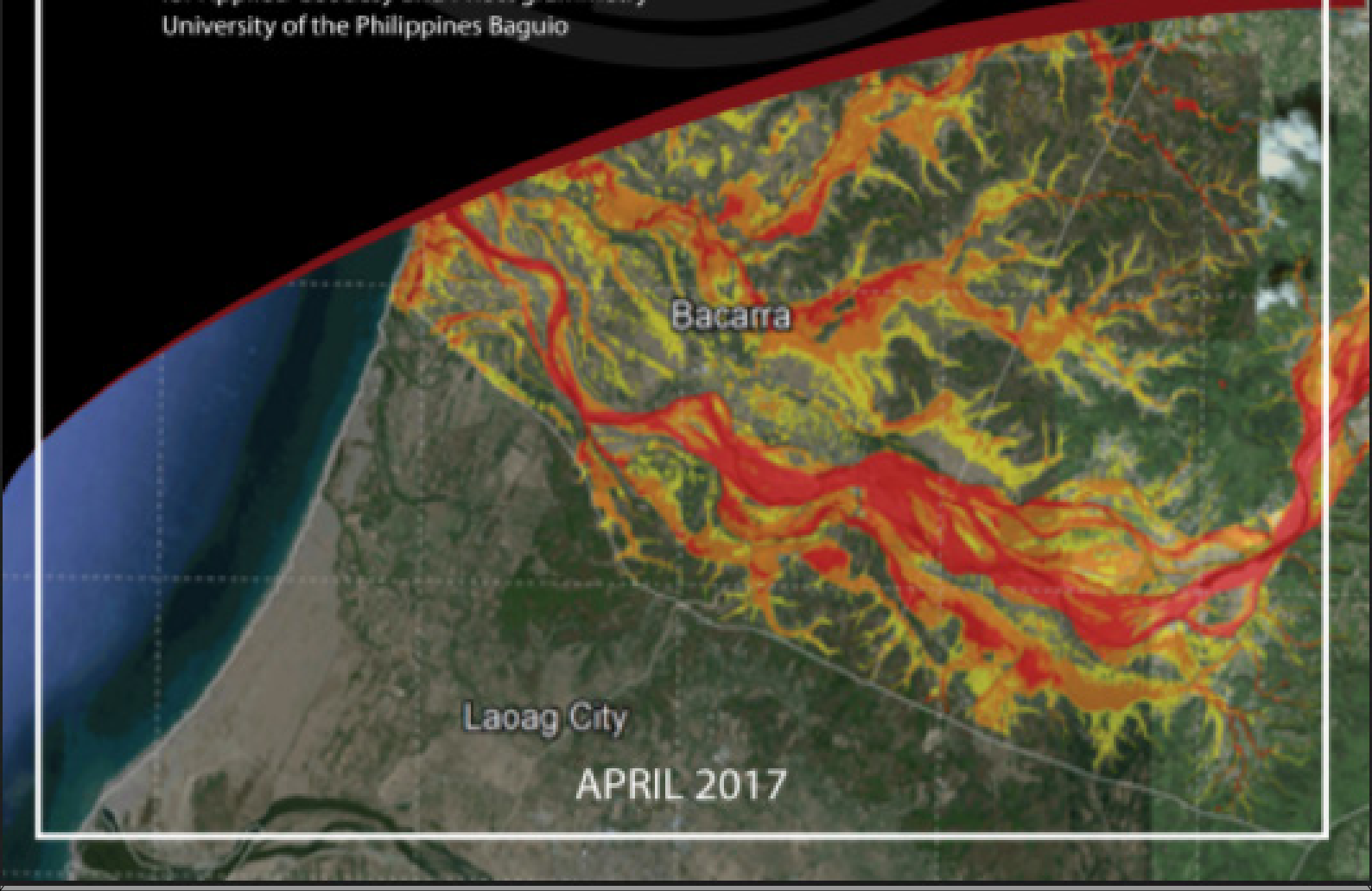
Hazard Mapping of the Philippines Using LIDAR (Phil-LIDAR 1)

LiDAR Surveys and Flood Mapping of Bacarra River

University of the Philippines Training Center
for Applied Geodesy and Photogrammetry
University of the Philippines Baguio



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For questions/queries regarding this report, contact:

Dr. Chelo Pascua
Project Leader, PHIL-LiDAR 1 Program
University of the Philippines Baguio
Baguio City, Philippines 2600
pascua.chelo@yahoo.com

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

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LIST OF ACRONYMS AND ABBREVIATIONS

AAC	Asian Aerospace Corporation
Ab	abutment
ALTM	Airborne LiDAR Terrain Mapper
ARG	automatic rain gauge
ATQ	Antique
AWLS	Automated Water Level Sensor
BA	Bridge Approach
BM	benchmark
CAD	Computer-Aided Design
CN	Curve Number
CSRS	Chief Science Research Specialist
DAC	Data Acquisition Component
DEM	Digital Elevation Model
DENR	Department of Environment and Natural Resources
DOST	Department of Science and Technology
DPPC	Data Pre-Processing Component
DREAM	Disaster Risk and Exposure Assessment for Mitigation [Program]
DRRM	Disaster Risk Reduction and Management
DSM	Digital Surface Model
DTM	Digital Terrain Model
DVBC	Data Validation and Bathymetry Component
FMC	Flood Modeling Component
FOV	Field of View
GiA	Grants-in-Aid
GCP	Ground Control Point
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HEC-HMS	Hydrologic Engineering Center - Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center - River Analysis System
HC	High Chord
IDW	Inverse Distance Weighted [interpolation method]
IMU	Inertial Measurement Unit
kts	knots
LAS	LiDAR Data Exchange File format
LC	Low Chord
LGU	local government unit
LiDAR	Light Detection and Ranging
LMS	LiDAR Mapping Suite
m AGL	meters Above Ground Level
MMS	Mobile Mapping Suite
MSL	mean sea level
NSTC	Northern Subtropical Convergence
PAF	Philippine Air Force
PAGASA	Philippine Atmospheric Geophysical and Astronomical Services Administration
PDOP	Positional Dilution of Precision
PPK	Post-Processed Kinematic [technique]
PRF	Pulse Repetition Frequency
PTM	Philippine Transverse Mercator
QC	Quality Check
QT	Quick Terrain [Modeler]
RA	Research Associate
RIDF	Rainfall-Intensity-Duration-Frequency
RMSE	Root Mean Square Error
SAR	Synthetic Aperture Radar
SCS	Soil Conservation Service
SRTM	Shuttle Radar Topography Mission
SRS	Science Research Specialist
SSG	Special Service Group
TBC	Thermal Barrier Coatings
UPC	University of the Philippines Cebu
UP-TCAGP	University of the Philippines – Training Center for Applied Geodesy and Photogrammetry

CHAPTER 1: OVERVIEW OF THE PROGRAM AND BACARRA RIVER

Dr. Chelo Pascua and Enrico C. Paringit, Dr. Eng.

1.1 Background of the Phil-LIDAR 1 Program

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

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

The implementing partner university for the Phil-LiDAR 1 Program is the University of the Philippines Mindanao (UPMin). UPMin 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 13 river basins in the Davao Region. The university is located in Davao City in the province of Davao del Sur.

1.2 Overview of the Bacarra River Basin

Bacarra River Basin covers the municipality of Vintar, located in the province of Bacarra. The DENR River Basin Control Office identified the basin to have a drainage area of 72 km2 and an estimated 1,888 million cubic meter (MCM) annual run-off (RBCO, 2015).

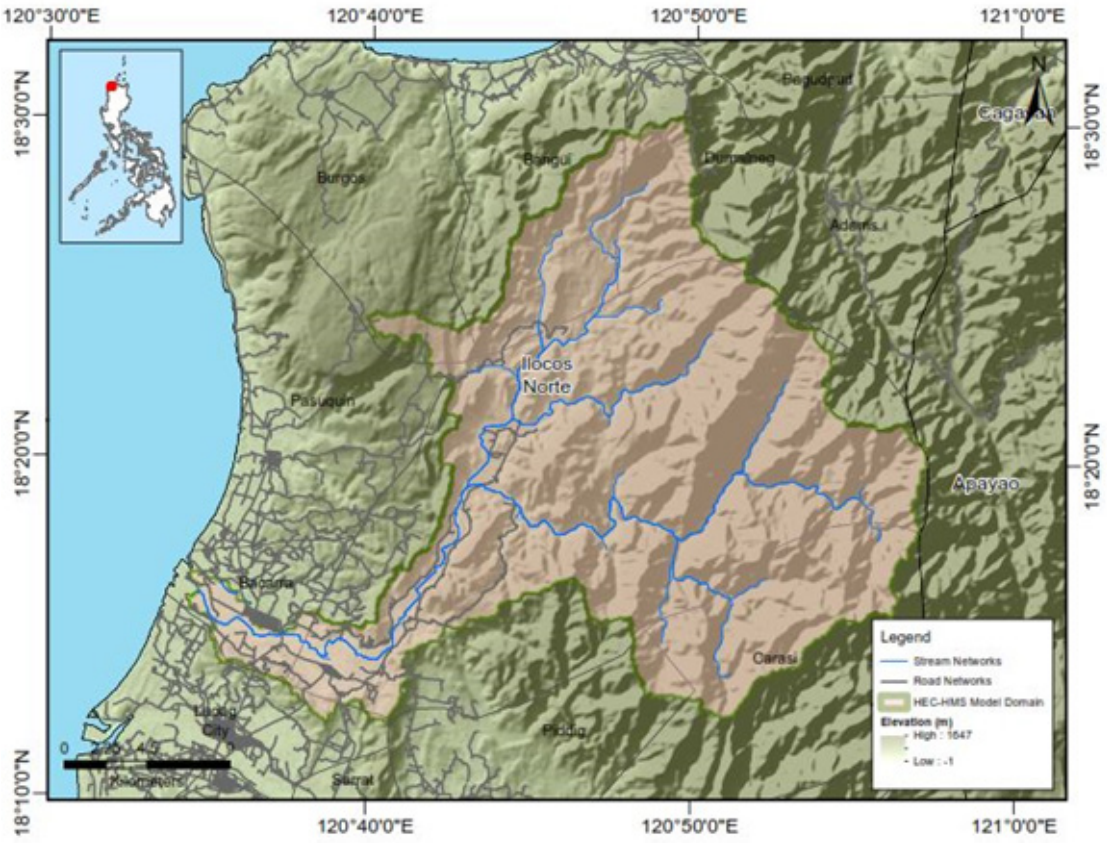


Figure 1. Map of Bacarra River Basin (in brown).

Bacarra River Basin is located in the province of Ilocos Norte. This river passes through the Municipality of Vintar which would drain to Bacarra to the West Philippine Sea. According to the DENR-RBCO, the catchment basin has an approximate area of 72 km2 and an estimated annual run off of 1,888 million cubic meter (MCM).

Its main stream, Bacarra River, is one of the river systems in Ilocos Region. A total of 30,762 people are residing in the immediate vicinity of the Bacarra River flood plain according to the 2010 census conducted by NSO. This population is distributed among the 14 barangays and 21 barangays of the Municipalities of Vintar and Bacarra, respectively.

CHAPTER 2: LIDAR DATA ACQUISITION OF THE BACARRA FLOODPLAIN

Engr. Louie P. Balicanta, Engr. Christopher Cruz, Lovely Gracia Acuña, Engr. Gerome Hipolito, Ms. Jasmine T. Alviar, Engr. Brylle Adam G. De Castro

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).

2.1 Flight Plans

To initiate the LiDAR acquisition survey of the Bacarra floodplain, the Data Acquisition Component (DAC) created flight plans within the delineated priority area for Bacarra Floodplain in Ilocos Norte. These flight missions were planned for 14 lines and ran for at most four and a half hours (4.5) including take-off, landing and turning time. The flight planning parameters for the LiDAR system are outlined in Table 1. Figure 2 shows the flight plan for Bacarra floodplain survey.

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

Block Name	Flying Height (m AGL)	Overlap (%)	Field of View (θ)	Pulse Repetition Frequency (PRF) (kHz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
BLK04A	1000	25	30	100	50	120	5
BLK05A	1000	25	40	70	50	120	5
BLK05B	1000	25	30	100	50	120	5
	1000	30	40	50	50	120	5
BLK05C	1200	30	40	50	50	120	5
	1000	25	40	70	50	120	5
	850	30	40	70	50	120	5
BLK05D	1300, 1400,1500	30	40	100,70,50	50	120	5
BLK05E	1000	25	40	100	50	120	5
BLK05F	1000	25,30	40	100	50	120	5
BLK05G	1000	25,30	40	100	40	120	5
BLK04C	1000	45	40	100	50	120	5
BLK04B	1000	45	40	100	50	120	5
BLK05K	1500	30	30	100	50	120	5
BLK04D	1300, 1400, 1500	30	40	100, 70, 50	50	120	5
BLK04E	1350	30	40	100, 70	50	120	5

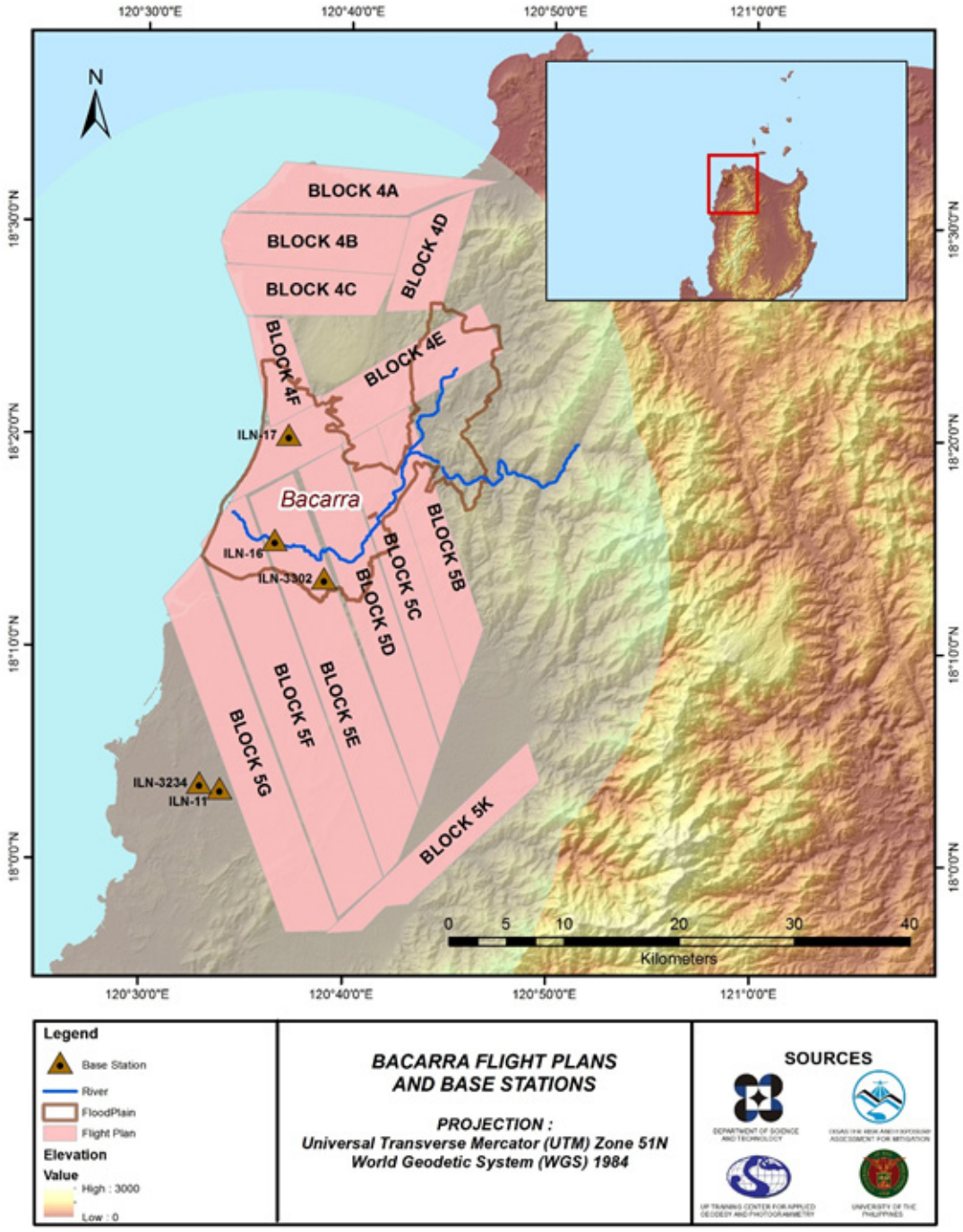


Figure 2. Flight plans and base stations used for Bacarra floodplain using Gemini LiDAR system.

2.2 Ground Base Stations

The project team was able to recover five (5) NAMRIA ground control points: ILN-11, ILN-16, ILN-17 which are of second (2nd) order accuracy and ILN-3234 AND ILN-3302, which are of fourth (4th) order accuracy.

The certifications for the base stations are found in Annex 2 while the baseline processing reports for the established control points are found in Annex 3. These were used as base stations during flight operations for the entire duration of the survey from February 21, 2014 to March 2, 2014. Base stations were observed using dual frequency GPS receivers, TRIMBLE SPS 852 and SPS 985. Flight plans and location of base stations used during the aerial LiDAR acquisition in Bacarra floodplain are shown in Figure 2.

The succeeding sections depict the sets of reference points, control stations and established points, and the ground control points for the entire Bacarra Floodplain LiDAR Survey. Figure 3 to Figure 6 show the recovered NAMRIA reference points within the area of the floodplain, while Table 2 to Table 6 show the details about the following NAMRIA control stations and established points. Table 7, on the other hand, shows the list of all ground control points occupied during the acquisition together with the corresponding dates of utilization.

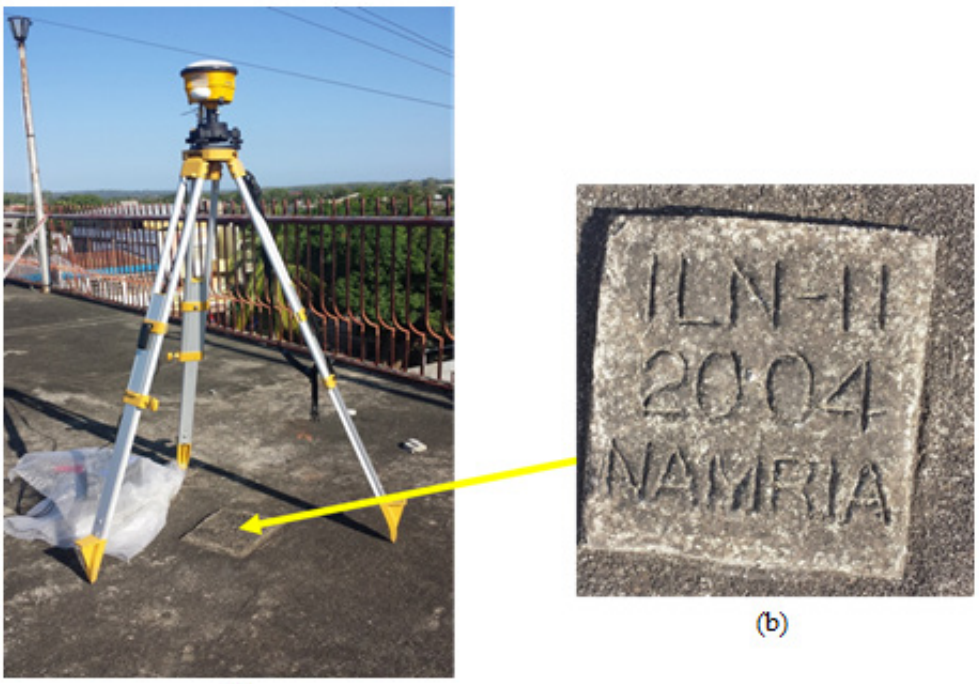


Figure 3. GPS set-up over ILN-11 located on the rooftop of Batac Municipal Hall Building in Batac Ilocos Norte (a) and NAMRIA reference point ILN-11 (b) as recovered by the field team.

Table 2. Details of the recovered NAMRIA horizontal control point ILN-11 used as base station for the LiDAR data acquisition

Station Name	ILN-11	
Order of Accuracy	2nd Order	
Relative Error (horizontal positioning)	1:50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	18°3'26.86785" North 120°33'49.91547" East 42.96000 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	453,827.436 meters 1,998,122.81 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	7°12'52.33155" North 126°32'25.86780" East 69.522 meters
Grid Coordinates, Universal Transverse Mercator Zone 52 North (UTM 52N PRS 92)	Easting Northing	242,121.13 meters 1,998,122.81 meters

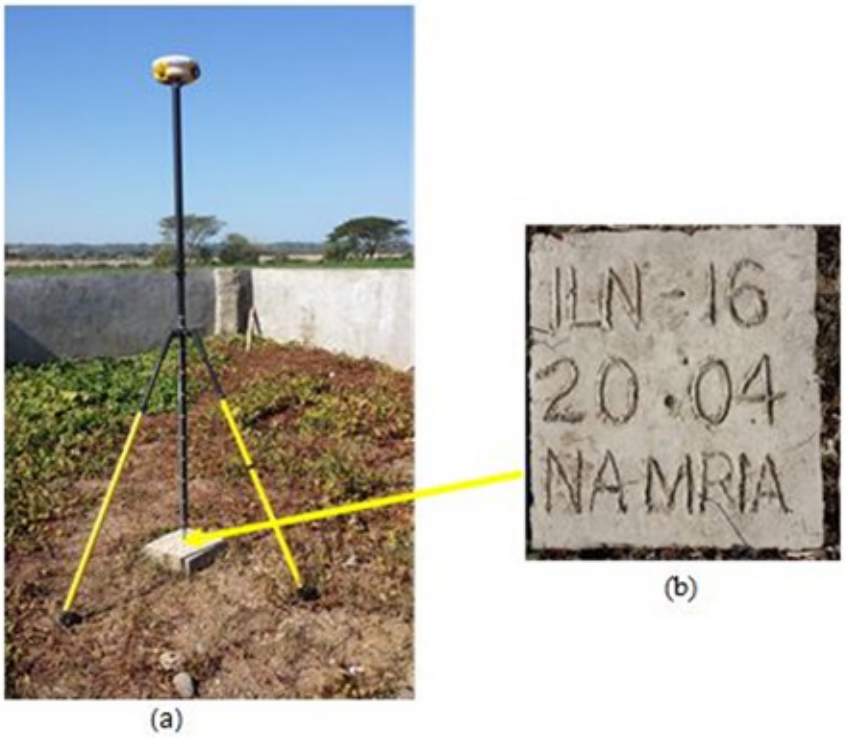


Figure 4. GPS set-up over ILN-16 located inside Bacarra Central Elementary School in Bacarra, Ilocos Norte (a) and NAMRIA reference point ILN-16 (b) as recovered by the field team.

Table 3. Details of the recovered NAMRIA horizontal control point ILN-16 used as base station for the LiDAR data acquisition.

Station Name	ILN-16	
Order of Accuracy	2nd Order	
Relative Error (horizontal positioning)	1:50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	18°15'10.11635" North 120°36'24.06955" East 22.50000 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	458,407.057 meters 2,018,785.646 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	18°15'3.85580" North 120°36'28.65812" East 53.87800 meters
Grid Coordinates, Universal Transverse Mercator Zone 52 North (UTM 52N PRS 92)	Easting Northing	246,937.75 meters 2,019,690.45 meters

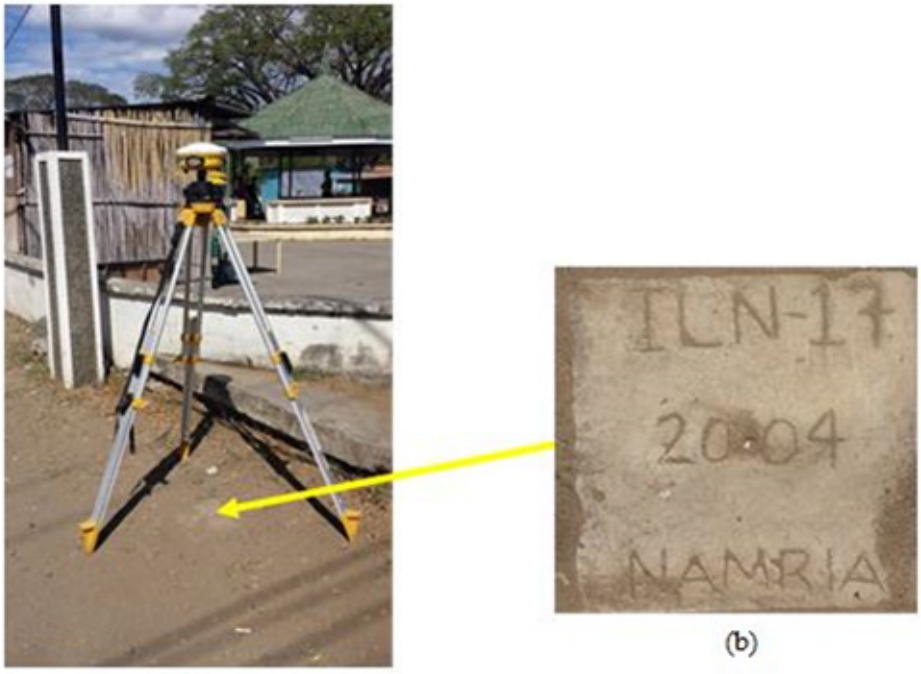


Figure 5. GPS set-up over ILN-17 located inside the park in front of Pasuquin Municipal Hall in Pasuquin Ilocos Norte (a) and NAMRIA reference point ILN-17 (b) as recovered by the field team.

Table 4. Details of the recovered NAMRIA horizontal control point ILN-17 used as base station for the LiDAR data acquisition.

Station Name	ILN-17	
Order of Accuracy	2nd Order	
Relative Error (horizontal positioning)	1:50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	18°20'6.62958" North 120°37'1.30945" East 16.73900 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	459,520.118 meters 2,027,898.996 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	18°20'0.3524" North 120°37'5.89113" East 47.87100 meters
Grid Coordinates, Universal Transverse Mercator Zone 52 North (UTM 52N PRS 92)	Easting Northing	248,151.17 meters 2,028,794.85 meters

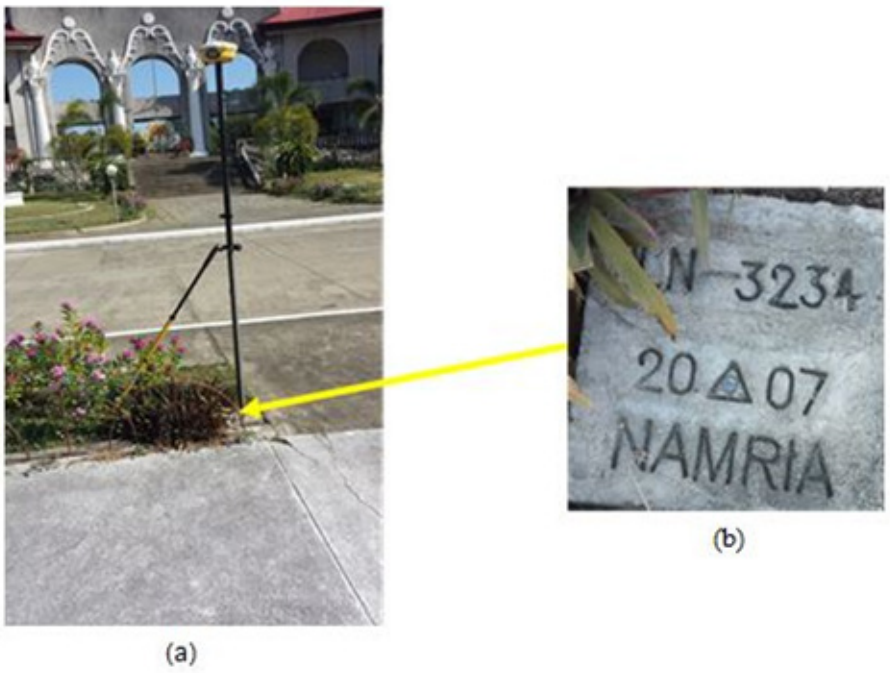


Figure 6. GPS set-up over ILN-3234 located in front of the Administration Building of Mariano Marcos Memorial University in Batac Ilocos Norte (a) and NAMRIA reference point ILN-3234 (b) as recovered by the field team.

Table 5. Details of the recovered NAMRIA horizontal control point ILN-3234 used as base station for the LiDAR data acquisition.

Station Name	ILN-3234	
Order of Accuracy	4th Order	
Relative Error (horizontal positioning)	1:10,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	18°3'41.82025" North 120°32'3.1072" East 22.632 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	452,075.694 meters 1,997,640.111 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	18°3'35.59528" North 120°32'54.91553" East 54.492 meters
Grid Coordinates, Universal Transverse Mercator Zone 52 North (UTM 52N PRS 92)	Easting Northing	240,373.73 meters 1,998,605.86 meters

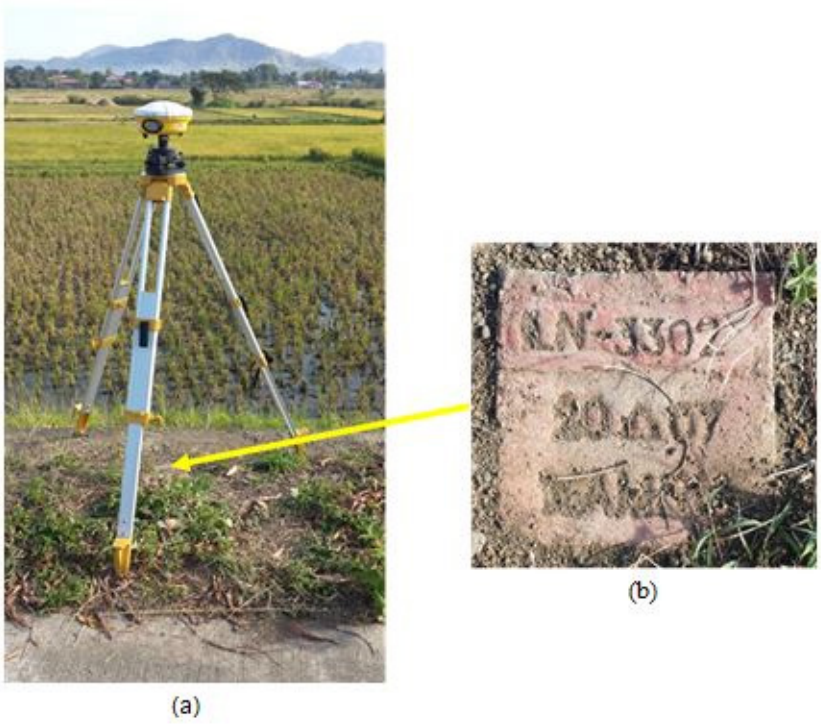


Figure 7. GPS set-up over ILN-3302 located near the public market of Barangay San Nicolas in Vintar Ilocos Norte (a) and NAMRIA reference point ILN-3302 (b) as recovered by the field team.

Table 6. Details of the recovered NAMRIA horizontal control point ILN-3302 used as base station for the LiDAR data acquisition.

Station Name	ILN-3302	
Order of Accuracy	4th Order	
Relative Error (horizontal positioning)	1:10,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	18°13'22.82114" North 120°38'50.91391" East 37.535 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	462,714.303 meters 2,015,478.316 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	18°13'16.56953" North 120°38'55.50479" East 69.108 meters
Grid Coordinates, Universal Transverse Mercator Zone 52 North (UTM 52N PRS 92)	Easting Northing	251, 210.34 meters 2,016,334.86 meters

Table 7. Ground control points used during the LiDAR data acquisition.

Date Surveyed	Flight Number	Mission Name	Ground Control Points
21-Feb-14	7085G	2BLK05G052A	ILN-11, ILN-3234
22-Feb-14	7087G	2BLK05GS053B & 2BLK05F053B	ILN-11, ILN-3234
23-Feb-14	7088G	2BLKFS054A & 2BLKE054A	ILN-11, ILN-3234
24-Feb-14	7091G	2BLK05ES055B & 2BLK05D055B	ILN-11, ILN-16
25-Feb-14	7092G	2BLK05DS056A & 2BLK05K056A	ILN-11, ILN-16
25-Feb-14	7093G	2BLK05C&A056B	ILN-11, ILN-16
26-Feb-14	7094G	2BLK05B057A & 2BLK05AS05B & 2BLK04F057A	ILN-16, ILN-3302
26-Feb-14	7095G	2BLK04C057B	ILN-16, ILN-3302
27-Feb-14	7097G	2BLK04A058B & 2BLK04B059B	ILN-16, ILN-17, ILN-3302
2-Mar-14	7102GC	2BLK04E061A & 2BLK04D061A	ILN-3234
2-Mar-14	7103GC	2CASITEST061B	ILN-3234

2.3 Flight Missions

A total of eleven (11) missions were conducted to complete the LiDAR data acquisition in Bacarra floodplain, for a total of thirty-eight hours and twenty-five minutes (38+25) of flying time for RP-C9322 (See Annex 6). All missions were acquired using Gemini LiDAR system. As shown below, the total area of actual coverage per mission and the corresponding flying hours are depicted in Table 8, while the actual parameters used during the LiDAR data acquisition are presented in Table 9.

Table 8. Flight missions for LiDAR data acquisition in Bacarra floodplain.

Date Surveyed	Flight Number	Flight Plan Area (km2)	Surveyed Area (km2)	Area Surveyed within the Floodplain (km2)	Area Surveyed Outside the Floodplain (km2)	Flying Hours	
						Hr	Min
21-Feb-14	7085G	146.90	129.54	1.03	128.51	2	59
22-Feb-14	7087G	321.92	253.85	21.19	232.66	4	17
23-Feb-14	7088G	328.82	170.84	44.54	126.30	3	41
24-Feb-14	7091G	110.91	169.13	69.53	99.61	3	47
25-Feb-14	7092G	175.00	209.11	37.01	172.10	3	41
25-Feb-14	7093G	125.95	201.70	69.88	131.82	3	23
26-Feb-14	7094G	143.84	176.14	45.80	130.34	3	59
26-Feb-14	7095G	55.73	77.98	0.00	77.98	2	41
27-Feb-14	7097G	138.95	157.33	0.00	157.33	3	41
2-Mar-14	7102GC	119.87	193.18	50.48	142.70	3	47
2-Mar-14	7103GC	153.80	73.01	33.53	128.51	2	29
TOTAL		1821.69	1811.80	372.97	1438.83	38	25

Table 9. Actual parameters used during LiDAR data acquisition

Flight Number	Flying Height (m AGL)	Overlap (%)	FOV (θ)	PRF (KHz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
7085G	1000	25	40	100	40	120	5
7087G	1000	30	40	100	50	120	5
7088G	1000	25	40	100	50	120	5
7091G	1000, 1400	25, 30	40	100, 70	50	120	5
7092G	1500	30	40	70	50	120	5
7093G	1500	25,30	40	100, 70	50	120	5
7094G	1200,1400, 1600	25,30	30,40	100, 70	50	120	5
7095G	1500	30	30	70	50	120	5
7097G	1200	40	30	100	50	120	5
7102G	1800	40	30	70	50	120	5
7103GC	1000	30	40	100	50	120	5

2.4 Survey Coverage

This certain LiDAR acquisition survey covered the Bacarra floodplain (See Annex 7). It is located in the province of Ilocos Norte with majority of the floodplain situated within the municipality of Bacarra. The list of municipalities and cities surveyed, with at least one (1) square kilometer coverage, is shown in Table 10. Figure 5, on the other hand, shows the actual coverage of the LiDAR acquisition for the Bacarra floodplain.

Table 10. List of municipalities and cities surveyed during Bacarra floodplain LiDAR survey

Province	Municipality/City	Area of Municipality/City (km2)	Total Area Surveyed (km2)	Percentage of Area Surveyed
Ilocos Norte	San Nicolas	40.23	40.23	100%
	Bacarra	47.10	47.10	100%
	Sarrat	92.25	92.25	100%
	Marcos	73.57	73.33	100%
	Banna	89.62	87.15	97%
	Laoag City	114.36	108.63	95%
	Dingras	90.65	84.86	94%
	Burgos	170.90	154.44	90%
	Pasuquin	154.16	133.38	87%
	Bangui	142.86	101.50	71%
	Piddig	128.57	83.34	65%
	Batac City	134.62	73.91	55%
	Vintar	497.40	189.27	38%
	Solsona	153.14	51.50	34%
	Paoay Lake	3.64	0.30	8%
	Paoay	71.62	3.92	5%
	Nueva Era	619.00	14.43	2%
	Dumalneg	82.95	1.51	2%
Total		**2706.6**	**1341.04**	**49.55%**

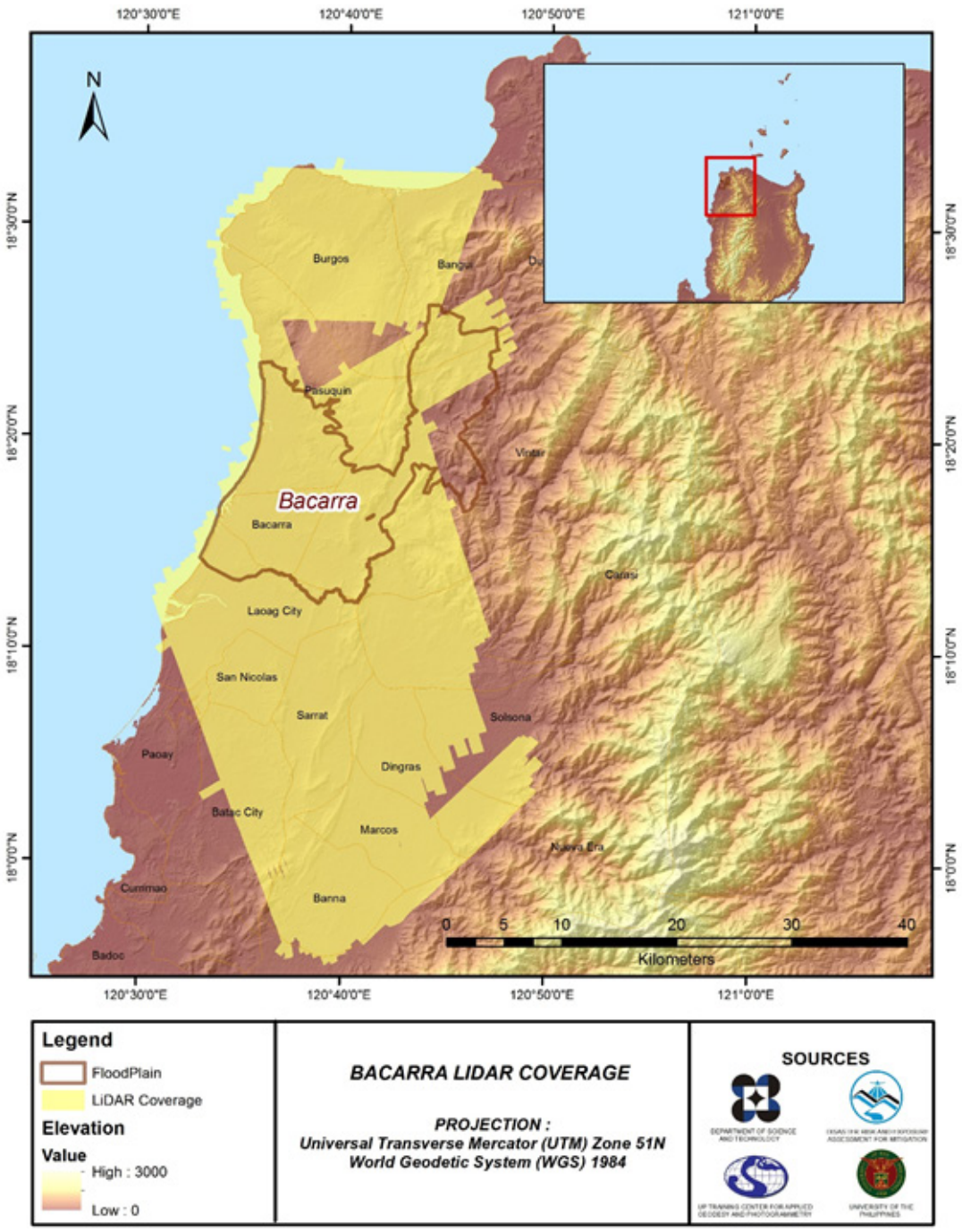


Figure 8. Actual LiDAR survey coverage for Bacarra floodplain

CHAPTER 3: LIDAR DATA PROCESSING OF THE BACARRA FLOODPLAIN

Engr. Ma. Rosario Concepcion O. Ang, Engr. John Louie D. Fabila, Engr. Sarah Jane D. Samalburo , Engr. Harmond F. Santos , Jovy Anne S. Narisma , Engr. Ma. Ailyn L. Olanda, Engr. Justine Y. Francisco, Engr. Kenneth A. Solidum , Engr. Jommer M. Medina, Carl Joshua S. Lacsina

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

3.1 Overview of the LIDAR Data Pre-Processing

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

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

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

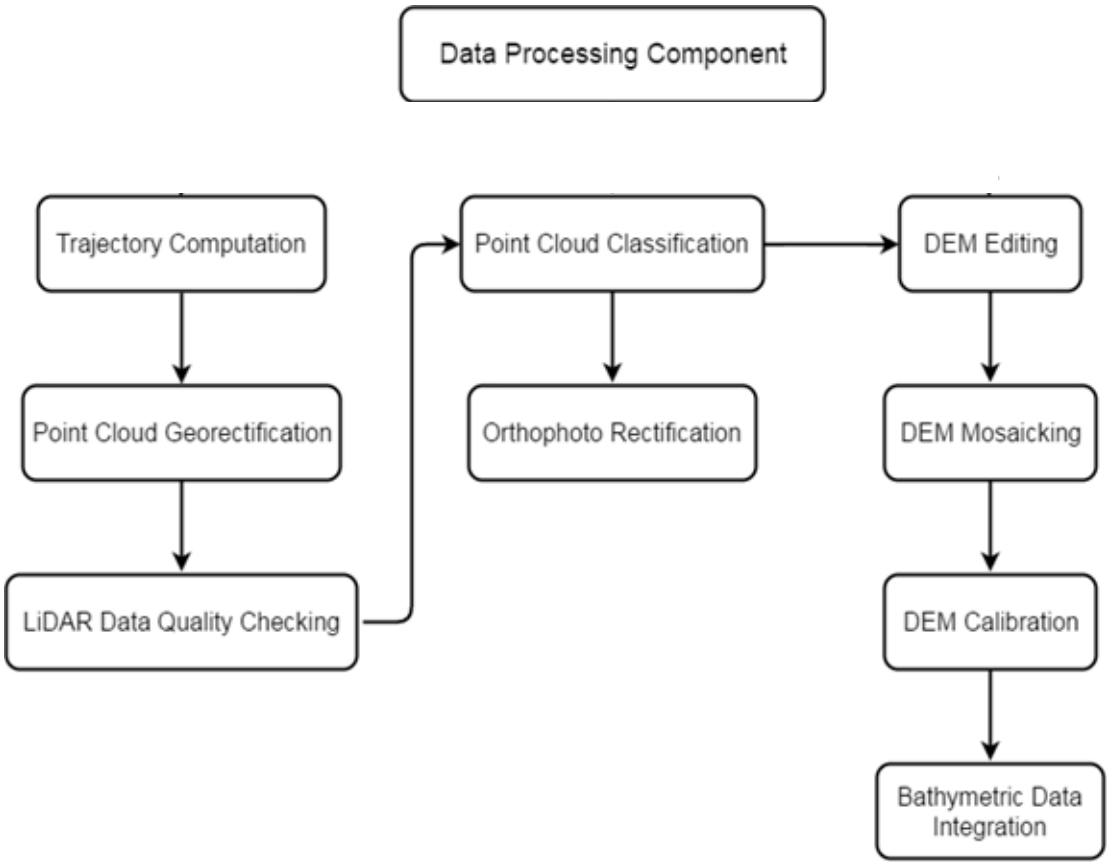


Figure 9. Schematic diagram for the data pre-processing.

3.2 Transmittal of Acquired LiDAR Data

Data transfer sheets for all the LiDAR missions of the Bacarra Floodplain can be found in Annex 5. The missions flown during the conduct of the survey in February 2014 utilized the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.) Gemini system over Bacarra, Ilocos Norte.

The Data Acquisition Component (DAC) transferred a total of 165.25 Gigabytes of Range data, 1.95 Gigabytes of POS data, 798.02 Megabytes of GPS base station data, and 28.5 Gigabytes of raw image data to the data server on March 19, 2014 for the survey. The Data Pre-processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for Bacarra was fully transferred on July 28, 2015, as indicated on the Data Transfer Sheets for Bacarra floodplain.

3.3 Trajectory Computation

The Smoothed Performance Metric parameters of the computed trajectory for Flight 7095G, one of the Bacarra flights, which is the North, East, and Down position RMSE values are shown in Figure 10. The x-axis corresponds to the time of the flight, which was measured by the number of seconds from the midnight of the start of the GPS week, which fell on the date and time of February 26, 2014, 00:00AM. The y-axis, on the other hand, represents the RMSE value for that particular position.

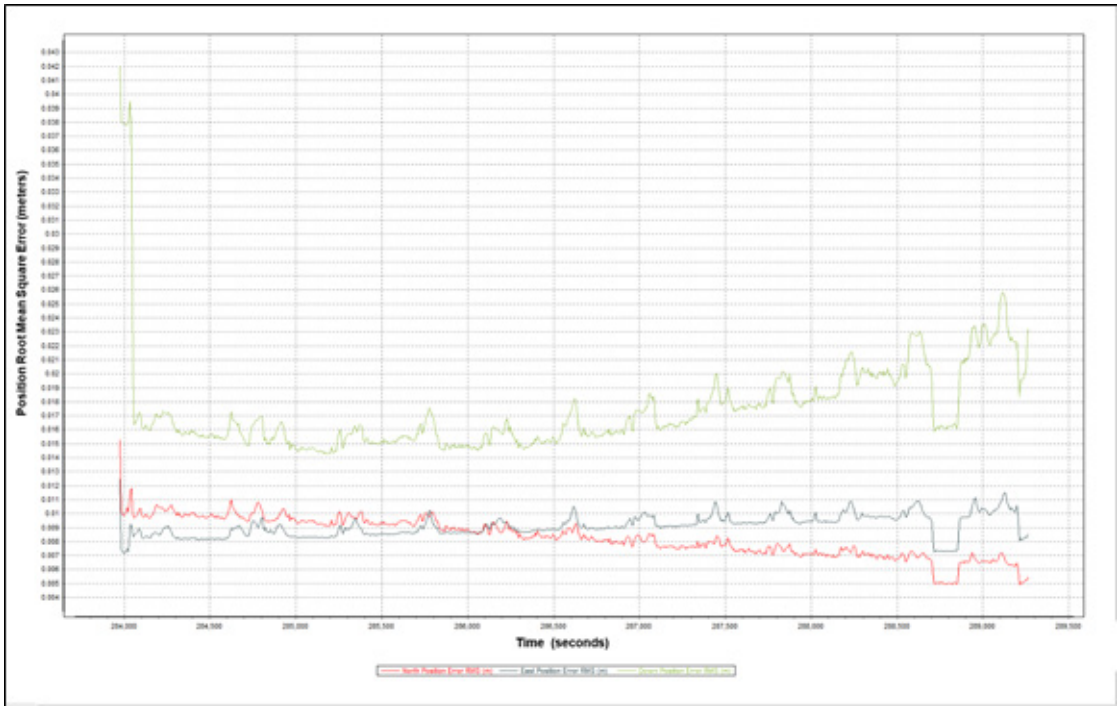


Figure 10. Smoothed Performance Metric Parameters of Bacarra Flight 7095G.

The time of flight was from 284,000 seconds to 289,500 seconds, which corresponds to afternoon of February 26, 2014. The initial spike that is seen on the data corresponds to the time that the aircraft was getting into position to start the acquisition, and the POS system starts computing for the position and orientation of the aircraft.

Redundant measurements from the POS system quickly minimized the RMSE value of the positions. The periodic increase in RMSE values from an otherwise smoothly curving RMSE values correspond to the turn-around period of the aircraft, when the aircraft makes a turn to start a new flight line. Figure 11 shows that the North position RMSE peaks at 1.50 centimeters, the East position RMSE peaks at 1. 20 centimeters, and the Down position RMSE peaks at 4.20 centimeters, which are within the prescribed accuracies described in the methodology.

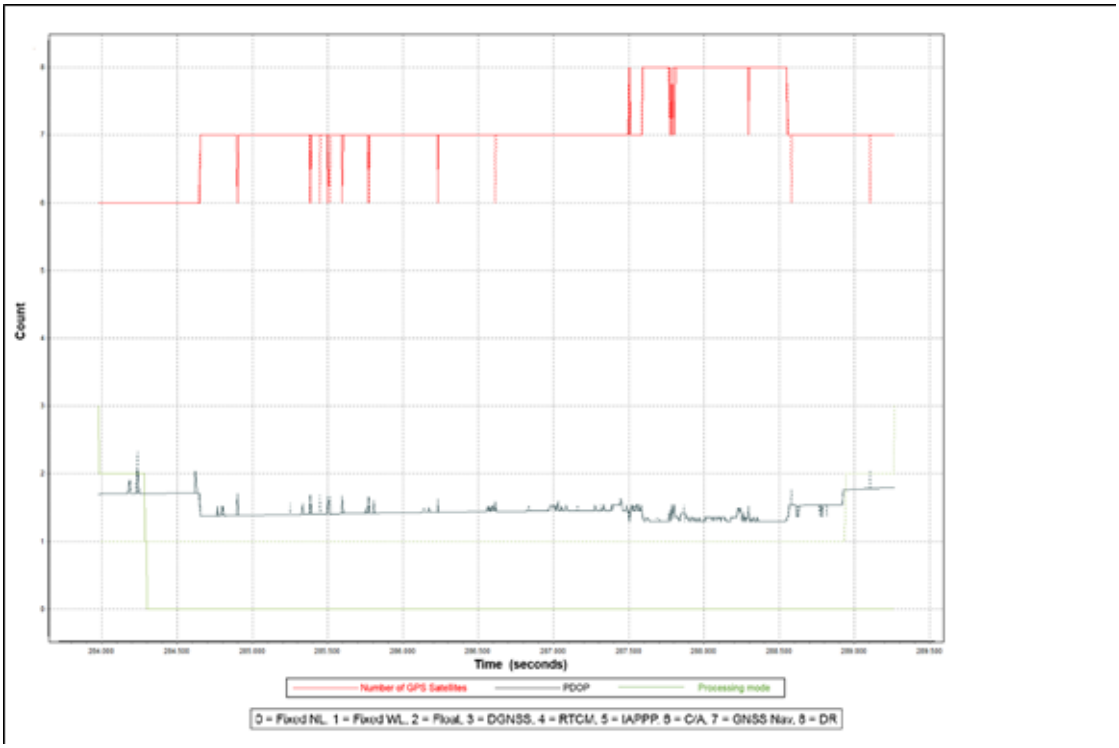


Figure 11. Solution Status Parameters of Bacarra Flight 7095G.

The Solution Status parameters, which indicate the number of GPS satellites; Positional Dilution of Precision (PDOP); and the GPS processing mode used for Bacarra Flight 7095G are shown in Figure 11. For the Solution Status parameters, the figure above signifies that the number of satellites utilized and tracked during the acquisition were between 6 and 8, not going lower than 6. Similarly, the PDOP value did not go above the value of 2.5, which indicates optimal GPS geometry. The processing mode also stayed at the value of 0 for the majority of the survey stayed at the value of 0 for majority of the survey with some peaks up to 1 attributed to the turns performed by the aircraft. The value of 0 corresponds to a Fixed, Narrow-Lane Mode, which is the optimum carrier-cycle integer ambiguity resolution technique available for the POSPAC MMS. Fundamentally, 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 Bacarra flights is shown in Figure 12.

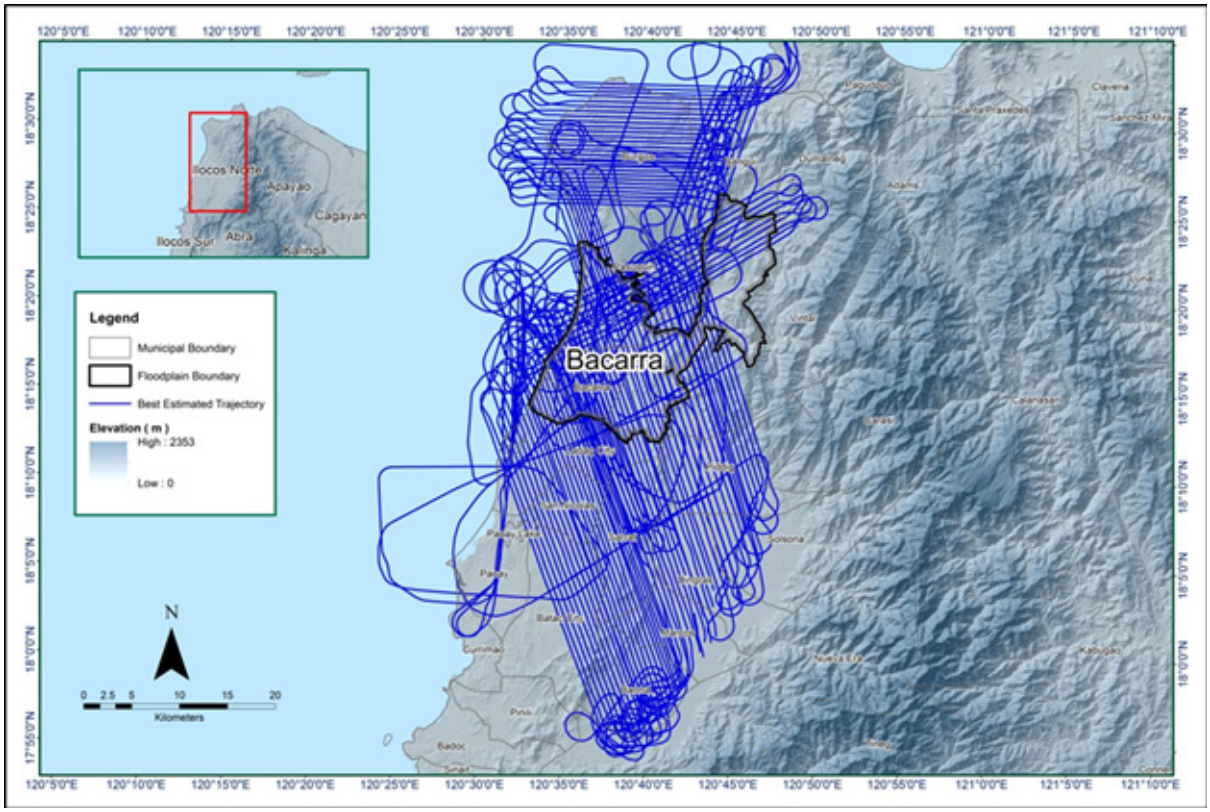


Figure 12. Best Estimated Trajectory of the LiDAR missions conducted over the Bacarra Floodplain.

3.4 LiDAR Point Cloud Computation

The produced LAS contains 154 flight lines, with each flight line contains one channel, since the Gemini system contains only one channel. The summary of the self-calibration results obtained from LiDAR processing in the LiDAR Mapping Suite (LMS) software for all flights over the Bacarra floodplain are given in Table 11.

Table 11. Self-calibration Results values for Bacarra flights.

Parameter	Acceptable Value	Computed Value
Boresight Correction stdev)	<0.001degrees	0.000261
IMU Attitude Correction Roll and Pitch Corrections stdev)	<0.001degrees	0.000865
GPS Position Z-correction stdev)	<0.01meters	0.0111

The optimum accuracy values for all Bacarra flights were also calculated, which are based on the computed standard deviations of the corrections of the orientation parameters. The standard deviation values for individual blocks are presented in the Mission Summary Reports (Annex 8).

3.5 LiDAR Quality Checking

The boundary of the processed LiDAR data on top of the SAR Elevation Data over the Bacarra Floodplain is shown in Figure 13. The map shows gaps in the LiDAR coverage that are attributed to cloud coverage.

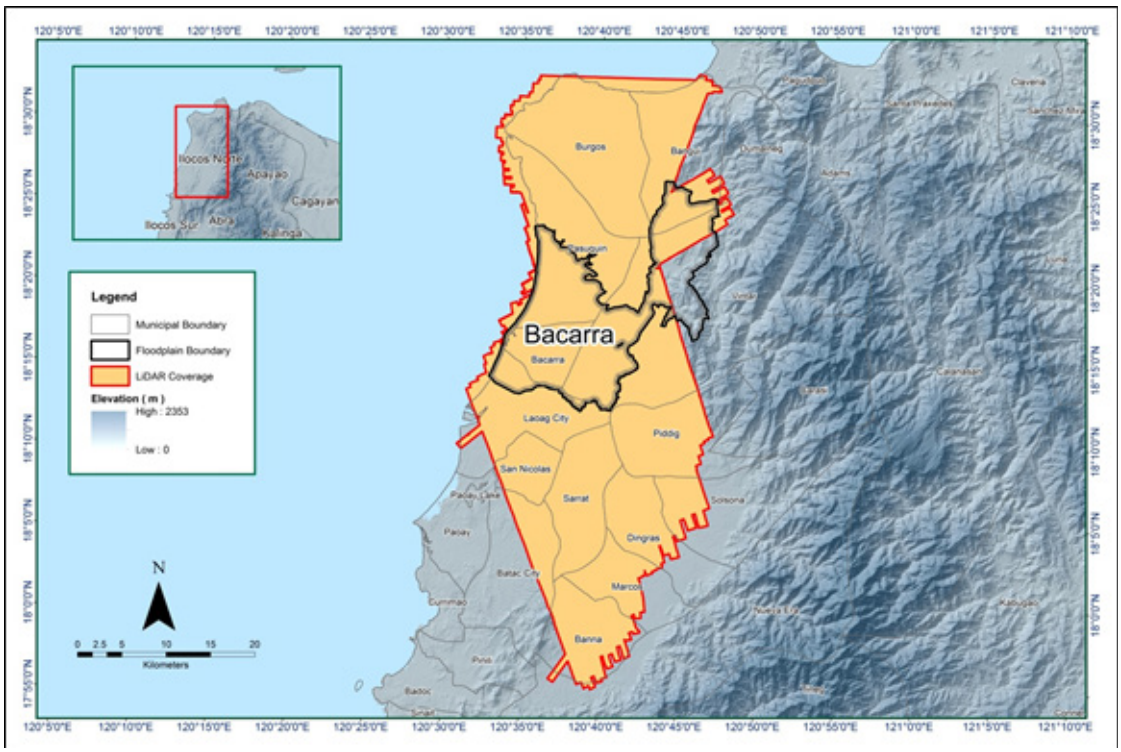


Figure 13. Boundaries of the processed LiDAR data over the Bacarra Floodplain.

A total area of 1,663.40 square kilometers (sq. kms.) were covered by the Bacarra flight missions as a result of eleven (11) flight acquisitions, which were grouped and merged into thirteen (13) block accordingly, as portrayed in Table 12.

Table 12. List of LiDAR blocks for the Bacarra floodplain.

LiDAR Blocks	Flight Numbers	Area (sq.km)
Ilocos_Blk04AB	7097G	159.58
Ilocos_Blk04C	7095G	75.99
Ilocos_Blk04DE	7102G	186.82
Ilocos_Blk04F	7094G	40.34
Ilocos_Blk05A	7093G	174.75
	7094G	
Ilocos_Blk05B	7094G	112.07
Ilocos_Blk05C	7093G	155.84
Ilocos_Blk05D	7092G	91.81
Ilocos_Blk05D_supplement_E_supplement	7091G	146.47
Ilocos_Blk05E_supplement	7103GC	71.30
Ilocos_Blk05EF	7088G	164.15
Ilocos_Blk05EF_additional	7087GC	163.33
Ilocos_Blk05G	7085G	120.95
TOTAL		**1663.40 sq.km**

The overlap data for the merged LiDAR blocks, showing the number of channels that pass through a particular location is shown in Figure 14. Since the Gemini system employs one channel, we would expect an average value of 1 (blue) for areas where there is limited overlap, and a value of 2 (yellow) or more (red) for areas with three or more overlapping flight lines.

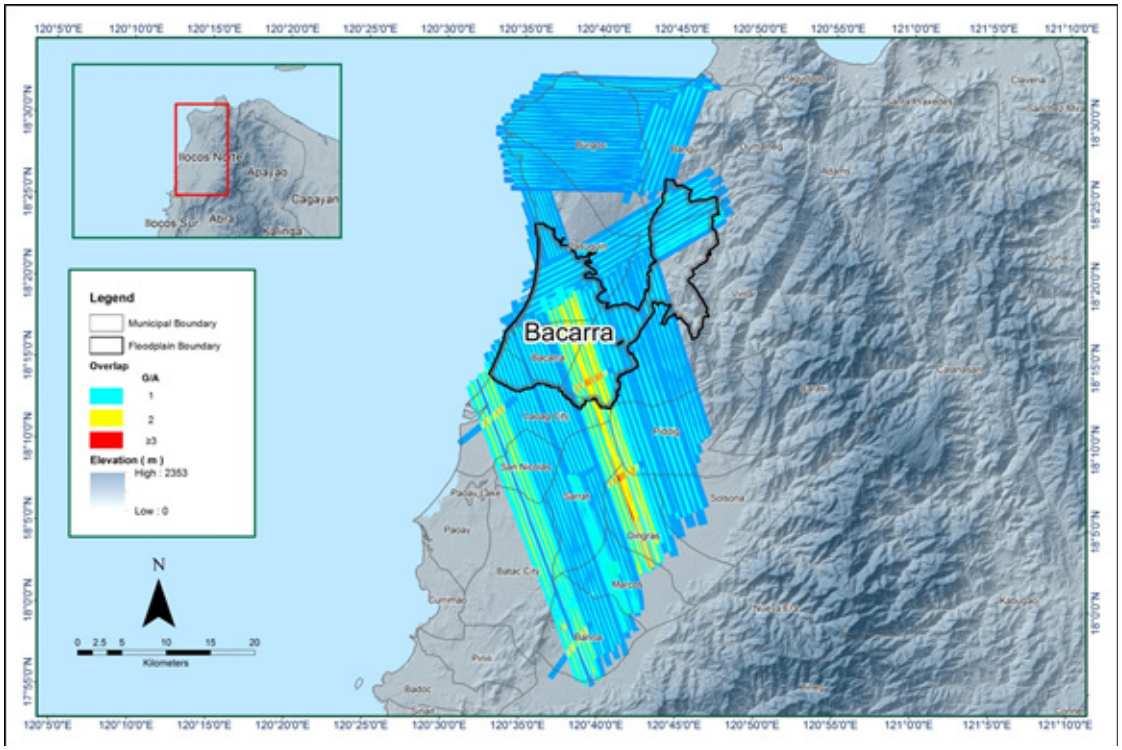


Figure 14. Image of data overlap for Bacarra floodplain.

The overlap statistics per block for the Bacarra floodplain can be found in the Mission Summary Reports (Annex 8). One pixel corresponds to 25.0 square meters on the ground. For this area, the percent overlap is 25.42%, which passed the 25% requirement.

The pulse density map for the merged LiDAR data, with the red parts showing the portions of the data that satisfy the two (2) points per square meter criterion is shown in Figure 15. As seen in the figure below, it was determined that all LiDAR data for the Bacarra Floodplain Survey satisfy the point density requirement, as the average density for the entire survey area is 2.85 points per square meter.

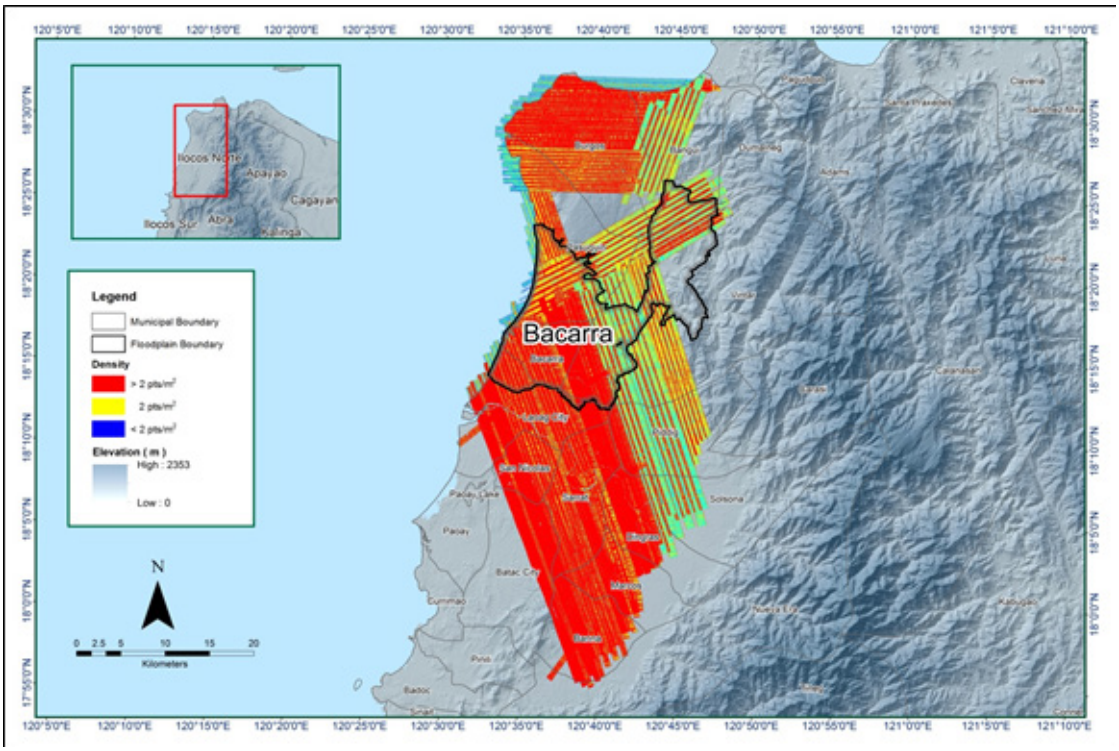


Figure 15. Pulse density map of the merged LiDAR data for Bacarra floodplain.

The elevation difference between overlaps of adjacent flight lines is shown in Figure 16. The default color range is blue to red, where bright blue areas correspond to portions where elevations of a previous flight line are higher by more than 0.20m, as identified by its acquisition time; which is relative to the elevations of its adjacent flight line. Similarly, bright red areas indicate portions where elevations of a previous flight line are lower by more than 0.20m, relative to the elevations of its adjacent flight line. Areas highlighted in bright red or bright blue necessitate further investigation using the Quick Terrain Modeler software.

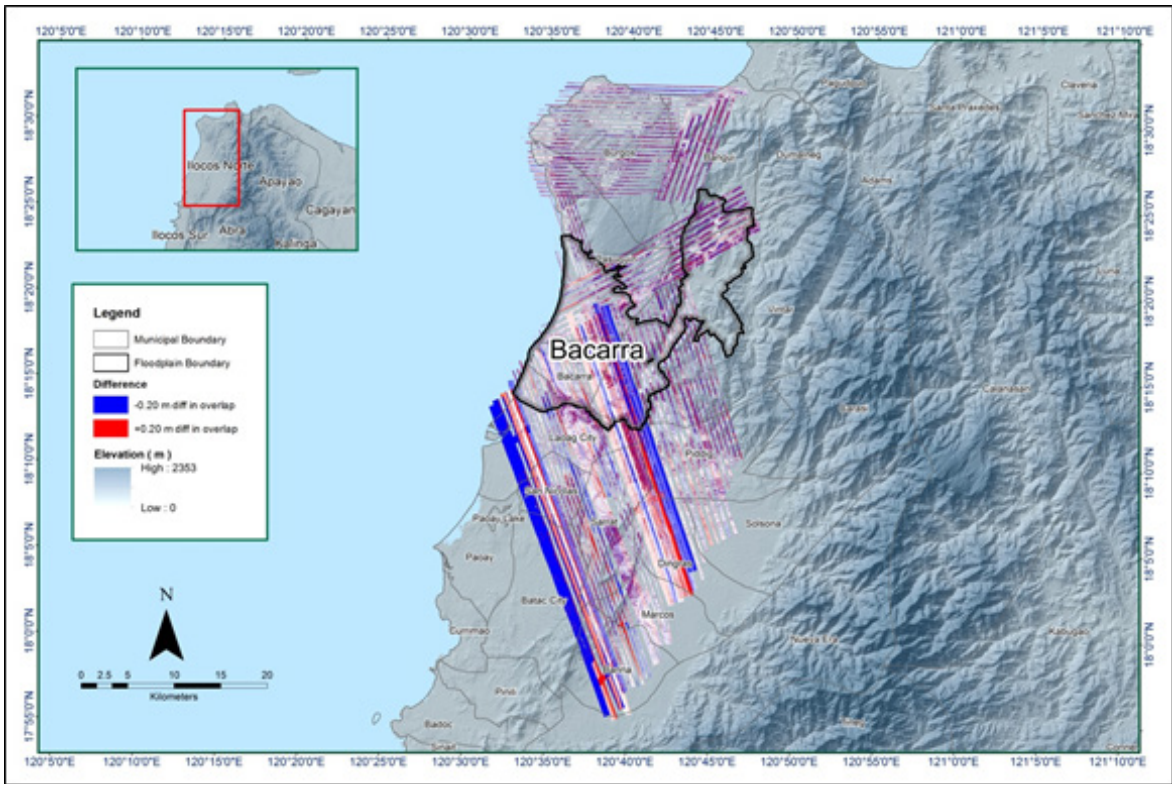


Figure 16. Elevation difference Map between flight lines for the Bacarra Floodplain Survey.

A screen-capture of the processed LAS data from Bacarra flight 7095G loaded in QT Modeler is shown in Figure 17. The upper left image shows the elevations of the points from two overlapping flight strips traversed by the profile, illustrated by a dashed red line. The x-axis corresponds to the length of the profile. It is evident that there are differences in elevation, but the differences do not exceed the 20-centimeter mark. This profiling was repeated until the quality of the LiDAR data generated satisfactory results. No reprocessing was done for this LiDAR dataset.

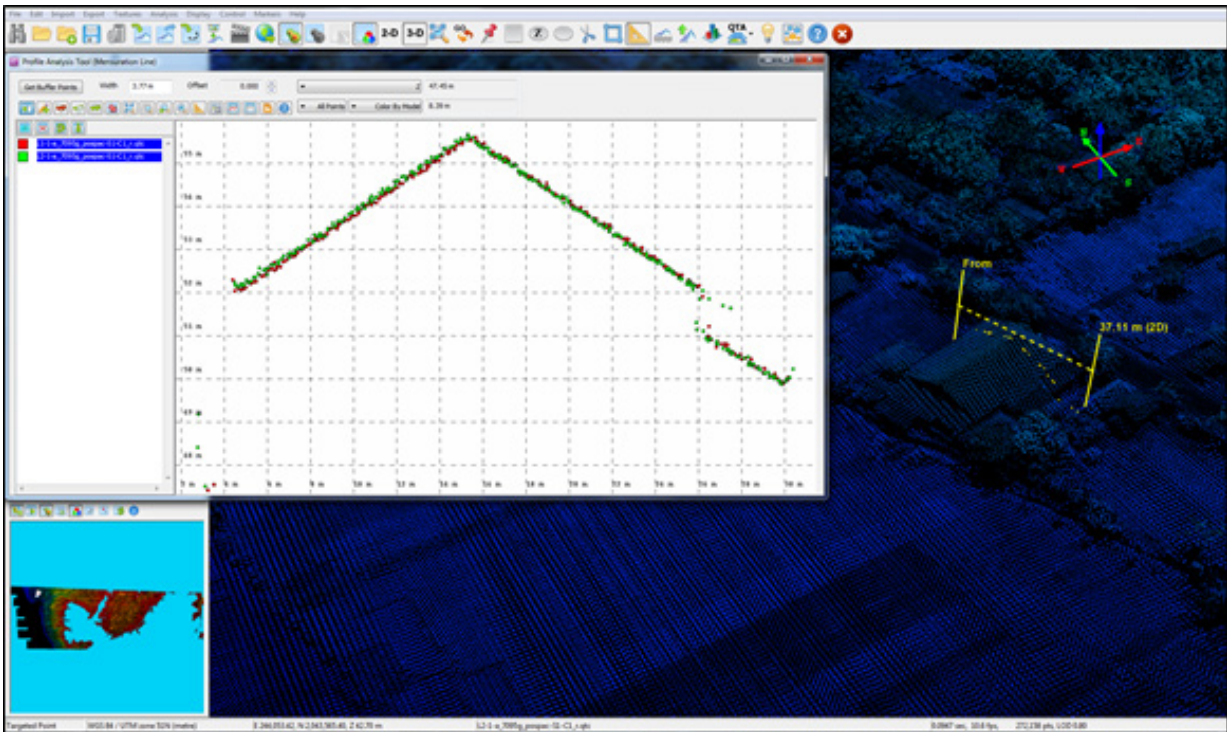


Figure 17. Quality checking for Bacarra flight 1560A using the Profile Tool of QT Modeler.

3.6 LiDAR Point Cloud Classification and Rasterization

Table 13. Bacarra classification results in TerraScan.

Pertinent Class	Total Number of Points
Ground	769,386,371
Low Vegetation	963,612,197
Medium Vegetation	1,077,575,615
High Vegetation	1,784,370,510
Building	67,989,087

The tile system that TerraScan employed for the LiDAR data as well as the final classification image for a block of the Bacarra floodplain is shown in Figure 18. A total of 2,384 tiles with 1 km. X 1 km. (one kilometer by one kilometer) size were produced. Correspondingly, Table 13 summarizes the number of points classified to the pertinent categories. The point cloud has a maximum and minimum height of 629.52 meters and 37.83 meters respectively.

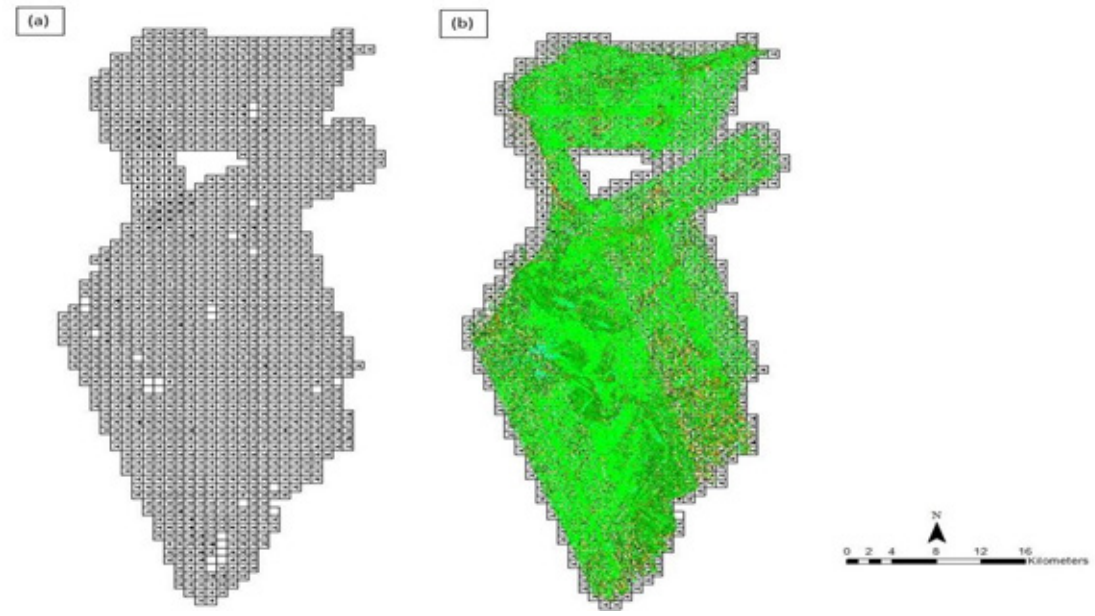


Figure 18. Tiles for Bacarra floodplain (a) and classification results (b) in TerraScan.

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

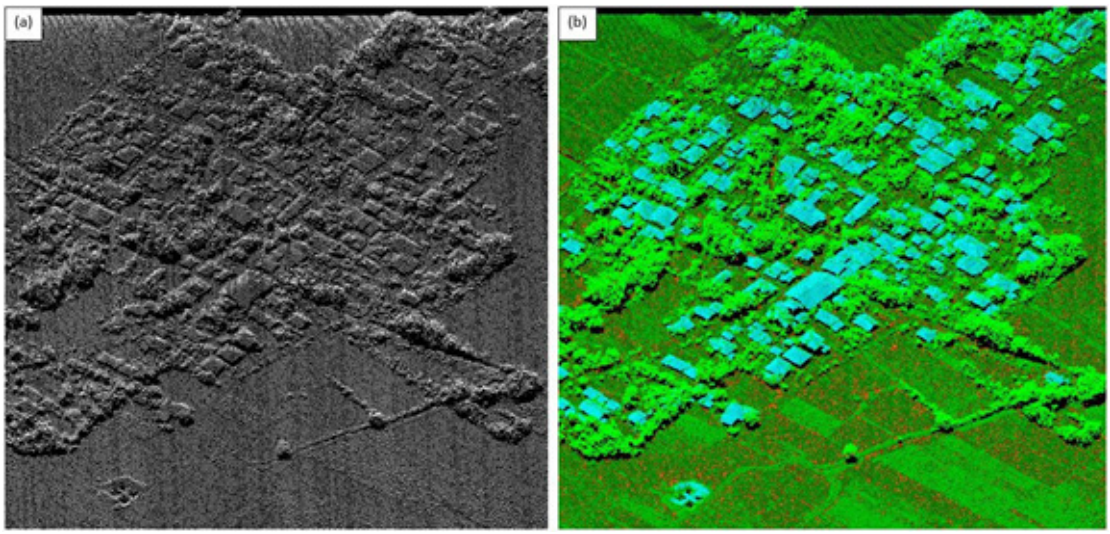


Figure 19. Point cloud before (a) and after (b) classification.

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

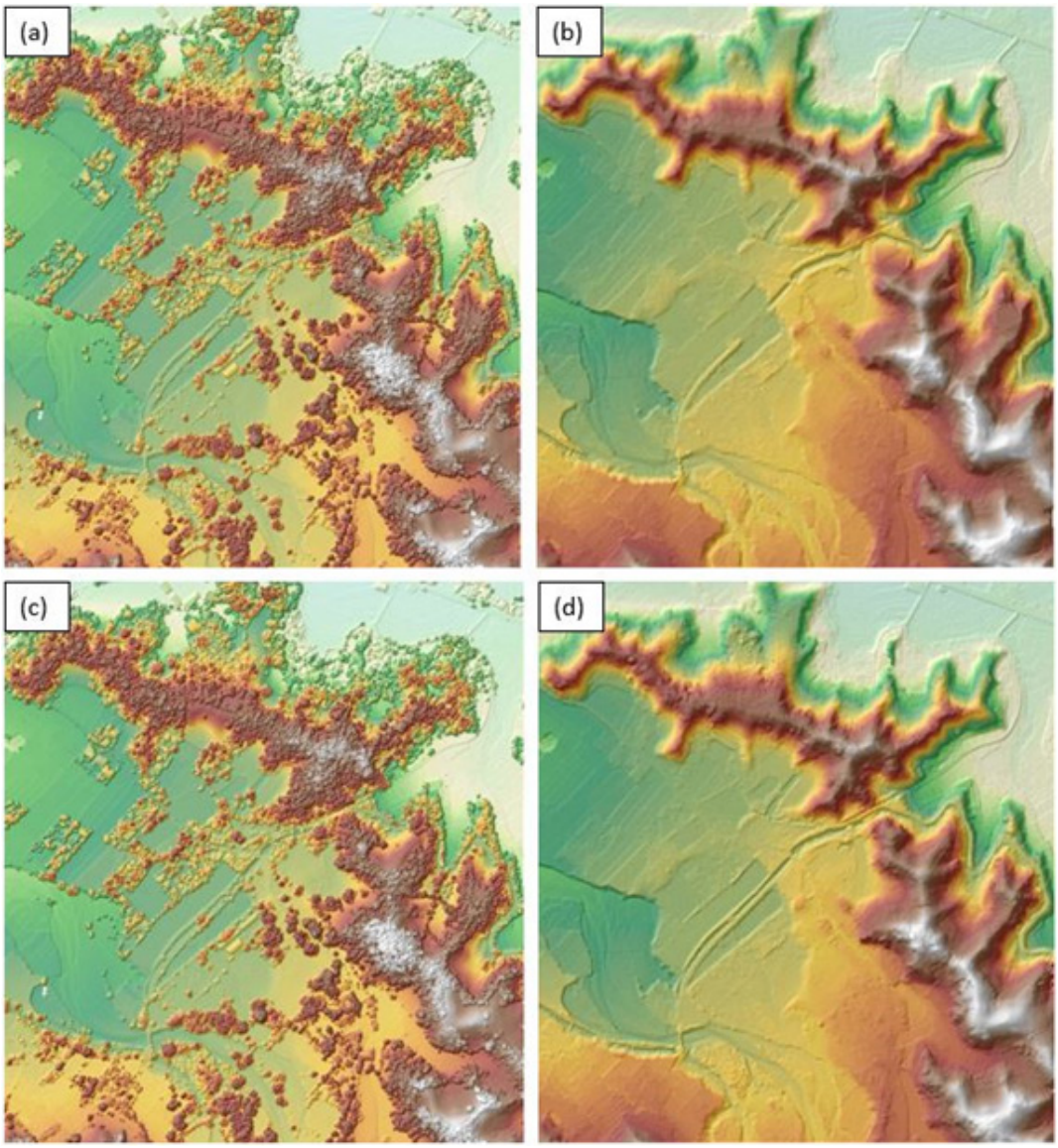


Figure 20. The production of last return DSM (a) and DTM (b), first return DSM (c) and secondary DTM (d) in some portion of Bacarra floodplain.

3.7 LiDAR Image Processing and Orthophotograph Rectification

There are no available orthophotographs for the Bacarra floodplain.

3.8 DEM Editing and Hydro-Correction

Thirteen (13) mission blocks were processed for the Bacarra Floodplain Survey. The blocks is composed of Ilocos blocks with a total area of 1,663.40 square kilometers. Table 14 shows the name and corresponding area of each block in square kilometers.

Table 14. LiDAR blocks with its corresponding areas.

LiDAR Blocks	Area (sq. km.)
LiDAR Blocks	Area (sq. km.)
Ilocos_Blk04AB	159.58
Ilocos_Blk04C	75.99
Ilocos_Blk04DE	186.82
Ilocos_Blk04F	40.34
Ilocos_Blk05A	174.75
Ilocos_Blk05B	112.07
Ilocos_Blk05C	155.84
Ilocos_Blk05D	91.81
Ilocos_Blk05D_supplement_E_supplement	146.47
Ilocos_Blk05E_supplement	71.30
Ilocos_Blk05EF	164.15
Ilocos_Blk05EF_additional	163.33
Ilocos_Blk05G	120.95
TOTAL	1663.40 sq.km

Figure 21 shows portions of a DTM before and after manual editing. As evident in the figure, the bridge (Figure 21a) has obstructed the flow of water along the river. To correct the river hydrologically, the bridge was removed through manual editing (Figure 21b). The mountain (Figure 21c) has been misclassified and removed during classification process and has to be retrieved to complete the surface (Figure 21d).

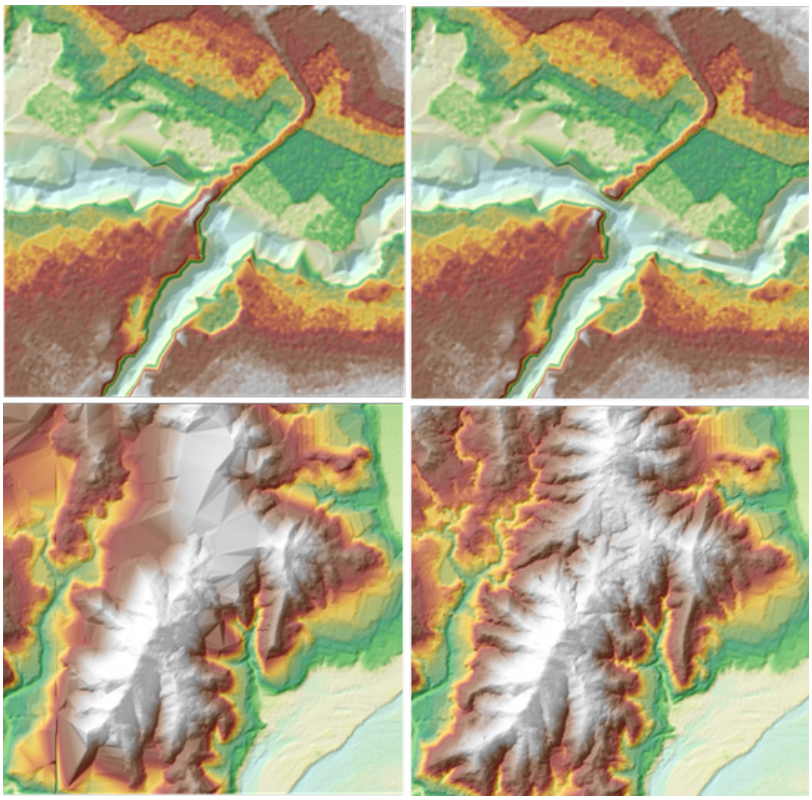


Figure 21. Portions in the DTM of the Bacarra Floodplain – a bridge before (a) and after (b) manual editing; a mountain before (c) and after (d) data retrieval.

3.9 Mosaicking of Blocks

Ilocos_Blk5A was used as the reference block at the start of mosaicking because it was referred to a base station with an acceptable order of accuracy. Table 15 shows the shift values applied to each LiDAR block during mosaicking.

Mosaicked LiDAR DTM for Bacarra Floodplain is shown in Figure 22. Map of processed LiDAR data for the Bacarra Floodplain. It can be seen that the entire Bacarra floodplain is 87.04% covered by LiDAR data.

Table 15. Shift values of each LiDAR block of Bacarra Floodplain.

Mission Blocks	Shift Values (meters)		
	x	y	z
Ilocos_Blk04AB	0.00	0.00	0.00
Ilocos_Blk04C	-4.00	0.70	-0.65
Ilocos_Blk04DE	0.00	0.00	0.00
Ilocos_Blk04F	0.40	-0.70	-0.72
Ilocos_Blk05A	0.00	0.00	0.00
Ilocos_Blk05B	0.00	0.00	-0.18
Ilocos_Blk05C	0.00	0.00	-0.07
Ilocos_Blk05D	0.00	0.00	-0.14
Ilocos_Blk05D_supplement_E_ supplement	0.00	0.00	0.36
Ilocos_Blk05EF	0.00	0.00	0.17
Ilocos_Blk05EF_additional	-1.20	1.40	-0.30
Ilocos_Blk05G	-1.00	1.50	-0.25

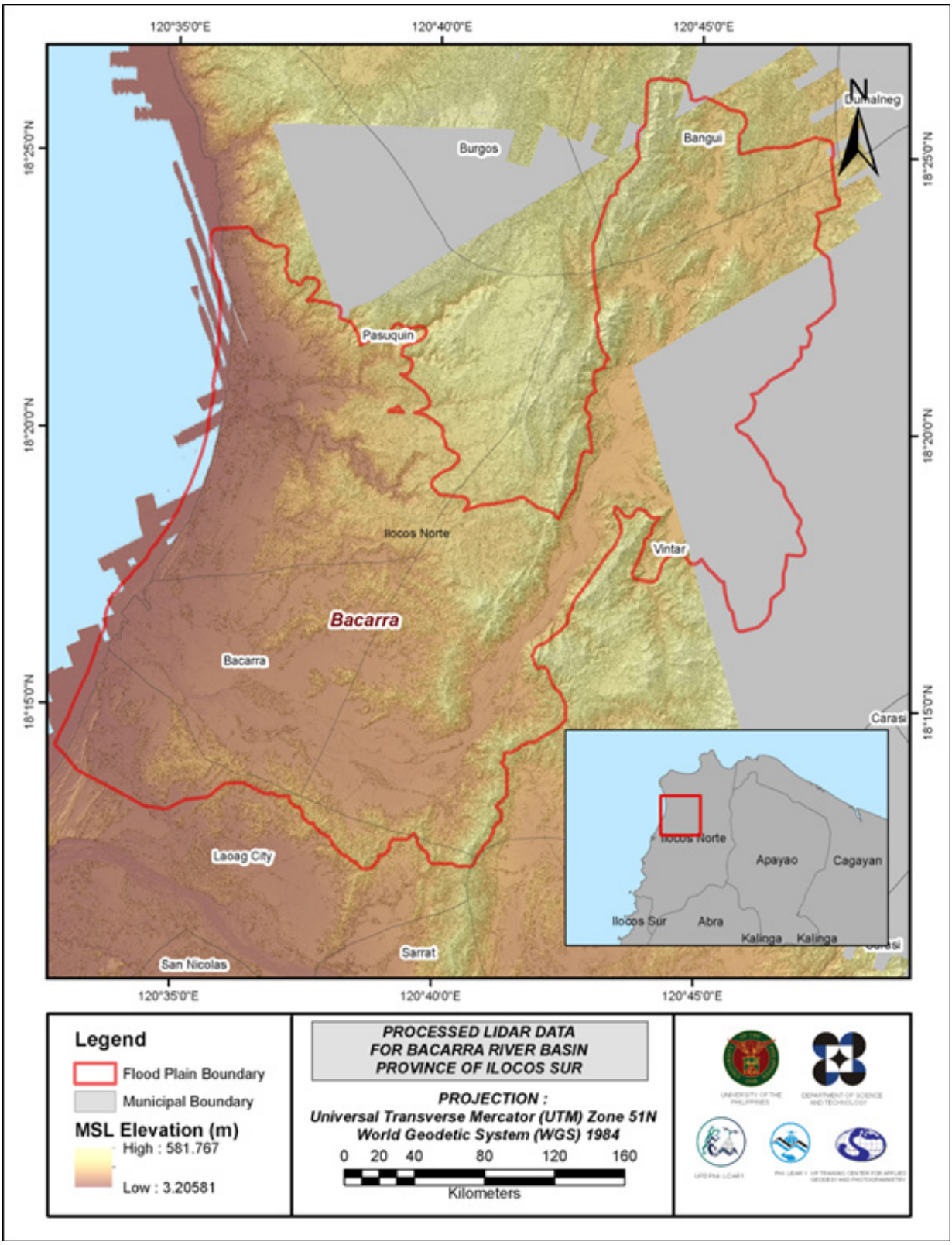


Figure 22. Map of processed LiDAR data for the Bacarra Floodplain.

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 Bacarra to collect points with which the LiDAR dataset is validated is shown in Figure 23, with the validation survey points highlighted in green. A total of 1,427 survey points were gathered for the Bacarra floodplain and were used for calibration. Random selection of 80% of the survey points, resulting to 1427 points, was used for calibration.

A good correlation between the uncalibrated LiDAR DTM and the ground survey elevation values is shown in Figure 24. Statistical values were computed from extracted LiDAR values using the selected points to assess the quality of the data and obtain the value for vertical adjustment. The computed height difference between the LiDAR DTM and calibration points is 5.2 meters, with a standard deviation of 1.54 meters. The calibration of the LiDAR data was accomplished by subtracting the height difference value of 5.2 meters to the mosaicked LiDAR data. Table 16 shows the statistical values of the compared elevation values between the Bacarra LiDAR data and the calibration data.

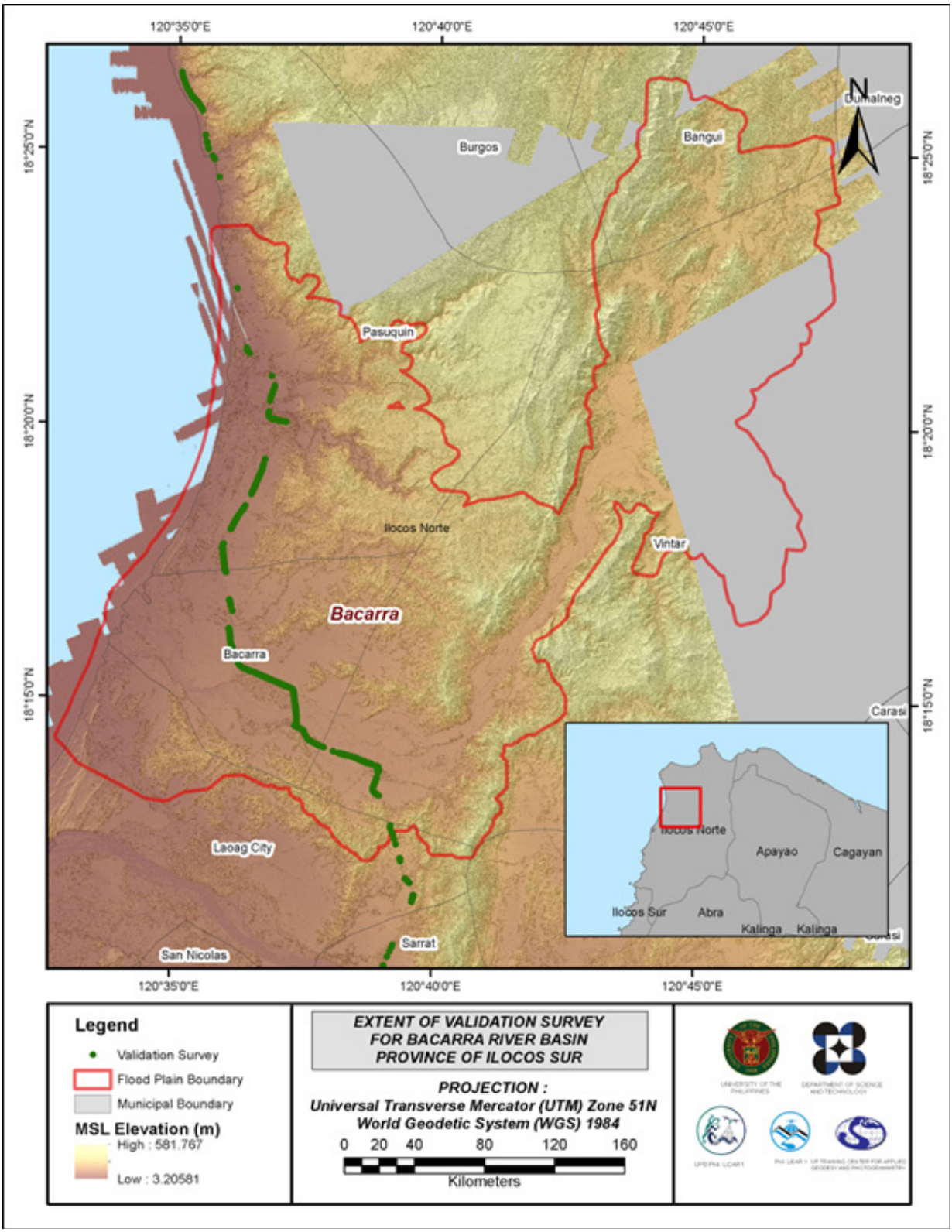


Figure 23. Map of Bacarra Floodplain with validation survey points in green.

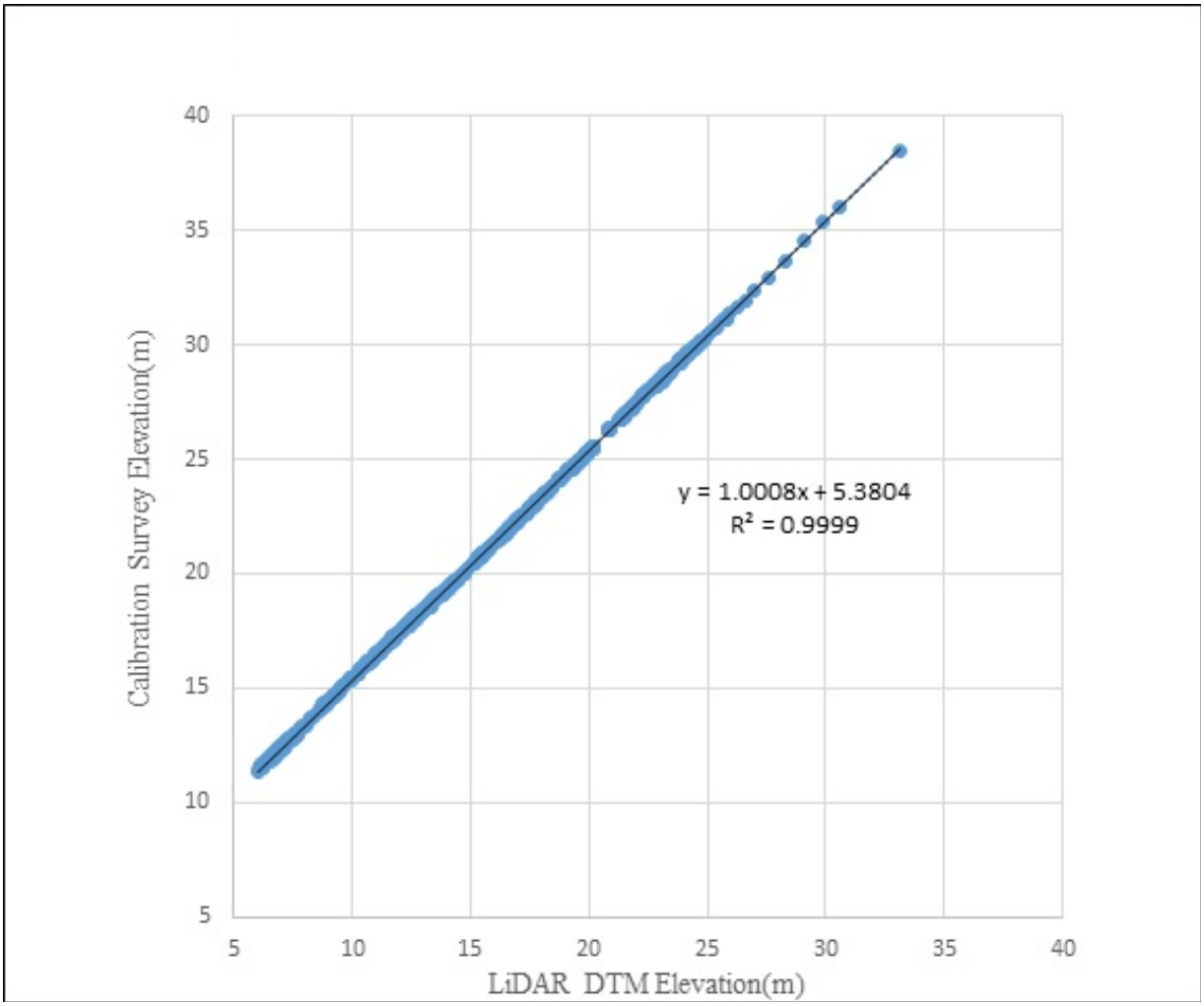


Figure 24. Correlation plot between calibration survey points and LiDAR data.

Table 16. Calibration Statistical Measures.

Calibration Statistical Measures	Value (meters)
Height Difference	5.20
Standard Deviation	1.54
Average	-4.96
Minimum	8.05
Maximum	-1.88

All survey points were used to validate the calibrated Bacarra DTM. A good correlation between the calibrated mosaicked LiDAR elevation and the ground survey elevation values, which point toward the quality of the LiDAR DTM is shown in Figure 25. The computed RMSE value between the calibrated LiDAR DTM and the validation elevation values is at 0.10 meters with a standard deviation of 0.09 meters, as shown in Table 17.

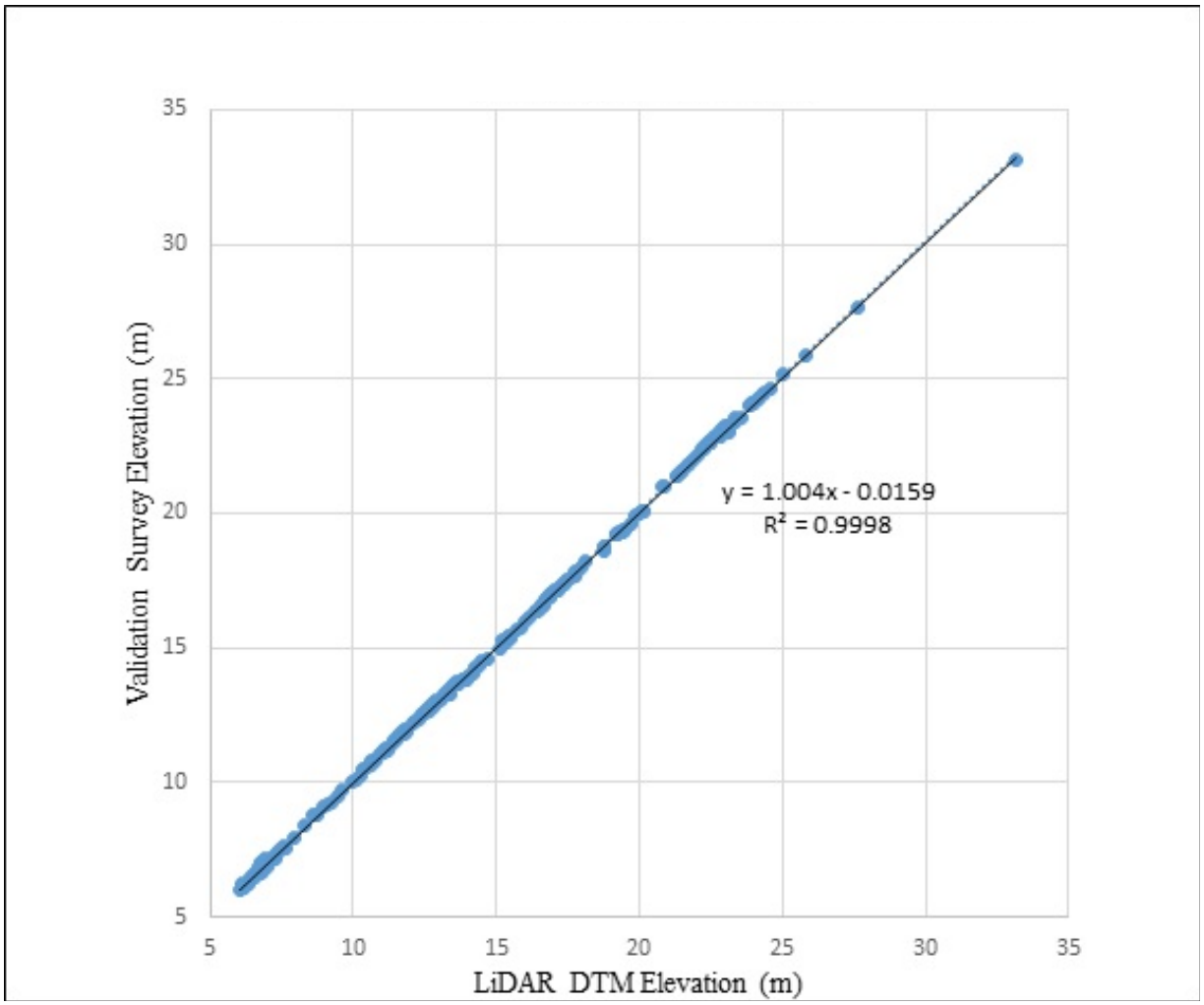


Figure 25. Correlation plot between the validation survey points and the LiDAR data.

Table 17. Validation Statistical Measures

Validation Statistical Measures	Value (meters)
RMSE	0.10
Standard Deviation	0.09
Average	-0.04
Minimum	-0.23
Maximum	0.16

3.11 Integration of Bathymetric Data into the LiDAR Digital Terrain Model

For bathy integration, centerline and zigzag data were available for Bacarra with a total of 947 bathymetric survey points. The resulting raster surface produced was done by Inverse Distance Weighted (IDW) interpolation method. After burning the bathymetric data to the calibrated DTM, assessment of the interpolated surface is represented by the computed RMSE value of 0.07 meters. The extent of the bathymetric survey done by the Data Validation and Bathymetry Component (DVBC) in Bacarra integrated with the processed LiDAR DEM is shown in Figure 26.

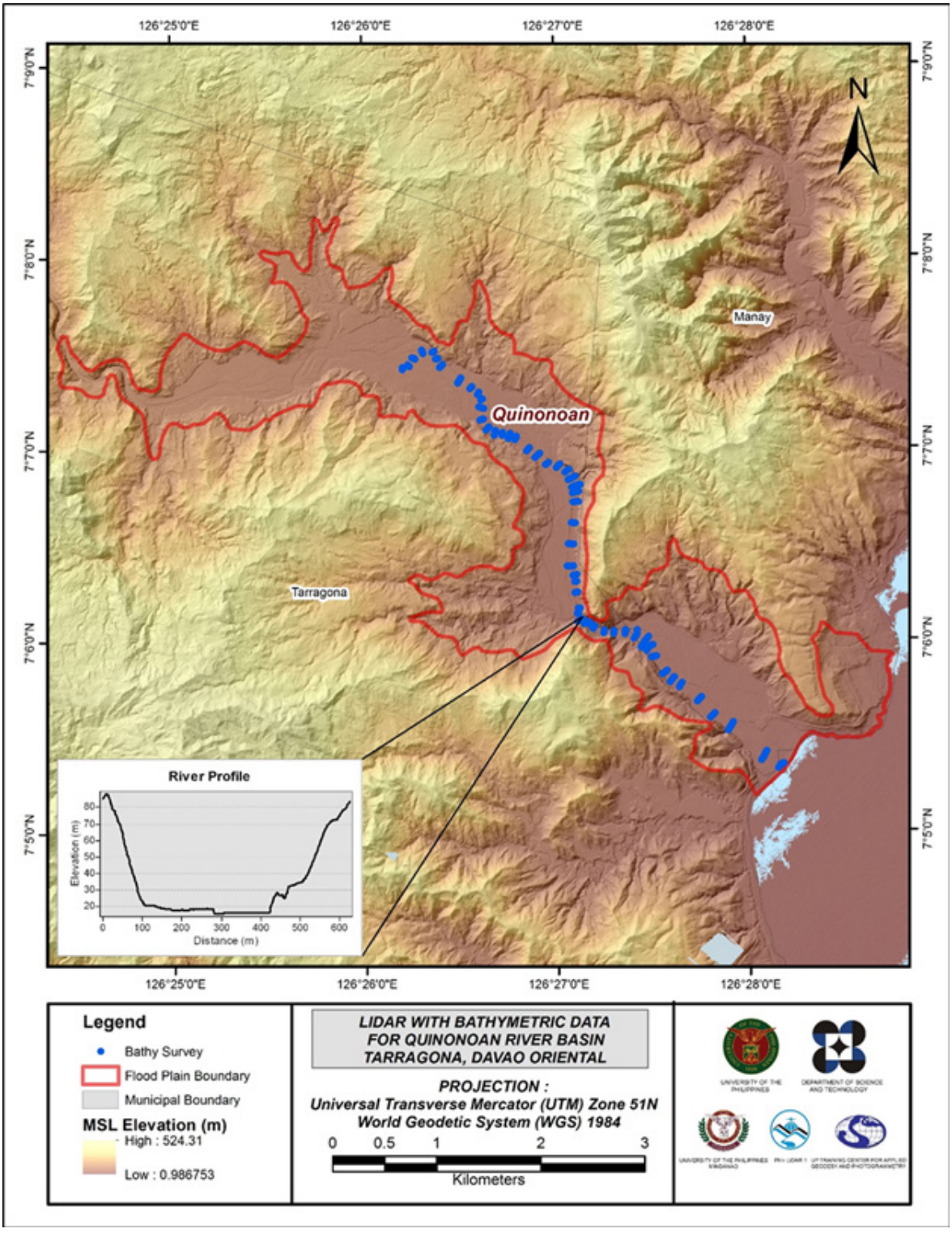


Figure 26. Map of Bacarra floodplain with bathymetric survey points in blue.

3.12 Feature Extraction

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

3.12.1 Quality Checking (QC) of Digitized Features' Boundary

Bacarra floodplain, including its 200-m buffer, has a total area of 317.30 sq km. For this area, a total of 10.0 sq. km., corresponding to a total of 1,754 building features, were considered for QC. Figure 27 shows the QC block for the Bacarra floodplain.

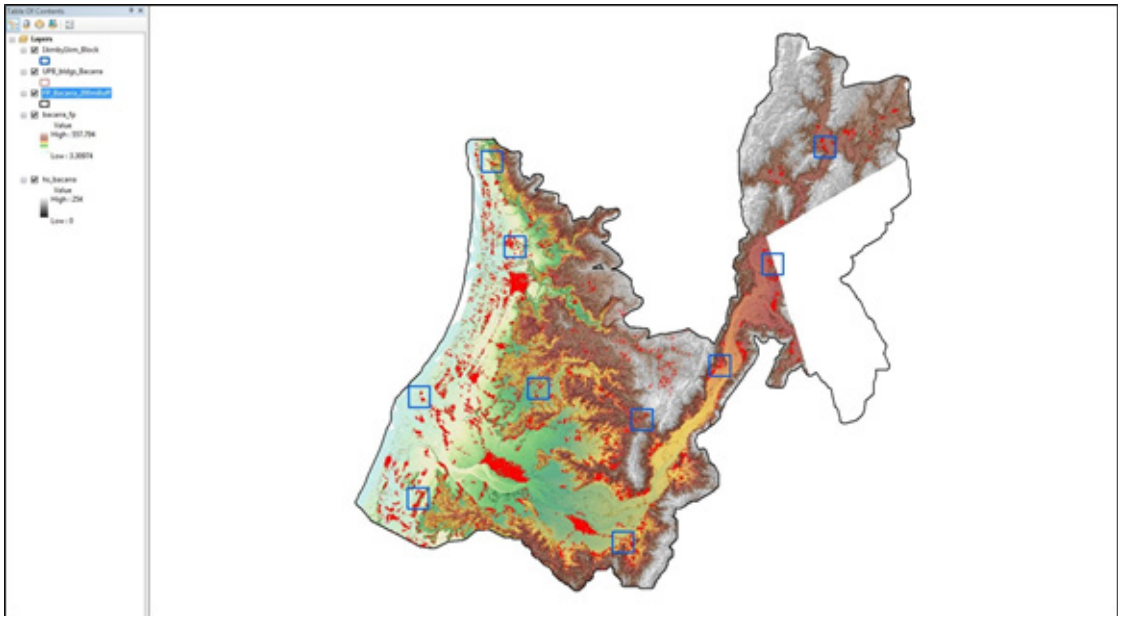


Figure 27. Block (in blue) of Bacarra building features that was subjected to QC.

Quality checking of Bacarra building features resulted in the ratings shown in Table 18.

Table 18. Details of the quality checking ratings for the building features extracted for the Bacarra River Basin.

FLOODPLAIN	COMPLETENESS	CORRECTNESS	QUALITY	REMARKS
Bacarra	98.37	100.00	96.10	PASSED

3.12.2 Height Extraction

Height extraction was done for 24,400 building features in Bacarra floodplain. Of these building features, 647 were filtered out after height extraction, resulting to 23,793 buildings with height attributes. The lowest building height is at 2.00 meters, while the highest building is at 12.56 meters.

3.12.3 Feature Attribution

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

Table 19 summarizes the number of building features per type, while Table 20 shows the total length of each road type. Table 21, on the other hand, shows the number of water features extracted per type.

Table 19. Building features extracted for Bacarra Floodplain.

Facility Type	No. of Features
Residential	12,046
School	141
Market	2
Agricultural/Agro-Industrial Facilities	1
Medical Institutions	0
Barangay Hall	2
Military Institution	0
Sports Center/Gymnasium/Covered Court	23
Telecommunication Facilities	0
Transport Terminal	0
Warehouse	160
Power Plant/Substation	0
NGO/CSO Offices	0
Police Station	2
Water Supply/Sewerage	0
Religious Institutions	12
Bank	1
Factory	0
Gas Station	0
Fire Station	0
Other Government Offices	15
Other Commercial Establishments	10
Total	12,415

Table 20. Total length of extracted roads for Bacarra Floodplain.

Floodplain	Road Network Length (km)					Total
	Barangay Road	City/ Municipal Road	Provincial Road	National Road	Others	
Bacarra	42.83	26.05	61.91	19.01	0.00	149.80

Table 21. Number of extracted water bodies for Bacarra Floodplain.

Floodplain	Water Body Type					Total
	Rivers/ Streams	Lakes/Ponds	Sea	Dam	Fish Pen	
Bacarra	24	0	0	1	0	25

A total of 36 bridges and culverts over small channels that are part of the river network were also extracted for the floodplain.

3.12.4 Final Quality Checking of Extracted Features

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

Figure 28 shows the completed Digital Surface Model (DSM) of the Bacarra floodplain overlaid with its ground features.

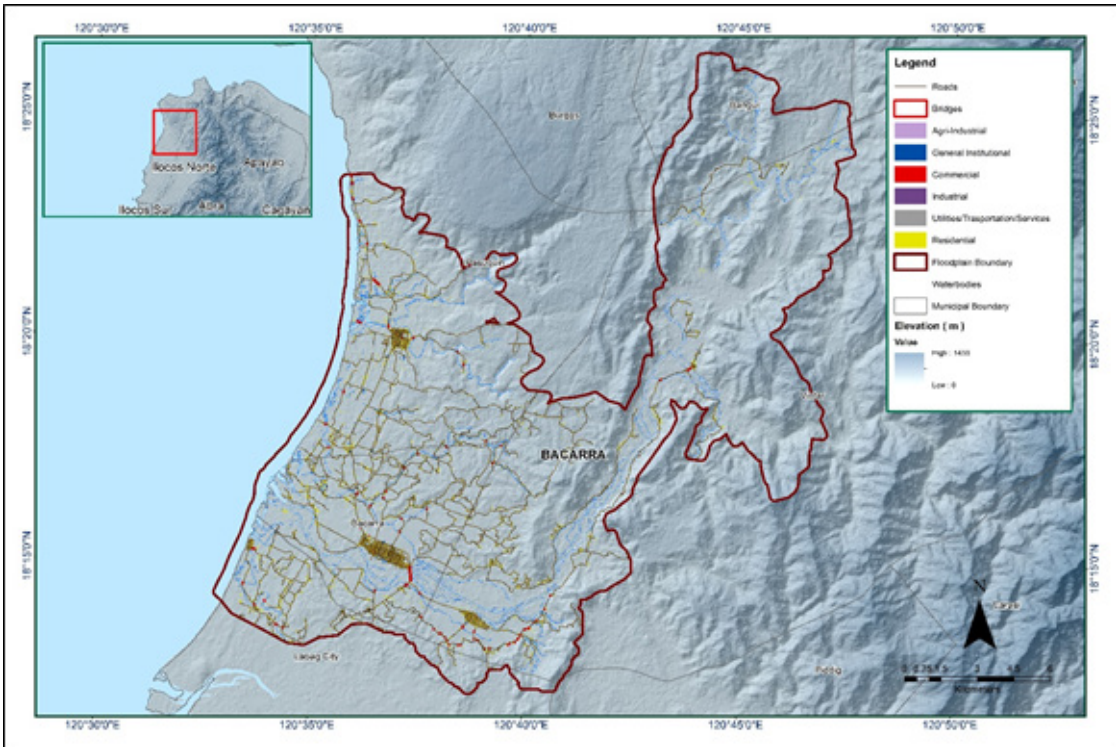


Figure 28. Extracted features of the Bacarra Floodplain.

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

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

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

4.1 Summary of Activities

The Data Validation and Bathymetry Component (DVBC) conducted a field survey in Bacarra River on January 28, 2015 to February 11, 2015 with the following scope: reconnaissance; control survey; cross-section and as-built survey at Bacarra Bridge in Brgy. Buyo, Municipality of Bacarra; validation points data acquisition of about 20 km; and bathymetric survey from Brgy. Tamdagan, Vintar, Ilocos Norte to the mouth of the river in Casilian, Bacarra, Ilocos Norte, with an estimated length of 26.9 km by GNSS PPK survey technique. The entire survey extent is illustrated in Figure 29.

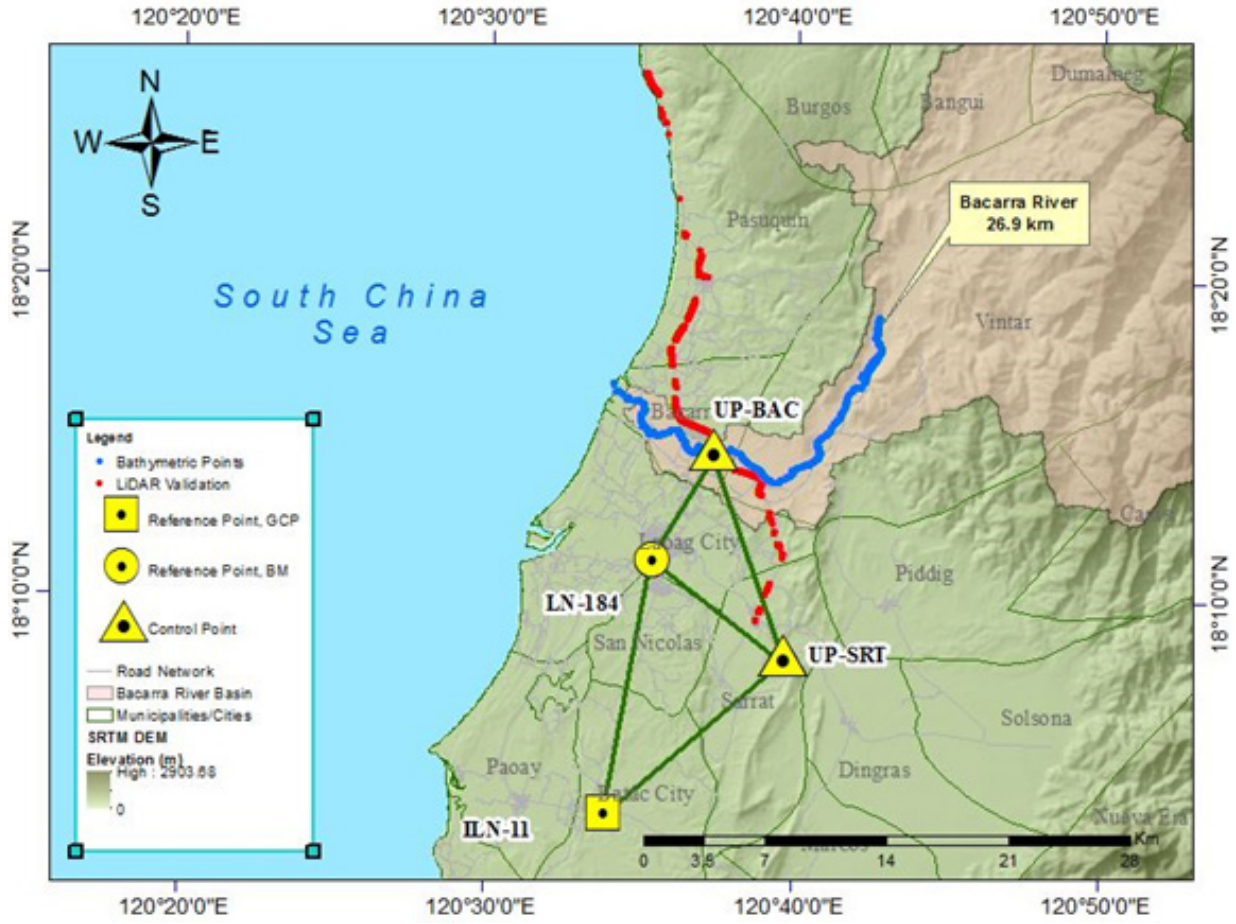


Figure 29. Bacarra River Survey Extent.

4.2 Control Survey

The GNSS network used for Bacarra River survey is composed of two (2) loops established on February 4 and February 10, 2015 occupying the following reference points: ILN-11, a 1st order NAMRIA GCP in in Brgy. Ricarte Poblacion, Batac City; and UP-184, a 1st order NAMRIA GCP in Brgy. No. 51-A, Nangalisan East, Laog City, all in Ilocos Norte.

Two (2) control points were established in the area: UP-SRT located Sarrat Bridge, Brgy. San Marcos, Municipality of Sarrat, Ilocos Norte; and UP-BAC located at Bacarra Bridge, Brgy. Buyon, Municipality of Bacarra, all in Ilocos Norte.

Table 22 depicts the summary of reference and control points utilized, with their corresponding locations, while Figure 30 shows the GNSS network established in the Bacarra River Survey.

Table 22. List of Reference and Control points used in Bacarra River Basin Survey (Source: NAMRIA, UP-TCAGP).

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)				
		Latitude	Longitude	Ellipsoid Height (m)	Elevation (MSL) (m)	Date of Establishment
Control Survey on December 10, 2016						
LN-184	1st order, BM	-	-	49.22	12.678	2007
ILN-11	1st order, GCP	18°03'20.64552"	120°33'54.52048"	69.613	-	2004
UP-BAC	UP Established	-	-	-	-	2015
UP-SRT	UP Established	-	-	-	-	2015
UP_QUI-1	Established	7°05'25.95862"N	126°27'58.08622"E	70.854	6.305	2-20-16

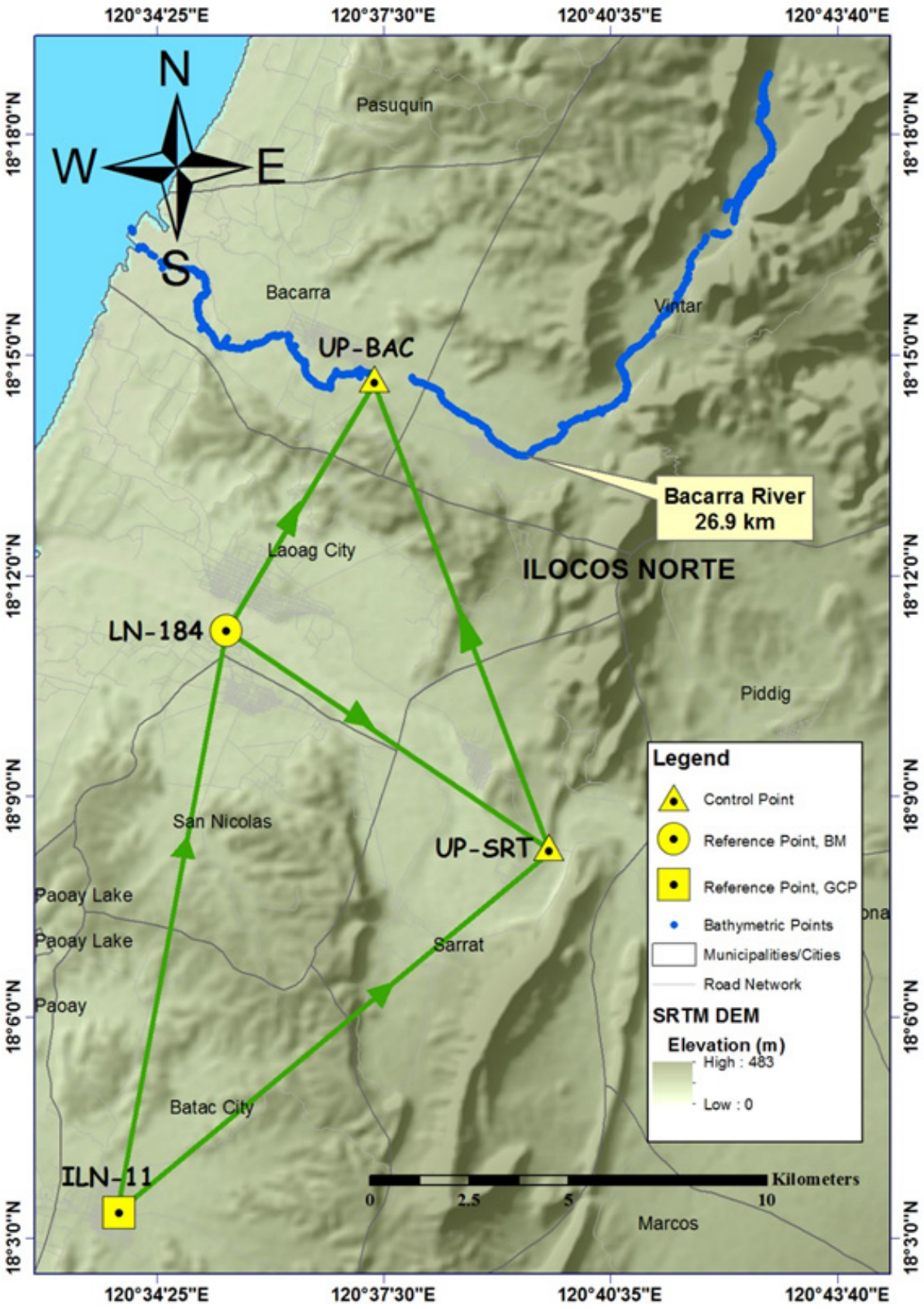


Figure 30. Bacarra River Basin Control Survey Extent.

Figure 31 to Figure 34 depict the setup of the GNSS on recovered reference points and established control points in the Bacarra River.

Figure 31. Base setup, Trimble® SPS 852, at ILN-11 located on the rooftop of the Batac City Hall in Brgy. Ricarte Poblacion, Batac City, Ilocos Norte.

Figure 32. GNSS receiver setup, Trimble® SPS 882 at BM LN-184 on the approach of Gilbert Bridge in Brgy. No. 51-A, Nangalisan East, Laog City, Ilocos Norte.

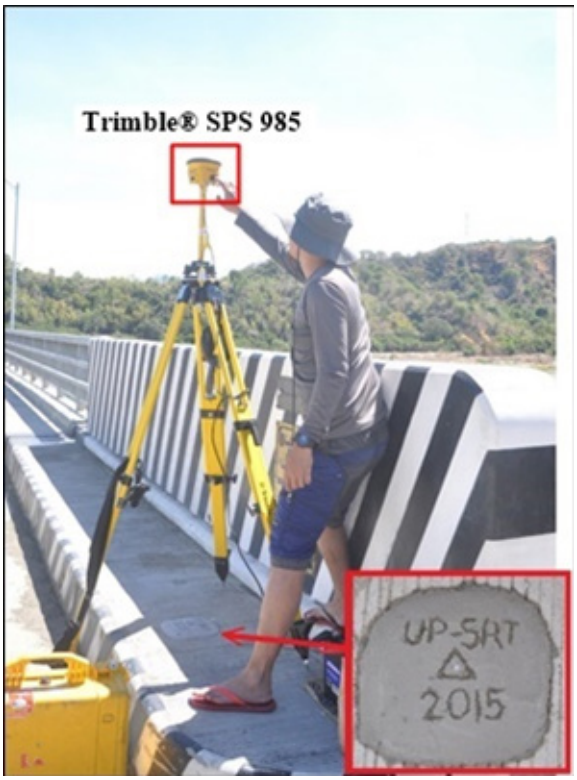


Figure 33. GNSS receiver setup, Trimble® SPS 985 at UP-SRT at Sarrat Bridge in Brgy. San Marcos, Municipality of Sarrat, Ilocos Norte.

Figure 34. GNSS receiver setup, Trimble® SPS 852 at UP-BAC, Bacarra Bridge in Brgy. Buyon, Municipality of Bacarra, Ilocos Norte.

4.3 Baseline Processing

The GNSS Baselines were processed simultaneously in TBC by observing that all baselines have fixed solutions with horizontal and vertical precisions within +/- 20 cm and +/- 10 cm requirement respectively. In cases where one or more baselines did not meet all of these criteria, masking was performed. Masking is the removal or covering of portions of the baseline data using the same processing software. The data is then repeatedly processed until all baseline requirements are met. If the reiteration yields out of the required accuracy, a resurvey is initiated. Table 23 presents the baseline processing results of control points in the Bacarra River Basin, as generated by the TBC software.

Table 23. The Baseline processing report for the Bacarra River GNSS static observation survey.

Observation	Date of Observation	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
UPSRT --- LN184	02-04-2015	Fixed	0.003	0.015	305°08'44"	9465.918	-19.930
UPBAC --- UPSRT	02-10-2015	Fixed	0.008	0.030	340°24'15"	12475.784	-12.150
LN184 --- UPBAC	02-10-2015	Fixed	0.003	0.016	29°24'15"	7237.867	7.791
LN184 --- UPSRT	02-04-2015	Fixed	0.006	0.021	125°07'21"	9465.916	19.975
ILN11 --- UPSRT	02-04-2015	Fixed	0.004	0.016	48°22'30"	13790.462	-0.448
ILN11 --- LN184	02-04-2015	Fixed	0.008	0.025	9°57'44"	14828.958	-20.388

As shown in Table 20, a total of six (6) baselines were processed and all baselines passed the required accuracy.

4.4 Network Adjustment

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

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

where:

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

For complete details, see the Network Adjustment Report shown in Table 24 to Table 27.

The four (4) control points, ILN-11, LN-184, UP-BAC, and UP-SRT were occupied and observed simultaneously to form a GNSS loop. The coordinate values of ILN-11 and elevation value of LN-184 were held fixed during the processing of the control points as presented in Table 24. Through these reference points, the coordinates and elevation of the unknown control points will be computed.

Table 24. Constraints applied to the adjustment of the control points.

Point ID	Type	East σ (Meter)	North σ (Meter)	Height σ (Meter)	Elevation σ (Meter)
ILN-11	Global	Fixed	Fixed		
LN-184	Grid				Fixed
Fixed = 0.000001(Meter)					

Likewise, the list of adjusted grid coordinates, i.e. Northing, Easting, Elevation and computed standard errors of the control points in the network is indicated in Table 25.

Table 25. Adjusted grid coordinates for the control points used in the Bacarra River flood plain survey.

Point ID	Easting (Meter)	Easting Error (Meter)	Northing (Meter)	Northing Error (Meter)	Elevation (Meter)	Elevation Error (Meter)	Constraint
ILN-11	242257.819	?	1998049.985	?	32.761	0.097	LL
LN-184	245017.255	0.019	2012626.167	0.013	12.678	?	e
UP-BAC	248654.887	0.024	2018886.801	0.017	20.421	0.092	
UP-SRT	252690.427	0.017	2007076.912	0.012	31.954	0.068	

The results of the computation for accuracy are as follows:

a. ILN-11

Horizontal accuracy = Fixed
Vertical accuracy = 9.7 cm < 10 cm

b. LN-184

Horizontal accuracy = $\sqrt{((1.9)^2 + (1.3)^2}$
= $\sqrt{(3.61 + 1.69)}$
= 2.3 cm < 20 cm
Vertical accuracy = Fixed

c. UP-BAC

Horizontal accuracy = $\sqrt{((2.4)^2 + (1.7)^2}$
= $\sqrt{(5.76 + 2.89)}$
= 2.9 cm < 20 cm
Vertical accuracy = 9.2 cm < 10 cm

d. UP-SRT

Horizontal accuracy = $\sqrt{((1.7)^2 + (1.2)^2}$
= $\sqrt{(2.89 + 1.44)}$
= 2.1 cm < 20 cm
Vertical accuracy = 6.8 cm < 10 cm

Following the given formula, the horizontal and vertical accuracy result of the four (4) occupied control points are within the required precision.

Table 26. Adjusted geodetic coordinates for control points used in the Bacarra River Flood Plain validation.

Point ID	Latitude	Longitude	Ellipsoid Height (Meter)	Height Error (Meter)	Constraint
ILN11	N18°03'20.64552"	E120°33'54.52048"	69.613	0.097	LL
LN184	N18°11'15.68970"	E120°35'21.81725"	49.220	?	e
UPBAC	N18°14'40.76723"	E120°37'22.77972"	57.009	0.092	
UPSRT	N18°08'18.50472"	E120°39'45.20843"	69.166	0.068	
UP_QUI-1	N7°05'25.95862"	E126°27'58.08622"	70.854	0.034	
DE-160	N6°59'41.20398"	E126°19'30.03464"	71.754	?	e

The corresponding geodetic coordinates of the observed points are within the required accuracy as shown in Table 26. Based on the results of the computation, the accuracy conditions are satisfied; hence, the required accuracy for the program was met. The computed coordinates of the reference and control points utilized in the Bacarra River GNSS Static Survey are seen in Table 27.

Table 27. The reference and control points utilized in the Bacarra 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)
LN-184	1st order, BM	18°11'15.68970"	120°35'21.81725"	49.22	2012626.167	245017.255	2012626
ILN-11	1st order, GCP	18°03'20.64552"	120°33'54.52048"	69.613	1998049.985	242257.819	1998050
UP-BAC	UP Established	18°14'40.76723"	120°37'22.77972"	57.009	2018886.801	248654.887	2018887
UP-SRT	UP Established	18°08'18.50472"	120°39'45.20843"	69.166	2007076.912	252690.427	2007077
UP_ QUI-1	Established	7°05'25.95862"N	126°27'58.08622"E	70.854	784522.58	220097.24	6.305

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

The bridge cross-section and as-built surveys were conducted on January 30, 2015 at the downstream side of Bacarra Bridge in Brgy. Buyon, Municipality of Bacarra, Ilocos Norte as shown in Figure 35. GNSS receiver Trimble® SPS 985 in PPK survey technique was utilized for this survey (Figure 36).

Figure 35. Quinonoan Bridge facing downstream

Figure 36. As-built survey conducted at Bacarra Bridge.

The length of the cross-sectional line surveyed at Bacarra Bridge is about 433 meters (Figure 35) with fifty-six (56) cross-sectional points acquired using the control point UP-BAC as the GNSS base station. The location map, cross-section diagram, and the accomplished bridge data form are shown in Figure 37, 38 and 39 respectively.

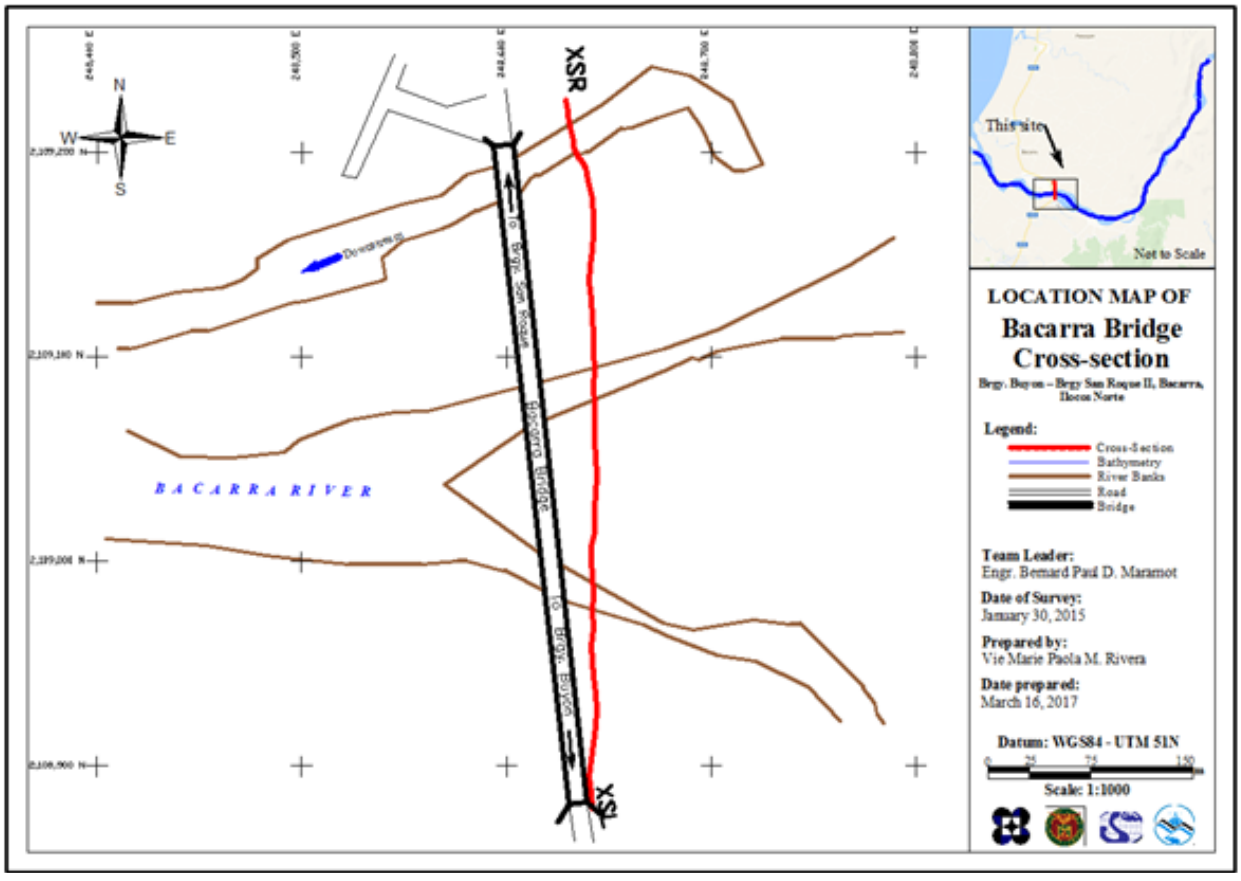


Figure 37. Location map of the Bacarra Bridge Cross Section.

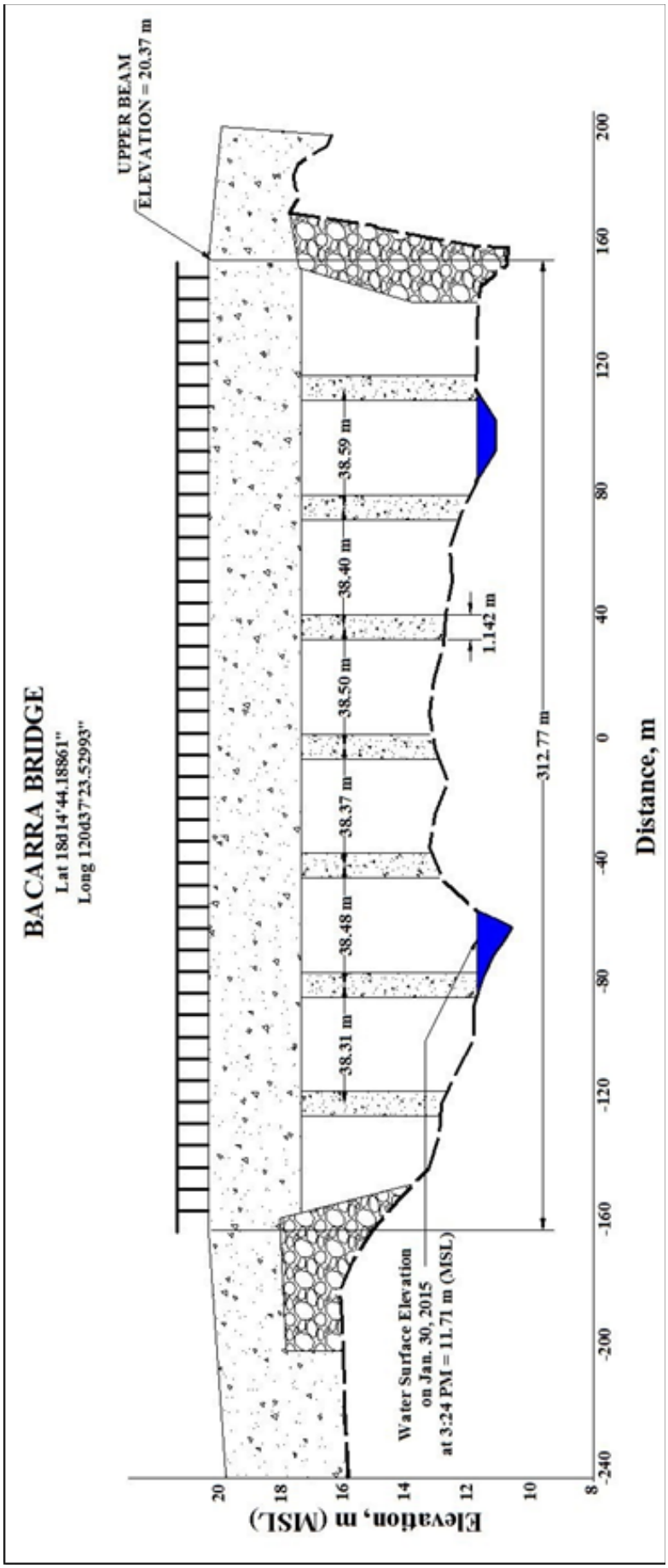


Figure 38. The Bacarra Bridge cross-section diagram.

Bridge Data Form

Bridge Name: Bacarra Bridge **Date:** January 30, 2015

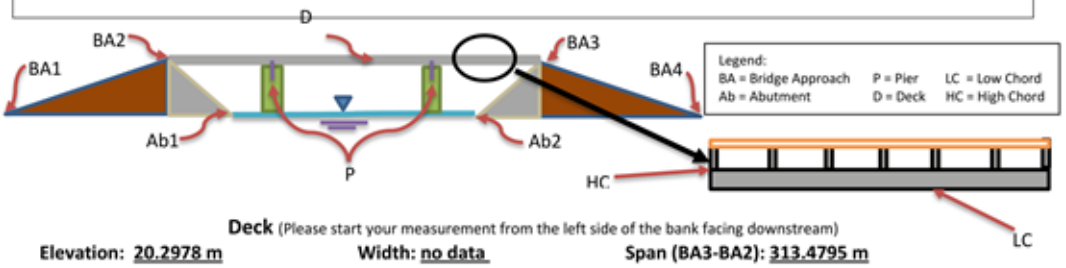
River Name: BACARRA RIVER **Time:** 3;14 pm

Location (Brgy, City, Region): Brgy. Buyon, Bacarra, Ilocos Norte

Survey Team: Laoag and Bacarra Survey Team

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

Latitude: 18°14'40.76602"N **Longitude:** 120°37'22.78041" E



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

Elevation: 20.2978 m **Width:** no data **Span (BA3-BA2):** 313.4795 m

	Station	High Chord Elevation	Low Chord Elevation
1	Pier 2 (175.47)	20.37	17.37
2	Pier 4 (252.23)	20.37	17.37
3	Pier 6 (329.24)	20.33	17.33

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

	Station(Distance from BA1)	Elevation		Station(Distance from BA1)	Elevation
BA1	0	17.74	BA3	408.89	20.376
BA2	95.41	20.37	BA4	522.25	19.35

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

	Station (Distance from BA1)	Elevation
Ab1	109.44	13.79
Ab2	395.76	14.52

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

Shape: Rectangular **Number of Piers:** seven (7) **Height of column footing:** n/a

	Station (Distance from BA1)	Elevation	Pier Width
Pier 1	137.03	12.36	1.142
Pier 2	175.47	11.71	1.142
Pier 3	213.80	13.05	1.142
Pier 4	252.23	13.11	1.142
Pier 5	290.69	12.50	1.142
Pier 6	329.24	11.13	1.142
Pier 7	367.72	11.71	1.142

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

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

The water surface elevation of Bacarra River was determined by PPK survey technique on January 30, 2015 at 3:24 PM at Bacarra Bridge with a value of 13 m in MSL. This was translated into marking on the bridge's deck as shown in Figure 40b. It now serves as the reference for flow data gathering and depth gauge deployment of the UP Baguio, the partner HEI responsible for the monitoring of the Bacarra River.

Figure 40. Water-level markings on Bacarra Bridge.

4.6 Validation Points Acquisition Survey

The validation points acquisition survey was conducted on February 3, 2014 using a survey GNSS rover receiver Trimble® SPS 882 mounted on a range pole, which was attached in front of the vehicle as shown in Figure 41. The antenna height was 1.53 m and measured from the ground up to the bottom of notch of the GNSS Rover receiver. The PPK technique utilized for the conduct of the survey was set to continuous topo mode in the conduct of the survey.

Figure 41. GNSS Receiver Trimble® SPS 882 installed on a vehicle for Ground Validation Survey.

The survey acquired a total one thousand six hundred ninety-seven (1,697) with approximate length of 28 km using UP-BAC as GNSS base station for the entire extent validation points acquisition survey as illustrated in the map in Figure 42.

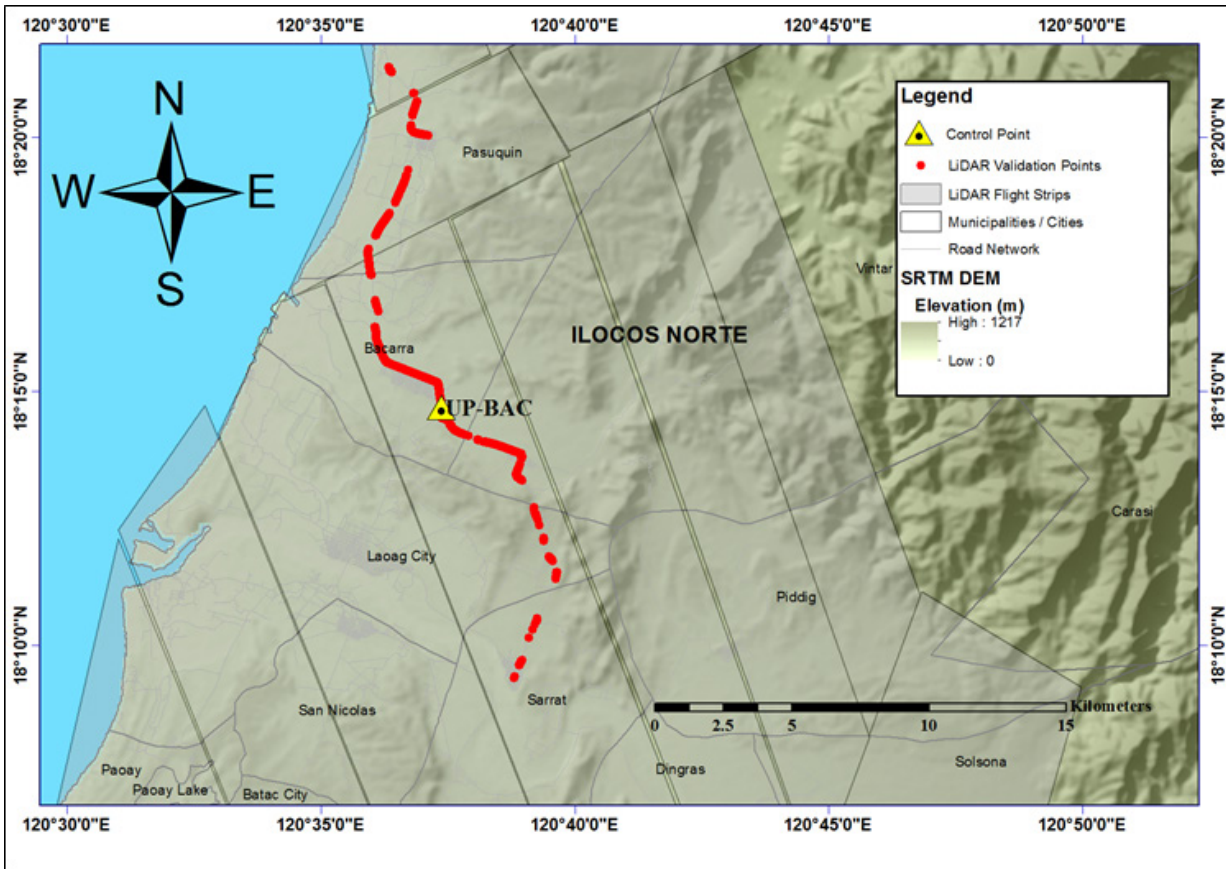


Figure 42. The extent of the LiDAR ground validation survey (in red) for Bacarra River Basin.

4.7 River Bathymetric Survey

Manual bathymetric survey was conducted on January 31 to February 3, 2015 using a GPS receiver, Trimble® SPS 852 in GNSS PPK technique as shown in Figure 43. The survey started in the upstream part of the river in Brgy. Tamdagan, Municipality of Vintar with coordinates 18°18'49.21447" 120°42'44.63259", traversed down by foot to the mouth of the river and ended in Brgy. Casilian, Municipality of Bacarra with coordinates 18°16'41.90157" 120°34'05.80297". The UP established control point UP-BAC was used to serve as the GNSS base all throughout the survey.

Figure 43. Set up of the bathymetric survey at Bacarra River using Trimble® SPS 852 in GNSS PPK survey technique.

Overall, the bathymetric survey for Bacarra River, with an estimated length of 26.9 km, gathered a total of 1,459 points of the river traversing 28 barangays in Bacarra and Vintar. The extent of the bathymetric survey for the Bacarra River is shown in Figure 44. To further illustrate this, a CAD drawing of the riverbed profile of the Bacarra River was produced. As seen in Figure 45, an elevation drop of 10 meters in MSL was observed within the approximate distance of 25 kilometers. The highest elevation observed was 52.56 m below MSL located at the upstream part of the river; while the lowest was -1.793 m below MSL located at the mouth of the river.

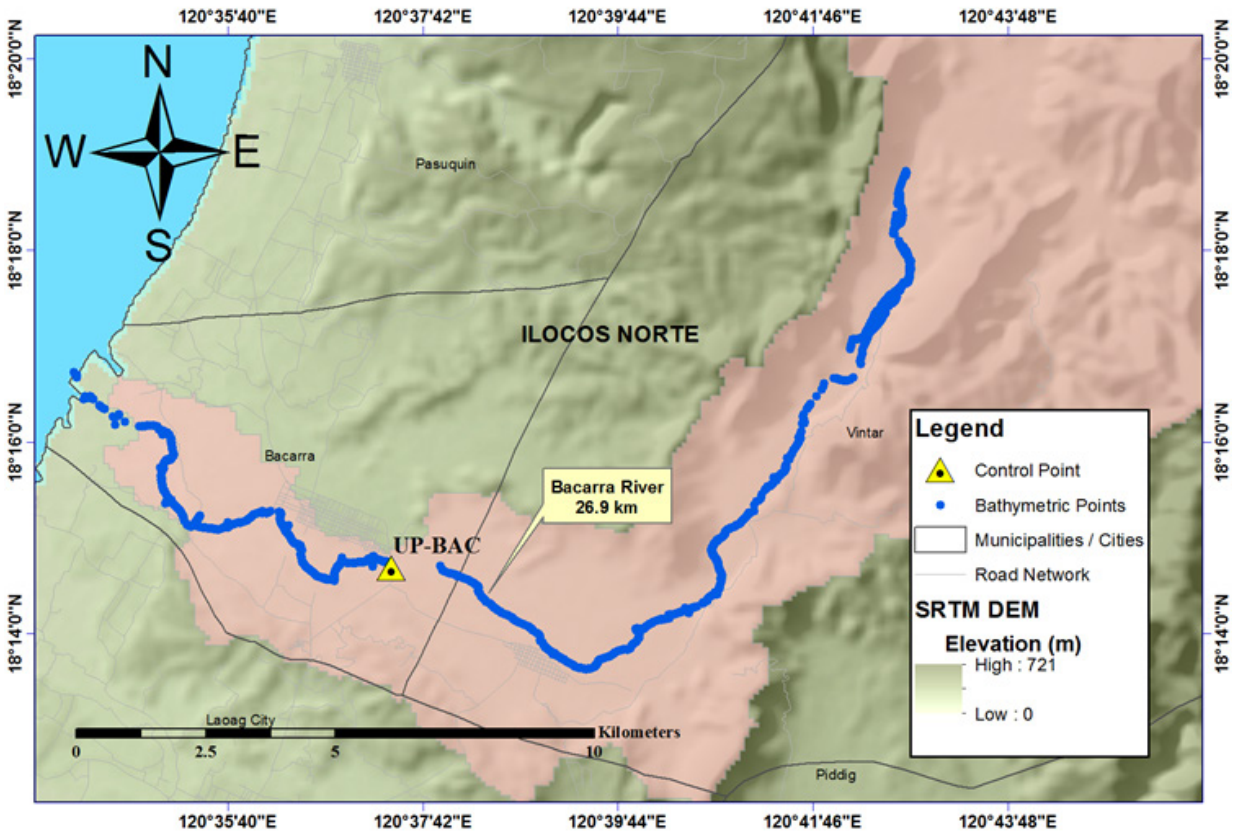


Figure 44. The extent of the Bacarra River Bathymetry Survey.

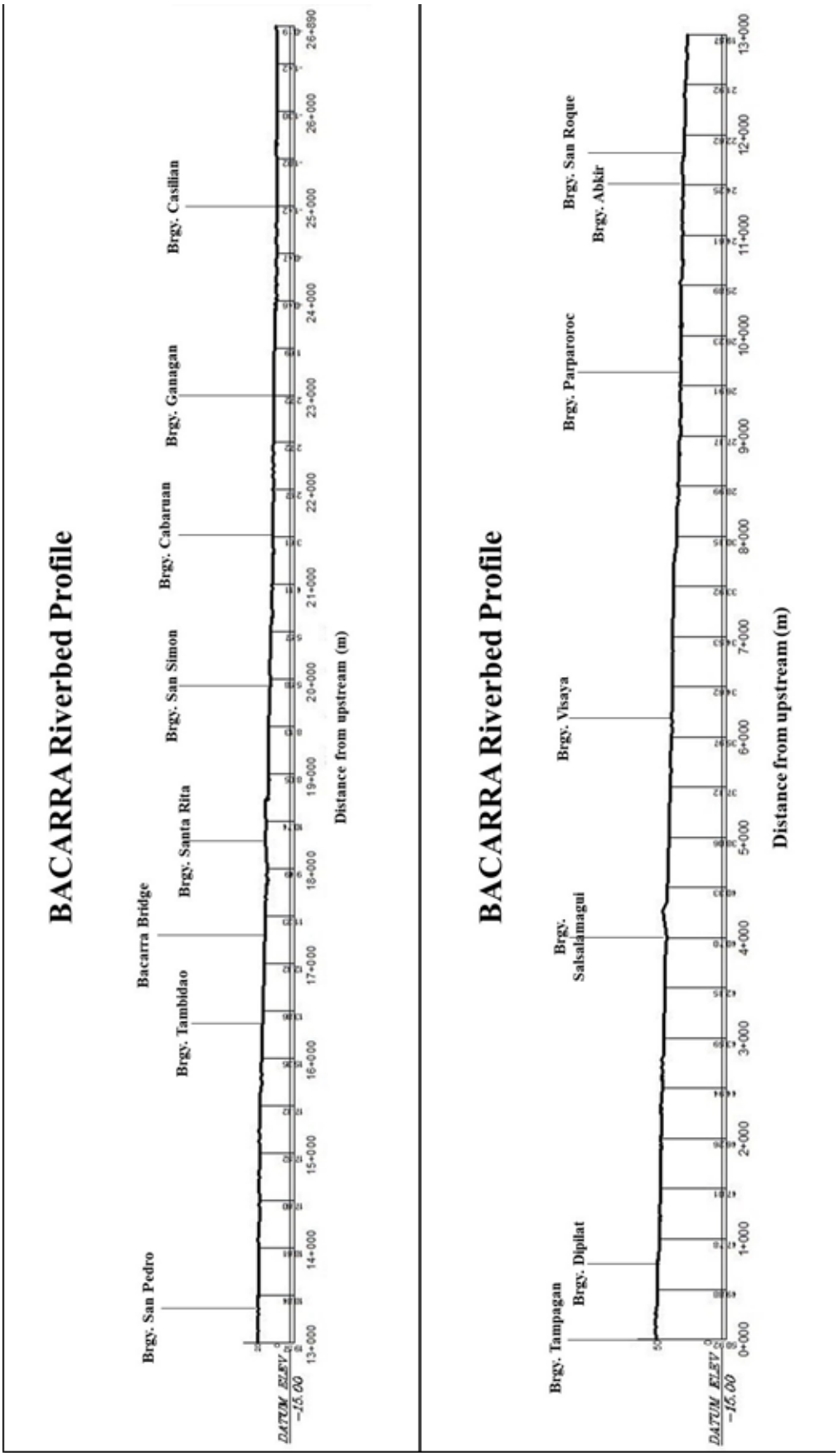


Figure 45. The Bacarra Riverbed Profile.

CHAPTER 5: FLOOD MODELING AND MAPPING

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

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).

5.1 Data Used for Hydrologic Modeling

5.1.1 Hydrometry and Rating Curves

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

5.1.2 Precipitation

Precipitation data was taken from the interpolation of rain data from automatic rain gauges (ARG) installed by the Department of Science and Technology – Advanced Science and Technology Institute (DOST-ASTI). These rain gauges are the LGU Carasi ARG (18°8’23.2” N, 120°49’14.74” E), located in Carasi, Ilocos Norte and Mariano Marcos State University ARG (18°3’4.48” N, 120°32’12.55” E), located in Batac City, Ilocos Norte as shown in Figure 46. The location of the interpolated rainfall (18°13’58.14” N, 120°38’57.92” E) situated in Vintar, Ilocos Norte. The precipitation data collection started from July 31, 2016 at 6:30 AM to August 2, 2016 at 8:00 AM with a 15-minute recording interval.

The total precipitation for this event in the installed rain gauge was 30.27 mm. It has a peak rainfall of 3.07 mm. on July 31, 2016 at 2:45 PM. The lag time between the peak rainfall and discharge is 9 hours and 45 minutes.

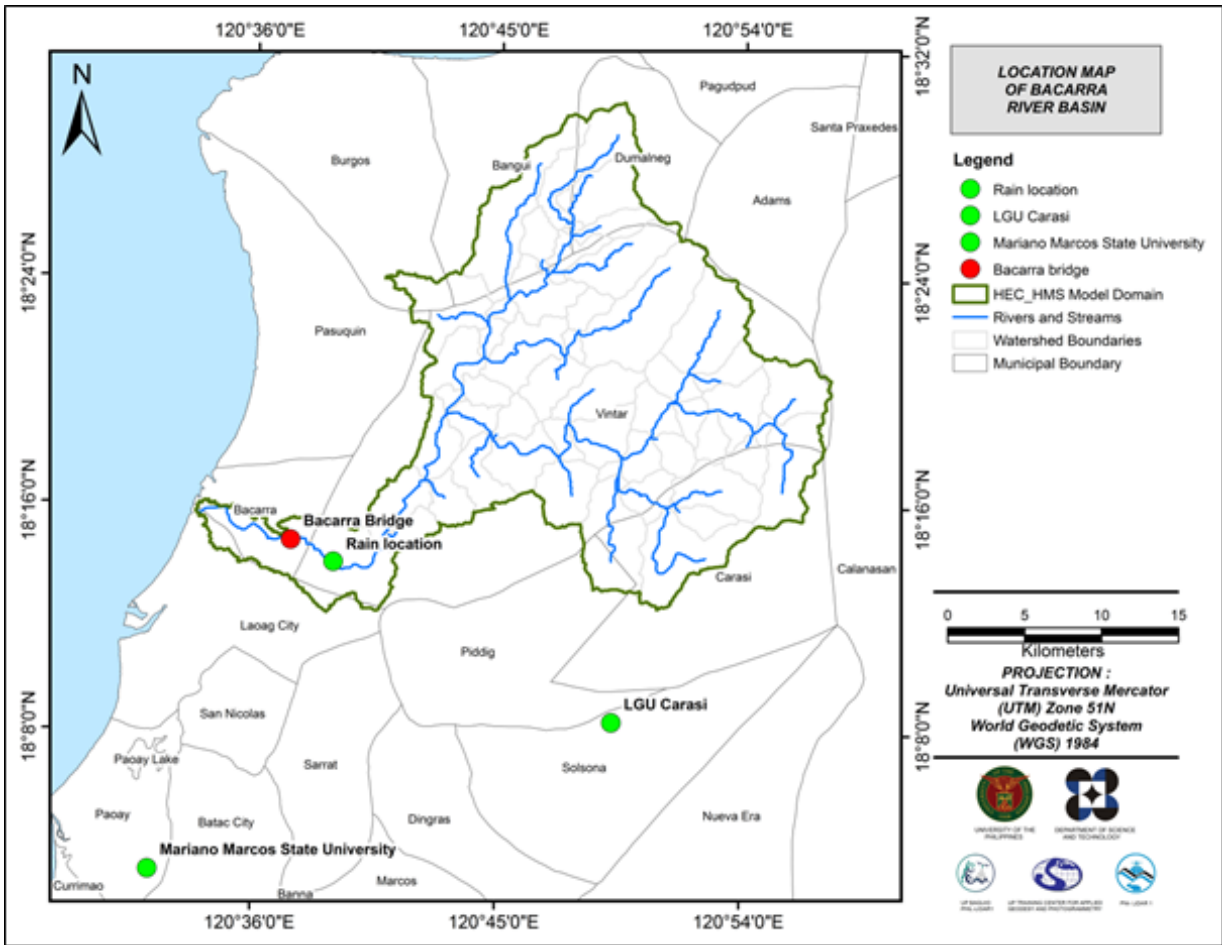


Figure 46. Location Map of the Bacarra HEC-HMS model used for calibration.

5.1.3 Rating Curves and River Outflow

A rating curve was developed at Bacarra Bridge, Bacarra, Ilocos Norte (18°14'42" N, 120°37'22.8" E). It gives the relationship between the observed water level from the Bacarra Bridge and outflow of the watershed at this location.

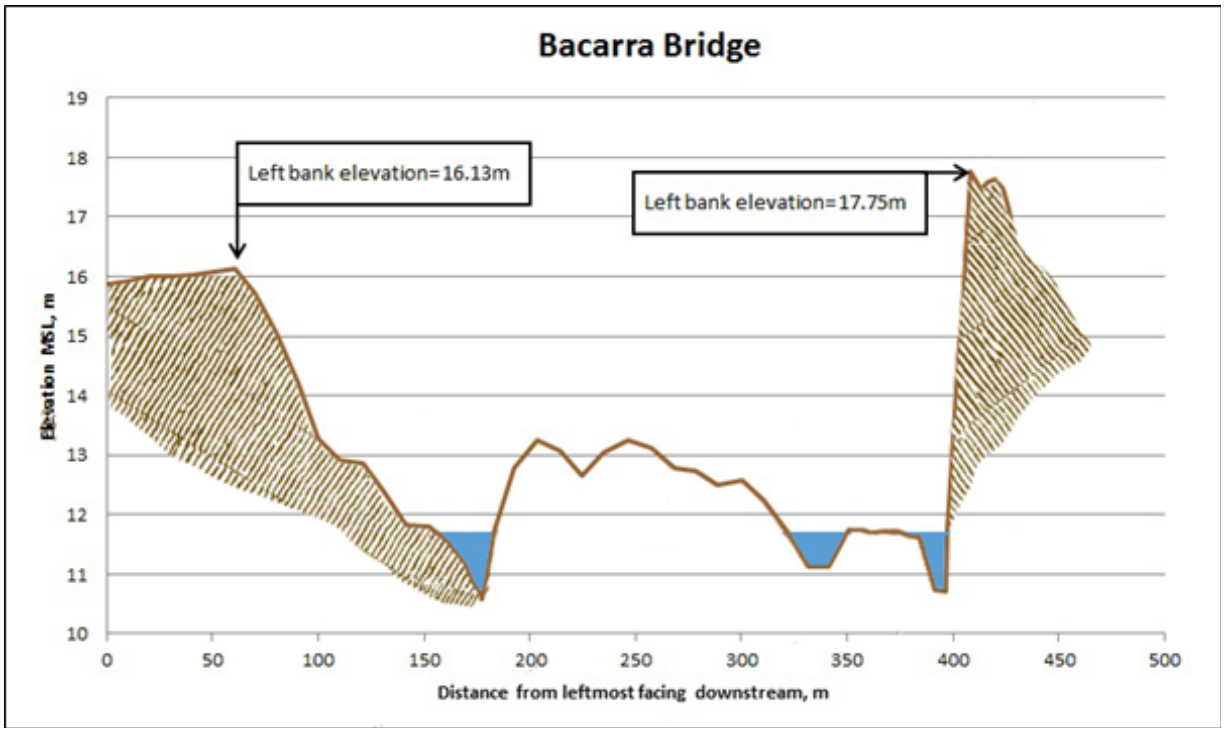


Figure 47. Cross-Section Plot of Bacarra Bridge.

For Bacarra Bridge, the rating curve is expressed as Q = 0.094e0.3989h as shown in Figure 48.

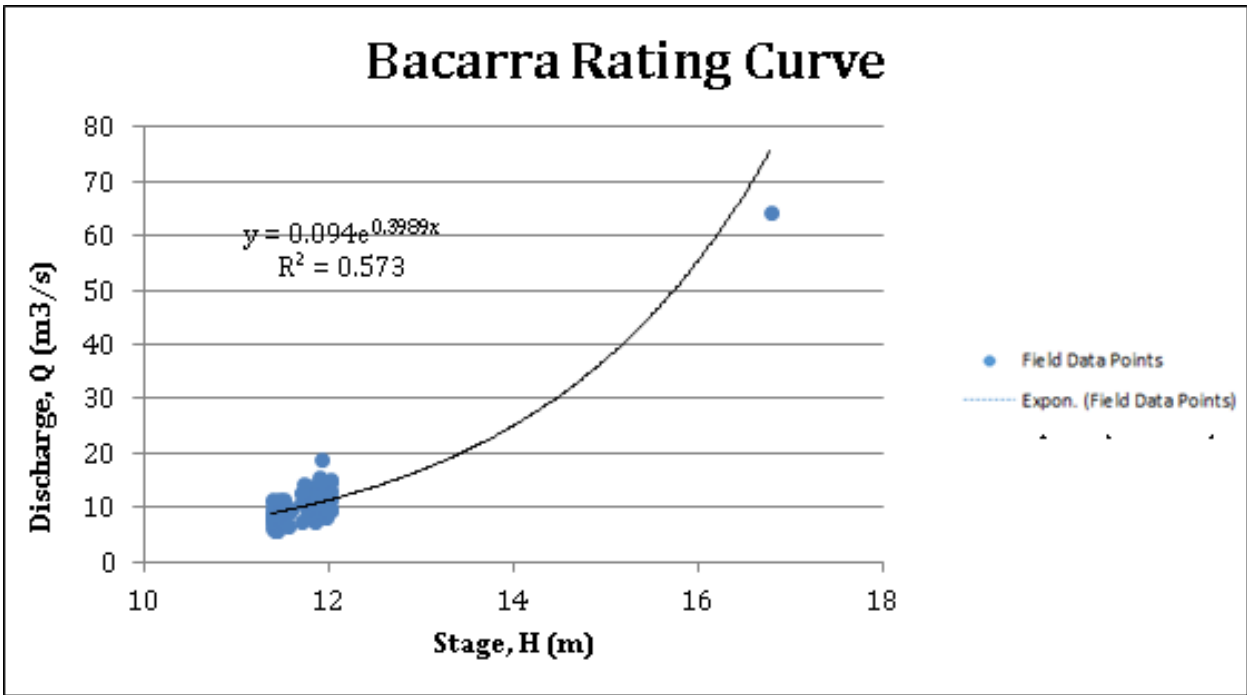


Figure 48. The rating curve at Bacarra Bridge, Bacarra, Ilocos Norte.

This rating curve equation was used to compute the river outflow at Bacarra Bridge for the calibration of the HEC-HMS model for Bacarra shown in Figure 49. The total rainfall for this event in rain gauge is 30.27 mm and the peak discharge is 21.18 m3 at 4:30 AM of August 1, 2016.

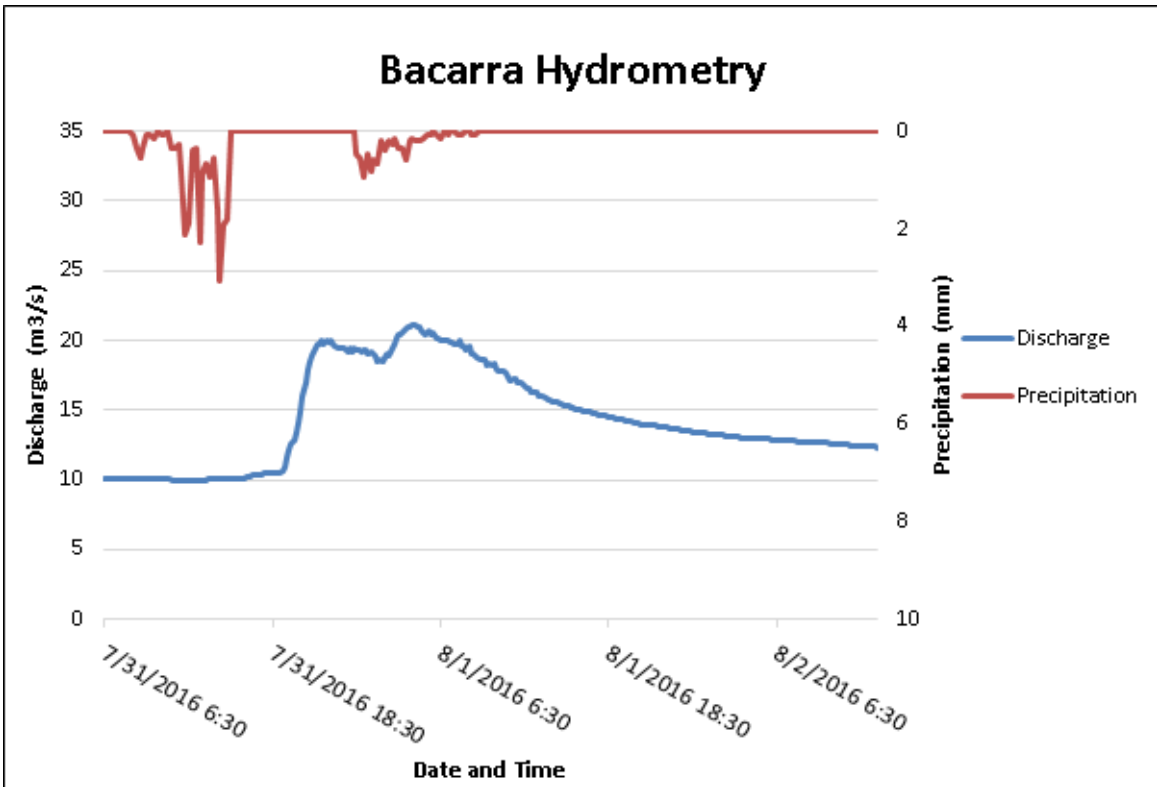


Figure 49. Rainfall and outflow data at Bacarra Bridge, which was used for modeling.

5.2 RIDF Station

The Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) computed for Rainfall Intensity Duration Frequency (RIDF) values for the Laoag Rain Gauge. The RIDF rainfall amount for 24 hours was converted to a synthetic storm by interpolating and re-arranging the values in such a way a certain peak value will be attained at a certain time (Table 28). This station is chosen based on its proximity to the Bacarra watershed. The extreme values for this watershed were computed based on a 59-year record.

Table 28. RIDF values for the Bacarra River Basin based on average RIDF data of Borongan station, as computed by PAGASA.

COMPUTED EXTREME VALUES (in mm) OF PRECIPITATION									
T (yrs)	10 mins	20 mins	30 mins	1 hr	2 hrs	3 hrs	6 hrs	12 hrs	24 hrs
2	22.7	35.4	45.7	62.5	89	110.9	148.5	187.8	232.8
5	31.4	48	61.5	87.1	124.6	157.8	211.7	266.3	331.7
10	37.2	56.3	71.9	103.5	148.2	189	253.6	318.3	397.1
15	40.5	61	77.8	112.7	161.6	206.5	277.2	347.7	434
20	42.8	64.3	81.9	119.1	170.9	218.8	293.7	368.2	459.9
25	44.5	66.8	85.1	124.1	178.1	228.3	306.4	384.1	479.8
50	50	74.6	94.8	139.4	200.2	257.4	345.7	432.8	541.1
100	55.3	82.4	104.5	154.6	222.2	286.4	384.6	481.2	602

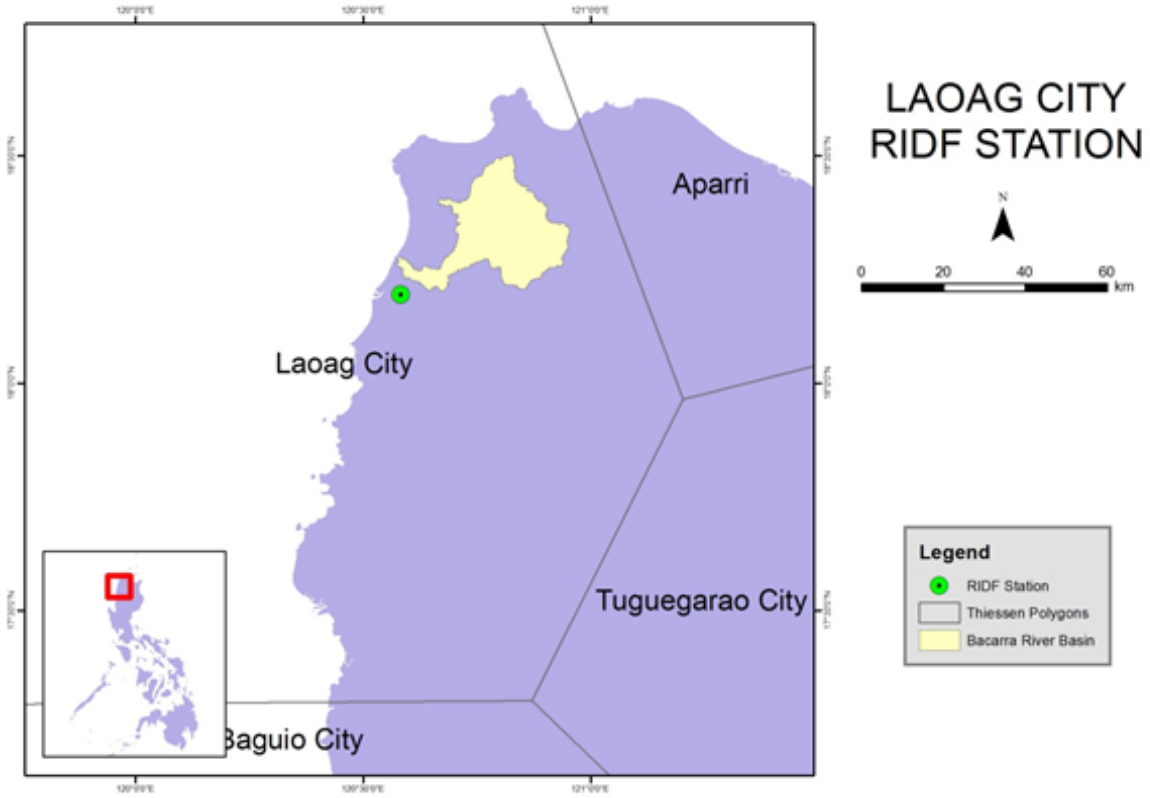


Figure 50. The location of the Borongan RIDF station relative to the Bacarra River Basin.

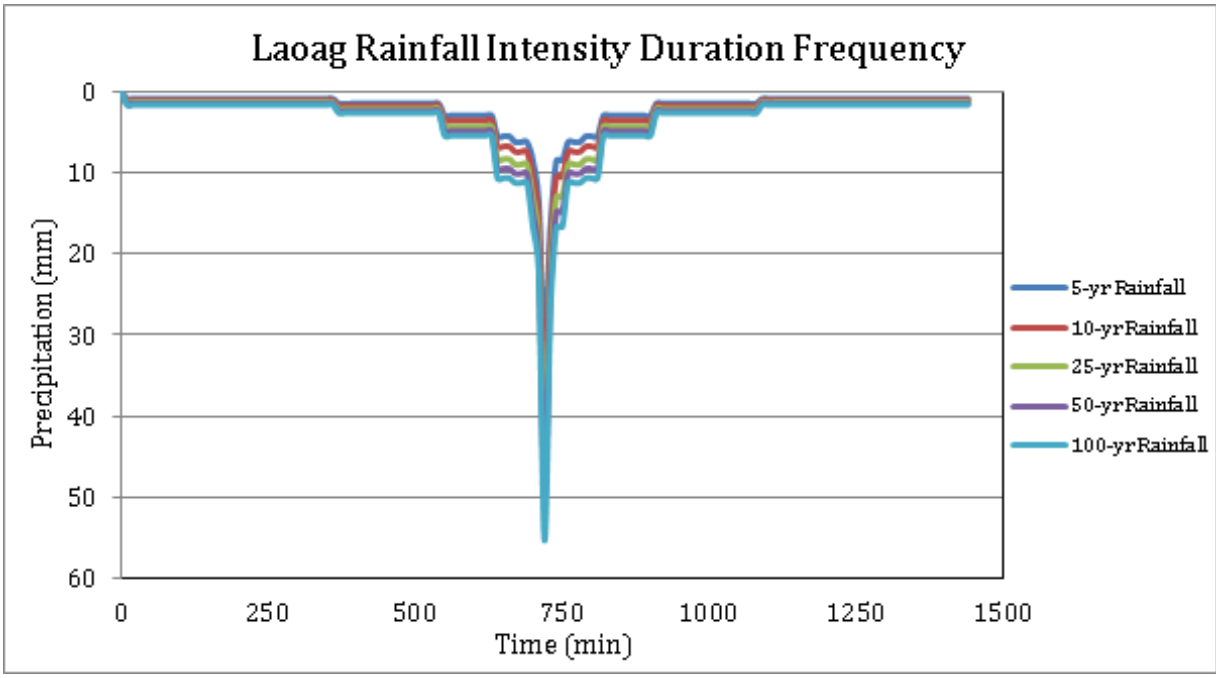


Figure 51. The synthetic storm generated for a 24-hour period rainfall for various return periods.

5.3 HMS Model

These soil dataset was taken on 2004 from the Bureau of Soils and Water Management (BSWM). It is 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 Bacarra River Basin are shown in Figure 52 and Figure 53, respectively.

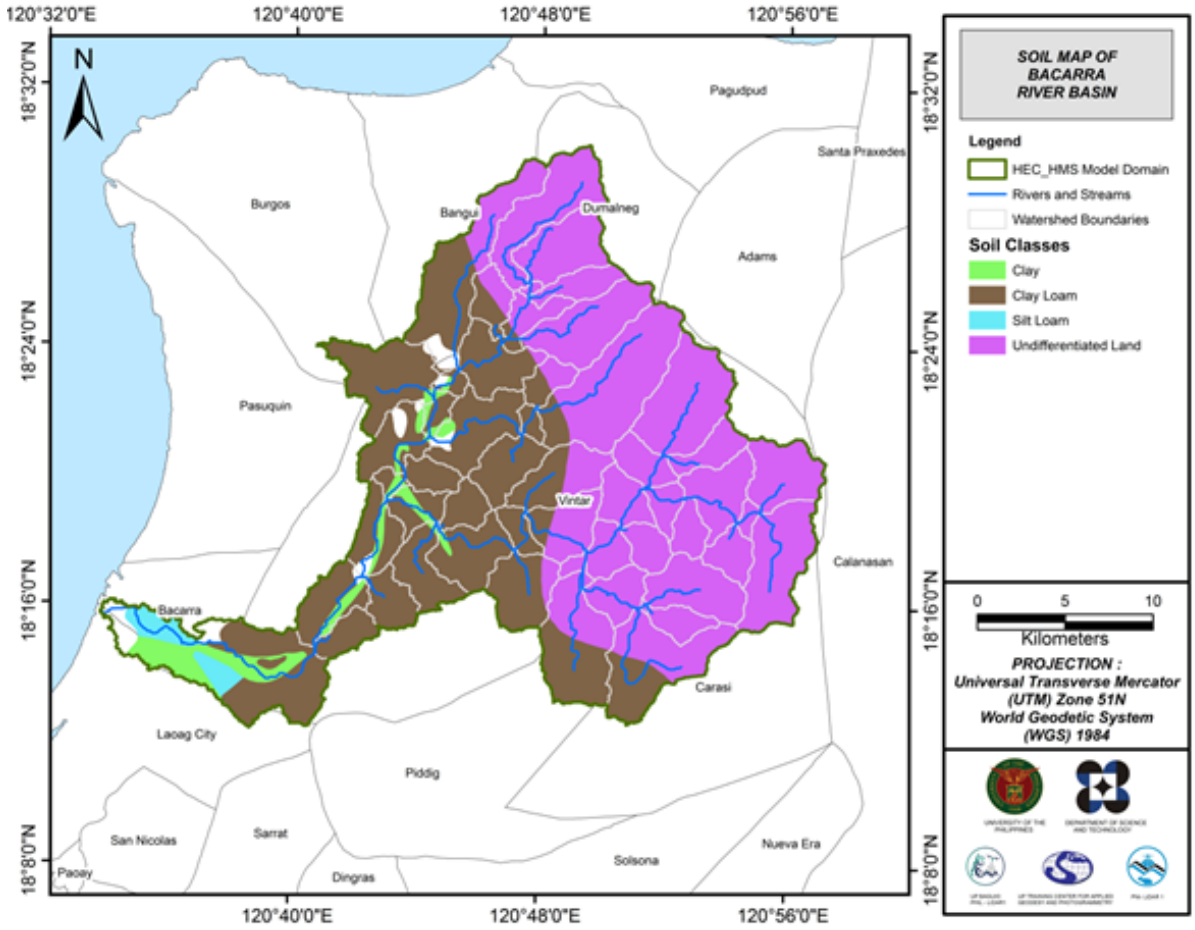


Figure 52. Soil Map of Bacarra River Basin.

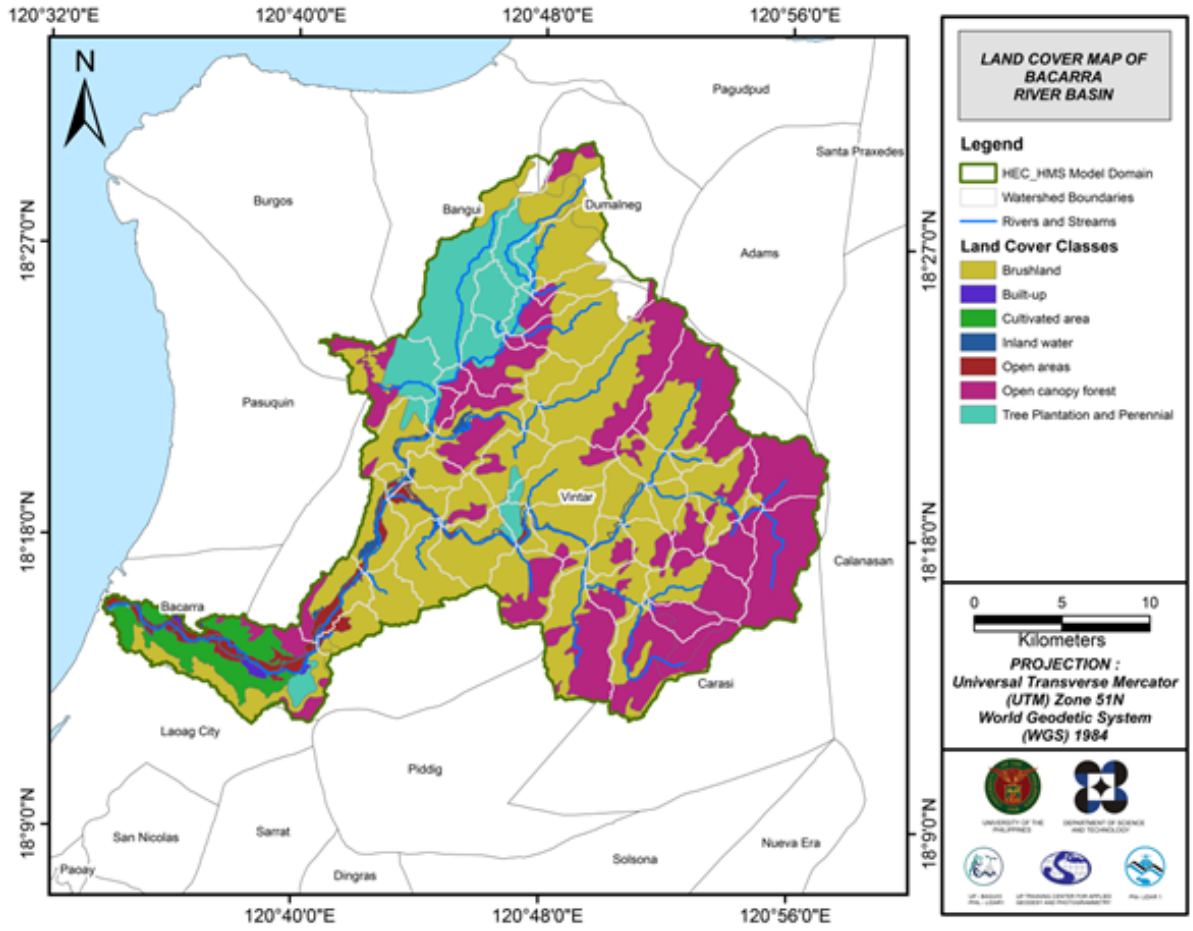


Figure 53. Land Cover Map of Bacarra River Basin.

For Bacarra, four (4) soil classes were identified. These are clay, clay loam, silt loam and undifferentiated land. Moreover, seven (7) land cover classes were identified. These are brushlands, built-up areas, cultivated areas, inland water, open areas, open canopy forests, and tree plantations.

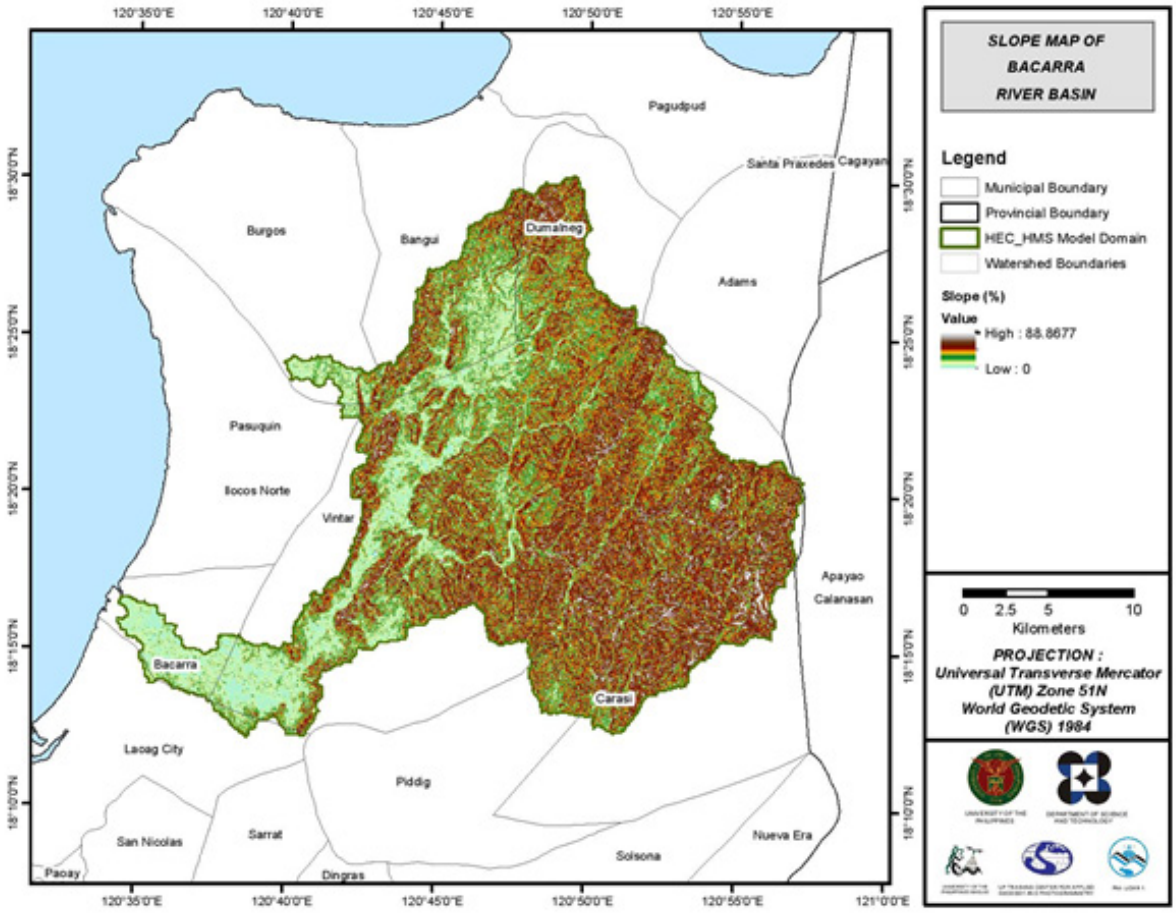


Figure 54. Slope Map of the Bacarra River Basin

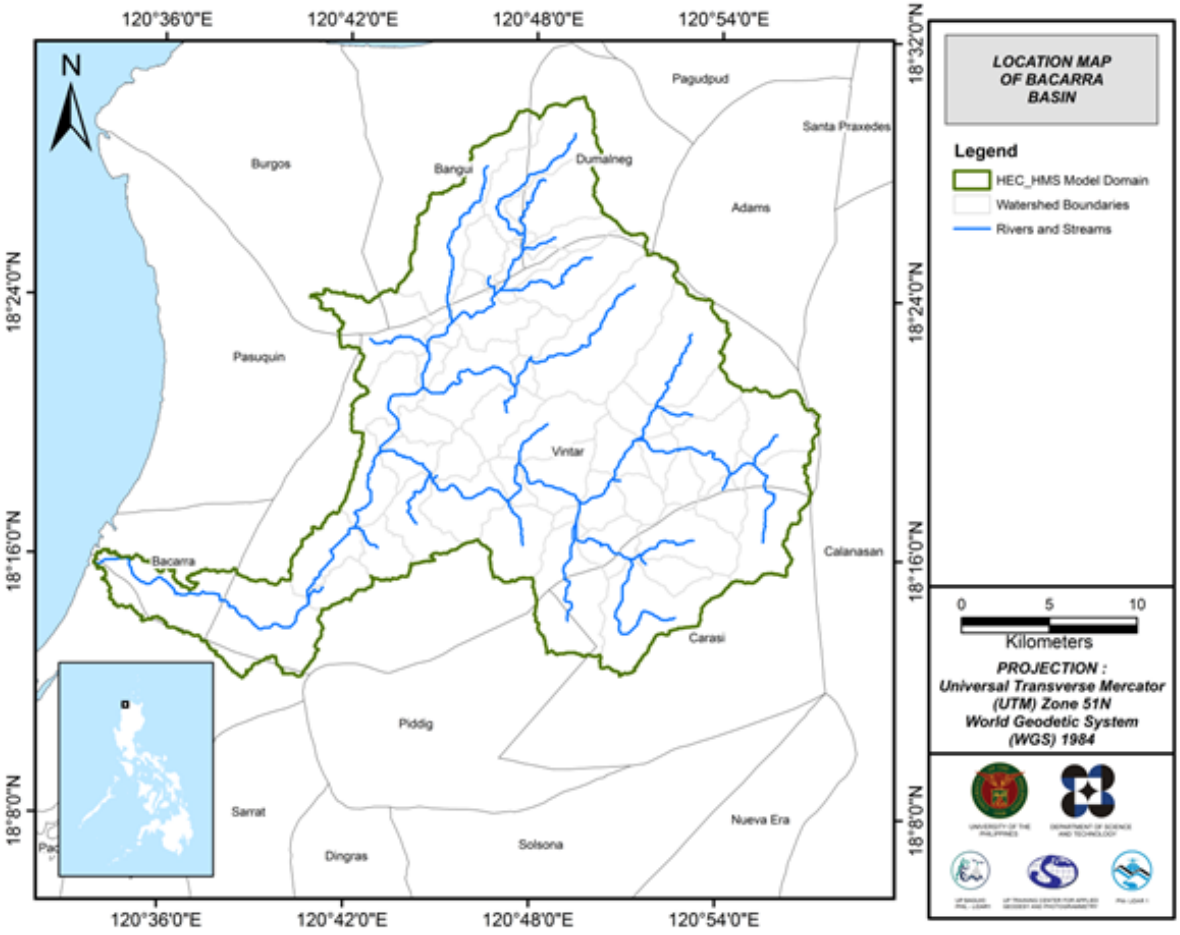


Figure 55. Stream Delineation Map of Bacarra River Basin.

Using the SAR-based DEM, the Bacarra basin was delineated and further subdivided into subbasins. The model consists of 55 sub basins, 27 reaches, and 27 junctions as shown in Figure 56. The main outlet is Outlet 170.

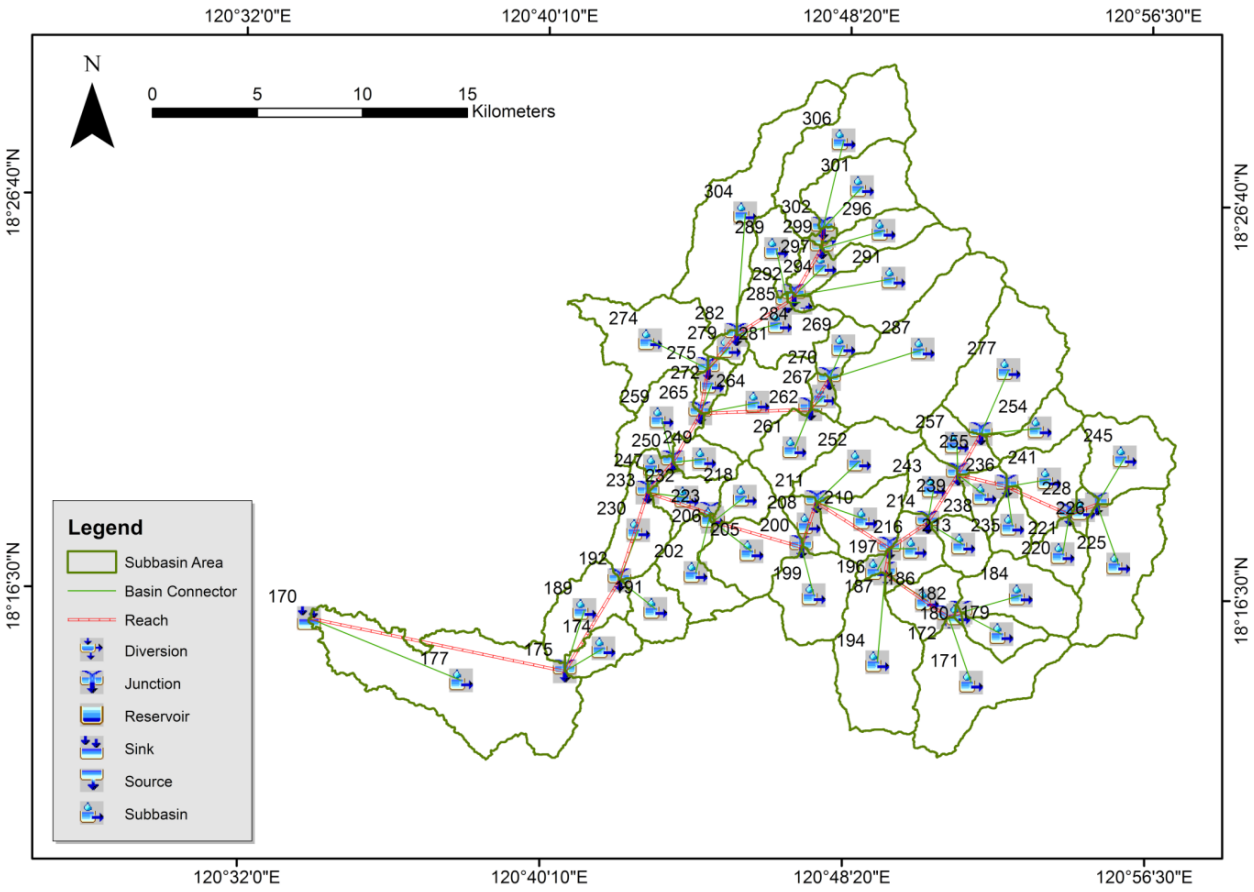


Figure 56. Bacarra river basin model generated in HEC-HMS.

5.4 Cross-section Data

The riverbed cross-sections of the watershed were necessary in the HEC-RAS model setup. The cross-section data for the HEC-RAS model was derived from the LiDAR DEM data, which was defined using the Arc GeoRAS tool and was post-processed in ArcGIS (Figure 57).

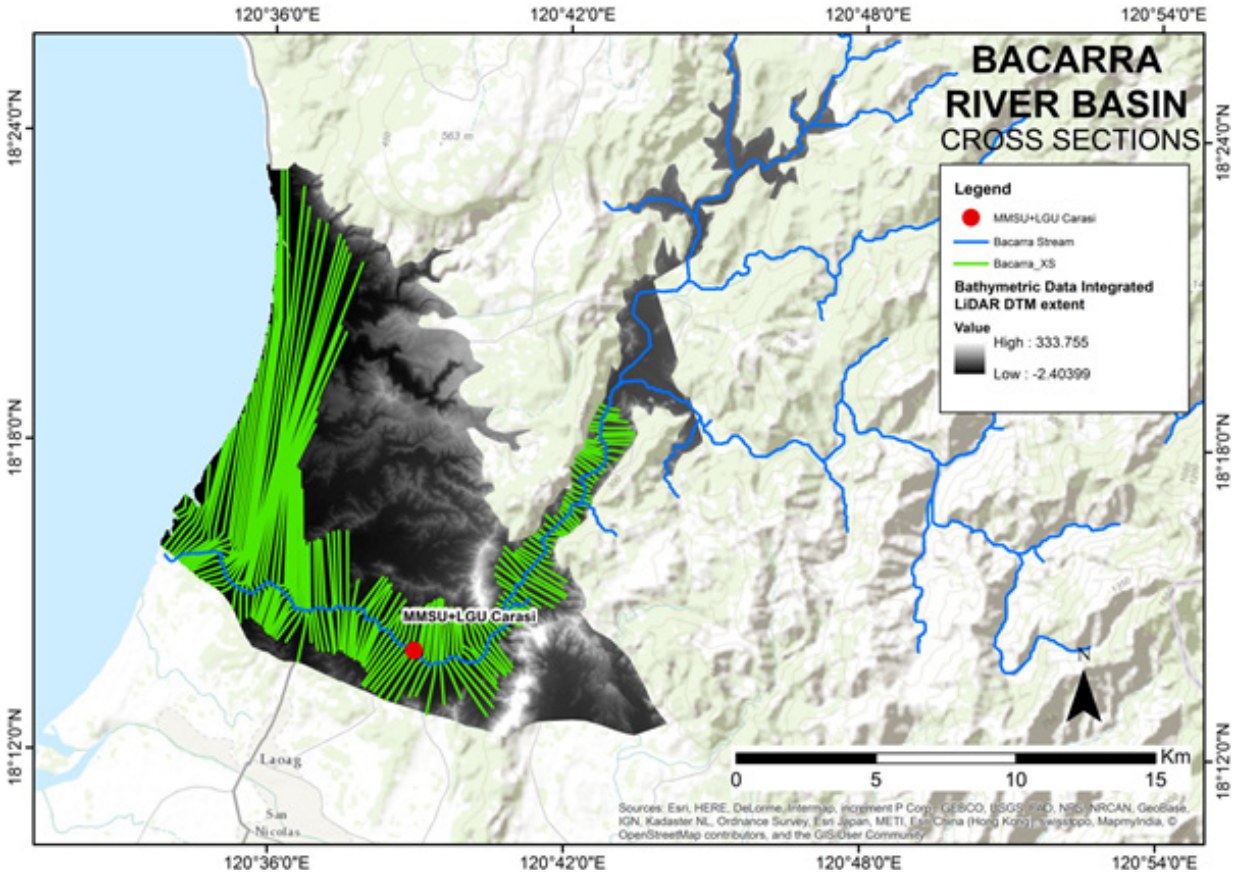


Figure 57. River cross-section of the Bacarra River through the ArcMap HEC GeoRas tool.

5.5 Flo 2D Model

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

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

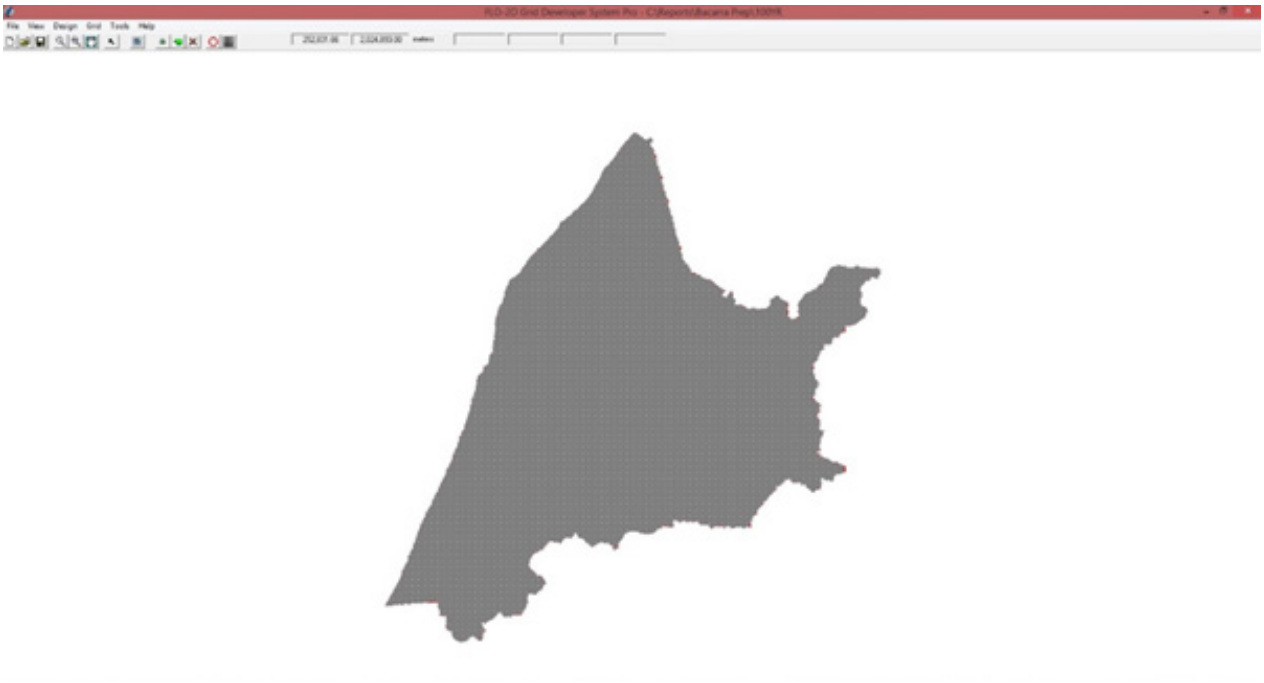


Figure 58. A screenshot of the river sub-catchment with the computational area to be modeled in FLO-2D Grid Developer System Pro (FLO-2D GDS Pro).

The simulation is then run through FLO-2D GDS Pro. This particular model had a computer run time of 20.09155 hours. After the simulation, FLO-2D Mapper Pro is used to transform the simulation results into spatial data that shows flood hazard levels, as well as the extent and inundation of the flood. Assigning the appropriate flood depth and velocity values for Low, Medium, and High creates the following food hazard map. Most of the default values given by FLO-2D Mapper Pro are used, except for those in the Low hazard level. For this particular level, the minimum h (Maximum depth) is set at 0.2 m while the minimum vh (Product of maximum velocity (v) times maximum depth (h)) is set at 0 m2/s. The generated hazard maps for Bacarra are in Figure 62, 64, and 66.

The creation of a flood hazard map from the model also automatically creates a flow depth map depicting the maximum amount of inundation for every grid element. The legend used by default in Flo-2D Mapper is not a good representation of the range of flood inundation values, so a different legend is used for the layout. In this particular model, the inundated parts cover a maximum land area of 20804000.00 m2. The generated flood depth maps for Bacarra are in Figure 63, 65, and 67.

There is a total of 46214352.05 m3 of water entering the model. Of this amount, 12449823.05 m3 is due to rainfall while 33764529.00 m3 is inflow from other areas outside the model. 3953909.25 m3 of this water is lost to infiltration and interception, while 8477063.60 m3 is stored by the flood plain. The rest, amounting up to 33783378.54 m3, is outflow.

5.6 Results of HMS Calibration

After calibrating the Bacarra HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 59 shows the comparison between the two discharge data.

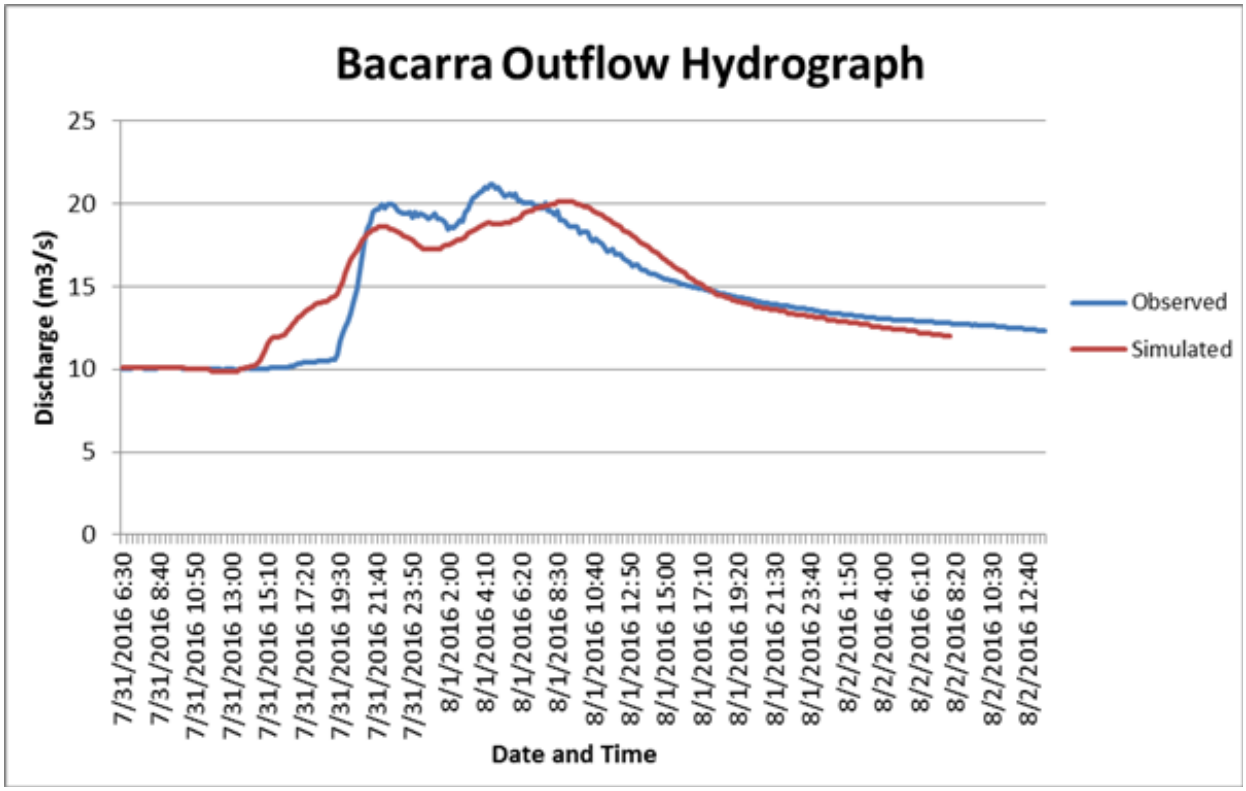


Figure 59. Outflow Hydrograph of Bacarra produced by the HEC-HMS model compared with observed outflow.

Table 29 shows the adjusted ranges of values of the parameters used in calibrating the model.

Table 29. Range of calibrated values for the Bacarra River Basin.

Hydrologic Element	Calculation Type	Method	Parameter	Range of Calibrated Values
Basin	Loss	SCS Curve Number	Initial Abstraction (mm)	1.033 – 37.45
			Curve Number	35 – 81.7
	Transform	Clark Unit Hydrograph	Time of Concentration (hr)	0.147 – 11.028
			Storage Coefficient (hr)	0.75 – 22.6
	Baseflow	Recession	Recession Constant	0.432 - 1
			Ratio to Peak	0.24 – 1
Reach	Routing	Muskingum-Cunge	Manning's Coefficient	0.0067 - 0.015

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 1.033 mm to 37.45 mm means that there is a small initial fraction of the storm depth after which runoff begins, increasing the river outflow.

The curve number is the estimate of the precipitation excess of soil cover, land use, and antecedent moisture. The magnitude of the outflow hydrograph increases as curve number increases. The range of 65 to 90 for curve number is advisable for Philippine watersheds depending on the soil and land cover of the area (M. Horritt, personal communication, 2012). For Bacarra, the basin consists mainly of brushlands and open canopy forests and the soil consists of mostly undifferentiated land 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 0.147 hours to 22.6 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 values within the range of 0.432 to 1 indicate that the discharge leaving every subbasin within Bacarra recede differ significantly. Values of ratio to peak within the range of 0.24 to 1 indicate an average receding limb of the outflow hydrograph.

Manning's roughness coefficients correspond to the common roughness of Philippine watersheds. Bacarra river basin reaches' Manning's coefficients range from 0.0067 to 0.015, showing that there is variety in surface roughness all over the catchment (Brunner, 2010).

Table 30. Summary of the Efficiency Test of the Bacarra HMS Model

Accuracy measure	Value
RMSE	1.4
r2	0.8879
NSE	0.86
PBIAS	-0.98
RSR	0.38

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was computed as 1.4 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 0.8879.

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 0.86.

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 -0.98.

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 0.38.

A positive Percent Bias (PBIAS) indicates a model's propensity towards under-prediction. Negative values indicate bias towards over-prediction. Again, the optimal value is 0. In the model, the PBIAS is -8.82.

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 0.38.

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

5.7.1 Hydrograph using the Rainfall Runoff Model

The summary graph (Figure 60) shows the Bacarra outflow using the Laoag Rainfall Intensity-Duration-Frequency curves (RIDF) in 5 different return periods (5-year, 10-year, 25-year, 50-year, and 100-year rainfall time series) based on the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) data. The simulation results reveal increasing outflow magnitude as the rainfall intensity increases for a range of durations and return periods.

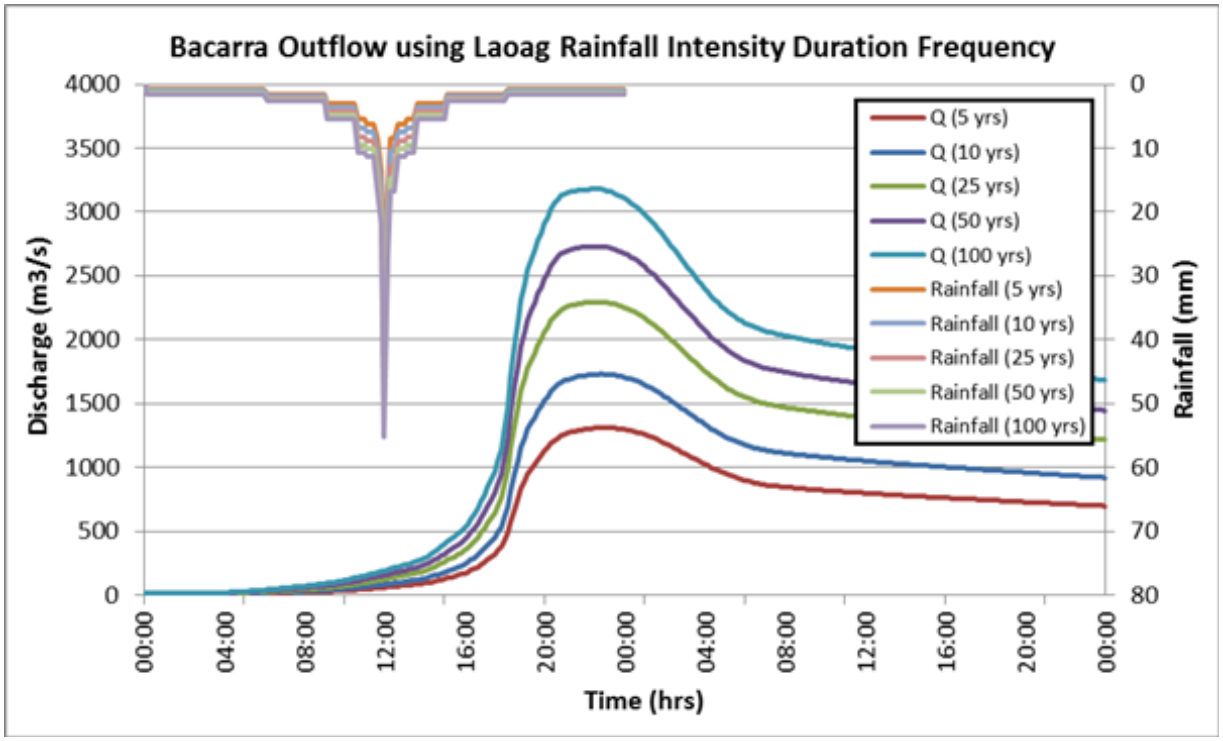


Figure 60. The Outflow hydrograph at the Bacarra Station, generated using the Laoag RIDF simulated in HEC-HMS.

A summary of the total precipitation, peak rainfall, peak outflow and time to peak of the Bacarra discharge using the Laoag Rainfall Intensity-Duration-Frequency curves (RIDF) in five different return periods is shown in Table 31.

Table 31. The peak values of the Bacarra HEC-HMS Model outflow using the Laoag RIDF

RIDF Period	Total Precipitation (mm)	Peak rainfall (mm)	Peak outflow (m 3/s)	Time to Peak
5-Year	331.7	31.4	1309.8	11 hours
10-Year	397.1	37.2	1729.3	10 hours 50 minutes
25-Year	479.8	44.5	2294.6	10 hours 50 minutes
50-Year	541.1	50	2730.5	10 hours minutes
100-Year	602	55.3	3178	10 hours 40 minutes

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. Figure 61 shows a generated sample map of the Bacarra River using the calibrated HMS base flow.

Figure 61. Sample output map of the Bacarra RAS Model.

5.9 Flow Depth and Flood Hazard

The resulting hazard and flow depth maps have a 10m resolution. Figure 62 to Figure 67 shows the 5-, 25-, and 100-year rain return scenarios of the Bacarra floodplain. The floodplain, with an area of 175.11 sq. km., covers four municipalites. Table 32 shows the percentage of area affected by flooding per municipality.

Table 32. Municipalities affected in Bacarra floodplain.

Municipality	Total Area	Area Flooded	% Flooded
Ilocos Norte	Bacarra	47.1	46.9
Ilocos Norte	Laoag City	114.36	0.43
Ilocos Norte	Pasuquin	154.16	63.22
Ilocos Norte	Vintar	497.39	63.5

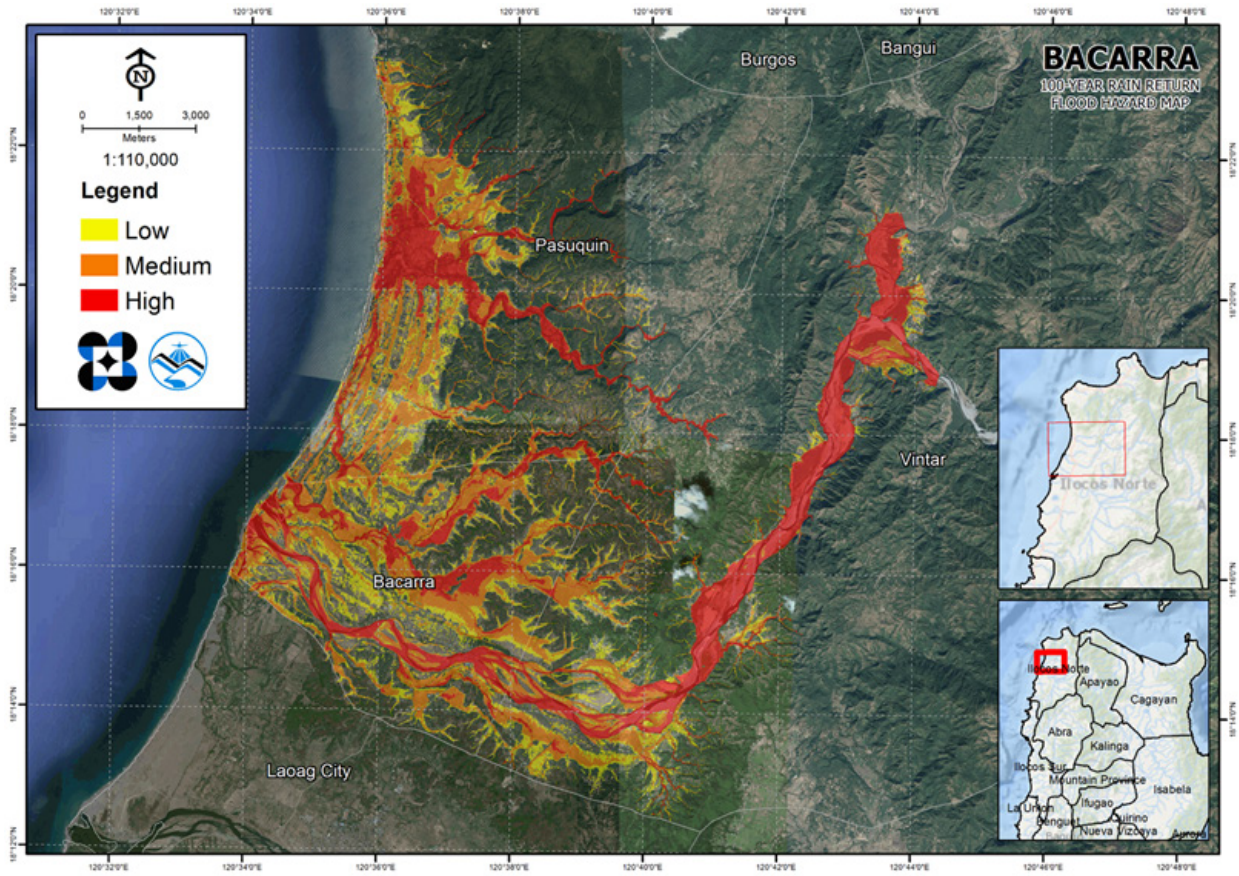


Figure 62. A 100-year Flood Hazard Map for Bacarra Floodplain overlaid on Google Earth imagery.

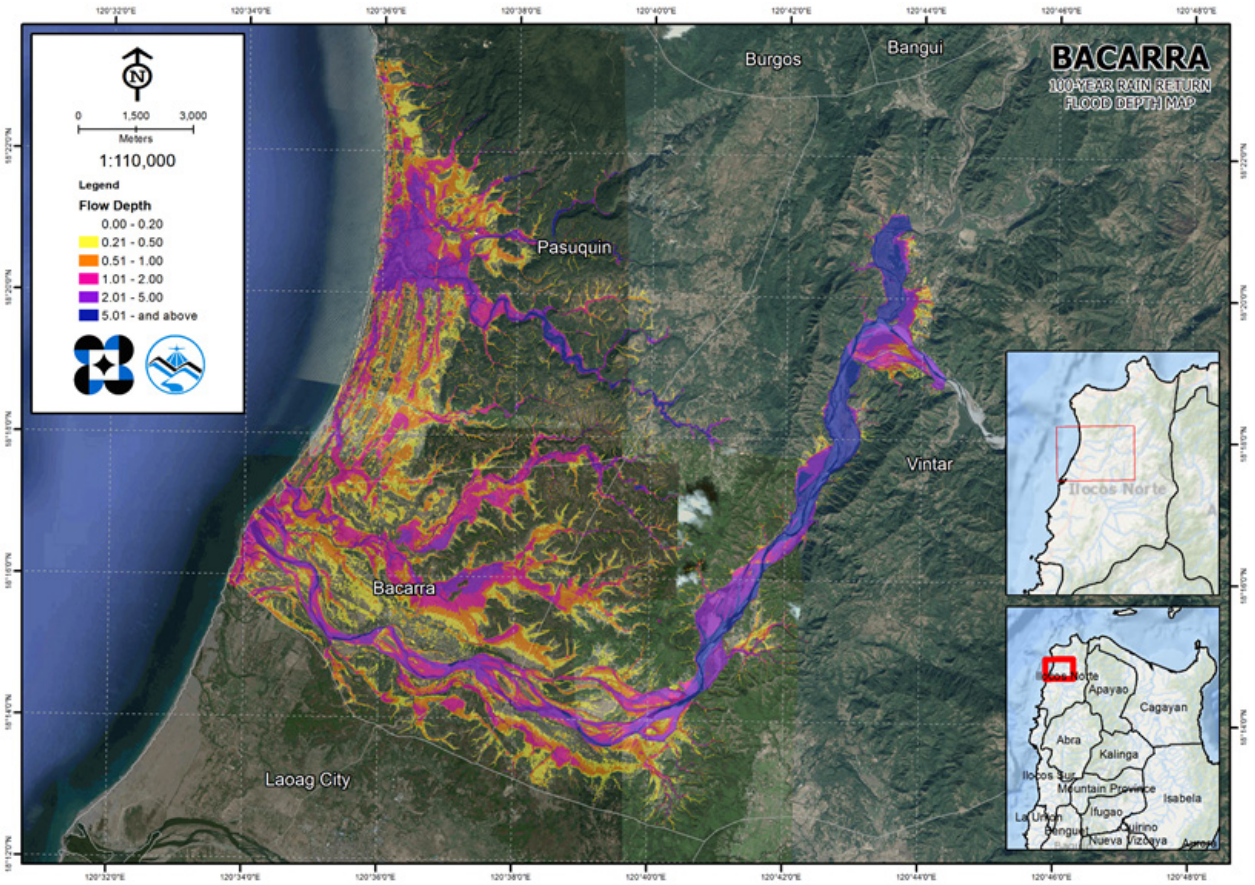


Figure 63. A 100-year Flow Depth Map for Bacarra Floodplain overlaid on Google Earth imagery.

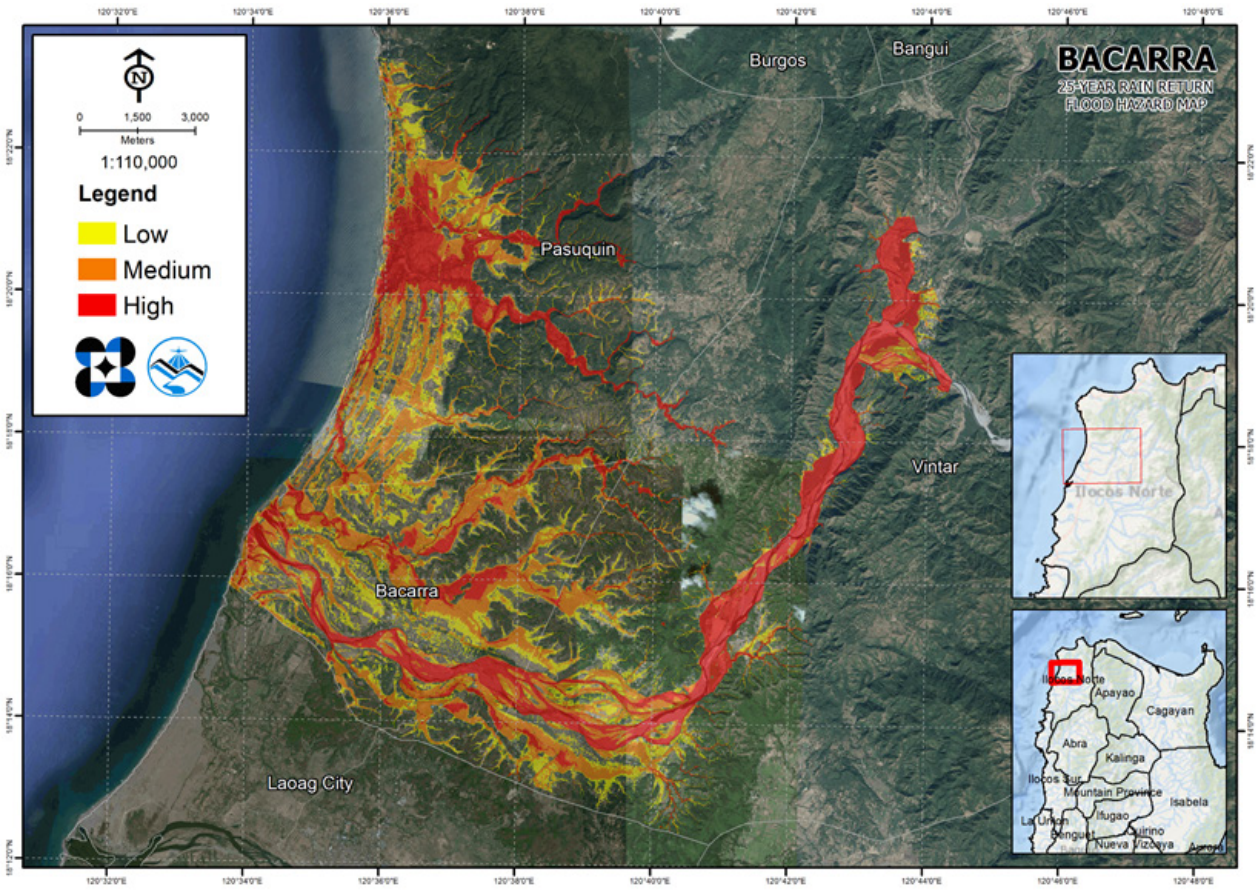


Figure 64. Figure 64. A 25-year Flood Hazard Map for Bacarra Floodplain overlaid on Google Earth imagery.

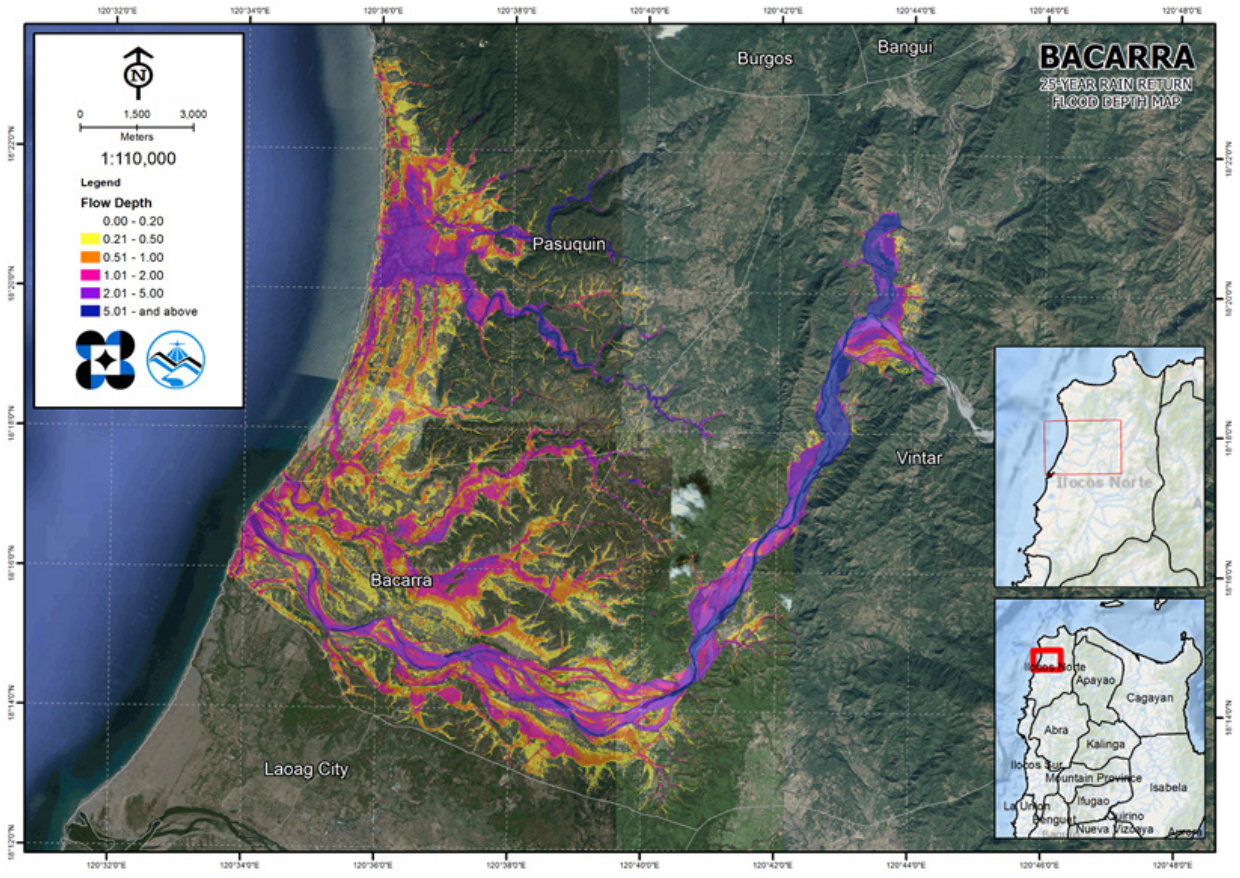


Figure 65. A 25-year Flow Depth Map for Bacarra Floodplain overlaid on Google Earth imagery.

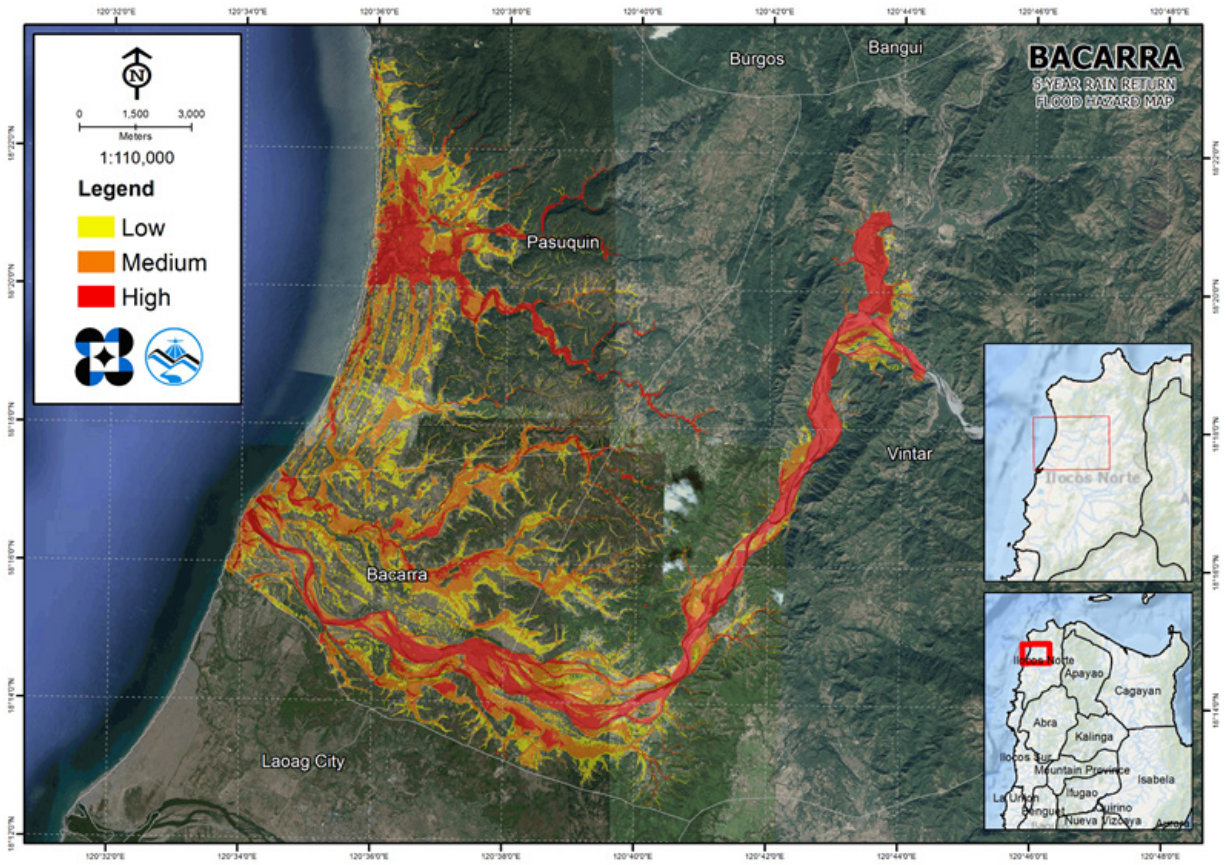


Figure 66. A 5-year Flood Hazard Map for Bacarra Floodplain overlaid on Google Earth imagery.

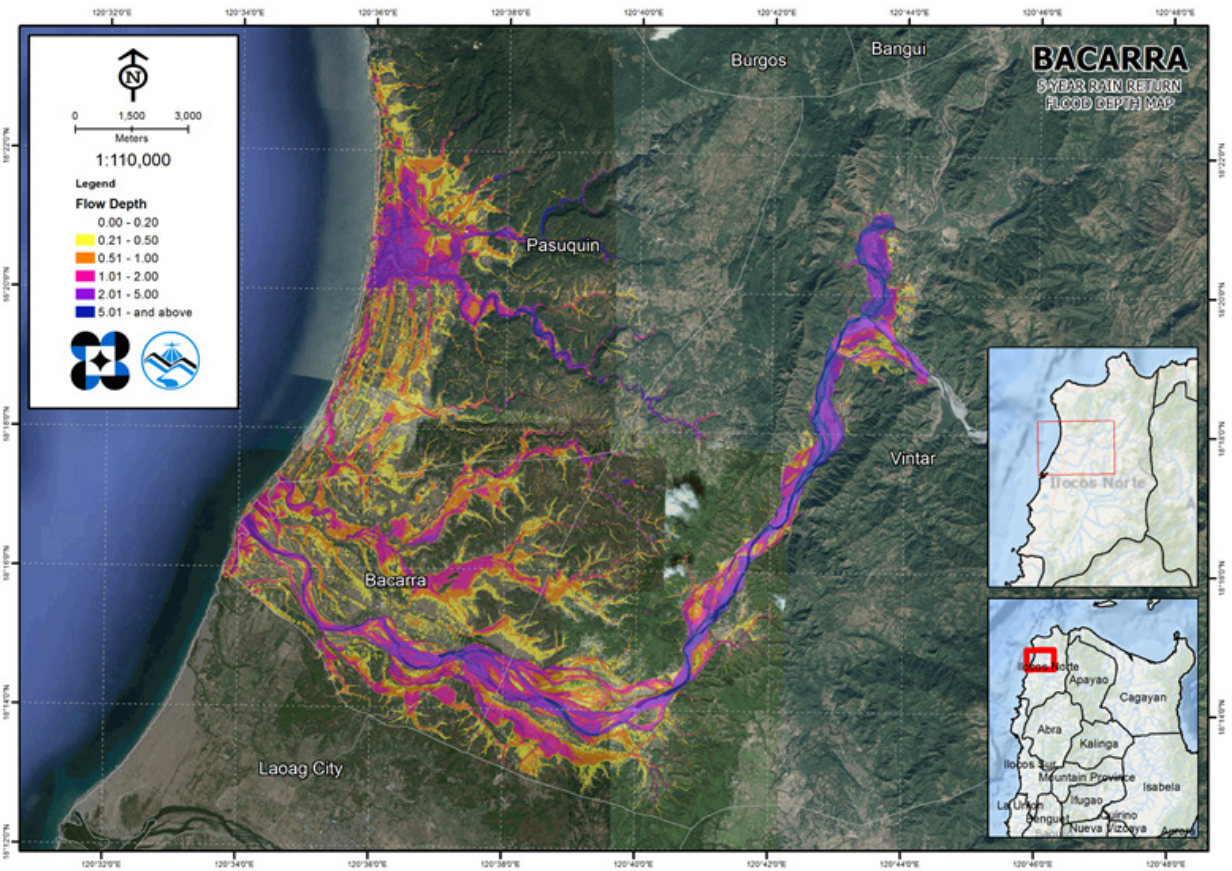


Figure 67. A 5-year Flood Depth Map for Bacarra Floodplain overlaid on Google Earth imagery.

5.10 Inventory of Areas Exposed to Flooding

Listed below are the affected barangays in the Bacarra River Basin, grouped accordingly by municipality. For the said basin, three municipalities are expected to experience flooding when subjected to 5-yr rainfall return period.

For the 5-year return period, 52.58% of the municipality of Bacarra with an area of 47.1 sq. km. will experience flood levels of less than 0.20 meters. 14.73% of the area will experience flood levels of 0.21 to 0.50 meters while 13.40%, 11.93%, 6.54%, and 0.46% 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 33, 34, 35 and 36 are the affected areas in square kilometers by flood depth per barangay. Annex 12 and Annex 13 show the educational and health institutions exposed to flooding.

Table 33. Affected Areas in Bacarra, Ilocos Norte during 5-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)					
	Bani	Buyon	Cabaruan	Cabulalaan	Cabusligan	Cadaratan
0.03-0.20	0.74	1.93	2.38	0.16	0.47	0.5
0.21-0.50	0.35	0.36	0.72	0.11	0.11	0.24
0.51-1.00	0.41	0.58	0.32	0.19	0.057	0.15
1.01-2.00	0.39	0.88	0.18	0.14	0.069	0.036
2.01-5.00	0.17	0.63	0.18	0.05	0.011	0

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)					
	Calioet-Libong	Casilian	Corocor	Duripes	Ganagan	Libtong
0.03-0.20	0.27	0.9	0.69	0.97	1	1.55
0.21-0.50	0.14	0.31	0.19	0.16	0.33	0.35
0.51-1.00	0.28	0.42	0.29	0.14	0.22	0.34
1.01-2.00	0.22	0.55	0.18	0.082	0.22	0.46
2.01-5.00	0.084	0.4	0.042	0.022	0.12	0.068

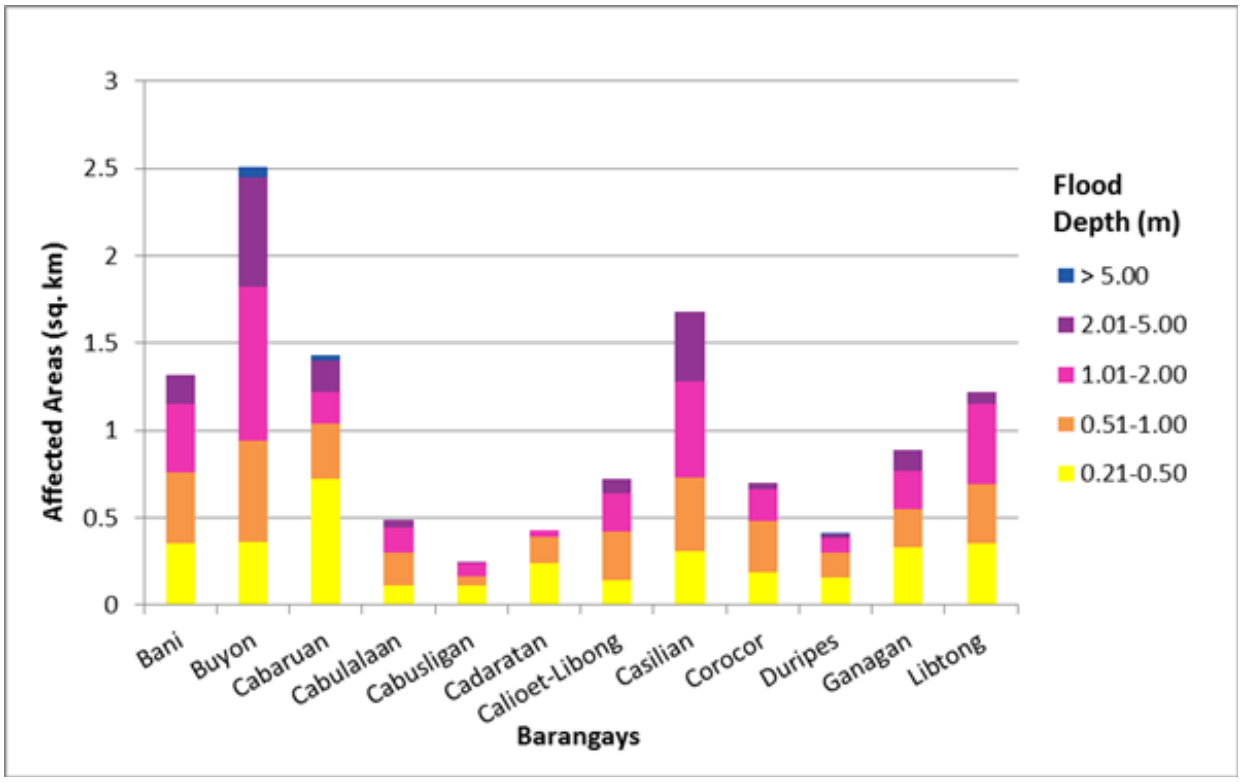


Figure 68. Affected Areas in Bacarra, Ilocos Norte during 5-Year Rainfall Return Period.

Table 34. Affected Areas in Bacarra, Ilocos Norte during 5-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)					
	Macupit	Nambaran	Natba	Paninaan	Pasiocan	Pasngal
0.03-0.20	0.63	2.34	0.044	1.05	1.34	0.72
0.21-0.50	0.079	0.62	0.045	0.082	0.34	0.12
0.51-1.00	0.075	0.47	0.051	0.045	0.31	0.044
1.01-2.00	0.095	0.19	0.04	0.056	0.29	0.015
2.01-5.00	0.026	0.0035	0.0022	0.068	0.13	0

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)					
	Pipias	Pulangi	Pungto	San Agustin I	San Agustin II	San Andres I
0.03-0.20	0.12	1.35	0.46	0.014	0.019	0.1
0.21-0.50	0.14	0.28	0.19	0.0007	0.0047	0.045
0.51-1.00	0.16	0.28	0.064	0.0011	0.0087	0.0073
1.01-2.00	0.039	0.35	0.0066	0.0095	0.0066	0
2.01-5.00	0.0064	0.025	0	0.015	0.005	0

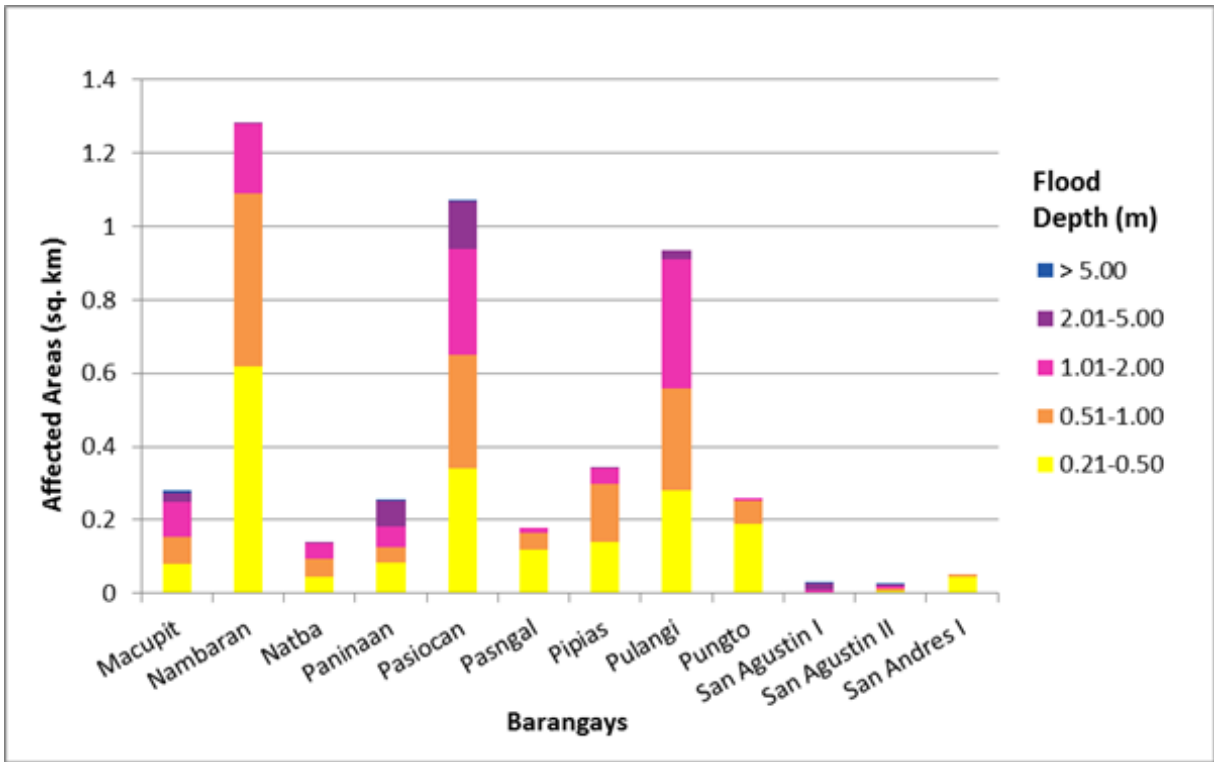


Figure 69. Affected Areas in Bacarra, Ilocos Norte during 5-Year Rainfall Return Period.

Table 35. Affected Areas in Bacarra, Ilocos Norte during 5-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)					
	San Andres II	San Gabriel I	San Gabriel II	San Pedro I	San Pedro II	San Roque I
0.03-0.20	0.091	0.025	0.026	0.054	0.064	0.068
0.21-0.50	0.051	0.013	0.019	0.022	0.025	0.0092
0.51-1.00	0.027	0.0022	0.0036	0.0055	0.0087	0.0033
1.01-2.00	0.0003	0	0	0	0	0.0081
2.01-5.00	0	0	0	0	0	0.03

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)					
	San Roque II	San Simon I	San Simon II	San Vicente	Sangil	Santa Filomena I
0.03-0.20	0.058	0.051	0.059	0.058	0.9	0.027
0.21-0.50	0.0071	0.023	0.0099	0.014	0.23	0.013
0.51-1.00	0.001	0.031	0.0014	0.0034	0.25	0.016
1.01-2.00	0.0011	0.052	0.0039	0	0.28	0.011
2.01-5.00	0.008	0.11	0.0002	0	0.085	0.03

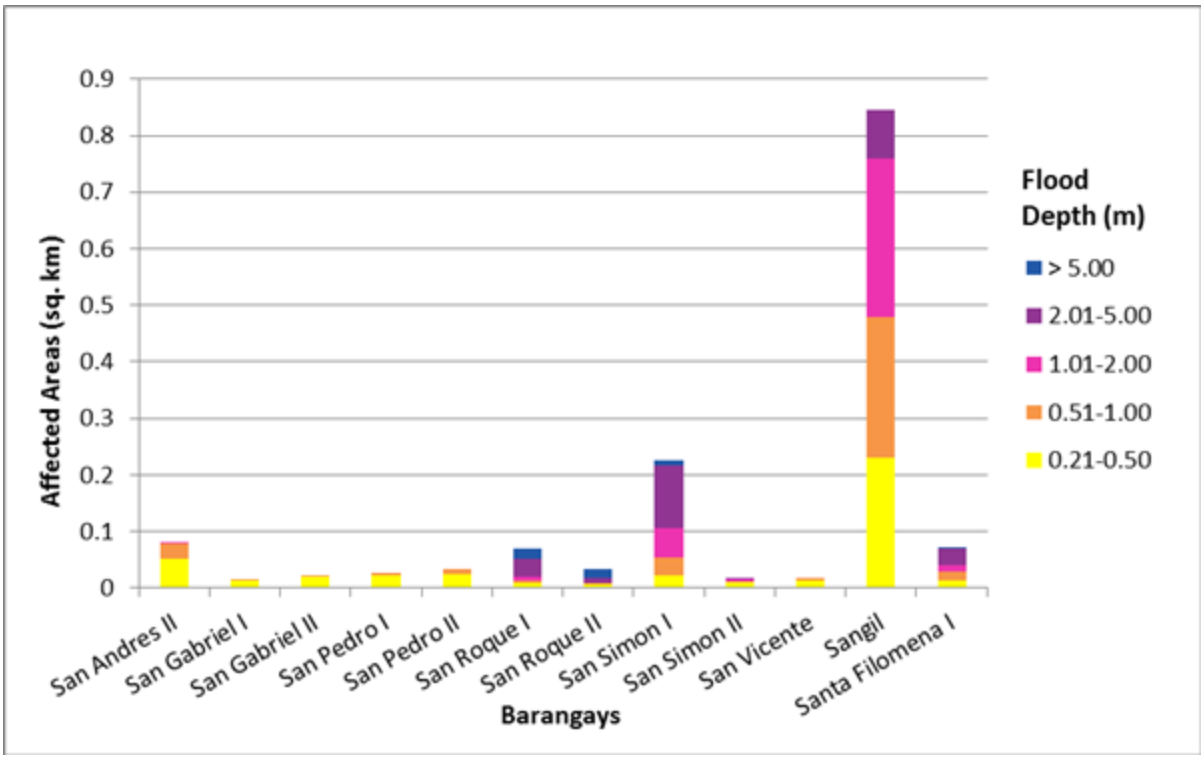


Figure 70. Affected Areas in Bacarra, Ilocos Norte during 5-Year Rainfall Return Period.

Table 36. Affected Areas in Bacarra, Ilocos Norte during 5-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)				
	Santa Filomena II	Santa Rita	Santo Cristo I	Santo Cristo II	Tambidao
0.03-0.20	0.055	0.33	0.087	0.045	1.81
0.21-0.50	0.013	0.22	0.043	0.021	0.55
0.51-1.00	0.016	0.17	0.018	0.0035	0.22
1.01-2.00	0.016	0.29	0.0015	0	0.15
2.01-5.00	0.023	0.42	0	0	0.27

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)			
	Teppang	Tubburan		
0.03-0.20	0.57	0.64		
0.21-0.50	0.14	0.2		
0.51-1.00	0.35	0.27		
1.01-2.00	0.2	0.1		
2.01-5.00	0.047	0		

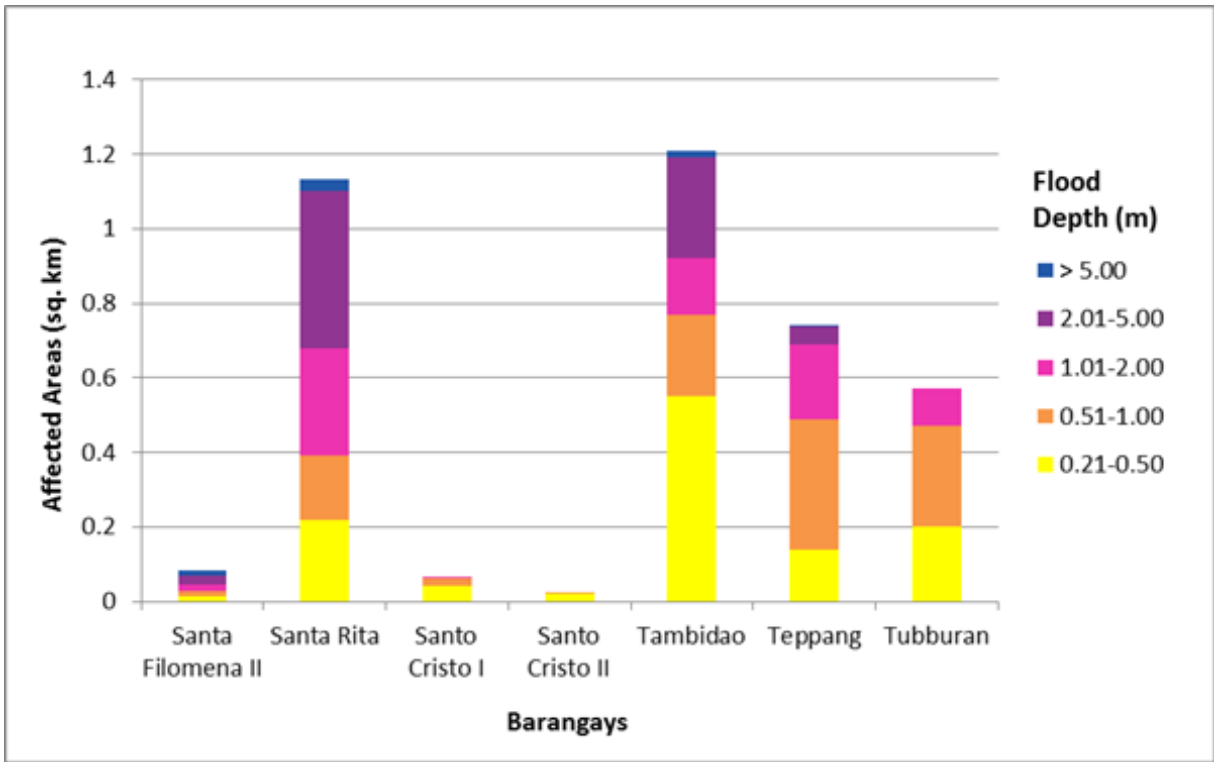


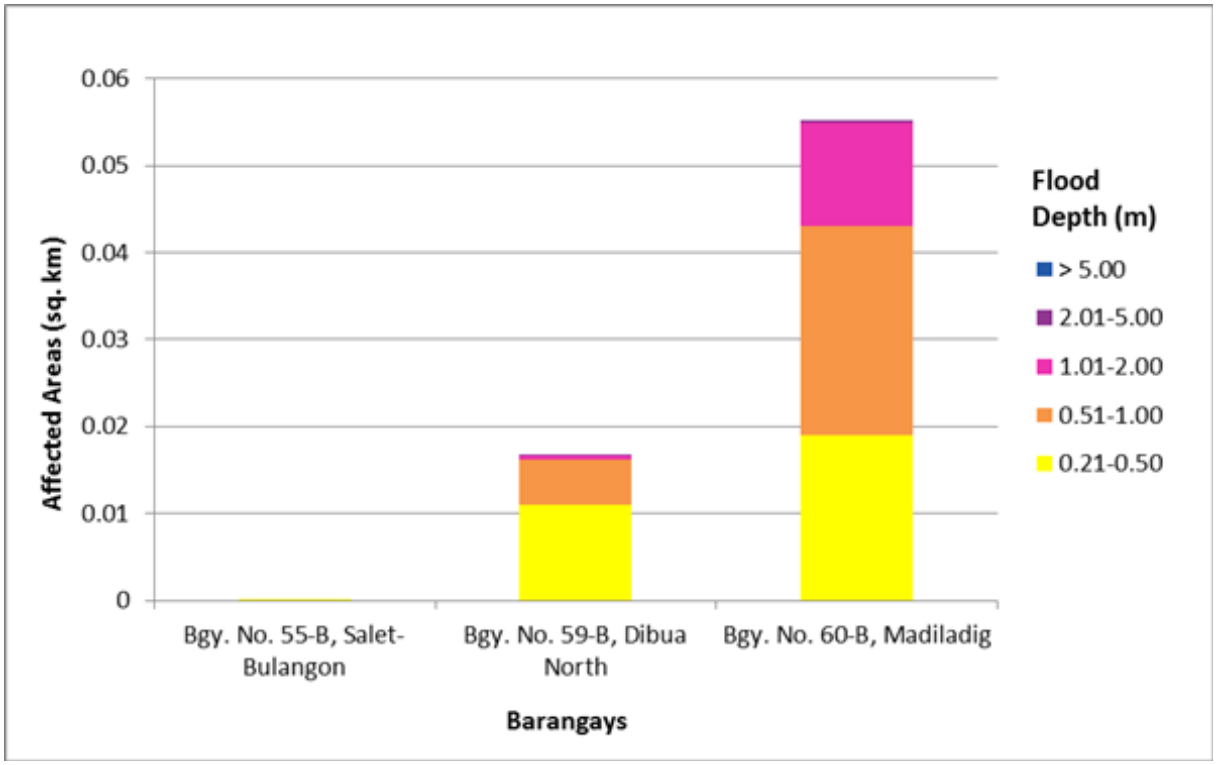
Figure 71. Affected Areas in Bacarra, Ilocos Norte during 5-Year Rainfall Return Period.

For the municipality of Laoag City with an area of 114.355 sq. km., 0.31% will experience flood levels of less than 0.20 meters. 0.03% of the area will experience flood levels of 0.21 to 0.50 meters while 0.03% and 0.01% of the area will experience flood depths of 0.51 to 1 meter and 1.01 to 2 meters, respectively. Listed in Table 37 are the affected areas in square kilometers by flood depth per barangay.

Table 37. Affected Areas in Laoag, Ilocos Norte during 5-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Laoag City (in sq.km.)			
	Bgy. No. 55-A, Barit-Pandan	Bgy. No. 55-B, Salet-Bulangon	Bgy. No. 59-B, Dibua North	Bgy. No. 60-B, Madiladig
0.03-0.20	0.0079	0.094	0.16	0.097
0.21-0.50	0	0.00015	0.011	0.019
0.51-1.00	0	0	0.0052	0.024
1.01-2.00	0	0	0.00036	0.012
2.01-5.00	0	0	0.000033	0.00029

Figure 72. Affected Areas in Laoag City, Ilocos Norte during 5-Year Rainfall Return Period.



For the municipality of Pasuquin with an area of 154.156 sq. km., 26.77% will experience flood levels of less than 0.20 meters. 4.60% of the area will experience flood levels of 0.21 to 0.50 meters while 3.92%, 2.93%, 2.45%, and 0.34% 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, 39, and 40 are the affected areas in square kilometers by flood depth per barangay.

Table 38. Affected Areas in Pasuquin, Ilocos Norte during 5-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Pasuquin (in sq.km.)					
	Batuli	Binsang	Caruan	Carusipan	Dadaeman	Darupidip
0.03-0.20	1.39	2.46	0.00018	0.45	0.93	1.38
0.21-0.50	0.43	0.76	0	0.2	0.13	0.13
0.51-1.00	0.28	0.63	0	0.068	0.14	0.054
1.01-2.00	0.088	0.5	0	0.003	0.055	0.0043
2.01-5.00	0.025	0.031	0	0	0.0053	0

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Pasuquin (in sq.km.)					
	Dilanis	Estancia	Naglicuan	Nagsanga	Nalvo	Ngabangab
0.03-0.20	2.89	1.64	1.07	0.069	0.12	1.01
0.21-0.50	0.13	0.52	0.57	0.1	0.085	0.53
0.51-1.00	0.056	0.25	0.53	0.13	0.13	0.5
1.01-2.00	0.047	0.12	0.19	0.23	0.31	0.11
2.01-5.00	0.013	0.0045	0.018	0.049	0.26	0

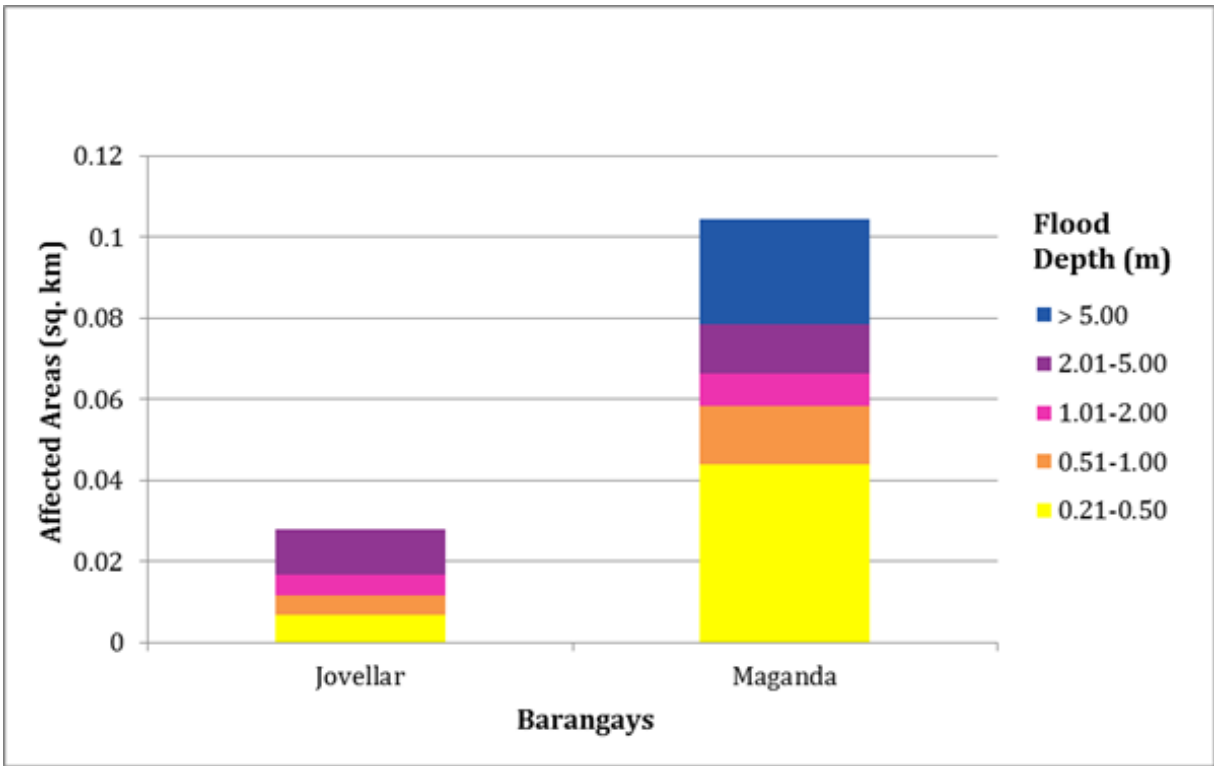


Figure 73. Affected Areas in Pasuquin, Ilocos Norte during 5-Year Rainfall Return Period.

Table 39. Affected Areas in Pasuquin, Ilocos Norte during 5-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Pasuquin (in sq.km.)					
	Pangil	Poblacion 1	Poblacion 2	Poblacion 3	Poblacion 4	Pragata
0.03-0.20	0.96	0.034	0.13	0.12	0.031	0.13
0.21-0.50	0.077	0.0081	0.043	0.051	0.015	0.074
0.51-1.00	0.049	0.012	0.039	0.00033	0.016	0.2
1.01-2.00	0.02	0.058	0.086	0	0.041	0.68
2.01-5.00	0.0052	0.14	0.053	0	0.041	1.58

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Pasuquin (in sq.km.)					
	Puyupuyan	Salpad	San Juan	Santa Catalina	Santa Matilde	Sapat
0.03-0.20	1.58	0.44	10.14	1.69	3.27	4.38
0.21-0.50	0.48	0.44	0.67	0.14	0.18	0.22
0.51-1.00	0.61	0.31	0.47	0.23	0.061	0.16
1.01-2.00	0.44	0.026	0.41	0.22	0.043	0.11
2.01-5.00	0.29	0.0031	0.56	0.084	0.074	0.1

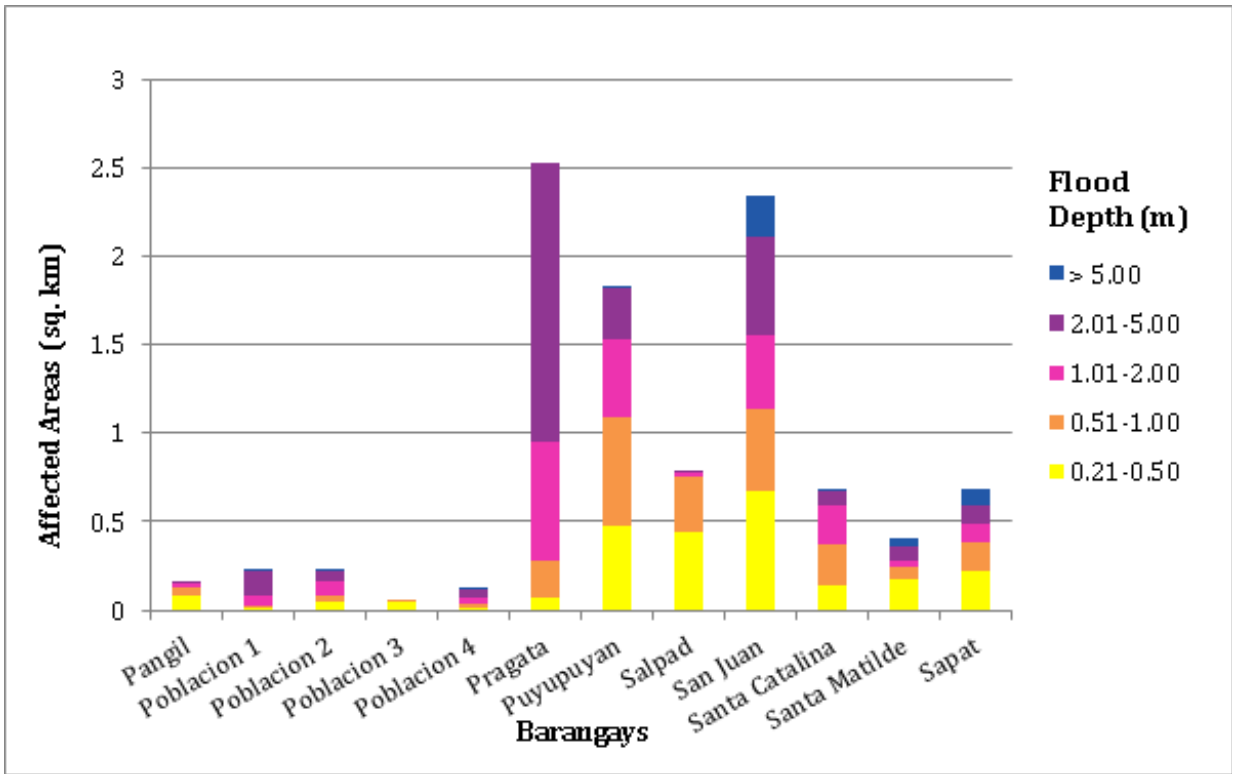


Figure 74. Affected Areas in Pasuquin, Ilocos Norte during 5-Year Rainfall Return Period.

Table 40. Affected Areas in Pasuquin, Ilocos Norte during 5-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Pasuquin (in sq.km.)				
	Sulbec	Sulongan	Surong	Susugaen	Tabungao
0.03-0.20	0.66	1.36	0.98	0.48	1.48
0.21-0.50	0.37	0.28	0.056	0.31	0.09
0.51-1.00	0.37	0.17	0.034	0.47	0.066
1.01-2.00	0.38	0.035	0.055	0.2	0.063
2.01-5.00	0.26	0.0027	0.12	0.035	0.019

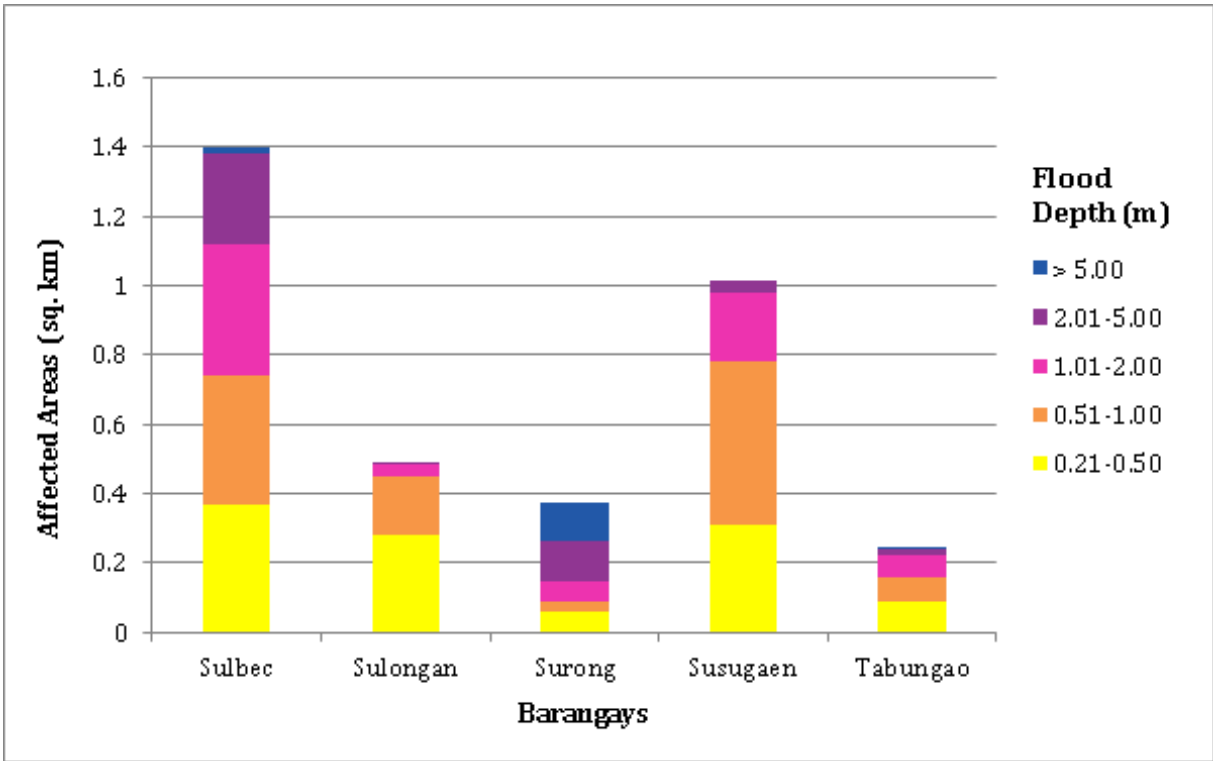


Figure 75. Affected Areas in Pasuquin, Ilocos Norte during 5-Year Rainfall Return Period.

For the municipality of Vintar with an area of 497.395 sq. km., 7.71% will experience flood levels of less than 0.20 meters. 1.17% of the area will experience flood levels of 0.21 to 0.50 meters while 1.04%, 1.05%, 1.21%, and 0.58% 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, 42, and 43 are the affected areas in square kilometers by flood depth per barangay.

Table 41. Affected Areas in Vintar, Ilocos Norte during 5-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Vintar (in sq.km.)					
	Abkir	Alejo Malasig	Alsem	Bago	Bulbulala	Cabayo
0.03-0.20	4.29	0.81	0.16	0.7	0.32	0.32
0.21-0.50	1.3	0.31	0.0044	0.029	0.0064	0.017
0.51-1.00	1.26	0.29	0.01	0.025	0.0018	0.01
1.01-2.00	1.28	0.15	0.021	0.028	0.0008	0.017
2.01-5.00	0.94	0.017	0.014	0.11	0.000054	0.071

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Vintar (in sq.km.)					
	Cabisocolan	Columbia	Dagupan	Dipilat	Esperanza	Ester
0.03-0.20	2.44	2.93	0.015	2	0.51	1.27
0.21-0.50	0.19	0.58	0.014	0.21	0.17	0.13
0.51-1.00	0.09	0.45	0.01	0.21	0.095	0.05
1.01-2.00	0.052	0.1	0.0059	0.32	0.18	0.031
2.01-5.00	0.018	0.0048	0	0.83	0.39	0.018

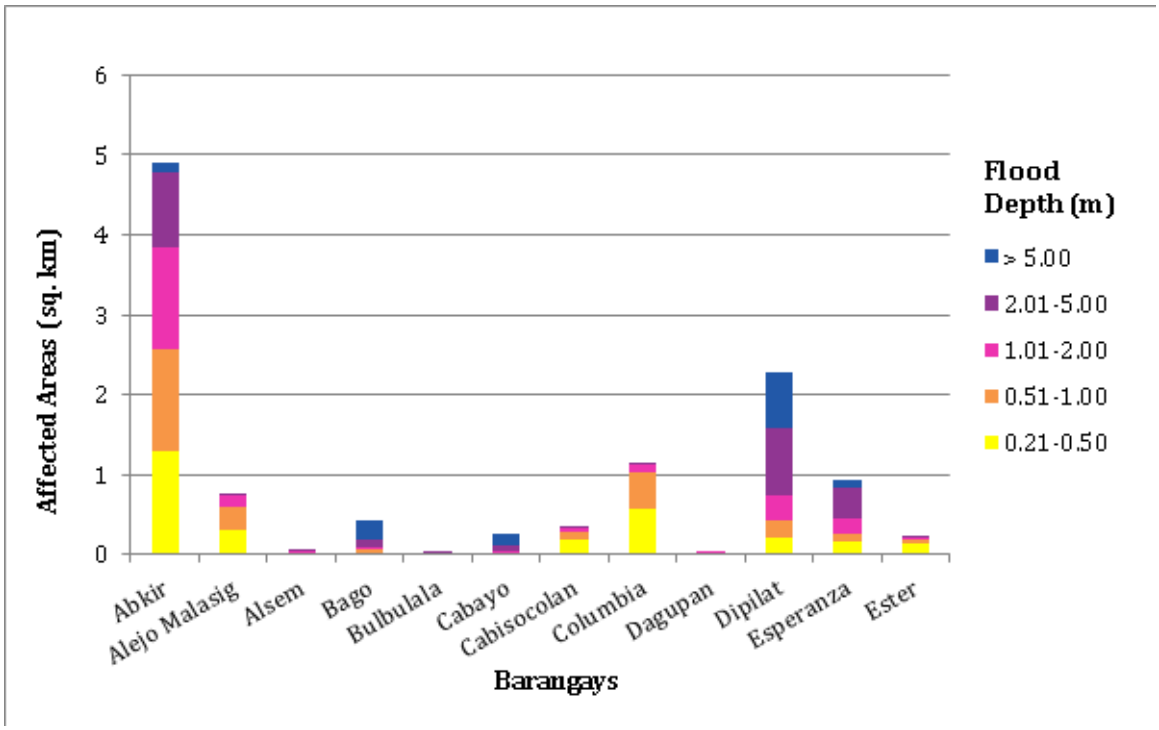


Figure 76. Affected Areas in Vintar, Ilocos Norte during 5-Year Rainfall Return Period.

Table 42. Affected Areas in Vintar, Ilocos Norte during 5-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Vintar (in sq.km.)					
	Lubnac	Malampa	Manarang	Margaay	Parparoroc	Parut
0.03-0.20	1.72	2	1.47	1.4	2.98	0.8
0.21-0.50	0.12	0.075	0.074	0.47	0.32	0.27
0.51-1.00	0.042	0.041	0.051	0.29	0.3	0.25
1.01-2.00	0.045	0.049	0.068	0.025	0.3	0.4
2.01-5.00	0.032	0.075	0.12	0.0015	0.49	0.067

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Vintar (in sq.km.)					
	Pedro F. Alviar	Salsalamagui	San Jose	San Nicolas	San Pedro	San Ramon
0.03-0.20	1.05	4.67	1.09	0.11	0.1	0.14
0.21-0.50	0.035	0.41	0.088	0.057	0.038	0.065
0.51-1.00	0.011	0.51	0.053	0.083	0.016	0.12
1.01-2.00	0.0031	0.65	0.091	0.11	0.066	0.17
2.01-5.00	0.0026	0.58	0.73	0.05	0.0026	0.058

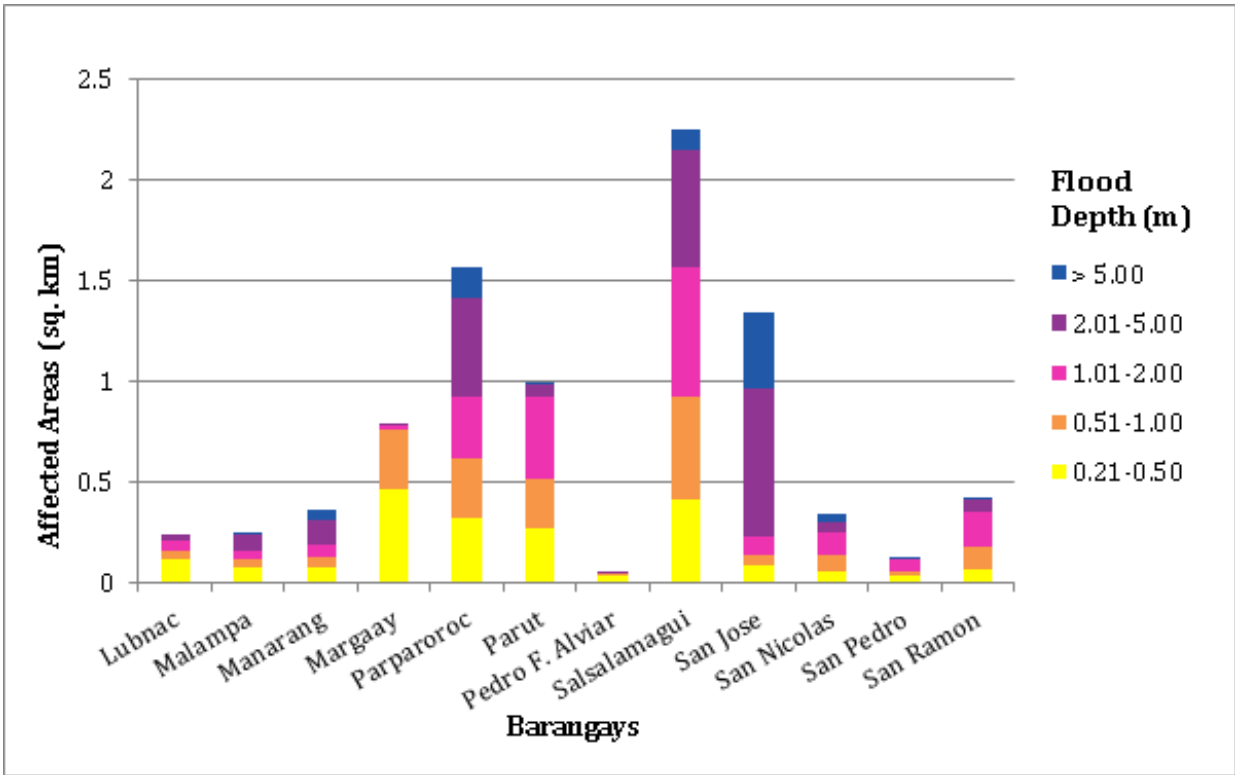


Figure 77. Affected Areas in Vintar, Ilocos Norte during 5-Year Rainfall Return Period.

Table 43. Affected Areas in Vintar, Ilocos Norte during 5-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Vintar (in sq.km.)			
	San Roque	Santa Maria	Tamdagan	Visaya
0.03-0.20	0.11	0.061	2.09	2.81
0.21-0.50	0.16	0.051	0.38	0.25
0.51-1.00	0.29	0.034	0.36	0.24
1.01-2.00	0.17	0.099	0.52	0.27
2.01-5.00	0.18	0.019	0.73	0.49

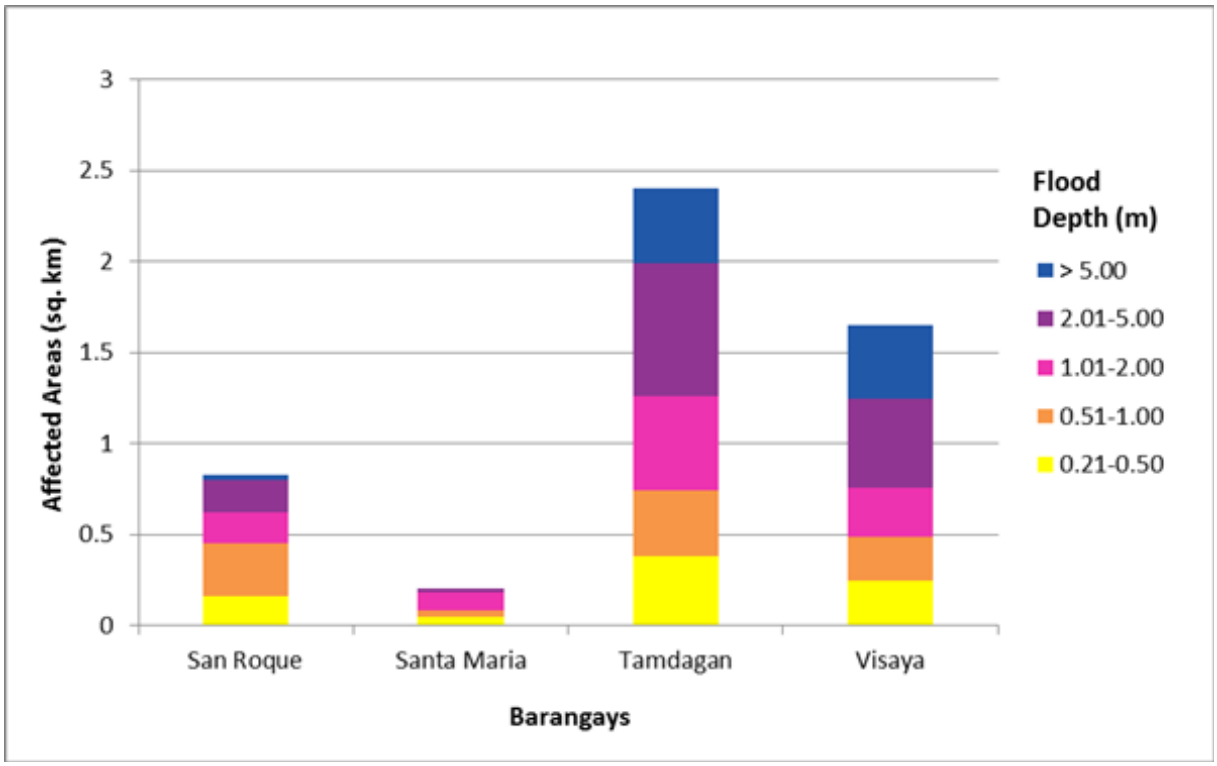


Figure 78. Affected Areas in Vintar, Ilocos Norte during 5-Year Rainfall Return Period.

For the 25-year return period, 47.32% of the municipality of Bacarra with an area of 47.1 sq. km. will experience flood levels of less than 0.20 meters. 15.40% of the area will experience flood levels of 0.21 to 0.50 meters while 14.26%, 14.30%, 8.00%, and 0.41% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 44, 45, 46, and 47 are the affected areas in square kilometers by flood depth per barangay.

Table 44. Affected Areas in Bacarra, Ilocos Norte during 25-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)					
	Bani	Buyon	Cabaruan	Cabulalaan	Cabusligan	Cadaratan
0.03-0.20	0.54	2.04	1.97	0.1	0.41	0.37
0.21-0.50	0.24	0.42	0.98	0.095	0.14	0.29
0.51-1.00	0.47	0.64	0.38	0.2	0.059	0.2
1.01-2.00	0.56	0.79	0.19	0.2	0.071	0.069
2.01-5.00	0.25	0.51	0.22	0.057	0.036	0

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)					
	Calioet-Libong	Casilian	Corocor	Duripes	Ganagan	Libtong
0.03-0.20	0.23	0.64	0.55	0.85	0.86	1.28
0.21-0.50	0.12	0.33	0.24	0.22	0.34	0.36
0.51-1.00	0.27	0.42	0.28	0.15	0.27	0.33
1.01-2.00	0.27	0.65	0.28	0.13	0.21	0.52
2.01-5.00	0.11	0.54	0.054	0.029	0.2	0.28

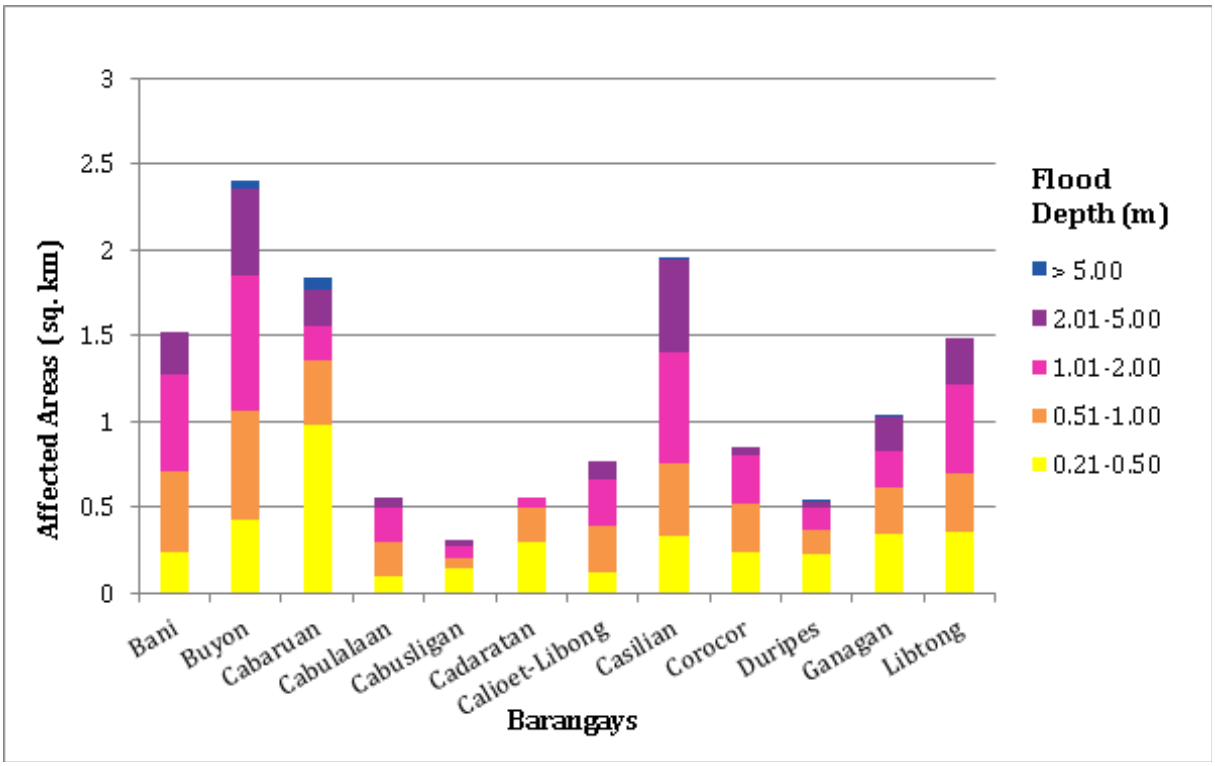


Figure 79. Affected Areas in Bacarra, Ilocos Norte during 25-Year Rainfall Return Period.

Table 45. Affected Areas in Bacarra, Ilocos Norte during 25-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)					
	Macupit	Nambaran	Natba	Paninaan	Pasiocan	Pasngal
0.03-0.20	0.59	2.09	0.029	1.01	1.45	0.65
0.21-0.50	0.084	0.6	0.032	0.085	0.34	0.17
0.51-1.00	0.057	0.56	0.057	0.056	0.26	0.066
1.01-2.00	0.13	0.35	0.055	0.061	0.25	0.017
2.01-5.00	0.038	0.017	0.0099	0.092	0.11	0.0012

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)					
	Pipias	Pulangi	Pungto	San Agustin I	San Agustin II	San Andres I
0.03-0.20	0.079	1.2	0.4	0.014	0.021	0.1
0.21-0.50	0.12	0.24	0.19	0.0011	0.0074	0.044
0.51-1.00	0.21	0.27	0.11	0.0027	0.006	0.0083
1.01-2.00	0.049	0.4	0.012	0.0093	0.0049	0
2.01-5.00	0.01	0.17	0	0.015	0.0045	0

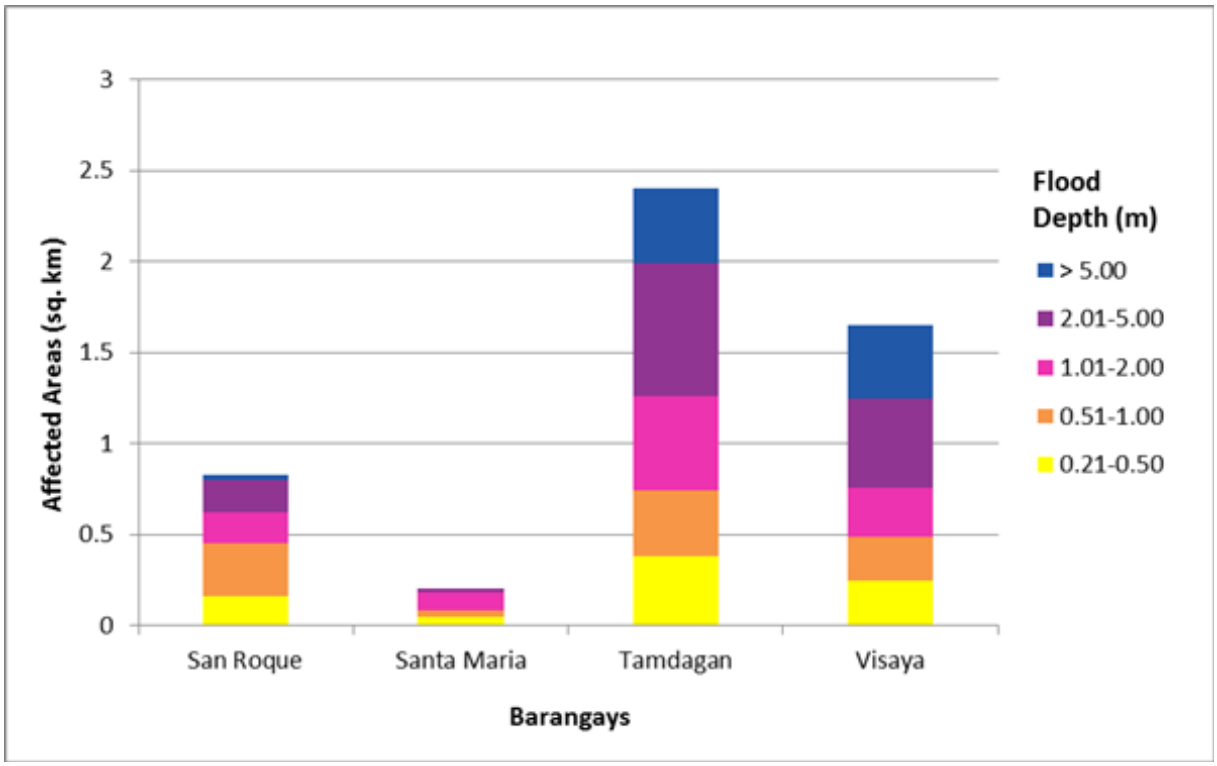


Figure 80. Affected Areas in Bacarra, Ilocos Norte during 25-Year Rainfall Return Period.

Table 46. Affected Areas in Bacarra, Ilocos Norte during 25-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)					
	San Andres II	San Gabriel I	San Gabriel II	San Pedro I	San Pedro II	San Roque I
0.03-0.20	0.091	0.025	0.024	0.05	0.054	0.068
0.21-0.50	0.055	0.012	0.019	0.025	0.028	0.011
0.51-1.00	0.022	0.0033	0.0053	0.0066	0.015	0.0041
1.01-2.00	0.0003	0	0	0	0.0002	0.0071
2.01-5.00	0	0	0	0	0	0.03

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)					
	San Roque II	San Simon I	San Simon II	San Vicente	Sangil	Santa Filomena I
0.03-0.20	0.058	0.062	0.06	0.052	0.96	0.035
0.21-0.50	0.0078	0.027	0.0092	0.019	0.22	0.015
0.51-1.00	0.0009	0.028	0.0029	0.0048	0.25	0.013
1.01-2.00	0.0011	0.051	0.002	0	0.21	0.0049
2.01-5.00	0.012	0.11	0	0	0.11	0.031

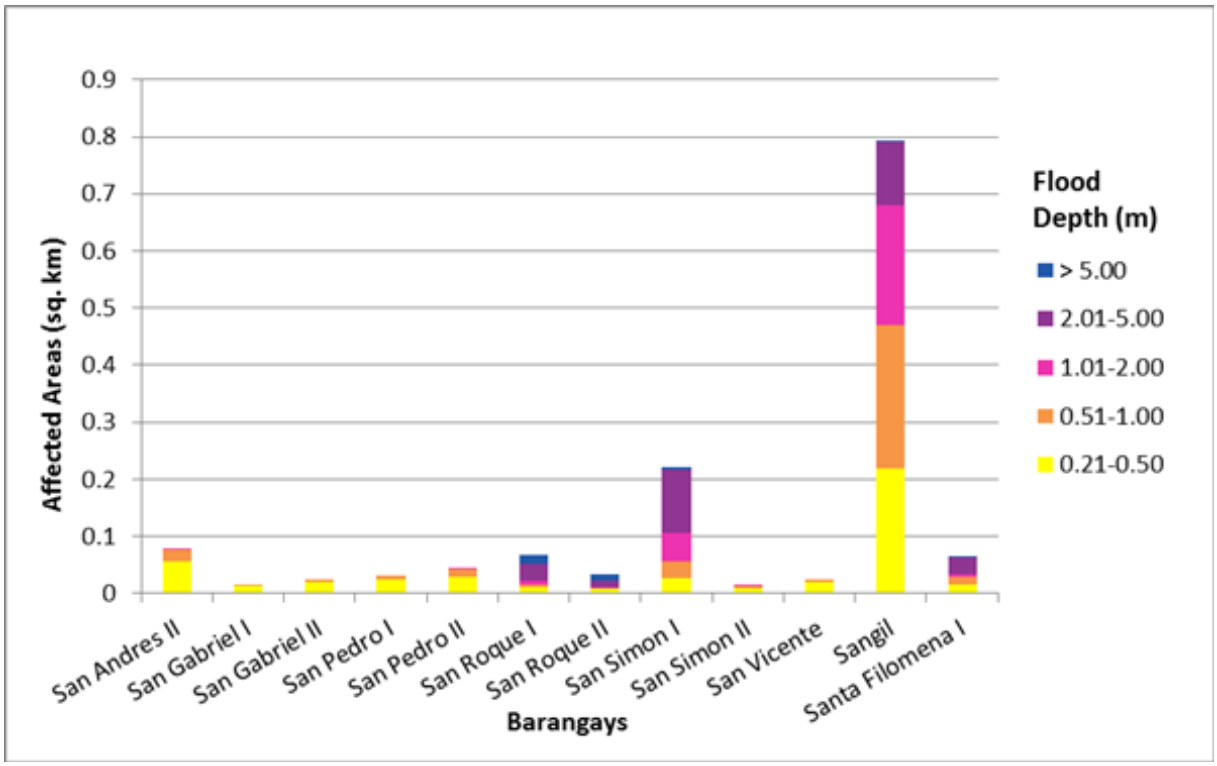


Figure 81. Affected Areas in Bacarra, Ilocos Norte during 25-Year Rainfall Return Period.

Table 47. Affected Areas in Bacarra, Ilocos Norte during 25-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)						
	Santa Filomena II	Santa Rita	Santo Cristo I	Santo Cristo II	Tambidao	Teppang	Tubburan
0.03-0.20	0.061	0.42	0.07	0.043	1.61	0.5	0.57
0.21-0.50	0.017	0.2	0.056	0.022	0.55	0.11	0.16
0.51-1.00	0.012	0.16	0.021	0.0059	0.39	0.2	0.24
1.01-2.00	0.0096	0.31	0.0025	0.0002	0.21	0.41	0.24
2.01-5.00	0.025	0.35	0	0	0.25	0.096	0.0016

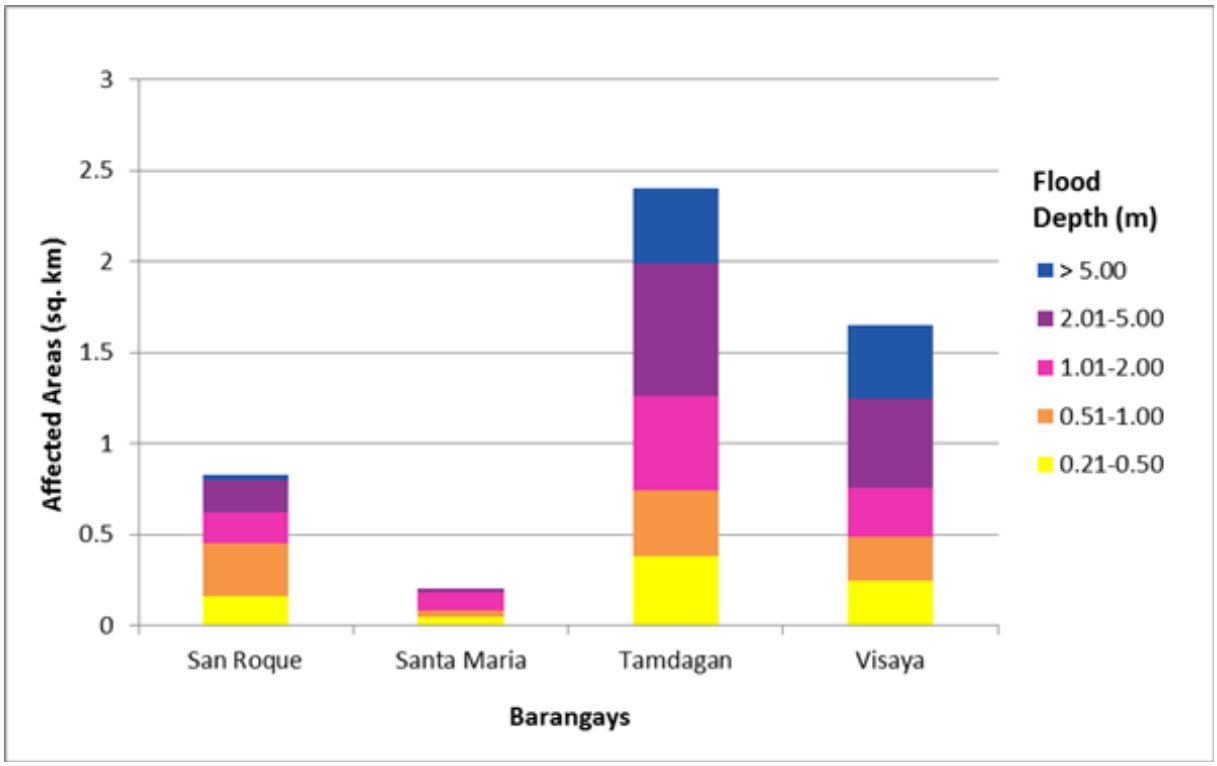


Figure 82. Affected Areas in Bacarra, Ilocos Norte during 25-Year Rainfall Return Period.

For the municipality of Laoag City with an area of 114.355 sq. km., 0.31% will experience flood levels of less than 0.20 meters. 0.02% of the area will experience flood levels of 0.21 to 0.50 meters while 0.03% and 0.02% of the area will experience flood depths of 0.51 to 1 meter and 1.01 to 2 meters, respectively. Listed in Table 48 are the affected areas in square kilometers by flood depth per barangay.

Table 48. Affected Areas in Laoag, Ilocos Norte during 25-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Laoag City (in sq.km.)			
	Bgy. No. 55-A, Barit-Pandan	Bgy. No. 55-B, Salet-Bulangon	Bgy. No. 59-B, Dibua North	Bgy. No. 60-B, Madiladig
0.03-0.20	0.0079	0.094	0.16	0.09
0.21-0.50	0	0.00015	0.0097	0.014
0.51-1.00	0	0	0.0039	0.027
1.01-2.00	0	0	0.000079	0.021

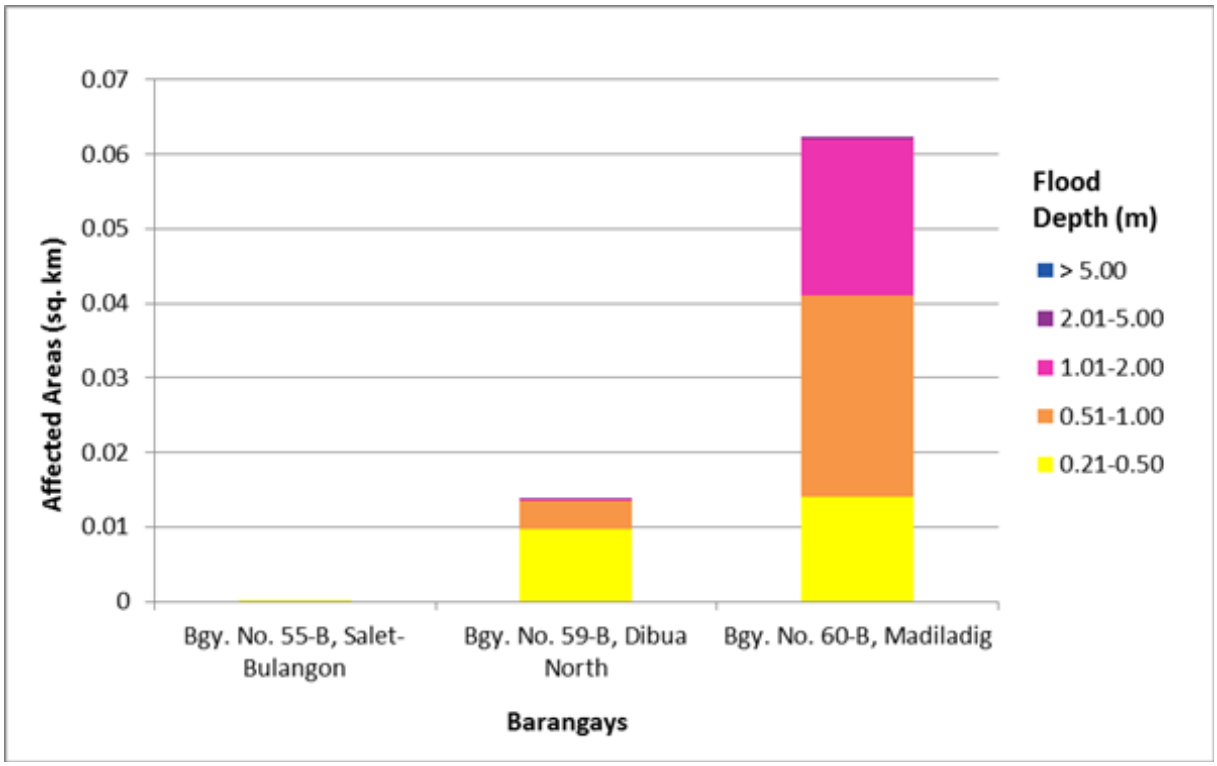


Figure 83. Affected Areas in Laoag City, Ilocos Norte during 25-Year Rainfall Return Period.

For the municipality of Pasuquin with an area of 154.156 sq. km., 24.58% will experience flood levels of less than 0.20 meters. 4.45% of the area will experience flood levels of 0.21 to 0.50 meters while 4.43%, 3.55%, 3.43%, and 0.60% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 49, 50, and 51 are the affected areas in square kilometers by flood depth per barangay.

Table 49. Affected Areas in Pasuquin, Ilocos Norte during 25-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Pasuquin (in sq.km.)						
	Batuli	Binsang	Caruan	Carusipan	Dadaeman	Darupidip	Dilanis
0.03-0.20	1.21	2.06	0.00018	0.4	0.87	1.33	2.85
0.21-0.50	0.52	0.75	0	0.19	0.13	0.16	0.14
0.51-1.00	0.32	0.77	0	0.12	0.16	0.077	0.067
1.01-2.00	0.12	0.7	0	0.01	0.093	0.0096	0.052
2.01-5.00	0.036	0.1	0	0	0.011	0	0.028

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Pasuquin (in sq.km.)						
	Estancia	Naglicuan	Nagsanga	Nalvo	Ngabangab		
0.03-0.20	1.44	0.84	0.035	0.076	0.87		
0.21-0.50	0.61	0.48	0.07	0.067	0.45		
0.51-1.00	0.3	0.74	0.12	0.13	0.58		
1.01-2.00	0.18	0.27	0.2	0.29	0.25		
2.01-5.00	0.01	0.057	0.15	0.35	0.0005		

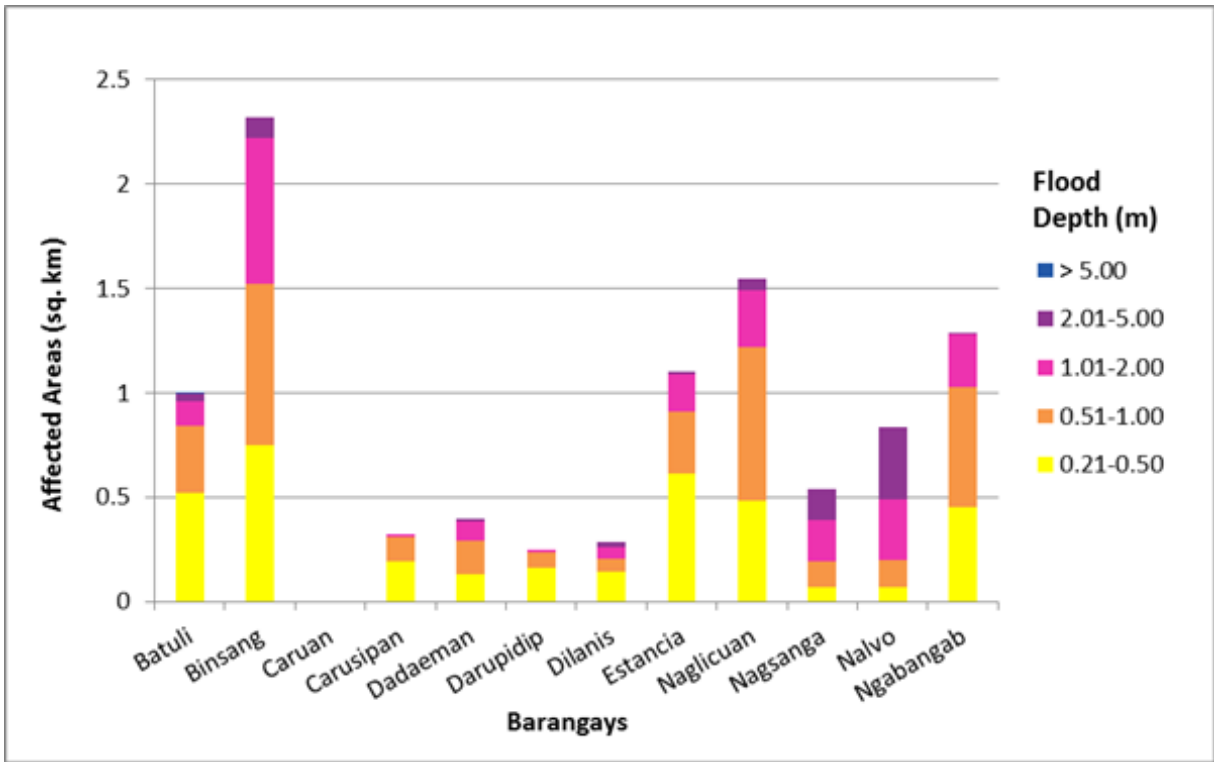


Figure 84. Affected Areas in Pasuquin, Ilocos Norte during 25-Year Rainfall Return Period.

Table 50. Affected Areas in Pasuquin, Ilocos Norte during 25-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Pasuquin (in sq.km.)						
	Pangil	Poblacion 1	Poblacion 2	Poblacion 3	Poblacion 4	Pragata	Puyupuyan
0.03-0.20	0.93	0.016	0.058	0.026	0.0094	0.086	1.16
0.21-0.50	0.085	0.0061	0.052	0.089	0.0094	0.033	0.52
0.51-1.00	0.061	0.015	0.07	0.055	0.023	0.1	0.6
1.01-2.00	0.029	0.025	0.054	0.00026	0.036	0.42	0.65
2.01-5.00	0.009	0.18	0.11	0	0.065	2.01	0.48

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Pasuquin (in sq.km.)						
	Salpad	San Juan	Santa Catalina	Santa Matilde	Sapat	Pragata	Tubburan
0.03-0.20	0.34	9.69	1.61	3.18	4.26	0.086	0.57
0.21-0.50	0.37	0.68	0.13	0.21	0.23	0.033	0.16
0.51-1.00	0.43	0.45	0.17	0.081	0.17	0.1	0.24
1.01-2.00	0.06	0.57	0.31	0.042	0.14	0.42	0.24
2.01-5.00	0.0045	0.68	0.14	0.092	0.11	2.01	0.0016

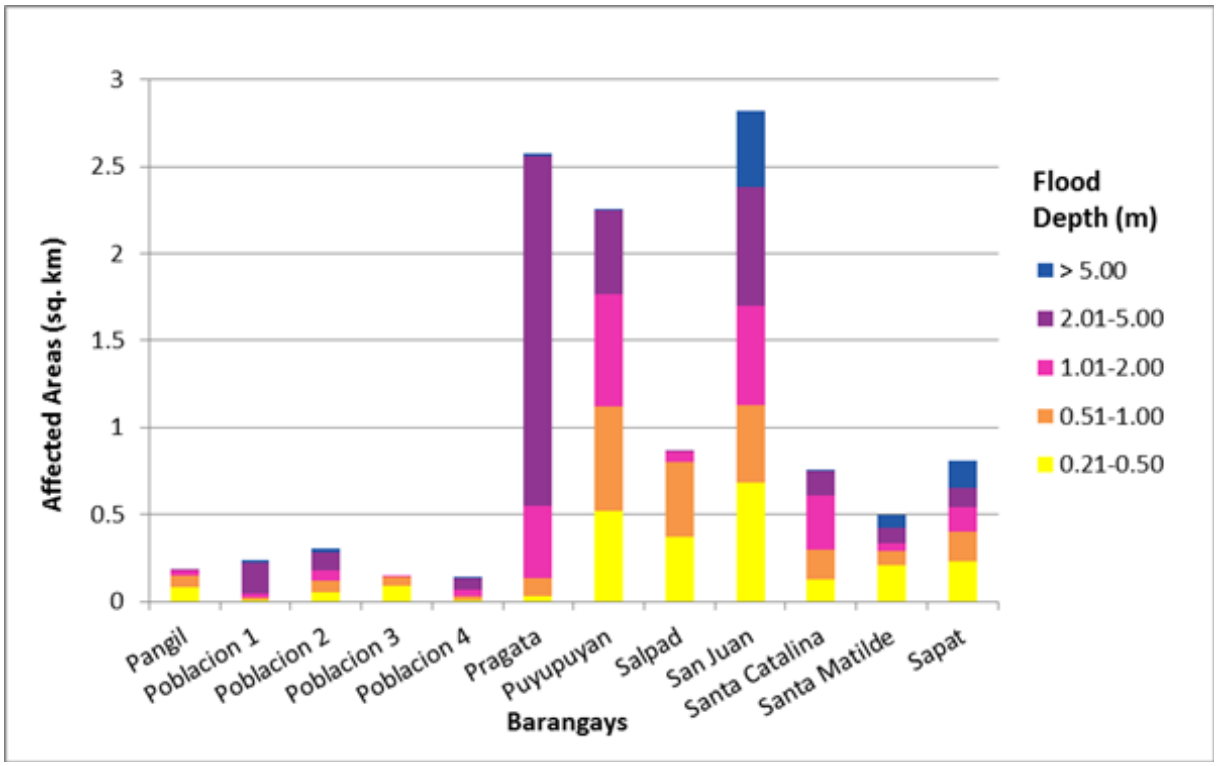


Figure 85. Affected Areas in Pasuquin, Ilocos Norte during 25-Year Rainfall Return Period.

Table 51. Affected Areas in Pasuquin, Ilocos Norte during 25-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Pasuquin (in sq.km.)				
	Sulbec	Sulongan	Surong	Susugaen	Tabungao
0.03-0.20	0.5	1.29	0.92	0.4	1.44
0.21-0.50	0.26	0.24	0.06	0.23	0.095
0.51-1.00	0.41	0.26	0.029	0.46	0.064
1.01-2.00	0.46	0.054	0.044	0.33	0.078
2.01-5.00	0.42	0.007	0.14	0.062	0.038

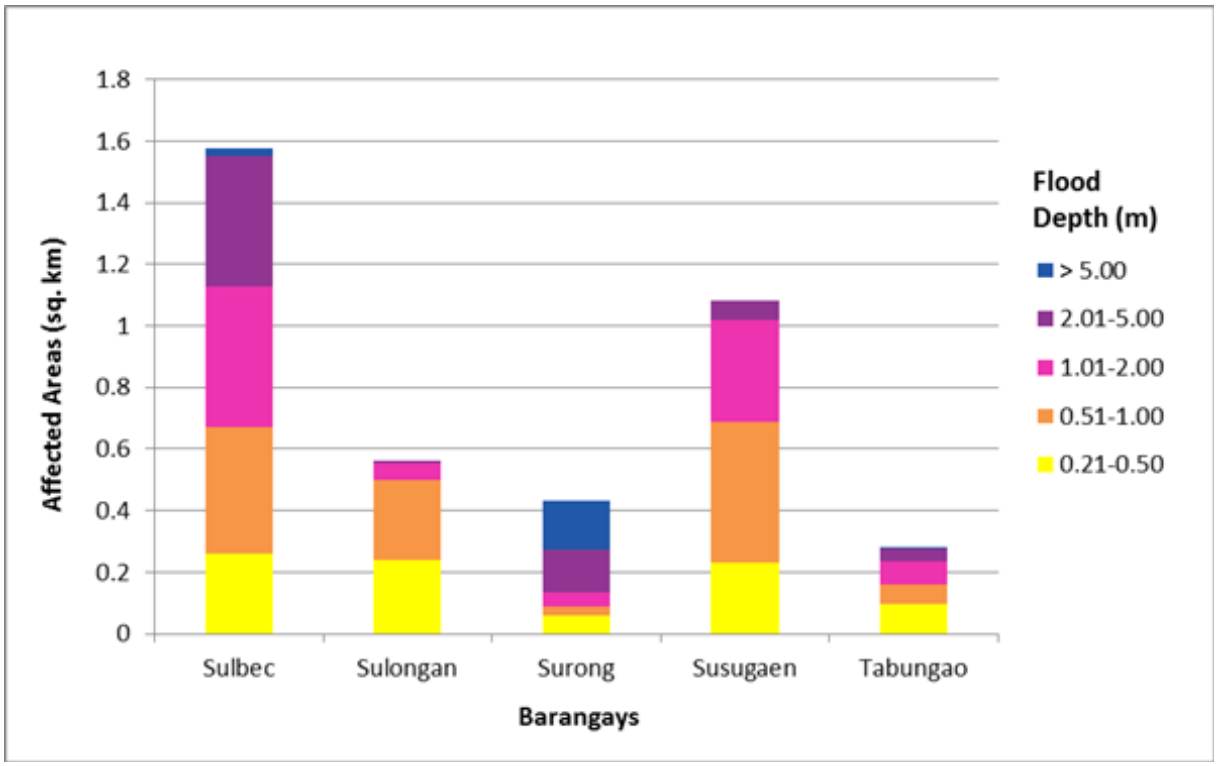


Figure 86. Affected Areas in Pasuquin, Ilocos Norte during 25-Year Rainfall Return Period.

For the municipality of Vintar with an area of 497.395 sq. km., 7.34% will experience flood levels of less than 0.20 meters. 1.19% of the area will experience flood levels of 0.21 to 0.50 meters while 0.99%, 0.93%, 1.35%, and 0.98% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 52, 53, and 54 are the affected areas in square kilometers by flood depth per barangay.

Table 52. Affected Areas in Vintar, Ilocos Norte during 25-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Vintar (in sq.km.)						
	Abkir	Alejo Malasig	Alsem	Bago	Bulbulala	Cabayo	Cabisocolan
0.03-0.20	4.02	0.87	0.15	0.68	0.32	0.3	2.36
0.21-0.50	1.44	0.33	0.005	0.029	0.0071	0.016	0.22
0.51-1.00	1.34	0.24	0.0077	0.025	0.0024	0.0099	0.11
1.01-2.00	1.26	0.12	0.016	0.031	0.0009	0.013	0.073
2.01-5.00	1.02	0.011	0.03	0.058	0.00025	0.039	0.024

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Vintar (in sq.km.)				
	Columbia	Dagupan	Dipilat	Esperanza	Ester
0.03-0.20	2.76	0.01	1.81	0.42	1.22
0.21-0.50	0.53	0.014	0.2	0.17	0.16
0.51-1.00	0.57	0.01	0.078	0.096	0.06
1.01-2.00	0.2	0.011	0.13	0.13	0.035
2.01-5.00	0.0097	0.00025	0.65	0.47	0.025

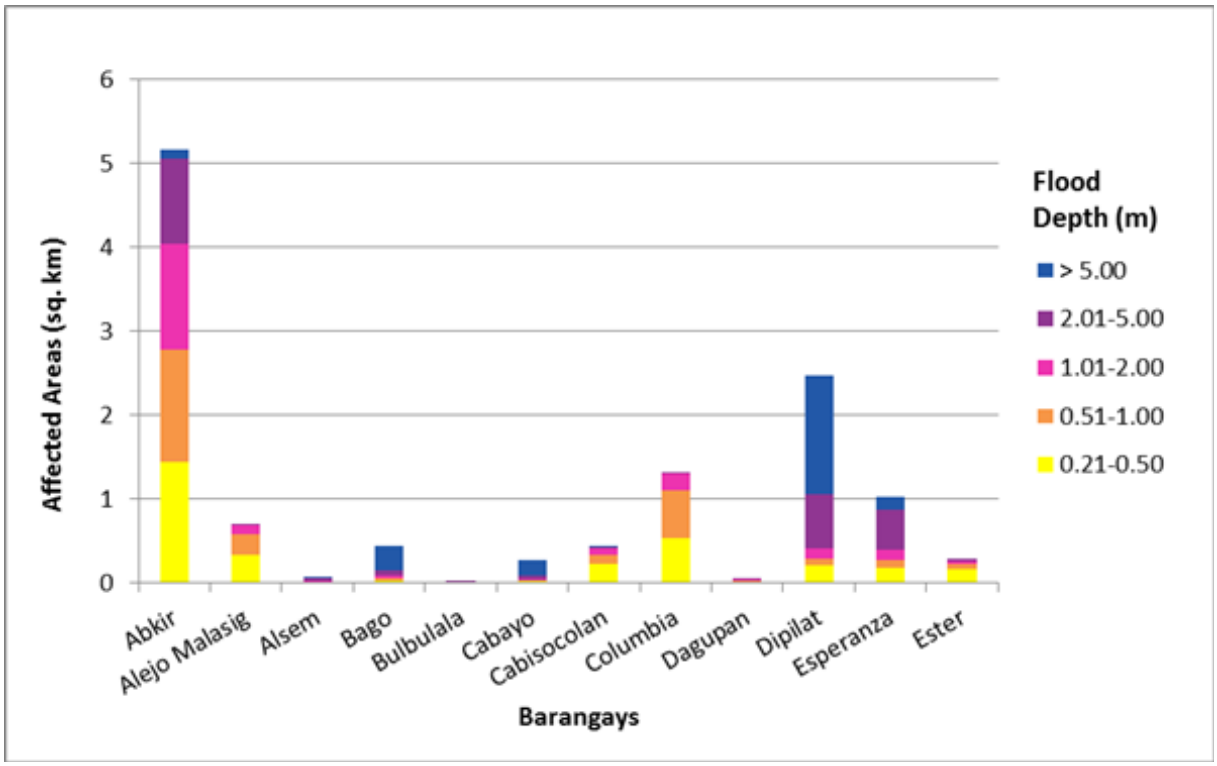


Figure 87. Affected Areas in Vintar, Ilocos Norte during 25-Year Rainfall Return Period.

Table 53. Affected Areas in Vintar, Ilocos Norte during 25-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Vintar (in sq.km.)						
	Lubnac	Malampa	Manarang	Margaay	Parparoroc	Parut	Cabisocolan
0.03-0.20	1.65	1.93	1.41	1.38	2.75	0.86	2.36
0.21-0.50	0.15	0.099	0.085	0.45	0.36	0.29	0.22
0.51-1.00	0.054	0.051	0.05	0.31	0.22	0.28	0.11
1.01-2.00	0.051	0.053	0.06	0.048	0.28	0.31	0.073
2.01-5.00	0.042	0.099	0.14	0.0036	0.72	0.038	0.024

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Vintar (in sq.km.)					
	Pedro F. Alviar	Salsalamagui	San Jose	San Nicolas	San Pedro	San Ramon
0.03-0.20	1.04	4.43	1.01	0.13	0.11	0.18
0.21-0.50	0.039	0.34	0.094	0.052	0.031	0.088
0.51-1.00	0.016	0.25	0.053	0.095	0.017	0.12
1.01-2.00	0.0037	0.44	0.063	0.083	0.061	0.11
2.01-5.00	0.0036	1.27	0.46	0.05	0.0027	0.053

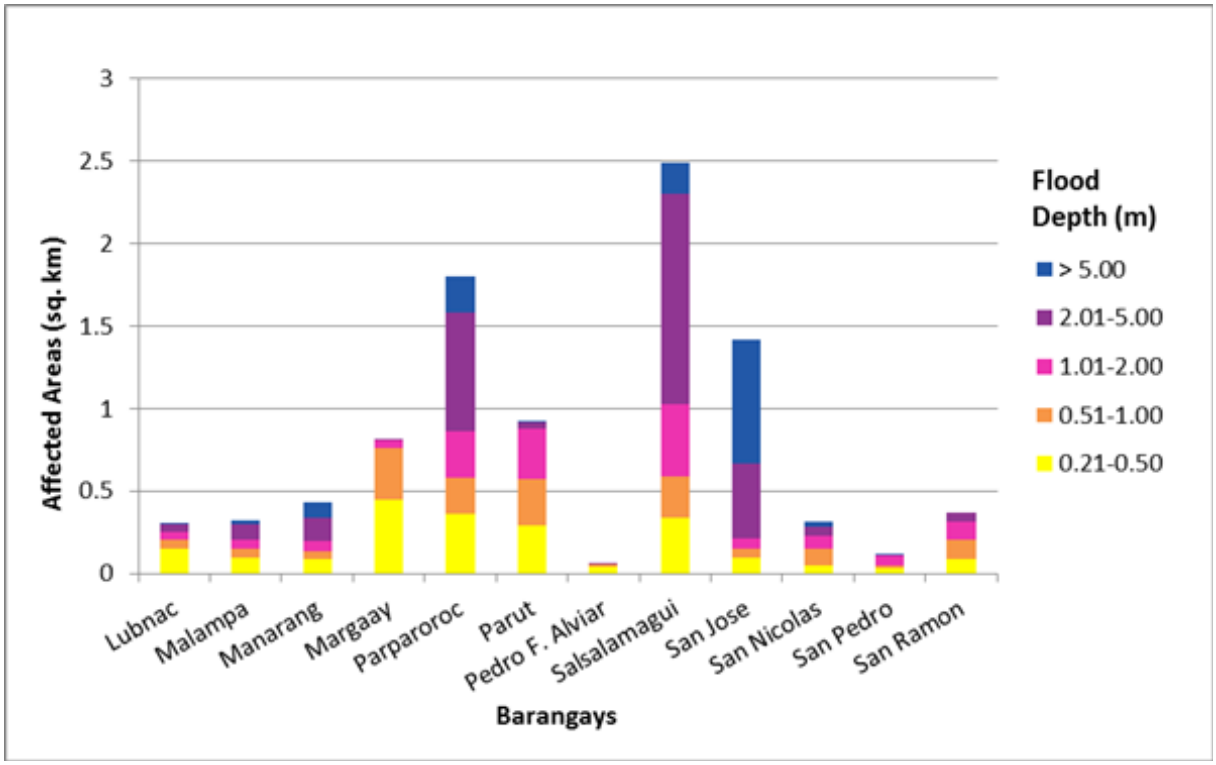


Figure 88. Affected Areas in Vintar, Ilocos Norte during 25-Year Rainfall Return Period.

Table 54. Affected Areas in Vintar, Ilocos Norte during 25-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Vintar (in sq.km.)			
	San Roque	Santa Maria	Tamdagan	Visaya
0.03-0.20	0.14	0.075	1.84	2.64
0.21-0.50	0.15	0.048	0.26	0.28
0.51-1.00	0.29	0.038	0.37	0.17
1.01-2.00	0.17	0.092	0.51	0.25
2.01-5.00	0.16	0.011	0.75	0.56

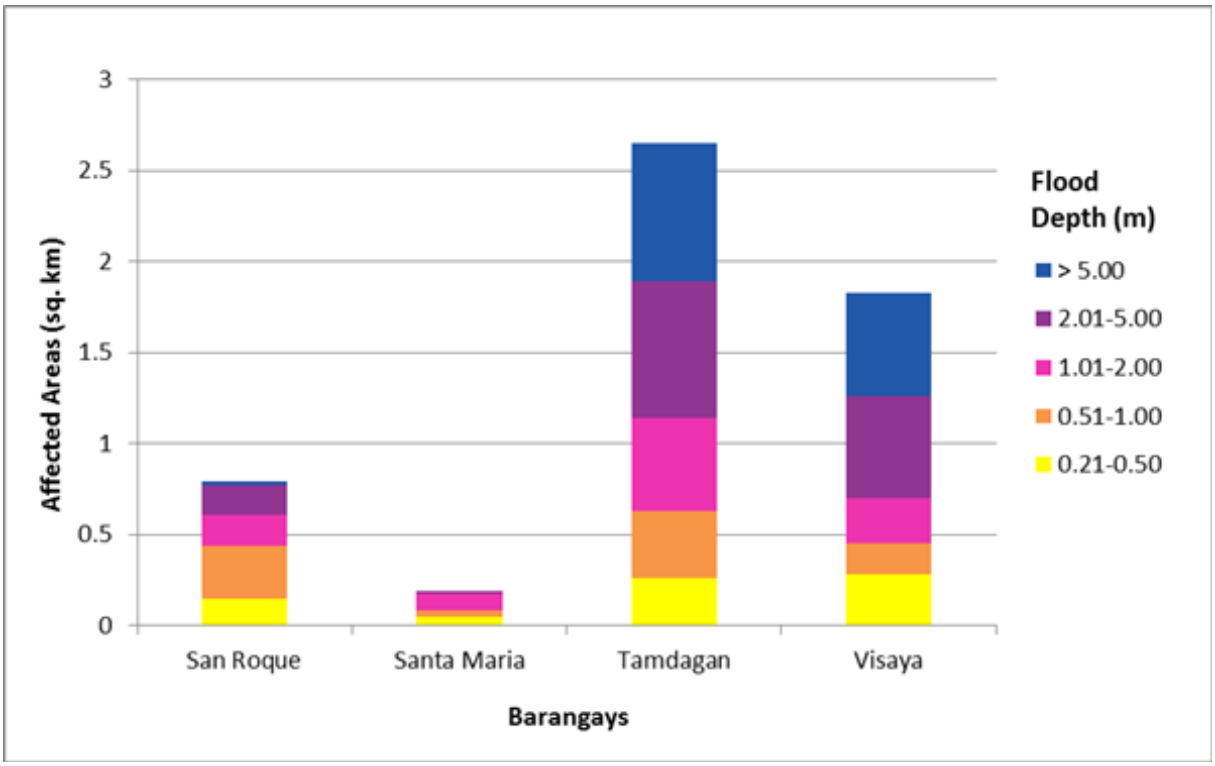


Figure 89. Affected Areas in Vintar, Ilocos Norte during 25-Year Rainfall Return Period

For the 100-year return period, 45.62% of the municipality of Bacarra with an area of 47.1 sq. km. will experience flood levels of less than 0.20 meters. 15.04% of the area will experience flood levels of 0.21 to 0.50 meters while 14.48%, 15.61%, 8.62%, and 0.25% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 55, 56, 57, and 58 are the affected areas in square kilometers by flood depth per barangay.

Table 55. Affected Areas in Bacarra, Ilocos Norte during 100-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)					
	Bani	Buyon	Cabaruan	Cabulalaan	Cabusligan	Cadaratan
0.03-0.20	0.43	2.34	1.67	0.062	0.37	0.28
0.21-0.50	0.17	0.49	1.17	0.1	0.16	0.3
0.51-1.00	0.43	0.6	0.45	0.2	0.062	0.24
1.01-2.00	0.7	0.63	0.21	0.22	0.07	0.11
2.01-5.00	0.32	0.38	0.23	0.068	0.055	0

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)					
	Calioet-Libong	Casilian	Corocor	Duripes	Ganagan	Libtong
0.03-0.20	0.21	0.56	0.42	0.78	0.79	1.17
0.21-0.50	0.093	0.31	0.26	0.22	0.33	0.3
0.51-1.00	0.24	0.41	0.23	0.18	0.33	0.35
1.01-2.00	0.32	0.69	0.43	0.16	0.22	0.52
2.01-5.00	0.14	0.6	0.07	0.037	0.22	0.43

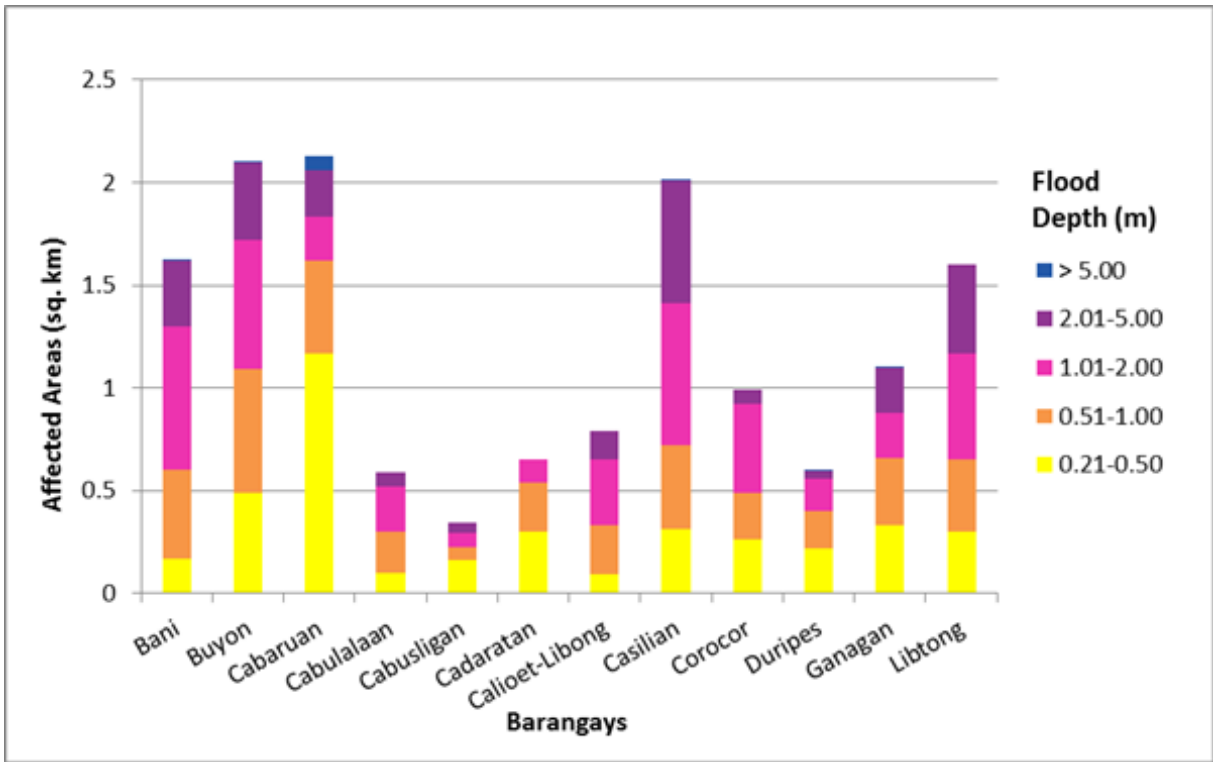


Figure 90. Affected Areas in Bacarra, Ilocos Norte during 100-Year Rainfall Return Period.

Table 56. Affected Areas in Bacarra, Ilocos Norte during 100-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)					
	Macupit	Nambaran	Natba	Paninaan	Pasiocan	Pasngal
0.03-0.20	0.57	1.93	0.022	0.98	1.64	0.58
0.21-0.50	0.072	0.57	0.015	0.091	0.3	0.22
0.51-1.00	0.072	0.6	0.054	0.059	0.21	0.079
1.01-2.00	0.13	0.49	0.075	0.058	0.18	0.027
2.01-5.00	0.056	0.031	0.015	0.11	0.073	0.0028

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)					
	Pipias	Pulangi	Pungto	San Agustin I	San Agustin II	San Andres I
0.03-0.20	0.056	1.17	0.37	0.015	0.031	0.11
0.21-0.50	0.093	0.17	0.17	0.0025	0.0048	0.04
0.51-1.00	0.24	0.27	0.15	0.0049	0.0027	0.0074
1.01-2.00	0.064	0.38	0.021	0.0082	0.0014	0.0004
2.01-5.00	0.014	0.3	0	0.012	0.0044	0

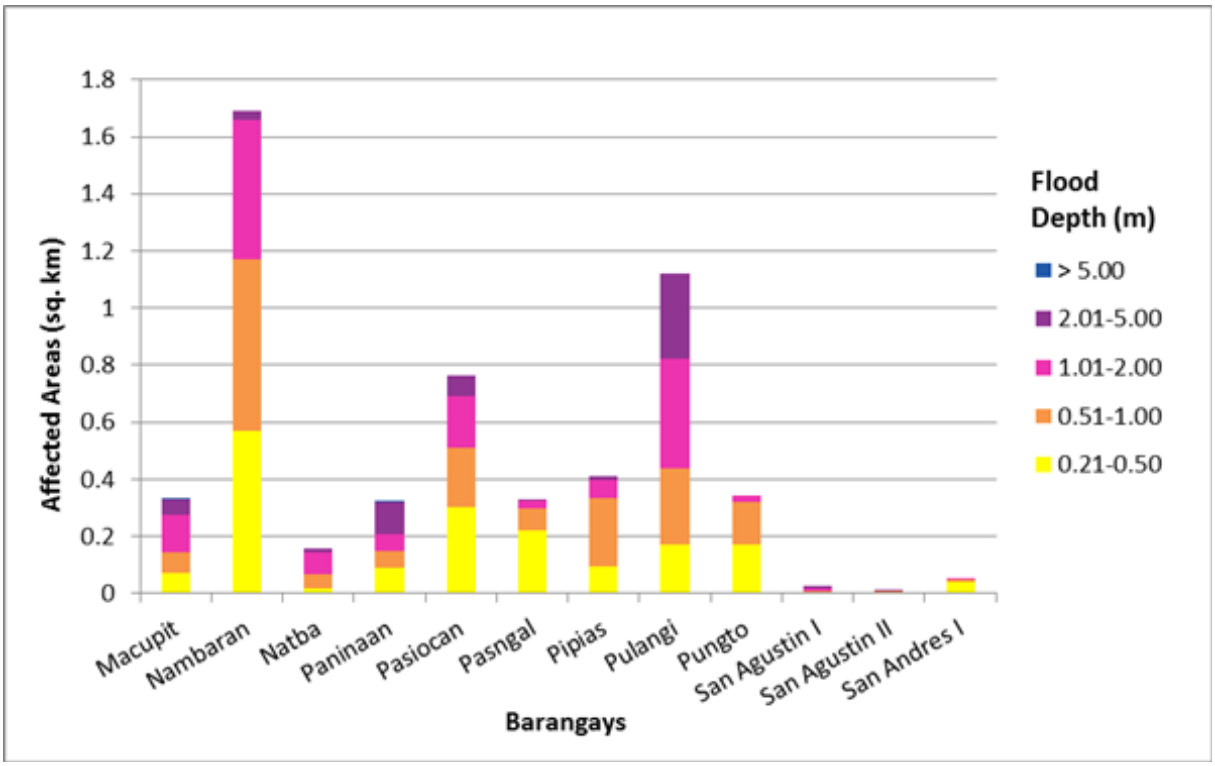


Figure 91. Affected Areas in Bacarra, Ilocos Norte during 100-Year Rainfall Return Period.

Table 57. Affected Areas in Bacarra, Ilocos Norte during 100-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)					
	San Andres II	San Gabriel I	San Gabriel II	San Pedro I	San Pedro II	San Roque I
0.03-0.20	0.097	0.027	0.024	0.05	0.044	0.071
0.21-0.50	0.051	0.0099	0.019	0.025	0.031	0.011
0.51-1.00	0.019	0.0038	0.0065	0.0069	0.021	0.0048
1.01-2.00	0.00027	0	0	0	0.0016	0.0042
2.01-5.00	0	0	0	0	0	0.036

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)					
	San Roque II	San Simon I	San Simon II	San Vicente	Sangil	Santa Filomena I
0.03-0.20	0.058	0.086	0.064	0.046	1.06	0.048
0.21-0.50	0.0083	0.027	0.0091	0.024	0.21	0.011
0.51-1.00	0.0007	0.03	0.0014	0.006	0.23	0.0076
1.01-2.00	0.0012	0.055	0.00023	0.0001	0.12	0.0019
2.01-5.00	0.02	0.083	0	0	0.11	0.03

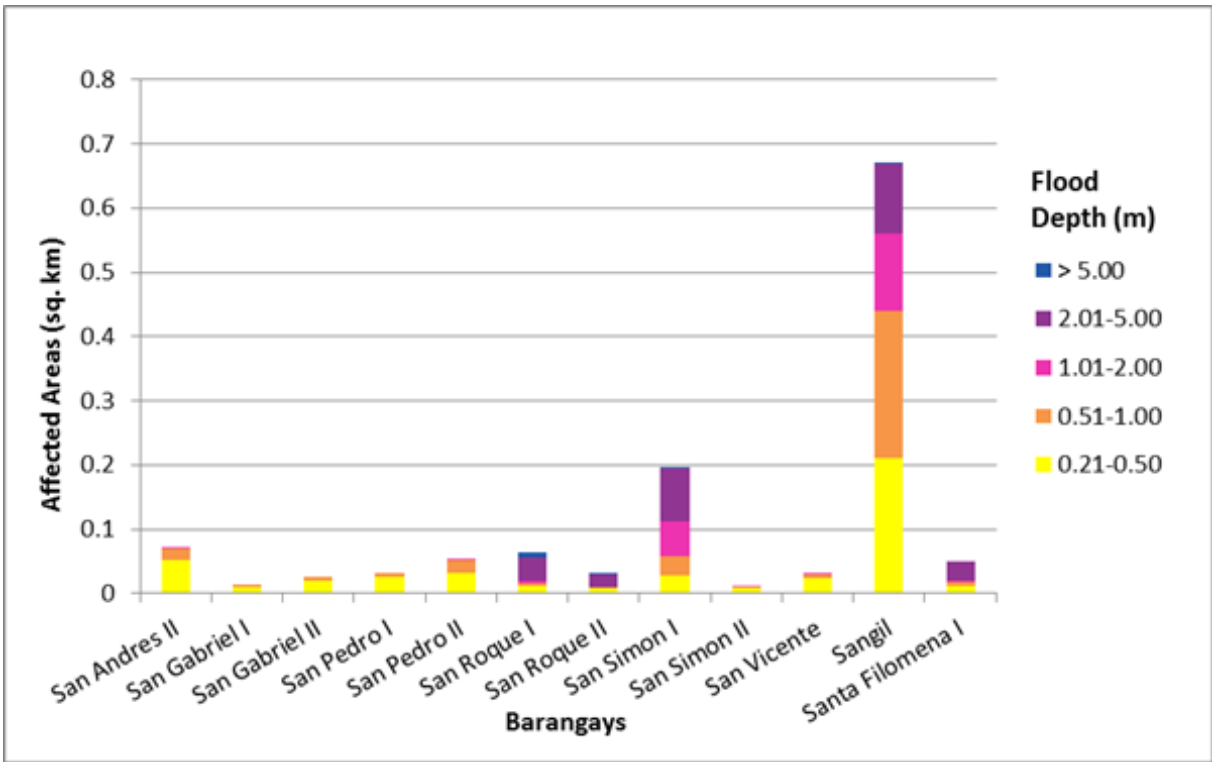


Figure 92. Affected Areas in Bacarra, Ilocos Norte during 100-Year Rainfall Return Period.

Table 58. Affected Areas in Bacarra, Ilocos Norte during 100-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)				
	Santa Filomena II	Santa Rita	Santo Cristo I	Santo Cristo II	Tambidao
0.03-0.20	0.076	0.56	0.059	0.042	1.52
0.21-0.50	0.013	0.16	0.061	0.021	0.53
0.51-1.00	0.01	0.16	0.026	0.0077	0.49
1.01-2.00	0.0019	0.34	0.003	0.0002	0.29
2.01-5.00	0.029	0.24	0.0001	0	0.18

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Bacarra (in sq.km.)			
	Teppang	Tubburan		
0.03-0.20	0.47	0.53		
0.21-0.50	0.093	0.12		
0.51-1.00	0.11	0.21		
1.01-2.00	0.5	0.32		
2.01-5.00	0.14	0.023		

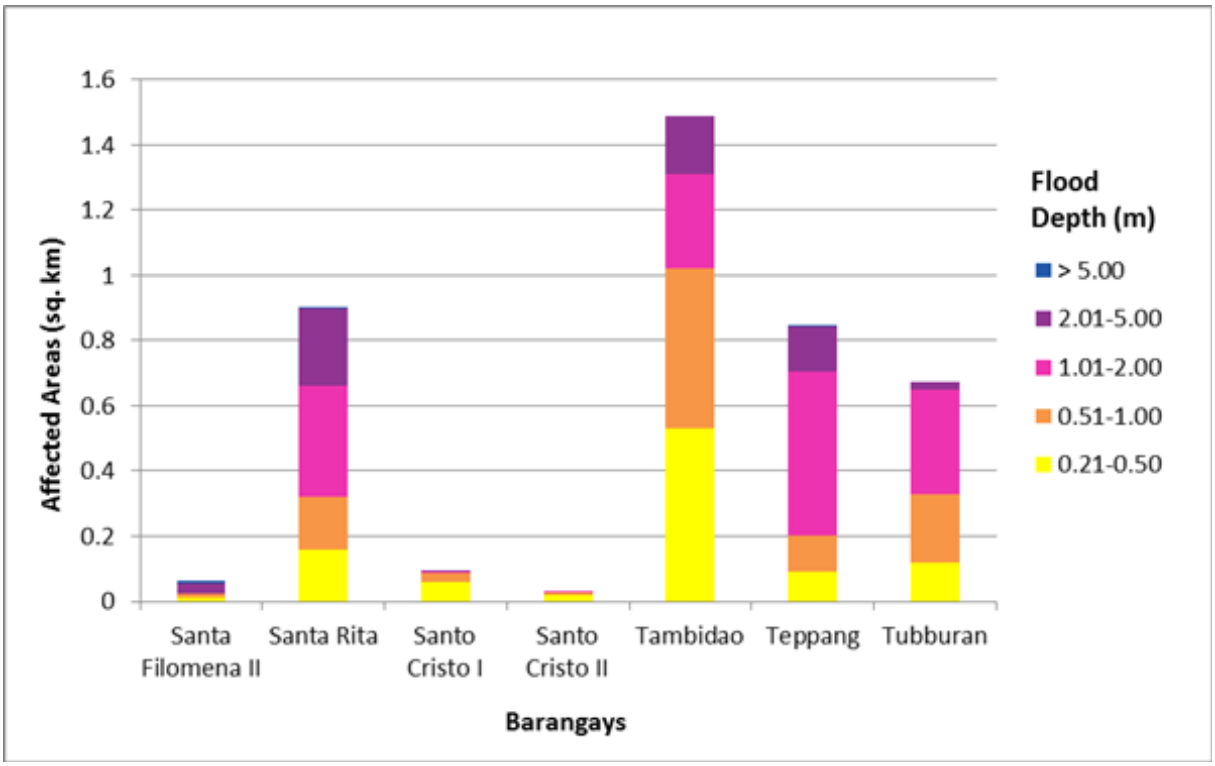


Figure 93. Affected Areas in Bacarra, Ilocos Norte during 100-Year Rainfall Return Period.

For the municipality of Laoag City with an area of 114.355 sq. km., 0.30% will experience flood levels of less than 0.20 meters. 0.02% of the area will experience flood levels of 0.21 to 0.50 meters while 0.03% and 0.02% of the area will experience flood depths of 0.51 to 1 meter and 1.01 to 2 meters, respectively. Listed in Table 59 are the affected areas in square kilometers by flood depth per barangay.

Table 59. Affected Areas in Laoag, Ilocos Norte during 100-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Laoag (in sq.km.)			
	Bgy. No. 55-A, Barit-Pandan	Bgy. No. 55-B, Salet-Bulangon	Bgy. No. 59-B, Dibua North	Bgy. No. 60-B, Madiladig
0.03-0.20	0.0079	0.094	0.16	0.086
0.21-0.50	0	0.000077	0.0077	0.013
0.51-1.00	0	0	0.0027	0.028
1.01-2.00	0	0	0.000001	0.024
2.01-5.00	0	0	0.000033	0.00045
> 5.00	0	0	0	0

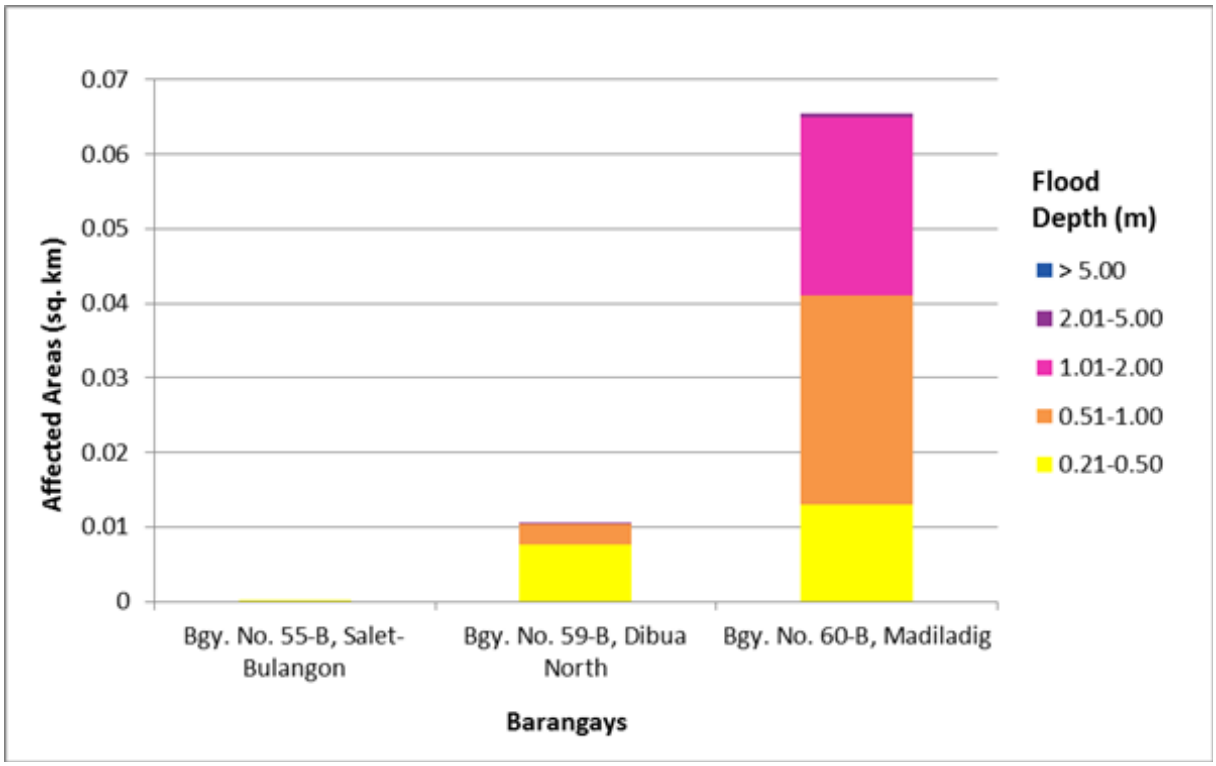


Figure 94. Affected Areas in Laoag City, Ilocos Norte during 100-Year Rainfall Return Period.

For the municipality of Pasuquin with an area of 154.156 sq. km., 23.85% will experience flood levels of less than 0.20 meters. 4.45% of the area will experience flood levels of 0.21 to 0.50 meters while 4.77%, 4.12%, 3.32%, and 0.49% 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 60, 61, and 62 are the affected areas in square kilometers by flood depth per barangay.

Table 60. Affected Areas in Pasuquin, Ilocos Norte during 100-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Pasuquin (in sq.km.)					
	Batuli	Binsang	Caruan	Carusipan	Dadaeman	Darupidip
0.03-0.20	1.07	1.85	0.00018	0.37	0.84	1.3
0.21-0.50	0.54	0.68	0	0.16	0.12	0.17
0.51-1.00	0.36	0.85	0	0.17	0.17	0.088
1.01-2.00	0.22	0.83	0	0.026	0.12	0.021
2.01-5.00	0.031	0.17	0	0.0002	0.021	0

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Pasuquin (in sq.km.)					
	Dilanis	Estancia	Naglicuan	Nagsanga	Nalvo	Ngabangab
0.03-0.20	2.8	1.32	0.72	0.027	0.063	0.75
0.21-0.50	0.15	0.63	0.45	0.058	0.063	0.4
0.51-1.00	0.084	0.34	0.75	0.12	0.14	0.64
1.01-2.00	0.053	0.22	0.37	0.22	0.28	0.36
2.01-5.00	0.04	0.017	0.088	0.15	0.36	0.0018

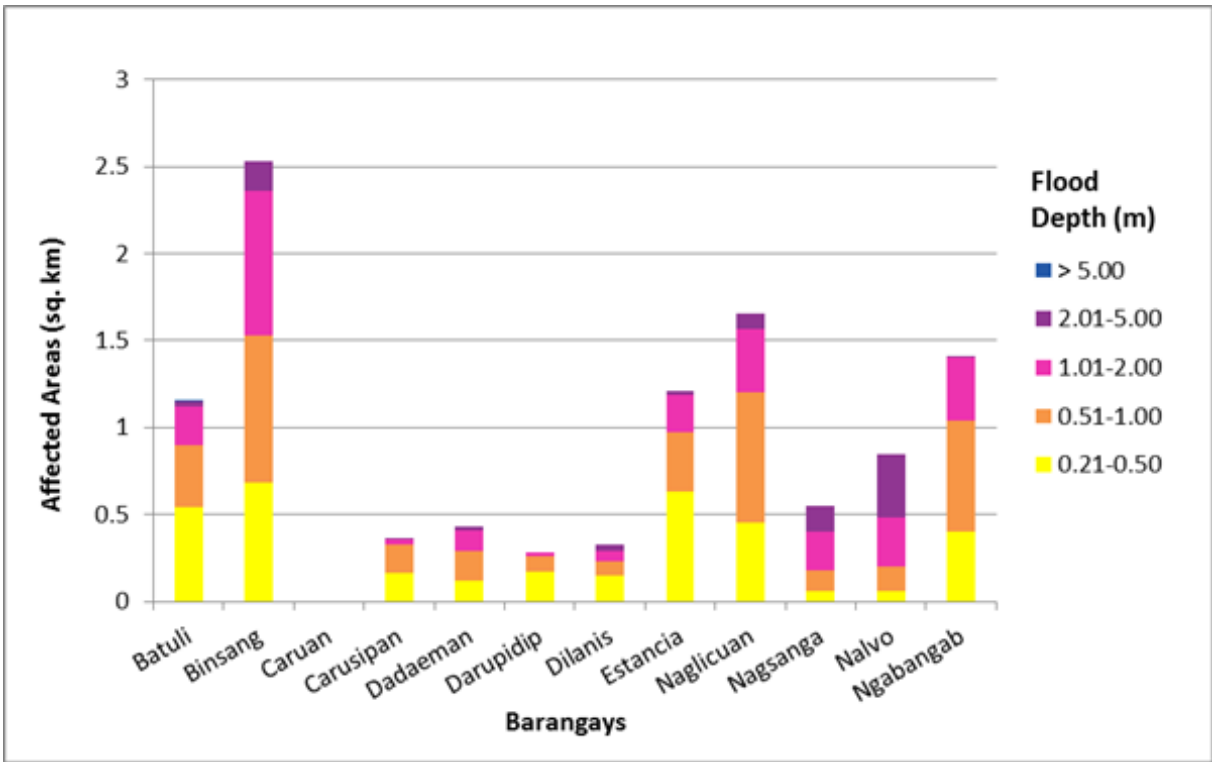


Figure 95. Affected Areas in Pasuquin, Ilocos Norte during 100-Year Rainfall Return Period.

Table 61. Affected Areas in Pasuquin, Ilocos Norte during 100-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Pasuquin (in sq.km.)					
	Pangil	Poblacion 1	Poblacion 2	Poblacion 3	Poblacion 4	Pragata
0.03-0.20	0.91	0.02	0.073	0.055	0.015	0.11
0.21-0.50	0.09	0.0096	0.063	0.085	0.012	0.053
0.51-1.00	0.063	0.012	0.052	0.03	0.021	0.14
1.01-2.00	0.041	0.03	0.067	0	0.037	0.52
2.01-5.00	0.013	0.17	0.09	0	0.057	1.83

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Pasuquin (in sq.km.)					
	Puyupuyan	Salpad	San Juan	Santa Catalina	Santa Matilde	Sapat
0.03-0.20	1.1	0.3	9.68	1.56	3.12	4.27
0.21-0.50	0.52	0.32	0.79	0.13	0.22	0.24
0.51-1.00	0.64	0.46	0.51	0.12	0.1	0.19
1.01-2.00	0.67	0.12	0.56	0.35	0.045	0.16
2.01-5.00	0.47	0.0066	0.6	0.19	0.1	0.13

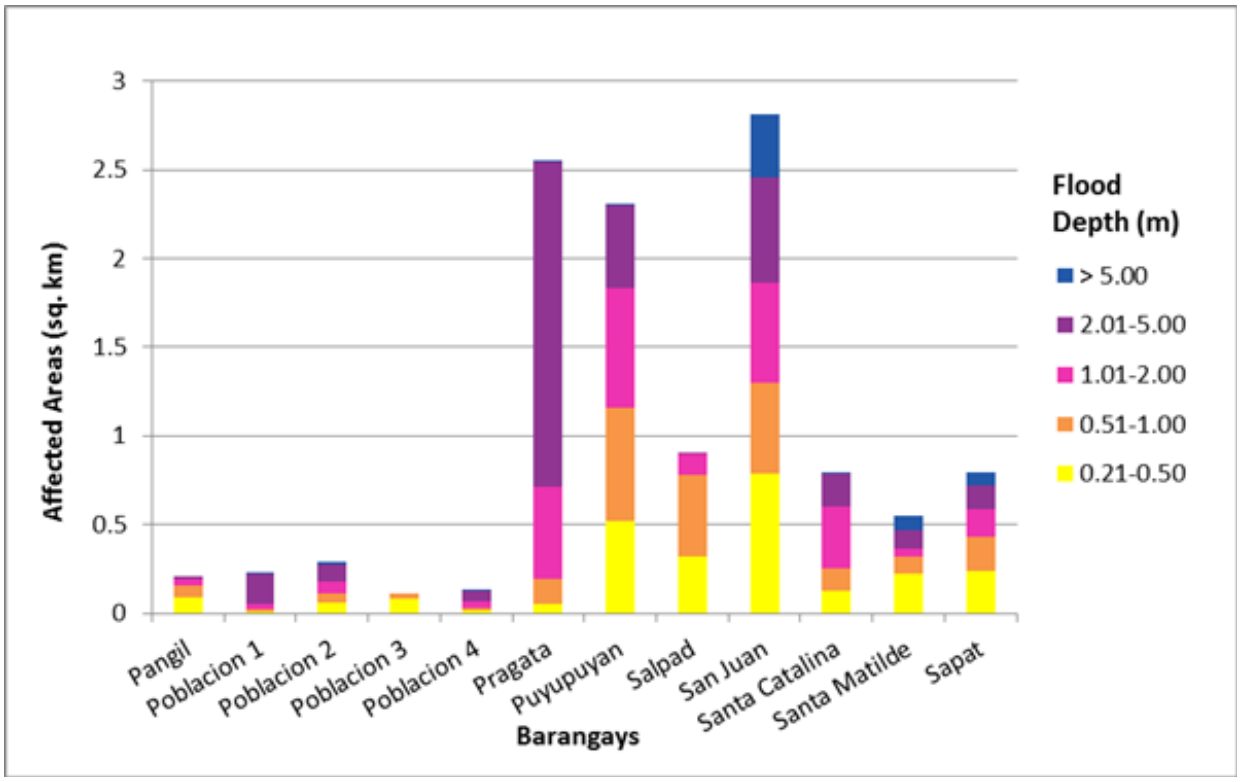


Figure 96. Affected Areas in Pasuquin, Ilocos Norte during 100-Year Rainfall Return Period.

Table 62. Affected Areas in Pasuquin, Ilocos Norte during 100-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Pasuquin (in sq.km.)				
	Sulbec	Sulongan	Surong	Susugaen	Tabungao
0.03-0.20	0.57	1.24	0.91	0.31	1.42
0.21-0.50	0.34	0.22	0.062	0.19	0.099
0.51-1.00	0.47	0.3	0.034	0.43	0.076
1.01-2.00	0.36	0.075	0.042	0.46	0.094
2.01-5.00	0.3	0.011	0.15	0.096	0.033

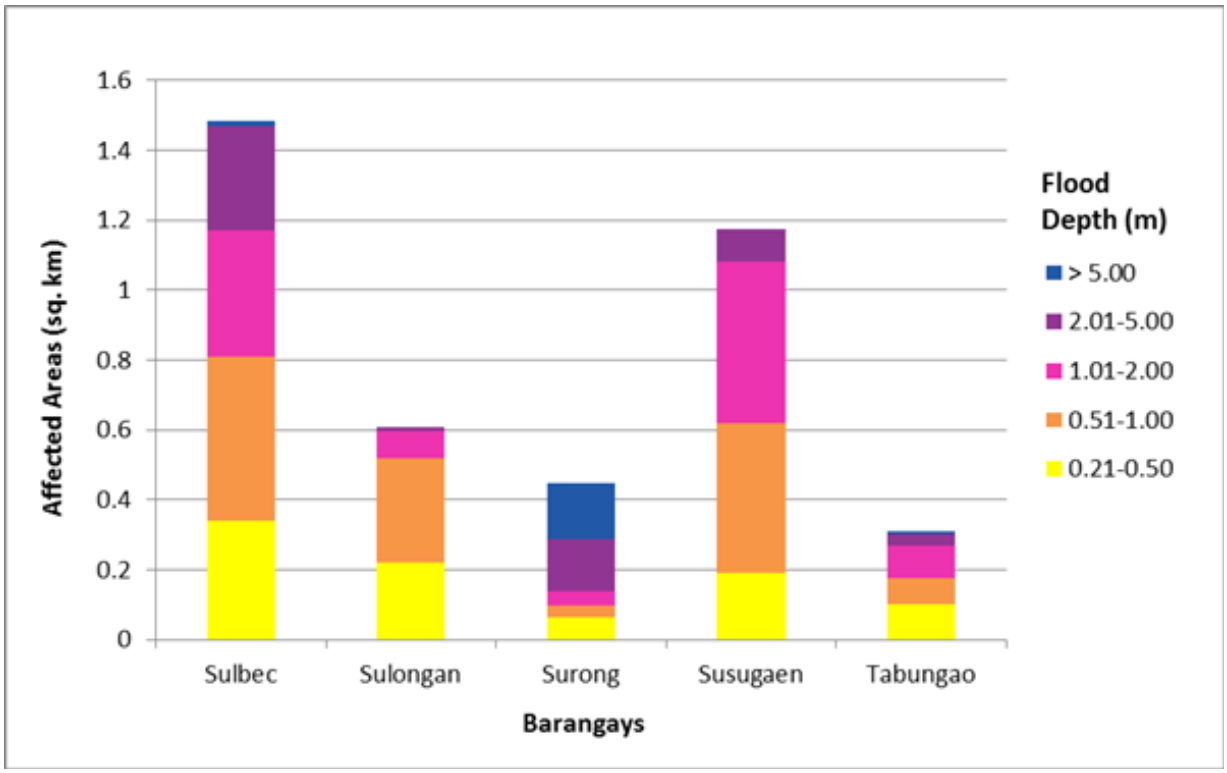


Figure 97. Affected Areas in Pasuquin, Ilocos Norte during 100-Year Rainfall Return Period.

For the municipality of Vintar with an area of 497.395 sq. km., 7.36% will experience flood levels of less than 0.20 meters. 1.16% of the area will experience flood levels of 0.21 to 0.50 meters while 0.95%, 0.77%, 1.33%, and 1.21% 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 63, 64, and 65 are the affected areas in square kilometers by flood depth per barangay.

Table 63. Affected Areas in Vintar, Ilocos Norte during 100-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Vintar (in sq.km.)					
	Abkir	Alejo Malasig	Alsem	Bago	Bulbulala	Cabayo
0.03-0.20	4.73	0.97	0.14	0.67	0.32	0.29
0.21-0.50	1.24	0.34	0.0065	0.031	0.0084	0.019
0.51-1.00	1.12	0.17	0.0063	0.024	0.0027	0.012
1.01-2.00	1	0.096	0.015	0.032	0.001	0.014
2.01-5.00	0.99	0.0058	0.034	0.055	0.00025	0.036

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Vintar (in sq.km.)					
	Cabisocolan	Columbia	Dagupan	Dipilat	Esperanza	Ester
0.03-0.20	2.31	2.66	0.0072	1.69	0.37	1.18
0.21-0.50	0.25	0.5	0.013	0.21	0.17	0.18
0.51-1.00	0.12	0.6	0.012	0.075	0.1	0.074
1.01-2.00	0.09	0.29	0.011	0.092	0.11	0.039
2.01-5.00	0.032	0.017	0.0024	0.48	0.48	0.028

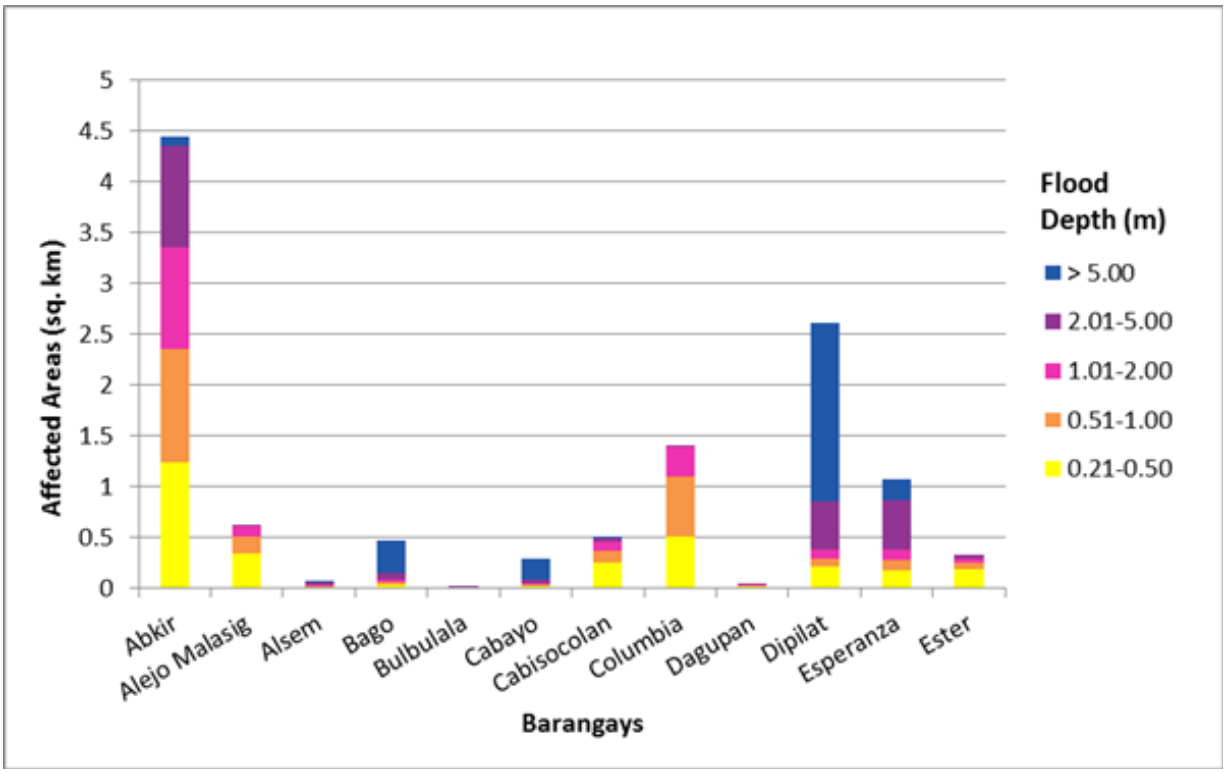


Figure 98. Affected Areas in Vintar, Ilocos Norte during 100-Year Rainfall Return Period.

Table 64. Affected Areas in Vintar, Ilocos Norte during 100-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Vintar (in sq.km.)					
	Lubnac	Malampa	Manarang	Margaay	Parparoroc	Parut
0.03-0.20	1.59	1.9	1.36	1.41	2.64	0.96
0.21-0.50	0.19	0.1	0.089	0.42	0.34	0.34
0.51-1.00	0.063	0.062	0.054	0.29	0.29	0.3
1.01-2.00	0.051	0.057	0.054	0.07	0.21	0.18
2.01-5.00	0.053	0.11	0.14	0.0054	0.8	0.015

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Vintar (in sq.km.)					
	Pedro F. Alviar	Salsalamagui	San Jose	San Nicolas	San Pedro	San Ramon
0.03-0.20	1.03	4.33	0.94	0.16	0.13	0.27
0.21-0.50	0.043	0.34	0.085	0.064	0.022	0.095
0.51-1.00	0.02	0.21	0.057	0.1	0.028	0.1
1.01-2.00	0.0038	0.26	0.082	0.042	0.045	0.044
2.01-5.00	0.0041	1.4	0.24	0.046	0.0023	0.045

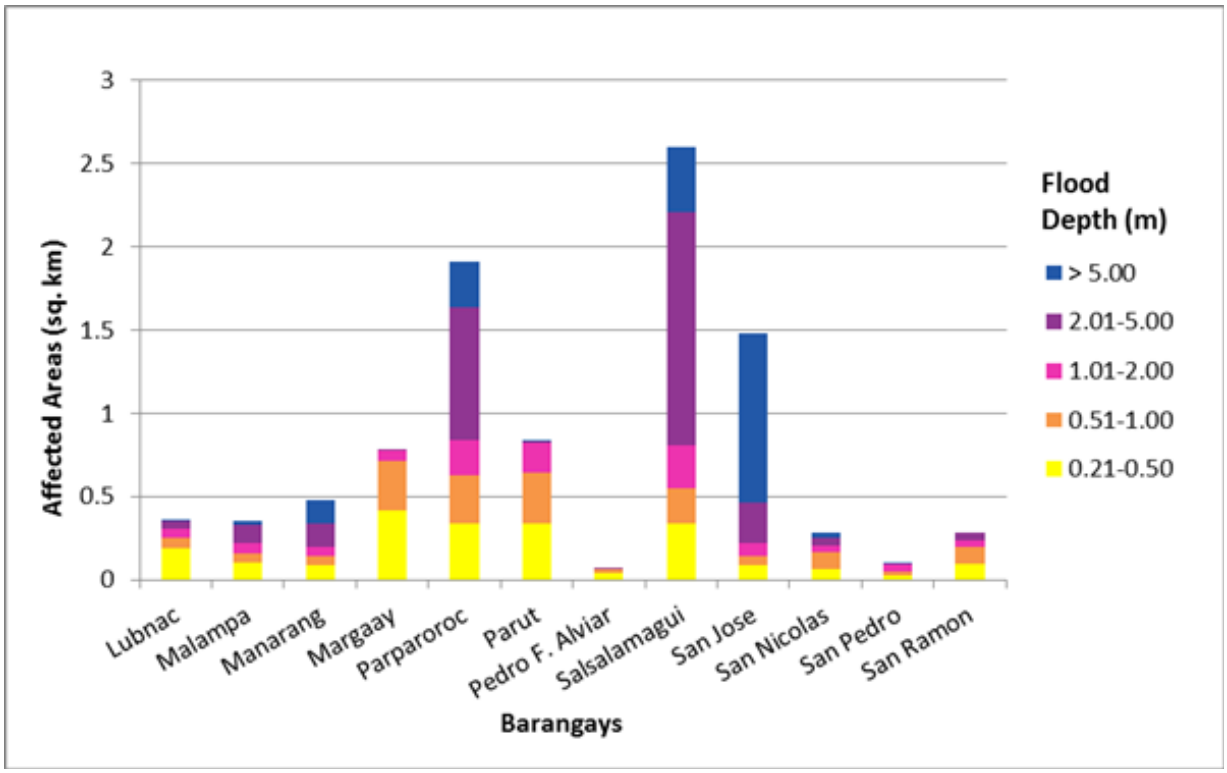


Figure 99. Affected Areas in Vintar, Ilocos Norte during 100-Year Rainfall Return Period.

Table 65. Affected Areas in Vintar, Ilocos Norte during 100-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)	Areas of affected Barangays in Vintar (in sq.km.)			
	San Roque	Santa Maria	Tamdagan	Visaya
0.03-0.20	0.2	0.095	1.72	2.54
0.21-0.50	0.18	0.041	0.2	0.27
0.51-1.00	0.25	0.048	0.33	0.21
1.01-2.00	0.16	0.075	0.53	0.17
2.01-5.00	0.12	0.0054	0.87	0.58

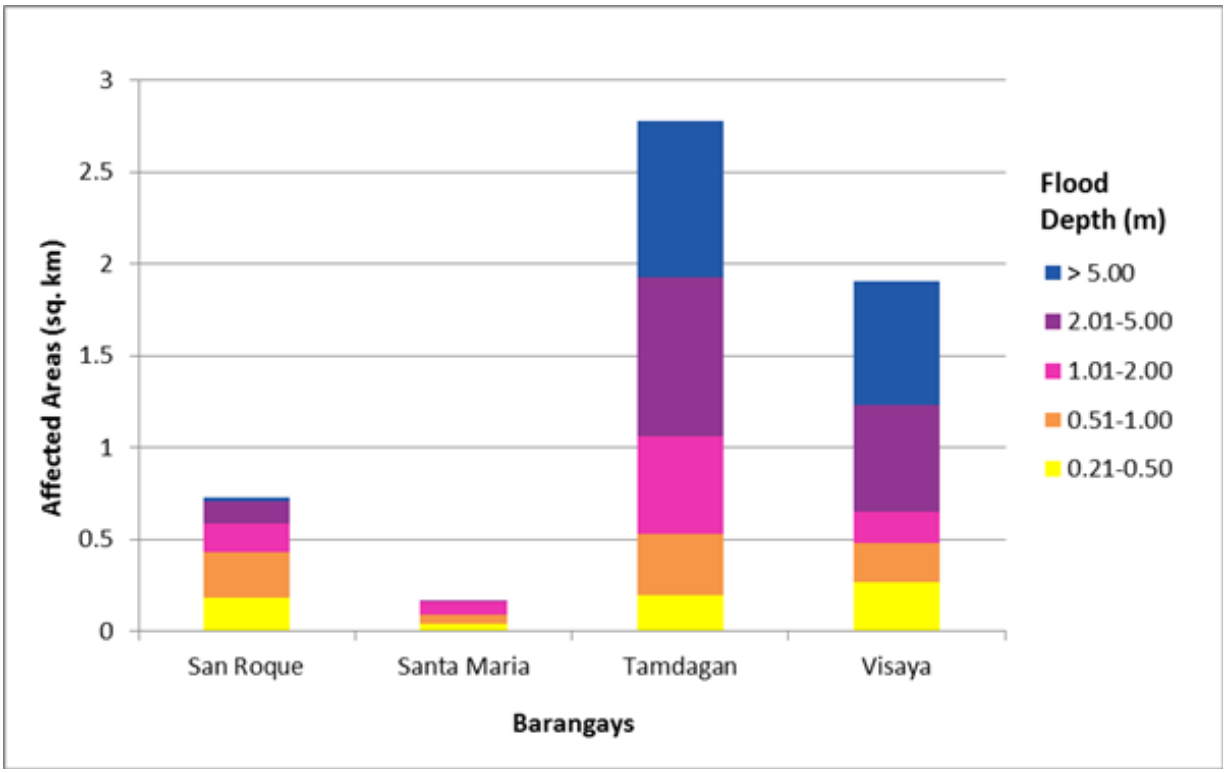


Figure 100. Affected Areas in Vintar, Ilocos Norte during 100-Year Rainfall Return Period.

Among the barangays in the municipality of Bacarra in Ilocos Norte, Buyon is projected to have the highest percentage of area that will experience flood levels at 9.42%. Meanwhile, Cabaruan posted the second highest percentage of area that may be affected by flood depths at 8.10%.

Among the barangays in the municipality of Laoag City in Ilocos Norte, Bgy. No. 59-B, Dibua North is projected to have the highest percentage of area that will experience flood levels at 0.15%. Meanwhile, Bgy. No. 60-B, Madiladig posted the second highest percentage of area that may be affected by flood depths at 0.13%.

Among the barangays in the municipality of Pasuquin in Ilocos Norte, San Juan is projected to have the highest percentage of area that will experience flood levels at 8.10%. Meanwhile, Sapat posted the second highest percentage of area that may be affected by flood depths at 3.28%.

Among the barangays in the municipality of Vintar in Ilocos Norte, Abkir is projected to have the highest percentage of area that will experience flood levels at 1.85%. Meanwhile, Salsalamagui posted the second highest percentage of area that may be affected by flood depths at 1.39%.

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

Table 66. Area covered by each warning level with respect to the rainfall scenarios

Warning Level	Area Covered in sq. km.		
	5 year	25 year	100 year
Low	0.15315	0.15652	0.16761
Medium	0.31632	0.19045	0.16419
High	0.73306	0.96915	1.04159

Of the three (3) identified educational institutions in the Quinonoan floodplain, none are supposedly at risk for any of the flood hazards. See Annex 12. Additionally, no medical institutions were identified in the said floodplain.

5.11 Flood Validation

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

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

The validation personnel then went to the specified points identified in a river basin and gathered 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.

The actual data from the field were compared to the simulated data to assess the accuracy of the Flood Depth Maps produced and to improve on the results of the flood map. The points in the flood map versus its corresponding validation depths are shown in Figure 101.

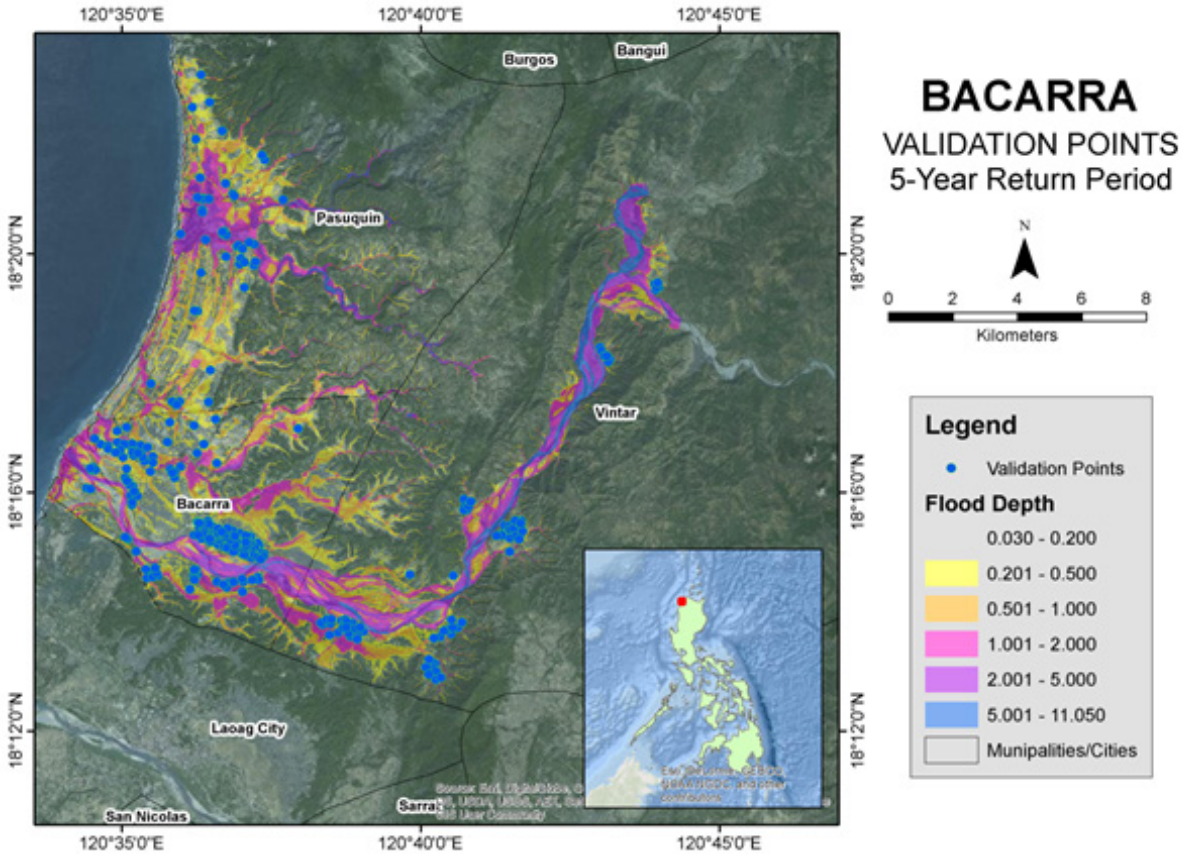


Figure 101. Validation Points for a 5-year Flood Depth Map of the Bacarra Floodplain.

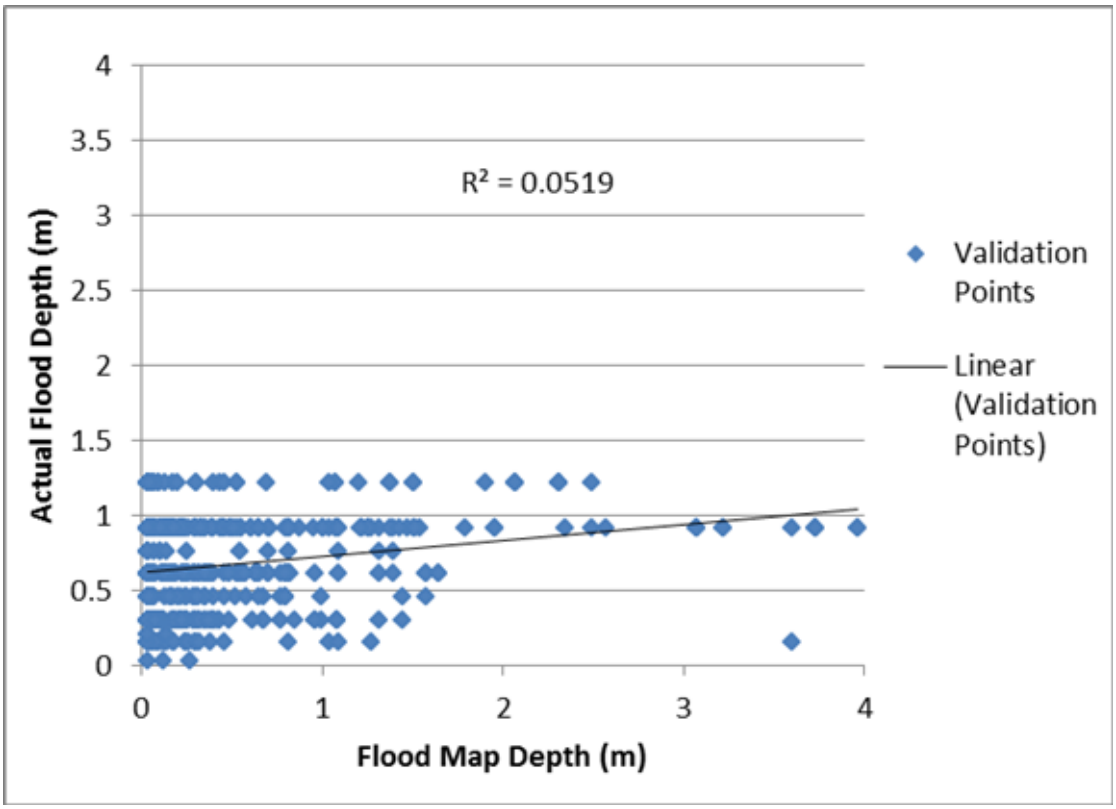


Figure 102. Flood Map depth versus Actual Flood Depth.

Table 67. Actual Flood Depth versus Simulated Flood Depth at different levels in the Bacarra River Basin.

BACARRA 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	17	9	1	3	1	0	31
	0.21-0.50	77	45	17	7	0	0	146
	0.51-1.00	156	80	56	36	14	0	342
	1.01-2.00	21	5	3	9	7	0	45
	2.01-5.00	0	0	0	0	0	0	0
	> 5.00	0	0	0	0	0	0	0
	Total	271	139	77	55	22	0	564

On the whole, the overall accuracy generated by the flood model is estimated at 22.52%, with 127 points correctly matching the actual flood depths. In addition, there were 229 points estimated one level above and below the correct flood depths while there were 183 points and 25 points estimated two levels above and below, and three or more levels above and below the correct flood. A total of 95 points were overestimated while a total of 342 points were underestimated in the modelled flood depths of Bacarra. Table 68 depicts the summary of the Accuracy Assessment in the Bacarra River Basin Flood Depth Map.

Table 68. Summary of the Accuracy Assessment in the Bacarra River Basin Survey.

	No. of Points	%
Correct	127	22.52
Overestimated	95	16.84
Underestimated	342	60.64
Total	564	100

REFERENCES

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

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

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

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

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

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

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

ANNEXES

Annex 1. Technical Specifications of the LIDAR Sensors used in the Quinonoan Floodplain Survey

1. GEMINI SENSOR

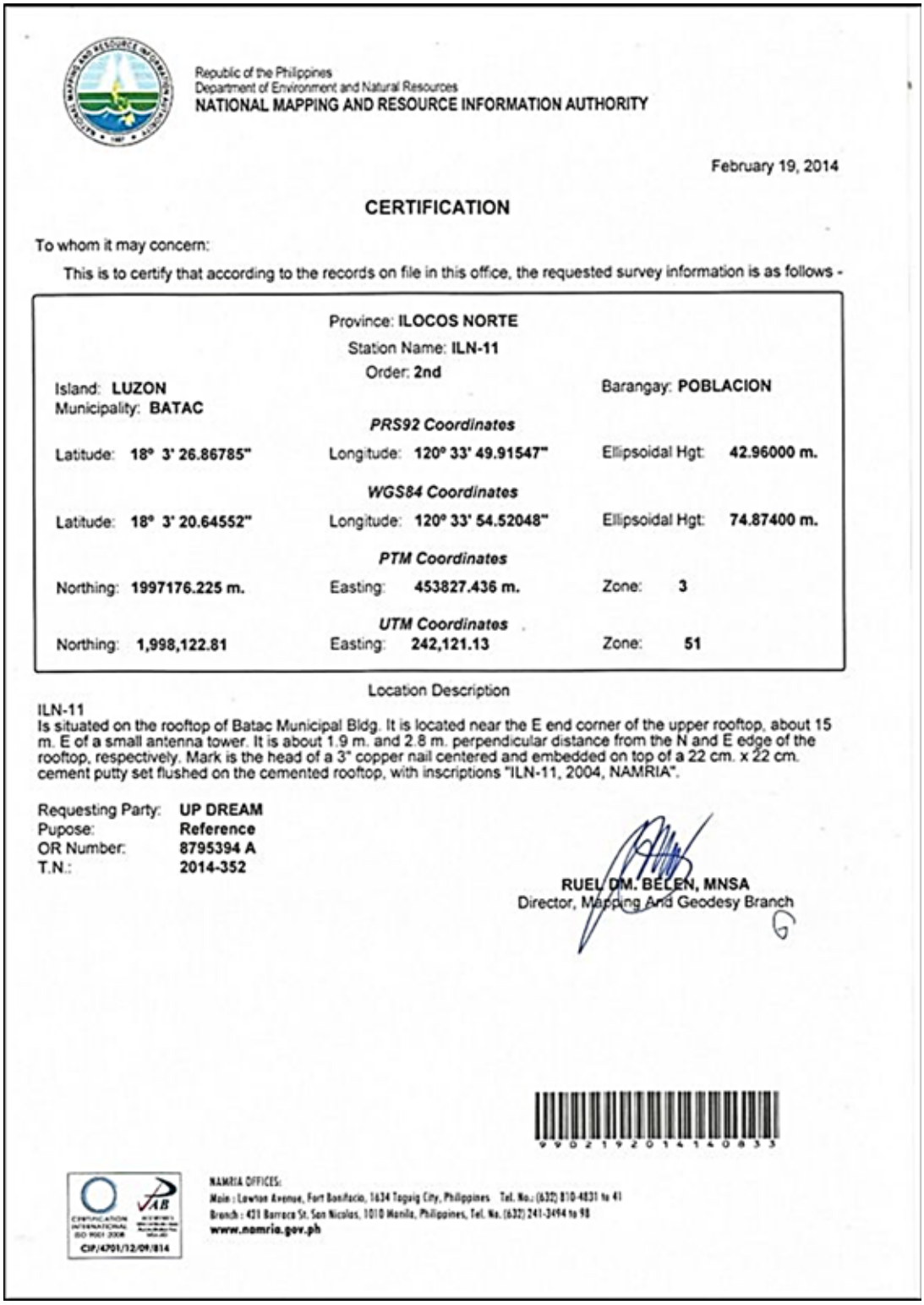
Figure A-1.1. Gemini Sensor

Table A-1.1. Parameters and Specifications of Gemini Sensor

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

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

1. ILN-11



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

February 19, 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: **ILOCOS NORTE**
Station Name: **ILN-11**
Order: **2nd**

Island: **LUZON**
Municipality: **BATAC**
Barangay: **POBLACION**

PRS92 Coordinates

Latitude: **18° 3' 26.86785"** Longitude: **120° 33' 49.91547"** Ellipsoidal Hgt: **42.96000 m.**

WGS84 Coordinates

Latitude: **18° 3' 20.64552"** Longitude: **120° 33' 54.52048"** Ellipsoidal Hgt: **74.87400 m.**

PTM Coordinates

Northing: **1997176.225 m.** Easting: **453827.436 m.** Zone: **3**

UTM Coordinates

Northing: **1,998,122.81** Easting: **242,121.13** Zone: **51**

Location Description

ILN-11
Is situated on the rooftop of Batac Municipal Bldg. It is located near the E end corner of the upper rooftop, about 15 m. E of a small antenna tower. It is about 1.9 m. and 2.8 m. perpendicular distance from the N and E edge of the rooftop, respectively. Mark is the head of a 3" copper nail centered and embedded on top of a 22 cm. x 22 cm. cement putty set flushed on the cemented rooftop, with inscriptions "ILN-11, 2004, NAMRIA".

Requesting Party: **UP DREAM**
Pupose: **Reference**
OR Number: **8795394 A**
T.N.: **2014-352**

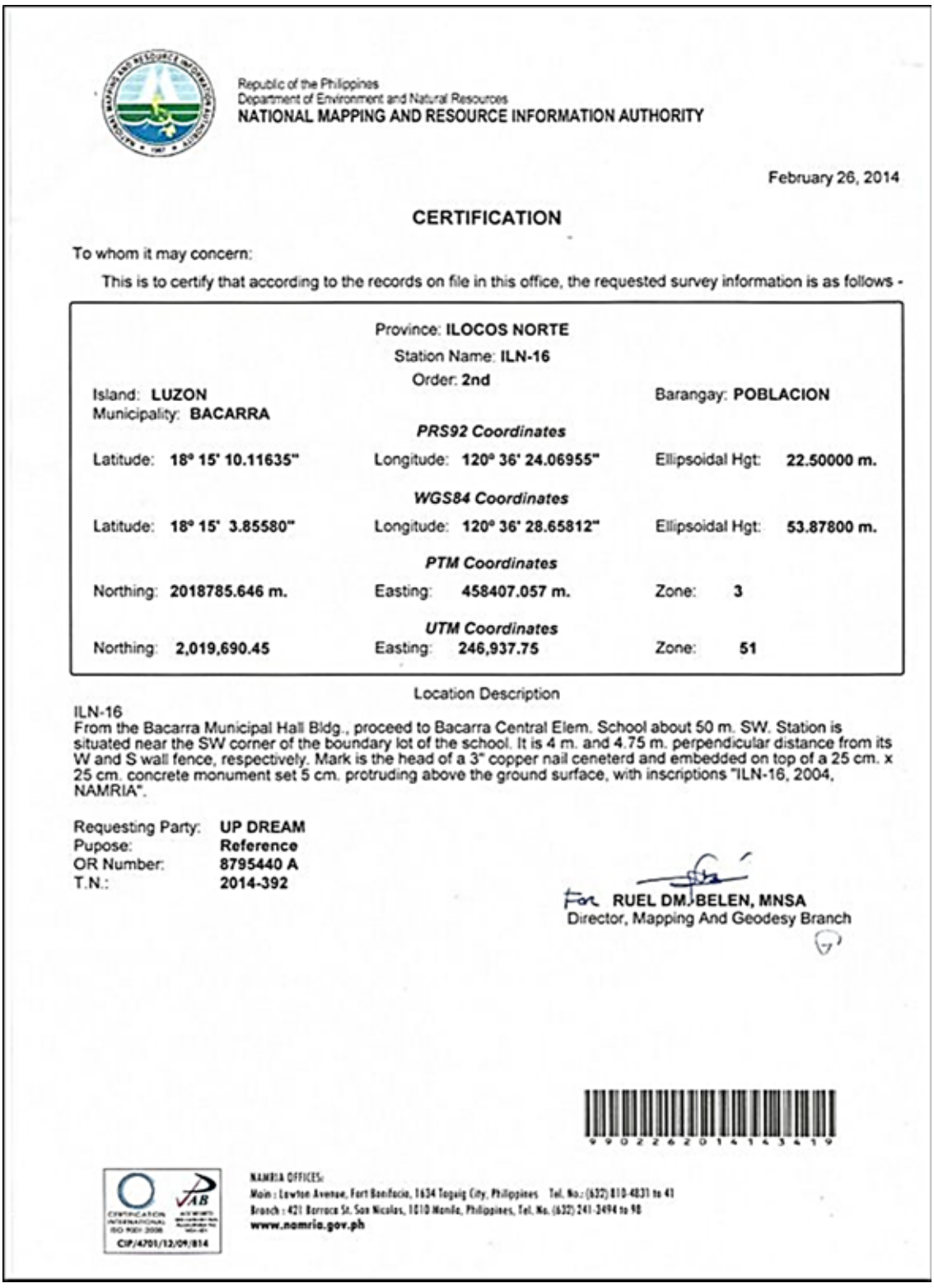
RUEL DM. BELEN, MNSA
Director, Mapping And Geodesy Branch

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

CIP/4701/12/09/814

Figure A-2.1. ILN-11

2. ILN-16



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

February 26, 2014

CERTIFICATION

To whom it may concern:

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

Province: **ILOCOS NORTE**
Station Name: **ILN-16**
Order: **2nd**

Island: **LUZON**
Municipality: **BACARRA**
Barangay: **POBLACION**

PRS92 Coordinates

Latitude: **18° 15' 10.11635"** Longitude: **120° 36' 24.06955"** Ellipsoidal Hgt: **22.50000 m.**

WGS84 Coordinates

Latitude: **18° 15' 3.85580"** Longitude: **120° 36' 28.65812"** Ellipsoidal Hgt: **53.87800 m.**

PTM Coordinates

Northing: **2018785.646 m.** Easting: **458407.057 m.** Zone: **3**

UTM Coordinates

Northing: **2,019,690.45** Easting: **246,937.75** Zone: **51**

Location Description

ILN-16
From the Bacarra Municipal Hall Bldg., proceed to Bacarra Central Elem. School about 50 m. SW. Station is situated near the SW corner of the boundary lot of the school. It is 4 m. and 4.75 m. perpendicular distance from its W and S wall fence, respectively. Mark is the head of a 3" copper nail ceneterd and embedded on top of a 25 cm. x 25 cm. concrete monument set 5 cm. protruding above the ground surface, with inscriptions "ILN-16, 2004, NAMRIA".

Requesting Party: **UP DREAM**
Pupose: **Reference**
OR Number: **8795440 A**
T.N.: **2014-392**

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

CIP/4701/12/09/814

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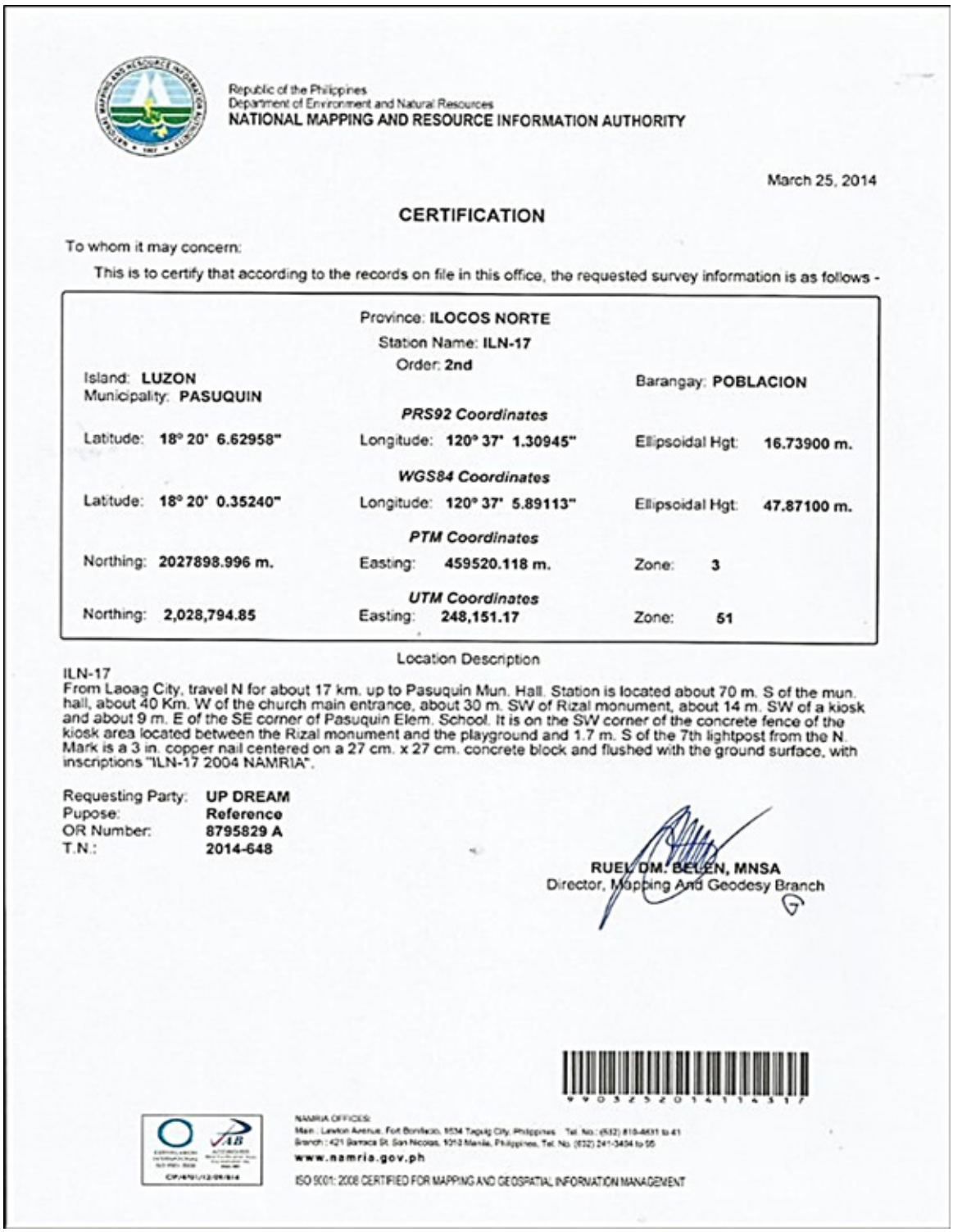
Figure A-2.2 ILN-16

3. ILN-17



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

March 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: **ILOCOS NORTE**
Station Name: **ILN-17**
Order: **2nd**

Island: **LUZON**
Municipality: **PASUQUIN**
Barangay: **POBLACION**

PRS92 Coordinates

Latitude: **18° 20' 6.62958"** Longitude: **120° 37' 1.30945"** Ellipsoidal Hgt: **16.73900 m.**

WGS84 Coordinates

Latitude: **18° 20' 0.35240"** Longitude: **120° 37' 5.89113"** Ellipsoidal Hgt: **47.87100 m.**

PTM Coordinates

Northing: **2027898.996 m.** Easting: **459520.118 m.** Zone: **3**

UTM Coordinates

Northing: **2,028,794.85** Easting: **248,151.17** Zone: **51**

Location Description

ILN-17
From Laoag City, travel N for about 17 km. up to Pasuquin Mun. Hall. Station is located about 70 m. S of the mun. hall, about 40 Km. W of the church main entrance, about 30 m. SW of Rizal monument, about 14 m. SW of a kiosk and about 9 m. E of the SE corner of Pasuquin Elem. School. It is on the SW corner of the concrete fence of the kiosk area located between the Rizal monument and the playground and 1.7 m. S of the 7th lightpost from the N. Mark is a 3 in. copper nail centered on a 27 cm. x 27 cm. concrete block and flushed with the ground surface, with inscriptions "ILN-17 2004 NAMRIA".

Requesting Party: **UP DREAM**
Pupose: **Reference**
OR Number: **8795829 A**
T.N.: **2014-648**

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

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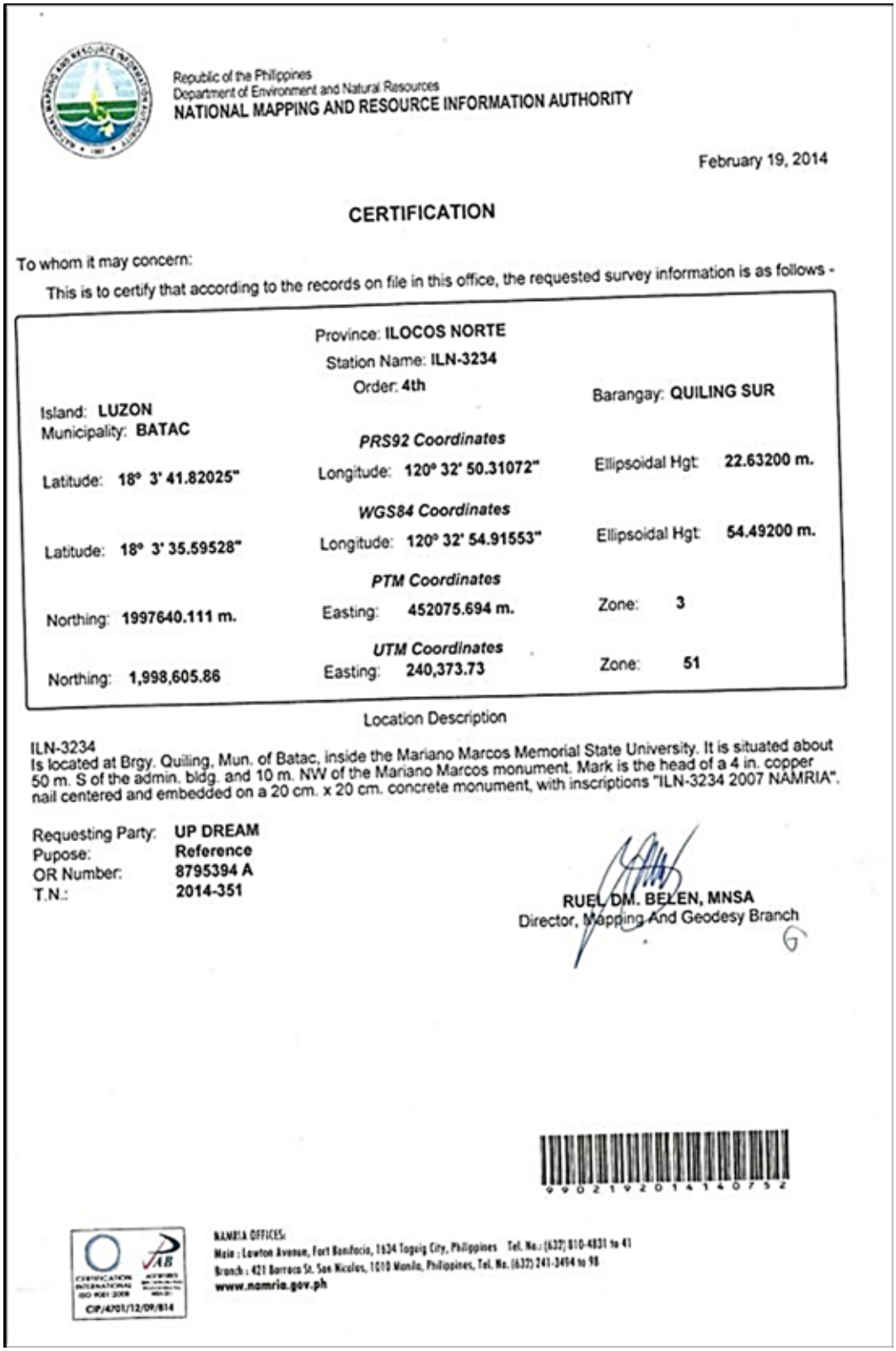
Figure A-2.3 ILN-17

4. ILN-3234



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

February 19, 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: ILOCOS NORTE
Station Name: ILN-3234
Order: 4th
Island: LUZON
Municipality: BATAC
Barangay: QUILING SUR

PRS92 Coordinates
Latitude: 18° 3' 41.82025" Longitude: 120° 32' 50.31072" Ellipsoidal Hgt: 22.63200 m.

WGS84 Coordinates
Latitude: 18° 3' 35.59528" Longitude: 120° 32' 54.91553" Ellipsoidal Hgt: 54.49200 m.

PTM Coordinates
Northing: 1997640.111 m. Easting: 452075.694 m. Zone: 3

UTM Coordinates
Northing: 1,998,605.86 Easting: 240,373.73 Zone: 51

Location Description

ILN-3234
Is located at Brgy. Quiling, Mun. of Batac, inside the Mariano Marcos Memorial State University. It is situated about 50 m. S of the admin. bldg. and 10 m. NW of the Mariano Marcos monument. Mark is the head of a 4 in. copper nail centered and embedded on a 20 cm. x 20 cm. concrete monument, with inscriptions "ILN-3234 2007 NAMRIA".

Requesting Party: UP DREAM
Pupose: Reference
OR Number: 8795394 A
T.N.: 2014-351

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

CIP/4701/12/09/814

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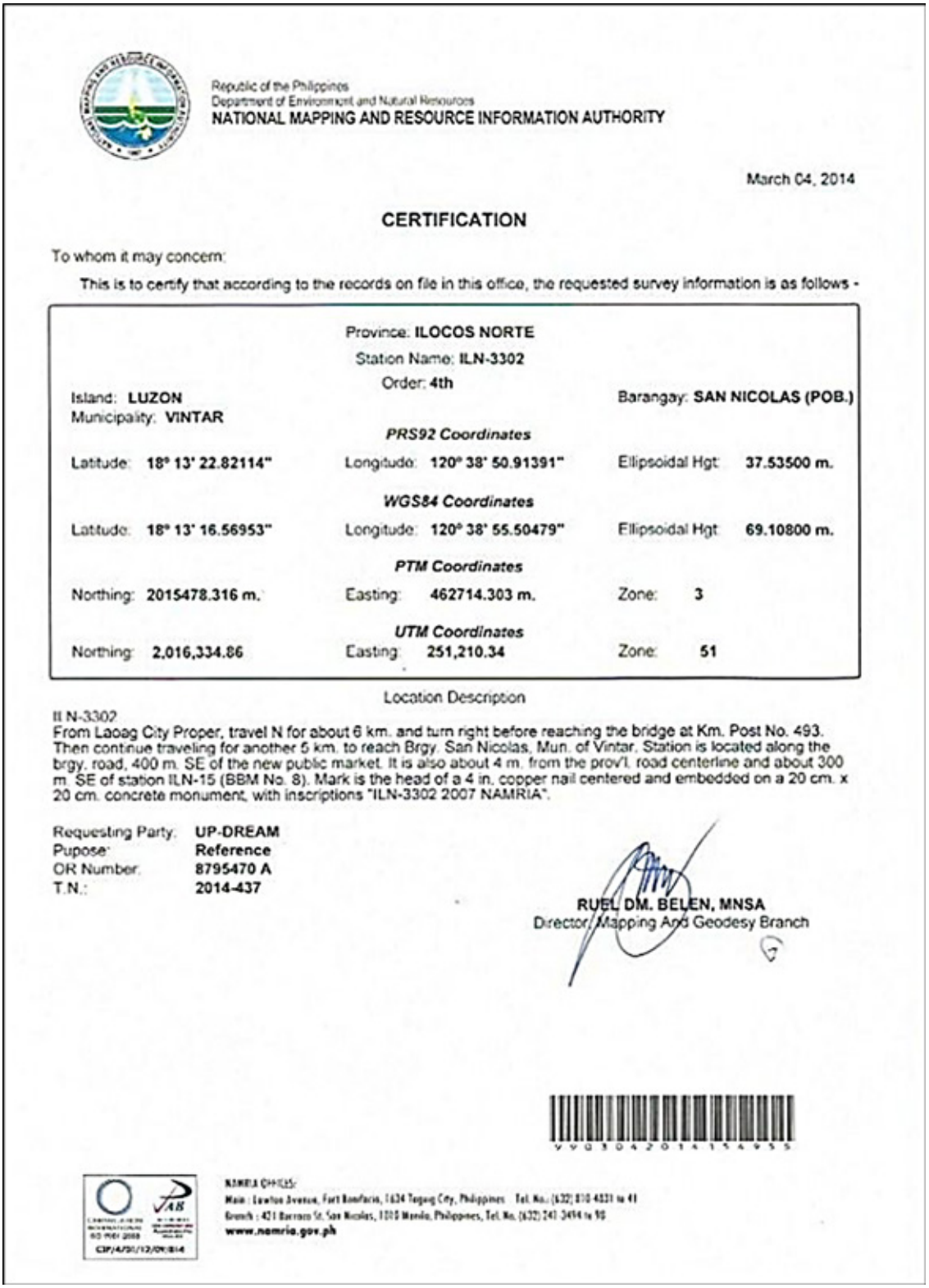
Figure A-2.4. ILN-3234

5. ILN-3302



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

March 04, 2014

CERTIFICATION

To whom it may concern:

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

Province: **ILOCOS NORTE**
Station Name: **ILN-3302**
Order: **4th**
Island: **LUZON**
Municipality: **VINTAR**
Barangay: **SAN NICOLAS (POB.)**

PRS92 Coordinates

Latitude: **18° 13' 22.82114"** Longitude: **120° 38' 50.91391"** Ellipsoidal Hgt: **37.53500 m.**

WGS84 Coordinates

Latitude: **18° 13' 16.56953"** Longitude: **120° 38' 55.50479"** Ellipsoidal Hgt: **69.10800 m.**

PTM Coordinates

Northing: **2015478.316 m.** Easting: **462714.303 m.** Zone: **3**

UTM Coordinates

Northing: **2,016,334.86** Easting: **251,210.34** Zone: **51**

Location Description

ILN-3302
From Laoag City Proper, travel N for about 6 km. and turn right before reaching the bridge at Km. Post No. 493. Then continue traveling for another 5 km. to reach Brgy. San Nicolas, Mun. of Vintar. Station is located along the brgy. road, 400 m. SE of the new public market. It is also about 4 m. from the prov'l. road centerline and about 300 m. SE of station ILN-15 (BBM No. 8). Mark is the head of a 4 in. copper nail centered and embedded on a 20 cm. x 20 cm. concrete monument, with inscriptions "ILN-3302 2007 NAMRIA".

Requesting Party: **UP-DREAM**
Pupose: **Reference**
OR Number: **8795470 A**
T.N.: **2014-437**

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

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Figure A-2.5. ALN-3302

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

1. SE-16

Table A-3.1. SE-16

SME-3139 - SE-16 (6:11:03 AM-11:04:02 AM) (S2)

Baseline observation:	SME-3139 — SE-16 (B2)
Processed:	6/30/2014 5:42:19 PM
Solution type:	Fixed
Frequency used:	Dual Frequency (L1, L2)
Horizontal precision:	0.001 m
Vertical precision:	0.002 m
RMS:	0.000 m
Maximum PDOP:	3.434
Ephemeris used:	Broadcast
Antenna model:	Trimble Relative
Processing start time:	6/9/2014 6:11:10 AM (Local: UTC+8hr)
Processing stop time:	6/9/2014 11:04:02 AM (Local: UTC+8hr)
Processing duration:	04:52:52
Processing interval:	1 second

Vector Components (Mark to Mark)

From:	SME-3139				
Grid		Local		Global	
Easting	765219.591 m	Latitude	N11°50'02.95701"	Latitude	N11°49'58.57713"
Northing	1309289.260 m	Longitude	E125°26'03.02189"	Longitude	E125°26'08.12160"
Elevation	2.987 m	Height	0.356 m	Height	62.185 m

To:	SE-16				
Grid		Local		Global	
Easting	765219.942 m	Latitude	N11°50'03.05106"	Latitude	N11°49'58.67117"
Northing	1309292.154 m	Longitude	E125°26'03.03429"	Longitude	E125°26'08.13400"
Elevation	3.103 m	Height	0.472 m	Height	62.301 m

Vector					
ΔEasting	0.350 m	NS Fwd Azimuth	7°23'58"	ΔX	-0.028 m
ΔNorthing	2.894 m	Ellipsoid Dist.	2.914 m	ΔY	-0.608 m
ΔElevation	0.116 m	ΔHeight	0.116 m	ΔZ	2.852 m

Standard Errors

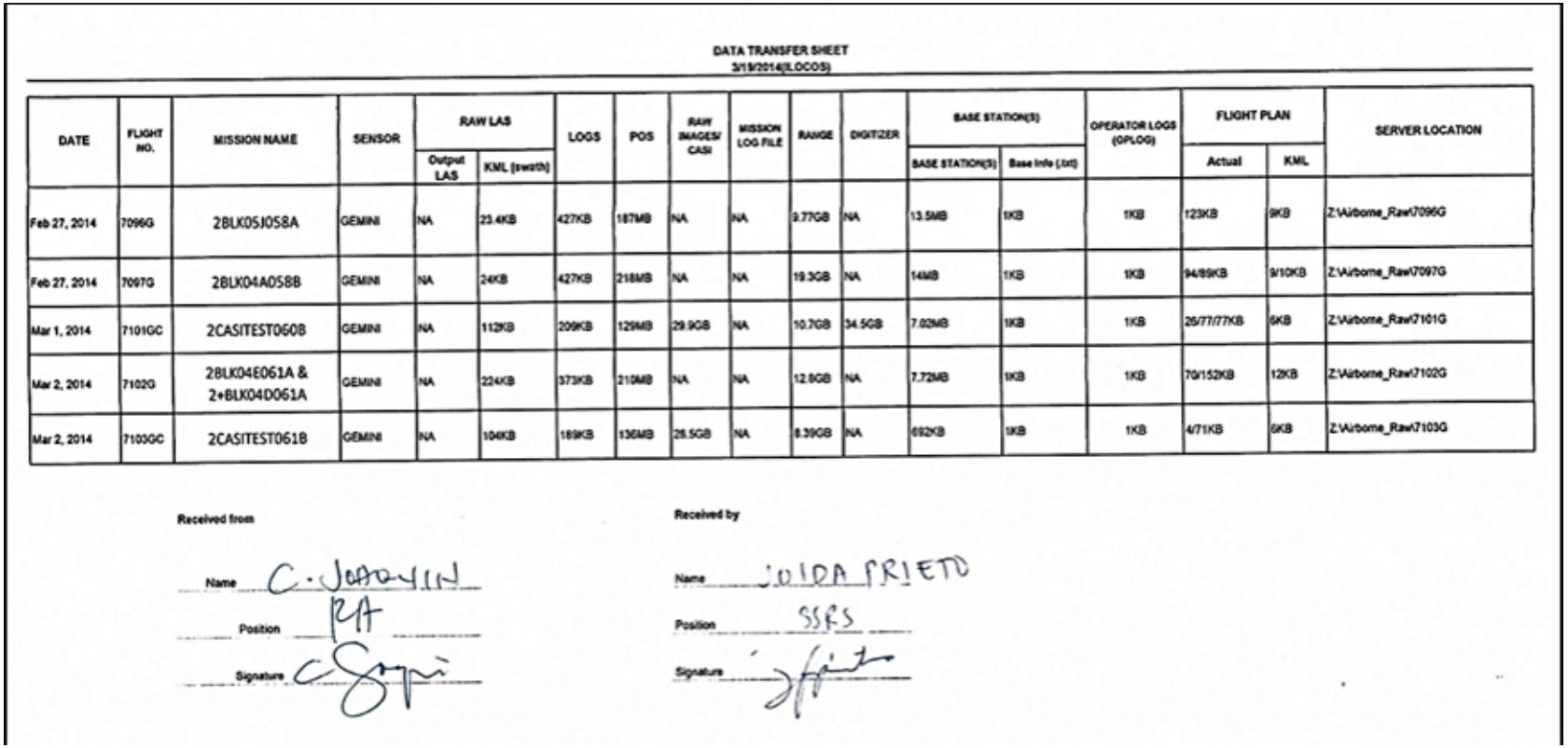
Vector errors:					
σ ΔEasting	0.000 m	σ NS fwd Azimuth	0°00'35"	σ ΔX	0.001 m
σ ΔNorthing	0.000 m	σ Ellipsoid Dist.	0.000 m	σ ΔY	0.001 m
σ ΔElevation	0.001 m	σ ΔHeight	0.001 m	σ ΔZ	0.000 m

Annex 4. The LiDAR Survey Team Composition

Table A-4.1. The LiDAR Survey Team Composition

Data Acquisition Component Sub-Team	Designation	Name	Agency/ Affiliation
PHIL-LIDAR 1	Program Leader	ENRICO C. PARINGIT, D.ENG	UP-TCAGP
Data Acquisition Component Leader	Data Component Project Leader - I	ENGR. CZAR JAKIRI SARMIENTO	UP-TCAGP
	Data Component Project Leader – I	ENGR. LOUIE P. BALICANTA	UP-TCAGP
Survey Supervisor	Supervising Science Research Specialist (SSRS)	ENGR. LOVELYN ASUNCION	UP-TCAGP
	Supervising Science Research Specialist (Supervising SRS)	LOVELY GRACIA ACUÑA	UP-TCAGP
		LOVELYN ASUNCION	UP-TCAGP
FIELD TEAM			
LiDAR Operation	Senior Science Research Associate (SSRS)	AUBREY PAGADOR	UP-TCAGP
	RA	MA. VERLINA TONGA MARY CATHERINE ELIZABETH BALIGUAS	UP-TCAGP
Ground Survey, Data Download and Transfer	RA	ENGR. IRO NIEL ROXAS	UP-TCAGP
LiDAR Operation	Airborne Security	DIOSCORO SOBERANO	PHILIPPINE AIR FORCE (PAF)
	Pilot	CAPT. RAUL CZ SAMAR	ASIAN AEROSPACE CORPORATION (AAC)
		CAPT. CESAR SHERWIN ALFONSO III	AAC

Annex 5. Data Transfer Sheet for Bacarra Floodplain



DATA TRANSFER SHEET
3/19/2014(ILOCOS)

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS	POS	RAW IMAGES/ CASI	MISSION LOG FILE	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
Feb 27, 2014	7096G	2BLK05J058A	GEMINI	NA	23.4KB	427KB	187MB	NA	NA	9.77GB	NA	13.5MB	1KB	1KB	123KB	9KB	Z:\Airborne_Raw\7096G
Feb 27, 2014	7097G	2BLK04A058B	GEMINI	NA	24KB	427KB	218MB	NA	NA	19.3GB	NA	14MB	1KB	1KB	94/89KB	9/10KB	Z:\Airborne_Raw\7097G
Mar 1, 2014	7101GC	2CASITEST060B	GEMINI	NA	112KB	209KB	129MB	29.9GB	NA	10.7GB	34.5GB	7.02MB	1KB	1KB	26/77/77KB	6KB	Z:\Airborne_Raw\7101G
Mar 2, 2014	7102G	2BLK04E061A & 2+BLK04D061A	GEMINI	NA	224KB	373KB	210MB	NA	NA	12.8GB	NA	7.72MB	1KB	1KB	70/152KB	12KB	Z:\Airborne_Raw\7102G
Mar 2, 2014	7103GC	2CASITEST061B	GEMINI	NA	104KB	189KB	136MB	26.5GB	NA	8.39GB	NA	692KB	1KB	1KB	4/71KB	6KB	Z:\Airborne_Raw\7103G

Received from

Name C. JOAQUIN

Position PA

Signature

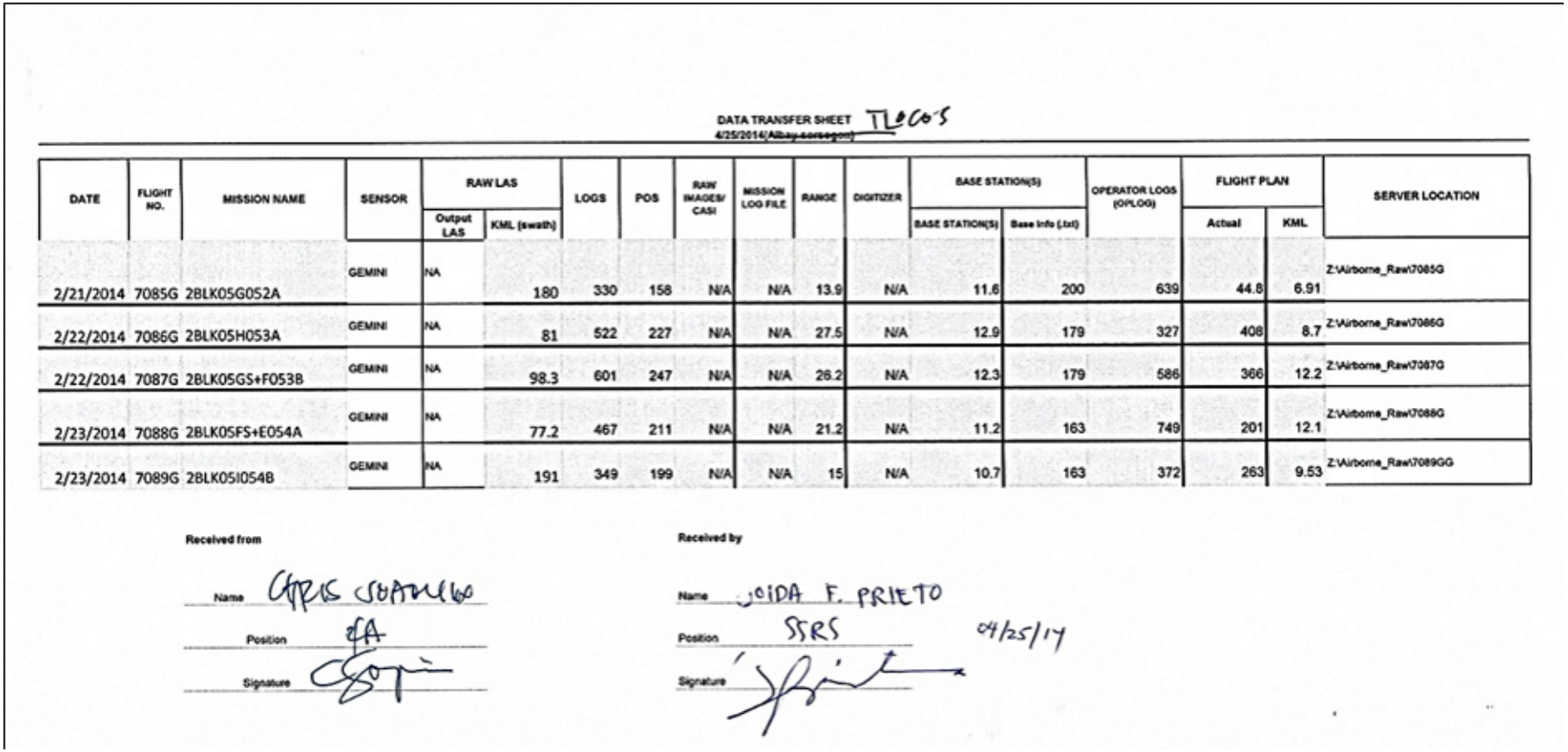
Received by

Name JOIDA PRIETO

Position SSFS

Signature

Figure A-5.1. Transfer Sheet for Bacarra Floodplain - A



DATA TRANSFER SHEET TLCO'S
4/25/2014(Albay-sorsogon)

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS	POS	RAW IMAGES/ CASI	MISSION LOG FILE	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
2/21/2014	7085G	2BLK05G052A	GEMINI	NA	180	330	158	N/A	N/A	13.9	N/A	11.6	200	639	44.8	6.91	Z:\Airborne_Raw\7085G
2/22/2014	7086G	2BLK05H053A	GEMINI	NA	81	522	227	N/A	N/A	27.5	N/A	12.9	179	327	408	8.7	Z:\Airborne_Raw\7086G
2/22/2014	7087G	2BLK05GS+F053B	GEMINI	NA	98.3	601	247	N/A	N/A	26.2	N/A	12.3	179	586	366	12.2	Z:\Airborne_Raw\7087G
2/23/2014	7088G	2BLK05FS+E054A	GEMINI	NA	77.2	467	211	N/A	N/A	21.2	N/A	11.2	163	749	201	12.1	Z:\Airborne_Raw\7088G
2/23/2014	7089G	2BLK05I054B	GEMINI	NA	191	349	199	N/A	N/A	15	N/A	10.7	163	372	263	9.53	Z:\Airborne_Raw\7089GG

Received from

Name CHRIS SOARIEZO

Position GA

Signature

Received by

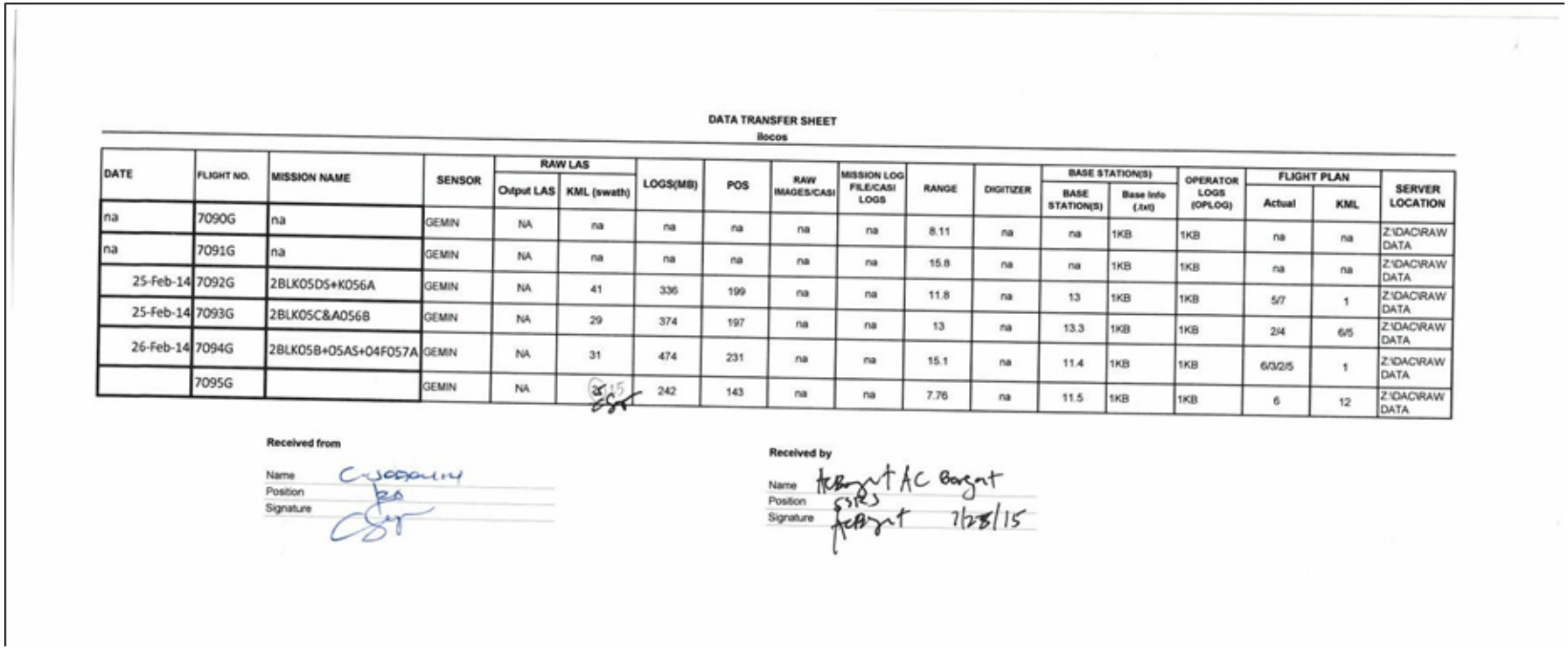
Name JOIDA F. PRIETO

Position SSRS

Signature

04/25/14

Figure A-5.2. Transfer Sheet for Bacarra Floodplain - A



DATA TRANSFER SHEET

Ilocos

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	
na	7090G	na	GEMIN	NA	na	na	na	na	na	8.11	na	na	1KB	1KB	na	na	Z:\DAC\RAW DATA
na	7091G	na	GEMIN	NA	na	na	na	na	na	15.8	na	na	1KB	1KB	na	na	Z:\DAC\RAW DATA
25-Feb-14	7092G	2BLK05D5+K056A	GEMIN	NA	41	336	199	na	na	11.8	na	13	1KB	1KB	5/7	1	Z:\DAC\RAW DATA
25-Feb-14	7093G	2BLK05C&A056B	GEMIN	NA	29	374	197	na	na	13	na	13.3	1KB	1KB	2/4	6/5	Z:\DAC\RAW DATA
26-Feb-14	7094G	2BLK05B+05AS+04F057A	GEMIN	NA	31	474	231	na	na	15.1	na	11.4	1KB	1KB	6/3/2/5	1	Z:\DAC\RAW DATA
	7095G		GEMIN	NA	25 ESAT	242	143	na	na	7.76	na	11.5	1KB	1KB	6	12	Z:\DAC\RAW DATA

Received from

Name

Position

Signature

Received by

Name

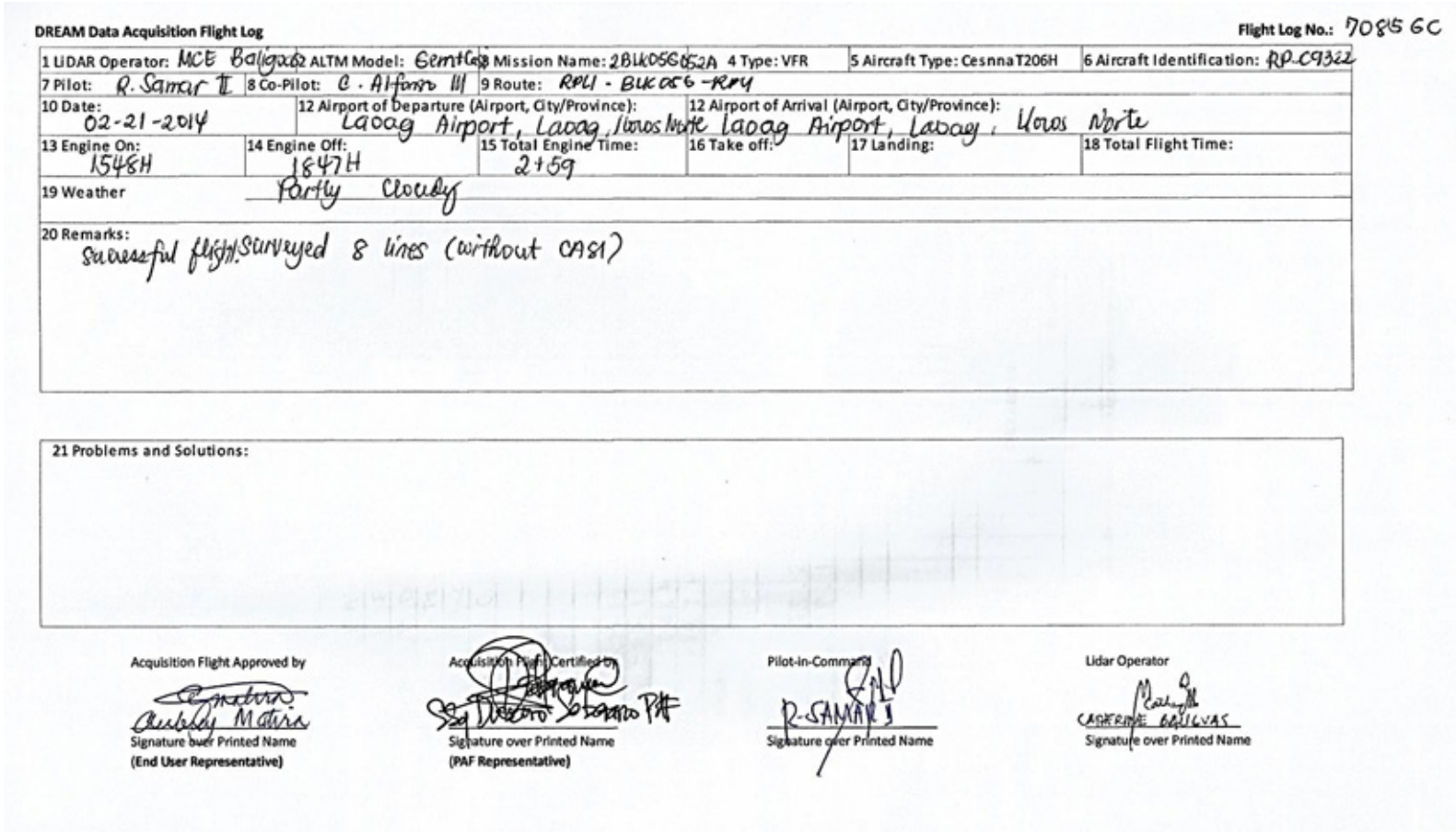
Position

Signature 7/28/15

Figure A-5.3. Transfer Sheet for Bacarra Floodplain - A

Annex 6. Flight logs for the flight missions

1. Flight Log for 7085G Mission



DREAM Data Acquisition Flight Log — Flight Log No.: 7085 GC

1 LiDAR Operator: MCE Baligad	2 ALTM Model: Gemini	3 Mission Name: 2BLK05G052A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9322
7 Pilot: R. Samar II	8 Co-Pilot: C. Alfonso III	9 Route: RPLI - BLK05G - RPLI			
10 Date: 02-21-2014	12 Airport of Departure (Airport, City/Province): Laoag Airport, Laoag, Ilocos Norte	12 Airport of Arrival (Airport, City/Province): Laoag Airport, Laoag, Ilocos Norte			
13 Engine On: 1548H	14 Engine Off: 1847H	15 Total Engine Time: 2+59	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Partly Cloudy					
20 Remarks: Successful flight. Surveyed 8 lines (without CAS1)					
21 Problems and Solutions:					

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

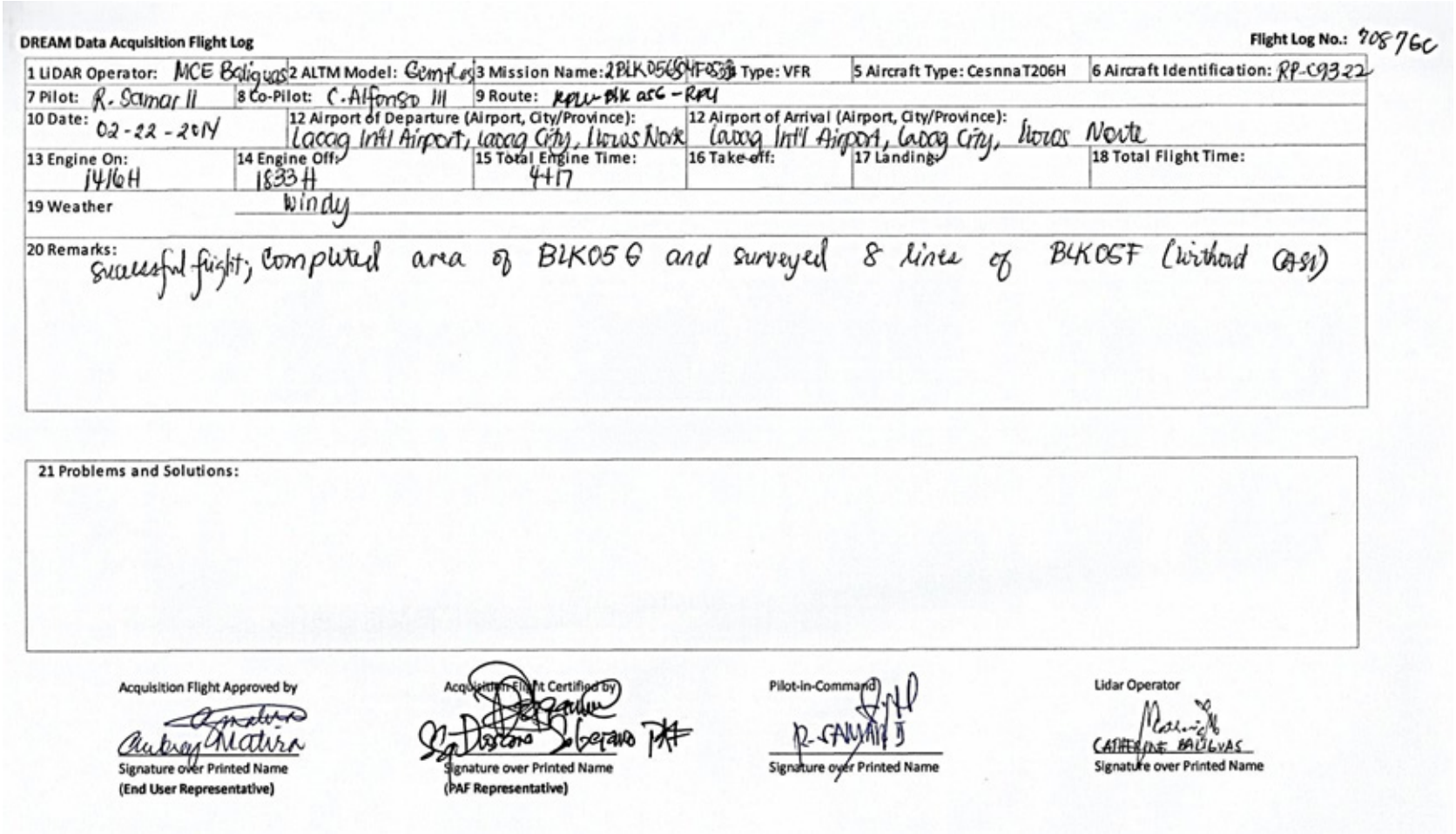
Acquisition Flight Certified by — Signature over Printed Name (PAF Representative)

Pilot-in-Command — R-SAMAR II — Signature over Printed Name

Lidar Operator — CATHERINE BALIGAD — Signature over Printed Name

Figure A-6.1. Flight Log for Mission 7085G

2. Flight Log for 7087G Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 7087GC

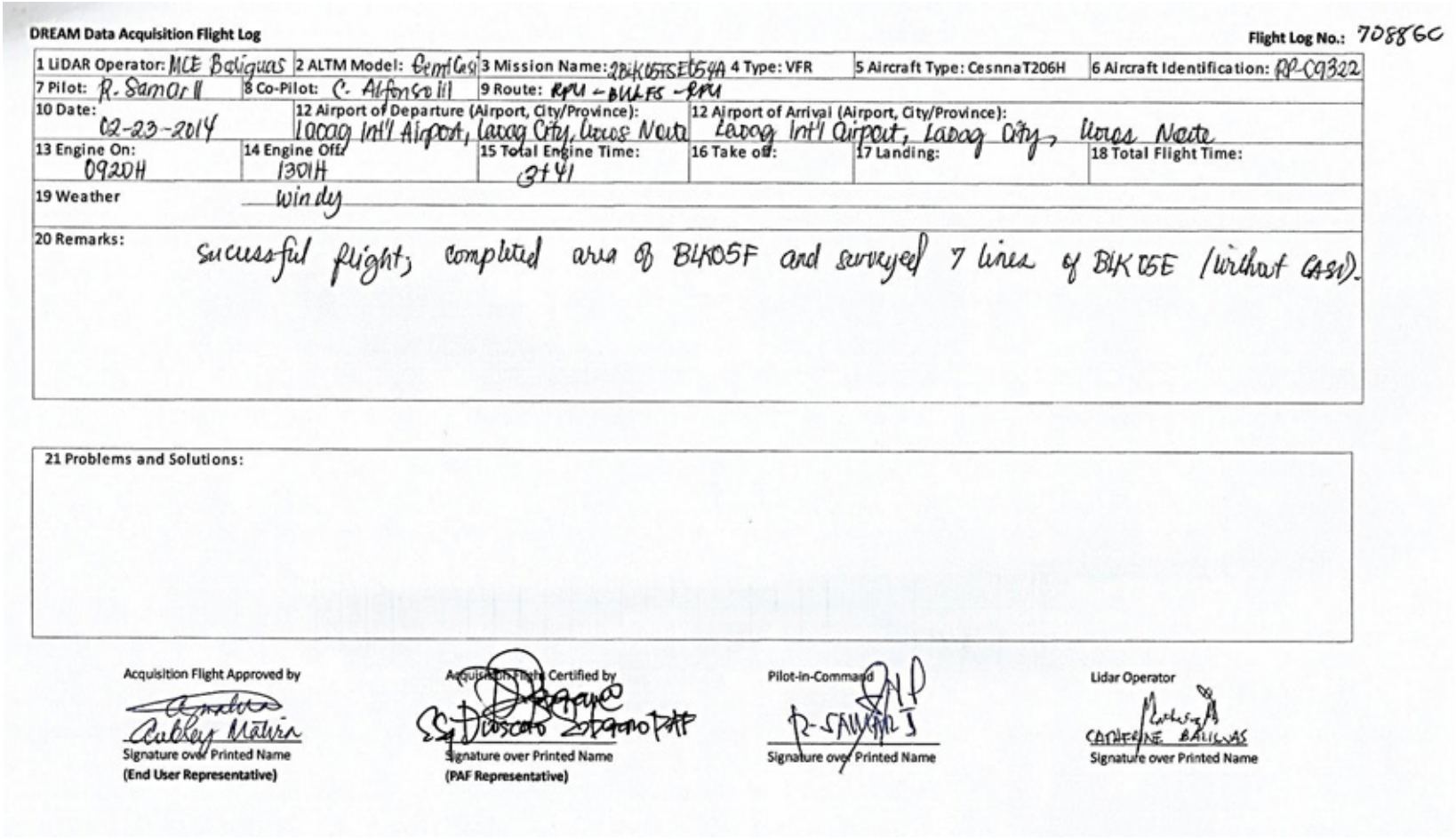
1 LiDAR Operator: MCE Baligwas	2 ALTM Model: Gemini	3 Mission Name: 2BLK05GF053	4 Flight Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9322
7 Pilot: R. Samar II	8 Co-Pilot: C. Alfonso III	9 Route: RPLL-BLK ASC - RPLL			
10 Date: 02-22-2014	12 Airport of Departure (Airport, City/Province): Laoag Int'l Airport, Laoag City, Ilocos Norte		12 Airport of Arrival (Airport, City/Province): Laoag Int'l Airport, Laoag City, Ilocos Norte		
13 Engine On: 1416H	14 Engine Off: 1833H	15 Total Engine Time: 4+17	16 Take-off:	17 Landing:	18 Total Flight Time:
19 Weather	windy				
20 Remarks: Successful flight; Computed area of BLK05G and surveyed 8 lines of BLK05F (without GAS)					

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)	Signature over Printed Name	Signature over Printed Name

Figure A-6.2. Flight Log for Mission 7087G

3. Flight log for 7088G Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 7088G

1 LiDAR Operator: MCE Baliguas	2 ALTM Model: Gemini	3 Mission Name: 2BLK05SE054A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9322
7 Pilot: R. Samor II	8 Co-Pilot: C. Alfonso III	9 Route: RPU – BULFS – RPU			
10 Date: 02-23-2014	12 Airport of Departure (Airport, City/Province): Laoag Int'l Airport, Laoag City, Ilocos Norte		12 Airport of Arrival (Airport, City/Province): Laoag Int'l Airport, Laoag City, Ilocos Norte		
13 Engine On: 0920H	14 Engine Off: 1301H	15 Total Engine Time: 3+41	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: windy					
20 Remarks: successful flight; completed area of BLK05F and surveyed 7 lines of BLK05E (without GAs).					

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)	Signature over Printed Name	Signature over Printed Name

Figure A-6.3. Flight Log for Mission 7088G

4. Flight Log for 7091G Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 7090

1 LiDAR Operator: MVE Tongo	2 ALTM Model: Gemini	3 Mission Name: 2BLK05L055A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9322
7 Pilot: R. Samson II	8 Co-Pilot: C. Alfonso III	9 Route:			
10 Date: 02-24-2014	12 Airport of Departure (Airport, City/Province): Laoag Int'l Airport, Laoag City, Ilocos Norte		12 Airport of Arrival (Airport, City/Province): Laoag Int'l Airport, Laoag City, Ilocos Norte		
13 Engine On: 0851H	14 Engine Off: 1144H	15 Total Engine Time: 2+53	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	windy				

20 Remarks:

Successful flight; mission completed without CASI

21 Problems and Solutions:

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

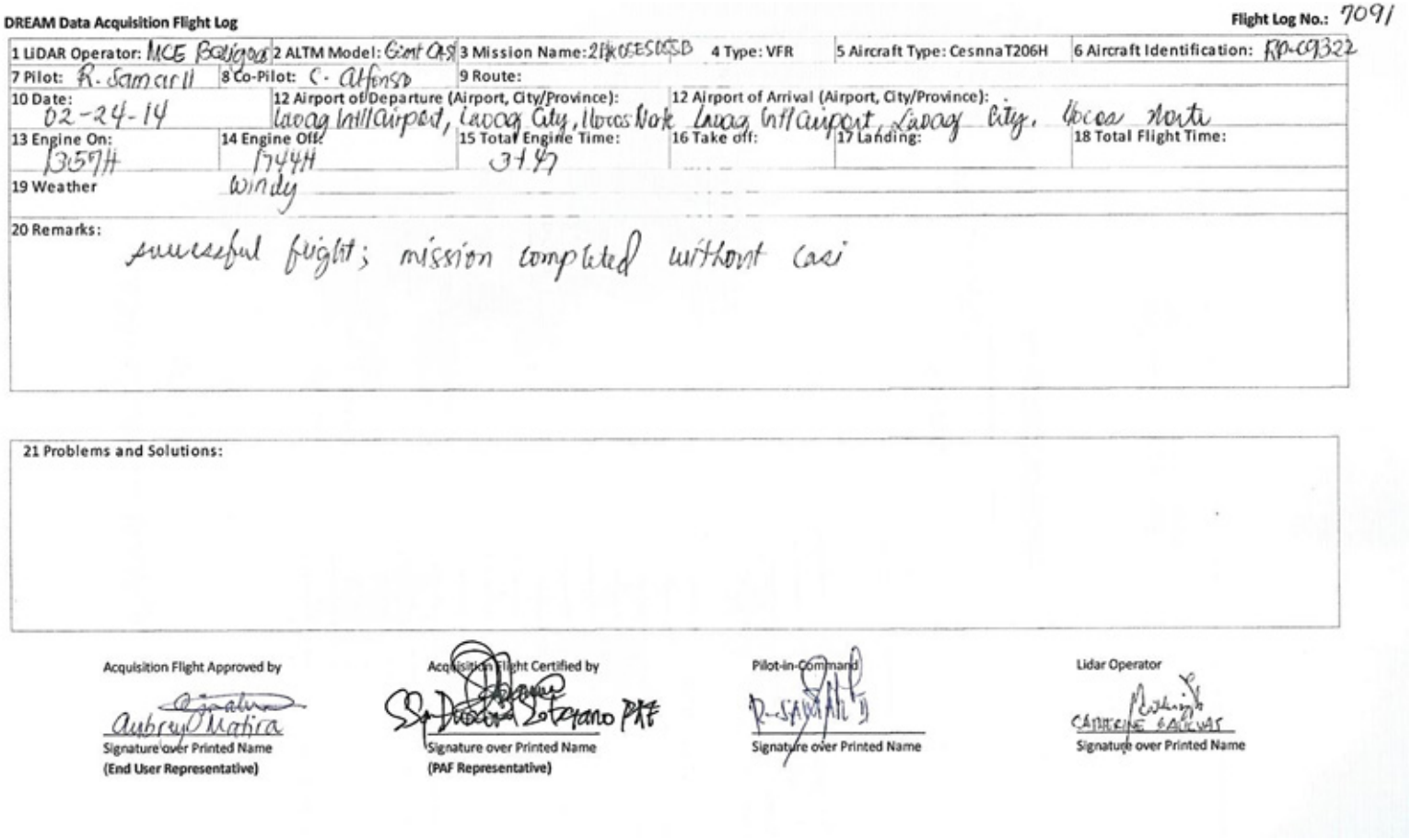
Acquisition Flight Certified by: Sgt. Rosario Sobrepeña PAF — Signature over Printed Name (PAF Representative)

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

Lidar Operator: MVE Tongo — Signature over Printed Name

Figure A-6.4. Flight Log for Mission 7091G

5. Flight Log for 7092G Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 7091

1 LiDAR Operator: MCE Boligoa	2 ALTM Model: Gemini	3 Mission Name: 21k0515055D	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9322
7 Pilot: R. Samaniego II	8 Co-Pilot: C. Alfonso	9 Route:			
10 Date: 02-24-14	12 Airport of Departure (Airport, City/Province): Laoag Intl Airport, Laoag City, Ilocos Nork	12 Airport of Arrival (Airport, City/Province): Laoag Intl Airport, Laoag City, Ilocos Norte			
13 Engine On: 1357H	14 Engine Off: 1744H	15 Total Engine Time: 3.47	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	windy				
20 Remarks:	successful flight; mission completed without casi				
21 Problems and Solutions:					

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

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

Pilot-in-Command
Signature over Printed Name

Lidar Operator
CATHERINE GALICIAS
Signature over Printed Name

Figure A-6.5. Flight Log for Mission 7092G

6. Flight Log for 7092G Mission

DREAM Data Acquisition Flight Log Flight Log No.: 7092

1 LiDAR Operator: MCE GALIBVAS	2 ALTM Model: GEN 1 ALTM	3 Mission Name: ANGOS K2564	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9322
7 Pilot: R. SAMAR II	8 Co-Pilot: C. ALFONSO II	9 Route:			
10 Date: 02-25-2014	12 Airport of Departure (Airport, City/Province): Laoag Int'l Airport, Laoag City, Ilocos Norte		12 Airport of Arrival (Airport, City/Province): Laoag Int'l Airport		
13 Engine On: 0954/14	14 Engine Off: 1322 H	15 Total Engine Time: 3+11	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	Partly cloudy				
20 Remarks: Mission completed (without ASI)					
21 Problems and Solutions:					

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

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

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

Lidar Operator
CATHERINE GALIBVAS
Signature over Printed Name

Figure A-6.6. Flight Log for Mission 7092G

8. Flight Log for 7094G Mission

DREAM Data Acquisition Flight Log Flight Log No.: 7094

1 LiDAR Operator: [illegible]	2 ALTM Model: [illegible]	3 Mission Name: [illegible]	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9322
7 Pilot: [illegible]	8 Co-Pilot: [illegible]	9 Route:			
10 Date: 02-26-2014	12 Airport of Departure (Airport, City/Province): RPLI		12 Airport of Arrival (Airport, City/Province): RPLI		
13 Engine On: 0850H	14 Engine Off: 1249H	15 Total Engine Time: 3:59	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Windy					

20 Remarks:

Blocks of 05A & 05B completed and surveyed 4 lines of BLK 04F (without CASI)

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)	Signature over Printed Name	Signature over Printed Name

Figure A-6.8. Flight Log for Mission 7094G

9. Flight Log for 7095G Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 7095

1 LIDAR Operator: MCE BALICUAS	2 ALTM Model: LEICA	3 Mission Name: 2BLK4C05	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9122
7 Pilot: R - SAMAR II	8 Co-Pilot: E ALFONSO III	9 Route:			
10 Date: 02-26-2014	12 Airport of Departure (Airport, City/Province): Laoag Int'l Airport, Laoag City, Ilocos Norte		12 Airport of Arrival (Airport, City/Province): Laoag Int'l Airport		
13 Engine On: 1421H	14 Engine Off: 1702H	15 Total Engine Time: 2+41	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	Windy				

20 Remarks:

Mission completed (without dsi)

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)	R-SAMAR II Signature over Printed Name	CATHERINE BALICUAS Signature over Printed Name

Figure A-6.9. Flight Log for Mission 7095G

10. Flight Log for 7102G Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 7102

1 LIDAR Operator: NOE BALICUAS	2 ALTM Model: GEMINI ALS	3 Mission Name: 2BLK64E061A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 9322
7 Pilot: R-SAMAR II	8 Co-Pilot: C. ALFONSO IV	9 Route:			
10 Date: 03-02-2014	12 Airport of Departure (Airport, City/Province): RPLI		12 Airport of Arrival (Airport, City/Province): RPLI		
13 Engine On: 0960H	14 Engine Off: 1247H	15 Total Engine Time: 3+47	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	Partly cloudy				

20 Remarks:

Mission completed (without case)

21 Problems and Solutions:

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

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

Pilot-In-Command
Signature over Printed Name

Lidar Operator
CATALINO BALICUAS
Signature over Printed Name

Figure A-6.10. Flight Log for Mission 7102G

11. Flight Log for 7103G Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 7103

1 LIDAR Operator: MVE Tongga	2 ALTM Model: Gemini	3 Mission Name: 2CASITESTG	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9322
7 Pilot: A. SAMAR II	8 Co-Pilot: C. ALFONSO III	9 Route:			
10 Date: 03-02-2014	12 Airport of Departure (Airport, City/Province): RPLI		12 Airport of Arrival (Airport, City/Province): RPLI		
13 Engine On: 1516H	14 Engine Off: 1745H	15 Total Engine Time: 2+29	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Fair					

20 Remarks:

Test flight of GS1

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)	Signature over Printed Name	Signature over Printed Name

Figure A-6.11. Flight Log for Mission 7103G

Annex 7. Flight status reports

Bacarra Mission
February 18, 2014 to March 14, 2014

Table A-7.1. Flight Status Report

FLIGHT NO.	AREA	MISSION	OPERATOR	DATE FLOWN	REMARKS
7085	BLK05	2BLK05G052A	MCE BALIGU-AS	21 FEB 14	Surveyed 8 line (without CASI)
7087	BLK05	2BLK05GS053B & 2BLK05F053B	MCE BALIGU-AS	22 FEB 14	Completed area of BLK05G and surveyed 8 lines at BLK05F (without CASI)
7088	BLK05	2BLKFS054A & 2BLKE054A	MCE BALIGU-AS	23 FEB 14	Completed area of BLK05F and surveyed 7 lines at BLK05E (without CASI)
7091	BLK05	2BLK05ES055B & 2BLK05D055B	MCE BALIGU-AS	24 FEB 14	Mission completed (without CASI)
7092	BLK05	2BLK05DS056A & 2BLK05K056A	MCE BALIGU-AS	25 FEB 14	Mission completed (without CASI)
7093	BLK05	2BLK05C056B & 2BLK05A056B	MVE TONGA	25 FEB 14	Mission completed (without CASI)
7094	BLK05 and BLK04	2BLK05B057A & 2BLK05AS057A & 2BLK04F057A	MVE TONGA	26 FEB 14	Blocks 05A and 05 B completed and surveyed 9 lines of BLK04F (without CASI)
7095	BLK04	2BLK04C057B	MCE BALIGU-AS	26 FEB 14	Mission completed (without CASI)
7097	BLK04	2BLK04A058B & 2BLK04B059B	MVE TONGA	27 FEB 14	Mission completed (without CASI)
7102	BLK04	2BLK04E061A & 2BLK04D061A	MCE BALIGU-AS	02 MAR 14	Mission completed (without CASI)
7103	BLK05	2CASITEST061B	MVE TONGA	02 MAR 14	Test Flight of CASI

SWATH PER FLIGHT MISSION

Flight No. : 7085G

Area: BLOCK 5

Mission Name: 2BLK05G052A

Altitude: 1000m

PRF: 40 kHz

Lidar FOV: 25 deg

Overlap: 25%

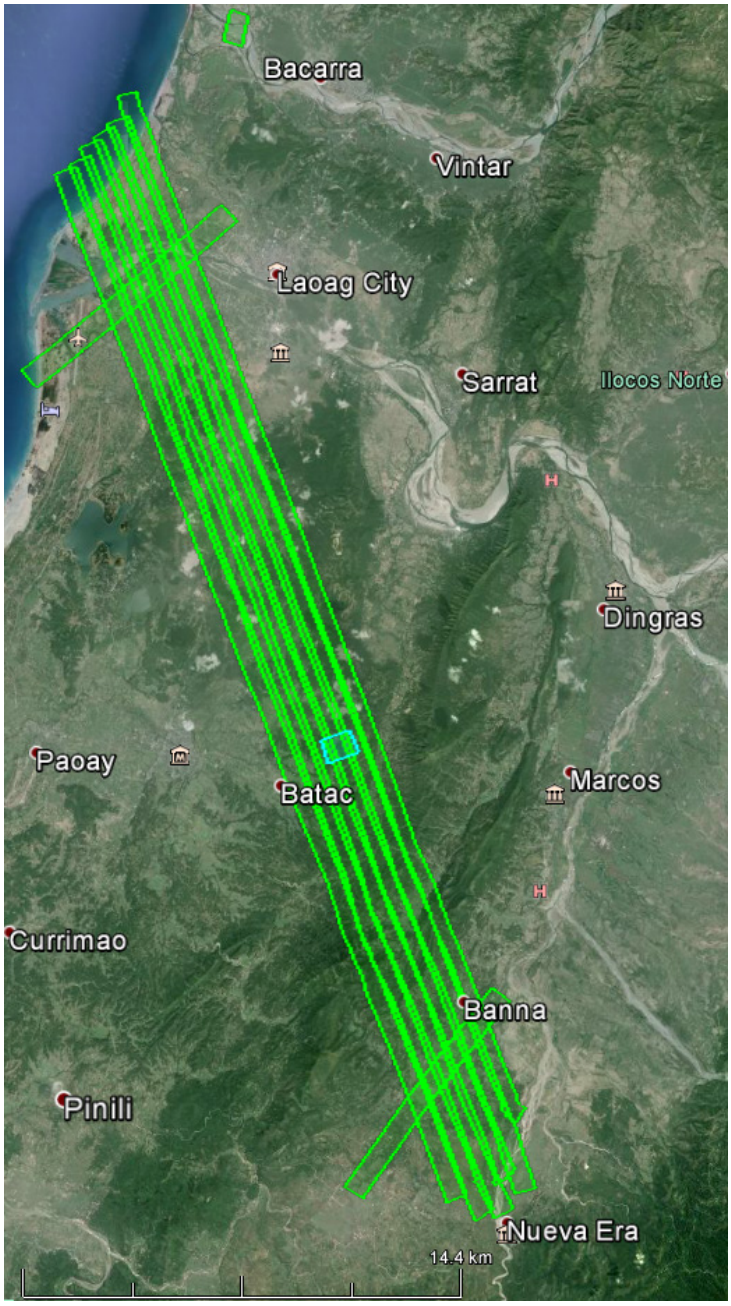


Figure A-7.1. Swath for Flight No. 7085G

Flight No. : 7087G

Area: BLOCK 5

Mission Name: 2BLK05GS053B & 2BLK05F053B

Altitude: 1000m

PRF: 50 kHz

Lidar FOV: 20 deg

overlap: 30%

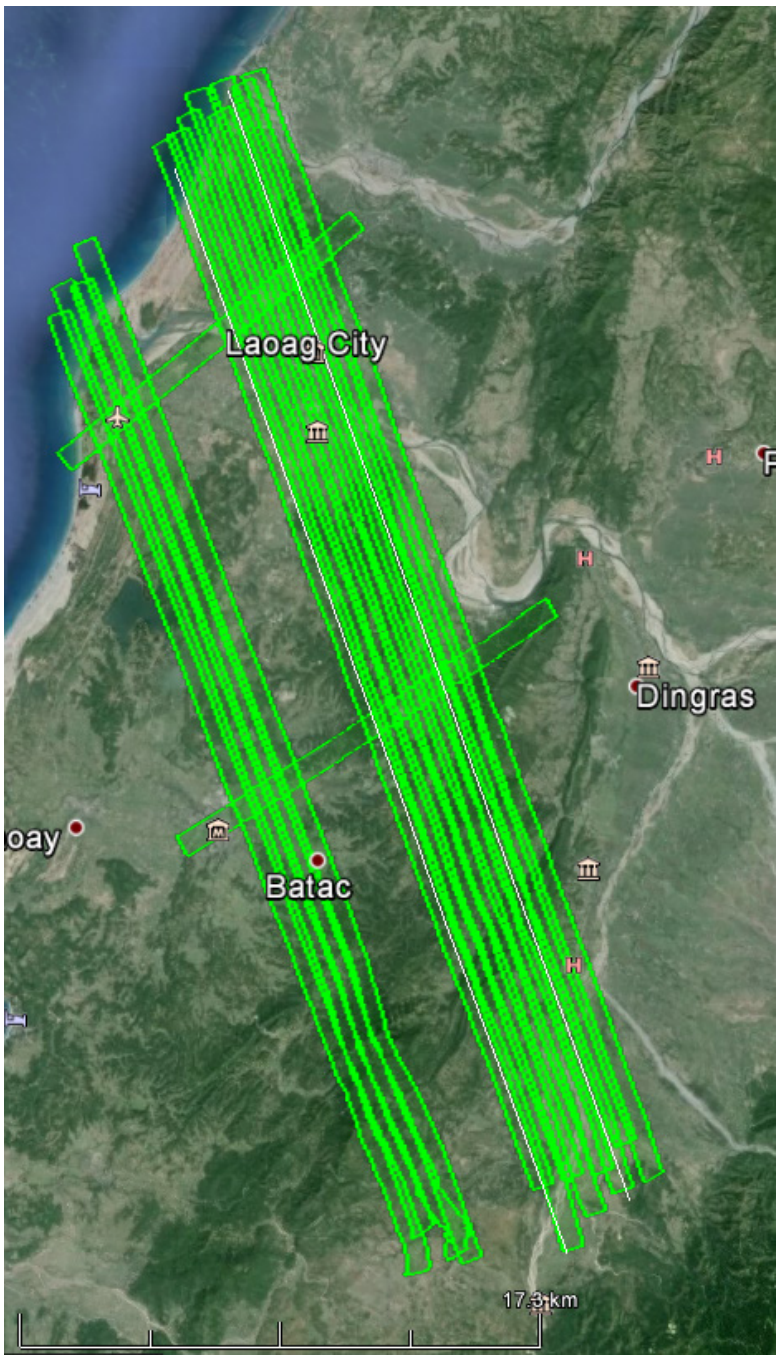


Figure A-7.2. Swath for Flight No. 7087G

Flight No. : 7088G

Area: BLOCK 5

Mission Name: 2BLK05FS053B & 2BLK05E054A

Altitude: 1000m

PRF: 50 kHz

Lidar FOV: 20 deg

Overlap: 25%

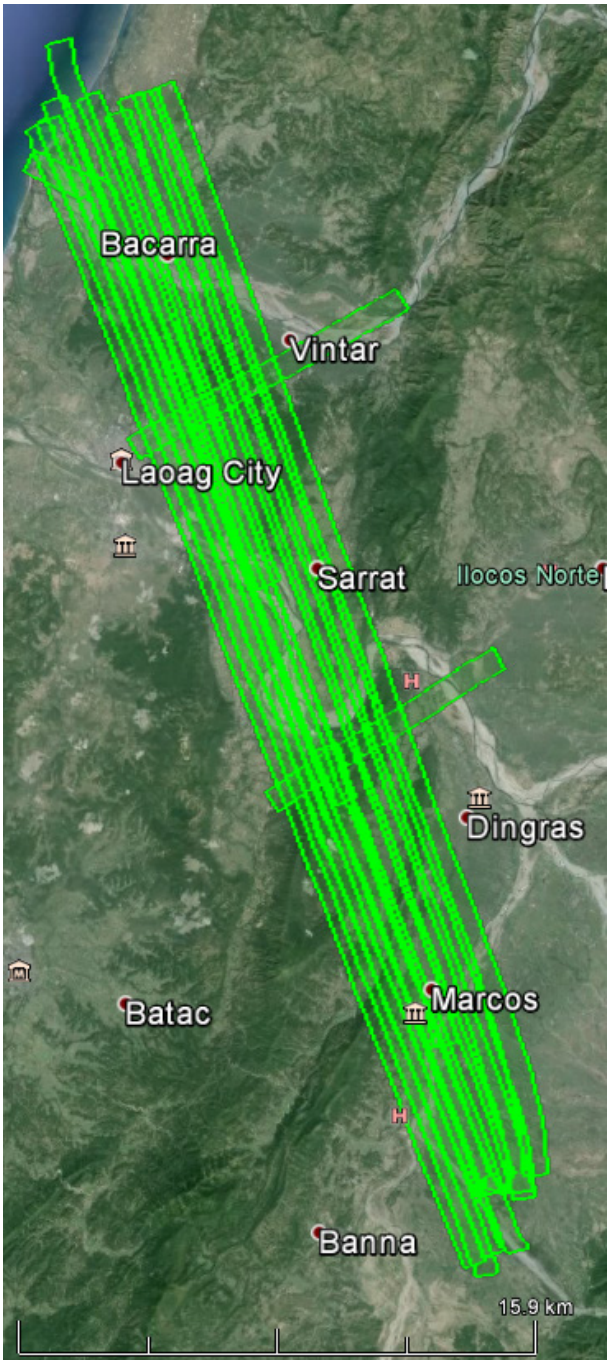


Figure A-7.3. Swath for Flight No. 7088G

Flight No. : 7091G

Area: BLOCK 5

Mission Name: 2BLK05ES055B & 2BLK05D055B

2BLK05ES055B

Altitude: 1000m

PRF: 50 kHz

Lidar FOV: 20 deg

Overlap: 25%

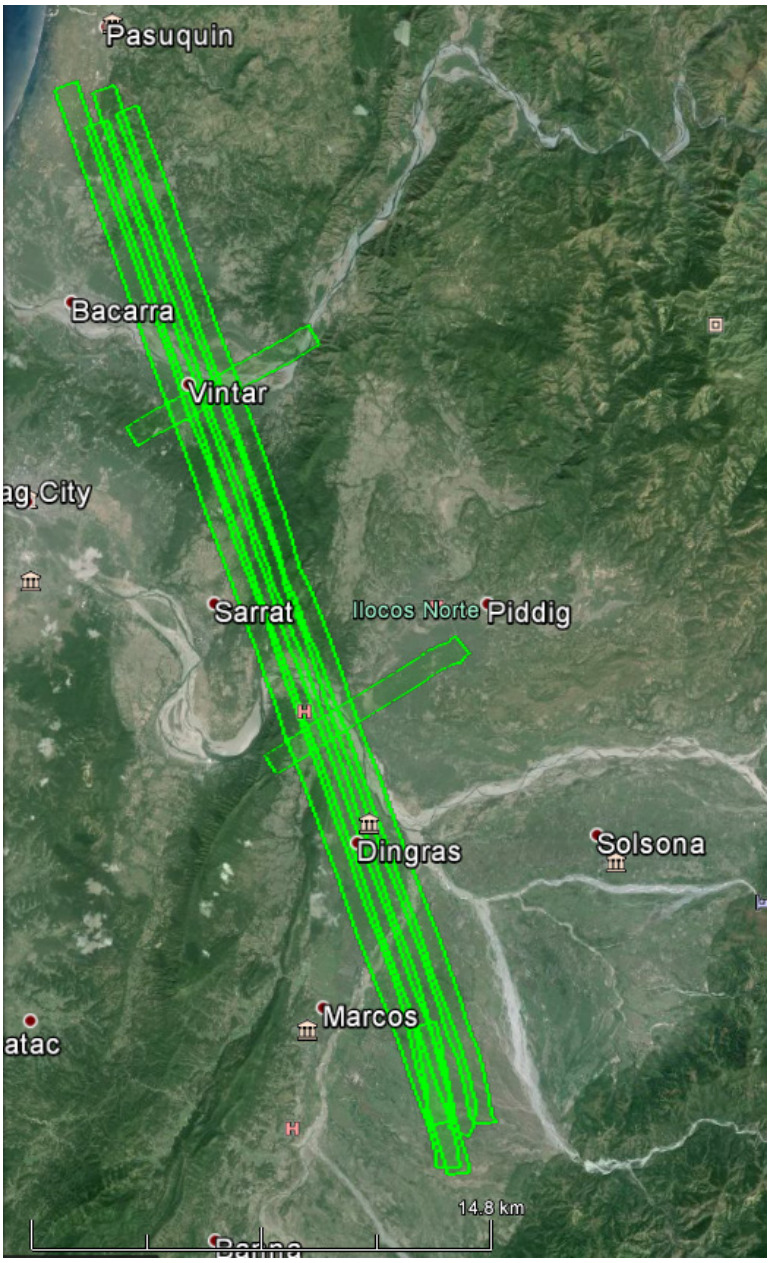


Figure A-7.4. Swath for Flight No. 7091G

Flight No. : 7092G

Area: BLOCK 5

Mission Name: 2BLK05DS056A & 2BLK05K056a

Altitude: 1400m

PRF: 50 kHz

Lidar FOV: 20 deg

Overlap: 30%

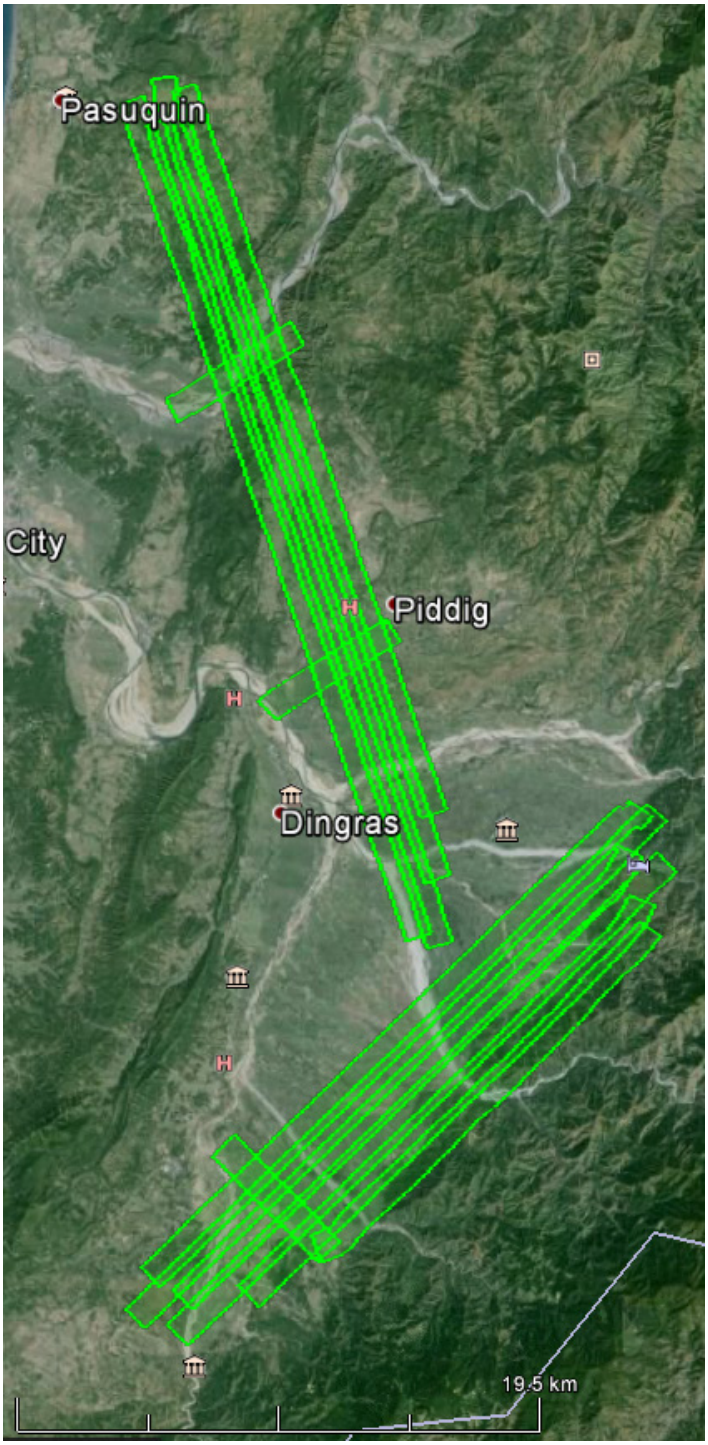


Figure A-7.5. Swath for Flight No. 7092G

Flight No. : 7093G

Area: BLOCK 5

Mission Name: 2BLK05C056B & 2BLK05A056B

Altitude: 1400m to 1200m

PRF: 50 kHz

Lidar FOV: 20 deg

Overlap: 30% to 25%

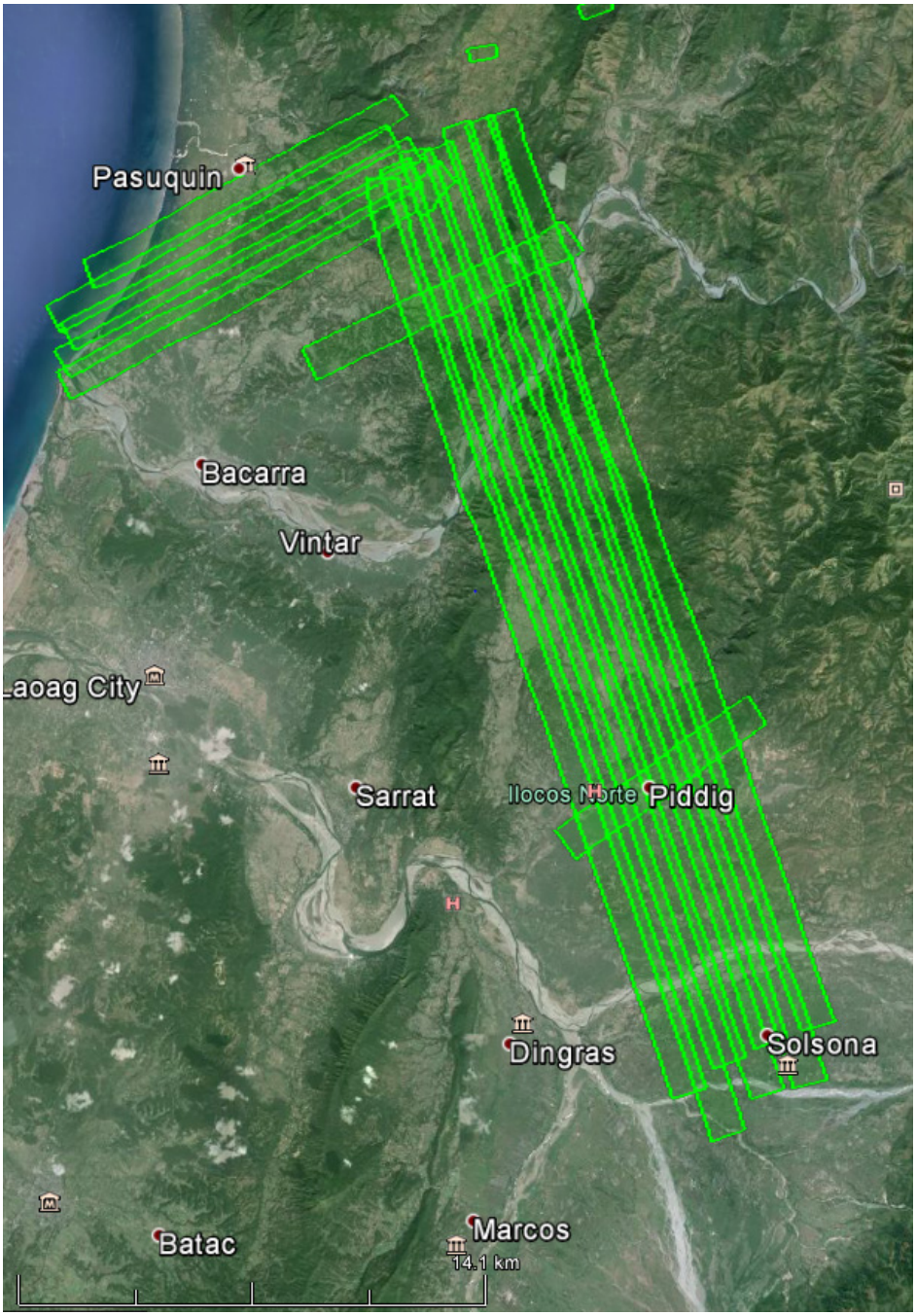


Figure A-7.6. Swath for Flight No. 7093G

Flight No. : 7094G

Area: BLOCK 5 & BLOCK 4

Mission Name: 2BLK05B057A & 2BLK05AS057A & 2BLK04F057A

Altitude: 1500m to 1200m to 1100m

PRF: 50 kHz

Lidar FOV: 20 deg

Overlap: 15% to 20% to 15%

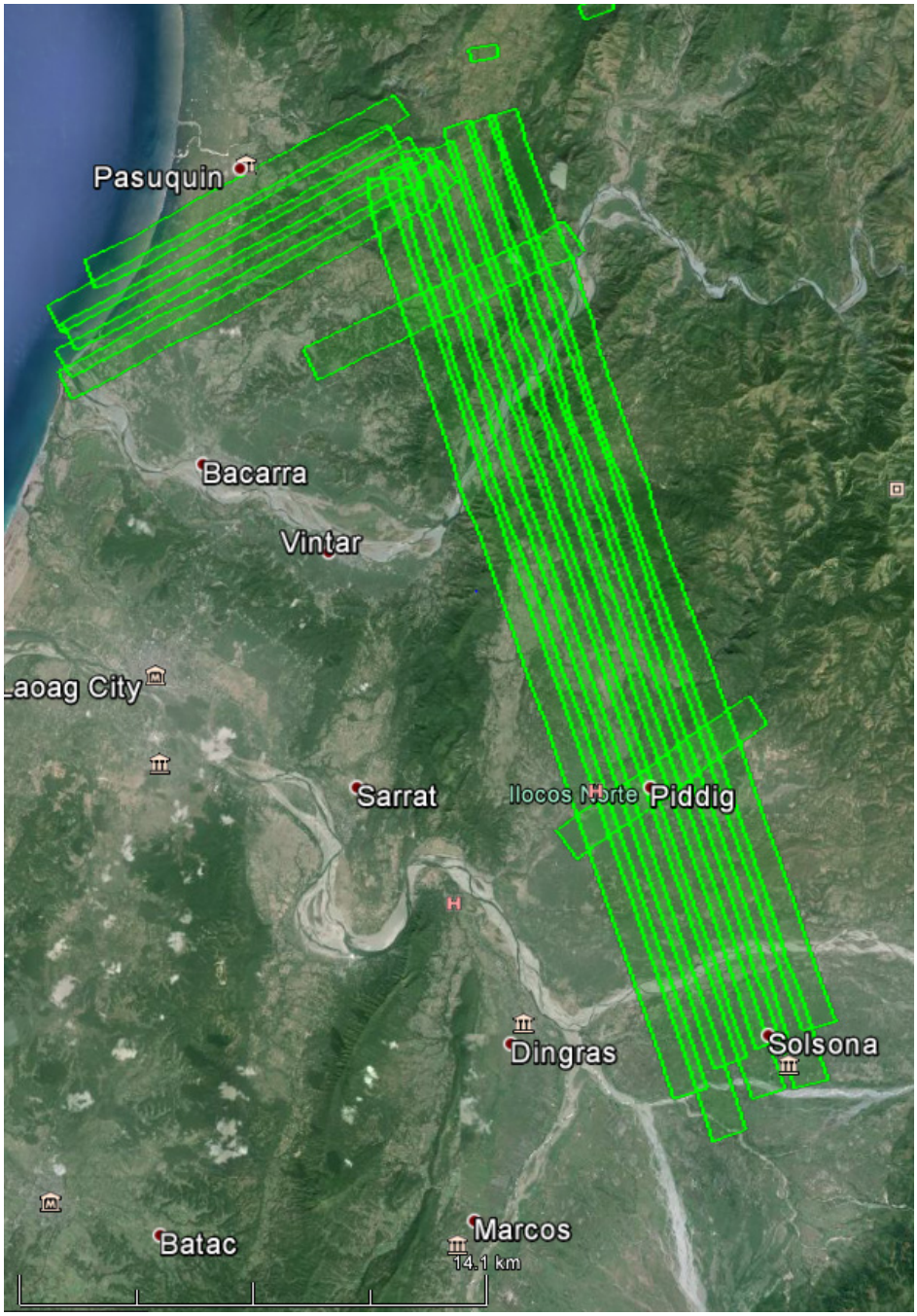


Figure A-7.7. Swath for Flight No. 7094G

Flight No. : 7095G

Area: BLOCK 4

Mission Name: 2BLK04C057B

Altitude: 1200m

PRF: 50 kHz

Lidar FOV: 15 deg

Overlap: 30%

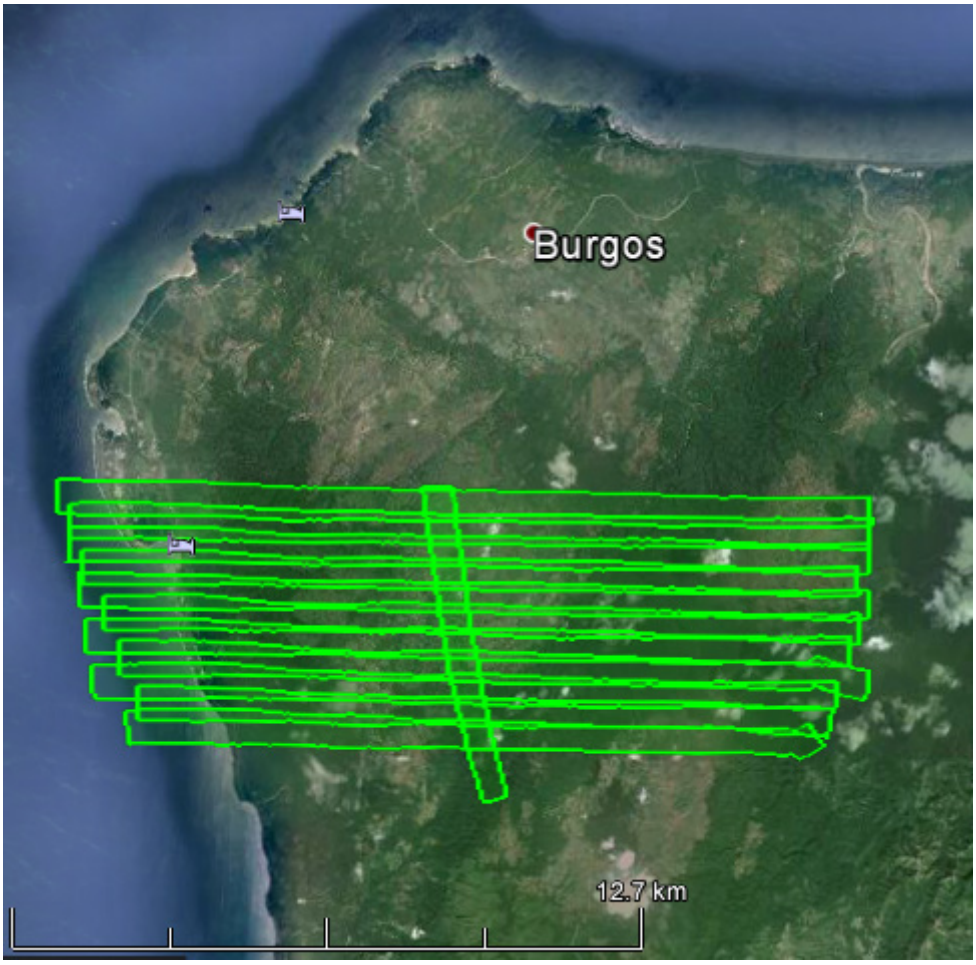


Figure A-7.8. Swath for Flight No. 7095G

Flight No. : 7097G

Area: BLOCK 4

Mission Name: 2BLK04A058B & 2BLK04B059B

Altitude: 1200m

PRF: 50 kHz

Lidar FOV: 15 deg

Overlap: 40%

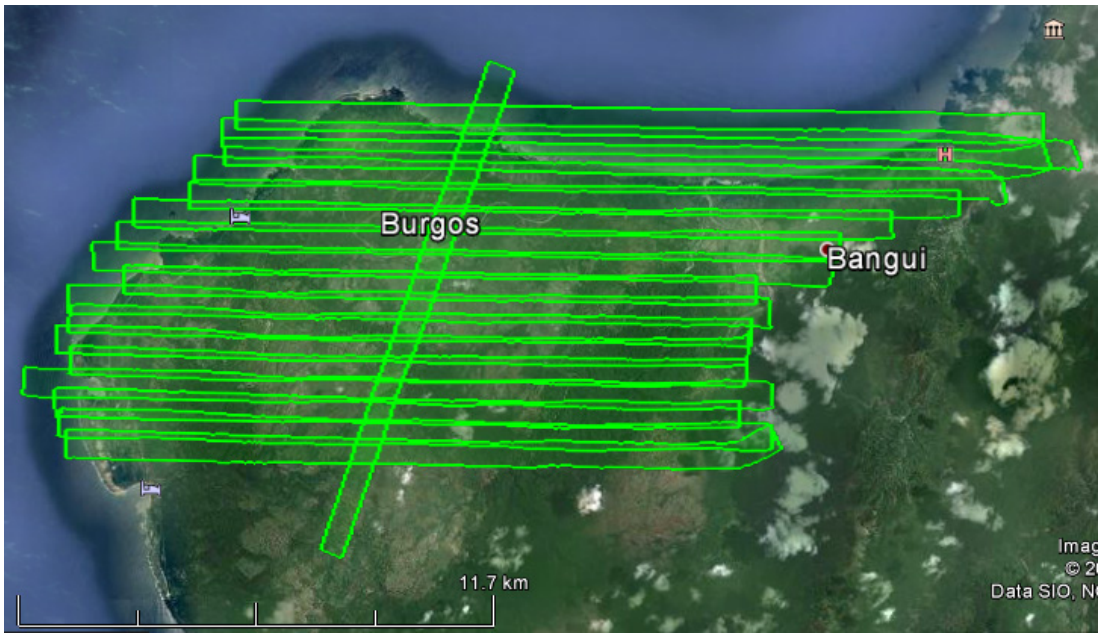


Figure A-7.9. Swath for Flight No. 7097G

Flight No. : 7102G

Area: BLOCK 4

Mission Name: 2BLK04E061A & 2BLK04D061A

Altitude: 1700m

PRF: 50 kHz

Lidar FOV: 15 deg

Overlap: 40%

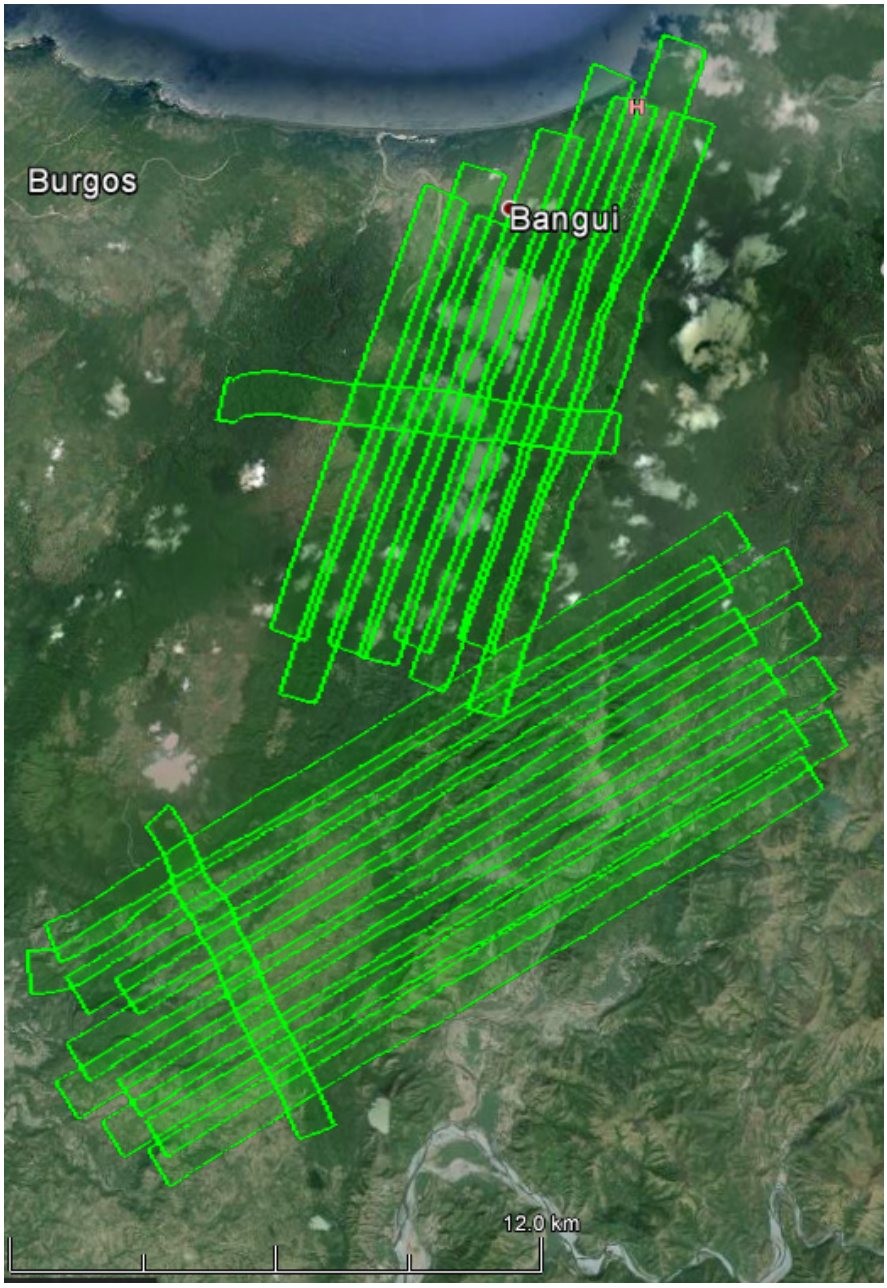


Figure A-7.10. Swath for Flight No. 7102G

Flight No. : 7103G

Area: BLOCK 5

Mission Name: 2CASITEST061B

Altitude: 1000m

PRF: 50 kHz

Lidar FOV: 20 deg

Overlap: 30%

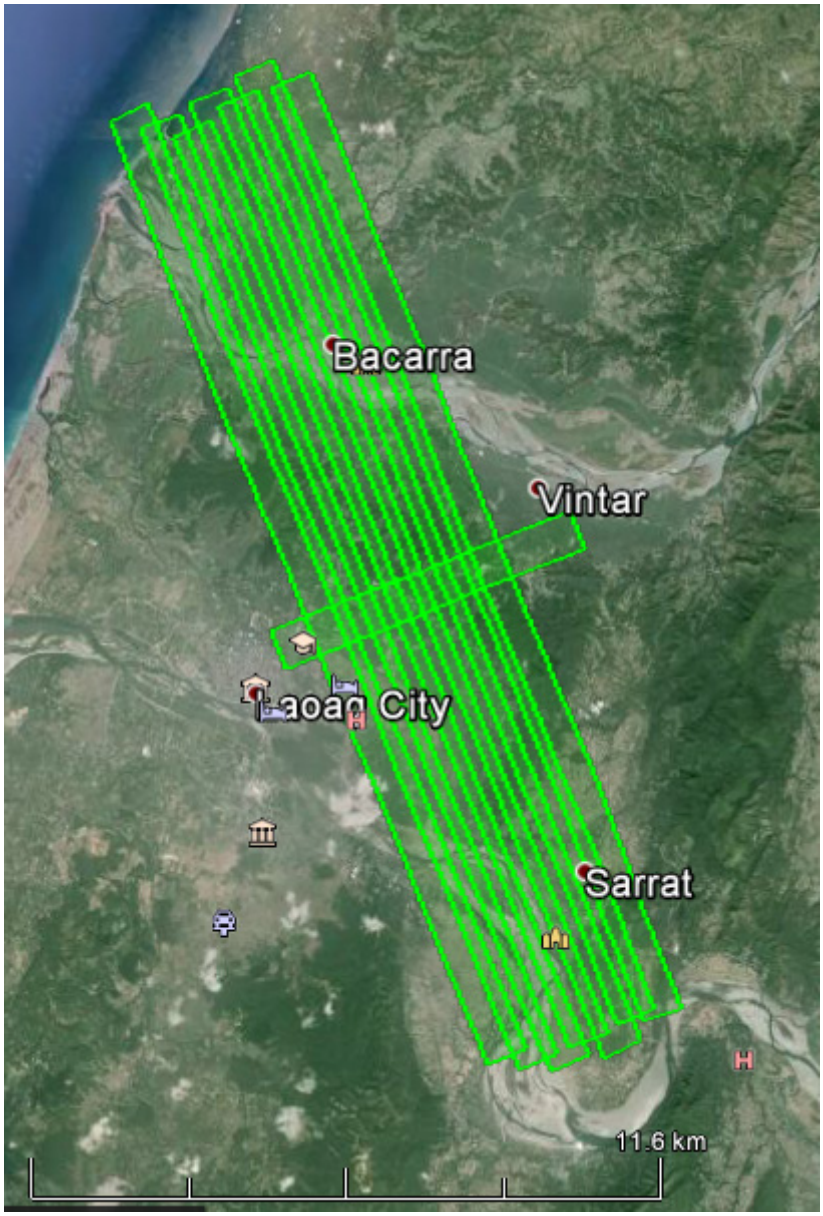


Figure A-7.11. Swath for Flight No. 7103G

Annex 8. Mission Summary Reports

Table A-8.1. Mission Summary Report for Mission Blk4AB

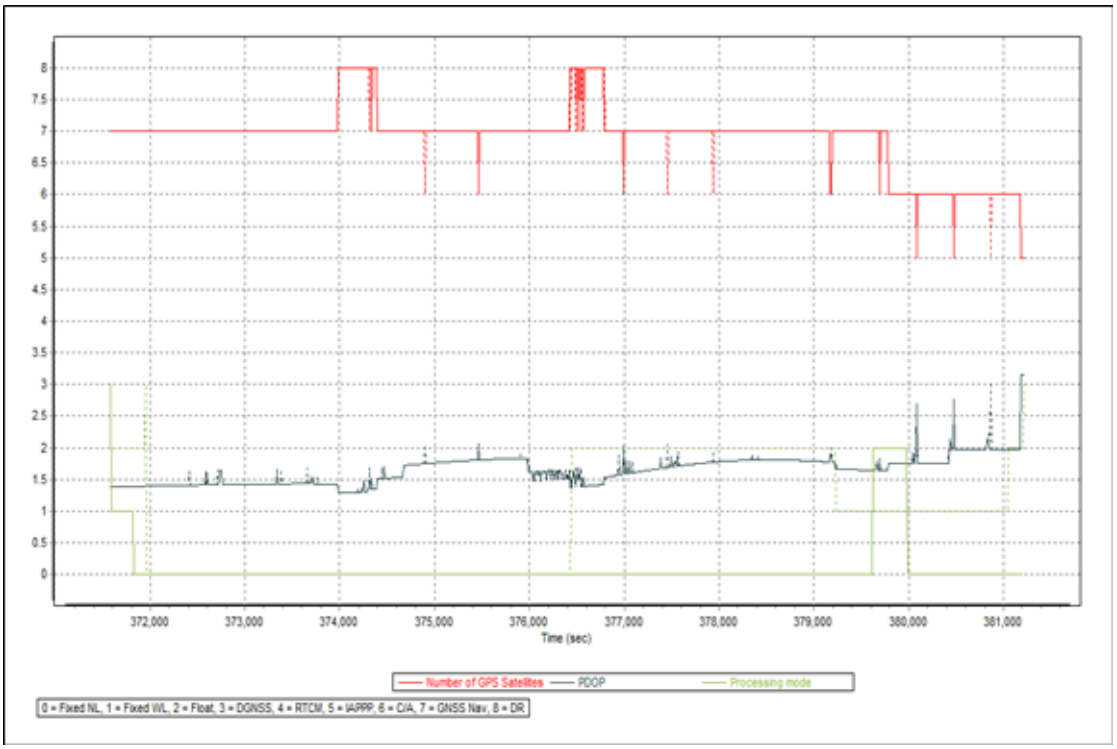


Figure A-8.1 Solution Status

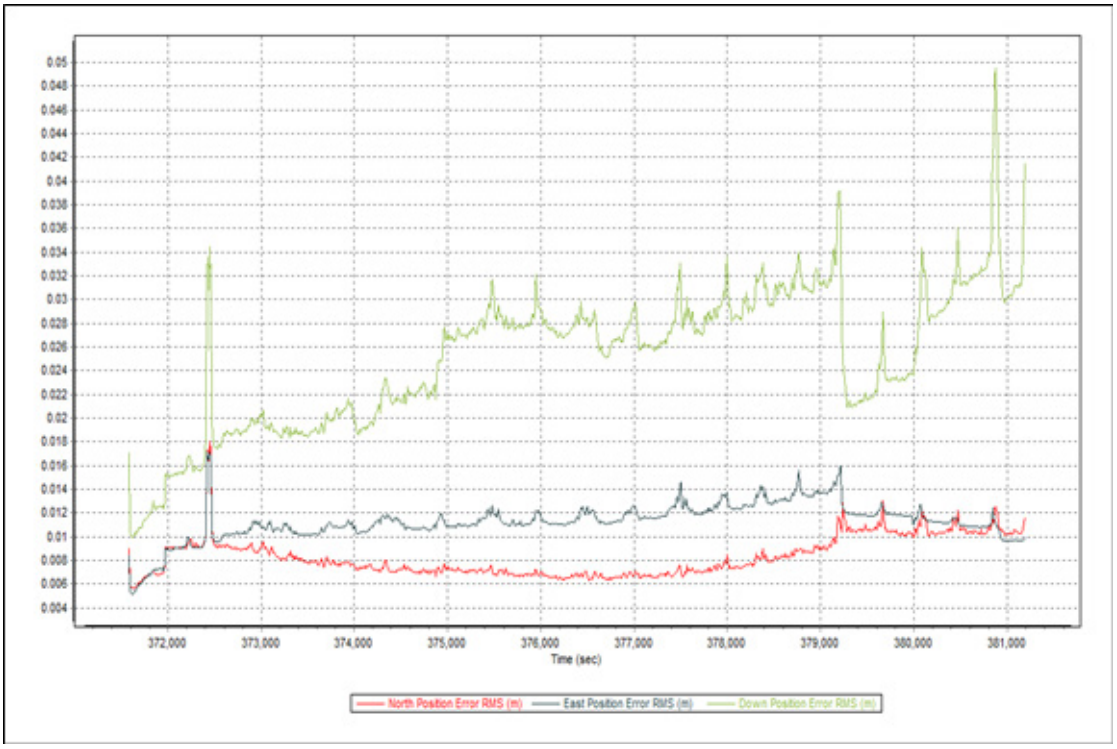


Figure A-8.2 Smoothed Performance Metric Parameters

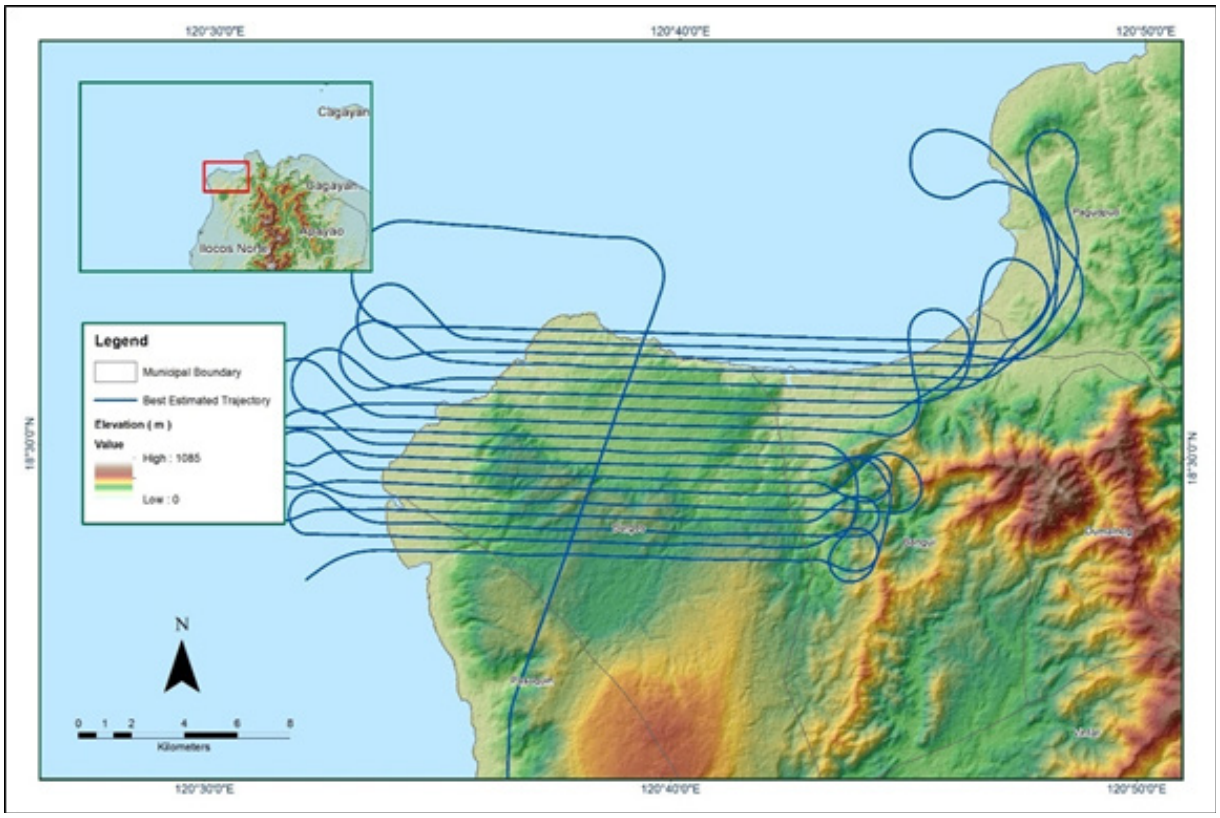


Figure A-8.3 Best Estimated Trajectory

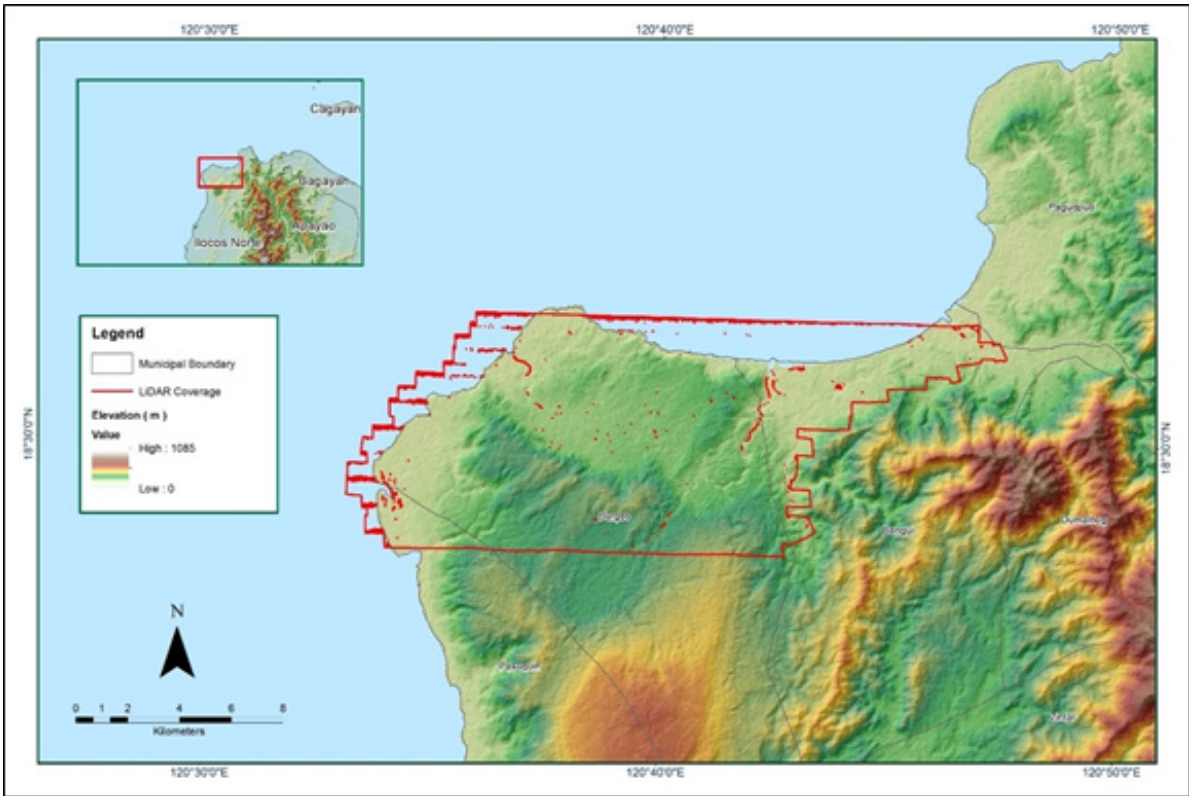


Figure A-8.4 Coverage of LiDAR data

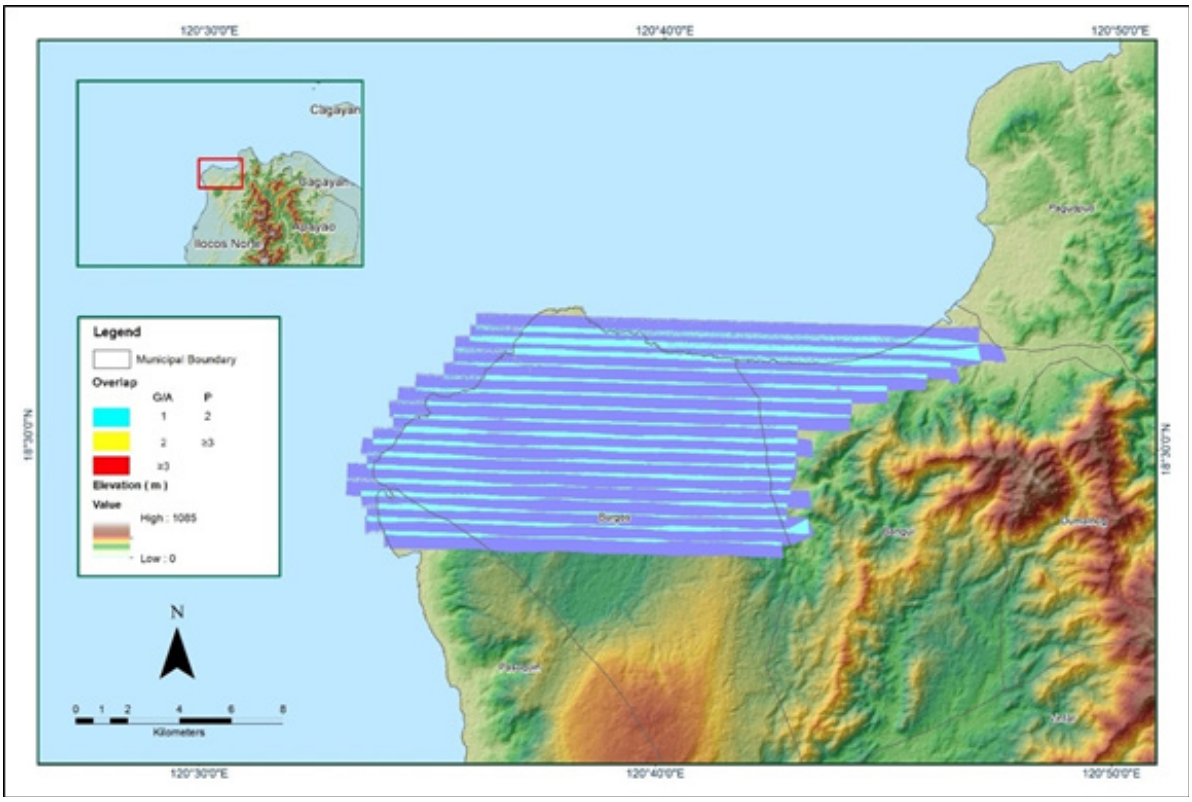


Figure A-8.5 Image of data overlap

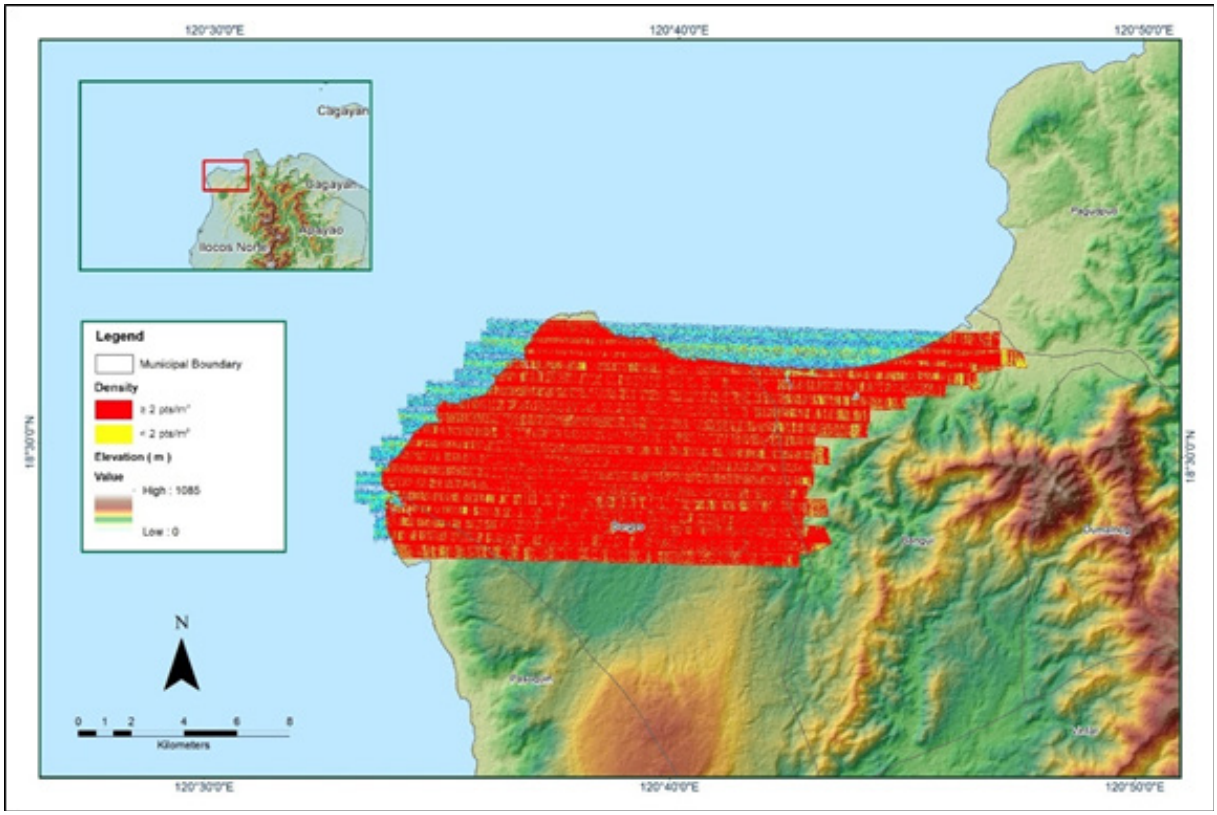


Figure A-8.6 Density map of merged LiDAR data

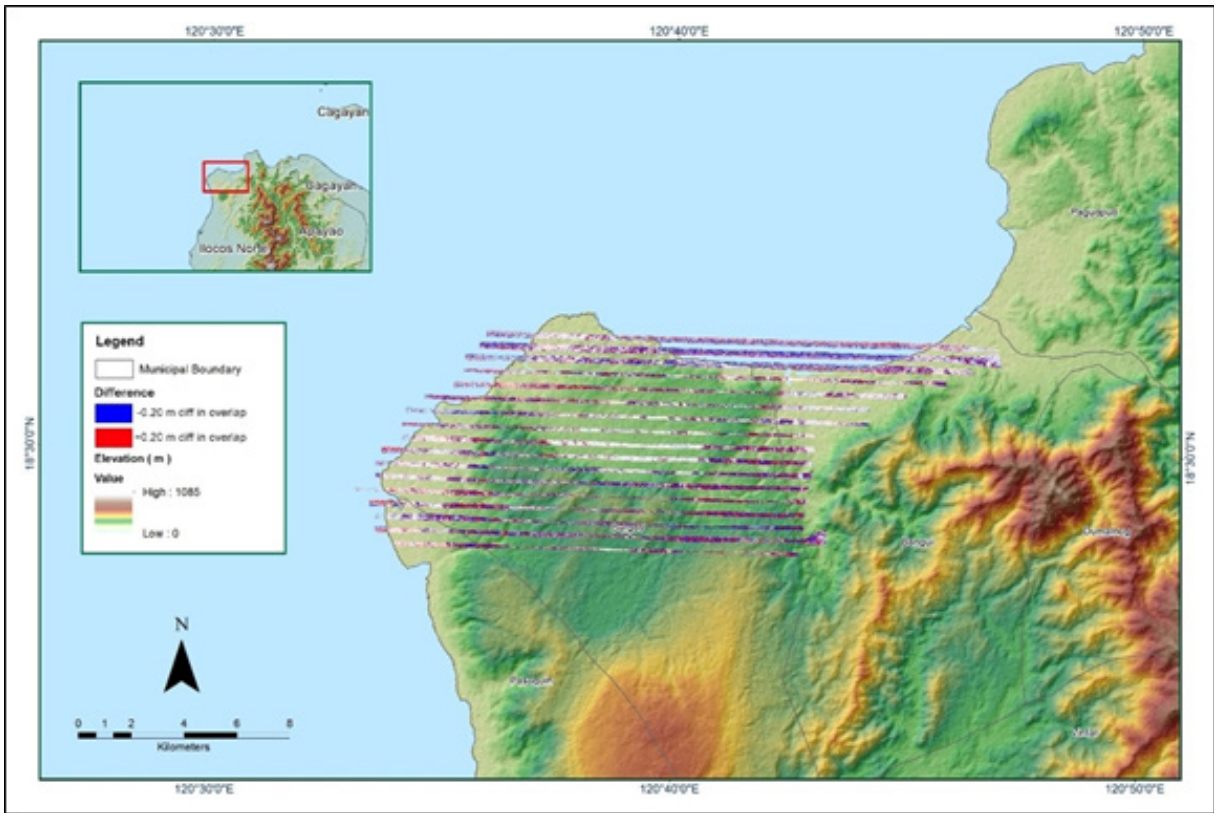


Figure A-8.7 Elevation difference between flight lines

Table A-8.2. Mission Summary Report for Mission Blk4C

Flight Area	**Ilocos**
Mission Name	Blk4C
Inclusive Flights	7095G
Range data size	7.76 GB
Base data size	11.5 MB
POS	143 MB
Image	N/A
Transfer date	July 28, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.5
RMSE for East Position (<4.0 cm)	1.2
RMSE for Down Position (<8.0 cm)	4.2
Boresight correction stdev (<0.001deg)	0.000261
IMU attitude correction stdev (<0.001deg)	0.000865
GPS position stdev (<0.01m)	0.0111
Minimum % overlap (>25)	24.64
Ave point cloud density per sq.m. (>2.0)	2.63
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	106
Maximum Height	487.85 m
Minimum Height	39.19 m
Classification (# of points)	
Ground	24,508,502
Low vegetation	14,017,716
Medium vegetation	25,357,669
High vegetation	106,079,278

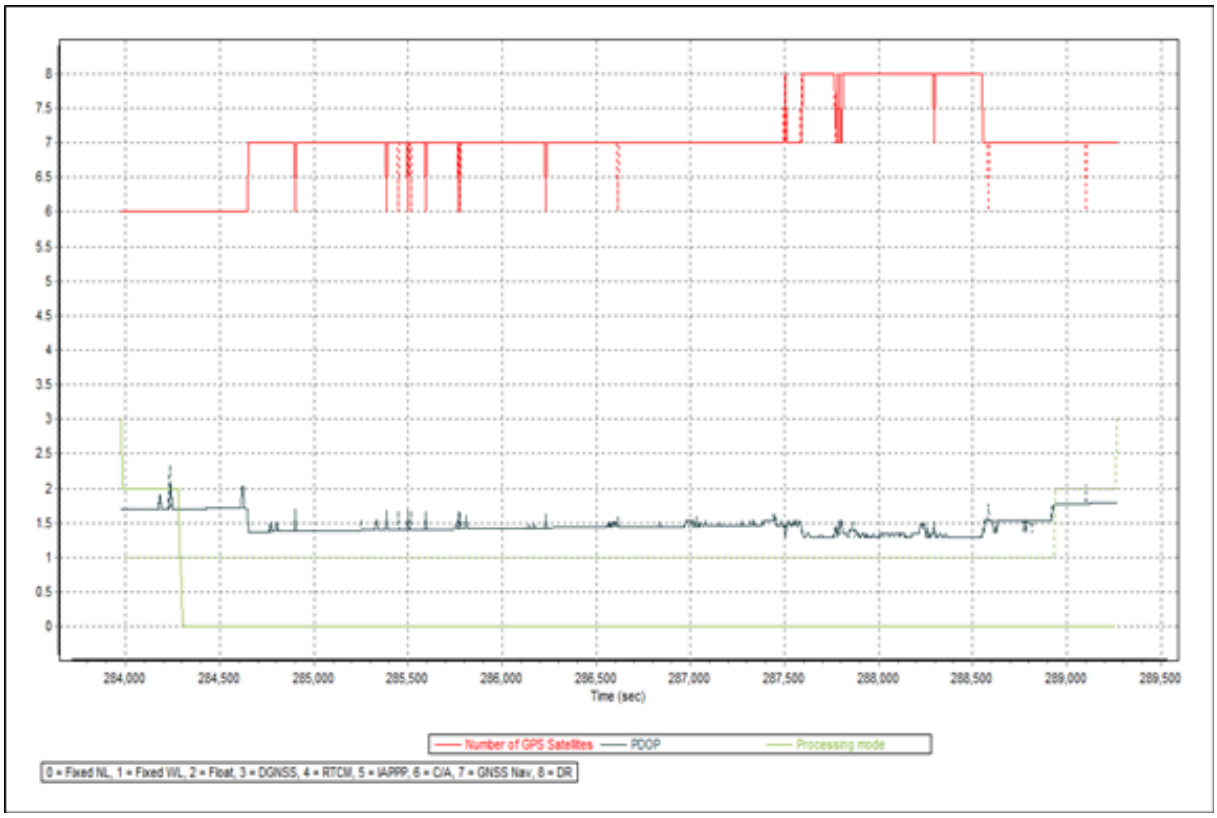


Figure A-8.8 Solution Status

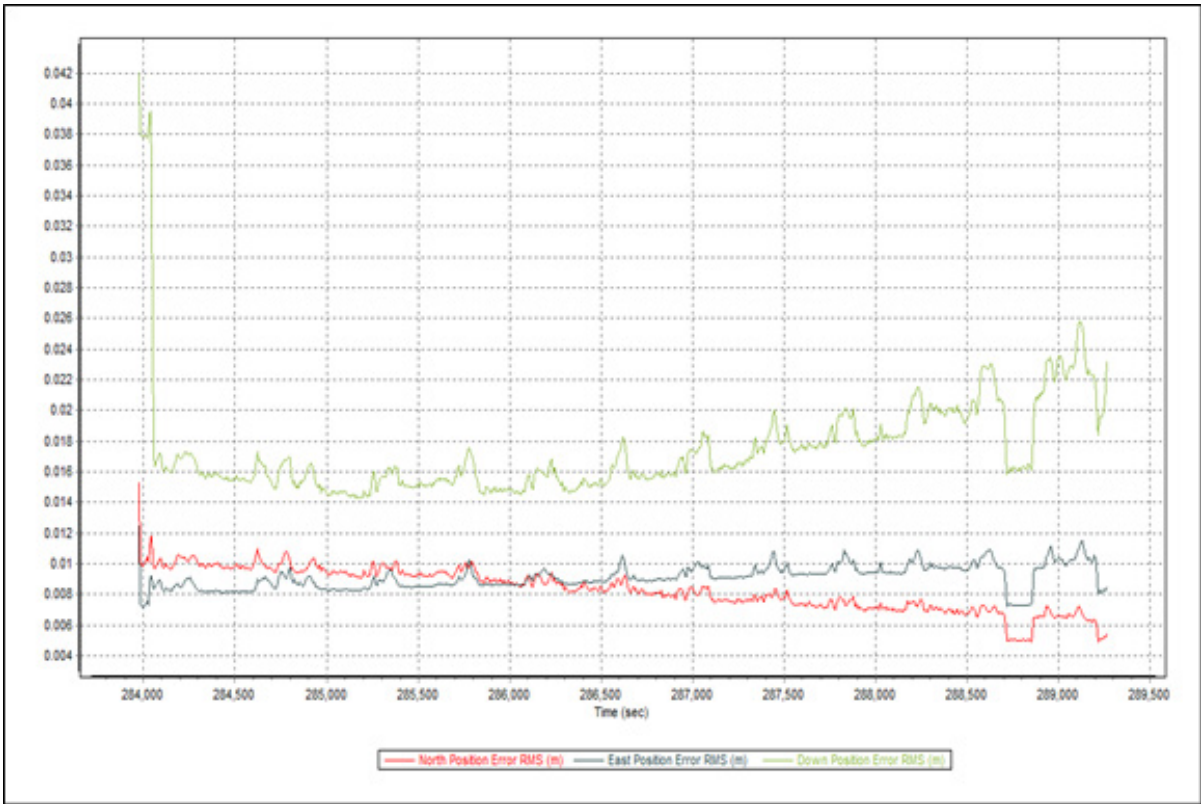


Figure A-8.9 Smoothed Performance Metric Parameters

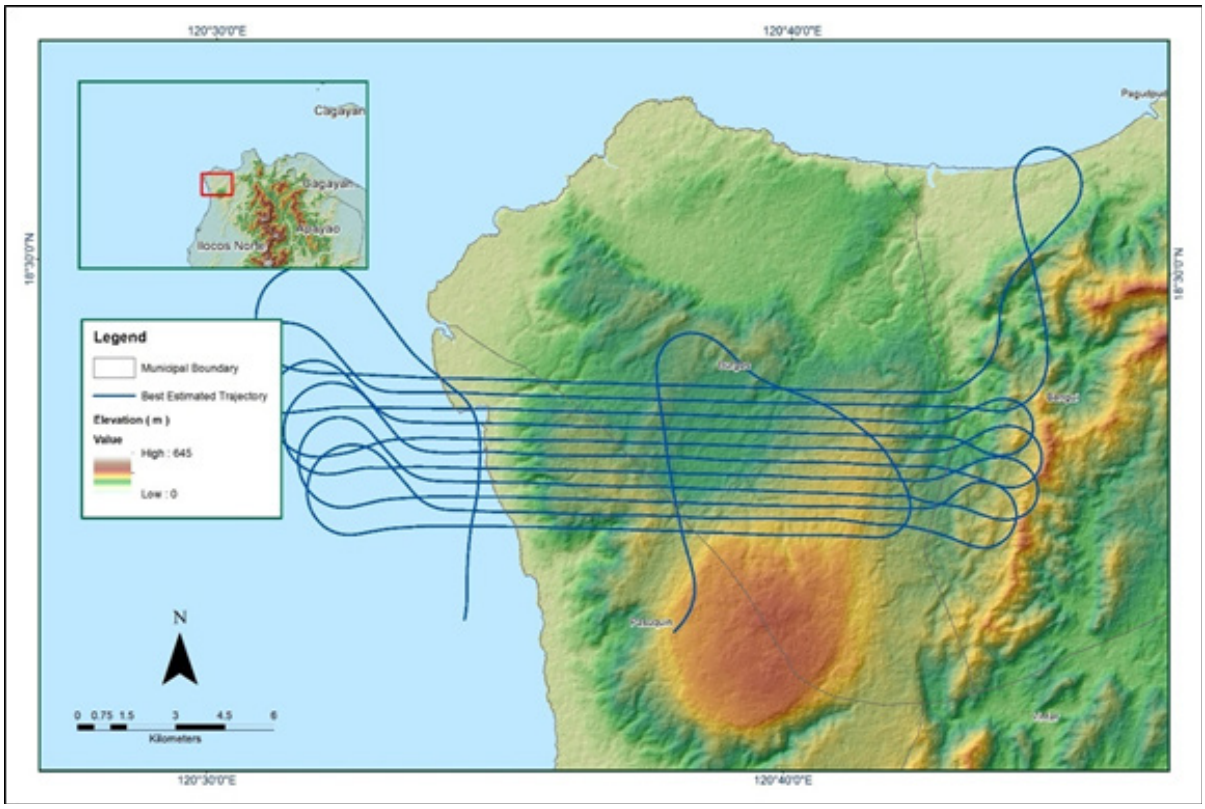


Figure A-8.10 Best Estimated Trajectory

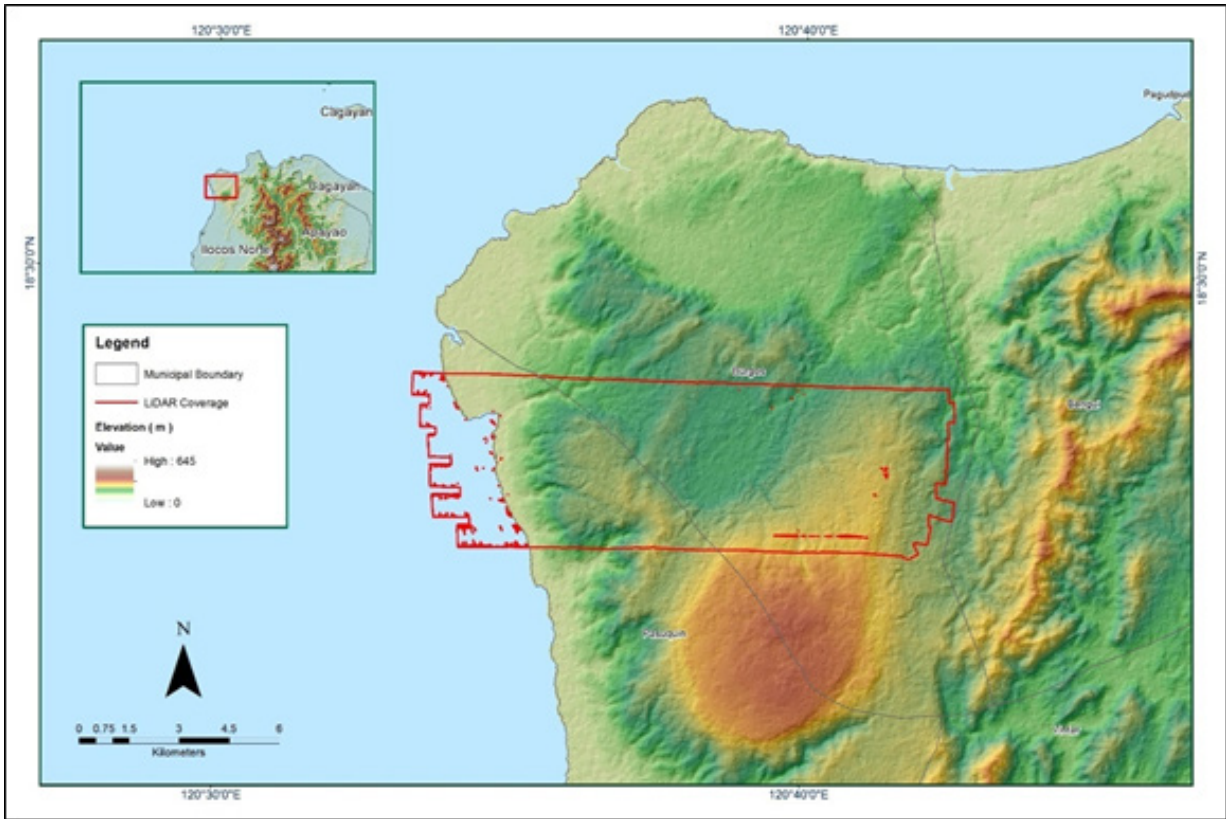


Figure A-8.11 Coverage of LiDAR data

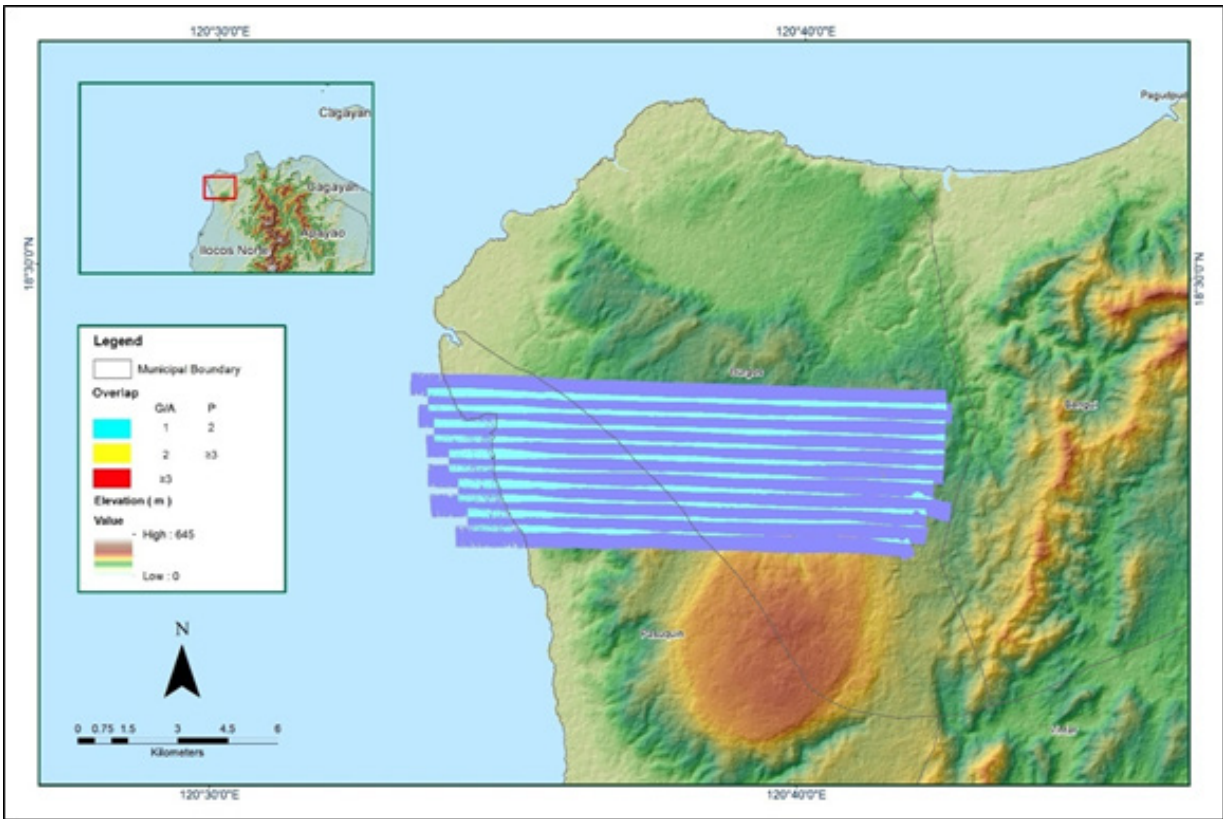


Figure A-8.12 Image of data overlap

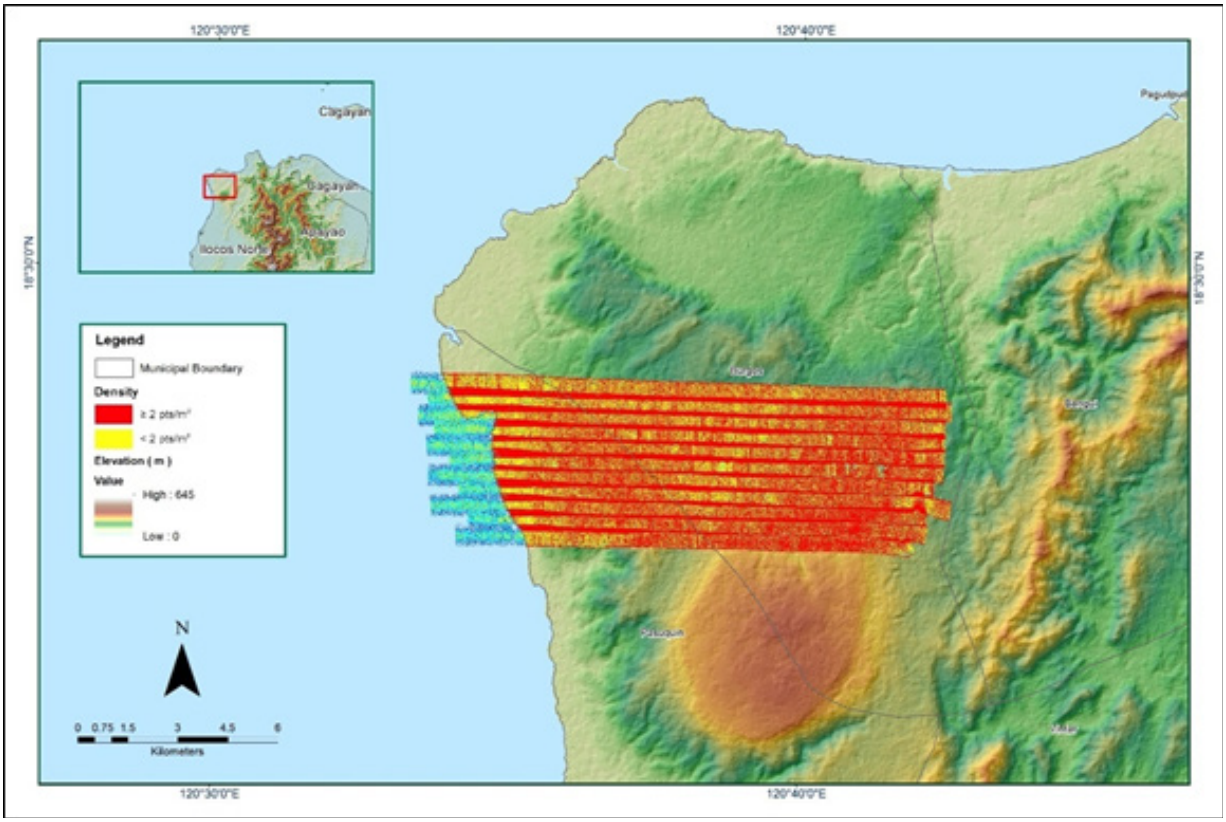


Figure A-8.13 Density map of merged LiDAR data

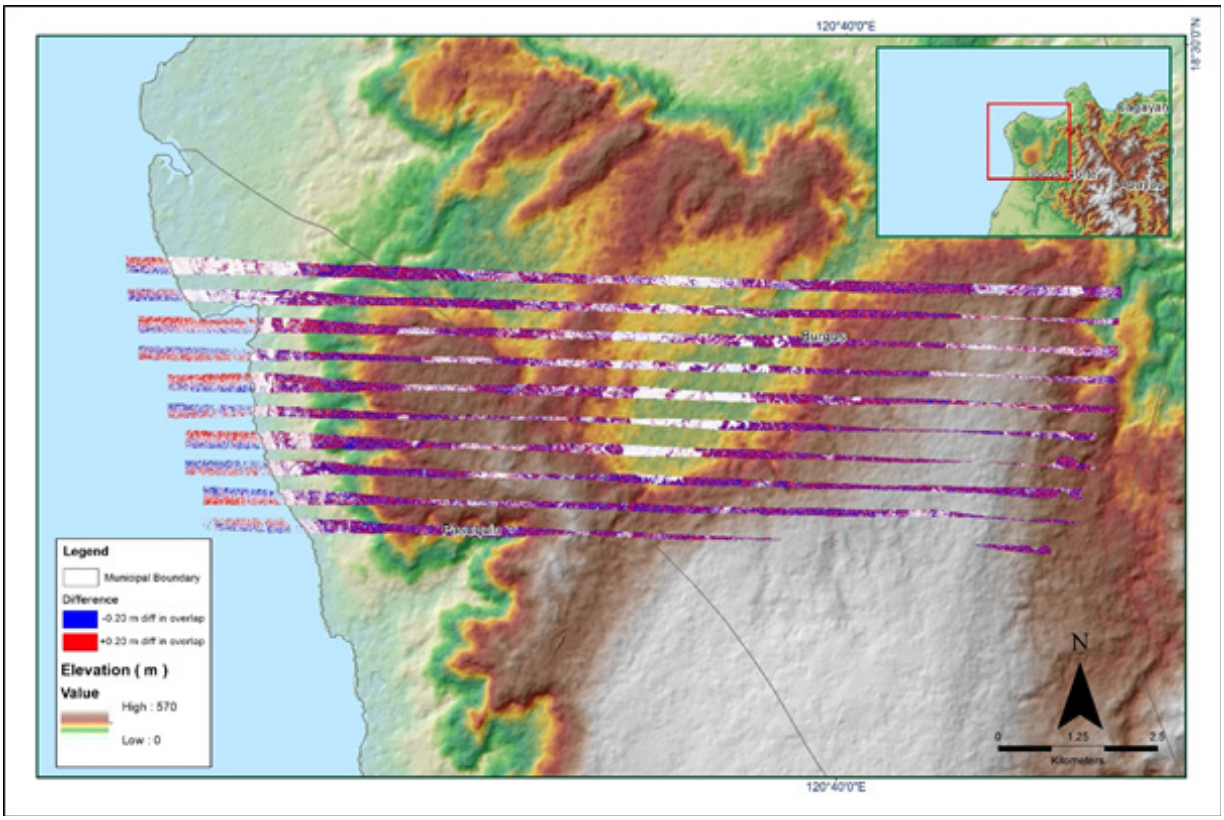


Figure A-8.14 Elevation difference between flight lines

Table A-8.3. Mission Summary Report for Mission Blk4DE

Flight Area	**Ilocos**
Mission Name	Blk4DE
Inclusive Flights	7102G
Range data size	12.8 GB
Base data size	7.72 MB
POS	210 MB
Image	N/A
Transfer date	March 19, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	No
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.5
RMSE for East Position (<4.0 cm)	1.2
RMSE for Down Position (<8.0 cm)	4.2
Boresight correction stdev (<0.001deg)	0.000177
IMU attitude correction stdev (<0.001deg)	0.000278
GPS position stdev (<0.01m)	0.0024
Minimum % overlap (>25)	32.75%
Ave point cloud density per sq.m. (>2.0)	2.00
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	248
Maximum Height	615.81 m
Minimum Height	39.31 m
Classification (# of points)	
Ground	66,181,369
Low vegetation	30,838,792
Medium vegetation	57,075,976

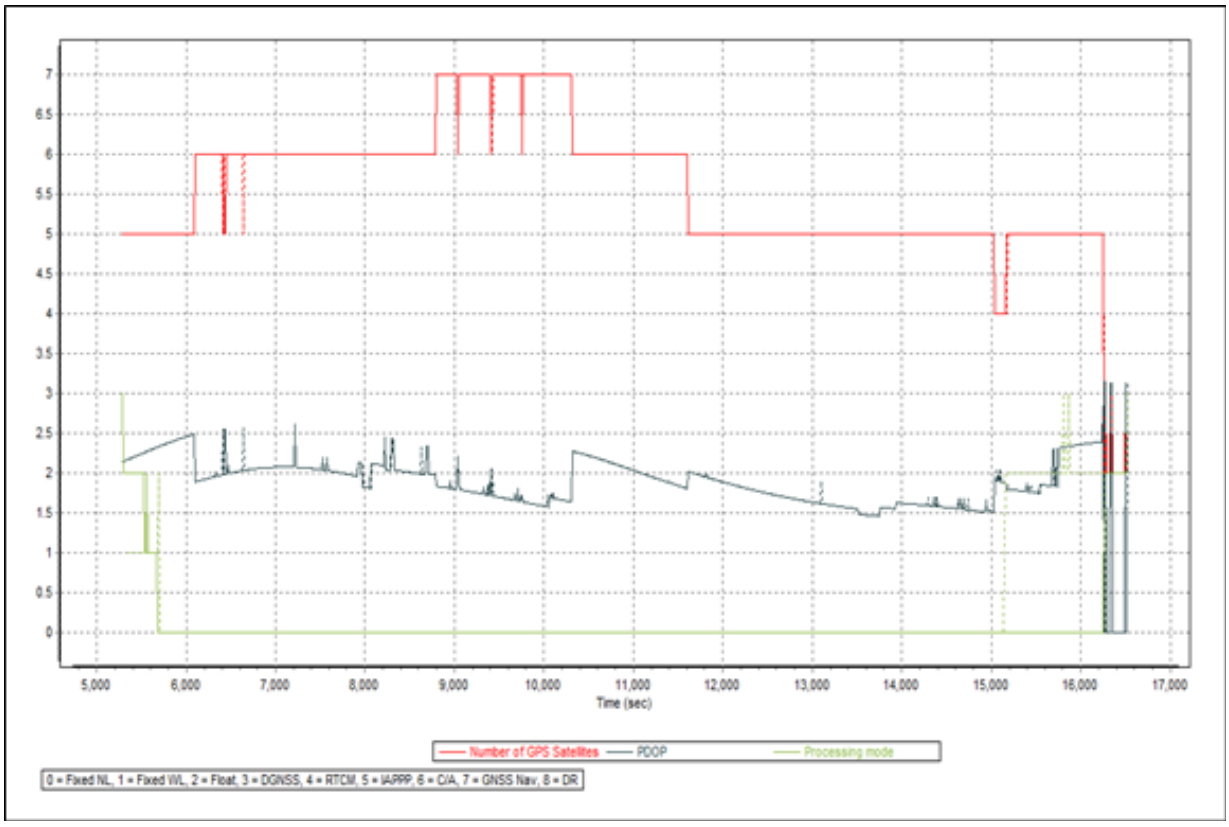


Figure A-8.15 Solution Status

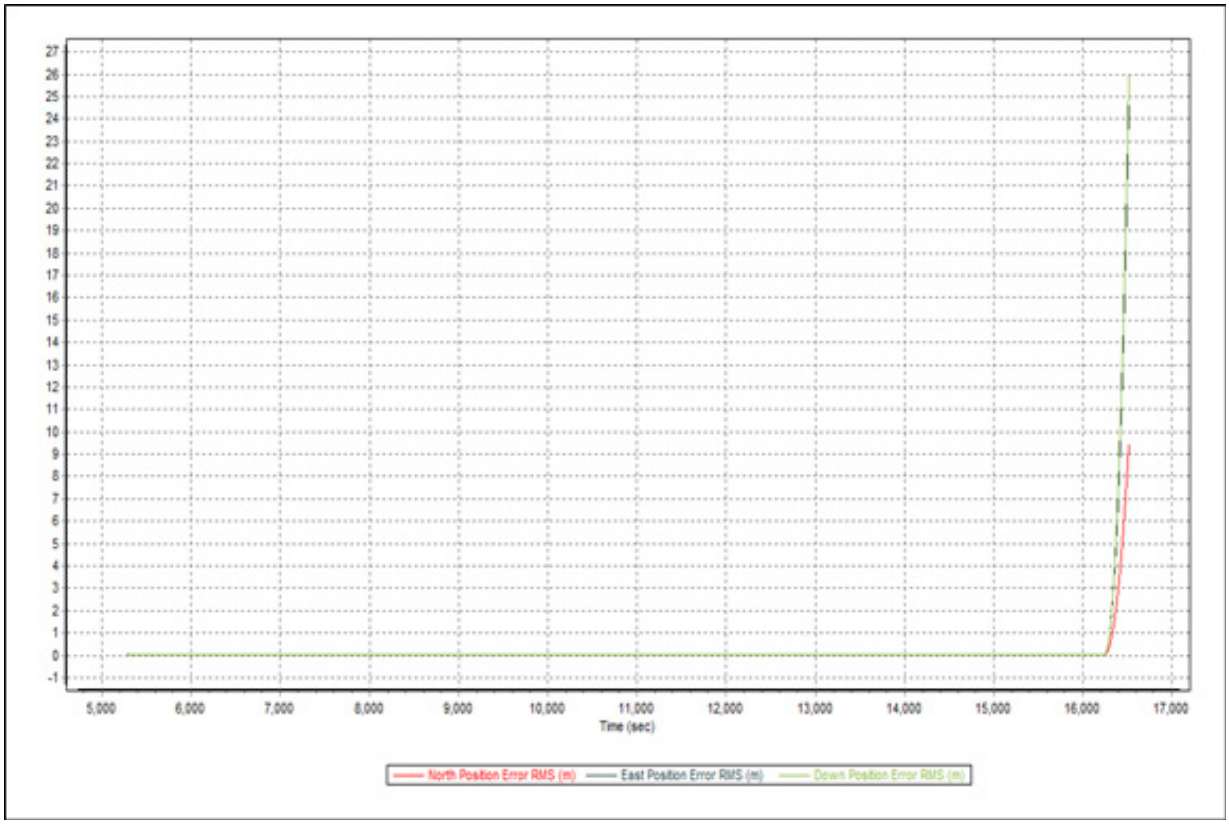


Figure A-8.16 Smoothed Performance Metric Parameters

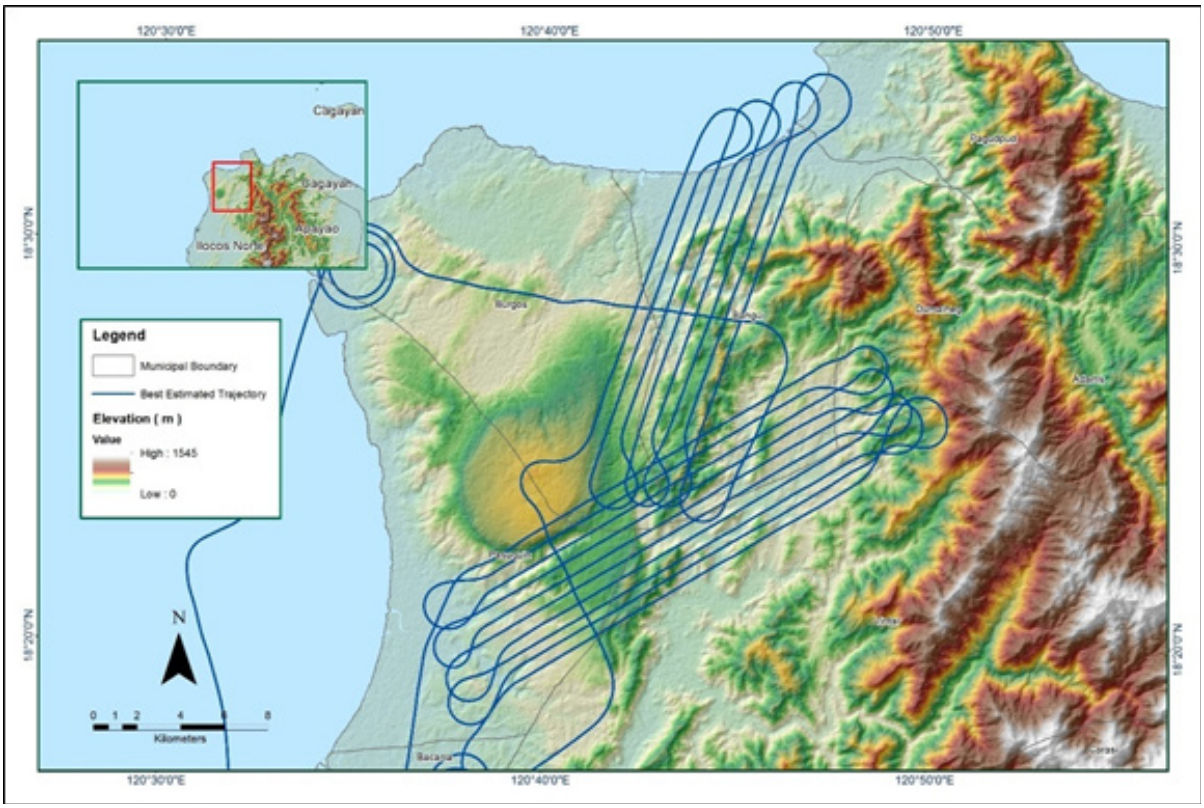


Figure A-8.17 Best Estimated Trajectory

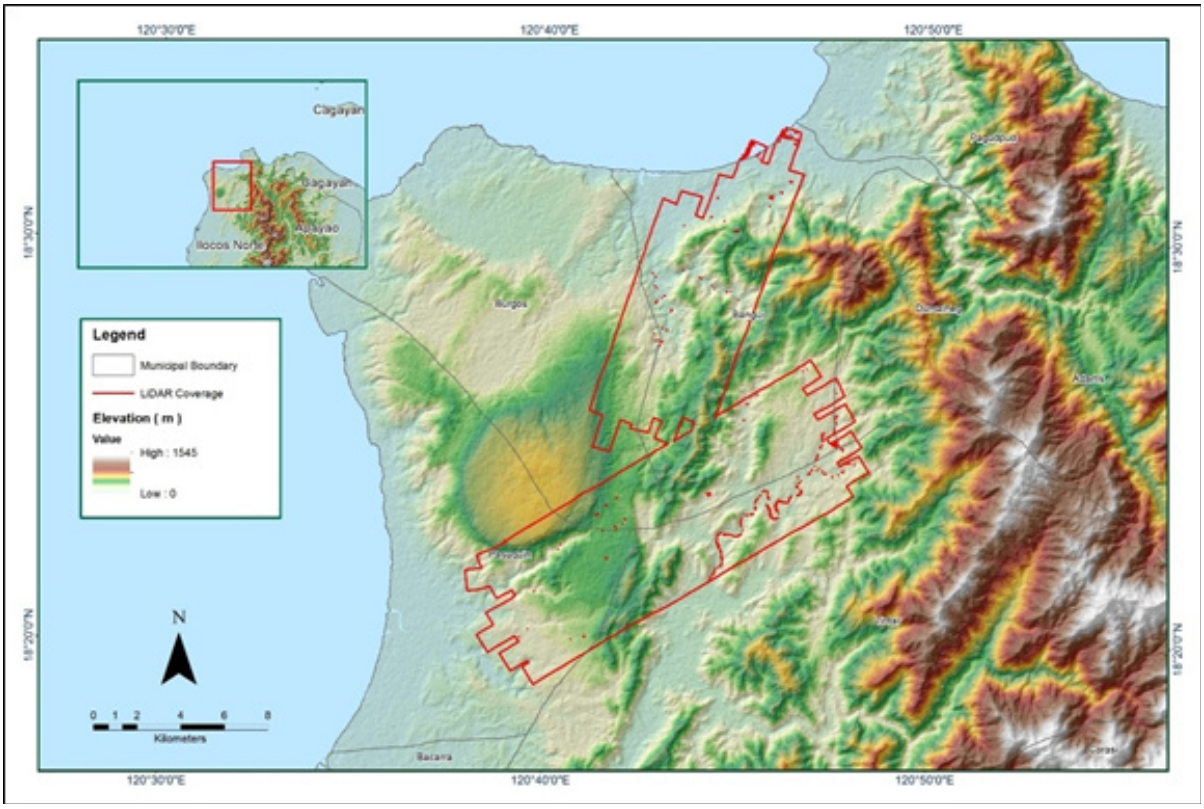


Figure A-8.18 Coverage of LiDAR data

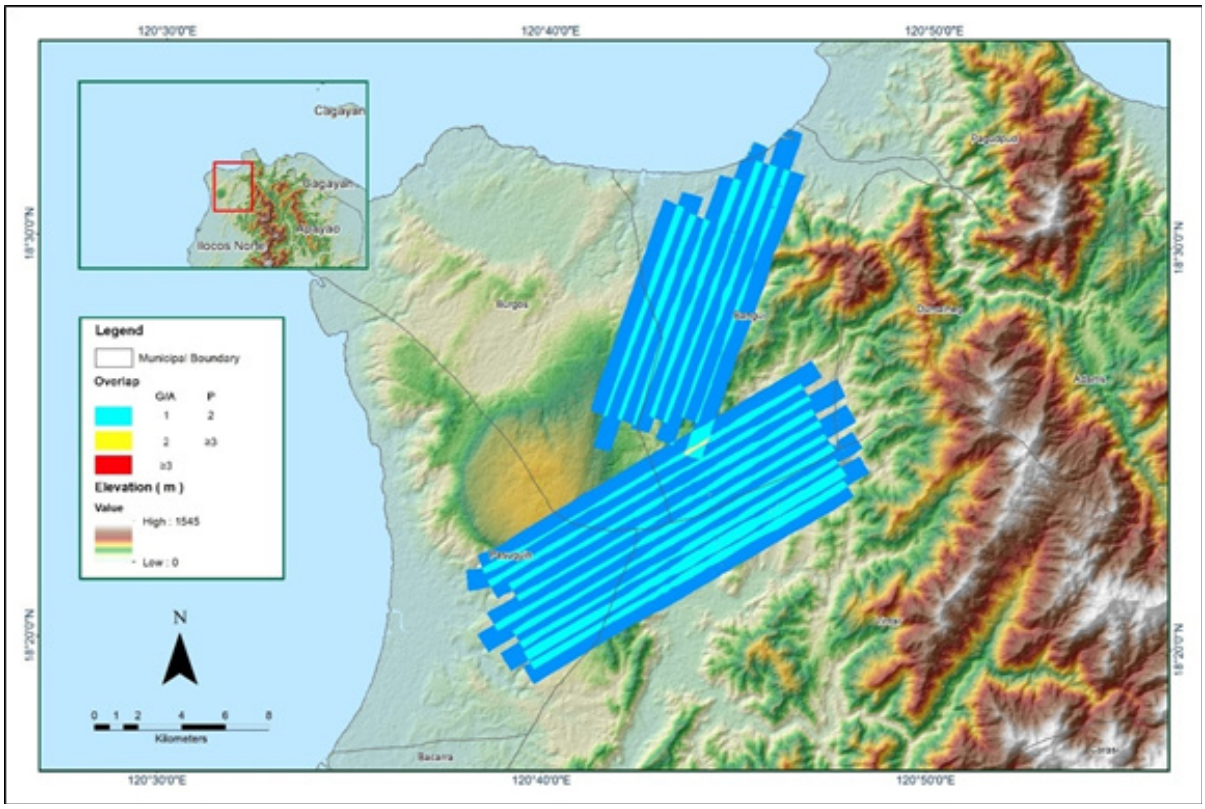


Figure A-8.19 Image of data overlap

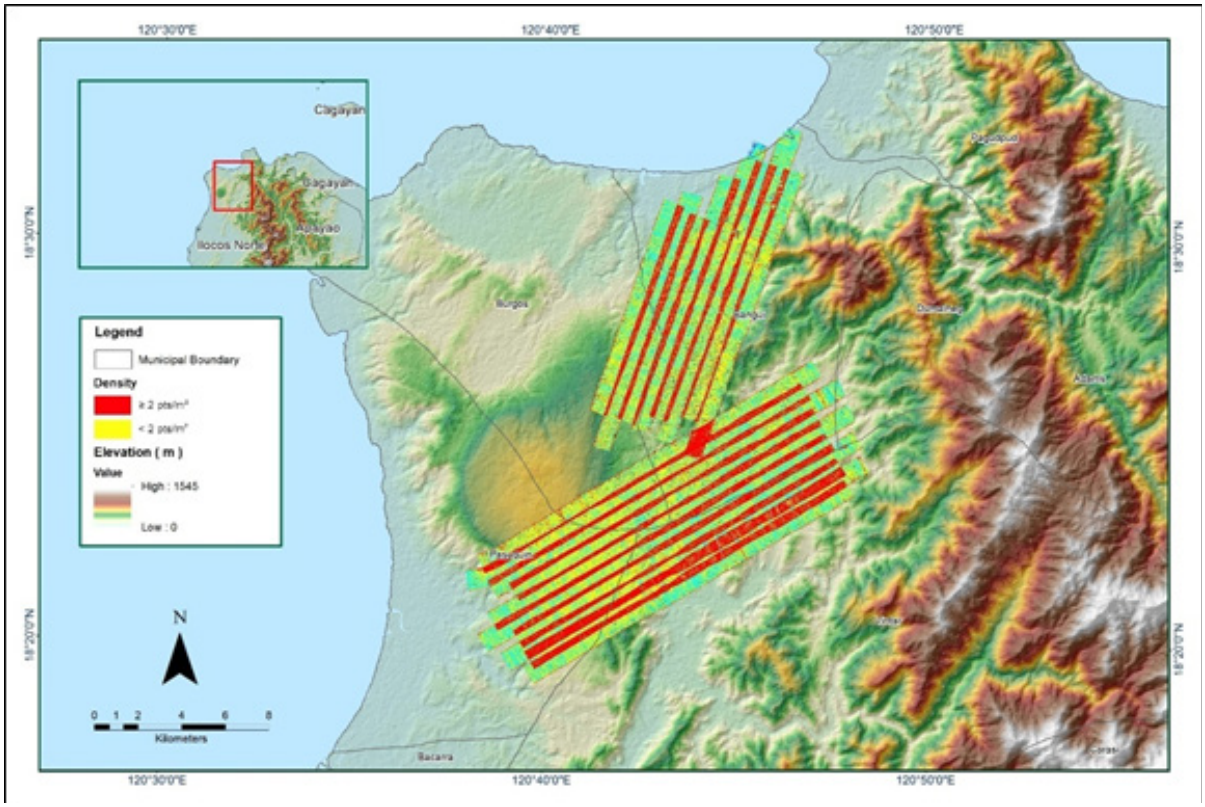


Figure A-8.20 Density map of merged LiDAR data

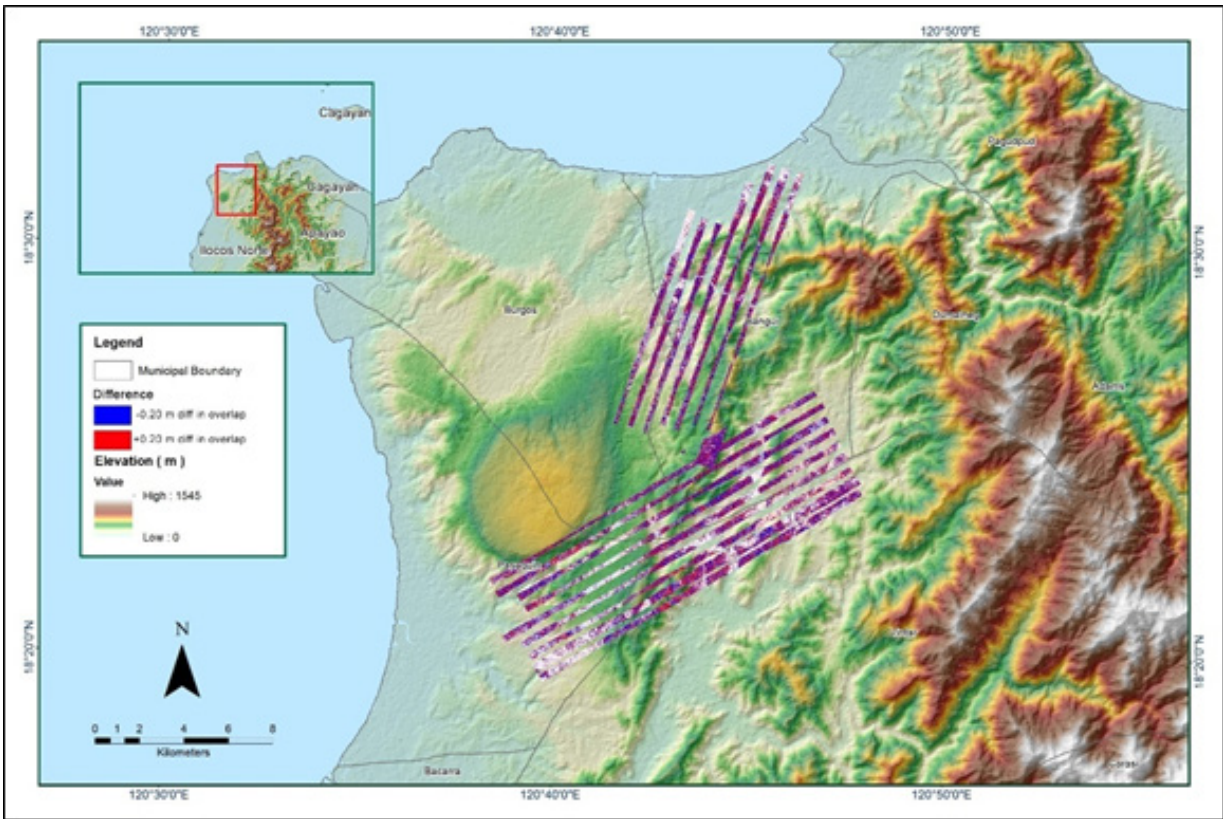


Figure A-8.21 Elevation difference between flight lines

Table A-8.4. Mission Summary Report for Mission Blk4F

Flight Area	**Ilocos**
Mission Name	Blk4F
Inclusive Flights	7094G
Range data size	15.1 GB
Base data size	11.4 MB
POS	231 MB
Image	N/A
Transfer date	July 28, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	5.4
RMSE for East Position (<4.0 cm)	2.0
RMSE for Down Position (<8.0 cm)	9.4
Boresight correction stdev (<0.001deg)	0.000309
IMU attitude correction stdev (<0.001deg)	0.000682
GPS position stdev (<0.01m)	0.0029
Minimum % overlap (>25)	23.14%
Ave point cloud density per sq.m. (>2.0)	2.37
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	65
Maximum Height	363.27 m
Minimum Height	39.11 m
Classification (# of points)	
Ground	16,593,168
Low vegetation	11,356,639
Medium vegetation	12,478,283
High vegetation	4,2150,256
Building	704,787
Orthophoto	No
Processed by	Engr. Angelo Carlo Bongat, Engr. Melanie Hingpit, Marie Joyce Ilagan

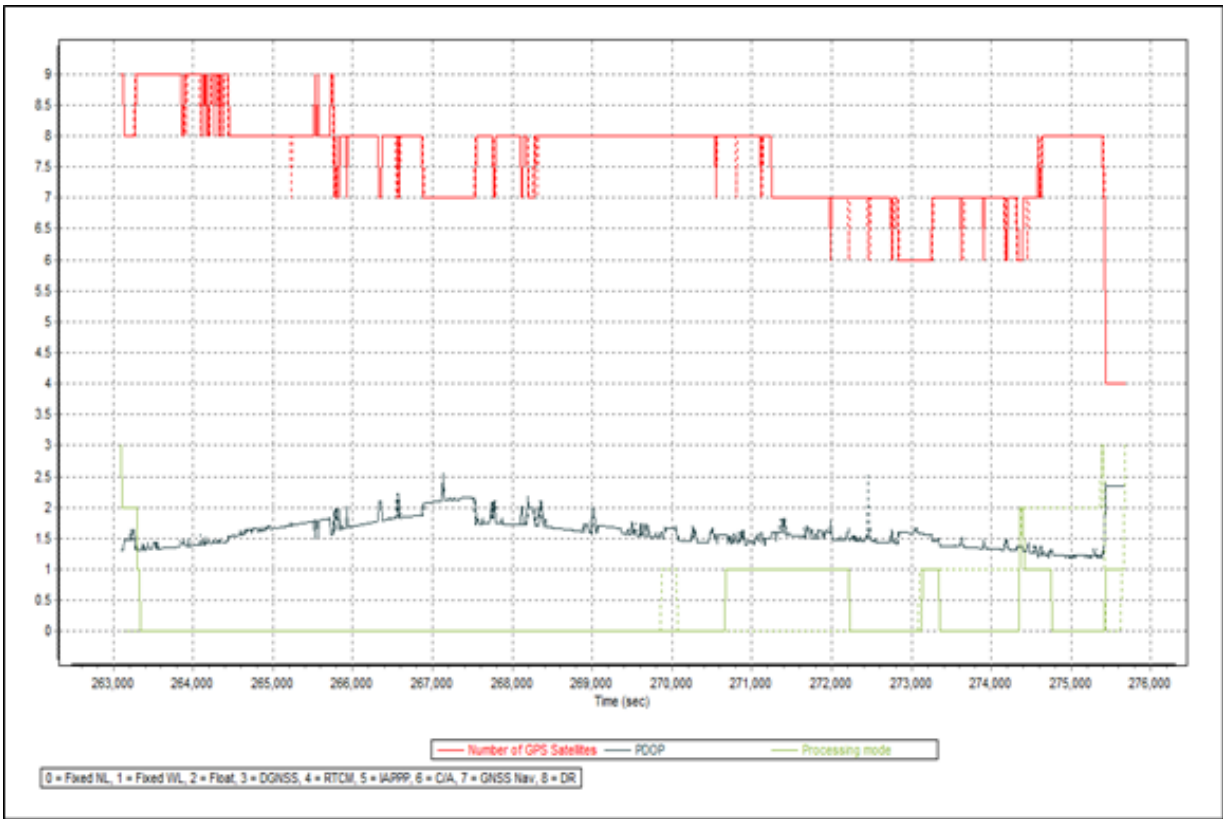


Figure A-8.22 Solution Status

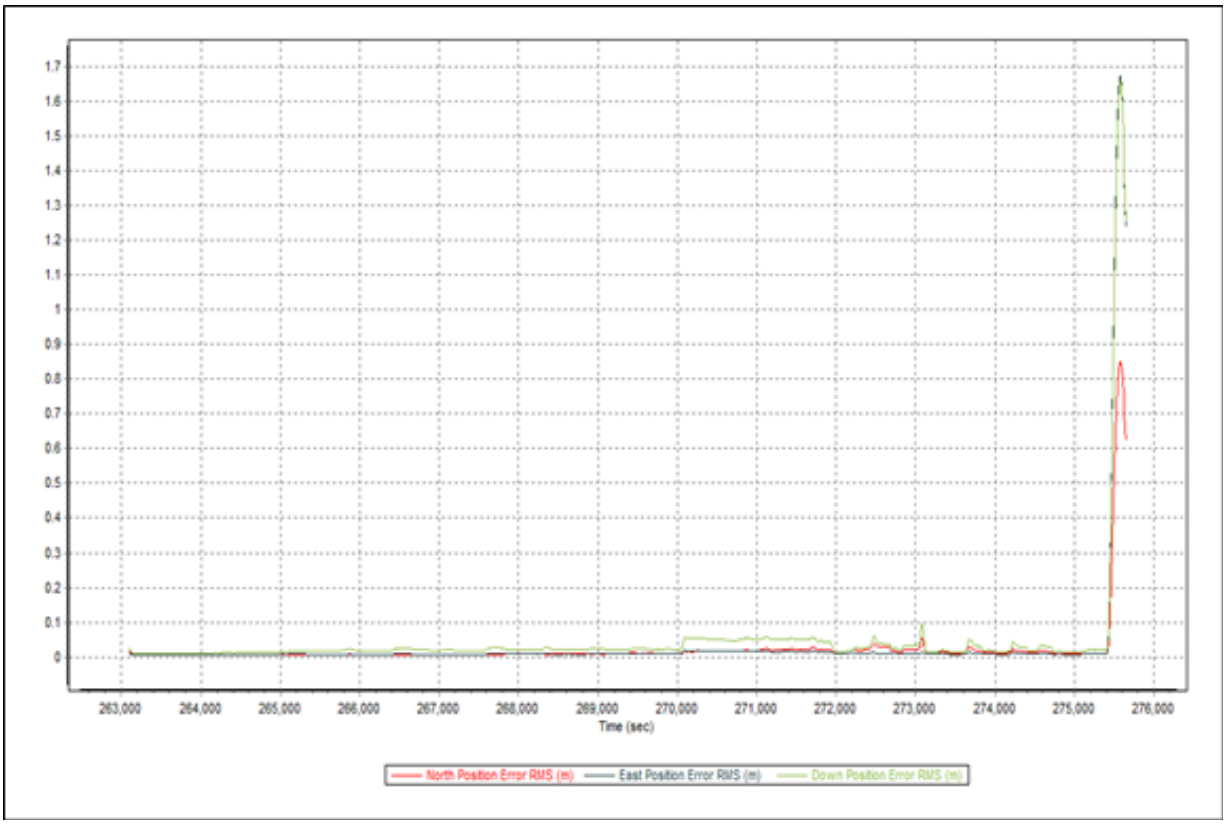


Figure A-8.23 Smoothed Performance Metric Parameters

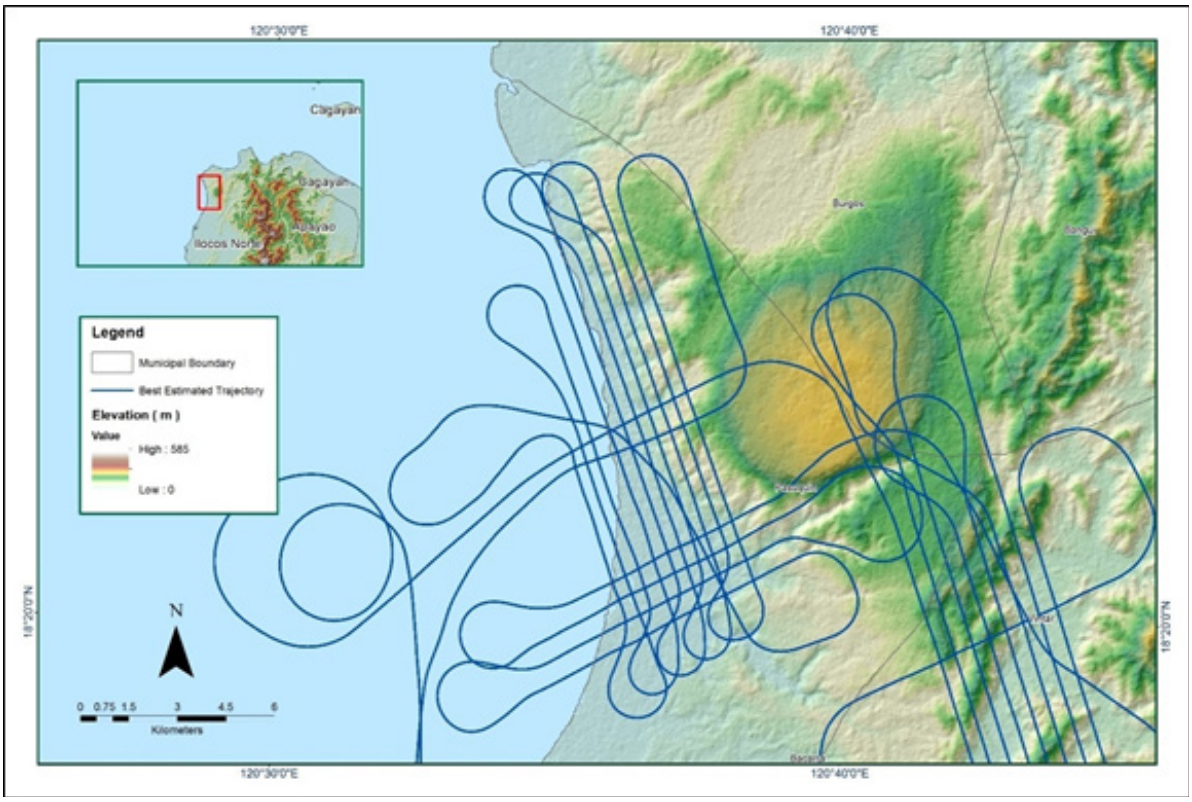


Figure A-8.24 Best Estimated Trajectory

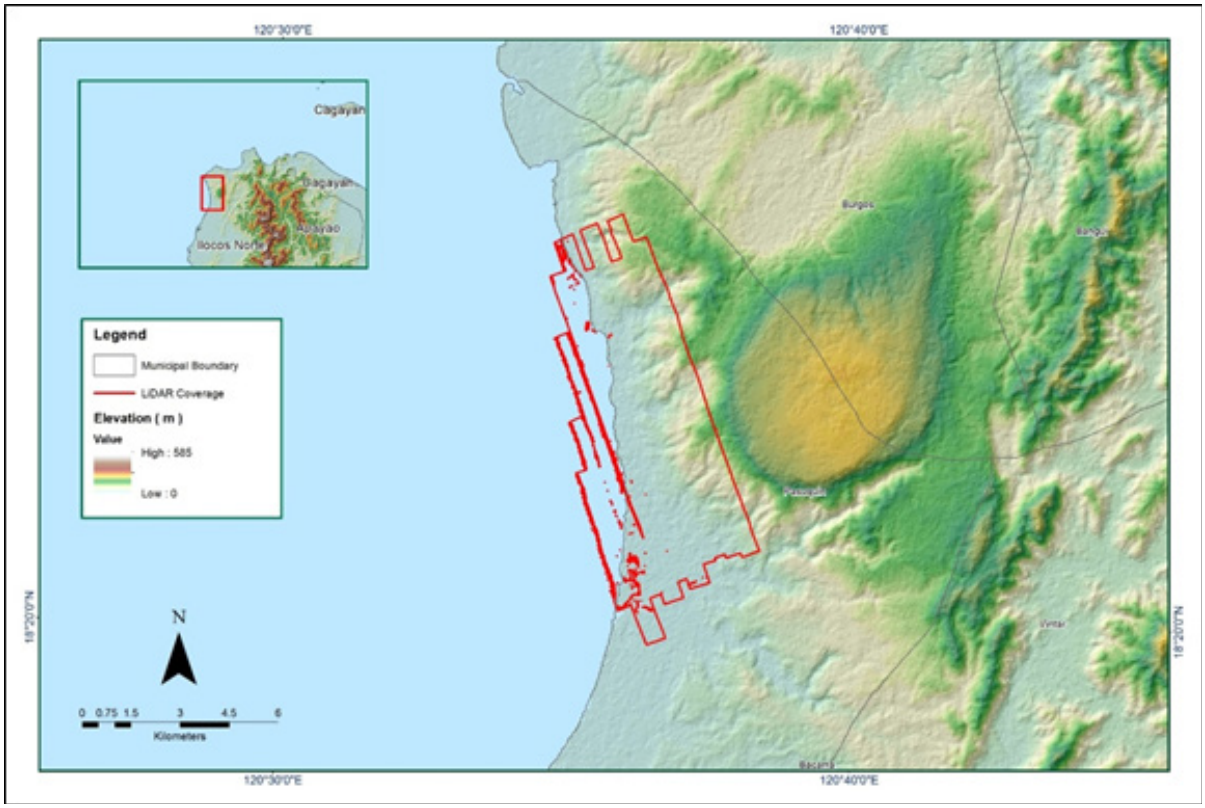


Figure A-8.25 Coverage of LiDAR data

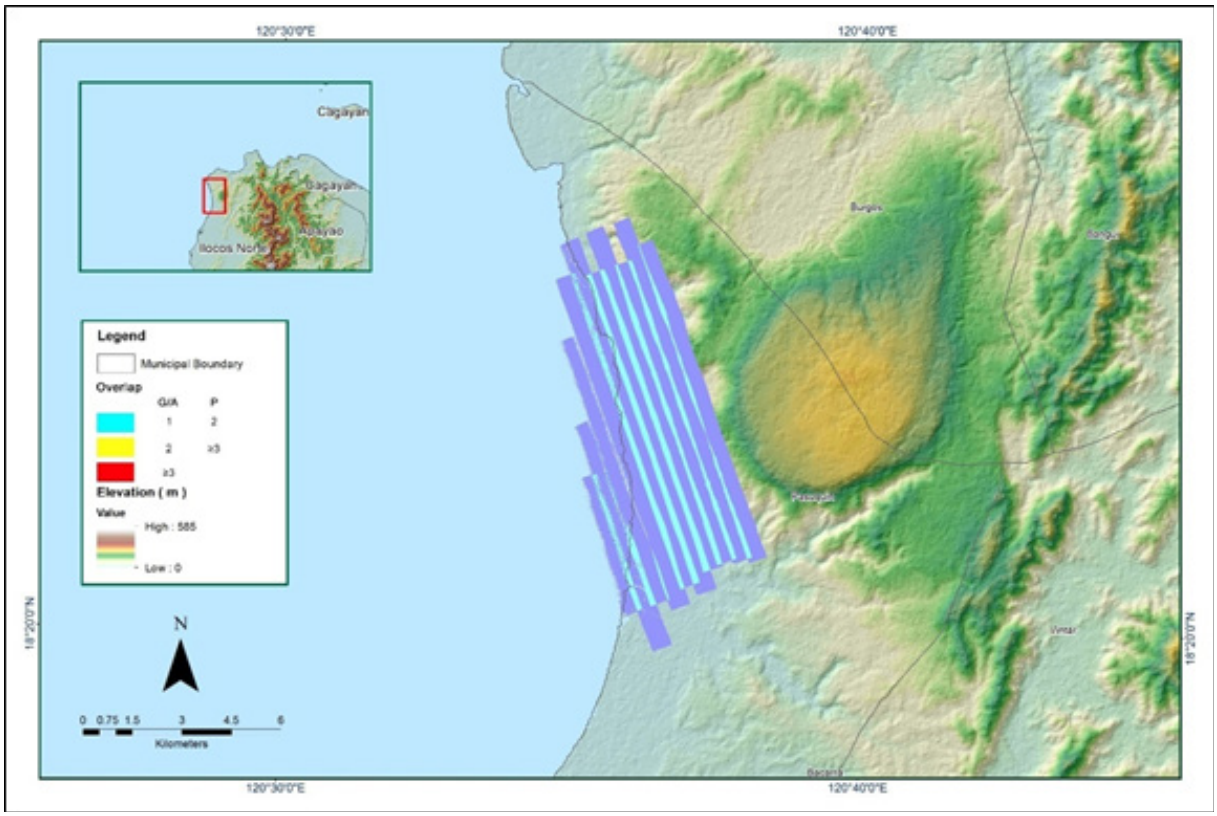


Figure A-8.26 Image of data overlap

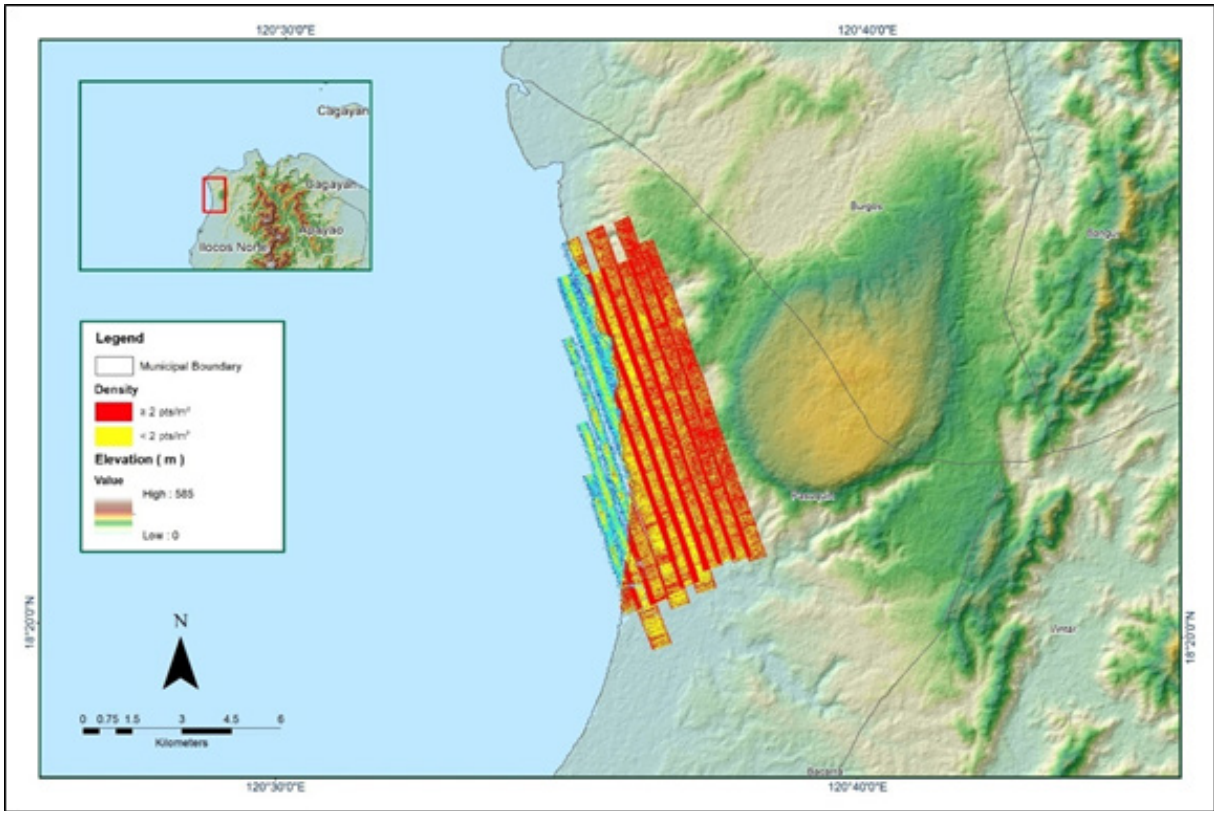


Figure A-8.27 Density map of merged LiDAR data

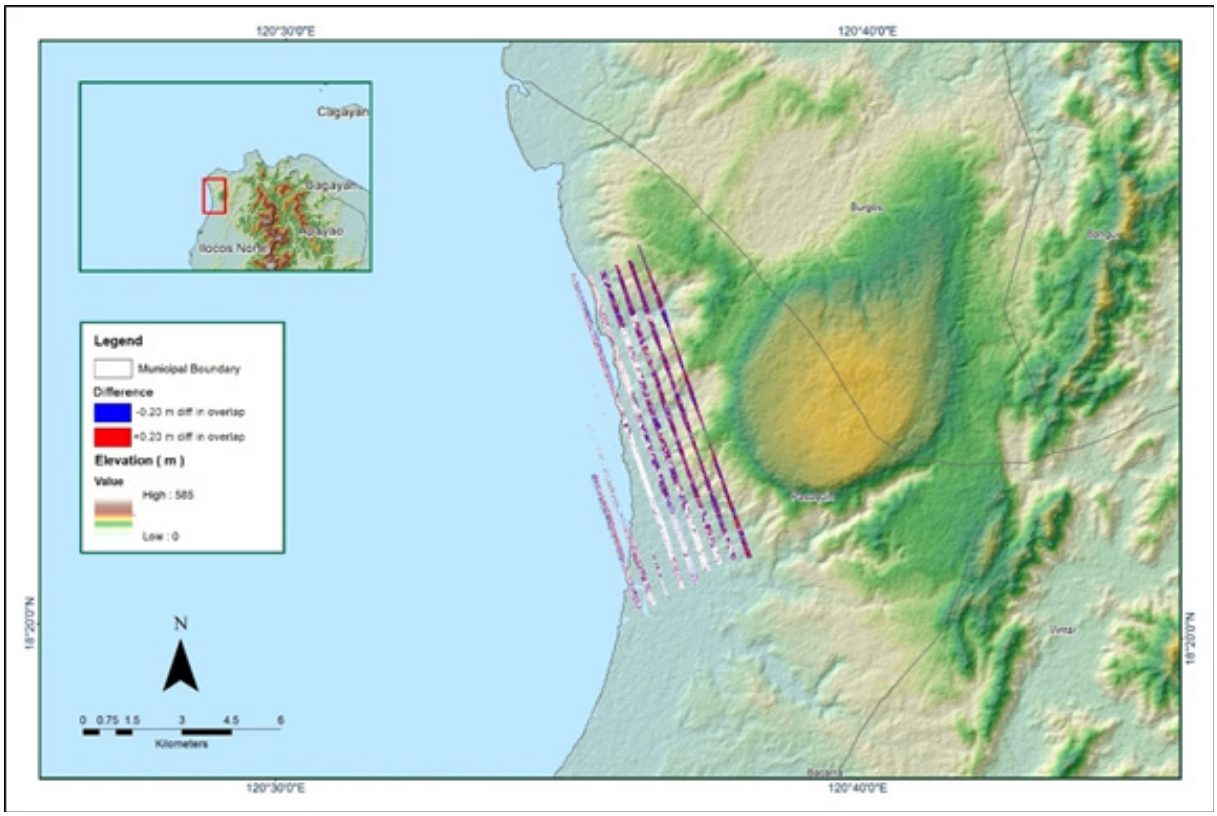


Figure A-8.28 Elevation difference between flight lines

Table A-8.5. Mission Summary Report for Mission Blk5A

Flight Area	**Ilocos**
Mission Name	Blk5A
Inclusive Flights	7093G and 7094G
Range data size	28.1 GB
Base data size	24.7 MB
POS	428 MB
Image	N/A
Transfer date	July 28, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	3.4
RMSE for East Position (<4.0 cm)	3.2
RMSE for Down Position (<8.0 cm)	3.9
Boresight correction stdev (<0.001deg)	0.000177
IMU attitude correction stdev (<0.001deg)	0.001821
GPS position stdev (<0.01m)	0.0029
Minimum % overlap (>25)	31.94%
Ave point cloud density per sq.m. (>2.0)	1.78
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	248
Maximum Height	502.99 m
Minimum Height	39.12 m
Classification (# of points)	
Ground	72,403,808
Low vegetation	49,318,800
Medium vegetation	62,219,702
High vegetation	98,593,809
Building	1,272,957
Orthophoto	No
Processed by	Engr. Angelo Carlo Bongat, Engr. Melanie Hingpit, Ryan James Nicholai Dizon

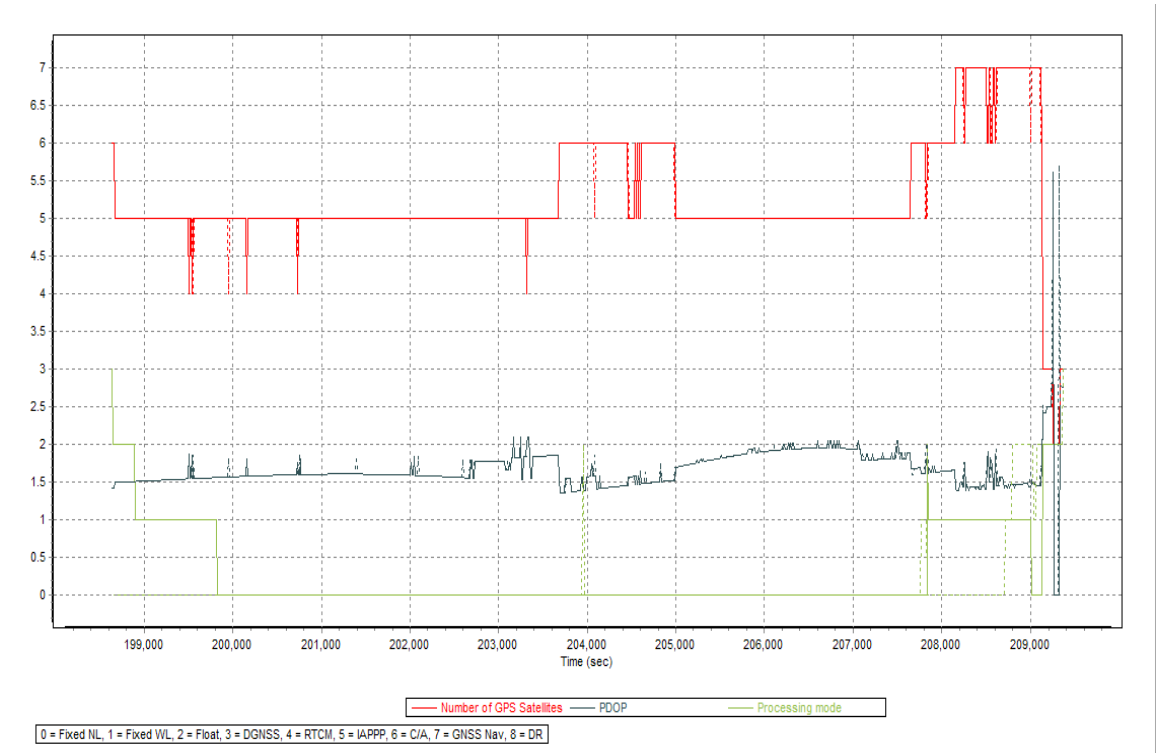


Figure A-8.29 Solution Status

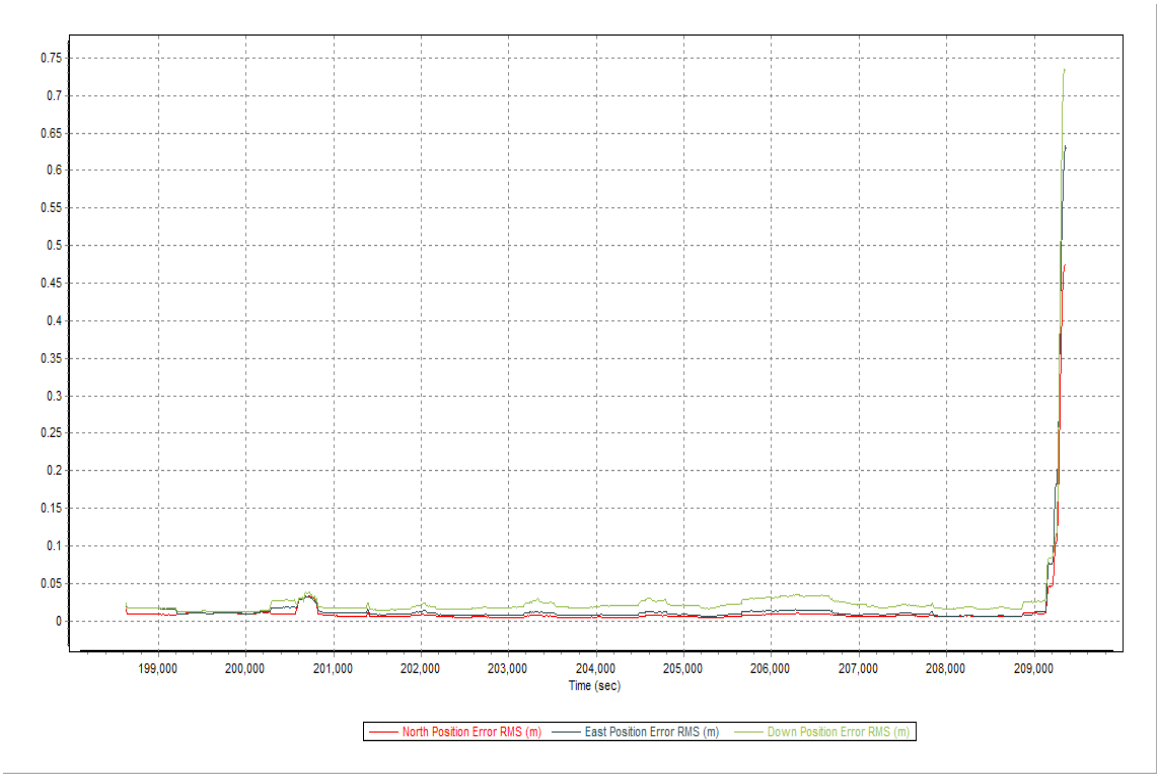


Figure A-8.30 Smoothed Performance Metric Parameters

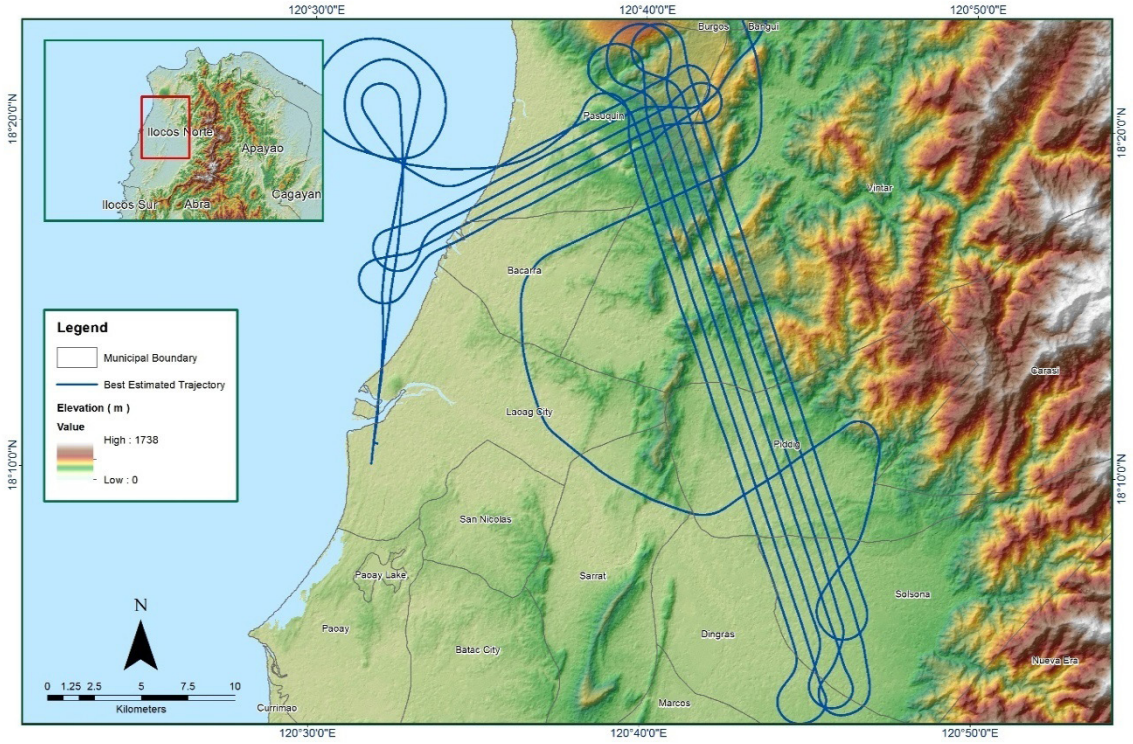


Figure A-8.31 Best Estimated Trajectory

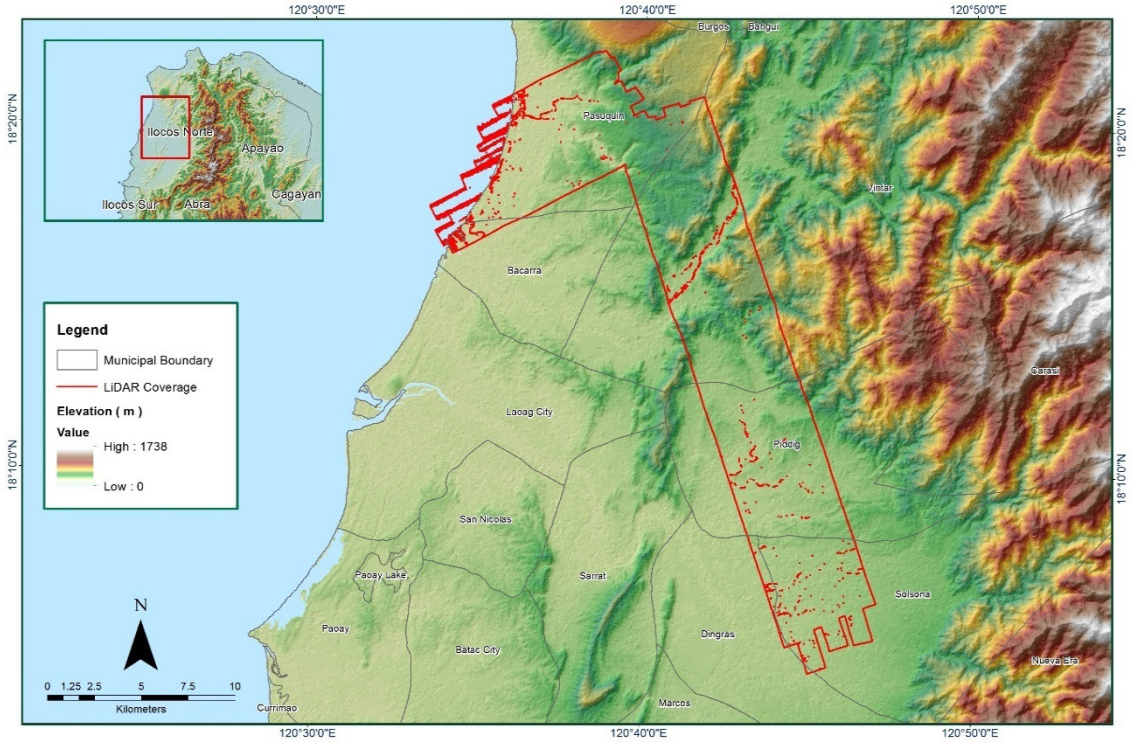


Figure A-8.32 Coverage of LiDAR data

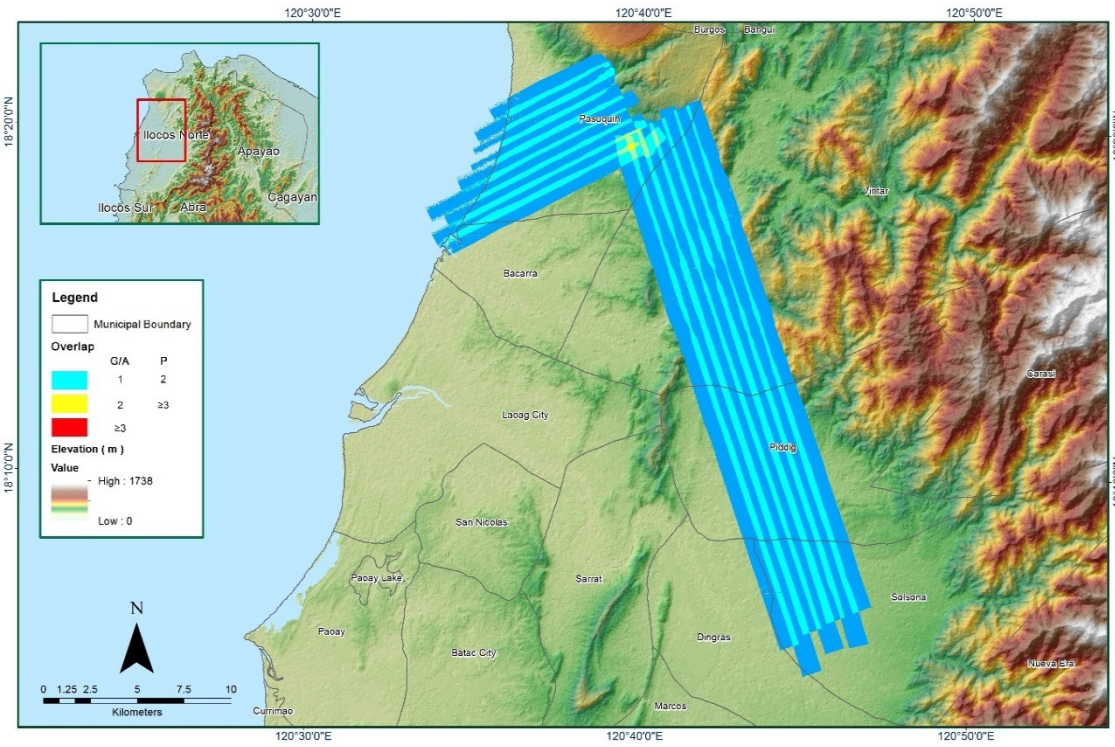


Figure A-8.33 Image of data overlap

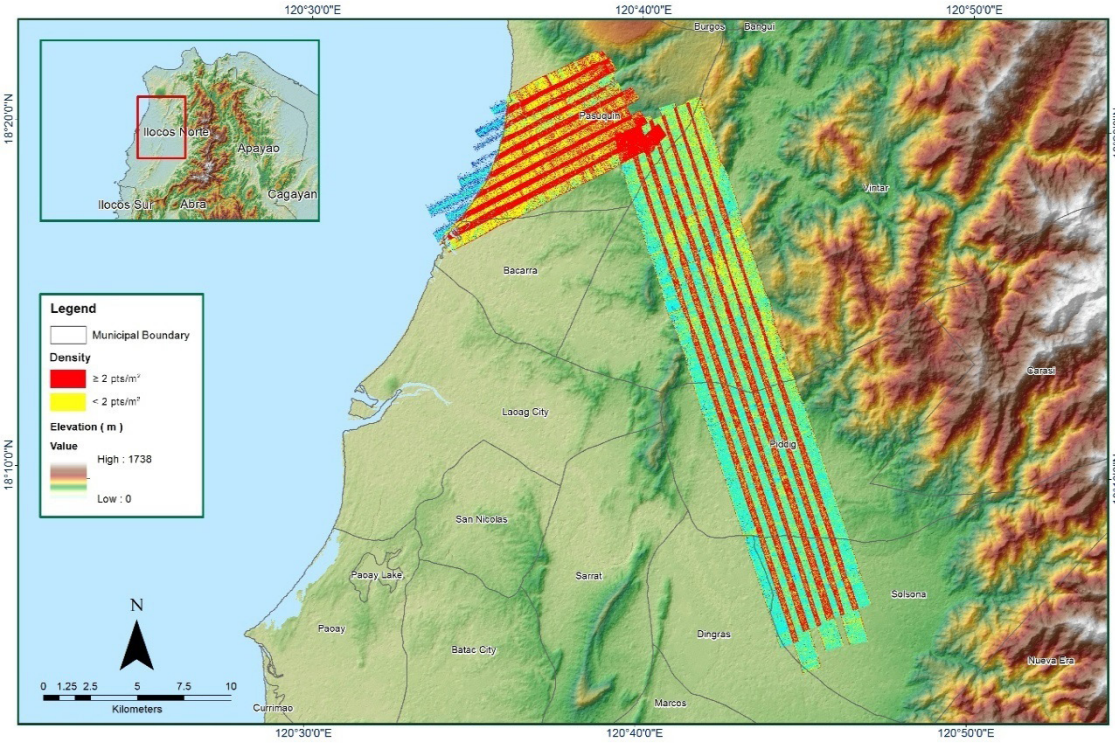


Figure A-8.34 Density map of merged LiDAR data

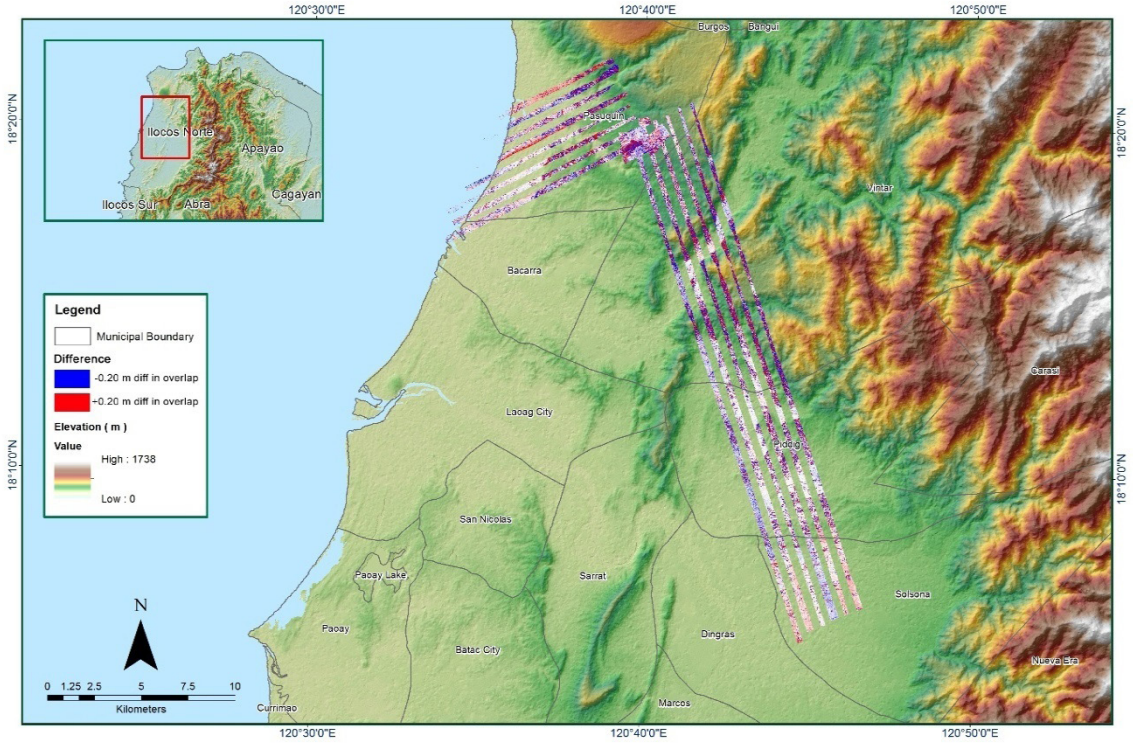


Figure A-8.35 Elevation difference between flight lines

Table A-8.6. Mission Summary Report for Mission Blk5B

Flight Area	**Ilocos**
Mission Name	**Blk5B**
Inclusive Flights	7094G
Range data size	15.1 GB
Base data size	11.4 MB
POS	231 MB
Image	N/A
Transfer date	July 28, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	5.4
RMSE for East Position (<4.0 cm)	2.0
RMSE for Down Position (<8.0 cm)	9.4
Boresight correction stdev (<0.001deg)	0.000309
IMU attitude correction stdev (<0.001deg)	0.000682
GPS position stdev (<0.01m)	0.0029
Minimum % overlap (>25)	23.14%
Ave point cloud density per sq.m. (>2.0)	2.37
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	152
Maximum Height	629.52 m
Minimum Height	75.34 m
Classification (# of points)	38,645,276
Ground	14,305,851
Low vegetation	22,951,466
Medium vegetation	44,471,526
High vegetation	83,933,604
Building	732,377
Orthophoto	No
Processed by	Engr. Angelo Carlo Bongat, Engr. Christy Lubiano, Engr. Gladys Mae Apat

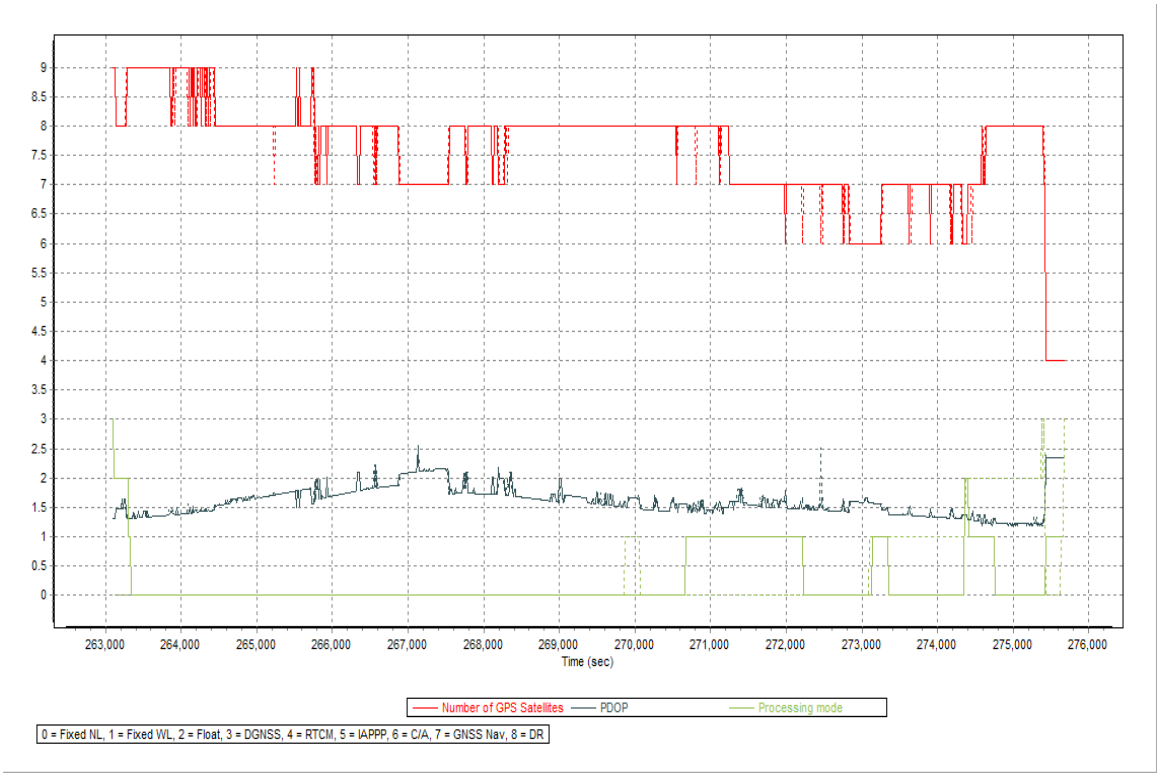


Figure A-8.36 Solution Status

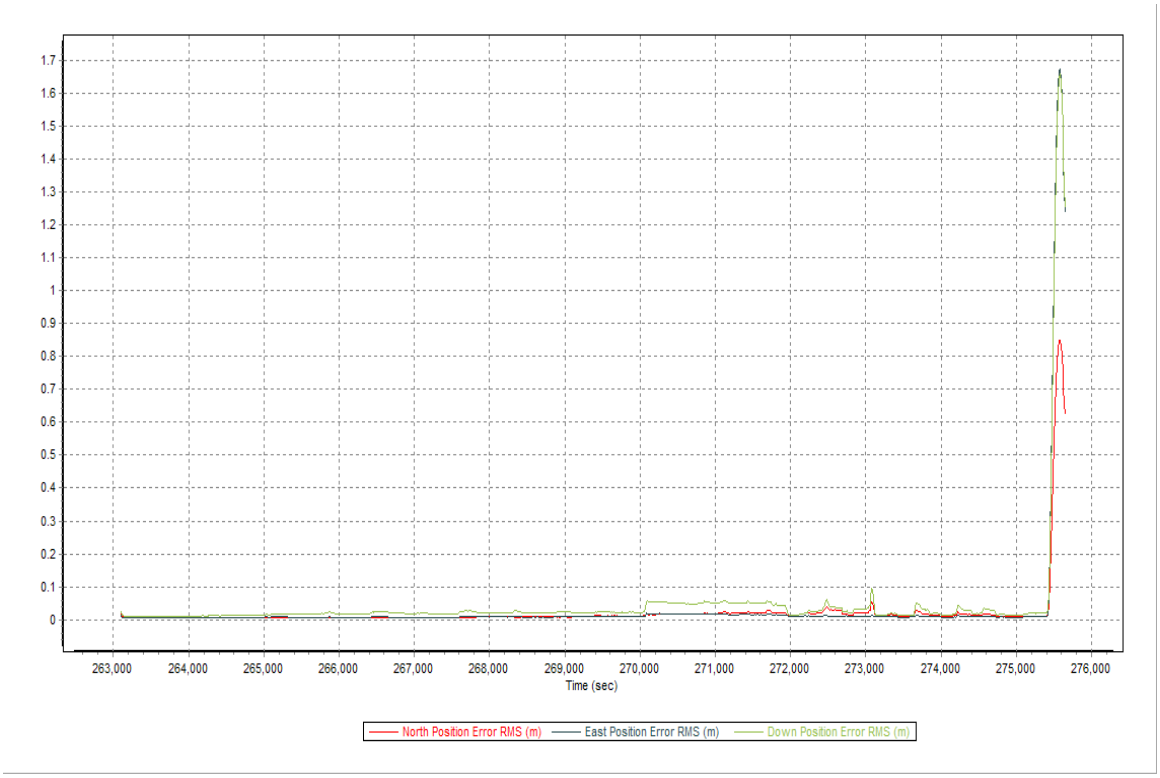


Figure A-8.37 Smoothed Performance Metric Parameters

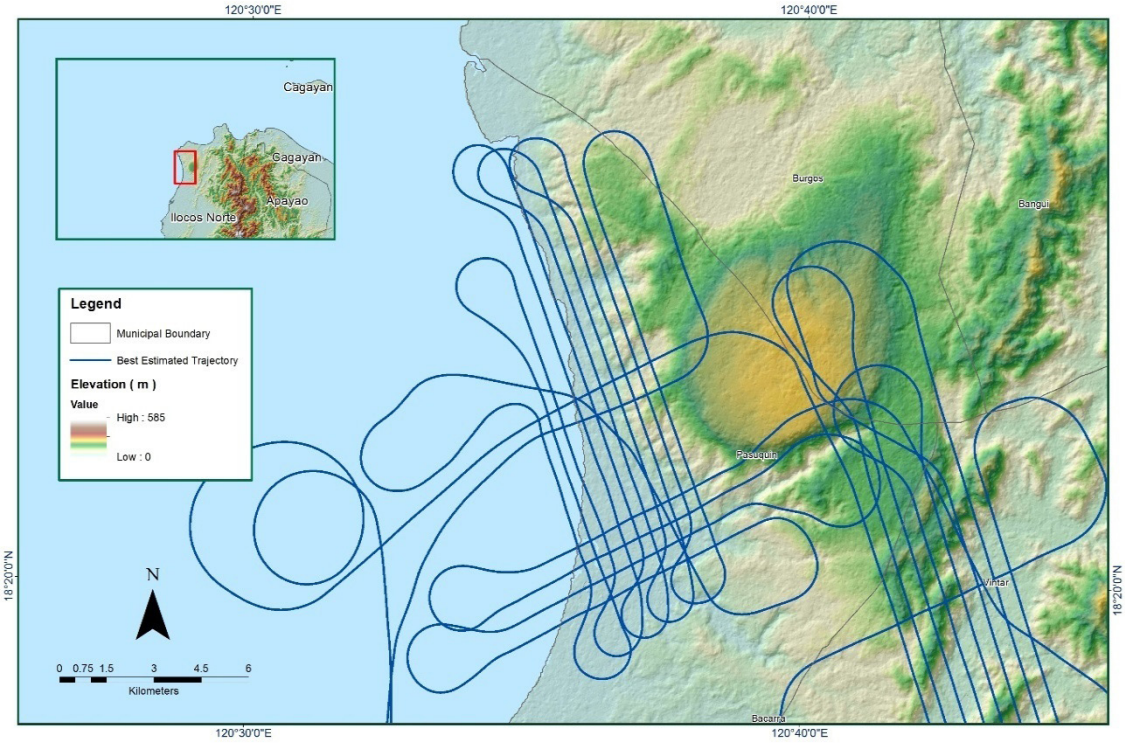


Figure A-8.38 Best Estimated Trajectory

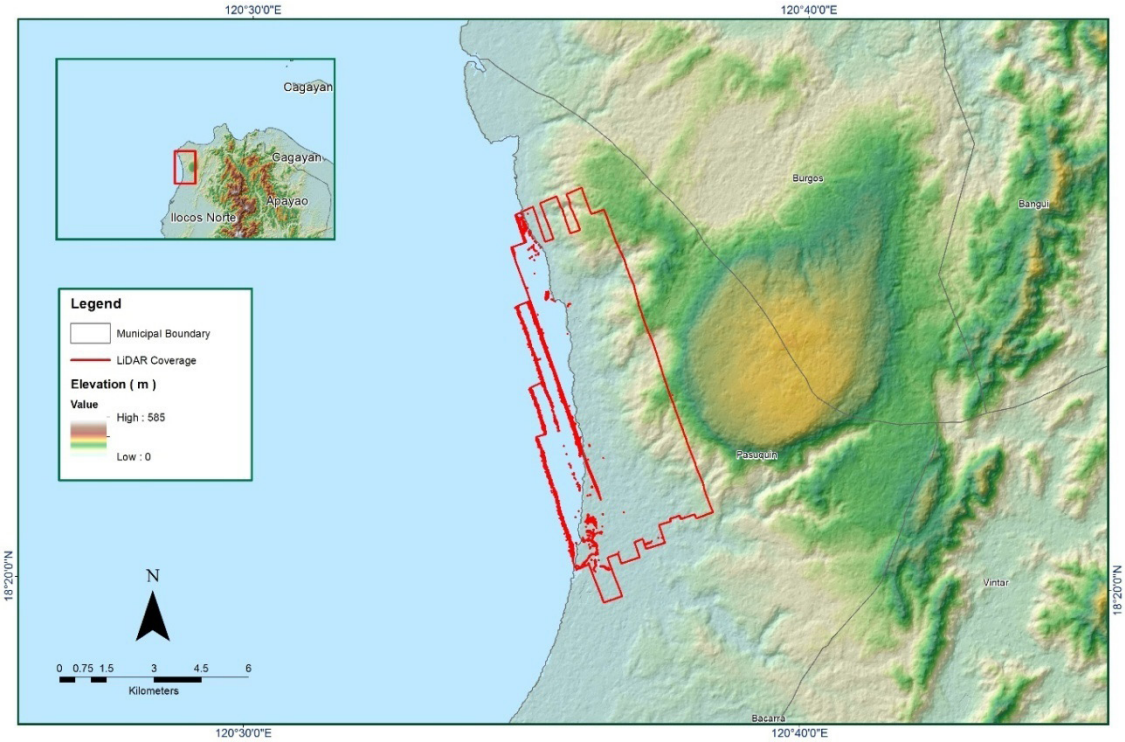


Figure A-8.39 Coverage of LiDAR data

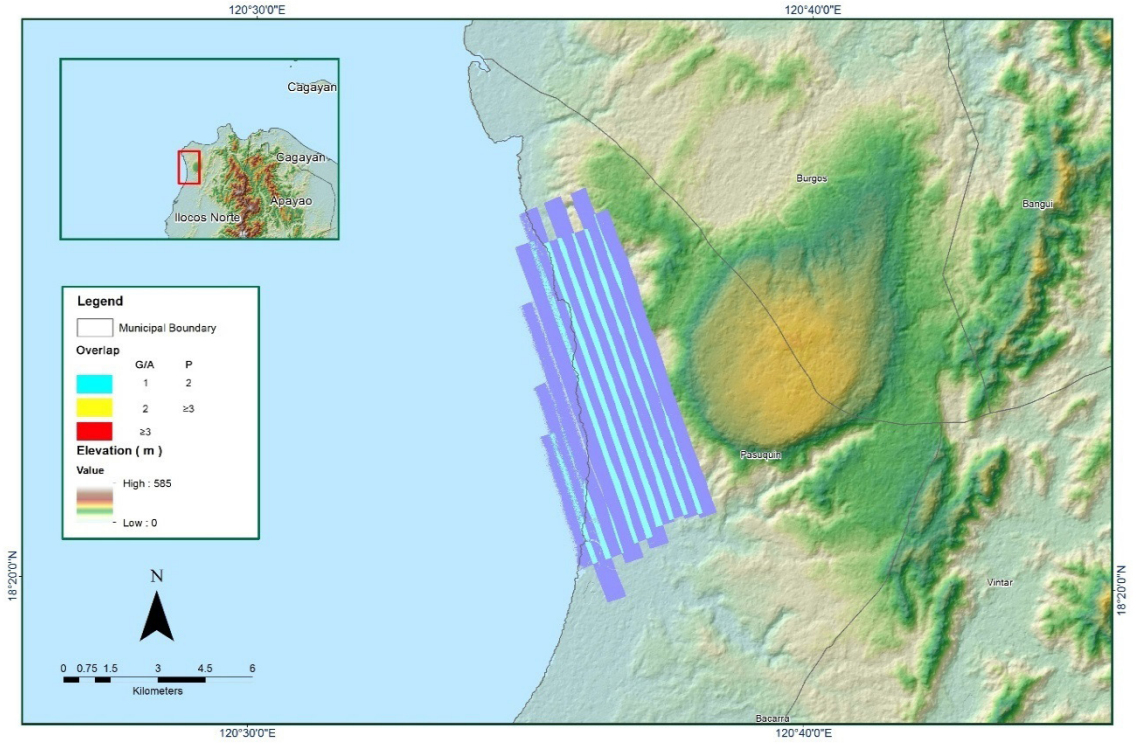


Figure A-8.40 Image of data overlap

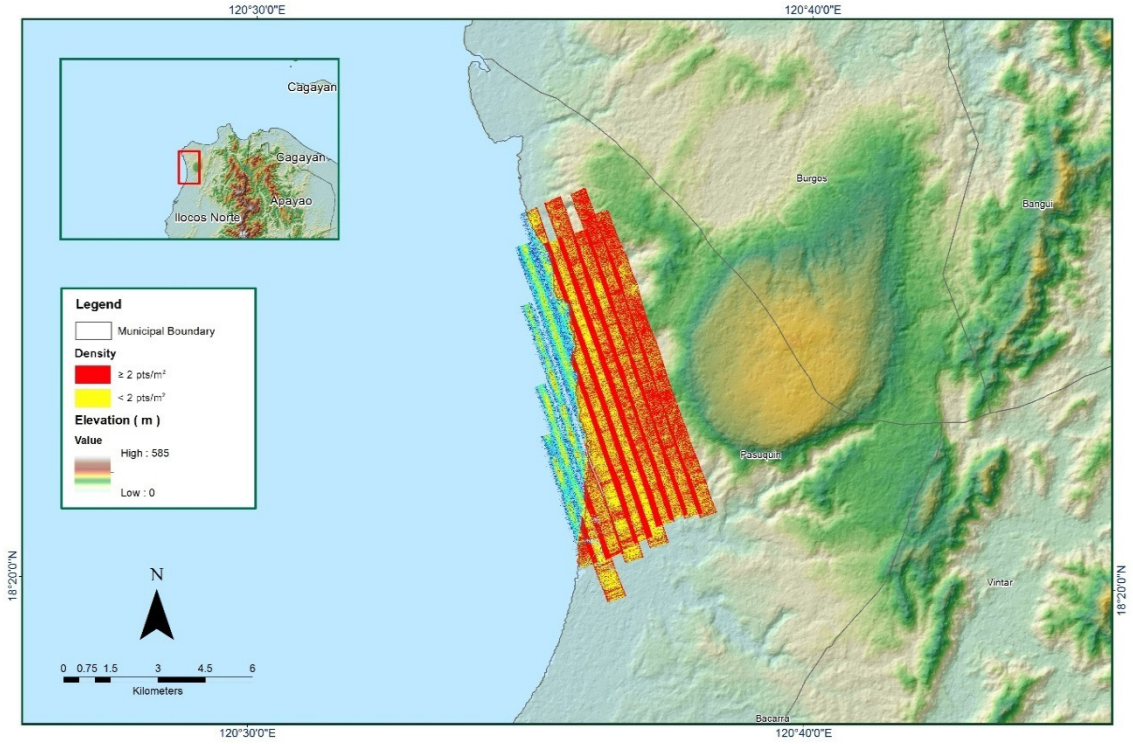


Figure A-8.41 Density map of merged LiDAR data

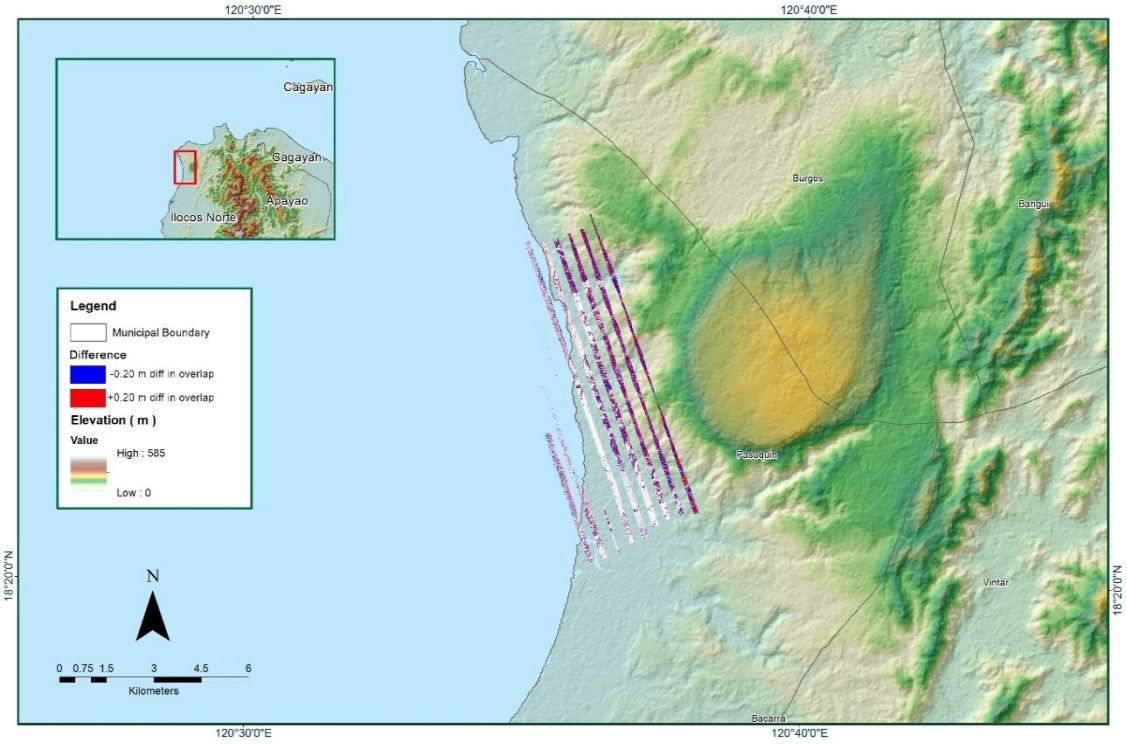


Figure A-8.42 Elevation difference between flight lines

Table A-8.7. Mission Summary Report for Mission Blk5C

Flight Area	**Ilocos**
Mission Name	**Blk5C**
Inclusive Flights	7093G
Range data size	13.0 GB
Base data size	13.3 MB
POS	197 MB
Image	N/A
Transfer date	July 28, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	3.4
RMSE for East Position (<4.0 cm)	3.2
RMSE for Down Position (<8.0 cm)	3.9
Boresight correction stdev (<0.001deg)	0.000177
IMU attitude correction stdev (<0.001deg)	0.001821
GPS position stdev (<0.01m)	0.0029
Minimum % overlap (>25)	31.94%
Ave point cloud density per sq.m. (>2.0)	1.78
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	204
Maximum Height	503.01 m
Minimum Height	61.68 m
Classification (# of points)	
Ground	36,640,456
Low vegetation	38,807,563
Medium vegetation	38,435,176
High vegetation	76,650,235
Building	1,181,514
Orthophoto	No
Processed by	Engr. Carlyn Ann Ibañez, Celina Rosete, Engr. Elainne Lopez

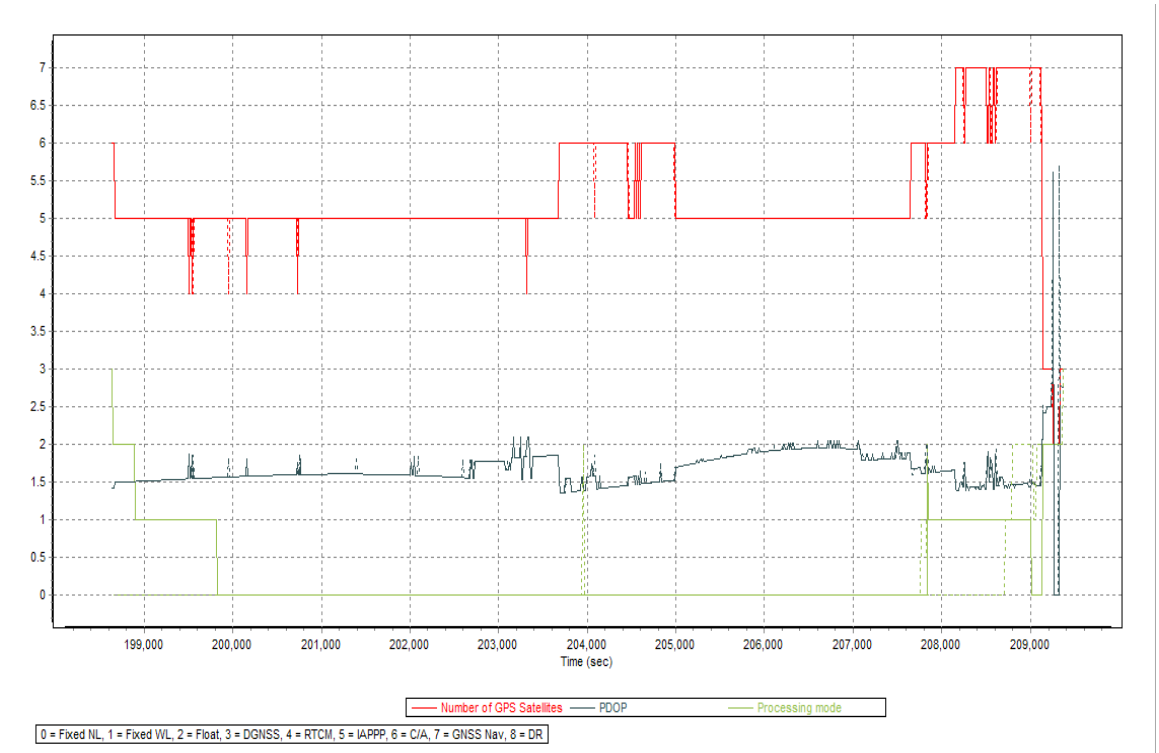


Figure A-8.43 Solution Status

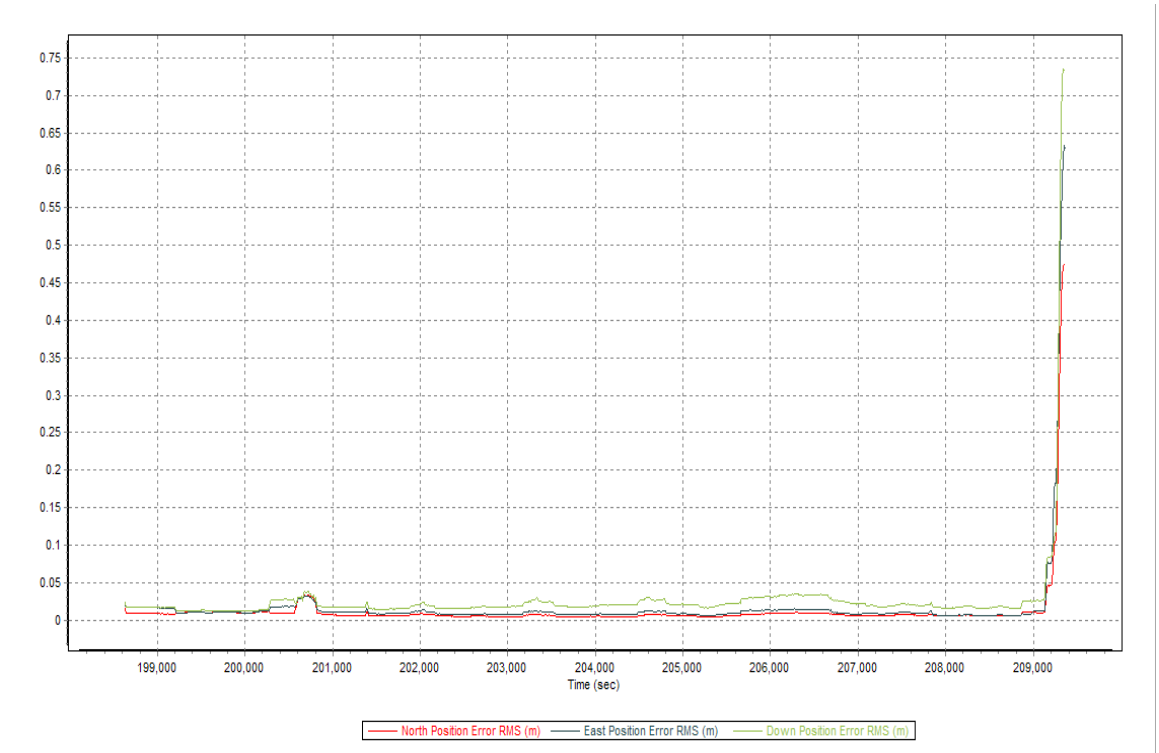


Figure A-8.44 Smoothed Performance Metric Parameters

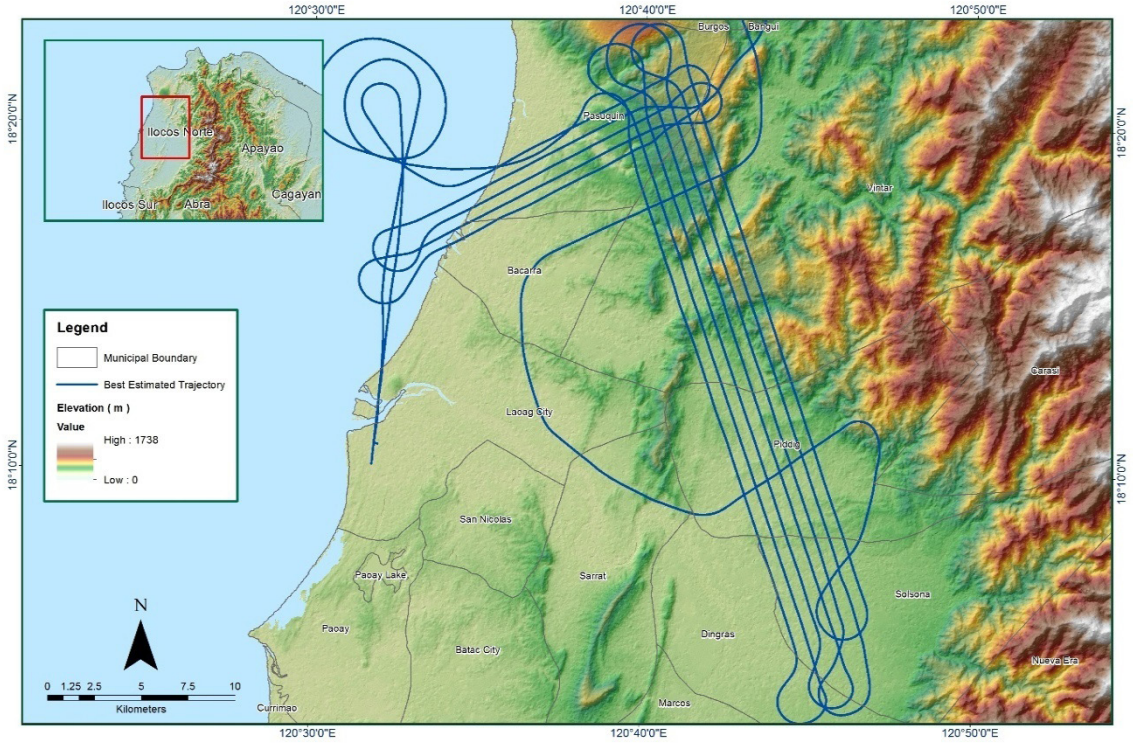


Figure A-8.45 Best Estimated Trajectory

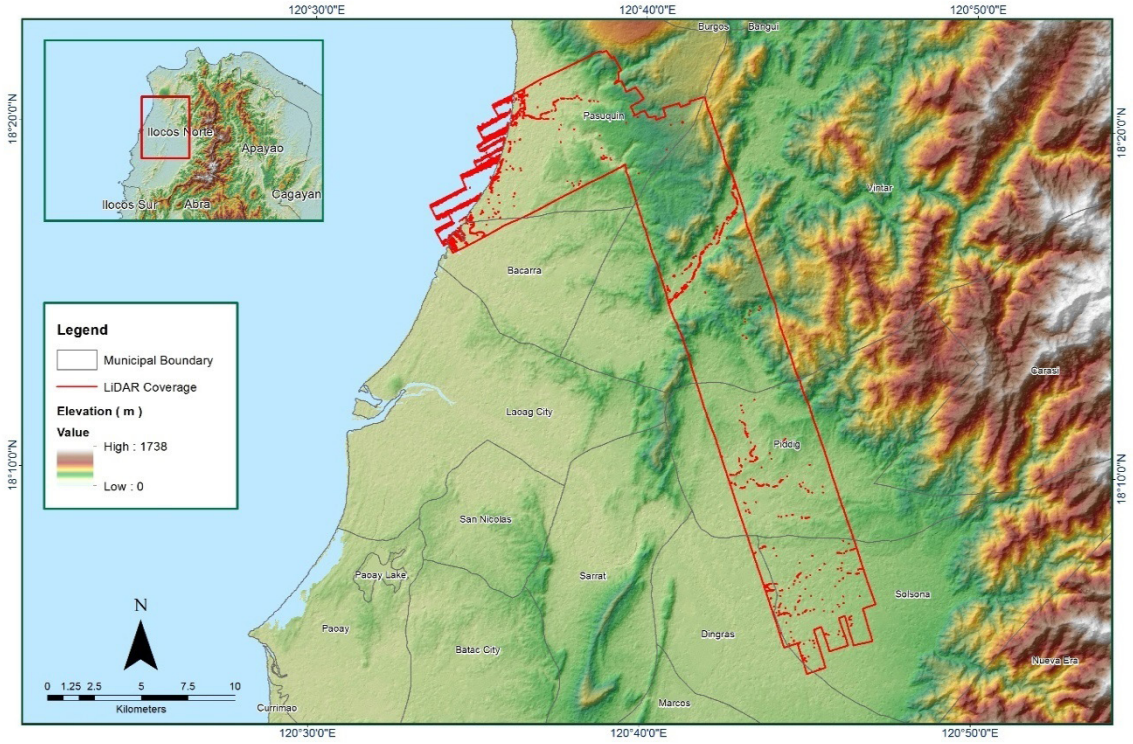


Figure A-8.46 Coverage of LiDAR data

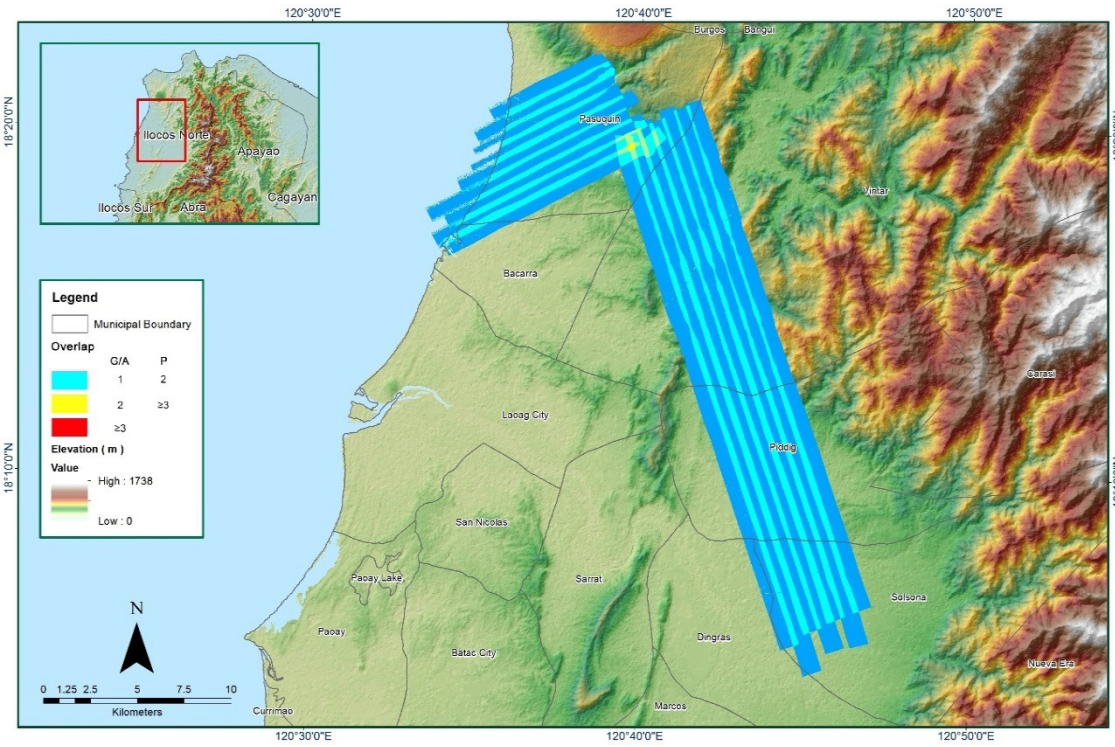


Figure A-8.47 Image of data overlap

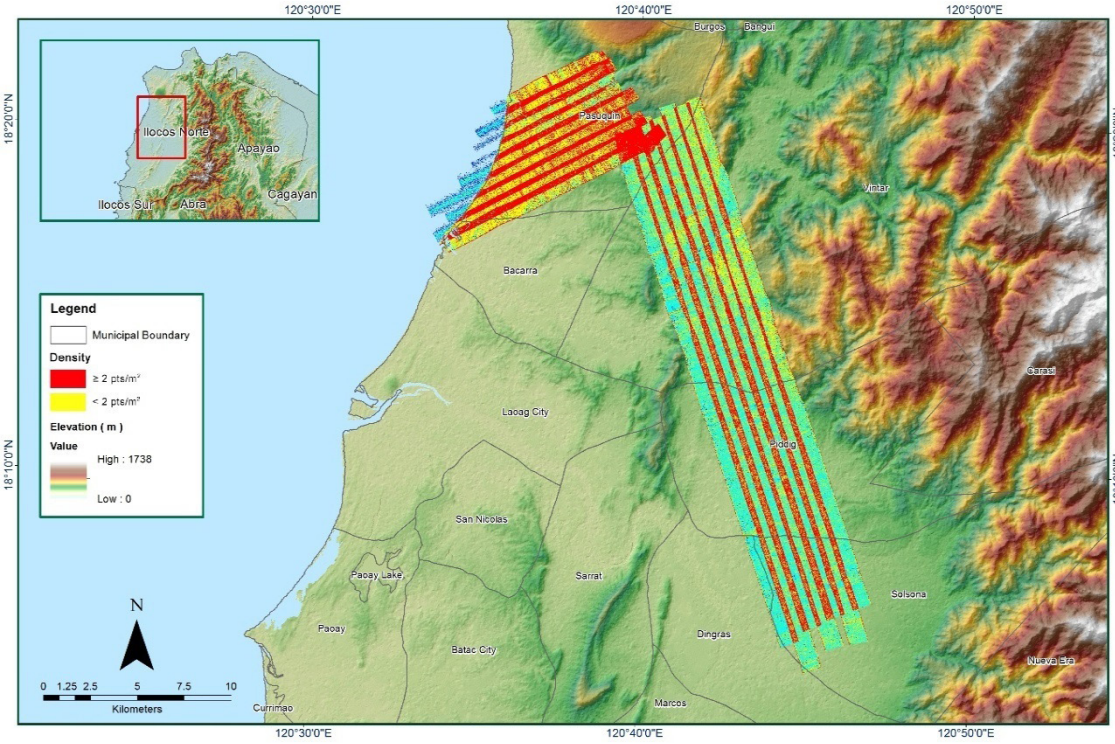


Figure A-8.48 Density map of merged LiDAR data

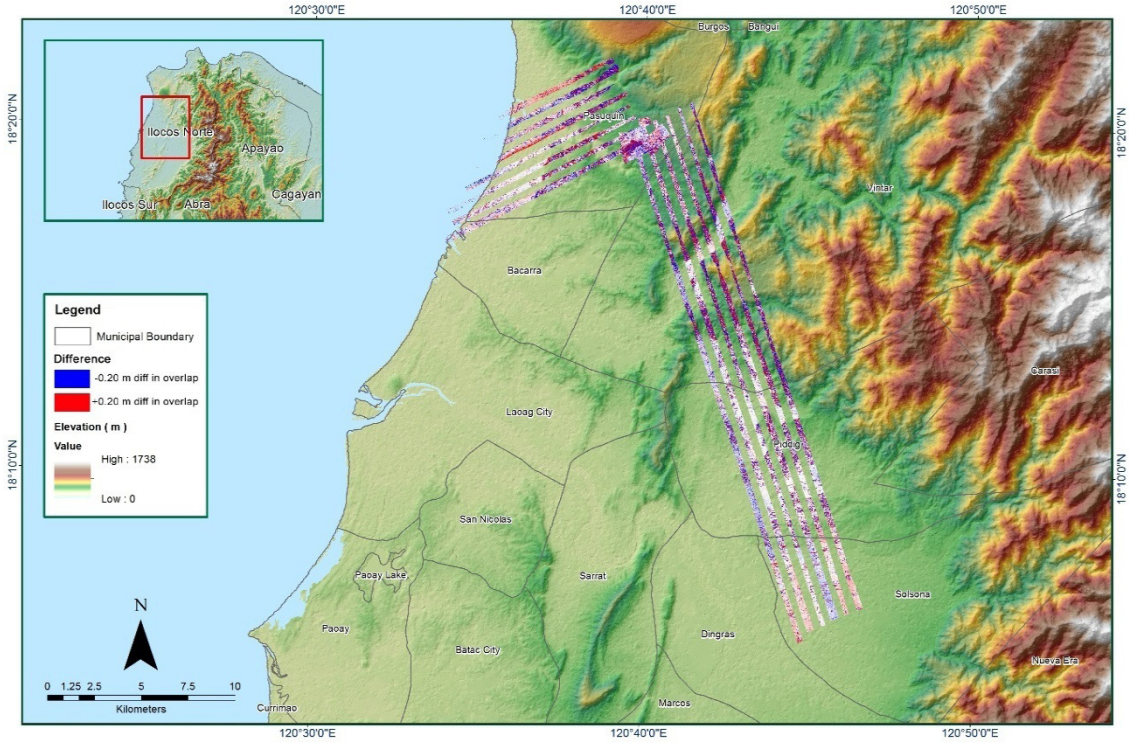


Figure A-8.49 Elevation difference between flight lines

Table A-8.8. Mission Summary Report for Mission Blk5D

Flight Area	**Ilocos**
Mission Name	**Blk5D**
Inclusive Flights	7092G
Range data size	11.8 GB
Base data size	13 MB
POS	199 MB
Image	N/A
Transfer date	July 28, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	2.6
RMSE for East Position (<4.0 cm)	2.5
RMSE for Down Position (<8.0 cm)	3.3
Boresight correction stdev (<0.001deg)	0.000314
IMU attitude correction stdev (<0.001deg)	0.000547
GPS position stdev (<0.01m)	0.0104
Minimum % overlap (>25)	68.68%
Ave point cloud density per sq.m. (>2.0)	1.62
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	136
Maximum Height	453.01 m
Minimum Height	47.27 m
Classification (# of points)	
Ground	43,938,236
Low vegetation	24,884,917
Medium vegetation	19,773,139
High vegetation	41,805,680
Building	978,440
Orthophoto	No
Processed by	Engr. Irish Cortez, Engr. Christy Lubiano, Engr. Ma. Ailyn Olanda

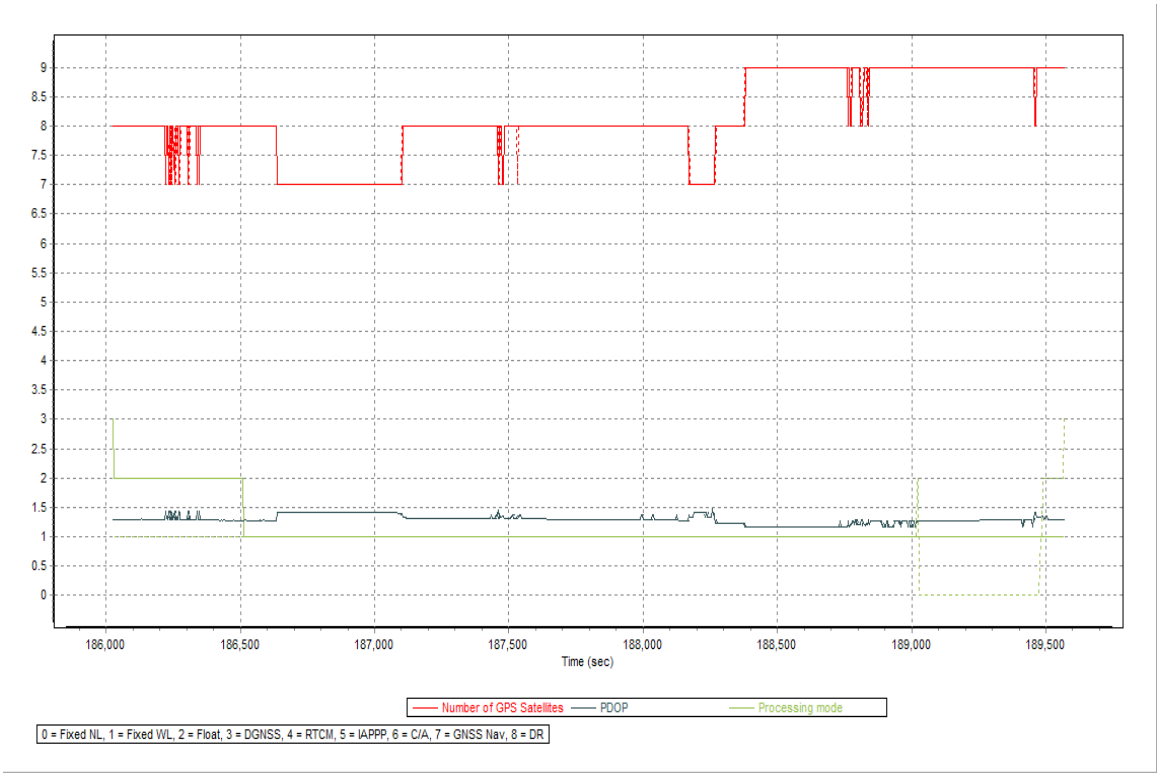


Figure A-8.50 Solution Status

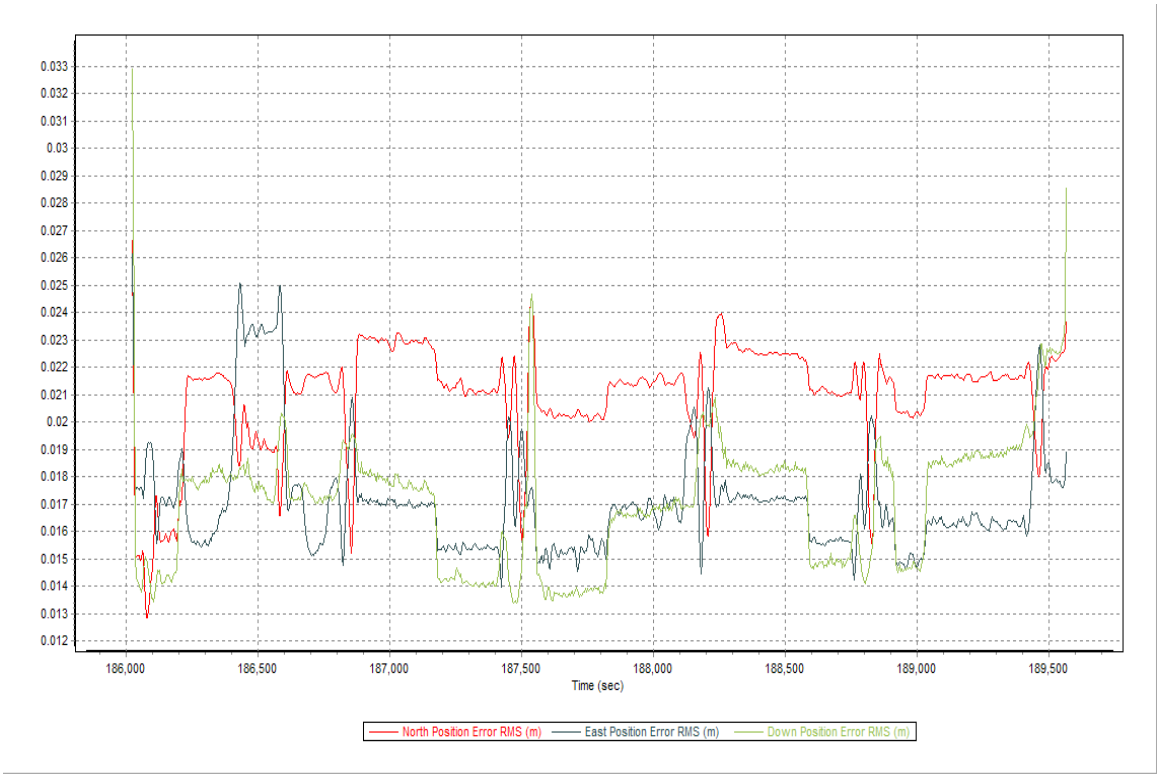


Figure A-8.51 Smoothed Performance Metric Parameters

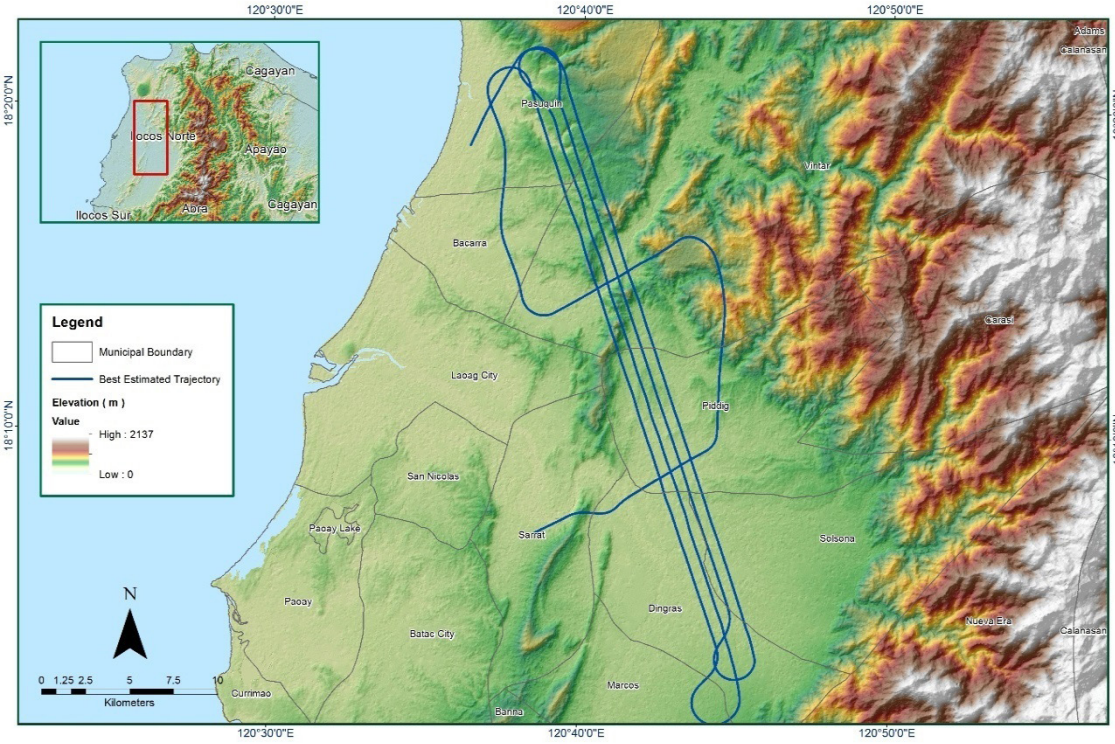


Figure A-8.52 Best Estimated Trajectory

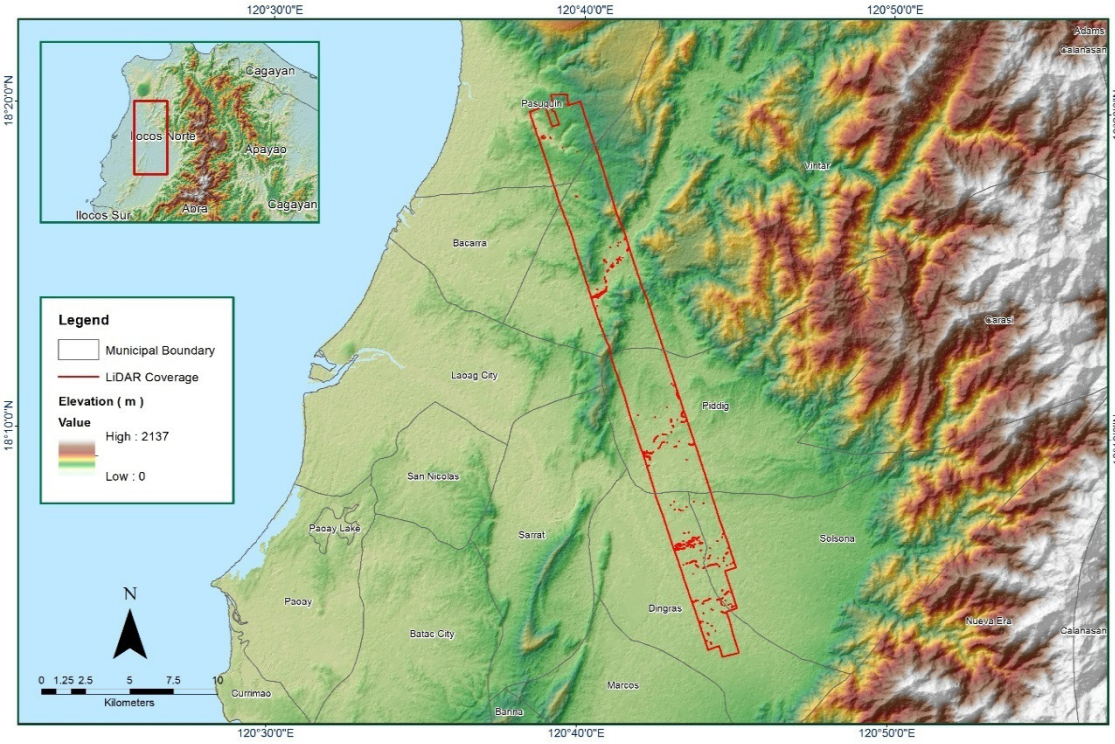


Figure A-8.53 Coverage of LiDAR data

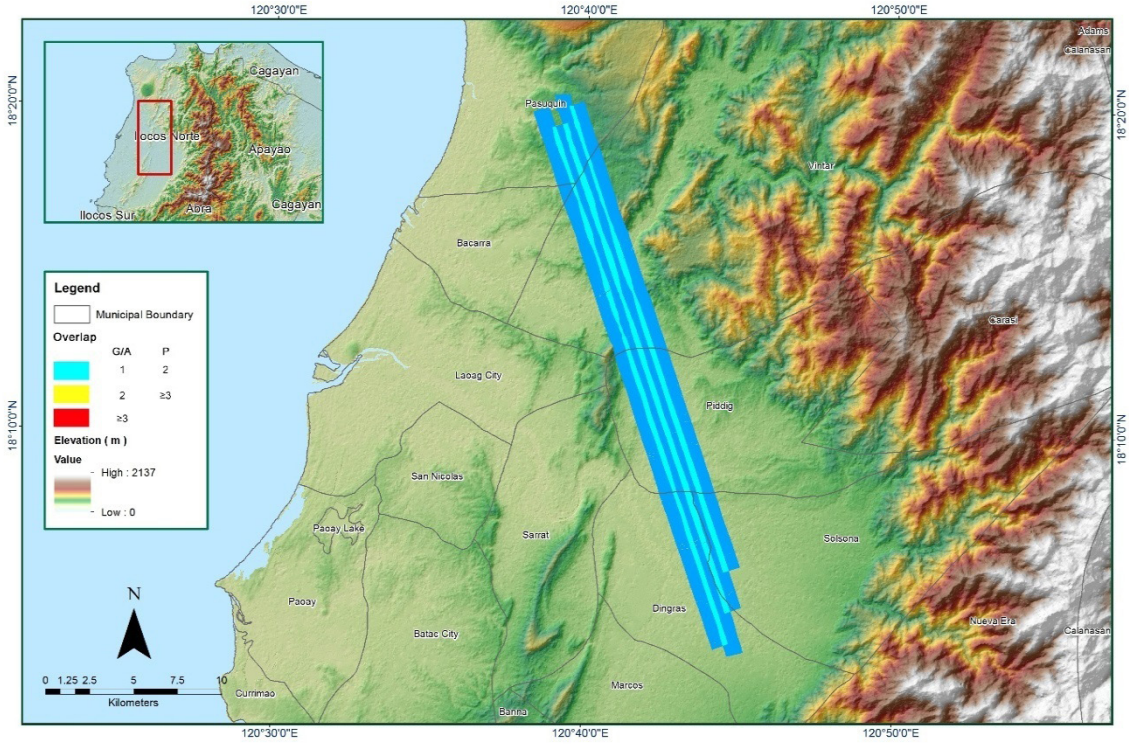


Figure A-8.54 Image of data overlap

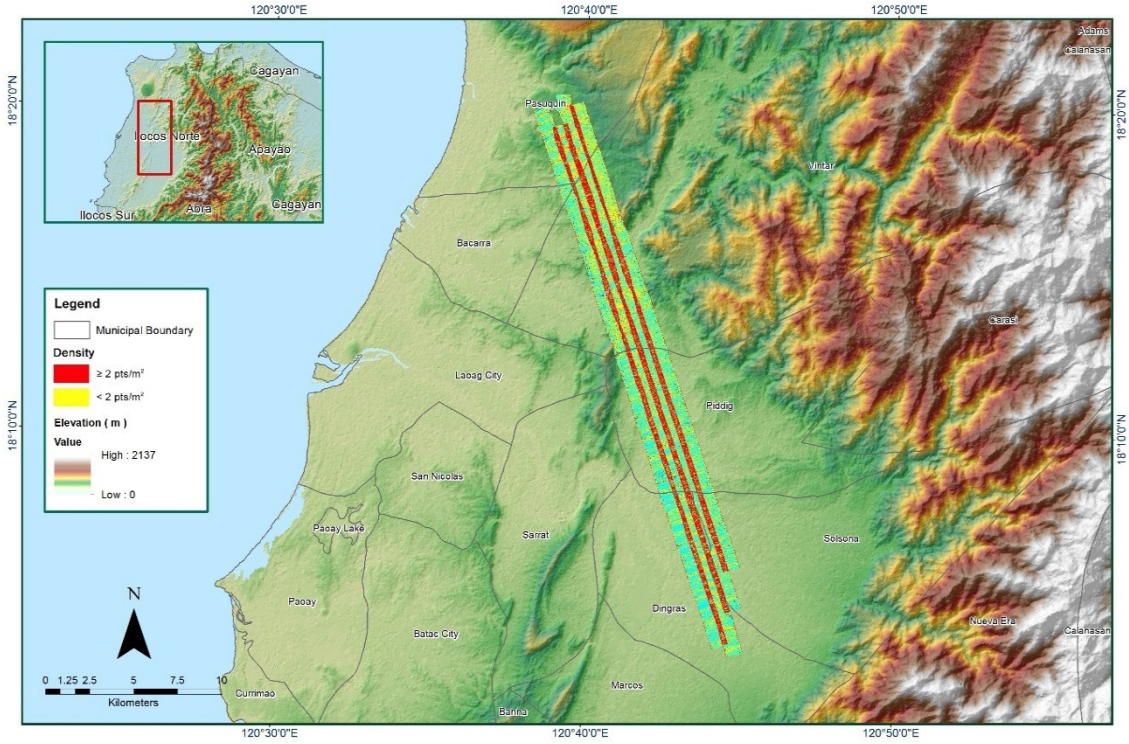


Figure A-8.55 Density map of merged LiDAR data

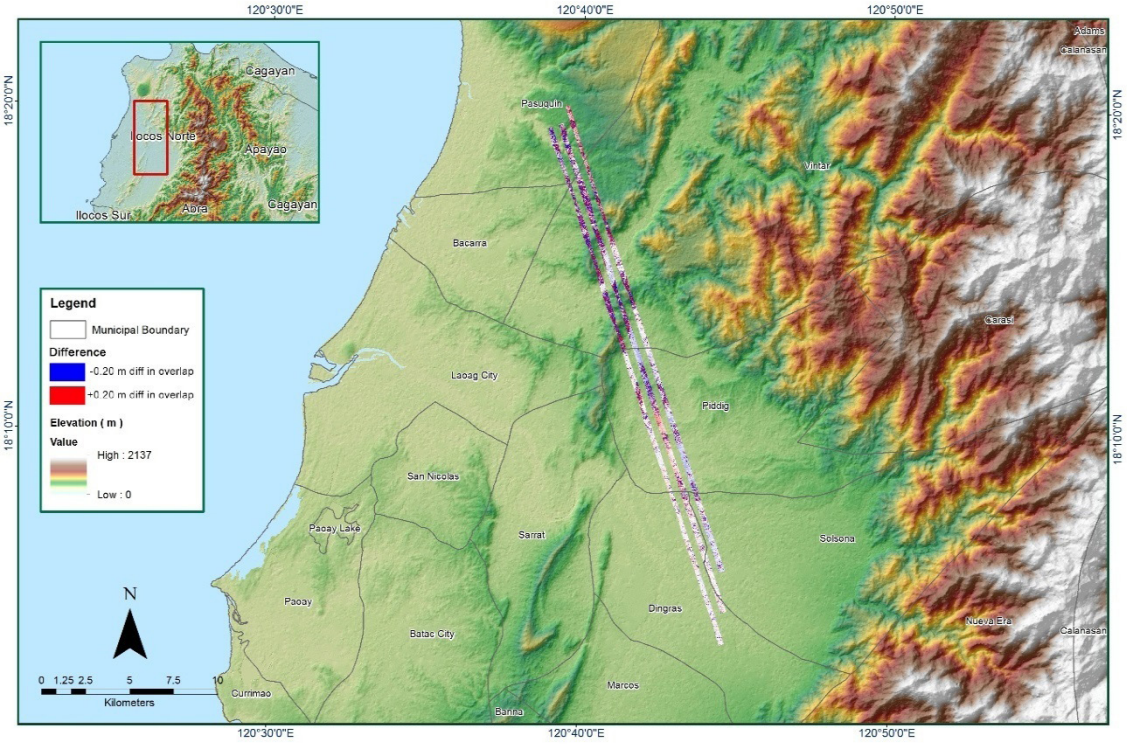


Figure A-8.56 Elevation difference between flight lines

Table A-8.9. Mission Summary Report for Mission 5DsEs

Flight Area	**Ilocos**
Mission Name	**5DsEs**
Inclusive Flights	7091G
Range data size	15.8
Base data size	N/A
POS	N/A
Image	N/A
Transfer date	July 28, 2014
Solution Status	
Number of Satellites (>6)	N/A
PDOP (<3)	N/A
Baseline Length (<30km)	N/A
Processing Mode (<=1)	N/A
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	N/A
RMSE for East Position (<4.0 cm)	N/A
RMSE for Down Position (<8.0 cm)	N/A
Boresight correction stdev (<0.001deg)	N/A
IMU attitude correction stdev (<0.001deg)	N/A
GPS position stdev (<0.01m)	N/A
Minimum % overlap (>25)	98.51
Ave point cloud density per sq.m. (>2.0)	5.09
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	196
Maximum Height	387.52 m
Minimum Height	42.55 m
Classification (# of points)	
Ground	91289416
Low vegetation	164468879
Medium vegetation	211773161
High vegetation	198073691
Building	11618600
Orthophoto	No
Processed by	Engr. Irish Cortez, Engr. Harmond Santos, Ailyn Biñas

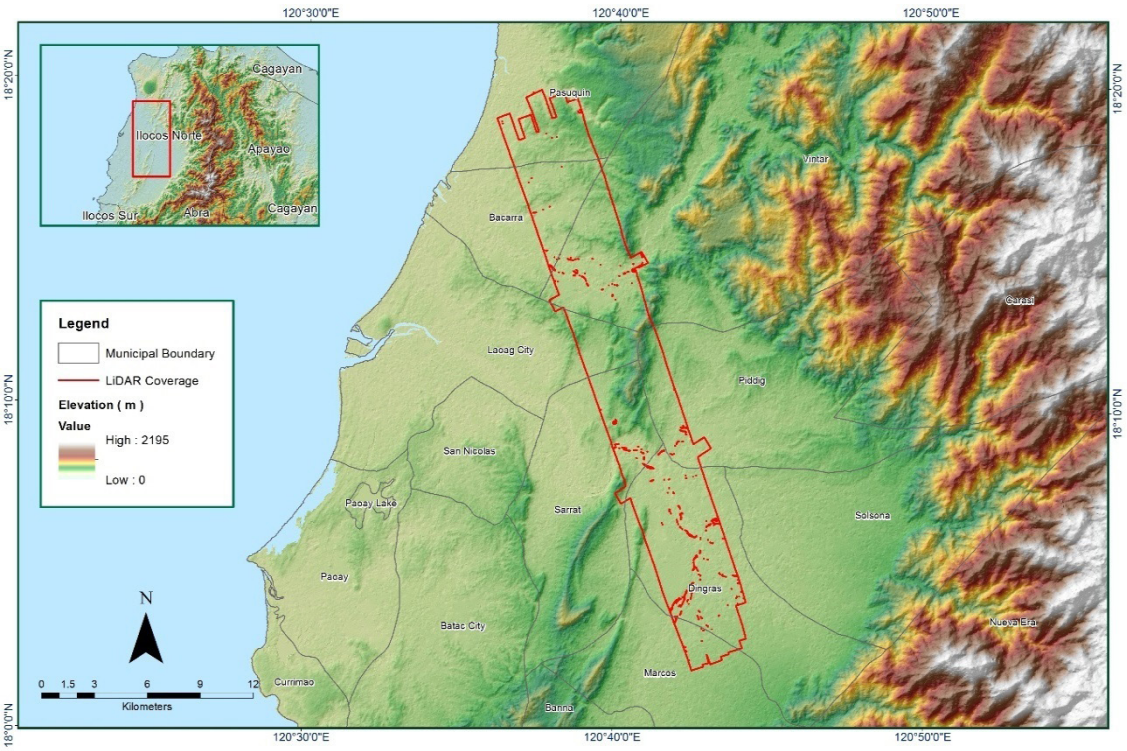


Figure A-8.57 Coverage of LiDAR data

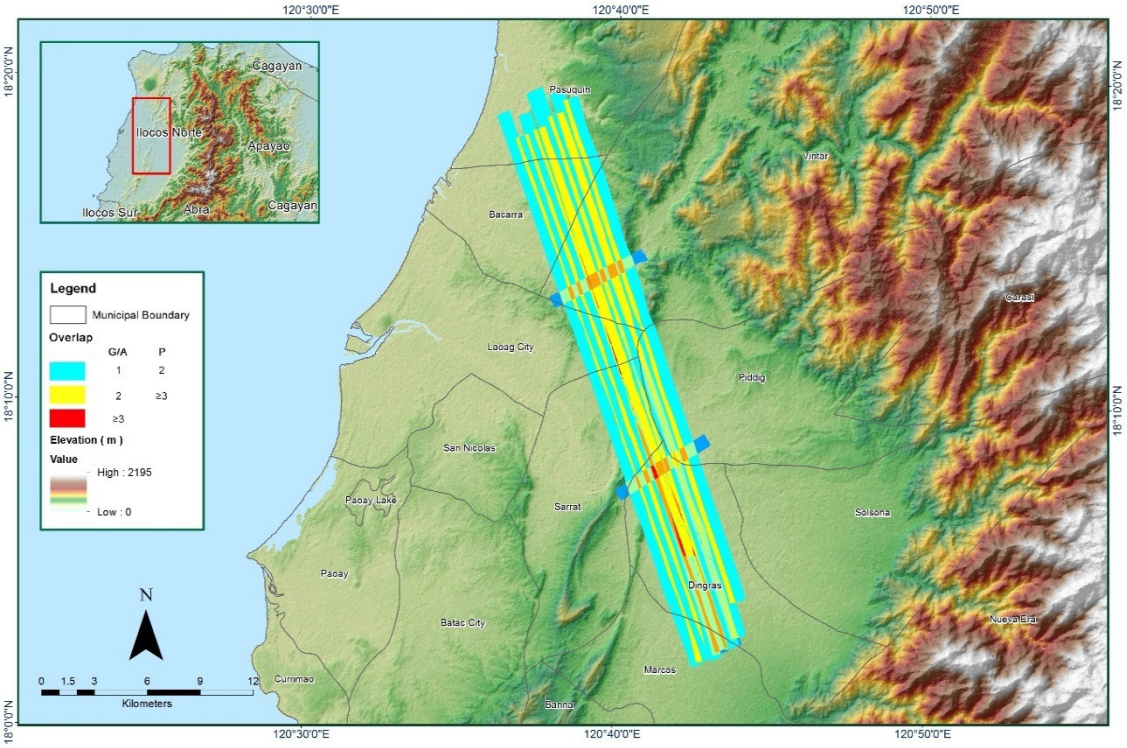


Figure A-8.58 Image of data overlap

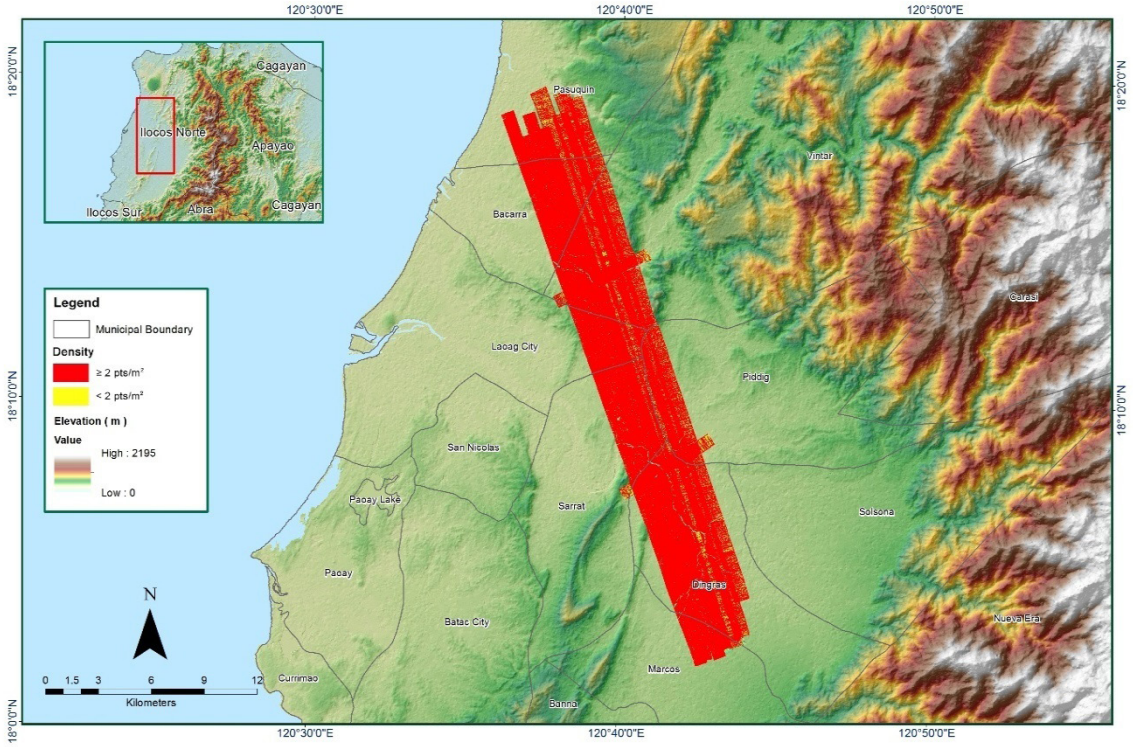


Figure A-8.59 Density map of merged LiDAR data

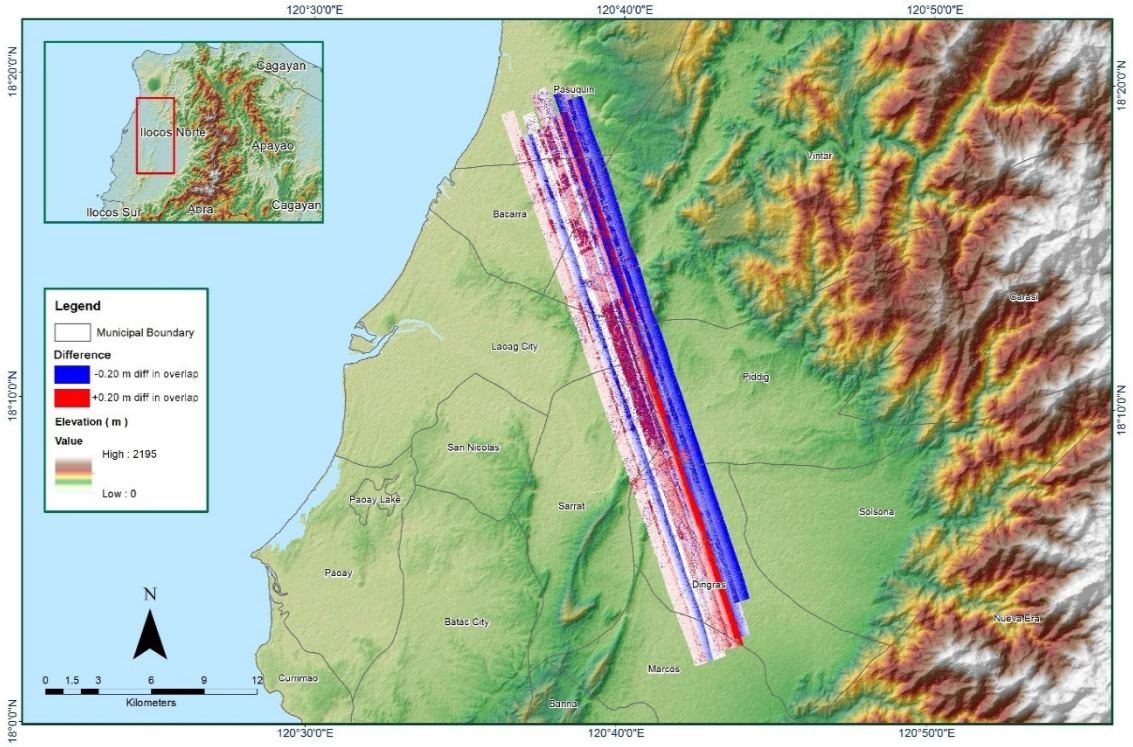


Figure A-8.60 Elevation difference between flight lines

Table A-8.10. Mission Summary Report for Mission Blk5Es

Flight Area	**Ilocos**
Mission Name	**Blk5Es**
Inclusive Flights	7103GC
Range data size	8.39 GB
Base data size	6.92 KB
POS	136 MB
Image	N/A
Transfer date	March 19, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	No
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	6.1
RMSE for East Position (<4.0 cm)	5.4
RMSE for Down Position (<8.0 cm)	1.1
Boresight correction stdev (<0.001deg)	0.000312
IMU attitude correction stdev (<0.001deg)	0.001893
GPS position stdev (<0.01m)	0.0093
Minimum % overlap (>25)	37.72%
Ave point cloud density per sq.m. (>2.0)	3.05
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	103
Maximum Height	180.33 m
Minimum Height	39.57 m
Classification (# of points)	
Ground	45,668,783
Low vegetation	55,842,716
Medium vegetation	48,568,491
High vegetation	46,041,084
Building	4,125,980
Orthophoto	No
Processed by	Engr. Angelo Carlo Bongat, Engr. Harmond Santos, Engr. Carlyn Ann Ibañez

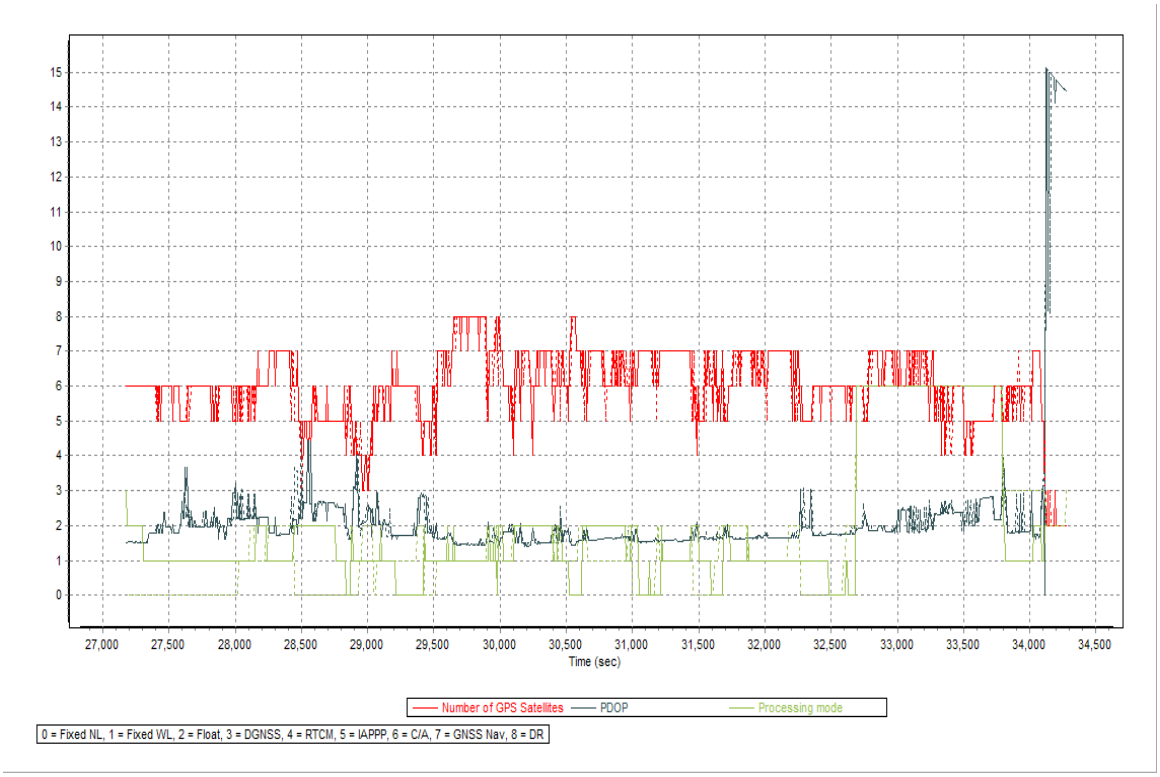


Figure A-8.61 Solution Status

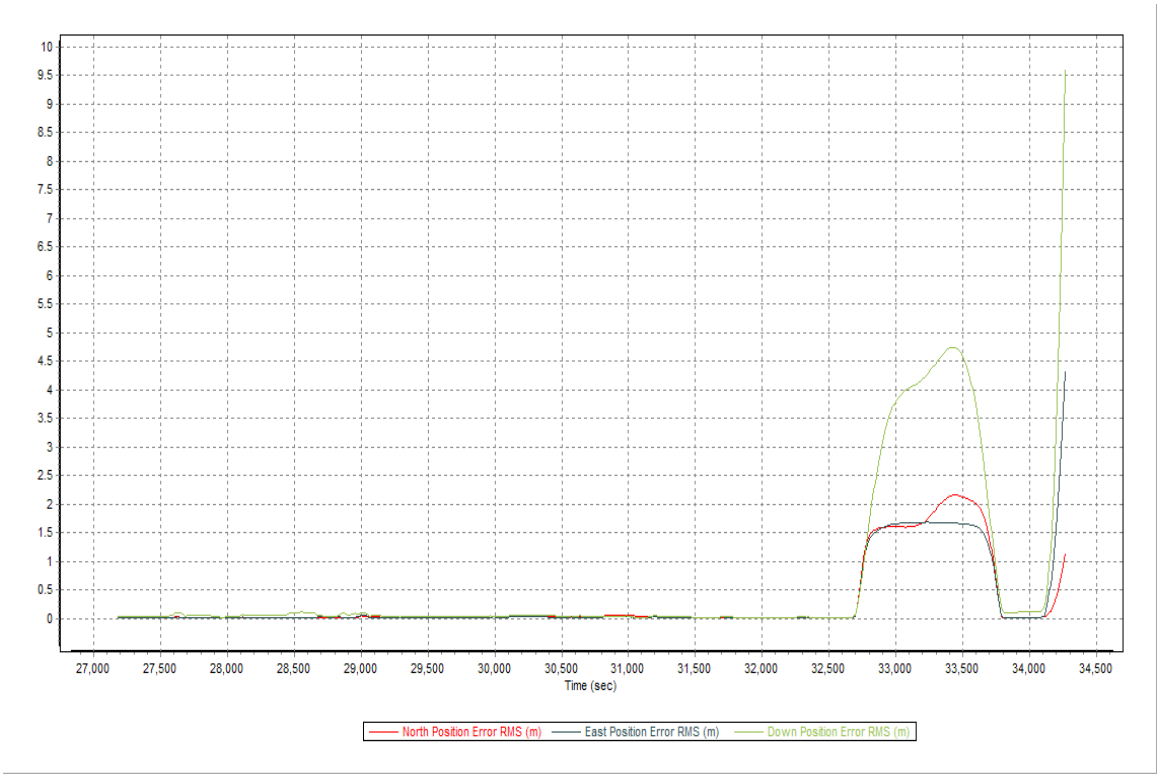


Figure A-8.62 Smoothed Performance Metric Parameters

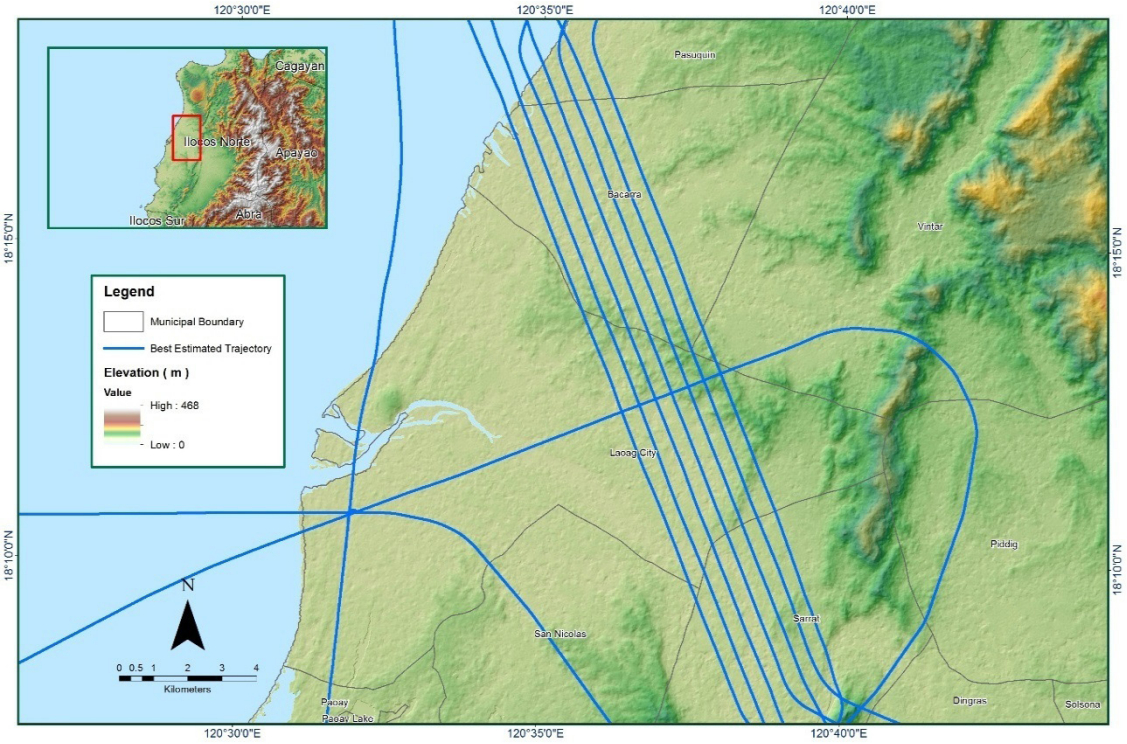


Figure A-8.63 Best Estimated Trajectory

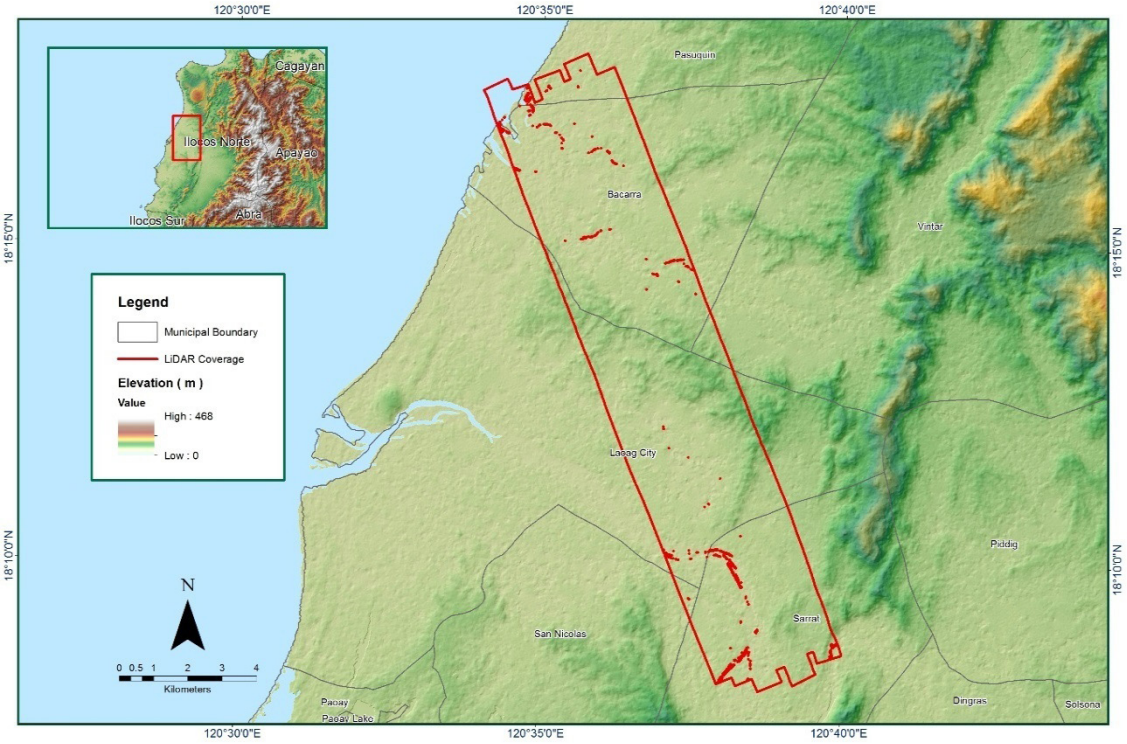


Figure A-8.64 Coverage of LiDAR data

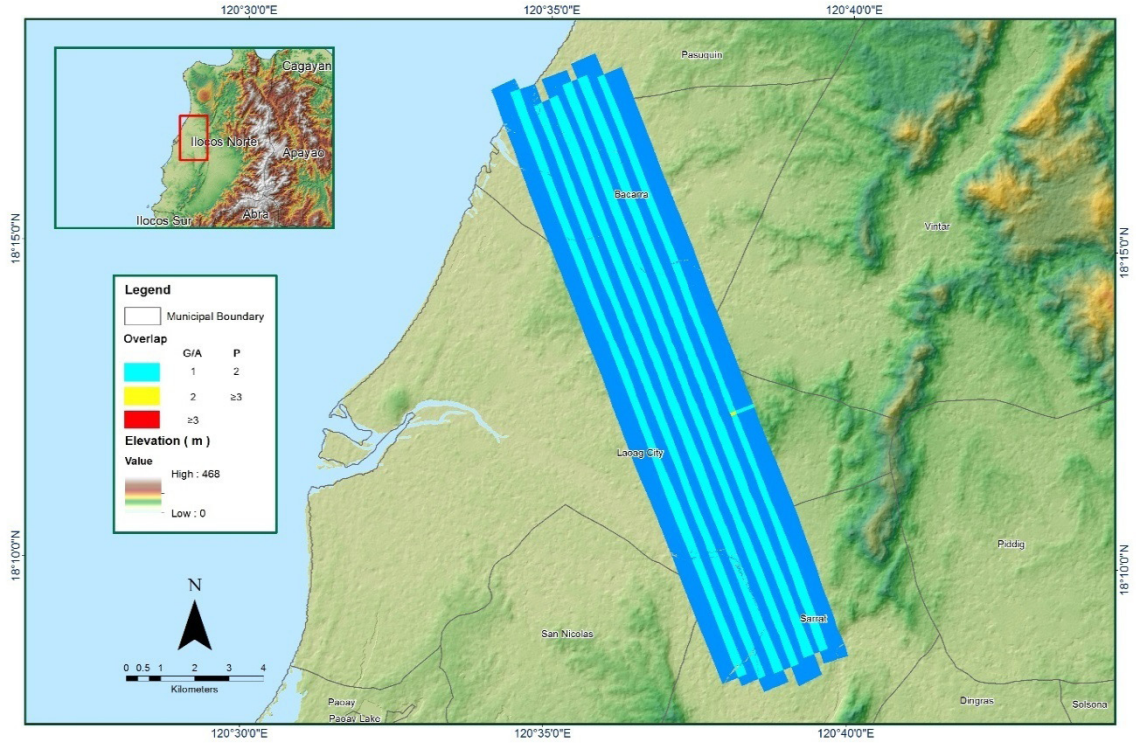


Figure A-8.65 Image of data overlap

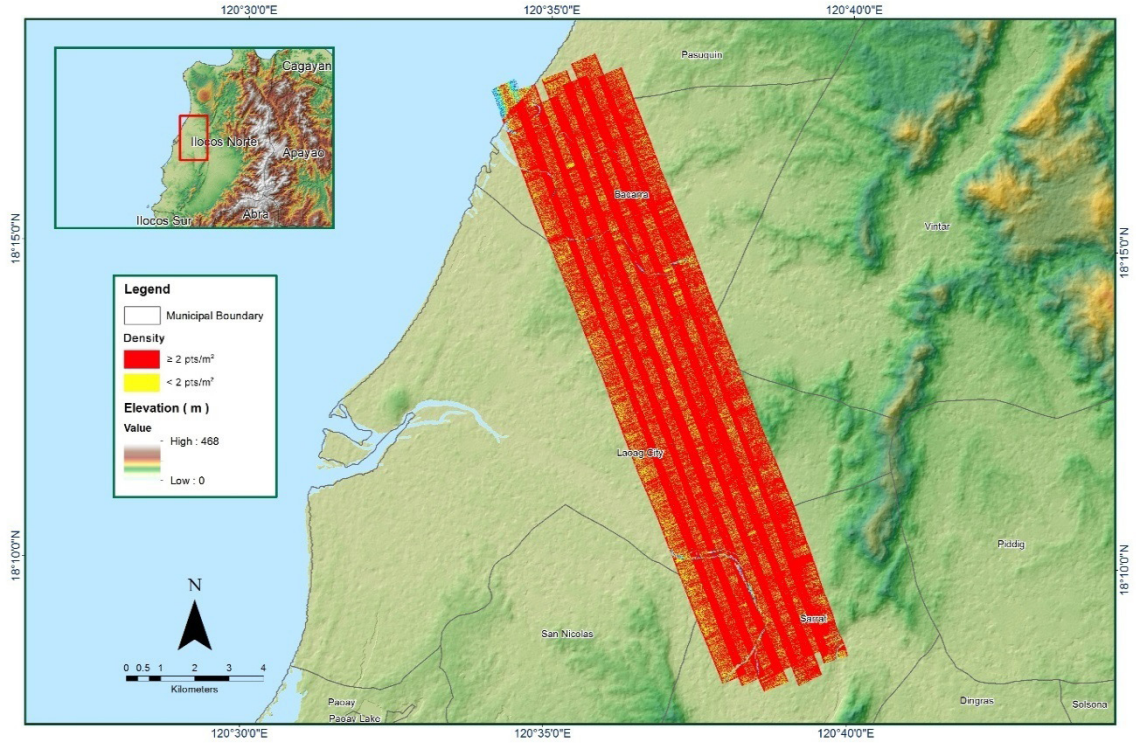


Figure A-8.66 Density map of merged LiDAR data

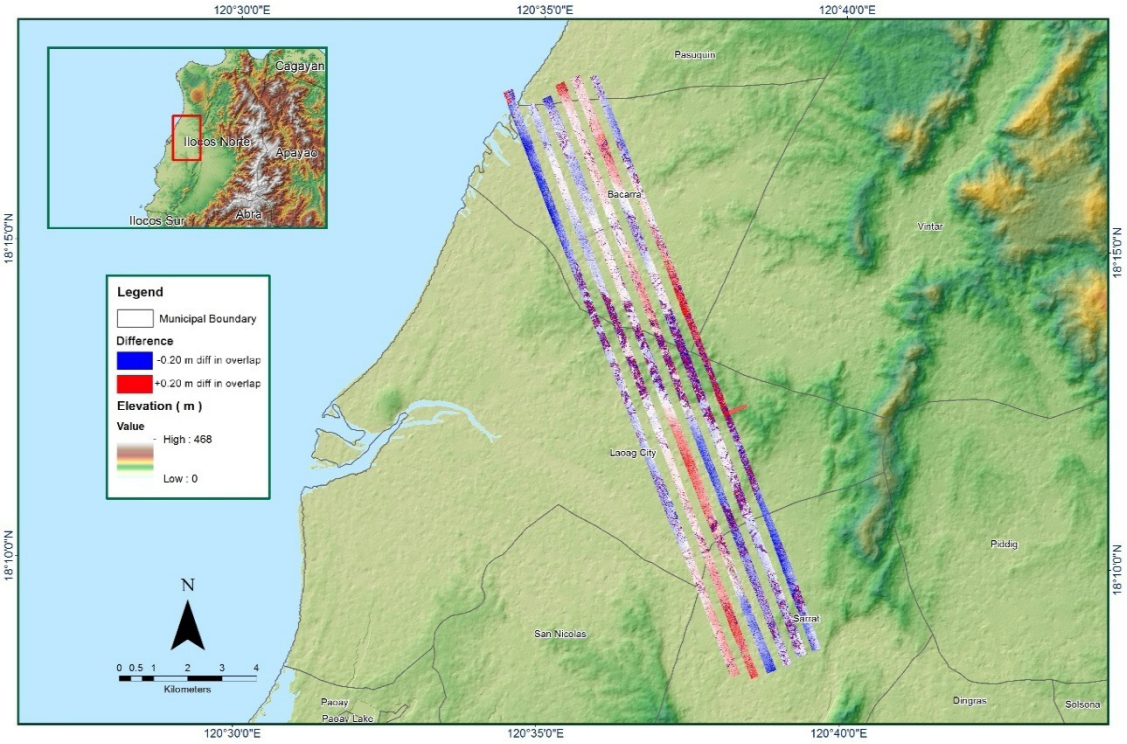


Figure A-8.67 Elevation difference between flight lines

Table A-8.11. Mission Summary Report for Mission Blk5EF

Flight Area	**Ilocos**
Mission Name	**Blk5EF**
Inclusive Flights	7088G
Range data size	21.2 GB
Base data size	11.2 MB
POS	211 MB
Image	N/A
Transfer date	April 25, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.3
RMSE for East Position (<4.0 cm)	1.4
RMSE for Down Position (<8.0 cm)	2.9
Boresight correction stdev (<0.001deg)	0.000312
IMU attitude correction stdev (<0.001deg)	0.0001893
GPS position stdev (<0.01m)	0.0093
Minimum % overlap (>25)	50.57%
Ave point cloud density per sq.m. (>2.0)	3.56
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	222
Maximum Height	349.30 m
Minimum Height	39.75 m
Classification (# of points)	
Ground	129,214,820
Low vegetation	316,462,897
Medium vegetation	240953904
High vegetation	257358666
Building	24520904
Orthophoto	No
Processed by	Engr. Irish Cortez, Engr. Harmond Santos, Engr. Roa Shalemar Redo

Figure A-8.68 Solution Status

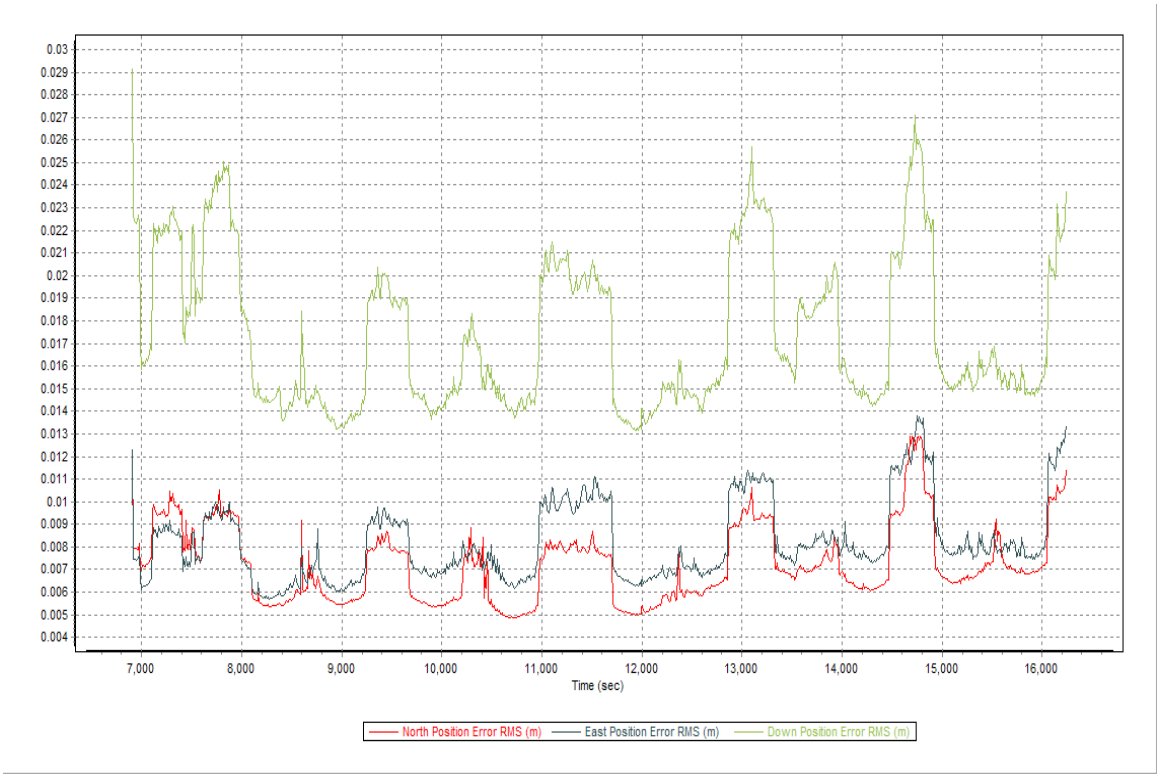


Figure A-8.69 Smoothed Performance Metric Parameters

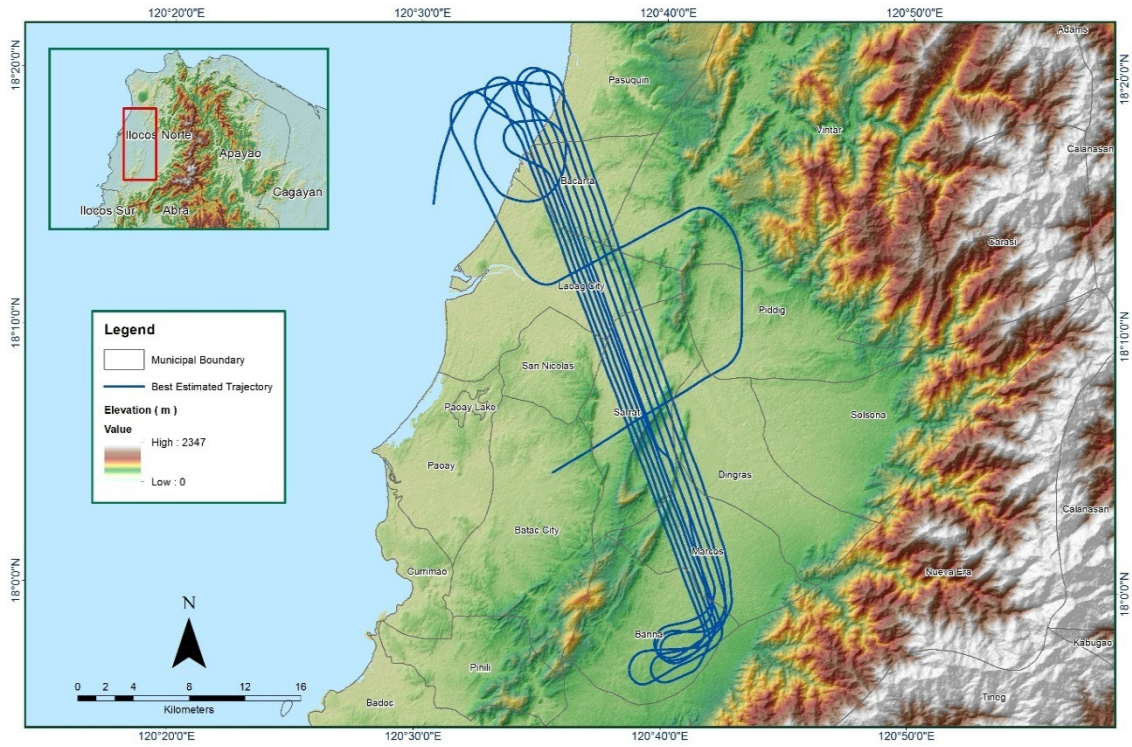


Figure A-8.70 Best Estimated Trajectory

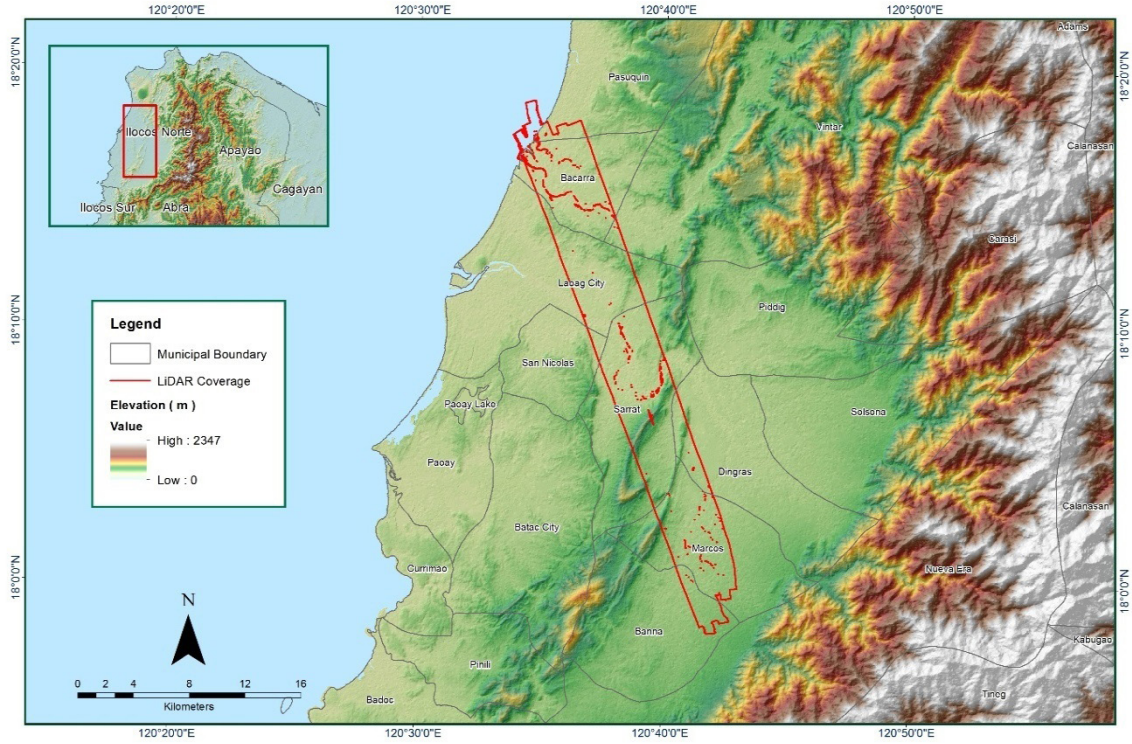


Figure A-8.71 Coverage of LiDAR data

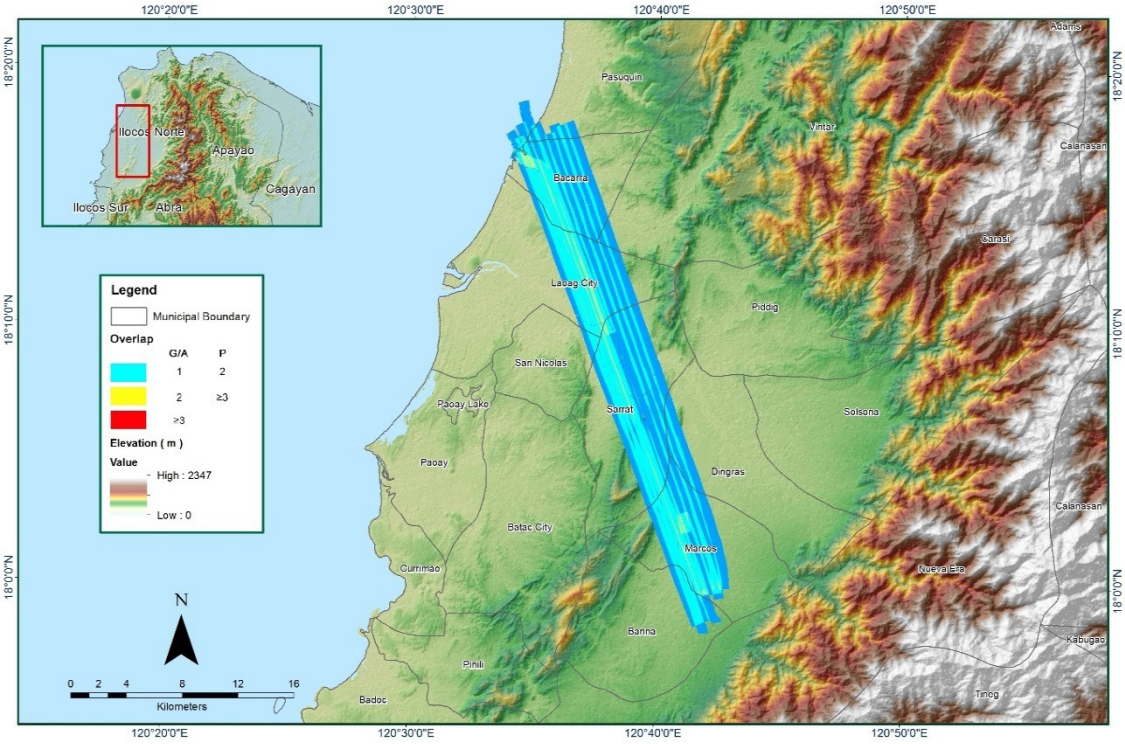


Figure A-8.72 Image of data overlap

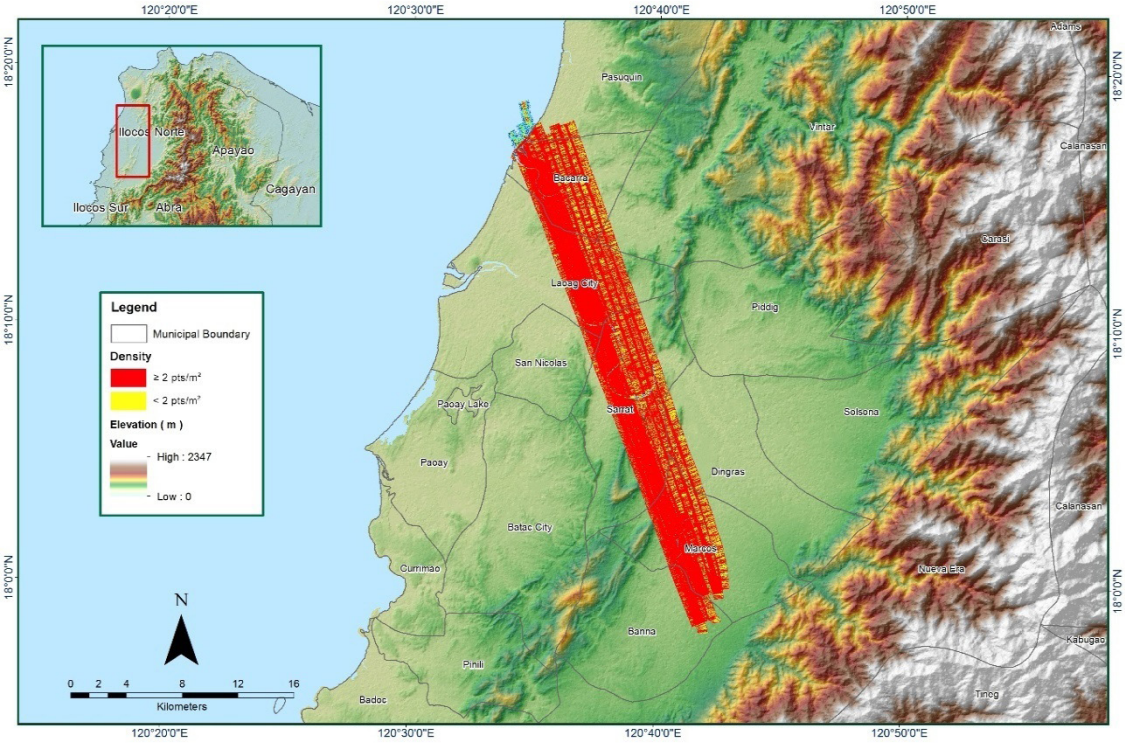


Figure A-8.73 Density map of merged LiDAR data

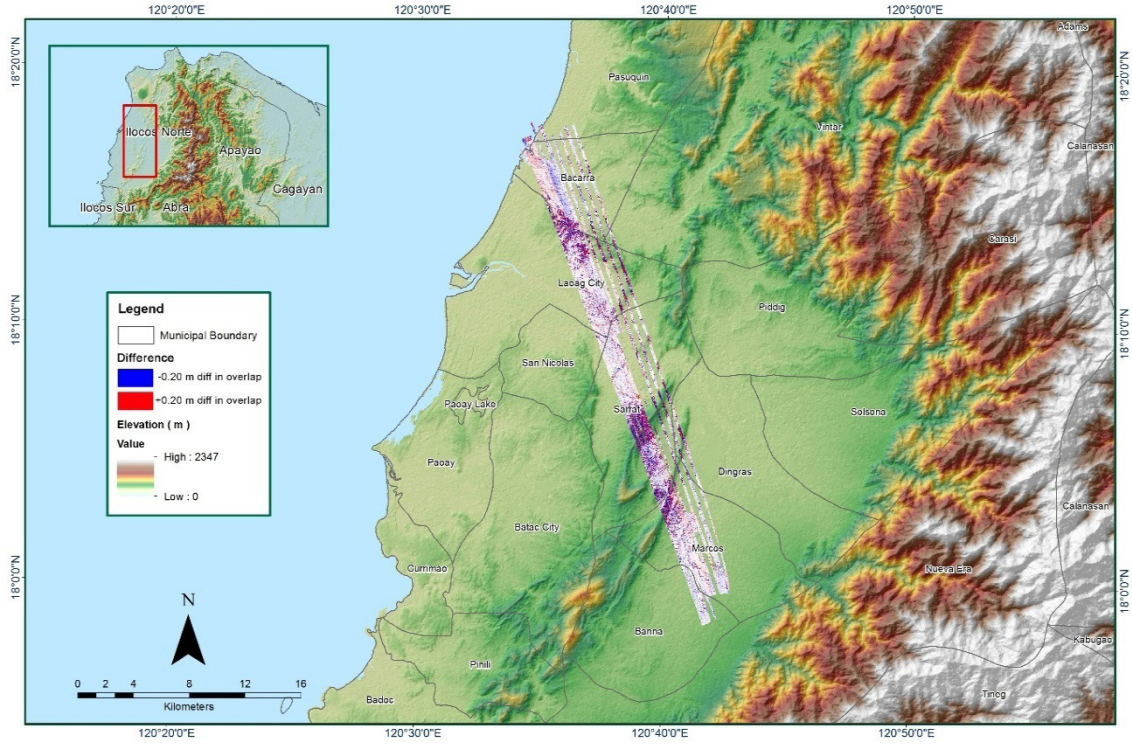


Figure A-8.74 Elevation difference between flight lines

Table A-8.12. Mission Summary Report for Mission Blk5EFadditional

Flight Area	**Ilocos**
Mission Name	**Blk5EFadditional**
Inclusive Flights	7087G
Range data size	26.2 GB
Base data size	12.3 MB
POS	247 MB
Image	N/A
Transfer date	April 25, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	4.6
RMSE for East Position (<4.0 cm)	7.7
RMSE for Down Position (<8.0 cm)	8.4
Boresight correction stdev (<0.001deg)	0.000353
IMU attitude correction stdev (<0.001deg)	0.001157
GPS position stdev (<0.01m)	0.0031
Minimum % overlap (>25)	32.82%
Ave point cloud density per sq.m. (>2.0)	3.09
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	222
Maximum Height	466.06 m
Minimum Height	39.20 m
Classification (# of points)	
Ground	83,228,672
Low vegetation	90,581,648
Medium vegetation	104,895,186
High vegetation	167,061,020
Building	8,465,630
Orthophoto	No
Processed by	Victoria Rejuso, Aljon Rie Araneta, Engr. Ma. Ailyn Olanda

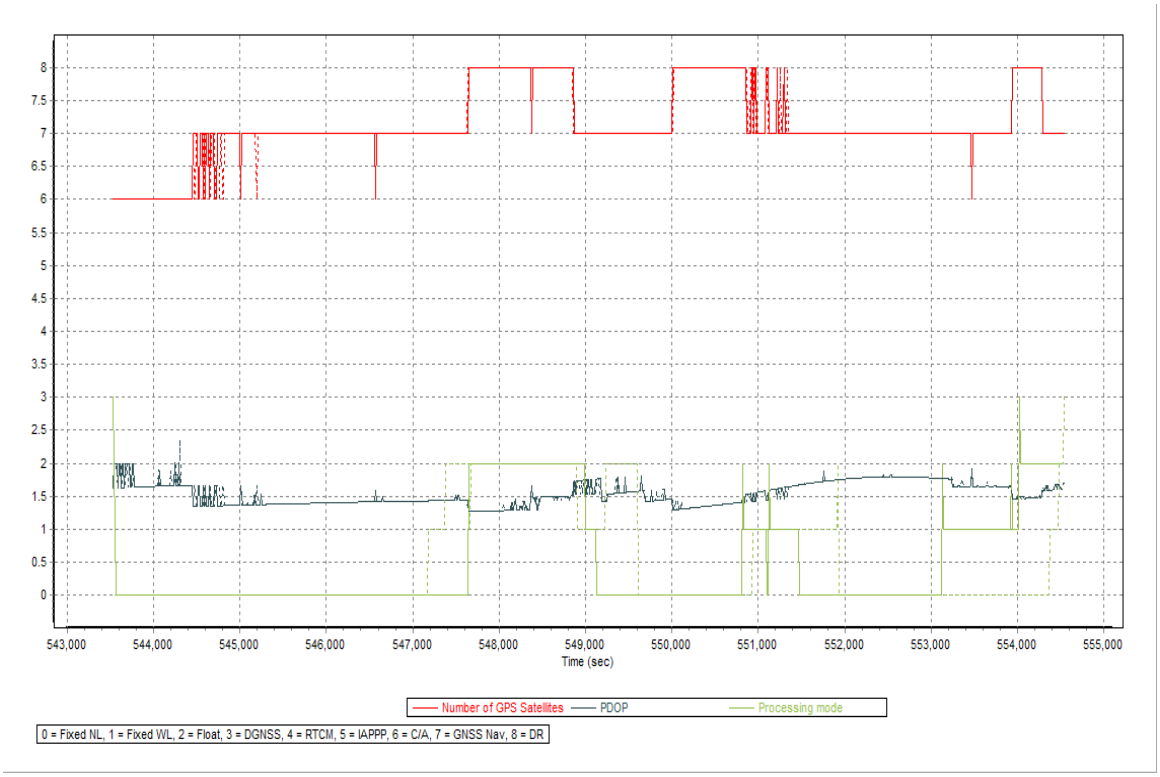


Figure A-8.75 Solution Status

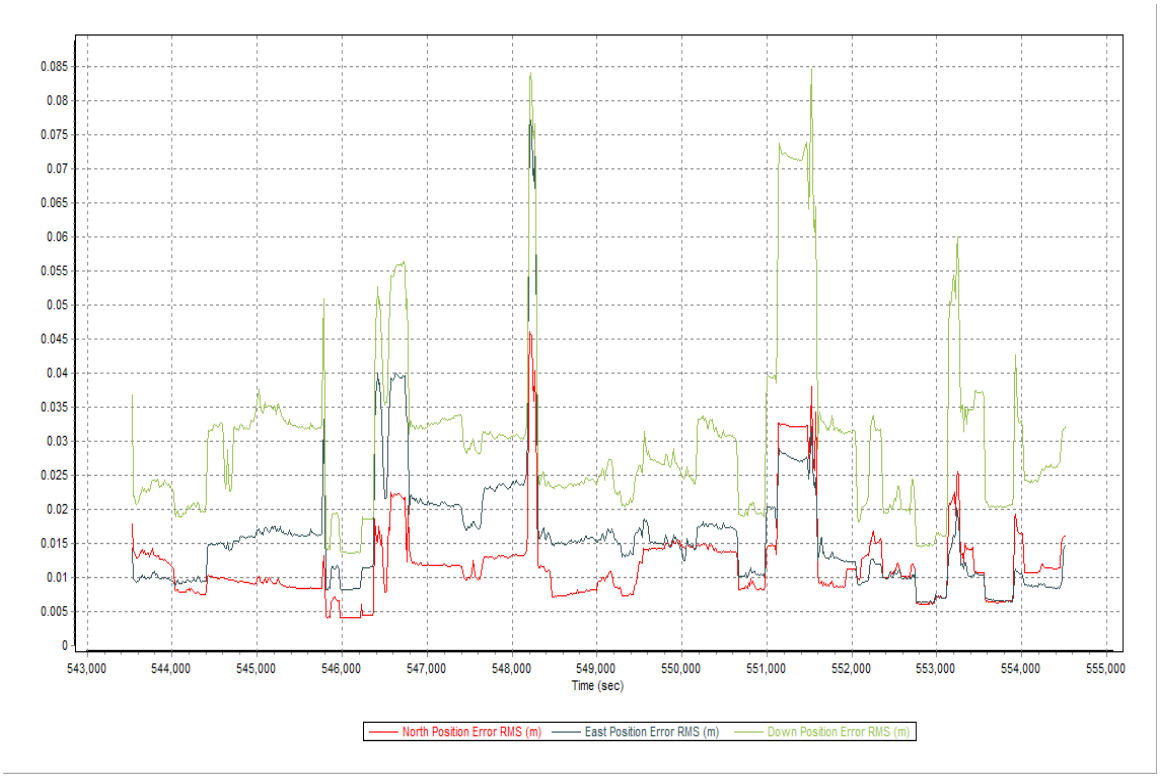


Figure A-8.76 Smoothed Performance Metric Parameters

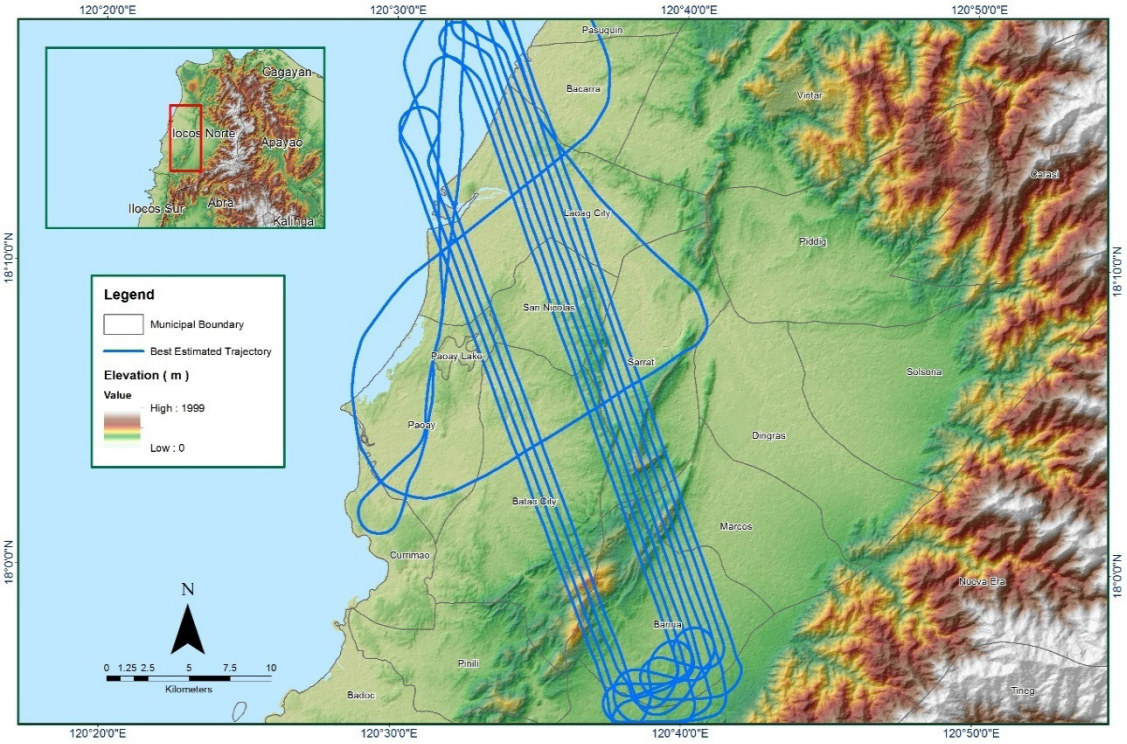


Figure A-8.77 Best Estimated Trajectory

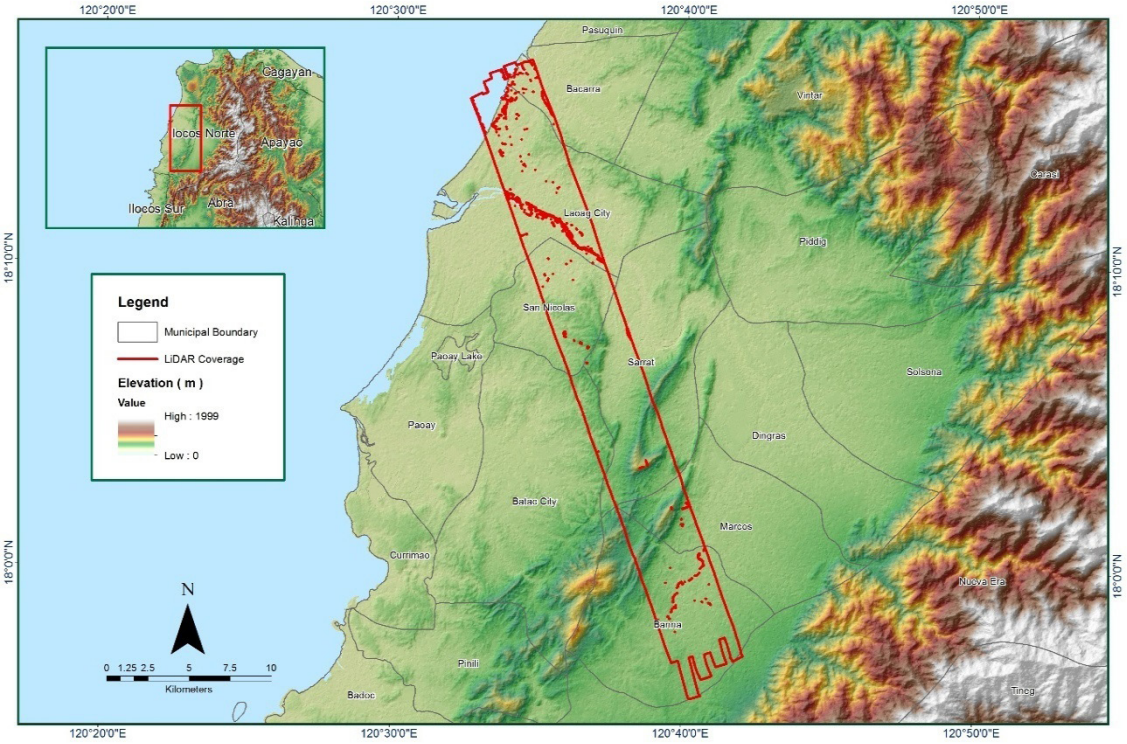


Figure A-8.78 Coverage of LiDAR data

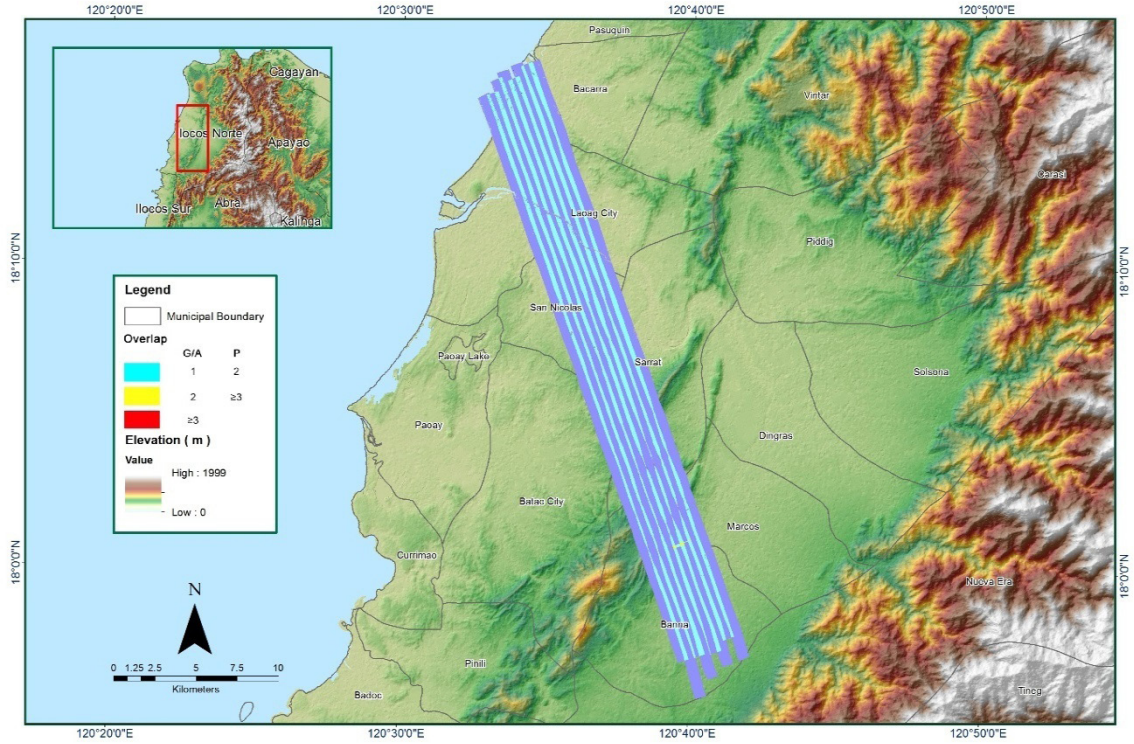


Figure A-8.79 Image of data overlap

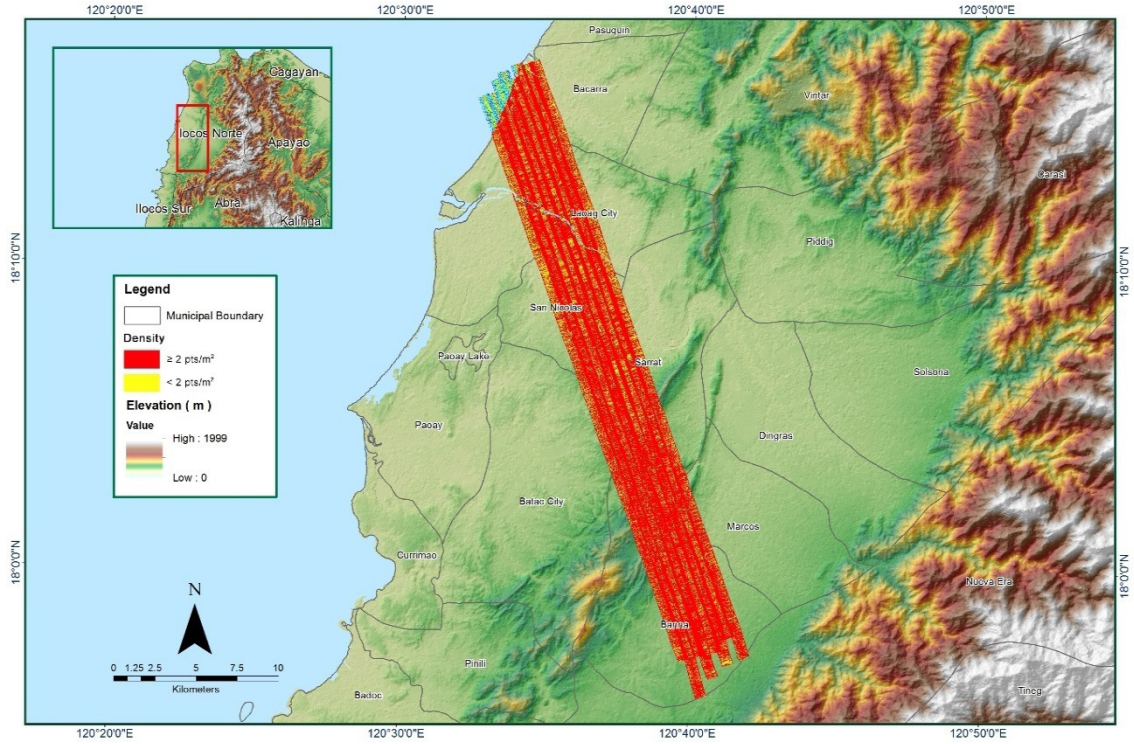


Figure A-8.80 Density map of merged LiDAR data

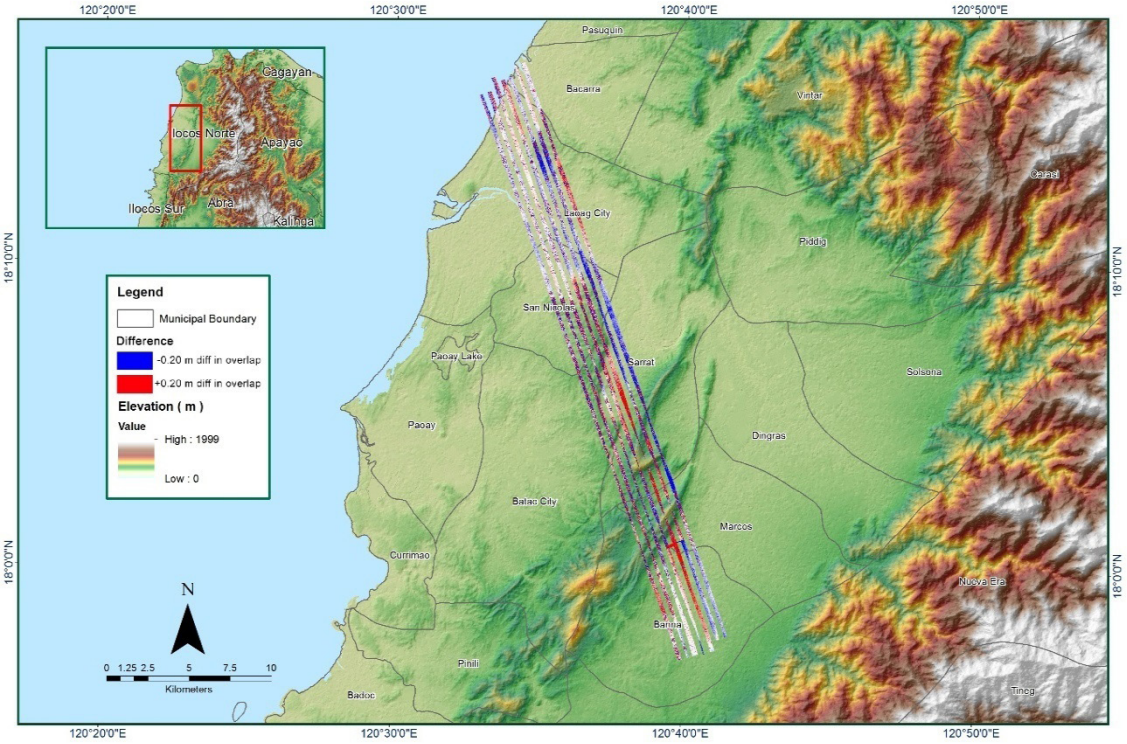


Figure A-8.81 Elevation difference between flight lines

Table A-8.12. Mission Summary Report for Mission Blk5G

Flight Area	**Oriental Mindoro**
Mission Name	**Blk05_G**
Inclusive Flights	7085G
Range data size	13.9 GB
Base data size	11.6 MB
POS	158 MB
Image	N/A
Transfer date	April 25, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	3.1
RMSE for East Position (<4.0 cm)	3.7
RMSE for Down Position (<8.0 cm)	9.2
Boresight correction stdev (<0.001deg)	0.000673
IMU attitude correction stdev (<0.001deg)	0.000756
GPS position stdev (<0.01m)	0.0112
Minimum % overlap (>25)	84.28%
Ave point cloud density per sq.m. (>2.0)	5.65
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	176
Maximum Height	537.85 m
Minimum Height	38.95 m
Classification (# of points)	
Ground	62,450,922
Low vegetation	62,751,467
Medium vegetation	74,301,334
High vegetation	133,270,609
Building	3,941,158
Orthophoto	No
Processed by	Victoria Rejuso, Engr. Antonio Chua Jr., Engr. Gladys Mae Apat

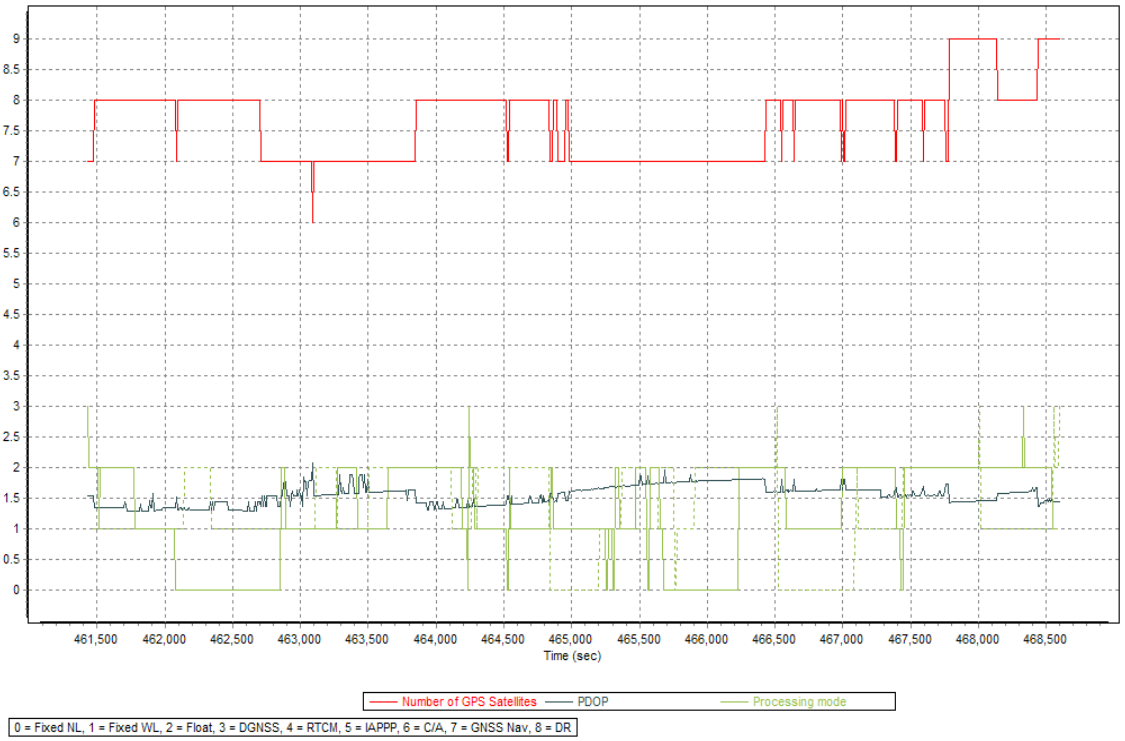


Figure A-8.82 Solution Status

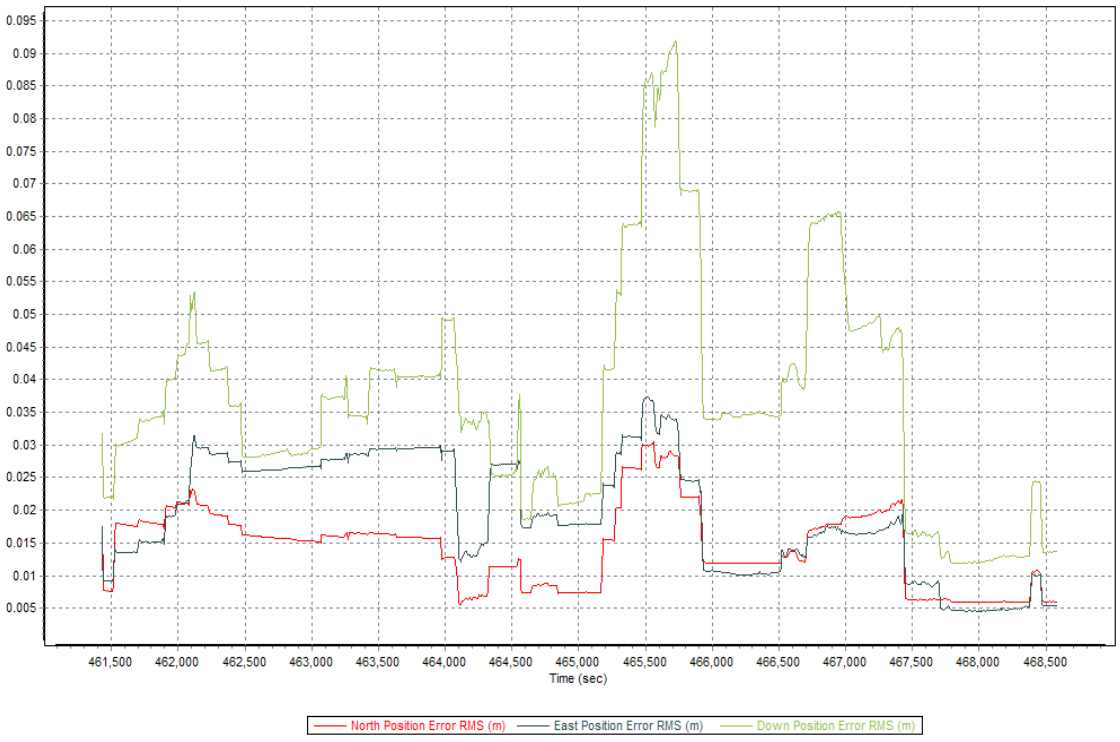


Figure A-8.83 Smoothed Performance Metric Parameters

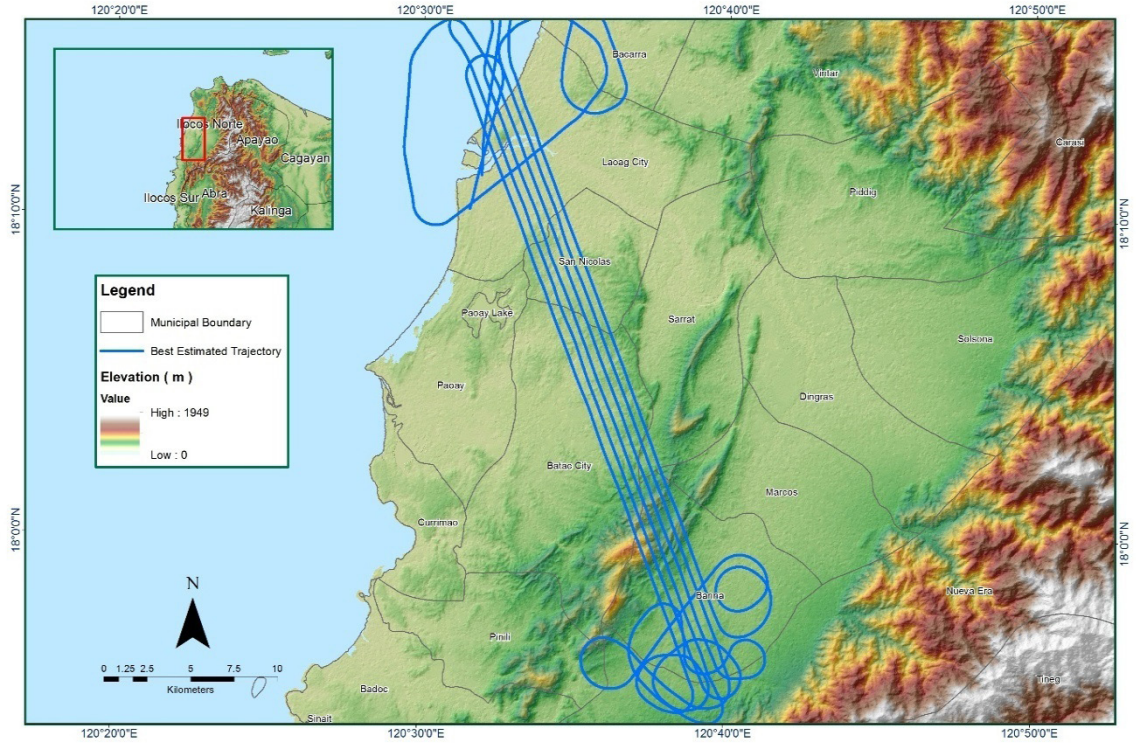


Figure A-8.84 Best Estimated Trajectory

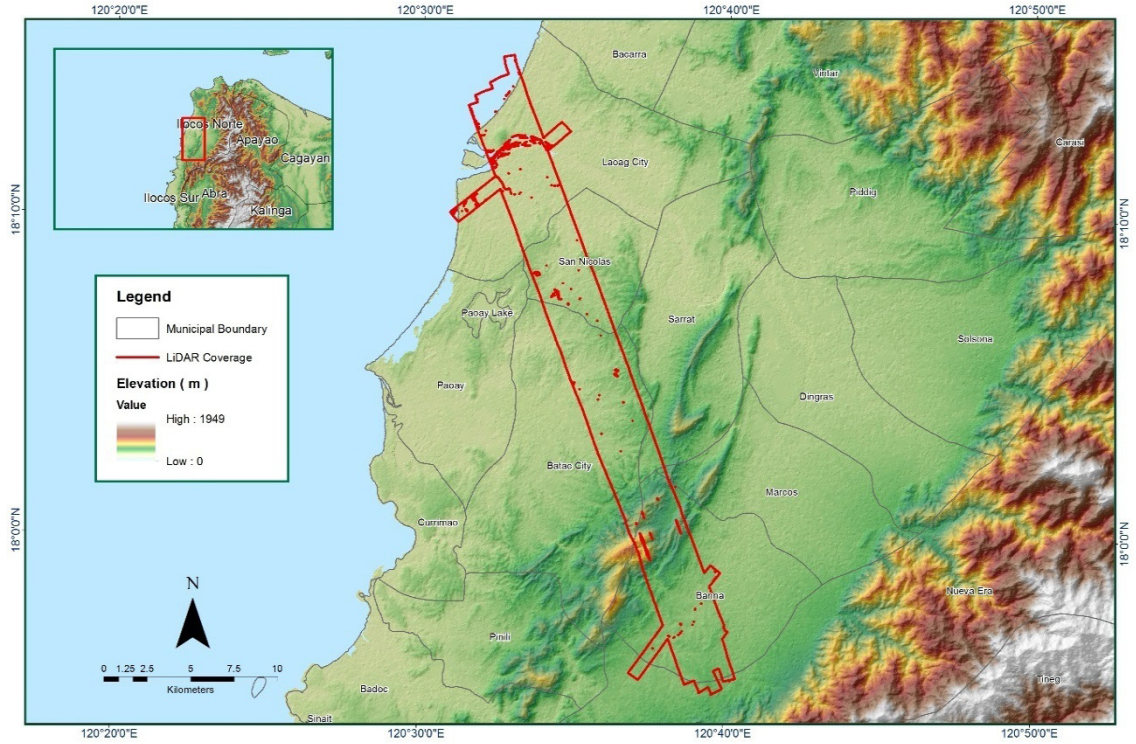


Figure A-8.85 Coverage of LiDAR data

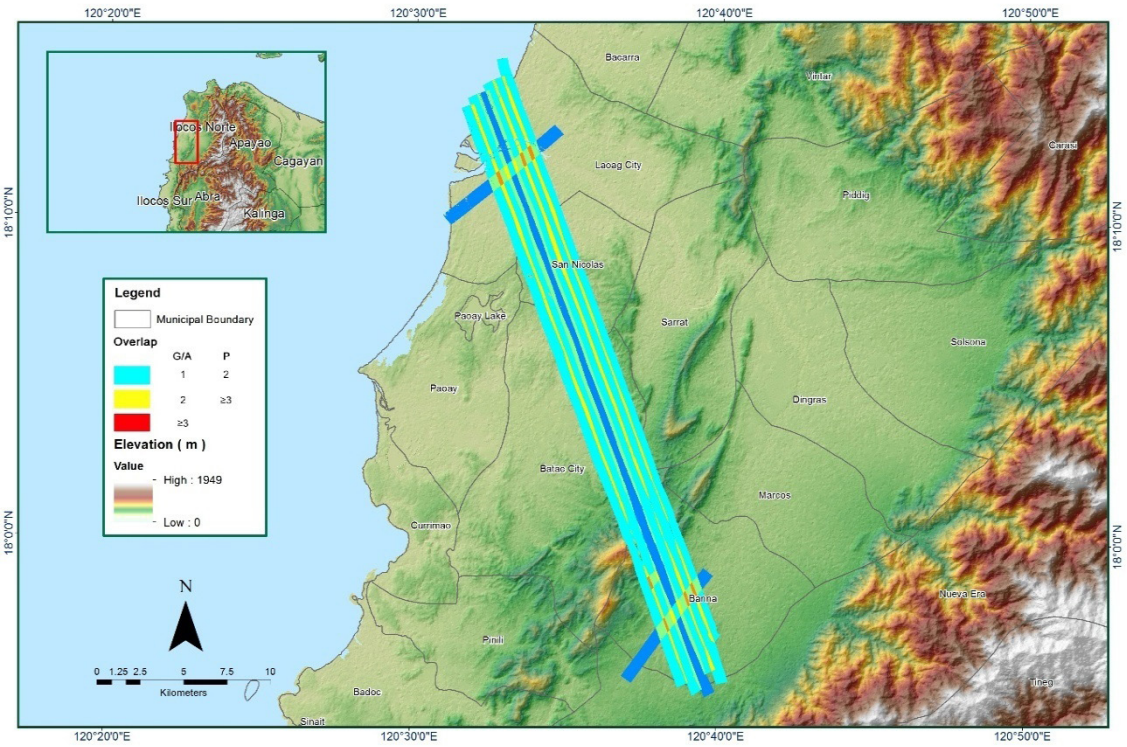


Figure A-8.86 Image of data overlap

Figure A-8.87 Density map of merged LiDAR data

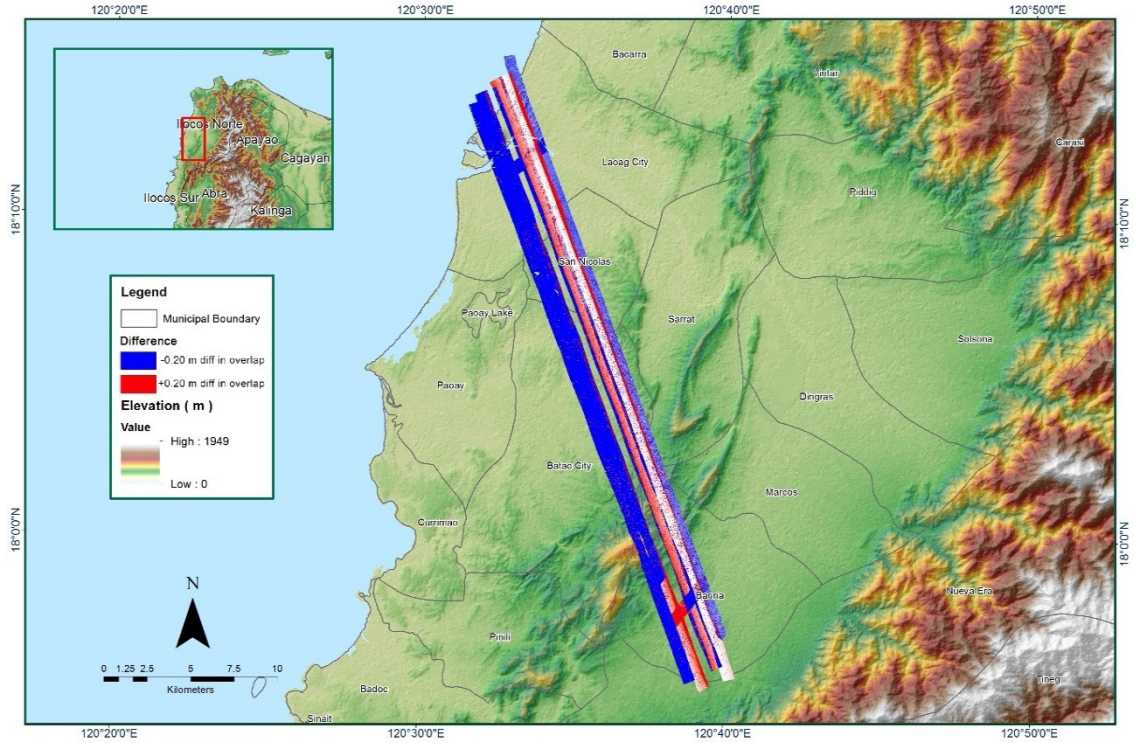


Figure A-8.88 Elevation difference between flight lines

Annex 9. Bacarra Model Basin Parameters

Table A-9.1. Bacarra 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 (cms)	Recession Constant	Threshold Type	Ratio to Peak
W1000	2.7877	35	0	3.0852	12.8	Discharge	0.033832	0.65333	Ratio to Peak	0.741
W1010	5.2584	37.462	0	8.4806	16.555	Discharge	0.43405	0.4821	Ratio to Peak	0.99415
W1020	19.152	35	0	0.65576	4.4248	Discharge	0.13949	0.78908	Ratio to Peak	0.70079
W1030	8.0186	56.291	0	0.51024	2.3061	Discharge	0.20937	0.81117	Ratio to Peak	0.46029
W1040	5.9319	37.512	0	2.2814	10.326	Discharge	0.14672	0.85395	Ratio to Peak	1
W1050	5.157	35.188	0	6.5718	5.8161	Discharge	0.27554	0.78724	Ratio to Peak	0.71835
W1060	29.593	68.823	0	8.0652	16.045	Discharge	0.004118	0.66667	Ratio to Peak	0.494
W1070	2.8734	42.442	0	7.2465	6.1565	Discharge	0.097116	0.86209	Ratio to Peak	0.70753
W1080	11.75372	35	0	1.9074	11.673	Discharge	0.88762	1	Ratio to Peak	0.52
W1090	3.4179	46.806	0	0.50207	1.0377	Discharge	0.11103	0.81086	Ratio to Peak	0.42885
W1100	2.2456	35	0	3.5409	4.7951	Discharge	0.44394	0.77134	Ratio to Peak	0.32274
W560	5.3086	46.295	0	0.75282	5.2183	Discharge	0.37724	0.48	Ratio to Peak	0.29047
W570	7.4964	35	0	3.0602	20.978	Discharge	0.55265	1	Ratio to Peak	1
W580	1.7371	54.687	0	9.0911	6.153	Discharge	0.27648	0.80484	Ratio to Peak	0.69317
W590	3.0523	68.104	0	1.3497	4.062	Discharge	0.013326	0.52527	Ratio to Peak	0.23983
W600	5.7596	35	0	7.6004	6.9371	Discharge	0.12286	0.76186	Ratio to Peak	0.80601

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 (cms)	Recession Constant	Threshold Type	Ratio to Peak
W610	8.9397	40.038	0	0.16612	0.75104	Discharge	0.10392	1	Ratio to Peak	0.72032
W620	2.5972	41.844	0	4.8755	6.6519	Discharge	0.35123	0.69149	Ratio to Peak	0.55096
W630	4.9867	38.96	0	1.5098	4.6611	Discharge	0.12263	0.75295	Ratio to Peak	0.43077
W640	2.1761	43.694	0	2.8166	8.0397	Discharge	0.66207	0.432	Ratio to Peak	0.49774
W650	29.684	45.301	0	0.9968	10.483	Discharge	0.014838	1	Ratio to Peak	0.49895
W660	24.664	35	0	1.2019	4.8465	Discharge	0.23558	0.81006	Ratio to Peak	0.72057
W670	8.1633	36.416	0	3.8195	11.634	Discharge	0.041128	1	Ratio to Peak	0.49401
W680	3.0712	39.588	0	0.97284	6.4074	Discharge	0.459171	0.72	Ratio to Peak	0.49476
W690	6.9578	45.982	0	0.50037	1.4067	Discharge	0.36262	0.81047	Ratio to Peak	0.47284
W700	14.214	52.339	0	0.72581	5.1243	Discharge	0.05809	0.81178	Ratio to Peak	0.69016
W710	6.1472	39.989	0	2.577	7.9137	Discharge	0.095495	0.969	Ratio to Peak	0.6702
W720	2.6446	64.211	0	4.5736	9.668	Discharge	0.040506	0.76946	Ratio to Peak	0.66667
W730	22.728	42.36	0	0.29196	6.565	Discharge	0.30314	0.79125	Ratio to Peak	0.6927
W740	7.5412	35	0	2.3159	7.3025	Discharge	0.19618	1	Ratio to Peak	0.33097
W750	4.0758	41.721	0	0.33316	1.538	Discharge	0.204	0.81045	Ratio to Peak	0.46889
W760	2.602	37.364	0	1.1388	7.8302	Discharge	0.12732	0.52594	Ratio to Peak	0.51629
W770	27.586	35	0	1.2927	7.6996	Discharge	0.12554	1	Ratio to Peak	0.32226
W780	9.2194	35.065	0	2.4103	10.159	Discharge	0.25782	1	Ratio to Peak	0.31778

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 (cms)	Recession Constant	Threshold Type	Ratio to Peak
W790	1.0329	54.723	0	0.14714	0.95807	Discharge	0.093754	0.80326	Ratio to Peak	0.32124
W800	15.351	81.7	0	0.50794	1.5592	Discharge	0.038824	0.80343	Ratio to Peak	0.33097
W810	1.3882	53.812	0	3.7685	7.3229	Discharge	0.25599	0.53595	Ratio to Peak	0.53468
W820	28.99	41.545	0	2.0383	6.4588	Discharge	0.1453	1	Ratio to Peak	0.55672
W830	5.3606	40.43	0	2.8983	6.19	Discharge	0.2306	0.52267	Ratio to Peak	0.50582
W840	4.5764	39.578	0	3.2564	7.7193	Discharge	0.082473	0.7878	Ratio to Peak	0.67951
W850	3.2376	40.25	0	0.82516	3.7582	Discharge	0.095164	0.784	Ratio to Peak	0.31454
W860	4.8053	42.833	0	0.72886	7.4446	Discharge	0.11569	0.52267	Ratio to Peak	0.33889
W870	5.1442	43.07	0	1.6427	7.7614	Discharge	0.18539	0.76832	Ratio to Peak	0.56447
W880	2.2429	60.922	0	3.2227	5.9486	Discharge	0.032218	1	Ratio to Peak	0.46871
W890	37.449	35	0	1.3689	4.2335	Discharge	0.40432	1	Ratio to Peak	0.32275
W900	3.1052	38.307	0	9.0929	11.364	Discharge	0.001193	0.76832	Ratio to Peak	0.73566
W910	3.2151	69.388	0	3.1034	4.3826	Discharge	0.11548	0.76832	Ratio to Peak	0.32433
W920	3.9905	44.747	0	2.6672	7.909	Discharge	0.10494	0.53584	Ratio to Peak	0.48582
W930	8.2582	35	0	2.3428	6.2911	Discharge	0.12041	0.80569	Ratio to Peak	0.65925
W940	5.1406	35	0	2.9936	8.0757	Discharge	0.10615	0.76832	Ratio to Peak	0.65982
W950	12.348	36.353	0	0.26124	0.8745	Discharge	0.20883	0.80758	Ratio to Peak	0.46709
W960	14.858	52.647	0	0.54784	1.122	Discharge	0.076699	1	Ratio to Peak	0.32475

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 (cms)	Recession Constant	Threshold Type	Ratio to Peak
W970	3.1565	35	0	11.028	22.606	Discharge	0.247495	0.80461	Ratio to Peak	1
W980	3.9396	38.666	0	0.66874	6.2713	Discharge	0.19835	0.76832	Ratio to Peak	0.44279
W990	7.0109	37.423	0	6.2066	6.2931	Discharge	0.25403	0.78489	Ratio to Peak	0.64668

Annex 10. Bacarra Model Reach Parameters

Table A-10.1. Bacarra 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	3831.9	0.002945	0.010044	Trapezoid	21.267	1
R120	Automatic Fixed Interval	2536.5	0.004541	0.006667	Trapezoid	31.7	1
R150	Automatic Fixed Interval	1991.4	0.010764	0.010135	Trapezoid	12.26	1
R160	Automatic Fixed Interval	2409.9	0.004145	0.006667	Trapezoid	69	1
R170	Automatic Fixed Interval	7626	0.006236	0.009991	Trapezoid	113.6	1
R210	Automatic Fixed Interval	4153.6	0.002322	0.0098	Trapezoid	24.6	1
R230	Automatic Fixed Interval	2651.8	0.042105	0.010034	Trapezoid	78.067	1
R250	Automatic Fixed Interval	2851.4	0.031365	0.009957	Trapezoid	25.333	1
R260	Automatic Fixed Interval	1988.1	0.0001	0.010047	Trapezoid	50.1	1
R290	Automatic Fixed Interval	3770.9	0.002633	0.0098	Trapezoid	31.1	1
R30	Automatic Fixed Interval	1100.1	0.002932	0.015	Trapezoid	34.867	1
R300	Automatic Fixed Interval	4231.3	0.037466	0.014177	Trapezoid	94.967	1
R310	Automatic Fixed Interval	1637.5	0.079126	0.010036	Trapezoid	34.367	1
R320	Automatic Fixed Interval	427.99	0.0001	0.010048	Trapezoid	40	1
R340	Automatic Fixed Interval	3039.2	0.02404	0.0098	Trapezoid	29.567	1
R370	Automatic Fixed Interval	5828.5	0.006621	0.0098	Trapezoid	101.7	1
Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
R380	Automatic Fixed Interval	2985.6	0.00455	0.006667	Trapezoid	56.9	1
R390	Automatic Fixed Interval	5005.9	0.017326	0.009779	Trapezoid	126.6667	1
R400	Automatic Fixed Interval	2647.1	0.005727	0.01003	Trapezoid	96.333	1
R410	Automatic Fixed Interval	1272.8	0.0001	0.010047	Trapezoid	79.233	1

R430	Automatic Fixed Interval	5380.7	0.003368	0.0098	Trapezoid	64.2	1
R480	Automatic Fixed Interval	4880.6	0.028357	0.010025	Trapezoid	56.3	1
R490	Automatic Fixed Interval	701.13	0.020912	0.015	Trapezoid	86.9	1
R50	Automatic Fixed Interval	2969.8	0.003936	0.01	Trapezoid	44.933	1
R510	Automatic Fixed Interval	5979.4	0.002057	0.0098	Trapezoid	24.167	1
R540	Automatic Fixed Interval	16786	0.0001	0.01	Trapezoid	178	1
R80	Automatic Fixed Interval	424.26	0.0001	0.01005	Trapezoid	264.6667	1

Annex 11. Bacarra Field Validation Points

Table A-11.1. Bacarra Field Validation Points

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error (m)	Event/Date	Rain Return/ Scenario
	Lat	Long					
1	18.274759	120.609849	0.140	0.914	0.600	Igme/ July 24-28, 2008	5-Year
2	18.264605	120.586189	0.080	0.914	0.696	Igme/ July 24-28, 2008	5-Year
3	18.25382	120.617466	0.120	0.610	0.240	Igme/ July 24-28, 2008	5-Year
4	18.25266	120.617054	0.240	0.457	0.047	Igme/ July 24-28, 2008	5-Year
5	18.251599	120.617046	0.670	0.305	0.133	Igme/ July 24-28, 2008	5-Year
6	18.253347	120.617001	0.400	0.305	0.009	Igme/ July 24-28, 2008	5-Year
7	18.255979	120.606297	0.550	0.610	0.004	Igme/ July 24-28, 2008	5-Year
8	18.255749	120.606594	0.170	0.457	0.082	Igme/ July 24-28, 2008	5-Year
9	18.256364	120.60699	0.080	0.305	0.051	Igme/ July 24-28, 2008	5-Year
10	18.255836	120.607522	0.300	0.305	0.000	Igme/ July 24-28, 2008	5-Year
11	18.257424	120.608209	0.820	0.610	0.044	Igme/ July 24-28, 2008	5-Year
12	18.257153	120.608469	0.120	0.305	0.034	Igme/ July 24-28, 2008	5-Year
13	18.258542	120.607293	0.320	0.305	0.000	Igme/ July 24-28, 2008	5-Year
14	18.257824	120.60752	0.030	0.305	0.076	Igme/ July 24-28, 2008	5-Year
15	18.254242	120.611507	0.140	0.914	0.600	Igme/ July 24-28, 2008	5-Year
16	18.254247	120.610919	0.330	0.914	0.342	Igme/ July 24-28, 2008	5-Year
17	18.253779	120.6098	0.490	0.914	0.180	Igme/ July 24-28, 2008	5-Year
18	18.254135	120.612484	0.120	0.914	0.631	Igme/ July 24-28, 2008	5-Year
19	18.25397	120.611686	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
20	18.253387	120.610944	0.810	0.914	0.011	Igme/ July 24-28, 2008	5-Year
21	18.254772	120.609912	1.090	0.762	0.108	Igme/ July 24-28, 2008	5-Year
22	18.248974	120.620246	0.030	0.610	0.336	Igme/ July 24-28, 2008	5-Year
23	18.26558	120.587676	0.810	0.610	0.040	Igme/ July 24-28, 2008	5-Year
24	18.255047	120.610638	0.210	0.305	0.009	Igme/ July 24-28, 2008	5-Year
25	18.255112	120.614146	0.170	0.914	0.554	Igme/ July 24-28, 2008	5-Year
26	18.254451	120.61293	0.600	0.914	0.099	Igme/ July 24-28, 2008	5-Year
27	18.254343	120.611893	1.080	0.914	0.027	Igme/ July 24-28, 2008	5-Year
28	18.250335	120.617264	0.040	0.610	0.324	Igme/ July 24-28, 2008	5-Year
29	18.2541	120.612534	0.290	0.610	0.102	Igme/ July 24-28, 2008	5-Year
30	18.248543	120.621152	0.250	0.457	0.043	Igme/ July 24-28, 2008	5-Year
31	18.248743	120.622763	0.210	0.457	0.061	Igme/ July 24-28, 2008	5-Year
32	18.247889	120.622026	0.180	0.305	0.016	Igme/ July 24-28, 2008	5-Year
33	18.273152	120.596927	0.520	0.457	0.004	Igme/ July 24-28, 2008	5-Year
34	18.243402	120.603368	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
35	18.255792	120.606213	0.220	0.914	0.482	Igme/ July 24-28, 2008	5-Year
36	18.244408	120.603555	0.030	0.762	0.536	Igme/ July 24-28, 2008	5-Year
37	18.251358	120.611789	0.030	0.762	0.536	Igme/ July 24-28, 2008	5-Year
38	18.244982	120.603559	0.030	0.610	0.336	Igme/ July 24-28, 2008	5-Year
39	18.255171	120.608109	0.080	0.610	0.280	Igme/ July 24-28, 2008	5-Year
40	18.250863	120.613359	0.350	0.305	0.002	Igme/ July 24-28, 2008	5-Year
41	18.268335	120.586338	0.270	0.025	0.060	Igme/ July 24-28, 2008	5-Year
42	18.251303	120.614141	0.290	0.305	0.000	Igme/ July 24-28, 2008	5-Year

43	18.251064	120.612765	0.240	0.152	0.008	Igme/ July 24-28, 2008	5-Year
44	18.25298	120.607978	0.030	0.152	0.015	Igme/ July 24-28, 2008	5-Year
45	18.253762	120.605507	1.000	0.914	0.007	Igme/ July 24-28, 2008	5-Year
46	18.254205	120.608862	0.250	0.762	0.262	Igme/ July 24-28, 2008	5-Year
47	18.254921	120.605896	0.030	0.762	0.536	Igme/ July 24-28, 2008	5-Year
48	18.253444	120.60873	0.060	0.305	0.060	Igme/ July 24-28, 2008	5-Year
49	18.253858	120.608041	0.210	0.305	0.009	Igme/ July 24-28, 2008	5-Year
50	18.253295	120.607156	0.080	0.305	0.051	Igme/ July 24-28, 2008	5-Year
51	18.254623	120.606688	0.050	0.305	0.065	Igme/ July 24-28, 2008	5-Year
52	18.263126	120.586213	0.120	0.025	0.009	Igme/ July 24-28, 2008	5-Year
53	18.254323	120.605656	1.080	0.305	0.601	Igme/ July 24-28, 2008	5-Year
54	18.254593	120.605465	0.400	0.305	0.009	Igme/ July 24-28, 2008	5-Year
55	18.254165	120.606951	0.040	0.305	0.070	Igme/ July 24-28, 2008	5-Year
56	18.258356	120.604319	0.430	0.914	0.235	Igme/ July 24-28, 2008	5-Year
57	18.258211	120.604715	0.230	0.914	0.468	Igme/ July 24-28, 2008	5-Year
58	18.257443	120.604951	0.040	0.610	0.324	Igme/ July 24-28, 2008	5-Year
59	18.258073	120.604853	0.030	0.610	0.336	Igme/ July 24-28, 2008	5-Year
60	18.242721	120.60373	0.340	0.914	0.330	Igme/ July 24-28, 2008	5-Year
61	18.24513	120.590072	1.080	0.914	0.027	Igme/ July 24-28, 2008	5-Year
62	18.26982	120.584691	0.030	0.025	0.000	Igme/ July 24-28, 2008	5-Year
63	18.245495	120.592701	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
64	18.243799	120.604357	0.170	0.914	0.554	Igme/ July 24-28, 2008	5-Year
65	18.242668	120.590366	0.870	0.914	0.002	Igme/ July 24-28, 2008	5-Year
66	18.245038	120.604039	0.180	0.914	0.539	Igme/ July 24-28, 2008	5-Year
67	18.243915	120.59223	0.350	0.914	0.319	Igme/ July 24-28, 2008	5-Year
68	18.24333	120.59341	0.440	0.914	0.225	Igme/ July 24-28, 2008	5-Year
69	18.243031	120.591902	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
70	18.24409	120.59302	0.100	0.914	0.663	Igme/ July 24-28, 2008	5-Year
71	18.250163	120.587382	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
72	18.253667	120.607792	0.090	0.914	0.680	Igme/ July 24-28, 2008	5-Year
73	18.279919	120.585167	2.070	1.219	0.724	Igme/ July 24-28, 2008	5-Year
74	18.2528	120.608964	0.060	0.914	0.730	Igme/ July 24-28, 2008	5-Year
75	18.254303	120.607705	0.150	0.914	0.584	Igme/ July 24-28, 2008	5-Year
76	18.241683	120.617194	1.470	0.914	0.309	Igme/ July 24-28, 2008	5-Year
77	18.242409	120.616946	0.710	0.914	0.042	Igme/ July 24-28, 2008	5-Year
78	18.254446	120.607678	0.180	0.914	0.539	Igme/ July 24-28, 2008	5-Year
79	18.230696	120.644641	0.210	0.914	0.496	Igme/ July 24-28, 2008	5-Year
80	18.254208	120.609757	0.240	0.914	0.455	Igme/ July 24-28, 2008	5-Year
81	18.254194	120.609607	0.480	0.914	0.189	Igme/ July 24-28, 2008	5-Year
82	18.253418	120.609668	0.150	0.914	0.584	Igme/ July 24-28, 2008	5-Year
83	18.252672	120.610216	0.160	0.914	0.569	Igme/ July 24-28, 2008	5-Year
84	18.279808	120.58851	2.310	1.219	1.190	Igme/ July 24-28, 2008	5-Year
85	18.254396	120.608516	0.180	0.914	0.539	Igme/ July 24-28, 2008	5-Year
86	18.252088	120.610261	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
87	18.254587	120.608901	0.400	0.914	0.265	Igme/ July 24-28, 2008	5-Year
88	18.248597	120.618776	0.230	0.914	0.468	Igme/ July 24-28, 2008	5-Year
89	18.241372	120.613272	0.450	0.914	0.216	Igme/ July 24-28, 2008	5-Year
90	18.250055	120.618041	0.210	0.914	0.496	Igme/ July 24-28, 2008	5-Year

91	18.252873	120.608062	0.390	0.914	0.275	Igme/ July 24-28, 2008	5-Year
92	18.243011	120.621215	0.460	0.914	0.206	Igme/ July 24-28, 2008	5-Year
93	18.249363	120.616939	0.070	0.914	0.713	Igme/ July 24-28, 2008	5-Year
94	18.28021	120.586293	1.370	1.219	0.023	Igme/ July 24-28, 2008	5-Year
95	18.249363	120.616939	0.070	0.914	0.713	Igme/ July 24-28, 2008	5-Year
96	18.242255	120.60358	0.300	0.914	0.377	Igme/ July 24-28, 2008	5-Year
97	18.242261	120.621425	0.700	0.610	0.008	Igme/ July 24-28, 2008	5-Year
98	18.242145	120.619676	1.310	0.610	0.491	Igme/ July 24-28, 2008	5-Year
99	18.250092	120.616954	0.540	0.610	0.005	Igme/ July 24-28, 2008	5-Year
100	18.24012	120.612576	1.390	0.610	0.609	Igme/ July 24-28, 2008	5-Year
101	18.241566	120.614457	0.770	0.457	0.098	Igme/ July 24-28, 2008	5-Year
102	18.24164	120.609854	0.460	0.457	0.000	Igme/ July 24-28, 2008	5-Year
103	18.228895	120.646953	0.070	0.457	0.150	Igme/ July 24-28, 2008	5-Year
104	18.24091	120.611727	0.990	0.305	0.469	Igme/ July 24-28, 2008	5-Year
105	18.254216	120.615215	0.140	0.914	0.600	Igme/ July 24-28, 2008	5-Year
106	18.276592	120.591947	1.070	1.219	0.022	Igme/ July 24-28, 2008	5-Year
107	18.228376	120.646522	0.340	0.305	0.001	Igme/ July 24-28, 2008	5-Year
108	18.251551	120.621181	0.670	0.457	0.045	Igme/ July 24-28, 2008	5-Year
109	18.251485	120.62161	0.070	0.457	0.150	Igme/ July 24-28, 2008	5-Year
110	18.251903	120.620651	0.580	0.457	0.015	Igme/ July 24-28, 2008	5-Year
111	18.250204	120.621853	0.200	0.305	0.011	Igme/ July 24-28, 2008	5-Year
112	18.250294	120.621018	0.420	0.305	0.013	Igme/ July 24-28, 2008	5-Year
113	18.251461	120.620312	0.070	0.305	0.055	Igme/ July 24-28, 2008	5-Year
114	18.251994	120.621678	0.030	0.305	0.076	Igme/ July 24-28, 2008	5-Year
115	18.24958	120.622964	0.050	0.152	0.010	Igme/ July 24-28, 2008	5-Year
116	18.249806	120.622098	0.030	0.152	0.015	Igme/ July 24-28, 2008	5-Year
117	18.279184	120.59057	1.500	1.219	0.079	Igme/ July 24-28, 2008	5-Year
118	18.249989	120.621278	0.240	0.152	0.008	Igme/ July 24-28, 2008	5-Year
119	18.250584	120.620084	0.290	0.152	0.019	Igme/ July 24-28, 2008	5-Year
120	18.252418	120.621132	0.170	0.152	0.000	Igme/ July 24-28, 2008	5-Year
121	18.252854	120.61934	0.390	0.914	0.275	Igme/ July 24-28, 2008	5-Year
122	18.253238	120.618465	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
123	18.251318	120.620307	0.030	0.762	0.536	Igme/ July 24-28, 2008	5-Year
124	18.253176	120.619276	0.030	0.762	0.536	Igme/ July 24-28, 2008	5-Year
125	18.252322	120.618612	0.250	0.305	0.003	Igme/ July 24-28, 2008	5-Year
126	18.254281	120.619336	0.030	0.305	0.076	Igme/ July 24-28, 2008	5-Year
127	18.254386	120.618554	0.180	0.305	0.016	Igme/ July 24-28, 2008	5-Year
128	18.274958	120.592009	0.650	0.914	0.070	Igme/ July 24-28, 2008	5-Year
129	18.250903	120.619217	0.110	0.305	0.038	Igme/ July 24-28, 2008	5-Year
130	18.25249	120.618919	0.170	0.305	0.018	Igme/ July 24-28, 2008	5-Year
131	18.22744	120.643637	1.220	0.914	0.093	Igme/ July 24-28, 2008	5-Year
132	18.226737	120.641275	1.250	0.914	0.113	Igme/ July 24-28, 2008	5-Year
133	18.228708	120.644884	0.530	0.610	0.006	Igme/ July 24-28, 2008	5-Year
134	18.230235	120.647065	0.060	0.610	0.302	Igme/ July 24-28, 2008	5-Year
135	18.226364	120.647027	1.440	0.305	1.289	Igme/ July 24-28, 2008	5-Year
136	18.227727	120.65061	0.060	0.305	0.060	Igme/ July 24-28, 2008	5-Year
137	18.275397	120.589632	0.790	0.914	0.015	Igme/ July 24-28, 2008	5-Year
138	18.254216	120.615215	0.140	0.914	0.600	Igme/ July 24-28, 2008	5-Year

139	18.248284	120.619656	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
140	18.250846	120.61544	0.100	0.914	0.663	Igme/ July 24-28, 2008	5-Year
141	18.249239	120.617482	0.140	0.914	0.600	Igme/ July 24-28, 2008	5-Year
142	18.238846	120.617046	0.650	0.914	0.070	Igme/ July 24-28, 2008	5-Year
143	18.256716	120.604906	0.140	0.914	0.600	Igme/ July 24-28, 2008	5-Year
144	18.27821	120.586801	0.280	0.610	0.109	Igme/ July 24-28, 2008	5-Year
145	18.26558	120.587676	0.810	0.610	0.040	Igme/ July 24-28, 2008	5-Year
146	18.273856	120.599719	0.290	0.305	0.000	Igme/ July 24-28, 2008	5-Year
147	18.265842	120.585772	0.050	0.914	0.747	Igme/ July 24-28, 2008	5-Year
148	18.269328	120.585327	0.290	0.914	0.390	Igme/ July 24-28, 2008	5-Year
149	18.26982	120.584691	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
150	18.279919	120.585167	2.070	1.219	0.724	Igme/ July 24-28, 2008	5-Year
151	18.279808	120.58851	2.310	1.219	1.190	Igme/ July 24-28, 2008	5-Year
152	18.28021	120.586293	1.370	1.219	0.023	Igme/ July 24-28, 2008	5-Year
153	18.276592	120.591947	1.070	1.219	0.022	Igme/ July 24-28, 2008	5-Year
154	18.276486	120.589118	0.160	0.610	0.202	Igme/ July 24-28, 2008	5-Year
155	18.279184	120.59057	1.500	1.219	0.079	Igme/ July 24-28, 2008	5-Year
156	18.274958	120.592009	0.650	0.610	0.002	Igme/ July 24-28, 2008	5-Year
157	18.275397	120.589632	0.790	0.610	0.033	Igme/ July 24-28, 2008	5-Year
158	18.27821	120.586801	0.280	0.305	0.001	Igme/ July 24-28, 2008	5-Year
159	18.276486	120.589118	0.160	0.305	0.021	Igme/ July 24-28, 2008	5-Year
160	18.272493	120.591313	0.090	0.152	0.004	Igme/ July 24-28, 2008	5-Year
161	18.277888	120.586285	0.120	0.152	0.001	Igme/ July 24-28, 2008	5-Year
162	18.280122	120.606147	0.090	0.152	0.004	Igme/ July 24-28, 2008	5-Year
163	18.286135	120.596732	0.380	0.152	0.052	Igme/ July 24-28, 2008	5-Year
164	18.283775	120.582026	0.810	0.152	0.432	Igme/ July 24-28, 2008	5-Year
165	18.278973	120.589723	0.430	0.305	0.016	Igme/ July 24-28, 2008	5-Year
166	18.273603	120.575452	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
167	18.269797	120.585165	0.290	0.914	0.390	Igme/ July 24-28, 2008	5-Year
168	18.277888	120.586285	0.120	0.305	0.034	Igme/ July 24-28, 2008	5-Year
169	18.267849	120.573513	0.030	0.152	0.015	Igme/ July 24-28, 2008	5-Year
170	18.273347	120.574554	0.140	0.152	0.000	Igme/ July 24-28, 2008	5-Year
171	18.270739	120.598049	0.460	0.152	0.095	Igme/ July 24-28, 2008	5-Year
172	18.277615	120.60438	0.950	0.914	0.001	Igme/ July 24-28, 2008	5-Year
173	18.280128	120.577464	1.040	0.152	0.788	Igme/ July 24-28, 2008	5-Year
174	18.239552	120.602297	1.270	0.152	1.249	Igme/ July 24-28, 2008	5-Year
175	18.280685	120.596006	0.060	0.152	0.009	Igme/ July 24-28, 2008	5-Year
176	18.280626	120.582108	1.950	0.914	1.072	Igme/ July 24-28, 2008	5-Year
177	18.276449	120.583691	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
178	18.280075	120.583916	0.650	0.914	0.070	Igme/ July 24-28, 2008	5-Year
179	18.276946	120.586596	0.130	0.457	0.107	Igme/ July 24-28, 2008	5-Year
180	18.278418	120.582899	0.400	0.457	0.003	Igme/ July 24-28, 2008	5-Year
181	18.273202	120.58465	0.030	0.152	0.015	Igme/ July 24-28, 2008	5-Year
182	18.285283	120.603438	0.040	0.914	0.765	Igme/ July 24-28, 2008	5-Year
183	18.277733	120.581607	0.030	0.152	0.015	Igme/ July 24-28, 2008	5-Year
184	18.287069	120.609423	0.260	0.152	0.012	Igme/ July 24-28, 2008	5-Year
185	18.254666	120.603444	3.600	0.152	11.886	Igme/ July 24-28, 2008	5-Year
186	18.25473	120.60464	1.090	0.152	0.879	Igme/ July 24-28, 2008	5-Year

187	18.25521	120.615091	0.170	1.219	1.101	Igme/ July 24-28, 2008	5-Year
188	18.253862	120.614479	0.360	0.610	0.062	Igme/ July 24-28, 2008	5-Year
189	18.2534	120.61411	0.810	0.610	0.040	Igme/ July 24-28, 2008	5-Year
190	18.252546	120.615293	0.260	0.610	0.122	Igme/ July 24-28, 2008	5-Year
191	18.252777	120.61601	0.180	0.305	0.016	Igme/ July 24-28, 2008	5-Year
192	18.248284	120.619656	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
193	18.284798	120.584646	0.080	0.914	0.696	Igme/ July 24-28, 2008	5-Year
194	18.25519	120.616322	0.030	0.305	0.076	Igme/ July 24-28, 2008	5-Year
195	18.255981	120.614233	0.080	0.305	0.051	Igme/ July 24-28, 2008	5-Year
196	18.25329	120.613437	0.110	0.305	0.038	Igme/ July 24-28, 2008	5-Year
197	18.254358	120.614751	1.080	0.305	0.601	Igme/ July 24-28, 2008	5-Year
198	18.253993	120.611746	0.290	0.914	0.390	Igme/ July 24-28, 2008	5-Year
199	18.254997	120.610037	0.150	0.914	0.584	Igme/ July 24-28, 2008	5-Year
200	18.254164	120.612247	0.380	0.610	0.053	Igme/ July 24-28, 2008	5-Year
201	18.255109	120.612121	0.630	0.610	0.000	Igme/ July 24-28, 2008	5-Year
202	18.25557	120.610036	0.700	0.610	0.008	Igme/ July 24-28, 2008	5-Year
203	18.256665	120.612715	0.320	0.305	0.000	Igme/ July 24-28, 2008	5-Year
204	18.270584	120.584248	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
205	18.256548	120.610263	0.390	0.305	0.007	Igme/ July 24-28, 2008	5-Year
206	18.255568	120.611159	0.090	0.305	0.046	Igme/ July 24-28, 2008	5-Year
207	18.253207	120.618263	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
208	18.253808	120.617632	0.170	0.914	0.554	Igme/ July 24-28, 2008	5-Year
209	18.251506	120.617528	0.190	0.610	0.176	Igme/ July 24-28, 2008	5-Year
210	18.252075	120.617738	0.340	0.610	0.073	Igme/ July 24-28, 2008	5-Year
211	18.253982	120.617764	0.030	0.610	0.336	Igme/ July 24-28, 2008	5-Year
212	18.251128	120.617751	0.030	0.305	0.076	Igme/ July 24-28, 2008	5-Year
213	18.251784	120.618049	0.120	0.305	0.034	Igme/ July 24-28, 2008	5-Year
214	18.254536	120.617967	0.400	0.305	0.009	Igme/ July 24-28, 2008	5-Year
215	18.252666	120.617831	0.240	0.305	0.004	Igme/ July 24-28, 2008	5-Year
216	18.25382	120.617466	0.120	0.914	0.631	Igme/ July 24-28, 2008	5-Year
217	18.25266	120.617054	0.240	0.610	0.137	Igme/ July 24-28, 2008	5-Year
218	18.251599	120.617046	0.670	0.305	0.133	Igme/ July 24-28, 2008	5-Year
219	18.253347	120.617001	0.400	0.305	0.009	Igme/ July 24-28, 2008	5-Year
220	18.255979	120.606297	0.550	0.914	0.133	Igme/ July 24-28, 2008	5-Year
221	18.255749	120.606594	0.170	0.610	0.193	Igme/ July 24-28, 2008	5-Year
222	18.256364	120.60699	0.080	0.152	0.005	Igme/ July 24-28, 2008	5-Year
223	18.255836	120.607522	0.300	0.152	0.022	Igme/ July 24-28, 2008	5-Year
224	18.257424	120.608209	0.820	0.914	0.009	Igme/ July 24-28, 2008	5-Year
225	18.26757	120.574592	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
226	18.257153	120.608469	0.120	0.610	0.240	Igme/ July 24-28, 2008	5-Year
227	18.258542	120.607293	0.320	0.152	0.028	Igme/ July 24-28, 2008	5-Year
228	18.257824	120.60752	0.030	0.152	0.015	Igme/ July 24-28, 2008	5-Year
229	18.254242	120.611507	0.140	0.914	0.600	Igme/ July 24-28, 2008	5-Year
230	18.254247	120.610919	0.330	0.914	0.342	Igme/ July 24-28, 2008	5-Year
231	18.253779	120.6098	0.490	0.914	0.180	Igme/ July 24-28, 2008	5-Year
232	18.254135	120.612484	0.120	0.914	0.631	Igme/ July 24-28, 2008	5-Year
233	18.25397	120.611686	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
234	18.253387	120.610944	0.810	0.914	0.011	Igme/ July 24-28, 2008	5-Year

235	18.254772	120.609912	1.090	0.914	0.031	Igme/ July 24-28, 2008	5-Year
236	18.248974	120.620246	0.030	0.610	0.336	Igme/ July 24-28, 2008	5-Year
237	18.255047	120.610638	0.210	0.305	0.009	Igme/ July 24-28, 2008	5-Year
238	18.255112	120.614146	0.170	0.914	0.554	Igme/ July 24-28, 2008	5-Year
239	18.254451	120.61293	0.600	0.914	0.099	Igme/ July 24-28, 2008	5-Year
240	18.254343	120.611893	1.080	0.914	0.027	Igme/ July 24-28, 2008	5-Year
241	18.250335	120.617264	0.040	0.610	0.324	Igme/ July 24-28, 2008	5-Year
242	18.2541	120.612534	0.290	0.610	0.102	Igme/ July 24-28, 2008	5-Year
243	18.248543	120.621152	0.250	0.305	0.003	Igme/ July 24-28, 2008	5-Year
244	18.248743	120.622763	0.210	0.305	0.009	Igme/ July 24-28, 2008	5-Year
245	18.247889	120.622026	0.180	0.305	0.016	Igme/ July 24-28, 2008	5-Year
246	18.272751	120.574993	0.040	0.914	0.765	Igme/ July 24-28, 2008	5-Year
247	18.243402	120.603368	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
248	18.255792	120.606213	0.220	0.914	0.482	Igme/ July 24-28, 2008	5-Year
249	18.244408	120.603555	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
250	18.258016	120.60537	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
251	18.251358	120.611789	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
252	18.244982	120.603559	0.030	0.610	0.336	Igme/ July 24-28, 2008	5-Year
253	18.252382	120.611562	0.160	0.610	0.202	Igme/ July 24-28, 2008	5-Year
254	18.272959	120.575351	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
255	18.250863	120.613359	0.350	0.457	0.011	Igme/ July 24-28, 2008	5-Year
256	18.251303	120.614141	0.290	0.457	0.028	Igme/ July 24-28, 2008	5-Year
257	18.251064	120.612765	0.240	0.305	0.004	Igme/ July 24-28, 2008	5-Year
258	18.25298	120.607978	0.030	0.305	0.076	Igme/ July 24-28, 2008	5-Year
259	18.253762	120.605507	1.000	0.914	0.007	Igme/ July 24-28, 2008	5-Year
260	18.254205	120.608862	0.250	0.610	0.129	Igme/ July 24-28, 2008	5-Year
261	18.254921	120.605896	0.030	0.610	0.336	Igme/ July 24-28, 2008	5-Year
262	18.258073	120.604853	0.030	1.219	1.414	Igme/ July 24-28, 2008	5-Year
263	18.245495	120.592701	0.030	1.219	1.414	Igme/ July 24-28, 2008	5-Year
264	18.253667	120.607792	0.090	1.219	1.275	Igme/ July 24-28, 2008	5-Year
265	18.254587	120.608901	0.400	1.219	0.671	Igme/ July 24-28, 2008	5-Year
266	18.248597	120.618776	0.230	0.914	0.468	Igme/ July 24-28, 2008	5-Year
267	18.241372	120.613272	0.450	0.914	0.216	Igme/ July 24-28, 2008	5-Year
268	18.250055	120.618041	0.210	0.914	0.496	Igme/ July 24-28, 2008	5-Year
269	18.252873	120.608062	0.390	0.914	0.275	Igme/ July 24-28, 2008	5-Year
270	18.243011	120.621215	0.460	0.914	0.206	Igme/ July 24-28, 2008	5-Year
271	18.249363	120.616939	0.070	0.914	0.713	Igme/ July 24-28, 2008	5-Year
272	18.242255	120.60358	0.300	0.914	0.377	Igme/ July 24-28, 2008	5-Year
273	18.242261	120.621425	0.700	0.914	0.046	Igme/ July 24-28, 2008	5-Year
274	18.242145	120.619676	1.310	0.914	0.156	Igme/ July 24-28, 2008	5-Year
275	18.250092	120.616954	0.540	0.914	0.140	Igme/ July 24-28, 2008	5-Year
276	18.24012	120.612576	1.390	0.914	0.226	Igme/ July 24-28, 2008	5-Year
277	18.229792	120.645454	0.210	0.914	0.496	Igme/ July 24-28, 2008	5-Year
278	18.272974	120.575955	0.030	0.203	0.030	Igme/ July 24-28, 2008	5-Year
279	18.22744	120.643637	1.220	0.914	0.093	Igme/ July 24-28, 2008	5-Year
280	18.226737	120.641275	1.250	0.914	0.113	Igme/ July 24-28, 2008	5-Year
281	18.228708	120.644884	0.530	0.610	0.006	Igme/ July 24-28, 2008	5-Year
282	18.230235	120.647065	0.060	0.610	0.302	Igme/ July 24-28, 2008	5-Year

283	18.273347	120.574554	0.140	0.203	0.004	Igme/ July 24-28, 2008	5-Year
284	18.226364	120.647027	1.440	0.457	0.966	Igme/ July 24-28, 2008	5-Year
285	18.227727	120.65061	0.060	0.457	0.158	Igme/ July 24-28, 2008	5-Year
286	18.284407	120.632459	0.430	1.219	0.623	Igme/ July 24-28, 2008	5-Year
287	18.268713	120.585612	0.030	1.219	1.414	Mario/ September 18-22, 2014	5-Year
288	18.270739	120.598049	0.460	1.219	0.576	Mario/ September 18-22, 2014	5-Year
289	18.279919	120.585167	2.070	1.219	0.724	Igme/ July 24-28, 2008	5-Year
290	18.279808	120.58851	2.310	1.219	1.190	Igme/ July 24-28, 2008	5-Year
291	18.28021	120.586293	1.370	0.914	0.208	Igme/ July 24-28, 2008	5-Year
292	18.276592	120.591947	1.070	0.914	0.024	Igme/ July 24-28, 2008	5-Year
293	18.279184	120.59057	1.500	0.914	0.343	Igme/ July 24-28, 2008	5-Year
294	18.274958	120.592009	0.650	0.610	0.002	Igme/ July 24-28, 2008	5-Year
295	18.275397	120.589632	0.790	0.610	0.033	Igme/ July 24-28, 2008	5-Year
296	18.27821	120.586801	0.280	0.457	0.031	Igme/ July 24-28, 2008	5-Year
297	18.276486	120.589118	0.160	0.457	0.088	Igme/ July 24-28, 2008	5-Year
298	18.272493	120.591313	0.090	0.305	0.046	Igme/ July 24-28, 2008	5-Year
299	18.277888	120.586285	0.120	0.305	0.034	Igme/ July 24-28, 2008	5-Year
300	18.248597	120.618776	0.230	0.914	0.468	Igme/ July 24-28, 2008	5-Year
301	18.241372	120.613272	0.450	0.914	0.216	Igme/ July 24-28, 2008	5-Year
302	18.250055	120.618041	0.210	0.914	0.496	Igme/ July 24-28, 2008	5-Year
303	18.252873	120.608062	0.390	0.914	0.275	Igme/ July 24-28, 2008	5-Year
304	18.243011	120.621215	0.460	0.914	0.206	Igme/ July 24-28, 2008	5-Year
305	18.242255	120.60358	0.300	0.914	0.377	Igme/ July 24-28, 2008	5-Year
306	18.242261	120.621425	0.700	0.762	0.004	Igme/ July 24-28, 2008	5-Year
307	18.242145	120.619676	1.310	0.762	0.300	Igme/ July 24-28, 2008	5-Year
308	18.250092	120.616954	0.540	0.762	0.049	Igme/ July 24-28, 2008	5-Year
309	18.272324	120.59805	0.030	0.203	0.030	Igme/ July 24-28, 2008	5-Year
310	18.24012	120.612576	1.390	0.762	0.394	Igme/ July 24-28, 2008	5-Year
311	18.241566	120.614457	0.770	0.610	0.026	Igme/ July 24-28, 2008	5-Year
312	18.24164	120.609854	0.460	0.610	0.022	Igme/ July 24-28, 2008	5-Year
313	18.228895	120.646953	0.070	0.610	0.291	Igme/ July 24-28, 2008	5-Year
314	18.24091	120.611727	0.990	0.457	0.284	Igme/ July 24-28, 2008	5-Year
315	18.228376	120.646522	0.340	0.457	0.014	Igme/ July 24-28, 2008	5-Year
316	18.254216	120.615215	0.140	0.914	0.600	Igme/ July 24-28, 2008	5-Year
317	18.248284	120.619656	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
318	18.250846	120.61544	0.100	0.762	0.438	Igme/ July 24-28, 2008	5-Year
319	18.249239	120.617482	0.140	0.610	0.221	Igme/ July 24-28, 2008	5-Year
320	18.238846	120.617046	0.650	0.457	0.037	Igme/ July 24-28, 2008	5-Year
321	18.26558	120.587676	0.810	0.762	0.002	Igme/ July 24-28, 2008	5-Year
322	18.272082	120.597392	0.250	0.610	0.129	Igme/ July 24-28, 2008	5-Year
323	18.267002	120.586756	0.770	0.305	0.216	Igme/ July 24-28, 2008	5-Year
324	18.26373	120.586325	0.030	0.305	0.076	Igme/ July 24-28, 2008	5-Year
325	18.26982	120.584691	0.030	0.305	0.076	Igme/ July 24-28, 2008	5-Year
326	18.280128	120.577464	1.040	1.219	0.032	Mario/ September 18-22, 2014	5-Year
327	18.280685	120.596006	0.060	1.219	1.344	Mario/ September 18-22, 2014	5-Year

328	18.228708	120.644884	0.530	1.219	0.475	Mario/ September 18-22, 2014	5-Year
329	18.276449	120.583691	0.030	1.219	1.414	Mario/ September 18-22, 2014	5-Year
330	18.254242	120.611507	0.140	0.914	0.600	Igme/ July 24-28, 2008	5-Year
331	18.254247	120.610919	0.330	0.914	0.342	Igme/ July 24-28, 2008	5-Year
332	18.253779	120.6098	0.490	0.914	0.180	Igme/ July 24-28, 2008	5-Year
333	18.254135	120.612484	0.120	0.914	0.631	Igme/ July 24-28, 2008	5-Year
334	18.25397	120.611686	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
335	18.253387	120.610944	0.810	0.914	0.011	Igme/ July 24-28, 2008	5-Year
336	18.254772	120.609912	1.090	0.610	0.231	Igme/ July 24-28, 2008	5-Year
337	18.248974	120.620246	0.030	0.610	0.336	Igme/ July 24-28, 2008	5-Year
338	18.255047	120.610638	0.210	0.305	0.009	Igme/ July 24-28, 2008	5-Year
339	18.255112	120.614146	0.170	0.914	0.554	Igme/ July 24-28, 2008	5-Year
340	18.254451	120.61293	0.600	0.914	0.099	Igme/ July 24-28, 2008	5-Year
341	18.254343	120.611893	1.080	0.914	0.027	Igme/ July 24-28, 2008	5-Year
342	18.250335	120.617264	0.040	0.610	0.324	Igme/ July 24-28, 2008	5-Year
343	18.253526	120.585036	0.090	0.305	0.046	Igme/ July 24-28, 2008	5-Year
344	18.2541	120.612534	0.290	0.610	0.102	Igme/ July 24-28, 2008	5-Year
345	18.248543	120.621152	0.250	0.305	0.003	Igme/ July 24-28, 2008	5-Year
346	18.248743	120.622763	0.210	0.305	0.009	Igme/ July 24-28, 2008	5-Year
347	18.247889	120.622026	0.180	0.152	0.001	Igme/ July 24-28, 2008	5-Year
348	18.253667	120.607792	0.090	1.219	1.275	Mario/ September 18-22, 2014	5-Year
349	18.250846	120.61544	0.100	0.762	0.438	Igme/ July 24-28, 2008	5-Year
350	18.253723	120.58475	0.030	0.305	0.076	Igme/ July 24-28, 2008	5-Year
351	18.254111	120.584283	0.120	0.305	0.034	Igme/ July 24-28, 2008	5-Year
352	18.280128	120.577464	1.040	0.914	0.016	Igme/ July 24-28, 2008	5-Year
353	18.281667	120.575749	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
354	18.279657	120.579539	0.290	0.610	0.102	Igme/ July 24-28, 2008	5-Year
355	18.278873	120.57951	0.030	0.305	0.076	Igme/ July 24-28, 2008	5-Year
356	18.250027	120.6145	0.070	0.762	0.479	Igme/ July 24-28, 2008	5-Year
357	18.239552	120.602297	1.270	0.914	0.126	Igme/ July 24-28, 2008	5-Year
358	18.280685	120.596006	0.060	0.914	0.730	Igme/ July 24-28, 2008	5-Year
359	18.280626	120.582108	1.950	0.914	1.072	Igme/ July 24-28, 2008	5-Year
360	18.276449	120.583691	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
361	18.280075	120.583916	0.650	0.914	0.070	Igme/ July 24-28, 2008	5-Year
362	18.277606	120.587788	0.060	0.610	0.302	Igme/ July 24-28, 2008	5-Year
363	18.278418	120.582899	0.400	0.610	0.044	Igme/ July 24-28, 2008	5-Year
364	18.273202	120.58465	0.030	0.457	0.182	Igme/ July 24-28, 2008	5-Year
365	18.277733	120.581607	0.030	0.457	0.182	Igme/ July 24-28, 2008	5-Year
366	18.249239	120.617482	0.140	0.762	0.387	Igme/ July 24-28, 2008	5-Year
367	18.287069	120.609423	0.260	0.914	0.428	Igme/ July 24-28, 2008	5-Year
368	18.254666	120.603444	3.600	0.914	7.212	Igme/ July 24-28, 2008	5-Year
369	18.25473	120.60464	1.090	0.914	0.031	Igme/ July 24-28, 2008	5-Year
370	18.25521	120.615091	0.170	0.914	0.554	Igme/ July 24-28, 2008	5-Year
371	18.253862	120.614479	0.360	0.610	0.062	Igme/ July 24-28, 2008	5-Year
372	18.2534	120.61411	0.810	0.610	0.040	Igme/ July 24-28, 2008	5-Year
373	18.252546	120.615293	0.260	0.610	0.122	Igme/ July 24-28, 2008	5-Year

374	18.252777	120.61601	0.180	0.305	0.016	Igme/ July 24-28, 2008	5-Year
375	18.25519	120.616322	0.030	0.305	0.076	Igme/ July 24-28, 2008	5-Year
376	18.251926	120.615014	0.030	0.762	0.536	Igme/ July 24-28, 2008	5-Year
377	18.255981	120.614233	0.080	0.305	0.051	Igme/ July 24-28, 2008	5-Year
378	18.25329	120.613437	0.110	0.305	0.038	Igme/ July 24-28, 2008	5-Year
379	18.254358	120.614751	1.080	0.305	0.601	Igme/ July 24-28, 2008	5-Year
380	18.253993	120.611746	0.290	0.914	0.390	Igme/ July 24-28, 2008	5-Year
381	18.254997	120.610037	0.150	0.914	0.584	Igme/ July 24-28, 2008	5-Year
382	18.254164	120.612247	0.380	0.610	0.053	Igme/ July 24-28, 2008	5-Year
383	18.255109	120.612121	0.630	0.610	0.000	Igme/ July 24-28, 2008	5-Year
384	18.25557	120.610036	0.700	0.610	0.008	Igme/ July 24-28, 2008	5-Year
385	18.256665	120.612715	0.320	0.305	0.000	Igme/ July 24-28, 2008	5-Year
386	18.256548	120.610263	0.390	0.305	0.007	Igme/ July 24-28, 2008	5-Year
387	18.238846	120.617046	0.650	0.610	0.002	Igme/ July 24-28, 2008	5-Year
388	18.255568	120.611159	0.090	0.305	0.046	Igme/ July 24-28, 2008	5-Year
389	18.253207	120.618263	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
390	18.253808	120.617632	0.170	0.914	0.554	Igme/ July 24-28, 2008	5-Year
391	18.251506	120.617528	0.190	0.610	0.176	Igme/ July 24-28, 2008	5-Year
392	18.252075	120.617738	0.340	0.610	0.073	Igme/ July 24-28, 2008	5-Year
393	18.253982	120.617764	0.030	0.610	0.336	Igme/ July 24-28, 2008	5-Year
394	18.251128	120.617751	0.030	0.305	0.076	Igme/ July 24-28, 2008	5-Year
395	18.251784	120.618049	0.120	0.305	0.034	Igme/ July 24-28, 2008	5-Year
396	18.254536	120.617967	0.400	0.305	0.009	Igme/ July 24-28, 2008	5-Year
397	18.252666	120.617831	0.240	0.305	0.004	Igme/ July 24-28, 2008	5-Year
398	18.323875	120.617442	0.230	0.914	0.468	Igme/ July 24-28, 2008	5-Year
399	18.37561	120.607822	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
400	18.317316	120.604396	0.060	0.914	0.730	Igme/ July 24-28, 2008	5-Year
401	18.350006	120.61426	0.330	0.914	0.342	Igme/ July 24-28, 2008	5-Year
402	18.349483	120.614682	3.070	0.914	4.647	Igme/ July 24-28, 2008	5-Year
403	18.292023	120.599399	0.060	0.914	0.730	Igme/ July 24-28, 2008	5-Year
404	18.335929	120.620218	2.490	0.914	2.483	Igme/ July 24-28, 2008	5-Year
405	18.331138	120.620534	0.200	0.914	0.510	Igme/ July 24-28, 2008	5-Year
406	18.332004	120.616539	0.060	0.914	0.730	Igme/ July 24-28, 2008	5-Year
407	18.297021	120.591434	0.130	0.914	0.615	Igme/ July 24-28, 2008	5-Year
408	18.335678	120.615885	0.530	0.914	0.148	Igme/ July 24-28, 2008	5-Year
409	18.345557	120.605751	1.250	0.914	0.113	Igme/ July 24-28, 2008	5-Year
410	18.338875	120.599738	3.730	0.914	7.928	Igme/ July 24-28, 2008	5-Year
411	18.348783	120.605968	1.540	0.914	0.391	Igme/ July 24-28, 2008	5-Year
412	18.348641	120.605369	2.340	0.914	2.032	Igme/ July 24-28, 2008	5-Year
413	18.33878	120.611631	1.790	0.914	0.767	Igme/ July 24-28, 2008	5-Year
414	18.335348	120.615482	1.000	0.914	0.007	Igme/ July 24-28, 2008	5-Year
415	18.332494	120.612348	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
416	18.359541	120.623169	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
417	18.330025	120.620192	0.030	0.914	0.782	Igme/ July 24-28, 2008	5-Year
418	18.348445	120.628286	0.140	0.914	0.600	Igme/ July 24-28, 2008	5-Year
419	18.383238	120.605434	0.510	0.914	0.164	Igme/ July 24-28, 2008	5-Year
420	18.330356	120.61623	0.210	0.914	0.496	Igme/ July 24-28, 2008	5-Year
421	18.367606	120.611341	0.050	0.914	0.747	Igme/ July 24-28, 2008	5-Year

422	18.297021	120.591434	0.130	1.219	1.186	Igme/ July 24-28, 2008	5-Year
423	18.291937	120.597373	0.030	1.219	1.414	Igme/ July 24-28, 2008	5-Year
424	18.36531	120.603984	0.030	1.219	1.414	Igme/ July 24-28, 2008	5-Year
425	18.291093	120.598685	0.180	0.914	0.539	Igme/ July 24-28, 2008	5-Year
426	18.317401	120.603594	0.070	1.219	1.321	Igme/ July 24-28, 2008	5-Year
427	18.352906	120.612238	1.200	1.219	0.000	Igme/ July 24-28, 2008	5-Year
428	18.354525	120.605183	0.690	1.219	0.280	Igme/ July 24-28, 2008	5-Year
429	18.300733	120.607985	0.030	1.219	1.414	Igme/ July 24-28, 2008	5-Year
430	18.335929	120.620218	2.490	1.219	1.615	Igme/ July 24-28, 2008	5-Year
431	18.331138	120.620534	0.200	1.219	1.039	Igme/ July 24-28, 2008	5-Year
432	18.332004	120.616539	0.060	1.219	1.344	Igme/ July 24-28, 2008	5-Year
433	18.335678	120.615885	0.530	1.219	0.475	Igme/ July 24-28, 2008	5-Year
434	18.339631	120.611939	1.430	0.914	0.266	Igme/ July 24-28, 2008	5-Year
435	18.344974	120.605779	1.210	0.914	0.087	Igme/ July 24-28, 2008	5-Year
436	18.348974	120.604424	3.070	0.914	4.647	Igme/ July 24-28, 2008	5-Year
437	18.348612	120.607592	3.220	0.914	5.316	Igme/ July 24-28, 2008	5-Year
438	18.339088	120.611807	3.730	0.914	7.928	Igme/ July 24-28, 2008	5-Year
439	18.337225	120.606628	3.960	0.914	9.276	Igme/ July 24-28, 2008	5-Year
440	18.328009	120.605403	0.040	1.219	1.391	Igme/ July 24-28, 2008	5-Year
441	18.336416	120.618816	1.900	1.219	0.463	Igme/ July 24-28, 2008	5-Year
442	18.334717	120.616974	0.030	1.219	1.414	Igme/ July 24-28, 2008	5-Year
443	18.374185	120.60301	0.300	1.219	0.845	Igme/ July 24-28, 2008	5-Year
444	18.330947	120.617573	0.070	1.219	1.321	Igme/ July 24-28, 2008	5-Year
445	18.360906	120.62244	0.040	1.219	1.391	Igme/ July 24-28, 2008	5-Year
446	18.338548	120.612454	1.510	0.914	0.355	Igme/ July 24-28, 2008	5-Year
447	18.348613	120.606309	2.570	0.914	2.741	Igme/ July 24-28, 2008	5-Year
448	18.348974	120.604424	3.070	0.914	4.647	Igme/ July 24-28, 2008	5-Year
449	18.348612	120.607592	3.220	0.914	5.316	Igme/ July 24-28, 2008	5-Year
450	18.339446	120.611422	3.730	0.914	7.928	Igme/ July 24-28, 2008	5-Year
451	18.337225	120.606628	3.960	0.914	9.276	Igme/ July 24-28, 2008	5-Year
452	18.374185	120.60301	0.300	1.219	0.845	Mario/ September 18-22, 2014	5-Year
453	18.291874	120.607581	0.030	1.219	1.414	Mario/ September 18-22, 2014	5-Year
454	18.328009	120.605403	0.040	1.219	1.391	Mario/ September 18-22, 2014	5-Year
455	18.226561	120.649051	0.150	0.610	0.211	Mario/ September 18-22, 2014	5-Year
456	18.220005	120.66897	0.310	0.457	0.022	Mario/ September 18-22, 2014	5-Year
457	18.261778	120.679589	0.030	0.610	0.336	Mario/ September 18-22, 2014	5-Year
458	18.254982	120.689132	0.110	0.610	0.250	Mario/ September 18-22, 2014	5-Year
459	18.254599	120.689224	0.030	0.610	0.336	Mario/ September 18-22, 2014	5-Year
460	18.258755	120.694688	0.070	0.610	0.291	Mario/ September 18-22, 2014	5-Year
461	18.250086	120.691455	0.540	0.610	0.005	Mario/ September 18-22, 2014	5-Year
462	18.262522	120.678866	0.380	0.610	0.053	Mario/ September 18-22, 2014	5-Year

463	18.264738	120.678775	0.290	0.610	0.102	Mario/ September 18-22, 2014	5-Year
464	18.254465	120.687863	0.630	0.610	0.000	Mario/ September 18-22, 2014	5-Year
465	18.262746	120.680114	0.030	0.610	0.336	Mario/ September 18-22, 2014	5-Year
466	18.258526	120.693565	0.350	0.610	0.067	Mario/ September 18-22, 2014	5-Year
467	18.23001	120.647679	0.790	0.457	0.111	Mario/ September 18-22, 2014	5-Year
468	18.257428	120.694668	0.030	0.610	0.336	Mario/ September 18-22, 2014	5-Year
469	18.258741	120.693074	0.320	0.610	0.084	Mario/ September 18-22, 2014	5-Year
470	18.255784	120.695064	0.220	0.610	0.152	Mario/ September 18-22, 2014	5-Year
471	18.257934	120.694473	0.040	0.610	0.324	Mario/ September 18-22, 2014	5-Year
472	18.253524	120.694119	0.110	0.610	0.250	Mario/ September 18-22, 2014	5-Year
473	18.231093	120.645731	0.180	0.610	0.185	Mario/ September 18-22, 2014	5-Year
474	18.229697	120.639358	1.570	0.610	0.922	Mario/ September 18-22, 2014	5-Year
475	18.230245	120.63881	1.640	0.610	1.062	Mario/ September 18-22, 2014	5-Year
476	18.229973	120.641575	0.790	0.610	0.033	Mario/ September 18-22, 2014	5-Year
477	18.231126	120.640499	0.960	0.610	0.123	Mario/ September 18-22, 2014	5-Year
478	18.228598	120.648498	0.090	0.305	0.046	Mario/ September 18-22, 2014	5-Year
479	18.231177	120.641722	0.480	0.610	0.017	Mario/ September 18-22, 2014	5-Year
480	18.231093	120.645731	0.180	0.610	0.185	Mario/ September 18-22, 2014	5-Year
481	18.229697	120.639358	1.570	0.457	1.238	Mario/ September 18-22, 2014	5-Year
482	18.230479	120.646034	0.080	0.305	0.051	Mario/ September 18-22, 2014	5-Year
483	18.231126	120.640499	0.960	0.305	0.429	Mario/ September 18-22, 2014	5-Year
484	18.231177	120.641722	0.480	0.305	0.031	Mario/ September 18-22, 2014	5-Year
485	18.21684	120.669593	0.200	0.457	0.066	Ineng/ August 20-23, 2015	5-Year
486	18.257348	120.690064	0.040	0.457	0.174	Ineng/ August 20-23, 2015	5-Year
487	18.257293	120.691415	0.150	0.457	0.094	Ineng/ August 20-23, 2015	5-Year
488	18.255131	120.690529	0.030	0.457	0.182	Ineng/ August 20-23, 2015	5-Year
489	18.218832	120.670692	0.050	0.457	0.166	Ineng/ August 20-23, 2015	5-Year
490	18.243334	120.6757	0.030	0.457	0.182	Ineng/ August 20-23, 2015	5-Year
491	18.256268	120.691558	0.030	0.305	0.076	Ineng/ August 20-23, 2015	5-Year
492	18.253789	120.691528	0.040	0.305	0.070	Ineng/ August 20-23, 2015	5-Year
493	18.21933	120.669764	0.250	0.305	0.003	Ineng/ August 20-23, 2015	5-Year
494	18.217324	120.670372	0.040	0.305	0.070	Ineng/ August 20-23, 2015	5-Year
495	18.2263	120.67204	0.040	0.305	0.070	Ineng/ August 20-23, 2015	5-Year
496	18.228756	120.676978	0.060	0.305	0.060	Ineng/ August 20-23, 2015	5-Year

497	18.216526	120.671039	0.030	0.305	0.076	Ineng/ August 20-23, 2015	5-Year
498	18.227085	120.675156	0.050	0.305	0.065	Ineng/ August 20-23, 2015	5-Year
499	18.214254	120.670944	1.310	0.305	1.010	Ineng/ August 20-23, 2015	5-Year
500	18.228449	120.674411	0.030	0.305	0.076	Ineng/ August 20-23, 2015	5-Year
501	18.230384	120.678144	0.850	0.305	0.297	Ineng/ August 20-23, 2015	5-Year
502	18.303788	120.719454	0.030	0.610	0.336	Mario/ September 18-22, 2014	5-Year
503	18.228858	120.675508	0.030	0.305	0.076	Ineng/ August 20-23, 2015	5-Year
504	18.231006	120.67526	0.610	0.305	0.093	Ineng/ August 20-23, 2015	5-Year
505	18.257032	120.692923	0.060	0.305	0.060	Ineng/ August 20-23, 2015	5-Year
506	18.25445	120.694364	0.370	0.305	0.004	Ineng/ August 20-23, 2015	5-Year
507	18.256549	120.692523	0.030	0.305	0.076	Ineng/ August 20-23, 2015	5-Year
508	18.254377	120.69324	0.220	0.305	0.007	Ineng/ August 20-23, 2015	5-Year
509	18.214868	120.67228	0.030	0.305	0.076	Ineng/ August 20-23, 2015	5-Year
510	18.307102	120.716758	0.060	0.610	0.302	Mario/ September 18-22, 2014	5-Year
511	18.217797	120.668149	0.030	0.610	0.336	Mario/ September 18-22, 2014	5-Year
512	18.303137	120.718924	0.030	0.610	0.336	Mario/ September 18-22, 2014	5-Year
513	18.227907	120.673153	0.350	0.610	0.067	Mario/ September 18-22, 2014	5-Year
514	18.323835	120.733027	0.030	0.610	0.336	Mario/ September 18-22, 2014	5-Year
515	18.323228	120.732209	0.040	0.610	0.324	Mario/ September 18-22, 2014	5-Year
516	18.324849	120.731838	0.320	0.610	0.084	Mario/ September 18-22, 2014	5-Year
517	18.3062	120.717143	0.030	0.610	0.336	Mario/ September 18-22, 2014	5-Year
518	18.225628	120.648963	0.570	0.610	0.002	Mario/ September 18-22, 2014	5-Year
519	18.264013	120.680685	0.030	0.610	0.336	Mario/ September 18-22, 2014	5-Year
520	18.261778	120.679589	0.030	0.610	0.336	Mario/ September 18-22, 2014	5-Year
521	18.254982	120.689132	0.110	0.610	0.250	Mario/ September 18-22, 2014	5-Year
522	18.254599	120.689224	0.030	0.610	0.336	Mario/ September 18-22, 2014	5-Year
523	18.258755	120.694688	0.070	0.610	0.291	Mario/ September 18-22, 2014	5-Year
524	18.250086	120.691455	0.540	0.610	0.005	Mario/ September 18-22, 2014	5-Year
525	18.262522	120.678866	0.380	0.610	0.053	Mario/ September 18-22, 2014	5-Year
526	18.261655	120.678741	0.060	0.610	0.302	Mario/ September 18-22, 2014	5-Year
527	18.254465	120.687863	0.630	0.610	0.000	Mario/ September 18-22, 2014	5-Year
528	18.262746	120.680114	0.030	0.610	0.336	Mario/ September 18-22, 2014	5-Year
529	18.227236	120.646578	0.570	0.610	0.002	Mario/ September 18-22, 2014	5-Year
530	18.258526	120.693565	0.350	0.610	0.067	Mario/ September 18-22, 2014	5-Year

531	18.257428	120.694668	0.030	0.610	0.336	Mario/ September 18-22, 2014	5-Year
532	18.258741	120.693074	0.320	0.610	0.084	Mario/ September 18-22, 2014	5-Year
533	18.255784	120.695064	0.220	0.610	0.152	Mario/ September 18-22, 2014	5-Year
534	18.257934	120.694473	0.040	0.457	0.174	Mario/ September 18-22, 2014	5-Year
535	18.253524	120.694119	0.110	0.305	0.038	Mario/ September 18-22, 2014	5-Year
536	18.231093	120.645731	0.180	0.610	0.185	Mario/ September 18-22, 2014	5-Year
537	18.229697	120.639358	1.570	0.610	0.922	Mario/ September 18-22, 2014	5-Year
538	18.230245	120.63881	1.640	0.610	1.062	Mario/ September 18-22, 2014	5-Year
539	18.229973	120.641575	0.790	0.457	0.111	Mario/ September 18-22, 2014	5-Year
540	18.225883	120.670361	0.030	0.610	0.336	Mario/ September 18-22, 2014	5-Year
541	18.231126	120.640499	0.960	0.305	0.429	Mario/ September 18-22, 2014	5-Year
542	18.231177	120.641722	0.480	0.610	0.017	Mario/ September 18-22, 2014	5-Year
543	18.226561	120.649051	0.150	0.610	0.211	Mario/ September 18-22, 2014	5-Year
544	18.217797	120.668149	0.030	0.610	0.336	Mario/ September 18-22, 2014	5-Year
545	18.227907	120.673153	0.350	0.610	0.067	Mario/ September 18-22, 2014	5-Year
546	18.225628	120.648963	0.570	0.610	0.002	Mario/ September 18-22, 2014	5-Year
547	18.227236	120.646578	0.570	0.610	0.002	Mario/ September 18-22, 2014	5-Year
548	18.225883	120.670361	0.030	0.610	0.336	Mario/ September 18-22, 2014	5-Year
549	18.215726	120.66884	0.140	0.610	0.221	Mario/ September 18-22, 2014	5-Year
550	18.215726	120.66884	0.140	0.610	0.221	Mario/ September 18-22, 2014	5-Year
551	18.228864	120.649745	0.130	0.610	0.230	Mario/ September 18-22, 2014	5-Year
552	18.228925	120.64593	0.230	0.610	0.144	Mario/ September 18-22, 2014	5-Year
553	18.220005	120.66897	0.310	0.457	0.022	Mario/ September 18-22, 2014	5-Year
554	18.23001	120.647679	0.790	0.457	0.111	Mario/ September 18-22, 2014	5-Year
555	18.228598	120.648498	0.090	0.305	0.046	Mario/ September 18-22, 2014	5-Year
556	18.230479	120.646034	0.080	0.305	0.051	Mario/ September 18-22, 2014	5-Year
557	18.243656	120.663664	0.030	0.610	0.336	Mario/ September 18-22, 2014	5-Year
558	18.228864	120.649745	0.130	0.610	0.230	Mario/ September 18-22, 2014	5-Year
559	18.228925	120.64593	0.230	0.610	0.144	Mario/ September 18-22, 2014	5-Year

560	18.304751	120.717838	0.030	0.914	0.782	Mario/ September 18-22, 2014	5-Year
561	18.323923	120.732325	0.030	0.914	0.782	Mario/ September 18-22, 2014	5-Year
562	18.325243	120.732783	0.100	0.914	0.663	Mario/ September 18-22, 2014	5-Year
563	18.304712	120.718589	0.030	0.914	0.782	Mario/ September 18-22, 2014	5-Year
564	18.264013	120.680685	0.030	0.610	0.336	Mario/ September 18-22, 2014	5-Year
				RMSE	0.68772		

Annex 12. Educational Institutions affected by flooding in Bacarra Flood Plain

Table A-12.1. Educational Institutions in Bacarra, Ilocos Norte affected by flooding in Bacarra Flood Plain

Ilocos Norte				
Bacarra				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
BANGSIRIT ES	Bani			
BUYON ES	Buyon			
CABARUAN ES	Cabaruan			
CABULALAAN ES	Cabulalaan			Low
CALIOET ES	Calioet-Libong			
CASILIAN PS	Casilian			
CASILIAN PS - TAGUIPURO ANNEX	Casilian			
PARANG ES	Duripes			
TUBBURAN ES	Duripes	Medium	Medium	Medium
PASIOCAN ES	Pasiocan			
THE RIVERDEEP ACADEMY, INC.	Pasngal	Low	Low	Medium
PULANGI ES	Pulangi			
BACARRA MEDICAL CENTER SCHOOL OF MIDWIFERY	San Andres II			
SAN AGUSTIN ES	San Pedro I			Low
SANTO CRISTO ELEMENTARY SCHOOL	San Roque I	Low	Low	Low
APALENG-LIBTONG ES	San Simon II			
TAMBIDAO ELEMENTARY SCHOOL	San Vicente	Low	Low	Low
GANAGAN ELEMENTARY SCHOOL	Sangil			
SABAS-SAGISI MEMORIAL ELEM. SCHOOL	Sangil			
BACARRA CES	Santa Rita			
BACARRA NCHS	Santa Rita	Low	Low	Low
SPECIAL EDUCATION CENTER	Santa Rita			
ST. ANDREW ACADEMY	Santa Rita	Low	Low	Low
ST. ANDREW GRADE SCHOOL	Santa Rita			
Bangui				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
CABAYO ES	Payac			
Laoag City				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
ALEJO MALASIG ES	Bgy. No. 54-A, Lagui-Sail			
PILA ES	Bgy. No. 57, Pila			

D. G. R. RAFALES MEMORIAL ES	Bgy. No. 59-A, Dibua South			
CATABAN PS	Bgy. No. 61, Cataban			
NAVOTAS ES	Bgy. No. 62-A, Navotas North			
CAAOACAN ES	Bgy. No. 6-A, Caaoacan			
Pasuquin				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
ILOCOS NORTE AGRICULTURAL COLLEGE	Batuli			Low
SAN ISIDRO PS	Batuli		Low	Low
BINSANG DAYCARE CENTER	Binsang			
BINSANG ELEMENTARY SCHOOL	Binsang		Low	Low
CADARATAN DAY CARE	Binsang			Low
CADARATAN ES	Binsang			
CADARATAN NATIONAL HIGH SCHOOL	Binsang			Low
PUNGTO PS	Carusipan			
DADAEMAN ELEMENTARY SCHOOL	Dadaeman		Low	Medium
NAGLICUAN ES	Naglicuan			
PANGIL ES	Pangil			
EAST CENTRAL ELEMENTARY SCHOOL (HERITAGE BUILDING)	Poblacion 1		Medium	Medium
SAINT JAMES ACADEMY OF PASUQUIN, ILOCOS NORTE, INC.	Poblacion 2			
PASUQUIN CENTRAL ELEMENTARY SCHOOL	Poblacion 3	Low	Medium	Medium
NAGSANGA ES	Pragata			
GABALDON ES	Puyupuyan		Low	Low
PUYUPUYAN ES	Puyupuyan		Low	Low
DILANIS ES	San Juan			
MACUPIT ELEMENTARY SCHOOL	Santa Catalina			Low
STA. CATALINA ES	Santa Catalina			
CARUAN ES	Sulongan		Low	Low
SURONG PS	Surong		High	High
CABABAAN ES	Susugaen			
Vintar				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
ABKIR ES	Abkir			
SALPAD INTEGRATED SCHOOL	Abkir			
ALSEM ES	Alsem			
ISIC ISIC ELEMENTARY SCHOOL	Cabayo			
ISIC-ISIC ES	Cabayo			
ISIC-ISIC NHS	Cabayo			

CABISUCULAN-COLUMBIA ES	Cabisocolan			
COLUMBIA PS	Columbia			
VINTAR CES	Columbia	Low	Low	Low
DIPILAT ES	Dipilat			
SAGPAT ES	Dipilat		Medium	High
DIMAMAGA ELEMENTARY SCHOOL	Esperanza			
VINTAR NHS	Esperanza			
ISIC ISIC NATIONAL HIGH SCHOOL	Isic Isic			
LUBNAC ES	Lubnac			
MALAMPA ES	Malampa	Low	Low	Low
MANARANG ES	Manarang			
MARGAAY PS	Margaay	Low	Low	Medium
PARPAROROC ES	Parparoroc	Low	Low	Medium
LIPAY ES	San Jose			
SALPAD INTEGRATED SCHOOL	San Pedro			
F. CAMAQUIN INTEGRATED SCHOOL	Santa Maria	Medium	Medium	Medium
TAMDAGAN ES	Tamdagan			
VISAYA ES	Visaya			

Annex 13. Medical Institutions affected by flooding in Bacarra Flood Plain

Table A-13.1. Medical Institutions in Bacarra, Ilocos Norte affected by flooding in Bacarra Flood Plain.

Ilocos Norte				
Bacarra				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
CABULALAAN HEALTH CENTER	Cabulalaan			
SALDUA DENTAL CLINIC	San Simon II			
BRGY. HEALTH CENTER	Sangil			
DENTAL CLINIC	Santa Rita			
Pasuquin				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
CADARATAN HEALTH CENTER	Binsang			
Vintar				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
VINTAR DISTRICT HOSPITAL	Esperanza			