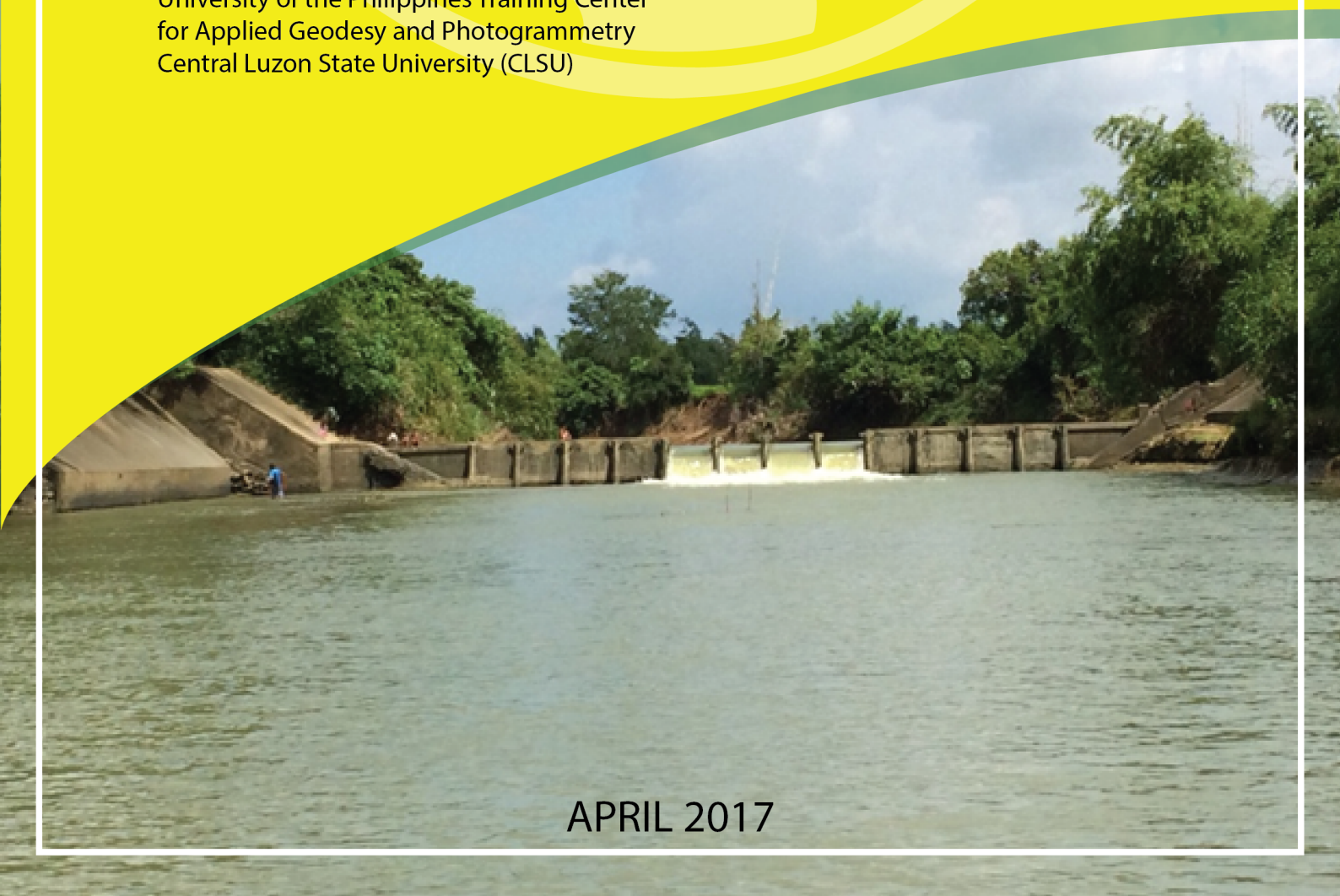
Hazard Mapping of the Philippines Using LIDAR (Phil-LIDAR 1)

LiDAR Surveys and Flood Mapping of Alaminos River

University of the Philippines Training Center
for Applied Geodesy and Photogrammetry
Central Luzon State University (CLSU)



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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
UTM	Universal Transverse Mercator
WGS	World Geodetic System

CHAPTER 1: OVERVIEW OF THE PROGRAM AND ALAMINOS RIVER

Enrico C. Paringit, Dr. Eng., Dr. Annie Melinda Paz-Alberto, and Ms. Kathrina M. Mapanao

1.1 Background of the Phil-LIDAR 1 Program

The University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP-TCAGP) launched a research program entitled "Nationwide Hazard Mapping using LiDAR" or Phil-LiDAR 1 in 2014, supported by the Department of Science and Technology (DOST) 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.

The program was also aimed at producing an up-to-date and detailed national elevation dataset suitable for 1:5,000 scale mapping, with 50 cm and 20 cm horizontal and vertical accuracies, respectively. These accuracies were achieved through the use of the state-of-the-art Light Detection and Ranging (LiDAR) airborne technology procured by the project through DOST. The methods applied in this report are thoroughly described in a separate publication titled Flood Mapping of Rivers in the Philippines Using Airborne LiDAR: Methods (Paringit et al., 2017).

The implementing partner university for the Phil-LiDAR 1 Program is the Central Luzon State University (CLSU). CLSU 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 8 river basins in the Central Luzon Region. The university is located in the Science City of Muñoz in the province of Nueva Ecija.

1.2 Overview of the Alaminos River Basin

Alaminos River Basin covers most of the City of Alaminos, the Municipality of Sual, and a small portion of the Municipality of Mabini, all of which are in Pangasinan. The DENR-RCBO identified it to be one of the 421 river basins in the Philippines, having a drainage area of 200 km2 and an estimated 224 million cubic meter annual run-off. It is also one of the major river basins in Pangasinan.

Its main stem, Alaminos River, passes along Alaminos City and a small portion of the Municipality of Sual. There is a total of 38,798 people residing within the immediate vicinity of the river. The population is distributed among thirteen (13) barangays, namely: Cabutuan, Balangobong, Palamis, Poblacion, Amandiego, Magsaysay, San Jose, Lucap, Cayucay, Polo, Mona, and Pangapisan in Alaminos City; and Seselangen in the Municipality of Sual (NSO, 2010). Meanwhile, based on the latest Census of Population conducted and released by the National Statistical Coordination Board (NSCB) in 2010, there were about 107,086 people who are living within the watershed. Alaminos was the most populous with 70,454 people, followed by Mabini with 18,869 people and Sual with 17,763 people (DENR, 2013).

Alaminos river watershed is one of the very important resources in the country, specifically in the province of Pangasinan. Pangasinan is the third biggest province in the whole Philippine archipelago, and its name is derived from salt or "asin" in the vernacular. Owing to rich and fine salt beds which are the prime source of livelihood for the province's coastal towns, "Pinagasinan or Pangasian" which means "where salt is made" came to be its name.

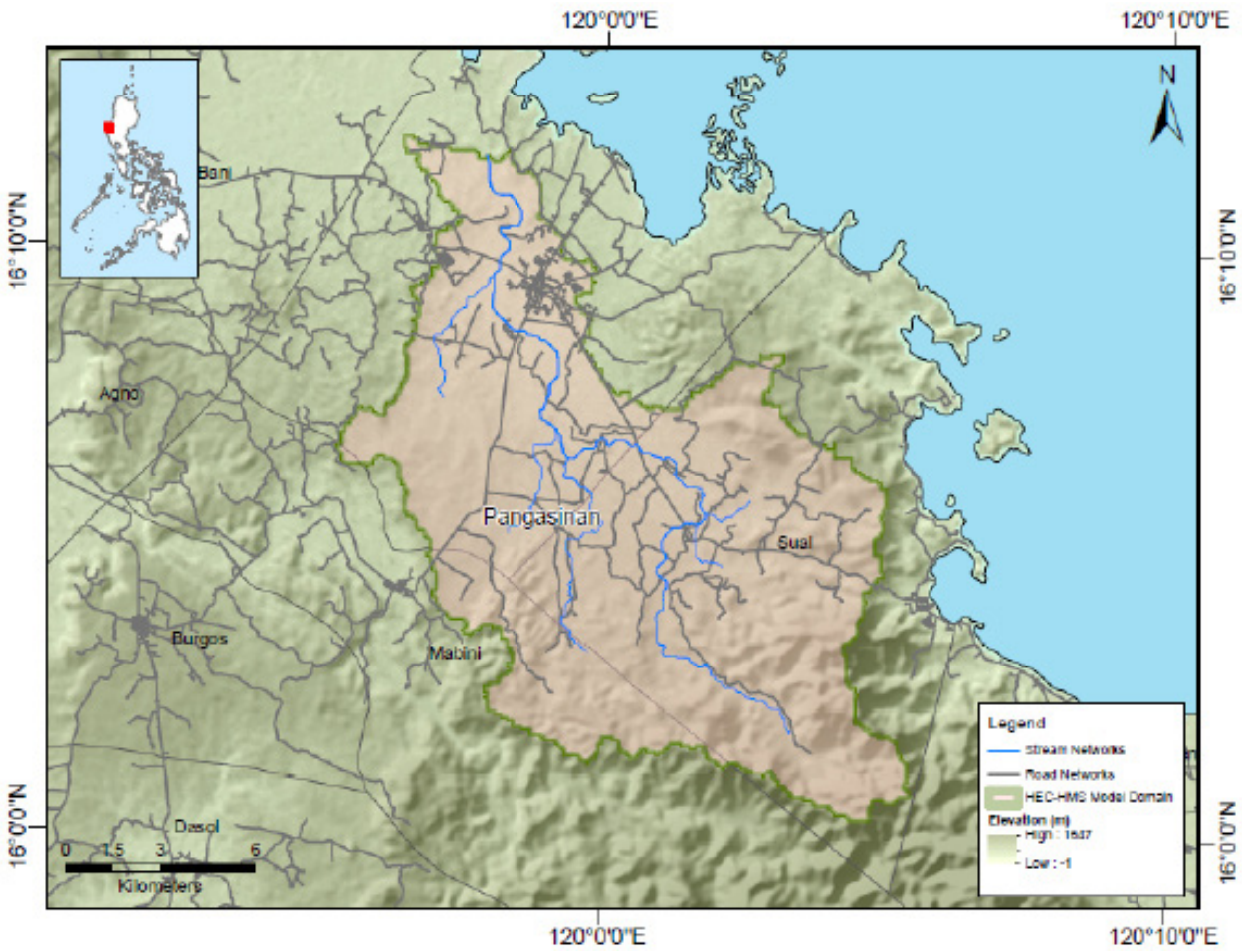

Figure 1. Map of Alaminos River Basin (in brown)

The watershed is composed of flat to rolling hills and steep mountains. Elevation ranges from 2 meters above sea level (masl) to 410 masl. The lowest elevation is located in Brgy. Pangapisan, Alaminos while the highest elevation is located in Brgy. Sioasio East, Sual.

Agriculture is the main source of income in Alaminos. From the three components of the agriculture sector such as crops, fishery and livestock, majority of the household obtained their earnings from farming. Other residents are also engaged in fishing and fish trading, because Alaminos City is endowed with diverse coastal and marine resources.

CHAPTER 2: LIDAR ACQUISITION IN ALAMINOS 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 Alaminos Floodplain in Pangasinan. These missions were planned for nine (9) lines and ran for at most four and a half (4.5) hours including take-off, landing, and turning time. The flight planning parameters for the LiDAR system are found in Table 1 and Table 2. Figure 2 and Figure 3 show the flight plans and base stations for Alaminos Floodplain.

Table 1. Flight planning parameters for Pegasus LiDAR system

Block Name	Flying Height (AGL)	Overlap (%)	Field of View	Pulse Repetition Frequency (PRF) (kHz)	Scan Frequency	Average Speed	Average Turn Time (Minutes)
12AC	1200	30	50	200	30	130	5
12C	1200	30	50	200	30	130	5
12D	1000, 850	30	50	200, 250	30	130	5

Table 2. Flight planning parameters for Gemini LiDAR system

Block Name	Flying Height (AGL)	Overlap (%)	Field of View	Pulse Repetition Frequency (PRF) (kHz)	Scan Frequency	Average Speed	Average Turn Time (Minutes)
BLK15	1000	30	40	100	50	125	5
BLK12A	1000	30	40	100	50	125	5
BLK12C	1000	30	40	100	50	125	5
BLK12D	1000	30	40	100	50	125	5
BLK12E	1000	30	40	100	50	125	5
BLK12F	1000	30	40	100	50	125	5

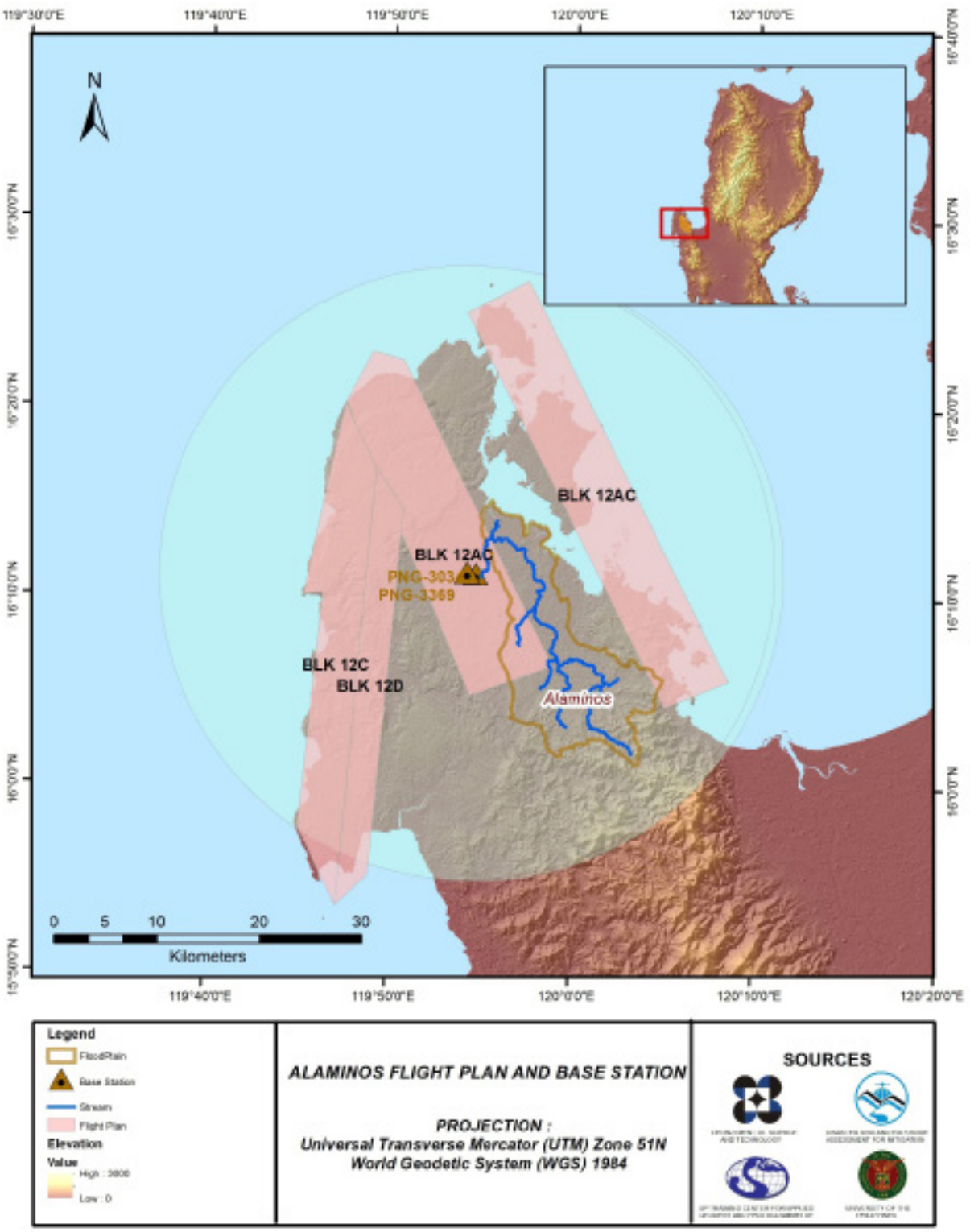

Figure 2. Flight plans and base stations used for Alaminos Floodplain using Pegasus Sensor

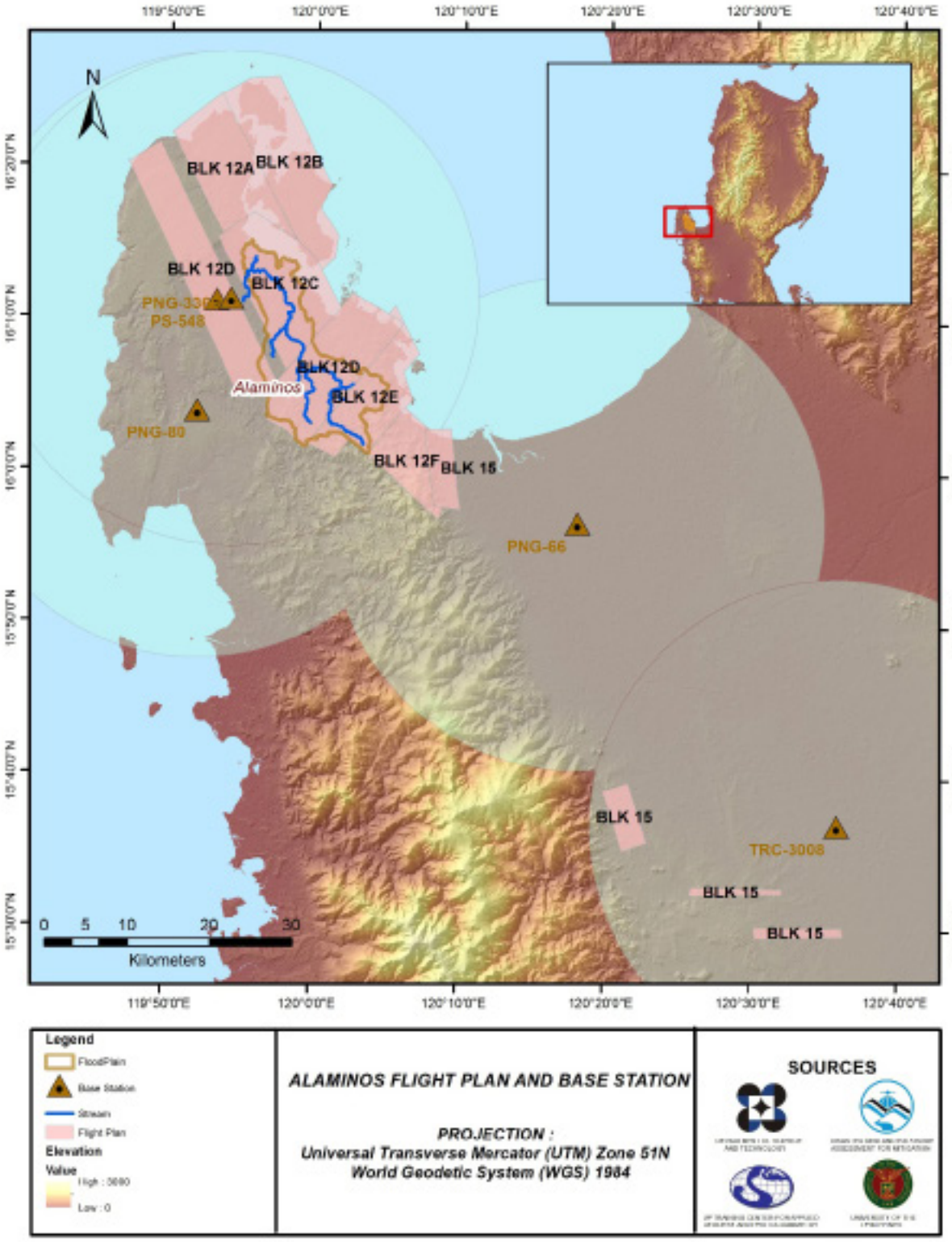

Figure 3. Flight plans and base stations used for Alaminos Floodplain using Gemini Sensor

2.2 Ground Base Stations

The project team was able to recover two (2) NAMRIA horizontal ground control points: PNG-66 and PNG-80 which are both of second (2nd)-order accuracy and PNG-3034 with third (3rd)-order accuracy. The project team also re-processed coordinates of two (2) ground control points: PNG-3369 and TRC-3008, all with third (3rd)-order accuracy. One (1) NAMRIA benchmark, PS-548, was recovered. This benchmark was used as a vertical reference point and was also established as a ground control point. The certification for the NAMRIA reference points and benchmark are found in ANNEX 2 while the baseline processing reports for re-processed control points are found in ANNEX 3.These points were used as base stations during flight operations for the entire duration of the survey (March 5–6, May 23, 2014, and November 5–8, 2015). Base stations were observed using dual frequency GPS receivers, TRIMBLE SPS 852 and SPS 882. Flight plans and location of base stations used during the aerial LiDAR acquisition in Alaminos Floodplain are presented in Figure 2 and Figure 3.

Figure 4 and Figure 5 show the recovered NAMRIA reference points within the area. In addition, Table 3 to Table 8 list the details about the following NAMRIA control stations and established points, while Table 9 shows the list of all ground control points occupied during the acquisition with the corresponding dates of utilization.

Figure 3 to Figure 4 show the recovered NAMRIA control station within the area, in addition Table 2 to Table 3 show the details about the following NAMRIA control stations and established points, while Table 4 shows the list of all ground control points occupied during the acquisition with the corresponding dates of utilization.

Table 3. Details of the recovered NAMRIA horizontal control point PNG-66 used as base station for the LiDAR acquisition

Station Name	**PNG-66**	
Order of Accuracy	**2nd**	
Relative Error (horizontal positioning)	**1 in 50,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	15° 56’47.31803” North 120° 17’ 57.03550” East 10.57500 meters
Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 3 PRS 92)	Easting Northing	424968.98 meters 1763650.683 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	15° 56’ 41.53646” North 120° 18’ 1.81867” East 48.46800 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	210862.35 meters 1764780.62 meters

Figure 4. GPS set-up over PNG-80 located on the open ground west of the academics compound of Burgos National Highschool Brgy. Don Matias, Pangasinan (a) and NAMRIA reference point PNG-80 (b) as recovered by the field team

Table 4. Details of the recovered NAMRIA horizontal control point PNG-80 used as base station for the LiDAR acquisition

Station Name	**PNG-80**	
Order of Accuracy	**2nd**	
Relative Error (horizontal positioning)	**1:50,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	16° 03’ 57.54921” North 119° 51’ 57.50829” East 9.14500 meters
Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 3 PRS 92)	Easting Northing	378657.843 meters 1777080.247 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	16° 03’ 51.70677” North119° 52’ 02.28323” East124.473 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	806647.53 meters 1778249.73 meters

Table 5. Details of the recovered NAMRIA horizontal control point PNG-3034 used as base station for the LiDAR acquisition

Station Name	PNG-3034	
Order of Accuracy	3rd	
Relative Error (horizontal positioning)	1:10,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	16° 11'17.38811" 119° 54' 39.49132" 8.60000 m
Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 3 PRS 92)	Easting Northing	383544.293 m 1790575.207 m
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	16° 11' 11.52189" North 119° 54' 44.25583" East 44.82200 m
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	811274.25 m 1291845.87 m

Figure 5. GPS set-up over PNG-3369 located beside DPWH kilometer post in Brgy. Banog, Pangasinan (a) and NAMRIA reference point PNG-3369 (b) as recovered by the field team

Table 6. Details of the recovered NAMRIA horizontal control point PNG-3369 used as base station for the LiDAR acquisition

Station Name	PNG-3369	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	16° 11' 21.73909" 119° 54' 10.85883" 8.221 m
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	16° 11' 15.87198" North 119° 54' 15.62327" East 44.420 m
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	168821.042 m 1792270.967 m

Table 7. Details of the recovered NAMRIA horizontal control point TRC-3008 used as base station for the LiDAR acquisition

Station Name	TRC-3008	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1:50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	15° 37' 01.26741" 120° 35' 46.76169" 28.544 m
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	15° 36' 55.58374" North 120° 35' 51.57129" East 68.142 m
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	242274.052 m 1727923.206 m

Table 8. Details of the recovered NAMRIA horizontal control point PS-548 used as base station for the LiDAR acquisition with established coordinates

Station Name	PS-548	
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	16o 11' 10.61299" North 119o 53' 16.08019" East 11.042 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	16o 11' 04.74538" North 119o 53' 20.84496" East 47.214 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	167187.327 meters 1791953.316 meters

Table 9. Ground control points used during LiDAR data acquisition

Date Surveyed	Flight Number	Mission Name	Ground Control Points
March 5, 2014	1183P	1BLK12AC064A	PNG-3369 and PNG-3034
March 5, 2014	1185P	1BLK12D064B	PNG-3369 and PNG-3034
March 6, 2014	1187P	1BLK12CS065A	PNG-3369 and PNG-3034
March 6, 2014	1189P	1BLK12DS065B	PNG-3369 and PNG-3034
May 23, 2014	7266G	2BLK15S143A	PNG-66 and TRC-3008
November 5, 2015	8534G	2BLK12C309A	PNG-3369 and PNG-80
November 6, 2015	8536G	2BLK12D310A	PNG-3369 and PS-548
November 7, 2015	8538G	2BLK12E311A	PNG-3369 and PS-548
November 7, 2015	8539G	2BLK12EF311B	PNG-3369 and PS-548
November 8. 2015	8540G	2BLK12AB312A	PNG-80 and PS-548

2.3 Flight Missions

Ten (10) missions were conducted to complete LiDAR data acquisition in Alaminos Floodplain, for a total of twenty seven hours and fifty eight minutes (27+58) of flying time for RP-C9022 and RP-C9322. All missions were acquired using Pegasus and Gemini LiDAR systems. Table 10 shows the total area of actual coverage and the corresponding flying hours per mission, while Table 11 presents the actual parameters used during the LiDAR data acquisition.

Table 10. Flight missions for the LiDAR data acquisition of the Alaminos Floodplain.

Date Surveyed	Flight Number	Flight Plan Area (km2)	Surveyed Area (km2)	Area Surveyed within the Floodplain (km2)	Area Surveyed Outside the Floodplain (km2)	No. of Images (Frames)	Flying Hours	
							Hr	Min
March 5, 2014	1183P	550.01	210.04	38.83	171.21	602	3	43
March 5, 2014	1185P	118.07	140.97	-	140.97	279	2	30
March 6, 2014	1187P	191.66	232.94	-	232.94	595	3	25
March 6, 2014	1189P	149.54	166.72	10.12	156.6	654	2	43
March 23, 2014	7266G	78.47	105.68	-	105.68	NA	3	38
November 5, 2015	8534G	142.78	130.098	70.31	59.79	NA	2	19
November 6, 2015	8536G	139.08	126.10	61.85	64.25	NA	2	13
November 7, 2015	8538G	79.15	122.22	61.02	61.2	NA	2	31
November 7, 2015	8539G	145.98	75.72	6.89	68.83	NA	1	37
November 8. 2015	8540G	117.78	197.76	3.70	194.06	NA	3	19
TOTAL		1712.50	1508.248	252.72	1255.53	2130	27	58

Table 11. Actual parameters used during LiDAR data acquisition.

Flight Number	Flying Height (AGL) (m)	Overlap (%)	Field of View (θ)	Pulse Repetition Frequency (kHz)	Scan Frequency (Hz)	Average Speed (Kts)	Average Turn Time (Minutes)
1183P	1200	30	50	200	30	130	5
1185P	1000	30	50	200	30	130	5
1187P	1200	30	50	200	30	130	5
1189P	850	30	50	250	30	130	5
7266G	1000	30	40	100	50	125	5
8534G	1000	30	40	100	50	125	5
8536G	1000	30	40	100	50	125	5
8538G	1000	30	40	100	50	125	5
8539G	1000	30	40	100	50	125	5
8540G	1000	30	40	100	50	125	5

2.4 Survey Coverage

Alaminos Floodplain is located in the province of Pangasinan with majority of the floodplain situated within Alaminos City. The city of Alaminos and municipalities of Bani, Sual, and Bolinao are mostly covered by the survey. The list of municipalities and cities surveyed, with at least one (1) square kilometer coverage, is shown in Table 12. The actual coverage of the LiDAR acquisition for Alaminos Floodplain is presented in Figure 6.

Table 12. The list of municipalities and cities surveyed of the Alaminos Floodplain LiDAR acquisition.

Province	Municipality/City	Area of Municipality/City	Total Area Surveyed	Percentage of Area Surveyed
Pangasinan	Alaminos City	165.51	163.54	98.81%
	Bani	180.62	171.63	95.02%
	Sual	162.96	147.98	90.81%
	Bolinao	207.06	185.42	89.55%
	Agno	148.75	116.59	78.38%
	Anda	75.53	39.87	52.79%
	Labrador	92.63	42.16	45.52%
	Burgos	113.81	46.30	40.68%
	Mabini	260.03	47.85	18.40%
	Dasol	256.23	38.04	14.85%
	Lingayen	68.74	1.93	2.80%
	Bugallon	158.15	2.41	1.52%
	Camiling	130.78	10.53	8.05%
Tarlac	Mayantoc	244.09	18.72	7.67%
	San Clemente	69.75	4.29	6.15%
	Santa Ignacia	145.32	8.77	6.03%
	Tarlac City	241.67	12.82	5.31%
		626.98	12.38	1.97%
Total		3348.61	1071.23	31.99%

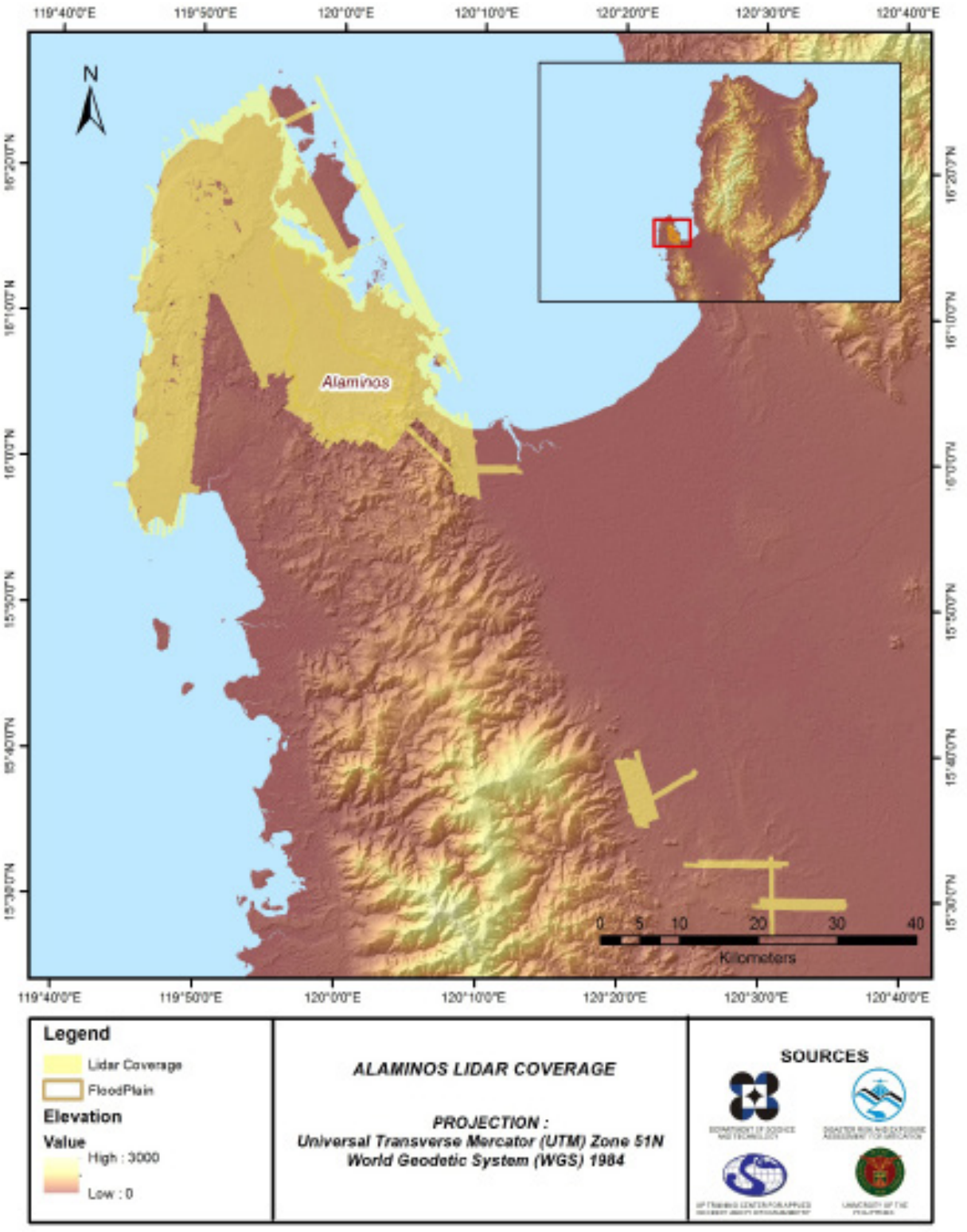

Figure 6. Actual LiDAR survey coverage for Alaminos Floodplain.

CHAPTER 3: LIDAR DATA PROCESSING FOR ALAMINOS 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 LiDAR Data Pre-Processing

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

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

These processes are summarized in the flowchart shown in Figure 7.

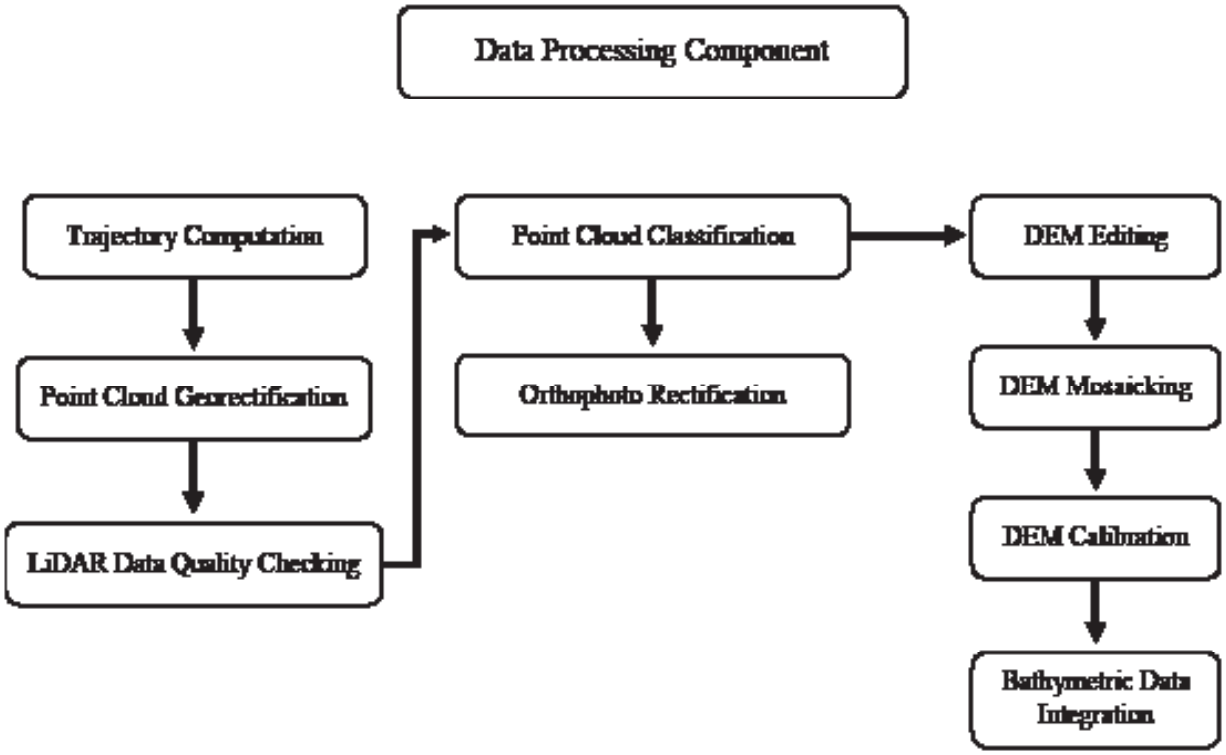


Figure 7. Schematic Diagram for Data Pre-Processing Component

3.2 Transmittal of Acquired LiDAR Data

Data transfer sheets for all the LiDAR missions for Alaminos Floodplain can be found in ANNEX 5. Missions flown during the first survey conducted on February 2015 used the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.)Gemini system over Alaminos City, Pangasinan. The Data Acquisition Component (DAC) transferred a total of164.89 Gigabytes of Range data, 1.66 Gigabytes of POS data, 76.0 Megabytes of GPS base station data, and 125.0 Gigabytes of raw image data to the data server on November 12, 2015 for the first survey. The Data Pre-Processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for Alaminos was fully transferred on November 2015, as indicated on the data transfer sheets for Alaminos Floodplain.

3.3 Trajectory Computation

The Smoothed Performance Metrics of the computed trajectory for flight 8538G, one of the Alaminos flights, which is the North, East, and Down position RMSE values are shown in Figure 8. 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 November 7, 2015 00:00AM. The y-axis is the RMSE value for that particular position.

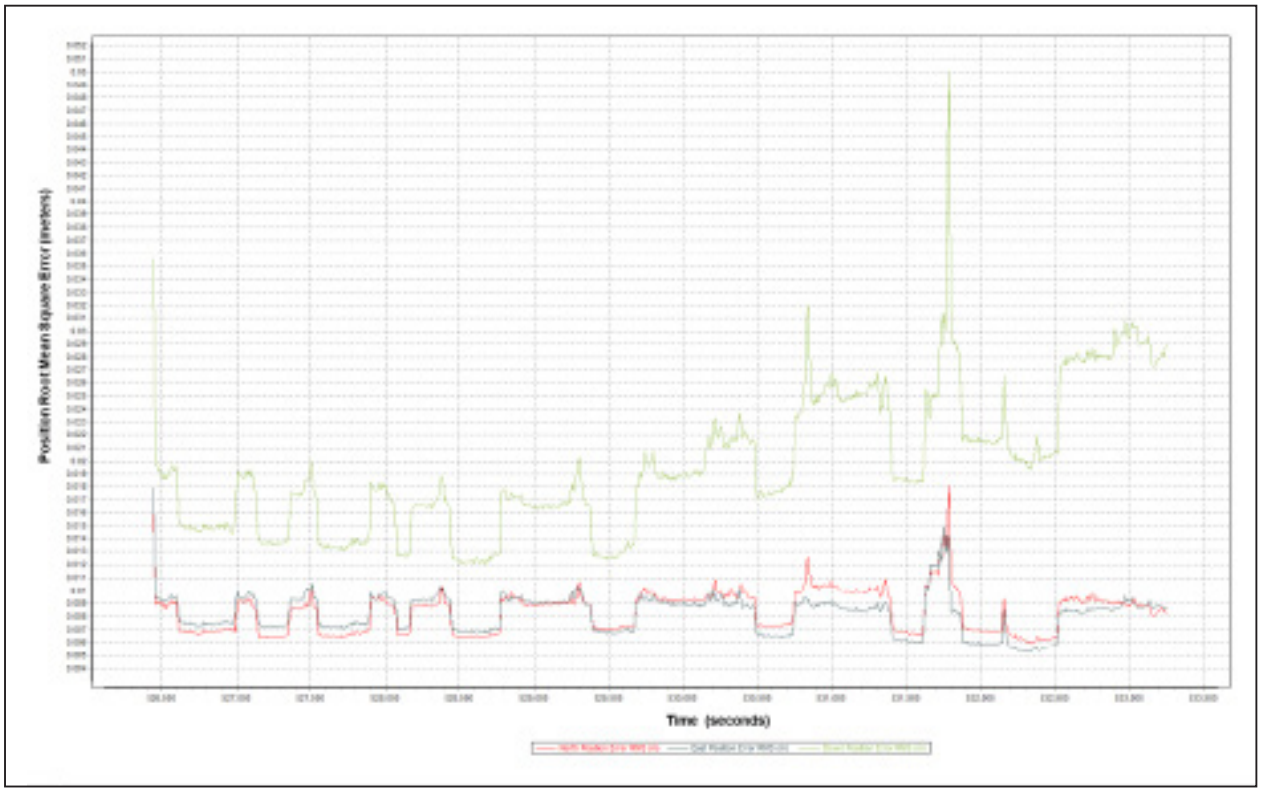


Figure 8. Smoothed Performance Metrics of Alaminos Flight 8538G

The time of flight was from 526500 seconds to 533000 seconds, which corresponds to morning of November 7, 2015. 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 time the POS system started computing for the position and orientation of the aircraft. Redundant measurements from the POS system quickly minimized the RMSE value of the positions. The periodic increase in RMSE values from an otherwise smoothly curving RMSE values correspond to the turn-around period of the aircraft, when the aircraft makes a turn to start a new flight line. Figure 8 shows that the North position RMSE peaks at 2.9 centimeters, the East position RMSE peaks at 3.25centimeters, and the Down position RMSE peaks at 9.0 centimeters, which are within the prescribed accuracies described in the methodology.

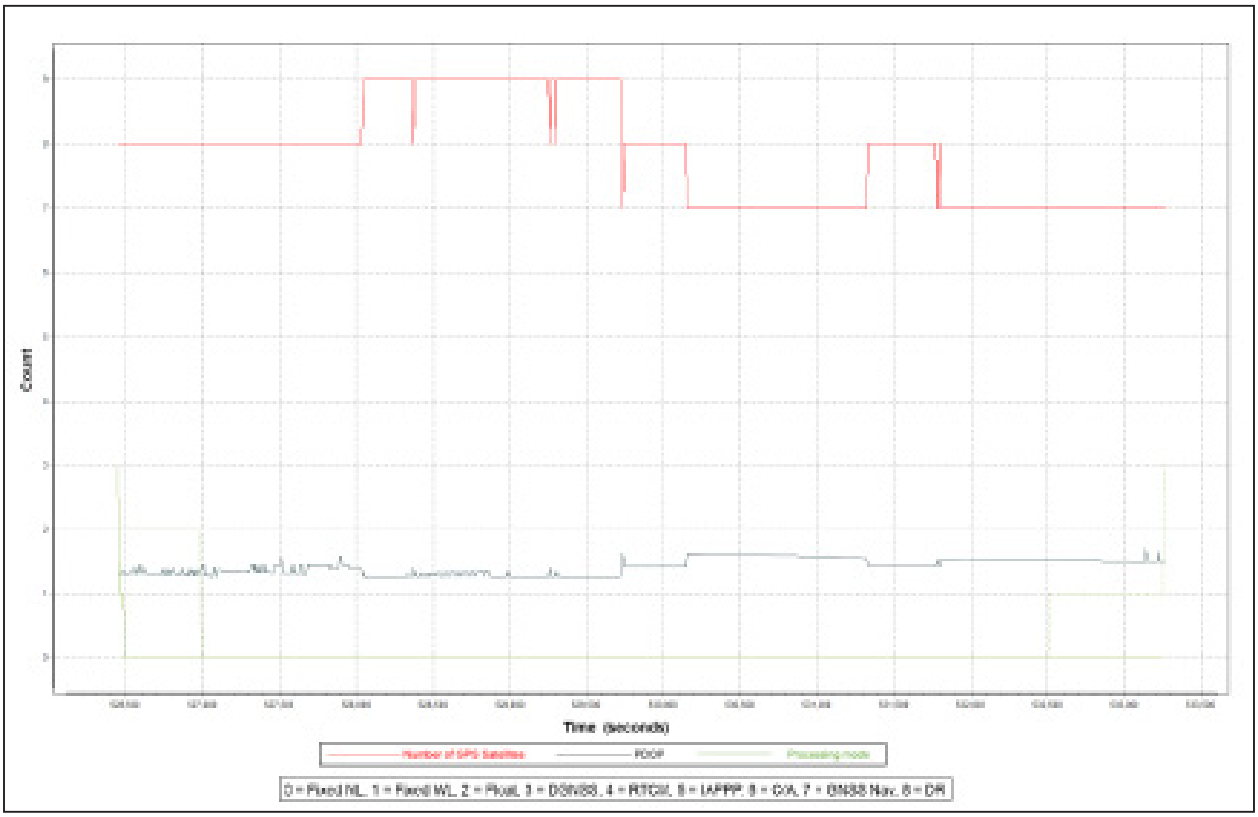


Figure 9. Solution Status Parameters of Alaminos Flight 8538G

The Solution Status parameters of flight 8538G, one of the Alaminos flights, which are the number of GPS satellites, Positional Dilution of Precision (PDOP), and the GPS processing mode used, are shown in Figure 9. The graphs indicate that the number of satellites during the acquisition did not go down to 7. Majority of the time, the number of satellites tracked was between 7 and 9. The PDOP value also did not go above the value of 3, which indicates optimal GPS geometry. The processing mode stayed at the value of 0 for majority of the survey 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 Alaminos flights is shown in Figure 10.

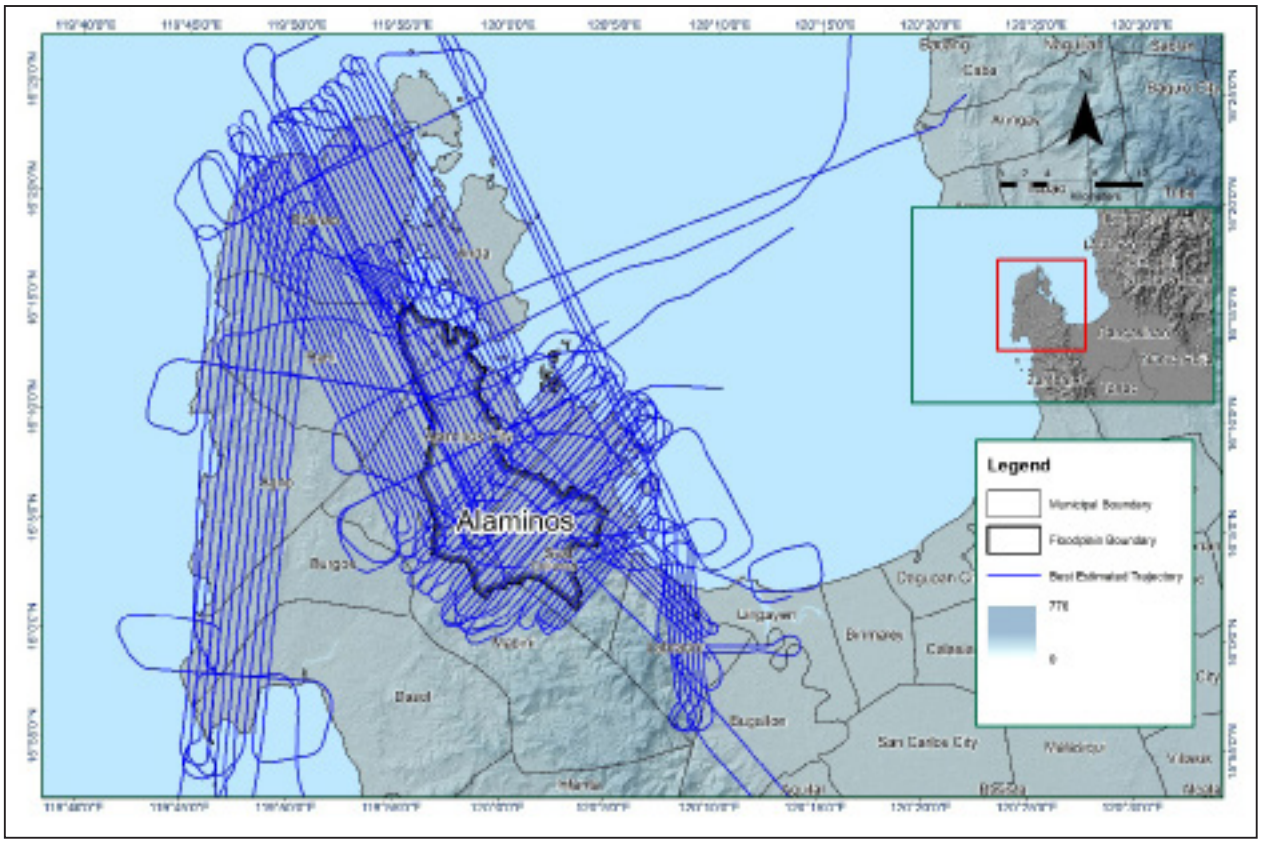


Figure 10. Best estimated trajectory of the LiDAR missions conducted over the Alaminos Floodplain

3.4 LiDAR Point Cloud Computation

The produced LAS data contains 123 flight lines, with each flight line containing one channel, since the Gemini system contains only one channel. The summary of the self-calibration results obtained from LiDAR processing in LiDAR Mapping Suite (LMS) software for all flights over Alaminos Floodplain are given in Table 13.

Table 13. Self-calibration Results values for Alaminos flights.

Parameter	Acceptable Value	Value
Boresight Correction stdev	(<0.001degrees)	0.00062
IMU Attitude Correction Roll and Pitch Corrections stdev	(<0.001degrees)	0.00394827
GPS Position Z-correction stdev	(<0.01meters)	0.0077

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

3.5 LiDAR Data Quality Checking

The boundary of the processed LiDAR data on top of a SAR Elevation Data over Alaminos Floodplain is shown in Figure 11. The map shows gaps in the LiDAR coverage that are attributed to cloud coverage.

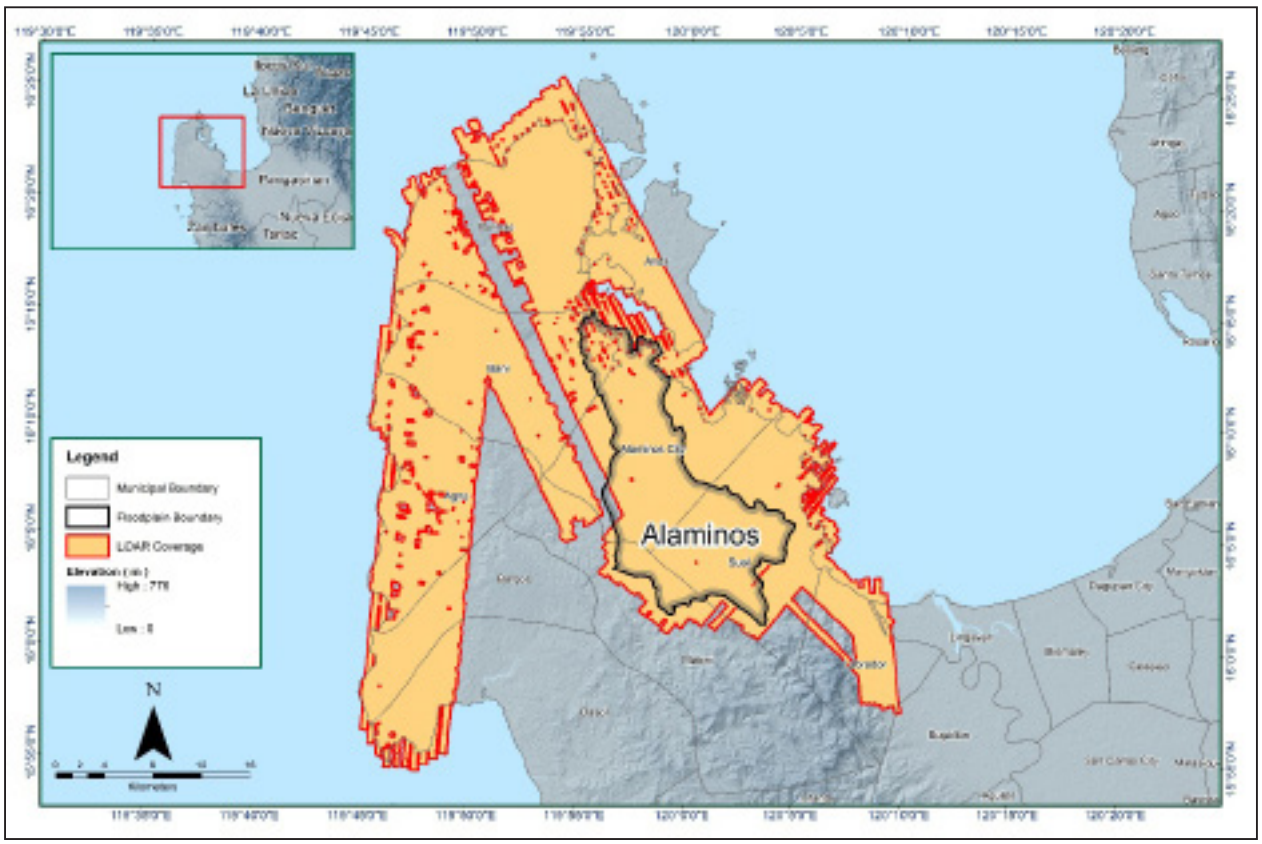


Figure 11. Boundaries of the processed LiDAR data over the Alaminos Floodplain.

The total area covered by the Alaminos missions is 1,246.78 sq km comprised of ten (10) flight acquisitions grouped and merged into ten (10) blocks as shown in Table 14.

Table 14. List of LiDAR blocks for the Alaminos floodplain.

LiDAR Blocks	Flight Numbers	Area (sq. km)
Pangasinan_Blk12A	8540G	156.81
Pangasinan_Blk12A_additional	8540G	27.34
Pangasinan_Blk12C	8534G	124.45
Pangasinan_Blk12D	8536G	124.59
Pangasinan_Blk12E	8538G	119.45
Pangasinan_Blk12F	8539G	36.52
Pangasinan_Blk12G	8539G	41.35
LaUnion_Blk12C	1183P	254.52
	1189P	
LaUnion_Blk12D	1185P	330.18
	1187P	
Agno_Blk5H_reflight	7266G	31.57
TOTAL		1246.78 sq. kmsq km

The overlap data for the merged LiDAR blocks, showing the number of channels that pass through a particular locationn, is shown in Figure 12. Since the Gemini system employs one channel, an average value of 1 (blue) would be expected for areas where there is limited overlap, and a value of 2 (yellow) or more (red) for areas with three or more overlapping flight lines. Meanwhile, for the Pegasus system which employs two channels, an average value of 2 (blue) would be expected 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.

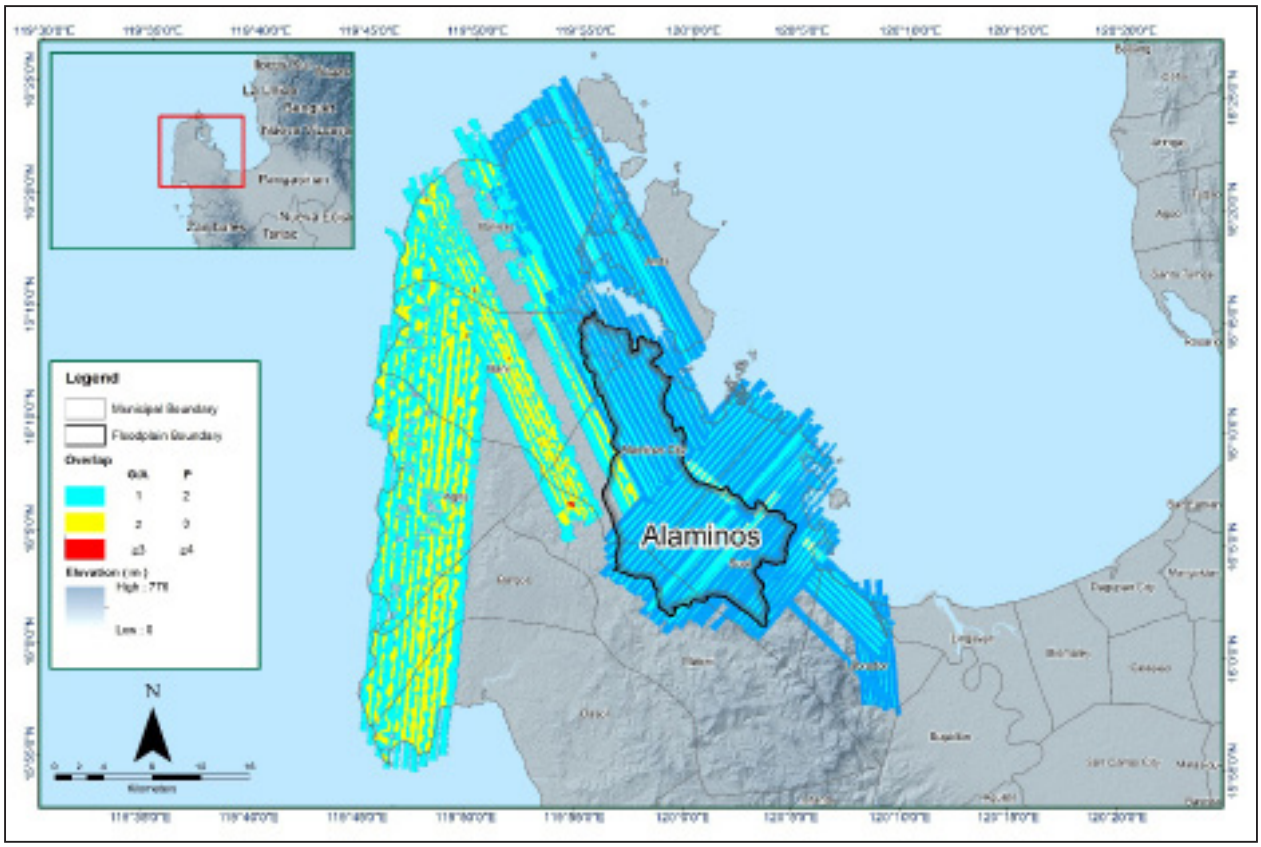


Figure 12. Image of data overlap for Alaminos Floodplain.

The overlap statistics per block for the Alaminos 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 45.59% and 43.41%, respectively, which passed the 25% requirement.

The pulse density map for the merged LiDAR data, with the red parts showing the portions of the data that satisfy the 2 points per square meter criterion, is shown in Figure 13. It was determined that all LiDAR data for Alaminos Floodplain satisfy the point density requirement, and the average density for the entire survey area is 3.14 points per square meter.

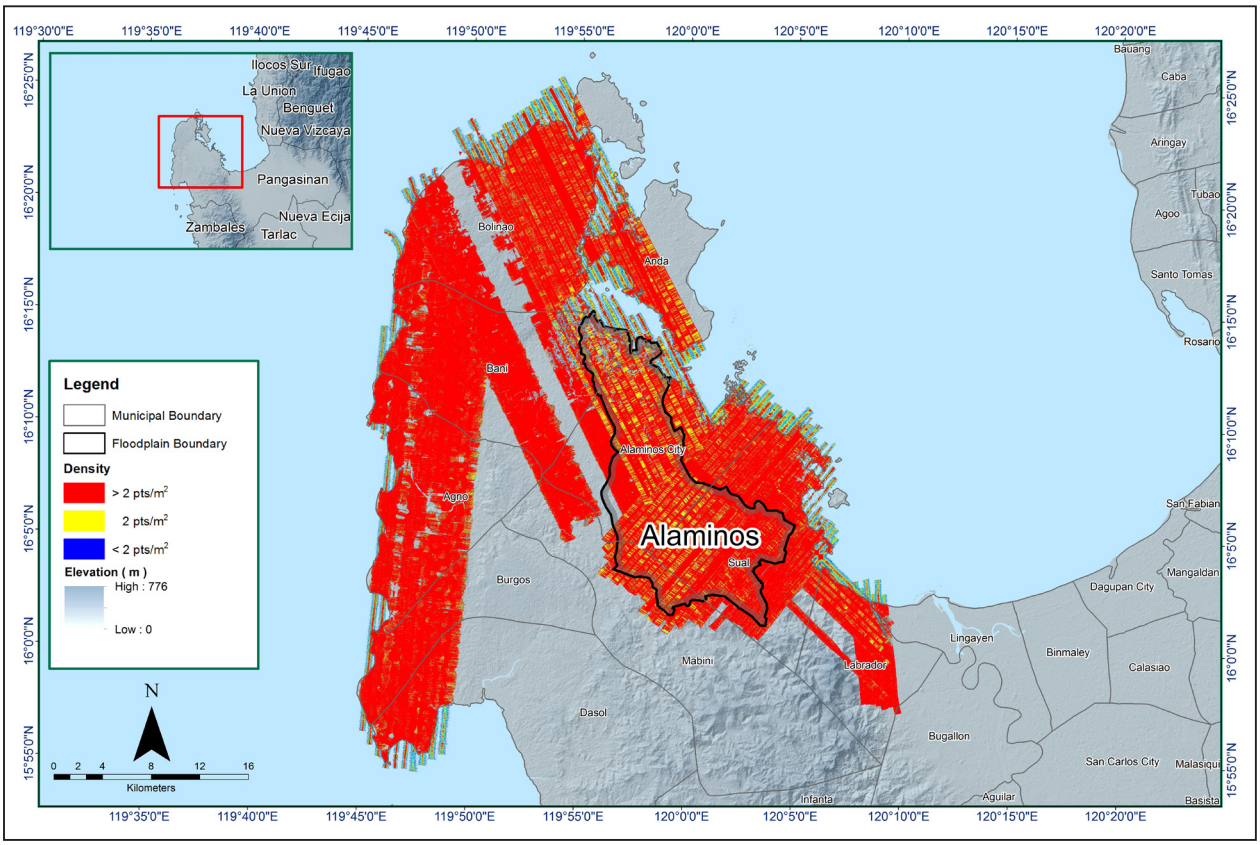


Figure 13. Pulse density map of merged LiDAR data for Alaminos Floodplain.

The elevation difference between overlaps of adjacent flight lines is shown in Figure 14. The default color range is from blue to red, in which bright blue areas correspond to portions where elevations of a previous flight line, identified by its acquisition time, are higher by more than 0.20 m 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 0.20 m 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.

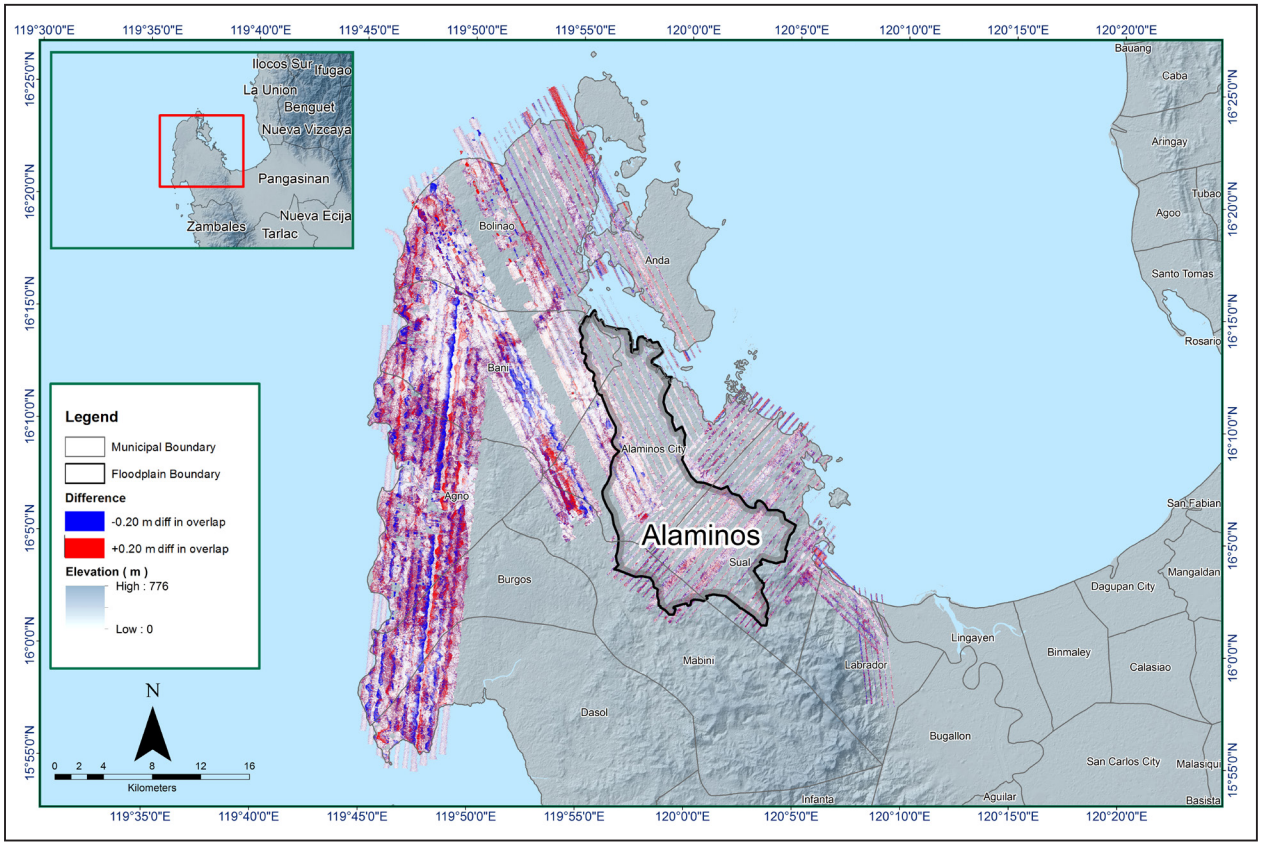


Figure 14. Elevation difference map between flight lines for Alaminos Floodplain.

A screen capture of the processed LAS data from Alaminos flight 8538G loaded in QT Modeler is shown in Figure 15. The upper left image shows the elevations of the points from two overlapping flight strips traversed by the profile, illustrated by a dashed yellow line. The x-axis corresponds to the length of the profile. It is evident that there are differences in elevation, but the differences do not exceed the 20-centimeter mark. This profiling was repeated until the quality of the LiDAR data becomes satisfactory. No reprocessing was done for this LiDAR dataset.

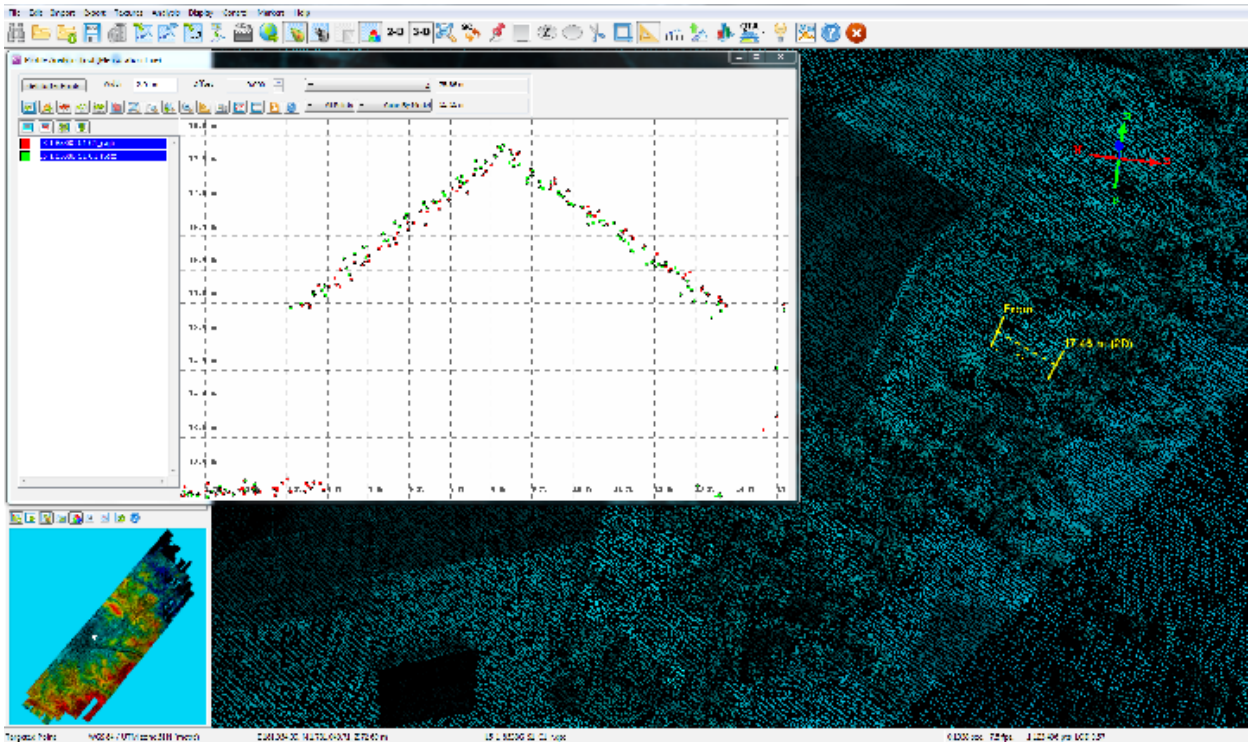


Figure 15. Screen capture of the quality checking for a Alaminos flight 8538G using the Profile Tool of QT Modeler

3.6 LiDAR Point Cloud Classification and Rasterization

Table 15. Alaminos classification results in TerraScan.

Pertinent Class	Total Number of Points
Ground	1,018,721,255
Low Vegetation	841,300,622
Medium Vegetation	1,405,635,286
High Vegetation	812,887,153
Building	21,490,369

The tile system that TerraScan employed for the LiDAR data and the final classification image for a block in Alaminos Floodplain is shown in Figure 16. A total of 389 1 km by 1 km tiles were produced. The number of points classified to the pertinent categories is illustrated in Table 15. The point cloud has a maximum and minimum height of 441.37 meters and 23.57 meters, respectively.

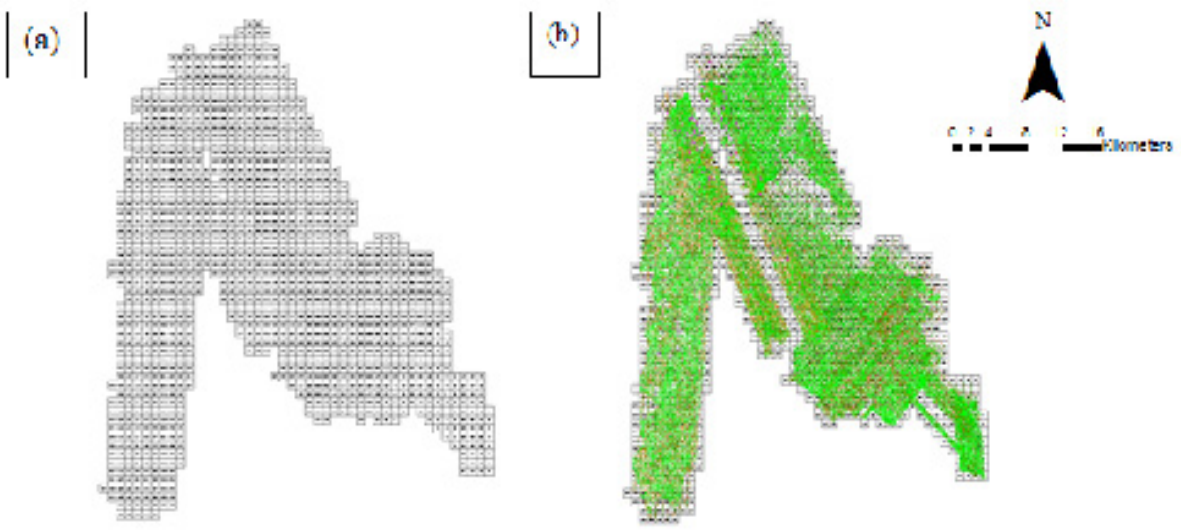


Figure 16. Tiles for Alaminos Floodplain (a) and classification results (b) in TerraScan

An isometric view of an area before and after running the classification routines is shown in Figure 17. 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.

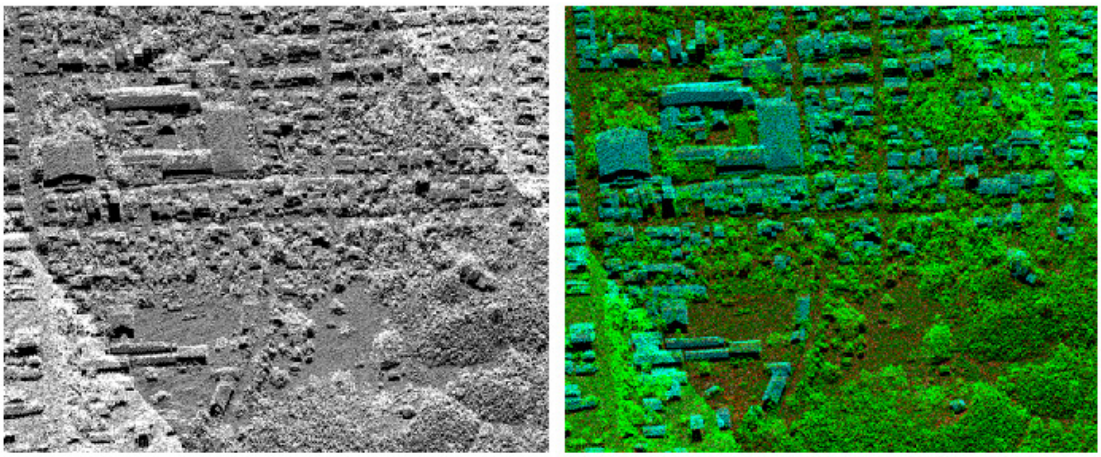


Figure 17. Point cloud before (a) and after (b) classification.

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 18. It shows that DTMs are the representation of the bare earth while on the DSMs, all features are present such as buildings and vegetation.

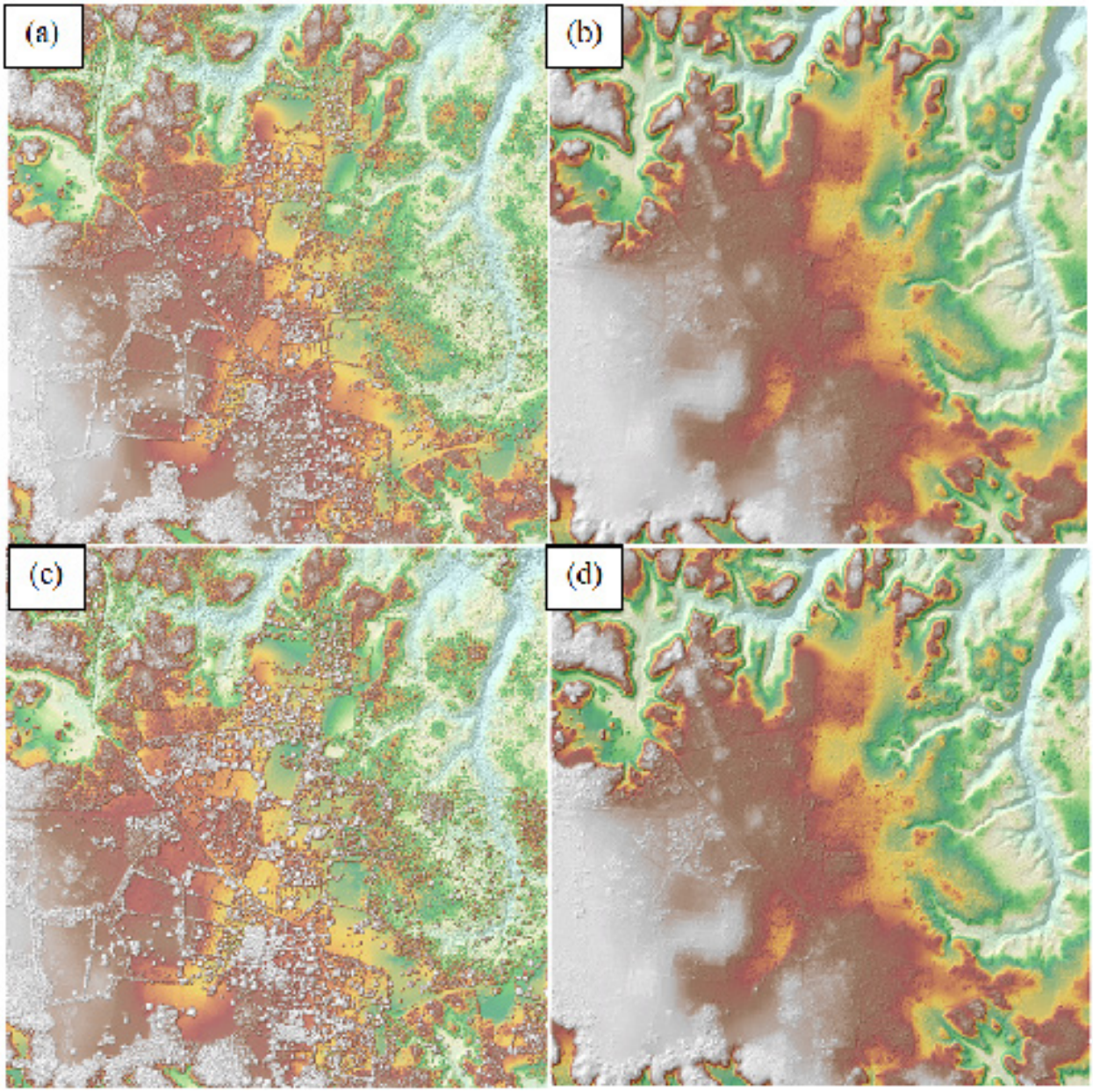


Figure 18. The production of last return DSM (a) and DTM (b), first return DSM (c) and secondary DTM (d) in some portion of Alaminos Floodplain

3.7 LiDAR Image Processing and Orthophotograph Rectification

The 694 1 km by 1 km tiles area covered by Alaminos Floodplain is shown in Figure 19. After tie-point selection to fix photo misalignments, color points were added to smoothen out visual inconsistencies along the seamlines where photos overlap. The Alaminos Floodplain attained a total of 558.54 sq km in orthophotogaph coverage comprised of 1,792 images. A zoomed in version of sample orthophotographs named in reference to its tile number is shown in Figure 20.

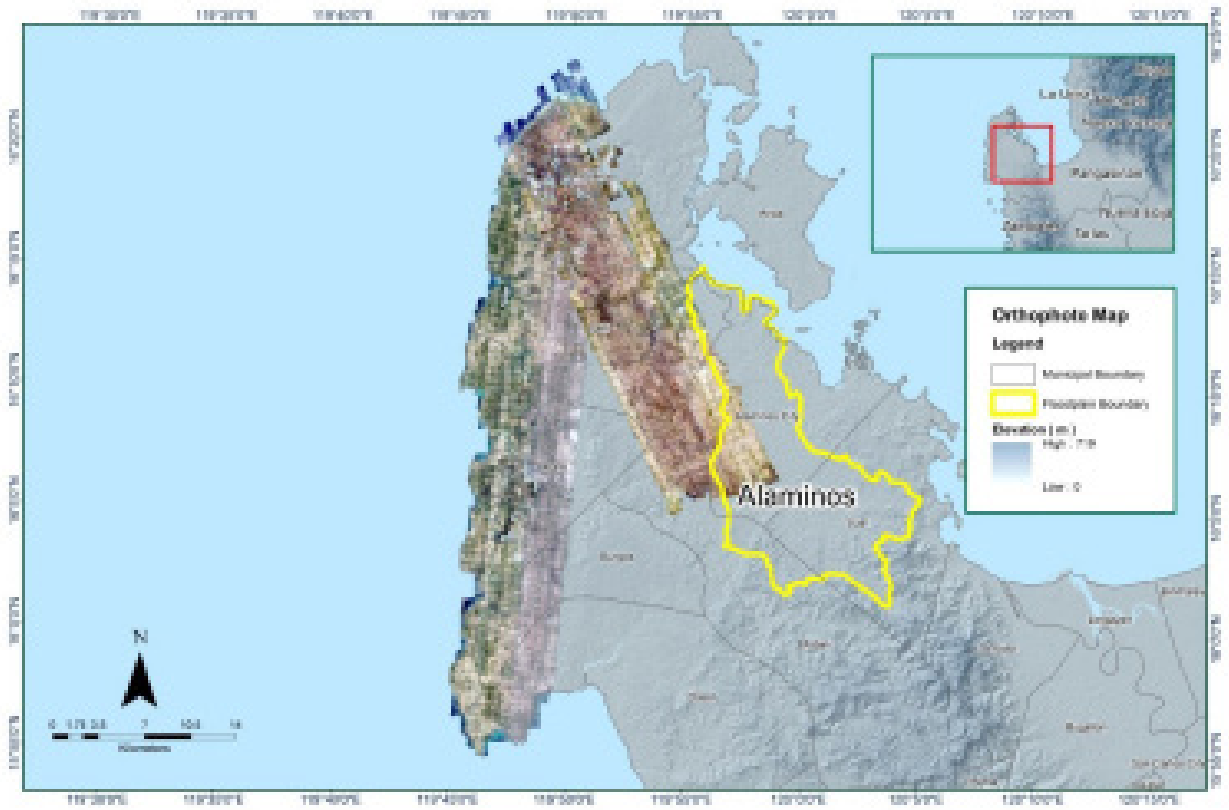


Figure 19. Alaminos Floodplain with available orthophotographs.

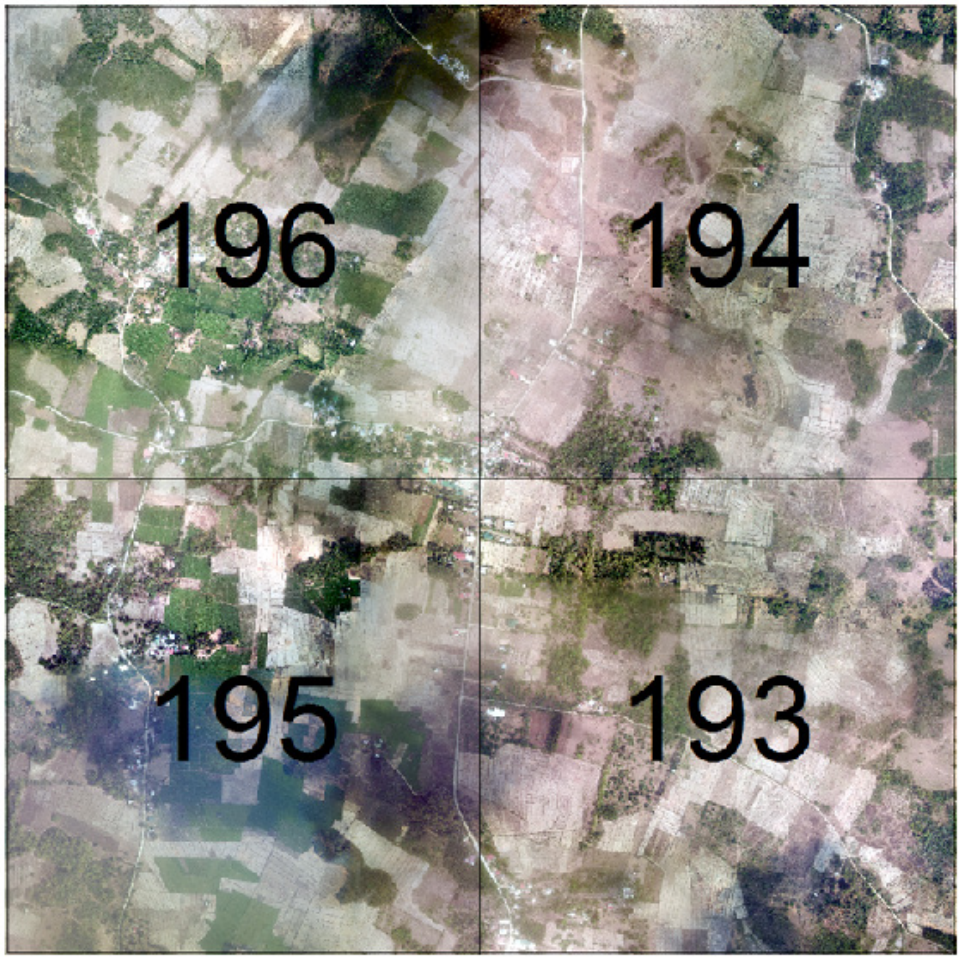


Figure 20. Sample orthophotograph tiles for Alaminos Floodplain.

3.8 DEM Editing and Hydro-Correction

Ten (10) mission blocks were processed for Alaminos Floodplain. These blocks were composed of Pangasinan blocks with a total area of 1,246.78 square kilometers. Table 16 shows the name and corresponding area of each block in square kilometers.

Table 16. LiDAR blocks with its corresponding area.

LiDAR Blocks	Area (sq.km)
Pangasinan_Blk12A	156.81
Pangasinan_Blk12A_additional	27.34
Pangasinan_Blk12C	124.45
Pangasinan_Blk12D	124.59
Pangasinan_Blk12E	119.45
Pangasinan_Blk12F	36.52
Pangasinan_Blk12G	41.35
LaUnion_Blk12C	254.52
LaUnion_Blk12D	330.18
Agno_Blk5H_reflight	31.57
TOTAL	1246.78 sq.kmsq km.

Portions of DTM before and after manual editing are shown in Figure 21. The bridge (Figure 21a) was considered to be an impedance to the flow of water along the river and had to be removed (Figure 21b) in order to hydrologically correct the river. The river embankment (Figure 21c) had been misclassified and removed during classification process and had to be retrieved to complete the surface (Figure 21d) to allow the correct flow of water. Another example is a building that was still present in the DTM after classification (Figure 21e) and had to be removed through manual editing (Figure 21f).

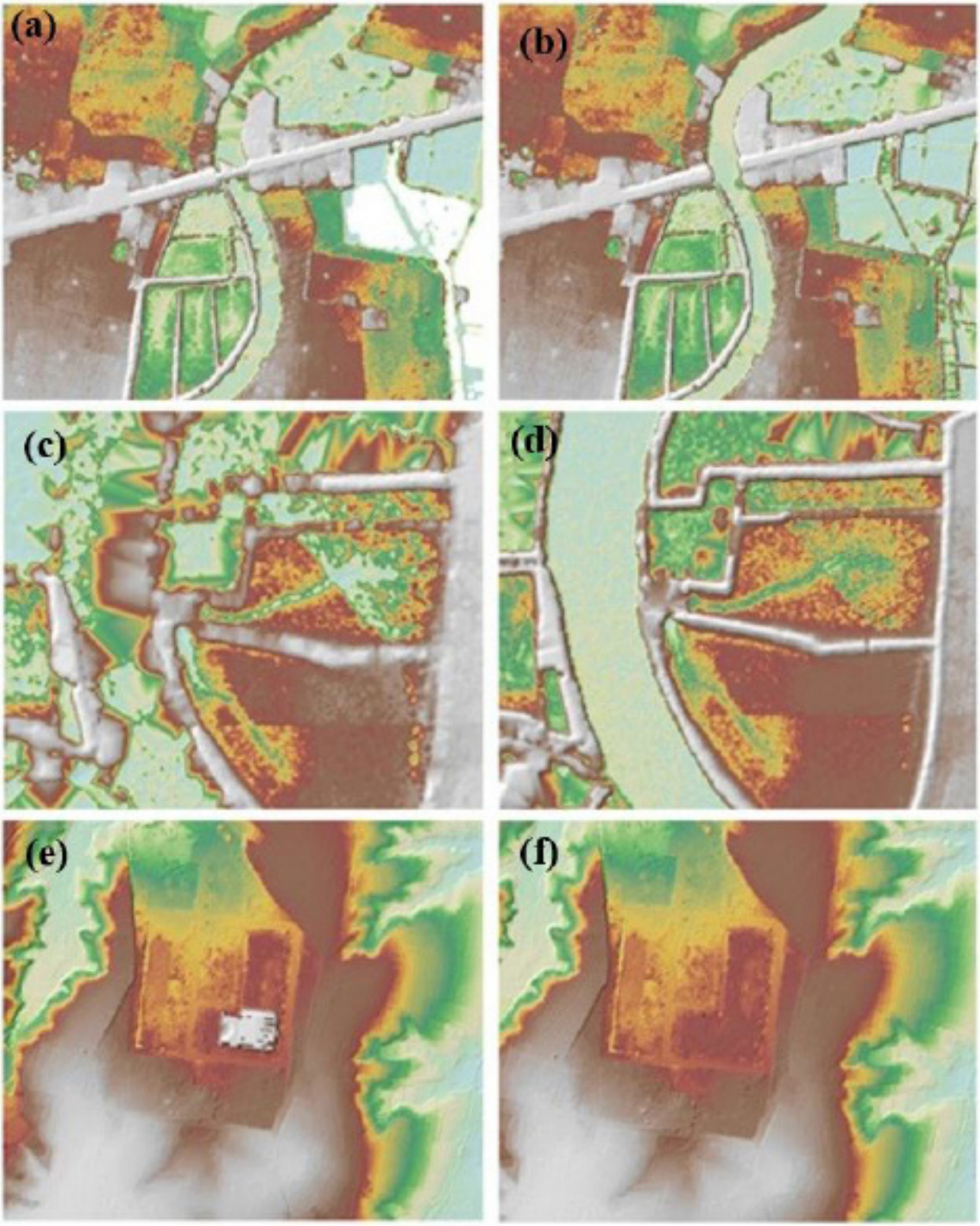


Figure 21. Portions in the DTM of Alaminos Floodplain — a bridge before (a) and after (b) manual editing; a paddy field before (c) and after (d) data retrieval; and a building before (e) and after (f) manual editing

3.9 Mosaicking of Blocks

Pangasinan_Blk12C was used as the reference block at the start of mosaicking because the Alaminos River Basin is located in this block. Table 17 shows the area of each LiDAR block and the shift values applied during mosaicking.

Mosaicked LiDAR DTM for Alaminos Floodplain is shown in Figure 22. It can be seen that the entire Alaminos Floodplain is 98.33% covered by LiDAR data.

Table 17. Shift Values of each LiDAR Block of Alaminos Floodplain.

Mission Blocks	Shift Values (meters)		
	x	y	z
Pangasinan_Blk12A	0.00	0.00	0.00
Pangasinan_Blk12A_additional	0.00	0.00	0.00
Pangasinan_Blk12C	0.00	0.00	0.00
Pangasinan_Blk12D	0.00	0.00	0.00
Pangasinan_Blk12E	0.00	0.00	0.00
Pangasinan_Blk12F	0.00	0.00	0.00
Pangasinan_Blk12G	0.00	0.00	0.00
LaUnion_Blk12C	0.00	0.00	-0.64
LaUnion_Blk12D	0.00	0.00	-0.35
Agno_Blk5H_reflight	0.00	0.00	-1.1

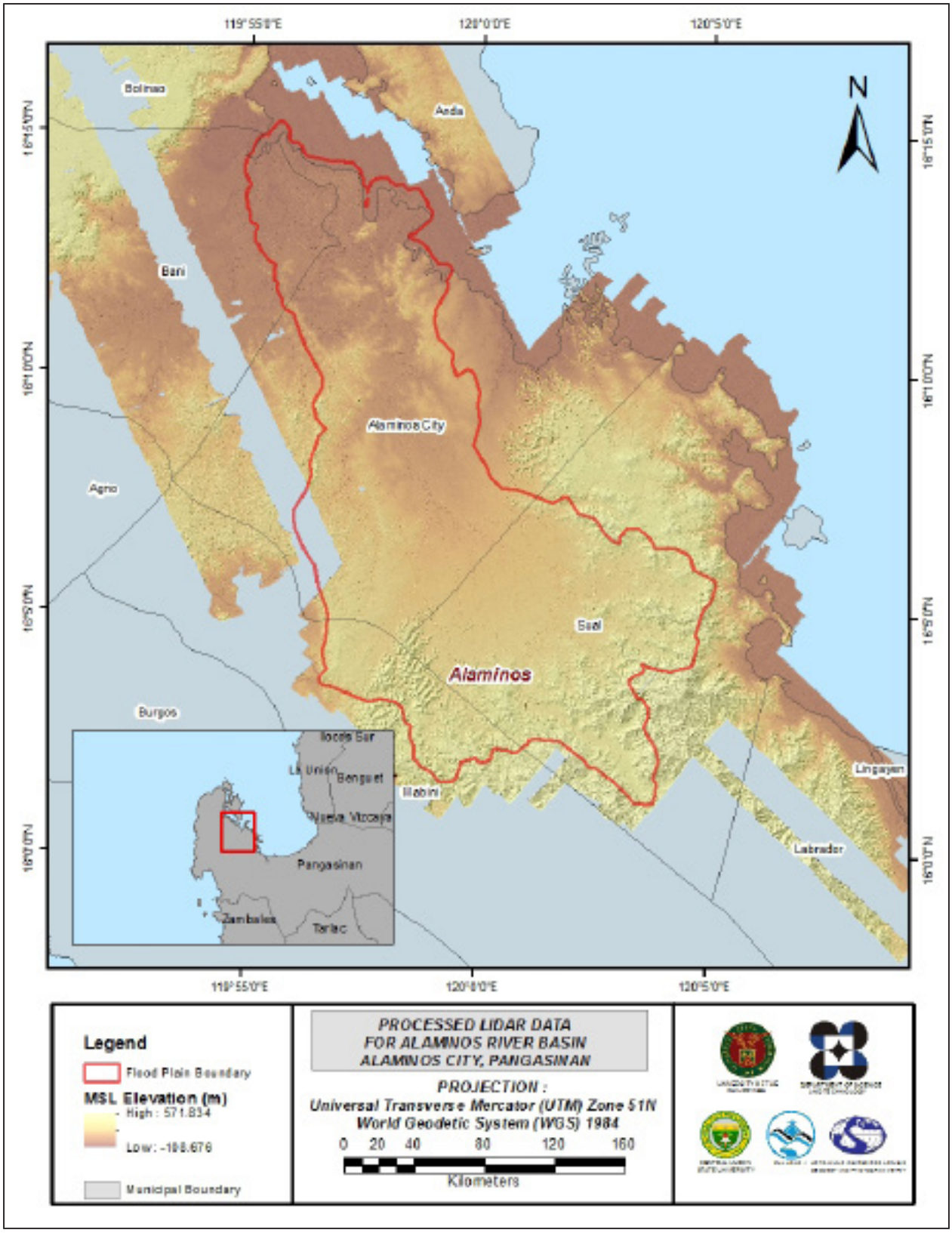


Figure 22. Map of Processed LiDAR Data for Alaminos Floodplain.

3.10 Calibration and Validation of Mosaicked LiDAR Digital Elevation Model

The extent of the validation survey done by the Data Validation and Bathymetry Component (DVBC) in Alaminos to collect points with which the LiDAR dataset was validated is shown in Figure 23. A total of 3,479 survey points were used for calibration and validation of Alaminos LiDAR data. Eighty percent of the survey points, which were randomly selected and resulting in 2,784 points, were used for calibration.

A good correlation between the uncalibrated mosaicked LiDAR elevation values and the ground survey elevation values is shown in Figure 24. Statistical values were computed from extracted LiDAR values using the selected points to assess the quality of data and obtain the value for vertical adjustment. The computed height difference between the LiDAR DTM and calibration elevation values is 3.36 meters with a standard deviation of 0.13 meters. Calibration of Alaminos LiDAR data was done by subtracting the height difference value, 3.36 meters, to Alaminos mosaicked LiDAR data. Table 18 shows the statistical values of the compared elevation values between LiDAR data and calibration data.

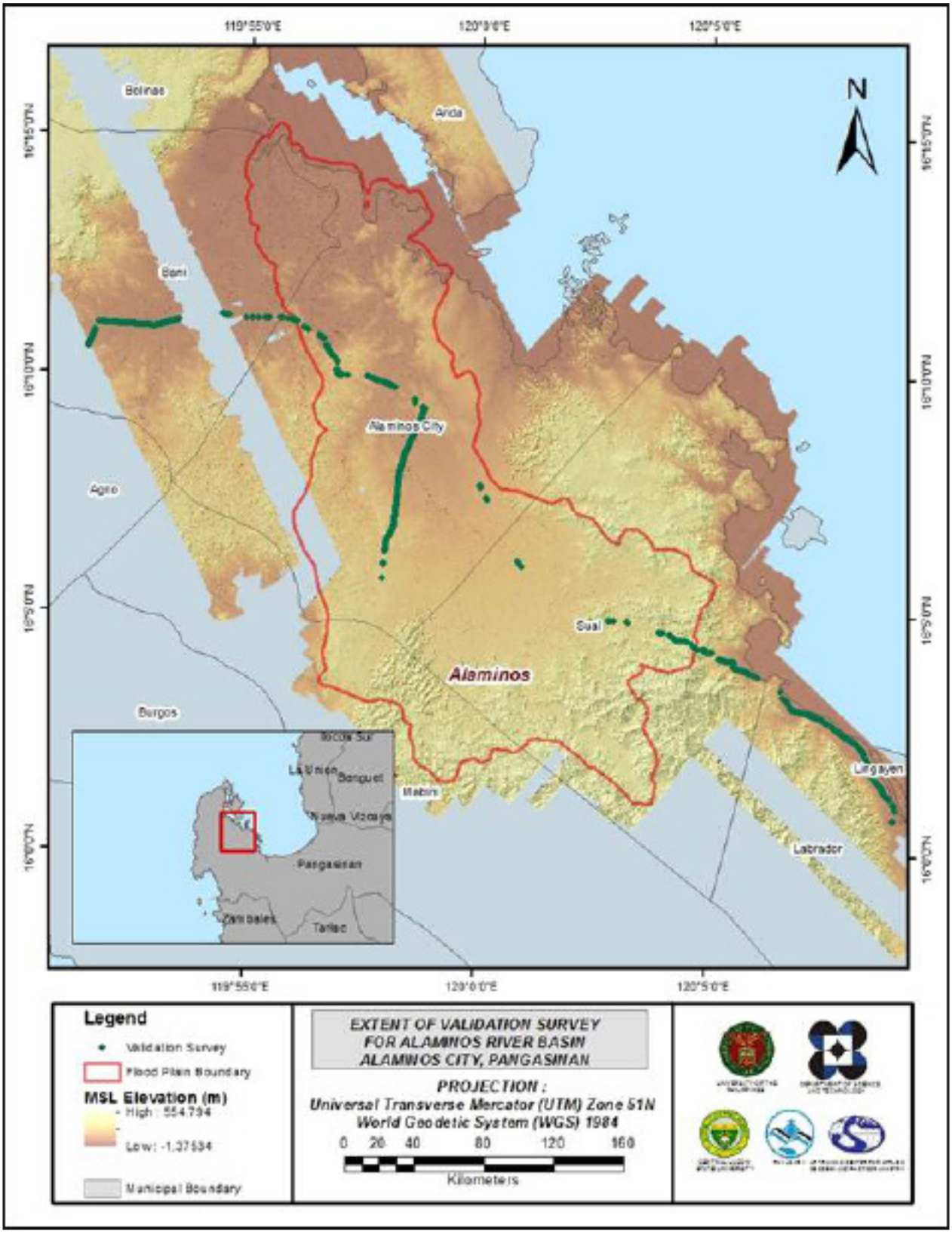


Figure 23. Map of Alaminos Floodplain with validation survey points in green.

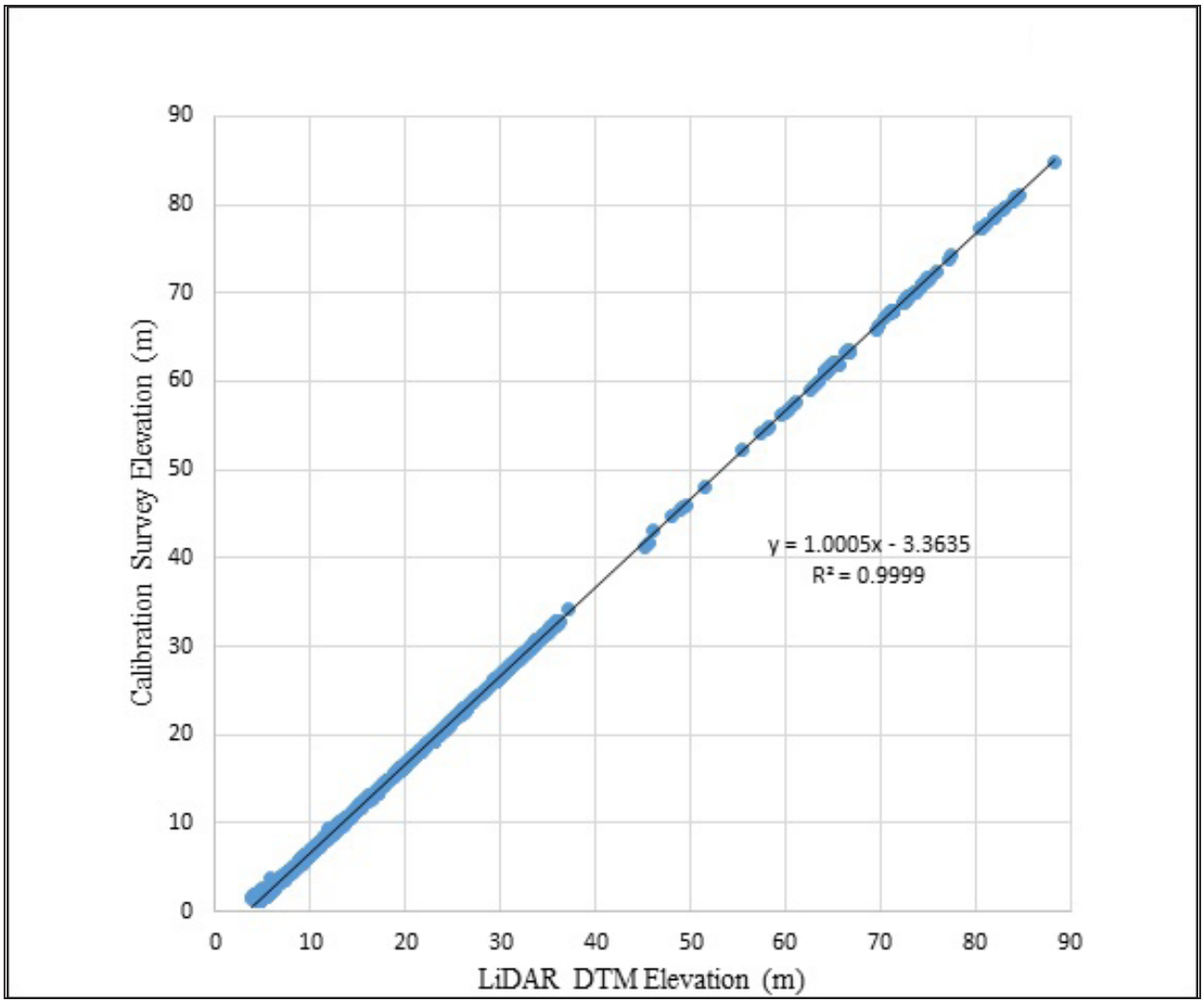


Figure 24. Correlation plot between calibration survey points and LiDAR data.

Table 18. Calibration Statistical Measures.

Calibration Statistical Measures	Value (meters)
Height Difference	3.36
Standard Deviation	0.13
Average	-3.36
Minimum	-3.93
Maximum	-2.12

The remaining 20% of the total survey points, resulting in 695 points, were used for the validation of calibrated Alaminos 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 25. The computed RMSE between the calibrated LiDAR DTM and validation elevation values is 0.09 meters with a standard deviation of 0.08 meters, as shown in Table 19.

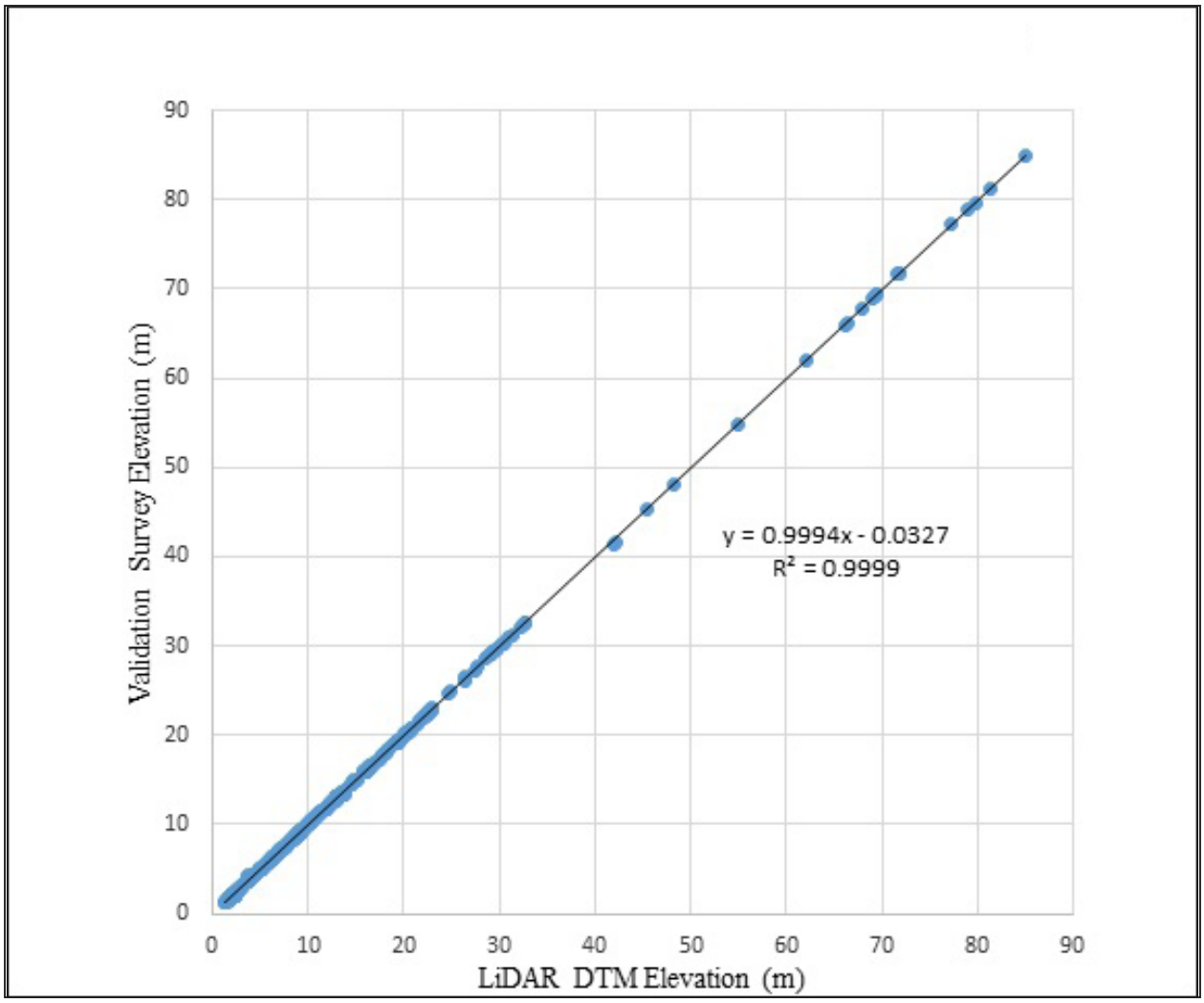


Figure 25. Correlation plot between the validation survey points and the LiDAR data.

Table 19. Validation Statistical Measures.

Validation Statistical Measures	Value (meters)
RMSE	0.09
Standard Deviation	0.08
Average	-0.04
Minimum	-0.58
Maximum	0.47

3.11 Integration of Bathymetric Data into the LiDAR Digital Terrain Model

For bathy integration, merged centerline data were available for Alaminos with 12,301 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 0.44 meters. The extent of the bathymetric survey done by the Data Validation and Bathymetry Component (DVBC) in Alaminos integrated with the processed LiDAR DEM is shown in Figure 26.

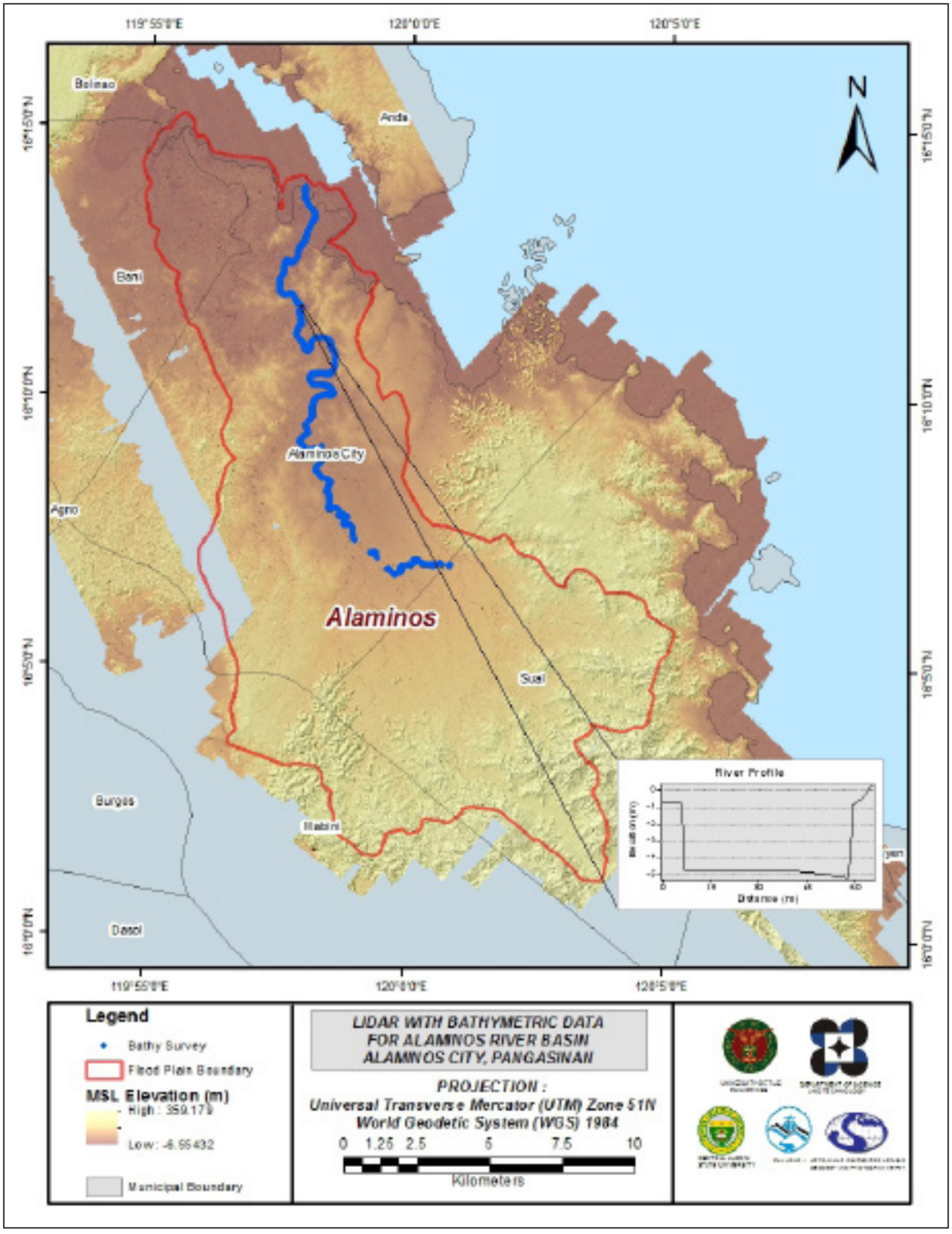


Figure 26. Map of Alaminos Floodplain with bathymetric survey points shown in blue.

3.12 Feature Extraction

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

3.12.1 Quality Checking (QC) of Digitized Features' Boundary

Alaminos Floodplain, including its 200 m buffer, has a total area of 210.88 sq km. For this area, a total of 6.0 sq km, corresponding to a total of 1,480 building features, are considered for QC. Figure 27 shows the QC blocks for Alaminos Floodplain.

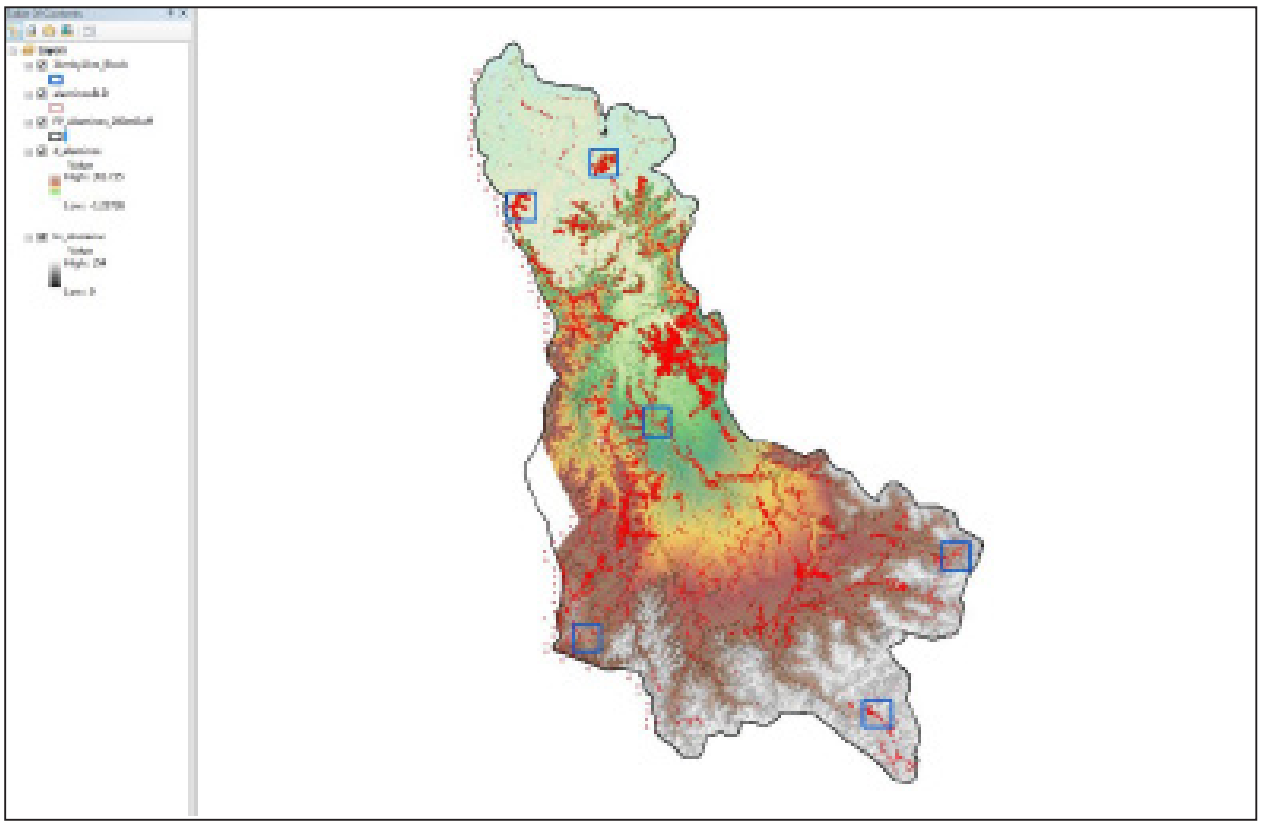


Figure 27. Blocks (in blue) of Alaminos building features subjected to QC

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

Table 20. Details of the quality checking ratings for the building features extracted for the Alaminos River Basin

FLOODPLAIN	COMPLETENESS	CORRECTNESS	QUALITY	REMARKS
Alaminos	99.86	99.59	99.39	PASSED

3.12.2 Height Extraction

Height extraction was done for 25,095 building features in Alaminos Floodplain. Of these building features, 2,544 were filtered out after height extraction, resulting in 22,553 buildings with height attributes. The lowest building height is at 2.00 m, while the highest building is at 9.89 m.

3.12.3 Feature Attribution

For improved accuracy in building footprints attribution, all the necessary data such as name and type were gathered, verified, and field validated with the use of video-tagging device or geo-tagged video capturing tool.

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

Table 21. Number of Building Features Extracted for Alaminos Floodplain.

Facility Type	No. of Features
Residential	21,657
School	443
Market	28
Agricultural/Agro-Industrial Facilities	1
Medical Institutions	23
Barangay Hall	38
Military Institution	0
Sports Center/Gymnasium/Covered Court	29
Telecommunication Facilities	2
Transport Terminal	3
Warehouse	13
Power Plant/Substation	0
NGO/CSO Offices	8
Police Station	3
Water Supply/Sewerage	1
Religious Institutions	54
Bank	6
Factory	0
Gas Station	27
Fire Station	1
Other Government Offices	45
Other Commercial Establishments	171
Total	**22,553**

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

Floodplain	Road Network Length (km)					Total
	Barangay Road	City/Municipal Road	Provincial Road	National Road	Others	
Alaminos	213.19	8.92	28.94	0.00	0.00	251.05

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

Floodplain	Water Body Type					Total
	Rivers/Streams	Lakes/Ponds	Sea	Dam	Fish Pen	
Alaminos	5	923	0	0	0	928

A total of 44 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 28 shows the Digital Surface Model (DSM) of Alaminos Floodplain overlaid with its ground features.

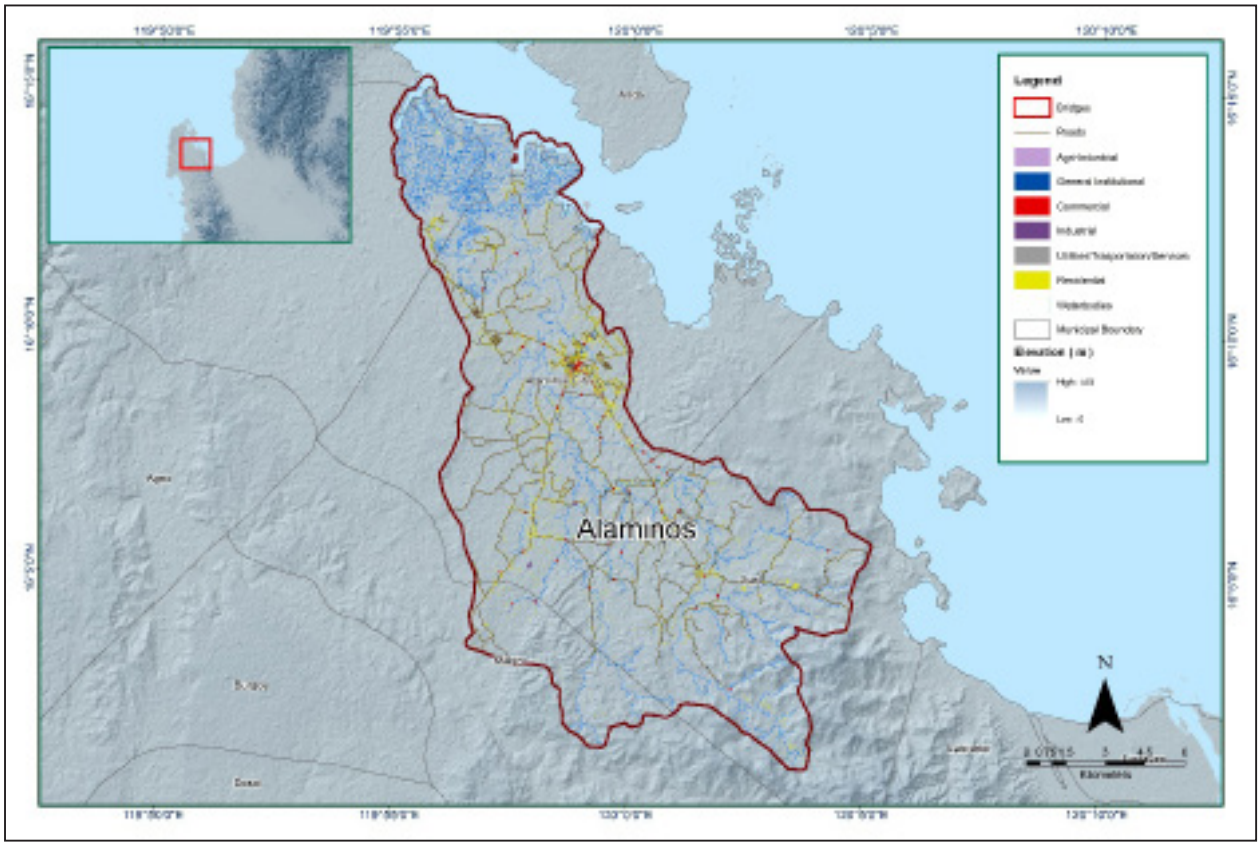


Figure 28. Extracted features for Alaminos Floodplain.

CHAPTER 4: DATA VALIDATION SURVEY AND MEASUREMENTS IN THE ALAMINOS RIVER BASIN

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

The methods applied in this Chapter were based on the DREAM methods manual (Balicanta, 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 Alaminos River on September 8–22, 2015 with the following scope of work: reconnaissance; control survey for the establishment of a control point; cross-section, bridge as-built of Gayaga Bridge piers; ground validation data acquisition of about 162.06 km for the whole province of Pangasinan; and bathymetric survey from Brgy. Seselangen, Municipality of Sual down to Brgy. Pangapisan, Alaminos City, with an estimated length of 17.4 km using GNSS PPK survey technique.

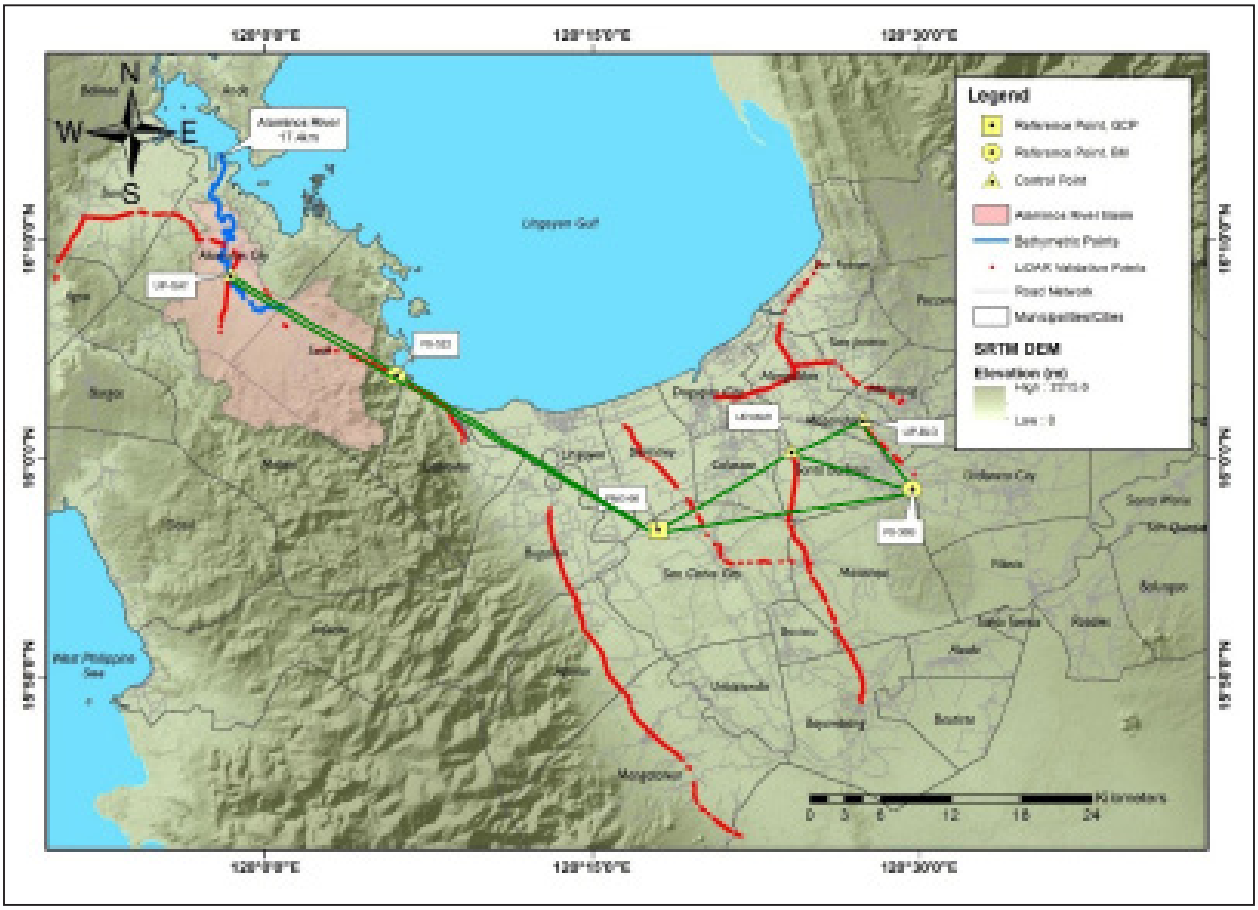


Figure 29. Extent of the bathymetric survey (in blue) in Alaminos River and the LiDAR validation survey (in red)

4.2 Control Survey

The GNSS network used for Alaminos River Basin is composed of three (3) loops established on September 10, 16, and 19, 2015 occupying the following reference points: PNG-66, second-order GCP, located in San Carlos City, PS-36B, first-order BM, located in Urdaneta City, and PS-522, first-order BM, located in the Municipality of Sual, Pangasinan.

Three control points were established along the approach of the bridges namely; UP-BLG is a located at the left side, facing upstream, of the approach of Baloling bridge, Brgy. Poblacion, Municipality of Mapandan; UP-GAY located at the left side, facing downstream, of the approach of Gayaga bridge, Brgy. Amandiego, Alaminos City; UP-MAR located at the right side, facing downstream, of the approach of Maramba bridge. Maramba Bridge is built in Brgy. Dalongue, Municipality of Santa Barbara, all in the Province of Pangasinan.

The summary of the reference and control points and its location is summarized in Table 24 while the GNSS network established is illustrated in Figure 30.

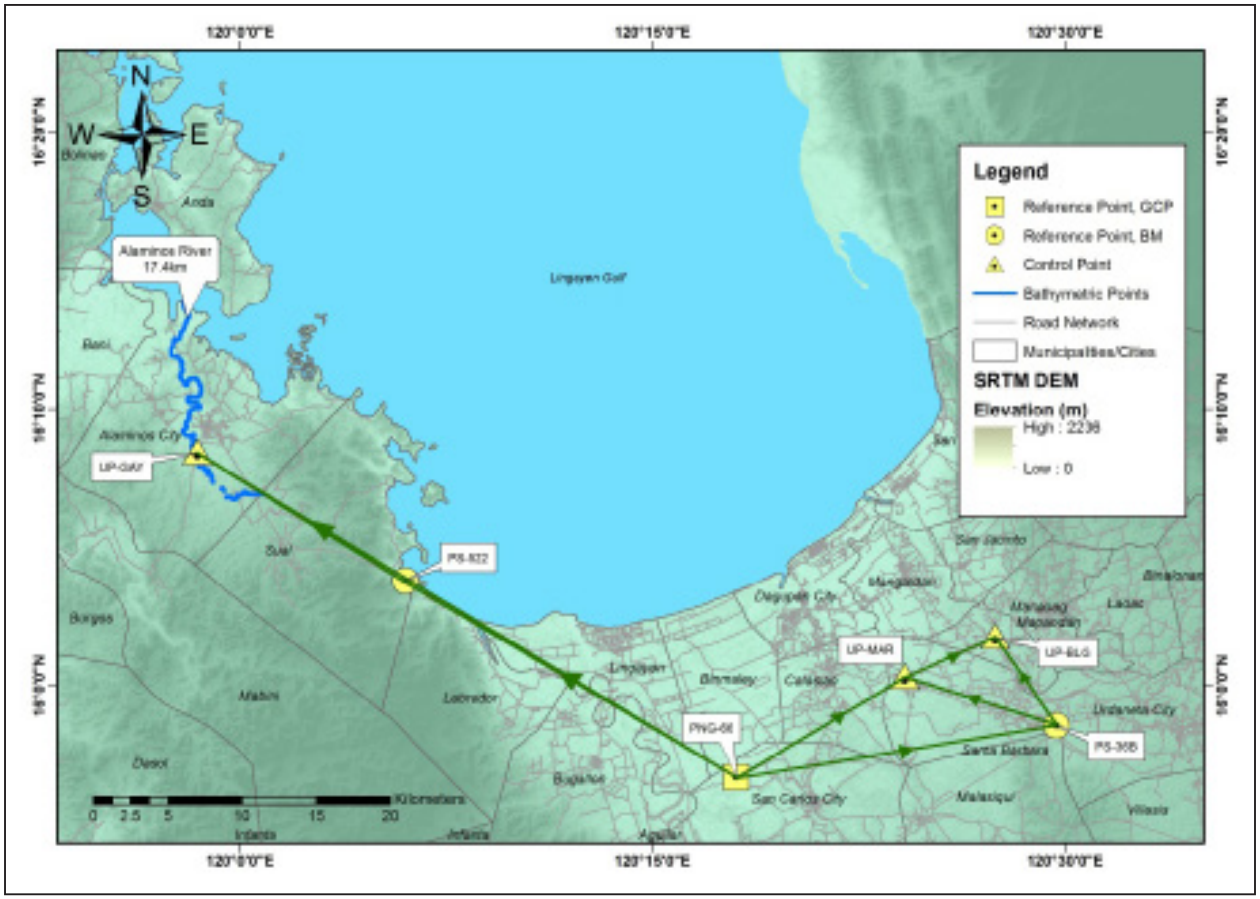


Figure 30. The GNSS Network established in the Alaminos River Survey.

Table 24. List of reference and control points used during the survey in Alaminos River (Source: NAMRIA, UP-TCAGP)

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)				
		Latitude	Longitude	Ellipsoidal Height (m)	Elevation in MSL (m)	Date Established
PNG-66	2nd Order, GCP	15°56'41.53646"	120°18'01.81867"	45.135	-	2007
PS-36B	1st Order, BM	-	-	60.309	18.639	1991
PS-522	1st Order, BM	-	-	44.330	1.812	2007
UP-BLG	UP Established	-	-	-	-	Sept. 15, 2015
UP-GAY	UP Established	-	-	-	-	Sept. 17, 2015
UP-MAR	UP Established	-	-	-	-	Sept. 17, 2015

The GNSS set-ups made in the location of the reference and control points are exhibited in Figure 31 to Figure 36.

Figure 31. GNSS base receiver set-up, Trimble® SPS 852 at PNG-66 in Calamboyan Elementary School, San Carlos City, Pangasinan

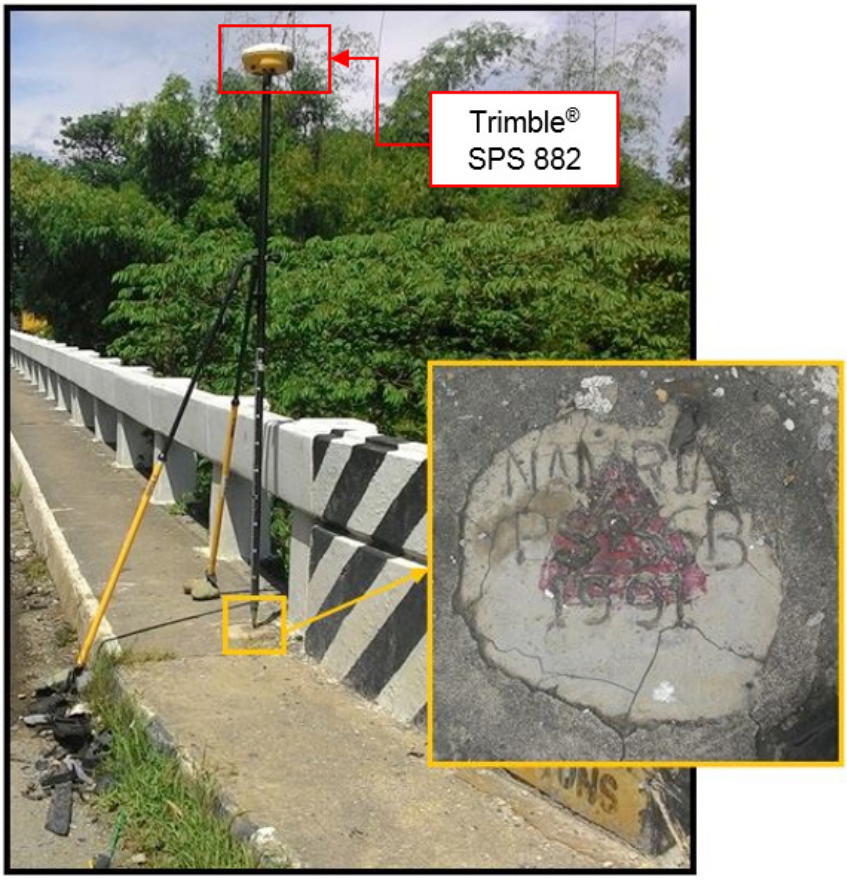


Figure 32. GNSS receiver set-up, Trimble® SPS 882 at PS-36B in Villamil Bridge, Urdaneta City, Pangasinan

Figure 33. GNSS receiver occupation, Trimble® SPS 882 at PS-522 in Quartel Bridge, Municipality of Sual, Pangasinan

Figure 34. GNSS base receiver set-up, Trimble® SPS 852 at UP-BLG in Baloling Bridge, Municipality of Mapandan, Pangasinan

Figure 35. GNSS base receiver setup, Trimble® SPS 852 at UP-GAY in Gayaga Bridge, Alaminos City, Pangasinan

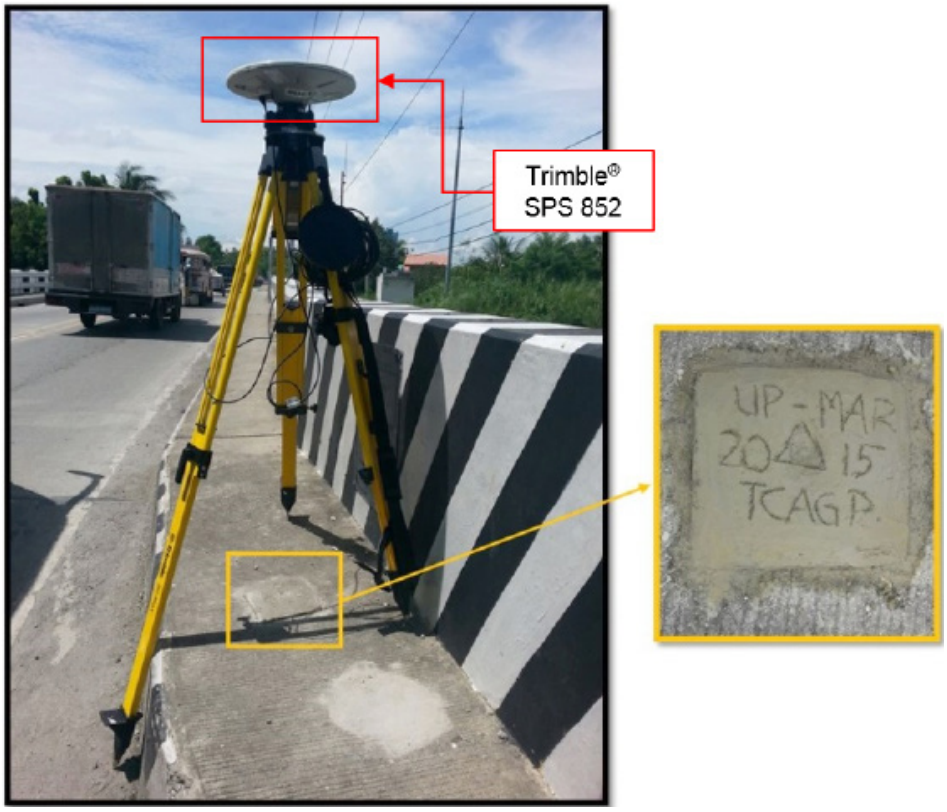


Figure 36. GNSS base receiver set-up, Trimble® SPS 852 at UP-MAR inMaramba Bridge, Municipality of Santa Barbara, Pangasinan

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

Table 25. Baseline processing report for Alaminos River static survey

Observation	Date of Observation	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
PNG-66 - PS-36B	Sept. 10, 2015	Fixed	0.004	0.032	80°34'24"	21076.72	15.257
PNG-66 -vPS-36B	Sept. 19, 2015	Fixed	0.004	0.023	80°34'24"	21076.73	15.178
PNG-66 - UP-MAR	Sept. 19, 2015	Fixed	0.005	0.033	58°24'17"	12839.72	6.668
PNG-66 - UP-BLG	Sept. 19, 2015	Fixed	0.005	0.03	60°45'33"	19259.28	10.98
PNG-66 - PS-522	Sept. 16, 2015	Fixed	0.005	0.022	301°25'35"	25130.95	-0.832
UP-MAR - PS-36B	Sept. 19, 2015	Fixed	0.004	0.029	108°24'33"	10385.5	8.6
PS-36B - UP-BLG	Sept. 10, 2015	Fixed	0.004	0.025	326°15'14"	7167.08	-4.244
PS-522 - UP-GAY	Sept. 16, 2015	Fixed	0.004	0.026	302°25'36"	15998.92	6.786
PNG-66 - UP-GAY	Sept. 16, 2015	Fixed	0.004	0.028	301°50'14"	41128.23	5.941

As shown in Table 25, a total of nine (9) baselines were processed with reference point PNG-66 held fixed for coordinate values; and PS-36B and PS-522 fixed for elevation values. All of them passed the required accuracy.

4.4 Network Adjustment

After the baseline processing procedure, network adjustment was performed using TBC. Looking at the Adjusted Grid Coordinates table 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 in equation from:

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

Where:

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

The six (6) control points, PNG-66, PS-36B, PS-522, UP-BLG, UP-GAY, and UP-MAR were occupied and observed simultaneously to form a GNSS loop. Coordinates of PNG-66 and elevation values of PS-36B and PS-522 were held fixed during the processing of the control points as presented in Table 26. Through these reference points, the coordinates and elevation of the unknown control points were computed.

Table 26. Control Point Constraints

Point ID	Type	East σ (Meter)	North σ (Meter)	Height σ (Meter)	Elevation σ (Meter)
PNG-66	Local	Fixed	Fixed		
PS-36B	Grid				Fixed
PS-522	Grid				Fixed
Fixed = 0.000001(Meter)					

The list of adjusted grid coordinates, i.e., Northing, Easting, Elevation, and computed standard errors of the control points in the network is indicated in Table 27. All fixed control points have no values for grid and elevation values.

Table 27. Adjusted Grid Coordinates

Point ID	Easting	Easting Error (Meter)	Northing (Meter)	Northing Error (Meter)	Elevation (Meter)	Elevation Error (Meter)	Constraint
PNG-66	211006.342	?	1764708.591	?	2.268	0.050	LL
PS-36B	231853.134	0.008	1767892.575	0.007	18.639	?	e
PS-522	189718.885	0.012	1778099.180	0.009	1.812	?	e
UP-BLG	227941.936	0.011	1773902.67	0.010	14.378	0.083	
UP-GAY	176325.127	0.011	1786874.424	0.009	9.759	0.082	
UP-MAR	222035.735	0.011	1771296.986	0.009	9.726	0.092	

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

a. PNG-66
horizontal accuracy = Fixed
vertical accuracy = 5 cm < 10 cm

b. PS-36B
horizontal accuracy = √((0.8)² + (0.7)²)
= √(0.64 + 0.49)
= 1.06 cm < 20 cm
vertical accuracy = Fixed

c. PS-522
horizontal accuracy = √((1.2)² + (0.9)²)
= √(1.44 + 0.81)
= 1.50cm < 20 cm
vertical accuracy = Fixed

d. UP-BLG
horizontal accuracy = √((1.1)² + (1.0)²)
= √((1.21 + 1)
= 1.49 cm < 20 cm
vertical accuracy = 8.3 cm < 10 cm

e. UP-GAY
horizontal accuracy = √((1.1)² + (0.9)²)
= √(1.21 + 0.81)
= 1.42 cm < 20 cm
vertical accuracy = 8.2 cm < 10 cm

f. UP-MAR
horizontal accuracy = √((1.1)² + (0.9)²)
= √(1.21 + 0.81)
= 1.42 cm < 20 cm
vertical accuracy = 8.2 cm < 10 cm

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

Table 28. Adjusted Geodetic Coordinates

Point ID	Latitude	Longitude	Height (Meter)	Height Error (Meter)	Constraint
PNG-66	N15°56'41.53646"	E120°18'01.81867"	45.135	0.050	LL
PS-36B	N15°58'33.52429"	E120°29'41.05846"	60.309	?	e
PS-522	N16°03'47.48583"	E120°06'00.32645"	44.330	?	e
UP-BLG	N16°01'47.38965"	E120°27'27.12781"	56.071	0.083	
UP-GAY	N16°08'26.44413"	E119°58'25.80151"	51.092	0.082	
UP-MAR	N16°00'20.29399"	E120°24'09.66719"	51.750	0.092	

The corresponding geodetic coordinates of the observed points are within the required accuracy as shown in Table 22. 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 23.

Table 29. 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)
PNG-66	2nd Order, GCP	15°56' 41.53646"	120°18' 01.81867"	45.135	1764708.591	211006.342	2.268
PS-36B	1st Order, BM	15°58' 33.52429"	120°29' 41.05846"	60.309	1767892.575	231853.134	18.639
PS-522	1st Order, BM	16°03' 47.48583"	120°06' 00.32645"	44.330	1778099.180	189718.885	1.812
UP-BLG	UP Established	16°01' 47.38965"	120°27' 27.12781"	56.071	1773902.67	227941.936	14.378
UP-GAY	UP Established	16°08' 26.44413"	119°58' 25.80151"	51.092	1786874.424	176325.127	9.759
UP-MAR	UP Established	16°00' 20.29399"	120°24' 09.66719"	51.750	1771296.986	222035.735	9.726

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

Cross-section survey was conducted along the downstream side of Gayaga Bridge using GNSS receiver Trimble® SPS 882 in PPK survey technique in Brgy. Amandiego, Alaminos City on September 14, 2015, as shown in Figure 37.

Figure 37. Cross-section survey along the downstream side of Gayaga Bridge, Alaminos City

The cross-sectional line for Gayaga Bridge is about 124 m with thirty-seven (37) points acquired using the control point UP-GAY as the GNSS base station. In addition to cross-section survey, bridge as-built features determination was performed to get the distance of piers and abutments from the bridge approach, found in Figure 37. Figure 38 to Figure 40 show the summary of gathered planimetric map, cross-section, and as-built data.

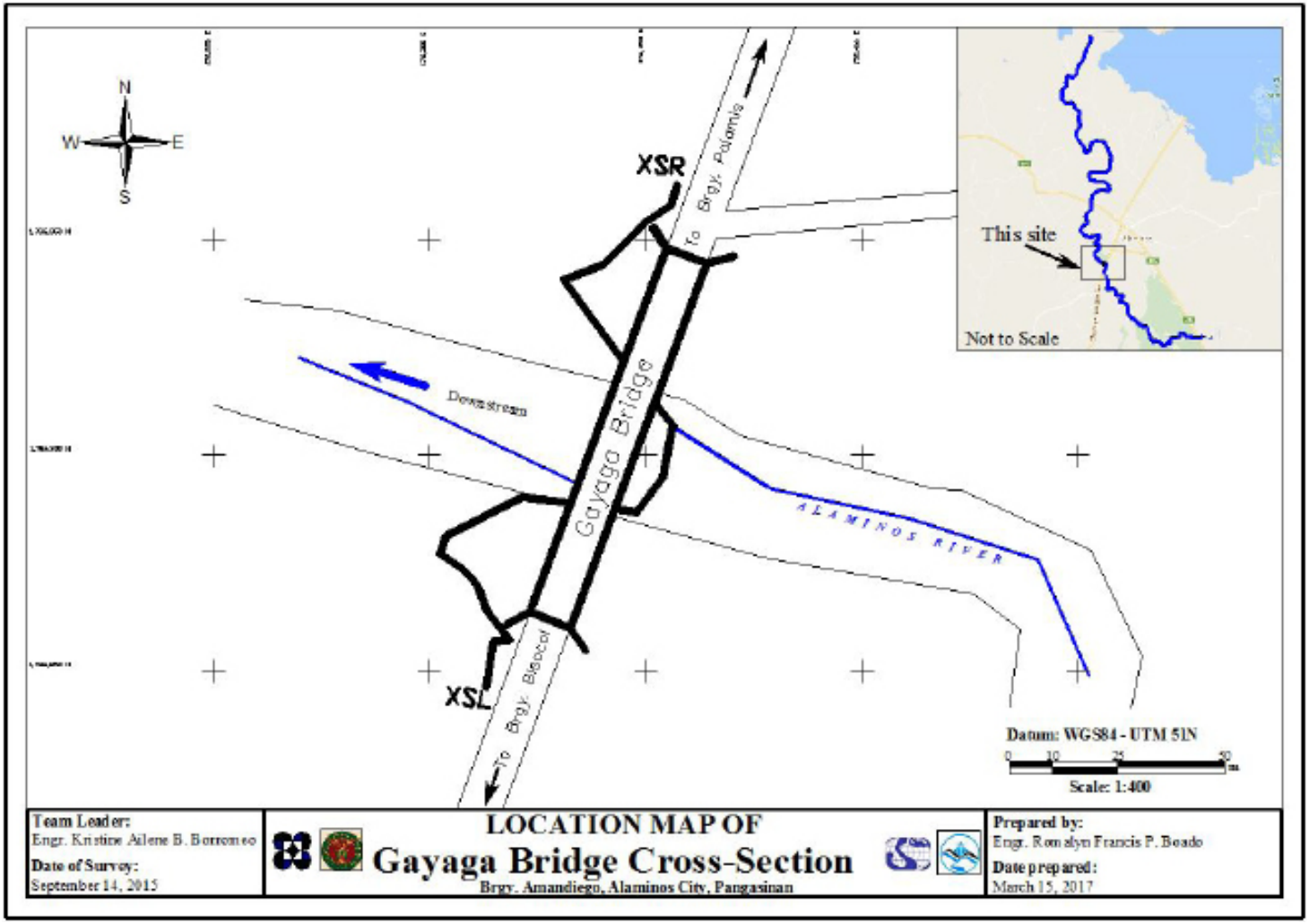


Figure 38. Gayaga Bridge planimetric map

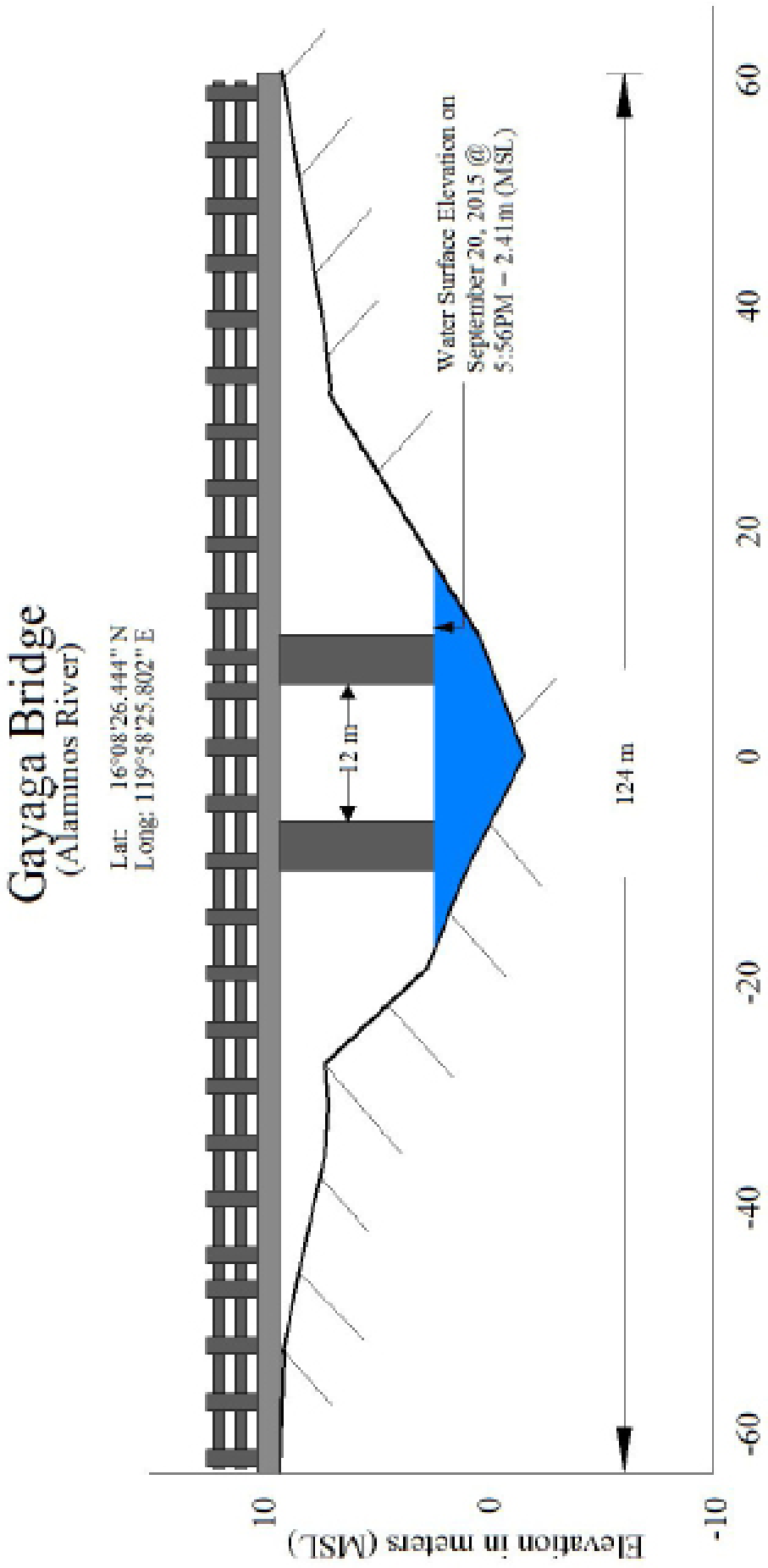


Figure 39. Gayaga Bridge cross-section diagram

Bridge Data Form

Bridge Name: Gayaga Bridge **Date:** September 14, 2015

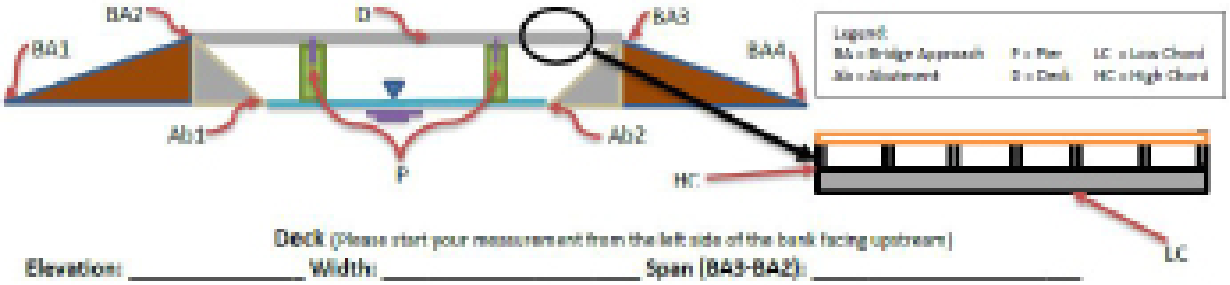
River Name: Alaminos River **Time:** 2:20 PM

Location (Brgy, City,Region): Brgy. Amandiego, Alaminos City

Survey Team: Abrio, Alberto, Borromeo, Salvador

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

Latitude: 16d08'26.44386" **Longitude:** 119d58'25.80176"



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

Elevation: _____ **Width:** _____ **Span (BA3-BA2):** _____

	Station	High Chord Elevation	Low Chord Elevation
1			
2			
3			
4			

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	9.256m	BA3	99.05m	9.417m
BA2	28.94m	9.519m	BA4	119.57m	9.259m

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

	Station (Distance from BA1)	Elevation
Ab1		
Ab2		

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

Shape: _____ Number of Piers: _____ Height of column footing: _____

	Station (Distance from BA1)	Elevation	Pier Width
Pier 1	47.19m	9.832m	
Pier 2	63.61m	9.829m	

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

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure 40. Gayaga Bridge data form

Figure 41. Water level marking on the pier of Gayaga Bridge

Water surface elevation in MSL of Alaminos River was determined using Trimble® SPS 882 in PPK mode survey on September 20, 2015 at 5:56 PM. This was translated onto marking the bridge's pier using the same technique as shown in Figure 41. The marking would serve as reference for flow data gathering and depth gauge deployment by the partner HEI, Central Luzon State University, who is responsible for Alaminos River.

4.6 Validation Points Acquisition Survey

Validation Points Acquisition Survey was conducted on September 11, 12, 13, 14, 16, and 18, 2015 using a survey-grade GNSS rover receiver, Trimble® SPS 882, mounted on a pole which was attached in front of the vehicle as shown in Figure 42. It was secured with a nylon rope to ensure that it was horizontally and vertically balanced. The antenna height of 2.53 m was measured from the ground up to the bottom of notch of the GNSS Rover receiver. The survey was conducted using PPK technique on a continuous topo mode.

On September 11, 2015, gathering of ground validation points started from the Municipality of Santa Barbara traversing major roads going to the Municipality of Malasiqui. The next day, September 12, 2015, the team divided into two groups, Group 1 started from Urdaneta City going to the Municipality of Mangaldan, while Group 2 started from the Municipality of San Fabian up to the Municipality of Santa Barbara. On September 13, 2015, Group 1 validated roads from San Carlos City going to the Municipality of Binmaley, and then continued from Dagupan City up to the Municipality of San Fabian. Group 2 started from the Municipality of Bayambang going to the Municipality of Malasiqui, and continued the extent up to the Municipality of Santa Barbara. Then on September 14, 2015, the team validated the areas in Alaminos City going to the Municipalities of Mabini and Bani. The remaining validation extent was surveyed on September 16 and 18, 2015. The GNSS base stations occupied for the surveys are PNG-66, UP-MAR, UP-GAY, and UP-BLG.

Figure 42. (A) Set-up of Trimble® SPS 882 attached to a vehicle and (B) Setting up of GNSS base station at PNG-66

The survey acquired 15,327 ground validation points with an approximate length of 162.06 km using the base stations PNG-66, UP-MAR, UP-GAY, and UP-BLG, as shown in the map in Figure 43.

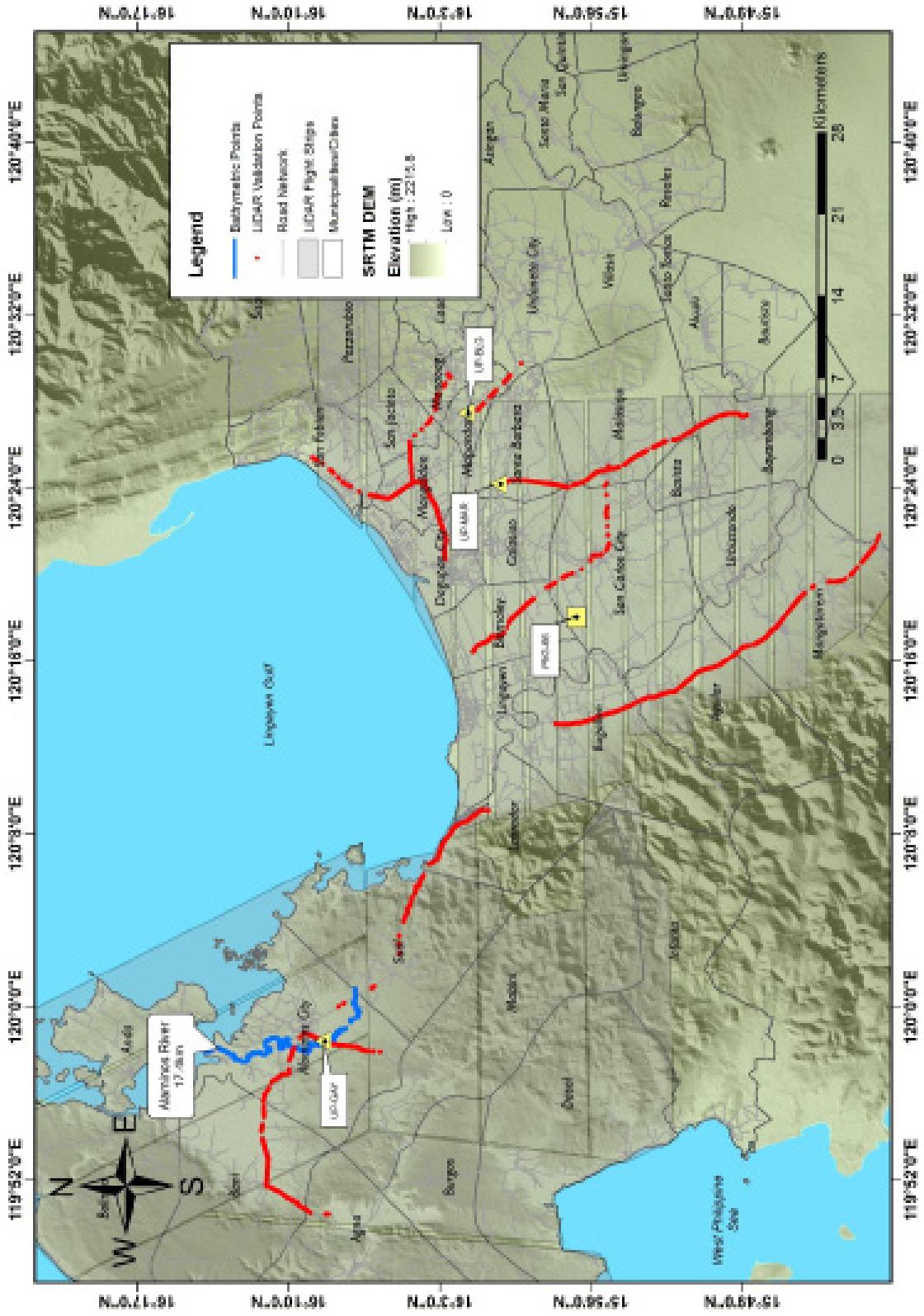


Figure 43. Validation point acquisition survey of Tigaplan River Basin

4.7 Bathymetric Survey

Bathymetric survey was conducted in four different days. On September 14, 2015, the team used a survey-grade GNSS rover receiver, Trimble® SPS 882, mounted on a pole with an OHMEXTM attached to the bottom and mounted on a boat with the assistance from PDRRMMO Pangasinan as shown in Figure 44. The survey started from the midstream part of the river in Brgy. Palamis, Alaminos City with coordinates 16°09'03.15607" 119°57'59.79458", down to the mouth of the river in Brgy. Pangapisan, also in Alaminos City.

Figure 44. Bathymetric survey using OHMEXTM echo sounder

Manual bathymetric survey on the other hand was conducted on September 15, 20 and 21, 2015 using GNSS rover receiver, Trimble® SPS 882 as shown in Figure 45. The survey started from the upstream part of the river in Brgy. Seselangen, Municipality of Sual with coordinates 16°06'54.87781" 120°00'50.87699", traversed down the river via foot, and ended at the starting point of the bathymetric survey using boat in Brgy. Palamis, Alaminos City. The UP-established control point, UP-GAY, was used as the GNSS base station all throughout the survey.

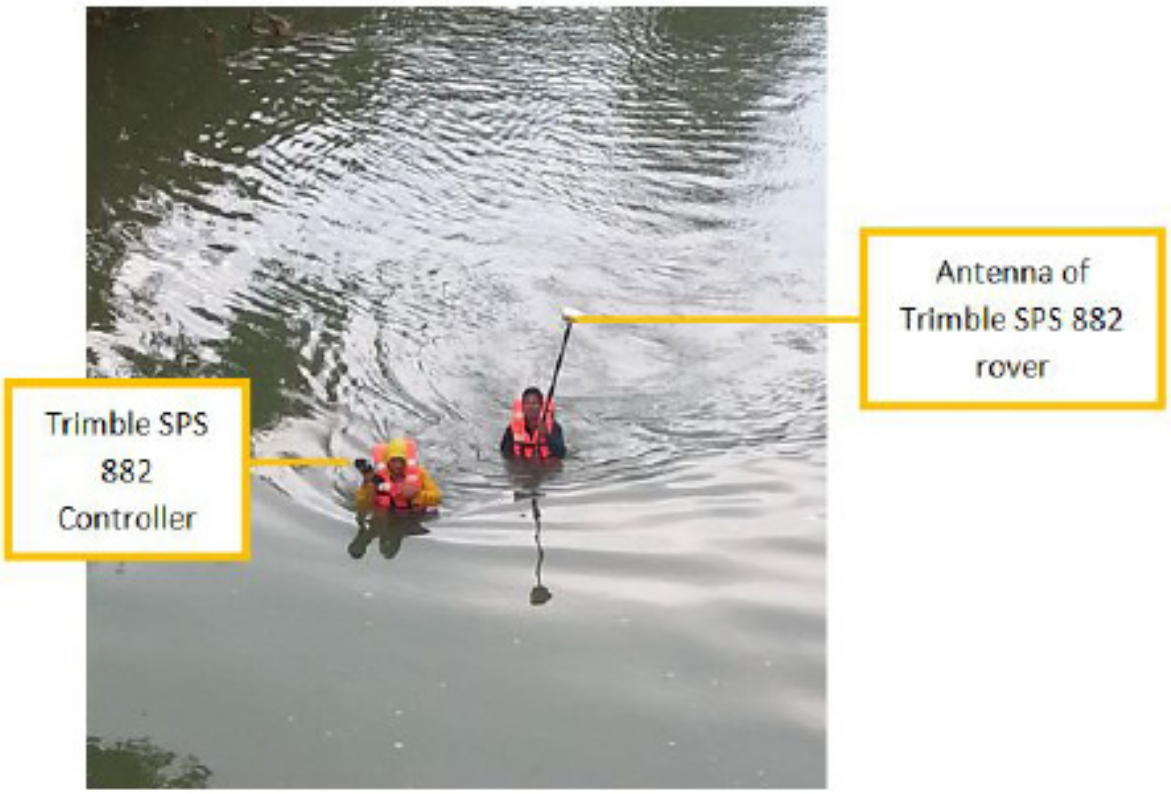


Figure 45. Manual bathymetry using PPK survey

Figure 46. Dam in Brgy. Amandiego

The bathymetric line length surveyed has an estimated line length of 17 km with a total of 12,418 bathymetric points gathered covering 17 barangays in Alaminos City, and one barangay in Municipality of Sual as shown in Figure 47. The processed data were generated into a map using GIS and processed further using CAD for plotting the centerline of the river. As shown in Figure 48 to Figure 49, there is an elevation change of about 14 m within the 12 km of the 17.4 km acquired data. Lowest elevation was recorded in Brgy. Amandiego with a value of -5.0 m and the highest elevation observed was 9.148 m in MSL located in Brgy. Seselangen, Municipality of Sual. Problems encountered during the survey include the presence of three consecutive dams from Brgy. Amandiego going upstream and the occurrence of debris along the river which made it difficult to traverse the river while conducting manual bathymetry.

Figure 47. Bathymetric points gathered from Alaminos River

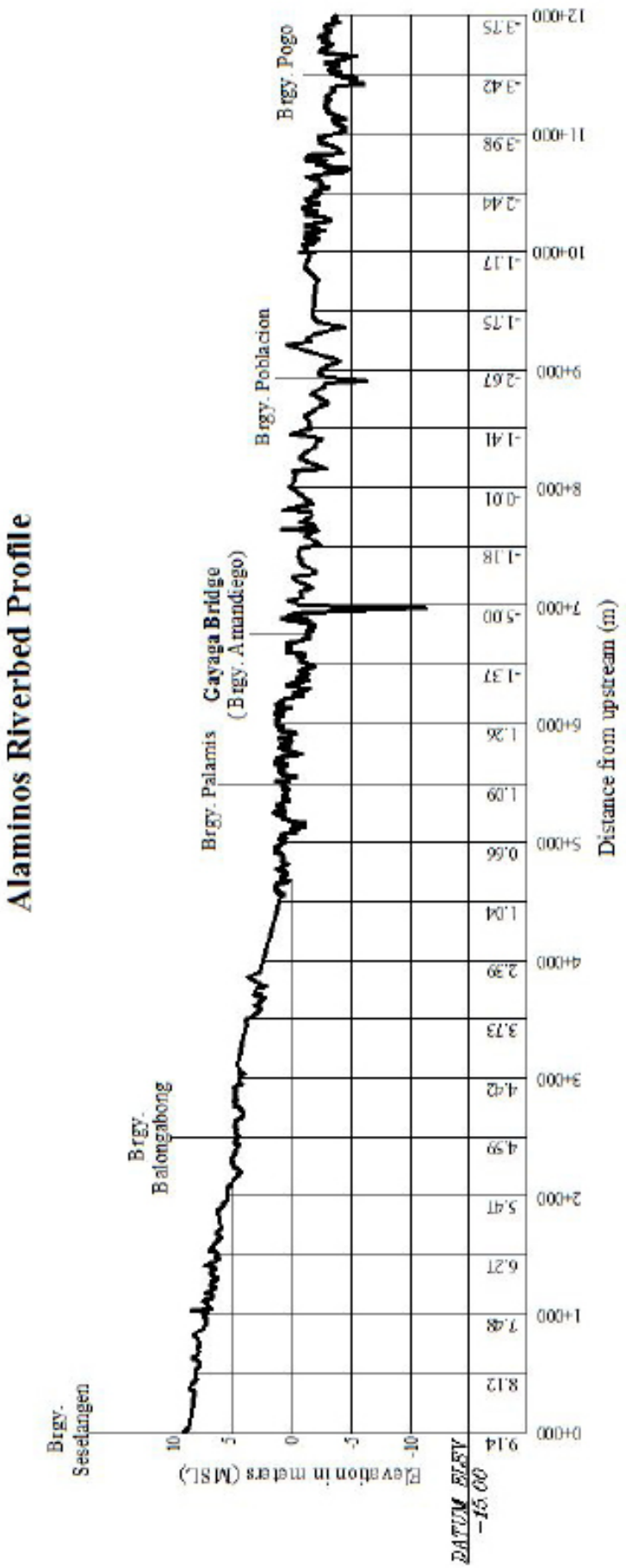


Figure 48. Alaminos riverbed profile from Brgy. Seselangen, Municipality of Sual down to Brgy. Pogo, Alaminos City

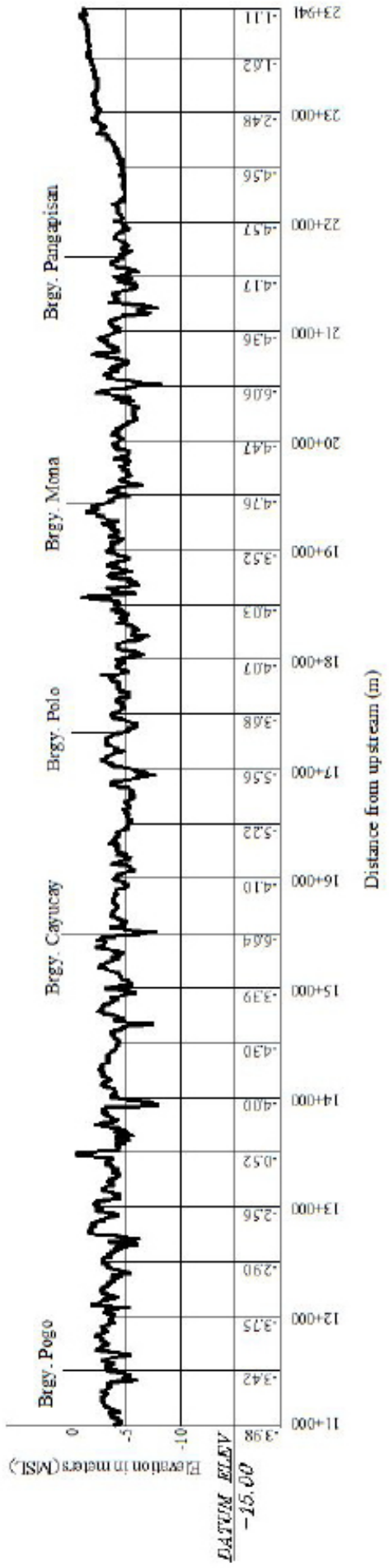


Figure 49. Continuation of Alaminos riverbed profile from Brgy. Pogo, Alaminos City down to Brgy. Pangapisan, Alaminos City

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, Girlie David, Mariel Monteclaro, Eleazar Raneses, Jr. and Jose T. Gavino

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

5.1 Data used in Hydrologic Modeling

5.1.1 Hydrometry and Rating Curves

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

5.1.2 Precipitation

In the absence of automatic rain gauge in Alaminos, precipitation data was recorded through manual reading in an 8 inches standard rain gauge installed in the study area. The rain gauge was installed one (1) kilometer upstream from the flow measurement site.

The total rain recorded in this event from the rain gauge is 51.53 mm. It peaked to 14.65 mm on 22 June 2016 at 13:50PM. The lag time between the peak rainfall and discharge is 6 hours and 50 minutes.

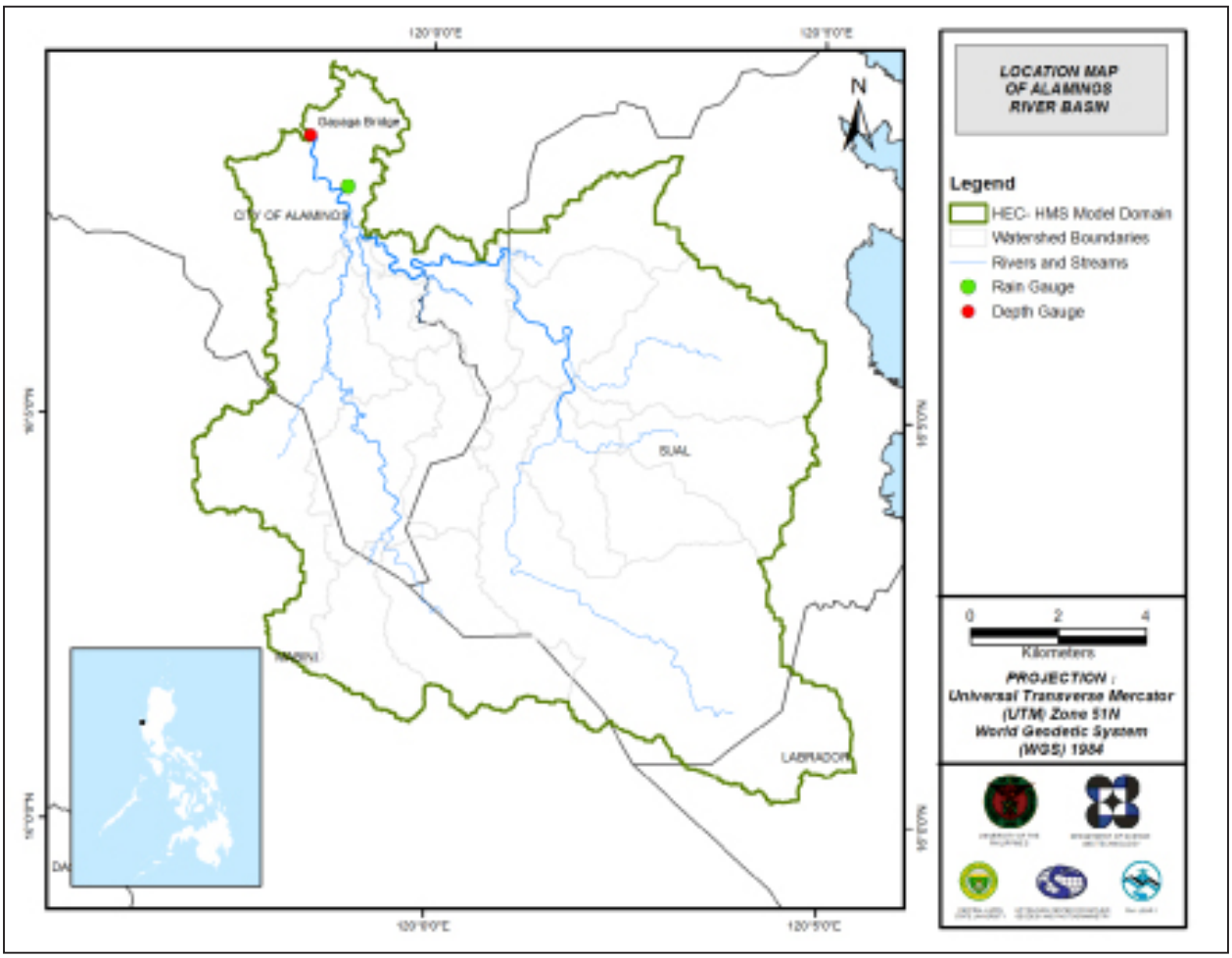


Figure 50. The location map of Alaminos HEC-HMS model used for calibration

5.1.3 Rating Curves and River Outflow

A rating curve was developed at Gayaga Bridge, Alaminos, Pangasinan (16°8' 26.801"N, 119°58' 26.202"E). It gives the relationship between the observed water levels at Gayaga Bridge and outflow of the watershed at this location.

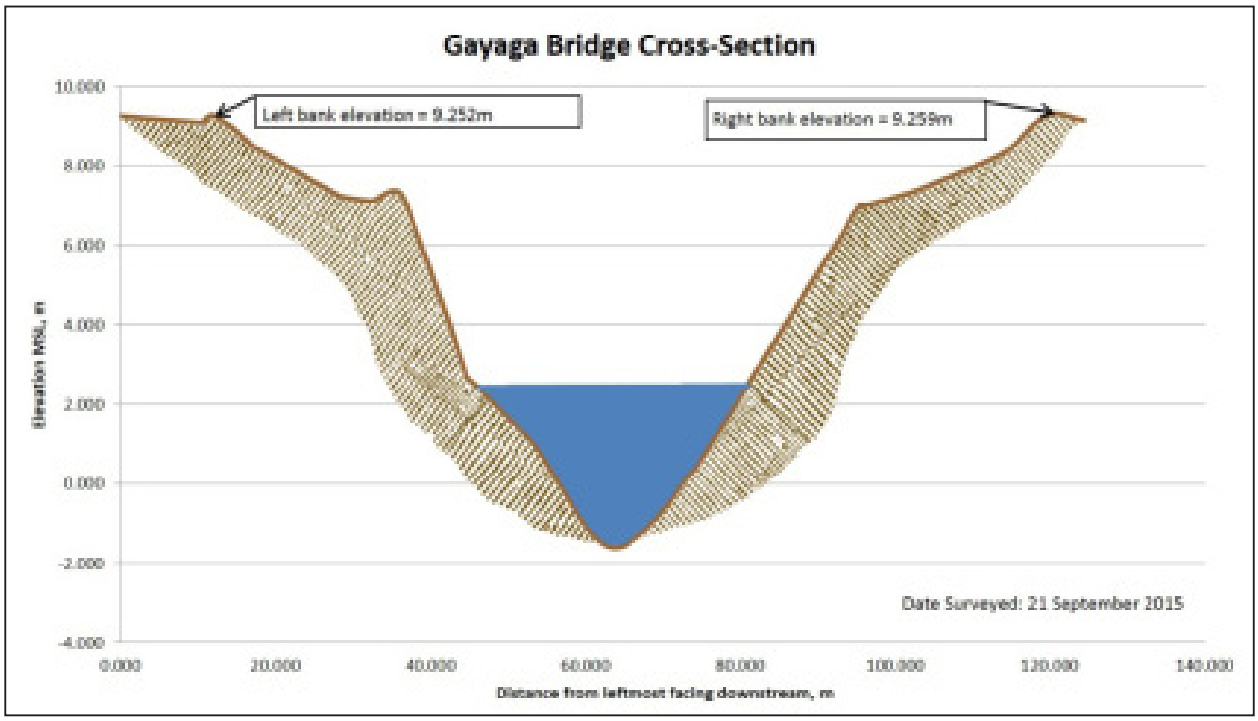


Figure 51. The Cross-section plot of Gayaga Bridge

For Gayaga Bridge, the rating curve is expressed as Q = 0.2016e0.9203h as shown in Figure 52.

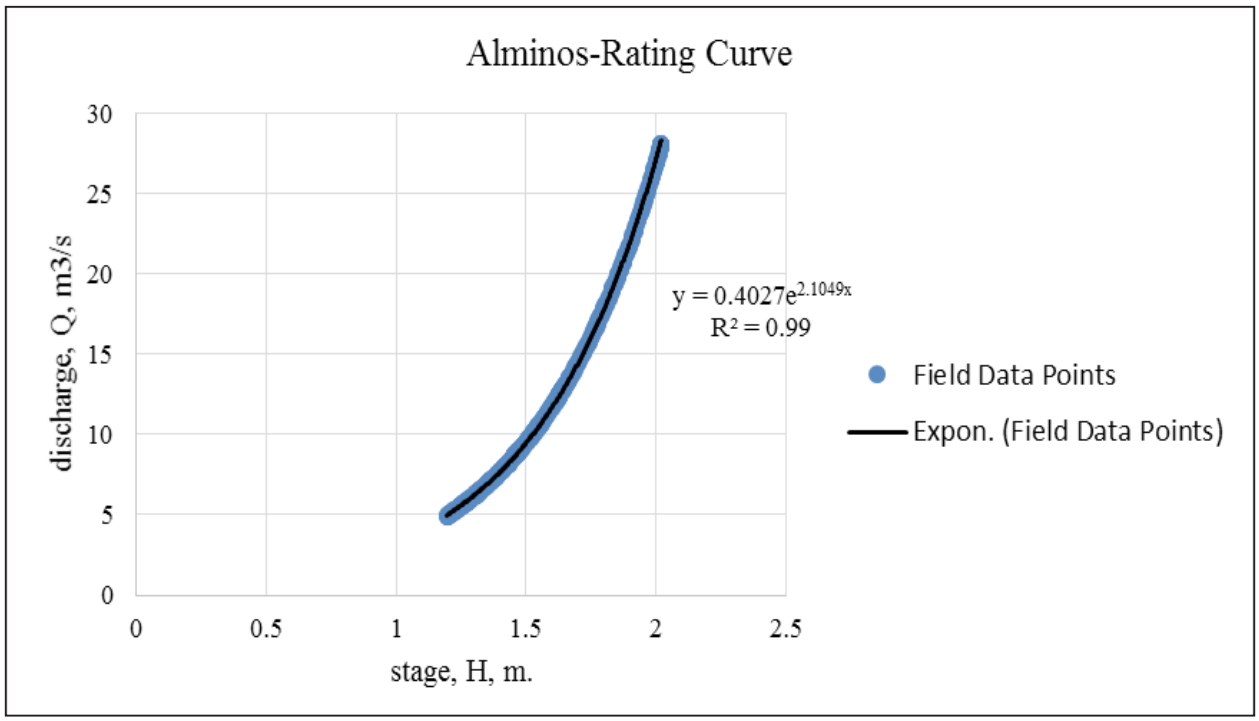


Figure 52. Rating curve at Gayaga Bridge, Alaminos, Pangasinan

This rating curve equation was used to compute the river outflow at Gayaga Bridge for the calibration of the HEC-HMS model shown in Figure 53. Peak discharge is 28.036 cms at 20:40 PM, June 22, 2016.

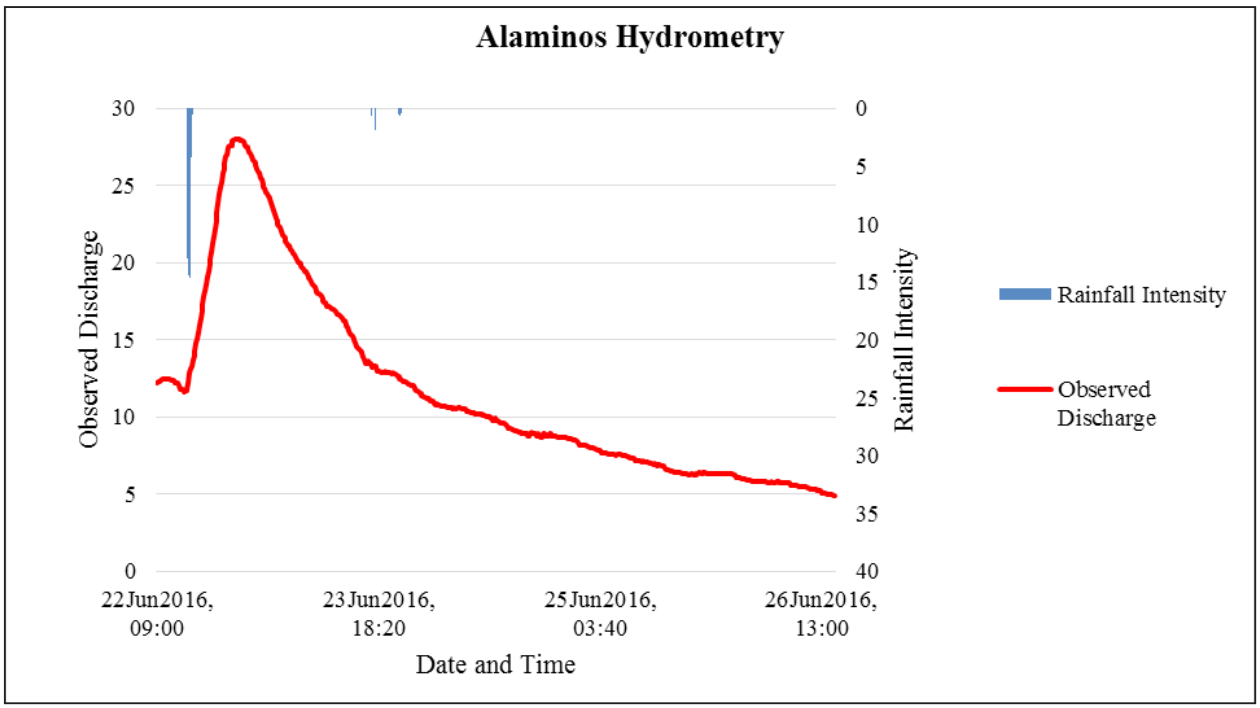


Figure 53. HQ Curve of HEC-HMS model

5.2 RIDF Station

The Philippines Atmospheric Geophysical and Astronomical Services Administration (PAGASA) computed Rainfall Intensity Duration Frequency (RIDF) values for the Dagupan, Pangasinan Rain Gauge. The RIDF rainfall amount for 24 hours was converted to a synthetic storm by interpolating and re-arranging the value in such a way certain peak value would be attained at a certain time. This station was chosen based on its proximity to the Alaminos watershed. The extreme values for this watershed were computed based on a 26-year record.

Table 30. RIDF values for Dagupan 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	23.9	34.3	42.3	55.4	77.6	93	121.2	148.3	175.8
5	33.9	47.4	58.8	77.3	109.1	131.3	170.8	209	246.7
10	40.5	56.1	69.7	91.9	129.9	156.6	203.6	249.2	293.6
15	44.3	61	75.9	100.1	141.6	170.9	222.1	271.9	320
20	46.9	64.4	80.2	105.8	149.8	180.9	235.1	287.8	338.6
25	48.9	67.1	83.5	110.2	156.2	188.7	245.1	300	352.9
50	55.1	75.2	93.8	123.8	175.7	212.4	275.8	337.7	396.8
100	61.2	83.3	103.9	137.3	195	236	306.3	375.1	440.5

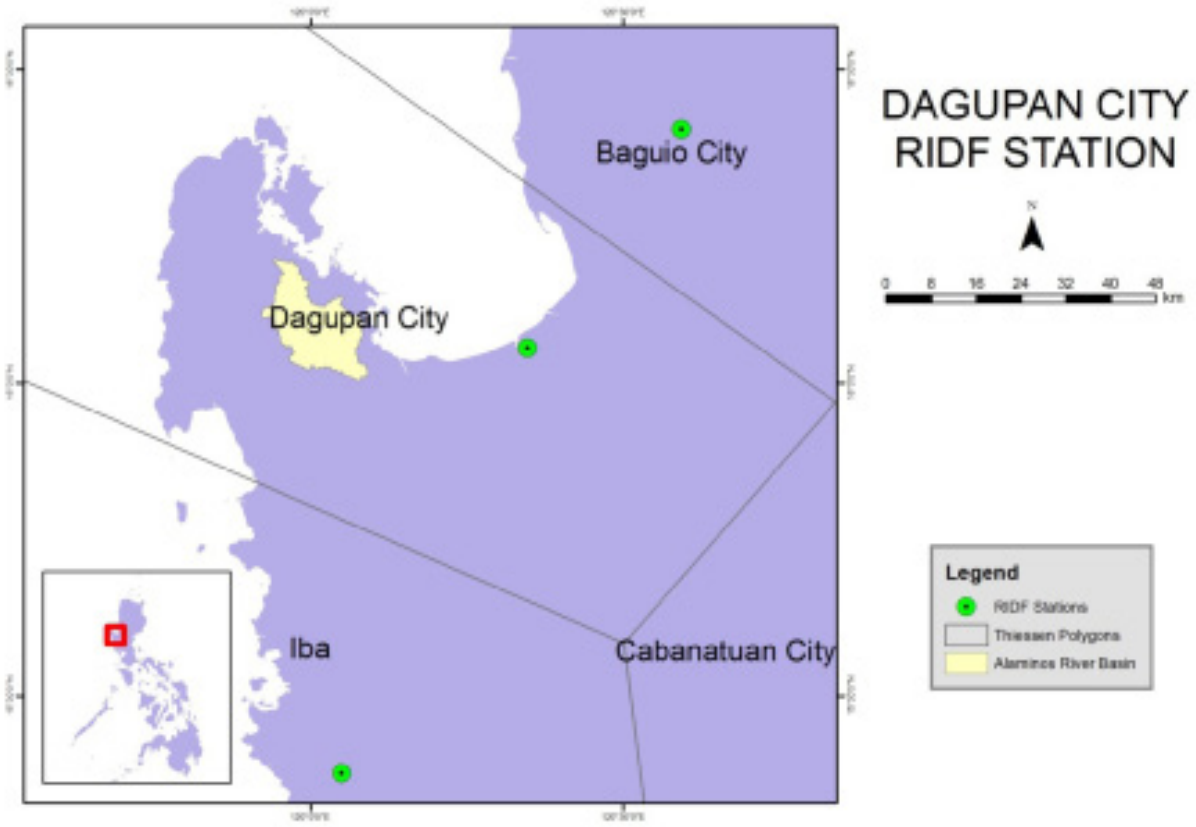


Figure 54. Dagupan RIDF location relative to Alaminos River Basin

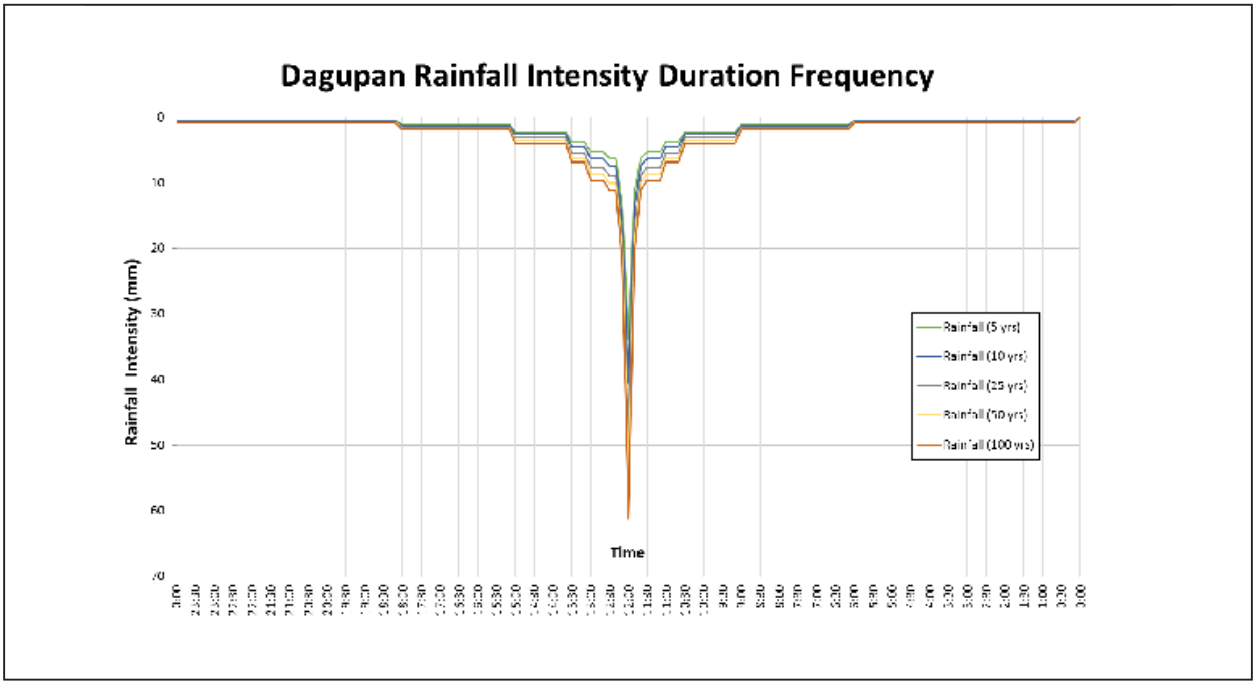


Figure 55. Synthetic storm generated for a 24-hour period rainfall for various return periods

5.3 HMS Model

The soil dataset was taken from and generated by the Bureau of Soils and Water Management under the Department of Agriculture. The land cover dataset was from the National Mapping and Resource information Authority (NAMRIA). The soil and land cover of the Alaminos River Basin are shown in Figure 56 and Figure 57, respectively.

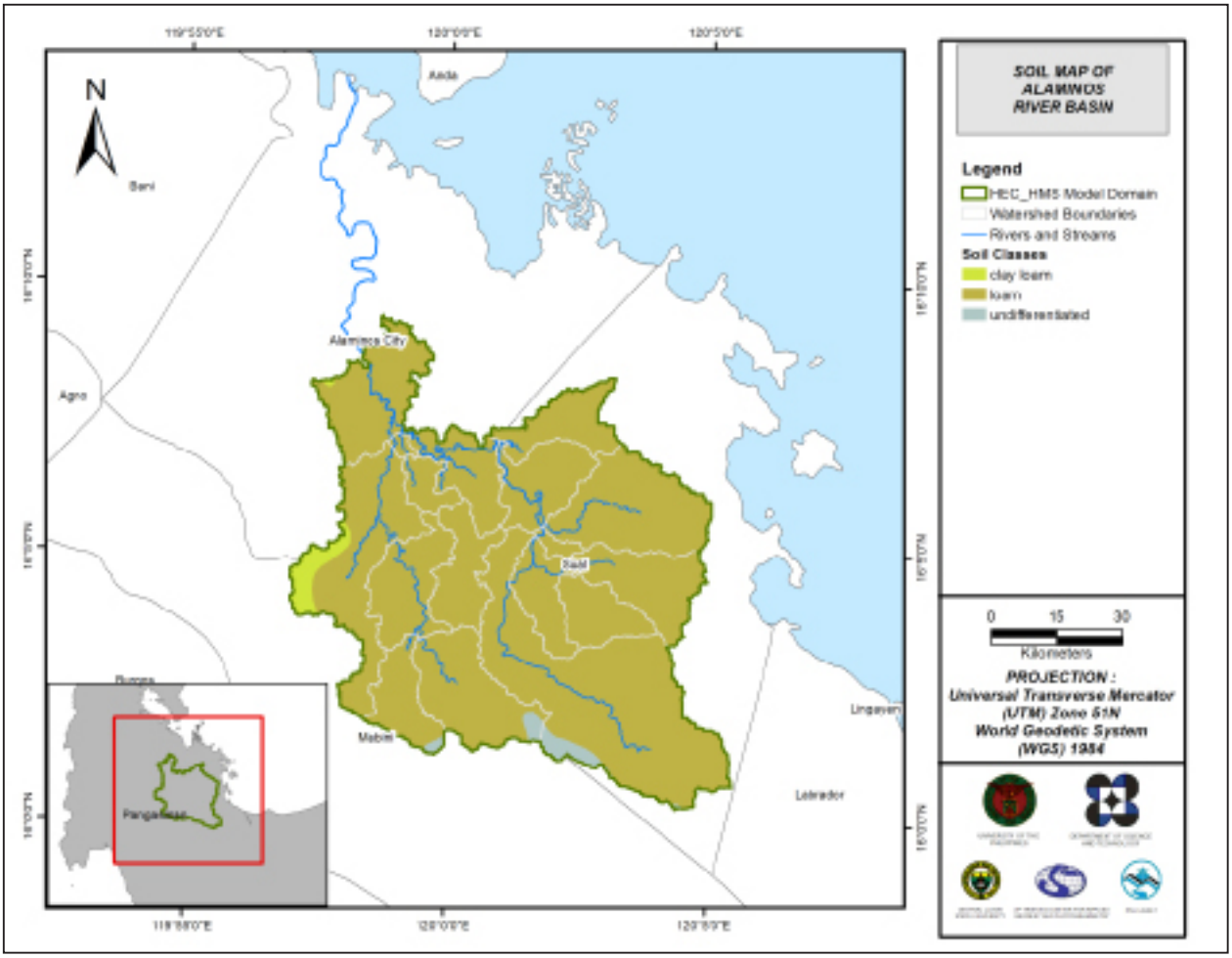


Figure 56. Soil map of Alaminos River Basin

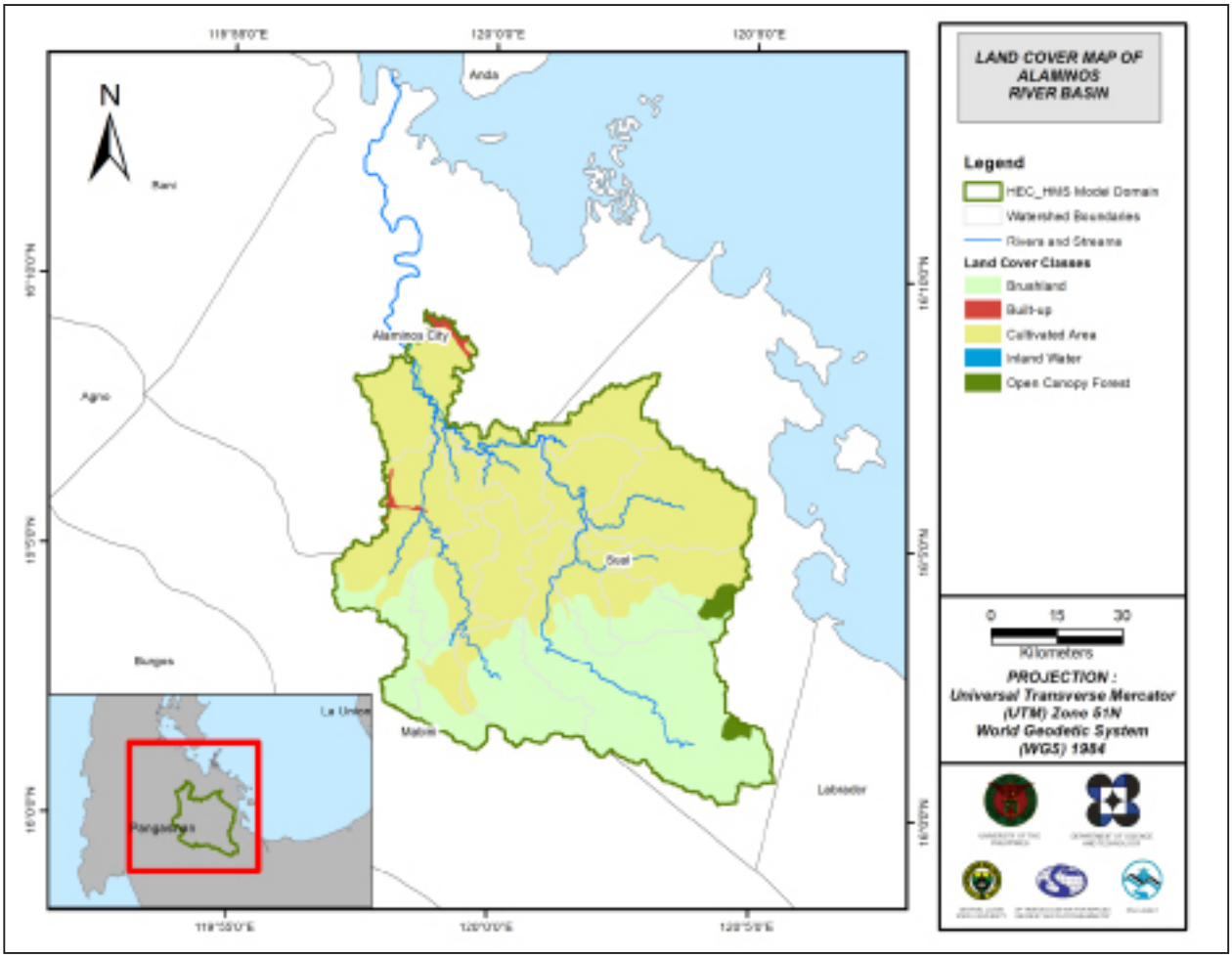


Figure 57. Land cover map of Alaminos River Basin

For Alaminos, three soil classes were identified. These are clay loam, loam, and undifferentiated soil. Moreover, five land cover classes were identified. These are brushland, built-up, cultivated area, inland water, and open canopy forest.

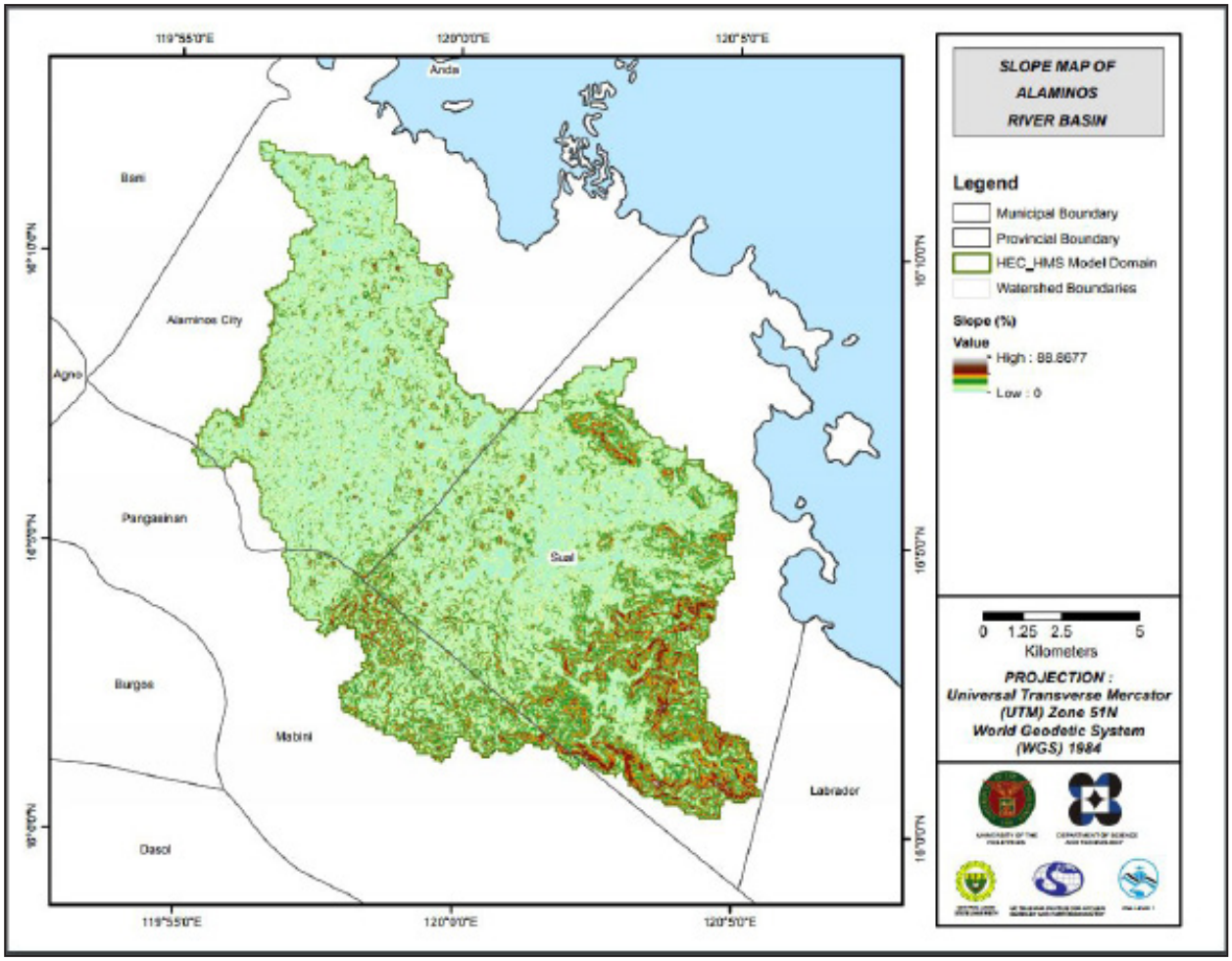


Figure 58. Slope map of Alaminos River Basin

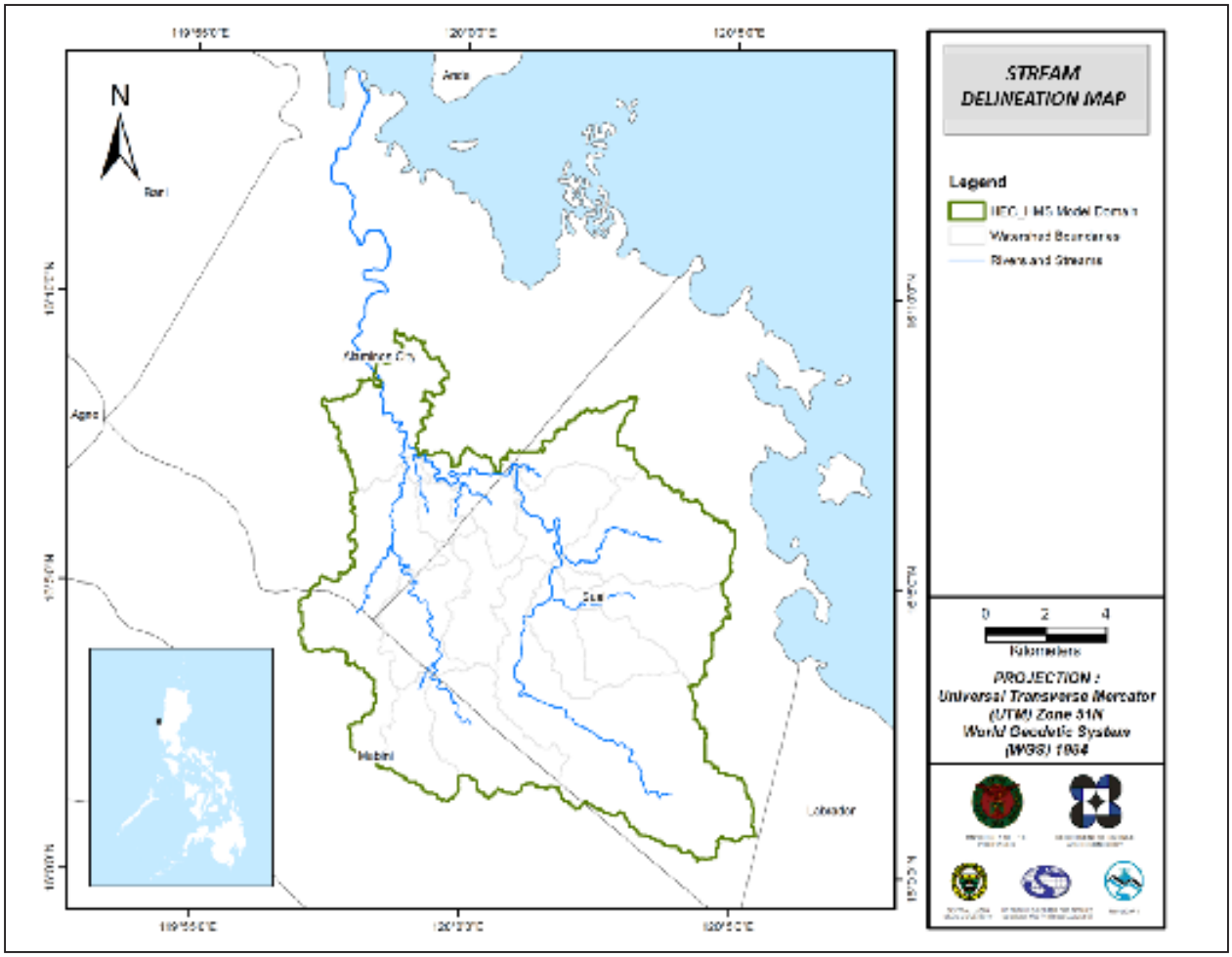


Figure 59. Stream Delineation Map of the Alaminos River Basin

Using the SAR-based DEM, the Alaminos Basin was delineated and further subdivided into subbasin. The Alaminos basin model consists of 19 subbasins, 9 reaches, and 9 junctions as shown in Figure 60. The main outlet is Outlet. Finally, it was calibrated using depth gauge installed in Alaminos Bridge.

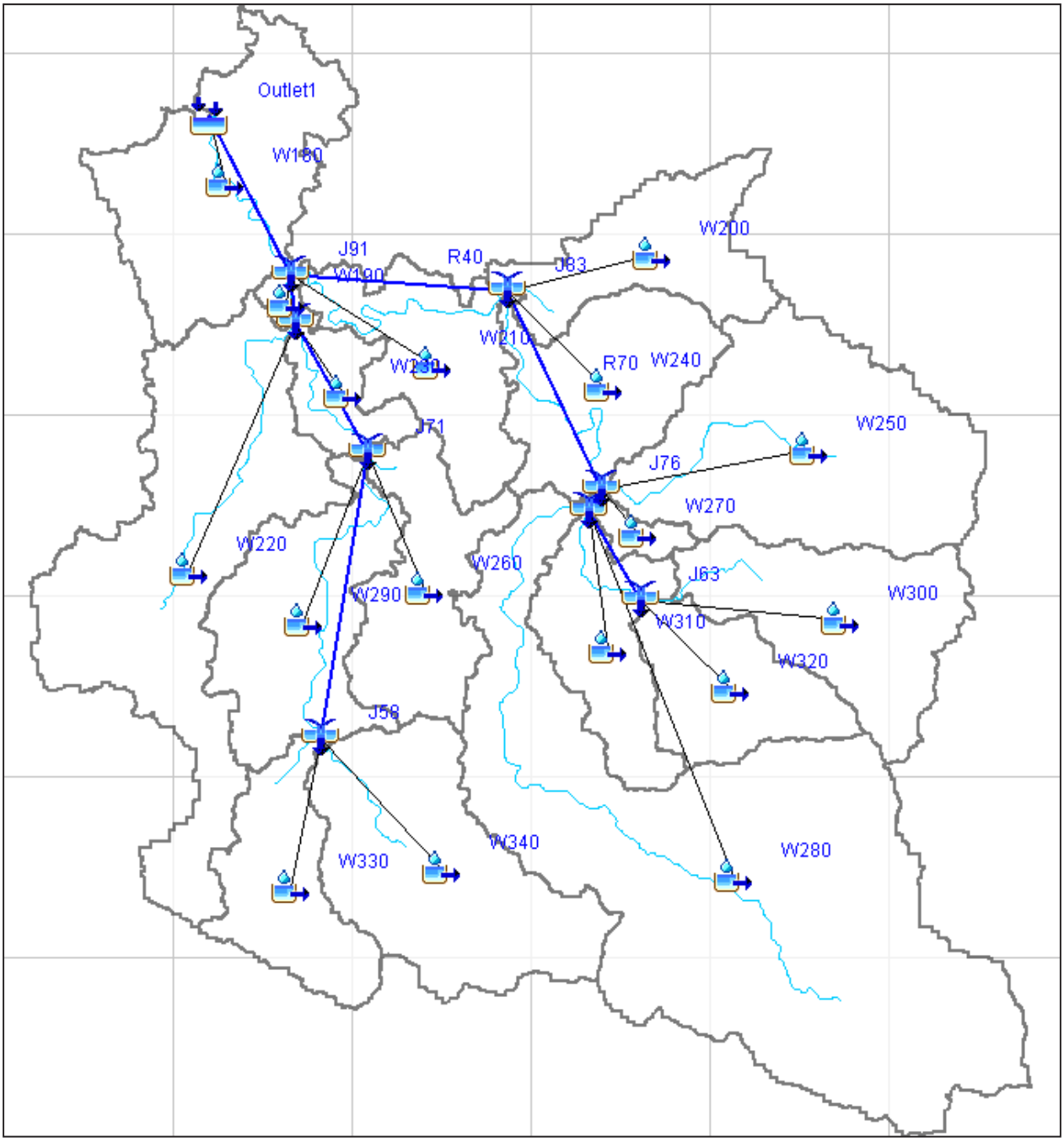


Figure 60. The Alaminos River Basin model generated using HEC-HMS

5.4 Cross-section Data

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

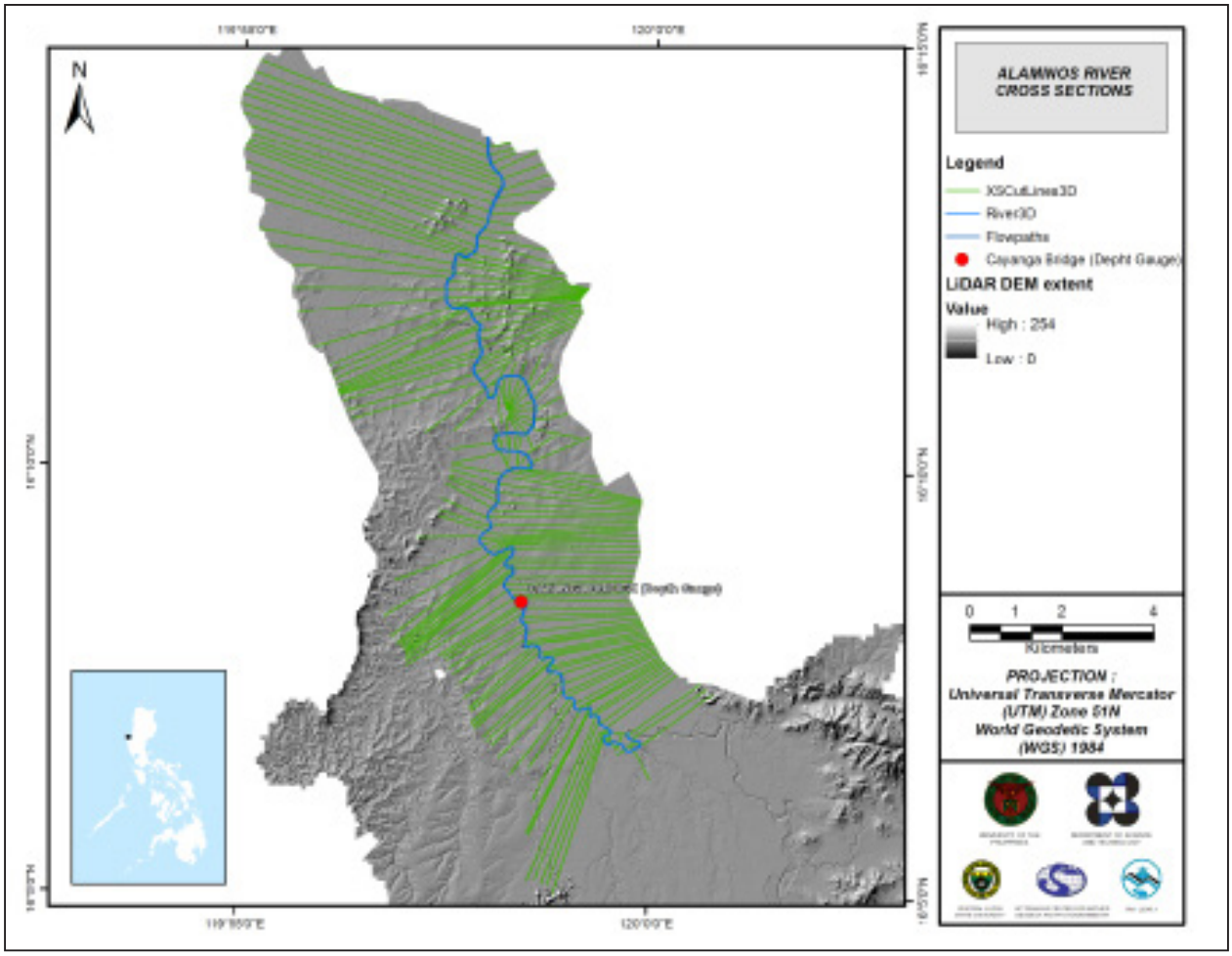


Figure 61. River cross-section of Alaminos River generated through Arcmap HEC GeoRAS tool

5.5 Flo 2D Model

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

Based on the elevation and flow direction, it is seen that the water will generally flow from the south of the model to the north, following the main channel. As such, boundary elements north of the model are assigned as outflow elements.

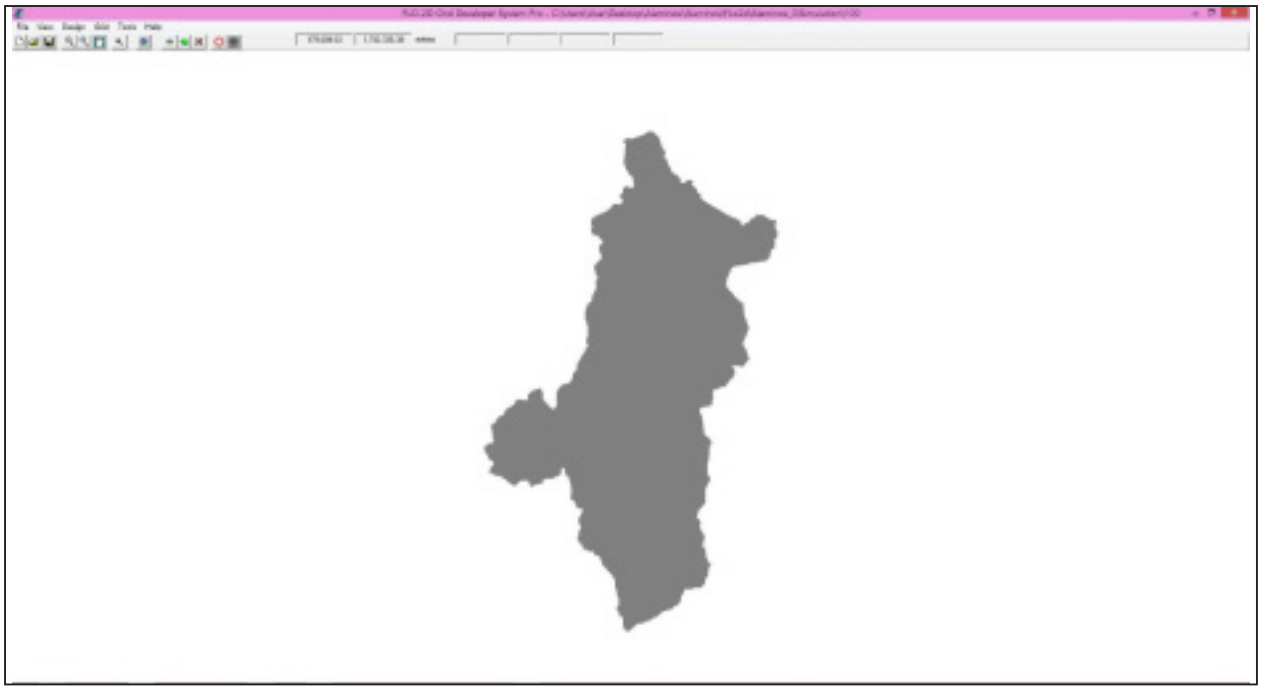


Figure 62. Figure 62. Screenshot of subcatchment with the computational area to be modeled in FLO-2D GDS Pro

The simulation was then run through FLO-2D GDS Pro. This particular model had a computer run time of 68.86 hours. After the simulation, FLO-2D Mapper Pro as used to transform the simulation results into spatial data that shows flood hazard levels, as well as the extent and inundation of the flood. Assigning the appropriate flood depth and velocity values for Low, Medium, and High created the following flood hazard maps. Most of the default values given by FLO-2D Mapper Pro are used, except for those in the Low-hazard level. For this particular level, the minimum h (Maximum depth) is set at 0.2 m while the minimum vh (Product of maximum velocity (v) times maximum depth (h)) is set at 0 m2/s.

The creation of a flood hazard map from the model also automatically creates a flow depth map depicting the maximum amount of inundation for every grid element. The legend used by default in Flo-2D Mapper was not a good representation of the range of flood inundation values, so a different legend was used for the layout. In this particular model, the inundated parts cover a maximum land area of 78,685,632.00 m2.

There is a total of 72,194,879.13 m3 of water entering the model, of which 38,389,102.82 m3 is due to rainfall and 33,805,776.31 m3 is inflow from basins upstream. Moreover, 12,742,608.00 m3 of this water is lost to infiltration and interception, while 54,128,329.34 m3 is stored by the floodplain. The rest, amounting up to 5,324,024.64m3, is outflow.

5.6 Results of HMS Calibration

After calibrating the Alaminos HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 63 shows the comparison between the two discharge data.

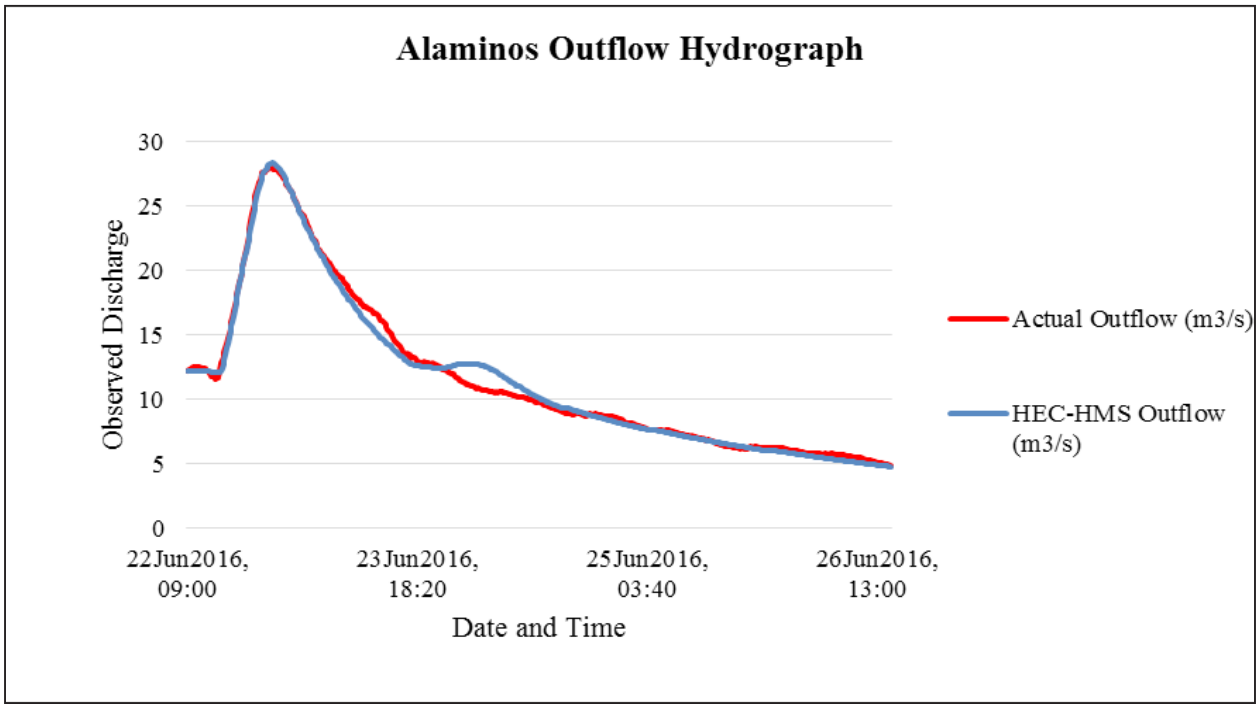


Figure 63. Outflow hydrograph of Alaminos produced by the HEC-HMS model compared with observed outflow

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

Table 31. Range of calibrated values for the Alaminos River Basin.

Hydrologic Element	Calculation Type	Method	Parameter	Range of Calibrated Values
Basin	Loss	SCS Curve number	Initial Abstraction (mm)	1.5 - 11
			Curve Number	46 -79
	Transform	Clark Unit Hydrograph	Time of Concentration (hr)	0.1 – 9.7
			Storage Coefficient (hr)	0.7 - 17
	Baseflow	Recession	Recession Constant	0.50 - 0.76
			Ratio to Peak	0.09 – 0.33
Reach	Routing	Muskingum-Cunge	Manning's Coefficient	0.03 – 0.08

Initial abstraction defines the amount of precipitation that must fall before surface runoff. The magnitude of the outflow hydrograph increases as initial abstraction decreases. The range of values from 1.5 mm to 11 mm signifies that there is minimal amount of infiltration or rainfall interception by vegetation.

The curve number is the estimate of the precipitation excess of soil cover, land use, and antecedent moisture. The magnitude of the outflow hydrograph increases as curve number increases. The range for the curve number of Alaminos River Basin is 46 to 79. For Alaminos, the basin mostly consists of brushland and cultivated areas and the soil mostly consists of loam.

The 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 0.1 hours to 17 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, while ratio to peak is the ratio of the baseflow discharge to the peak discharge. Recession constant of 0.50–0.76 indicates that the basin is unlikely to quickly go back to its original discharge and instead, will be higher. Ratio to peak of 0.09–0.33 indicates a steeper receding limb of the outflow hydrograph.

Manning's roughness coefficient of 0.03–0.08 corresponds to the common roughness in Alaminos watershed, which is determined to be cultivated with mature field crops (Brunner, 2010).

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

Accuracy measure	Value
RMSE	0.6
r2	0.6
NSE	0.99
PBIAS	0.37
RSR	0.10

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was computed at 0.6 m3/s.

The Pearson correlation coefficient (r2) assesses the strength of the linear relationship between the observations and the model. A value close to 1 corresponds to an almost perfect match of the observed discharge and the resulting discharge from the HEC HMS model. A value of r2 = 0.99 was computed for this model. This means that the degree of collinearity between simulated and measured data is relatively high.

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 0.99 which means that the model has a very good performance rating in simulating discharge.

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 negative 0.37 which implies that the model was underestimated at 0.37 percent difference in streamflow volume between simulated and measured data for a particular period.

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 are quantified. The model has an RSR value of 0.10 which indicates that the model has a better simulation performance due to low value of computed RSR.

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

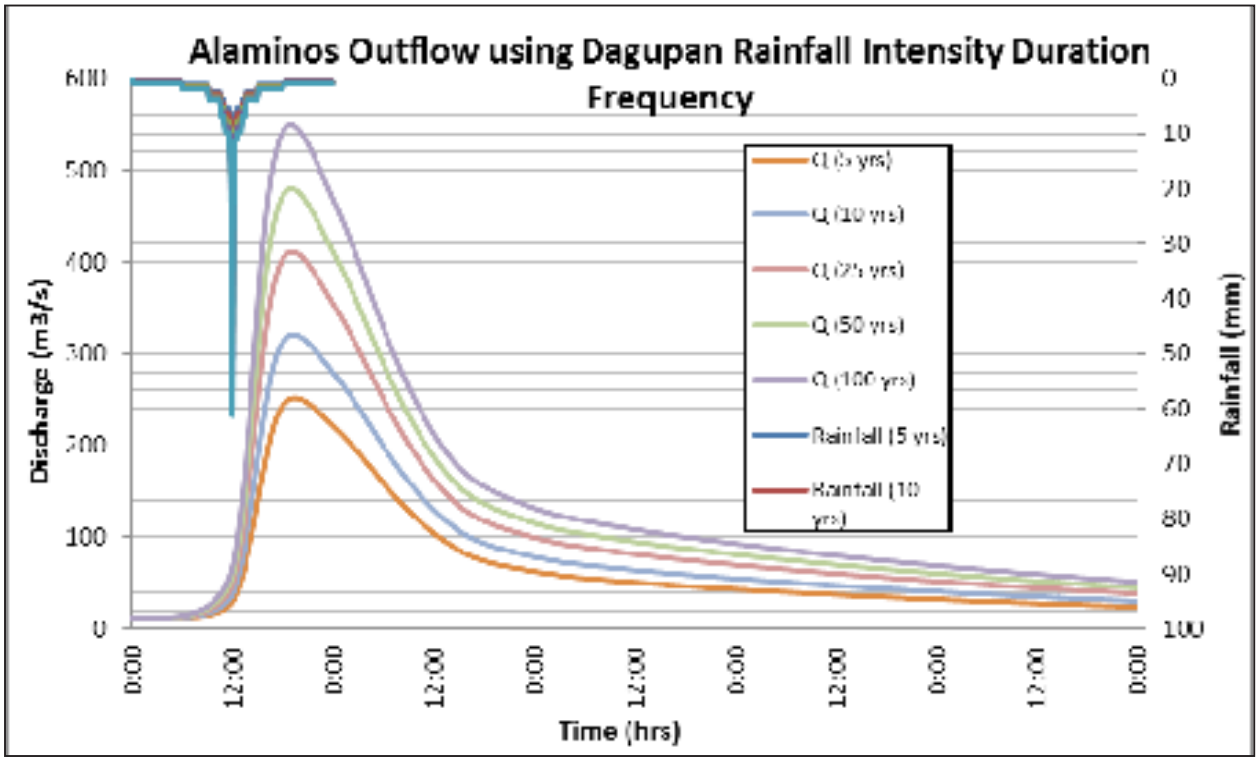


Figure 64. Outflow hydrograph at Alaminos Station generated using Dagupan RIDF simulated in HEC-HMS

A summary of the total precipitation, peak rainfall, peak outflow and time to peak of the Alaminos discharge using the Dagupan RIDF in five different return periods is shown in Table 33.

Table 33. Peak values of the Alaminos HEC-HMS Model outflow using the Dagupan RIDF

RIDF Period	Total Precipitation (mm)	Peak rainfall (mm)	Peak outflow (m 3/s)	Time to Peak
5-Year	246.7	33.9	251.8	7 hours 30 minutes
10-Year	293.6	40.5	320.9	7 hours 20 minutes
25-Year	352.9	48.9	411.2	7 hours 10 minutes
50-Year	396.8	55.1	480.1	7 hours
100-Year	440.5	61.2	549.7	7 hours

5.8 River Analysis Model Simulation

The HEC-RAS flood model produced a simulated water level at every cross-section for every time step for every flood simulation created. The resulting model will be used in determining the flooded areas within the model. The simulated model will be an integral part in determining real-time flood inundation extent of the river after it has been automated and uploaded on the DREAM website.

The Alaminos model has a minimum and maximum flow discharge of 11.62 and 28.03 m3/s, respectively, and these data were needed for unsteady flow analysis as input file. The simulation results showed that the maximum water surface depth elevation of Alaminos River has a value of 5.43 meter; it was located at the downstream portion of the river. The simulation results also showed that there is no overflow of water along the banks of the river. However, some areas are being flooded due to low-lying areas like fishpond and salt pan located in Barangay Pangapisan and Mona in Alaminos City (located at the downstream portion of the river). The sample 1D flood hazard map using the calibrated discharge of Alaminos River from HMS model is shown in Figure 65.

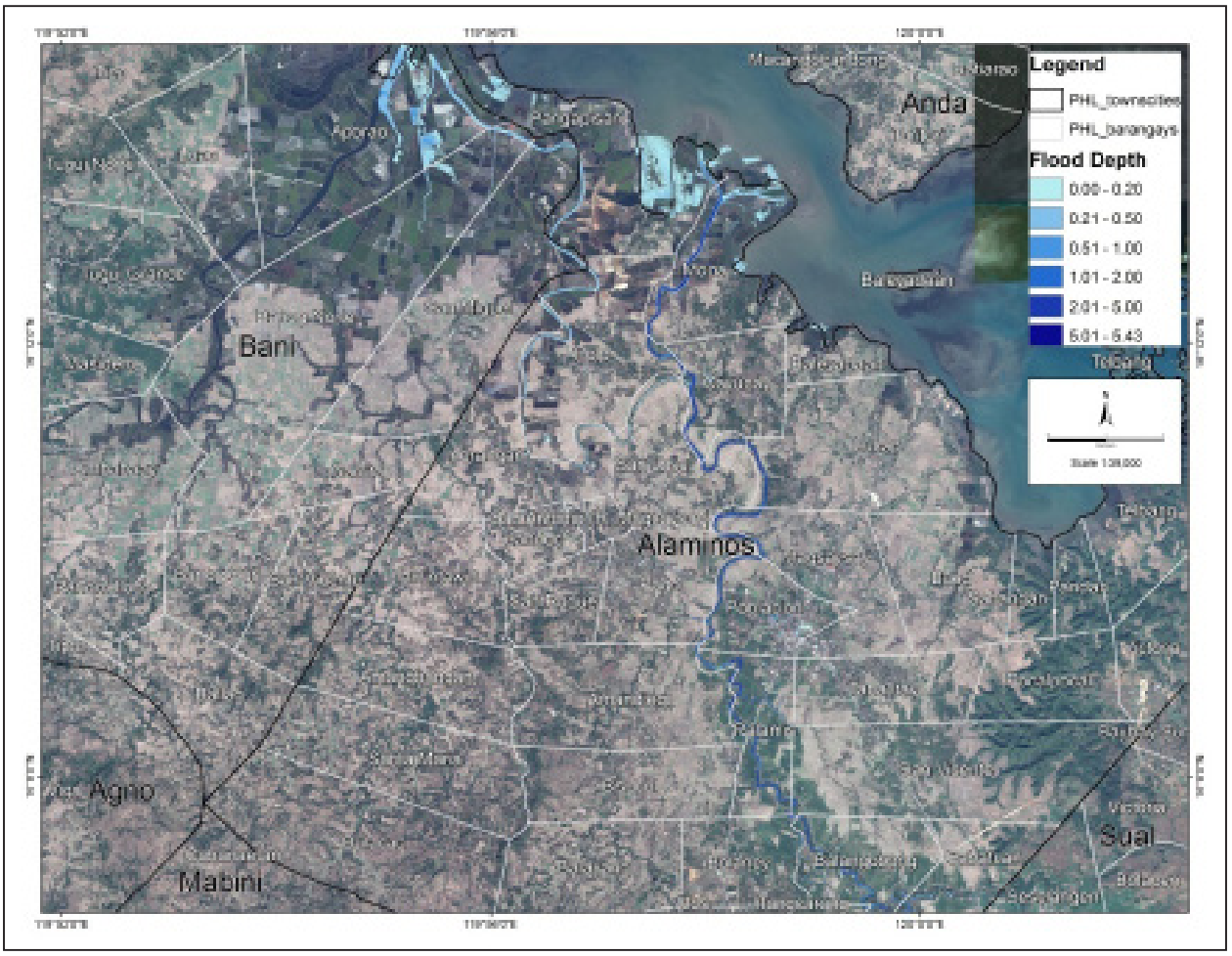


Figure 65. Sample output of Alaminos RAS Model

5.9 Flood Hazard and Flow Depth Map

The resulting hazard and flow depth maps have a 10 m resolution. Figure 66 to Figure 71 show the 100-, 25-, and 5-year rain return scenarios of the Alaminos Floodplain. The floodplain, with an area of 274.89 sq km, covers four municipalities, namely Alaminos City, Bani, Mabini, and Sual. Table 34 shows the percentage of area affected by flooding per municipality.

Table 34. Municipalities affected in Alaminos Floodplain

City / Municipality	Total Area	Area Flooded	% Flooded
Alaminos City	165.51	132.01	78%
Bani	180.62	10.58	6%
Mabini	260.03	25.70	10%
Sual	162.96	106.60	65%

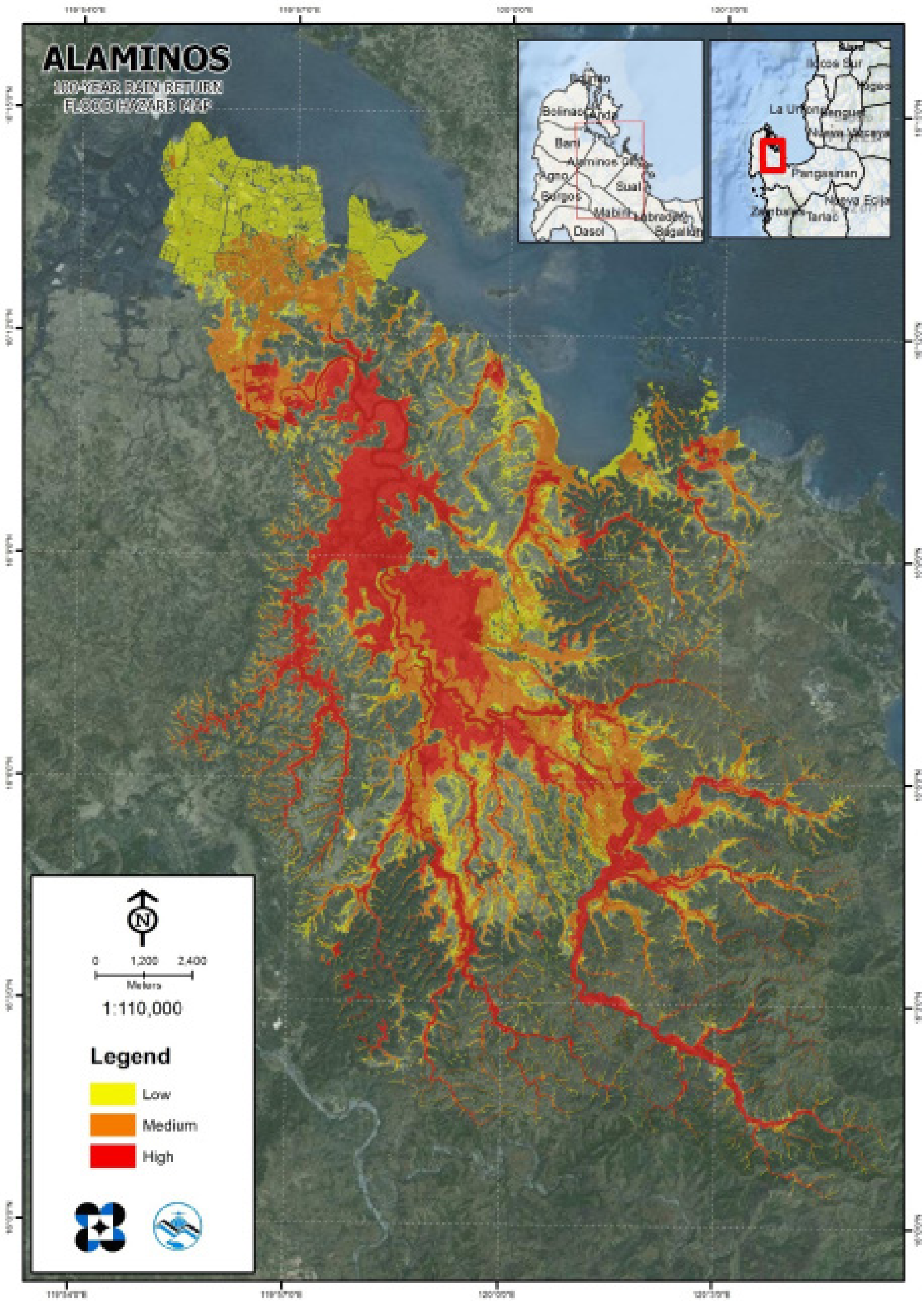


Figure 66. 100-year flood hazard map for Alaminos Floodplain

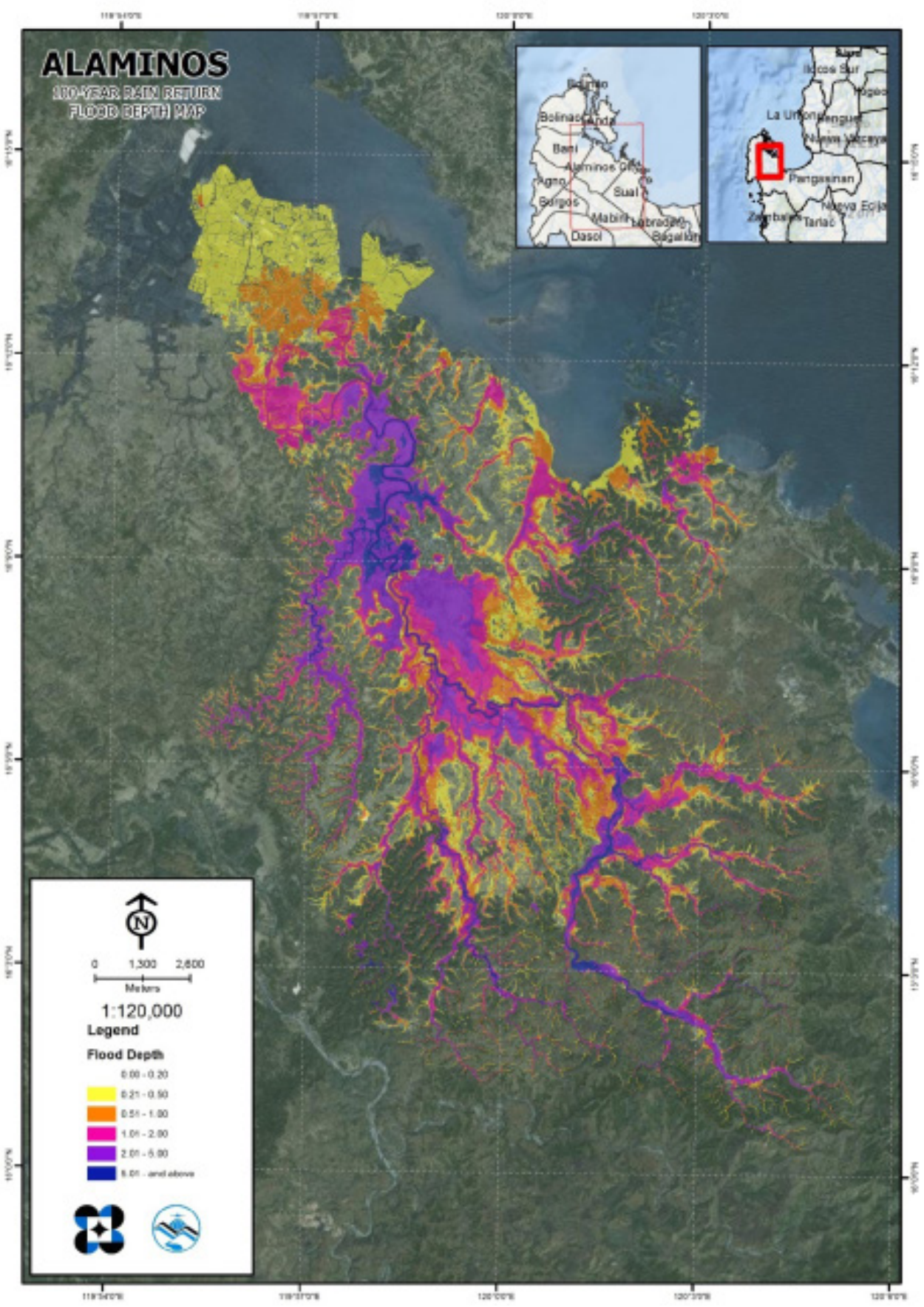


Figure 67. 100-year flow depth map for Alaminos Floodplain

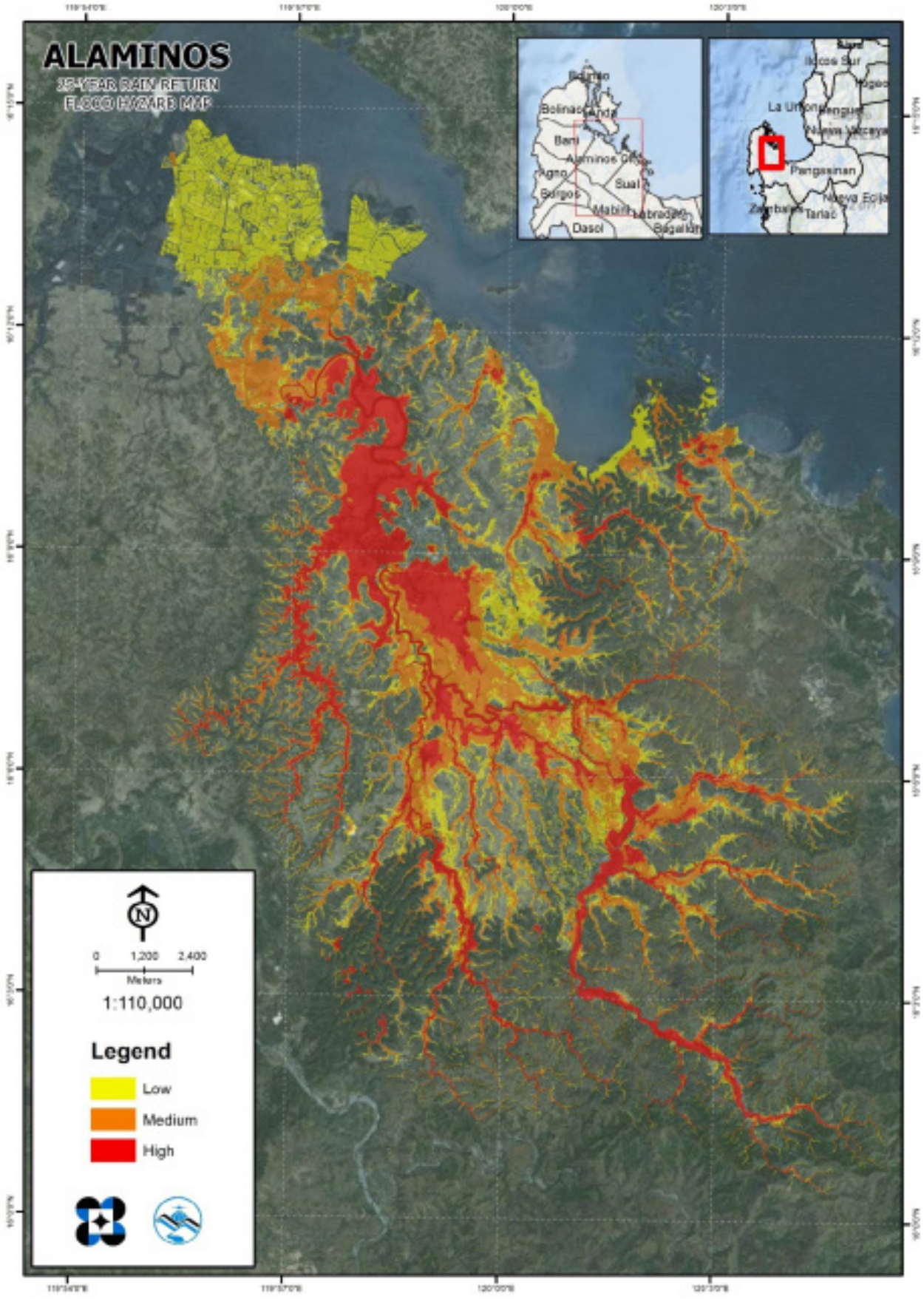


Figure 68. 25-year flood hazard map for Alaminos Floodplain

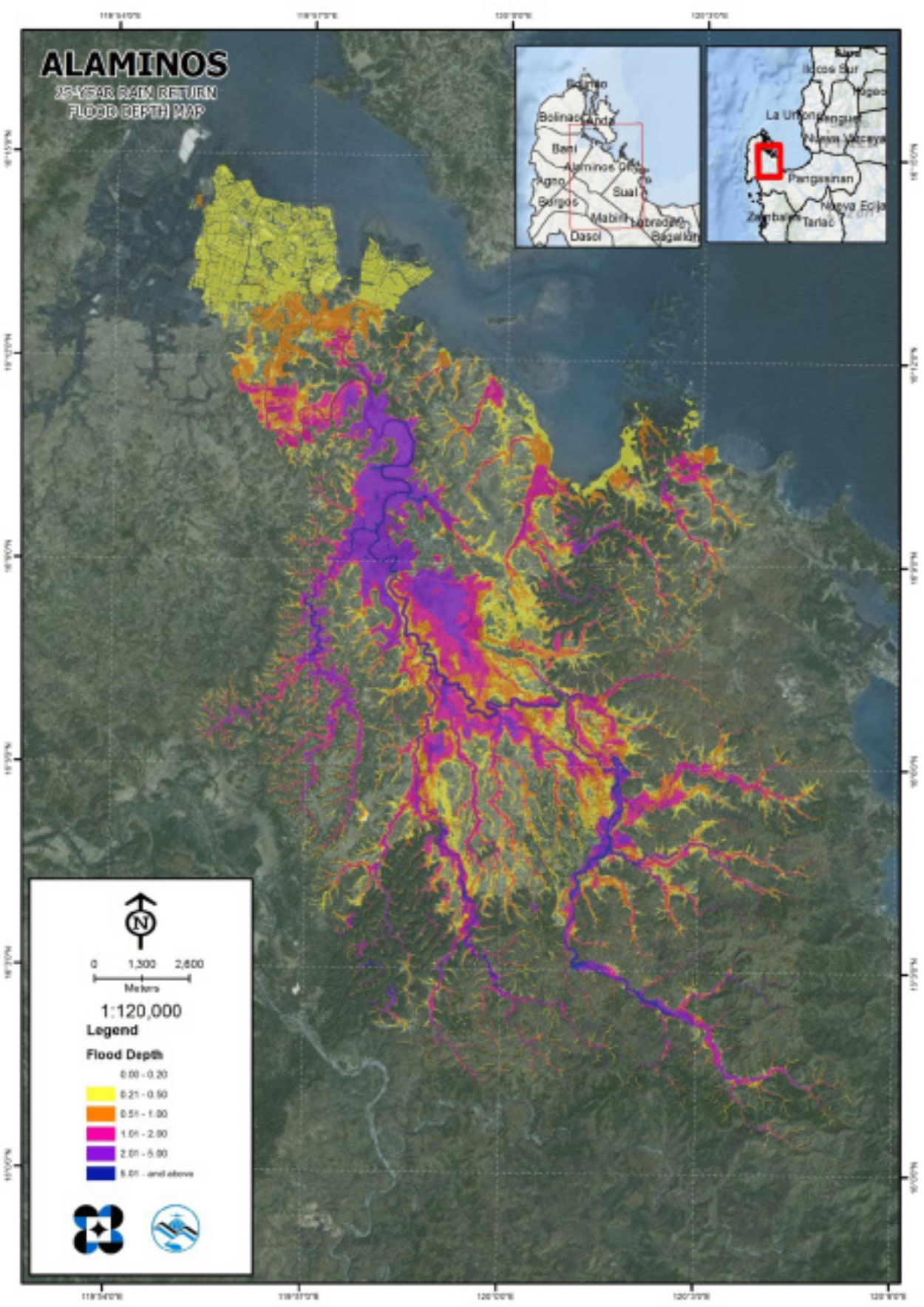


Figure 69. 25-year flow depth map for Alaminos Floodplain

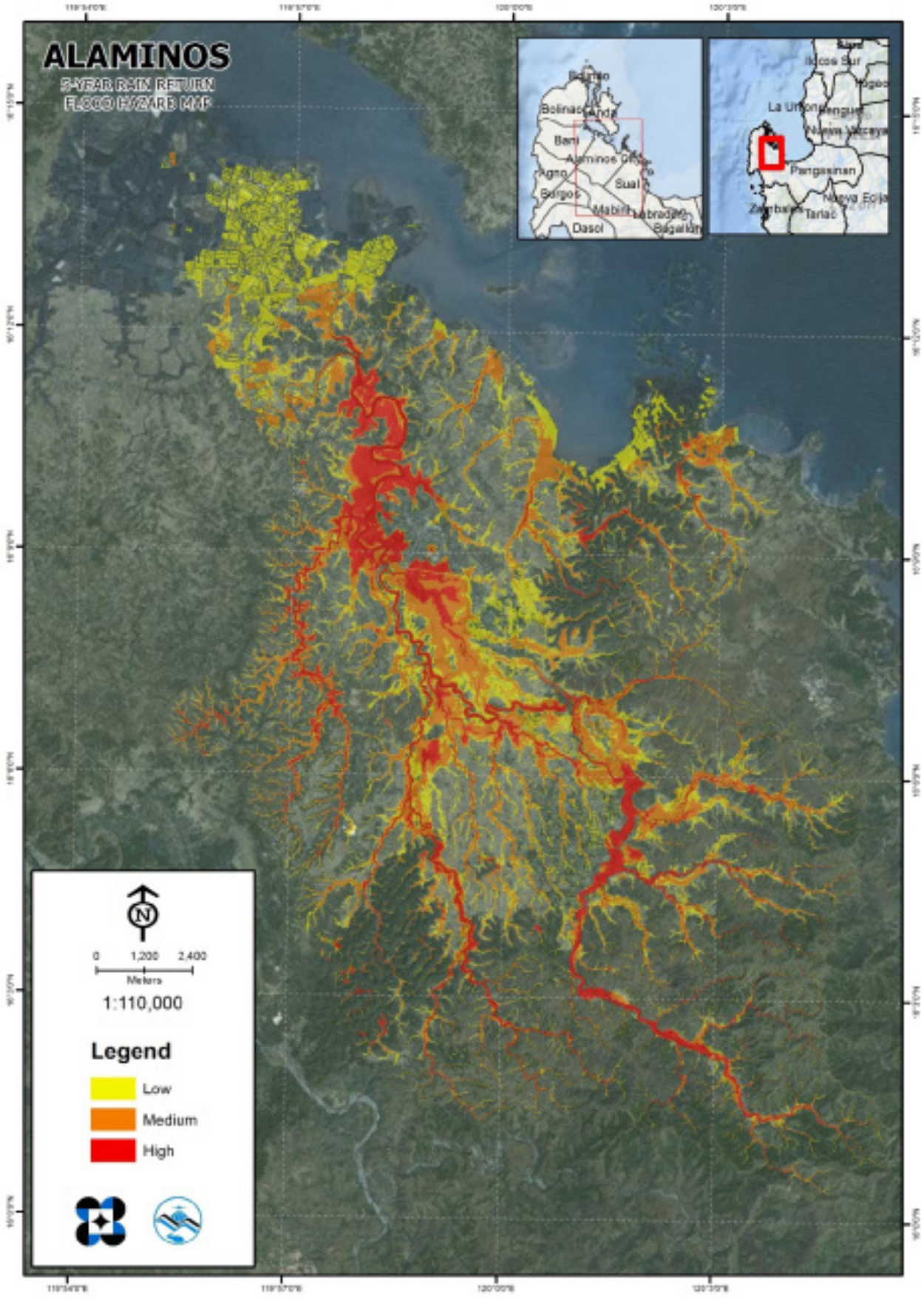


Figure 70. 5-year flood hazard map for Alaminos Floodplain

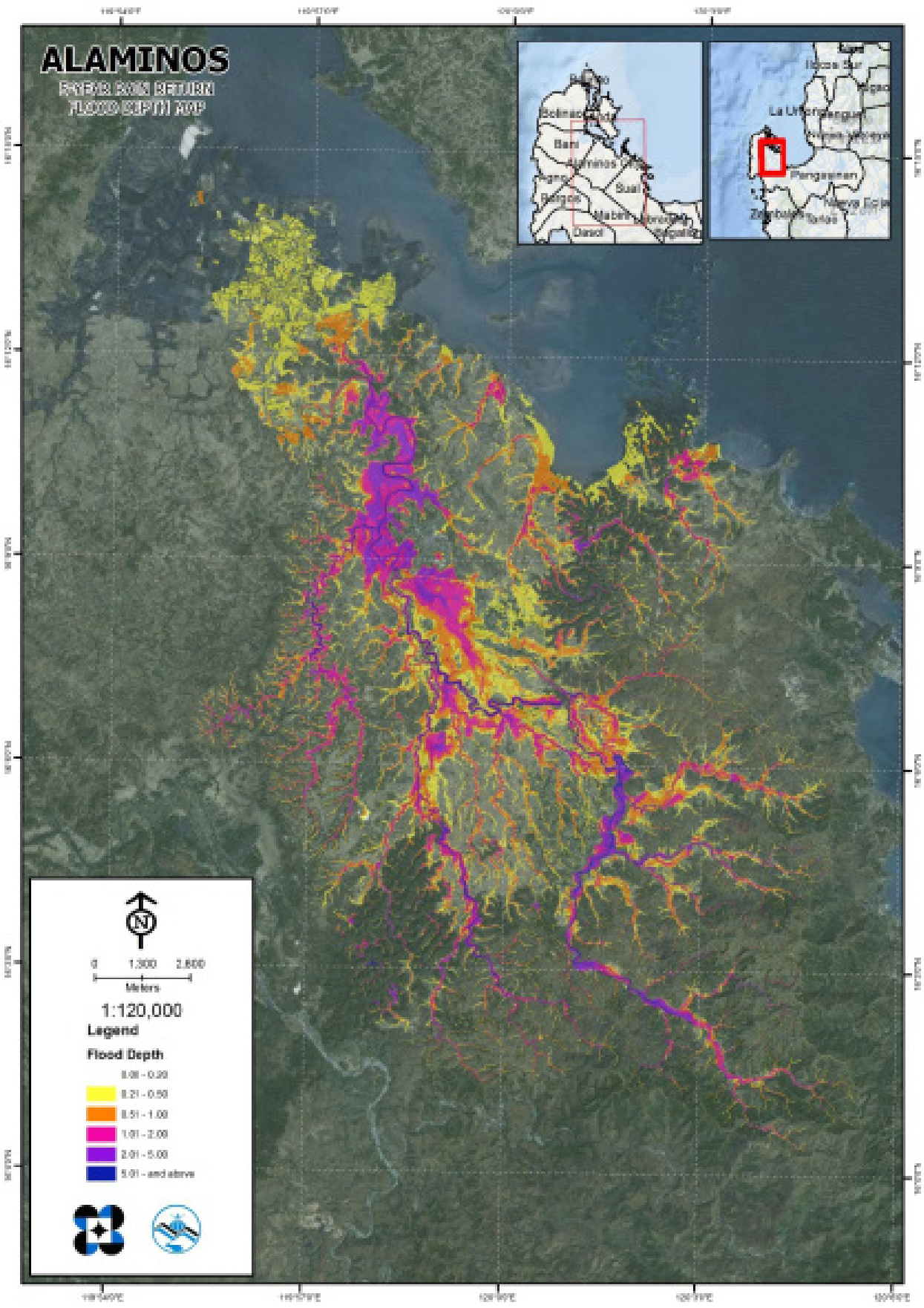
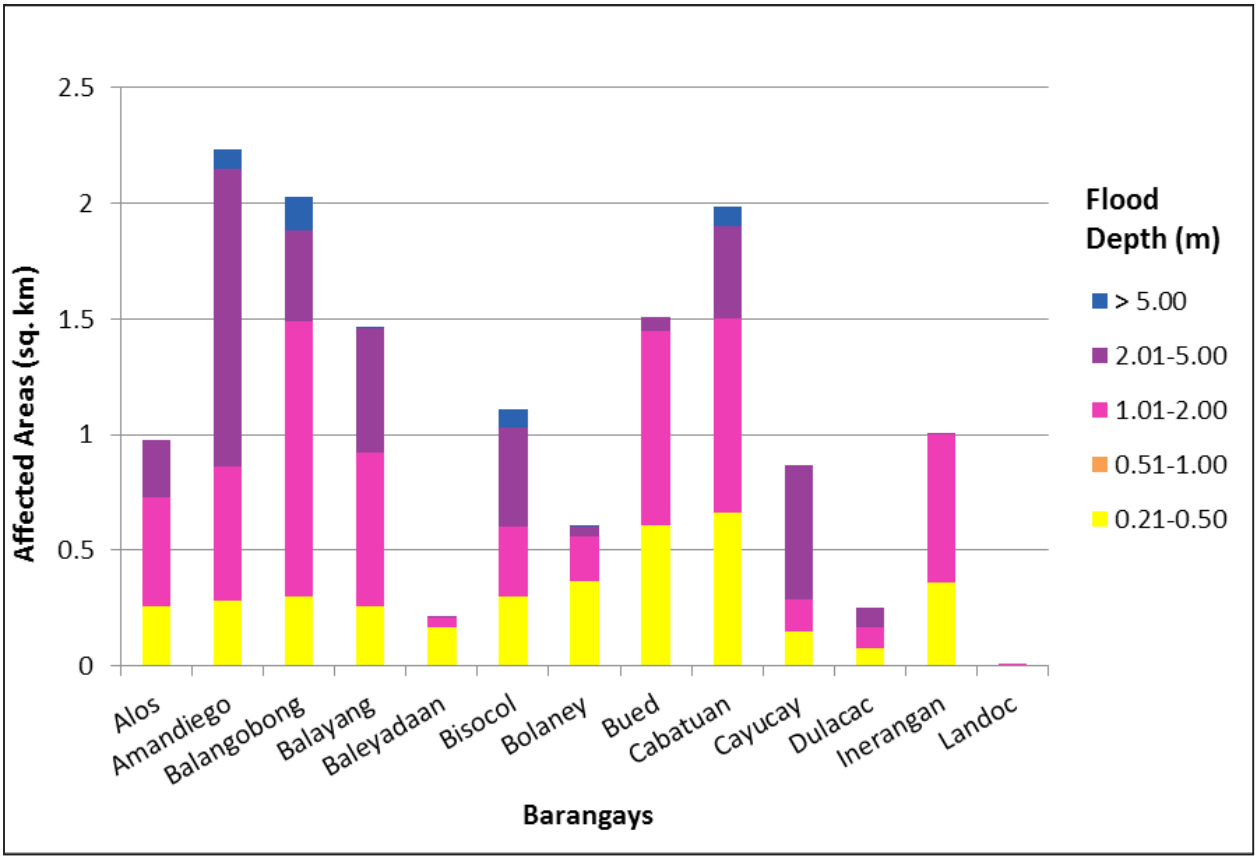


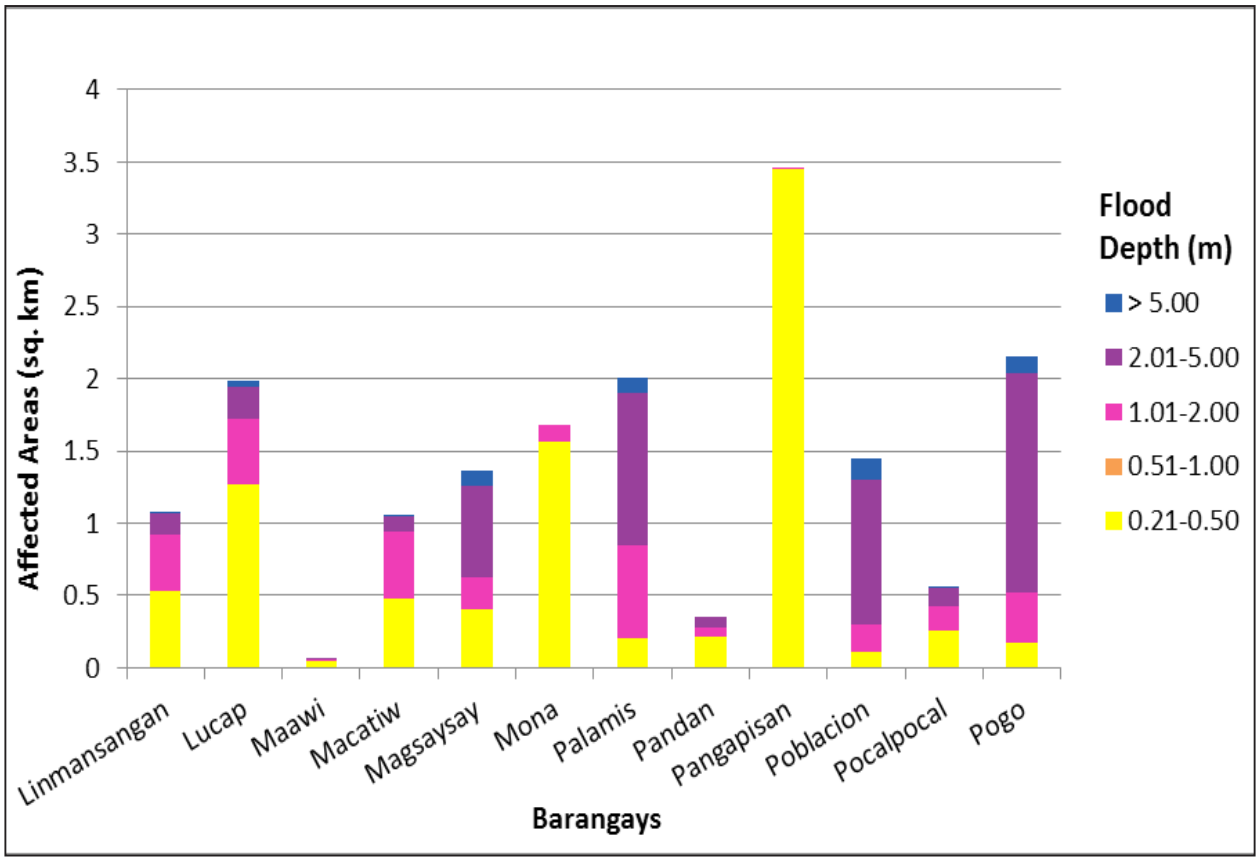
Figure 71. 5-year flood depth map for Alaminos Floodplain

5.10 Inventory of Areas Exposed to Flooding

Affected barangays in Alaminos River Basin, grouped by municipality, are listed below. For the said basin, four municipalities consisting of 63 barangays are expected to experience flooding when subjected to 5-, 25-, and 100-year rainfall return period.

For the 5-year return period, 51.94% of the municipality of Alaminos City with an area of 165.505289 sq km will experience flood levels of less than 0.20 meters; 10.74% of the area will experience flood levels of 0.21 to 0.50 meters; while 7.59%, 6.07%, 3.14%, and 0.28% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 35 are the affected areas in square kilometers by flood depth per barangay.





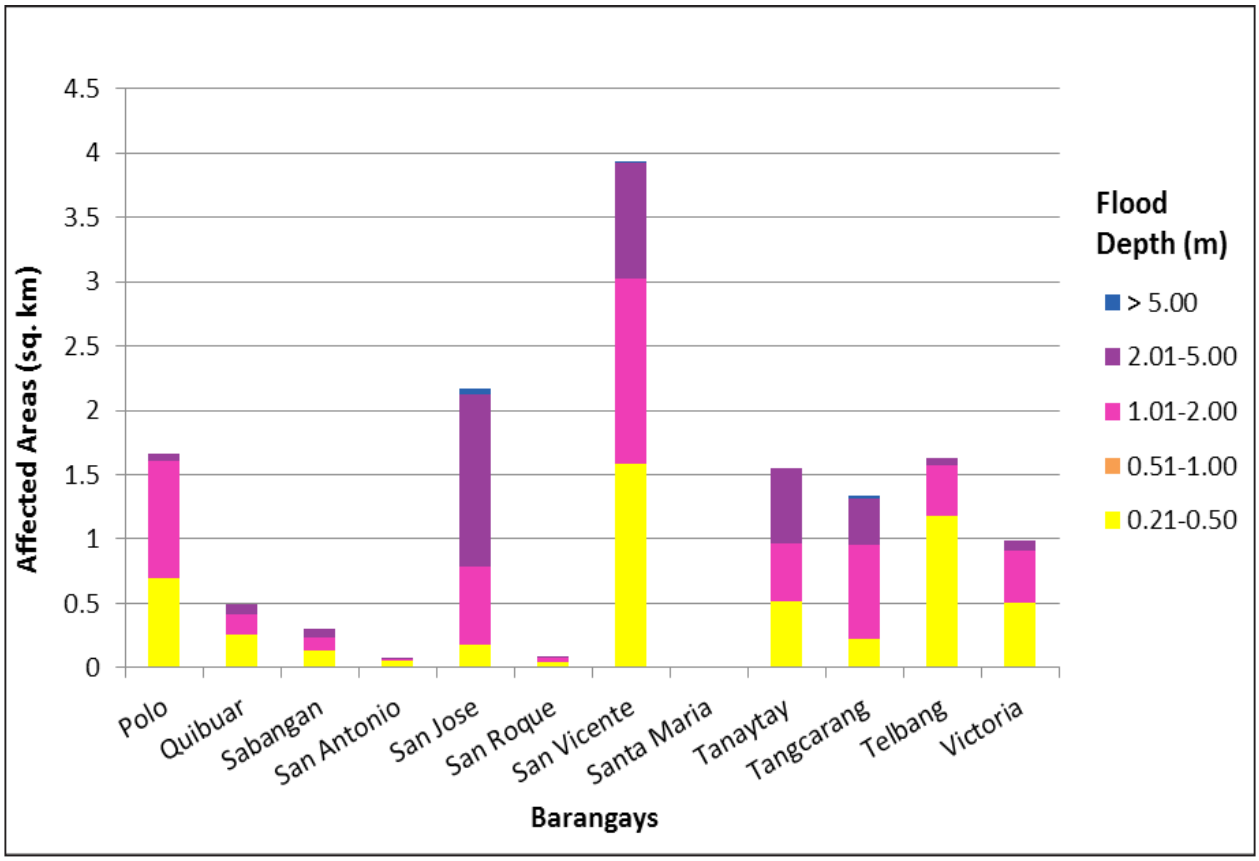


Figure 72. Affected areas in Alaminos City, Pangasinan during a 5-year rainfall return period

Table 35. Affected areas in Alaminos City, Pangasinan during a 5-year rainfall return period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Alaminos City (in sq. km)												
	Alos	Amandiego	Balangobong	Balayang	Baleyadaan	Bisocol	Bolaney	Bued	Cabatuan	Cayucay	Dulacac	Inerangan	Landoc
0.03-0.20	4.95	3.18	0.43	4.05	1.08	3.02	2.12	3.07	1.96	2.23	1.37	1.69	0.094
0.21-0.50	0.24	0.43	1	0.31	0.18	0.31	0.47	0.53	0.76	0.16	0.081	0.65	0.0046
0.51-1.00	0.3	0.53	1.06	0.48	0.13	0.28	0.27	0.77	0.68	0.14	0.078	0.38	0.0043
1.01-2.00	0.4	0.65	0.48	0.58	0.016	0.29	0.078	0.21	0.52	0.3	0.082	0.0085	0
2.01-5.00	0.076	0.36	0.22	0.16	0	0.069	0.034	0.024	0.16	0.3	0.042	0	0
> 5.00	0	0.019	0.13	0.0011	0	0.059	0.008	0	0.081	0	0	0	0

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Alaminos City (in sq. km)											
	Linmansangan	Lucap	Maawi	Macatiw	Magsaysay	Mona	Palamis	Pandan	Pangapisan	Poblacion	Pocalpocal	Pogo
0.03-0.20	2.22	5.62	0.63	1.5	3.14	3.14	0.75	0.97	4.93	1.46	2.7	1.81
0.21-0.50	0.44	1.09	0.036	0.47	0.37	0.93	0.41	0.2	1.14	0.11	0.26	0.26
0.51-1.00	0.37	0.59	0.022	0.36	0.21	0.29	0.41	0.067	0.019	0.11	0.17	0.3
1.01-2.00	0.23	0.34	0.013	0.21	0.3	0.017	0.65	0.058	0.0013	0.42	0.11	0.76
2.01-5.00	0.098	0.13	0.0033	0.045	0.36	0	0.54	0.041	0	0.58	0.086	0.7
> 5.00	0.0028	0	0	0.0044	0.028	0	0.042	0	0	0.024	0	0.04

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Alaminos City (in sq. km)											
	Polo	Quibuar	Sabangan	San Antonio	San Jose	San Roque	San Vicente	Santa Maria	Tanaytay	Tangca-rang	Telbang	Victoria
0.03-0.20	3.34	3.36	0.91	0.53	2.24	0.66	4.57	0.0034	2.14	1.57	4	4.53
0.21-0.50	1.77	0.24	0.13	0.045	0.33	0.043	1.72	0	0.5	0.41	1.23	0.52
0.51-1.00	0.75	0.14	0.12	0.014	0.37	0.033	1.38	0	0.29	0.58	0.43	0.43
1.01-2.00	0.094	0.12	0.072	0.0058	0.58	0.017	0.89	0	0.51	0.51	0.28	0.24
2.01-5.00	0.013	0.027	0.036	0.00039	0.6	0.0014	0.13	0	0.11	0.18	0.031	0.033
> 5.00	0	0	0	0	0	0	0.0083	0	0	0.018	0	0

For the 5-year return period, 4.12% of the municipality of Bani with an area of 180.615338 sq km will experience flood levels of less than 0.20 meters; 1.61% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.13% of the area will experience flood depths of 0.51 to 1 meter. Listed in Table 36 are the affected areas in square kilometers by flood depth per barangay.

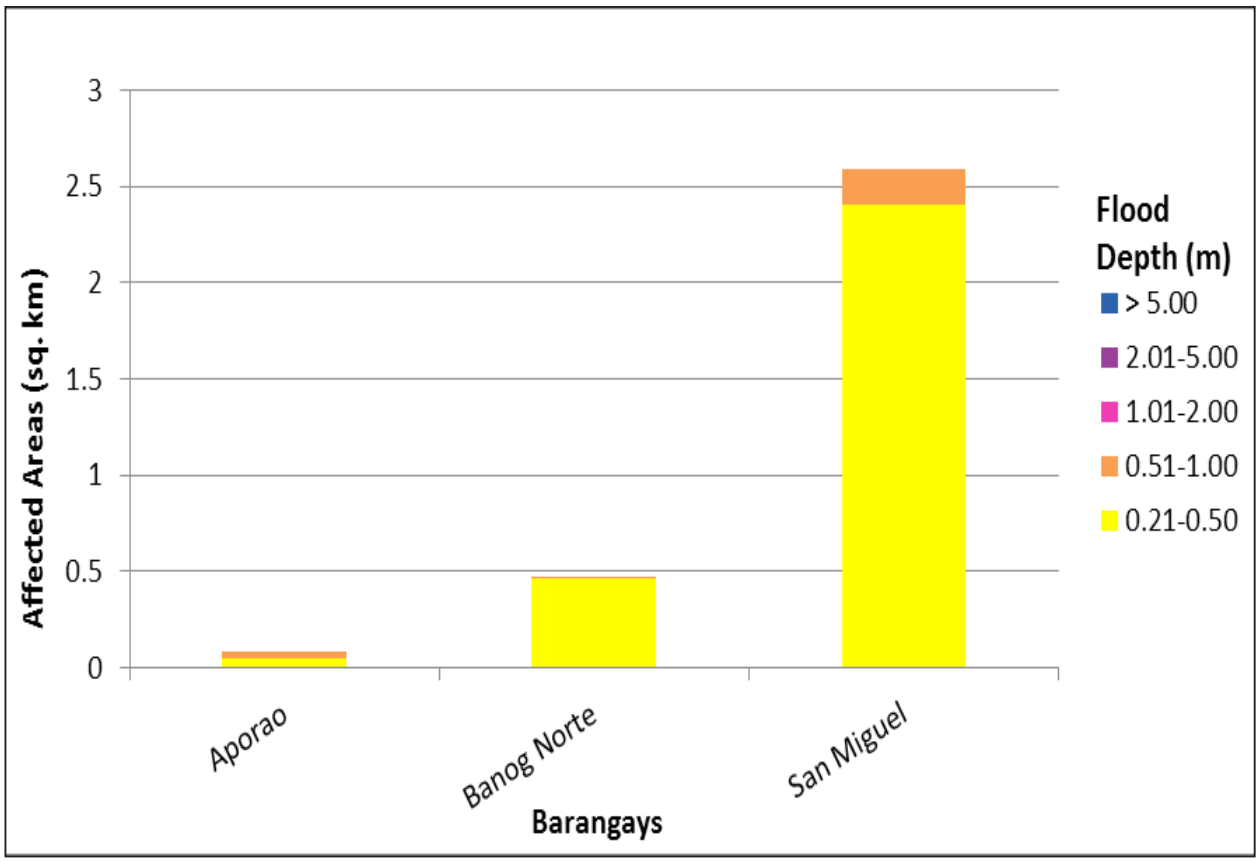


Figure 73. Affected areas in Bani, Pangasinan during a 5-year rainfall return period

Table 36. Affected areas in Bani, Pangasinan during a 5-year rainfall return period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Bani (in sq km)		
	Aporao	Banog Norte	San Miguel
0.03-0.20	2.47	2.4	2.58
0.21-0.50	0.053	0.46	2.4
0.51-1.00	0.033	0.0036	0.19
1.01-2.00	0	0	0
2.01-5.00	0	0	0
> 5.00	0	0	0

For the 5-year return period, 1.97% of the municipality of Mabini with an area of 260.028831 sq km will experience flood levels of less than 0.20 meters; 0.08% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.05%, 0.04%, 0.04%, 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 Table 37 are the affected areas in square kilometers by flood depth per barangay.

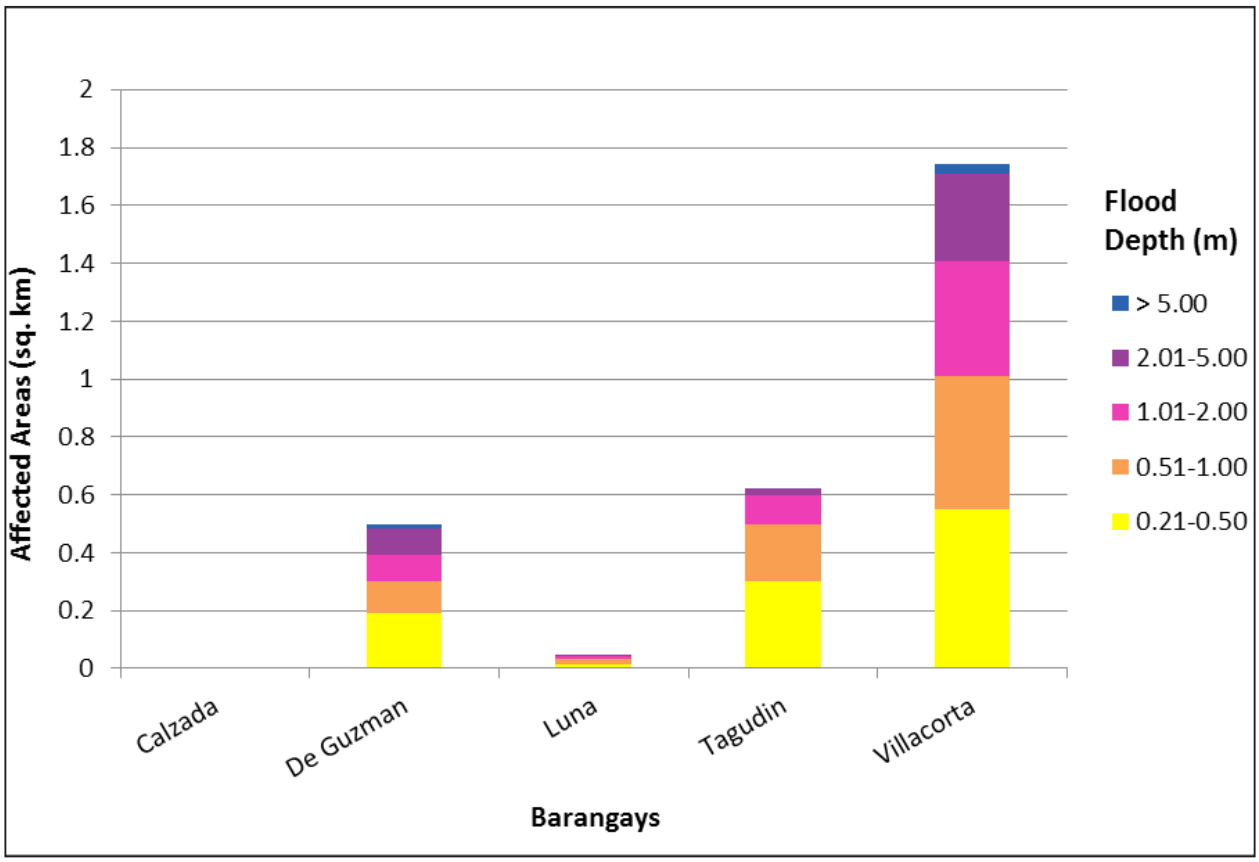
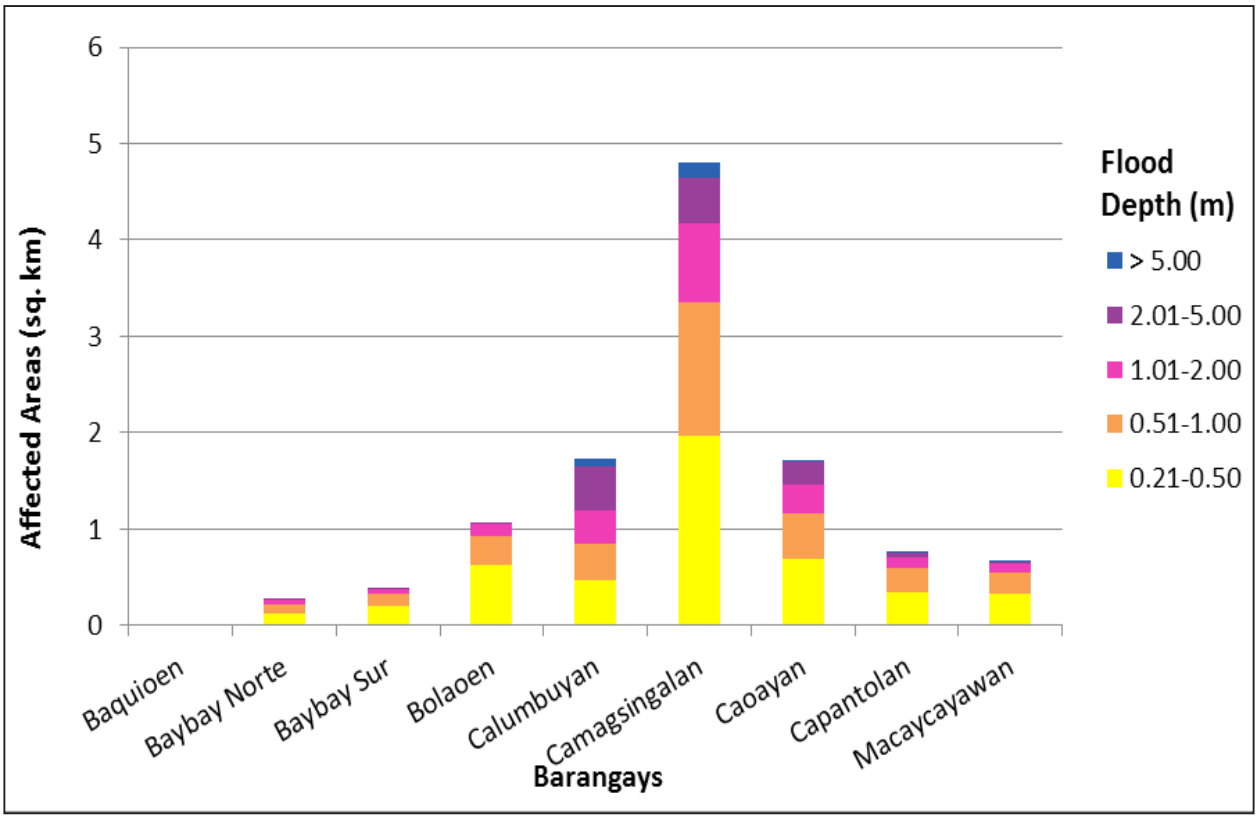


Figure 74. Affected areas in Mabini, Pangasinan during a 5-year rainfall return period

Table 37. Affected areas in in Mabini, Pangasinan during a 5-year rainfall return period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Mabini (in sq km)				
	Calzada	De Guzman	Luna	Tagudin	Villacorta
0.03-0.20	0.00042	4.79	0.34	3.61	14.06
0.21-0.50	0	0.19	0.016	0.3	0.55
0.51-1.00	0	0.11	0.016	0.2	0.46
1.01-2.00	0	0.09	0.01	0.098	0.4
2.01-5.00	0	0.093	0.0012	0.024	0.3
> 5.00	0	0.014	0	0	0.034

For the 5-year return period, 51.73% of the municipality of Sual with an area of 162.961823 sq km will experience flood levels of less than 0.20 meters; 5.10% of the area will experience flood levels of 0.21 to 0.50 meters; while 4.15%, 2.52%, 1.52%, and 0.33% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 38 are the affected areas in square kilometers by flood depth per barangay.



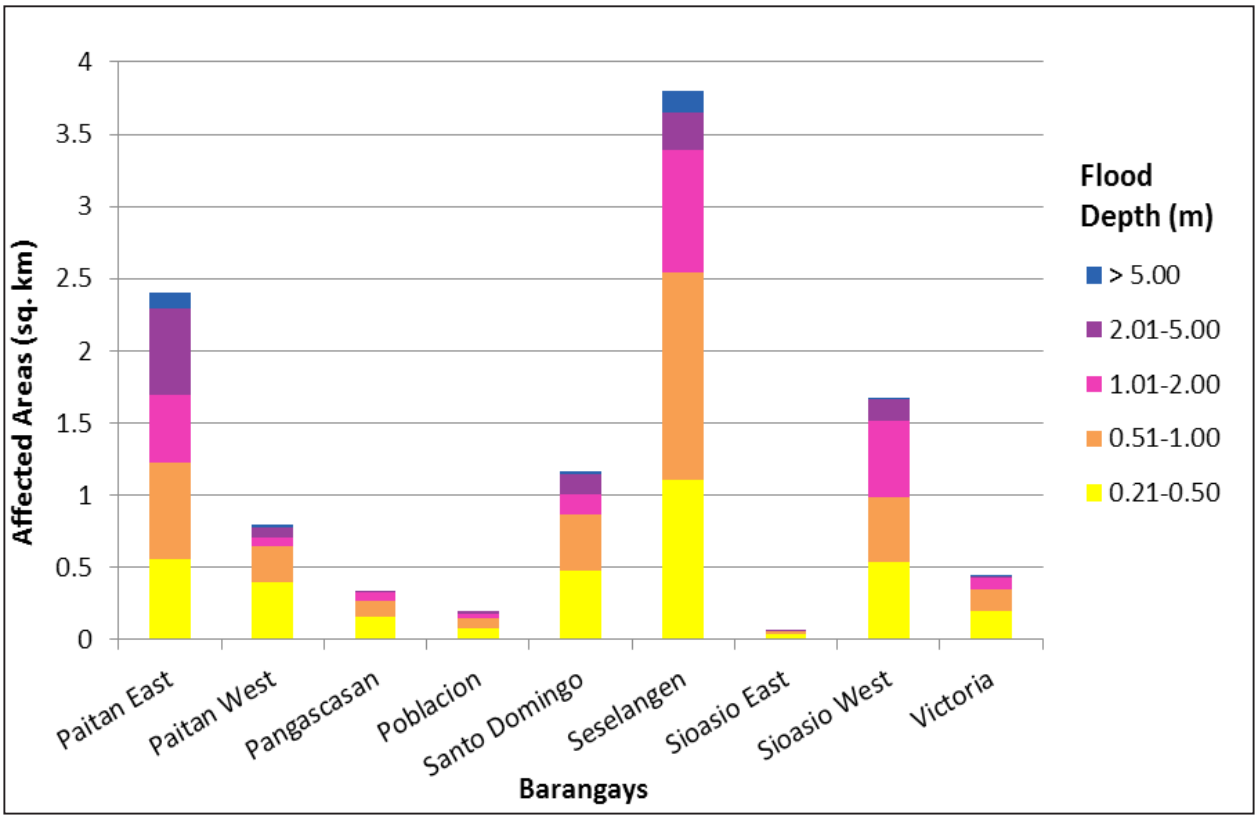


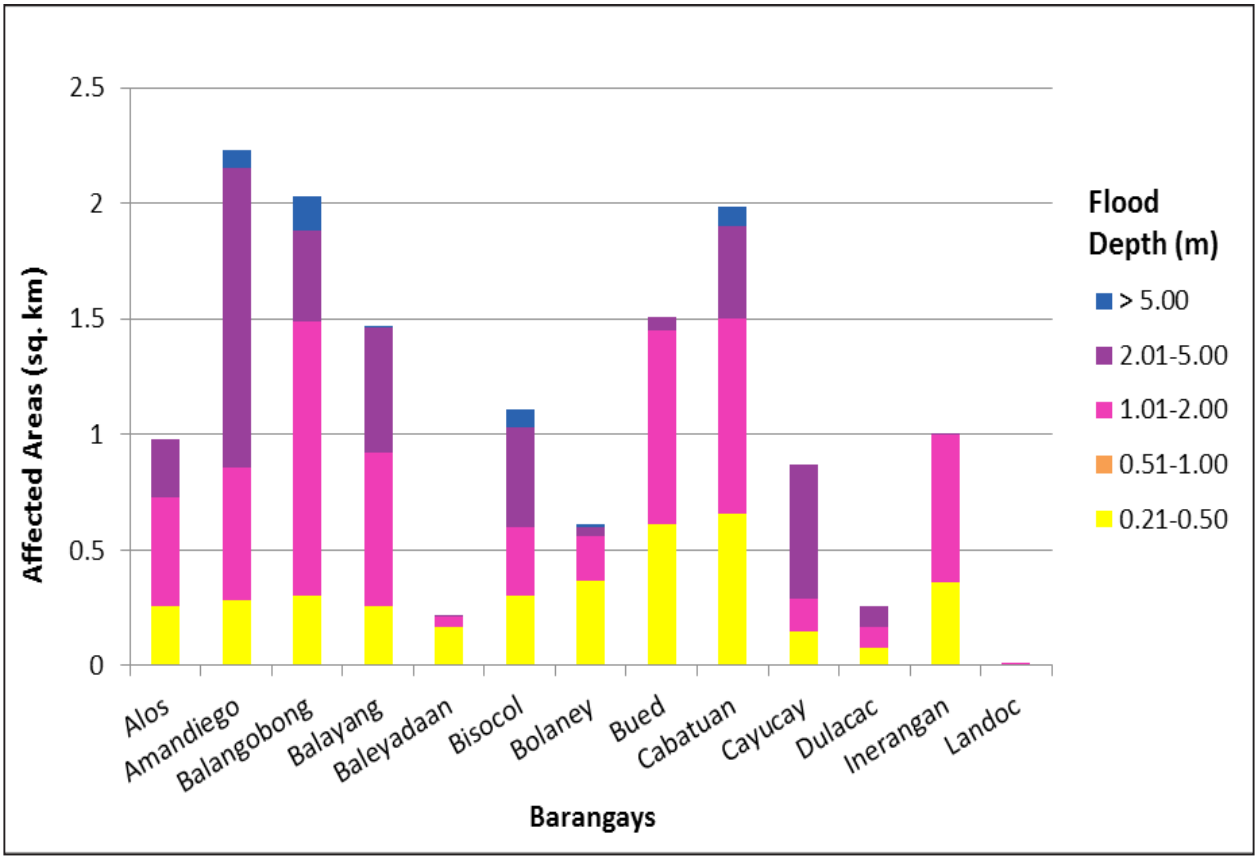
Figure 75. Affected areas in Sual, Pangasinan during a 5-year rainfall return period

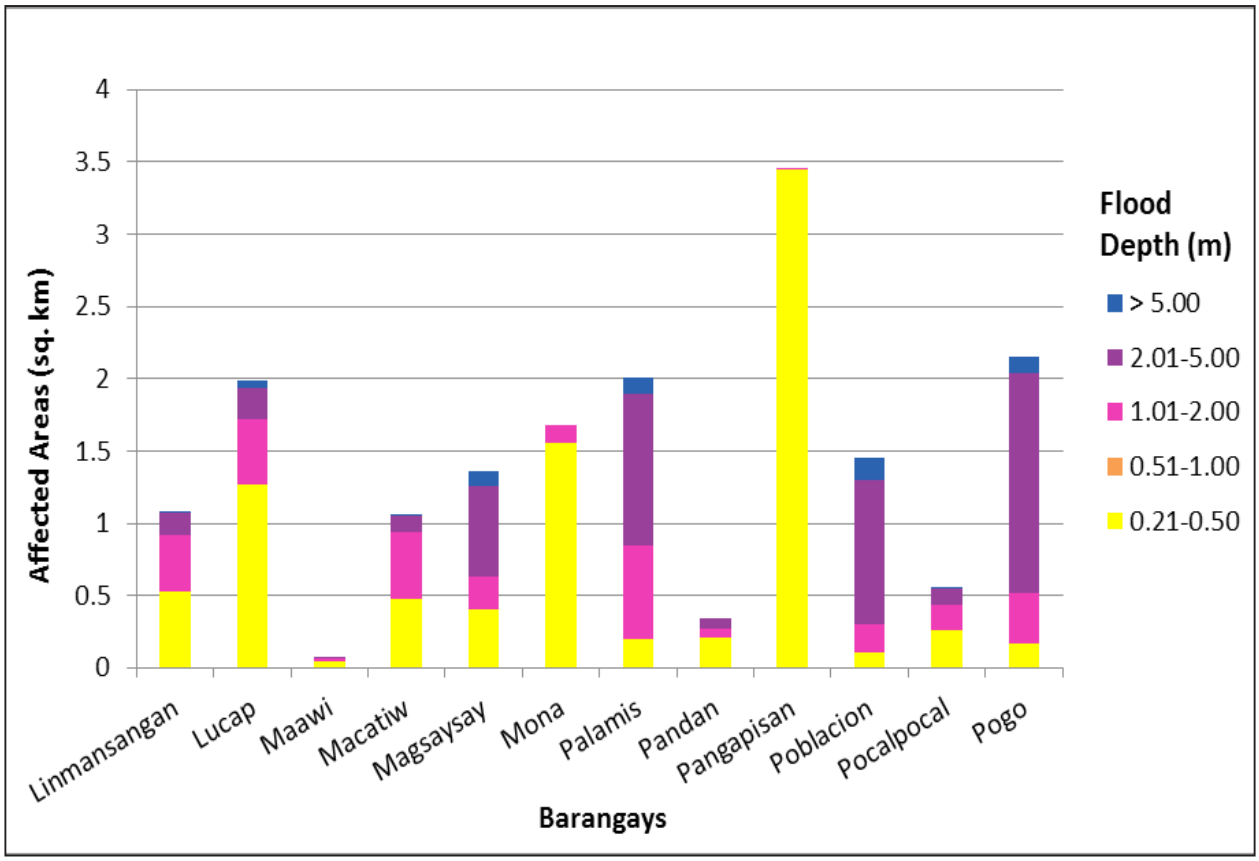
Table 38. Affected areas in Sual, Pangasinan during a 5-year rainfall return period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Sual (in sq km)								
	Baquioen	Baybay Norte	Baybay Sur	Bolaoen	Calumbuyan	Camagsingalan	Caoayan	Capantolan	Macaycayawan
0.03-0.20	0.062	1.35	3.04	5.5	10.96	13.78	12.06	2.77	3.97
0.21-0.50	0.0043	0.13	0.2	0.62	0.47	1.96	0.69	0.35	0.32
0.51-1.00	0.0008	0.085	0.13	0.3	0.37	1.39	0.47	0.25	0.23
1.01-2.00	0	0.043	0.041	0.13	0.35	0.83	0.31	0.11	0.09
2.01-5.00	0	0.0017	0.0003	0.015	0.46	0.47	0.23	0.04	0.014
> 5.00	0	0	0	0	0.079	0.15	0.007	0.0007	0.0002

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Sual (in sq km)								
	Paitan East	Paitan West	Pangascasan	Poblacion	Santo Domingo	Seselangen	Sioasio East	Sioasio West	Victoria
0.03-0.20	2.7	1.76	2.43	1.68	2.08	2.61	1.13	12.81	3.61
0.21-0.50	0.56	0.4	0.16	0.083	0.48	1.11	0.039	0.54	0.2
0.51-1.00	0.67	0.25	0.11	0.068	0.39	1.43	0.016	0.45	0.15
1.01-2.00	0.46	0.06	0.056	0.024	0.14	0.85	0.0045	0.53	0.076
2.01-5.00	0.6	0.062	0.0077	0.019	0.14	0.26	0.002	0.14	0.013
> 5.00	0.11	0.024	0	0	0.016	0.15	0	0.0013	0.0003

For the 25-year return period, 42.86% of the municipality of Alaminos City with an area of 165.505289 sq km will experience flood levels of less than 0.20 meters; 10.80% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.00%, 8.64%, 7.53%, and 0.61% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 39 are the affected areas in square kilometers by flood depth per barangay.





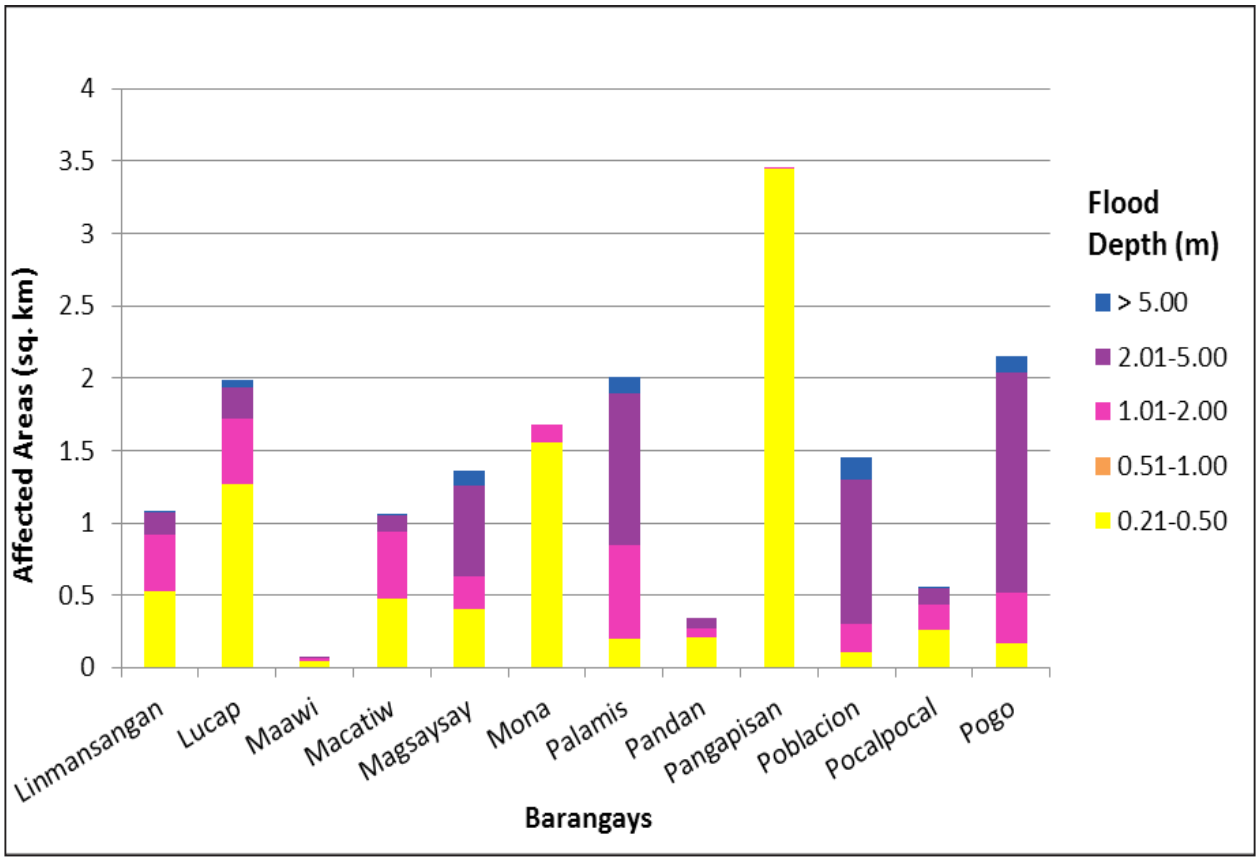


Figure 76. Affected areas in Alaminos City, Pangasinan during a 25-year rainfall return period

Table 39. Affected areas in Alaminos City, Pangasinan during a 25-year rainfall return period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Alaminos City (in sq. km)												
	Alos	Amandiego	Balangobong	Balayang	Baleyadaan	Bisocol	Bolaney	Bued	Cabatuan	Cayucay	Dulacac	Inerangan	Landoc
0.03-0.20	4.73	2.68	0.065	3.74	1	2.63	1.87	2.54	1.35	2.12	1.31	1.1	0.091
0.21-0.50	0.26	0.28	0.3	0.26	0.17	0.3	0.37	0.61	0.66	0.15	0.075	0.36	0.0051
0.51-1.00	0	0	0	0	0	0	0	0	0	0	0	0	0
1.01-2.00	0.47	0.58	1.19	0.66	0.039	0.3	0.19	0.84	0.84	0.14	0.093	0.64	0.0003
2.01-5.00	0.25	1.29	0.39	0.54	0.0007	0.43	0.041	0.059	0.4	0.58	0.087	0.0016	0
> 5.00	0	0.082	0.15	0.0028	0	0.078	0.0088	0	0.087	0	0	0	0

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Alaminos City (in sq. km)											
	Linmansangan	Lucap	Maawi	Macatiw	Magsaysay	Mona	Palamis	Pandan	Pangapisan	Poblacion	Pocalpocal	Pogo
0.03-0.20	1.85	4.93	0.61	1.06	2.79	2.11	0.32	0.86	2.54	1.15	2.54	1.51
0.21-0.50	0.53	1.27	0.042	0.48	0.4	1.56	0.2	0.21	3.45	0.11	0.26	0.17
0.51-1.00	0	0	0	0	0	0	0	0	0	0	0	0
1.01-2.00	0.39	0.45	0.02	0.46	0.23	0.12	0.65	0.064	0.0033	0.19	0.17	0.35
2.01-5.00	0.15	0.22	0.0053	0.11	0.63	0	1.05	0.073	0	1	0.12	1.52
> 5.00	0.0035	0.047	0	0.0075	0.1	0	0.11	0	0	0.15	0.0013	0.11

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Alaminos City (in sq. km)											
	Polo	Quibuar	Sabangan	San Antonio	San Jose	San Roque	San Vicente	Santa Maria	Tanaytay	Tangca-rang	Telbang	Victoria
0.03-0.20	2.23	3.21	0.84	0.5	1.66	0.64	3.55	0.0034	1.59	1.4	3.57	4.24
0.21-0.50	0.7	0.26	0.13	0.055	0.18	0.047	1.59	0	0.52	0.22	1.18	0.51
0.51-1.00	0	0	0	0	0	0	0	0	0	0	0	0
1.01-2.00	0.91	0.15	0.11	0.0088	0.61	0.026	1.43	0	0.45	0.74	0.39	0.4
2.01-5.00	0.048	0.083	0.062	0.0011	1.34	0.0036	0.9	0	0.58	0.35	0.062	0.08
> 5.00	0	0	0	0	0.038	0	0.0086	0	0	0.023	0	0

For the 25-year return period, 2.01% of the municipality of Bani with an area of 180.615338 sq km will experience flood levels of less than 0.20 meters; 3.38% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.00% of the area will experience flood depths of 0.51 to 1 meter. Listed in Table 40 are the affected areas in square kilometers by flood depth per barangay.

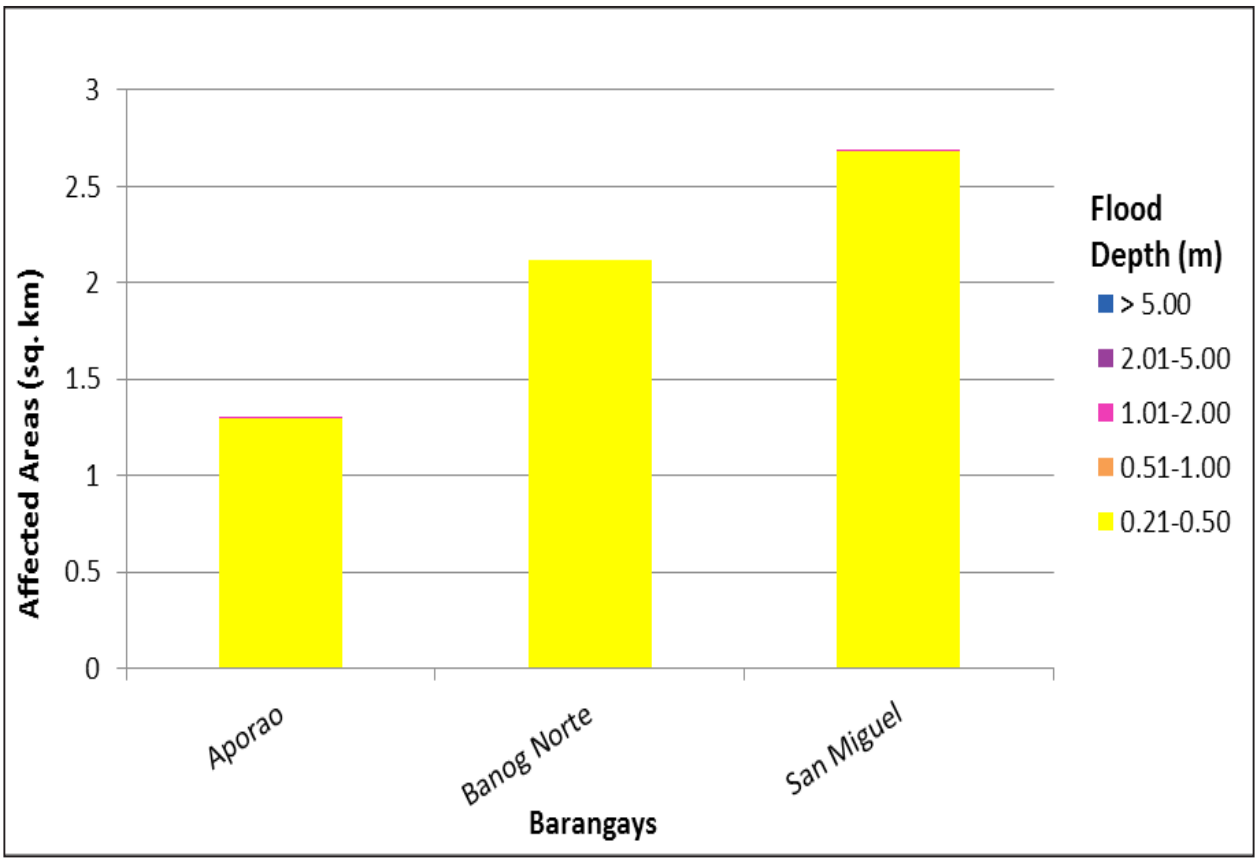


Figure 77. Affected areas in Bani, Pangasinan during a 25-year rainfall return period

Table 40. Affected areas in Bani, Pangasinan during a 25-year rainfall return period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Bani (in sq km)		
	Aporao	Banog Norte	San Miguel
0.03-0.20	1.22	0.74	1.67
0.21-0.50	1.3	2.12	2.68
0.51-1.00	0	0	0
1.01-2.00	0.0016	0	0.007
2.01-5.00	0	0	0
> 5.00	0	0	0

For the 25-year return period, 8.50% of the municipality of Mabini with an area of 260.028831 sq km will experience flood levels of less than 0.20 meters; 0.44% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.00%, 0.32%, 0.25%, and 0.04% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 41 are the affected areas in square kilometers by flood depth per barangay.

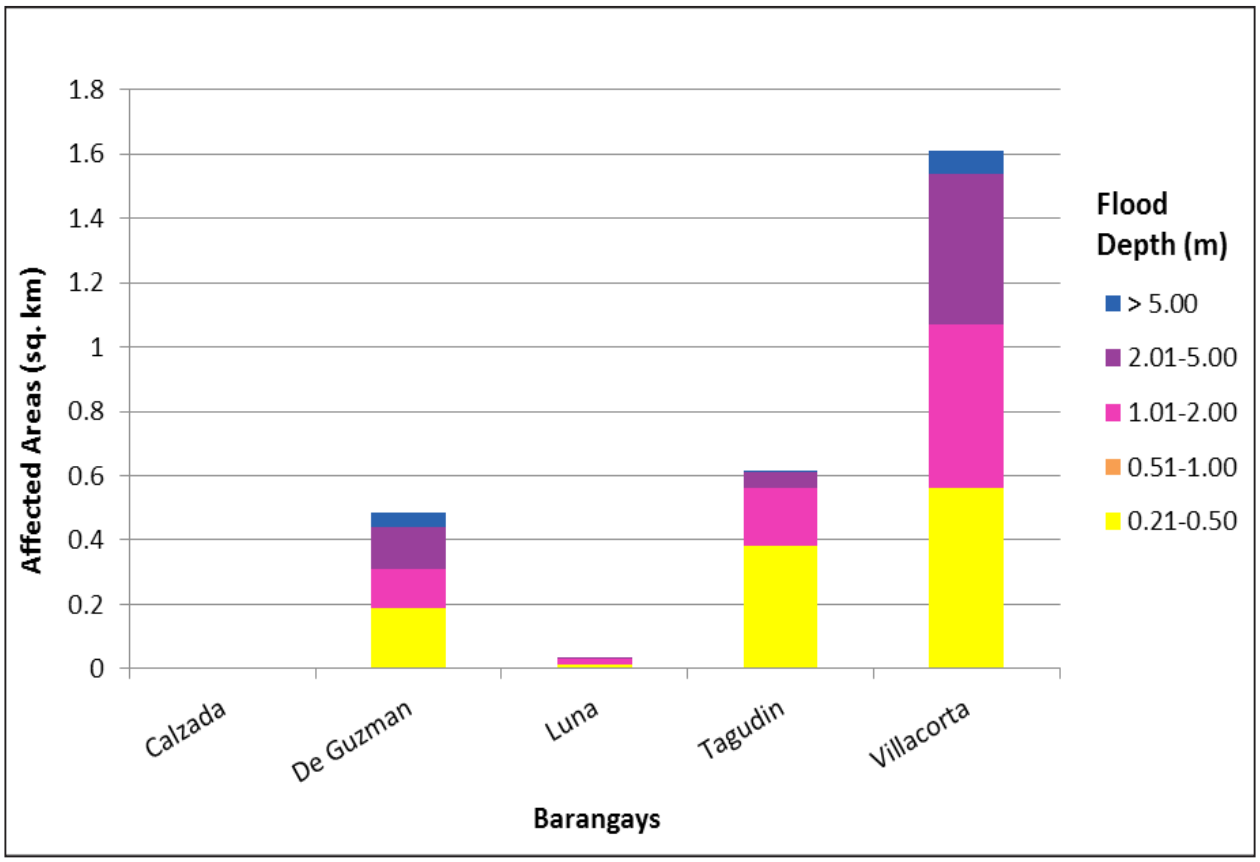
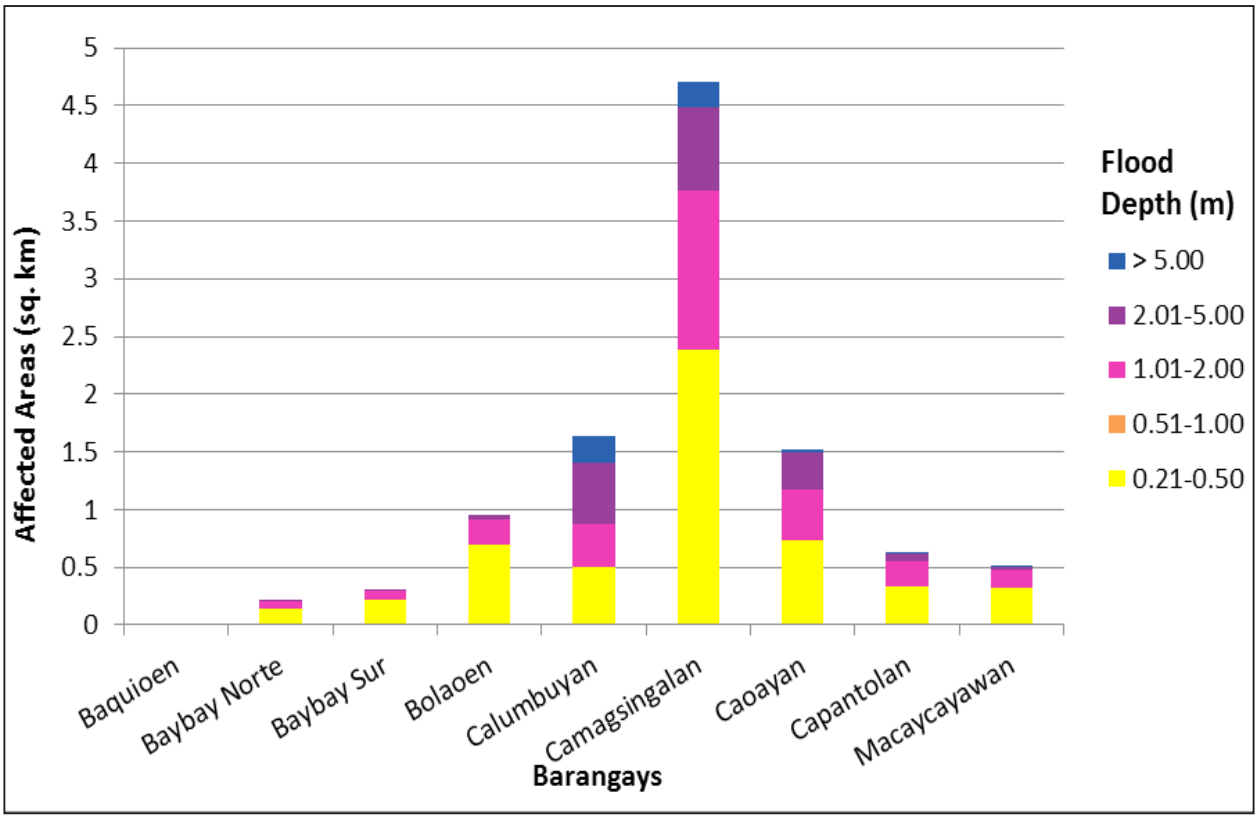


Figure 78. Affected areas in Mabini, Pangasinan during a 25-year rainfall return period

Table 41. Affected areas in in Mabini, Pangasinan during a 25-year rainfall return period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Mabini (in sq km)				
	Calzada	De Guzman	Luna	Tagudin	Villacorta
0.03-0.20	0.00042	4.65	0.33	3.41	13.7
0.21-0.50	0	0.19	0.014	0.38	0.56
0.51-1.00	0	0	0	0	0
1.01-2.00	0	0.12	0.015	0.18	0.51
2.01-5.00	0	0.13	0.0035	0.05	0.47
> 5.00	0	0.045	0	0.0011	0.07

For the 25-year return period, 47.99% of the municipality of Sual with an area of 162.961823 sq km will experience flood levels of less than 0.20 meters; 5.42% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.00%, 4.04%, 2.20%, and 0.55% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 42 are the affected areas in square kilometers by flood depth per barangay.



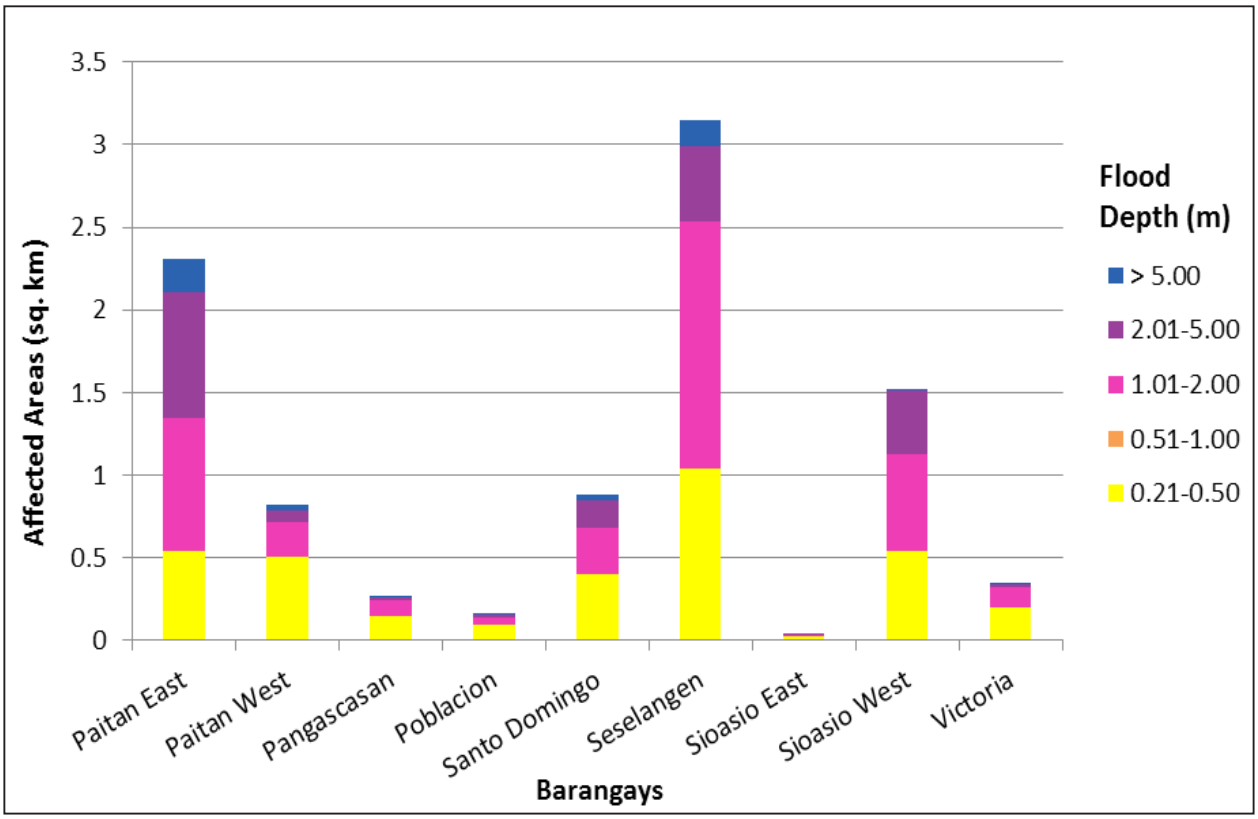


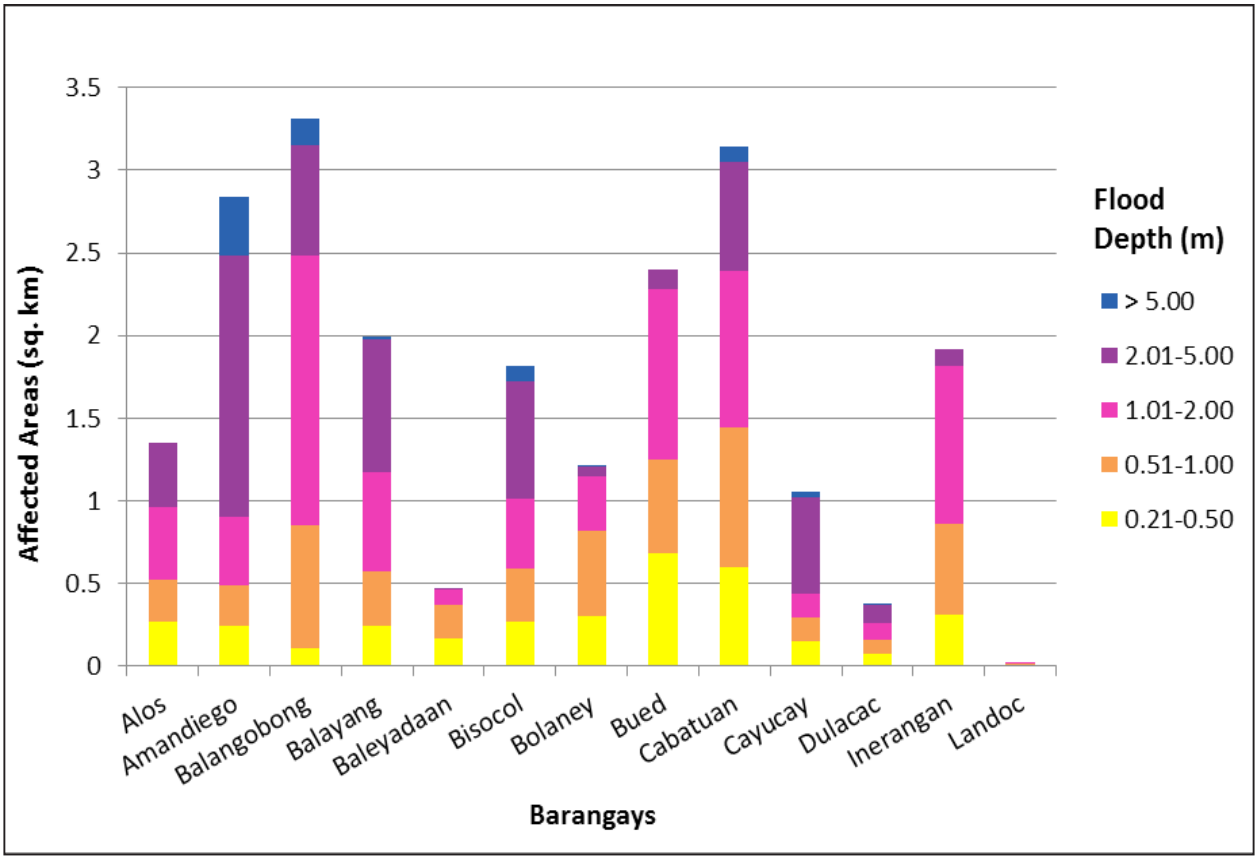
Figure 79. Affected areas in Sual, Pangasinan during a 25-year rainfall return period

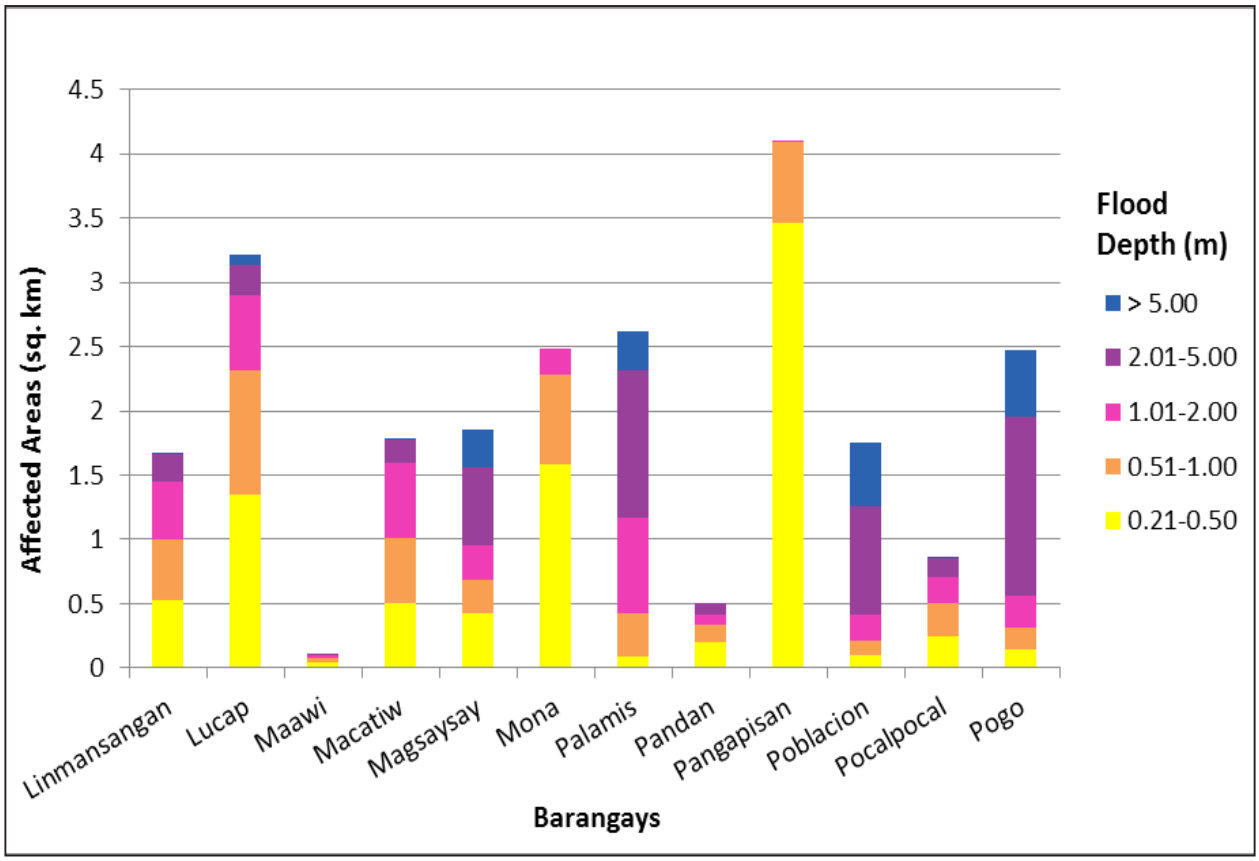
Table 42. Affected areas in Sual, Pangasinan during a 25-year rainfall return period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Sual (in sq km)								
	Baquioen	Baybay Norte	Baybay Sur	Bolaoen	Calumbuyan	Camagsingalan	Caoayan	Capantolan	Macaycayawan
0.03-0.20	0.062	1.28	2.95	5.22	10.68	12	11.61	2.62	3.85
0.21-0.50	0.0011	0.14	0.22	0.7	0.5	2.39	0.73	0.33	0.32
0.51-1.00	0	0	0	0	0	0	0	0	0
1.01-2.00	0.00052	0.063	0.076	0.22	0.38	1.37	0.44	0.22	0.16
2.01-5.00	0	0.0083	0.0033	0.035	0.53	0.72	0.32	0.063	0.021
> 5.00	0	0	0	0	0.22	0.22	0.027	0.0007	0.0002

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Sual (in sq km)								
	Paitan East	Paitan West	Pangascasan	Poblacion	Santo Domingo	Seselangen	Sioasio East	Sioasio West	Victoria
0.03-0.20	2.11	1.14	2.37	1.64	1.79	1.71	1.12	12.53	3.52
0.21-0.50	0.54	0.51	0.15	0.091	0.4	1.04	0.027	0.54	0.2
0.51-1.00	0	0	0	0	0	0	0	0	0
1.01-2.00	0.81	0.21	0.097	0.045	0.28	1.5	0.01	0.59	0.12
2.01-5.00	0.76	0.068	0.015	0.023	0.17	0.45	0.0036	0.38	0.023
> 5.00	0.2	0.033	0.0001	0.00025	0.034	0.16	0	0.0067	0.0006

For the 100-year return period, 39.11% of the municipality of Alaminos City with an area of 165.505289 sq km will experience flood levels of less than 0.20 meters; 10.18% of the area will experience flood levels of 0.21 to 0.50 meters; while 9.06%, 10.40%, 9.41%, and 1.60% 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 43 are the affected areas in square kilometers by flood depth per barangay.





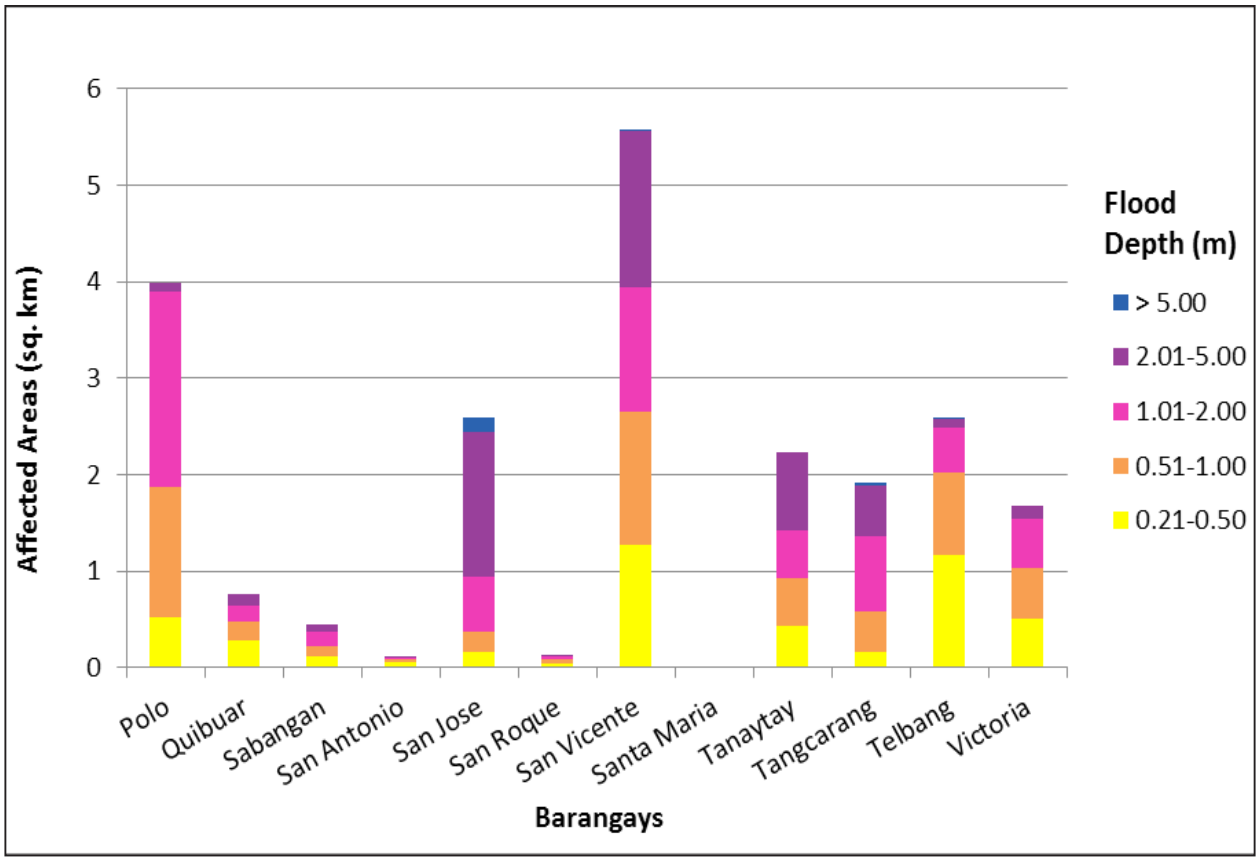


Figure 80. Affected areas in Alaminos City, Pangasinan during a 100-year rainfall return period

Table 43. Affected areas in Alaminos City, Pangasinan during a 100-year rainfall return period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Alaminos City (in sq. km)												
	Alos	Amandiego	Balangobong	Balayang	Baleyadaan	Bisocol	Bolaney	Bued	Cabatuan	Cayucay	Dulacac	Inerangan	Landoc
0.03-0.20	4.61	2.34	0.013	3.59	0.95	2.21	1.75	2.21	1.02	2.07	1.28	0.81	0.09
0.21-0.50	0.27	0.24	0.11	0.24	0.17	0.27	0.3	0.68	0.6	0.15	0.072	0.31	0.0051
0.51-1.00	0.25	0.25	0.74	0.33	0.2	0.32	0.52	0.57	0.84	0.14	0.09	0.55	0.0069
1.01-2.00	0.44	0.41	1.63	0.6	0.089	0.42	0.33	1.03	0.95	0.15	0.098	0.96	0.0004
2.01-5.00	0.39	1.58	0.67	0.81	0.0013	0.71	0.054	0.12	0.66	0.58	0.11	0.094	0
> 5.00	0	0.36	0.16	0.012	0	0.092	0.011	0	0.092	0.038	0.00099	0	0

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Alaminos City (in sq. km)											
	Linmansangan	Lucap	Maawi	Macatiw	Magsaysay	Mona	Palamis	Pandan	Pangapisan	Poblacion	Pocalpocal	Pogo
0.03-0.20	1.7	4.56	0.6	0.8	2.56	1.88	0.2	0.83	2	0.94	2.47	1.41
0.21-0.50	0.53	1.35	0.043	0.5	0.43	1.58	0.083	0.2	3.46	0.097	0.25	0.14
0.51-1.00	0.47	0.97	0.033	0.51	0.26	0.7	0.34	0.14	0.63	0.11	0.25	0.17
1.01-2.00	0.45	0.58	0.022	0.59	0.27	0.21	0.74	0.073	0.0049	0.21	0.21	0.25
2.01-5.00	0.21	0.24	0.0067	0.18	0.6	0	1.15	0.087	0	0.84	0.14	1.4
> 5.00	0.0044	0.071	0	0.0088	0.29	0	0.31	0	0	0.5	0.0059	0.51

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Alaminos City (in sq. km)											
	Polo	Quibuar	Sabangan	San Antonio	San Jose	San Roque	San Vicente	Santa Maria	Tanaytay	Tangca-rang	Telbang	Victoria
0.03-0.20	1.99	3.12	0.81	0.49	1.52	0.62	3.13	0.0034	1.33	1.34	3.4	4.08
0.21-0.50	0.53	0.28	0.12	0.057	0.16	0.049	1.28	0	0.44	0.17	1.17	0.51
0.51-1.00	1.35	0.2	0.097	0.029	0.22	0.041	1.38	0	0.49	0.42	0.86	0.52
1.01-2.00	2.02	0.16	0.16	0.012	0.57	0.032	1.28	0	0.5	0.78	0.46	0.52
2.01-5.00	0.082	0.12	0.078	0.0017	1.5	0.0056	1.62	0	0.8	0.52	0.085	0.13
> 5.00	0	0	0	0	0.15	0	0.01	0	0	0.026	0.0012	0

For the 100-year return period, 1.34% of the municipality of Bani with an area of 180.615338 sq km will experience flood levels of less than 0.20 meters; 3.53% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.90% and 0.10% of the area will experience flood depths of 0.51 to 1 meter and 1.01 to 2 meters, respectively. Listed in Table 44 are the affected areas in square kilometers by flood depth per barangay.

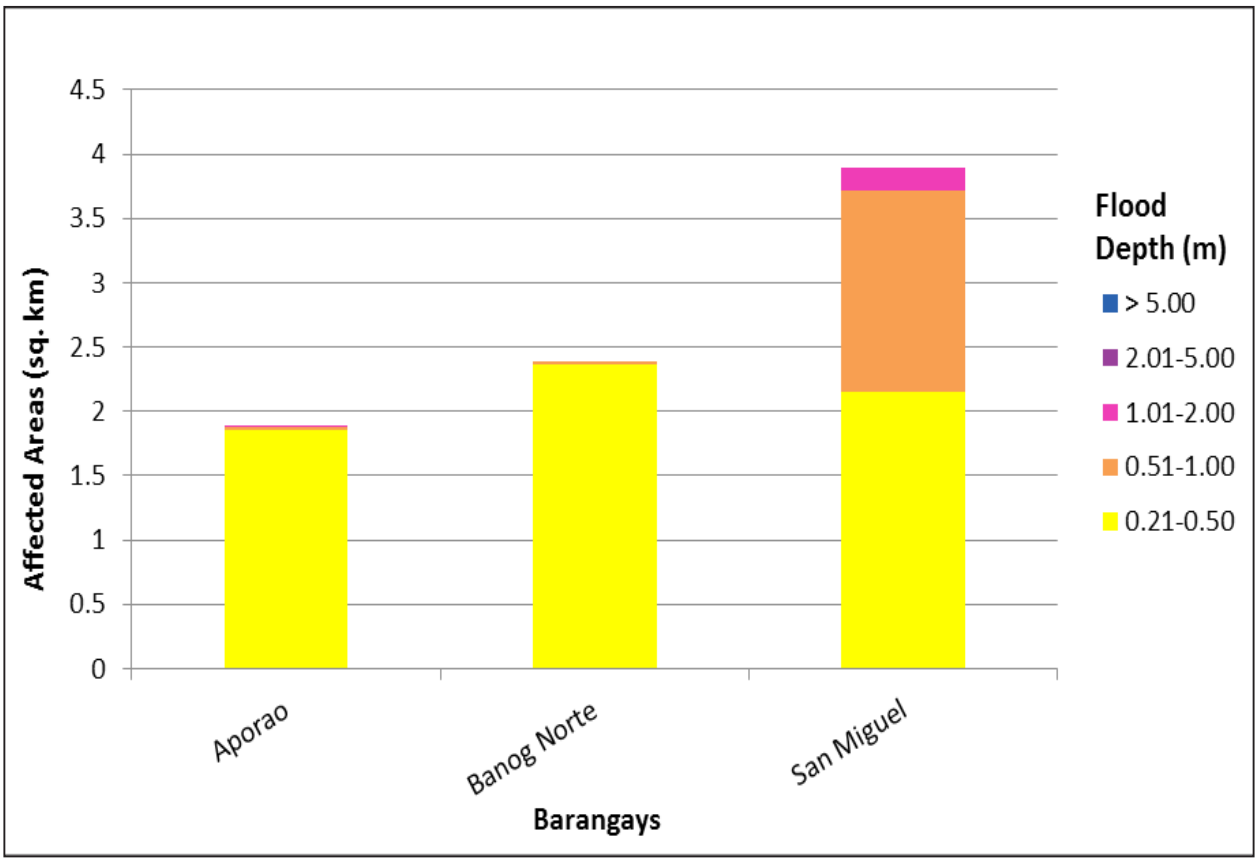


Figure 81. Affected areas in Bani, Pangasinan during a 100-year rainfall return period

Table 44. Affected areas in Bani, Pangasinan during a 100-year rainfall return period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Bani (in sq km)		
	Aporao	Banog Norte	San Miguel
0.03-0.20	1.22	0.74	1.67
0.21-0.50	1.3	2.12	2.68
0.51-1.00	0	0	0
1.01-2.00	0.0016	0	0.007
2.01-5.00	0	0	0
> 5.00	0	0	0

For the 100-year return period, 8.33% of the municipality of Mabini with an area of 260.028831 sq km will experience flood levels of less than 0.20 meters; 0.47% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.35%, 0.36%, 0.31%, and 0.07% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 45 are the affected areas in square kilometers by flood depth per barangay.

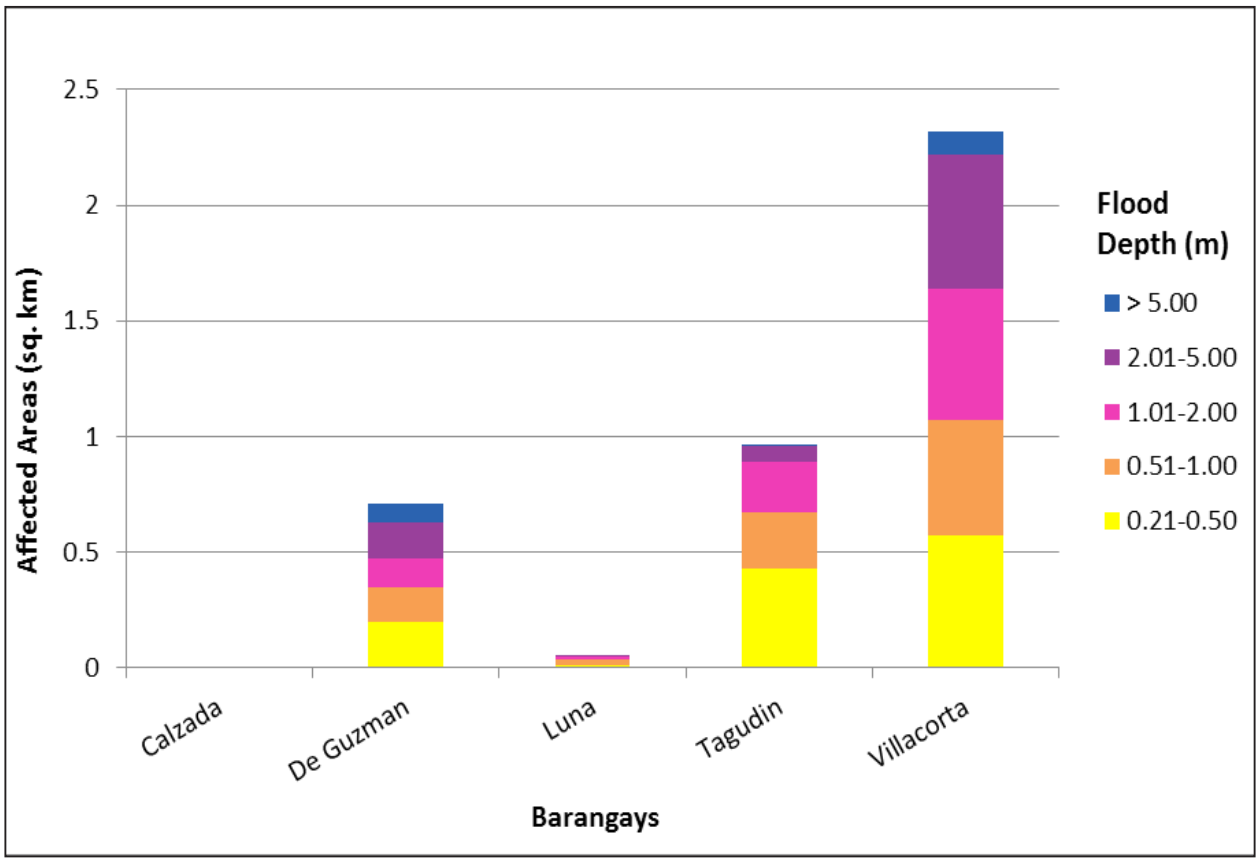
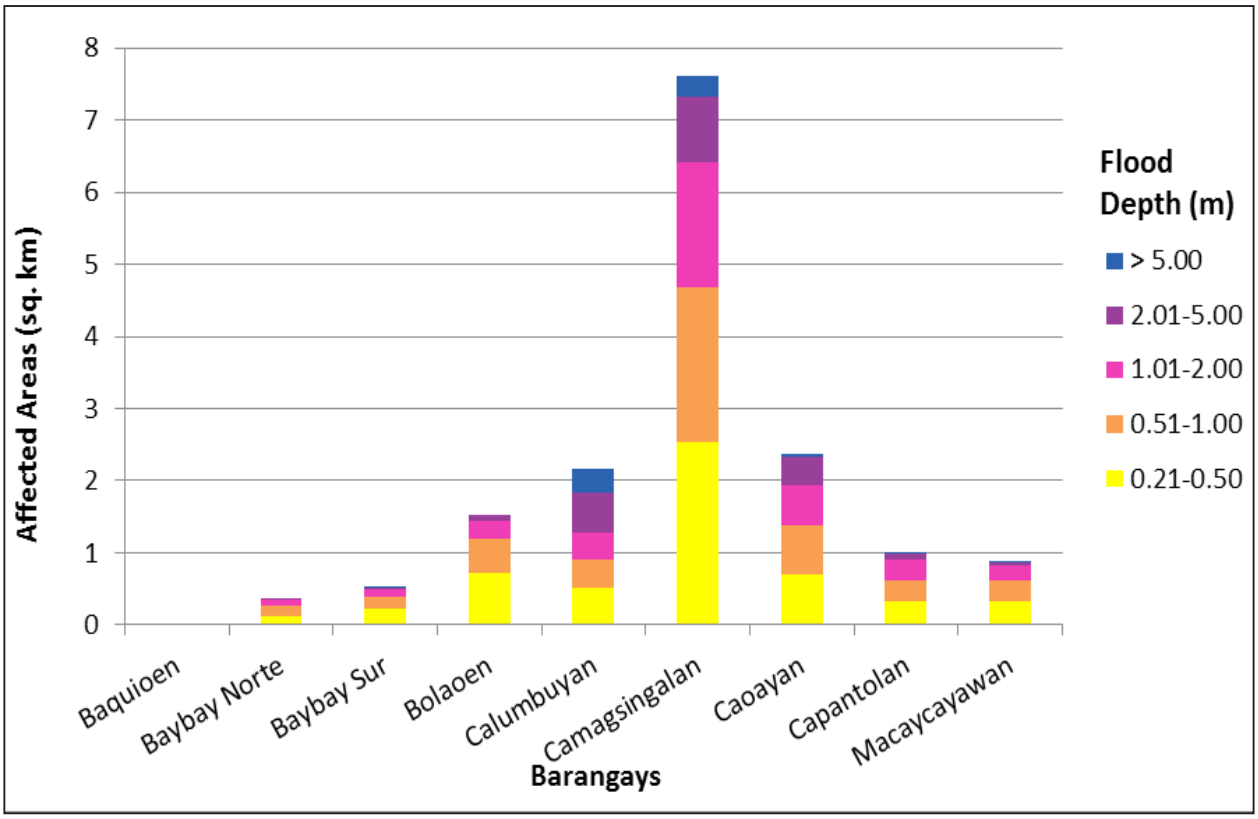


Figure 82. Affected areas in Mabini, Pangasinan during a 100-year rainfall return period

Table 45. Affected areas in in Mabini, Pangasinan during a 100-year rainfall return period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Mabini (in sq km)				
	Calzada	De Guzman	Luna	Tagudin	Villacorta
0.03-0.20	0.00042	4.65	0.33	3.41	13.7
0.21-0.50	0	0.19	0.014	0.38	0.56
0.51-1.00	0	0	0	0	0
1.01-2.00	0	0.12	0.015	0.18	0.51
2.01-5.00	0	0.13	0.0035	0.05	0.47
> 5.00	0	0.045	0	0.0011	0.07

For the 100-year return period, 46.10% of the municipality of Sual with an area of 162.961823 sq km will experience flood levels of less than 0.20 meters; 5.19% of the area will experience flood levels of 0.21 to 0.50 meters; while 5.50%, 4.99%, 2.90%, and 0.72% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 46 are the affected areas in square kilometers by flood depth per barangay.



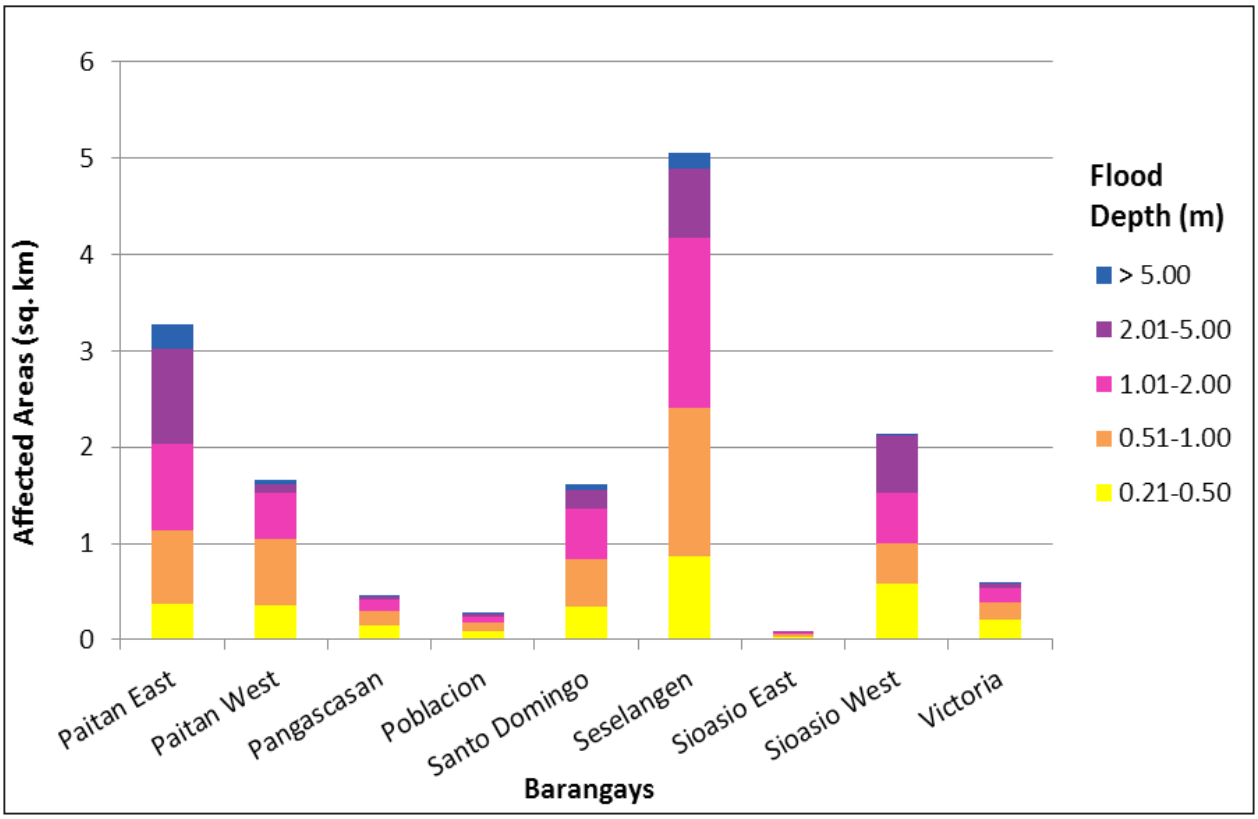


Figure 83. Affected areas in Sual, Pangasinan during a 25-year rainfall return period

Table 46. Affected areas in Sual, Pangasinan during a 100-year rainfall return period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Sual (in sq km)								
	Baquioen	Baybay Norte	Baybay Sur	Bolaoen	Calumbuyan	Camagsingalan	Caoayan	Capantolan	Macaycayawan
0.03-0.20	0.062	1.24	2.89	5.05	10.52	10.98	11.41	2.54	3.77
0.21-0.50	0.0011	0.13	0.22	0.72	0.52	2.53	0.7	0.33	0.32
0.51-1.00	0.0026	0.14	0.18	0.47	0.39	2.16	0.68	0.29	0.29
1.01-2.00	0.0016	0.076	0.098	0.26	0.37	1.72	0.56	0.28	0.22
2.01-5.00	0	0.019	0.0088	0.072	0.55	0.91	0.39	0.09	0.032
> 5.00	0	0	0.0001	0	0.33	0.28	0.033	0.001	0.0002

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Sual (in sq km)								
	Paitan East	Paitan West	Pangascasan	Poblacion	Santo Domingo	Seselangen	Sioasio East	Sioasio West	Victoria
0.03-0.20	1.86	0.92	2.33	1.61	1.65	1.37	1.11	12.35	3.47
0.21-0.50	0.37	0.36	0.15	0.093	0.34	0.86	0.031	0.58	0.21
0.51-1.00	0.77	0.68	0.15	0.078	0.5	1.55	0.031	0.42	0.18
1.01-2.00	0.9	0.49	0.12	0.066	0.52	1.76	0.015	0.53	0.15
2.01-5.00	0.98	0.085	0.025	0.027	0.19	0.72	0.005	0.59	0.04
> 5.00	0.25	0.037	0.0001	0.00055	0.057	0.17	0	0.013	0.0012

Among the barangays in the municipality of Alaminos City in Pangasinan, San Vicente is projected to have the highest percentage of area that will experience flood levels at 5.26%. Meanwhile, Lucap posted the second highest percentage of area that may be affected by flood depths at 4.70%.

Among the barangays in the municipality of Bani in Pangasinan, San Miguel is projected to have the highest percentage of area that will experience flood levels at 3.12%. Meanwhile, Banog Norte posted the second highest percentage of area that may be affected by flood depths at 1.73%.

Among the barangays in the municipality of Mabini in Pangasinan, Villacorta is projected to have the highest percentage of area that will experience flood levels at 9.55%. Meanwhile, De Guzman posted the second highest percentage of area that may be affected by flood depths at 3.19%.

Among the barangays in the municipality of Sual in Pangasinan, Camagsingalan is projected to have the highest percentage of area that will experience flood levels at 11.23%. Meanwhile, Sioasio West posted the second highest percentage of area that may be affected by flood depths at 8.75%.

Moreover, the generated flood hazard maps for the Alaminos Floodplain were used to assess the vulnerability of the educational and medical institutions in the floodplain. Using the flood depth units of PAGASA for hazard maps ("Low," "Medium," and "High"), the affected institutions were given their individual assessment for each flood hazard scenario (5-year, 25-year, and 10-year).

Table 47. Areas 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	31.24	34.64	33.22
Medium	29.79	39.65	42.69
High	15.25	27.25	36.26
TOTAL	**76.28**	**101.54**	**75.91**

Of the 413 identified educational institutions in Alaminos Floodplain, thirty (30) school buildings were discovered exposed to low-level flooding during a 5-year scenario, while ten (10) school buildings were found exposed to medium-level flooding in the same scenario.

For the 25-year scenario, nineteen (19) school buildings were discovered exposed to low-level flooding while thirty-seven (37) school buildings were found exposed to medium-level flooding, In the same scenario, thirteen (13) school buildings were discovered exposed to high-level flooding.

For the 100-year scenario, thirty (30) school buildings were discovered exposed to Low-level flooding while thirty-seven (37) school buildings were found exposed to medium-level flooding, In the same scenario, twenty-one (21) school buildings were discovered exposed to high-level flooding.

Of the 23 identified medical institutions in Alaminos Floodplain, two (2) buildings were discovered exposed to low-level flooding during a 5-year scenario.

For the 25-year scenario, one (1) building was found exposed to medium-level flooding and to high-level flooding.

For the 100-year scenario, two (2) buildings were discovered exposed to high-level flooding.

5.11 Flood Validation

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

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

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

After which, 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 what is needed. The points in the flood map versus its corresponding validation depths are shown in Figure 85.

The flood validation consists of 180 points randomly selected all over the Alaminos floodplain (Figure 35). Comparing it with the flood depth map of the nearest storm event, the map has an RMSE value of 0.61 m. Table 48 shows a contingency matrix of the comparison.

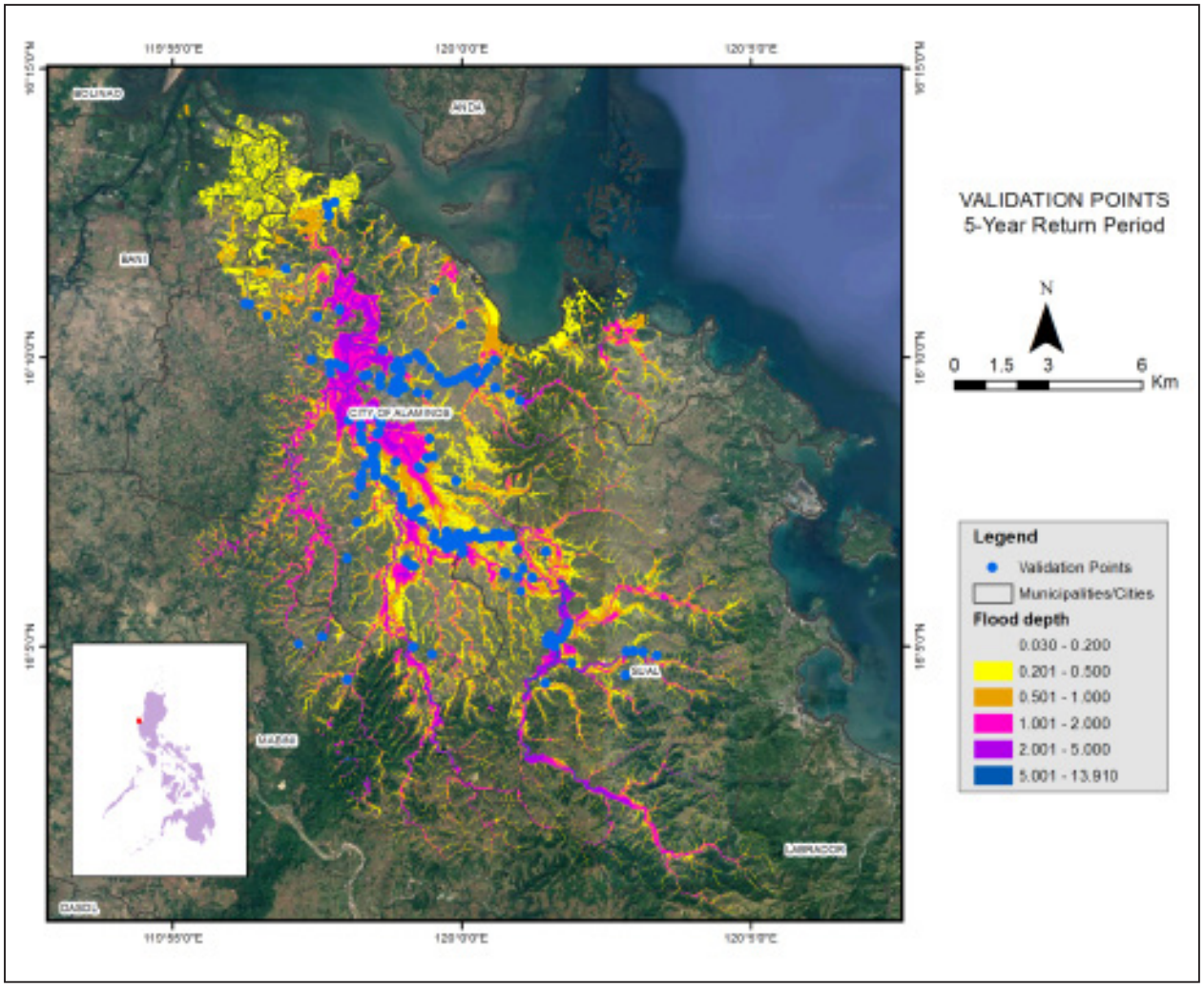


Figure 84. Validation points for 5-year flood depth map of Alaminos Floodplain

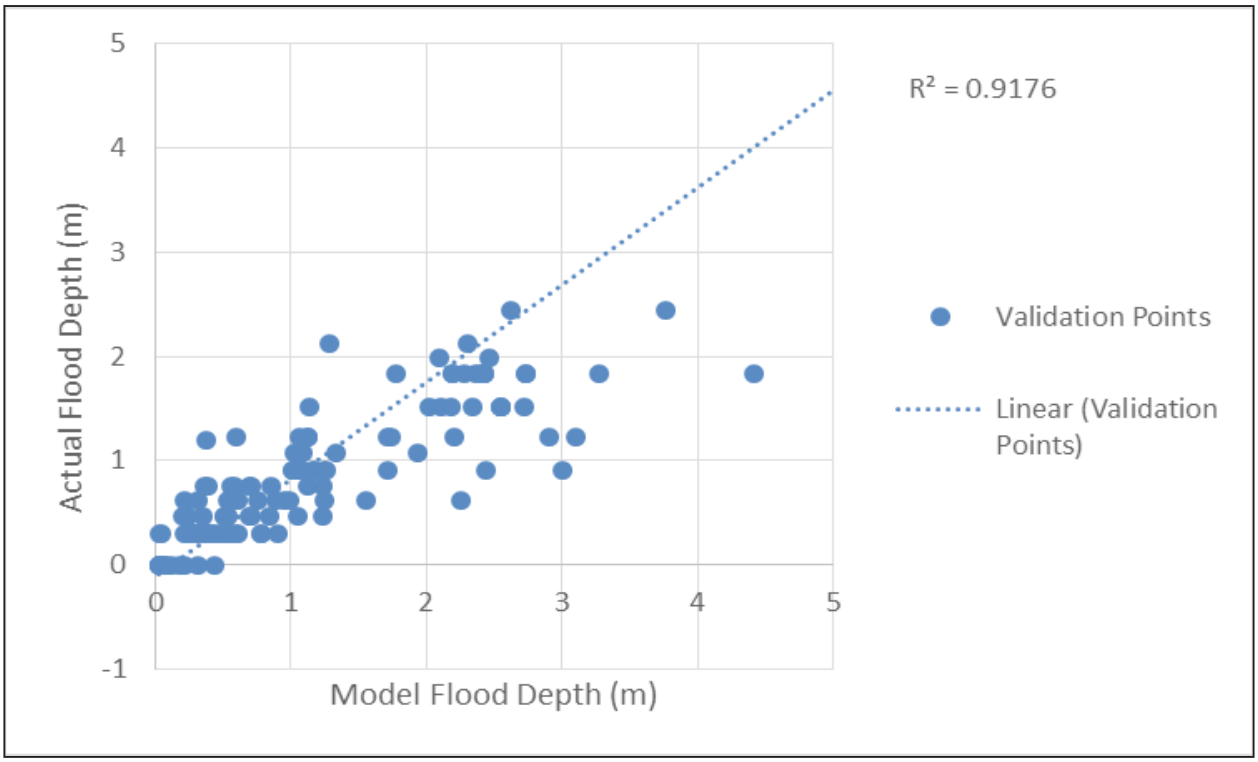


Figure 85. Flood map depth versus actual flood depth.

Table 48. Actual flood depth vs. simulated flood depth in Alaminos

Actual Flood Depth (m)	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
0-0.20	28	3	0	0	0	0	31
0.21-0.50	2	22	16	2	0	0	42
0.51-1.00	0	4	13	16	3	0	36
1.01-2.00	0	1	1	11	24	0	37
2.01-5.00	0	0	0	1	3	6	10
> 5.00	0	0	0	0	0	24	24
Total	30	30	30	30	30	30	180

The overall accuracy generated by the flood model is estimated at 56.11% with 101 points correctly matching the actual flood depths. In addition, there were 69 points estimated one level above and below the correct flood depths while there were 6 points and 0 points estimated two levels above and below, and three or more levels above and below the correct flood. A total of 4 points were overestimated while a total of 9 points were underestimated in the modeled flood depths of Alaminos.

Table 49. Summary of the Accuracy Assessment in the Alaminos River Basin Survey

	No. of Points	%
Correct	101	56.11
Overestimated	70	38.89
Underestimated	9	5.00
Total	180	100.00

REFERENCES

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

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

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

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

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

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

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

ANNEXES

Annex 1. Optech Technical Specification of the Sensor

1. PEGASUS SENSOR

Figure A-1.1 Pegasus Sensor

2. PARAMETERS AND SPECIFICATIONS OF THE PEGASUS SENSOR

Table A-1.1 Parameters and Specifications of the Pegasus Sensor

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

1. Target reflectivity ≥20%
2. Dependent on selected operational parameters using nominal FOV of up to 40° in standard atmospheric conditions with 24-km visibility
3. Angle of incidence ≤20˚
4. Target size ≥ laser footprint5 Dependent on system configuration

3. GEMINI SENSOR

Figure A-1.2 Gemini Sensor

4. PARAMETERS AND SPECIFICATIONS OF THE GEMINI SENSOR

Table A-1.2 Parameters and Specifications of the 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 Certificates of Reference Points Used

1. PNG-66

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

May 29, 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: **PANGASINAN**
Station Name: **PNG-66**
Order: **2nd**

Island: **LUZON**
Municipality: **SAN CARLOS**
Barangay: **CALOMBOYAN**

PRS92 Coordinates

Latitude: **15° 56' 47.31803"** Longitude: **120° 17' 67.03550"** Ellipsoidal Hgt: **10.57500 m.**

WGS84 Coordinates

Latitude: **15° 56' 41.53646"** Longitude: **120° 18' 1.81867"** Ellipsoidal Hgt: **48.46800 m.**

PTM Coordinates

Northing: **1763650.683 m.** Easting: **424968.98 m.** Zone: **3**

UTM Coordinates

Northing: **1,764,780.62** Easting: **210,862.35** Zone: **51**

Location Description

PNG-66

From San Carlos Mun. Hall, travel along the highway going to Binmaley. Then turn left to the brgy. road going to Brgy. Pangalangan. Station is located inside the compound of Calomboyan Elem. School. It is situated along and beside the SE side of the concrete base of the flagpole, which is about 20 m. NW of the gate. Mark is the head of a 4 in. copper nail centered and embedded in a 30 cm. x 30 cm. concrete block protruding 20 cm. above ground surface, with inscriptions "PNG-66 2007 NAMRIA".

Requesting Party: **UP-DREAM**
Pupose: **Reference**
OR Number: **8796225 A**
T.N.: **2014-1185**

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

NAMRIA OFFICES:
Main : Lawton Avenue, Fort Bonifacio, 1634 Taguig City, Philippines Tel. No.: (632) 810-4831 to 41
Branch : 421 Barraca St. San Nicolas, 1010 Manila, Philippines, Tel. No. (632) 241-3464 to 69
www.namria.gov.ph
ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

Figure A-2.1 PNG-66

2. PNG-80

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

November 11, 2015

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: **PANGASINAN**
Station Name: **PNG-80**
Order: **2nd**
Island: **LUZON** Barangay: **DON MATIAS**
Municipality: **BURGOS** MSL Elevation:

PRS92 Coordinates

Latitude: **16° 3' 57.54921"** Longitude: **119° 51' 57.50829"** Ellipsoidal Hgt: **87.99000 m.**

WGS84 Coordinates

Latitude: **16° 3' 51.70677"** Longitude: **119° 52' 2.28323"** Ellipsoidal Hgt: **124.47300 m.**

PTM / PRS92 Coordinates

Northing: **1777080.247 m.** Easting: **378657.843 m.** Zone: **3**

UTM / PRS92 Coordinates

Northing: **1,778,249.73** Easting: **806,647.53** Zone: **50**

Location Description

PNG-80

Is located on the open ground W of the academics compound of Burgos Nat'l. High School. It is situated 15 m. S of a Mango tree, which is 125 m. W of BBM No. 14. The boundary marker is about 150 m. N of the cemented brgy. road of Don Matias bounding the E side of the said school. Mark is the head of a 4 in. copper nail centered and embedded in a 30 cm. x 30 cm. x 10 cm. concrete block, with inscriptions "PNG-80 2007 NAMRIA".

Requesting Party: **UP DREAM**
Purpose: **Reference**
OR Number: **8088606 I**
T.N.: **2015-3725**

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

9911112015150326

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
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Figure A-2.2 PNG-80

3. PNG-3034

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: **PANGASINAN**
Station Name: **PNG-3034**
Order: **3rd**

Island: **Luzon**
Municipality: **BANI**
Barangay: **GARRITA**

PRS92 Coordinates

Latitude: **16° 11' 17.38811"** Longitude: **119° 54' 39.49132"** Ellipsoidal Hgt: **8.60000 m.**

WGS84 Coordinates

Latitude: **16° 11' 11.52189"** Longitude: **119° 54' 44.25583"** Ellipsoidal Hgt: **44.82200 m.**

PTM Coordinates

Northing: **1790575.207 m.** Easting: **383544.293 m.** Zone: **3**

UTM Coordinates

Northing: **1,791,845.87** Easting: **811,274.25** Zone: **50**

Location Description

PNG-3034

From Alaminos along the highway travel west going to Bani Town Proper to reach Barangay Garrita. The station is located about 20 meters E of the Barangay Health Center and about 200 meters W of Garrita Bridge.

Station mark is the head of a copper nail embedded at the center of a 25cm. x 25cm. cement putty with inscriptions "PNG-3034; 2007; NAMRIA."

Requesting Party: **UP DREAM**
Pupose: **Reference**
OR Number: **8795829 A**
T.N.: **2014-655**

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

NAMRIA OFFICES:
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Figure A-2.3 PNG-3034

4. PNG-3369

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: **PANGASINAN**
Station Name: **PNG-3369**
Order: **4th**

Island: **LUZON**
Municipality: **BANI**
Barangay: **BANOG NORTE**

PRS92 Coordinates

Latitude: **16° 11' 21.74066"** Longitude: **119° 54' 10.85493"** Ellipsoidal Hgt: **9.14500 m.**

WGS84 Coordinates

Latitude: **16° 11' 16.87356"** Longitude: **119° 54' 15.61937"** Ellipsoidal Hgt: **45.34400 m.**

PTM Coordinates

Northing: **1790713.532 m.** Easting: **382694.297 m.** Zone: **3**

UTM Coordinates

Northing: **1,791,967.70** Easting: **810,421.15** Zone: **50**

Location Description

PNG-3369
From the municipal hall of Bani, Pangasinan travel eastward on the national road going to Alaminos, just go ahead after reaching the Caltex Gas station, it is located just beside DPWH km post. It is exactly 29.20 m w of the concrete welcome sign of Brgy. Banog and Garrita. Station mark is the hed of a 4" copper nail on a 0.40 m x 0.40 m concrete monument with inscription PNG-3369, PRS-92, 2008, DENR-LMS R-1.

Requesting Party: **UP DREAM**
Pupose: **Reference**
OR Number: **8796829 A**
T.N.: **2014-659**

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

NAMRIA OFFICES
Main : Lawton Avenue, Fort Bonifacio, 1634 Taguig City, Philippines Tel. No.: (632) 810-4831 to 41
Branch : 421 Barraca St. San Nicolas, 1010 Manila, Philippines, Tel. No. (632) 241-3484 to 93
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Figure A-2.4 PNG-3369

5. TRC-3008

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

May 29, 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: **TARLAC**
Station Name: **TRC-3008**
Order: **3rd**

Island: **LUZON**
Municipality: **GERONA**
Barangay: **MAGASPAC**

PRS92 Coordinates

Latitude: **15° 37' 1.26155"** Longitude: **120° 35' 46.75495"** Ellipsoidal Hgt: **28.39700 m.**

WGS84 Coordinates

Latitude: **15° 36' 55.57785"** Longitude: **120° 35' 51.56455"** Ellipsoidal Hgt: **67.99500 m.**

PTM Coordinates

Northing: **1727112.619 m.** Easting: **456712.374 m.** Zone: **3**

UTM Coordinates

Northing: **1,727,923.03** Easting: **242,273.84** Zone: **51**

Location Description

TRC-3008
Mark is located in Magaspac Elementary School, about 6m SW of the flagpole. Station is marked with a head of a 4" copper nail embedded on the center of a 0.30 x 0.30 x 1 m concrete monument with inscriptions TRC-3008 2007 NAMRIA.

Requesting Party: **UP-DREAM**
Pupose: **Reference**
OR Number: **8796226 A**
T.N.: **2014-1186**

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

NAMRIA OFFICES:
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Figure A-2.5 TRC-3008

Annex 3. Baseline Processing Report of Reference Points Used

1. PNG-3369

Vector Components (Mark to Mark)

From:	PNG-80				
Grid		Local		Global	
Easting	164648.757 m	Latitude	N16°03'57.54922"	Latitude	N16°03'51.70577"
Northing	1778666.044 m	Longitude	E119°51'57.50830"	Longitude	E119°52'02.28323"
Elevation	83.821 m	Height	87.991 m	Height	124.473 m

To:	PNG-3369				
Grid		Local		Global	
Easting	168821.042 m	Latitude	N16°11'21.73909"	Latitude	N16°11'15.87198"
Northing	1792270.967 m	Longitude	E119°54'10.65883"	Longitude	E119°54'15.62327"
Elevation	3.929 m	Height	8.221 m	Height	44.420 m

Vector					
ΔEasting	4172.285 m	NS Fwd Azimuth	16°10'41"	ΔX	-1507.240 m
ΔNorthing	13604.924 m	Ellipsoid Dist.	14216.472 m	ΔY	-5328.771 m
ΔElevation	-79.892 m	ΔHeight	-79.770 m	ΔZ	13093.870 m

Standard Errors

Vector errors:					
σ ΔEasting	0.004 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.007 m
σ ΔNorthing	0.003 m	σ Ellipsoid Dist.	0.002 m	σ ΔY	0.010 m
σ ΔElevation	0.012 m	σ ΔHeight	0.012 m	σ ΔZ	0.005 m

Apcsteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.0000437476		
Y	-0.0000527592	0.0001062067	
Z	-0.0000191867	0.0000455839	0.0000256337

Vector Components (Mark to Mark)

From:	PNG-80				
Grid		Local		Global	
Easting	164648.757 m	Latitude	N16°03'57.54922"	Latitude	N16°03'51.70577"
Northing	1778666.044 m	Longitude	E119°51'57.50830"	Longitude	E119°52'02.28323"
Elevation	83.821 m	Height	87.991 m	Height	124.473 m

To:	PNG-3369				
Grid		Local		Global	
Easting	168821.068 m	Latitude	N16°11'21.73932"	Latitude	N16°11'15.87221"
Northing	1792270.974 m	Longitude	E119°54'10.65070"	Longitude	E119°54'15.62414"
Elevation	3.944 m	Height	8.236 m	Height	44.435 m

Vector					
ΔEasting	4172.311 m	NS Fwd Azimuth	16°10'41"	ΔX	-1507.269 m
ΔNorthing	13604.930 m	Ellipsoid Dist.	14216.486 m	ΔY	-5328.773 m
ΔElevation	-79.877 m	ΔHeight	-79.755 m	ΔZ	13093.881 m

Figure A-3.1 PNG-3369

2. PS-548

Vector Components (Mark to Mark)

From:	PNG-80				
Grid		Local		Global	
Easting	164648.757 m	Latitude	N16°03'57.54922"	Latitude	N16°03'51.70677"
Northing	1778666.044 m	Longitude	E119°51'57.50830"	Longitude	E119°52'02.28323"
Elevation	83.821 m	Height	87.991 m	Height	124.473 m

To:	PS-548				
Grid		Local		Global	
Easting	167187.327 m	Latitude	N16°11'10.61299"	Latitude	N16°11'04.74538"
Northing	1791953.316 m	Longitude	E119°53'16.08019"	Longitude	E119°53'20.84496"
Elevation	6.839 m	Height	11.042 m	Height	47.214 m

Vector					
ΔEasting	2538.570 m	NS Fwd Azimuth	9°56'42"	ΔX	-145.481 m
ΔNorthing	13287.272 m	Ellipsoid Dist.	13514.348 m	ΔY	-4432.755 m
ΔElevation	-76.982 m	ΔHeight	-76.948 m	ΔZ	12766.183 m

Standard Errors

Vector errors:					
σ ΔEasting	0.002 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.004 m
σ ΔNorthing	0.002 m	σ Ellipsoid Dist.	0.002 m	σ ΔY	0.009 m
σ ΔElevation	0.010 m	σ ΔHeight	0.010 m	σ ΔZ	0.003 m

Aposteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.0000192868		
Y	-0.0000357568	0.0000879700	
Z	-0.0000087107	0.0000180333	0.0000074092

Figure A-3.2 PS-548

3. TRC-3008

Vector Components (Mark to Mark)

From:	PNG-66				
Grid		Local		Global	
Easting	210862.353 m	Latitude	N15°56'47.31803"	Latitude	N15°56'41.53646"
Northing	1764780.617 m	Longitude	E120°17'57.03550"	Longitude	E120°18'01.81867"
Elevation	5.601 m	Height	10.575 m	Height	48.468 m

To:	TRC-3008				
Grid		Local		Global	
Easting	242274.052 m	Latitude	N15°37'01.26741"	Latitude	N15°36'55.58374"
Northing	1727923.206 m	Longitude	E120°35'46.76169"	Longitude	E120°35'51.57129"
Elevation	25.975 m	Height	28.544 m	Height	68.142 m

Vector					
ΔEasting	31411.699 m	NS Fwd Azimuth	138°49'32"	ΔX	-32482.383 m
ΔNorthing	-36857.412 m	Ellipsoid Dist.	48401.442 m	ΔY	-7573.227 m
ΔElevation	20.374 m	ΔHeight	17.969 m	ΔZ	-35074.763 m

Standard Errors

Vector errors:					
σ ΔEasting	0.018 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.016 m
σ ΔNorthing	0.003 m	σ Ellipsoid Dist.	0.013 m	σ ΔY	0.016 m
σ ΔElevation	0.014 m	σ ΔHeight	0.014 m	σ ΔZ	0.004 m

Figure A-3.3 TRC-3008

Annex 4. The LiDAR Survey Team Composition

Table A-4.1 LiDAR Survey Team Composition

Data Acquisition Component Sub -Team	Designation	Name	Agency / Affiliation
PHIL-LIDAR 1	Program Leader	ENRICO C. PARINGIT, D.ENG	UP-TCAGP
Data Acquisition Component Leader	Data Component Project Leader – I	ENGR. CZAR JAKIRI SARMIENTO	UP-TCAGP
Survey Supervisor	Chief Science Research Specialist (CSRS)	ENGR. CHRISTOPHER CRUZ	UP-TCAGP
	Supervising Science Research Specialist (Supervising SRS)	LOVELY GRACIA ACUÑA	UP-TCAGP
		ENGR. LOVELYN ASUNCION	UP-TCAGP
FIELD TEAM			
LiDAR Operation	Supervising SRS	LOVE GRACIA ACUÑA	UP-TCAGP
	Senior Science Research Specialist (SSRS)	JULIE PEARL MARS	UP-TCAGP
	SSRS	JASMINE ALVIAR	UP-TCAGP
	Research Associate (RA)	ENGR. RENAN PUNTO	UP-TCAGP
	RA	FAITH JOY SABLE	UP-TCAGP
		FOR. MARIA VERLINA TONGA	UP-TCAGP
		KRISTINE JOY ANDAYA	UP-TCAGP
		ENGR. LARAH KRISELLE PARAGAS	UP-TCAGP
Ground Survey, Data Download and Transfer	RA	KENNETH QUISADO	UP-TCAGP
LiDAR Operation	Airborne Security	OLIVIER SACLOT	PHILIPPINE AIR FORCE (PAF)
		ARIEL SACOPON	PAF
	Pilot	CAPT. MARK LAWRENCE TANGONAN	ASIAN AEROSPACE CORPORATION (AAC)
		CAPT. BRYAN DONGUINES	AAC
		CAPT. ALBERT LIM	AAC
		CAPT. RANDY LAGCO	AAC

Annex 5. Data Transfer Sheet For Alaminos Floodplain

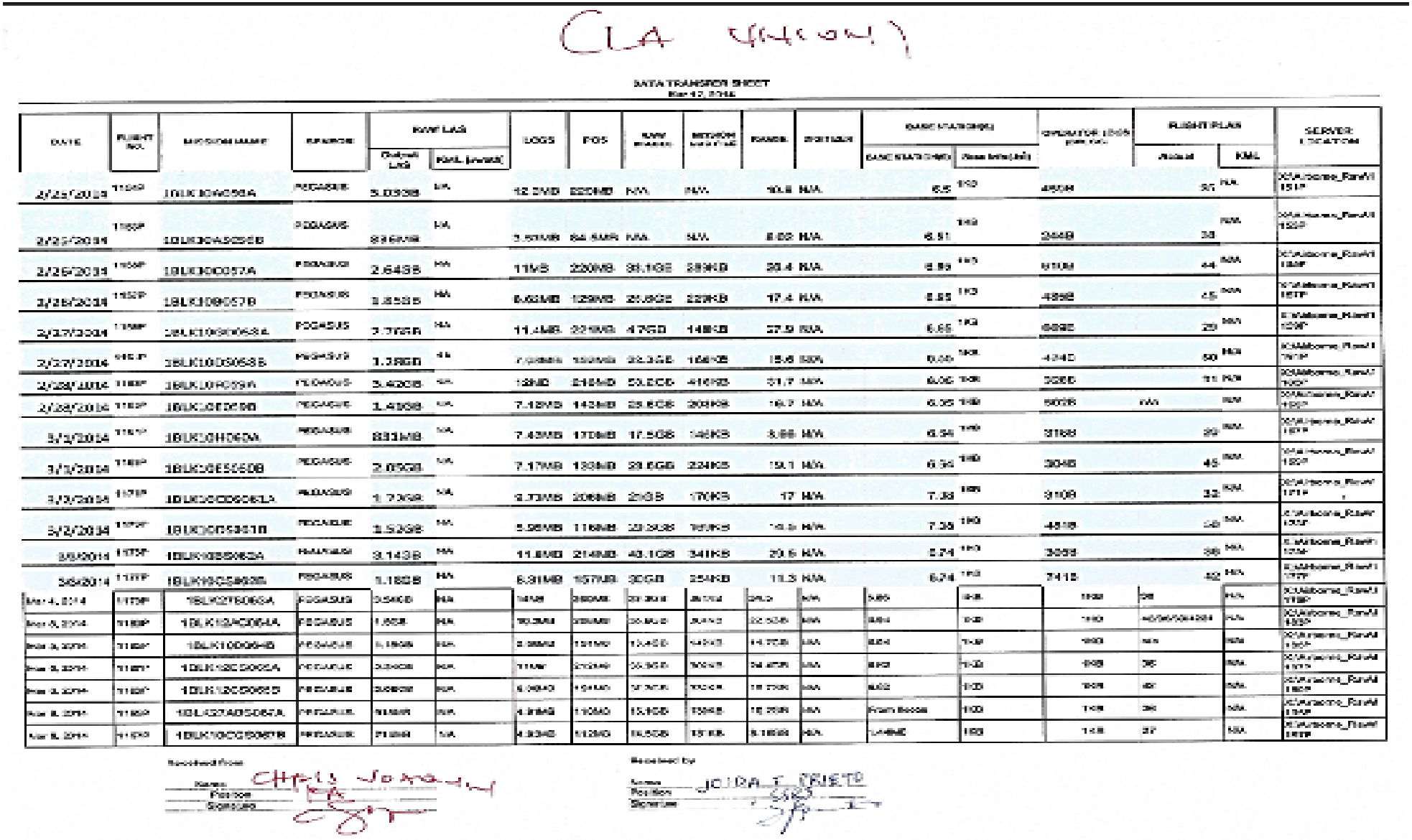


Figure A-5.1 Data Transfer Sheet for Alaminos Floodplain - A

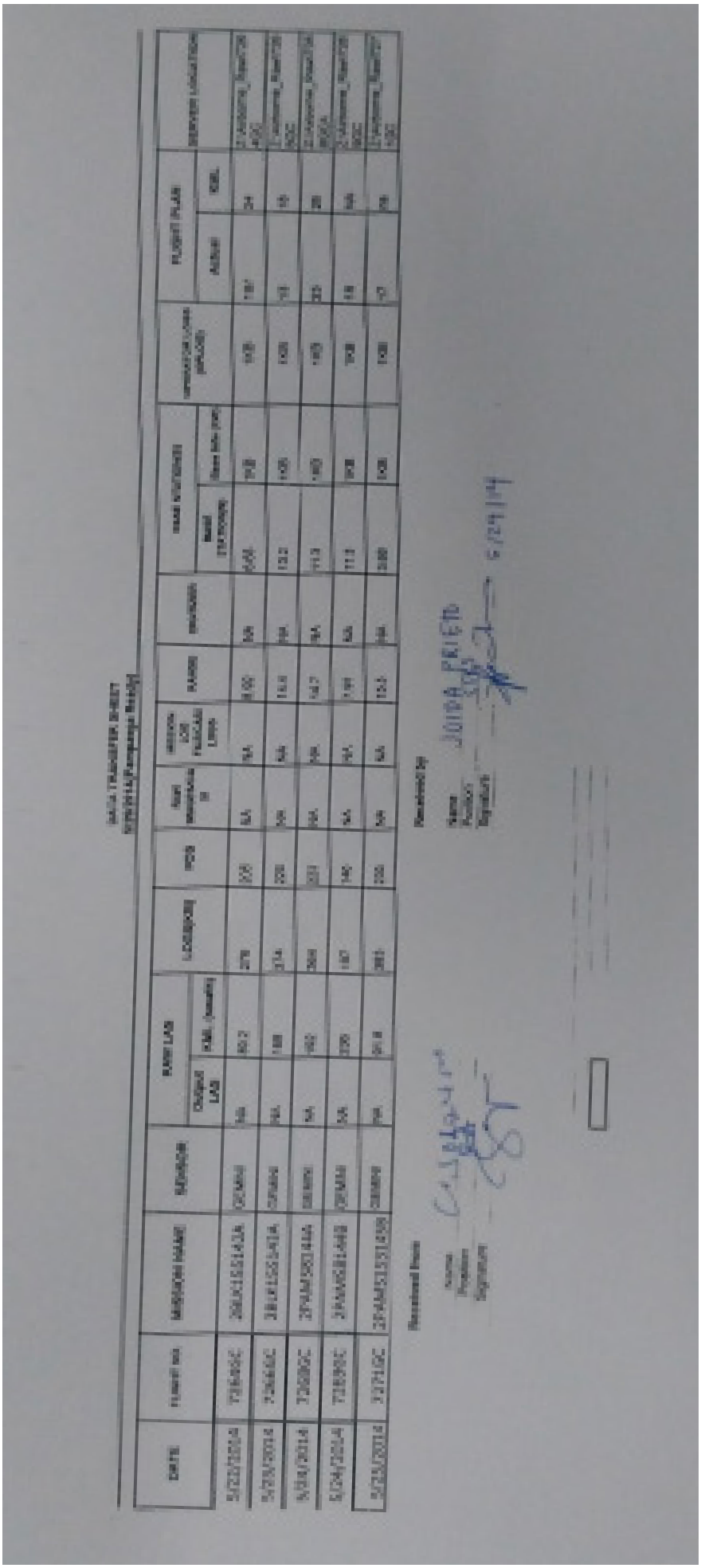


Figure A-5.2 Data Transfer Sheet for Alaminos Floodplain - B

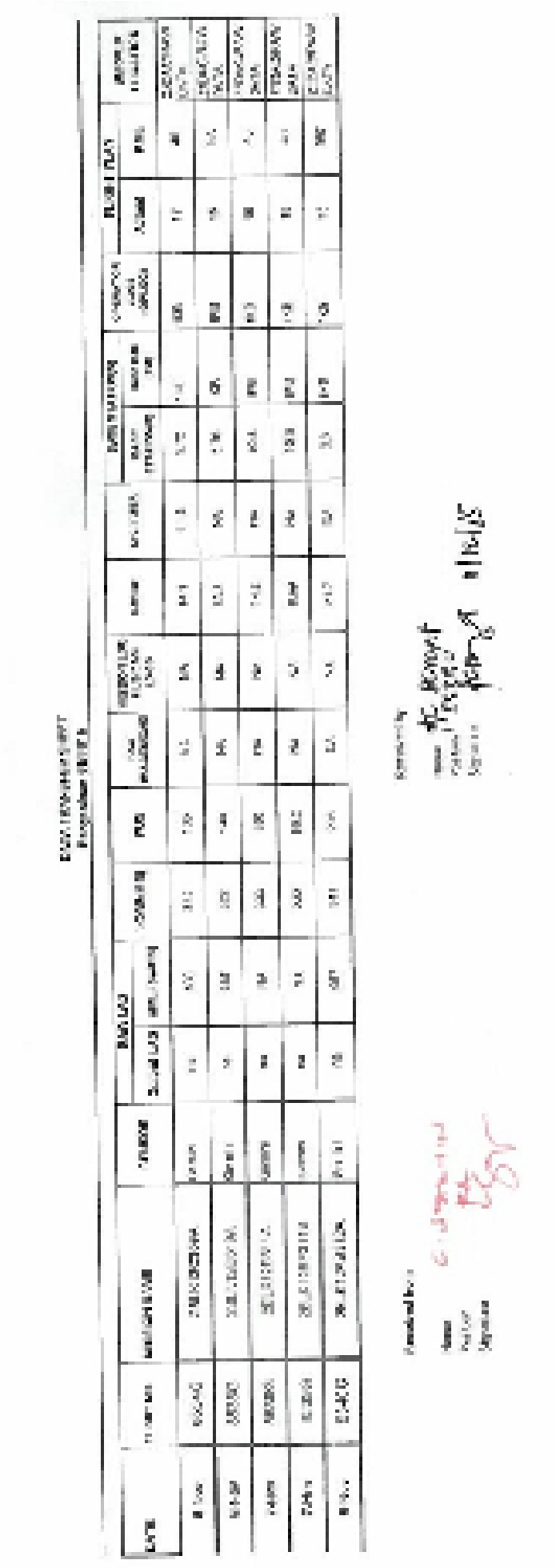


Figure A-5.3 Data Transfer Sheet for Alaminos Floodplain - C

Annex 6. Flight Logs

Flight log for 1183P Mission

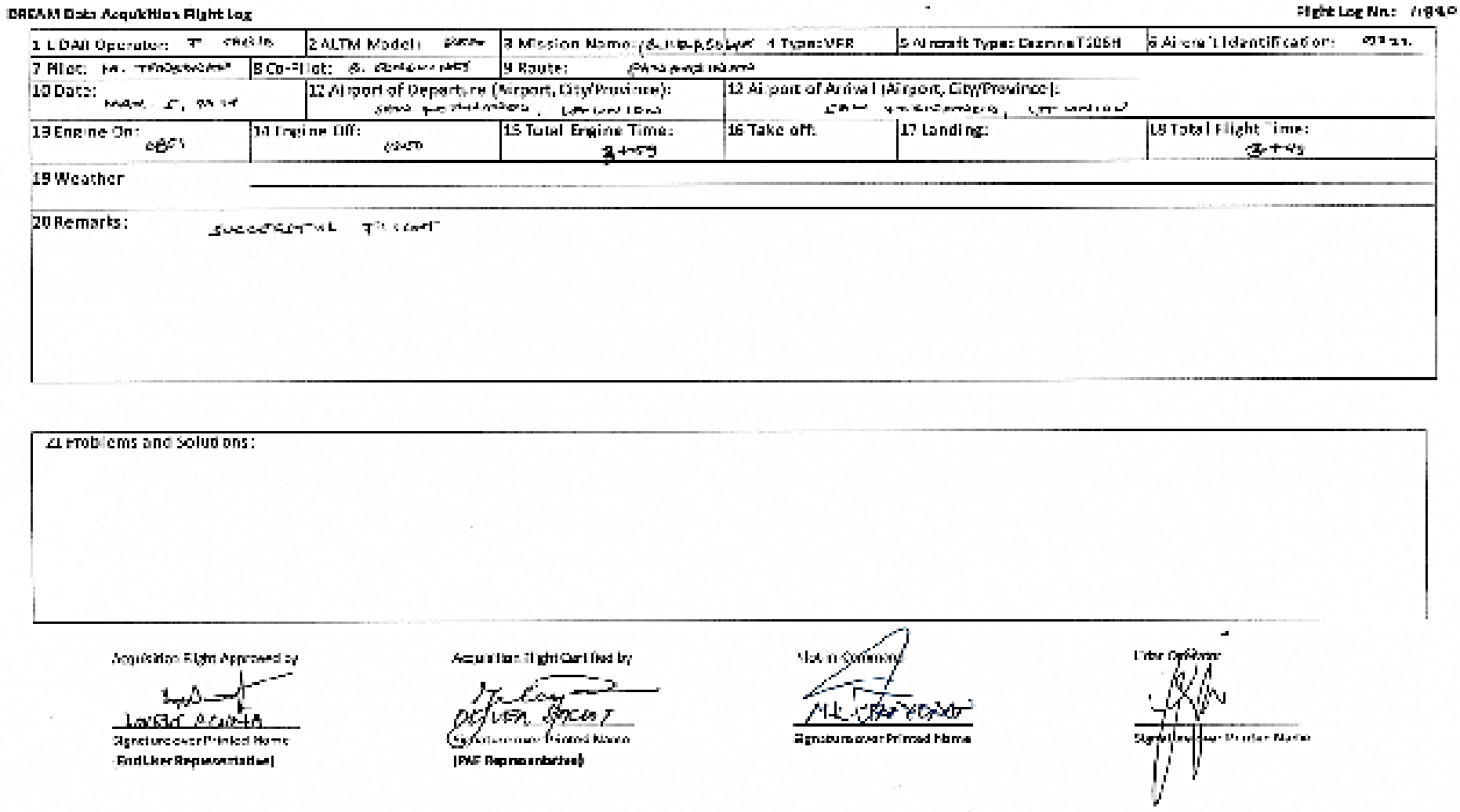


Figure A-6.1 Flight Log for Mission 1183P

Flight log for 1185P Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 1185P

1 LiDAR Operator:	2 ALTM Model:	3 Mission Name:	4 Type: VFR	5 Aircraft Type: CessnaT206H	6 Aircraft Identification:
7 Pilot:	8 Co-Pilot:	9 Route:			
10 Date:	12 Airport of Departure (Airport, City/Province):	12 Airport of Arrival (Airport, City/Province):			
13 Engine On:	14 Engine Off:	15 Total Engine Time:	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					
20 Remarks:					

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Signature over Printed Name (End User Representative)	Signature over Printed Name (RAF Representative)	Signature over Printed Name	Signature over Printed Name

Figure A-6.2 Flight Log for Mission 1185P

Flight log for 1187P Mission

CREAM Data Acquisition Flight Log

Flight Log No.: 1187P

1 LiDAR Operator:	2 ALTM Model:	3 Mission Name:	4 Type: VFR	5 Aircraft Type: CessnaT206H	6 Aircraft Identification:
7 Pilot:	8 Co-Pilot:	9 Route:			
10 Date:	12 Airport of Departure (Airport, City/Province):	12 Airport of Arrival (Airport, City/Province):			
13 Engine On:	14 Engine Off:	15 Total Engine Time:	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					
20 Remarks:					

21 Problems and Solutions:

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

Figure A-6.3 Flight Log for Mission 1187P

Flight log for 1189P Mission

DREAM Data Acquisition Flight Log — Flight Log No.: 1189P

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

21 Problems and Solutions:

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

Figure A-6.4 Flight Log for Mission 1189P

Flight log for 7266G Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 7266

1 U DAR Operator: MVE Tonga	2 ALTM Model: Gem Cat	3 Mission Name: 16K155[illegible]	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 7322
7 Pilot: Samar II	8 Co-Pilot: V. Kawai	9 Route: RPLC - RPLC			
10 Date: 5-23-14	12 Airport of Departure (Airport, City/Province): RPLC	12 Airport of Arrival (Airport, City/Province): RPLC			
13 Engine On: 0856H	14 Engine Off: 1152H	15 Total Engine Time: 2.9	16 Take off: 0909H	17 Landing: 1147H	18 Total Flight Time: 2.38
19 Weather: good					
20 Remarks: Mission completed (with ATC)					

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

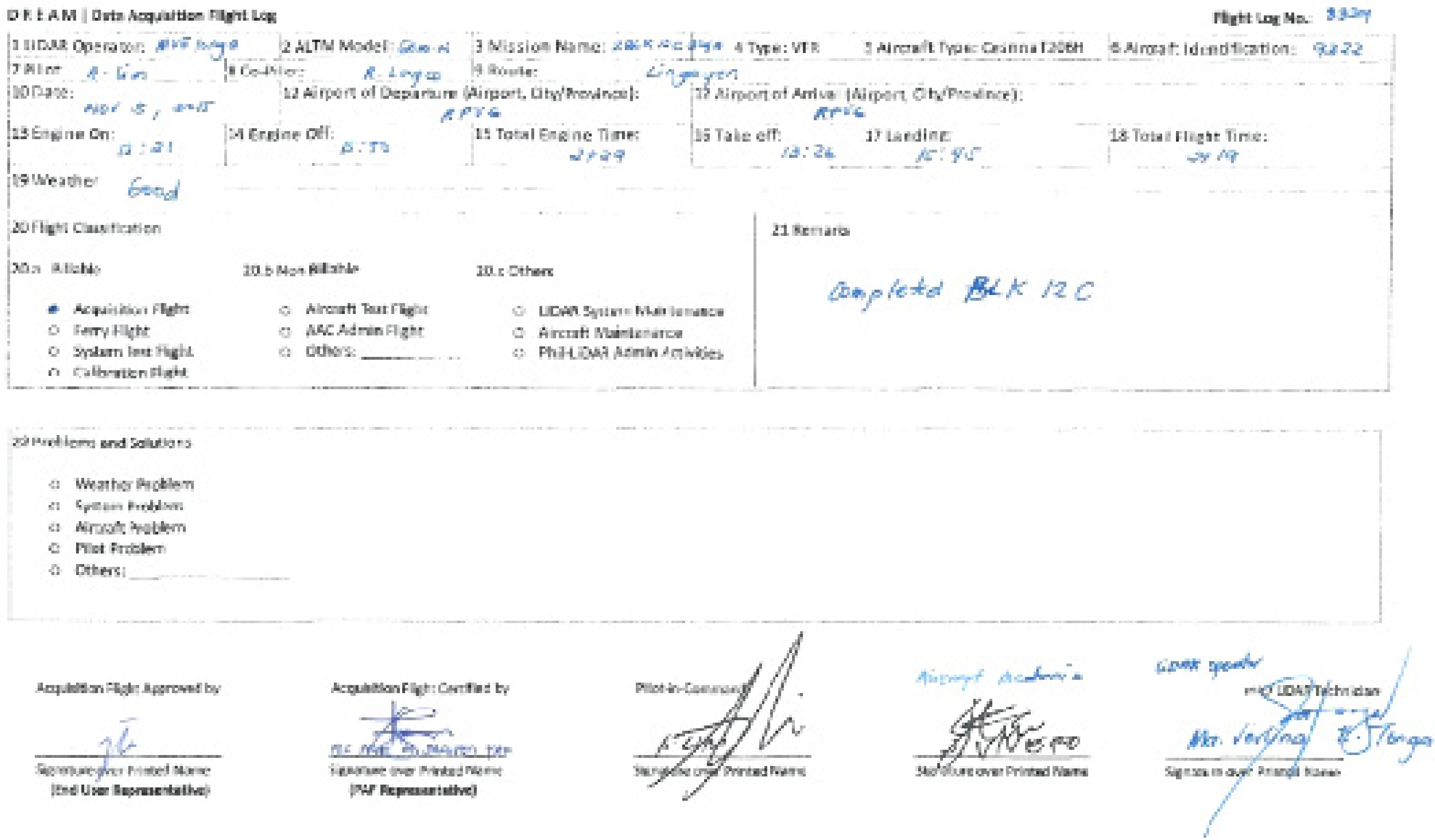
Signature over Printed Name

User Operator

Signature over Printed Name

Figure A-6.5 Flight Log for Mission 7266G

Flight log for 8534G Mission



D R E A M | Data Acquisition Flight Log

Flight Log No.: 8534

1 LiDAR Operator:	2 ALTM Model:	3 Mission Name:	4 Type: VFR	5 Aircraft Type: Cessna T206H
6 Aircraft Identification: 9322				
7 Pilot:	8 Co-Pilot:	9 Route:		
10 Date:	12 Airport of Departure (Airport, City/Province): RPVG		12 Airport of Arrival (Airport, City/Province): RPVG	
13 Engine On:	14 Engine Off:	15 Total Engine Time:	16 Take off:	17 Landing:
18 Total Flight Time:				
19 Weather: Good				

20 Flight Classification

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

21 Remarks

Completed BLK 12C

22 Problems and Solutions

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

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

Figure A-6.6 Flight Log for Mission 8534G

Flight log for 8536G Mission

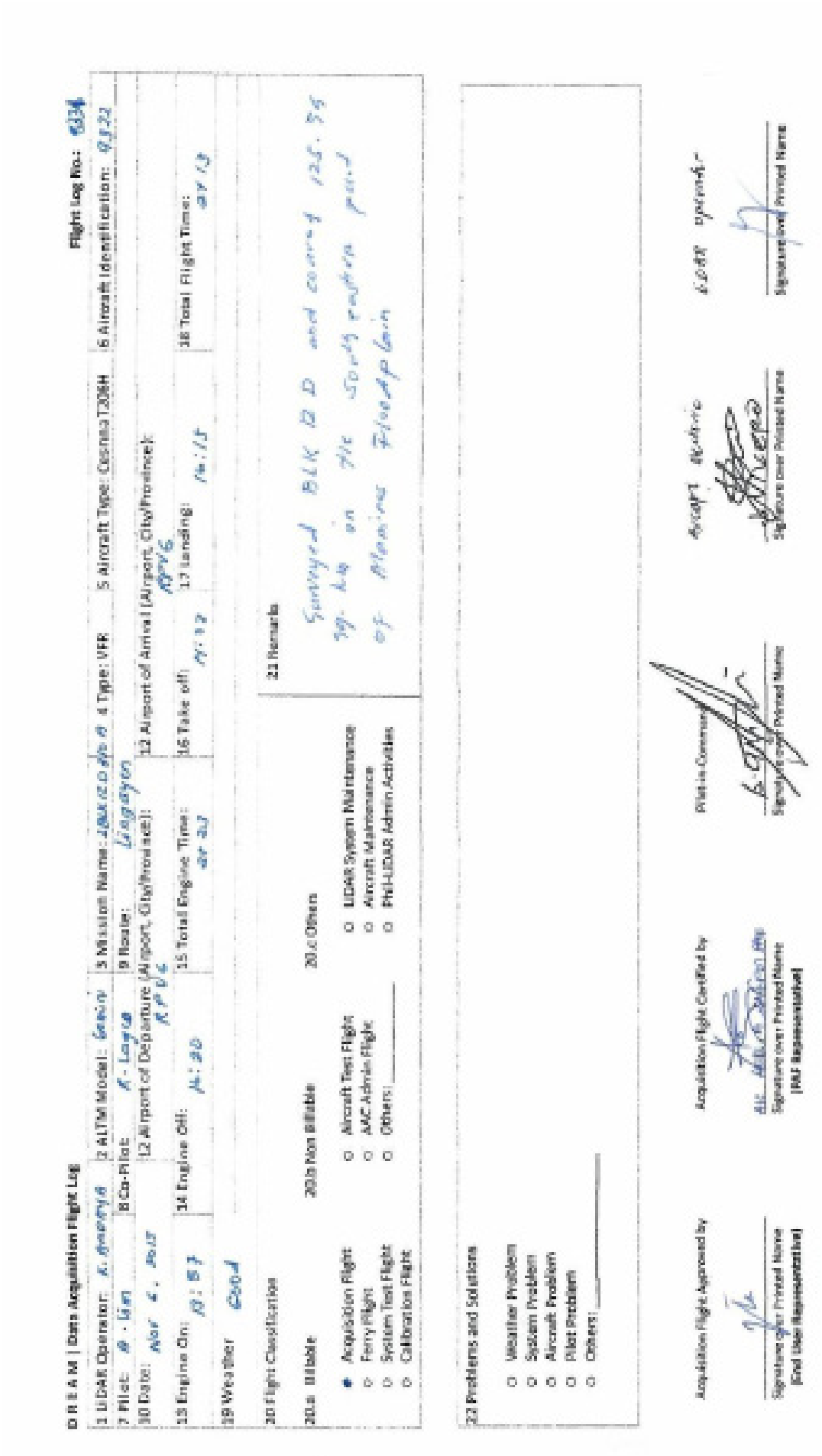


Figure A-6.7 Flight Log for Mission 8536G

Flight log for 8538G Mission

DREAM | Data Acquisition Flight Log

Flight Log No.: 9332

1 LiDAR Operator: J. Alviar	2 ALTM Model: Gemini	3 Mission Name: BAK12E 9[illegible]	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 9892
7 Pilot: A. Lim	8 Co-Pilot: R. Lagco	9 Route: Lingayen - [illegible]			
10 Date: Nov 7, 2015	12 Airport of Departure (Airport, City/Province): RPVL	12 Airport of Arrival (Airport, City/Province): RPVL			
13 Engine On: 09:47	14 Engine Off: 12:28	15 Total Engine Time: 2.4 hr	16 Take off: 09:52	17 Landing: 12:28	18 Total Flight Time: 2.6 hr
19 Weather: Good					

20 Flight Classification

20.a Billable
- (●) Acquisition Flight
- ( ) Ferry Flight
- ( ) System Test Flight
- ( ) Calibration Flight

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

20.c Others
- ( ) LiDAR System Maintenance
- ( ) Aircraft Maintenance
- ( ) PHI-LiDAR Admin Activities

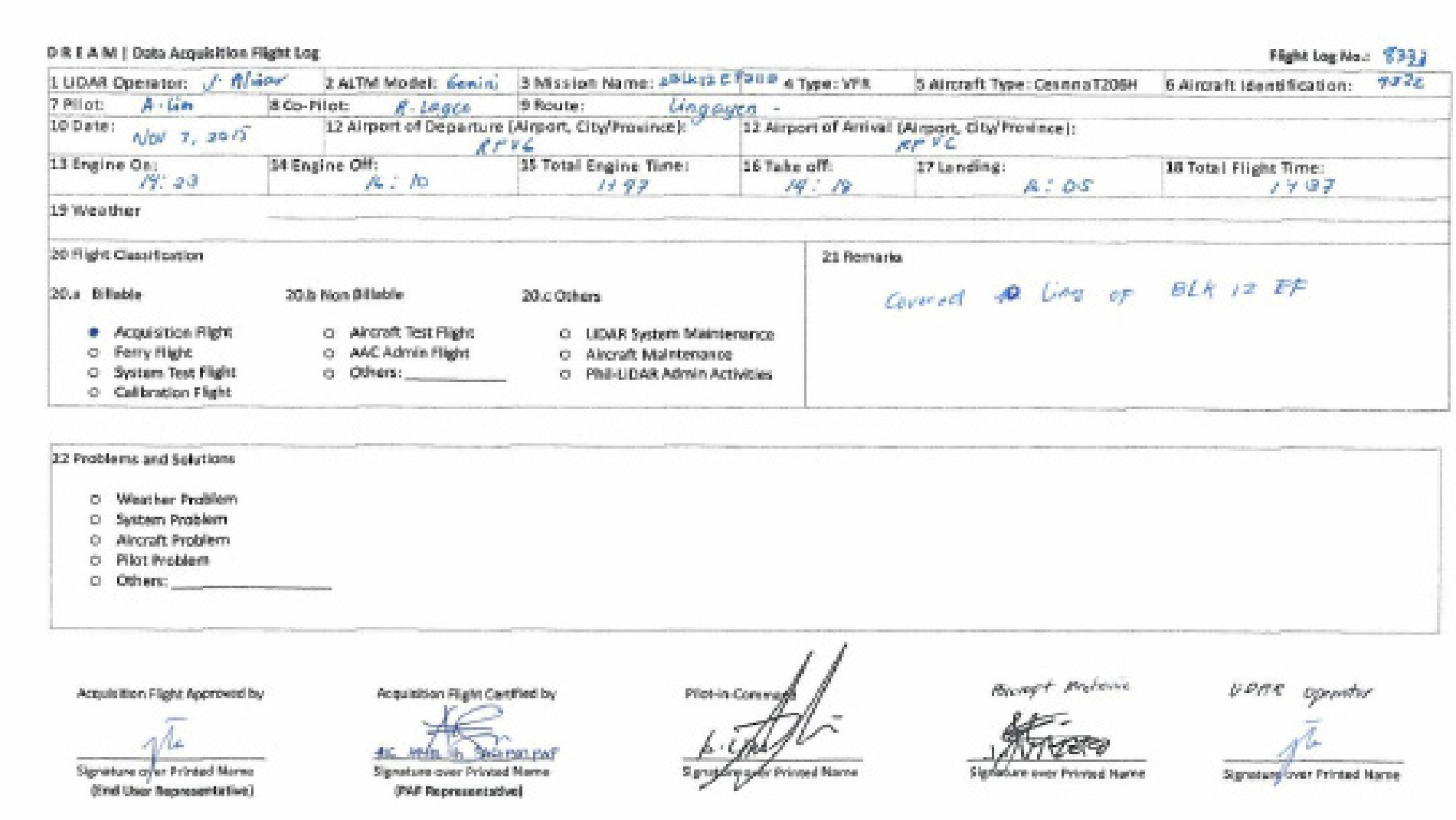
21 Remarks: Covered 12 Line of BLK 12E

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

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	[illegible]	[illegible]
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name	Signature over Printed Name

Figure A-6.8 Flight Log for Mission 8538G

Flight log for 8539G Mission



D R E A M | Data Acquisition Flight Log

Flight Log No.: 8339

1 LiDAR Operator: J. Alviar	2 ALTM Model: Gemini	3 Mission Name: 28Blk12C_supp	4 Type: VFR	5 Aircraft Type: CessnaT206H	6 Aircraft Identification: 9926
7 Pilot: A. Lim	8 Co-Pilot: R. Legco	9 Route: Lingayen -			
10 Date: NOV 7, 2015	12 Airport of Departure (Airport, City/Province): RPUC	12 Airport of Arrival (Airport, City/Province): RPUC			
13 Engine On: 14:23	14 Engine Off: 16:10	15 Total Engine Time: 1:47	16 Take off: 14:18	17 Landing: 16:05	18 Total Flight Time: 1:47
19 Weather					

20 Flight Classification

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

21 Remarks: Covered 40 Line of BLK 12 EF

22 Problems and Solutions

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

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Receipt Received	LiDAR Operator
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name	Signature over Printed Name

Figure A-6.9 Flight Log for Mission 8539G

Flight log for 8540G Mission

D R E A M | Data Acquisition Flight Log

Flight Log No.: 8284

1 LiDAR Operator: R. Andaya	2 ALTM Model: Gemini	3 Mission Name: 3BLK12BB8284	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 9202
7 Pilot: R. Gan	8 Co-Pilot: R. Lagco	9 Route:			
10 Date: March 8, 2017	11 Airport of Departure (Airport, City/Province):		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 08:19	14 Engine Off: 11:58	15 Total Engine Time: 3h 39	16 Take off: 08:44	17 Landing: 11:43	18 Total Flight Time: 3h 19

19 Weather: Good

20 Flight Classification

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

21 Remarks: Covered 18 Lines of Blk 12 BB

22 Problems and Solutions

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

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Accept Actual	LiDAR operator
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name	Signature over Printed Name

Figure A-6.10 Flight Log for Mission 8540G

Annex 7. Flight Status

FLIGHT STATUS REPORT
LA UNION AND LINGAYEN
February 25-March 8, 2014; May 23, 2014; and November 4-8, 2015

Table A-7.1 LiDAR Survey Team Composition

FLIGHT NO	AREA	MISSION	OPERATOR	DATE FLOWN	REMARKS
1183P	12A, 12C	1BLK12AC064A	F. SABLE	March 5, 2014	Surveyed 2lines (BLK10A) and BLK 10C; with data voids due to clouds
1185P	12D	1BLK10D064B	R. PUNTO	March 5, 2014	Survey BLK 12D; not finish
1187P	12D	1BLK12DS065A	R. PUNTO	March 6, 2014	Completed Supplementary flight for Block 12D
1189P	12C	1BLK12CS065B	F. SABLE	March 6, 2014	Completed supplementary flight for Block 12C
7266G	BLK15	2BLK15S143A	V. TONGA	May 23, 2014	Completed 20 lines; changed altitude 3 times due to clouds
8534G	BLK 12C	2BLK12C309A	V. TONGA	November 5, 2015	Surveyed BLK 12C (Alaminos FloodplainAlaminos Floodplain)
8536G	BLK 12D	2BLK12D310A	V. TONGA, KJ ANDAYA	November 6, 2015	Surveyed BLK 12D (Alaminos FloodplainAlaminos Floodplain)
8538G	BLK 12E	2BLK12E311A	J. ALVIAR	November 7, 2015	Surveyed BLK 12E (Alaminos FloodplainAlaminos Floodplain)
8539G	BLK 12EF	2BLK12EF311B	J. ALVIAR	November 7, 2015	Surveyed BLK 12EF
8540G	BLK 12A	2BLK12AB312A	KJ ANDAYA	November 8, 2015	Surveyed BLK 12AB (Bolinao and Anda)

SWATH PER FLIGHT MISSION

Flight No.:	1183P	
Area:	12AC	
Mission Name:	1BLK12AC064A	
Parameters:	Altitude: 1200m	Scan Frequency: 30Hz
	Scan Angle: 25 degrees	Overlap: 30%

SWATH

Figure A-7.1 Swath for Flight No. 1183P

Flight No.: 1185P
Area: 12D
Mission Name: 1BLK12D064B
Parameters: Altitude: 1000m Scan Frequency: 30Hz
Scan Angle: 25 degrees Overlap: 30%

SWATH

Figure A-7.2 Swath for Flight No. 1185P

Flight No.:	1187P	
Area:	12C	
Mission Name:	1BLK12CS065A	
Parameters:	Altitude: 1200m	Scan Frequency: 30Hz
	Scan Angle: 25 degrees	Overlap: 30%

SWATH

Figure A-7.3 Swath for Flight No. 1187P

Flight No.:	1189P	
Area:	12D	
Mission Name:	1BLK12DS065B	
Parameters:	Altitude: 850m	Scan Frequency: 30Hz
	Scan Angle: 25 degrees	Overlap: 30%

SWATH

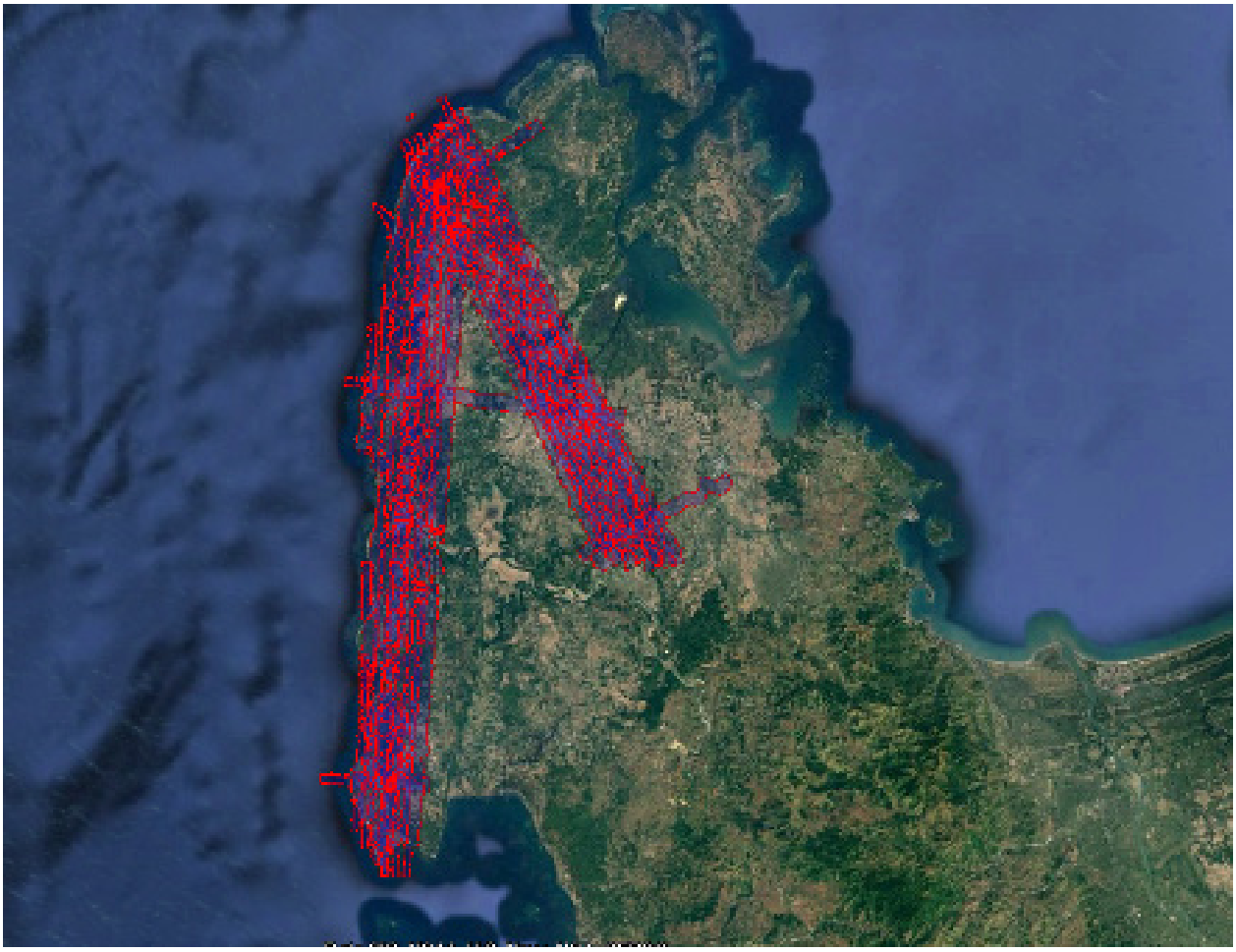


Figure A-7.4 Swath for Flight No. 1189P

Flight No. :	7266G	
Area:	2BLK15S143A	
Mission name:	BLK15S	
Parameters:	Altitude: 1000	Scan Frequency: 50
	Scan Angle: 20	Overlap: 30

SWATH

Figure A-7.5 Swath for Flight No. 7266G

Flight No. : 8534G
Area: BLK 12C
Mission Name: 2BLK12C309A
Parameters: Altitude: 1000 Scan Frequency: 40
Scan Angle: 20 Overlap: 30

SWATH

Figure A-7.6 Swath for Flight No. 8534G

Flight No. :	8536G	
Area:	BLK 12D	
Mission Name:	2BLK12D310A	
Parameters:	Altitude: 1000	Scan Frequency: 50
	Scan Angle: 20	Overlap: 30

SWATH

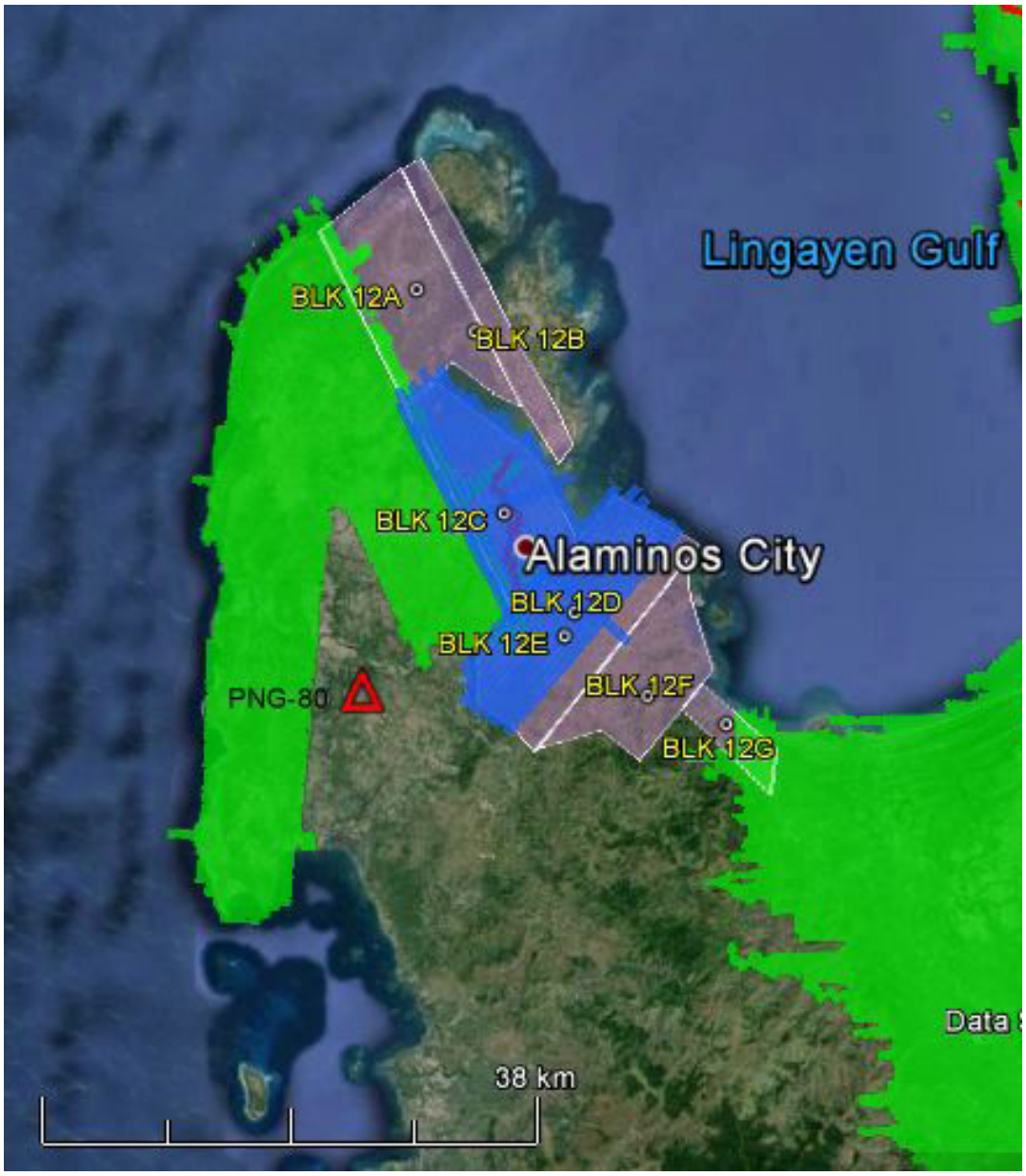


Figure A-7.7 Swath for Flight No. 8536G

Flight No. : 8538G
Area: BLK 12E
Mission Name: 2BLK12E311A
Parameters: Altitude: 1000 Scan Frequency: 50
Scan Angle: 20 Overlap: 30

SWATH

Figure A-7.8 Swath for Flight No. 8538G

Flight No. :	8539G	
Area:	BLK 12EF	
Mission Name:	2BLK12EF311B	
Parameters:	Altitude: 1000	Scan Frequency: 50
	Scan Angle: 20	Overlap: 30

SWATH

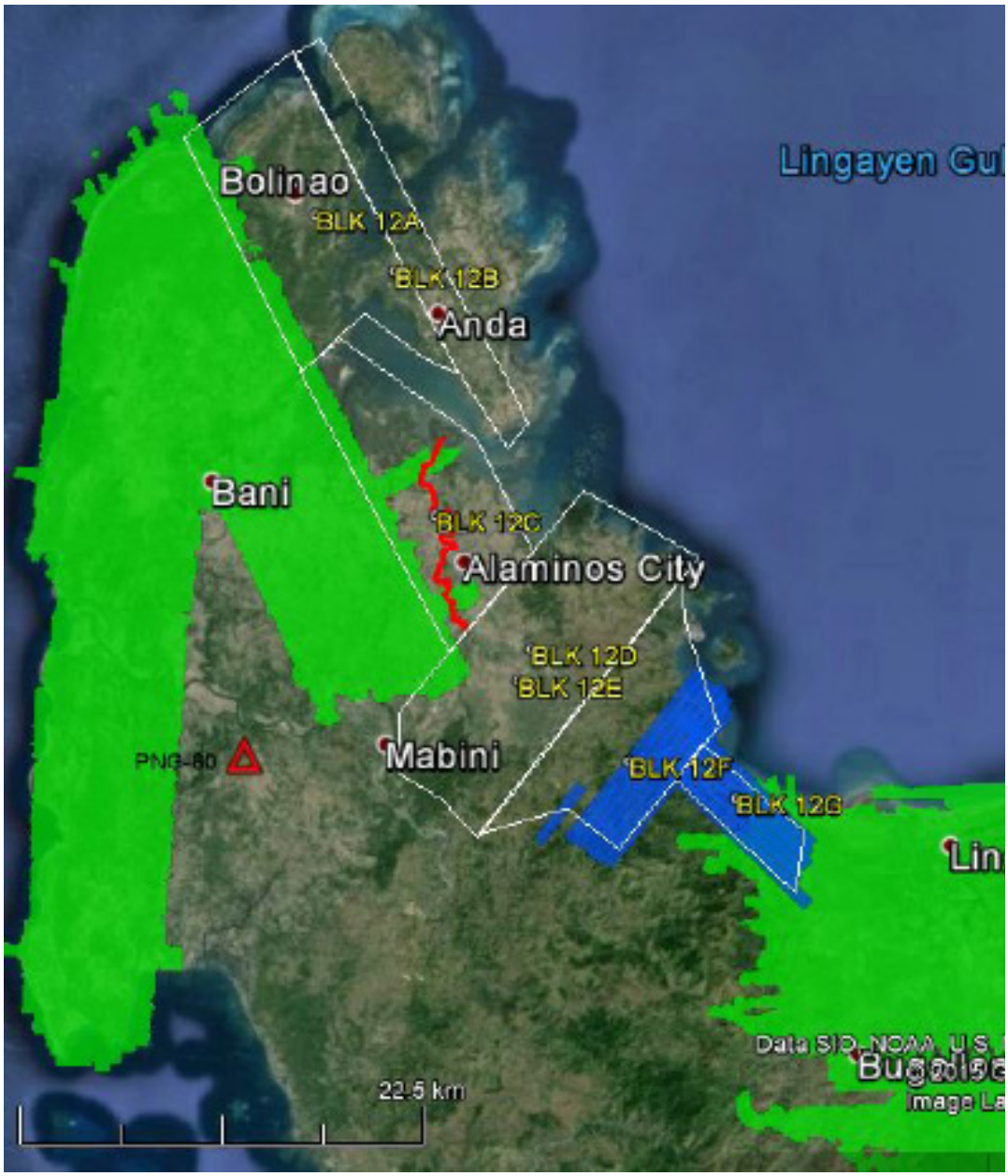


Figure A-7.9 Swath for Flight No. 8539G

Flight No. : 8540G
Area: BLK 12A
Mission Name: 2BLK12A312A
Parameters: Altitude: 1000 Scan Frequency: 50
Scan Angle: 20 Overlap: 30

SWATH

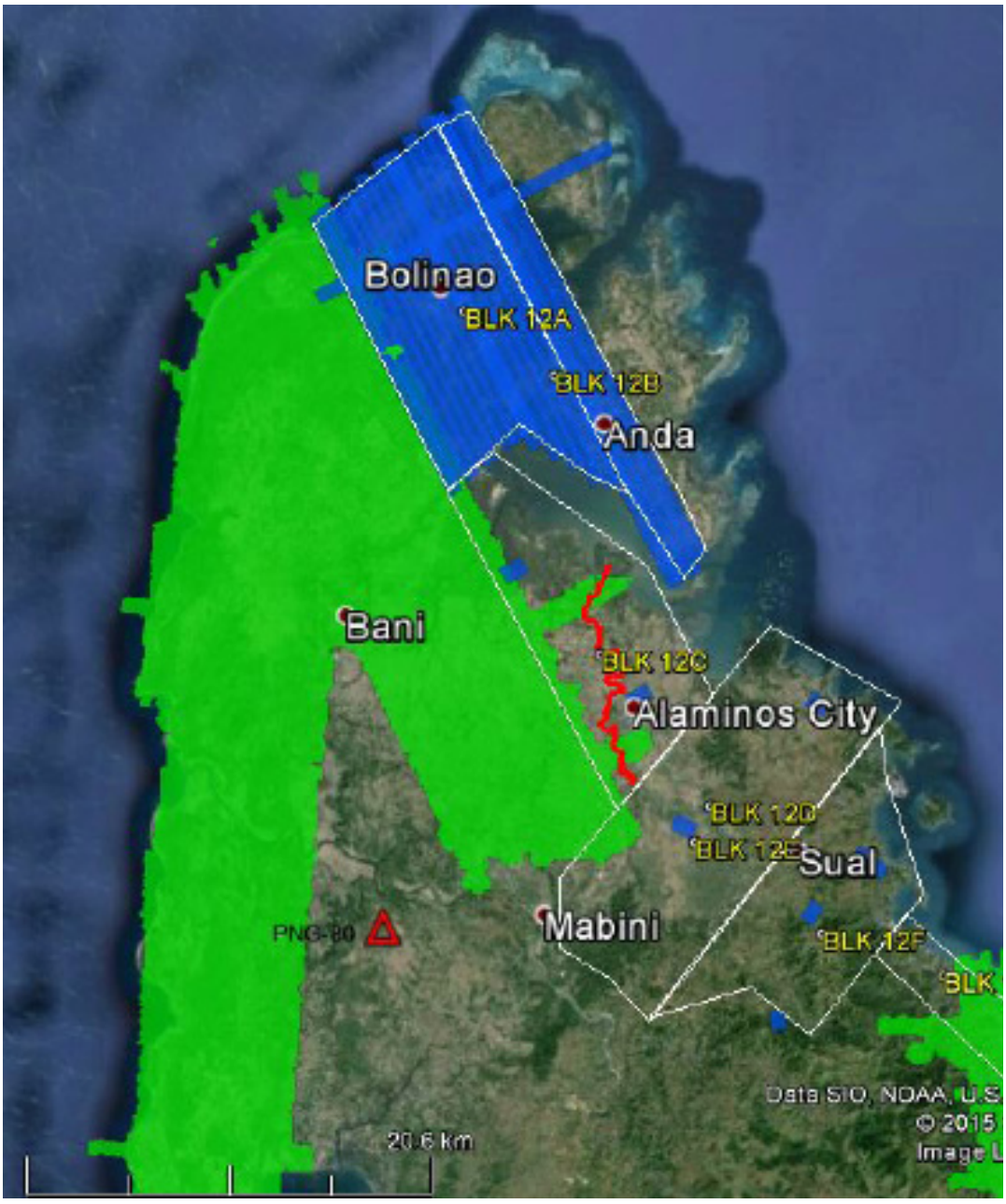


Figure A-7.10 Swath for Flight No. 8540G

Annex 8. Mission Summary Reports

Table A-8.1 Mission Summary Report for Blk12C

Flight Area	La Union
Mission Name	Blk12C
Inclusive Flights	1183P, 1189P
Range data size	42.2 GB
Base data size	6.62 MB
POS	357 MB
Image	73.3 GB
Transfer date	March 06, 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)	2.9
RMSE for East Position (<4.0 cm)	3.25
RMSE for Down Position (<8.0 cm)	9.0
Boresight correction stdev (<0.001deg)	0.00062
IMU attitude correction stdev (<0.001deg)	0.00394827
GPS position stdev (<0.01m)	0.0077
Minimum % overlap (>25)	43.41%
Ave point cloud density per sq.m. (>2.0)	2.79
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	344
Maximum Height	214.71 m
Minimum Height	37.13 m
Classification (# of points)	
Ground	336,885,031
Low vegetation	260,976,163
Medium vegetation	338,638,979
High vegetation	118,627,965
Building	6,509,912
Orthophoto	YES
Processed by	Engr. Angelo Carlo Bongat, Engr. Velina Angela Bemida, Alex John Escobido

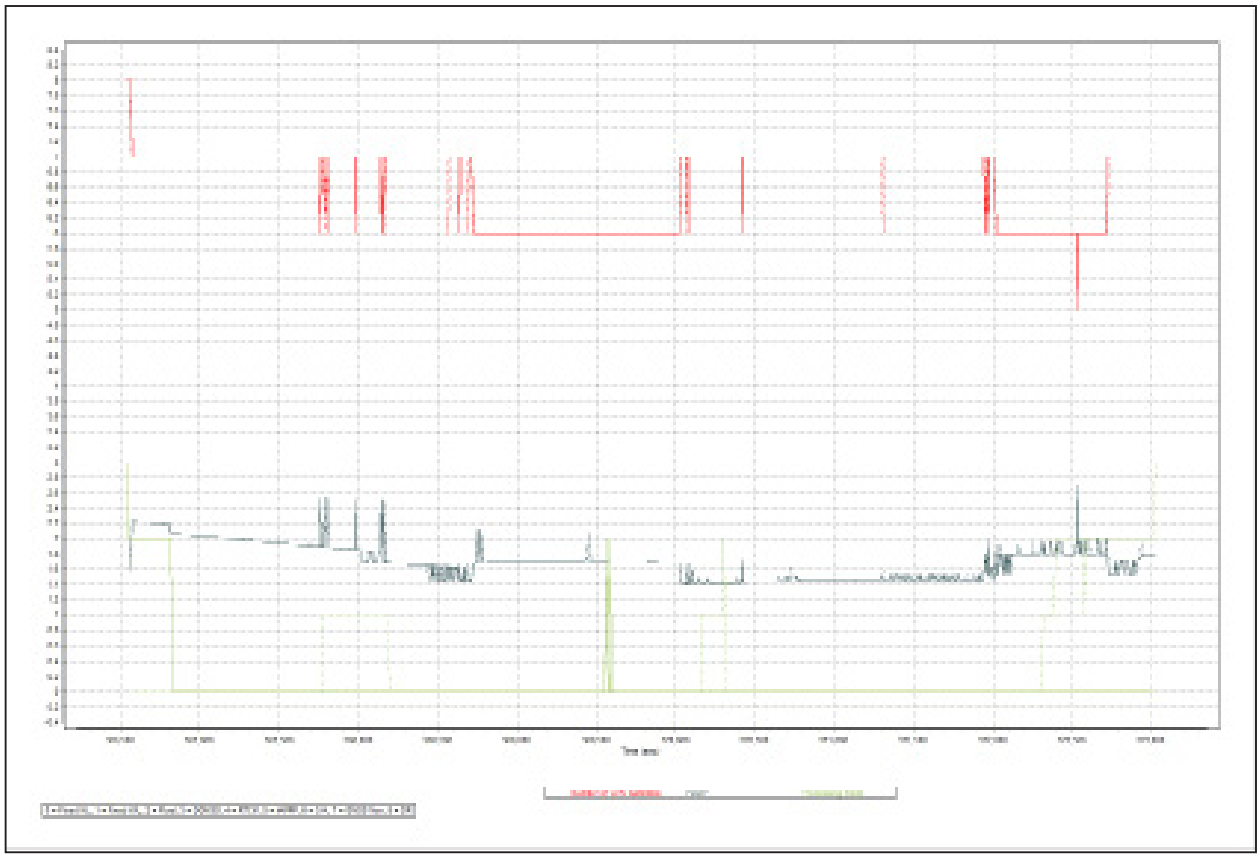


Figure A-8.1. Solution Status

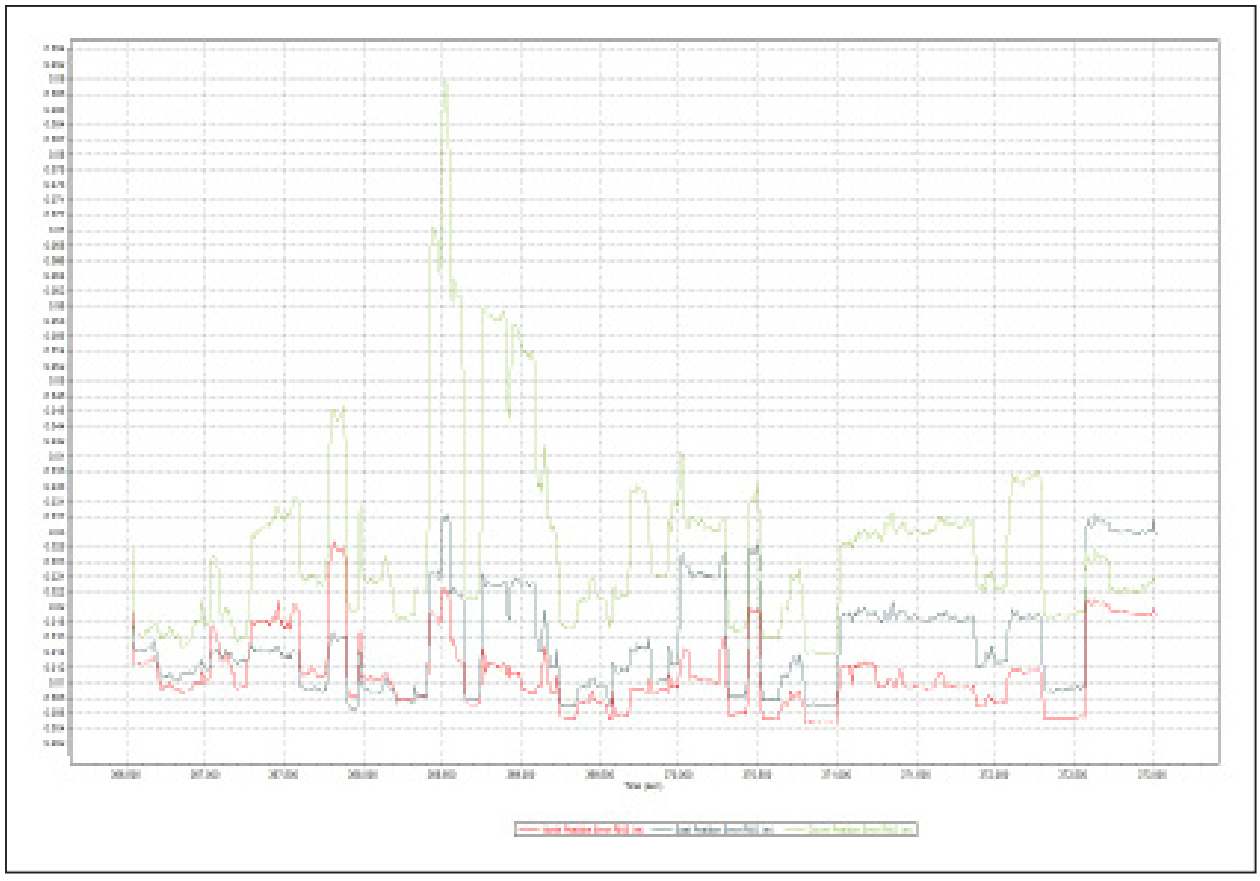


Figure A-8.2. Smoothed Performance Metric Parameters

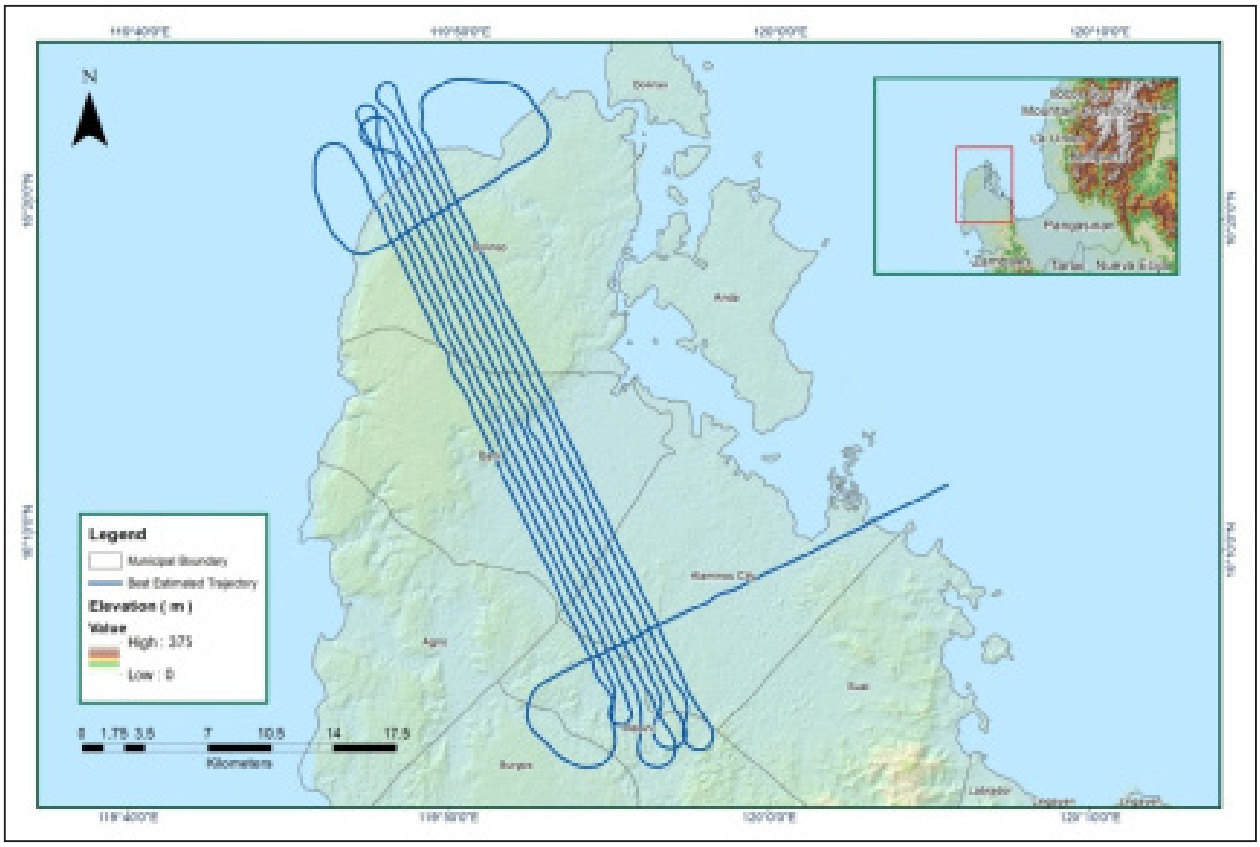


Figure A-8.3. Best Estimated Trajectory

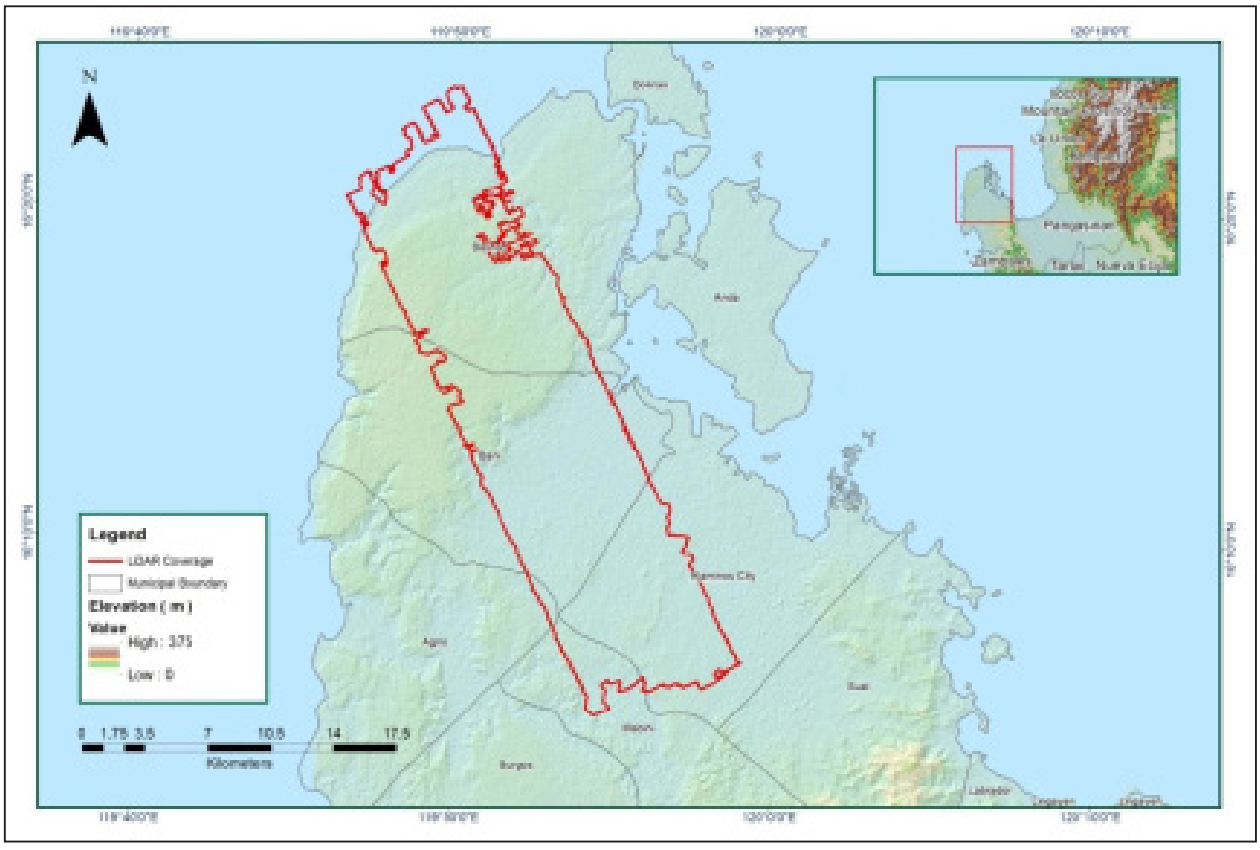


Figure A-8.4. Coverage of LiDAR data

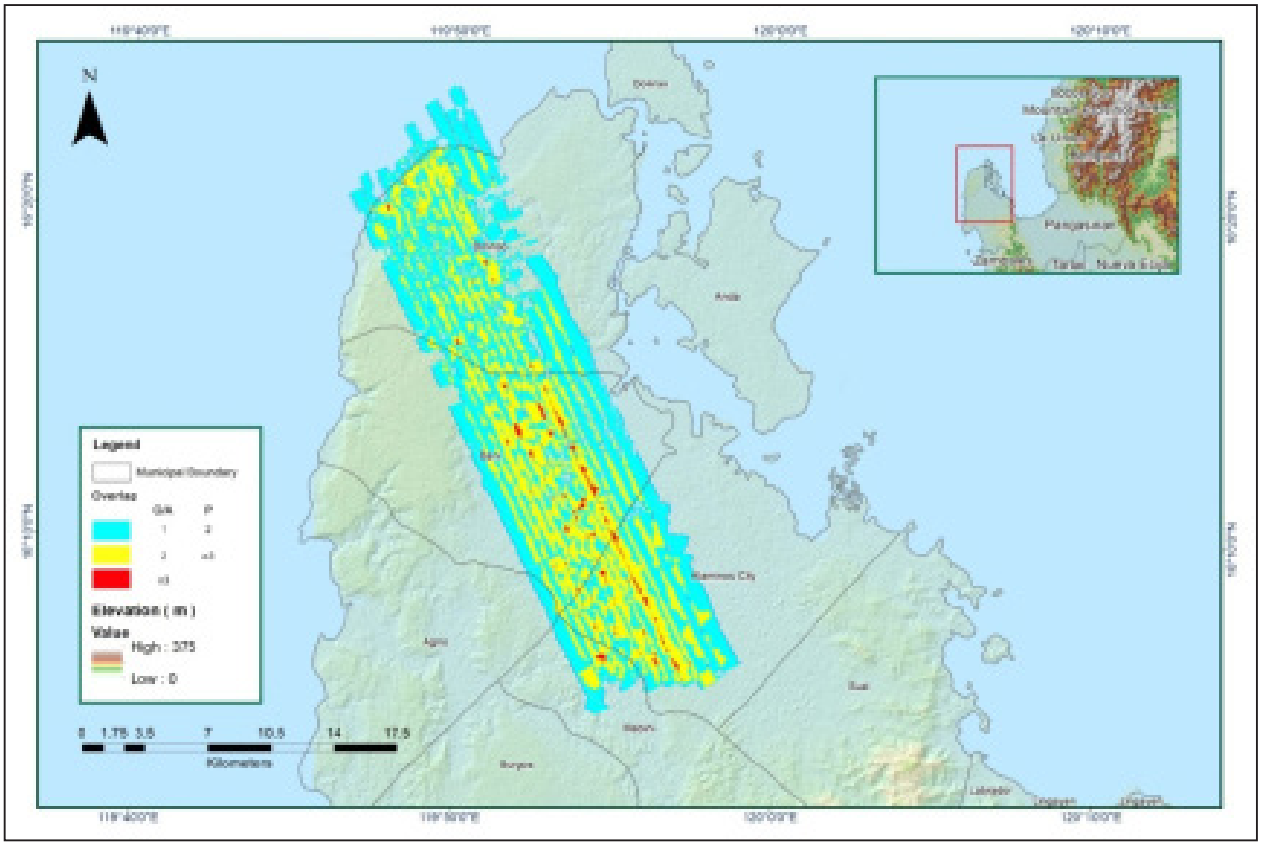


Figure A-8.5. Image of data overlap

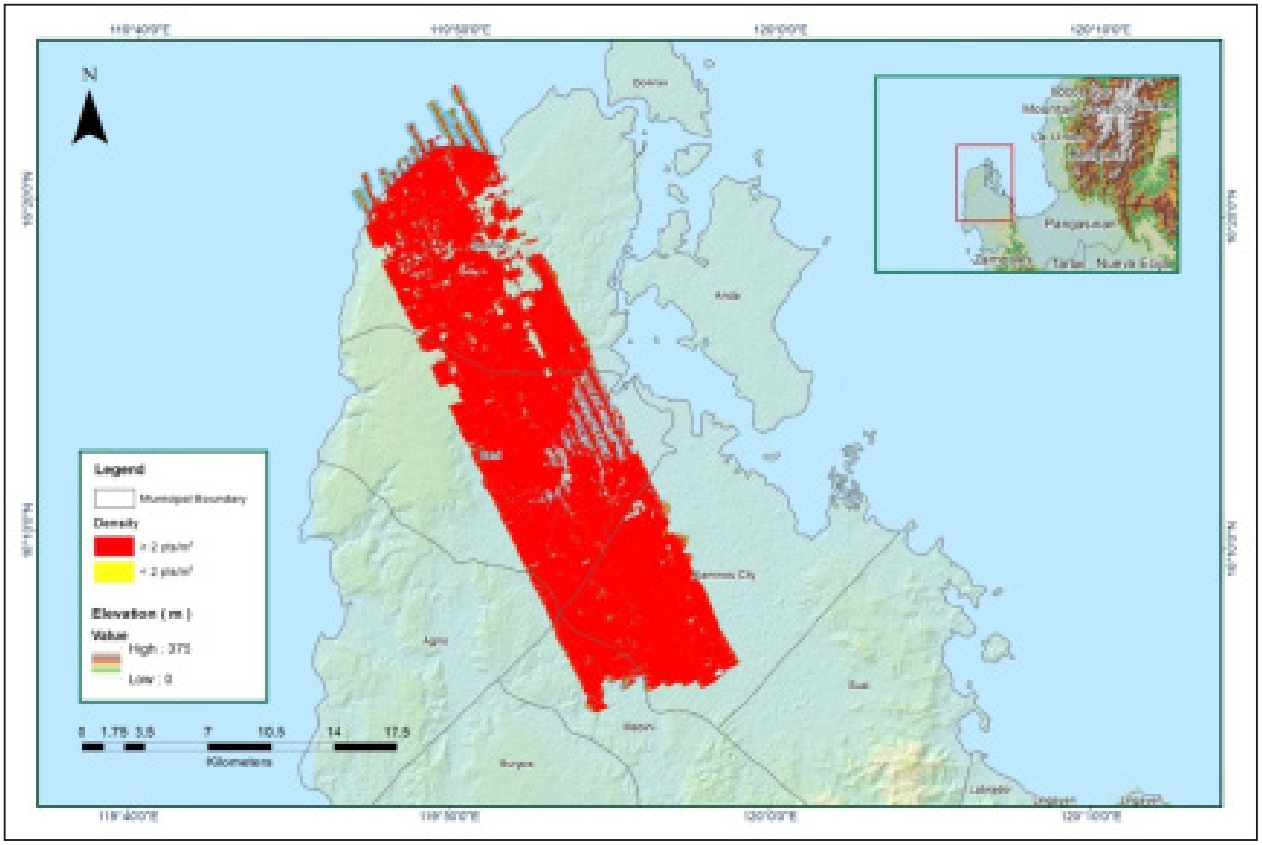


Figure A-8.6. Density map of merged LiDAR data

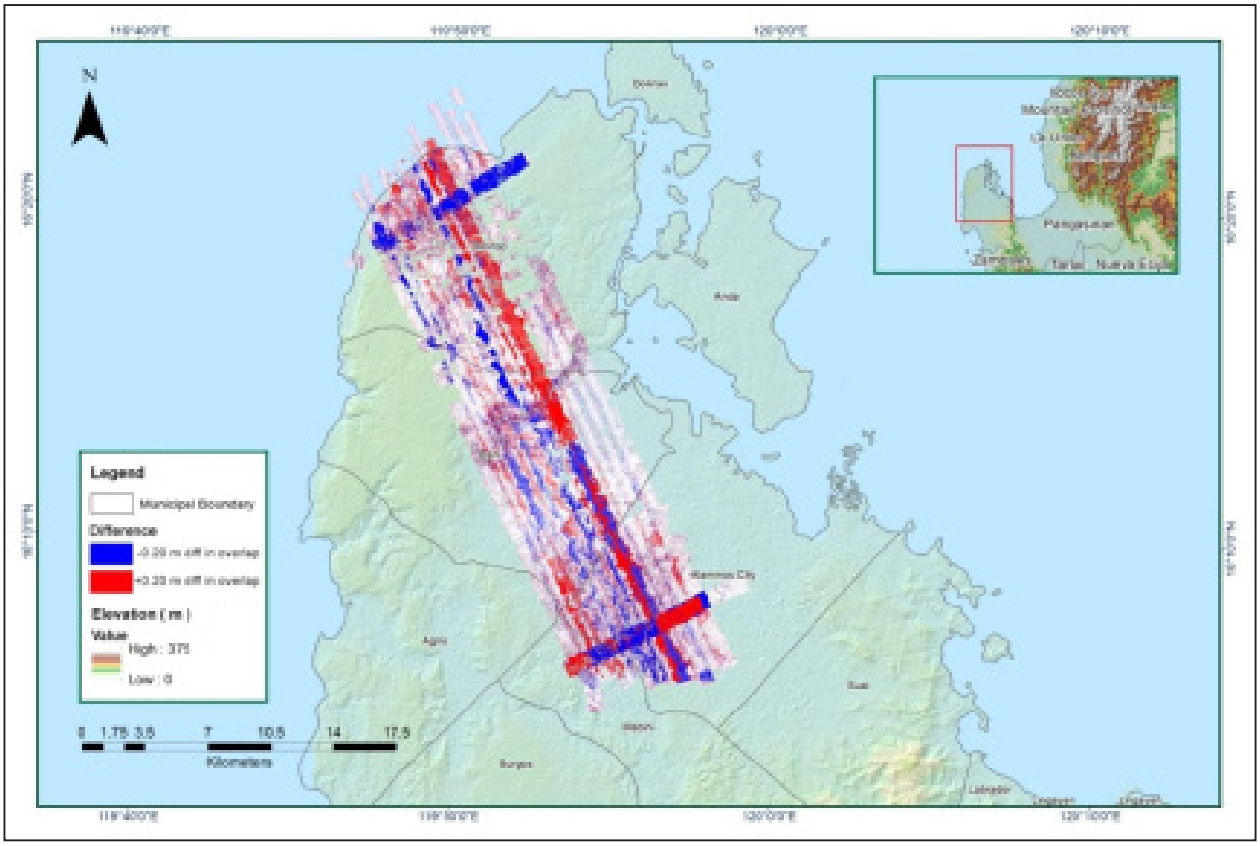


Figure A-8.7. Elevation difference between flight lines

Table A-8.2 Mission Summary Report for Blk12D

Flight Area	La Union
Mission Name	Blk12D
Inclusive Flights	1185P, 1187P
Range data size	36.1 GB
Baste data size	5.62 MB
POS	363 MB
Image	51.7 GB
Transfer date	March 06, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	2.45
RMSE for East Position (<4.0 cm)	1.65
RMSE for Down Position (<8.0 cm)	3.4
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)	37.83%
Ave point cloud density per sq.m. (>2.0)	2.10
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	419
Maximum Height	217.61 m
Minimum Height	41.04 m
Classification (# of points)	
Ground	296,410,371
Low vegetation	237,811,403
Medium vegetation	314,721,018
High vegetation	228,236,492
Building	4,602,558
Orthophoto	YES
Processed by	Engr. Irish Cortez,Engr. Harmond Santos, Engr. Ma. AilynOlanda, Engr. Jeffrey Delica

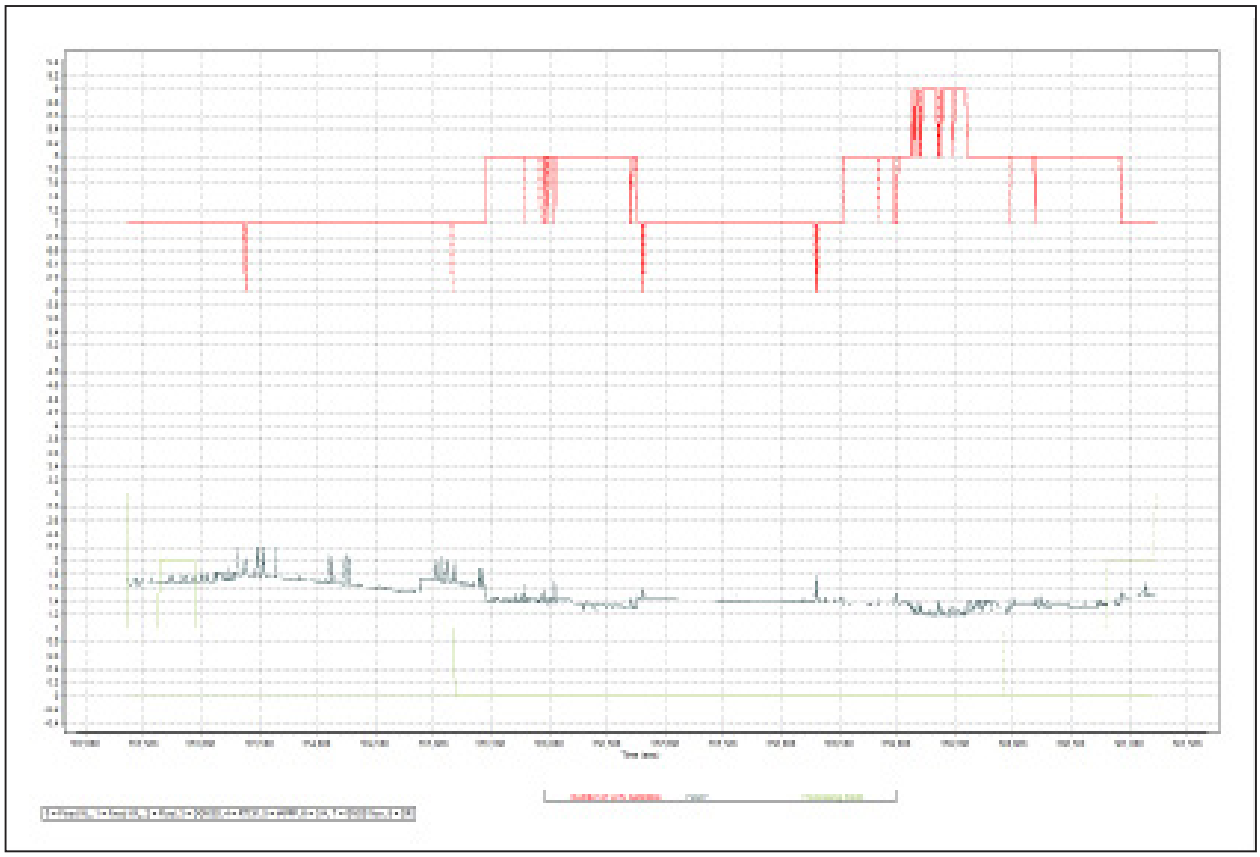


Figure A-8.8. Solution Status

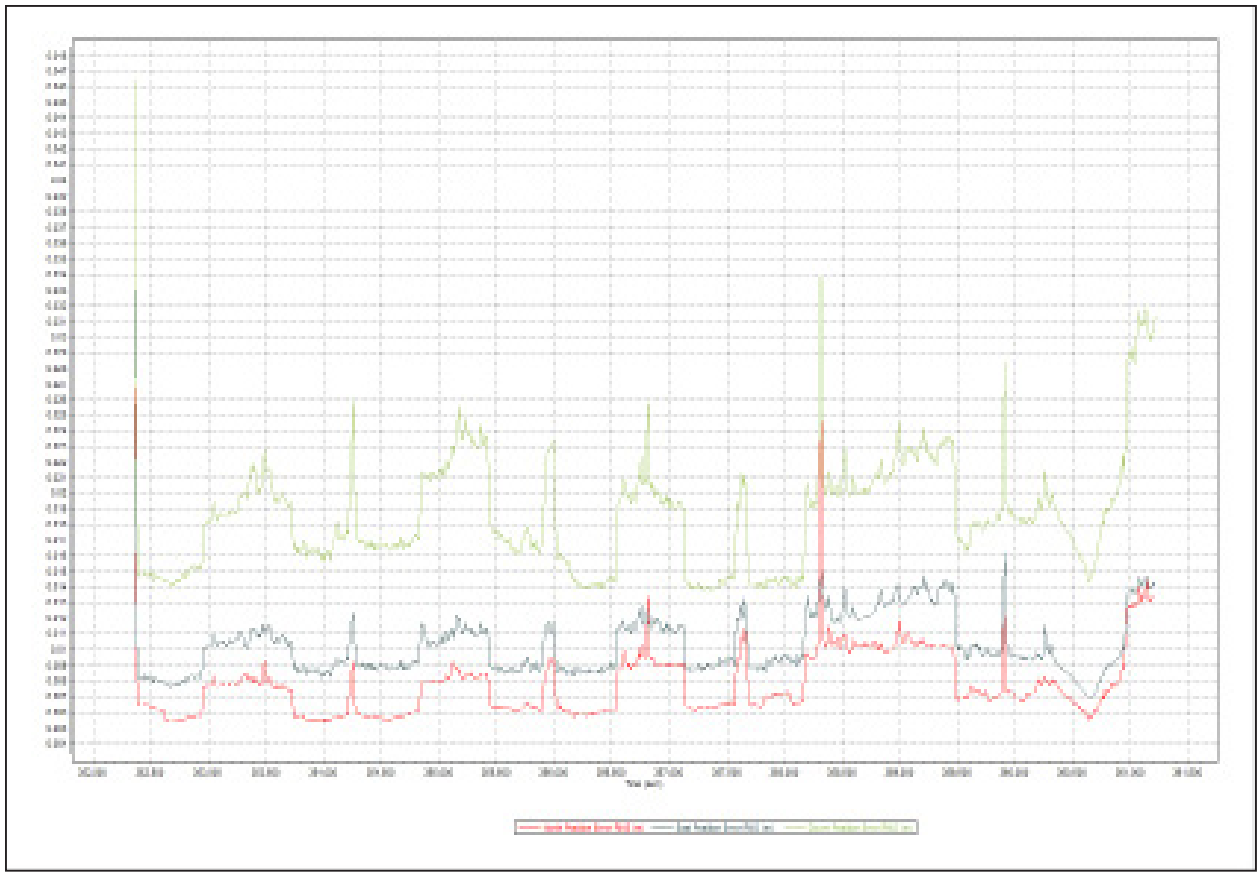


Figure A-8.9. Smoothed Performance Metric Parameters

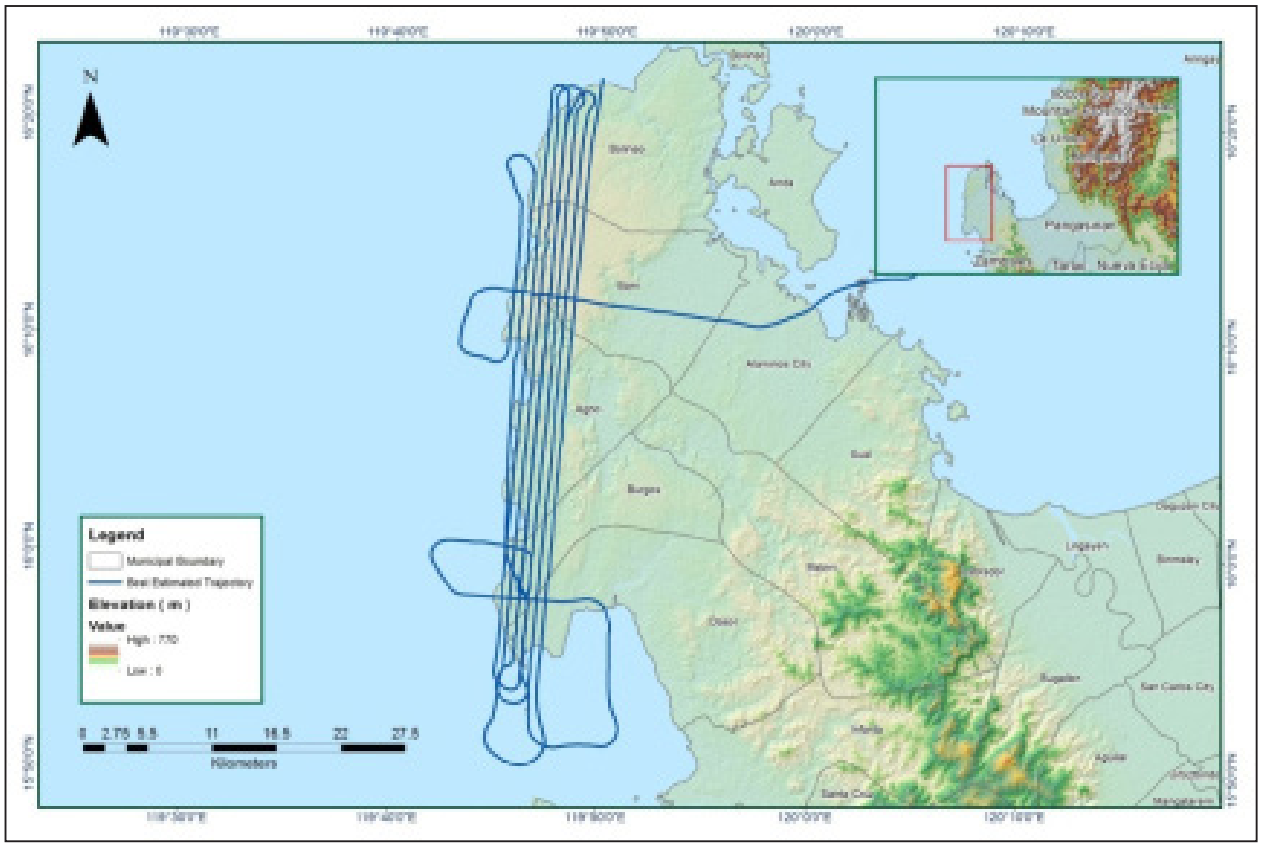


Figure A-8.10. Best Estimated Trajectory

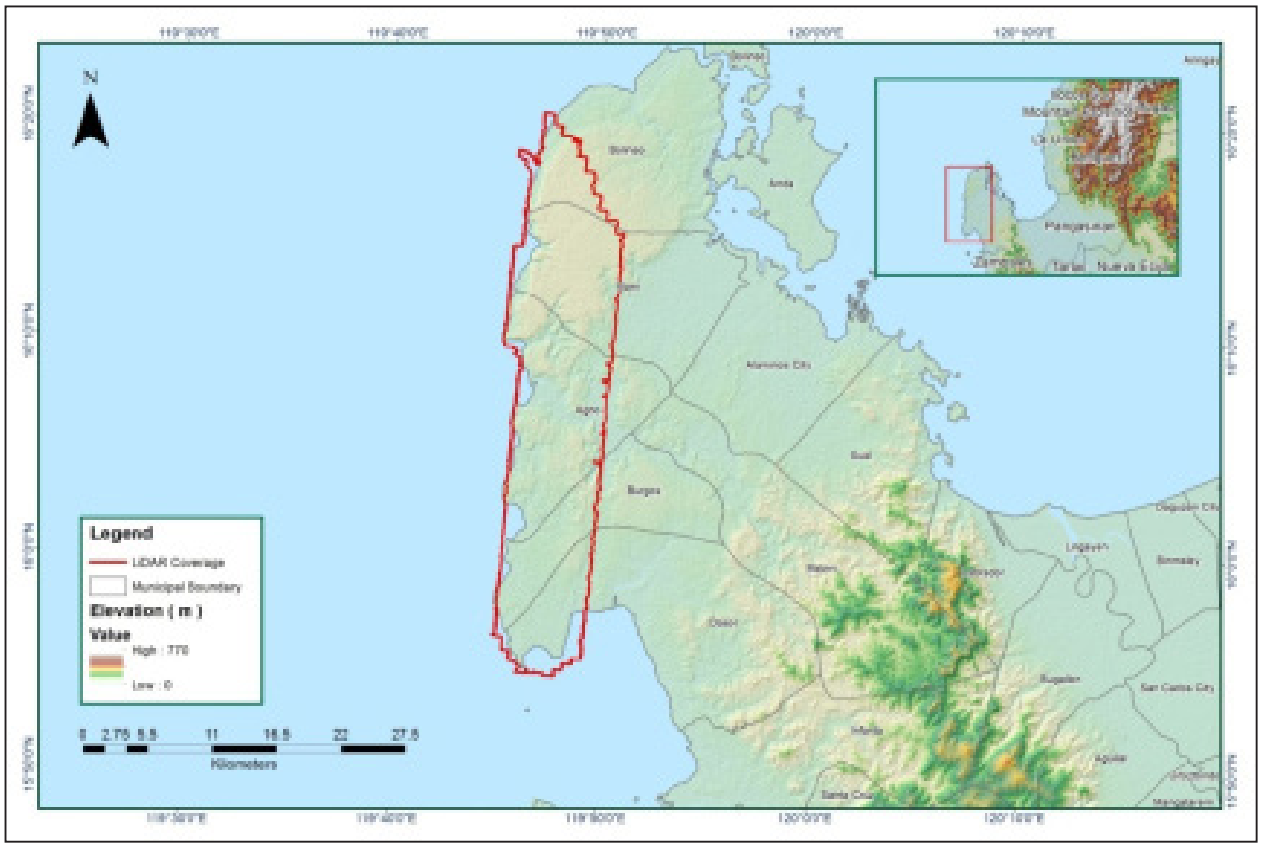


Figure A-8.11. Coverage of LiDAR data

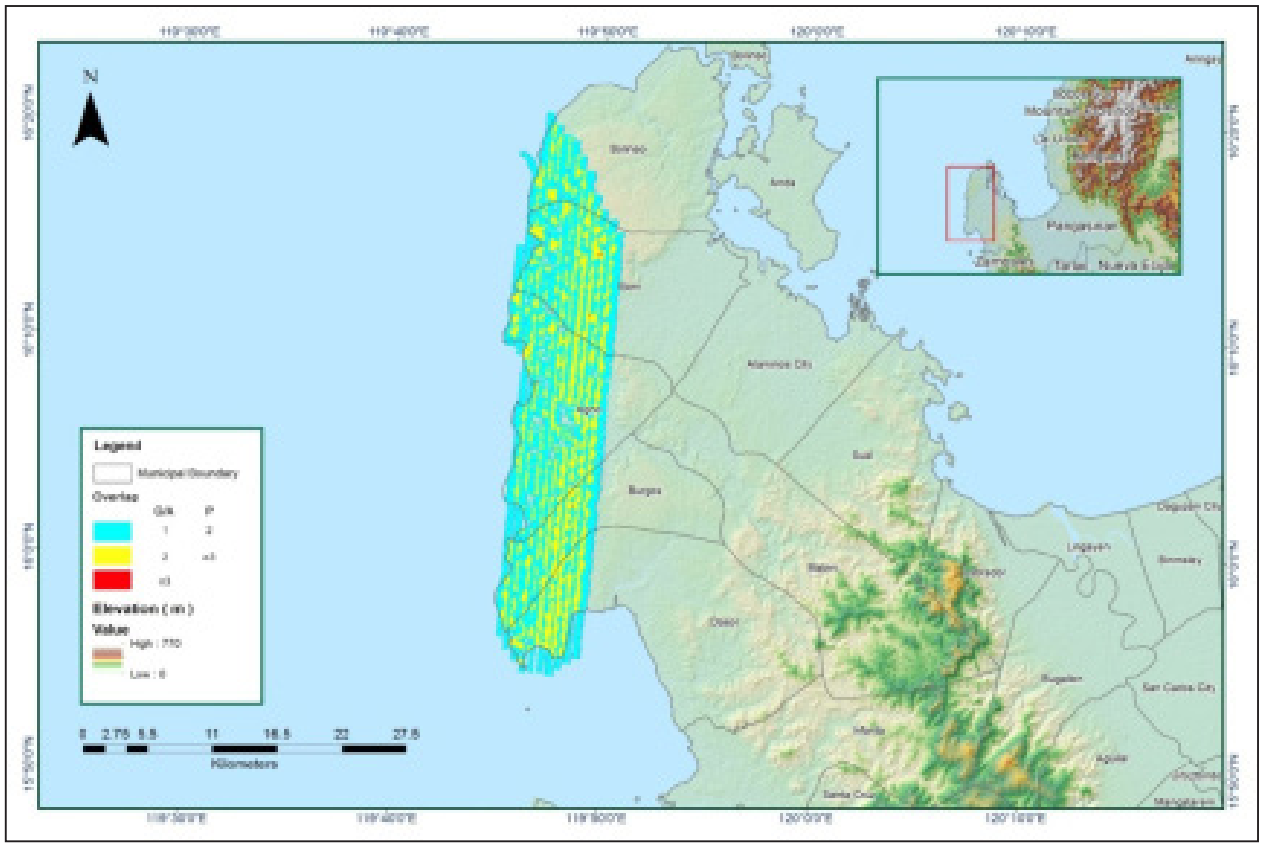


Figure A-8.12. Image of data overlap

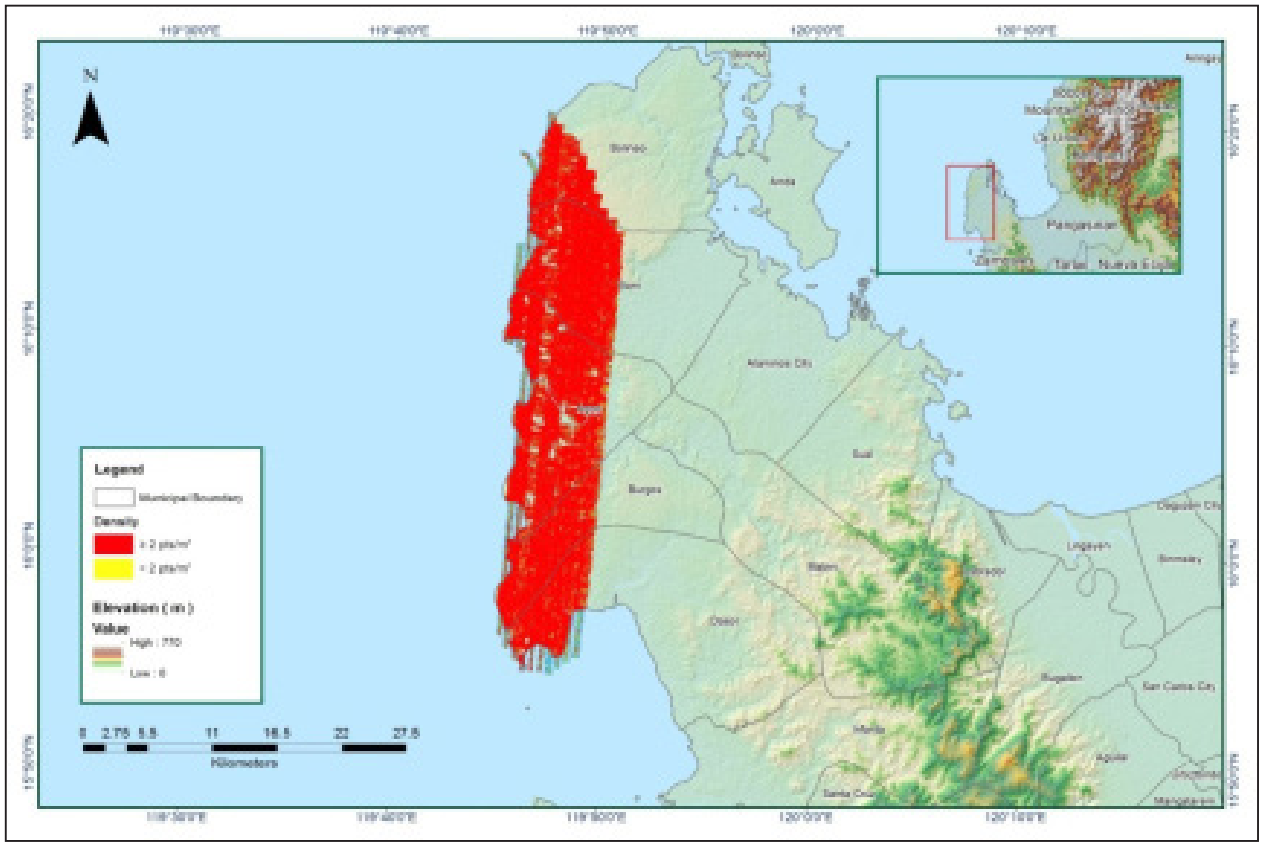


Figure A-8.13. Density map of merged LiDAR data

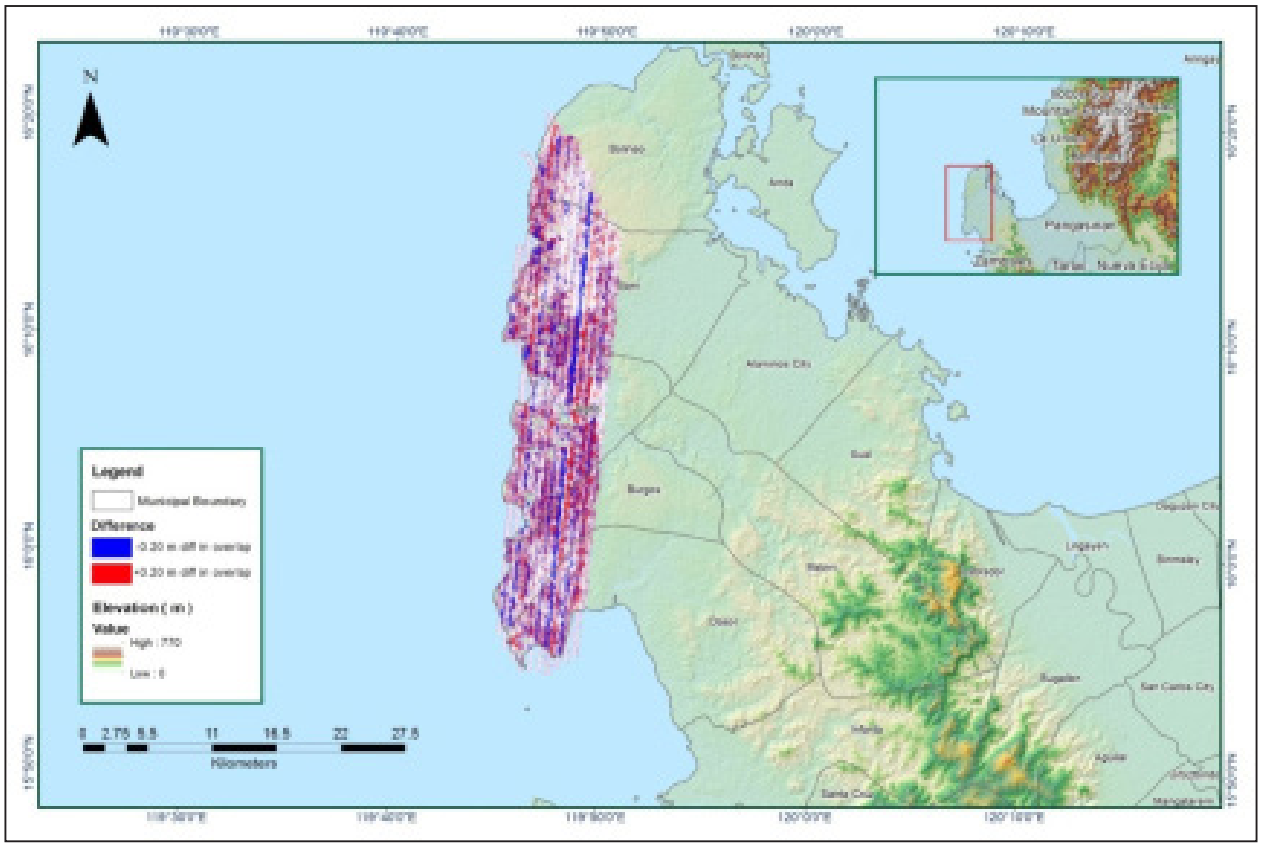


Figure A-8.14. Elevation difference between flight lines

Table A-8.3 Mission Summary Report for Blk12A

Flight Area	Pangasinan
Mission Name	Blk12A
Inclusive Flights	8540G
Range data size	21.7 GB
Base data size	6.6MB
POS	206 MB
Image	NA
Transfer date	November 12, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	3.13
RMSE for East Position (<4.0 cm)	3.39
RMSE for Down Position (<8.0 cm)	11.59
Boresight correction stdev (<0.001deg)	0.000710
IMU attitude correction stdev (<0.001deg)	0.001787
GPS position stdev (<0.01m)	0.0026
Minimum % overlap (>25)	NA
Ave point cloud density per sq.m. (>2.0)	3.11
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	204
Maximum Height	155.89 m
Minimum Height	28.82 m
Classification (# of points)	
Ground	66,134,631
Low vegetation	64,985,573
Medium vegetation	187,463,519
High vegetation	121,295,134
Building	2,062,482
Orthophoto	No
Processed by	Engr. Angelo Carlo Bongat, Engr. Merven Matthew Natino, Engr. John Dill Macapagal

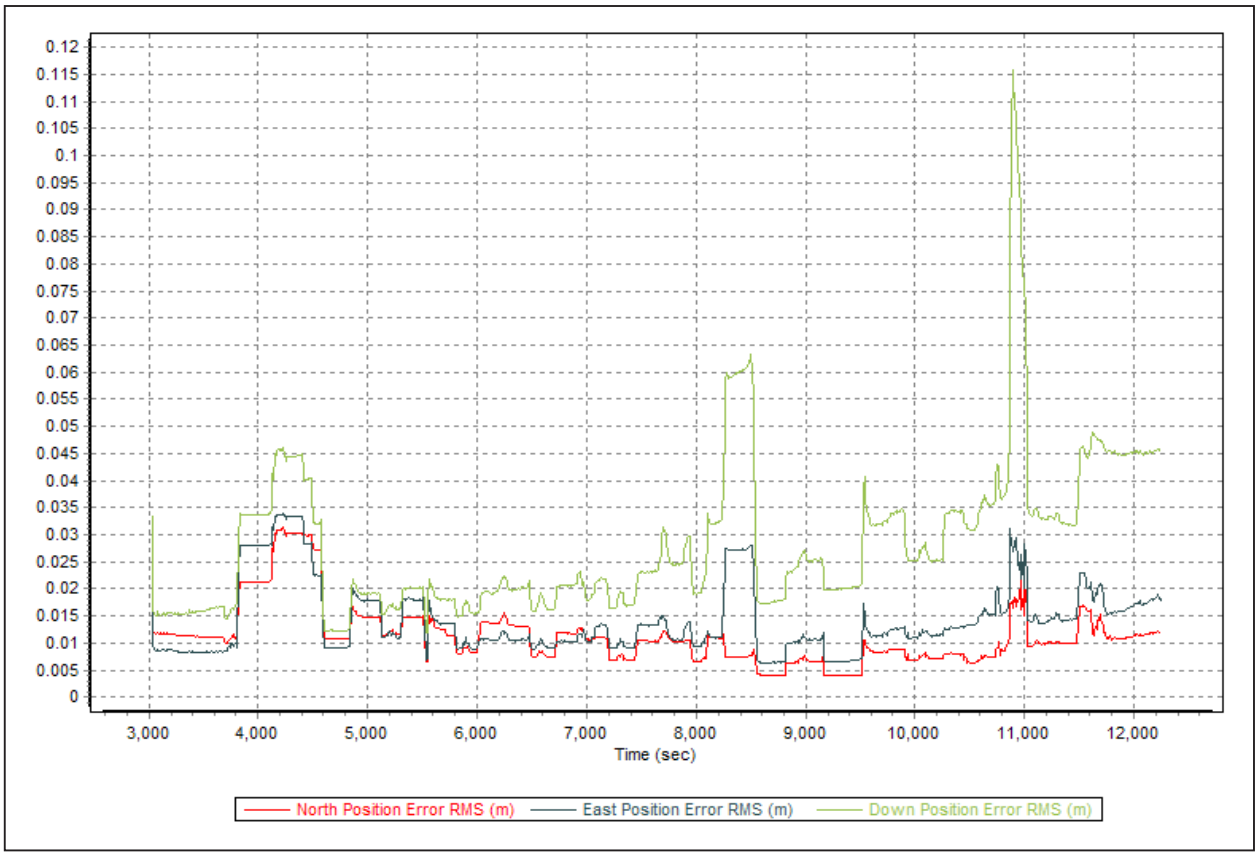


Figure A-8.15. Solution Status

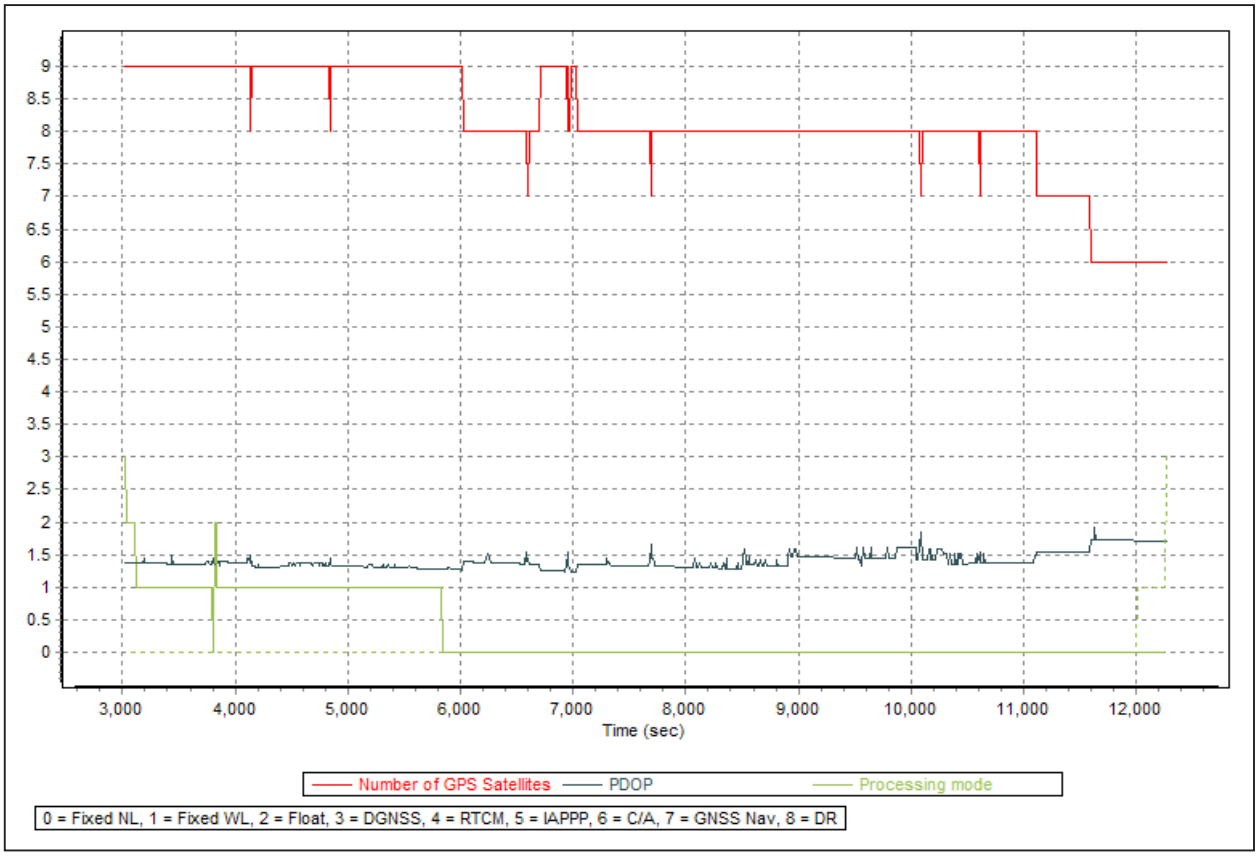


Figure A-8.16. Smoothed Performance Metric Parameters

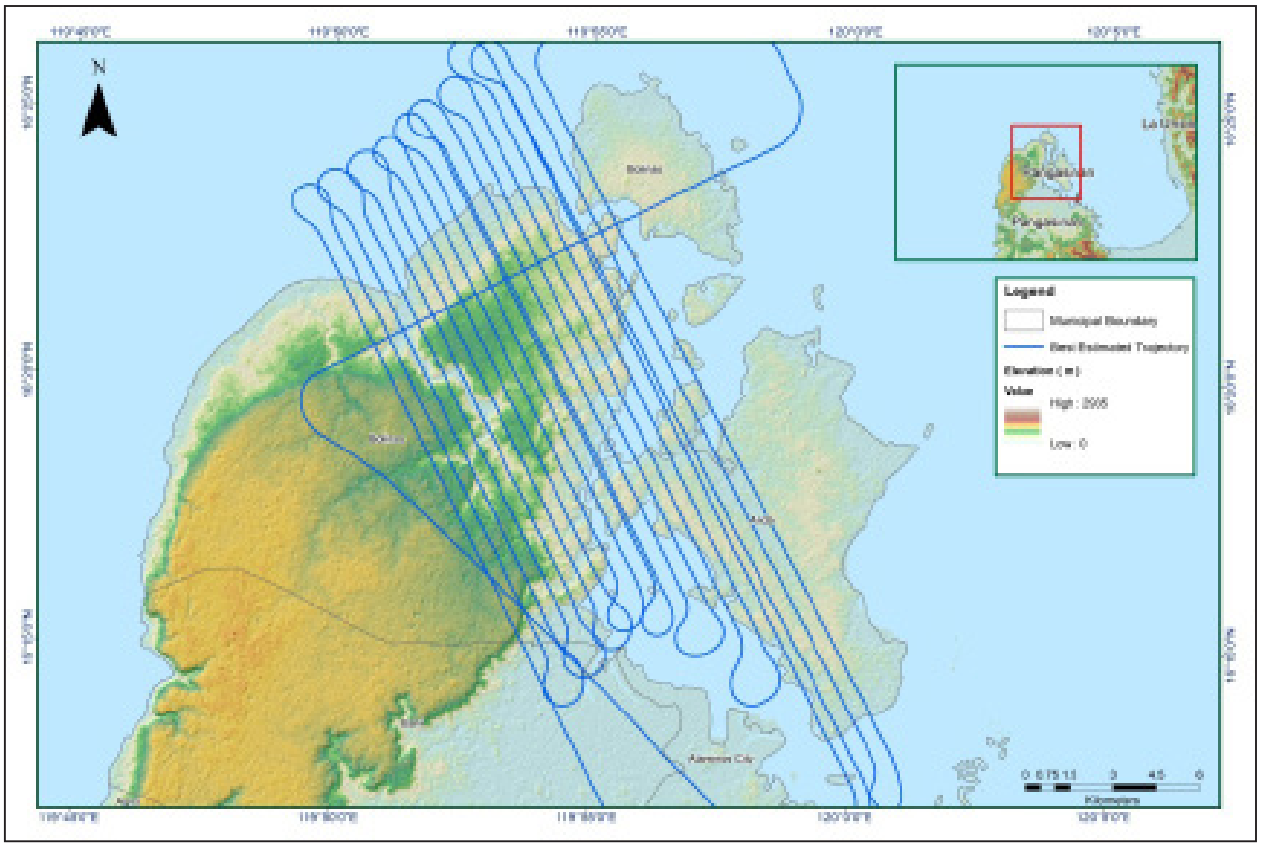


Figure A-8.17. Best Estimated Trajectory

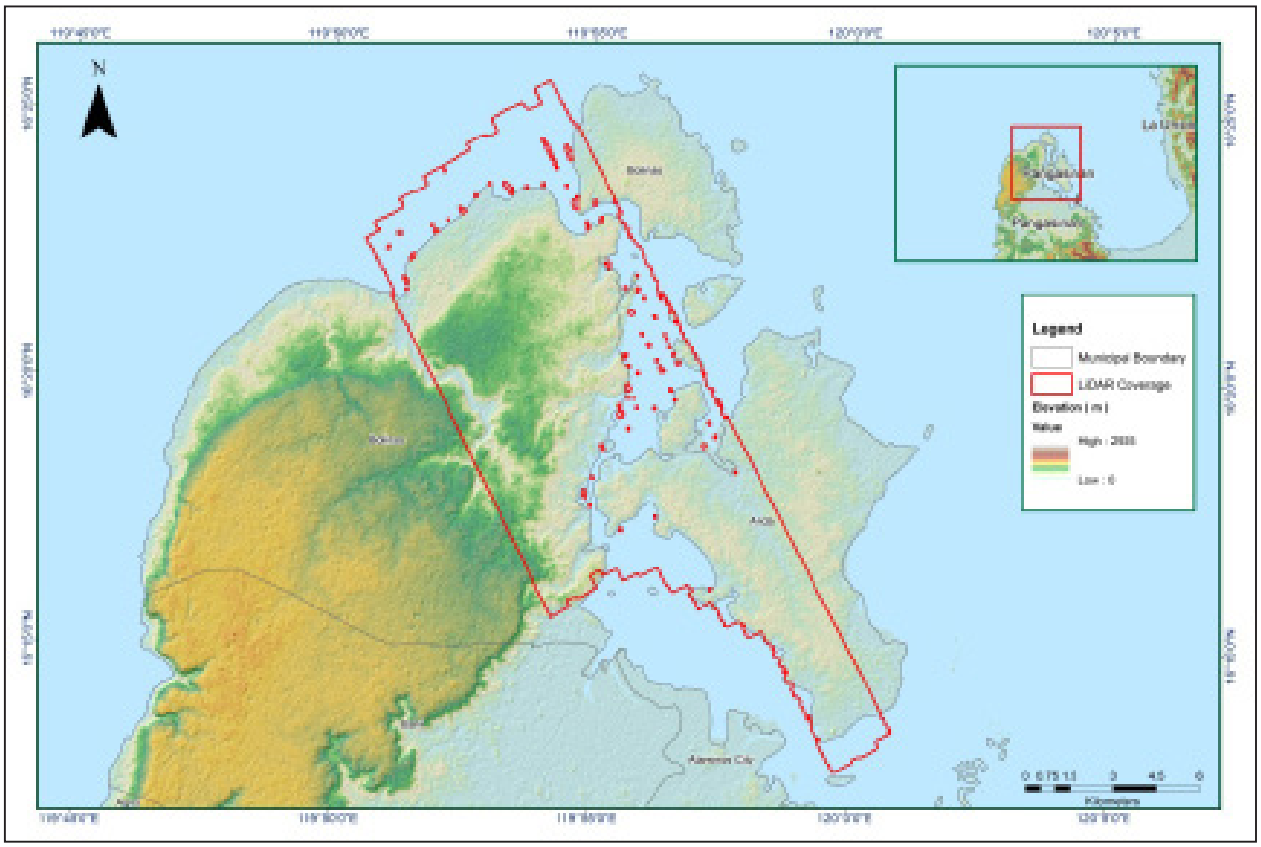


Figure A-8.18. Coverage of LiDAR data

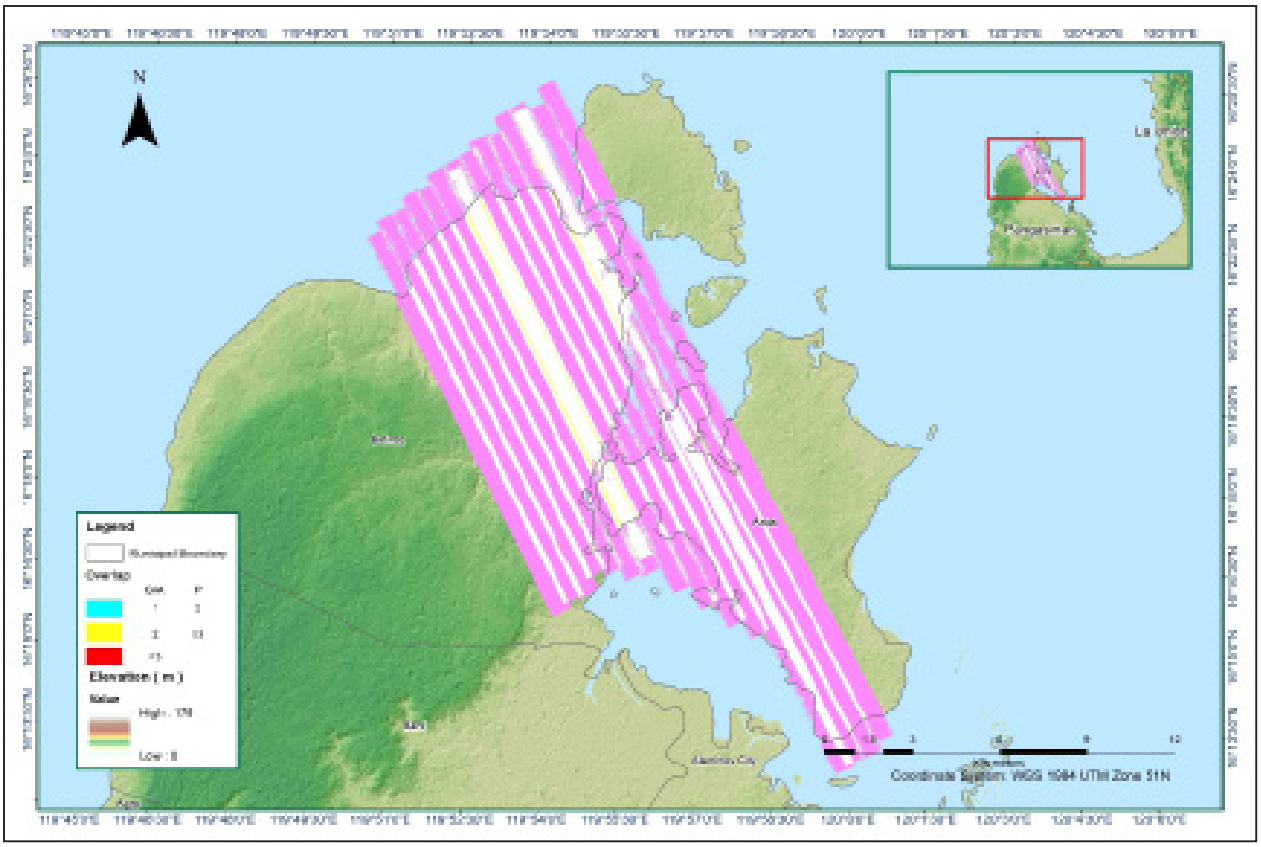


Figure A-8.19. Image of data overlap

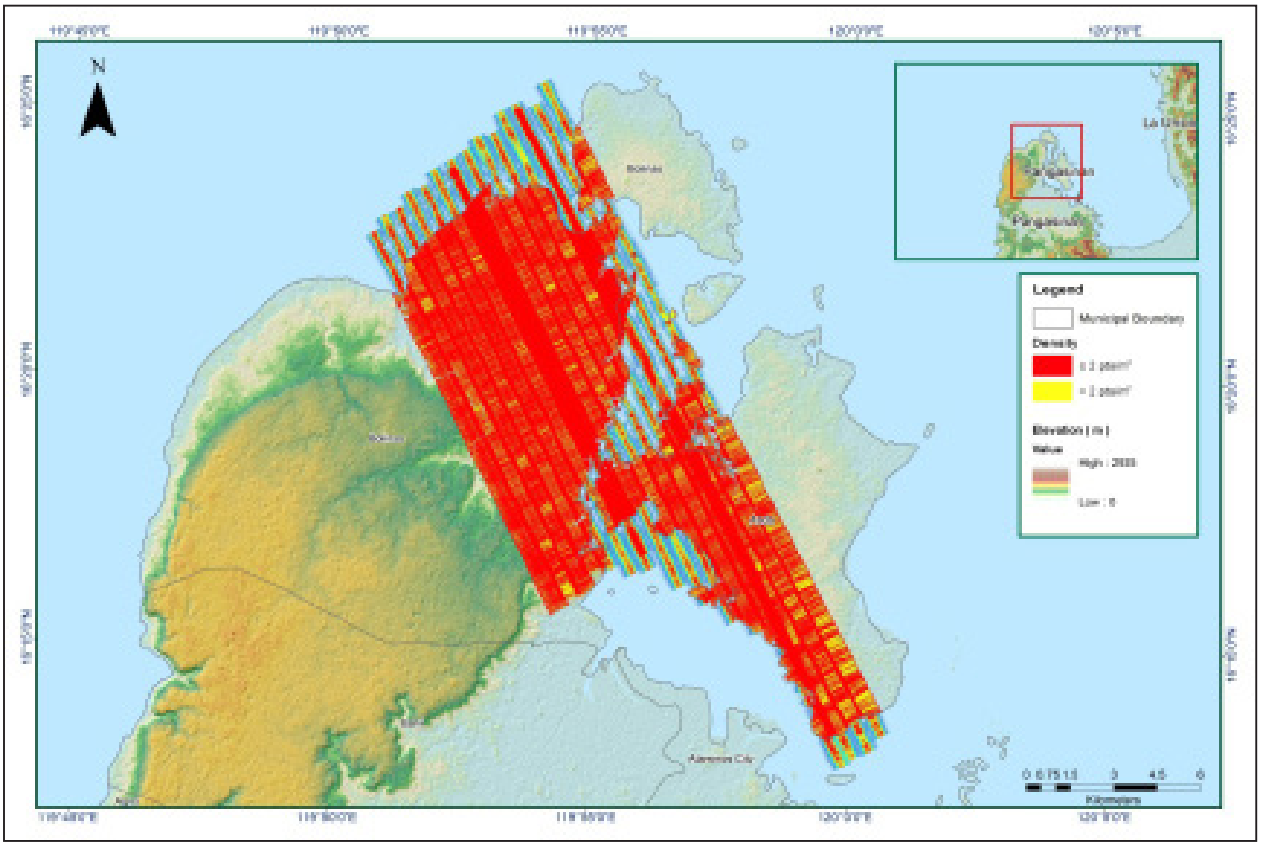


Figure A-8.20. Density map of merged LiDAR data

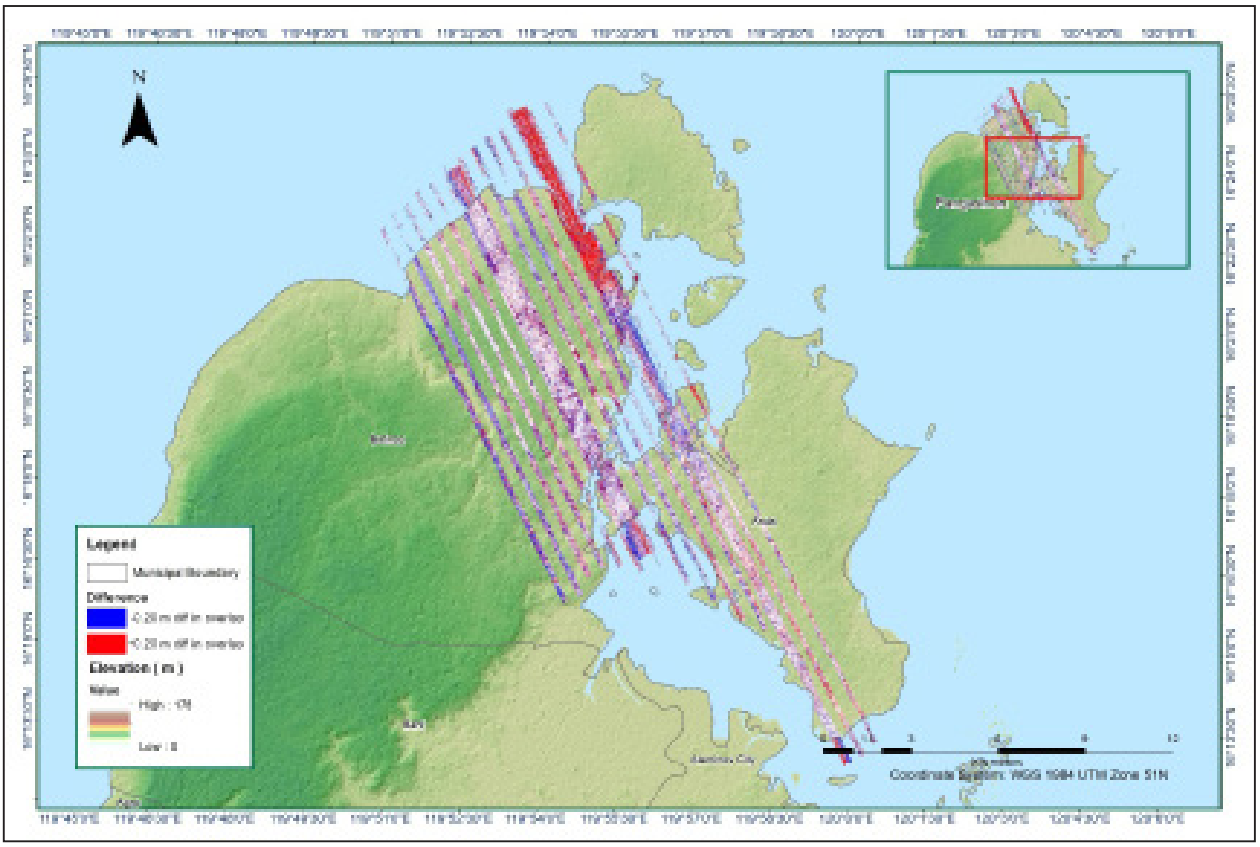


Figure A-8.21. Elevation difference between flight lines

Table A-8.4 Mission Summary Report for Blk12A_additional

Flight Area	Pangasinan
Mission Name	Blk12A_additional
Inclusive Flights	8540G
Range data size	21.7 GB
Base data size	6.6 MB
POS	206 MB
Image	NA
Transfer date	November 12, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	3.13
RMSE for East Position (<4.0 cm)	3.39
RMSE for Down Position (<8.0 cm)	11.59
Boresight correction stdev (<0.001deg)	0.002286
IMU attitude correction stdev (<0.001deg)	0.002625
GPS position stdev (<0.01m)	0.0026
Minimum % overlap (>25)	17.24
Ave point cloud density per sq.m. (>2.0)	3.00
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	49
Maximum Height	196.33 m
Minimum Height	37.79 m
Classification (# of points)	
Ground	18,115,342
Low vegetation	8,483,978
Medium vegetation	29,837,667
High vegetation	22,410,533
Building	157,082
Orthophoto	No
Processed by	Engr. Angelo Carlo Bongat, AljonRieAraneta, Engr. Krisha Marie Bautista

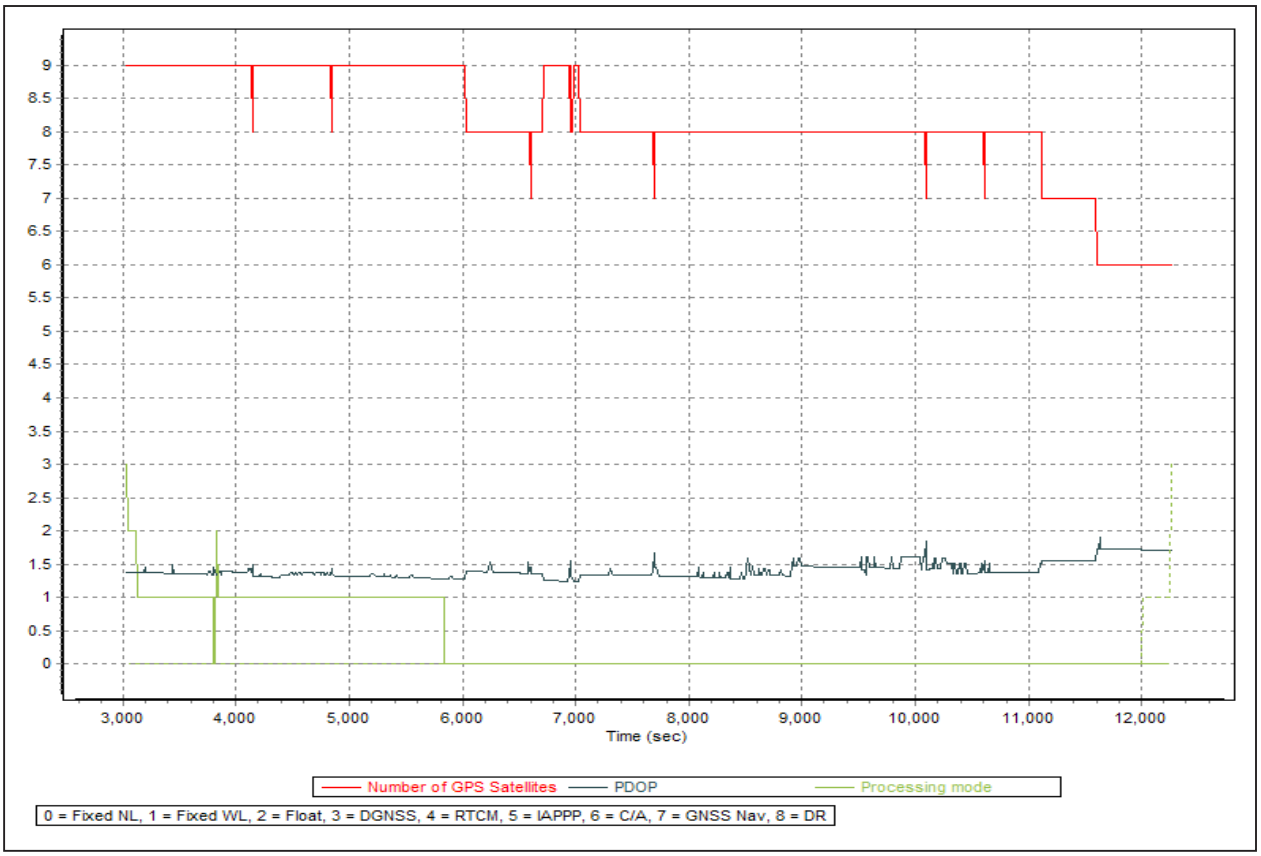


Figure A-8.22. Solution Status

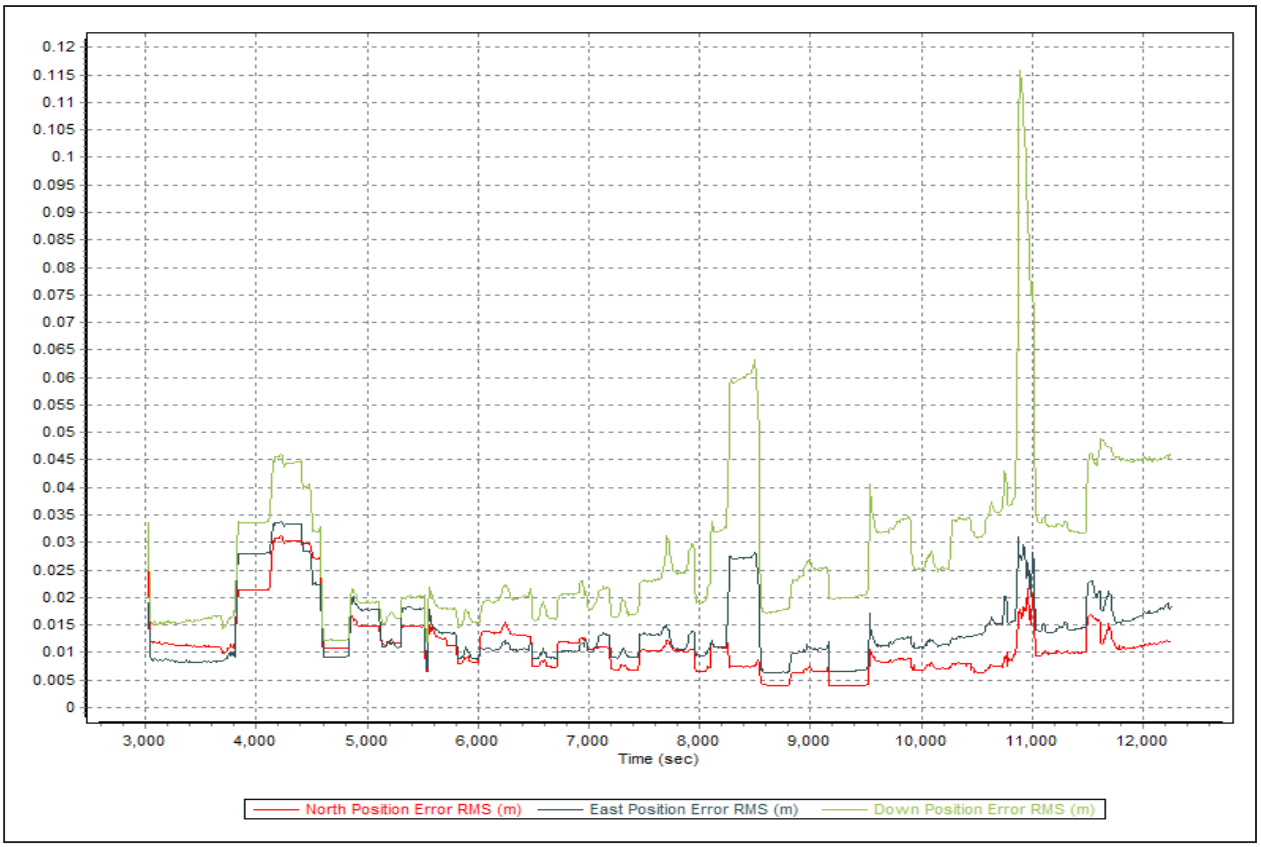


Figure A-8.23. Smoothed Performance Metric Parameters

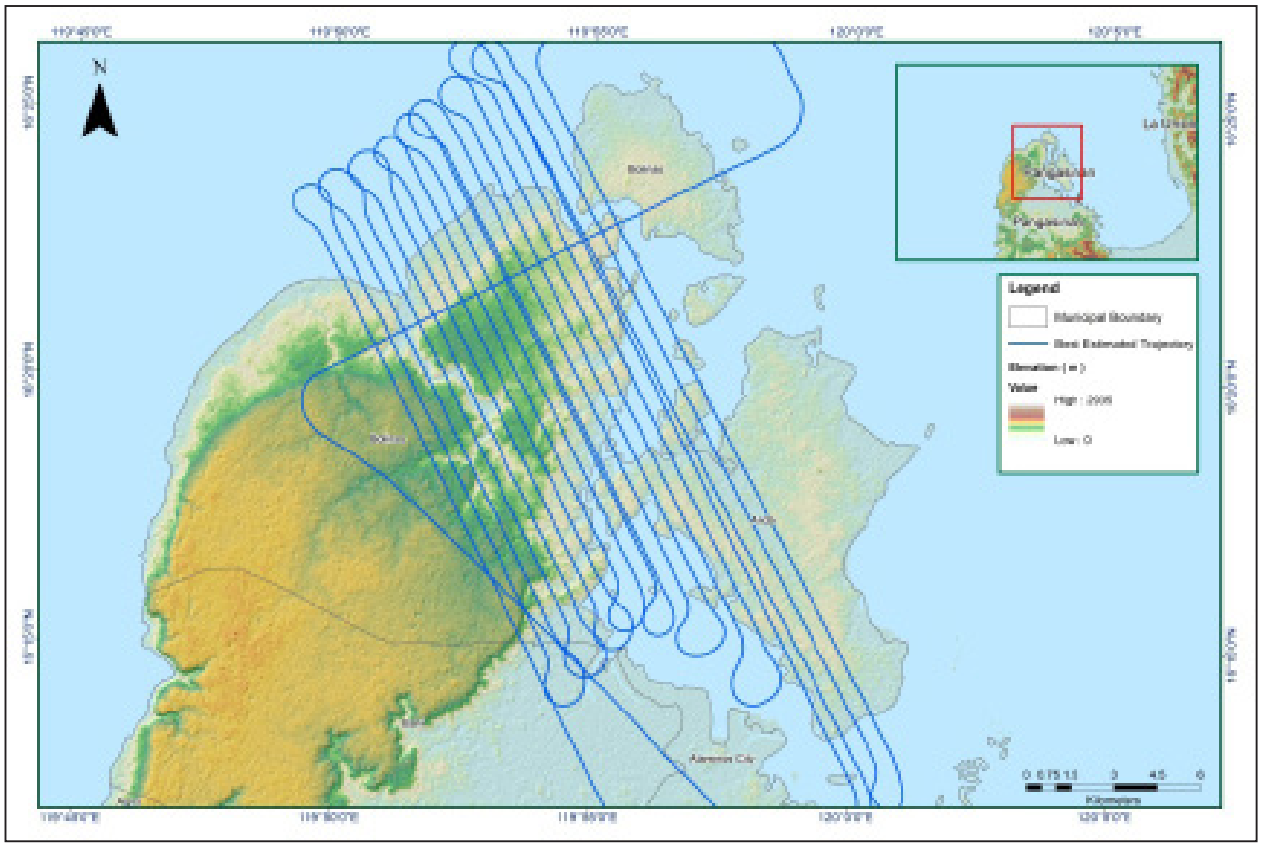


Figure A-8.24. Best Estimated Trajectory

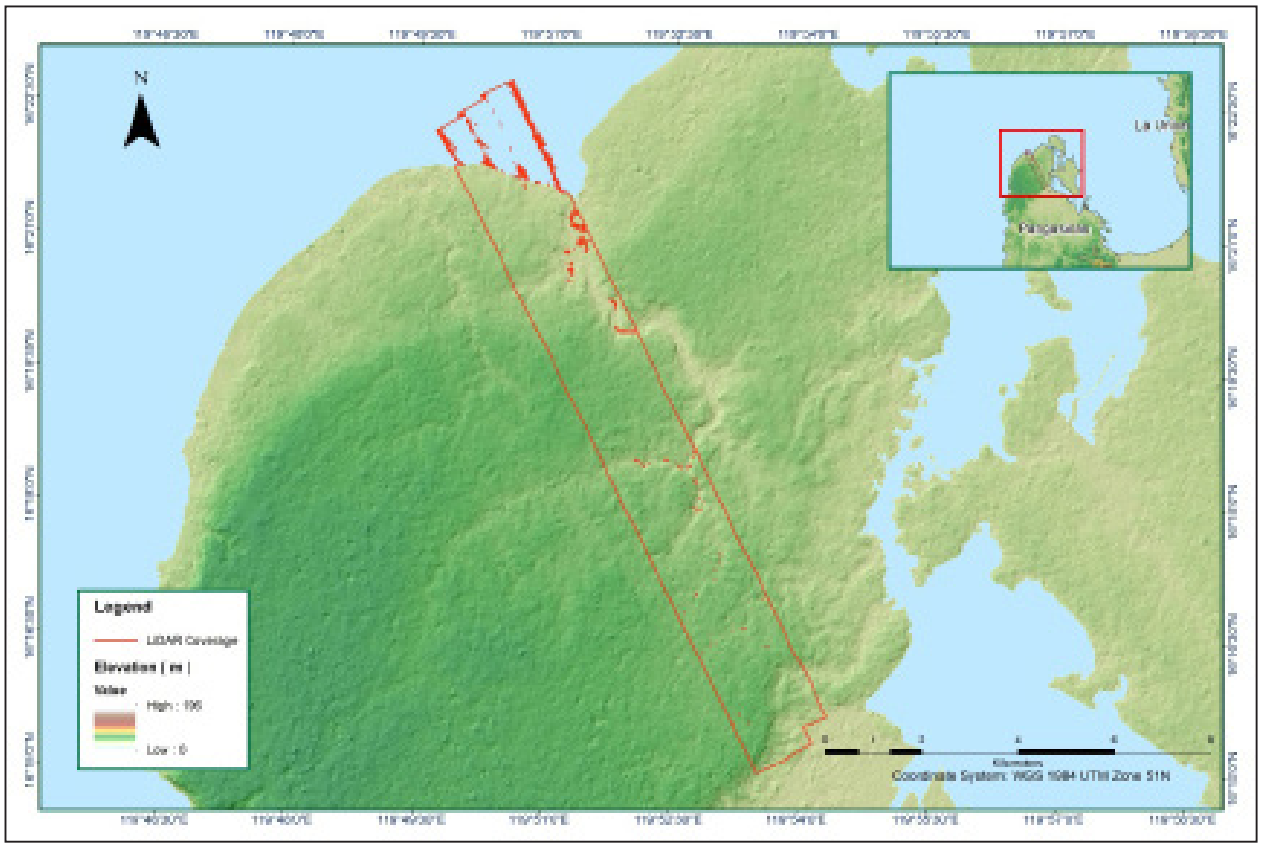


Figure A-8.25. Coverage of LiDAR data

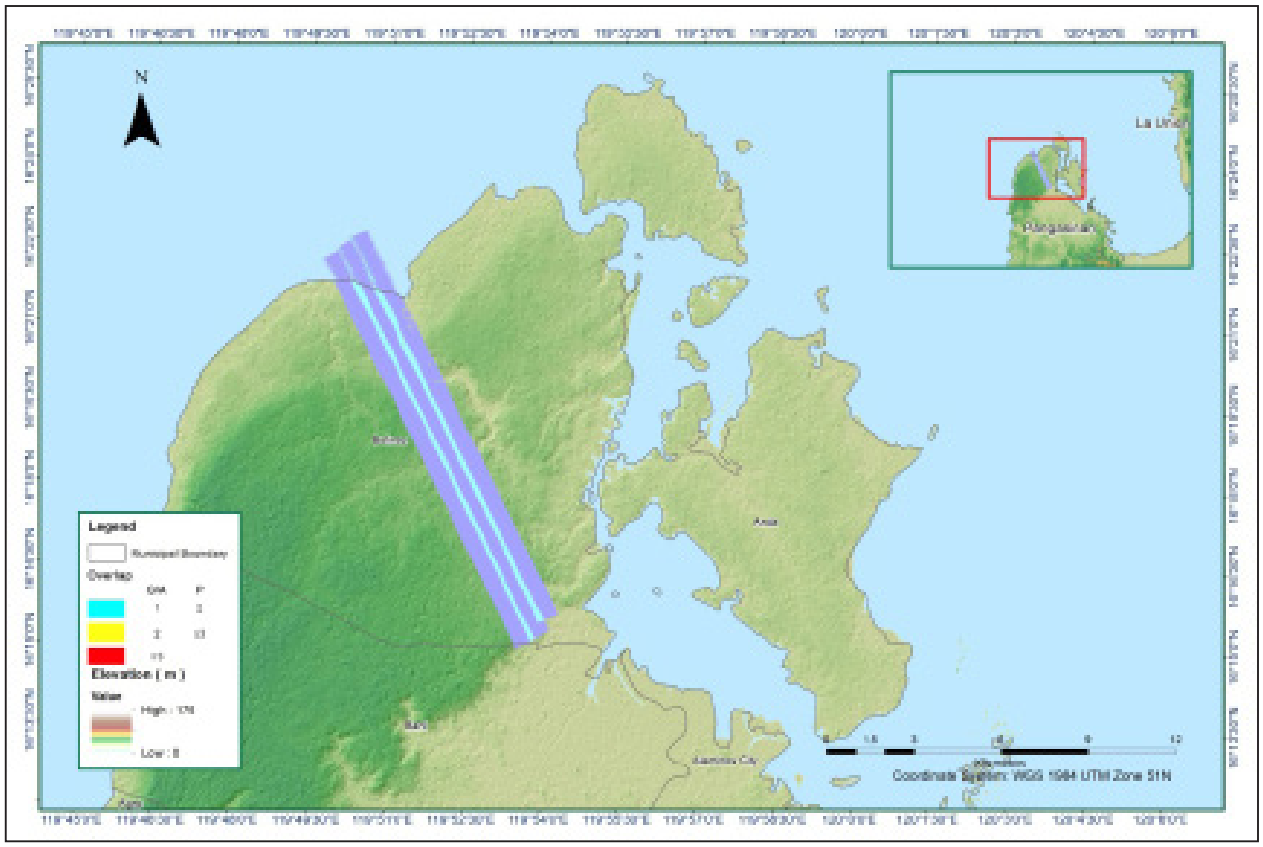


Figure A-8.26. Image of data overlap

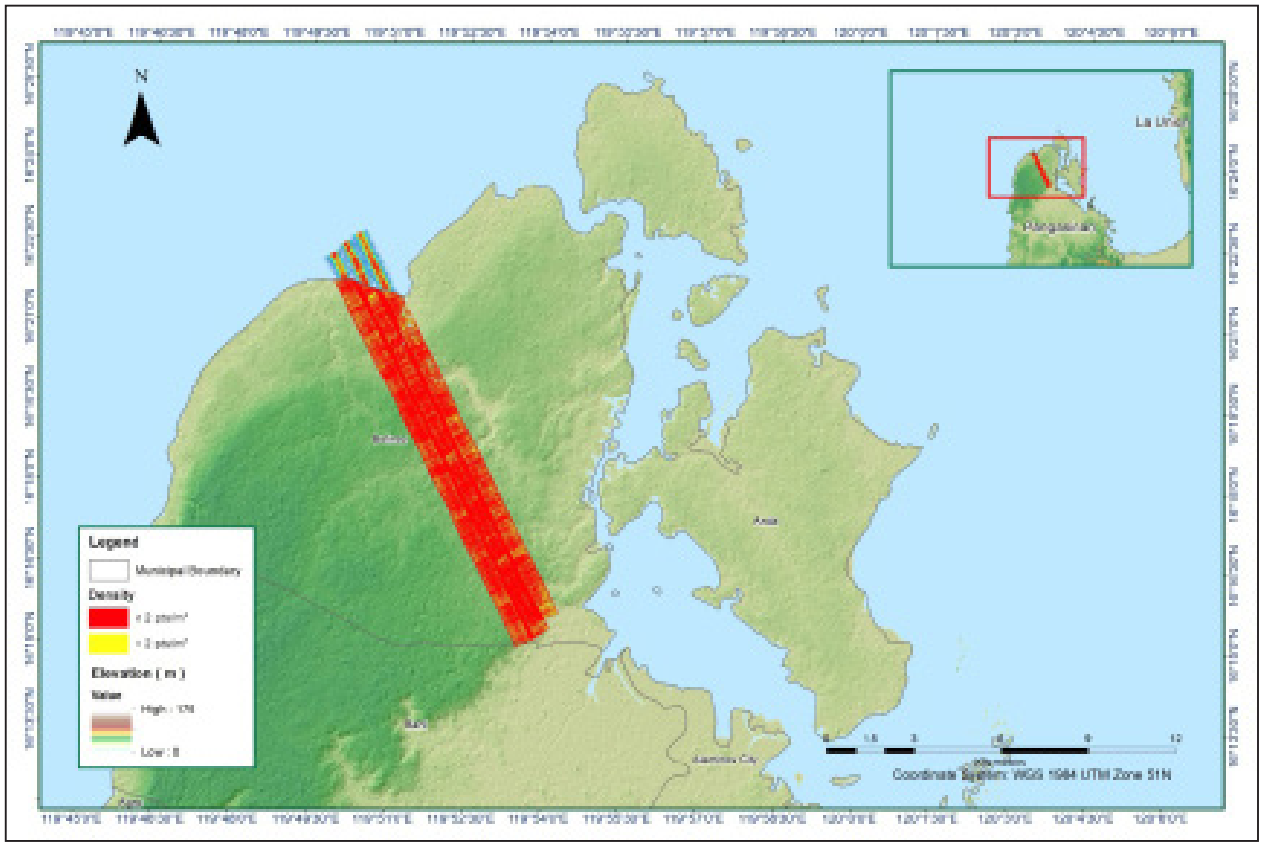


Figure A-8.27. Density map of merged LiDAR data

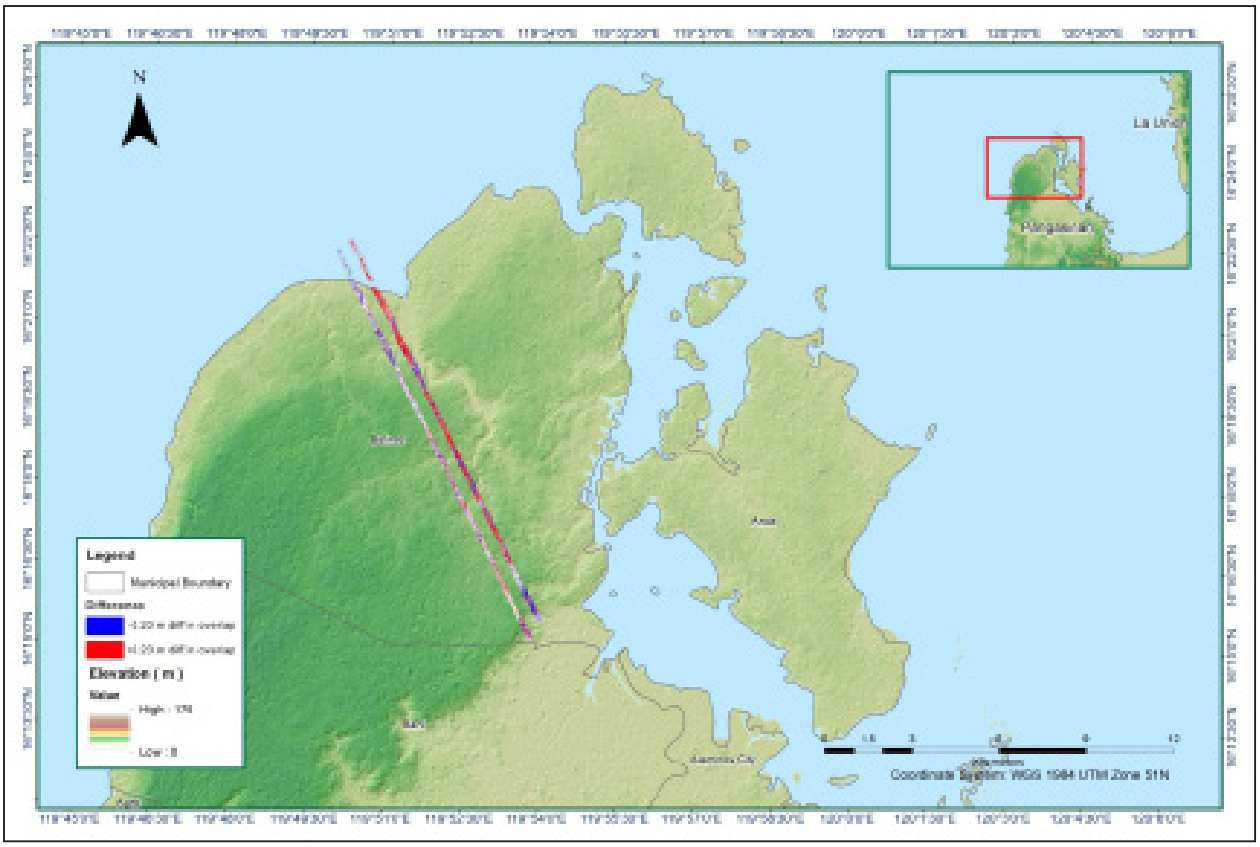


Figure A-8.28. Elevation difference between flight lines

Table A-8.5 Mission Summary Report for Blk12C

Flight Area	Pangasinan
Mission Name	Blk12C
Inclusive Flights	8534G
Range data size	14.1 GB
Base data size	5.72 MB
POS	136 MB
Image	NA
Transfer date	November 12, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.04
RMSE for East Position (<4.0 cm)	1.33
RMSE for Down Position (<8.0 cm)	2.33
Boresight correction stdev (<0.001deg)	0.000634
IMU attitude correction stdev (<0.001deg)	0.005010
GPS position stdev (<0.01m)	0.0290
Minimum % overlap (>25)	25.59
Ave point cloud density per sq.m. (>2.0)	2.84
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	163
Maximum Height	161.87 m
Minimum Height	37.26 m
Classification (# of points)	
Ground	60,865,980
Low vegetation	77,976,409
Medium vegetation	119,221,591
High vegetation	35,628,293
Building	3,275,842
Orthophoto	No
Processed by	Engr. AnalynNaldo, Engr. JovelleAnjeanette Canlas, Alex John Escobido

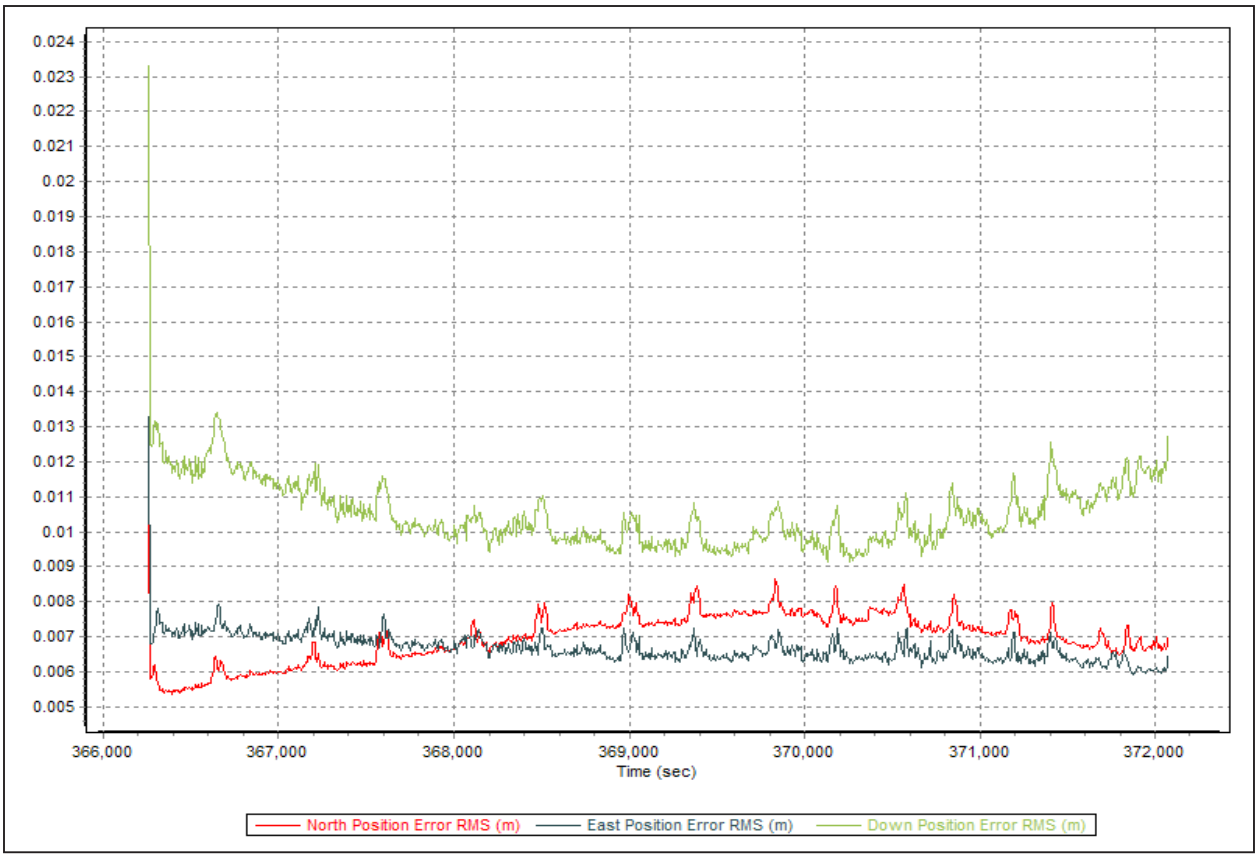


Figure A-8.29. Solution Status

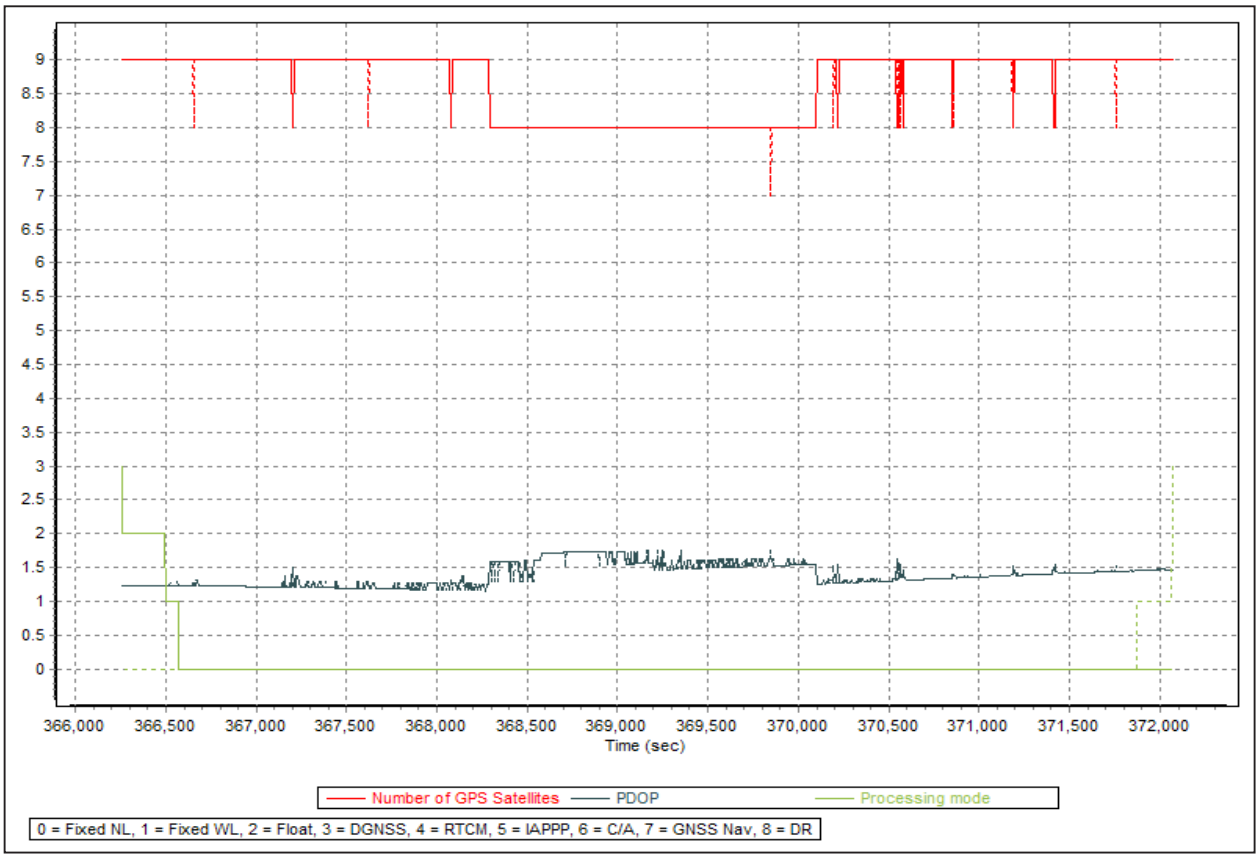


Figure A-8.30. Smoothed Performance Metric Parameters

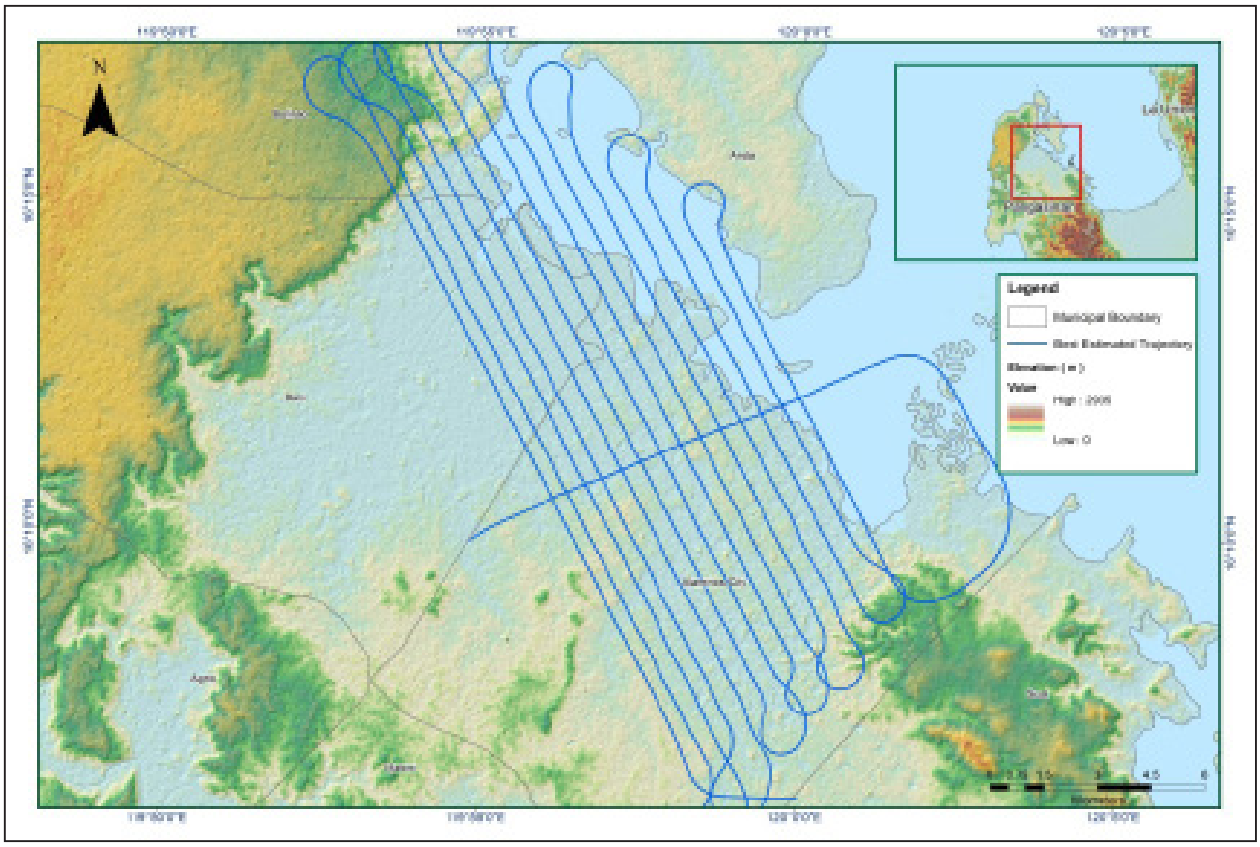


Figure A-8.31. Best Estimated Trajectory

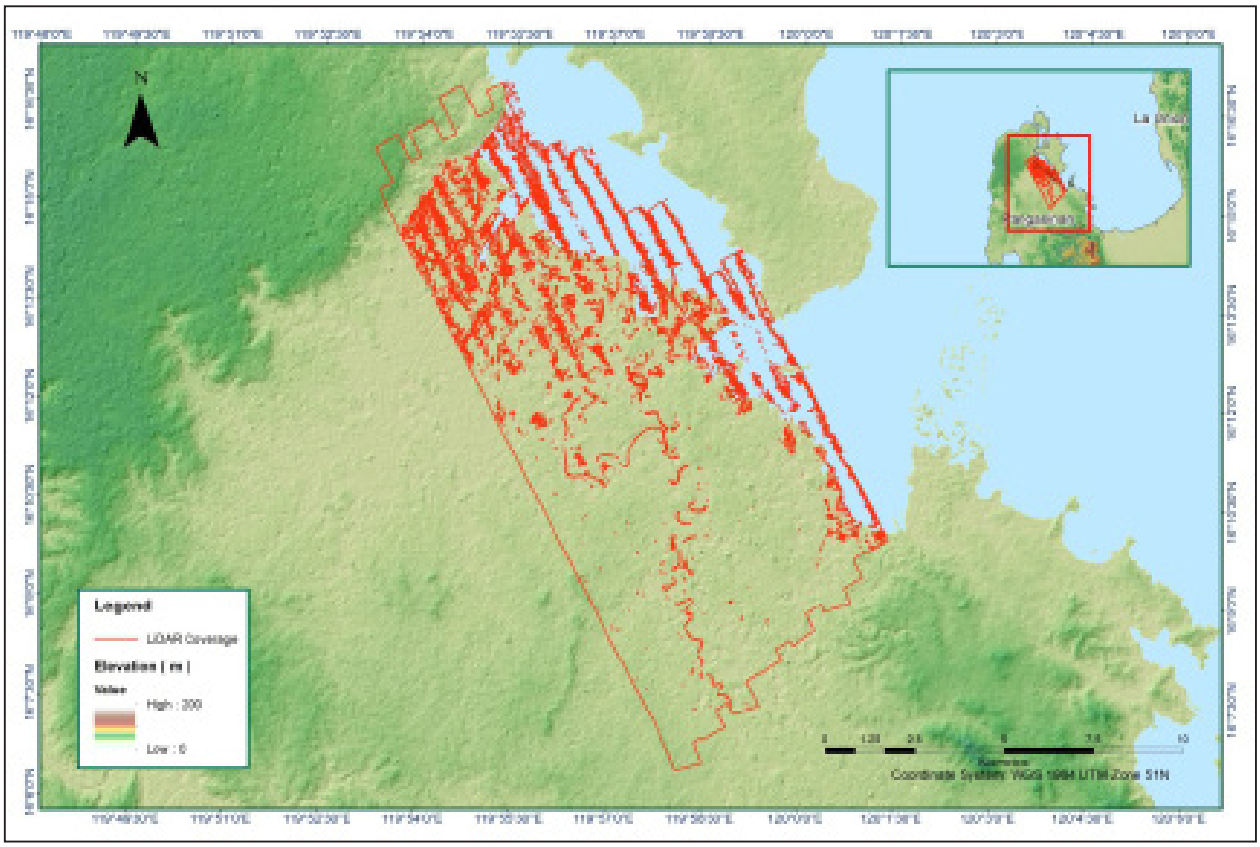


Figure A-8.32. Coverage of LiDAR data

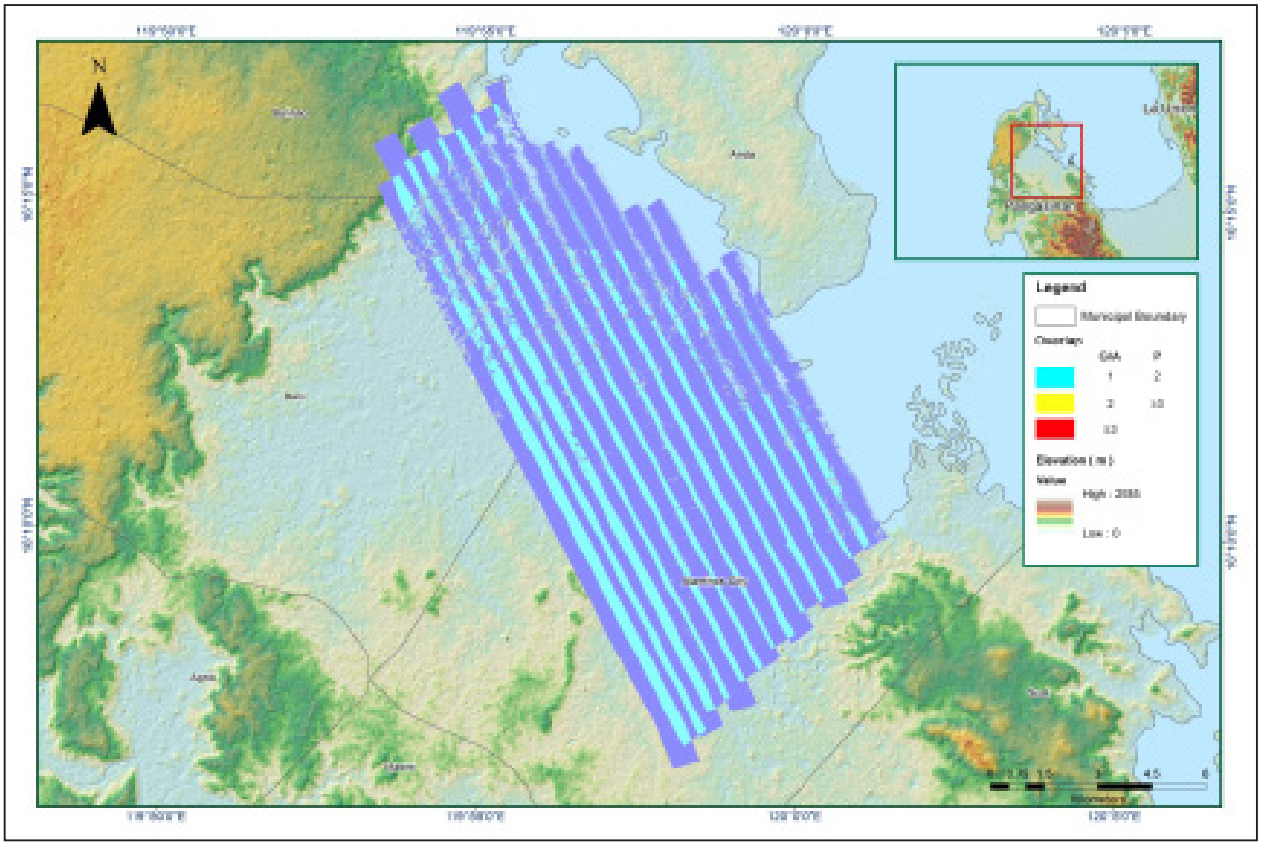


Figure A-8.33. Image of data overlap

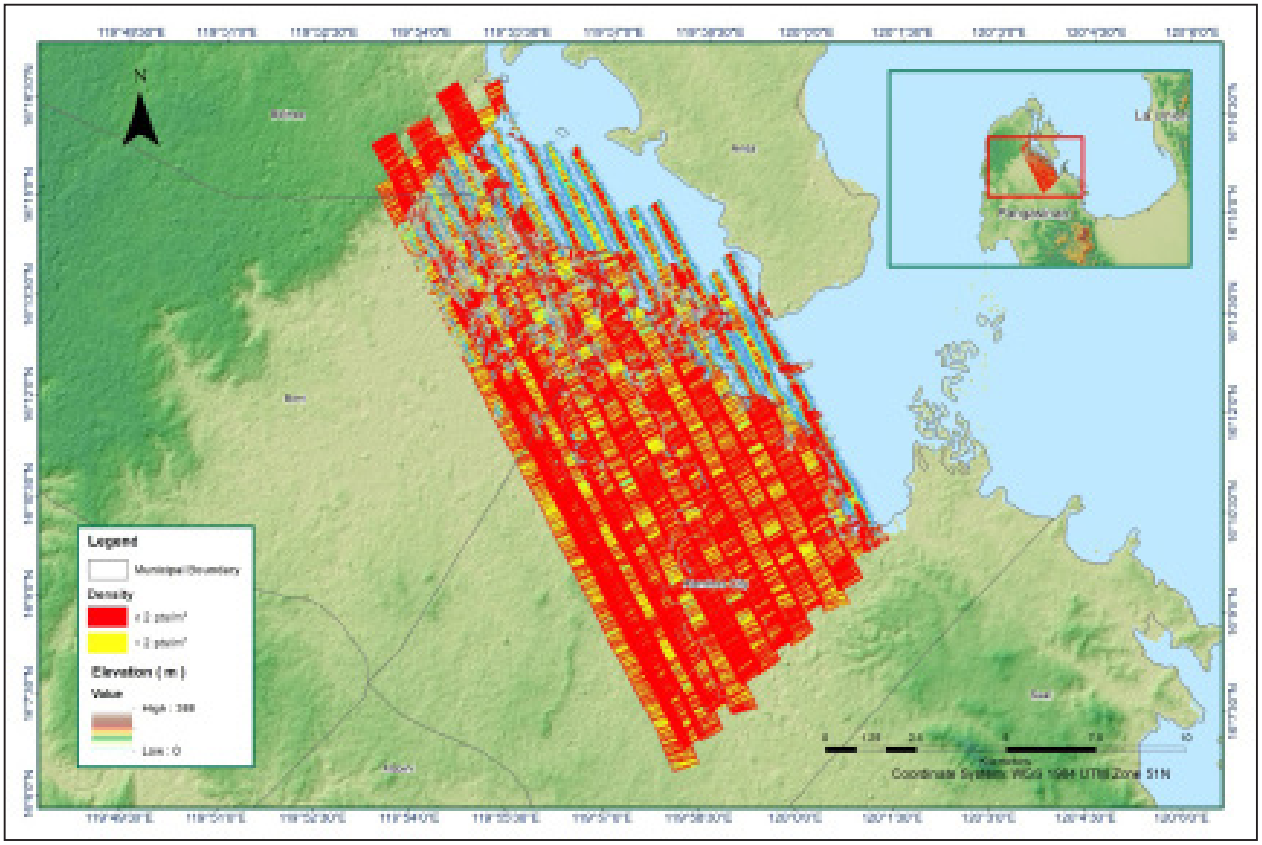


Figure A-8.34. Density map of merged LiDAR data

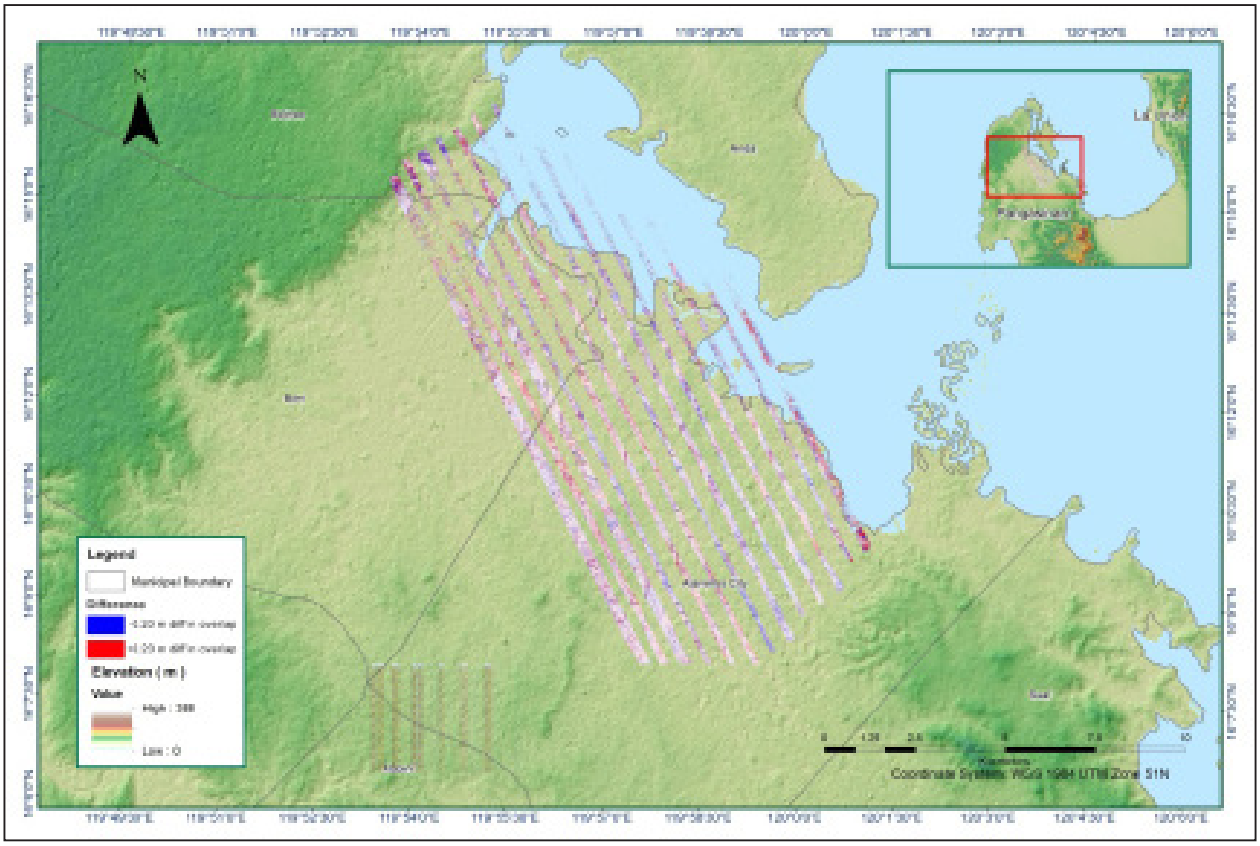


Figure A-8.35. Elevation difference between flight lines

Table A-8.6 Mission Summary Report for Blk12D

Flight Area	Pangasinan
Mission Name	Blk12D
Inclusive Flights	8536G
Range data size	13.5 GB
Base data size	3.76 MB
POS	140 MB
Image	NA
Transfer date	November 12, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.39
RMSE for East Position (<4.0 cm)	1.11
RMSE for Down Position (<8.0 cm)	2.76
Boresight correction stdev (<0.001deg)	0.000703
IMU attitude correction stdev (<0.001deg)	0.001325
GPS position stdev (<0.01m)	0.0016
Minimum % overlap (>25)	31.95
Ave point cloud density per sq.m. (>2.0)	3.22
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	162
Maximum Height	233.77 m
Minimum Height	39.18 m
Classification (# of points)	
Ground	74,931,832
Low vegetation	84,118,598
Medium vegetation	140,268,415
High vegetation	72,120,281
Building	1,901,291
Orthophoto	No
Processed by	Engr. RaymodSta Ana, Engr. Velina Angela Bemida, Alex John Escobido

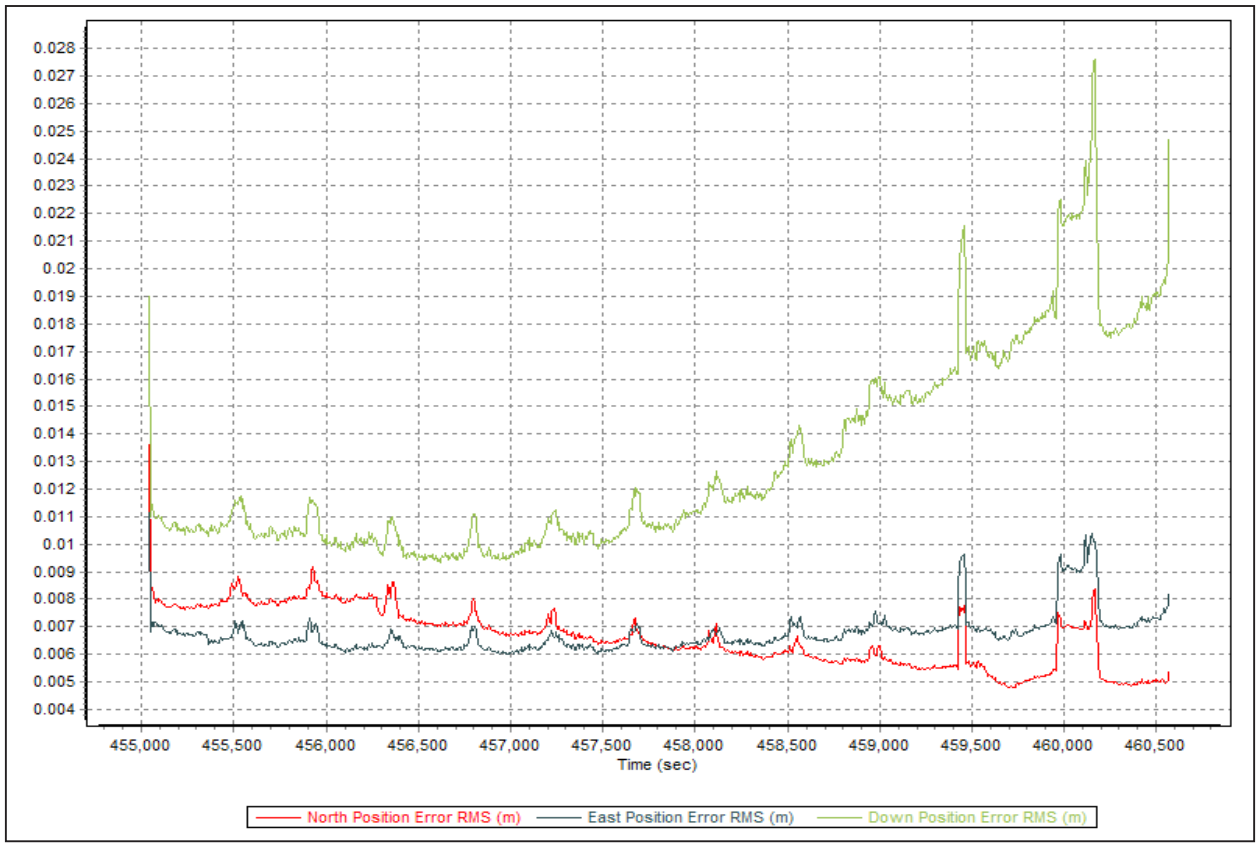


Figure A-8.36. Solution Status

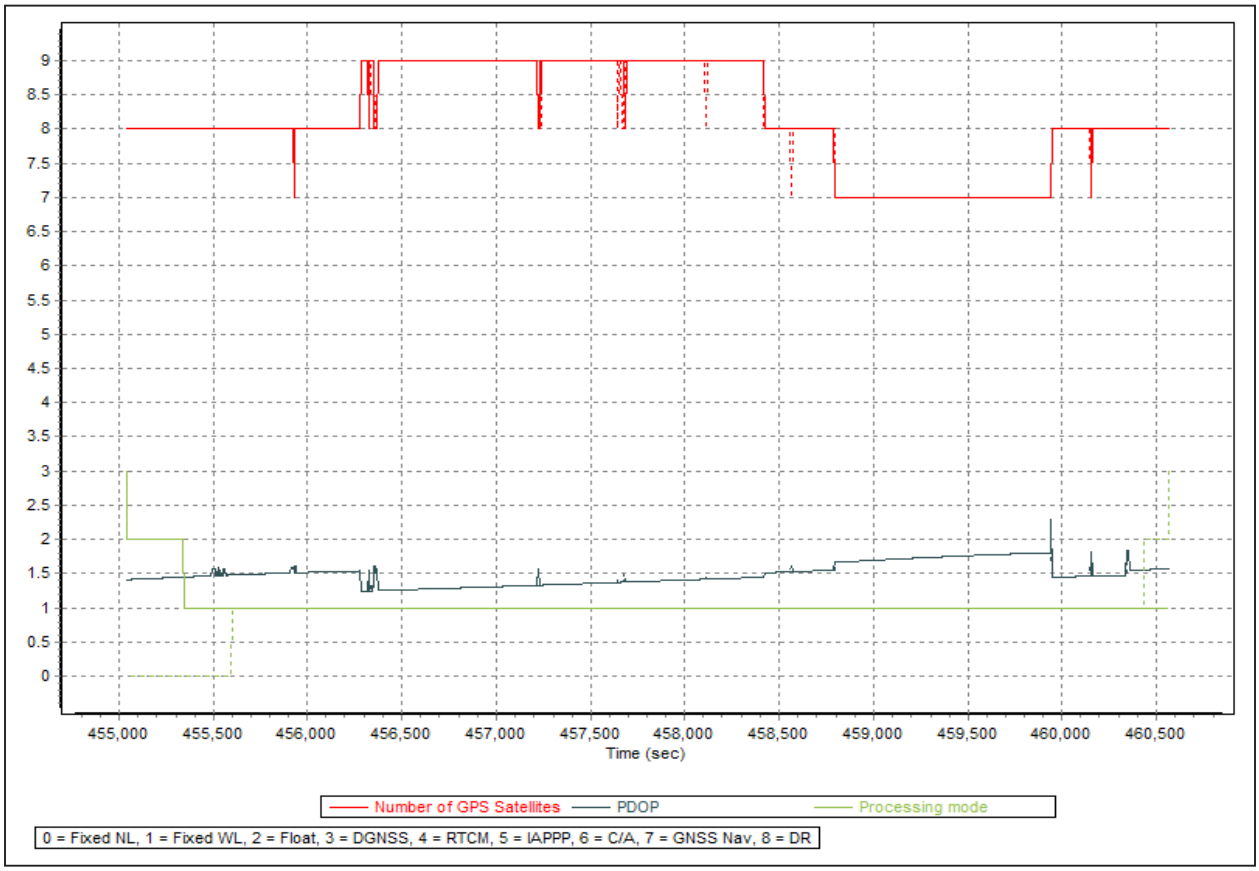


Figure A-8.37. Smoothed Performance Metric Parameters

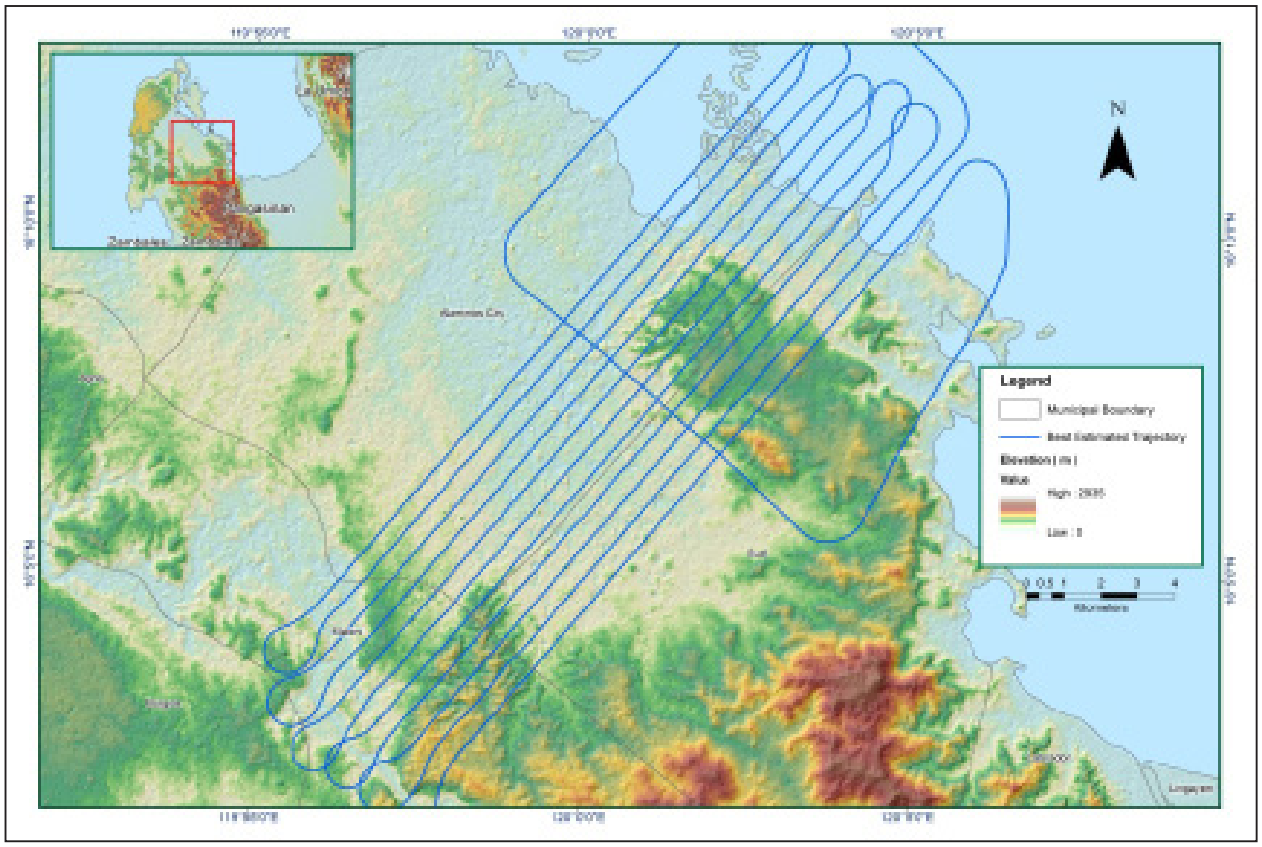


Figure A-8.38. Best Estimated Trajectory

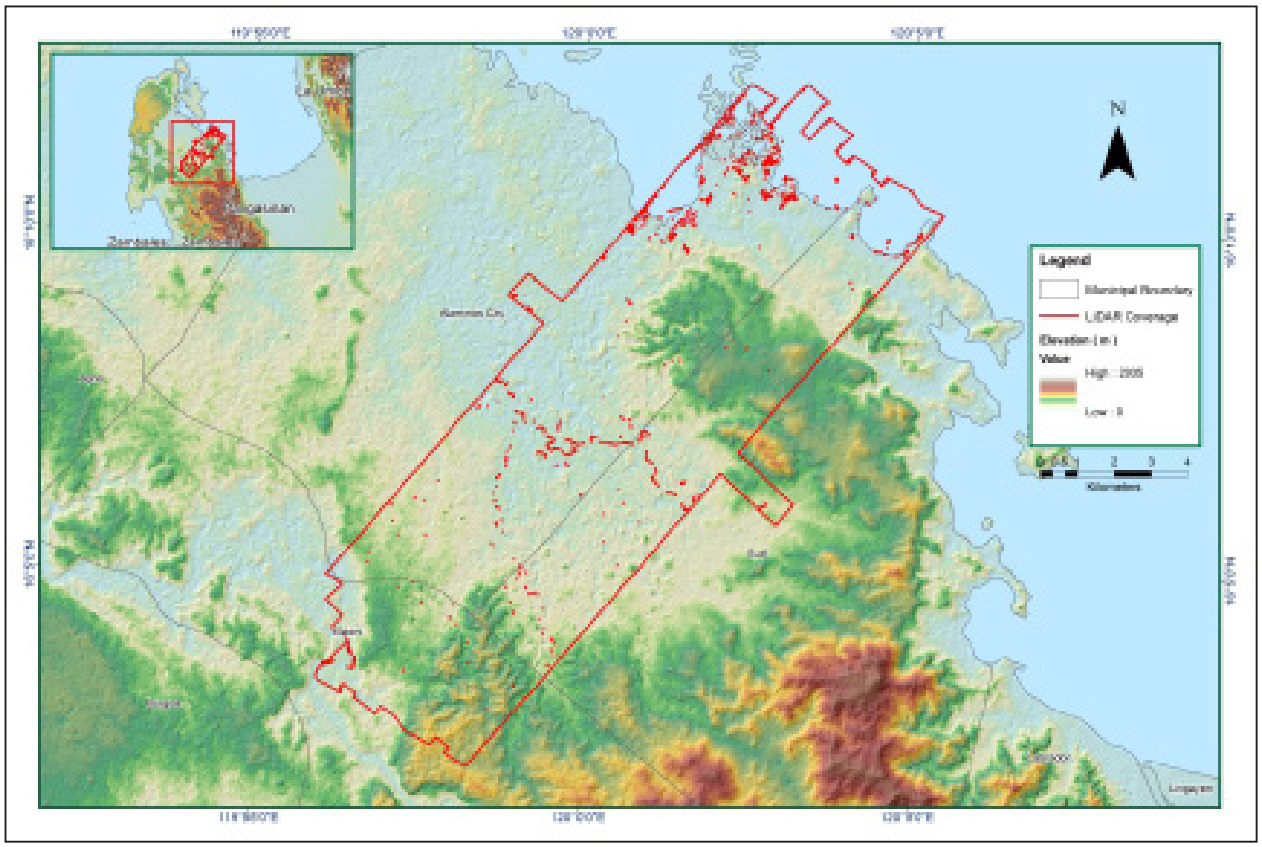


Figure A-8.39. Coverage of LiDAR data

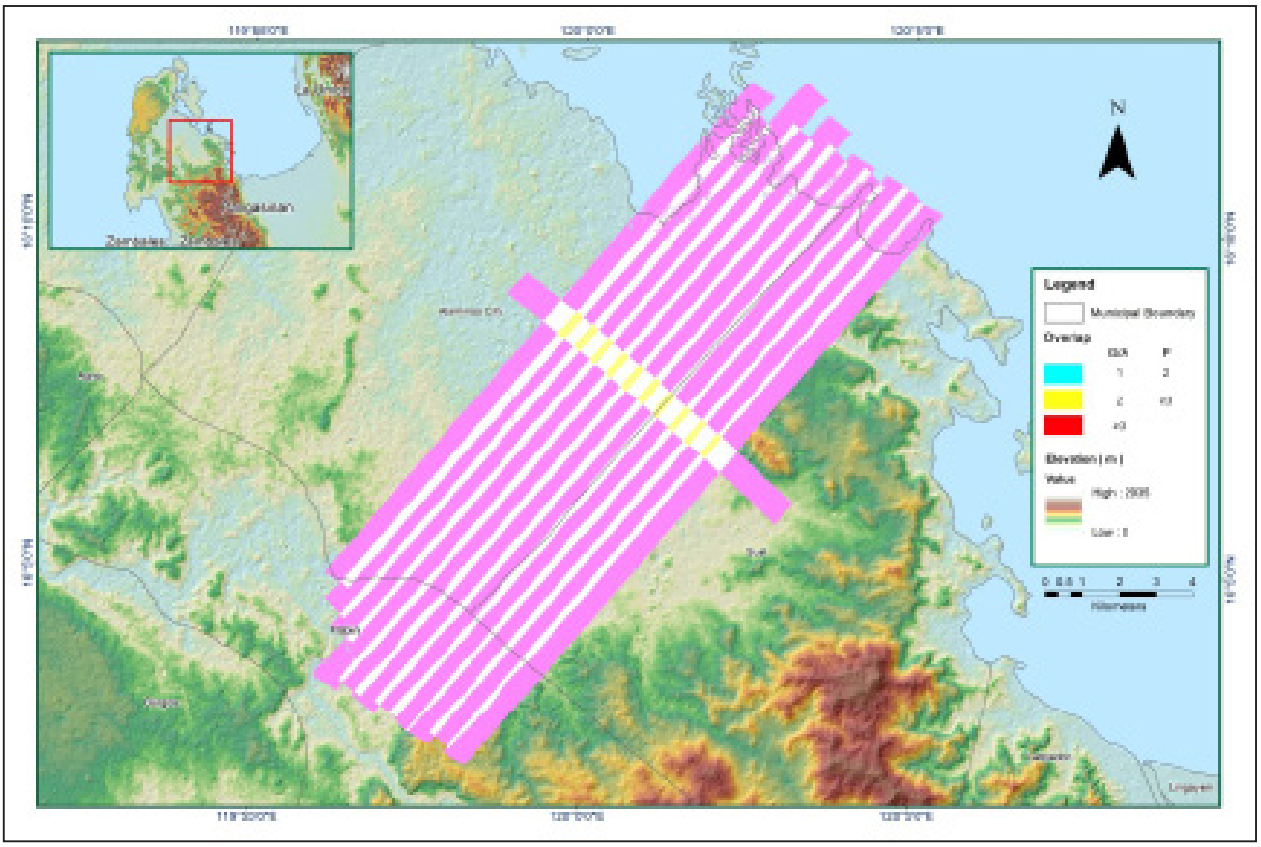


Figure A-8.40. Image of data overlap

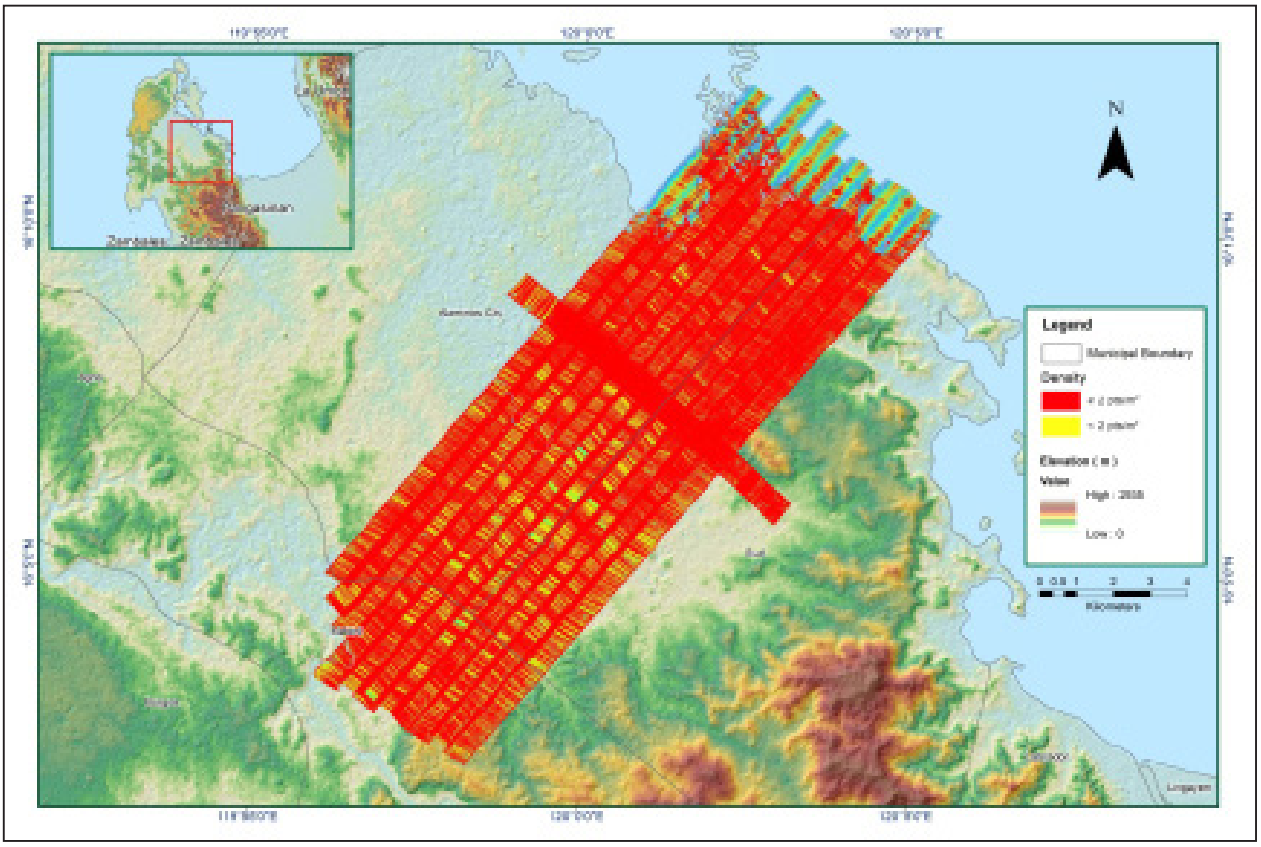


Figure A-8.41. Density map of merged LiDAR data

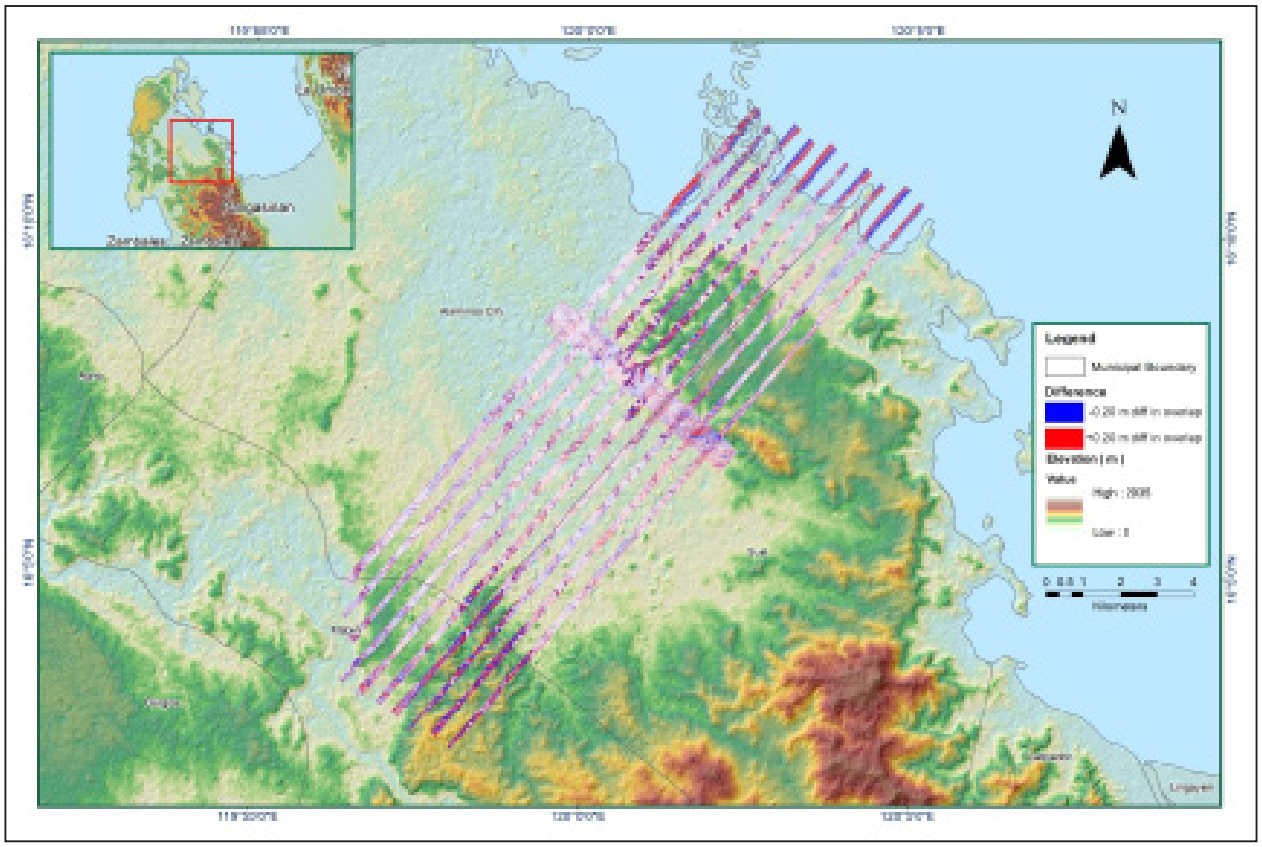


Figure A-8.42. Elevation difference between flight lines

Table A-8.7 Mission Summary Report for Blk12E

Flight Area	Pangasinan
Mission Name	Blk12E
Inclusive Flights	8538G
Range data size	14.2 GB
Base data size	10.8 MB
POS	150 MB
Image	NA
Transfer date	November 12, 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)	1.81
RMSE for East Position (<4.0 cm)	1.79
RMSE for Down Position (<8.0 cm)	5.00
Boresight correction stdev (<0.001deg)	0.000684
IMU attitude correction stdev (<0.001deg)	0.002518
GPS position stdev (<0.01m)	0.0024
Minimum % overlap (>25)	31.84
Ave point cloud density per sq.m. (>2.0)	3.55
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	160
Maximum Height	293.14 m
Minimum Height	39.06 m
Classification (# of points)	
Ground	104,106,905
Low vegetation	66,857,438
Medium vegetation	121,606,700
High vegetation	90,107,370
Building	1,063,706
Orthophoto	No
Processed by	Engr. Sheila Maye SantillanEngr. Edgardo Gubatanga, Marie Denise Bueno

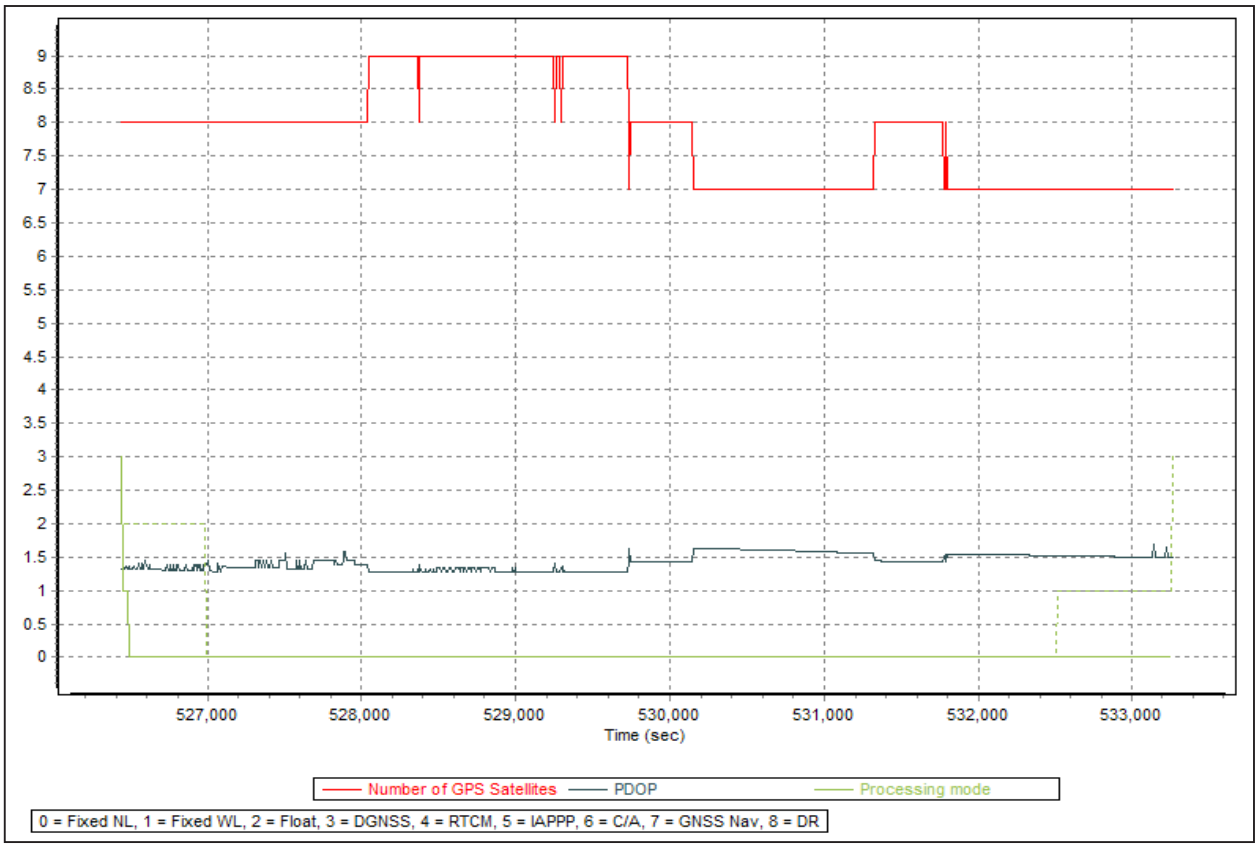


Figure A-8.43. Solution Status

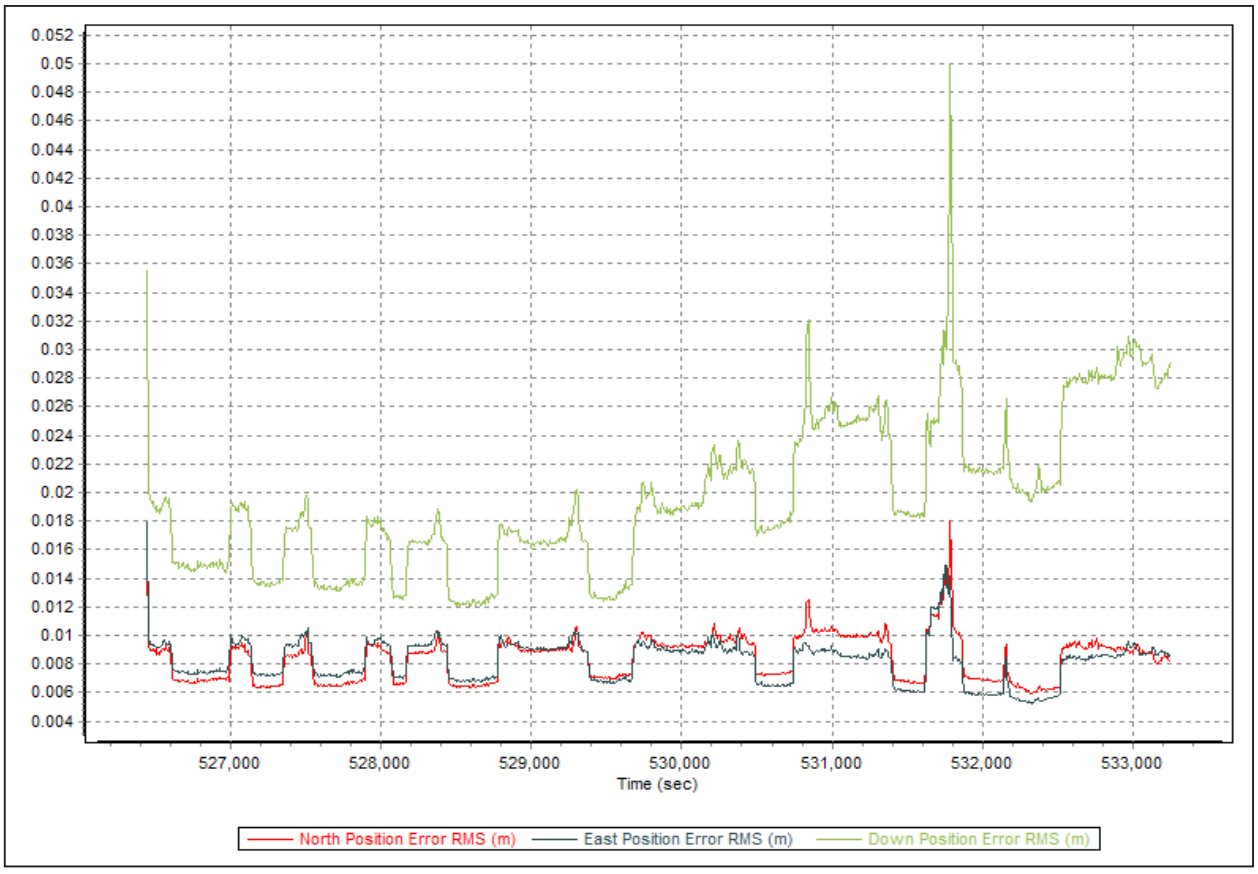


Figure A-8.44. Smoothed Performance Metric Parameters

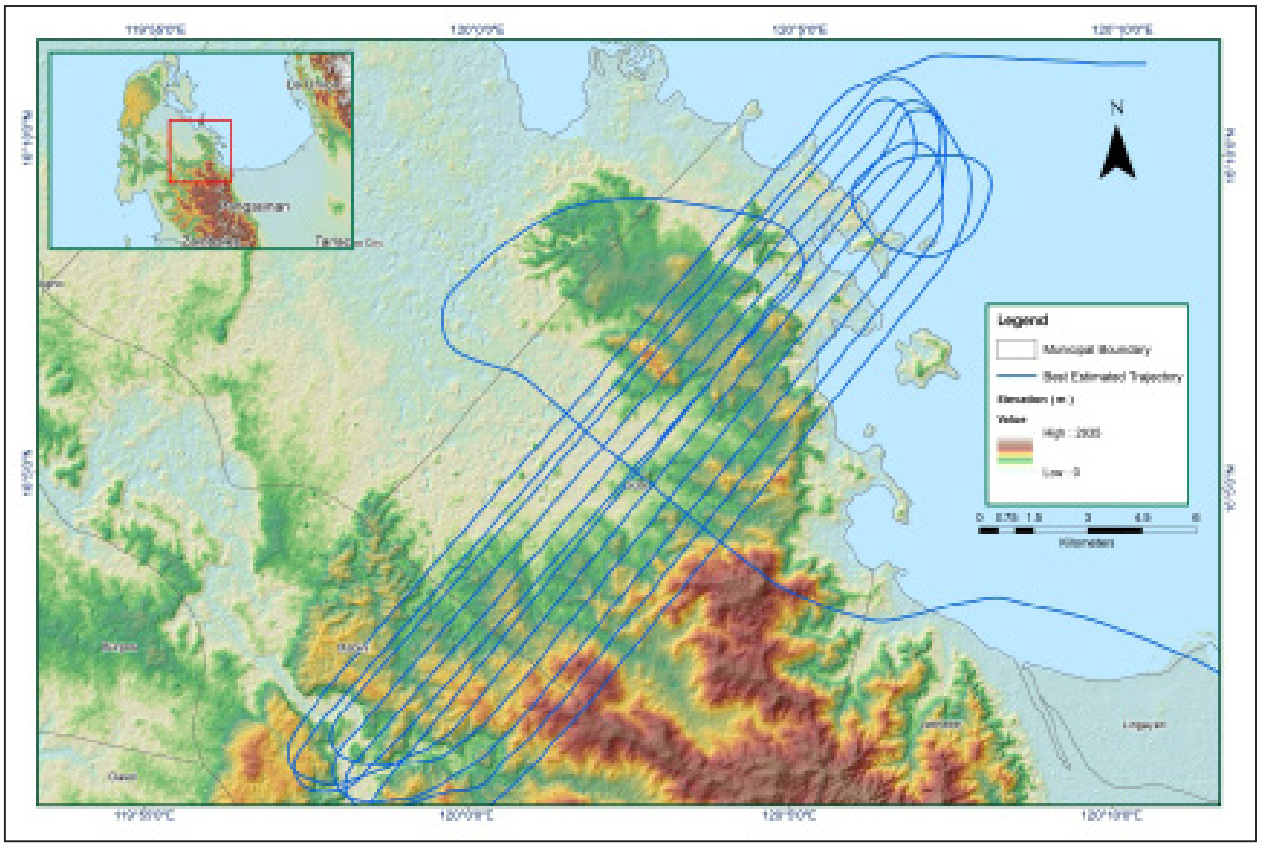


Figure A-8.45. Best Estimated Trajectory

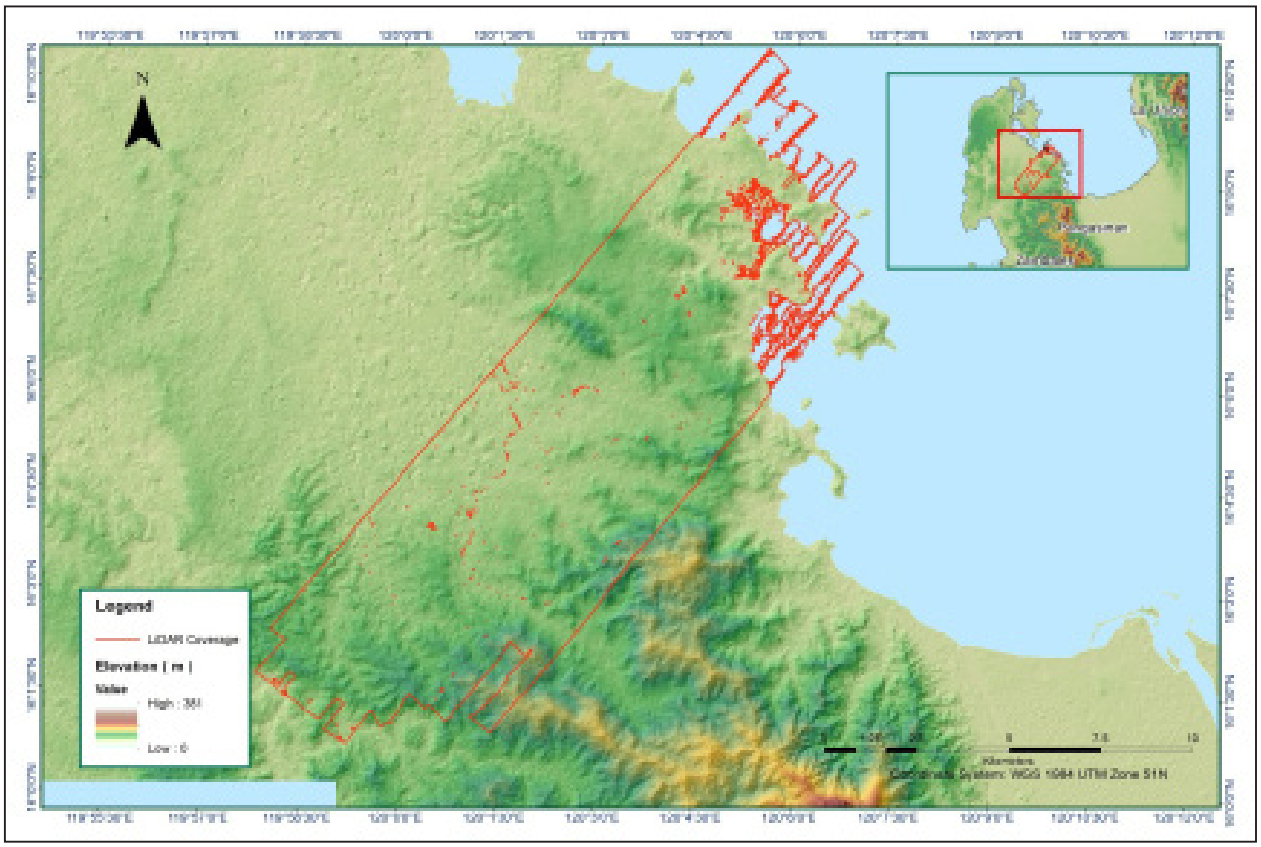


Figure A-8.46. Coverage of LiDAR data

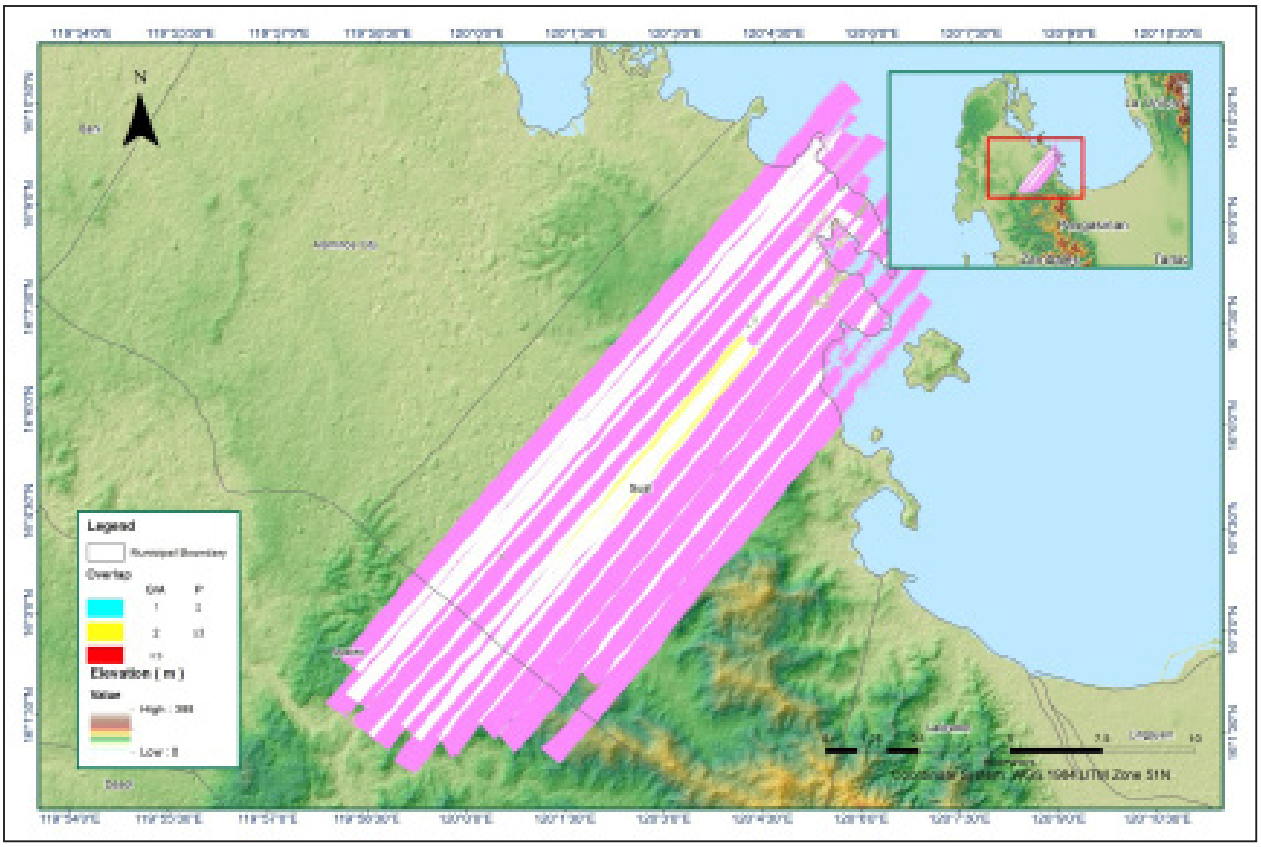


Figure A-8.47. Image of data overlap

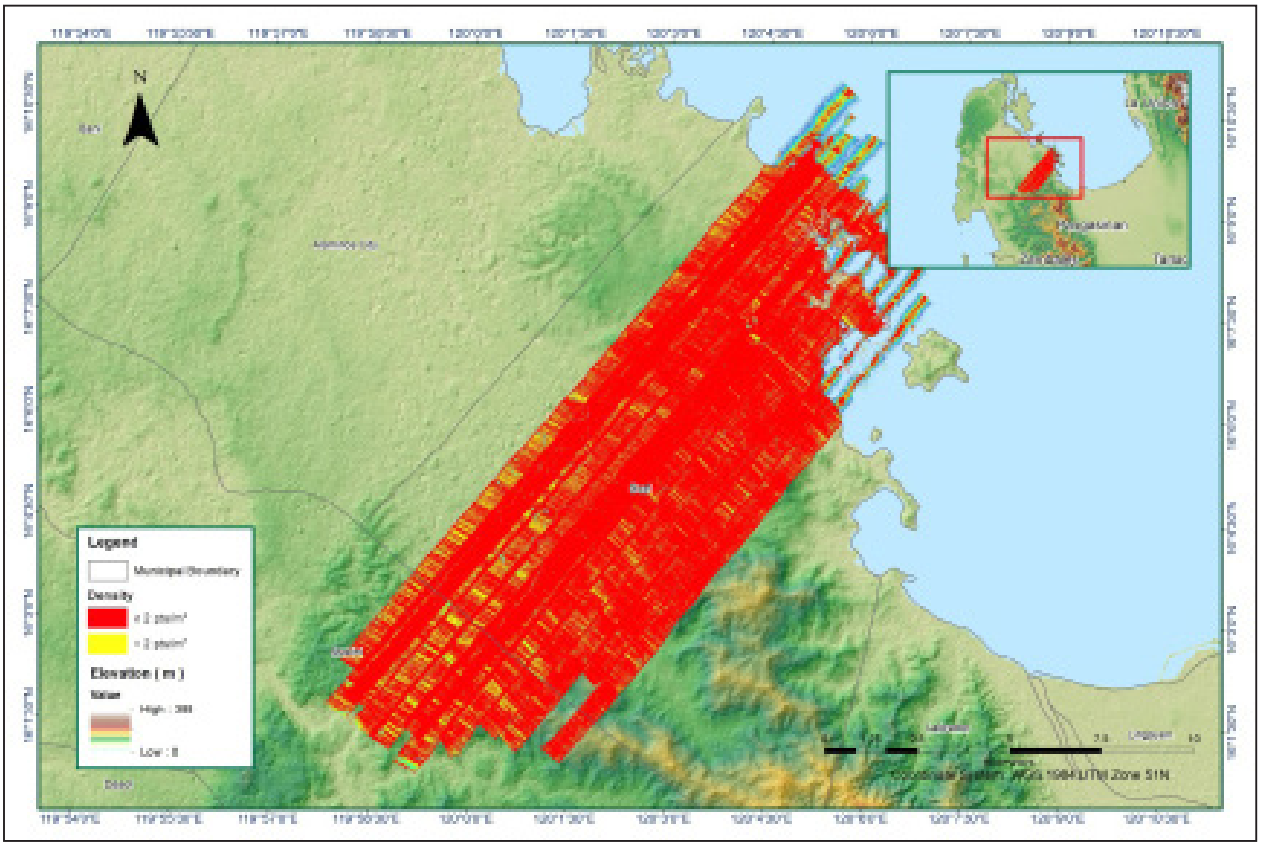


Figure A-8.48. Density map of merged LiDAR data

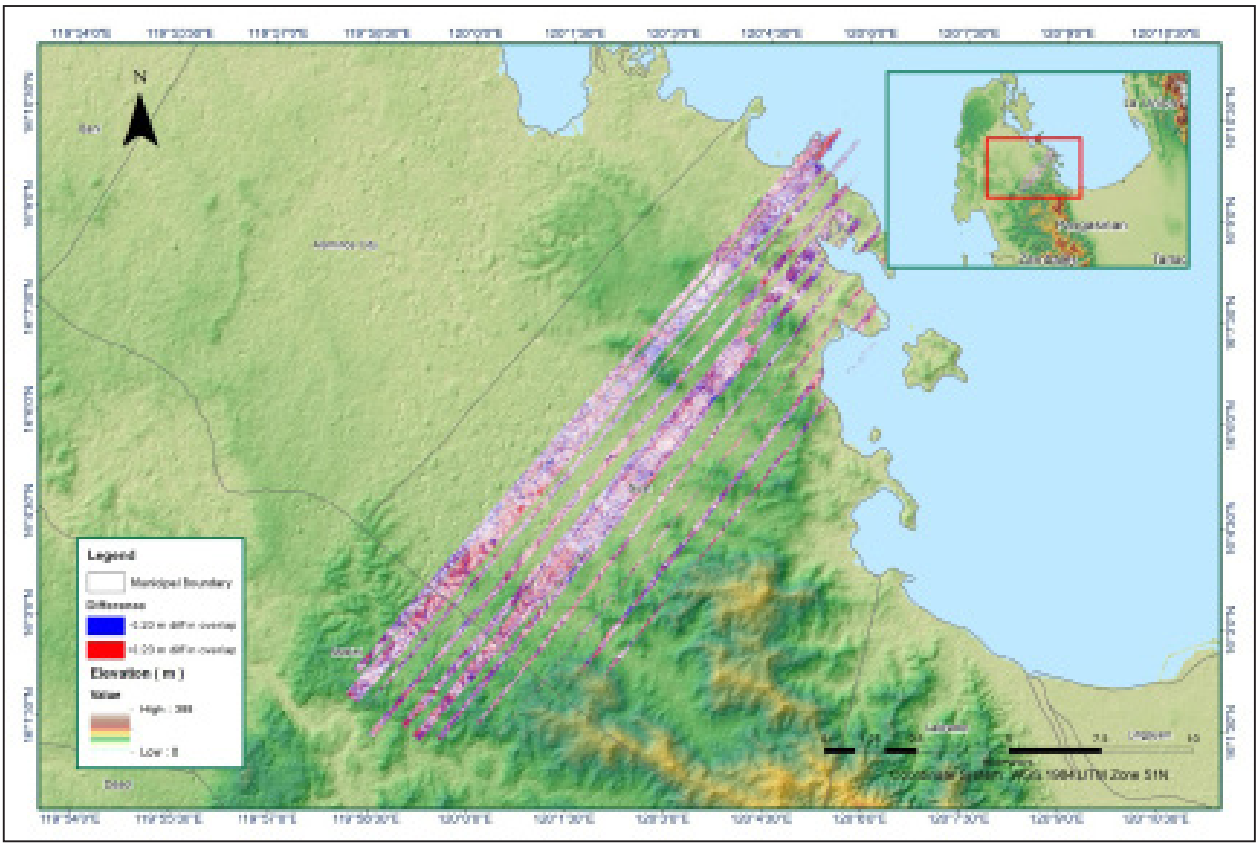


Figure A-8.49. Elevation difference between flight lines

Table A-8.8 Mission Summary Report for Blk12F

Flight Area	Pangasinan
Mission Name	Blk12F
Inclusive Flights	8539G
Range data size	8.69 GB
Base data size	10.8 MB
POS	85.2 MB
Image	NA
Transfer date	November 12, 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)	1.47
RMSE for East Position (<4.0 cm)	1.71
RMSE for Down Position (<8.0 cm)	3.67
Boresight correction stdev (<0.001deg)	0.000634
IMU attitude correction stdev (<0.001deg)	0.000934
GPS position stdev (<0.01m)	0.0117
Minimum % overlap (>25)	24.61
Ave point cloud density per sq.m. (>2.0)	3.63
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	61
Maximum Height	441.37 m
Minimum Height	23.57 m
Classification (# of points)	
Ground	19,060,189
Low vegetation	13,954,097
Medium vegetation	42,198,982
High vegetation	49,211,130
Building	676,843
Orthophoto	No
Processed by	Engr. Jennifer Saguran, Engr. Harmond Santos, Kathryn Claudine Zarate

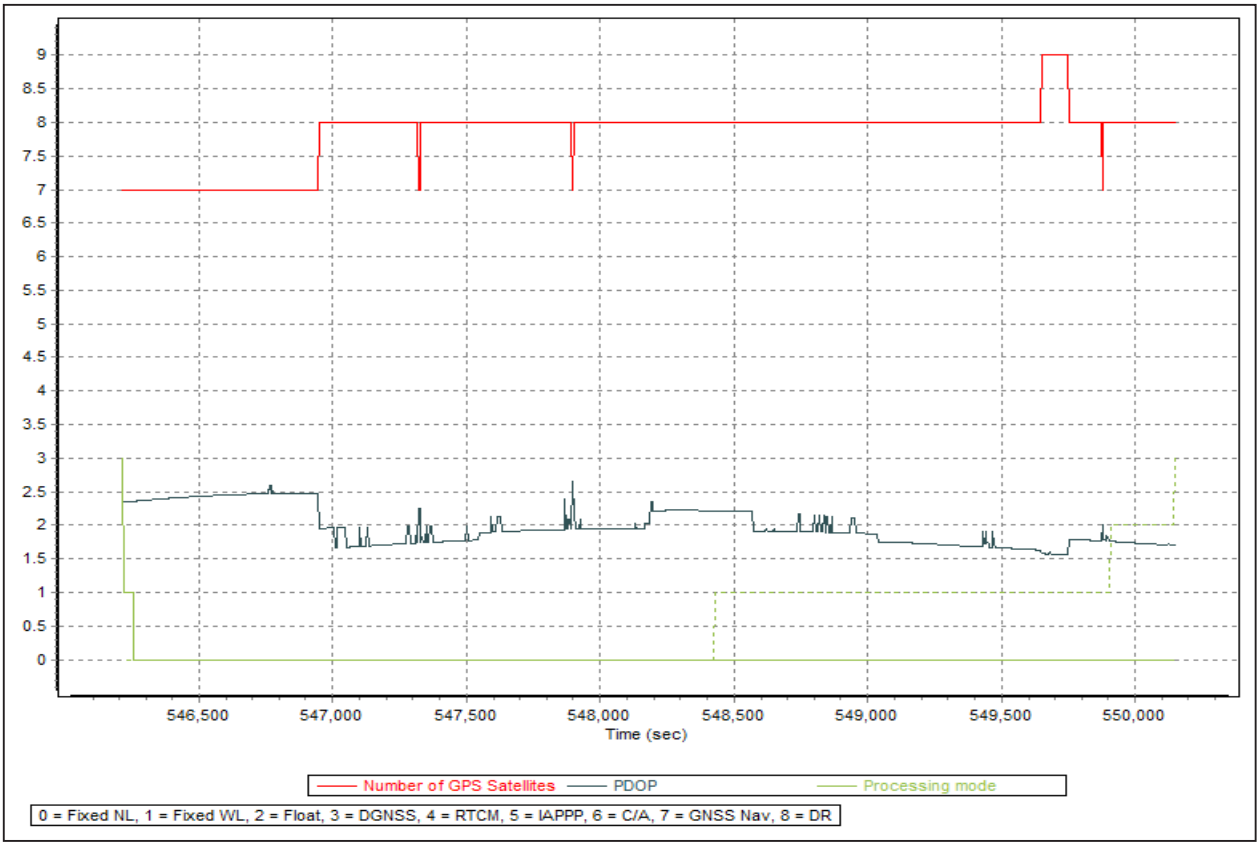


Figure A-8.50. Solution Status

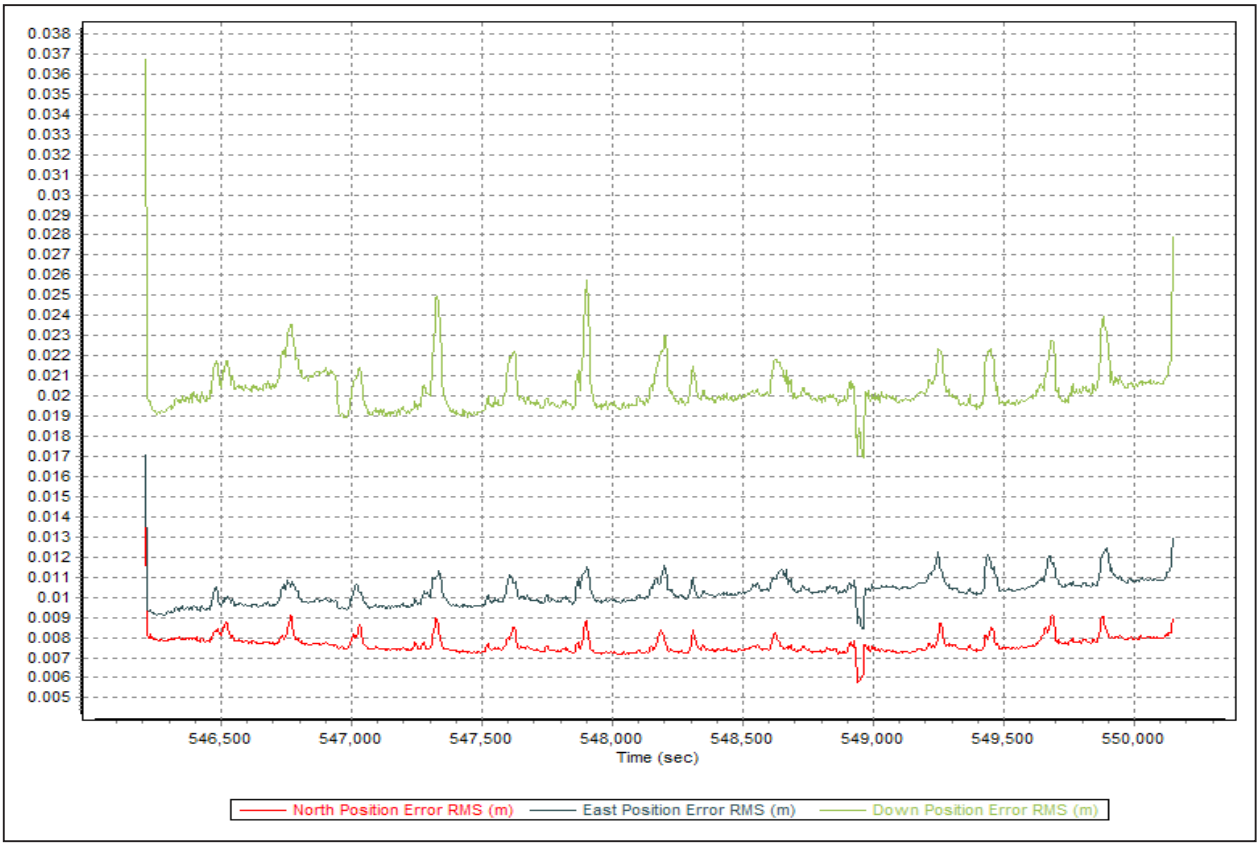


Figure A-8.51. Smoothed Performance Metric Parameters

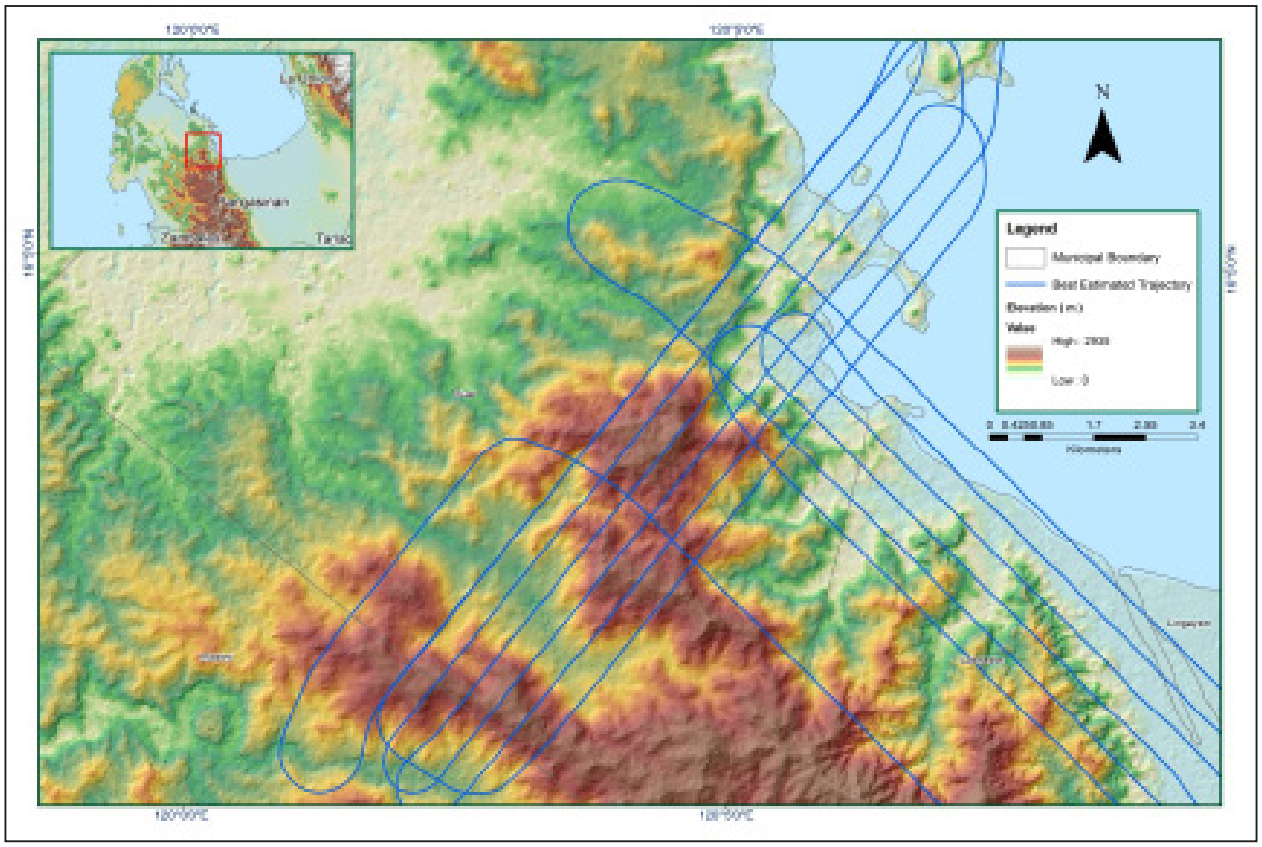


Figure A-8.52. Best Estimated Trajectory

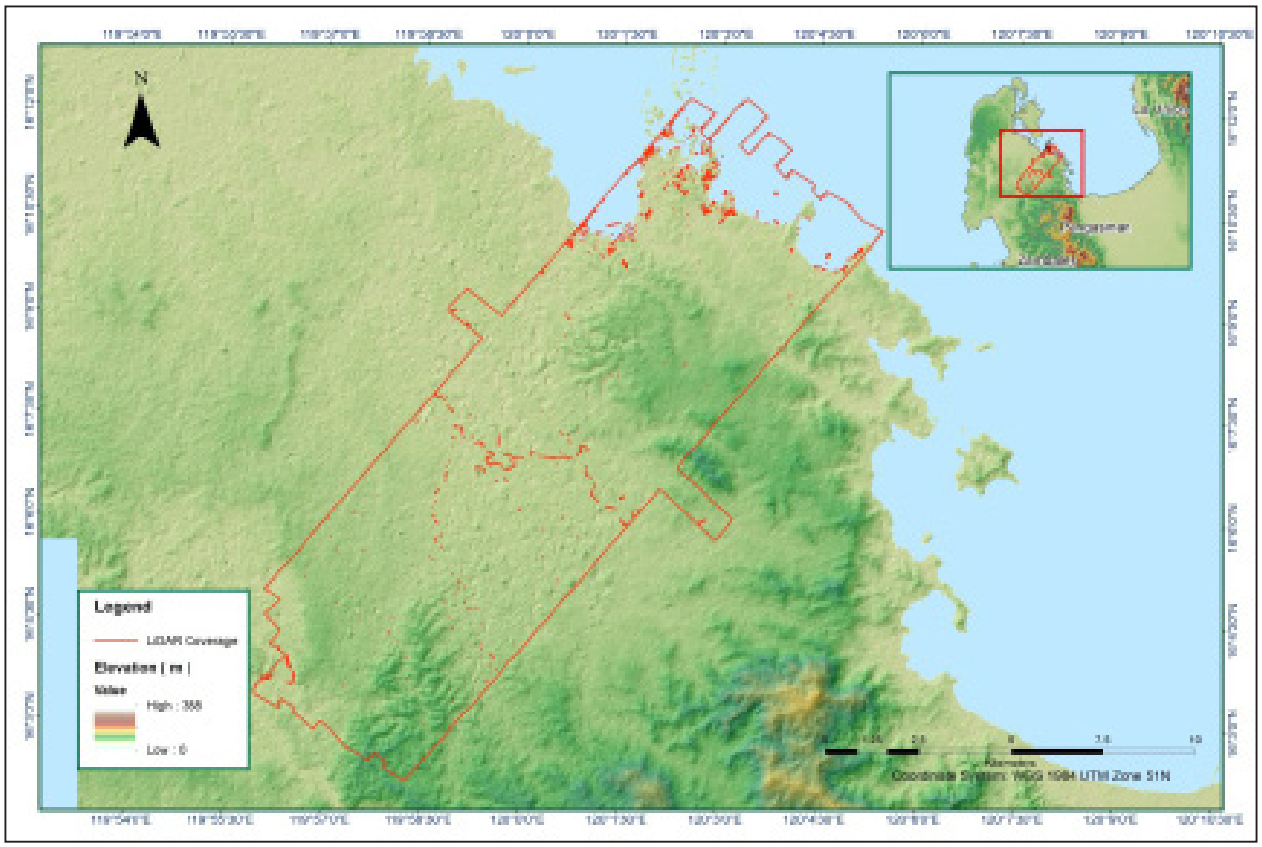


Figure A-8.53. Coverage of LiDAR data

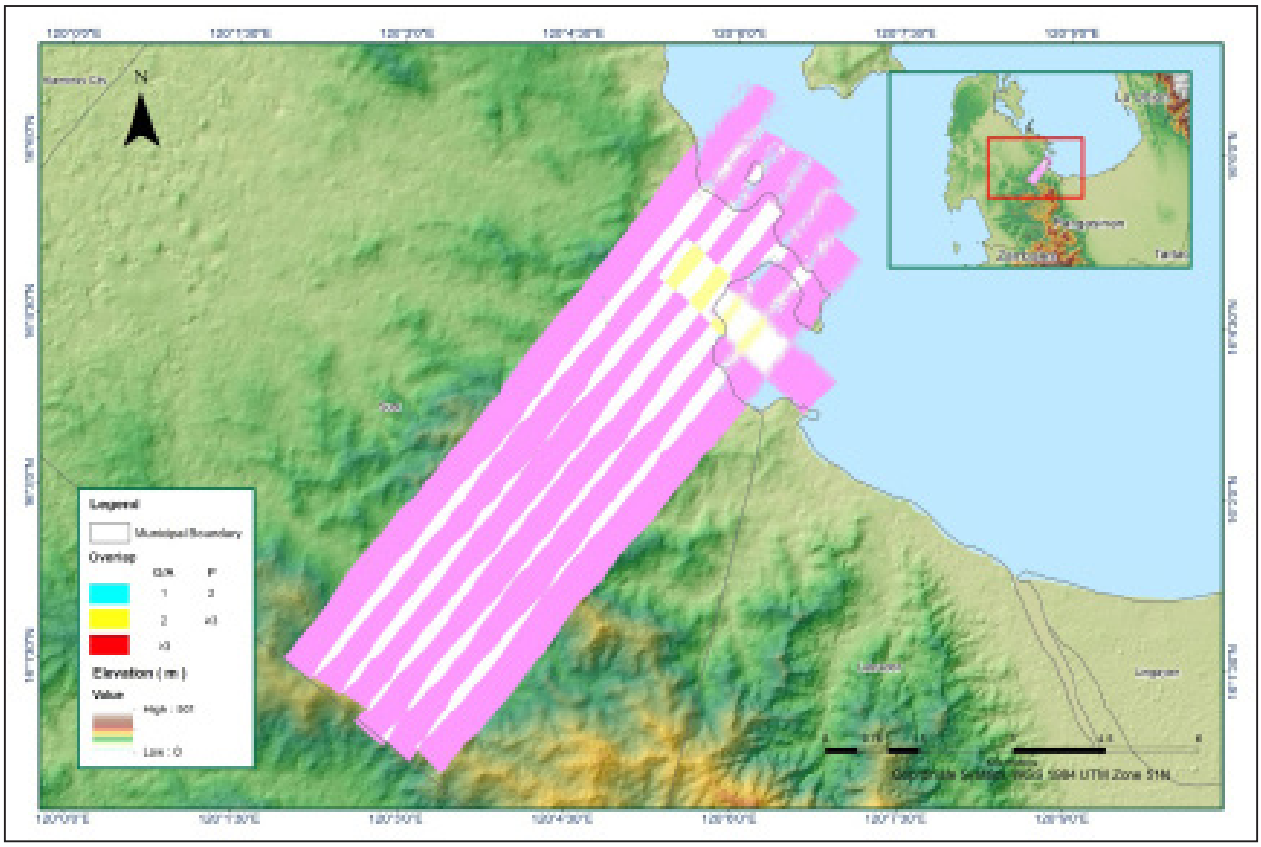


Figure A-8.54. Image of data overlap

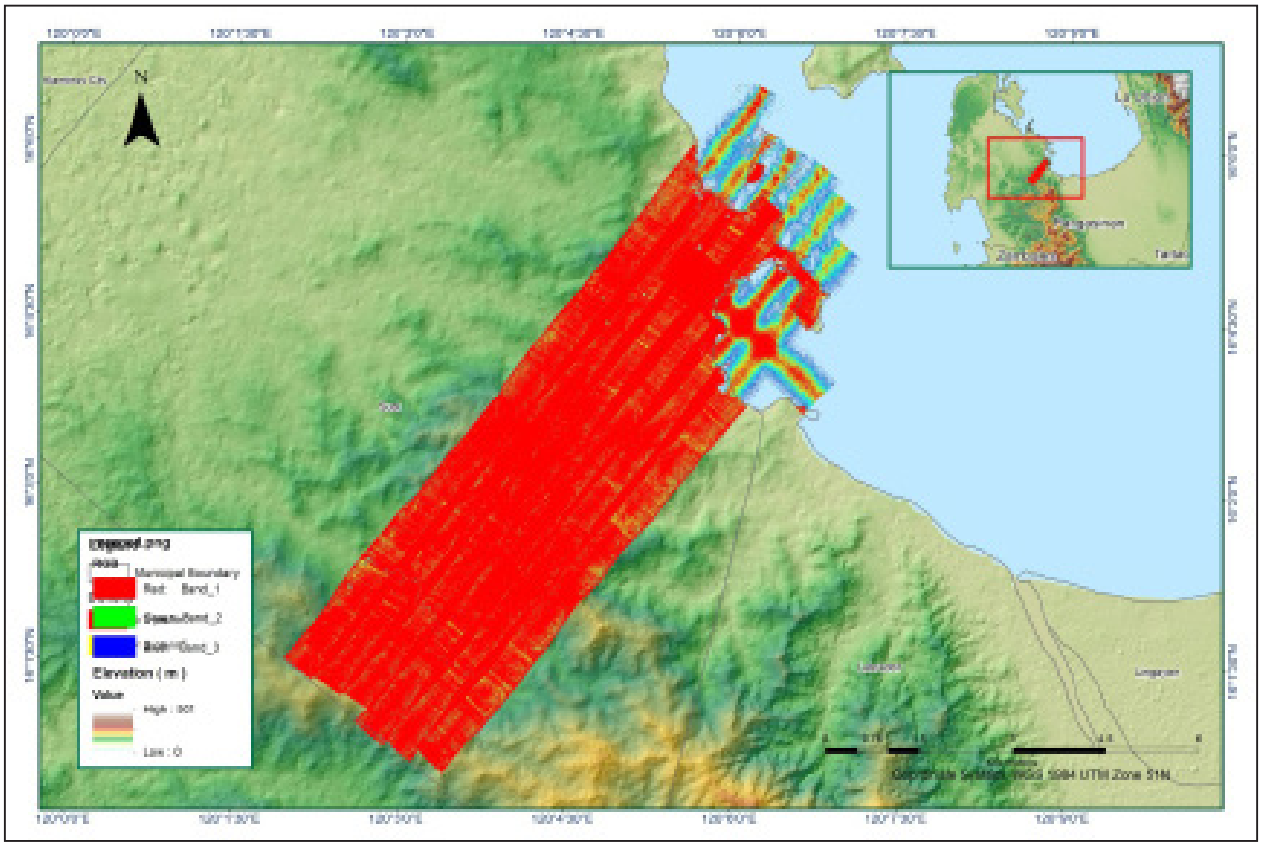


Figure A-8.55. Density map of merged LiDAR data

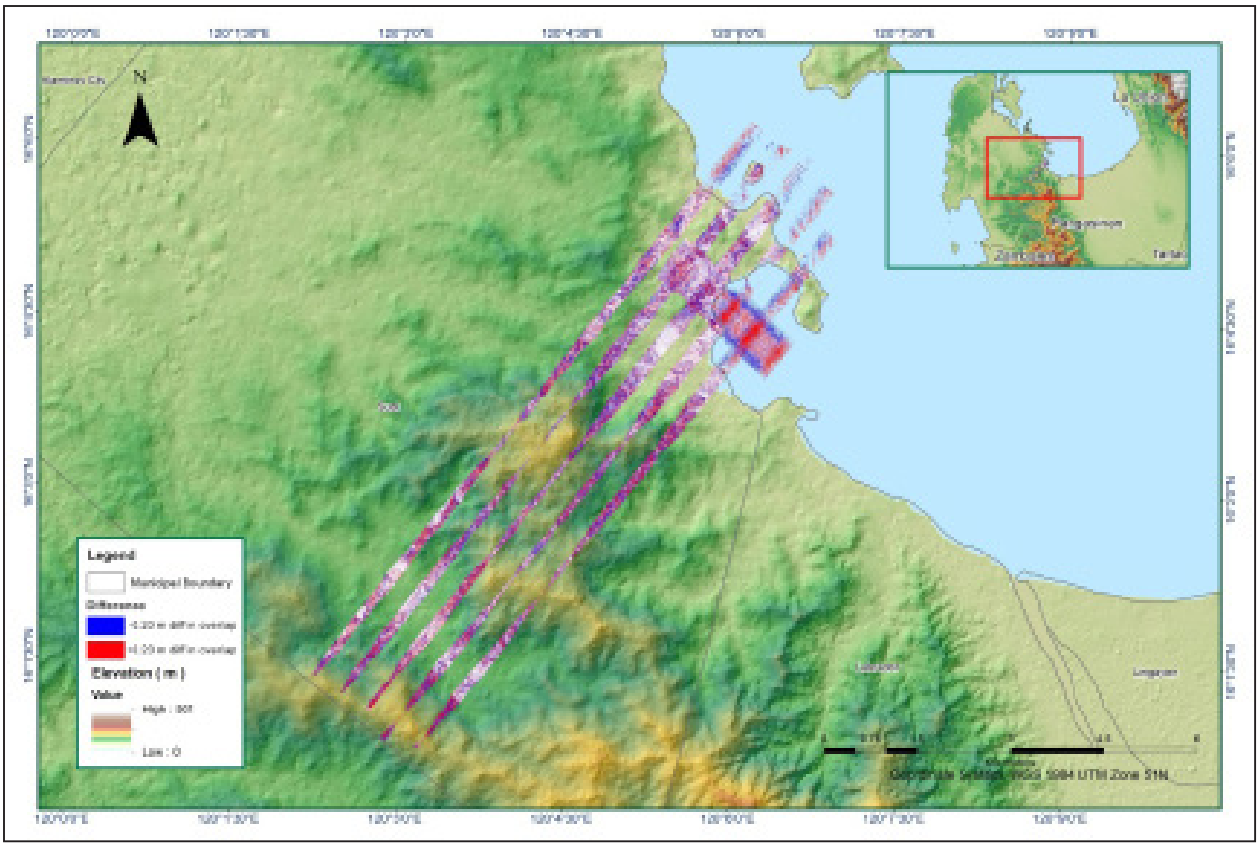


Figure A-8.56. Elevation difference between flight lines

Table A-8.9 Mission Summary Report for Blk12G

Flight Area	Pangasinan
Mission Name	Blk12G
Inclusive Flights	8539G
Range data size	8.69 GB
Base data size	6.6 MB
POS	85.2 MB
Image	NA
Transfer date	November 12, 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)	1.47
RMSE for East Position (<4.0 cm)	1.71
RMSE for Down Position (<8.0 cm)	3.67
Boresight correction stdev (<0.001deg)	0.000547
IMU attitude correction stdev (<0.001deg)	0.000934
GPS position stdev (<0.01m)	0.002588
Minimum % overlap (>25)	27.68
Ave point cloud density per sq.m. (>2.0)	3.45
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	82
Maximum Height	294.81 m
Minimum Height	42.16 m
Classification (# of points)	
Ground	30,490,738
Low vegetation	14,316,126
Medium vegetation	45,617,908
High vegetation	43,164,423
Building	1,136,023
Ortophoto	No
Processed by	Engr. Jennifer Saguran, Engr.Mark Joshua Salvacion, Engr. Elainne Lopez

Figure A-8.57. Solution Status

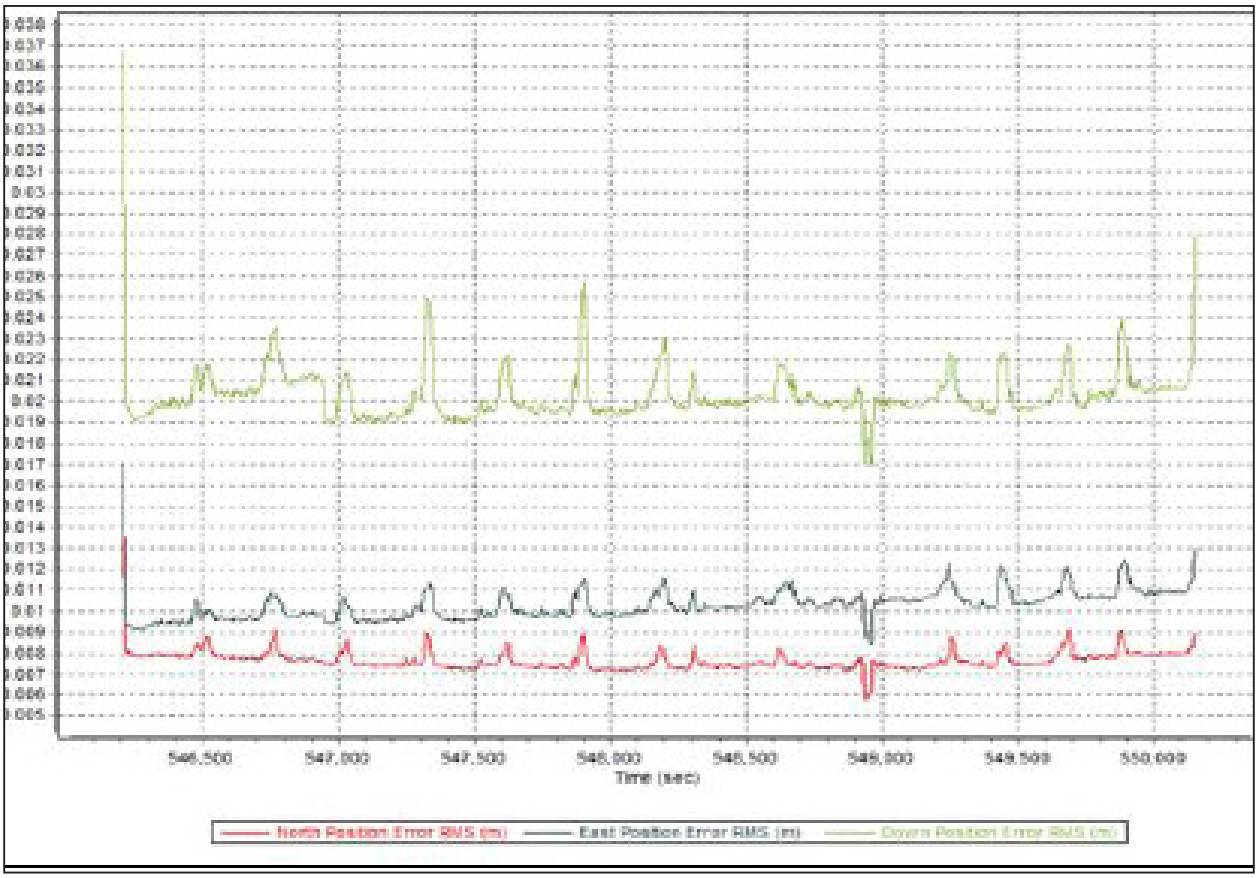


Figure A-8.58. Smoothed Performance Metric Parameters

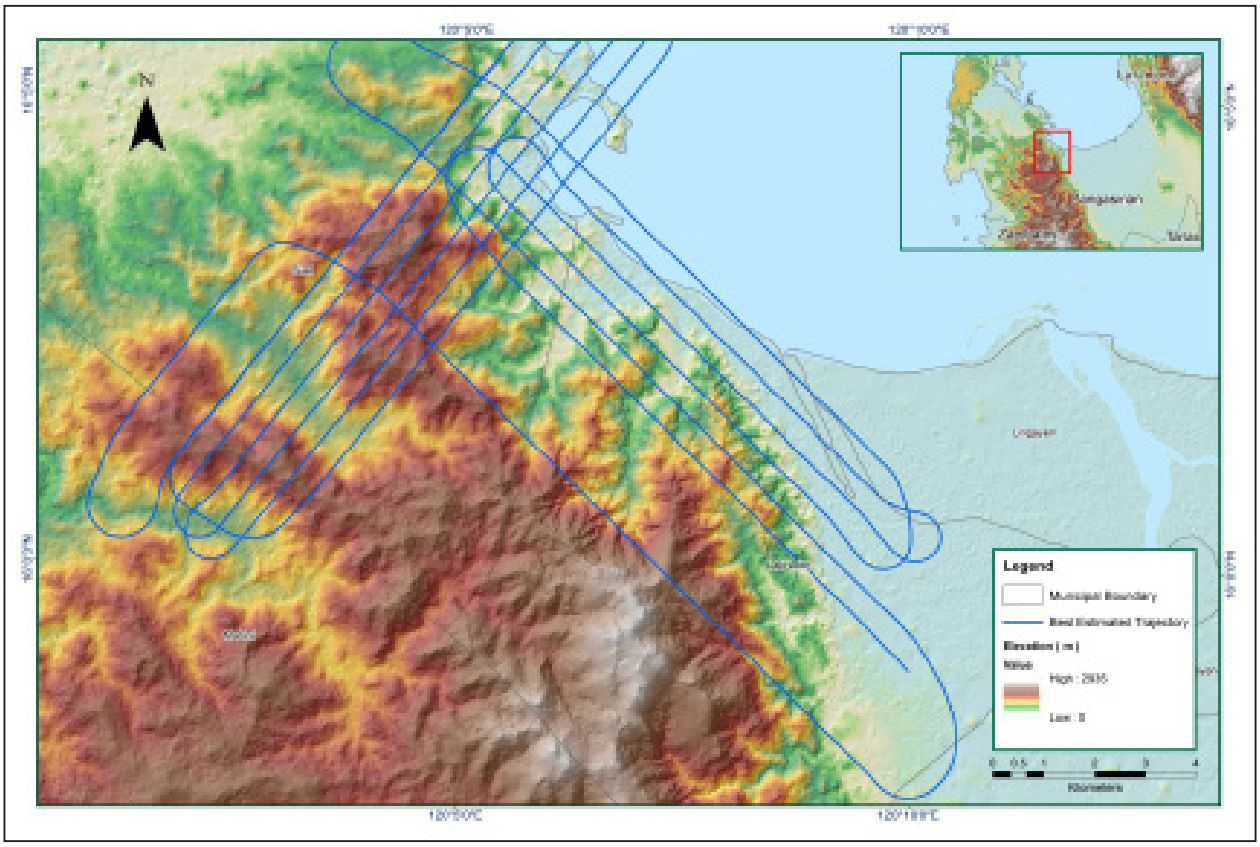


Figure A-8.59. Best Estimated Trajectory

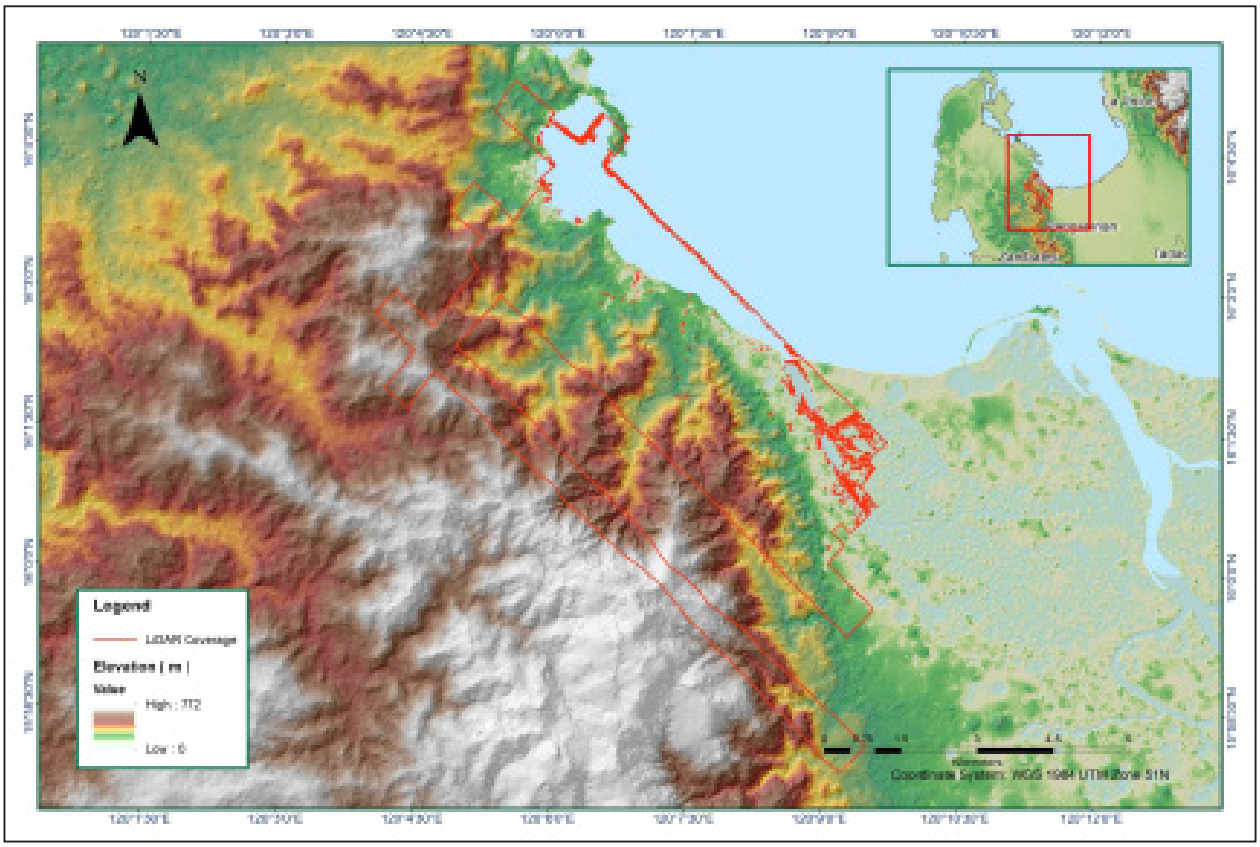


Figure A-8.60. Coverage of LiDAR data

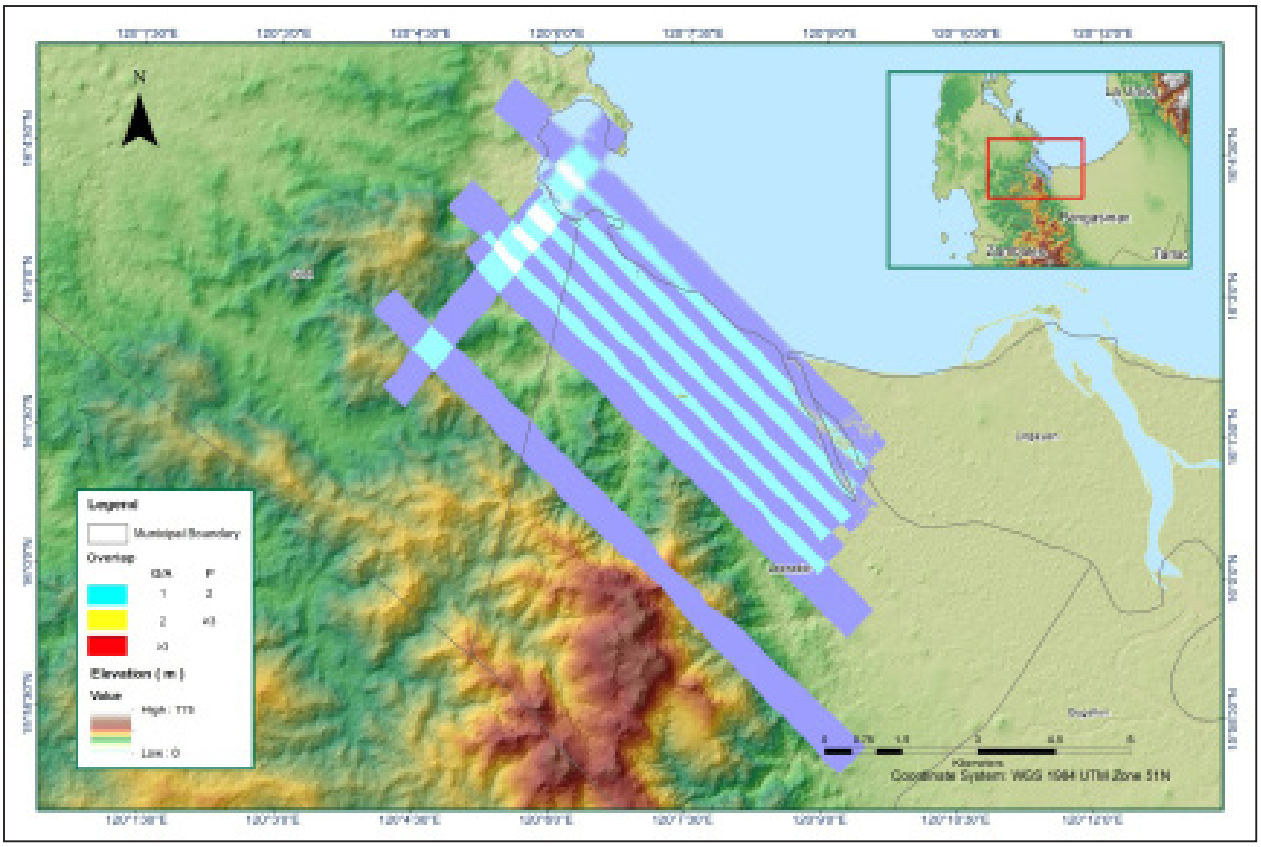


Figure A-8.61. Image of data overlap

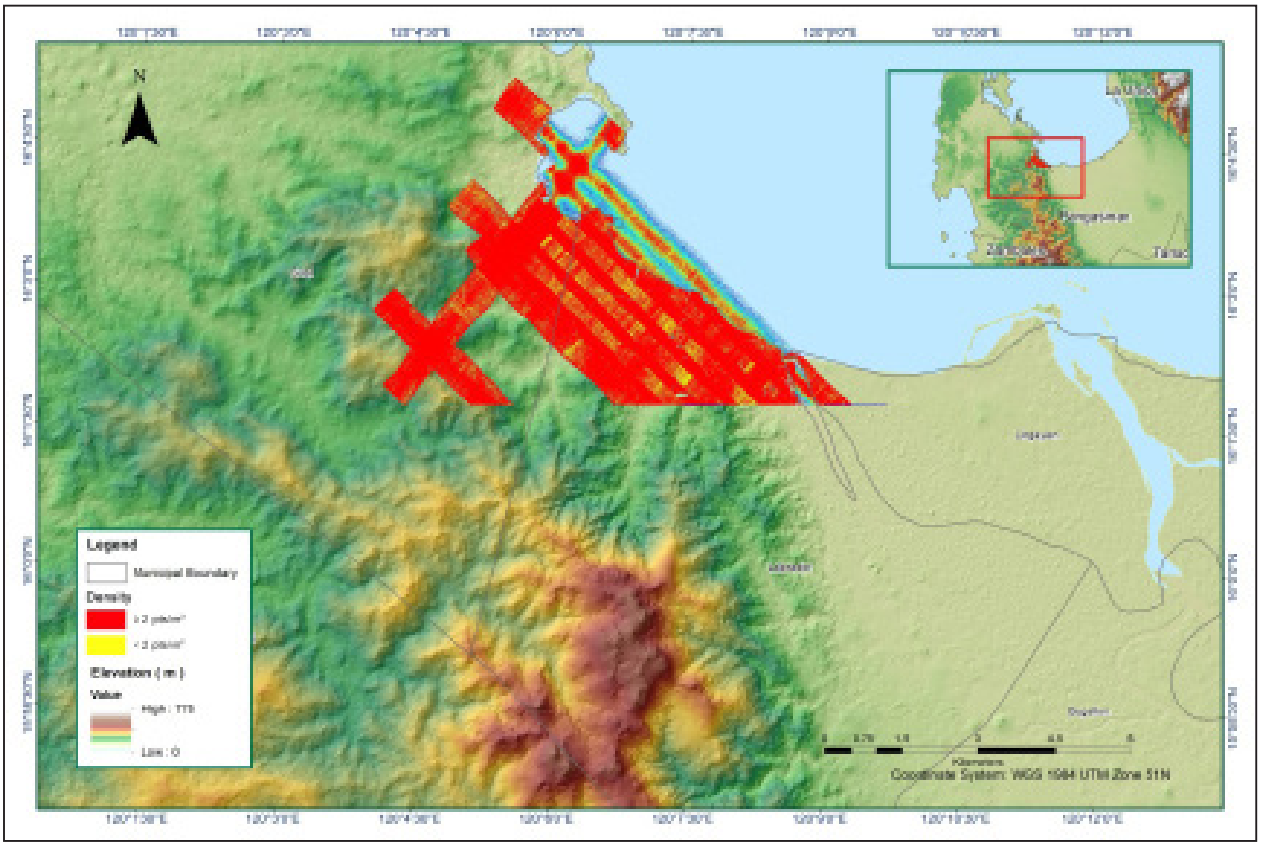


Figure A-8.62. Density map of merged LiDAR data

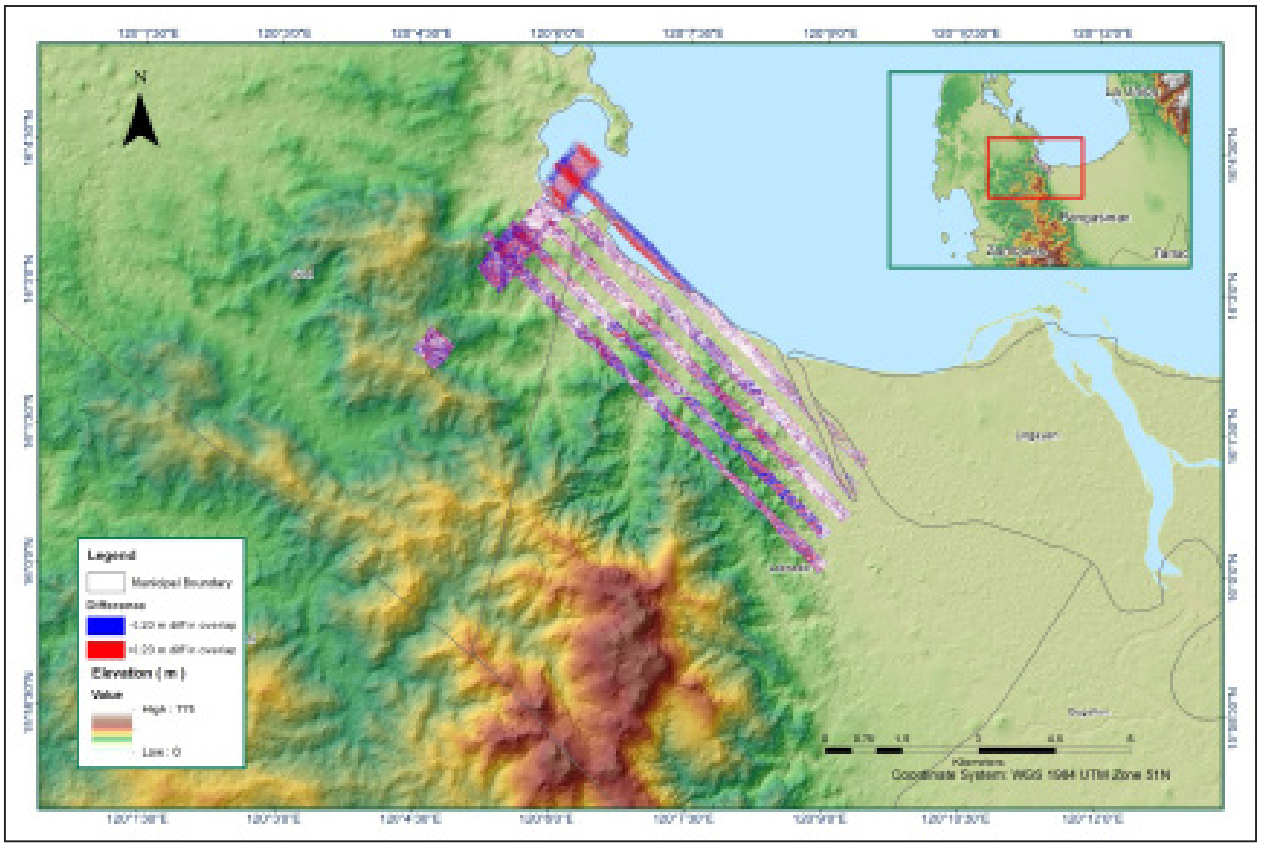


Figure A-8.63. Elevation difference between flight lines

Table A-8.10 Mission Summary Report for Agno_Blk5H_Reflights

Flight Area	Pam_Agno
Mission Name	Agno_Blk5H_Reflights
Inclusive Flights	7266G
Range data size	14.7 GB
Base data size	11.3 MB
POS	223 MB
Image	NA
Transfer date	May 24, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	2.21
RMSE for East Position (<4.0 cm)	3.16
RMSE for Down Position (<8.0 cm)	5.68
Boresight correction stdev (<0.001deg)	Yes
IMU attitude correction stdev (<0.001deg)	No
GPS position stdev (<0.01m)	No
Minimum % overlap (>25)	17.03%
Ave point cloud density per sq.m. (>2.0)	4.08
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	49
Maximum Height	434.34 m
Minimum Height	45.90 m
Classification (# of points)	
Ground	11,720,236
Low vegetation	11,820,837
Medium vegetation	66,060,507
High vegetation	32,085,532
Building	104,630
Ortophoto	No
Processed by	Engr. AnalynNaldo, Engr. Melanie Hingpit, Engr. Elainne Lopez

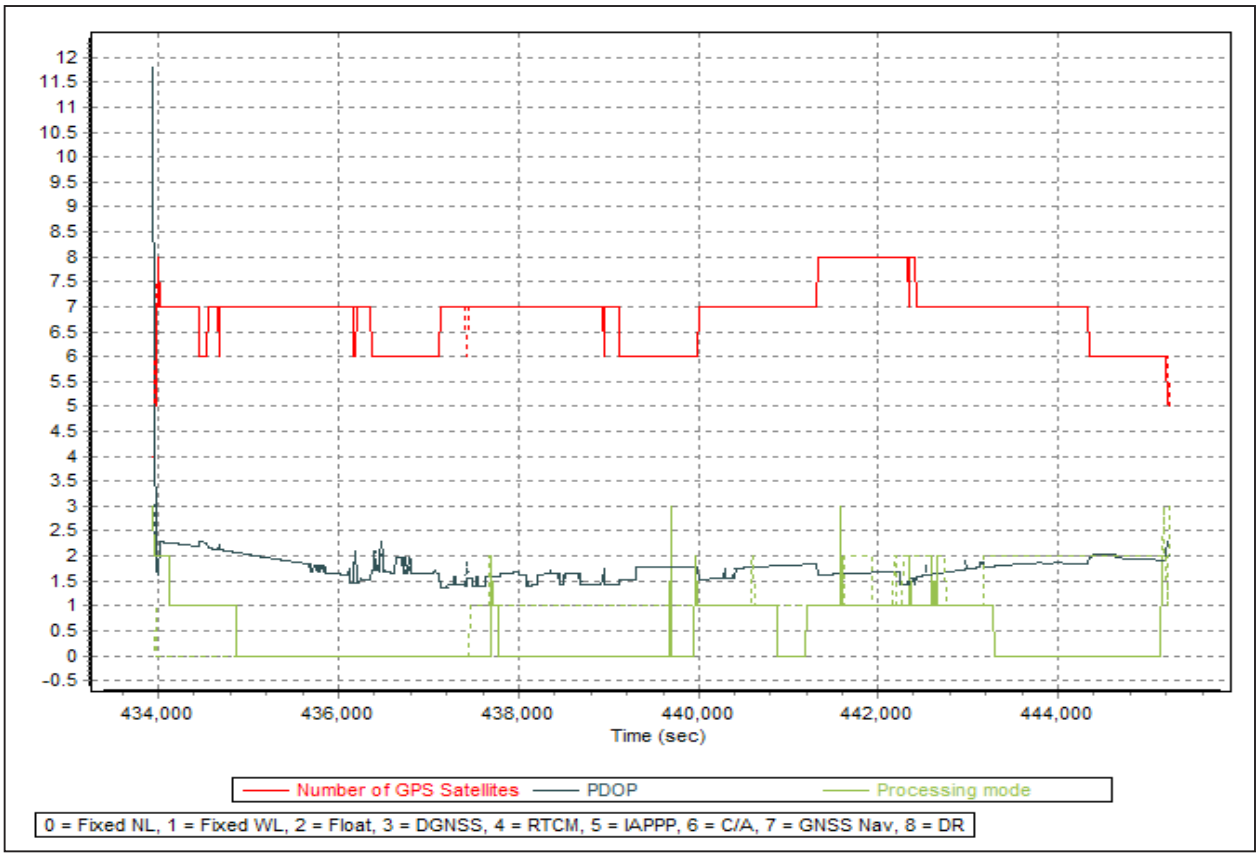


Figure A-8.64. Solution Status

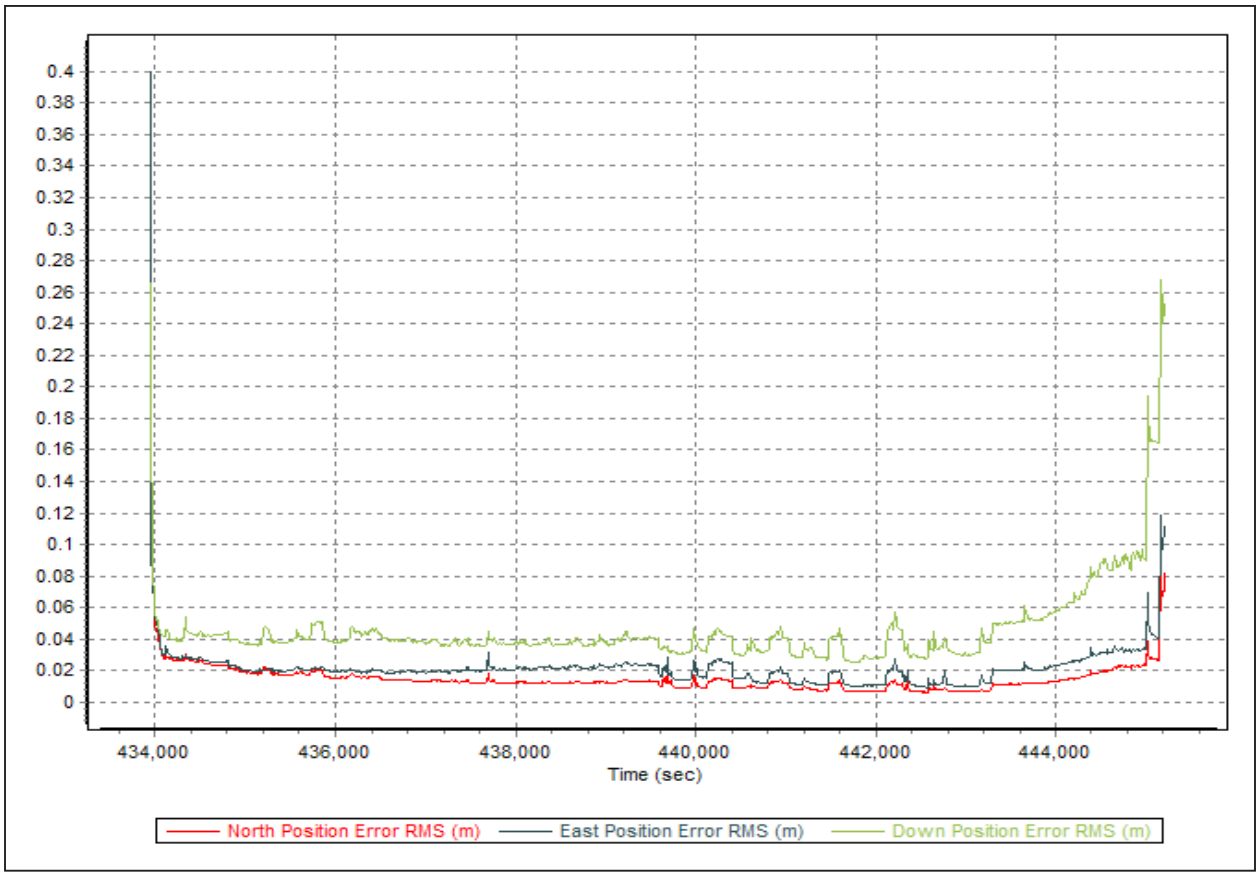


Figure A-8.65. Smoothed Performance Metric Parameters

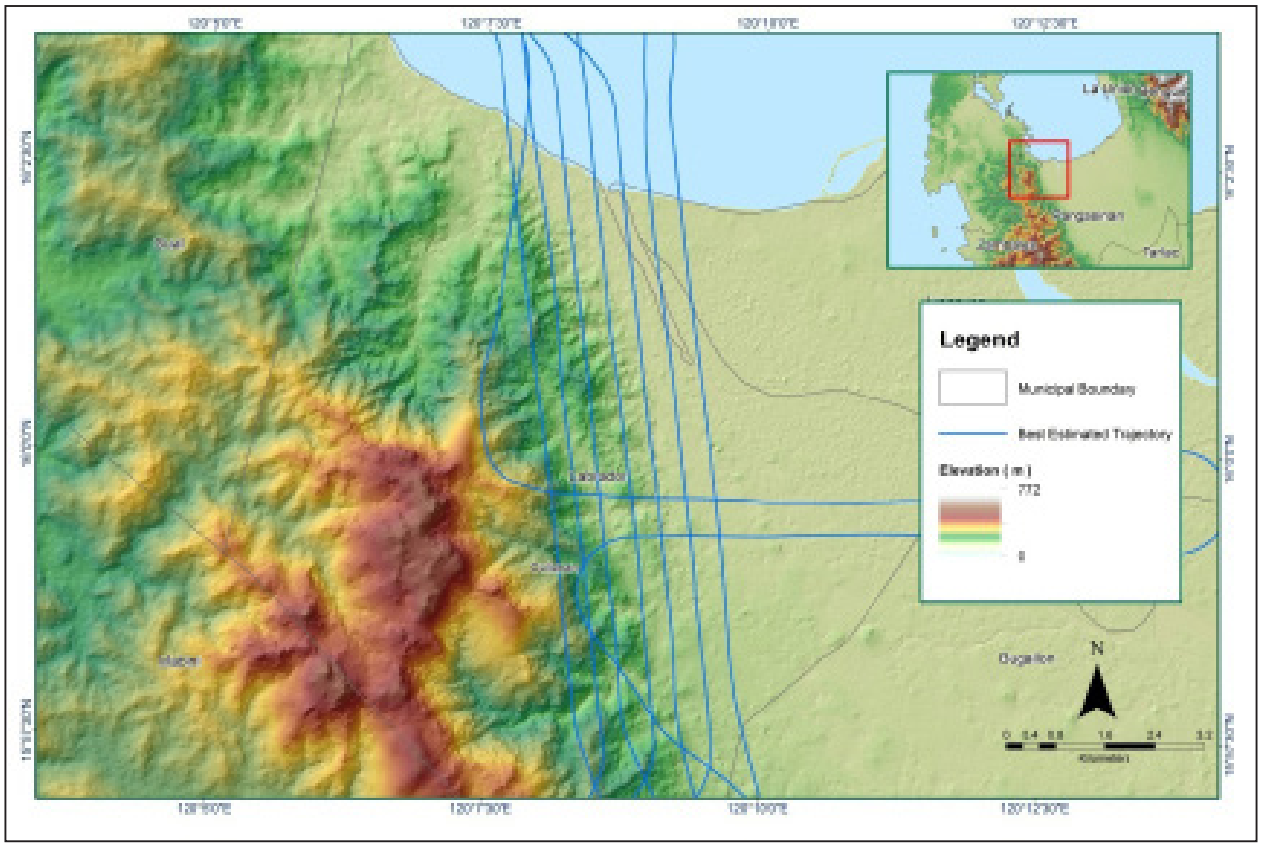


Figure A-8.66. Best Estimated Trajectory

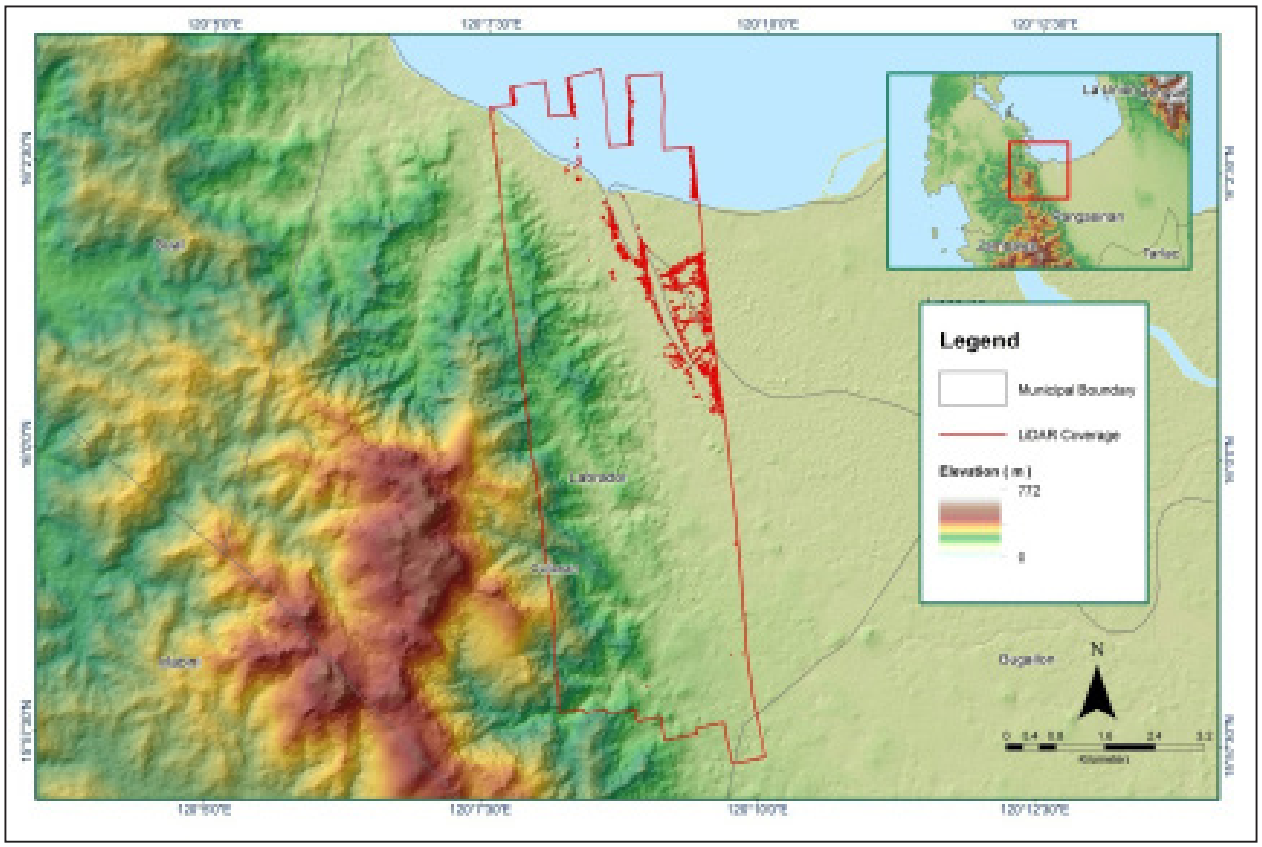


Figure A-8.67. Coverage of LiDAR data

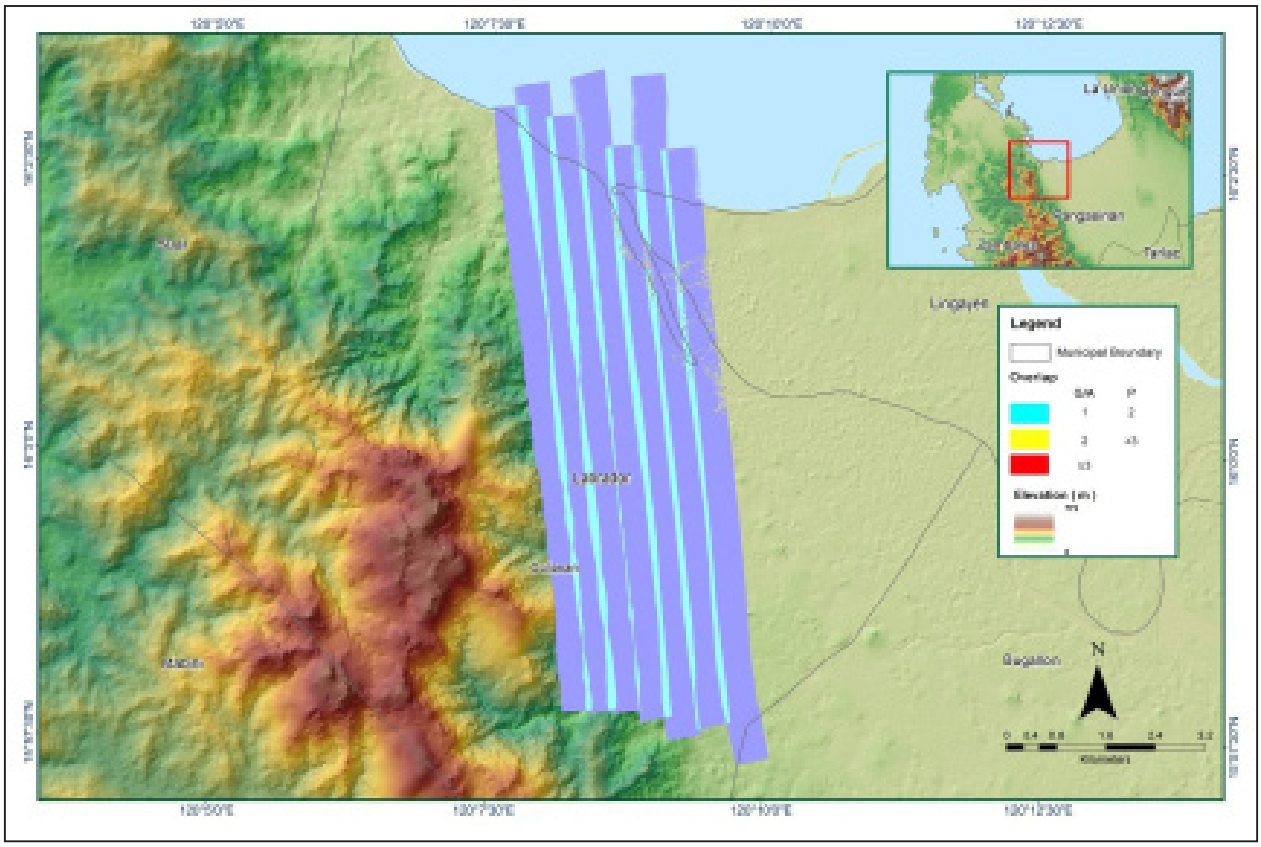


Figure A-8.68. Image of data overlap

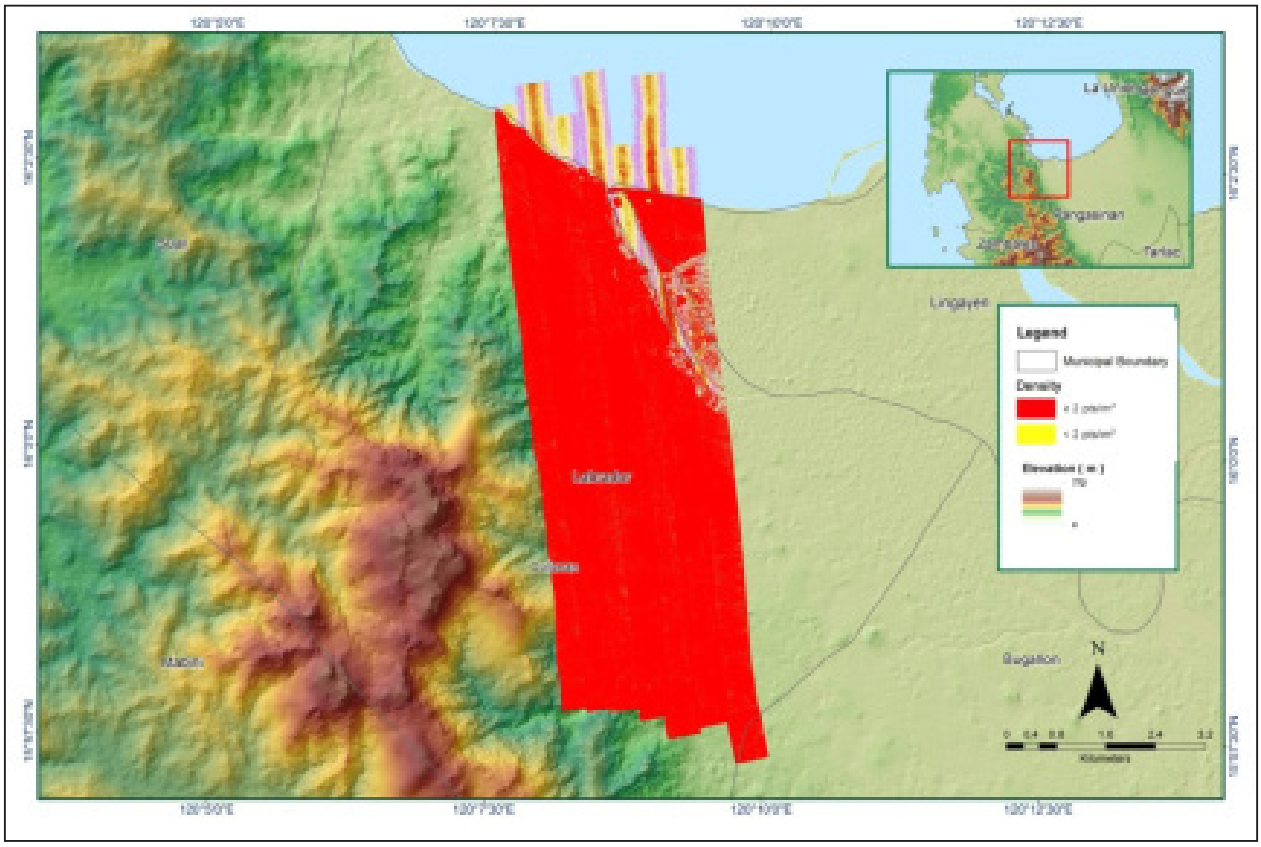


Figure A-8.69. Density map of merged LiDAR data

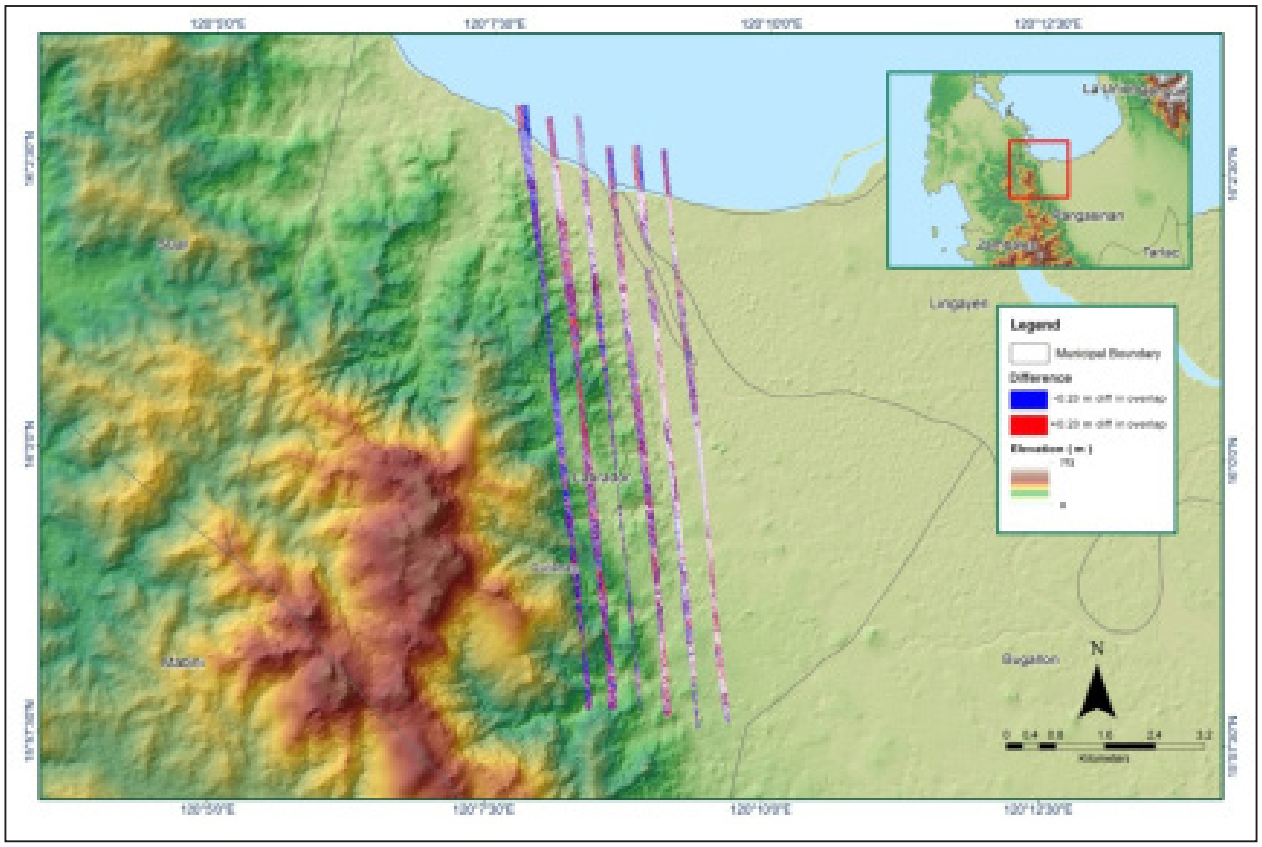


Figure A-8.70. Elevation difference between flight lines

Annex 9. Alaminos Model Basin Parameters

Table A-9.1 Alaminos Model Basin Parameters

Basin Number	SCS Curve Number Loss			SCS Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W200	3.2358	70.408	0	0.89508	12.827	Discharge	0.41152	0.74041	Ratio to Peak	0.19903
W210	3.0502	70.173	0	0.89651	13.118	Discharge	0.28849	0.74044	Ratio to Peak	0.19822
W220	3.2477	69.676	0	0.91254	1.1834	Discharge	0.016063	0.73789	Ratio to Peak	0.19399
W230	3.3107	69.258	0	2.4462	10.999	Discharge	0.79243	0.74006	Ratio to Peak	0.19385
W240	1.527	78.84	0	0.24115	6.2395	Discharge	0.027634	0.50197	Ratio to Peak	0.08912
W250	2.0641	68.064	0	1.9774	9.0815	Discharge	0.84851	0.74009	Ratio to Peak	0.19271
W260	3.304	70.493	0	0.58845	12.663	Discharge	0.089866	0.73789	Ratio to Peak	0.1979
W270	3.304	69.583	0	1.1202	15.729	Discharge	0.57155	0.74044	Ratio to Peak	0.28937
W280	2.4241	65.404	0	0.11664	0.74694	Discharge	0.001873	0.73789	Ratio to Peak	0.194
W290	3.3963	69.437	0	1.9339	12.835	Discharge	0.57443	0.73862	Ratio to Peak	0.26517
W300	3.304	45.62	0	2.9167	8.8855	Discharge	0.15591	0.50197	Ratio to Peak	0.18447
W310	3.304	70.739	0	3.0181	12.407	Discharge	1.2216	0.73446	Ratio to Peak	0.22722
W320	3.3791	67.031	0	0.42342	6.4734	Discharge	0.1113	0.67766	Ratio to Peak	0.12549
W330	5.9423	59.55	0	9.7212	17.126	Discharge	0.69481	0.74029	Ratio to Peak	0.13067
W340	5.8857	59.558	0	2.5692	16.309	Discharge	0.58628	0.73982	Ratio to Peak	0.33281
W350	11.318	46.326	0	5.3437	14.501	Discharge	3.0586	0.73789	Ratio to Peak	0.2
W360	5.6522	61.76	0	1.805	11.927	Discharge	1.3219	0.75295	Ratio to Peak	0.28357
W370	6.3105	53.525	0	2.7933	15.334	Discharge	0.48108	0.75461	Ratio to Peak	0.25957
W380	10.311	49.03	0	4.1951	11.674	Discharge	0.9935	0.76443	Ratio to Peak	0.3

Annex 1. Alaminos Model Reach Parameters

Table A-10.1 Alaminos Model Reach Parameters

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
R10	Automatic Fixed Interval	3051	0.00341	0.0455895	Trapezoid	25.21	1
R100	Automatic Fixed Interval	4335	0.00191	0.0683541	Trapezoid	11.5	1
R110	Automatic Fixed Interval	5403.4	0.00258	0.0458429	Trapezoid	15.73	1
R130	Automatic Fixed Interval	2123.5	0.00173	0.0684711	Trapezoid	16.87	1
R160	Automatic Fixed Interval	7216.2	0.00252	0.0684759	Trapezoid	16.87	1
R20	Automatic Fixed Interval	717.99	0.00281	0.0304001	Trapezoid	9.96	1
R40	Automatic Fixed Interval	3617.5	0.00102	0.0511421	Trapezoid	21.65	1
R50	Automatic Fixed Interval	243.76	0.00306	0.0282358	Trapezoid	6.74	1
R60	Automatic Fixed Interval	2705.8	0.00122	0.0762955	Trapezoid	11.14	1

Annex 11. Alaminos Field Validation Data

Table A-11.1 Alaminos Field Validation Data

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/ Date	Rain Return / Scenario
	Lat	Long					
1	16.157190	119.979664	0.03	0	-0.03	TS Lando	5 -Year
2	16.158254	119.980885	0.03	0	-0.03	TS Lando	5 -Year
3	16.158768	119.981898	0.03	0	-0.03	TS Lando	5 -Year
4	16.159478	119.980720	0.03	0	-0.03	TS Lando	5 -Year
5	16.163682	120.007664	0.03	0.3	0.27	TS Lando	5 -Year
6	16.161330	120.002331	0.03	0	-0.03	TS Lando	5 -Year
7	16.160758	119.981921	0.04	0	-0.04	TS Lando	5 -Year
8	16.158693	119.976619	0.04	0	-0.04	TS Lando	5 -Year
9	16.160045	119.976296	0.04	0	-0.04	TS Lando	5 -Year
10	16.161206	119.976467	0.04	0	-0.04	TS Lando	5 -Year
11	16.160173	119.997921	0.04	0	-0.04	TS Lando	5 -Year
12	16.116095	119.999430	0.04	0	-0.04	TS Lando	5 -Year
13	16.158461	119.982498	0.05	0	-0.05	TS Lando	5 -Year
14	16.159118	119.981359	0.05	0	-0.05	TS Lando	5 -Year
15	16.167621	119.987050	0.05	0	-0.05	TS Lando	5 -Year
16	16.166786	119.987921	0.05	0	-0.05	TS Lando	5 -Year
17	16.159675	119.996194	0.05	0.3	0.25	TS Lando	5 -Year
18	16.156215	120.014117	0.05	0	-0.05	TS Lando	5 -Year
19	16.162835	120.002654	0.05	0	-0.05	TS Lando	5 -Year
20	16.163646	120.004114	0.05	0	-0.05	TS Lando	5 -Year
21	16.161076	119.999916	0.05	0	-0.05	TS Lando	5 -Year
22	16.119231	119.969920	0.05	0	-0.05	TS Lando	5 -Year
23	16.165915	119.988763	0.06	0	-0.06	TS Lando	5 -Year
24	16.163651	119.991128	0.06	0	-0.06	TS Lando	5 -Year
25	16.161316	119.993465	0.06	0	-0.06	TS Lando	5 -Year
26	16.158014	120.009777	0.06	0	-0.06	TS Lando	5 -Year
27	16.160690	120.002736	0.06	0	-0.06	TS Lando	5 -Year
28	16.159693	119.995064	0.08	0	-0.08	TS Lando	5 -Year
29	16.165938	120.009584	0.12	0	-0.12	TS Lando	5 -Year
30	16.131137	119.998439	0.18	0	-0.18	TS Lando	5 -Year
31	16.182167	119.937754	0.21	0.46	0.25	TS Lando	5 -Year
32	16.181984	119.938959	0.22	0.61	0.39	TS Lando	5 -Year
33	16.164954	119.961988	0.22	0.3	0.08	TS Lando	5 -Year
34	16.161822	120.000999	0.22	0	-0.22	TS Lando	5 -Year
35	16.147685	119.976673	0.24	0.3	0.06	TS Lando	5 -Year
36	16.158100	119.983643	0.24	0.46	0.22	TS Lando	5 -Year
37	16.165972	119.956919	0.25	0.3	0.05	TS Lando	5 -Year
38	16.178393	119.958517	0.28	0.3	0.02	TS Lando	5 -Year
39	16.156425	119.981455	0.28	0.3	0.02	TS Lando	5 -Year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/ Date	Rain Return / Scenario
	Lat	Long					
40	16.207593	119.961843	0.28	0.3	0.02	TS Lando	5 -Year
41	16.133125	119.971413	0.28	0.3	0.02	TS Lando	5 -Year
42	16.080730	120.056303	0.3	0.3	0	TS Lando	5 -Year
43	16.164965	119.963797	0.3	0.3	0	TS Lando	5 -Year
44	16.140056	119.973600	0.3	0.3	0	TS Lando	5 -Year
45	16.150316	119.986012	0.31	0	-0.31	TS Lando	5 -Year
46	16.085764	120.024599	0.32	0.3	-0.02	TS Lando	5 -Year
47	16.075148	120.047444	0.32	0.61	0.29	TS Lando	5 -Year
48	16.081678	120.052334	0.33	0.3	-0.03	TS Lando	5 -Year
49	16.180408	119.964863	0.35	0.46	0.11	TS Lando	5 -Year
50	16.210125	119.961400	0.37	0.76	0.39	TS Lando	5 -Year
51	16.162282	119.962114	0.38	0.3	-0.08	TS Lando	5 -Year
52	16.156099	119.990526	0.38	0.3	-0.08	TS Lando	5 -Year
53	16.211376	119.963417	0.38	1.2	0.82	TS Lando	5 -Year
54	16.135819	119.972623	0.39	0.3	-0.09	TS Lando	5 -Year
55	16.143542	119.971260	0.39	0.76	0.37	TS Lando	5 -Year
56	16.081891	120.047672	0.41	0.3	-0.11	TS Lando	5 -Year
57	16.084505	120.025446	0.43	0.3	-0.13	TS Lando	5 -Year
58	16.178791	119.944024	0.44	0	-0.44	TS Lando	5 -Year
59	16.192238	119.949440	0.46	0.3	-0.16	TS Lando	5 -Year
60	16.162215	120.006812	0.5	0.3	-0.2	TS Lando	5 -Year
61	16.134621	119.988281	0.51	0.46	-0.05	TS Lando	5 -Year
62	16.176028	119.999920	0.51	0.46	-0.05	TS Lando	5 -Year
63	16.104241	120.012888	0.52	0.3	-0.22	TS Lando	5 -Year
64	16.116617	119.995811	0.53	0.3	-0.23	TS Lando	5 -Year
65	16.099406	120.017089	0.53	0.61	0.08	TS Lando	5 -Year
66	16.115407	120.003668	0.53	0.3	-0.23	TS Lando	5 -Year
67	16.110653	120.024280	0.54	0.3	-0.24	TS Lando	5 -Year
68	16.160185	120.005478	0.54	0.46	-0.08	TS Lando	5 -Year
69	16.121173	119.986164	0.55	0.61	0.06	TS Lando	5 -Year
70	16.137711	119.990020	0.56	0.76	0.2	TS Lando	5 -Year
71	16.138132	119.991875	0.56	0.61	0.05	TS Lando	5 -Year
72	16.106807	119.985334	0.56	0.3	-0.26	TS Lando	5 -Year
73	16.156652	119.987205	0.58	0.76	0.18	TS Lando	5 -Year
74	16.108727	119.967033	0.6	0.3	-0.3	TS Lando	5 -Year
75	16.161413	119.971958	0.6	1.23	0.63	TS Lando	5 -Year
76	16.082137	120.049631	0.61	0.61	0	TS Lando	5 -Year
77	16.143466	119.990727	0.61	0.3	-0.31	TS Lando	5 -Year
78	16.163792	119.980703	0.69	0.76	0.07	TS Lando	5 -Year
79	16.114346	120.005475	0.7	0.46	-0.24	TS Lando	5 -Year
80	16.166191	119.984505	0.71	0.76	0.05	TS Lando	5 -Year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/ Date	Rain Return / Scenario
	Lat	Long					
81	16.126891	119.969171	0.71	0.46	-0.25	TS Lando	5 -Year
82	16.073913	119.967032	0.76	0.61	-0.15	TS Lando	5 -Year
83	16.161732	119.973006	0.78	0.3	-0.48	TS Lando	5 -Year
84	16.073013	120.024162	0.78	0.3	-0.48	TS Lando	5 -Year
85	16.136634	119.981234	0.84	0.46	-0.38	TS Lando	5 -Year
86	16.131167	119.971170	0.85	0.76	-0.09	TS Lando	5 -Year
87	16.154261	120.016848	0.89	0.61	-0.28	TS Lando	5 -Year
88	16.116057	120.010917	0.9	0.3	-0.6	TS Lando	5 -Year
89	16.130325	119.979796	0.95	0.61	-0.34	TS Lando	5 -Year
90	16.150102	119.975596	0.99	0.61	-0.38	TS Lando	5 -Year
91	16.114680	120.005805	1.01	0.91	-0.1	TS Lando	5 -Year
92	16.108006	119.984048	1.02	0.91	-0.11	TS Lando	5 -Year
93	16.141233	119.974989	1.03	1.07	0.04	TS Lando	5 -Year
94	16.104937	120.012430	1.03	0.91	-0.12	TS Lando	5 -Year
95	16.131562	119.970690	1.05	0.46	-0.59	TS Lando	5 -Year
96	16.086196	119.959994	1.06	0.91	-0.15	TS Lando	5 -Year
97	16.150744	119.976704	1.06	1.23	0.17	TS Lando	5 -Year
98	16.110371	120.000198	1.06	0.91	-0.15	TS Lando	5 -Year
99	16.123228	119.987702	1.08	0.91	-0.17	TS Lando	5 -Year
100	16.084215	119.953015	1.08	0.91	-0.17	TS Lando	5 -Year
101	16.144722	119.975646	1.09	1.07	-0.02	TS Lando	5 -Year
102	16.081099	119.991650	1.13	1.22	0.09	TS Lando	5 -Year
103	16.135118	119.987586	1.13	1.22	0.09	TS Lando	5 -Year
104	16.136487	119.975029	1.13	0.76	-0.37	TS Lando	5 -Year
105	16.129505	119.971007	1.14	1.52	0.38	TS Lando	5 -Year
106	16.168737	119.977172	1.16	0.91	-0.25	TS Lando	5 -Year
107	16.114478	119.995513	1.18	0.91	-0.27	TS Lando	5 -Year
108	16.159362	120.004180	1.23	0.76	-0.47	TS Lando	5 -Year
109	16.140588	119.973898	1.24	0.46	-0.78	TS Lando	5 -Year
110	16.122671	119.986985	1.25	0.61	-0.64	TS Lando	5 -Year
111	16.106616	119.986304	1.25	0.91	-0.34	TS Lando	5 -Year
112	16.126527	119.982724	1.26	0.91	-0.35	TS Lando	5 -Year
113	16.115152	119.999899	1.29	2.13	0.84	TS Lando	5 -Year
114	16.162512	119.982619	1.34	1.07	-0.27	TS Lando	5 -Year
115	16.121950	119.986357	1.55	0.61	-0.94	TS Lando	5 -Year
116	16.164059	119.965466	1.71	0.91	-0.8	TS Lando	5 -Year
117	16.148591	119.967557	1.71	1.22	-0.49	TS Lando	5 -Year
118	16.115682	120.012003	1.74	1.22	-0.52	TS Lando	5 -Year
119	16.186249	119.992249	1.78	1.83	0.05	TS Lando	5 -Year
120	16.116125	120.009676	1.94	1.07	-0.87	TS Lando	5 -Year
121	16.084119	120.024857	2.02	1.52	-0.5	TS Lando	5 -Year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/ Date	Rain Return / Scenario
	Lat	Long					
122	16.165477	119.981899	2.09	1.98	-0.11	TS Lando	5 -Year
123	16.086743	120.025555	2.11	1.52	-0.59	TS Lando	5 -Year
124	16.134003	119.975161	2.18	1.52	-0.66	TS Lando	5 -Year
125	16.090277	120.030854	2.19	1.83	-0.36	TS Lando	5 -Year
126	16.145154	119.976001	2.19	1.83	-0.36	TS Lando	5 -Year
127	16.085893	120.026305	2.21	1.23	-0.98	TS Lando	5 -Year
128	16.137731	119.974344	2.26	0.61	-1.65	TS Lando	5 -Year
129	16.147359	119.970931	2.28	1.83	-0.45	TS Lando	5 -Year
130	16.163740	119.966332	2.3	2.13	-0.17	TS Lando	5 -Year
131	16.144513	119.970884	2.34	1.52	-0.82	TS Lando	5 -Year
132	16.140464	119.975354	2.37	1.83	-0.54	TS Lando	5 -Year
133	16.083837	120.026089	2.4	1.83	-0.57	TS Lando	5 -Year
134	16.163548	119.982640	2.43	1.83	-0.6	TS Lando	5 -Year
135	16.142351	119.971369	2.43	1.83	-0.6	TS Lando	5 -Year
136	16.111769	120.000207	2.44	0.91	-1.53	TS Lando	5 -Year
137	16.114613	120.002070	2.47	1.98	-0.49	TS Lando	5 -Year
138	16.085652	120.028682	2.55	1.52	-1.03	TS Lando	5 -Year
139	16.087441	120.029878	2.55	1.52	-1.03	TS Lando	5 -Year
140	16.132530	119.975077	2.55	1.52	-1.03	TS Lando	5 -Year
141	16.114966	120.011679	2.62	2.44	-0.18	TS Lando	5 -Year
142	16.116198	119.992316	2.72	1.52	-1.2	TS Lando	5 -Year
143	16.105962	120.017733	2.73	1.83	-0.9	TS Lando	5 -Year
144	16.131720	119.978051	2.73	1.83	-0.9	TS Lando	5 -Year
145	16.103476	120.016229	2.91	1.23	-1.68	TS Lando	5 -Year
146	16.139584	119.974961	3	0.91	-2.09	TS Lando	5 -Year
147	16.113470	119.994625	3.1	1.22	-1.88	TS Lando	5 -Year
148	16.114789	120.006860	3.27	1.83	-1.44	TS Lando	5 -Year
149	16.078629	120.031876	3.76	2.44	-1.32	TS Lando	5 -Year
150	16.111698	119.995770	4.42	1.83	-2.59	TS Lando	5 -Year
151	16.111941	119.996875	5.03	5.44	0.41	TS Lando	5 -Year
152	16.135226	119.975224	5.04	6.05	1.01	TS Lando	5 -Year
153	16.103282	120.020572	5.06	5.44	0.38	TS Lando	5 -Year
154	16.115661	120.014004	5.08	5.74	0.66	TS Lando	5 -Year
155	16.114772	119.991764	5.1	4.83	-0.27	TS Lando	5 -Year
156	16.112662	119.998345	5.1	5.74	0.64	TS Lando	5 -Year
157	16.083408	120.026851	5.15	6.05	0.9	TS Lando	5 -Year
158	16.113073	119.994523	5.16	5.13	-0.03	TS Lando	5 -Year
159	16.115427	120.001935	5.19	6.05	0.86	TS Lando	5 -Year
160	16.114490	119.999366	5.22	6.05	0.83	TS Lando	5 -Year
161	16.124926	119.982866	5.26	5.13	-0.13	TS Lando	5 -Year
162	16.122937	119.983162	5.27	4.83	-0.44	TS Lando	5 -Year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/ Date	Rain Return / Scenario
	Lat	Long					
163	16.133090	119.975063	5.28	4.83	-0.45	TS Lando	5 -Year
164	16.113610	119.993649	5.3	5.44	0.14	TS Lando	5 -Year
165	16.114909	120.009375	5.35	5.74	0.39	TS Lando	5 -Year
166	16.114485	119.998788	5.37	5.74	0.37	TS Lando	5 -Year
167	16.111313	120.015979	5.38	5.74	0.36	TS Lando	5 -Year
168	16.129594	119.980899	5.42	5.74	0.32	TS Lando	5 -Year
169	16.114700	120.000746	5.6	5.74	0.14	TS Lando	5 -Year
170	16.114080	119.996359	5.67	4.52	-1.15	TS Lando	5 -Year
171	16.084439	120.026859	5.88	6.05	0.17	TS Lando	5 -Year
172	16.114886	120.014110	5.99	6.35	0.36	TS Lando	5 -Year
173	16.114796	120.007572	6.05	5.59	-0.46	TS Lando	5 -Year
174	16.114820	119.997837	6.08	5.74	-0.34	TS Lando	5 -Year
175	16.115193	120.004285	6.31	6.05	-0.26	TS Lando	5 -Year
176	16.119724	119.988604	6.41	4.83	-1.58	TS Lando	5 -Year
177	16.116377	120.003808	6.45	4.83	-1.62	TS Lando	5 -Year
178	16.121888	119.984965	6.57	5.13	-1.44	TS Lando	5 -Year
179	16.089158	120.030796	6.73	5.13	-1.6	TS Lando	5 -Year
180	16.083188	119.986188	6.86	5.74	-1.12	TS Lando	5 -Year

Annex 12. Educational Institutions Affected in Alaminos Floodplain

Table A-12.1 Educational Institutions in Alaminos City, Pangasinan Affected by Flooding in Alaminos Floodplain

Pangasinan				
Alaminos City				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
MAAWI ELEMENTARY SCHOOL 1	Alos			
MAAWI ELEMENTARY SCHOOL 2	Alos			
MAAWI ELEMENTARY SCHOOL 3	Alos			
MAAWI ELEMENTARY SCHOOL 4	Alos			
MAAWI ELEMENTARY SCHOOL 5	Alos			
BISOCOL ELEMENTARY SCHOOL 1	Amandiego			
BISOCOL ELEMENTARY SCHOOL 2	Amandiego			
BISOCOL ELEMENTARY SCHOOL 3	Amandiego			
BISOCOL ELEMENTARY SCHOOL 4	Amandiego			
BISOCOL ELEMENTARY SCHOOL 5	Amandiego			
BISOCOL ELEMENTARY SCHOOL 6	Amandiego			
BISOCOL ELEMENTARY SCHOOL 7	Amandiego			
BALANGOBONG ELEMENTARY SCHOOL 1	Balangobong	Low	Medium	Medium
BALANGOBONG ELEMENTARY SCHOOL 2	Balangobong	Low	Medium	Medium
BALANGOBONG ELEMENTARY SCHOOL 3	Balangobong	Low	Medium	Medium
BALANGOBONG ELEMENTARY SCHOOL 4	Balangobong	Low	Medium	Medium
BALANGOBONG ELEMENTARY SCHOOL 5	Balangobong	Low	Low	Medium
BALANGOBONG ELEMENTARY SCHOOL 6	Balangobong		Low	Medium
BALANGOBONG ELEMENTARY SCHOOL 7	Balangobong		Low	Medium
BALEYADAAN ELEMENTARY SCHOOL 1	Baleyadaan			
BALEYADAAN ELEMENTARY SCHOOL 2	Baleyadaan			
BALEYADAAN ELEMENTARY SCHOOL 3	Baleyadaan			
BALEYADAAN ELEMENTARY SCHOOL 4	Baleyadaan			
BALEYADAAN ELEMENTARY SCHOOL 5	Baleyadaan			
BALEYADAAN ELEMENTARY SCHOOL 6	Baleyadaan			
BALEYADAAN ELEMENTARY SCHOOL 7	Baleyadaan			
BALEYADAAN ELEMENTARY SCHOOL 8	Baleyadaan			
AMANDIEGO ELEMENTARY SCHOOL 1	Bisocol			
AMANDIEGO ELEMENTARY SCHOOL 2	Bisocol			Low
AMANDIEGO ELEMENTARY SCHOOL 3	Bisocol			Low
AMANDIEGO ELEMENTARY SCHOOL 4	Bisocol			Low
AMANDIEGO ELEMENTARY SCHOOL 5	Bisocol			Low
AMANDIEGO ELEMENTARY SCHOOL 6	Bisocol			Low
BOLANEY ELEMENTARY SCHOOL 1	Bolaney			
BOLANEY ELEMENTARY SCHOOL 2	Bolaney			
BOLANEY ELEMENTARY SCHOOL 3	Bolaney			
BOLANEY ELEMENTARY SCHOOL 4	Bolaney			
BOLANEY ELEMENTARY SCHOOL 5	Bolaney			

Pangasinan				
Alaminos City				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
PANGASINAN STATE UNIVERSITY ALAMINOS CITY CAMPUS 1	Bolaney			
PANGASINAN STATE UNIVERSITY ALAMINOS CITY CAMPUS 2	Bolaney			
PANGASINAN STATE UNIVERSITY ALAMINOS CITY CAMPUS 3	Bolaney			
BUED ELEMENTARY SCHOOL 1	Bued			
BUED ELEMENTARY SCHOOL 10	Bued			
BUED ELEMENTARY SCHOOL 11	Bued			
BUED ELEMENTARY SCHOOL 12	Bued			
BUED ELEMENTARY SCHOOL 2	Bued			
BUED ELEMENTARY SCHOOL 3	Bued			
BUED ELEMENTARY SCHOOL 4	Bued			
BUED ELEMENTARY SCHOOL 6	Bued			
BUED ELEMENTARY SCHOOL 7	Bued			
BUED ELEMENTARY SCHOOL 8	Bued			
BUED ELEMENTARY SCHOOL 9	Bued			
CABATUAN ELEMENTARY SCHOOL 1	Cabatuan	Low	Medium	Medium
CABATUAN ELEMENTARY SCHOOL 2	Cabatuan	Low	Medium	Medium
CABATUAN ELEMENTARY SCHOOL 3	Cabatuan	Low	Medium	Medium
CABATUAN ELEMENTARY SCHOOL 4	Cabatuan	Low	Low	Medium
CABATUAN ELEMENTARY SCHOOL 5	Cabatuan	Low	Low	Medium
CABATUAN ELEMENTARY SCHOOL 6	Cabatuan		Low	Low
CABATUAN ELEMENTARY SCHOOL 7	Cabatuan		Low	Low
CAYUCAY ELEMENTARY SCHOOL 1	Cayucay			
CAYUCAY ELEMENTARY SCHOOL 2	Cayucay			
CAYUCAY ELEMENTARY SCHOOL 3	Cayucay			
CAYUCAY ELEMENTARY SCHOOL 4	Cayucay			
CAYUCAY ELEMENTARY SCHOOL 5	Cayucay			
CAYUCAY ELEMENTARY SCHOOL 6	Cayucay			
CAYUCAY ELEMENTARY SCHOOL 7	Cayucay			
CAYUCAY ELEMENTARY SCHOOL 8	Cayucay			
CAYUCAY ELEMENTARY SCHOOL 9	Cayucay			
CAYUCAY NATIONAL HIGH SCHOOL 1	Cayucay			
CAYUCAY NATIONAL HIGH SCHOOL 2	Cayucay			
CAYUCAY NATIONAL HIGH SCHOOL 3	Cayucay			
MONA ELEMENTARY SCHOOL 2	Cayucay			
MONA ELEMENTARY SCHOOL 3	Cayucay			
INERANGAN ELEMENTARY SCHOOL 1	Inerangan			Low
INERANGAN ELEMENTARY SCHOOL 10	Inerangan			
INERANGAN ELEMENTARY SCHOOL 11	Inerangan			

Pangasinan				
Alaminos City				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
INERANGAN ELEMENTARY SCHOOL 12	Inerangan			
INERANGAN ELEMENTARY SCHOOL 13	Inerangan			
INERANGAN ELEMENTARY SCHOOL 14	Inerangan			
INERANGAN ELEMENTARY SCHOOL 2	Inerangan			
INERANGAN ELEMENTARY SCHOOL 3	Inerangan			
INERANGAN ELEMENTARY SCHOOL 4	Inerangan			
INERANGAN ELEMENTARY SCHOOL 5	Inerangan			
INERANGAN ELEMENTARY SCHOOL 6	Inerangan			
INERANGAN ELEMENTARY SCHOOL 7	Inerangan			
INERANGAN ELEMENTARY SCHOOL 8	Inerangan			
INERANGAN ELEMENTARY SCHOOL 9	Inerangan			Low
INERANGAN NATIONAL HIGH SCHOOL 1	Inerangan			
INERANGAN NATIONAL HIGH SCHOOL 10	Inerangan			
INERANGAN NATIONAL HIGH SCHOOL 2	Inerangan			
INERANGAN NATIONAL HIGH SCHOOL 5	Inerangan			
INERANGAN NATIONAL HIGH SCHOOL 6	Inerangan			
INERANGAN NATIONAL HIGH SCHOOL 9	Inerangan			
QUIBUAR ELEMENTARY SCHOOL 1	Macatiw			
QUIBUAR ELEMENTARY SCHOOL 2	Macatiw			
QUIBUAR ELEMENTARY SCHOOL 3	Macatiw			
QUIBUAR ELEMENTARY SCHOOL 4	Macatiw			
QUIBUAR ELEMENTARY SCHOOL 5	Macatiw			
QUIBUAR ELEMENTARY SCHOOL 6	Macatiw			
QUIBUAR ELEMENTARY SCHOOL 8	Macatiw			
QUIBUAR ELEMENTARY SCHOOL 9	Macatiw			
ALAMINOS ADVENTIST MULTIGRADE SCHOOL	Magsaysay		Medium	Medium
ALAMINOS NATIONAL HIGH SCHOOL 1	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 10	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 11	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 12	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 13	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 14	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 15	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 16	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 17	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 18	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 19	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 2	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 20	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 21	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 22	Magsaysay			

Pangasinan				
Alaminos City				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
ALAMINOS NATIONAL HIGH SCHOOL 23	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 24	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 25	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 26	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 27	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 28	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 29	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 3	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 30	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 31	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 32	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 33	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 4	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 5	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 6	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 7	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 8	Magsaysay			
ALAMINOS NATIONAL HIGH SCHOOL 9	Magsaysay			
BARANGAY MAGSAYSAY DAY CARE CENTER	Magsaysay			
MAGSAYSAY ELEMENTARY SCHOOL 1	Magsaysay			
MAGSAYSAY ELEMENTARY SCHOOL 10	Magsaysay			
MAGSAYSAY ELEMENTARY SCHOOL 2	Magsaysay			
MAGSAYSAY ELEMENTARY SCHOOL 3	Magsaysay			
MAGSAYSAY ELEMENTARY SCHOOL 4	Magsaysay			
MAGSAYSAY ELEMENTARY SCHOOL 5	Magsaysay			
MAGSAYSAY ELEMENTARY SCHOOL 6	Magsaysay			
MAGSAYSAY ELEMENTARY SCHOOL 7	Magsaysay			
MAGSAYSAY ELEMENTARY SCHOOL 8	Magsaysay			
MAGSAYSAY ELEMENTARY SCHOOL 9	Magsaysay			
MONA DAY CARE CENTER 1	Mona			
MONA DAY CARE CENTER 2	Mona			
MONA ELEMENTARY SCHOOL 1	Mona			
MONA ELEMENTARY SCHOOL 2	Mona			
MONA ELEMENTARY SCHOOL 3	Mona			
MONA ELEMENTARY SCHOOL 4	Mona			
PALAMIS DAY CARE CENTER	Palamis		Low	Low
PALAMIS ELEMENTARY SCHOOL	Palamis		Medium	High
PANGAPISAN ELEMENTARY SCHOOL 1	Pangapisan			
PANGAPISAN ELEMENTARY SCHOOL 10	Pangapisan			
PANGAPISAN ELEMENTARY SCHOOL 11	Pangapisan			
PANGAPISAN ELEMENTARY SCHOOL 12	Pangapisan			

Pangasinan				
Alaminos City				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
PANGAPISAN ELEMENTARY SCHOOL 2	Pangapisan			
PANGAPISAN ELEMENTARY SCHOOL 3	Pangapisan			
PANGAPISAN ELEMENTARY SCHOOL 4	Pangapisan			
PANGAPISAN ELEMENTARY SCHOOL 5	Pangapisan			
PANGAPISAN ELEMENTARY SCHOOL 6	Pangapisan			
PANGAPISAN ELEMENTARY SCHOOL 7	Pangapisan			
PANGAPISAN ELEMENTARY SCHOOL 8	Pangapisan			
PANGAPISAN ELEMENTARY SCHOOL 9	Pangapisan			
ACLC AND MONTEMAYOR BUILDING	Poblacion			
ACLC COLLEGE	Poblacion			
AIE COLLEGE	Poblacion			
ALAMINOS CENTRAL ELEMENTARY SCHOOL 1	Poblacion			
ALAMINOS CENTRAL ELEMENTARY SCHOOL 10	Poblacion			
ALAMINOS CENTRAL ELEMENTARY SCHOOL 11	Poblacion			
ALAMINOS CENTRAL ELEMENTARY SCHOOL 12	Poblacion			
ALAMINOS CENTRAL ELEMENTARY SCHOOL 13	Poblacion			
ALAMINOS CENTRAL ELEMENTARY SCHOOL 14	Poblacion			
ALAMINOS CENTRAL ELEMENTARY SCHOOL 15	Poblacion			
ALAMINOS CENTRAL ELEMENTARY SCHOOL 16	Poblacion			
ALAMINOS CENTRAL ELEMENTARY SCHOOL 17	Poblacion			
ALAMINOS CENTRAL ELEMENTARY SCHOOL 18	Poblacion			
ALAMINOS CENTRAL ELEMENTARY SCHOOL 19	Poblacion			
ALAMINOS CENTRAL ELEMENTARY SCHOOL 2	Poblacion			
ALAMINOS CENTRAL ELEMENTARY SCHOOL 20	Poblacion			
ALAMINOS CENTRAL ELEMENTARY SCHOOL 21	Poblacion			
ALAMINOS CENTRAL ELEMENTARY SCHOOL 22	Poblacion			
ALAMINOS CENTRAL ELEMENTARY SCHOOL 23	Poblacion			
ALAMINOS CENTRAL ELEMENTARY SCHOOL 24	Poblacion			
ALAMINOS CENTRAL ELEMENTARY SCHOOL 25	Poblacion			
ALAMINOS CENTRAL ELEMENTARY SCHOOL 3	Poblacion			
ALAMINOS CENTRAL ELEMENTARY SCHOOL 4	Poblacion			
ALAMINOS CENTRAL ELEMENTARY SCHOOL 5	Poblacion			
ALAMINOS CENTRAL ELEMENTARY SCHOOL 6	Poblacion			Low
ALAMINOS CENTRAL ELEMENTARY SCHOOL 7	Poblacion			Medium
ALAMINOS CENTRAL ELEMENTARY SCHOOL 8	Poblacion			Medium
ALAMINOS CENTRAL ELEMENTARY SCHOOL 9	Poblacion			Low
ALAMINOS CITY ESCOLAR INSTITUTE	Poblacion			
CHILDREN'S PARK AND ACITVITY CENTER	Poblacion		Medium	Medium
CSJA COLLEGE DEPARTMENT	Poblacion			
CSJA ELEMENTARY DEPARTMENT 1	Poblacion			
CSJA ELEMENTARY DEPARTMENT 2	Poblacion			

Pangasinan				
Alaminos City				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
CSJA ELEMENTARY DEPARTMENT 3	Poblacion			
CSJA ELEMENTARY DEPARTMENT 4	Poblacion			
CSJA HIGH SCHOOL DEPARTMENT 1	Poblacion			
CSJA HIGH SCHOOL DEPARTMENT 2	Poblacion			
CSJA HIGH SCHOOL DEPARTMENT 3	Poblacion			
GOLDEN WEST COLLEGE	Poblacion			
GREAT PLEBEIAN COLLEGE 1	Poblacion			Low
GREAT PLEBEIAN COLLEGE 2	Poblacion			
GREAT PLEBEIAN COLLEGE 3	Poblacion			Low
GREAT PLEBEIAN COLLEGE 4	Poblacion		Low	Low
GREAT PLEBEIAN COLLEGE 5	Poblacion			
GREAT PLEBEIAN COLLEGE 6	Poblacion			Low
MANANTAN INSTITUE OF TECHNOLOGY AND TRAINING CENTER	Poblacion			
MARY THE QUEEN EDUCATIONAL FOUNDATION 1	Poblacion			
MARY THE QUEEN EDUCATIONAL FOUNDATION 3	Poblacion			
PASS COLLEGE	Poblacion			
PHILIPPINE WESTERN UNION COLLEGE	Poblacion			
SHEKINAH GRACE SCHOOL	Poblacion			
POGO ELEMENTARY SCHOOL 1	Pogo			
POGO ELEMENTARY SCHOOL 3	Pogo			
POGO ELEMENTARY SCHOOL 4	Pogo			
POGO ELEMENTARY SCHOOL 5	Pogo			
POGO ELEMENTARY SCHOOL 6	Pogo			
POGO ELEMENTARY SCHOOL 7	Pogo			
POGO ELEMENTARY SCHOOL 8	Pogo			
POGO ELEMENTARY SCHOOL 9	Pogo			
PANGAPISAN ELEMENTARY SCHOOL 8	Polo			
PANGAPISAN ELEMENTARY SCHOOL 9	Polo			
POLO ELEMENTARY SCHOOL 1	Polo			
POLO ELEMENTARY SCHOOL 10	Polo			
POLO ELEMENTARY SCHOOL 2	Polo			
POLO ELEMENTARY SCHOOL 3	Polo			
POLO ELEMENTARY SCHOOL 4	Polo			
POLO ELEMENTARY SCHOOL 5	Polo			
POLO ELEMENTARY SCHOOL 6	Polo			
POLO ELEMENTARY SCHOOL 7	Polo			
POLO ELEMENTARY SCHOOL 8	Polo			
POLO ELEMENTARY SCHOOL 9	Polo			
POLO NATINAL HIGH SCHOOL 1	Polo			
POLO NATINAL HIGH SCHOOL 2	Polo			

Pangasinan				
Alaminos City				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
POLO NATINAL HIGH SCHOOL 3	Polo			
POLO NATINAL HIGH SCHOOL 4	Polo			
POLO NATINAL HIGH SCHOOL 5	Polo		Low	Low
POLO NATINAL HIGH SCHOOL 6	Polo			
POLO NATINAL HIGH SCHOOL 7	Polo			
POLO NATINAL HIGH SCHOOL 8	Polo			
POLO NATINAL HIGH SCHOOL 9	Polo			
ALOS ELEMENTARY SCHOOL 1	Quibuar			
ALOS ELEMENTARY SCHOOL 10	Quibuar			
ALOS ELEMENTARY SCHOOL 2	Quibuar			
ALOS ELEMENTARY SCHOOL 4	Quibuar			
ALOS ELEMENTARY SCHOOL 5	Quibuar			
ALOS ELEMENTARY SCHOOL 6	Quibuar			
ALOS ELEMENTARY SCHOOL 7	Quibuar			
ALOS ELEMENTARY SCHOOL 8	Quibuar			
ALOS ELEMENTARY SCHOOL 9	Quibuar			
ALOS NATIONAL HIGH SCHOOL 1	Quibuar			
ALOS NATIONAL HIGH SCHOOL 10	Quibuar			
ALOS NATIONAL HIGH SCHOOL 11	Quibuar			
ALOS NATIONAL HIGH SCHOOL 12	Quibuar			
ALOS NATIONAL HIGH SCHOOL 13	Quibuar			
ALOS NATIONAL HIGH SCHOOL 14	Quibuar			
ALOS NATIONAL HIGH SCHOOL 15	Quibuar			
ALOS NATIONAL HIGH SCHOOL 2	Quibuar			
ALOS NATIONAL HIGH SCHOOL 3	Quibuar			
ALOS NATIONAL HIGH SCHOOL 4	Quibuar			
ALOS NATIONAL HIGH SCHOOL 5	Quibuar			
ALOS NATIONAL HIGH SCHOOL 6	Quibuar			
ALOS NATIONAL HIGH SCHOOL 7	Quibuar			
ALOS NATIONAL HIGH SCHOOL 8	Quibuar			
ALOS NATIONAL HIGH SCHOOL 9	Quibuar			
TAGUDIN ELEMENTARY SCHOOL 1	Quibuar			
TAGUDIN ELEMENTARY SCHOOL 2	Quibuar			
TAGUDIN ELEMENTARY SCHOOL 4	Quibuar			
TAGUDIN ELEMENTARY SCHOOL 5	Quibuar			
TAGUDIN ELEMENTARY SCHOOL 6	Quibuar			
TAGUDIN ELEMENTARY SCHOOL 7	Quibuar			
TAGUDIN ELEMENTARY SCHOOL 8	Quibuar			
TAGUDIN NATIONA HIGH SCHOOL 1	Quibuar			
TAGUDIN NATIONA HIGH SCHOOL 10	Quibuar			
TAGUDIN NATIONA HIGH SCHOOL 11	Quibuar			

Pangasinan				
Alaminos City				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
TAGUDIN NATIONA HIGH SCHOOL 13	Quibuar			
TAGUDIN NATIONA HIGH SCHOOL 2	Quibuar			
TAGUDIN NATIONA HIGH SCHOOL 3	Quibuar			
TAGUDIN NATIONA HIGH SCHOOL 4	Quibuar			
TAGUDIN NATIONA HIGH SCHOOL 5	Quibuar			
TAGUDIN NATIONA HIGH SCHOOL 6	Quibuar			
TAGUDIN NATIONA HIGH SCHOOL 7	Quibuar			
TAGUDIN NATIONA HIGH SCHOOL 8	Quibuar			
TAGUDIN NATIONA HIGH SCHOOL 9	Quibuar			
SAN JOSE ELEMENTARY SCHOOL 1	San Jose			
SAN JOSE ELEMENTARY SCHOOL 2	San Jose			
SAN JOSE ELEMENTARY SCHOOL 3	San Jose			
SAN JOSE ELEMENTARY SCHOOL 4	San Jose			
SAN JOSE ELEMENTARY SCHOOL 5	San Jose			
SAN JOSE ELEMENTARY SCHOOL 6	San Jose			
SAN JOSE ELEMENTARY SCHOOL 7	San Jose			
SAN JOSE ELEMENTARY SCHOOL 8	San Jose			
SAN JOSE ELEMENTARY SCHOOL 9	San Jose			
SAN VICENTE ELEMENTARY SCHOOL 1	San Vicente		Medium	Medium
SAN VICENTE ELEMENTARY SCHOOL 2	San Vicente		Medium	Medium
SAN VICENTE ELEMENTARY SCHOOL 3	San Vicente		Medium	Medium
SAN VICENTE ELEMENTARY SCHOOL 4	San Vicente		Medium	Medium
SAN VICENTE ELEMENTARY SCHOOL 5	San Vicente		Medium	Medium
SAN VICENTE ELEMENTARY SCHOOL 6	San Vicente		Medium	Medium
SAN VICENTE ELEMENTARY SCHOOL 7	San Vicente			
SAN VICENTE ELEMENTARY SCHOOL 8	San Vicente		Medium	Medium
SAN VICENTE HIGH SCHOOL 1	San Vicente	Low	High	High
SAN VICENTE HIGH SCHOOL 10	San Vicente	Low	Medium	High
SAN VICENTE HIGH SCHOOL 11	San Vicente	Low	Medium	High
SAN VICENTE HIGH SCHOOL 2	San Vicente	Low	Medium	High
SAN VICENTE HIGH SCHOOL 3	San Vicente	Low	High	High
SAN VICENTE HIGH SCHOOL 4	San Vicente	Low	High	High
SAN VICENTE HIGH SCHOOL 5	San Vicente	Low	High	High
SAN VICENTE HIGH SCHOOL 6	San Vicente	Medium	High	High
SAN VICENTE HIGH SCHOOL 7	San Vicente	Low	Medium	High
SAN VICENTE HIGH SCHOOL 8	San Vicente		Medium	High
SAN VICENTE HIGH SCHOOL 9	San Vicente	Low	High	High
POCALPOCAL DAYCARE CENTER	Tanaytay			
POPANTAY ELEMENTARY SCHOOL 1	Tanaytay			
POPANTAY ELEMENTARY SCHOOL 10	Tanaytay			
POPANTAY ELEMENTARY SCHOOL 11	Tanaytay			

Pangasinan				
Alaminos City				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
POPANTAY ELEMENTARY SCHOOL 12	Tanaytay			
POPANTAY ELEMENTARY SCHOOL 13	Tanaytay			Low
POPANTAY ELEMENTARY SCHOOL 2	Tanaytay	Low	Low	Low
POPANTAY ELEMENTARY SCHOOL 3	Tanaytay		Low	Low
POPANTAY ELEMENTARY SCHOOL 4	Tanaytay	Low	Low	Low
POPANTAY ELEMENTARY SCHOOL 5	Tanaytay		Low	Low
POPANTAY ELEMENTARY SCHOOL 6	Tanaytay			Low
POPANTAY ELEMENTARY SCHOOL 7	Tanaytay			
POPANTAY ELEMENTARY SCHOOL 8	Tanaytay			Low
POPANTAY ELEMENTARY SCHOOL 9	Tanaytay			
TANGKARANG ELEMENTARY SCHOOL 1	Tangcarang			
TANGKARANG ELEMENTARY SCHOOL 10	Tangcarang			
TANGKARANG ELEMENTARY SCHOOL 11	Tangcarang			
TANGKARANG ELEMENTARY SCHOOL 2	Tangcarang			
TANGKARANG ELEMENTARY SCHOOL 3	Tangcarang			
TANGKARANG ELEMENTARY SCHOOL 4	Tangcarang			
TANGKARANG ELEMENTARY SCHOOL 5	Tangcarang			
TANGKARANG ELEMENTARY SCHOOL 6	Tangcarang			
TANGKARANG ELEMENTARY SCHOOL 7	Tangcarang			
TANGKARANG ELEMENTARY SCHOOL 8	Tangcarang			
TANGKARANG ELEMENTARY SCHOOL 9	Tangcarang			

Table A-12.2 Educational Institutions in Bani, Pangasinan Affected by Flooding in Alaminos Floodplain

Pangasinan				
Bani				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
SAN MIGUEL ELEMENTARY SCHOOL 11	San Miguel			
SAN MIGUEL ELEMENTARY SCHOOL 12	San Miguel			
SAN MIGUEL ELEMENTARY SCHOOL 5	San Miguel			

Table A-12.3 Educational Institutions in Sual, Pangasinan Affected by Flooding in Alaminos Floodplain

Pangasinan				
Sual				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
BOLAOEN DAY CARE CENTER	Bolaoen			
BOLAOEN ELEMENTARY SCHOOL 1	Bolaoen			
BOLAOEN ELEMENTARY SCHOOL 2	Bolaoen			
BOLAOEN ELEMENTARY SCHOOL 3	Bolaoen			
BOLAOEN ELEMENTARY SCHOOL 4	Bolaoen			
BOLAOEN ELEMENTARY SCHOOL 5	Bolaoen			

Pangasinan				
Sual				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
CAAROSIPAN ELEMENTARY SCHOOL 1	Camagsingalan			
CAAROSIPAN ELEMENTARY SCHOOL 2	Camagsingalan			
CAAROSIPAN ELEMENTARY SCHOOL 3	Camagsingalan			
CAAROSIPAN ELEMENTARY SCHOOL 4	Camagsingalan	Low	Low	Low
CAAROSIPAN ELEMENTARY SCHOOL 5	Camagsingalan	Low	Low	Low
CAAROSIPAN ELEMENTARY SCHOOL 6	Camagsingalan	Low	Low	Low
CAAROSIPAN ELEMENTARY SCHOOL 7	Camagsingalan			Low
CAAROSIPAN ELEMENTARY SCHOOL 8	Camagsingalan			Low
CALOMBUYAN ELEMENTARY SCHOOL 1	Camagsingalan			
CALOMBUYAN ELEMENTARY SCHOOL 2	Camagsingalan			
CALOMBUYAN ELEMENTARY SCHOOL 3	Camagsingalan			
CALOMBUYAN ELEMENTARY SCHOOL 4	Camagsingalan			
CALOMBUYAN ELEMENTARY SCHOOL 5	Camagsingalan			
LINMANSANGAN DAY CARE CENTER	Camagsingalan	Low	Medium	Medium
LINMANSANGAN ELEMENTARY SCHOOL 1	Camagsingalan	Medium	Medium	Medium
LINMANSANGAN ELEMENTARY SCHOOL 2	Camagsingalan	Medium	Medium	Medium
LINMANSANGAN ELEMENTARY SCHOOL 3	Camagsingalan	Medium	Medium	Medium
MALIGA ELEMENTARY SCHOOL 1	Camagsingalan			
MALIGA ELEMENTARY SCHOOL 2	Camagsingalan			
MALIGA ELEMENTARY SCHOOL 3	Camagsingalan			
MALIGA ELEMENTARY SCHOOL 4	Camagsingalan			
MALIGA ELEMENTARY SCHOOL 5	Camagsingalan			
MALIGA ELEMENTARY SCHOOL 6	Camagsingalan			
MALIGA ELEMENTARY SCHOOL 7	Camagsingalan			
MACAYCAYAOAN ELEMENTARY SCHOOL 1	Macaycayawan			
MACAYCAYAOAN ELEMENTARY SCHOOL 2	Macaycayawan			
MACAYCAYAOAN ELEMENTARY SCHOOL 3	Macaycayawan			
MACAYCAYAOAN ELEMENTARY SCHOOL 4	Macaycayawan			
MACAYCAYAOAN ELEMENTARY SCHOOL 5	Macaycayawan			
BOLAOEN ELEMENTARY SCHOOL 5	Paitan East			
PAITAN EAST ELEMENTARY SCHOOL 1	Paitan East			
PAITAN EAST ELEMENTARY SCHOOL 2	Paitan East			
PAITAN INTEGRATED SCHOOL 1	Paitan East		Medium	Medium
PAITAN INTEGRATED SCHOOL 10	Paitan East	Medium	High	High
PAITAN INTEGRATED SCHOOL 11	Paitan East	Medium	High	High
PAITAN INTEGRATED SCHOOL 12	Paitan East	Medium	High	High
PAITAN INTEGRATED SCHOOL 13	Paitan East	Medium	High	High
PAITAN INTEGRATED SCHOOL 14	Paitan East	Medium	High	High
PAITAN INTEGRATED SCHOOL 2	Paitan East		Medium	Medium
PAITAN INTEGRATED SCHOOL 3	Paitan East	Medium	High	High
PAITAN INTEGRATED SCHOOL 4	Paitan East	Low	Medium	High

Pangasinan				
Sual				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
PAITAN INTEGRATED SCHOOL 5	Paitan East		Medium	Medium
PAITAN INTEGRATED SCHOOL 6	Paitan East		Medium	Medium
PAITAN INTEGRATED SCHOOL 7	Paitan East		Medium	Medium
PAITAN INTEGRATED SCHOOL 8	Paitan East		Medium	Medium
PAITAN INTEGRATED SCHOOL 9	Paitan East	Low	High	High
PAITAN WEST DAY CARE ENTER	Paitan East	Low	Medium	Medium
SANTO DOMINGO ELEMENTARY SCHOOL 1	Santo Domingo			
SANTO DOMINGO ELEMENTARY SCHOOL 10	Santo Domingo			
SANTO DOMINGO ELEMENTARY SCHOOL 2	Santo Domingo			
SANTO DOMINGO ELEMENTARY SCHOOL 3	Santo Domingo			
SANTO DOMINGO ELEMENTARY SCHOOL 4	Santo Domingo			
SANTO DOMINGO ELEMENTARY SCHOOL 5	Santo Domingo			
SANTO DOMINGO ELEMENTARY SCHOOL 6	Santo Domingo			
SANTO DOMINGO ELEMENTARY SCHOOL 7	Santo Domingo			
SANTO DOMINGO ELEMENTARY SCHOOL 8	Santo Domingo			
SANTO DOMINGO ELEMENTARY SCHOOL 9	Santo Domingo			
JETSOO SCHOOL INC. 1	Seselangen		Medium	Medium
JETSOO SCHOOL INC. 2	Seselangen		Medium	Medium
SESELANGEN DAY CARE CENTER	Seselangen		Low	Medium
SESELANGEN ELEMENTARY SCHOOL	Seselangen	Low	Medium	High
VICTORIA DAY CARE CENTER	Seselangen	Low	Low	Low

Annex 13. Health Institutions Affected in Alaminos Floodplain

Table A-13.1 Educational Institutions in Alaminos City, Pangasinan Affected by Flooding in Alaminos Floodplain

Pangasinan				
Alaminos City				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
ALAMINOS DOCTOR'S HOSPITAL	Bisocol	Low	High	High
JDA MEDICAL AND LYING IN CLINIC	Magsaysay			
RIVERA DIABETES CLINIC	Magsaysay			
THE CITY DOCTORS MEDICAL CENTER	Magsaysay			
WESTERN PANGASINAN DISTRICT HOSPITAL 1	Magsaysay			
WESTERN PANGASINAN DISTRICT HOSPITAL 10	Magsaysay			
WESTERN PANGASINAN DISTRICT HOSPITAL 11	Magsaysay			
WESTERN PANGASINAN DISTRICT HOSPITAL 12	Magsaysay			
WESTERN PANGASINAN DISTRICT HOSPITAL 13	Magsaysay			
WESTERN PANGASINAN DISTRICT HOSPITAL 14	Magsaysay			
WESTERN PANGASINAN DISTRICT HOSPITAL 15	Magsaysay			
WESTERN PANGASINAN DISTRICT HOSPITAL 2	Magsaysay			
WESTERN PANGASINAN DISTRICT HOSPITAL 3	Magsaysay			
WESTERN PANGASINAN DISTRICT HOSPITAL 4	Magsaysay			
WESTERN PANGASINAN DISTRICT HOSPITAL 5	Magsaysay			
WESTERN PANGASINAN DISTRICT HOSPITAL 6	Magsaysay			
WESTERN PANGASINAN DISTRICT HOSPITAL 7	Magsaysay			
WESTERN PANGASINAN DISTRICT HOSPITAL 8	Magsaysay			
WESTERN PANGASINAN DISTRICT HOSPITAL 9	Magsaysay			
C & H MEDICAL AND SURGICAL CLINIS INC. HOSPITAL	Poblacion			
F & N APARTMENT AND MATERNITY CLINIC	Poblacion			
PA-MA SURGICAL CLINIC	Poblacion			
WESTERN PANGASINAN EMISSION TESTING CENTER	Tanaytay	Low	Medium	High