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

LiDAR Surveys and Flood Mapping of Clarin River

University of the Philippines Training Center
for Applied Geodesy and Photogrammetry
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LIST OF ACRONYMS AND ABBREVIATIONS

AAC	Asian Aerospace Corporation
Ab	Abutment
ALTM	Airborne LiDAR Terrain Mapper
ARG	automatic rain gauge
ATQ	Antique
AWLS	Automated Water Level Sensor
BA	Bridge Approach
BM	Benchmark
CAD	Computer-Aided Design
CN	Curve Number
CSRS	Chief Science Research Specialist
DAC	Data Acquisition Component
DEM	Digital Elevation Model
DENR	Department of Environment and Natural Resources
DOST	Department of Science and Technology
DPPC	Data Pre-Processing Component
DREAM	Disaster Risk and Exposure Assessment for Mitigation [Program]
DRRM	Disaster Risk Reduction and Management
DSM	Digital Surface Model
DTM	Digital Terrain Model
DVBC	Data Validation and Bathymetry Component
FMC	Flood Modeling Component
FOV	Field of View
GiA	Grants-in-Aid
GCP	Ground Control Point
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HEC-HMS	Hydrologic Engineering Center - Hydrologic Modeling System
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
NAMRIA	National Mapping and Resource Information Authority
NSTC	Northern Subtropical Convergence
PAF	Philippine Air Force
PAGASA	Philippine Atmospheric Geophysical and Astronomical Services Administration
PDOP	Positional Dilution of Precision
PPK	Post-Processed Kinematic [technique]
PRF	Pulse Repetition Frequency
PTM	Philippine Transverse Mercator
QC	Quality Check
QT	Quick Terrain [Modeler]
RA	Research Associate
RIDF	Rainfall-Intensity-Duration-Frequency
RMSE	Root Mean Square Error
SAR	Synthetic Aperture Radar
SCS	Soil Conservation Service
SRTM	Shuttle Radar Topography Mission
SRS	Science Research Specialist
SSG	Special Service Group
TBC	Thermal Barrier Coatings
UPC	University of the Philippines Cebu
WGS	World Geodetic System

CHAPTER 1: OVERVIEW OF THE PROGRAM AND THE CLARIN RIVER

Enrico C. Paringit, Dr. Eng., and Prof. Alan E. Milano

1.1 Background of the Phil-LiDAR 1 Program

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

Also, the program was aimed at producing an up-to-date and detailed national elevation dataset suitable for 1:5,000 scale mapping, with 50 cm and 20 cm horizontal and vertical accuracies, respectively. These accuracies were achieved through the use of the state-of-the-art Light Detection and Ranging (LiDAR) airborne technology procured by the project through DOST. The methods described 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-IIT is in charge of processing LiDAR data and conducting data validation reconnaissance, cross section, bathymetric survey, validation, river flow measurements, flood height and extent data gathering, flood modeling, and flood map generation for the 16 river basins in the Northern Mindanao Region. The university is located in Iligan City, Lanao del Norte.

1.2 Overview of the Clarin River Basin

The Clarin River Basin is situated in the northern part of Mindanao; it is bounded on the north by the municipality of Bonifacio and the cities of Ozamiz and Tangub; on the east by Panguil Bay and on the west by the province of Zamboanga del Sur. The land features of the municipality are characterized by low flat elevations in the urban areas. The coastline portion of the Barangays of Mialen, Poblacion, Dela Paz, Lupagan and Lapasan consists of alluvial soils and some swap lands with an average elevation of 2.1 meters above sea level. Two major rivers that cut across the town are the Clarin River in the northern portion and the Clarin River in the southern part.The rainiest months of this area are November and December and the driest month is from February to April. The average monthly rainfall is 17.3cm.Clarin has a total land area of 115.02 square kilometres, 68 % of which is tillable land and about 3,550 hectares or 35.50 square kilometers along the western portion of the town is forest area. The municipality has a population of 23,802 in 1990.

Clarin is one of the municipalities in the province of Misamis Occidental where the outlet of the river basin is located, specifically in Brgy. Masabud. The delineated catchment traverses through the municipalities of Clarin, Tudela, Sinacaban, and Don Victoriano Chiongbian. Greater parts of the river basin are inside the area of Clarin and Tudela, thus, these municipalities dominates the river basin. Most barangays of Clarin is flood prone area namely: Canibungan Daku, Caniacan, Dela Paz, Dolores, Gata Diot, Kinangay Norte, Kinangay Sur, Lapasan, Lupagan, Malibangcacao, Masabud, mialen, Pan-ay, Poblacion I, Poblacion II Cabunga-an, Poblacion III, Poblacion IV, Segatic Daku, Segatic Diot, Tinacla-an.The river basin has an estimated drainage area of 138.31 square kilometers and travels 24.1 km from its source to its outlet and 27.7 km from its source to the mouth of Iligan Bay. The Clarin riverbasin consists of 42 sub basins, 25 reaches, and 25 junctions. The main outlet is located at Masabud Pan-ay Bridge, Clarin.

Furthermore, there are incidents that has been recorded of flooding in Clarin, Misamis Occidental, one of which is that according to the National Disaster Risk Reduction and Management Council (NDRRMC) flooding incident occurred in the Clarin River basin specifically in the municipalities of Clarin and Tudela, Misamis Occidental due to Intertropical Convergence Zone (ITCZ) and heavy downpour of rain affecting the province from November 22-28, 2011. Flood water reached up to 2-meter high in Tudela and the Paca River in Clarin. Some road sections/causeways in Tudela (Taguima and Pan-ay Diot) and Clarin (Pan-ay Dako and Dolores) were partially damaged/ not passable. The Irrigation Dike in Pana-ay Dako, Clarin was also damaged. About 403 families/ 2,032 persons were affected in five (5) barangays (three (3) in Clarin and two (2) in Tudela). The estimated cost of damaged to infrastructure was pegged at PhP 2,300,000.00. Moreover, another incident happened on February 9, 2012, where flooding occurred in the municipality of Clarin and eight (8) barangays were affected. There are 114 families/ 578 persons affected population and twelve (12) totally damaged houses and one hundred one (101) partially damaged houses.

The provincial government has approved the creation of a committee that will oversee activities of river systems in Misamis Occidental called the Misamis Occidental River Basin Management Committee (MORBMC)I under the Executive Order No. 007-2012 . This committee aims to monitor and study the activities of the river systems in the province relative to climate change especially in the towns of Clarin, Misamis Occidental, which experienced flooding that resulted in the damage of properties.

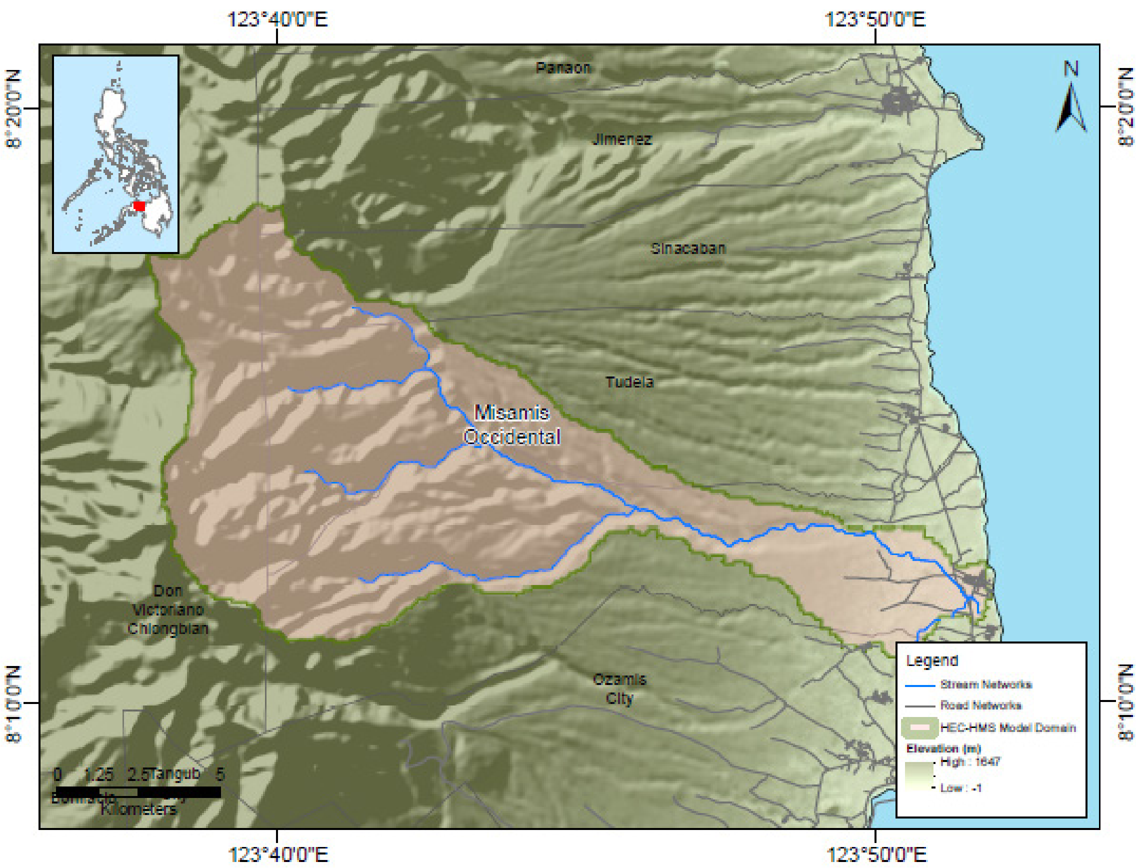

Figure 1. Map of the Clarin River Basin (in brown)

CHAPTER 2: LIDAR DATA ACQUISITION OF THE CLARIN FLOODPLAIN

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

2.1 Flight Plans

Plans were made to acquire LiDAR data within the delineated priority area for Clarin Floodplain in Zamboanga. Each flight mission has an average of 10 lines and run for at most four and a half (4.5) hours including take-off, landing and turning time. The parameter used in the LiDAR system for acquisition is found in Table 1. Figure 2 shows the flight plans for Clarin Floodplain.

Table 1.Flight Planning Parameters for LiDAR Pegasus 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)
BLK71ext	1000/1100	30	50	200	30	130	5
BLK69F	800/1000	30	50	200	30	130	5
BLK76O	800/900/1000	30	50	200	30	130	5

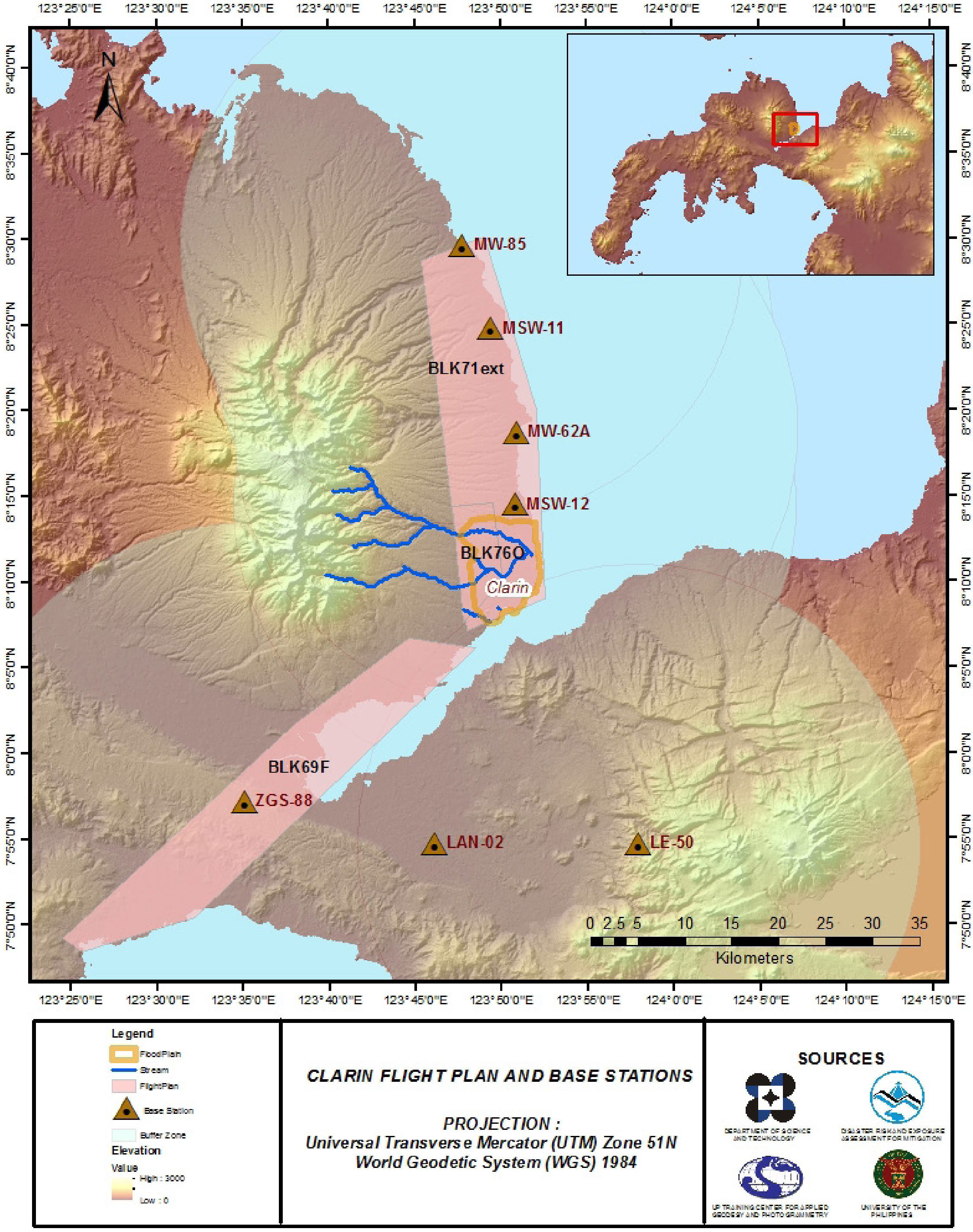


Figure 2. Flight plan used to cover Clarin Floodplain.

2.2 Ground Base Station

The project team was able to recover Four (4) NAMRIA ground control point: LAN-02, ZGS-88,MSW-11 and MSW-12 which is of first (1^{st}) and second (2nd) order accuracy and three (3) bench mark point: LE-50, MW-85 and MW-62A. The certifications for the NAMRIA reference points and processing report for the established points are found in Annex B. These were used as base stations during flight operations for the entire duration of the survey (May22-July 10, 2014; October 8-November 11, 2014 and February 4-March 4, 2016). Base stations were observed using dual frequency GPS receivers, TRIMBLE SPS 882, SPS 852 and SPS 985. Flight plans and location of base stations used during the aerial LiDAR acquisition in Clarin floodplain are also shown in Figure 2.

Figure 3 to Figure 8 shows the recovered NAMRIA control stations within the area, in addition Table 2 to Table 8 show the details about the following NAMRIA control stations and established points, Table 9 shows the list of all ground control points occupied during the acquisition together with the dates they are utilized during the survey.

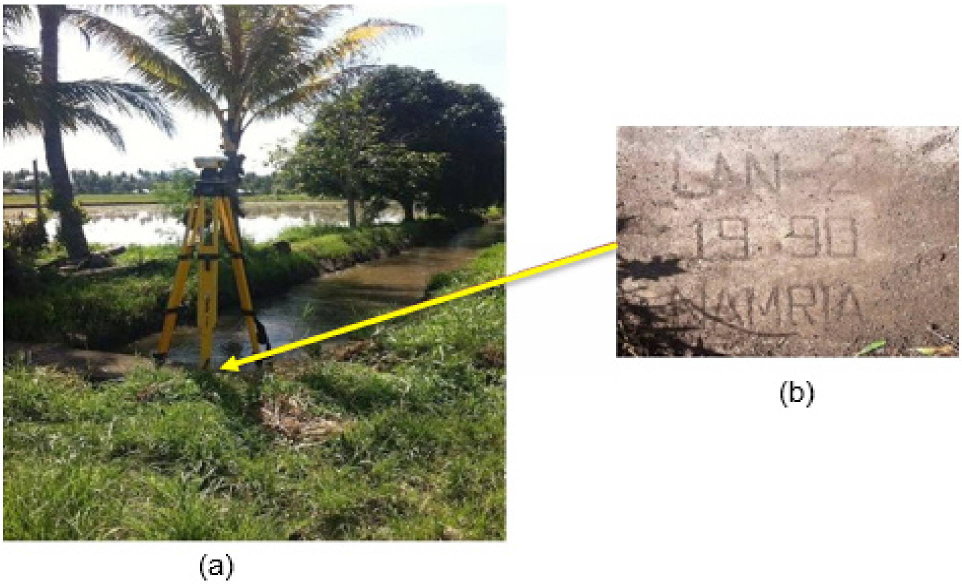


Figure 3. a) GPS set-up over LAN-02 on top of a concrete irrigation canal water gate in Brgy. Pinoyak, Lala, Lanao del Norte. b) NAMRIA reference point LAN-02 as recovered by the field team.

Table 2. Details of the recovered NAMRIA horizontal control point LAN-02 used as 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

(b)

(a)

Figure 4. a) GPS set-up over ZGS-88 on a center island in Purok Saray, Aurora, Zamboanga del Sur. 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 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

(a) (b)

Figure 5. a) GPS set-up over MSW-11 in Brgy. Ospital, Aloran, Misamis Occidental. b) NAMRIA reference point MSW-11 as recovered by the field team.

Table 4. Details of the recovered NAMRIA horizontal control point MSW-11 used as base station for the LiDAR Acquisition

Station Name	**MSW-11**	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	8° 24’ 49.21851” North
	Longitude	123° 49’ 18.84776” East
	Ellipsoidal Height	4.399 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	590515.033 meters
	Northing	930392.306 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	8°24’ 45.57851” North
	Longitude	123° 49’ 24.26581” East
	Ellipsoidal Height	70.095 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting	590483.35 meters
	Northing	930066.65 meters

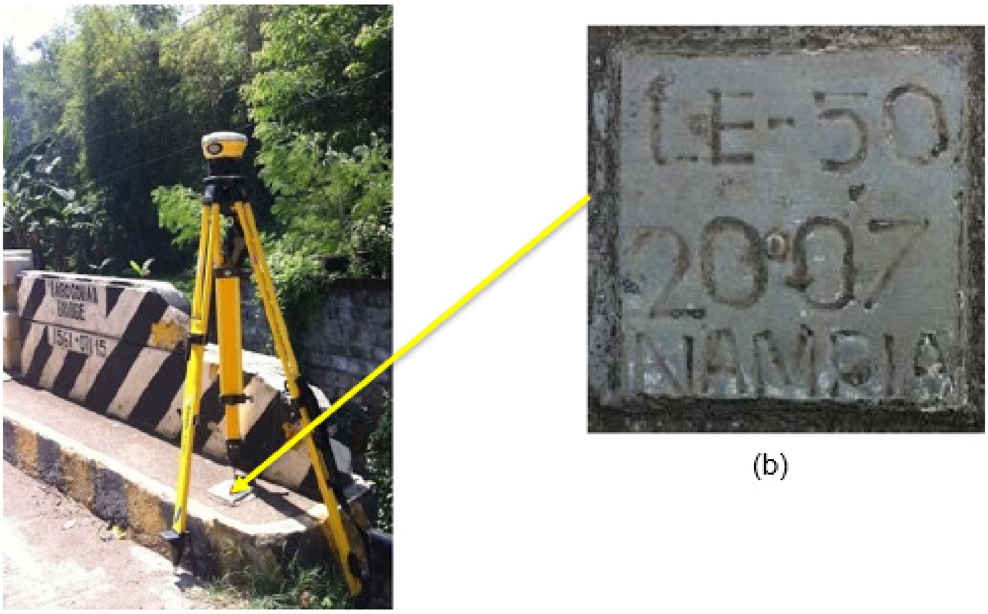
(b)

(a)

Figure 6. a) GPS set-up over MSW-12 in Brgy. Manicahan, Zamboanga del Sur. b) NAMRIA reference point MSW-12 as recovered by the field team.

Table 5. Details of the recovered NAMRIA horizontal control point MSW-12 used as base station for the LiDAR Acquisition

Station Name	**MSW-12**	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	8° 14' 33.61728" North
	Longitude	123° 50' 41.11353" East
	Ellipsoidal Height	5.698 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	911485.567 meters
	Northing	593072.214 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	8° 14' 30.02425" North
	Longitude	123° 50' 46.54685" East
	Ellipsoidal Height	71.798 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting	911166.576 meters
	Northing	593039.64 meters



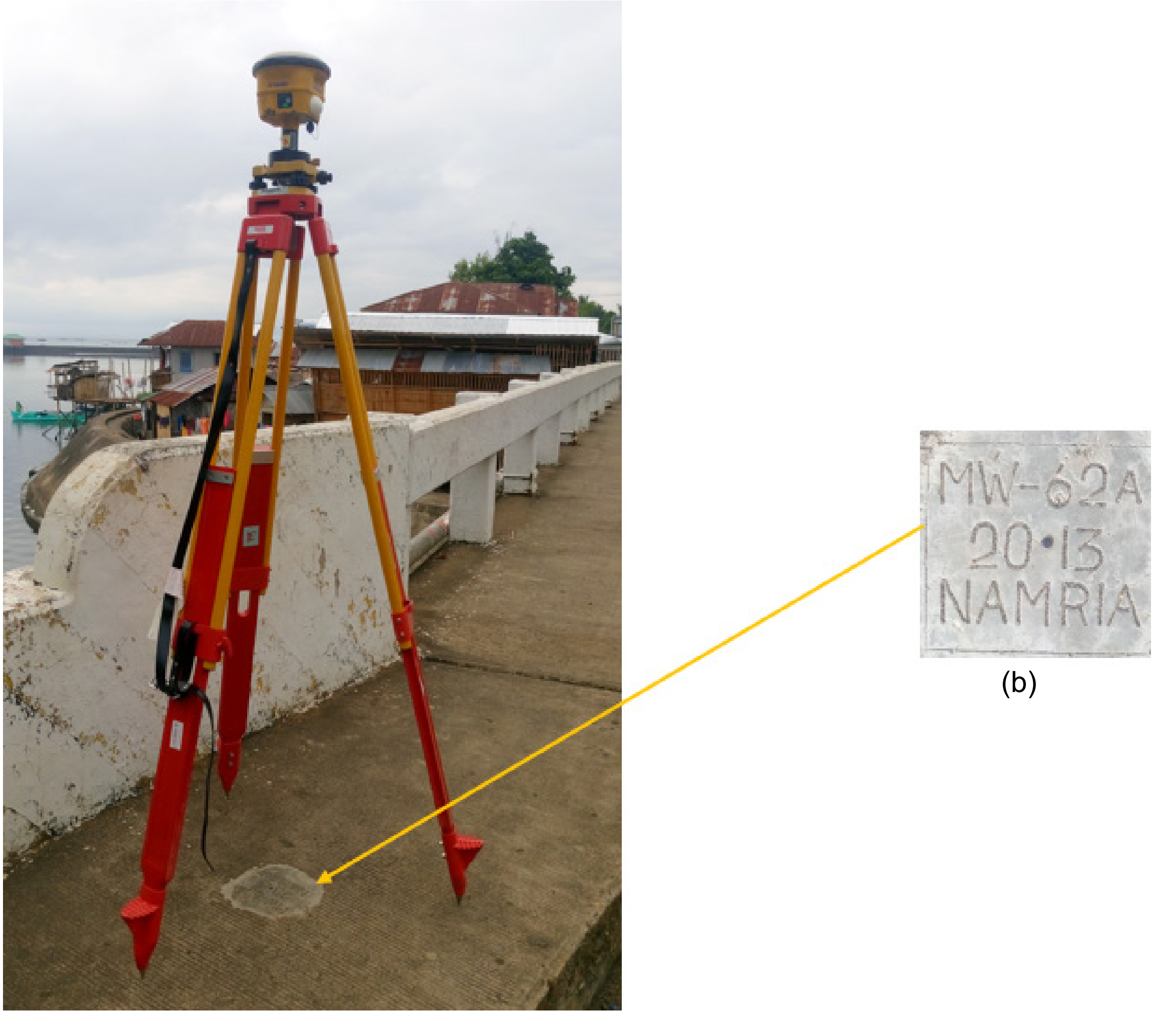
(b)

(a)

Figure 7. a) GPS set-up over LE-50 on the Barogohan Bridge in Maigo, Lanao del Norte. b) NAMRIA bench mark point LE-50 as recovered by the field team.

Table 6. Details of the recovered NAMRIA horizontal control point LE-50 used as 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



(a) (b)

Figure 8. a) GPS set-up over MW-62A in Curuan, Zamboanga City. b) NAMRIA bench mark point as recovered by the field team.

Table 7. Details of the recovered NAMRIA horizontal control point MW-62A used as base station for the LiDAR Acquisition.

Station Name	**MW-62A**	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	8°18’46.72583” North
	Longitude	123°50’46.44781” East
	Ellipsoidal Height	7.578 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting	593186.315 meters
	Northing	918939.972 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	8°18’43.11445” North
	Longitude	123°50’51.87475” East
	Ellipsoidal Height	73.593 meters

Table 8. Details of the recovered NAMRIA horizontal control point MW-85 used as base station for the LiDAR Acquisition.

Station Name	MW-85	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	8°29'41.44871" North
	Longitude	123°47'37.52758" East
	Ellipsoidal Height	4.320 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting	587366.444 meters
	Northing	939034.768 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	8°29'37.78490"North
	Longitude	123°47'42.93851" East
	Ellipsoidal Height	69.779 meters

Table 9. Ground Control Points used during LiDAR Data Acquisition

Date Surveyed	Flight Number	Mission Name	Ground Control Points
July 3, 2014	1665P	1BLK71ES184A	LAN-02 and LE-50
July 5, 2014	1673P	1BLK71ES186A	ZGS-88 and LAN-02
July 6, 2014	1677P	1BLK71S187A	ZGS-88 and LAN-02
October 28, 2014	2133P	1BLK69FE301A	MWS-11 and MW-85
October 28, 2014	2135P	1BLK69F301B	MWS-11 and MW-85
November 9, 2014	2181P	1BLK69F313A	MWS-11 and MW-85
February 15, 2016	23096P	1BLK76NO46A	MSW-12 and MW-62A
February 20, 2016	23116P	1BLK76NO51A	MSW-12 and MW-62A

2.3 Flight Missions

Eight (8) missions were conducted to complete LiDAR data acquisition in Clarin Floodplain, for a total of 24 hours and 36 minutes of flying time for RP-C9022. All missions were acquired using the Pegasus system. Table 10 shows the total area of actual coverage per mission and the flying length for each mission and Table 11 shows the actual parameters used during the LiDAR data acquisition.

Table 10. Flight Missions for LiDAR Data Acquisition in Clarin 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
July 3, 2014	1665P	324.36	42.73	22.1	20.63	NA	2	59
July 5, 2014	1673P	225	125.28	18.03	107.25	330	2	55
July 5, 2014	1677P	324.36	90.14	17	73.14	170	2	35
October 28, 2014	2133P	322.28	184.23	32.81	151.42	826	3	53
October 28, 2014	2135P	322.28	49.01	19.52	29.5	NA	1	47
November 9, 2014	2181P	322.282	137.57	20.44	117.13	361	3	11
February 15, 2016	23096P	47.79	53.53	30.32	23.21	196	2	41
February 20, 2016	23116P	71	157.2	28.23	128.97	NA	4	35
TOTAL		1959.35	839.69	188.45	651.25	1883	24	36

Table 11. Actual Parameters used during LiDAR Data Acquisition

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)**
1665P	1100	30	50	200	30	130	5
1673P	1000	30	50	200	30	130	5
1677P	1000	30	50	200	30	130	5
2133P	800	30	50	200	30	130	5
2135P	1000	30	50	200	30	130	5
2181P	1000	30	50	200	30	130	5
23096P	1100	30	50	200	30	130	5
23116P	1000	30	50	200	30	130	5

2.4 Survey Coverage

Clarin floodplain is located in the province of Misamis Occidental with the floodplain situated within the municipalities of Aloran, Bonifacio, Clarin, Jimenez, Lopez Jaena, Oroquieta City, Ozamiz City, Panaon, Plaridel, Sinacaban, Tangub City and Tudela. The list of municipalities and cities surveyed with at least one (1) square kilometer coverage, is shown in Table 12. The actual coverage of the LiDAR acquisition for Tupilac floodplain is presented in Figure 9.

Table 12. List of municipalities and cities surveyed of the Clarin Floodplain LiDAR Acquisition

Province	Municipality/ City	Area of Municipality/ City (km2)	Total Area Surveyed (km2)	Percentage of Area Surveyed =(Total Area covered/ Area of Municipality)*100
Lanao del Norte	Baroy	62.08	5.19	8%
	Kapatagan	184.77	5.94	3%
	Lala	125.18	12.38	10%
	Tubod	121.95	4.13	4%
Misamis Occidental	Aloran	105.66	33.79	32%
	Bonifacio	103.87	1.78	2%
	Clarin	114	40.22	35%
	Jimenez	78.48	27.84	36%
	Lopez Jaena	90.54	10.91	12%
	Oroquieta City	195.63	45.96	24%
	Ozamiz City	149.44	64.16	43%
	Panaon	52.52	15.22	29%
	Plaridel	56.35	11.08	20%
	Sinacaban	70.99	23.22	33%
	Tangub City	141.82	44.51	31%
	Tudela	108.93	29.84	27%
Zamboanga del Sur	Tambulig	142.93	8.32	6%
	Tukuran	119.01	10.12	9%
	Aurora	162.23	15.28	9%
	Labangan	176.44	1.02	1%
Total		2362.82	410.91	17.39%

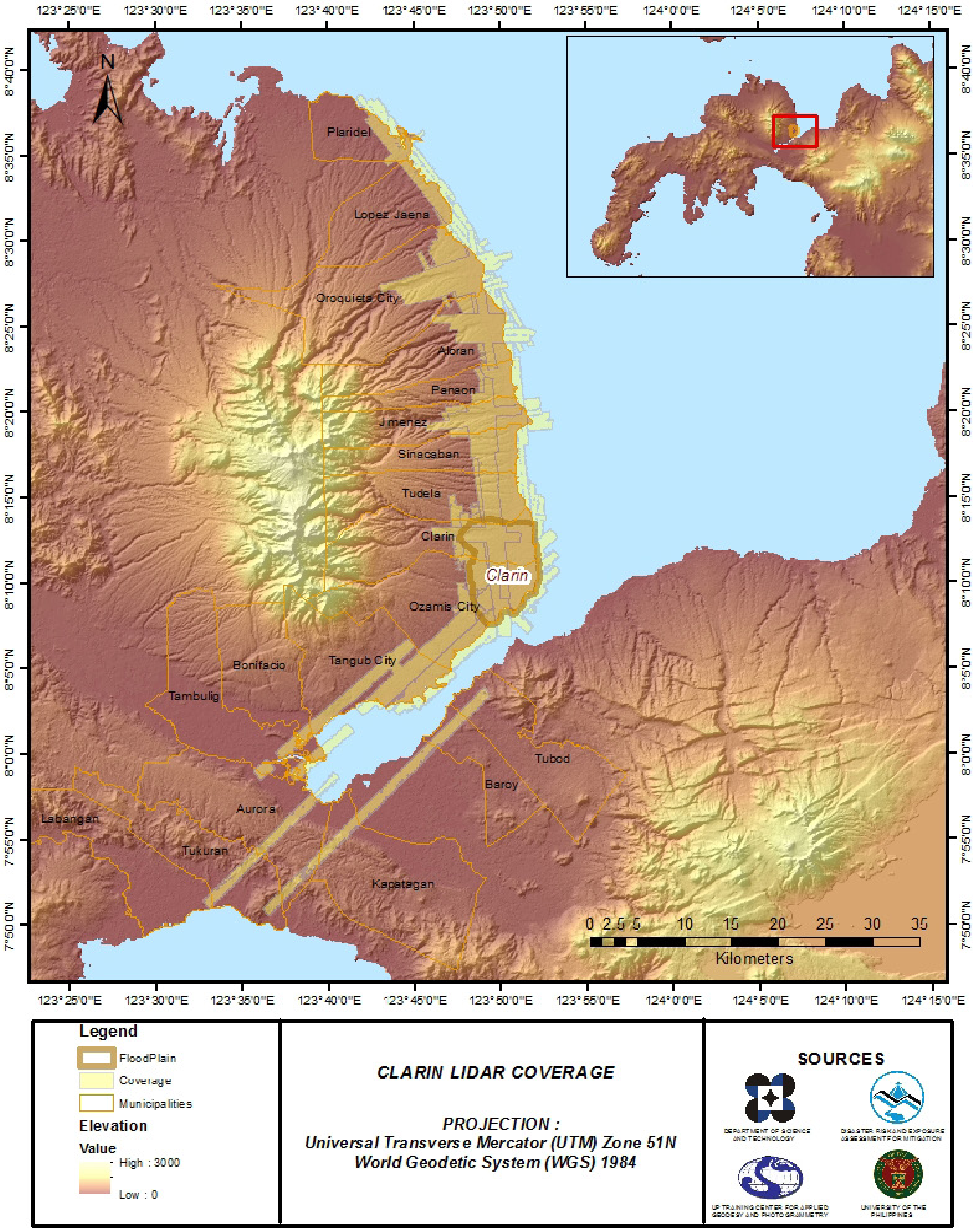


Figure 9. Actual LiDAR data acquisition of the Clarin floodplain.

CHAPTER 3: LIDAR DATA PROCESSING OF THE CLARIN FLOODPLAIN

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

3.1 Overview of the LiDAR Data Pre-Processing

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

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

These processes are summarized in the flowchart shown in Figure 10.

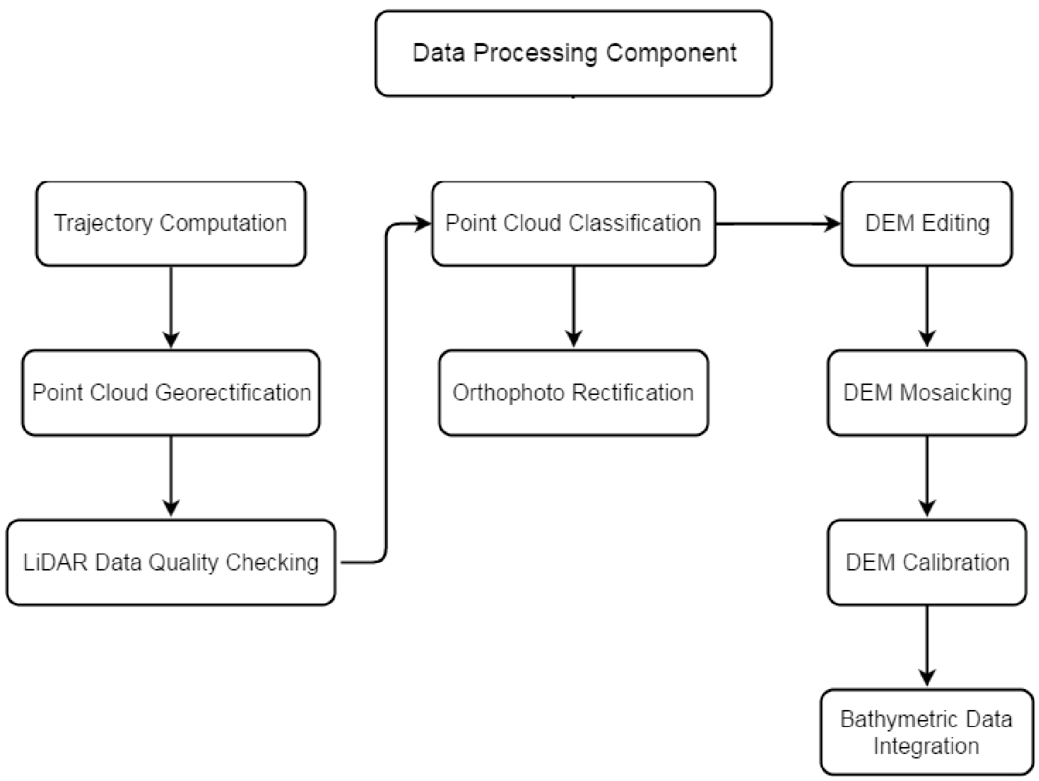


Figure 10. Schematic Diagram for Data Pre-Processing Component

3.2 Transmittal of Acquired LiDAR Data

Data transfer sheets for all the LiDAR missions for Clarin floodplain can be found in Annex 5. Missions flown for all the surveys conducted used the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.) Pegasus system over Northern Mindanao. The Data Acquisition Component (DAC) transferred a total of 79.13 Gigabytes of Range data, 1.46 Gigabytes of POS data, 262.69 Megabytes of GPS base station data, and 123.10 Gigabytes of raw image data to the data server on July 3, 2014 for the first survey and February 20, 2016 for the last survey. The Data Pre-processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for Clarin was fully transferred on March 10, 2016, as indicated on the Data Transfer Sheets for Clarin floodplain.

3.3 Trajectory Computation

The *Smoothed Performance Metric*parameters of the computed trajectory for flight 23096P, one of the Clarin flights, which is the North, East, and Down position RMSE values are shown in Figure 11. The x-axis corresponds to the time of flight, which is measured by the number of seconds from the midnight of the start of the GPS week, which on that week fell on February 15, 2016 00:00AM. The y-axis is the RMSE value for that particular position.

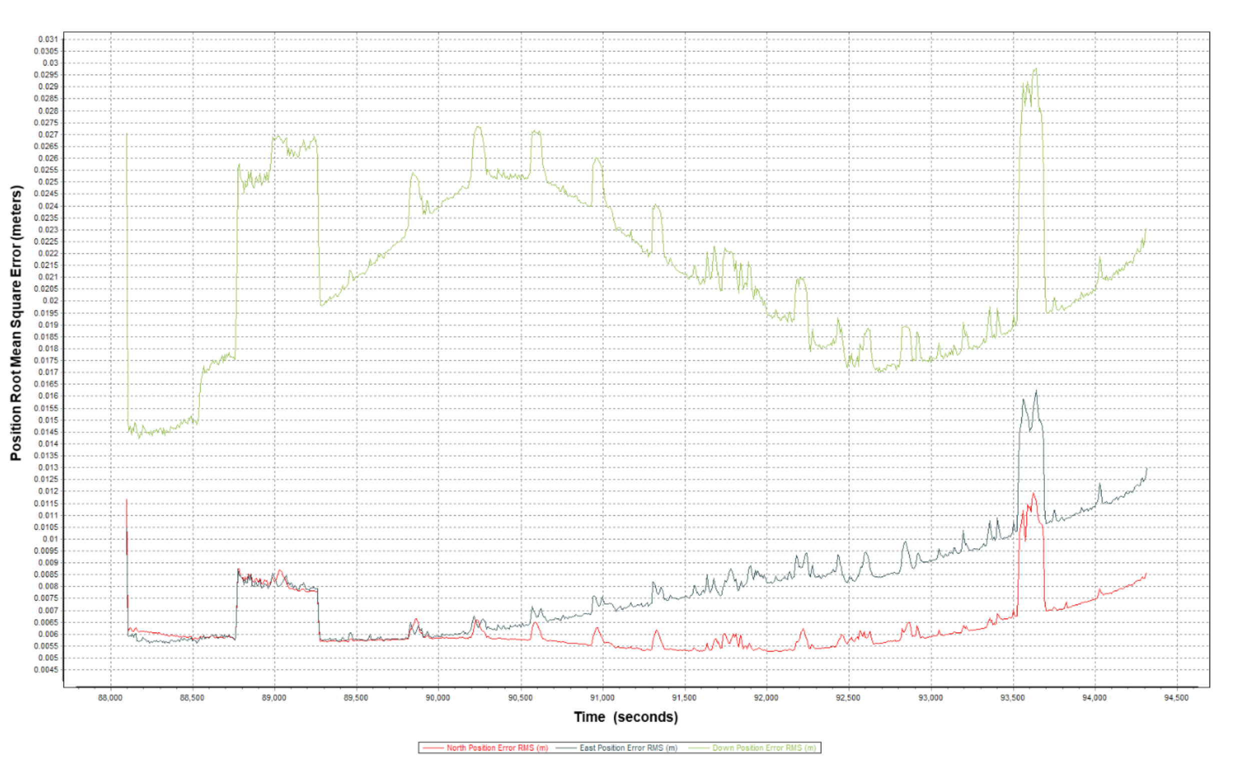


Figure 11. Smoothed Performance Metric Parameters of a Clarin Flight 23096P.

The time of flight was from 88000 seconds to 94500 seconds, which corresponds to morning of February 15, 2016. The initial spike that is seen on the data corresponds to the time that the aircraft was getting into position to start the acquisition, and the POS system starts computing for the position and orientation of the aircraft. Redundant measurements from the POS system quickly minimized the RMSE value of the positions. The periodic increase in RMSE values from an otherwise smoothly curving RMSE values correspond to the turn-around period of the aircraft, when the aircraft makes a turn to start a new flight line. Figure 11 shows that the North position RMSE peaks at 1.20 centimeters, the East position RMSE peaks at 1.65 centimeters, and the Down position RMSE peaks at 3.00 centimeters, which are within the prescribed accuracies described in the methodology.

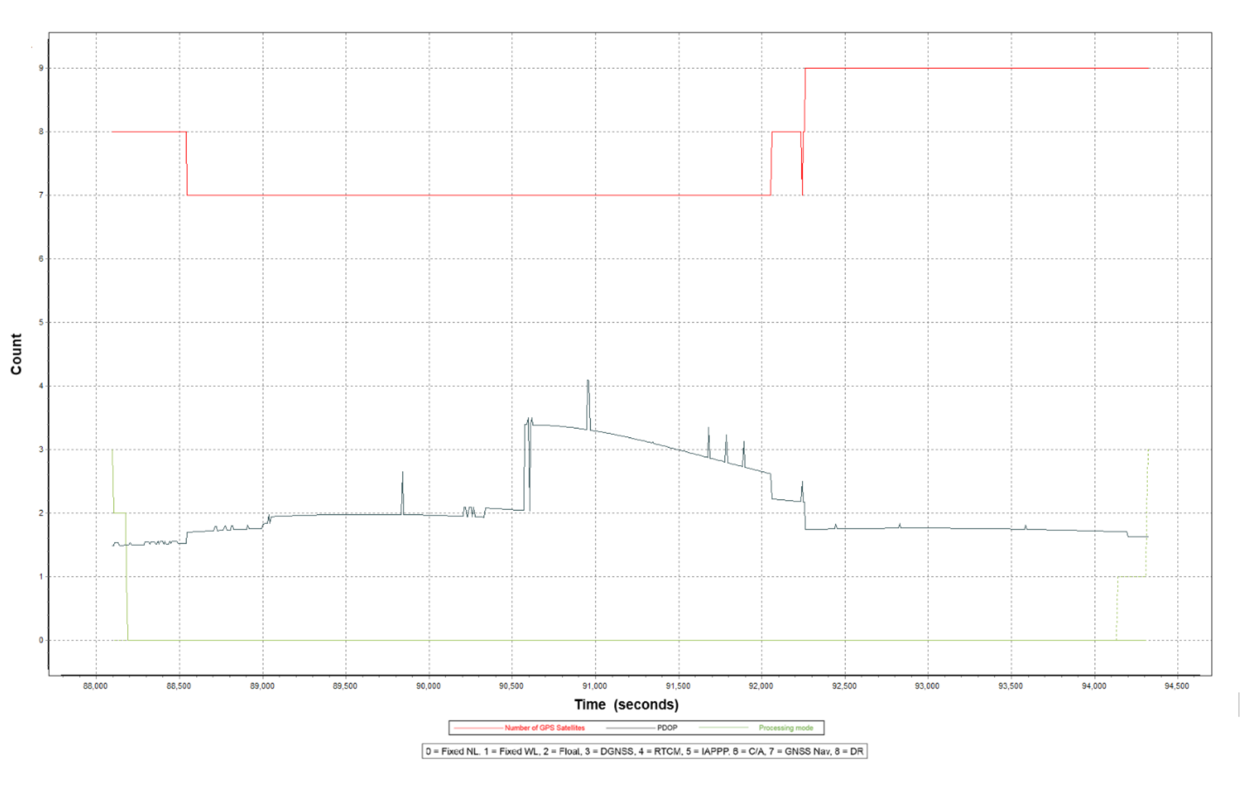


Figure 12. Solution Status Parameters of Clarin Flight 23096P.

The Solution Status parameters of flight 23096P, one of the Clarin flights, which are the number of GPS satellites, Positional Dilution of Precision (PDOP), and the GPS processing mode used, are shown in Figure 12. The graphs indicate that the number of satellites during the acquisition did not go down to 6. Majority of the time, the number of satellites tracked was between 7 and 9. The PDOP value also did not go above the value of 3, which indicates optimal GPS geometry. The processing mode stayed at the value of 0 for majority of the survey. The value of 0 corresponds to a Fixed, Narrow-Lane mode, which is the optimum carrier-cycle integer ambiguity resolution technique available for POSPAC MMS. All of the parameters adhered to the accuracy requirements for optimal trajectory solutions, as indicated in the methodology. The computed best estimated trajectory for all Clarin flights is shown in Figure 13.

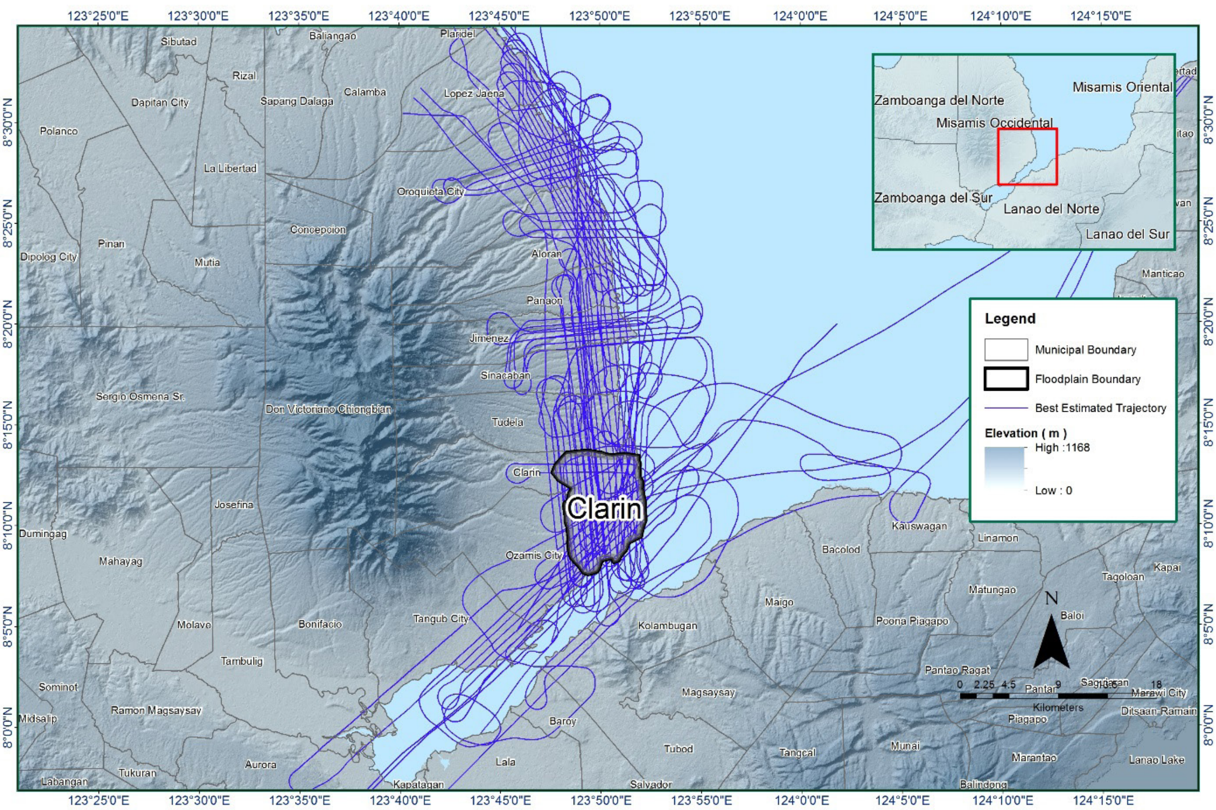


Figure 13. Best Estimated Trajectory for Clarin floodplain.

3.4 LiDAR Point Cloud Computation

The produced LAS data contains 56 flight lines, with each flight line containing one channel, since the Pegasus system contains two channels. The summary of the self-calibration results obtained from LiDAR processing in LiDAR Mapping Suite (LMS) software for all flights over Clarin floodplain are given in Table 13.

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

Parameter	Accepted Value	Computed Value
Boresight Correction stdev	(<0.001degrees)	0.000290
IMU Attitude Correction Roll and Pitch Corrections stdev	(<0.001degrees)	0.000405
GPS Position Z-correction stdev	(<0.01meters)	0.0022

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

3.5 LiDAR Data Quality Checking

The boundary of the processed LiDAR data on top of a SAR Elevation Data over Clarin Floodplain is shown in Figure 14. The map shows gaps in the LiDAR coverage that are attributed to cloud coverage.

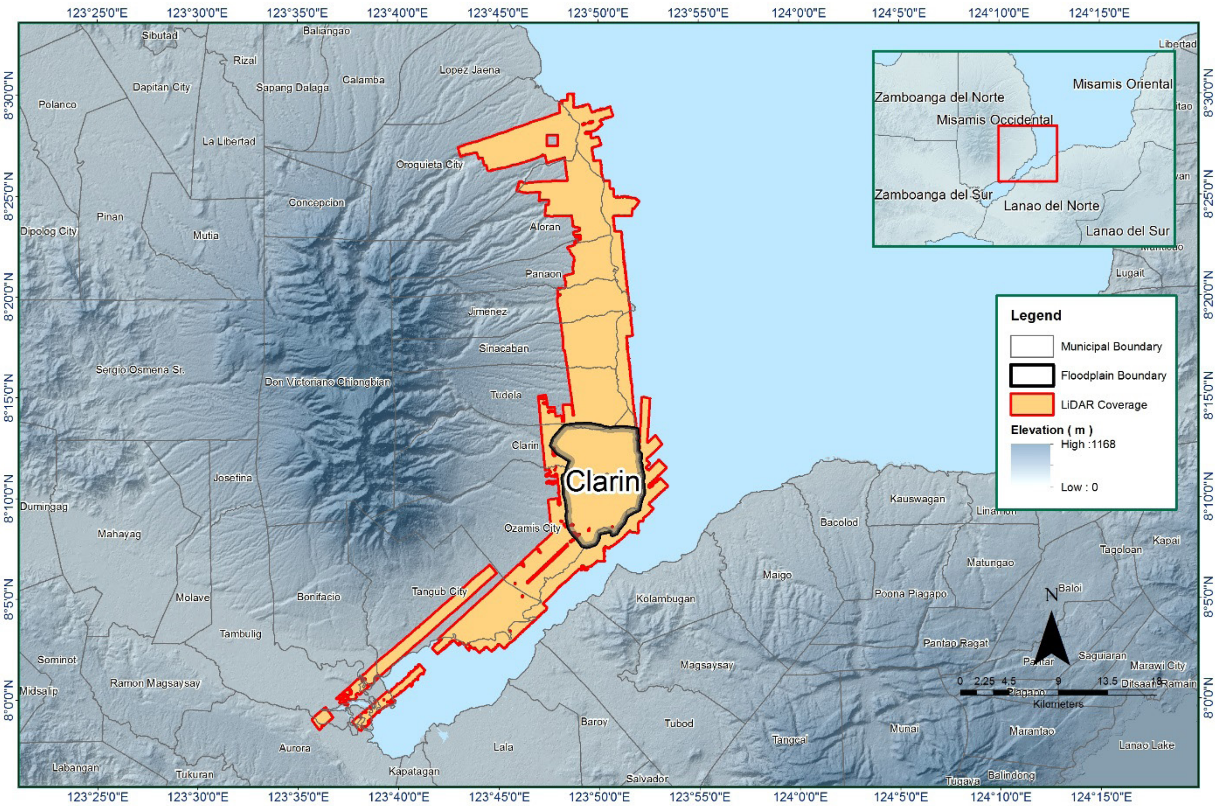


Figure 14. Boundary of the processed LiDAR data over Clarin Floodplain

The total area covered by the Clarin missions is 455.84 sq.km that is comprised of eight (8) flight acquisitions grouped and merged into four (4) blocks as shown in Table 14.

Table 14. List of LiDAR blocks for Clarin floodplain.

LiDAR Blocks	Flight Numbers	Area (sq. km)
Pagadian_Blk76O	23096P	51.12
Pagadian_Blk76O_supplement	23116P	34.02
Dipolog_Blk69F	2133P	232.40
	2135P	
	2181P	
Northern Mindanao_Blk71_extension	1665P	138.30
	1673P	
	1677P	
	TOTAL	**455.84 sq.km**

The overlap data for the merged LiDAR blocks, showing the number of channels that pass through a particular location is shown in Figure 15. Since the Pegasus system employs two channels, we would expect an average value of 2 (blue) for areas where there is limited overlap, and a value of 3 (yellow) or more (red) for areas with three or more overlapping flight lines.

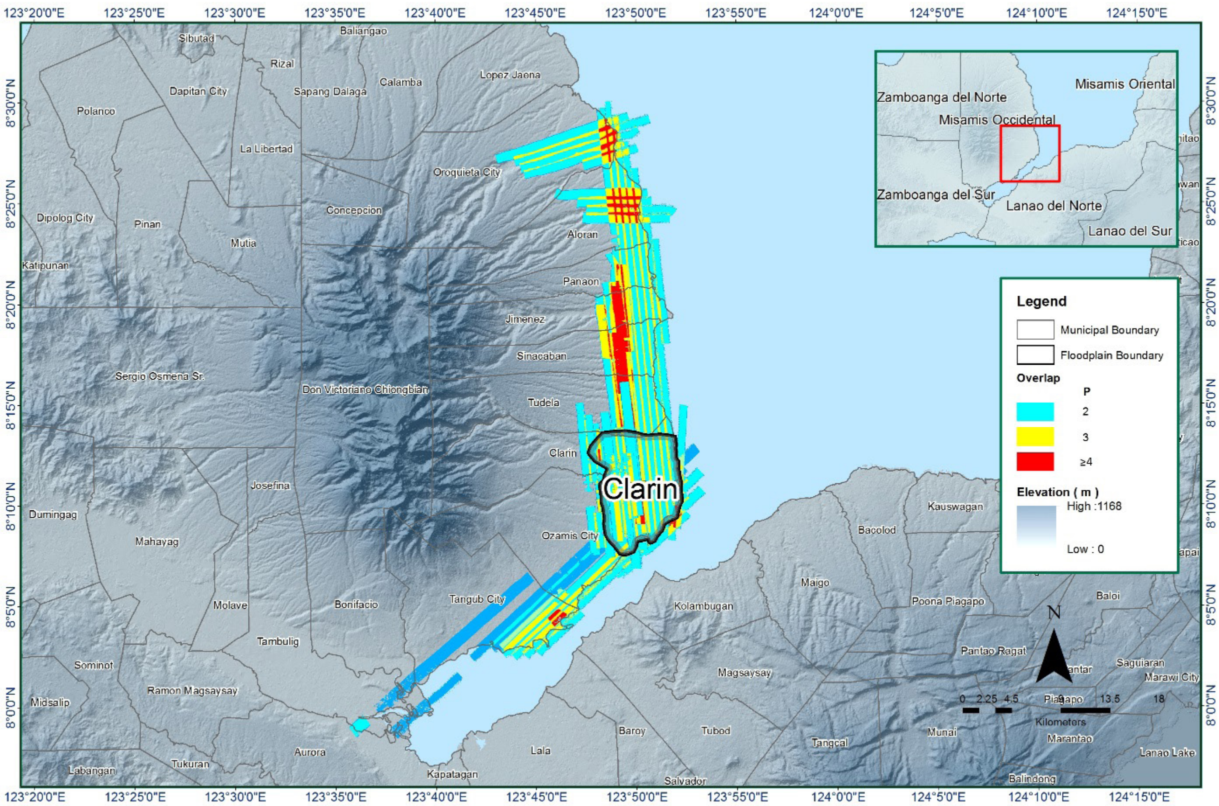


Figure 15. Image of data overlap for Clarin floodplain.

The overlap statistics per block for the Clarin floodplain can be found in Annex 5. One pixel corresponds to 25.0 square meters on the ground. For this area, the minimum and maximum percent overlaps are 21.83% and 40.81% respectively, which passed the 25% requirement.

The pulse density map for the merged LiDAR data, with the red parts showing the portions of the data that satisfy the 2 points per square meter criterion is shown in Figure16. It was determined that all LiDAR data for Clarin floodplain satisfy the point density requirement, and the average density for the entire survey area is 4.29 points per square meter.

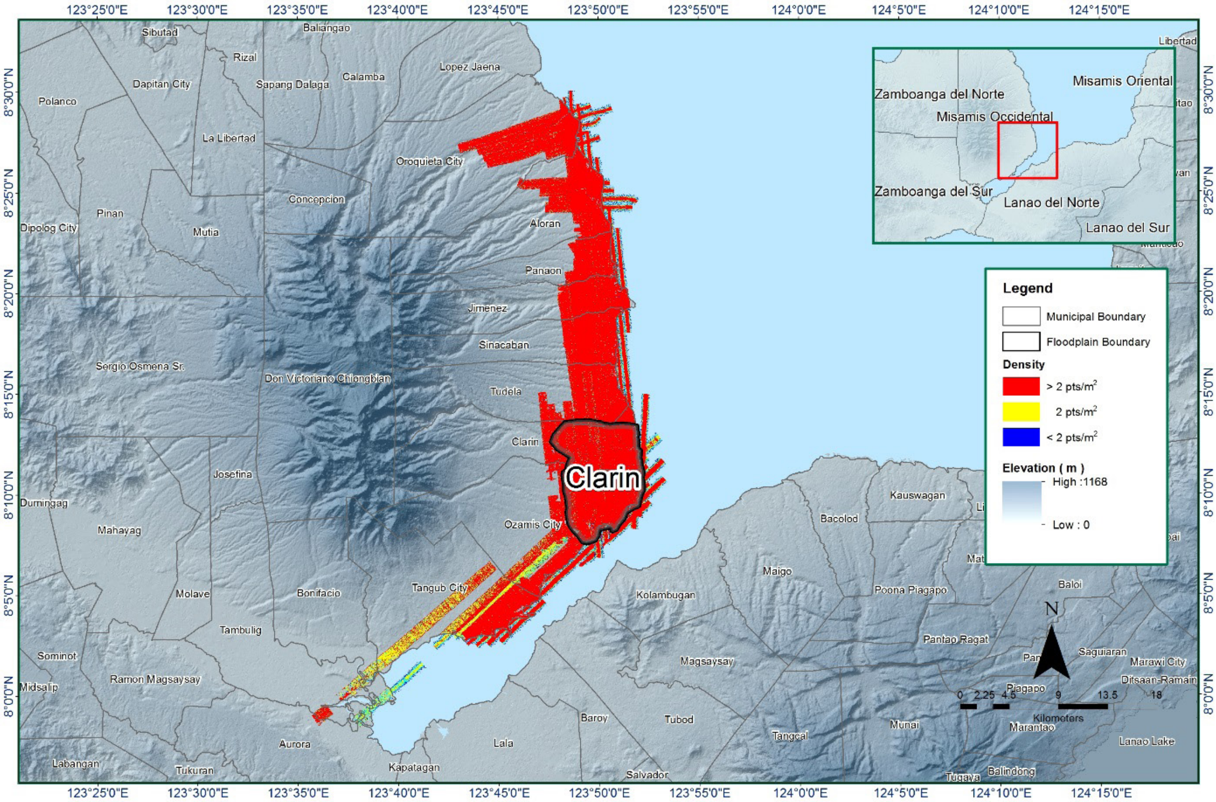


Figure 16. Pulse density map of merged LiDAR data for Clarin floodplain.

The elevation difference between overlaps of adjacent flight lines is shown in Figure 17. The default color range is from blue to red, where bright blue areas correspond to portions where elevations of a previous flight line, identified by its acquisition time, are higher by more than 0.20m relative to elevations of its adjacent flight line. Bright red areas indicate portions where elevations of a previous flight line are lower by more than 0.20m relative to elevations of its adjacent flight line. Areas with bright red or bright blue need to be investigated further using Quick Terrain Modeler software.

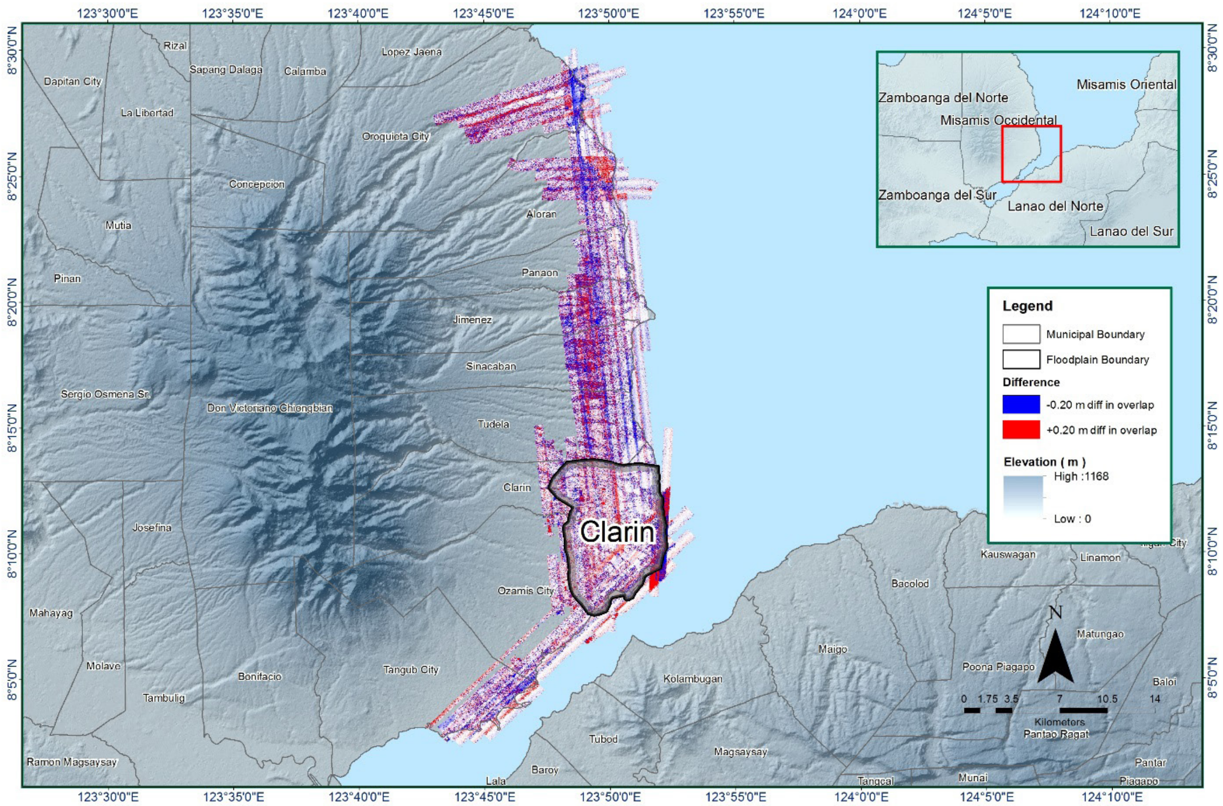


Figure 17. Elevation difference map between flight lines for Clarin floodplain.

A screen capture of the processed LAS data from a Clarin flight 23096P loaded in QT Modeler is shown in Figure 18. The upper left image shows the elevations of the points from two overlapping flight strips traversed by the profile, illustrated by a dashed red line. The x-axis corresponds to the length of the profile. It is evident that there are differences in elevation, but the differences do not exceed the 20-centimeter mark. This profiling was repeated until the quality of the LiDAR data becomes satisfactory. No reprocessing was done for this LiDAR dataset.

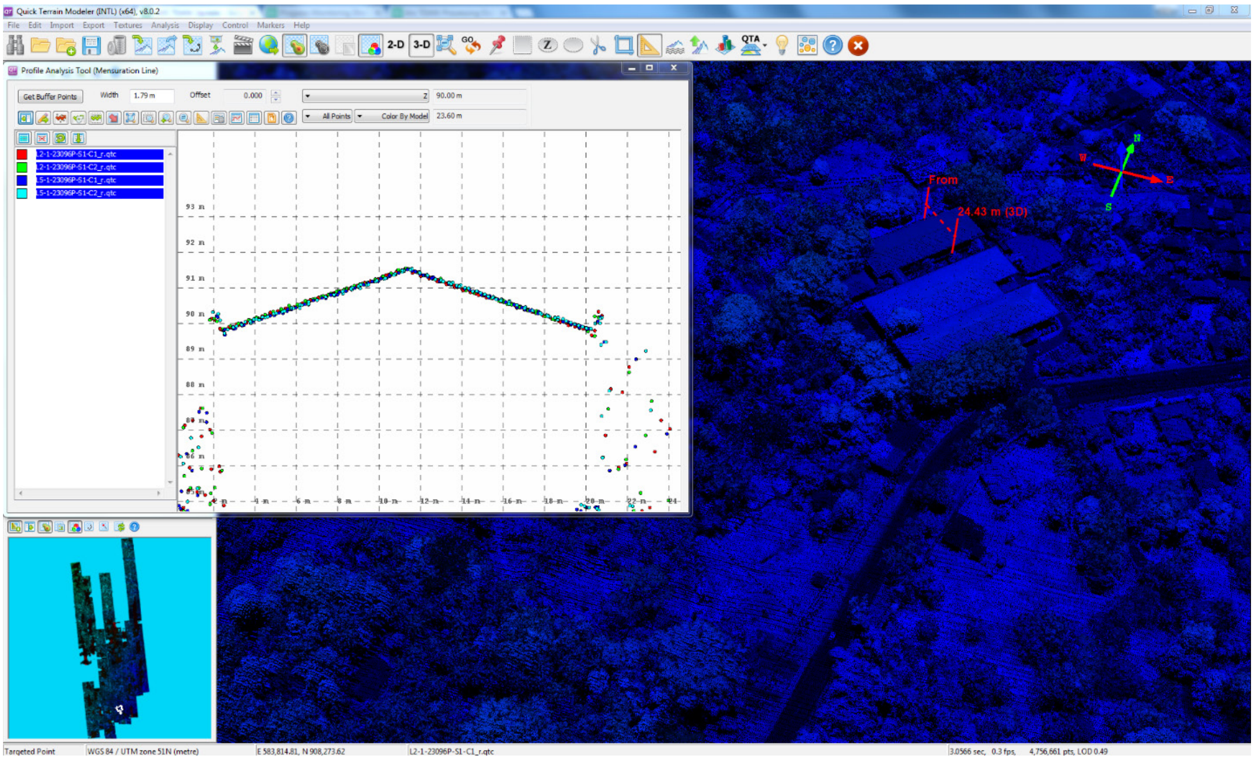


Figure 18. Quality checking for a Clarin flight 23096P using the Profile Tool of QT Modeler.

3.6 LiDAR Point Cloud Classification and Rasterization

Table 15. Clarin classification results in TerraScan.

Pertinent Class	Total Number of Points
Ground	469,382,151
Low Vegetation	473,227,191
Medium Vegetation	489,414,876
High Vegetation	748,111,770
Building	57,556,351

The tile system that TerraScan employed for the LiDAR data and the final classification image for a block in Clarin floodplain is shown in Figure 19. A total of 688 1km by 1km tiles were produced. The number of points classified to the pertinent categories is illustrated in Table 15. The point cloud has a maximum and minimum height of 420.83 meters and 53.91 meters, respectively.

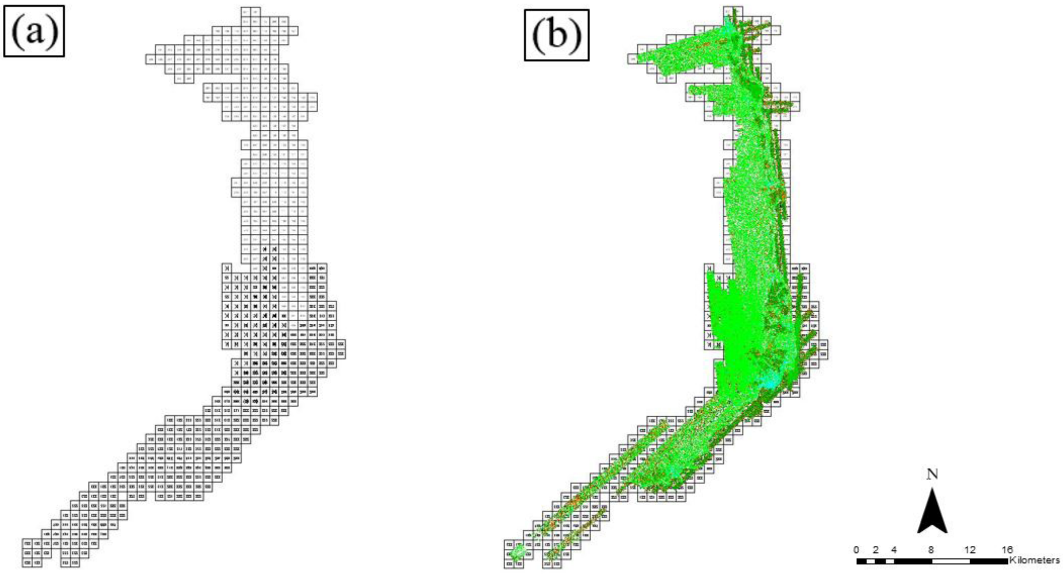


Figure 19. Tiles for Clarin floodplain (a) and classification results (b) in TerraScan.

An isometric view of an area before and after running the classification routines is shown in Figure 20. The ground points are in orange, the vegetation is in different shades of green, and the buildings are in cyan. It can be seen that residential structures adjacent or even below canopy are classified correctly, due to the density of the LiDAR data.

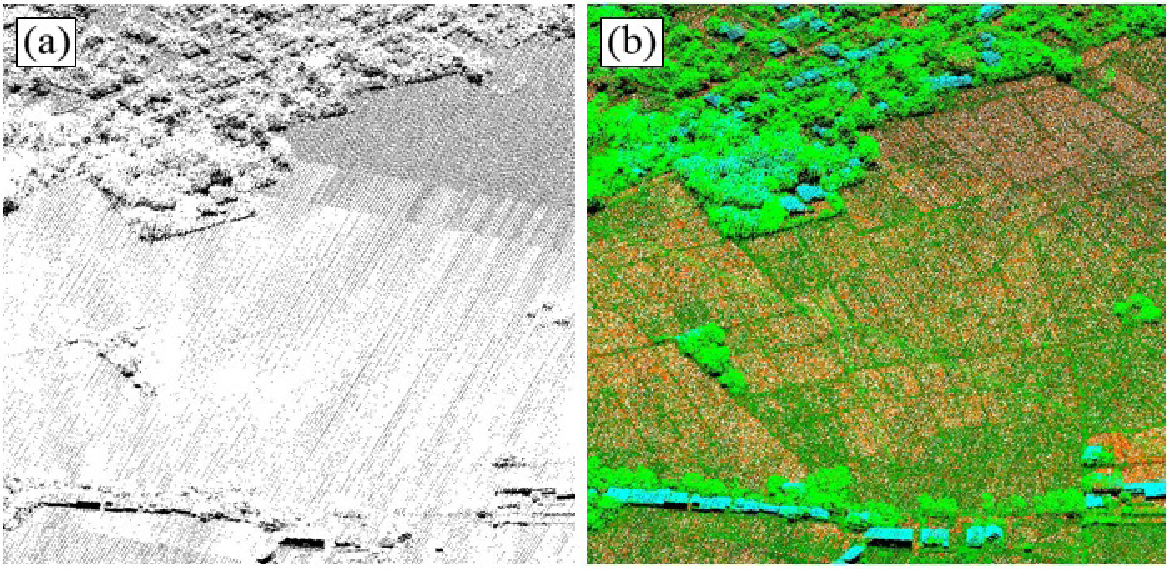


Figure 20. Point cloud before (a) and after (b) classification.

The production of last return (V_ASCII) and the secondary (T_ ASCII) DTM, first (S_ ASCII) and last (D_ ASCII) return DSM of the area in top view display are shown in Figure 21. It shows that DTMs are the representation of the bare earth while on the DSMs, all features are present such as buildings and vegetation.

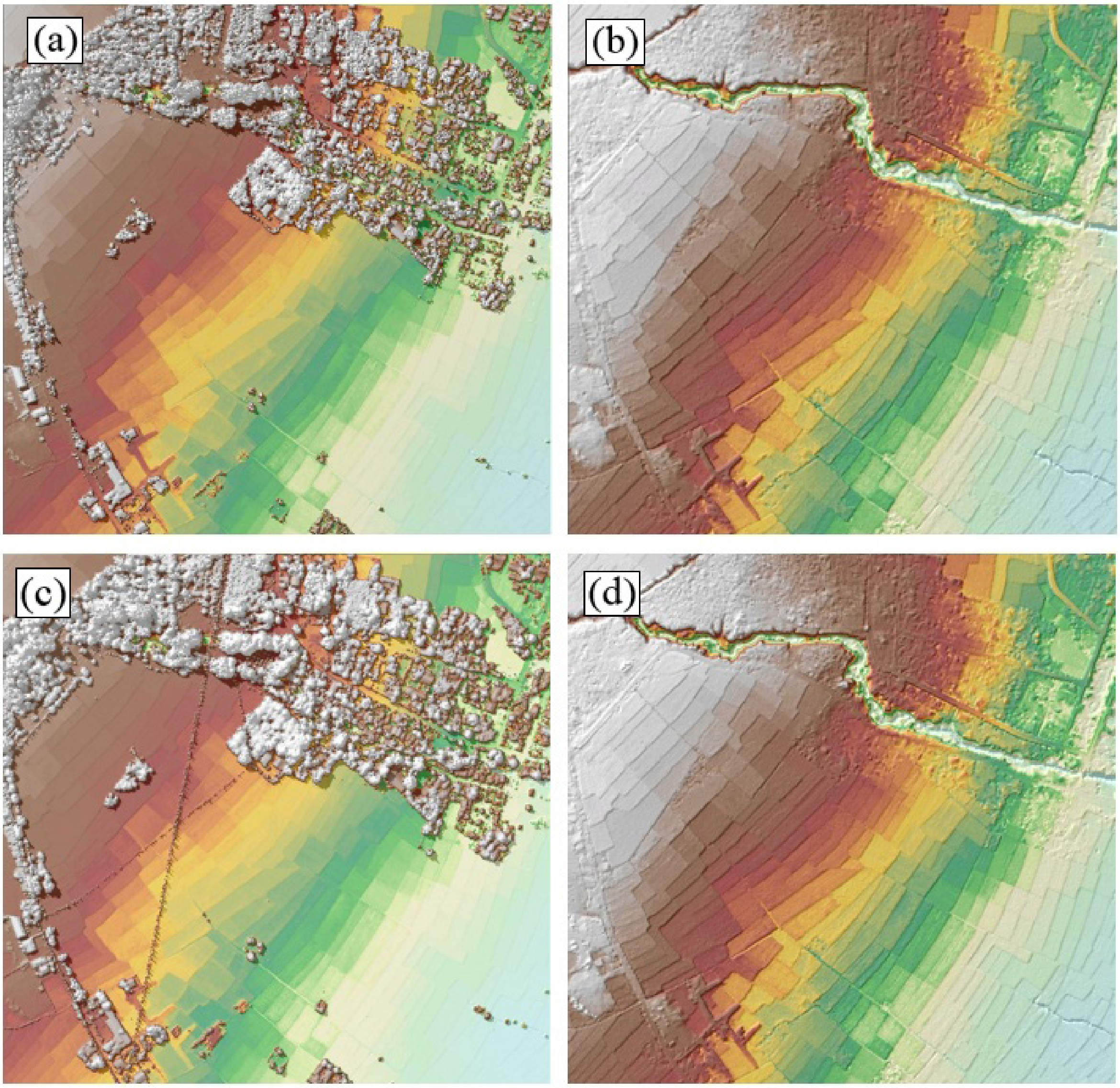


Figure 21. The production of last return DSM (a) and DTM (b), first return DSM (c) and secondary DTM (d) in some portion of Clarin floodplain.

3.7 LiDAR Image Processing and Orthophotograph Rectification

The 87 1km by 1km tiles area covered by Clarin floodplain is shown in Figure 22. After tie point selection to fix photo misalignments, color points were added to smoothen out visual inconsistencies along the seamlines where photos overlap. The Clarin floodplain has a total of 48.70 sq.km orthophotogaph coverage comprised of 159 images. A zoomed in version of sample orthophotographs named in reference to its tile number is shown in Figure 23.

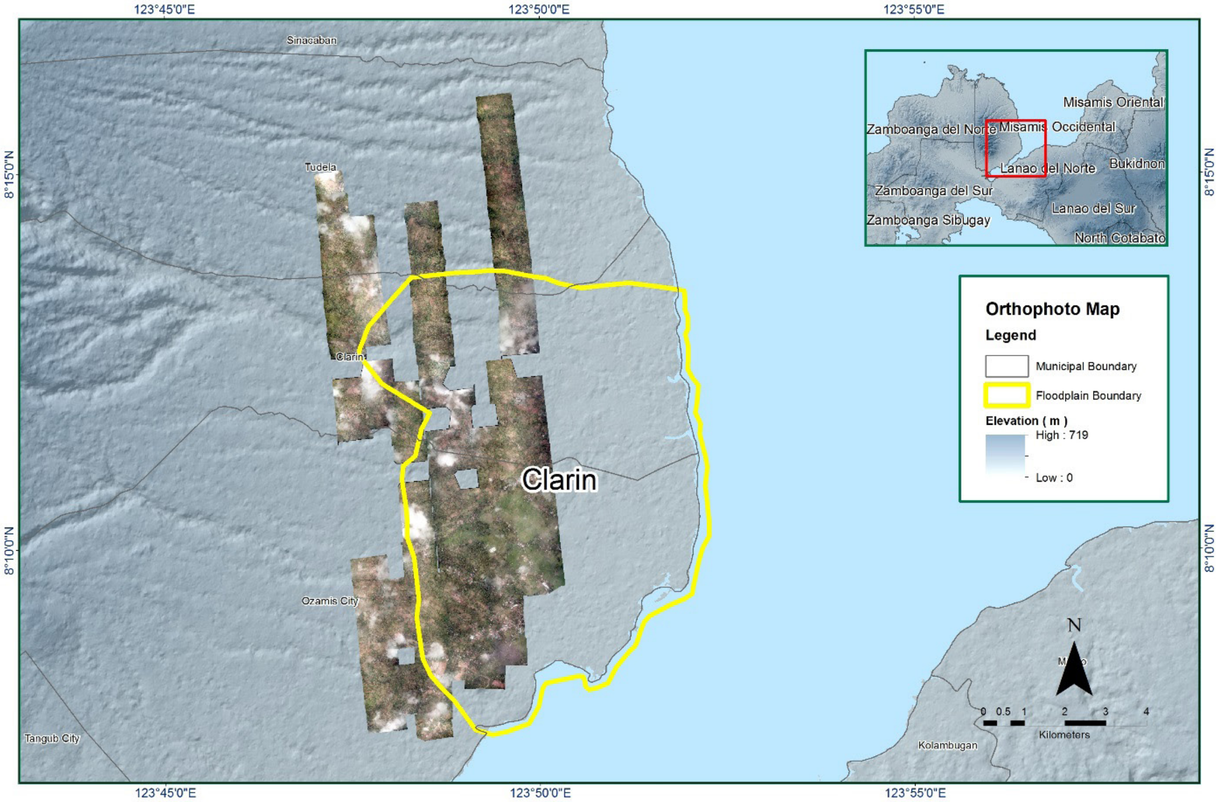


Figure 22. Clarin floodplain with available orthophotographs.

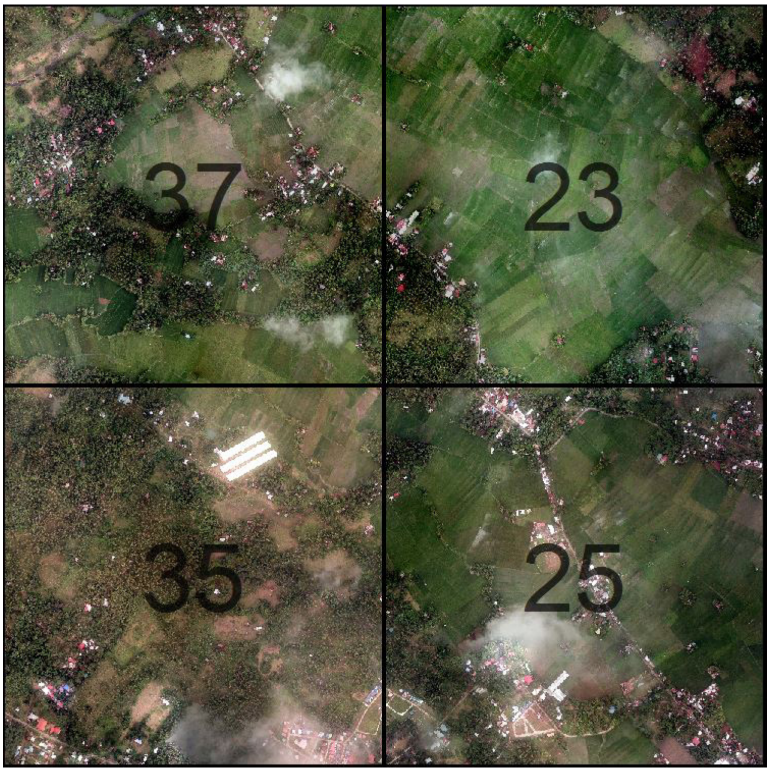


Figure 23. Sample orthophotograph tiles for Clarin floodplain.

3.8 DEM Editing and Hydro-Correction

Four (4) mission blocks were processed for Clarin flood plain. These blocks are composed of Pagadian, Dipolog and Northern Mindanao blocks with a total area of 455.84 square kilometers. Table 16 shows the name and corresponding area of each block in square kilometers.

Table 16. LiDAR blocks with its corresponding area.

LiDAR Blocks	Area (sq.km)
Pagadian_Blk76O	51.12
Pagadian_Blk76O_supplement	34.02
Dipolog_Blk69F	232.40
Northern Mindanao_Blk71_extension	138.30
TOTAL	**455.84 sq.km**

Portions of DTM before and after manual editing are shown in Figure 24. The bridge (Figure 24a) is also considered to be an impedance to the flow of water along the river and has to be removed (Figure 24b) in order to hydrologically correct the river. The river embankment (Figure 24c) has been misclassified and removed during classification process and has to be retrieved to complete the surface (Figure 24d) to allow the correct flow of water.

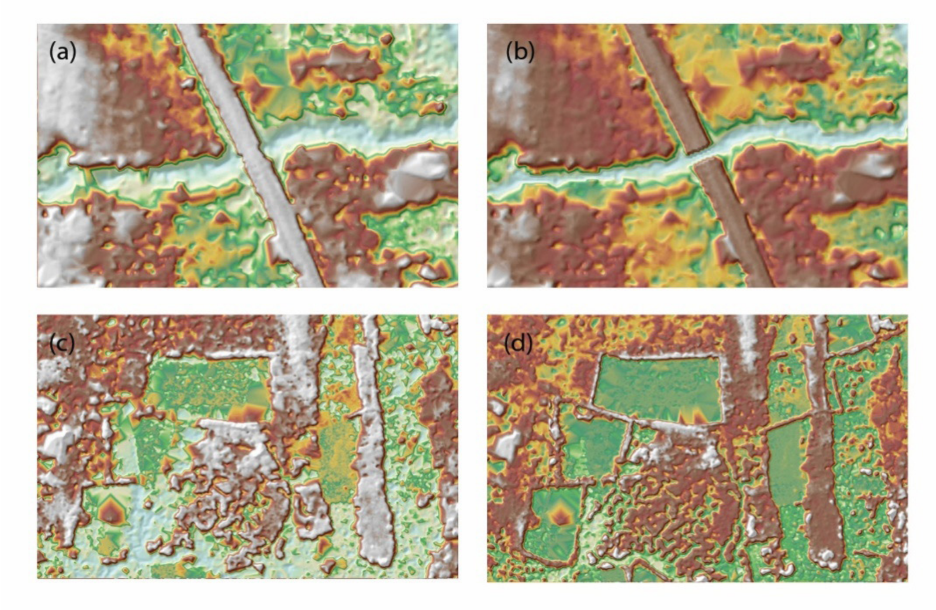


Figure 24. Portions in the DTM of Clarin floodplain – a bridge before (a) and after (b) manual editing; and a paddy field before (c) and after (d) data retrieval

3.9 Mosaicking of Blocks

NorthernMindanao_Blk71_Extension was used as the reference block at the start of mosaicking because it is already vertically calibrated to MSL and it overlaps Dipolog_Blk69F which is the largest DTM of Clarin river basin. Table 17 shows the shift values applied to each LiDAR block during mosaicking

Table 17. Shift Values of each LiDAR Block of Clarin floodplain.

Mission Blocks	Shift Values (meters)		
	x	y	z
Pagadian_Blk76O	0.00	0.00	0.00
Pagadian_Blk76O_supplement	0.00	0.00	0.00
Dipolog_Blk69F	-0.15	0.21	0.00
NorthernMindanao_Blk71_extension	0.00	0.00	0.00

Mosaicked LiDAR DTM for Clarin floodplain is shown in Figure 25. It can be seen that the entire Clarin floodplain is 99.44% covered by LiDAR data.

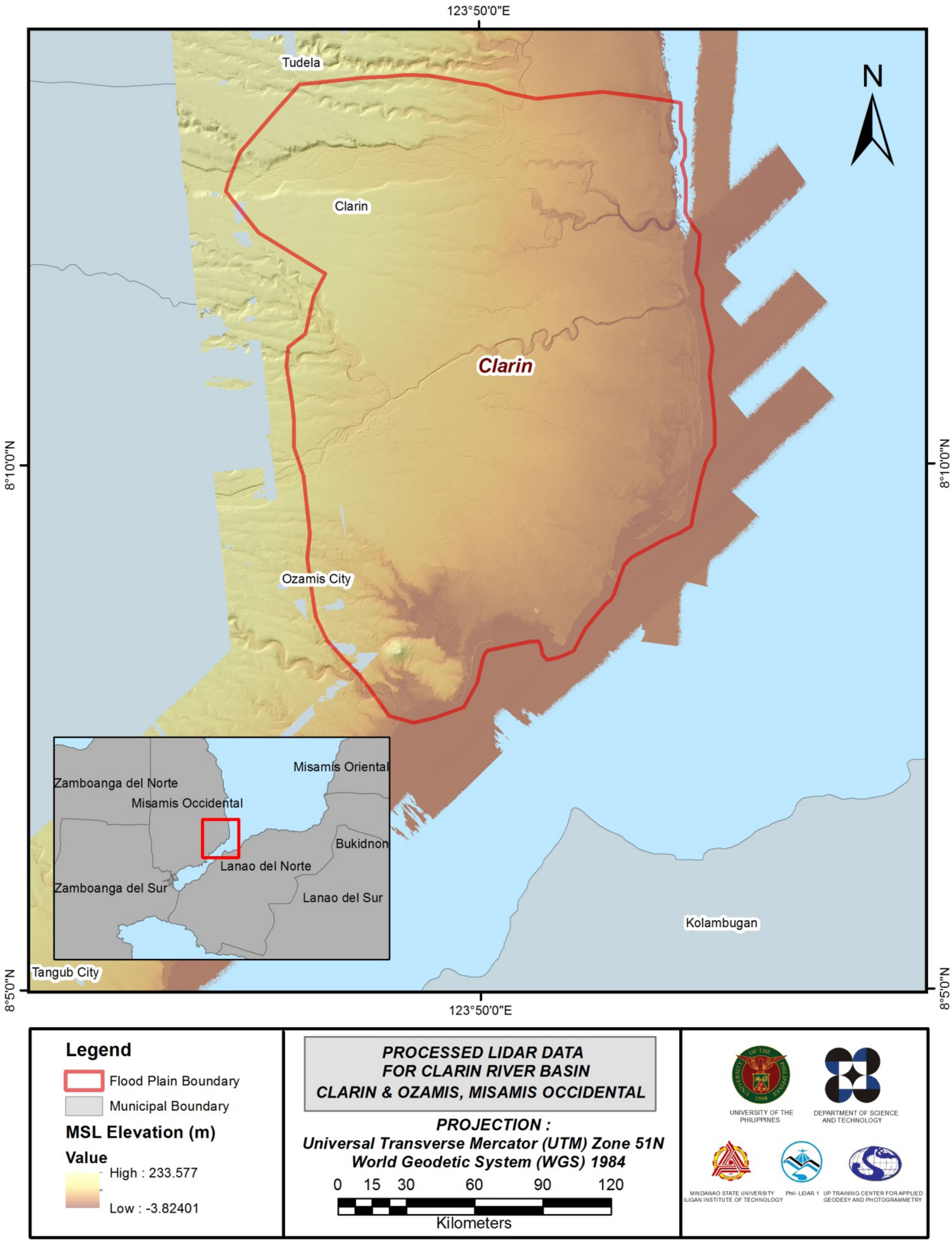


Figure 25. Map of Processed LiDAR Data for Clarin Flood Plain.

3.10 Calibration and Validation of Mosaicked LiDAR DEM

The extent of the validation survey done by the Data Validation and Bathymetry Component (DVBC) in Clarin to collect points with which the LiDAR dataset is validated is shown in Figure 26. The Clarin LiDAR data were calibrated with NorthernMindanao_Blk71_Extension as the reference block. A total of 2003 survey points were used for calibration of Clarin LiDAR data. Random selection of 80% of the survey points, resulting to 1602 points, were used for calibration.

A good correlation between the uncalibrated mosaicked LiDAR elevation values and the ground survey elevation values is shown in Figure 27. Statistical values were computed from extracted LiDAR values using the selected points to assess the quality of data and obtain the value for vertical adjustment. The computed height difference between the LiDAR DTM and calibration elevation values is 2.27 meters with a standard deviation of 0.08 meters. Calibration of Clarin LiDAR data was done by adding the height difference value, 2.27 meters, to Clarin mosaicked LiDAR data. Table 18 shows the statistical values of the compared elevation values between LiDAR data and calibration data.

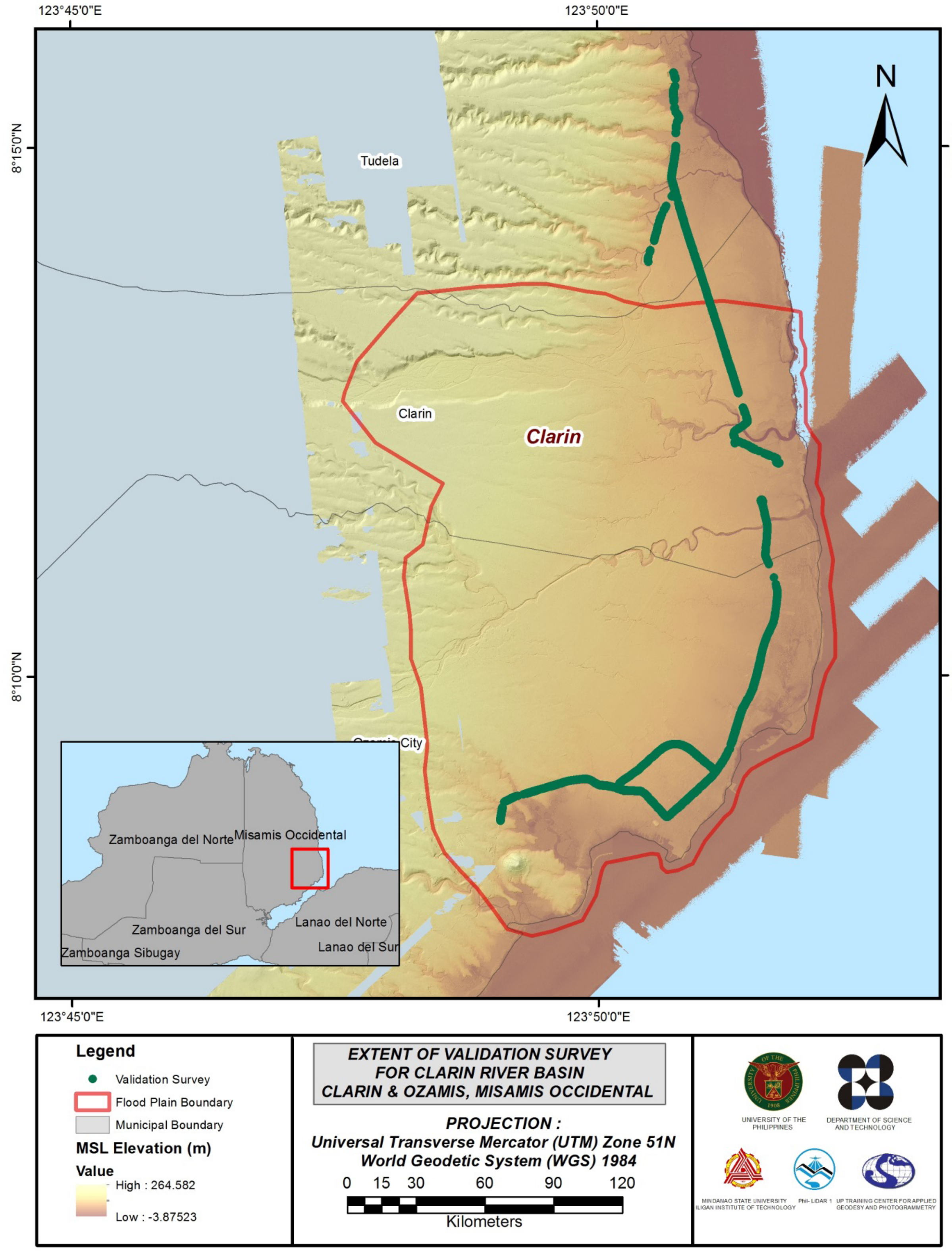


Figure 26. Map of Clarin Flood Plain with validation survey points in green.

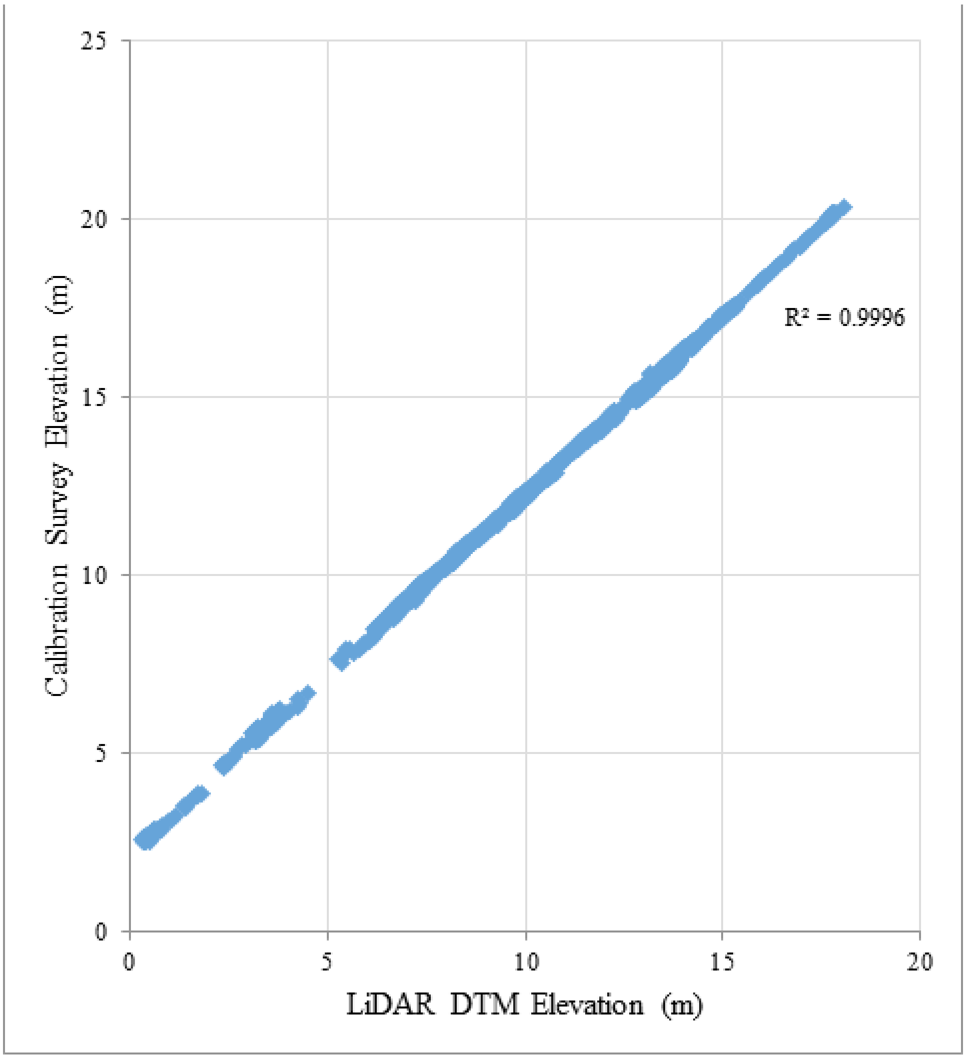


Figure 27. Correlation plot between calibration survey points and LiDAR data.

Table 18. 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 2517 survey points were collected by DVBC for the Clarin river basin. Random selection of 20% of the total survey points, resulting to 504 points, were used for the validation of calibrated Clarin DTM. A good correlation between the calibrated mosaicked LiDAR elevation values and the ground survey elevation, which reflects the quality of the LiDAR DTM is shown in Figure 28. The computed RMSE between the calibrated LiDAR DTM and validation elevation values is 0.07 meters with a standard deviation of 0.06 meters, as shown in Table 19.

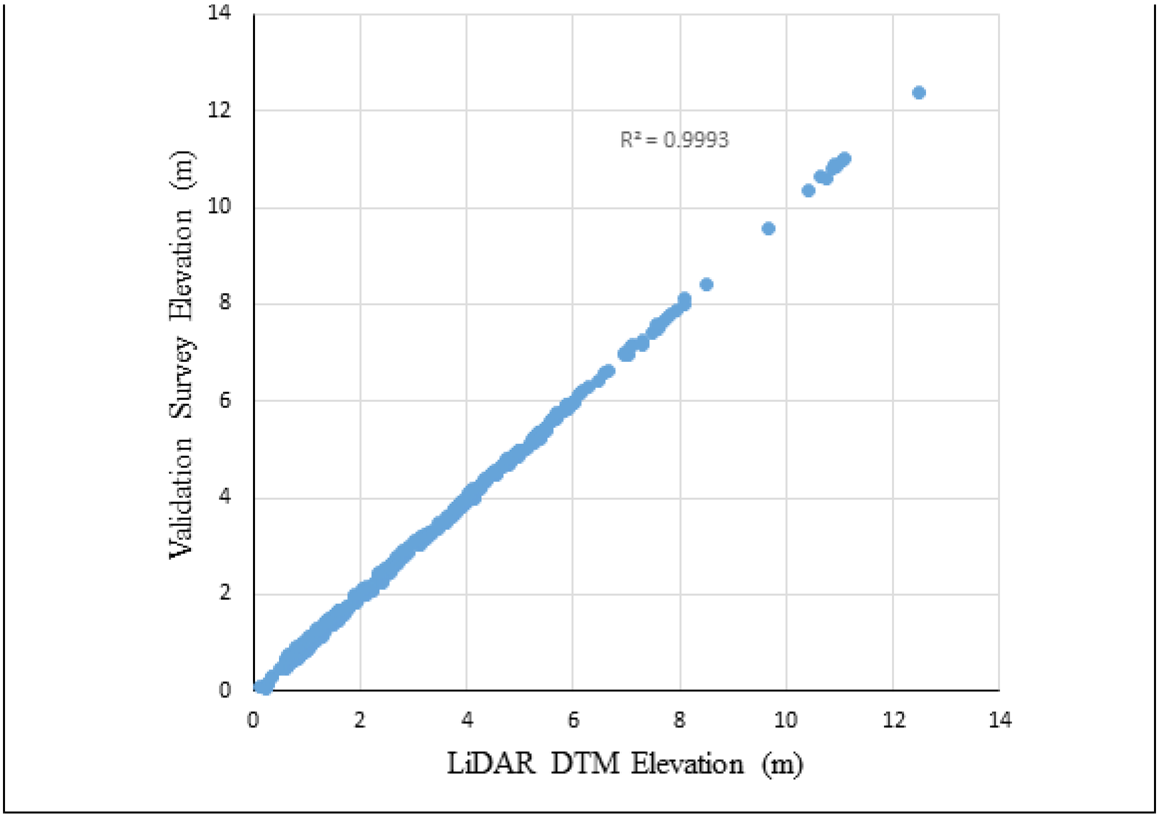


Figure 28. Correlation plot between validation survey points and LiDAR data.

Table 19. Validation Statistical Measures.

Validation Statistical Measures	Value (meters)
RMSE	0.07
Standard Deviation	0.06
Average	-0.04
Minimum	-0.18
Maximum	0.09

3.11 Integration of Bathymetric Data into the LiDAR Digital Terrain Model

For bathy integration, centerline, zigzag line, and cross-section data were available for Clarin with 14,531 bathymetric survey points. The resulting raster surface produced was done by 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 0.28 meters. The extent of the bathymetric survey done by the Data Validation and Bathymetry Component (DVBC) in Clarin integrated with the processed LiDAR DEM is shown in Figure 29.

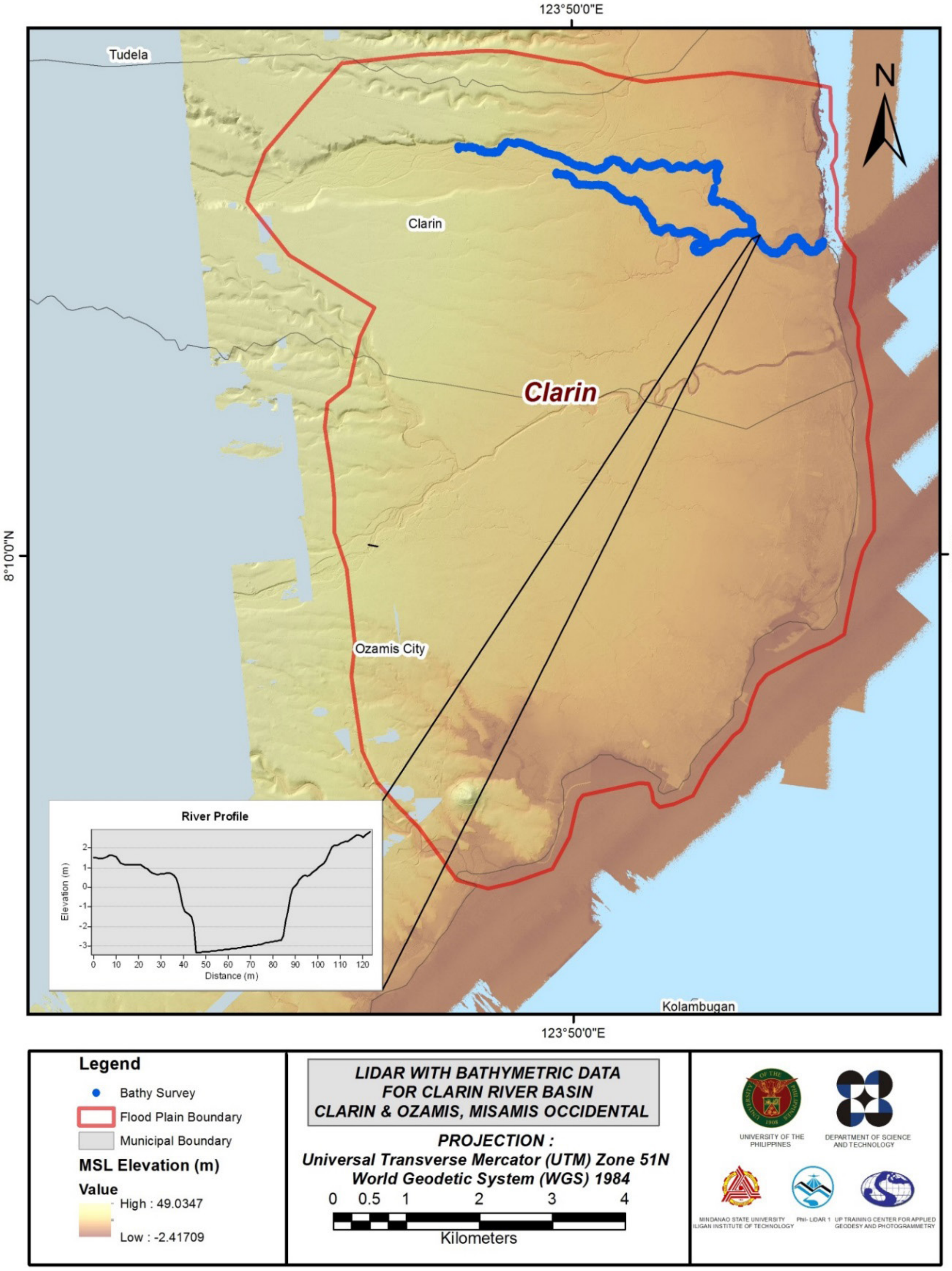


Figure 29. Map of Clarin Flood Plain with bathymetric survey points shown in blue.

3.12 Feature Extraction

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

3.12.1 Quality Checking of Digitized Features' Boundary

Clarin floodplain, including its 200 m buffer, has a total area of 77.05 sq km. For this area, a total of 5.0 sq km, corresponding to a total of 2399 building features, are considered for QC. Figure 30 shows the QC blocks for Clarin floodplain.

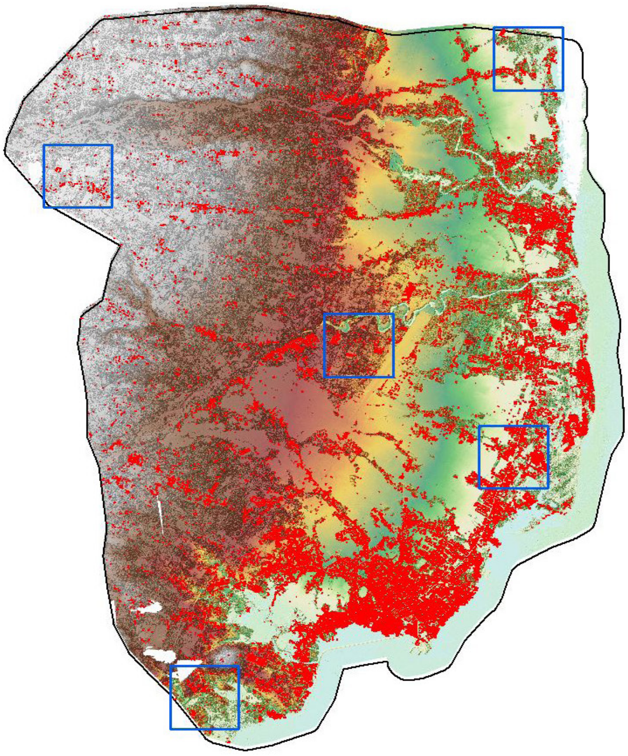


Figure 30. QC blocks for Clarin building features.

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

Table 20. Quality Checking Ratings for Clarin Building Features.

FLOODPLAIN	COMPLETENESS	CORRECTNESS	QUALITY	REMARKS
Clarin	98.01	96.42	82.20	PASSED

3.12.2 Height Extraction

Height extraction was done for 37,938 building features in Clarin floodplain. Of these building features, 1,293 were filtered out after height extraction, resulting to 36,645 buildings with height attributes. The lowest building height is at 2.00 m, while the highest building is at 16.32 m.

3.12.3 Feature Attribution

Clarin floodplain is shared by one (1) municipality and one (1) city namely municipality of Clarin and city of Ozamiz. The building attribution on the municipality of Clarin and city of Ozamiz was done with the Google Earth approach. In Google Earth approach, aid from Purok representatives were sought for participatory mapping over the Google Earth software. The attributions of road, bridge and water body features were done using NAMRIA maps, municipal and city records, and participatory mapping of municipals and cities.

Table 21 summarizes the number of building features per type. On the other hand, Table 22 shows the total length of each road type, while Table 23 shows the number of water features extracted per type.

Table 21. Building Features Extracted for Clarin Floodplain.

Facility Type	No. of Features
Residential	34,760
School	364
Market	9
Agricultural/Agro-Industrial Facilities	161
Medical Institutions	75
Barangay Hall	42
Military Institution	3
Sports Center/Gymnasium/Covered Court	38
Telecommunication Facilities	11
Transport Terminal	18
Warehouse	103
Power Plant/Substation	0
NGO/CSO Offices	3
Police Station	7
Water Supply/Sewerage	6
Religious Institutions	170
Bank	20
Factory	70
Gas Station	27
Fire Station	2
Other Government Offices	177
Other Commercial Establishments	579
Total	**36,645**

Table 22. Total Length of Extracted Roads for Clarin Floodplain.

Floodplain	Road Network Length (km)					Total
	Barangay Road	City/Municipal Road	Provincial Road	National Road	Others	
Clarin	130.69	82.50	22.73	15.80	2.21	**253.93**

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

Floodplain	Water Body Type					Total
	Rivers/Streams	Lakes/Ponds	Sea	Dam	Fish Pen	
Clarin	21	0	0	0	1	**22**

A total of 87 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 31 shows the Digital Surface Model (DSM) of Clarin floodplain overlaid with its ground features.

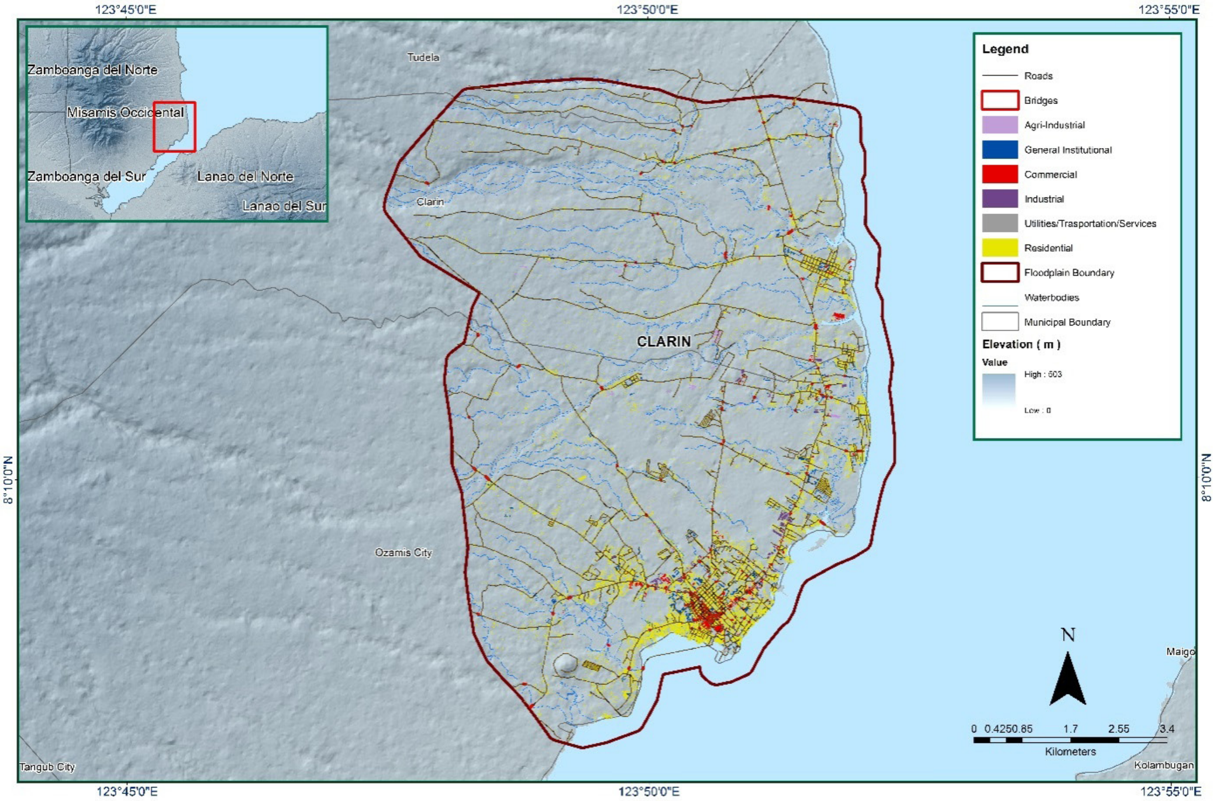


Figure 31. Extracted features for Clarin floodplain.

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

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

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

4.1 Summary of Activities

Clarin River Basin is located in Misamis Occidental, mainly bounded within the Municipality of Clarin. It has an approximate land area of 134 km2 with the estimated run-off of 100 MCM. Its main stream, the Clarin River is among the 16 rivers in the Northern Mindanao Region. There is a total of 35,753 people living within the immediate vicinity of the river according to the 2010 census conducted by NSO. The river is vital for the municipality because it serves as drainage and source of water for irrigation. The recent flood recorded was last December 4, 2014 where the river overflowed caused by heavy rains during Typhoon Ruby (Hagupit) which affected Brgys. Masabud, Mialen, Poblacions 1 to 3, Panay, Tinacla-an and Canicapan, Clarin.

(http://www.rappler.com/business/industries/77237-rubyph-cuts-power-lines-southern-luzon-visayas, 2014).

In line with this, DVC conducted a field survey in Clarin River on October 8 to 19, 2015 and October 23 to November 11, 2016 with the following scope of work: reconnaissance to determine the viability of traversing the planned routes for bathymetric survey; courtesy call with MSU-IIT, Tubod LGUs and MDRRMC; control survey for the establishment of control point at the approach of Clarin Bridge; cross-section survey, bridge as-built features determination and water level marking at two (2) hanging bridge, namely: Masabud-CaniCapan and Masabud-Pan-ay Hanging Bridge; ground validation survey covering Brgy. Tigdok, Municipality of Tudela to Brgy. Bagakay, Ozamiz City with an approximate distance of 21.196 km.; and bathymetric survey of 10.013 km from upstream in Brgy. Segatic Daku to its mouth in Brgy. Poblacion III, Municipality of Clarin, Misamis Oriental. Survey area is illustrated in Figure 32.

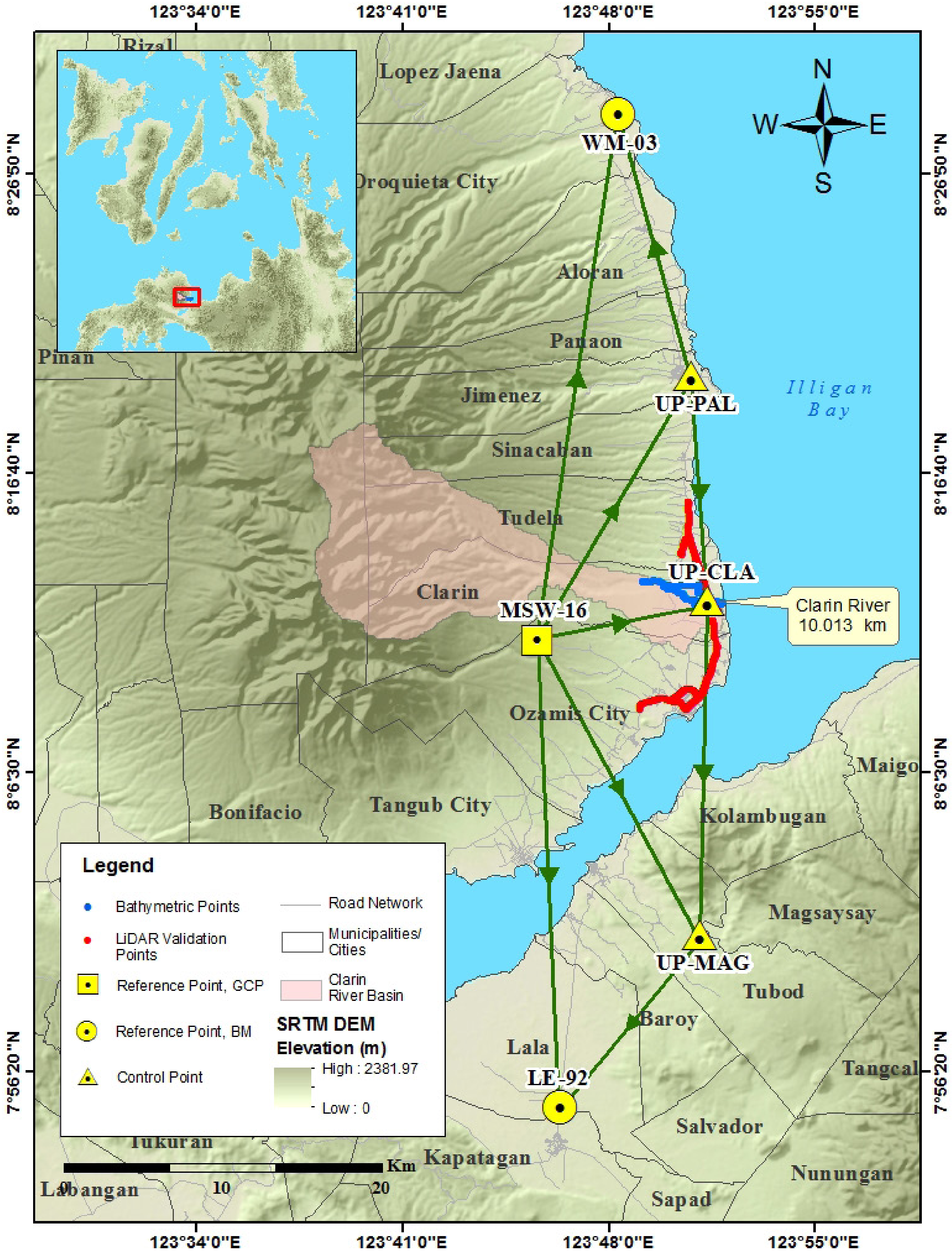


Figure 32. Extent of the bathymetric survey (in blue line) in Clarin River and the LiDAR data validation survey (in red).

4.2 Control Survey

A GNSS network for previous PHIL-LiDAR 1 survey in Palilan River was established on October 9 and 16, 2015 occupying the following reference points: MSW-16, a 2nd order GCP located in Brgy. Stimson Abordo, Ozamiz City; and LE-92, a 1st order BM in Brgy. Maraning Annex, Municipality of Kapatagan, Lanao Del Norte. The GNSS network used for Clarin River is composed of a loop and a baseline established on October 24, 2016 occupying the reference points: MSW-16, a 2nd order GCP located in Brgy. Stimson Abordo, Ozamiz City; and UP-CLA, a fixed control point from Palilan river survey.

A control point was established along approach of bridges namely: UP-OZA2 at Ozamiz Bridge in Brgy. Magsaysay, Municipality of Clarin, Misamis Occidental; and a NAMRIA established control point MW-42 in Brgy. Carmen Annex, Ozamiz City. The list of control points used in the survey is summarized in Table 24 while the GNSS network established is illustrated in Figure 33.

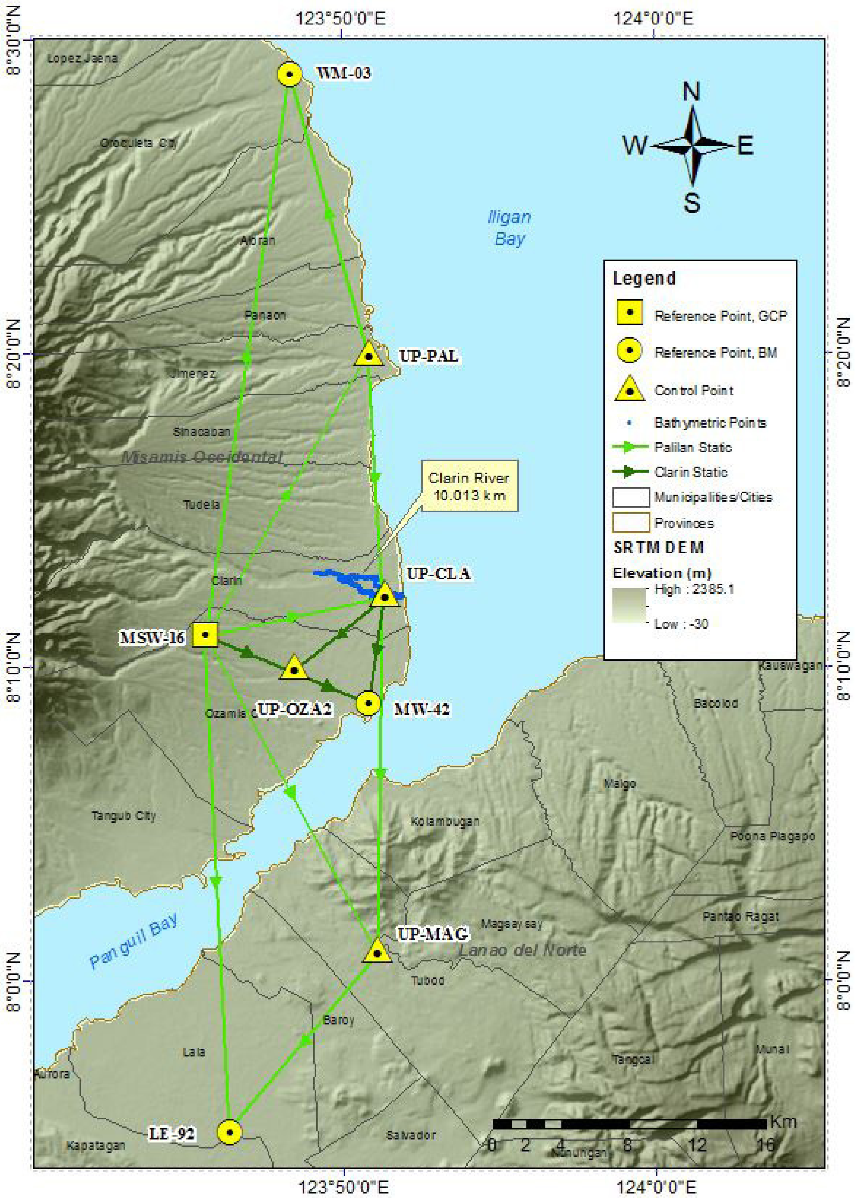


Figure 33. The GNSS Network established in the Clarin River survey.

Table 24. List of references and control points occupied during control survey in Clarin River, Misamis Occidental (Source: NAMRIA, UP-TCAGP)

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)				
		Latitude	Longitude	Ellipsoid Height, (m)	MSL Elevation (m)	Date Established
Control Survey on October 9 and 16, 2015						
MSW-16	2nd Order, GCP	8°11'00.29163"N	123°45'35.16283"E	358.16	289.316	2007
LE-91	1st Order, BM	7°55'08.47407"N	123°46'19.89123"E	87.116	18.440	10-16-2015
Control Survey on October 24, 2016						
MSW-16	2nd Order, GCP	8°11'00.29163"N	123°45'35.16283"E	358.16	289.316	2007
UP-CLA	Fixed	8°12'20.32560"N	123°51'20.80387"E	72.796	4.138	10-16-2015
MW-42	Used as Marker	-	-	-	-	10-24-2016
UP-OZA2	UP Established	-	-	-	-	10-24-2016

The GNSS set up made in the location of the reference and control points are shown in Figure 34 to Figure 37.

Figure 34. GNSS receiver, Trimble® SPS 852 setup at MSW-16 located beside the fence on the basketball court along the road in Brgy. Stimson Abordo, Ozamiz City, Misamis Occidental

Figure 35. GNSSS setup of Trimble® SPS 985 at CLA, Clarin Bridge approach in Brgy. Poblacion IV, Municipality of Clarin, Misamis Occidental

Figure 36. GNSSS setup of Trimble® SPS 852 at MW-42, located at the end of a center island near Citi Hardware in Brgy. Carmen Annex, Ozamiz City, Misamis Occidental

Figure 37. GNSSS setup of Trimble® SPS 852 at UP-OZA2, located near the Ozamiz Steel Bridge approach in Brgy. Mentering, Ozamiz City, Misamis Occidental

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 +/- 20 cm and +/- 10 cm requirement, respectively. In cases where one or more baselines did not meet all of these criteria, masking is performed. Masking is done by removing/masking portions of these baseline data using the same processing software. It is repeatedly processed until all baseline requirements are met. If the reiteration yields out of the required accuracy, resurvey is initiated. Baseline processing result of control points used in Clarin River Basin survey is summarized in Table 25 generated by TBC software.

Table 25. Baseline processing report for Clarin River control survey

Observation	Date of Observation	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)
MSW16 --- UPOZA2	10-24-2016	Fixed	0.008	0.034	109°06’50”	5544.745
MW42 --- UPOZA2	10-24-2016	Fixed	0.012	0.052	116°29’34”	4918.751
UPCLA --- UPOZA2	10-24-2016	Fixed	0.009	0.051	231°19’52”	6840.944
MSW16 --- MW42	10-24-2016	Fixed	0.008	0.034	112°34’45”	10441.939
MW42 --- UPCLA	10-24-2016	Fixed	0.010	0.052	188°15’40”	6536.884

As shown in Table 25, a total of five (5) baselines were processed with reference points MSW-16 and UP-CLA from Palilan Survey held fixed for grid and elevation values respectively. All of them passed the required accuracy.

4.4 Network Adjustment

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

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

Where:

x_e is the Easting Error,
y_e is the Northing Error, and
z_e is the Elevation Error

For complete details, see the Network Adjustment Report shown in Table 26 to Table 28 for the complete details.

The five (5) control points, MSW-16, UP-CLA, MW-42 and UP-OZA2 were occupied and observed simultaneously to form a GNSS loop. Elevation and coordinates of points MSW-16 and UP-CLA were held fixed during the processing of the control points as presented in Table 26. Through these reference points, the coordinates and elevation of the unknown control points will be computed.

Table 26. Constraints applied to the adjustment of the control points.

	Type	East σ (Meter)	North σ (Meter)	Height σ (Meter)	Elevation σ (Meter)
MSW-16	Grid	Fixed	Fixed		Fixed
UP-CLA	Grid	Fixed	Fixed		Fixed
Fixed = 0.000001(Meter)					

The list of adjusted grid coordinates, i.e. Northing, Easting, Elevation and computed standard errors of the control points in the network is indicated in Table 27. The fixed control point MSW-16 and UP-CLA have no values for grid errors and elevation error, respectively.

Table 27. Adjusted grid coordinates for the control points used in the Clarin River flood plain survey.

Point ID	Easting (Meter)	Easting Error (Meter)	Northing (Meter)	Northing Error (Meter)	Elevation (Meter)	Elevation Error (Meter)	Constraint
MSW-16	583690.278	?	904653.668	?	289.316	?	ENe
MW-42	593336.441	0.021	900663.777	0.022	0.922	0.099	
UP-CLA	594261.657	?	907132.927	?	4.138	?	ENe
UP-OZA2	588931.138	0.017	902848.507	0.013	55.604	0.098	

The network is fixed at control points MSW-16 and UP-CLA. No adjustments have been made for the said points. With the mentioned equation, for horizontal and for the vertical; the accuracy computation for the horizontal and vertical accuracy are as follows:

a. **MSW-16**

horizontal accuracy = fixed

vertical accuracy = fixed

b. **UP-CLA**

horizontal accuracy = fixed

vertical accuracy = fixed

c. **MW-42**

horizontal accuracy $= \sqrt{(2.1)^2 + (2.2)^2}$

$= \sqrt{4.41 + 4.84}$

$= 3.04 < 20$ cm

vertical accuracy $= 9.9$ cm < 10 cm

d. **UP-OZA2**

horizontal accuracy $= \sqrt{(1.7)^2 + (1.3)^2}$

$= \sqrt{2.89 + 1.69}$

$= 2.14 < 20$ cm

vertical accuracy $= 9.8$ cm < 10 cm

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

Table 28. Adjusted geodetic coordinates for control points used in the Clarin River Flood Plain validation

Point ID	Latitude	Longitude	Height (Meter)	Height Error (Meter)	Constraint
MSW16	N8°11’00.29163”	E123°45’35.16283”	358.160	?	ENe
MW42	N8°08’49.75314”	E123°50’50.12216”	69.691	0.099	
UPCLA	N8°12’20.32560”	E123°51’20.80387”	72.796	?	ENe
UPOZA2	N8°10’01.18254”	E123°48’26.31494”	124.346	0.098	

Corresponding geodetic coordinates and elevation values of MW-42 and UP-OZA2 which were derived from fixed reference points MSW-16 and UP-CLA are within the required accuracy as shown in Table 28. Based on the result of the computation, the equation is satisfied hence the required accuracy for the program was met.

The summary of reference and control points used is indicated in Table 29.

Table 29. The reference and control points utilized in the Clarin River Static Survey, with their corresponding locations (Source: NAMRIA, UP-TCAGP)

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)			UTM ZONE 51 N		
		Latitude	Longitude	Ellipsoidal Height (m)	Northing (m)	Easting (m)	BM Ortho (m)
MSW-16	Fixed	8°11’00.29163”	123°45’35.16283”	358.16	904653.668	583690.278	289.316
UP-CLA	Fixed	8°12’20.32560”	123°51’20.80387”	72.796	907132.927	594261.657	4.138
MW-42	Used as marker	8°08’49.75314”	123°50’50.12216”	69.691	900663.777	593336.441	0.922
UP-OZA2	UP Established	8°10’01.18254”	123°48’26.31494”	124.346	902848.507	588931.138	55.604

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

Cross-section survey was conducted on October 11, 2015 at the downstream side Masabud-Pan-ay Hanging Bridge in Brgy. Segatic Diot as shown in Figure 38; and on October 16 and 18 at the downstream side of Masabud-Canipacan Hanging Bridge in Brgy. Segatic-Daku as shown in Figure 39, located both in Ozamiz City, Misamis Occidental using Trimble® SPS 882 in GNSS PPK survey technique.

Figure 38. Cross-section survey on the downstream side of Masabud-Pan-ay Hanging Bridge Municipality of Clarin, Misamis Occidental

Figure 39. Cross-section survey on the downstream side of Masabud-Canicapan Hanging Bridge, Municipality of Clarin, Misamis Occidental

The cross-sectional line length of Masabud-Pan-ay Hanging Bridge is about 55.269 meters with 29 cross-sectional points while the cross-sectional line length in Masabud-CaniCapan Hanging Bridge is about 36.722 meters with 26 cross-sectional points, both used UP-CLA as the GNSS base station. The summary of gathered cross-section diagrams and planimetric maps for the two-mentioned Hanging Bridges are shown in Figure 40 to Figure 43.

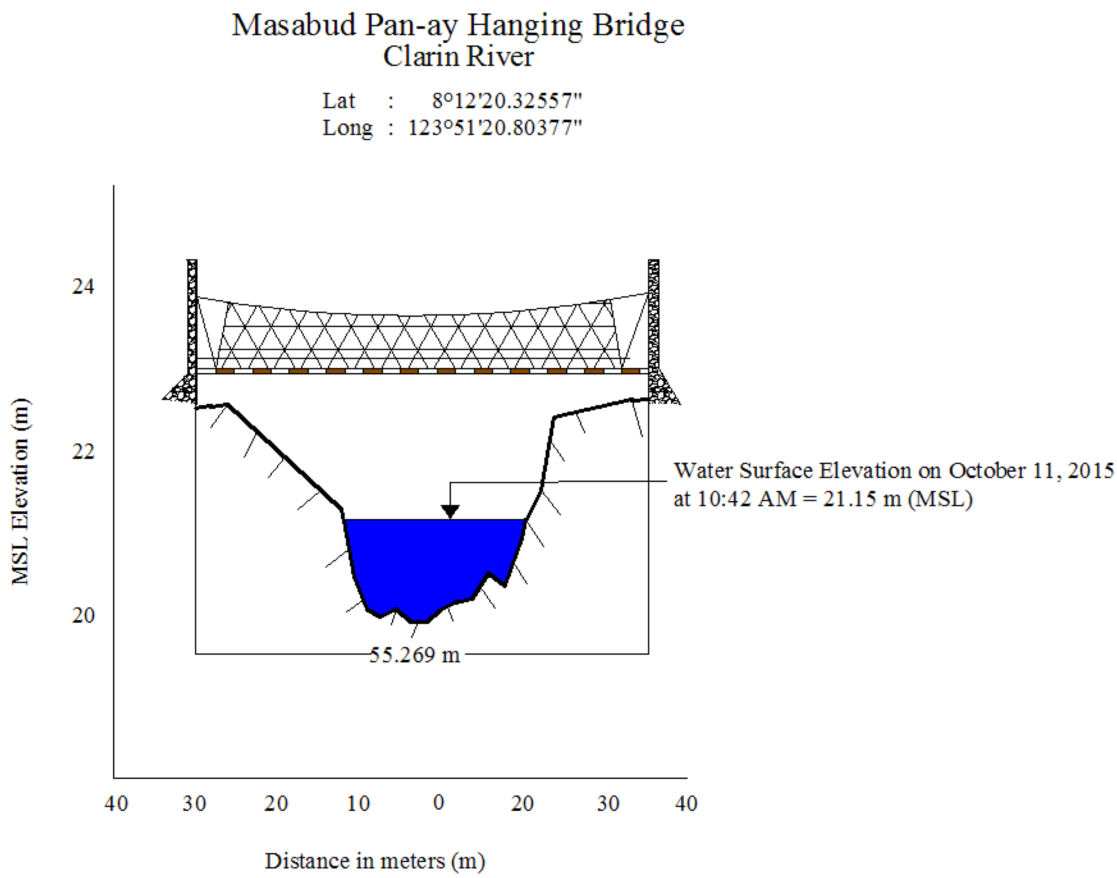


Figure 40. Masabud-Pan-ay Hanging Bridge cross-section survey drawn to scale

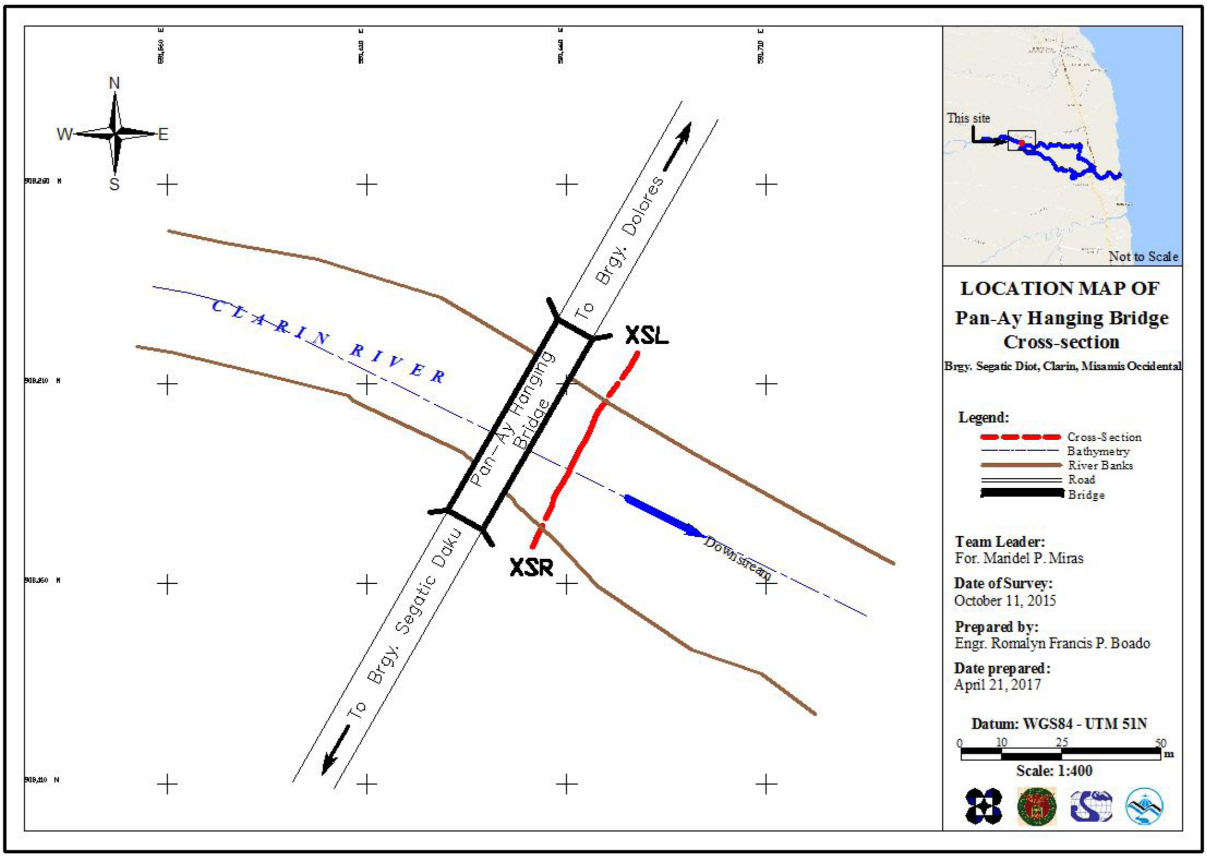


Figure 41. Location map of the Pan-ay hanging bridge cross-section survey

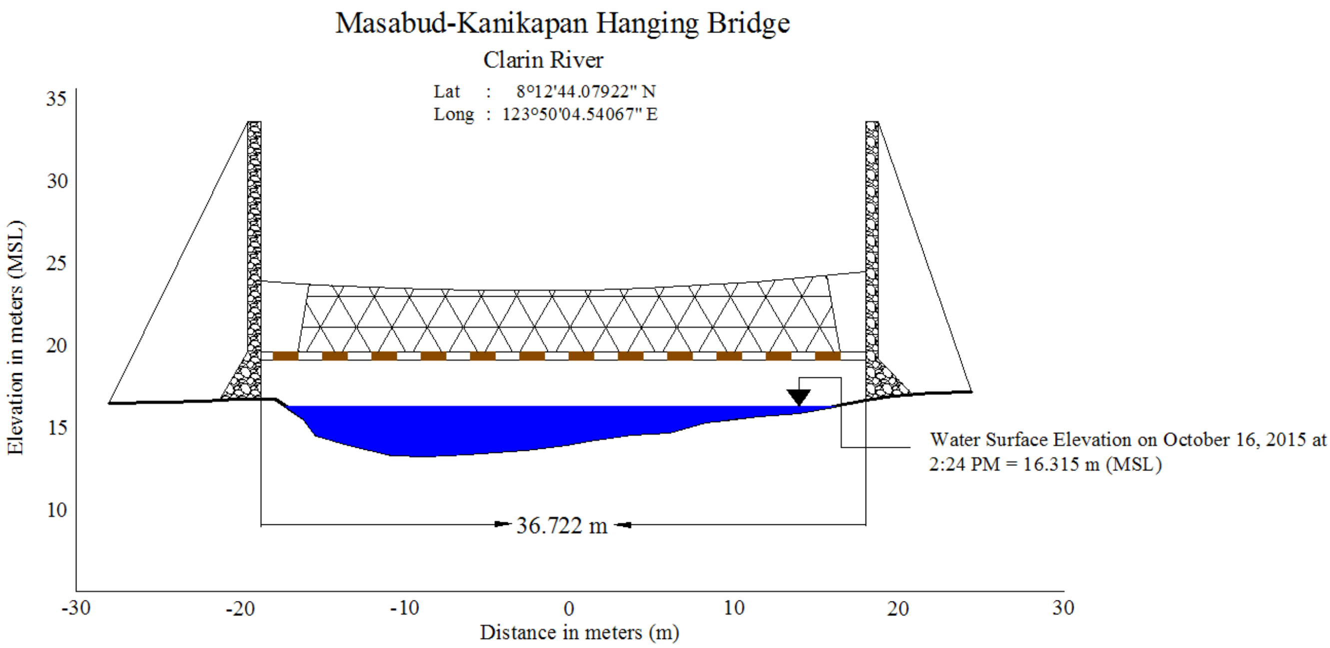


Figure 42. Masabud-Canicapan Hanging Bridge cross-section survey drawn to scale.

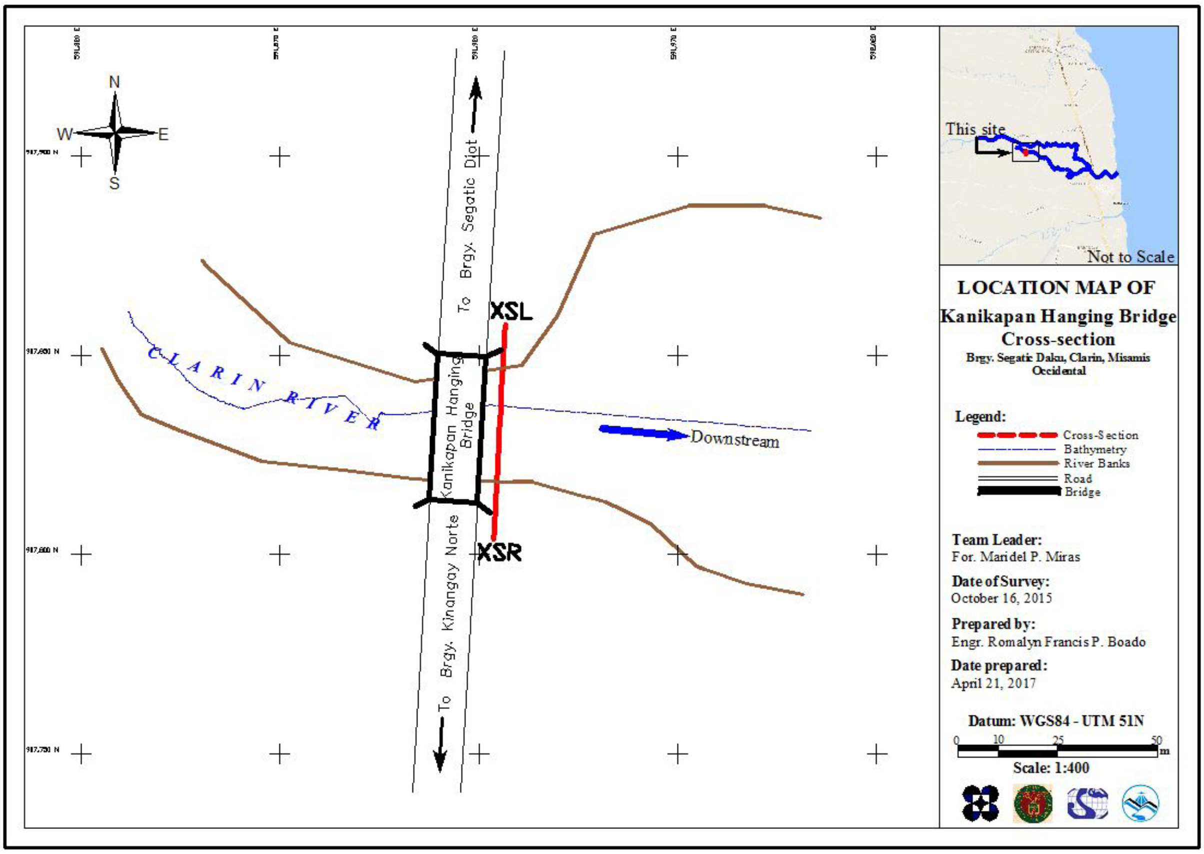


Figure 43. Location map of the Canicapan Bridge cross-section survey.

Water surface elevation in MSL of Clarin River was determined using Trimble® SPS 882 in PPK mode survey on October 11, 2015 at 10:42 AM with a value of 21.15 meters in MSL marked in the abutment near Masabud-Pan-ay Hanging Bridge. The marked abutment is shown in Figure 44.

Figure 44. Water level marking on the abutment of Masabud-Pan-ay Hanging Bridge, Municipality of Clarin, Misamis Occidental

Another water surface elevation was conducted at the abutment of Masabud-Canicapan Hanging Bridge on October 16, 2015 at 2:24 PM with value of 16.315 meters in MSL as shown in Figure 45. Both markings in the two hanging bridges shall serve as reference for flow data gathering and depth gauge deployment by the accompanying HEI, MSU-IIT, who is responsible for Clarin River.

Figure 45. Water level marking on the abutment of Masabud-Canicapan Hanging Bridge, Municipality of Clarin, Misamis Occidental

4.6 Validation Points Acquisition Survey

Validation points acquisition survey was conducted on October 14, 2015 using a survey-grade GNSS Rover receiver, Trimble®SPS 882, mounted on a range pole which was attached on the back of the vehicle as shown in Figure 46. It was secured with a cable-tie to ensure that it was horizontally and vertically balanced. The antenna height was measured and recorded to be 1.923 m from the ground up to the bottom of the notch of the GNSS Rover receiver.

Figure 46. The validation point acquisition survey setup using a GNSS receiver fixed in a vehicle along the Clarin River Basin

The survey was conducted using PPK technique on a continuous topography mode using UP-CLA as base station. The survey began in Brgy. Tigdok, Municipality of Tudela to Brgy. Bagakay, Ozamiz City, covering an approximate distance of 21.196 km with 2,796 validation points gathered. The gaps in the validation line as shown in Figure 47 were due to difficulties in receiving satellite signals because of the presence of obstruction such as dense canopy cover of trees along the roads.

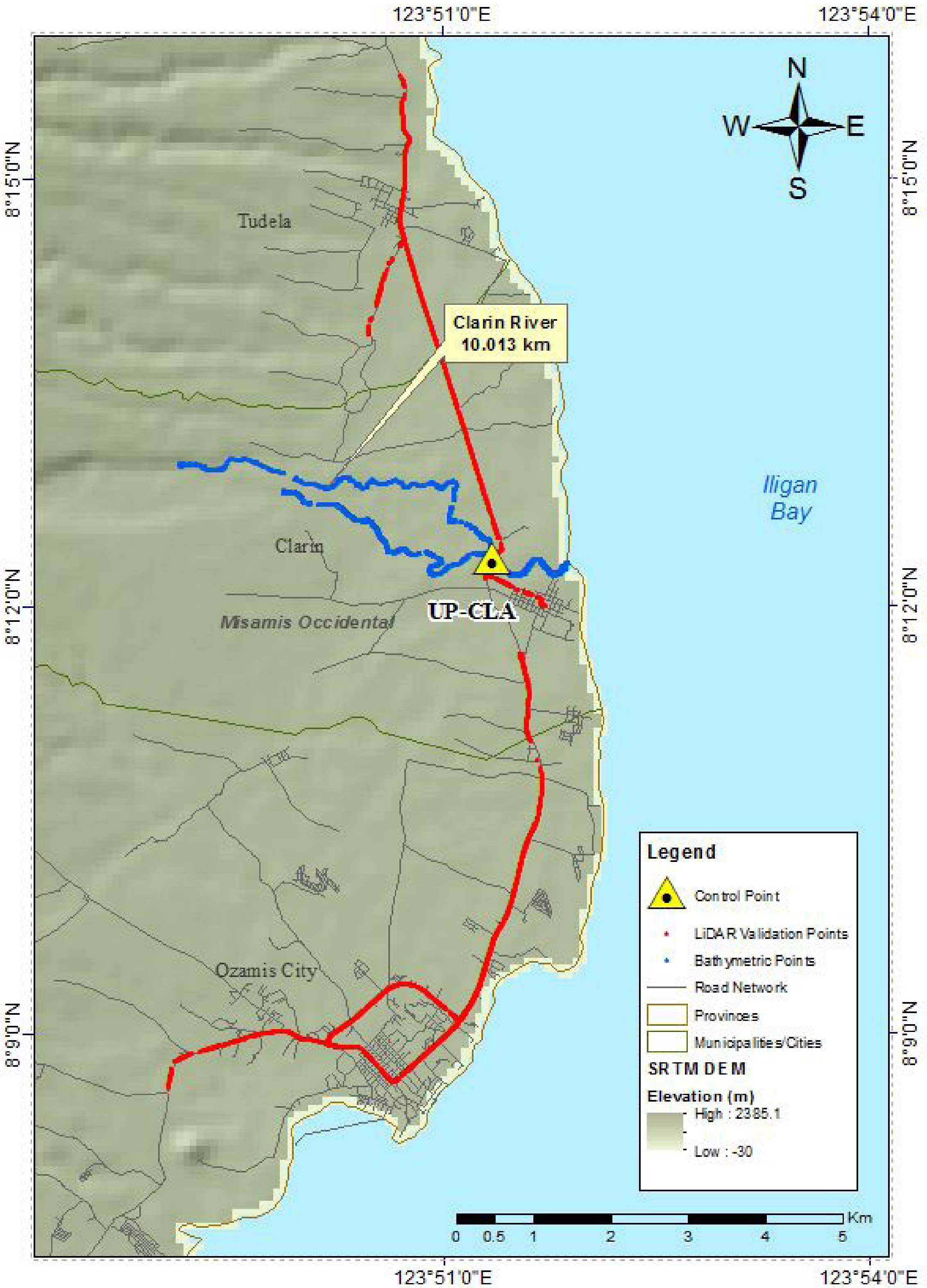


Figure 47. Extent of the LiDAR ground validation survey for the Clarin River Basin

4.7 Bathymetric Survey

Bathymetric survey was executed on October 14, 2015 and October 27, 2016 using Trimble® SPS 882 in GNSS PPK survey technique and an Ohmex™ single beam echo sounder attached to a boat as shown in Figure 48. The survey started from two different upstream tributaries: in Brgy. Masabud with coordinates 08°12'27.74893"N, 123°51'19.65627"E, and in Brgy. Poblacion IV with coordinates 8°12'22.79503"N, 123°50'53.40850"E; down to its mouth in Brgy. Poblacion II with coordinates 8°12'18.13126"N, 123°51'52.55175"E.

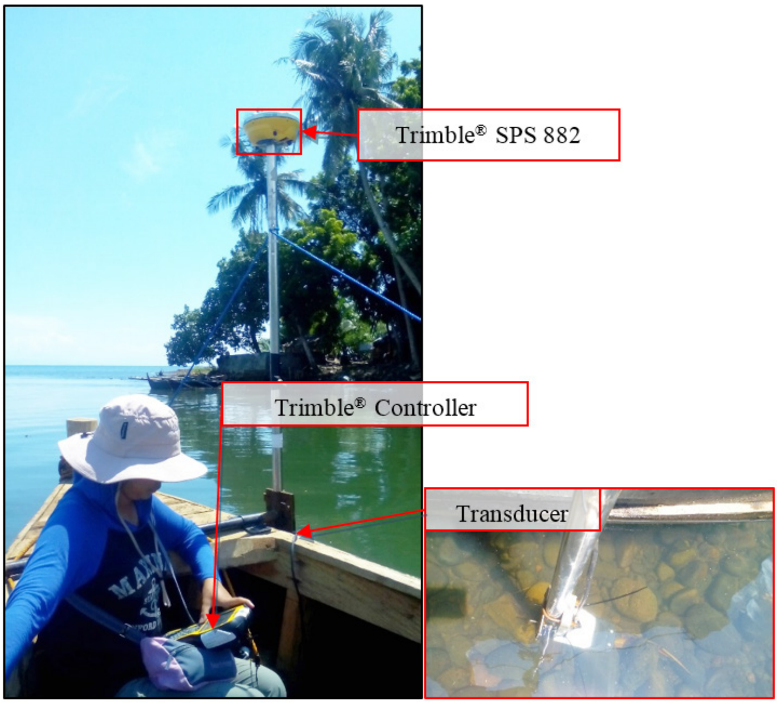


Figure 48. Bathymetric survey using an Ohmex™ single beam echo sounder along Clarin River

Manual bathymetric survey on the other hand was conducted on October 14 and 15, 2015; and October 27, 2016 using Trimble® SPS882 in GNSS PPK survey technique as shown in Figure 49. The survey started from two upstream tributaries: in Brgy. Segatic Diot with coordinates 8°12'59.26721"N, 123°49'09.41681"E; and in Brgy. Segatic Daku with coordinates 8°12'48.01581"N, 123°49'53.12664"E; traversed down by foot and ended at the starting point of bathymetric survey using boat in Brgy. Masabud and Brgy. Poblacion IV, respectively. The control point UP-CLA was used as GNSS base station all throughout the bathymetric survey.

Figure 49. Manual bathymetric survey along Clarin River

The entire bathymetric survey gathered a total of 14,995 points covering a total of 10.013 km of the river traversing six barangays in Municipality of Clarin namely: Canipacan, Masabud, Poblacion II, Poblacion IV, Segatic Diot, and Segatic Daku as shown in Figure 50. A CAD drawing was also produced to illustrate the riverbed profile of Clarin River. As shown in Figure 51 and Figure 52. The highest and lowest elevation has a 43-km difference. The highest elevation observed is 37.165 m in MSL located at the upstream part of the river in Brgy. Segatic Diot, while the lowest elevation observed is -5.417 m below MSL located at the mouth of the river in Brgy. Poblacion III.The gaps in the bathymetric survey was due to difficulties in acquiring satellite caused by obstructions such as dense canopy cover of trees and presence of rapids along the river.

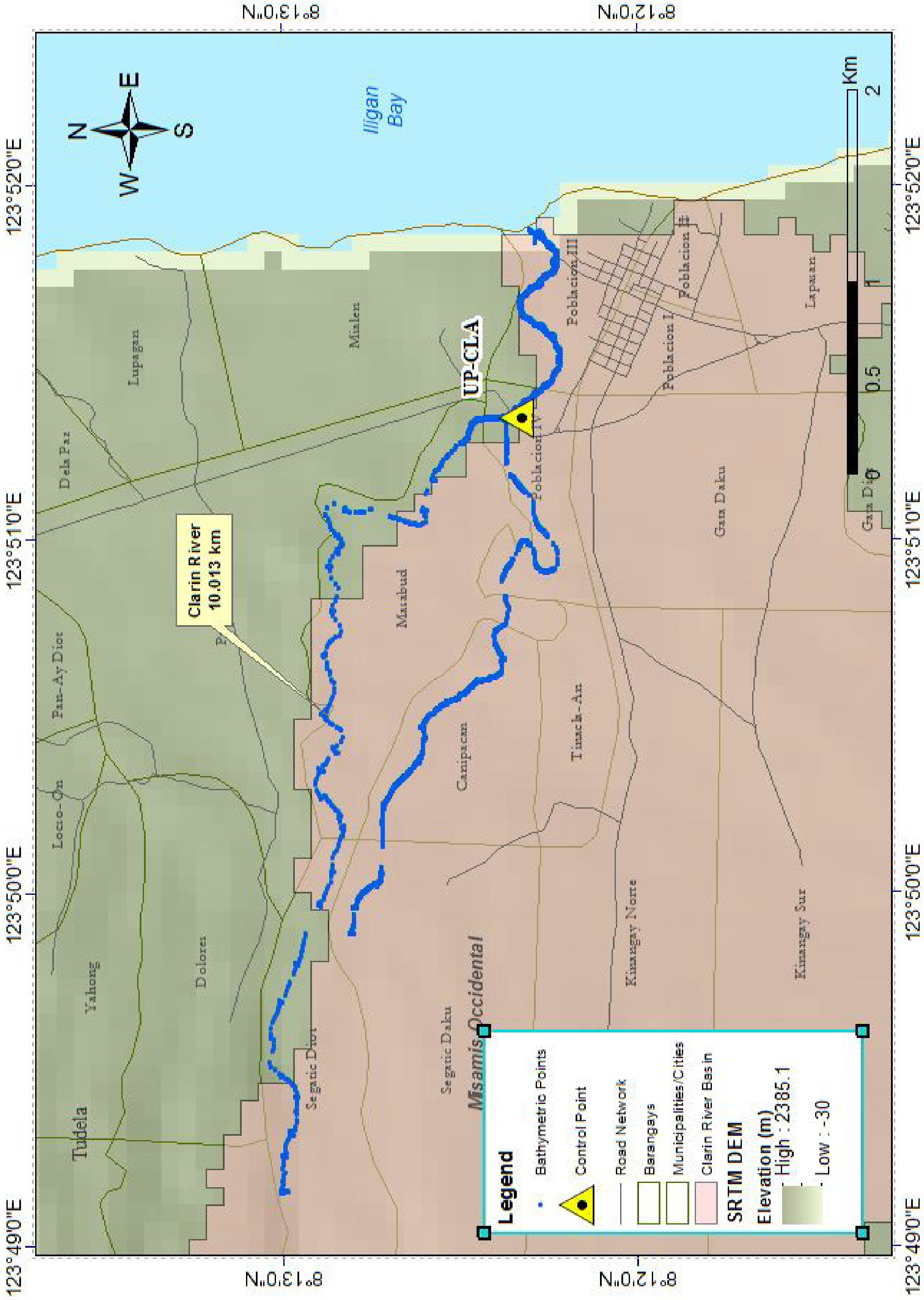


Figure 50. Extent of the Clarin River Bathymetry Survey.

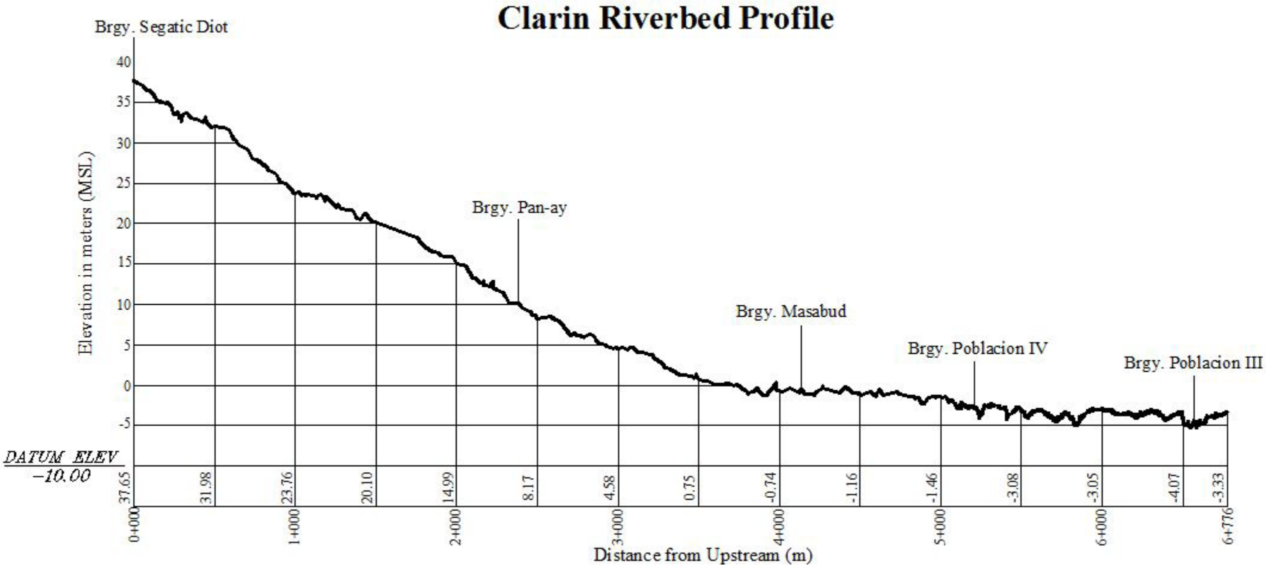


Figure 51. The Clarin riverbed profile from Brgy. Segatic Diot

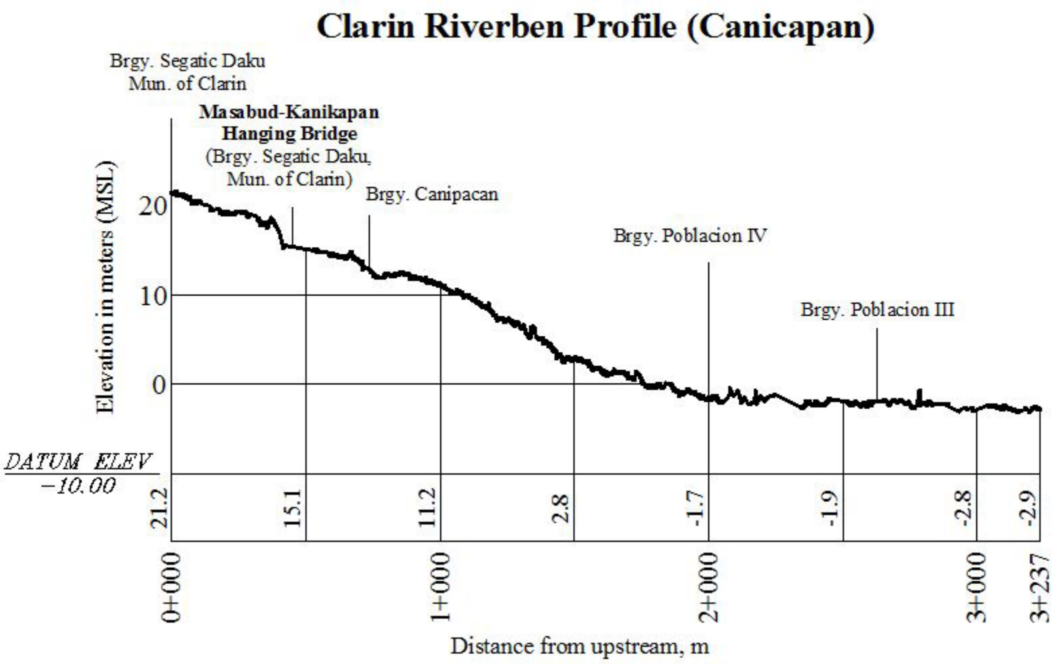


Figure 52. The Clarin riverbed profile from Brgy. Segatic Daku

CHAPTER 5: FLOOD MODELING AND MAPPING

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

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

5.1 Data Used for Hydrologic Modeling

5.1.1 Hydrometry and Rating Curves

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

5.1.2 Precipitation

Precipitation data was taken from the Portable Rain Gauge (PRG) deployed upstream by the MSU-IIT Data Validation Component (DVC) team. The PRG was specifically installed in the municipality of Clarin with coordinates 8°15'5.24"N Latitude and 123°44'36.81"E Longitude. The location of the rain gauge is shown in Figure 53 below.

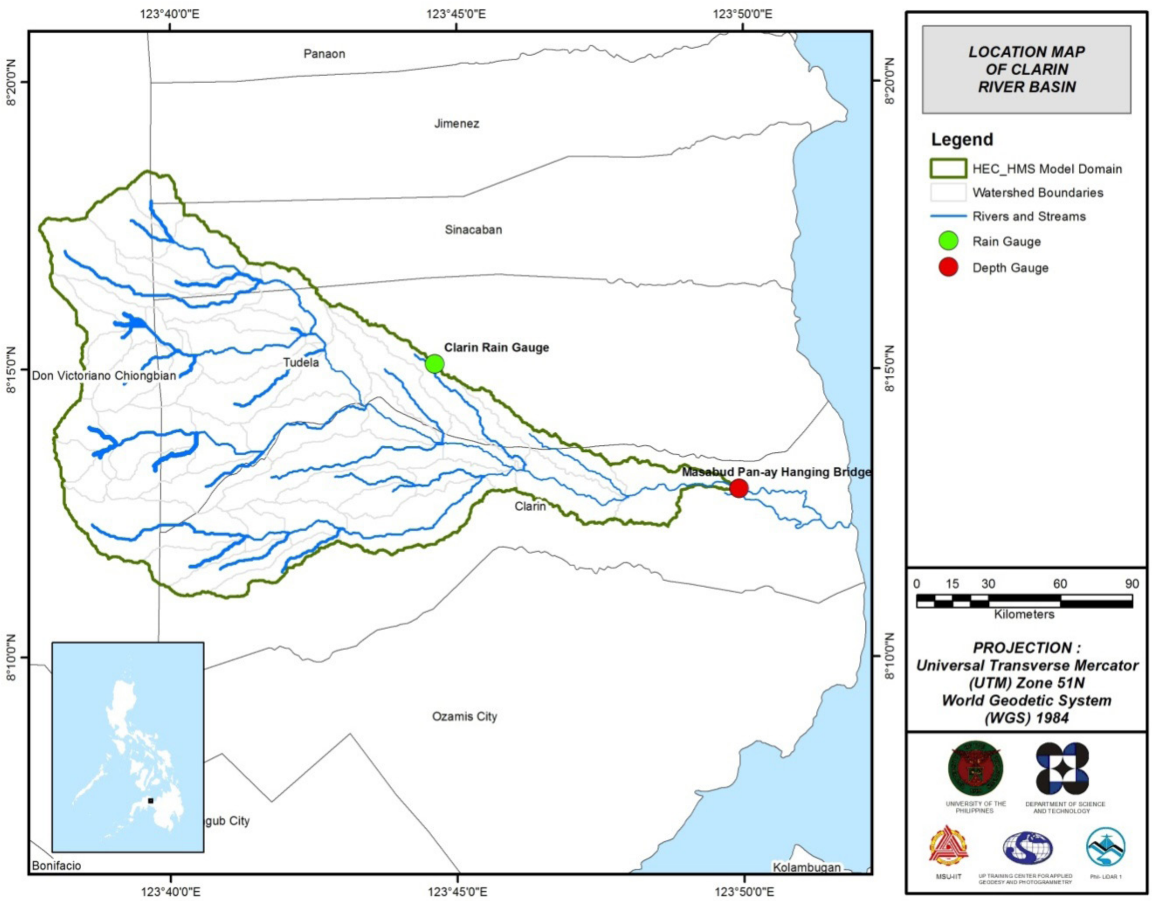


Figure 53. The location map of Clarin HEC-HMS model used for calibration.

5.1.3 Rating Curves and River Outflow

The rating curve of the river was computed based on the prevailing corss-section shown below (Figure 54). For the Masabud Pan-ay Hanging Bridge, the rating curve is expressed as Q = 2E-09.e5^0288x as shown in Figure 55.

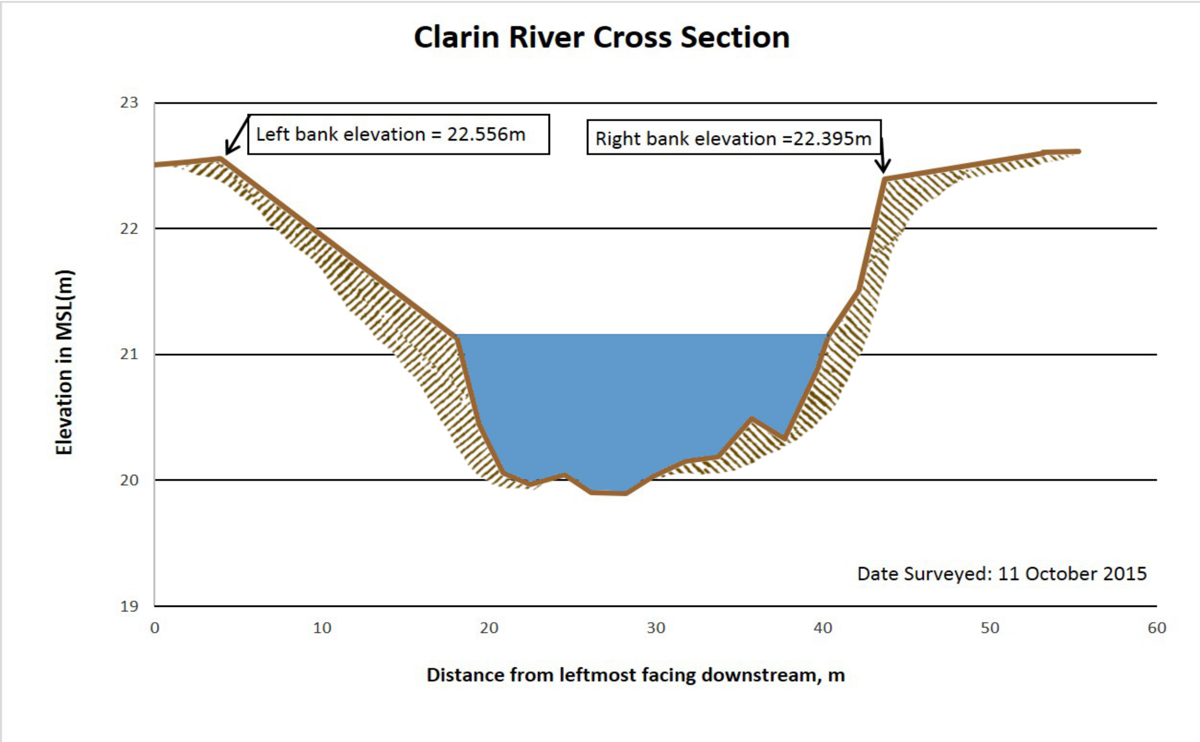


Figure 54. Cross-Section Plot of Masabud Pan-ay Hanging Bridge

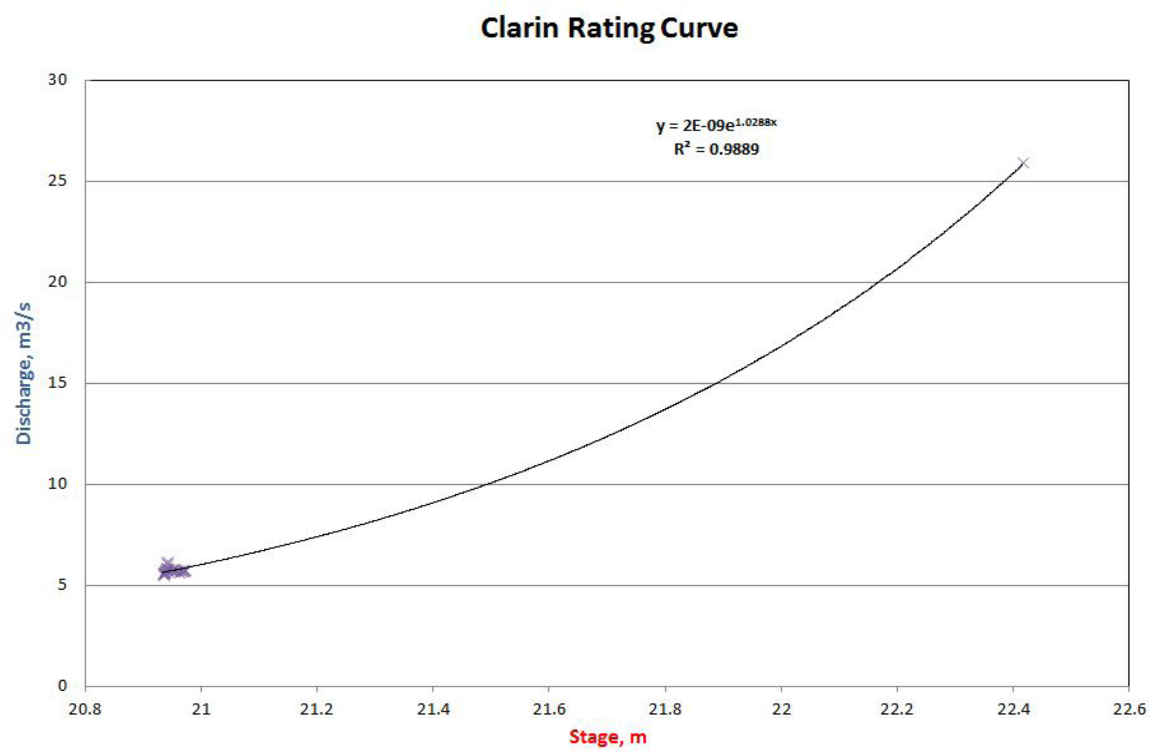


Figure 55. Rating Curve at Masabud Pan-ay Hanging Bridge

This rating curve equation was used to compute the river outflow at Masabud Pan-ay Hanging Bridge for the calibration of the HEC-HMS model. Total rainfall for this event was taken from the PRG was at 75.8 mm. It peaked to 15.6 mm on 28 July 2016, 17:30. Peak discharge was 9.3 cms at 21:00, July 28, 2016. The lag time between the peak rainfall and discharge was 3 hours and 30 minutes shown in Figure 56 below.

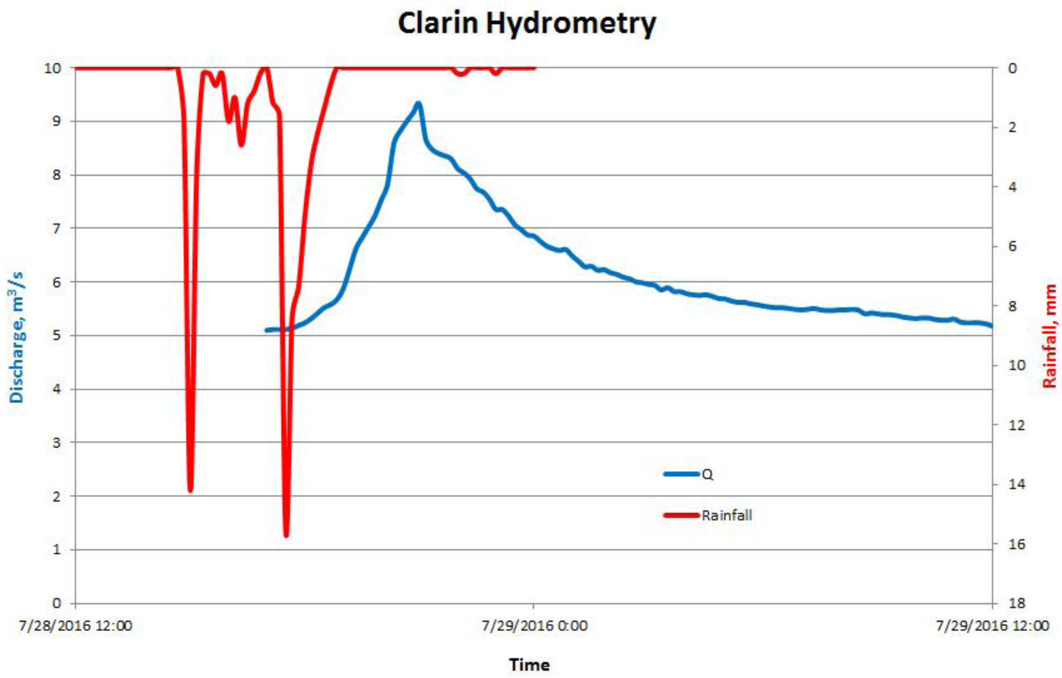


Figure 56. Rainfall and outflow data of the Masabud Pan-ay Hanging Bridge, which was used for modeling.

5.2 RIDF Station

The Philippines Atmospheric Geophysical and Astronomical Services Administration (PAGASA) computed Rainfall Intensity Duration Frequency (RIDF) values for the Dipolog Rain Gauge. The RIDF rainfall amount for 24 hours was converted to a synthetic storm by interpolating and re-arranging the value in such a way certain peak value will be attained at a certain time. This station chosen based on its proximity to the Clarin watershed. The extreme values for this watershed were computed based on a 51-year record shown in Table 30.

Table 30. RIDF values for the Dipolog Rain Gauge, as computed by PAGASA

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

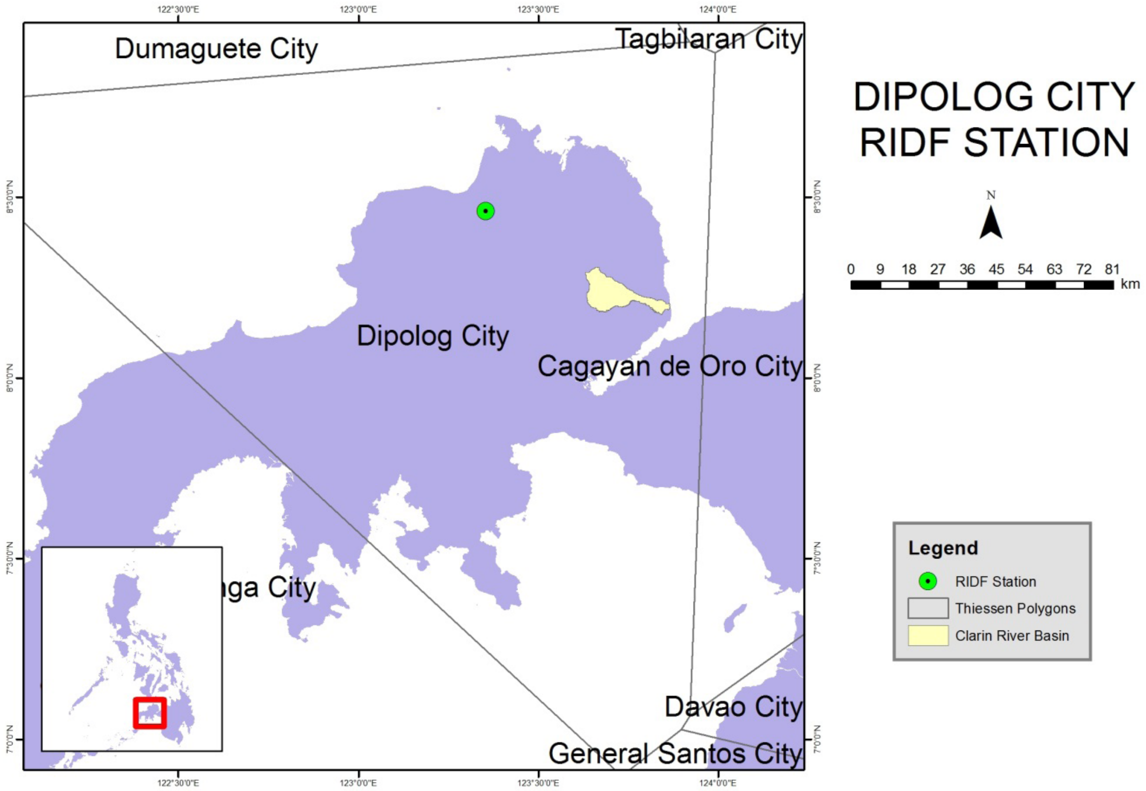


Figure 57. Location of the Dipolog RIDF station relative to the Clarin River Basin.

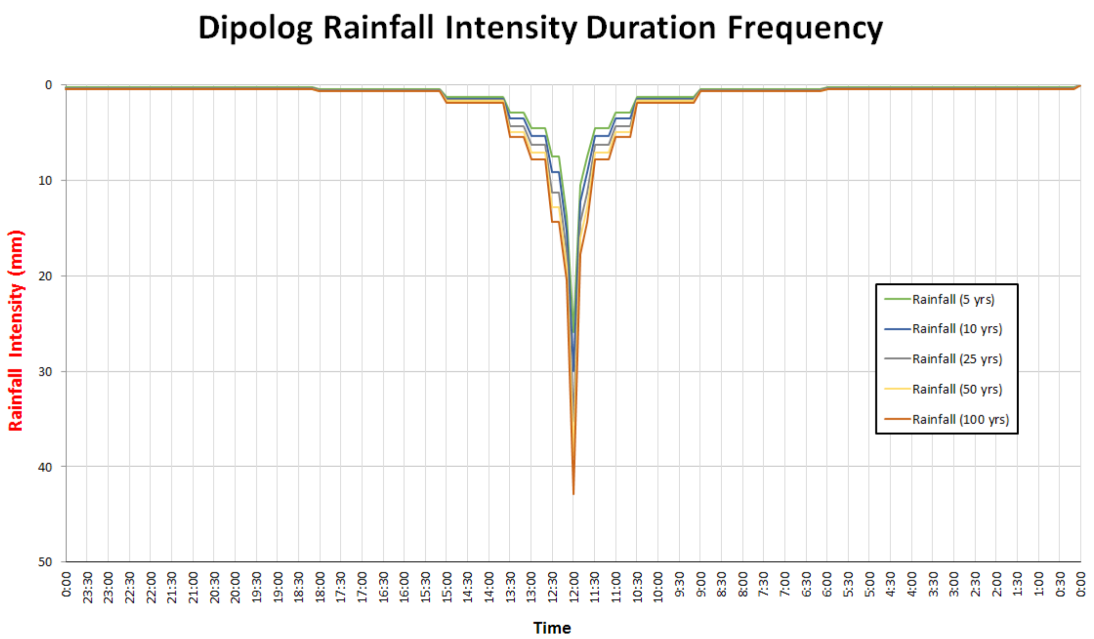


Figure 58. Synthetic storm generated for a 24-hr period rainfall for various return periods

5.3 HMS Model

The soil dataset was generated before 2004 by the Bureau of Soils under the Department of Agriculture (DA). The land cover dataset is from the National Mapping and Resource information Authority (NAMRIA). The soil and land cover of the Clarin River Basin are shown in Figures 59 and 60, respectively.

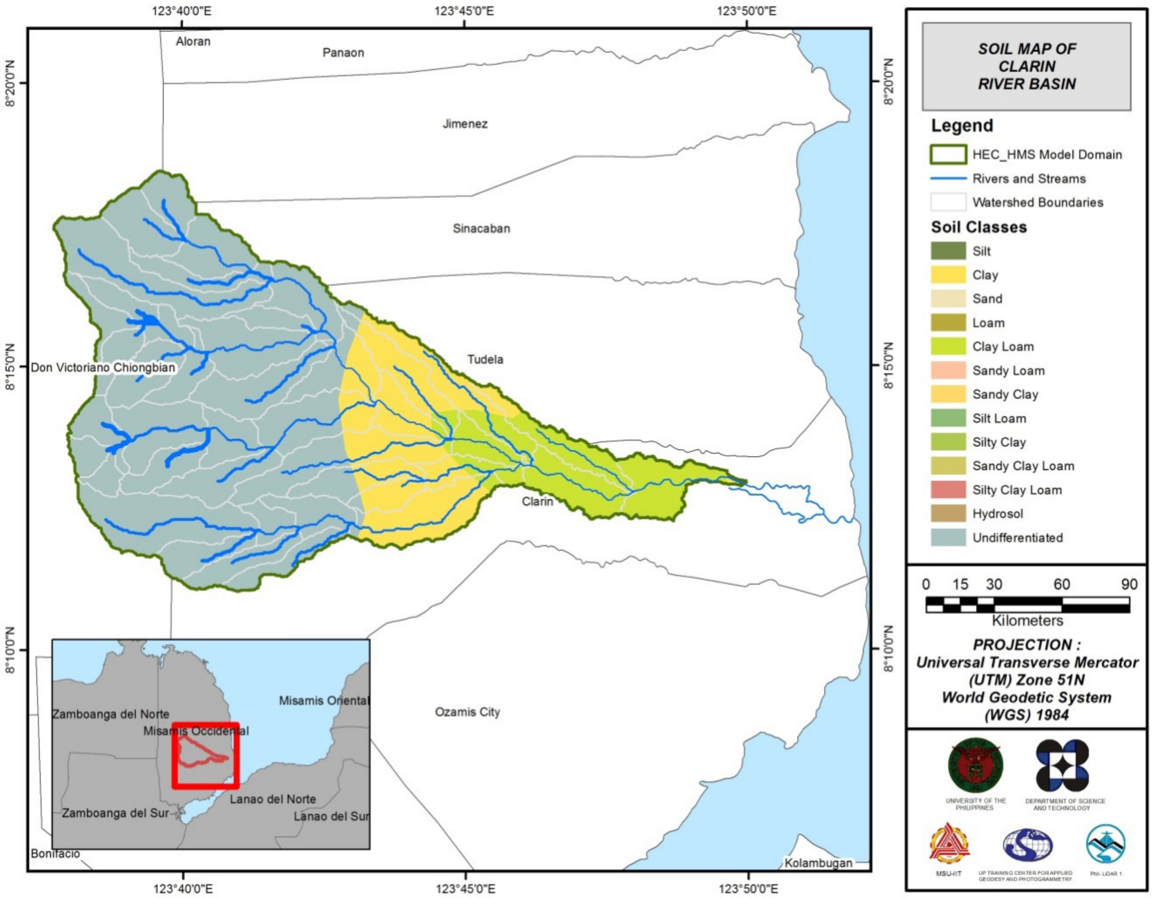


Figure 59. Soil Map of Clarin River Basin

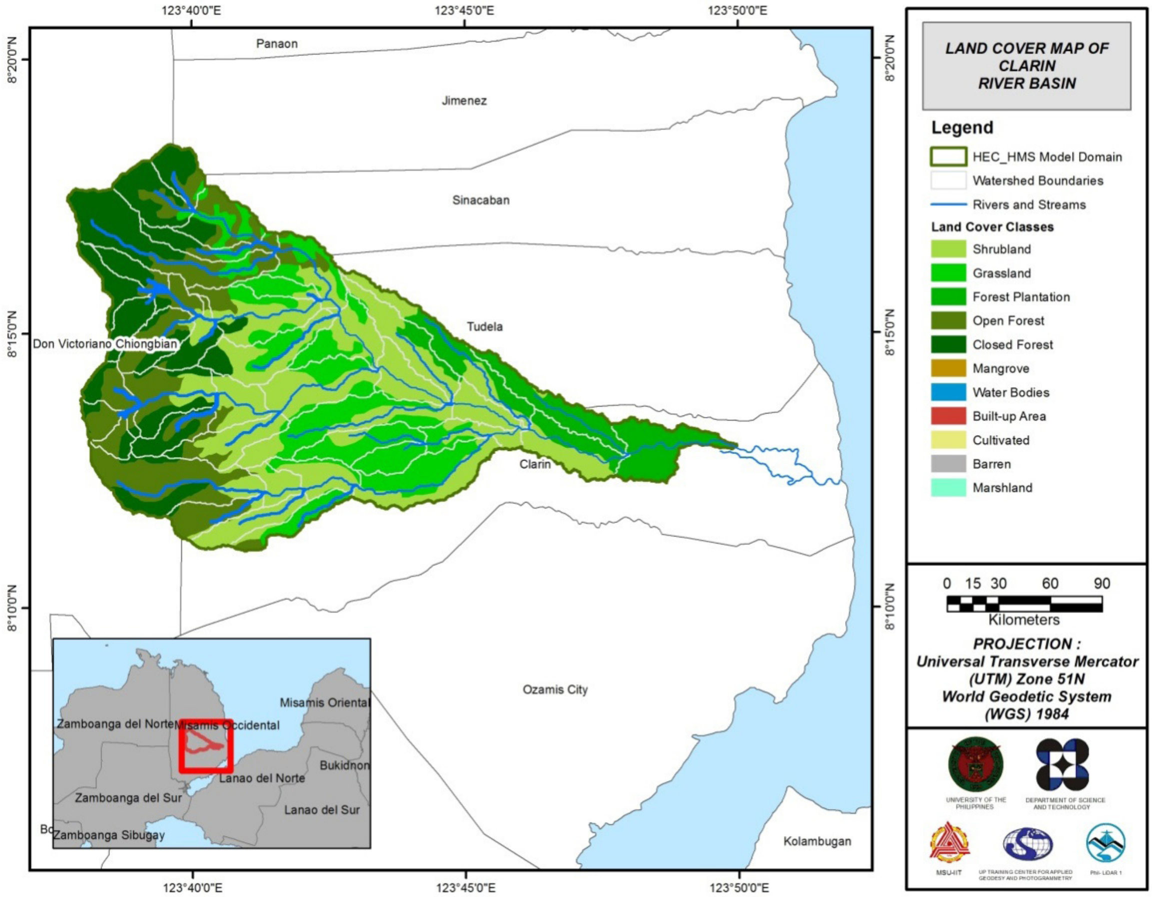


Figure 60. Land Cover Map of Clarin River Basin

For Clarin, the soil classes identified were clay loam, sandy clay, and undifferentiated. The land cover types identified were shrubland, grassland, forest plantation, open forest, and closed forest.

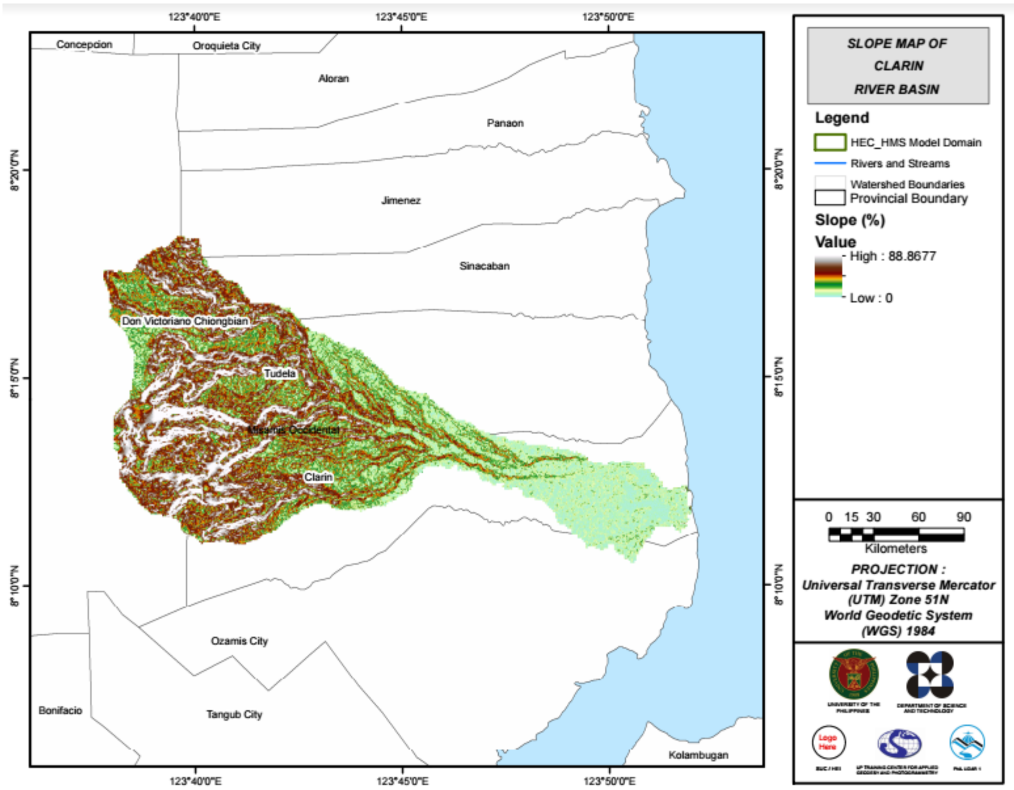
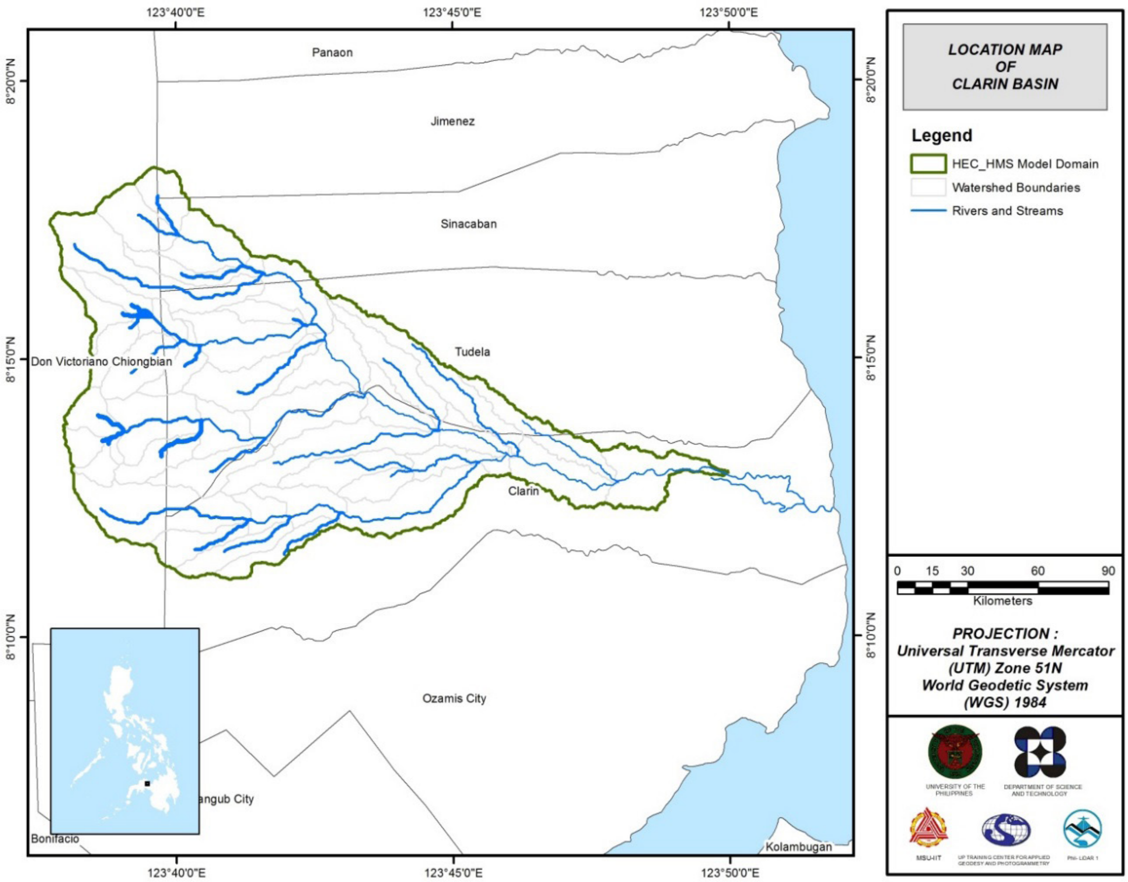


Figure 61. Slope Map of Clarin River Basin



Fig

Figure 62. Stream Delineation Map of the Clarin River Basin

Using the SAR-based DEM, the Clarin basin was delineated and further subdivided into subbasins. The model consists of 42 sub basins, 25 reaches, and 25 junctions shown in Figure 62. The main outlet is located at Masabud Pan-ay Bridge, Clarin. Finally, it was calibrated using hydrological data derived from the depth gauge and flow meter deployed at Masabud Pan-ay Bridge.

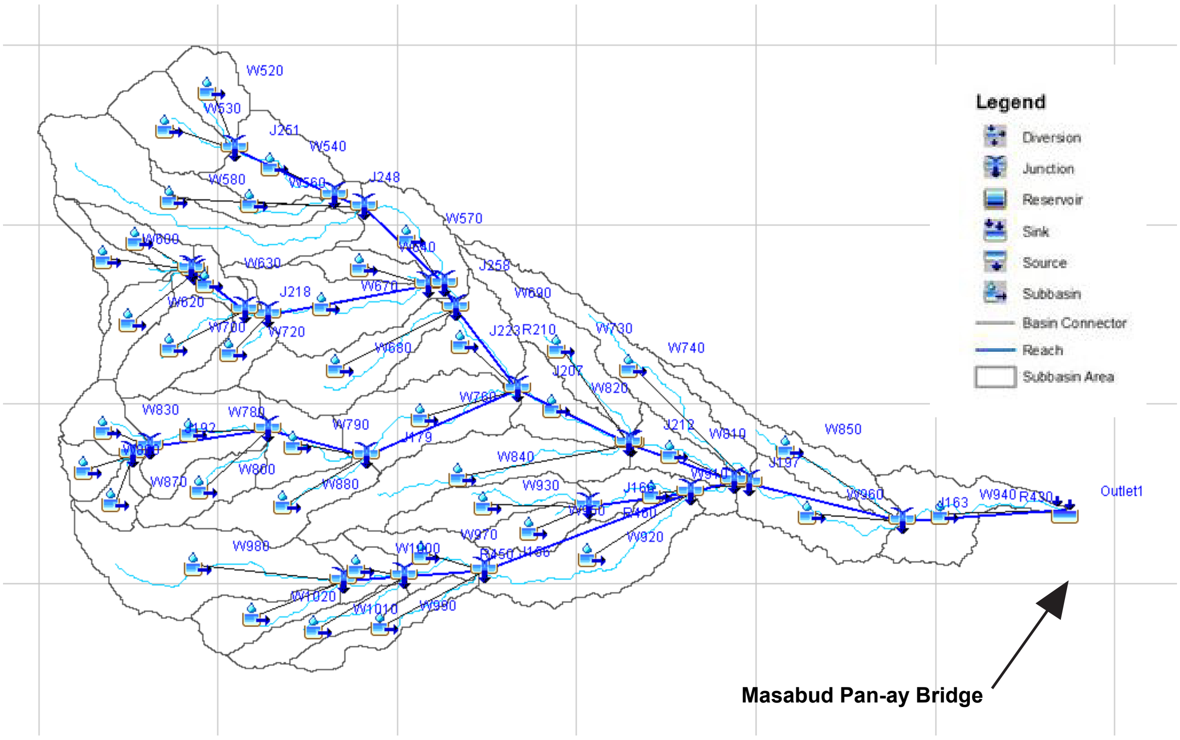


Figure 63. The Clarin Hydrologic Model generated in HEC-GeoHMS

5.4 Cross-section Data

Riverbed cross-sections of the watershed are crucial in the HEC-RAS model setup. The cross-section data for the HEC-RAS model was derived using the LiDAR DEM data. It was defined using the Arc GeoRAS tool and was post-processed in ArcGIS (Figure 64).

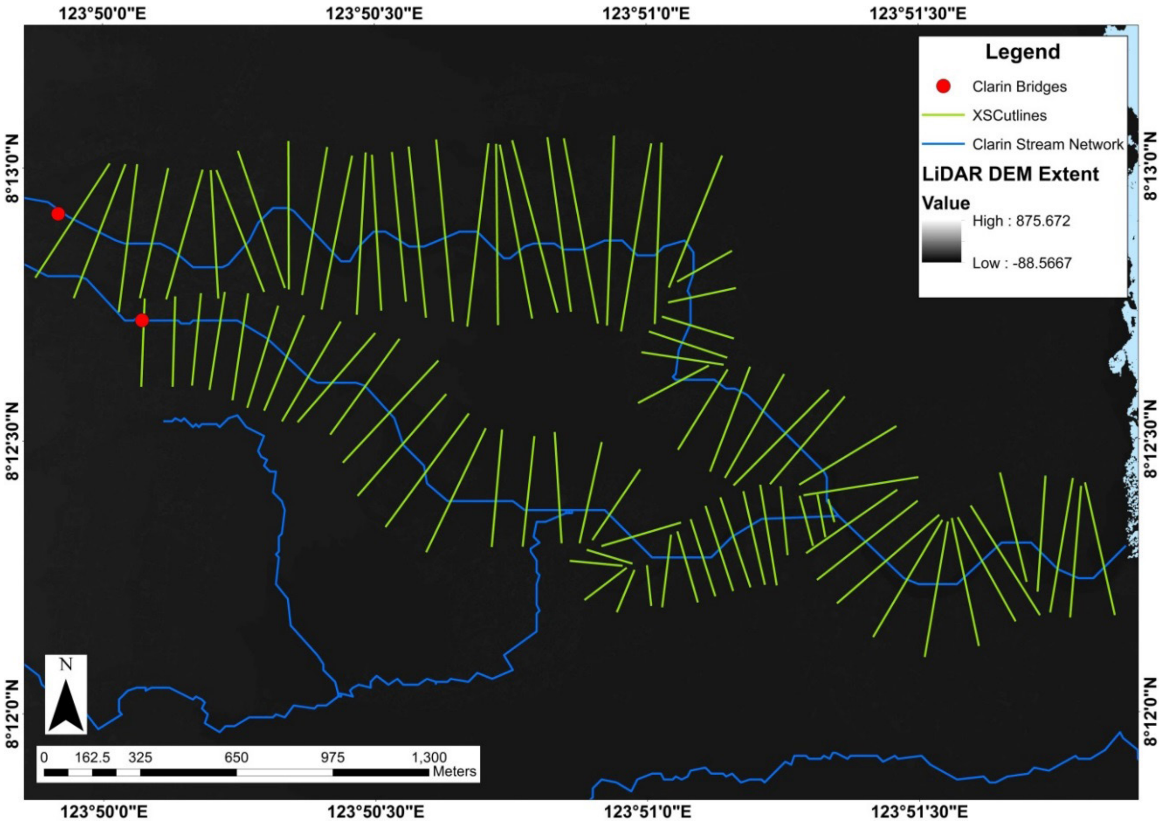


Figure 64. River cross-section of Clarin River through the ArcMap HEC GeoRAS tool.

5.5 Flo 2D Model

The simulation is then run through FLO-2D GDS Pro. This particular model had a computer run time of 44.87689 hours. After the simulation, FLO-2D Mapper Pro is used to transform the simulation results into spatial data that shows flood hazard levels, as well as the extent and inundation of the flood. Assigning the appropriate flood depth and velocity values for Low, Medium, and High creates the following food hazard map. Most of the default values given by FLO-2D Mapper Pro are used, except for those in the Low hazard level. For this particular level, the minimum h (Maximum depth) is set at 0.2 m while the minimum vh (Product of maximum velocity (v) times maximum depth (h)) is set at 0 m2/s

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

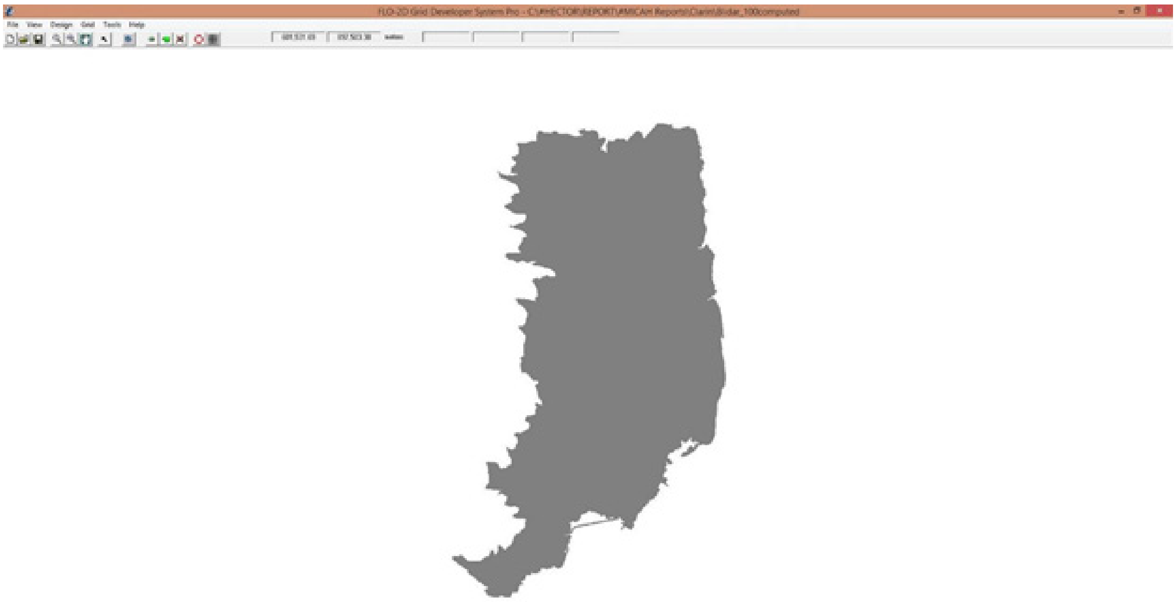


Figure 65. A screenshot of the river sub-catchment with the computational area to be modeled in FLO-2D Grid Developer System Pro (FLO-2D GDS Pro)

5.6 Results of HMS Calibration

After calibrating the Clarin HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 66 shows the comparison between the two discharge data.

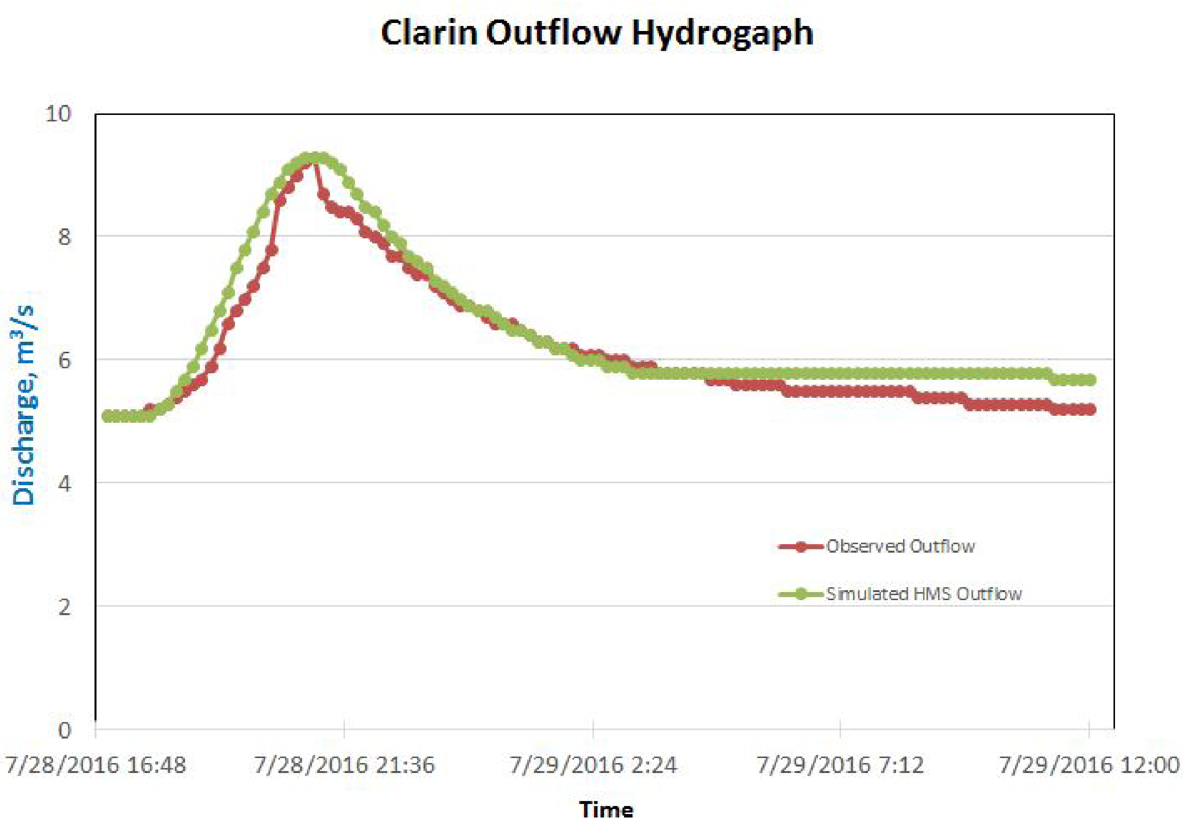


Figure 66. Outflow Hydrograph of Clarin Bridge produced by the HEC-HMS model compared with observed outflow.

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

Table 31. Range of Calibrated Values for the Clarin River Basin.

Hydrologic Element	Calculation Type	Method	Parameter	Range of Calibrated Values
Basin	Loss	SCS Curve number	Initial Abstraction (mm)	48 - 250
			Curve Number	48 - 83
	Transform	Clark Unit Hydrograph	Time of Concentration (hr)	1 - 5
			Storage Coefficient (hr)	0.8 - 4
	Baseflow	Recession	Recession Constant	0.98
			Ratio to Peak	0.23
Reach	Routing	Muskingum-Cunge	Manning's Coefficient	0.04

Initial abstraction defines the amount of precipitation that must fall before surface runoff. The magnitude of the outflow hydrograph increases as initial abstraction decreases. The range of values from 48mm to 250mm means that there is a diverse amount of infiltration or rainfall interception by vegetation.

Curve number is the estimate of the precipitation excess of soil cover, land use, and antecedent moisture. The magnitude of the outflow hydrograph increases as curve number increases. The range of 48 to 83 for curve number is advisable for Philippine watersheds depending on the soil and land cover of the area (M. Horritt, personal communication, 2012). For Clarin, the basin mostly consists of shrublands, grasslands, and forests, and the soil consists of clay, and clay loam.

Time of concentration and storage coefficient are the travel time and index of temporary storage of runoff in a watershed. The range of calibrated values from 1 to 5 hours determines the reaction time of the model with respect to the rainfall. The peak magnitude of the hydrograph also decreases when these parameters are increased.

Recession constant is the rate at which baseflow recedes between storm events and ratio to peak is the ratio of the baseflow discharge to the peak discharge. Recession constant of 0.98 indicates that the basin is unlikely to quickly go back to its original discharge and instead, will be higher. Ratio to peak of 0.23 indicates a steeper receding limb of the outflow hydrograph.

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

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

Accuracy measure	Value
RMSE	0.35
r^2	0.9889
NSE	0.90
PBIAS	-3.80
RSR	0.32

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was computed as 0.35 (m3/s).

The Pearson correlation coefficient (r2) assesses the strength of the linear relationship between the observations and the model. This value being close to 1 corresponds to an almost perfect match of the observed discharge and the resulting discharge from the HEC HMS model. Here, it measured 0.9889.

The Nash-Sutcliffe (E) method was also used to assess the predictive power of the model. Here the optimal value is 1. The model attained an efficiency coefficient of 0.90.

A positive Percent Bias (PBIAS) indicates a model's propensity towards under-prediction. Negative values indicate bias towards over-prediction. Again, the optimal value is 0. In the model, the PBIAS is -3.80.

The Observation Standard Deviation Ratio, RSR, is an error index. A perfect model attains a value of 0 when the error in the units of the valuable a quantified. The model has an RSR value of 0.32.

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

5.7.1 Hydrograph using the Rainfall Runoff Model

The summary graph (Figure 67) shows the Clarin outflow using the Dipolog Rainfall Intensity-Duration-Frequency curves (RIDF) in 5 different return periods (5-year, 10-year, 25-year, 50-year, and 100-year rainfall time series) based on the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAG-ASA) data. The simulation results reveal significant increase in outflow magnitude as the rainfall intensity increases for a range of durations and return periods.

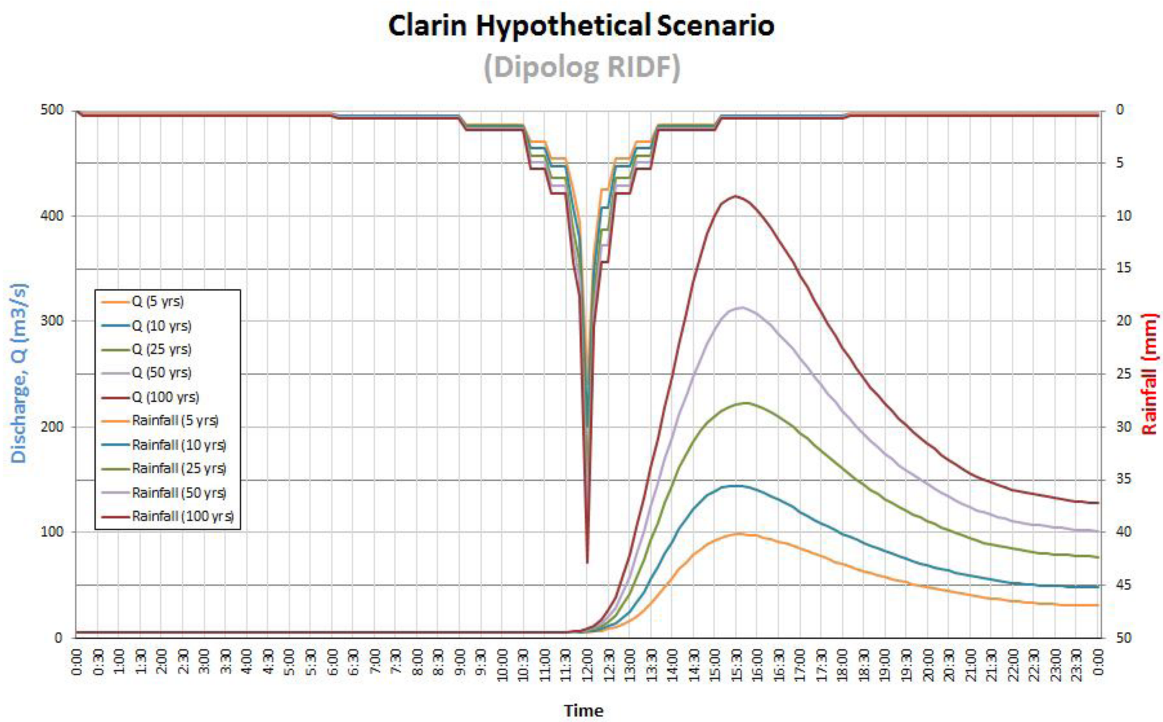


Figure 67. Outflow hydrograph at Clarin Station generated using the Dipolog RIDF simulated in HEC-HMS

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

Table 33. Peak values of the Clarin 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	98	15 hours 40 mins

10-Year	206.37	30	144.3	15 hours 30 mins
25-Year	241.91	35.2	222.5	15 hours 40 mins
50-Year	268.14	39	313	15 hours 40 mins
100-Year	294.55	42.9	418.7	15 hours 30 mins

5.7.2 Discharge data using Dr. Horritts's recommended hydrologic method

The river discharges for the two rivers entering the floodplain are shown in Figure 68 and Figure 69 and the peak values are summarized in Table 34 to Table 35.

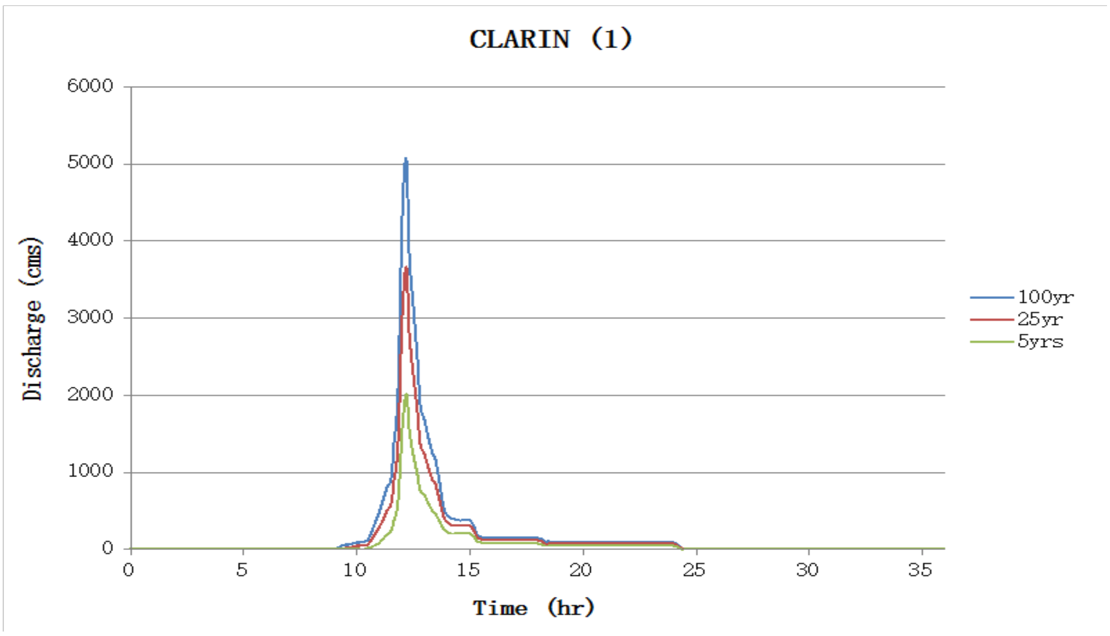


Figure 68. Clarin river (1) generated discharge using 5-, 25-, and 100-year Dipolog rainfall intensity-duration-frequency (RIDF) in HEC-HMS

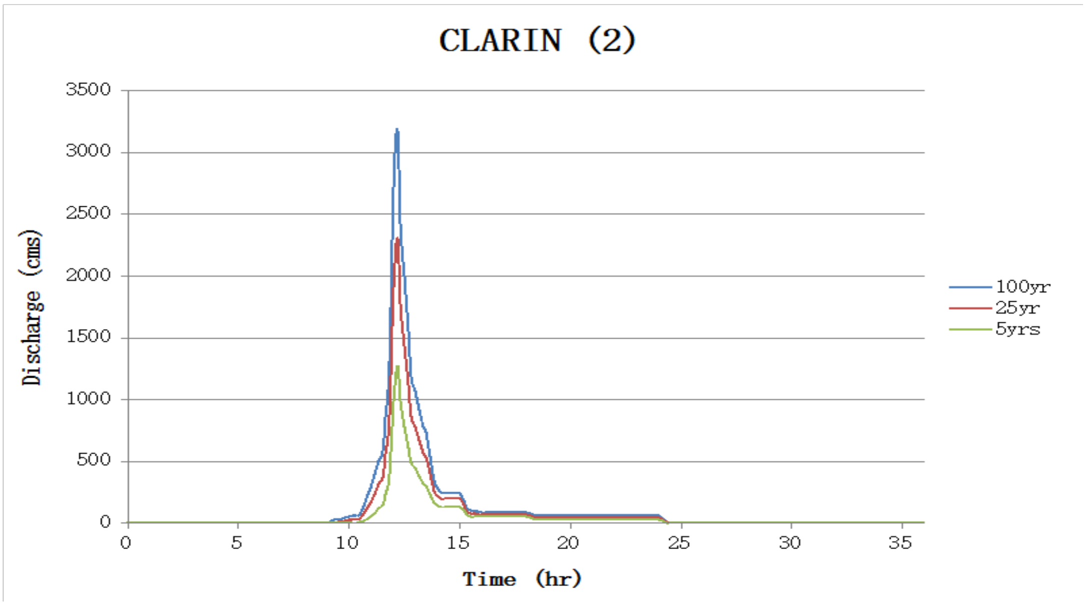


Figure 69. Clarin river (2) generated discharge using 5-, 25-, and 100-year Dipolog rainfall intensity-duration-frequency (RIDF) in HEC-HMS

Table 34. Summary of Clarin river (1) discharge generated in HEC-HMS

RIDF Period	Peak discharge (cms)	Time-to-peak
100-Year	5046.1	12 hours, 10 minutes
25-Year	3659.1	12 hours, 10 minutes
5-Year	2011.1	12 hours, 10 minutes

Table 35. Summary of Clarin river (2) discharge generated in HEC-HMS

RIDF Period	Peak discharge (cms)	Time-to-peak
100-Year	3178	12 hours, 10 minutes
25-Year	2304.4	12 hours, 10 minutes
5-Year	1271	12 hours, 10 minutes

The comparison of the discharge results using Dr. Horritt's recommended hydrological method against the bankful and specific discharge estimates is shown in Table 36.

Table 36. Validation of river discharge estimates

Discharge Point	$Q_{MED(SCS)}$, cms	$Q_{BANKFUL}$, cms	$Q_{MED(SPEC)}$, cms	VALIDATION	
				Bankful Discharge	Specific Discharge
Clarin (1)	271.128	224.133	444.630	Pass	Pass
Clarin (2)	229.152	189.295	336.073	Pass	Pass

All two values from the HEC-HMS river discharge estimates were able to satisfy the conditions for validation using the bankful and specific discharge methods. The calculated values are based on theory but are supported using other discharge computation methods so they were good to use flood modeling. However, these values will need further investigation for the purpose of validation. It is therefore recommended to obtain actual values of the river discharges for higher-accuracy modeling.

5.8 River Analysis (RAS) Model Simulation

The HEC-RAS Flood Model produced a simulated water level at every cross-section for every time step for every flood simulation created. The resulting model will be used in determining the flooded areas within the model. The simulated model will be an integral part in determining real-time flood inundation extent of the river after it has been automated and uploaded on the DREAM website. The sample generated map of Clarin River using the calibrated HMS base flow is shown in Figure 70.

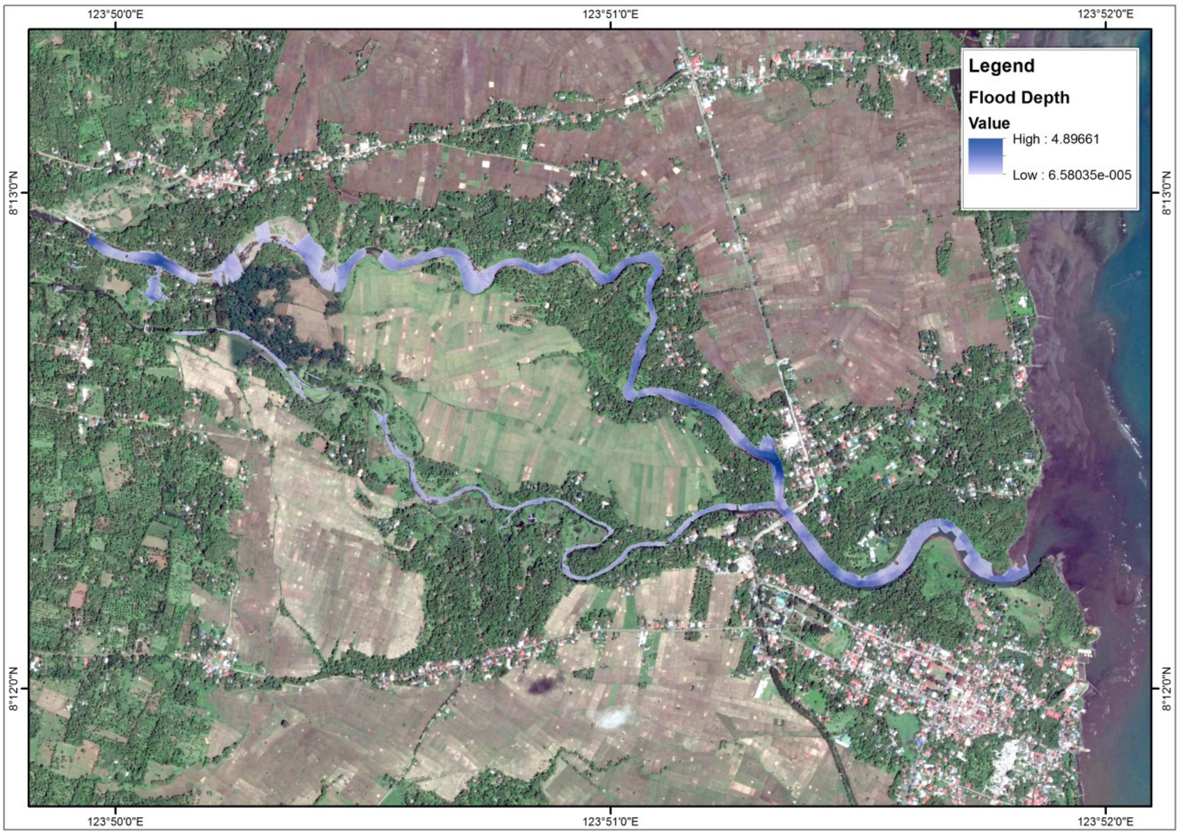


Figure 70. Sample output map of the Clarin RAS Model

5.9 Flow Depth and Flood Hazard

The resulting hazard and flow depth maps have a 10m resolution. Figure 71 to Figure 76 shows the 5-, 25-, and 100-year rain return scenarios of the Clarin floodplain. The floodplain, with an area of 50.22 sq. km., covers Ozamiz City and two municipalities namely Clarin and Tudela. Table 37 shows the percentage of area affected by flooding per municipality.

Table 37. Municipalities affected in Clarin floodplain

City / Municipality	Total Area	Area Flooded	% Flooded
Clarin	113.99	22.29	20%
Ozamiz City	149.437	25.68098	17%
Tudela	108.933	1.983236	2%

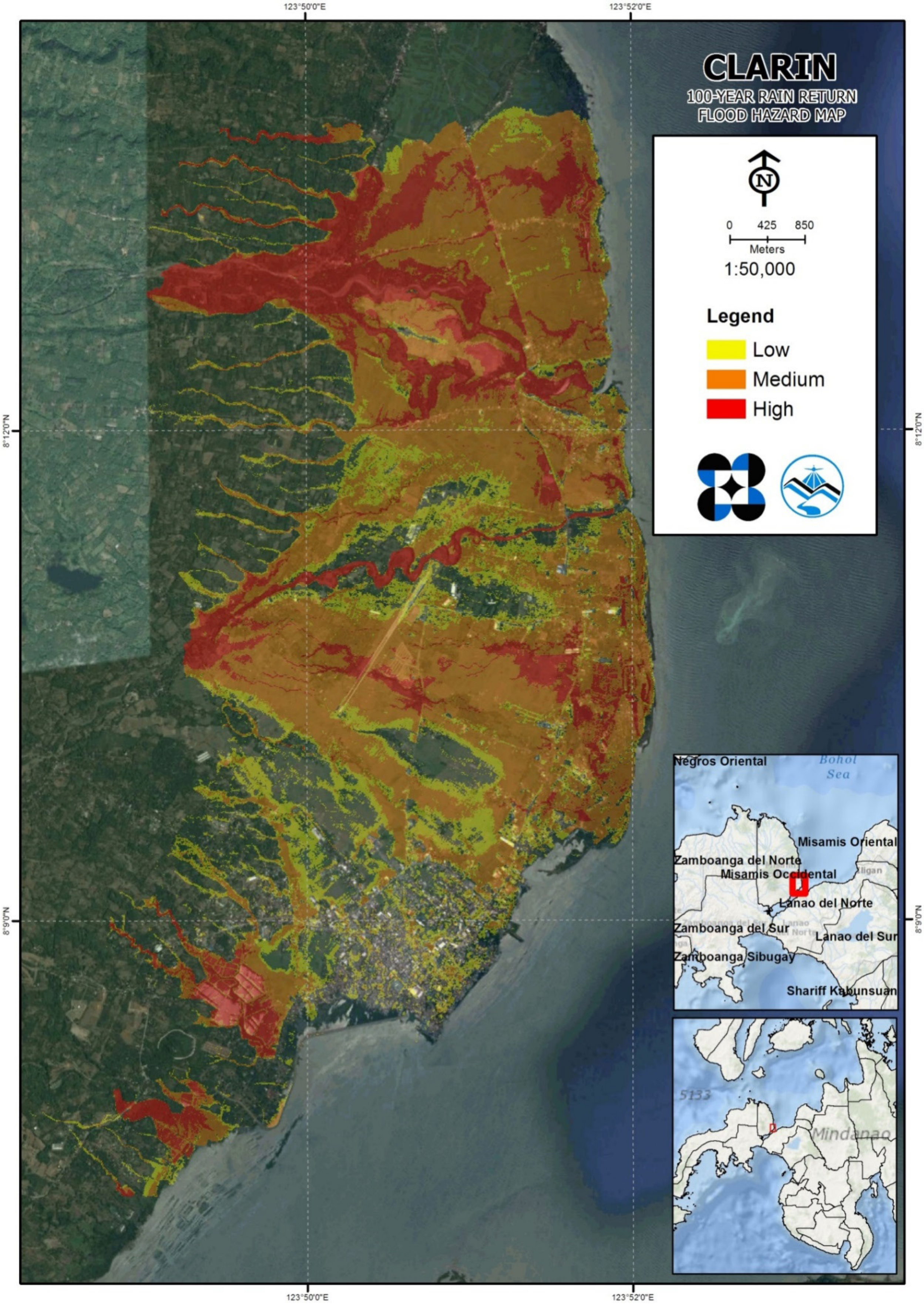


Figure 71. 100-year Flood Hazard Map for Clarin Floodplain overlaid on Google Earth imagery

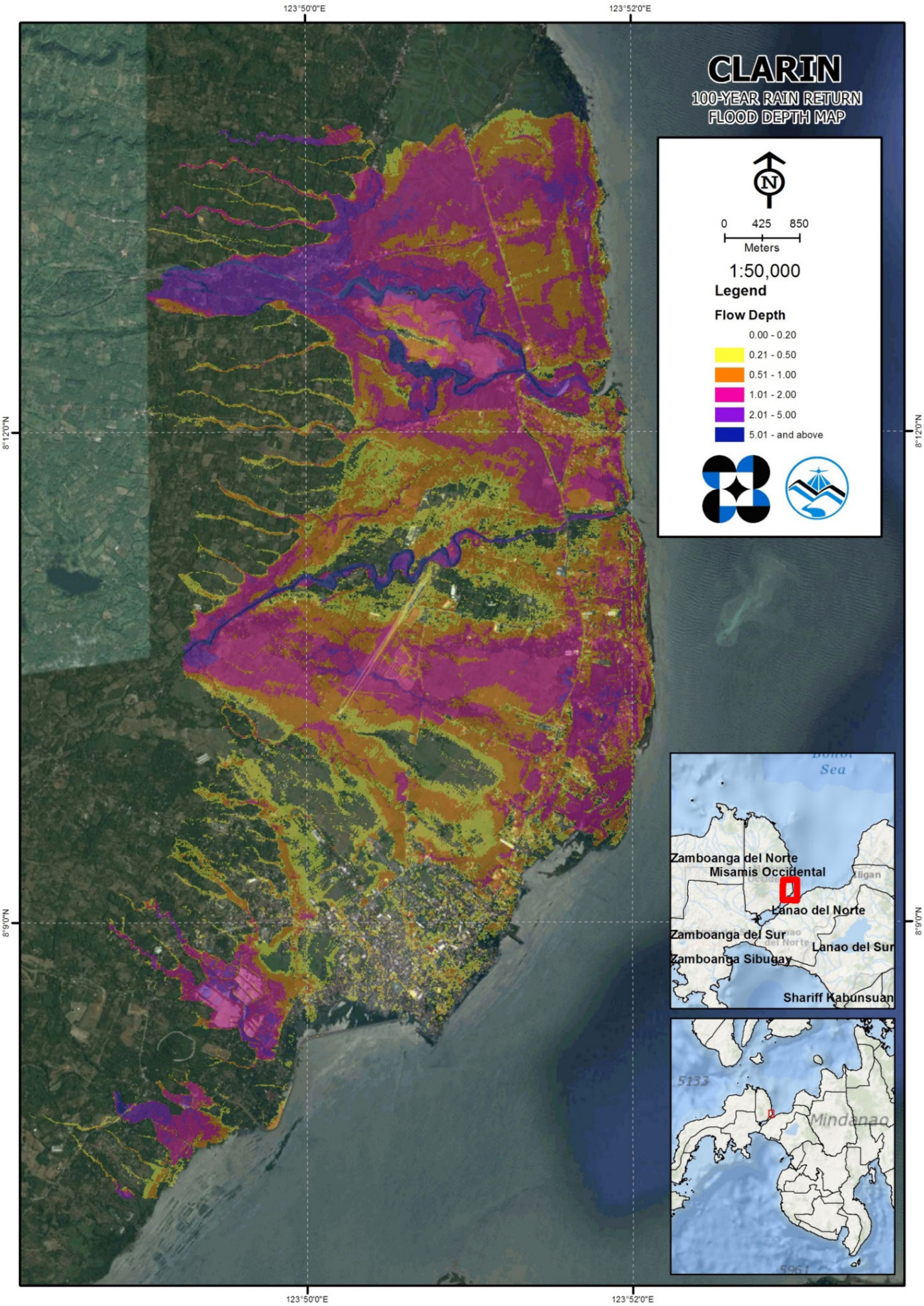


Figure 72. 100-year Flow Depth Map for Clarin Floodplain overlaid on Google Earth imagery

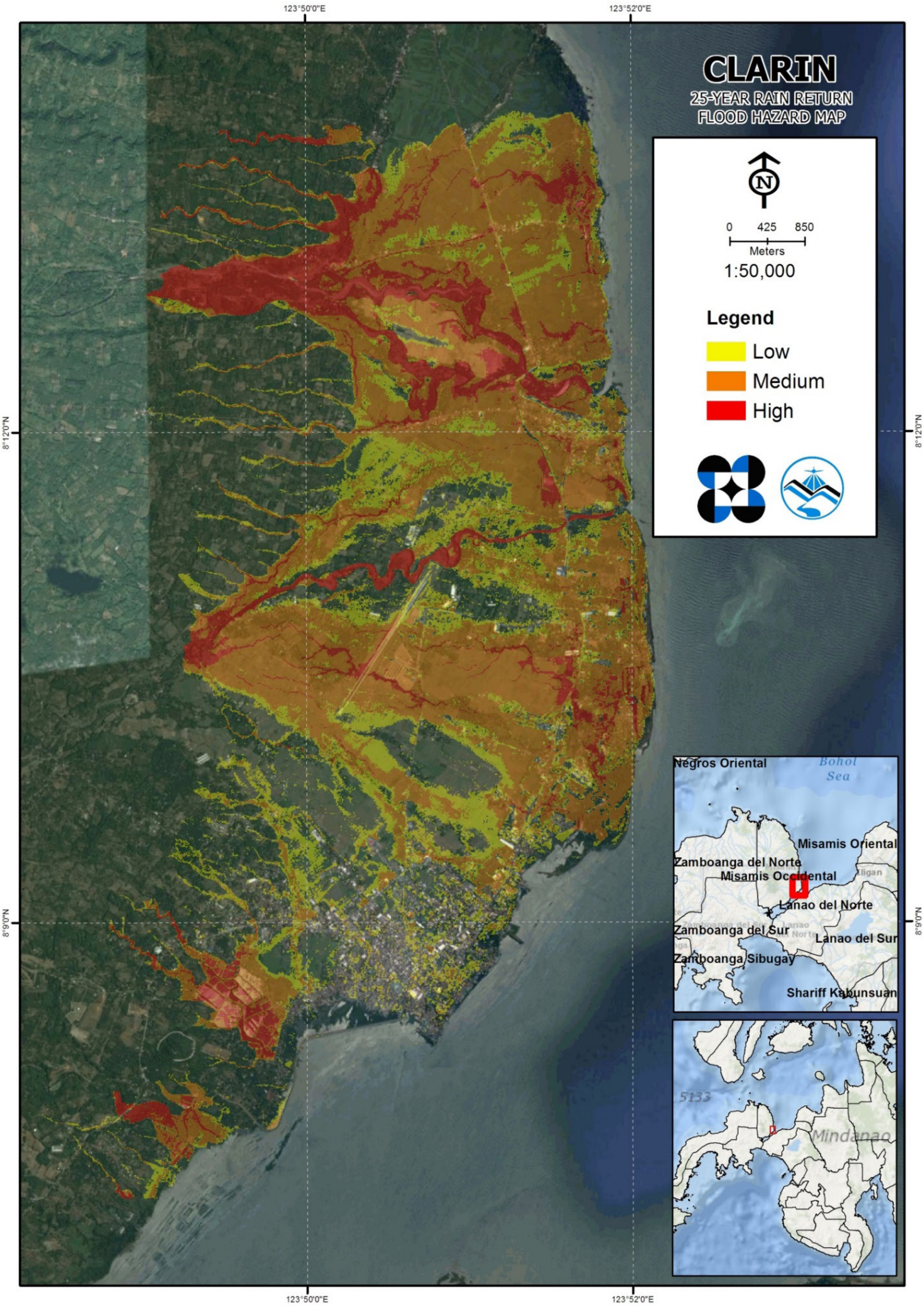


Figure 73. 25-year Flood Hazard Map for Clarin Floodplain overlaid on Google Earth imagery

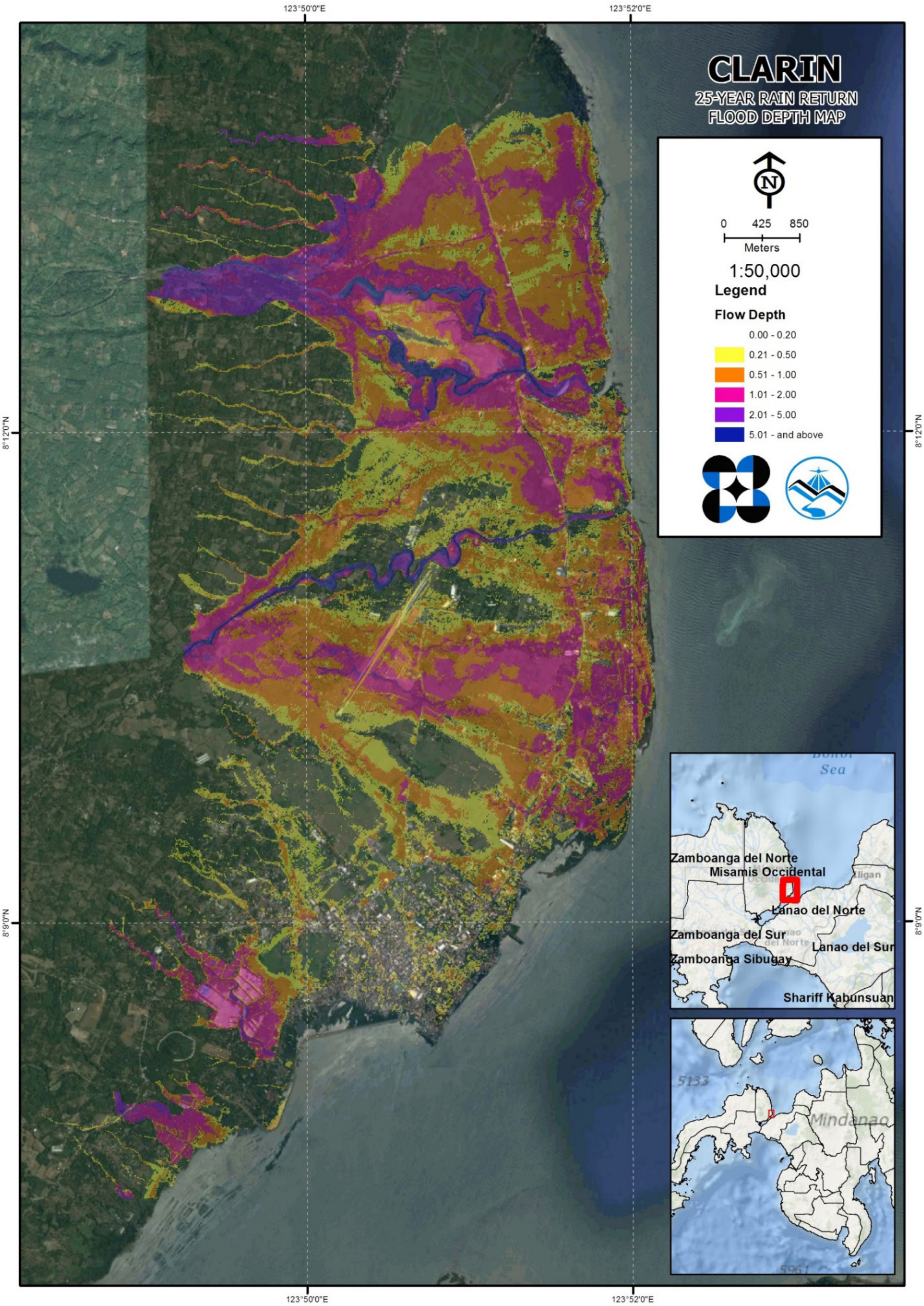


Figure 74. 25-year Flow Depth Map for Clarin Floodplain overlaid on Google Earth imagery

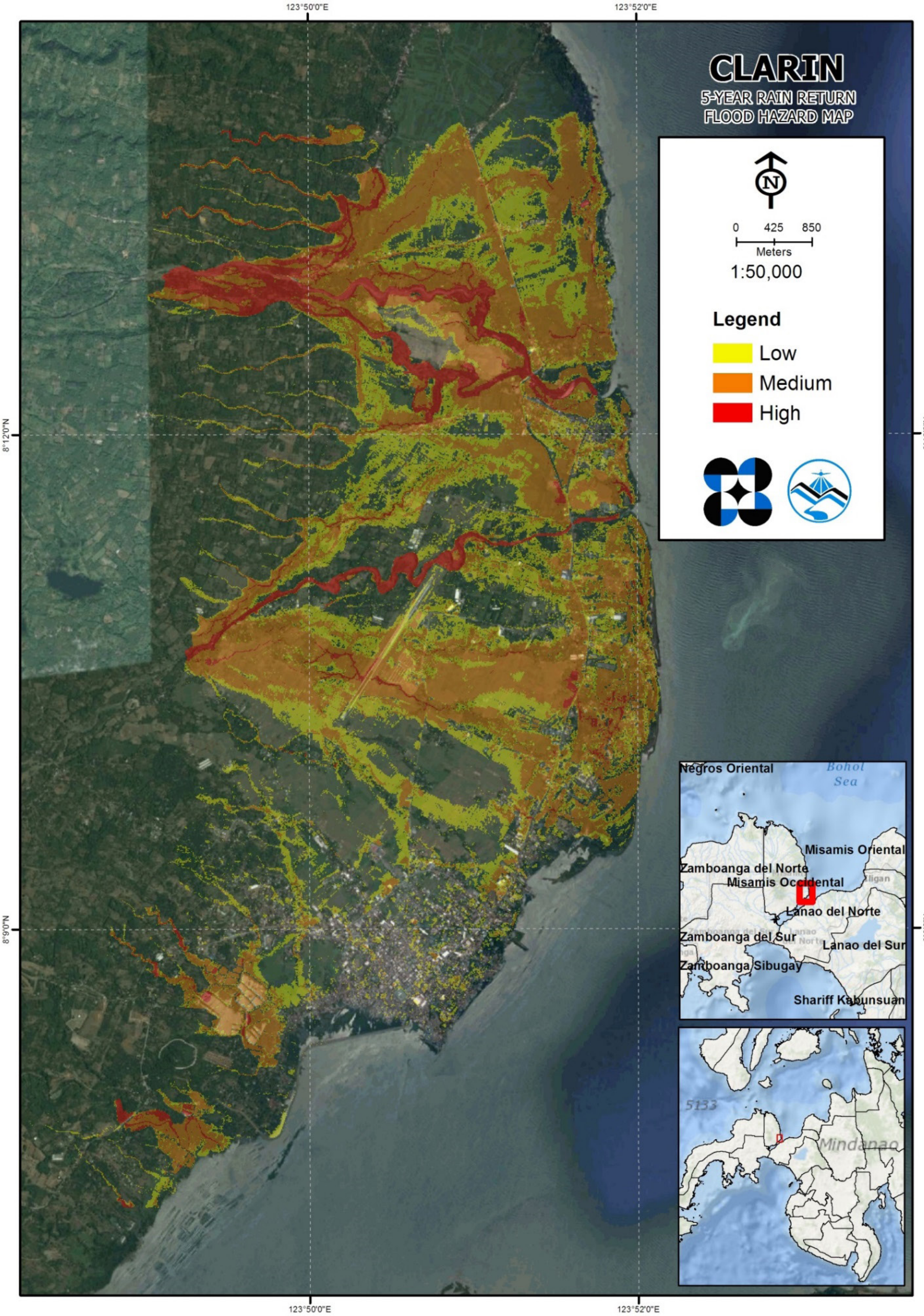


Figure 75. 5-year Flood Hazard Map for Clarin Floodplain overlaid on Google Earth imagery

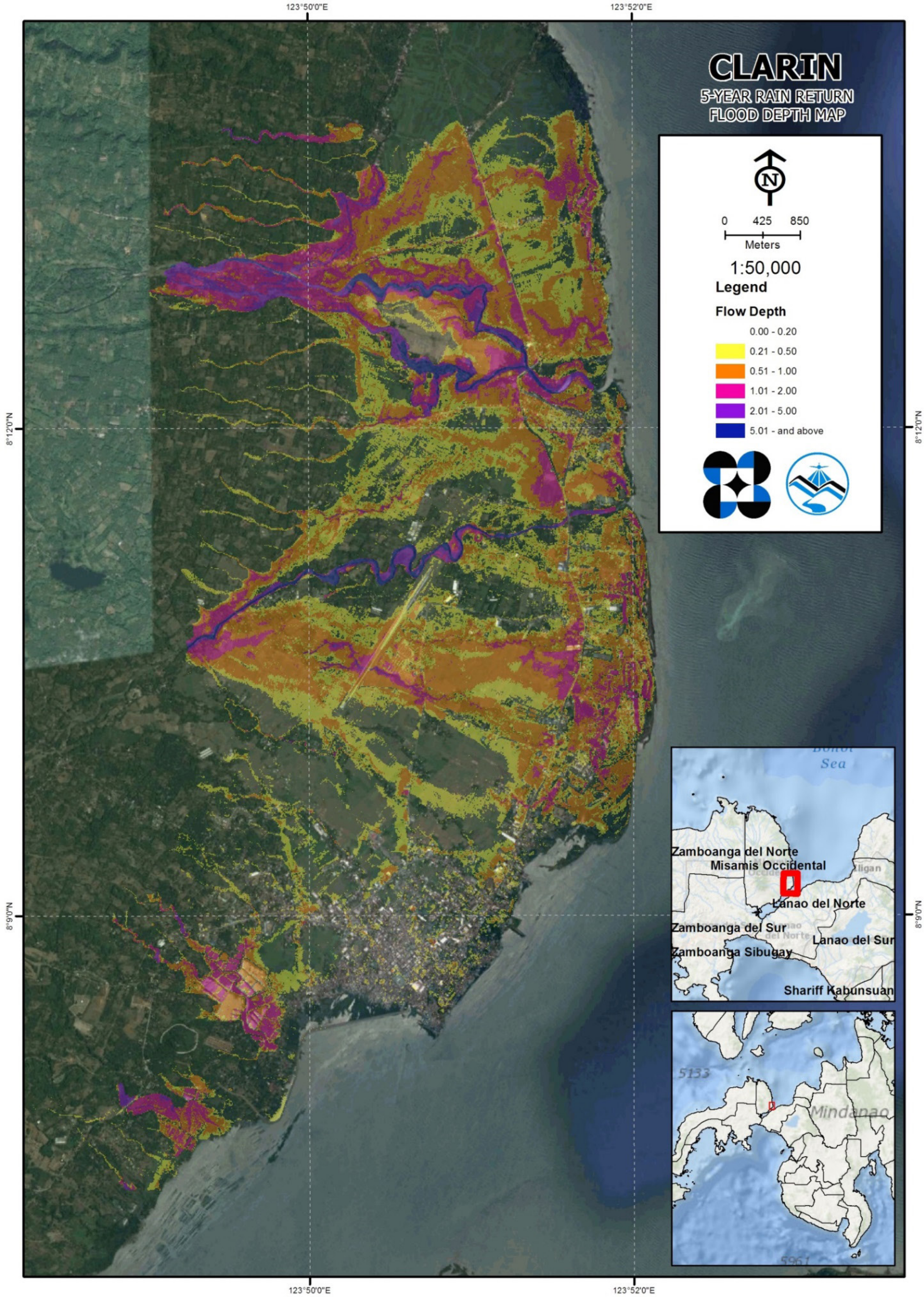


Figure 76. 5-year Flow Depth Map for Clarin Floodplain overlaid on Google Earth imagery

5.10 Inventory of Areas Exposed to Flooding of Affected Areas

Affected barangays in Clarin river basin, grouped by municipality, are listed below. For the said basin, three municipalities consisting of 49 barangays are expected to experience flooding when subjected to 5-, 25-, and 100-yr rainfall return period.

For the 5-year return period, 7.64% of the municipality of Clarin with an area of 113.99 sq. km. will experience flood levels of less 0.20 meters. The 4.35% of the area will experience flood levels of 0.21 to 0.50 meters while 4.33%, 2.12%, 0.81%, and 0.30% 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 kilometres by flood depth per barangay.

Table 38. Affected Areas in Clarin, Misamis Occidental during 5-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Clarin (in sq. km.)									
	Canibungan Daku	Canipacan	Dela Paz	Dolores	Gata Daku	Gata Diot	Kinangay Norte	Kinangay Sur	Lapasan	Lupagan
0.03-0.20	0.21	0.24	0.32	0.87	0.42	0.25	1.41	1.93	0.34	0.16
0.21-0.50	0.008	0.17	0.22	0.054	0.68	0.26	0.4	0.61	0.26	0.36
0.51-1.00	0.0036	0.17	0.12	0.076	0.49	0.19	0.14	0.35	0.45	0.34
1.01-2.00	0.0059	0.079	0.013	0.21	0.034	0.024	0.018	0.04	0.14	0.2
2.01-5.00	0.0012	0.081	0	0.036	0.013	0.036	0.0089	0.047	0.024	0
> 5.00	0	0.039	0	0.0002	0.012	0.03	0	0.046	0.0059	0

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Clarin (in sq. km.)									
	Masabud	Mialen	Pan-ay	Poblacion I	Poblacion II	Poblacion III	Poblacion IV	Segatic Daku	Segatic Diot	Tinacla-An
0.03-0.20	0.23	0.2	0.25	0.099	0.091	0.2	0.039	1.23	0.085	0.14
0.21-0.50	0.2	0.54	0.67	0.12	0.066	0.088	0.062	0.055	0.023	0.12
0.51-1.00	0.41	0.5	1.05	0.091	0.047	0.11	0.17	0.047	0.055	0.11
1.01-2.00	0.26	0.11	0.53	0.053	0.012	0.083	0.095	0.1	0.37	0.037
2.01-5.00	0.19	0.00052	0.046	0	0	0.04	0.051	0.066	0.26	0.023
> 5.00	0.13	0	0.0036	0	0	0.0066	0.057	0	0.017	0.0014

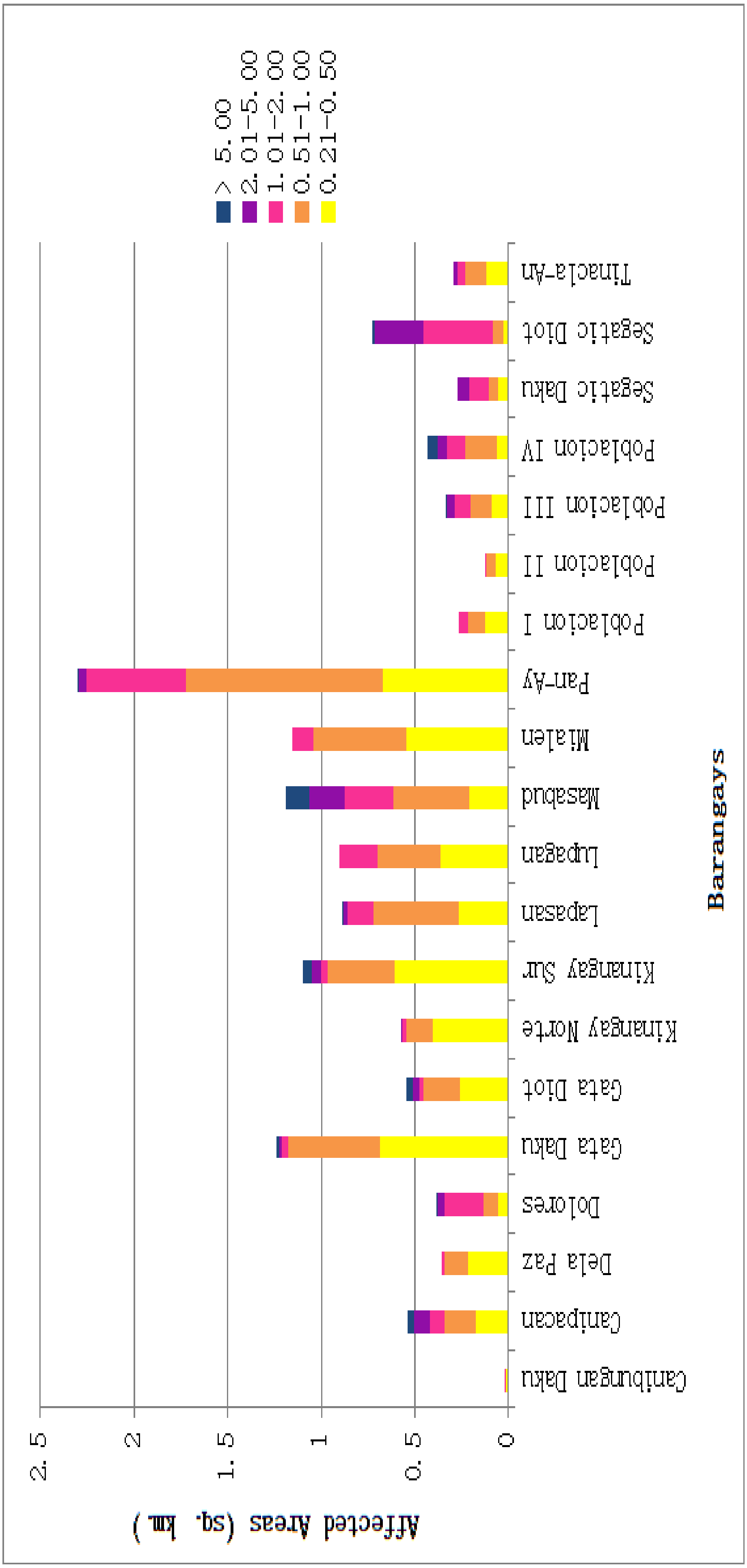


Figure 77. Affected Areas in Clarin, Misamis Occidental during 5-Year Rainfall Return Period

For the city of Ozamiz, with an area of 149.44 sq. km., 9.58% will experience flood levels of less 0.20 meters. 3.10% of the area will experience flood levels of 0.21 to 0.50 meters while 3.25%, 1.07%, 0.10%, and 0.08% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 39 are the affected areas in square kilometres by flood depth per barangay.

Table 39. Affected Areas in Ozamiz City, Misamis Occidental during 5-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Ozamiz City (in sq. km.)												
	50th District	Aguada	Bacolod	Bagakay	Banade-ro	Baybay San Roque	Baybay San-ta Cruz	Baybay Triunfo	Bongbong	Caran-gan	Carmen	Catadman-Manabay	Doña Consuelo
0.03-0.20	0.15	0.12	2.6	0.58	1	0.53	0.19	0.17	0.000002	2.13	0.28	0.22	0.19
0.21-0.50	0.018	0.024	0.9	0.026	0.11	0.047	0.023	0.028	0.000025	0.37	0.056	0.048	0.11
0.51-1.00	0.0022	0.00022	0.65	0.026	0.012	0.0023	0.002	0.00092	0	0.074	0.0085	0.0066	0.19
1.01-2.00	0	0	0.089	0.043	0.0015	0	0	0	0.0001	0.0052	0.0005	0.0001	0.045
2.01-5.00	0	0	0.0038	0.014	0	0	0	0	0.0002	0.00042	0	0	0
> 5.00	0	0	0	0	0	0	0	0	0	0	0	0	0

Affected area (sq. km.) by flood depth (in m.)	Area of affected barangays in Ozamiz City (in sq. km.)											
	Embargo	Gango	Gotokan Diot	Clarin	Lam-An	Malaubang	Maningcol	Mentering	Molicay	Pulot	San Antonio	Tinago
0.03-0.20	0.29	0.28	0.00013	0.99	0.37	1.27	0.7	0.00015	0.61	0.86	0.18	0.61
0.21-0.50	0.078	0.37	0.0002	0.7	0.06	0.11	0.46	0.00088	0.52	0.084	0.26	0.23
0.51-1.00	0.11	0.6	0.000041	1.09	0.0097	0.24	0.45	0.000013	0.6	0.08	0.47	0.22
1.01-2.00	0.17	0.2	0	0.13	0.0001	0.21	0.062	0	0.12	0.075	0.28	0.16
2.01-5.00	0.042	0	0	0.051	0	0.014	0.0005	0	0.0015	0.028	0	0
> 5.00	0.035	0	0	0.084	0	0	0	0	0	0.00056	0	0

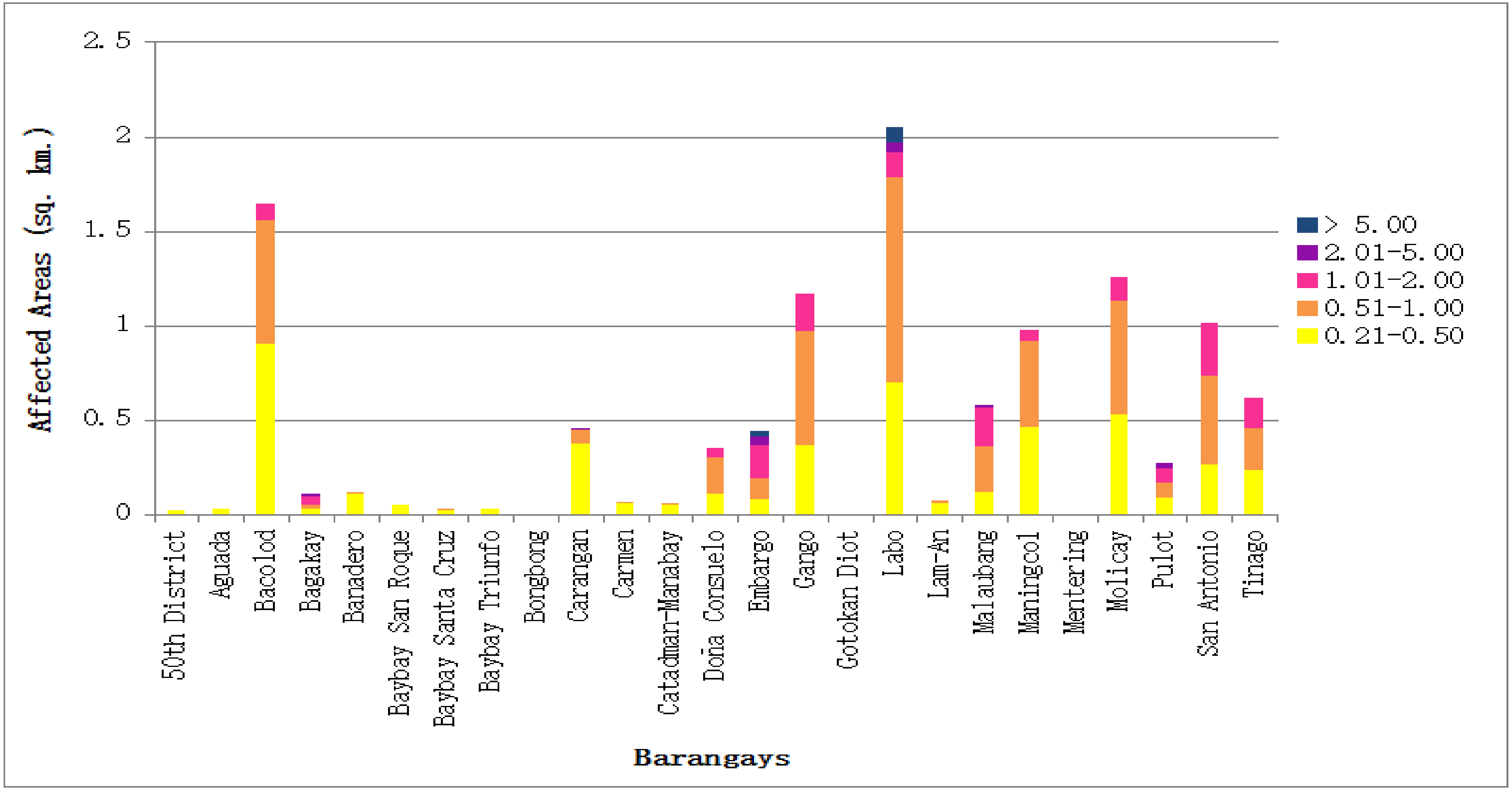


Figure 78. Affected Areas in Ozamiz City, Misamis Occidental during 5-Year Rainfall Return Period

For the municipality of Tudela, with an area of 108.933 sq. km., 1.35% will experience flood levels of less 0.20 meters. 0.12% of the area will experience flood levels of 0.21 to 0.50 meters while 0.21%, 0.12%, and 0.03% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively. Listed in Table 40 are the affected areas in square kilometres by flood depth per barangay.

Table 40. Affected Areas in Tudela, Misamis Occidental during 5-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Tudela (in sq. km.)			
	Canibungan Proper	Locso-On	Pan-ay Diot	Yahong
0.03-0.20	0.084	0.49	0.11	0.78
0.21-0.50	0.00069	0.03	0.077	0.024
0.51-1.00	0.0018	0.078	0.11	0.04
1.01-2.00	0.0022	0.076	0.02	0.034
2.01-5.00	0	0.023	0	0.0054
> 5.00	0	0	0	0

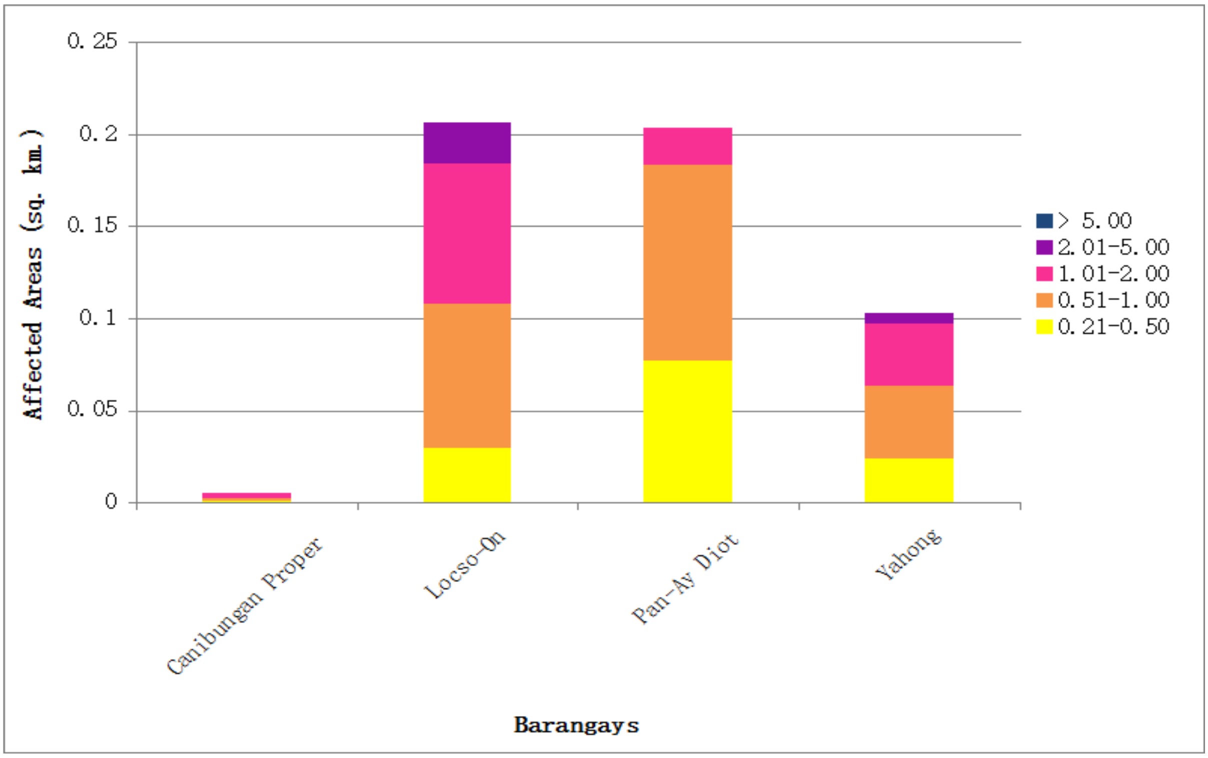


Figure 79. Affected Areas in Tudela, Misamis Occidental during 5-Year Rainfall Return Period

For the 25-year return period, 5.58% of the municipality of Clarin with an area of 113.99 sq. km. will experience flood levels of less 0.20 meters. 2.79% of the area will experience flood levels of 0.21 to 0.50 meters while 5.44%, 3.96%, 1.41%, 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 41 are the affected areas in square kilometres by flood depth per barangay.

Table 41. Affected Areas in Clarin, Misamis Occidental during 25-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Clarin (in sq. km.)									
	Canibungan Daku	Canipacan	Dela Paz	Dolores	Gata Daku	Gata Diot	Kinangay Norte	Kinangay Sur	Lapasan	Lupagan
0.03-0.20	0.2	0.14	0.075	0.82	0.17	0.22	1.24	1.6	0.25	0.014
0.21-0.50	0.011	0.1	0.19	0.055	0.47	0.26	0.36	0.54	0.23	0.089
0.51-1.00	0.0028	0.22	0.3	0.049	0.74	0.22	0.31	0.68	0.47	0.46
1.01-2.00	0.0063	0.17	0.099	0.16	0.25	0.025	0.06	0.11	0.24	0.48
2.01-5.00	0.0028	0.083	0	0.16	0.014	0.036	0.011	0.049	0.027	0.022
> 5.00	0	0.06	0	0.0006	0.013	0.03	0.0001	0.048	0.0067	0

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Clarin (in sq. km.)									
	Masabud	Mialen	Pan-ay	Poblacion I	Poblacion II	Poblacion III	Poblacion IV	Segatic Daku	Segatic Diot	Tinacla-An
0.03-0.20	0.088	0.035	0.015	0.016	0.015	0.11	0.022	1.18	0.048	0.1
0.21-0.50	0.099	0.19	0.18	0.079	0.05	0.086	0.016	0.066	0.03	0.067
0.51-1.00	0.33	0.78	0.95	0.15	0.11	0.13	0.092	0.05	0.02	0.15
1.01-2.00	0.53	0.33	1.28	0.12	0.04	0.14	0.21	0.065	0.12	0.082
2.01-5.00	0.23	0.006	0.12	0	0	0.053	0.067	0.14	0.56	0.032
> 5.00	0.15	0	0.0054	0	0	0.0079	0	0	0	0

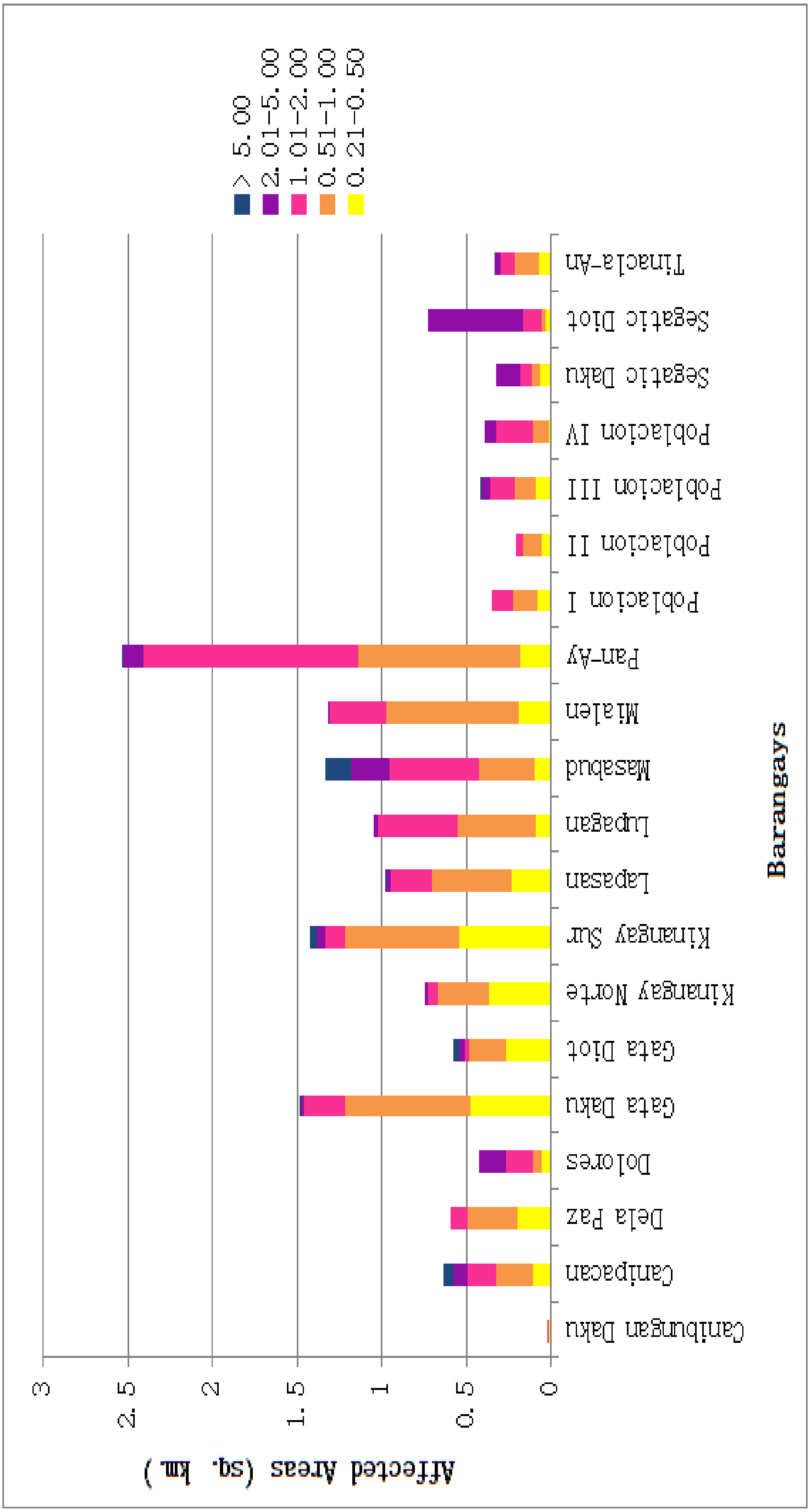


Figure 80. Affected Areas in Clarin, Misamis Occidental during 25-Year Rainfall Return Period

For the city of Ozamiz, with an area of 149.44 sq. km., 7.36% will experience flood levels of less 0.20 meters. 3.00% of the area will experience flood levels of 0.21 to 0.50 meters while 3.64%, 2.88%, and 0.22% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively. Listed in Table 42 are the affected areas in square kilometres by flood depth per barangay.

Table 42. Affected Areas in Ozamiz City, Misamis Occidental during 25-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Ozamiz City (in sq. km.)												
	50th District	Aguada	Bacolod	Bagakay	Banade-ro	Baybay San Roque	Baybay Santa Cruz	Baybay Triunfo	Bongbong	Caran-gan	Carmen	Catadman-Manabay	Doña Con-suelo
0.03-0.20	0.14	0.099	1.82	0.56	0.94	0.47	0.18	0.15	0	1.78	0.21	0.18	0.11
0.21-0.50	0.025	0.042	0.96	0.031	0.14	0.1	0.035	0.049	0	0.62	0.11	0.079	0.081
0.51-1.00	0.0044	0.0026	0.99	0.025	0.034	0.0054	0.0039	0.0029	0.000025	0.17	0.018	0.021	0.15
1.01-2.00	0.0001	0	0.46	0.039	0.0036	0.0001	0	0	0.000002	0.014	0.0011	0.0007	0.2
2.01-5.00	0	0	0.0096	0.032	0.00027	0	0	0	0.00031	0.00042	0	0	0
> 5.00	0	0	0	0	0	0	0	0	0	0	0	0	0

Affected area (sq. km.) by flood depth (in m.)	Area of affected barangays in Ozamiz City (in sq. km.)											
	Embargo	Gango	Gotokan Diot	Clarin	Lam-An	Malaubang	Maningcol	Mentering	Molicay	Pulot	San Antonio	Tinago
0.03-0.20	0.23	0.12	0	0.6	0.33	1.2	0.29	0	0.32	0.8	0.062	0.42
0.21-0.50	0.078	0.23	0	0.49	0.086	0.078	0.51	0.000003	0.3	0.1	0.095	0.22
0.51-1.00	0.072	0.6	0.00013	1.05	0.018	0.15	0.64	0.00015	0.77	0.055	0.41	0.24
1.01-2.00	0.25	0.49	0.00024	0.74	0.00051	0.35	0.23	0.00089	0.46	0.12	0.6	0.34
2.01-5.00	0.068	0.0004	0	0.065	0	0.069	0.002	0	0.016	0.05	0.015	0.0022
> 5.00	0	0	0	0	0	0	0	0	0	0	0	0

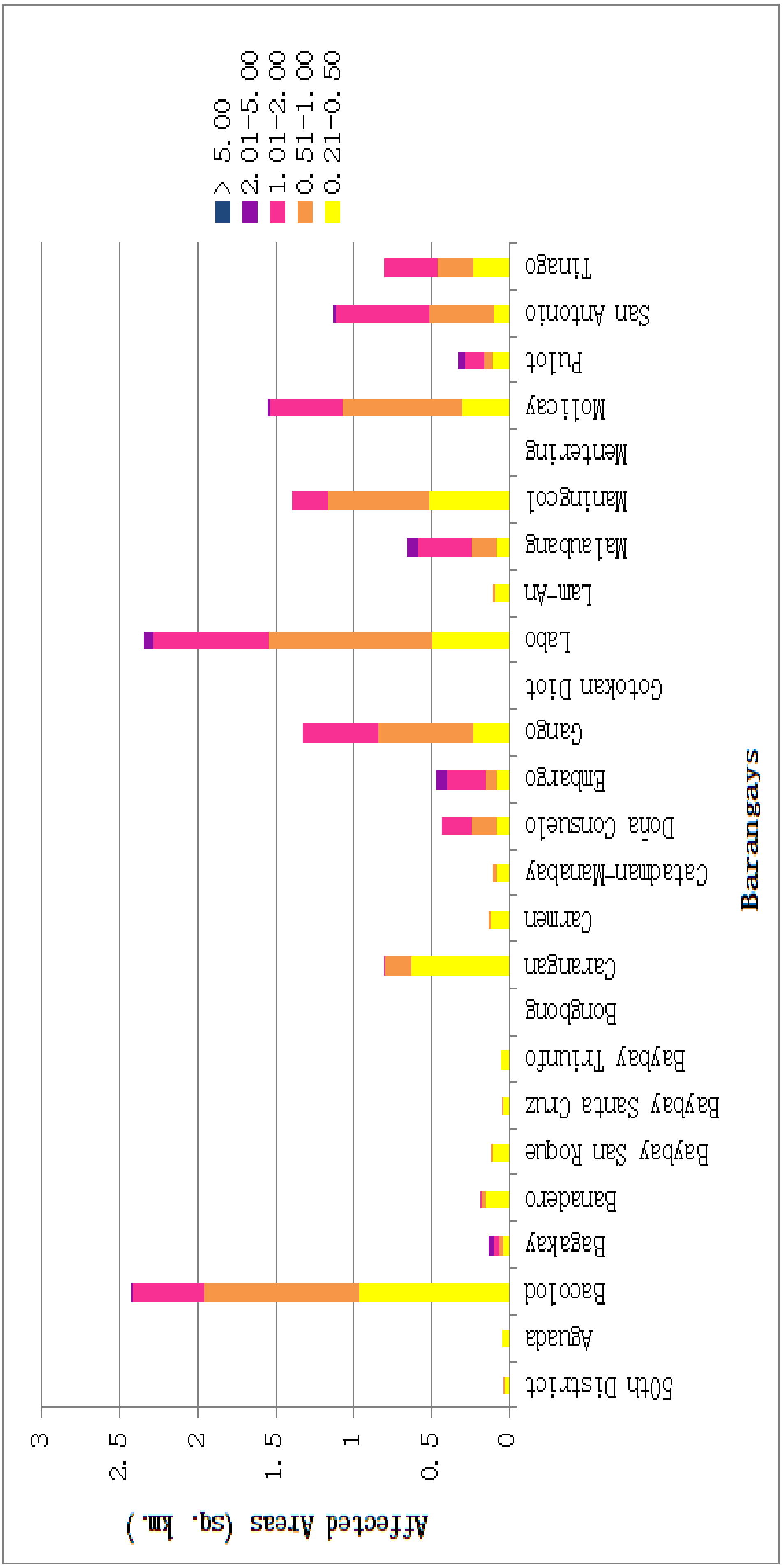


Figure 81. Affected Areas in Ozamiz City, Misamis Occidental during 25-Year Rainfall Return Period

For the municipality of Tudela, with an area of 108.933 sq. km., 1.25% will experience flood levels of less 0.20 meters. 0.11% of the area will experience flood levels of 0.21 to 0.50 meters while 0.19%, 0.20%, and 0.06% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively. Listed in Table 42 are the affected areas in square kilometres by flood depth per barangay.

Table 43. Affected Areas in Tudela, Misamis Occidental during 25-Year Rainfall Return Period

Affected area (sq. km.) by flood depth (in m.)	Area of affected barangays in Tudela (in sq. km.)			
	Canibungan Proper	Locso-On	Pan-ay Diot	Yahong
0.03-0.20	0.084	0.47	0.044	0.77
0.21-0.50	0.0009	0.029	0.065	0.029
0.51-1.00	0.0013	0.048	0.12	0.032
1.01-2.00	0.0032	0.089	0.081	0.049
2.01-5.00	0	0.059	0	0.012
> 5.00	0	0	0	0

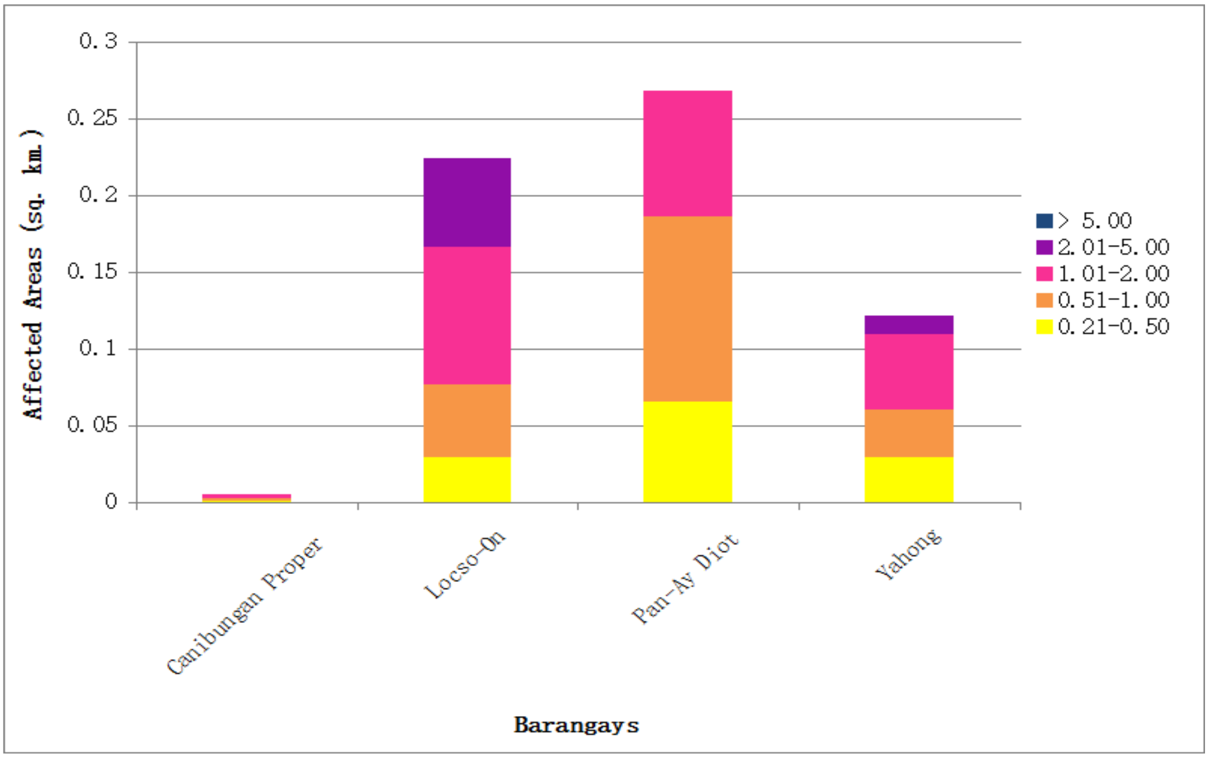


Figure 82. Affected Areas in Tudela, Misamis Occidental during 25-Year Rainfall Return Period

For the 100-Year return period, 5.04% of the municipality of Clarin with an area of 113.99 sq. km. will experience flood levels of less 0.20 meters. 2.02% of the area will experience flood levels of 0.21 to 0.50 meters while 4.67%, 5.42%, 1.95%, 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 44 are the affected areas in square kilometres by flood depth per barangay.

Table 44. Affected Areas in Clarin, Misamis Occidental during 100-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Clarin (in sq. km.)									
	Canibungan Daku	Canipacan	Dela Paz	Dolores	Gata Daku	Gata Diot	Kinangay Norte	Kinangay Sur	Lapasan	Lupagan
0.03-0.20	0.2	0.091	0.033	0.79	0.12	0.23	1.18	1.47	0.23	0.0056
0.21-0.50	0.012	0.051	0.11	0.058	0.35	0.26	0.28	0.51	0.21	0.027
0.51-1.00	0.0027	0.17	0.31	0.039	0.67	0.21	0.38	0.75	0.43	0.28
1.01-2.00	0.006	0.29	0.2	0.12	0.48	0.024	0.12	0.19	0.31	0.63
2.01-5.00	0.0045	0.094	0.0047	0.24	0.014	0.036	0.013	0.051	0.031	0.12
> 5.00	0	0.077	0	0.002	0.013	0.03	0.0002	0.048	0	0

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Clarin (in sq. km.)									
	Masabud	Mialen	Pan-ay	Poblacion I	Poblacion II	Poblacion III	Poblacion IV	Segatic Daku	Segatic Diot	Tinacla-An
0.03-0.20	0.027	0.017	0.0042	0.0042	0.0073	0.056	0.009	1.14	0.04	0.083
0.21-0.50	0.036	0.072	0.039	0.032	0.021	0.097	0.017	0.059	0.0024	0.042
0.51-1.00	0.22	0.66	0.55	0.15	0.11	0.12	0.047	0.063	0.032	0.12
1.01-2.00	0.68	0.58	1.63	0.17	0.074	0.18	0.25	0.064	0.035	0.14
2.01-5.00	0.29	0.017	0.32	0.0012	0.0002	0.069	0.084	0.17	0.63	0.042
> 5.00	0	0	0	0	0	0	0	0	0	0

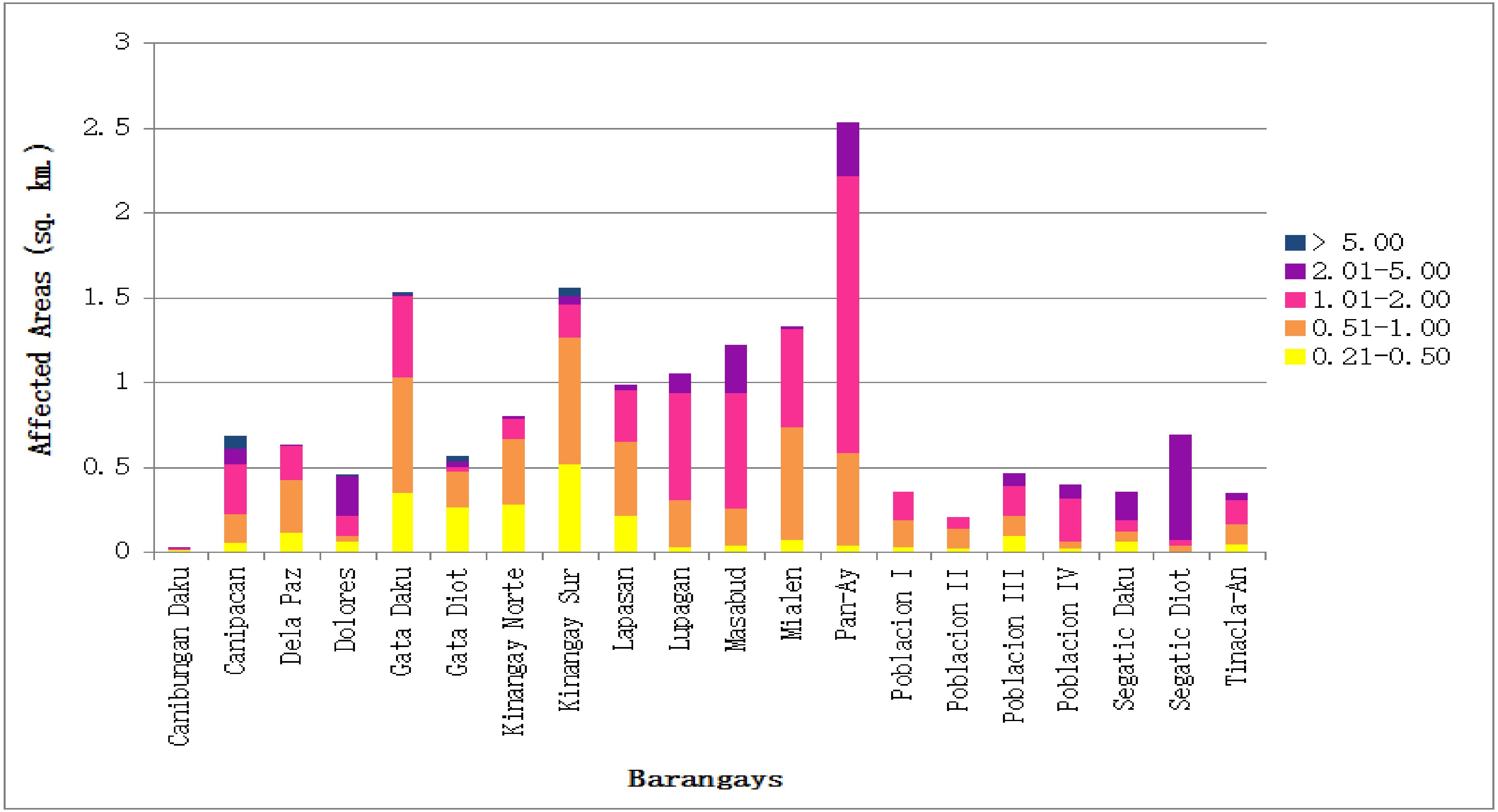


Figure 83. Affected Areas in Clarin, Misamis Occidental during 100-Year Rainfall Return Period

For the city of Ozamiz, with an area of 149.44 sq. km., 6.20% will experience flood levels of less 0.20 meters. 2.92% of the area will experience flood levels of 0.21 to 0.50 meters while 3.44%, 4.03%, and 0.50% 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 45 are the affected areas in square kilometres by flood depth per barangay.

Table 45. Affected Areas in Ozamiz City, Misamis Occidental during 100-Year Rainfall Return Period

Affected area (sq. km.) by flood depth (in m.)	Area of affected barangays in Ozamiz City (in sq. km.)												
	50th District	Aguada	Bacolod	Bagakay	Banadero	Baybay San Roque	Baybay Santa Cruz	Baybay Triunfo	Bongbong	Caran-gan	Carmen	Catad-man-Manabay	Doña Consue-lo
0.03-0.20	0.14	0.086	1.38	0.55	0.9	0.4	0.17	0.13	0	1.49	0.18	0.14	0.063
0.21-0.50	0.03	0.051	0.91	0.035	0.16	0.16	0.044	0.061	0	0.83	0.14	0.097	0.078
0.51-1.00	0.0063	0.0063	1.2	0.025	0.053	0.012	0.0054	0.0069	0	0.24	0.028	0.04	0.12
1.01-2.00	0.0001	0	0.73	0.039	0.0056	0.00029	0	0	0.000027	0.024	0.0016	0.0012	0.28
2.01-5.00	0	0	0.019	0.041	0.00047	0	0	0	0.00031	0.00052	0	0	0.0028
> 5.00	0	0	0	0	0	0	0	0	0	0	0	0	0

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Ozamiz City (in sq. km.)											
	Embargo	Gango	Gotokan Diot	Clarin	Lam-An	Malaubang	Maningcol	Mentering	Molicay	Pulot	San Antonio	Tinago
0.03-0.20	0.21	0.075	0	0.44	0.31	1.17	0.12	0	0.19	0.77	0.029	0.35
0.21-0.50	0.077	0.17	0	0.41	0.11	0.07	0.41	0	0.19	0.11	0.062	0.16
0.51-1.00	0.061	0.54	0	0.79	0.023	0.11	0.68	0.000003	0.62	0.061	0.26	0.25
1.01-2.00	0.22	0.65	0.00033	1.22	0.0012	0.35	0.46	0.001	0.8	0.11	0.74	0.38
2.01-5.00	0.13	0.0083	0.000041	0.087	0	0.15	0.0071	0.000013	0.06	0.077	0.089	0.084
> 5.00	0	0	0	0	0	0	0	0	0	0	0	0

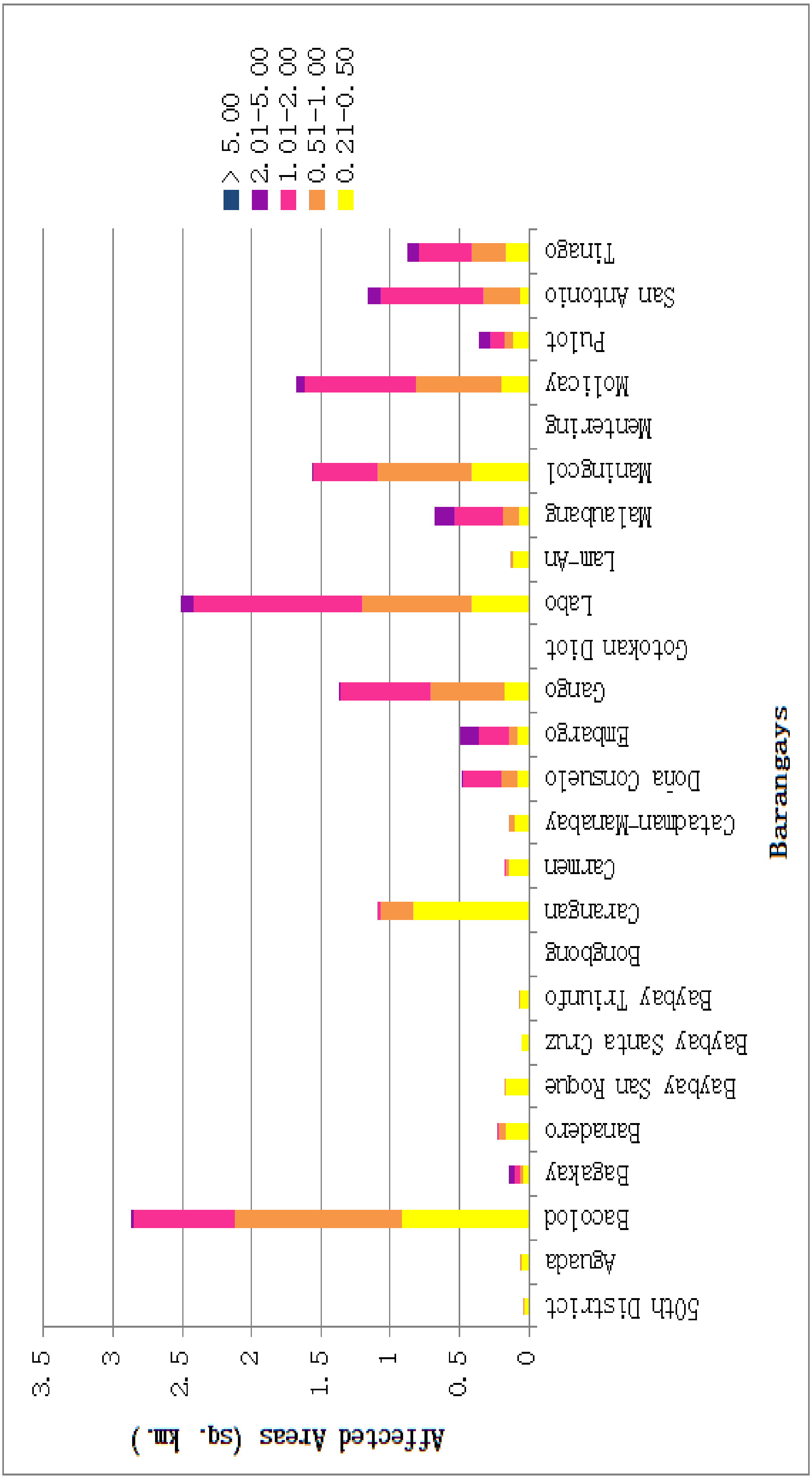


Figure 84. Affected Areas in Ozamiz City, Misamis Occidental during 100-Year Rainfall Return Period

For the municipality of Tudela, with an area of 108.933 sq. km., 1.21% will experience flood levels of less 0.20 meters. 0.10% of the area will experience flood levels of 0.21 to 0.50 meters while 0.15%, 0.28%, and 0.08% 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 45 are the affected areas in square kilometres by flood depth per barangay.

Table 46. Affected Areas in Tudela, Misamis Occidental during 100-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Tudela (in sq. km.)			
	Canibungan Proper	Locso-On	Pan-ay Diot	Yahong
0.03-0.20	0.083	0.46	0.025	0.75
0.21-0.50	0.0011	0.029	0.047	0.03
0.51-1.00	0.0012	0.034	0.096	0.031
1.01-2.00	0.0038	0.098	0.14	0.057
2.01-5.00	0	0.069	0.0001	0.017
> 5.00	0	0	0	0

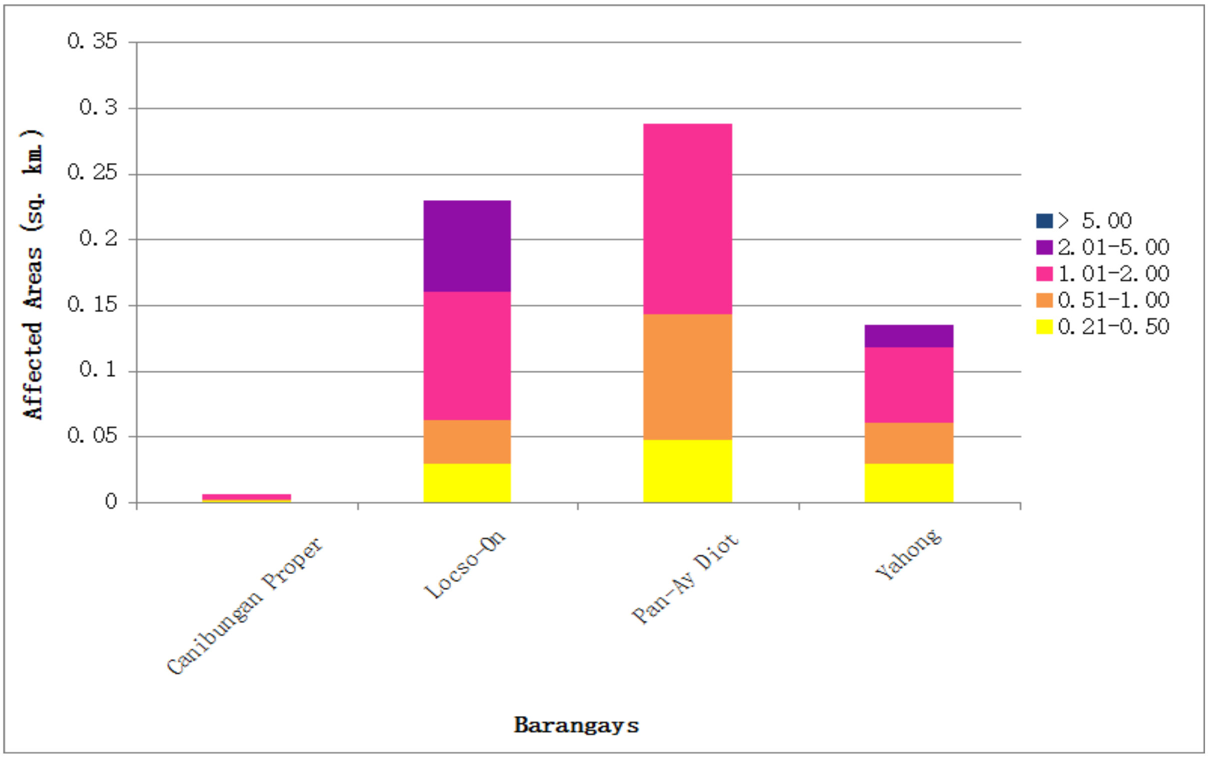


Figure 85. Affected Areas in Tudela, Misamis Occidental during 100-Year Rainfall Return Period

Among the barangays in the municipality of Clarin, Kinangay Sur is projected to have the highest percentage of area that will experience flood levels at 2.65%. Meanwhile, Pan-ay posted the second highest percentage of area that may be affected by flood depths at 2.23%.

Among the barangays in the city of Ozamiz, Bacolod is projected to have the highest percentage of area that will experience flood levels at 2.84%. Meanwhile, Clarin posted the second highest percentage of area that may be affected by flood depths at 1.97%.

Among the barangays in the municipality of Tudela, Yahong is projected to have the highest percentage of area that will experience flood levels of at 0.81%. Meanwhile, Locso-on posted the percentage of area that may be affected by flood depths of at 0.63%.

Moreover, the generated flood hazard maps for the Clarin Floodplain were used to assess the vulnerability of the educational and medical institutions in the floodplain. Using the flood depth units of PAG-ASA for hazard maps - “Low”, “Medium”, and “High” - the affected institutions were given their individual assessment for each Flood Hazard Scenario (5 yr, 25 yr, and 100 yr) shown in Table 47.

Table 47. 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	9.76	7.80	6.80
Medium	13.22	18.48	19.04
High	2.58	5.05	7.91

Of the 114 identified Education Institutions in Clarin Flood plain, 21 schools were assessed to be exposed to the Low level flooding during a 5 year scenario while 30 schools were assessed to be exposed to Medium level flooding and 2 schools were assessed to be exposed to High level flooding in the same scenario.

In the 25 year scenario, 20 schools were assessed to be exposed to the Low level flooding while 41 schools were assessed to be exposed to Medium level flooding and 4 schools were assessed to be exposed to High level flooding in the same scenario.

For the 100 year scenario, 22 school was assessed for Low level flooding and 43 schools for Medium level flooding. In the same scenario, 8 schools were assessed to be exposed to High level flooding. See Appendix D for a detailed enumeration of schools inside Clarin floodplain.

Of the 54 identified Medical Institutions in Clarin Flood plain, 12 were assessed to be exposed to the Low level flooding during a 5 year scenario while 9 were assessed to be exposed to Medium level flooding in the same scenario.

In the 25 year scenario, 10 were assessed to be exposed to the Low level flooding while 15 were assessed to be exposed to Medium level flooding and 1 school were assessed to be exposed to High level flooding in the same scenario.

For the 100 year scenario, 18 schools were assessed for Low level flooding and 16 for Medium level flooding. In the same scenario, 1 was assessed to be exposed to High level flooding. See Appendix E for a detailed enumeration of medical institutions inside Clarin floodplain.

5.11 Flood Validation

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

From the Flood Depth Maps produced by Phil-LiDAR 1 Program, multiple points representing the different flood depths for different scenarios are identified for validation.

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

After which, the actual data from the field will be compared to the simulated data to assess the accuracy of the Flood Depth Maps produced and to improve on what is needed. The points in the flood map versus its corresponding validation depths are shown in Figure 86.

The flood validation consists of 154 points randomly selected all over the Clarin flood plain. It has an RMSE value of 1.62. Table shows a contingency matrix of the comparison.

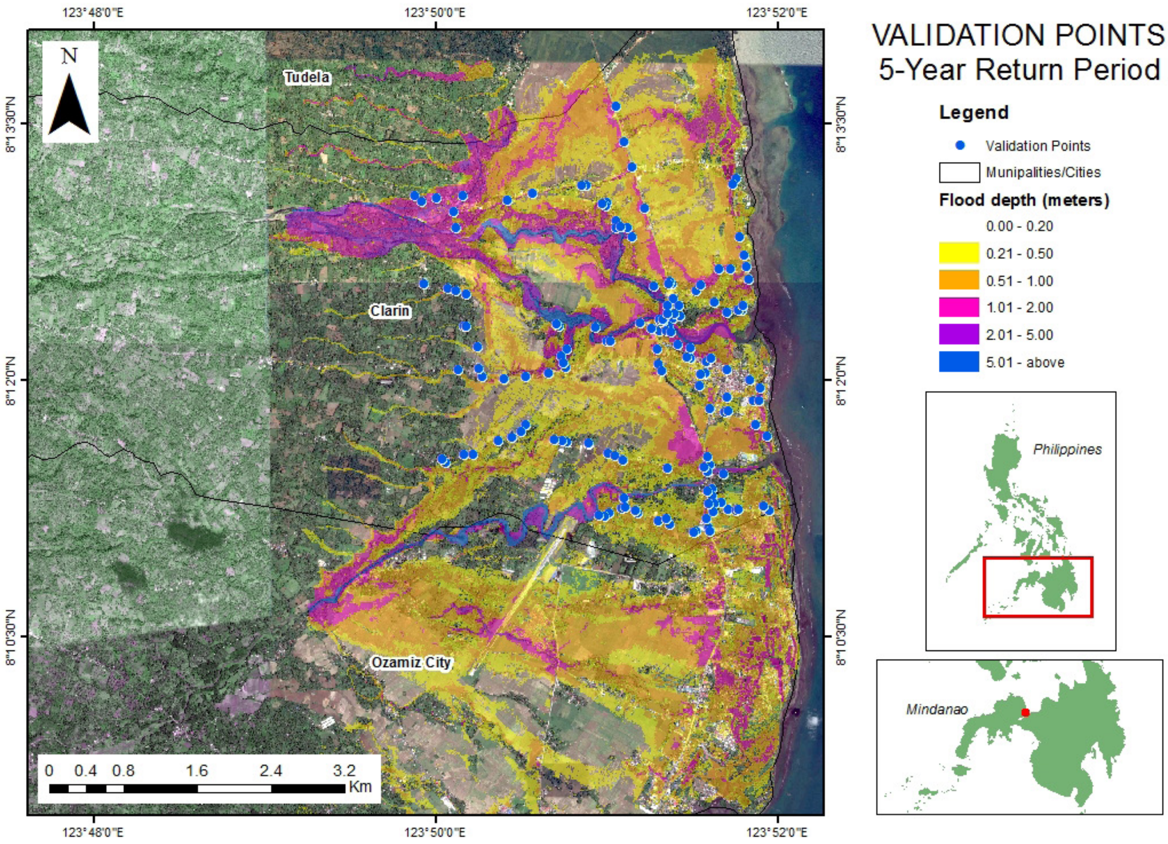


Figure 86. Validation points for 5-year Flood Depth Map of Clarin Floodplain

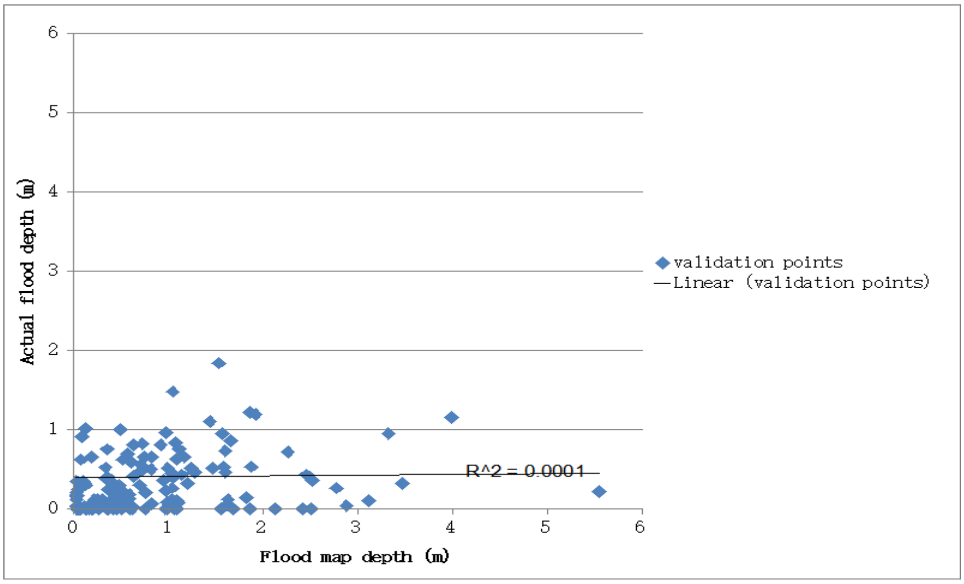


Figure 87. Flood map depth vs actual flood depth

Table 48. Actual Flood Depth vs Simulated Flood Depth in Clarin

CLARIN 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**	34	16	14	12	5	0	81
	0.21-0.50	6	7	8	7	4	1	33
	0.51-1.00	3	3	12	11	2	0	31
	1.01-2.00	1	0	0	5	1	0	7
	2.01-5.00	0	0	0	0	0	0	0
	> 5.00	1	0	0	0	0	0	1
	Total	45	26	34	35	12	1	153

The overall accuracy generated by the flood model is estimated at 37.91%, with 58 points correctly matching the actual flood depths. In addition, there were 45 points estimated one level above and below the correct flood depths while there were 26 points and 24 points estimated two levels above and below, and three or more levels above and below the correct flood. A total of 81 points were overestimated while a total of 14 points were underestimated in the modelled flood depths of Clarin.

Table 49. Summary of Accuracy Assessment in Clarin

	No. of Points	%
Correct	58	**37.91**
Overestimated	81	52.94
Underestimated	14	9.15
Total	153	100

REFERENCES

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

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

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

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

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

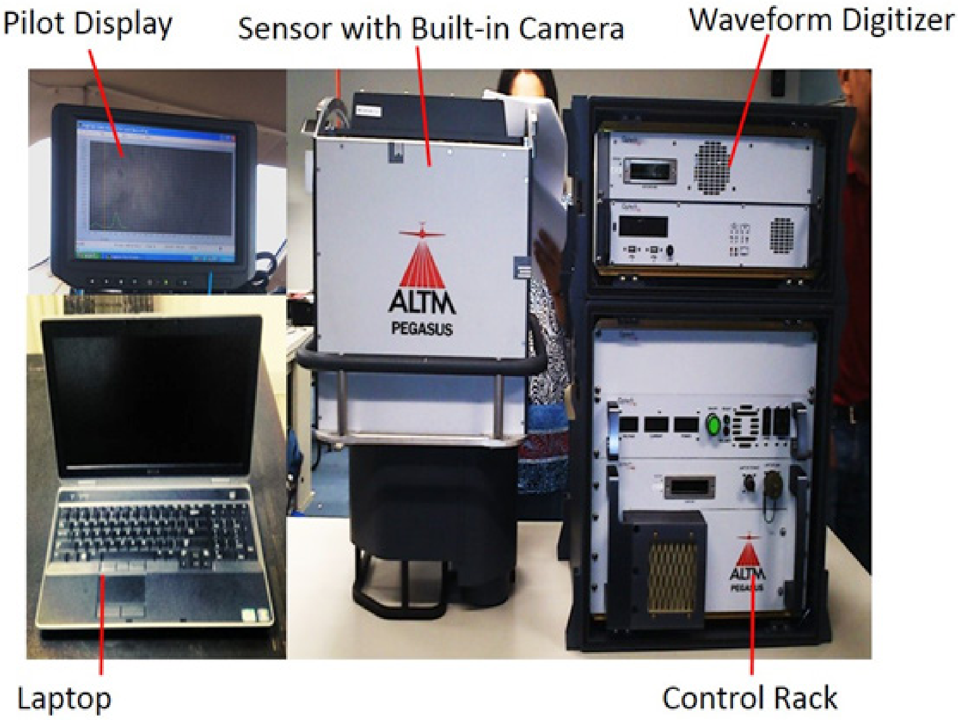
Sarmiento C., Paringit E.C., et al. 2014. *DREAM Data Acquisition Component Manual*. Quezon City, Philippines: UP Training Center for Applied Geodesy and Photogrammetry.

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

ANNEXES

ANNEX A. Technical Specifications of the LiDAR Sensors used in the Clarin Floodplain Survey

Table A-1.1. Technical Specifications of the LiDAR Sensprs used in the Clarin Floodplain Survey



Parameters and Specifications of the OPTECH 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

OPTECH TECHNICAL SPECIFICATION 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 B. NAMRIA Certification of Reference Points Used in the LiDAR Survey

1. 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**	
Island: **MINDANAO**	Order: **1st**	Barangay: **PINOYAK**
Municipality: **LALA**		
	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**

For **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

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

ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

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**	
Island: **MINDANAO**	Order: **2nd**	Barangay: **SAN JOSE**
Municipality: **AURORA**		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**

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

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

ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

3. MSW-11

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: **MISAMIS OCCIDENTAL**	
	Station Name: **MSW-11**	
	Order: **2nd**	
Island: **MINDANAO**	Barangay: **OSPITAL (POB.)**	
Municipality: **ALORAN**	MSL Elevation:	
	PRS92 Coordinates	
Latitude: **8° 24' 49.21851"**	Longitude: **123° 49' 18.84776"**	Ellipsoidal Hgt: **4.39900 m.**
	WGS84 Coordinates	
Latitude: **8° 24' 45.57851"**	Longitude: **123° 49' 24.26581"**	Ellipsoidal Hgt: **70.09500 m.**
	PTM / PRS92 Coordinates	
Northing: **930392.306 m.**	Easting: **590515.033 m.**	Zone: **4**
	UTM / PRS92 Coordinates	
Northing: **930,066.65**	Easting: **590,483.35**	Zone: **51**

Location Description

MSW-11
Is located beside the fence inside Aloran Trade High School compound. It is about 100 m. from the school main bldg. Mark is the head of a 4 in. copper nail embedded on a 30 cm. x 30 cm. concrete block, with inscriptions "MSW-11 2007 NAMRIA".

Requesting Party: **PHIL-LIDAR I**
Purpose: **Reference**
OR Number: **8075910 I**
T.N.: **2014-2582**

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

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

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

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

ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

4. MSW-12

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: **MISAMIS OCCIDENTAL**
Station Name: **MSW-12**
Order: **2nd**

Island: **MINDANAO**	Barangay:	
Municipality: **TUDELA**	MSL Elevation:	
	PRS92 Coordinates	
Latitude: **8° 14' 33.61728"**	Longitude: **123° 50' 41.11353"**	Ellipsoidal Hgt: **5.69800 m.**
	WGS84 Coordinates	
Latitude: **8° 14' 30.02425"**	Longitude: **123° 50' 46.54685"**	Ellipsoidal Hgt: **71.79800 m.**
	PTM / PRS92 Coordinates	
Northing: **911485.567 m.**	Easting: **593072.214 m.**	Zone: **4**
	UTM / PRS92 Coordinates	
Northing: **911,166.53**	Easting: **593,039.64**	Zone: **51**

Location Description

MSW-12
Is located on the open ground in Brgy. Poblacion, Mun. of Tudela. It is situated in the middle of the houses and about 100 m. from the tennis court. Mark is the head of a 4 in. copper nail embedded on a 30 cm. x 30 cm. concrete block, with inscriptions "MSW-12 2007 NAMRIA".

Requesting Party:	**PHIL-LIDAR I**
Purpose:	**Reference**
OR Number:	**8075910 I**
T.N.:	**2014-2583**

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

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

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

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

ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

5. LE-50

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

July 25, 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: **LE-50**	
Island: **Mindanao**	Municipality: **MAIGO**	Barangay: **CLARO M. RECTO**
Elevation: **5.3895 m.**	Order: **1st Order**	Datum: **Mean Sea Level**

Location Description

BM LE-50 is in the Province of Lanao Del Norte, Town of Maigo, Brgy. C.M. Recto, along the Butuan - Zamboanga National Road, and about 50 meters North East of the Covenant Baptist Church. The station is located at the South West end of the Barogohan Bridge footwalk and about 70 meters South West of KM post 1561.

A brass rod is set on a drilled hole and cemented flushed on top of a 15cm x 15cm cement putty with inscription "LE-50, 2007, NAMRIA".

Requesting Party: **UP-TCAGP / Engr. Christopher Cruz**
Purpose: **Reference**
OR Number: **8799582 A**
T.N.: **2014-1723**

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

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

ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

6. MW-85

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: **MISAMIS OCCIDENTAL**
Station Name: **MW-85**

Island: **Mindanao**	Municipality: **OROQUIETA CITY (CAPITAL)**	Barangay:
Elevation: **8.3932 m.**	Order: **1st Order**	Datum: **Mean Sea Level**
Latitude:	Longitude:	

Location Description

MW-85 is in the Province of Misamis Occidental, City of Oroqueta,Brgy. Lutao, along the Oroqueta city-Dipolog city National road.The station is located east -northeast of Lutao Bridge at KM 1744+185 and about 4 m. southeast of the centerline of the road.

Mark is the head of a 4" copper nail set on drilled hole and cemented flushed on top of 15 cm x 15 cm cement putty with inscription "MW-85,2008,NAMRIA".

Requesting Party: **Christopher Cruz**
Purpose: **Reference**
OR Number: **8077396 I**
T.N.: **2014-2986**

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

9 9 1 2 0 9 2 0 1 4 1 0 5 7 3 0

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

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

ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

ANNEX C. Base Processing Reports of Control Points used in the LiDAR Survey

1. MW-62A

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

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
MSW-12 --- MW-62A (B1)	MSW-12	MW-62A	Fixed	0.004	0.019	1°12'09"	7777.102	1.880

Acceptance Summary

Processed	Passed	Flag	Fail
1	1	0	0

Vector Components (Mark to Mark)

From:	MSW-12				
Grid		Local		Global	
Easting	593039.637 m	Latitude	N8°14'33.61728"	Latitude	N8°14'30.02425"
Northing	911166.531 m	Longitude	E123°50'41.11353"	Longitude	E123°50'46.54685"
Elevation	3.251 m	Height	5.698 m	Height	71.798 m

To:	MW-62A				
Grid		Local		Global	
Easting	593186.315 m	Latitude	N8°18'46.72583"	Latitude	N8°18'43.11445"
Northing	918939.972 m	Longitude	E123°50'46.44781"	Longitude	E123°50'51.87475"
Elevation	5.373 m	Height	7.578 m	Height	73.539 m

Vector					
ΔEasting	146.678 m	NS Fwd Azimuth	1°12'09"	ΔX	487.058 m
ΔNorthing	7773.441 m	Ellipsoid Dist.	7777.102 m	ΔY	-1019.004 m
ΔElevation	2.121 m	ΔHeight	1.880 m	ΔZ	7694.655 m

Standard Errors

Vector errors:					
σ ΔEasting	0.002 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.006 m
σ ΔNorthing	0.001 m	σ Ellipsoid Dist.	0.001 m	σ ΔY	0.008 m
σ ΔElevation	0.010 m	σ ΔHeight	0.010 m	σ ΔZ	0.002 m

Aposteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.0000310428		
Y	-0.0000426646	0.0000655996	
Z	-0.0000079883	0.0000114693	0.0000036657

2. MW-85

Project information		Coordinate System	
Name:	C:\Users\Windows User\Documents \Business Center - HCE\MSW 11 - MW 85.vce	Name:	UTM
		Datum:	PRS 92
Size:	394 KB	Zone:	51 North (123E)
Modified:	12/10/2014 6:31:21 PM (UTC:8)	Geoid:	EGMPH
Time zone:	Taipei Standard Time	Vertical datum:	
Reference number:			
Description:			

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
MSW 11 --- MW 85 AM (B1)	MSW 11	MW 85 AM	Fixed	0.004	0.022	340°57'21"	9497.194	-0.079
MSW 11 --- MW 85 PM (B2)	MSW 11	MW 85 PM	Fixed	0.005	0.028	340°57'21"	9497.202	-0.087

Vector Components (Mark to Mark)

From:	MSW 11				
Grid		Local		Global	
Easting	590483.351 m	Latitude	N8°24'49.21851"	Latitude	N8°24'45.57851"
Northing	930066.653 m	Longitude	E123°49'18.84777"	Longitude	E123°49'24.26581"
Elevation	2.616 m	Height	4.400 m	Height	70.095 m

To:	MW 85 AM				
Grid		Local		Global	
Easting	587366.444 m	Latitude	N8°29'41.44871"	Latitude	N8°29'37.78490"
Northing	939034.768 m	Longitude	E123°47'37.52758"	Longitude	E123°47'42.93851"
Elevation	2.812 m	Height	4.320 m	Height	69.779 m

Vector					
ΔEasting	-3116.907 m	NS Fwd Azimuth	340°57'21"	ΔX	3309.807 m
ΔNorthing	8968.115 m	Ellipsoid Dist.	9497.194 m	ΔY	627.878 m
ΔElevation	0.196 m	ΔHeight	-0.079 m	ΔZ	8879.615 m

Standard Errors

Vector errors:					
σ ΔEasting	0.002 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.007 m
σ ΔNorthing	0.001 m	σ Ellipsoid Dist.	0.001 m	σ ΔY	0.009 m
σ ΔElevation	0.011 m	σ ΔHeight	0.011 m	σ ΔZ	0.002 m

Aposteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.0000422712		
Y	-0.0000580578	0.0000865740	
Z	-0.0000102507	0.0000149780	0.0000042223

3. 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:			

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

ANNEX D. The LiDAR Survey Team Composition

Data Acquisition Component Sub-Team	Designation	Name	Agency/ Affiliation
PHIL-LIDAR 1	Program Leader	ENRICO C. PARINGIT, D.ENG	UP-TCAGP
Data Acquisition Component Leader	Data Component Project Leader – I	ENGR. CZAR JAKIRI S. SARMIENTO	UP-TCAGP
Survey Supervisor	Chief Science Research Specialist (CSRS)	ENGR. CHRISTOPHER CRUZ	UP-TCAGP
LiDAR Operation	Senior Science Research Specialist (SSRS)	LOVELY GRACIA ACUNA	UP-TCAGP
LiDAR Operation	Senior Science Research Specialist (SSRS)	ENGR. GEROME HIPOLITO	UP-TCAGP
LiDAR Operation	Senior Science Research Specialist (SSRS)	JASMINE ALVIAR	UP-TCAGP
LiDAR Operation	Senior Science Research Specialist (SSRS)	PAULINE JOANNE ARCEO	UP-TCAGP
LiDAR Operation	Research Associate (RA)	ENGR. RENAN PUNTO	UP-TCAGP
	RA	ENGR. IRO NIEL ROXAS	UP-TCAGP
	RA	ENGR. KENNETH QUISADO	UP-TCAGP
	RA	ENGR. GRACE SINADJAN	UP-TCAGP
	RA	ENGR. GEF SORIANO	UP-TCAGP
	RA	JONATHAN ALMALVEZ	UP-TCAGP
	RA	KRISTINE JOY ANDAYA	UP-TCAGP
Ground Survey	RA	JASMIN DOMINGO	UP-TCAGP
	RA	LANCE CINCO	
LiDAR Operation	Airborne Security	JAYCO MANZANO	PILIPPINE AIR FORCE (PAF)
LiDAR Operation	Airborne Security	LEE JAY PUNZALAN	PILIPPINE AIR FORCE (PAF)
LiDAR Operation	Pilot	CAPT. SHERWIN CESAR ALFONSO	ASIAN AEROSPACE CORPORATION (AAC)
LiDAR Operation	Pilot	CAPT. JOSEPH LIM	AAC
LiDAR Operation	Pilot	CAPT. BRIAN DONGUINES	(AAC)
LiDAR Operation	Pilot	CAPT. FERDINAND DE OCA-MPO	AAC
LiDAR Operation	Pilot	CAPT. JERICO JECIEL	AAC

ANNEX E. Data Transfer Sheet for Clarin Floodplain

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 8/6/14
Position SSRS
Signature

DATA TRANSFER SHEET
11/17/2014(dipolog)

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	
19-Oct	2099P	1BLK99CALIB292A	PEGASUS	106	na	3.84	113	9.11	80	3.84	na	4.08	1KB	1KB	47/23	na	Z:\DAC\RAW DATA
20-Oct	2111P	1BLK69B296A	PEGASUS	2.01	458	12.4	230	28.5	292	22.2	na	7.80	1KB	1KB	28/34/808	na	Z:\DAC\RAW DATA
23-Oct	2113P	1BLK69B298A	PEGASUS	1.62	394	16	216	30.4	260	18.4	na	15.1	1KB	1KB	48/51/44/87	na	Z:\DAC\RAW DATA
23-Oct	2115P	1BLK69/70A298B	PEGASUS	784	171	6.26	195	13.6	115	8.18	na	15.1	1KB	1KB	40/91/26	na	Z:\DAC\RAW DATA
24-Oct	2117P	1BLK69B297A	PEGASUS	1.24	237	6.75	115	19.8	164	12.4	na	7.64	1KB	1KB	48/51/50	na	Z:\DAC\RAW DATA
26-Oct	2125P	1BLK69C299A	PEGASUS	1.8	267	8.41	211	32	239	15.4	na	37.4	1KB	1KB	48/51/50/11 30/49/23	na	Z:\DAC\RAW DATA
28-Oct	2127P	1BLK69/70A299B	PEGASUS	2.54	na	3.91	114	16	1	12.8	na	37.4	1KB	1KB	27/1	na	Z:\DAC\RAW DATA
28-Oct	2133P	1BLK69FE301A	PEGASUS	2.06	394/464	10.2	225	37.8	343	na	na	37.3	1KB	1KB	73/51/01/58	na	Z:\DAC\RAW DATA
28-Oct	2135P	1BLK69F301B	PEGASUS	288	170/167	3.42	64.6	na	na	8.4	na	37.3	1KB	1KB	80	na	Z:\DAC\RAW DATA
29-Oct	2137P	1BLK70D302A	PEGASUS	1.06	453/220	7.37	190	28.3	181	11.2	na	19.4	1KB	1KB	108/103/62/75	na	Z:\DAC\RAW DATA
31-Oct	2145P	1BLK69C304A	PEGASUS	2.33	1118/934	9.11	182	49.6	342	22.8	na	8.52	1KB	1KB	74	na	Z:\DAC\RAW DATA
1-Nov	2149P	1BLK70B306A	PEGASUS	1.79	338	7.38	192	32.1	227	23.3	na	39.2	1KB	1KB	54/79	na	Z:\DAC\RAW DATA
3-Nov	2157P	1BLK70C307A	PEGASUS	2.28	108	11.3	340	40.6	298	28.1	na	35.3	1KB	1KB	30	na	Z:\DAC\RAW DATA
6-Nov	2169P	1BLK73AS10A	PEGASUS	3.01	833	12.1	246	82.8	na	26.9	na	21.3	1KB	1KB	60	na	Z:\DAC\RAW DATA
8-Nov	2177P	1BLK70C312A	PEGASUS	1.75	327	8.80	198	23.1	na	17.6	na	17.0	1KB	1KB	60/60/67	na	Z:\DAC\RAW DATA
9-Nov	2181P	1BLK69F313A	PEGASUS	1.48	221	8.11	192	22.4	182	19.2	na	17	1KB	1KB	60/62/51	na	Z:\DAC\RAW DATA

Received from

Name C. Joaquin
Position RA
Signature

Received by

Name Angelo Carlo Bongat
Position SSRS
Signature 11/19/2014

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\23104P
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\23100P
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\23096P
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\23092P
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\23088P
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\23084P

Received from

Name R. PUNTO
Position RA
Signature

Received by

Name AC Borgat
Position SSRS
Signature 3/1/16

16-14

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

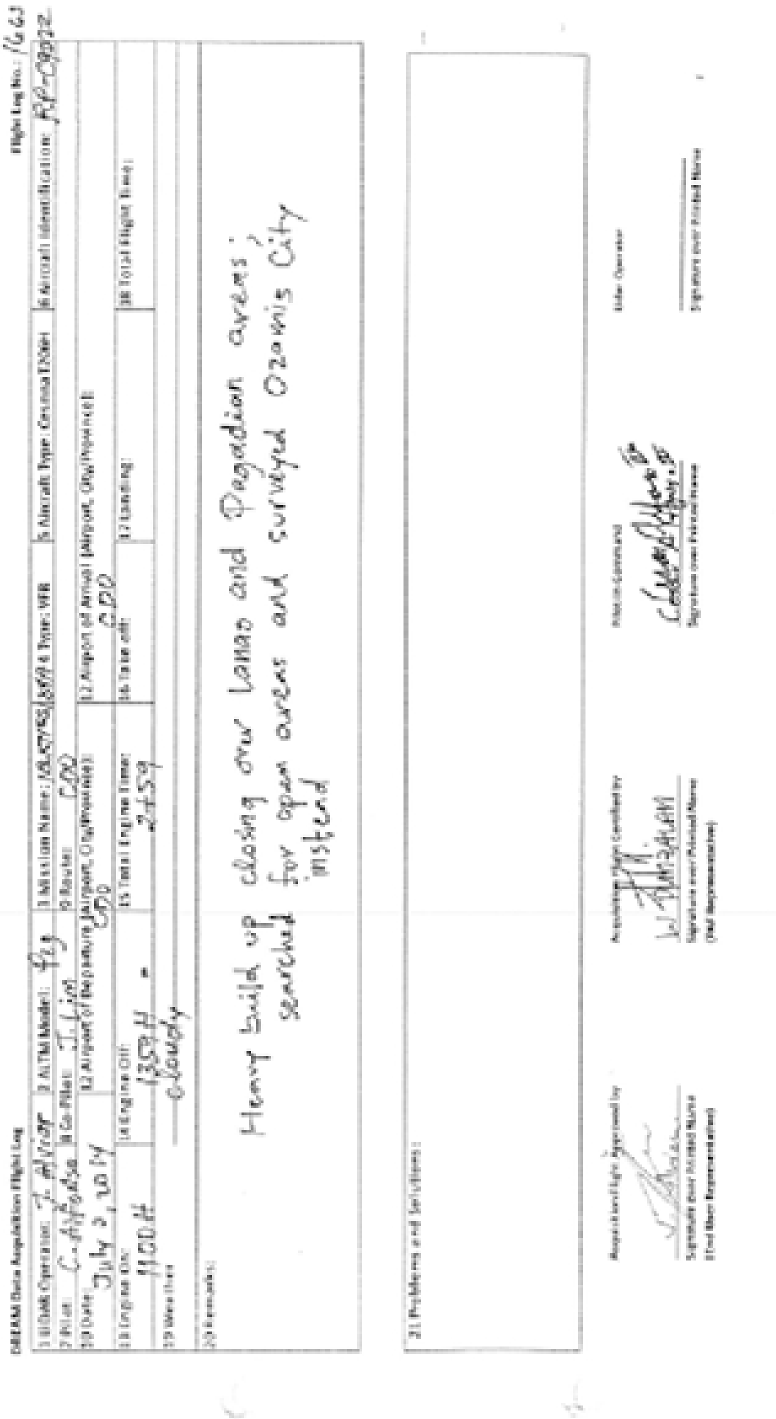
Received by

Name AC Bongat
Position SSRS
Signature 3/10/16

16-17

ANNEX F. Flight Logs for the LFight Missions

1. Flight Log for 1665P Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 1663

1 LiDAR Operator: J. Alviar	2 ALTM Model: Peg	3 Mission Name: 1BLK75S189A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C9022
7 Pilot: C. Alfonso	8 Co-Pilot: J. Lim	9 Route: CDO			
10 Date: July 2, 2014	12 Airport of Departure (Airport, City/Province): CDO		12 Airport of Arrival (Airport, City/Province): CDO		
13 Engine On: 1100H	14 Engine Off: 1359H	15 Total Engine Time: 2+59	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: cloudy					

20 Remarks:

Heavy build up closing over Lanao and Pagadian areas; searched for open areas and surveyed Ozamis City instead

21 Problems and Solutions:

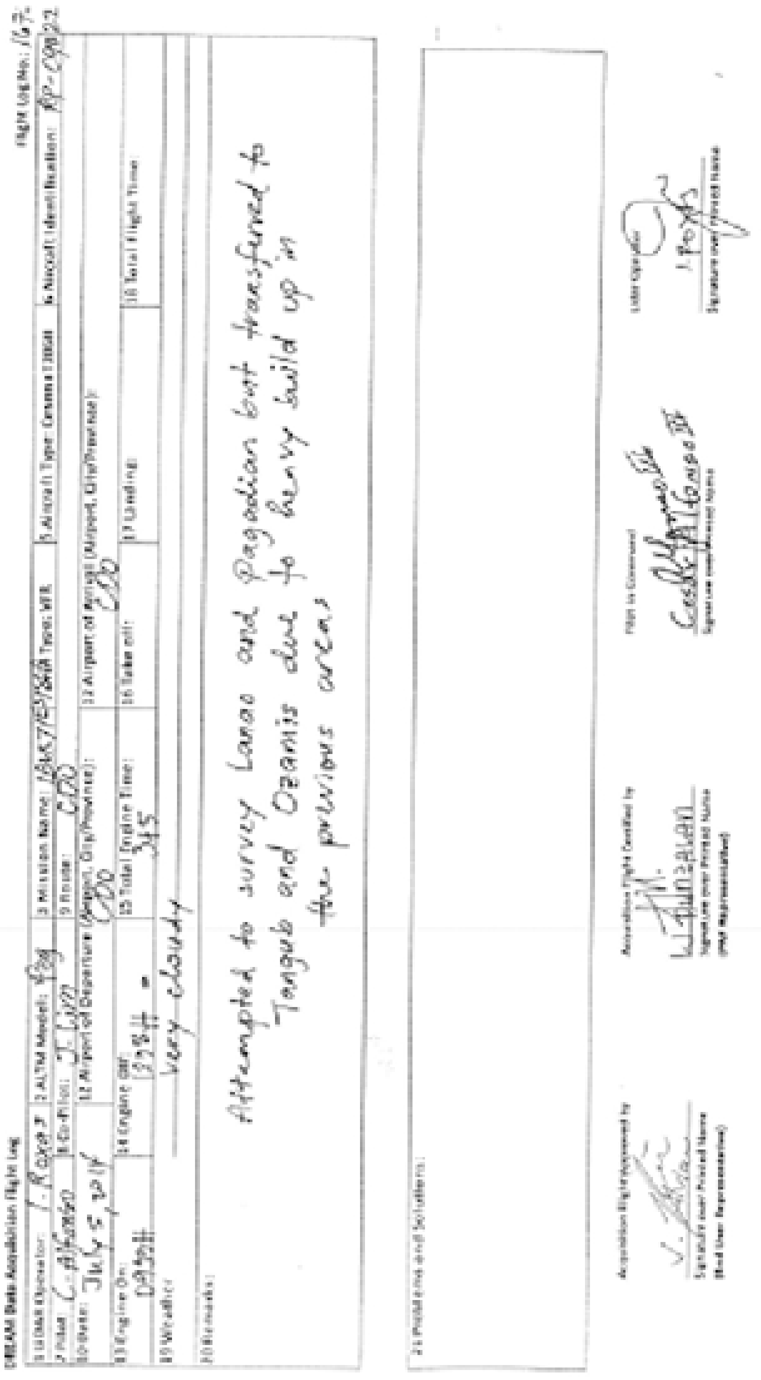
Acquisition Flight Approved by — Signature over Printed Name (End User Representative)

Acquisition Flight Certified by — W. [illegible] — Signature over Printed Name (PAF Representative)

Pilot-in-Command — Signature over Printed Name

Lidar Operator — Signature over Printed Name

2. Flight Log for 1673P Mission


DREAM Data Acquisition Flight Log

Flight Log No.: 167

1 LiDAR Operator: I. Roxas	2 ALTM Model: Peg	3 Mission Name: 1BLK71E186A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C9022
7 Pilot: C. Alfonso	8 Co-Pilot: J. Lim	9 Route: CDO			
10 Date: July 5, 2014	12 Airport of Departure (Airport, City/Province): CDO		12 Airport of Arrival (Airport, City/Province): CDO		
13 Engine On: 0933H	14 Engine Off: 0938H	15 Total Engine Time: 345	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: very cloudy					

20 Remarks:

Attempted to survey Lanao and Pagadian but transferred to Tangub and Ozamis due to heavy build up in the previous areas

21 Problems and Solutions:

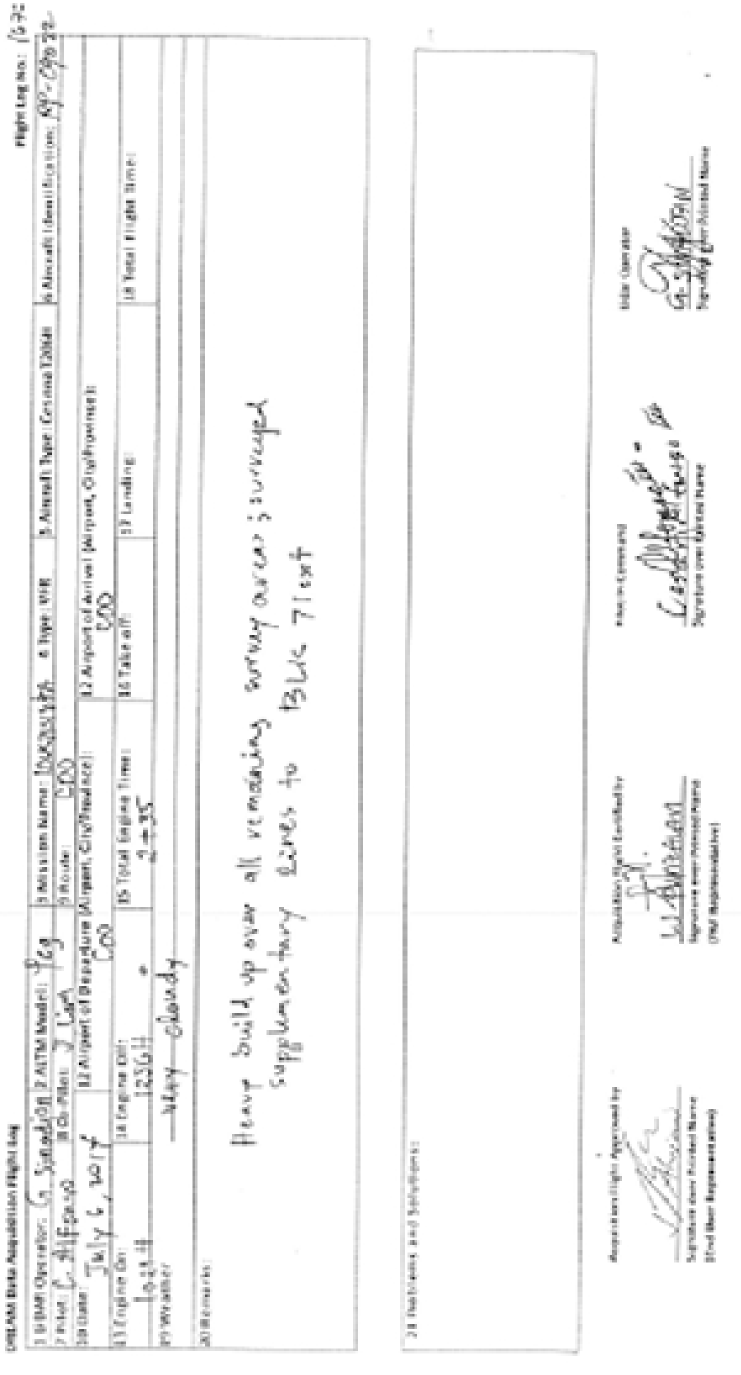
Acquisition Flight Approved by: J. [illegible] — Signature over Printed Name (End User Representative)

Acquisition Flight Certified by: L. Punzalan — Signature over Printed Name (PAF Representative)

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

LiDAR Operator: I. Roxas — Signature over Printed Name

3. 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: [illegible]	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C9022
7 Pilot: C. Alfonso	8 Co-Pilot: J. Lim	9 Route: CDO			
10 Date: July 6, 2017		12 Airport of Departure (Airport, City/Province): CDO		12 Airport of Arrival (Airport, City/Province): CDO	
13 Engine On: 1021H	14 Engine Off: 1256H	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: Signature over Printed Name (End User Representative)

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

Pilot-in-Command: C. Alfonso Signature over Printed Name

Lidar Operator: G. Sinadjan Signature over Printed Name

4. Flight Log for 2133P Mission

Flight Log No.: 2133P

PHIL-LiDAR 1 Data Acquisition Flight Log

1 LiDAR Operator: J. ALVIAR	2 ALTM Model: PEGASUS	3 Mission Name: 1BLK69FE301A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9022
7 Pilot: B. DONGUINES	8 Co-Pilot: F. DE OCAMPO	9 Route:			
10 Date: OCT. 28, 2014	12 Airport of Departure (Airport, City/Province): DIPOLOG		12 Airport of Arrival (Airport, City/Province): DIPOLOG		
13 Engine On: 9:05	14 Engine Off: 12:58	15 Total Engine Time: 3 HRS 53 MINS	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	VERY CLOUDY				

20 Remarks:

SUCCESSFUL FLIGHT.

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	FERDINAND B. DE OCAMPO Signature over Printed Name	Signature over Printed Name

5. Flight Log for 2135P Mission

PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.: 2135P

1 LiDAR Operator: I. ROXAS	2 ALTM Model: PEGASUS	3 Mission Name: 1BLK69PE301B	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9022
7 Pilot: B. DONGUINES	8 Co-Pilot: F. DE OCAMPO	9 Route:			
10 Date: OCT. 28, 2014	12 Airport of Departure (Airport, City/Province): DIPOLOG		12 Airport of Arrival (Airport, City/Province): DIPOLOG		
13 Engine On: 3:29	14 Engine Off: 5:16	15 Total Engine Time: 1 HR. 47 MINS	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: VERY CLOUDY					
20 Remarks: SUCCESSFUL FLIGHT.					

21 Problems and Solutions:

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

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

Pilot-in-Command
FERDINAND B. DEOCAMPO
Signature over Printed Name

Lidar Operator
Signature over Printed Name

6. Flight Log for 2181P Mission

Flight Log No.: 2181P

PHIL-LiDAR 1 Data Acquisition Flight Log

1 LiDAR Operator: I. ROXAS	2 ALTM Model: PEGASUS	3 Mission Name: 1BLK69F313A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9022
7 Pilot: B. DONGUINES	8 Co-Pilot: F. DE OCAMPO	9 Route:			
10 Date: NOV. 9, 2014	12 Airport of Departure (Airport, City/Province): DIPOLOG		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 13 : 15	14 Engine Off: 16 : 24	15 Total Engine Time:	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	cloudy				
20 Remarks: SUCCESSFUL FLIGHT.					

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
J. AHUIAN	JRA Manago	FERDINAND B. DEOCAMPO	I. ROXAS
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

7. Flight Log for 23096P Mission

PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.: 23096P

1 LiDAR Operator: J. Almalvez	2 ALTM Model: Peg	3 Mission Name: 1BLK76N096A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9122
7 Pilot: C. Alfonso III	8 Co-Pilot: J. Jeciel	9 Route:			
10 Date: 15 Feb 16	12 Airport of Departure (Airport, City/Province): Pagadian		12 Airport of Arrival (Airport, City/Province): Pagadian		
13 Engine On: 0758H	14 Engine Off: 1039H	15 Total Engine Time: 2+41	16 Take off: 0803H	17 Landing: 1034H	18 Total Flight Time: 2+31
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

Low clouds and precipitation encountered.
Surveyed 7 lines over BLK 76 N.

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
G. Hipol, Jr.	A1C [illegible] PAF	C. Alfonso III	J. Almalvez	N/A
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name	Signature over Printed Name

8. Flight Log for 23116P Mission

PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.:

1 LiDAR Operator: Jun Almalvez	2 ALTM Model: Pegasus	3 Mission Name: 1BLK76N0051A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RPC 9122
7 Pilot: C. Alfonso	8 Co-Pilot: J. Jeciel	9 Route:			
10 Date: 2/20/2016	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: 8:30	14 Engine Off: 13:05	15 Total Engine Time: 4+35	16 Take off: 8:35	17 Landing: 13:00	18 Total Flight Time: 4+25
19 Weather	Fair				

20 Flight Classification

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

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

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

21 Remarks

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]	LEE JAY PUNZALAN	C. ALFONSO III	Jonathan Almalvez	N/A
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name	Signature over Printed Name

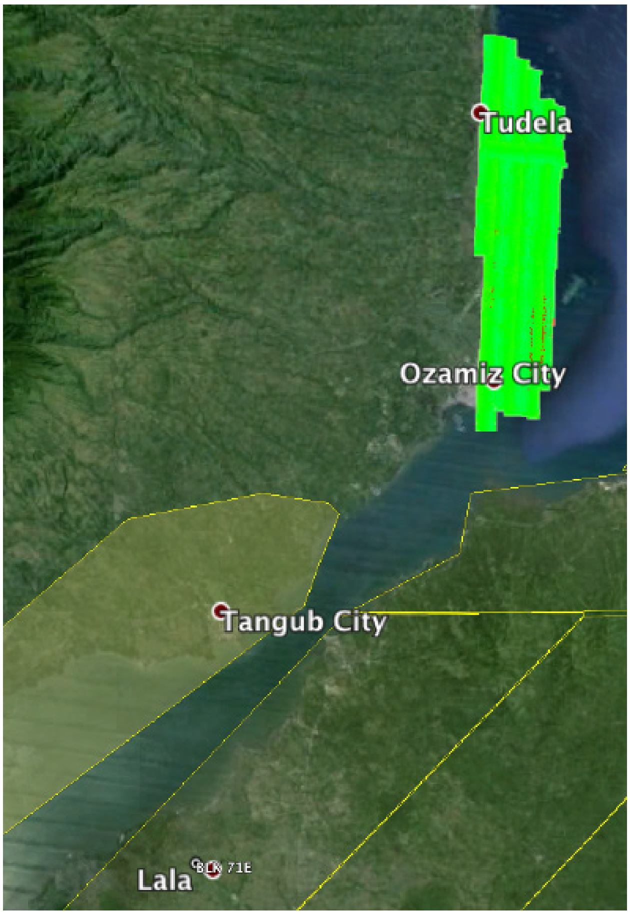
ANNEX F. Flight Status Reports

FLIGHT STATUS REPORT
Northern Mindanao; Dipolog; Pagadian
July 3, 5 and 6 ,2104; October 28 and November 9, 2014; February 15 and 20, 2016

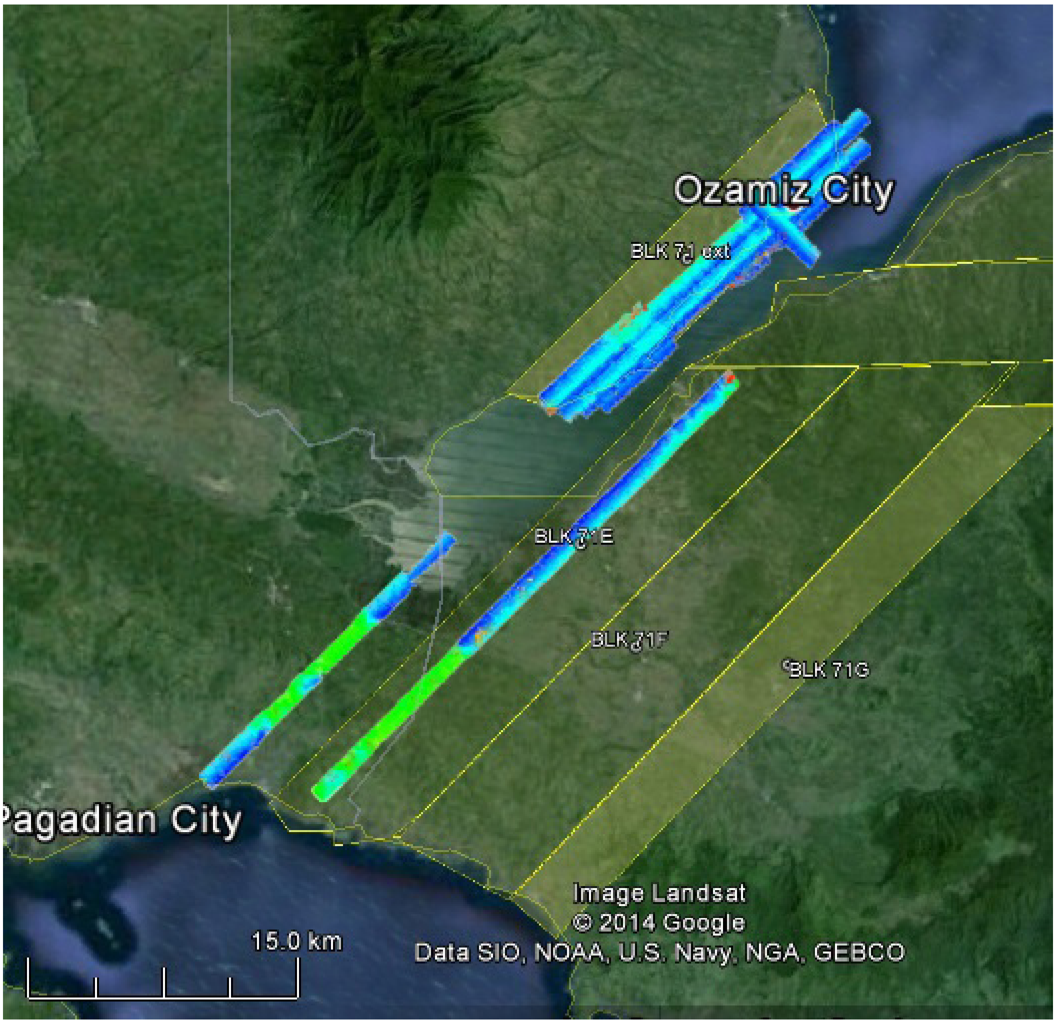
FLIGHT NO	AREA	MISSION	OPERATOR	DATE FLOWN	REMARKS
1665P	BLK 71 ext	1BLK71ES184A	J ALVIAR	JUL 3, 2014	HEAVY BUILD UP CLOSING IS OVER LANAO AND PAGADIAN AREAS; SEARCHED FOR OPEN AREAS AND SURVEYED Ozamiz CITY INSTEAD
1673P	BLK 71 ext	1BLK71ES186A	I ROXAS	JUL 5, 2014	ATTEMPTED TO SURVEY LANAO AND PAGADIAN BUT TRANSFERRED TO TANGUB AND Ozamiz DUE TO HEAVY BUILD UP IN THE PREVIOUS AREAS
1677P	BLK 71 ext	1BLK71S187A	G SINADJAN	JUL 6, 2014	HEAVY BUILD UP OVER ALL REMAINING SURVEY AREAS; SURVEYED SUPPLEMENTARY LINES TO BLK71ext
2133P	BLK 69FE	1BLK69FE301A	J ALVIAR	OCT 28, 2014	SURVEYED BLK 69E AND F, CLOUDY
2135P	BLK 69F	1BLK69F301B	I ROXAS	OCT 28, 2014	SURVEYED BLK 69F; LAS OUTPUT NOT SAVED IN LAS FOLDER
2181P	BLK 69F	1BLK69F313A	I ROXAS	NOV 9, 2014	FILLED GAPS IN BLK 69F
23096	BLK N,O	1BLK76N046A	JM ALMALVEZ	FEB 15, 2016	VERY CLOUDY IN THE SURVEY AREA
23116P	BLK 76 N, O	1BLK76NO051A	J ALMALVEZ	FEB 20, 2016	ENCOUNTERED LOST CHANNEL A .COMPLETED VOIDS OVER OROQUIETA AND Ozamiz CITY

LAS/SWATH BOUNDARIES PER MISSION FLIGHT

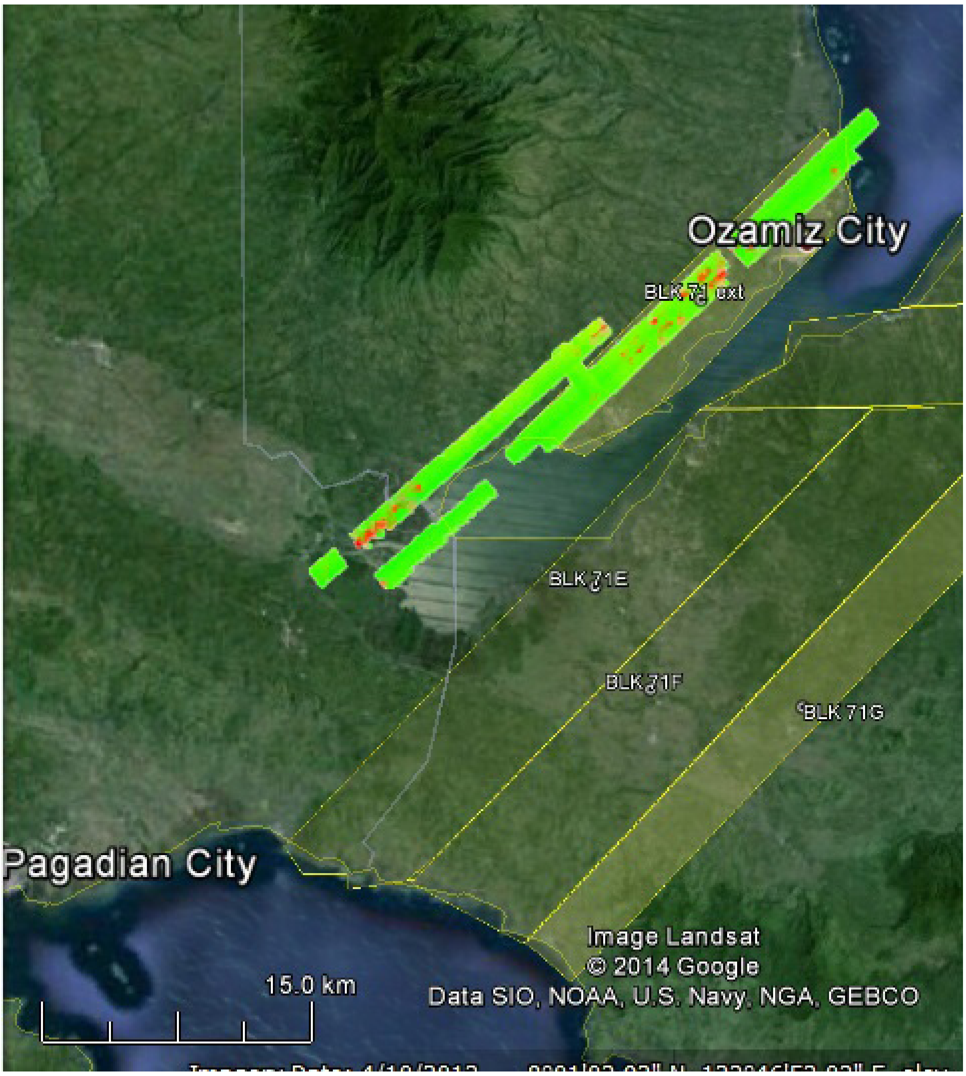
Flight No.: 1665P
Area: BLK 71E
Mission Name: 1BLK71ES184A
Parameters: Alt: 1100m; Scan Frequency: 30; Scan Angle: 50



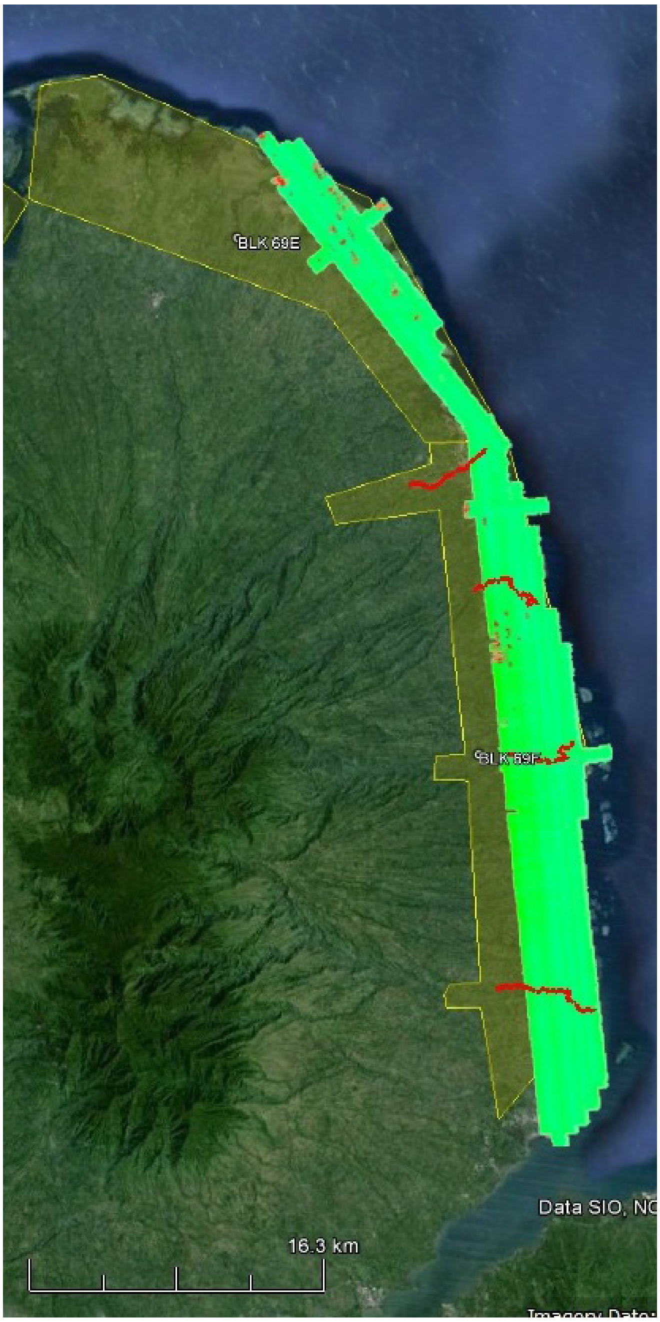
Flight No.:	1673P
Area:	BLK 71 ext
Mission Name:	1BLK71ES186A
Parameters:	Alt: 1000m; Scan Frequency: 30; Scan Angle: 50



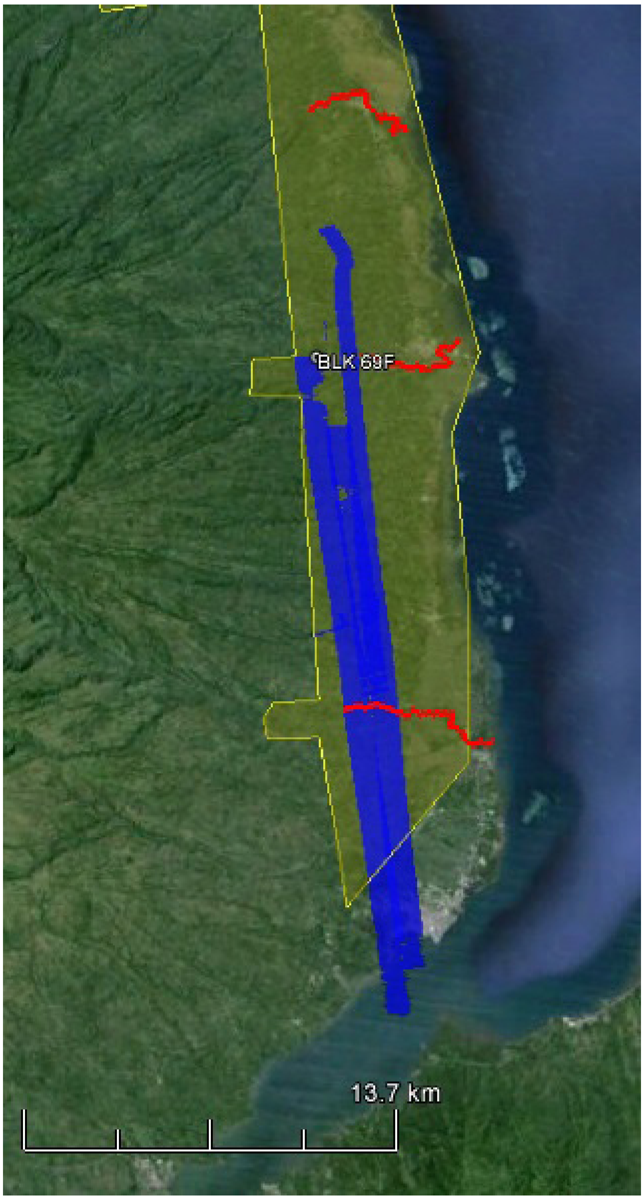
Flight No.: 1677P
Area: BLK 71 ext
Mission Name: 1BLK71S187A
Parameters: Alt: 1000m; Scan Frequency: 30; Scan Angle: 50



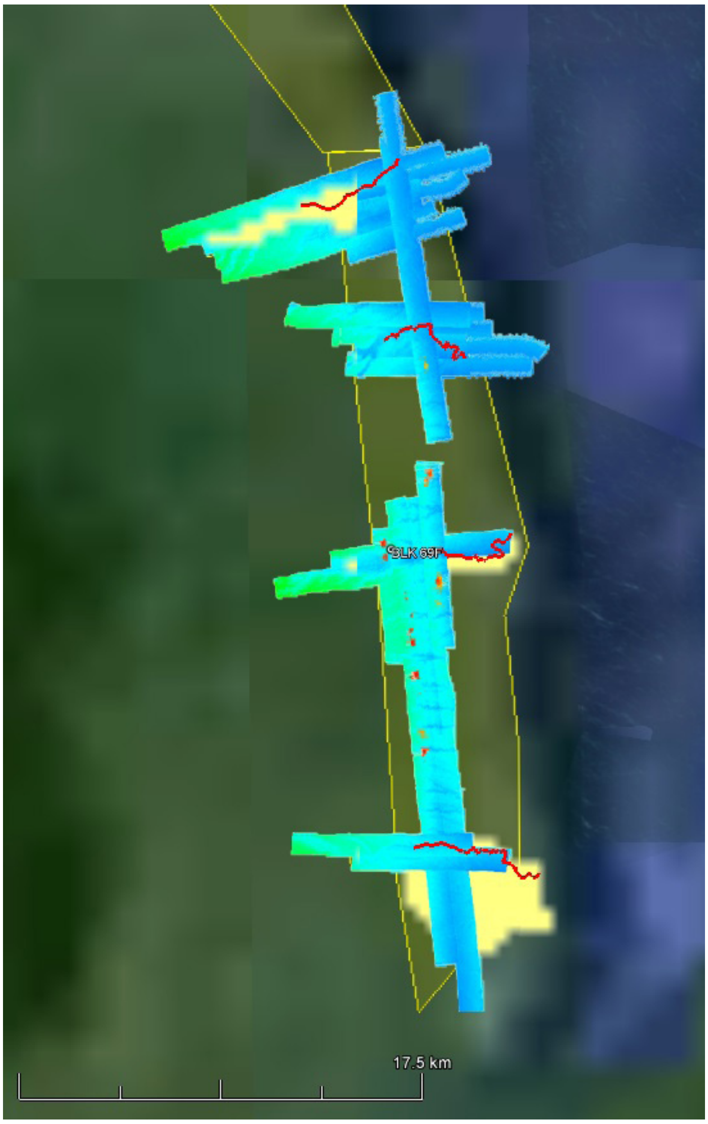
Flight No.:	2133P
Area:	BLK 69FE
Mission Name:	1BLKFE301A
Parameters:	Alt: 800 m; Scan Frequency: 30; Scan Angle: 50



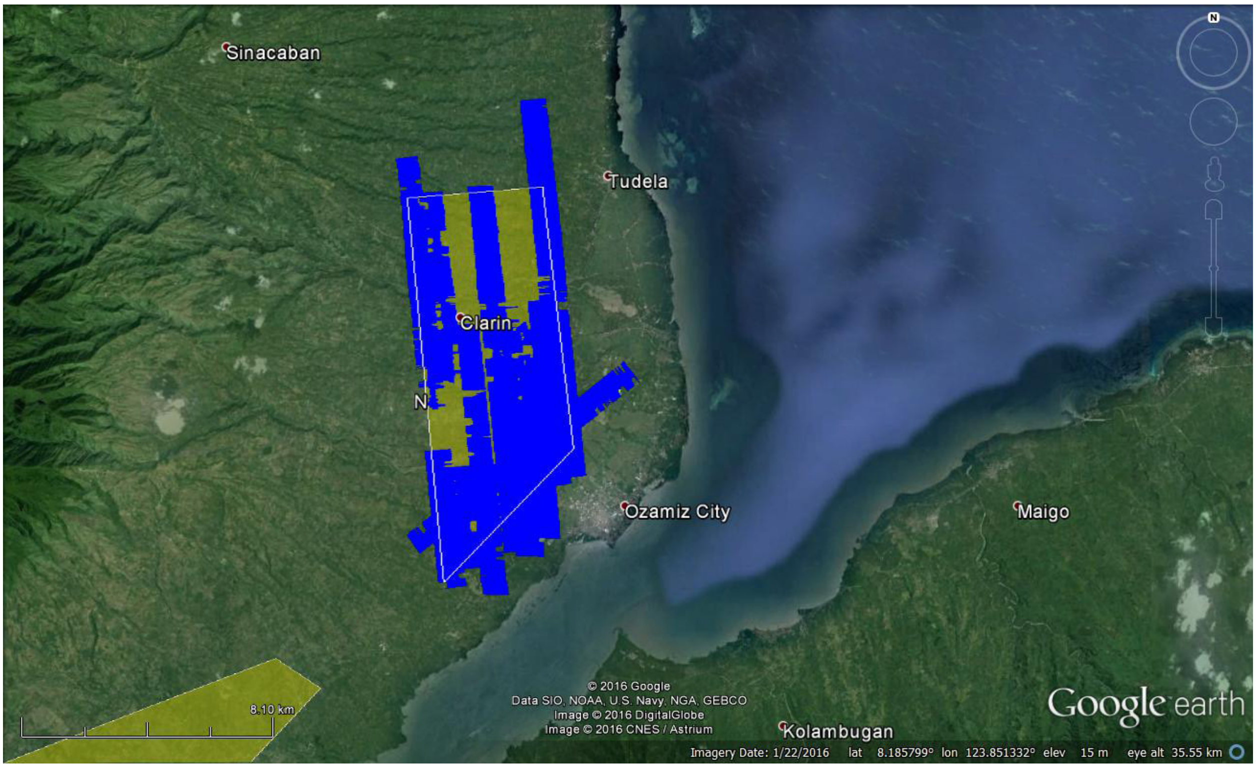
Flight No.:	2135P
Area:	BLK 69F
Mission Name:	1BLK69F301B
Parameters:	Alt: 1000m; Scan Frequency: 30; Scan Angle: 50



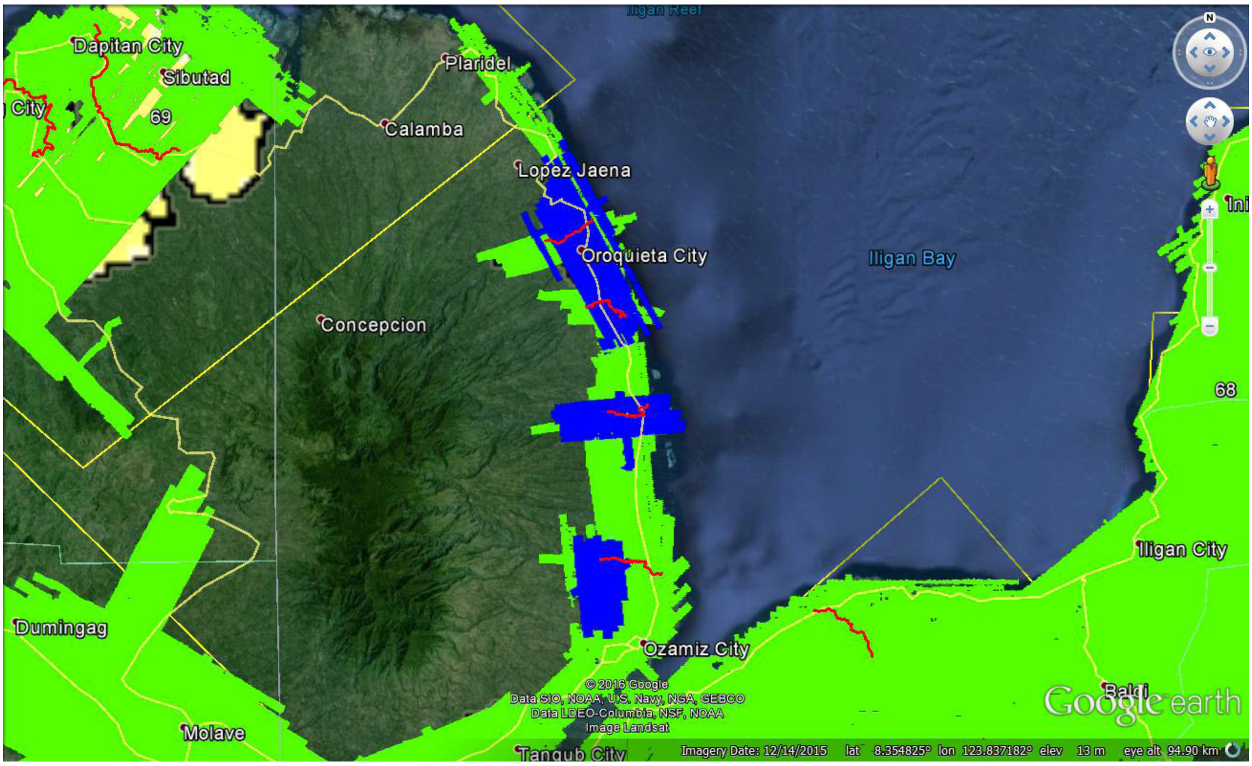
Flight No.:	2181P
Area:	BLK 69F
Mission Name:	1BLK69F313A
Parameters:	Alt: 1000m; Scan Frequency: 30; Scan Angle: 50



Flight No.: 23096
Area: BLK N, O
Mission Name: 1BLK76N046A
Parameters: Alt: 1100m; Scan Frequency: 30; Scan Angle: 50



Flight No.: 23116P
Area: BLK N, O
Mission Name: 1BLK76NO051A
Parameters: Alt: 1000m; Scan Frequency: 30; Scan Angle: 50



ANNEX G. Mission Summary Reports

Flight Area	Pagadian
Mission Name	**Blk 76O**
Inclusive Flights	23096P
Range data size	7.07 GB
POS data size	164.2 MB
Base data size	90.32 MB
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)	1.2
RMSE for East Position (<4.0 cm)	1.7
RMSE for Down Position (<8.0 cm)	3.0
Boresight correction stdev (<0.001deg)	0.000290
IMU attitude correction stdev (<0.001deg)	0.002830
GPS position stdev (<0.01m)	0.0022
Minimum % overlap (>25)	21.83
Ave point cloud density per sq.m. (>2.0)	4.05
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	87
Maximum Height	355.86 m
Minimum Height	67.90 m
Classification (# of points)	
Ground	58,381,992
Low vegetation	43,493,419
Medium vegetation	47,030,745
High vegetation	157,370,432
Building	4,864,208
Orthophoto	Yes
Processed by	Engr. Angelo Carlo Bongat, Engr. Merven Matthew Natino, Engr. Melissa Fernandez

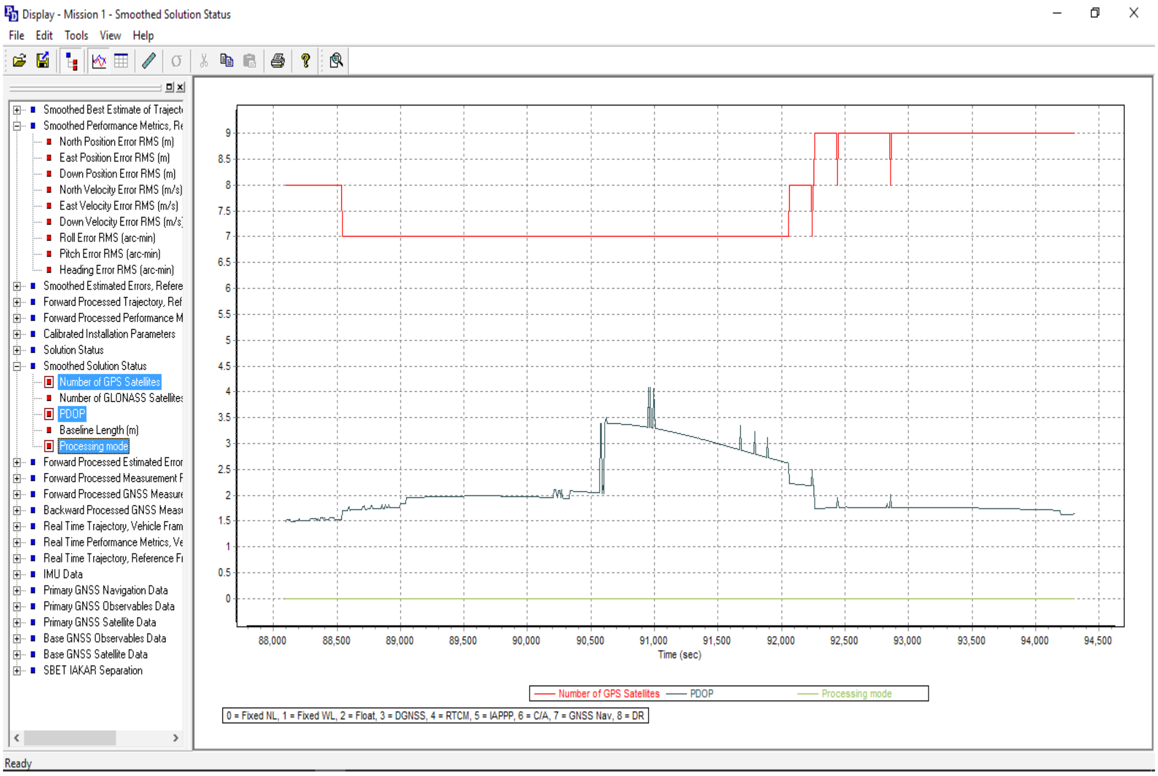


Figure 1.1.1. Solution Status

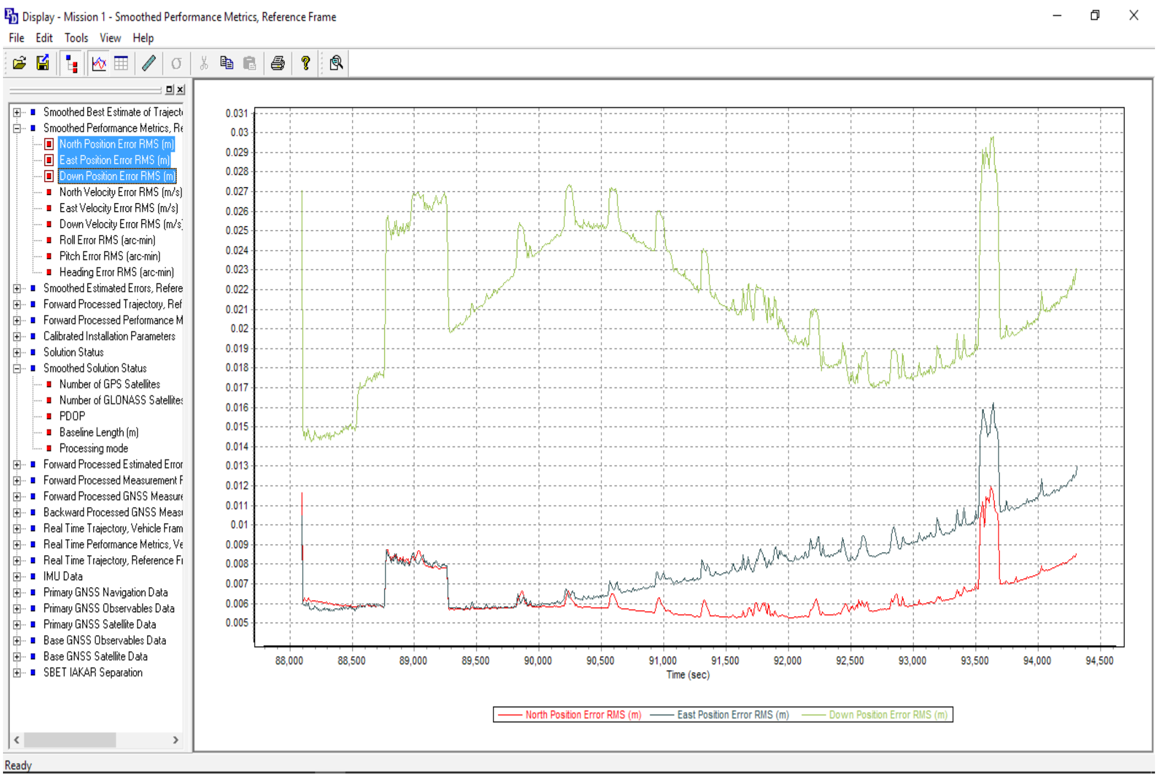


Figure 1.1.2. Smoothed Performance Metric Parameters

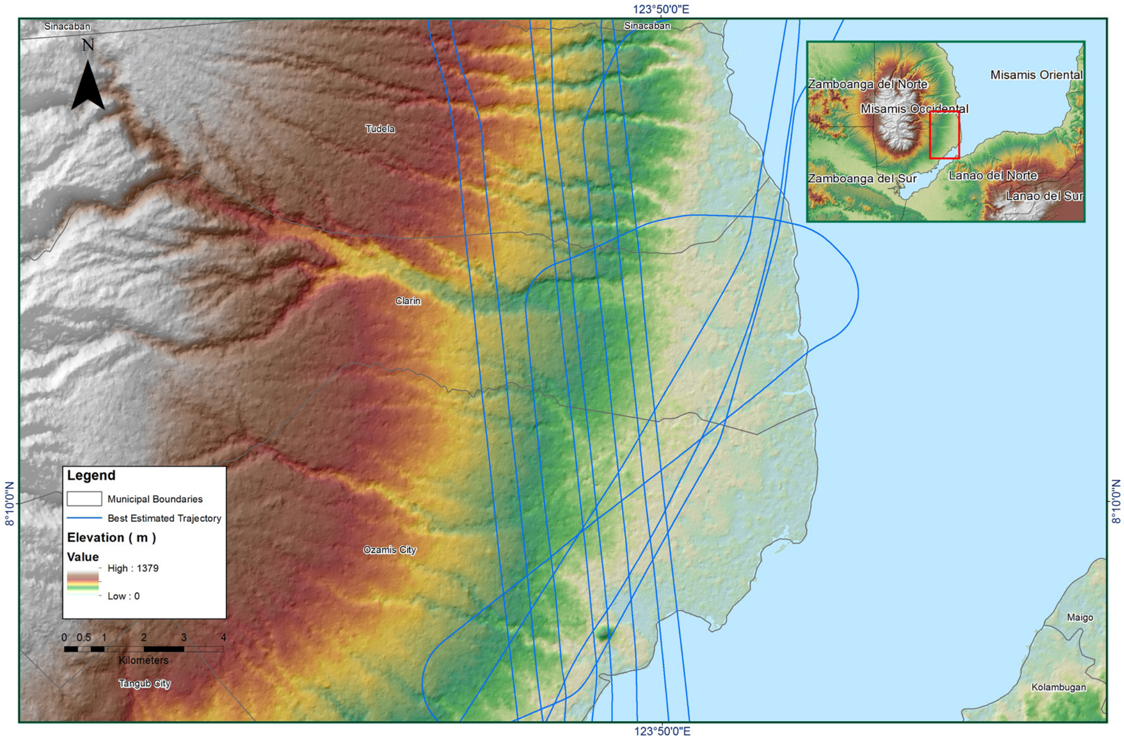


Figure 1.1.3. Best Estimated Trajectory

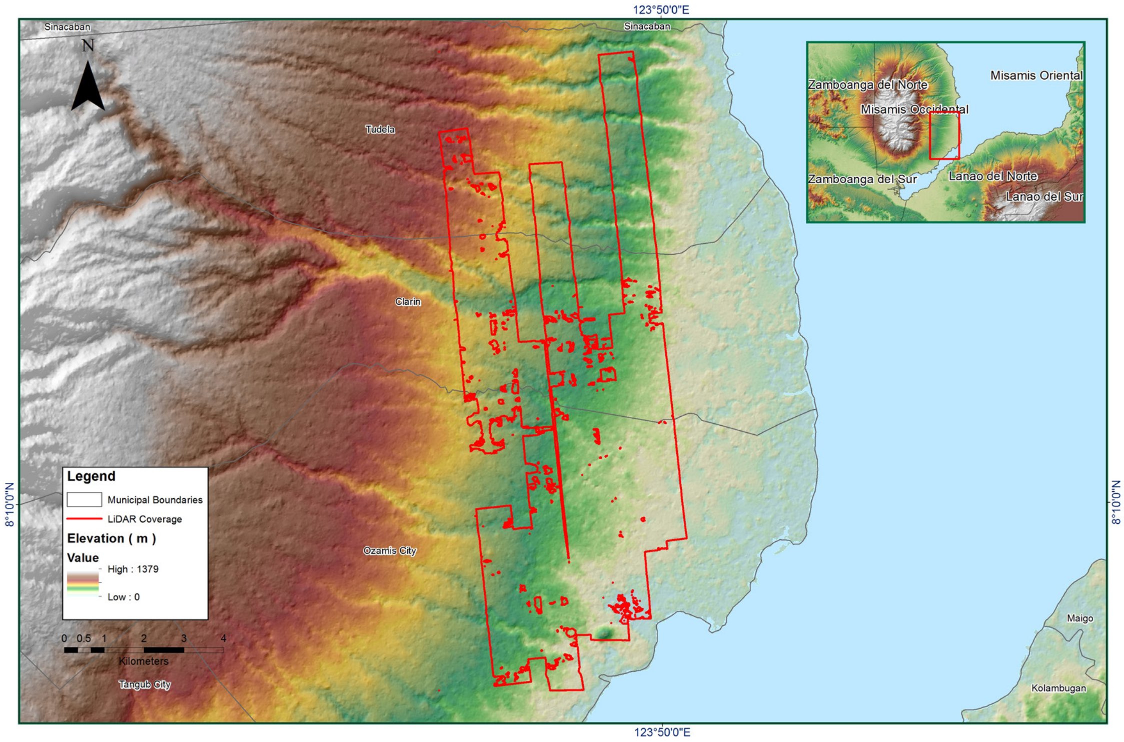


Figure 1.1.4. Coverage of LiDAR Data

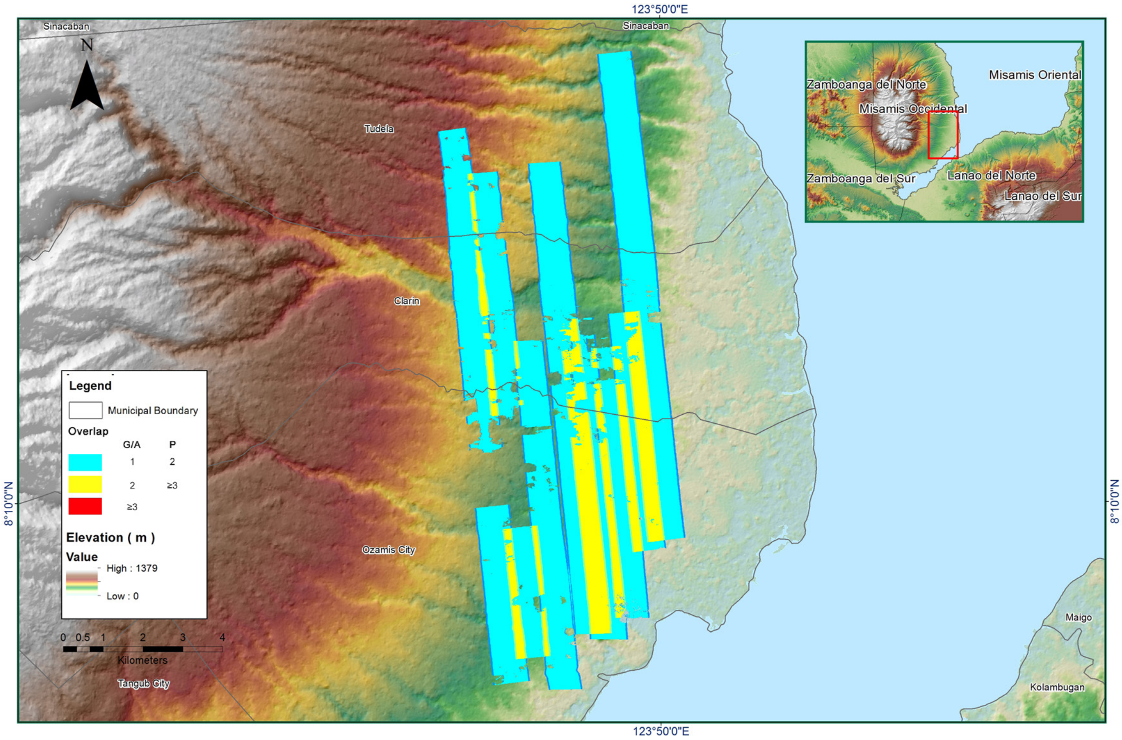


Figure 1.1.5. Image of data overlap

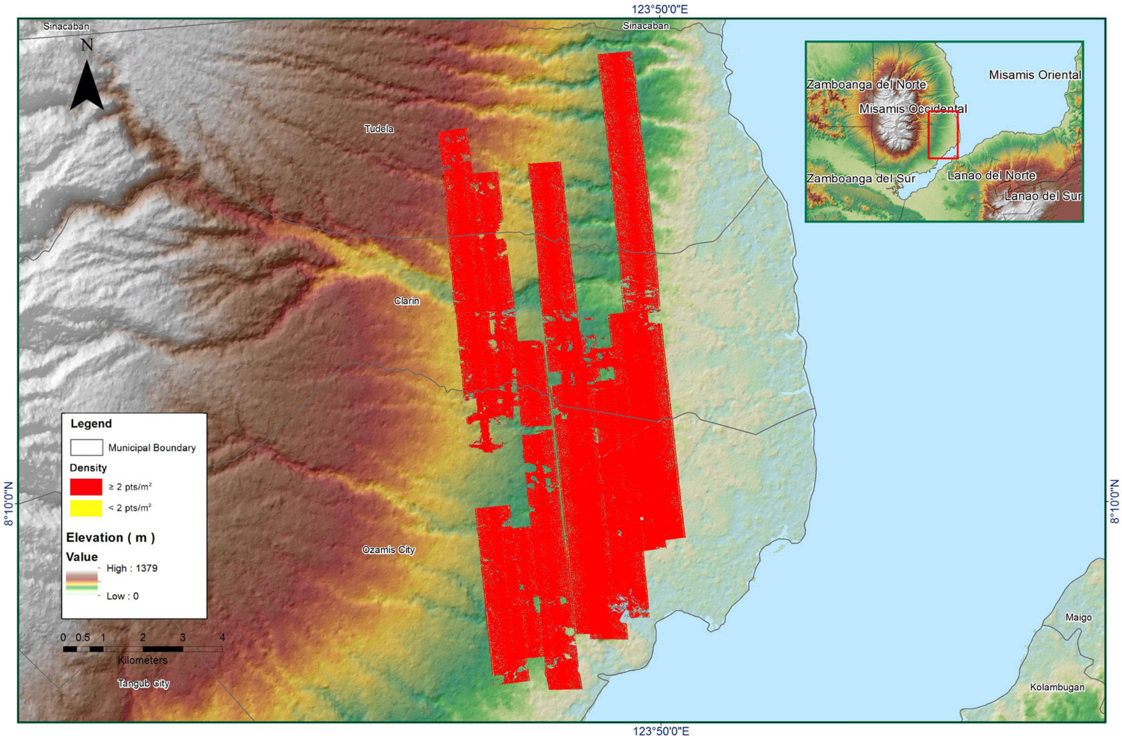


Figure 1.1.6. Density map of merged LiDAR data

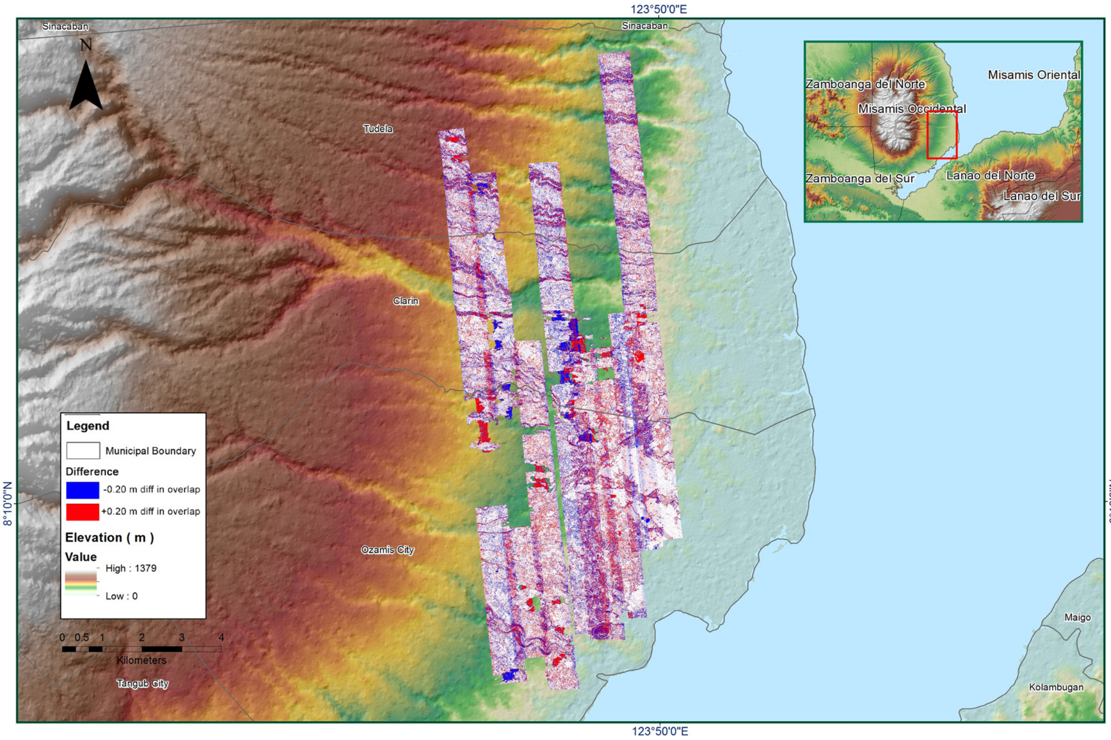


Figure 1.1.7. Elevation difference between flight lines

Flight Area	**Pagadian**
Mission Name	**Blk 76O_Supplement**
Inclusive Flights	23116P
Range data size	24.4 GB
POS data size	294 MB
Base data size	63.8 MB
Image	n/a
Transfer date	March 10, 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)	1.2
RMSE for East Position (<4.0 cm)	1.0
RMSE for Down Position (<8.0 cm)	3.5
Boresight correction stdev (<0.001deg)	0.000269
IMU attitude correction stdev (<0.001deg)	0.000354
GPS position stdev (<0.01m)	0.0009
Minimum % overlap (>25)	40.81
Ave point cloud density per sq.m. (>2.0)	4.53
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	50
Maximum Height	285.79 m
Minimum Height	73.96 m
Classification (# of points)	
Ground	50,283,577
Low vegetation	45,189,706
Medium vegetation	43,272,105
High vegetation	148,620,455
Building	3,336,066
Orthophoto	No
Processed by	Engr. Shiela-Maye Santillan, Aljon Rae Araneta, Marie Denise Bueno

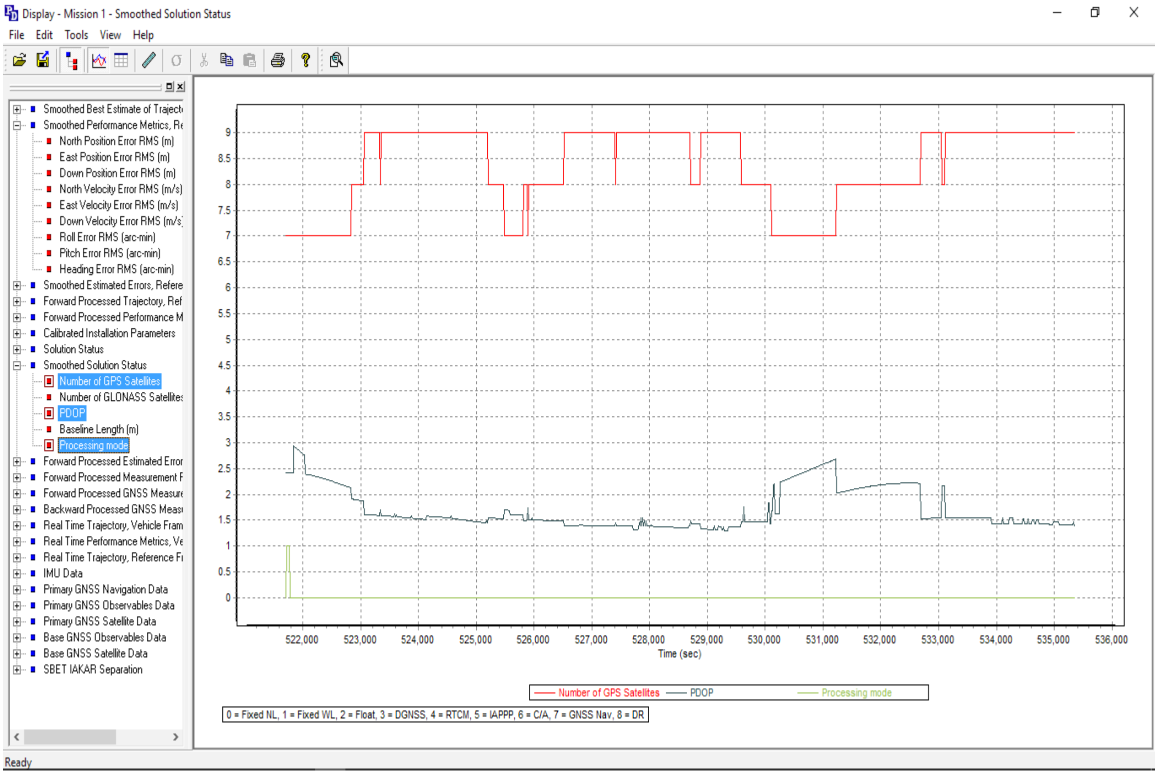


Figure 1.2.1. Solution Status

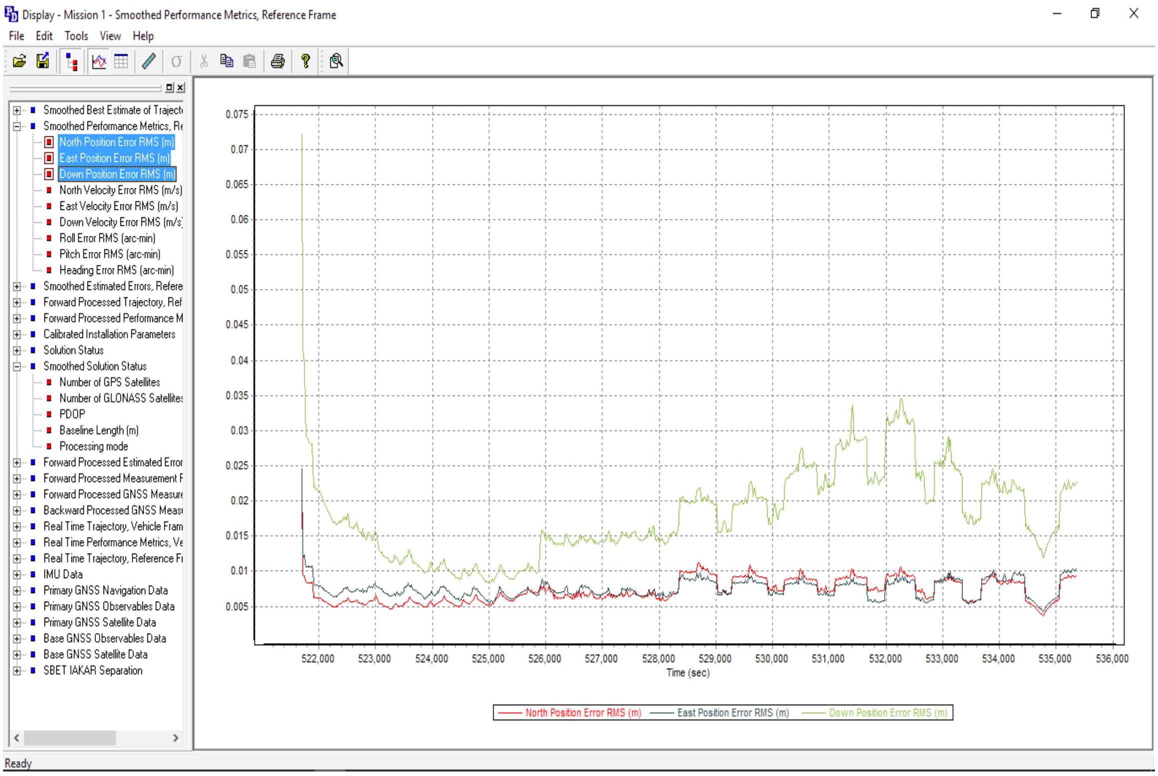


Figure 1.2.2. Smoothed Performance Metric Parameters

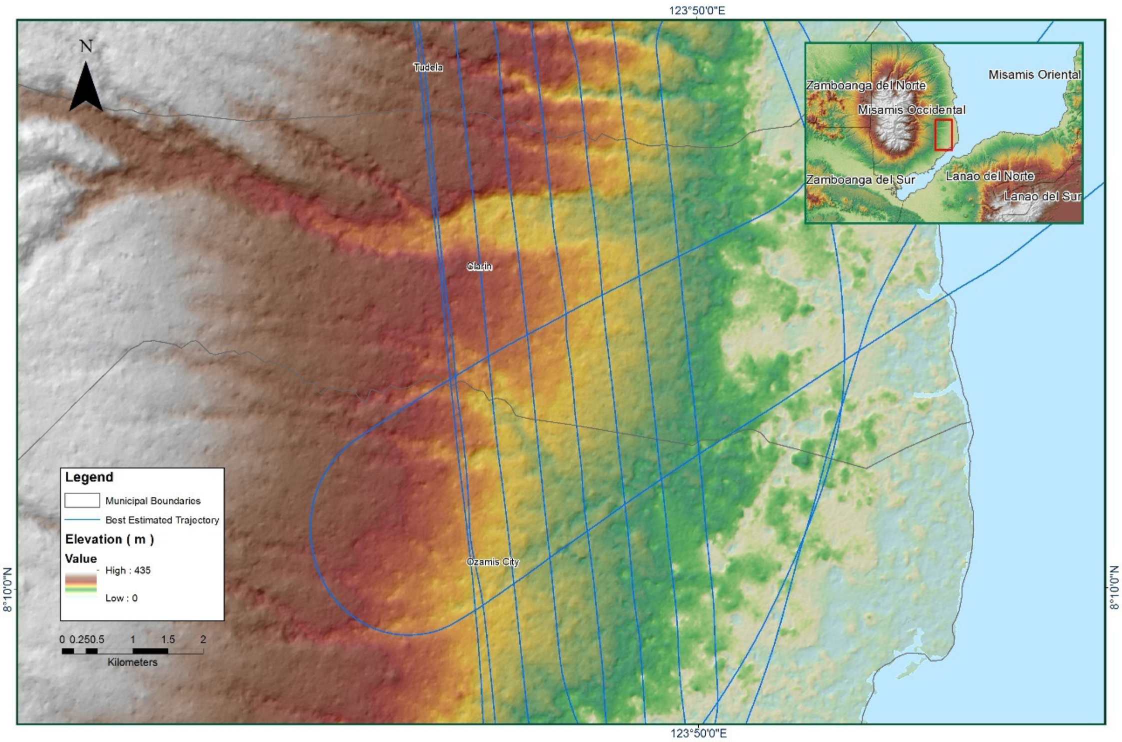


Figure 1.2.3. Best Estimated Trajectory

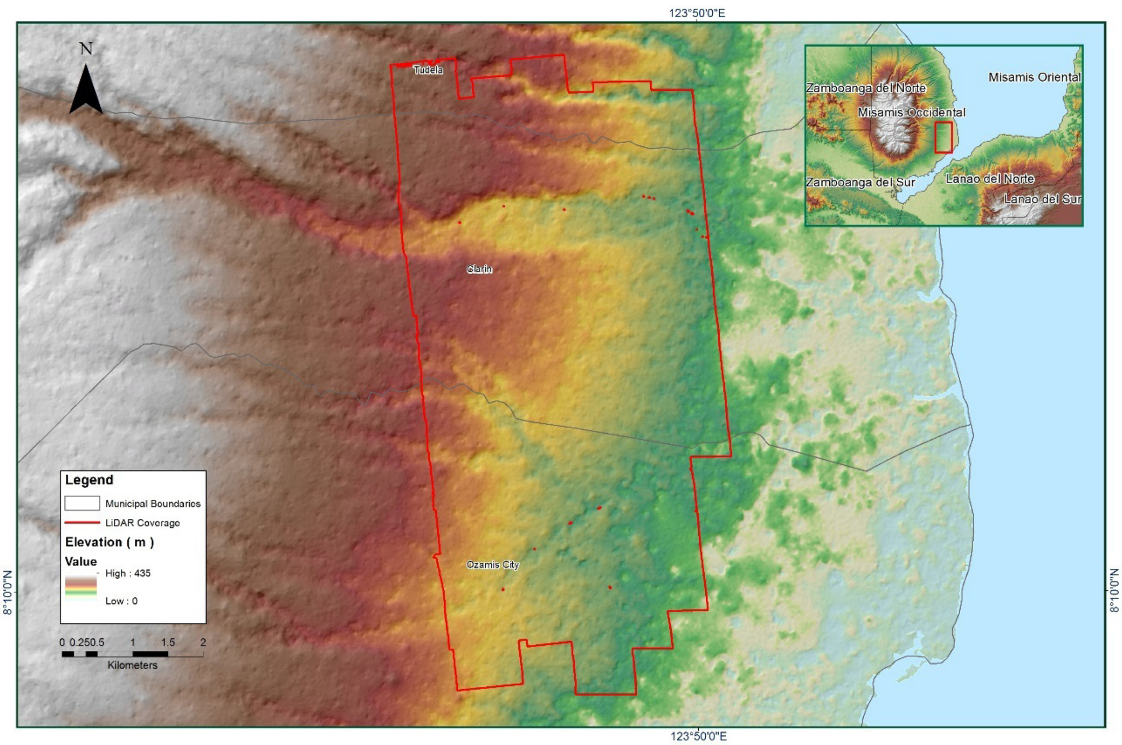


Figure 1.2.4. Coverage of LiDAR Data

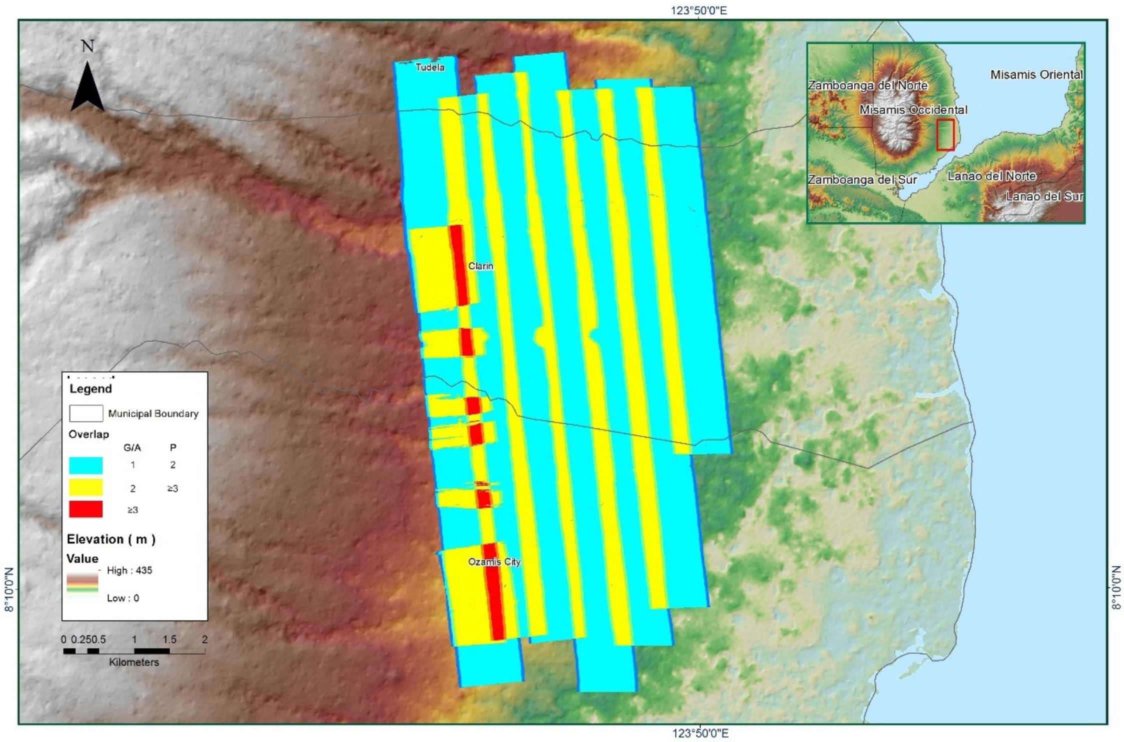


Figure 1.2.5. Image of data overlap

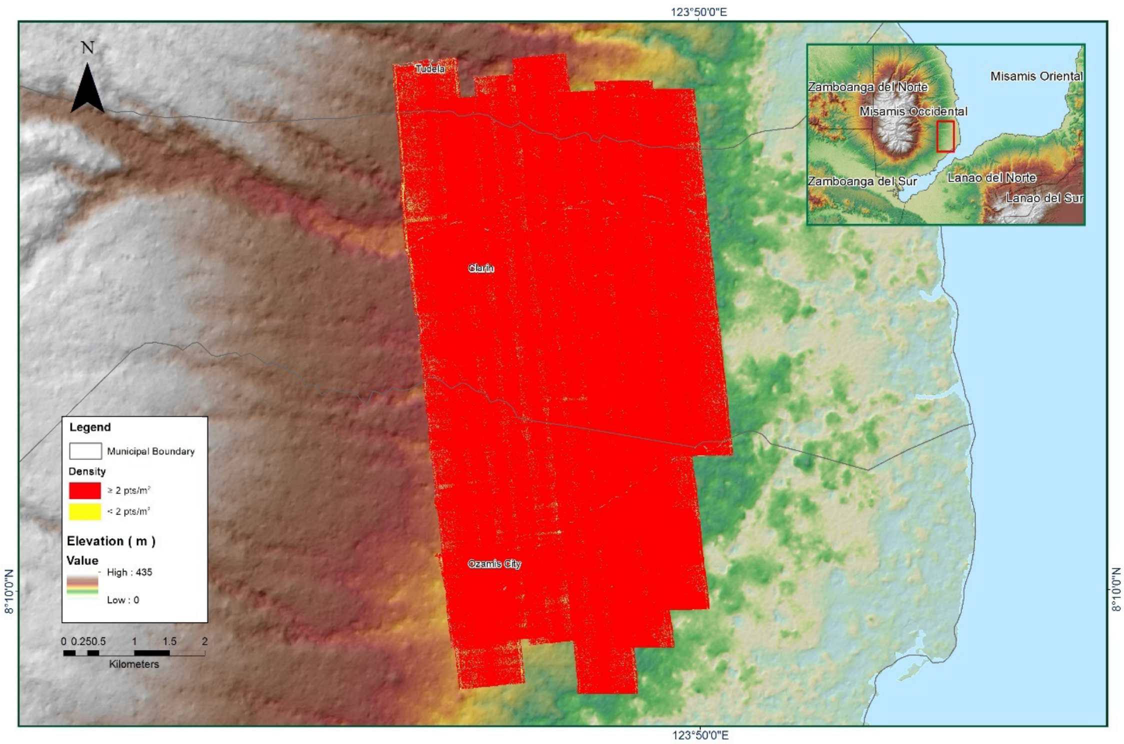


Figure 1.2.6. Density map of merged LiDAR data

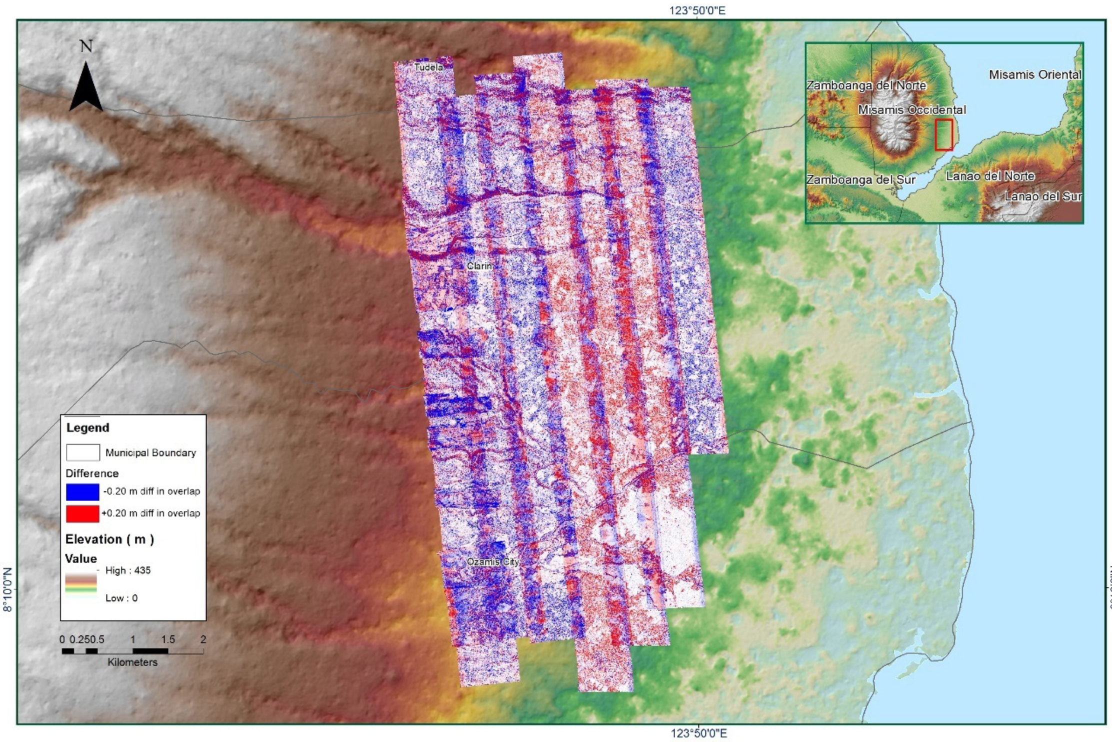


Figure 1.2.7. Elevation difference between flight lines

Flight Area	Dipolog
Mission Name	Blk69F
Inclusive Flights	2133P,2135P,2181P
Range data size	43.4 GB
POS	501.6 MB
Image	79.8 GB
Transfer date	November 19, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.16
RMSE for East Position (<4.0 cm)	1.04
RMSE for Down Position (<8.0 cm)	1.85
Boresight correction stdev (<0.001deg)	0.000253
IMU attitude correction stdev (<0.001deg)	0.001628
GPS position stdev (<0.01m)	0.0059
Minimum % overlap (>25)	46.32%
Ave point cloud density per sq.m. (>2.0)	4.58
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	308
Maximum Height	420.83 m
Minimum Height	53.91 m
Classification (# of points)	
Ground	252,809,434
Low vegetation	288,314,909
Medium vegetation	302,935,924
High vegetation	361,519,536
Building	32,102,903
Orthophoto	Yes

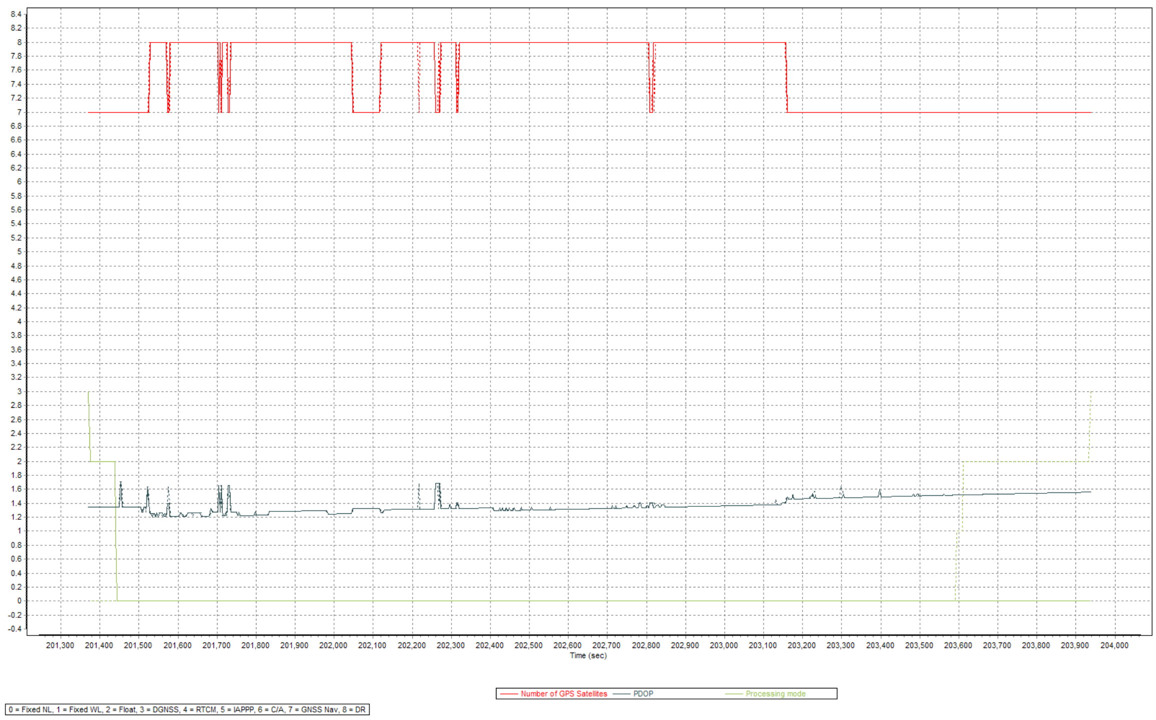


Figure 1.3.1 Solution Status

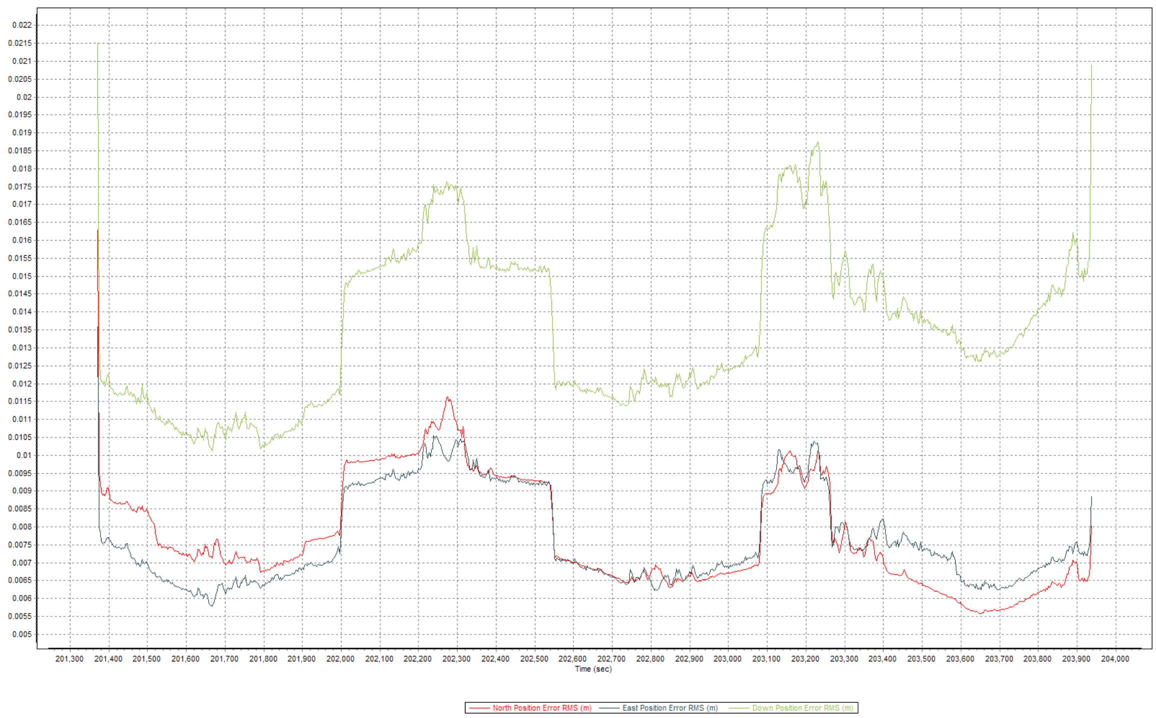


Figure 1.3.2 Smoothed Performance Metric Parameters

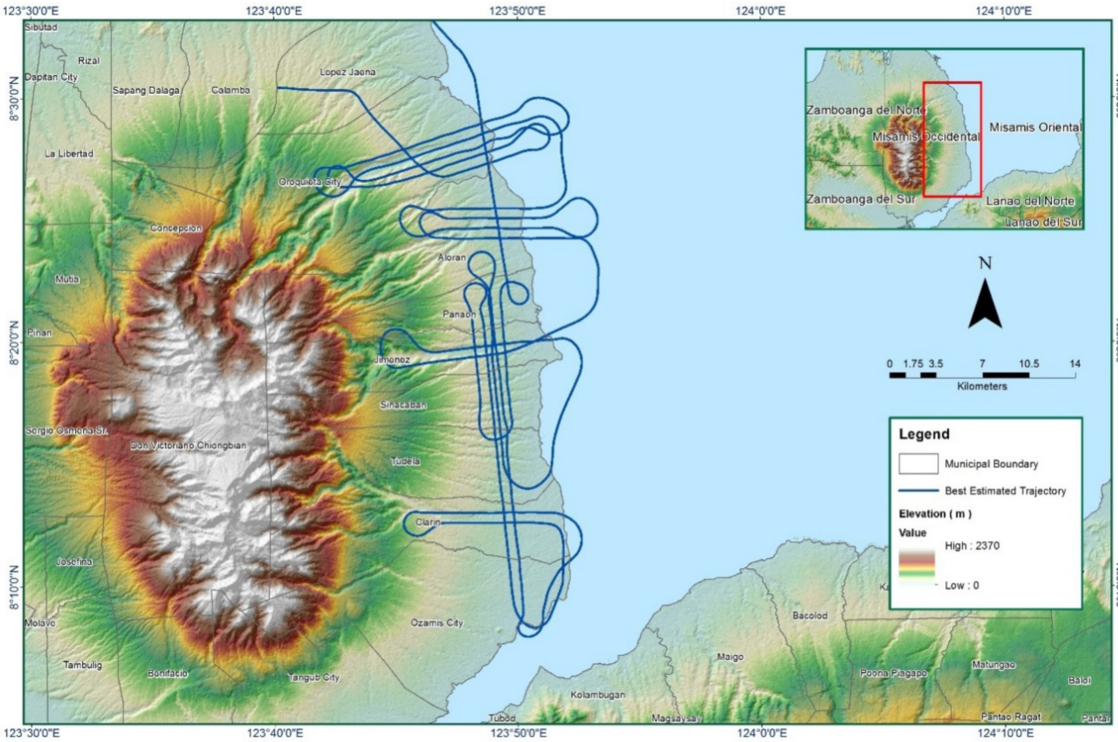


Figure 1.3.3 Best Estimated Trajectory

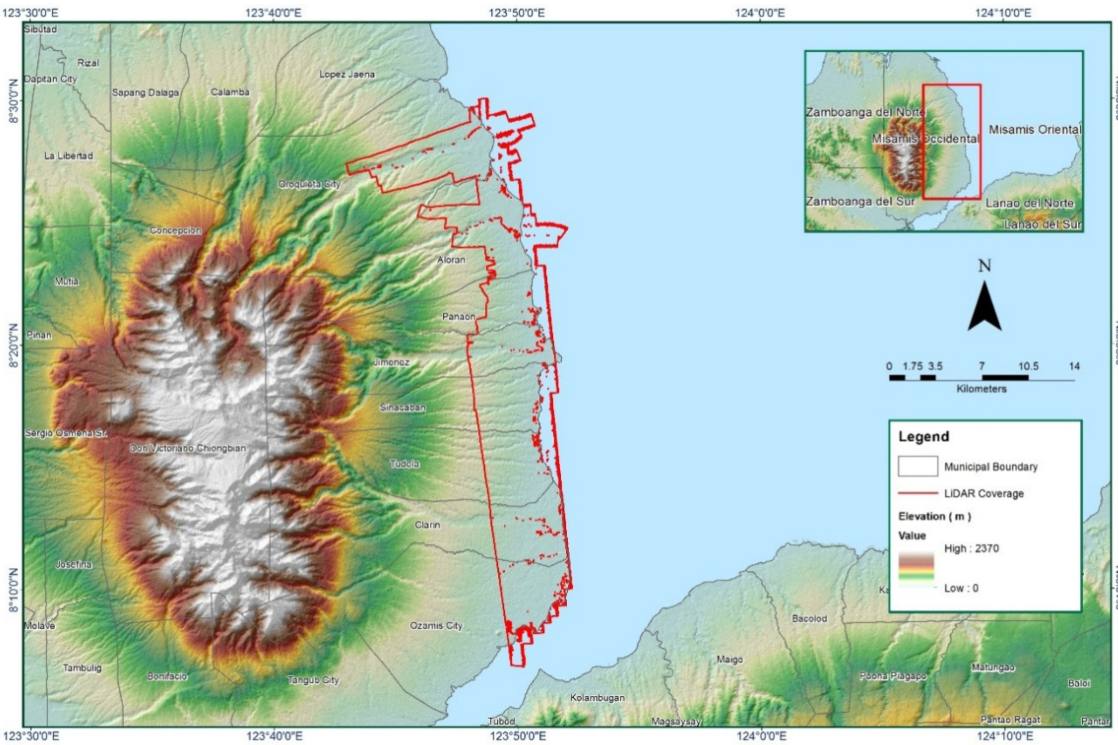


Figure 1.3.4 Coverage of LiDAR data

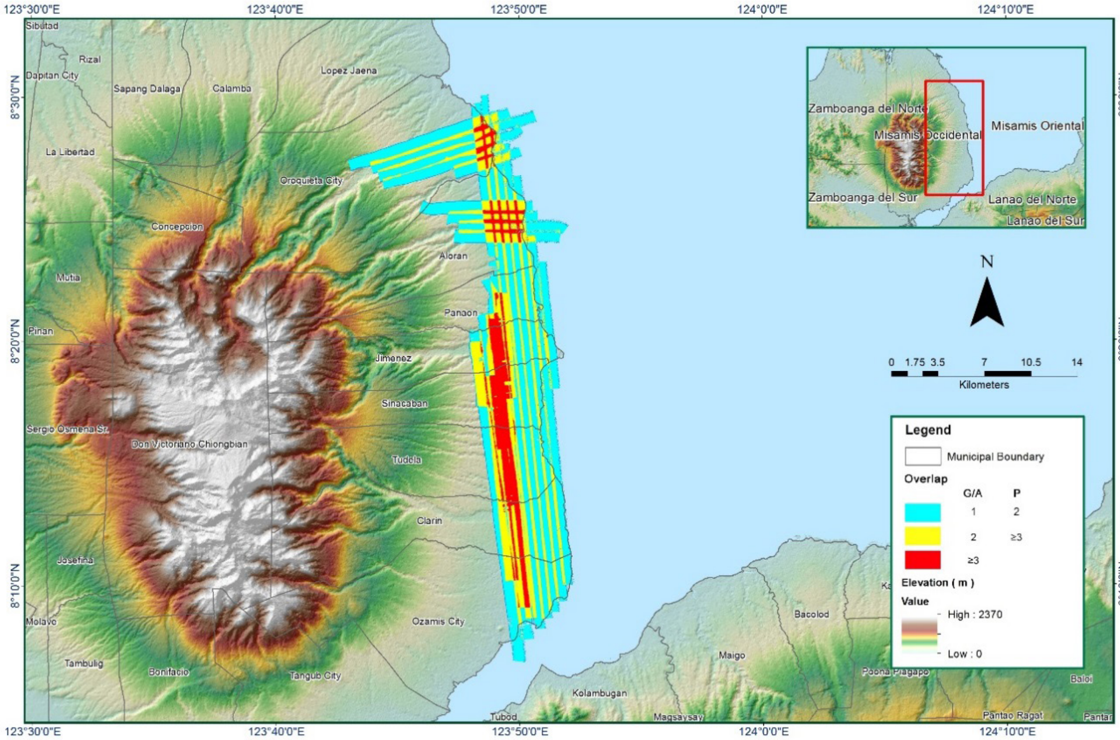


Figure 1.3.5 Image of data overlap

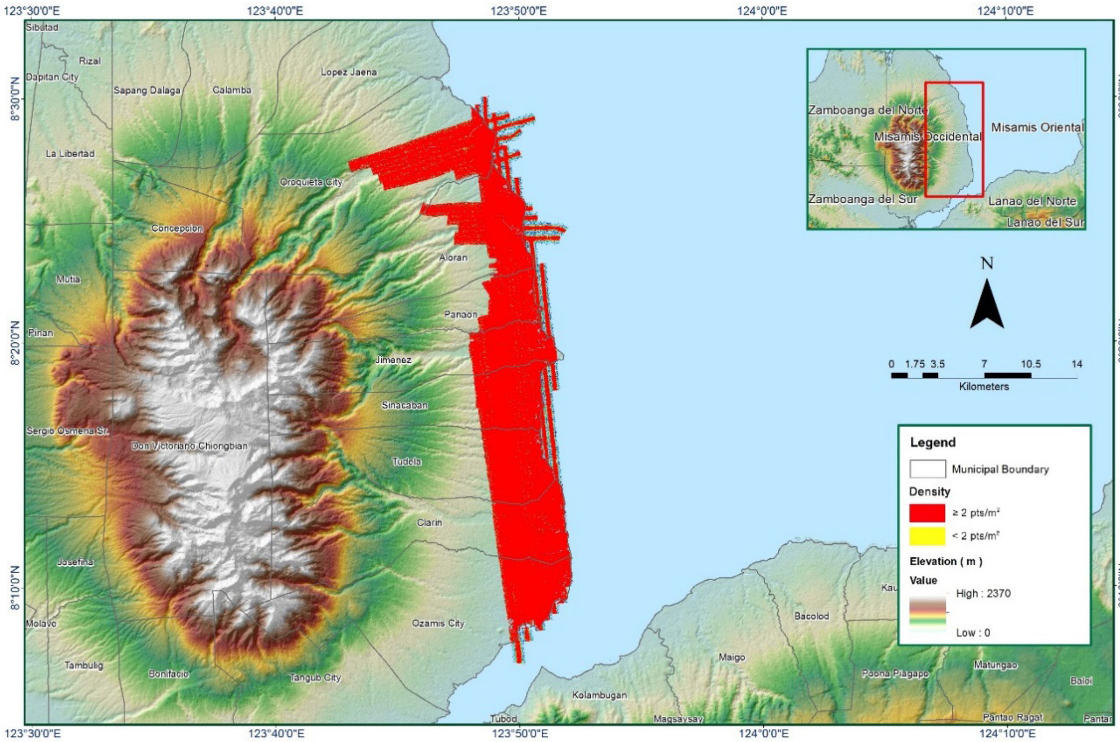


Figure 1.3.6 Density map of merged LiDAR data

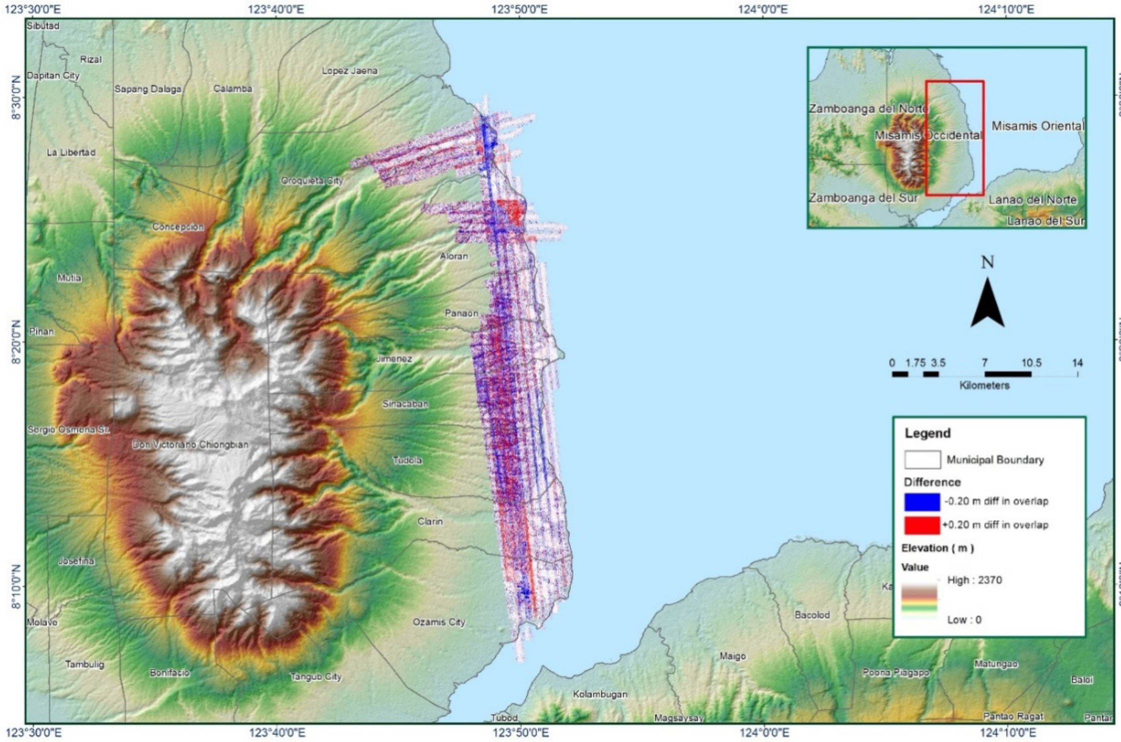


Figure 1.3.7 Elevation difference between flight lines

Flight Area	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

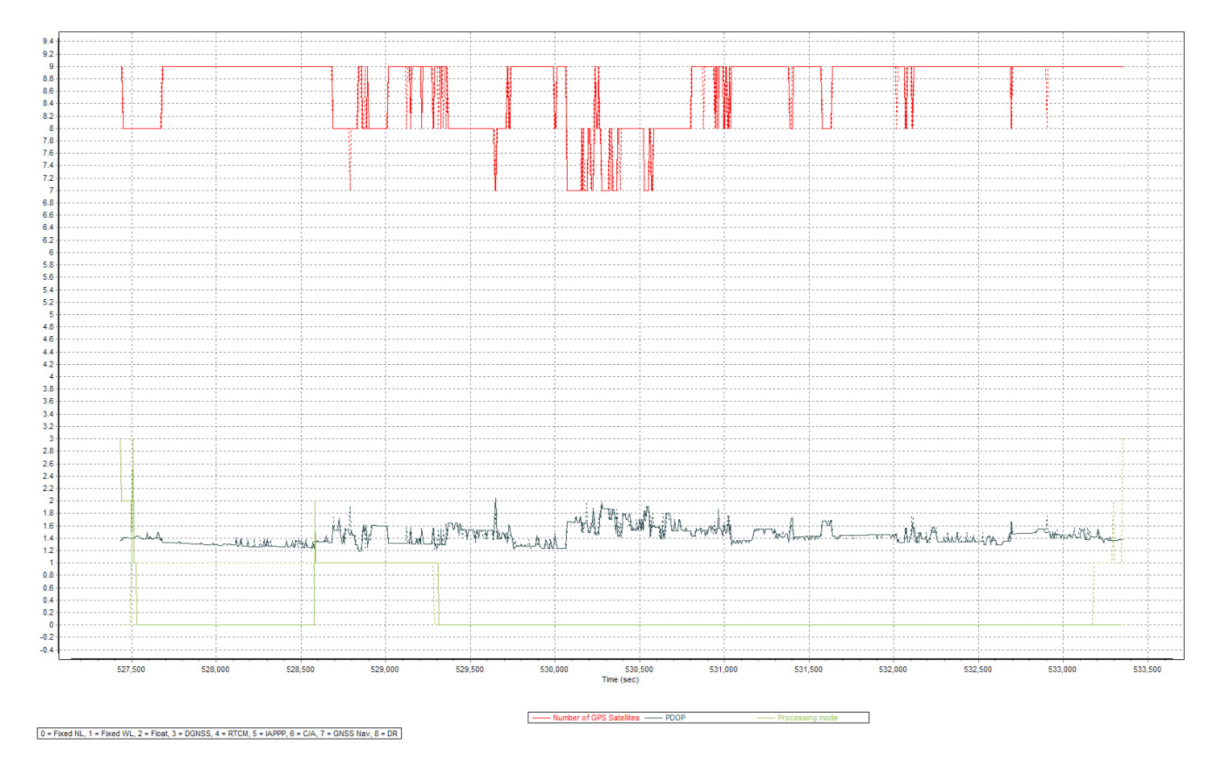


Figure 1.4.1 Solution Status

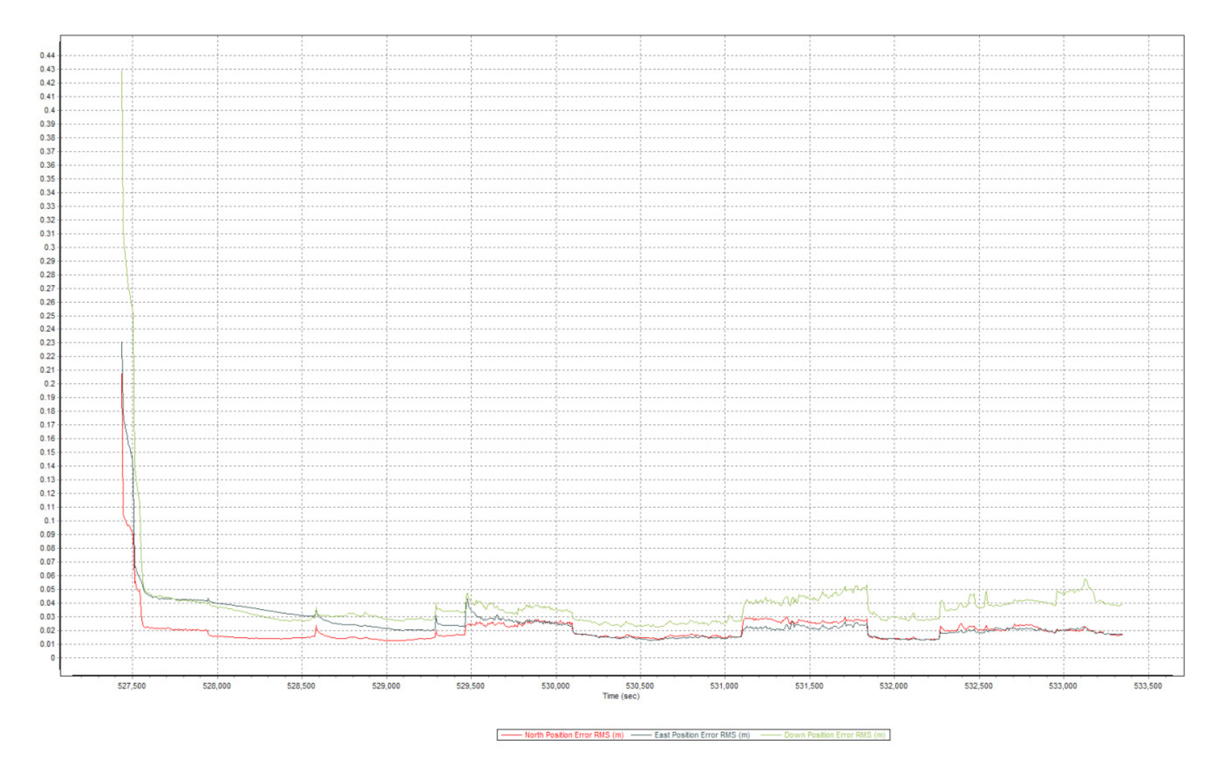


Figure 1.4.2 Smoothed Performance Metric Parameters

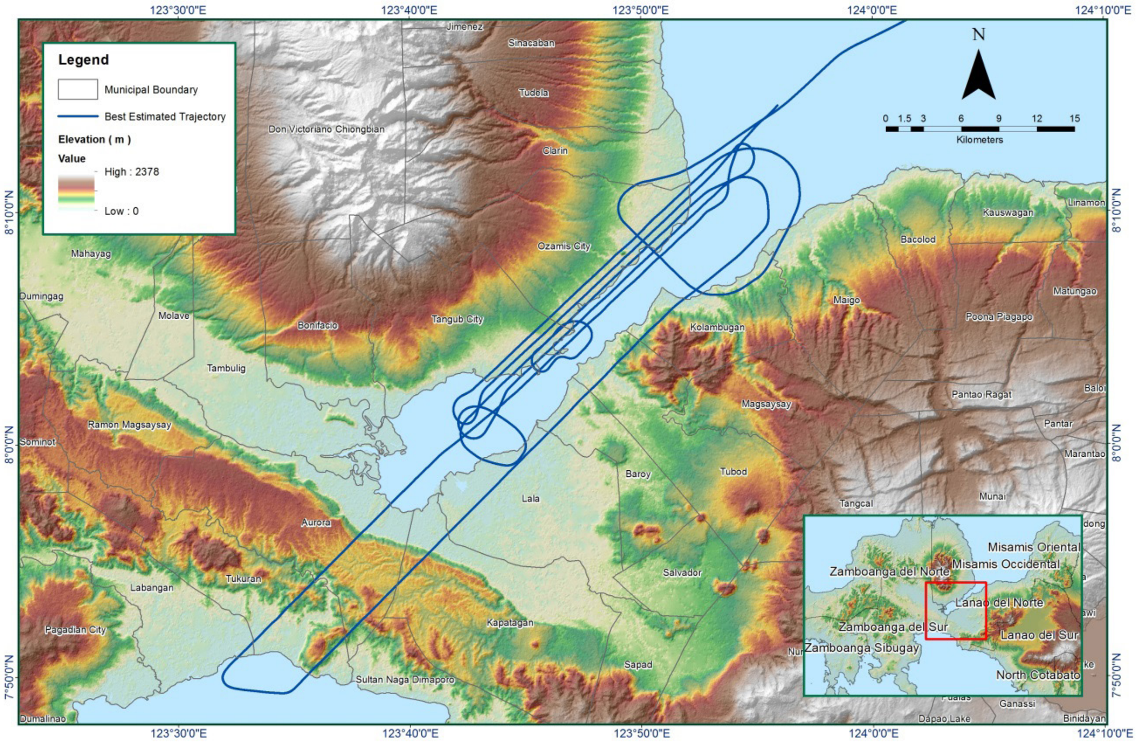


Figure 1.4.3Best Estimated Trajectory

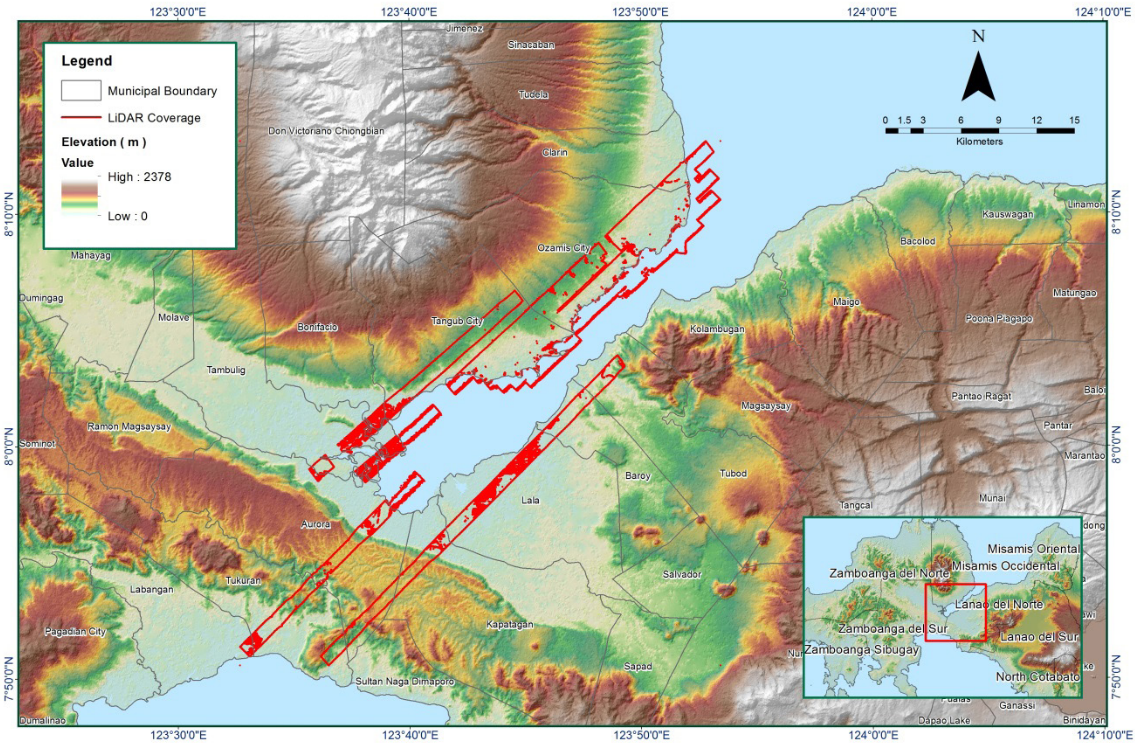


Figure 1.4.4 Coverage of LiDAR data

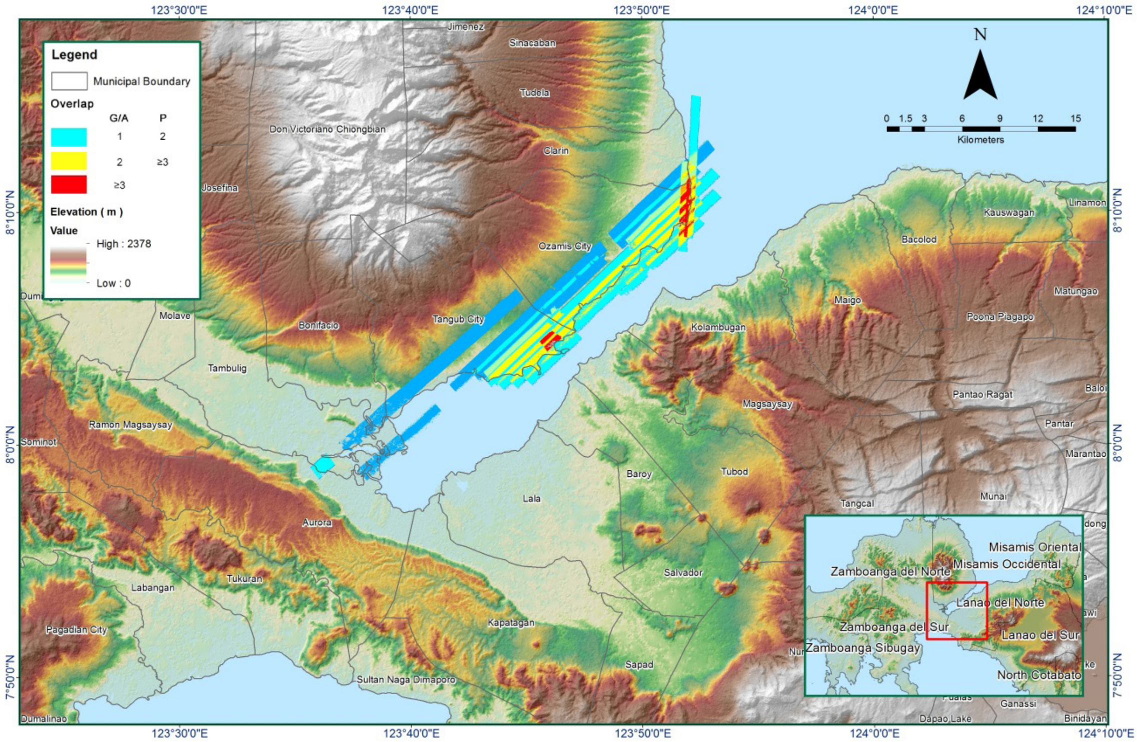


Figure 1.4.5 Image of data overlap

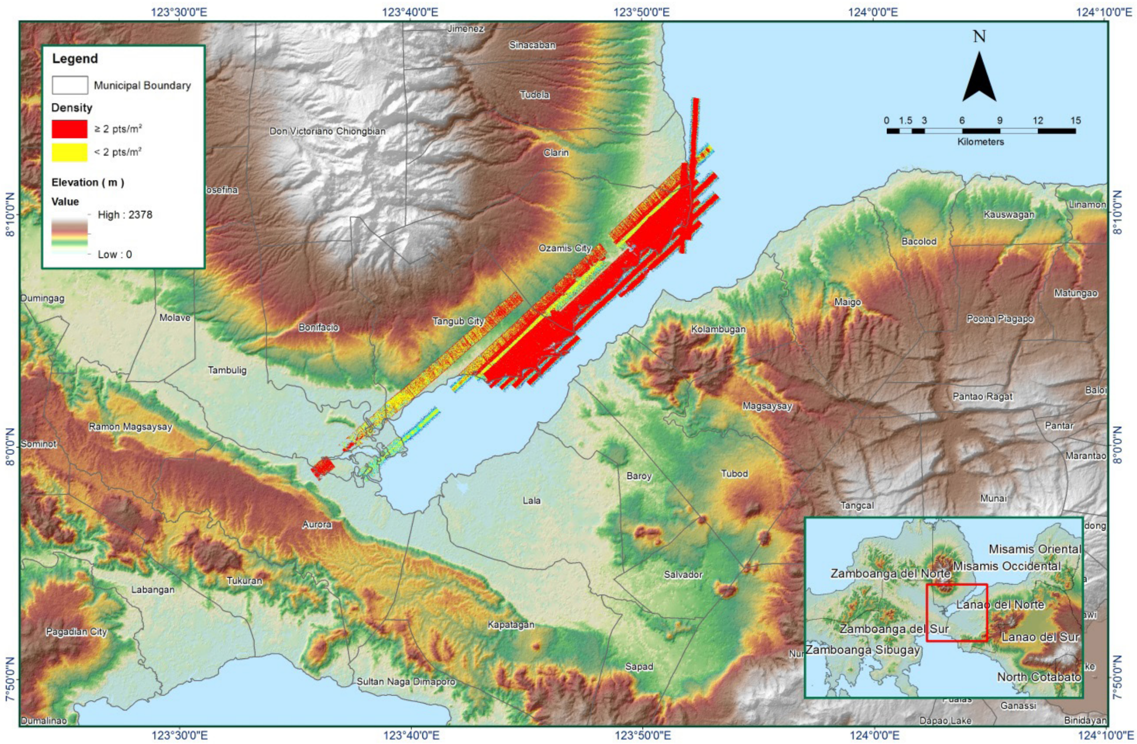


Figure 1.4.6 Density map of merged LiDAR data

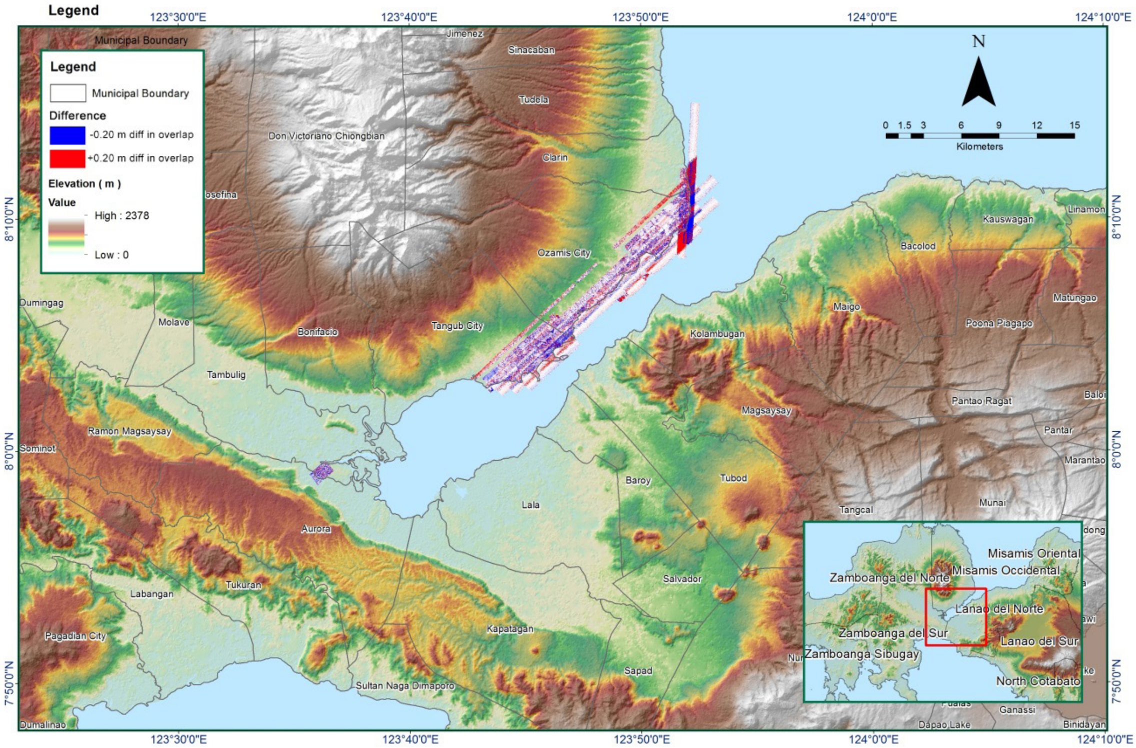


Figure 1.4.7 Elevation difference between flight lines

ANNEX H. Clarin Model Basin Parameters

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W1000	247.0504282	48.555	0.0	1.477792	1.200706	Discharge	0.0542044	0.98	Ratio to Peak	0.23
W1010	250.4268054	48.216	0.0	3.0264	2.45895	Discharge	0.0919483	0.98	Ratio to Peak	0.23
W1020	168.8071056	58.006	0.0	1.9312	1.5691	Discharge	0.0886961	0.98	Ratio to Peak	0.23
W520	178.3201027	56.665	0.0	1.69952	1.38086	Discharge	0.0843671	0.98	Ratio to Peak	0.23
W530	181.0835119	56.287	0.0	1.8888	1.53465	Discharge	0.12531	0.98	Ratio to Peak	0.23
W540	166.828	58.293	0.0	1.85072	1.50371	Discharge	0.13592	0.98	Ratio to Peak	0.23
W560	172.3022114	57.506	0.0	2.92304	2.37497	Discharge	0.0860412	0.98	Ratio to Peak	0.23
W570	189.4247812	55.176	0.0	3.04496	2.47403	Discharge	0.13552	0.98	Ratio to Peak	0.23
W580	177.0098949	56.846	0.0	4.65744	3.78417	Discharge	0.29934	0.98	Ratio to Peak	0.23
W600	188.3704666	55.314	0.0	2.29488	1.86459	Discharge	0.0661552	0.98	Ratio to Peak	0.23
W610	180.7672863	56.330	0.0	1.9632	1.5951	Discharge	0.0621507	0.98	Ratio to Peak	0.23
W620	190.4382027	55.044	0.0	2.168	1.7615	Discharge	0.0687990	0.98	Ratio to Peak	0.23
W630	165.4943931	58.488	0.0	1.397808	1.135719	Discharge	0.0477552	0.98	Ratio to Peak	0.23
W640	181.2160289	56.269	0.0	1.85952	1.51086	Discharge	0.0526926	0.98	Ratio to Peak	0.23
W670	208.6340898	52.777	0.0	3.18128	2.58479	Discharge	0.19116	0.98	Ratio to Peak	0.23
W680	215.1580967	52.009	0.0	3.52208	2.86169	Discharge	0.17276	0.98	Ratio to Peak	0.23
W690	136.1859813	63.129	0.0	2.32672	1.89046	Discharge	0.14169	0.98	Ratio to Peak	0.23
W700	172.4150586	57.490	0.0	2.008	1.6315	Discharge	0.12194	0.98	Ratio to Peak	0.23
W720	203.929884	53.345	0.0	1.66864	1.35577	Discharge	0.0769407	0.98	Ratio to Peak	0.23
W730	83.750	73.574	0.0	3.07632	2.49951	Discharge	0.14883	0.98	Ratio to Peak	0.23
W740	69.037	77.156	0.0	4.09424	3.32657	Discharge	0.18360	0.98	Ratio to Peak	0.23
W760	175.8371038	57.009	0.0	3.41184	2.77212	Discharge	0.19412	0.98	Ratio to Peak	0.23
W780	188.0278049	55.359	0.0	2.15088	1.74759	Discharge	0.17168	0.98	Ratio to Peak	0.23

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W790	236.5634902	49.639	0.0	2.61232	2.12251	Discharge	0.0952633	0.98	Ratio to Peak	0.23
W800	177.3276303	56.802	0.0	2.00576	1.62968	Discharge	0.0874940	0.98	Ratio to Peak	0.23
W810	85.813	73.098	0.0	1.94192	1.57781	Discharge	0.0733935	0.98	Ratio to Peak	0.23
W820	85.421212	73.188	0.0	2.1872	1.7771	Discharge	0.0999426	0.98	Ratio to Peak	0.23
W830	167.8116629	58.150	0.0	1.280992	1.040806	Discharge	0.0797394	0.98	Ratio to Peak	0.23
W840	130.5851957	64.101	0.0	4.09168	3.32449	Discharge	0.24740	0.98	Ratio to Peak	0.23
W850	48.580	82.758	0.0	3.26336	2.65148	Discharge	0.13433	0.98	Ratio to Peak	0.23
W860	161.8406209	59.029	0.0	1.032096	0.838578	Discharge	0.0462618	0.98	Ratio to Peak	0.23
W870	166.6496705	58.319	0.0	1.178144	0.957242	Discharge	0.0384962	0.98	Ratio to Peak	0.23
W880	222.0642358	51.220	0.0	2.59168	2.10574	Discharge	0.12541	0.98	Ratio to Peak	0.23
W910	77.451	75.066	0.0	2.44432	1.98601	Discharge	0.0851599	0.98	Ratio to Peak	0.23
W920	78.580	74.794	0.0	2.81728	2.28904	Discharge	0.22040	0.98	Ratio to Peak	0.23
W930	118.9079674	66.227	0.0	2.78128	2.25979	Discharge	0.11718	0.98	Ratio to Peak	0.23
W940	47.795	82.989	0.0	3.65216	2.96738	Discharge	0.16354	0.98	Ratio to Peak	0.23
W950	74.496	75.787	0.0	1.263472	1.026571	Discharge	0.0645032	0.98	Ratio to Peak	0.23
W960	68.205	77.369	0.0	3.0688	2.4934	Discharge	0.15047	0.98	Ratio to Peak	0.23
W970	231.3788338	50.193	0.0	2.38656	1.93908	Discharge	0.0906061	0.98	Ratio to Peak	0.23
W980	173.3768022	57.354	0.0	3.59088	2.91759	Discharge	0.29846	0.98	Ratio to Peak	0.23
W990	178.9528542	56.578	0.0	2.73984	2.22612	Discharge	0.0801709	0.98	Ratio to Peak	0.23

ANNEX I. Clarin Model Reach Parameters

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
R100	Automatic Fixed Interval	3270.2	0.0648484	0.04	Trapezoid	30	1
R120	Automatic Fixed Interval	352.43	0.0485347	0.04	Trapezoid	30	1
R140	Automatic Fixed Interval	652.55	0.0608107	0.04	Trapezoid	30	1
R150	Automatic Fixed Interval	1466.5	0.17577	0.04	Trapezoid	30	1
R160	Automatic Fixed Interval	4138.5	0.10485	0.04	Trapezoid	30	1
R170	Automatic Fixed Interval	572.13	0.13557	0.04	Trapezoid	30	1
R210	Automatic Fixed Interval	2557.4	0.0408915	0.04	Trapezoid	30	1
R220	Automatic Fixed Interval	3042.9	0.0242217	0.04	Trapezoid	30	1
R240	Automatic Fixed Interval	38.284	0.0026596	0.04	Trapezoid	30	1
R260	Automatic Fixed Interval	2994.5	0.12302	0.04	Trapezoid	30	1
R270	Automatic Fixed Interval	500.42	0.34760	0.04	Trapezoid	30	1
R280	Automatic Fixed Interval	4458.7	0.0541927	0.04	Trapezoid	30	1
R290	Automatic Fixed Interval	2633.1	0.0836170	0.04	Trapezoid	30	1
R30	Automatic Fixed Interval	2849.4	0.0986600	0.04	Trapezoid	30	1
R320	Automatic Fixed Interval	2776.2	0.0265729	0.04	Trapezoid	30	1
R350	Automatic Fixed Interval	347.28	0.0024175	0.04	Trapezoid	30	1
R360	Automatic Fixed Interval	1180.8	0.0357003	0.04	Trapezoid	30	1
R390	Automatic Fixed Interval	2757.2	0.0542653	0.04	Trapezoid	30	1
R40	Automatic Fixed Interval	761.84	0.26123	0.04	Trapezoid	30	1
R430	Automatic Fixed Interval	4346.7	1.0E-5	0.04	Trapezoid	30	1
R440	Automatic Fixed Interval	4174.2	0.0168008	0.04	Trapezoid	30	1
R450	Automatic Fixed Interval	2063.4	0.0591929	0.04	Trapezoid	30	1
R460	Automatic Fixed Interval	5889.4	0.0484266	0.04	Trapezoid	30	1
R470	Automatic Fixed Interval	1530.5	0.0786628	0.04	Trapezoid	30	1
R90	Automatic Fixed Interval	98.995	0.14765	0.04	Trapezoid	30	1

ANNEX J. Clarin Field Validation Points

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
1	8.185677	123.859978	0.20	0	0.20	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
2	8.187463	123.861853	0.03	0	0.03	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
3	8.189381	123.860233	0.19	0.65	-0.46	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
4	8.190829	123.861392	0.03	0.2	-0.17	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
5	8.201856	123.859697	0.03	0.12	-0.09	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
6	8.200094	123.863919	0.03	0	0.03	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
7	8.191781	123.860006	0.03	0.04	-0.01	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
8	8.196928	123.861541	0.18	0	0.18	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
9	8.198053	123.864289	0.03	16	-15.97	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
10	8.186276	123.855012	0.12	1.01	-0.89	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
11	8.188581	123.851672	0.09	0.91	-0.82	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
12	8.187568	123.851403	0.22	0.12	0.10	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
13	8.206044	123.856465	0.03	0	0.03	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
14	8.206642	123.861764	0.03	0	0.03	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
15	8.206854	123.863153	0.07	0	0.07	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
16	8.219659	123.862639	0.03	0	0.03	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
17	8.226688	123.850920	0.03	0.02	0.01	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
18	8.218042	123.831177	0.03	0	0.03	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
19	8.192896	123.850084	0.03	0	0.03	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
20	8.193977	123.846107	0.03	0.18	-0.15	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
21	8.195710	123.842109	0.06	0	0.06	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
22	8.200352	123.837859	0.03	0	0.03	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
23	8.201077	123.835520	0.03	0	0.03	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
24	8.208470	123.836269	0.04	0.17	-0.13	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
25	8.209411	123.832086	0.03	0	0.03	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
26	8.191997	123.834236	0.03	0.35	-0.32	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
27	8.203262	123.837348	0.05	0	0.05	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
28	8.192800	123.836031	0.05	0.34	-0.29	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
29	8.205342	123.836037	0.08	0	0.08	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
30	8.193819	123.848225	0.10	0.35	-0.25	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
31	8.185318	123.860043	0.35	0	0.35	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
32	8.187326	123.862577	0.13	0	0.13	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
33	8.188141	123.861193	0.14	0	0.14	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
34	8.188744	123.860246	0.07	0	0.07	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
35	8.187994	123.860431	0.35	0.75	-0.40	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
36	8.187217	123.860339	0.36	0.24	0.12	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
37	8.202149	123.858193	0.07	0	0.07	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
38	8.200707	123.859601	0.32	0.06	0.26	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
39	8.187698	123.851778	0.41	0.12	0.29	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
40	8.201048	123.861702	0.12	0	0.12	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
41	8.192568	123.859835	0.51	0	0.51	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
42	8.185995	123.856179	0.49	1	-0.51	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
43	8.187139	123.853036	0.44	0.08	0.36	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
44	8.185341	123.858751	0.55	0.08	0.47	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
45	8.187040	123.850262	0.37	0.39	-0.02	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
46	8.189190	123.859814	0.08	0.62	-0.54	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
47	8.206889	123.862830	0.05	0.24	-0.19	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
48	8.209443	123.856376	0.12	0.3	-0.18	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
49	8.206266	123.857186	0.15	0.02	0.13	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
50	8.192665	123.850723	0.40	0.23	0.17	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
51	8.194098	123.845595	0.12	0.03	0.09	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
52	8.192307	123.833887	0.34	0.38	-0.04	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
53	8.193857	123.848168	0.11	0.32	-0.21	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
54	8.201124	123.837515	0.03	0.15	-0.12	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
55	8.209012	123.834419	0.27	0	0.27	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
56	8.194478	123.840712	0.25	0.12	0.13	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
57	8.194089	123.839421	0.39	0.27	0.12	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
58	8.205334	123.836262	0.34	0.52	-0.18	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
59	8.194986	123.841558	0.17	0	0.17	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
60	8.208809	123.835251	0.52	0.62	-0.10	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
61	8.187261	123.865901	0.63	0.41	0.22	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
62	8.187396	123.862840	0.42	0	0.42	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
63	8.187707	123.865266	0.75	0	0.75	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
64	8.185239	123.858472	0.56	0.09	0.47	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
65	8.200628	123.859179	0.43	0.05	0.38	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
66	8.199281	123.864980	0.41	0.06	0.35	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
67	8.187960	123.859922	0.61	0	0.61	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
68	8.197017	123.861783	0.44	0.31	0.13	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
69	8.204860	123.855069	0.30	0.12	0.18	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
70	8.202286	123.857795	0.59	0.18	0.41	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
71	8.186780	123.849716	0.63	0.81	-0.18	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
72	8.186474	123.855810	0.72	0.82	-0.10	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
73	8.186564	123.859751	0.62	0.03	0.59	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
74	8.187290	123.852790	0.60	0.59	0.01	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
75	8.207986	123.856506	0.13	0	0.13	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
76	8.217382	123.849938	0.59	0	0.59	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
77	8.208741	123.858671	0.36	0	0.36	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
78	8.207324	123.863250	0.50	0.12	0.38	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
79	8.213961	123.862967	0.51	0.22	0.29	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
80	8.209661	123.856172	0.49	0.3	0.19	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
81	8.209917	123.863797	0.57	0.69	-0.12	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
82	8.207669	123.860434	0.45	0	0.45	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
83	8.214869	123.851997	0.73	0.5	0.23	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
84	8.207307	123.857059	0.23	0.09	0.14	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
85	8.192208	123.851539	0.82	0.5	0.32	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
86	8.192819	123.836870	0.58	0.13	0.45	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
87	8.201644	123.855050	0.49	0.19	0.30	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
88	8.194201	123.844892	0.66	0.43	0.23	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
89	8.191491	123.855879	0.82	0.65	0.17	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
90	8.191122	123.859774	0.74	0.65	0.09	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
91	8.199494	123.859055	0.71	0.55	0.16	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
92	8.195653	123.864528	0.75	0.51	0.24	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
93	8.198058	123.864825	0.99	0.51	0.48	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
94	8.202147	123.860136	1.14	0.43	0.71	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
95	8.197247	123.860027	0.56	0.06	0.50	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
96	8.198404	123.861754	0.92	0.81	0.11	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
97	8.205401	123.855646	0.82	0.06	0.76	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
98	8.186904	123.849220	1.06	0	1.06	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
99	8.214042	123.852397	1.09	0	1.09	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
100	8.212178	123.863419	0.95	0.36	0.59	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
101	8.209471	123.856014	0.70	0.3	0.40	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
102	8.217549	123.840322	0.99	0	0.99	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
103	8.209321	123.859136	0.97	0	0.97	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
104	8.206525	123.856560	0.76	0.2	0.56	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
105	8.211045	123.863611	1.04	0.45	0.59	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
106	8.210911	123.862088	1.05	0.4	0.65	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
107	8.218991	123.847985	1.92	1.19	0.73	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
108	8.220803	123.852452	1.17	0.65	0.52	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
109	8.223239	123.851678	0.97	0.96	0.01	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
110	8.217065	123.849901	0.97	0.23	0.74	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
111	8.210835	123.860914	1.28	0.46	0.82	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
112	8.216816	123.853726	1.11	0.08	1.03	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
113	8.215528	123.850902	1.56	0	1.56	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
114	8.200760	123.844344	1.04	0.12	0.92	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
115	8.200143	123.839896	1.24	0.51	0.73	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
116	8.191499	123.859434	1.12	0.75	0.37	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
117	8.203041	123.854937	1.04	0.26	0.78	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
118	8.200922	123.855397	1.21	0.32	0.89	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
119	8.205117	123.854370	0.98	0.08	0.90	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
120	8.201224	123.845981	1.09	0.1	0.99	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
121	8.205319	123.856035	1.86	0	1.86	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
122	8.217508	123.831905	1.87	0.53	1.34	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
123	8.217251	123.849558	2.26	0.72	1.54	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
124	8.209172	123.854532	3.32	0.95	2.37	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
125	8.205701	123.855436	1.87	1.22	0.65	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
126	8.203810	123.850030	2.51	0	2.51	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
127	8.203029	123.846026	2.13	0	2.13	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
128	8.205685	123.855210	1.82	0.14	1.68	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
129	8.205326	123.845323	2.42	0	2.42	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
130	8.205633	123.853280	2.88	0.04	2.84	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
131	8.205957	123.855161	2.46	0.43	2.03	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
132	8.205936	123.855407	2.52	0.36	2.16	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
133	8.202366	123.845490	3.47	0.32	3.15	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
134	8.201664	123.845711	2.77	0.26	2.51	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
135	8.203883	123.850321	3.11	0.1	3.01	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
136	8.203137	123.858099	1.58	0.53	1.05	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
137	8.204886	123.855828	1.53	1.84	-0.31	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
138	8.204787	123.856190	1.63	0.12	1.51	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
139	8.203494	123.856921	1.60	0.46	1.14	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
140	8.194575	123.865632	1.47	0.51	0.96	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
141	8.218003	123.835953	1.44	1.1	0.34	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
142	8.214844	123.835246	1.57	0.95	0.62	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
143	8.216429	123.835048	1.66	0.86	0.80	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
144	8.217766	123.833346	1.60	0.73	0.87	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
145	8.219053	123.847519	1.08	0.83	0.25	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
146	8.214905	123.850882	1.69	0	1.69	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
147	8.218256	123.842703	1.04	1.48	-0.44	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
148	8.219193	123.862282	1.62	0.05	1.57	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
149	8.214997	123.851322	1.68	0	1.68	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
150	8.207290	123.855893	0.12	0	0.12	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
151	8.206575	123.855897	0.03	0	0.03	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
152	8.205569	123.845088	3.99	1.15	2.84	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
153	8.200404	123.842070	1.09	0.63	0.46	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year
154	8.205158	123.848893	5.55	0.22	5.33	Tyhpoon Pablo/ Dec. 3-4,2012	5 -Year

ANNEX K. Educational Institutions Affected by flooding in Clarin Floodplain

MISAMIS OCCIDENTAL				
CLARIN				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Dolores Elementary School	Canibungan Daku			
Masabud Elementary School	Canipacan	Medium	Medium	High
Dolores Elementary School	Dolores			
Clarin Elementary School	Gata Daku	Medium	Medium	Medium
Clarin National High School	Gata Daku	Medium	Medium	Medium
Day Care Center	Gata Daku			
Gata Daku Elementary School	Gata Daku		Low	Low
Day Care Center	Gata Diot	Medium	Medium	Medium
Day Care Center	Kinangay Norte	High	High	High
Kinangay Norte Elementary School	Kinangay Norte			
Segatic Daku Elementary School	Kinangay Norte			
Tinacla-an Elementary School	Kinangay Norte	Medium	Medium	High
Segatic Elementary School	Kinangay Norte			
Kinangay Sur Elementary School	Kinangay Sur			
Purok High Reading Center	Kinangay Sur	Low	Low	Low
Day Care Center	Lapasan	Medium	Medium	Medium
ECCD Day Care Center	Lapasan	Medium	Medium	Medium
Lapasan Elementary School	Lapasan	Medium	Medium	Medium
San Roque Elementary School	Lapasan	Medium	Medium	Medium
St. Anne School of Clarin	Lapasan	Medium	Medium	Medium
Day Care Center	Lupagan	Low	Medium	Medium
International Greece Bible Institute	Lupagan	Low	Medium	Medium
Lupagan Elementary School	Lupagan	Low	Medium	Medium
Purok High Reading Center	Masabud	Medium	High	High
Emmanuel Christian Academy	Mialen	Low	Medium	Medium
Mialen Barra Day Care Center	Mialen	Medium	Medium	Medium
Mialen Central School	Mialen	Low	Medium	Medium
Clarin National Highschool Annex	Pan-ay	Medium	Medium	Medium
Day Care Center	Pan-ay	Medium	High	High
ECCD Day Care Center	Pan-ay	High	High	High
Pan-ay Elementary School	Pan-ay	Medium	Medium	High
Clarin Elementary School	Poblacion I	Low	Medium	Medium
GDMPC Learning Center	Poblacion I	Low	Medium	Medium
Holy Child Elementary School	Poblacion I		Low	Medium
Holy Child High School	Poblacion I	Low	Medium	Medium
San Roque Elementary School	Poblacion II	Medium	Medium	High
Anteru	Poblacion III		Low	Low
Day Care Center	Poblacion III	Medium	Medium	Medium
Holy Child Elementary School	Poblacion III		Low	Medium
Clarin National High School	Poblacion IV	Medium	Medium	Medium

MISAMIS OCCIDENTAL				
CLARIN				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Canicapan Elementary School	Segatic Daku			Low
Day Care Center	Segatic Daku			

MISAMIS OCCIDENTAL				
Ozamiz CITY				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Landon Academy	50th District			
Ozamiz City Central School	50th District			
PSALMS Christian Academy	50th District			
FMC MA School	Aguada			
ADC Elementary School	Bacolod		Low	Low
Anrea D.Costonera Elementary School	Bacolod	Low	Low	Low
Bacolod Elementary School	Bacolod			
Brgy. Aguada Day Care Literacy Center	Bacolod			
DEPED	Bacolod			
Firm Foundation Christian Academy	Bacolod			
Golden Horizon Pension House	Bacolod			
LSU College Building	Bacolod	Low	Low	Medium
LSU College Building Medium	Bacolod	Low	Low	Low
LSU High School Building	Bacolod			Low
LSU Integrated School	Bacolod			
Montessori Center-Kindergarten	Bacolod			
Our Lady of the Angels School	Bacolod			
Ozamiz City Technical and Vocational School	Bacolod			
Tutorial Center	Bacolod			
Sancho Capa Elementary School	Bagakay			
Misamis Institute of Technology	Banadero			
Misamis Instiute of Technology	Banadero			
Basakan Day Care Center	Baybay San Roque	Low	Low	Medium
City Library	Baybay San Roque			
Day Care Center	Baybay San Roque			
Ozamiz City Central School	Baybay San Roque			
Ozamiz City Christian School	Baybay San Roque			Low
Ozamiz City National High School	Baybay San Roque			Low
Sta. Cruz Elementary School	Baybay Santa Cruz			
Day Care Center	Baybay Santa Cruz			
Baybay Central School	Baybay Triunfo			Low
Day Care Center	Baybay Triunfo			
IHL	Baybay Triunfo			
WMST	Baybay Triunfo			
ALS Bldg.	Baybay Triunfo			Low

MISAMIS OCCIDENTAL				
Ozamiz CITY				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Faustino C. Decena Elementary School	Carangan			
Saint John Paul College Seminary	Carangan			Low
Day Care Center	Carangan			
Faustino C. Decena Elementary School	Carangan	Low	Low	Low
LSU College Building	Carmen	Low	Low	Medium
LSU Guard House - Entrance	Carmen	Low	Low	Low
LSU High School Building	Carmen		Low	Low
LSU Lobby	Carmen		Low	Low
LSU Registrars Office	Carmen			
Misamis Annex Integrated School	Carmen			
Catadman Elementary School	Catadman-Manabay	Low	Low	Medium
Clarin Day Care Center	Embargo	Medium	Medium	Medium
Gango Elementary School	Gango	Medium	Medium	Medium
San Antonio Elementary School	Gango	Medium	Medium	Medium
San Antonio Elemtary School	Gango	Medium	Medium	Medium
San Antonio National High School	Gango	Low	Medium	Medium
Clarin Central School	Clarin	Medium	Medium	Medium
Clarin Central School Stage	Clarin		Medium	Medium
Clarin National High School	Clarin	Medium	Medium	Medium
ClarinCentral School Gym	Clarin	Low	Medium	Medium
Misamis Union High School	Lam-An			
Misamis University	Lam-An			
MU Ma. Mercado Building	Lam-An			Low
MU Main Library	Lam-An		Low	Low
Ozamiz City Christian School	Lam-An		Low	Low
Sanctuary Christian Academy	Lam-An			
Day Care Center	Malaubang			
Malaubang Integrated School	Malaubang		Low	Low
Maningcol Elementary School	Maningcol	Medium	Medium	Medium
Medina College	Maningcol	Medium	Medium	Medium
Medina Medical College	Maningcol	Medium	Medium	Medium
OCSAT	Maningcol	Medium	Medium	Medium
Domingo A. Barloa Elementary School	Molicay	Low	Medium	Medium
Doña Consuelo Elementary School	San Antonio	Low	Medium	Medium
Malanoy Day Care Center	San Antonio	Medium	Medium	Medium
San Antonio Day Care Center	San Antonio	Medium	Medium	Medium
Basakan Day Care Center	Tinago		Low	Low

ANNEX L. Health Institutions Affected by flooding in Clarin Floodplain

MISAMIS OCCIDENTAL				
CLARIN				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Health Center	Canipacan	Medium	Medium	Medium
Health Center	Dolores			Low
Health Center	Gata Daku	Low	Medium	Medium
Health Center	Gata Diot	Medium	Medium	Medium
Health Center	Kinangay Norte			
Health Center	Lapasan	Medium	Medium	Medium
Botika ng Bayan	Lupagan	Low	Medium	Medium
Health Center	Lupagan	Low	Medium	Medium
Health Center	Masabud	Medium	Medium	Medium
Health Center	Pan-ay	Medium	Medium	Medium
Municipal Health Office	Poblacion I		Medium	Medium
Municipal Health Office	Poblacion II		Low	Low
Brgy. Poblacion Medium Health Center	Poblacion III	Medium	Medium	Medium
Olegario General Hospital	Poblacion IV	Low	Medium	Medium
Health Center	Segatic Daku			

MISAMIS OCCIDENTAL				
CLARIN				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Lourdes Pharmacy	50th District	Low	Medium	Medium
Metro Lab Center	50th District			
Ozamiz Mercury Drug Main	50th District			
St. Joseph General Hospital	50th District			
St. Joseph General Hospital	Aguada			
Health Center	Bacolod			Low
St. Cecile Diagnostics	Bacolod			
MU Medical Center	Bagakay			
Birthing Place	Baybay San Roque			
Community Hospital	Baybay San Roque			
Health Center	Baybay San Roque			Low
Dra. Juat Optical Clinic	Baybay Santa Cruz	Low	Low	Low
Love Mae Pharmacy	Baybay Santa Cruz			Low
Rose Pharmacy	Baybay Santa Cruz	Low	Low	Low
St. Joseph General Hospital	Baybay Santa Cruz			
Acebedo Optical Clinic	Baybay Triunfo			
Brgy Carmen Health Center	Baybay Triunfo			Low
Clinic	Baybay Triunfo		Low	Low
De Guzman Clinic	Baybay Triunfo			
Dr. Villaseran Clinic	Baybay Triunfo			Low

MISAMIS OCCIDENTAL				
CLARIN				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Dr. Ybañez Clinic	Baybay Triunfo			
Proposed Birthing Clinic	Baybay Triunfo			
Health Center	Carangan	Low	Low	Low
Family General Hospital	Carmen			Low
Medina Hospital	Carmen			Low
SM Lao Memorial General Hospital	Catadman-Manabay	Low	Low	Medium
Maningcol Sub Health Center	Doña Consuelo			Low
Health Center	Gango	Medium	High	High
Clarin Health Center	Clarin	Low	Medium	Medium
Animal Aide Clinic	Lam-An			
Faith Hospital Bldg. Low	Lam-An			
Faith Hospital Bldg. Medium	Lam-An	Low	Low	Low
Faith Hospital Bldg. High	Lam-An		Low	Low
Faith Hospital Guard House	Lam-An	Low	Low	Low
Zion Drugmart	Lam-An			
Gems Lying-in	Maningcol	Medium	Medium	Medium
SM Lao Memorial General Hospital	Maningcol		Low	Low
Brgy Health Center and BNS Office	San Antonio	Medium	Medium	Medium
MHARS TTH	San Antonio			