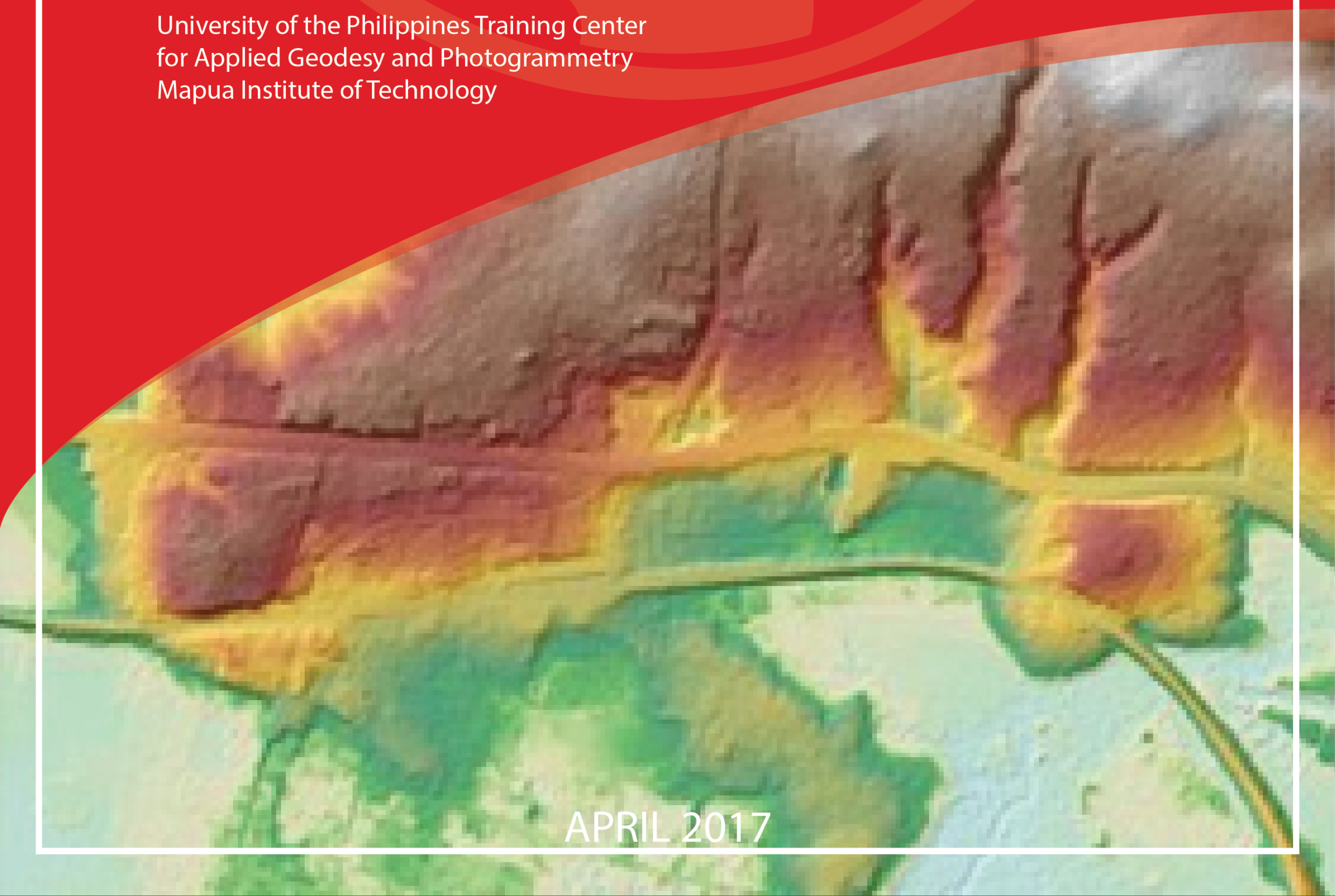
Hazard Mapping of the Philippines Using LIDAR (Phil-LIDAR 1)

LiDAR Surveys and Flood Mapping of Kilbay-Catabangan River

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



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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 KILBAY-CATABANGAN RIVER

Enrico C. Paringit, Dr. Eng., Dr. Francis Aldrine A. Uy, and Engr. FIbor Tan

1.1 Background of the Phil-LIDAR 1 Program

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

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

The implementing partner university for the Phil-LiDAR 1 Program is the University of the Philippines Baguio (UPB). UPB is in charge of processing LiDAR data and conducting data validation reconnaissance, cross section, bathymetric survey, validation, river flow measurements, flood height and extent data gathering, flood modeling, and flood map generation for the 26 river basins in the Southern Tagalog Region. The university is located in the City of Manila in Metro Manila.

1.2 Overview of the Kilbay-Catabangan River Basin

The Kilbay River Basin is located in the province of Camarines Sur in the Bicol Region. This river is situated along the municipality of Del Gallego, a fourth class municipality in Camarines Sur where the Quirino Highway meets with the municipality of Tagkawayan in Quezon Province. The main source of livelihood in this area is agriculture, which comprises almost 70% of the total working force in the municipality. This river also experiences backflow due to high tides and its location near the ocean. For the past two decades, the river basin is a frequent pathway of severe typhoons. In November 1995, typhoon Rosing flooded the entire municipality, where the flood depths are almost the same height as a two-story building. This greatly affected the entire community, especially those lying near and along the Kilbay river. Recently, in December 2016, typhoon Nina affected several waterways in Bicol region including the rivers and tributaries in Kilbay.

Sabang River Basin covers the Municipalities of Del Gallego and Tagkawayan in Camarines Sur. The DENR River Basin Control Office identified the basin to have a drainage area of 285 km2 and an estimated 386 million cubic meter (MCM) annual run-off (RBCO, 2015).

Its main stem, Sabang River, is part of the 28 river systems in Bicol. According to the 2015 national census of NSO, a total of 11,726 persons are residing within the immediate vicinity of the river which is distributed among eleven barangays in the Municipality of Del Gallego. The primary source of livelihood in the municipality are agriculture and fishing. It is said that 70% of the labor force are agricultural workers while the remaining 30% are non-agricultural worker. The most recent typhoon that resulted to evacuation of families around low lying areas including barangays along Sabang river was Typhoon Ruby on December 2014 (http://newsinfo.inquirer.net/655022/camarines-provinces-evacuate-families-on-riverbanks-low-lying-areas, 2014).

LiDAR or Light Detection and Ranging, a remote sensing technology used to examine the earth's surface, is used to create high resolution maps for the purpose of flood hazard mapping. Flood hazard mapping defines those coastal areas which are at risk of flooding under extreme conditions. With the adverse effects of flooding, the government has implemented the Phil-LiDAR1 project to mitigate the impacts of flooding in the country and to provide accurate flood hazard and risk data to guide the community for appropriate actions. Through flood hazard maps, one can easily identify the flood inundation of an area. This project is very beneficial to the community as this will bring knowledge and awareness of the things to do to prepare for disasters like flooding. The flood hazard maps incorporate data for river flows, storm tides, hydrologic and hydraulic analyses and rainfall and topographic surveys. Moreover, through the identification of the areas being flooded, engineers can also compute for the flood flows and design a drainage system to lessen the impact of flooding in the community. This also helps for the economic expansion in an area for locations not prone to flooding, as it will encourage more investors for development projects and businesses in different sectors, including the agricultural and non-agricultural sectors.

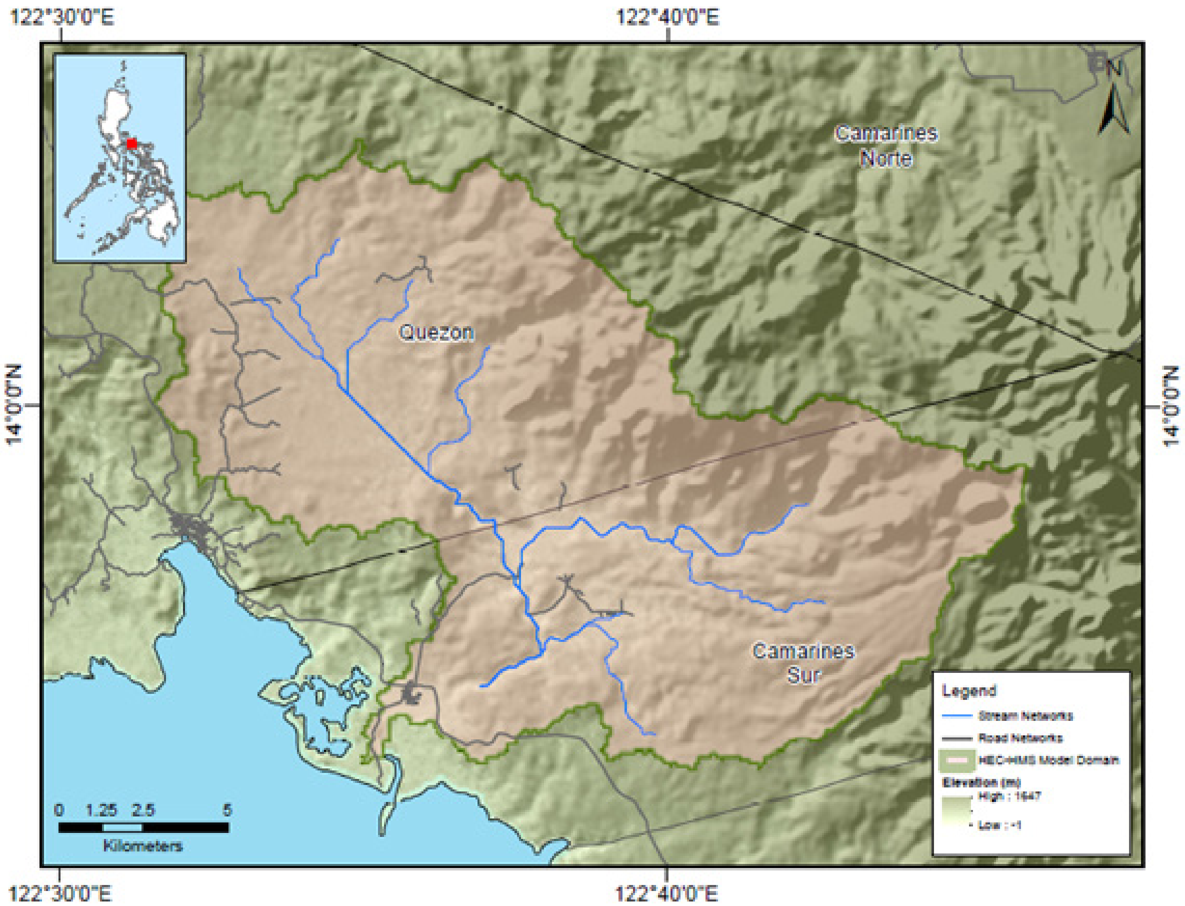

Figure 1. Map of Kilbay-Catabangan River Basin.

CHAPTER 2: LIDAR DATA ACQUISITION OF THE KILBAY-CATABANGAN FLOODPLAIN

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

2.1 Flight Plans

Plans were made to acquire LiDAR data within the delineated priority area for Kilbay-Catabangan floodplain in Camarines Sur Province. These missions were planned for 10 lines that run for at most four (4) hours including take-off, landing and turning time. The flight planning parameters for the LiDAR system is found in Table 1. Figure 1 shows the flight plan for Kilbay-Catabangan floodplain.

Table 1. Parameters used in Pegasus LiDAR System during Flight Acquisition.

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)
BLK 20J	1000	30	50	200	30	114.7	5
BLK 20K	1000	30	50	200	30	114.7	5
BLK 20L	1000/ 1100	30	50	200	30	114.7	5
BLK 20M	1100	30	50	200	30	114.7	5
BLK 20I	1100	30	50	200	30	114.7	5

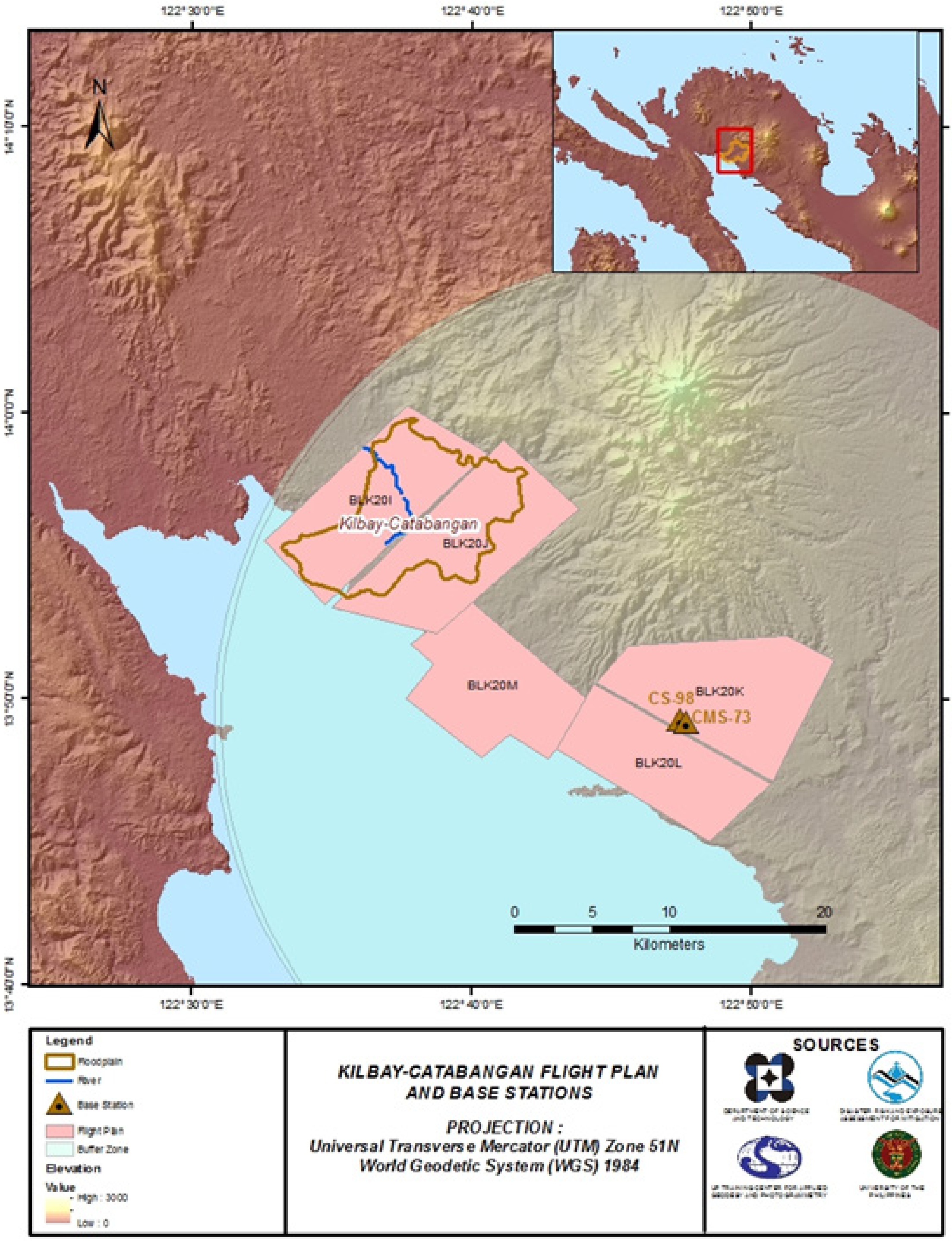

Figure 2. Flight plan and base stations used for Kilbay-Catabangan floodplain.

2.2 Ground Base Stations

The project team was able to recover one (1) NAMRIA ground control point CMS-73 which is of second (2nd) order accuracy. One (1) ground control point, CS-98 was also established. The certification for the base station is found in Annex 2 while the baseline processing report for the established ground control point is found in Annex C. These were used as base stations during flight operations for the entire duration of the survey (March 7-21, 2016). Base stations were observed using dual frequency GPS receivers, TRIMBLE SPS 852 and TOPCON GR-5. Flight plans and location of base stations used during aerial LiDAR acquisition in Kilbay-Catabangan floodplain are shown in Figure 1.

Table 2 to Table 3 show the details about the NAMRIA reference point and established control point, while Table 4 shows the list of all ground control points occupied during the acquisition together with the corresponding dates of utilization.

Table 2. Details of the recovered NAMRIA horizontal control point CMS-73 used as base station for the LiDAR data acquisition.

Station Name	CMS-73	
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	13° 49’ 23.30467” North 122°47’ 22.99347” East 29.10700 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	1528617.256 meters 477266.188 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	13° 49’18.21600” North 122° 47’ 27.94306” East 79.19600 meters
Grid Coordinates, Universal Transverse Mercator Zone 52 North (UTM 52N PRS 92)	Easting Northing	1,528,052.21 meters 477,274.14 meters

Table 3. Details of the established control point CS-98 used as base station for the LiDAR data acquisition.

Station Name	CS-98	
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	13° 49’ 19.4257” North 122° 47’ 36.54972” East 13.233 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	13° 49’14.3375” North 122° 47’ 41.49939” East 63.335 meters
Grid Coordinates, Universal Transverse Mercator Zone 52 North (UTM 52N PRS 92)	Easting Northing	477681.010 meters 1527962.695 meters

Table 4. Ground control points used during LiDAR data acquisition.

Date Surveyed	Flight Number	Mission Name	Ground Control Points
Mar. 15, 2016	23194	1BLK20JKL75A	CMS-73 and CS-98
Mar. 16, 2016	23198	1BLK20IM76A	CMS-73 and CS-98

2.3 Flight Missions

Two (2) missions were conducted to complete the LiDAR Data Acquisition in Kilbay-Catabangan Floodplain, for a total of eight hours and thirty minutes (8+30) of flying time for RP-C9122. All missions were acquired using the Pegasus LiDAR system. Table 5 shows the total area of actual coverage and the corresponding flying hours per mission, while Table 6 presents the actual parameters used during the LiDAR data acquisition.

Table 5. Flight Missions for LiDAR Data Acquisition in Kilbay-Catabangan 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	
Mar. 15, 2016	23194	379.78	194.06	41.11	152.95	NA	4	10
Mar. 16, 2016	23198	379.78	207.12	59.57	147.55	NA	4	20
TOTAL		759.56	401.18	100.68	300.5	NA	8	30

Table 6. 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)
23194	1000	30	50	200	30	114.7	5
23198	1100	30	50	200	30	114.7	5

2.4 Survey Coverage

Kilbay-Catabangan floodplain is situated within the municipalities of Camarines Sur and Quezon with majority of the floodplain located in Camarines Sur. The list of municipalities and cities surveyed with at least one (1) square kilometer coverage, is shown in Table 7. The actual coverage of the LiDAR acquisition for Kilbay-Catabangan floodplain is presented in Figure 2.

Table 7. List of Municipalities/Cities Surveyed during Kilbay-Catabangan Floodplain LiDAR survey.

Province	**Municipality/City**	**Area of Municipality/City (km2)**	**Total Area Surveyed (km2)**	**Percentage of Area Surveyed**
Camarines Sur	Del Gallego	279.27	137.01	49.06%
	Ragay	296.26	131.88	44.51%
	Lupi	230.62	7.09	3.07%
Quezon	Tagkawayan	551.73	35.01	6.35%
Total		**1357.88**	**310.99**	**22.90%**

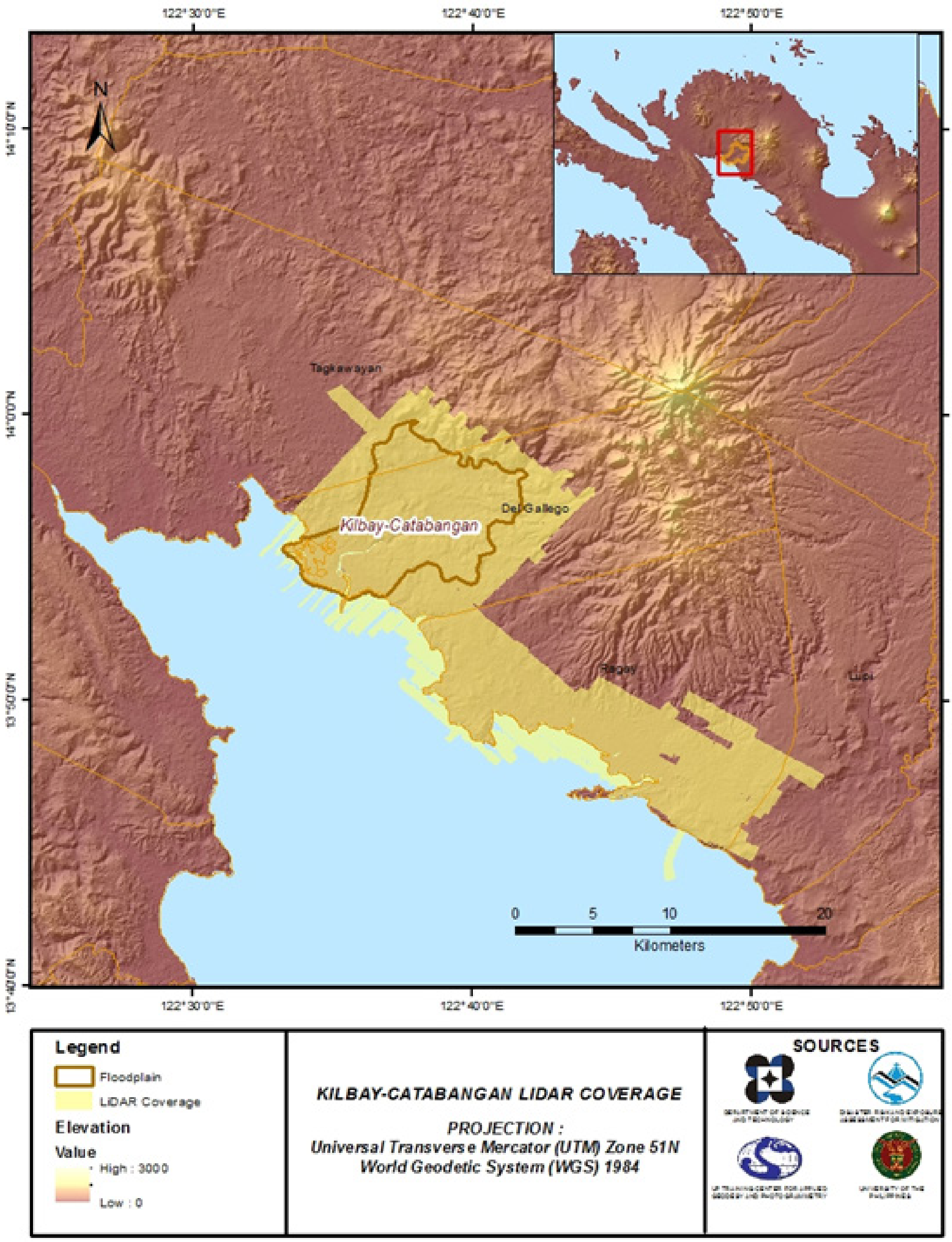

Figure 3. Actual LiDAR survey coverage for Kilbay-Catabangan floodplain.

CHAPTER 3: LIDAR DATA PROCESSING OF THE KILBAY-CATABANGAN FLOODPLAIN

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

3.1 Overview of the LIDAR Data Pre-Processing

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

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

These processes are summarized in the flowchart shown in Figure 4.

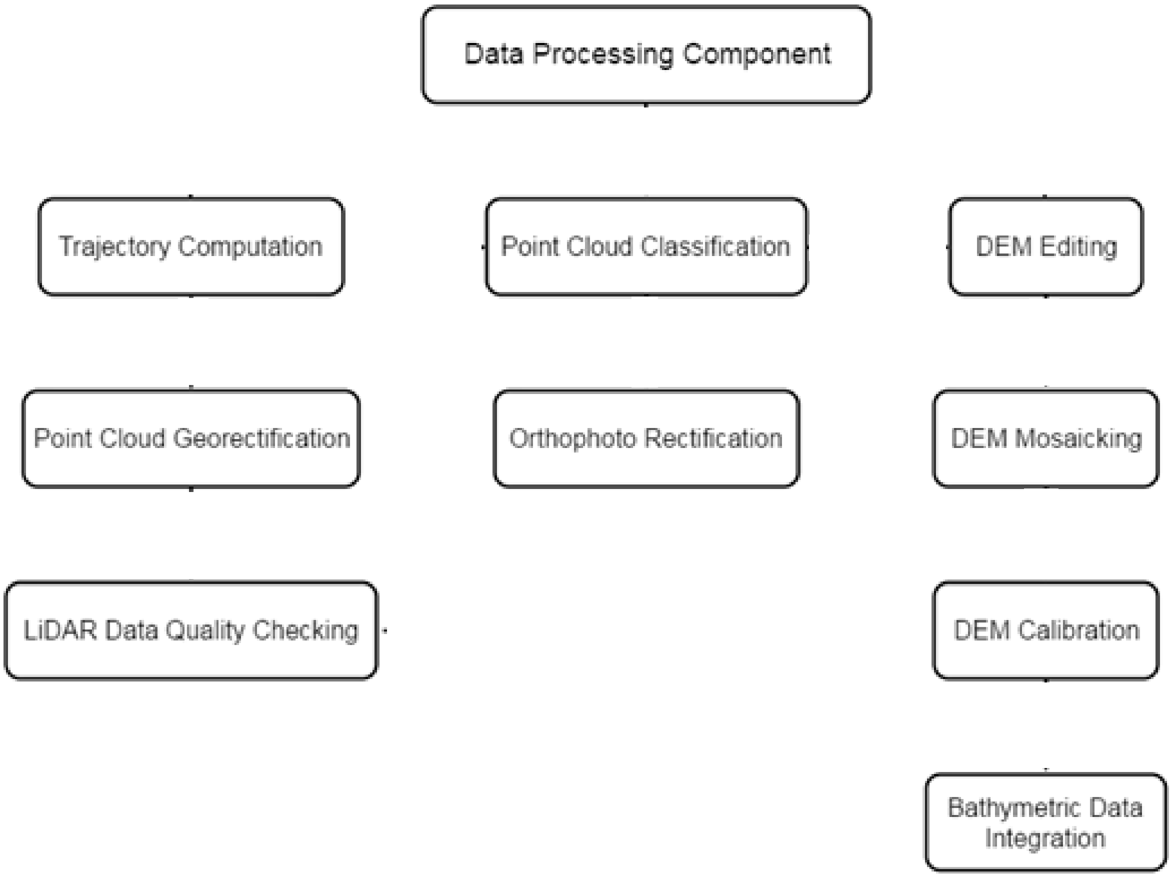

Figure 4. Schematic Diagram for Data Pre-Processing Component.

3.2 Transmittal of Acquired LiDAR Data

Data transfer sheets for all the LiDAR missions for Kilbay-Catabangan floodplain can be found in Annex 5. Missions flown over Del Gallego, Camarines Sur during the survey conducted on March 2016 used the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.) Pegasus system. The Data Acquisition Component (DAC) transferred a total of 44.4 Gigabytes of Range data, 0.55 Gigabytes of POS data, 165.5 Megabytes of GPS base station data, and 69.4 Gigabytes of raw image data to the data server on April 1, 2016 for survey. The Data Pre-processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for Kilbay-Catabangan was fully transferred on April 1, 2016, as indicated on the Data Transfer Sheets for Kilbay-Catabangan floodplain.

3.3 Trajectory Computation

The Smoothed Performance Metrics of the computed trajectory for flight 23198P, one of the Kilbay-Catabangan flights, which is the North, East, and Down position RMSE values are shown in Figure 5. The x-axis corresponds to the time of flight, which is measured by the number of seconds from the midnight of the start of the GPS week, which on that week fell on March 16, 2016 00:00AM. The y-axis is the RMSE value for that particular position.

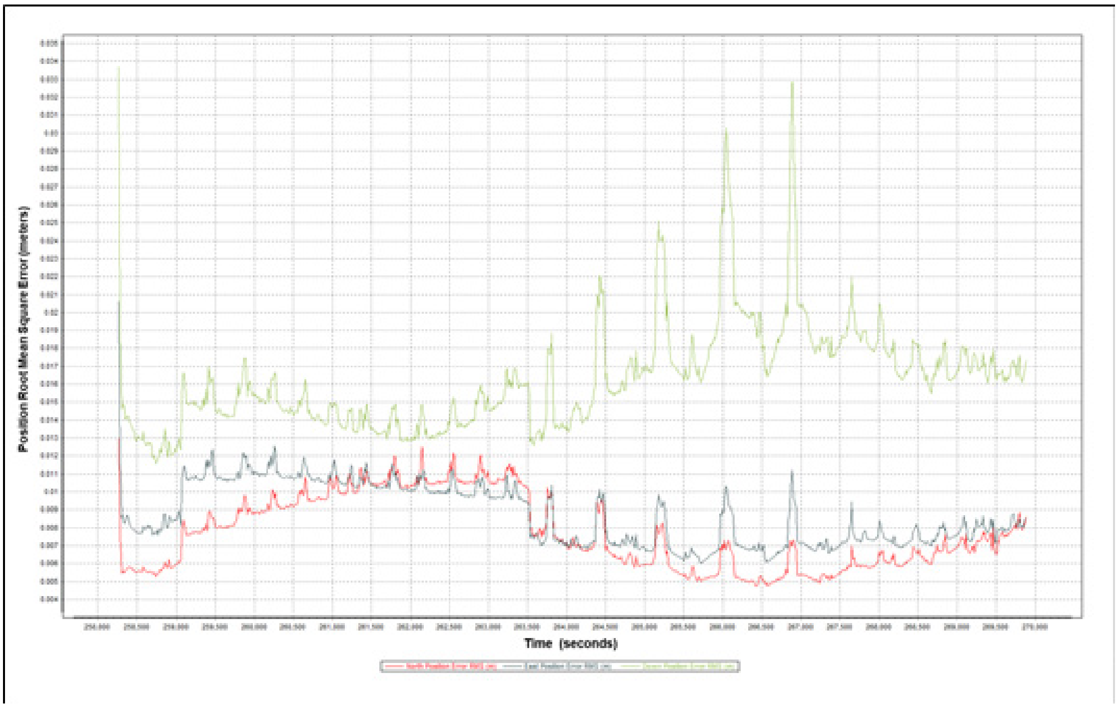

Figure 5. Smoothed Performance Metrics of a Kilbay-Catabangan Flight 23198P.

The time of flight was from 258,000 seconds to 270,000 seconds, which corresponds to afternoon of March 16, 2016. The initial spike that is seen on the data corresponds to the time that the aircraft was getting into position to start the acquisition, and the POS system starts computing for the position and orientation of the aircraft. Redundant measurements from the POS system quickly minimized the RMSE value of the positions. The periodic increase in RMSE values from an otherwise smoothly curving RMSE values correspond to the turn-around period of the aircraft, when the aircraft makes a turn to start a new flight line. Figure 5 shows that the North position RMSE peaks at 1.25 centimeters, the East position RMSE peaks at 1.25 centimeters, and the Down position RMSE peaks at 3.30 centimeters, which are within the prescribed accuracies described in the methodology.

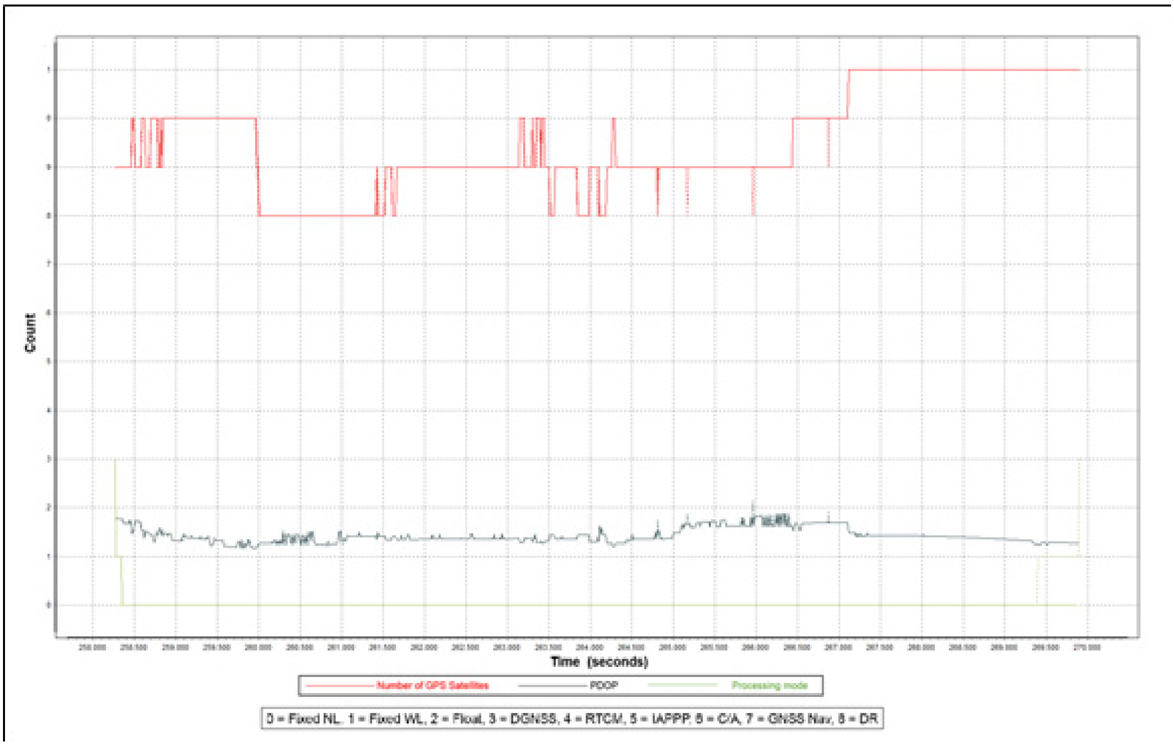

Figure 6. Solution Status Parameters of Kilbay-Catabangan Flight 23198P.

The Solution Status parameters of flight 23198P, one of the Kilbay-Catabangan flights, which indicate the number of GPS satellites, Positional Dilution of Precision (PDOP), and the GPS processing mode used, are shown in Figure 6. The graphs indicate that the number of satellites during the acquisition did not go down to 8. Most of the time, the number of satellites tracked was between 8 and 11. The PDOP value also did not go above the value of 3, which indicates optimal GPS geometry. The processing mode remained at 0 for majority of the survey with some peaks up to 1 attributed to the turns performed by the aircraft. The value of 0 corresponds to a Fixed, Narrow-Lane mode, which is the optimum carrier-cycle integer ambiguity resolution technique available for POSPAC MMS. All of the parameters adhered to the accuracy requirements for optimal trajectory solutions, as indicated in the methodology. The computed best estimated trajectory for all Kilbay-Catabangan flights is shown in Figure 7.

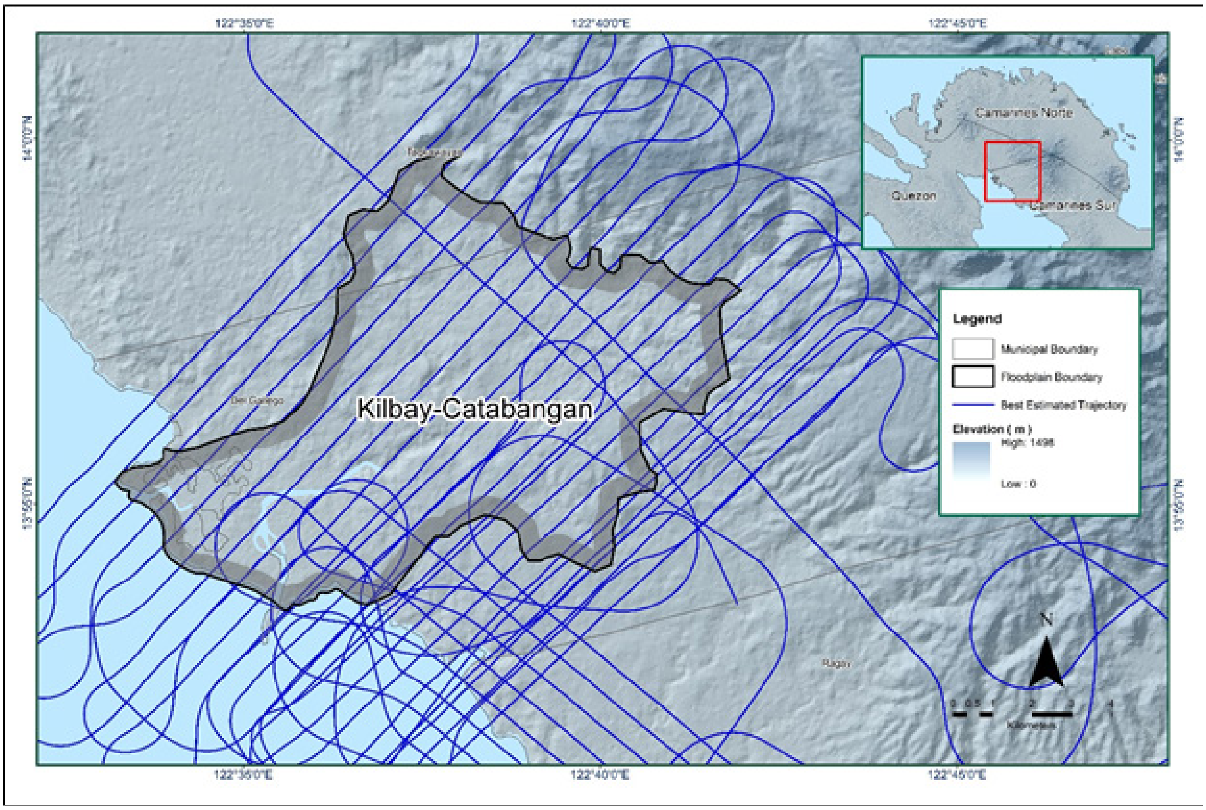

Figure 7. Best estimated trajectory for Kilbay-Catabangan floodplain.

3.4 LiDAR Point Cloud Computation

The produced LAS data contains 64 flight lines, with each flight line containing two channels, since the Pegasus system contains two channels. The summary of the self-calibration results obtained from LiDAR processing in LiDAR Mapping Suite (LMS) software for all flights over Kilbay-Catabangan floodplain are given in Table 8.

Table 8. Self-Calibration Results values for Kilbay-Catabangan flights.

Parameter	Acceptable Value	Computed Value
Boresight Correction stdev)	<0.001degrees	0.000236
IMU Attitude Correction Roll and Pitch Corrections stdev)	<0.001degrees	0.000524
GPS Position Z-correction stdev)	<0.01meters	0.0009

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

3.5 LiDAR Quality Checking

The boundary of the processed LiDAR data is shown in Figure 8. The map shows gaps in the LiDAR coverage that are attributed to cloud coverage.

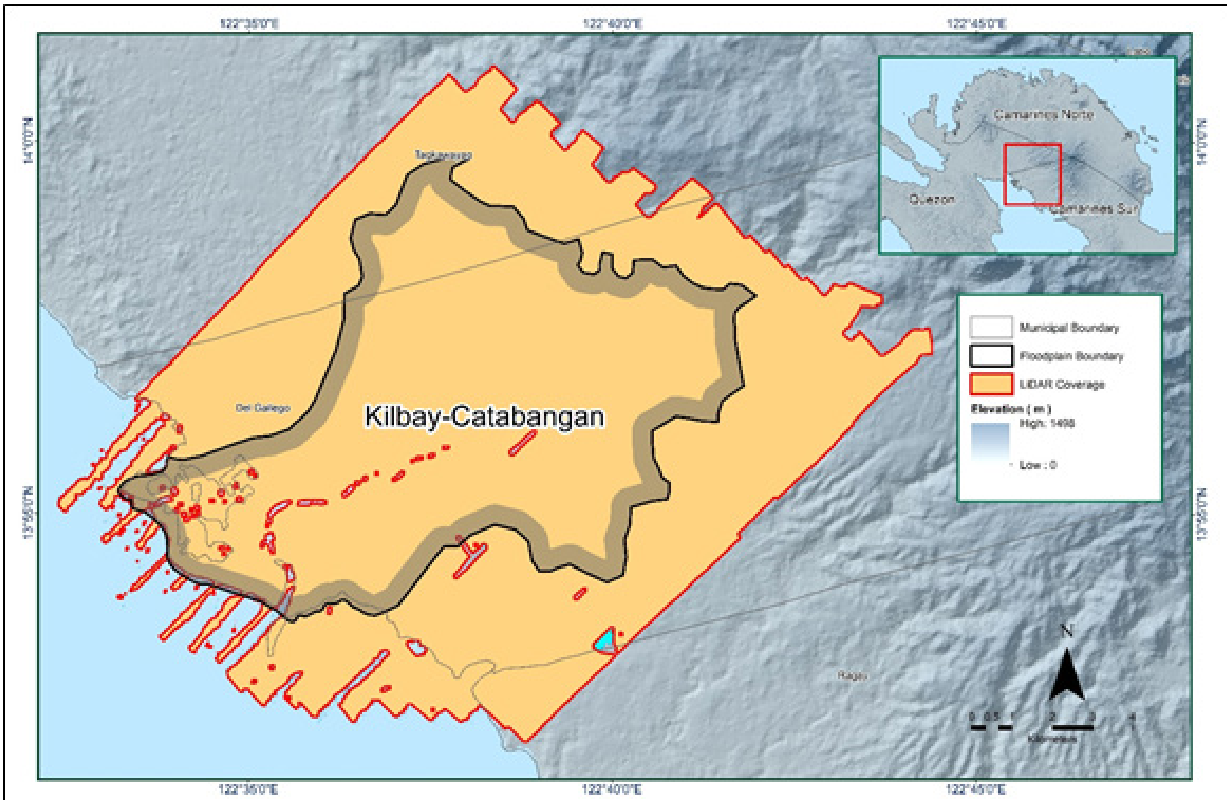

Figure 8. Boundary of the processed LiDAR data on top of a SAR Elevation Data over Kilbay-Catabangan Floodplain .

The total area covered by the Kilbay-Catabangan missions is 190.83 sq.km that is comprised of two (2) flight acquisitions grouped and merged into two (2) blocks as shown in Table 9.

Table 9. List of LiDAR blocks for Kilbay-Catabangan floodplain.

LiDAR Blocks	Flight Numbers	Area (sq.km)
Bagasbas_Blk20I	23198P	95.03
Bagasbas_Blk20J	23194P	95.80
TOTAL		**190.83 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 9. Since the Pegasus system employs two channels, we would expect an average value of 2 (blue) for areas where there is limited overlap, and a value of 3 (yellow) or more (red) for areas with three or more overlapping flight lines.

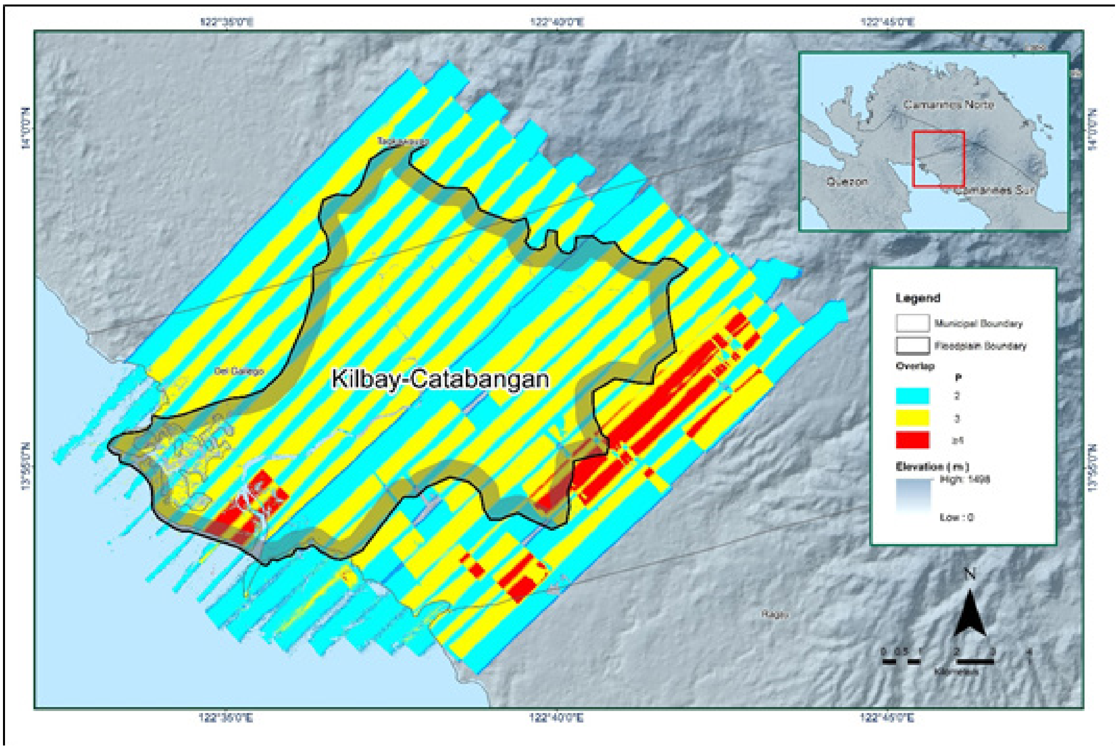

Figure 9. Image of data overlap for Kilbay-Catabangan floodplain.

The overlap statistics per block for the Kilbay-Catabangan floodplain can be found in Annex 8. One pixel corresponds to 25.0 square meters on the ground. For this area, the minimum and maximum percent overlaps are 50.44% and 55.67% respectively, which passed the 25% requirement.

The density map for the merged LiDAR data, with the red parts showing the portions of the data that satisfy the 2 points per square meter criterion is shown in Figure 10. It was determined that all LiDAR data for Kilbay-Catabangan floodplain satisfy the point density requirement, and the average density for the entire survey area is 3.58 points per square meter.

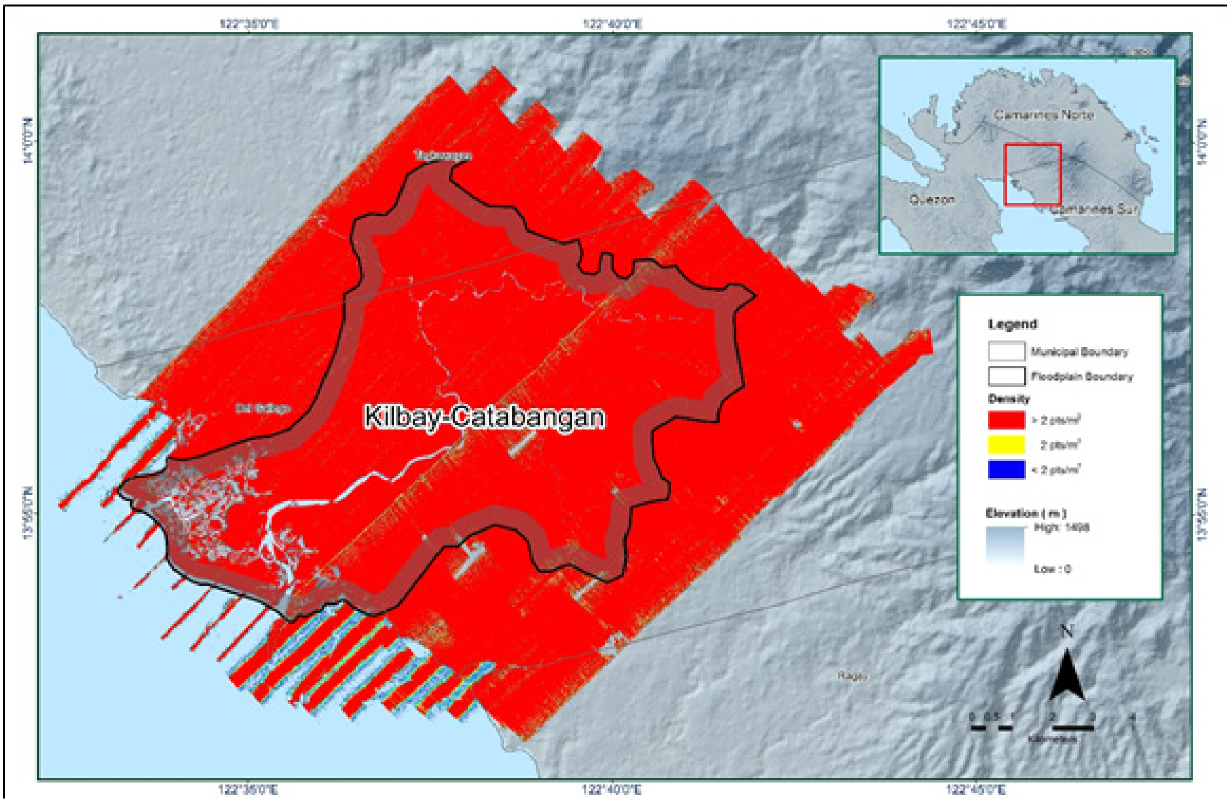

Figure 10. Density map of merged LiDAR data for Kilbay-Catabangan floodplain.

The elevation difference between overlaps of adjacent flight lines is shown in Figure 11. The default color range is from blue to red, where bright blue areas correspond to portions where elevations of a previous flight line, identified by its acquisition time, are higher by more than 0.20m relative to elevations of its adjacent flight line. Bright red areas indicate portions where elevations of a previous flight line are lower by more than 0.20m relative to elevations of its adjacent flight line. Areas with bright red or bright blue need to be investigated further using Quick Terrain Modeler software.

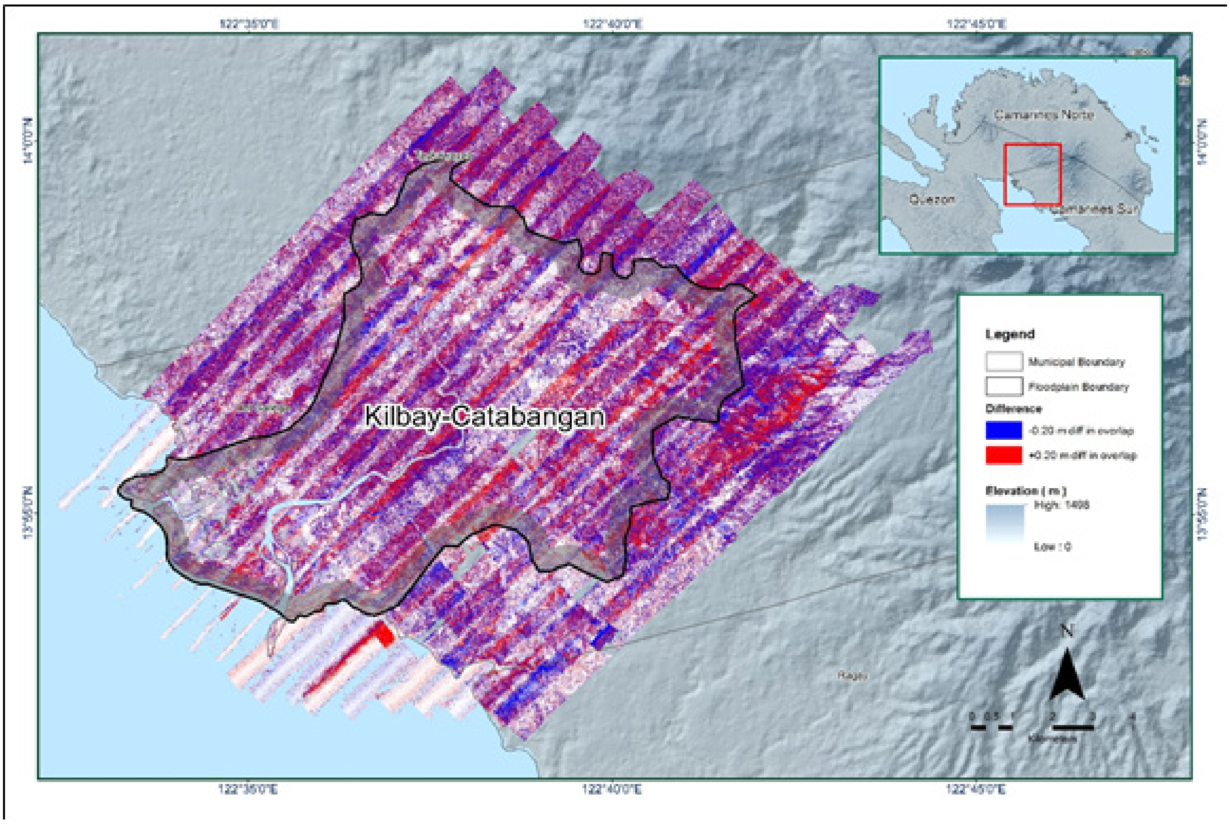

Figure 11. Elevation difference map between flight lines for Kilbay-Catabangan floodplain.

A screen capture of the processed LAS data from Kilbay-Catabangan flight 23198P loaded in QT Modeler is shown in Figure 12. The upper left image shows the elevations of the points from two overlapping flight strips traversed by the profile, illustrated by a dashed red line. The x-axis corresponds to the length of the profile. It is evident that there are differences in elevation, but the differences do not exceed the 20-centimeter mark. This profiling was repeated until the quality of the LiDAR data becomes satisfactory. No reprocessing was done for this LiDAR dataset.

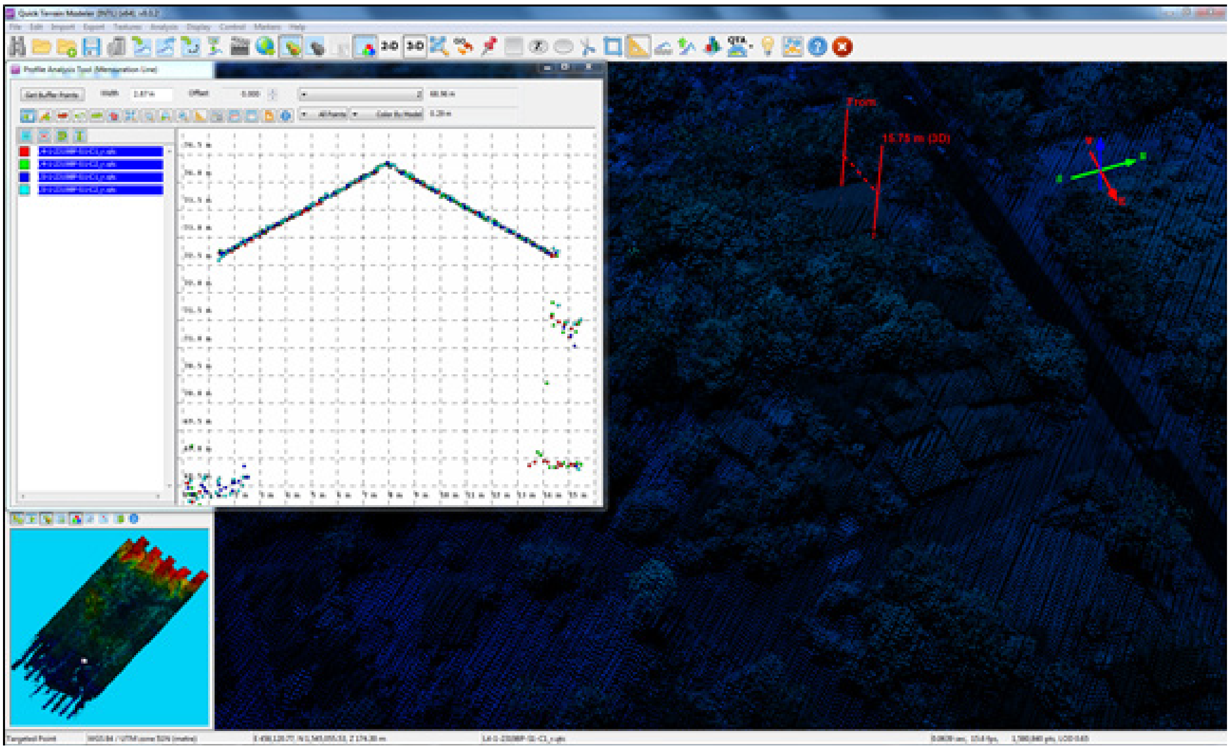

Figure 12. Quality checking for Kilbay-Catabangan flight 23198P using the Profile Tool of QT

3.6 LiDAR Point Cloud Classification and Rasterization

Table 10. Kilbay-Catabangan classification results in TerraScan.

Pertinent Class	Total Number of Points
Ground	38,159,294
Low Vegetation	48,577,390
Medium Vegetation	153,388,119
High Vegetation	339,802,293
Building	3,535,344

The tile system that TerraScan employed for the LiDAR data and the final classification image for a block in Kilbay-Catabangan floodplain is shown in Figure 13 A total of 279 1km by 1km tiles were produced. The number of points classified to the pertinent categories is illustrated in Table 10. The point cloud has a maximum and minimum height of 634.21 meters and 41.33 meters respectively.

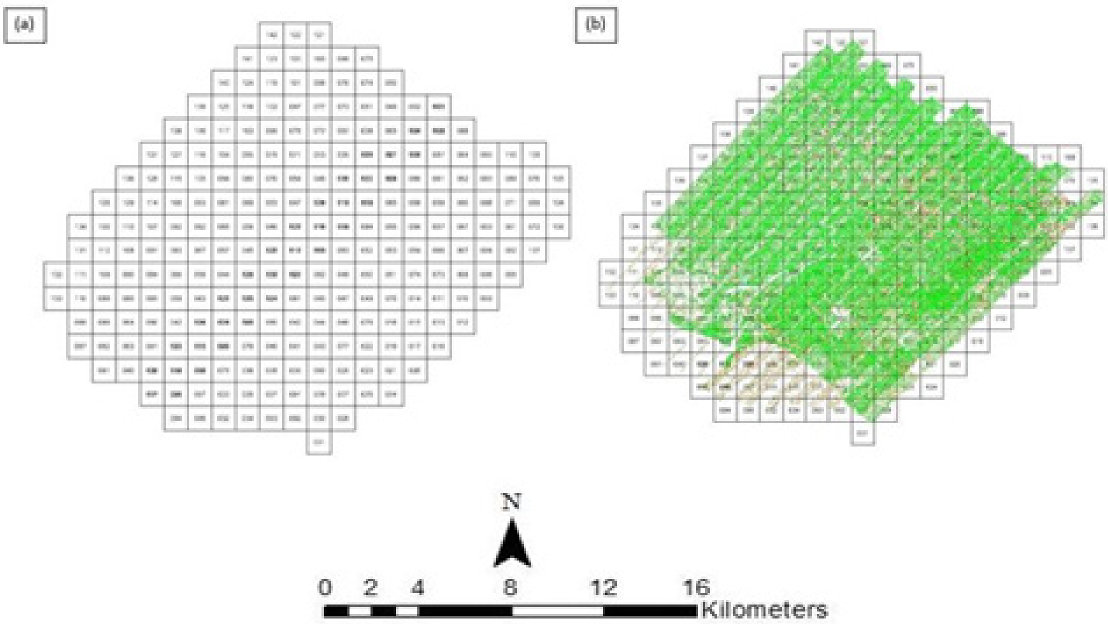

Figure 13. Tiles for Kilbay-Catabangan floodplain (a) and classification results (b) in TerraScan.

An isometric view of an area before and after running the classification routines is shown in Figure 14. The ground points are in orange, the vegetation is in different shades of green, and the buildings are in cyan. It can be seen that residential structures adjacent or even below canopy are classified correctly, due to the density of the LiDAR data.

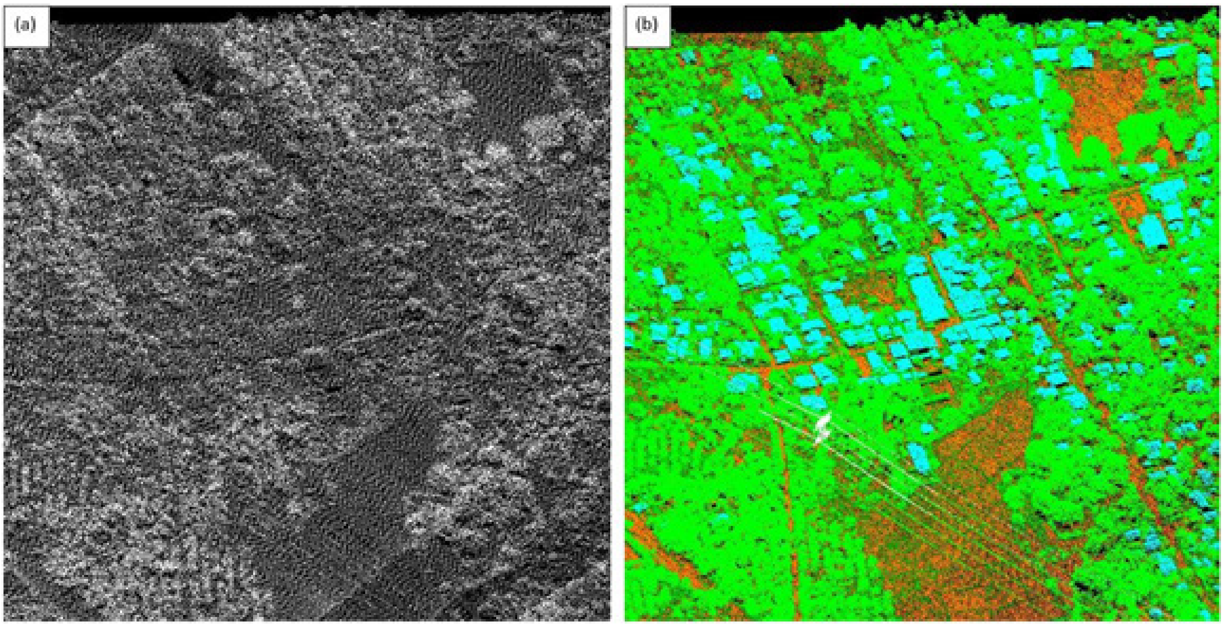

Figure 14. Point cloud before (a) and after (b) classification.

The production of last return (V_ASCII) and the secondary (T_ ASCII) DTM, first (S_ ASCII) and last (D_ ASCII) return DSM of the area in top view display are shown in Figure 15. It shows that DTMs are the representation of the bare earth while on the DSMs, all features are present such as buildings and vegetation.

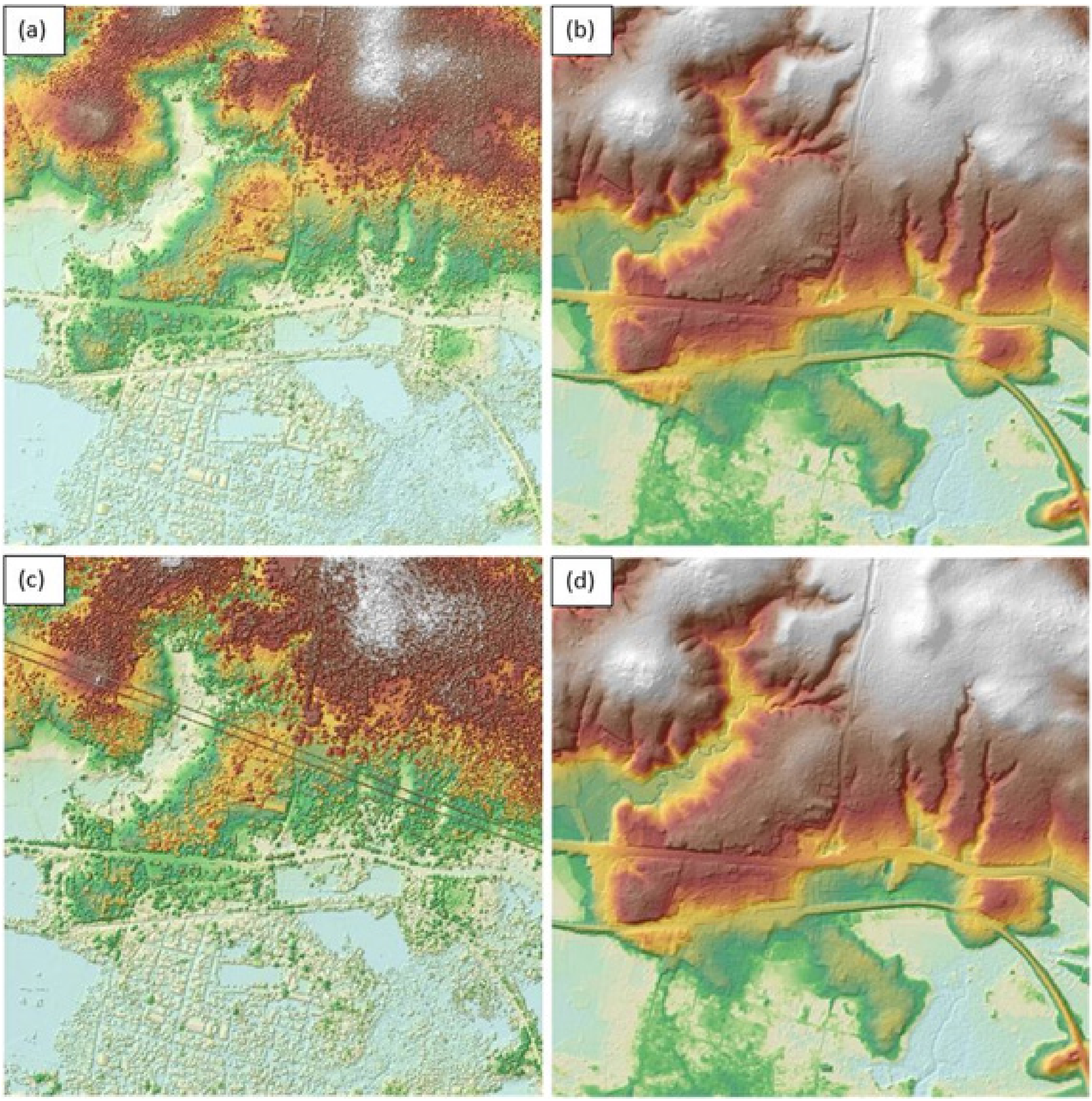

Figure 15. The production of last return DSM (a) and DTM (b), first return DSM (c) and secondary DTM (d) in some portion of Kilbay-Catabangan floodplain.

3.7 LiDAR Image Processing and Orthophotograph Rectification

The 273 1km by 1km tiles area covered by Kilbay-Catabangan floodplain is shown in Figure 16. After tie point selection to fix photo misalignments, color points were added to smoothen out visual inconsistencies along the seamlines where photos overlap. The Kilbay-Catabangan floodplain has a total of 203.58 sq.km orthophotograph coverage comprised of 549 images. A zoomed in version of sample orthophotographs named in reference to its tile number is shown in Figure 17.

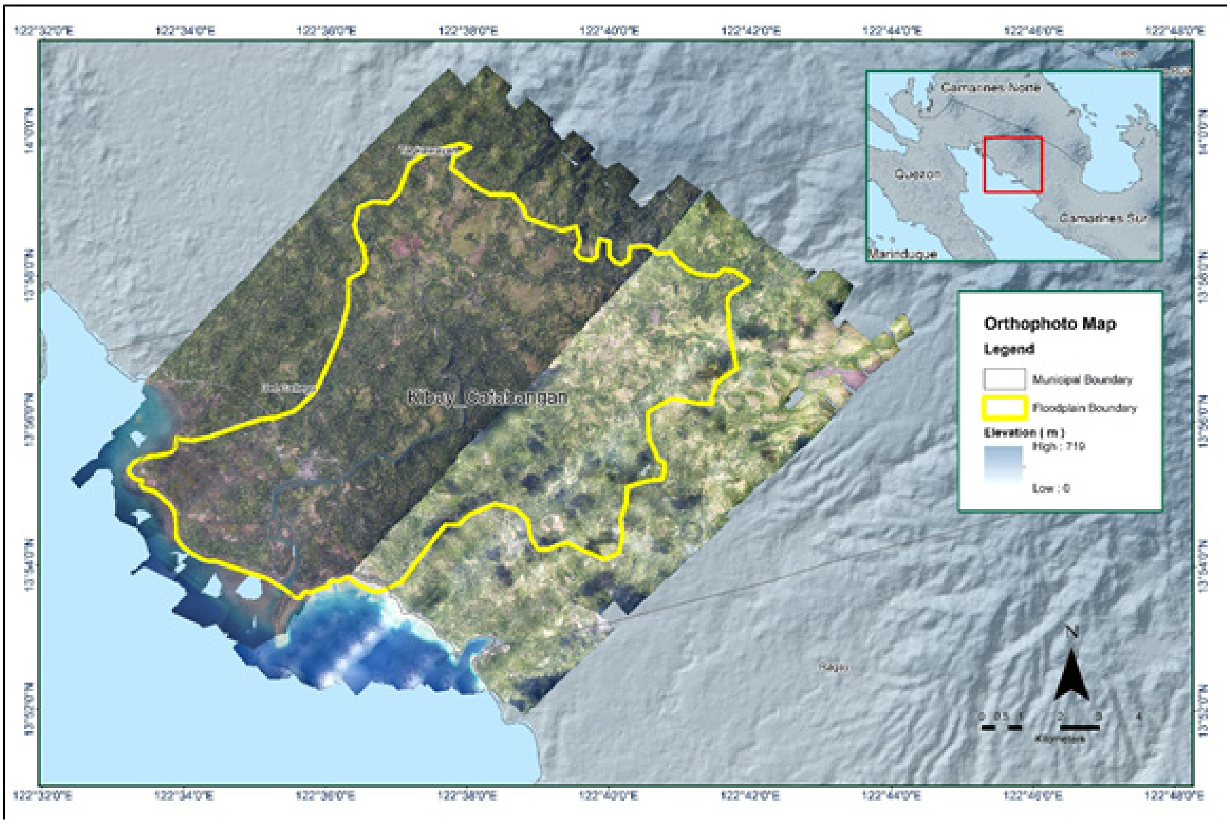

Figure 16. Kilbay-Catabangan floodplain with available orthophotographs.

Figure 17. Sample orthophotograph tiles for Kilbay-Catabangan floodplain.

3.8 DEM Editing and Hydro-Correction

Two (2) mission blocks were processed for Kilbay-Catabangan flood plain. These blocks are composed of Bagasbas blocks with a total area of 190.83 square kilometers. Table 11 shows the name and corresponding area of each block in square kilometers.

Table 11. LiDAR blocks with its corresponding area.

LiDAR Blocks	Area (sq. km.)
Bagasbas_Blk20I	95.03
Bagasbas_Blk20J	95.80
TOTAL	190.83 sq. km.

Portions of DTM before and after manual editing are shown in Figure 18. The bridge (Figure 18a) is also considered to be an impedance to the flow of water along the river and has to be removed (Figure 18b) in order to hydrologically correct the river. Some features on the mountainous areas (Figure 18c) have been misclassified and removed during classification process and has to be retrieved to complete the surface (Figure 18d) to allow the correct flow of water. Another example is a pit that is present in the DTM after classification (Figure 18e) and has to be filled through manual editing (Figure 18f).

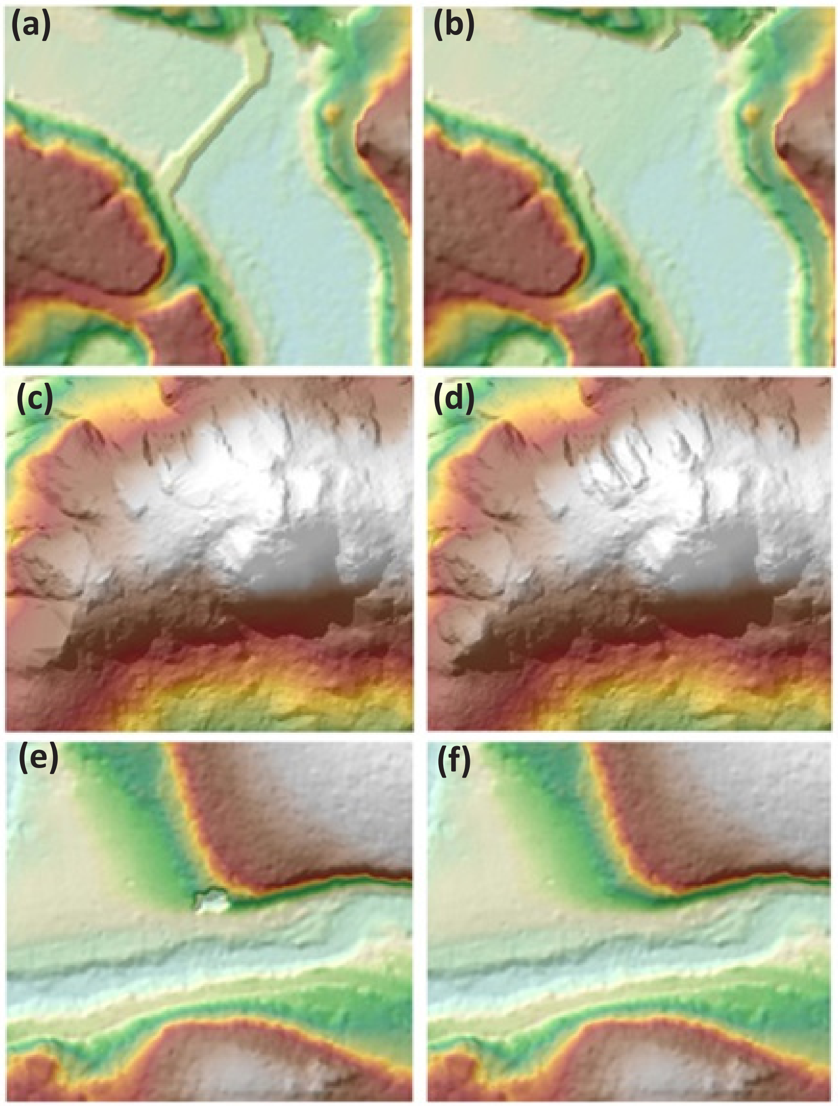

Figure 18. Portions in the DTM of Kilbay-Catabangan floodplain – a bridge before (a) and after (b) manual editing; a mountainous area before (c) and after (d) data retrieval; and a pit before (e) and after (f) manual editing.

3.9 Mosaicking of Blocks

Bagasbas_Blk20F was used as the reference block at the start of mosaicking because this block is the one used as a base for other floodplains covered by Bagasbas blocks. Table 12 shows the shift values applied to each LiDAR block during mosaicking.

Mosaicked LiDAR DTM for Kilbay-Catabangan floodplain is shown in Figure 19. It can be seen that the entire Kilbay-Catabangan floodplain is 100% covered by LiDAR data.

Table 12. Shift Values of each LiDAR Block of Kilbay-Catabangan floodplain.

Mission Blocks	Shift Values (meters)		
	x	y	z
Bagasbas_Blk20I	-1.24	-1.69	-0.16
Bagasbas_Blk20J	-1.53	-2.61	-0.21

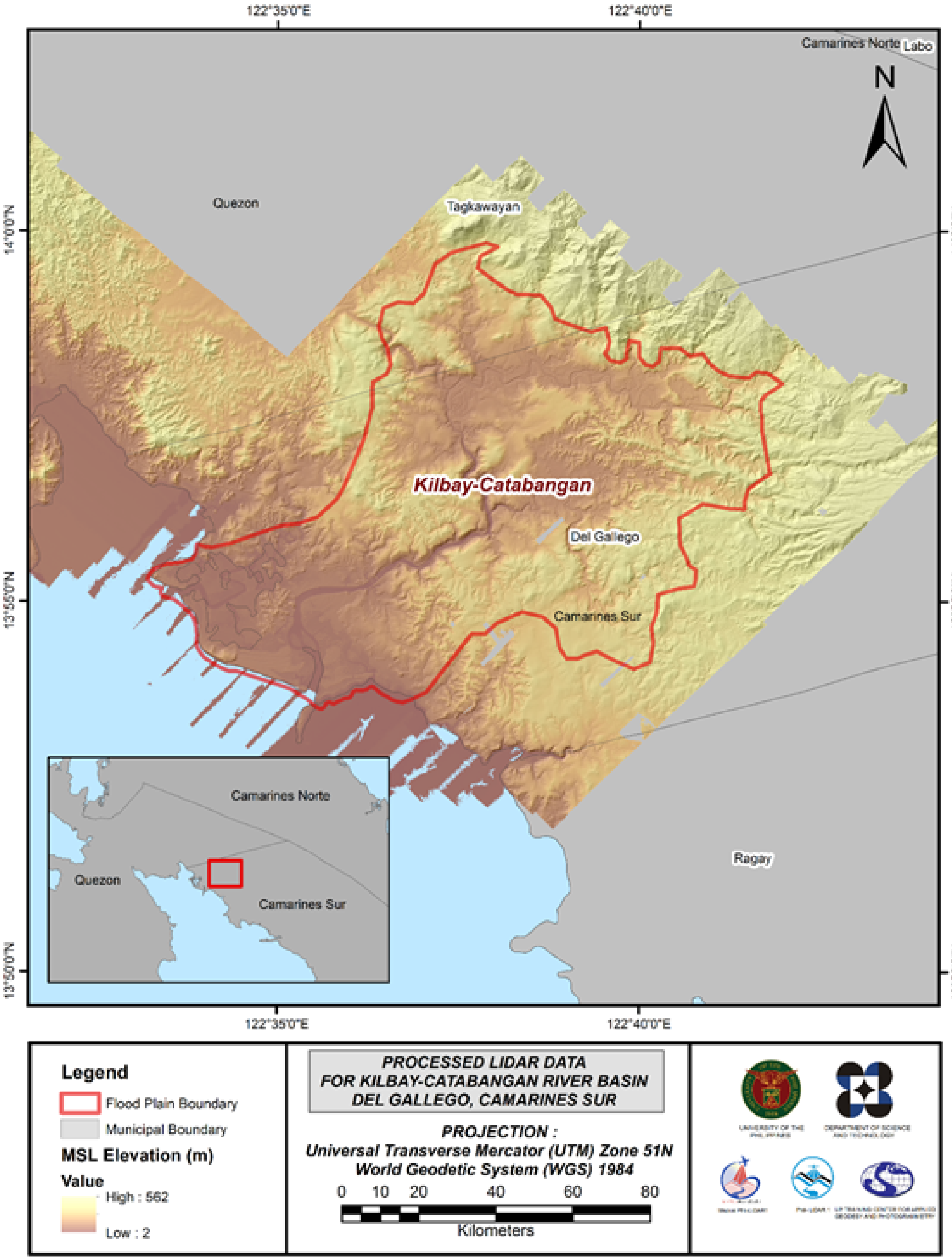

Figure 19. Map of Processed LiDAR Data for Kilbay-Catabangan Flood Plain.

3.10 Calibration and Validation of Mosaicked LiDAR DEM

The extent of the validation survey done by the Data Validation and Bathymetry Component (DVBC) in Kilbay-Catabangan to collect points with which the LiDAR dataset is validated is shown in Figure 20. A total of 15,500 survey points were gathered for all the flood plains within the provinces of Quezon and Camarines Sur wherein the Kilbay-Catabangan floodplain is located. Random selection of 80% of the survey points, resulting to 12400 points, was used for calibration.

A good correlation between the uncalibrated mosaicked LiDAR DTM and ground survey elevation values is shown in Figure 21. Statistical values were computed from extracted LiDAR values using the selected points to assess the quality of data and obtain the value for vertical adjustment. The computed height difference between the LiDAR DTM and calibration points is 3.08 meters with a standard deviation of 0.17 meters. Calibration of the LiDAR data was done by subtracting the height difference value, 3.08 meters, to the mosaicked LiDAR data. Table 13 shows the statistical values of the compared elevation values between the LiDAR data and calibration data.

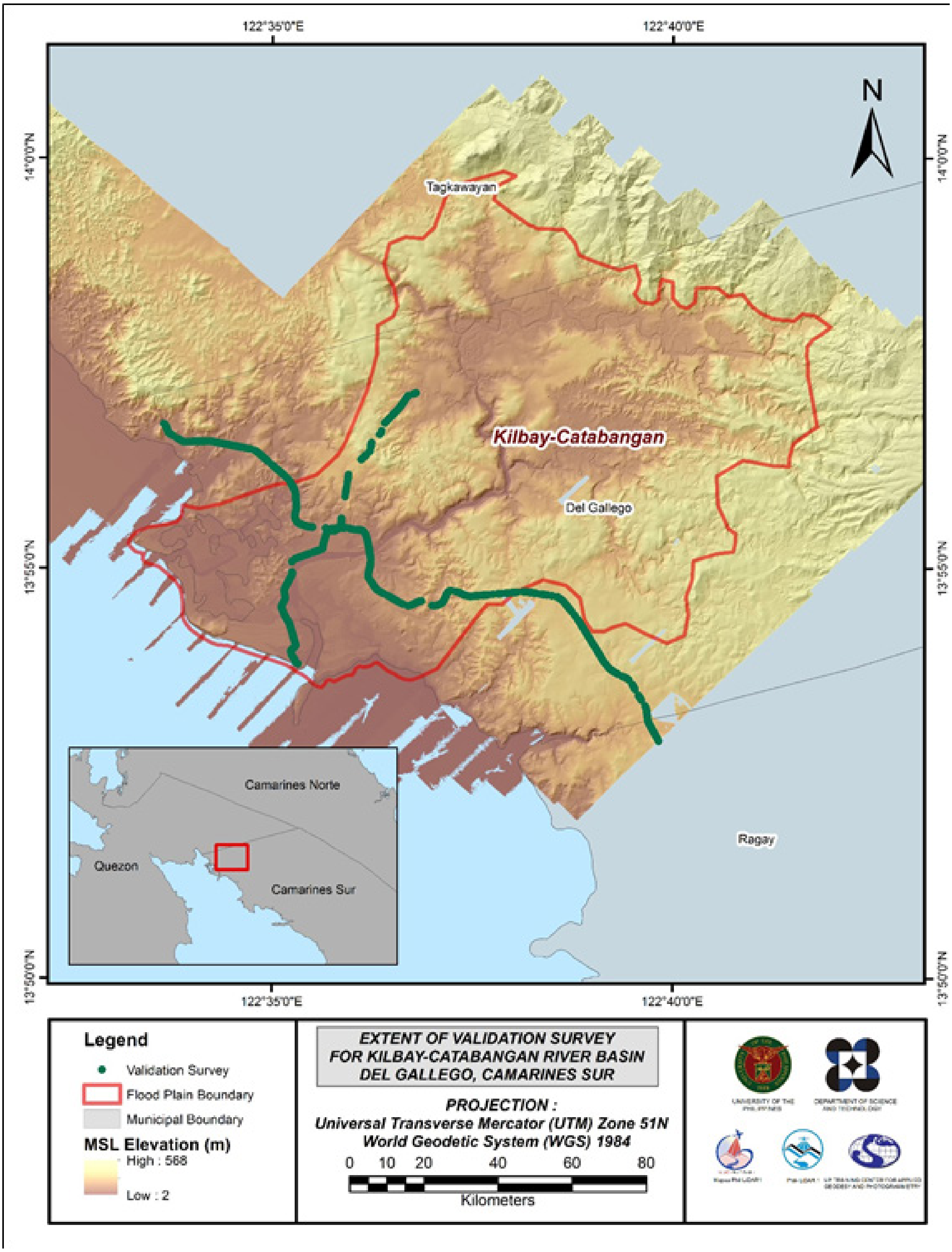

Figure 20. Map of Kilbay-Catabangan Flood Plain with validation survey points in green.

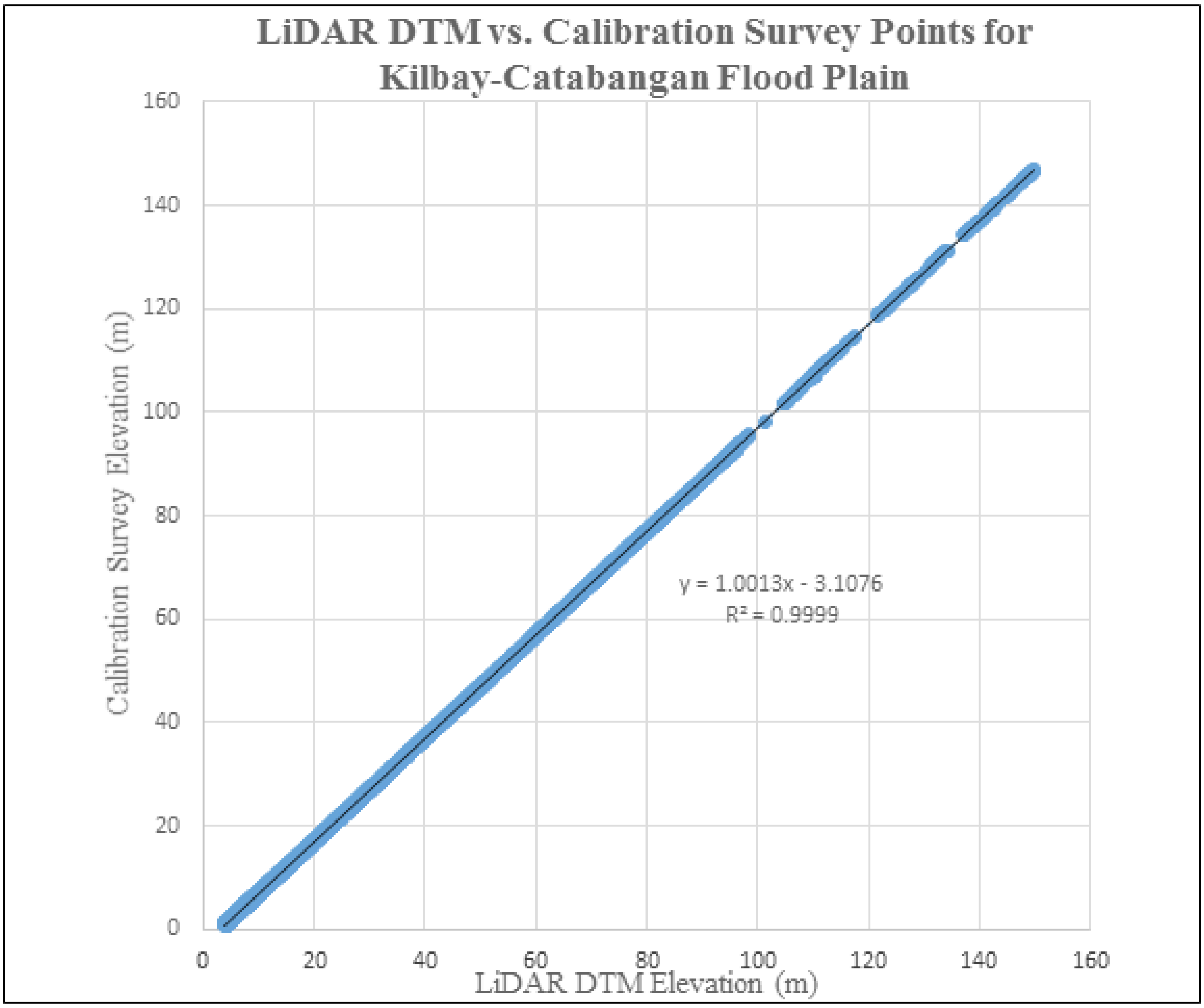

Figure 21. Correlation plot between calibration survey points and LiDAR data.

Table 13. Calibration Statistical Measures.

Calibration Statistical Measures	Value (meters)
Height Difference	3.08
Standard Deviation	0.17
Average	-3.07
Minimum	-3.40
Maximum	-2.60

The remaining 20% of the total survey points were intersected to the flood plain, resulting to 394 points, were used for the validation of calibrated Kilbay-Catabangan DTM. A good correlation between the calibrated mosaicked LiDAR elevation values and the ground survey elevation, which reflects the quality of the LiDAR DTM, is shown in Figure 22. The computed RMSE between the calibrated LiDAR DTM and validation elevation values is 0.14 meters with a standard deviation of 0.13 meters, as shown in Table 14.

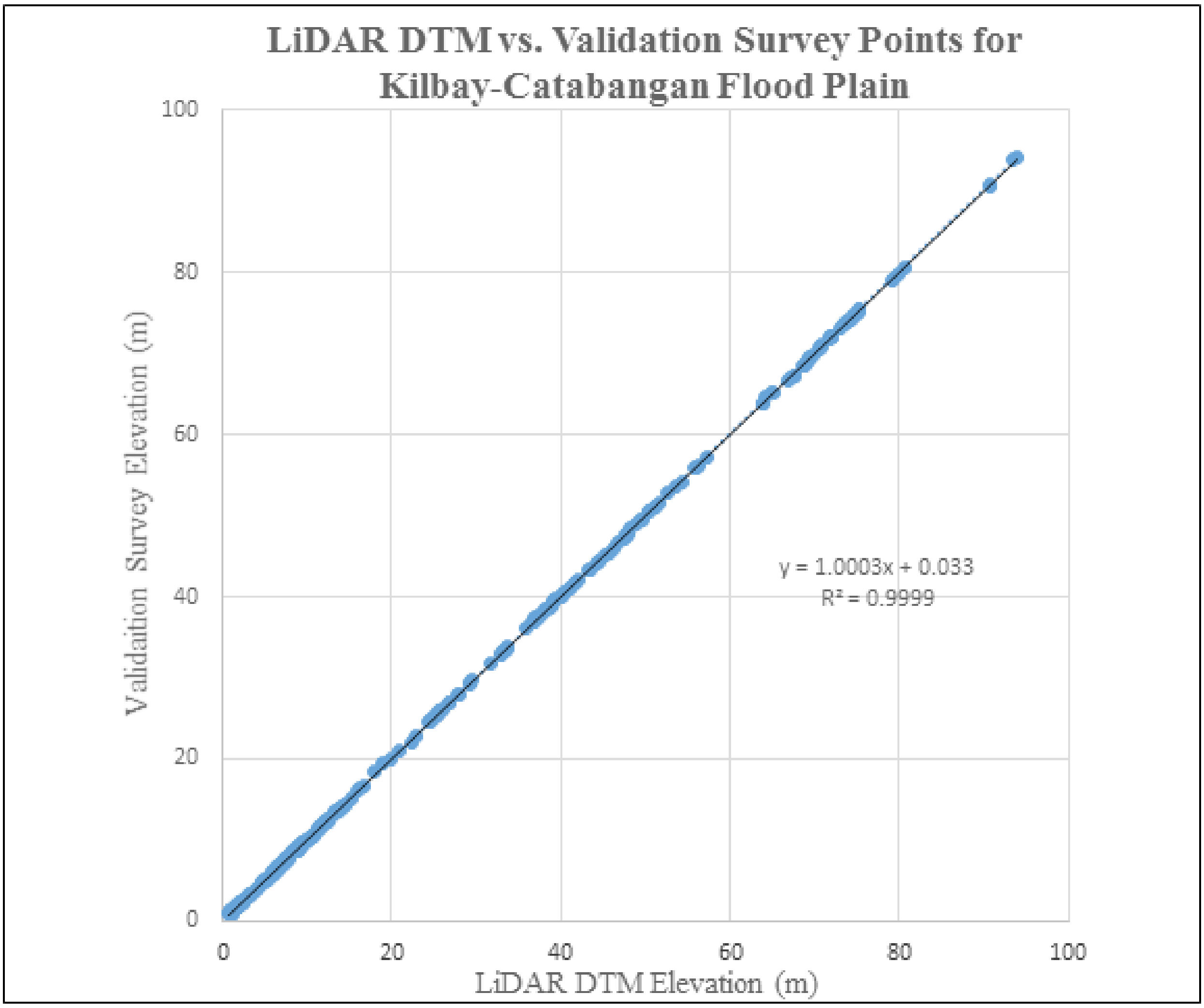

Figure 22. Correlation plot between validation survey points and LiDAR data.

Table 14. Validation Statistical Measures

Validation Statistical Measures	Value (meters)
RMSE	0.14
Standard Deviation	0.13
Average	0.04
Minimum	-0.32
Maximum	-0.48

3.11 Integration of Bathymetric Data into the LiDAR Digital Terrain Model

For bathy integration, only centerline data was available for Kilbay-Catabangan with 9,774 bathymetric survey points. The resulting raster surface produced was done by Kernel Interpolation with Barriers method. After burning the bathymetric data to the calibrated DTM, assessment of the interpolated surface is represented by the computed RMSE value of 0.50 meters. The extent of the bathymetric survey done by the Data Validation and Bathymetry Component (DVBC) in Kilbay-Catabangan integrated with the processed LiDAR DEM is shown in Figure 23.

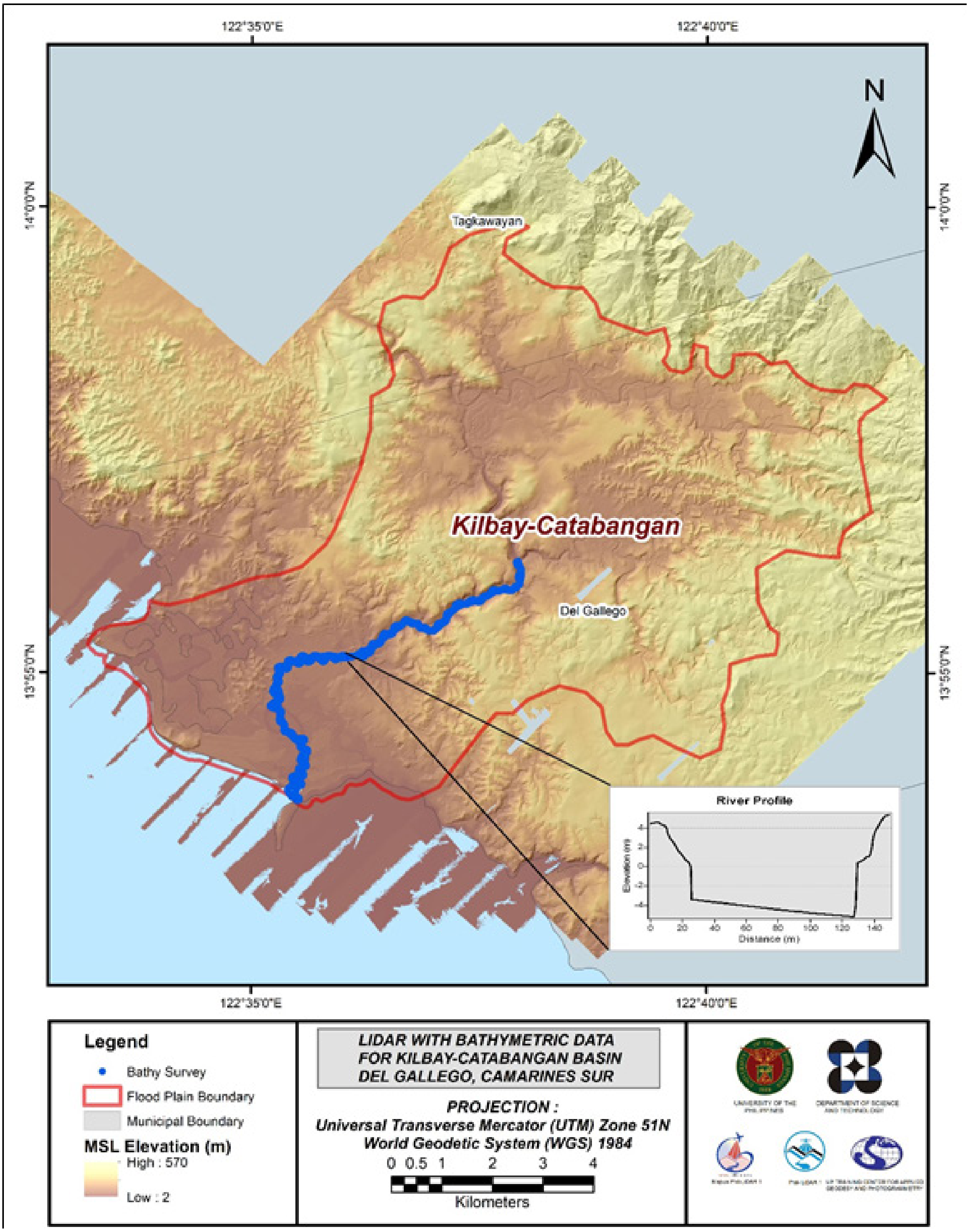

Figure 23. Map of Kilbay-Catabangan Flood Plain with bathymetric survey points shown in blue.

3.12 Feature Extraction

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

3.12.1 Quality Checking (QC) of Digitized Features' Boundary

Kilbay-Catabangan floodplain, including its 200 m buffer, has a total area of 101.96 sq km. For this area, a total of 5.0 sq km, corresponding to a total of 1829 building features, are considered for QC. Figure 24 shows the QC blocks for Kilbay-Catabangan floodplain.

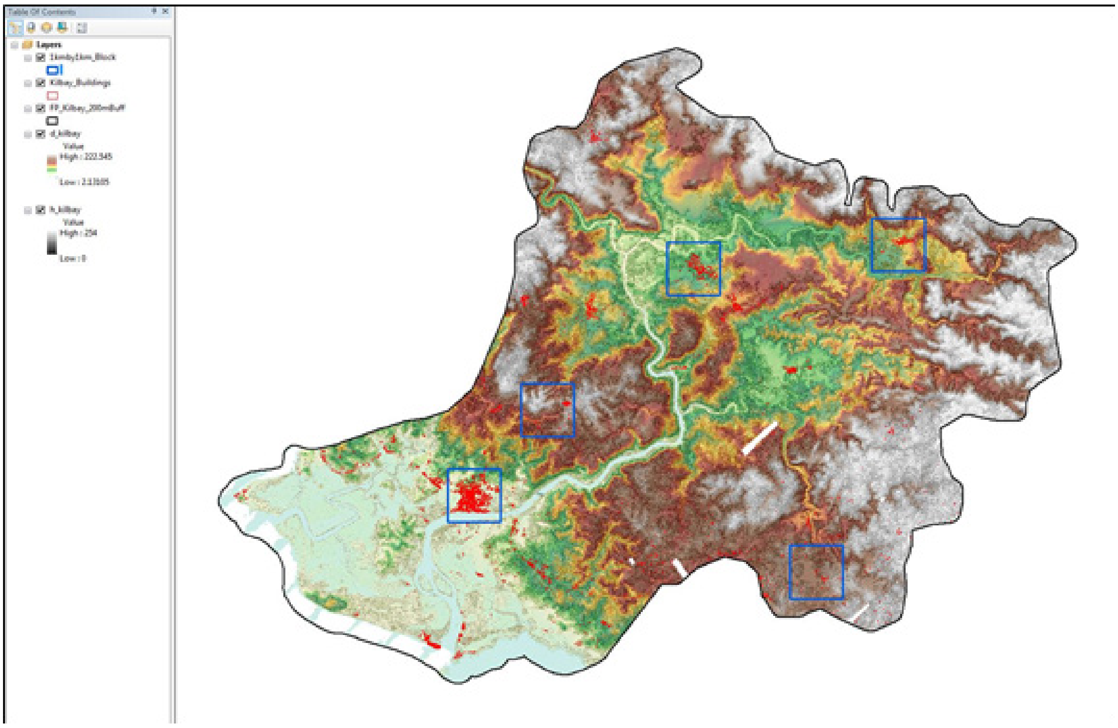

Figure 24. QC blocks for Kilbay-Catabangan building features.

Quality checking of Kilbay-Catabangan building features resulted in the ratings shown in Table 15.

Table 15. Quality Checking Ratings for Kilbay-Catabangan Building Features.

FLOODPLAIN	COMPLETENESS	CORRECTNESS	QUALITY	REMARKS
Kilbay-Catabangan	98.83	99.73	95.24	PASSED

3.12.2 Height Extraction

Height extraction was done for 3,850 building features in Kilbay-Catabangan floodplain. Of these building features, 39 were filtered out after height extraction, resulting to 3,811 buildings with height attributes. The lowest building height is at 2.00 m, while the highest building is at 6.03m.

3.12.3 Feature Attribution

The attributes were obtained by field data gathering. GPS devices were used to determine the coordinates of important features. These points are uploaded and overlaid in ArcMap and are then integrated with the shapefiles.

Table 16 summarizes the number of building features per type. On the other hand, Table 17 shows the total length of each road type, while Table 18 shows the number of water features extracted per type.

Table 16. Building Features Extracted for Kilbay-Catabangan Floodplain.

Facility Type	No. of Features
Residential	3,673
School	58
Market	8
Agricultural/Agro-Industrial Facilities	0
Medical Institutions	10
Barangay Hall	22
Military Institution	0
Sports Center/Gymnasium/Covered Court	0
Telecommunication Facilities	0
Transport Terminal	0
Warehouse	0
Power Plant/Substation	0
NGO/CSO Offices	0
Police Station	13
Water Supply/Sewerage	0
Religious Institutions	17
Bank	1
Factory	0
Gas Station	1
Fire Station	0
Other Government Offices	7
Other Commercial Establishments	1
Total	3,811

Table 17. Total Length of Extracted Roads for Kilbay-Catabangan Floodplain.

Floodplain	**Road Network Length (km)**					**Total**
	Barangay Road	**City/ Municipal Road**	**Provincial Road**	**National Road**	**Others**	
Kilbay-Catabangan	102.10	0.00	0.00	8.67	0.00	110.77

Table 18. Number of Extracted Water Bodies for Kilbay-Catabangan Floodplain

Floodplain	Water Body Type					Total
	Rivers/ Streams	Lakes/Ponds	Sea	Dam	Fish Pen	
Kilbay-Catabangan	2	0	0	0	0	2

A total of 15 bridges and culverts over small channels that are part of the river network were also extracted for the floodplain.

3.12.4 Final Quality Checking of Extracted Features

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

Figure 25 shows the Digital Surface Model (DSM) of Kilbay-Catabangan floodplain overlaid with its ground features.

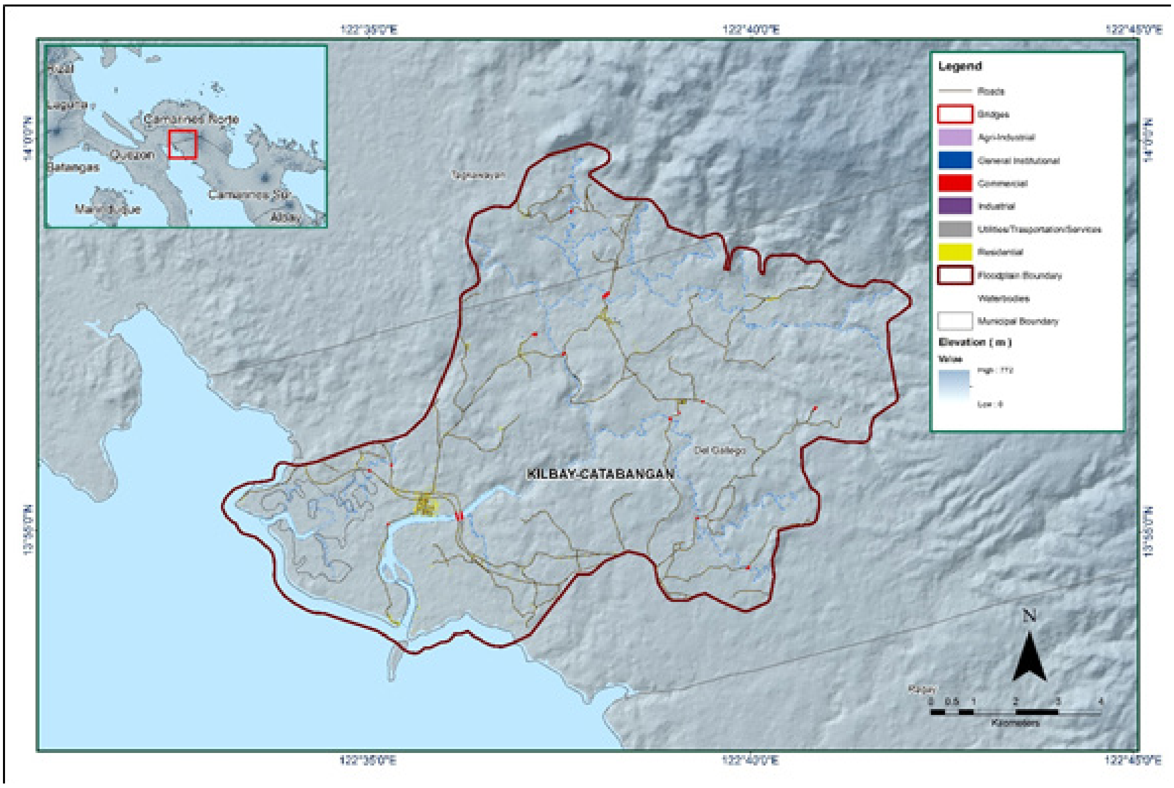

Figure 25. Extracted features for Kilbay-Catabangan floodplain.

CHAPTER 4: LIDAR VALIDATION SURVEY AND MEASUREMENTS OF THE KILBAY-CATABANGAN RIVER BASIN

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

4.1 Summary of Activities

The Data Validation and Bathymetry Component (DVBC) conducted a field survey in Sabang River on June 28 – July 12, 2016 with the following scope of work: reconnaissance; control survey; cross-section and as-built survey at Kilbay Bridge in Brgy. Cabasag, Municipality of Del Gallego; validation points acquisition of about 69 km covering the Sabang River Basin area; and bathymetric survey from its upstream in Brgy. Santa Rita II down to the mouth of the river located in Brgy. San Juan, both in Municipality of Del Gallego, with an approximate length of 8.689 km using Ohmex™ single beam echo sounder and Trimble® SPS 882 GNSS PPK survey technique (Figure 26).

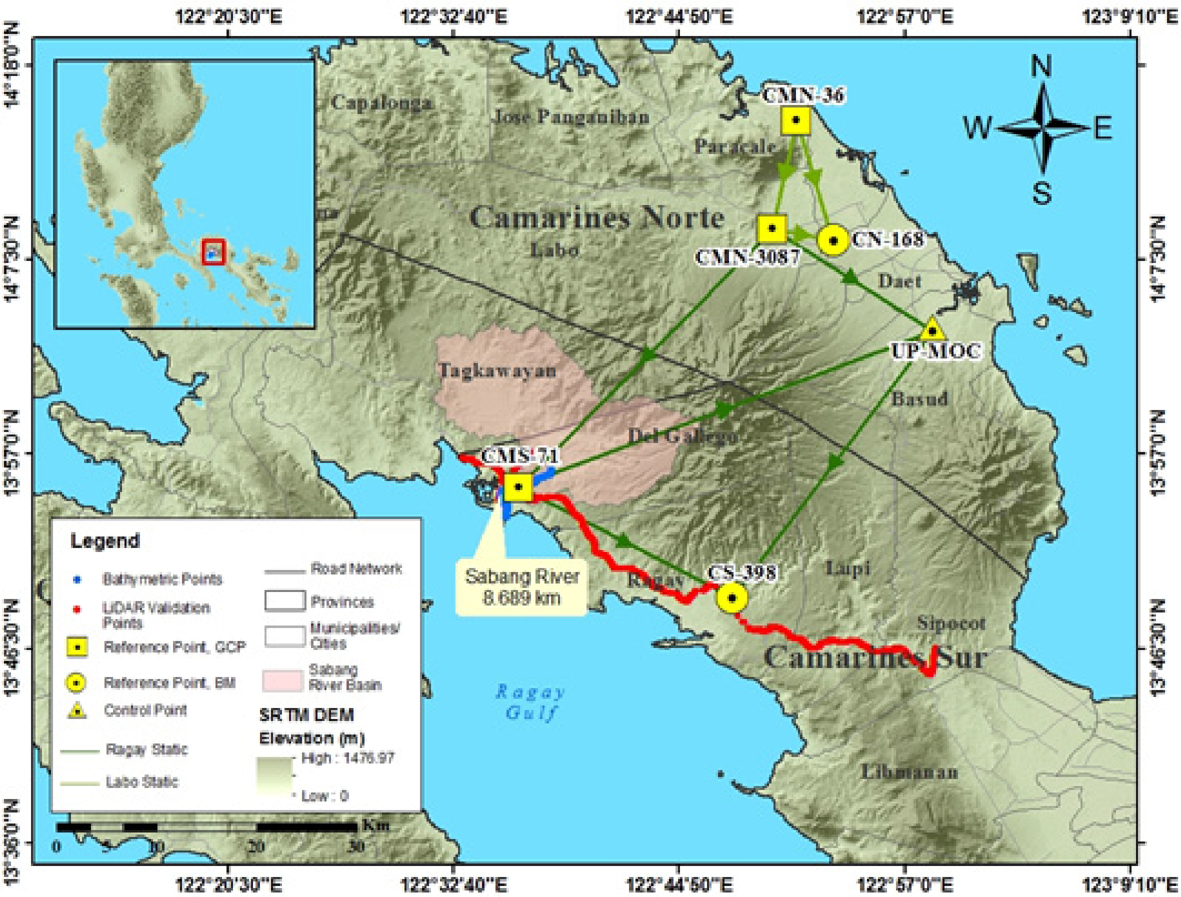


Figure 26. Sabang River Survey Extent.

4.2 Control Survey

A GNSS network from Labo River Survey was established on January 28, 2016 occupying the control points CMN-36, a second-order GCP, in Brgy. Mampungo, Municipality of Paracale; and CN-168, a first-order BM, in Brgy. Sant Domingo, Muncipality of Vinzonz; both in Camarines Norte.

The GNSS network used for Sabang River Basin is composed of two (2) loops established on June 30, 2016 occupying the following reference points: CMS-71, a second-order GCP in Brgy. Cabasag, Municipality of Del Gallego; CS-398, a first order BM, in Brgy. Pangitayan, Municipality of Ragay; and CMN-3087, a fixed point from Labo Survey, located in Brgy. Bakiad, Municipality of Labo.

A control point was established along the approach of Mocong Bridge namely: UP-MOC, located in Brgy. Mocong, Municipality of Basud, Camarines Norte.

The summary of reference and control points and its location is summarized in Table 19 while the GNSS network established is illustrated in Figure 27.

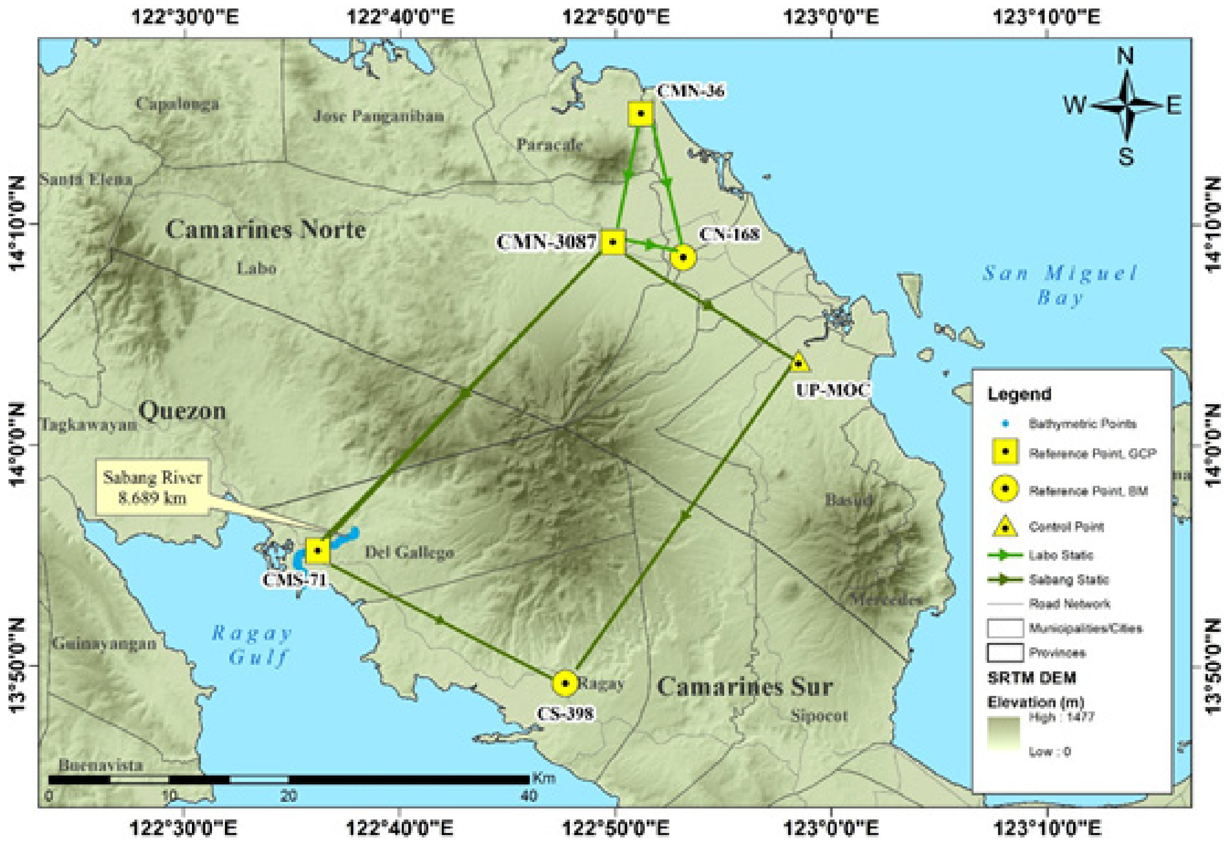


Figure 27. GNSS Network covering Sabang River.

Table 19. List of Reference and Control Points occupied for Sabang River Survey.

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)				
		Latitude	Longitude	Ellipsoidal Height (m)	MSL Elevation (m)	Date Established
Control Survey on January 28, 2016						
CMN-36	2nd Order GCP	14°15’02.89999”N	122°51’10.48832”E	54.569	5.129	2007
CN-168	1st Order BM	14°08’31.19463”N	122°53’08.49490”E	62.569	12.721	2008
CMN-3087	Used as Marker	14°09’12.36125”N	122°49’52.53365”E	64.661	14.905	2007
Control Survey on June 30, 2016						
CMS-71	2nd order, GCP	13°55’14.18695”N	122°36’12.89833”E	59.636	-	2007
CS-398	1st order, BM	-	-	60.994	10.576	2008
CMN-3087	Fixed Control	14°09’12.36125”N	122°49’52.53365”E	64.661	14.905	2007
UP-MOC	UP Established	-	-	-	-	June 30, 2016 10:50 AM

The GNSS set-ups on recovered reference points and established control points in Sabang River are shown in Figure 28 to Figure 31.

Figure 28. GNSS base set up, Trimble® SPS 985, at CMS-71, situated at the approach of Kilbay Bridge in Brgy. Cabasag, Municipality of Del Gallego, Camarines Sur.

Figure 29. GNSS receiver setup, Trimble® SPS 882, at CS-398, located at the approach of Ragay Bridge in Brgy. Pangitayan, Municipality of Ragay, Camarines Sur.

Figure 30. GNSS receiver setup, Trimble® SPS 852, at CMN-3087, located at the approach of Labo Bridge in Brgy. Bakiad, Municipality of Labo, Camarines Norte.

Figure 31. GNSS receiver setup, Trimble® SPS 822, at UP-MOC, located at the approach of Mocong Bridge in Brgy. Mocong, Municipality of Basud, Camarines Norte.

4.3 Baseline Processing

GNSS Baselines were processed simultaneously in TBC by observing that all baselines have fixed solutions with horizontal and vertical precisions within +/- 20 cm and +/- 10 cm requirement, respectively. In case where one or more baselines did not meet all of these criteria, masking is performed. Masking is done by removing/masking portions of these baseline data using the same processing software. It is repeatedly processed until all baseline requirements are met. If the reiteration yields out of the required accuracy, resurvey is initiated. Baseline processing result of control points in Sabang River Basin is summarized in Table 20 generated by TBC software.

Table 20. Baseline Processing Summary Report for Sabang River Survey.

Observation	Date of Observation	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
CMS-71 --- CS-398	06-30-16	Fixed	0.003	0.014	118°07'06"	23448.013	1.313
CMS-71 --- UP-MOC	06-30-16	Fixed	0.004	0.014	68°18'41"	43178.316	-4.130
UP-MOC --- CS-398	06-30-16	Fixed	0.004	0.015	215°50'13"	33277.281	5.437
CMN-3087 --- UP-MOC	06-30-16	Fixed	0.003	0.015	122°19'44"	18380.742	-9.211
CMN-3087 --- CMS-71	06-30-16	Fixed	0.003	0.017	223°41'59"	35614.428	-5.115

4.4 Network Adjustment

After the baseline processing procedure, network adjustment is performed using TBC. Looking at the Adjusted Grid Coordinates Table C-of the TBC generated Network Adjustment Report, it is observed that the square root of the sum of the squares of x and y must be less than 20 cm and z less than 10 cm or in equation 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 each control point. See the Network Adjustment Report shown in Table 21 to Table 24 for complete details.

The four (4) control points, CMS-71, CS-398, CMS-3087 and UP-MOC were occupied and observed simultaneously to form a GNSS loop. Coordinates of CMS-71 and CMN-3087; and elevation values of CS-398 and CMN-3087 were held fixed during the processing of the control points as presented in Table 21. Through these reference points, the coordinates and elevation of the unknown control points will be computed.

Table 21. Control Point Constraints.

Point ID	Type	East σ (Meter)	North σ (Meter)	Height σ (Meter)	Elevation σ (Meter)
CMS-71	Local	Fixed	Fixed		
CS-398	Grid				Fixed
CMN-3087	Local	Fixed	Fixed	Fixed	
Fixed = 0.000001 (Meter)					

The list of adjusted grid coordinates, i.e. Northing, Easting, Elevation and computed standard errors of the control points in the network is indicated in Table 22. The fixed control CMS-110 has no values for grid errors while CS-461 has no value for elevation errors.

Table 22. Adjusted Grid Coordinates.

Point ID	Easting (Meter)	Easting Error (Meter)	Northing (Meter)	Northing Error (Meter)	Elevation (Meter)	Elevation Error (Meter)	Constraint
CMS-71	457175.646	?	1538981.558	?	10.059	0.046	LL
CS-398	477829.729	0.011	1527900.590	0.010	10.576	?	e
CMN-3087	481789.697	?	1564701.975	?	14.905	?	LLh
UP-MOC	497307.927	0.011	1554865.116	0.010	5.214	0.046	

The results of the computation for accuracy are as follows:

a. **CMS-71**

horizontal accuracy	=	Fixed
vertical accuracy	=	4.6 cm < 10 cm

b. **CS-398**

horizontal accuracy	=	$\sqrt{((1.1)^2 + (1.0)^2}$
	=	$\sqrt{(1.21 + 1.0)}$
	=	1.49 < 20 cm
vertical accuracy	=	Fixed

c. **CMN-3087**

horizontal accuracy	=	Fixed
vertical accuracy	=	Fixed

d. **UP-MOC**

horizontal accuracy	=	$\sqrt{((1.1)^2 + (1.0)^2}$
	=	$\sqrt{(1.21 + 1.0)}$
	=	1.49 < 20 cm
vertical accuracy	=	4.6 cm < 10 cm

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

Table 23. Adjusted Geodetic Coordinates.

Point ID	Latitude	Longitude	Ellipsoid Height (Meter)	Height Error (Meter)	Constraint
CMS-71	N13°55'14.18695"	E122°36'12.89833"	59.636	0.046	LL
CS-398	N13°49'14.33596"	E122°47'41.49841"	60.994	?	e
CMN-3087	N14°09'12.36125"	E122°49'52.53365"	64.661	?	LLh
UP-MOC	N14°03'52.37147"	E122°58'30.23146"	55.501	0.046	

The corresponding geodetic coordinates of the observed points are within the required accuracy as shown in Table 23. Based on the result of the computation, the accuracy condition is satisfied; hence, the required accuracy for the program was met.

The summary of reference and control points used is indicated in Table 24.

Table 24. Reference and control points used and its location (Source: NAMRIA, UP-TCAGP).

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)			UTM ZONE 51 N		
		Latitude	Longitude	Ellipsoidal Height (m)	Northing (m)	Easting (m)	BM Ortho (m)
CMS-71	2nd order, GCP	13°55'14.18695"	122°36'12.89833"	59.636	1538981.558	457175.646	10.059
CS-398	1st order, BM	13°49'14.33596"	122°47'41.49841"	60.994	1527900.59	477829.729	10.576
CMN-3087	Fixed Control	14°09'12.36125"	122°49'52.53365"	64.661	1564701.975	481789.697	14.905
UP-MOC	UP Established	14°03'52.37147"	122°58'30.23146"	55.501	1554865.116	497307.927	5.214
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

Cross-section and as-built survey were conducted on July 9, 2016 at the downstream side of Kilbay Bridge in Brgy. Cabasag, Municipality of Del Gallego, Camarines Sur as shown in Figure 32. A total station through open traverse method and Trimble® SPS 882 GNSS PPK survey technique were utilized for this survey as shown in Figure 33.

Figure 32. Kilbay Bridge facing downstream.

Figure 33. Bridge As-Built Survey using PPK Technique.

The cross-sectional line of Kilbay Bridge is about 162 m with one hundred seventy-seven (177) cross-sectional points using the control point CMS-71 as the GNSS base station. The cross-section diagram, location map and the bridge data form are shown in Figure 34 to Figure 36, respectively.

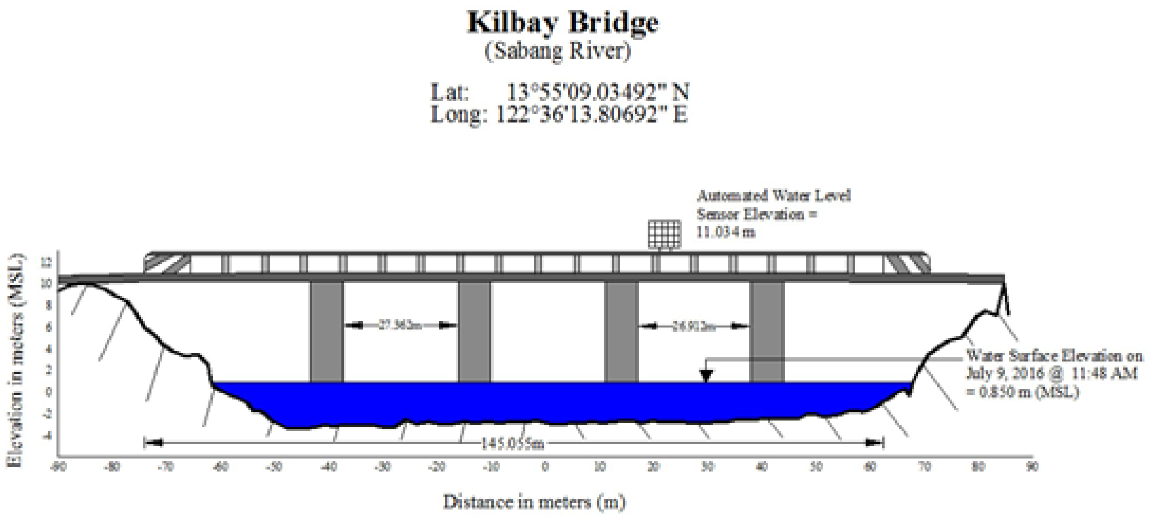


Figure 34. Kilbay Bridge cross-section diagram.

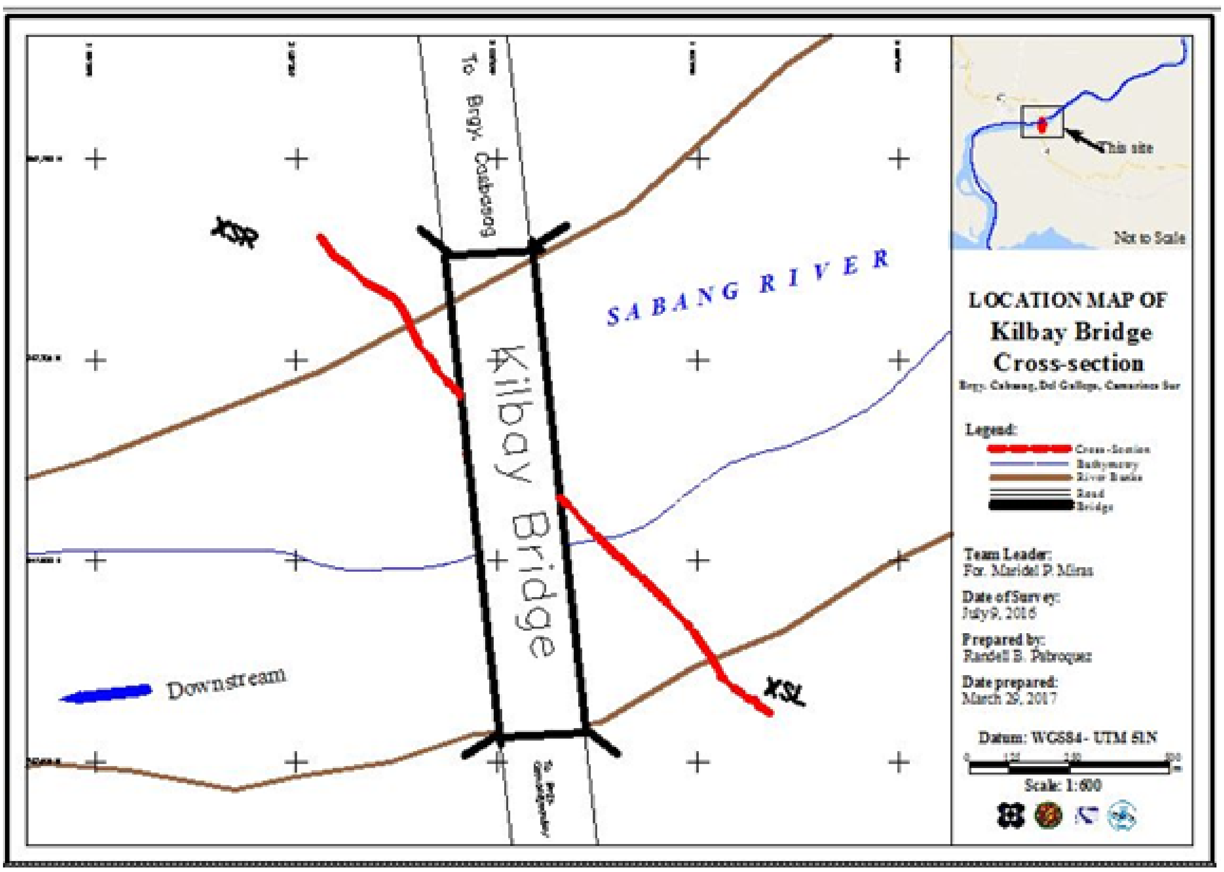


Figure 35. Kilbay bridge cross-section location map.

Bridge Data Form

Bridge Name: Kilbay Bridge **Date:** July 9, 2016

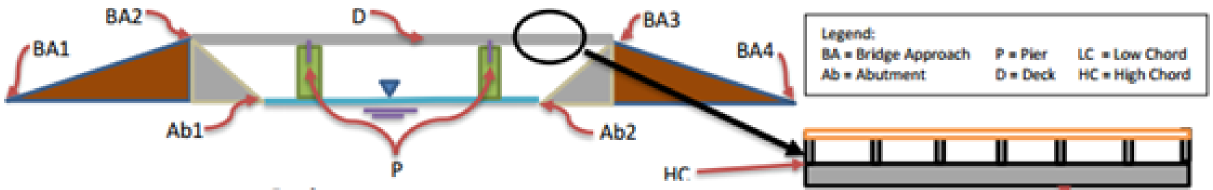
River Name: Sabang River **Time:** 11:48 AM

Location (Brgy, City,Region): Brgy. Cabsag, Municipality of Del Gallego, Camarines Sur

Survey Team: Maridel Miras, Caren Ordoña

Flow condition: normal **Weather Condition:** fair

Latitude: 13°55'09.03492" N **Longitude:** 122°36'13.80692" E



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

Elevation: 10.128 m **Width:** 9 m **Span (BA3-BA2):** 145.055 m

	Station	High Chord Elevation	Low Chord Elevation
1	Not available	Not available	Not available

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

	Station(Distance from BA1)	Elevation		Station(Distance from BA1)	Elevation
BA1	0	9.952 m	BA3	160.993 m	10.107 m
BA2	15.938 m	10.128 m	BA4	174.648 m	10.007 m

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

	Station (Distance from BA1)	Elevation
Ab1	Not available	Not available
Ab2	Not available	Not available

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

Shape: Flat oval Number of Piers: 5 Height of column footing: N/A

	Station (Distance from BA1)	Elevation	Pier Diameter
Pier 1	49.482 m	10.205 m	NA
Pier 2	76.845 m	10.186 m	NA
Pier 3	104.071 m	10.194 m	NA
Pier 4	130.983 m	10.191 m	NA

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

Figure 36. Bridge as-built form of Kilbay Bridge.

Water surface elevation of Sabang River was determined using a survey grade GNSS receiver Trimble® SPS 882 in PPK survey technique on July 9, 2016 at 11:48 AM with a value of 0.850 m in MSL as shown in Figure 34. This was translated into marking on the bridge's deck using the same technique. The marking has a value of 10.157 m above MSL as shown in Figure 37. This will serve as reference for flow data gathering and depth gauge deployment of partner HEI responsible for Sabang river, the Mapua Institute of Technology.

Figure 37. Water-level markings on Kilbay Bridge.

4.6 Validation Points Acquisition Survey

Validation points acquisition survey was conducted on July 5, 6 and 8, 2016 using a survey-grade GNSS Rover receiver, Trimble® SPS 882, mounted in front of a vehicle as shown in Figure 38. It was secured with a nylon rope to ensure that it was horizontally and vertically balanced. The antenna height was 2.10 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 with CS-398 occupied as the GNSS base station.

Figure 38. Validation points acquisition survey set up along Sabang River Basin.

The survey started from Brgy. Pasay, Municipality of Del Gallego, going south east traversing the Municipalities of Del Gallego, Ragay, Lupi and Sipocot in Camarines Sur. It ended in Brgy. Impig, Municipality of Sipocot. A total of 9,762 points were gathered with approximate length of 69 km using CS-398 as GNSS base station for the entire extent validation points acquisition survey as illustrated in the map in Figure 39.

Figure 39. Validation point acquisition survey of Sabang River Basin.

4.7 River Bathymetric Survey

Bathymetric survey was executed on July 8, 2016 using an Ohmex™ single beam echo sounder and Trimble® SPS 882 in GNSS PPK survey technique in continuous topo mode as illustrated in Figure 40. The survey started in Brgy. Santa Rita II, Municipality of Del Gallego, with coordinates 13°56’11.79547”N, 122°37’55.75521”E, and ended at the mouth of the river in Brgy. Sabang with coordinates 13°53’37.63768”N, 122°35’31.31363”E. The control point CMS-71 was used as the GNSS base station all throughout the entire survey.

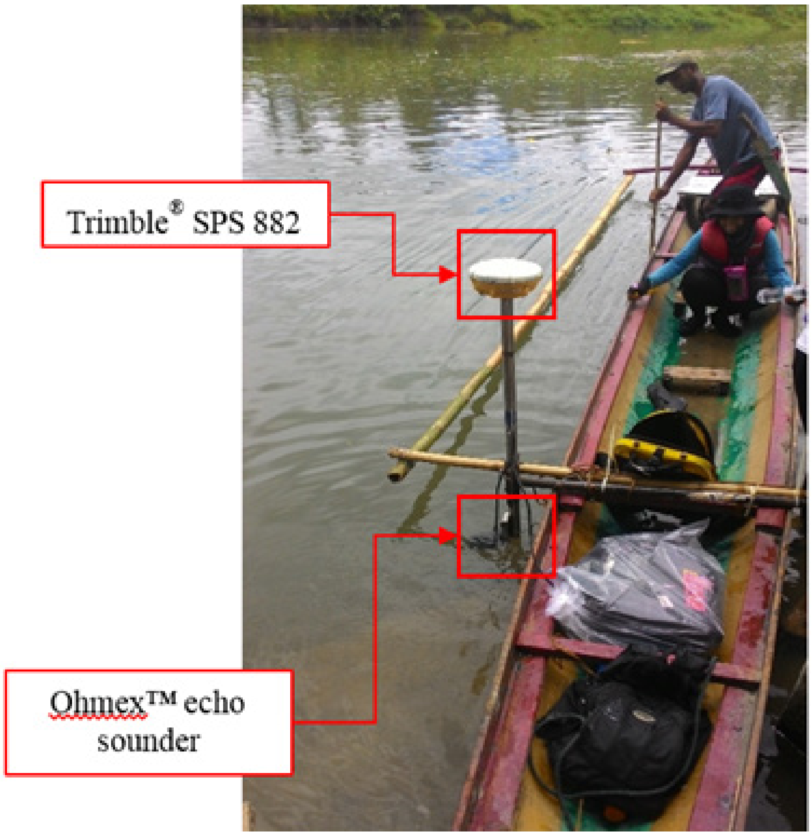


Figure 40. Bathymetric survey using Ohmex™ single beam echo sounder in Sabang River.

The bathymetric survey for Basud River gathered a total of 10,011 points covering 8.689 km of the river traversing eleven (11) barangays in the Municipality of Del Gallego. A CAD drawing was also produced to illustrate the riverbed profile of Sabang River. As shown in Figure 42, the highest and lowest elevation has a 12-m difference. The highest elevation observed was 0.226 m in MSL located at Brgy. Santa Rita II, while the lowest was -12.277 m below MSL located at the downstream portion of the river located in Brgy. San Juan, both in Municipality of Del Gallego.

Figure 41. Bathymetric survey of Sabang River.

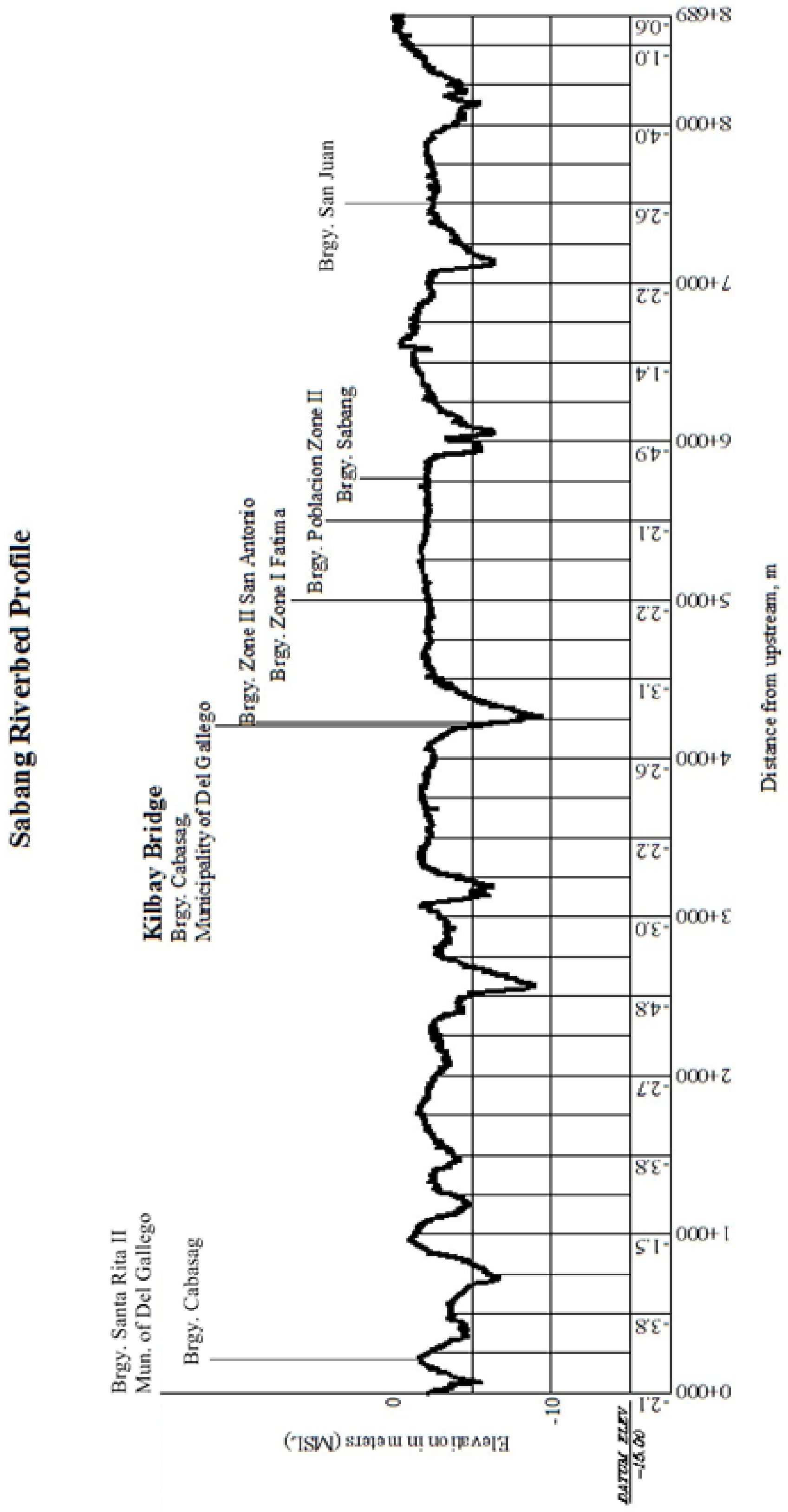


Figure 42. Sabang Riverbed Profile.

CHAPTER 5: FLOOD MODELING AND MAPPING

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

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

Components and data that affect the hydrologic cycle of the river basin was monitored, collected, and analyzed. These include the rainfall, water level, and flow in a certain period of time.

5.1.2 Precipitation

Precipitation data was taken from automatic rain gauge installed by Mapua-Phil-LiDAR1. This rain gauge is located at Sinuknipan 1 Barangay Hall (13°54.307'N, 122°38.696'E), municipality of Del Gallego, Camarines Sur. The location of the rain gauge is as shown in Figure 43.

The total rain from the rain gauge is 39.4 mm. It peaked to 3 mm on December 11, 2016, 12:40. The lag time between the peak rainfall and discharge is 8 hours and 40 minutes, as shown in Figure 46.

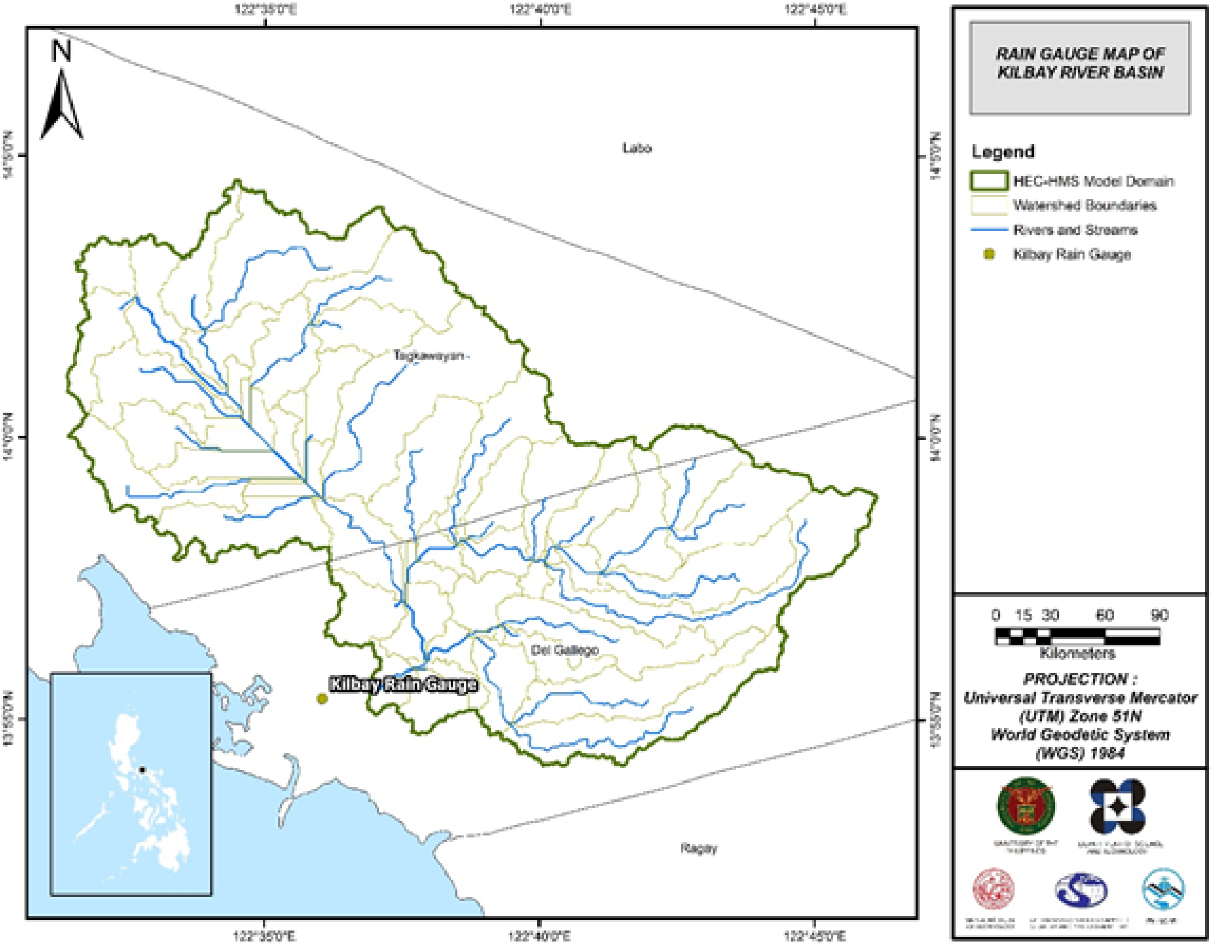


Figure 43. The location map of Kilbay Catabangan HEC-HMS model used for calibration.

5.1.3 Rating Curves and River Outflow

A rating curve was developed at Kilbay Bridge, Del Gallego, Camarines Sur (13°55’09.035”N, 122°36’13.807”E). It gives the relationship between the observed water levels and outflow of the watershed at this location. It is expressed in the form of the following equation:

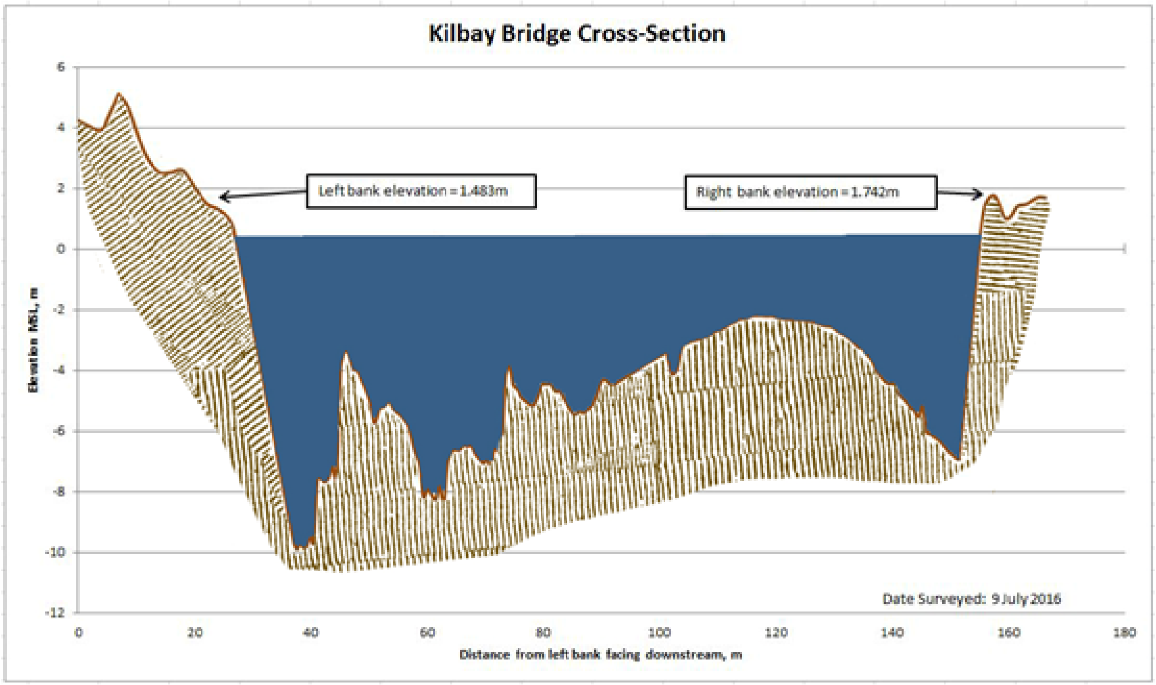


Figure 44. Cross-Section Plot of Kilbay Bridge.

Q=anh

where, Q : Discharge (m3/s),
h : Gauge height (reading from Kilbay bridge), and;
a and n: Constants.

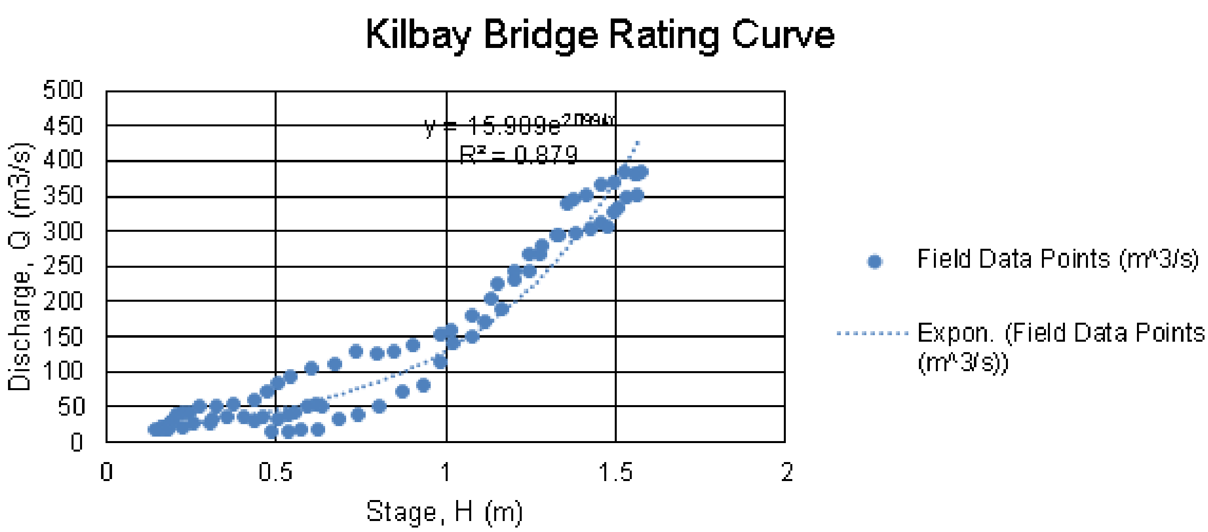


Figure 45. Rating Curve at Kilbay Bridge, Del Gallego, Camarines Sur.

This rating curve equation was used to compute the river outflow at Kilbay Bridge for the calibration of the HEC-HMS model shown in Figure 46. Peak discharge is 384.84 m3/s at 21:20, December 11, 2016.

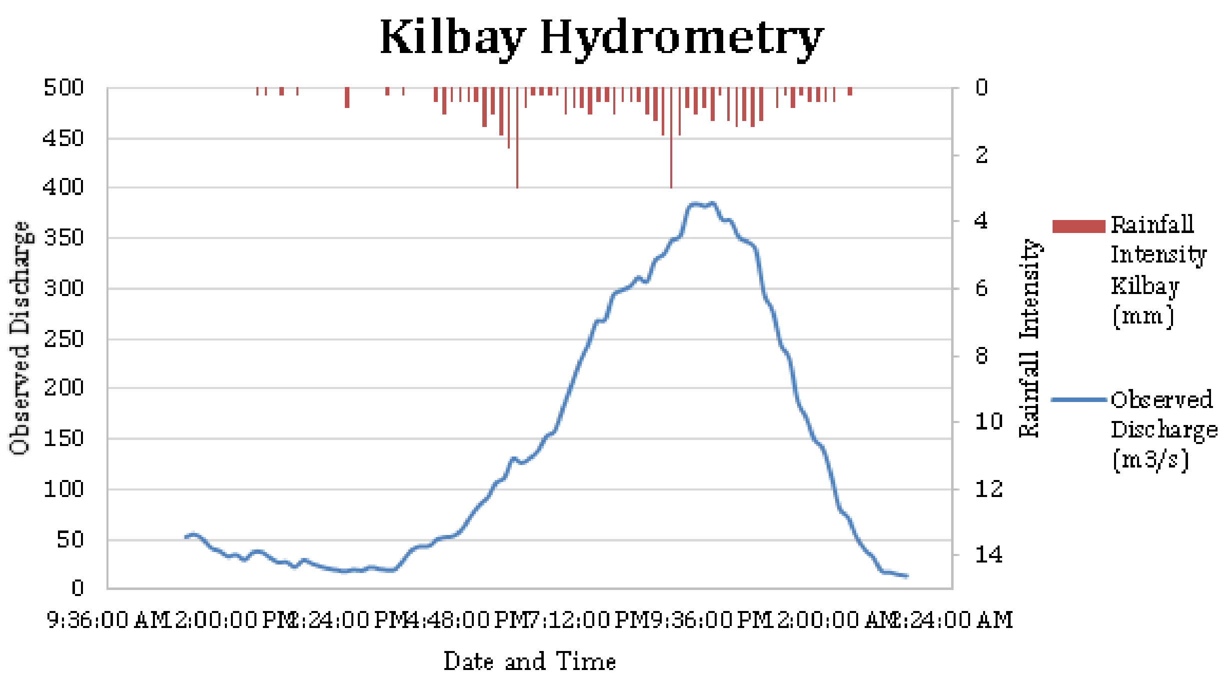


Figure 46. Rainfall and outflow data at Kilbay used for modeling.

5.2 RIDF Station

The Philippines Atmospheric Geophysical and Astronomical Services Administration (PAGASA) computed Rainfall Intensity Duration Frequency (RIDF) values for the Daet Gauge. This station chosen based on its proximity to the Kilbay Catabangan watershed. The extreme values for this watershed were computed based on a 58-year record.

Table 25. RIDF values for Daet Rain Gauge computed by PAGASA.

COMPUTED EXTREME VALUES (in mm) OF PRECIPITATION									
T (yrs)	10 mins	20 mins	30 mins	1 hr	2 hrs	3 hrs	6 hrs	12 hrs	24 hrs
2	21.8	33.8	43.1	59.6	84	101	130.4	163.2	190.4
5	31.8	47.2	59.1	81.9	120.3	146.8	194.7	236.8	278.7
10	38.5	56.1	69.7	96.7	144.4	177.1	237.2	285.6	337.2
15	42.3	61.1	75.7	105	158	194.1	261.2	313.1	370.2
20	44.9	64.6	79.9	110.8	167.5	206.1	278	332.4	393.3
25	46.9	67.3	83.1	115.3	174.8	215.3	291	347.2	411.1
50	53.2	75.6	93	129.2	197.3	243.7	330.8	392.9	465.9
100	59.4	83.9	102.9	143	219.7	271.9	370.4	438.3	520.3

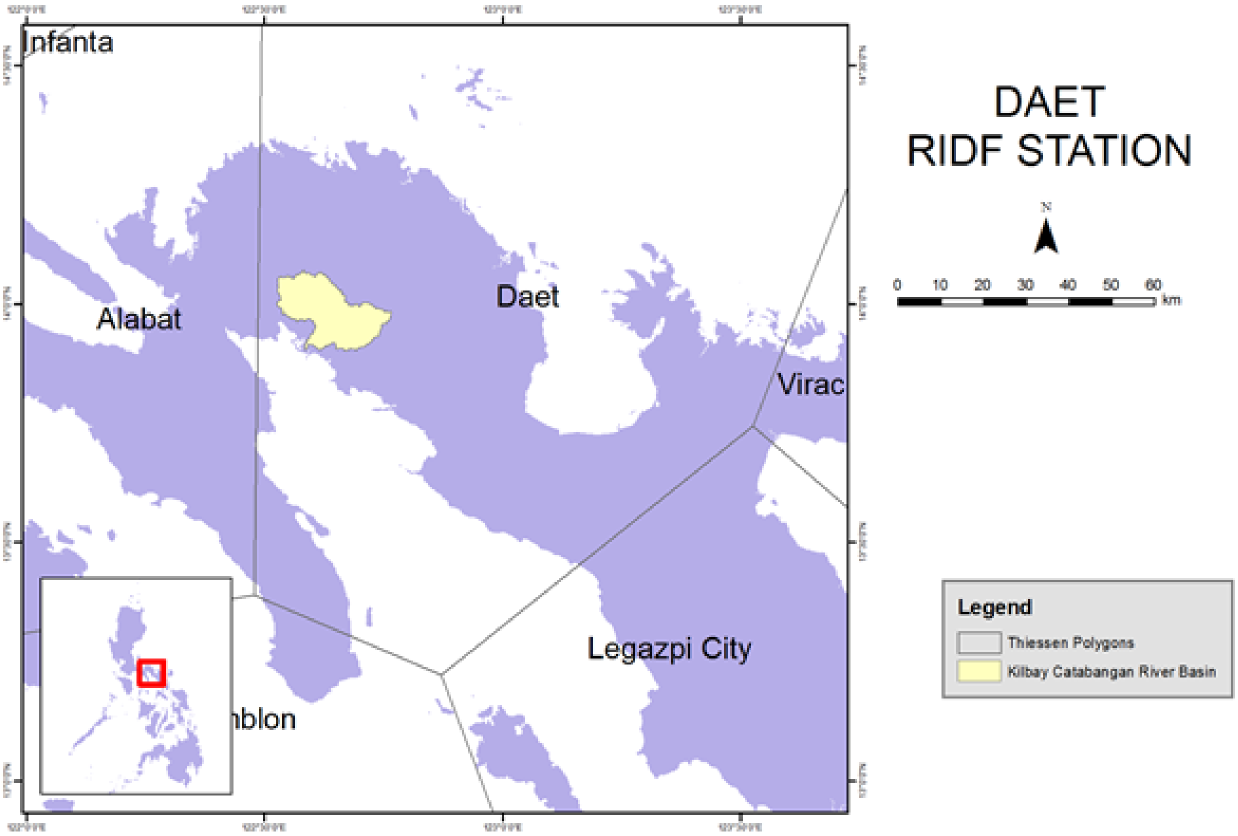


Figure 47. Daet RIDF location relative to Kilbay Catabangan River Basin.

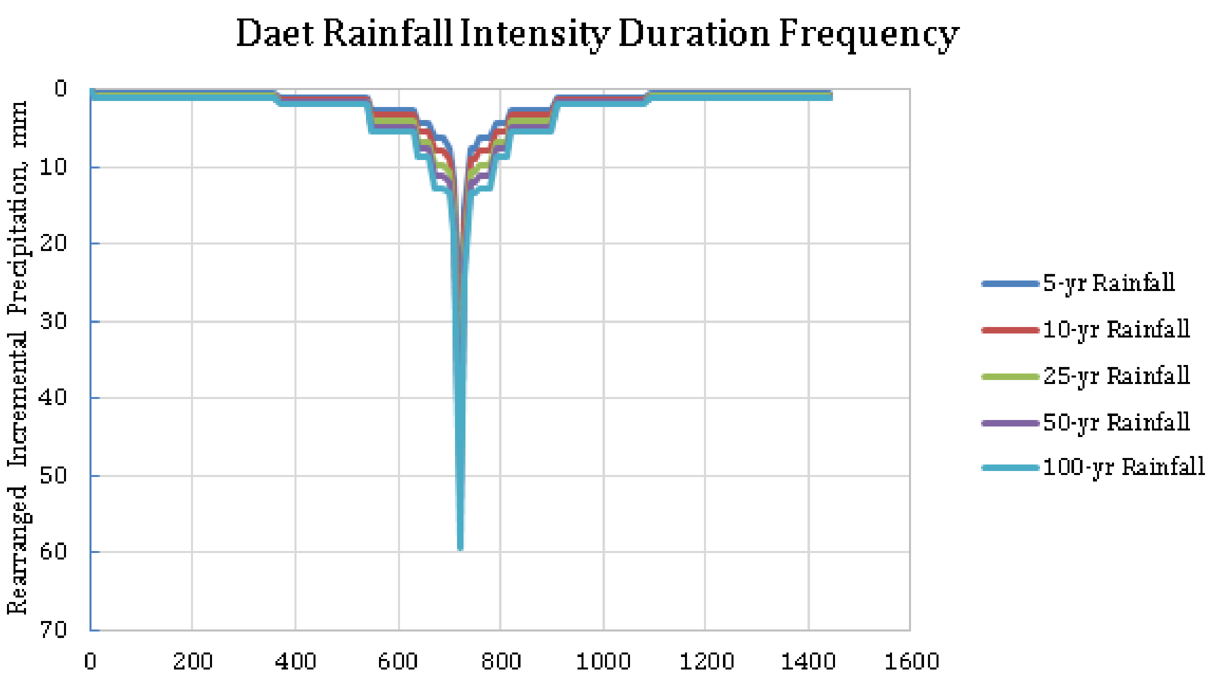


Figure 48. Synthetic storm generated for a 24-hr period rainfall for various return periods.

5.3 HMS Model

The soil shapefile was taken on 2004 from the Bureau of Soils; this is under the Department of Environment and Natural Resources Management (DENR). The land cover shape file is from the National Mapping and Resource information Authority (NAMRIA). The soil and land cover of the Kilbay Catabangan River Basin are shown in Figures 49 and 50, respectively.

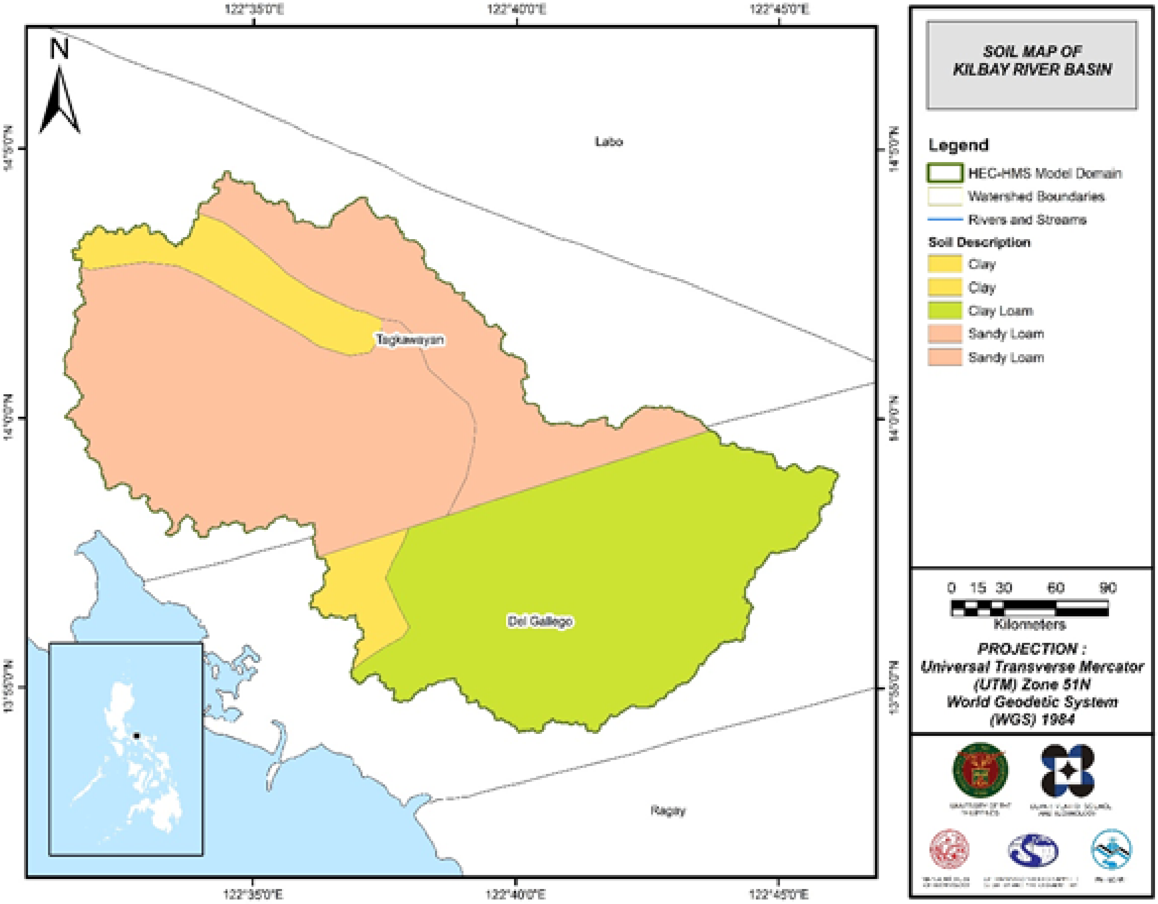


Figure 49. Soil Map of Kilbay Catabangan River Basin.

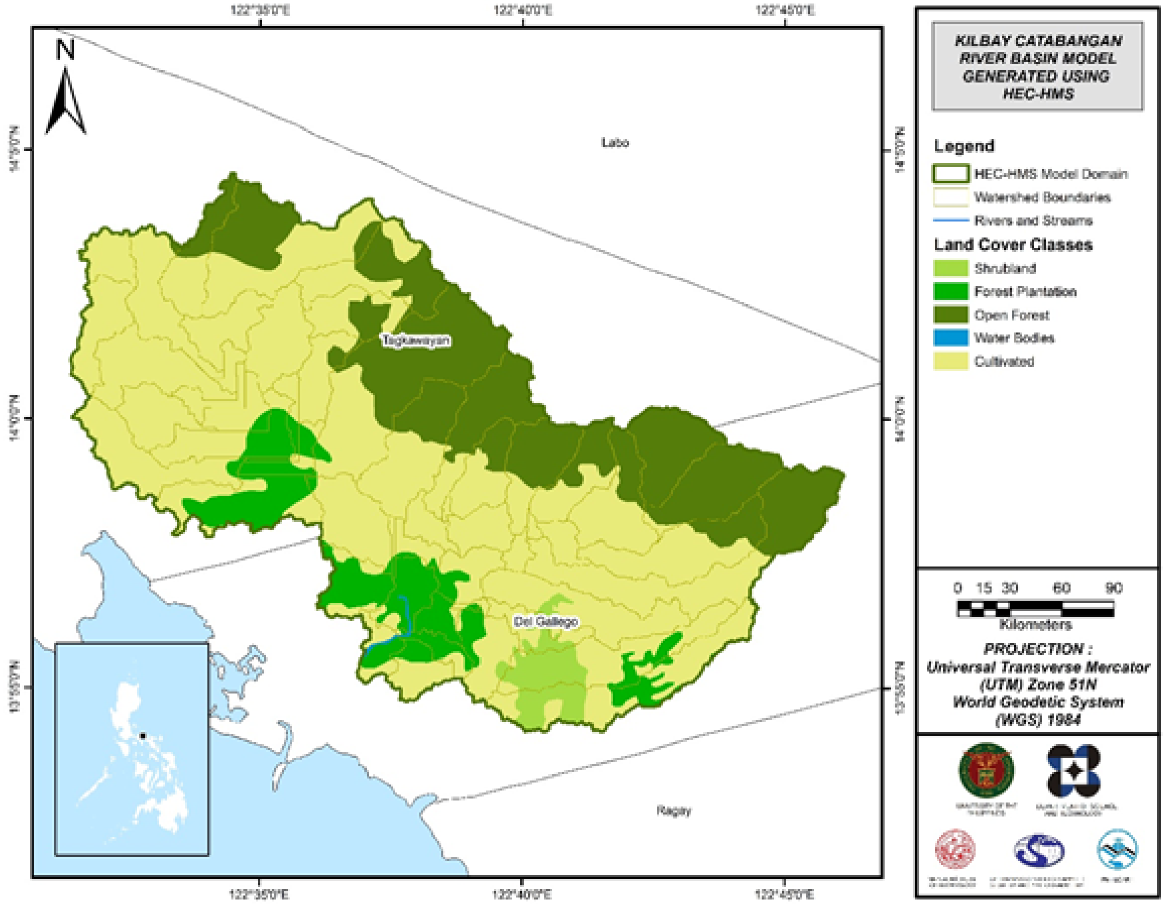


Figure 50. Land Cover Map of Kilbay Catabangan River Basin.

For Kilbay Catabangan, the soil classes identified were clay loam, clay, and sandy loam. The land cover types identified were shrubland, forest plantations, open canopy forests, inland water bodies and cultivated areas.

[insert Slope Map]

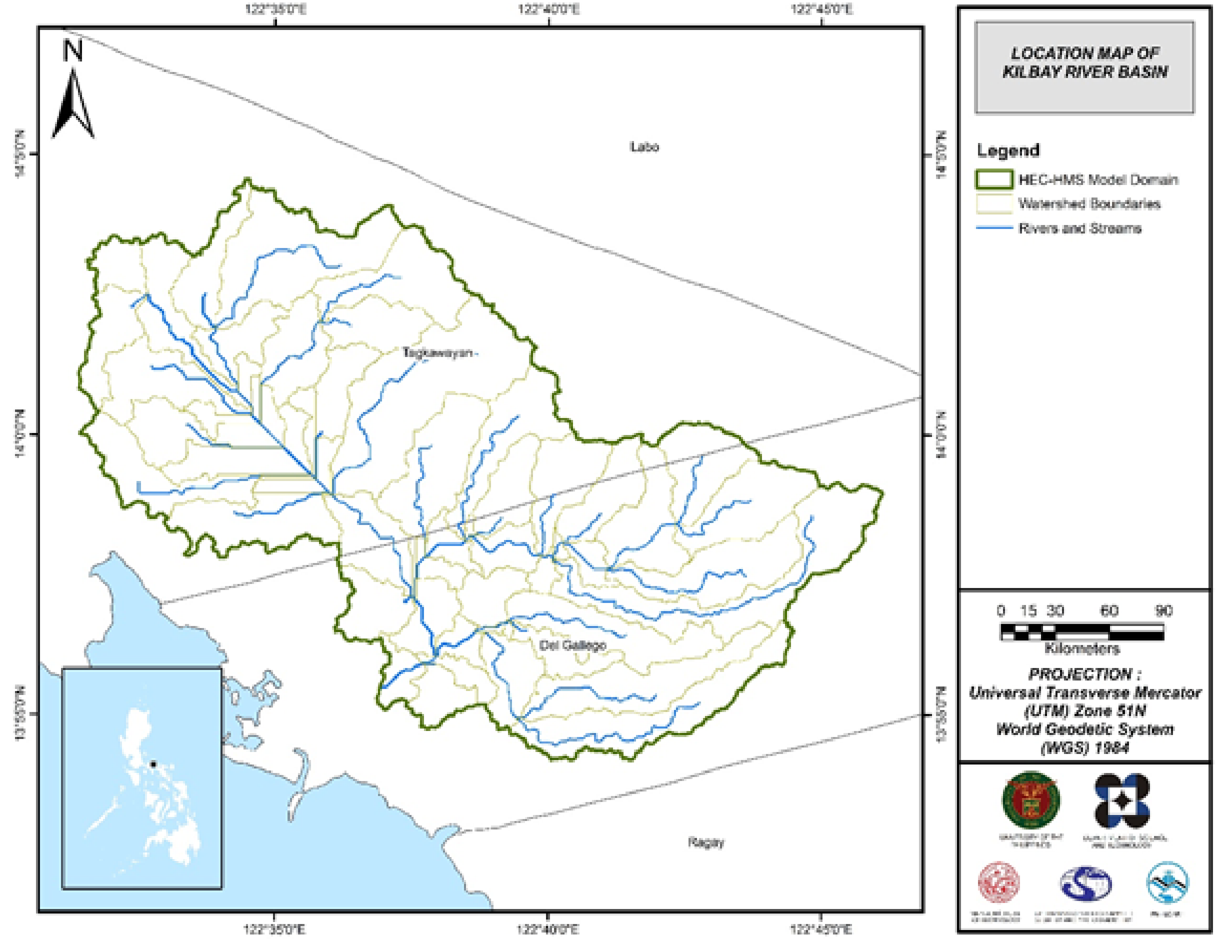


Figure 51. Stream delineation map of Kilbay Catabangan river basin.

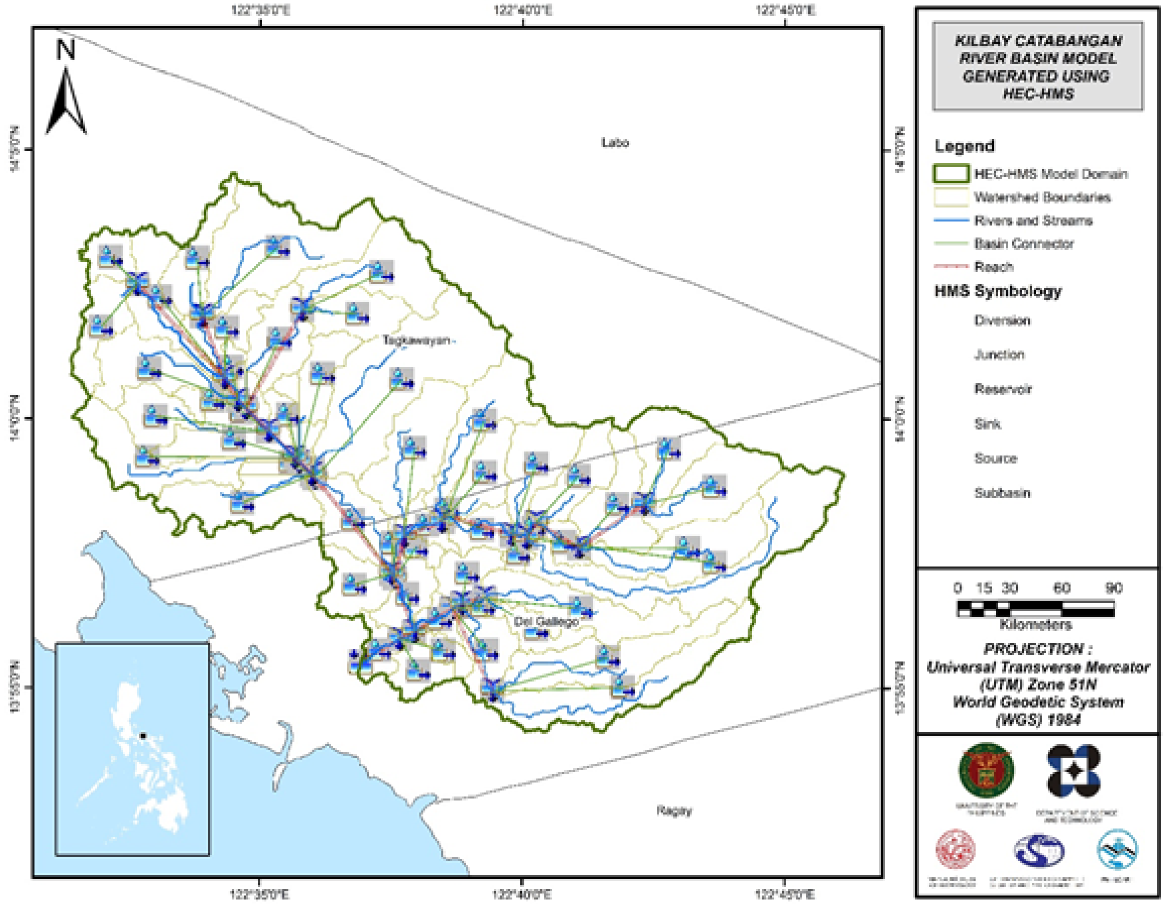


Figure 52. The Kilbay Catabangan River Basin Model Domain generated using HEC-HMS.

5.4 Cross-section Data

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

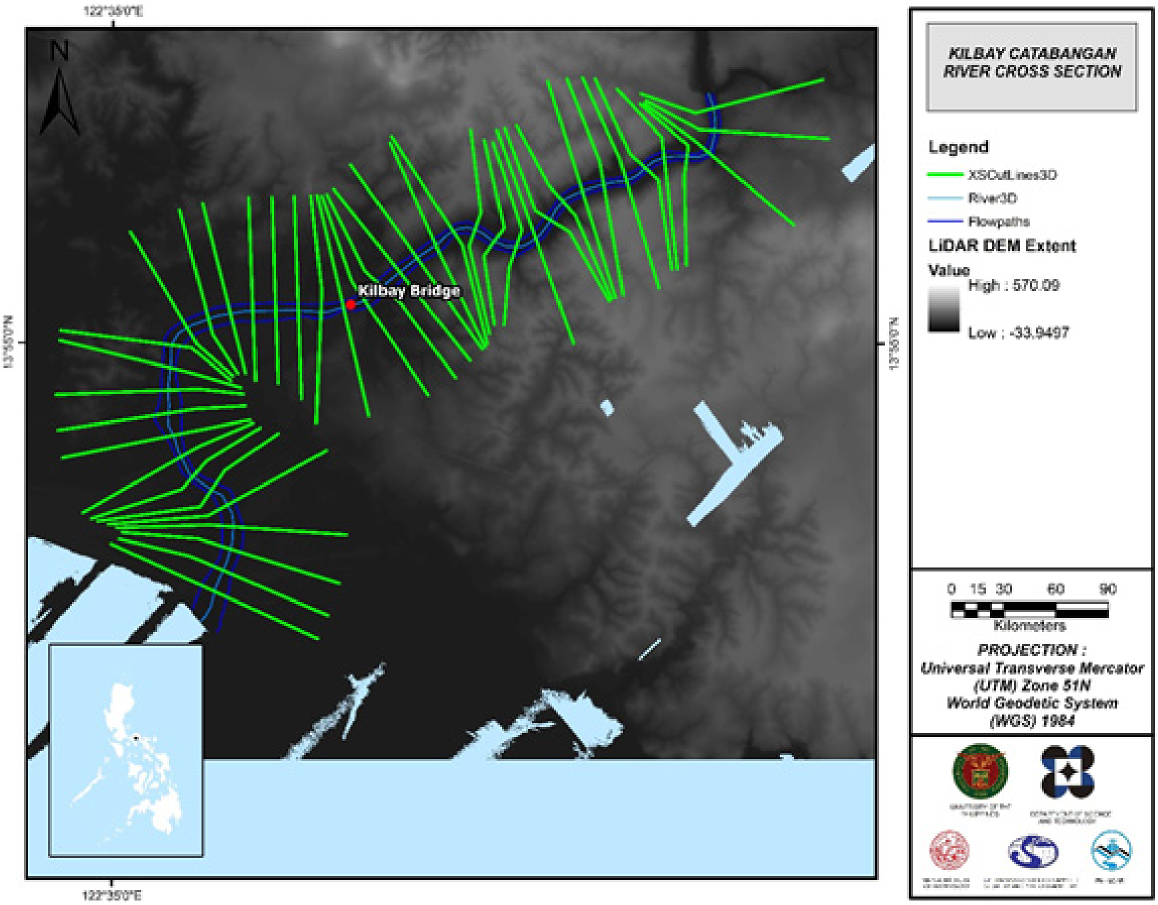


Figure 53. River cross-section of Kilbay Catabangan River generated through Arcmap HEC GeoRAS tool.

Manning's n

The Manning's n is a constant value that depends on the nature of the channel and its surface. Determining the roughness coefficient of the channel is important in determining the water flow. Appropriate selection of Manning's n values is based on the land cover type of the watershed area.

A look-up table was derived to have a standardized Manning's n value for the HEC-RAS model.

Table 26. Look-up table for Manning's n values (Source: Brunner, 2010).

Land-cover Class	Corresponding Manning's *n* Class	Manning's *n*
Barren Land	Cultivated areas, no crop	0.030
Built-up Area	Concrete, float finished	0.015
Cultivated land, annual crop	Cultivated areas, mature field crops	0.040
Cultivated land, perennial crop	Cultivated areas, mature row crops	0.035
Fishpond	Excavated, earth, straight and uniform	0.018
Inland Water	Main channel, clean, straight, no rifts or deep pools	0.030
Grassland	Pasture, no brush, short grass	0.030
Mangrove Forest	Trees, heavy stand, flow into branches	0.120
Shrub land	Medium to dense brush	0.100

5.5 Flo 2D Model

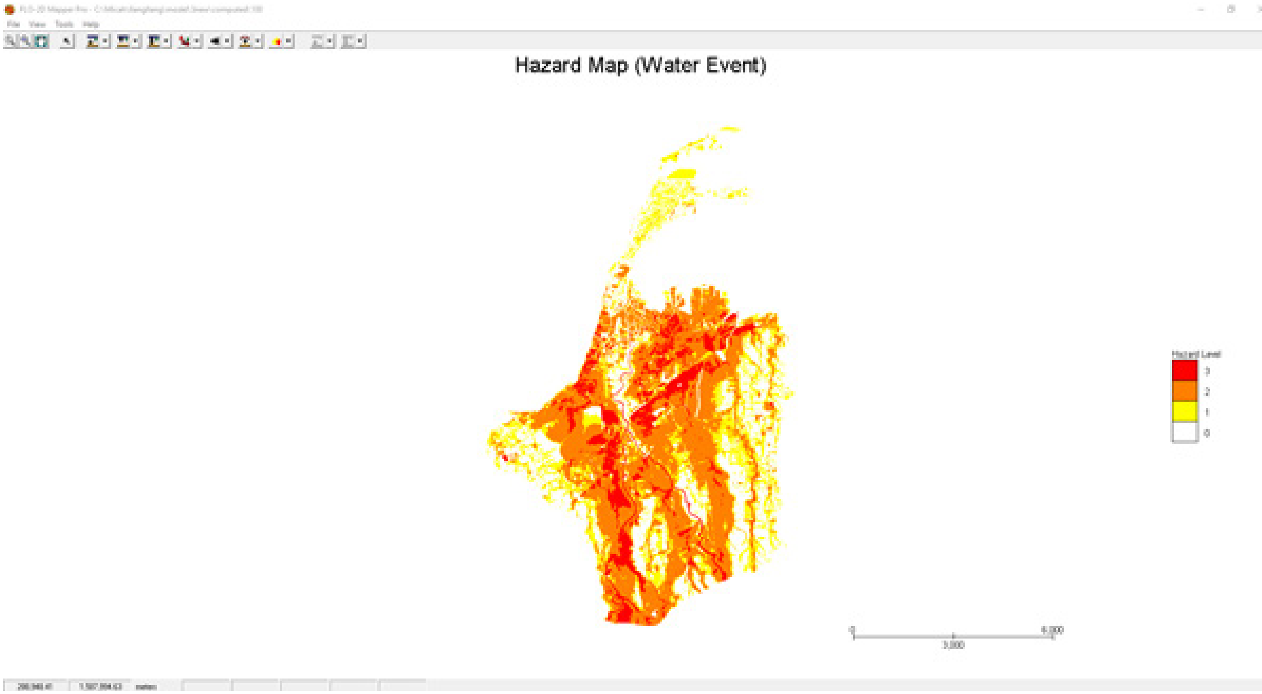


Figure 54. Generated 100-year Rain Return Hazard Map from FLO-2D Mapper.

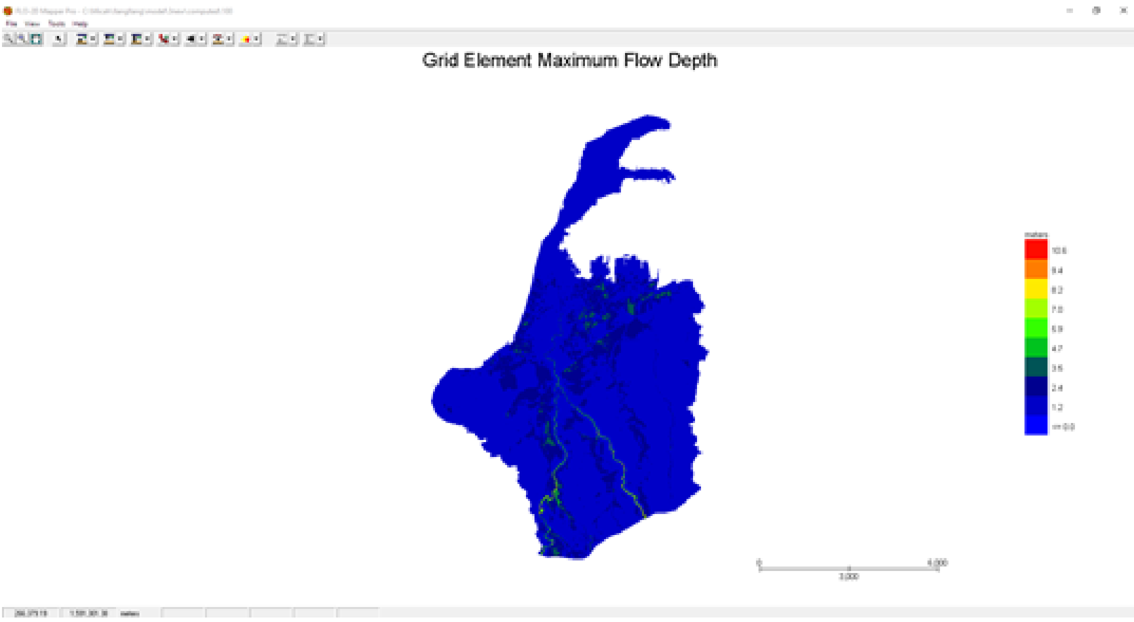


Figure 55. Generated 100-year Rain Return Flow Depth Map from FLO-2D Mapper.

5.6 Results of HMS Calibration

After calibrating the Kilbay Cabatangan HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 56 shows the comparison between the two discharge data.

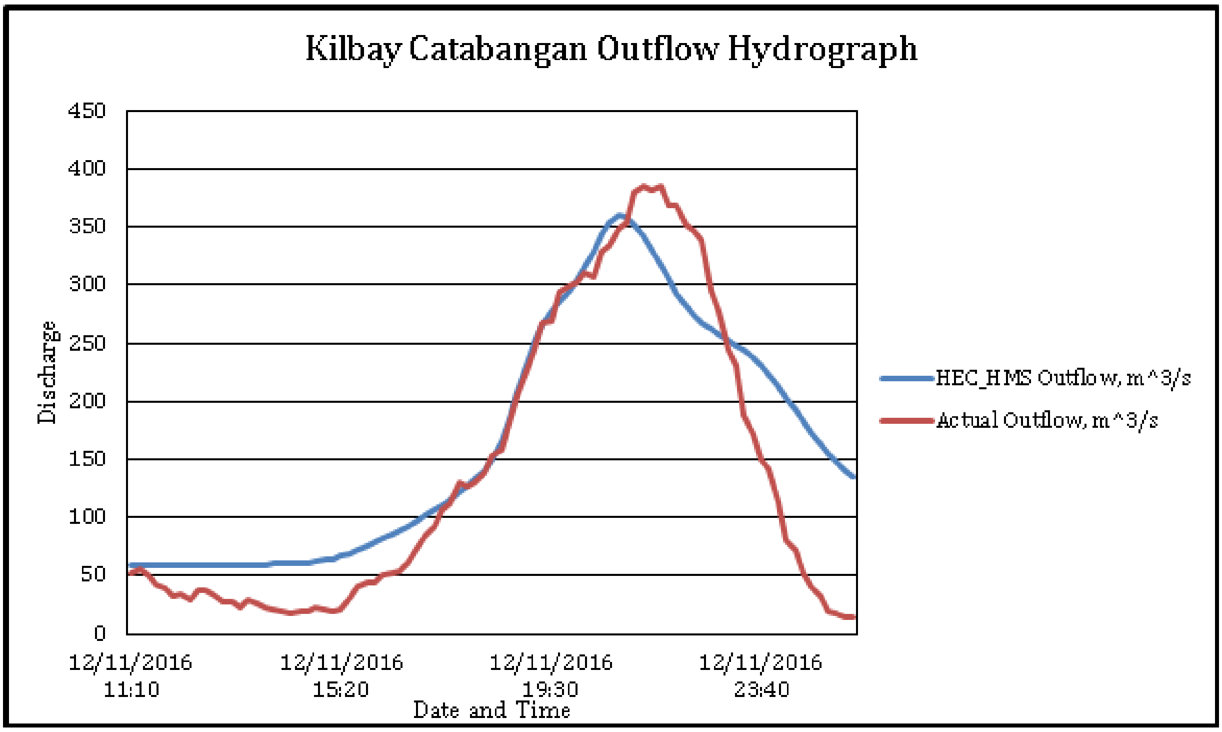


Figure 56. Outflow Hydrograph of Kilbay Catabangan produced by the HEC-HMS model compared with observed outflow.

Enumerated in Table 27 are the adjusted ranges of values of the parameters used in calibrating the model.

Table 27. Range of Calibrated Values for Kilbay Catabangan.

Hydrologic Element	Calculation Type	Method	Parameter	Range of Calibrated Values
Basin	Loss	SCS Curve Number	Initial Abstraction (mm)	6.41 – 32.80
			Curve Number	99
	Transform	Clark Unit Hydrograph	Time of Concentration (hr)	0.11 – 3.047
			Storage Coefficient (hr)	0.030 – 0.72
	Baseflow	Recession	Recession Constant	0.00001 - 1
			Ratio to Peak	0.00001 – 0.00055
Reach	Routing	Muskingum-Cunge	Manning's Coefficient	0.00037 – 1.00

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 6.41mm to 32.80mm means that there is minimal to average amount of infiltration or rainfall interception by vegetation.

Curve number is the estimate of the precipitation excess of soil cover, land use, and antecedent moisture. The magnitude of the outflow hydrograph increases as curve number increases. The curve number value for all subbasins is 99. For Kilbay Catabangan, the soil classes identified were clay loam, clay, and sandy loam. The land cover types identified were shrubland, forest plantations, open canopy forests, inland water bodies and cultivated areas.

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 0.030 hours to 3.047 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. The recession constant widely ranges from 0.00001 to 1 and the Ratio to Peak values range from 0.00001 to 0.00055. The receding limb of the outflow hydrograph returns relatively quickly from it original discharge levels.

The range of Manning's coefficient ranges from 0.00037 to 1.00 represents the varying roughness of the watershed's subbasins.

Table 28. Summary of the Efficiency Test of Kilbay Catabangan HMS Model.

Accuracy measure	Value
RMSE	54.4
r2	0.879
NSE	0.81
PBIAS	-14.94
RSR	0.43

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was identified at 54.4 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 0.8790.

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 0.81.

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 -14.94.

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 0.43.

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

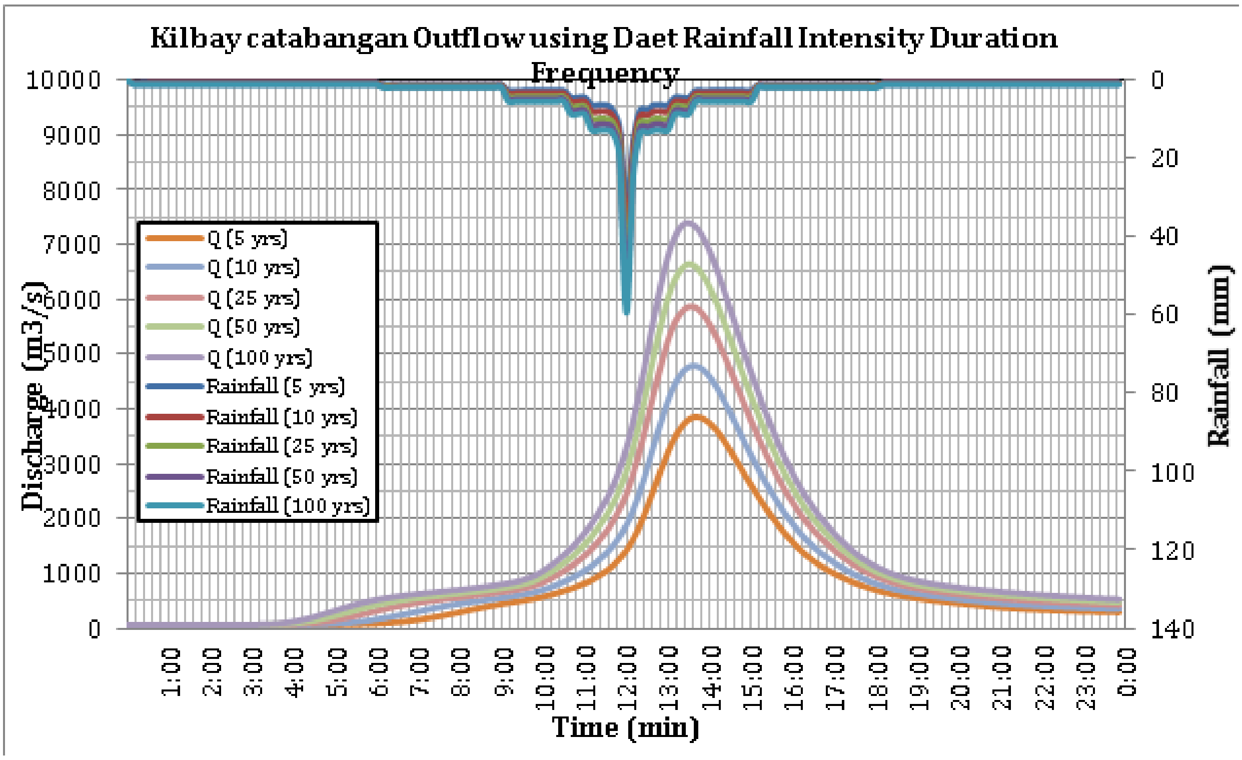


Figure 57. Outflow hydrograph at Kilbay generated using Daet RIDF simulated in HEC-HMS.

A summary of the total precipitation, peak rainfall, peak outflow and time to peak of the Kilbay Catabangan River discharge using the Daet Rainfall Intensity-Duration-Frequency curves (RIDF) in five different return periods is shown in Table 29.

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	278.7	31.8	3855.3	13 hours, 40 minutes
10-Year	337.2	38.5	4782.0	13 hours, 40 minutes
25-Year	411.1	46.9	5865.2	13 hours, 30 minutes
50-Year	465.9	53.2	6646.3	13 hours, 30 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. For this publication, only a sample output map river was to be shown, since only the Flood Acquisition and Validation Component (MIT-FAVC) base flow was calibrated. The sample generated map of Daet River using the calibrated HMS base flow is shown in Figure 58.

Figure 58. Sample output of Kilbay Catabangan RAS Model.

5.9 Flow Depth and Flood Hazard

The resulting hazard and flow depth maps have a 10m resolution. Figure 59 to Figure 64 shows the 5-, 25-, and 100-year rain return scenarios of the Kilbay-Catabamgan floodplain.

Table 30. Municipalities affected in Kilbay Cabatangan floodplain.

Municipality	Total Area	Area Flooded	% Flooded
Del Gallego	213.52	124.54	58.33%
Tagkawayan	551.33	36.83	7.85%

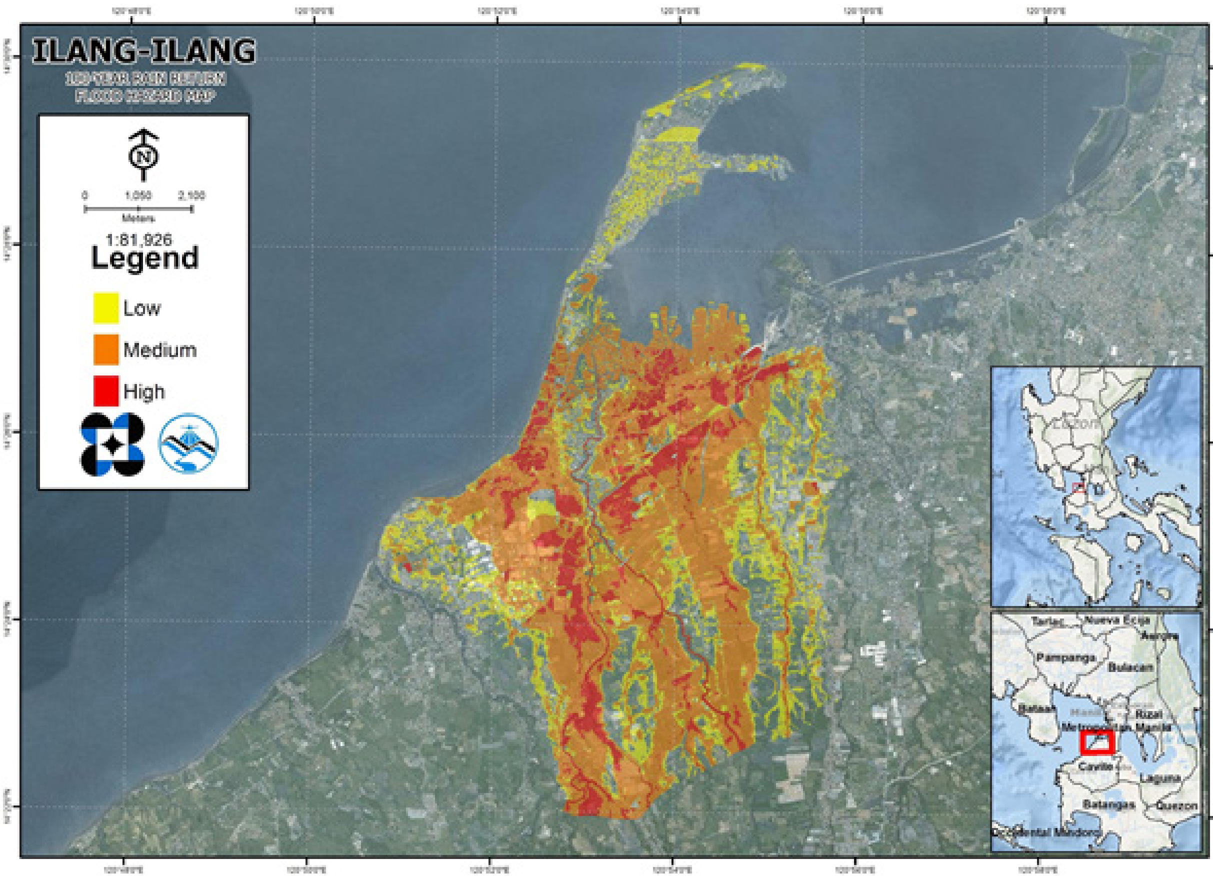


Figure 59. 100-year Flood Hazard Map for Kilbay Catabangan Floodplain.

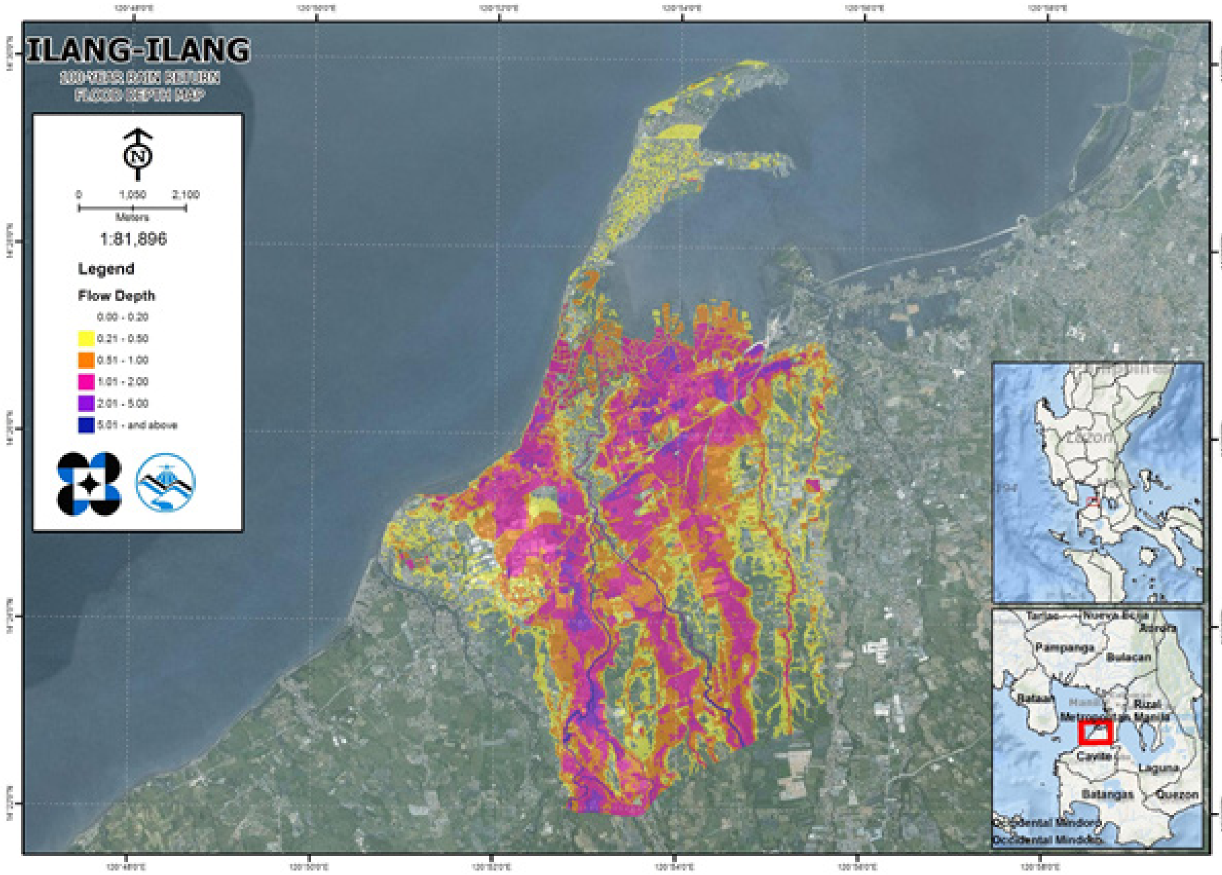


Figure 60. 100-year Flow Depth Map for Kilbay Catabangan Floodplain.

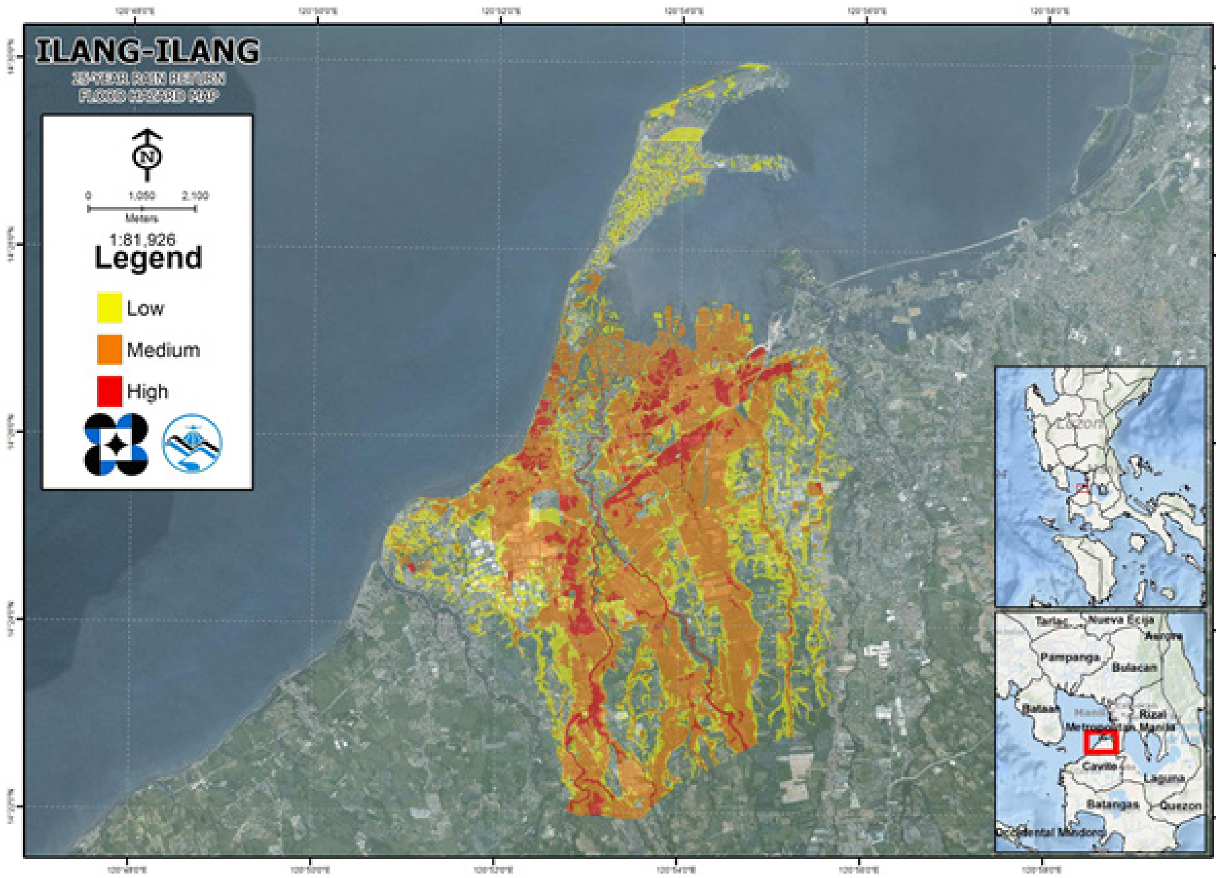


Figure 61. 25-year Flood Hazard Map for Kilbay Catabangan Floodplain

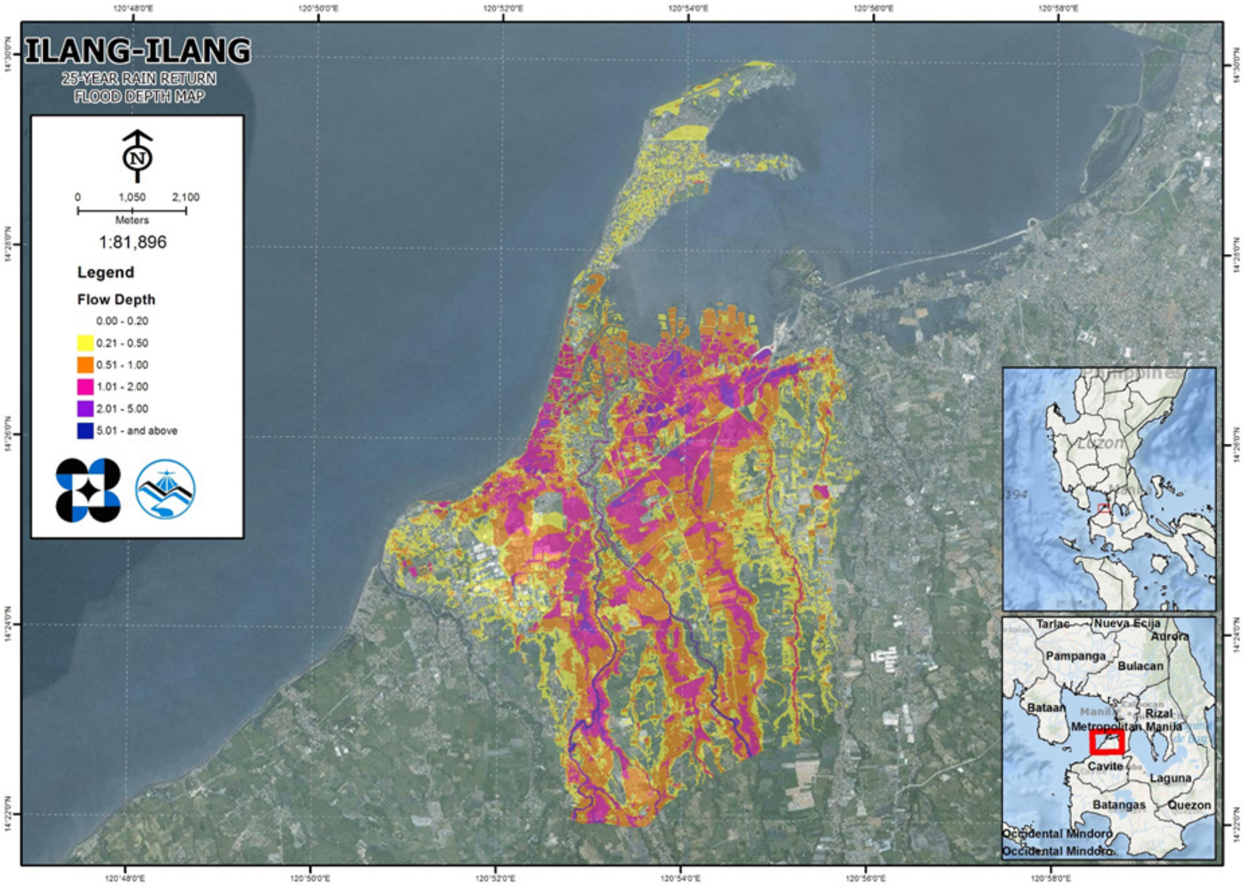


Figure 62. 25-year Flow Depth Map for Kilbay Catabangan Floodplain.

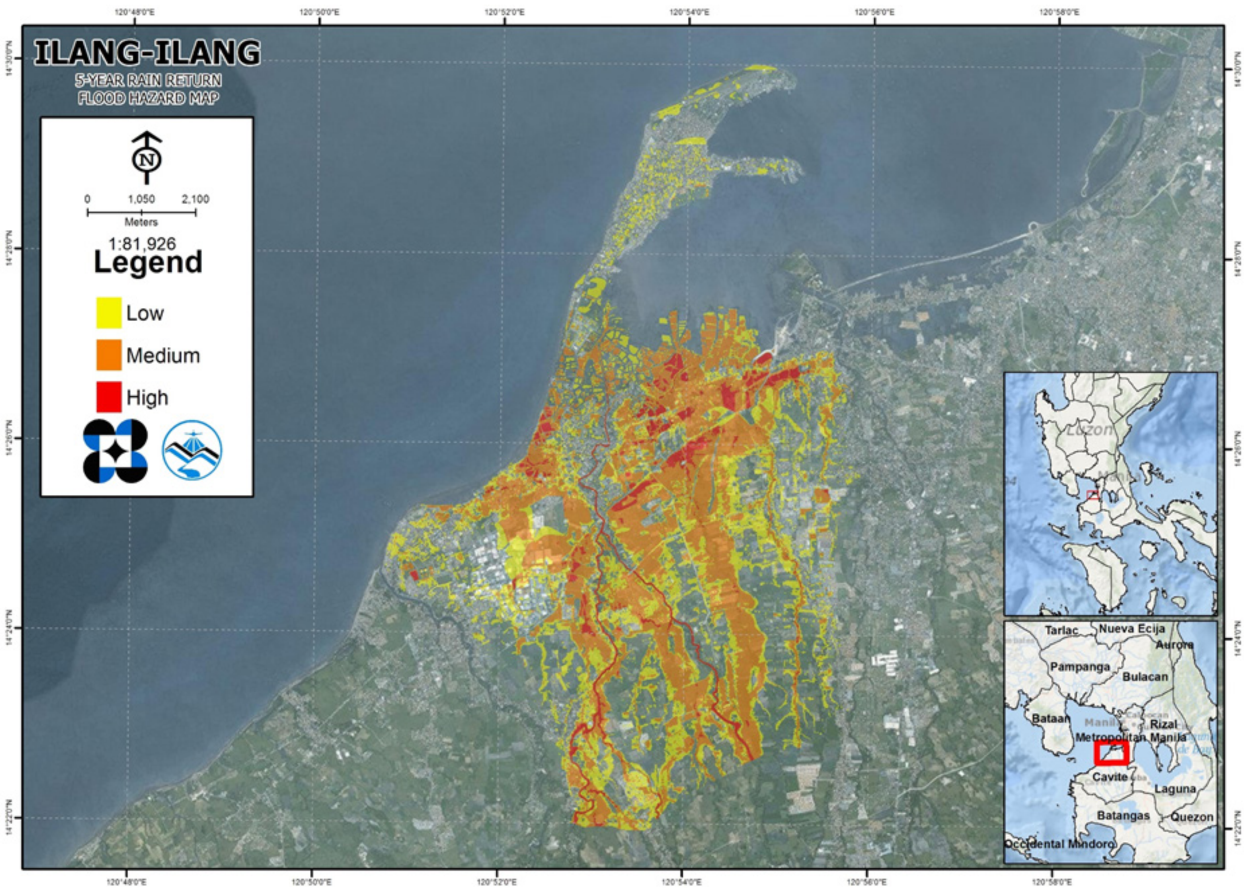


Figure 63. 5-year Flood Hazard Map for Kilbay Catabangan Floodplain.

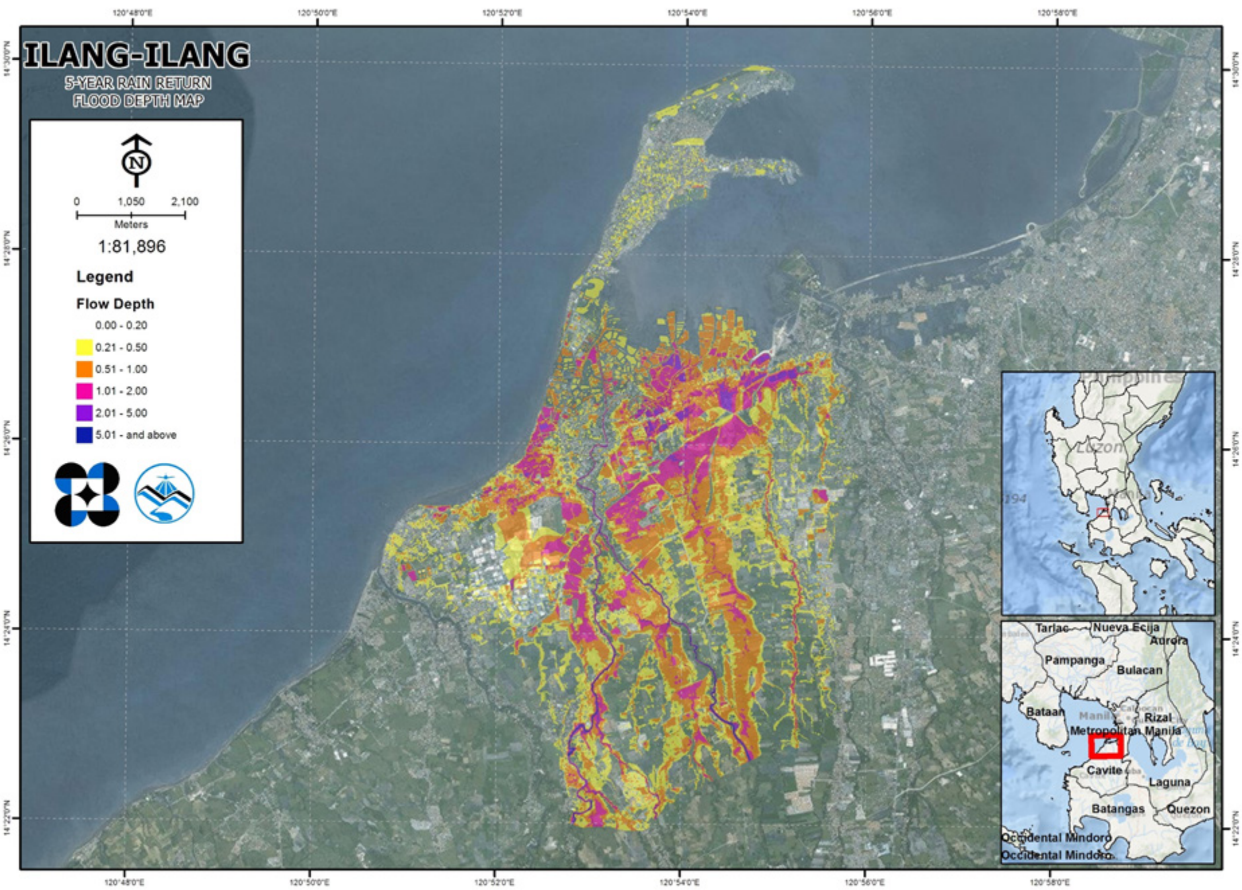


Figure 64. 5-year Flow Depth Map for Kilbay Catabangan Floodplain.

5.10 Inventory of Areas Exposed to Flooding

Listed below are the barangays affected by the Kilbay Cabatangan River Basin, grouped accordingly by municipality. For the said basin, two (2) municipalities consisting of 40 barangays are expected to experience flooding when subjected to a 5-year rainfall return period.

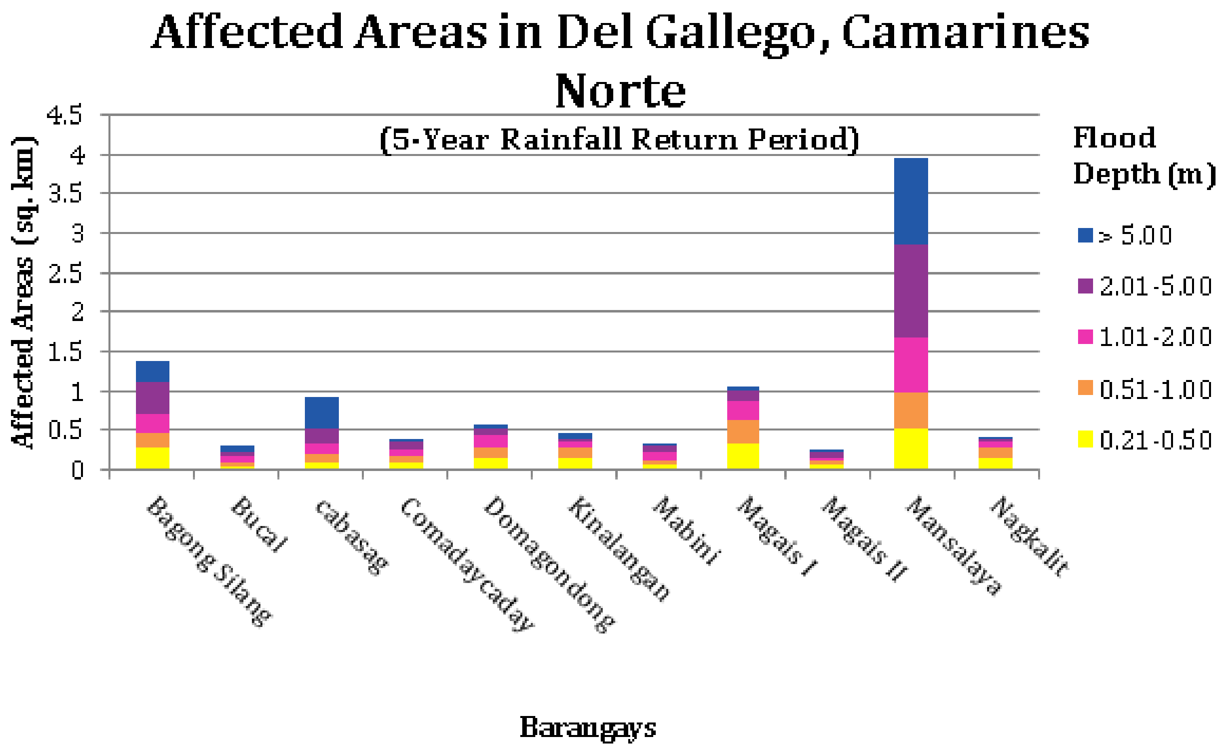
For the 5-year return period, 48.43% of the municipality of Del Gallego with an area of 213.52 sq. km. will experience flood levels of less than 0.20 meters. 2.71% of the area will experience flood levels of 0.21 to 0.50 meters while 2.07%, 1.82%, 2.04%, and 1.24% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

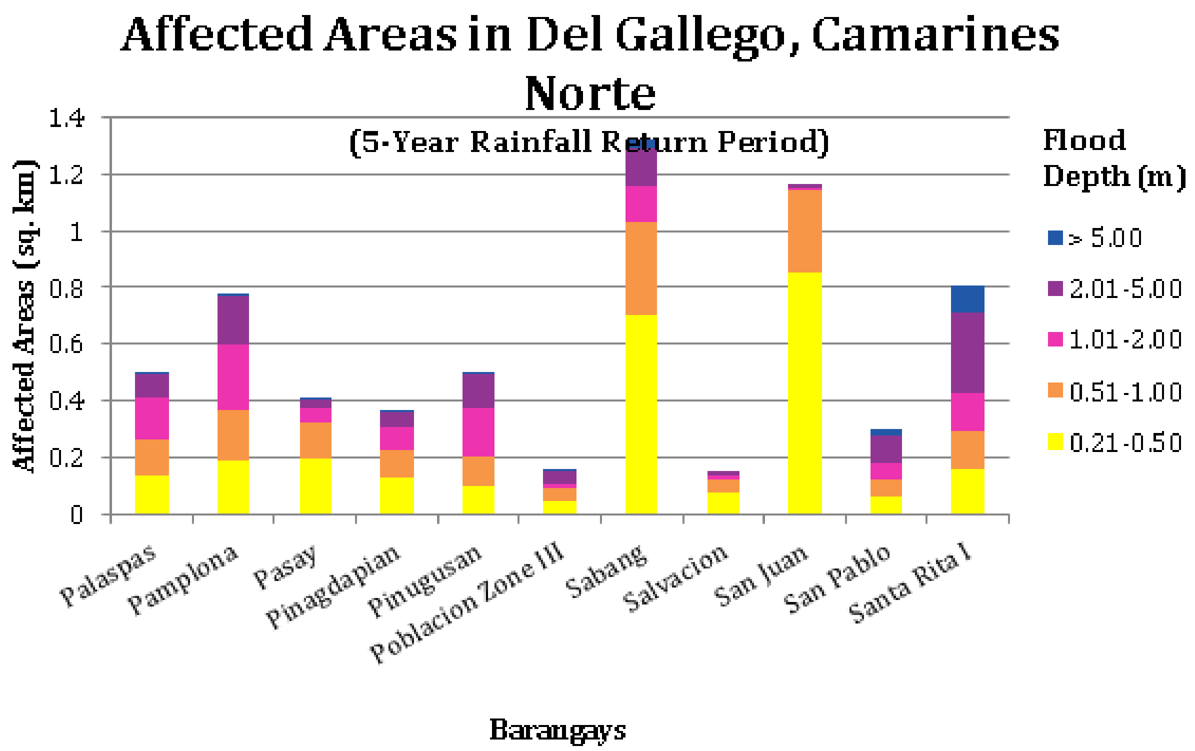
Table 31. Affected areas in Del Gallego, Camarines Norte during a 5-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)		Area of affected barangays in Guinayangan (in sq. km.)										
		Bagong Silang	Bucal	cabasag	Comadaycaday	Domagondong	Kinalangan	Mabini	Magais I	Magais II	Mansalaya	Nagkalit
Affected area (sq. km.)	1	7.29	1.1	3.16	1.68	4.38	4.19	1.82	2.78	2.09	12.65	3.07
	2	0.27	0.041	0.088	0.083	0.15	0.15	0.071	0.32	0.064	0.52	0.14
	3	0.2	0.051	0.1	0.077	0.13	0.12	0.059	0.32	0.044	0.46	0.13
	4	0.24	0.075	0.15	0.098	0.15	0.078	0.084	0.23	0.05	0.68	0.09
	5	0.41	0.051	0.18	0.094	0.1	0.029	0.089	0.13	0.072	1.18	0.037
	6	0.25	0.098	0.39	0.0014	0.045	0.078	0.0025	0.049	0.00021	1.12	0.0076

Affected area (sq. km.) by flood depth (in m.)		Area of affected barangays in Guinayangan (in sq. km.)										
		Palaspas	Pamplona	Pasay	Pinagdapian	Pinugusan	Poblacion Zone III	Sabang	Salvacion	San Juan	San Pablo	Santa Rita I
Affected area (sq. km.)	1	3.77	5.84	1.69	4.37	2.98	0.13	3.26	1.33	2.3	2.6	4.36
	2	0.14	0.19	0.2	0.13	0.097	0.046	0.7	0.077	0.85	0.065	0.16
	3	0.12	0.18	0.12	0.095	0.11	0.044	0.33	0.045	0.29	0.056	0.13
	4	0.15	0.23	0.053	0.08	0.17	0.018	0.13	0.014	0.013	0.061	0.14
	5	0.083	0.17	0.033	0.054	0.12	0.045	0.13	0.013	0.011	0.099	0.28
	6	0.0002	0.0047	0.0001	0.011	0.0029	0.0081	0.029	0	0	0.02	0.096

Affected area (sq. km.) by flood depth (in m.)		Area of affected barangays in Guinayangan (in sq. km.)										
		Bagong Silang	Bucal	cabasag	Comadaycaday	Domagondong	Kinalangan	Mabini	Magais I	Magais II	Mansalaya	Nagkalit
Affected area (sq. km.)	1	7.29	1.1	3.16	1.68	4.38	4.19	1.82	2.78	2.09	12.65	3.07
	2	0.27	0.041	0.088	0.083	0.15	0.15	0.071	0.32	0.064	0.52	0.14
	3	0.2	0.051	0.1	0.077	0.13	0.12	0.059	0.32	0.044	0.46	0.13
	4	0.24	0.075	0.15	0.098	0.15	0.078	0.084	0.23	0.05	0.68	0.09
	5	0.41	0.051	0.18	0.094	0.1	0.029	0.089	0.13	0.072	1.18	0.037
	6	0.25	0.098	0.39	0.0014	0.045	0.078	0.0025	0.049	0.00021	1.12	0.0076


Affected Areas in Del Gallego, Camarines Norte
(5-Year Rainfall Return Period)
Affected Areas (sq. km)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Bagong Silang
Bucal
cabasag
Comadaycaday
Domagondong
Kinalangan
Mabini
Magais I
Magais II
Mansalaya
Nagkalit
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50


Affected Areas in Del Gallego, Camarines Norte
(5-Year Rainfall Return Period)
Affected Areas (sq. km)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Palaspas
Pamplona
Pasay
Pinagdapian
Pinugusan
Poblacion Zone III
Sabang
Salvacion
San Juan
San Pablo
Santa Rita I
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50

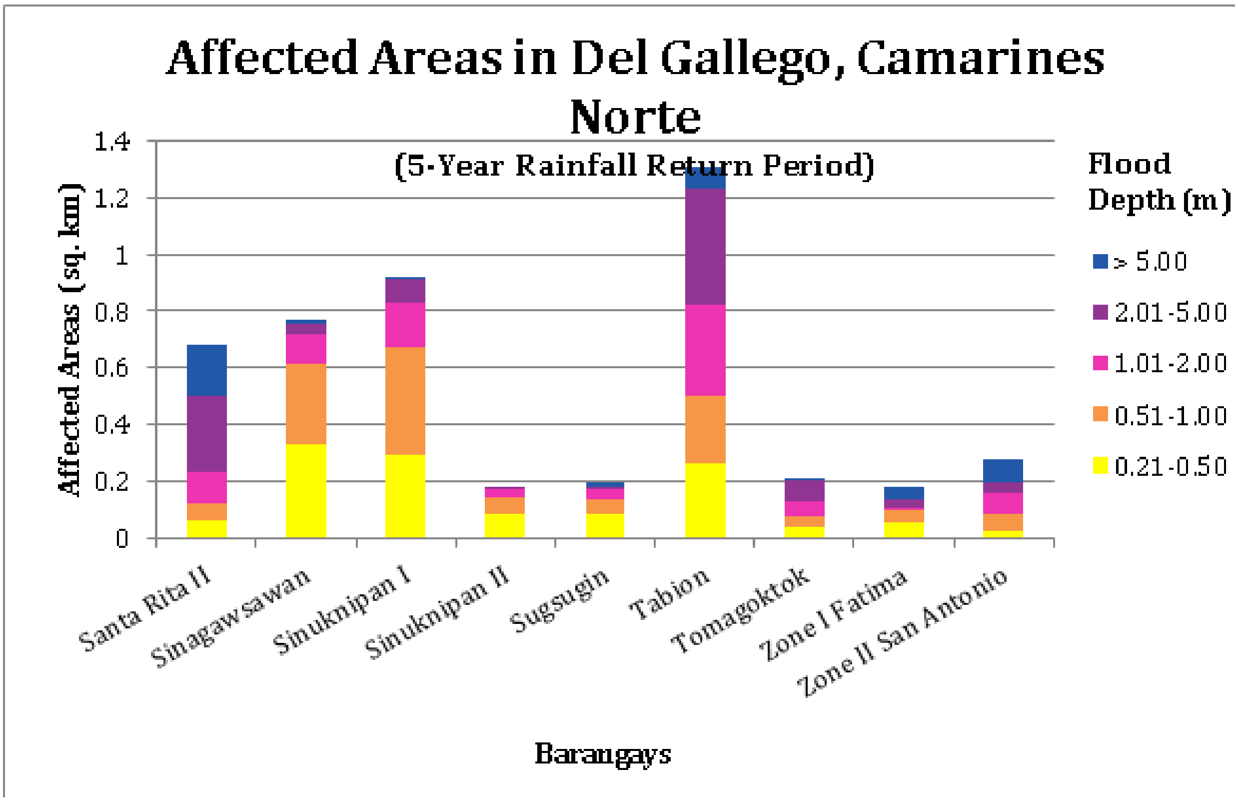


Figure 65. Affected areas in Del Gallego, Camarines Norte during a 5-Year Rainfall Return Period.

For the 5-year return period, 6.94% of the municipality of Tagkawayan with an area of 551.33 sq. km. will experience flood levels of less than 0.20 meters. 0.30% of the area will experience flood levels of 0.21 to 0.50 meters while 0.26%, 0.22%, 0.11%, and 0.01% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 32. Affected areas in Tagkawayan, Quezon during a 5-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)		Area of affected barangays in Tagkawayan (in sq. km.)					
		Bamban	Bukal	Maguibuay	Munting Parang	Payapa	San Vicente
Affected area (sq. km.)	1	0.82	4.58	20.75	1.84	7.42	0.00043
	2	0.17	0.16	0.7	0.058	0.37	0
	3	0.18	0.11	0.54	0.064	0.44	0.000088
	4	0.052	0.092	0.51	0.083	0.4	0.00016
	5	0	0.074	0.34	0.021	0.12	0
	6	0	0.022	0.045	0	0	0

Affected area (sq. km.) by flood depth (in m.)		Area of affected barangays in Tagkawayan (in sq. km.)					
		Santo Tomas	Tunton				
Affected area (sq. km.)	1	2.7	0.17				
	2	0.17	0.01				
	3	0.11	0.012				
	4	0.063	0.023				
	5	0.028	0.017				
	6	0.0001	0.0058				

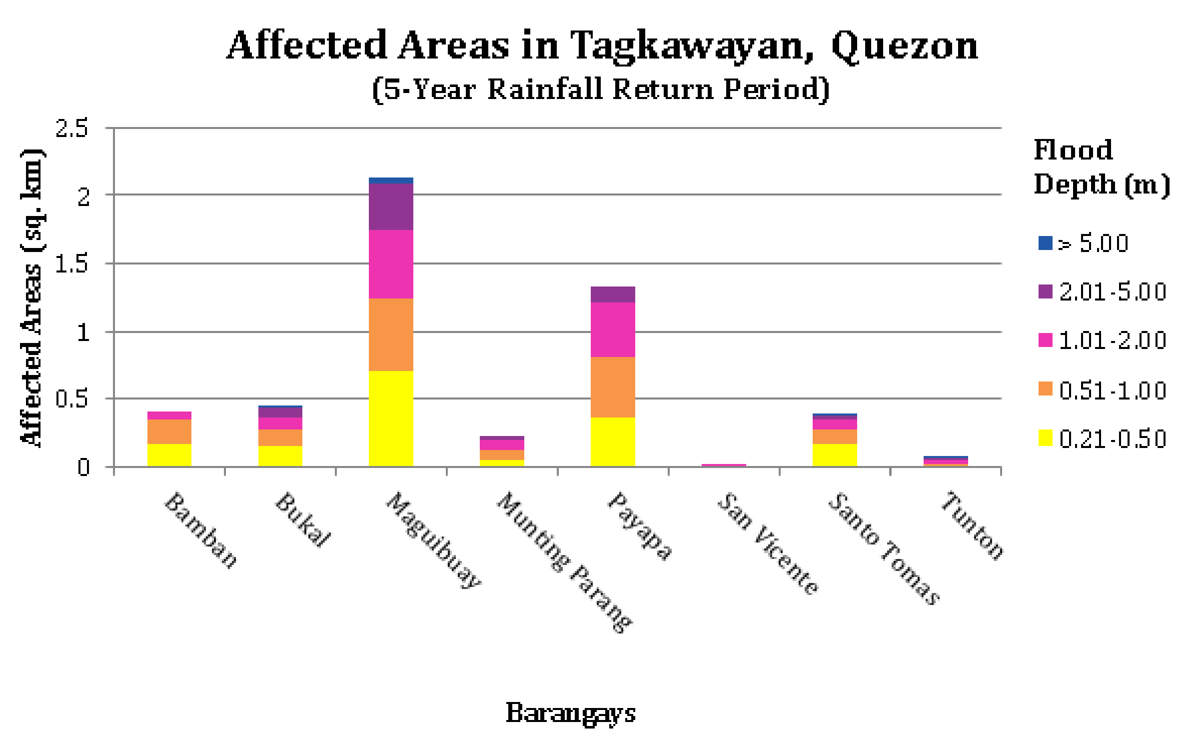


Figure 66. Areas affected by flooding in Tagkawayan, Quezon for a 5-Year Return Period rainfall event.

For the 5-year return period, 6.94% of the municipality of Tagkawayan with an area of 551.33 sq. km. will experience flood levels of less than 0.20 meters. 0.30% of the area will experience flood levels of 0.21 to 0.50 meters while 0.26%, 0.22%, 0.11%, and 0.01% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 33. Affected areas in Tagkawayan, Quezon during a 5-Year Rainfall Return Period.

Affected area (sq. km.) by flood depth (in m.)		Area of affected barangays in Tagkawayan (in sq. km.)					
		Bamban	Bukal	Maguibuay	Munting Parang	Payapa	San Vicente
Affected area (sq. km.)	1	0.82	4.58	20.75	1.84	7.42	0.00043
	2	0.17	0.16	0.7	0.058	0.37	0
	3	0.18	0.11	0.54	0.064	0.44	0.000088
	4	0.052	0.092	0.51	0.083	0.4	0.00016
	5	0	0.074	0.34	0.021	0.12	0
	6	0	0.022	0.045	0	0	0

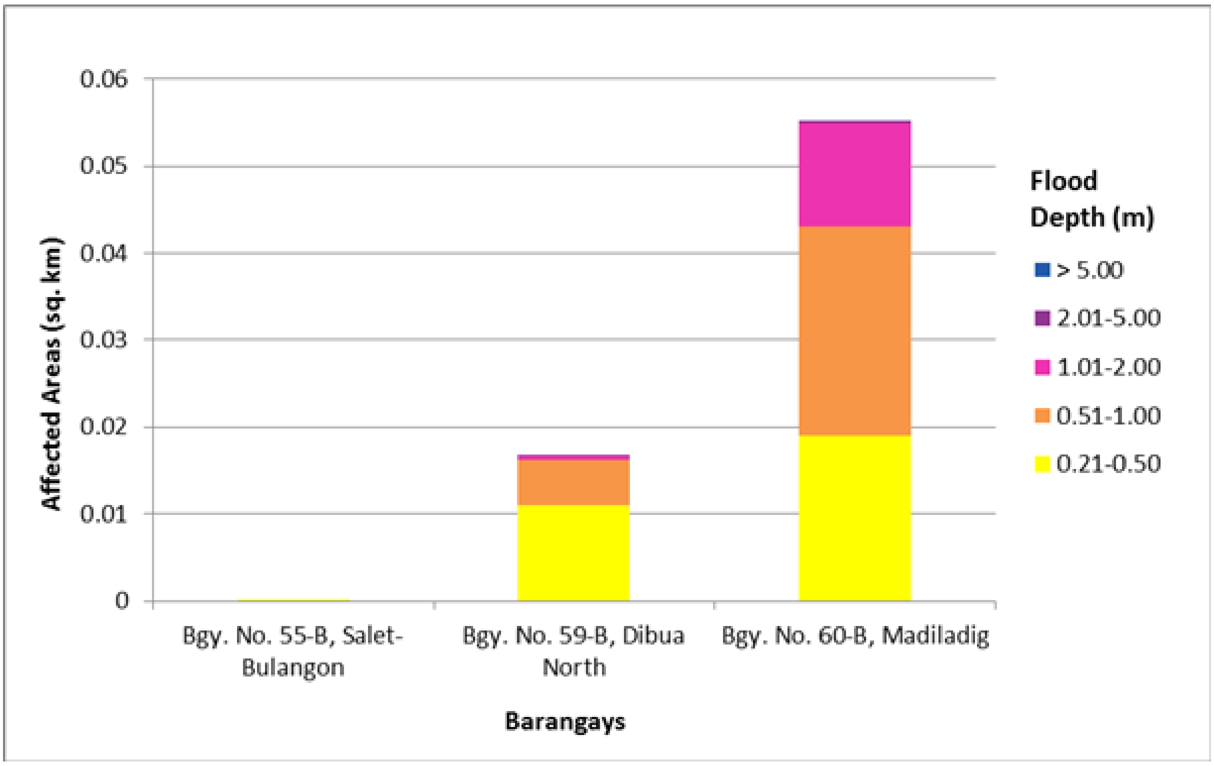
Affected area (sq. km.) by flood depth (in m.)		Area of affected barangays in Tagkawayan (in sq. km.)					
		Santo Tomas	Tunton				
Affected area (sq. km.)	1	2.7	0.17				
	2	0.17	0.01				
	3	0.11	0.012				
	4	0.063	0.023				
	5	0.028	0.017				
	6	0.0001	0.0058				

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.

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

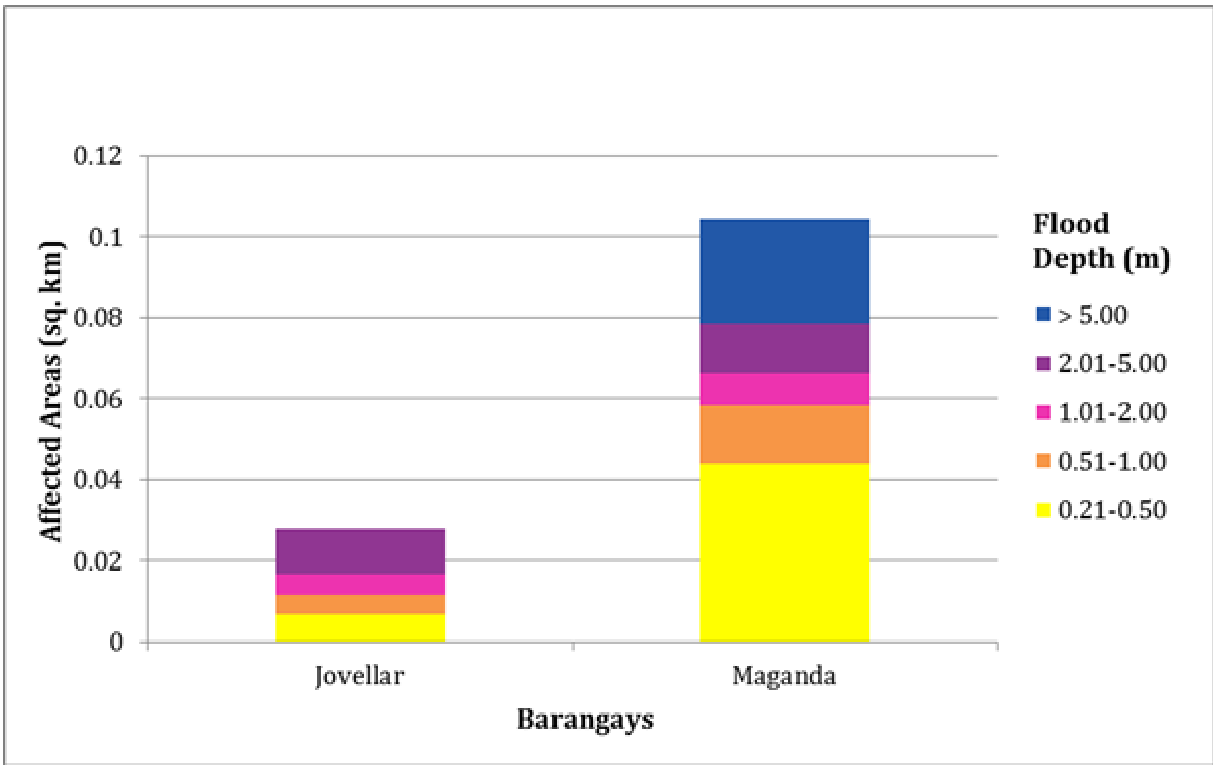


Figure 73. Affected Areas in Pasuquin, Ilocos Norte during 5-Year Rainfall Return Period.

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

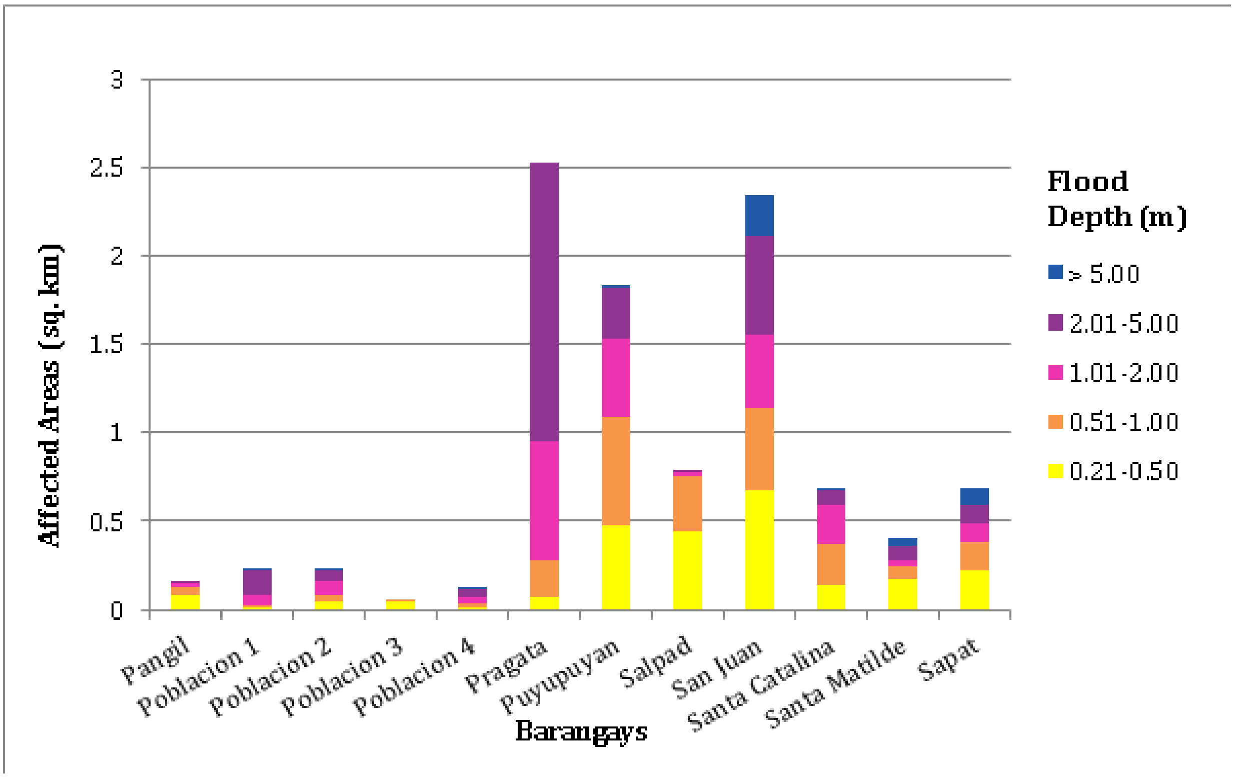


Figure 74. Affected Areas in Pasuquin, Ilocos Norte during 5-Year Rainfall Return Period.

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

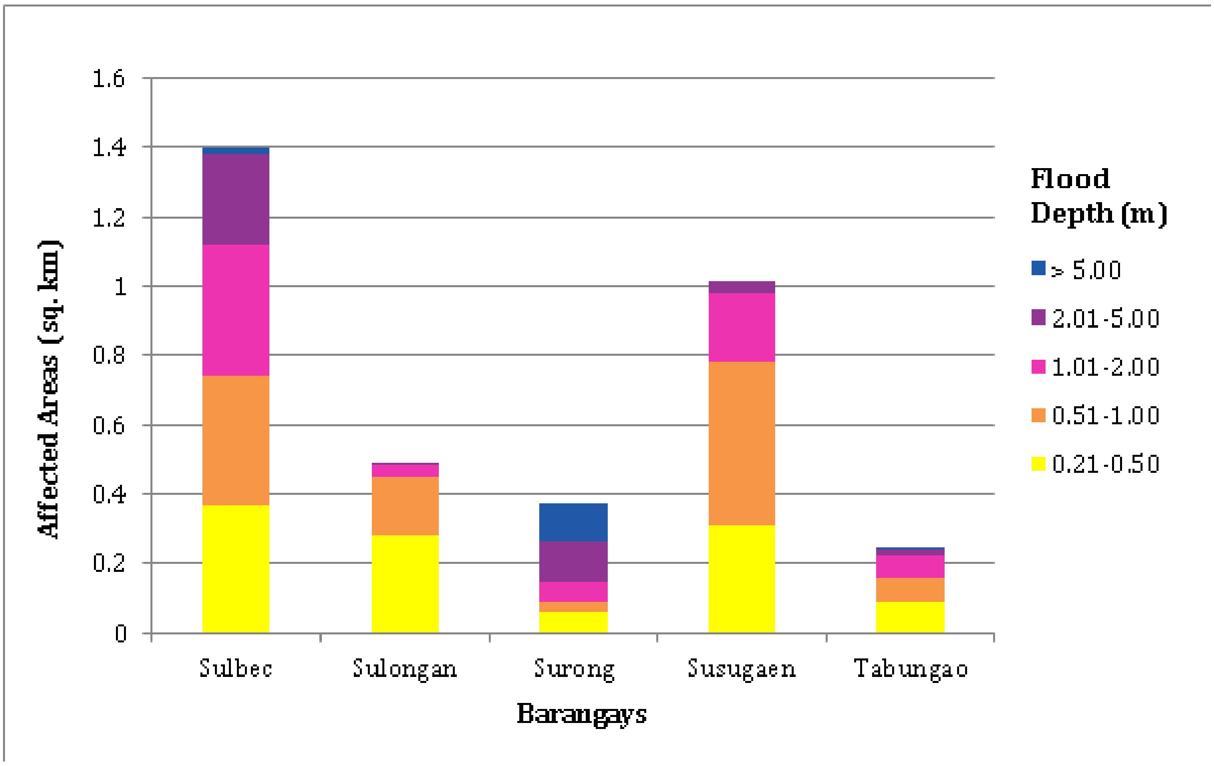


Figure 75. Affected Areas in Pasuquin, Ilocos Norte during 5-Year Rainfall Return Period.

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

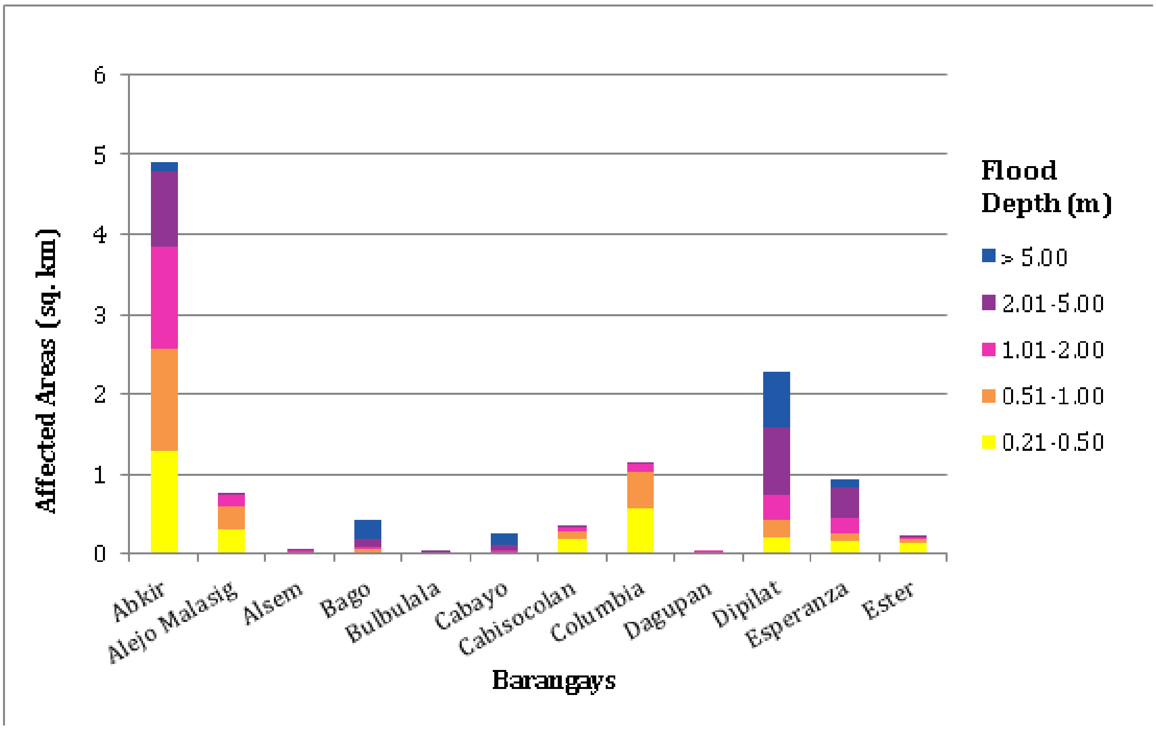


Figure 76. Affected Areas in Vintar, Ilocos Norte during 5-Year Rainfall Return Period.

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

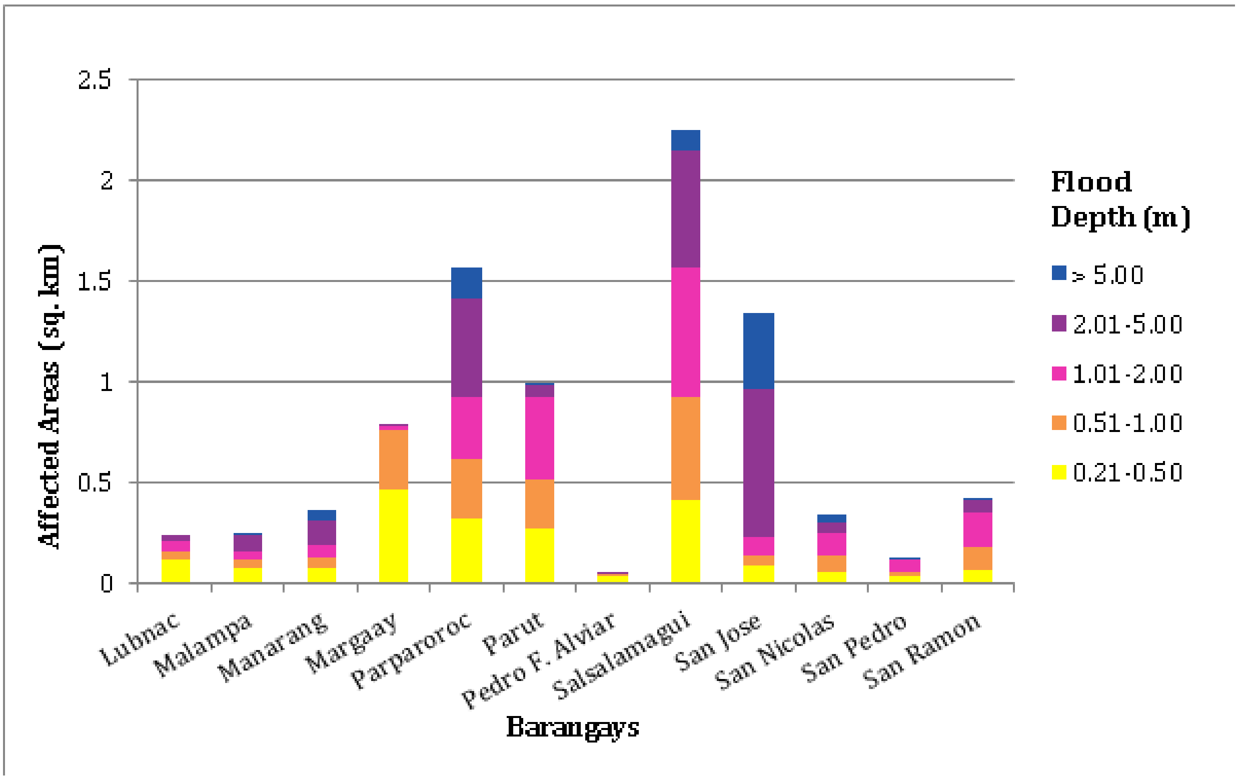


Figure 77. Affected Areas in Vintar, Ilocos Norte during 5-Year Rainfall Return Period.

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

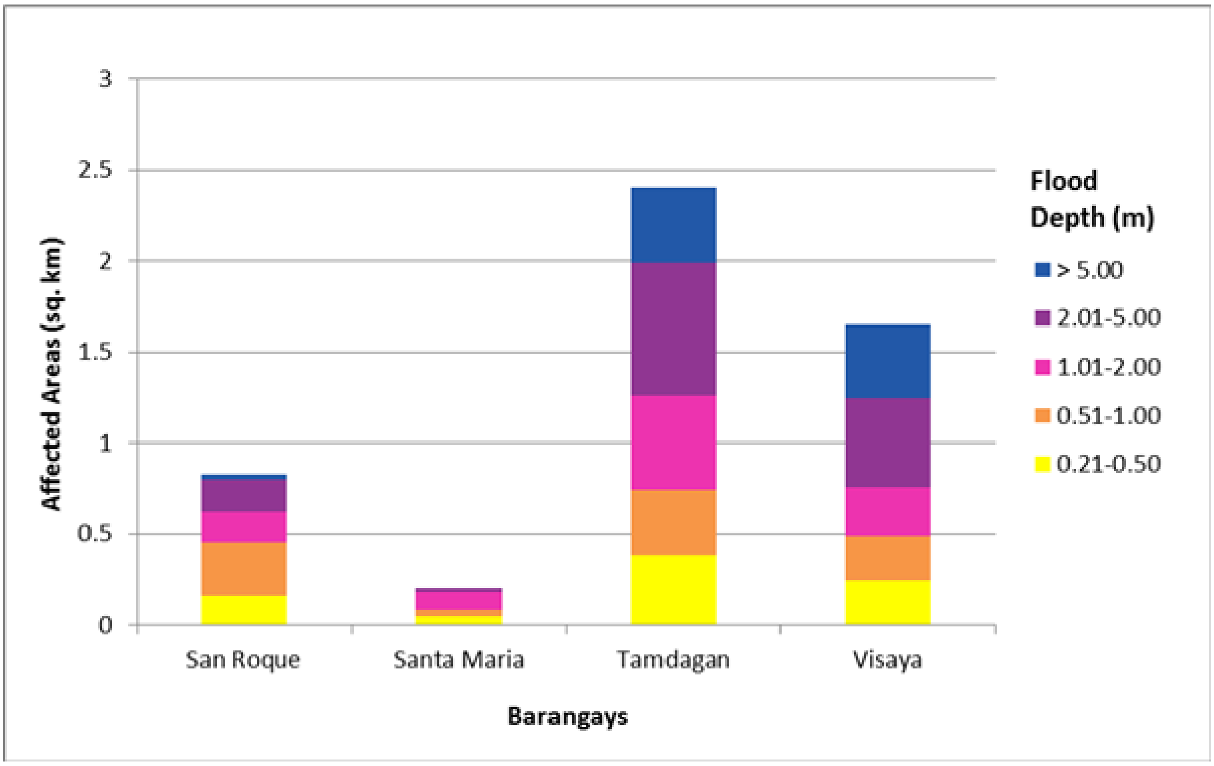


Figure 78. Affected Areas in Vintar, Ilocos Norte during 5-Year Rainfall Return Period.

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

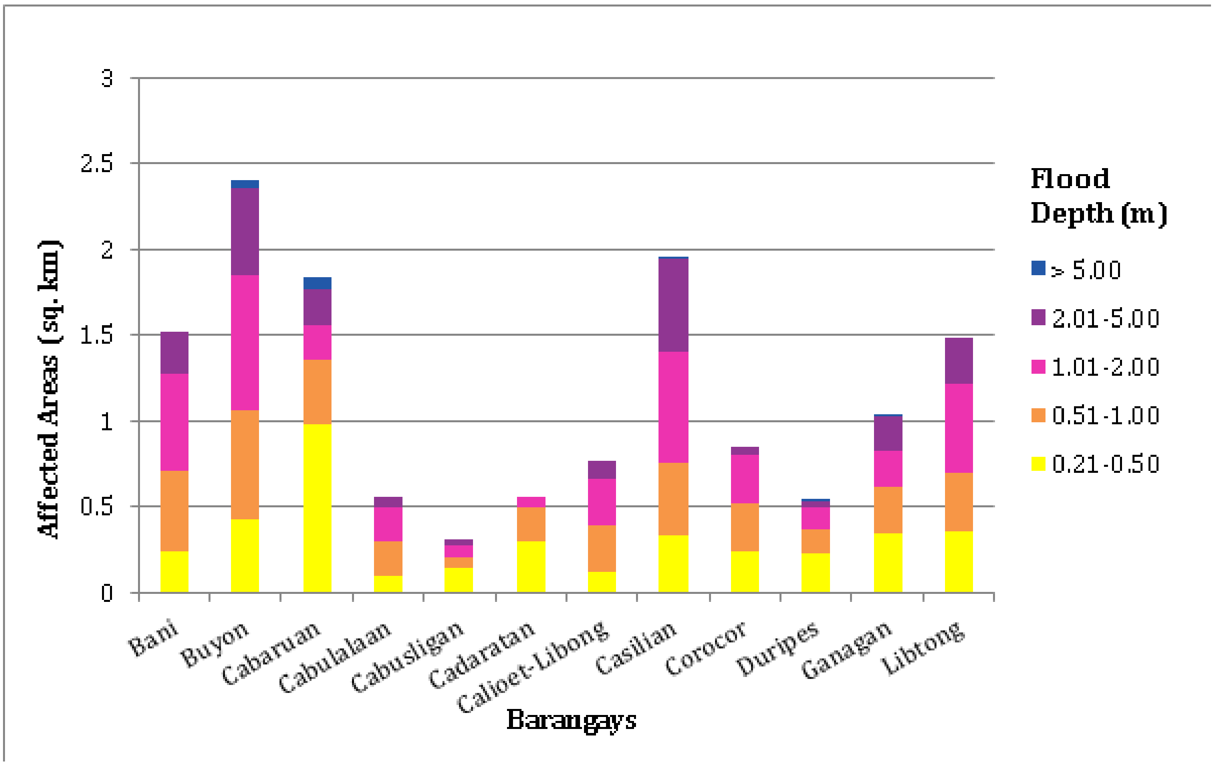


Figure 79. Affected Areas in Bacarra, Ilocos Norte during 25-Year Rainfall Return Period.

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

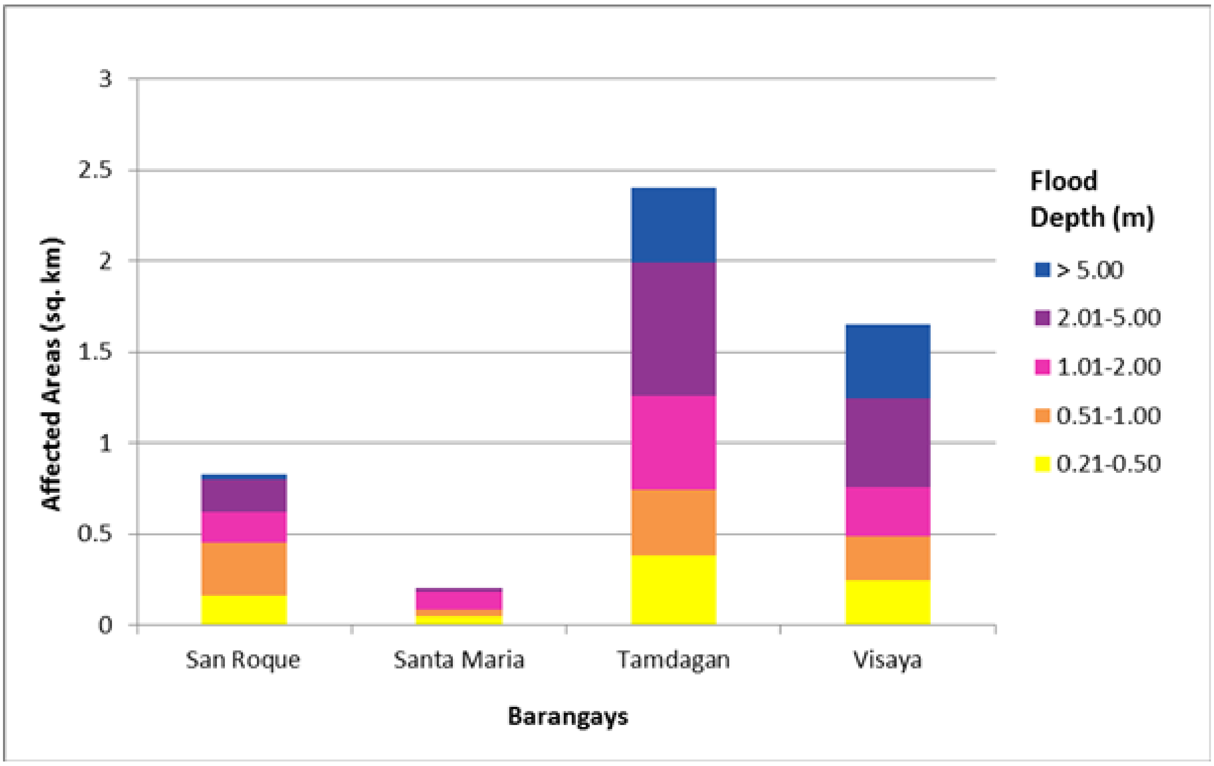


Figure 80. Affected Areas in Bacarra, Ilocos Norte during 25-Year Rainfall Return Period.

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

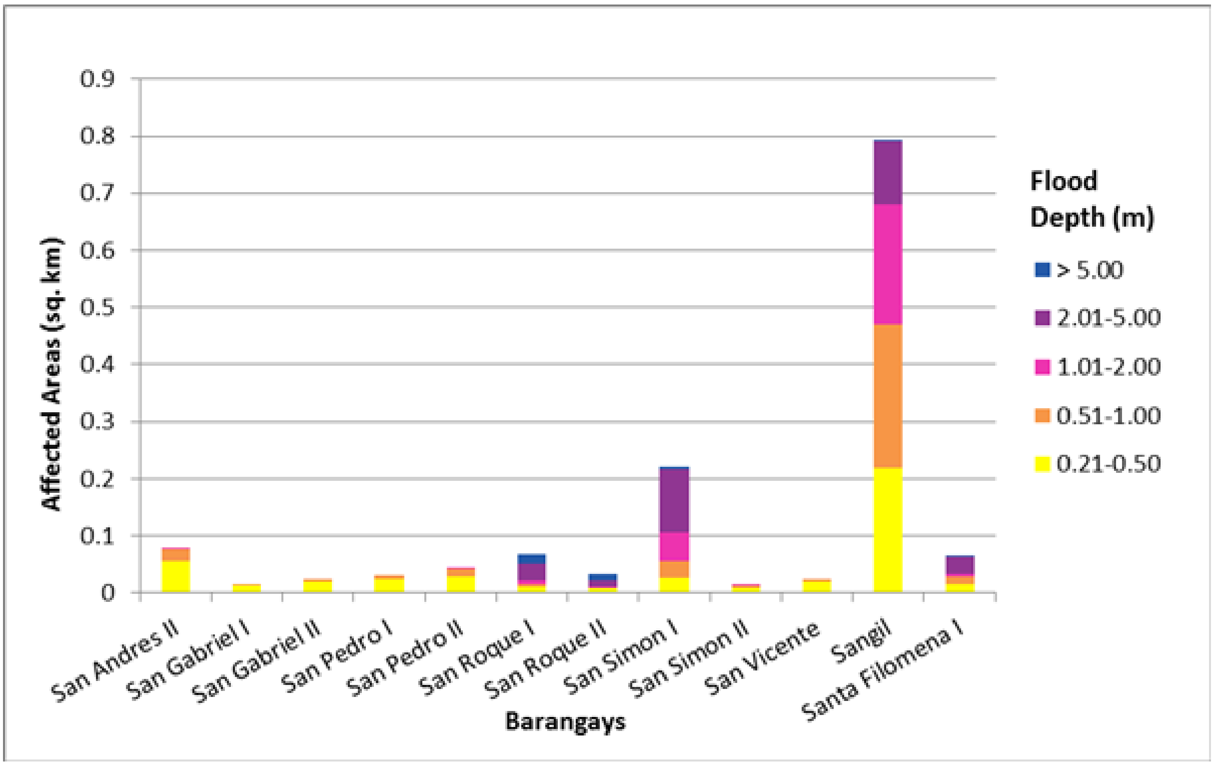


Figure 81. Affected Areas in Bacarra, Ilocos Norte during 25-Year Rainfall Return Period.

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

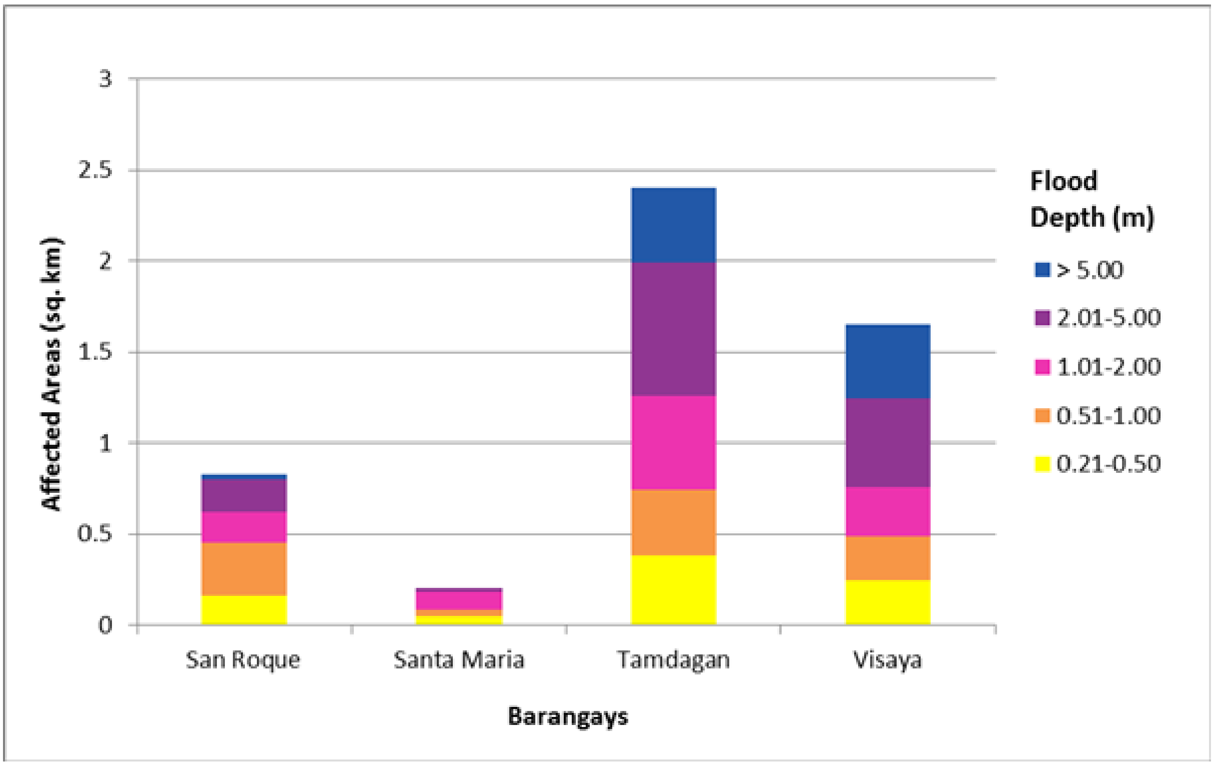


Figure 82. Affected Areas in Bacarra, Ilocos Norte during 25-Year Rainfall Return Period.

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

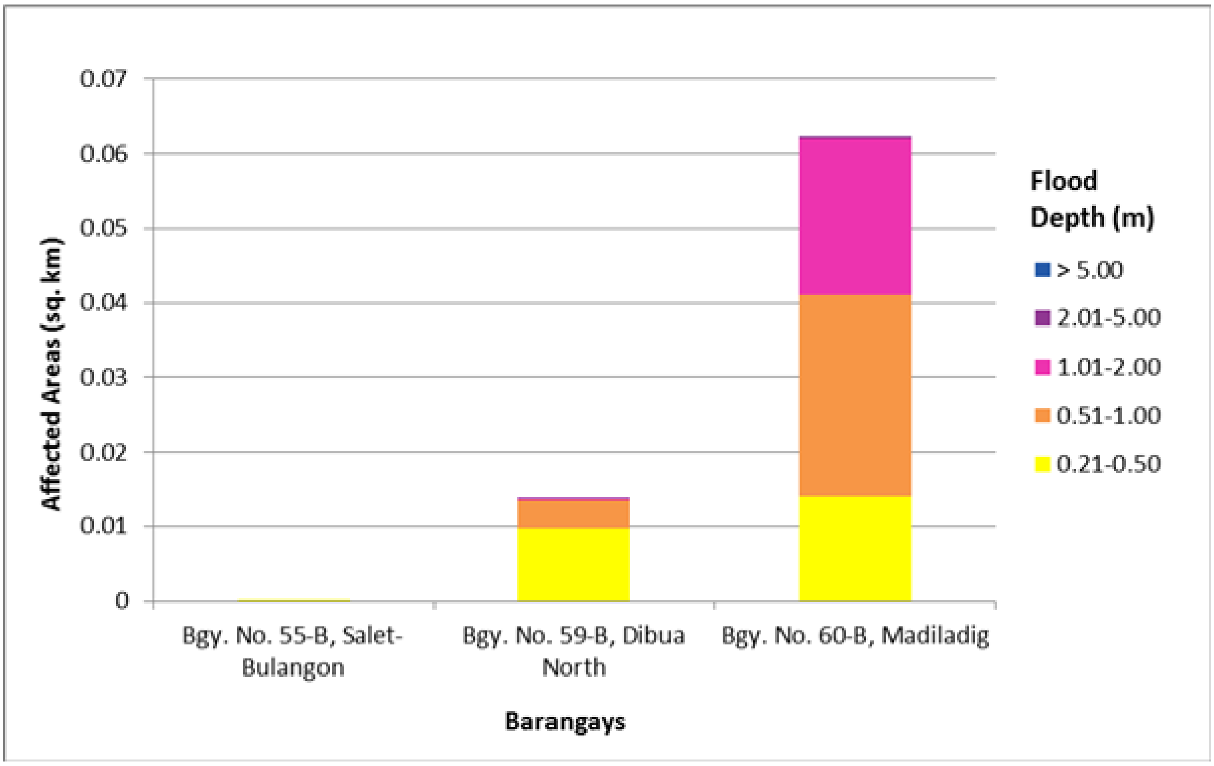


Figure 83. Affected Areas in Laoag City, Ilocos Norte during 25-Year Rainfall Return Period.

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		

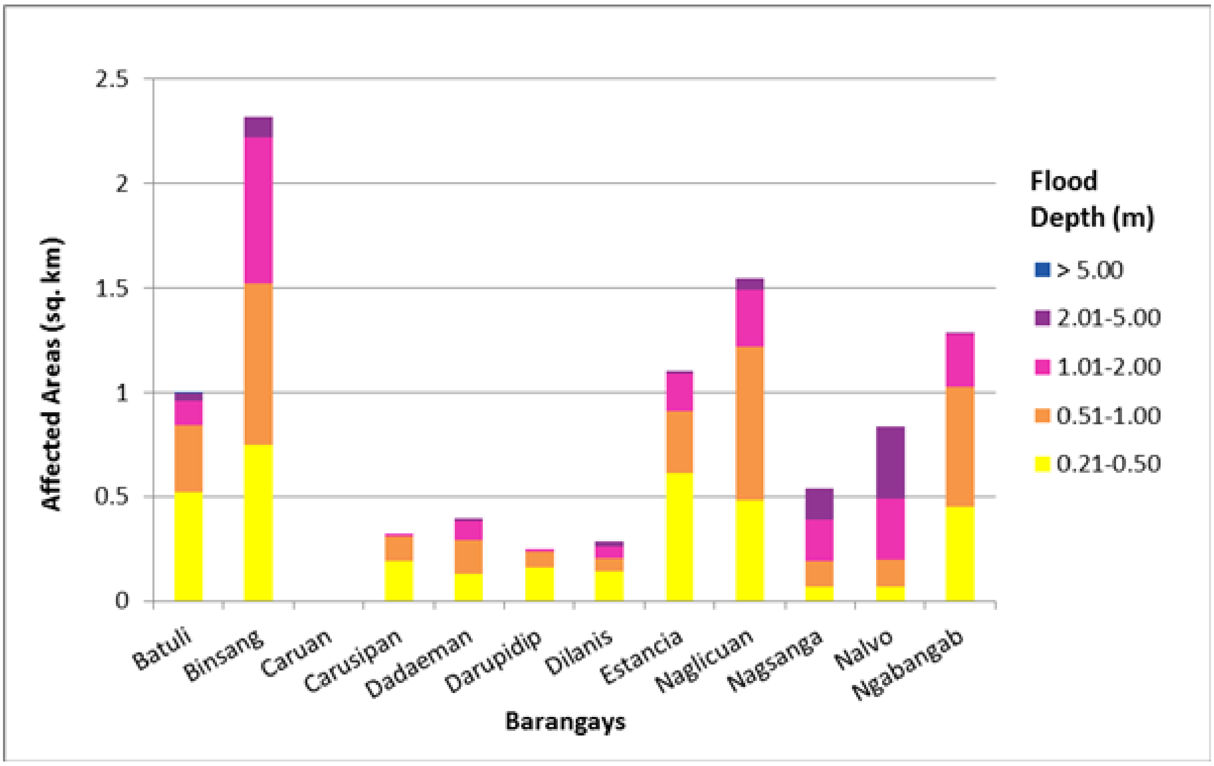


Figure 84. Affected Areas in Pasuquin, Ilocos Norte during 25-Year Rainfall Return Period.

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

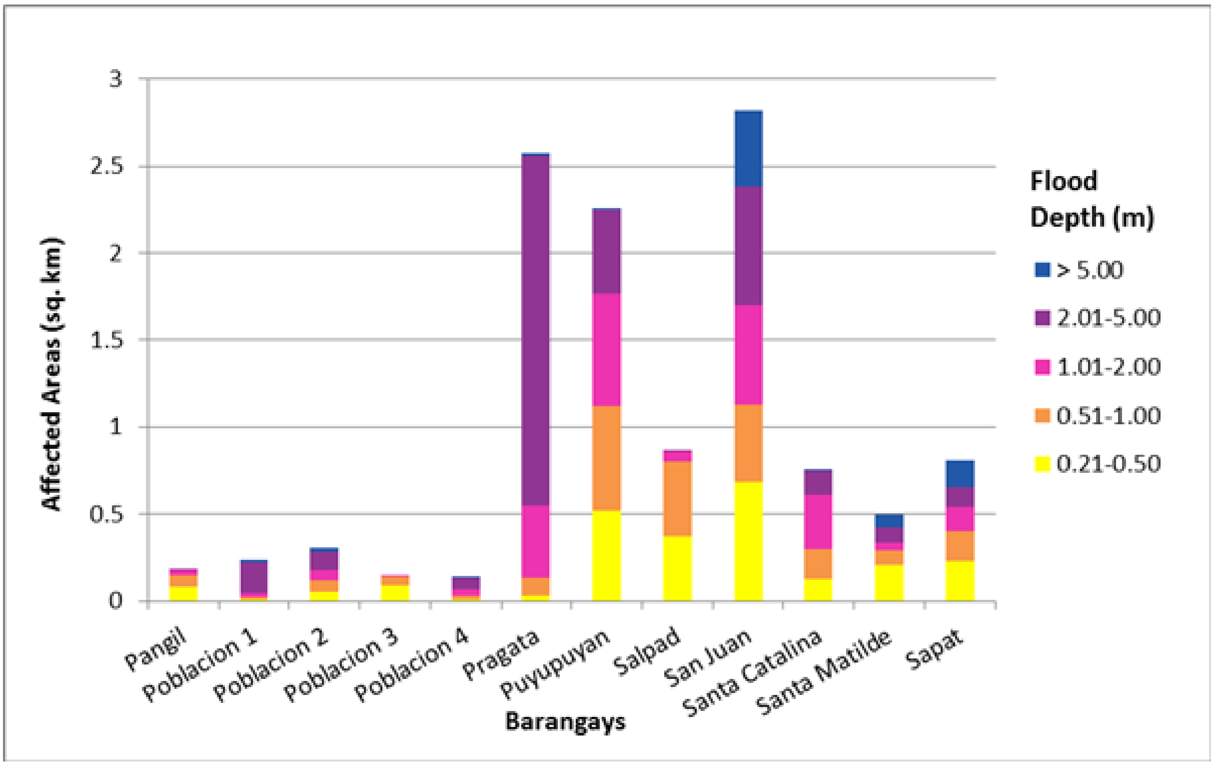


Figure 85. Affected Areas in Pasuquin, Ilocos Norte during 25-Year Rainfall Return Period.

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

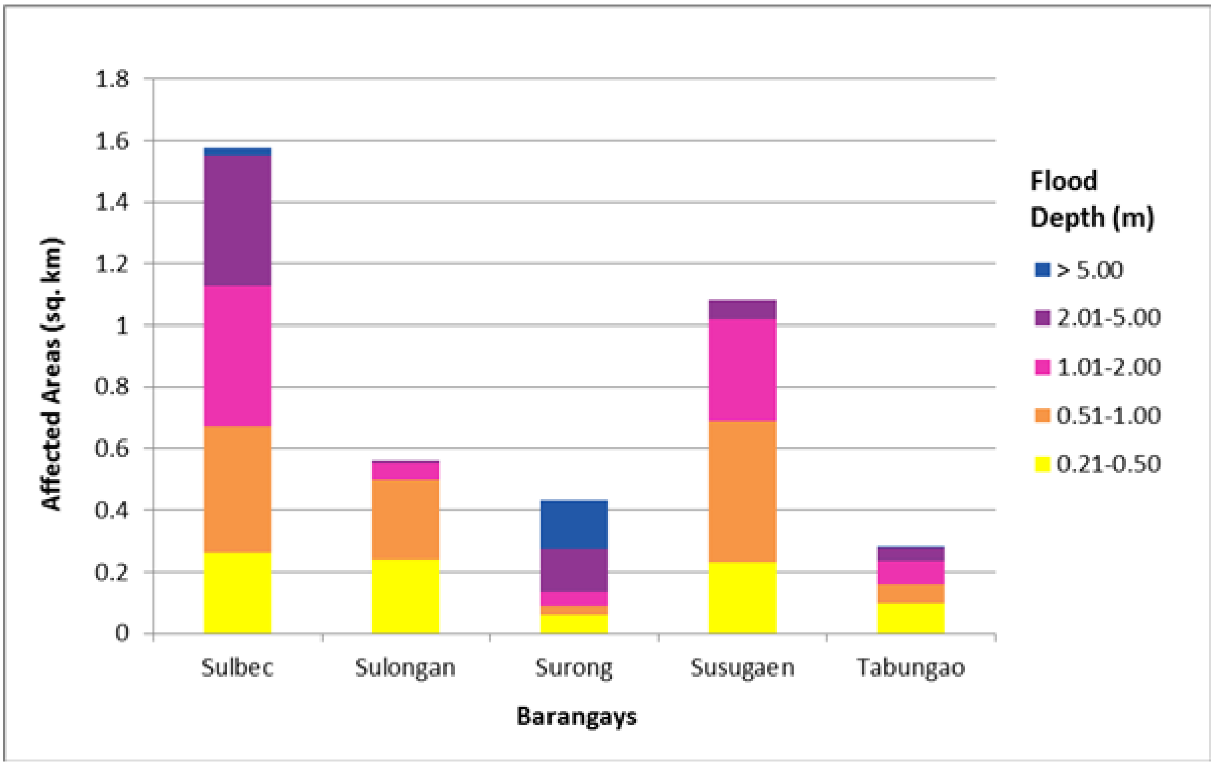


Figure 86. Affected Areas in Pasuquin, Ilocos Norte during 25-Year Rainfall Return Period.

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

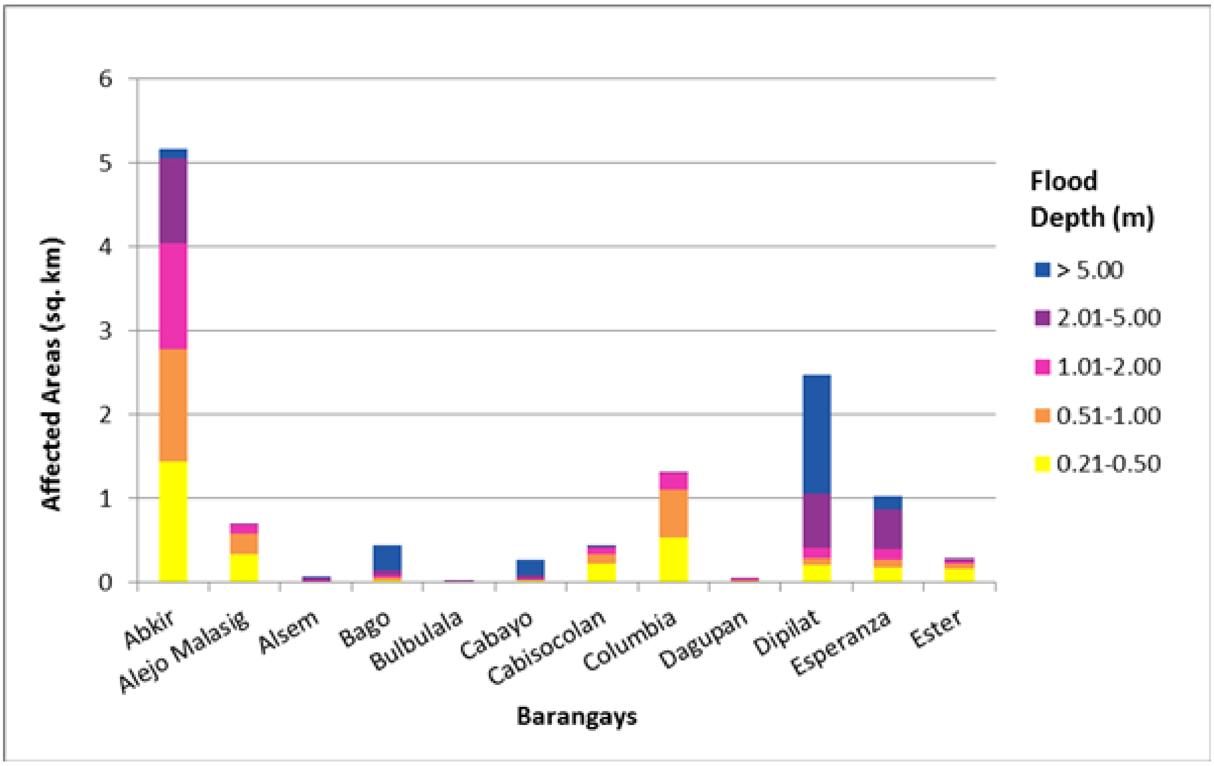


Figure 87. Affected Areas in Vintar, Ilocos Norte during 25-Year Rainfall Return Period.

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

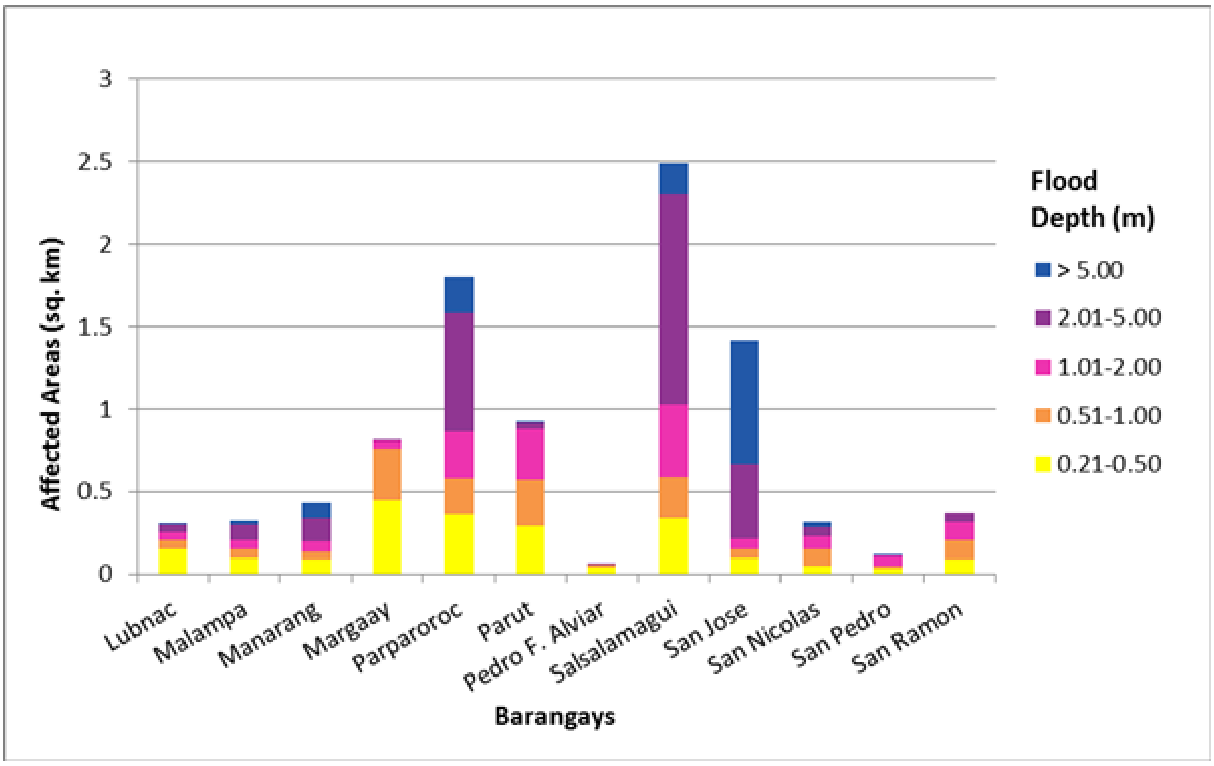


Figure 88. Affected Areas in Vintar, Ilocos Norte during 25-Year Rainfall Return Period.

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

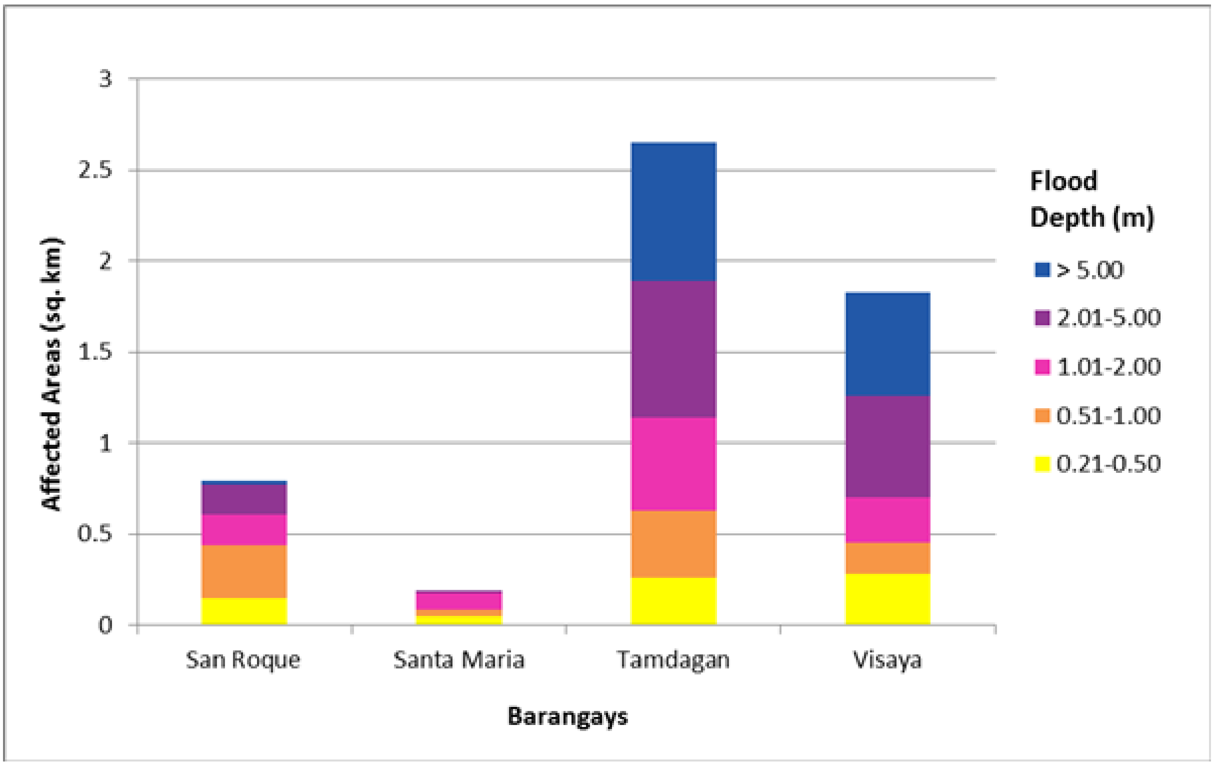


Figure 89. Affected Areas in Vintar, Ilocos Norte during 25-Year Rainfall Return Period

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

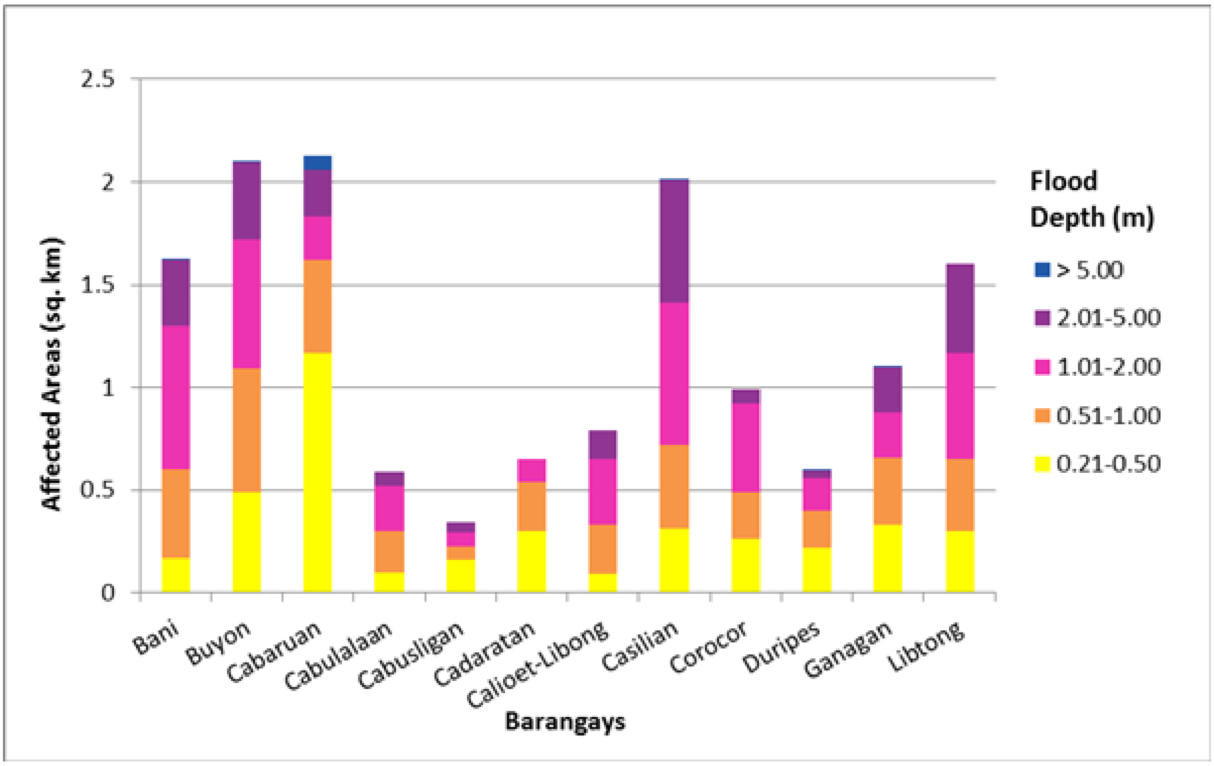


Figure 90. Affected Areas in Bacarra, Ilocos Norte during 100-Year Rainfall Return Period.

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

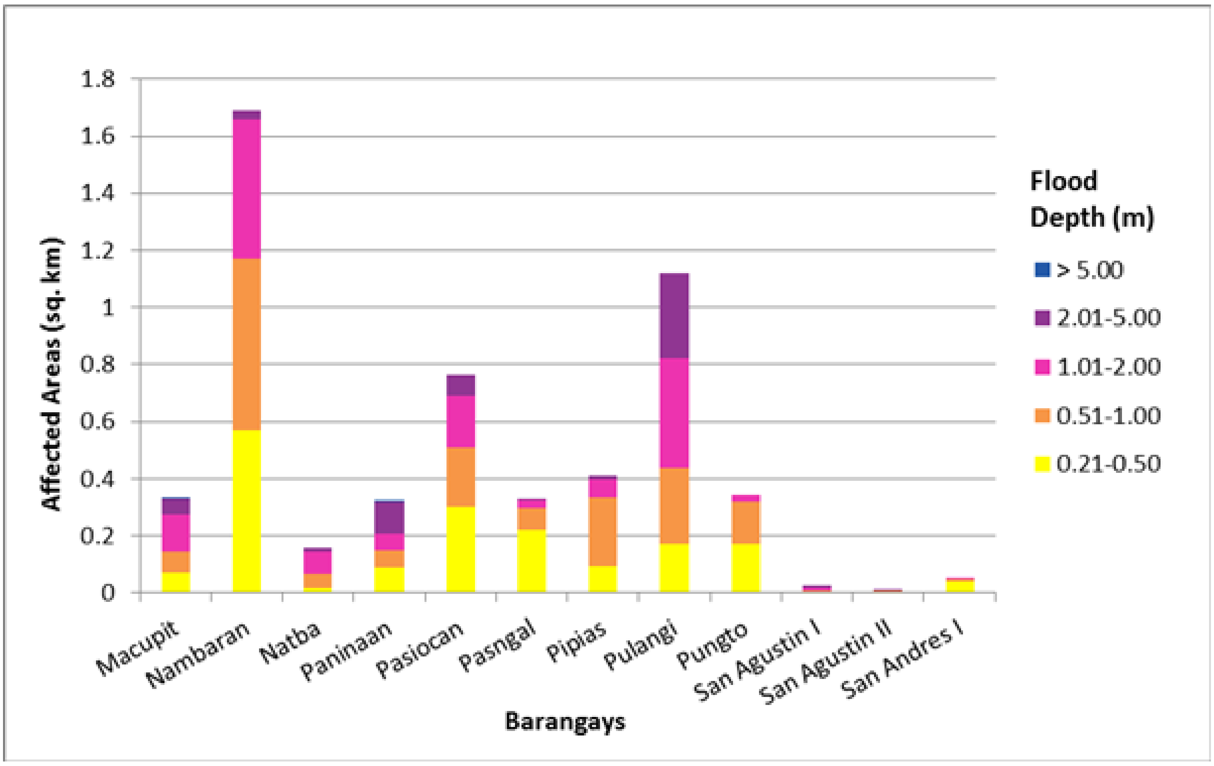


Figure 91. Affected Areas in Bacarra, Ilocos Norte during 100-Year Rainfall Return Period.

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

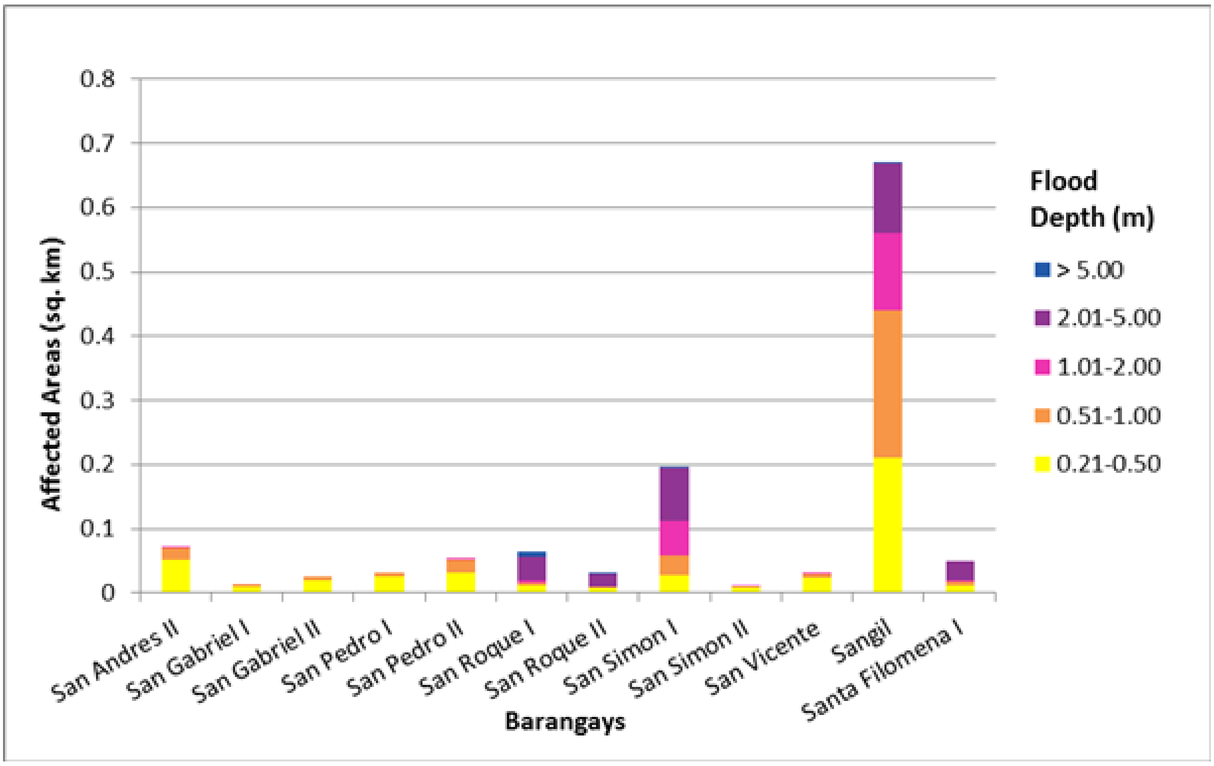


Figure 92. Affected Areas in Bacarra, Ilocos Norte during 100-Year Rainfall Return Period.

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		

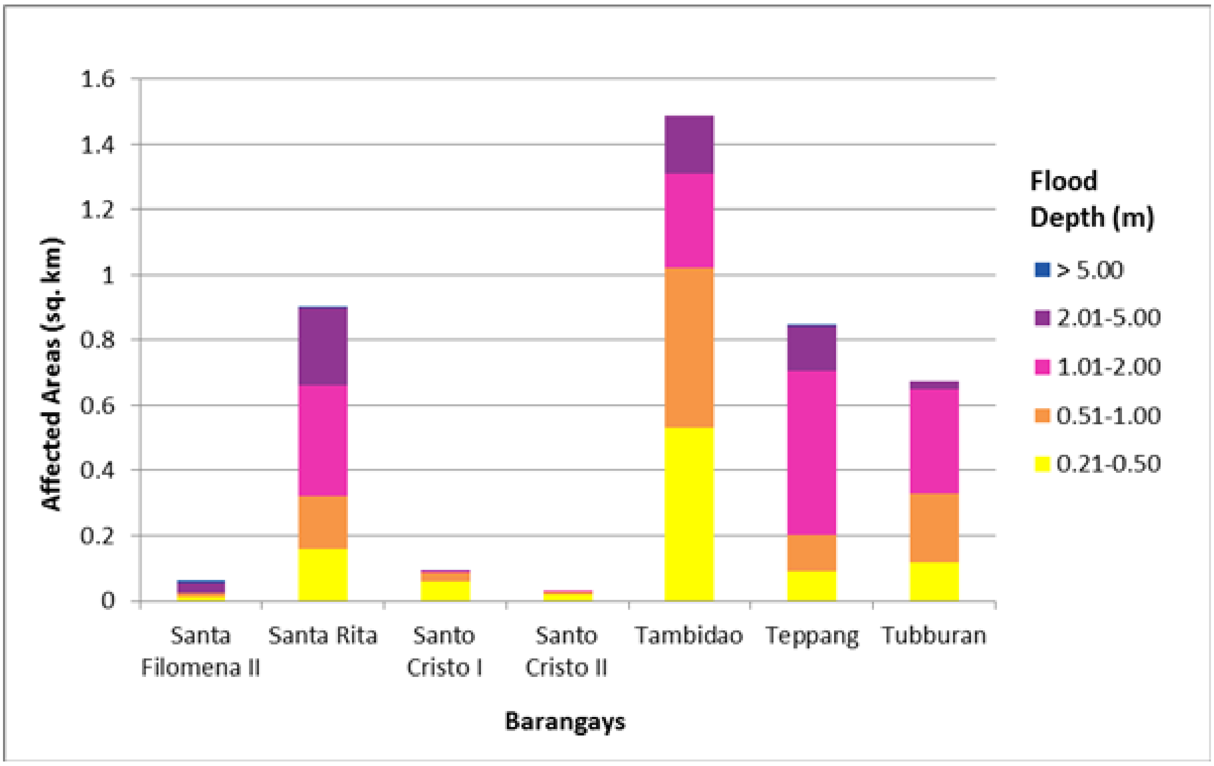


Figure 93. Affected Areas in Bacarra, Ilocos Norte during 100-Year Rainfall Return Period.

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

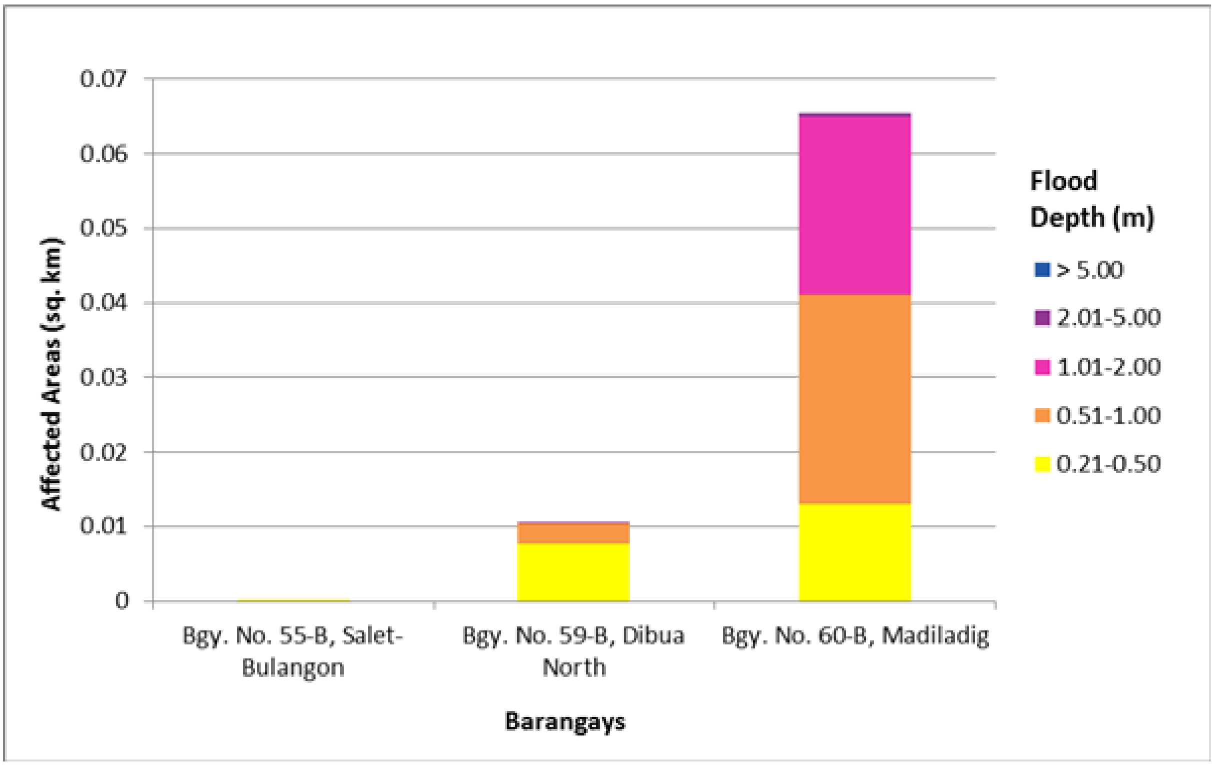


Figure 94. Affected Areas in Laoag City, Ilocos Norte during 100-Year Rainfall Return Period.

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

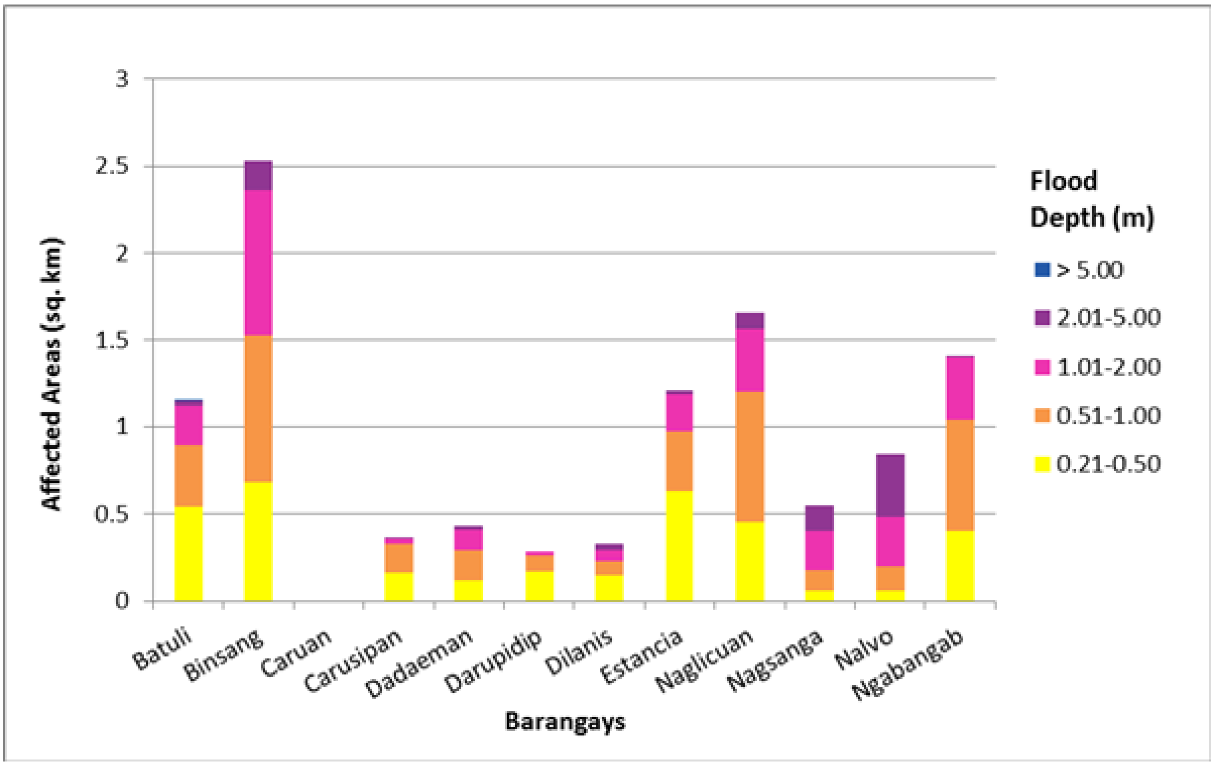


Figure 95. Affected Areas in Pasuquin, Ilocos Norte during 100-Year Rainfall Return Period.

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

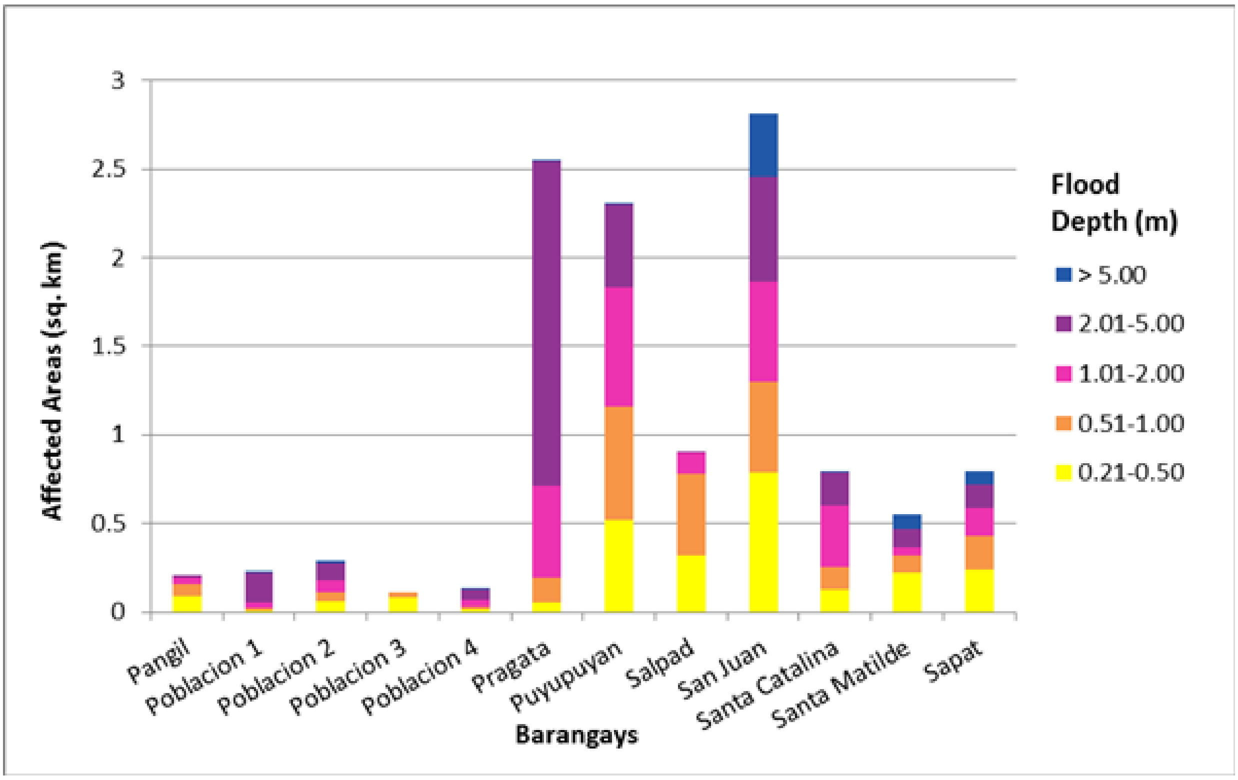


Figure 96. Affected Areas in Pasuquin, Ilocos Norte during 100-Year Rainfall Return Period.

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

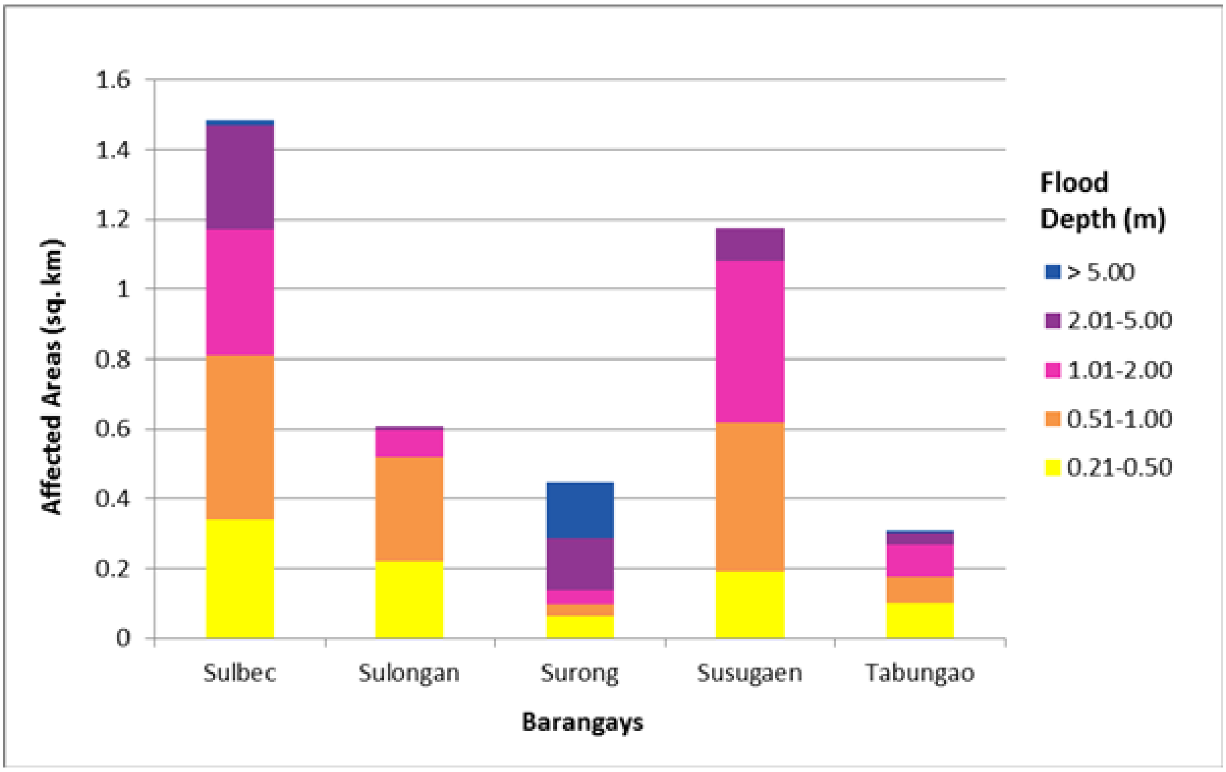


Figure 97. Affected Areas in Pasuquin, Ilocos Norte during 100-Year Rainfall Return Period.

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

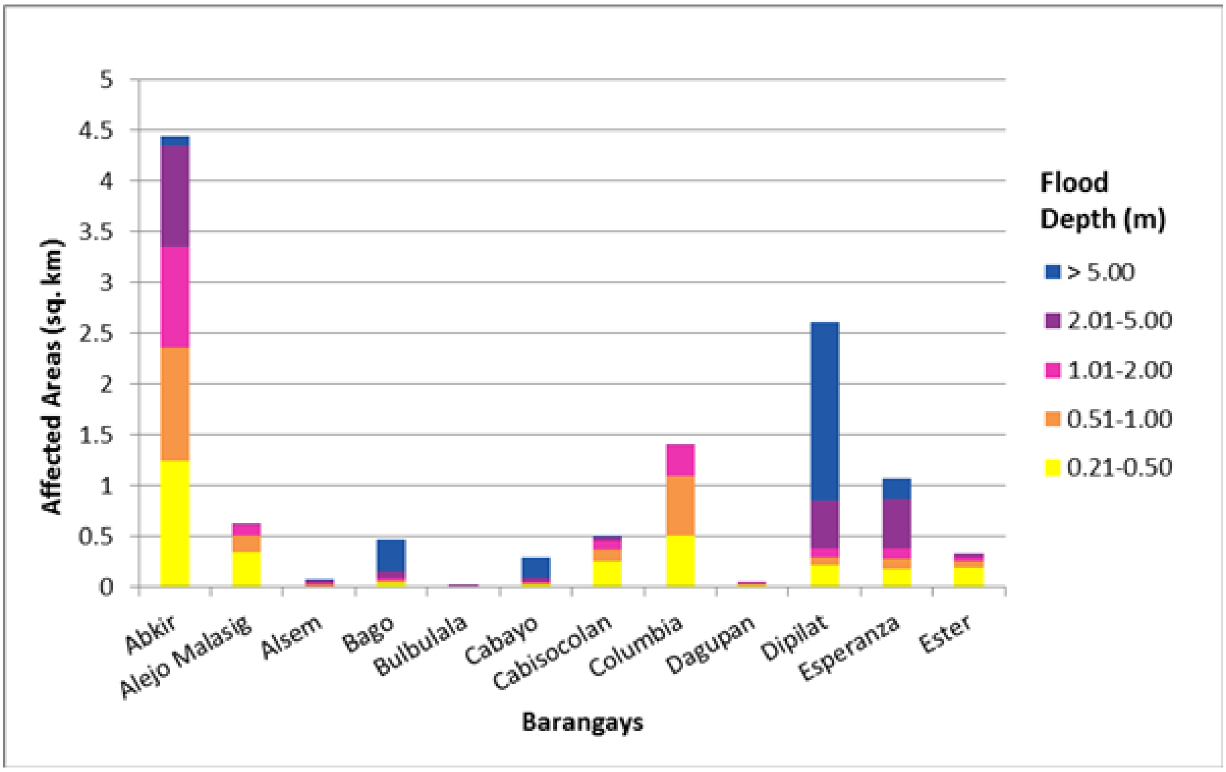


Figure 98. Affected Areas in Vintar, Ilocos Norte during 100-Year Rainfall Return Period.

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

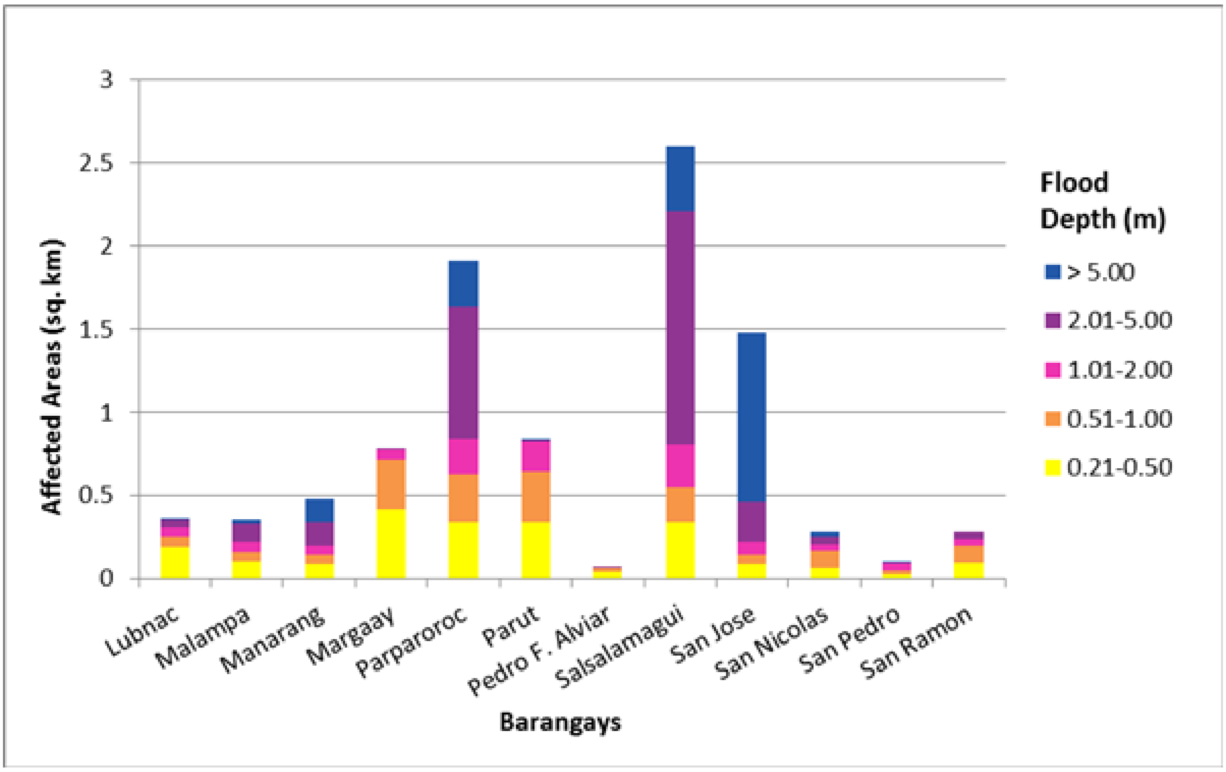


Figure 99. Affected Areas in Vintar, Ilocos Norte during 100-Year Rainfall Return Period.

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

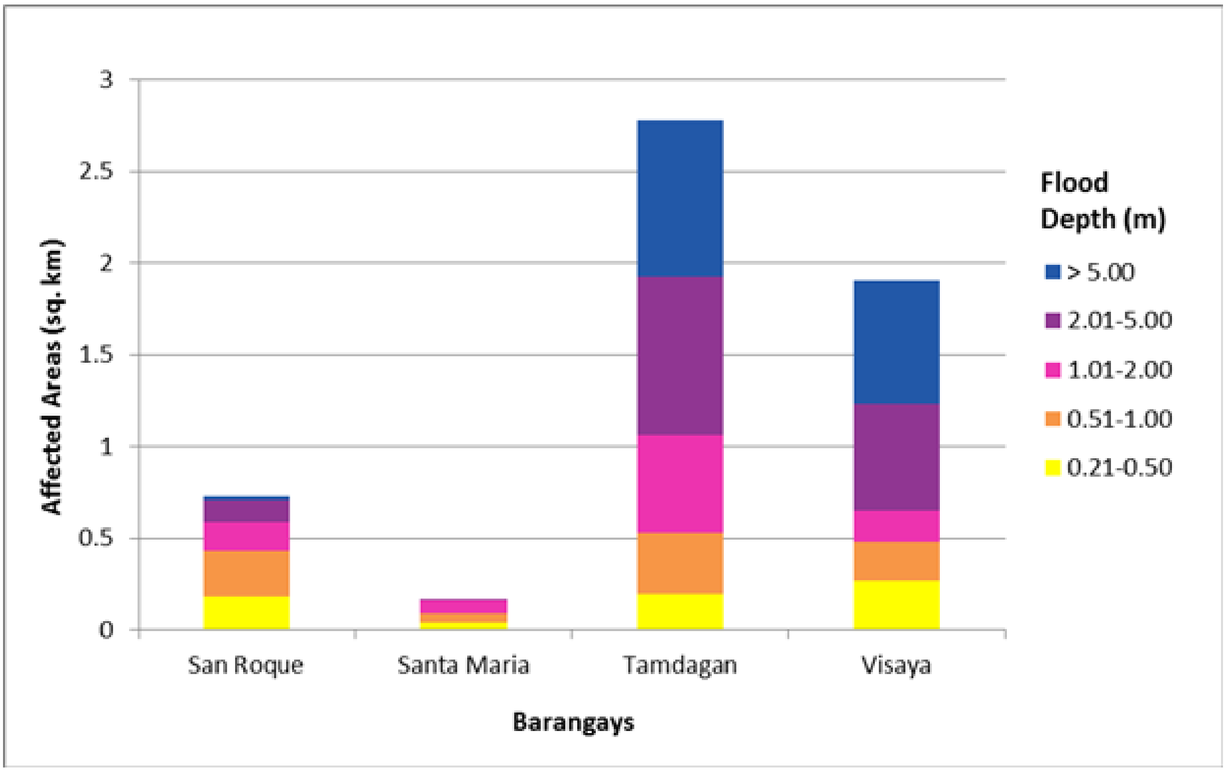


Figure 100. Affected Areas in Vintar, Ilocos Norte during 100-Year Rainfall Return Period.

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 gather secondary data regarding flood occurrence in the area within the major river system in the Philippines.

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

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

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.

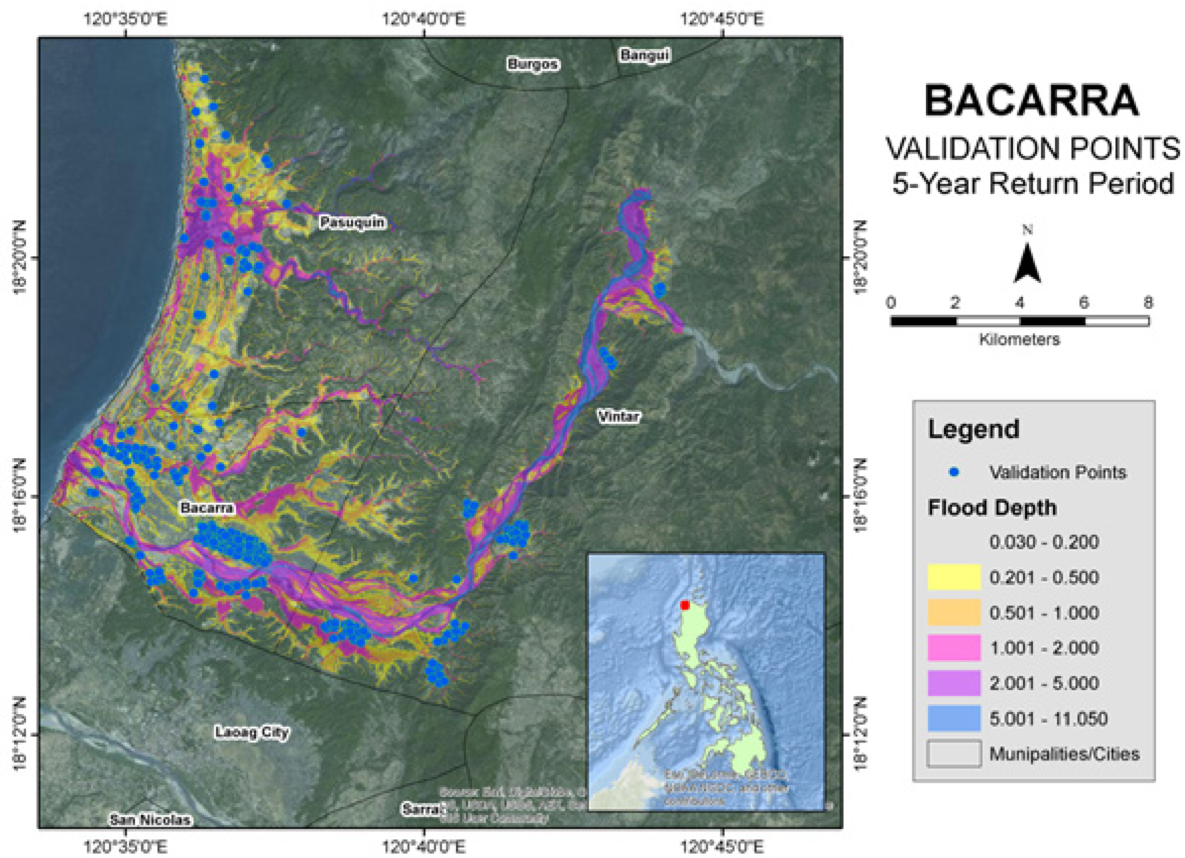


Figure 101. Validation Points for a 5-year Flood Depth Map of the Bacarra Floodplain.

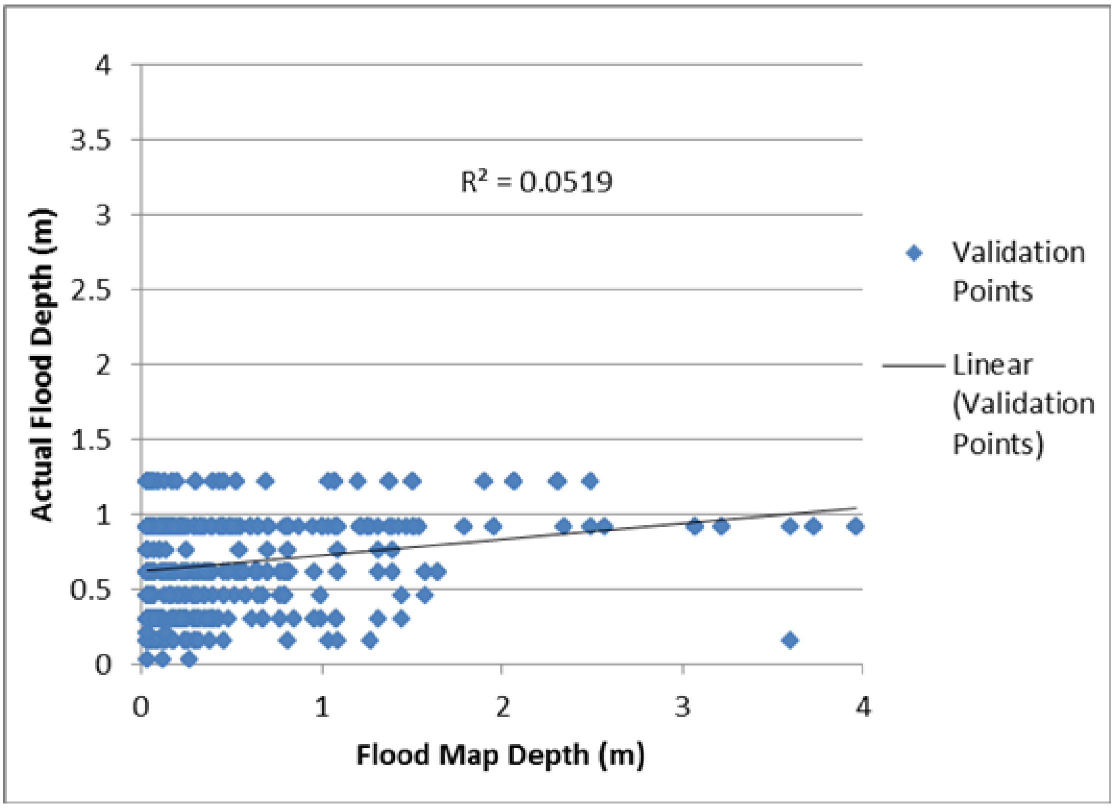


Figure 102. Flood Map depth versus Actual Flood Depth.

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

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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**	
Island: **LUZON**	Order: **2nd**	Barangay: **POBLACION**
Municipality: **BATAC**		
	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

CIP/4701/12/09/814

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

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**		Barangay: **POBLACION**
Municipality: **BACARRA**		
	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

9902262014143419

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

G

9902192014140752

CERTIFICATION INTERNATIONAL ISO 9001:2008
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**		Barangay: **SAN NICOLAS (POB.)**
Municipality: **VINTAR**		
	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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www.namria.gov.ph

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

<table>
<tr><th>Data Acquisition Component Sub-Team</th><th>Designation</th><th>Name</th><th>Agency/ Affiliation</th></tr>
<tr><td>PHIL-LIDAR 1</td><td>Program Leader</td><td>ENRICO C. PARINGIT, D.ENG</td><td>UP-TCAGP</td></tr>
<tr><td rowspan="2">Data Acquisition Component Leader</td><td>Data Component Project Leader - I</td><td>ENGR. CZAR JAKIRI SARMIENTO</td><td>UP-TCAGP</td></tr>
<tr><td>Data Component Project Leader – I</td><td>ENGR. LOUIE P. BALICANTA</td><td>UP-TCAGP</td></tr>
<tr><td rowspan="3">Survey Supervisor</td><td>Supervising Science Research Specialist (SSRS)</td><td>ENGR. LOVELYN ASUNCION</td><td>UP-TCAGP</td></tr>
<tr><td rowspan="2">Supervising Science Research Specialist (Supervising SRS)</td><td>LOVELY GRACIA ACUÑA</td><td>UP-TCAGP</td></tr>
<tr><td>LOVELYN ASUNCION</td><td>UP-TCAGP</td></tr>
<tr><td colspan="4">FIELD TEAM</td></tr>
<tr><td rowspan="2">LiDAR Operation</td><td>Senior Science Research Associate (SSRS)</td><td>AUBREY PAGADOR</td><td>UP-TCAGP</td></tr>
<tr><td>RA</td><td>MA. VERLINA TONGA
MARY CATHERINE ELIZABETH BALIGUAS</td><td>UP-TCAGP</td></tr>
<tr><td>Ground Survey, Data Download and Transfer</td><td>RA</td><td>ENGR. IRO NIEL ROXAS</td><td>UP-TCAGP</td></tr>
<tr><td rowspan="3">LiDAR Operation</td><td>Airborne Security</td><td>DIOSCORO SOBERANO</td><td>PHILIPPINE AIR FORCE (PAF)</td></tr>
<tr><td rowspan="2">Pilot</td><td>CAPT. RAUL CZ SAMAR</td><td>ASIAN AEROSPACE CORPORATION (AAC)</td></tr>
<tr><td>CAPT. CESAR SHERWIN ALFONSO III</td><td>AAC</td></tr>
</table>

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	28.5GB	NA	8.39GB	NA	692KB	1KB	1KB	4/71KB	6KB	Z:\Airborne_Raw\7103G

Received from

Name C. JOAQUIN

Position RA

Signature

Received by

Name JOIDA PRIETO

Position SSRS

Signature

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

DATA TRANSFER SHEET ILOCOS

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	2BLK05G5+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	2BLK05F5+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 CRUZ(?)

Position RA

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	2BLK05DS+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~~ 15	242	143	na	na	7.76	na	11.5	1KB	1KB	6	12	Z:\DAC\RAW DATA

Received from

Name [illegible]
Position [illegible]
Signature [illegible]

Received by

Name AC Bongat
Position SSRS
Signature [illegible] 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.: 7085GC

1 LiDAR Operator: MCE Baligod	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 CASI)

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Aubrey Matira	Sgt Dioscoro Solano PAF	R. SAMAR II	CATHERINE BALIGUAS
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	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.: 7087G

1 LiDAR Operator: MCE Baligvas	2 ALTM Model: Gemini	3 Mission Name: 2BLK05G5F053	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9322
7 Pilot: R. Samar II	8 Co-Pilot: C. Alfonso III	9 Route: Laoag - BLK 05G - Laoag			
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, completed area of BLK05G and surveyed 8 lines of BLK05F (without CASI)

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Aubrey Matira	Sg Dostano Sobejano PAF	R. Samar II	Catherine Baligvas
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.: 7088GC

1 LiDAR Operator: MCE Baliguas	2 ALTM Model: Gemini	3 Mission Name: 2BLK05FSE054A	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 – BLK5 – RPLI			
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 CASI).

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Aubrey Matira	SSg Dioscoro Sotomayor PAF	R. Samar II	Catherine Baliguas
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 Tongga	2 ALTM Model: Gemini	3 Mission Name: 2BLK05L055A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9322
7 Pilot: R. Samaa 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:

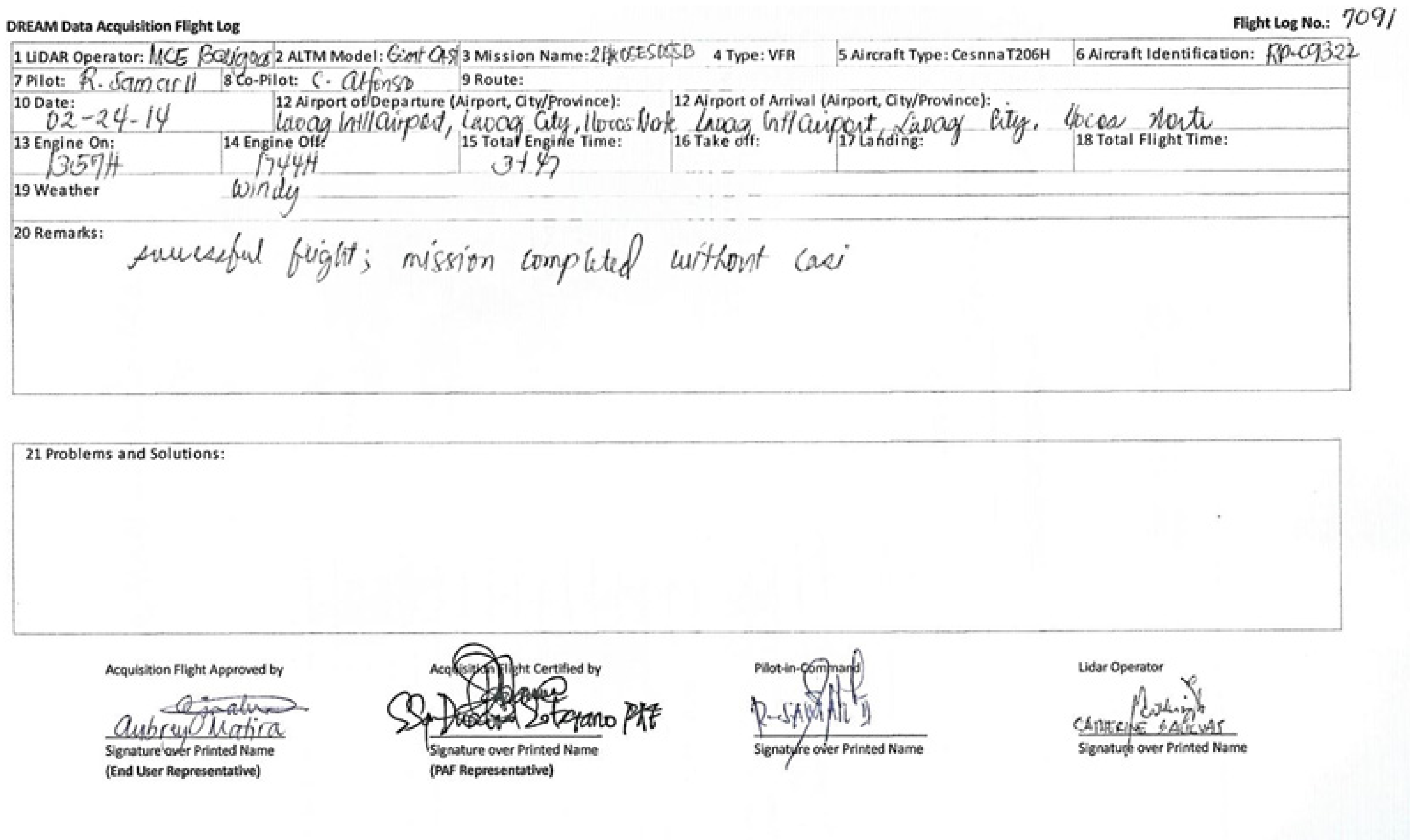
Successful flight; mission completed without CAS;

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Aubrey Matira	Sgt Pasco Zobayan PAF	R. Samaa II	MVE Tongga
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	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 Baligod	2 ALTM Model: Gmt CAS	3 Mission Name: 2BKOSESO55B	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9322
7 Pilot: R. Samaril	8 Co-Pilot: C. Alfonso	9 Route:			
10 Date: 02-24-14	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: 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 cas

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Aubrey Matira	SSgt Dexter Soriano PAF	R. Samaril	Catherine Baligod
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

Figure A-6.5. Flight Log for Mission 7092G

6. Flight Log for 7092G Mission

DREAM Data Acquisition Flight Log

2BLK5DS056A D

Flight Log No.: 7092

1 LIDAR Operator: MCE Baliguas	2 ALTM Model: GEM	3 Mission Name: 2BLK05K056A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9322
7 Pilot: R. Samar II	8 Co-Pilot: C. Alfonso III	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: 0941H	14 Engine Off: 1322H	15 Total Engine Time: 3+41	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	partly cloudy				

20 Remarks:

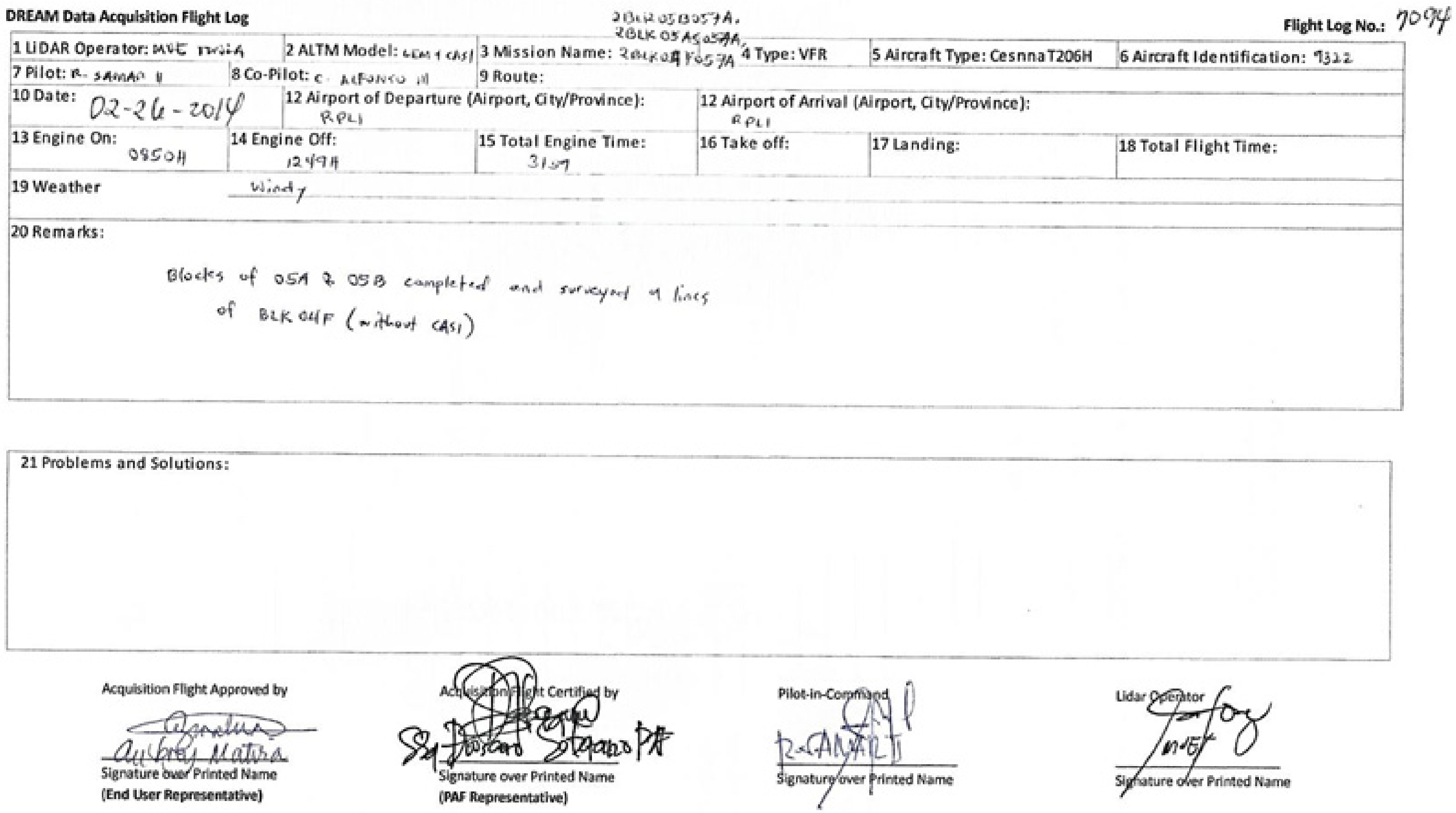
Mission completed (without ASI)

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Aubrey Matira		R. Samar II	Catherine Baliguas
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	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: MVE Ibañez	2 ALTM Model: Gem 4 CASI	3 Mission Name: 2BLK05B057A, 2BLK05A057A, 2BLK04F057A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9322
7 Pilot: R. Samar II	8 Co-Pilot: C. Alfonso III	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 9 lines of BLK 04F (without CASI)

21 Problems and Solutions:

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

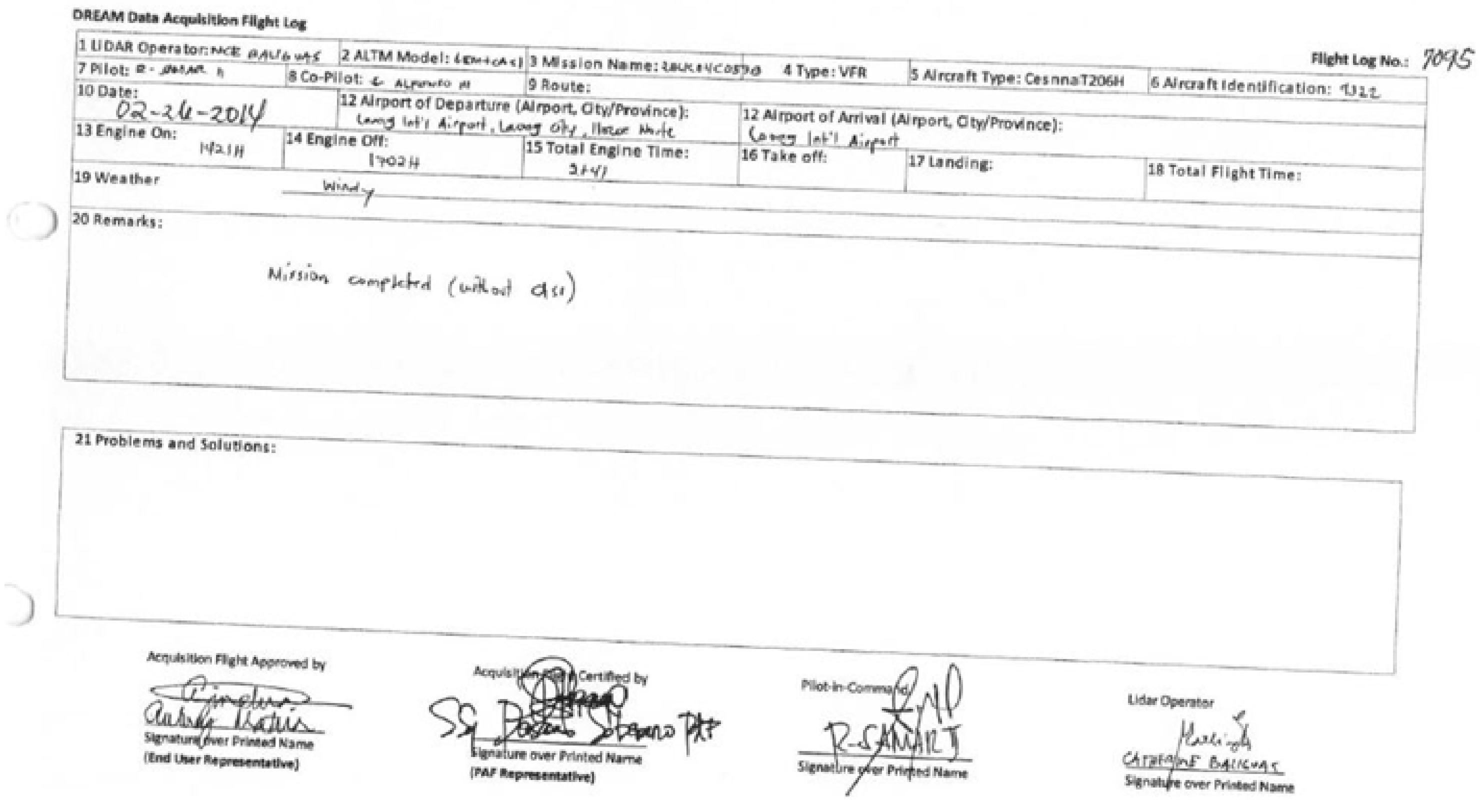
Acquisition Flight Certified by — Signature over Printed Name (PAF Representative)

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

Lidar Operator — 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: GEMINI	3 Mission Name: 2BLK4C0573	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9122
7 Pilot: R. SAMAR	8 Co-Pilot: E. ALFONSO	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
Signature over Printed Name
(End User Representative)

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

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

Lidar Operator
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: MCE BALICUAS	2 ALTM Model: GEMINI CASI	3 Mission Name: 2BLK64D041A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9122
7 Pilot: R. 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: 0760H	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 casi)

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 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 Fonda	2 ALTM Model: Gemini	3 Mission Name: 2CASITESTQ	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 CASI

21 Problems and Solutions:

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

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

Pilot-in-Command
Signature over Printed Name

Lidar Operator
Signature over Printed Name

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%

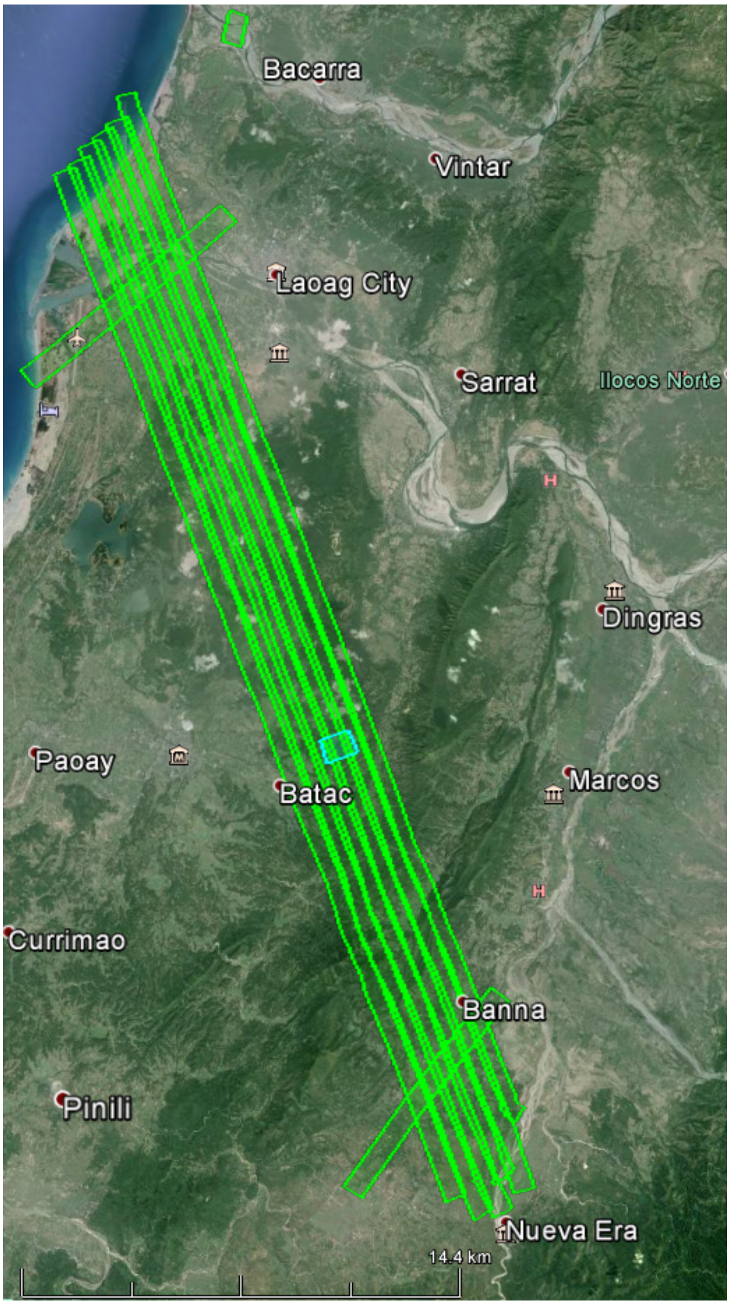


Figure A-7.1. Swath for Flight No. 7085G

Flight No. :	7087G
Area:	BLOCK 5
Mission Name:	2BLK05GS053B & 2BLK05F053B
Altitude:	1000m
PRF:	50 kHz
Lidar FOV:	20 deg
overlap:	30%

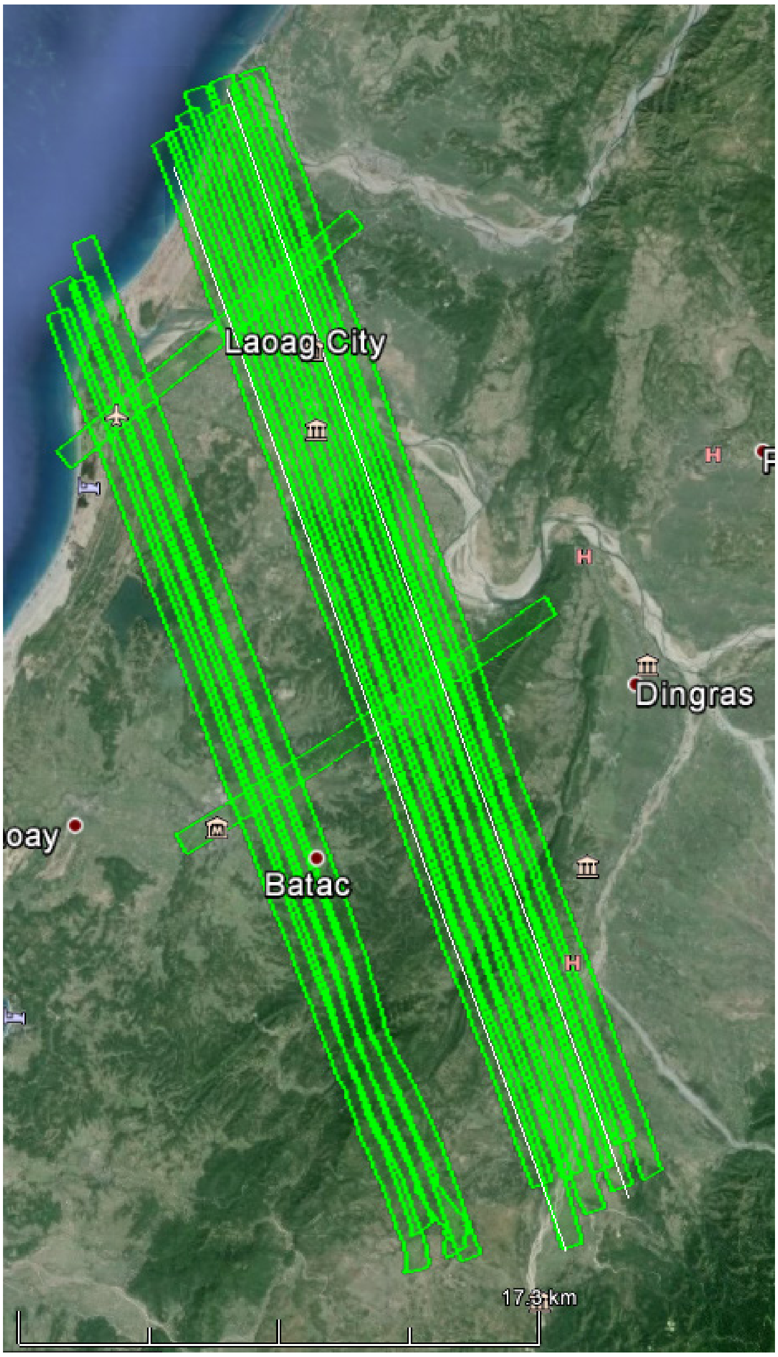


Figure A-7.2. Swath for Flight No. 7087G

Flight No. :	7088G
Area:	BLOCK 5
Mission Name:	2BLK05FS053B & 2BLK05E054A
Altitude:	1000m
PRF:	50 kHz
Lidar FOV:	20 deg
Overlap:	25%

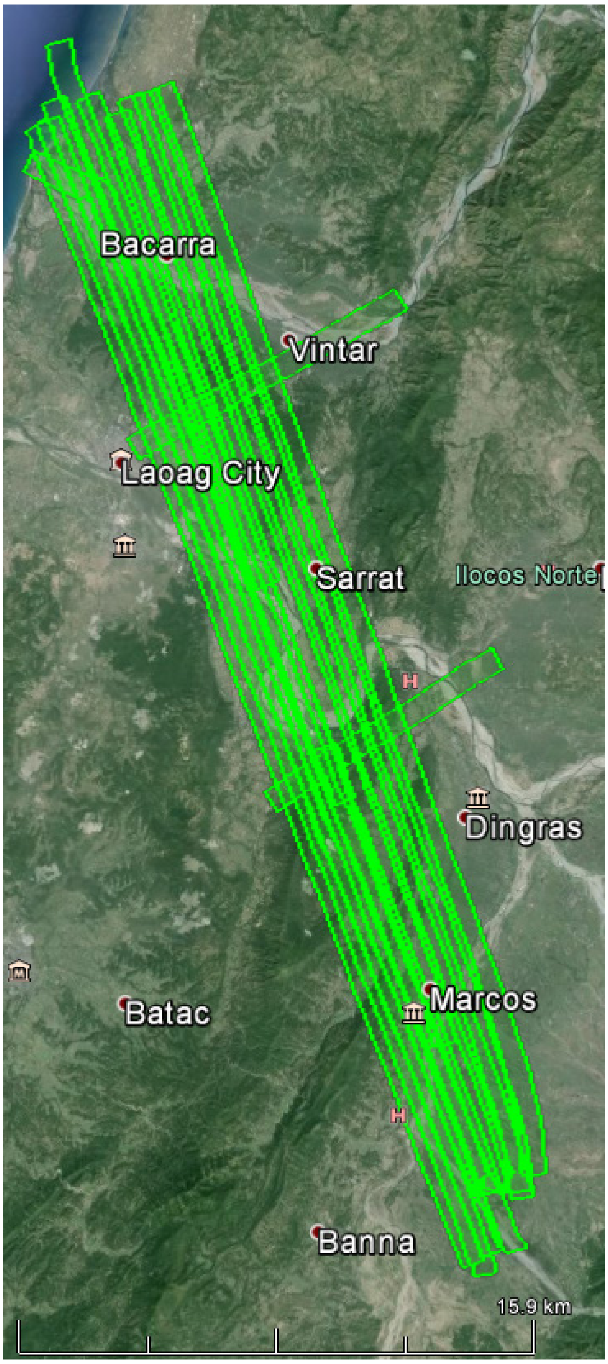


Figure A-7.3. Swath for Flight No. 7088G

Flight No. :	7091G
Area:	BLOCK 5
Mission Name:	2BLK05ES055B & 2BLK05D055B
	2BLK05ES055B
Altitude:	1000m
PRF:	50 kHz
Lidar FOV:	20 deg
Overlap:	25%

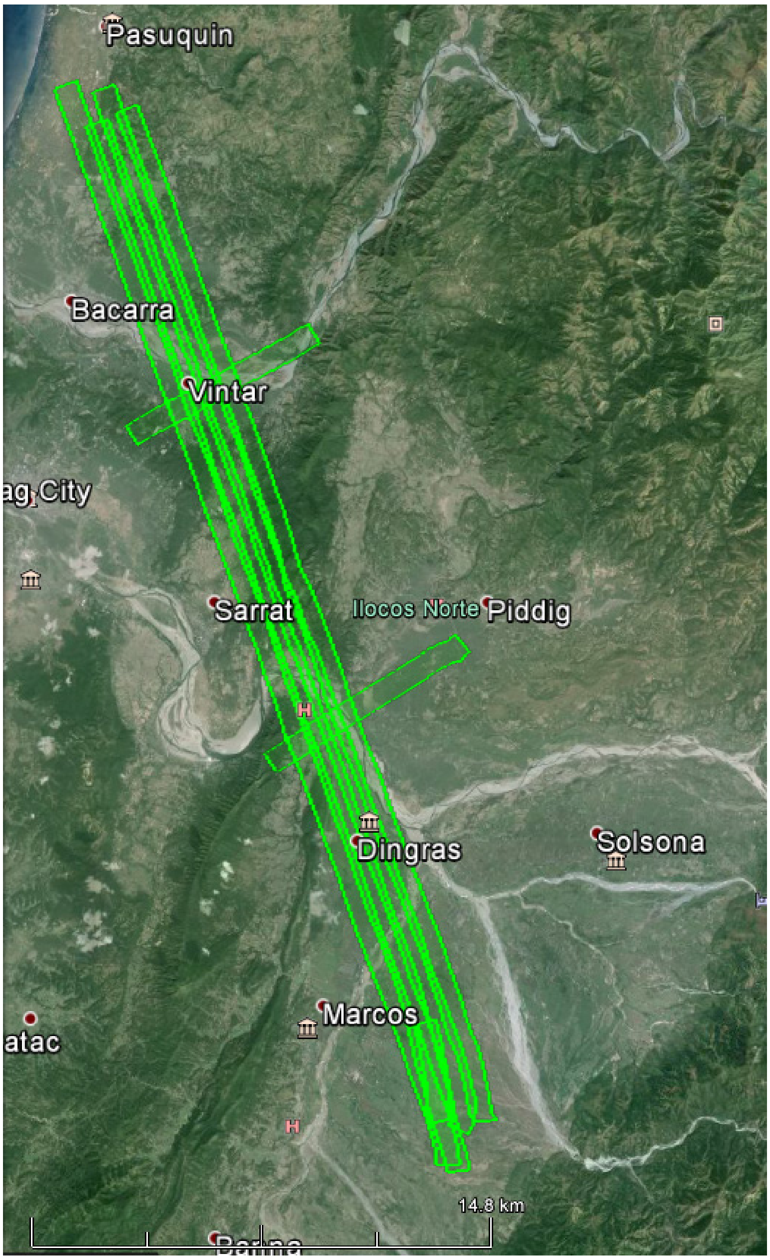


Figure A-7.4. Swath for Flight No. 7091G

Flight No. : 7092G

Area: BLOCK 5

Mission Name: 2BLK05DS056A & 2BLK05K056a

Altitude: 1400m

PRF: 50 kHz

Lidar FOV: 20 deg

Overlap: 30%

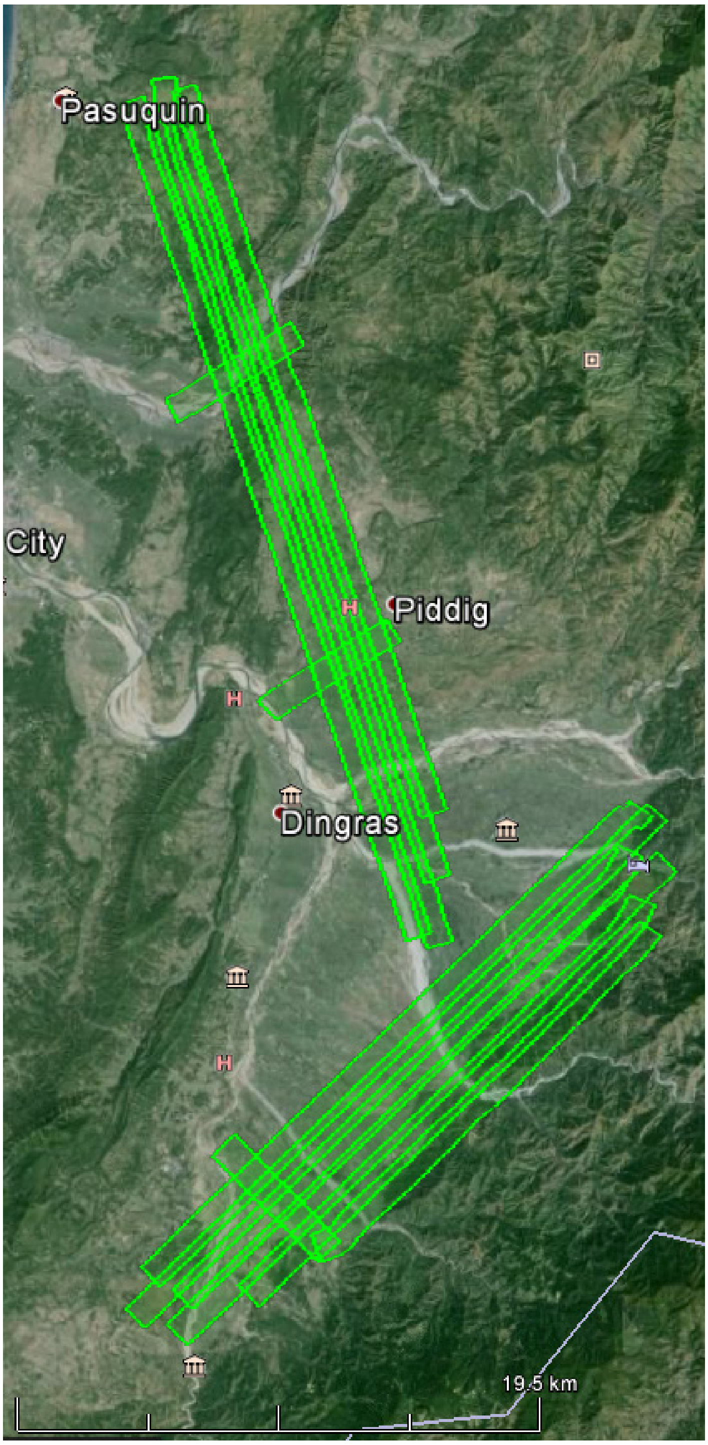


Figure A-7.5. Swath for Flight No. 7092G

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%

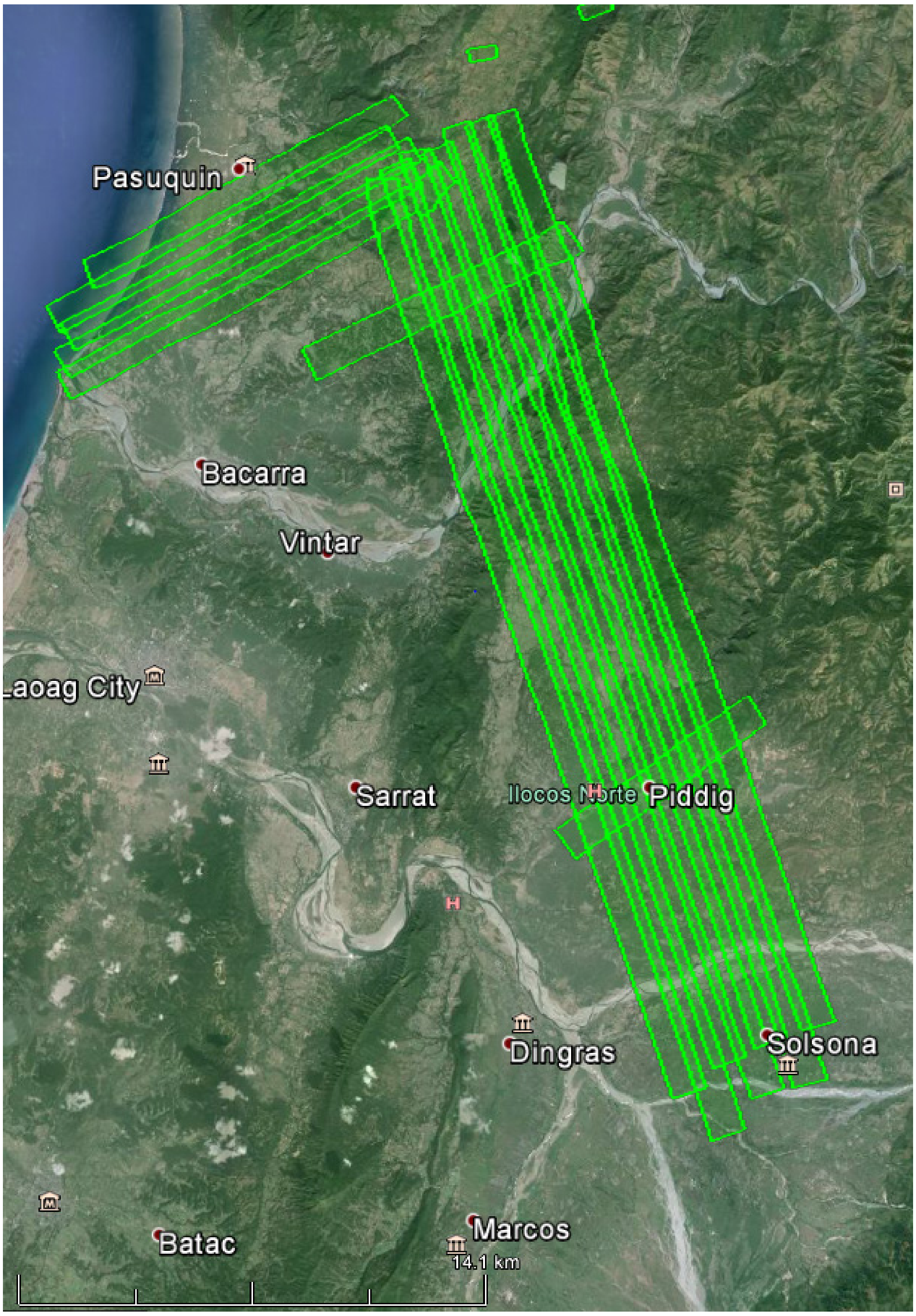


Figure A-7.6. Swath for Flight No. 7093G

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%

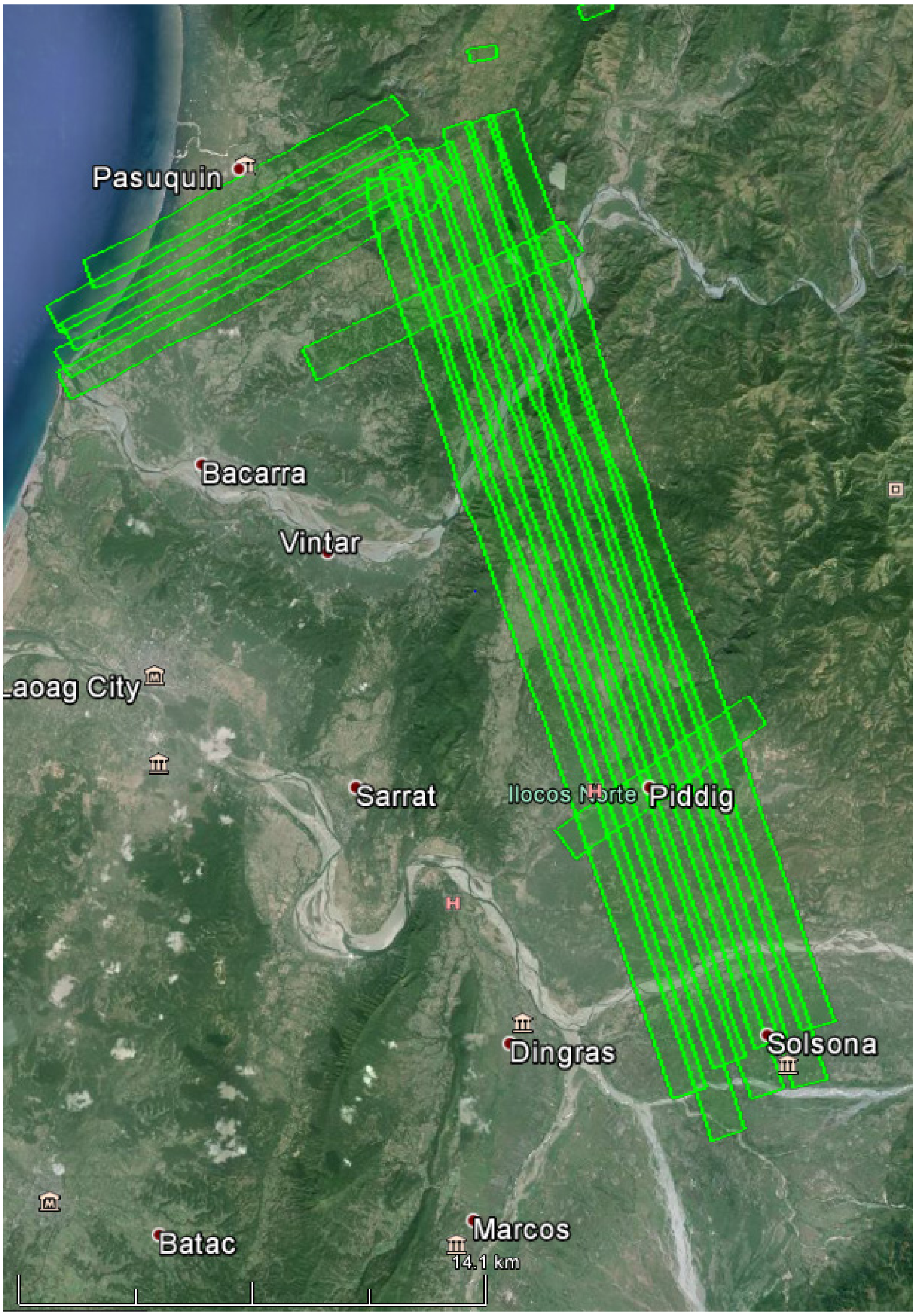


Figure A-7.7. Swath for Flight No. 7094G

Flight No. :	7095G
Area:	BLOCK 4
Mission Name:	2BLK04C057B
Altitude:	1200m
PRF:	50 kHz
Lidar FOV:	15 deg
Overlap:	30%

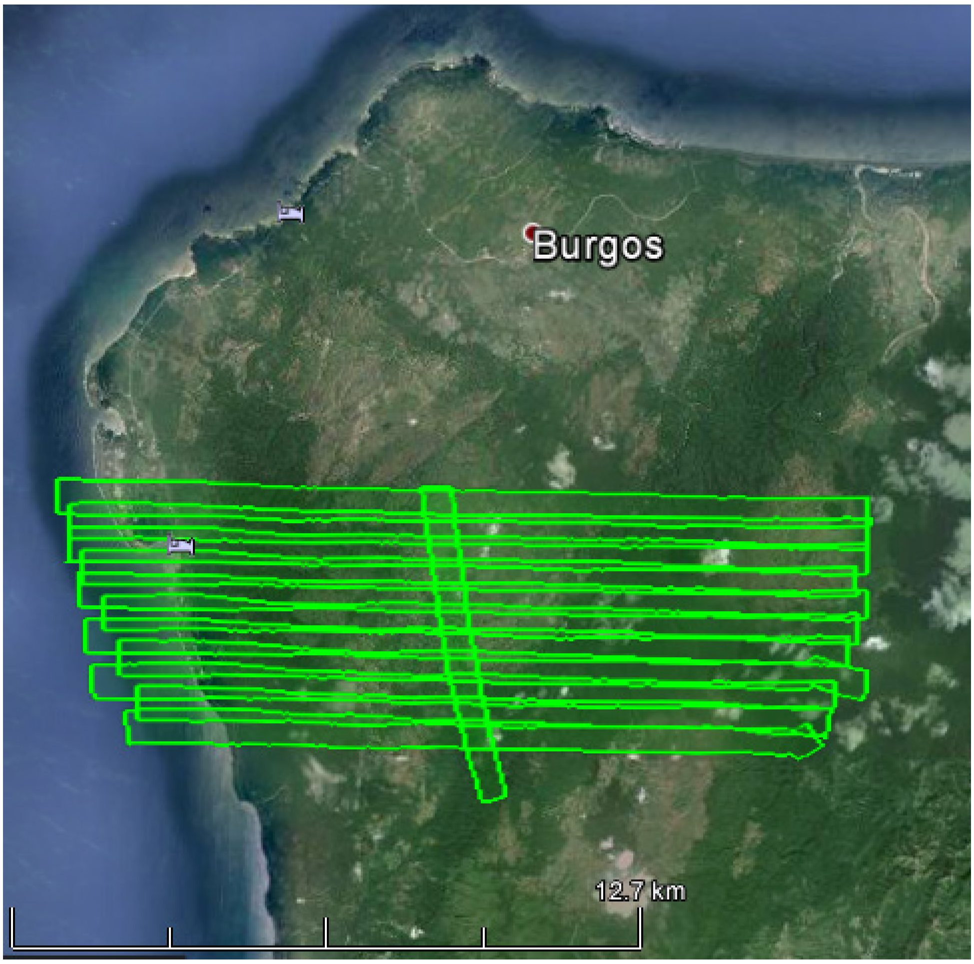


Figure A-7.8. Swath for Flight No. 7095G

Flight No. : 7097G

Area: BLOCK 4

Mission Name: 2BLK04A058B & 2BLK04B059B

Altitude: 1200m

PRF: 50 kHz

Lidar FOV: 15 deg

Overlap: 40%

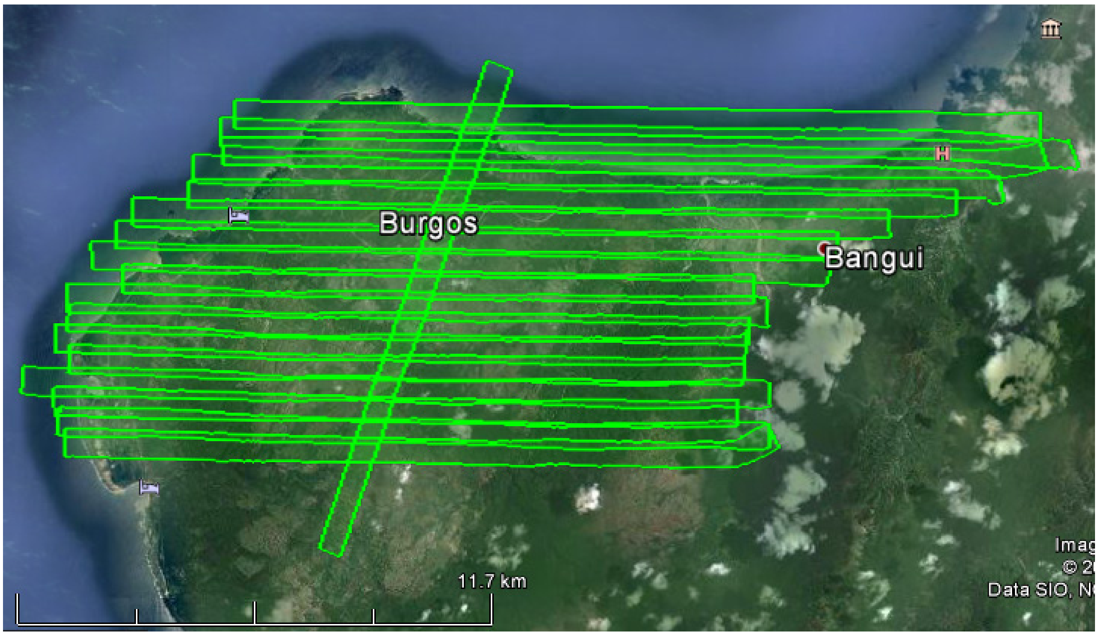


Figure A-7.9. Swath for Flight No. 7097G

Flight No. :	7102G
Area:	BLOCK 4
Mission Name:	2BLK04E061A & 2BLK04D061A
Altitude:	1700m
PRF:	50 kHz
Lidar FOV:	15 deg
Overlap:	40%

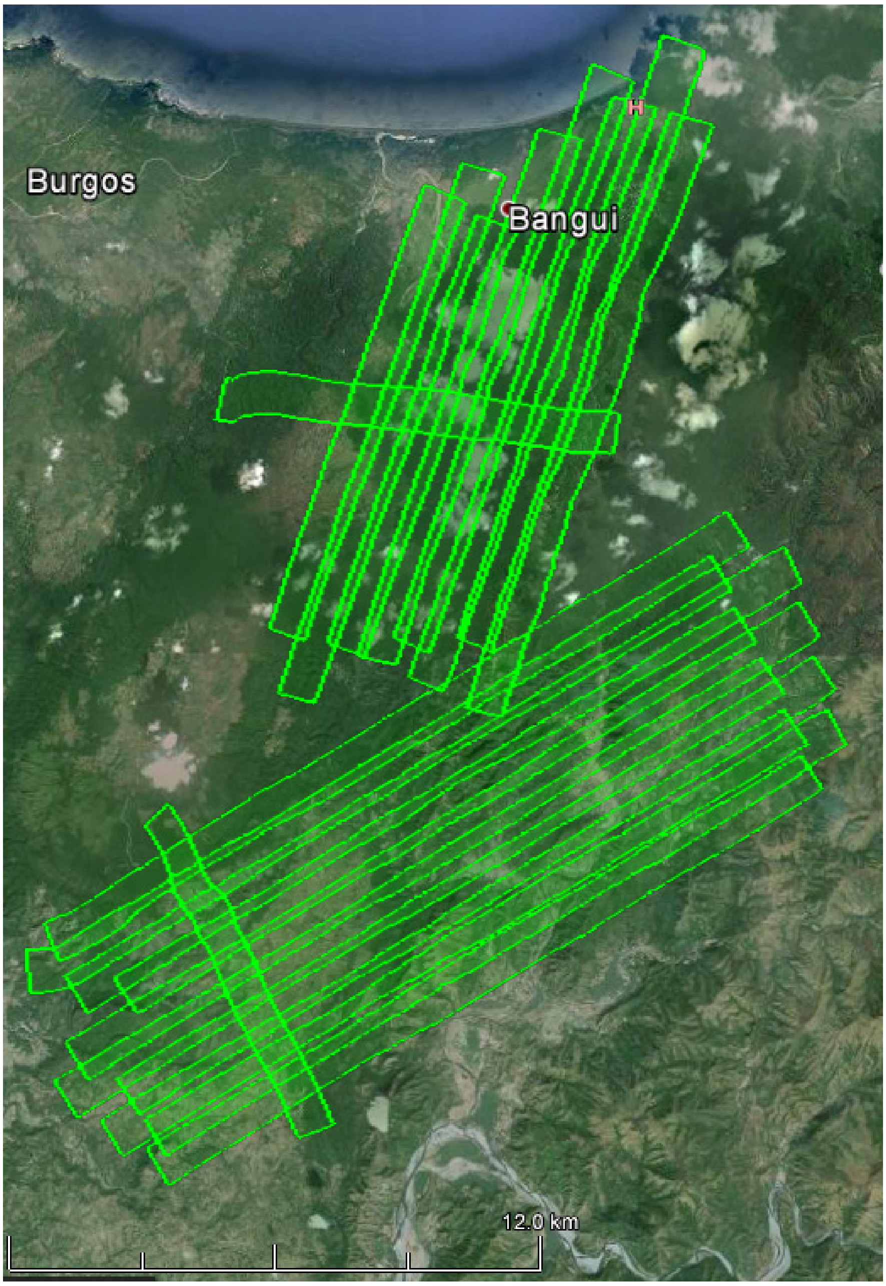


Figure A-7.10. Swath for Flight No. 7102G

Flight No. : 7103G

Area: BLOCK 5

Mission Name: 2CASITEST061B

Altitude: 1000m

PRF: 50 kHz

Lidar FOV: 20 deg

Overlap: 30%

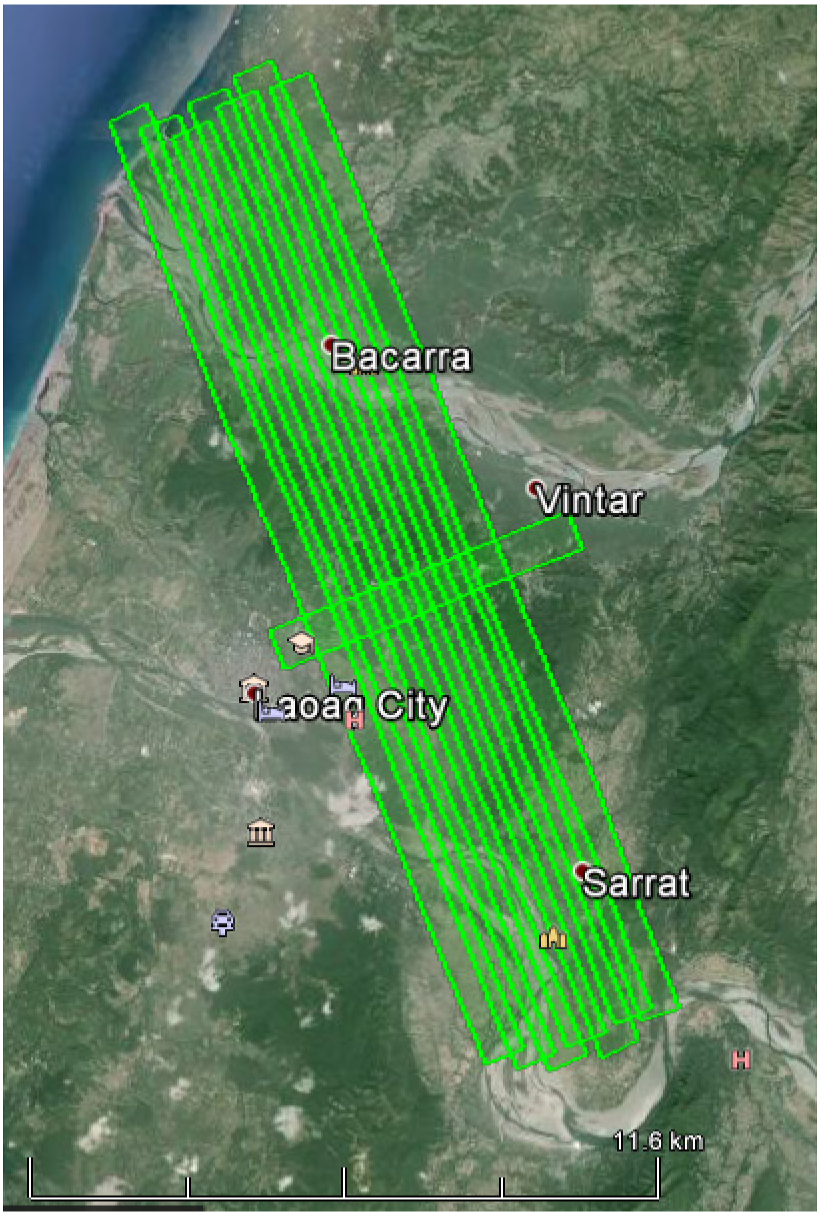


Figure A-7.11. Swath for Flight No. 7103G

Annex 8. Mission Summary Reports

Table A-8.1. Mission Summary Report for Mission Blk4AB

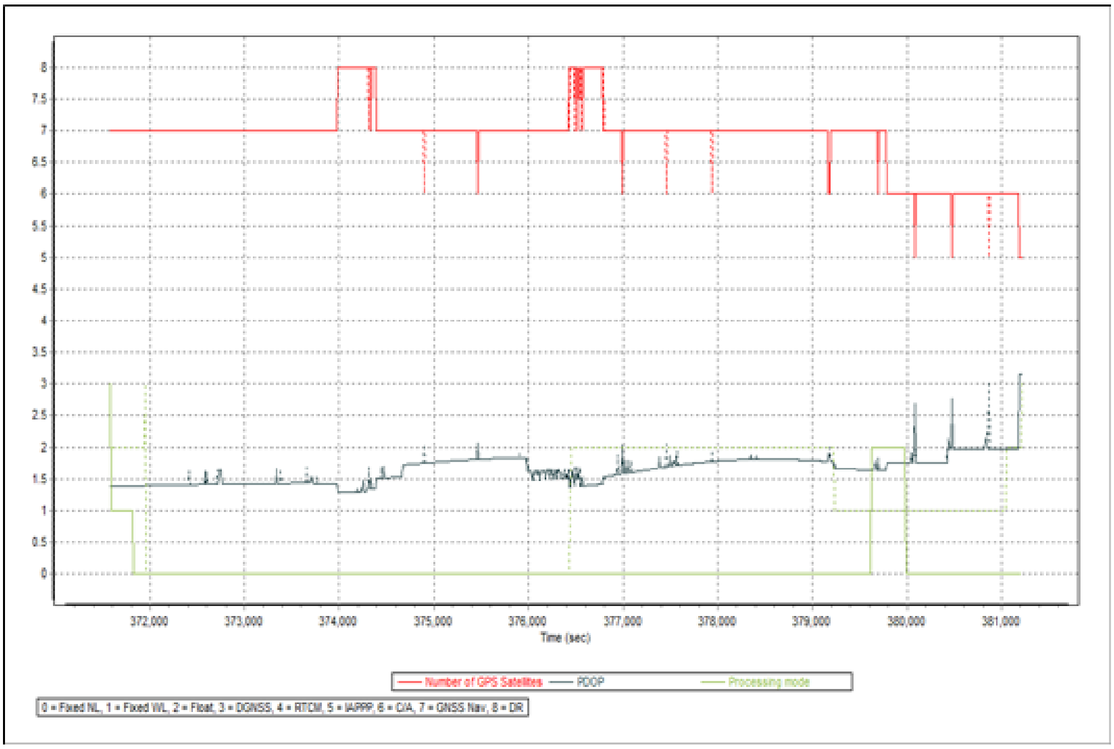


Figure A-8.1 Solution Status

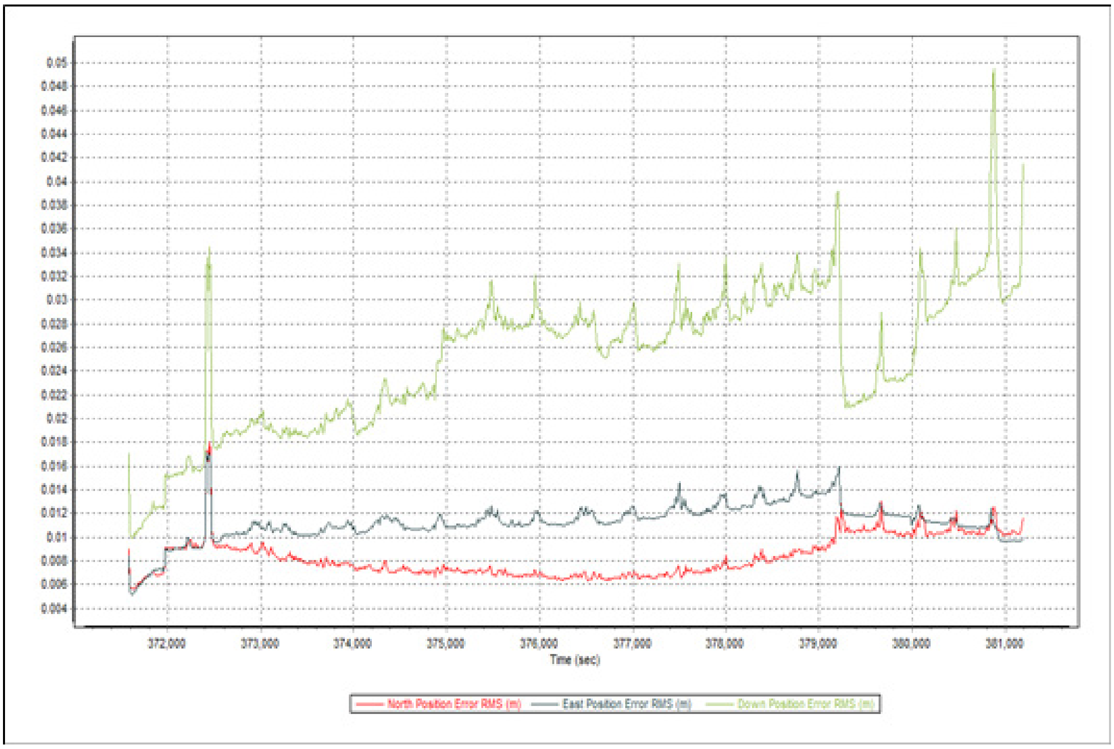


Figure A-8.2 Smoothed Performance Metric Parameters

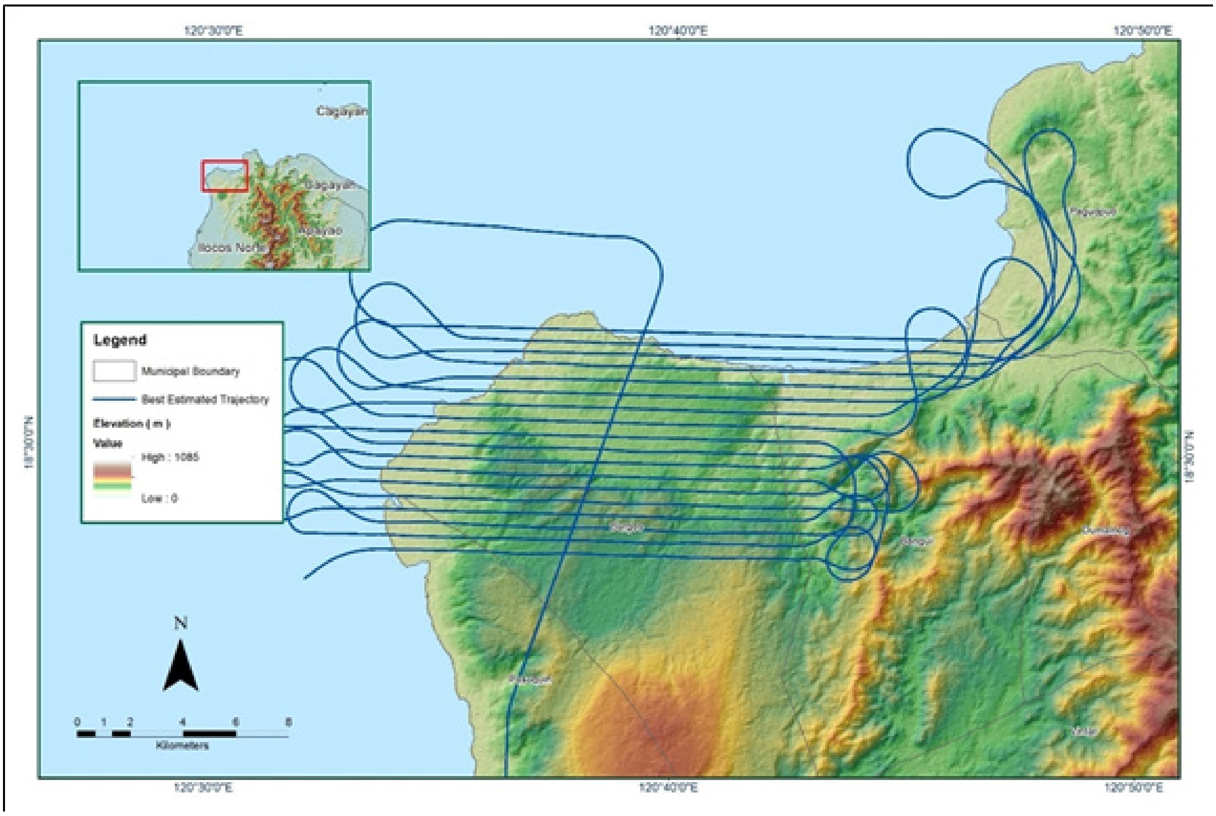


Figure A-8.3 Best Estimated Trajectory

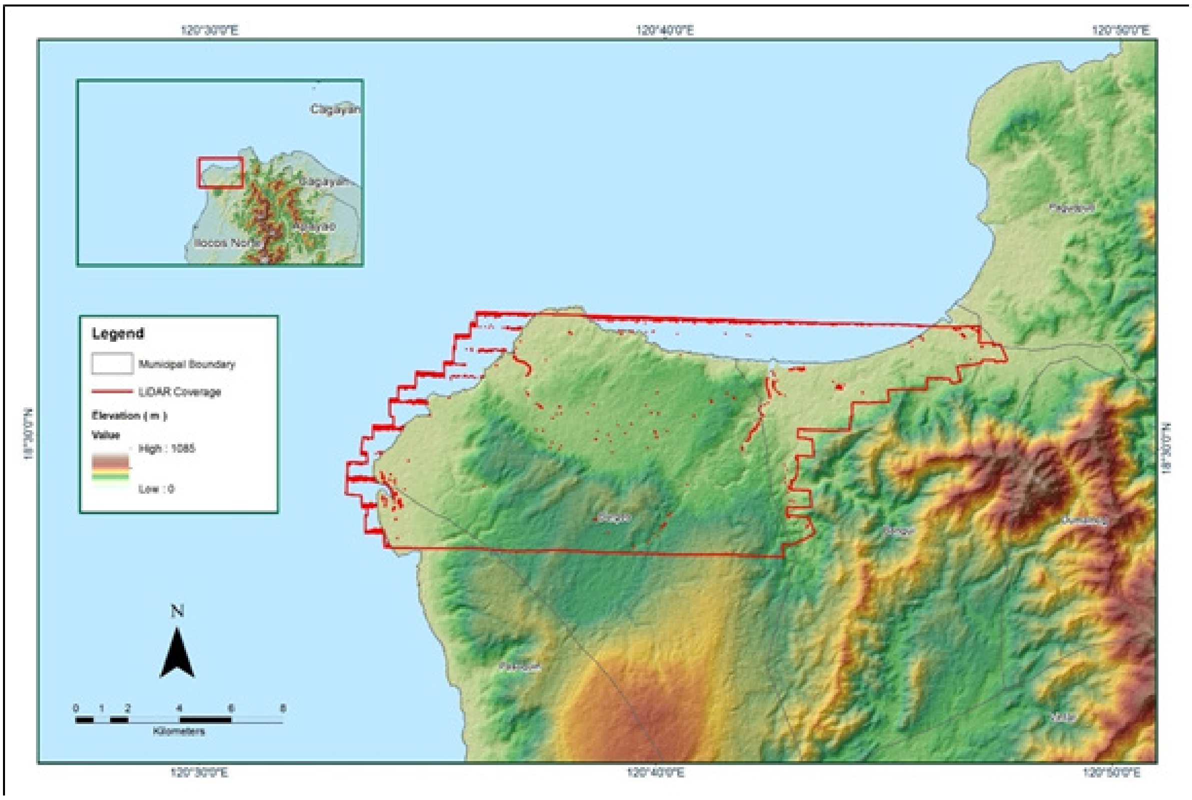


Figure A-8.4 Coverage of LiDAR data

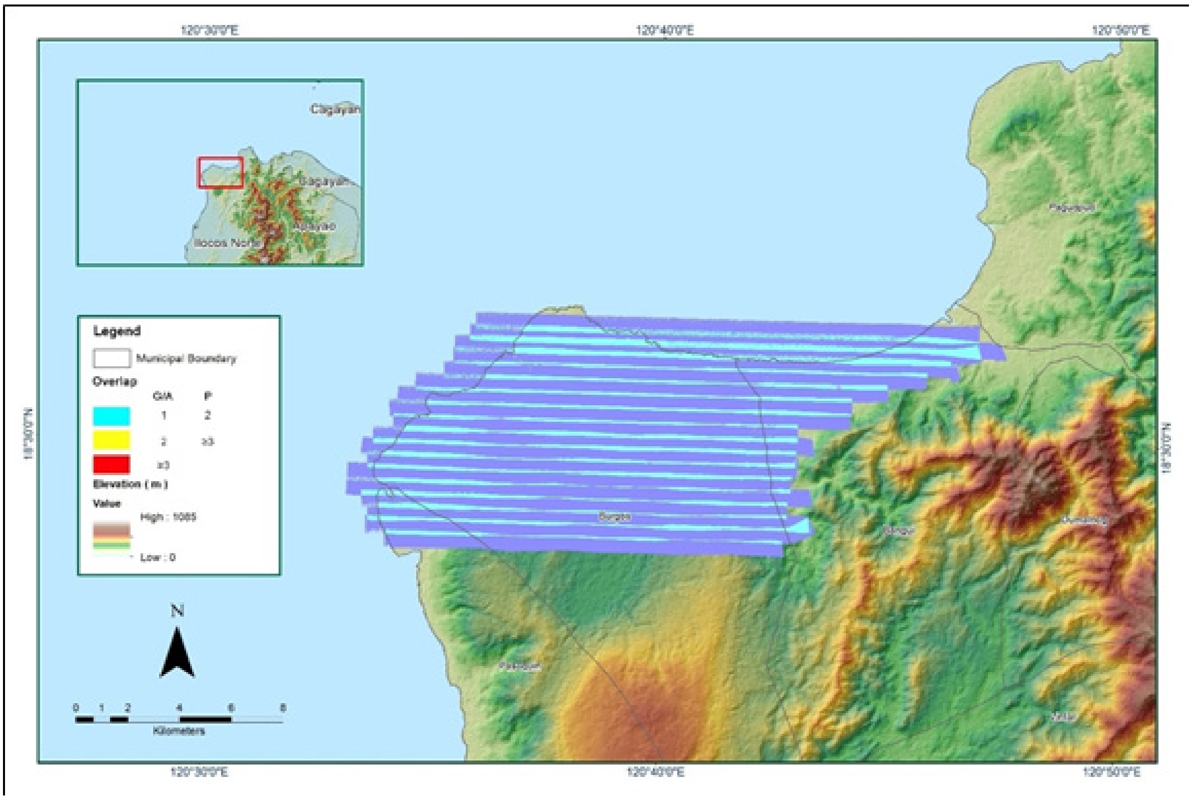


Figure A-8.5 Image of data overlap

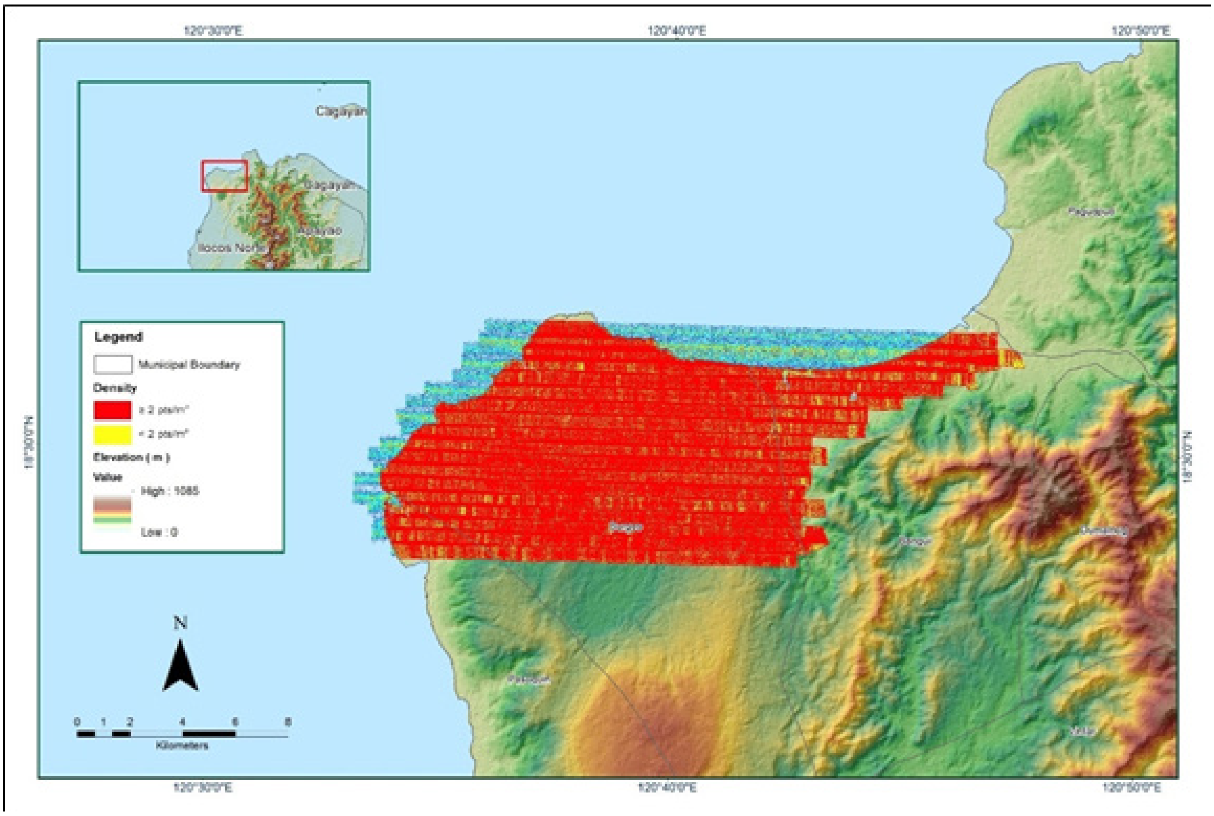


Figure A-8.6 Density map of merged LiDAR data

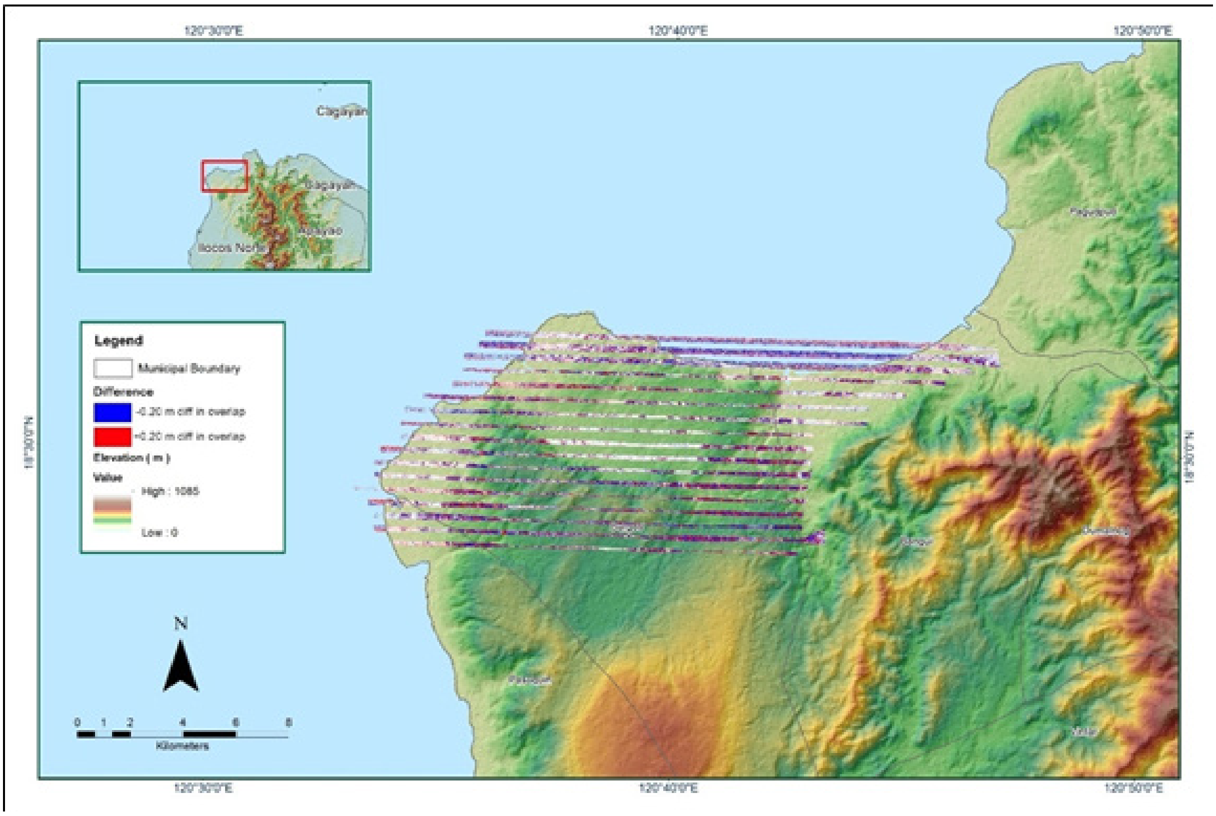


Figure A-8.7 Elevation difference between flight lines

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

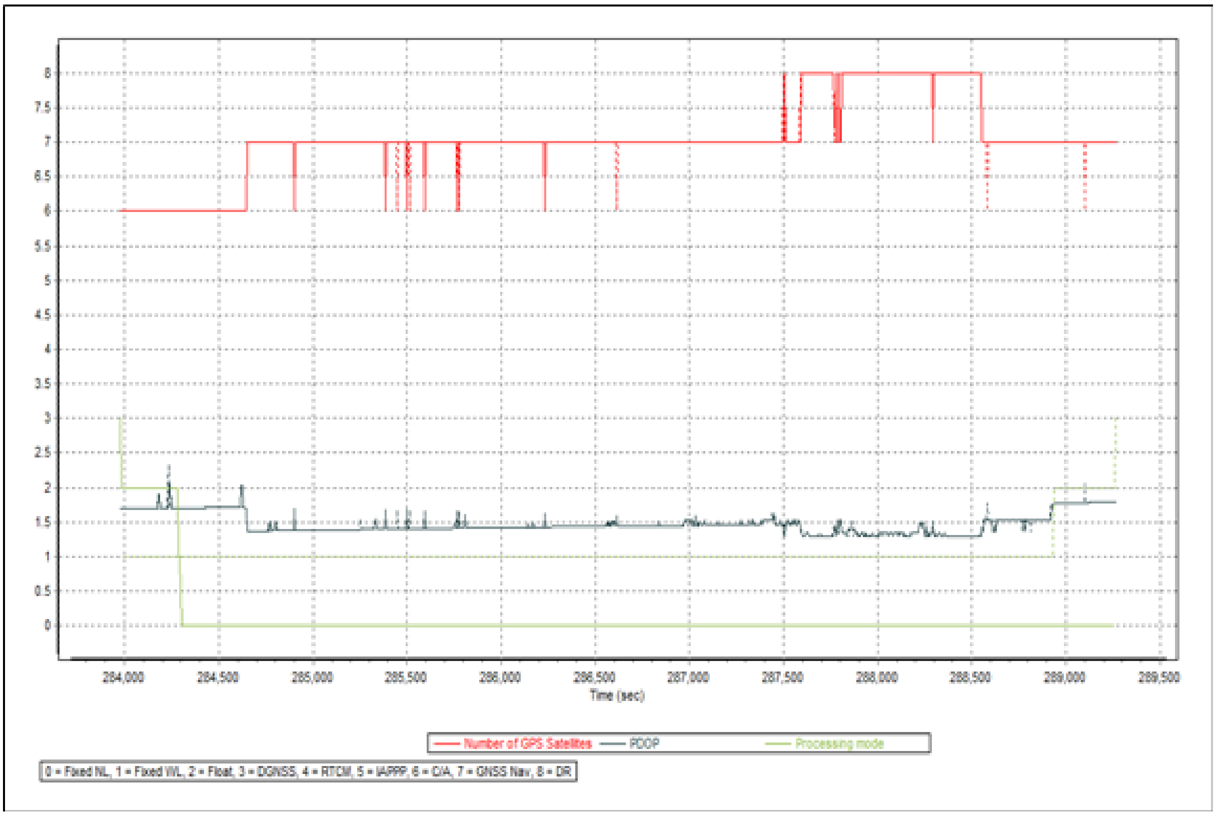


Figure A-8.8 Solution Status

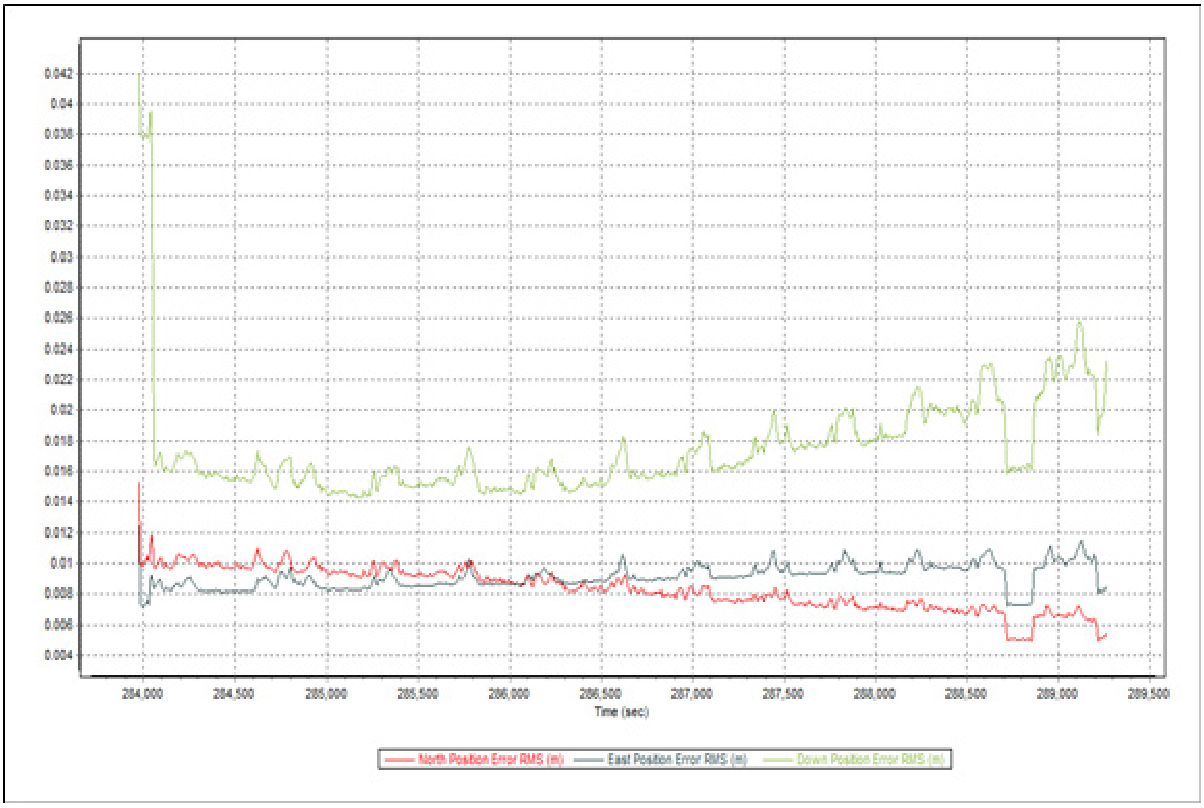


Figure A-8.9 Smoothed Performance Metric Parameters

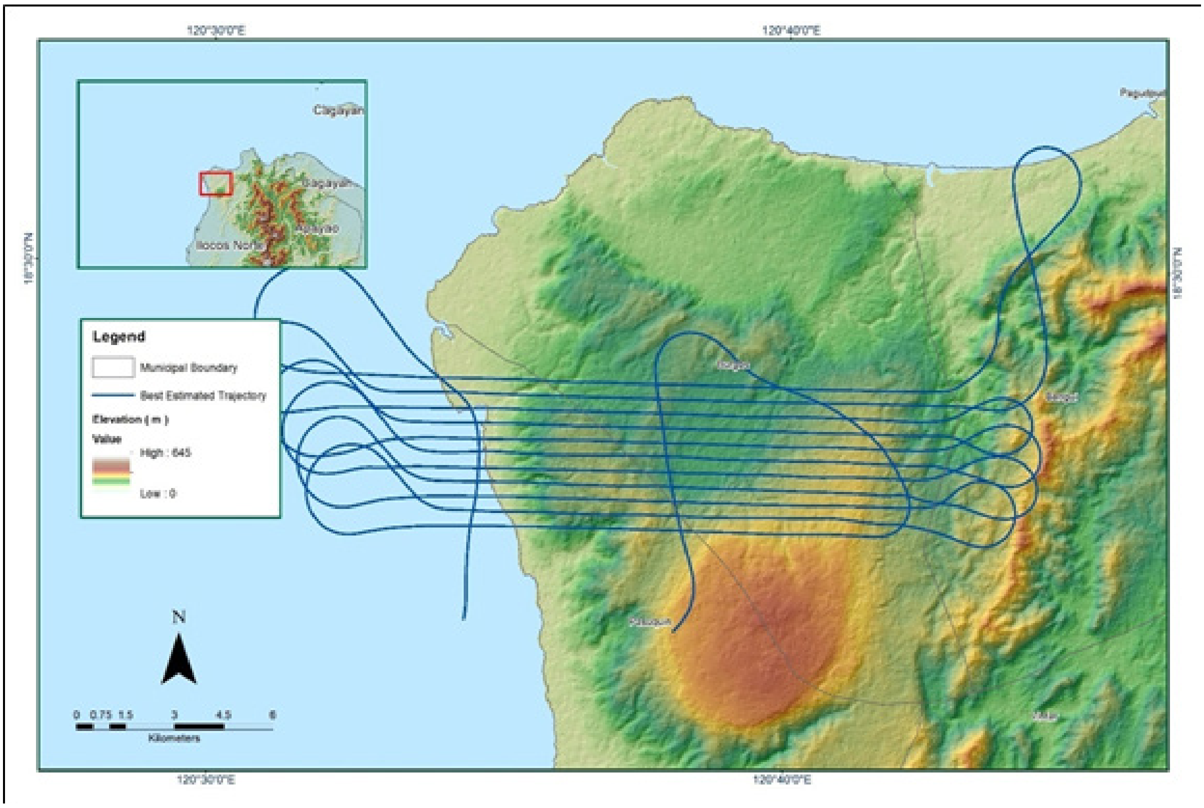


Figure A-8.10 Best Estimated Trajectory

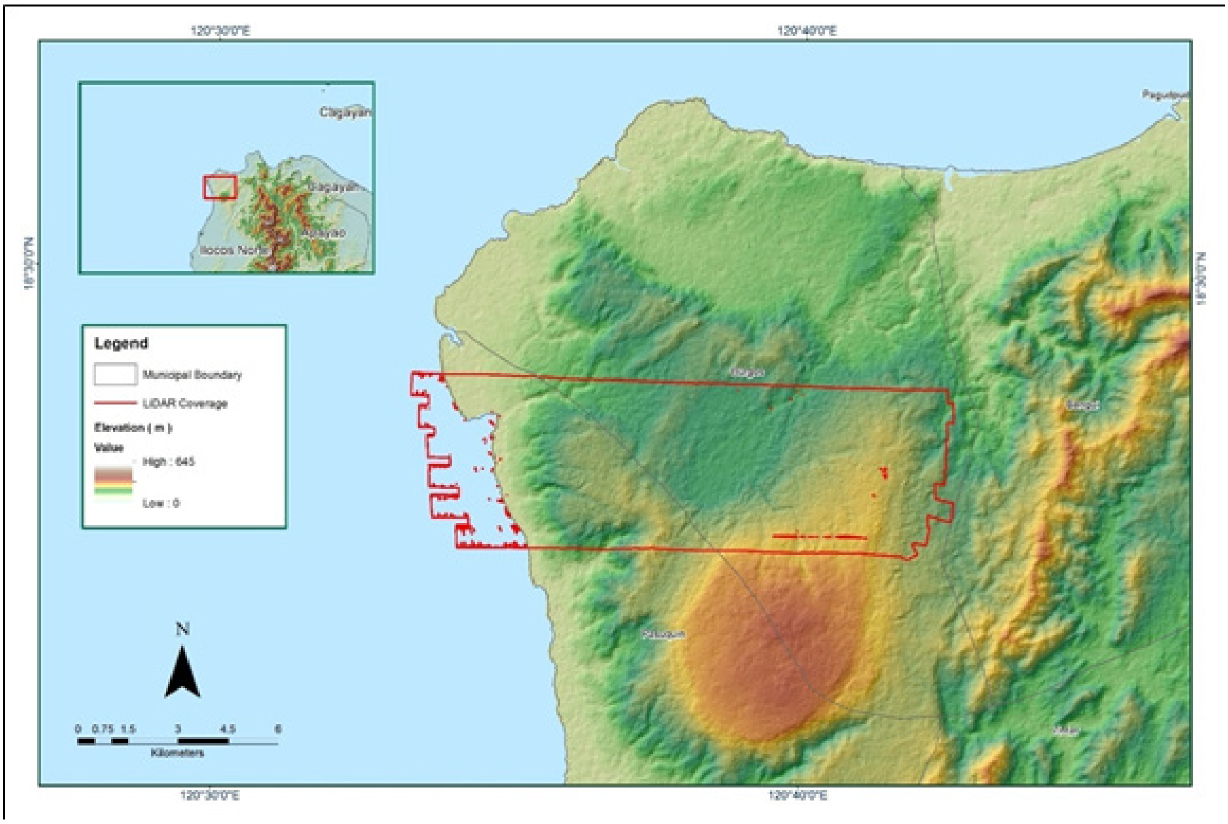


Figure A-8.11 Coverage of LiDAR data

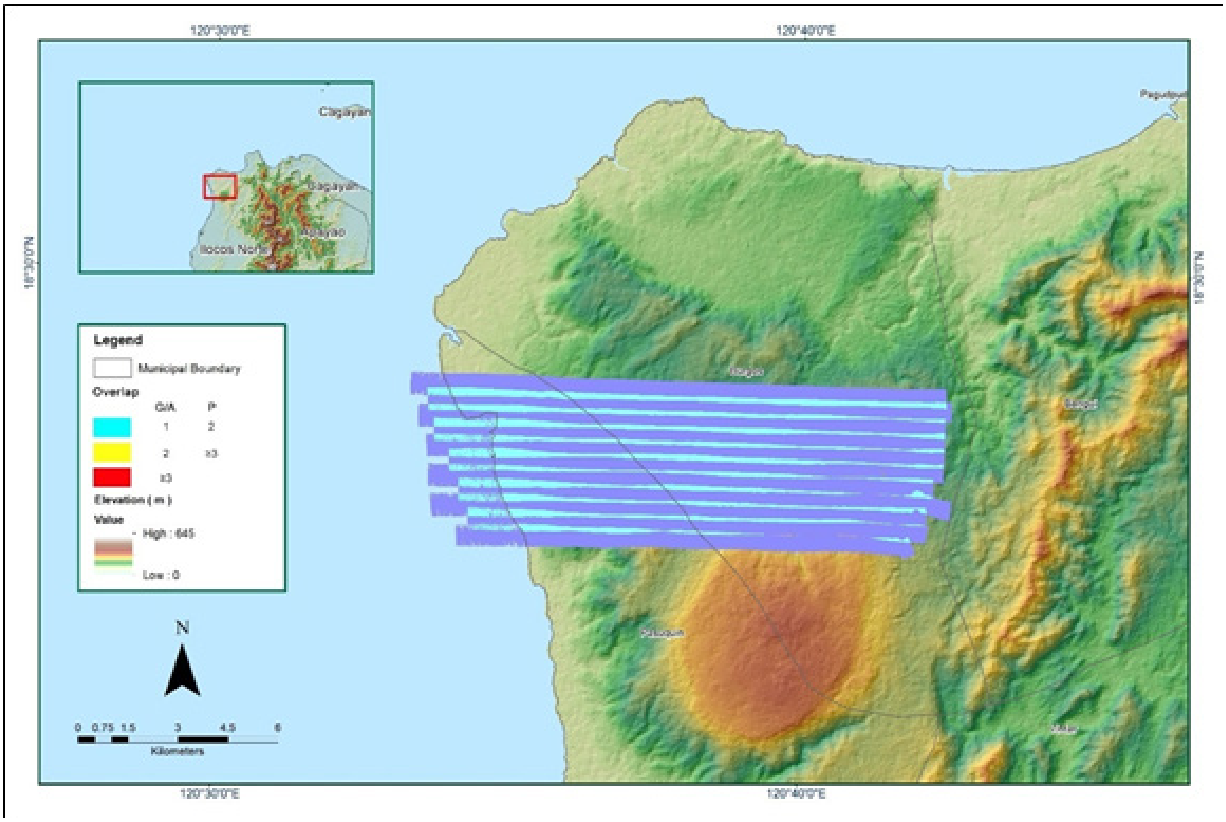


Figure A-8.12 Image of data overlap

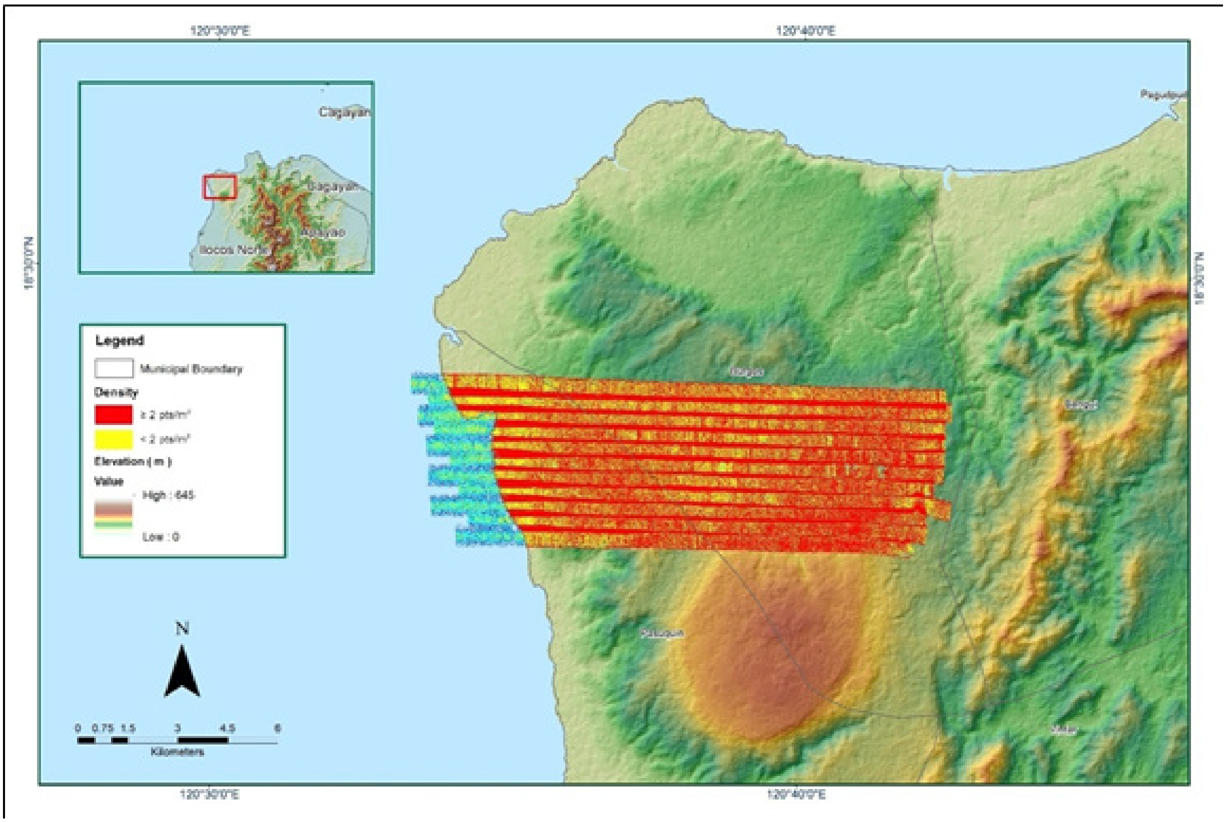


Figure A-8.13 Density map of merged LiDAR data

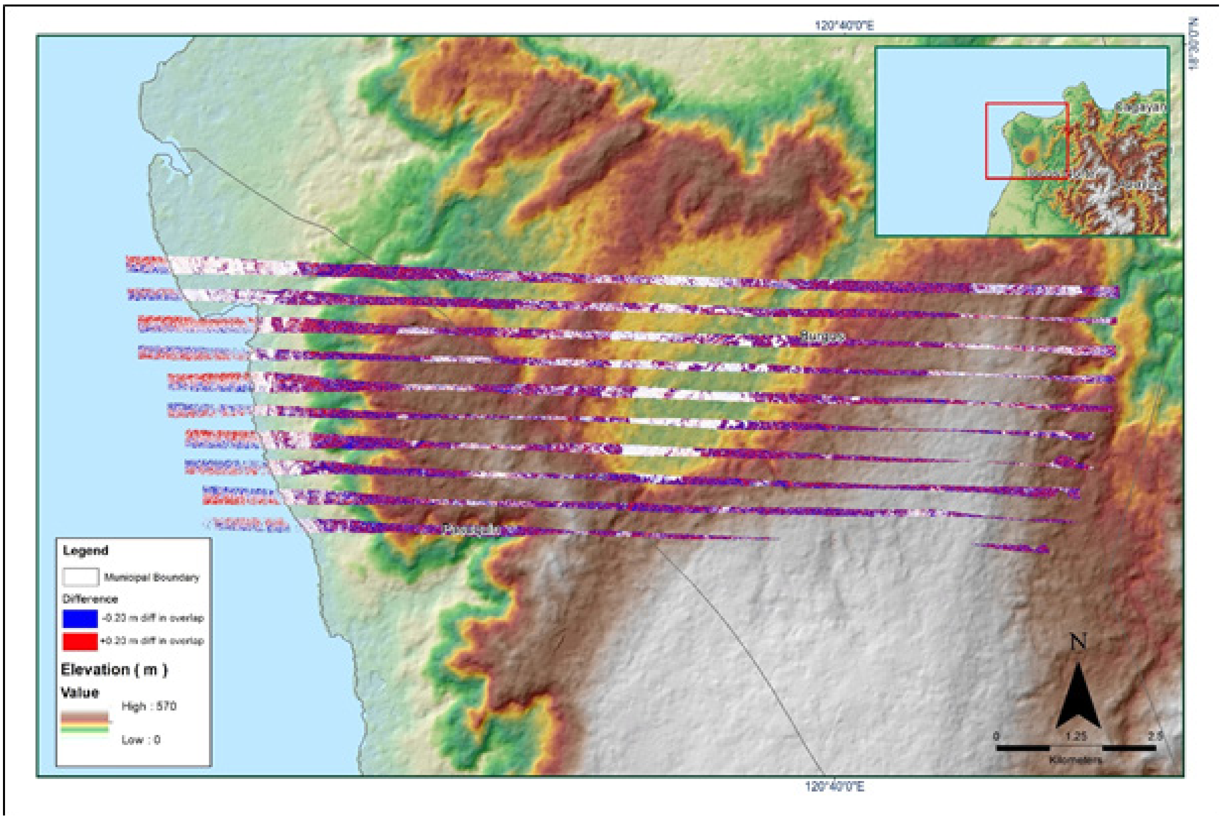


Figure A-8.14 Elevation difference between flight lines

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

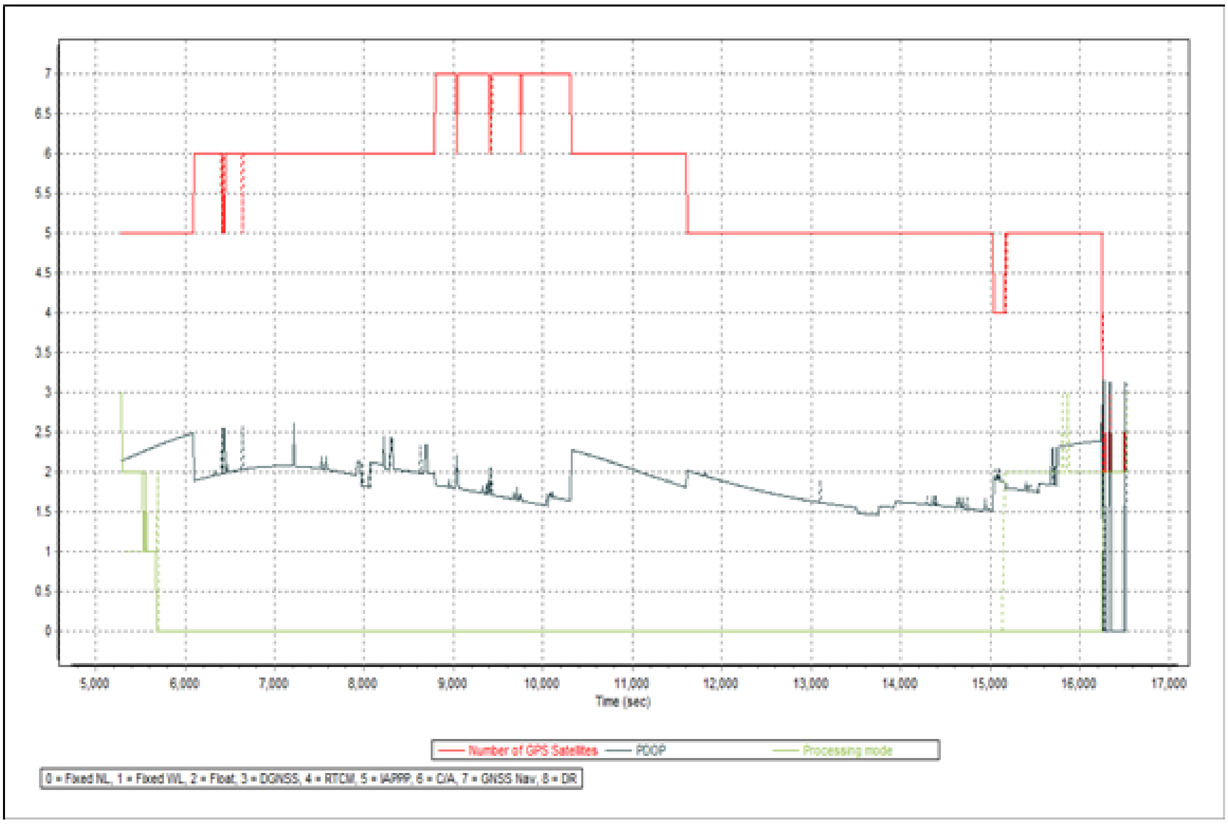


Figure A-8.15 Solution Status

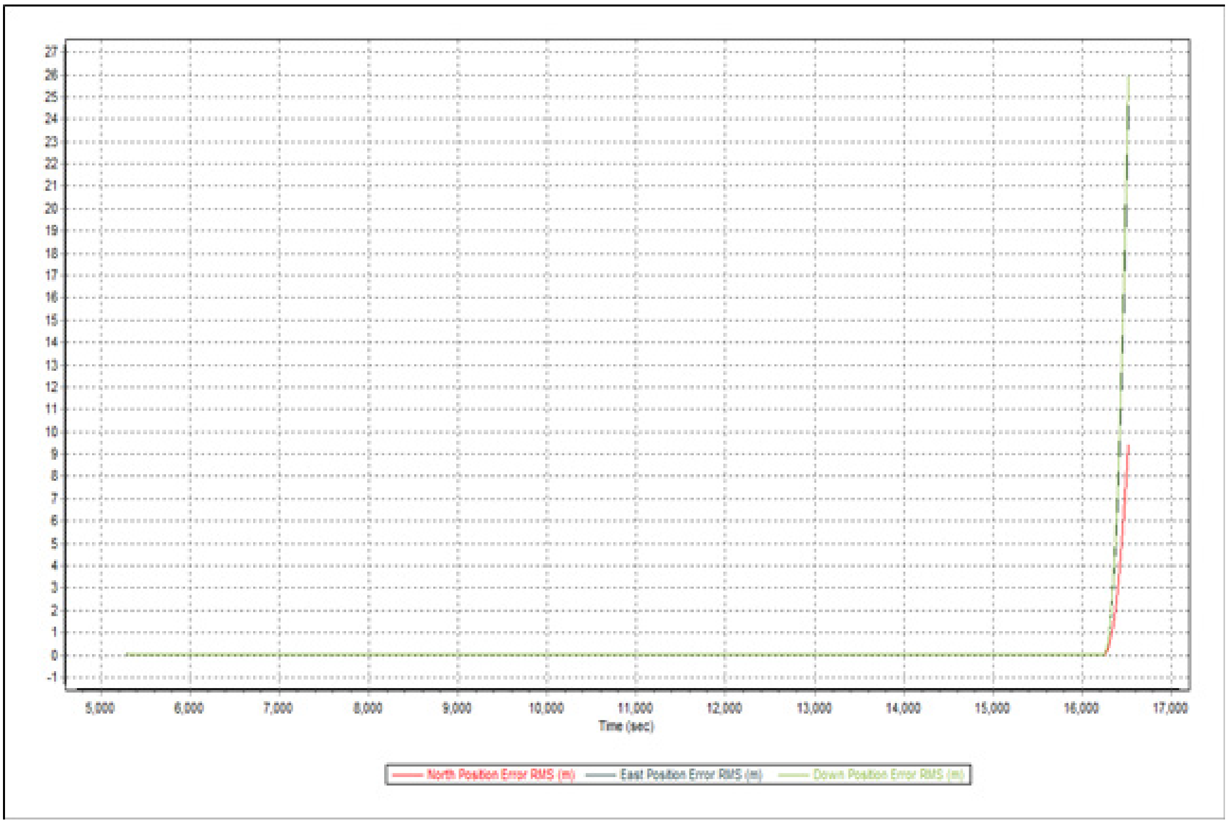


Figure A-8.16 Smoothed Performance Metric Parameters

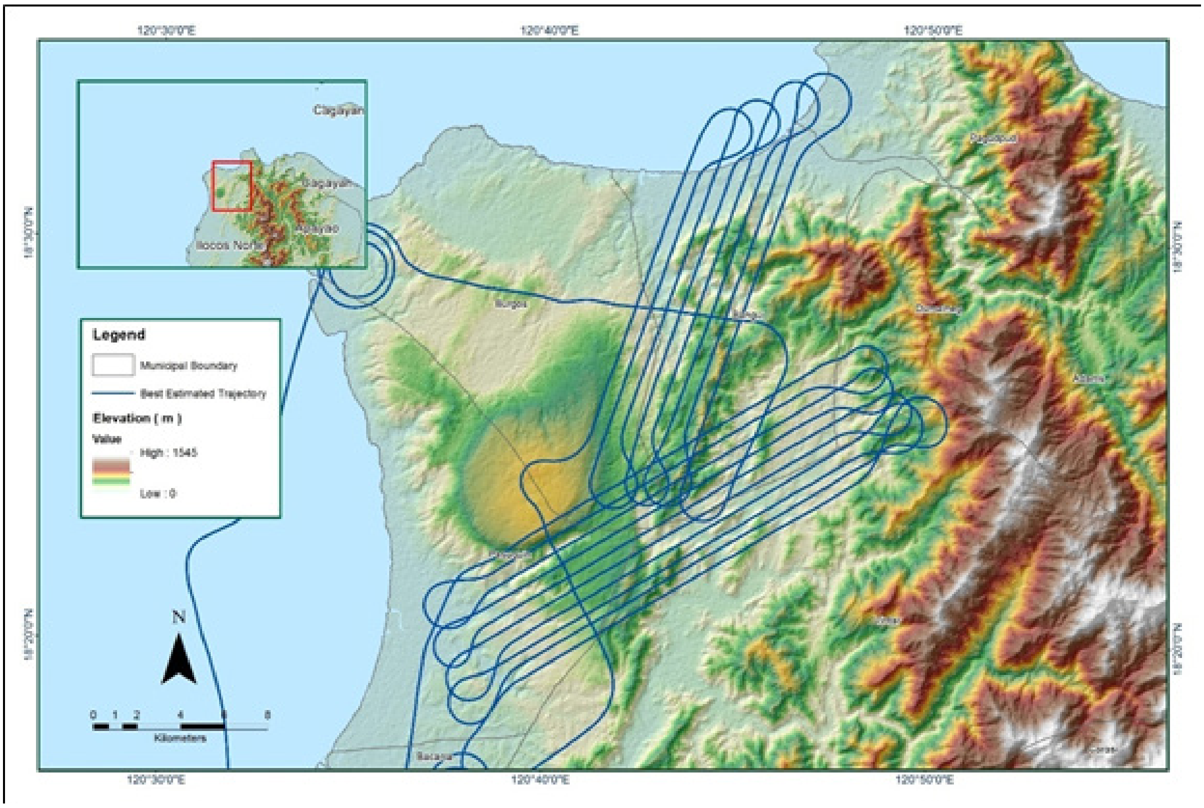


Figure A-8.17 Best Estimated Trajectory

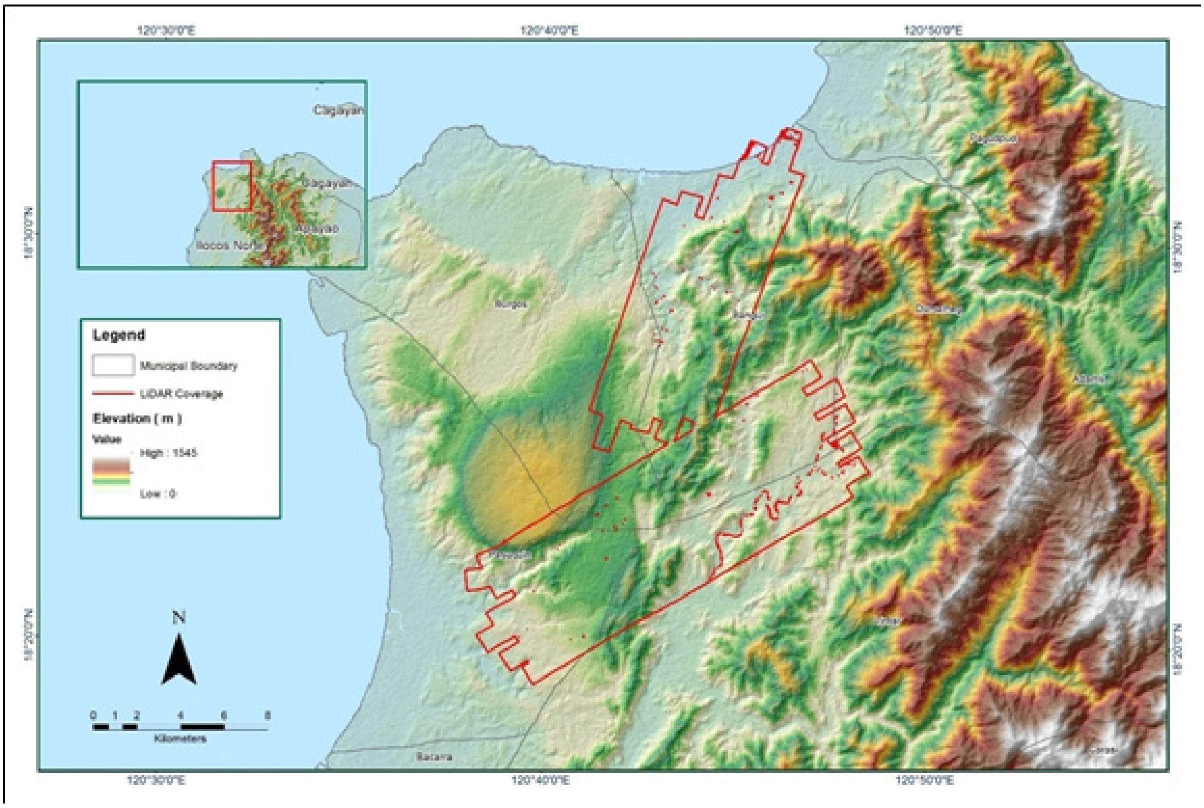


Figure A-8.18 Coverage of LiDAR data

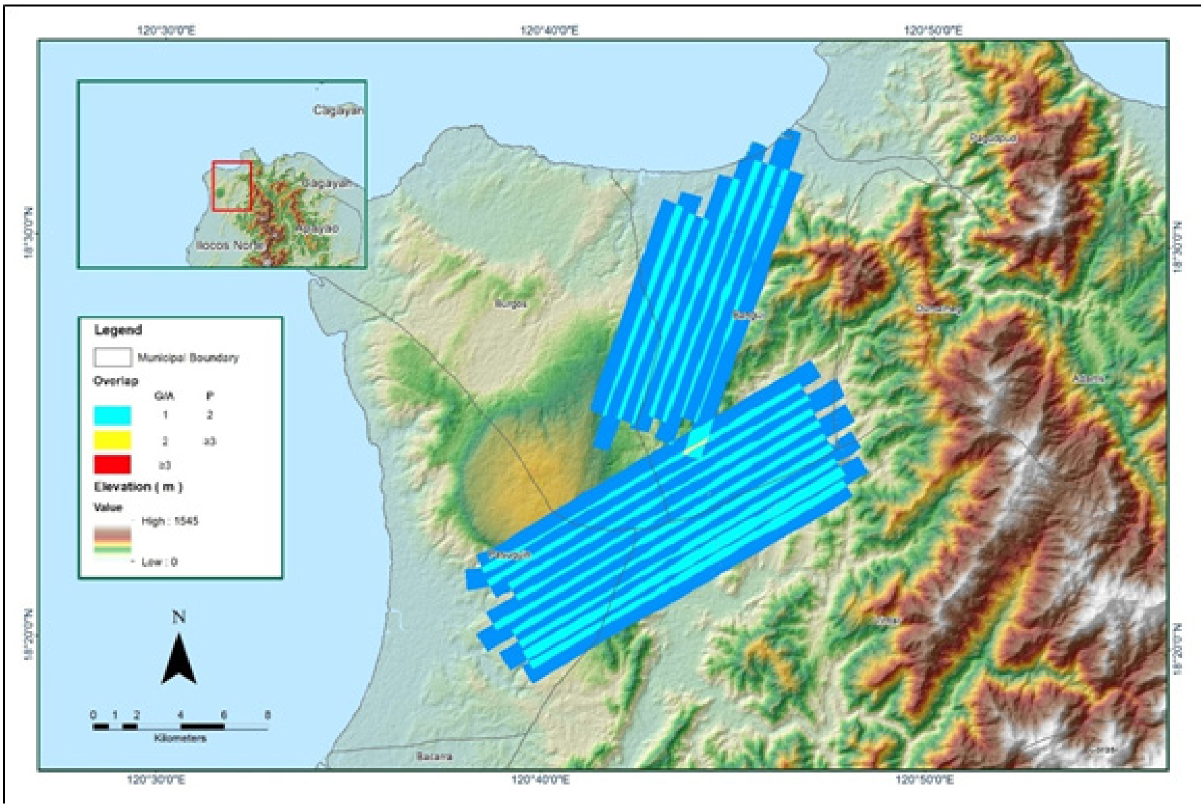


Figure A-8.19 Image of data overlap

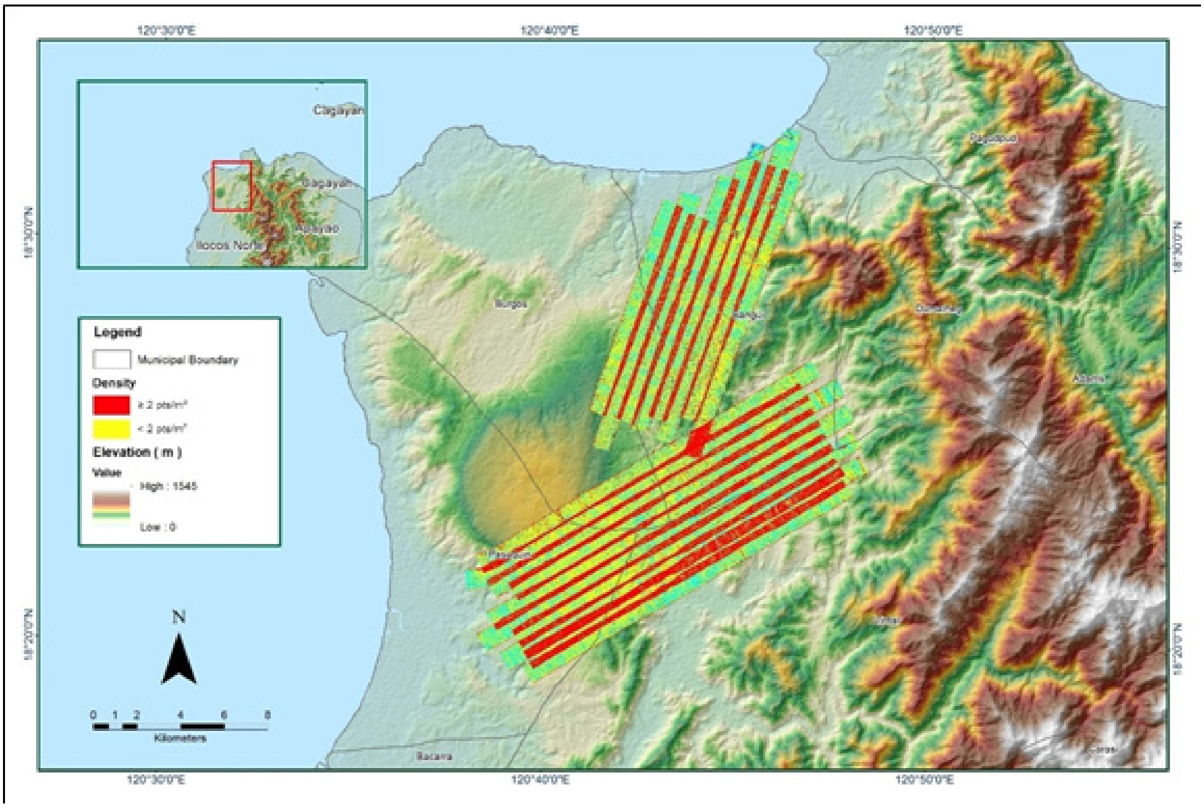


Figure A-8.20 Density map of merged LiDAR data

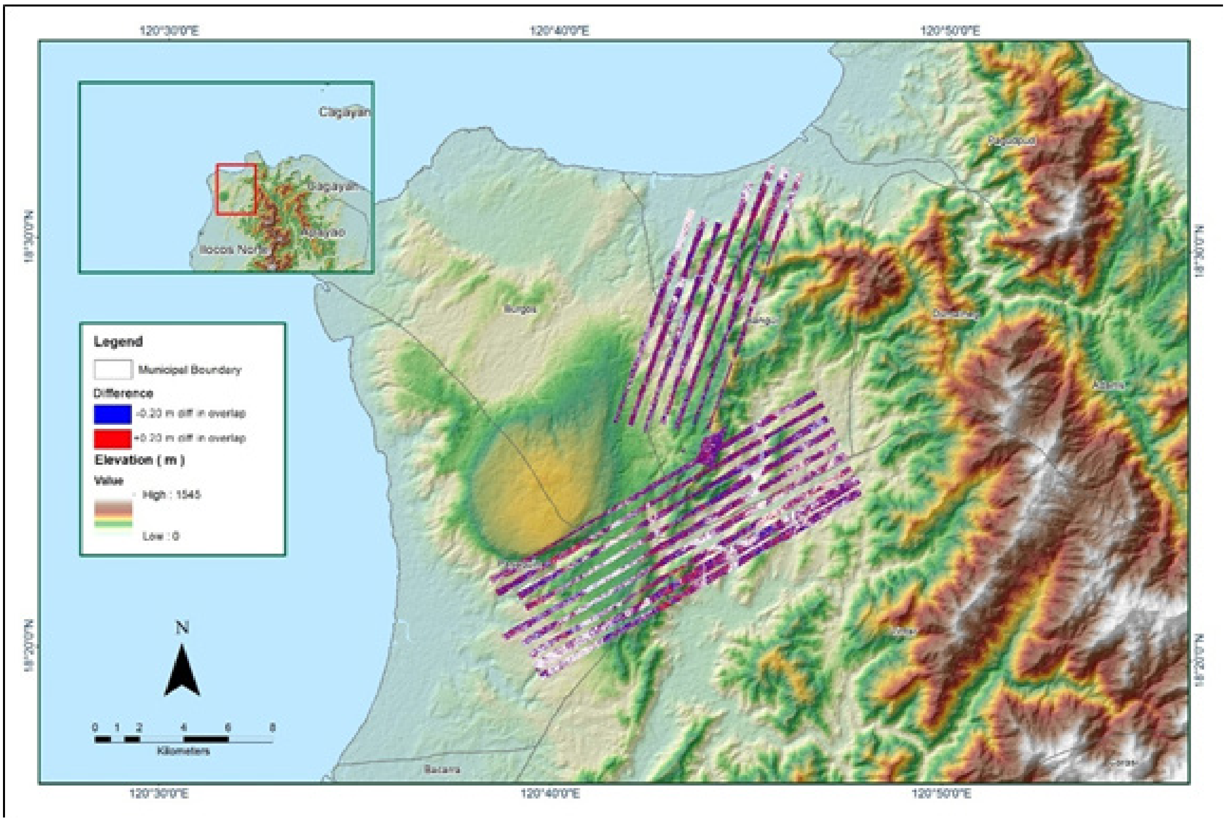


Figure A-8.21 Elevation difference between flight lines

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

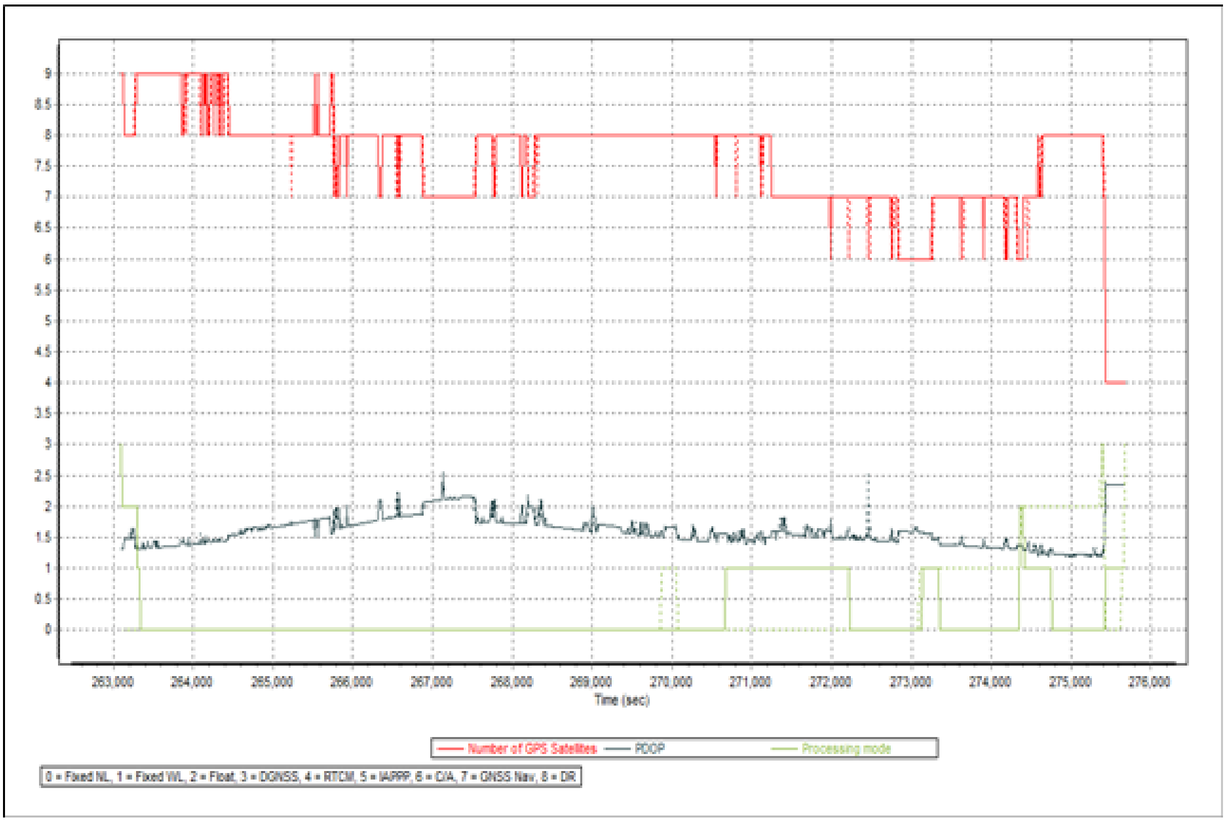


Figure A-8.22 Solution Status

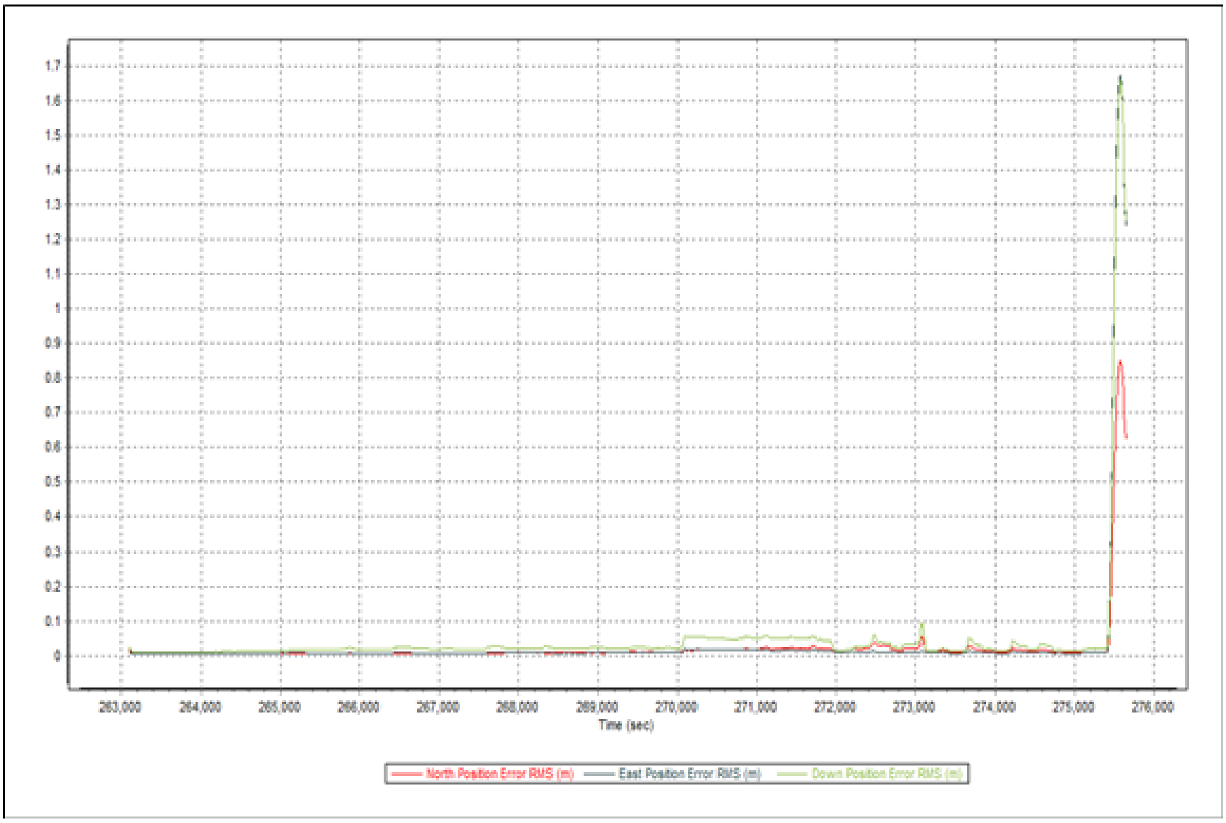


Figure A-8.23 Smoothed Performance Metric Parameters

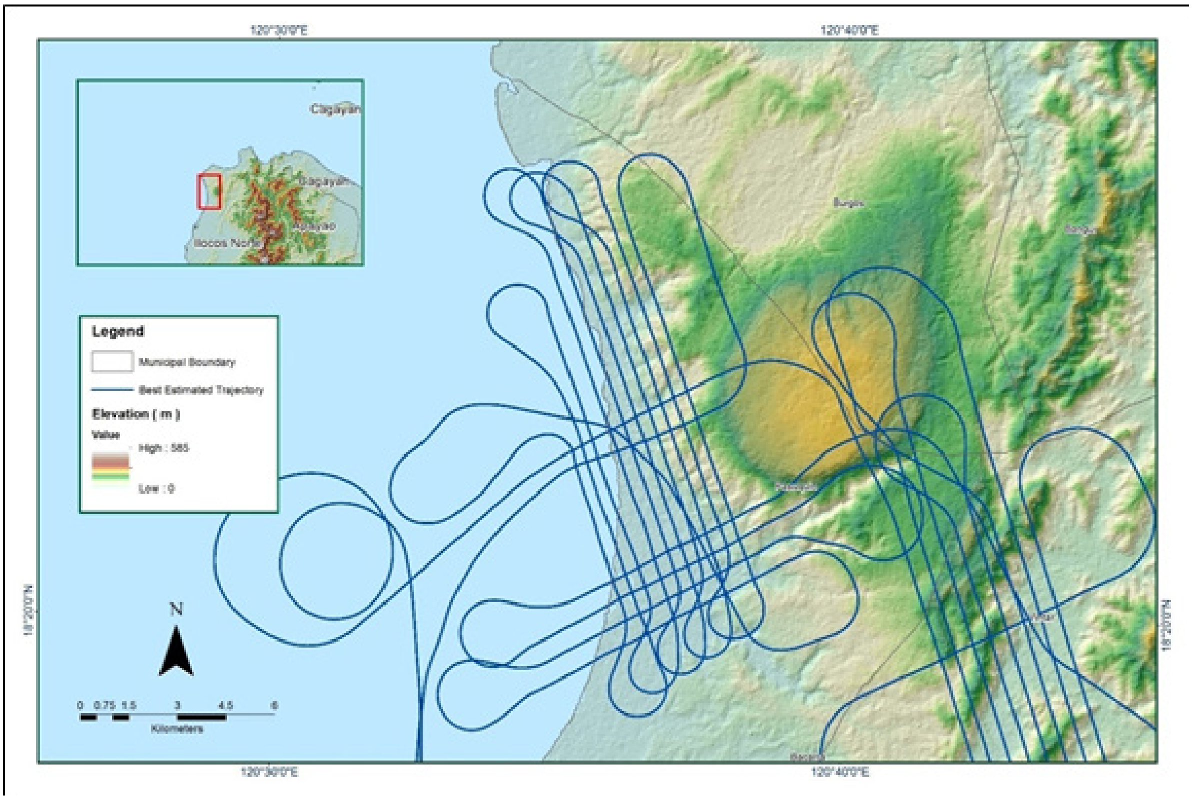


Figure A-8.24 Best Estimated Trajectory

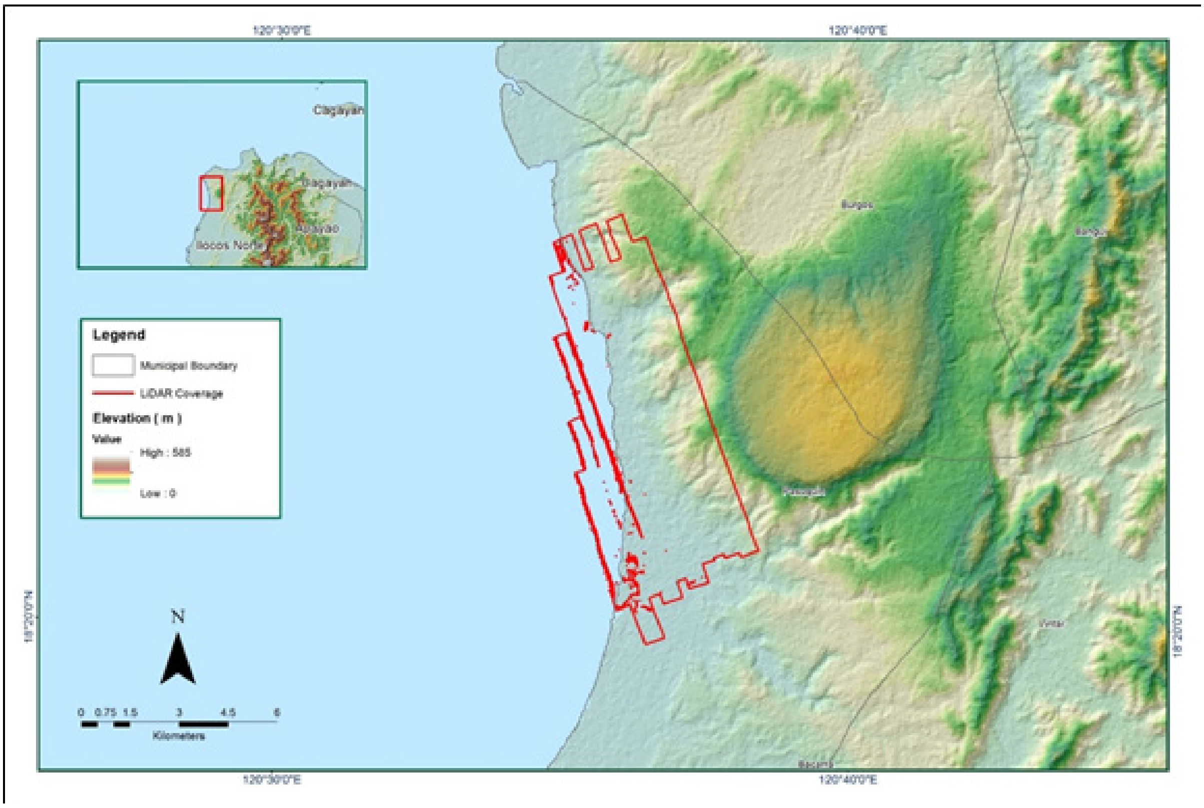


Figure A-8.25 Coverage of LiDAR data

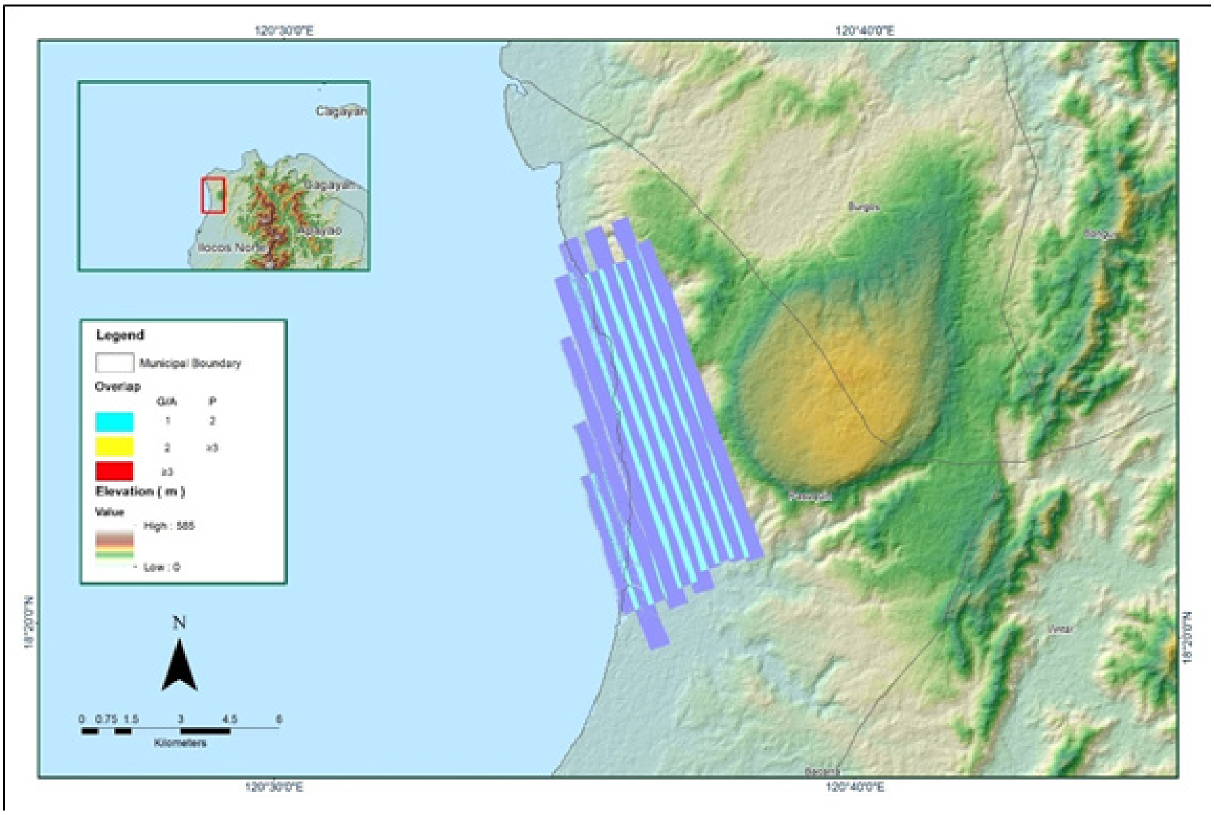


Figure A-8.26 Image of data overlap

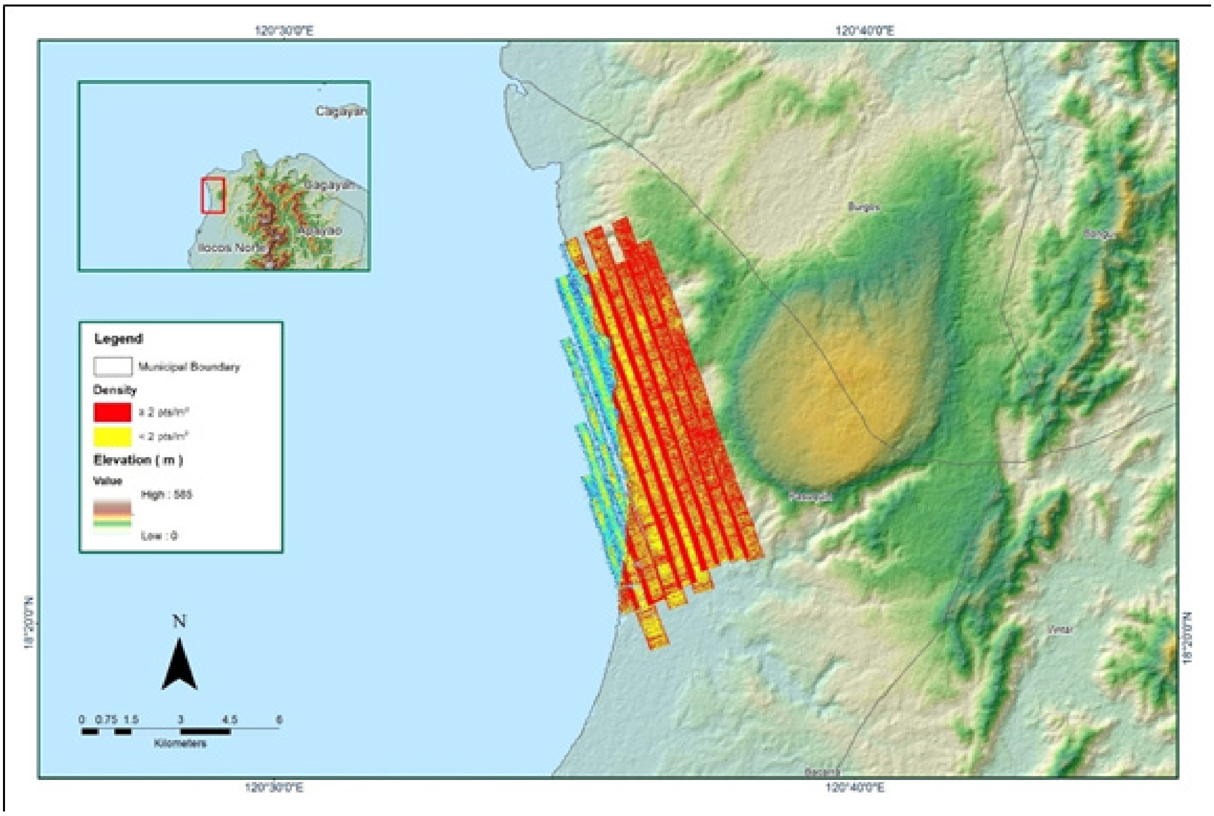


Figure A-8.27 Density map of merged LiDAR data

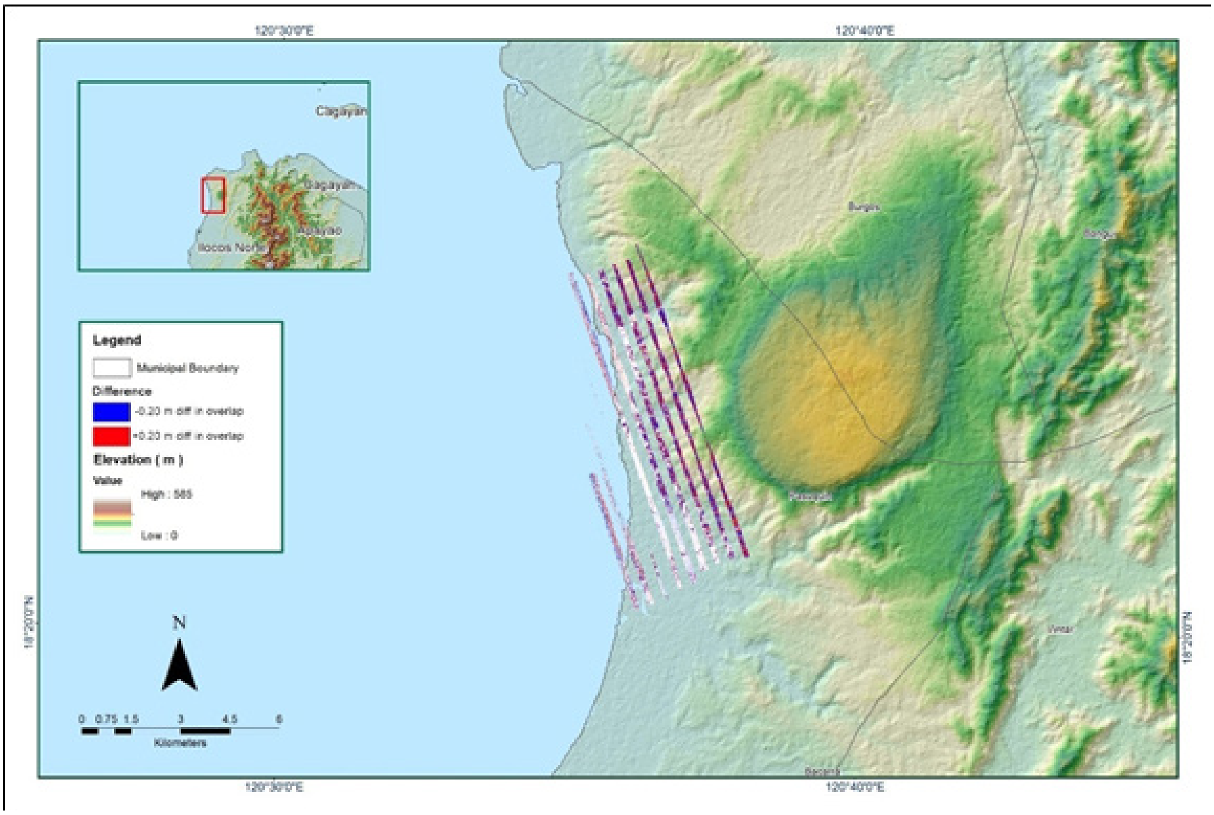


Figure A-8.28 Elevation difference between flight lines

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

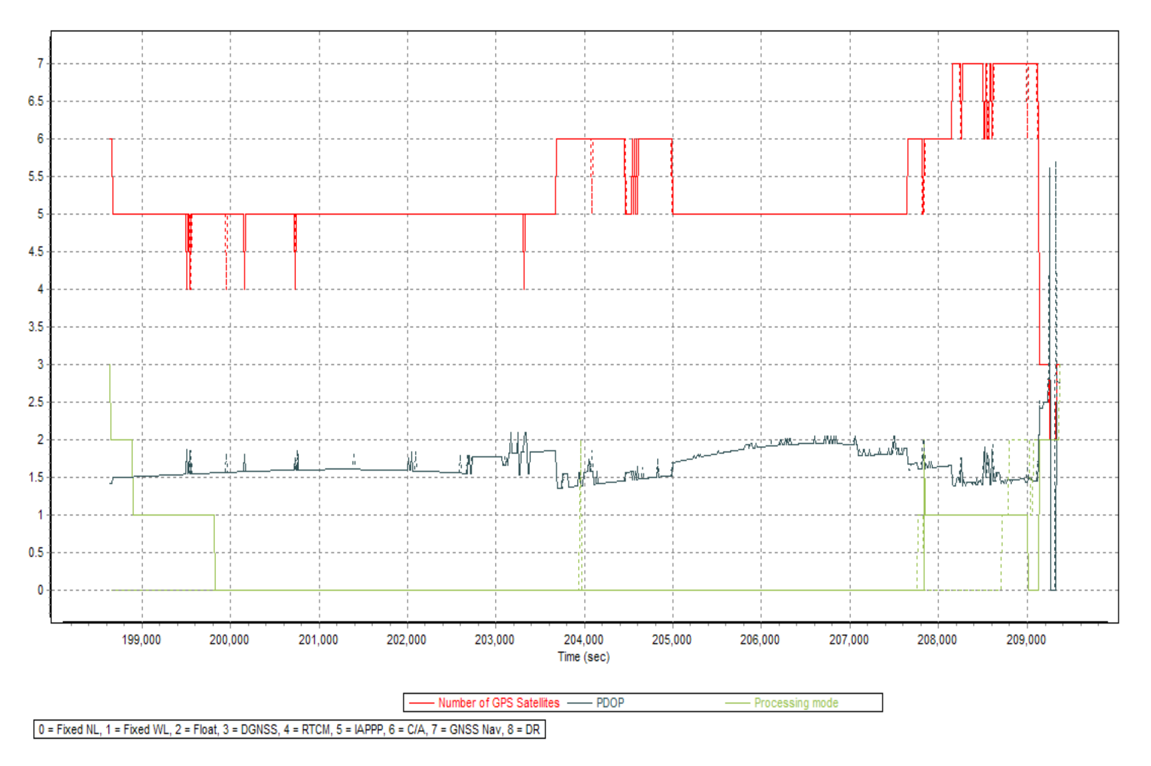


Figure A-8.29 Solution Status

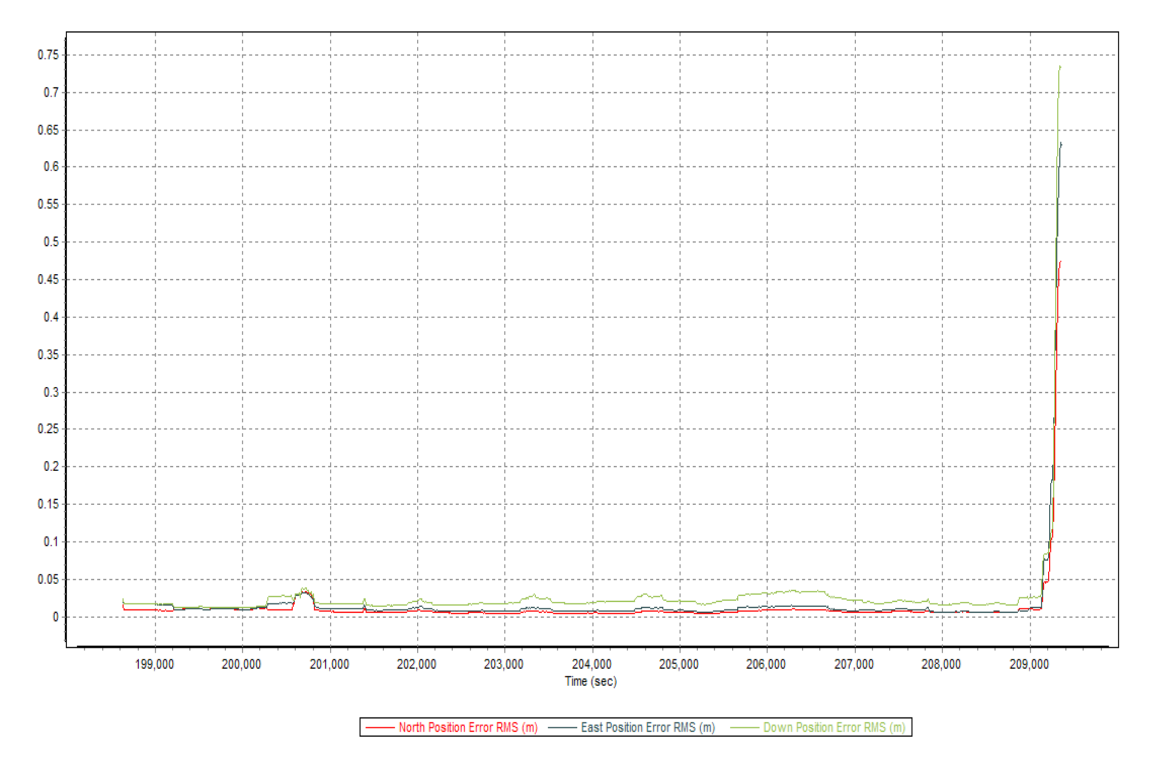


Figure A-8.30 Smoothed Performance Metric Parameters

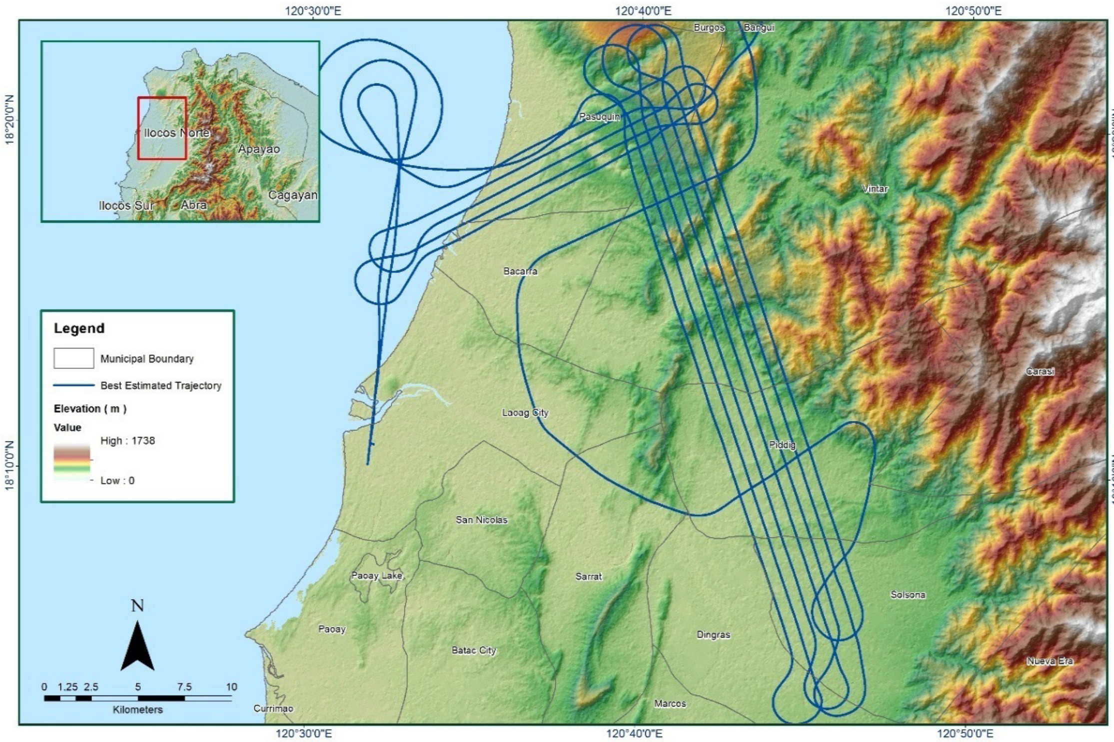


Figure A-8.31 Best Estimated Trajectory

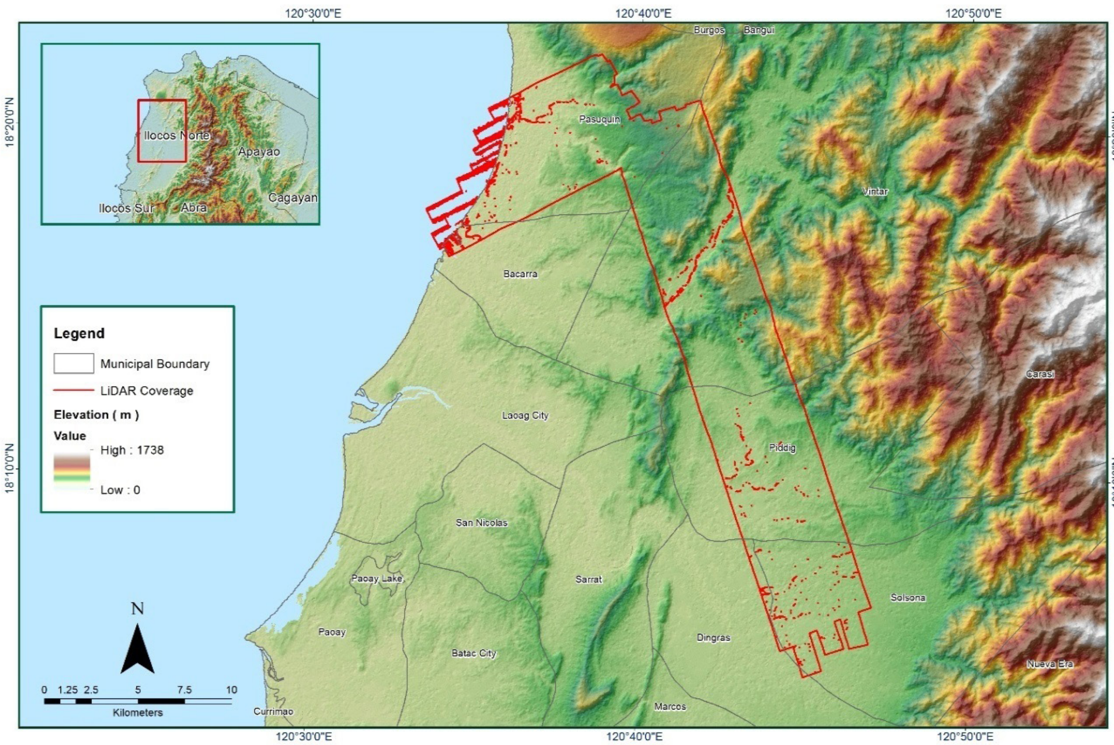


Figure A-8.32 Coverage of LiDAR data

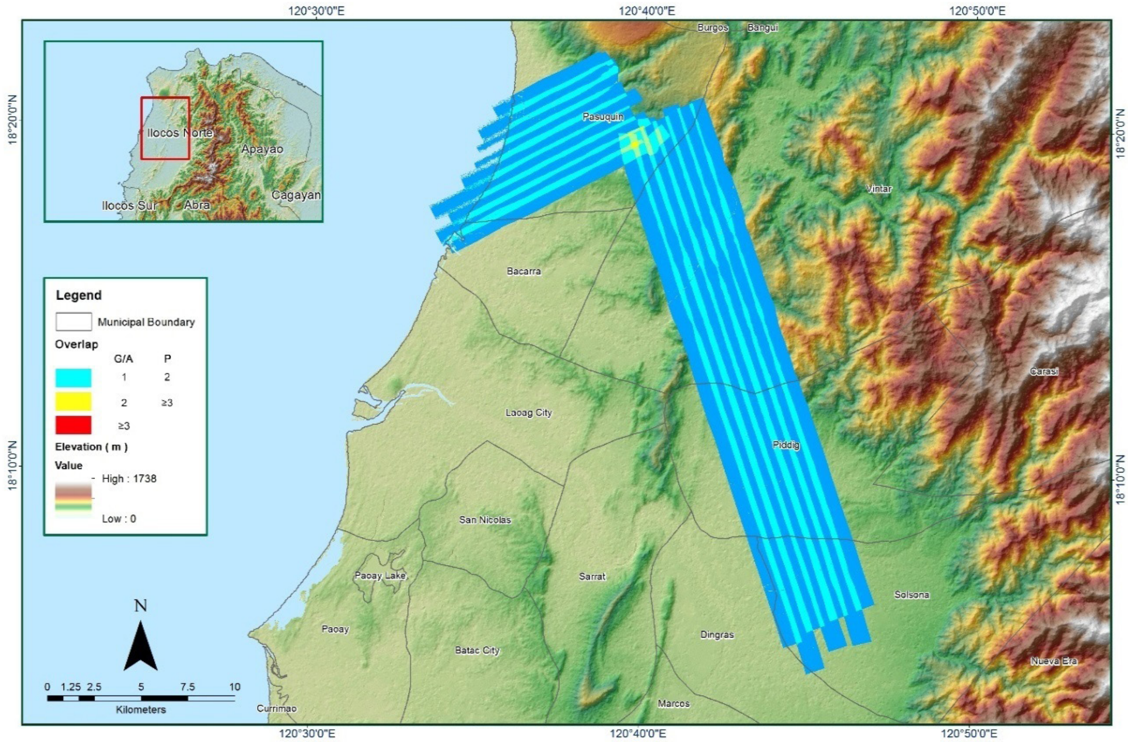


Figure A-8.33 Image of data overlap

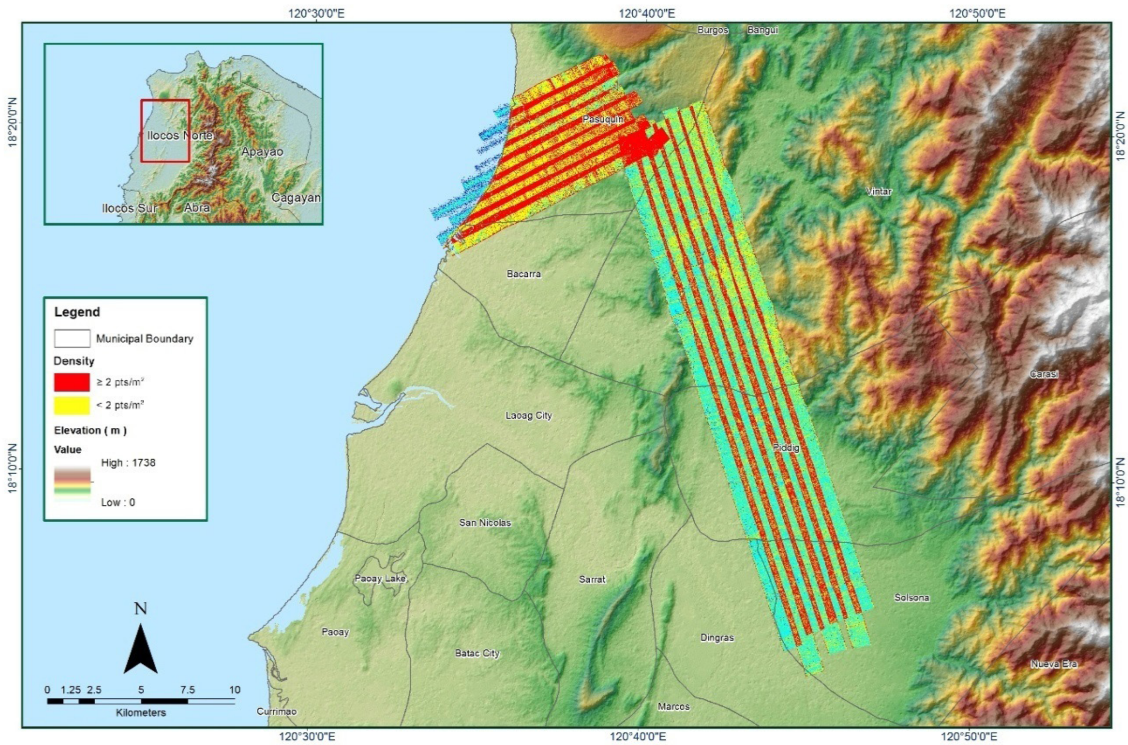


Figure A-8.34 Density map of merged LiDAR data

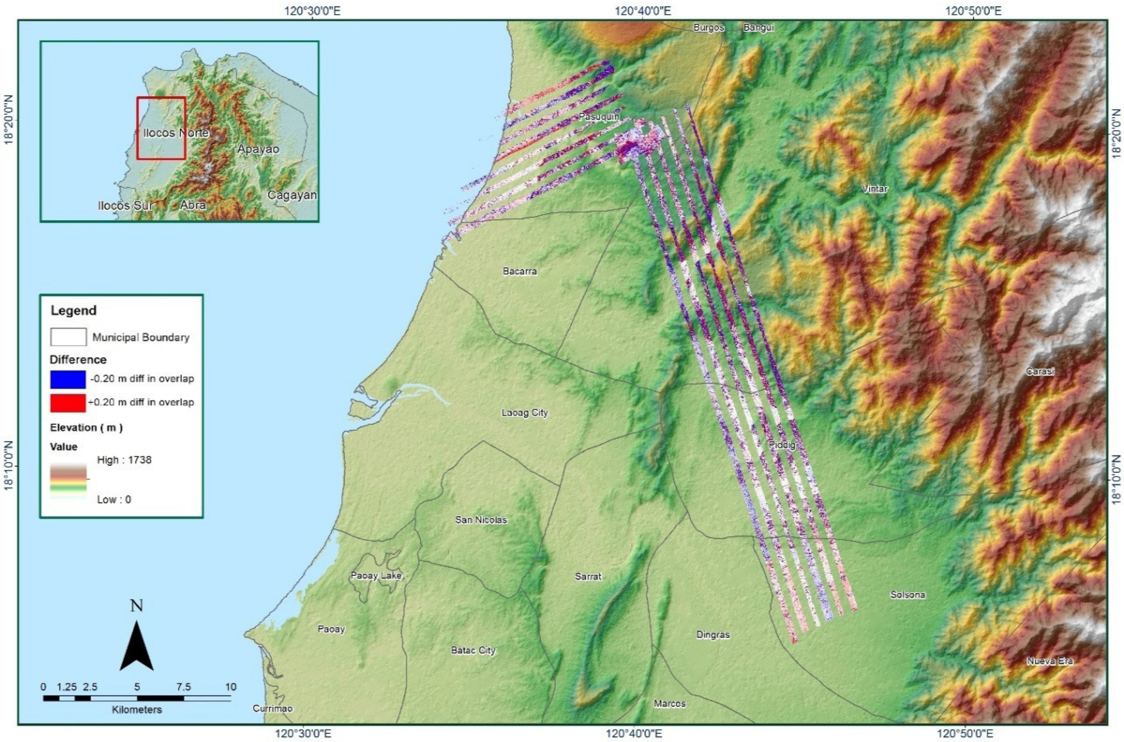


Figure A-8.35 Elevation difference between flight lines

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

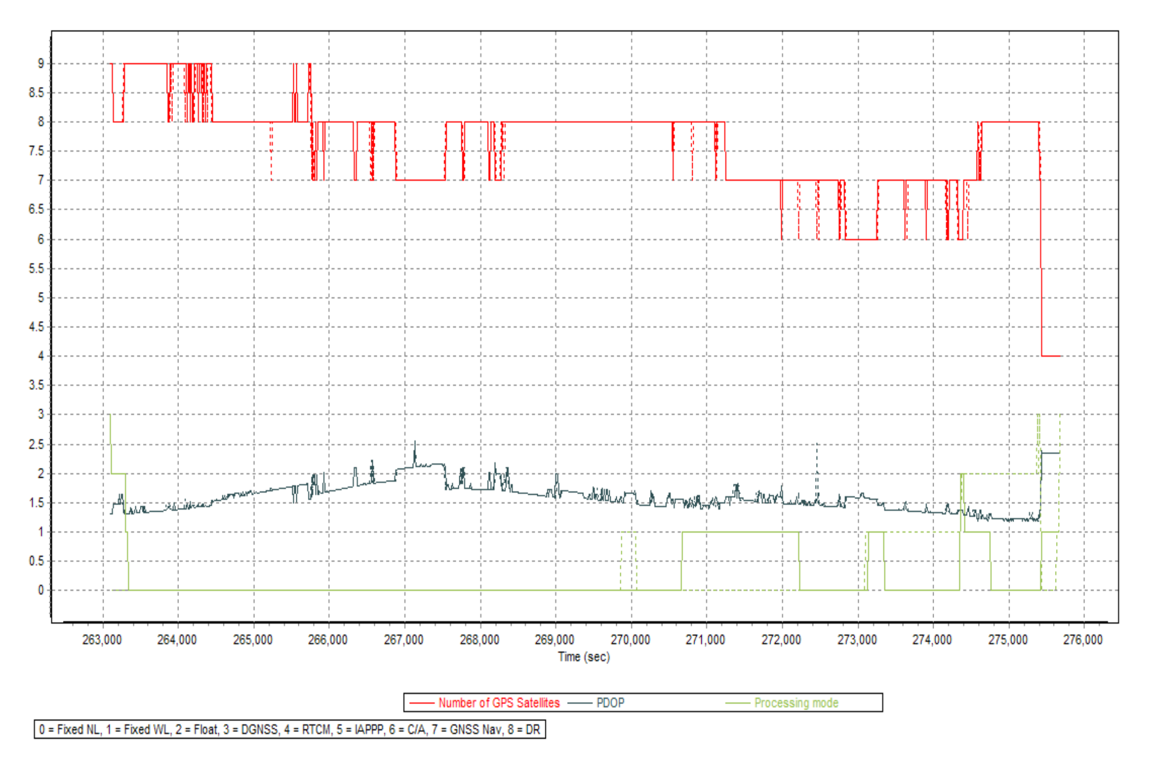


Figure A-8.36 Solution Status

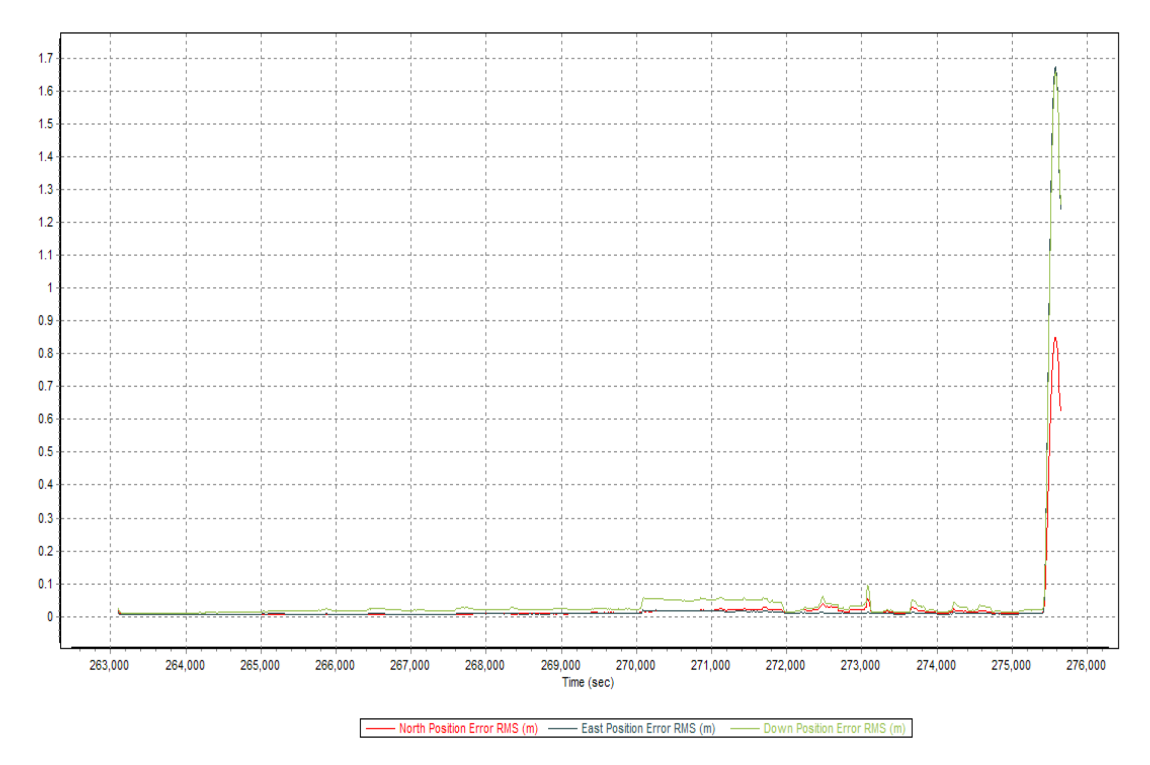


Figure A-8.37 Smoothed Performance Metric Parameters

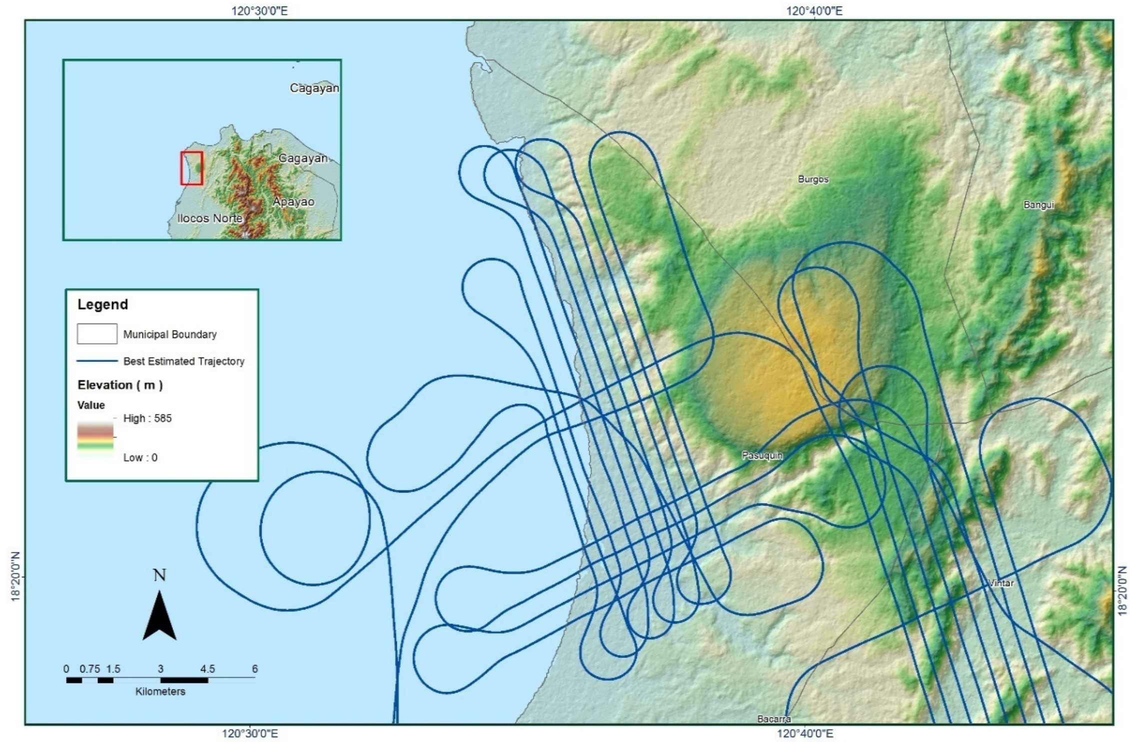


Figure A-8.38 Best Estimated Trajectory

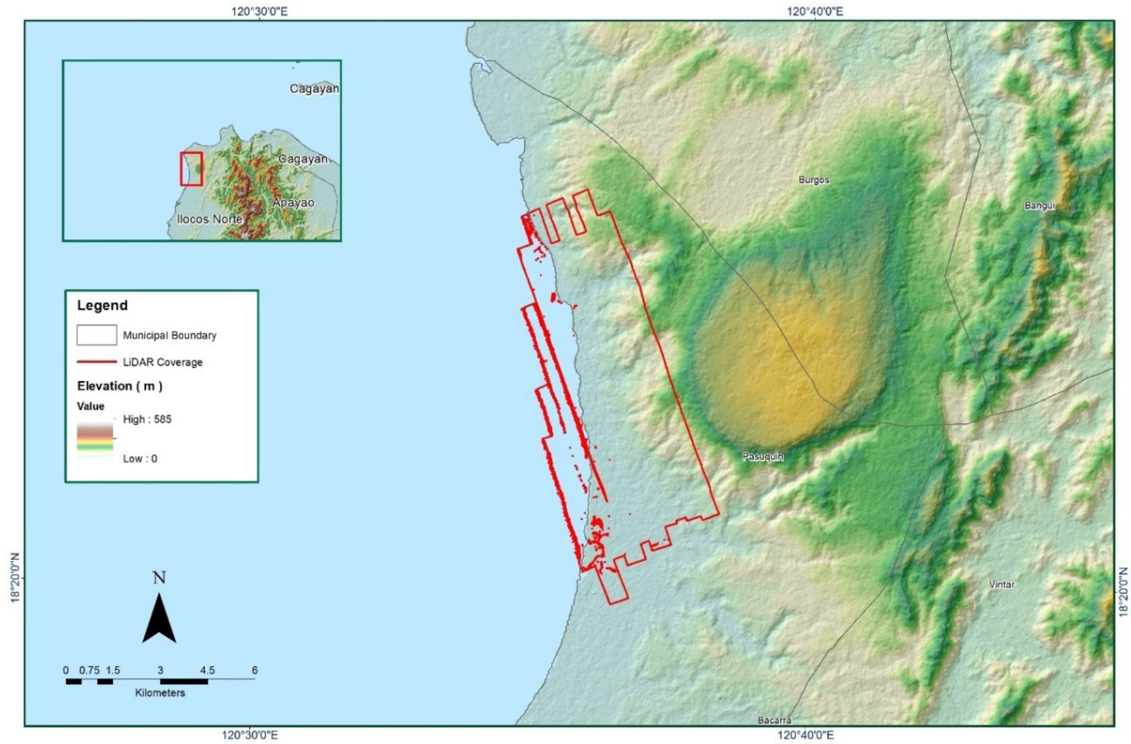


Figure A-8.39 Coverage of LiDAR data

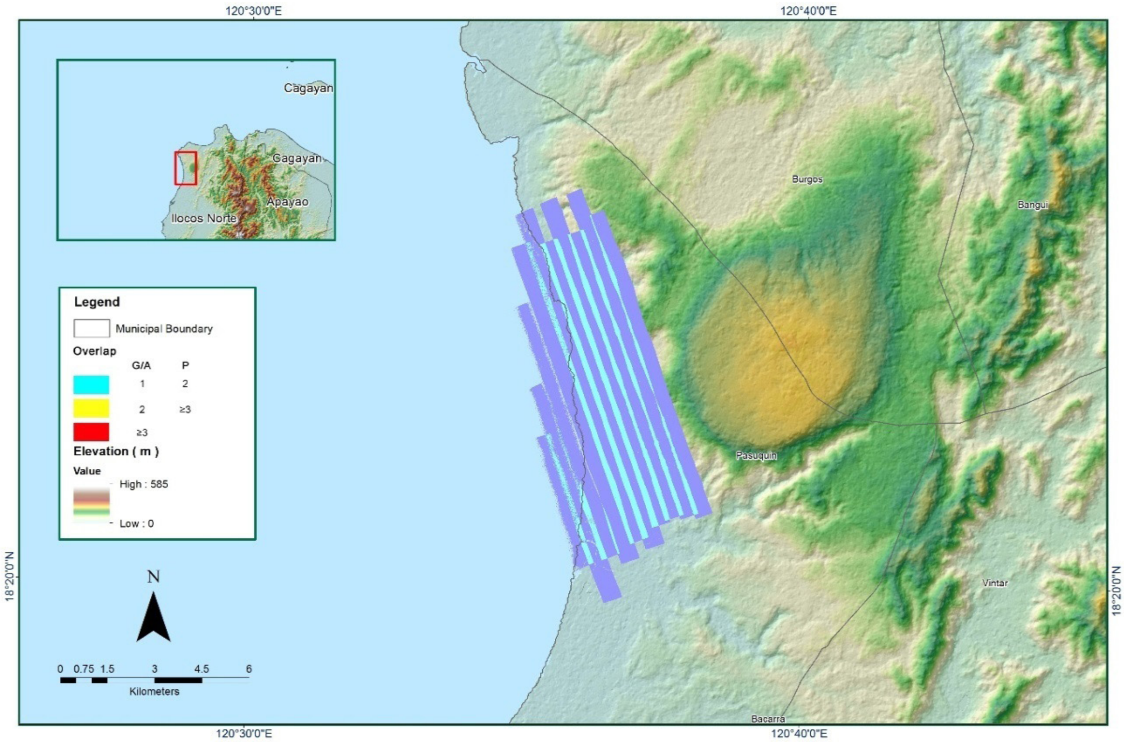


Figure A-8.40 Image of data overlap

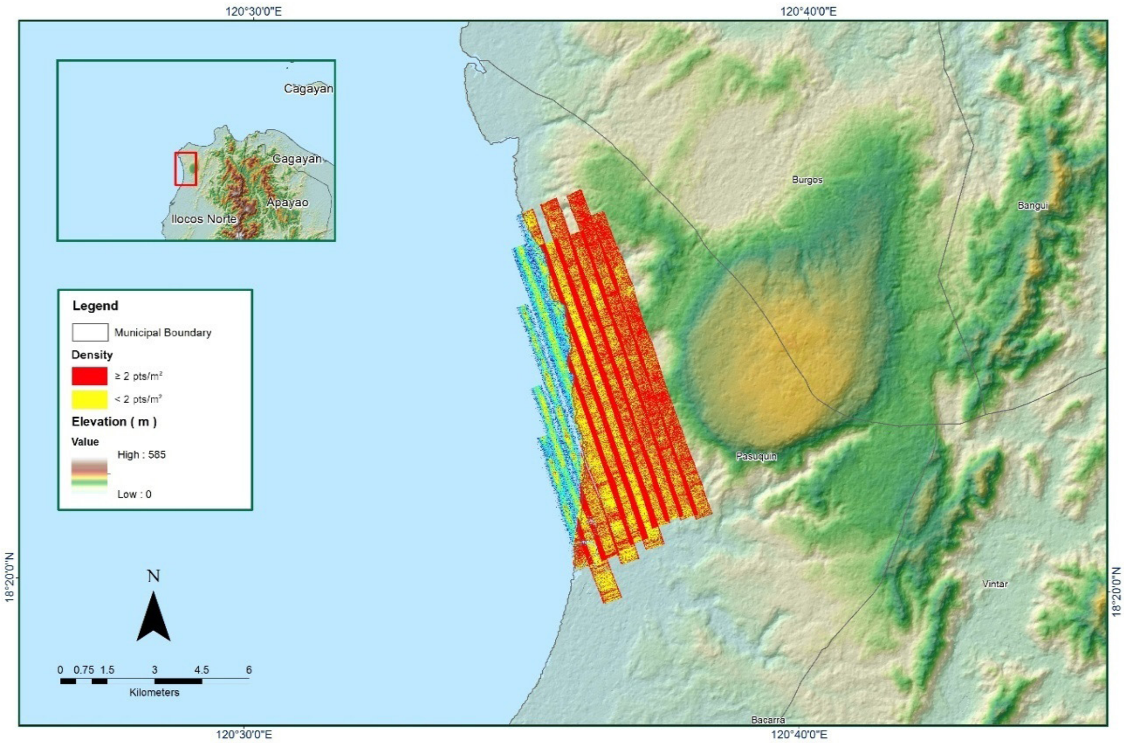


Figure A-8.41 Density map of merged LiDAR data

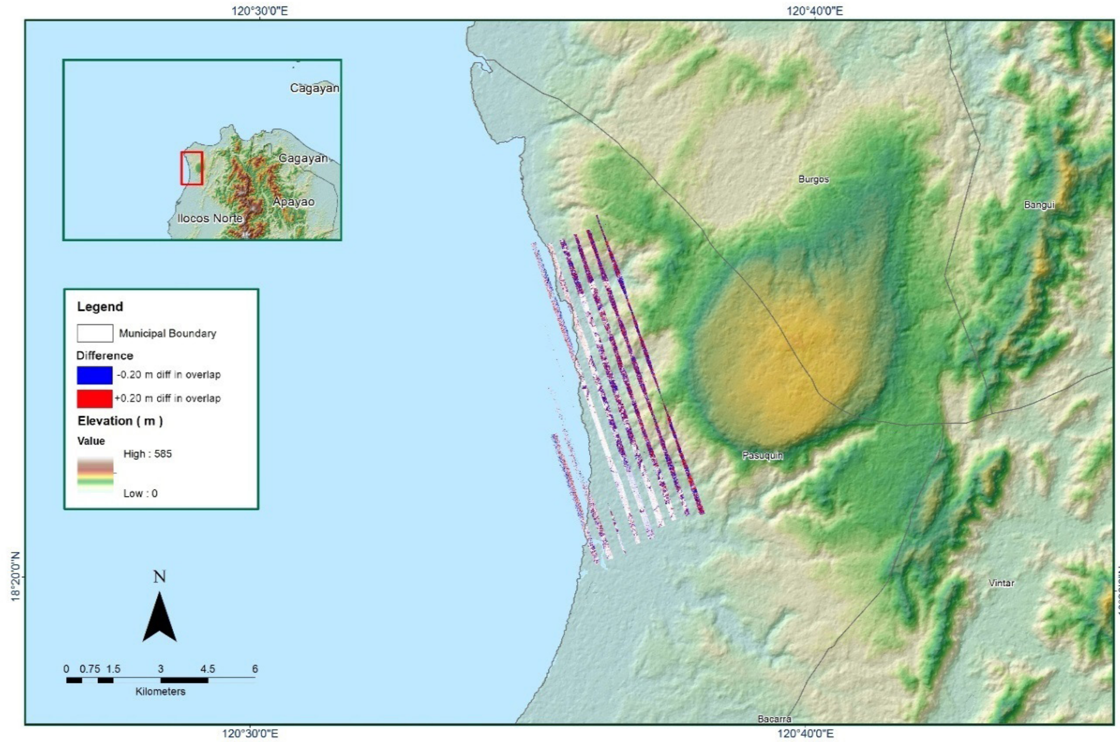


Figure A-8.42 Elevation difference between flight lines

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

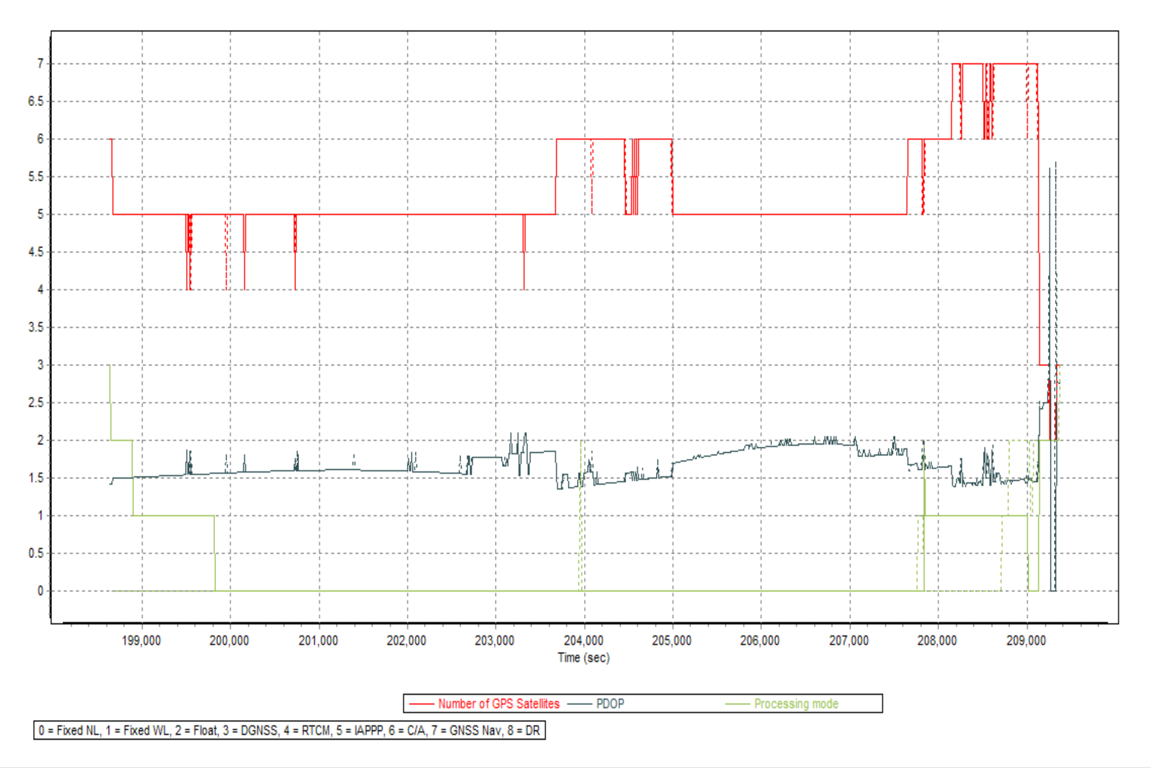


Figure A-8.43 Solution Status

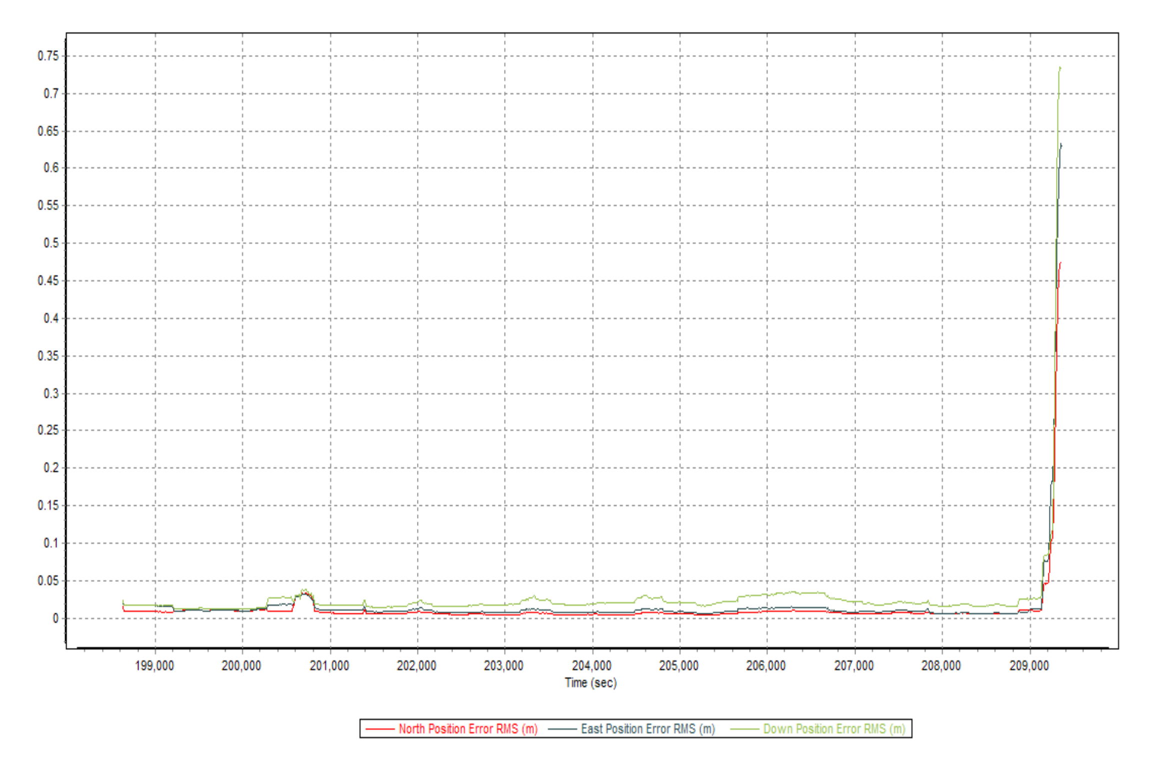


Figure A-8.44 Smoothed Performance Metric Parameters

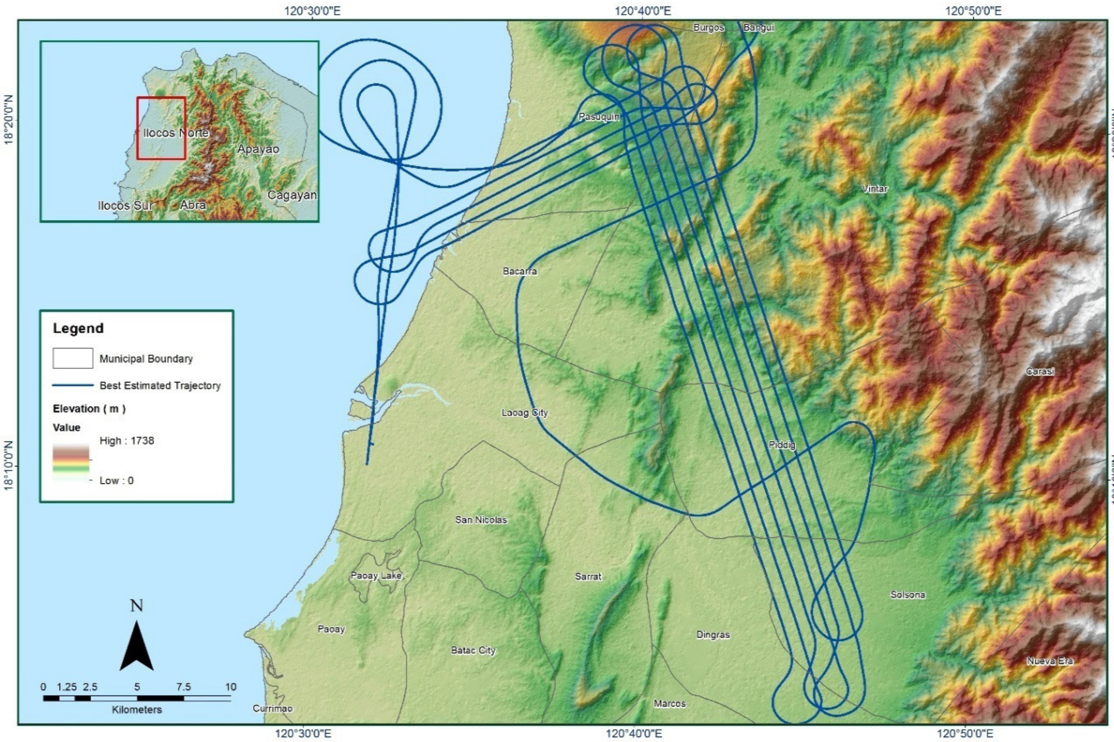


Figure A-8.45 Best Estimated Trajectory

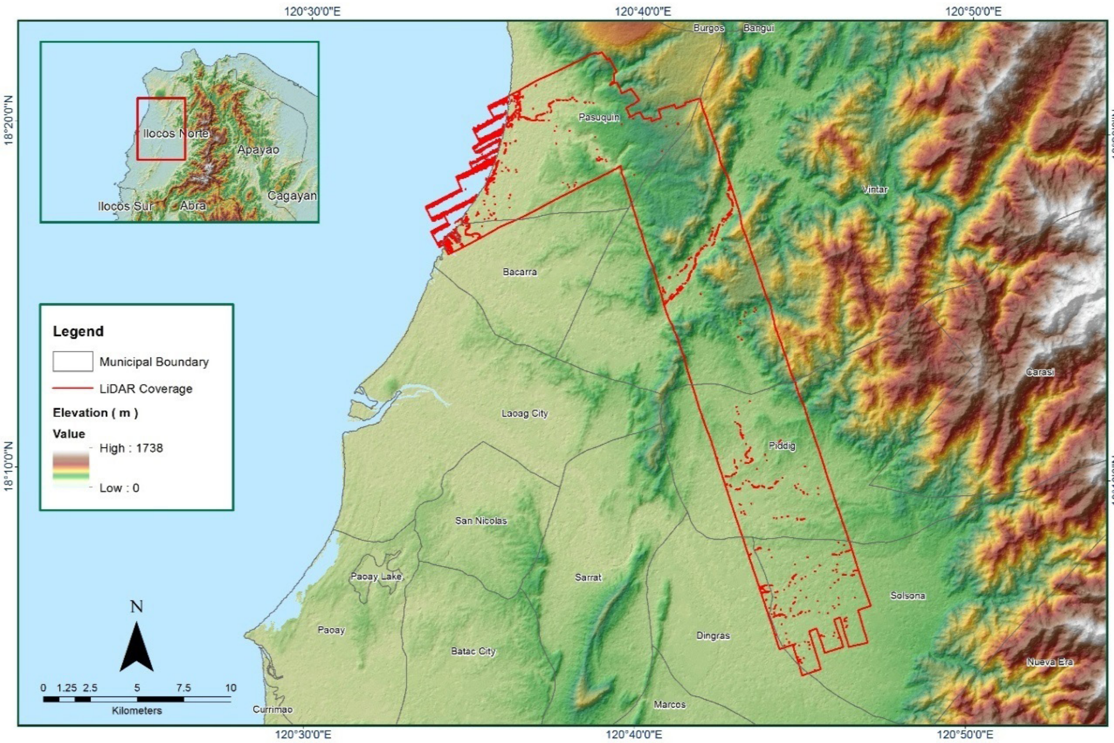


Figure A-8.46 Coverage of LiDAR data

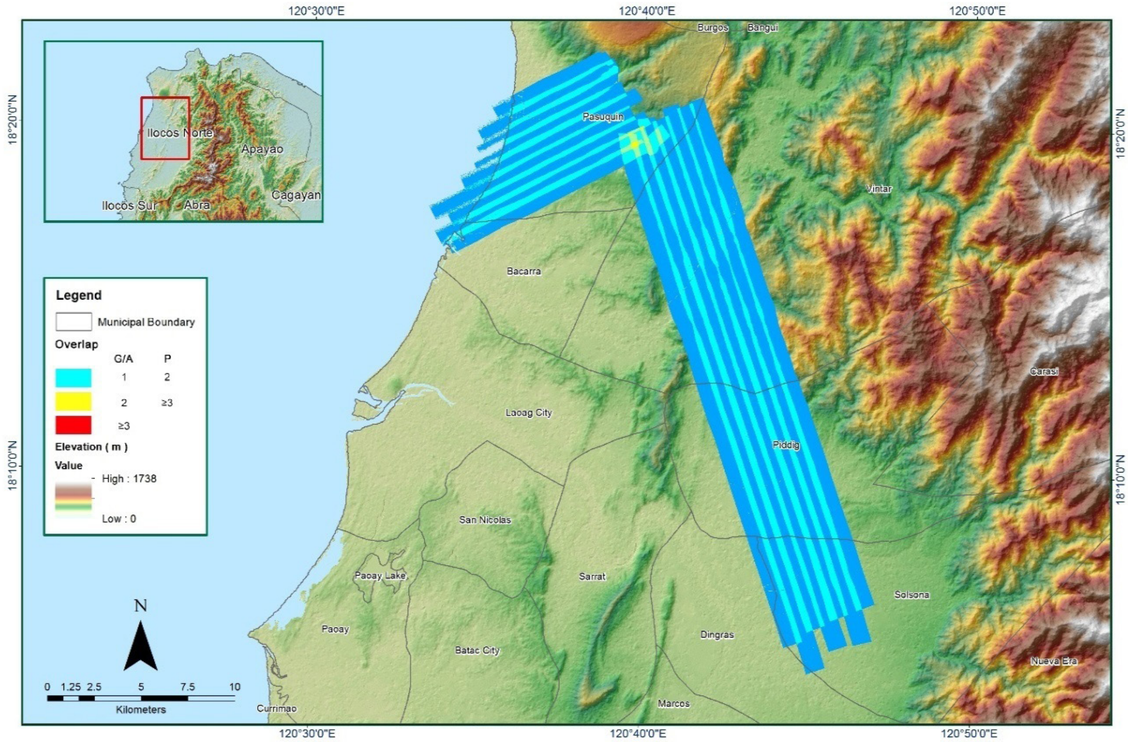


Figure A-8.47 Image of data overlap

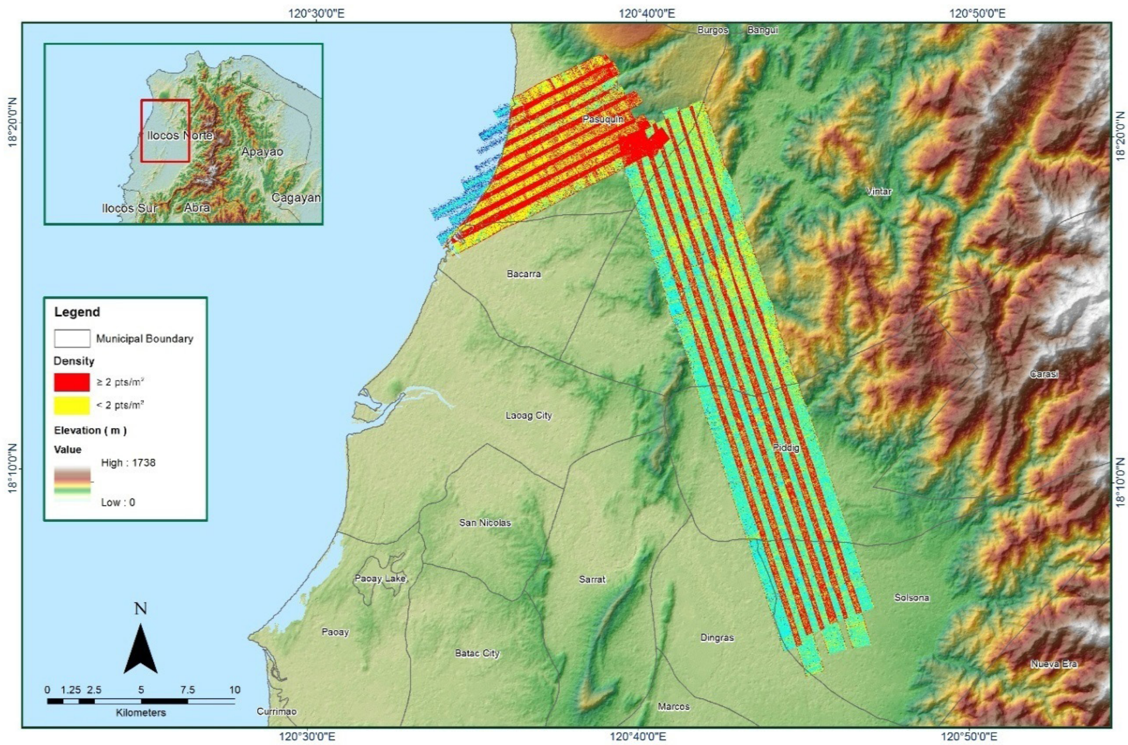


Figure A-8.48 Density map of merged LiDAR data

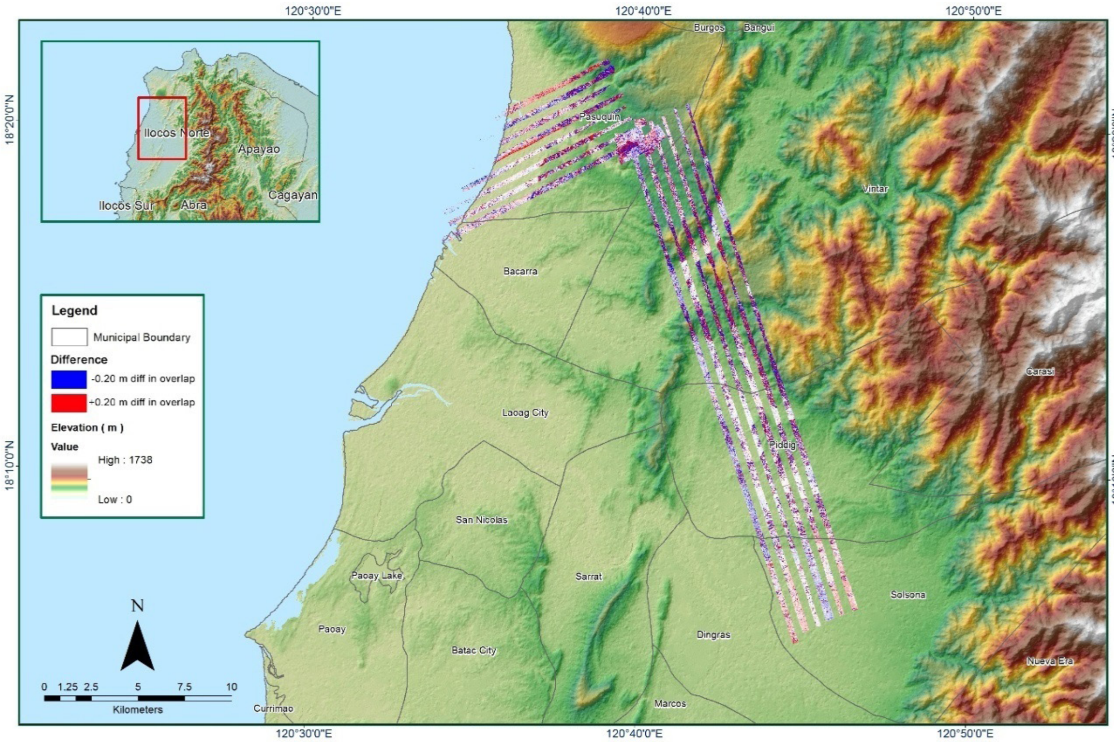


Figure A-8.49 Elevation difference between flight lines

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

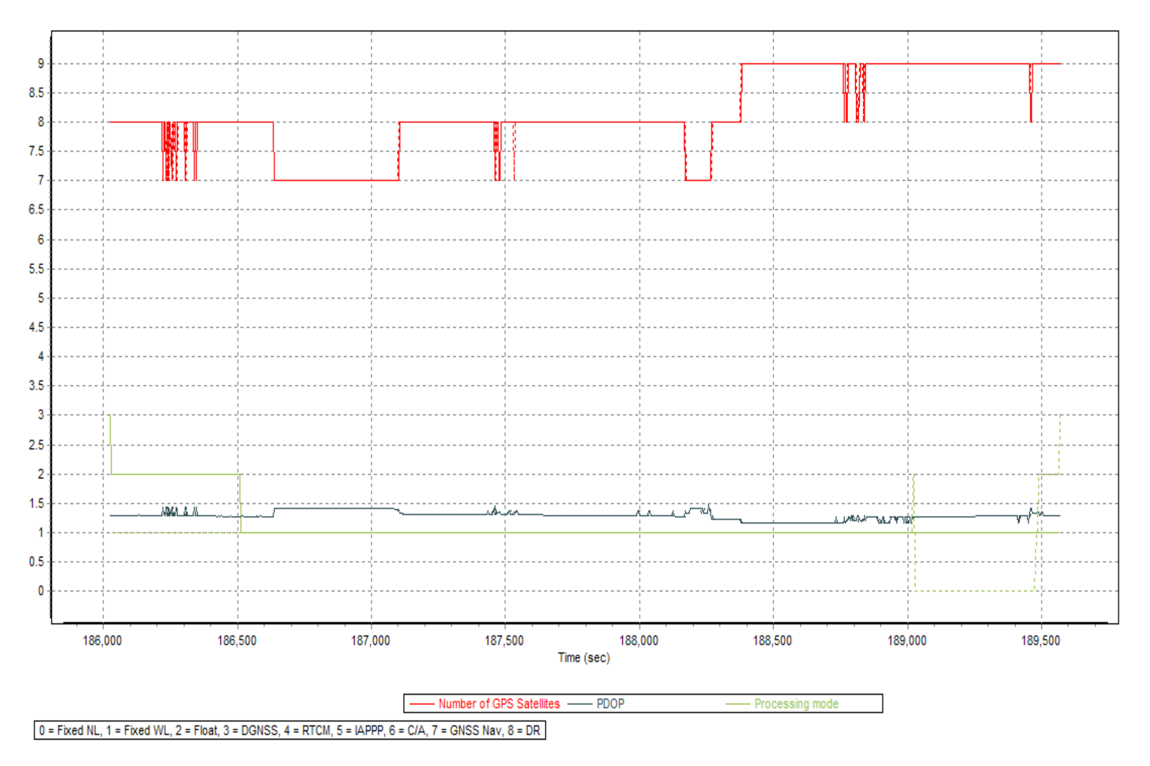


Figure A-8.50 Solution Status

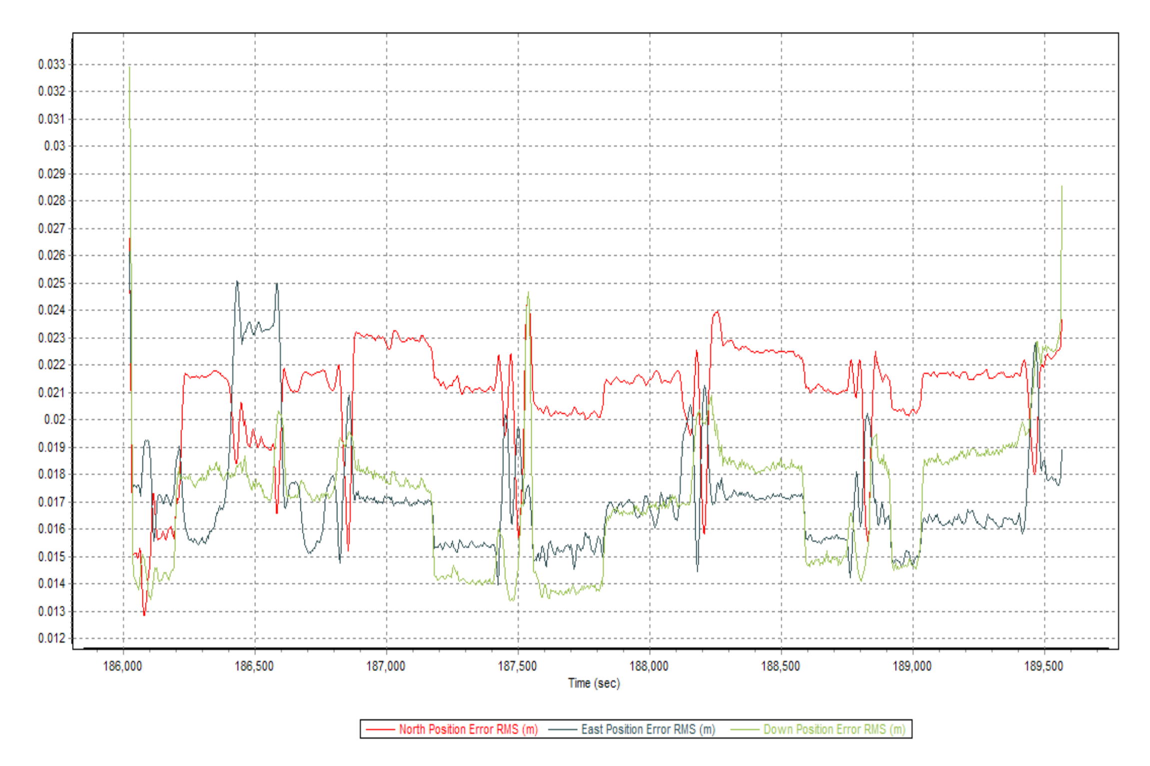


Figure A-8.51 Smoothed Performance Metric Parameters

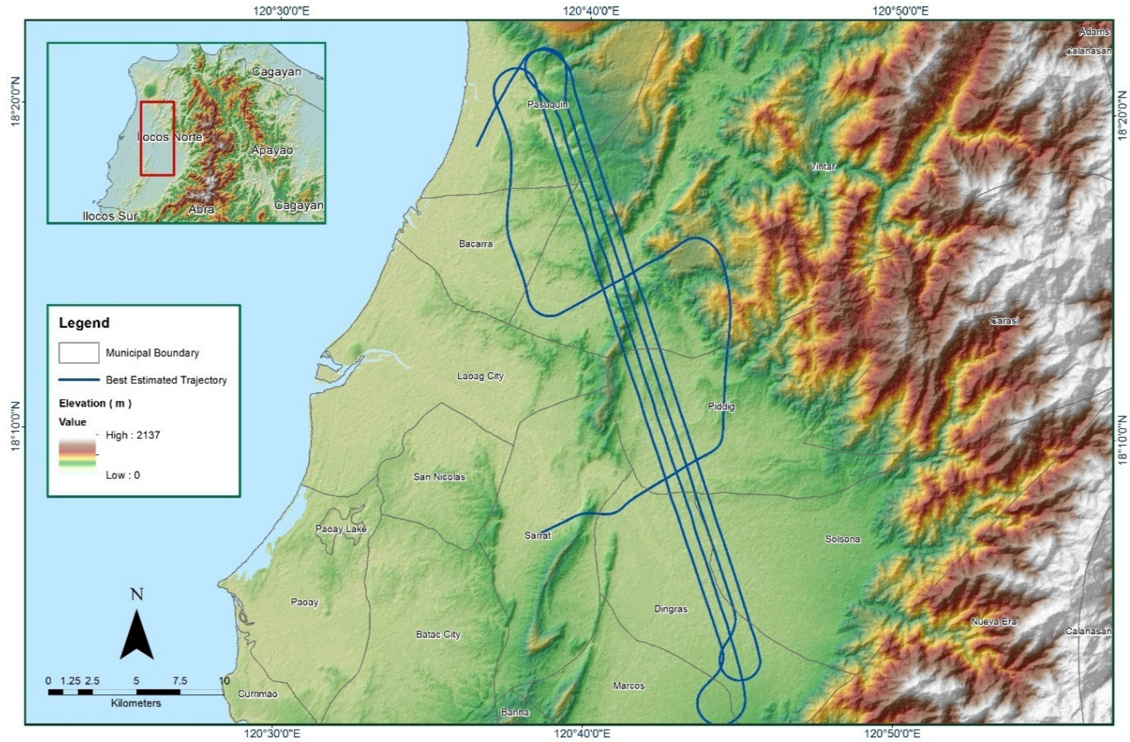


Figure A-8.52 Best Estimated Trajectory

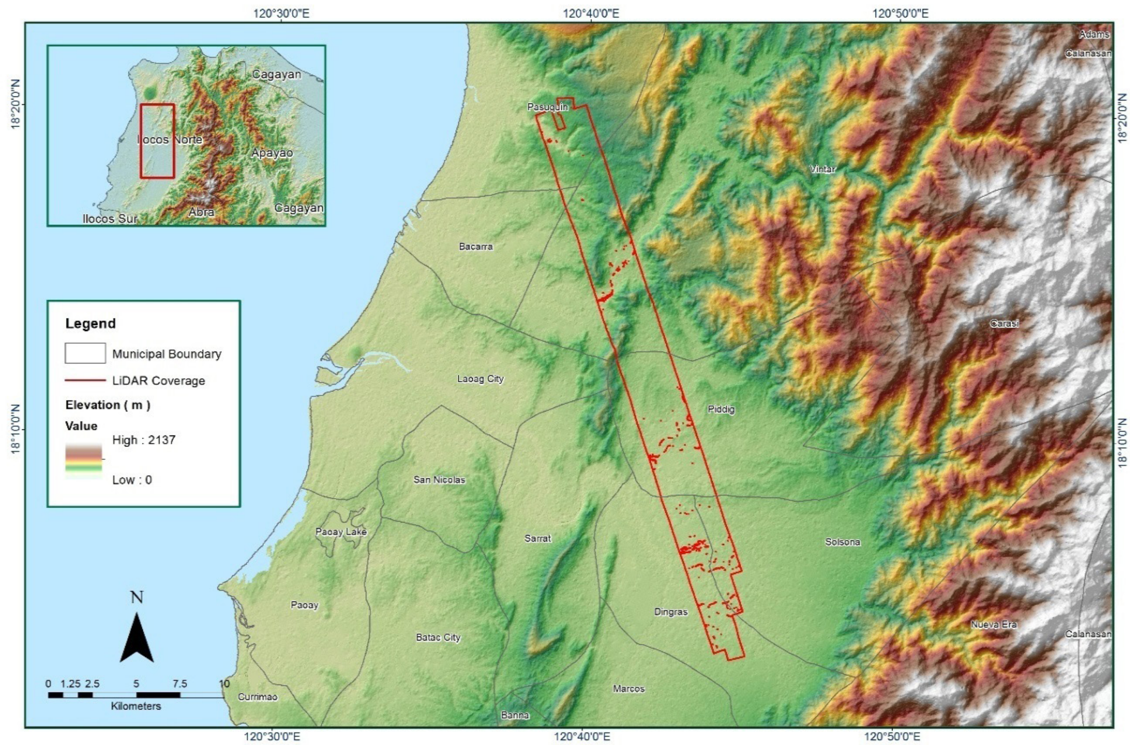


Figure A-8.53 Coverage of LiDAR data

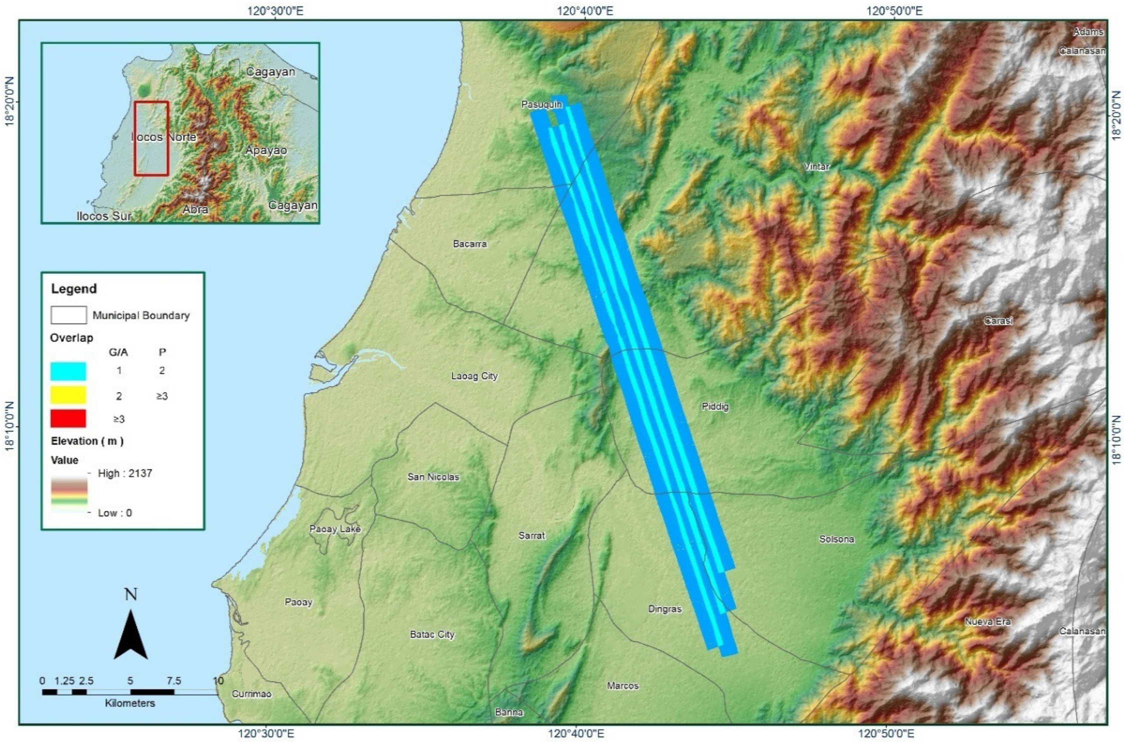


Figure A-8.54 Image of data overlap

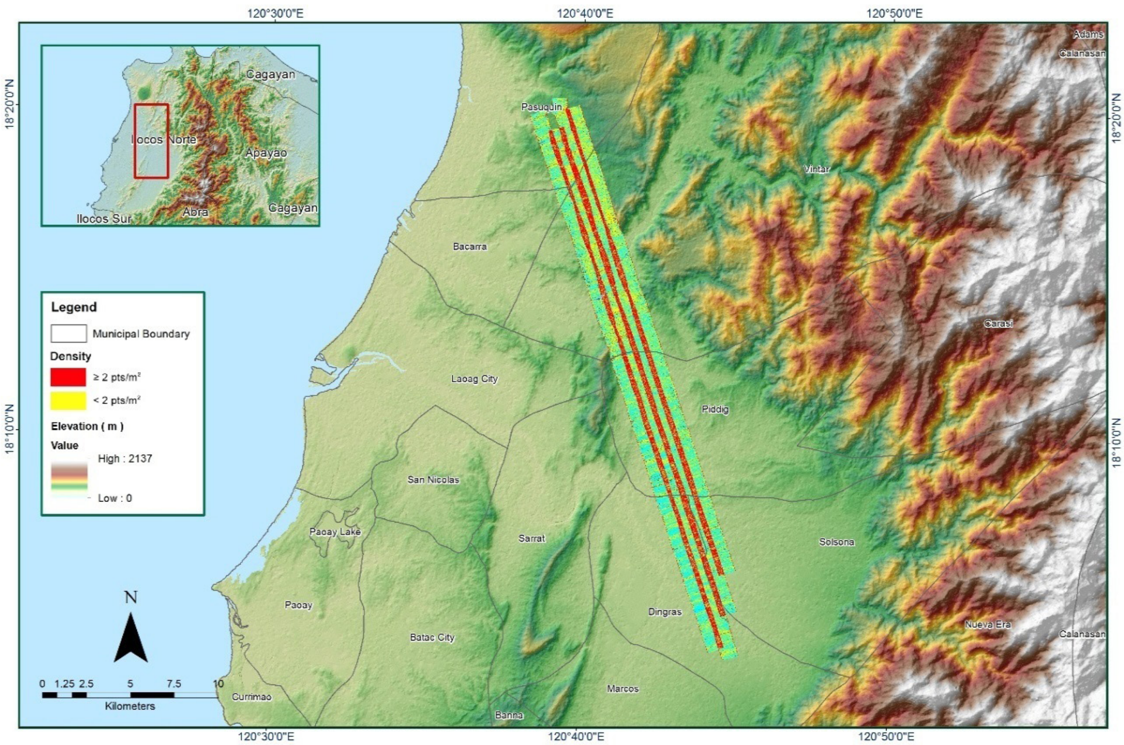


Figure A-8.55 Density map of merged LiDAR data

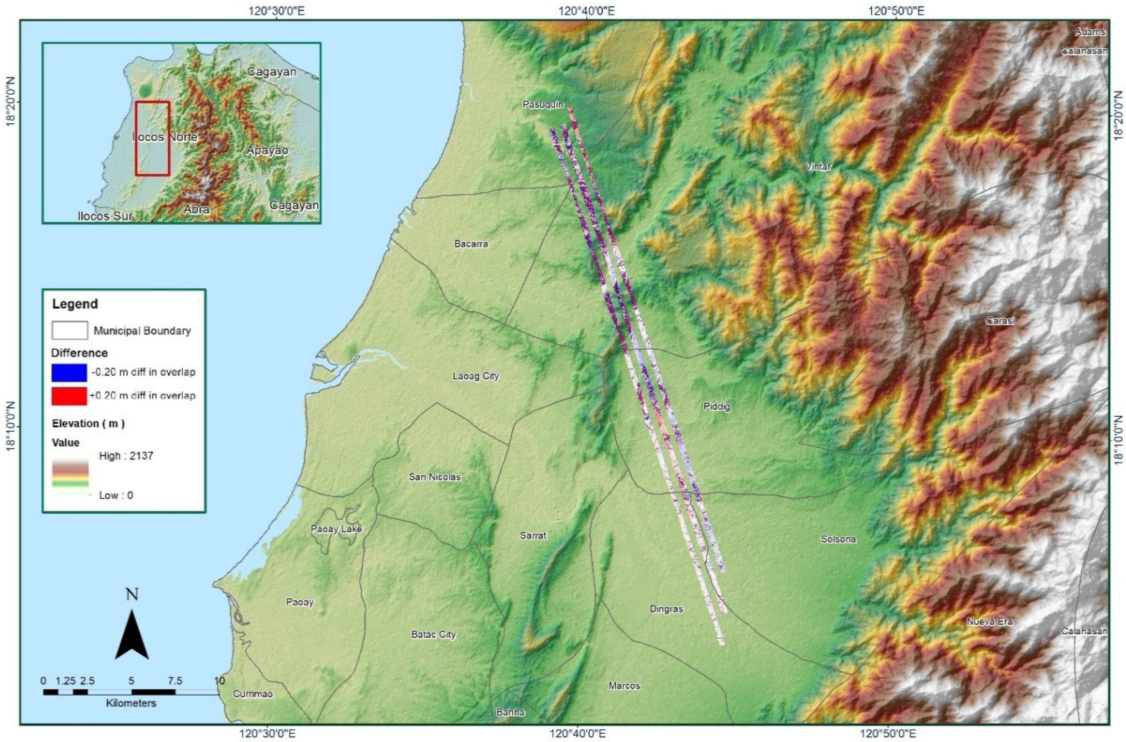


Figure A-8.56 Elevation difference between flight lines

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

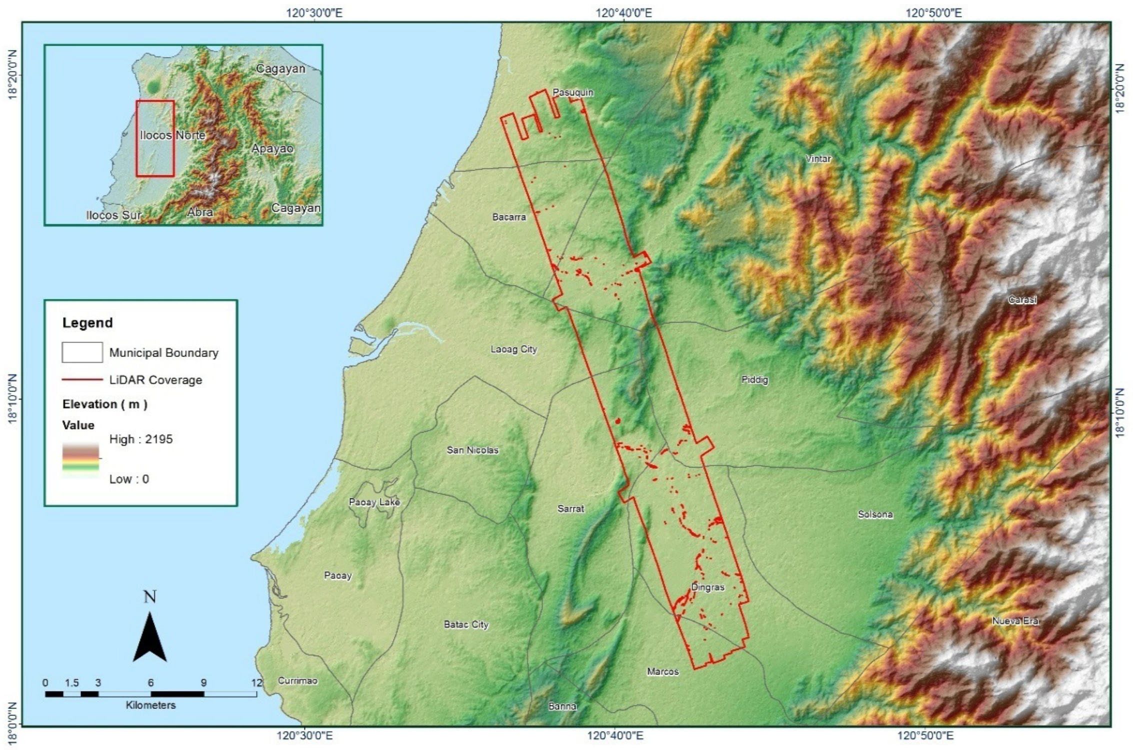


Figure A-8.57 Coverage of LiDAR data

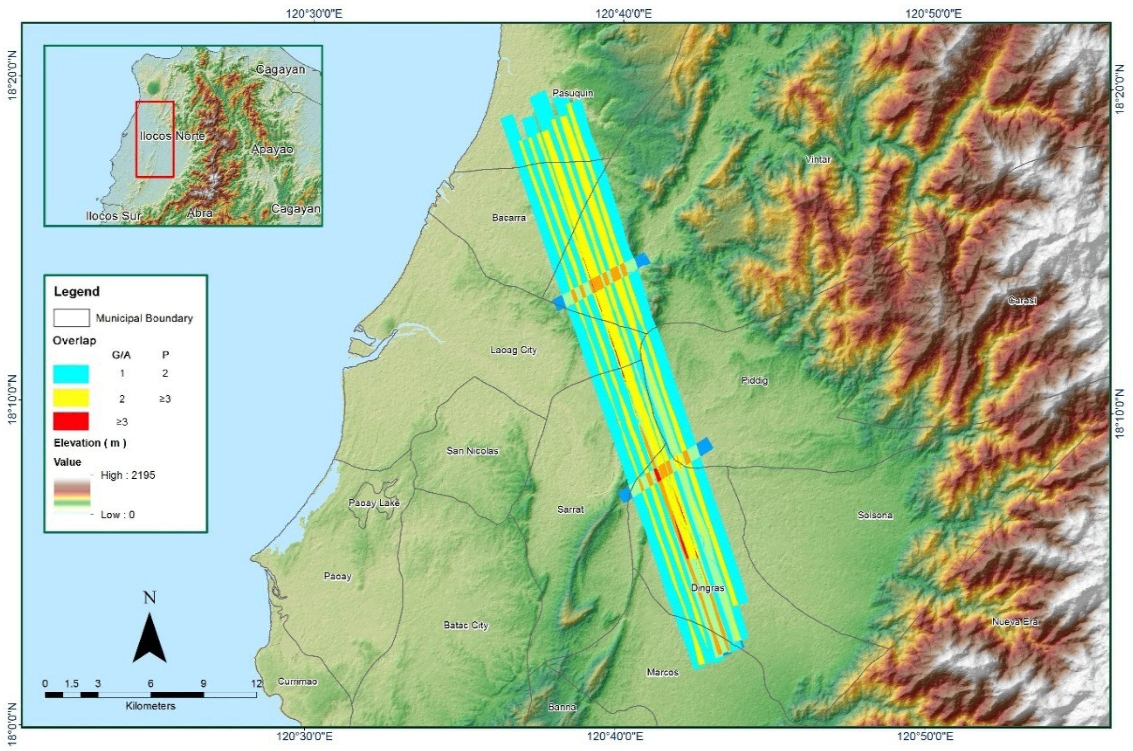


Figure A-8.58 Image of data overlap

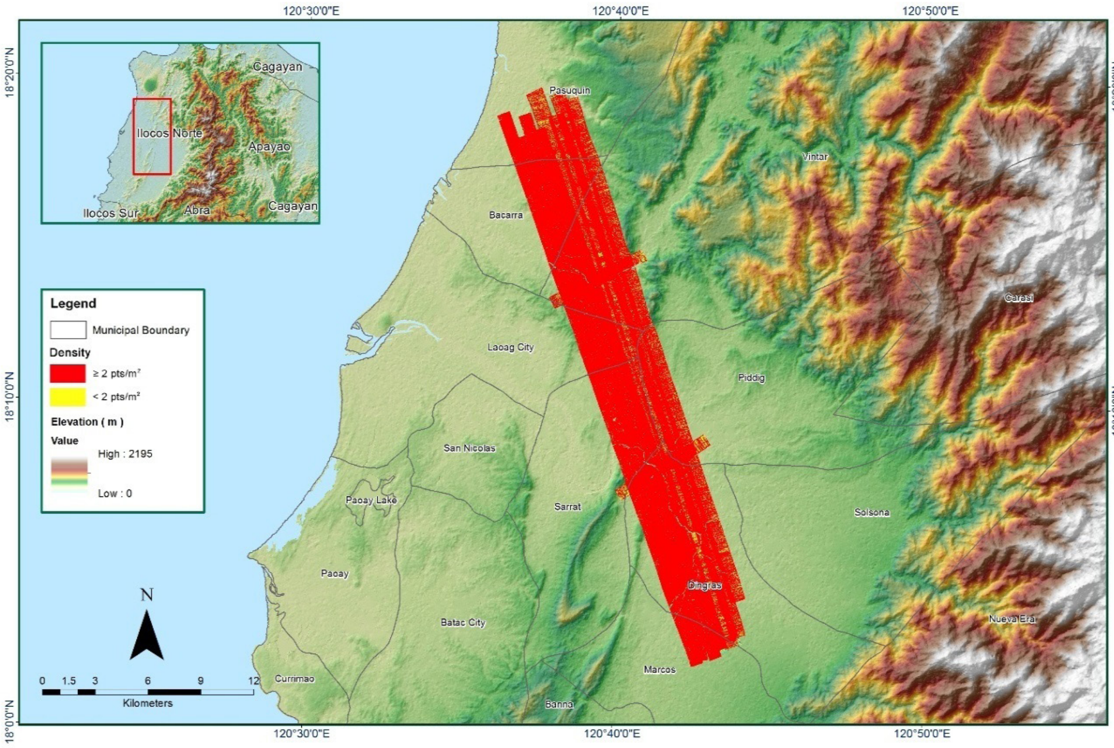


Figure A-8.59 Density map of merged LiDAR data

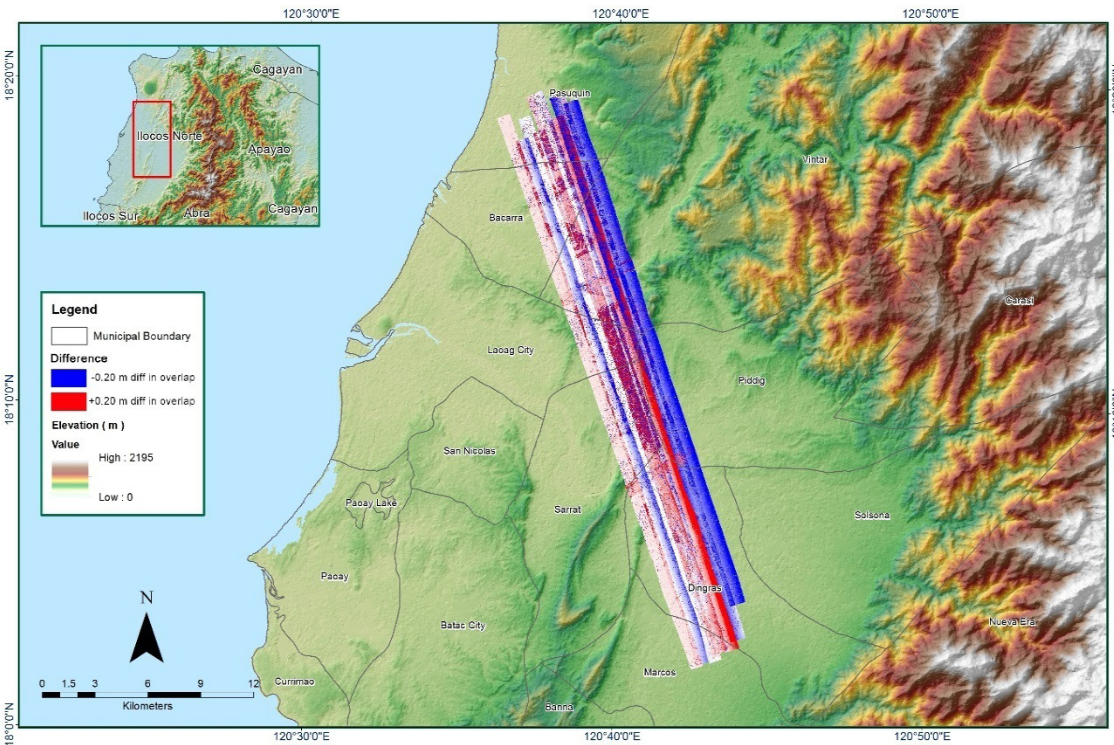


Figure A-8.60 Elevation difference between flight lines

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

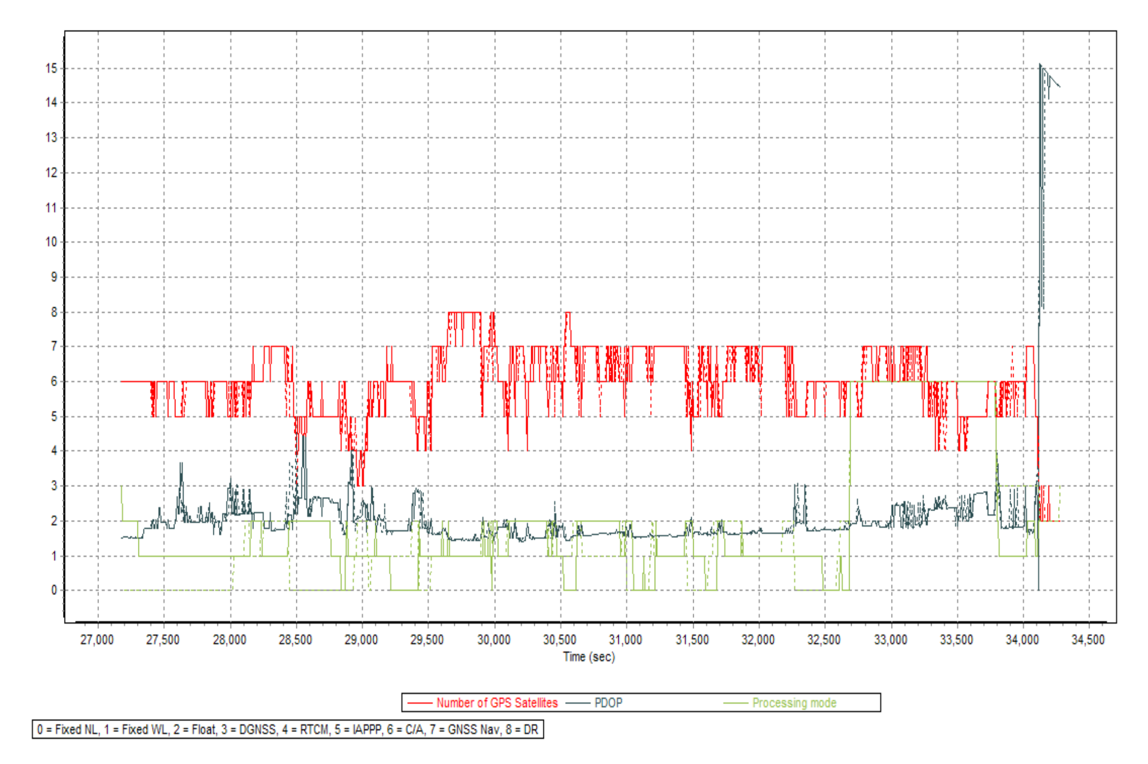


Figure A-8.61 Solution Status

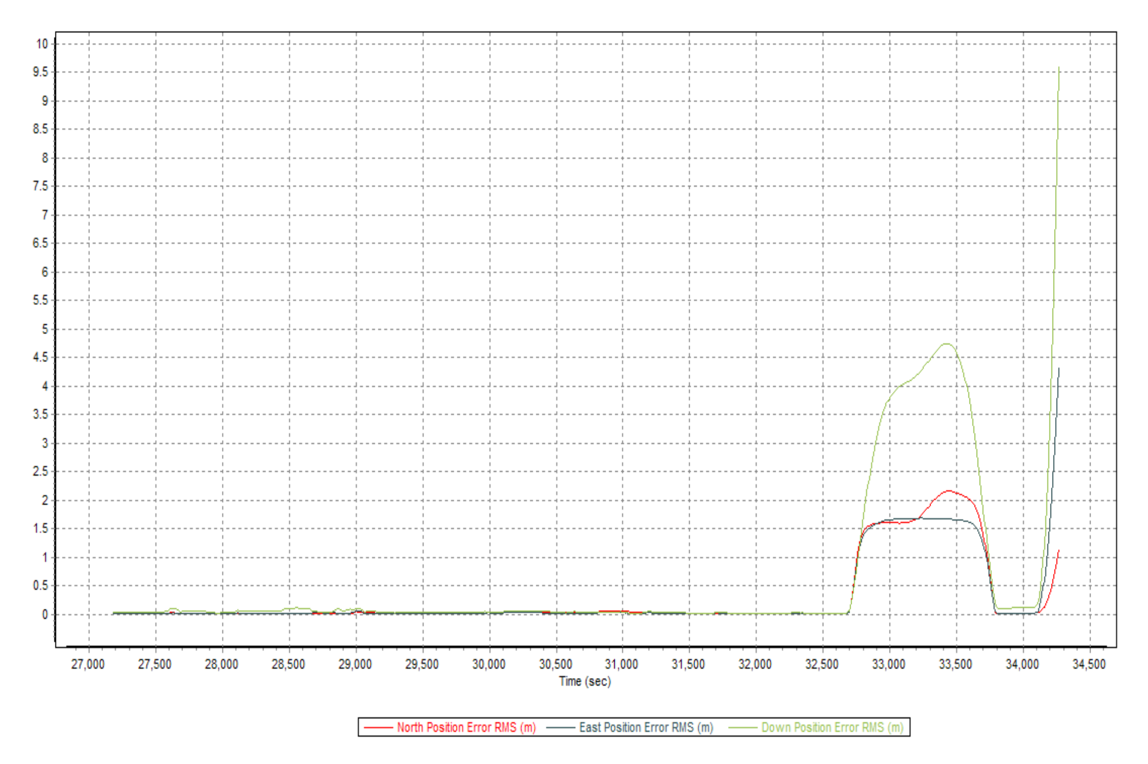


Figure A-8.62 Smoothed Performance Metric Parameters

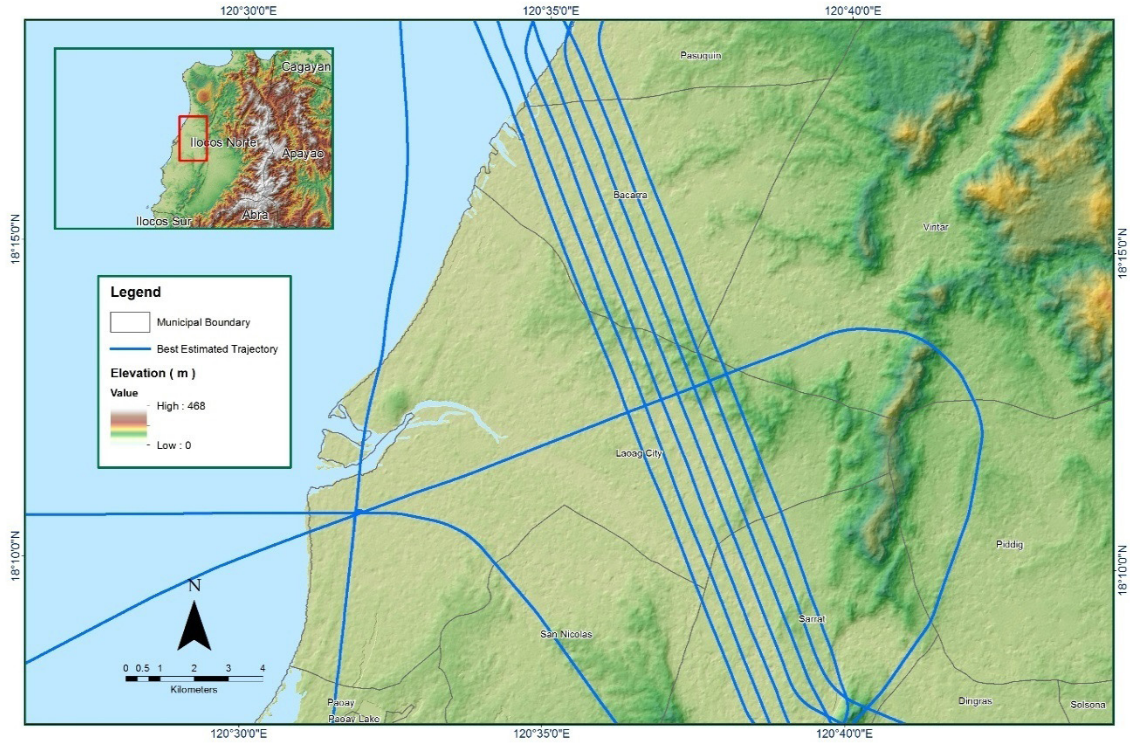


Figure A-8.63 Best Estimated Trajectory

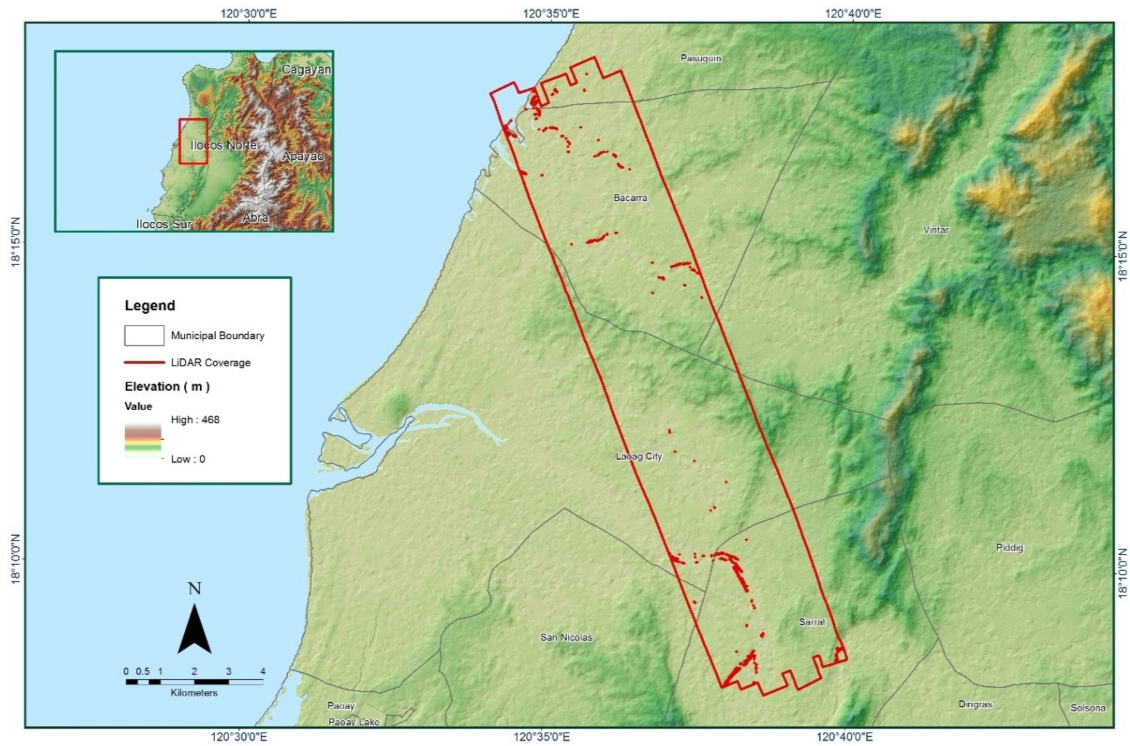


Figure A-8.64 Coverage of LiDAR data

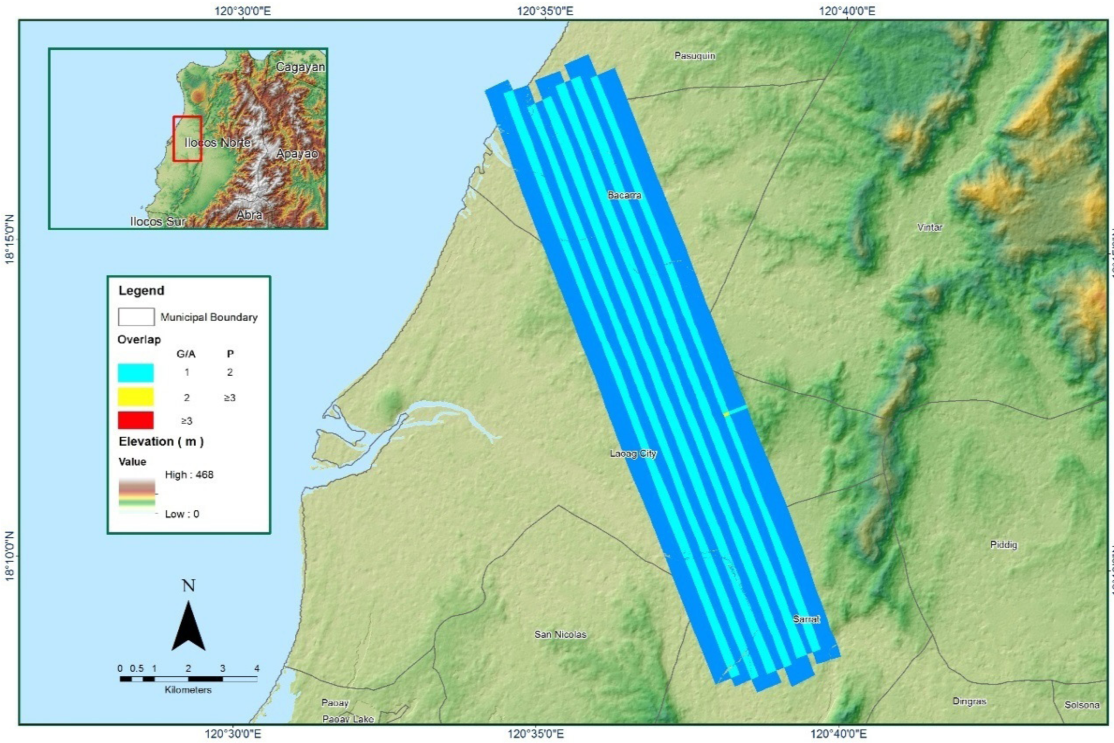


Figure A-8.65 Image of data overlap

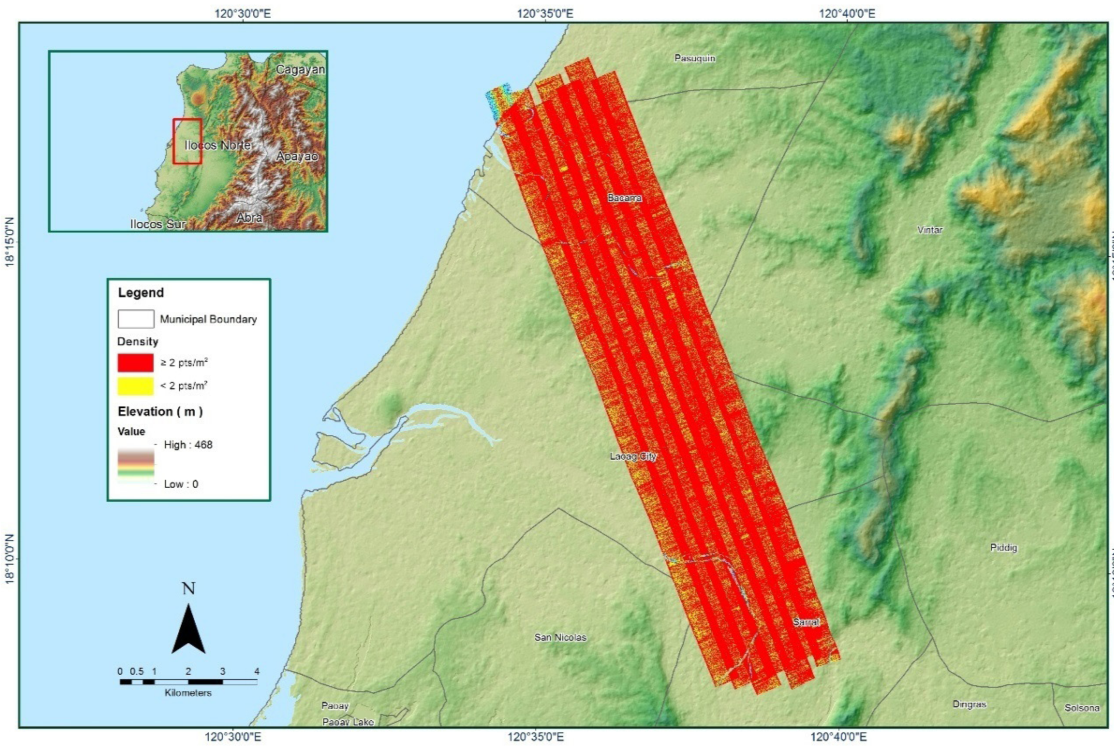


Figure A-8.66 Density map of merged LiDAR data

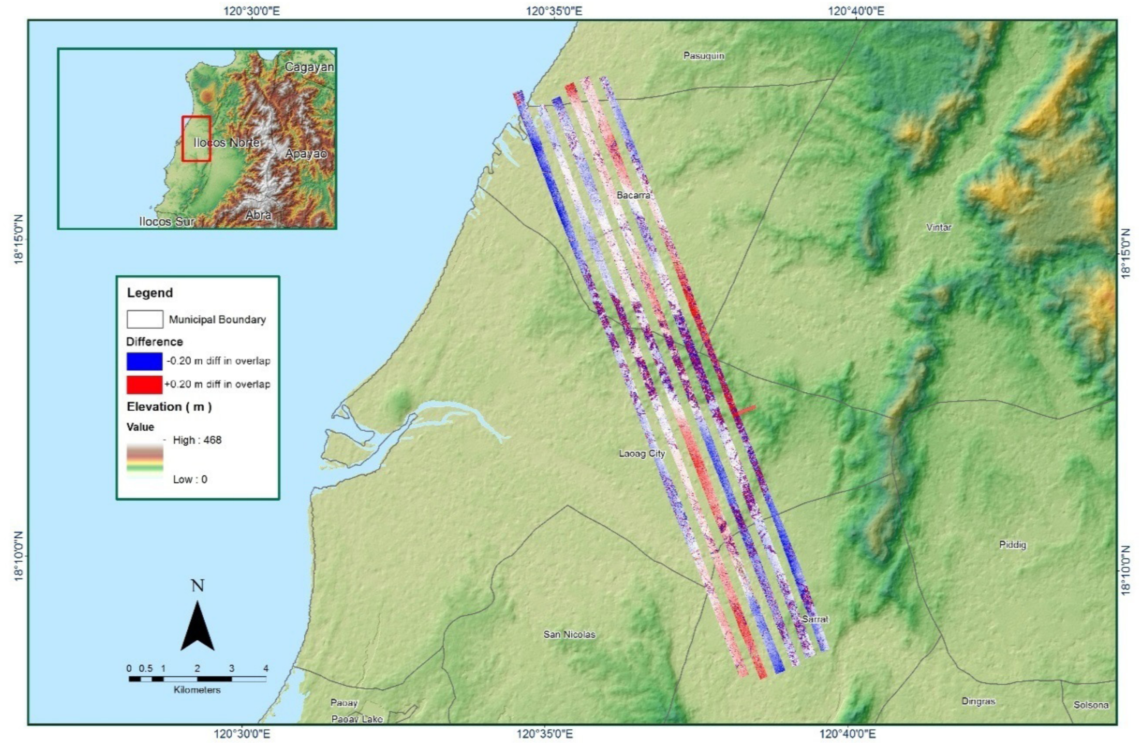


Figure A-8.67 Elevation difference between flight lines

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

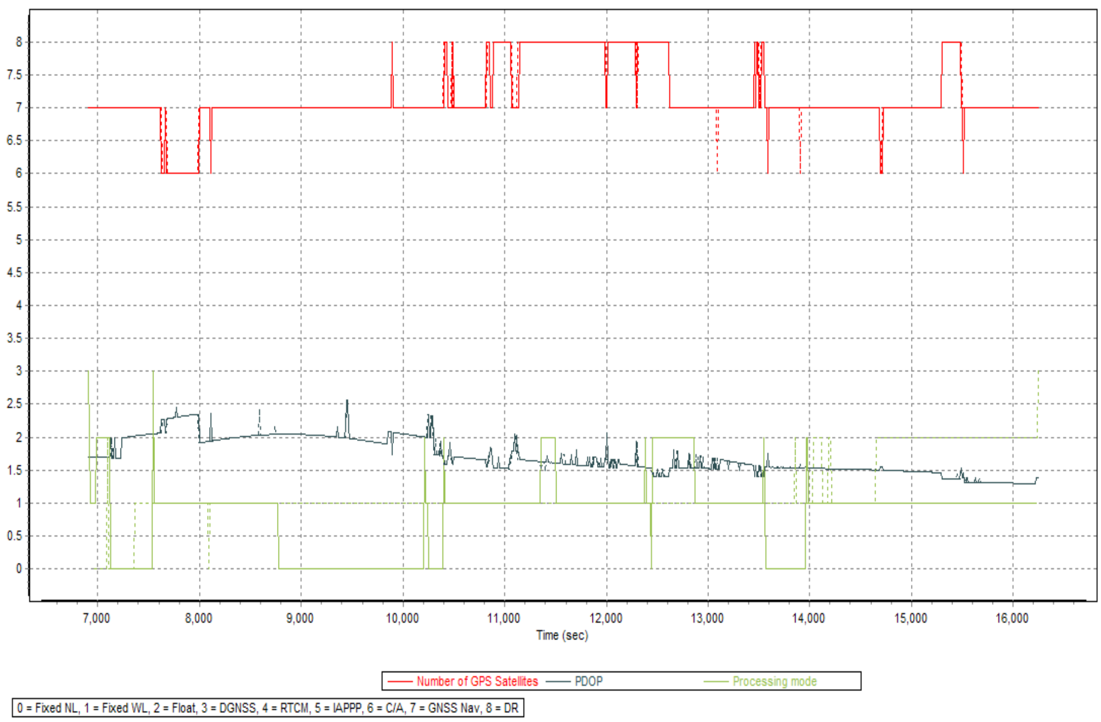


Figure A-8.68 Solution Status

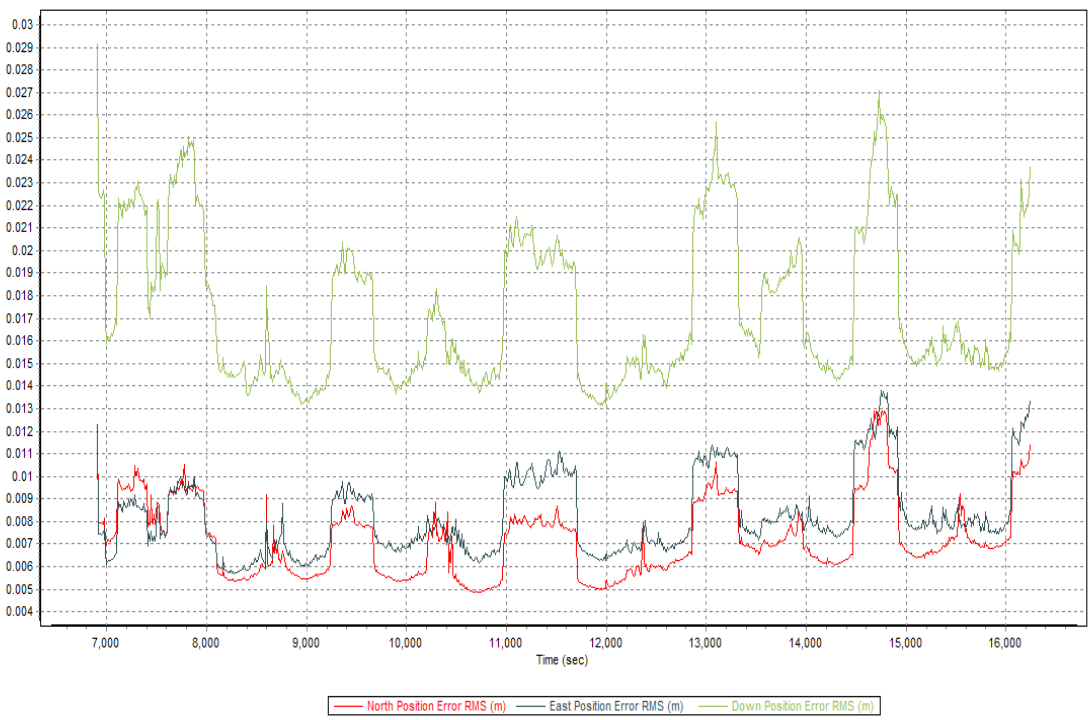


Figure A-8.69 Smoothed Performance Metric Parameters

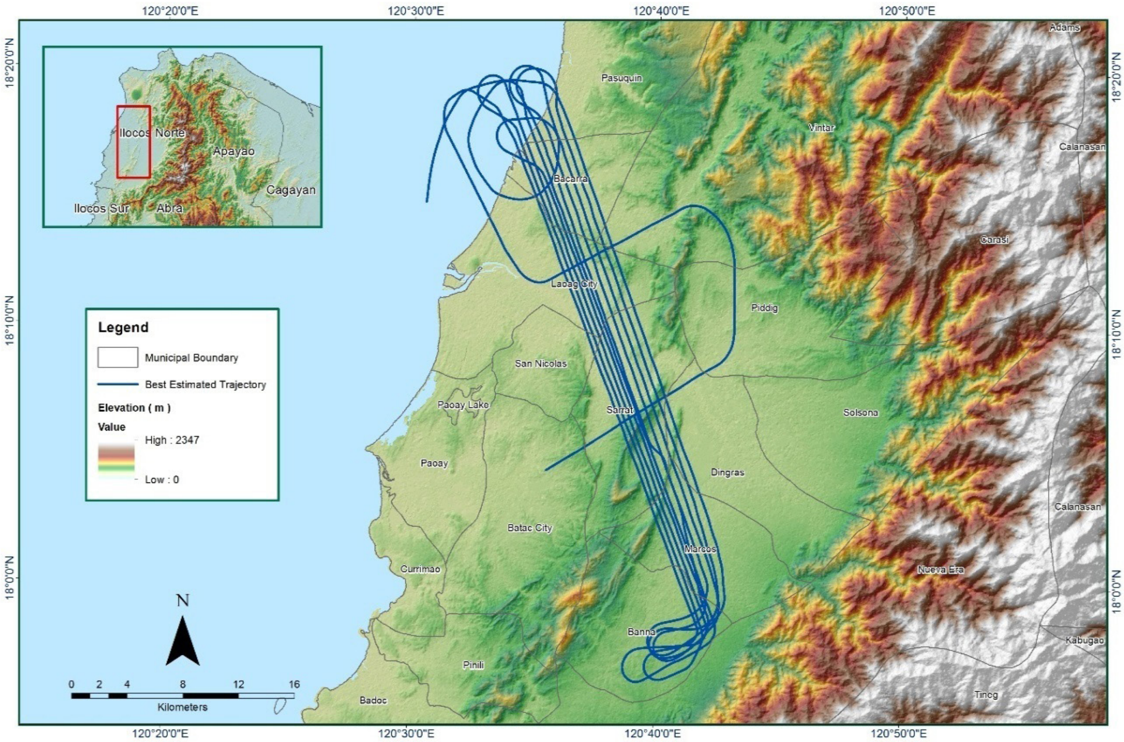


Figure A-8.70 Best Estimated Trajectory

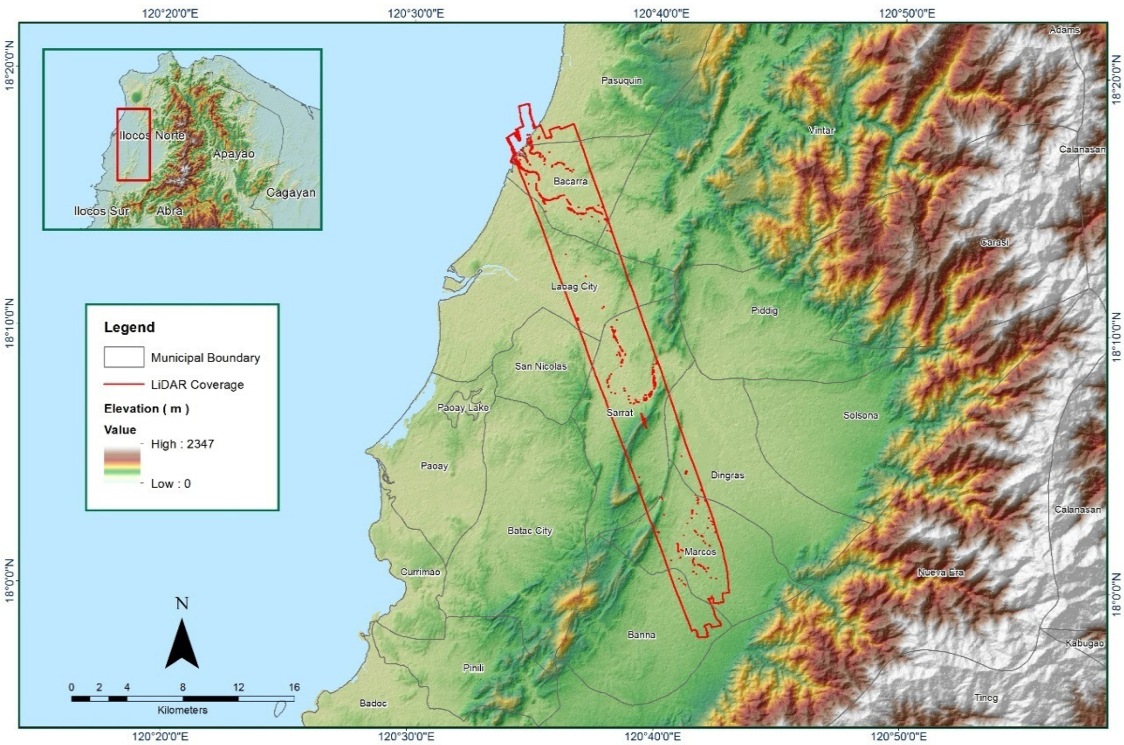


Figure A-8.71 Coverage of LiDAR data

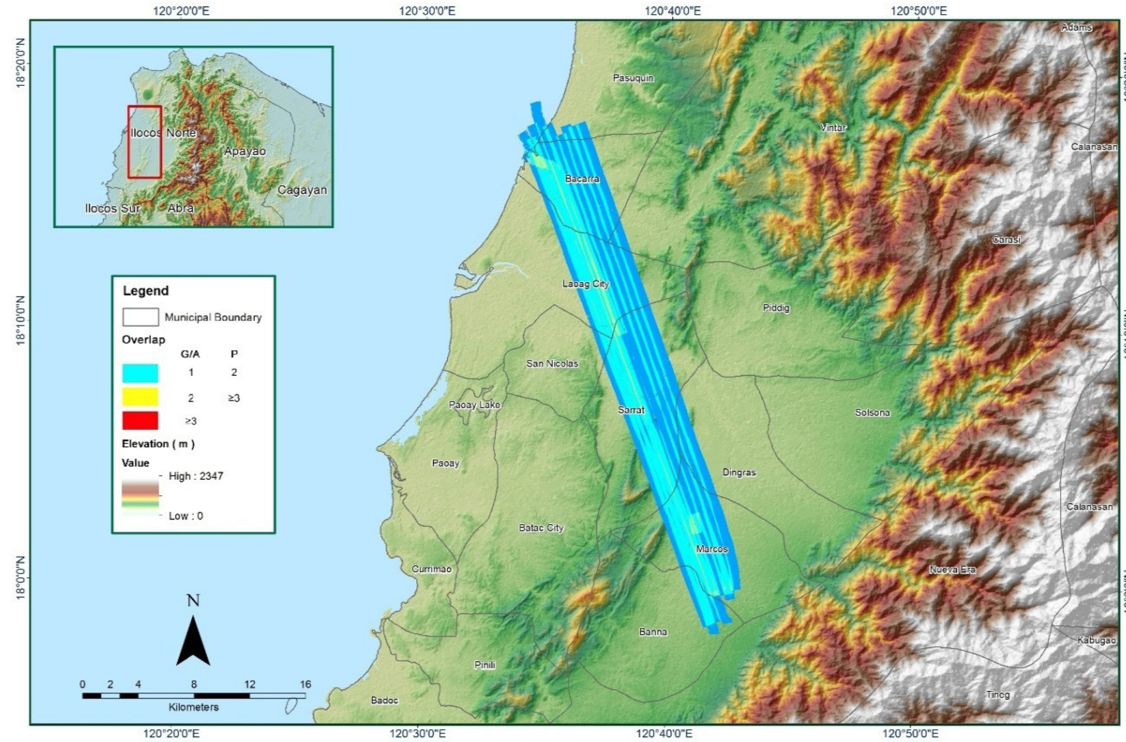


Figure A-8.72 Image of data overlap

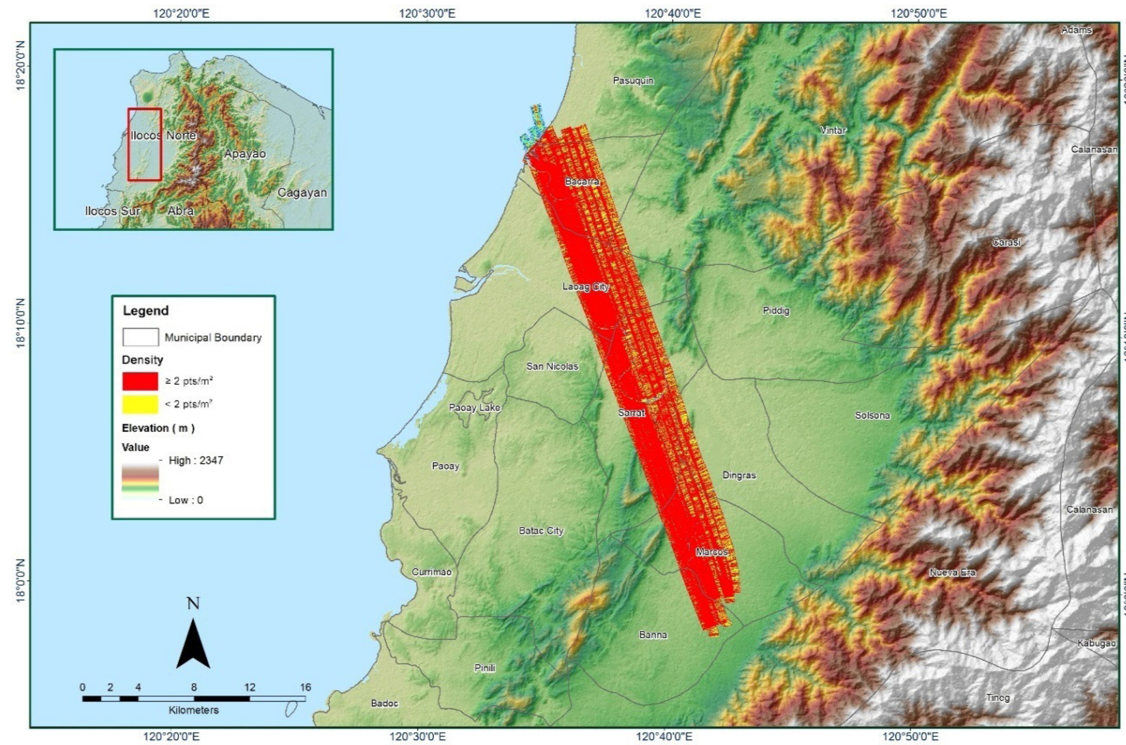


Figure A-8.73 Density map of merged LiDAR data

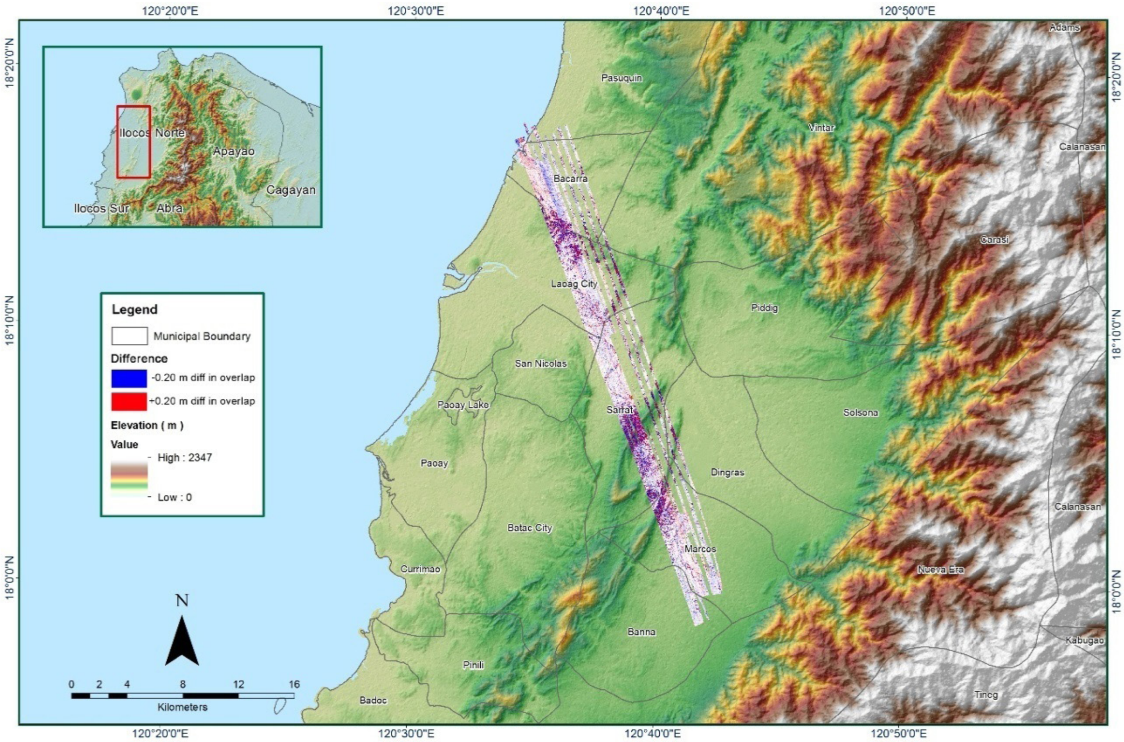


Figure A-8.74 Elevation difference between flight lines

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

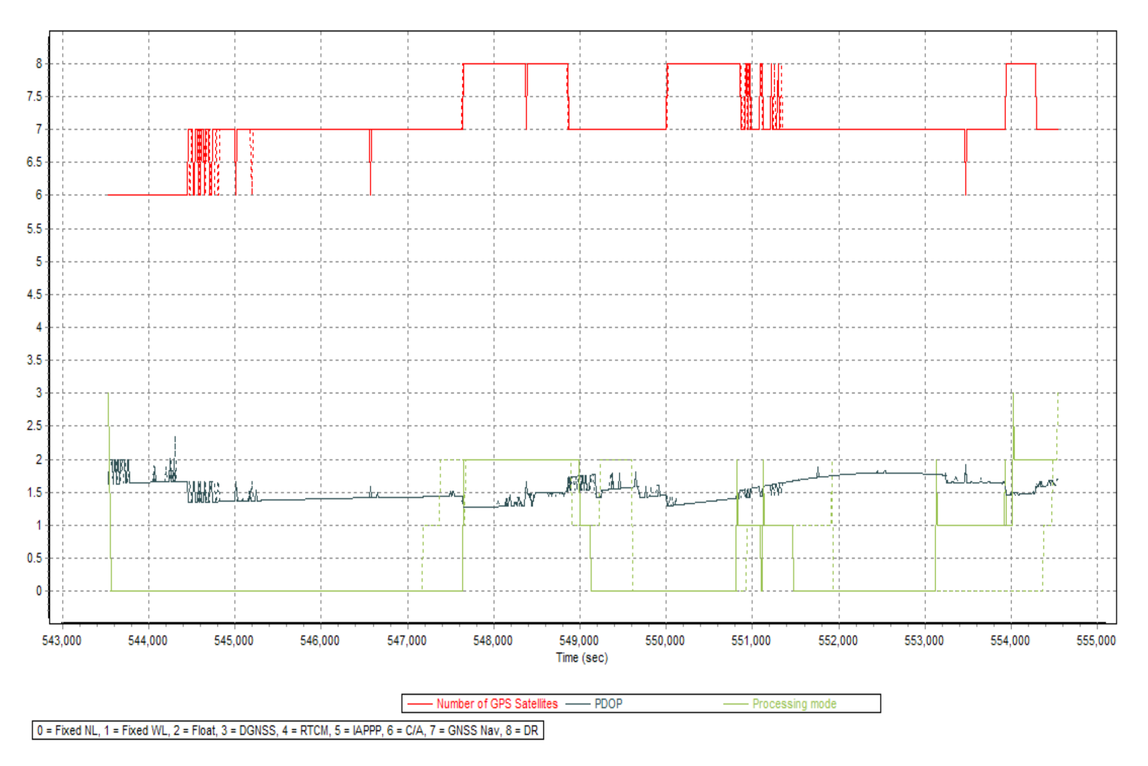


Figure A-8.75 Solution Status

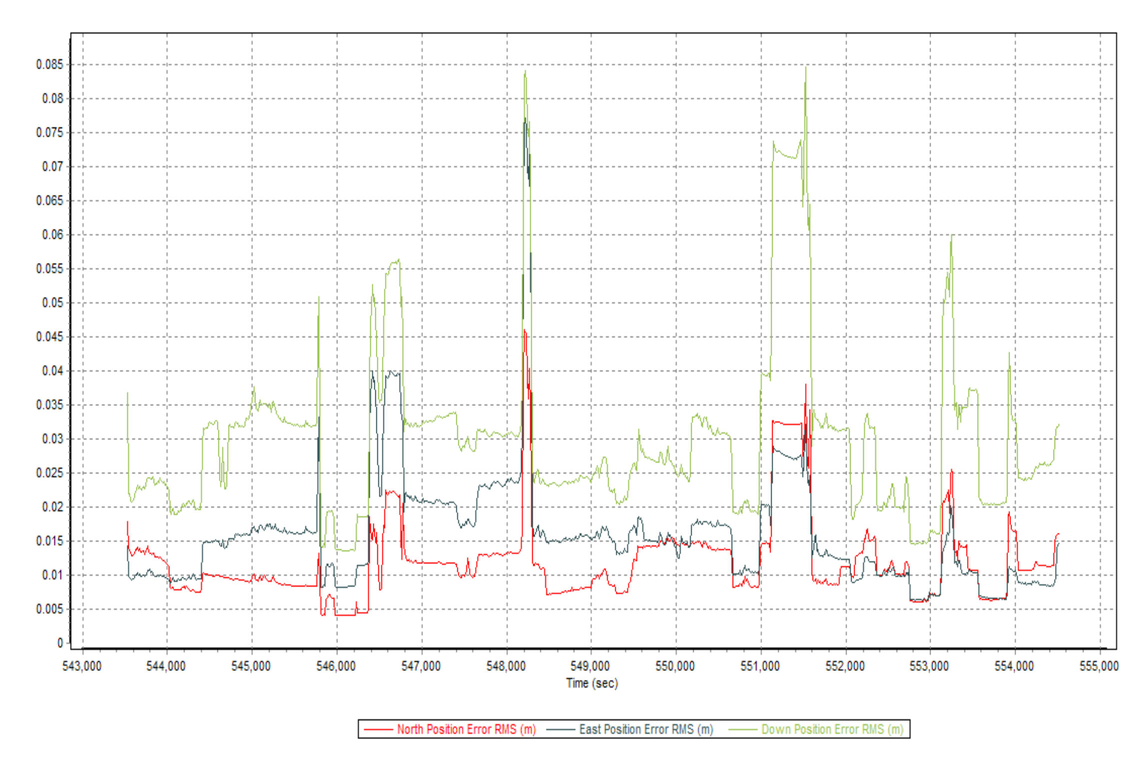


Figure A-8.76 Smoothed Performance Metric Parameters

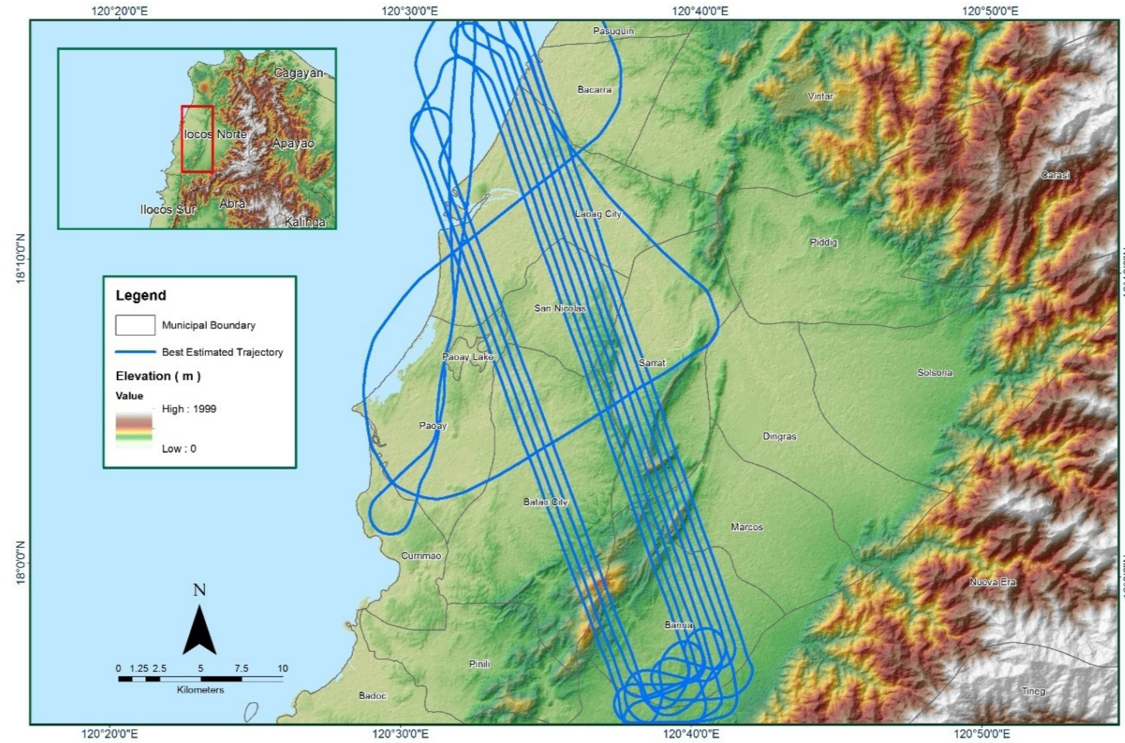


Figure A-8.77 Best Estimated Trajectory

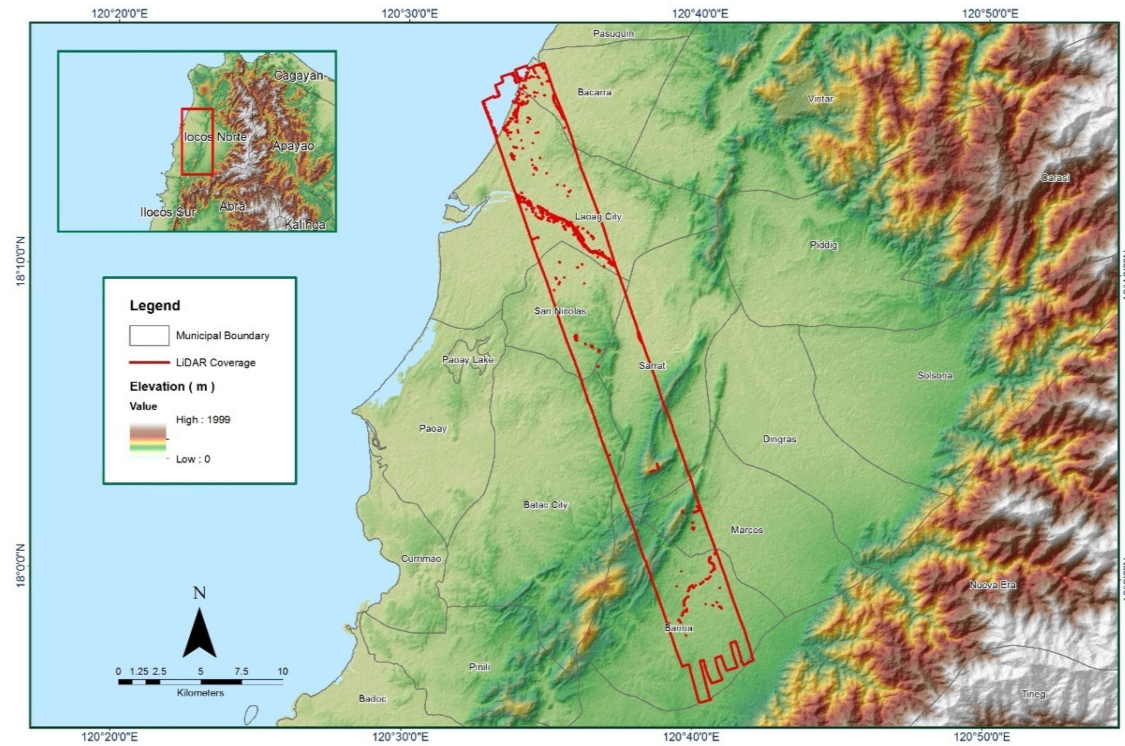


Figure A-8.78 Coverage of LiDAR data

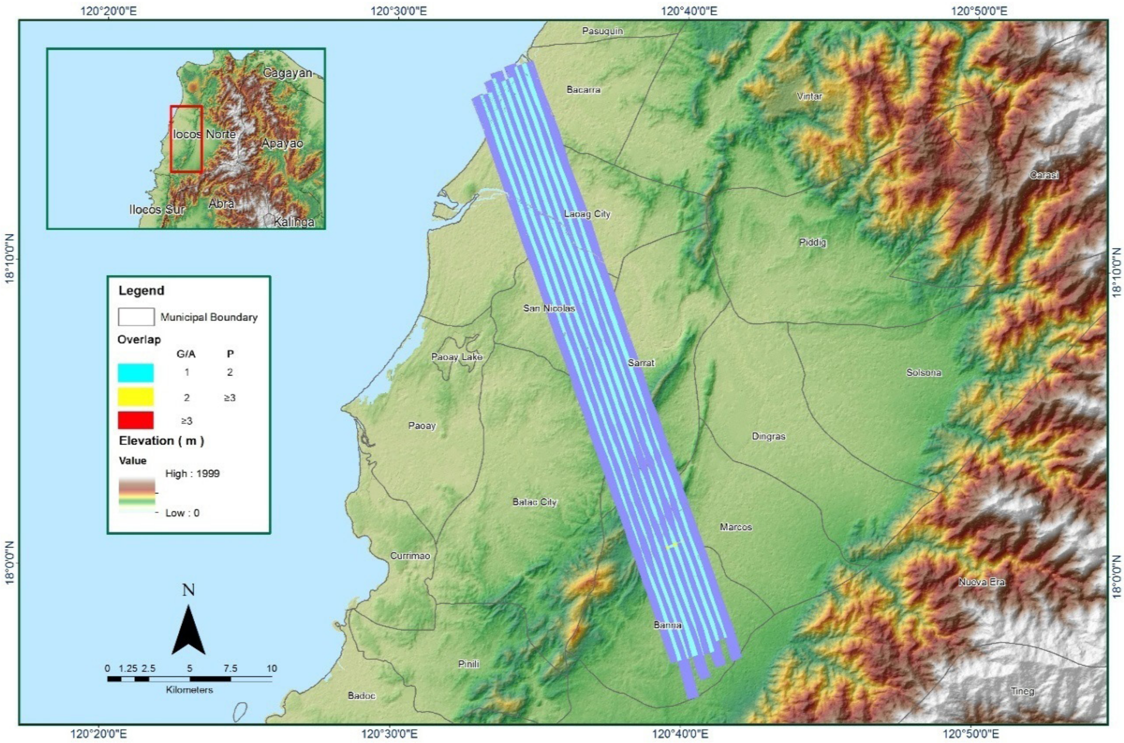


Figure A-8.79 Image of data overlap

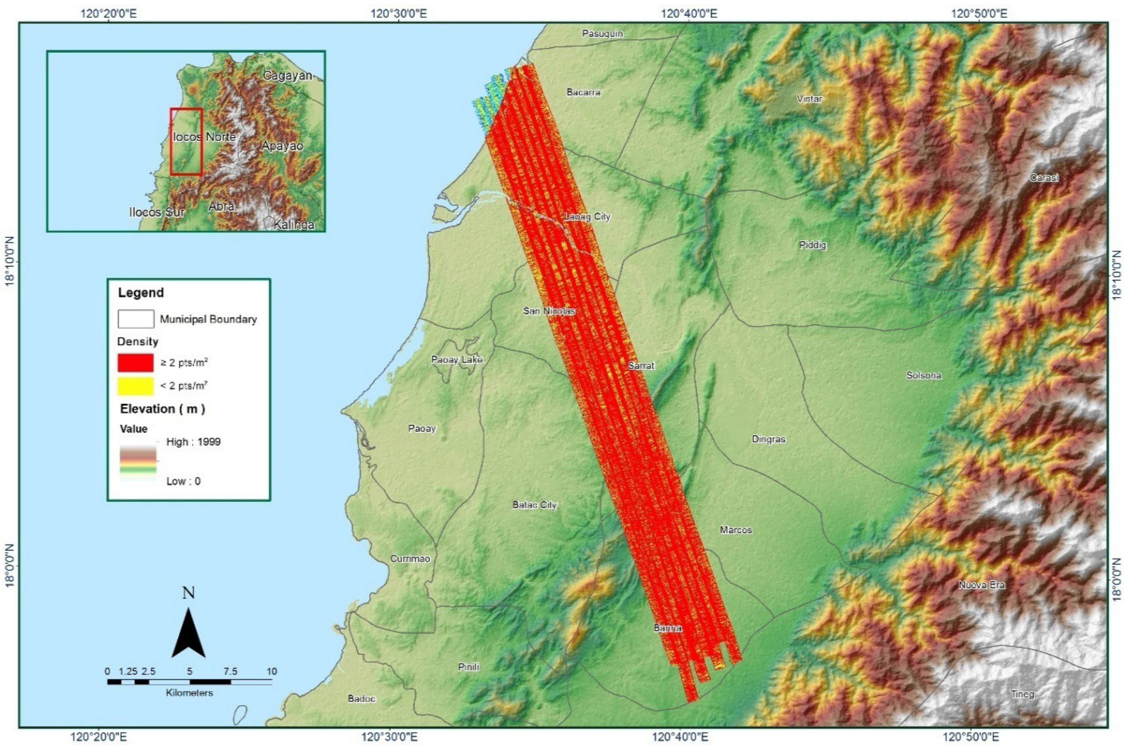


Figure A-8.80 Density map of merged LiDAR data

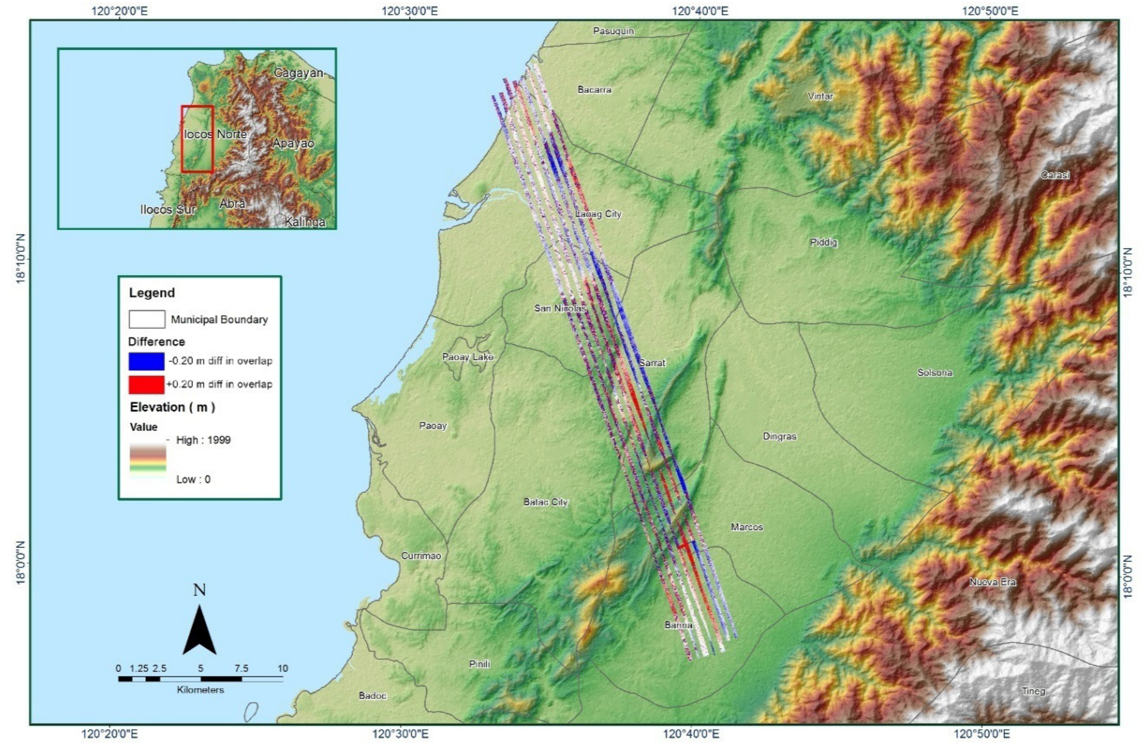


Figure A-8.81 Elevation difference between flight lines

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

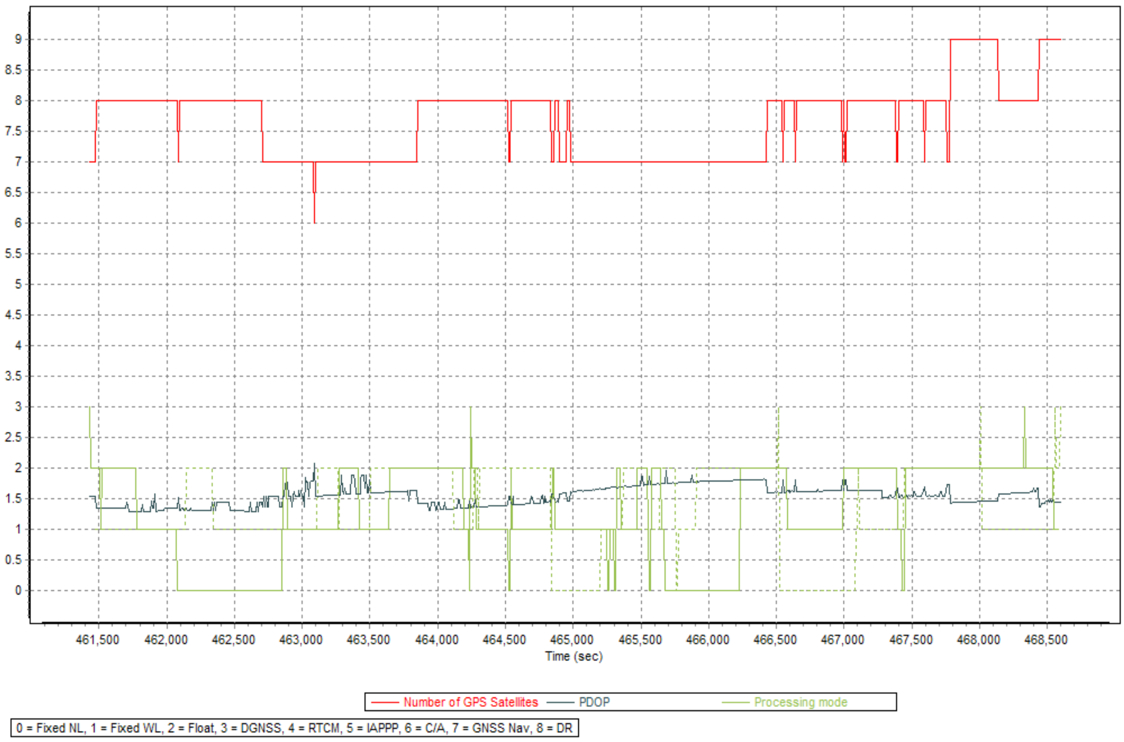


Figure A-8.82 Solution Status

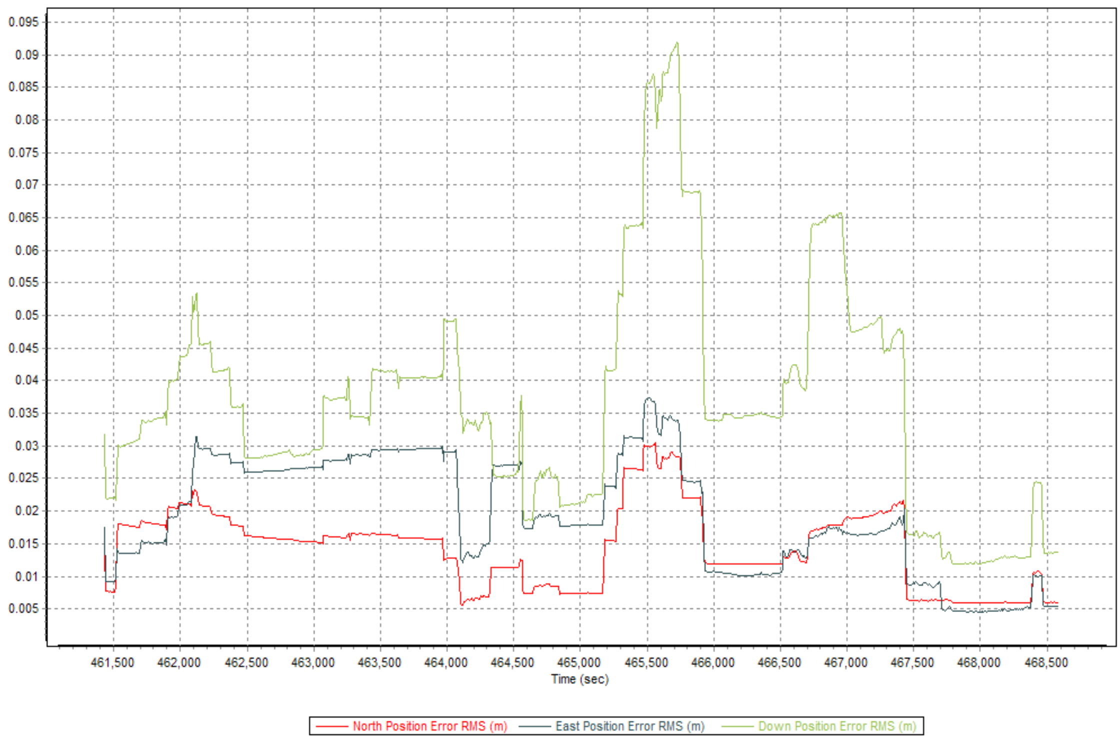


Figure A-8.83 Smoothed Performance Metric Parameters

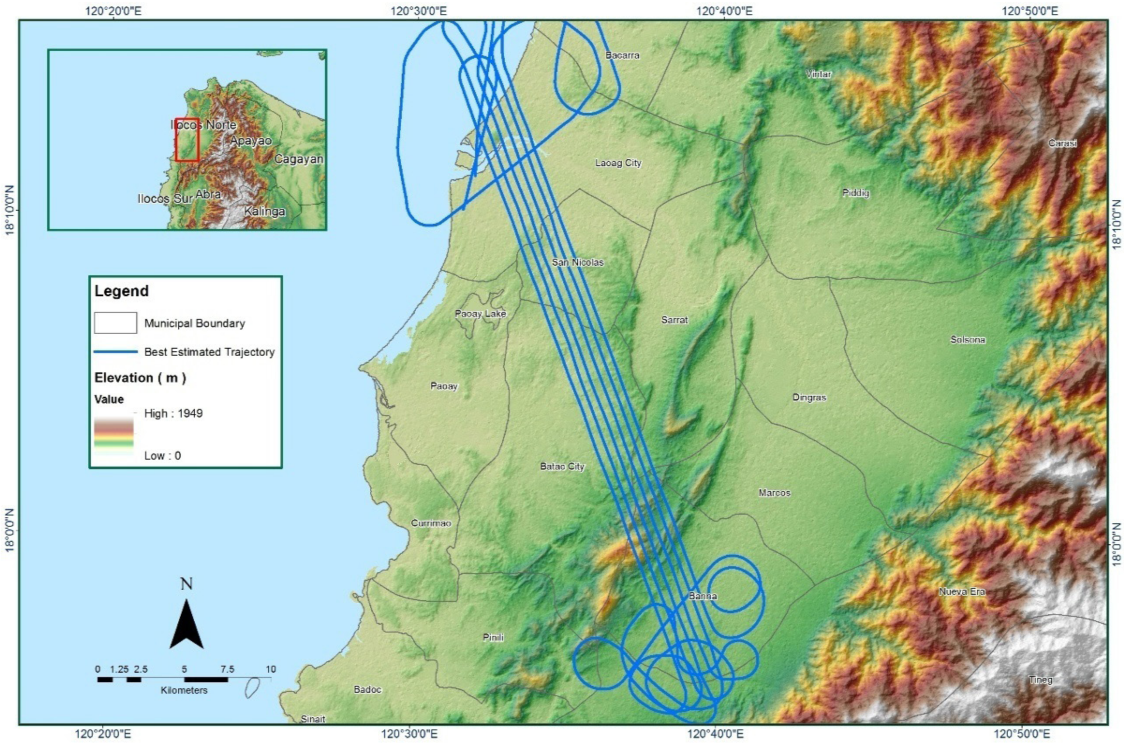


Figure A-8.84 Best Estimated Trajectory

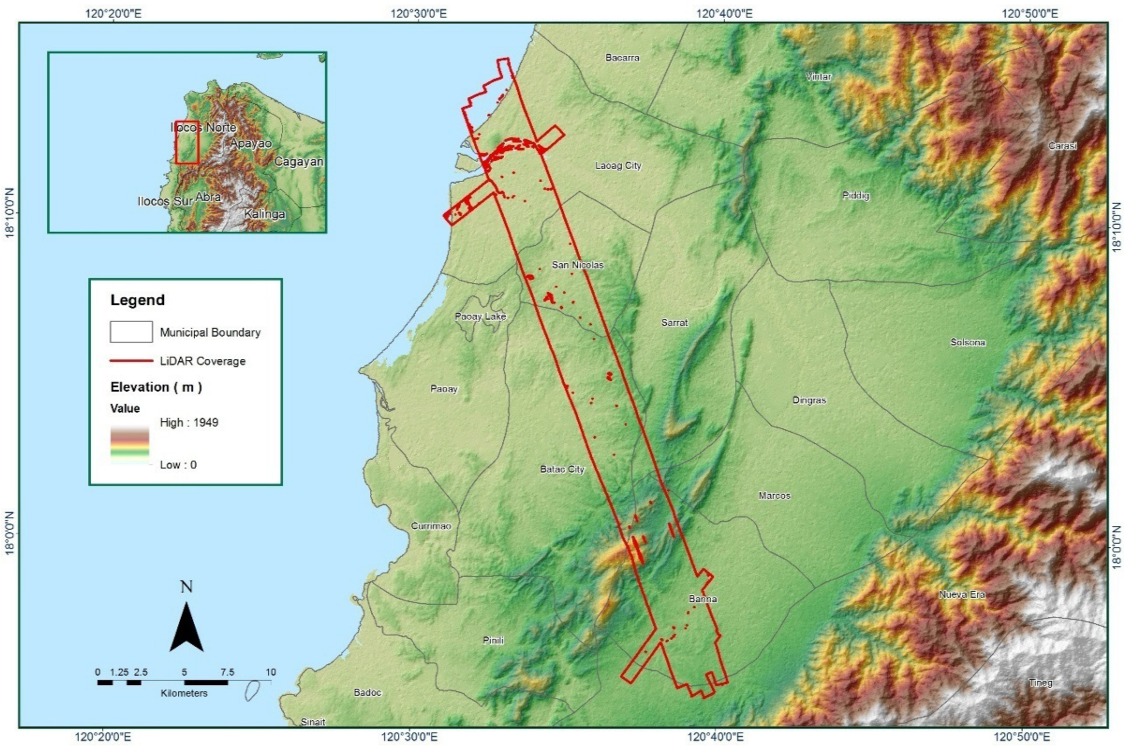


Figure A-8.85 Coverage of LiDAR data

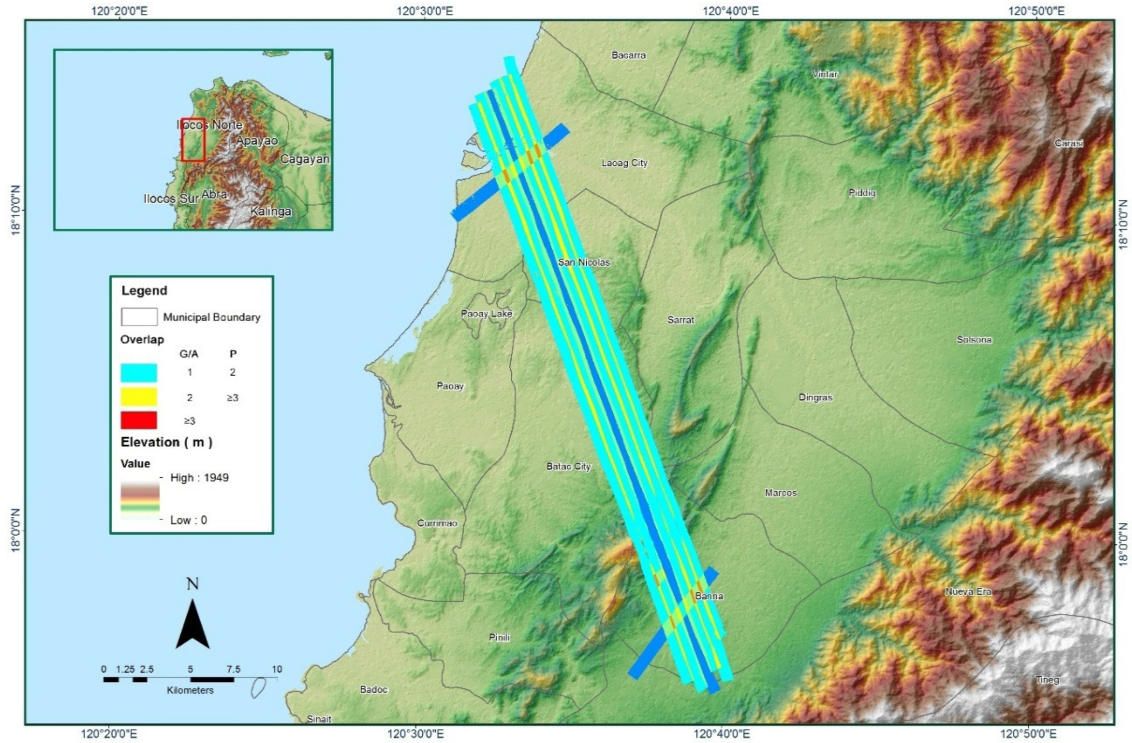


Figure A-8.86 Image of data overlap

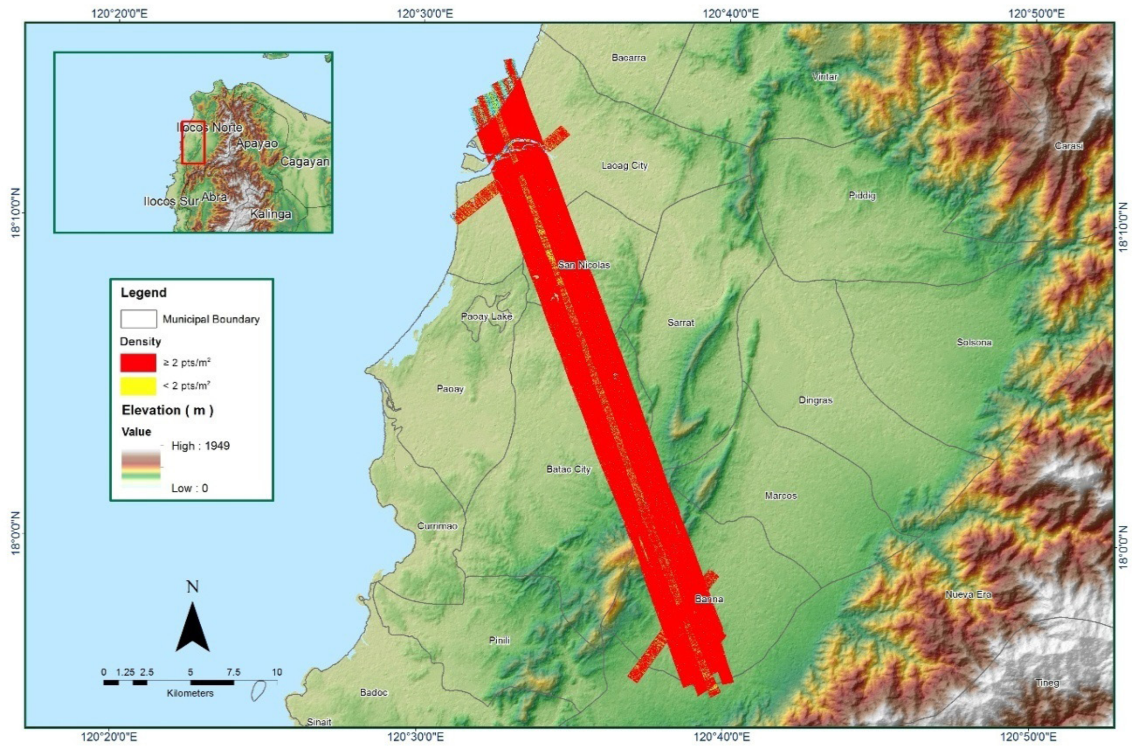


Figure A-8.87 Density map of merged LiDAR data

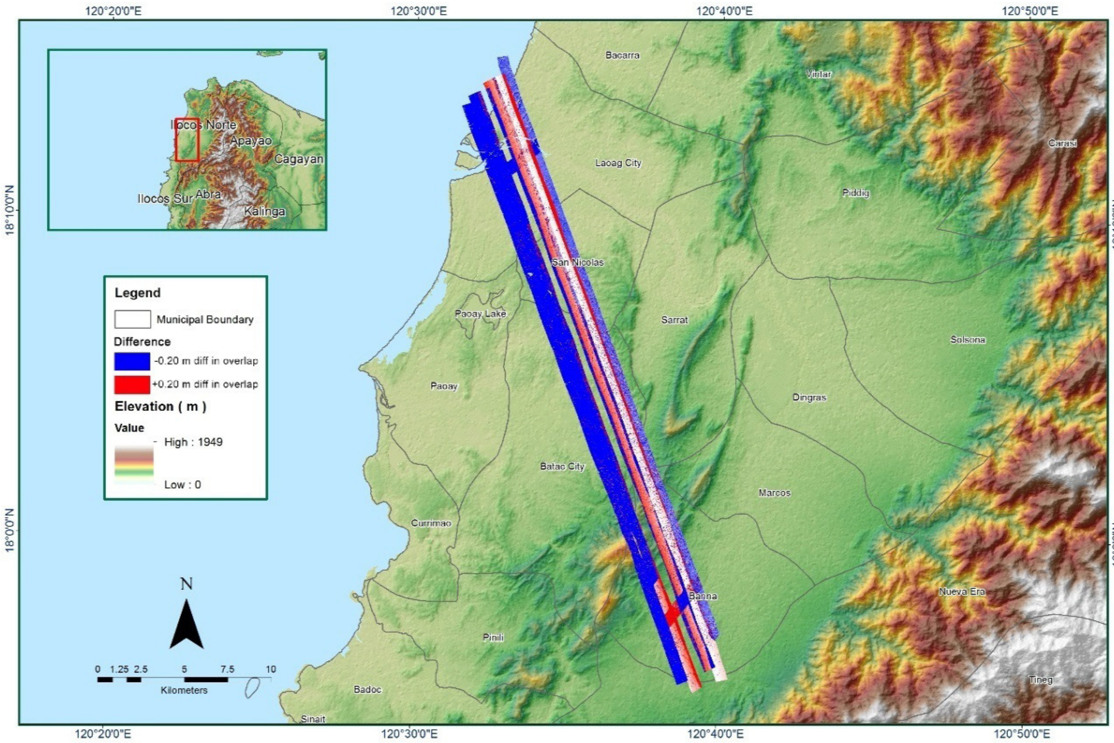


Figure A-8.88 Elevation difference between flight lines

Annex 9. Kilbay-Catabangan Model Basin Parameters

Table A-9.1. Kilbay-Catabangan 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. Kilbay-Catabangan Model Reach Parameters

Table A-10.1. Kilbay-Catabangan 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. Kilbay-Catabangan Field Validation Points

Table A-11.1. Kilbay-Catabangan 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 Kilbay-Catabangan Floodplain

Table A-12.1. Educational Institutions affected by flooding in Kilbay-Catabangan 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, Dib-ua South			
CATABAN PS	Bgy. No. 61, Cata-ban			
NAVOTAS ES	Bgy. No. 62-A, Navotas North			
CAAOACAN ES	Bgy. No. 6-A, Caao-acan			

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 Kilbay-Catabangan Floodplain

Table A-13.1. Medical Institutions in Bacarra, Ilocos Norte affected by flooding in Kilbay-Catabangan 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			