4 GB	0 B	49.7 MB	2KB	1KB	84/84/72/76/57	NA	Z:\DAC\RAW DATA
02/26/2016	23140P	1BLK73BS057A	Pegasus	2.47 GB	NA	13.5 MB	305 MB	NA	NA	26.5 GB	0 B	65.9 MB	2KB	1KB	85/83	NA	Z:\DAC\RAW DATA

Received from

Name R. PUNTO

Position RA

Signature

Received by

Name AC Bongat

Position SSRJ

Signature 3/10/16

Figure A-5.5. Data Transfer Sheet for Butadon Floodplain – E

DATA TRANSFER SHEET

PAGADIAN 2/29/16

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	POS	RAW IMAGES/CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
2016-02-17	23104P	1BLK76DLM48A	Pegasus	1.81 GB	NA	10.09 MB	287.01 MB	25.87 GB	193.97 KB	18.3 GB	0 B	116.78 MB	133 B	1.08 KB	0 B	NA	Z:\DAC\RAW DATA\23104 P
2016-02-16	23100P	1BLK76G047A	Pegasus	2.83 GB	NA	12.33 MB	285.96 MB	38 GB	297.52 KB	27.31 GB	0 B	103.23 MB	132 B	341B	0 B	NA	Z:\DAC\RAW DATA\23100 P
2016-02-15	23096P	1BLK76NO46A	Pegasus	665.91 MB	NA	4.64 MB	164.2 MB	9.7 GB	82.64 KB	7.07 GB	0 B	90.32 MB	133 B	603 B	0 B	NA	Z:\DAC\RAW DATA\23096 P
2016-02-14	23092P	1BLK76IG045A	Pegasus	2.19 GB	NA	10.66 MB	203.46 MB	28.87 GB	230.75 KB	22.33 GB	0 B	110.72 MB	132 B	279 B	0 B	NA	Z:\DAC\RAW DATA\23092 P
2016-02-13	23088P	1BLK76ILM044A	Pegasus	2.48 GB	NA	11.64 MB	283.62 MB	35.45 GB	263.38 KB	24.65 GB	0 B	101.29 MB	133 B	889 B	0 B	NA	Z:\DAC\RAW DATA\23088 P
2016-02-12	23084P	1BLK76KJLM043A	Pegasus	3.01 GB	NA	13.36 MB	276.9 MB	44.56 GB	332.83 KB	29.36 GB	0 B	129.73 MB	133 B	362 B	0 B	NA	Z:\DAC\RAW DATA\23084 P

Received from

Name R. PUNTO

Position RA

Signature

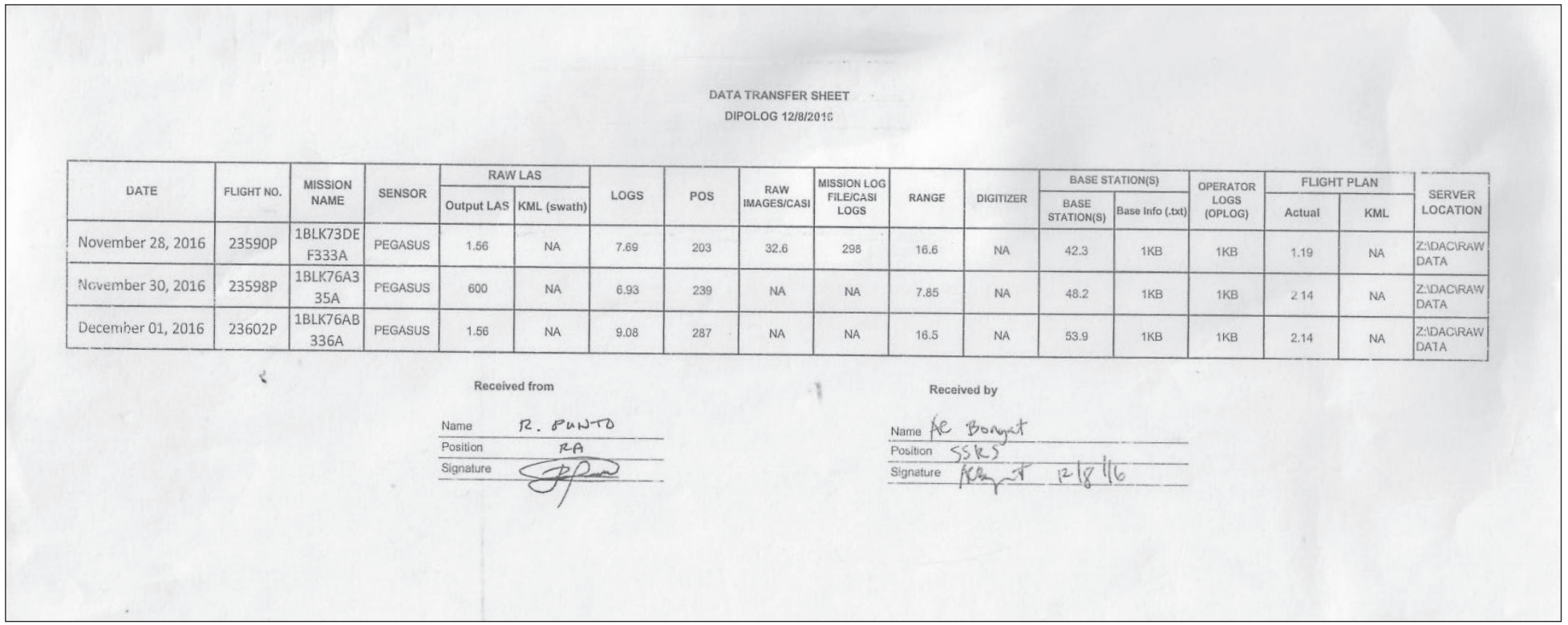
Received by

Name AC Borgat

Position SSRS

Signature 3/1/16

Figure A-5.6. Data Transfer Sheet for Butadon Floodplain – F



DATA TRANSFER SHEET
DIPOLOG 12/8/2016

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS	POS	RAW IMAGES/CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
November 28, 2016	23590P	1BLK73DEF333A	PEGASUS	1.56	NA	7.69	203	32.6	298	16.6	NA	42.3	1KB	1KB	1.19	NA	Z:\DAC\RAW DATA
November 30, 2016	23598P	1BLK76A335A	PEGASUS	600	NA	6.93	239	NA	NA	7.85	NA	48.2	1KB	1KB	2.14	NA	Z:\DAC\RAW DATA
December 01, 2016	23602P	1BLK76AB336A	PEGASUS	1.56	NA	9.08	287	NA	NA	16.5	NA	53.9	1KB	1KB	2.14	NA	Z:\DAC\RAW DATA

Received from

Name R. PUNTO
Position RA
Signature

Received by

Name AR Bongat
Position SSKS
Signature 12/8/16

Figure A-5.7. Data Transfer Sheet for Butadon Floodplain – G

Annex 6. Flight Logs for the Flight Missions

1. Flight Log for 1549PMission

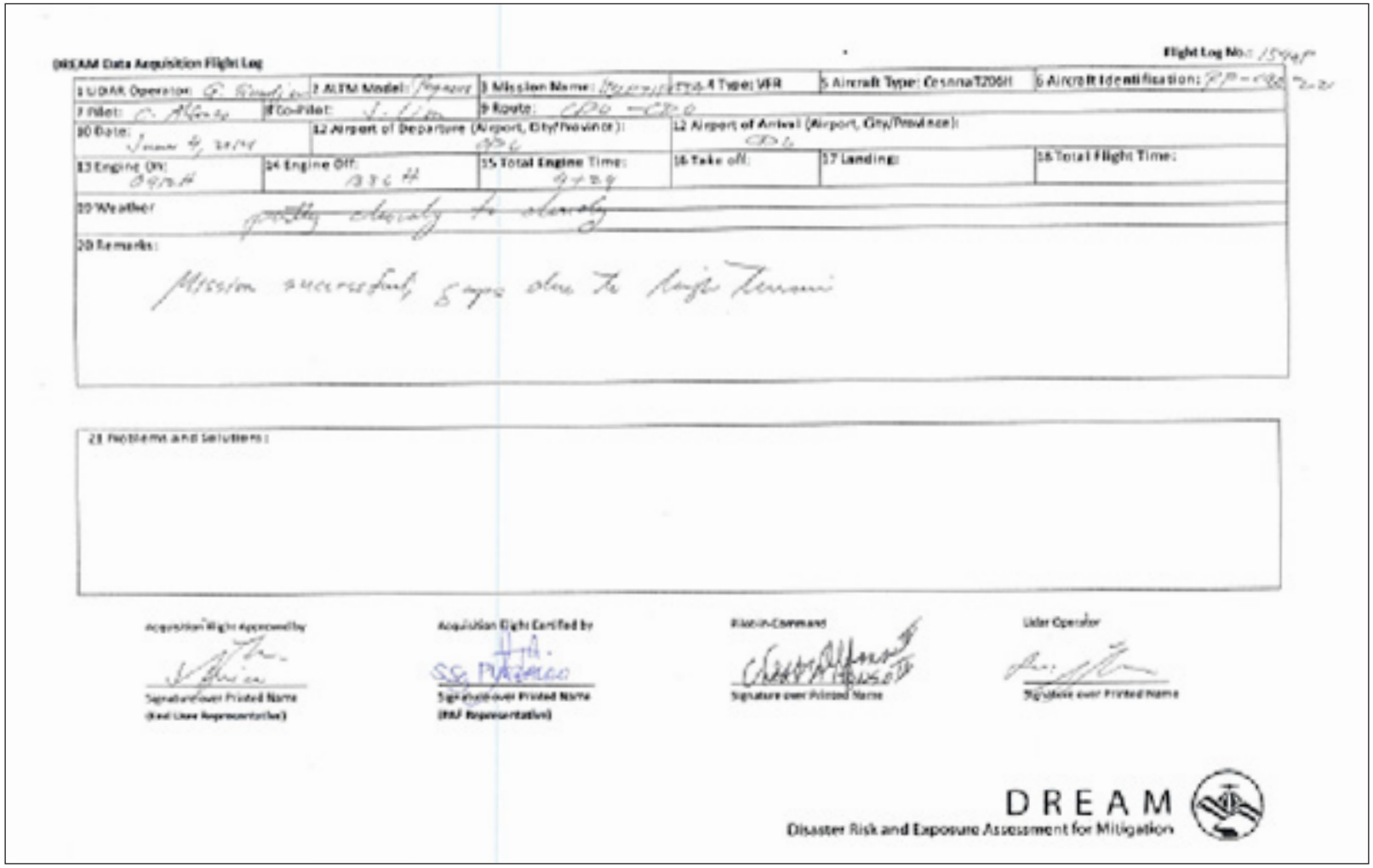


Figure A-6.1. Flight Log for Mission 1549P

2. Flight Log for 1565P Mission

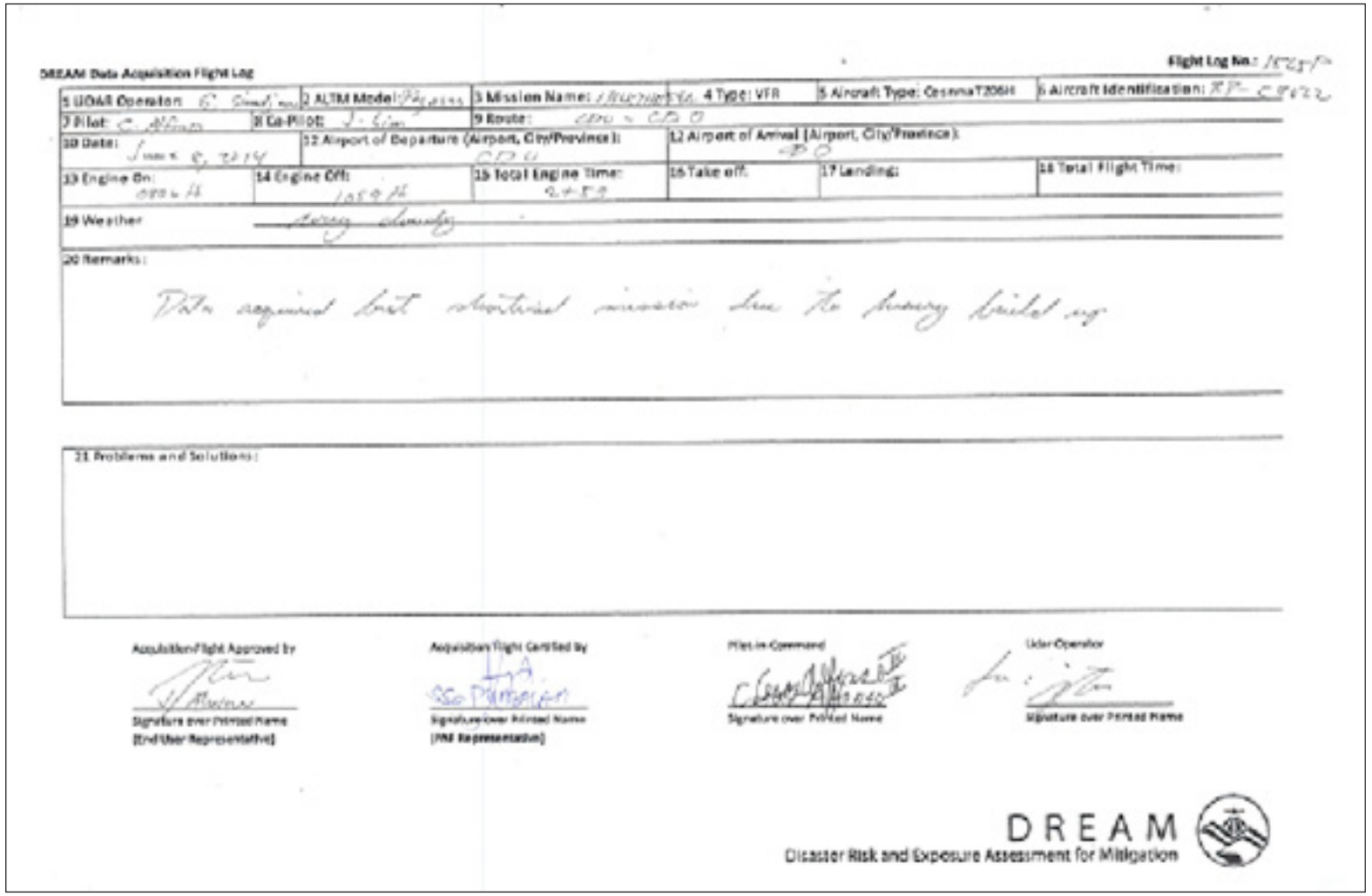


Figure A-6.2. Flight Log for Mission 1565P

3. Flight Log for 1613P Mission

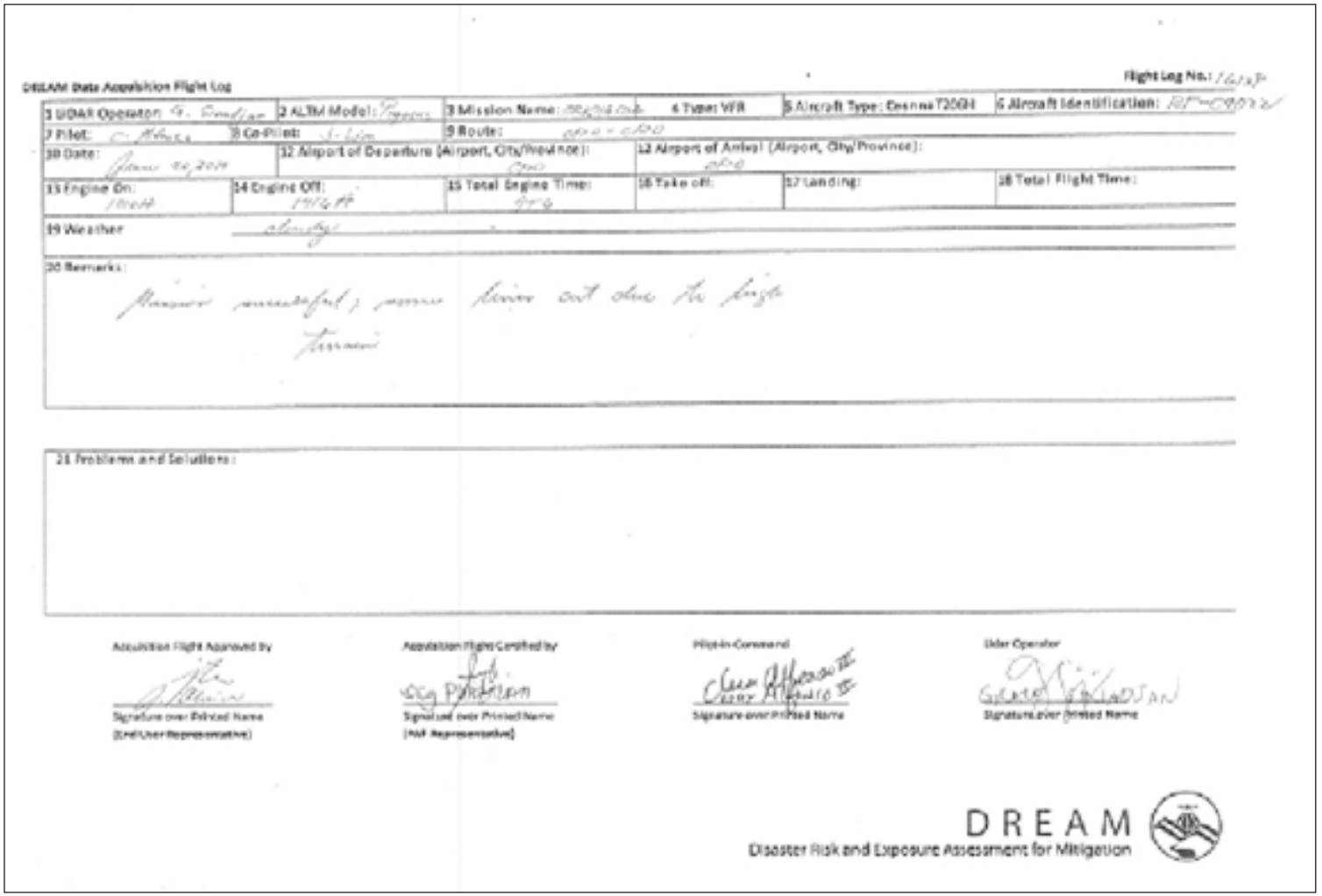
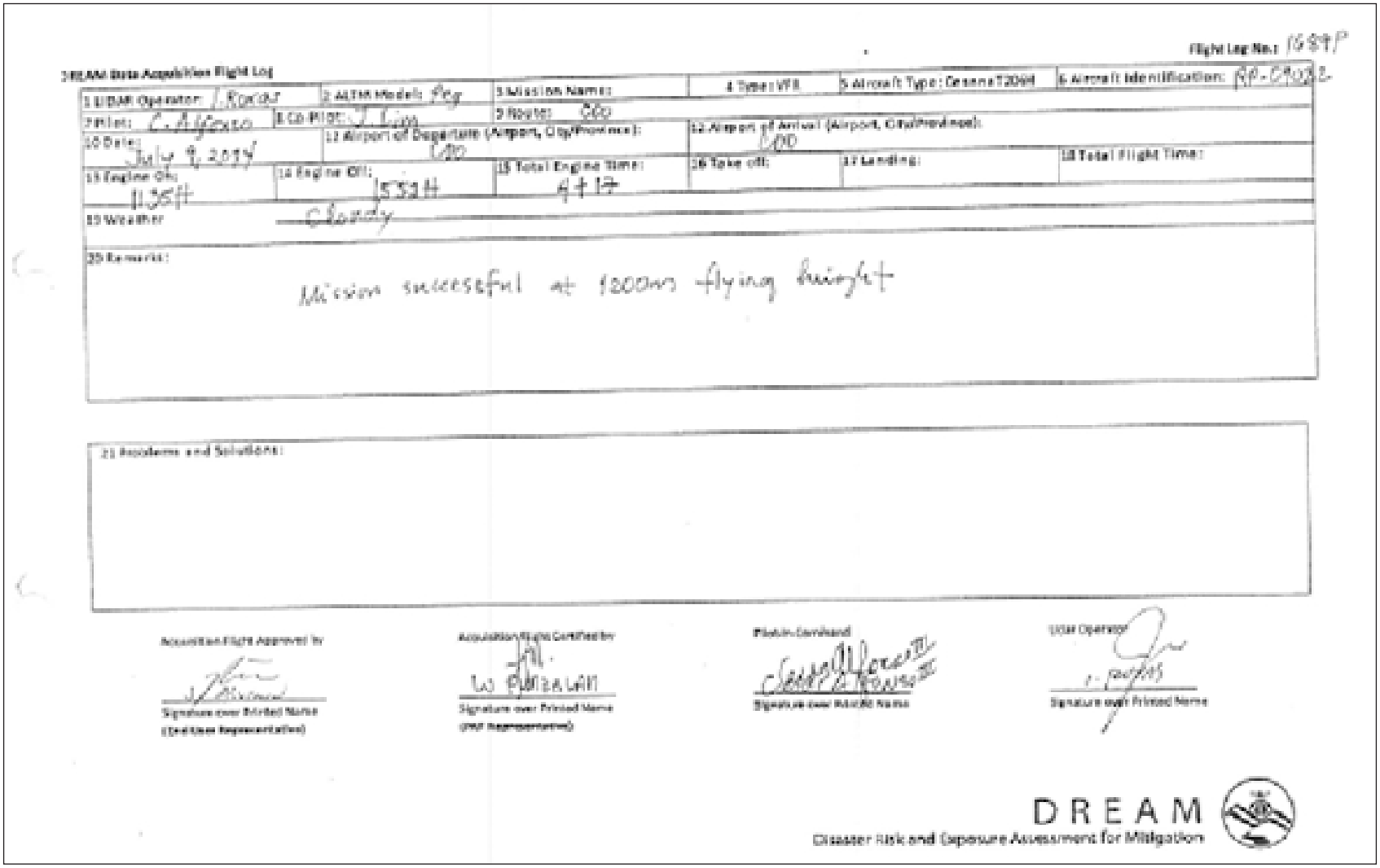


Figure A-6.3. Flight Log for Mission 1613P

4. Flight Log for 1665P Mission



Flight Log No.: 1665P

RPAM Data Acquisition Flight Log

1 UDAR Operator: [illegible]	2 ALTM Model: Pegasus	3 Mission Name:	4 Type: VFR	5 Aircraft Type: Cessna T206H / 6 Aircraft Identification: RP-C9022
7 Pilot: C. Alfonso	8 Co-Pilot: J. Luis	9 Route: CBO		
10 Date: July 9, 2024	11 Airport of Departure (Airport, City/Province): CBO		12 Airport of Arrival (Airport, City/Province): CBO	
13 Engine On: 11:35H	14 Engine Off: 15:32H	15 Total Engine Time: 4+12	16 Take off:	17 Landing: / 18 Total Flight Time:
19 Weather: Cloudy				

20 Remarks:

Mission successful at 1200m flying height

21 Accidents and Solutions:

Acquisition Flight Approved by

Signature over Printed Name
(Deputized Representative)

Acquisition Flight Certified by

Signature over Printed Name
(PAF Representative)

Pilot-in-Command

Signature over Printed Name

UDAR Operator

Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.4. Flight Log for Mission 1665P

5. Flight Log for 1673P Mission

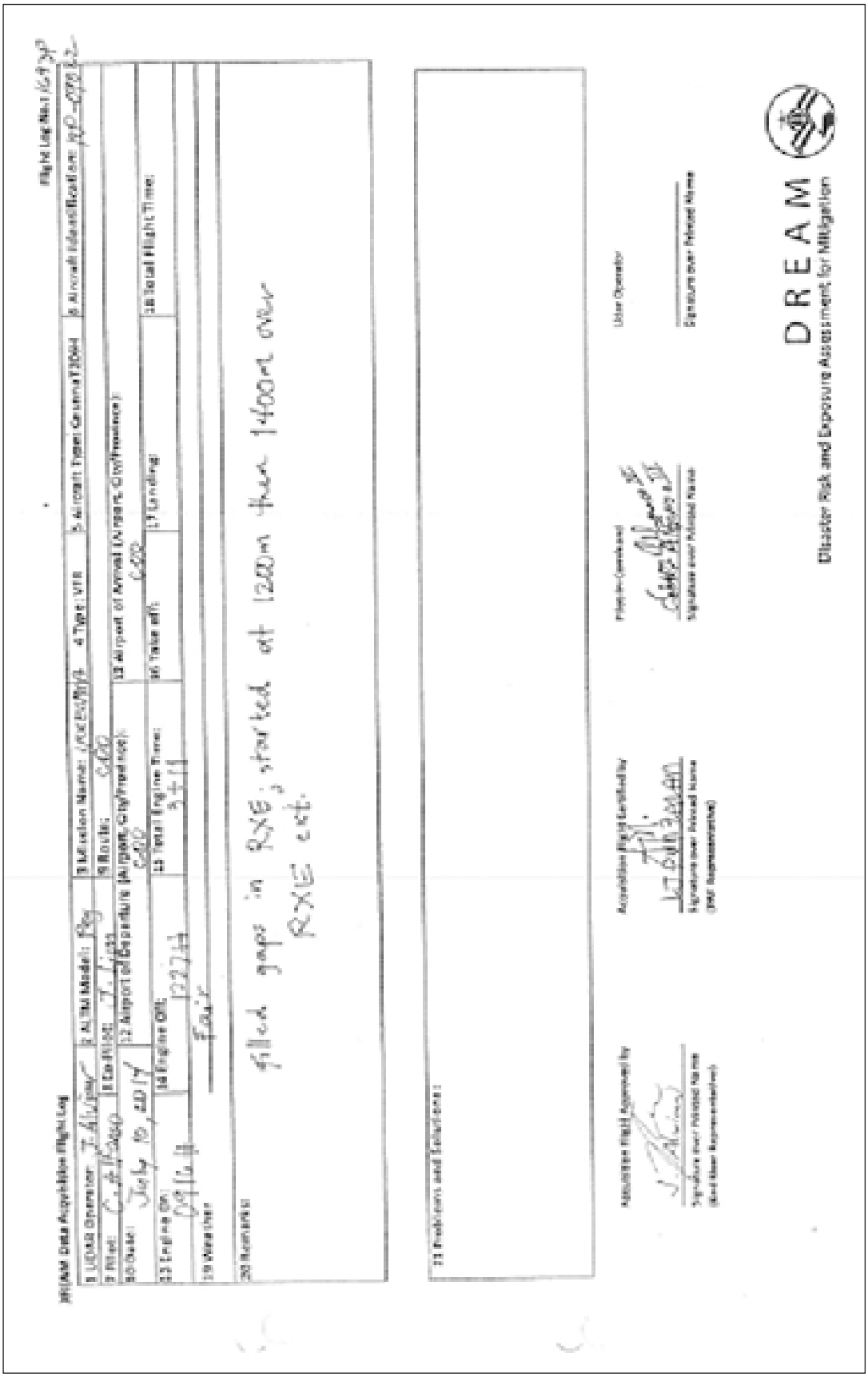


Figure A-6.5. Flight Log for Mission 1673P

6. Flight Log for 1677P Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 1677

1 LiDAR Operator: G Sinadjan	2 ALTM Model: Peg	3 Mission Name: DUK7151877A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9022
7 Pilot: C. Alfonso	8 co-Pilot: J Lim	9 Route: CDO			
10 Date: July 6, 2014	12 Airport of Departure (Airport, City/Province): CDO		12 Airport of Arrival (Airport, City/Province): CDO		
13 Engine On: 1021 H	14 Engine Off: 1256 H	15 Total Engine Time: 2+35	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: very cloudy					

20 Remarks:

Heavy build up over all remaining survey areas; surveyed supplementary lines to BLK 71ext

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Signature over Printed Name (End User Representative)	W PANZALAN Signature over Printed Name (PAF Representative)	Cesar Alfonso III Signature over Printed Name	G. SINADJAN Signature over Printed Name

Figure A-6.6. Flight Log for Mission 1677P

7. Flight Log for 1685P Mission

DREAM Data Acquisition Flight Log Flight Log No.: 1685P

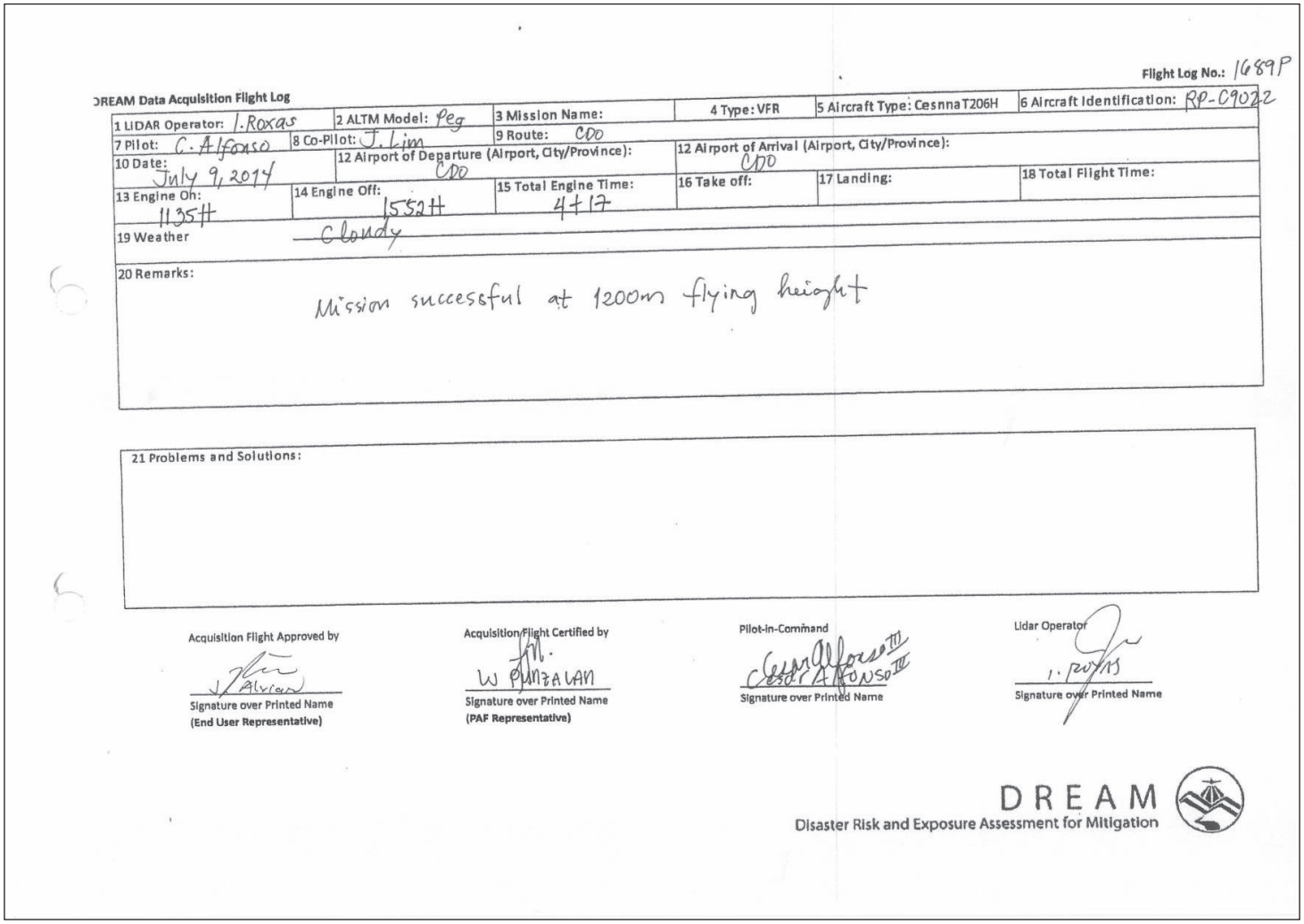
1 LiDAR Operator: I. Roxas	2 ALTM Model: Peg	3 Mission Name: BLK71587A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RPC9022
7 Pilot: C. Alfonso	8 Co-Pilot: J. Lim	9 Route: CDO			
10 Date: July 8, 2014	12 Airport of Departure (Airport, City/Province): CDO		12 Airport of Arrival (Airport, City/Province): CDO		
13 Engine On: 0958H	14 Engine Off: 1403H	15 Total Engine Time: 4+5	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	cloudy				
20 Remarks: Surveyed BLK 71F at 1200m.					

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
J. Alviar	W RUNTALAN	Cesar Alfonso III	I. Roxas
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

Figure A-6.7. Flight Log for Mission 1685P

8. Flight Log for 1689P Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 1689P

1 LIDAR Operator: J. Roxas	2 ALTM Model: Peg	3 Mission Name:	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9022
7 Pilot: C. Alfonso	8 Co-Pilot: J. Lim	9 Route: CDO			
10 Date: July 9, 2014	12 Airport of Departure (Airport, City/Province): CDO		12 Airport of Arrival (Airport, City/Province): CDO		
13 Engine On: 1135H	14 Engine Off: 1552H	15 Total Engine Time: 4+17	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Cloudy					

20 Remarks: Mission successful at 1200m flying height

21 Problems and Solutions:

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

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

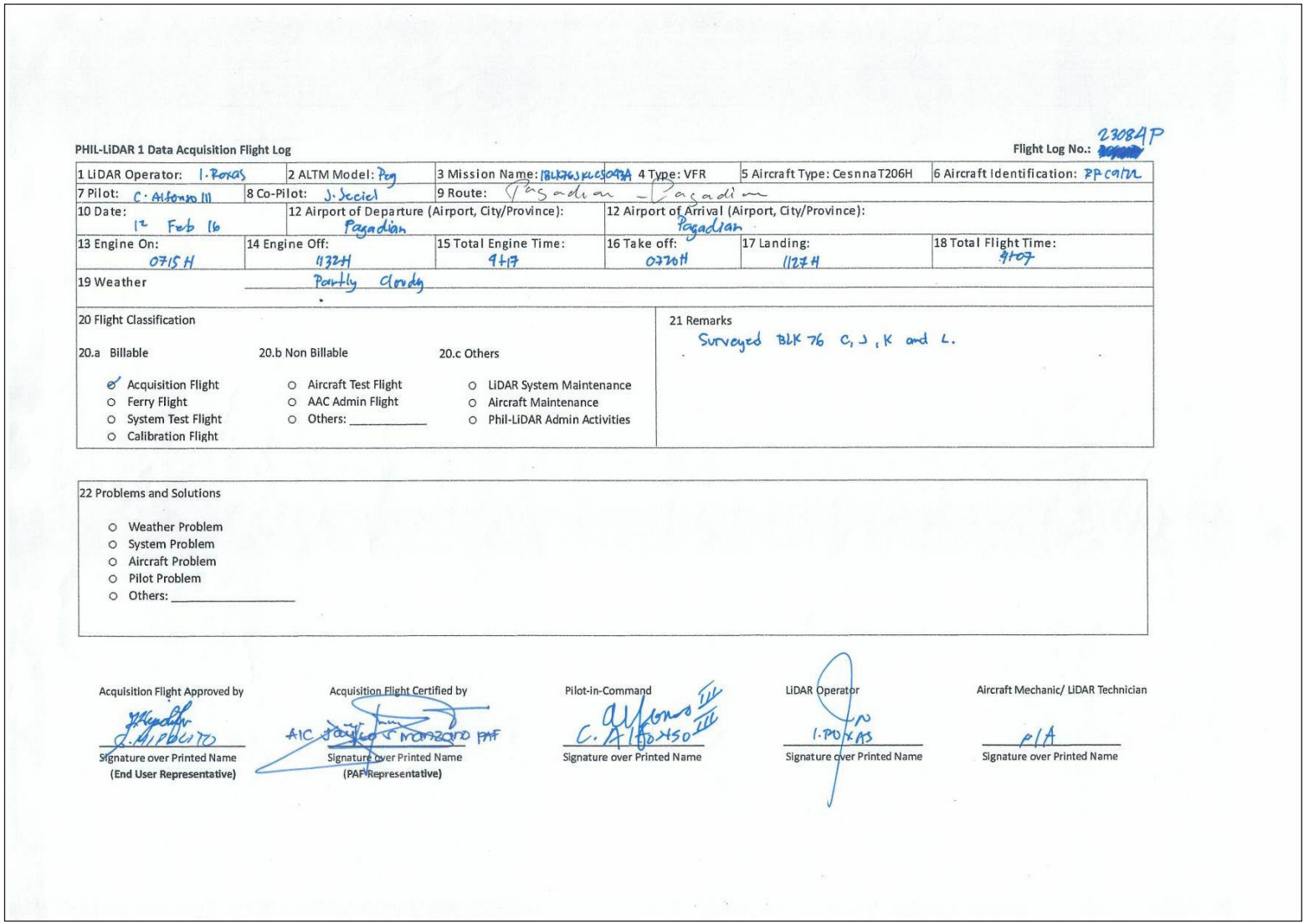
Pilot-in-Command
Cesar Alfonso III
Signature over Printed Name

Lidar Operator
1. Roxas
Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.8. Flight Log for Mission 1689P

9. Flight Log for 23084P Mission



PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.: 23084P

1 LiDAR Operator: I. Rojas	2 ALTM Model: Peg	3 Mission Name: BLK76JKLC5043A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP C9122
7 Pilot: C. Alfonso III	8 Co-Pilot: J. Jocjel	9 Route: Pagadian - Pagadian			
10 Date: 12 Feb 16	12 Airport of Departure (Airport, City/Province): Pagadian		12 Airport of Arrival (Airport, City/Province): Pagadian		
13 Engine On: 0715 H	14 Engine Off: 1132H	15 Total Engine Time: 4+17	16 Take off: 0726H	17 Landing: 1127 H	18 Total Flight Time: 4+07
19 Weather	Partly cloudy				

20 Flight Classification

20.a Billable	20.b Non Billable	20.c Others
✓ Acquisition Flight	○ Aircraft Test Flight	○ LiDAR System Maintenance
○ Ferry Flight	○ AAC Admin Flight	○ Aircraft Maintenance
○ System Test Flight	○ Others: _____	○ Phil-LiDAR Admin Activities
○ Calibration Flight		

21 Remarks: Surveyed BLK 76 C, J, K and L.

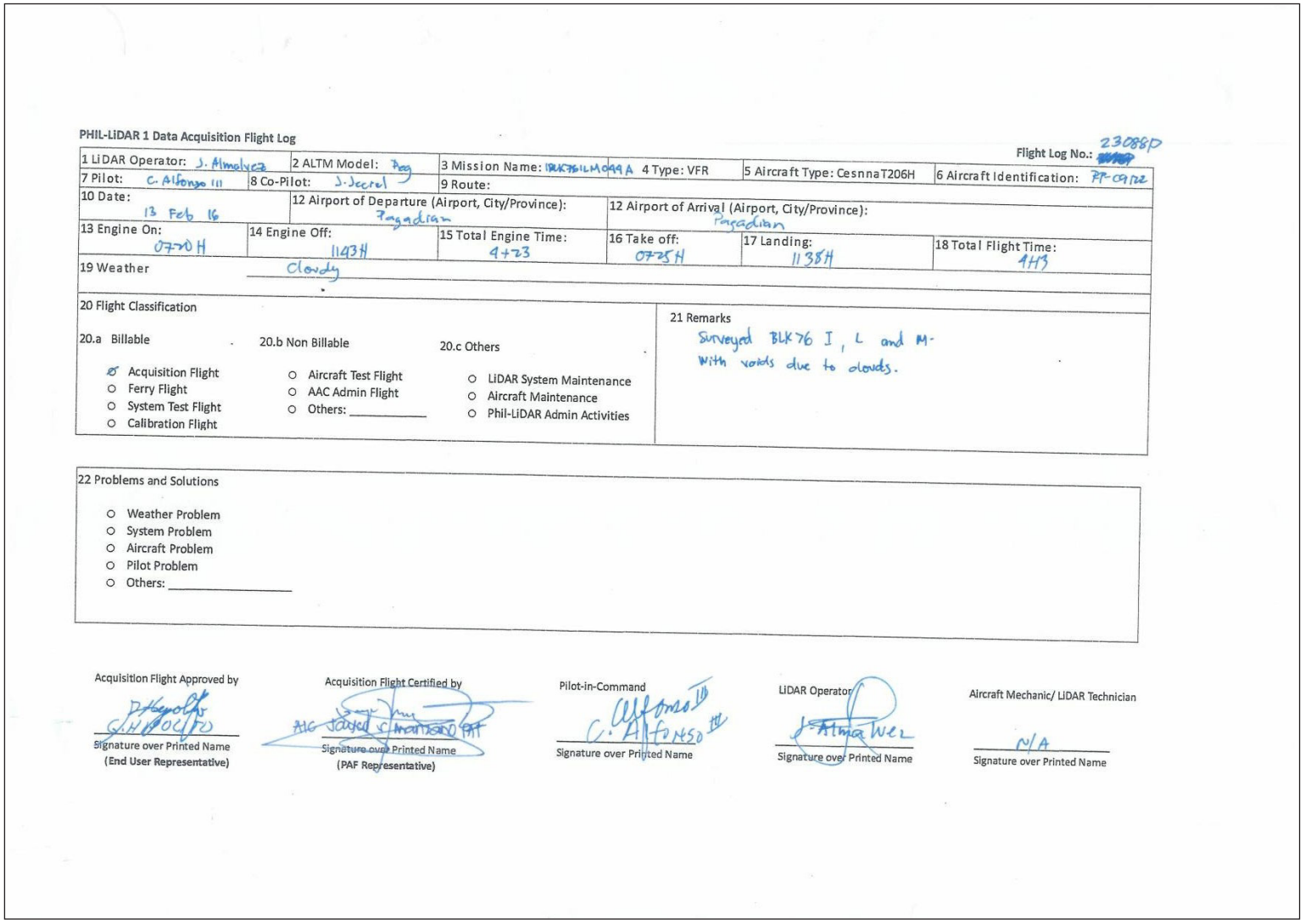
22 Problems and Solutions

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

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	LiDAR Operator	Aircraft Mechanic/ LiDAR Technician
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name	Signature over Printed Name

Figure A-6.9. Flight Log for Mission 23084P

10. Flight Log for 23088P Mission



PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.: 23088P

1 LiDAR Operator: J. Almolyez	2 ALTM Model: Pegasus	3 Mission Name: [illegible]	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9102
7 Pilot: C. Alfonso III	8 Co-Pilot: J. Jecrel	9 Route:			
10 Date: 13 Feb 16	12 Airport of Departure (Airport, City/Province): Pagadian	12 Airport of Arrival (Airport, City/Province): Pagadian			
13 Engine On: 0720 H	14 Engine Off: 1143 H	15 Total Engine Time: 4+23	16 Take off: 0725 H	17 Landing: 1138 H	18 Total Flight Time: 4H3
19 Weather: Cloudy					

20 Flight Classification

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

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

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

21 Remarks: Surveyed BLK 76 I, L and M- With voids due to clouds.

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

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	LiDAR Operator	Aircraft Mechanic/ LiDAR Technician
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name	N/A Signature over Printed Name

Figure A-6.10. Flight Log for Mission 23088P

11. Flight Log for 23104P Mission

PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.: 23104P

1 LiDAR Operator: J. Almario	2 ALTM Model: Pegasus	3 Mission Name: BLK76DKLM	Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: PR-C9122
7 Pilot: C. Alfonso III	8 Co-Pilot: J. Jeciel	9 Route:			
10 Date: 17 Feb 16	12 Airport of Departure (Airport, City/Province): Pagadian	12 Airport of Arrival (Airport, City/Province): Pagadian			
13 Engine On: 0805 H	14 Engine Off: 1240 H	15 Total Engine Time: 4+35	16 Take off: 0810 H	17 Landing: 1235 H	18 Total Flight Time: 4+25
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: Surveyed voids over BLK 76 P, K, L and M

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

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	LiDAR Operator	Aircraft Mechanic/ LiDAR Technician
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name	Signature over Printed Name

Figure A-6.11. Flight Log for Mission 23104P

12. Flight Log for 23128P Mission

PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.:

1 LiDAR Operator: K. Quisado	2 ALTM Model: Pegasus	3 Mission Name:	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RPC9122
7 Pilot: C. Alfonso	8 Co-Pilot: J. Jeciel	9 Route:			
10 Date: 2/23/2016	12 Airport of Departure (Airport, City/Province): Pagadian, Zamboanga del Sur		12 Airport of Arrival (Airport, City/Province): Pagadian, Zamboanga del Sur		
13 Engine On: 7:30	14 Engine Off: 11:47	15 Total Engine Time: 4:17	16 Take off: 7:35	17 Landing: 11:42	18 Total Flight Time: 4:07
19 Weather: Partly Cloudy					

20 Flight Classification

20.a Billable	20.b Non Billable	20.c Others
✓ Acquisition Flight	○ Aircraft Test Flight	○ LiDAR System Maintenance
○ Ferry Flight	○ AAC Admin Flight	○ Aircraft Maintenance
○ System Test Flight	○ Others: _____	○ Phil-LiDAR Admin Activities
○ Calibration Flight		

21 Remarks: Successful flight

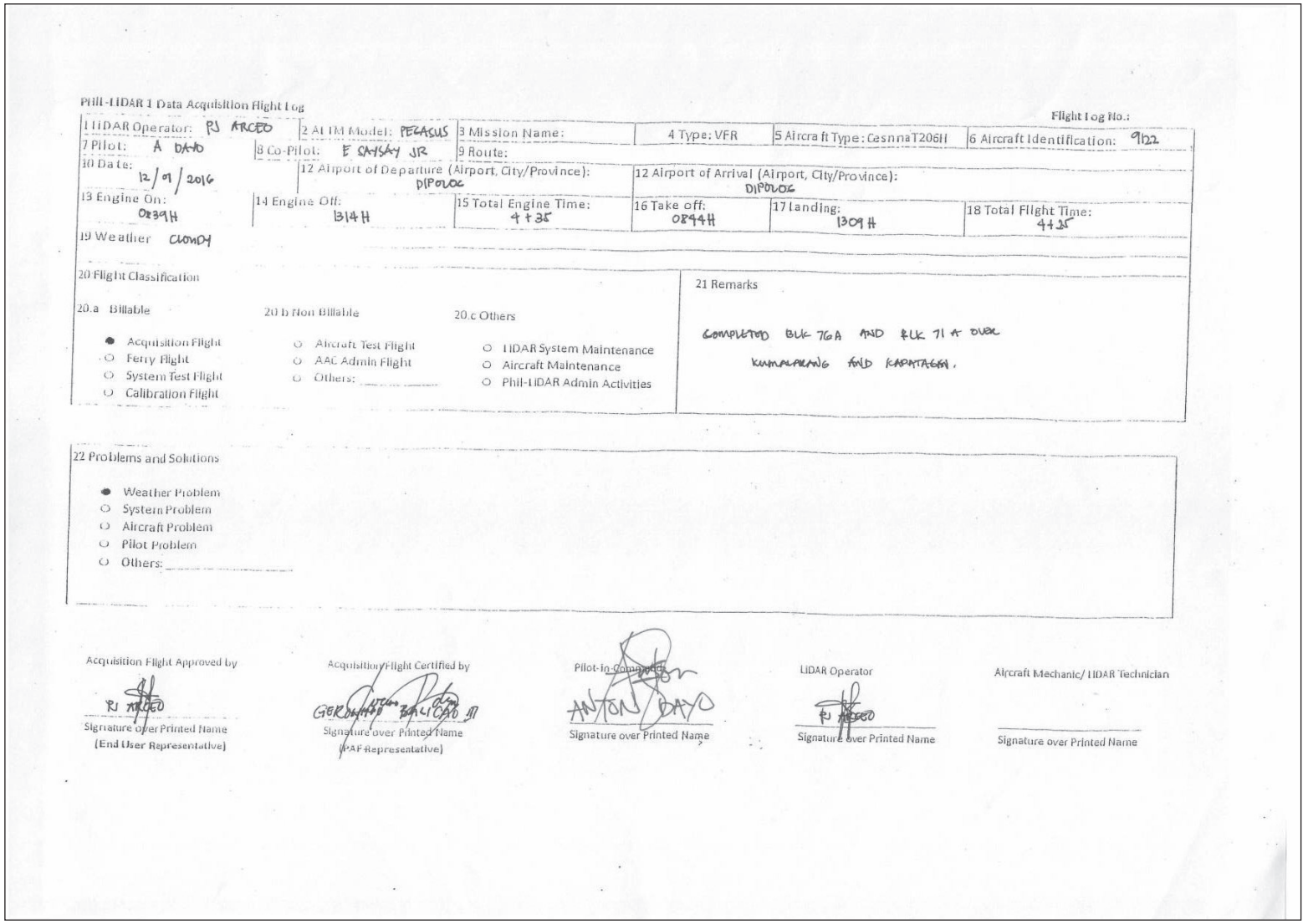
22 Problems and Solutions

- ○ 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
Signature over Printed Name (End User Representative)	LEE JAY A. PUNZALAN Jr. Signature over Printed Name (PAF Representative)	C. ALFONSO III Signature over Printed Name	Kenneth Quisado Signature over Printed Name	N/A Signature over Printed Name

Figure A-6.12. Flight Log for Mission 23128P

13. Flight Log for 23602P Mission



Phil-LiDAR 1 Data Acquisition Flight Log

Flight Log No.:

1 LiDAR Operator: RJ ARCEO	2 ALTM Model: PEGASUS	3 Mission Name:	4 Type: VFR	5 Aircraft Type: CessnaT206H	6 Aircraft Identification: 9122
7 Pilot: A DAYO	8 Co-Pilot: E SAYSAY JR	9 Route:			
10 Date: 12/09/2016	12 Airport of Departure (Airport, City/Province): DIPOLOG		12 Airport of Arrival (Airport, City/Province): DIPOLOG		
13 Engine On: 0839H	14 Engine Off: 1314H	15 Total Engine Time: 4+35	16 Take off: 0844H	17 Landing: 1309H	18 Total Flight Time: 4+25
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

COMPLETED BLK 76A AND BLK 71A OVER KUMALARANG AND KAPATAGAN.

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
RJ ARCEO	GERONIMO ZALICOS III	ANTON DAYO	RJ ARCEO	
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

Figure A-6.13. Flight Log for Mission 23602P

Annex 7. Flight Status Reports

Table A-7.1. Flight Status Report

FLIGHT STATUS REPORT

Northern Mindanao

(June 4-July9, 2014; February 12-23, 2016; December 1, 2016)

FLIGHT NO	AREA	MISSION	OPERATOR	DATE FLOWN	REMARKS
1549P	BLK 71E	1BLK 71D155A	G. Sinadjan	June 4, 2014	Surveyed BLK 71E with gaps due to clouds; to be renamed to 1BLK71E155A
1565P	BLK 71F	1BLK71B159A	G. Sinadjan	June 8, 2014	Surveyed half of BLK 71F with gaps due to clouds; to be renamed 1BLK71F159A
1613P	BLK 71G	1BLK71G171A	G. Sinadjan	June 20, 2014	Mission successful; some lines cut due to high terrain
1665P	BLK 71 ext	1BLK71ES184A	J. Alviar	July 3, 2014	Heavy build up closing is over Lanao and Pagadian areas; searched for open areas and surveyed Ozamis City instead
1673P	BLK 71 ext	1BLK71ES186A	I.Roxas	July 5, 2014	Attempted to survey Lanao and Pagadian but transferred to Tangub and Ozamis due to heavy build up in the previous areas
1677P	BLK 71 ext	1BLK71S187A	G. Sinadjan	July 6, 2014	Heavy build over all remaining survey areas; surveyed supplementary lines to BLK 71ext
1685P	BLK 71F	1BLK71S189A	I.Roxas	July 8, 2014	Surveyed BLK 71F at 1200m
1689P	BLK 71E and BLK 71ABCs	1BLK71S190A	I.Roxas	July 9, 2014	Surveyed BLK 71E and the gaps in BLK 71ABC

23084P	BLK C,D,E,H,J,K,L	1BLK76JKLCs043A	I.Roxas	February 12, 2016	Finished BLK76C,J,K. Please also process tie lines as production data, using the intersecting line as tie line for BLK76D,E,H as they cover parts of FP
23088P	BLK I,L,M	1BLK76ILM044A	J. Almalvez	February 13, 2016	Cloudy over L & M. Pegasus problem encountered so no tie lines over I; please use 23078's and 23092's tie line
23104P	BLKD,L,M	1BLK76DLM048A	J. Almalvez	February 17, 2016	Cloudy on BLK76M so no tie line, please use 23088's tie line; also cloudy in BLK76L
23128P	BLK70B, 71A	1BLK70B054A	K. Quisado	February 23, 2016	Encountered Lost Channel A error several times; Surveyed blks
23602P	KUMALARANG, KAPATAGAN BLK 76A, 71A	1BLK76AB336A	P. Arceo	December 1, 2016	Completed Kumalarang floodplain and voids over Kapatagan floodplain

LAS/SWATH BOUNDARIES PER MISSION FLIGHT

Flight No. : 1549P
Area: BLK 71E
Mission Name: 1BLK71D155A
Parameters: Altitude: 800m; Scan Frequency: 30; Scan Angle: 50

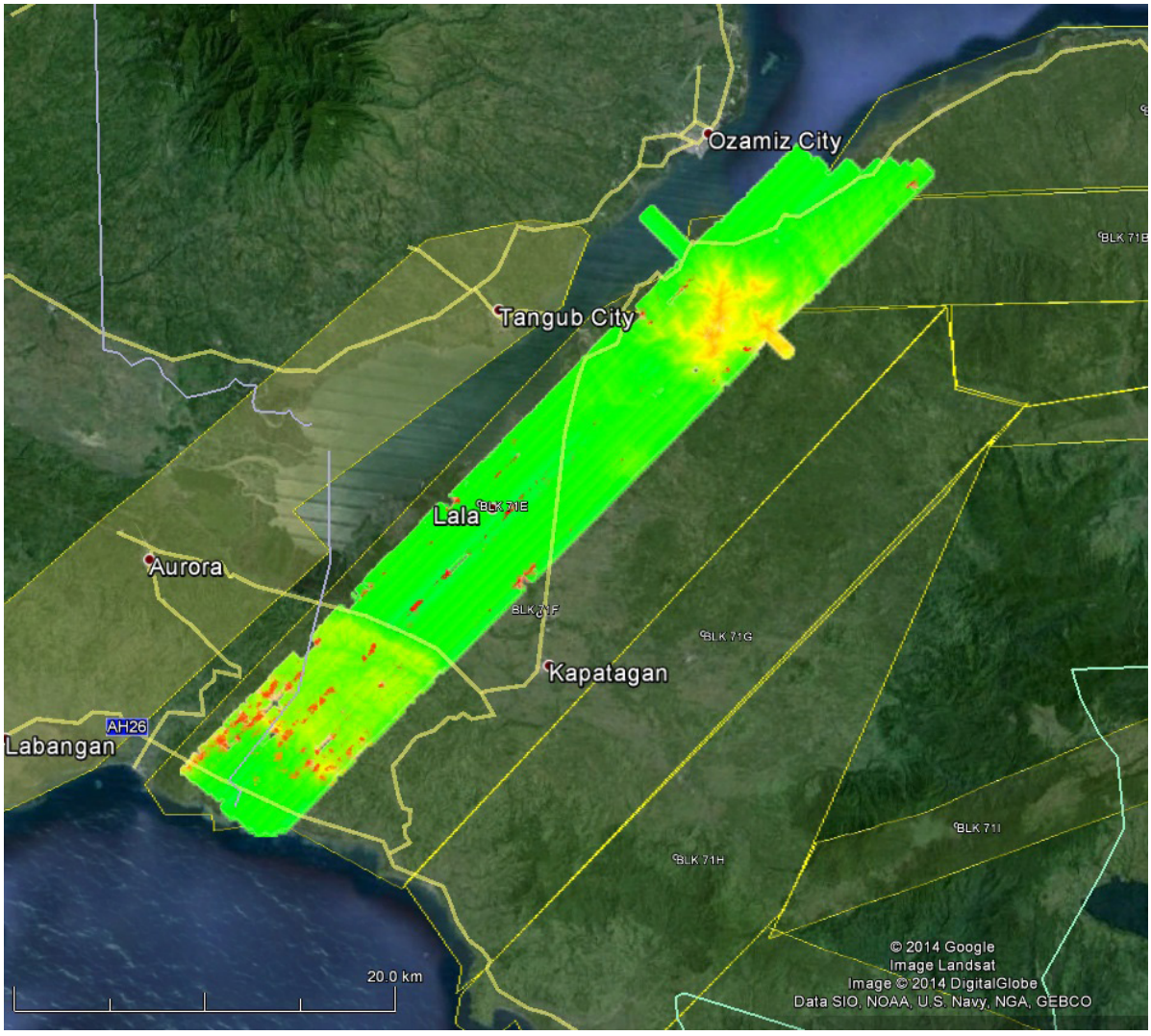


Figure A-7.1. Swath for Flight No. 1549P

Flight No. : 1565P
Area: BLK 71F
Mission Name: 1BLK71B159A
Parameters: Altitude: 1000m; Scan Frequency: 30; Scan Angle: 50

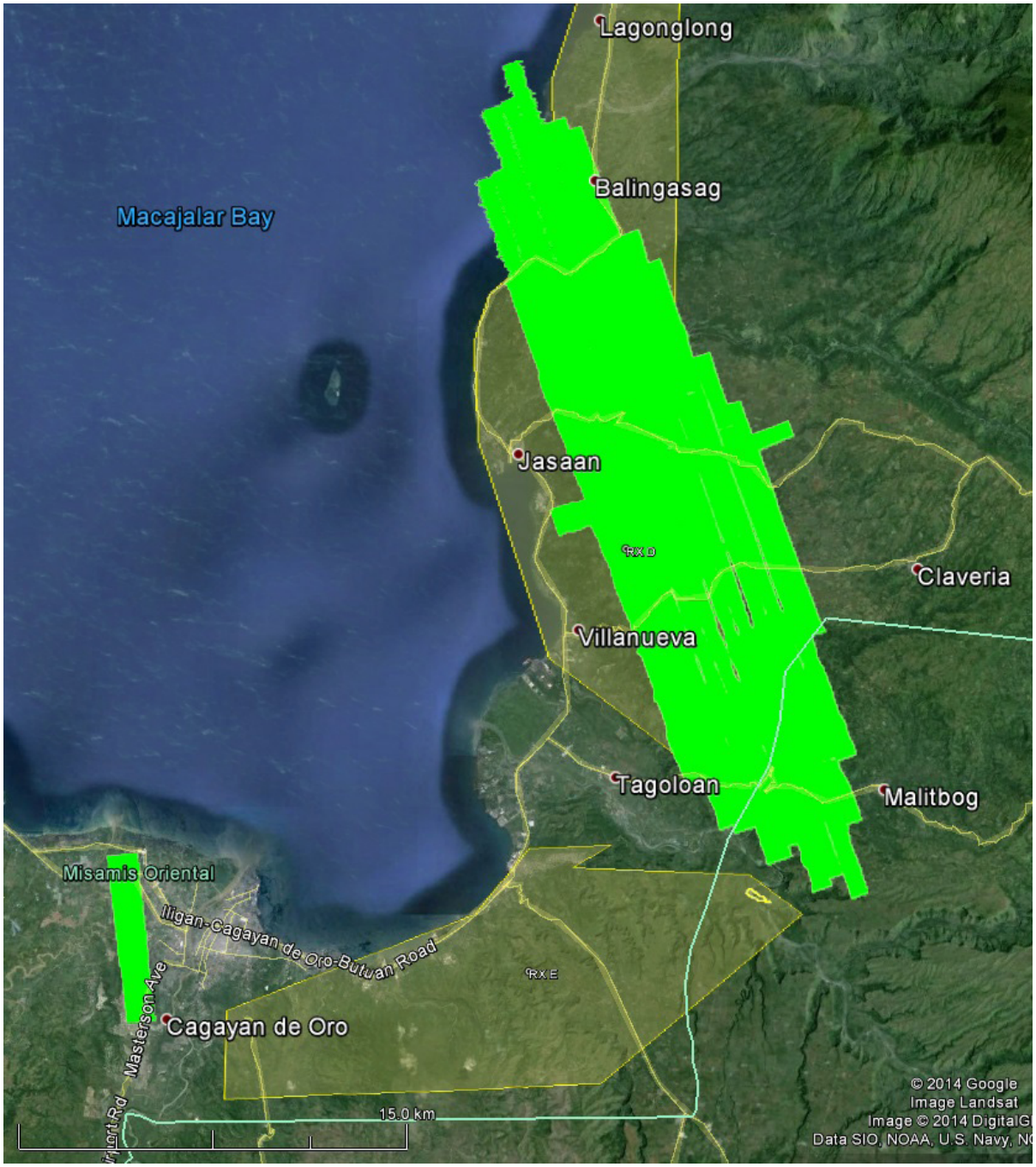


Figure A-7.2. Swath for Flight No. 1565P

Flight No. : 1613P
Area: BLK 71G
Mission Name: 1BLK71G171A
Parameters: Altitude: 900m; Scan Frequency: 30; Scan Angle: 50

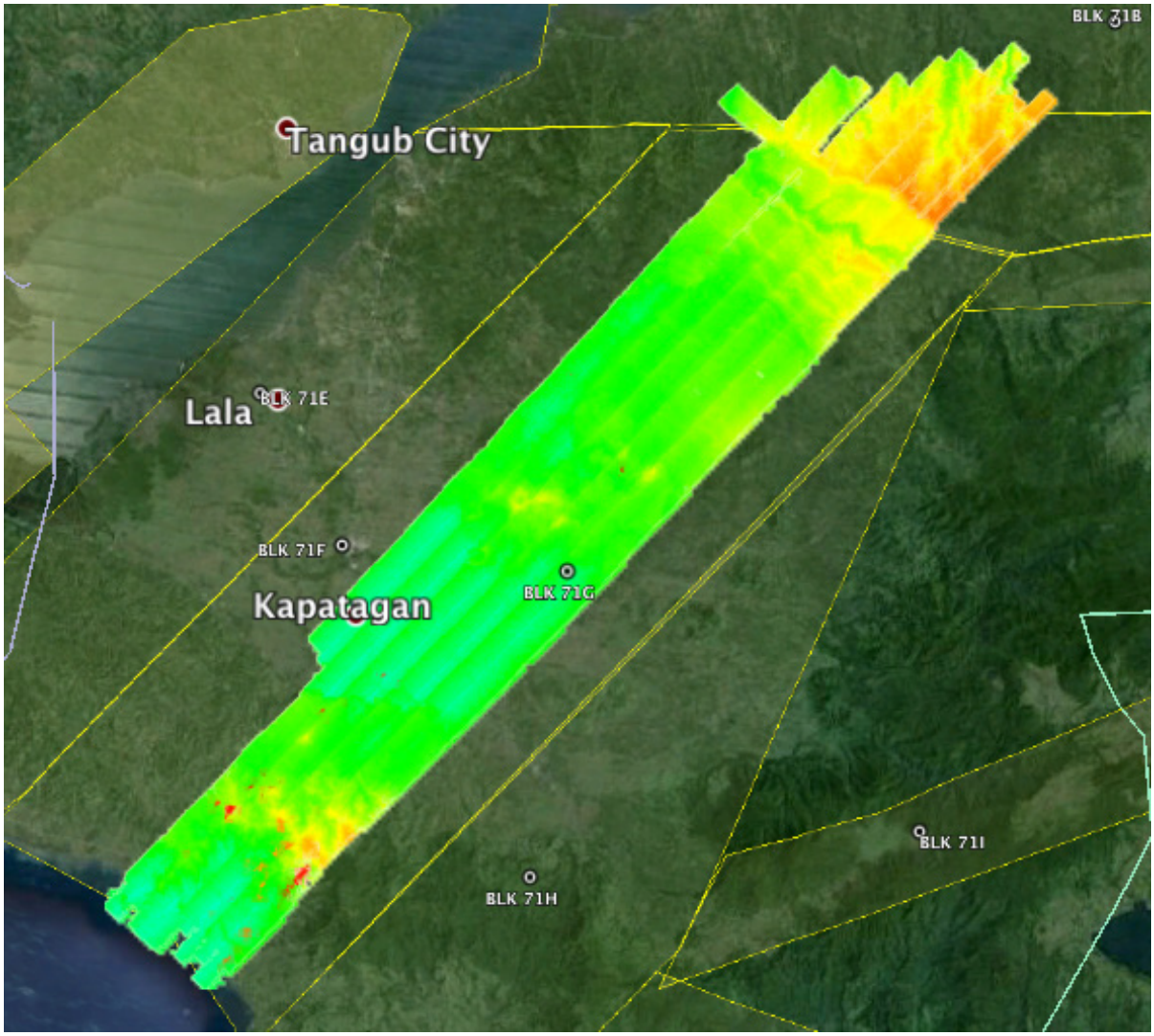


Figure A-7.3. Swath for Flight No. 1613P

Flight No. : 1665P
Area: BLK 71Es
Mission Name: 1BLK71ES184A
Parameters: Altitude: 1100m; Scan Frequency: 30; Scan Angle: 50

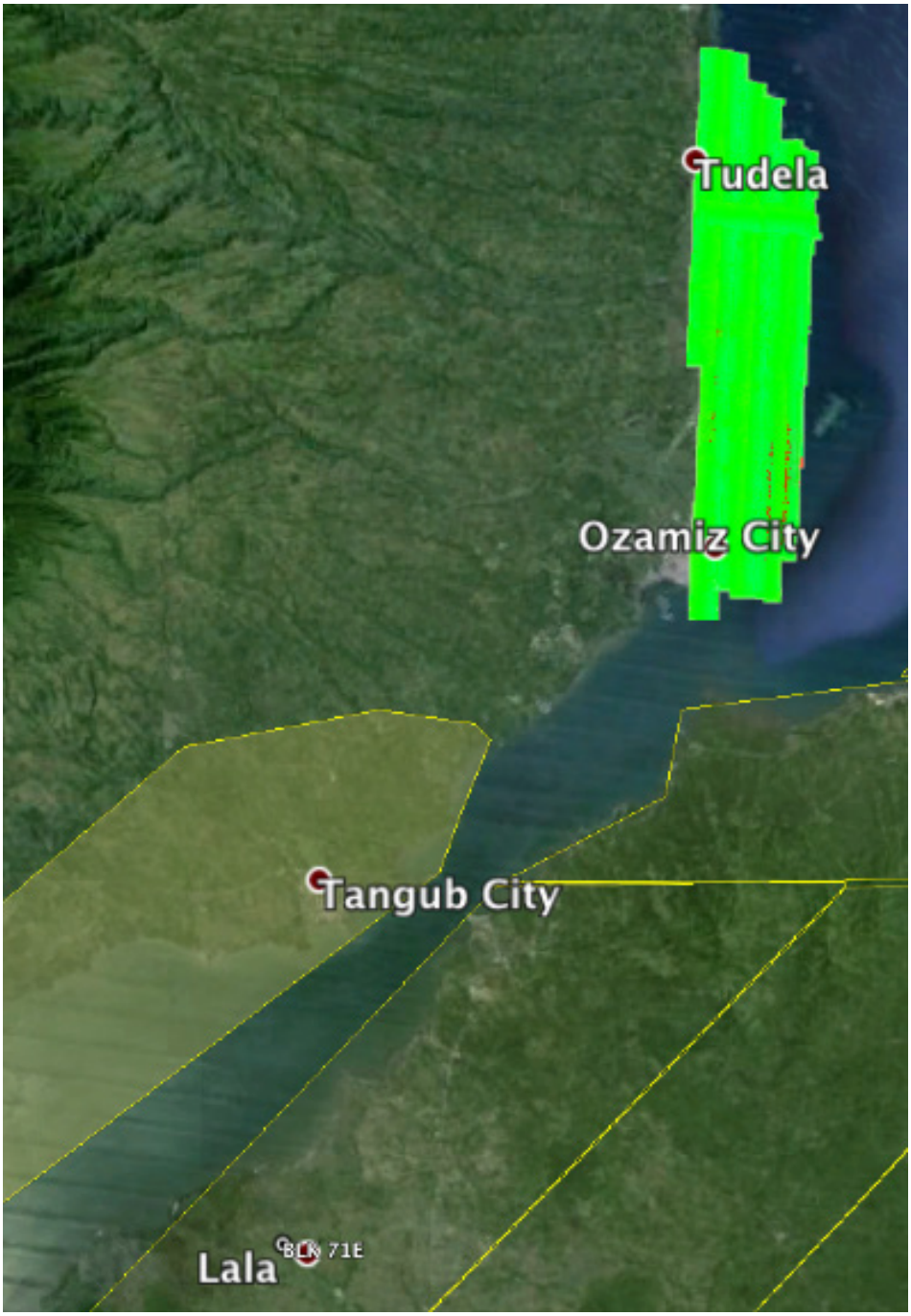


Figure A-7.4. Swath for Flight No. 1665P

Flight No. : 1673P
Area: BLK 71 ext
Mission Name: 1BLK71ES186A
Parameters: Altitude: 1000m; Scan Frequency: 30; Scan Angle: 50

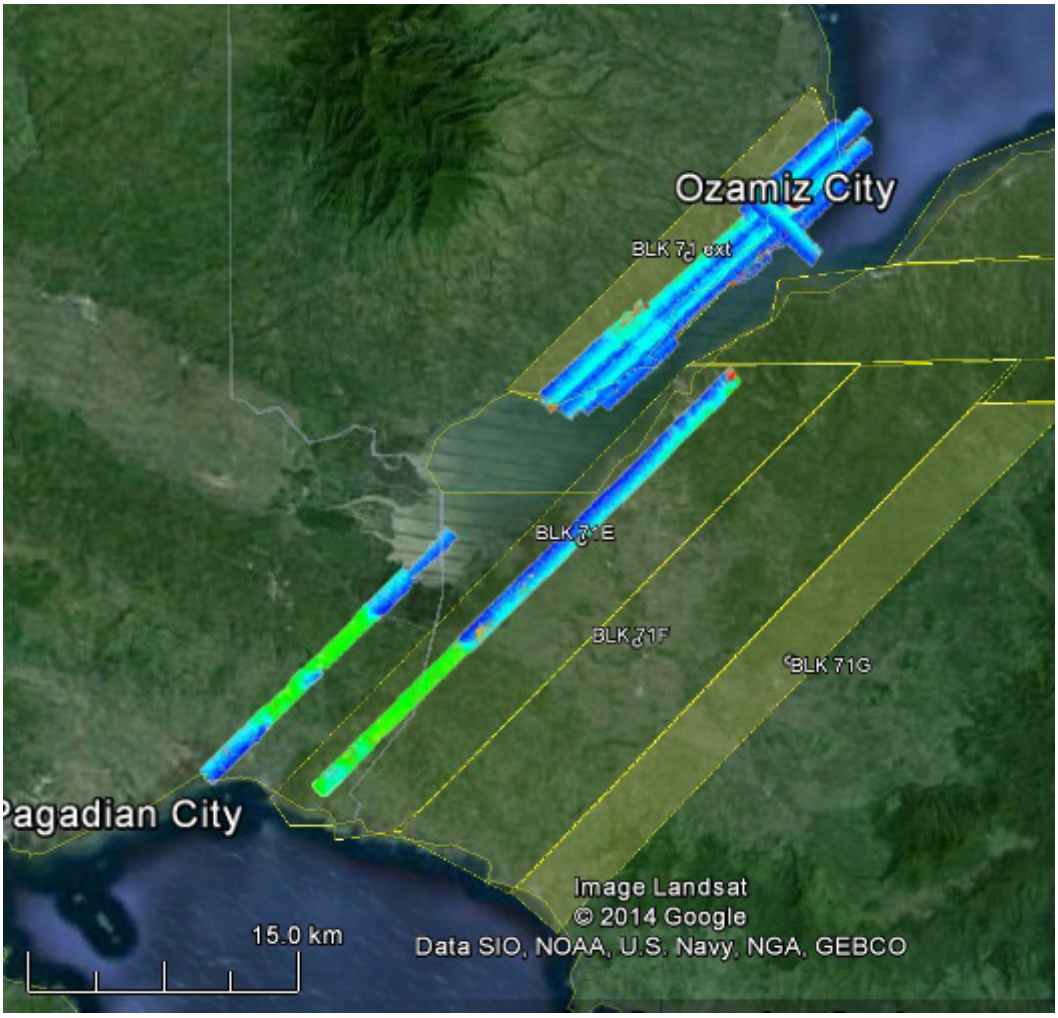


Figure A-7.5. Swath for Flight No. 1673P

Flight No. : 1677P
Area: BLK 71 ext
Mission Name: 1BLK71S187A
Parameters: Altitude: 1000m; Scan Frequency: 30; Scan Angle: 50

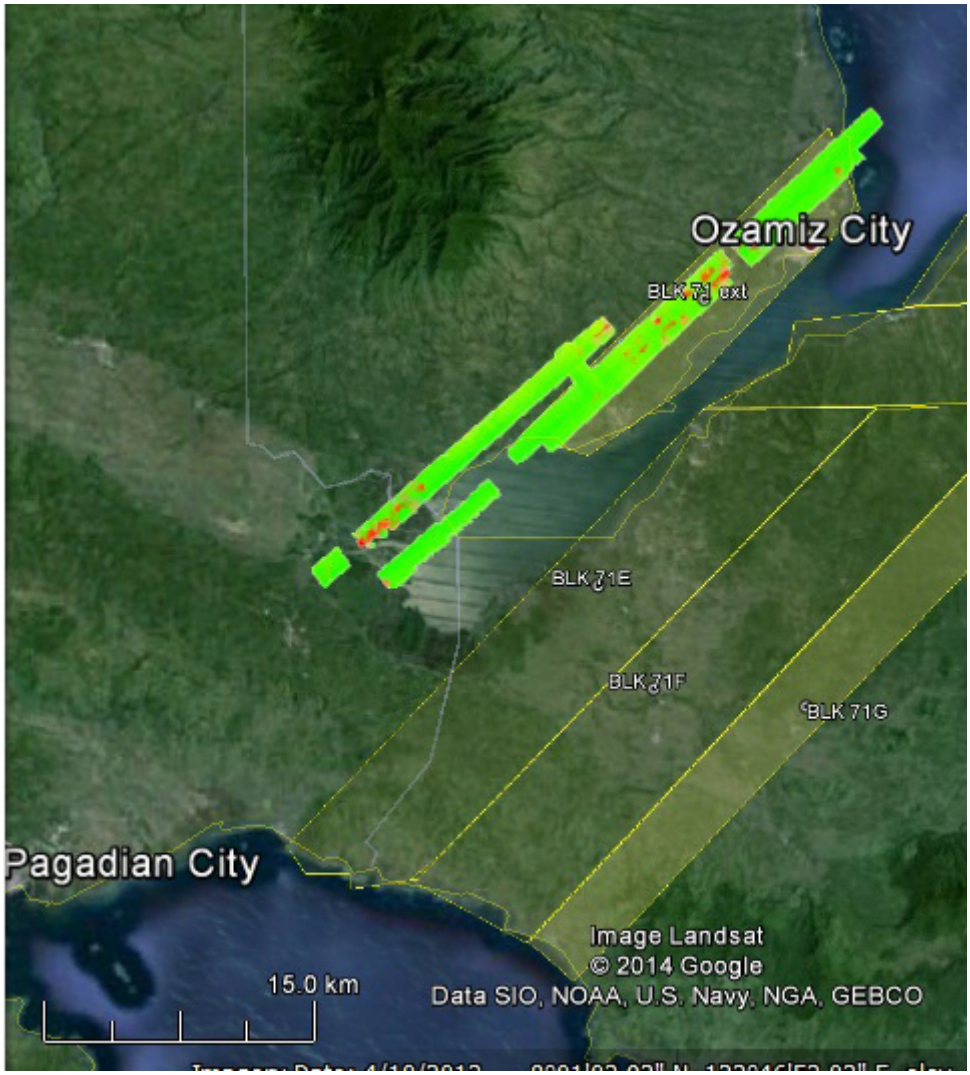


Figure A-7.6. Swath for Flight No. 1677P

Flight No. : 1685P
Area: BLK 71F
Mission Name: 1BLK71S189A
Parameters: Altitude: 1000m; Scan Frequency: 30; Scan Angle: 50

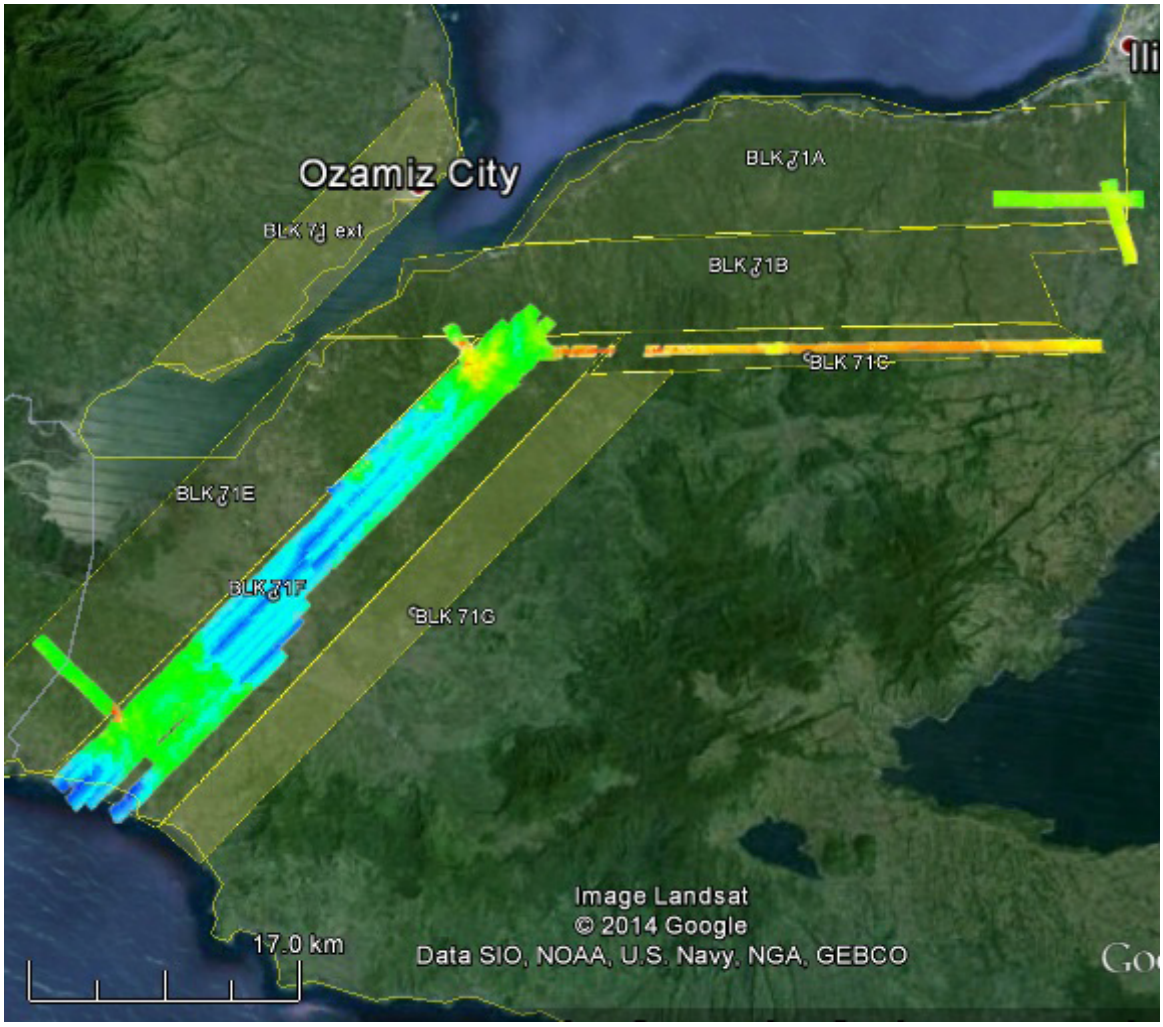


Figure A-7.7. Swath for Flight No. 1685P

Flight No. : 1689P
Area: BLK 71E and BLK 71ABCs
Mission Name: 1BLK71S190A
Parameters: Altitude: 1200m; Scan Frequency: 30; Scan Angle: 50

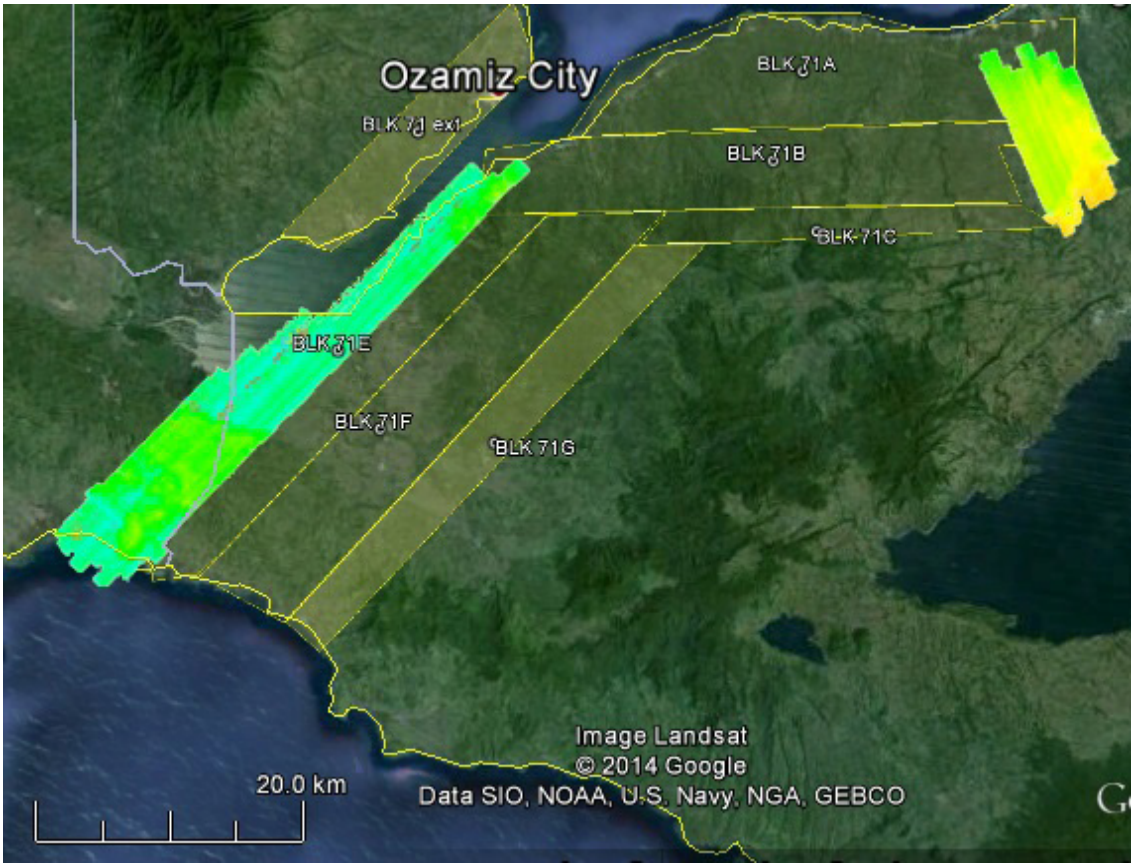


Figure A-7.8. Swath for Flight No. 1689P

Flight No. : 23084P
Area: BLK C,D,E,H,J,K,L
Mission Name: 1BLK76JKLCs043A
Parameters: Altitude: 1100m; Scan Frequency: 30; Scan Angle: 50

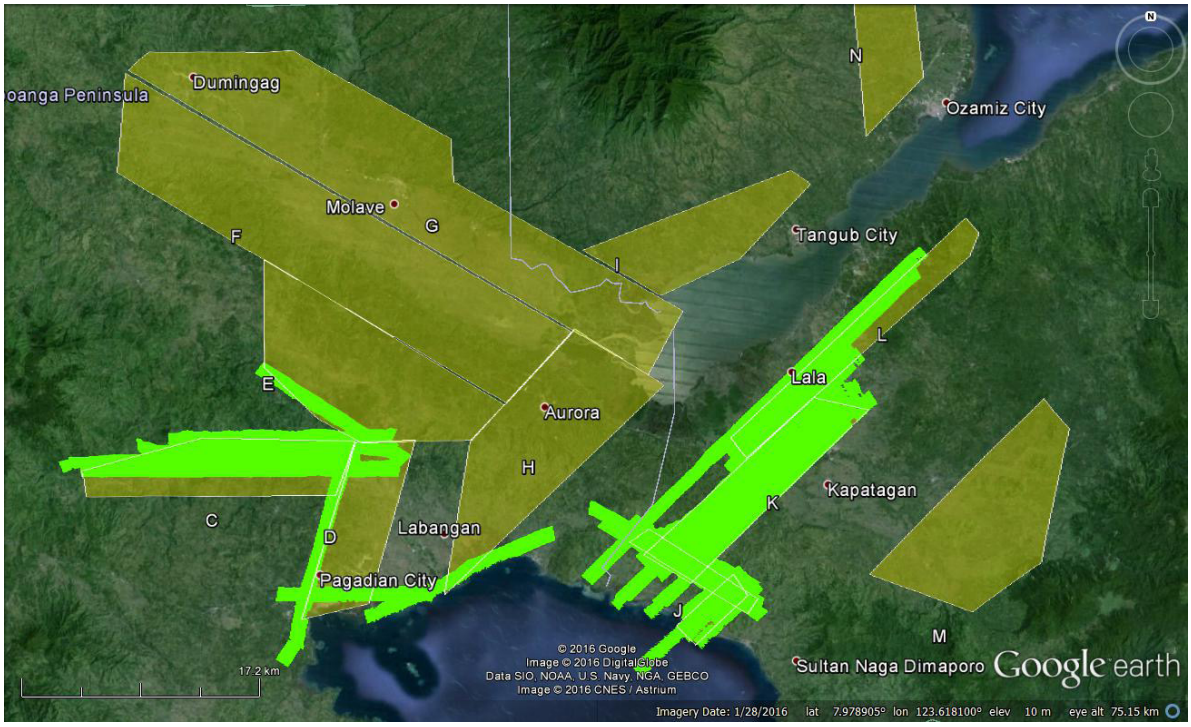


Figure A-7.9. Swath for Flight No. 23084P

Flight No. : 23088P
Area: BLK I,L,M
Mission Name: 1BLK7ILM044A
Parameters: Altitude: 1000-1200m; Scan Frequency: 30; Scan Angle: 50

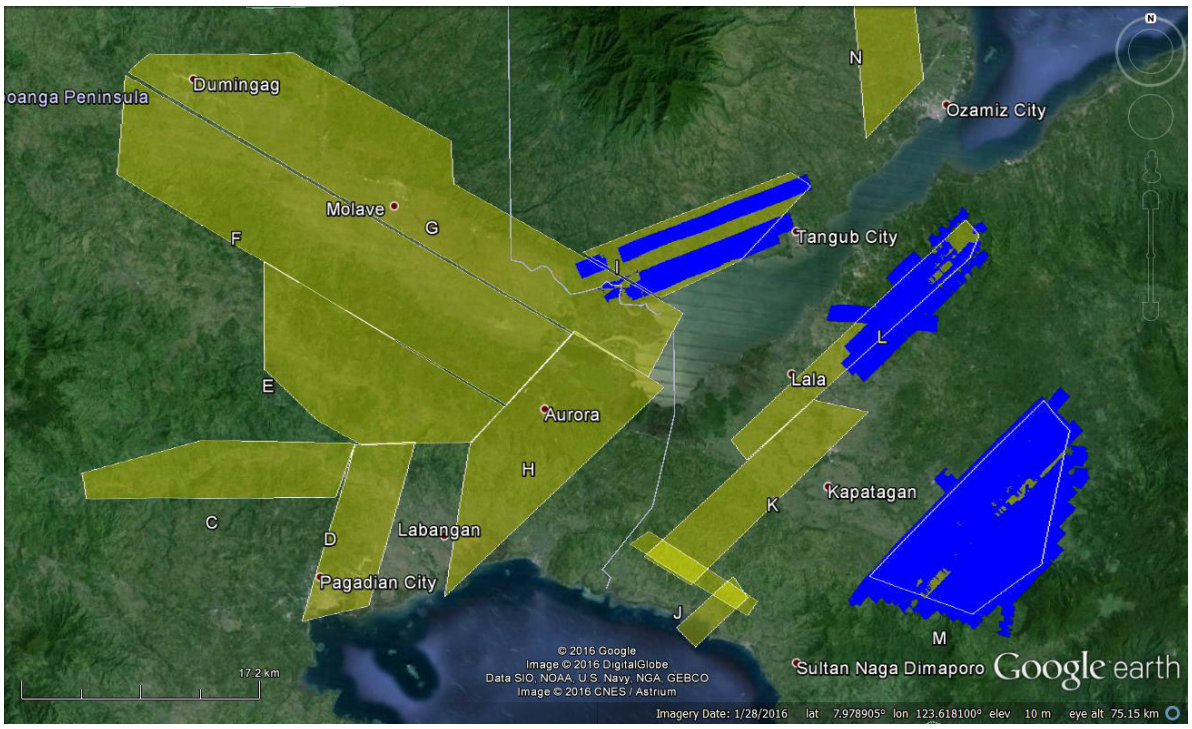


Figure A-7.10. Swath for Flight No. 23088P

Flight No. : 23104P
Area: BLK D,L,M
Mission Name: 1BLK76DLM048A
Parameters: Altitude: 1000m; Scan Frequency: 30; Scan Angle: 50

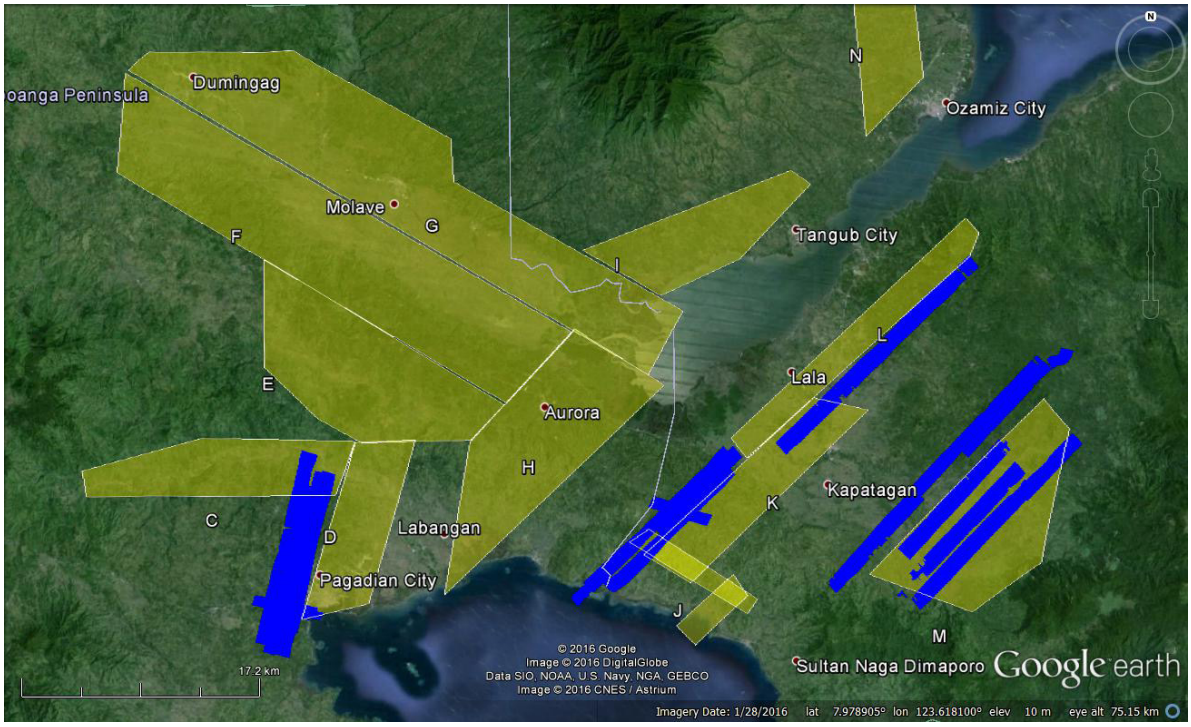


Figure A-7.11. Swath for Flight No. 23104P

Flight No. : 23128P
Area: BLK 70B, 71A
Mission Name: 1BLK70B054A
Parameters: Altitude: 1000m; Scan Frequency: 30; Scan Angle: 50

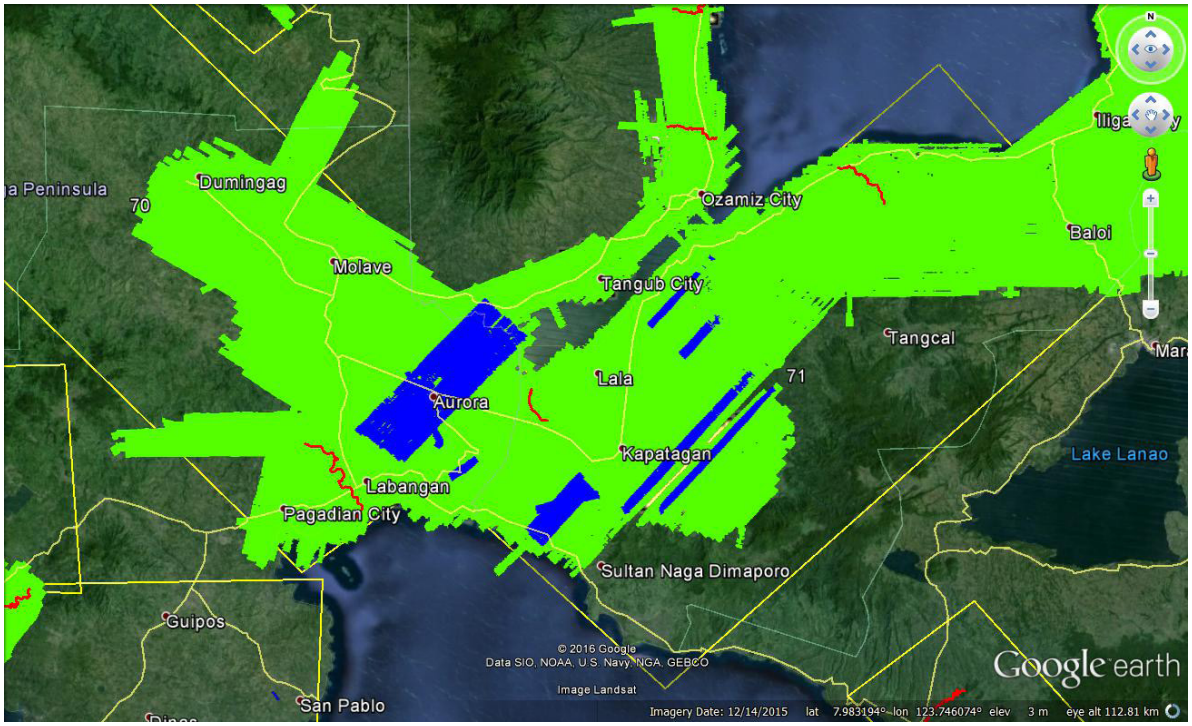


Figure A-7.12. Swath for Flight No. 23128P

Flight No. : 23602P
Area: KUMALARANG AND KAPATAGAN
Mission Name: 1BLK76AB336A
Parameters: Altitude: 1200m; Scan Frequency: 30; Scan Angle: 50

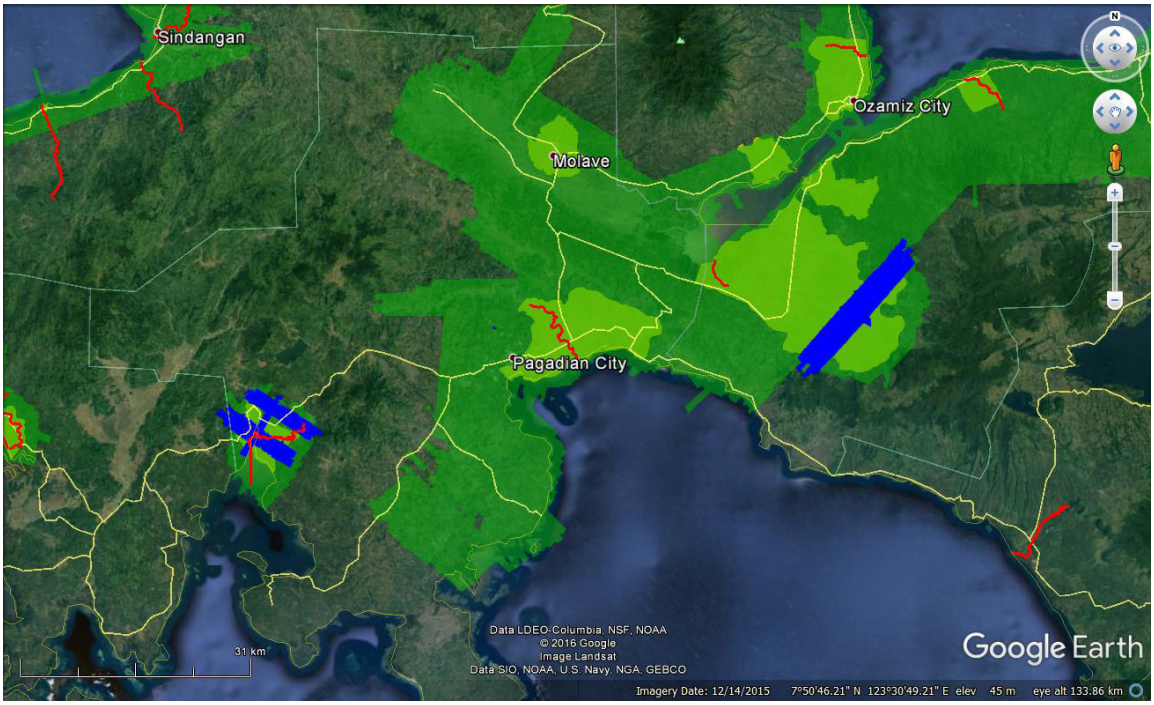


Figure A-7.13. Swath for Flight No. 23602P

Annex 8. Mission Summary Reports

Table A-8.1.Mission Summary Report for Mission 76J

Flight Area	Pagadian
Mission Name	**76J**
Inclusive Flights	23088P
Range data size	24.65
POS data size	283.62
Base data size	101.29
Image	n/a
Transfer date	March 01, 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)	1.3
RMSE for East Position (<4.0 cm)	1.4
RMSE for Down Position (<8.0 cm)	2.5
Boresight correction stdev (<0.001deg)	0.000281
IMU attitude correction stdev (<0.001deg)	0.000180
GPS position stdev (<0.01m)	0.0014
Minimum % overlap (>25)	27.90
Ave point cloud density per sq.m. (>2.0)	3.23
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	72
Maximum Height	698.51 m
Minimum Height	68.61 m
Classification (# of points)	
Ground	34,165,050
Low vegetation	19,594,241
Medium vegetation	28,178,750
High vegetation	95,242,866
Building	801,190
Orthophoto	Yes
Processed by	Engr. Regis Guhiting, Engr. Jovelle Canlas, Engr. Krisha Marie Bautista

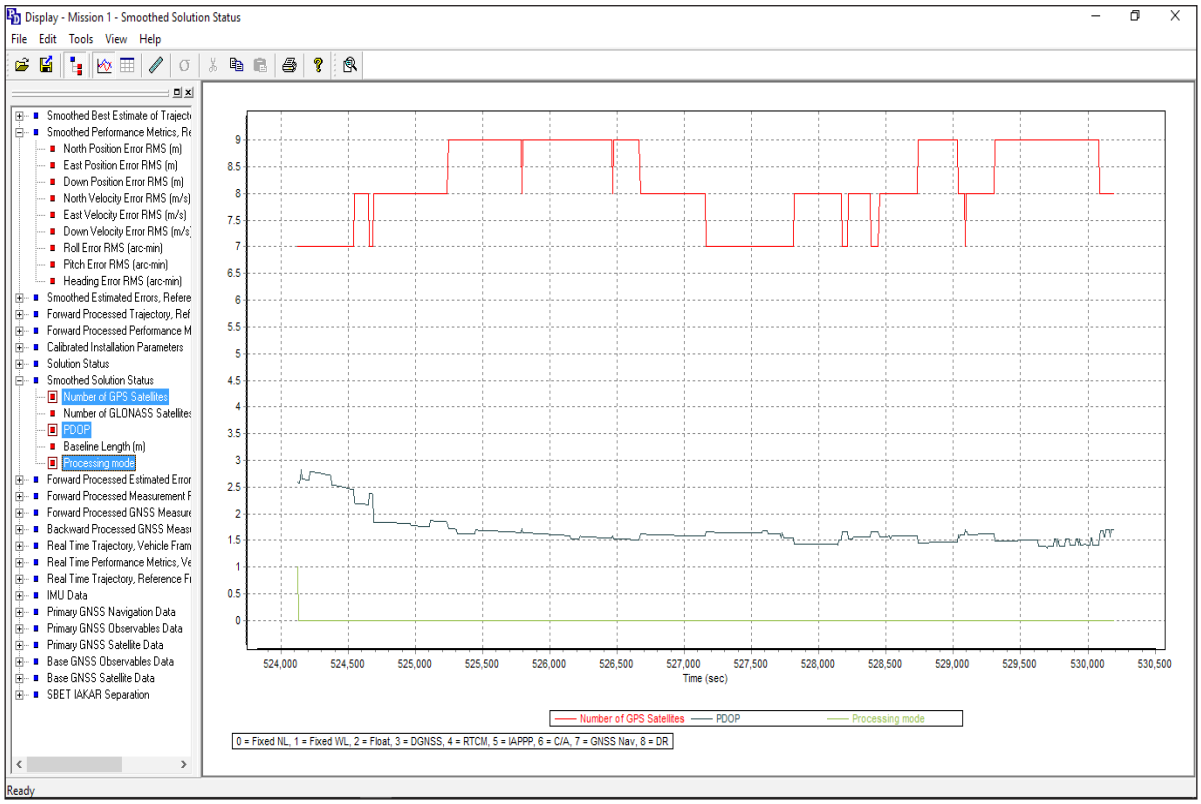


Figure A-8.1. Solution Status

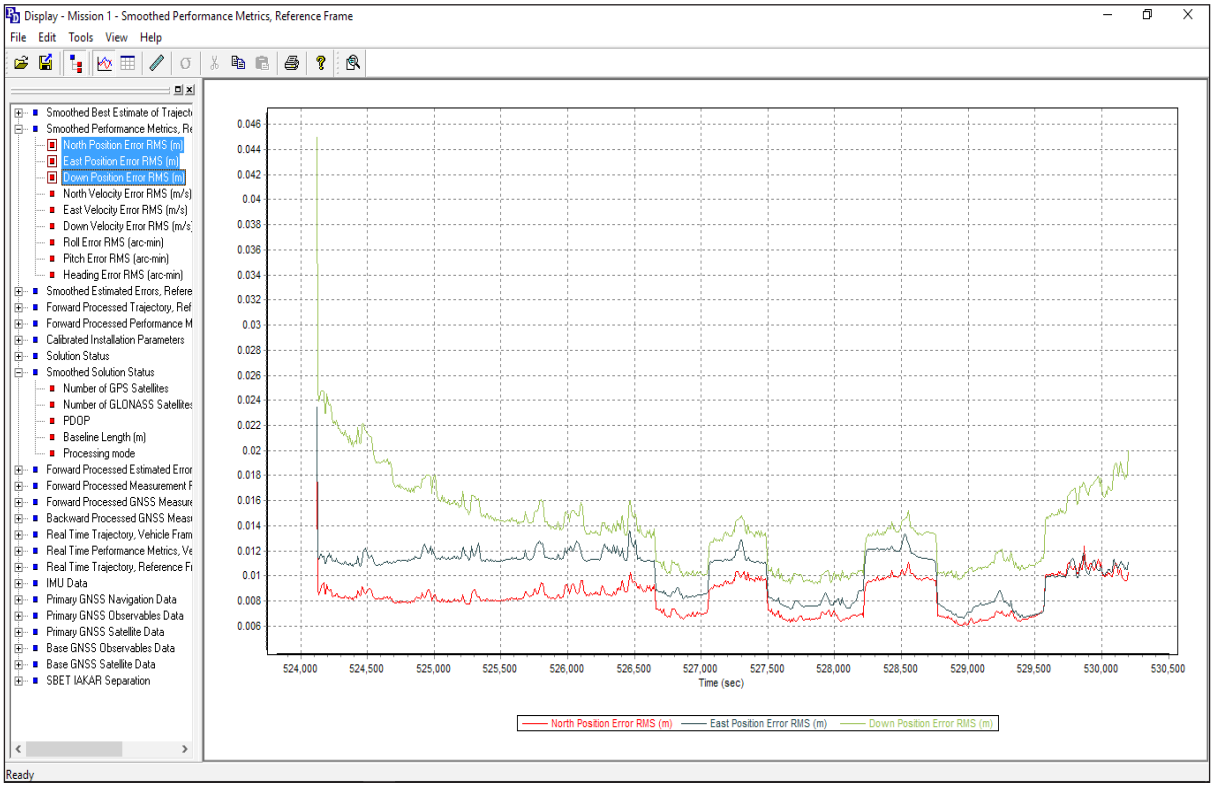


Figure A-8.2. Smoothed Performance Metric Parameters

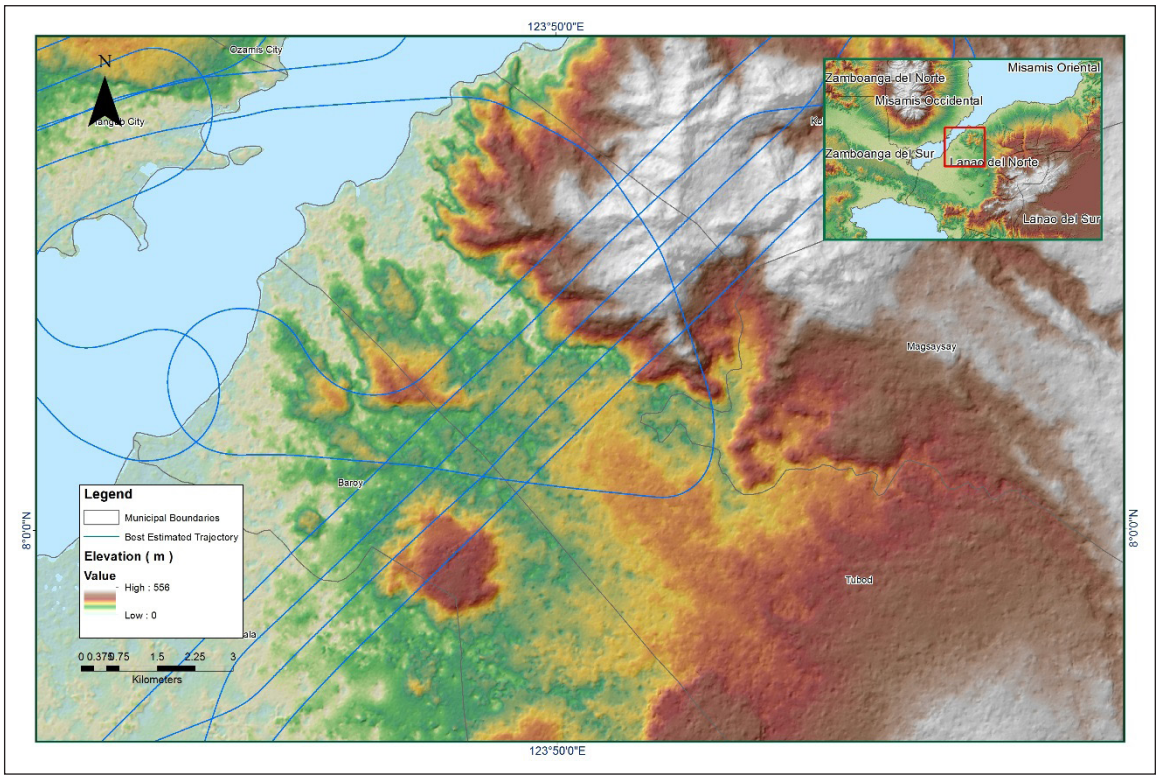


Figure A-8.3. Best Estimated Trajectory

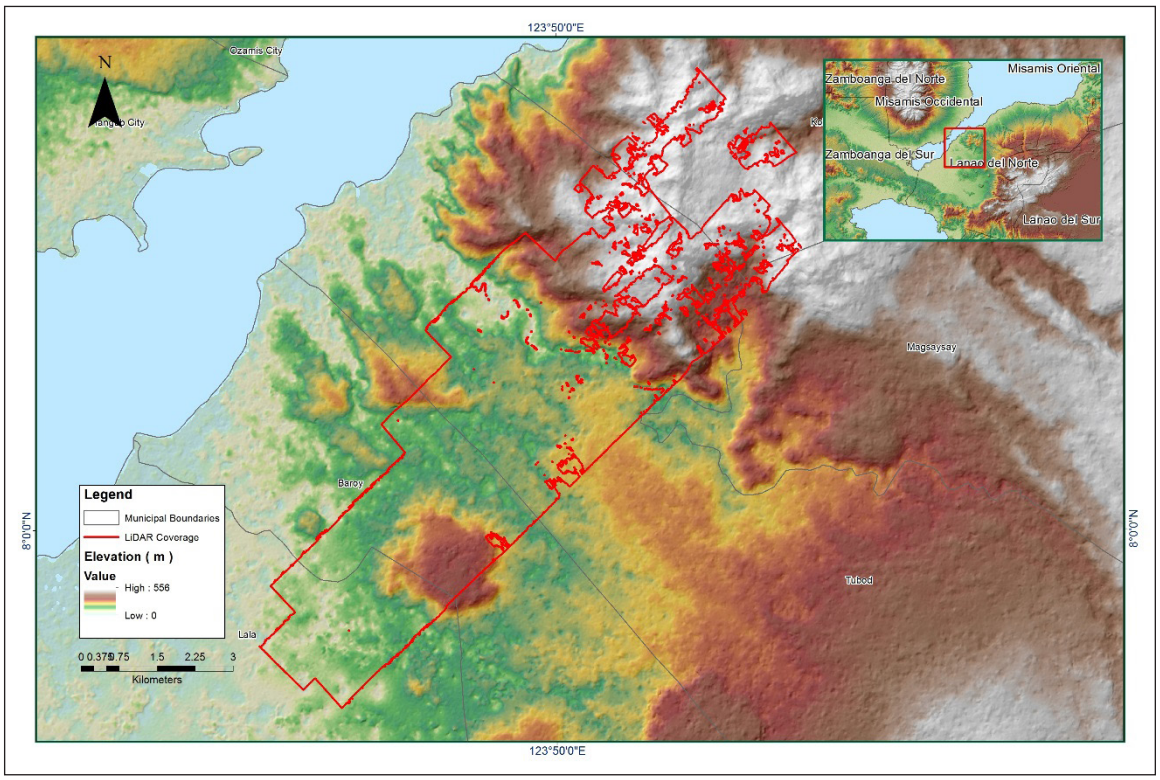


Figure A-8.4. Coverage of LiDAR Data

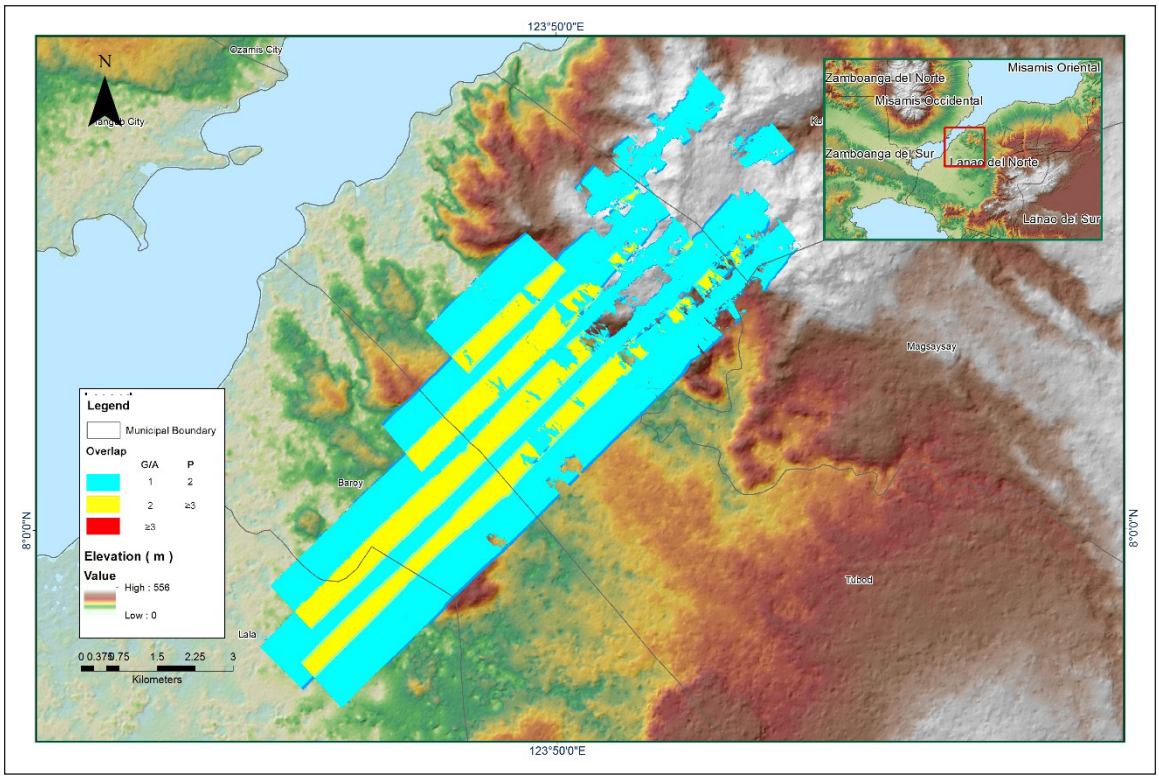


Figure A-8.5. Image of data overlap

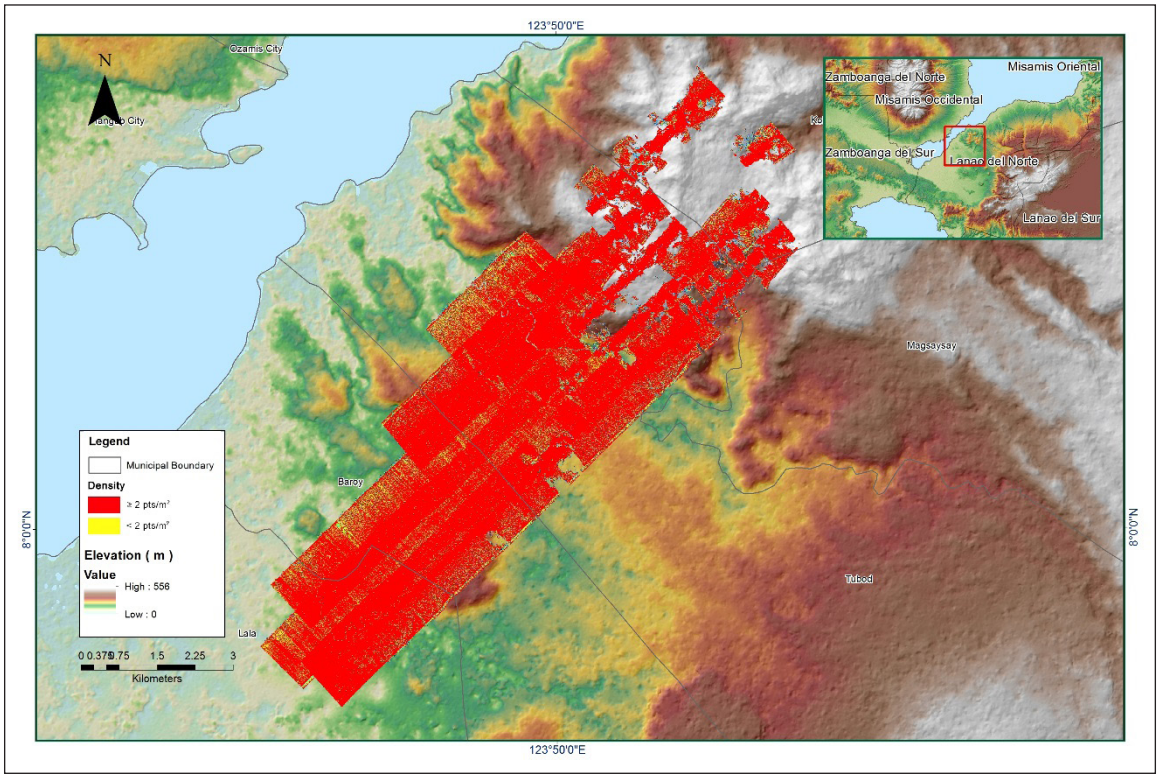


Figure A-8.6. Density map of merged LiDAR data

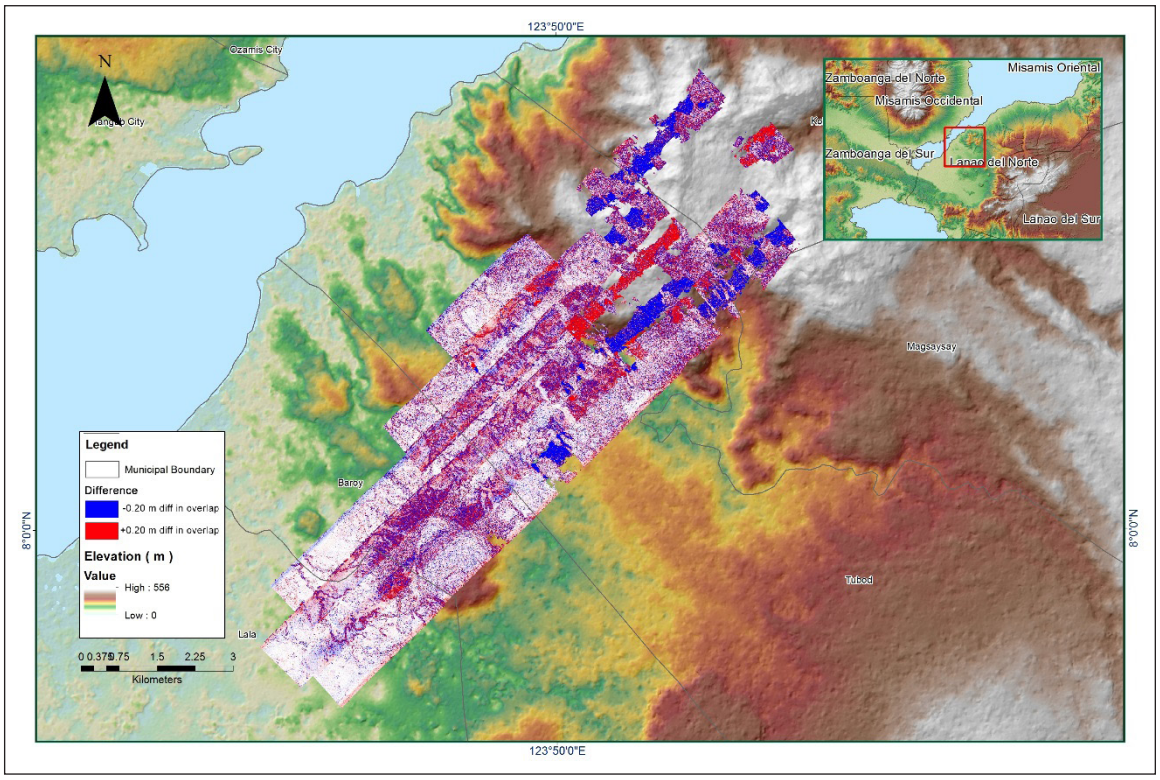


Figure A-8.7. Elevation difference between flight lines

Table A-8.2. Mission Summary Report for Mission 76K

Flight Area	Pagadian
Mission Name	**76K**
Inclusive Flights	23084P
Range data size	29.36
POS data size	276.9
Base data size	129.73
Image	n/a
Transfer date	March 01, 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)	1.3
RMSE for East Position (<4.0 cm)	1.8
RMSE for Down Position (<8.0 cm)	3.7
Boresight correction stdev (<0.001deg)	0.000134
IMU attitude correction stdev (<0.001deg)	0.000524
GPS position stdev (<0.01m)	0.0064
Minimum % overlap (>25)	39.61
Ave point cloud density per sq.m. (>2.0)	3.19
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	280
Maximum Height	475.01 m
Minimum Height	62.15 m
Classification (# of points)	
Ground	263,061,671
Low vegetation	186,080,376
Medium vegetation	173,663,045
High vegetation	1,062,882,246
Building	4,176,141
Orthophoto	Yes
Processed by	Engr. Kenneth Solidum, Engr. Justine Francisco, Maria Tamsyn Malabanan

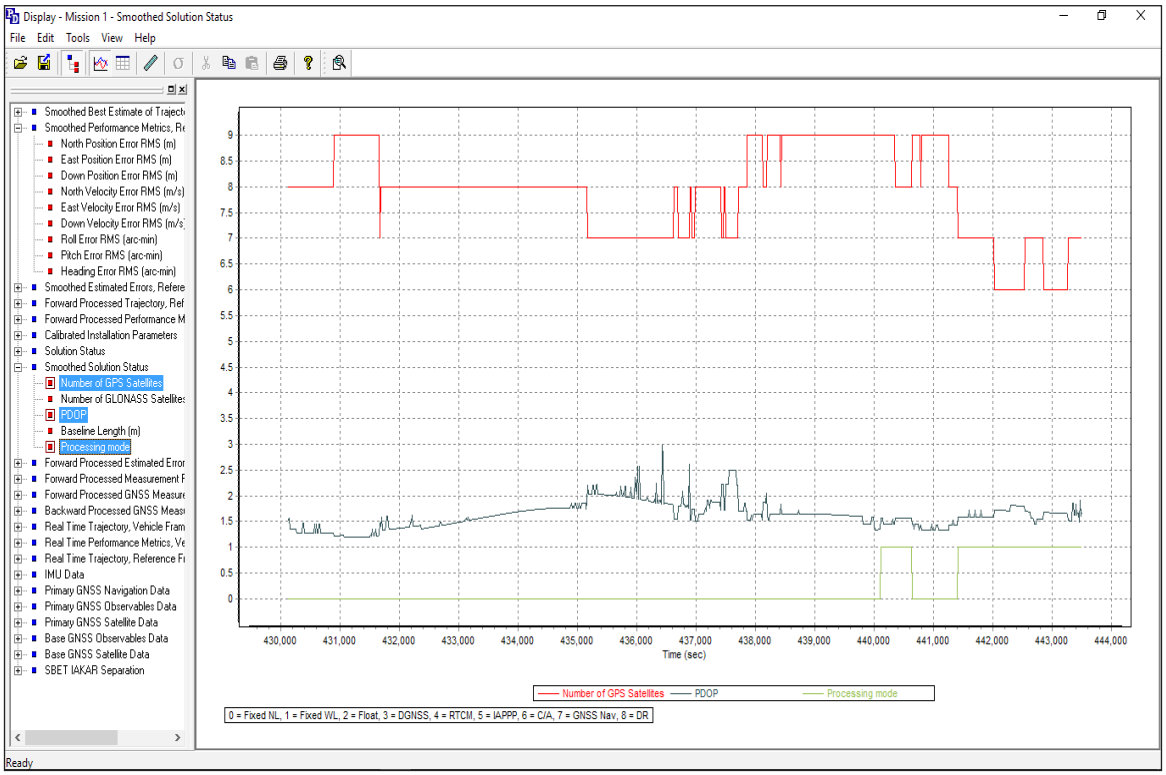


Figure A-8.8. Solution Status

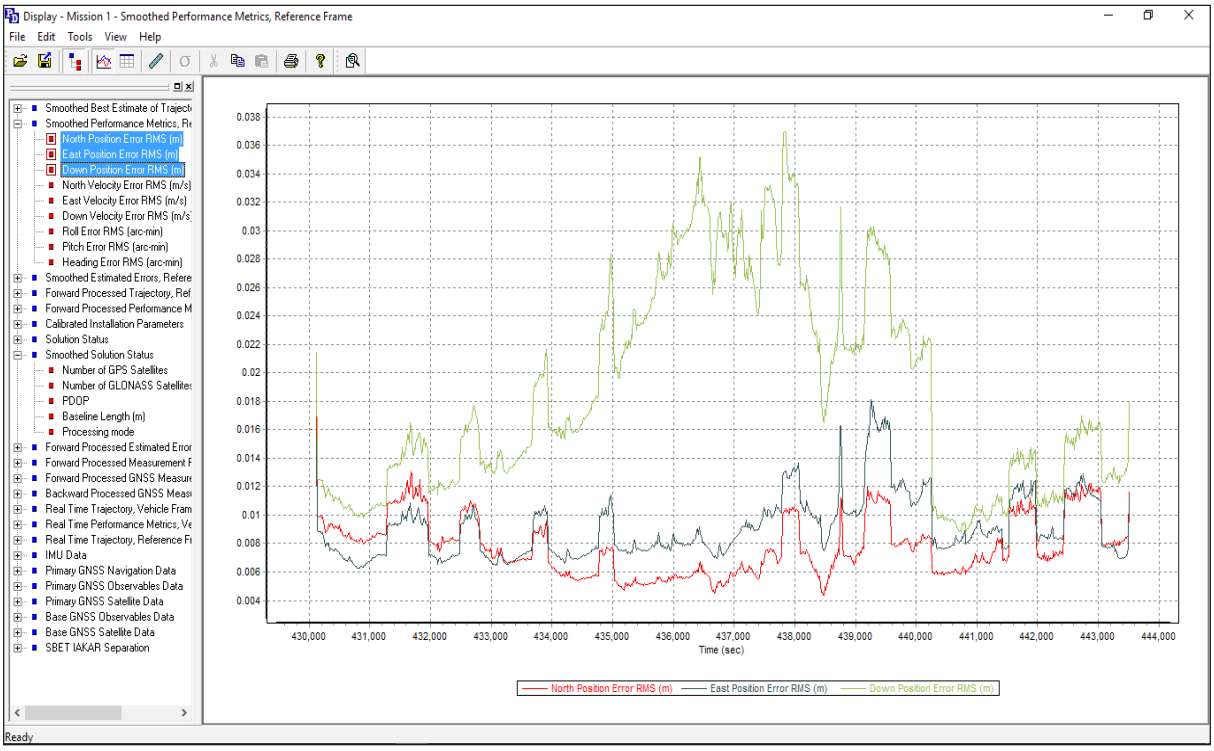


Figure A-8.9. Smoothed Performance Metric Parameters

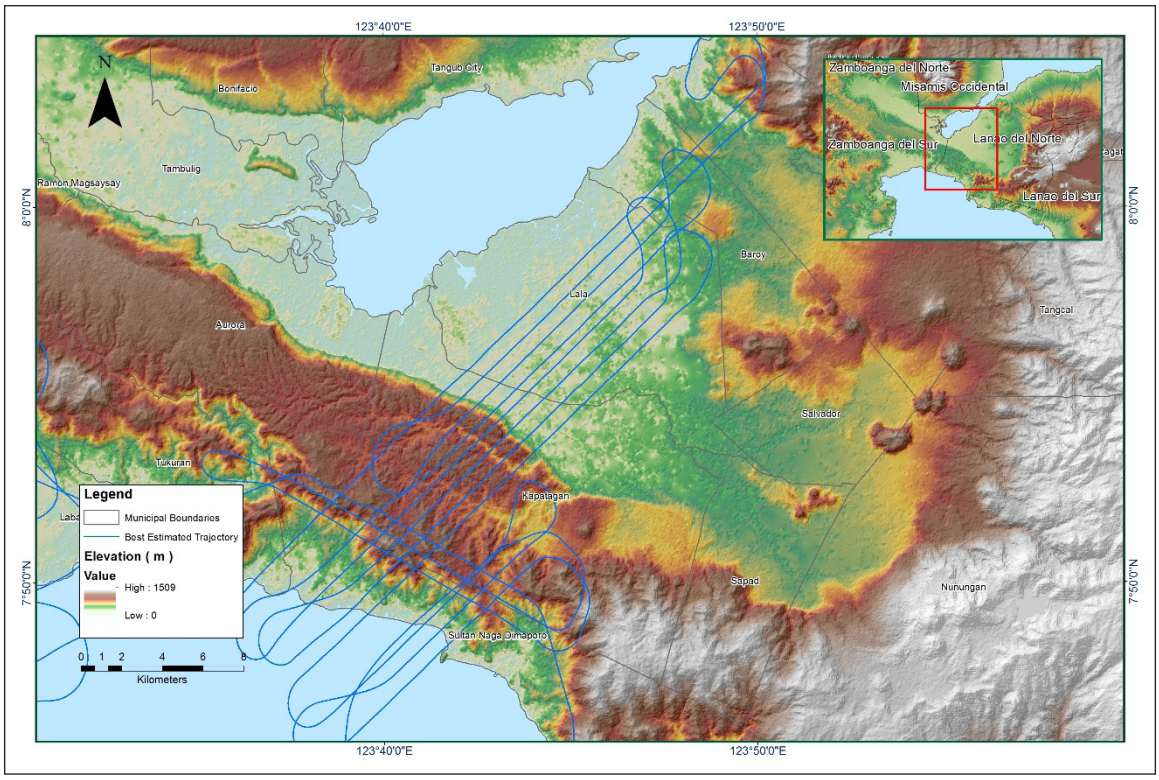


Figure A-8.10. Best Estimated Trajectory

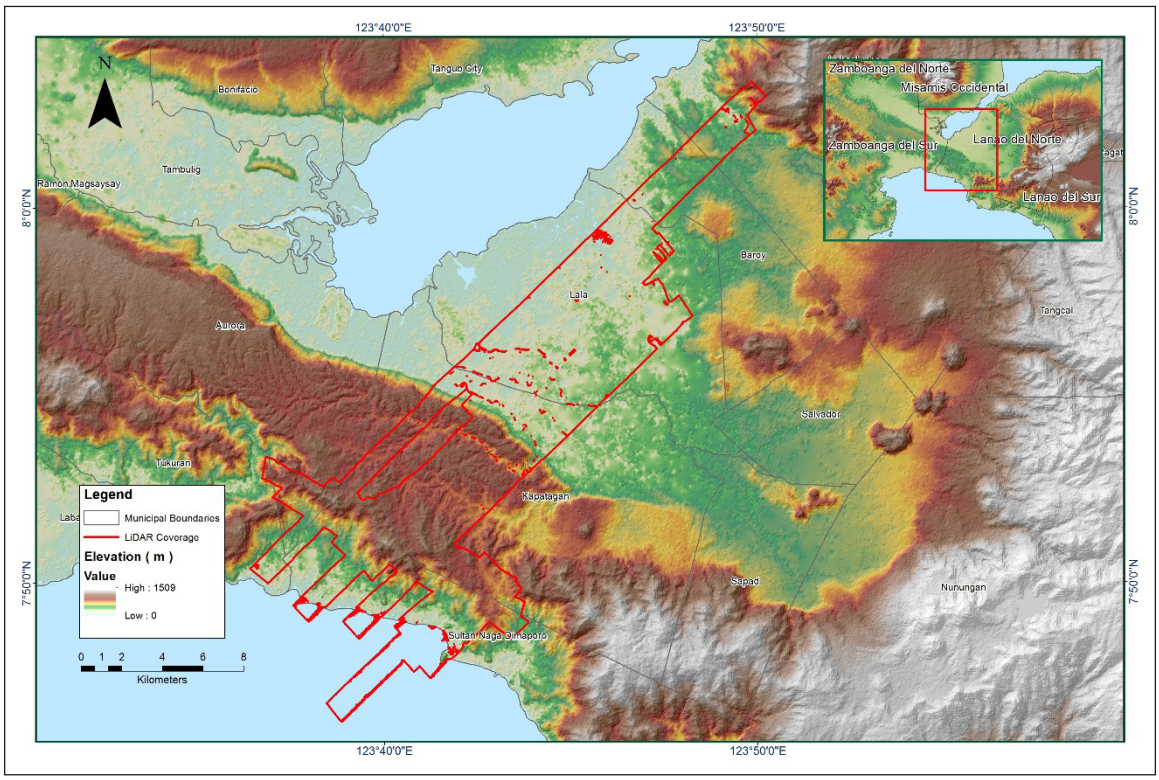


Figure A-8.11. Coverage of LiDAR Data

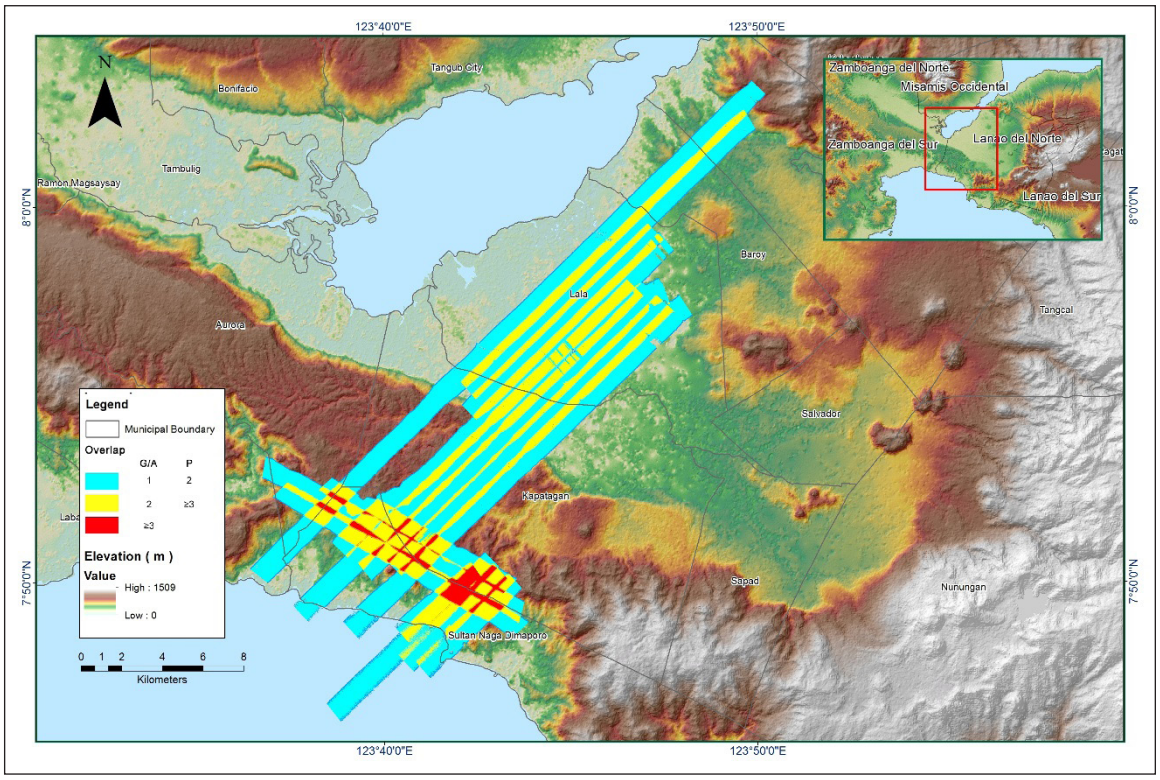


Figure A-8.12. Image of data overlap

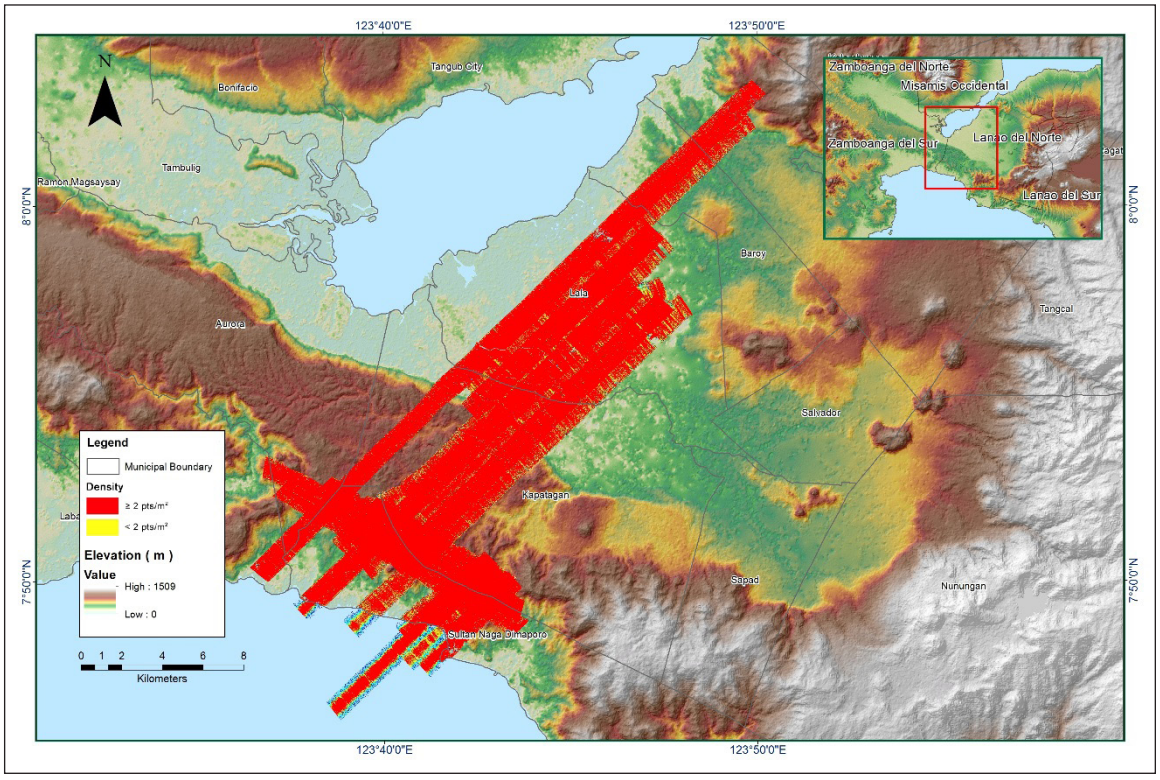


Figure A-8.13. Density map of merged LiDAR data

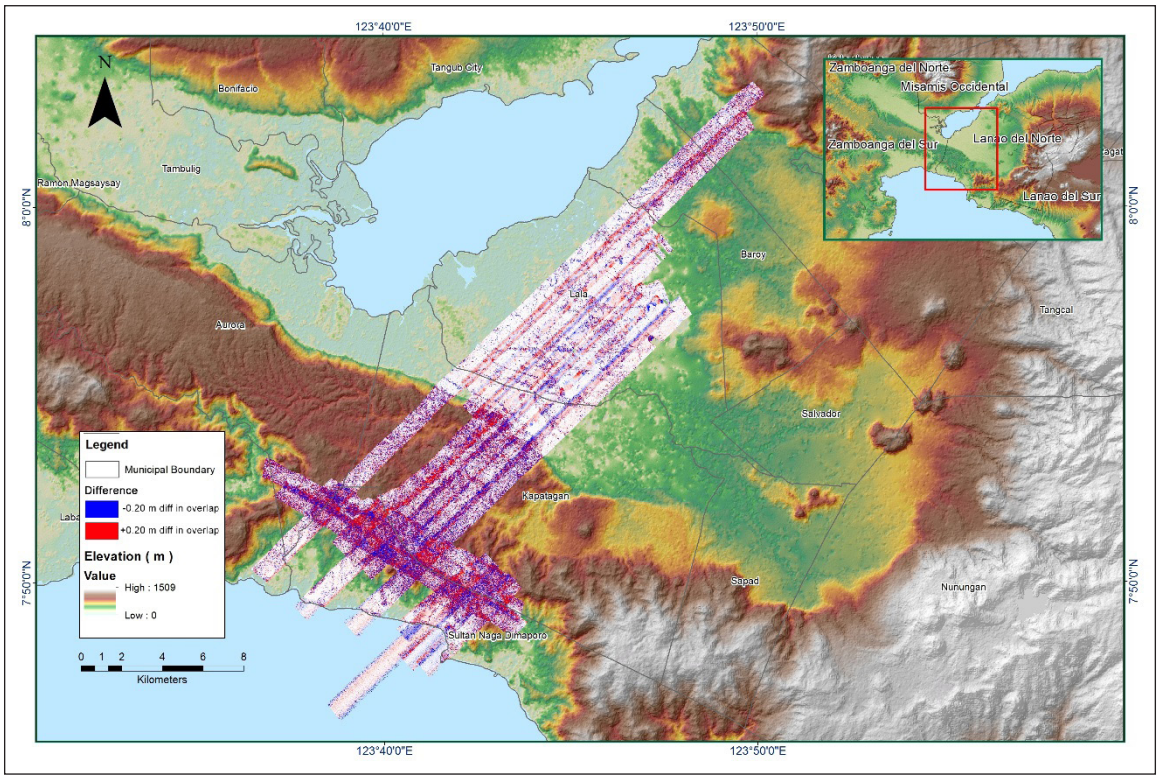


Figure A-8.14. Elevation difference between flight lines

Table A-8.3. Mission Summary Report for Mission 76K_Additional

Flight Area	Pagadian
Mission Name	**76K_Additional**
Inclusive Flights	23104P
Range data size	14.6
POS data size	202
Base data size	60.7
Image	n/a
Transfer date	March 16, 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)	1.8
RMSE for East Position (<4.0 cm)	2.2
RMSE for Down Position (<8.0 cm)	4.4
Boresight correction stdev (<0.001deg)	0.000102
IMU attitude correction stdev (<0.001deg)	N/A
GPS position stdev (<0.01m)	0.0014
Minimum % overlap (>25)	9.58
Ave point cloud density per sq.m. (>2.0)	2.85

Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	105
Maximum Height	416.26 m
Minimum Height	68.45 m
Classification (# of points)	
Ground	64,960,783
Low vegetation	36,364,032
Medium vegetation	44,325,454
High vegetation	121,969,533
Building	1,432,563
Orthophoto	Yes
Processed by	Engr. Don Matthew Banatin, Engr. Melanie Hingpit, Engr. Karl Adrian Vergara

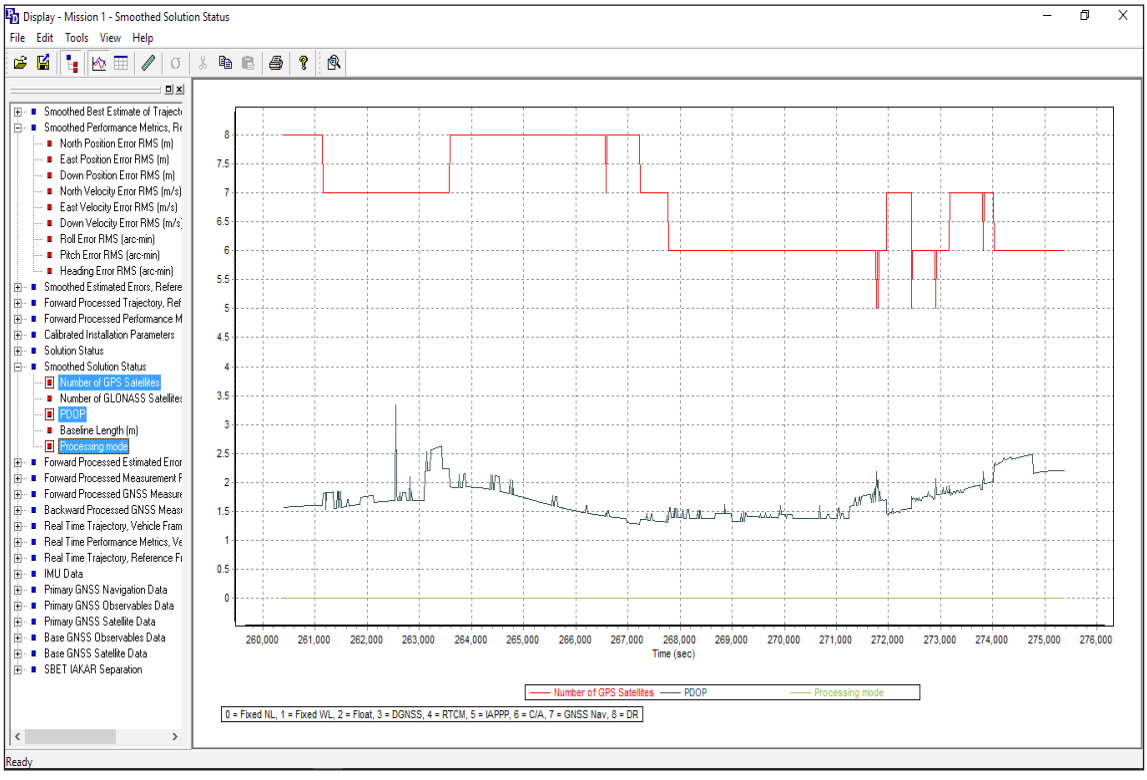


Figure A-8.15. Solution Status

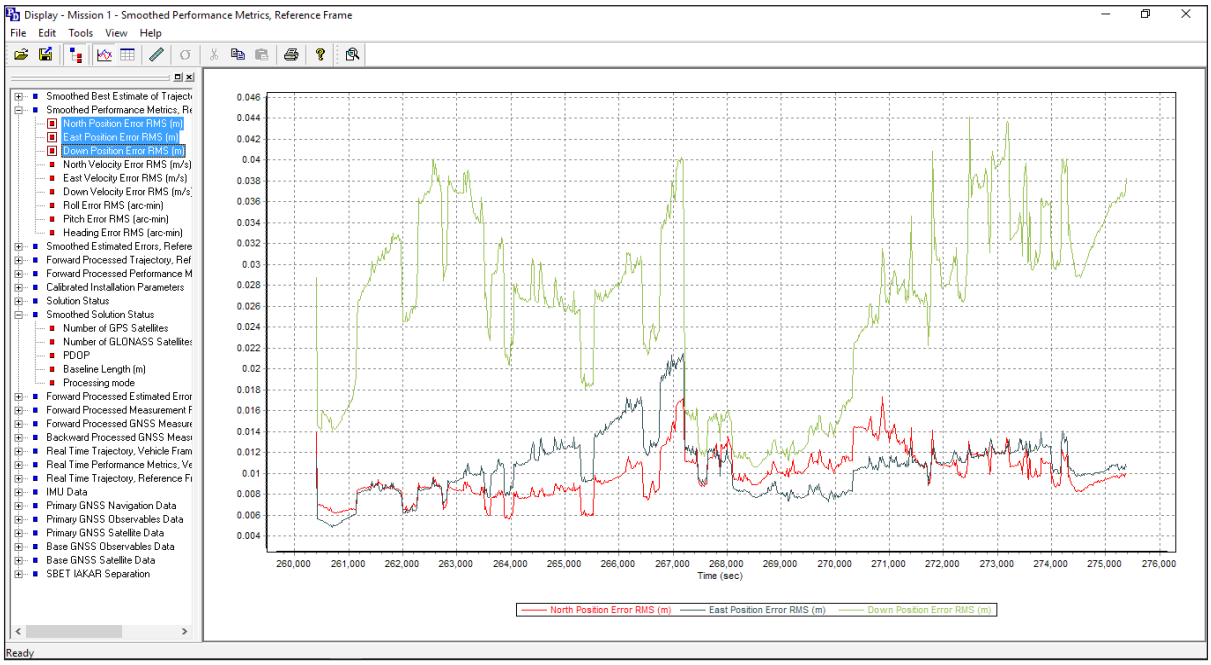


Figure A-8.16. Smoothed Performance Metric Parameters

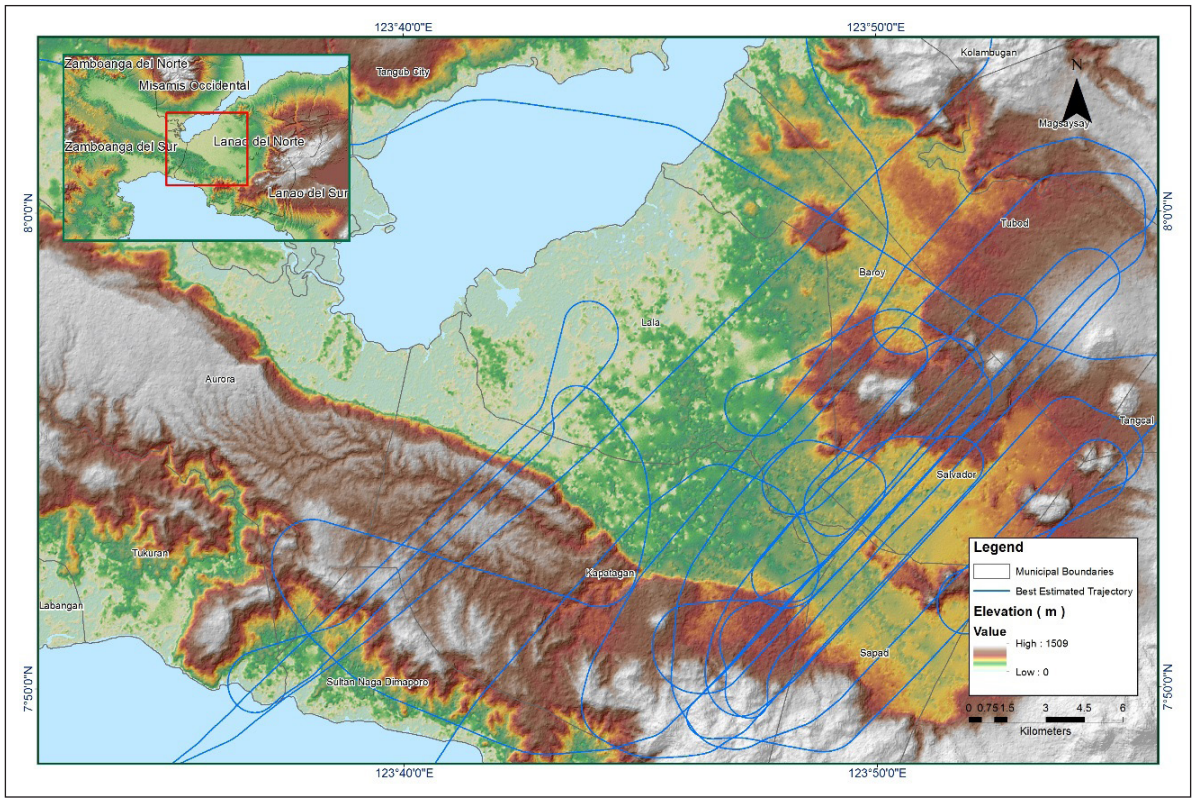


Figure A-8.17. Best Estimated Trajectory

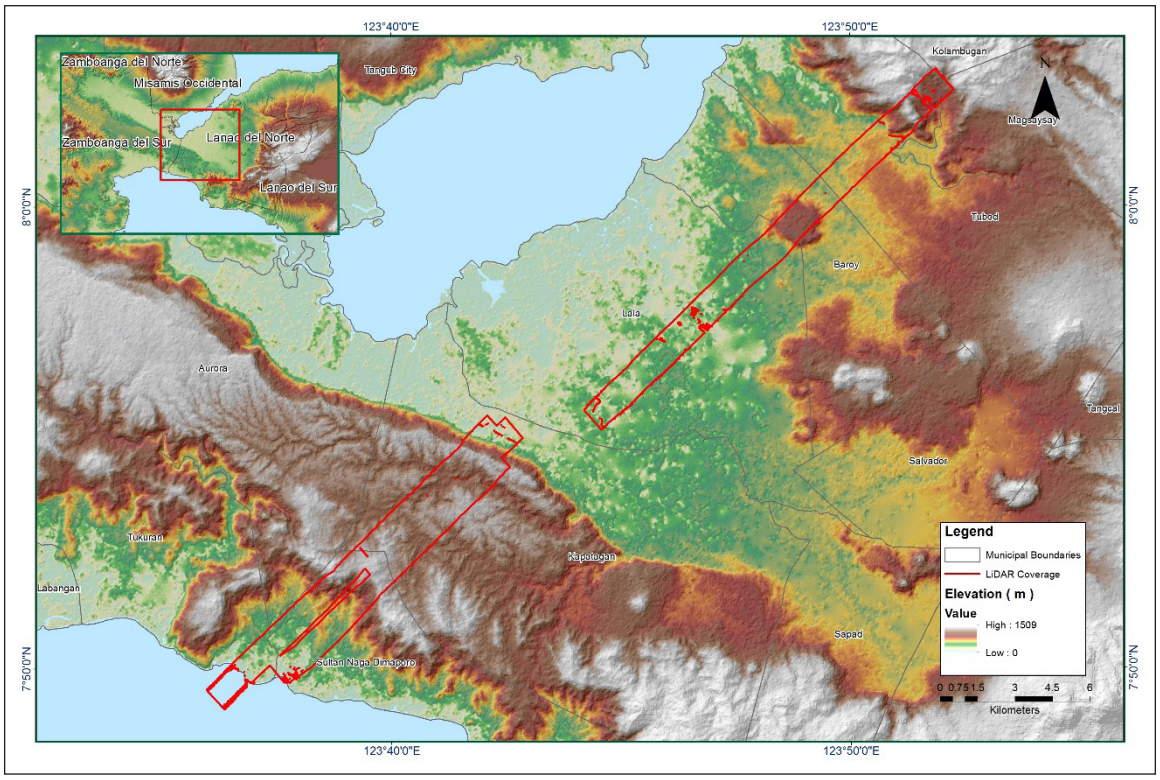


Figure A-8.18. Coverage of LiDAR Data

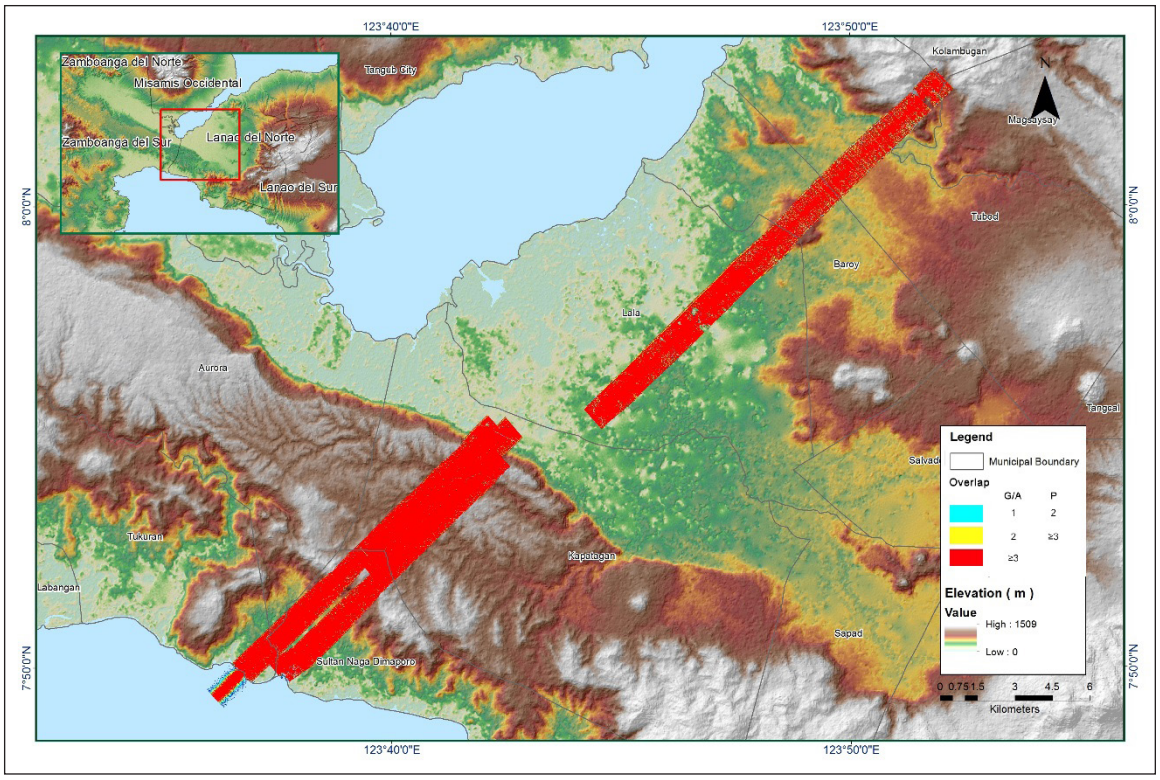


Figure A-8.19. Image of data overlap

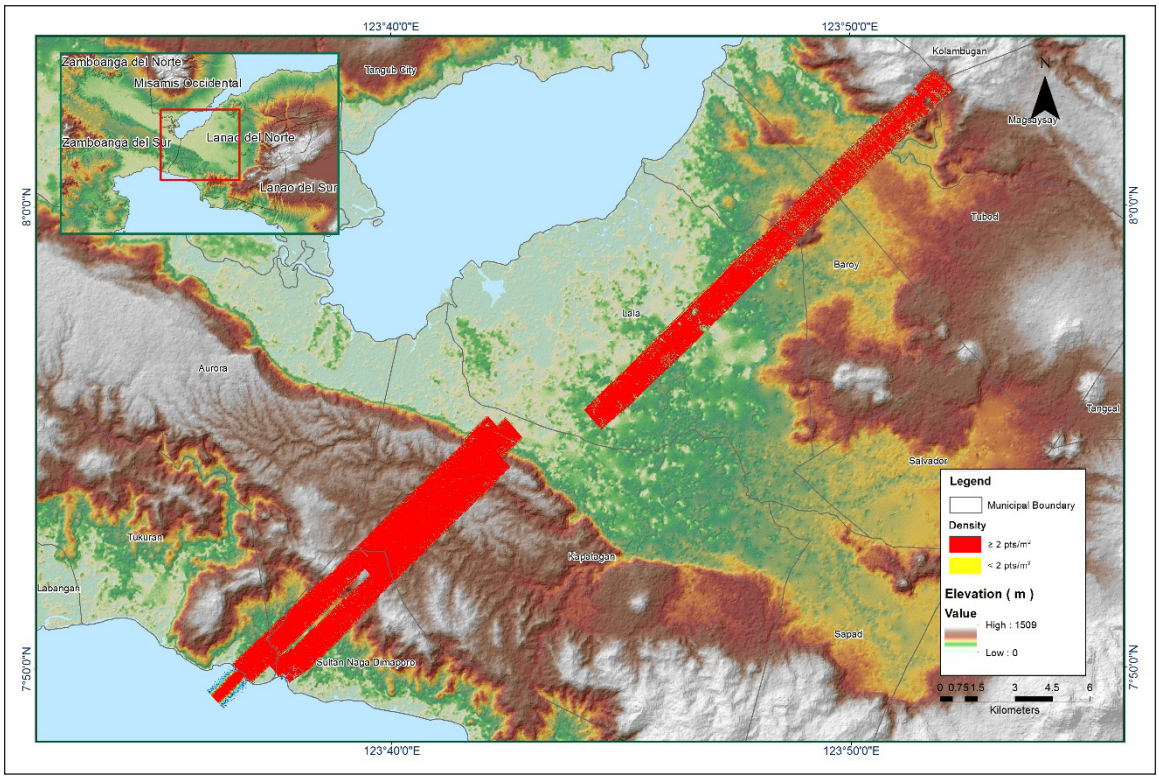


Figure A-8.20. Density map of merged LiDAR data

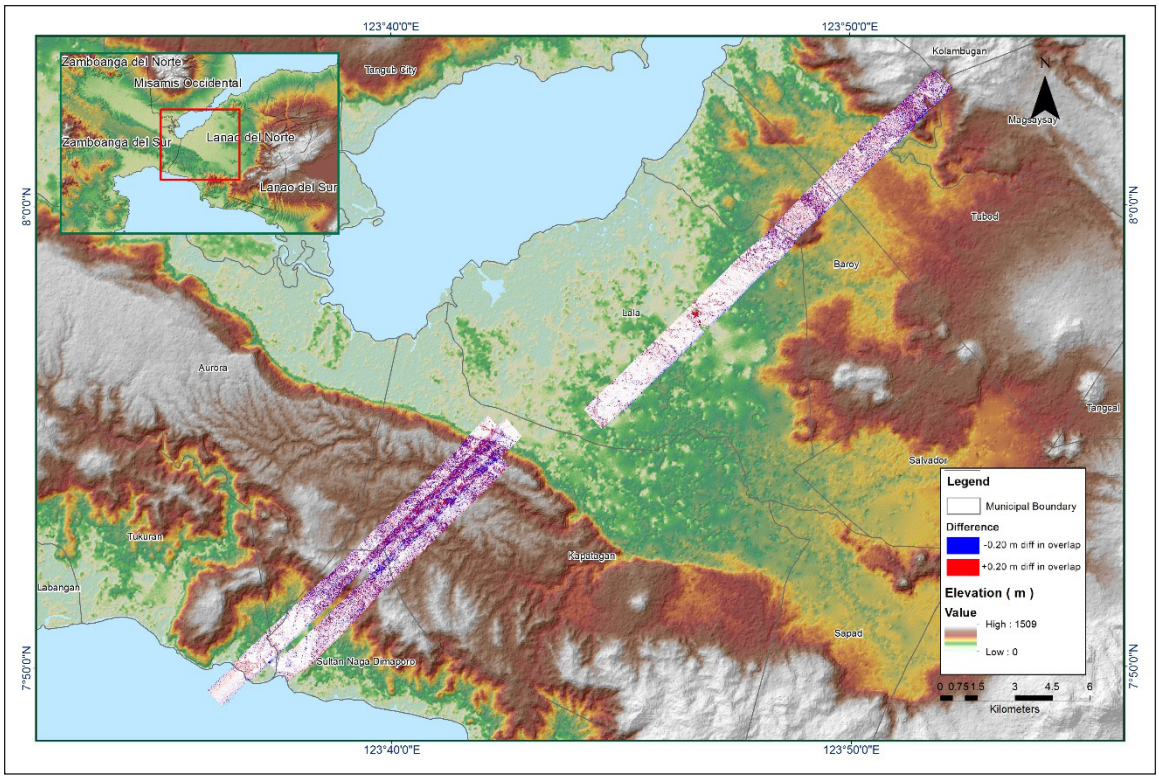


Figure A-8.21. Elevation difference between flight lines

Table A-8.4. Mission Summary Report for Mission 76M

Flight Area	Pagadian
Mission Name	**76M**
Inclusive Flights	23128P
Range data size	23.30 GB
POS data size	273 MB
Base data size	311 MB
Image	n/a
Transfer date	March 10, 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)	1.4
RMSE for East Position (<4.0 cm)	1.9
RMSE for Down Position (<8.0 cm)	4.1
Boresight correction stdev (<0.001deg)	0.000128
IMU attitude correction stdev (<0.001deg)	0.000139
GPS position stdev (<0.01m)	0.0122
Minimum % overlap (>25)	14.01
Ave point cloud density per sq.m. (>2.0)	3.32
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	173
Maximum Height	503.88 m
Minimum Height	67.66 m
Classification (# of points)	
Ground	100,531,253
Low vegetation	60,833,381
Medium vegetation	70,336,602
High vegetation	177,937,163
Building	1,895,317
Orthophoto	No
Processed by	Engr. Jennifer Saguran, Aljon Rei Araneta, Maria Tamsyn Malabanan

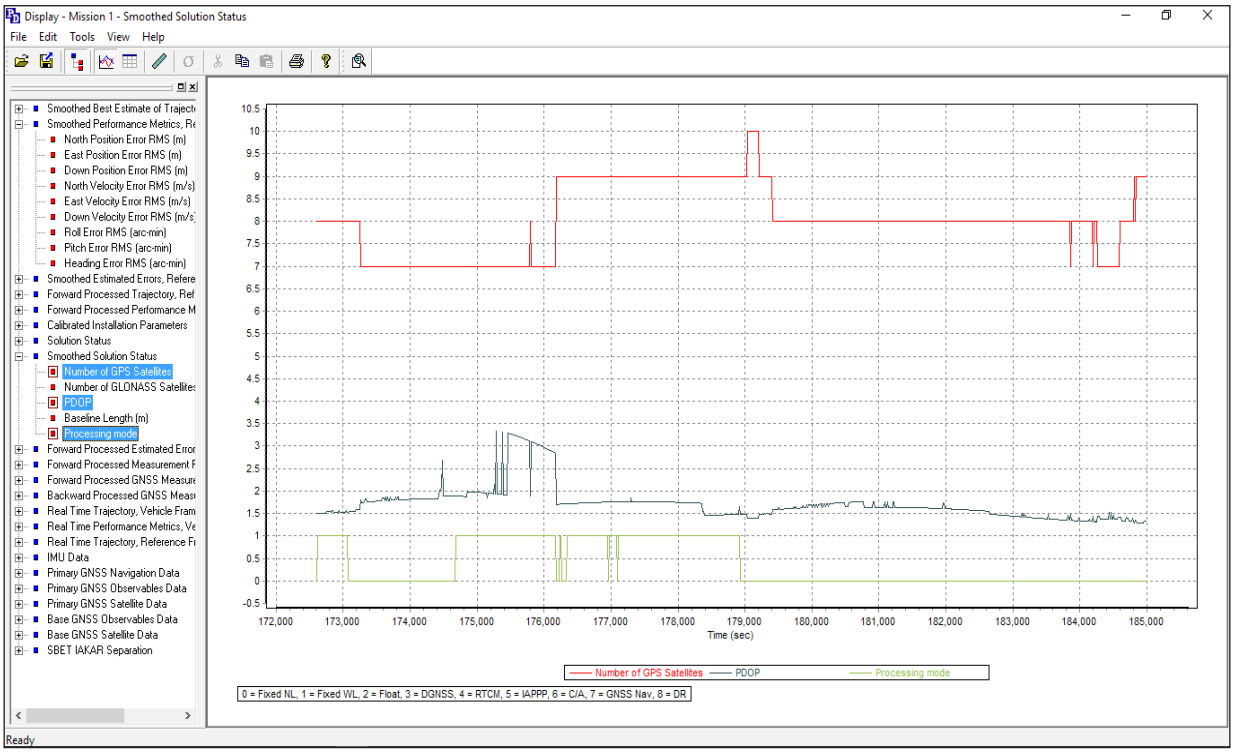


Figure A-8.22. Solution Status

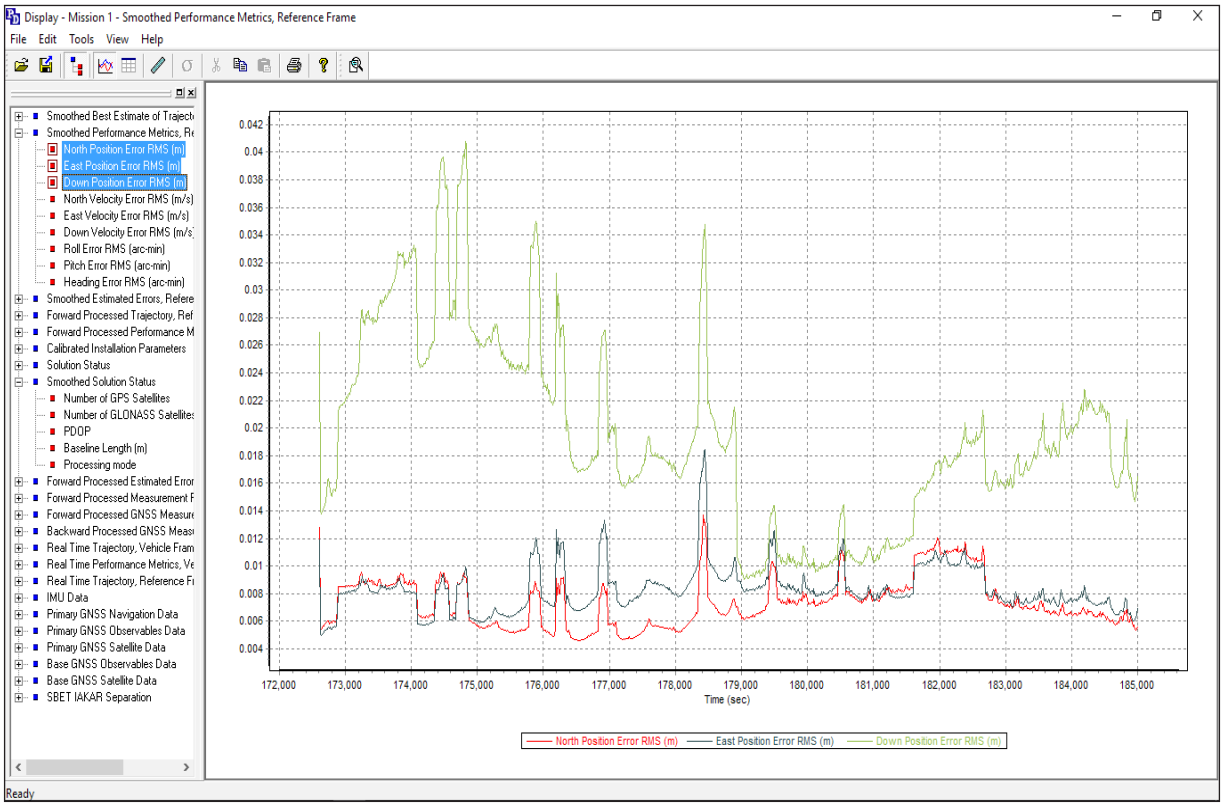


Figure A-8.23. Smoothed Performance Metric Parameters

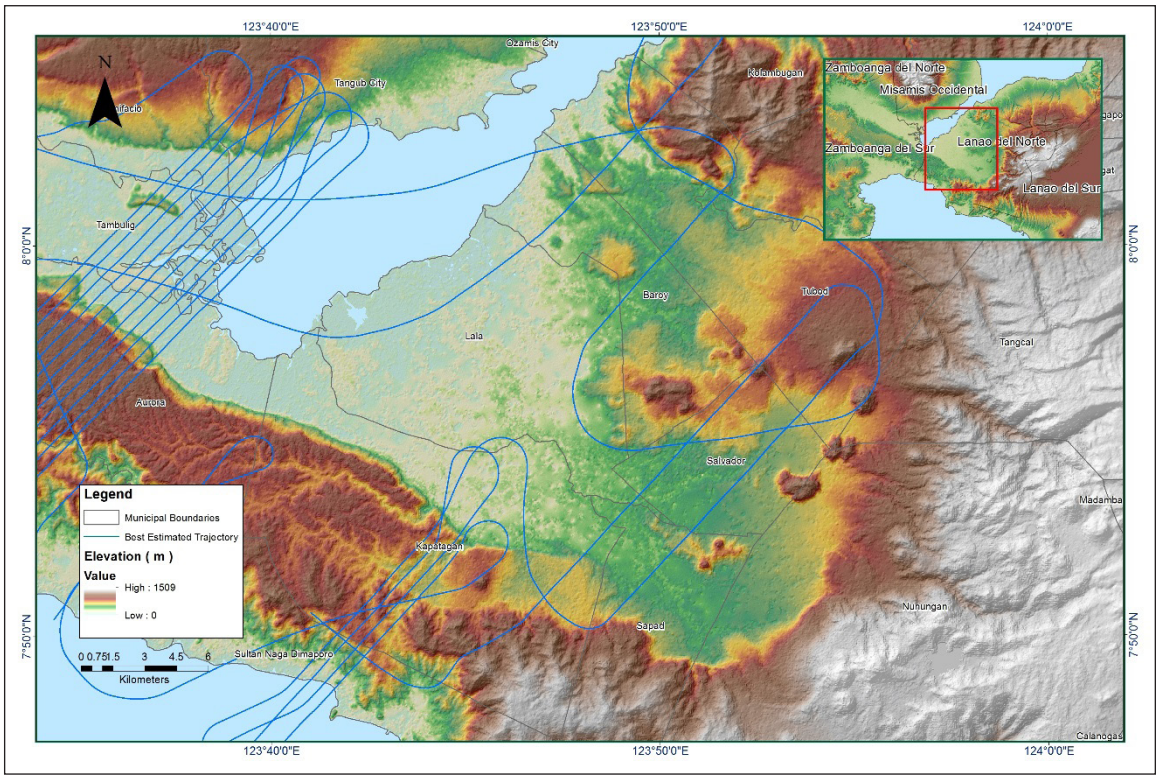


Figure A-8.24. Best Estimated Trajectory

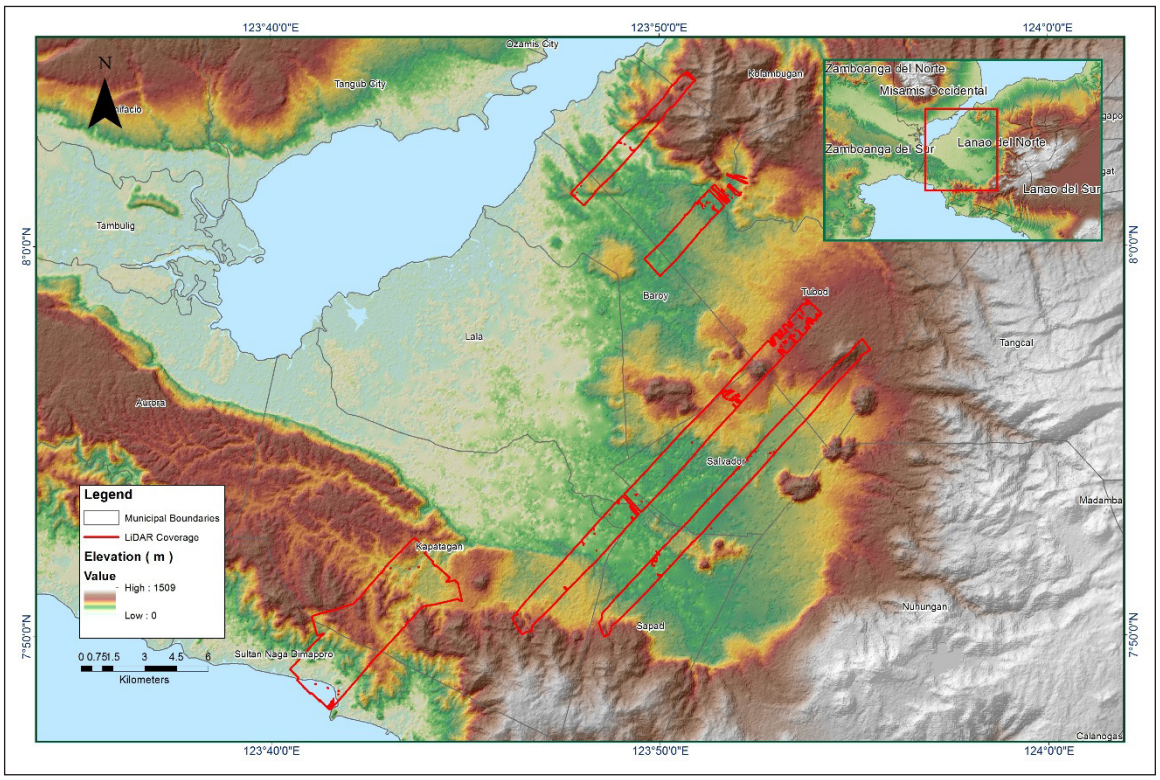


Figure A-8.25. Coverage of LiDAR Data

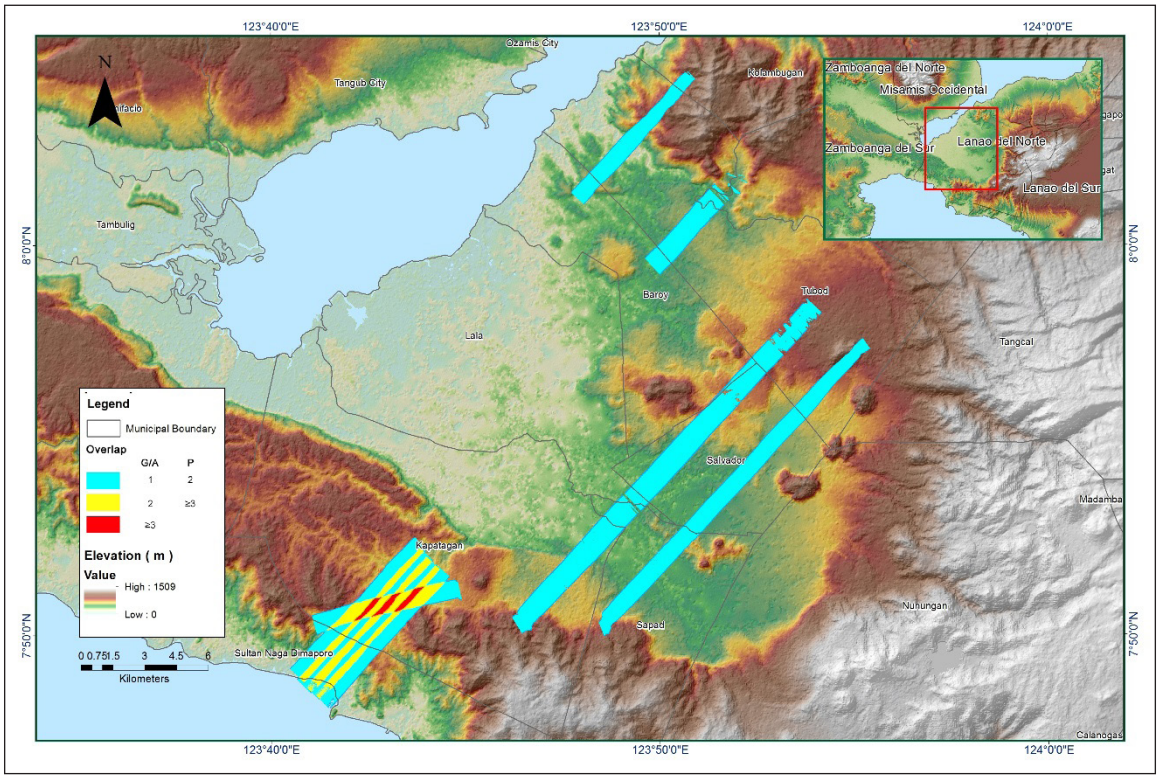


Figure A-8.26. Image of data overlap

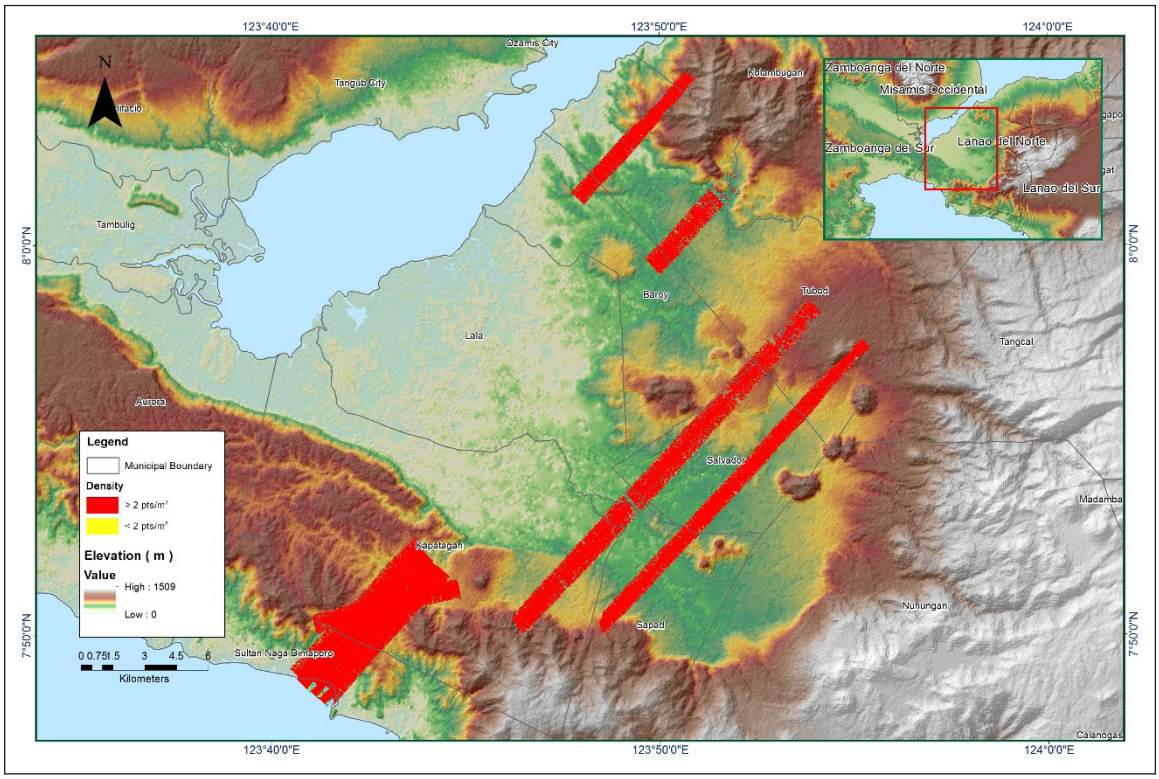


Figure A-8.27. Density map of merged LiDAR data

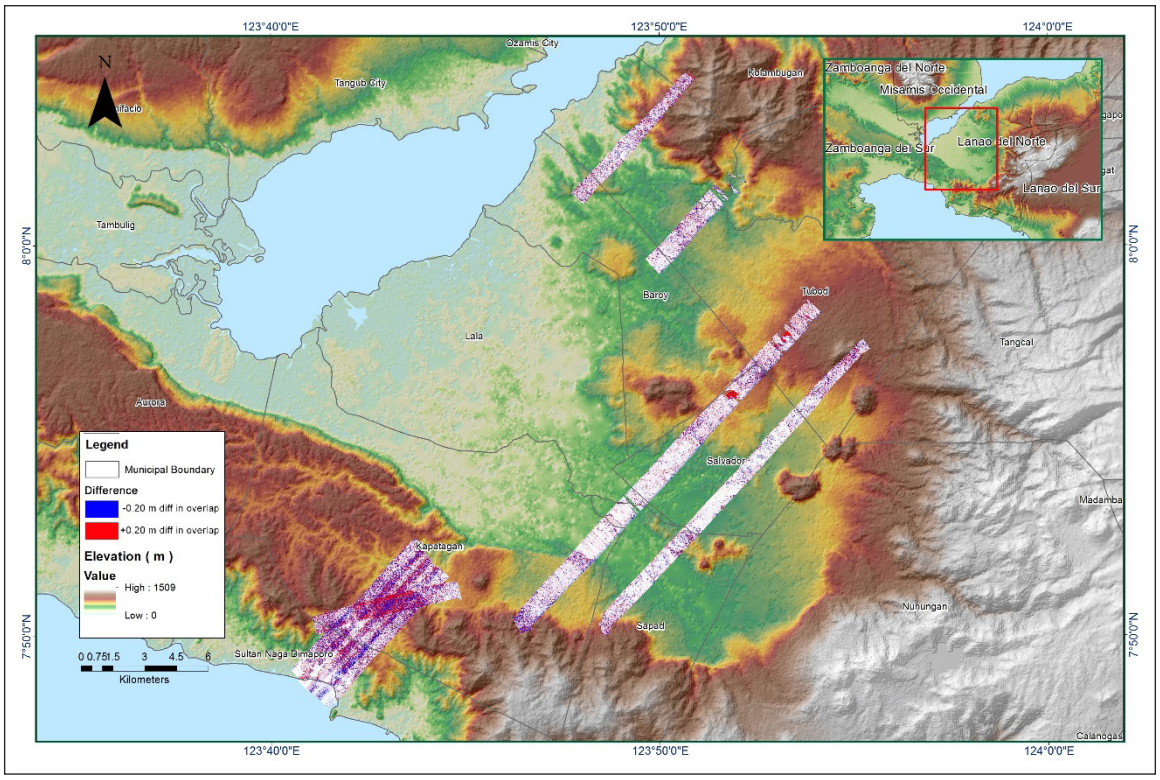


Figure A-8.28. Elevation difference between flight lines

Table A-8.5. Mission Summary Report for Mission 76N

Flight Area	Pagadian
Mission Name	**76N**
Inclusive Flights	23088P
Range data size	24.65
POS data size	283.62
Base data size	101.29
Image	n/a
Transfer date	March 01, 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)	1.5
RMSE for East Position (<4.0 cm)	1.5
RMSE for Down Position (<8.0 cm)	4.6
Boresight correction stdev (<0.001deg)	0.000274
IMU attitude correction stdev (<0.001deg)	0.001049
GPS position stdev (<0.01m)	0.0073
Minimum % overlap (>25)	41.91
Ave point cloud density per sq.m. (>2.0)	2.98
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	189
Maximum Height	726.06 m
Minimum Height	92.16 m
Classification (# of points)	
Ground	140,736,400
Low vegetation	124,627,028
Medium vegetation	126,549,841
High vegetation	285,028,320
Building	4,597,452
Orthophoto	Yes
Processed by	**Engr. Analyn Naldo, Engr. Merven Matthew Natino, Marie Denise Bueno**

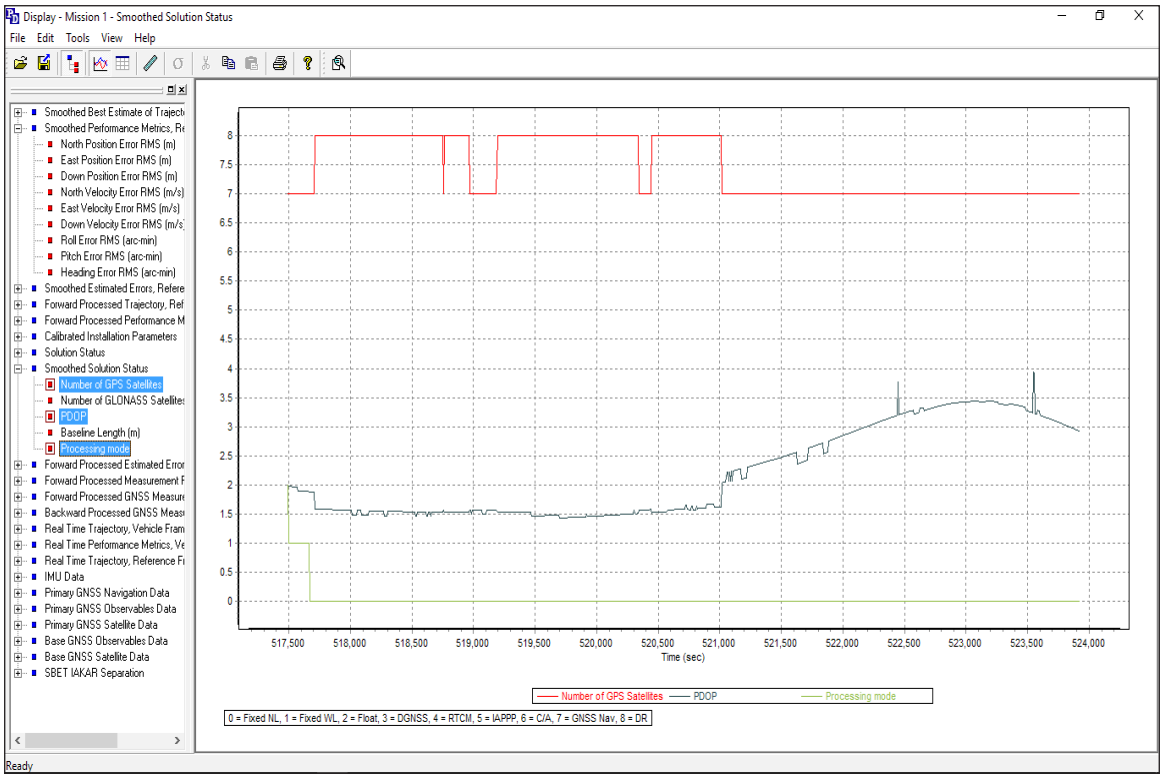


Figure A-8.29. Solution Status

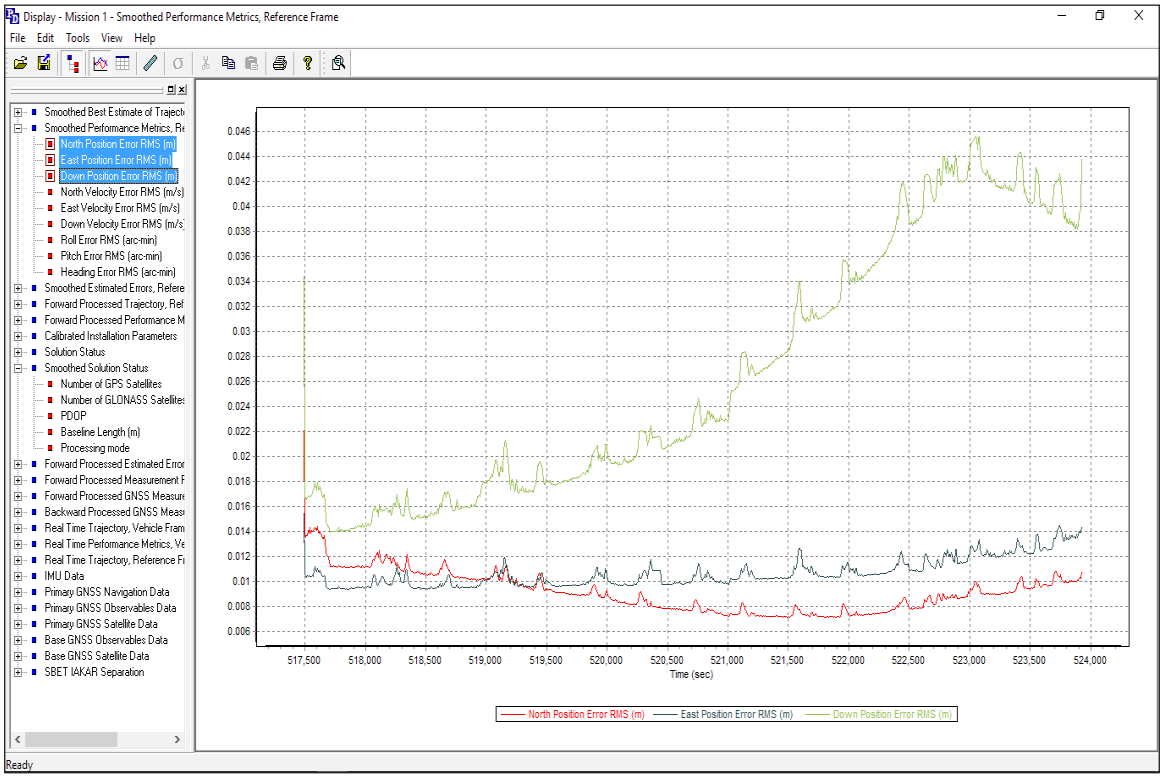


Figure A-8.30. Smoothed Performance Metric Parameters

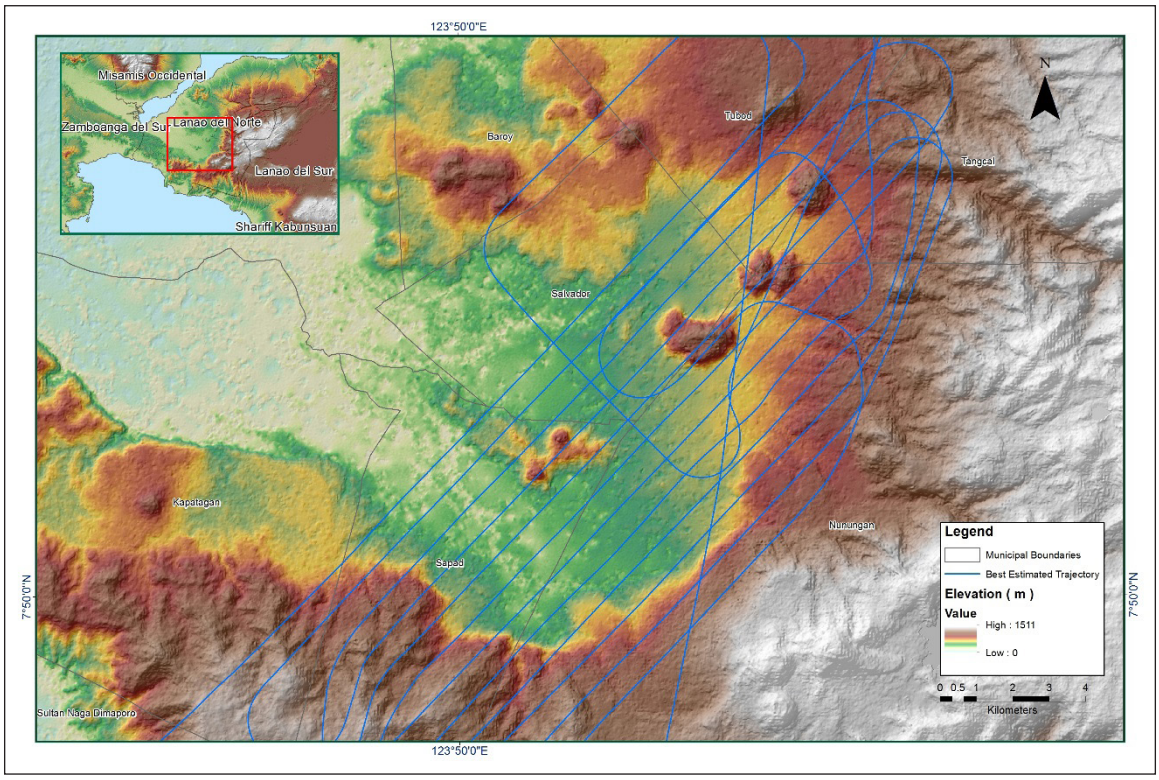


Figure A-8.31. Best Estimated Trajectory

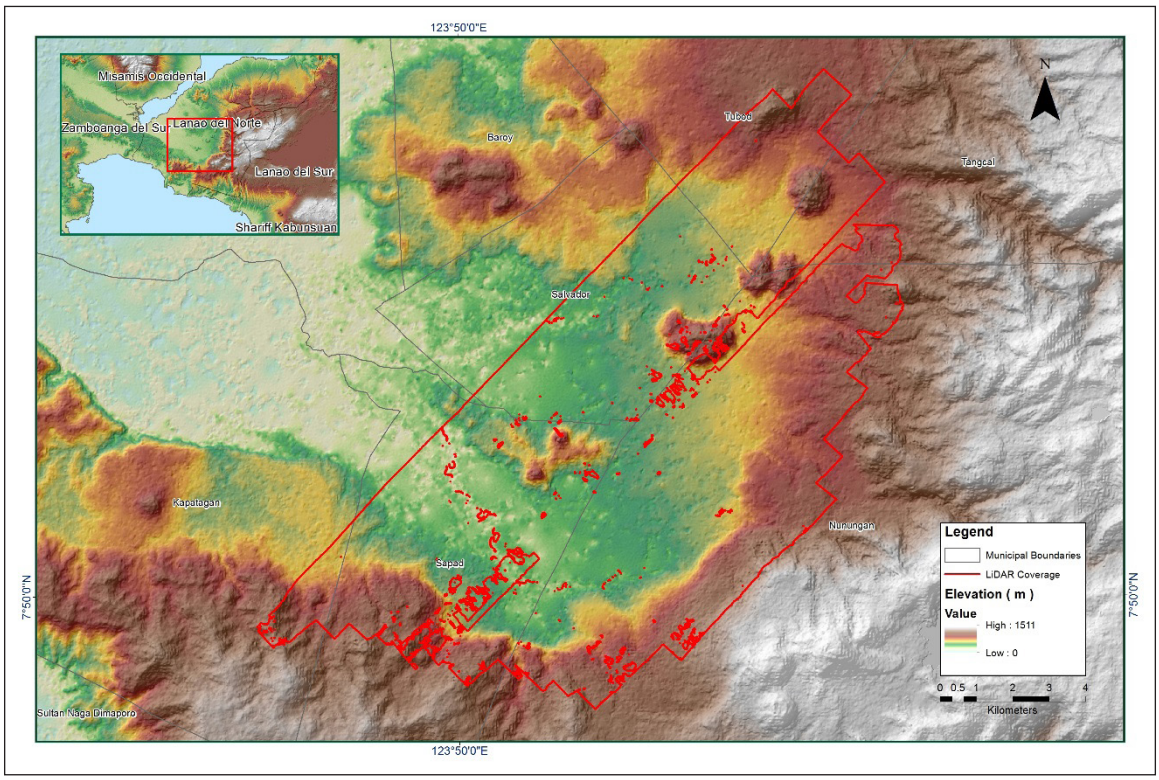


Figure A-8.32. Coverage of LiDAR Data

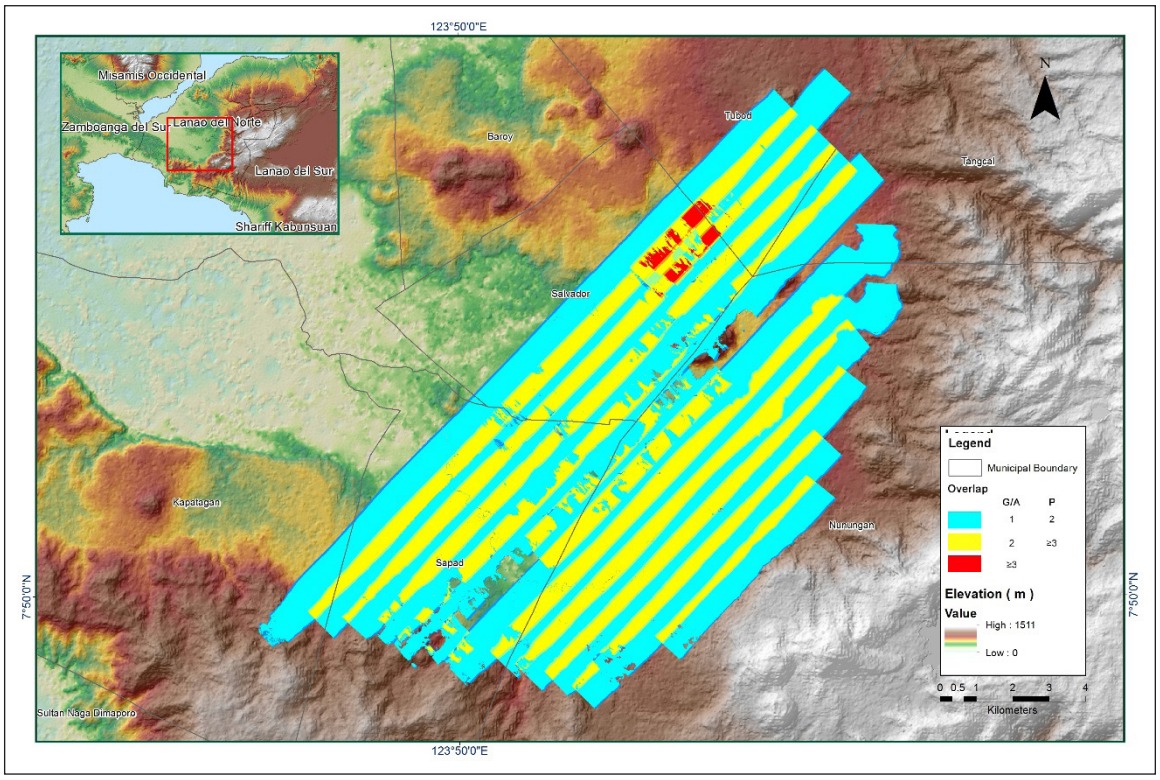


Figure A-8.33. Image of data overlap

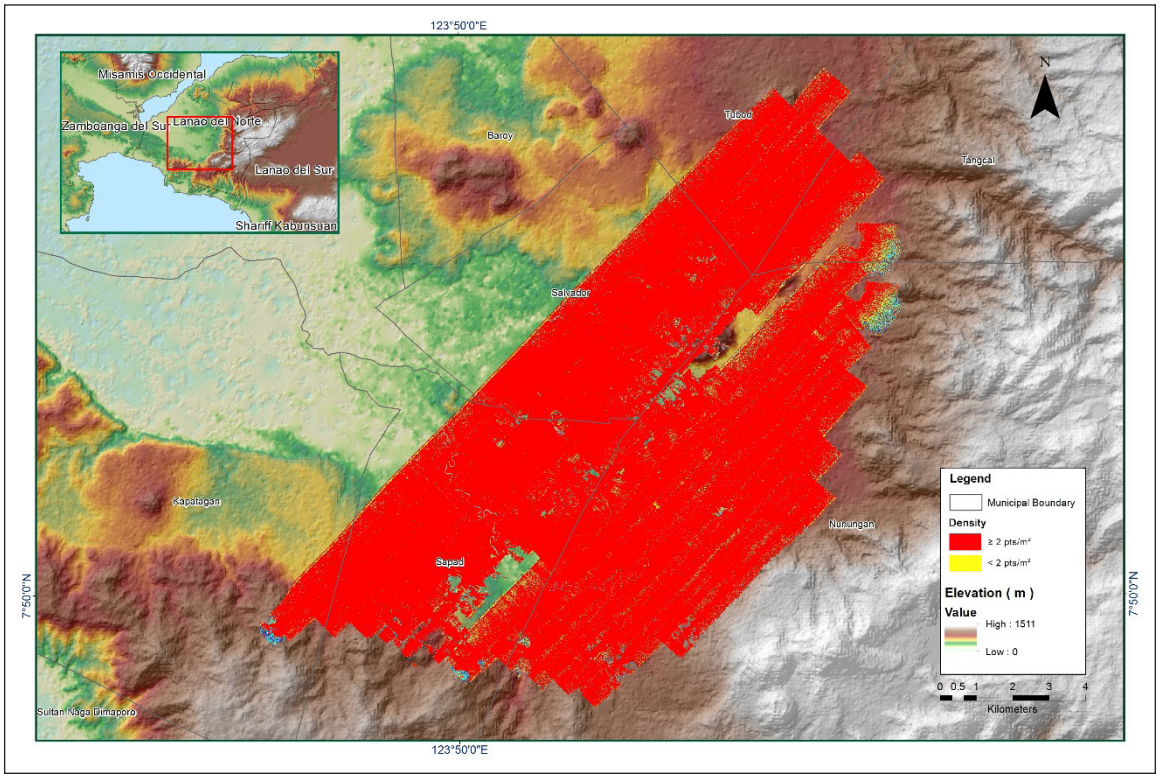


Figure A-8.34. Density map of merged LiDAR data

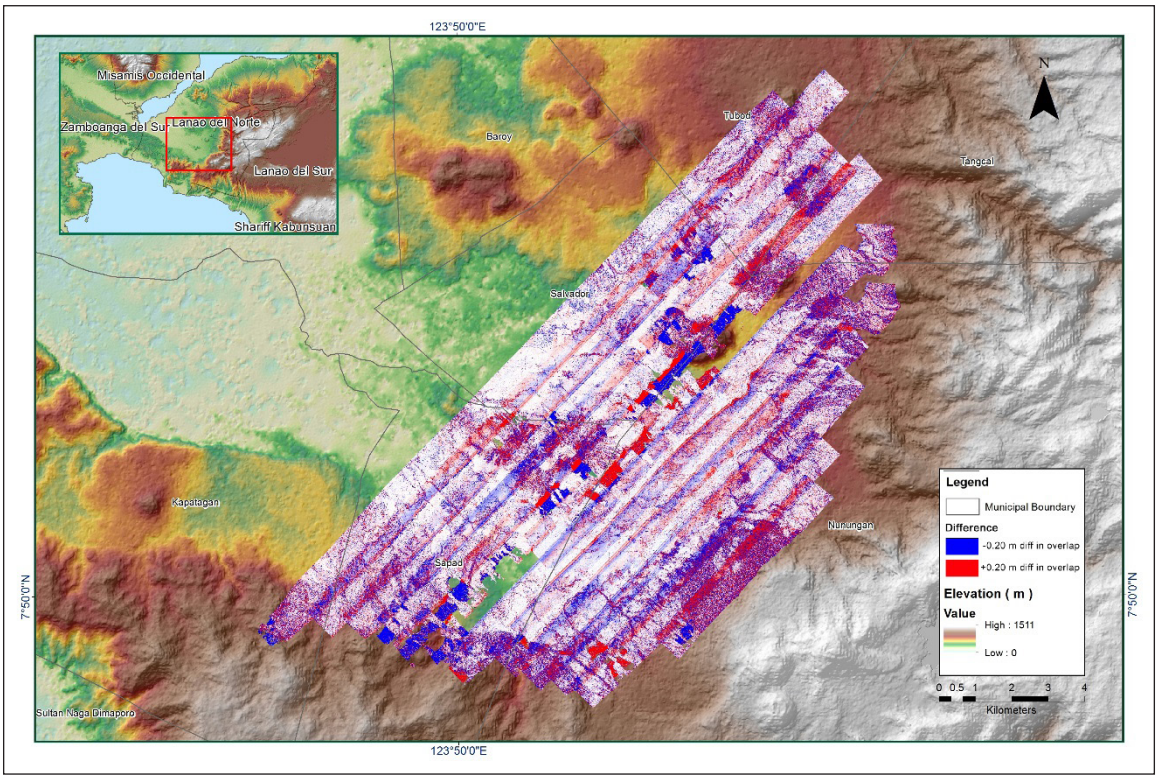


Figure A-8.35. Elevation difference between flight lines

Table A-8.6. Mission Summary Report for Mission 76N_Additional

Flight Area	Pagadian
Mission Name	**76N_Additional**
Inclusive Flights	23104P
Range data size	18.3
POS data size	287.01
Base data size	116.78
Image	n/a
Transfer date	March 01, 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)	2.2
RMSE for Down Position (<8.0 cm)	4.2
Boresight correction stdev (<0.001deg)	N/A
IMU attitude correction stdev (<0.001deg)	N/A
GPS position stdev (<0.01m)	N/A
Minimum % overlap (>25)	10.37
Ave point cloud density per sq.m. (>2.0)	2.38

Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	124
Maximum Height	436.04 m
Minimum Height	90.14 m
Classification (# of points)	
Ground	56,765,012
Low vegetation	52,157,492
Medium vegetation	41,240,260
High vegetation	93,342,982
Building	1,335,125
Orthophoto	Yes
Processed by	Engr. Don Matthew Banatin, Engr. Merven Matthew Natino, Jovy Narisma

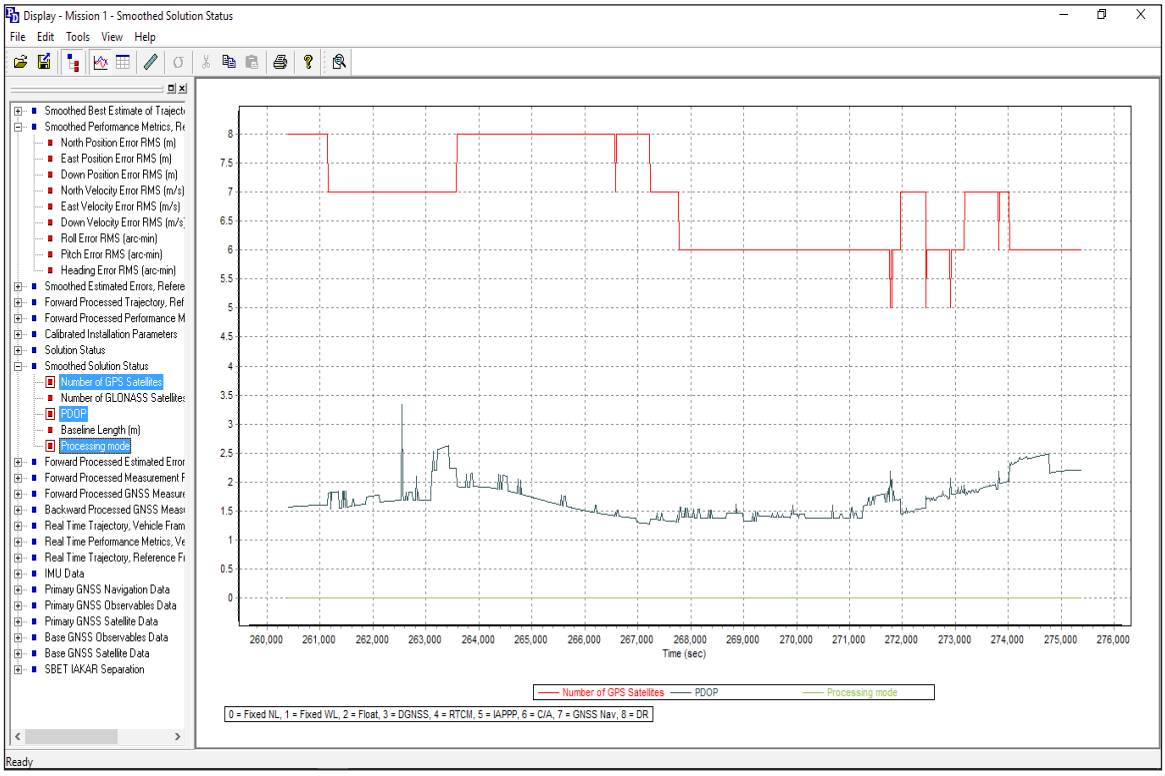


Figure A-8.36. Solution Status

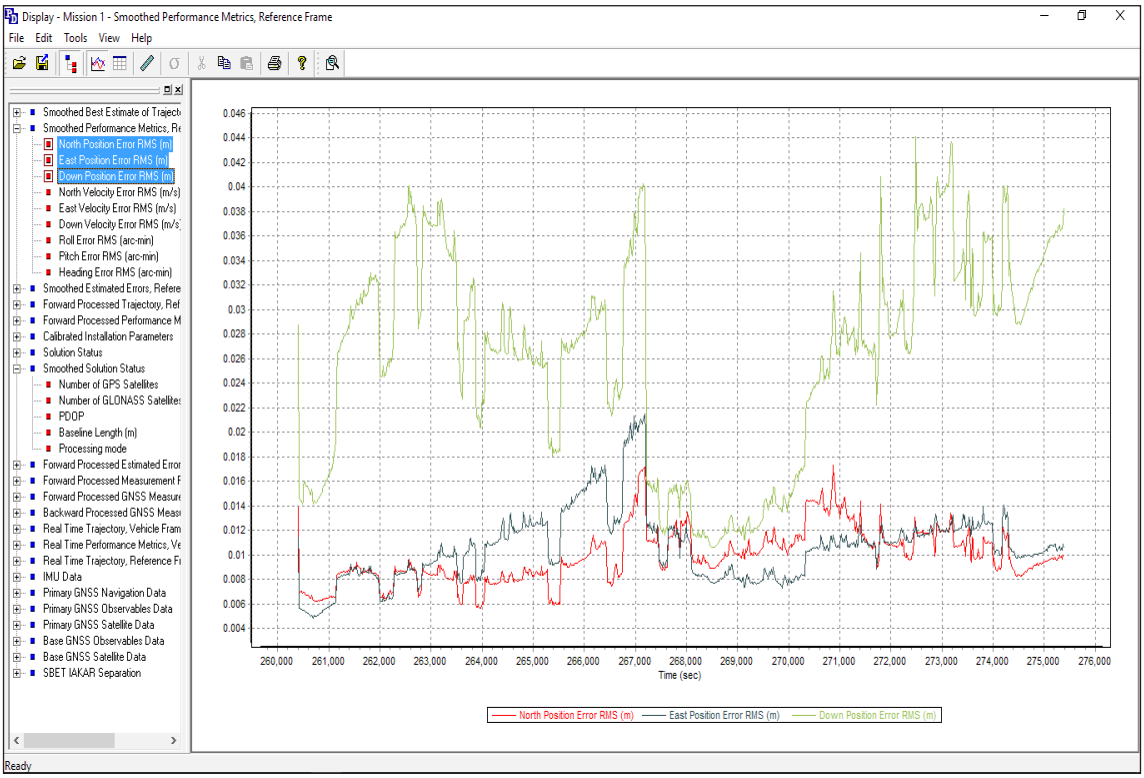


Figure A-8.37. Smoothed Performance Metric Parameters

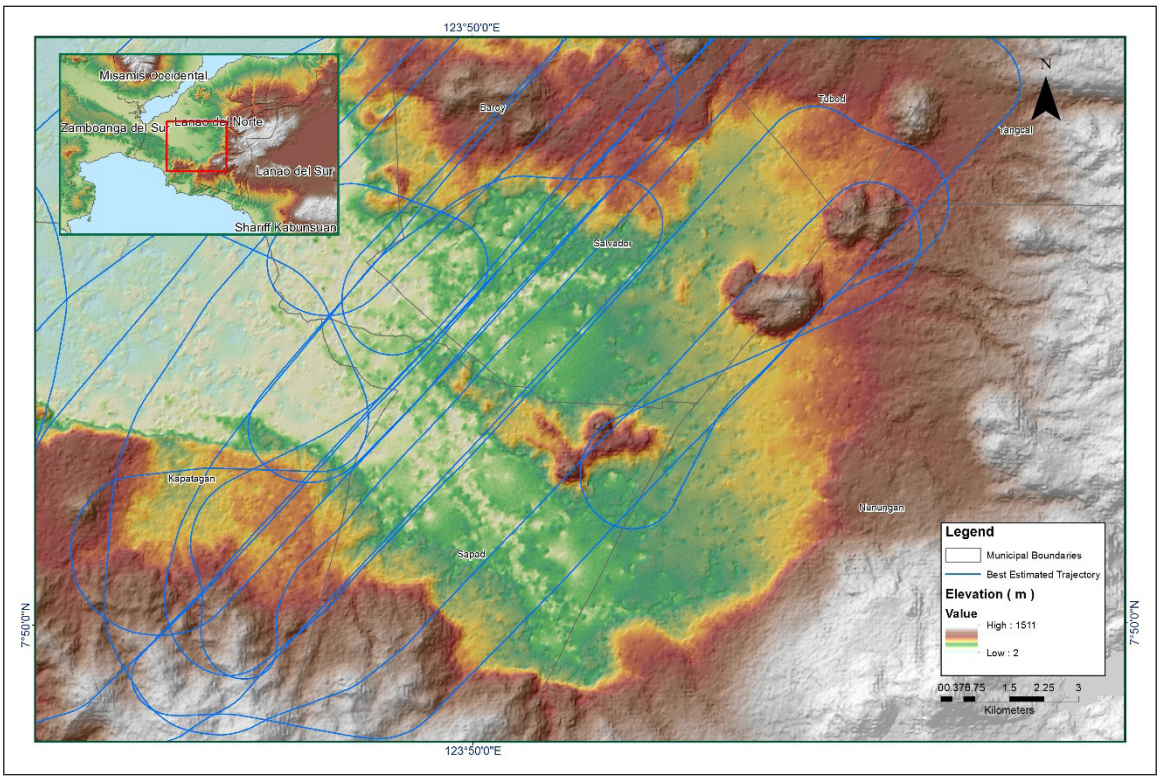


Figure A-8.38. Best Estimated Trajectory

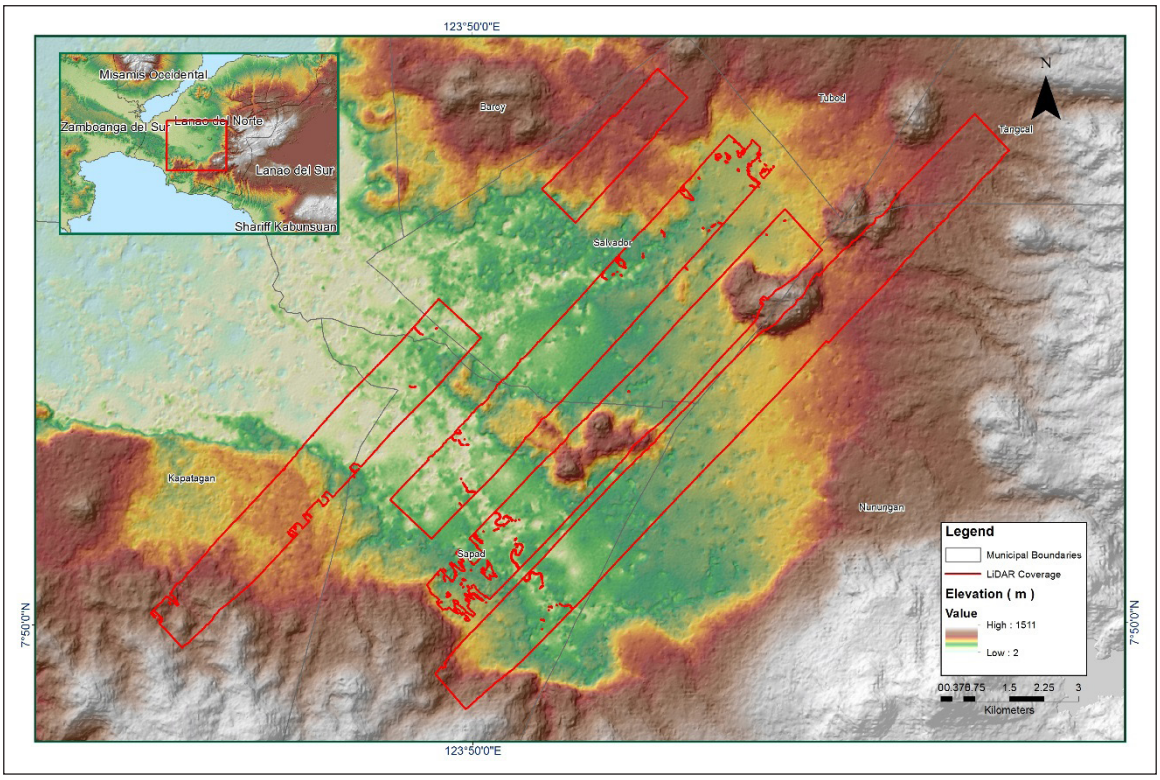


Figure A-8.39. Coverage of LiDAR Data

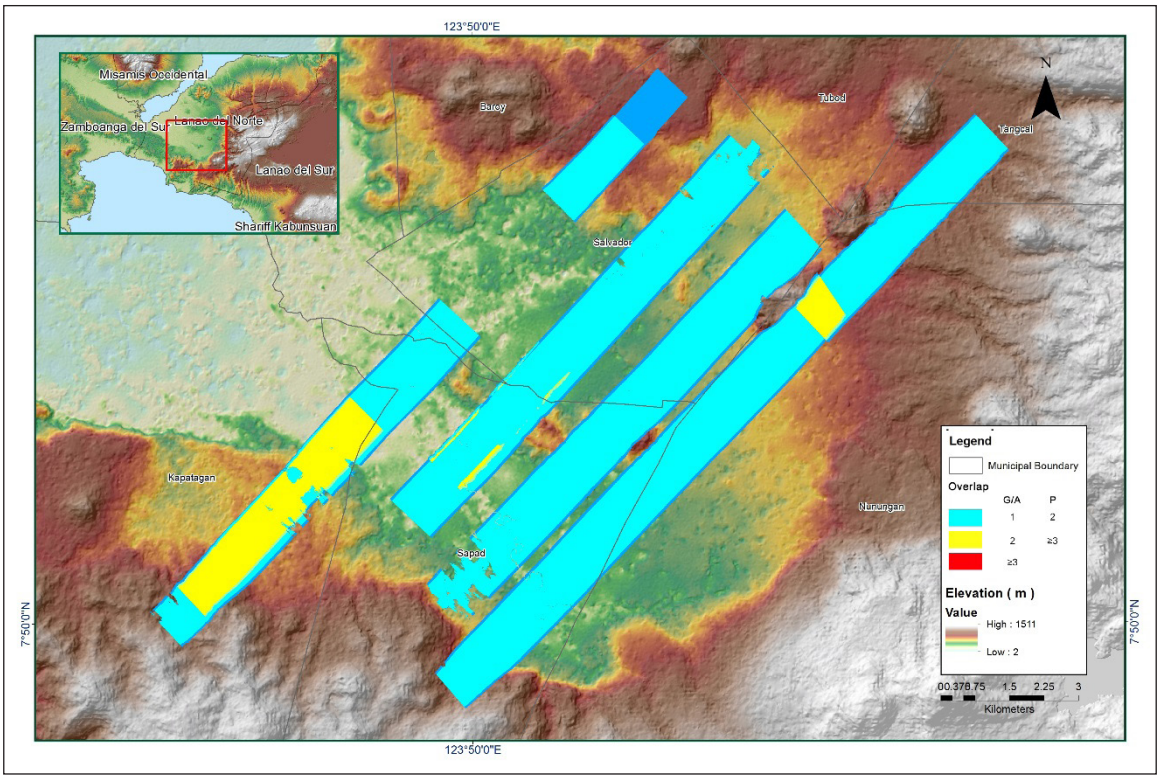


Figure A-8.40. Image of data overlap

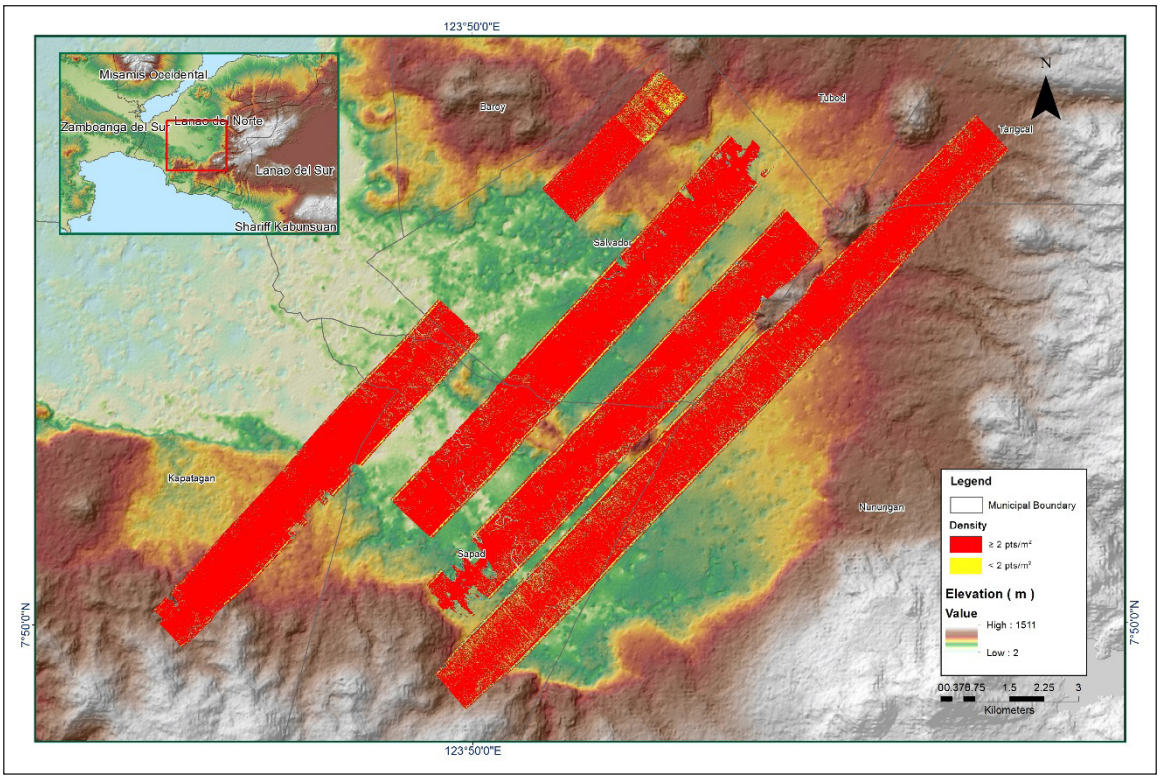


Figure A-8.41. Density map of merged LiDAR data

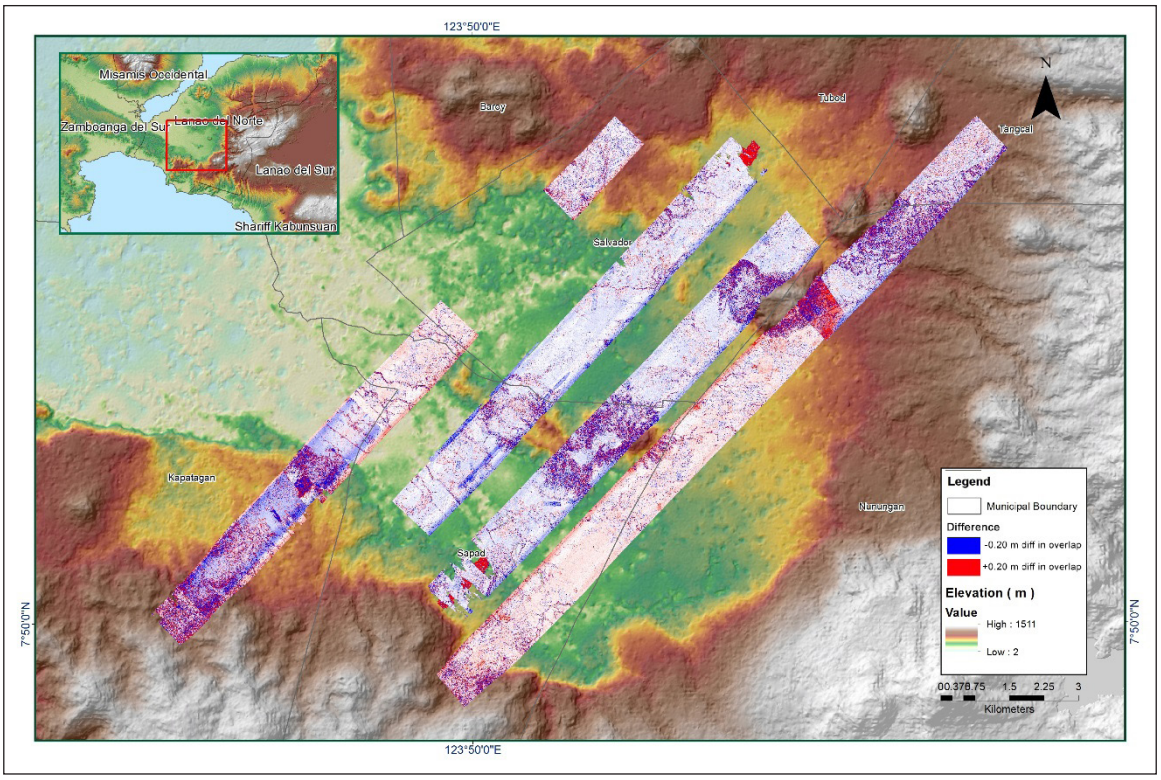


Figure A-8.42. Elevation difference between flight lines

Table A-8.7. Mission Summary Report for Mission Blk71Extension

Flight Area	Northern Mindanao
Mission Name	**Blk71Extension**
Inclusive Flights	1665P, 1673P, 1677P
Range data size	27.06 GB
POS	500 MB
Image	33.6 GB
Transfer date	August 6, 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)	3.0
RMSE for East Position (<4.0 cm)	4.0
RMSE for Down Position (<8.0 cm)	5.0
Boresight correction stdev (<0.001deg)	0.000243
IMU attitude correction stdev (<0.001deg)	0.001298
GPS position stdev (<0.01m)	0.0076
Minimum % overlap (>25)	27.83%
Ave point cloud density per sq.m. (>2.0)	2.41
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	243
Maximum Height	868.76 m
Minimum Height	63.2 m
Classification (# of points)	
Ground	107,907,148
Low vegetation	96,229,157
Medium vegetation	96,176,102
High vegetation	80,601,347
Building	17,253,174
Orthophoto	Yes
Processed by	Engr. Analyn Naldo, Engr. Edgardo Gubatanga Jr., Engr. Elainne Lopez

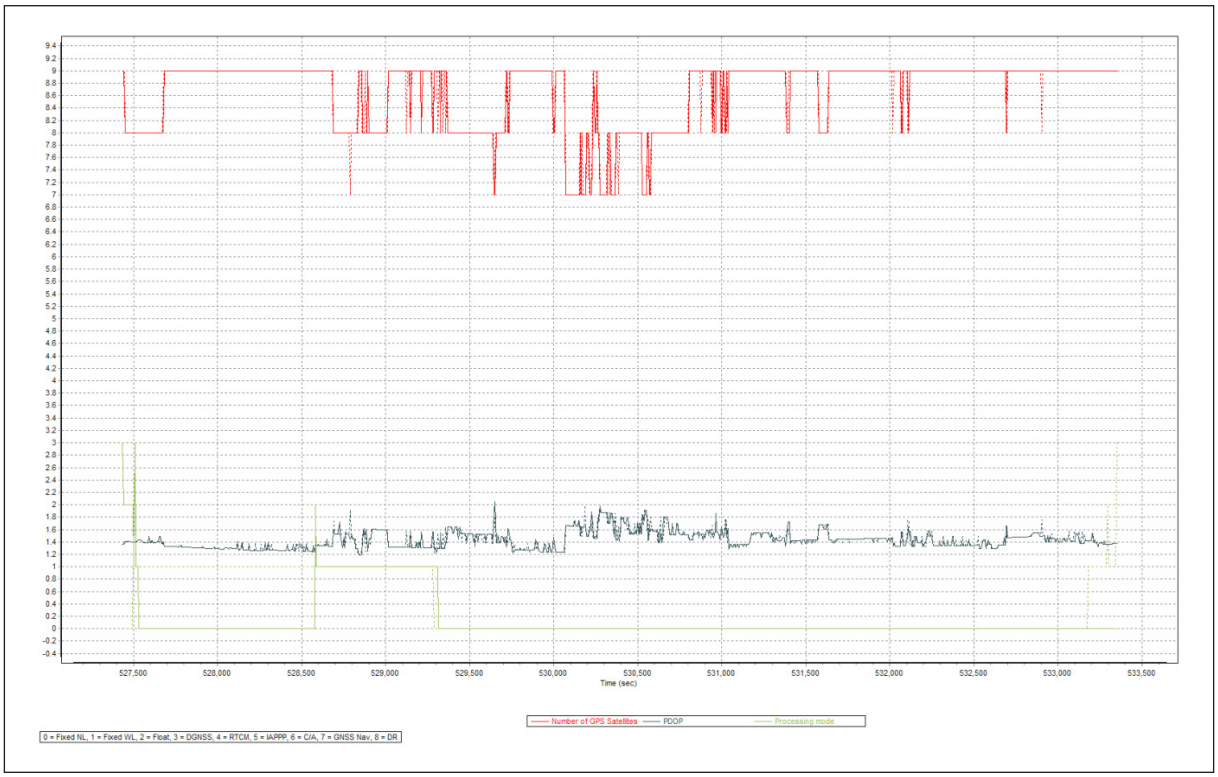


Figure A-8.43. Solution Status

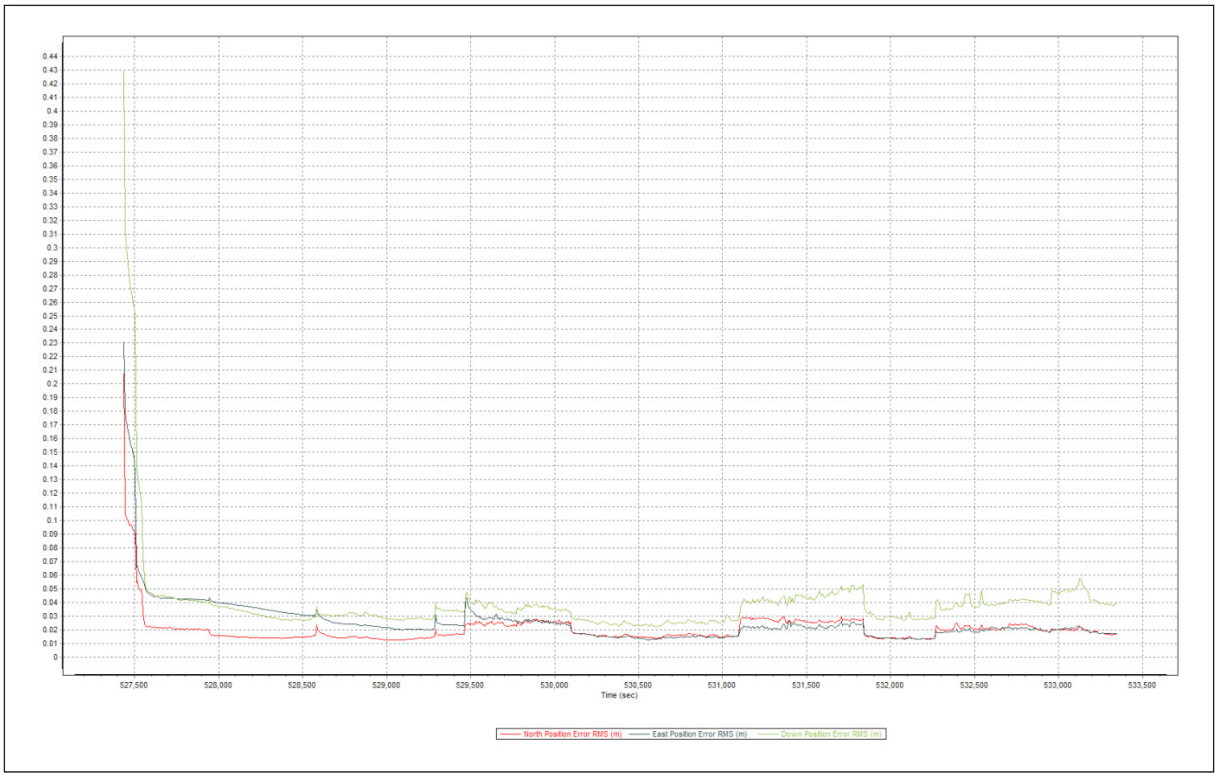


Figure A-8.44. Smoothed Performance Metric Parameters

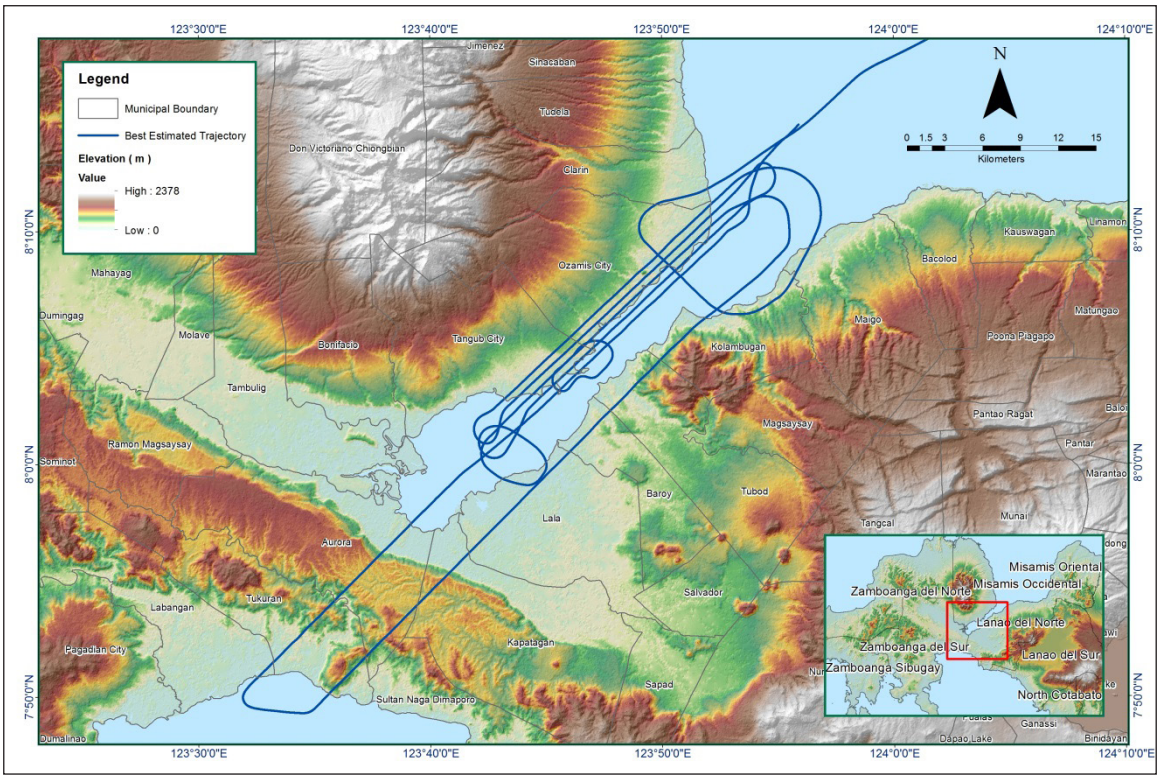


Figure A-8.45. Best Estimated Trajectory

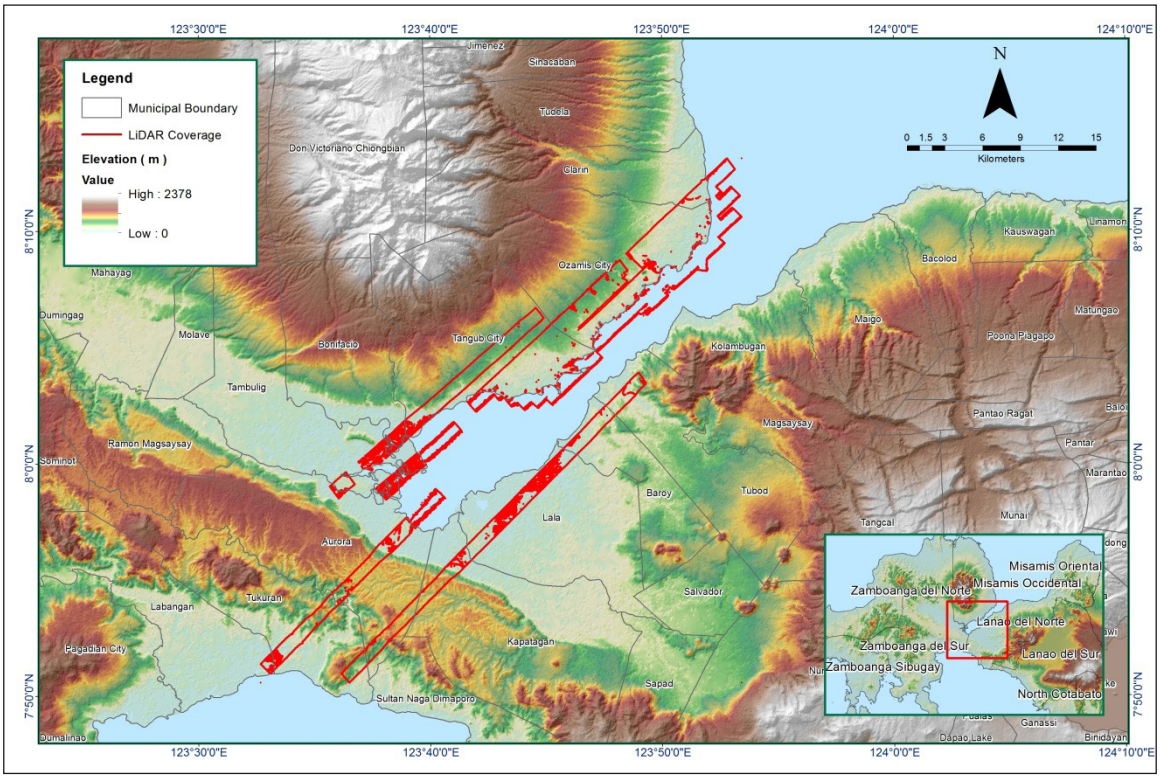


Figure A-8.46.Coverage of LiDAR data

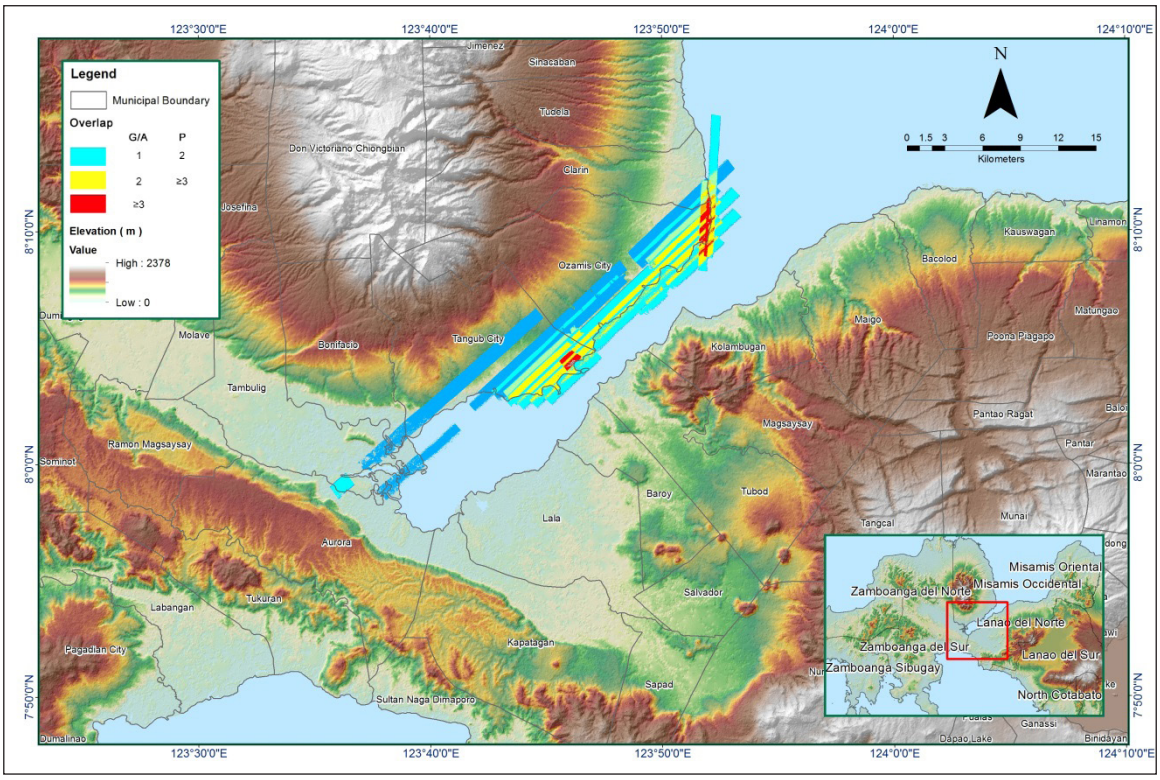


Figure A-8.47.Image of data overlap

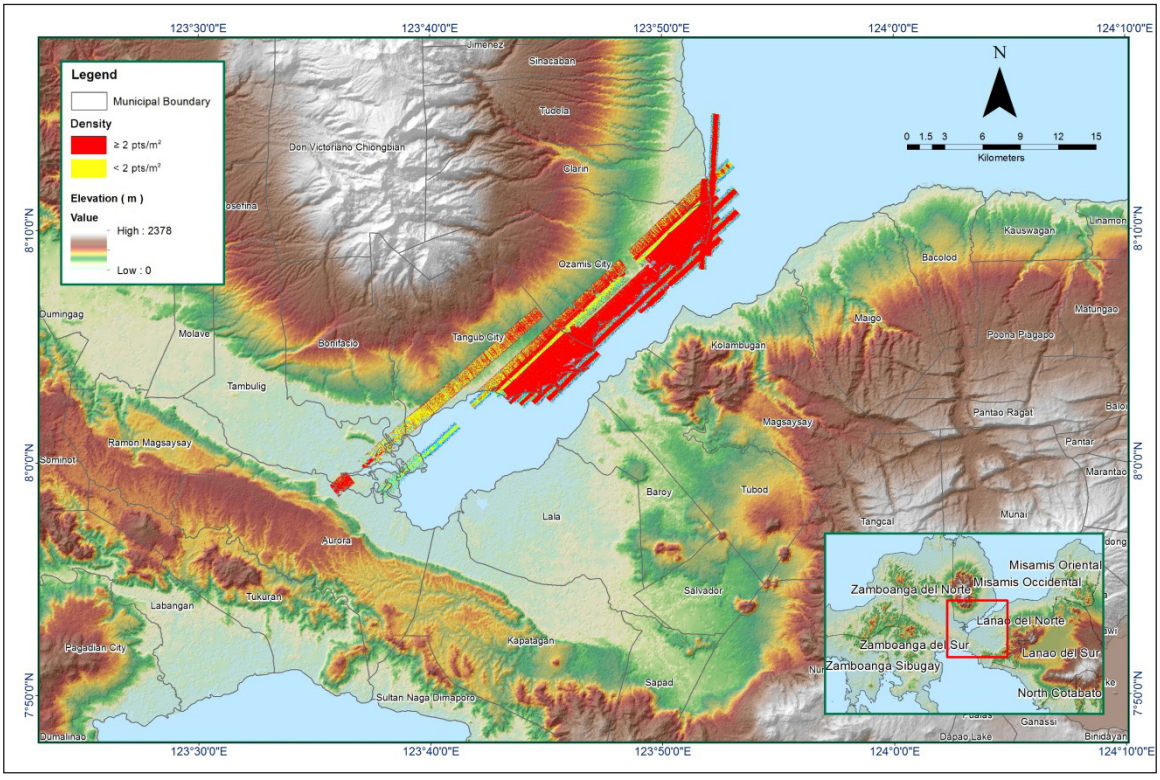


Figure A-8.48. Density map of merged LiDAR data

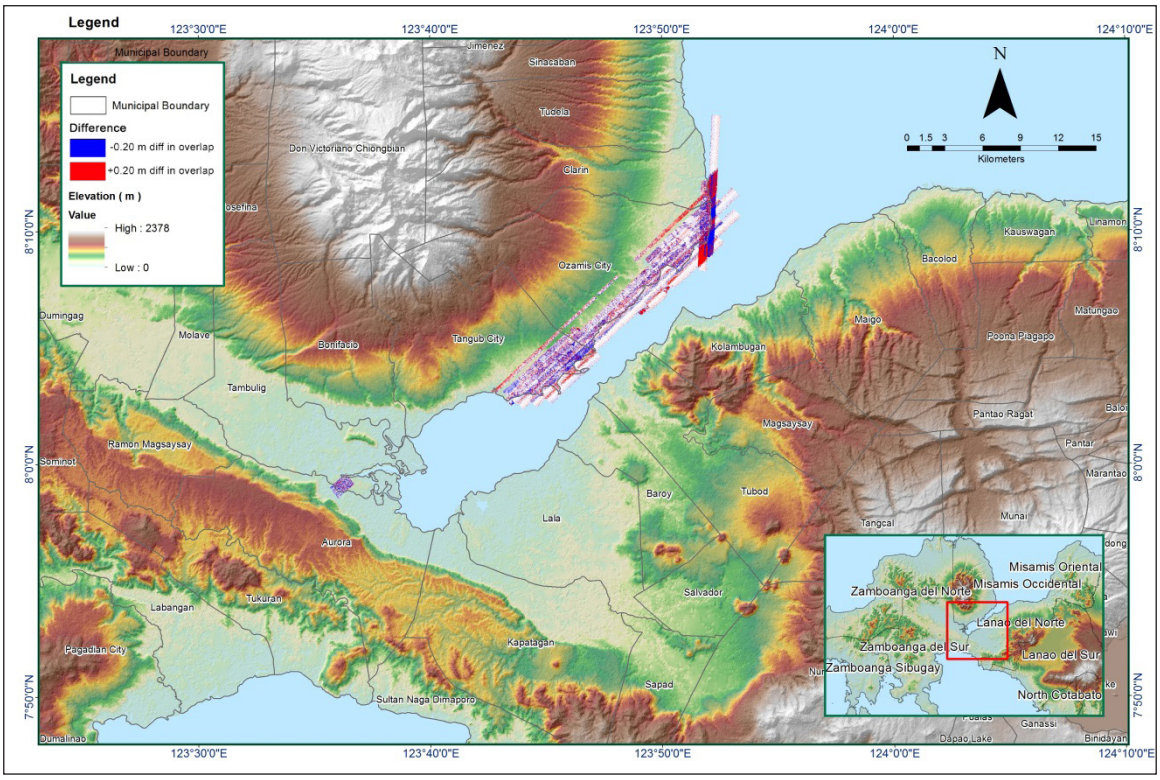


Figure A-8.49.Elevation difference between flight lines

Table A-8.8. Mission Summary Report for Mission Blk71E

Flight Area	Northern Mindanao
Mission Name	**Blk71E**
Inclusive Flights	1689P
Range data size	27.1 GB
POS	257 MB
Image	n/a
Transfer date	August 6, 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)	2.5
RMSE for East Position (<4.0 cm)	5.5
RMSE for Down Position (<8.0 cm)	10
Boresight correction stdev (<0.001deg)	0.000536
IMU attitude correction stdev (<0.001deg)	0.001171
GPS position stdev (<0.01m)	0.0079
Minimum % overlap (>25)	35.35%
Ave point cloud density per sq.m. (>2.0)	2.79
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	253
Maximum Height	476.79
Minimum Height	66.37
Classification (# of points)	
Ground	157,189,225
Low vegetation	118,155,426
Medium vegetation	187,516,392
High vegetation	168,342,412
Building	7,092,549
Orthophoto	NO
Processed by	Engr. Carlyn Ann Ibañez, Engr. Melanie Hingpit, Engr. John Dill Macapagal

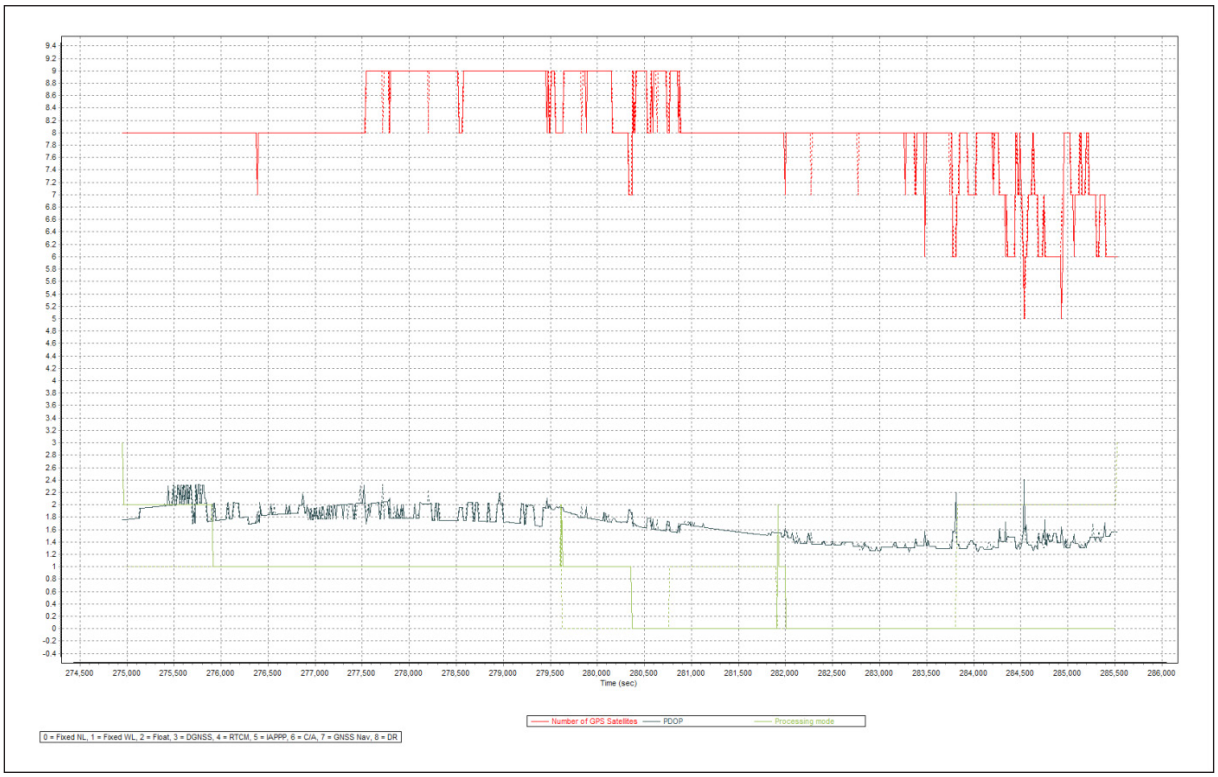


Figure A-8.50. Solution Status

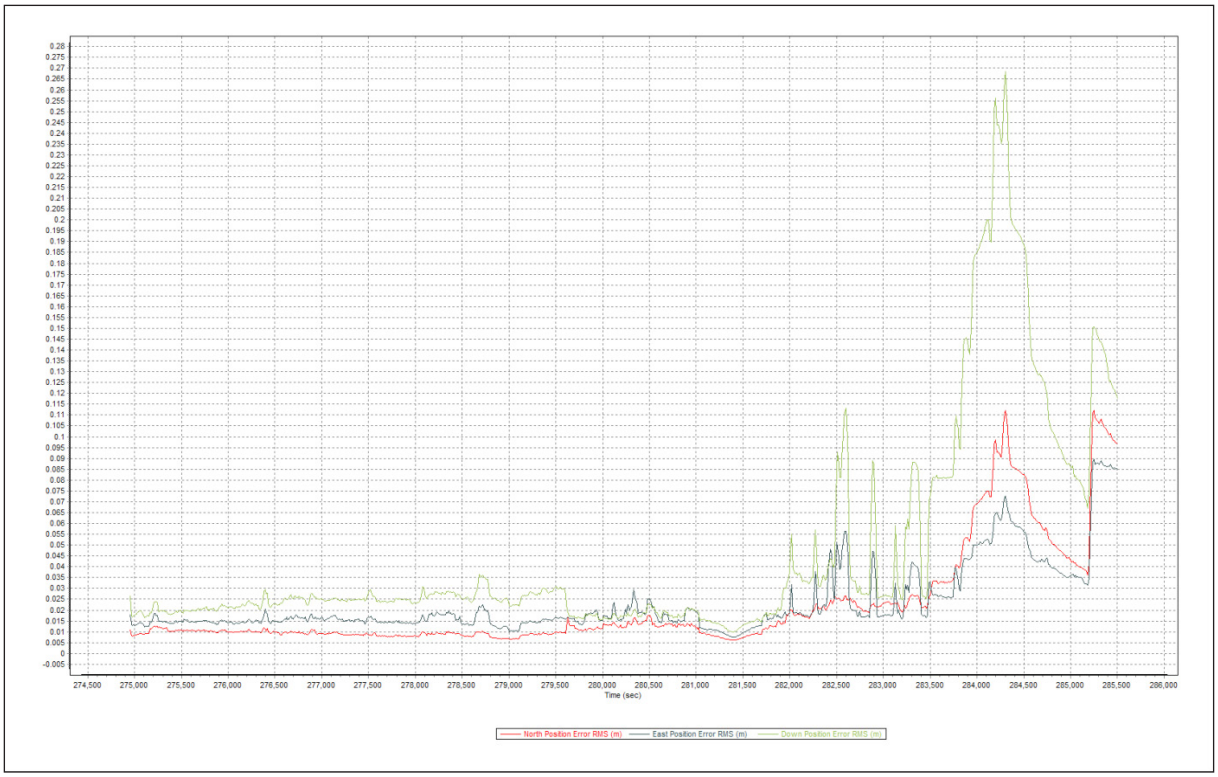


Figure A-8.51, Smoothed Performance Metric Parameters

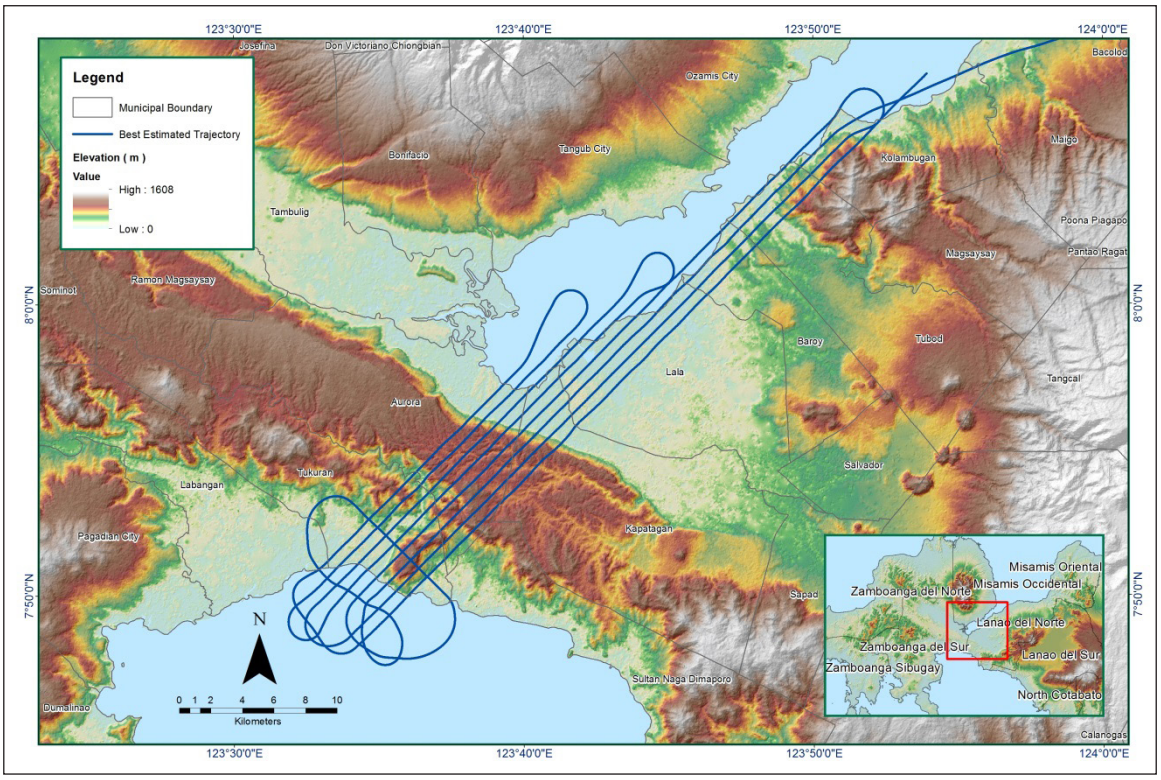


Figure A-8.52. Best Estimated Trajectory

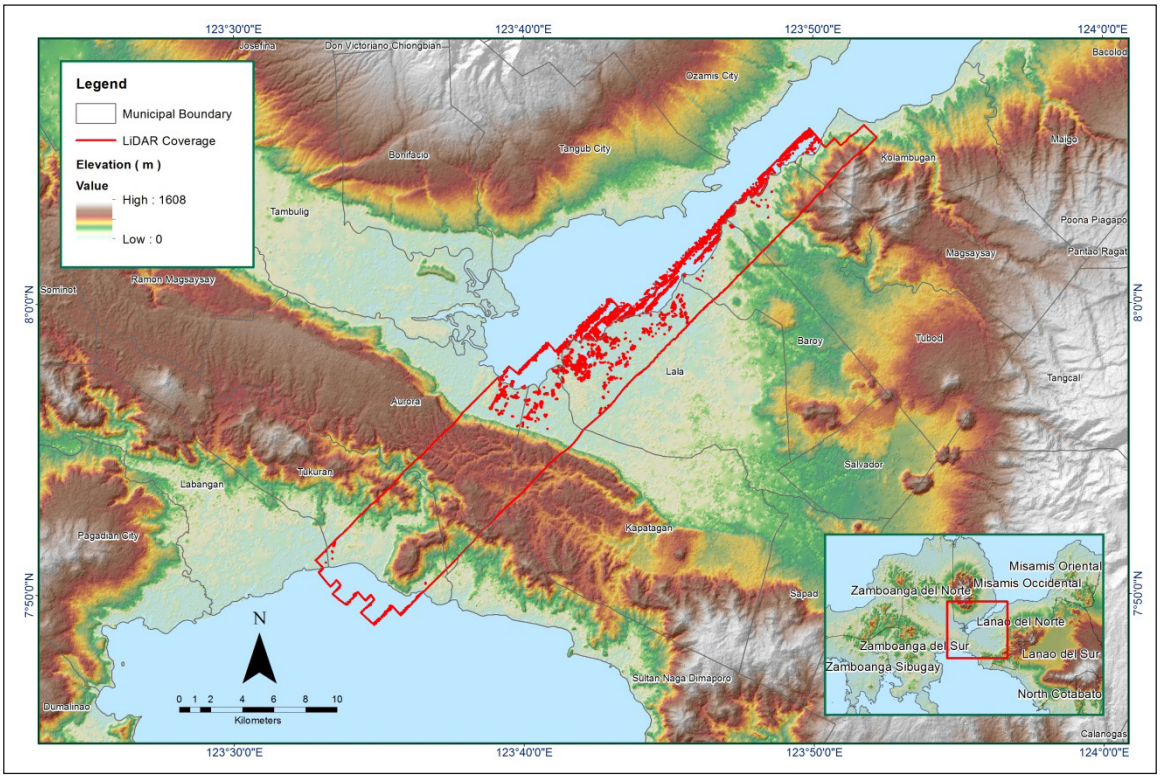


Figure A-8.53.Coverage of LiDAR data

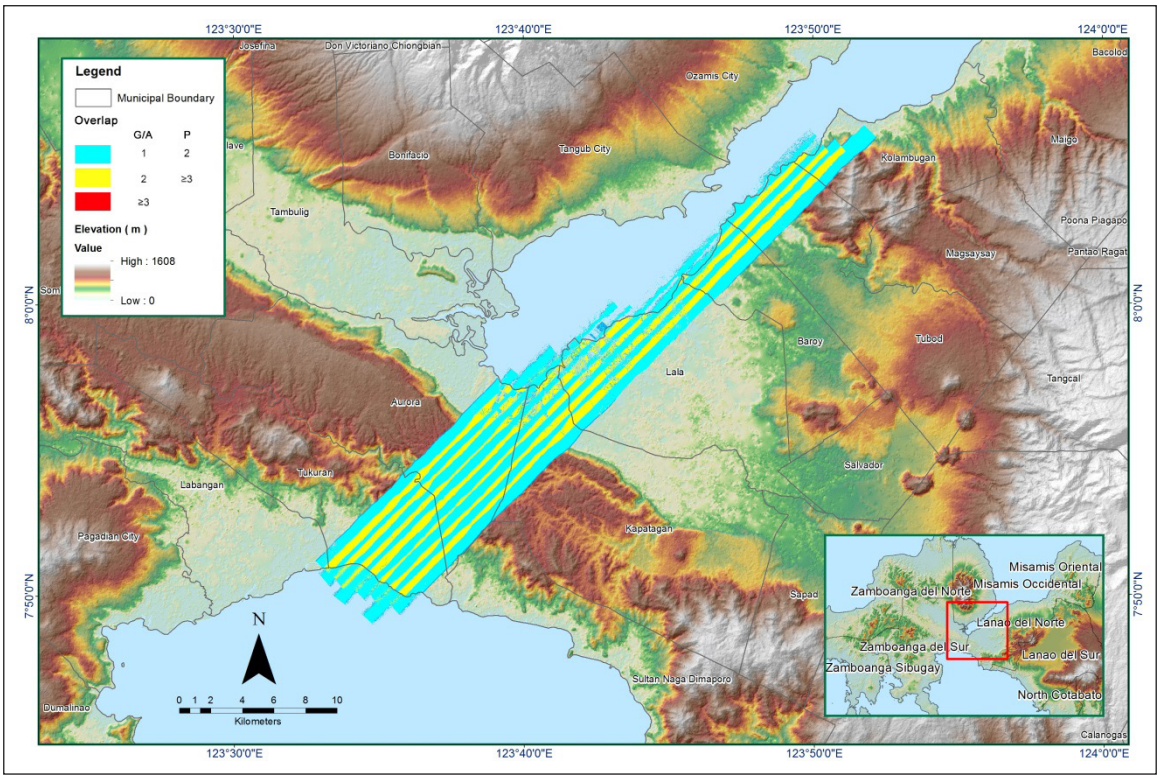


Figure A-8.54.Image of data overlap

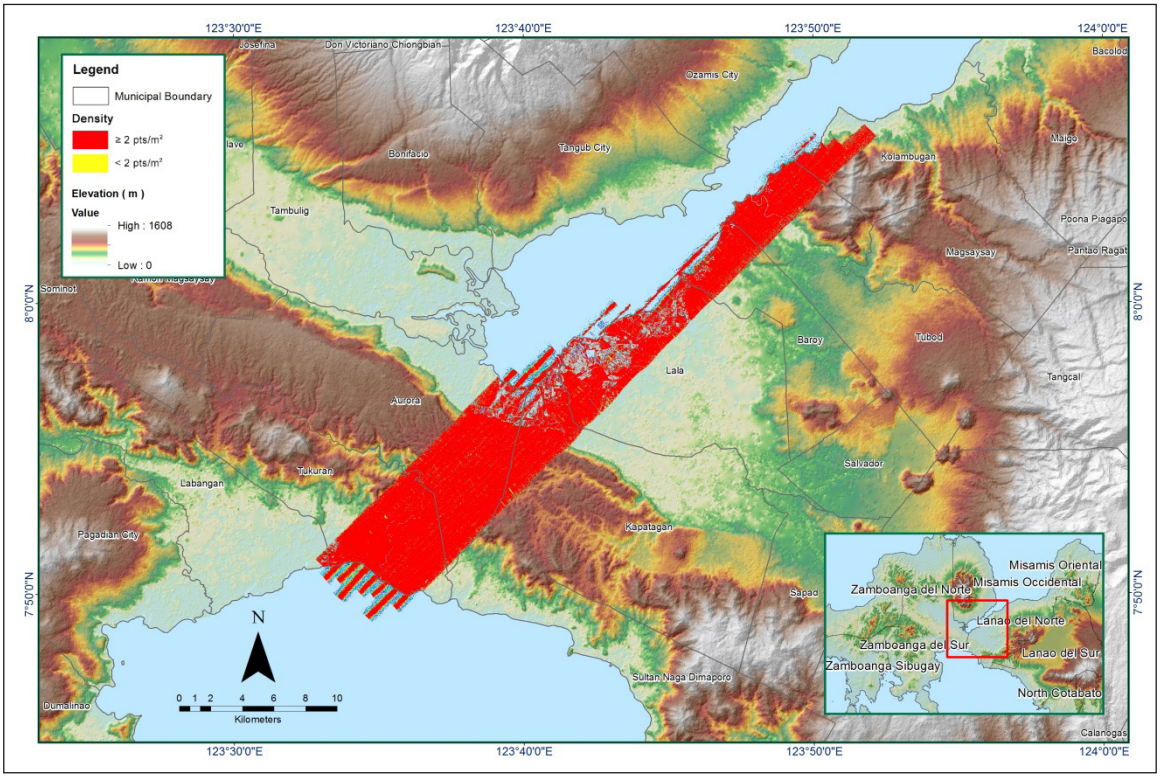


Figure A-8.55. Density map of merged LiDAR data

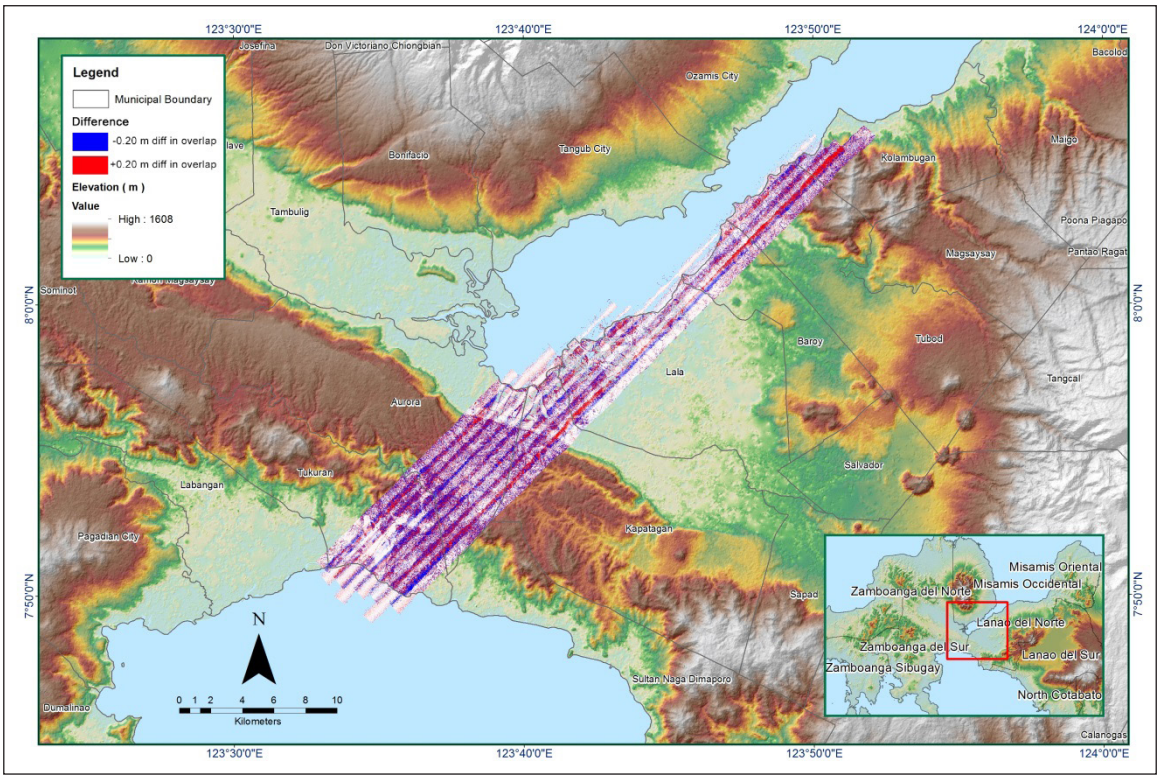


Figure A-8.56.Elevation difference between flight lines

Table A-8.9. Mission Summary Report for Mission Blk71F

Flight Area	Northern Mindanao
Mission Name	**Blk71F**
Inclusive Flights	1565P, 1549P, 1685P
Range data size	70.3 GB
POS	674 MB
Image	59.1 GB
Transfer date	June 23, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.1
RMSE for East Position (<4.0 cm)	1.1
RMSE for Down Position (<8.0 cm)	3.8
Boresight correction stdev (<0.001deg)	0.000471
IMU attitude correction stdev (<0.001deg)	0.004323
GPS position stdev (<0.01m)	0.0198
Minimum % overlap (>25)	51.56%
Ave point cloud density per sq.m. (>2.0)	4.06
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	614
Maximum Height	685.55
Minimum Height	64.65
Classification (# of points)	
Ground	591,908,481
Low vegetation	609,869,904
Medium vegetation	757,441,192
High vegetation	606,070,790
Building	21,867,436
Orthophoto	Yes
Processed by	Engr. Carlyn Ann Ibañez, Engr. Jennifer Saguran, Engr. Christy Lubiano, Engr. John Dill Macapagal

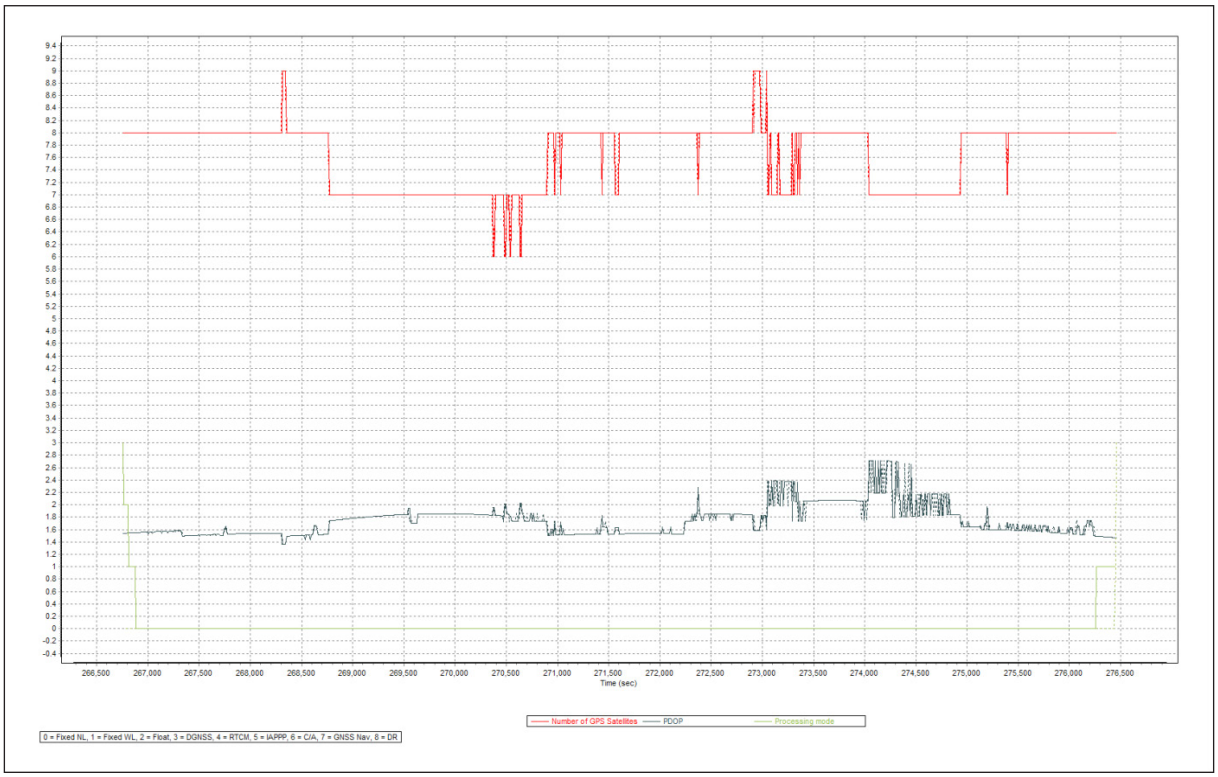


Figure A-8.57. Solution Status

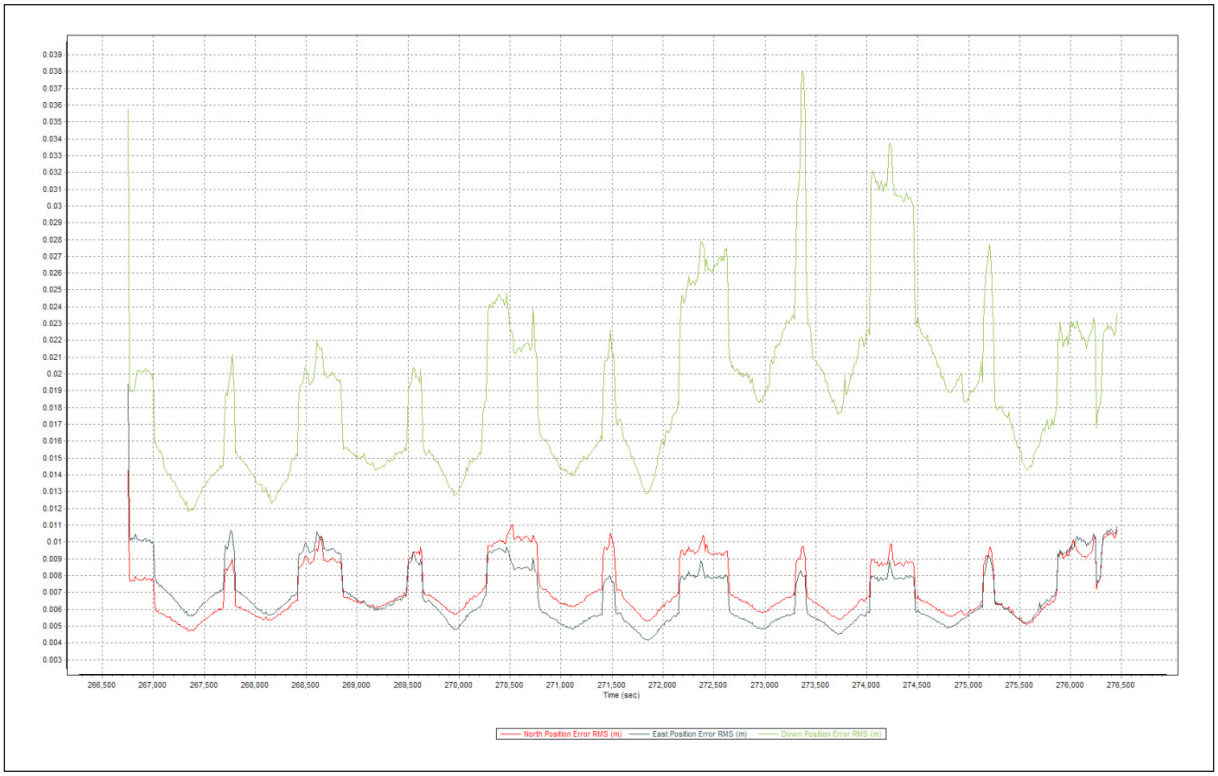


Figure A-8.58. Smoothed Performance Metric Parameters

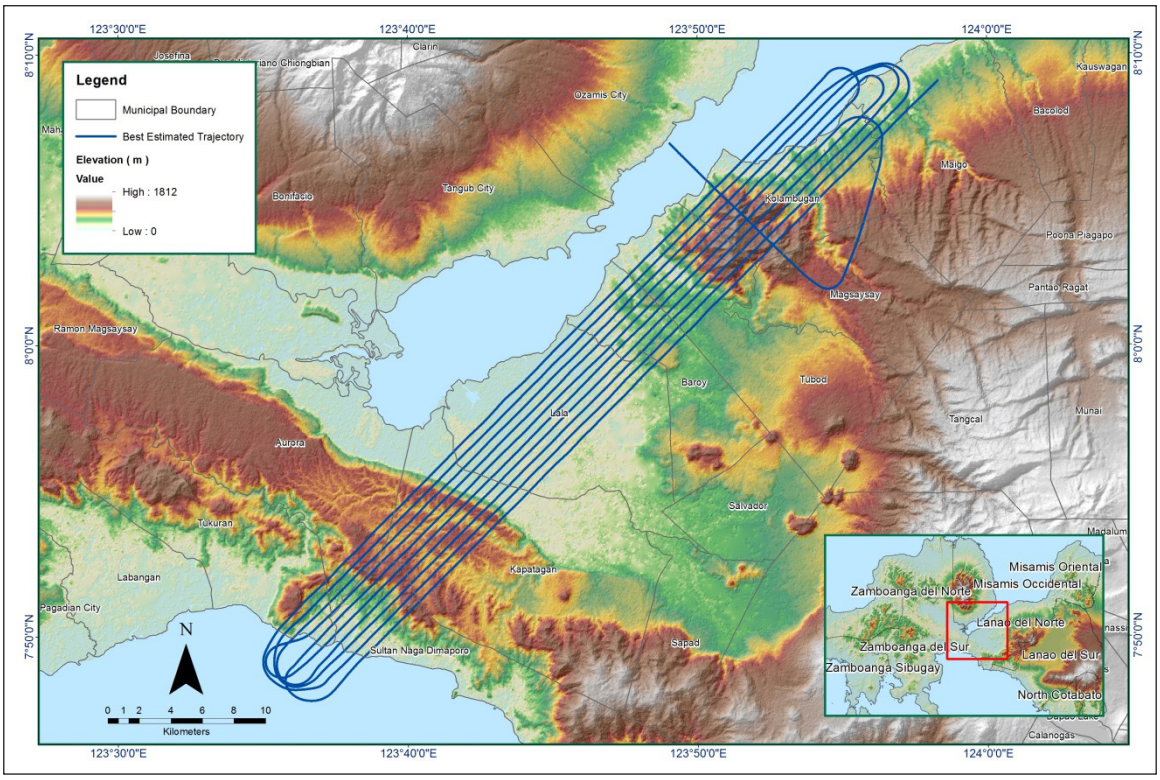


Figure A-8.59. Best Estimated Trajectory

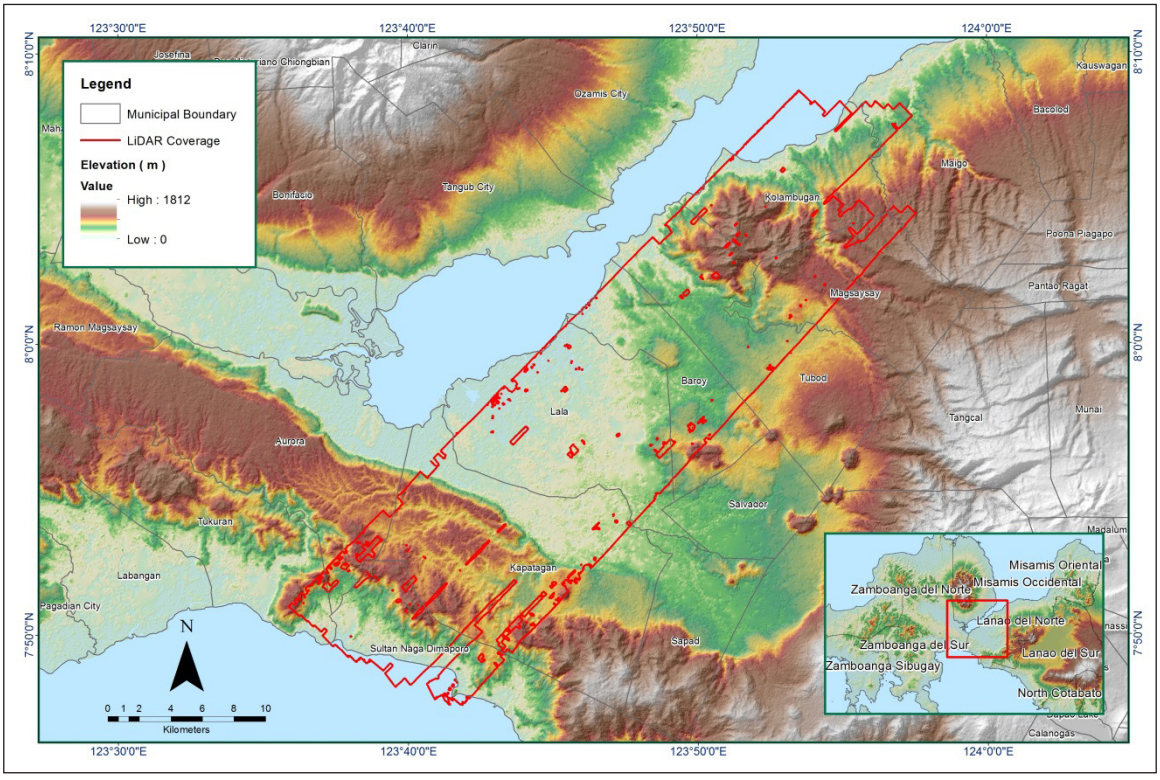


Figure A-8.60.

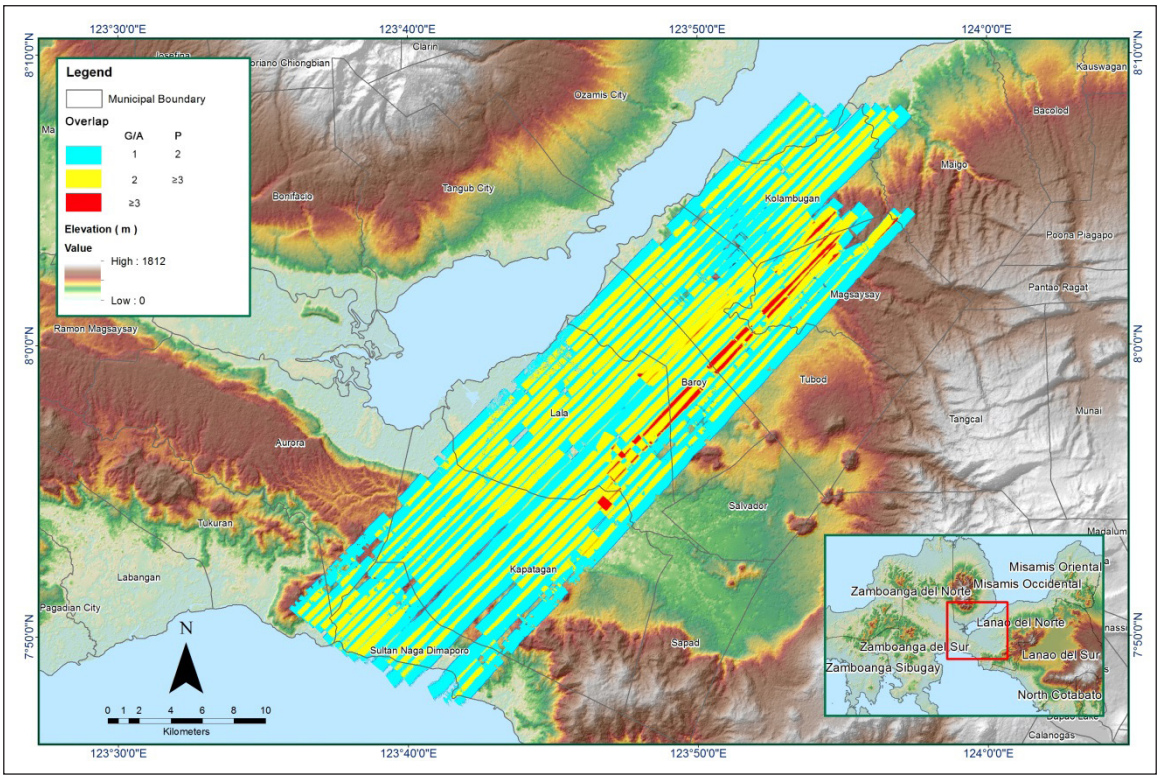


Figure A-8.61.

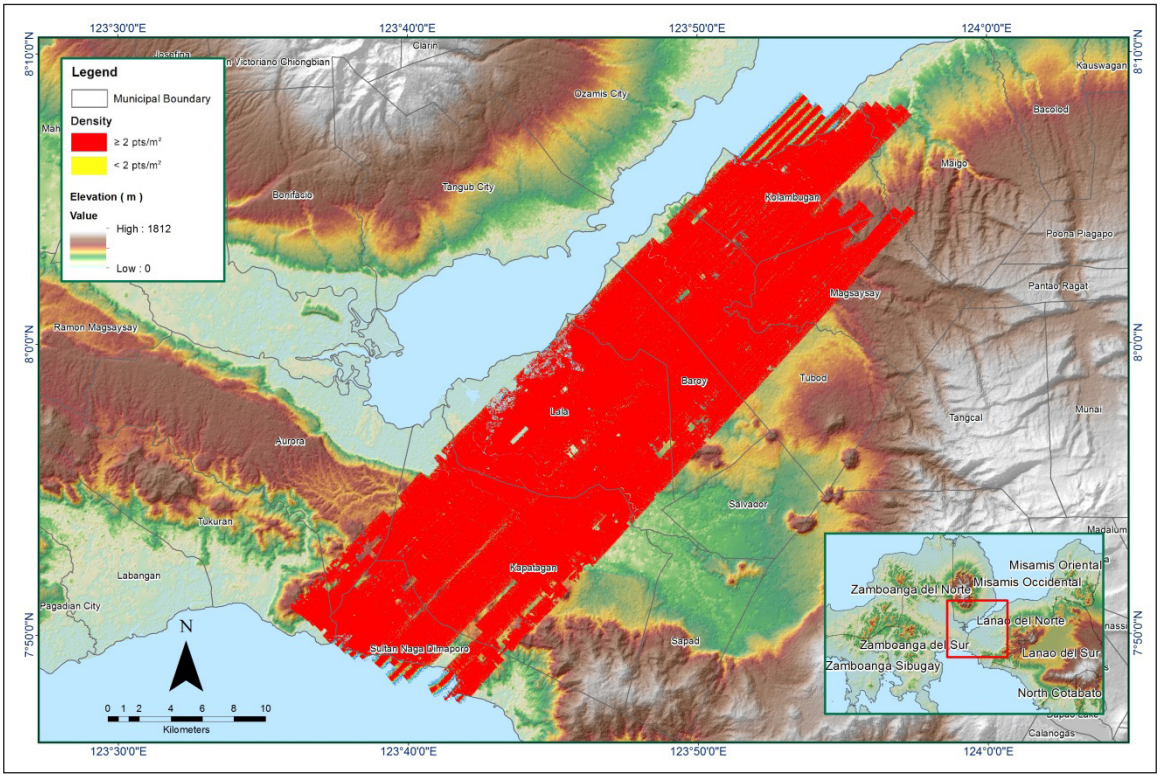


Figure A-8.62. Density map of merged LiDAR data

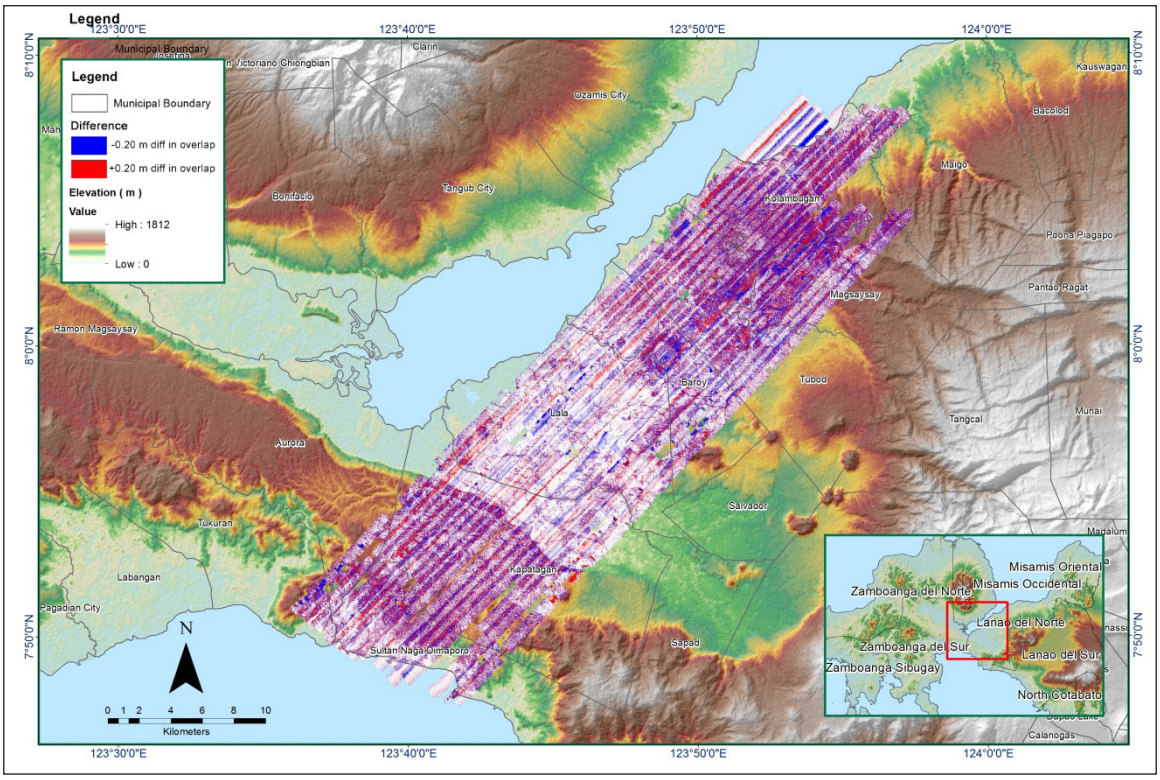

Legend
Municipal Boundary
Difference
-0.20 m diff in overlap
+0.20 m diff in overlap
Elevation (m)
Value
High : 1812
Low : 0
123°30'0"E
123°40'0"E
123°50'0"E
124°0'0"E
8°10'0"N
8°0'0"N
7°50'0"N
Clarin
Ozamis City
Bonifacio
Tangub City
Kolambugan
Baroy
Tubod
Lala
Aurora
Tukuran
Salvador
Kapatagan
Sapad
Sultan Naga Dimaporo
Labangan
Pagadian City
Ramon Magsaysay
Magsaysay
Pantao Ragat
Poona Piagapo
Maigo
Kauswagan
Tangcal
Munai
Misamis Oriental
Misamis Occidental
Zamboanga del Norte
Lanao del Norte
Zamboanga del Sur
Lanao del Sur
Zamboanga Sibugay
North Cotabato
N
0 1 2 4 6 8 10
Kilometers

Figure A-8.63.

Table A-8.10. Mission Summary Report for Mission Blk71G

Flight Area	**Northern Mindanao**
Mission Name	**Blk71G**
Inclusive Flights	1613P
Range data size	33.2 GB
POS	258 MB
Image	67.3 GB
Transfer date	August 1, 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)	1.2
RMSE for East Position (<4.0 cm)	1.3
RMSE for Down Position (<8.0 cm)	3.0
Boresight correction stdev (<0.001deg)	0.000236
IMU attitude correction stdev (<0.001deg)	0.000781
GPS position stdev (<0.01m)	0.0018
Minimum % overlap (>25)	36.24%
Ave point cloud density per sq.m. (>2.0)	6.63
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	362
Maximum Height	766.63 m
Minimum Height	62.51 m
Classification (# of points)	
Ground	286,954,240
Low vegetation	266,488,104
Medium vegetation	404,520,939
High vegetation	376,191,706
Building	8,947,468
Orthophoto	YES
Processed by	Engr. Irish Cortez, Engr. Chelou Prado, Engr. Ma. Ailyn Olanda

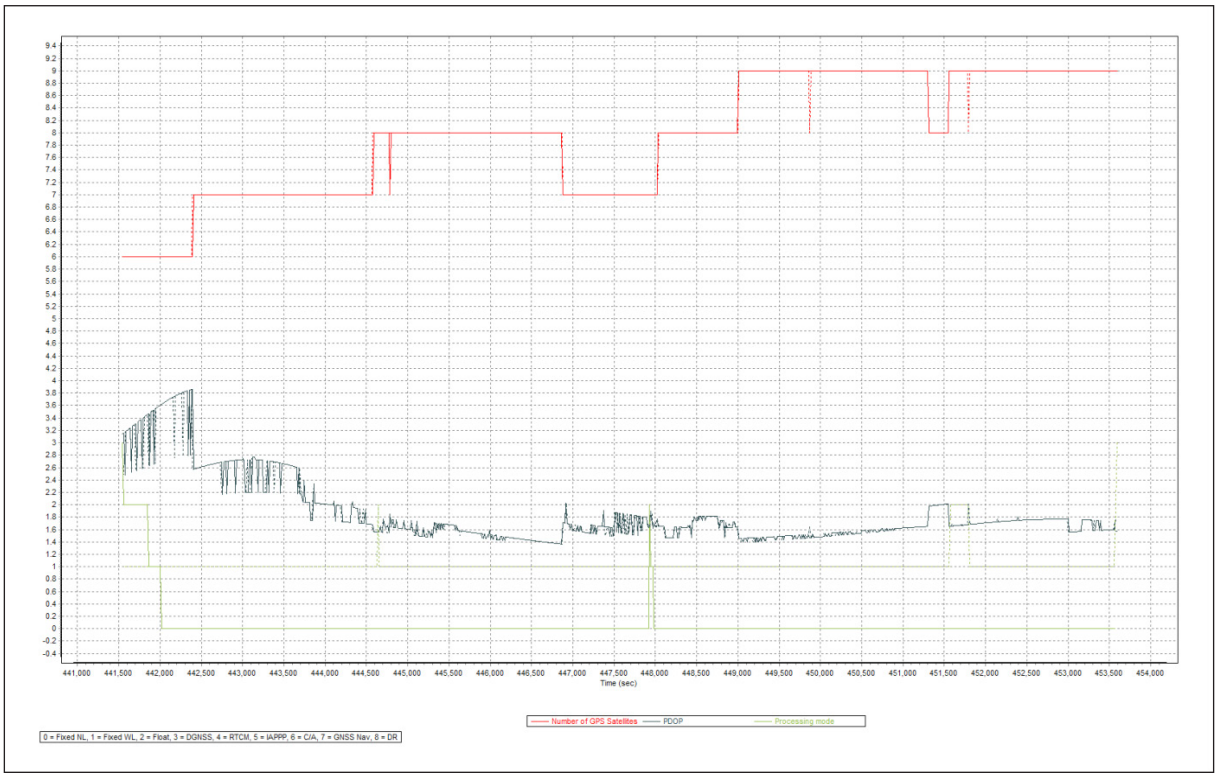


Figure A-8.64. Solution Status

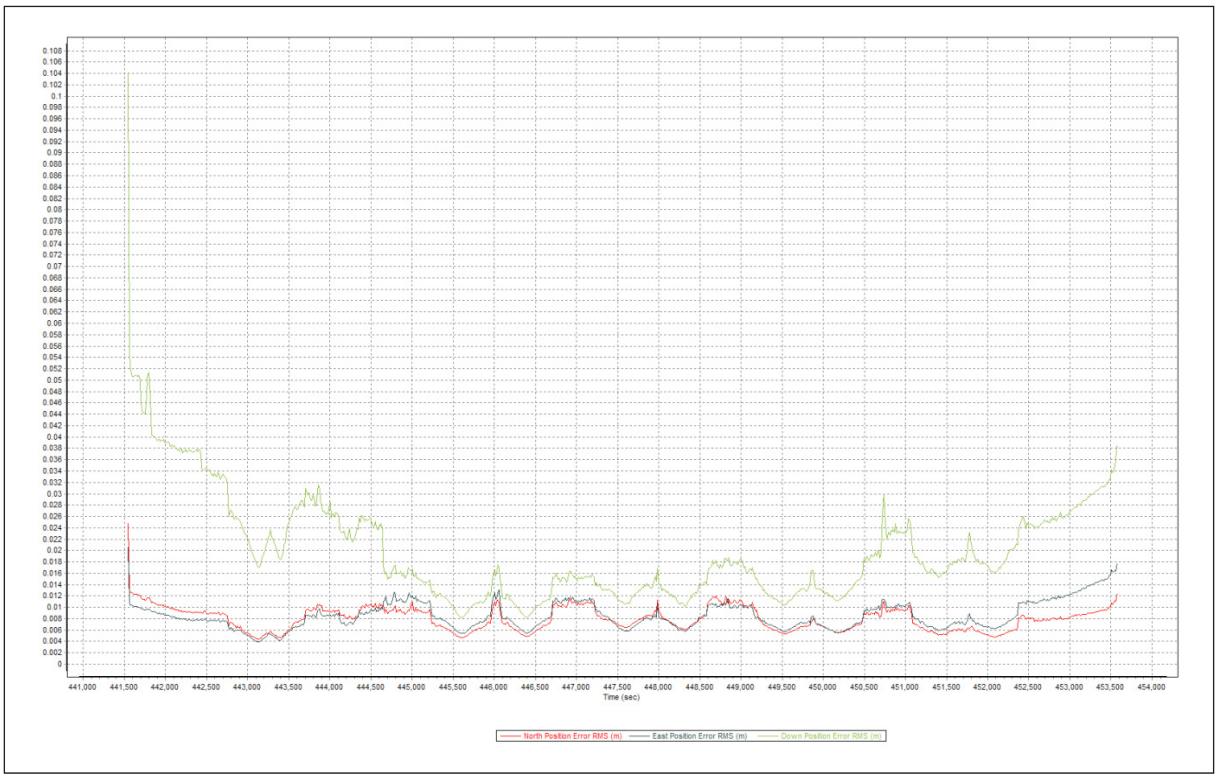


Figure A-8.65. Smoothed Performance Metric Parameters

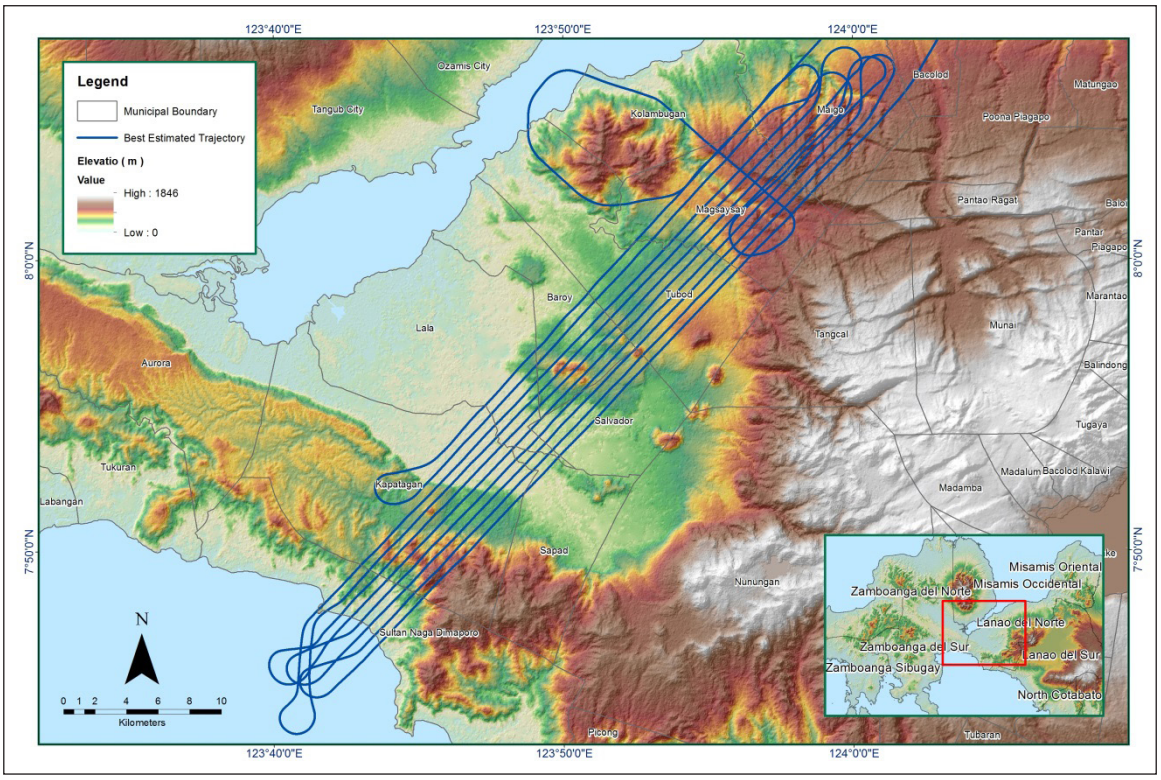


Figure A-8.66. Best Estimated Trajectory

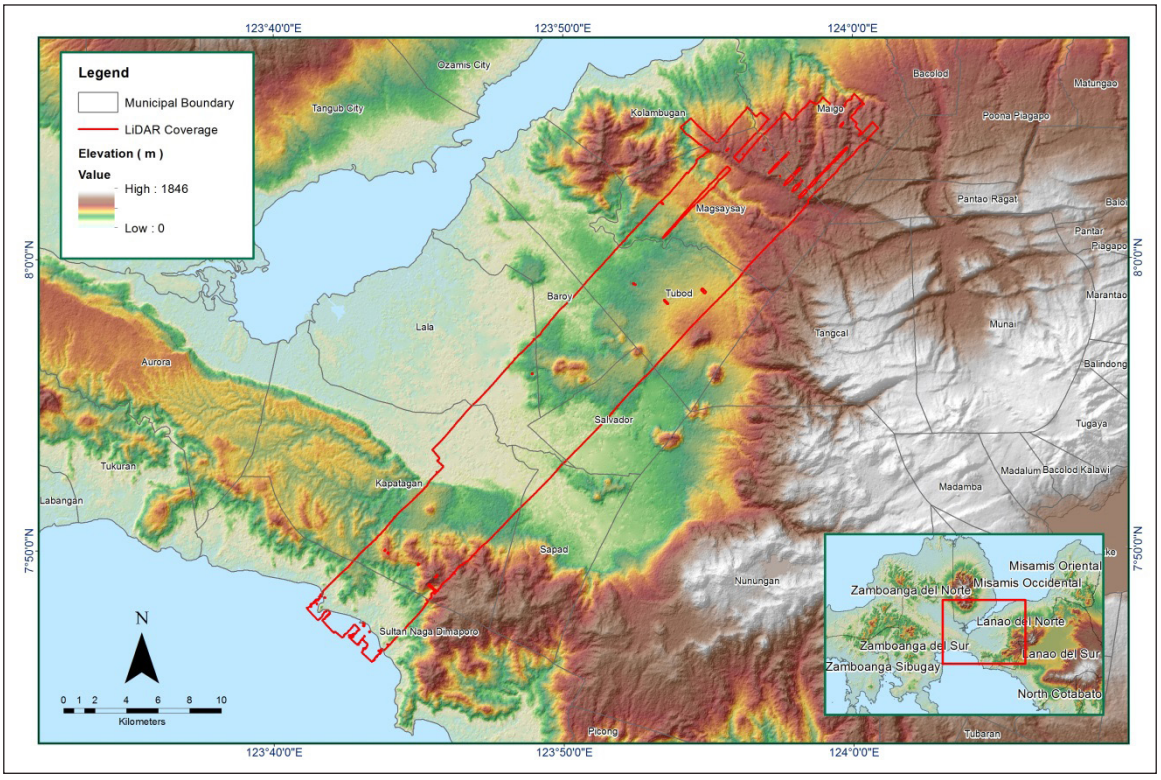


Figure A-8.67.

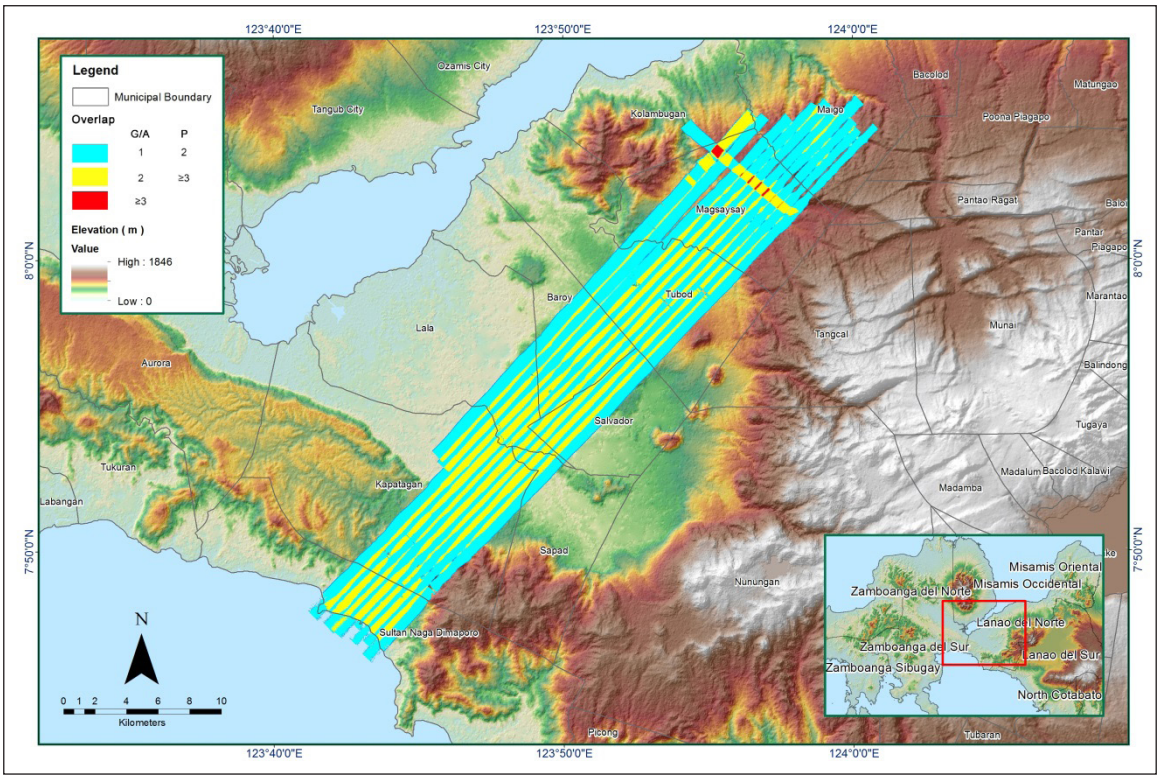


Figure A-8.68.

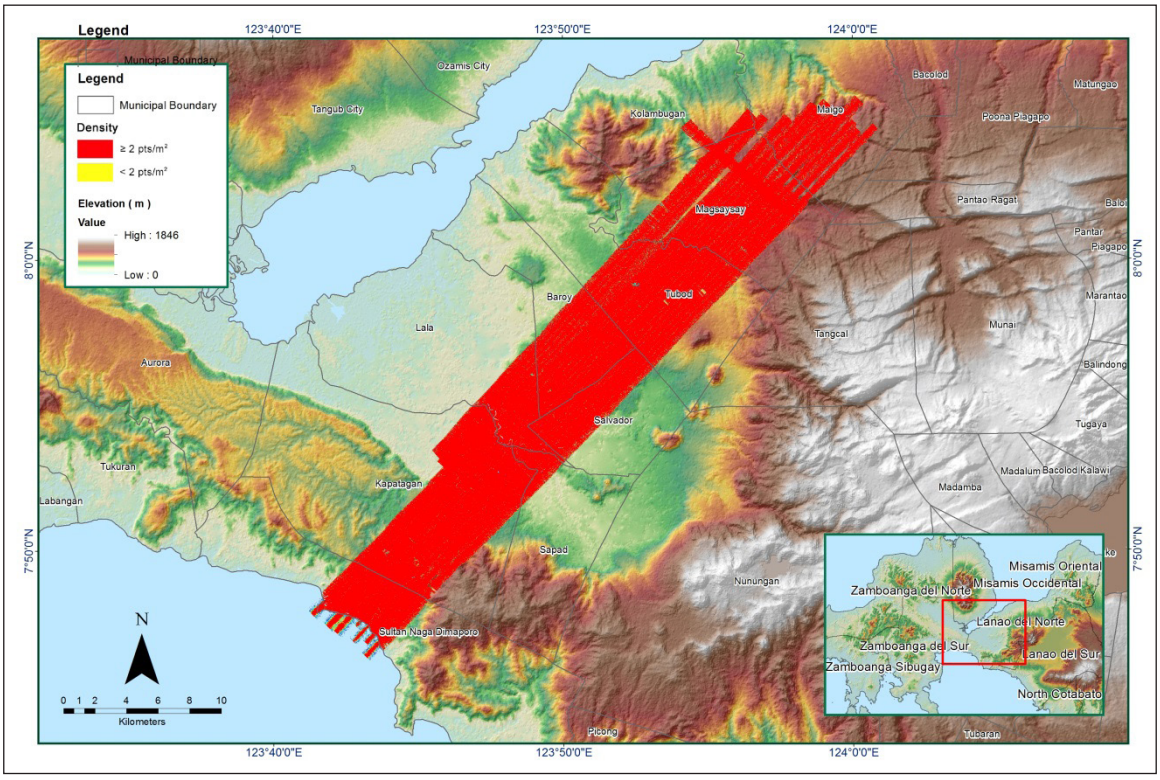


Figure A-8.69. Density map of merged LiDAR data

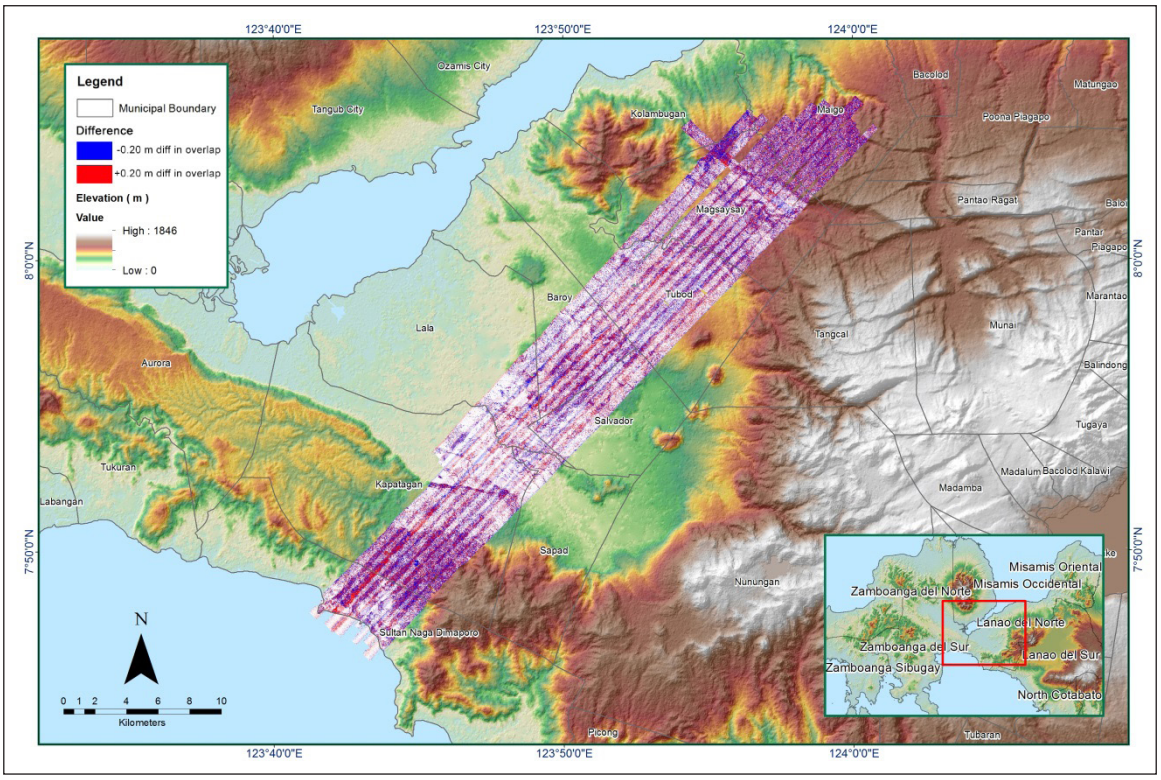

123°40'0"E
123°50'0"E
124°0'0"E
8°0'0"N
7°50'0"N
Legend
Municipal Boundary
Difference
-0.20 m diff in overlap
+0.20 m diff in overlap
Elevation (m)
Value
High : 1846
Low : 0
Ozamis City
Tangub City
Kolambugan
Maigo
Bacolod
Matungao
Poona Piagapo
Pantao Ragat
Magsaysay
Baroy
Tubod
Lala
Aurora
Tangcal
Munai
Marantao
Balindong
Salvador
Tugaya
Tukuran
Kapatagan
Madamba
Madalum
Bacolod Kalawi
Labangan
Sapad
Nunungan
Sultan Naga Dimaporo
Misamis Oriental
Misamis Occidental
Zamboanga del Norte
Lanao del Norte
Zamboanga del Sur
Lanao del Sur
Zamboanga Sibugay
North Cotabato
Tubaran
Piong
N
0 1 2 4 6 8 10
Kilometers

Figure A-8.70.

Table A-8.11. Mission Summary Report for Mission Blk76M

Flight Area	Dipolog Reflights
Mission Name	**Blk76M**
Inclusive Flights	23602P
Range data size	16.5 GB
POS data size	287 MB
Base data size	53.7 MB
Image	n/a
Transfer date	December 6, 2016
Solution Status	
Number of Satellites (>6)	No
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	2.005
RMSE for East Position (<4.0 cm)	2.665
RMSE for Down Position (<8.0 cm)	4.473
Boresight correction stdev (<0.001deg)	0.001490
IMU attitude correction stdev (<0.001deg)	0.001292
GPS position stdev (<0.01m)	0.0194
Minimum % overlap (>25)	42.48 %
Ave point cloud density per sq.m. (>2.0)	3.50
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	108
Maximum Height	745.53 m
Minimum Height	91.32 m
Classification (# of points)	
Ground	77,707,647
Low vegetation	71,425,986
Medium vegetation	116,978,079
High vegetation	217,831,248
Building	2,673,553
Orthophoto	No
Processed by	Engr. Irish Cortez, Engr. Erica Erin Elazegui, Engr. Monalyne Rabino

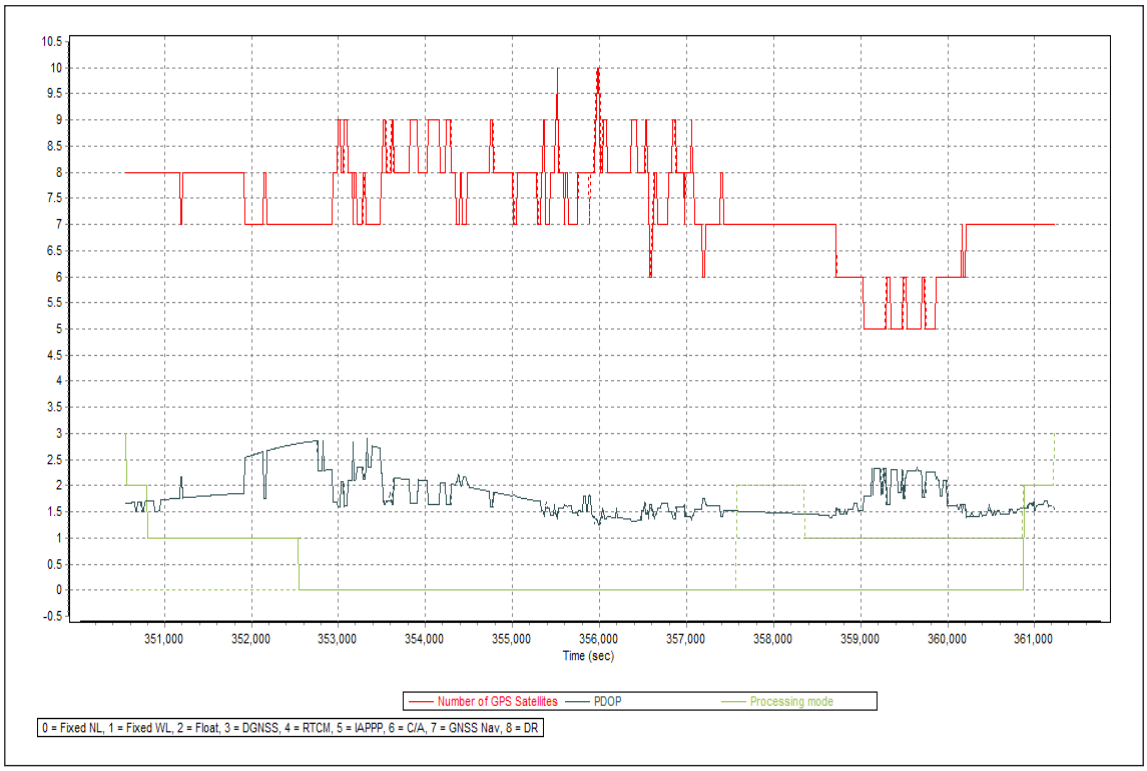


Figure A-8.71. Solution Status

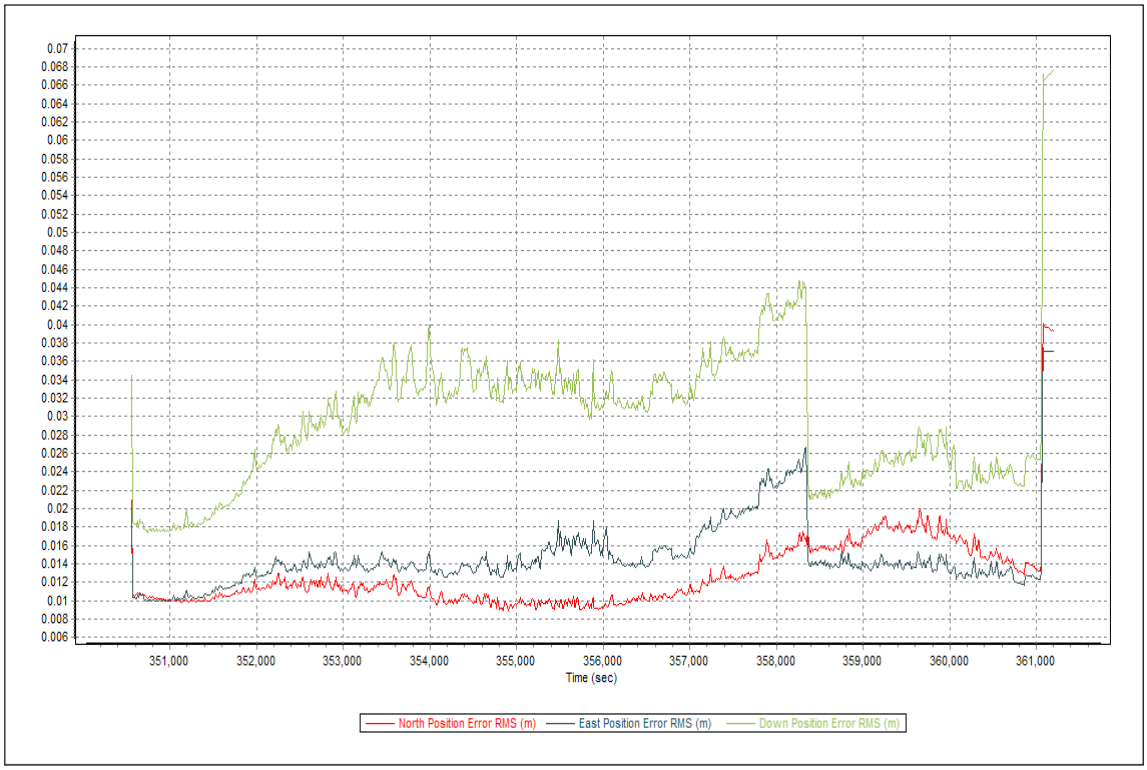


Figure A-8.72. Smoothed Performance Metric Parameters

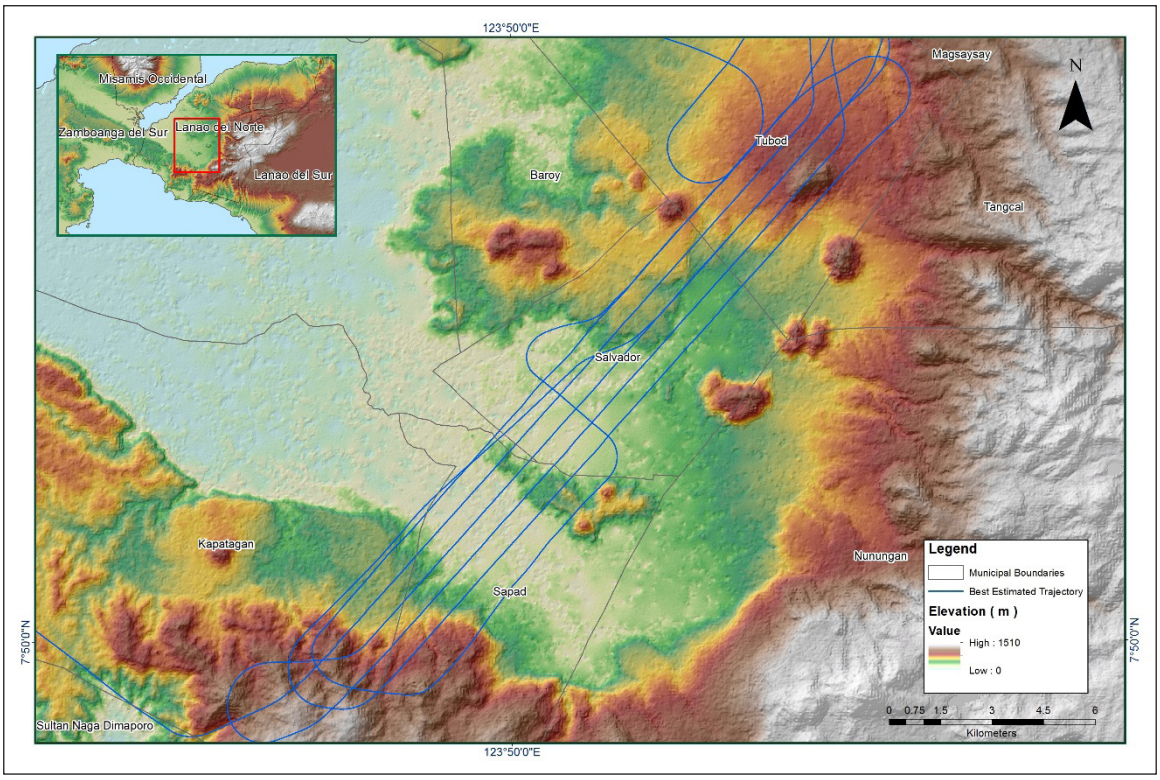


Figure A-8.73. Best Estimated Trajectory

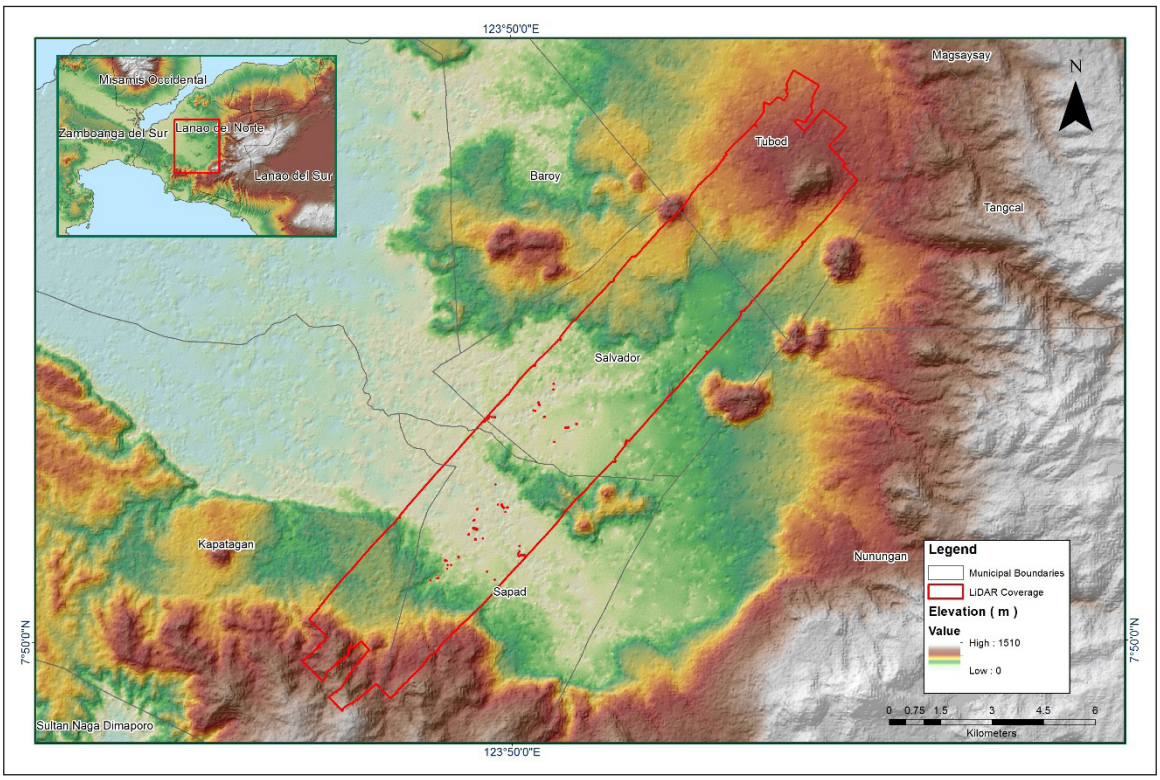


Figure A-8.74. Coverage of LiDAR Data

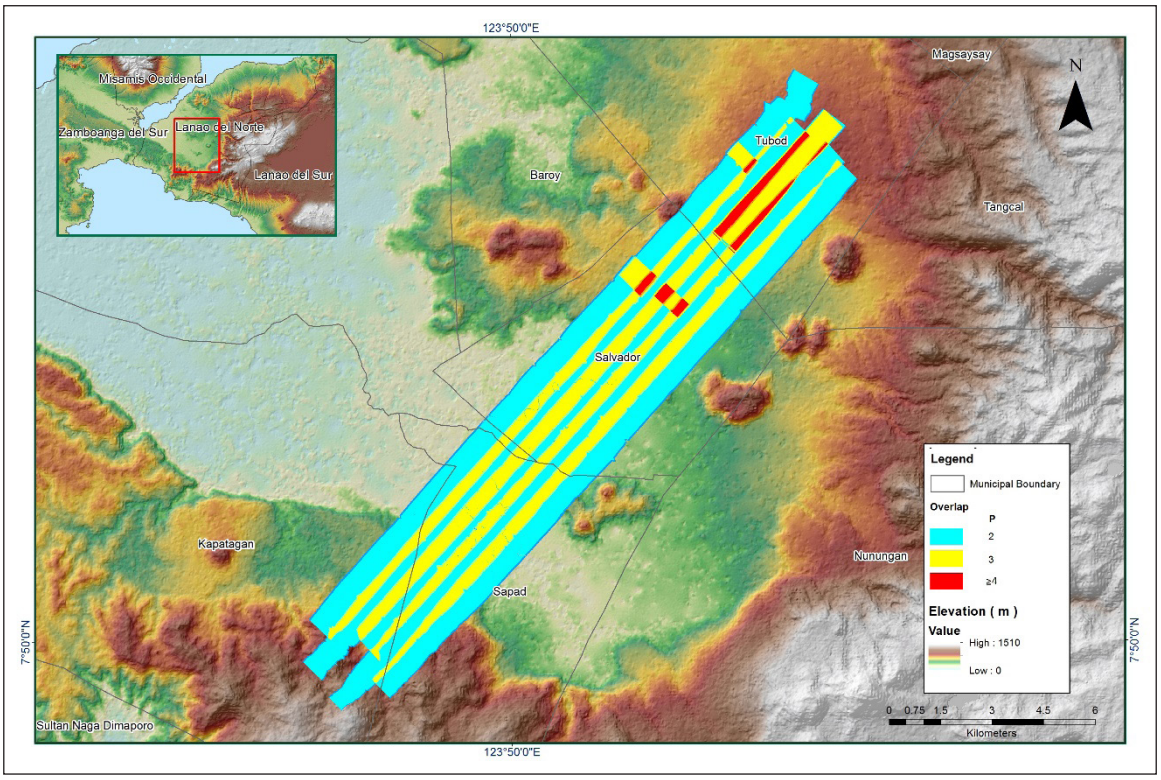


Figure A-8.75. Image of data overlap

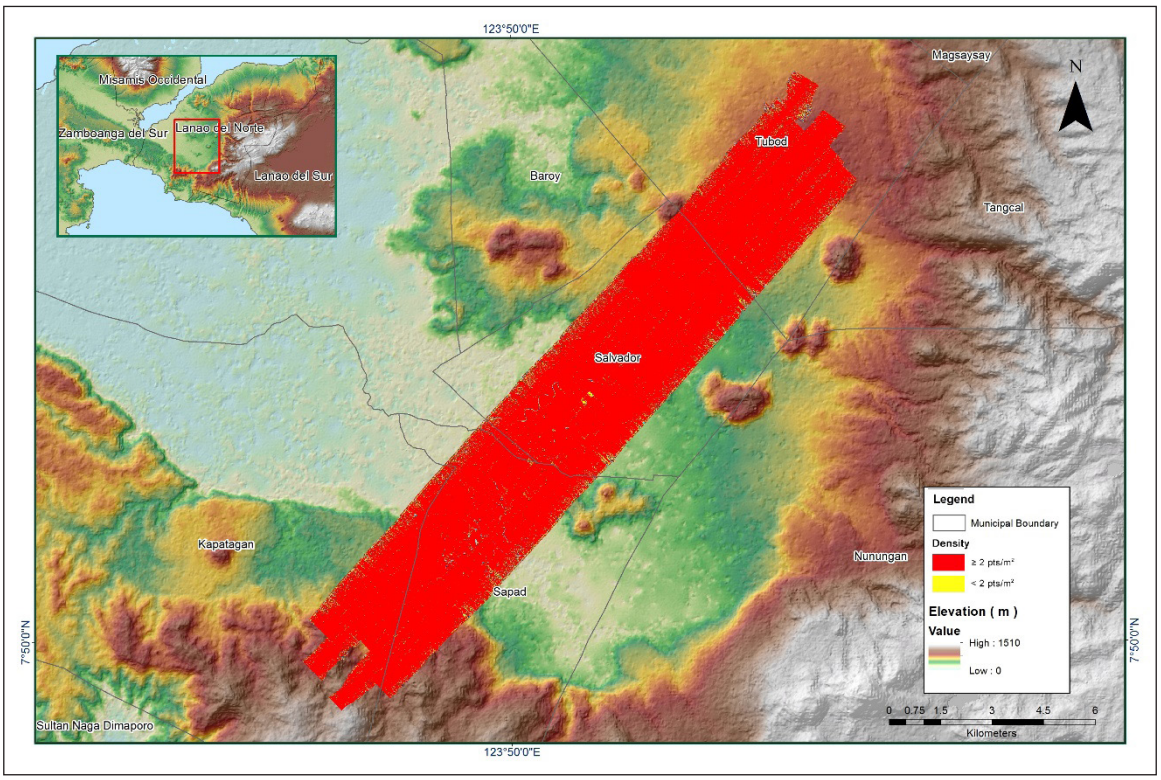


Figure A-8.76. Density map of merged LiDAR data

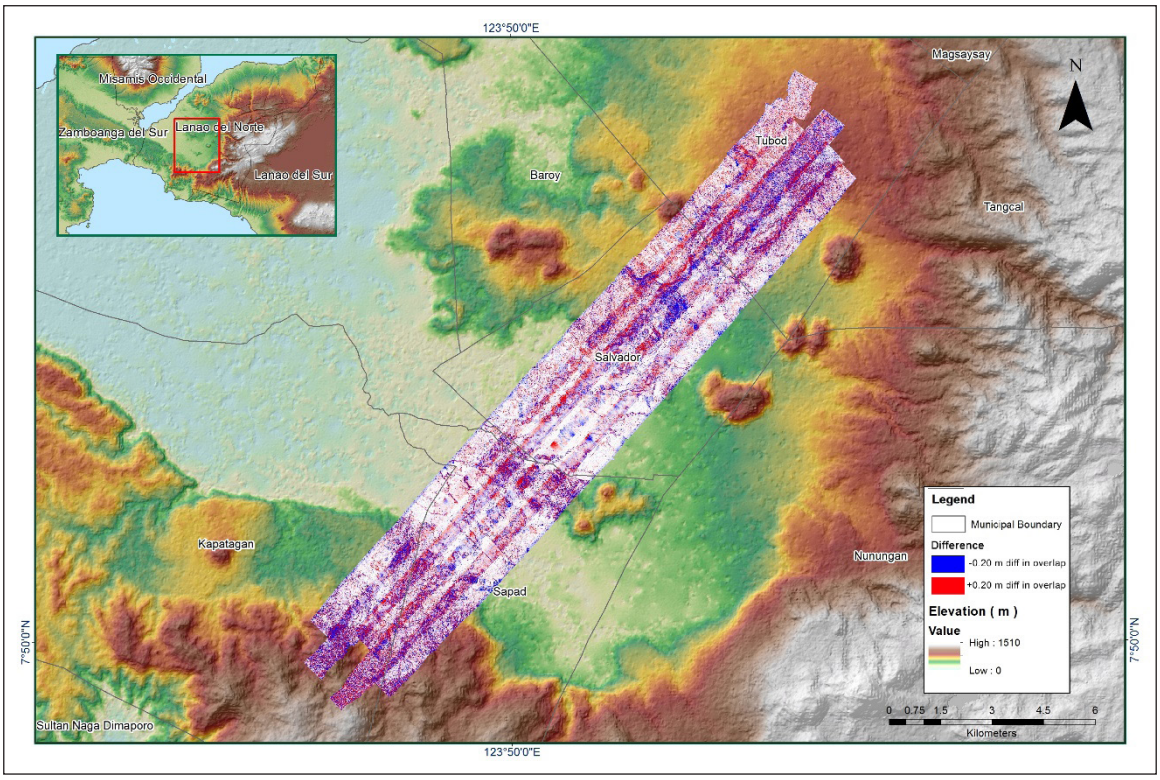


Figure A-8.77. Elevation difference between flight lines

Table A-8.12. Mission Summary Report for Mission Blk76N_Supplement

Flight Area	Pagadian
Mission Name	**Blk76N_Supplement**
Inclusive Flights	23104P
Range data size	18.3 GB
POS data size	287.01 MB
Base data size	116.78 MB
Image	25.87 GB
Transfer date	March 1, 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)	2.2
RMSE for Down Position (<8.0 cm)	4.2
Boresight correction stdev (<0.001deg)	0.000502
IMU attitude correction stdev (<0.001deg)	0.001509
GPS position stdev (<0.01m)	0.0017
Minimum % overlap (>25)	14.43
Ave point cloud density per sq.m. (>2.0)	2.64

Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	13
Maximum Height	368.25
Minimum Height	93.58
Classification (# of points)	
Ground	4,438,634
Low vegetation	1,755,258
Medium vegetation	1,534,601
High vegetation	4,444,966
Building	34,342
Orthophoto	Yes
Processed by	Engr. Don Matthew Banatin, Engr. Justine Francisco, Engr. Gladys Mae Apat

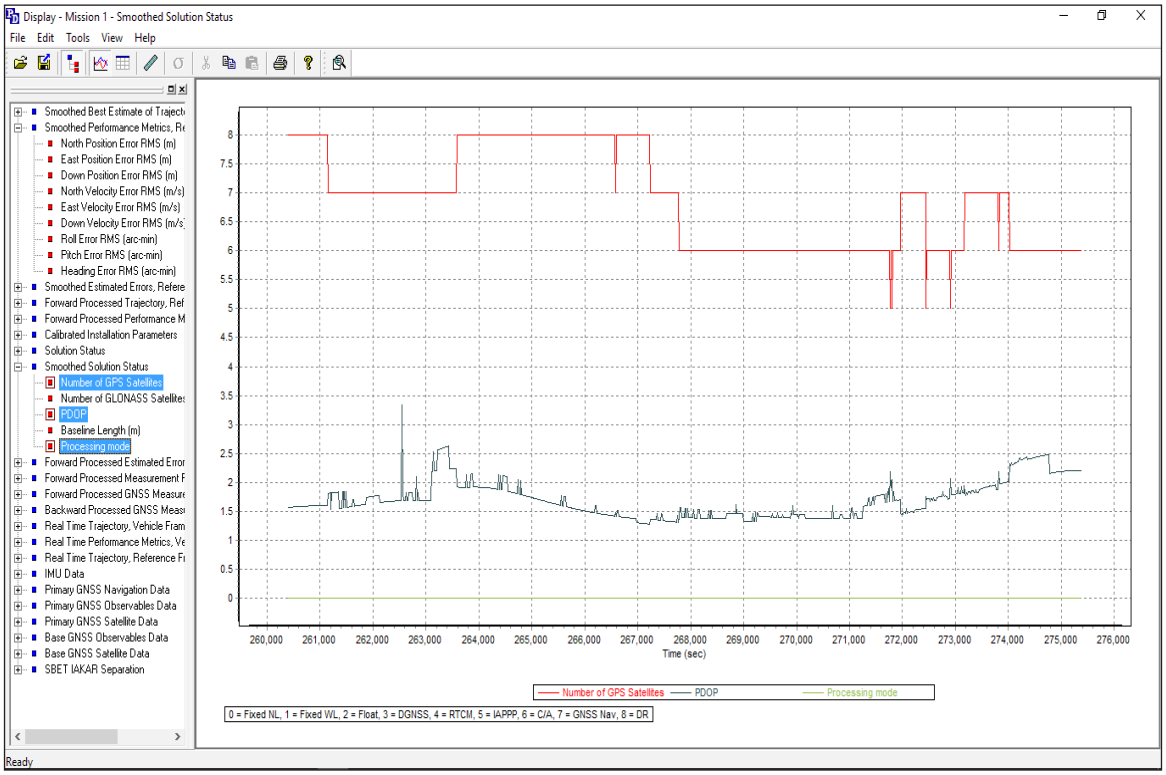


Figure A-8.78. Solution Status

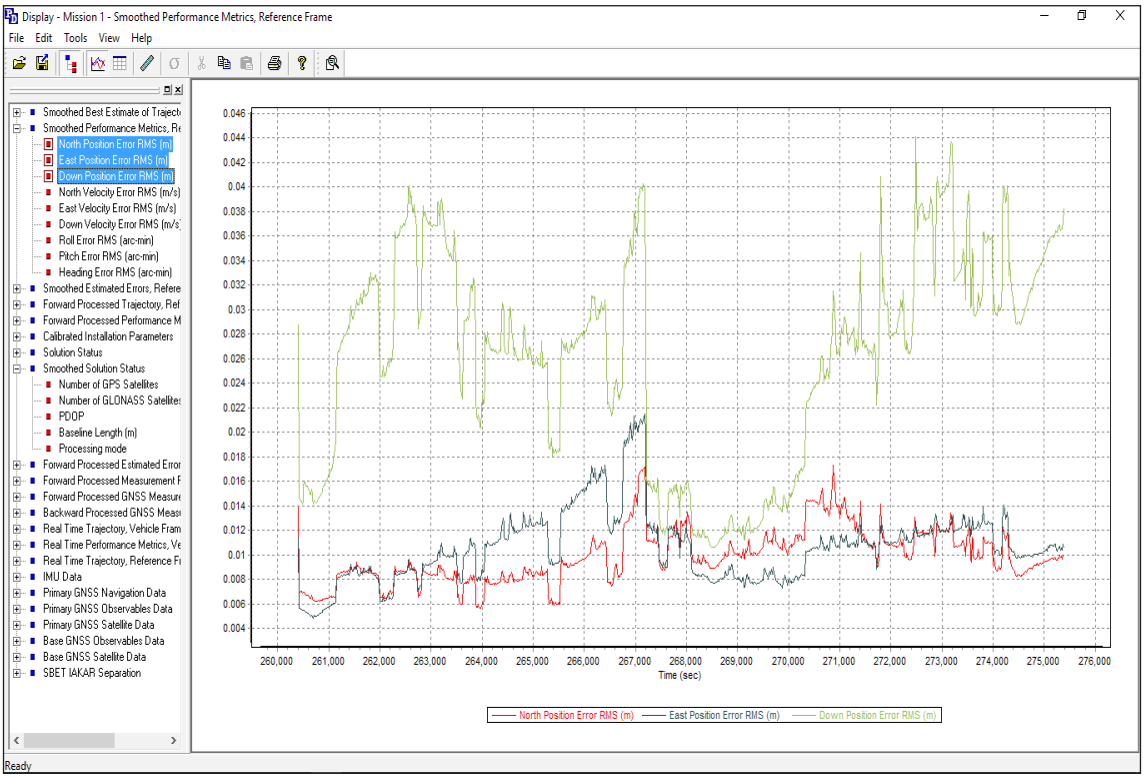


Figure A-8.79. Smoothed Performance Metric Parameters

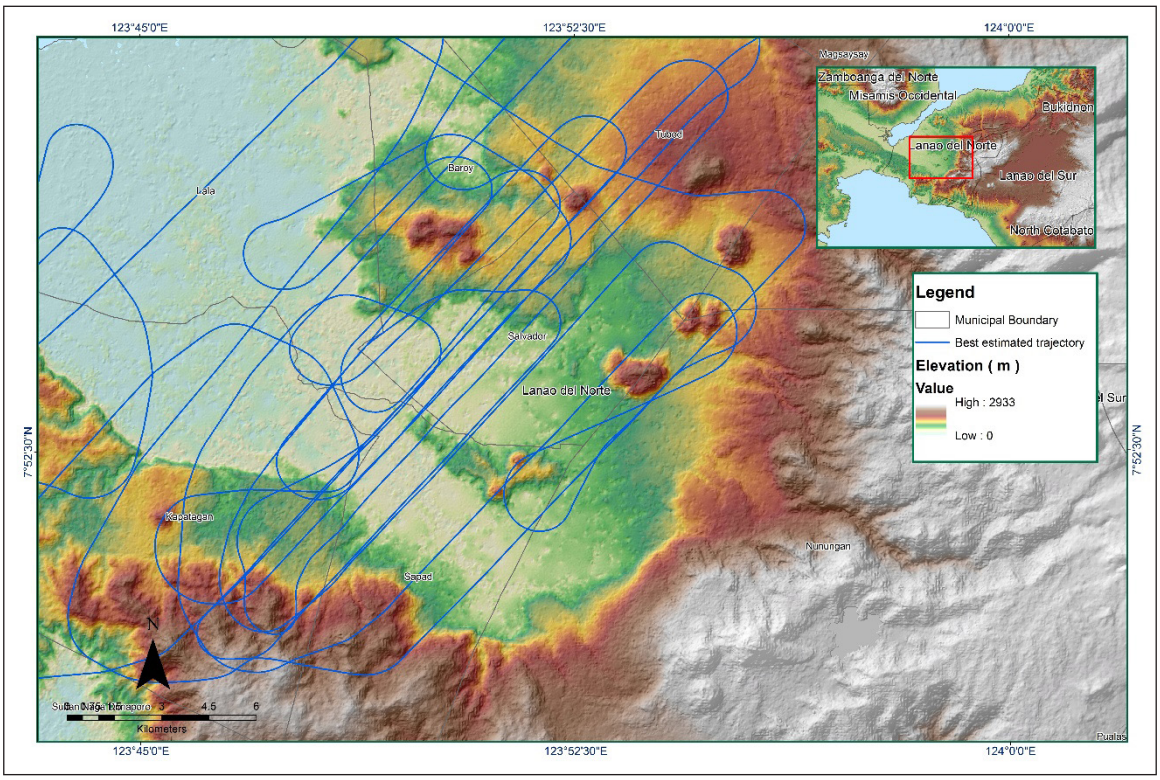


Figure A-8.80. Best Estimated Trajectory

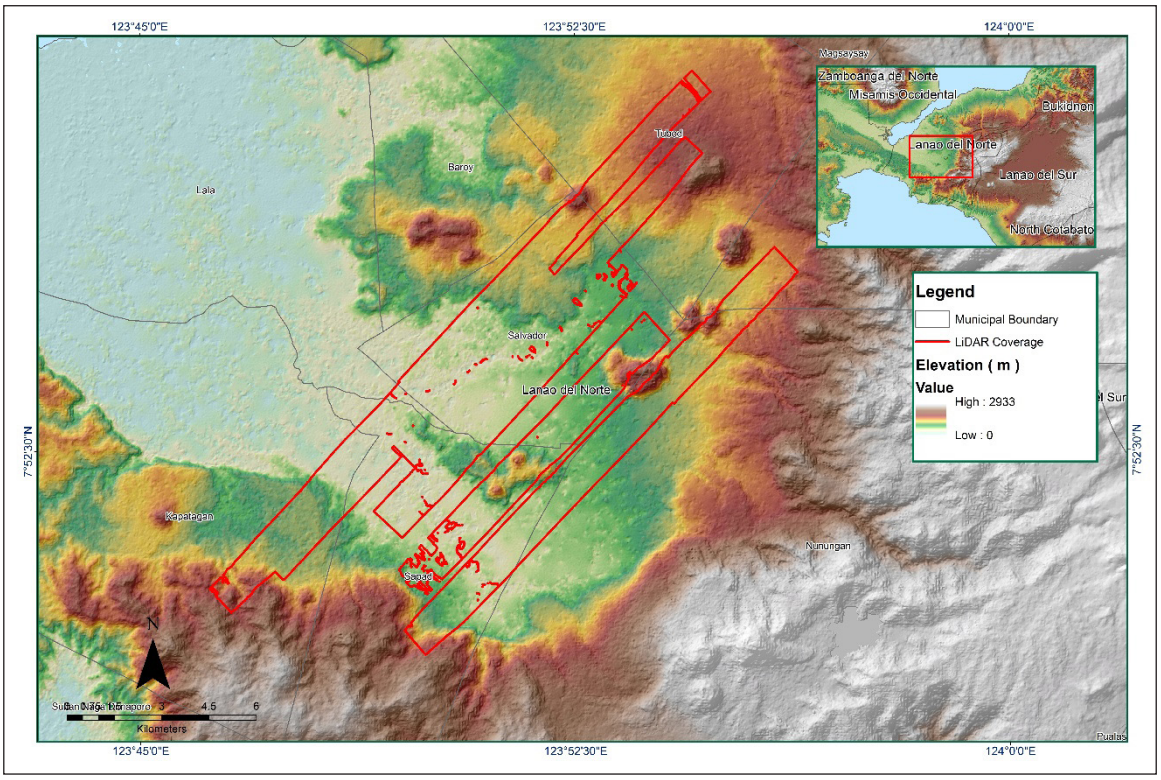


Figure A-8.81. Coverage of LiDAR Data

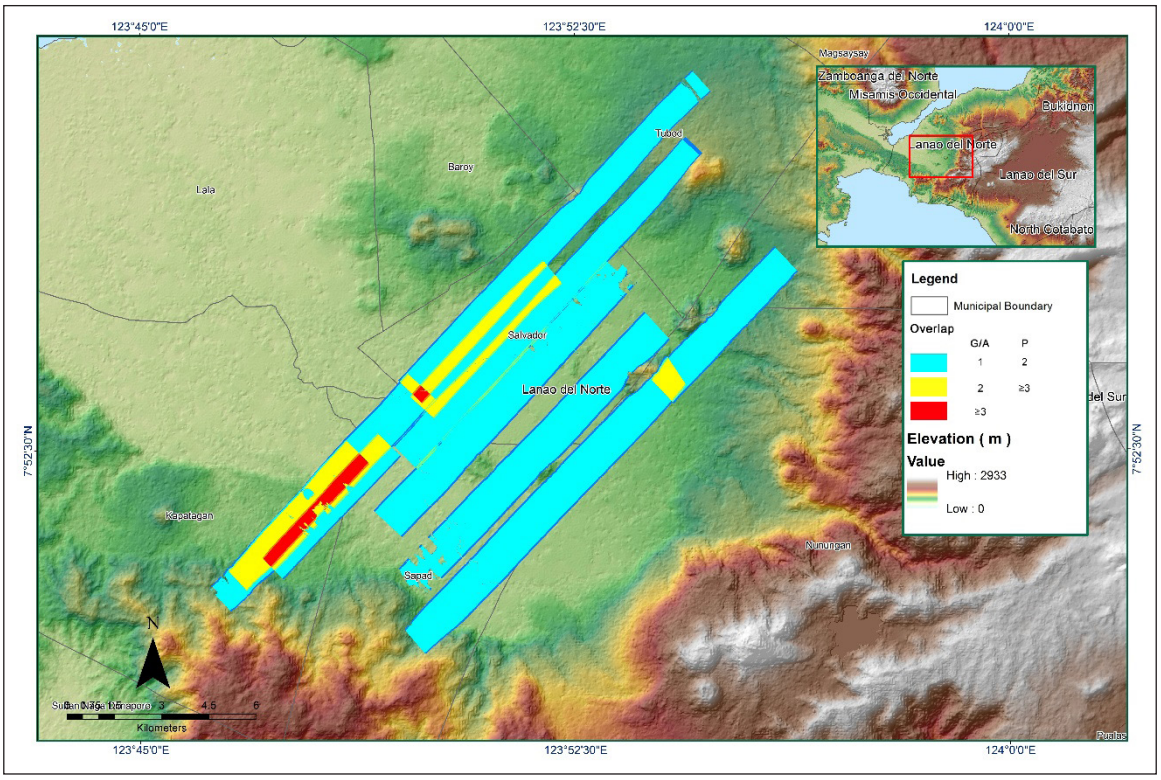


Figure A-8.82. Image of data overlap

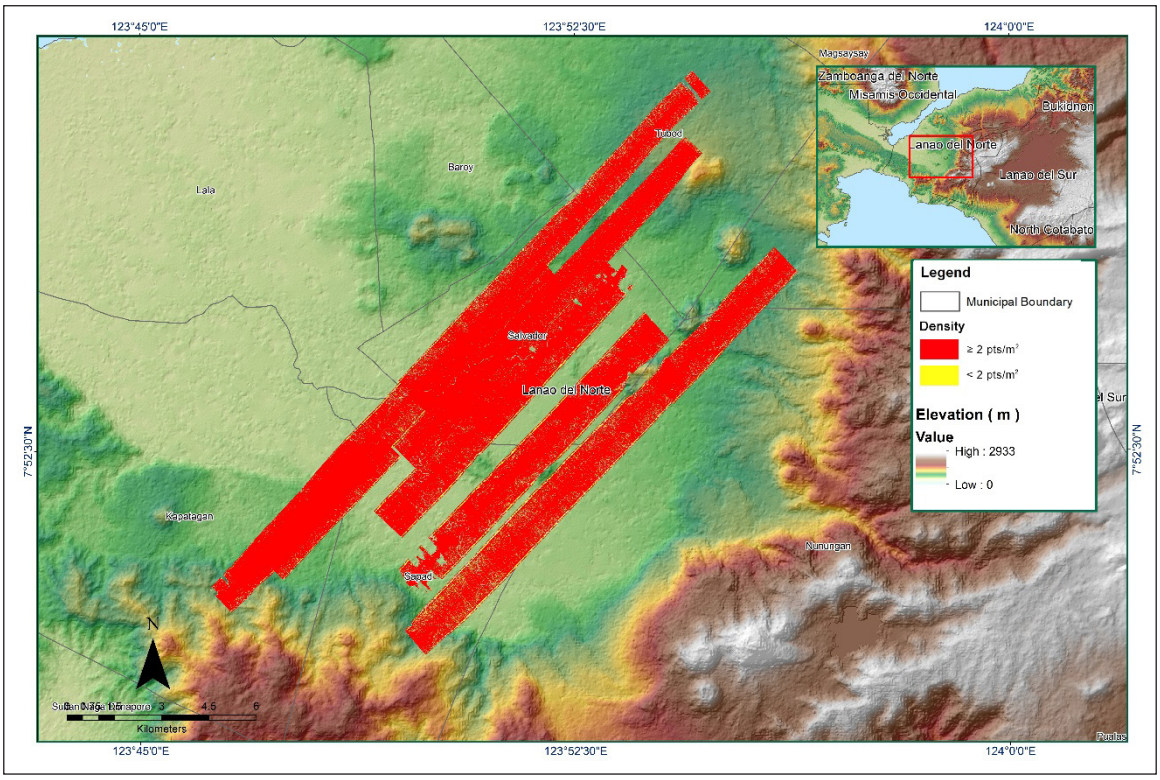


Figure A-8.83. Density map of merged LiDAR data

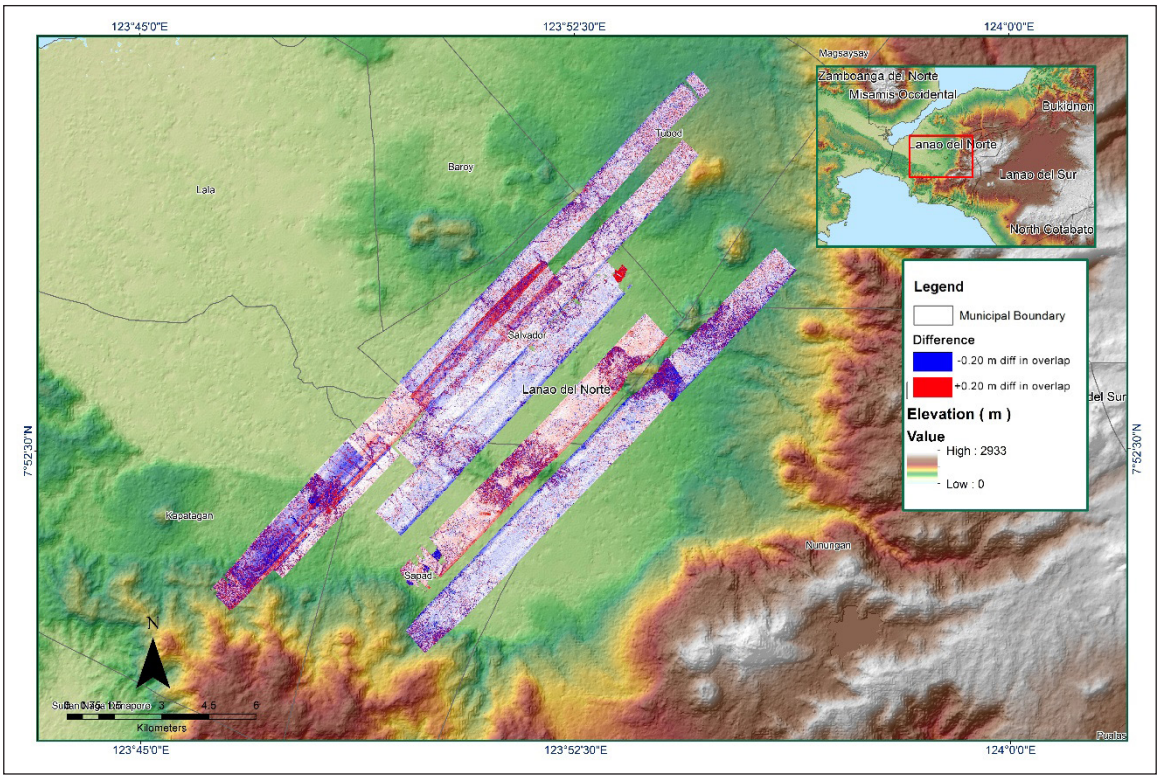


Figure A-8.84. Elevation difference between flight lines

Annex 9. Butadon Model Basin Parameters

Table A-9.1. Butadon Model Basin Parameters

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m^3/s)	Recession Constant	Threshold Type	Ratio to Peak
W310	6.96643	80.709	0	5.30575	0.2376	Discharge	0.64515	1	Ratio to Peak	0.01
W330	3.92326	88.136	0	2.292825	0.23607	Discharge	0.39334	1	Ratio to Peak	0.01
W340	4.18472	82.352	0	2.268025	0.15236	Discharge	0.3366	0.34341	Ratio to Peak	0.01
W350	4.55906	74.160	0	4.24875	0.999675	Discharge	0.64332	0.44444	Ratio to Peak	0.01
W360	5.0592	79.423	0	3.15375	0.14094	Discharge	0.44978	0.40994	Ratio to Peak	0.01
W370	3.69699	88.743	0	3.11225	0.219807	Discharge	0.3356	1	Ratio to Peak	0.01
W380	12.5188	60.936	0	4.57175	0.48105	Discharge	0.31801	0.62746	Ratio to Peak	0.01
W390	15.05129	56.473	0	6.3615	0.44622	Discharge	0.44198	1	Ratio to Peak	0.01
W400	10.08729	65.939	0	3.9095	0.26262	Discharge	0.2206	0.65333	Ratio to Peak	0.01
W420	15.65938	65.050	0	4.0755	0.642645	Discharge	0.38418	0.27887	Ratio to Peak	0.01
W440	28.7249	50.364	0	4.78975	0.482625	Discharge	0.38651	1	Ratio to Peak	0.01
W460	8.33306	60.973	0	4.485	0.4187475	Discharge	0.35373	1	Ratio to Peak	0.01
W480	21.0358	48.017	0	4.28325	0.440415	Discharge	0.14396	1	Ratio to Peak	0.01
W500	14.68613	56.954	0	15.27375	2.438775	Discharge	1.0143	0.64027	Ratio to Peak	0.01
W510	3.19549	85.937	0	3.6545	0.360855	Discharge	1.1533	1	Ratio to Peak	0.01
W520	7.88273	71.243	0	4.7875	0.2232405	Discharge	0.58942	0.40994	Ratio to Peak	0.01
W540	3.72453	77.841	0	5.46975	0.5643675	Discharge	1.4676	1	Ratio to Peak	0.01
W550	5.53486	70.273	0	5.11025	1.20663	Discharge	1.1189	1	Ratio to Peak	0.01
W560	27.1252	51.796	0	4.8145	1.7048025	Discharge	0.29077	0.66667	Ratio to Peak	0.01
W570	13.80502	58.585	0	5.1665	1.22544	Discharge	0.30009	1	Ratio to Peak	0.01
W580	2.42199	84.325	0	3.1215	0.3160125	Discharge	0.51532	0.066667	Ratio to Peak	0.01

Annex 10. Butadon Model Reach Parameters

Table A-10.1. Butadon Model Reach Parameters

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
R10	Automatic Fixed Interval	428.14	0.0010421	0.06	Trapezoid	35.592	1
R100	Automatic Fixed Interval	5800.6	0.0093503	0.06	Trapezoid	24.672	1
R120	Automatic Fixed Interval	770.83	0.0050567	0.06	Trapezoid	15.872	1
R140	Automatic Fixed Interval	933.26	0.0221706	0.06	Trapezoid	7.77	1
R150	Automatic Fixed Interval	4881.4	0.0087832	0.06	Trapezoid	14.086	1
R160	Automatic Fixed Interval	1823.4	0.0021696	0.06	Trapezoid	25.192	1
R170	Automatic Fixed Interval	3467.8	0.0038991	0.06	Trapezoid	11.516	1
R190	Automatic Fixed Interval	512.84	0.0045588	0.06	Trapezoid	11.804	1
R20	Automatic Fixed Interval	525.27	0.0020863	0.06	Trapezoid	14.728	1
R200	Automatic Fixed Interval	1437.8	0.0045993	0.06	Trapezoid	8.334	1
R210	Automatic Fixed Interval	1522.0	0.0052474	0.06	Trapezoid	14.828	1
R50	Automatic Fixed Interval	2798.1	.00042479912	0.06	Trapezoid	7.554	1
R60	Automatic Fixed Interval	1745.1	0.0036411	0.06	Trapezoid	7.554	1
R90	Automatic Fixed Interval	2384.8	0.0108841	0.06	Trapezoid	14.852	1

Annex 11. ButadonField Validation Points

Table A-11.1. Butadon Field Validation Points

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
1	7.981514	123.794207	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
2	7.981691	123.794444	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
3	7.988185	123.778945	0.03	0.55	-0.52	Typhoon Lando / Oct. 12-22, 2015	5-Year
4	7.992743	123.780535	0.03	0.40	-0.37	Typhoon Lando / Oct. 12-22, 2015	5-Year
5	7.992821	123.780438	0.03	0.40	-0.37	Typhoon Lando / Oct. 12-22, 2015	5-Year
6	7.980504	123.785704	0.03	0.30	-0.27	Typhoon Lando / Oct. 12-22, 2015	5-Year
7	7.980538	123.785841	0.03	0.30	-0.27	Typhoon Lando / Oct. 12-22, 2015	5-Year
8	7.980555	123.785979	0.03	0.30	-0.27	Typhoon Lando / Oct. 12-22, 2015	5-Year
9	7.980754	123.785458	0.03	0.30	-0.27	Typhoon Lando / Oct. 12-22, 2015	5-Year
10	7.992839	123.780658	0.03	0.62	-0.59	Typhoon Lando / Oct. 12-22, 2015	5-Year
11	7.980768	123.785349	0.03	0.30	-0.27	Typhoon Lando / Oct. 12-22, 2015	5-Year
12	7.986539	123.779016	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
13	7.986316	123.779231	0.03	0.70	-0.67	Typhoon Lando / Oct. 12-22, 2015	5-Year
14	7.964649	123.778707	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
15	7.964705	123.778708	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
16	7.935516	123.774080	0.03	0.23	-0.2	Typhoon Lando / Oct. 12-22, 2015	5-Year
17	7.938687	123.773976	0.03	0.15	-0.12	Typhoon Lando / Oct. 12-22, 2015	5-Year
18	7.939533	123.768720	0.03	0.10	-0.07	Typhoon Lando / Oct. 12-22, 2015	5-Year
19	7.939532	123.768876	0.03	0.10	-0.07	Typhoon Lando / Oct. 12-22, 2015	5-Year
20	7.980594	123.785456	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
21	7.992973	123.780689	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
22	7.998681	123.786342	0.03	0.20	-0.17	Typhoon Lando / Oct. 12-22, 2015	5-Year
23	7.979651	123.795676	0.03	1.90	-1.87	Typhoon Lando / Oct. 12-22, 2015	5-Year
24	8.001841	123.776630	0.03	0.46	-0.43	Typhoon Lando / Oct. 12-22, 2015	5-Year
25	7.986442	123.779019	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
26	7.987221	123.778188	0.03	0.17	-0.14	Typhoon Lando / Oct. 12-22, 2015	5-Year
27	7.938662	123.774095	0.03	0.15	-0.12	Typhoon Lando / Oct. 12-22, 2015	5-Year
28	7.993127	123.780453	0.03	0.40	-0.37	Typhoon Lando / Oct. 12-22, 2015	5-Year
29	7.932016	123.767185	0.04	0.17	-0.13	Typhoon Lando / Oct. 12-22, 2015	5-Year
30	7.987876	123.779290	0.03	0.09	-0.06	Typhoon Lando / Oct. 12-22, 2015	5-Year
31	7.931320	123.767503	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
32	7.988000	123.779309	0.03	0.55	-0.52	Typhoon Lando / Oct. 12-22, 2015	5-Year
33	7.935873	123.770076	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
34	7.938848	123.774109	0.04	0.15	-0.11	Typhoon Lando / Oct. 12-22, 2015	5-Year
35	7.938566	123.773949	0.05	0.15	-0.1	Typhoon Lando / Oct. 12-22, 2015	5-Year
36	7.935001	123.769311	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
37	7.932096	123.767065	0.09	0.10	-0.01	Typhoon Lando / Oct. 12-22, 2015	5-Year
38	7.931829	123.769548	0.06	0.00	0.06	Typhoon Lando / Oct. 12-22, 2015	5-Year
39	7.986930	123.779105	0.03	0.92	-0.89	Typhoon Lando / Oct. 12-22, 2015	5-Year
40	7.931425	123.767514	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
41	7.987375	123.778212	0.03	0.17	-0.14	Typhoon Lando / Oct. 12-22, 2015	5-Year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
42	7.980544	123.784704	0.03	0.40	-0.37	Typhoon Lando / Oct. 12-22, 2015	5-Year
43	7.939183	123.774124	0.13	0.17	-0.04	Typhoon Lando / Oct. 12-22, 2015	5-Year
44	7.939014	123.774196	0.14	0.30	-0.16	Typhoon Lando / Oct. 12-22, 2015	5-Year
45	7.930260	123.768649	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
46	7.935010	123.769158	0.17	0.00	0.17	Typhoon Lando / Oct. 12-22, 2015	5-Year
47	7.993366	123.780460	0.03	0.98	-0.95	Typhoon Lando / Oct. 12-22, 2015	5-Year
48	7.979634	123.793113	0.03	1.60	-1.57	Typhoon Lando / Oct. 12-22, 2015	5-Year
49	7.996981	123.784958	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
50	7.987914	123.779655	0.10	0.50	-0.4	Typhoon Lando / Oct. 12-22, 2015	5-Year
51	7.935659	123.769877	0.13	0.00	0.13	Typhoon Lando / Oct. 12-22, 2015	5-Year
52	7.931861	123.767512	0.17	0.00	0.17	Typhoon Lando / Oct. 12-22, 2015	5-Year
53	7.939637	123.769425	0.09	0.39	-0.3	Typhoon Lando / Oct. 12-22, 2015	5-Year
54	7.939741	123.769304	0.09	0.00	0.09	Typhoon Lando / Oct. 12-22, 2015	5-Year
55	7.935179	123.774188	0.18	0.26	-0.08	Typhoon Lando / Oct. 12-22, 2015	5-Year
56	7.939873	123.769270	0.11	0.00	0.11	Typhoon Lando / Oct. 12-22, 2015	5-Year
57	7.935655	123.770007	0.14	0.00	0.14	Typhoon Lando / Oct. 12-22, 2015	5-Year
58	7.930678	123.769031	0.13	0.00	0.13	Typhoon Lando / Oct. 12-22, 2015	5-Year
59	7.931603	123.766996	0.27	0.00	0.27	Typhoon Lando / Oct. 12-22, 2015	5-Year
60	7.934922	123.769301	0.19	0.00	0.19	Typhoon Lando / Oct. 12-22, 2015	5-Year
61	7.935779	123.774412	0.23	0.00	0.23	Typhoon Lando / Oct. 12-22, 2015	5-Year
62	7.939654	123.769303	0.21	0.10	0.11	Typhoon Lando / Oct. 12-22, 2015	5-Year
63	8.000130	123.781743	0.03	0.77	-0.74	Typhoon Lando / Oct. 12-22, 2015	5-Year
64	8.004384	123.781422	0.03	0.47	-0.44	Typhoon Lando / Oct. 12-22, 2015	5-Year
65	7.987845	123.779666	0.12	0.50	-0.38	Typhoon Lando / Oct. 12-22, 2015	5-Year
66	7.935589	123.774291	0.29	0.23	0.06	Typhoon Lando / Oct. 12-22, 2015	5-Year
67	7.930747	123.769059	0.26	0.00	0.26	Typhoon Lando / Oct. 12-22, 2015	5-Year
68	7.935669	123.774413	0.30	0.23	0.07	Typhoon Lando / Oct. 12-22, 2015	5-Year
69	8.004526	123.781697	0.09	0.09	0	Typhoon Lando / Oct. 12-22, 2015	5-Year
70	7.987685	123.780079	0.22	0.72	-0.5	Typhoon Lando / Oct. 12-22, 2015	5-Year
71	7.931765	123.769431	0.36	0.00	0.36	Typhoon Lando / Oct. 12-22, 2015	5-Year
72	7.935619	123.774513	0.42	0.23	0.19	Typhoon Lando / Oct. 12-22, 2015	5-Year
73	7.935541	123.774396	0.42	0.23	0.19	Typhoon Lando / Oct. 12-22, 2015	5-Year
74	8.001823	123.781163	0.11	0.80	-0.69	Typhoon Lando / Oct. 12-22, 2015	5-Year
75	7.935156	123.774110	0.51	0.51	0	Typhoon Lando / Oct. 12-22, 2015	5-Year
76	7.980502	123.793189	0.03	0.50	-0.47	Typhoon Lando / Oct. 12-22, 2015	5-Year
77	8.001977	123.781444	0.15	1.10	-0.95	Typhoon Lando / Oct. 12-22, 2015	5-Year
78	7.989308	123.777450	0.03	0.30	-0.27	Typhoon Lando / Oct. 12-22, 2015	5-Year
79	7.989308	123.777450	0.03	0.10	-0.07	Typhoon Lando / Oct. 12-22, 2015	5-Year
80	7.935554	123.774184	0.55	0.23	0.32	Typhoon Lando / Oct. 12-22, 2015	5-Year
81	7.987678	123.780216	0.37	0.70	-0.33	Typhoon Lando / Oct. 12-22, 2015	5-Year
82	8.001891	123.781368	0.20	1.10	-0.9	Typhoon Lando / Oct. 12-22, 2015	5-Year
83	7.935045	123.774146	0.63	0.26	0.37	Typhoon Lando / Oct. 12-22, 2015	5-Year
84	7.980517	123.785039	0.48	0.65	-0.17	Typhoon Lando / Oct. 12-22, 2015	5-Year
85	8.004312	123.781313	0.03	0.78	-0.75	Typhoon Lando / Oct. 12-22, 2015	5-Year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
86	7.987061	123.779624	0.63	0.15	0.48	Typhoon Lando / Oct. 12-22, 2015	5-Year
87	8.004427	123.781601	0.07	0.41	-0.34	Typhoon Lando / Oct. 12-22, 2015	5-Year
88	7.980478	123.785081	0.64	0.65	-0.01	Typhoon Lando / Oct. 12-22, 2015	5-Year
89	7.980526	123.785126	0.64	0.00	0.64	Typhoon Lando / Oct. 12-22, 2015	5-Year
90	7.980548	123.784899	0.67	0.50	0.17	Typhoon Lando / Oct. 12-22, 2015	5-Year
91	7.961692	123.777837	0.27	0.79	-0.52	Typhoon Lando / Oct. 12-22, 2015	5-Year
92	7.961655	123.777889	0.34	0.79	-0.45	Typhoon Lando / Oct. 12-22, 2015	5-Year
93	7.961480	123.777559	0.42	0.79	-0.37	Typhoon Lando / Oct. 12-22, 2015	5-Year
94	7.963154	123.778349	0.54	0.58	-0.04	Typhoon Lando / Oct. 12-22, 2015	5-Year
95	8.001065	123.780271	0.03	1.30	-1.27	Typhoon Lando / Oct. 12-22, 2015	5-Year
96	7.930322	123.768669	1.35	0.00	1.35	Typhoon Lando / Oct. 12-22, 2015	5-Year
97	7.963125	123.777910	0.90	0.50	0.4	Typhoon Lando / Oct. 12-22, 2015	5-Year
98	7.979766	123.797006	0.03	1.90	-1.87	Typhoon Lando / Oct. 12-22, 2015	5-Year
99	7.997823	123.786970	0.38	0.00	0.38	Typhoon Lando / Oct. 12-22, 2015	5-Year
100	7.930692	123.768669	1.95	0.00	1.95	Typhoon Lando / Oct. 12-22, 2015	5-Year
101	7.998250	123.785045	0.40	0.00	0.4	Typhoon Lando / Oct. 12-22, 2015	5-Year
102	8.004088	123.781440	2.11	0.60	1.51	Typhoon Lando / Oct. 12-22, 2015	5-Year
103	8.001012	123.777848	1.75	0.73	1.02	Typhoon Lando / Oct. 12-22, 2015	5-Year
104	7.979806	123.797487	1.34	1.90	-0.56	Typhoon Lando / Oct. 12-22, 2015	5-Year
105	7.980514	123.795708	1.37	1.90	-0.53	Typhoon Lando / Oct. 12-22, 2015	5-Year
106	8.000880	123.778092	2.09	0.40	1.69	Typhoon Lando / Oct. 12-22, 2015	5-Year
107	8.000870	123.781029	2.31	1.52	0.79	Typhoon Lando / Oct. 12-22, 2015	5-Year
108	7.980019	123.794219	3.33	1.90	1.43	Typhoon Lando / Oct. 12-22, 2015	5-Year
109	8.002403	123.776674	5.10	1.51	3.59	Typhoon Lando / Oct. 12-22, 2015	5-Year
110	8.000846	123.778118	5.61	0.40	5.21	Typhoon Lando / Oct. 12-22, 2015	5-Year
111	8.002970	123.776507	5.77	1.06	4.71	Typhoon Lando / Oct. 12-22, 2015	5-Year
112	8.000736	123.778621	5.56	1.50	4.06	Typhoon Lando / Oct. 12-22, 2015	5-Year
113	8.000801	123.778297	5.77	1.54	4.23	Typhoon Lando / Oct. 12-22, 2015	5-Year
114	8.000747	123.778686	5.81	1.13	4.68	Typhoon Lando / Oct. 12-22, 2015	5-Year
115	8.000762	123.778461	5.78	0.15	5.63	Typhoon Lando / Oct. 12-22, 2015	5-Year
116	8.000830	123.778207	6.17	0.77	5.4	Typhoon Lando / Oct. 12-22, 2015	5-Year
117	7.985071	123.791123	6.94	0.00	6.94	Typhoon Lando / Oct. 12-22, 2015	5-Year

Annex 12. Educational Institutions Affected by Flooding in ButadonFloodplain

Table A-12.1. Educational Institutions Affected by Flooding in the Butadon Floodplain – Baroy, Lanao del Norte

LANAO DEL NORTE				
BAROY				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Day Care	Andil			
Daycare Center	Andil			
Estevan Elementary School	Andil			
Grade High and 4	Andil			
Grade 5 and 6	Andil			
Pre-school and Grade Low	Andil			
Bagong Dawis Elementary School	Bagong Dawis			
Bagong Dawis Elementary School (Pre-school)	Bagong Dawis			
Daycare Center	Bagong Dawis			Low
Faculty Office	Bagong Dawis			
Grade Low	Bagong Dawis	Low	Low	Medium
Grade Medium	Bagong Dawis	Low	Low	Medium
Grade High	Bagong Dawis		Low	Medium
Grade 5 and 6	Bagong Dawis			
Kindergarten	Bagong Dawis		Low	Medium
Lanao Norte Nat'l High School	Baroy Daku			
Baroy Central Elem. School	Baroy Daku			
daycare	Baroy Daku			
Daycare	Baroy Daku			
Day Care Center	Bato			
Day Care Center	Cabasagan			
Non-functional School	Cabasagan	Low	Medium	Medium
Pendulonan Primary School	Cabasagan			
Daycare	Dalama			
canteen	Libertad			
Central elementary	Libertad	Low	Low	Low
Computer Room	Libertad	Low	Medium	Medium
Diosdado Yap High School	Libertad	Low	Low	Low
Primary School	Limwag			
Day Care Center	Lindongan			
Daycare	Manan-Ao			
Manan ao Elem	Manan-Ao			
Manan ao Elem School	Manan-Ao			
Manan ao Elem School	Manan-Ao			
Sario de roda elementary school (grade Low)	Pange			
Sario de roda elementary school (grade 4 and High)	Pange			
HE Building	Pindolonan			
Lindongan Elem. School	Pindolonan			
Principal's Office	Pindolonan			
School Canteen	Pindolonan			

LANAO DEL NORTE				
BAROY				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Baroy Central Elem. School	Poblacion			
District Office	Poblacion			
Lanao School of Science and Technology	Poblacion			
Principal's Office	Poblacion			
School Canteen	Poblacion			
Sto. Nino Academy	Poblacion			
Day Care Center	Princesa			
Princessa Elem. School	Princesa			
Computer Center/ Pre School	Rawan Point			
Grade Low-High-4	Rawan Point			
Grade 6	Rawan Point	Low	Medium	Medium
Multi-purpose Hall	Rawan Point			
Raw-an Point Elem. School	Rawan Point			
Mediumnd Yr	Riverside			
Computer Room	Riverside			
Diosdado Yap High School	Riverside	Medium	Medium	Medium
Sr. High	Riverside		Low	Low
Temporary Rooms	Riverside			
Baroy Central Elem. School	San Juan			
Elementary School	San Juan			
Primary School	San Juan			
UCCP Pre-School	San Juan			
Daycare	Tinubdan			
Maliwanag Elem School	Tinubdan			
Lanao Norte Nat'l High School	Village			

Table A-12.2. Educational Institutions Affected by Flooding in the Butadon Floodplain – Kapatagan, Lanao del Norte

LANAO DEL NORTE				
KAPATAGAN				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Computer Room	Bagong Silang	Low	Medium	Medium
Day Care Center	Bagong Silang	Low	Medium	Medium
Grade Medium	Bagong Silang	Low	Medium	Medium
Grade 4	Bagong Silang	Low	Medium	Medium
Kinder	Bagong Silang	Low	Medium	Medium
Principal's Office	Bagong Silang		Low	Medium
School Canteen	Bagong Silang	Low	Medium	Medium
Daycare Center Tiacongan	Bagong Silang		Medium	Medium
Day Care Center	Butadon		Medium	Medium
Grade 4	Butadon		Medium	Medium
Grade 5-6	Butadon		Medium	Medium
Grade 6	Butadon		Medium	Medium

LANAO DEL NORTE				
KAPATAGAN				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Pinoyak Elem. School	Butadon		Medium	Medium
Principal's Office	Butadon		Medium	Medium
Stage	Butadon		Medium	Medium
Grade Low	Cathedral Falls			
Kitchen	Cathedral Falls			
Anacurita Elem School	Cathedral Falls	Medium	Medium	Medium
Anacurita Elem.	Cathedral Falls	Medium	Medium	Medium
Day Care	Cathedral Falls			
Day Care Center	Cathedral Falls	Low	Low	Medium
Grade High and grade 4	Cathedral Falls			
Grade 5 B	Cathedral Falls			
Grade 6 A	Cathedral Falls			
Preschool	Cathedral Falls			
Day Care	Concepcion	Medium	Medium	High
Grade High	Concepcion	Low	Medium	Medium
Grade 4	Concepcion	Low	Medium	Medium
Grade 5&6	Concepcion	Low	Medium	Medium
principal’s Office	Concepcion	Low	Medium	Medium
Daycare Center	Concepcion		Low	Low
Emiliano Dizon Elem School	Concepcion	Medium	Medium	High
Curvada Elem	Curvada		Low	Medium
Kindergarten	De Asis	Medium	Medium	Medium
SCHOOL Stage	De Asis	Medium	Medium	Medium
Daycare	De Asis		Low	Low
Adventist School	Donggoan			
Butadon Day Care Center	Donggoan			
Grade Low	Donggoan		Low	Medium
Grade Low&4	Donggoan		Low	Medium
Grade Medium	Donggoan	Low	Medium	Medium
Grade High	Donggoan	Low	Medium	Medium
HE Building	Donggoan		Low	Medium
Kinder Low	Donggoan		Low	Low
Learning Center	Donggoan			
Old Building	Donggoan			
Donggoan Elem School	Donggoan			
Daycare center	Lapinig	High	High	High
Placida mequiabas national high school	Lapinig	Medium	Medium	High
Placida Mequiabas National High School	Lapinig			
Dishwashing Area	Maranding	Medium	Medium	Medium
School of Born Again Church	Maranding	Medium	Medium	Medium
Stage	Maranding	Medium	Medium	Medium
Waiting Shed	Maranding	Medium	Medium	Medium
Paradero Day Care	Maranding	Medium	Medium	Medium
Daycare Center	Margos			

LANAO DEL NORTE				
KAPATAGAN				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Sixto Magnanoy Sr. Central School	Margos		Low	Low
Abandoned	Poblacion	Low	Medium	High
Abandoned Day Care	Poblacion	Medium	Medium	High
Canteen	Poblacion	Low	Medium	Medium
District Office	Poblacion	Medium	Medium	Medium
Grade Low Classroom	Poblacion	Low	Medium	Medium
Grade High Classroom	Poblacion	Low	Medium	Medium
Grade 5 Classroom	Poblacion	Low	Medium	Medium
grade 6	Poblacion	Medium	Medium	High
Grade 6 Classroom	Poblacion		Medium	Medium
HE Classroom	Poblacion	Low	Medium	Medium
San Vicente Elem. School	Poblacion	Low	Medium	High
School Room	Poblacion	Low	Medium	High
Technical School	Poblacion	Low	Medium	Medium
Daycare	Poblacion	Medium	Medium	High
Daycare Center	Poblacion		Low	Medium
reading center(purok)	Poblacion	Low	Medium	Medium
Day Care Center	Santo Tomas	Low	Low	Medium
Grade Low	Santo Tomas	Medium	Medium	Medium
Grade 4 Room	Santo Tomas	Medium	Medium	Medium
Grade 6 Room	Santo Tomas		Low	Low
Kindergarten	Santo Tomas			
Butadon Elementary	Suso	Low	Medium	Medium
Daycare	Suso			
Daycare Center	Suso	Medium	Medium	Medium
Anacurita Elem.	Waterfalls	Medium	Medium	Medium
Daycare Center	Waterfalls	Medium	Medium	Medium
Itans Learning Center	Waterfalls	Low	Low	Medium

Table A-12.3. Educational Institutions Affected by Flooding in the Butadon Floodplain – Lala, Lanao del Norte

LANAO DEL NORTE				
LALA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Abaga Central Elementary School	Abaga			Low
Classroom	Abaga			Low
CR & Hand Washing	Abaga	Medium	Medium	Medium
Day Care Center Low	Abaga			
DU Tenazas Memorial Elem. School	Abaga		Low	Low
Function Hall	Abaga		Low	Low
Grade Low-High	Abaga			
Grade 4	Abaga		Low	Low
Grade 5	Abaga			

LANAO DEL NORTE				
LALA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Grade 6 & Kinder	Abaga		Low	Low
Hand Washing Area	Abaga	Low	Medium	Medium
Maranding Christian School KLow-KMedium rooms	Abaga			
MCS Gym	Abaga			
MCS Office	Abaga			
MCS Old Buildings	Abaga			
Principal's Office	Abaga	Low	Medium	Medium
School Canteen	Abaga		Low	Low
School Multipurpose Hall	Abaga	Low	Low	Low
Science Room	Abaga			
Sario de roda elementary school (grade Low)	Andil			
Sario de roda elementary school (grade 4 and High)	Andil			
Sario de roda elementary school stage	Andil			
Daycare center	Andil			
Sario de roda elementary school (grade 5 and 6)	Andil			Low
Daycare Center	Cabasagan			
Francisco Bolante Memorial School (Pre-School to grade 6)	Cabasagan			
Purok 4-B Daycare Center	Cabasagan			
Purok 6 Daycare Center	Cabasagan			
Camalan Primary School	Camalan			
Grade High-4	Camalan			
Day Care Center	Darumawang Bucana			
School Bldg.	Darumawang Bucana			
School C.R.	Darumawang Bucana			
C.R.	Darumawang Ilaya			
Day Care	Darumawang Ilaya			
Grade Low	Darumawang Ilaya		Low	Low
Grade 4	Darumawang Ilaya		Low	Low
Grade 5	Darumawang Ilaya	Low	Low	Low
Grade 6	Darumawang Ilaya		Low	Low
Guidance Office	Darumawang Ilaya			
Lutuanan	Darumawang Ilaya			
Office and School Dormitory	Darumawang Ilaya			
Principal's Office	Darumawang Ilaya		Low	Low
School Canteen	Darumawang Ilaya			
Simpak Adventist Institute of Technology	Darumawang Ilaya			
Social hall	Darumawang Ilaya			
Vocational Bldg.	Darumawang Ilaya		Low	Low
Vocational Bldg. Medium	Darumawang Ilaya			
Library	Darumawang Ilaya			

LANAO DEL NORTE				
LALA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
El Salvador Elem. School	El Salvador		Medium	Medium
Grade 4	El Salvador		Medium	Medium
Grade 4-5-6	El Salvador		Medium	Medium
Principal's Office	El Salvador		Low	Medium
Stage	El Salvador		Medium	Medium
Grade Low-6	Gumagamot	Low	Low	Medium
Panadtaran Elem. School	Gumagamot		Low	Low
LALA Elem School Proper	Lala Proper	Low	Low	Medium
Daycare	Lanipao			
LALA North District School	Lanipao			
Classroom	Magpatao			
Computer Center	Magpatao			
Grade Low-Medium-High	Magpatao			
Grade 6	Magpatao			
HE Room	Magpatao			
Magpatao Elem	Magpatao			
Prk Medium Day Care Center	Magpatao			
School Stage	Magpatao			
Stage	Magpatao			
Daycare center	Magpatao			
Magpatao Elementary School	Magpatao			
Bible Baptist School	Maranding	Medium	Medium	Medium
ClassroomLow Medium	Maranding	Medium	High	High
Canteen	Maranding	Medium	Medium	Medium
Classroom	Maranding	Medium	Medium	Medium
Classroom Low Low	Maranding	Medium	Medium	High
Classroom 4	Maranding	Medium	Medium	Medium
Classroom 5	Maranding	Medium	High	High
Classroom 6	Maranding	Medium	Medium	High
Classroom 7	Maranding	Medium	Medium	High
Classroom 8	Maranding	Medium	Medium	High
Classroom 9	Maranding	Medium	Medium	High
Classroom Low	Maranding	Medium	High	High
Classroom Medium	Maranding	Medium	High	High
Faculty Room	Maranding	Medium	Medium	High
Grade Medium	Maranding	Medium	Medium	Medium
grade High	Maranding	Medium	High	High
Grade 4	Maranding	Medium	Medium	Medium
Grade 5	Maranding	Medium	Medium	Medium
Guard House	Maranding	Medium	Medium	High
Lanao Norte-Learning Resource Center	Maranding	Medium	Medium	Medium
LNHS Gym	Maranding	Medium	High	High
LNHS Principal's Office	Maranding	Medium	Medium	High
Mini Canteen	Maranding	Medium	Medium	High

LANAO DEL NORTE				
LALA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
NCMC Building	Maranding	Low	Low	Medium
NCMC College Department	Maranding	Low	Low	Medium
NCMC Elementary Department	Maranding	Low	Medium	Medium
NCMC Gym	Maranding		Low	Low
NCMC HRM Department	Maranding	Medium	Medium	Medium
Preschool	Maranding	Medium	Medium	Medium
Principal's Office	Maranding		Low	Low
Prk. Rambutan Day Care Center	Maranding		Low	Medium
PTA Office	Maranding	Medium	Medium	Medium
School Clinic	Maranding	Medium	Medium	Medium
Social Hall	Maranding	Medium	Medium	Medium
Stage	Maranding	Medium	Medium	Medium
Grade Low	Maranding	Medium	Medium	Medium
Day Care Center Old	Matampay Bucana			
Matampay Bucana Elem. School	Matampay Bucana		Low	Medium
San Roque Chapel	Matampay Bucana			
Classrooms Low	Pacita			
Classrooms Medium	Pacita			
Day Care Center	Pacita			
Doggoan Elementary School	Pacita			
Grade Low-Medium	Pacita			
Grade High	Pacita			
Grade 4-5	Pacita			
Grade 6	Pacita			
Matampay Ilaya Elem. School	Pacita			
Prk Medium Day Care Center	Pacita	Low	Low	Low
School Clinic	Pacita			
Stage	Pacita			
Day Care Center Medium	Pendolonan		Low	Low
Comfort Room	Pendolonan			
Day Care Center	Pendolonan			
Generoso Lapasaran Memorial School Canteen	Pendolonan			
Grade Low	Pendolonan			
Grade 6	Pendolonan			
Pre-school and Faculty Office	Pendolonan			
School Library	Pendolonan			
Cabrera Day Care Center	Pinoyak	Low	Low	Low
Saavedra Day Care Center	Pinoyak			Low
FM Posadas Elementary School	Raw-An		Low	Medium
Classroom Low	Raw-An	Low	Low	Medium
Classroom Medium	Raw-An	Low	Low	Medium
Economics building	Raw-An		Low	Medium
Grade 5 and 6	Raw-An	Low	Medium	Medium
Kindergarten	Raw-An		Low	Medium

LANAO DEL NORTE				
LALA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
School Canteen	Raw-An		Low	Medium
Pedro B. Liwanag Memorial Elem	Rebe			
Antonio Lim Sr. Elem School	San Isidro Lower			
Brgy. Sta. Cruz Lower Elem. School	San Isidro Lower			
Day Care	San Isidro Lower			Low
daycare	San Isidro Lower			
Grade Low	San Isidro Lower			
Grade Low-Medium-4	San Isidro Lower			
Grade High	San Isidro Lower			
Grade 5-6	San Isidro Lower			
HE Room	San Isidro Lower			
Pre-School	San Isidro Lower			
Canteen	San Isidro Upper			
Computer Laboratory	San Isidro Upper	Low	Low	Low
Daycare Center	San Isidro Upper			
Grade Low	San Isidro Upper			
Pre-school and faculty room	San Isidro Upper			
San Isidro Elementary School(grade Medium-6)	San Isidro Upper			
Stage	San Isidro Upper			
Daycare	San Manuel	Medium	Medium	Medium
San Manuel Elem	San Manuel			
Daycare	Santa Cruz Lower			
Daycare	Santa Cruz Upper		Medium	Medium
Auditorium	Simpak		Low	Low
Grade Low	Simpak		Low	Low
Grade Medium	Simpak		Low	Low
Grade High	Simpak	Low	Low	Medium
Grade 4	Simpak	Medium	Medium	Medium
Grade 5	Simpak	Low	Medium	Medium
Kinder Garten	Simpak	Low	Medium	Medium
Principal's Office	Simpak	Low	Medium	Medium
Saavedra Elementary School	Simpak	Low	Low	Medium
School C.R.	Simpak			
School Canteen	Simpak	Low	Medium	Medium
School Clinic	Simpak		Low	Low
School Guard House	Simpak		Low	Low
School Old Canteen	Simpak		Low	Low
Stage	Simpak		Low	Low
Vermi Culture Center	Simpak		Low	Low
D.U. Tenzasas Elem	Tenazas			
D.u.Tenazasas Elem	Tenazas			
Daycare	Tenazas			
Montessori	Tenazas			Low
BFAR Dorm Low	Tuna-An			

LANAO DEL NORTE				
LALA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
BFAR Dorm Medium	Tuna-An	Low	Low	Medium
Day Care Center	Tuna-An			
Dorm High	Tuna-An	Medium	Medium	Medium
Dorm 4	Tuna-An			
Dorm 5	Tuna-An	Medium	Medium	Medium
Grade Low-4	Tuna-An			
Grade 5-6	Tuna-An			
Library	Tuna-An			
Tunaan Elem. School Stage	Tuna-An			

Table A-12.4. Educational Institutions Affected by Flooding in the Butadon Floodplain – Salvador, Lanao del Norte

LANAO DEL NORTE				
SALVADOR				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Daycare Center	Camp III		Low	Medium
Grade Low - High	Camp III		Low	Low
Grade Medium and 5	Camp III			
Grade 5	Camp III			Low
Grade 6	Camp III	Low	Low	Low
School Booth	Camp III			
School Stage	Camp III			
Sudlon Elementary School	Camp III		Low	Low
Abandoned School	Curva-Miagao		Low	Low
Classroom	Curva-Miagao	Low	Medium	High
Curva-Miagao Elem. School	Curva-Miagao		Medium	Medium
Day Care Center	Curva-Miagao			
School Waiting Shed	Curva-Miagao	Low	Medium	High
Stage	Curva-Miagao		Medium	High
San Manuel Elem	Curva-Miagao			
Classroom	Inasagan	Low	Low	Low
Classroom Medium	Inasagan			
Classroom High	Inasagan			
Day Care Center	Inasagan		Low	Low
Day Care Center Kalahi	Inasagan			
Former Canteen	Inasagan		Low	Low
Grade Medium	Inasagan			
Grade 4	Inasagan	Low	Low	Low
Grade 5-6	Inasagan		Low	Low
Grade 6	Inasagan			
Kinder	Inasagan	Medium	Medium	Medium
School Bldg.	Inasagan			
Stock Room	Inasagan	Low	Low	Low

LANAO DEL NORTE				
SALVADOR				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Social Hall	Inasagan			
Day Care Center	Mabatao			
Kinder	Poblacion		Low	Low
Social Hall	Poblacion		Low	Low
Daycare Center	Sudlon	Medium	Medium	Medium

Table A-12.5. Educational Institutions Affected by Flooding in the Butadon Floodplain – Tubod, Lanao del Norte

LANAO DEL NORTE				
TUBOD				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Day Care Center Medium	Licapao			
Lanao Norte Provincial Science and Technology High School	Licapao			Low
Licapao Elem. School	Licapao			
LNPSTHS School Bldg.	Licapao			
Malingao Central School	Licapao			
School Bldg.	Licapao		Low	Low
School Stage	Licapao			

Table A-12.6. Educational Institutions Affected by Flooding in the Butadon Floodplain – Aurora, Lanao del Norte

LANAO DEL NORTE				
AURORA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Canteen	Anonang		Low	Low
Comfort Room	Anonang	Low	Low	Low
Computer Room	Anonang			
Grade Higha	Anonang		Low	Low
Grade 4	Anonang	Medium	Medium	Medium
Grade 5	Anonang	Low	Low	Low
Margos Elementary School	Anonang	Low	Medium	Medium
Principal's Office	Anonang			
School Health Center	Anonang			Low
School Waiting Shed	Anonang	Low	Low	Low
Social Hall	Anonang	Low	Low	Medium
grade 6	Anonang		Low	Low
HE room	Anonang	Medium	Medium	Medium
School Waiting Shed	Anonang		Low	Low

Annex 13. Medical Institutions Affected by Flooding in ButadonFloodplain

Table A-13.1. Medical Institutions Affected in the Butadon Floodplain – Baroy, Lanao del Norte

LANAO DEL NORTE				
BAROY				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Health Center	Andil			
Health Care Center	Bagong Dawis			
Health Center	Bagong Dawis			Low
Health Center	Cabasagan			
Health center	Dalama			
Health Center	Libertad			
Health Center	Limwag			
Health Center	Lindongan			
OB Gyne Clinic	Poblacion			
Pharmacy	Poblacion			
Health Center	Princesa			
Temporary Health Center	Salong			Low
Rural Health Unit	San Juan			

Table A-13.2. Medical Institutions Affected in the Butadon Floodplain – Kapatagan, Lanao del Norte

LANAO DEL NORTE				
KAPATAGAN				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Clinic	Bagong Silang	Low	Medium	Medium
Polipog Health Center	Butadon	Low	Medium	Medium
Health Center	Cathedral Falls	Medium	Medium	Medium
Health Center	De Asis		Low	Low
Butadon Health Center Extension	Donggoan			
Health Center	Donggoan	Low	Low	Low
Health Center	Maranding	Medium	High	High
Provincial Hospital	Maranding	Low	Low	Medium
Provincial Hospital	Maranding			Low
Kapatagan Provincial Hospital	Poblacion	Low	Medium	Medium
Mercury	Poblacion	Low	Medium	Medium
RightMeds Pharmacy	Poblacion			Low
Delbert Jon's Hospital	Poblacion		Medium	Medium
Dr. Gatchalian Hospital (OLD)	Poblacion	Medium	Medium	High
Municipal Health Office	Poblacion		Medium	High
Old Health Center	Santo Tomas			
Sto. Tomas Health Center	Santo Tomas	Medium	Medium	Medium
Clinic	Waterfalls	Low	Medium	Medium

Table A-13.3. Medical Institutions Affected in the Butadon Floodplain – Lala, Lanao del Norte

LANAO DEL NORTE				
LALA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Health Center	Abaga			
School Clinic	Abaga			Low
Health center	Andil			
Health Center	Cabasagan			
Brgy. Health Center	Darumawang Bucana			Low
Health Center	Darumawang Ilaya			
Health Center	El Salvador			Low
Health Center	Lala Proper		Low	Low
Vet Clinic	Lanipao	Low	Low	Low
Prk Medium Health Center	Magpatao			
Health Center	Magpatao			
AFC AMY Pharmacy	Maranding	Medium	Medium	Medium
Asintesta Medical Clinic	Maranding	High	High	High
Barangay Health Station	Maranding	Medium	Medium	Medium
Bontilao Country Hospital	Maranding	Medium	Medium	Medium
Gozo Community Hospital	Maranding	Low	Medium	Medium
Maranding Community Hospital	Maranding			Low
Mendoza Macayan Optical Clinic	Maranding	Medium	Medium	Medium
Mercury Drug	Maranding	Medium	Medium	Medium
NCMC Lying In	Maranding	Low	Low	Medium
The Generics Pharmacy	Maranding	Low	Medium	Medium
Bulaclac Pharmacy	Maranding	Medium	Medium	Medium
Barangay Health Center	Matampay Bucana			
Health Center	Pacita			
Pacita Health Center	Pacita			Low
Health Center	Pendolonan			
Health Center	Rebe			
Health Center	San Isidro Lower			
Health Center	San Isidro Upper			
Health Center	San Manuel	Low	Low	Low
Health Center	Santa Cruz Upper		Low	Medium
Lanipao Health Center	Santa Cruz Upper		Low	Medium
Health Center	Simpak			
Health Center	Tuna-An			

Table A-13.4. Medical Institutions Affected in the Butadon Floodplain – Salvador, Lanao del Norte

LANAO DEL NORTE				
SALVADOR				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Barangay Health Center	Camp III			
Health Center	Curva-Miagao			
Barangay Health Center	Inasagan	Low	Low	Low
Health Center	Inasagan	Low	Medium	Medium
Health Center	Panaliwad-On			
Old Rural Health Center	Poblacion		Low	Low

Table A-13.5. Medical Institutions Affected in the Butadon Floodplain – Aurora, Lanao del Norte

LANAO DEL NORTE				
AURORA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Margos Health Center	Anonang			