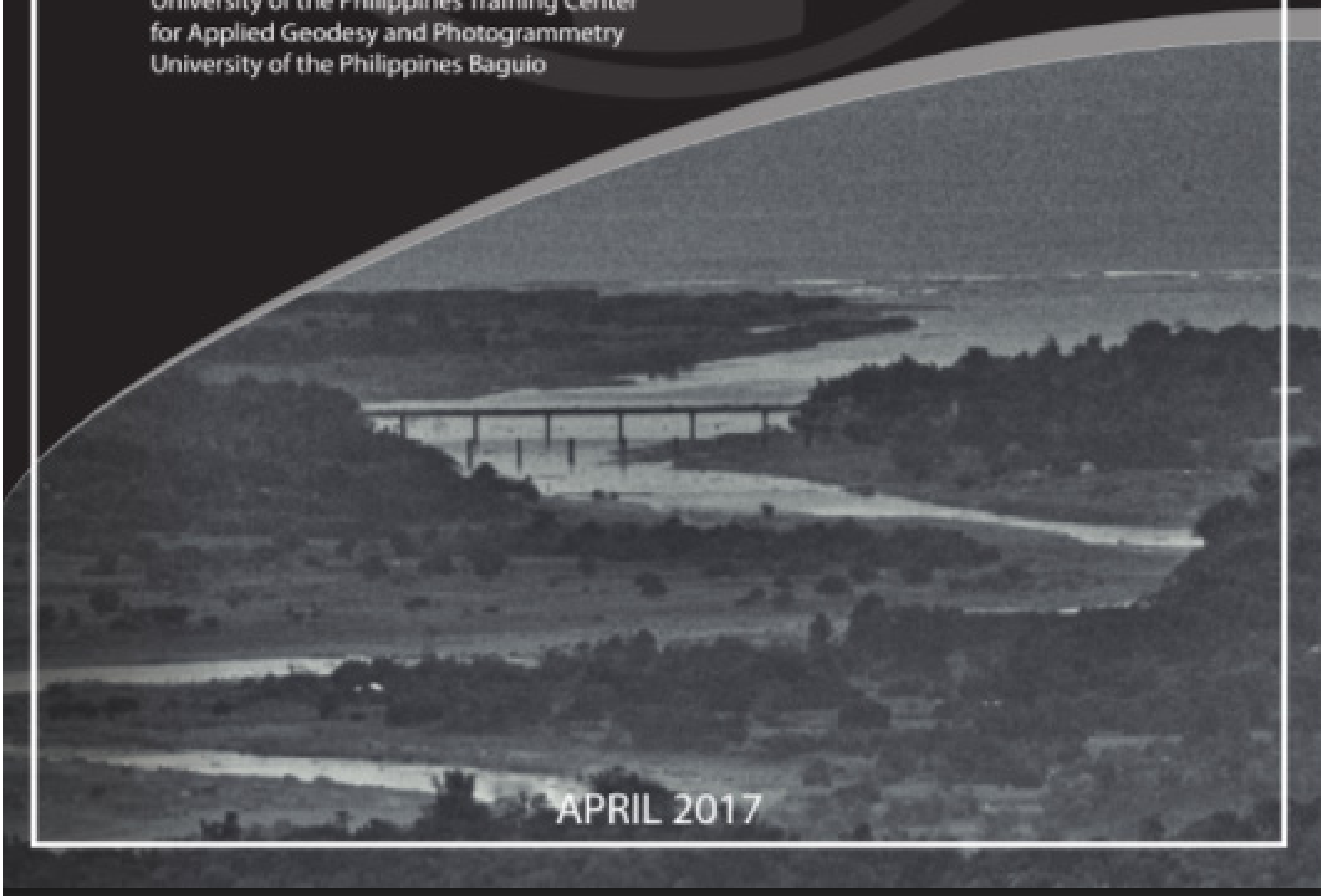
Hazard Mapping of the Philippines Using LIDAR (Phil-LIDAR 1)

LiDAR Surveys and Flood Mapping of Bauang River

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



APRIL 2017

Published by the UP Training Center for Applied Geodesy and Photogrammetry (TCAGP)
College of Engineering
University of the Philippines – Diliman
Quezon City
1101 PHILIPPINES

This research project is supported by the Department of Science and Technology (DOST) as part of its Grants-in-Aid (GIA) Program and is to be cited as:

E.C. Paringit and C. Pascua, (Eds.). (2017), LiDAR Surveys and Flood Mapping of Bauang River. Quezon City: University of the Philippines Training Center on Geodesy and Photogrammetry-302pp.

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National Library of the Philippines
ISBN: 978-621-430-088-4

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LIST OF ACRONYMS AND ABBREVIATIONS

AAC	Asian Aerospace Corporation
Ab	abutment
ALTM	Airborne LiDAR Terrain Mapper
ARG	automatic rain gauge
ASTI	Advanced Science and Technology Institute
AWLS	Automated Water Level Sensor
BA	Bridge Approach
BM	benchmark
BSWM	Bureau of Soils and Water Management
CAD	Computer-Aided Design
CN	Curve Number
CSRS	Chief Science Research Specialist
DA	Department of Agriculture
DAC	Data Acquisition Component
DEM	Digital Elevation Model
DENR	Department of Environment and Natural Resources
DOST	Department of Science and Technology
DPPC	Data Pre-Processing Component
DREAM	Disaster Risk and Exposure Assessment for Mitigation [Program]
DRRM	Disaster Risk Reduction and Management
DSM	Digital Surface Model
DTM	Digital Terrain Model
DVBC	Data Validation and Bathymetry Component
FMC	Flood Modeling Component
FOV	Field of View
GiA	Grants-in-Aid
GCP	Ground Control Point
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HEC-HMS	Hydrologic Engineering Center - Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center - River Analysis System
HC	High Chord
IDW	Inverse Distance Weighted [interpolation method]
IMU	Inertial Measurement Unit
kts	knots
LAS	LiDAR Data Exchange File format
LC	Low Chord
LGU	local government unit
LiDAR	Light Detection and Ranging
LMS	LiDAR Mapping Suite
m AGL	meters Above Ground Level
MMS	Mobile Mapping Suite
MSL	mean sea level
NAMRIA	National Mapping and Resource Information Authority
NSO	National Statistics Office
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
RBCO	River Basin Control Office
RIDF	Rainfall-Intensity-Duration-Frequency
RMSE	Root Mean Square Error
SAR	Synthetic Aperture Radar
SCS	Soil Conservation Service
SRTM	Shuttle Radar Topography Mission
SRS	Science Research Specialist
SSG	Special Service Group
TBC	Thermal Barrier Coatings
UPB	University of the Philippines Baguio
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 BAUANG RIVER

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

1.1 Background of the Phil-LiDAR 1 Program

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

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

The implementing partner university for the Phil-LiDAR 1 Program is the University of the Philippines Baguio (UPB). UPB is in charge of processing LiDAR data and conducting data validation reconnaissance, cross section, bathymetric survey, validation, river flow measurements, flood height and extent data gathering, flood modeling, and flood map generation for the twelve (12) river basins in the Northern Luzon Region. The university is located in Baguio City in the province of Benguet.

1.2 Overview of the Bauang River Basin

The Bauang River Basin covers five (5) municipalities and one (1) city in the province of La Union, and four (4) municipalities and one (1) city in the province of Benguet. According to the Department of Environment and Natural Resources - River Basin Control Office (DENR-RBCO), it has a drainage area of 353 square kilometers, and an estimated 863 million cubic meters (MCM) in annual run-off (River Basin Control Office, 2017).

Its main stem, the Bauang River, is part of the river systems in the Northern Luzon Region. The river stream network runs along the Municipalities of Bauang, Naguilian, and San Fernando City in the province of La Union.

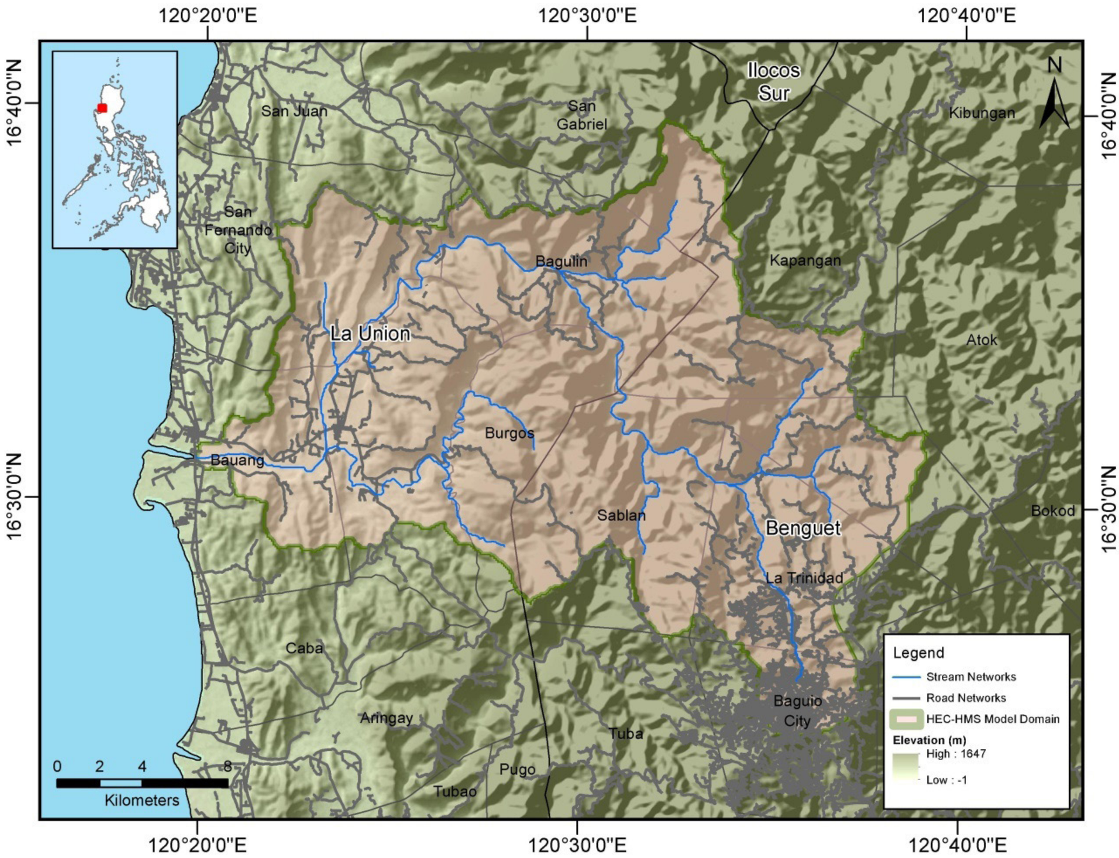

Figure 1. Location map of the Bauang River Basin (in brown)

According to the 2015 national census conducted by the National Statistics Office (NSO), the total of population of residents within the immediate vicinity of the river is 42,169, distributed among the twenty-four (24) barangays in the Municipalities of Bauang, Naguilian and San Fernando City (Philippine Statistics Authority, 2016).

The primary sources of livelihood for the locals are fishing, farming, and quarrying. The main agricultural products of Bauang include rice, corn, guapple, and native grapes. Bauang is also a tourist destination, known for its fine sand beaches (Inigo, 2015).

On July 2, 2015, the region was placed under a state of calamity due to floods caused by Typhoon Egay.

CHAPTER 2: LIDAR DATA ACQUISITION OF THE BAUANG 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

To initiate the LiDAR acquisition survey of the Bauang floodplain, the Data Acquisition Component (DAC) created flight plans within the delineated priority area for the floodplain in La Union. These missions were planned for sixteen (16) lines and ran for at most four and a half (4.5) hours, including take-off, landing, and turning time. The Pegasus LiDAR System was utilized for the missions (See Annex 1 for the sensor specifications). The flight planning parameters for the LiDAR system are found in Table 1. Figure 2 illustrates the flight plans and base stations for the Bauang floodplain survey.

Table 1. Flight planning parameters for the Pegasus LiDAR system

Block Name	Flying Height (m AGL)	Overlap (%)	Field of View (θ)	Pulse Repetition Frequency (PRF) (kHz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
10C	1200 / 1500 / 1800	30	50	200	30	130	5
10D	1200 / 1500	30	50	200	30	130	5
10F	1200	30	50	200	30	130	5
10G	1500	30	50	200	30	130	5

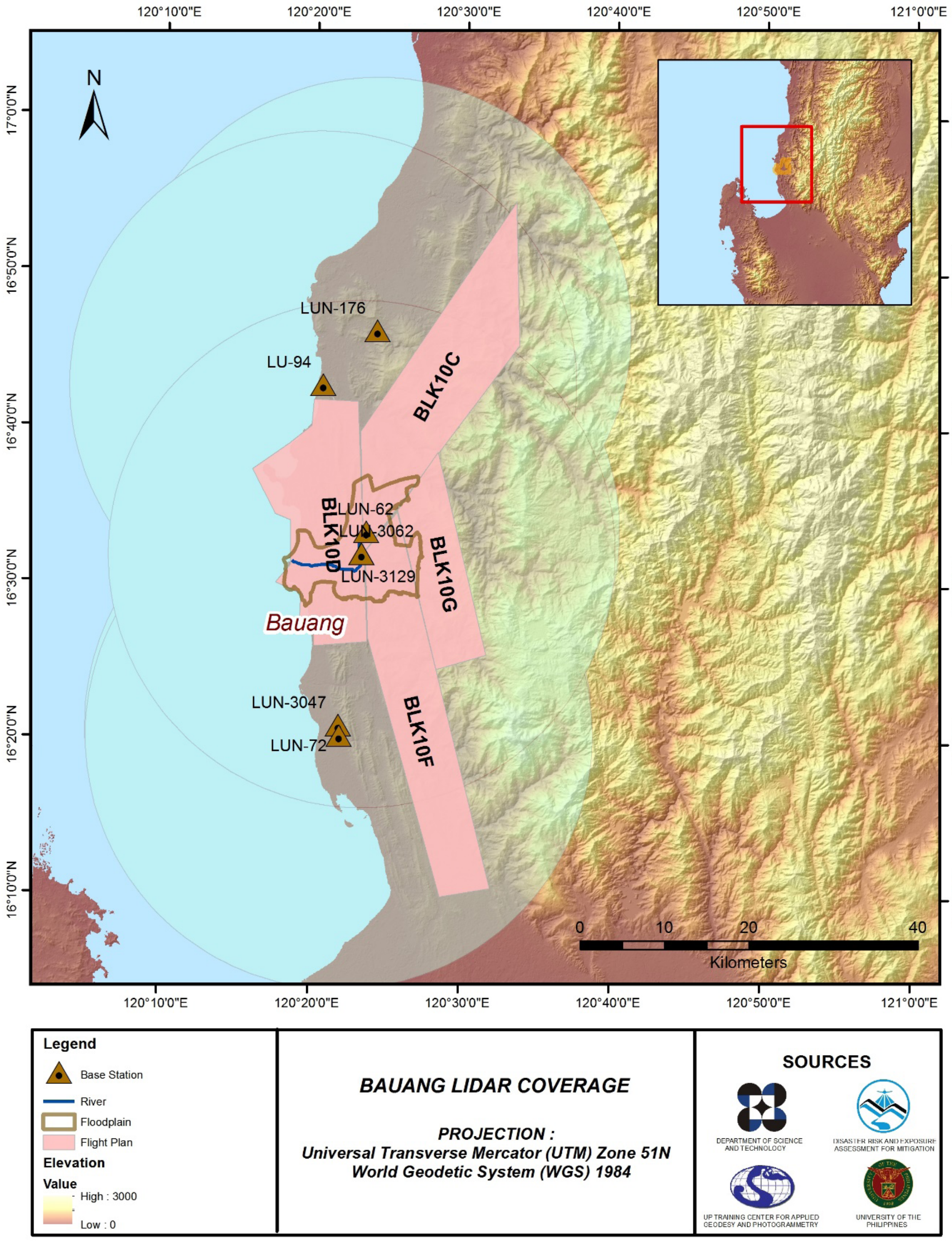


Figure 2. Flight plans and base stations used to cover the Bauang floodplain survey

2.2 Ground Base Stations

The field team for this undertaking was able to recover the following NAMRIA control stations: (i.) LUN-62 and (ii.) LUN-176), with second (2nd) order accuracy; (iii.) LUN-3062, (iv.) LUN-3047, and (v.) LUN-3129, with fourth (4th) order accuracy. The field team also recovered benchmark BM LU-94, which is of first (1st) order accuracy. The certifications for the NAMRIA reference points are found in Annex 2; while the baseline processing reports for the established control points are found in Annex 3. These were used as base stations during the flight operations for the entire duration of the survey, held on February 25 – March 8, 2015. The base stations were observed using dual frequency GPS receivers, TRIMBLE SPS 852 and SPS 985. The flight plans and the locations of base stations used during the aerial LiDAR acquisition in the Bauang floodplain are presented in Figure 2. The composition of the full project team is shown in Annex 4.

Figure 3 to Figure 8 exhibit the recovered NAMRIA reference points within the area. Table 2 to Table 7 provide the details about the NAMRIA control stations and established points. Table 8 lists all of the ground control points occupied during the acquisition, together with the dates of utilization.

(a) (b)

Figure 3. (a) GPS set-up over LUN-62, as recovered 15 m south from the first access ladder of the river control and about 100 m north from the end. It is also situated 300 m south of a hanging bridge. (b) NAMRIA reference point LUN-62, as recovered by the field team

Table 2. Details of the recovered NAMRIA horizontal control point LUN-62, used as a base station for the LiDAR acquisition

Station Name	LUN-62	
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° 33' 19.98115" 120° 23' 28.76004" 33.18400 m
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	435034.926 m 1831016.667 m
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	16° 33' 14.07106" 120° 23' 33.49149" 69.44500 m
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting Northing	221592.72 m 1832084.35 m

(a)

(b)

Figure 4. (a) GPS set-up over LUN-176, recovered near a corner of a farm dike, about 15 m southeast of the well, and about 20 m southwest of the nearest house. (b) NAMRIA reference point LUN-176, as recovered by the field team

Table 3. Details of the recovered NAMRIA horizontal control point LUN-176, used as a base station for the LiDAR acquisition

Station Name	LUN-176	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude	16° 46’ 14.35394” 120° 24’ 5.41918”
	Ellipsoidal Height	35.63300 m
Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 5 PRS 92)	Easting	436193.115 m
	Northing	1854816.574 m
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	16° 46’ 8.39718”
	Longitude	120° 24’ 10.13252”
	Ellipsoidal Height	71.25300 m
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting	222990.04 m
	Northing	1855884.50 m

(b)

(a)

Figure 5. (a) GPS set-up over LUN-3062, recovered at the top of a dike, approximately 100 m north of Philippine Central College of Arts Sciences & Technology, and 80 m north of Naguilian emission testing center in Barangay Natividad, Naguilian, La Union. (b) NAMRIA reference point LUN-3062, as recovered by the field team

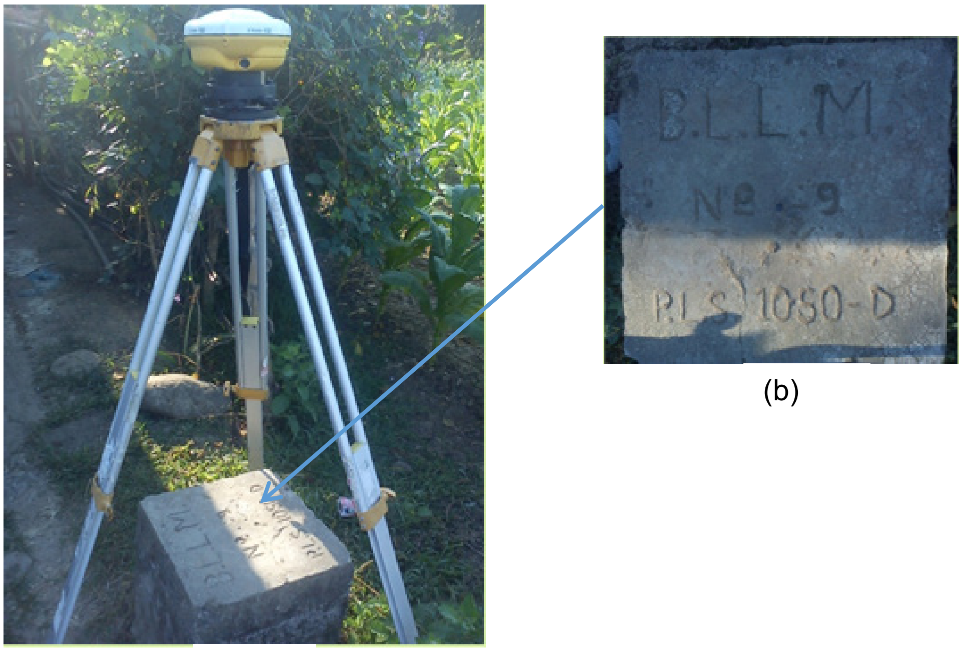
Table 4. Details of the recovered NAMRIA horizontal control point LUN-3062, used as a base station for the LiDAR acquisition

Station Name	LUN-3062	
Order of Accuracy	4th	
Relative Error (horizontal positioning)	1 in 10,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	16° 31’ 55.00993”
	Longitude	120° 23’ 12.50504”
	Ellipsoidal Height	25.32100 m
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	434545.028 m
	Northing	1828406.255 m
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	16° 31’ 49.10470” 120° 23’ 17.23850”
	Longitude	
	Ellipsoidal Height	61.64400 m
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting	221076.59 m
	Northing	1829477.48 m

Figure 6. LUN-3047, as recovered in Barangay Nazareno, Agoo, La Union

Table 5. Details of the established horizontal control point LUN-3047, used as a base station for the LiDAR acquisition

Station Name	LUN-3047	
Order of Accuracy	4th	
Relative Error (horizontal positioning)	1 in 10,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	16° 20’ 55.96430” North 120° 21’ 47.08672” East 43.62100 meters
Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 5 PRS 92)	Easting Northing	431948.446 meters 1808156.256 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	16°20’ 50.09786” North 120° 21’ 51.83567” East 80.44800 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	218278.33 meters 1809242.68 meters



(a) (b)

Figure 7. (a) GPS set-up over LUN-3129, recovered beside the National Road about 50 meters northeast of the nearest house. (b) NAMRIA reference point LUN-3129, as recovered by the field team

Table 6. Details of the recovered NAMRIA horizontal control point LUN-3129, used as a base station for the LiDAR acquisition

Station Name	LUN-3129	
Order of Accuracy	4th	
Relative Error (horizontal positioning)	1 in 10,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude	16° 31’ 55.00993” 120° 23’ 12.50504”
	Ellipsoidal Height	25.32100 m
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	434545.028 m
	Northing	1828406.255 m
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude	16° 31’ 49.10470” 120° 23’ 17.23850”
	Ellipsoidal Height	61.64400 m
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting	221076.59 m
	Northing	1829477.48 m

Figure 8. NAMRIA reference point LU-94, as recovered by the field team

Table 7. Details of the recovered NAMRIA vertical control point LU-94, used as a base station for the LiDAR acquisition

Station Name	LU-94	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1:50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	16°42’ 38.64674”
	Longitude	120°20’35.05091”
	Ellipsoidal Height	49.582 m
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	21672.143 m
	Northing	1849445.472 m
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	16°42’ 38.64674”
	Longitude	120°20’35.05091”
	Ellipsoidal Height	49.582 m

Table 8. Ground control points used during the LiDAR data acquisition

Date Surveyed	Flight Number	Mission Name	Ground Control Points
February 25, 2014	1153P	1BLK10AS056B	LUN-176 and LUN-3129
February 26, 2014	1155P	1BLK10C057A	LUN-176 and LU-94
February 27, 2014	1159P	1BLK10GD058A	LUN-62 and LUN-302
February 27, 2014	1161P	1BLK10D058B	LUN-62 & LUN-3062
February 28, 2014	1163P	1BLK10F059A	LUN-72 & LUN-3047
March 2, 2014	1171P	1BLK10CDS061A	LUN-62 and LUN-3062
March 2, 2014	1173P	1BLK10DS061B	LUN-62 and LUN-3062
March 3, 2014	1177P	1BLK10CS062B	LUN-176 and LUN-3129
March 8, 2014	1197P	1BLK10GCS067B	LUN-62 and LUN-3062

2.3 Flight Missions

A total of nine (9) flight missions were conducted to complete the LiDAR data acquisition in the Bauang floodplain, for a total of twenty-six hours and seven minutes (26+7) of flying time for RP-C9022. All missions were acquired using the Pegasus LiDAR system. The flight logs for the missions are provided in Annex 6. Table 9 indicates the total area of actual coverage and the corresponding flying hours per mission; while Table 10 presents the actual parameters used during the LiDAR data acquisition.

Table 9. Flight missions for the LiDAR data acquisition in the Bauang 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
February 25, 2014	1153P	223.74	0.000	0.000	92.675	NA	1	45
February 26, 2014	1155P	298.492	18.526	18.526	233.071	574	3	31
February 27, 2014	1159P	389.031	67.904	67.904	214.796	75	3	31
February 27, 2014	1161P	253.115	33.684	33.684	152.408	369	2	43
February 28, 2014	1163P	275.809	48.444	48.444	292.968	819	3	37
March 2, 2014	1171P	551.607	30.883	30.883	161.940	334	3	15
March 2, 2014	1173P	253.115	56.898	56.898	117.251	334	2	13
March 3, 2014	1177P	298.492	47.130	47.130	228.987	501	2	43
March 8, 2014	1197P	434.408	5.468	5.468	103.405	257	2	49
TOTAL		2977.809	1906.437	308.936	1597.502	3263	26	7

Table 10. Actual parameters used during the LiDAR data acquisition

Flight Number	Flying Height (m AGL)	Overlap (%)	FOV (θ)	PRF (Hz)	Scan Frequency (kHz)	Average Speed (kts)	Average Turn Time (Minutes)
1153P	1200	30	50	200	30	130	5
1155P	1200	30	50	200	30	130	5
1159P	1200	30	50	200	30	130	5
1161P	1200	50	30	200	50	130	5
1163P	1200	50	30	200	50	130	5
1171P	1500	30	50	200	30	130	5
1173P	1200	30	50	200	30	130	5
1177P	1800	30	50	200	30	130	5
1197P	1500	30	50	200	30	130	5

2.4 Survey Coverage

The Bauang floodplain is located in the province of La Union. The municipalities of Bauang, San Fernando City, San Juan, Naguilian, Pugo, Santol, Caba, Burgos, and Tubao in La Union were mostly covered by the survey. The municipalities and cities surveyed with at least one (1) square kilometer coverage are enumerated in Table 11. The actual coverage of the LiDAR acquisition for the Bauang floodplain is presented in Figure 9. See Annex 7 for the flight status reports.

Table 11. List of municipalities and cities surveyed during the Bauang floodplain LiDAR survey

Province	Municipality/City	Area of Municipality (km2)	Total Area Surveyed (km2)	Percentage of Area Surveyed (%)
La Union	Bauang	85.260	85.260	100%
	San Fernando City	121.053	121.033	100%
	San Juan	53.442	53.308	100%
	Naguilian	86.388	85.801	99%
	Pugo	60.537	56.057	93%
	Santol	97.972	85.920	88%
	Caba	56.191	46.611	83%
	Burgos	51.920	38.164	74%
	Tubao	53.873	37.759	70%
	Rosario	64.328	44.480	69%
	San Gabriel	154.189	88.684	58%
	Aringay	95.648	48.624	51%
	Bacnotan	80.671	38.888	48%
	Bagulin	77.967	33.921	44%
	Sudipen	75.745	28.585	38%
	Balaoan	60.960	15.085	25%
	Bangar	45.120	10.915	24%
	Agoo	33.707	5.938	18%
	Luna	50.658	4.962	10%
	Santo Tomas	58.531	3.714	6%
Ilocos Sur	Sugpon	180.280	49.474	27%
	Tagudin	54.348	11.711	22%
	Alilem	132.176	17.845	14%
	Suyo	148.521	16.742	11%
Pangasinan	Sison	151.962	50.992	34%
Benguet	Sablan	90.217	21.162	23%
	Tuba	322.020	7.266	2%
Total		2543.68	1108.9	43.59%

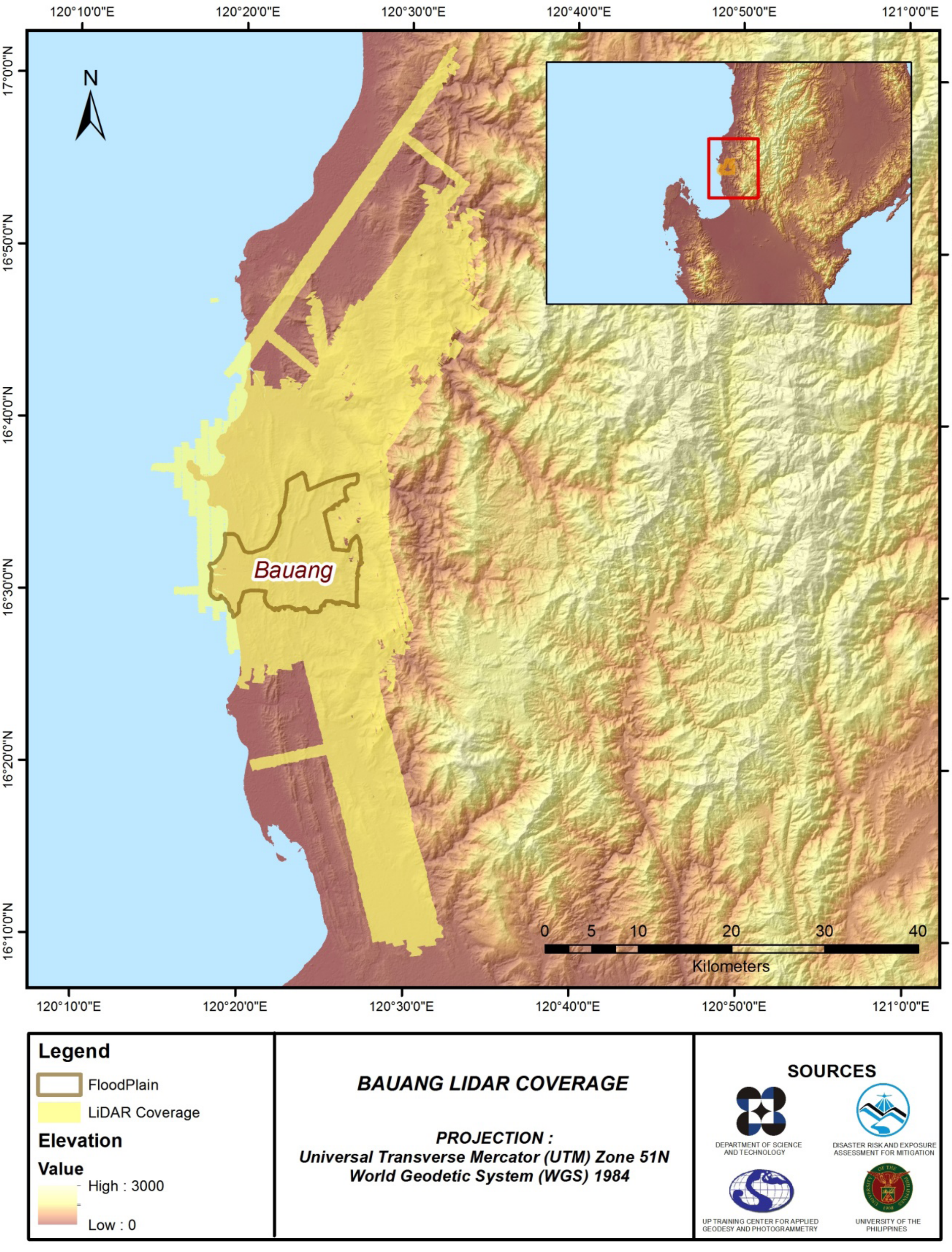


Figure 9. Actual LiDAR survey coverage for the Bauang floodplain

CHAPTER 3: LIDAR DATA PROCESSING OF THE BAUANG FLOODPLAIN

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

3.1 Overview of the LIDAR Data Pre-Processing

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

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

These processes are summarized in the diagram in Figure 10.

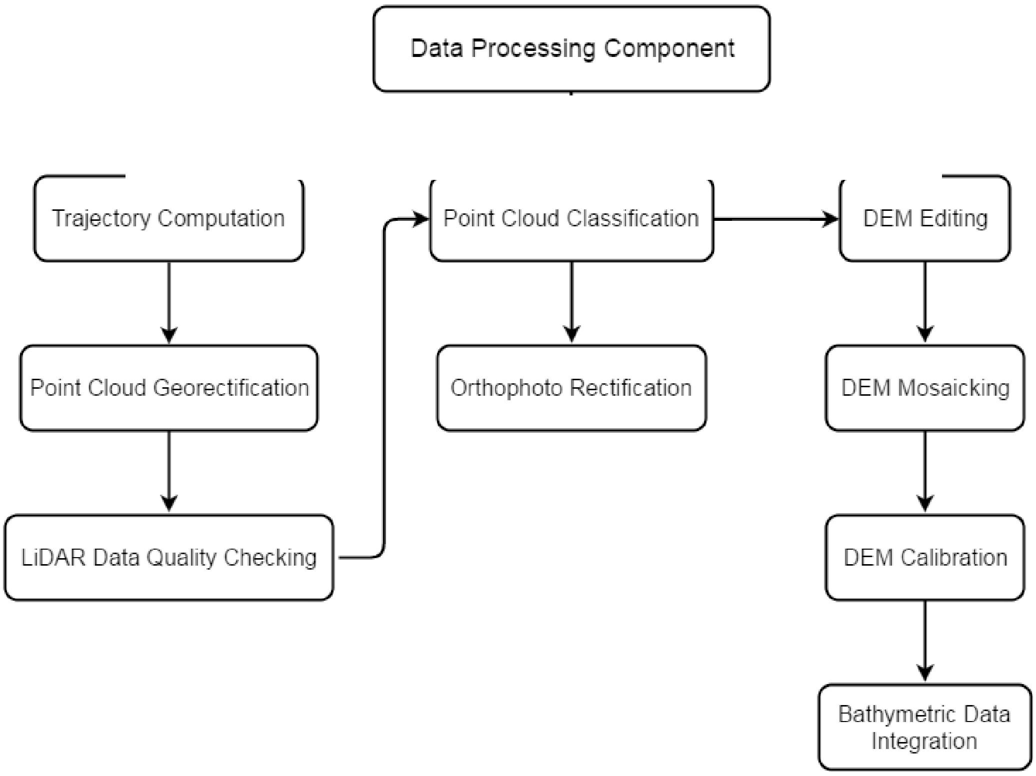

Figure 10. Schematic diagram for the Data Pre-Processing Component

3.2 Transmittal of Acquired LiDAR Data

The data transfer sheets for all the LiDAR missions for the Bauang floodplain can be found in Annex 5. Missions flown over Bauang, La Union during the first survey conducted in February 2014 and the second survey conducted in March 2014 both used the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.) Pegasus system. The DAC transferred a total of 142.68 Gigabytes of Range data, 1.23 Gigabytes of POS data, 121.72 Megabytes of GPS base station data, and 160 Gigabytes of raw image data to the data server on February 25, 2014 for the first survey, and on March 1, 2014 for the second survey. The Data Pre-processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for the Bauang survey was fully transferred on May, 17 2014, as indicated on the data transfer sheets for the Bauang floodplain.

3.3 Trajectory Computation

The Smoothed Performance Metric parameters of the computed trajectory for Flight 1153P, one of the Bauang flights, which are the North, East, and Down position RMSE values, are illustrated in Figure 11. The x-axis corresponds to the time of flight, which is measured by the number of seconds from the midnight of the start of the GPS week, which fell on February 25, 2014 at 00:00 hrs. on that week. The y-axis represents the RMSE value for that particular position.

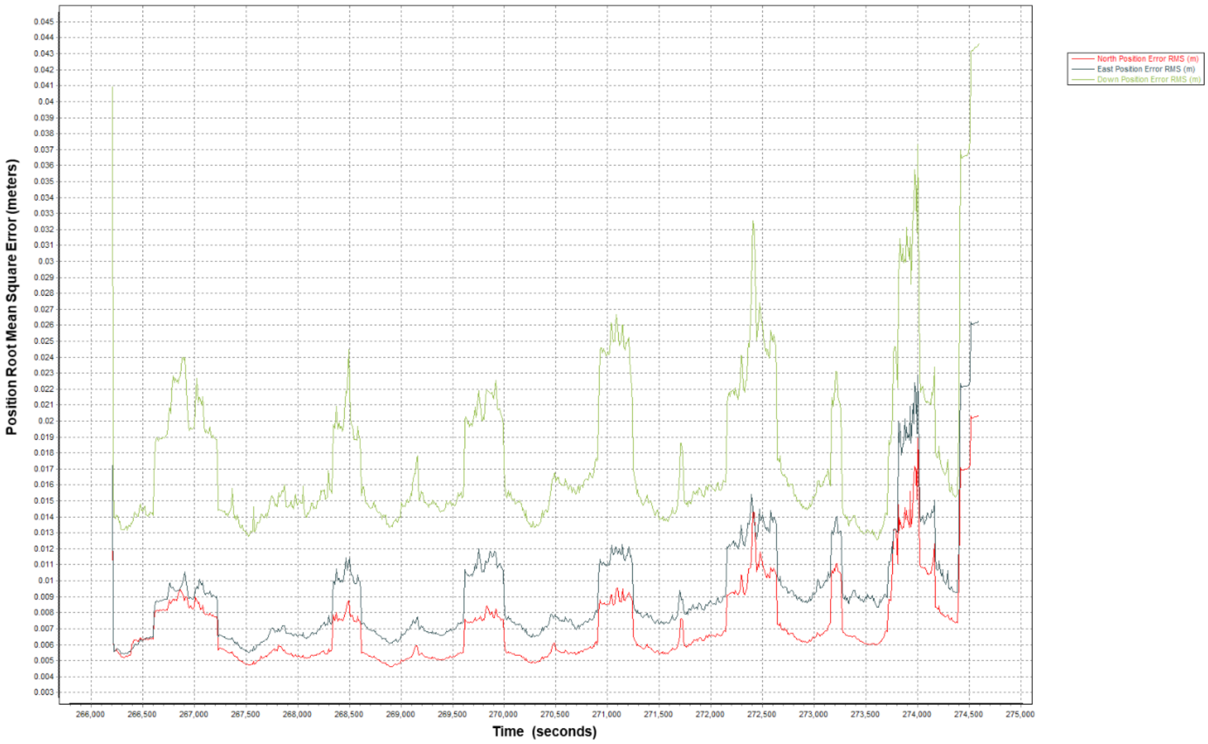

Figure 11. Smoothed Performance Metric Parameters of Bauang Flight 1153P

The time of flight was from 266,000 seconds to 275,000 seconds, which corresponds to the afternoon of February, 2014. The initial spike reflected on the data corresponds to the time that the aircraft was getting into position to start the acquisition, and the POS system was starting to compute for the position and orientation of the aircraft. Redundant measurements from the POS system quickly minimized the RMSE values of the positions. The periodic increase in RMSE values from an otherwise smoothly curving set of RMSE values indicates the turn-around period of the aircraft, when the aircraft makes a turn to start a new flight line. Figure 11 demonstrates that the North position RMSE peaked at 1.90 centimeters, the East position RMSE peaked at 2.20 centimeters, and the Down position RMSE peaked at 3.60 centimeters, which are within the prescribed accuracies described in the methodology.

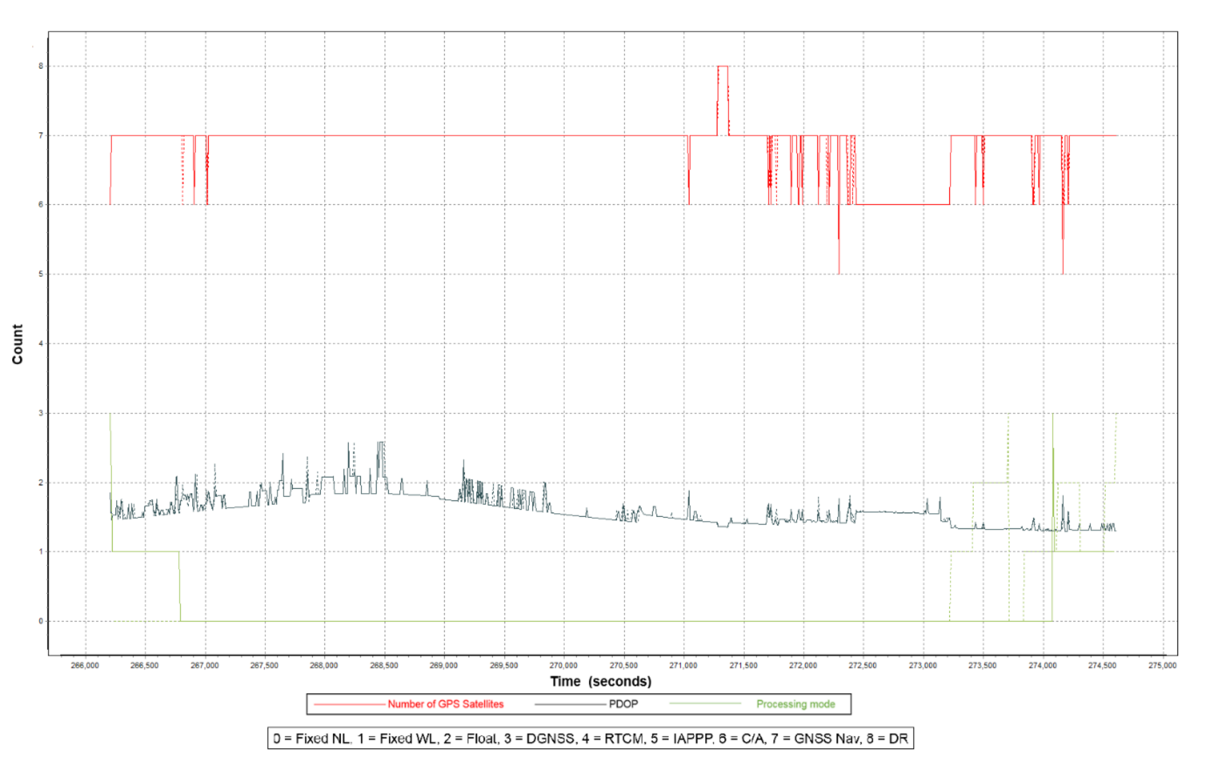

Figure 12. Solution Status Parameters of Bauang Flight 1153P

The Solution Status parameters of Flight 1153P, one of the Bauang flights, which are the number of GPS satellites, Positional Dilution of Precision (PDOP), and the GPS processing mode used, are depicted in Figure 12. The graphs indicate that the number of satellites during the acquisition did go down to 6. Majority of the time, the number of satellites tracked was between 5 and 8. The PDOP value did not go above the value of 3, which indicates optimal GPS geometry. The processing mode remained at the value of 0 for majority of the survey, with some peaks to up to 1, attributed to the turns performed by the aircraft. The value of 0 signifies a Fixed, Narrow-Lane mode, which is the optimum carrier-cycle integer ambiguity resolution technique available for POSPAC MMS. All of the parameters satisfied the accuracy requirements for optimal trajectory solutions, as indicated in the methodology. The computed best estimated trajectory for all Bauang flights is exhibited in Figure 13.

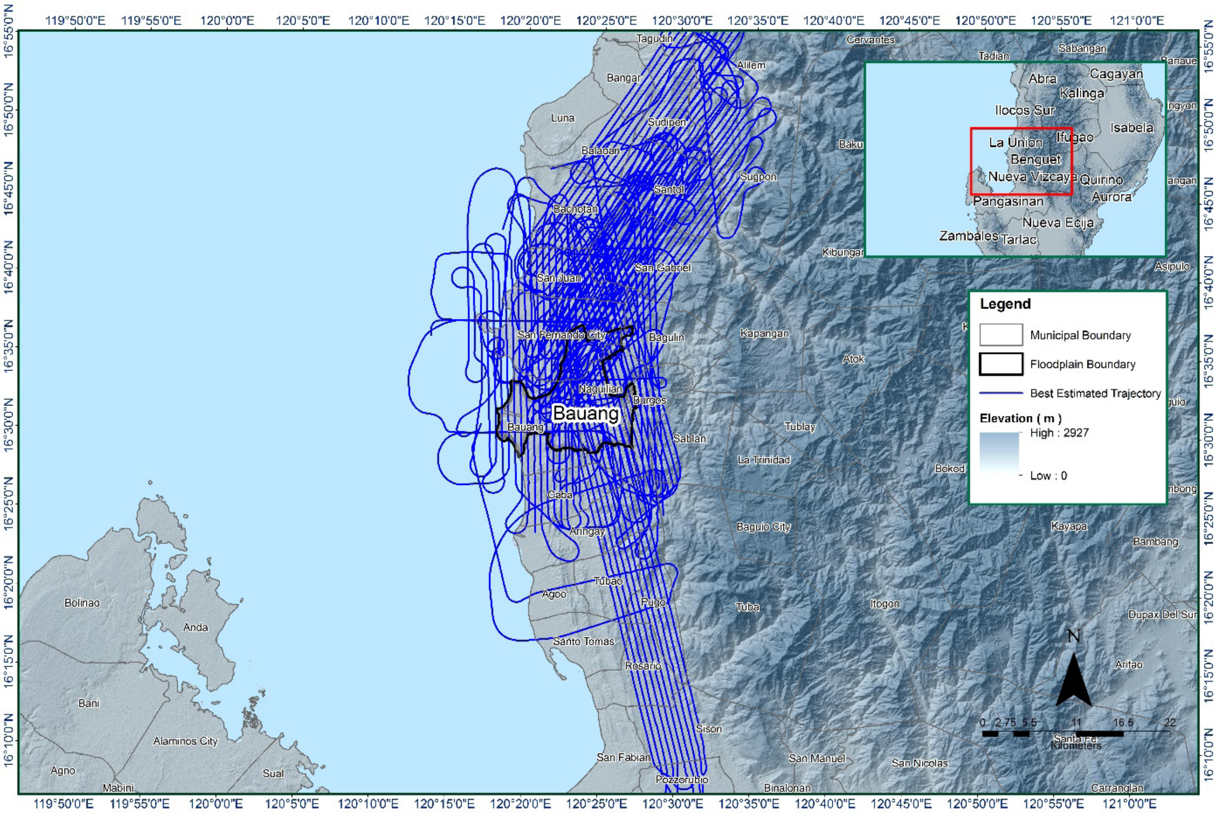

Figure 13. The best estimated trajectory conducted over the Bauang floodplain

3.4 LiDAR Point Cloud Computation

The produced LAS data contains two hundred and sixty (260) flight lines, with each flight line containing two (2) channels, since the Pegasus system contains two (2) channels. The summary of the self-calibration results for all flights over the Bauang floodplain, obtained through LiDAR processing in the LiDAR Mapping Suite (LMS) software, is given in in Table 12.

Table 12. Self-calibration results values for the Bauang flights

Parameter	Absolute Value	Computed Value
Boresight Correction stdev	(<0.001degrees)	0.000370
IMU Attitude Correction Roll and Pitch Corrections stdev	(<0.001degrees)	0.001263
GPS Position Z-correction stdev	(<0.01meters)	0.0076

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

3.5 LiDAR Data Quality Checking

The boundaries of the processed LiDAR data on top of a SAR Elevation Data over the Bauang Floodplain are represented in Figure 14. The map shows gaps in the LiDAR coverage that are attributed to cloud coverage.

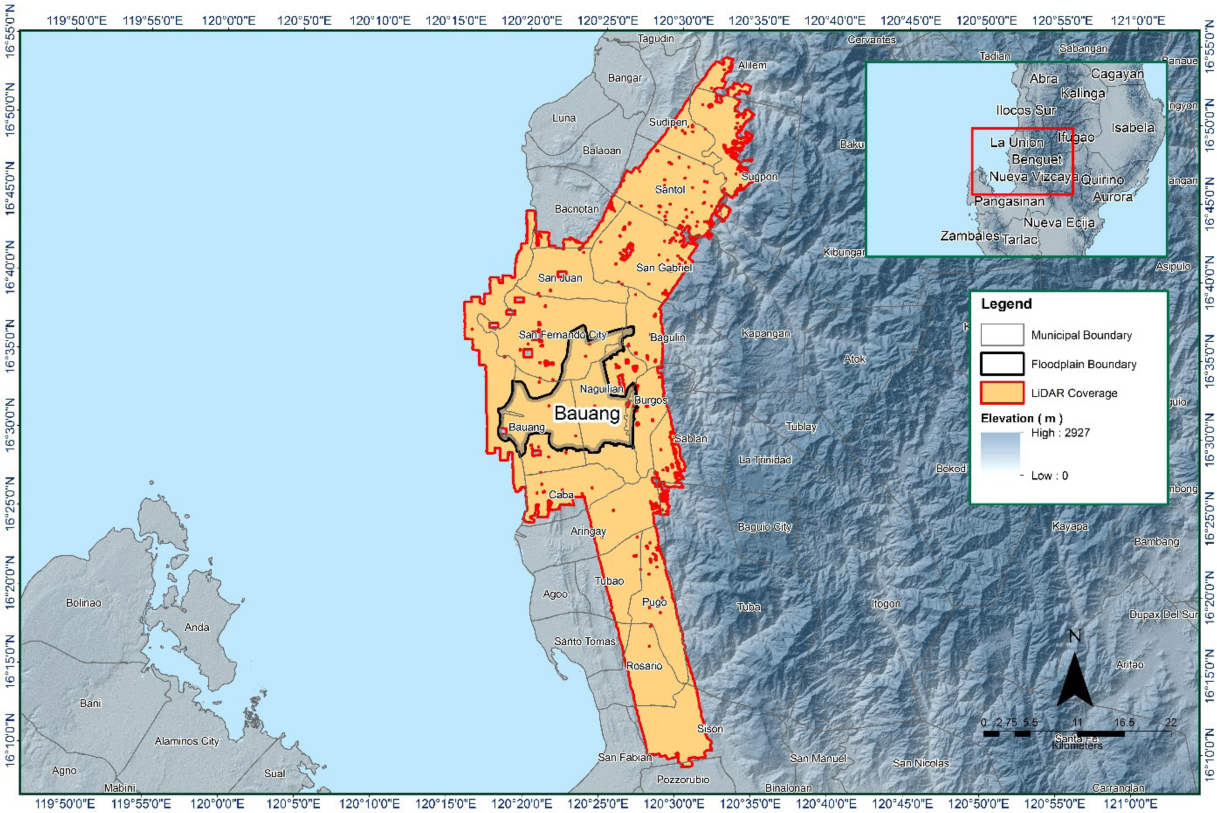

Figure 14. Boundaries of the processed LiDAR data over the Bauang floodplain

The total area covered by the Bauang missions is 1171.69 square kilometers, comprised of eight (8) flight acquisitions that are grouped and merged into four (4) blocks, as outlined in Table 13.

Table 13. List of LiDAR blocks for the Bauang floodplain

LiDAR Blocks	Flight Numbers	Area (sq. km)
LaUnion_Blk10C	1153P	399.93
	1169P	
	1175P	
	1197P	
LaUnion_Blk10D	1157P	326.71
	1159P	
	1171P	
LaUnion_Blk10F	1161P	324.81
LaUnion_Blk10G	1157P	120.23
	1197P	
TOTAL		1171.69 sq.km

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

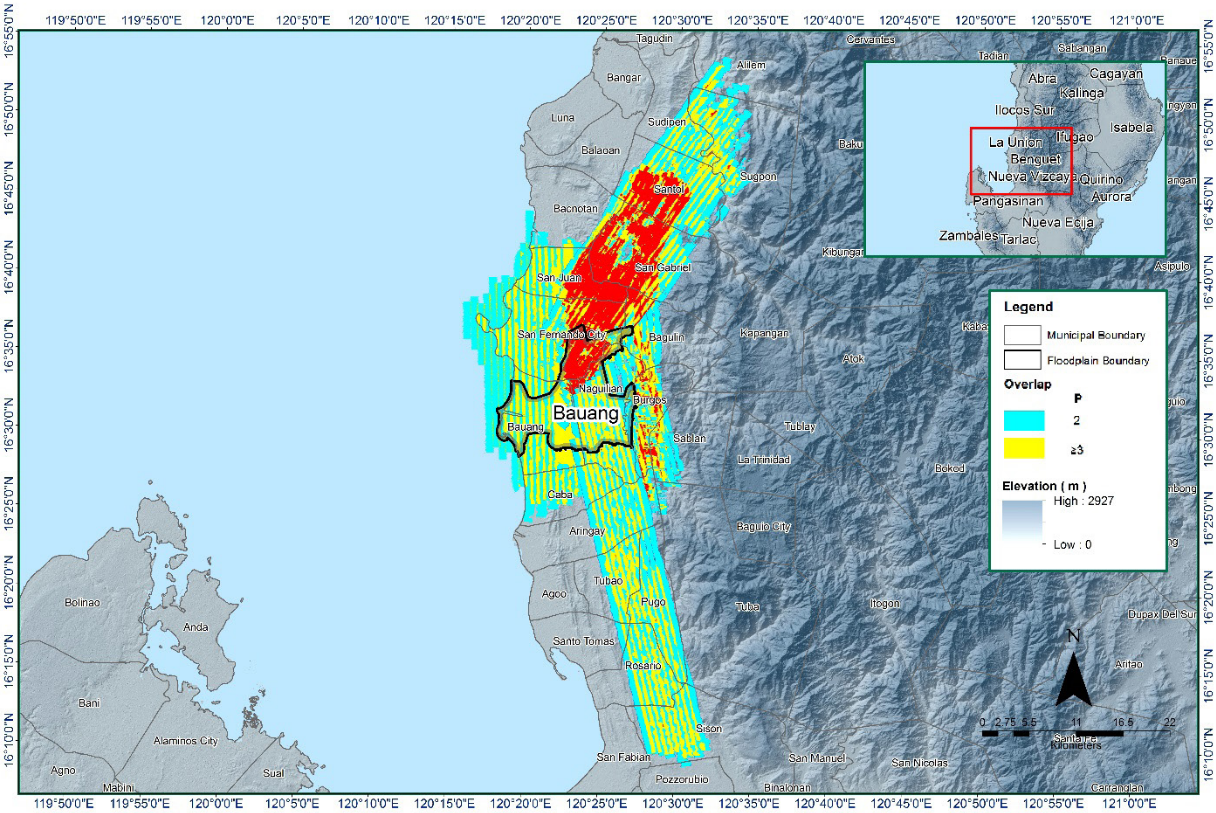

Figure 15. Image of data overlap for Bauang floodplain

The overlap statistics per block for the Bauang floodplain can be found in Annex 8. One (1) pixel corresponds to 25.0 square meters on the ground. For this area, the minimum and maximum percent overlaps were 35.05% and 68.41%, 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 two (2) points per square meter criterion, is exhibited in Figure 16. It was determined that all LiDAR data for the Bauang floodplain satisfy the point density requirement, and that the average density for the entire survey area is 3.12 points per square meter.

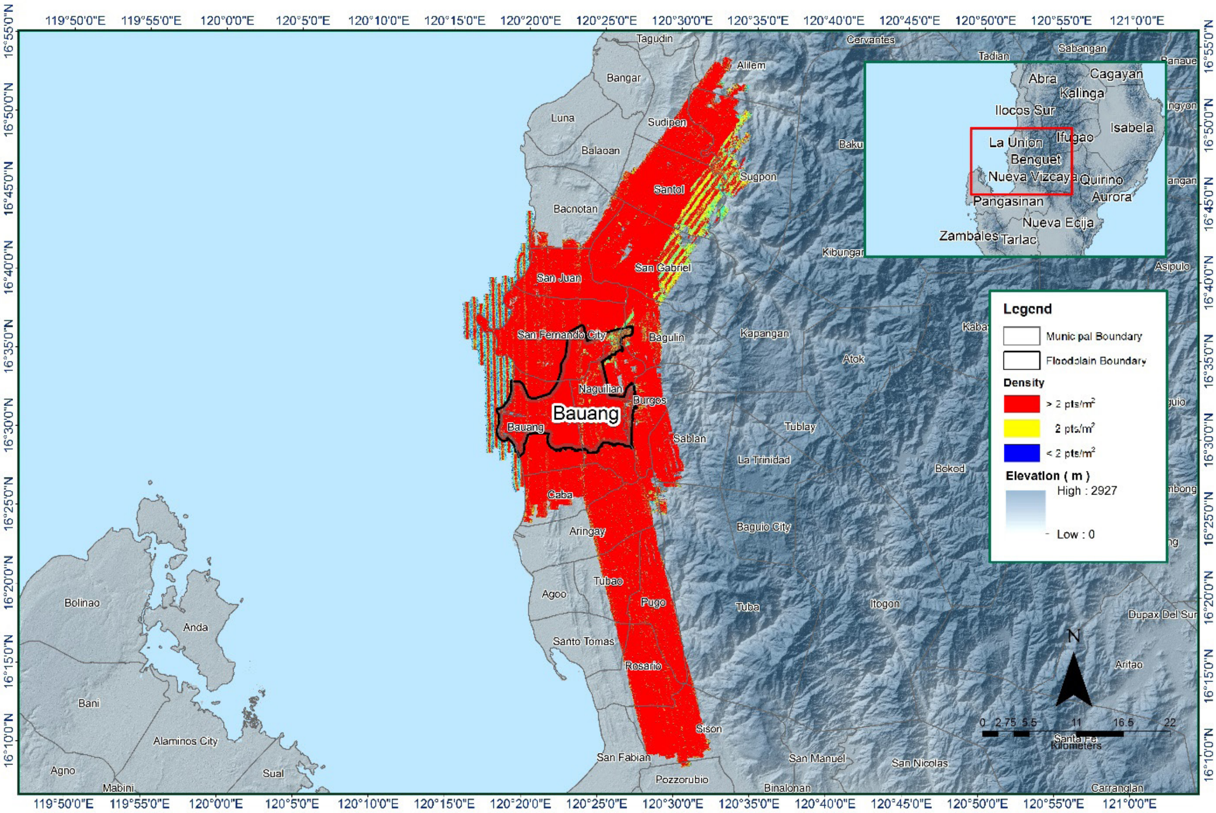

Figure 16. Density map of merged LiDAR data for the Bauang floodplain

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

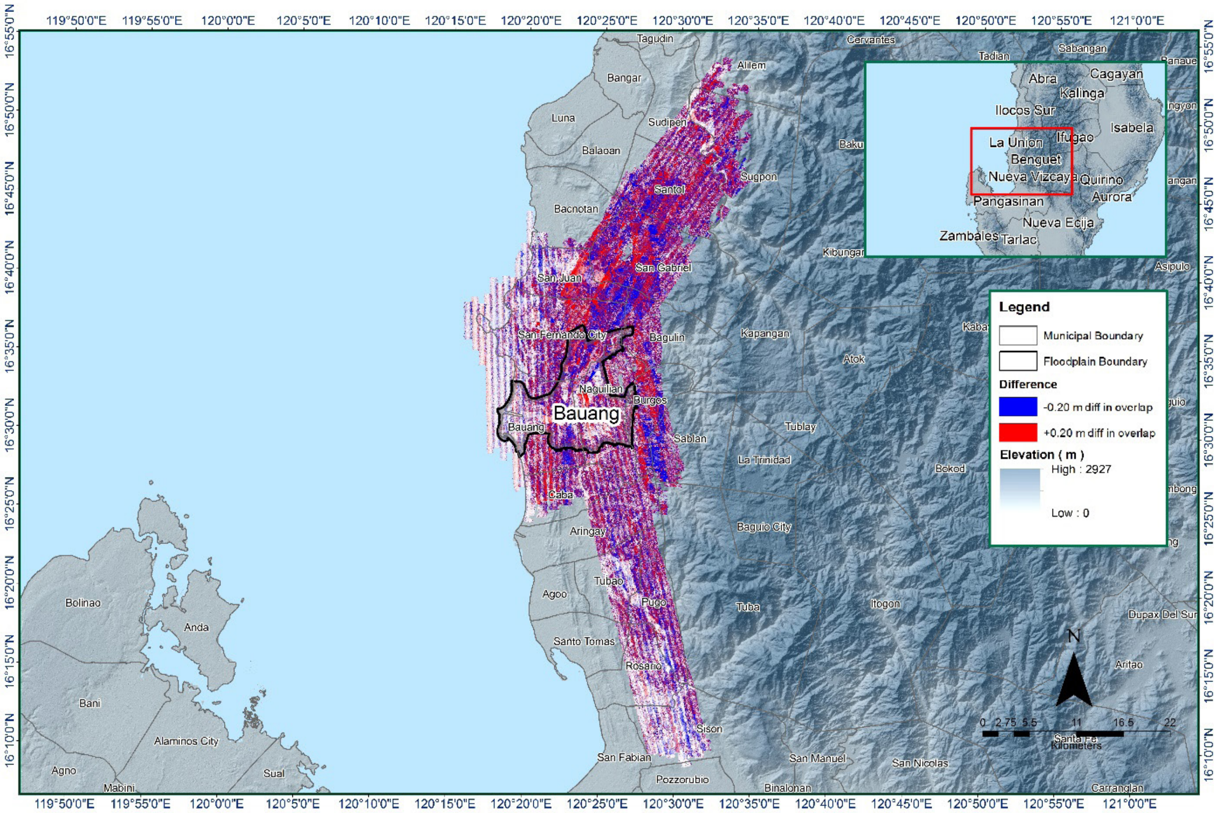

Figure 17. Elevation difference map between flight lines for the Bauang floodplain

A screen capture of the processed LAS data from Bauang Flight 1153P loaded in QT Modeler is provided in Figure 18. The upper left image shows the elevations of the points from two (2) overlapping flight strips traversed by the profile, illustrated by a dashed red line. The x-axis represents the length of the profile. It is evident that there were differences in elevation, but the differences did not exceed the 20-centimeter mark. This profiling was repeated until the quality of the LiDAR data became satisfactory. No reprocessing was done for this LiDAR dataset.

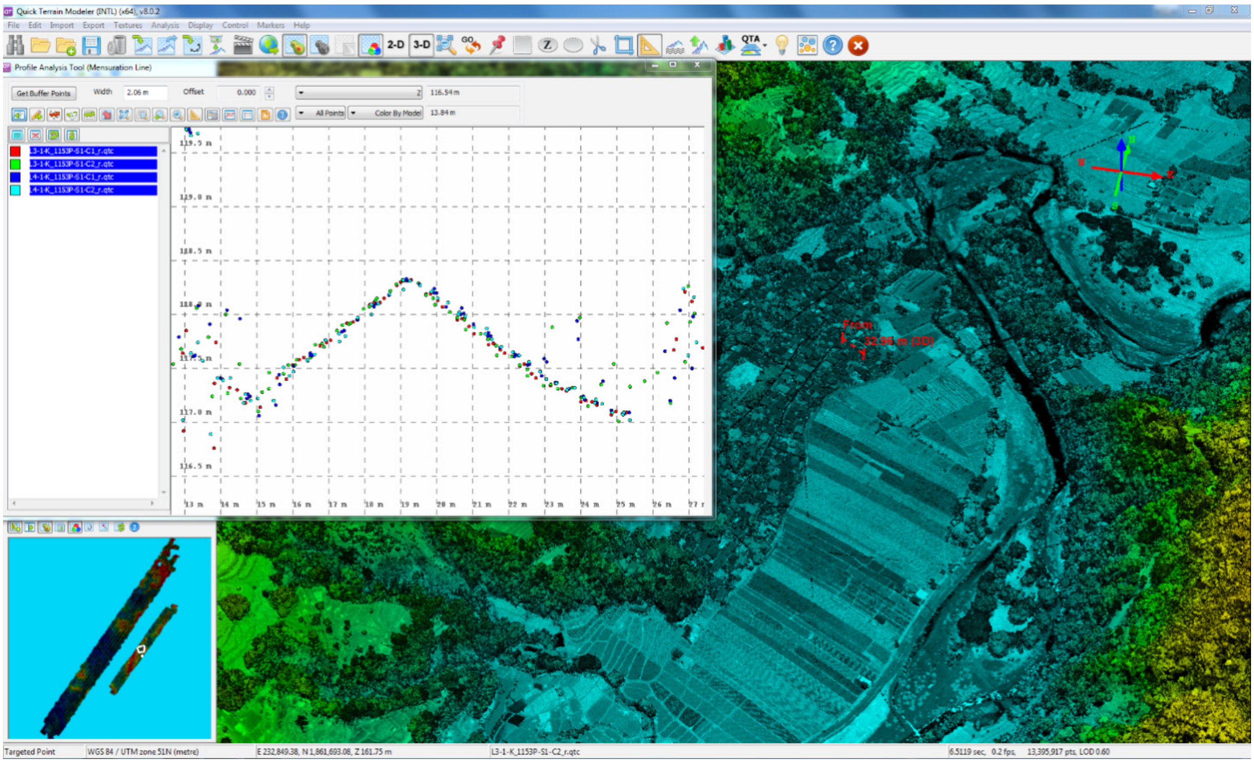

Figure 18. Quality checking for Bauang Flight 1153P, using the Profile Tool of QT Modeler

3.6 LiDAR Point Cloud Classification and Rasterization

Table 14. Bauang classification results in TerraScan

Pertinent Class	Total Number of Points
Ground	178,475,094
Low Vegetation	187,594,122
Medium Vegetation	317,240,334
High Vegetation	638,889,274
Building	23,295,587

The tile system that TerraScan employed for the LiDAR data, as well as the final classification image for a block in the Bauang floodplain, are presented in Figure 19. A total of 1,477 1km by 1km tiles were produced. The number of points classified according to the pertinent categories is illustrated in Table 14. The point cloud had a maximum and minimum height of 1038.37 meters and 45.5 meters, respectively.

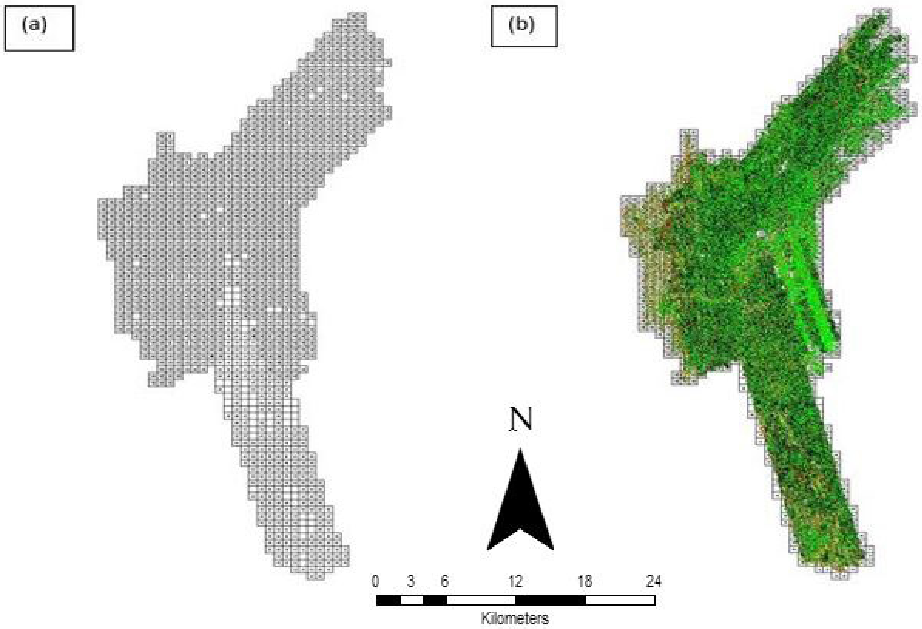

Figure 19. (a) Tiles for Bauang floodplain, and (b) classification results in TerraScan

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

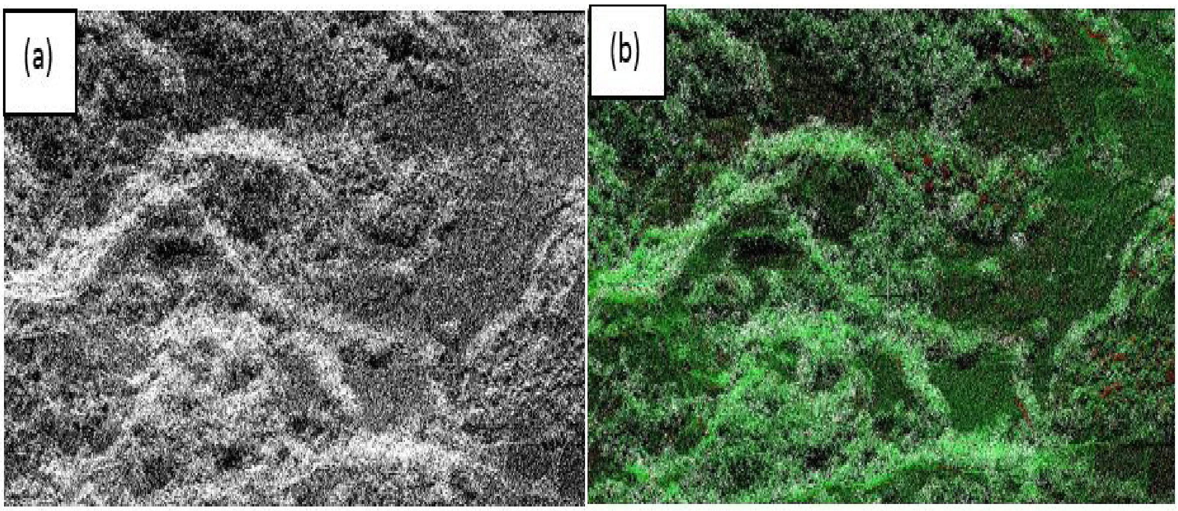

Figure 20. Point cloud (a) before and (b) after classification

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

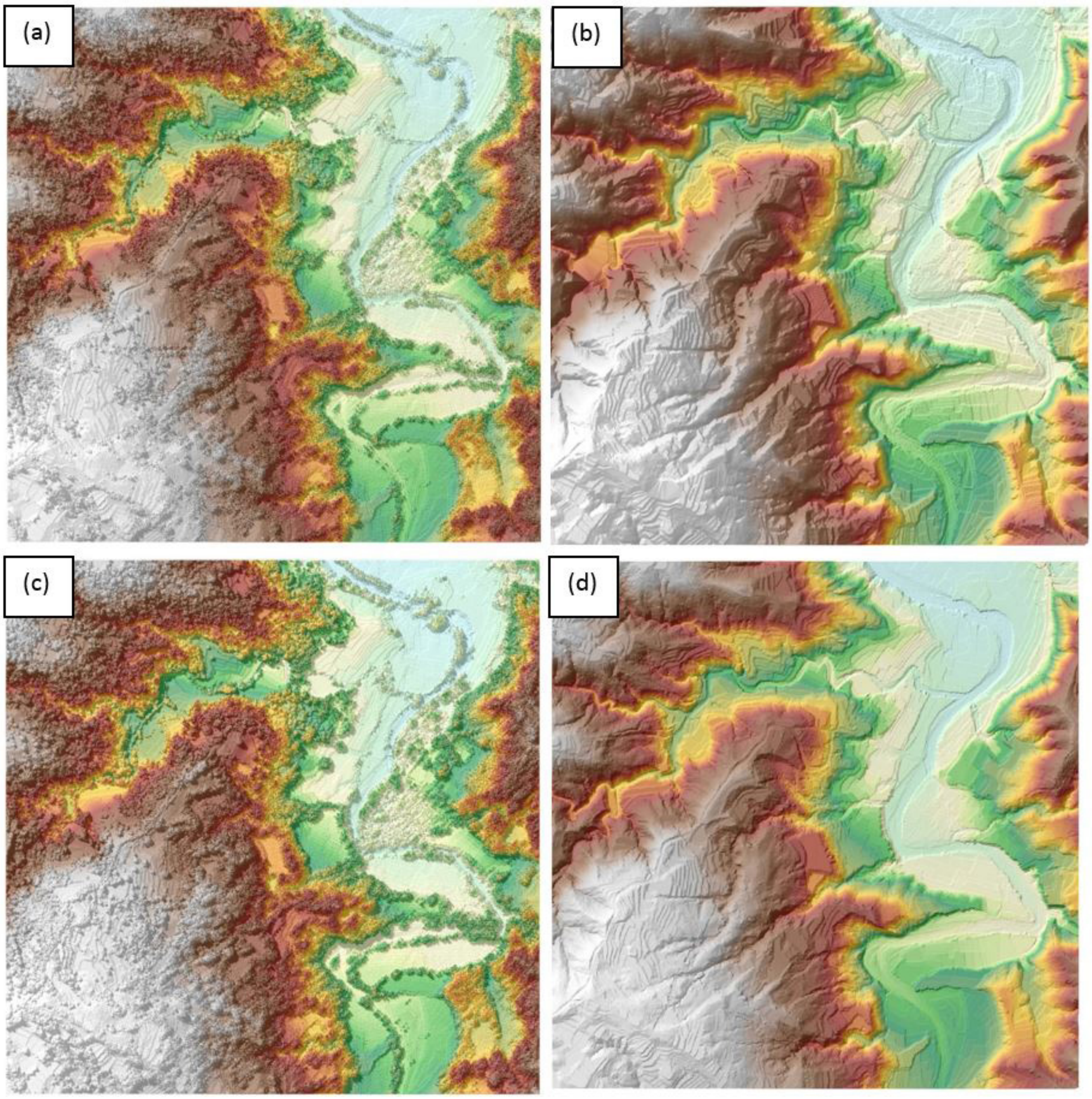

Figure 21. The production of (a) last return DSM and (b) DTM, (c) first return DSM and (d) secondary DTM in some portion of Bauang floodplain

3.7 LiDAR Image Processing and Orthophotograph Rectification

The 1,278 1km by 1km tiles area covered by the Bauang floodplain is displayed in Figure 22. After employing tie point selection to fix photo misalignments, color points were added to smoothen out visual inconsistencies along the seamlines where photos overlap. The Bauang floodplain survey attained a total of 971.99 square kilometers in orthophotographic coverage, comprised of 2,345 images. Zoomed-in versions of sample orthophotographs, identified by their tile numbers, are provided in Figure 23.

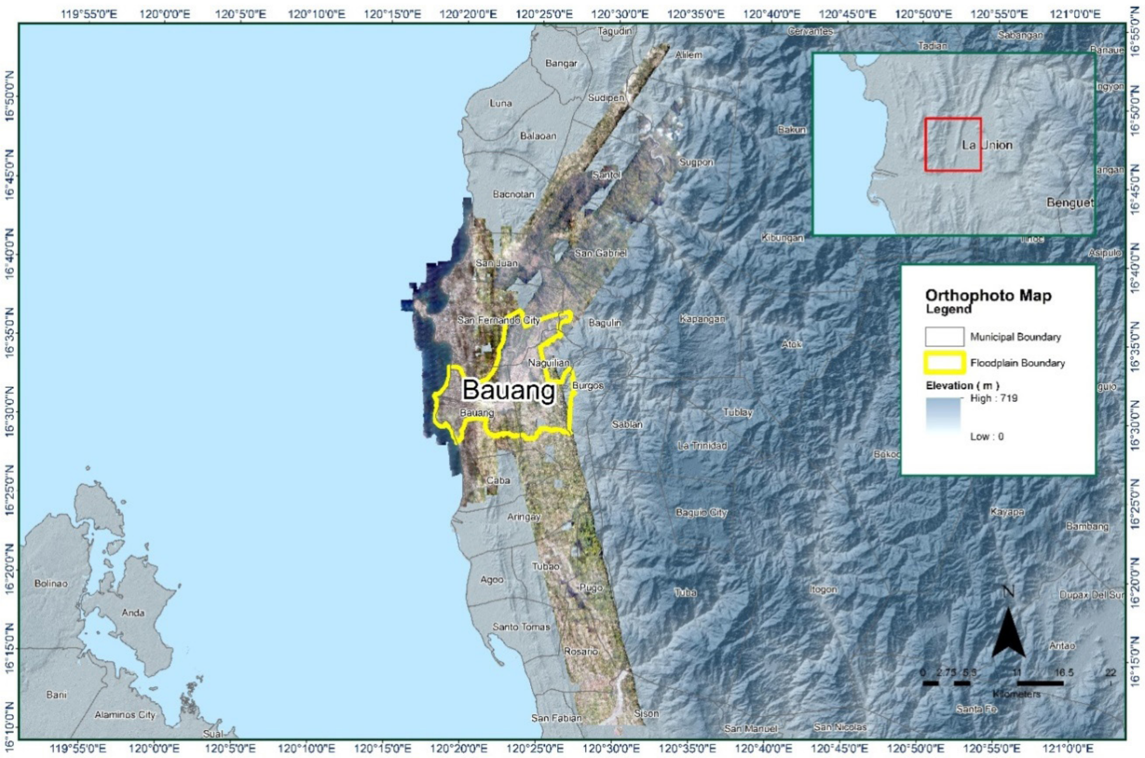

Figure 22. The Bauang floodplain, with available orthophotographs

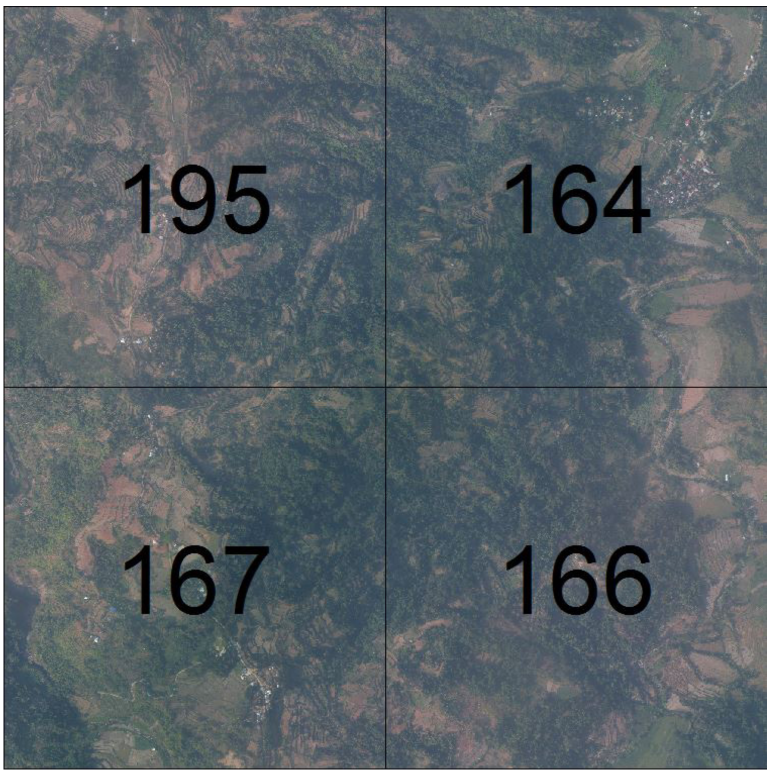

Figure 23. Sample orthophotograph tiles for the Bauang floodplain

3.8 DEM Editing and Hydro-Correction

Four (4) mission blocks were processed for the Bauang floodplain. These blocks are composed of La Union blocks, with a total area of 1173.92 square kilometers. Table 15 summarizes the names and corresponding areas of the blocks, in square kilometers.

Table 15. LiDAR blocks with their corresponding areas

LiDAR Blocks	Area (sq.km)
LaUnion_Blk10C	402.25
LaUnion_Blk10D	326.70
LaUnion_Blk10F	325.22
LaUnion_Blk10G	119.75
TOTAL	1173.92 sq.km

Portions of the DTM before and after manual editing are exhibited in Figure 24. The bridge (Figure 24a) was considered to be an obstruction to the flow of water along the river, and had to be removed (Figure 24b) in order to hydrologically correct the river. The embankment (Figure 24c) was misclassified and removed during the classification process, and had to be retrieved to complete the surface (Figure 24d) to allow for the correct flow of water. Another case was a building that was still present in the DTM after classification (Figure 24e), and had to be removed through manual editing (Figure 24f).

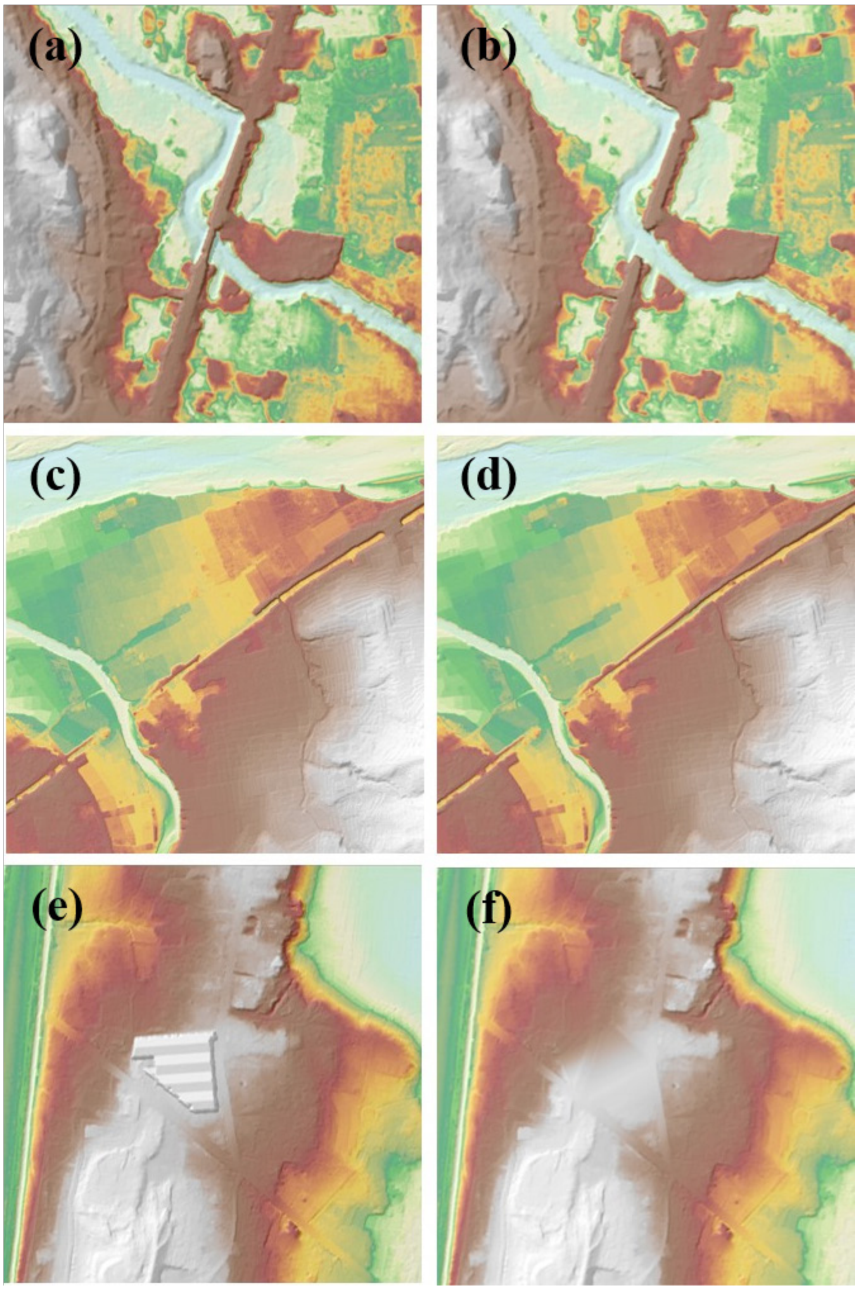

Figure 24. Portions in the DTM of the Bauang floodplain – a bridge (a) before and (b) after manual editing; an embankment (c) before and (d) after data retrieval; and a building (e) before and (f) after manual editing

3.9 Mosaicking of Blocks

The LaUnion_Blk10A block was used as the reference block at the start of mosaicking, because it was referred to a base station with an acceptable order of accuracy. Table 16 specifies the shift values applied to each LiDAR block during the mosaicking process.

The mosaicked LiDAR DTM for the Bauang floodplain is displayed in Figure 25. It is demonstrated that the entire Bauang floodplain is 99.69% covered by LiDAR data.

Table 16. Shift values of each LiDAR block of the Bauang floodplain

Mission Blocks	Shift Values (meters)		
	x	y	z
LaUnion_Blk10C	0.00	0.00	0.00
LaUnion_Blk10D	0.00	0.00	0.00
LaUnion_Blk10F	0.00	0.00	0.00
LaUnion_Blk10G	0.00	0.00	0.00

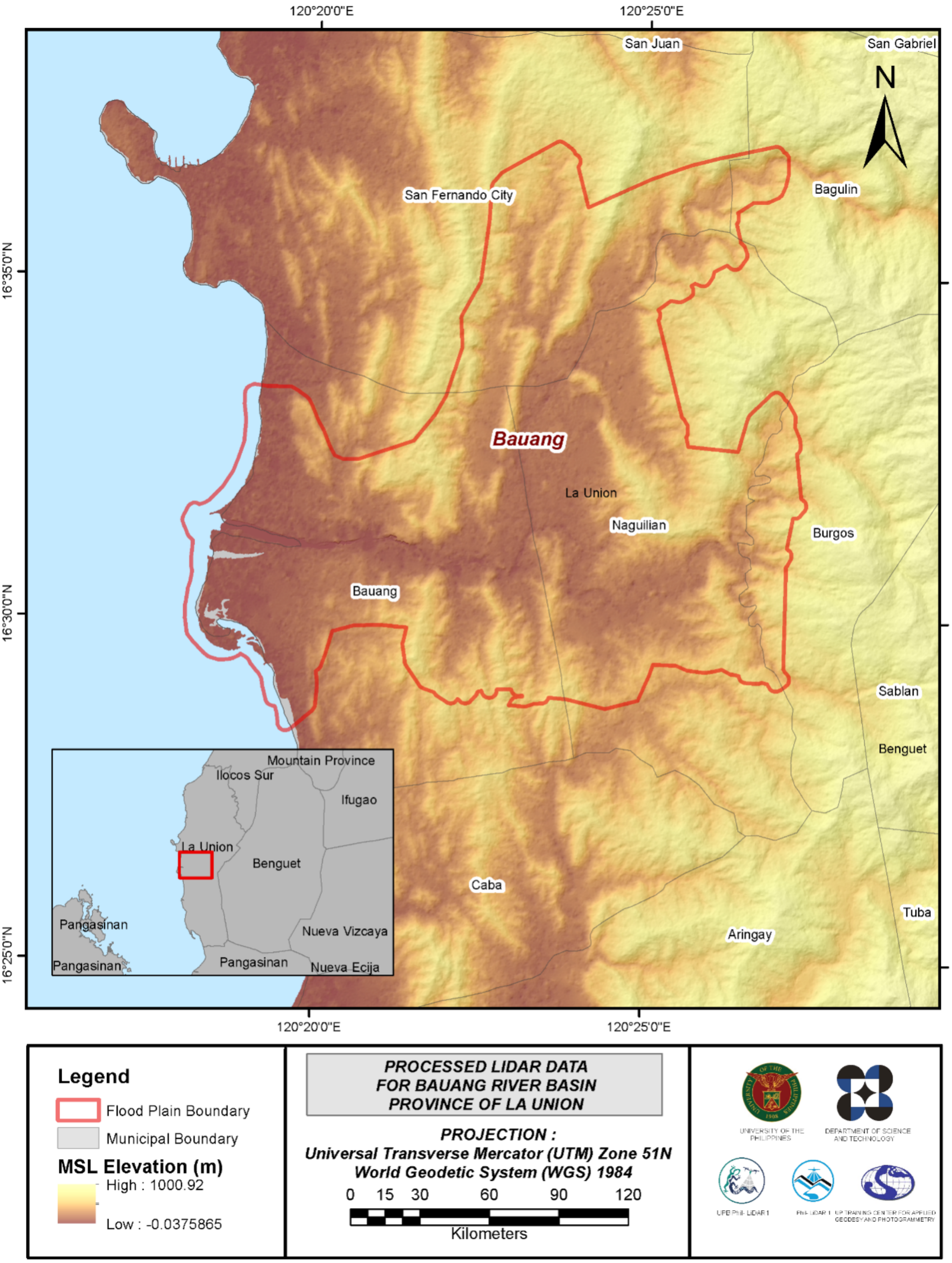

Figure 25. Map of processed LiDAR data for the Bauang floodplain

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3.10 Calibration and Validation of Mosaicked LiDAR DEM

To undertake the data validation of the mosaicked LiDAR DEMs, the DVBC conducted a validation survey along the Bauang floodplain. The extent of the validation survey done in Bauang to collect points with which the LiDAR dataset was validated is illustrated in Figure 26, with the validation survey points highlighted in green. A total of 4,794 survey points were used for the calibration and validation of the Bauang LiDAR data.

Random selection of 80% of the survey points resulted in 3,835 points, which were used for calibration. A good correlation between the uncalibrated mosaicked LiDAR elevation values and the ground survey elevation values is reflected in Figure 27. Statistical values were computed from the extracted LiDAR values using the selected points to assess the quality of the data and to obtain the values for vertical adjustment. The computed height difference between the LiDAR DTM and the calibration elevation values is 3.64 meters, with a standard deviation of 0.17 meters. Calibration of the Bauang LiDAR data was performed by subtracting the height difference value, 3.64 meters, from the Bauang mosaicked LiDAR data. Table 17 lists the statistical measurements of the compared elevation values between the LiDAR data and the calibration data.

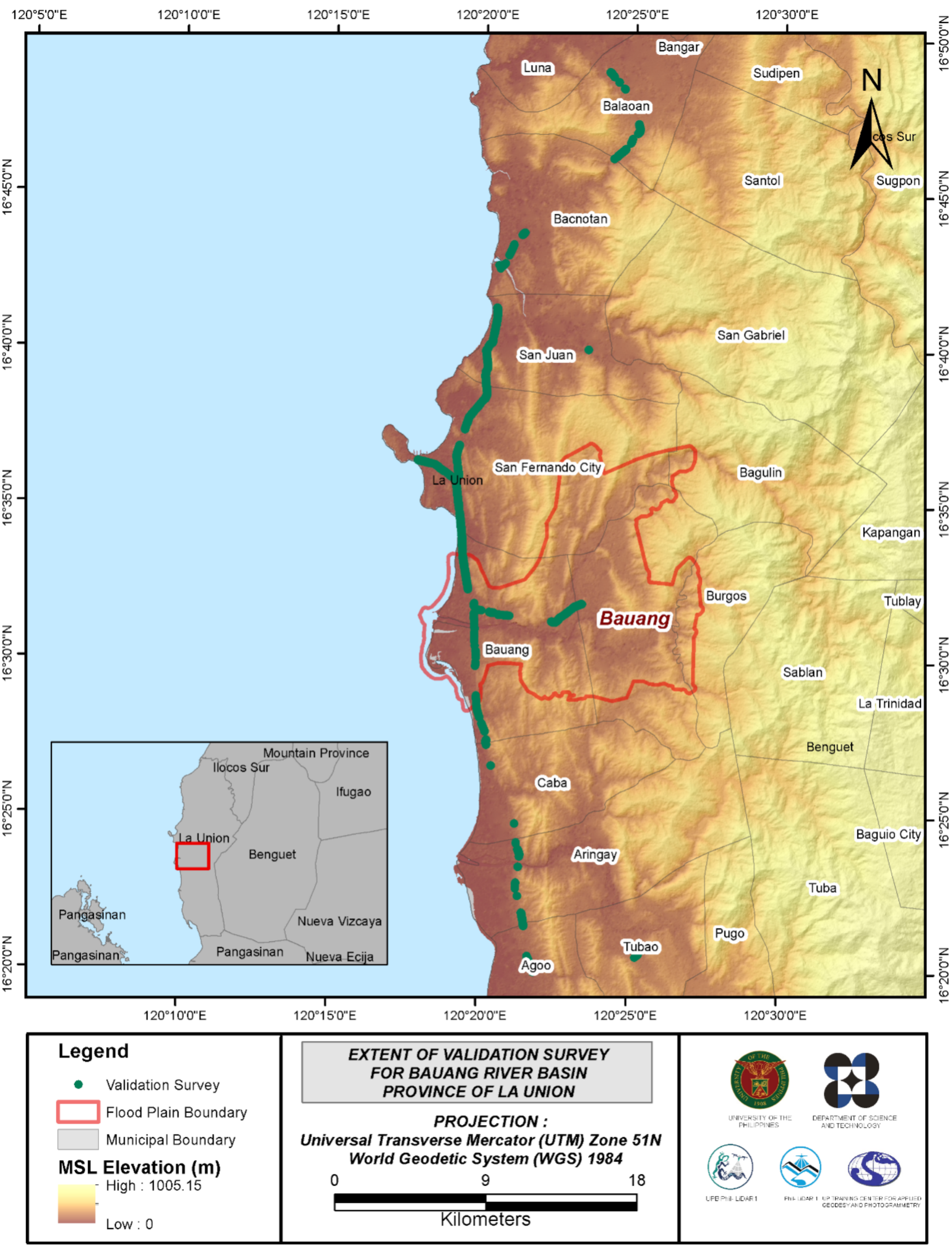


Figure 26. Map of the Bauang floodplain, with the validation survey points in green

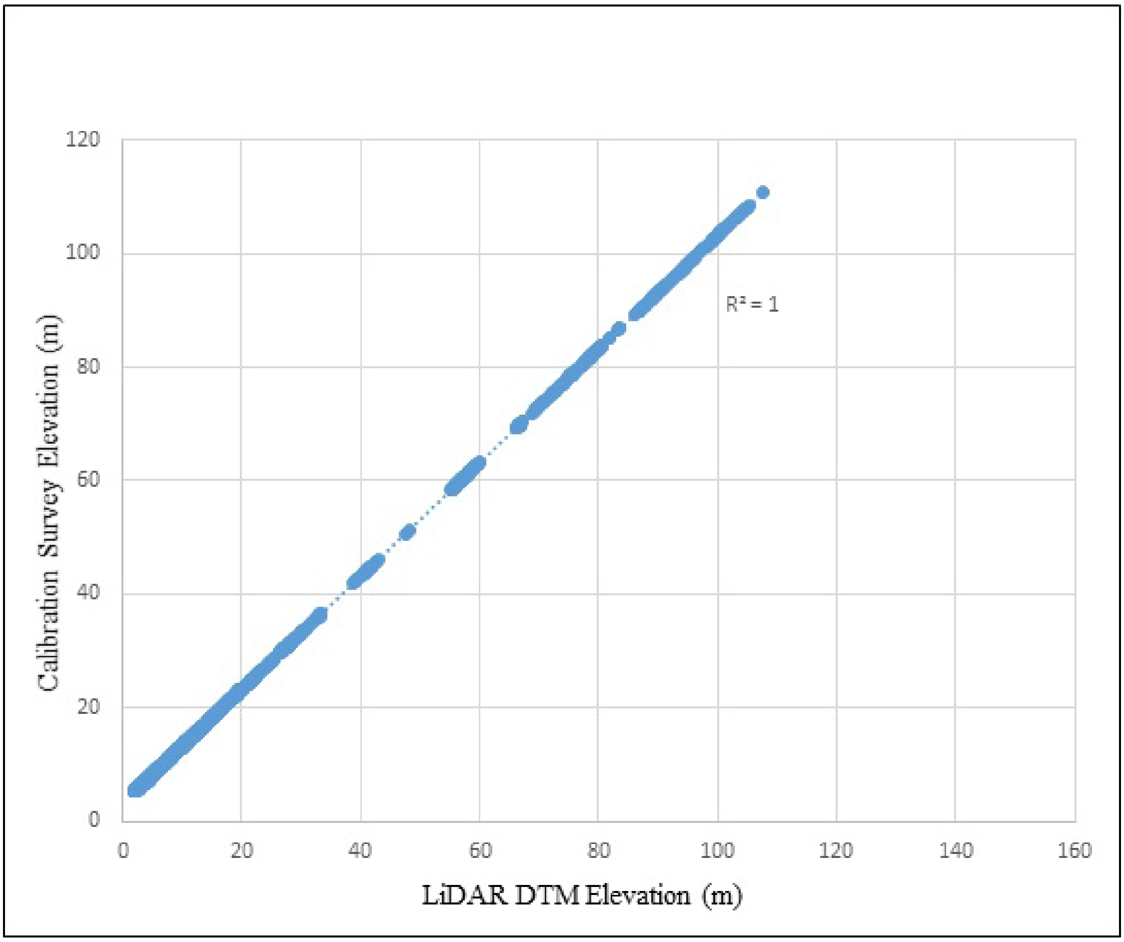


Figure 27. Correlation plot between the calibration survey points and the LiDAR data

Table 17. Calibration statistical measures

Calibration Statistical Measures	Value (meters)
Height Difference	3.64
Standard Deviation	0.17
Average	-3.64
Minimum	-3.98
Maximum	-3.29

The remaining 20% of the total survey points, resulting in 212 points, were used for the validation of the calibrated Bauang 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 demonstrated in Figure 28. The computed RMSE between the calibrated LiDAR DTM and the validation elevation values is 0.14 meters, with a standard deviation of 0.12 meters, as indicated in Table 18.

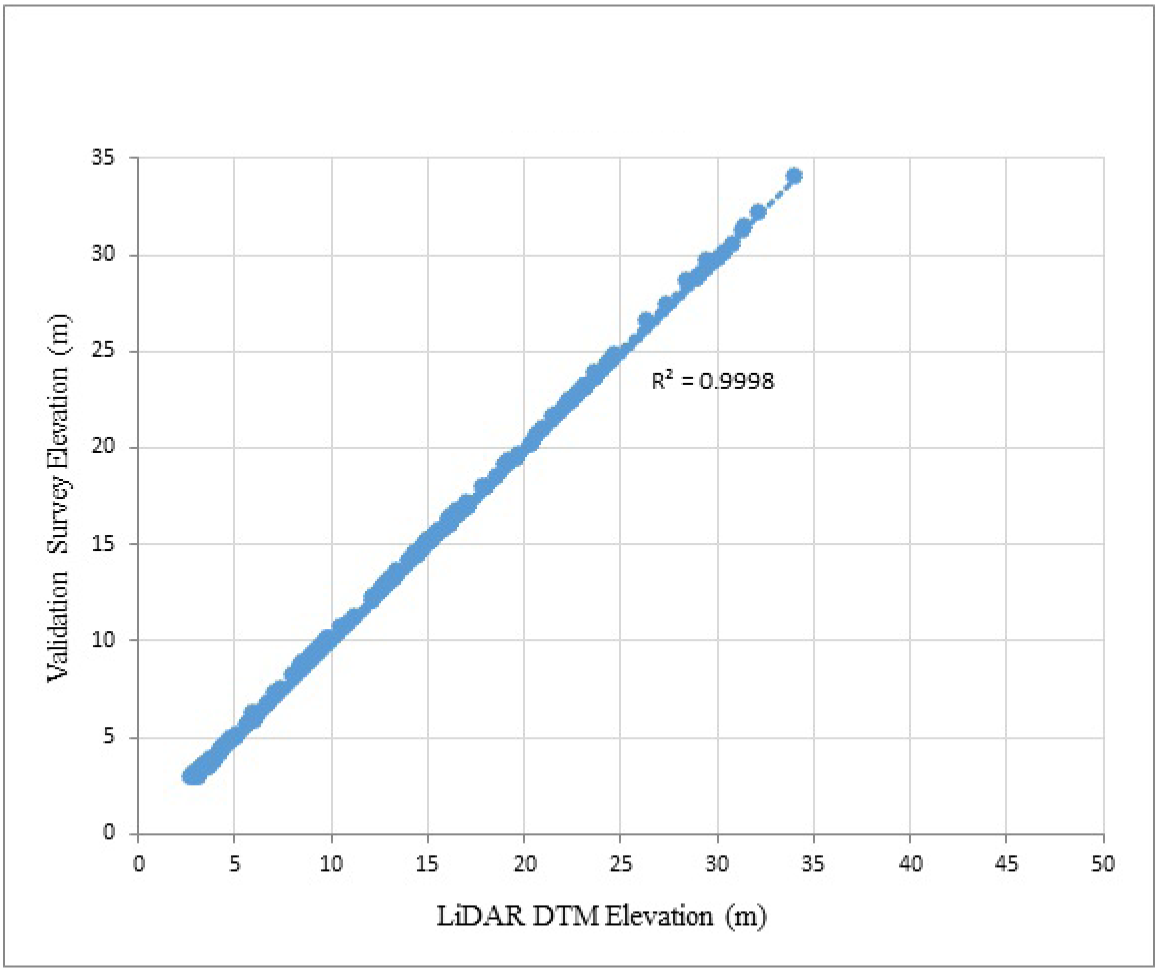


Figure 28. Correlation plot between the validation survey points and the LiDAR data

Table 18. Validation statistical measures

Validation Statistical Measures	Value (meters)
RMSE	0.14
Standard Deviation	0.12
Average	0.07
Minimum	-0.17
Maximum	0.38

3.11 Integration of Bathymetric Data into the LiDAR Digital Terrain Model

For bathy integration, centerline and cross-section data were available for Bauang, with 4,351 bathymetric survey points. The resulting raster surface produced was obtained through the Local Polynomial interpolation method. After burning the bathymetric data to the calibrated DTM, assessment of the interpolated surface is represented by the computed RMSE value of 0.50 meters. The extent of the bathymetric survey conducted by the DVBC in Bauang, integrated with the processed LiDAR DEM, is illustrated in Figure 29.

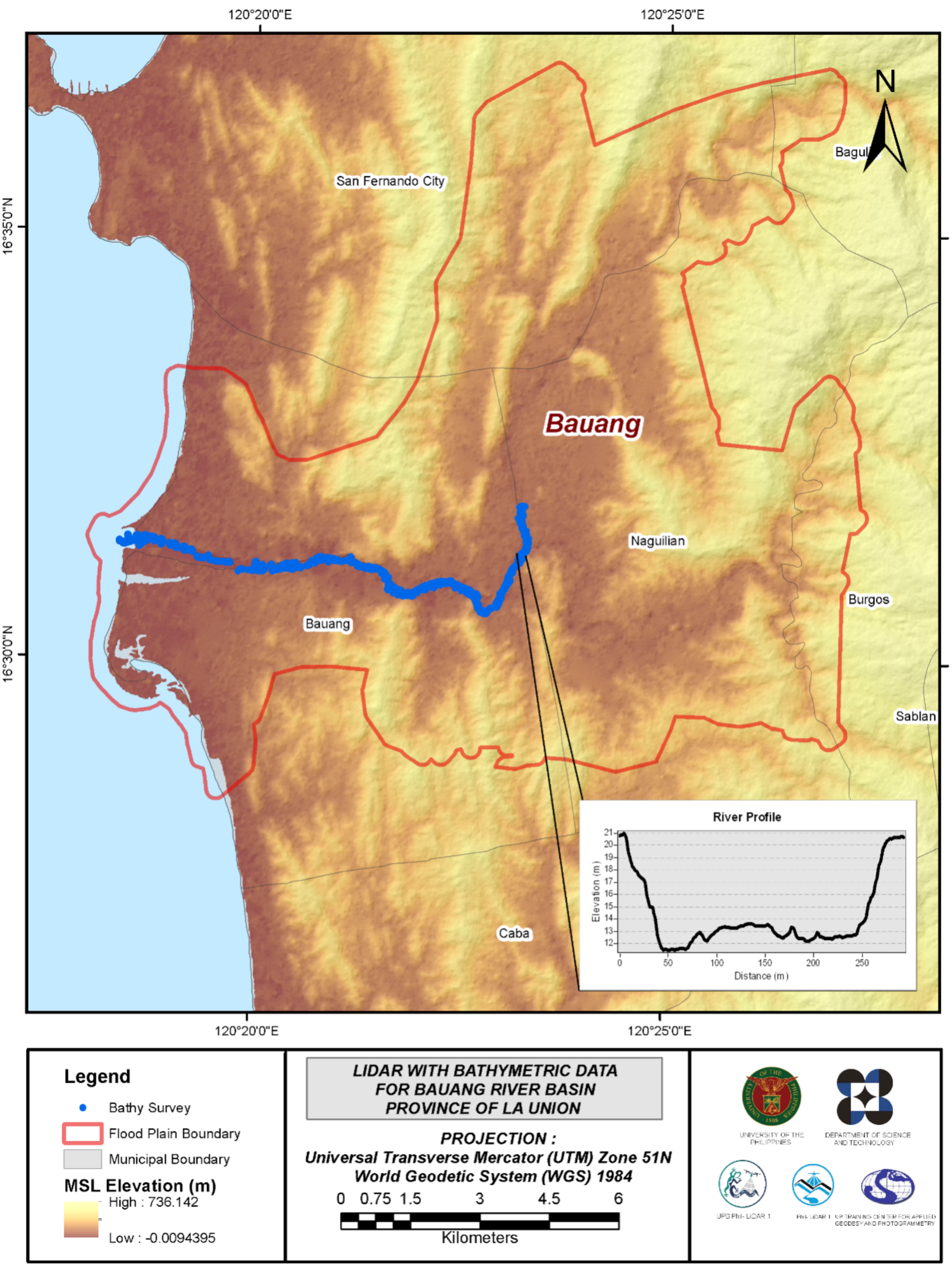


Figure 29. Map of the Bauang floodplain, with bathymetric survey points shown in blue

3.12 Feature Extraction

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

3.12.1 Quality Checking of Digitized Features' Boundary

The Bauang floodplain, including its 200-meter buffer zone, has a total area of 153.56 square kilometers. Of this area, a total of 5.0 square kilometers, corresponding to a total of 913 building features, were considered for quality checking (QC). Figure 30 displays the QC blocks for the Bauang floodplain.

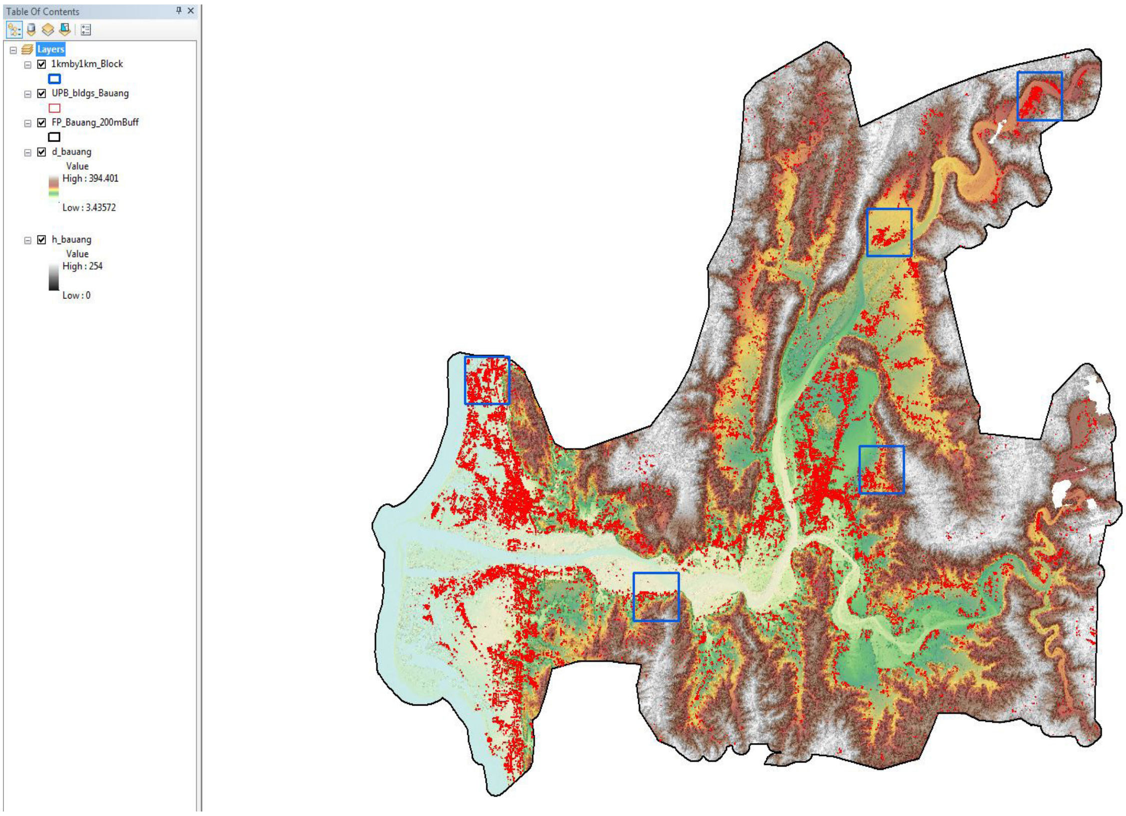


Figure 30. Blocks (in blue) of Bauang building features that were subjected to QC

Quality checking of the Bauang building features resulted in the ratings given in Table 19.

Table 19. Quality checking ratings for the Bauang building features

FLOODPLAIN	COMPLETENESS	CORRECTNESS	QUALITY	REMARKS
Bauang	99.87	100.00	98.50	PASSED

3.12.2 Height Extraction

Height extraction was done for 29,837 building features in the Bauang floodplain. Of these building features, 1,845 building features were filtered out after height extraction, resulting in 27,992 buildings with height attributes. The lowest building height is at 2.00 meters, while the highest building is at 9.52 meters.

3.12.3 Feature Attribution

Data collected from various sources, including OpenStreetMap, Google Maps, and Google Earth, were used in the attribution of building features. Areas without available data were subjected to field attribution using ESRI's Collector App. The application can be accessed offline, and the data collected can be synced with ArcGIS Online when WiFi or mobile data is available.

Table 20 summarizes the number of building features per type. Table 21 indicates the total length of each road type, and Table 22 specifies the number of water features extracted per type.

Table 20. Building features extracted for the Bauang floodplain

Facility Type	No. of Features
Residential	26,955
School	408
Market	57
Agricultural/Agro-Industrial Facilities	27
Medical Institutions	13
Barangay Hall	17
Military Institution	0
Sports Center/Gymnasium/Covered Court	11
Telecommunication Facilities	9
Transport Terminal	0
Warehouse	3
Power Plant/Substation	53
NGO/CSO Offices	17
Police Station	0
Water Supply/Sewerage	2
Religious Institutions	65
Bank	3
Factory	15
Gas Station	17
Fire Station	2
Other Government Offices	21
Other Commercial Establishments	296
Total	**27,991**

Table 21. Total length of extracted roads for the Bauang floodplain

Floodplain	Road Network Length (km)					Total
	Barangay Road	City/Municipal Road	Provincial Road	National Road	Others	
Bauang	90.56	72.41	32.78	6.33	0.00	205.59

Table 22. Number of extracted water bodies for the Bauang floodplain

Floodplain	Water Body Type					Total
	Rivers/Streams	Lakes/Ponds	Sea	Dam	Fish Pen	
Bauang	113	41	0	0	0	154

A total of sixty (60) bridges and culverts over small channels that are part of the river network were also extracted for the floodplain.

3.12.4 Final Quality Checking of Extracted Features

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

Figure 31 represents the Digital Surface Model (DSM) of the Bauang floodplain, overlaid with its ground features.

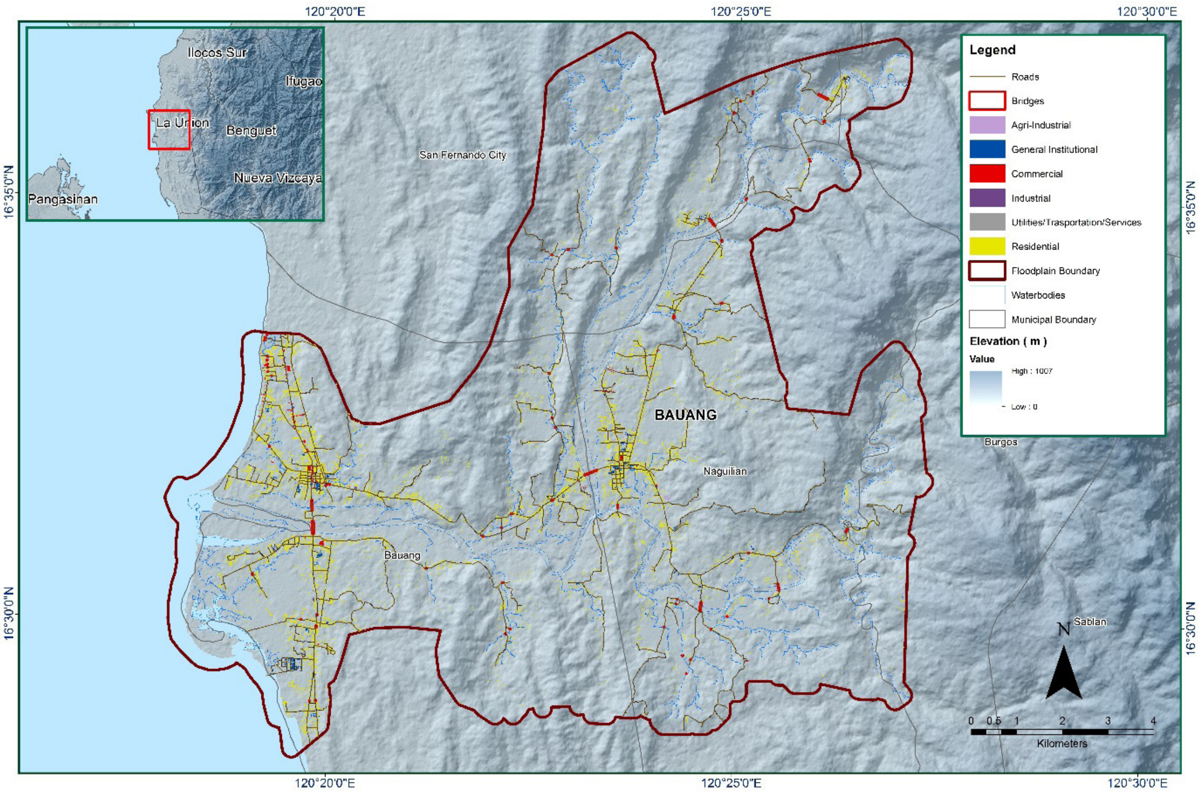


Figure 31. Extracted features for the Bauang floodplain

CHAPTER 4: LIDAR VALIDATION SURVEY AND MEASUREMENTS OF THE BAUANG 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, Cybil Claire Atacador, and Engr. Lorenz R. Taguse

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 DVBC, together with the UPB Phil-LiDAR 1 team, conducted field surveys in three (3) river basins in Northern Luzon, including the Bauang River Basin, on July 3-17, 2015, and on November 26, 2015. The scope of work was comprised of: (i.) initial reconnaissance; (ii.) control point survey; (iii.) cross-section and bridge as-built surveys of the Guesset and Mamat-ing Bridges; (iv.) validation point acquisition of about 50 kilometers covering the Bauang River Basin; and (v.) bathymetric survey from Barangay Cabaritan, Municipality of Naguilian down to the mouth of the river in Barangay Pugo, Municipality of Bauang, with an estimated length of 11.189 kilometers, using Trimble® SPS 882 GNSS in PPK and RTK survey technique and an OHMEX™ single beam echo sounder. See Figure 32 for the illustration of the extent of the surveys.

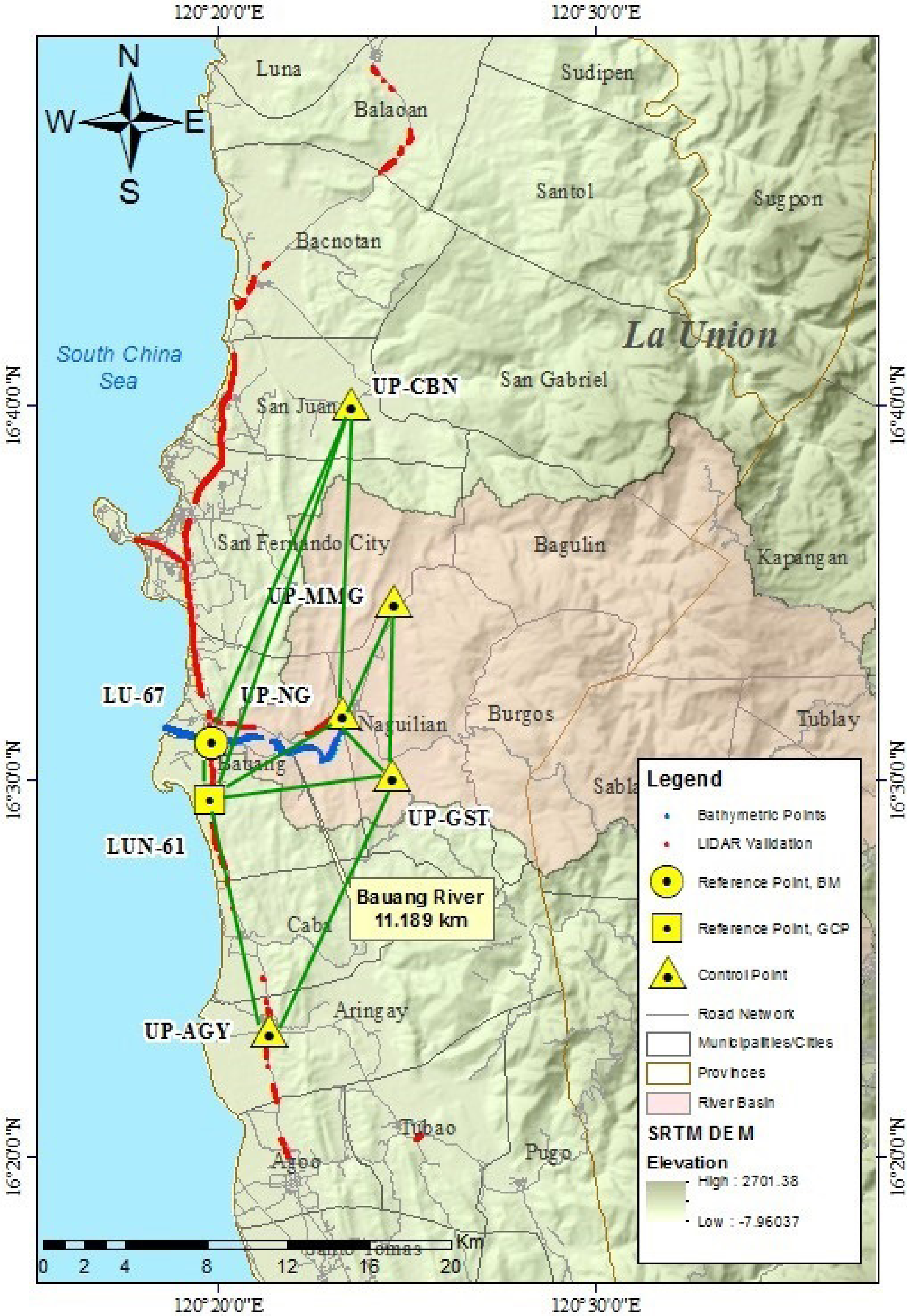


Figure 32. Extent of the bathymetric survey (in blue line) in Bauang River and the LiDAR data validation survey (in red)

4.2 Control Survey

The GNSS network used for the Bauang River Basin is composed of five (5) loops established on July 4, 11, and 16, 2015, occupying the following reference points: (i.) LU-67, a first-order BM in Barangay Nagrebcan; and (ii.) LUN-61, a second-order GCP in Barangay Guerrero. Both are located in the Municipality of Bauang.

Four (4) control points were established along the approach of bridges, namely: (i.) UP-AGY, at the Arigay Bridge in Barangay Poblacion, Municipality of Aringay; (ii.) UP-CBN, at the Cabaroan Bridge in Barangay Cabaroan, Municipality of San Juan; (iii.) UP-GST, at the Guesset Bridge in Barangay Ambaracao, Municipality of Naguilian; (iv.) UP-MMG, at the Mamat-ing Bridge in Barangay Mamat-ing Norte, Municipality of Naguilian; and (v.) UP-NG, at the Naguilian Bridge in Barangay Cabaritan Sur, Municipality of Naguilian.

The summary of reference and control points and their corresponding locations is given in Table 23; while the established GNSS network is illustrated in Figure 33.

Table 23. List of reference and control points occupied in the Bauang River Survey (Source: NAMRIA; UP-TCAGP)

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)				
		Latitude	Longitude	Ellipsoid Height (m)	Elevation in MSL (m)	Date Established
LUN-61	2nd order, GCP	16°29’30.73239”	120°19’46.68075”	49.954	9.213	2007
LU-67	1st order, BM	-	-	49.515	-	2007
UP-AGY	UP Established	-	-	-	-	7-4-2015
UP-CBN	UP Established	-	-	-	-	7-11-2015
UP-GST	UP Established	-	-	-	-	7-4-2015
UP-NG	UP Established	-	-	-	-	7-11-2015

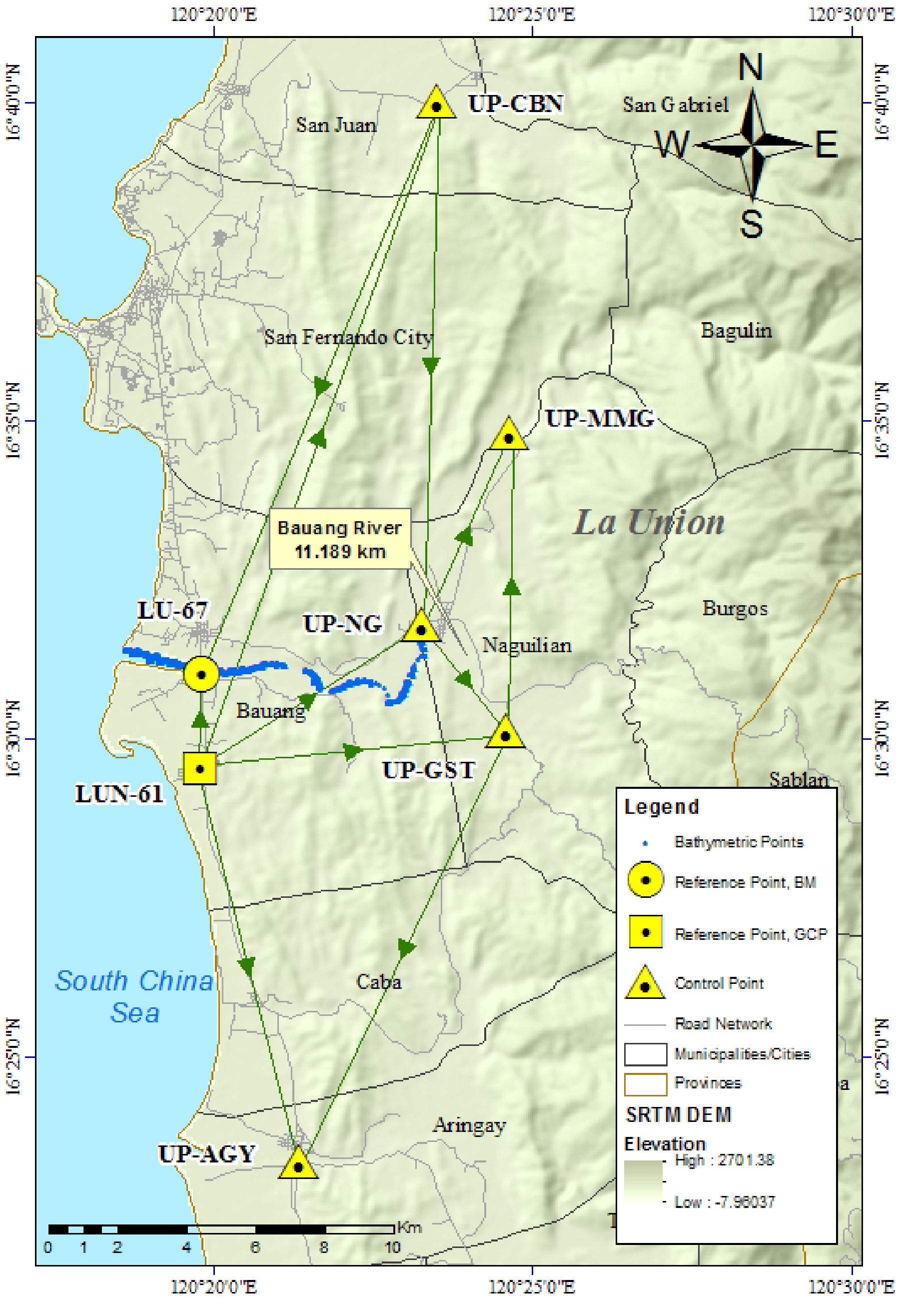


Figure 33. GNSS network of the Bauang River field survey

The GNSS set-ups of reference points and established control points in the Bauang survey are exhibited in Figure 34 to Figure 39.

Figure 34. GNSS receiver Trimble® SPS 985 at LU-67, located at the Bauang Bridge approach in Barangay Nagrebcan, Municipality of Bauang, La Union

Figure 35. GNSS receiver Trimble® SPS 985 at LUN-61, located near the BPPC Housing in Barangay Guerrero, Municipality of Bauang, La Union

Figure 36. GNSS receiver Trimble® SPS 882 at UP-AGY, located at the Aringay Bridge approach in Barangay Poblacion, Municipality of Aringay, La Union

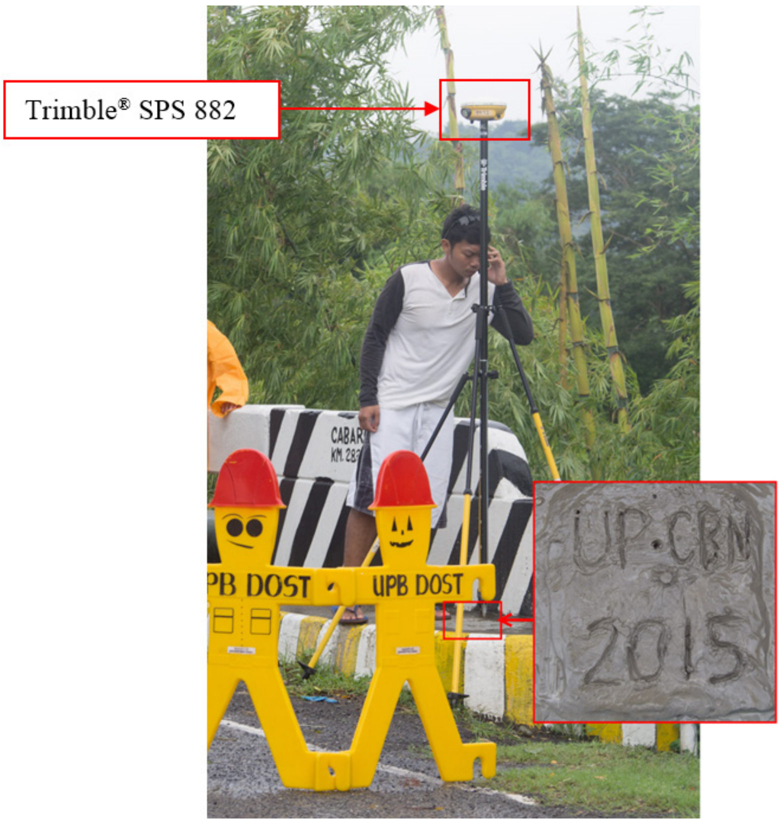


Figure 37. GNSS receiver Trimble® SPS 882 at UP-CBN, located at the Cabaroan Bridge approach in Barangay Cabaroan, Municipality of San Juan, La Union

Figure 38. GNSS receiver Trimble® SPS 985 at UP-GST, located at the Guesset Bridge approach in Barangay Ambaracao, Municipality of Naguilian, La Union

Figure 39. GNSS receiver Trimble® SPS 985 at UP-NG, located at the Naguilian Bridge approach in Barangay Cabaritan, Municipality of Naguilian, La Union

4.3 Baseline Processing

The GNSS baselines were processed simultaneously in TBC by observing that all baselines have fixed solutions with horizontal and vertical precisions within the +/- 20-centimeter and +/- 10-centimeter requirement, respectively. In cases where one or more baselines did not meet all of these criteria, masking was performed. Masking is the removal of portions of baseline data using the same processing software. It is repeatedly processed until all baseline requirements are met. If the reiteration yields out of the required accuracy, a re-survey is initiated. The baseline processing results of the control points in the Bauang River Basin, generated by the TBC software, are summarized in Table 24..

Table 24. Baseline processing report for the Bauang River survey

Observation	Date of Observation	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
UPAGY --- LUN61	7-4-2015	Fixed	0.004	0.027	166°05’07”	11694.520	0.436
LUN61 --- UPGST	7-4-2015	Fixed	0.003	0.018	82°19’22”	8640.260	13.306
LU67 --- LUN61	7-4-2015	Fixed	0.002	0.010	1°33’38”	2754.678	-0.469
UPAGY --- UPGST	7-4-2015	Fixed	0.005	0.025	24°42’08”	13764.436	12.818
UPAGY --- UPNG	7-11-2015	Fixed	0.004	0.019	12°25’55”	15950.207	7.998
UPAGY --- UPNG	7-11-2015	Fixed	0.007	0.030	12°25’56”	15950.202	8.024
UPNG --- LU67	7-11-2015	Fixed	0.002	0.011	76°34’58”	6342.089	8.805
UPCBN --- LU67	7-11-2015	Fixed	0.003	0.014	21°30’22”	17868.131	3.769
UPNG --- UPGST	7-11-2015	Fixed	0.003	0.013	142°57’42”	3848.102	4.774
UPNG --- LUN61	7-11-2015	Fixed	0.003	0.013	235°55’50”	7539.286	-8.335
UPNG --- LUN61	7-11-2015	Fixed	0.003	0.019	235°55’50”	7539.295	-8.524
UPNG --- UPCBN	7-11-2015	Fixed	0.004	0.017	1°27’31”	15157.305	-5.053
UPCBN --- LUN61	7-11-2015	Fixed	0.004	0.018	198°53’37”	20479.168	-3.321

A total of thirteen (13) baselines were processed for the static survey. All of the baselines satisfied the required accuracy of 0.20 meters for horizontal, and 0.10 meters for vertical, for the GNSS surveys of the project.

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 centimeters, and z less than 10 centimeters, or in equation form:

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

Where:

x_e is the Easting Error,

y_e is the Northing Error, and

z_e is the Elevation Error

The six (6) control points – LUN-61, LU-67, UP-AGY, UP-CBN, UP-GST, and UP-NG – were occupied and observed simultaneously to form a GNSS loop. The coordinates of LUN-61 and the elevation values of LU-67 were held fixed during the processing of the control points, as presented in Table 25. Through these reference points, the coordinates and elevation of the unknown control points were computed.

Table 25. Constraints applied to the adjustments of the control points

Point ID	Type	East σ (Meter)	North σ (Meter)	Height σ (Meter)	Elevation σ (Meter)
LU67	Grid				Fixed
LUN61	Global	Fixed	Fixed		
Fixed = 0.000001(Meter)					

The list of adjusted grid coordinates; i.e., Northing, Easting, Elevation, and computed standard errors of the control points in the network, is outlined in Table 26. All fixed control points did not yield values for grid and elevation errors.

Table 26. Adjusted grid coordinates for the control points used in the Bauang floodplain survey

Point ID	Easting (Meter)	Easting Error (Meter)	Northing (Meter)	Northing Error (Meter)	Elevation (Meter)	Elevation Error (Meter)	Constraint
LU67	215027.120	0.008	1827985.553	0.007	8.867	?	e
LUN61	214915.551	?	1825231.473	?	9.213	0.047	LL
UPAGY	217579.313	0.012	1813837.247	0.010	9.197	0.089	
UPCBN	221802.212	0.011	1844530.550	0.009	12.830	0.064	

The network was fixed at the reference points. The list of adjusted grid coordinates of the network is shown in Table 26.Using the equation for horizontal accuracy, and for vertical accuracy, following are the computations for accuracy:

a. **LUN-61**

Horizontal Accuracy	=	Fixed
Vertical Accuracy	=	4.7 cm < 10 cm

b. **LU-67**

Horizontal Accuracy	=	$\sqrt{((0.8)^2 + (0.7)^2}$
	=	$\sqrt{(0.64+ 0.49)}$
	=	1.06 cm < 20 cm
Vertical Accuracy	=	Fixed

c. **UP-AGY**

Horizontal Accuracy	=	$\sqrt{((1.2)^2 + (1.0)^2}$
	=	$\sqrt{(1.44 + 1.0)}$
	=	1.56 cm < 20 cm
Vertical Accuracy	=	8.9 cm < 10 cm

d. **UP-CBN**

Horizontal Accuracy	=	$\sqrt{((1.1)^2 + (0.9)^2}$
	=	$\sqrt{(1.21 + 0.81)}$
	=	2.02 cm < 20 cm
Vertical Accuracy	=	6.4 cm < 10 cm

e. **UP-GSN**

Horizontal Accuracy	=	$\sqrt{((1.0)^2 + (0.9)^2}$
	=	$\sqrt{(1.0 + 0.81)}$
	=	1.34 cm < 20 cm
Vertical Accuracy	=	7.5 cm < 10 cm

f. **UP-NG**

Horizontal Accuracy	=	$\sqrt{((0.7)^2 + (0.7)^2}$
	=	$\sqrt{(0.49 + 0.49)}$
	=	0.98 cm < 20 cm
Vertical Accuracy	=	5.0 cm < 10 cm

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

Table 27. Adjusted geodetic coordinates for control points used in the Bauang River floodplain validation

Point ID	Latitude	Longitude	Height (Meter)	Height Error (Meter)	Constraint
LU67	N16°31'00.31120"	E120°19'49.21075"	49.515	?	e
LUN61	N16°29'30.73239"	E120°19'46.68075"	49.954	0.047	LL
UPAGY	N16°23'21.45560"	E120°21'21.45371"	50.363	0.089	
UPCBN	N16°40'01.07082"	E120°23'30.27604"	53.288	0.064	
UPGSN	N16°30'08.22705"	E120°24'35.41408"	63.176	0.075	
UPNG	N16°31'48.15542"	E120°23'17.25573"	58.355	0.050	

The corresponding geodetic coordinates of the observed points are within the required accuracy, as demonstrated in Table 27. Based on the results of the computation, the accuracy conditions are satisfied; hence, the required accuracy for the program was met.

The computed coordinates of the reference and control points utilized in the Bauang River GNSS Static Survey are indicated in Table 28.

Table 28. Reference and control points used in the Bauang River Static Survey, with their corresponding locations (Source: NAMRIA, UP-TCAGP)

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)			UTM Zone 51		
		Latitude	Longitude	Ellipsoid Height (m)	Northing	Easting	Elevation in MSL (m)
LUN-61	1st order, BM	16°29'30.73239"	120°19'46.68075"	49.954	1825231.473	214915.551	9.213
LU-67	2nd order, GCP	16°31'00.31120"	120°19'49.21075"	49.515	1827985.553	215027.12	8.867
UP-AGY	UP Established	16°23'21.45560"	120°21'21.45371"	50.363	1813837.247	217579.313	9.197
UP-CBN	UP Established	16°40'01.07082"	120°23'30.27604"	53.288	1844530.559	221802.212	12.83
UP-GST	UP Established	16°30'08.22705"	120°24'35.41408"	63.176	1826272.861	223497.8	21.702
UP-NG	UP Established	16°31'48.15542"	120°23'17.25573"	58.355	1829376.051	221218.673	17.207

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

The cross-section and bridge as-built surveys were conducted at the upstream side of two (2) separate bridges along the Bauang River. The first was at the Guesset Bridge on July 9, 2015, with control point UP-GST as the base station; and the second was at the Mamat-ing Bridge on July 15, 2015, with UP-MMG as the base station. Both surveys were conducted using Trimble® SPS 882 GNSS in PPK survey technique (Figure 40).

Figure 40. Cross-section survey at the Guesset Bridge

The length of the cross-sectional line surveyed in the Guesset Bridge was 306.47 meters, with a total of fifty-six (56) points; while that of the Mamat-ing Bridge was 263.42 meters, forty-three (43) points. UP-GST and UP-MMG were utilized as the GNSS base stations, respectively. The location maps, cross-section diagrams, and the bridge data forms for both bridges are presented in Figure 42 to Figure 47.

Figure 41. Cross-section survey at the Mamat-ing Bridge

The water surface elevation in MSL of the Bauang River was determined on July 9, 2015 at 10:59 hrs., using Trimble® SPS 882 in PPK mode. A value of 5.12 meters in MSL was obtained, and was translated into markings on the Guesset Bridge's pier using a digital level scale (Figure 41). This was used by the UPB Phil-LiDAR 1 team as reference for flow data gathering and depth gauge deployment for the Bauang River.

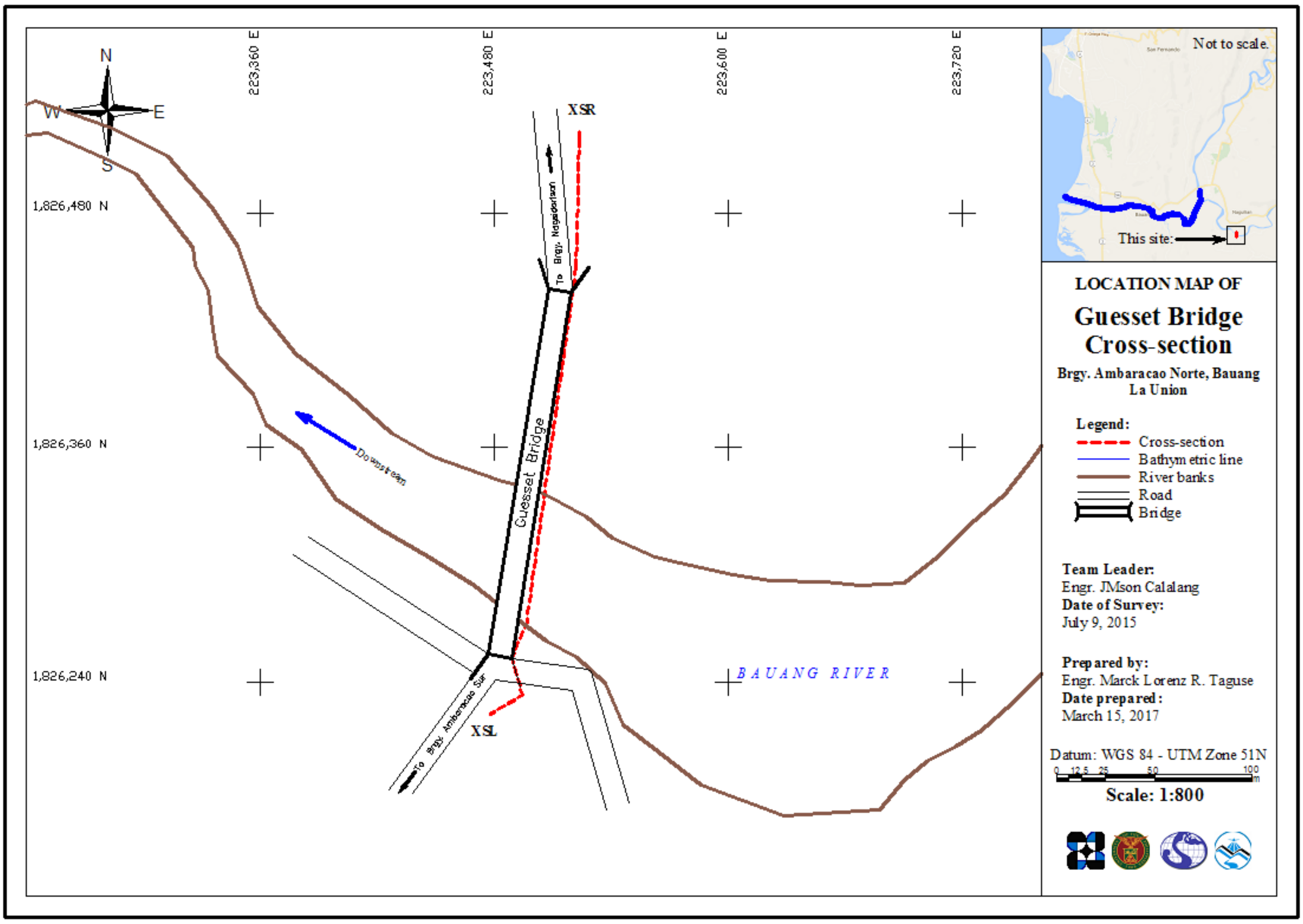


Figure 42. Guesset Bridge cross-section location map

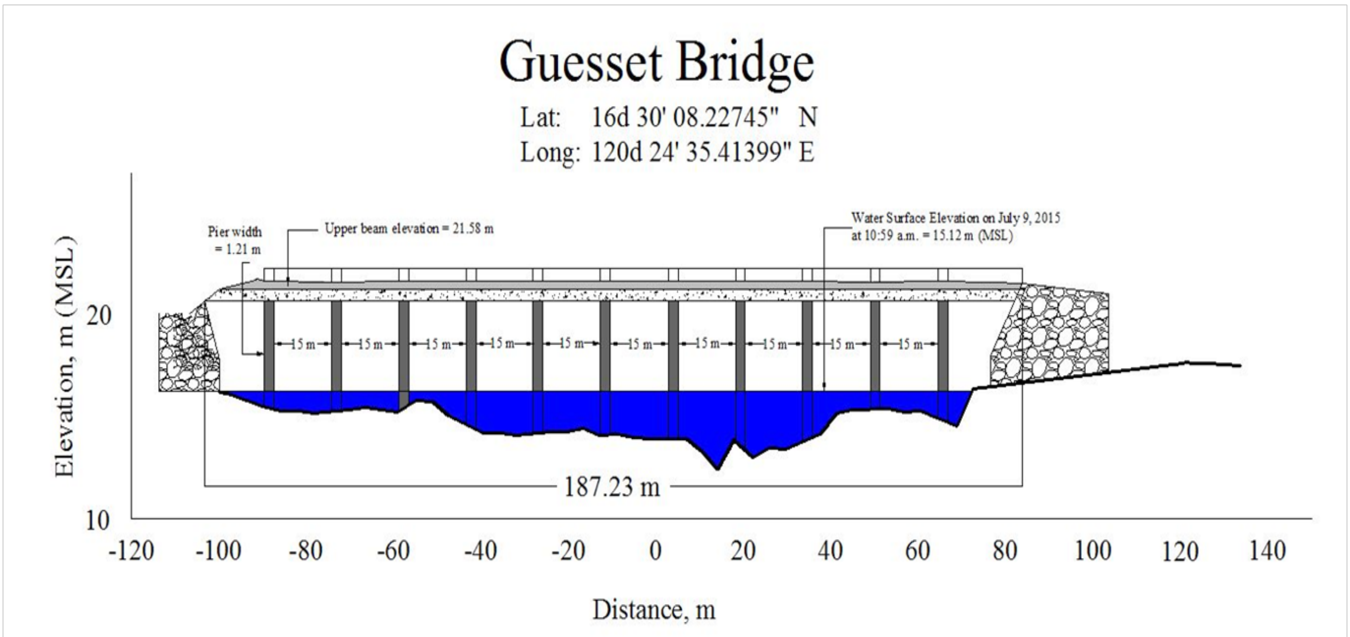


Figure 43. Bridge cross-section diagram of the Guesset Bridge

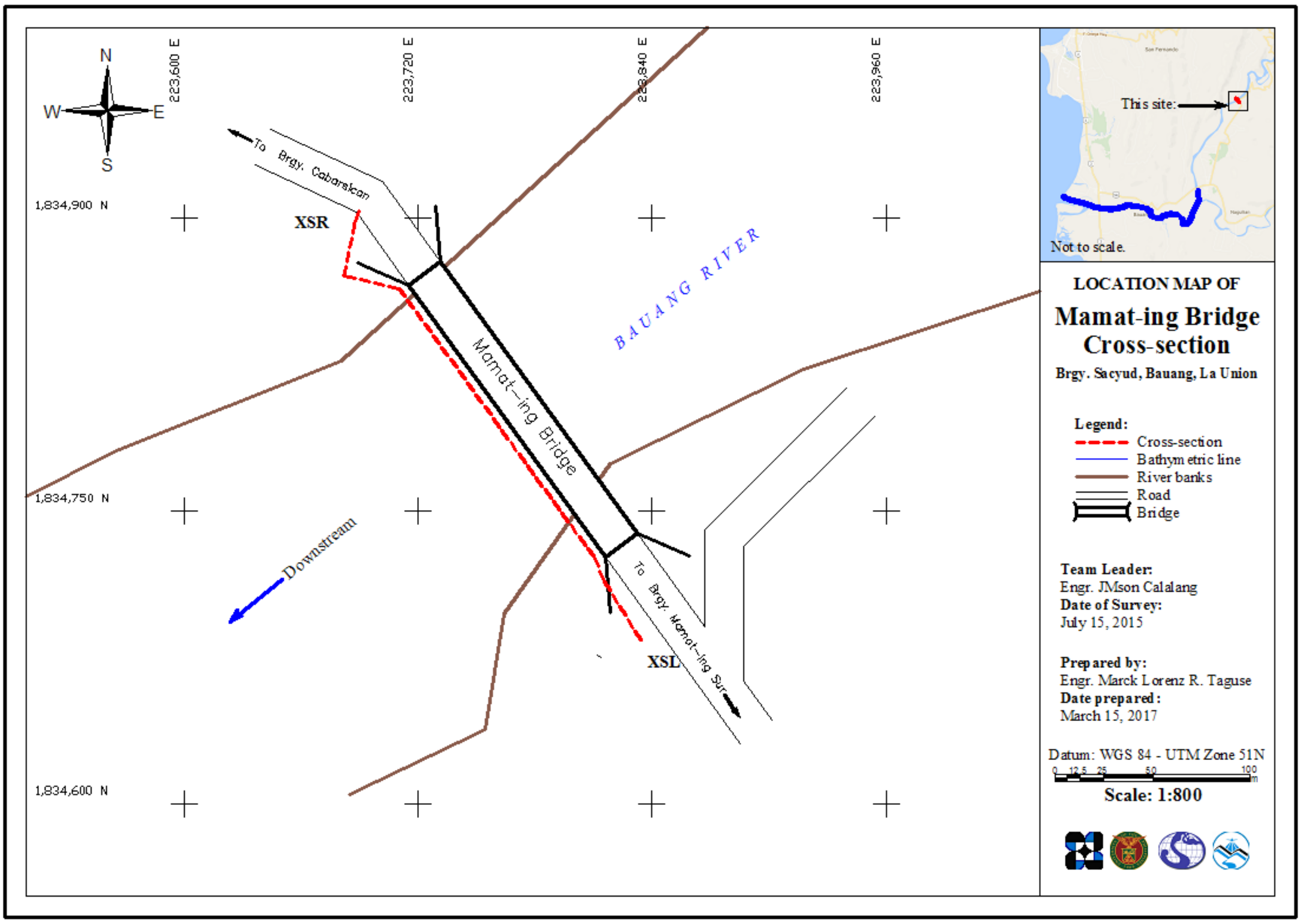


Figure 44. Mamat-ing Bridge cross-section location map

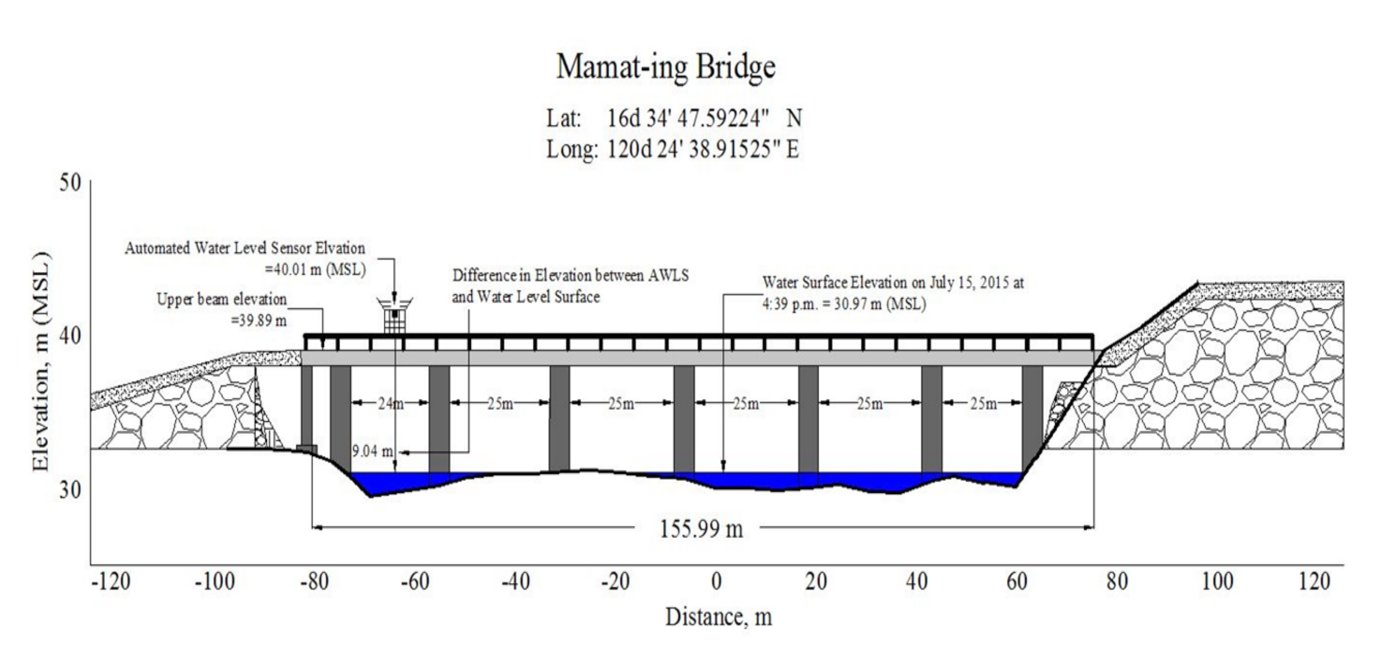


Figure 45. Bridge cross-section diagram of the Mamat-ing Bridge

Bridge Data Form

Bridge Name: Guesset Bridge **Date:** July 9, 2015

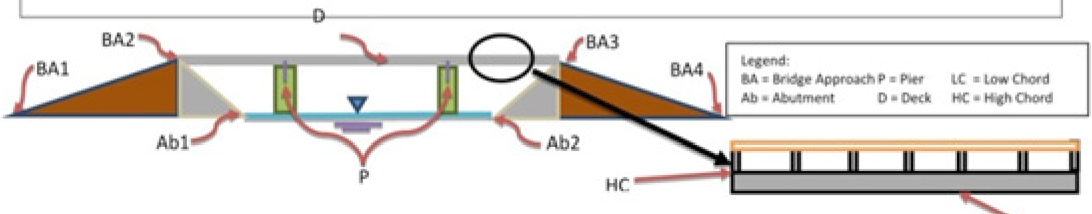
River Name: BAUANG RIVER **Time:** 10:01 a.m.

Location (Brgy, City,Region): Brgy. Boklaoan, Kapangan, La Union

Survey Team: Aringay, Bauang, Barroro Survey Team

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

Latitude: 16d30'08.22745"N **Longitude:** 120d24'35.41399"E



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

Elevation: 21.60 m **Width:** no data **Span (BA3-BA2):** 191.60 m

	Station	High Chord Elevation	Low Chord Elevation
1	Pier 2 (54.59)	21.58	20.27
2	Pier 4 (85.34)	21.64	20.33
3	Pier 6 (116.25)	21.60	20.29

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

	Station(Distance from BA1)	Elevation		Station(Distance from BA1)	Elevation
BA1	0	24.02	BA3	211.80	21.64
BA2	20.20	21.48	BA4	276.47	20.27

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

	Station (Distance from BA1)	Elevation
Ab1	27.38	18.00
Ab2	203.47	16.19

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

Shape: Round **Number of Piers:** Eleven (11) **Height of column footing:** n/a

	Station (Distance from BA1)	Elevation	Pier Width
Pier 1	39.05	21.60	1.21
Pier 2	54.59	21.58	1.21
Pier 3	69.89	21.64	1.21
Pier 4	85.34	21.64	1.21
Pier 5	100.67	21.59	1.21
Pier 6	116.25	21.60	1.21
Pier 7	131.66	21.58	1.21

	Station (Distance from BA1)	Elevation	Pier Width
Pier 8	146.97	21.62	1.21
Pier 9	162.36	21.59	1.21
Pier 10	177.80	21.57	1.21
Pier 11	193.23	21.63	1.21

Figure 46. Bridge data form for the Guesset Bridge

Bridge Data Form

Bridge Name: Mamat-ing Bridge **Date:** July 15, 2015

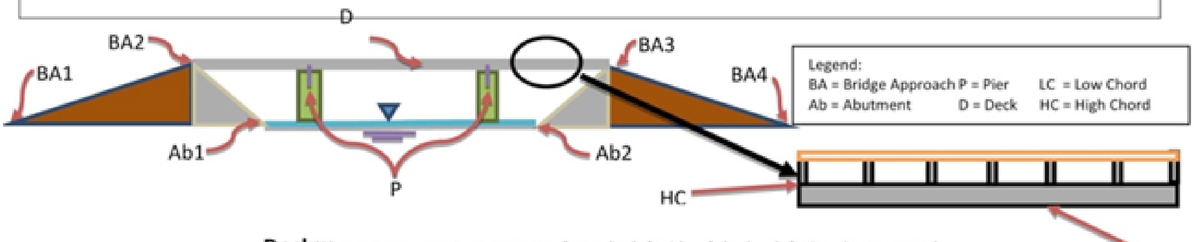
River Name: BAUANG RIVER **Time:** 4:26 p.m.

Location (Brgy, City,Region): Brgy. Sacyud, San Fernando City, La Union

Survey Team: Aringay, Bauang, Barroro Survey Team

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

Latitude: 16d34'47.59224"N **Longitude:** 120d24'38.91525"E



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

Elevation: 9.158 m **Width:** no data **Span (BA3-BA2):** 171.92 m

	Station	High Chord Elevation	Low Chord Elevation
1	Pier 2 (96.81)	40.01	
2	Pier 4 (146.88)	40.00	
3	Pier 6 (196.87)	39.93	

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

	Station(Distance from BA1)	Elevation		Station(Distance from BA1)	Elevation
BA1	0	46.59	BA3	217.45	39.66
BA2	45.53	39.82	BA4	241.17	36.13

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

	Station (Distance from BA1)	Elevation
Ab1	50.49	35.23
Ab2	211.25	32.53

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

Shape: Oblong **Number of Piers:** Eight (8) **Height of column footing:** n/a

	Station (Distance from BA1)	Elevation	Pier Width
Pier 1	72.00	40.10	
Pier 2	96.80	40.08	
Pier 3	121.72	40.07	
Pier 4	146.88	40.00	
Pier 5	171.87	40.03	
Pier 6	196.87	39.93	
Pier 7	201.09	39.97	

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

Figure 47. Bridge data form for the Mamat-ing Bridge

4.6 Validation Points Acquisition Survey

The validation points acquisition survey was conducted on July 13-14, 2015 using a survey-grade GNSS Rover receiver, Trimble® SPS 985. The receiver was mounted on a pole that was attached in front of a vehicle, as depicted in Figure 48. It was secured with a nylon rope and tied to the side mirrors of the vehicle to ensure that it was horizontally and vertically balanced. The PPK technique utilized for the conduct of the survey was set to continuous top mode, with UP-ABY, UP-CBN, and UP-NG occupied as the GNSS base stations.

Figure 48. Set-up for the validation points acquisition in the Bauang River Basin

The validation points acquisition survey for the Bauang River Basin traversed eight (8) municipalities and San Fernando City in the province of La Union. The route of the survey aimed to perpendicularly traverse the LiDAR flight strips for the basin. A total of 3,824 points was acquired for the validation points acquisition survey, with an approximate length of 51.482 kilometers, as illustrated in the map in Figure 49.

Figure 49. Extent of the LiDAR ground validation survey of the Bauang River Basin

4.7 Bathymetric Survey

A bathymetric survey of the Bauang River was conducted on July 14, 2015 using an OHMEX™ and a Trimble® SPS 882 GNSS rover receiver attached to a pole on the side of the boat, as demonstrated in Figure 50. The survey began in the upstream part of the river in Barangay Acao, with coordinates 16°31'09.7466"N 120°20'55.5551"E; and ended at the mouth of the river in Barangay Pugo with coordinates 16°31'23.9111"N 120°18'36.9876"E. Both points are located in the Municipality of Bauang.

A manual bathymetric survey, on the other hand, was executed on November 26, 2015 using a Trimble® SPS 882 in GNSS RTK survey technique. The survey began at the upstream portion of the river in Barangay Cabaritan in the Municipality of Naguilian, with coordinates 16°31'52.88892" 120°23'18.53929"; and ended at the starting point of the bathymetric survey by boat in Barangay Acao, Municipality of Bauang. The UP-established control point UP-NG, was occupied as the base station all throughout the surveys.

Figure 50. Bathymetry survey set-up for Bauang River

The bathymetric survey for the Bauang River gathered a total of 10,646 points, covering 11.189 kilometers of the river, traversing the six (6) barangays in Bauang and two (2) barangays in Naguilian, as displayed in Figure 51.

A CAD drawing was also produced to illustrate the riverbed profile of the Bauang River, as presented in Figure 52. The profile demonstrates that the elevation was steady, with a total elevation difference of approximately 11 meters for the surveyed area, except for the sudden drop near Barangay Nagrebcan. The highest elevation observed was 8 meters, located in Barangay Cabaritan, Municipality of Naguilian; while the lowest was -2.874 meters, located in Barangay Pugo, Municipality of Bauang.

Figure 51. Extent of the bathymetric survey of the Bauang River Basin

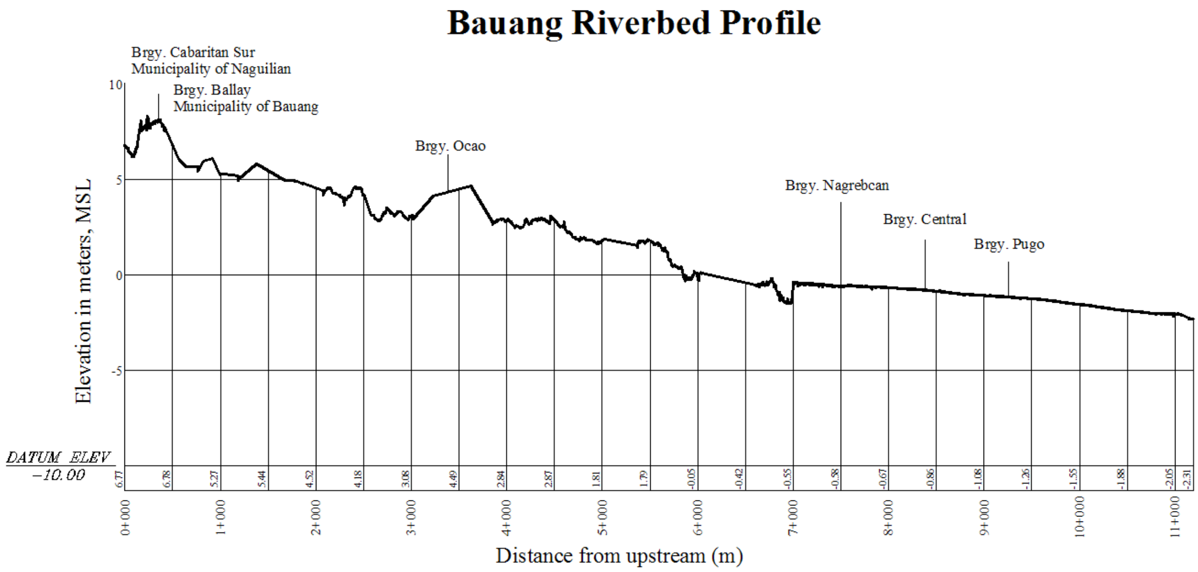


Figure 52. Bauang centerline riverbed profile

CHAPTER 5: FLOOD MODELING AND MAPPING

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

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

5.1 Data Used for Hydrologic Modeling

5.1.1 Hydrometry and Rating Curves

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

5.1.2 Precipitation

Precipitation data was taken from an automatic rain gauge (ARG) installed by the Department of Science and Technology – Advanced Science and Technology Institute (DOST-ASTI). This said rain gauge is the Sablan ARG (16°29’50.63” N, 120°29’13.21” E), located in Sablan, Benguet (Figure 53). The precipitation data collection started on July 4, 2015 at 00:00 hrs. until July 8, 2015 at 23:45 hrs., with a fifteen-minute recording interval.

The total precipitation for this event in the Sablan ARG was 286.2 millimeters. It had a peak rainfall of 8.6 millimeters on July 5, 2015 at 06:45 hrs. The lag time between the peak rainfall and the discharge was three (3) hours and fifty-five (55) minutes.

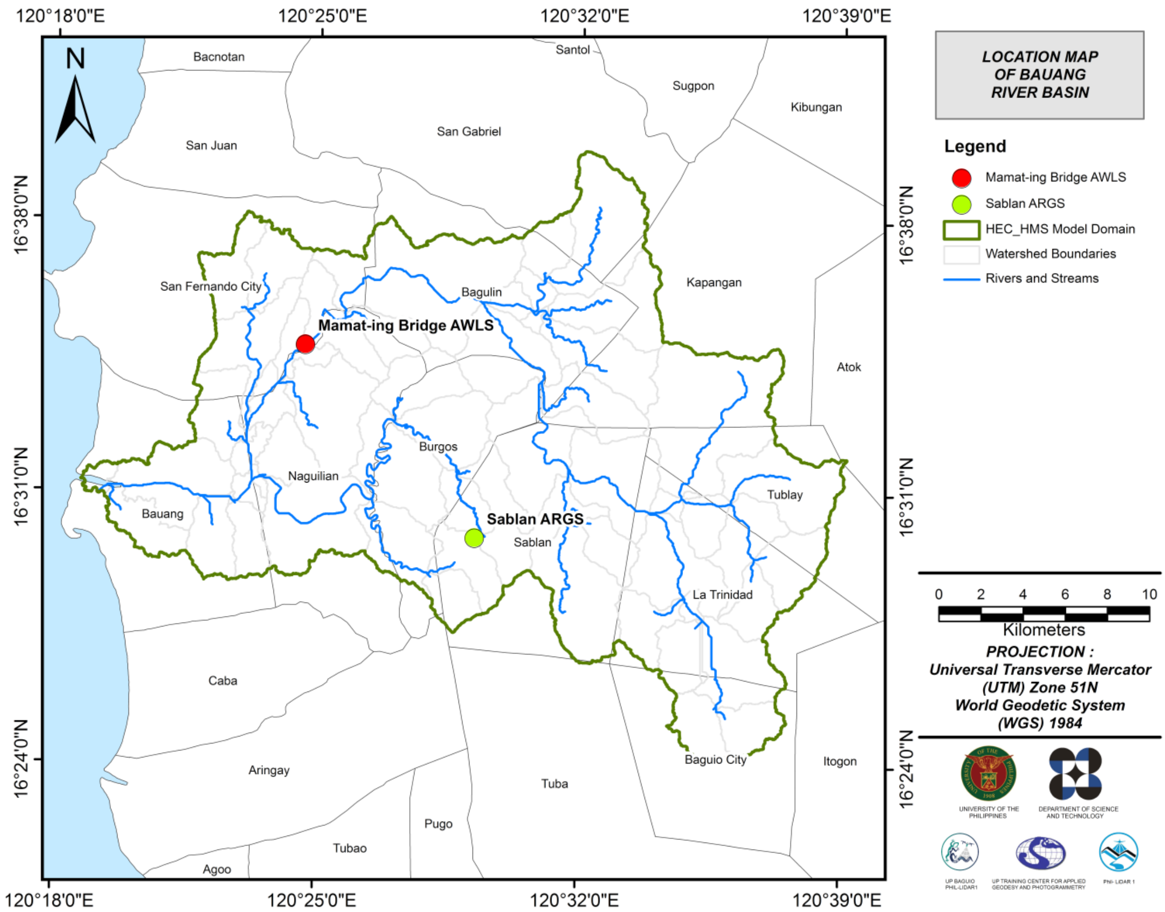


Figure 53. The location map of the Bauang HEC-HMS model, which was used for calibration

5.1.3 Rating Curves and River Outflow

A rating curve was computed at the prevailing cross-section (Figure 54) at the Mamat-Ing Bridge, San Fernando City, La Union (16°34'46.44" N, 120°24'39.42" E). It establishes the relationship between the observed water levels (H) from the Mamat-Ing Bridge and outflow (Q) of the watershed at this location.

For the Mamat-Ing Bridge, the rating curve was expressed as $Q = 1.0901E\text{-}06e^{0.54736x}$, as illustrated in Figure 55.

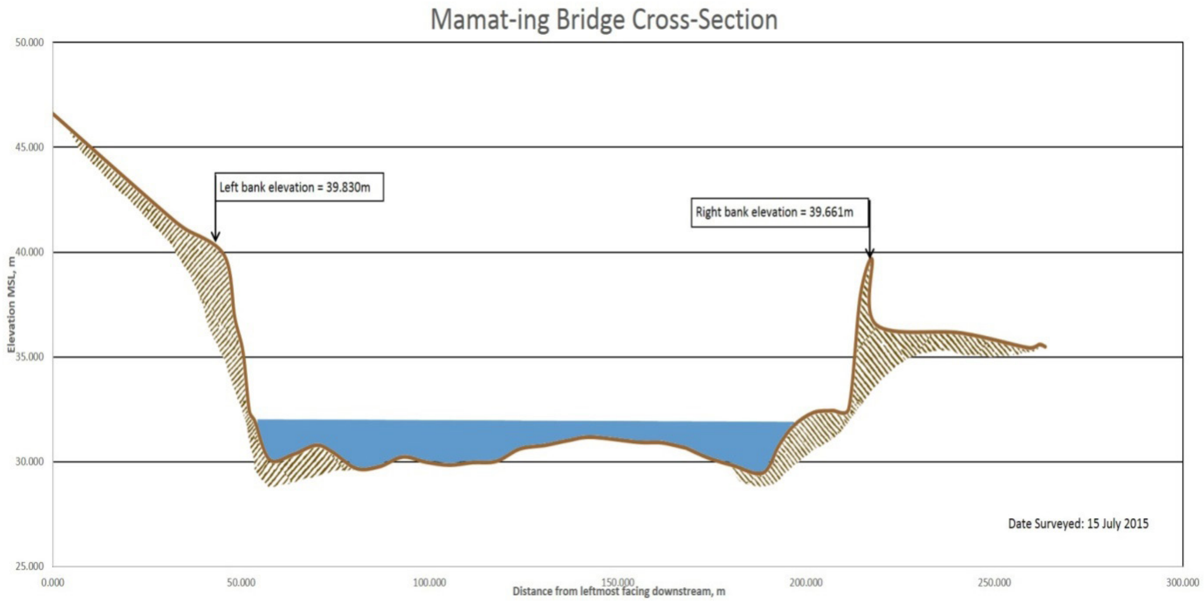


Figure 54. Cross-section plot of the Mamat-Ing Bridge

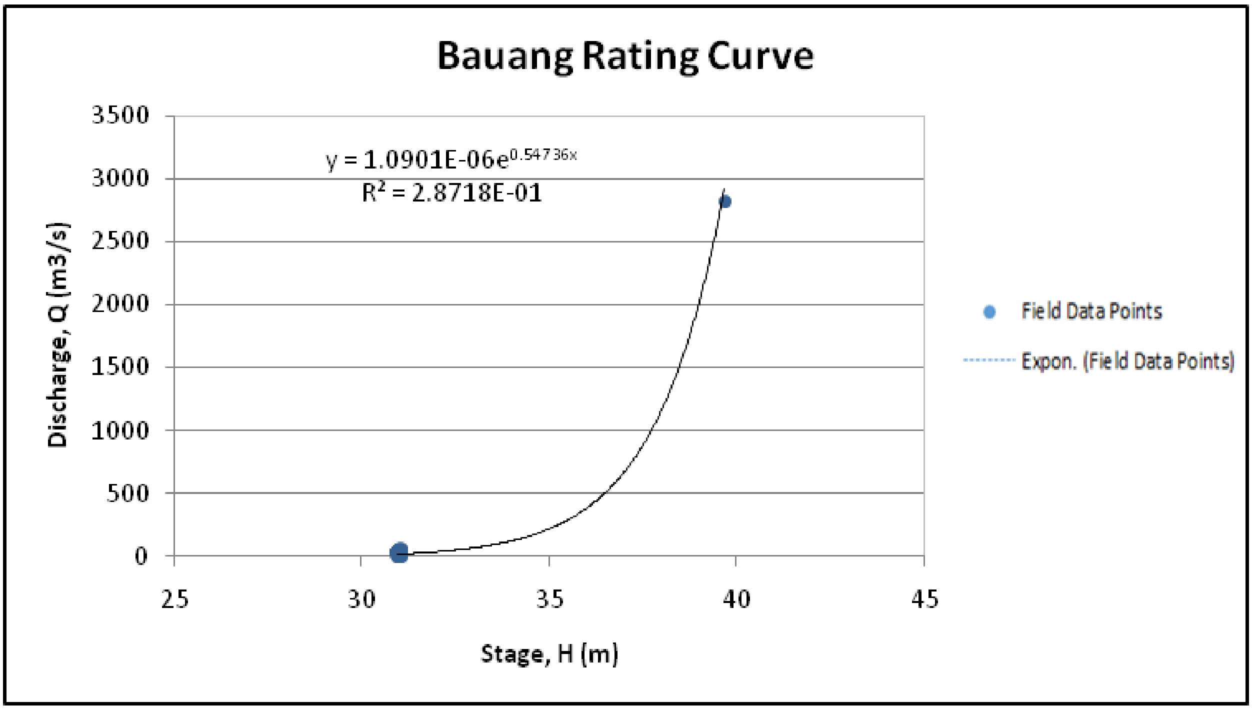


Figure 55. Rating curve at the Mamat-Ing Bridge, San Fernando City, La Union

The rating curve equation was used to compute for the river outflow at the Mamat-Ing Bridge, for the calibration of the HEC-HMS model for Bauang presented in Figure 56. The total rainfall for this event was 286.2 millimeters, and the peak discharge was 119.53 m^3/s on July 5, 2015 at 10:40 hrs.

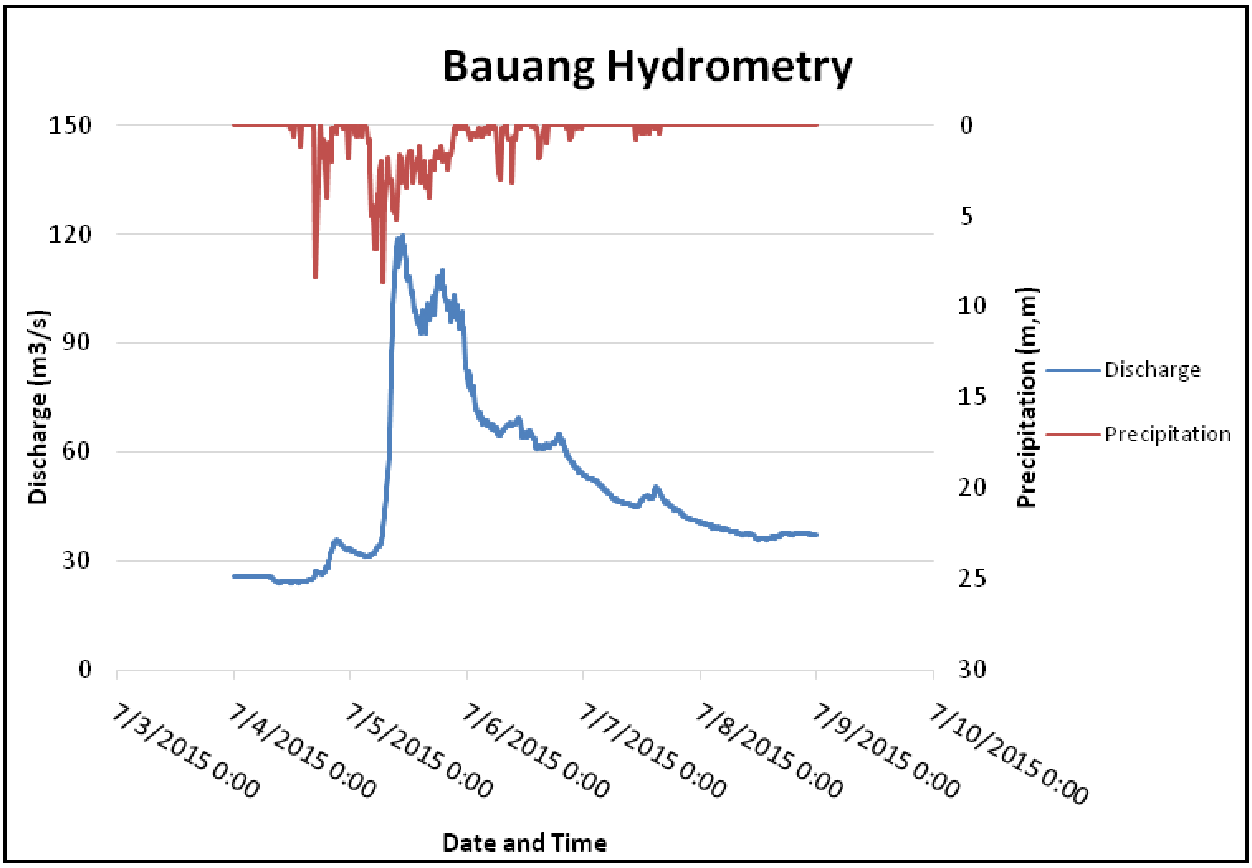


Figure 56. Rainfall and outflow data at the Mamat-Ing Bridge, which were used for modeling

5.2 RIDF Station

The Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) computed for the Rainfall Intensity Duration Frequency (RIDF) values for the Baguio Rain Gauge (Table 29). This station was selected based on its proximity to the Bauang watershed (Figure 57). The RIDF rainfall amount for twenty-four (24) hours was converted into a synthetic storm by interpolating and re-arranging the values such that certain peak values were attained at a certain time. The extreme values for this watershed were computed based on a 59-year record.

Table 29. RIDF values for the Baguio 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	27.4	41.6	51.9	72.5	108	136.3	199.5	258.6	355.1
5	49.3	75.2	94.2	127.7	189.7	235.7	334.8	436.9	563.6
10	63.8	97.5	122.1	164.3	243.8	301.5	424.3	555	701.7
15	72	110	137.9	184.9	274.4	338.6	474.8	621.6	779.6
20	77.7	118.8	149	199.3	295.7	364.6	510.2	668.2	834.1
25	82.1	125.6	157.5	210.5	312.2	384.6	537.5	704.1	876.1
50	95.8	146.4	183.7	244.7	362.9	446.3	621.4	814.8	1005.5
100	109.3	167.1	209.7	278.7	413.2	507.5	704.7	924.7	1134

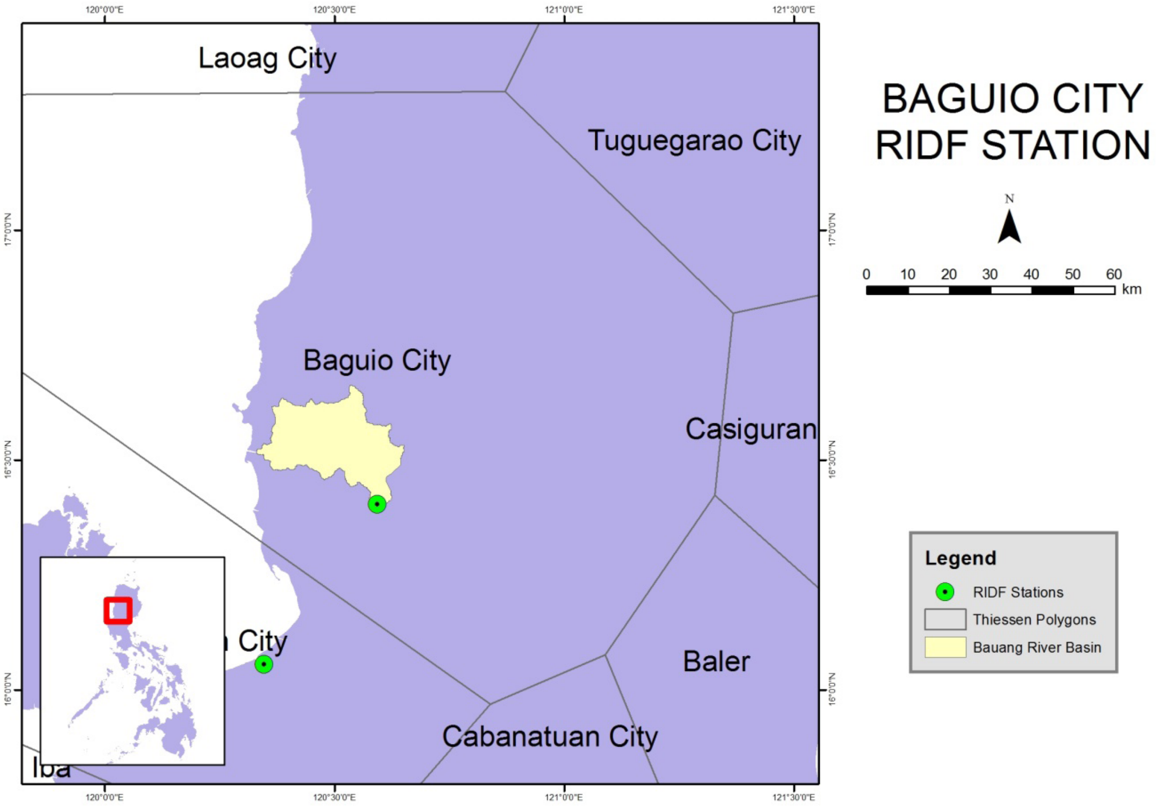


Figure 57. Baguio RIDF location relative to the Bauang River Basin

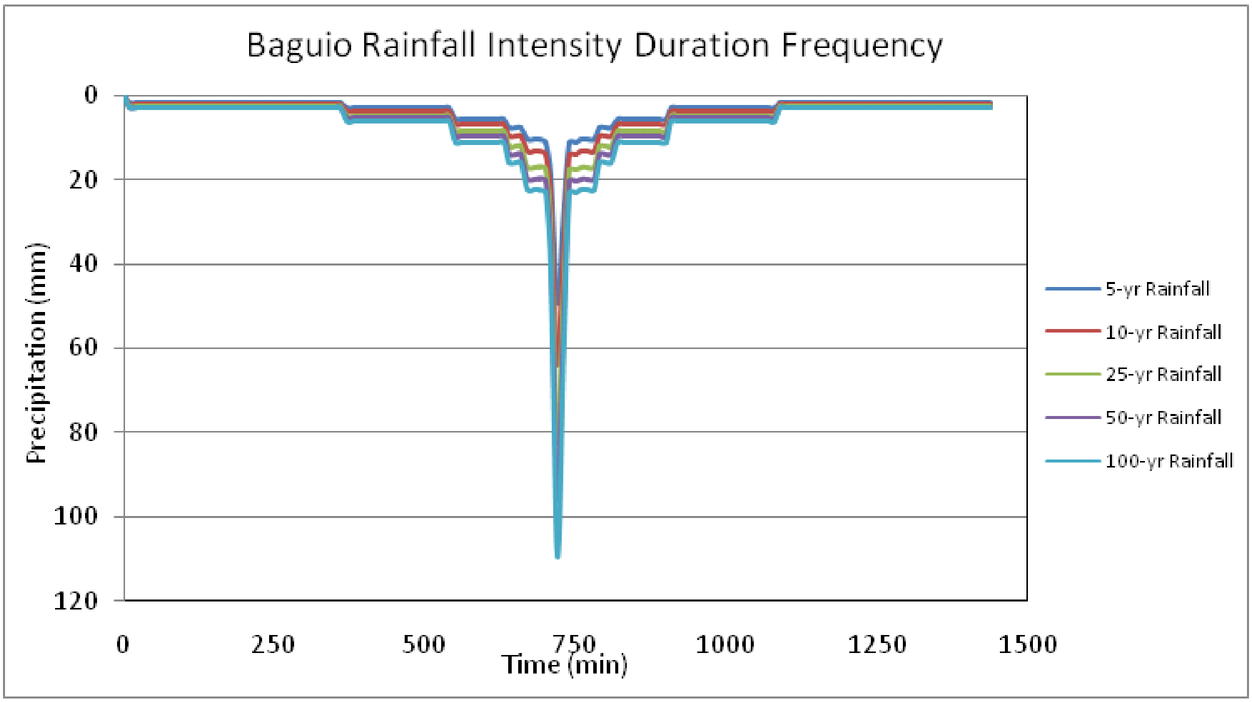


Figure 58. Synthetic storm generated from a 24-hour period rainfall, for various return periods

5.3 HMS Model

The soil shapefile was taken in 2004 from the Bureau of Soils and Water Management (BSWM) under the Department of Agriculture (DA). The land cover dataset is from the National Mapping and Resource information Authority (NAMRIA). The soil and land cover maps of the Bauang River Basin are displayed in Figures 59 and 60, respectively.

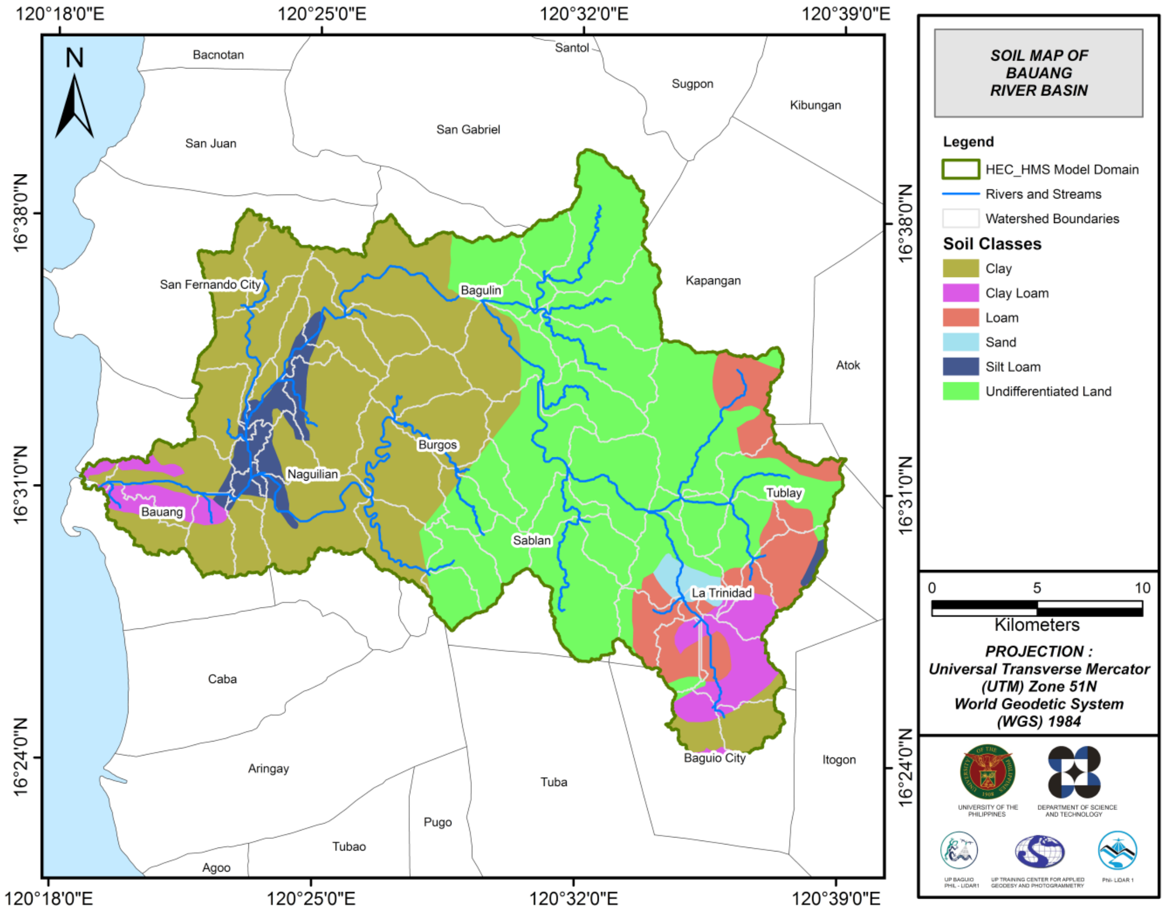


Figure 59. Soil map of the Bauang River Basin (Source: DA)

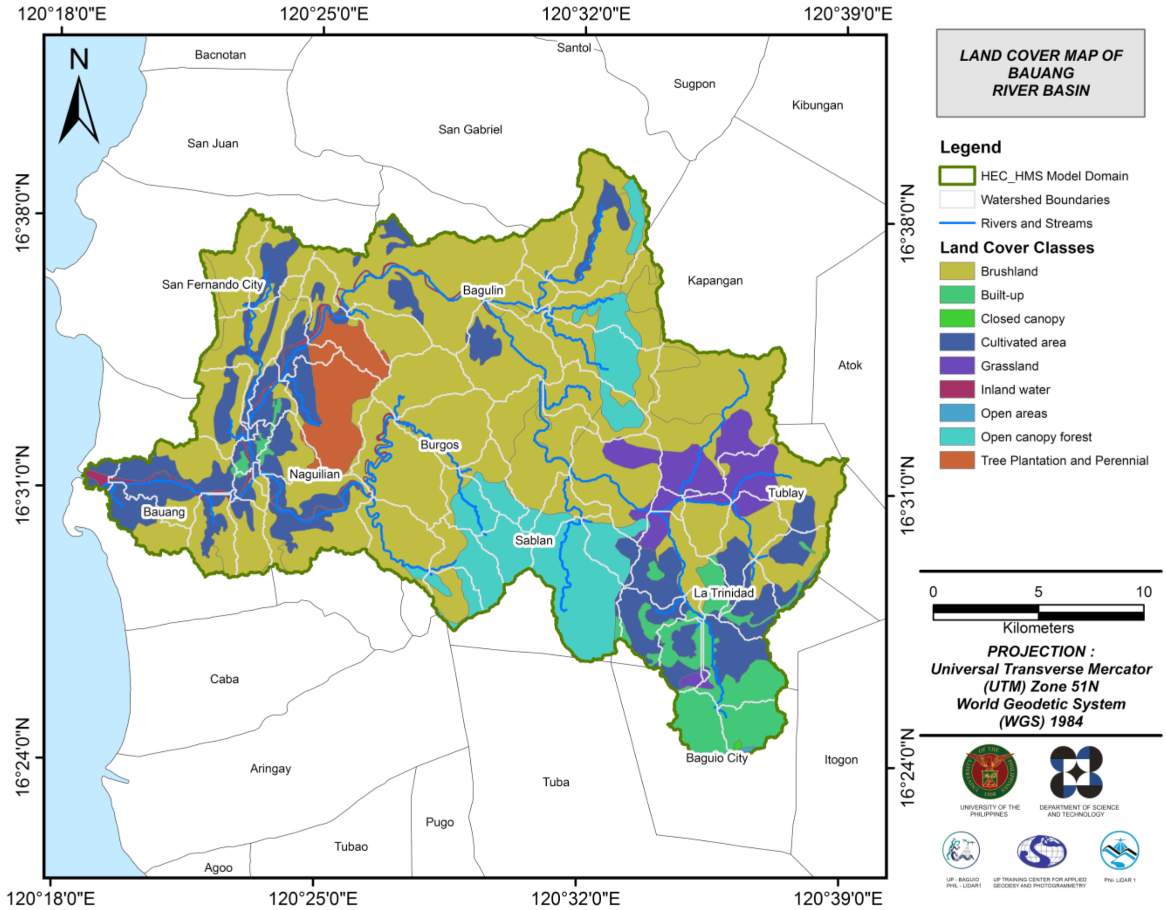


Figure 60. Land cover map of the Bauang River Basin (Source: NAMRIA)

Six (6) soil classes were identified in the Bauang River Basin. These are clay, clay loam, loam, sand, silt loam, and undifferentiated soil. Moreover, nine (9) land cover classes were identified. These are brush lands, built-up areas, closed canopies, cultivated areas, grasslands, inland water, open areas, open canopy forests, and tree plantations.

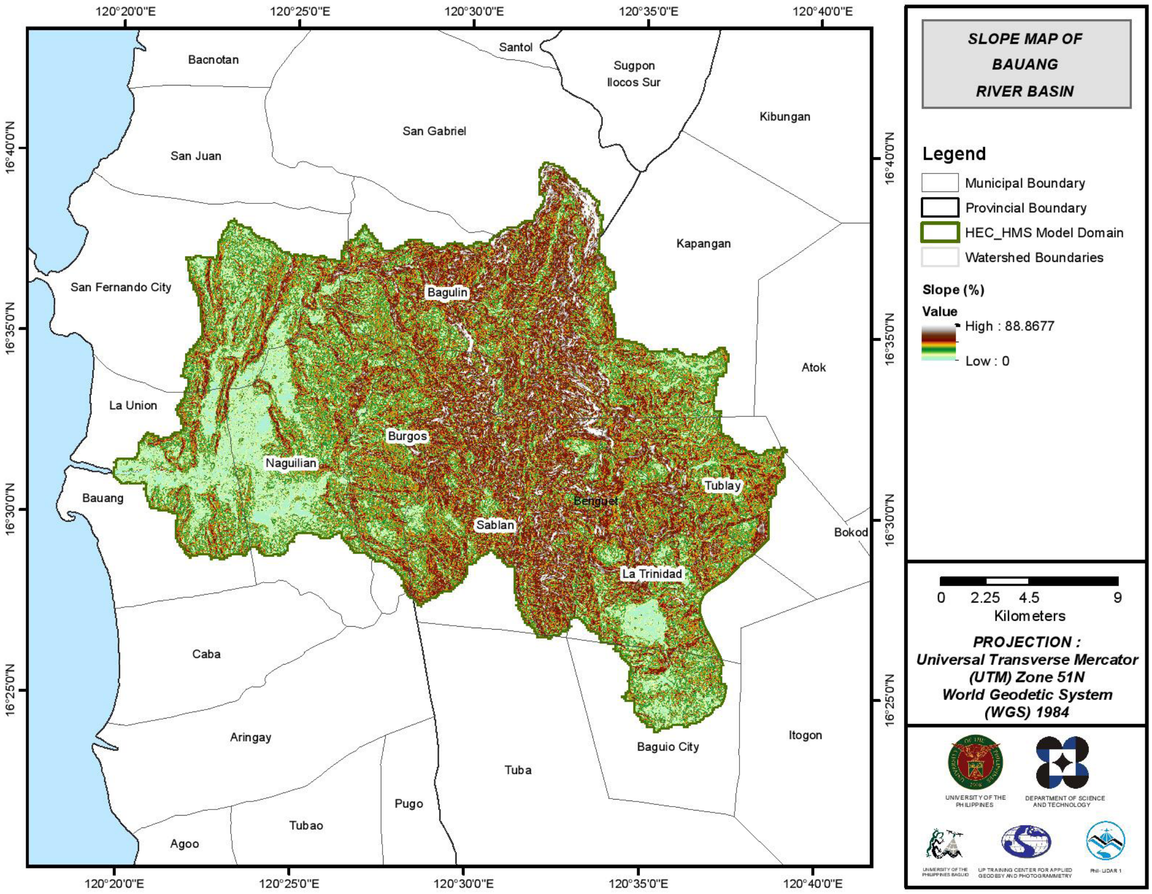


Figure 61. Slope map of the Bauang River Basin

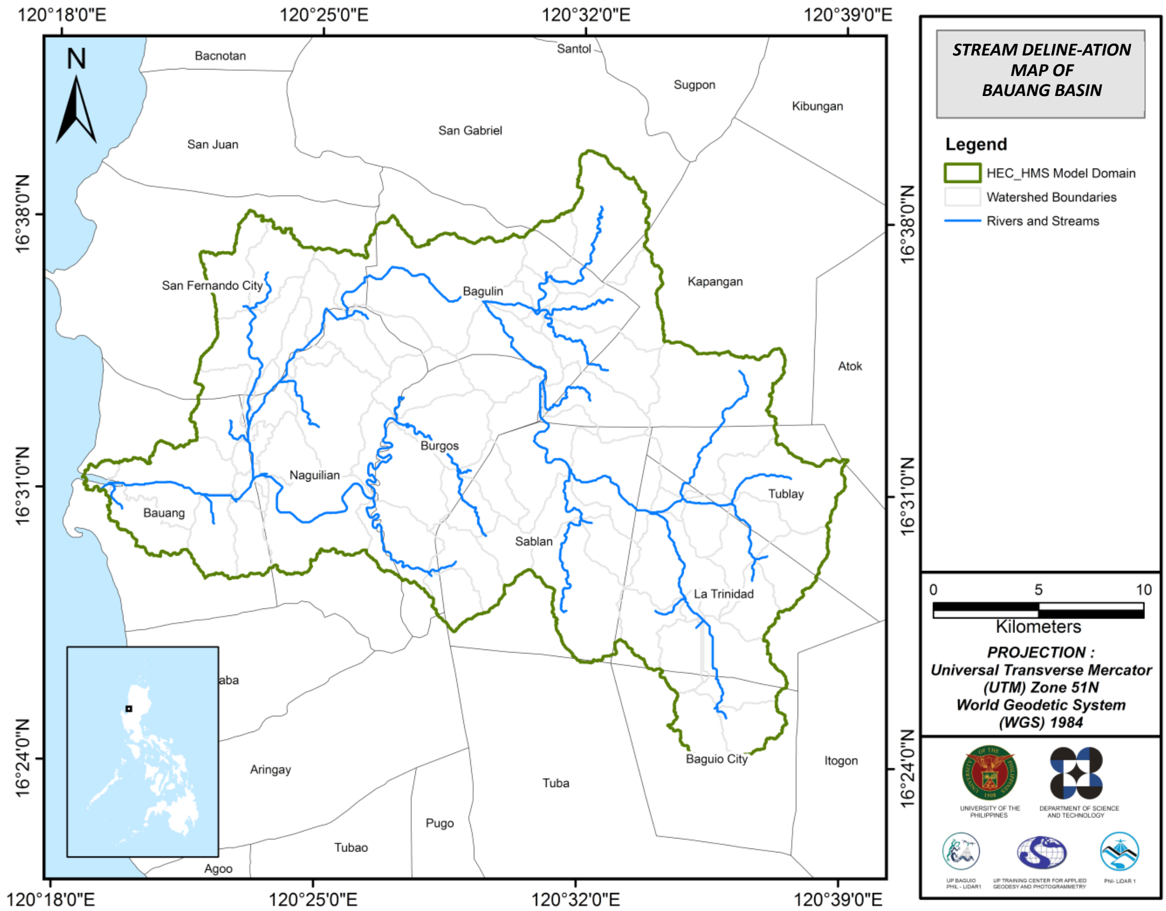


Figure 62. Stream delineation map of the Bauang River Basin

Using the SAR-based DEM, the Bauang basin was delineated and further subdivided into sub-basins. The model consists of sixty (60) sub basins, thirty-one (31) reaches, and thirty-one (31) junctions, as shown in Figure 63. The main outlet is at 194. See Annex 10 for the Bauang Model Reach Parameters.

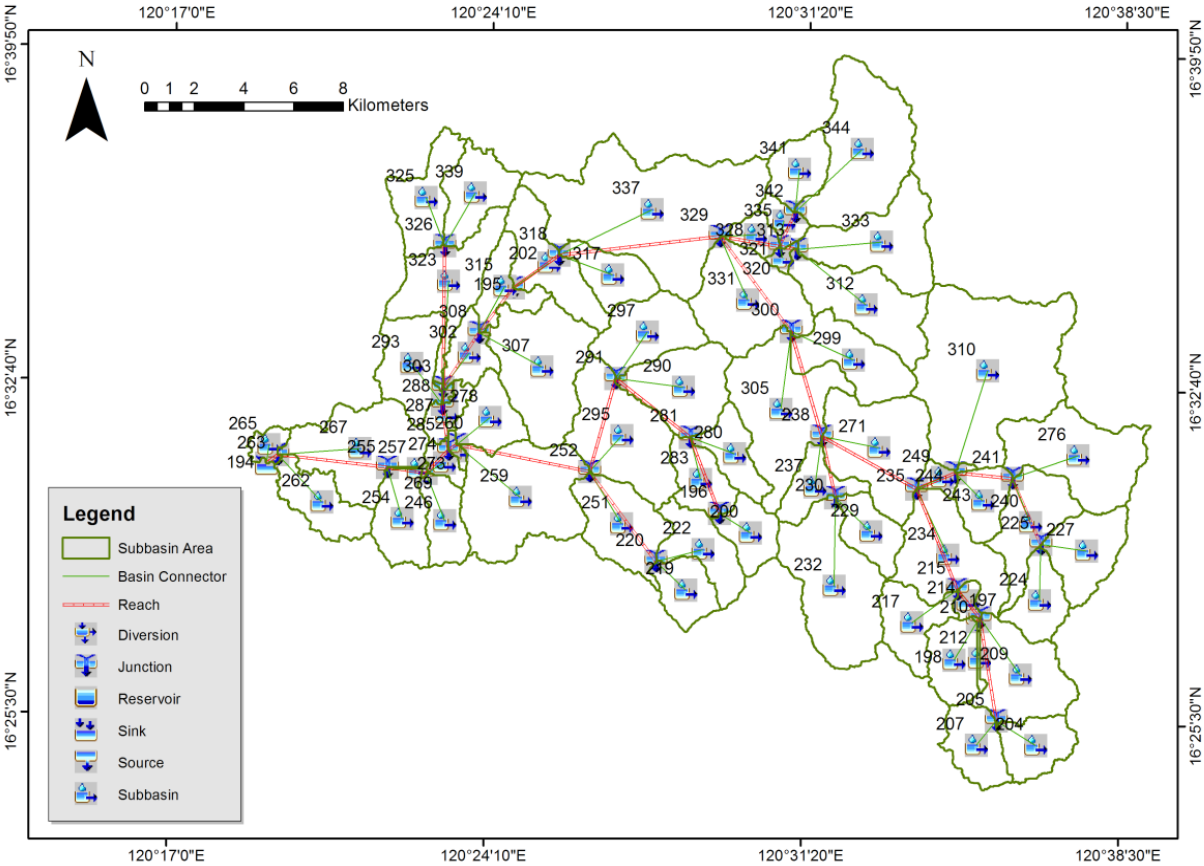


Figure 63. The Bauang River Basin model, generated using HEC-HMS

5.4 Cross-section Data

Riverbed cross-sections of the watershed were necessary in the HEC-RAS model set-up. The cross-section data for the HEC-RAS model was derived from the LiDAR DEM data. It was defined using the Arc GeoRAS tool, and was post-processed in ArcGIS (Figure 64).

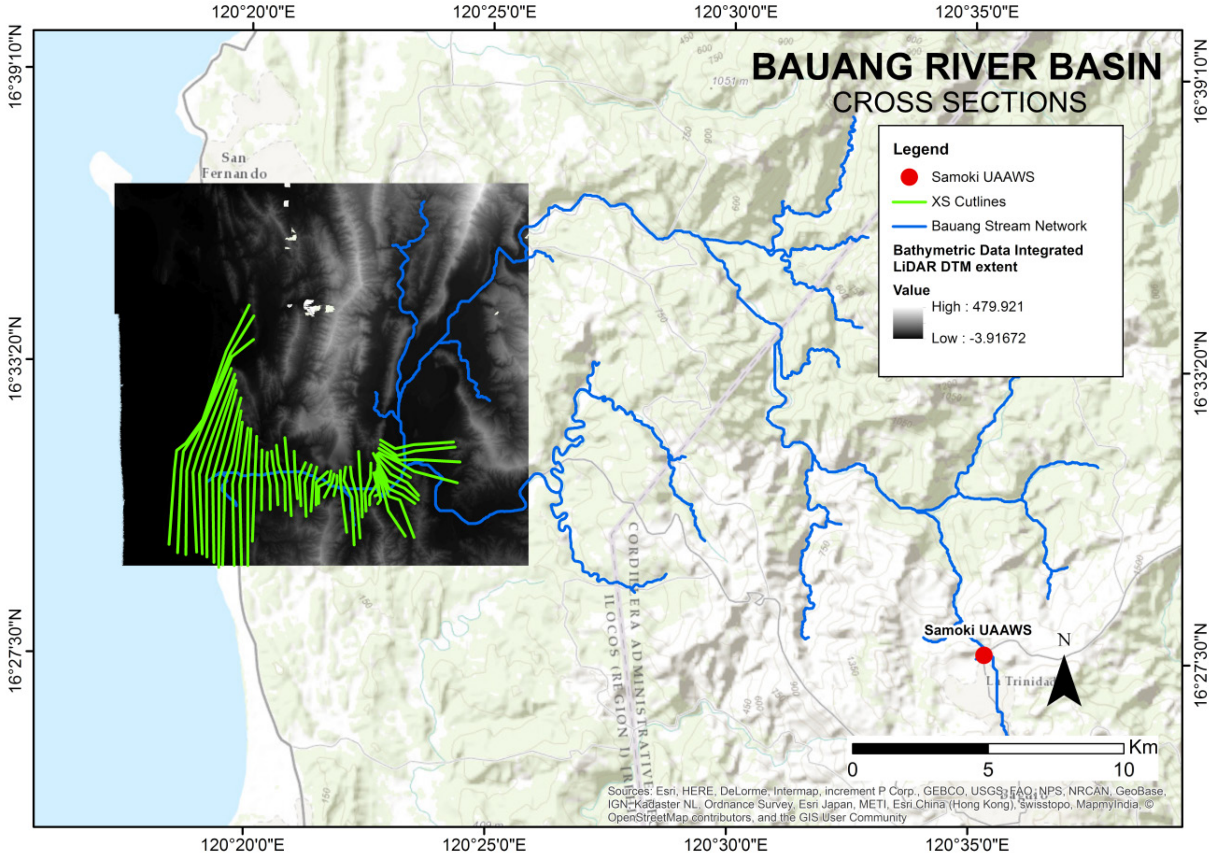


Figure 64. River cross-section of the Bauang River, generated through the ArcMap HEC GeoRAS tool

5.5 Flo 2D Model

The automated modeling process allowed for the creation of a model with boundaries that are almost exactly coincidental with that of the catchment area. As such, they have approximately the same land area and location. The entire area was divided into square grid elements, 10 meters by 10 meters in size. Each element was assigned a unique grid element number, which served as its identifier. The elements were then attributed with the parameters required for modeling, such as x- and y-coordinates of centroid, names of adjacent grid elements, Manning's coefficient of roughness, infiltration, and elevation values. The elements were arranged spatially to form the model, allowing the software to simulate the flow of water across the grid elements in eight (8) directions (i.e., north, south, east, west, northeast, northwest, southeast, and southwest).

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

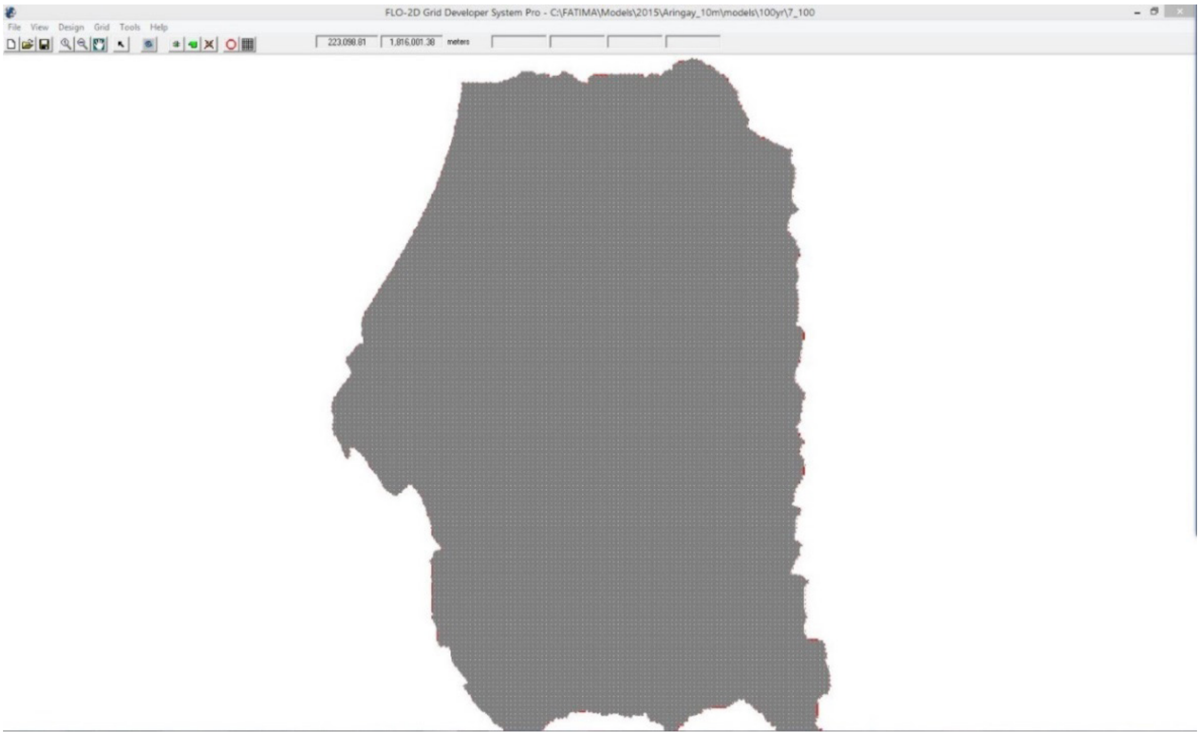


Figure 65. A screenshot of the river sub-catchment with the computational area to be modeled in FLO-2D Grid Developer System Pro (FLO-2D GDS Pro)

The simulation was then run through the FLO-2D GDS Pro. This particular model had a computer run time of 94.73828 hours. After the simulation, the FLO-2D Mapper Pro was used to transform the simulation results into spatial data that shows the flood hazard levels, as well as the extent and inundation. Assigning the appropriate flood depths and velocity values for Low, Medium, and High generated the flood hazard map. Most of the default values given by the FLO-2D Mapper Pro were used, except for those in the Low hazard level. For this particular level, the minimum h (maximum depth) was set at 0.2 meters; while the minimum vh (product of maximum velocity (v) and maximum depth (h)) was set at 0 m^2/s. The generated flood hazard maps for Bauang are in Figures 69, 71, and 73.

The creation of a flood hazard map from the model also automatically generated a flow depth map, depicting the maximum amount of inundation for every grid element. The legend used by default in the 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 covered a maximum land area of 45654200.00 m^2. The generated flood depth maps for Bauang are in Figures 70, 72, and 74.

There was a total of 374159128.62 m^3 of water that entered the model. Of this amount, 40277538.13 m^3 was due to rainfall, while 333881590.49 m^3 was inflow from areas outside the model. 8907278.00 m^3 of this water was lost to infiltration and interception, while 78375370.45 m^3 was stored by the flood plain. The rest, amounting to up to 286876474.75 m^3, was outflow.

5.6 Results of HMS Calibration

After calibrating the Bauang HEC-HMS River Basin model, its accuracy was measured against the observed values. Figure 66 depicts the comparison between the two discharge data. The Bauang Model Basin Parameters are available in Annex 9.

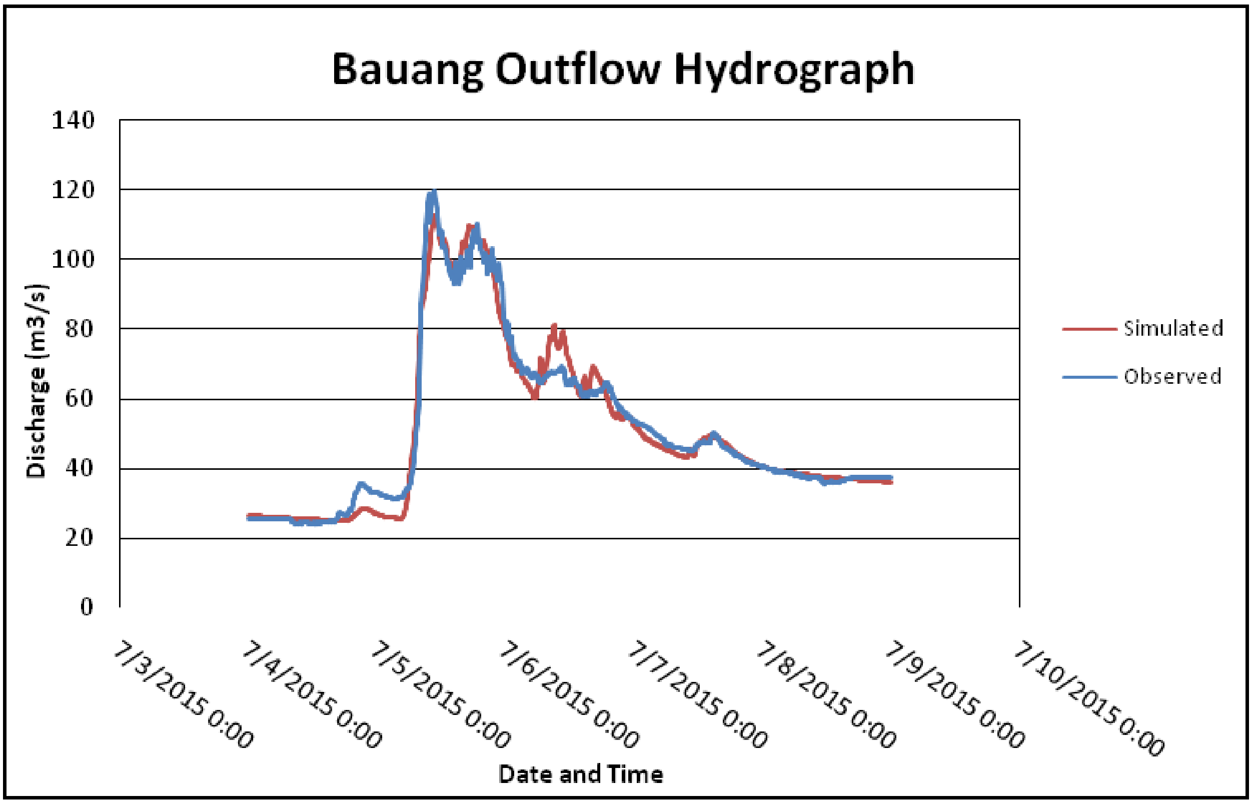


Figure 66. Outflow hydrograph of Bauang produced by the HEC-HMS model, compared with observed outflow

Enumerated in Table 30 are the adjusted ranges of values of the parameters used in calibrating the model.

Table 30. Range of calibrated values for the Bauang River Basin model

Hydrologic Element	Calculation Type	Method	Parameter	Range of Calibrated Values
Basin	Loss	SCS Curve Number	Initial Abstraction (mm)	8.84 - 454
			Curve Number	35 - 66.58
	Transform	Clark Unit Hydrograph	Time of Concentration (hr)	0.22 - 4.61
			Storage Coefficient (hr)	0.25 – 8.076
	Baseflow	Recession	Recession Constant	0.588 - 1
			Ratio to Peak	0.15 – 0.33
Reach	Routing	Muskingum-Cunge	Manning's Coefficient	0.0001 - 0.0042

The initial abstraction defines the amount of precipitation that must fall before surface runoff. The magnitude of the outflow hydrograph increases as the initial abstraction decreases. A range of values from 8.84 to 454 millimeters means that the amount of infiltration or rainfall interception by vegetation all over the basin varies greatly.

The curve number is the estimate of the precipitation excess of soil cover, land use, and antecedent moisture. The magnitude of the outflow hydrograph increases as the curve number increases. The range of 65 to 90 for the curve number is advisable for Philippine watersheds, depending on the soil and land cover of the area (M. Horritt, personal communication, 2012). For Bauang, the basin consists mainly of brush lands; and the soil consists of mostly undifferentiated soil and clay.

The time of concentration and storage coefficient are the travel time and the index of temporary storage of runoff in a watershed. The range of calibrated values from 0.22 hours to 8.076 hours determines the reaction time of the model, with respect to the rainfall. The peak magnitude of the hydrograph decreases when these parameters are increased.

The recession constant is the rate at which the baseflow recedes between storm events; and ratio to peak is the ratio of the baseflow discharge to the peak discharge. Recession constant values within the range of 0.588 to 1 imply that the basin is unlikely to quickly revert to its original discharge, and will be higher instead. Values of ratio to peak within the range of 0.15 to 0.33 indicate a steeper receding limb of the outflow hydrograph.

The Manning's roughness coefficients correspond to the common roughness of Philippine watersheds. The Bauang River Basin reaches' Manning's coefficients range from 0.0001 to 0.0042, signifying that there is a variety of surface roughness all over the catchment (Brunner, 2010).

Table 31. Efficiency Test of the Bauang HMS Model

RMSE	3.9
r^2	0.9738
NSE	0.97
PBIAS	0.88
RSR	0.17

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was computed as 3.9 m^3/s.

The Pearson correlation coefficient (r^2) assesses the strength of the linear relationship between the observations and the model. A coefficient value close to 1 represents an almost perfect match of the observed discharge and the resulting discharge from the HEC-HMS model. Here, it measured was at 0.9738.

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 0.97.

A positive Percent Bias (PBIAS) indicates a model's propensity towards under-prediction. Negative values indicate a bias towards over-prediction. The optimal value is 0. In the model, the PBIAS is 0.88.

The Observation Standard Deviation Ratio (RSR) is an error index. A perfect model attains a value of 0 when the error units of the values are quantified. The model attained an RSR value of 0.17.

5.7 Calculated outflow hydrographys and Discharge values for different rainfall return periods

5.7.1 Hydrograph using the Rainfall Runoff Model

The summary graph (Figure 67) illustrates the Bauang outflow using the Baguio RIDF curves in five (5) different return periods (i.e., 5-year, 10-year, 25-year, 50-year, and 100-year rainfall time series), based on the data from PAGASA. The simulation results reveal a significant increase in outflow magnitude as the rainfall intensity increases, for a range of durations and return periods.

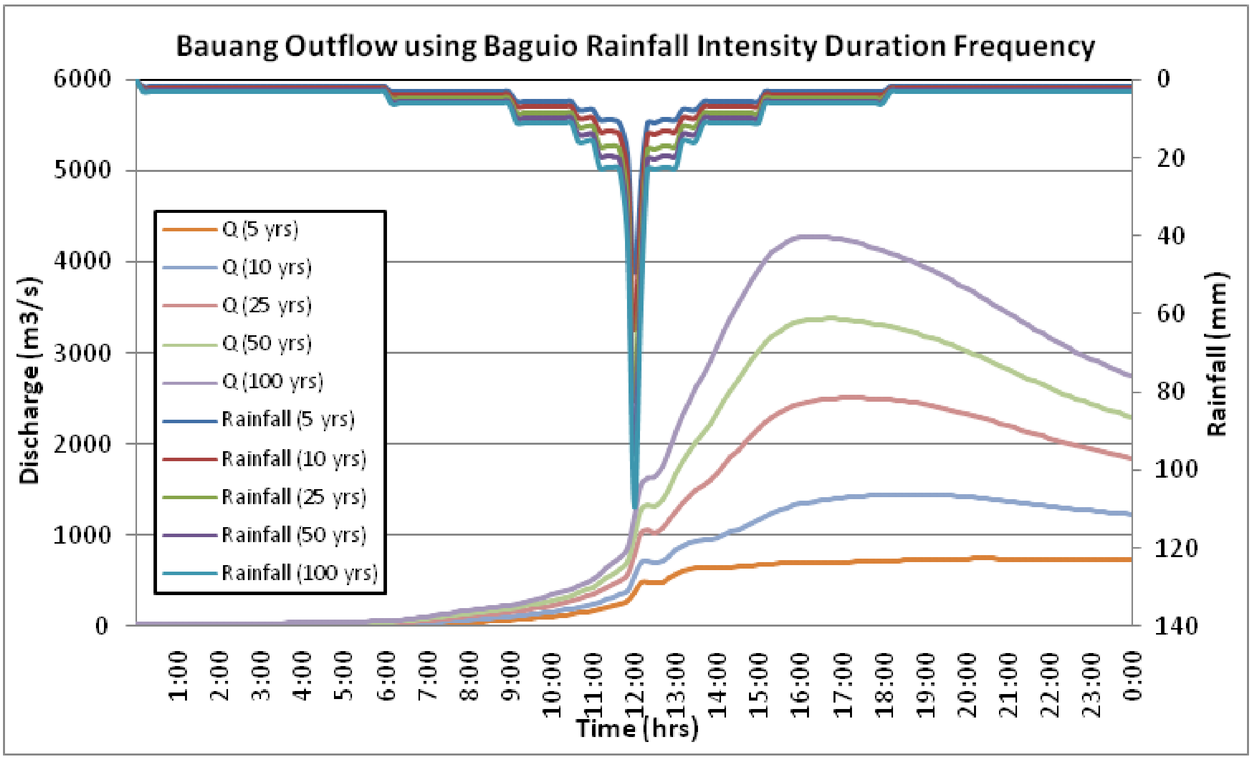


Figure 67. Outflow hydrograph at the Bauang Station, generated using the Baguio RIDF simulated in HEC-HMS

A summary of the total precipitation, peak rainfall, peak outflow, and time to peak of the Bauang discharge using the Baguio RIDF curves in five (5) different return periods is provided in Table 32.

Table 32. Peak values of the Bauang HEC-HMS Model outflow, using the Baguio RIDF

RIDF Period	Total Precipitation (mm)	Peak rainfall (mm)	Peak outflow (m3/s)	Time to Peak
5-Year	563.85	49.3	743.2	8 hours 20 minutes
10-Year	701.7	63.8	1448.7	6 hours 40 minutes
25-Year	876.1	82.1	2509.1	5 hours 10 minutes
50-Year	1005.5	95.8	3376.7	4 hours 40 minutes
100-Year	1134	109.3	4281.4	4 hours 20 minutes

5.8 River Analysis (RAS) Model Simulation

The HEC-RAS flood model produced a simulated water level at every cross-section, for every time step, for every flood simulation created. The resulting model will be used in determining the flooded areas within the model. The simulated model will be an integral part in determining the real-time flood inundation extent of the river, after it has been automated and uploaded on the DREAM website. For this publication, only a sample output map river is presented. The sample generated map of the Bauang River using the calibrated HMS base flow is shown in Figure 68.

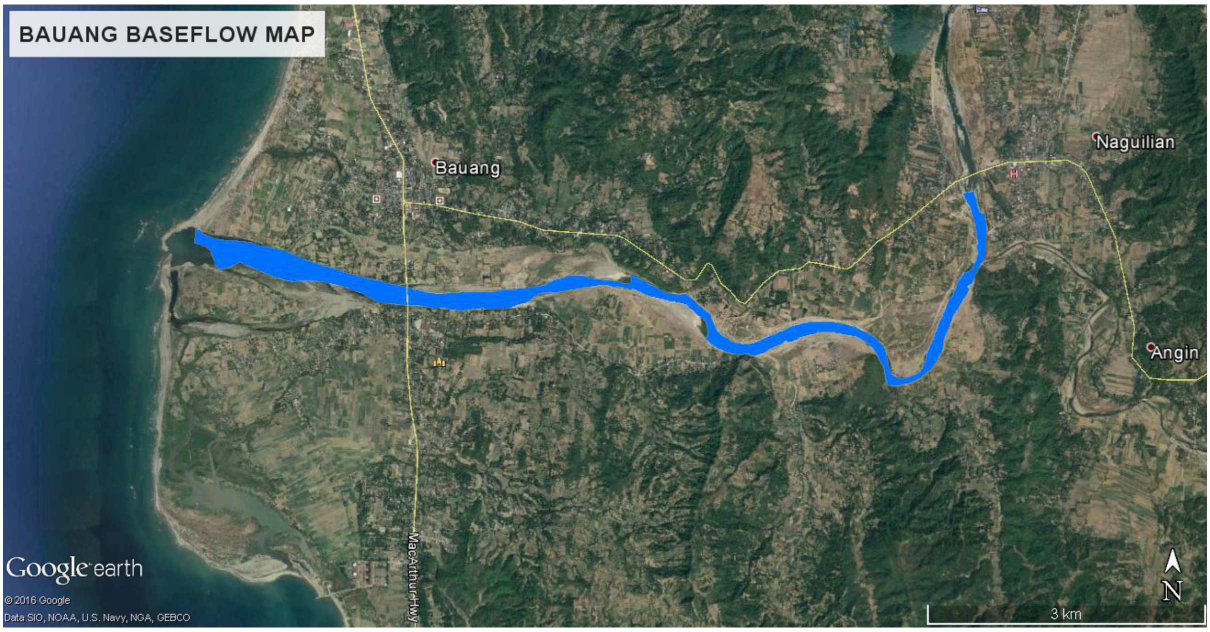


Figure 68. Sample output map of the Bauang RAS Model

5.9 Flow Depth and Flood Hazard

The resulting hazard and flow depth maps have a 10-meter resolution. The 5-year, 25-year, and 100-year rain return scenarios of the Bauang floodplain are shown in Figures 69 to 74. The floodplain, with an area of 1,027.9 square kilometers, covers nineteen (19) municipalities from two (2) provinces. Table 33 summarizes the percentage of area affected by flooding per municipality.

Table 33. Municipalities affected in the Bauang floodplain

Province	Municipality	Total Area	Area Flooded	% Flooded
Benguet	Baguio City	60.8979	33.175	54.48%
Benguet	Kapangan	133.9	44.5919	33.30%
Benguet	La Trinidad	74.908	63.2633	84.45%
Benguet	Sablan	90.2168	90.2168	100.00%
Benguet	Tuba	322.02	137.594	42.73%
Benguet	Tublay	63.209	35.2287	55.73%
La Union	Agoo	33.7074	2.6153	7.76%
La Union	Aringay	95.6482	95.2867	99.62%
La Union	Bagulin	77.9673	65.656	84.21%
La Union	Bauang	85.26	84.1416	98.69%
La Union	Burgos	51.9196	51.9196	100.00%
La Union	Caba	56.1911	56.1165	99.87%
La Union	Naguilian	86.3875	86.3875	100.00%
La Union	Pugo	60.537	50.1692	82.87%
La Union	Rosario	64.3275	4.53607	7.05%
La Union	San Fernando City	121.053	56.8372	46.95%
La Union	San Gabriel	154.189	16.9234	10.98%
La Union	Santo Tomas	58.5311	5.21613	8.91%
La Union	Tubao	53.8728	45.1865	83.88%

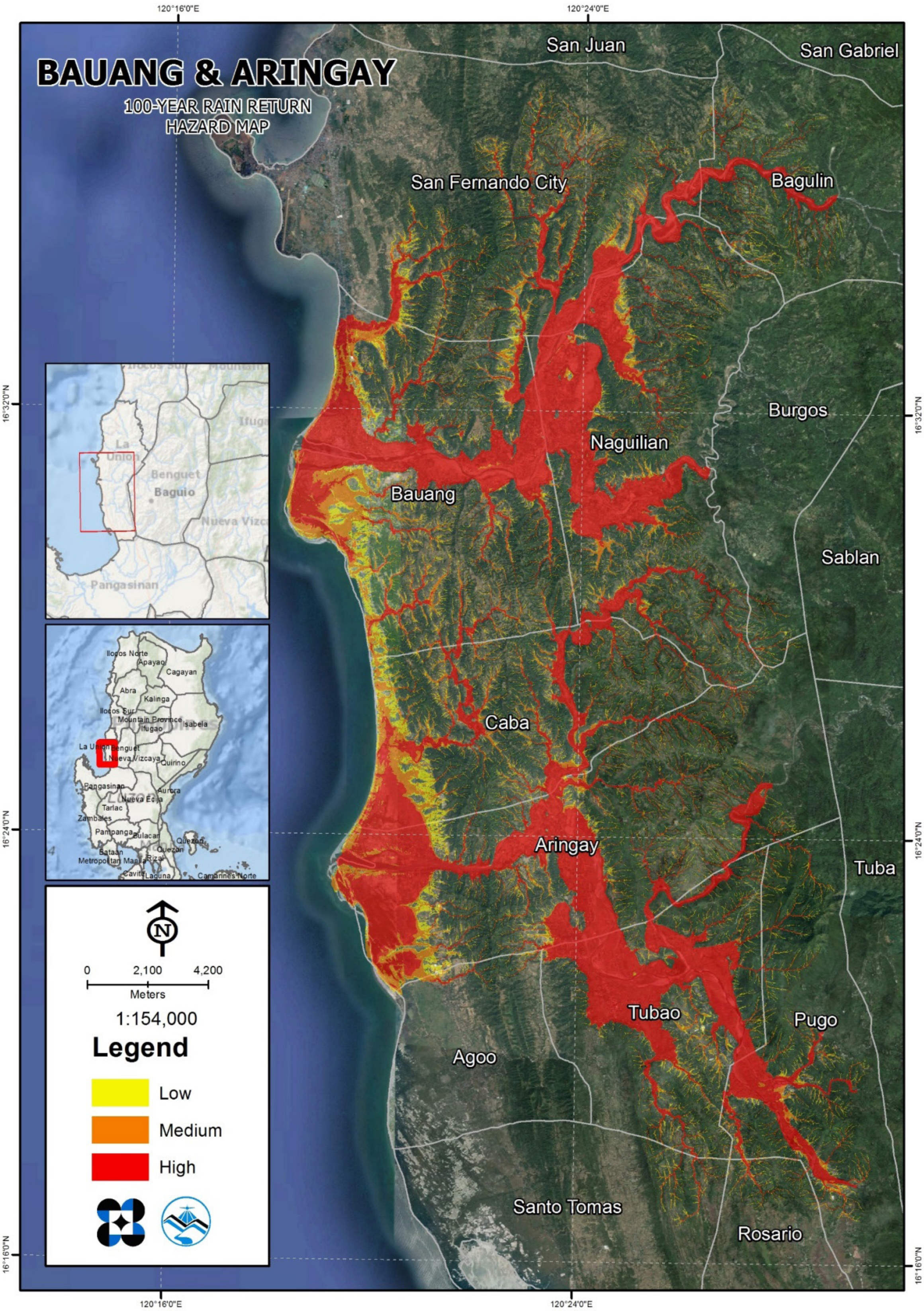


Figure 69. 100-year flood hazard map for the Bauang floodplain, overlaid on Google Earth imagery

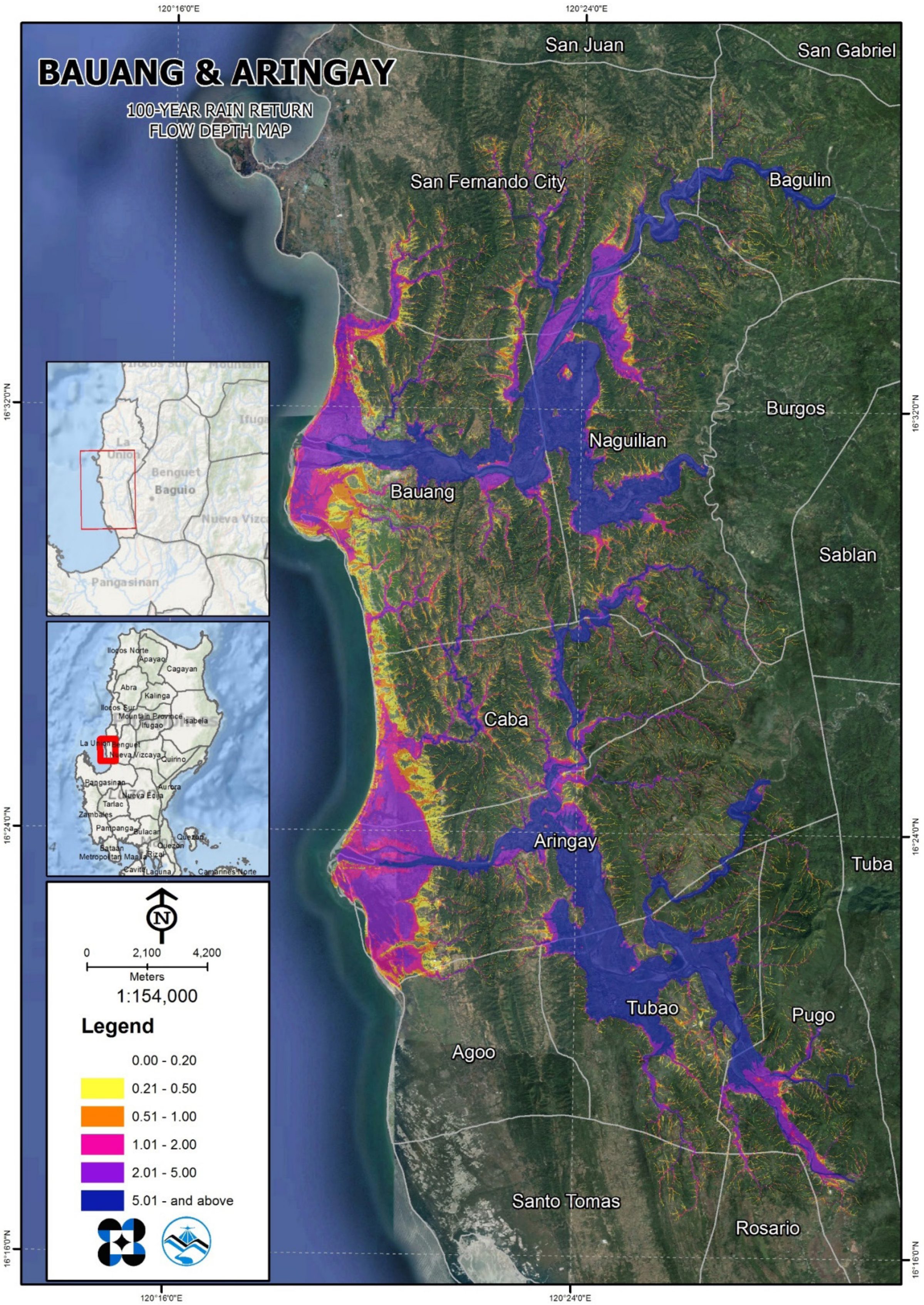


Figure 70. 100-year flow depth map for the Bauang floodplain, overlaid on Google Earth imagery

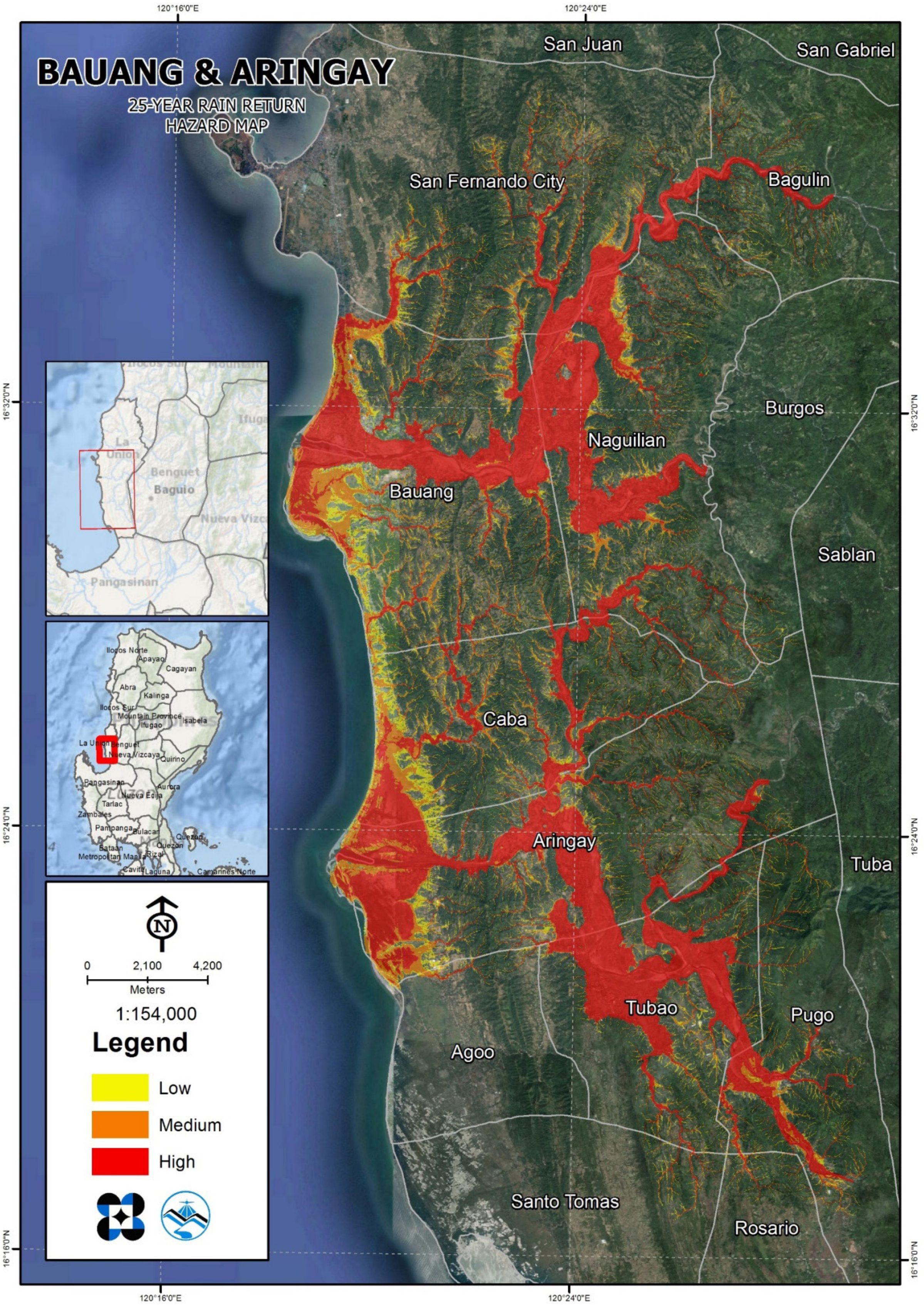


Figure 71. 25-year flood hazard map for the Bauang floodplain, overlaid on Google Earth imagery

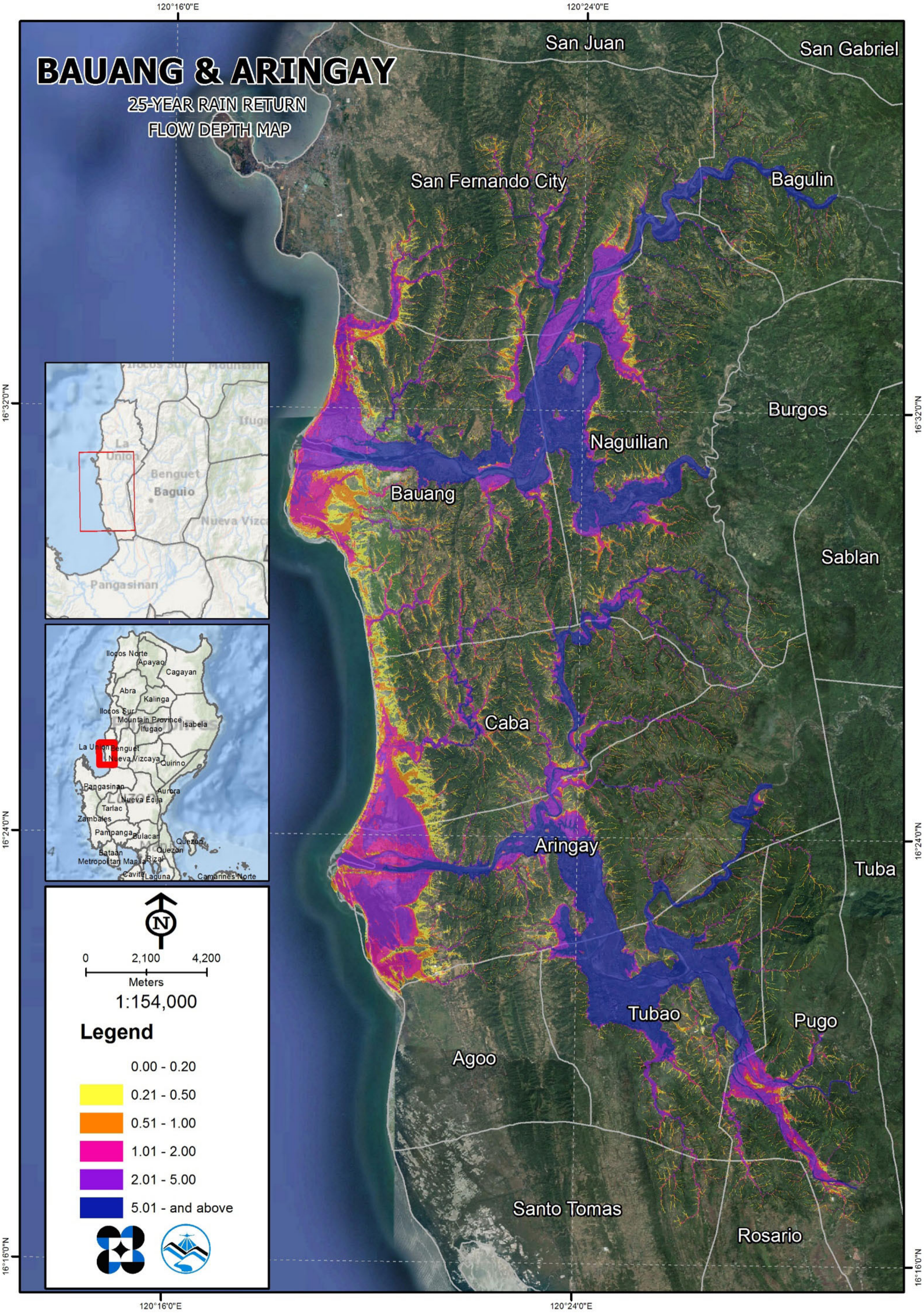


Figure 72. 25-year flow depth map for the Bauang floodplain, overlaid on Google Earth imagery

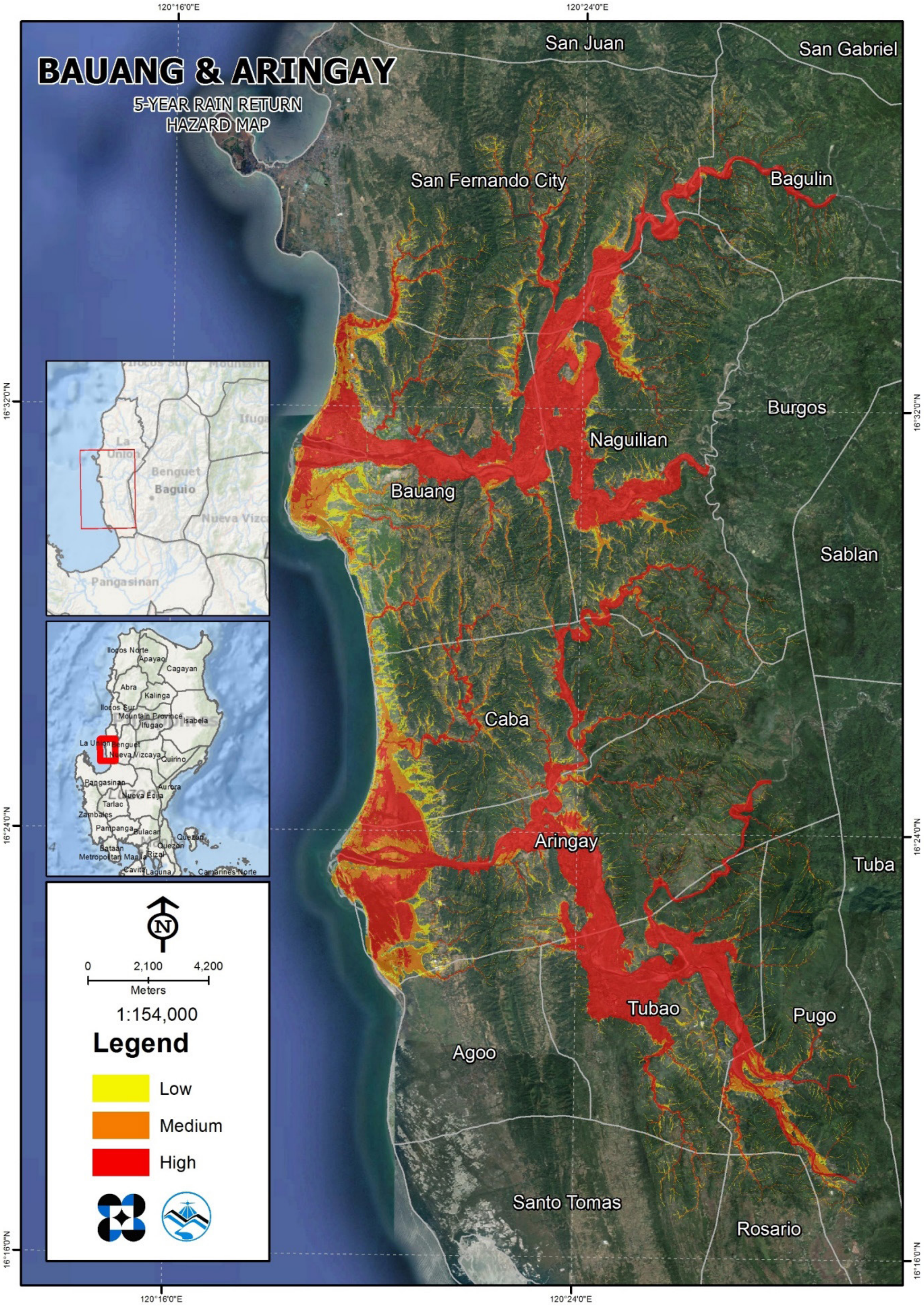


Figure 73. 5-year flood hazard map for the Bauang floodplain, overlaid on Google Earth imagery

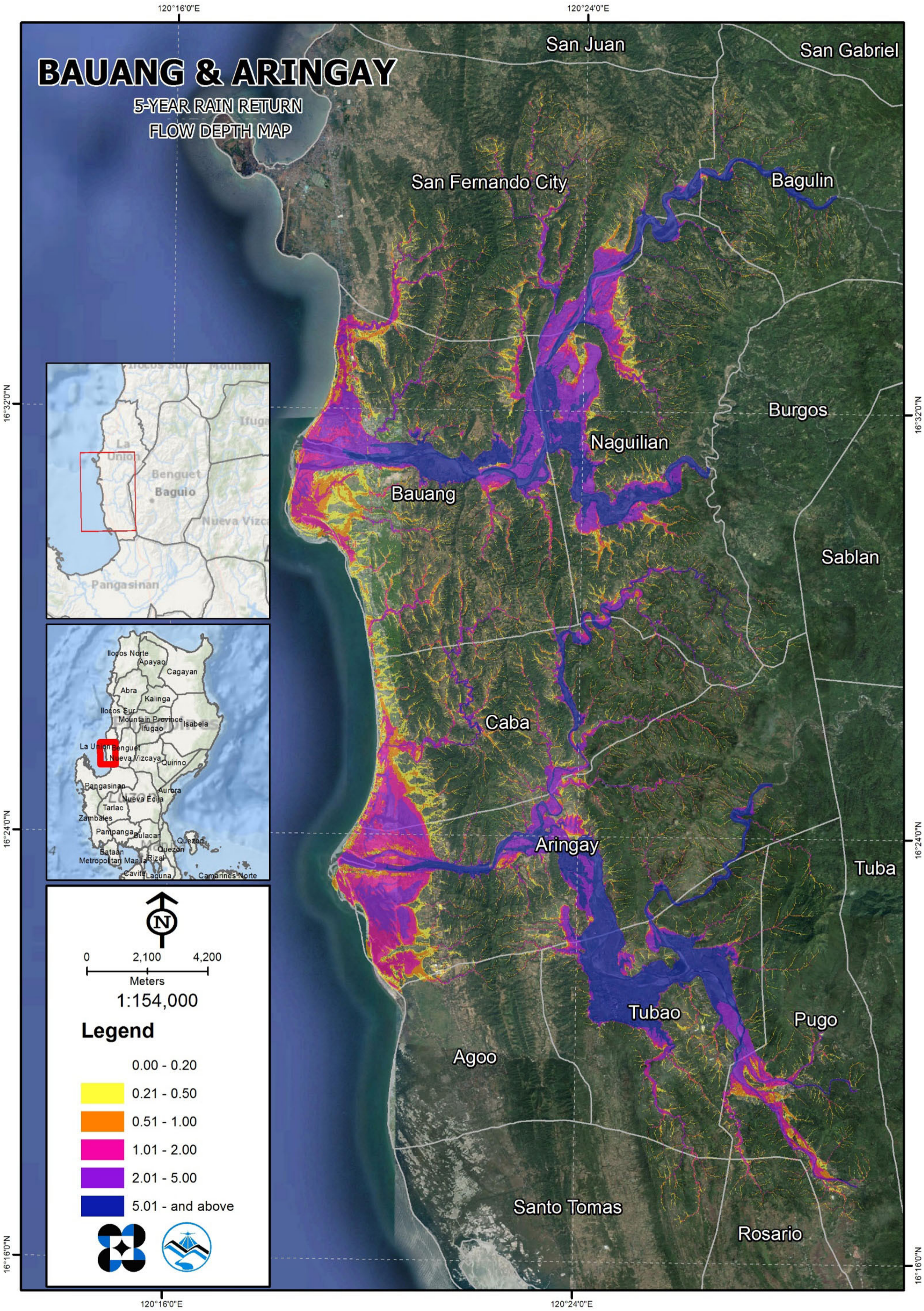


Figure 74. 5-year flow depth map for the Bauang floodplain, overlaid on Google Earth imagery

5.10 Inventory of Areas Exposed to Flooding

The affected barangays in the Bauang River Basin, grouped by municipality, are listed below. For the said basin, two (2) provinces with nineteen (19) municipalities, consisting of three hundred and sixty-six (366) barangays are expected to experience flooding when subjected to 5-year, 25-year, and 100-year rainfall return periods.

For the 5-year return period, 48.86% of the Municipality of Baguio City, with an area of 60.8979 square kilometers, will experience flood levels of less than 0.20 meters. 2.08% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 1.18%, 1.01%, 0.72%, and 0.15% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Tables 34-42 are the affected areas, in square kilometers, by flood depth per barangay.

Table 34. Affected areas in Baguio City, Benguet during a 5-year rainfall return period - A

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City, Benguet											
		A. Bonifacio-Caguioa-Rimando	Aban-ao-Zandueta-Kayong-Chugum-Otek	Alfonso Tabora	Ambiong	Andres Bonifacio	Asin Road	Aurora Hill Proper	Aurora Hill, North Central	Aurora Hill, South Central	Bakakeng Central	Bakakeng North	Bal-Marcoville
Affected Area (sq. km.)	0-0.20	0.054	0.037	0.08	0.24	0.075	4.35	0.025	0.044	0.07	0.72	0.084	0.12
	0.21-0.50	0.0031	0.006	0.0026	0.0091	0.003	0.18	0.00085	0.0021	0.00082	0.028	0.004	0.0034
	0.51-1.00	0.00036	0.0007	0.0073	0.0073	0.0001	0.082	0.0013	0.0023	0	0.024	0	0.0065
	1.01-2.00	0.00038	0	0.0082	0.0003	0	0.073	0.0024	0.002	0	0.013	0	0.0022
	2.01-5.00	0.00021	0	0.0055	0	0	0.031	0.0007	0	0	0.0088	0	0.0001
	> 5.00	0	0	0.00061	0	0	0.0013	0	0	0	0.0022	0	0

Table 35. Affected areas in Baguio City, Benguet during a 5-year rainfall return period - B

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City, Benguet											
		Balsigan	Bayan Park East	Bayan Park West	Bgh Compound	Brookside	Brookspoint	Cabinet Hill-Teacher's Camp	Camdas Subdivision	Camp 8	Camp Allen	Campo Filipino	City Camp Central
Affected Area (sq. km.)	0-0.20	0.054	0.17	0.076	0.017	0.092	0.1	0.36	0.16	0.09	0.13	0.13	0.069
	0.21-0.50	0.000047	0.0053	0.0012	0.00078	0.0035	0.0051	0.0045	0.0012	0.0027	0.0057	0.017	0.0024
	0.51-1.00	0.00019	0.0083	0.0027	0.0021	0.0015	0.0055	0.0058	0.00075	0	0.0068	0.024	0.0001
	1.01-2.00	0	0.0022	0.0007	0.00028	0	0.0043	0.014	0.00021	0	0.0023	0.042	0
	2.01-5.00	0	0	0	0	0	0.0011	0.0046	0.0011	0	0.00012	0.0001	0
	> 5.00	0	0	0	0	0	0	0	0	0	0	0	0

Table 36. Affected areas in Baguio City, Benguet during a 5-year rainfall return period - C

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City, Benguet											
		City Camp Proper	Country Club Village	Cresencia Village	Dizon Subdivision	Dominican Hill-Mirador	Dontogan	Dps Area	Engineers' Hill	Fairview Village	Ferdinand	General Emilio F. Aguinaldo	General Luna, Lower
Affected Area (sq. km.)	0-0.20	0.085	0.2	0.17	0.26	1.23	0.56	0.12	0.1	0.26	0.095	0.065	0.029
	0.21-0.50	0.00089	0.012	0.0055	0.0025	0.042	0.009	0.0015	0.0012	0.02	0.008	0.0014	0.0023
	0.51-1.00	0	0.0051	0.0076	0.001	0.022	0.0055	0.0027	0	0.019	0.0047	0.0013	0.0016
	1.01-2.00	0	0.0052	0.013	0.0015	0.025	0.0057	0.0055	0	0.014	0.0012	0.0024	0.00099
	2.01-5.00	0	0.0007	0.0014	0.0011	0.055	0.0087	0.021	0	0.0024	0	0.0034	0.0029
	> 5.00	0	0	0	0	0.043	0.000098	0	0	0	0	0	0

Table 37. Affected areas in Baguio City, Benguet during a 5-year rainfall return period - D

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City, Benguet											
		General Luna, Upper	Gibraltar	Greenwater Village	Guisad Central	Guisad Sorong	Happy Hollow	Happy Homes	Holy Ghost Extension	Holy Ghost Proper	Honeymoon	Imelda R. Marcos	Imelda Village
Affected Area (sq. km.)	0-0.20	0.034	0.2	0.13	0.077	0.3	0.78	0.19	0.3	0.047	0.073	0.025	0.08
	0.21-0.50	0.0014	0.0022	0.0033	0.0004	0.012	0.039	0.002	0.009	0.0029	0.0043	0.0001	0.0064
	0.51-1.00	0.000007	0.00024	0.00055	0.0002	0.0041	0.014	0.0017	0.0059	0.0012	0.0014	0	0.0048
	1.01-2.00	0	0.000071	0.00013	0	0.0012	0.015	0.0035	0.013	0.0023	0.0007	0	0.0056
	2.01-5.00	0	0	0	0	0.00019	0.0045	0.012	0.008	0.0091	0	0	0.0018
	> 5.00	0	0	0	0	0	0.0001	0.001	0	0	0	0	0

Table 38. Affected areas in Baguio City, Benguet during a 5-year rainfall return period - E

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City, Benguet											
		Irisan	Kabaya-nihan	Kagi-ti-ngan	Kayang Extension	Kayang-Hill-top	Legar-da-Burn-ham-Kisad	Lopez Jaena	Lourdes Subdivision Extension	Lourdes Sub-di-vision, Lower	Lourdes Sub-di-vision, Proper	Lualhati	Mag-say-say Private Road
Affected Area (sq. km.)	0-0.20	5.77	0.062	0.033	0.091	0.01	0.37	0.047	0.028	0.032	0.081	0.33	0.027
	0.21-0.50	0.23	0.0025	0.00081	0.004	0.00019	0.025	0.0023	0.005	0.0023	0.0017	0.016	0.0039
	0.51-1.00	0.14	0.0047	0.0015	0.00065	0.000001	0.024	0	0	0	0	0.016	0.00077
	1.01-2.00	0.11	0.0018	0.0024	0.000086	0	0.04	0	0	0	0	0.006	0.0031
	2.01-5.00	0.086	0	0.0054	0	0	0.04	0	0	0	0	0	0.0066
	> 5.00	0.026	0	0	0	0	0.0054	0	0	0	0	0	0

Table 39. Affected areas in Baguio City, Benguet during a 5-year rainfall return period - F

ARINGAY-BAU-ANG BASIN		Affected Barangays in Baguio City, Benguet											
		Mag-say-say, Lower	Magsay-say, Upper	Malcolm Square-Per-fecto	Manuel A. Roxas	Middle Que-zon Hill Sub-divi-sion	Military Cut-Off	Modern Site, West	Mrr-Queen Of Peace	New Lucban	Outlook Drive	Pacdal	Padre Burgos
Affected Area (sq. km.)	0-0.20	0.097	0.0096	0.045	0.099	0.15	0.29	0.098	0.062	0.12	0.14	1.1	0.12
	0.21-0.50	0.011	0.0007	0.00012	0.0038	0.0072	0.017	0.0047	0.0036	0.0087	0.0037	0.044	0.0045
	0.51-1.00	0.0025	0.0028	0	0.0072	0.0008	0.0038	0.0002	0.0011	0.0076	0.0029	0.018	0.0082
	1.01-2.00	0.0068	0.0031	0	0.011	0	0.00097	0	0.00051	0.0088	0.00073	0.003	0.0044
	2.01-5.00	0.0087	0.00092	0	0.0022	0	0	0	0	0.0069	0	0.0006	0.01
	> 5.00	0	0	0	0	0	0	0	0	0	0	0	0

Table 40. Affected areas in Baguio City, Benguet during a 5-year rainfall return period - G

ARINGAY-BAU-ANG BASIN		Affected Barangays in Baguio City, Benguet											
		Padre Zamora	Palma-Ur-bano	Phil-Am	Pinget	Pinsao Pilot Proj-ect	Pinsao Proper	Poliwes	Pucsusan	Quezon Hill Prop-er	Quezon Hill, Up-per	Quirino Hill, East	Quirino Hill, Low-er
Affected Area (sq. km.)	0-0.20	0.031	0.077	0.034	0.36	0.094	2.18	0.063	0.15	0.17	0.32	0.055	0.034
	0.21-0.50	0.0054	0.00029	0.0043	0.014	0.0019	0.092	0.0024	0.0091	0.019	0.021	0.0029	0.0028
	0.51-1.00	0.0093	0	0.0026	0.0055	0.0009	0.038	0.0003	0.0028	0.015	0.007	0.0041	0.0021
	1.01-2.00	0.025	0	0.0022	0.0054	0.0013	0.019	0	0.0001	0.007	0.0013	0.0045	0.0003
	2.01-5.00	0.024	0	0	0.0059	0.001	0.0064	0	0	0	0.0005	0.0077	0.0008
	> 5.00	0	0	0	0.0037	0.00014	0.0024	0	0	0	0	0	0

Table 41. Affected areas in Baguio City, Benguet during a 5-year rainfall return period - H

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City, Benguet											
		Quirino Hill, Middle	Quirino-Magsaysay, Upper	Rizal Monument Area	Rock Quarry, Lower	Rock Quarry, Middle	Rock Quarry, Upper	Saint Joseph Village	Salud Mitra	San Antonio Village	San Luis Village	San Roque Village	San Vicente
Affected Area (sq. km.)	0-0.20	0.058	0.1	0.074	0.037	0.059	0.065	0.65	0.15	0.13	0.62	0.057	0.2
	0.21-0.50	0.0092	0.003	0.0027	0.0026	0.003	0.011	0.03	0.0048	0.0031	0.022	0.0019	0.0088
	0.51-1.00	0.0029	0.0026	0.0011	0.0011	0.00033	0.00076	0.022	0.000093	0.0003	0.008	0	0.0041
	1.01-2.00	0.0009	0.0056	0	0	0.000014	0	0.01	0	0	0.0054	0	0.0036
	2.01-5.00	0.0002	0.019	0	0	0	0	0.0031	0	0	0.0002	0	0.0027
	> 5.00	0	0.0048	0	0	0	0	0	0	0	0	0	0

Table 42. Affected areas in Baguio City, Benguet during a 5-year rainfall return period - I

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City, Benguet											
		Sanitary Camp, North	Sanitary Camp, South	Santa Escolas-tica	Santo Rosario	Santo Tomas Proper	Session Road Area	Slaughter House Area	Slu-Svp Housing Village	South Drive	Teodora Alonzo	Tranco-ville	Victoria Village
Affected Area (sq. km.)	0-0.20	0.15	0.085	0.08	0.2	0.22	0.21	0.025	0.21	0.34	0.058	0.23	0.19
	0.21-0.50	0.0029	0.006	0.0037	0.0083	0.0074	0.006	0.00038	0.0035	0.034	0.0053	0.011	0.012
	0.51-1.00	0.00046	0.0013	0.0016	0.0011	0.0024	0.013	0.00063	0.0017	0.015	0.0026	0.0072	0.0013
	1.01-2.00	0	0	0.0026	0.00029	0.0005	0.0081	0.0016	0.0032	0.0086	0.0071	0.0081	0.0008
	2.01-5.00	0	0	0.0002	0	0	0	0.0041	0.0015	0.004	0.0032	0.0041	0.0001
	> 5.00	0	0	0	0	0	0	0	0	0	0	0.00059	0

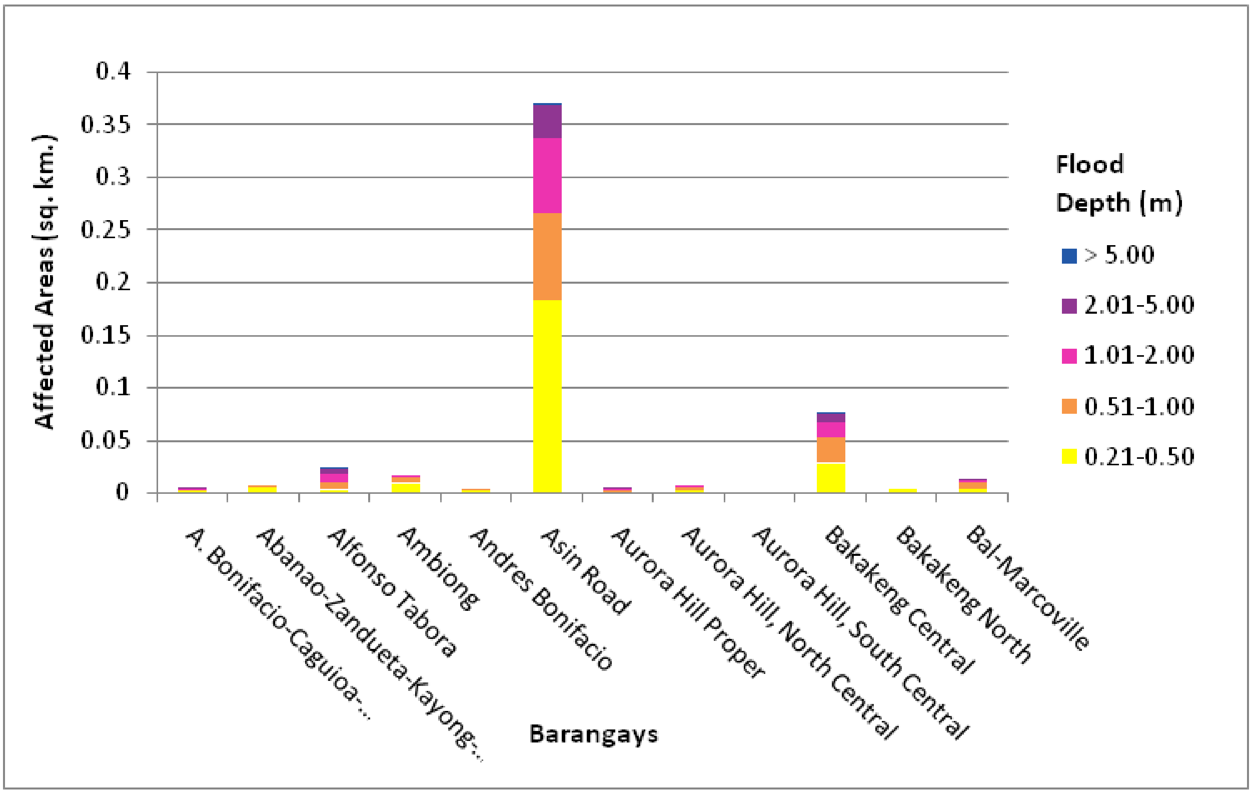


Figure 75. Affected areas in Baguio City, Benguet during a 5-year rainfall return period - A

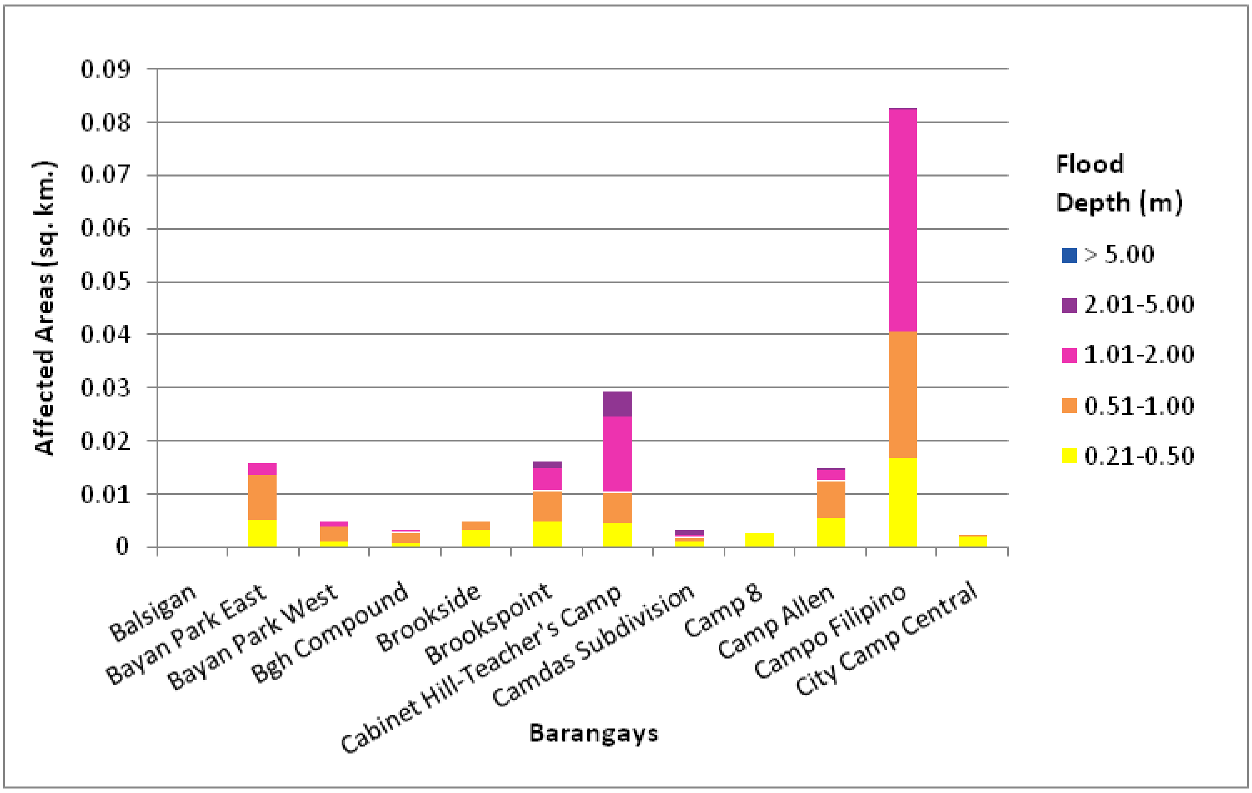


Figure 76. Affected areas in Baguio City, Benguet during a 5-year rainfall return period - B

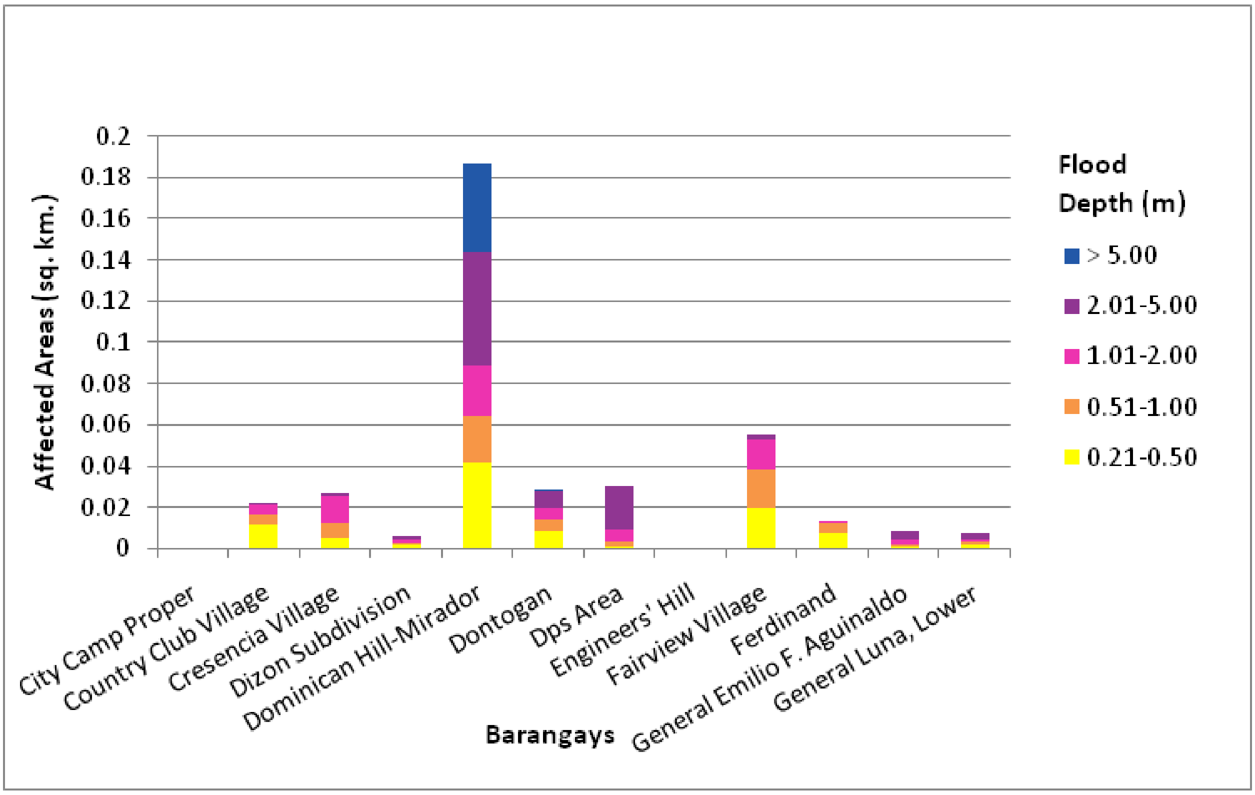


Figure 77. Affected areas in Baguio City, Benguet during a 5-year rainfall return period - C

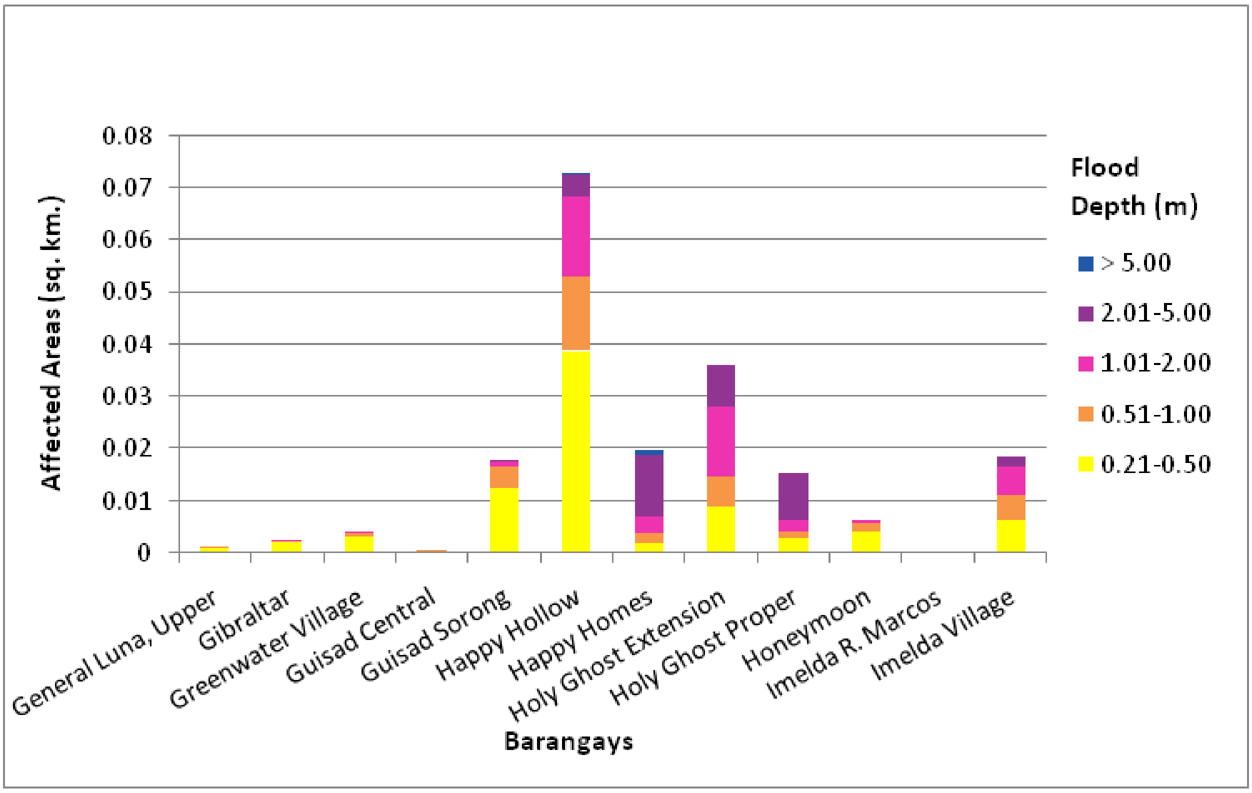


Figure 78. Affected areas in Baguio City, Benguet during a 5-year rainfall return period - D

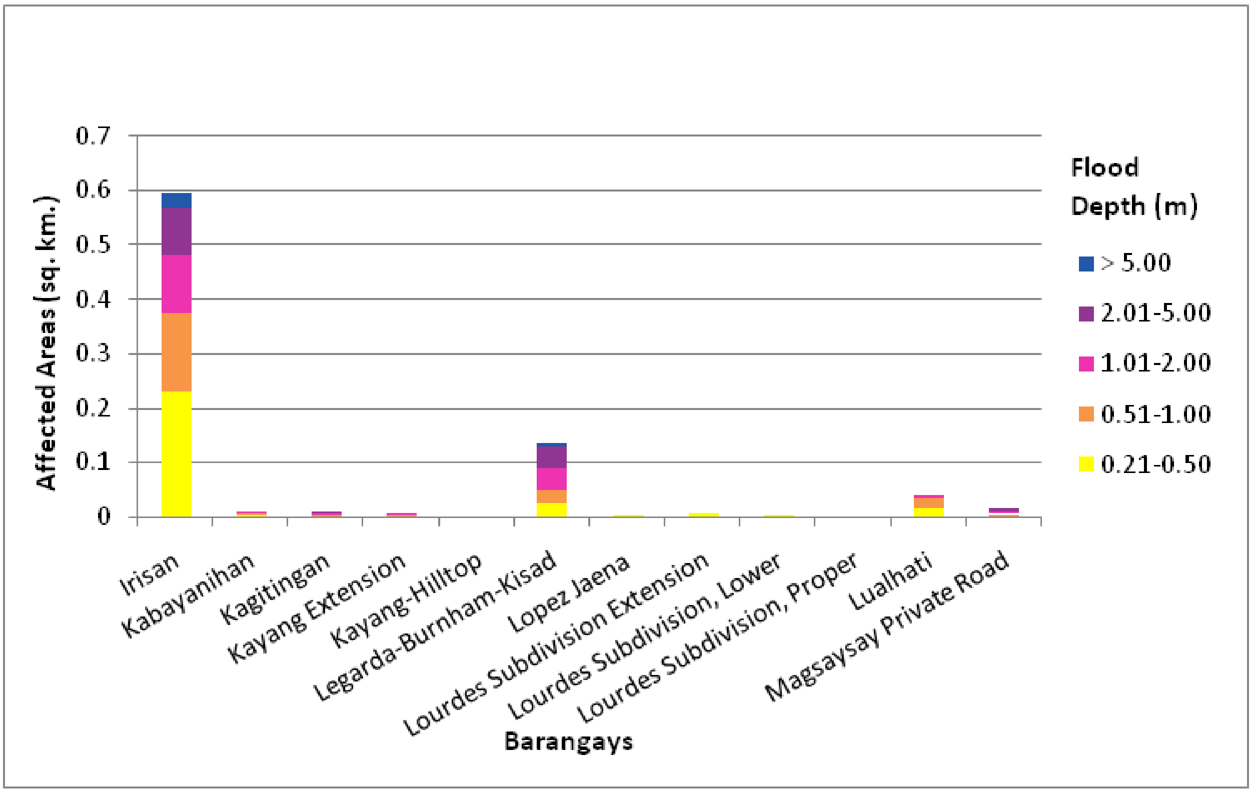


Figure 79. Affected areas in Baguio City, Benguet during a 5-year rainfall return period - E

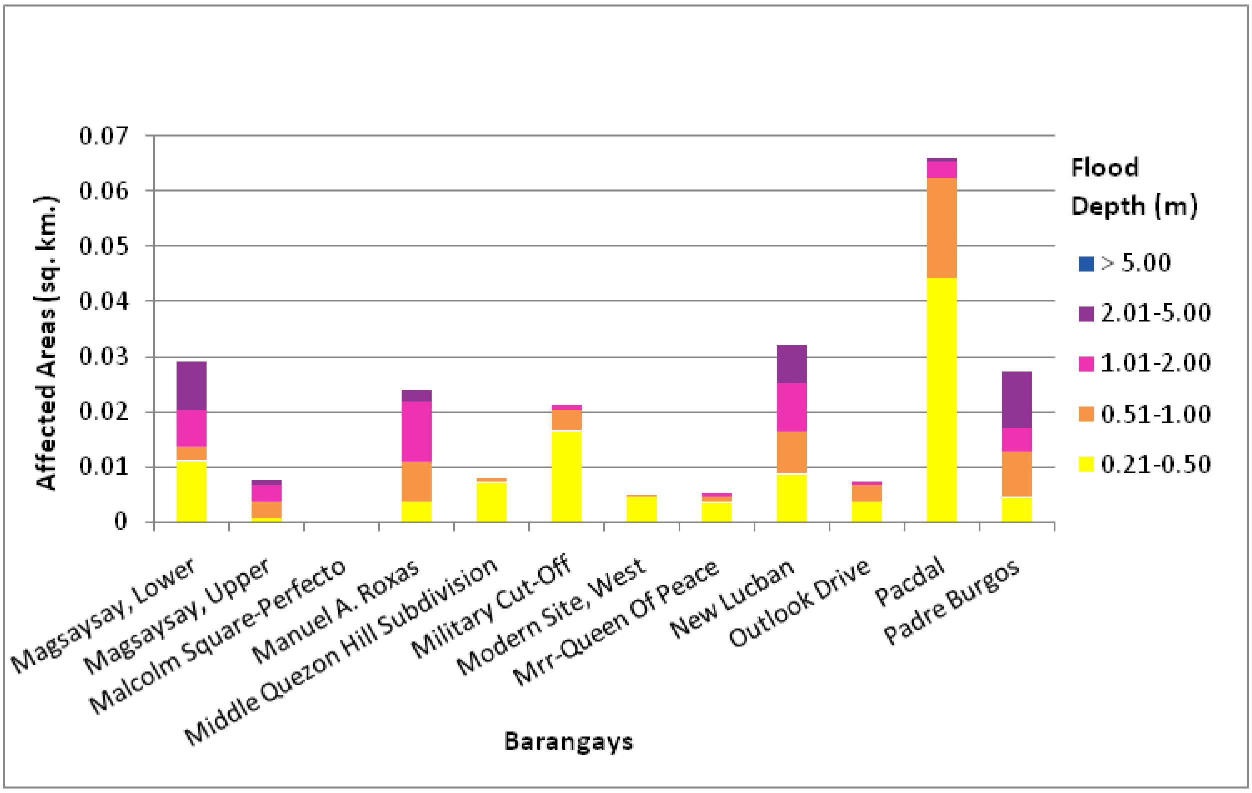


Figure 80. Affected areas in Baguio City, Benguet during a 5-year rainfall return period - F

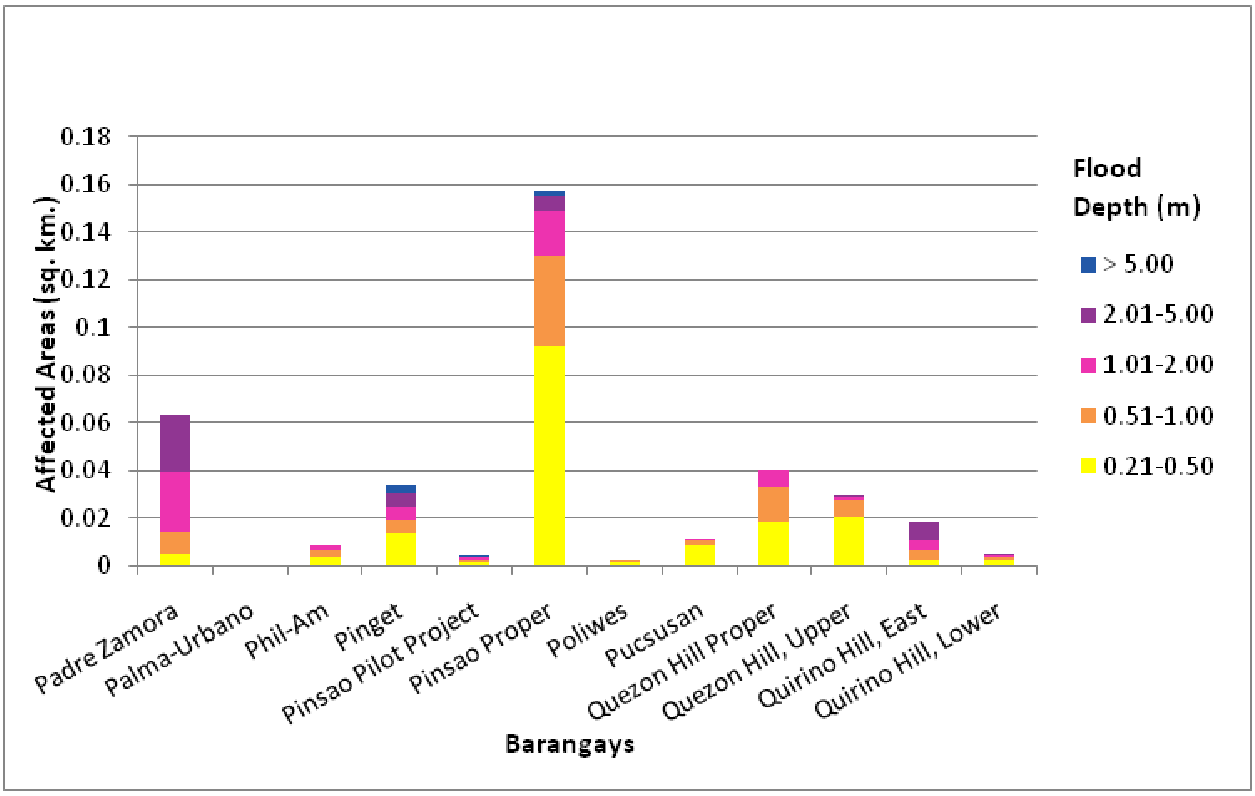


Figure 81. Affected areas in Baguio City, Benguet during a 5-year rainfall return period - G

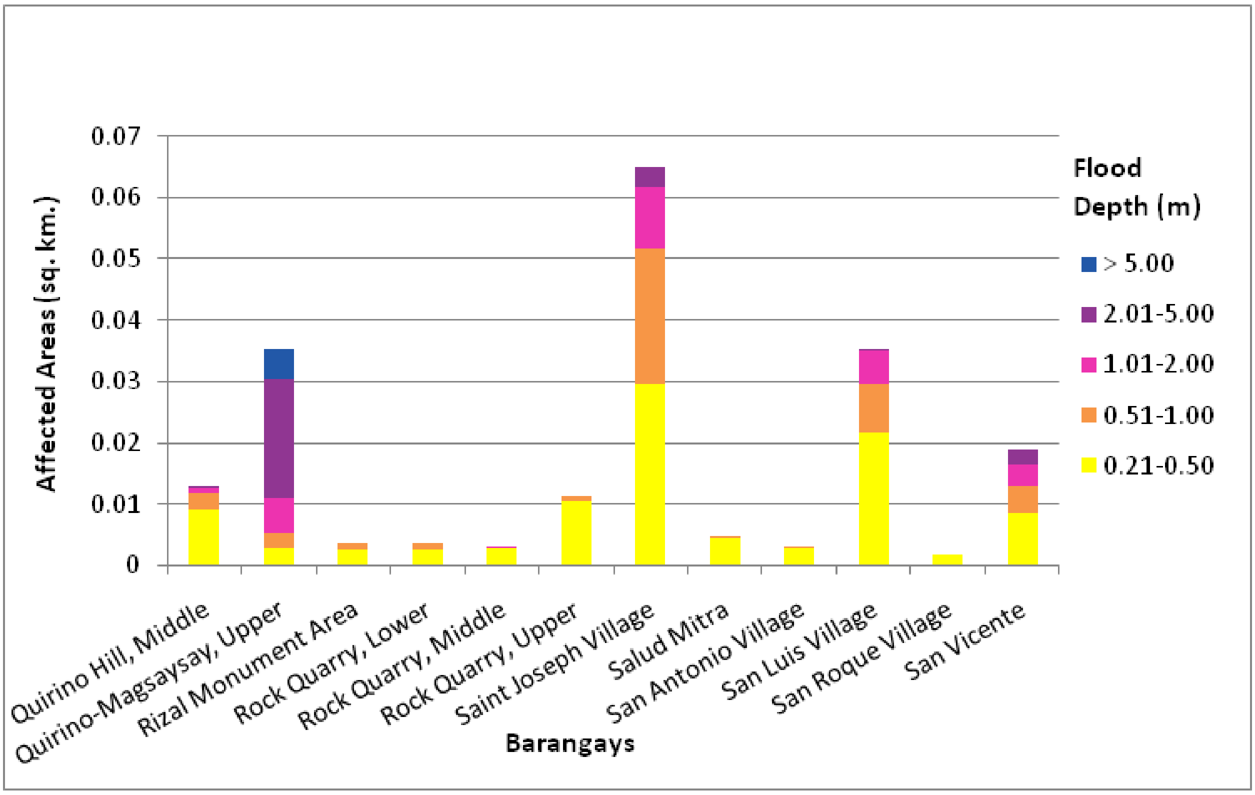


Figure 82. Affected areas in Baguio City, Benguet during a 5-year rainfall return period - H

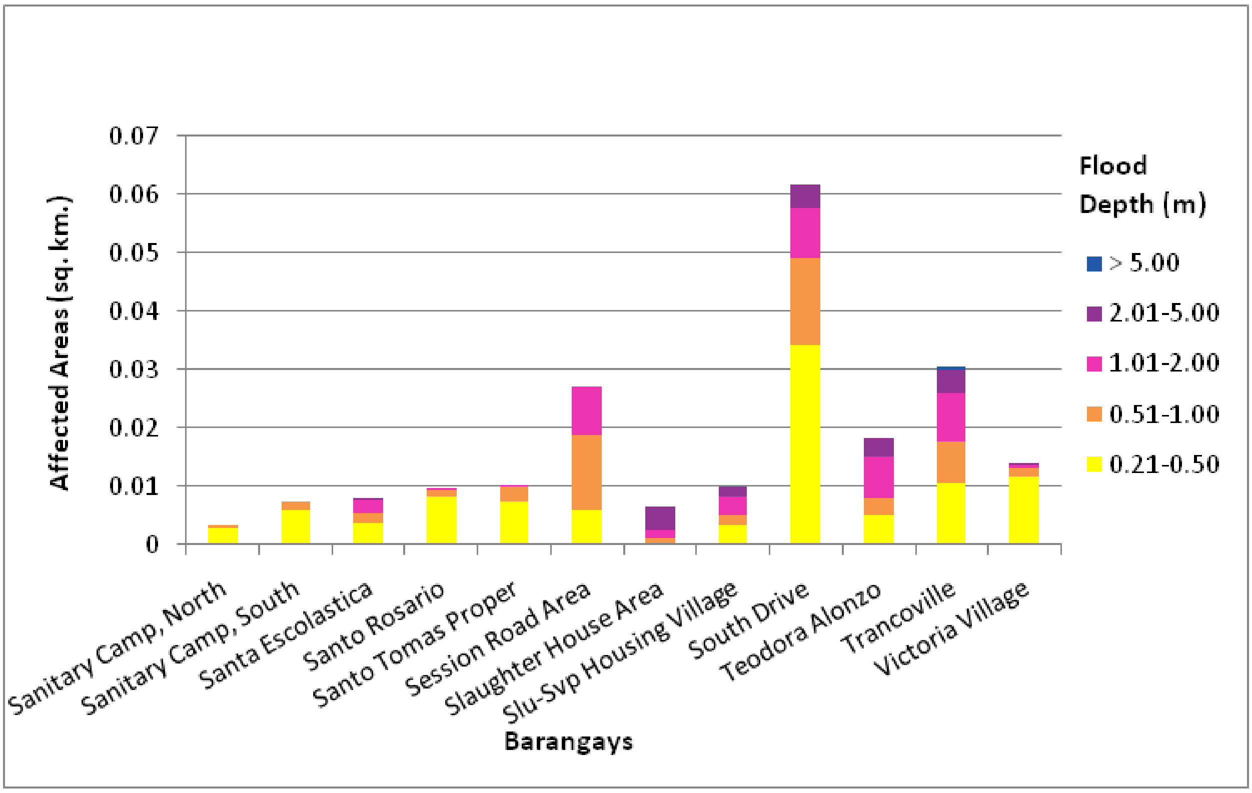


Figure 83. Affected areas in Baguio City, Benguet during a 5-year rainfall return period - I

For the 5-year return period, 31.09% of the Municipality of Kapangan, with an area of 133.9 square kilometers, will experience flood levels of less than 0.20 meters. 0.95% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 0.47%, 0.32%, 0.28%, and 0.19% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 43 are the affected areas, in square kilometers, by flood depth per barangay.

Table 43. Affected areas in Kapangan, Benguet during a 5-year rainfall return period

ARIN-GAY-BAU-ANG BASIN		Affected Barangays in Kapangan, Benguet							
		Datakan	Gadang	Gas-we-ling	Labueg	Paykek	Poblacion Central	Pon-ga-yan	Sagubo
Affected Area (sq. km.)	0-0.20	3.91	0.19	15.45	2.06	0.036	1.88	9.9	8.2
	0.21-0.50	0.12	0.0006	0.32	0.1	0.0013	0.068	0.36	0.3
	0.51-1.00	0.061	0	0.15	0.082	0.000037	0.048	0.17	0.12
	1.01-2.00	0.033	0	0.12	0.062	0.000038	0.05	0.1	0.055
	2.01-5.00	0.053	0	0.12	0.067	0	0.041	0.064	0.027
	> 5.00	0.094	0	0.15	0.013	0	0.00093	0.0011	0.0001

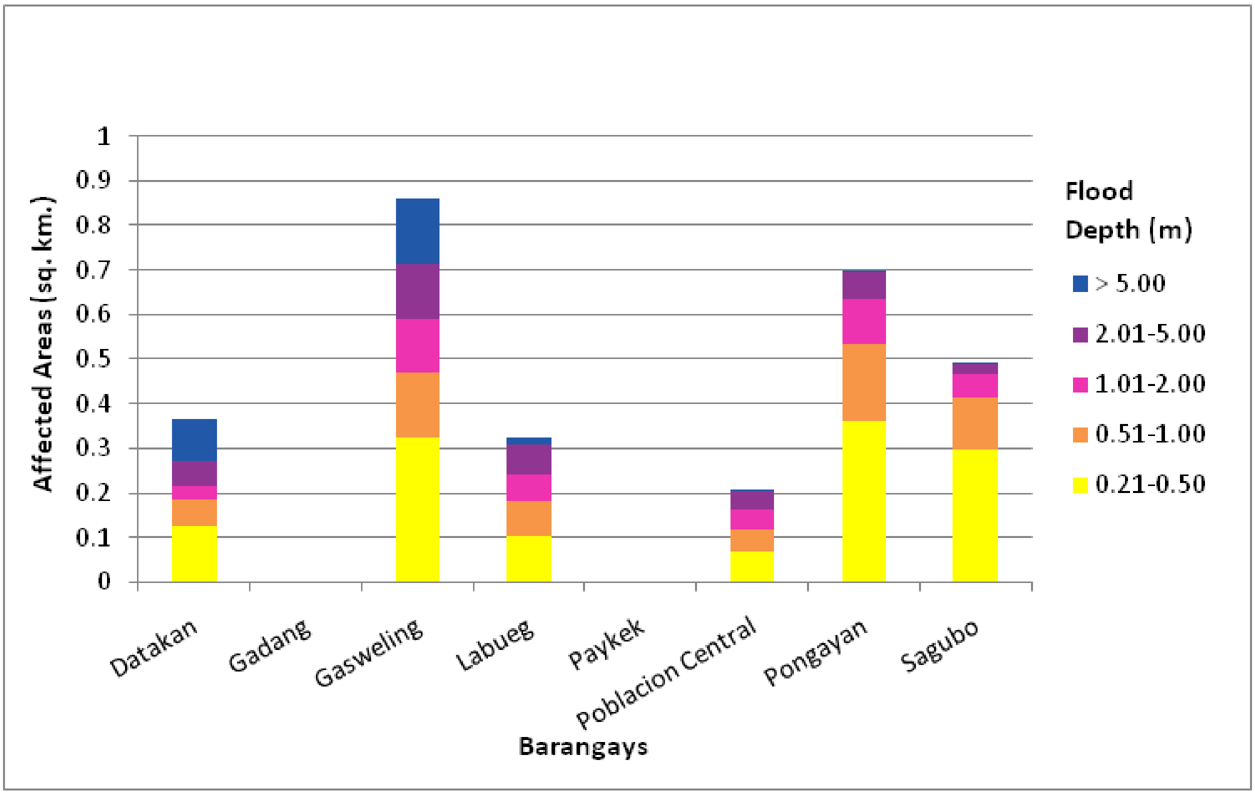


Figure 84. Affected areas in Kapangan, Benguet during a 5-year rainfall return period

For the 5-year return period, 73.97% of the Municipality of La Trinidad, with an area of 74.908 square kilometers, will experience flood levels of less than 0.20 meters. 3.56% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 2.18%, 2.03%, 1.83%, and 0.89% 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 Tables 44-45 are the affected areas, in square kilometers, by flood depth per barangay.

Table 44. Affected areas in La Trinidad, Benguet during a 5-year rainfall return period - A

ARINGAY-BAU-ANG BASIN		Affected Barangays in La Trinidad, Benguet							
		Alapang	Alno	Ambiong	Bahong	Balili	Beckel	Betag	Bineng
Affected Area (sq. km.)	0-0.20	4.11	10.09	1.59	4.54	0.34	1.48	0.21	11.2
	0.21-0.50	0.19	0.33	0.055	0.28	0.11	0.055	0.11	0.43
	0.51-1.00	0.097	0.15	0.039	0.13	0.2	0.019	0.17	0.13
	1.01-2.00	0.096	0.088	0.041	0.072	0.21	0.011	0.47	0.056
	2.01-5.00	0.072	0.14	0.01	0.04	0.11	0.0016	0.59	0.029
	> 5.00	0.0025	0.53	0.0002	0.0021	0.0012	0	0.0044	0.1

Table 45. Affected areas in La Trinidad, Benguet during a 5-year rainfall return period - B

ARINGAY-BAU-ANG BASIN		Affected Barangays in La Trinidad, Benguet							
		Cruz	Lubas	Pico	Poblacion	Puguis	Shilan	Tawang	Wangal
Affected Area (sq. km.)	0-0.20	0.47	1.43	1.11	1.85	3.58	6.69	2.29	4.41
	0.21-0.50	0.0087	0.069	0.36	0.084	0.15	0.2	0.067	0.16
	0.51-1.00	0.00089	0.033	0.31	0.058	0.055	0.12	0.014	0.11
	1.01-2.00	0.0004	0.03	0.2	0.071	0.024	0.07	0.01	0.074
	2.01-5.00	0	0.02	0.14	0.096	0.0065	0.041	0.0031	0.069
	> 5.00	0	0.0005	0.0067	0	0	0.0071	0.0001	0.009

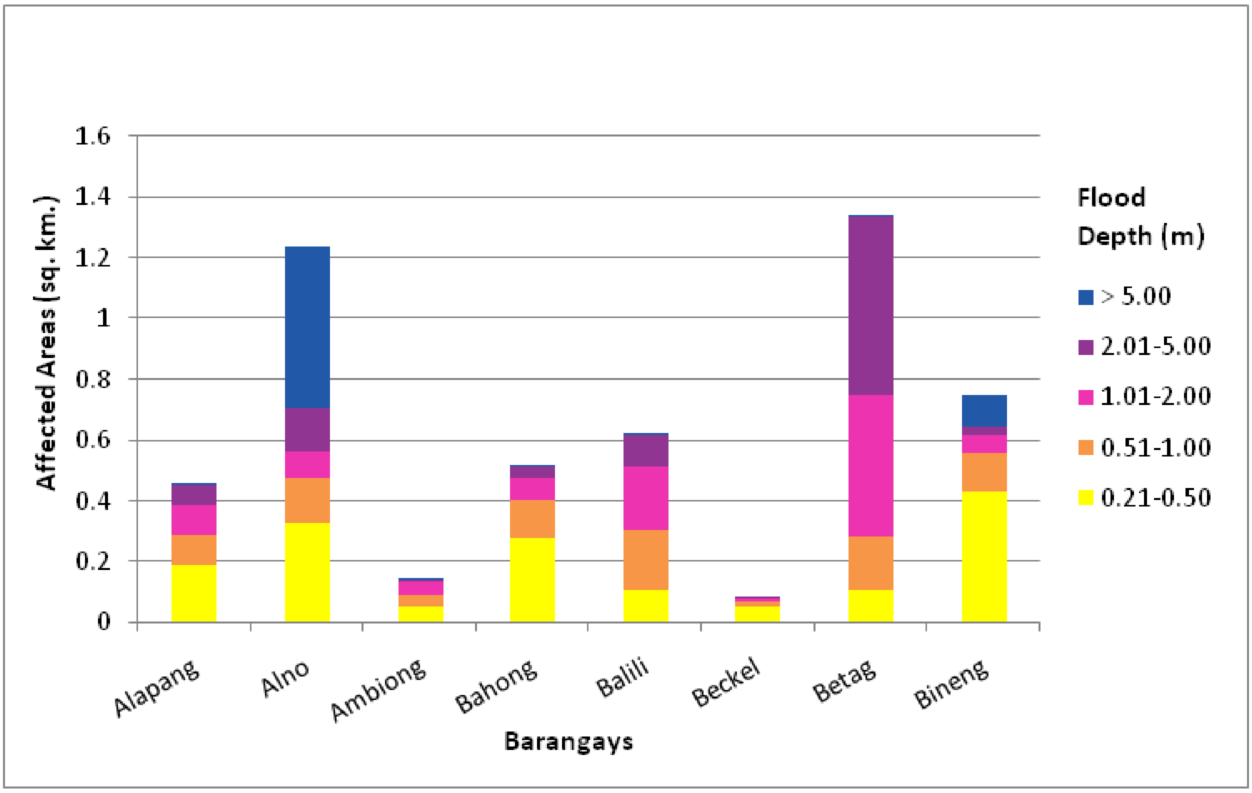


Figure 85. Affected areas in La Trinidad, Benguet during a 5-year rainfall return period - A

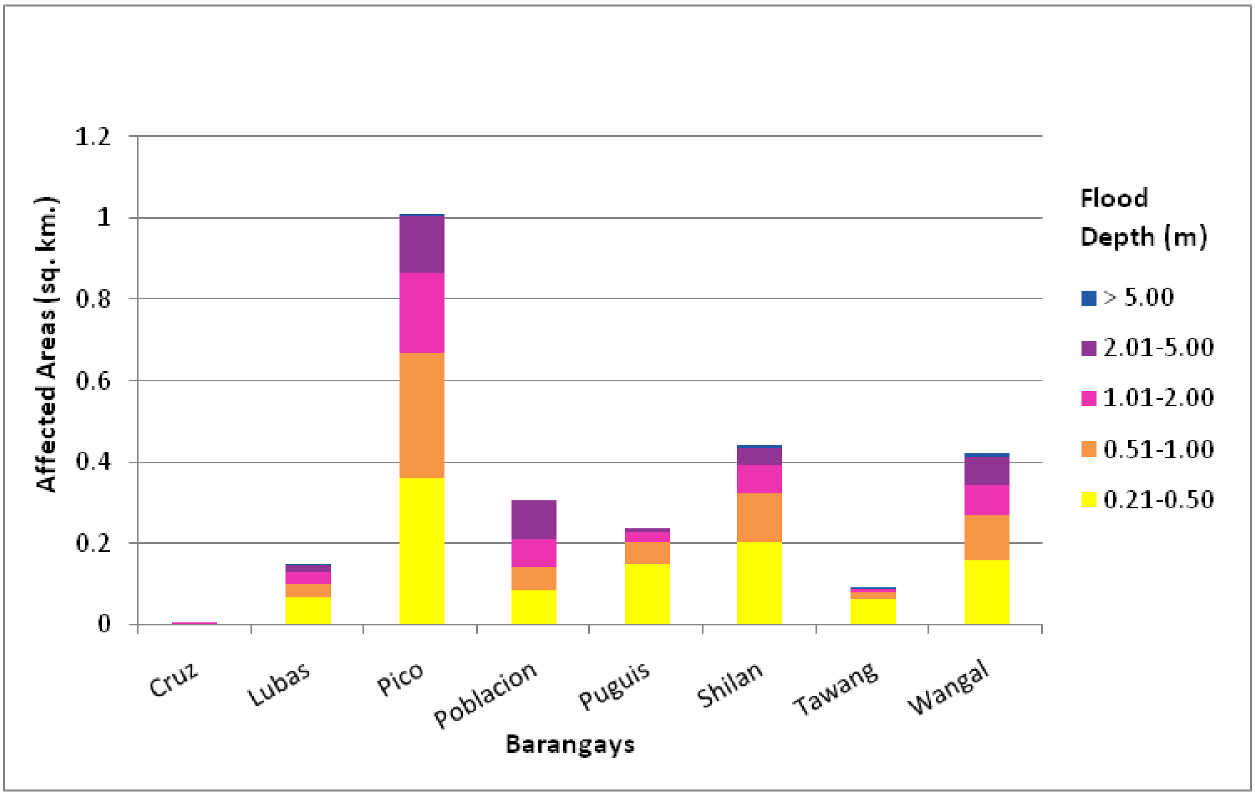


Figure 86. Affected areas in La Trinidad, Benguet during a 5-year rainfall return period - B

For the 5-year return period, 93.11% of the Municipality of Sablan, with an area of 90.22 square kilometers, will experience flood levels of less than 0.20 meters. 2.68% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 1.36%, 0.90%, 0.71%, and 1.24% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table

46 are the affected areas, in square kilometers, by flood depth per barangay.

Table 46. Affected areas in Sablan, Benguet during a 5-year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in Sablan							
		Bagong	Balluay	Banangan	Baneng-beng	Bayabas	Kamog	Pappa	Poblacion
Affected Area (sq. km.)	0-0.20	5	8.66	17.83	13.08	12.79	10.91	10.45	5.3
	0.21-0.50	0.083	0.29	0.5	0.39	0.43	0.26	0.28	0.18
	0.51-1.00	0.04	0.16	0.25	0.18	0.2	0.15	0.16	0.095
	1.01-2.00	0.038	0.077	0.19	0.1	0.12	0.096	0.11	0.074
	2.01-5.00	0.078	0.035	0.14	0.13	0.068	0.032	0.12	0.031
	> 5.00	0.71	0.08	0.013	0.27	0.012	0.034	0.0048	0

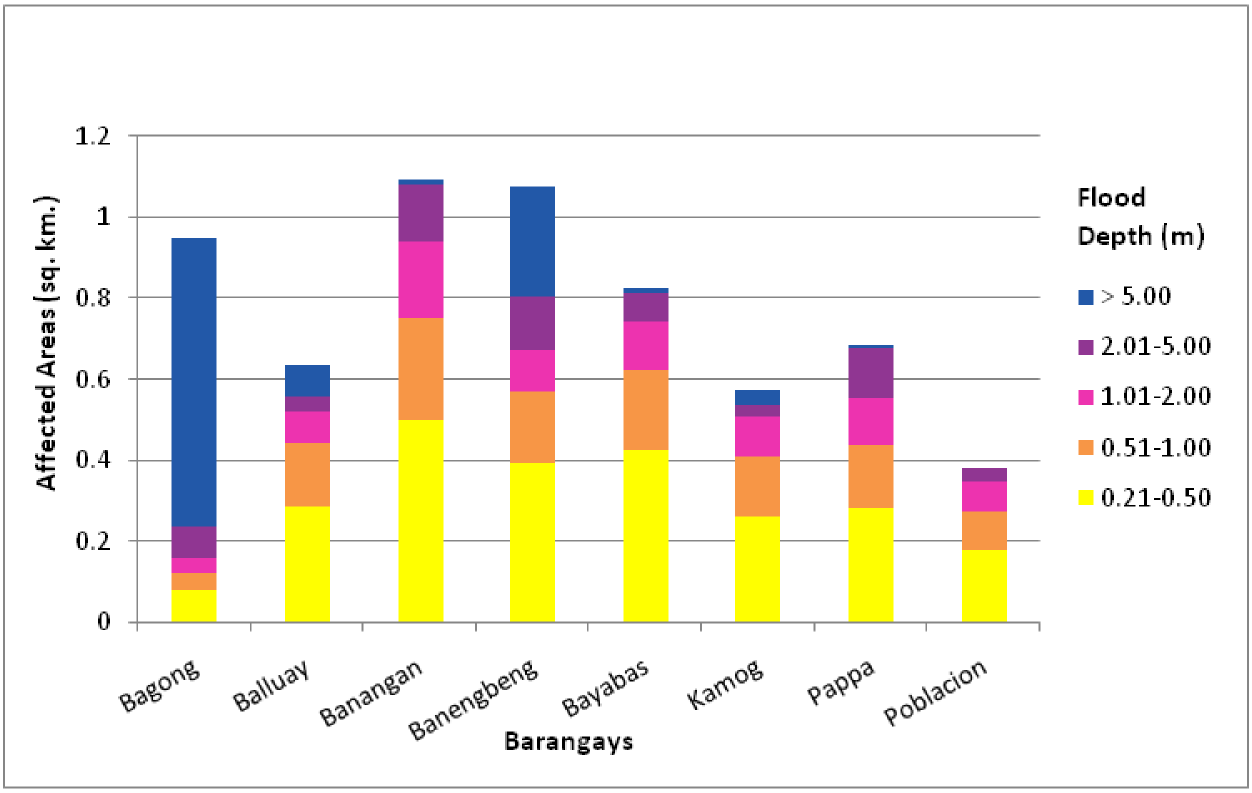


Figure 87. Affected areas in Sablan, Benguet during a 5-year rainfall return period

For the 5-year return period, 39.63% of the Municipality of Tuba, with an area of 322.02 square kilometers, will experience flood levels of less than 0.20 meters. 1.39% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 0.60%, 0.36%, 0.43%, and 0.32% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 47 are the affected areas, in square kilometers, by flood depth per barangay.

Table 47. Affected areas in Tuba, Benguet during a 5-year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in Tuba									
		Nangalisan	Poblacion	San Pascual	Tabaan Norte	Tabaan Sur	Tadiangan	Taloy Norte	Taloy Sur	Twin Peaks
Affected Area (sq. km.)	0-0.20	10.95	20.69	6.44	16.95	23.47	12.08	14.8	19.58	2.66
	0.21-0.50	0.41	0.85	0.2	0.55	0.83	0.45	0.48	0.6	0.11
	0.51-1.00	0.21	0.36	0.097	0.18	0.37	0.21	0.21	0.26	0.027
	1.01-2.00	0.17	0.18	0.085	0.098	0.19	0.14	0.12	0.17	0.0011
	2.01-5.00	0.29	0.25	0.057	0.1	0.26	0.16	0.11	0.18	0.0003
	> 5.00	0.5	0.032	0.007	0.13	0.15	0.11	0.045	0.062	0

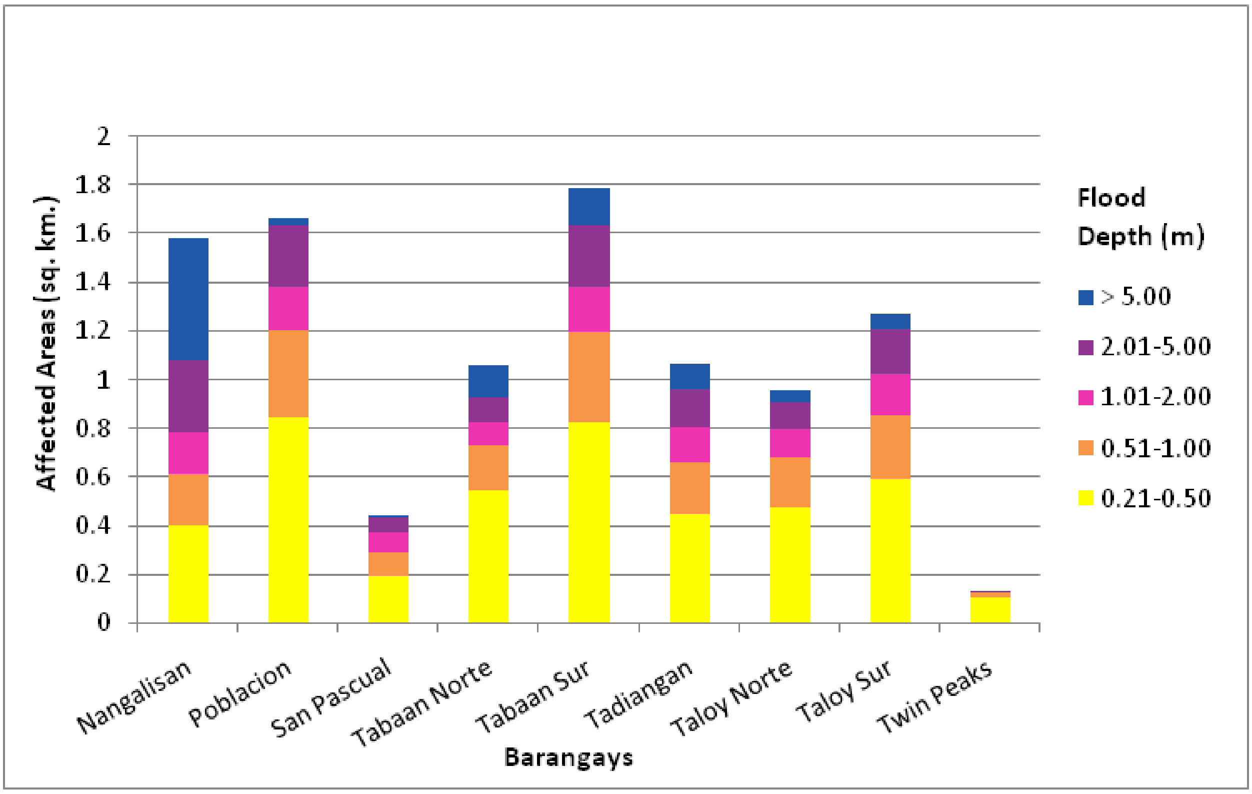


Figure 88. Affected areas in Tuba, Benguet during a 5-year rainfall return period

For the 5-year return period, 51.58% of the Municipality of Tublay, with an area of 63.21 square kilometers, will experience flood levels of less than 0.20 meters. 1.90% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 0.88%, 0.59%, 0.44%, 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 48 are the affected areas, in square kilometers, by flood depth per barangay.

Table 48. Affected areas in Tublay, Benguet during a 5-year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in Tublay							
		Ambassa-dor	Ambong-dolan	Ba-Ayan	Basil	Caponga	Daclan	Tublay Central	Tuel
Affected Area (sq. km.)	0-0.20	0.023	3.74	2.05	3.89	2.96	4.95	3.56	11.43
	0.21-0.50	0.0001	0.13	0.065	0.13	0.17	0.16	0.15	0.39
	0.51-1.00	0	0.08	0.019	0.05	0.064	0.072	0.11	0.17
	1.01-2.00	0	0.076	0.0097	0.03	0.028	0.032	0.083	0.11
	2.01-5.00	0	0.017	0.0004	0.05	0.0035	0.0022	0.083	0.13
	> 5.00	0	0.014	0	0.089	0	0	0.012	0.096

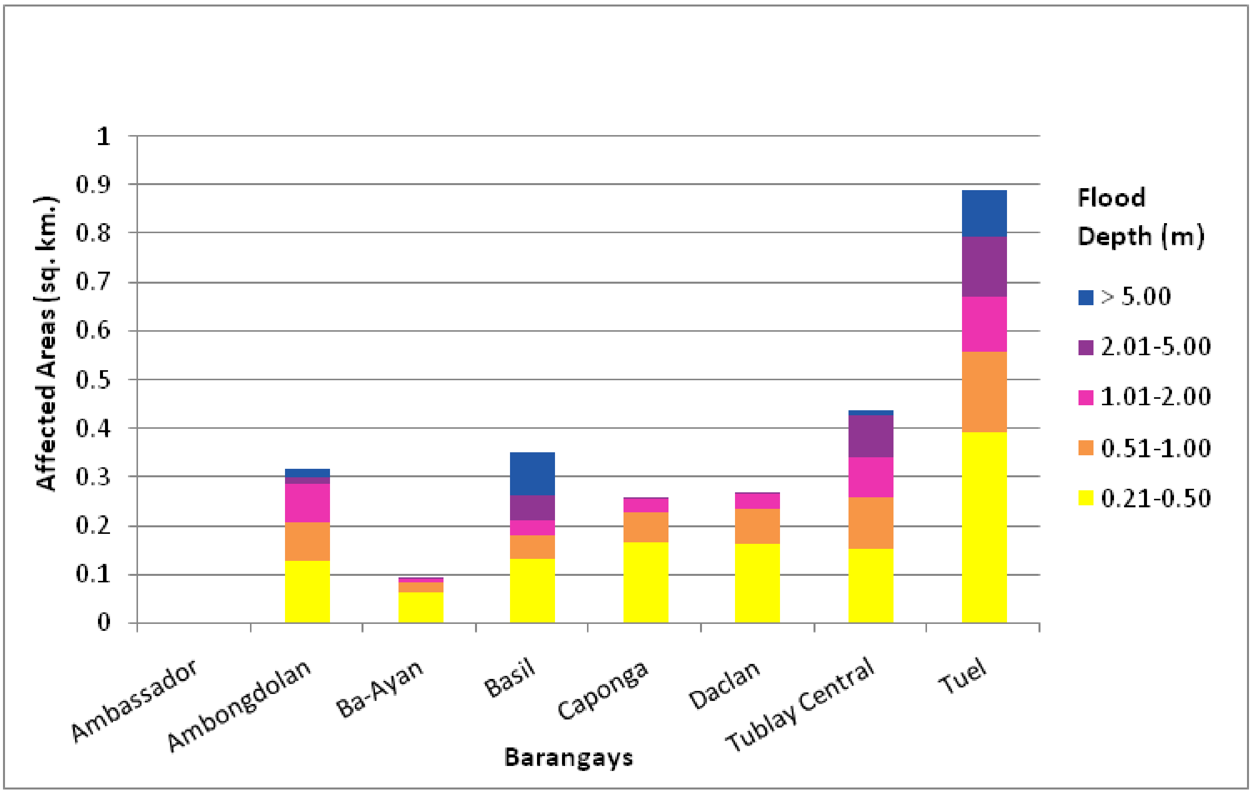


Figure 89. Affected areas in Tublay, Benguet during a 5-year rainfall return period

For the 5-year return period, 6.53% of the Municipality of Agoo, with an area of 33.71 square kilometers, will experience flood levels of less than 0.20 meters. 0.48% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 0.38%, 0.23%, and 0.15% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and 2.01 to 5 meters, respectively. Listed in Table 49 are the affected areas, in square kilometers, by flood depth per barangay.

Table 49. Affected areas in Agoo, La Union during a 5-year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in Agoo					
		Macalva Norte	Nazareno	Santa Ana	Santa Rita	Santa Rita East	Santa Rita Norte
Affected Area (sq. km.)	0-0.20	1.55	0.016	0.54	0.031	0.012	0.058
	0.21-0.50	0.071	0.0002	0.038	0.019	0.0027	0.029
	0.51-1.00	0.039	0	0.021	0.016	0.0041	0.047
	1.01-2.00	0.028	0	0.027	0.0025	0.0046	0.015
	2.01-5.00	0.0067	0	0.033	0	0.0045	0.0062
	> 5.00	0	0	0.0001	0	0	0

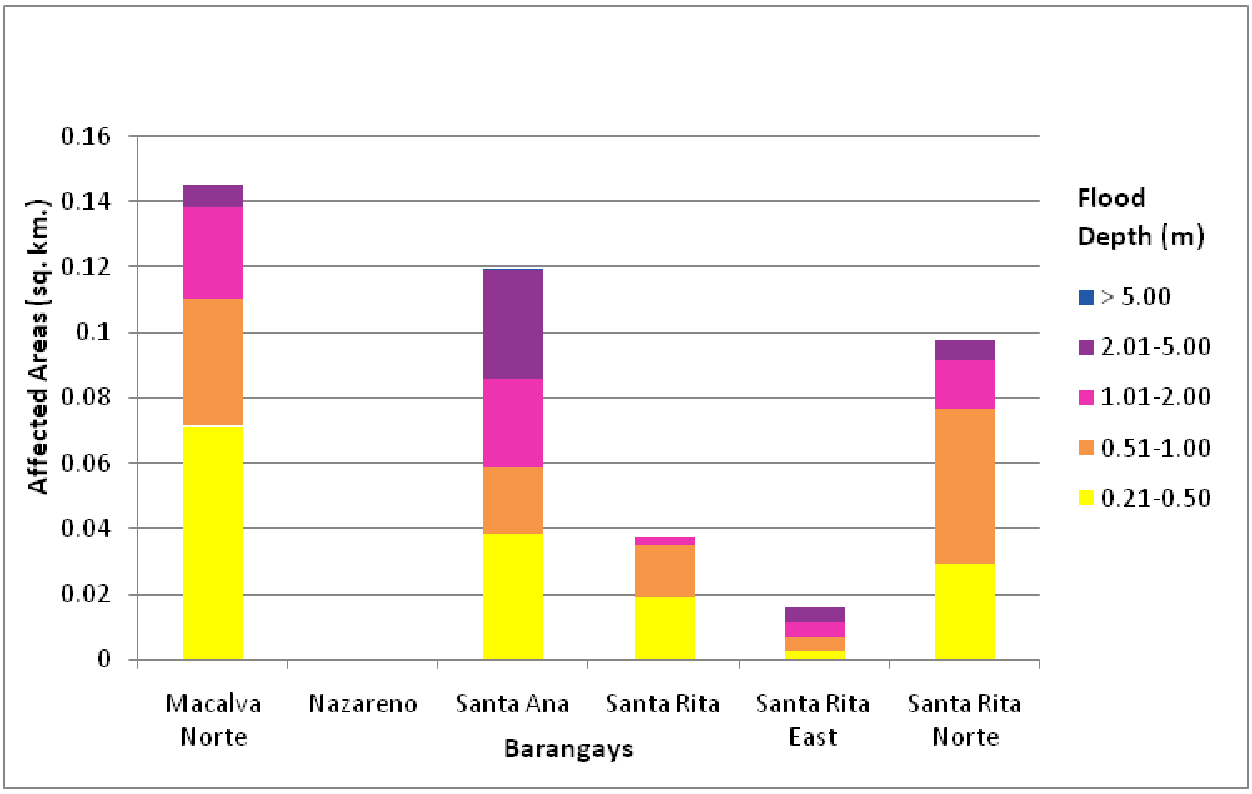


Figure 90. Affected areas in Agoo, La Union during a 5-year rainfall return period

For the 5-year return period, 68.77% of the Municipality of Aringay, with an area of 95.65 square kilometers, will experience flood levels of less than 0.20 meters. 4.18% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 3.70%, 7.66%, 7.90%, and 7.43% 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 Tables 50-51 are the affected areas, in square kilometers, by flood depth per barangay.

Table 50. Affected areas in Aringay, La Union during a 5-year rainfall return period - A

ARINGAY-BAUANG BASIN		Affected Barangays in Aringay											
		Alaska	Basca	Dulao	Gallano	Maca-ba-to	Manga	Pan-gao-Aoan East	Pan-gao-Aoan West	Pobla-ci-on	Samara	San An-tonio	San Beni-to Norte
Affected Area (sq. km.)	0-0.20	0.45	5.9	0.92	22.74	5.68	7.58	2.11	1.56	0.65	0.063	0.78	1.77
	0.21-0.50	0.089	0.24	0.56	0.84	0.2	0.26	0.1	0.14	0.025	0.12	0.12	0.14
	0.51-1.00	0.11	0.15	0.75	0.42	0.12	0.16	0.066	0.082	0.015	0.63	0.17	0.031
	1.01-2.00	0.84	0.1	1.22	0.25	0.11	0.11	0.094	0.11	0.03	2.05	0.25	0.028
	2.01-5.00	0.5	0.11	0.019	0.37	0.14	0.053	0.47	0.053	0.079	1.21	0.93	0.014
	> 5.00	0	0.12	0	1.49	0.0082	0.0005	1.37	0	0.44	0.04	0.85	0

Table 51. Affected areas in Aringay, La Union during a 5-year rainfall return period- B

ARINGAY-BAUANG BASIN		Affected Barangays in Aringay											
		San Beni-to Sur	San Eu-genio	San Juan East	San Juan West	San Simon East	San Simon West	Santa Cecilia	Santa Lucia	Santa Rita East	Santa Rita West	Santo Rosario East	Santo Rosario West
Affected Area (sq. km.)	0-0.20	0.6	5.27	2.19	1.93	1.28	1.68	0.25	0.25	1.63	0.29	0.21	0.0073
	0.21-0.50	0.034	0.25	0.23	0.086	0.064	0.14	0.017	0.13	0.065	0.038	0.093	0.025
	0.51-1.00	0.024	0.11	0.19	0.067	0.032	0.098	0.012	0.2	0.032	0.0071	0.027	0.038
	1.01-2.00	0.039	0.079	0.28	0.1	0.027	0.083	0.02	1.18	0.023	0.0092	0.059	0.23
	2.01-5.00	0.063	0.048	0.34	0.61	0.026	0.054	0.58	0.8	0.0055	0.0031	0.018	1.06
	> 5.00	0.13	0	0.054	0.72	0.096	0.0025	1.52	0.26	0	0	0	0

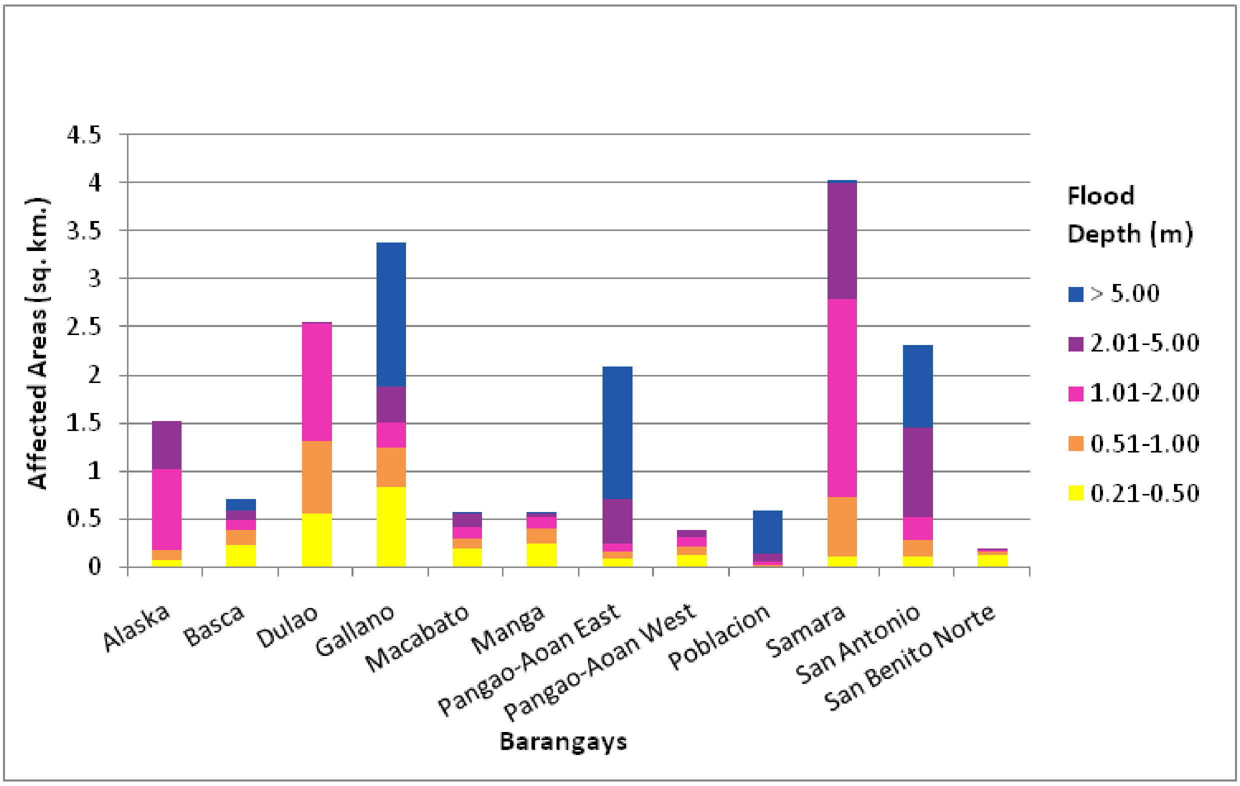


Figure 91. Affected areas in Aringay, La Union during a 5-year rainfall return period - A

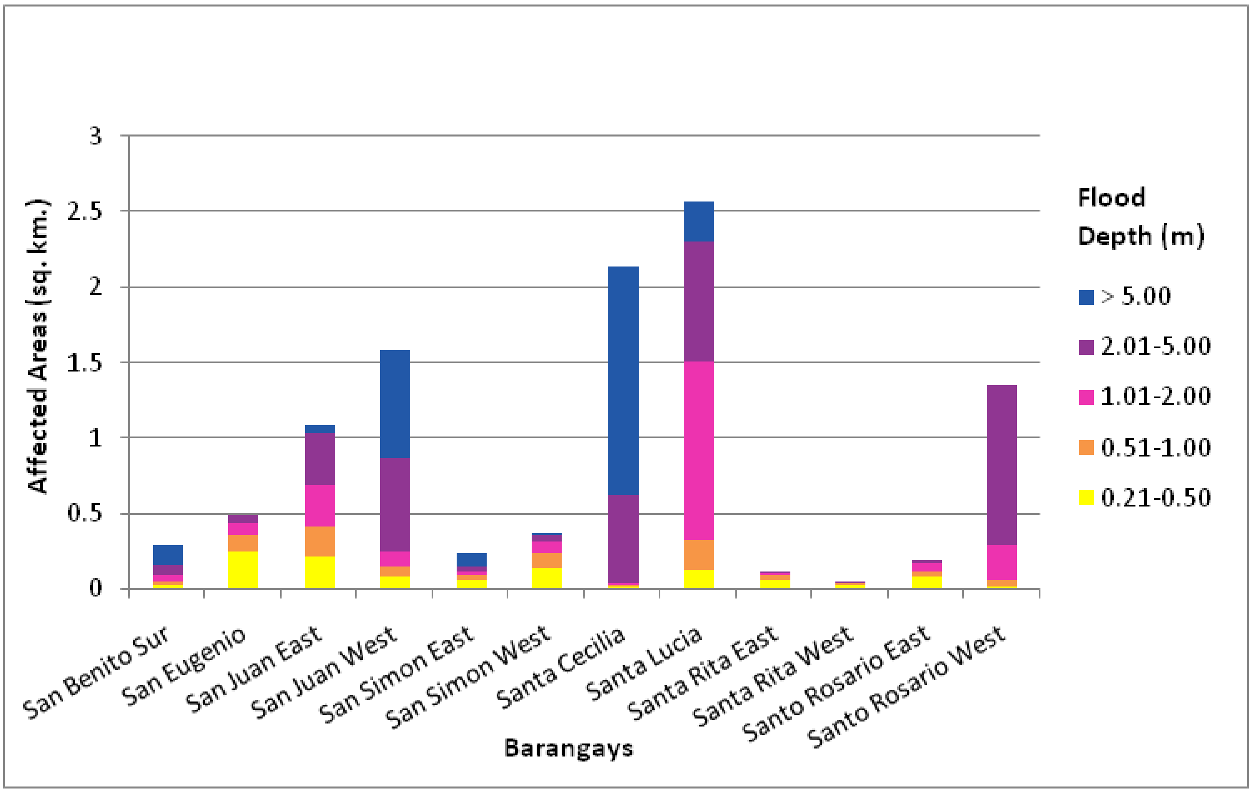


Figure 92. Affected areas in Aringay, La Union during a 5-year rainfall return period - B

For the 5-year return period, 75.19% of the Municipality of Bagulin, with an area of 77.97 square kilometers, will experience flood levels of less than 0.20 meters. 2.28% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 1.10%, 0.69%, 0.85%, and 4.10% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 52 are the affected areas, in square kilometers, by flood depth per barangay.

Table 52. Affected areas in Bagulin, La Union during a 5-year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in Bagulin									
		Alibangsay	Baay	Cambaly	Cardiz	Dagup	Libbo	Suyo	Tagudtud	Tio-Angan	Wallayan
Affected Area (sq. km.)	0-0.20	11.32	1.88	3.15	4.6	5.18	4.83	7.71	2.82	13.64	3.51
	0.21-0.50	0.27	0.056	0.1	0.13	0.2	0.12	0.31	0.11	0.35	0.12
	0.51-1.00	0.15	0.0071	0.064	0.061	0.13	0.037	0.16	0.05	0.14	0.053
	1.01-2.00	0.097	0.0054	0.035	0.022	0.094	0.016	0.094	0.025	0.12	0.032
	2.01-5.00	0.092	0.014	0.016	0.022	0.086	0.028	0.061	0.019	0.28	0.045
	> 5.00	0.85	0.32	0.052	0	0.5	0.082	0.39	0.14	0.3	0.56

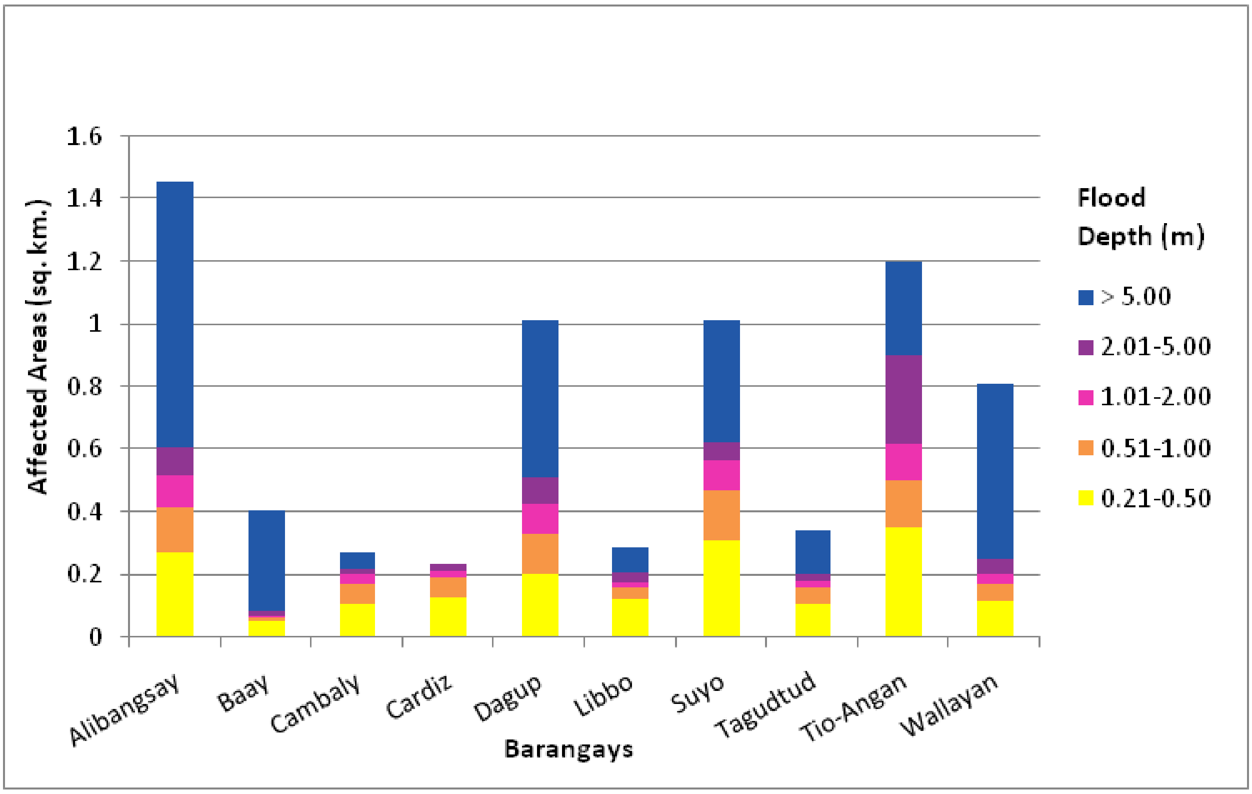


Figure 93. Affected areas in Bagulin, La Union during a 5-year rainfall return period

For the 5-year return period, 64.67% of the Municipality of Bauang, with an area of 85.26 square kilometers, will experience flood levels of less than 0.20 meters. 6.93% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 5.64%, 6.71%, 8.26%, and 6.60% 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 Tables 53-56 are the affected areas, in square kilometers, by flood depth per barangay.

Table 53. Affected areas in Bauang, La Union during a 5-year rainfall return period - A

ARINGAY-BAUANG BASIN		Affected Barangays in Bauang									
		Acao	Baccuit Norte	Baccuit Sur	Bagbag	Ballay	Bawanta	Boy-Utan	Bucayab	Cabalayangan	Cabisilan
Affected Area (sq. km.)	0-0.20	3.09	0.17	0.023	0.57	0.28	0.77	3.36	3.02	4.79	1.82
	0.21-0.50	0.17	0.11	0.075	0.12	0.0058	0.034	0.29	0.14	0.27	0.15
	0.51-1.00	0.15	0.27	0.13	0.084	0.012	0.016	0.15	0.1	0.21	0.058
	1.01-2.00	0.29	0.34	0.17	0.086	0.046	0.0043	0.086	0.14	0.26	0.038
	2.01-5.00	0.65	0.07	0.22	0.039	1.2	0.00056	0.13	0.078	0.53	0.09
	> 5.00	2.93	0	0	0.0004	0.76	0	0.67	0.022	0.56	0.0081

Table 54. Affected areas in Bauang, La Union during a 5-year rainfall return period - B

ARINGAY-BAUANG BASIN		Affected Barangays in Bauang									
		Calumbaya	Carmay	Casilagan	Central East	Central West	Dili	Disso-Or	Guerrero	Lower San Agustin	Nagrebcan
Affected Area (sq. km.)	0-0.20	1.03	0.027	5.97	0.31	0.0068	0.37	0.51	0.52	2.28	0.22
	0.21-0.50	0.2	0.051	0.42	0.021	0.0018	0.052	0.094	0.1	0.11	0.039
	0.51-1.00	0.11	0.096	0.29	0.01	0.0035	0.051	0.045	0.0098	0.059	0.054
	1.01-2.00	0.09	0.045	0.29	0.023	0.015	0.031	0.032	0.0036	0.049	0.028
	2.01-5.00	0.0055	0.084	0.2	0.34	0.23	0.0003	0.016	0.0001	0.11	0.15
	> 5.00	0	0	0.0035	0.21	0.0087	0	0	0	0.011	0.41

Table 55. Affected areas in Bauang, La Union during a 5-year rainfall return period - C

ARINGAY-BAUANG BASIN		Affected Barangays in Bauang									
		Pagdalag-an Sur	Palintu-cang	Palug-si-Lim-mansan-gan	Parian Este	Parian Oeste	Paringao	Payocpoc Norte Este	Payocpoc Norte Oeste	Payocpoc Sur	Pilar
Affected Area (sq. km.)	0-0.20	0	0.49	5.16	0.42	0.13	0.023	1.66	0.66	0.47	0.034
	0.21-0.50	0	0.061	0.31	0.46	0.21	0.042	0.17	0.48	0.15	0.03
	0.51-1.00	0.000003	0.092	0.19	0.32	0.6	0.094	0.13	0.4	0.082	0.014
	1.01-2.00	0	0.053	0.089	0.11	0.8	0.27	0.094	0.26	0.065	0.000094
	2.01-5.00	0	0.044	0.022	0.28	0.13	0.072	0.089	0.0003	0.0021	0
	> 5.00	0	0.0017	0.0002	0.0096	0	0	0	0	0	0

Table 56. Affected areas in Bauang, La Union during a 5-year rainfall return period - D

ARINGAY-BAUANG BASIN		Affected Barangays in Bauang								
		Pottot	Pudoc	Pugo	Quinavite	Santa Monica	Santiago	Taberna	Upper San Agus-tin	Urayong
Affected Area (sq. km.)	0-0.20	0.55	0.066	0.0002	0.56	5.84	1.24	0.01	8.24	0.46
	0.21-0.50	0.15	0.071	0.0033	0.1	0.26	0.2	0.012	0.58	0.16
	0.51-1.00	0.089	0.076	0.043	0.033	0.17	0.083	0.044	0.35	0.071
	1.01-2.00	0.01	0.41	0.6	0.031	0.13	0.041	0.28	0.39	0.025
	2.01-5.00	0	0.38	0.78	0.051	0.048	0.0028	0.85	0.16	0.0001
	> 5.00	0	0	0.01	0	0.0007	0	0	0.0024	0

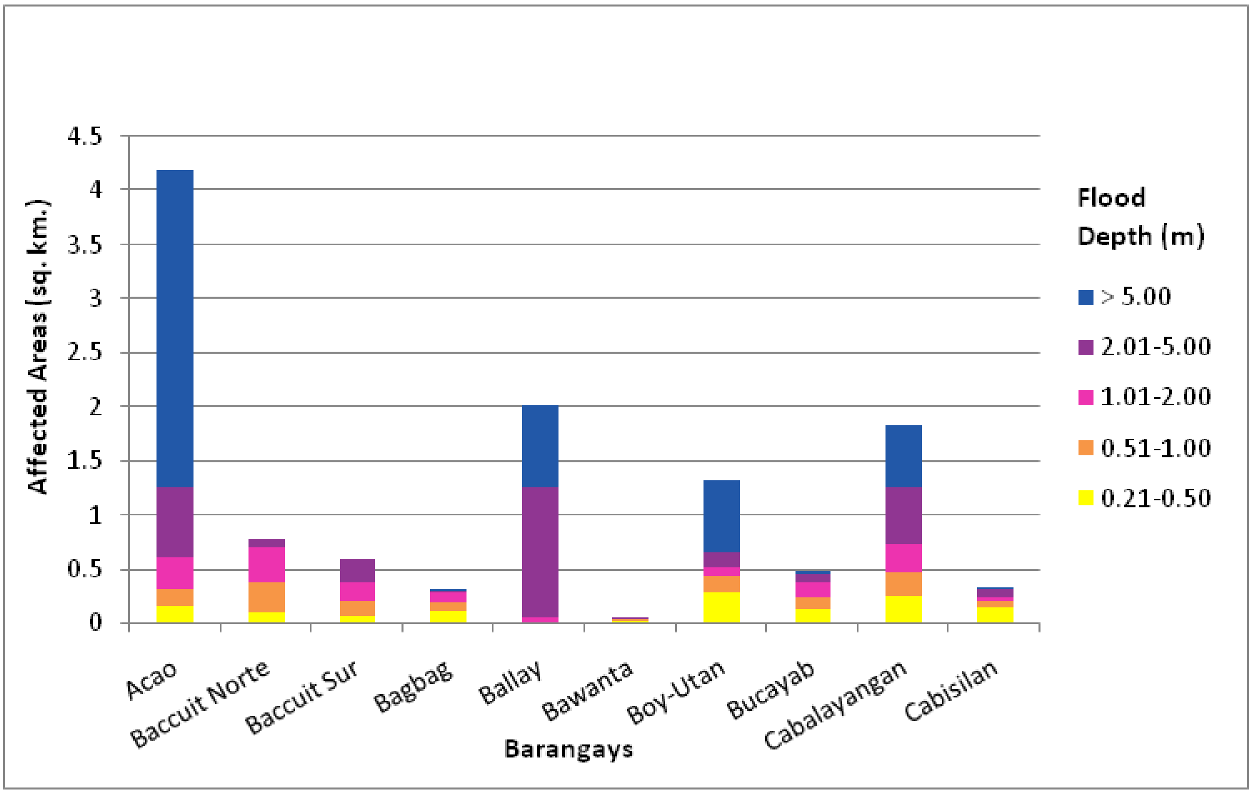


Figure 94. Affected areas in Bauang, La Union during a 5-year rainfall return period - A

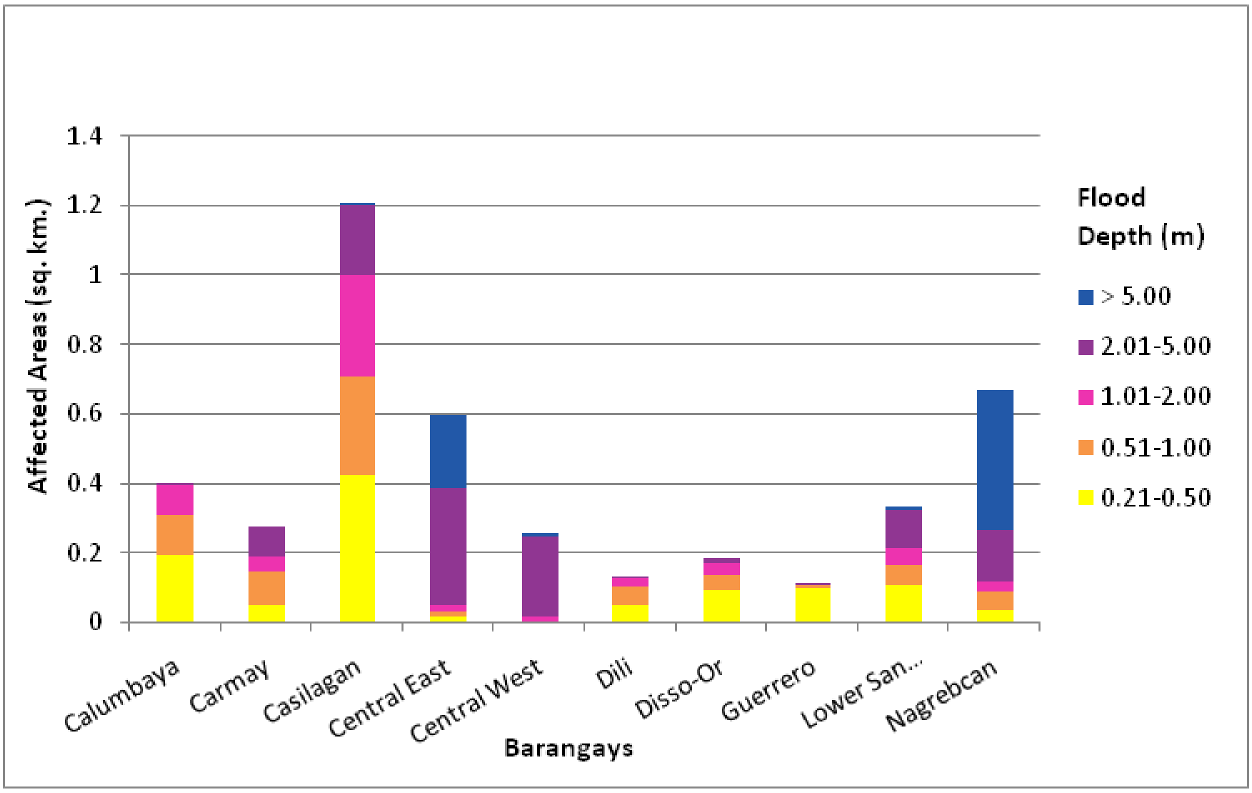


Figure 95. Affected areas in Bauang, La Union during a 5-year rainfall return period - B

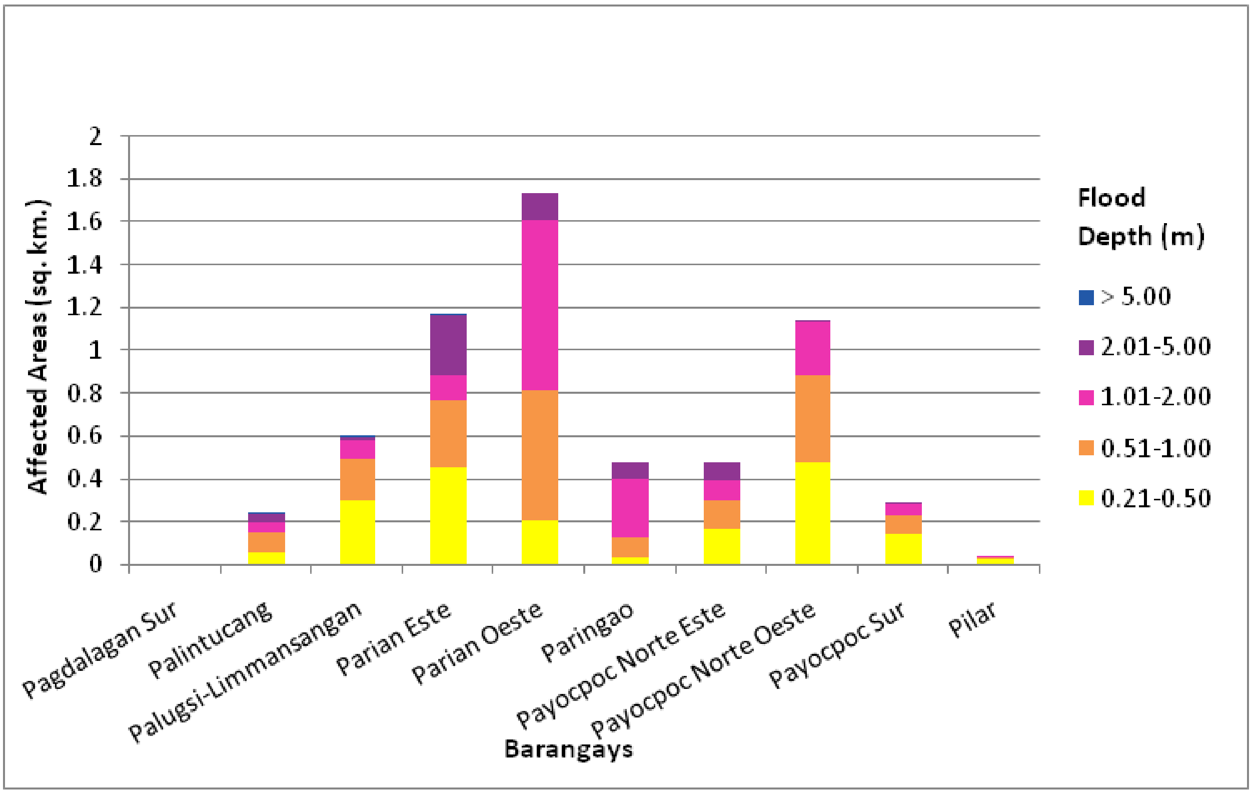


Figure 96. Affected areas in Bauang, La Union during a 5-year rainfall return period - C

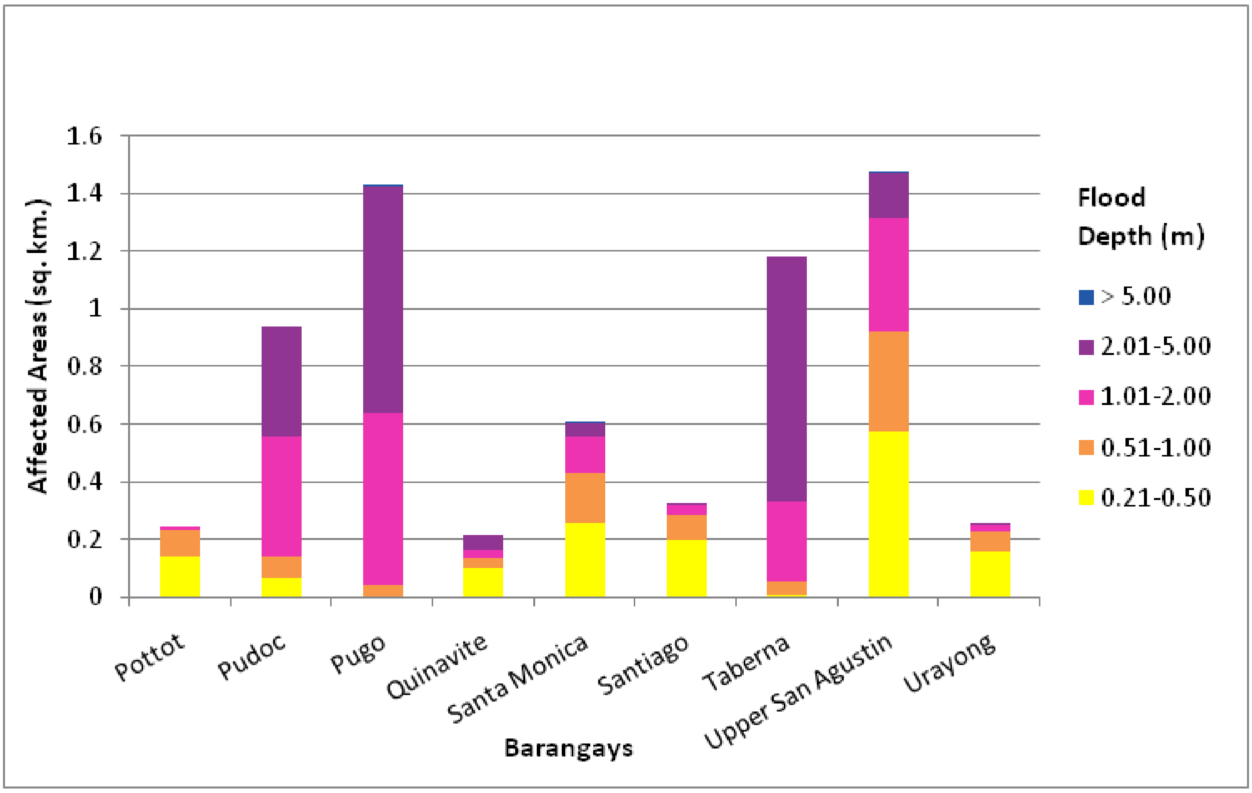


Figure 97. Affected areas in Bauang, La Union during a 5-year rainfall return period - D

For the 5-year return period, 91.67% of the Municipality of Burgos, with an area of 51.92 square kilometers, will experience flood levels of less than 0.20 meters. 2.85% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 1.25%, 0.91%, 1.15%, and 2.18% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 57 are the affected areas, in square kilometers, by flood depth per barangay.

Table 57. Affected areas in Burgos, La Union during a 5-year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in Burgos											
		Agpay	Bilis	Caoayan	Dalacdac	Delles	Imelda	Libtong	Linuan	Lower Tumapoc	New Poblacion	Old Poblacion	Upper Tumapoc
Affected Area (sq. km.)	0-0.20	3.07	4.75	0.38	2.34	11.75	3.95	4.77	4.12	1.09	3.4	1.36	6.61
	0.21-0.50	0.1	0.13	0.011	0.064	0.36	0.14	0.17	0.087	0.035	0.13	0.052	0.2
	0.51-1.00	0.049	0.049	0.011	0.035	0.17	0.074	0.065	0.052	0.016	0.031	0.018	0.078
	1.01-2.00	0.027	0.029	0.006	0.03	0.11	0.056	0.043	0.033	0.021	0.027	0.022	0.073
	2.01-5.00	0.028	0.051	0.01	0.12	0.032	0.055	0.05	0.041	0.045	0.013	0.046	0.11
	> 5.00	0.077	0.022	0.061	0.28	0.0025	0.057	0.033	0.42	0.0044	0.0055	0.065	0.1

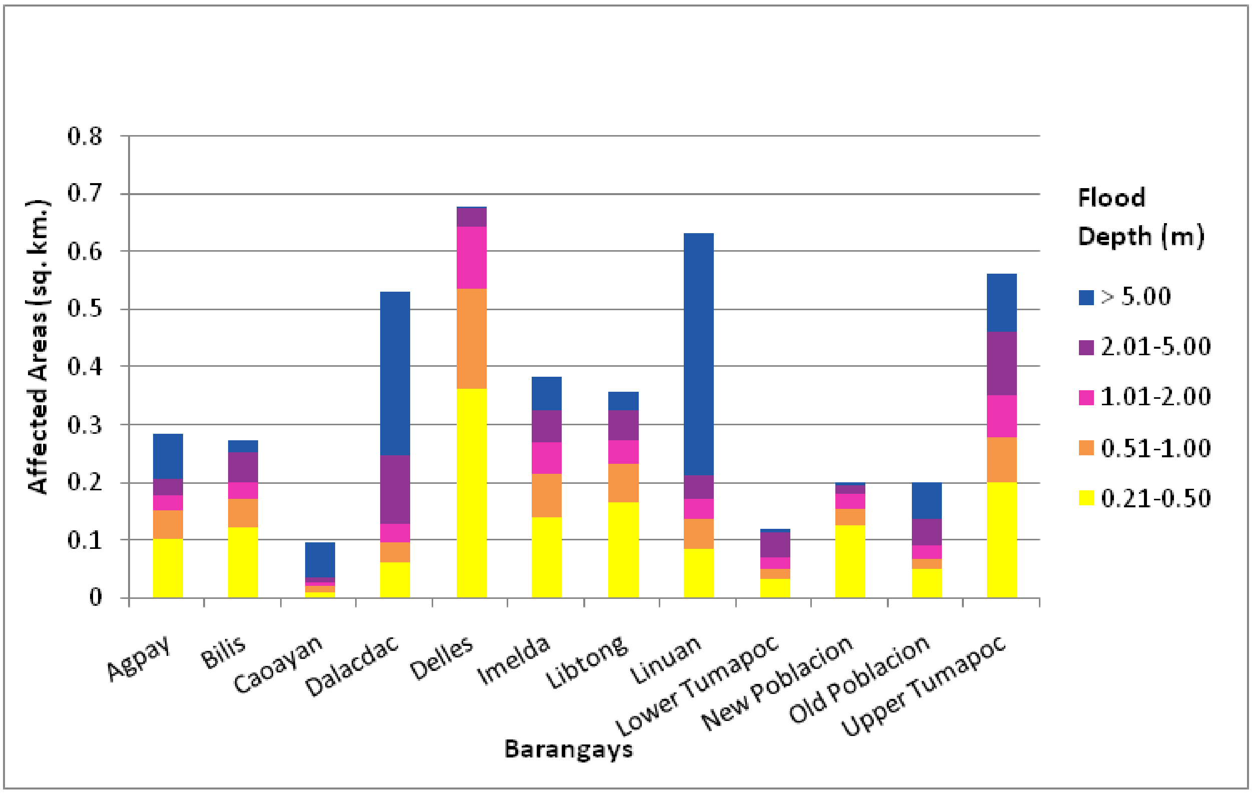


Figure 98. Affected areas in Burgos, La Union during a 5-year rainfall return period

For the 5-year return period, 74.14% of the Municipality of Caba, with an area of 56.19 square kilometers, will experience flood levels of less than 0.20 meters. 6.95% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 4.69%, 5.37%, 6.35%, and 2.47% 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 Tables 58-59 are the affected areas, in square kilometers, by flood depth per barangay.

Table 58. Affected areas in Caba, La Union during a 5-year rainfall return period - A

ARIN-GAY-BAUANG BASIN		Affected Barangays in Caba								
		Bautista	Gana	Juan Cartas	Las-Ud	Liquicia	Pobla-cion Norte	Pobla-cion Sur	San Carlos	San Corne-lio
Affected Area (sq. km.)	0-0.20	2.68	1.21	2.44	0.13	13.46	0.44	0.38	0.37	5.23
	0.21-0.50	0.35	0.61	0.17	0.037	0.51	0.054	0.096	0.3	0.39
	0.51-1.00	0.13	0.16	0.079	0.042	0.38	0.098	0.027	0.32	0.24
	1.01-2.00	0.05	0.1	0.031	0.031	0.42	0.21	0.018	0.27	0.18
	2.01-5.00	0.026	0.055	0.013	0.0063	0.63	0.16	0.011	0.046	0.26
	> 5.00	0.00013	0	0.0003	0	0.84	0.00047	0	0	0.12

Table 59. Affected areas in Caba, La Union during a 5-year rainfall return period - B

ARIN-GAY-BAU-ANG BASIN		Affected Barangays in Caba							
		San Fer-min	San Gre-gorio	San Jose	Santiago Norte	Santiago Sur	Sobre-dillo	Urayong	Wences-lao
Affected Area (sq. km.)	0-0-.20	5	1.97	2.33	0.084	0.05	3.81	1.9	0.17
	0.21-0.50	0.31	0.13	0.2	0.094	0.13	0.14	0.23	0.14
	0.51-1.00	0.19	0.11	0.11	0.23	0.29	0.084	0.06	0.083
	1.01-2.00	0.16	0.081	0.17	0.21	1.02	0.042	0.014	0.01
	2.01-5.00	0.27	0.12	0.5	0.044	1.4	0.027	0.0013	0
	> 5.00	0.23	0.077	0.094	0	0	0.014	0	0

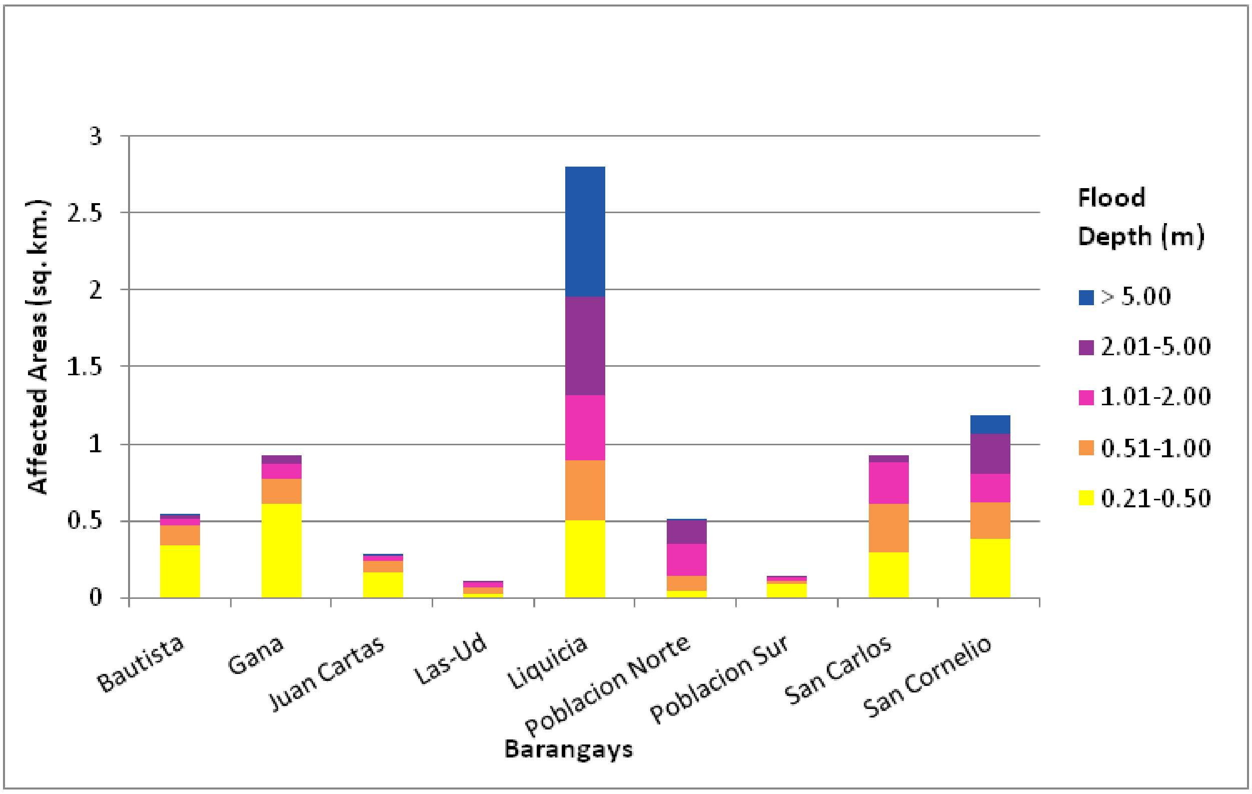


Figure 99. Affected areas in Caba, La Union during a 5-year rainfall return period - A

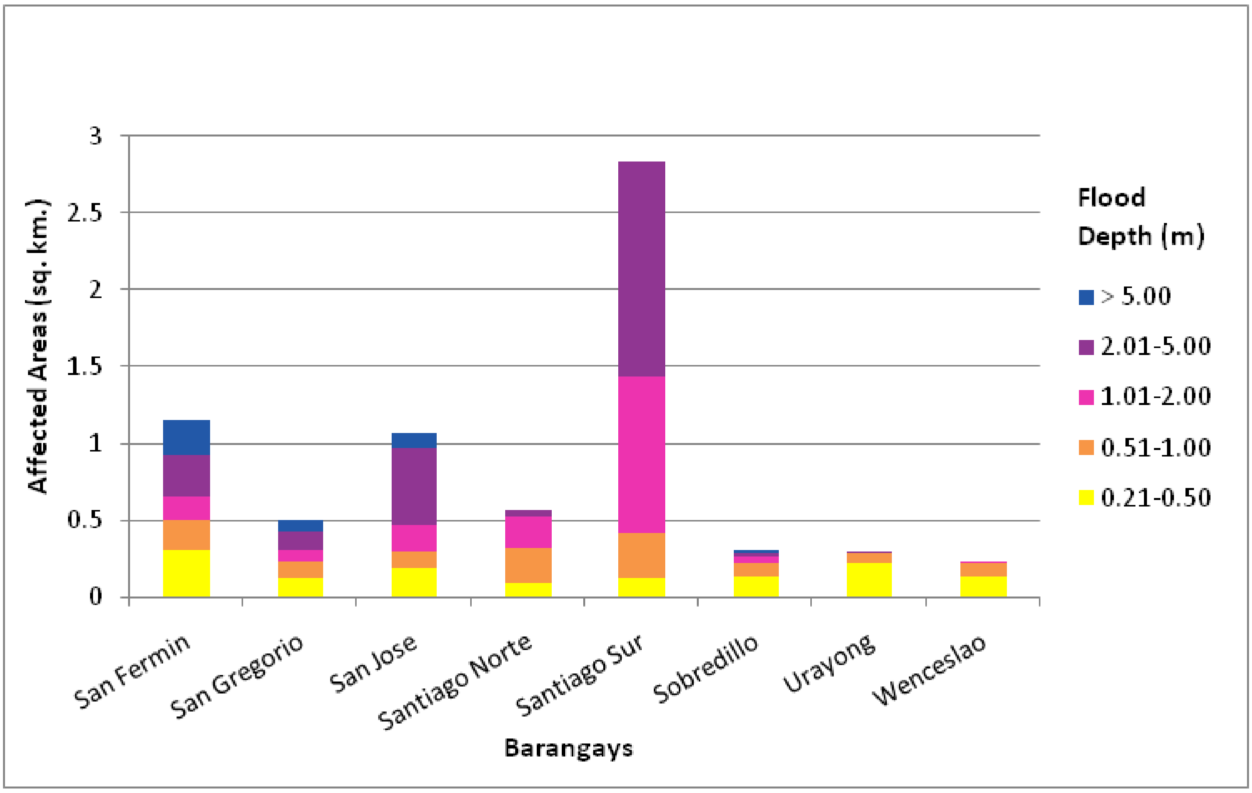


Figure 100. Affected areas in Caba, La Union during a 5-year rainfall return period - B

For the 5-year return period, 69.65% of the Municipality of Naguilian, with an area of 86.39 square kilometers, will experience flood levels of less than 0.20 meters. 3.41% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 2.47%, 2.33%, 7.58%, and 14.60% 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 Tables 60-63 are the affected areas, in square kilometers, by flood depth per barangay.

Table 60. Affected areas in Naguilian, La Union during a 5-year rainfall return period - A

ARINGAY-BAUANG BASIN		Affected Barangays in Naguilian									
		Aguioas	Al-Alinao Norte	Al-Alinao Sur	Ambara-cao Norte	Ambara-cao Sur	Angin	Balecbec	Bancagan	Baraoas Norte	Baraoas Sur
Affected Area (sq. km.)	0-0.20	0.53	2.13	3.12	2.4	1.72	0.24	3.66	0.43	0.082	0.058
	0.21-0.50	0.016	0.2	0.11	0.27	0.15	0.011	0.14	0.012	0.083	0.0057
	0.51-1.00	0.011	0.22	0.042	0.27	0.11	0.0024	0.091	0.04	0.1	0.044
	1.01-2.00	0.025	0.23	0.029	0.21	0.035	0.00048	0.087	0.1	0.13	0.067
	2.01-5.00	0.2	0.37	0.065	0.74	0.054	0.000085	0.17	0.31	0.26	0.3
	> 5.00	0.49	0.66	0.22	1.26	0.026	0	0.12	1.09	0	0

Table 61. Affected areas in Naguilian, La Union during a 5-year rainfall return period - B

ARINGAY-BAUANG BASIN		Affected Barangays in Naguilian									
		Bariquir	Bato	Bimmoto-bot	Cabaritan Norte	Cabaritan Sur	Casilagan	Dal-Li-paoen	Dara-muangan	Guesset	Gusing Norte
Affected Area (sq. km.)	0-0.20	1.06	1.64	4.16	0.0012	0.04	5.55	0.0087	0.14	0.44	3.64
	0.21-0.50	0.025	0.081	0.16	0.00016	0.0022	0.21	0	0.0062	0.025	0.11
	0.51-1.00	0.012	0.073	0.092	0.00082	0.0049	0.11	0.0003	0.0052	0.013	0.065
	1.01-2.00	0.0059	0.031	0.052	0.0025	0.022	0.11	0.0004	0.023	0.003	0.05
	2.01-5.00	0.015	0.019	0.051	0.04	0.18	0.28	0.19	0.23	0	0.083
	> 5.00	0.012	0.0028	0.002	0.25	0.092	0.14	0.28	0.49	0	0.67

Table 62. Affected areas in Naguilian, La Union during a 5-year rainfall return period - C

ARINGAY-BAUANG BASIN		Affected Barangays in Naguilian									
		Gusing Sur	Lioac Norte	Lioac Norte	Lioac Sur	Magungu-nay	Mamat-Ing Norte	Mamat-Ing Sur	Nagsido-risan	Natividad	Ortiz
Affected Area (sq. km.)	0-0.20	2.01	0.27	0.55	0.53	2.93	1.24	1.22	0.56	1.17	0.024
	0.21-0.50	0.071	0.0081	0.012	0.022	0.18	0.028	0.039	0.046	0.13	0.013
	0.51-1.00	0.06	0.0037	0.009	0.0098	0.17	0.016	0.025	0.018	0.052	0.0075
	1.01-2.00	0.065	0.0033	0.018	0.015	0.17	0.023	0.029	0.017	0.048	0.017
	2.01-5.00	0.2	0.0003	0.36	0.042	0.43	0.1	0.1	0.014	0.28	0.29
	> 5.00	1.22	0	0.08	0.0076	0.18	0.69	1.7	0.00021	0.094	0.14

Table 63. Affected areas in Naguilian, La Union during a 5-year rainfall return period - D

ARINGAY-BAUANG BASIN		Affected Barangays in Naguilian						
		Ribsuan	San Anto-nio	San Isidro	Sili	Suguidan Norte	Suguidan Sur	Tuddingan
Affected Area (sq. km.)	0-0.20	1.03	4.77	7.41	0.75	0.33	2.24	2.14
	0.21-0.50	0.043	0.2	0.27	0.049	0.013	0.13	0.07
	0.51-1.00	0.0052	0.095	0.15	0.028	0.0096	0.11	0.057
	1.01-2.00	0.0049	0.067	0.1	0.007	0.0071	0.14	0.071
	2.01-5.00	0.019	0.036	0.14	0.017	0.1	0.71	0.16
	> 5.00	0.17	0.003	0.041	0.1	0.46	1.66	0.28

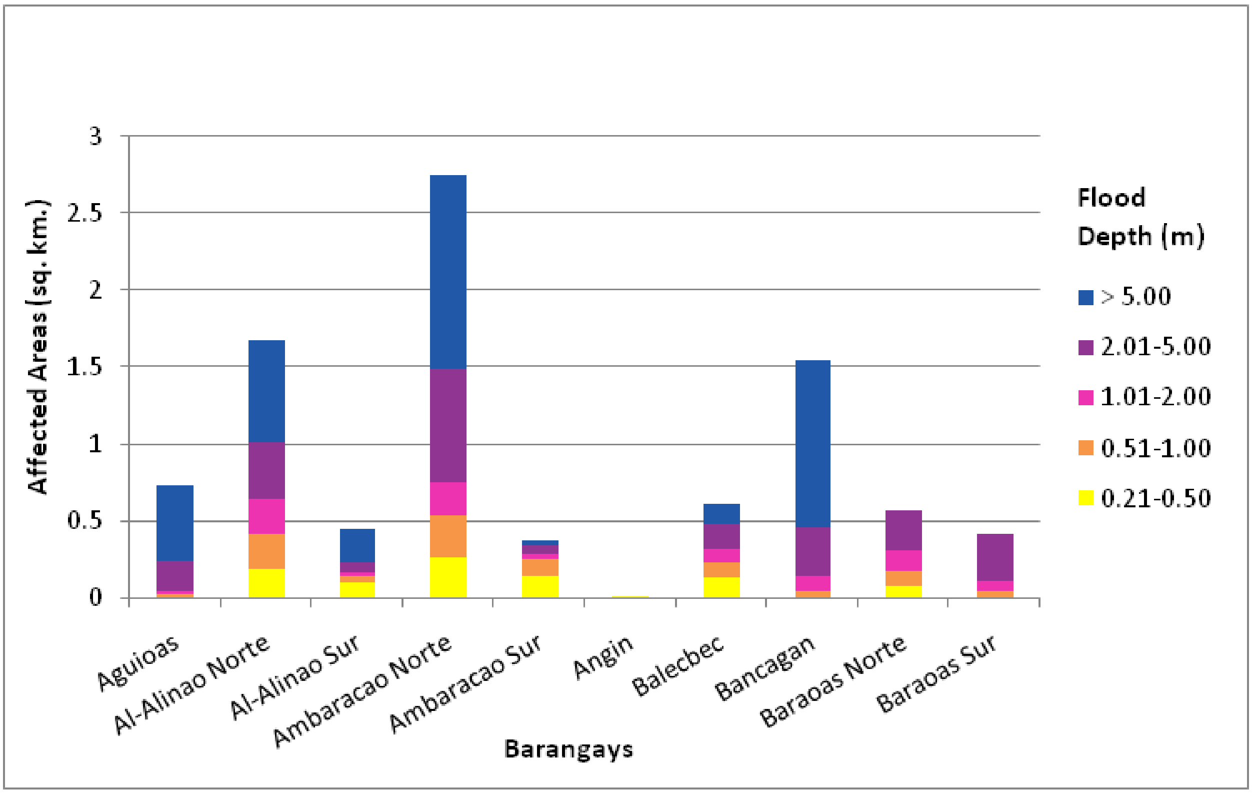


Figure 101. Affected areas in Naguilian, La Union during a 5-year rainfall return period - A

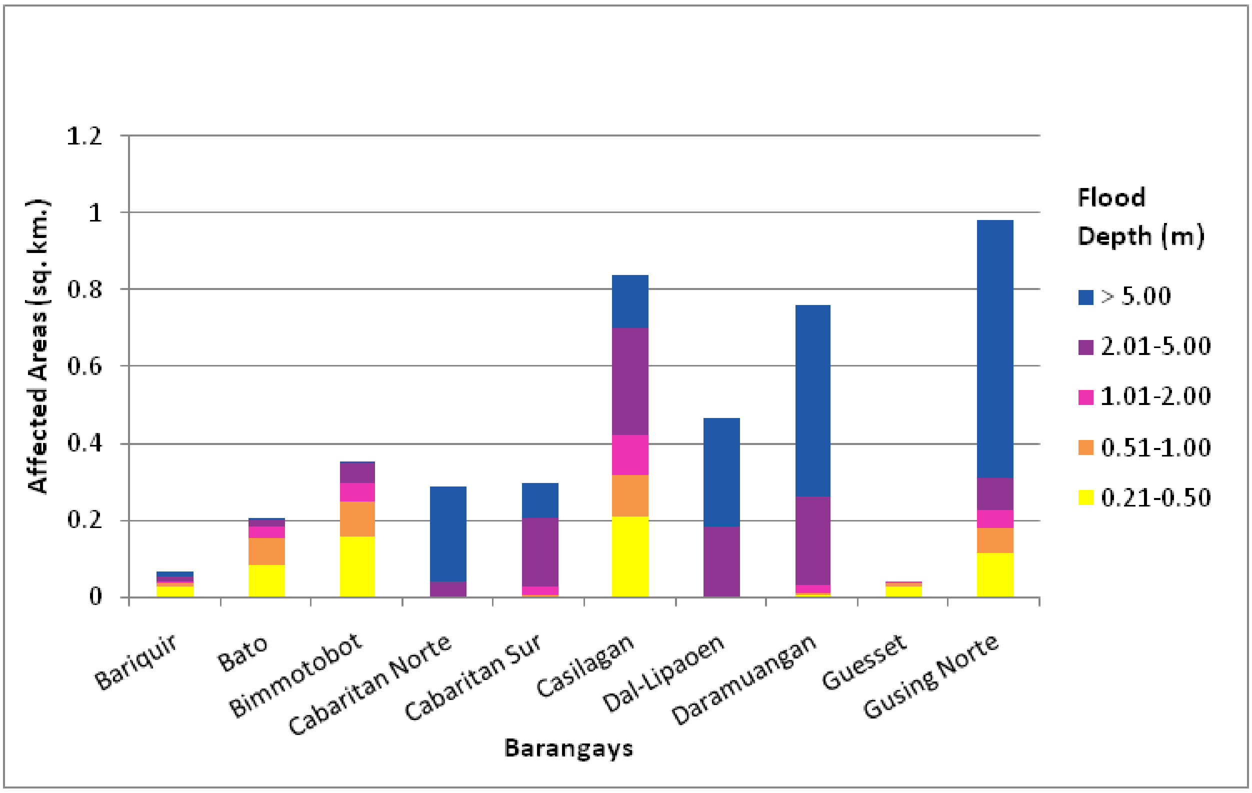


Figure 102. Affected areas in Naguilian, La Union during a 5-year rainfall return period - B

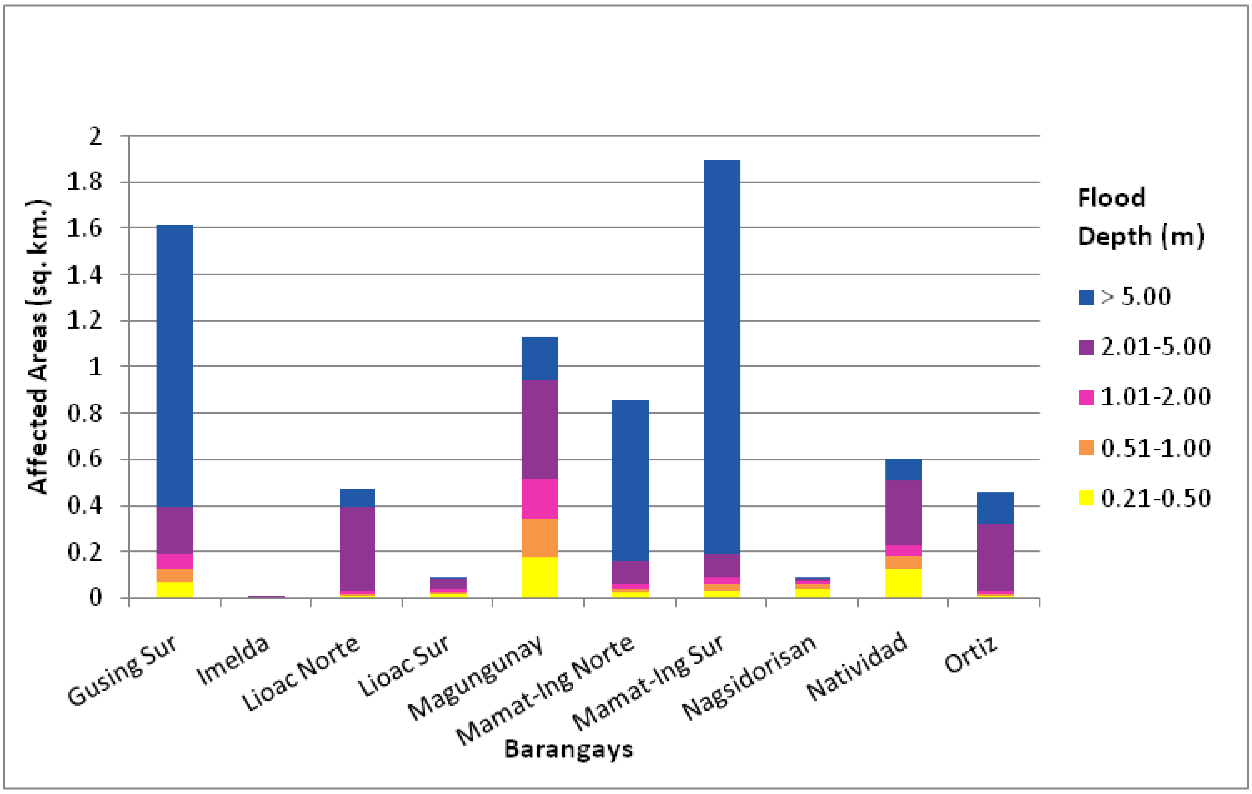


Figure 103. Affected areas in Naguilian, La Union during a 5-year rainfall return period - C

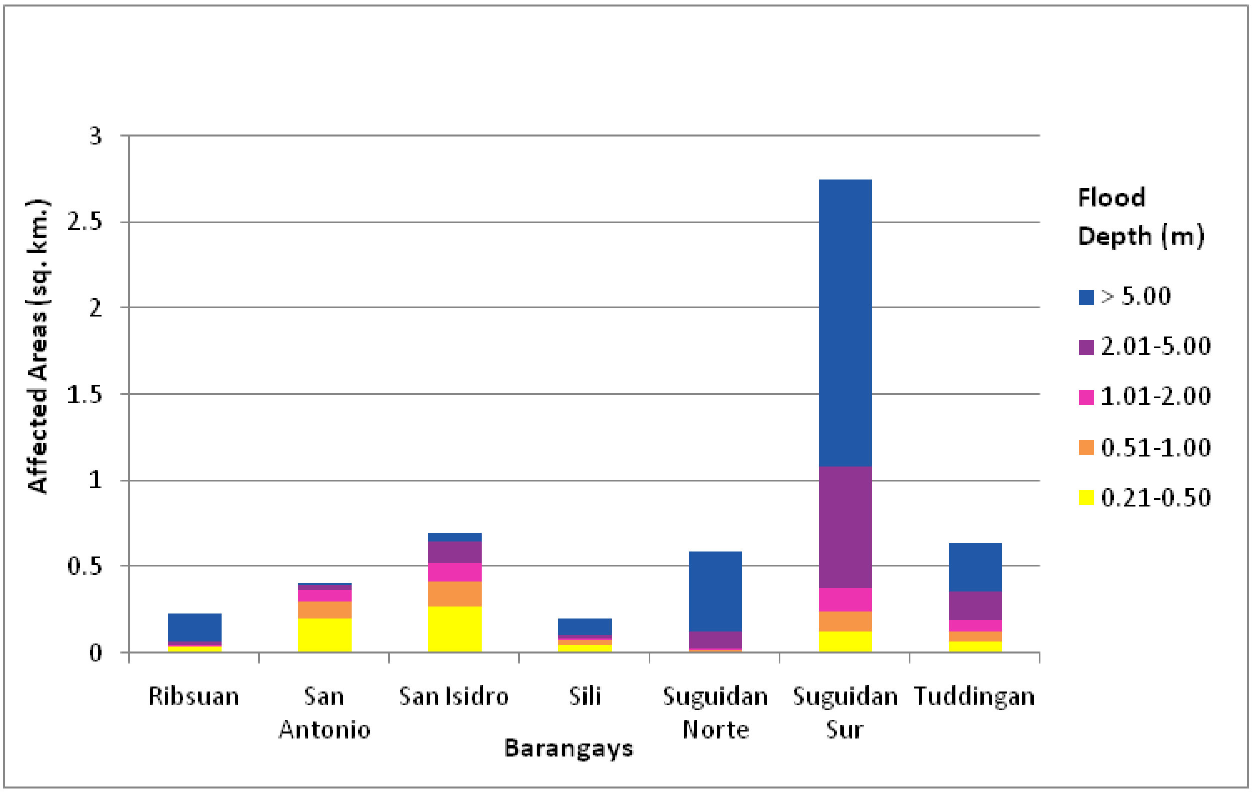


Figure 104. Affected areas in Naguilian, La Union during a 5-year rainfall return period - D

For the 5-year return period, 70.12% of the Municipality of Pugo, with an area of 60.54 square kilometers, will experience flood levels of less than 0.20 meters. 3.44% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 2.88%, 2.96%, 2.86%, and 0.64% 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 64 are the affected areas, in square kilometers, by flood depth per barangay.

Table 64. Affected areas in Pugo, La Union during a 5-year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in Pugo											
		Ambalite	Ambangonan	Cares	Duplas	Mao-asoas Norte	Mao-asoas Sur	Palina	Poblacion East	Poblacion West	San Luis	Tavora East	Tavora Proper
Affected Area (sq. km.)	0-0.20	2.71	4.22	3.33	0.91	1.28	1.62	20.44	3.04	2.23	1.13	0.3	1.24
	0.21-0.50	0.19	0.19	0.22	0.04	0.099	0.08	0.77	0.14	0.13	0.038	0.061	0.13
	0.51-1.00	0.21	0.14	0.23	0.027	0.12	0.051	0.35	0.078	0.08	0.018	0.16	0.29
	1.01-2.00	0.24	0.16	0.26	0.041	0.11	0.039	0.2	0.042	0.095	0.01	0.28	0.31
	2.01-5.00	0.18	0.078	0.19	0.046	0.093	0.028	0.19	0.021	0.14	0.0012	0.51	0.26
	> 5.00	0.0014	0	0.096	0.0001	0.084	0.051	0.047	0.031	0.041	0	0.024	0.0088

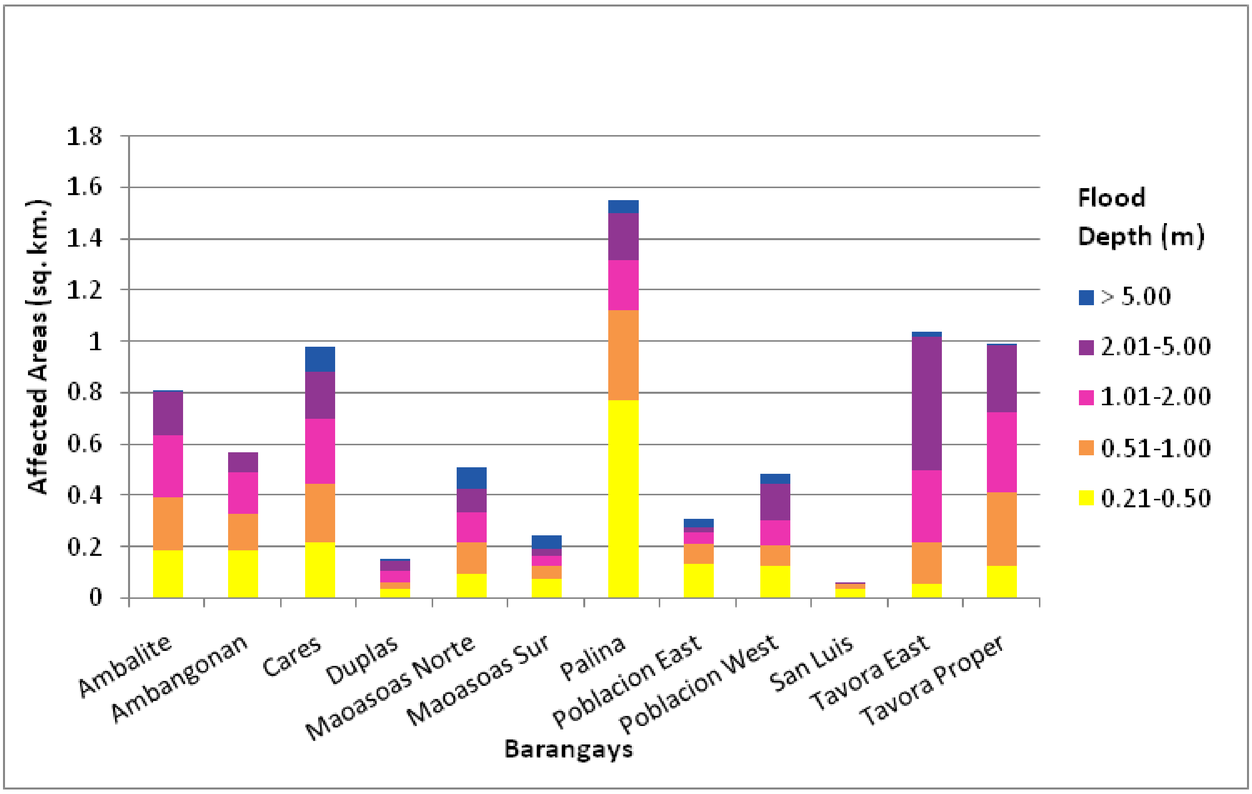


Figure 105. Affected areas in Pugo, La Union during a 5-year rainfall return period

For the 5-year return period, 6.50% of the Municipality of Rosario, with an area of 64.33 square kilometers, will experience flood levels of less than 0.20 meters. 0.26% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 0.14%, 0.12%, and 0.03% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and 2.01 to 5 meters, respectively. Listed in Table 65 are the affected areas, in square kilometers, by flood depth per barangay.

Table 65. Affected areas in Rosario, La Union during a 5-year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in Rosario				
		Ambangonan	Inabaan Norte	Marcos	Parasapas	San Jose
Affected Area (sq. km.)	0-0.20	0.26	0.76	1.27	1.25	0.64
	0.21-0.50	0.011	0.018	0.061	0.052	0.026
	0.51-1.00	0.004	0.011	0.035	0.027	0.012
	1.01-2.00	0.0033	0.0043	0.044	0.02	0.0059
	2.01-5.00	0.0004	0.0006	0.0075	0.0054	0.003
	> 5.00	0	0	0	0	0

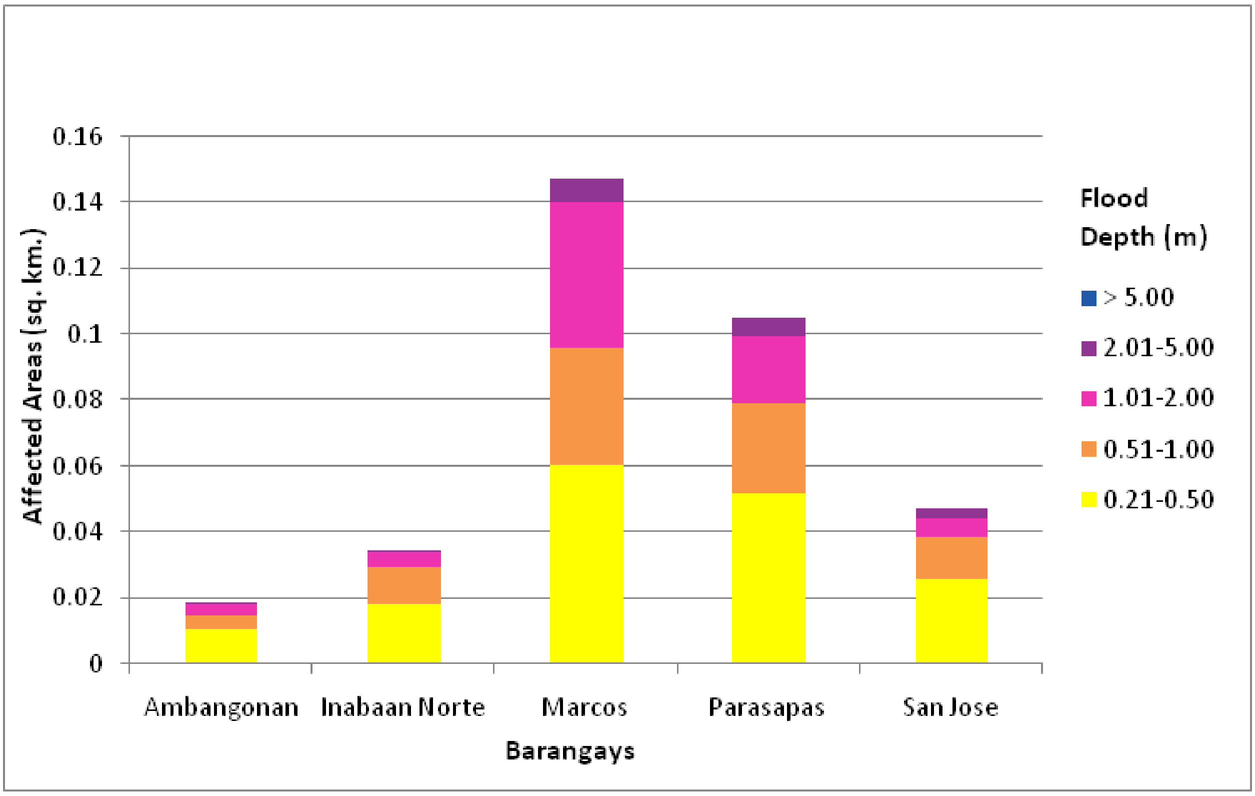


Figure 106. Affected areas in Rosario, La Union during a 5-year rainfall return period

For the 5-year return period, 37.86% of the Municipality of San Fernando City, with an area of 121.05 square kilometers, will experience flood levels of less than 0.20 meters. 2.05% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 1.19%, 1.04%, 1.15%, and 3.68% 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 Tables 66-67 are the affected areas, in square kilometers, by flood depth per barangay.

Table 66. Affected areas in San Fernando City, La Union during a 5-year rainfall return period - A

ARINGAY-BAUANG BASIN		Affected Barangays in San Fernando City											
		Apaleng	Bacsil	Bangban-golan	Birunget	Bungro	Cabarsi-can	Cadaclan	Cala-bugao	Langcuas	Masicong	Nagyu-buyuban	Namtut-an
Affected Area (sq. km.)	0-0.20	4.26	5.59	0.9	3.05	0.31	1.41	2.3	1.66	0.21	1.36	0.74	0.16
	0.21-0.50	0.2	0.28	0.053	0.19	0.079	0.042	0.1	0.076	0.0098	0.041	0.029	0.0073
	0.51-1.00	0.14	0.19	0.016	0.13	0.052	0.029	0.045	0.049	0.004	0.019	0.017	0.0022
	1.01-2.00	0.14	0.14	0.003	0.061	0.064	0.047	0.026	0.023	0.0006	0.012	0.0069	0.0021
	2.01-5.00	0.26	0.16	0.0005	0.0091	0.04	0.17	0.047	0.0081	0.0002	0.034	0.001	0
	> 5.00	0.11	0.027	0	0	0	0.89	0.0001	0	0	1.56	0	0

Table 67. Affected areas in San Fernando City, La Union during a 5-year rainfall return period - B

ARINGAY-BAUANG BASIN		Affected Barangays in San Fernando City											
		Narra Este	Narra Oeste	Pacpaco	Pao Norte	Pao Sur	Pias	Puspus	Sacyud	Sagayad	Sevilla	Sibo-an-Otong	Tan-quigan
Affected Area (sq. km.)	0-0.20	4	2.48	0.74	2.54	3.3	0.97	0.65	3.64	0.49	0.41	3.02	1.65
	0.21-0.50	0.19	0.2	0.033	0.096	0.19	0.1	0.028	0.14	0.053	0.028	0.18	0.12
	0.51-1.00	0.11	0.091	0.014	0.046	0.11	0.042	0.015	0.11	0.048	0.039	0.095	0.033
	1.01-2.00	0.095	0.1	0.0068	0.014	0.065	0.0096	0.0063	0.098	0.055	0.18	0.082	0.015
	2.01-5.00	0.05	0.11	0.0021	0.0022	0.1	0.0064	0.0006	0.22	0.048	0.08	0.039	0.0056
	> 5.00	0	0.003	0	0	0.074	0.0001	0	1.78	0	0.0026	0	0

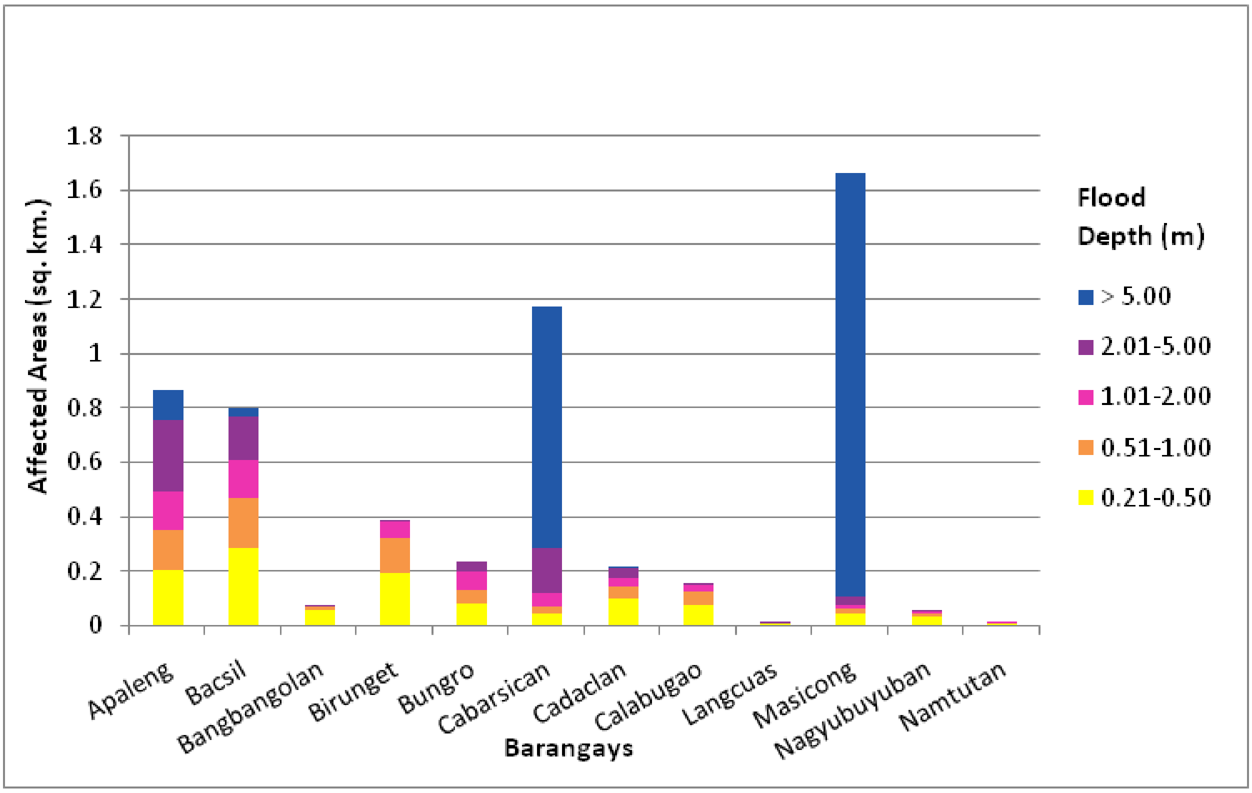


Figure 107. Affected areas in San Fernando City, La Union during a 5-year rainfall return period - A

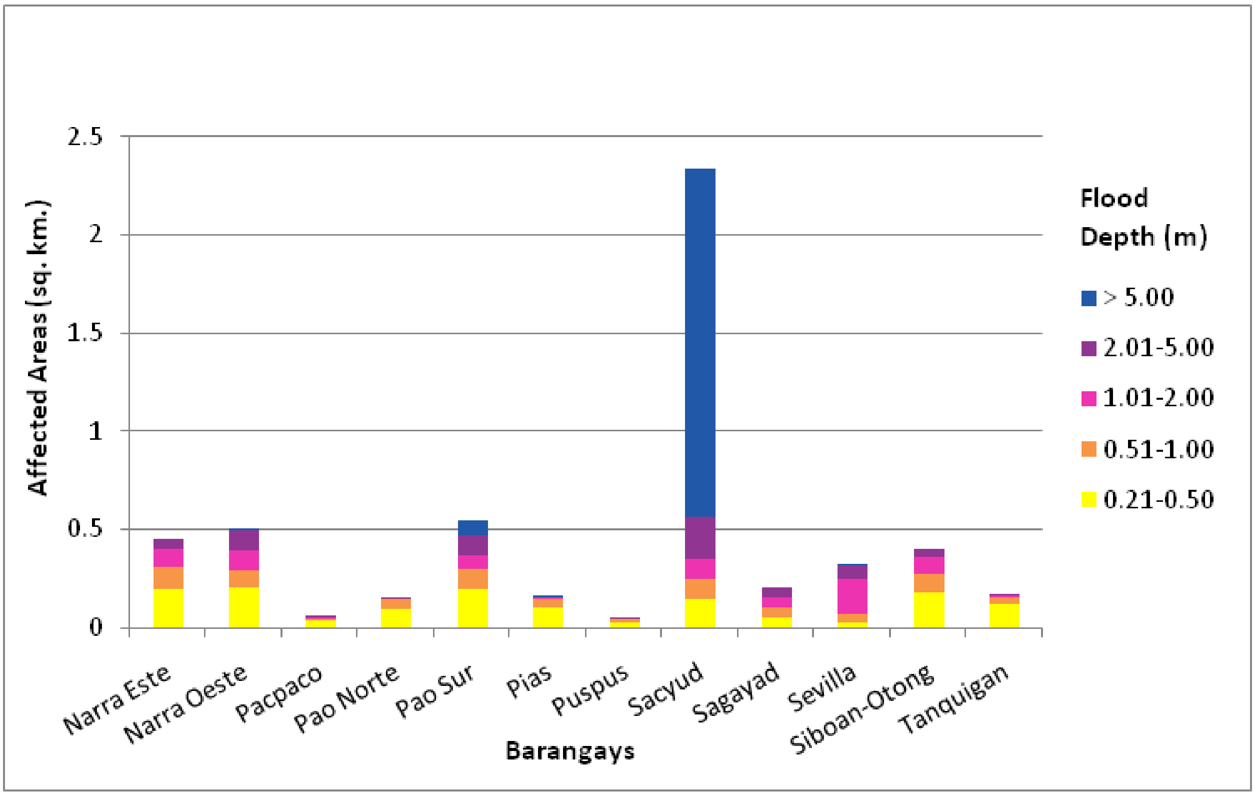


Figure 108. Affected areas in San Fernando City, La Union during a 5-year rainfall return period - B

For the 5-year return period, 10.27% of the Municipality of San Gabriel, with an area of 154.19 square kilometers, will experience flood levels of less than 0.20 meters. 0.36% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 0.14%, 0.09%, 0.09%, and 0.03% 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 68 are the affected areas, in square kilometers, by flood depth per barangay.

Table 68. Affected areas in San Gabriel, La Union during a 5-year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in San Gabriel		
		Amontoc	Apayao	Bayabas
Affected Area (sq. km.)	0-0.20	3.35	12.07	0.42
	0.21-0.50	0.072	0.49	0.000089
	0.51-1.00	0.021	0.2	0.0001
	1.01-2.00	0.011	0.12	0
	2.01-5.00	0.01	0.13	0
	> 5.00	0.0075	0.035	0

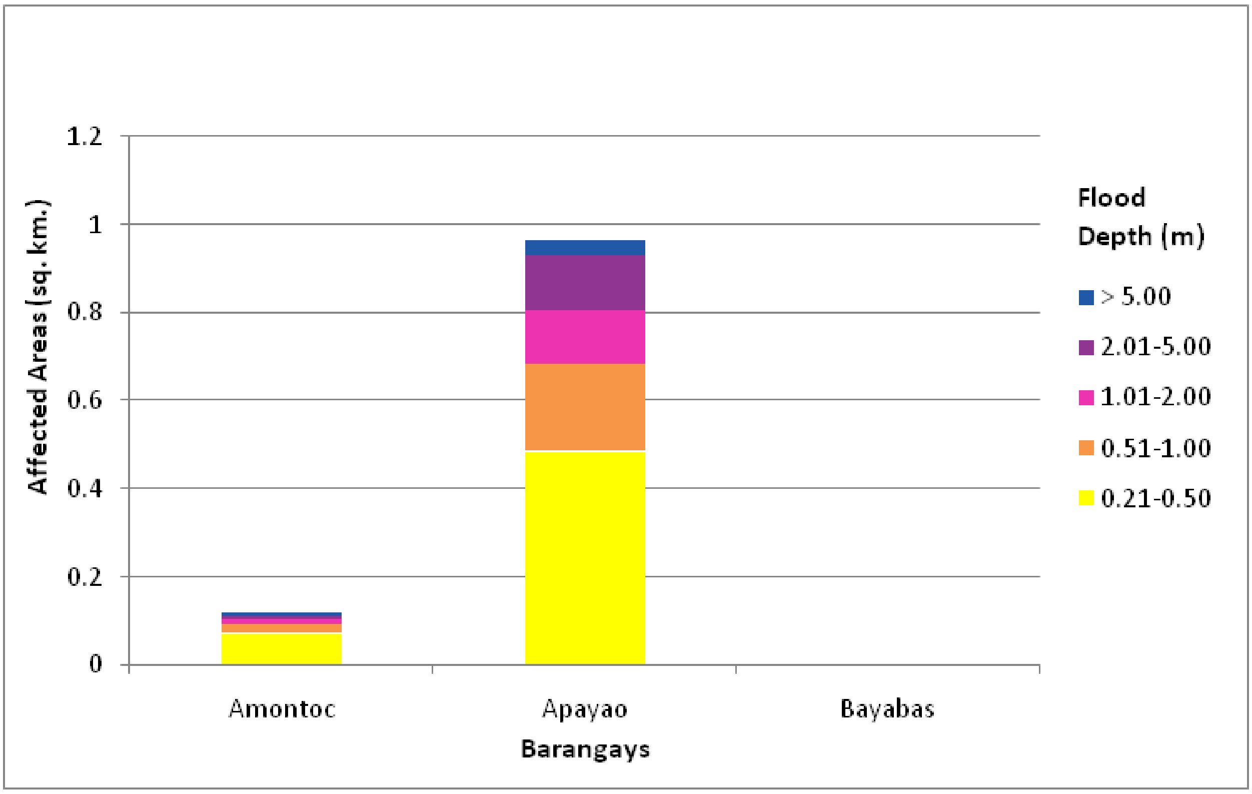


Figure 109. Affected areas in San Gabriel, La Union during a 5-year rainfall return period

For the 5-year return period, 8.19% of the Municipality of Santo Tomas, with an area of 58.53 square kilometers, will experience flood levels of less than 0.20 meters. 0.33% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 0.19%, 0.15%, and 0.05% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and 2.01 to 5 meters, respectively. Listed in Table 69 are the affected areas, in square kilometers, by flood depth per barangay.

Table 69. Affected areas in Santo Tomas, La Union during a 5-year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in Santo Tomas		
		Ambitacay	Bail	Pongpong
Affected Area (sq. km.)	0-0.20	0.36	0.14	4.29
	0.21-0.50	0.011	0.008	0.17
	0.51-1.00	0.0068	0.0029	0.099
	1.01-2.00	0.0033	0.0013	0.085
	2.01-5.00	0.0023	0	0.029
	> 5.00	0	0	0.0015

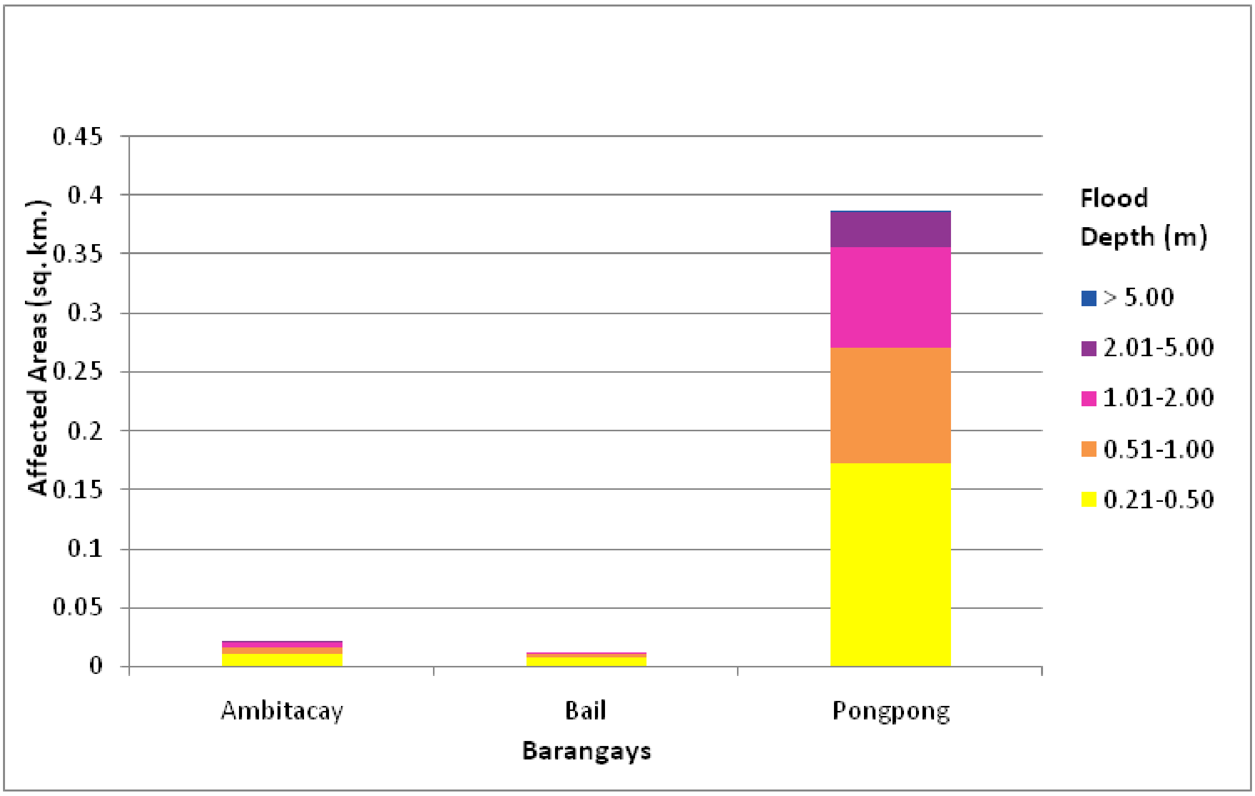


Figure 110. Affected areas in Santo Tomas, La Union during a 5-year rainfall return period

For the 5-year return period, 52.15% of the Municipality of Tubao, with an area of 53.87 square kilometers, will experience flood levels of less than 0.20 meters. 2.74% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 1.56%, 1.90%, 5.17%, and 20.39% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Tables 70-71 are the affected areas, in square kilometers, by flood depth per barangay.

Table 70. Affected areas in Tubao, La Union during a 5-year rainfall return period - A

ARINGAY-BAU-ANG BASIN		Affected Barangays in Tubao								
		Anduyan	Caoigue	Francia Sur	Francia West	Garcia	Gonzales	Halog East	Halog West	Leones East
Affected Area (sq. km.)	0-0.20	5.36	1.4	0.94	0.36	0.49	0.14	0.1	0.14	0
	0.21-0.50	0.37	0.094	0.037	0.013	0.022	0.0042	0.0027	0.016	0
	0.51-1.00	0.19	0.055	0.019	0.0062	0.012	0.0046	0.002	0.019	0
	1.01-2.00	0.12	0.15	0.016	0.0061	0.012	0.0086	0.0037	0.048	0
	2.01-5.00	0.95	0.13	0.052	0.015	0.052	0.028	0.021	0.088	0.000097
	> 5.00	0.67	0	0.0072	0.015	0.55	0.89	0.74	0.58	0.93

Table 71. Affected areas in Tubao, La Union during a 5-year rainfall return period - B

ARINGAY-BAU-ANG BASIN		Affected Barangays in Tubao							
		Leones West	Linapew	Lloren	Magsay-say	Pideg	Poblacion	Rizal	Santa Teresa
Affected Area (sq. km.)	0-0.20	1.02	2.01	2.74	0.38	2.49	0.28	4.68	5.59
	0.21-0.50	0.069	0.065	0.23	0.012	0.11	0.016	0.21	0.21
	0.51-1.00	0.054	0.022	0.12	0.0099	0.078	0.0085	0.13	0.12
	1.01-2.00	0.084	0.0029	0.14	0.013	0.094	0.011	0.16	0.16
	2.01-5.00	0.16	0.003	0.29	0.039	0.1	0.038	0.31	0.51
	> 5.00	0.26	0.0001	0.23	0.82	0.0063	0.71	2.79	1.79

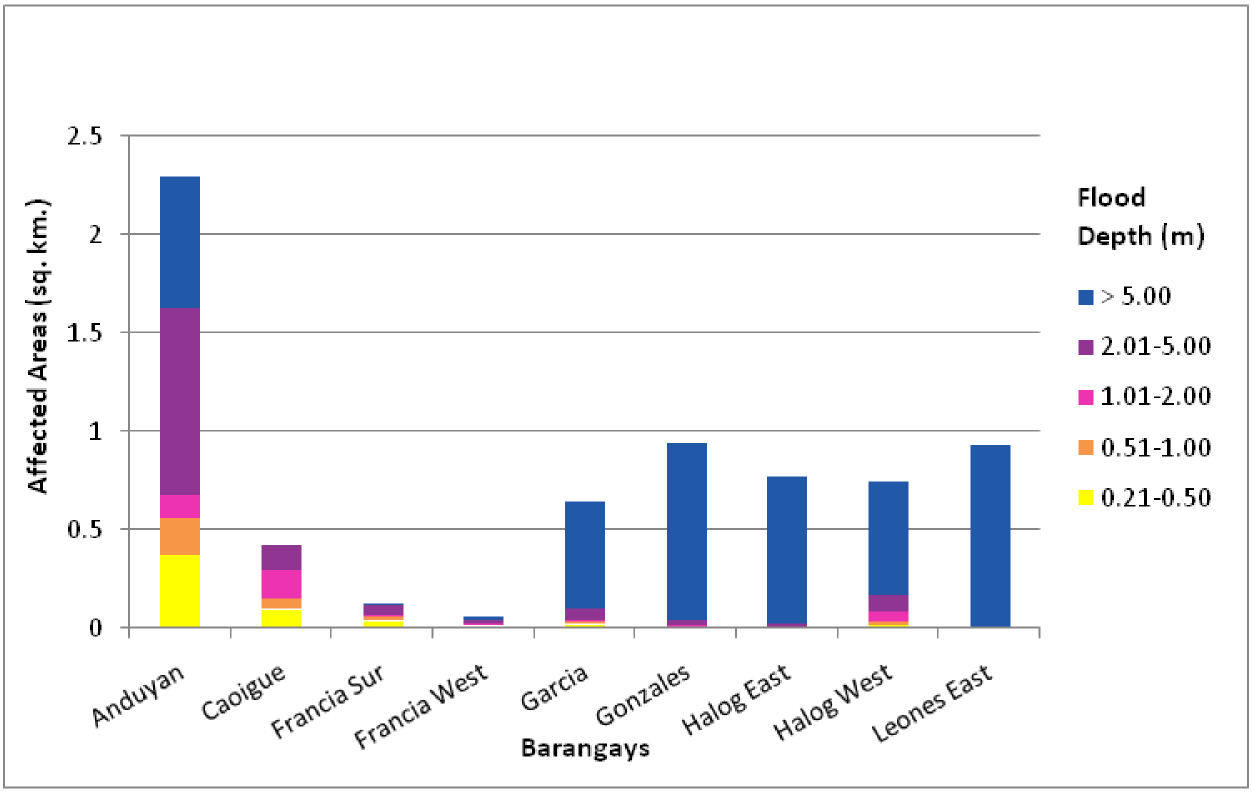


Figure 111. Affected areas in Tubao, La Union during a 5-year rainfall return period - A

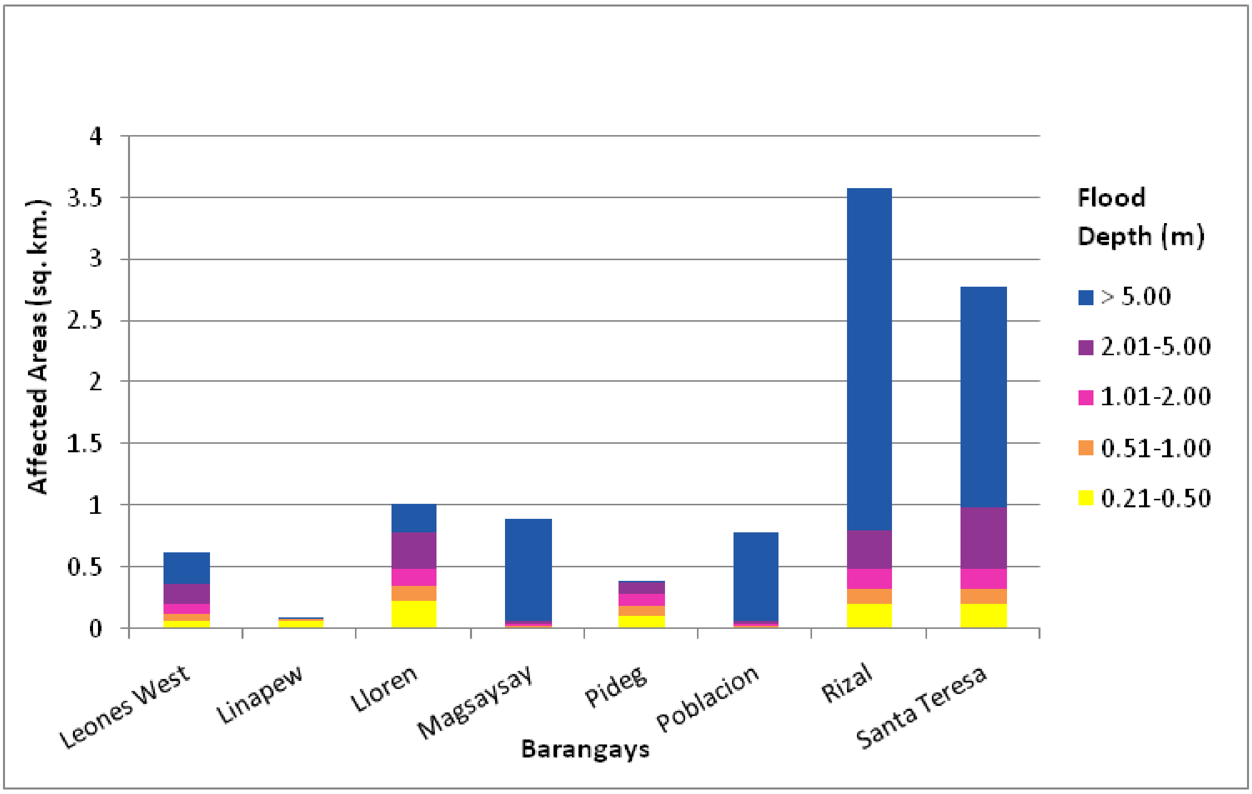


Figure 112. Affected areas in Tubao, La Union during a 5-year rainfall return period - B

For the 25-year return period, 47.52% of the Municipality of Baguio City, with an area of 60.8979 square kilometers, will experience flood levels of less than 0.20 meters. 2.51% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 1.39%, 1.19%, 1.18%, and 0.32% 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 Tables 72-81 are the affected areas, in square kilometers, by flood depth per barangay.

Table 72. Affected areas in Baguio City, Benguet during a 25-year rainfall return period - A

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City										
		A. Bonifacio-Caguioa-Rimando	Aban-ao-Zandueta-Kayong-Chugum-Otek	Alfonso Tabora	Ambiong	Andres Bonifacio	Asin Road	Aurora Hill Proper	Aurora Hill, North Central	Aurora Hill, South Central	Bakakeng Central	Bakakeng North
Affected Area (sq. km.)	0-0.20	0.049	0.034	0.075	0.24	0.073	4.22	0.024	0.042	0.069	0.71	0.082
	0.21-0.50	0.0067	0.0057	0.0028	0.009	0.005	0.24	0.0002	0.0026	0.0019	0.03	0.0048
	0.51-1.00	0.00061	0.0041	0.0027	0.009	0.0004	0.11	0.00086	0.0018	0	0.025	0.00059
	1.01-2.00	0.00053	0	0.0098	0.0027	0	0.083	0.0021	0.0038	0	0.02	0
	2.01-5.00	0.00053	0	0.011	0	0	0.065	0.0032	0.00097	0	0.012	0
	> 5.00	0	0	0.0038	0	0	0.0036	0	0	0	0.0055	0

Table 73. Affected areas in Baguio City, Benguet during a 25-year rainfall return period - B

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City										
		Bal-Marcoville	Balsigan	Bayan Park East	Bayan Park West	Bgh Compound	Brookside	Brookspoint	Cabinet Hill-Teacher's Camp	Camdas Subdivision	Camp 8	Camp Allen
Affected Area (sq. km.)	0-0.20	0.12	0.054	0.17	0.075	0.017	0.091	0.098	0.35	0.16	0.087	0.13
	0.21-0.50	0.0025	0.00018	0.0071	0.0014	0.00049	0.0042	0.0075	0.01	0.0022	0.0058	0.0055
	0.51-1.00	0.0054	0.00023	0.0069	0.0025	0.0016	0.0023	0.0047	0.0053	0.0012	0	0.008
	1.01-2.00	0.0051	0.000012	0.0052	0.0014	0.0011	0	0.0055	0.0092	0.00032	0	0.0046
	2.01-5.00	0.0007	0	0.00035	0	0	0	0.0031	0.017	0.00091	0	0.0012
	> 5.00	0	0	0	0	0	0	0	0.00021	0.00067	0	0

Table 74. Affected areas in Baguio City, Benguet during a 25-year rainfall return period - C

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City										
		Campo Filipino	City Camp Central	City Camp Proper	Country Club Village	Cresencia Village	Dizon Subdivision	Dominican Hill-Mirador	Dontogan	Dps Area	Engineers' Hill	Fairview Village
Affected Area (sq. km.)	0-0.20	0.12	0.069	0.083	0.19	0.16	0.25	1.18	0.55	0.12	0.1	0.25
	0.21-0.50	0.014	0.0024	0.0028	0.016	0.0047	0.0044	0.045	0.016	0.0015	0.0021	0.017
	0.51-1.00	0.021	0.0007	0	0.0068	0.0072	0.0013	0.026	0.0077	0.0019	0.0001	0.021
	1.01-2.00	0.043	0	0	0.007	0.013	0.0017	0.024	0.0077	0.006	0	0.02
	2.01-5.00	0.019	0	0	0.0013	0.0079	0.0011	0.063	0.0093	0.022	0	0.0067
	> 5.00	0	0	0	0	0	0	0.077	0.00041	0.0017	0	0

Table 75. Affected areas in Baguio City, Benguet during a 25-year rainfall return period - D

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City										
		Ferdinand	General Emilio F. Aguinaldo	General Luna, Lower	General Luna, Upper	Gibraltar	Greenwater Village	Guisad Central	Guisad Sorong	Happy Hollow	Happy Homes	Holy Ghost Extension
Affected Area (sq. km.)	0-0.20	0.091	0.062	0.027	0.034	0.2	0.13	0.077	0.29	0.74	0.19	0.29
	0.21-0.50	0.0085	0.0029	0.0016	0.0016	0.0035	0.0048	0.0005	0.015	0.061	0.00093	0.0079
	0.51-1.00	0.0057	0.0013	0.0026	0.0002	0.00034	0.0012	0.0002	0.0064	0.02	0.0014	0.0064
	1.01-2.00	0.0041	0.0023	0.00094	0	0.000071	0.00029	0	0.002	0.02	0.0026	0.0081
	2.01-5.00	0.00025	0.0049	0.0032	0	0	0.000026	0	0.00039	0.0097	0.011	0.021
	> 5.00	0	0	0.0011	0	0	0	0	0	0.0015	0.007	0.000015

Table 76. Affected areas in Baguio City, Benguet during a 25-year rainfall return period - E

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City										
		Holy Ghost Proper	Honey-moon	Imelda R. Marcos	Imelda Village	Irisan	Kabayani-han	Kagitin-gan	Kayang Extension	Kayang-Hill-top	Legar-da-Burn-ham-Kisad	Lopez Jaena
Affected Area (sq. km.)	0-0.20	0.043	0.071	0.024	0.074	5.61	0.061	0.031	0.089	0.0099	0.35	0.047
	0.21-0.50	0.0029	0.005	0.00064	0.0084	0.28	0.0021	0.00073	0.0045	0.00048	0.024	0.0016
	0.51-1.00	0.0013	0.0026	0	0.0044	0.17	0.0041	0.0015	0.0013	0.000098	0.028	0.001
	1.01-2.00	0.0025	0.0008	0	0.0069	0.13	0.0037	0.0022	0.00022	0	0.037	0
	2.01-5.00	0.01	0.0002	0	0.0048	0.12	0	0.0083	0	0	0.059	0
	> 5.00	0.0024	0	0	0	0.052	0	0.000055	0	0	0.0091	0

Table 77. Affected areas in Baguio City, Benguet during a 25-year rainfall return period - F

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City										
		Lourdes Subdivision Extension	Lourdes Subdivi-sion, Lower	Lourdes Subdi-vision, Proper	Lualhati	Magsaysay Private Road	Magsaysay, Lower	Magsaysay, Upper	Malcolm Square-Per-fecto	Manuel A. Roxas	Middle Quezon Hill Subdivision	Military Cut-Off
Affected Area (sq. km.)	0-0.20	0.027	0.03	0.078	0.32	0.022	0.089	0.0086	0.045	0.095	0.14	0.28
	0.21-0.50	0.0039	0.0033	0.005	0.019	0.0055	0.014	0.00062	0.00016	0.0037	0.012	0.021
	0.51-1.00	0.0028	0.0011	0	0.017	0.0011	0.0021	0.0008	0.000023	0.0036	0.0012	0.0062
	1.01-2.00	0	0	0	0.013	0.002	0.0049	0.0036	0	0.011	0	0.0018
	2.01-5.00	0	0	0	0	0.0076	0.015	0.0036	0	0.0095	0	0.00018
	> 5.00	0	0	0	0	0.0026	0.00065	0	0	0	0	0

Table 78. Affected areas in Baguio City, Benguet during a 25-year rainfall return period - G

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City										
		Modern Site, West	Mrr-Queen Of Peace	New Luc-ban	Outlook Drive	Pacdal	Padre Bur-gos	Padre Zamora	Palma-Ur-bano	Phil-Am	Pinget	Pinsao Pi-lot Project
Affected Area (sq. km.)	0-0.20	0.095	0.061	0.11	0.14	1.08	0.11	0.024	0.076	0.032	0.35	0.091
	0.21-0.50	0.0074	0.0029	0.0062	0.0046	0.048	0.0048	0.0024	0.0011	0.0047	0.019	0.0043
	0.51-1.00	0.00045	0.0026	0.0067	0.0027	0.028	0.0051	0.0044	0	0.0027	0.0071	0.00088
	1.01-2.00	0	0.00072	0.0038	0.0023	0.0067	0.01	0.015	0	0.0034	0.0065	0.0013
	2.01-5.00	0	0	0.016	0	0.001	0.013	0.046	0	0	0.0076	0.0015
	> 5.00	0	0	0.0033	0	0	0.0036	0.0025	0	0	0.0053	0.00033

Table 79. Affected areas in Baguio City, Benguet during a 25-year rainfall return period - H

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City										
		Pinsao Proper	Poliwes	Pucsusan	Quezon Hill Proper	Quezon Hill, Upper	Quirino Hill, East	Quirino Hill, Lower	Quirino Hill, Middle	Quirino Hill, West	Quiri-no-Mag-saysay, Upper	Rizal Monument Area
Affected Area (sq. km.)	0-0.20	2.13	0.062	0.14	0.17	0.32	0.052	0.033	0.05353	0.054	0.099	0.072
	0.21-0.50	0.11	0.0031	0.013	0.016	0.024	0.0022	0.0028	0.00999	0.01	0.0025	0.004
	0.51-1.00	0.053	0.0006	0.0043	0.017	0.012	0.0035	0.0029	0.005461	0.0055	0.0039	0.0018
	1.01-2.00	0.027	0	0.0003	0.014	0.0024	0.0027	0.0006	0.0015	0.0015	0.0054	0.0001
	2.01-5.00	0.012	0	0	0.0008	0.00081	0.013	0.0009	0.0002	0.0002	0.021	0
	> 5.00	0.0029	0	0	0	0	0.00069	0	0	0	0.0065	0

Table 80. Affected areas in Baguio City, Benguet during a 25-year rainfall return period - I

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City										
		Rock Quarry, Lower	Rock Quarry, Middle	Rock Quarry, Upper	Saint Joseph Village	Salud Mitra	San Antonio Village	San Luis Village	San Roque Village	San Vicente	Sanitary Camp, North	Sanitary Camp, South
Affected Area (sq. km.)	0-0.20	0.036	0.055	0.061	0.63	0.15	0.13	0.61	0.055	0.2	0.15	0.082
	0.21-0.50	0.0017	0.0032	0.011	0.03	0.0061	0.0042	0.031	0.004	0.012	0.0053	0.0072
	0.51-1.00	0.0018	0.0012	0.0044	0.027	0.0005	0.00067	0.011	0	0.0058	0.00082	0.003
	1.01-2.00	0.00085	0.0018	0.00022	0.017	0	0	0.0081	0	0.0038	0	0.0001
	2.01-5.00	0.00062	0.001	0	0.0061	0	0	0.0022	0	0.0037	0	0
	> 5.00	0	0	0	0	0	0	0	0	0	0	0

Table 81. Affected areas in Baguio City, Benguet during a 25-year rainfall return period - J

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City									
		Santa Escolastica	Santo Rosario	Santo Tomas Proper	Session Road Area	Slaughter House Area	Slu-Svp Housing Village	South Drive	Teodora Alonzo	Trancoville	Victoria Village
Affected Area (sq. km.)	0-0.20	0.077	0.19	0.21	0.2	0.024	0.2	0.33	0.056	0.22	0.18
	0.21-0.50	0.006	0.01	0.01	0.0054	0.0005	0.0052	0.038	0.0063	0.011	0.013
	0.51-1.00	0.0012	0.0035	0.0025	0.01	0.0006	0.0033	0.017	0.0012	0.0069	0.0039
	1.01-2.00	0.003	0.00069	0.0014	0.014	0.0011	0.003	0.014	0.0051	0.0089	0.0012
	2.01-5.00	0.00067	0	0	0.0014	0.0051	0.0025	0.0062	0.0082	0.008	0.0001
	> 5.00	0	0	0	0	0.00085	0	0	0	0.0025	0

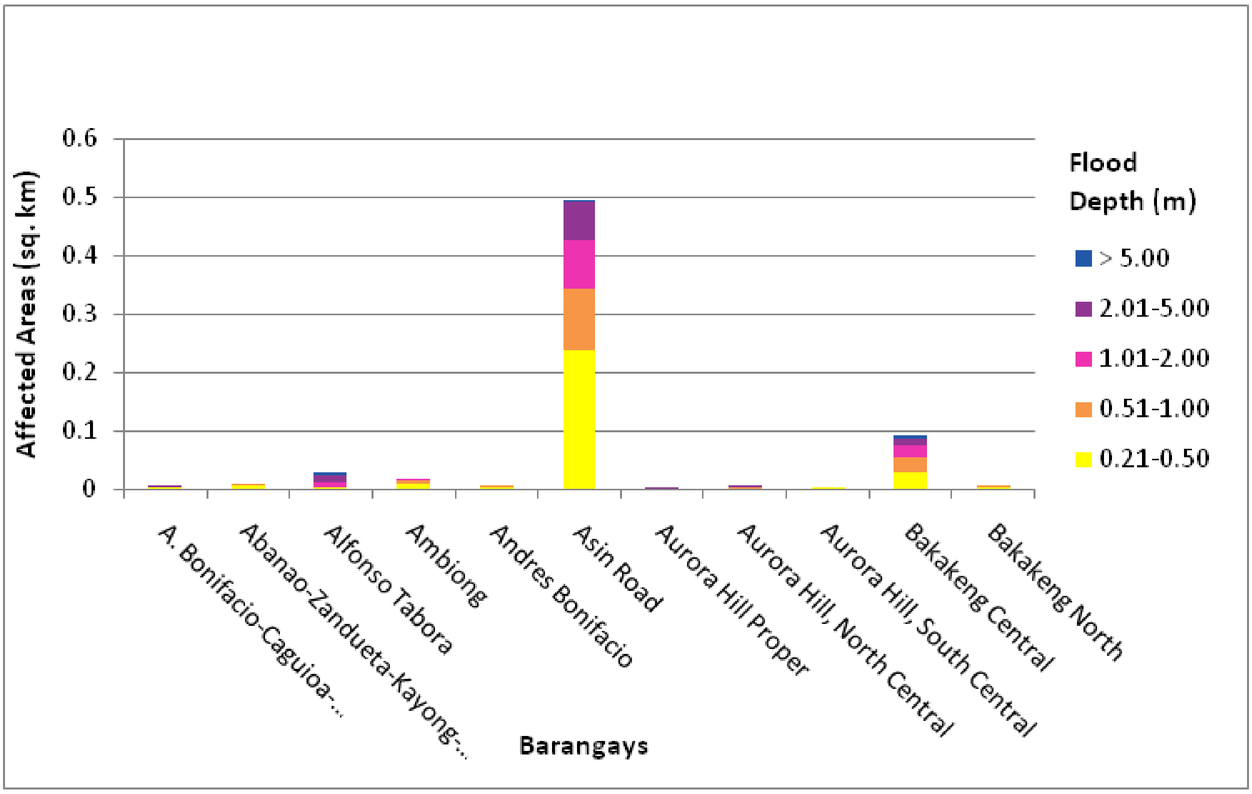


Figure 113. Affected areas in Baguio City, Benguet during a 25-year rainfall return period - A

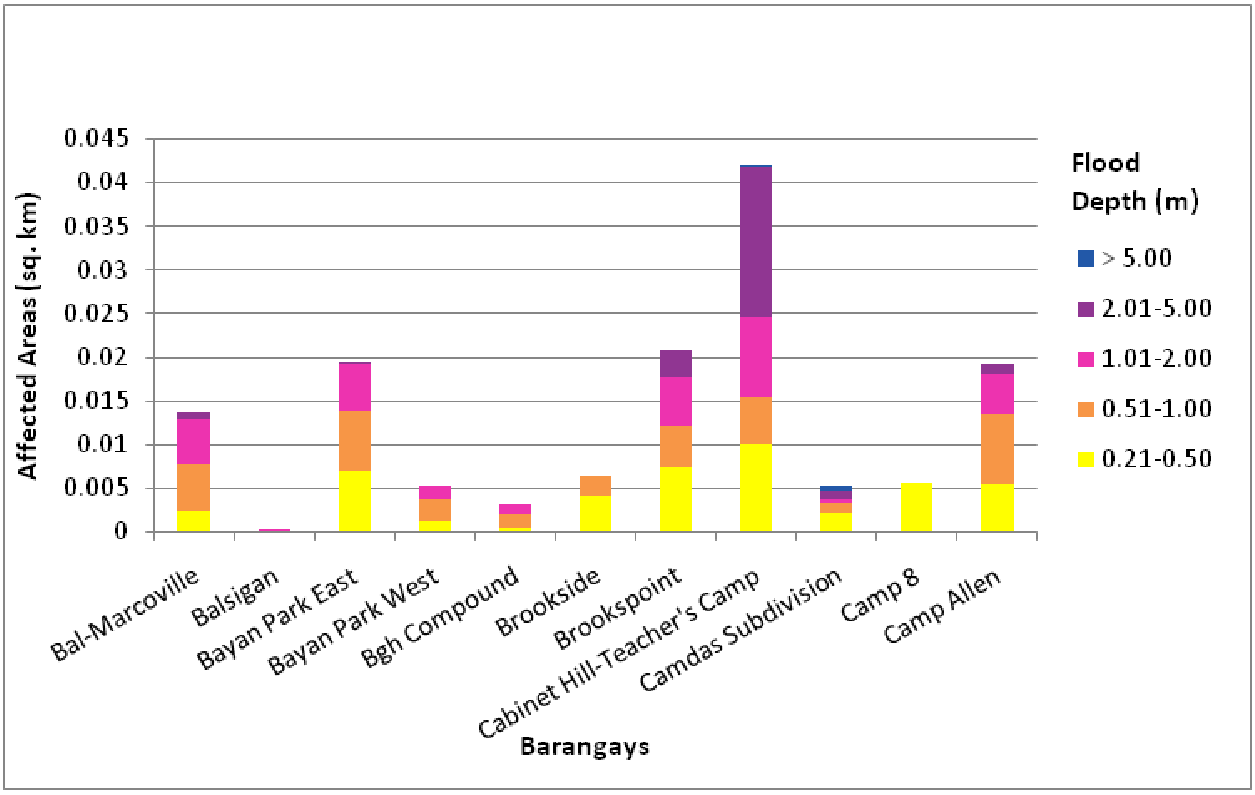


Figure 114. Affected areas in Baguio City, Benguet during a 25-year rainfall return period - B

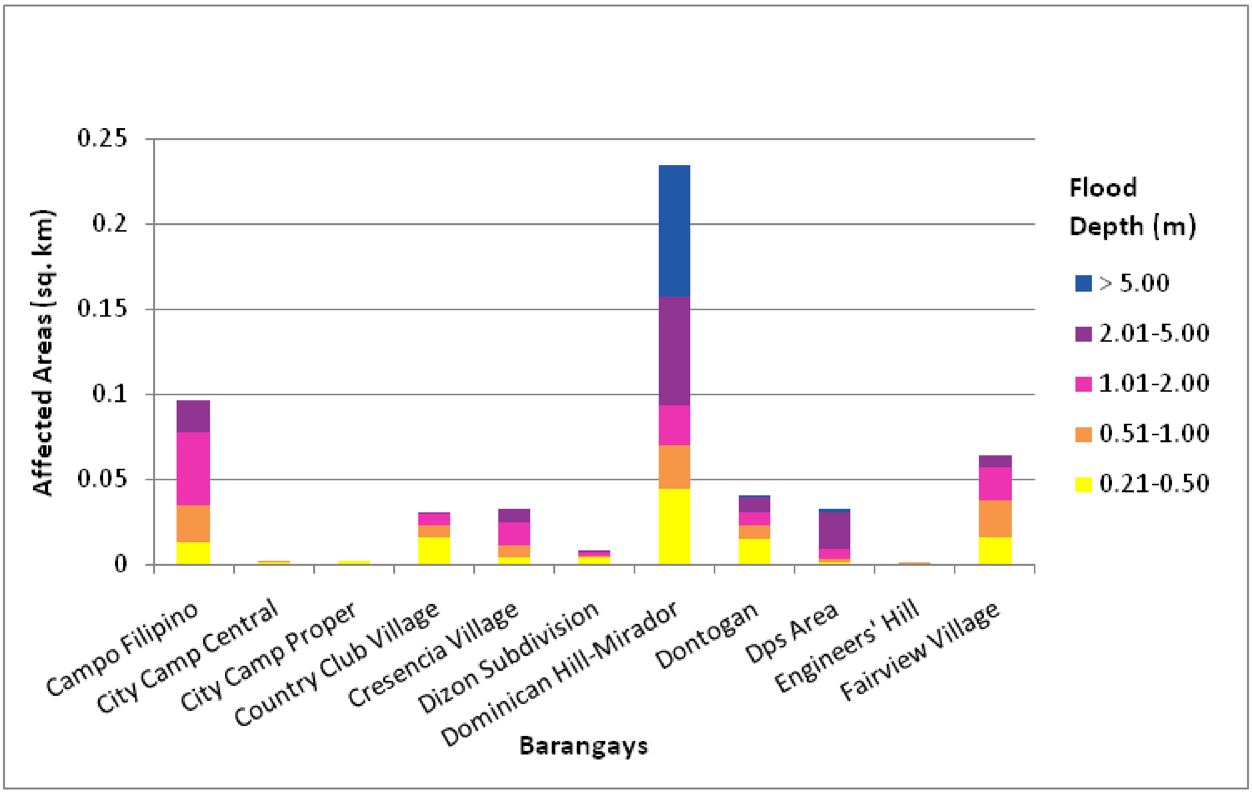


Figure 115. Affected areas in Baguio City, Benguet during a 25-year rainfall return period - C

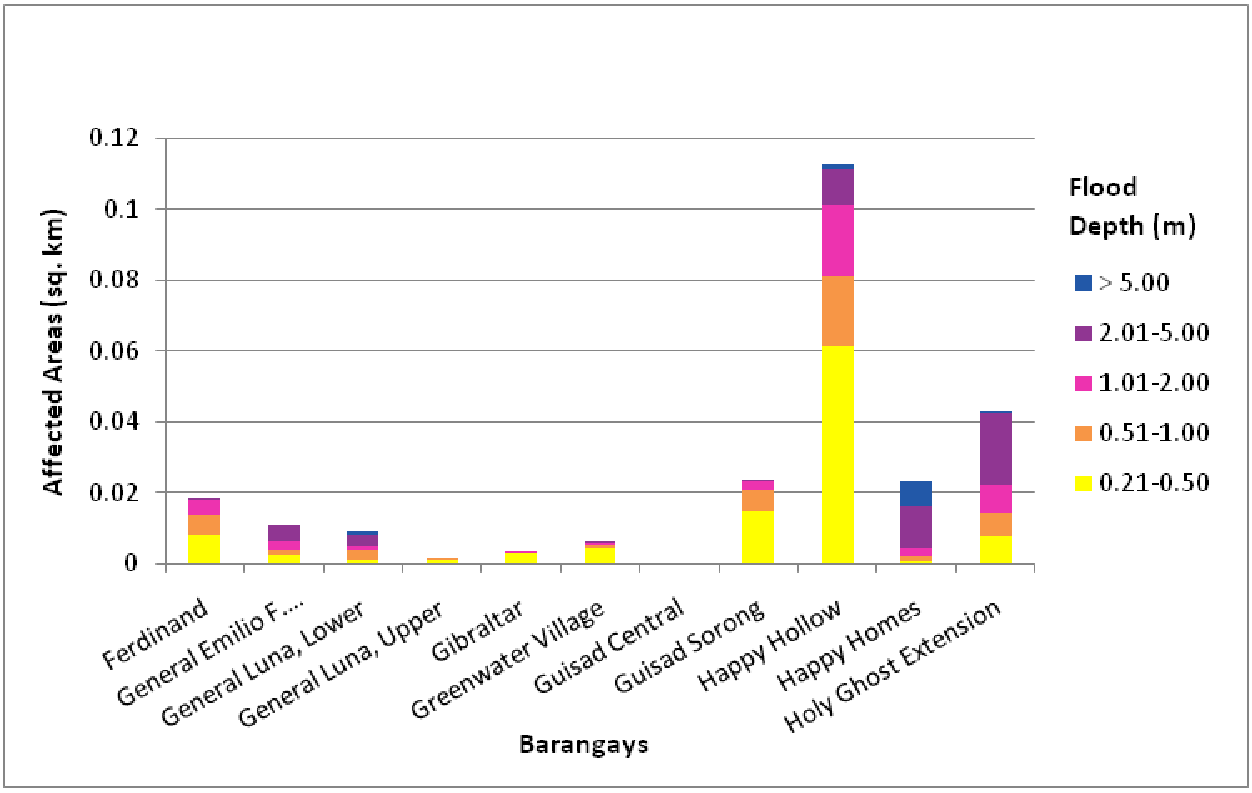


Figure 116. Affected areas in Baguio City, Benguet during a 25-year rainfall return period - D

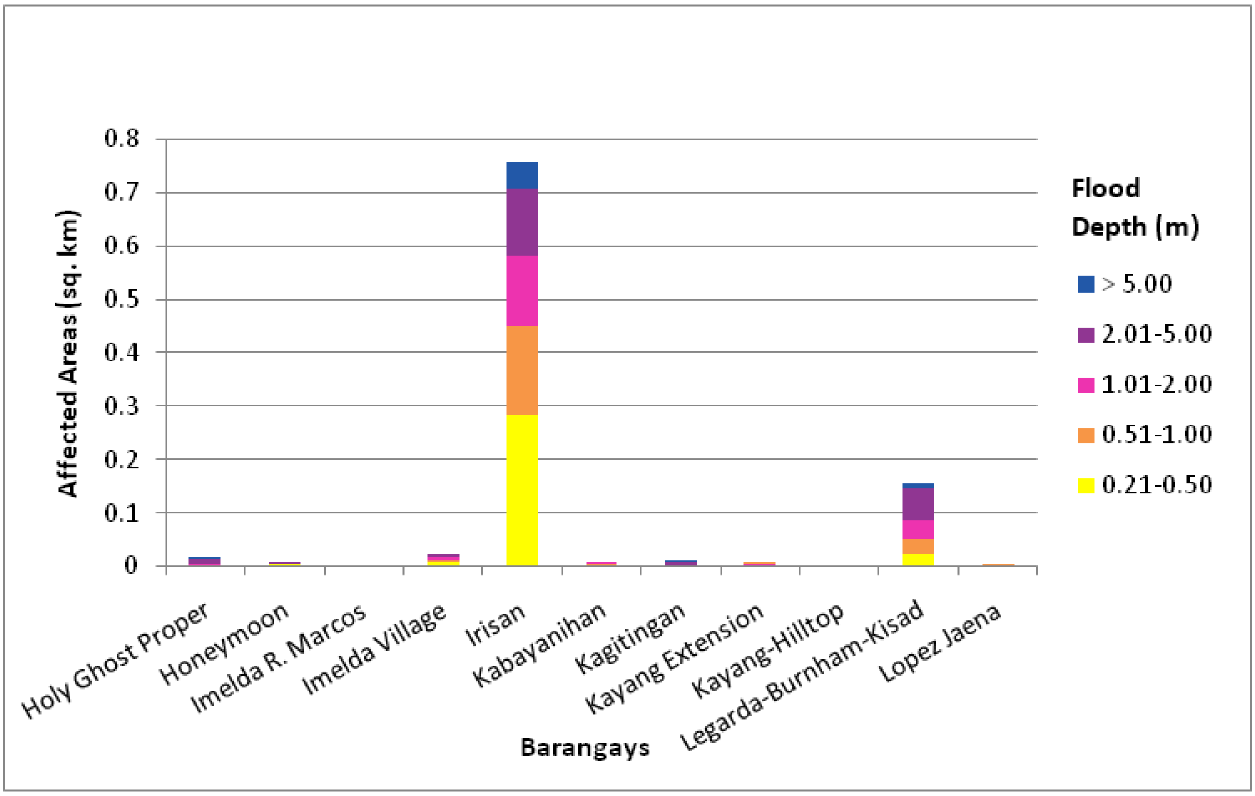


Figure 117. Affected areas in Baguio City, Benguet during a 25-year rainfall return period - E

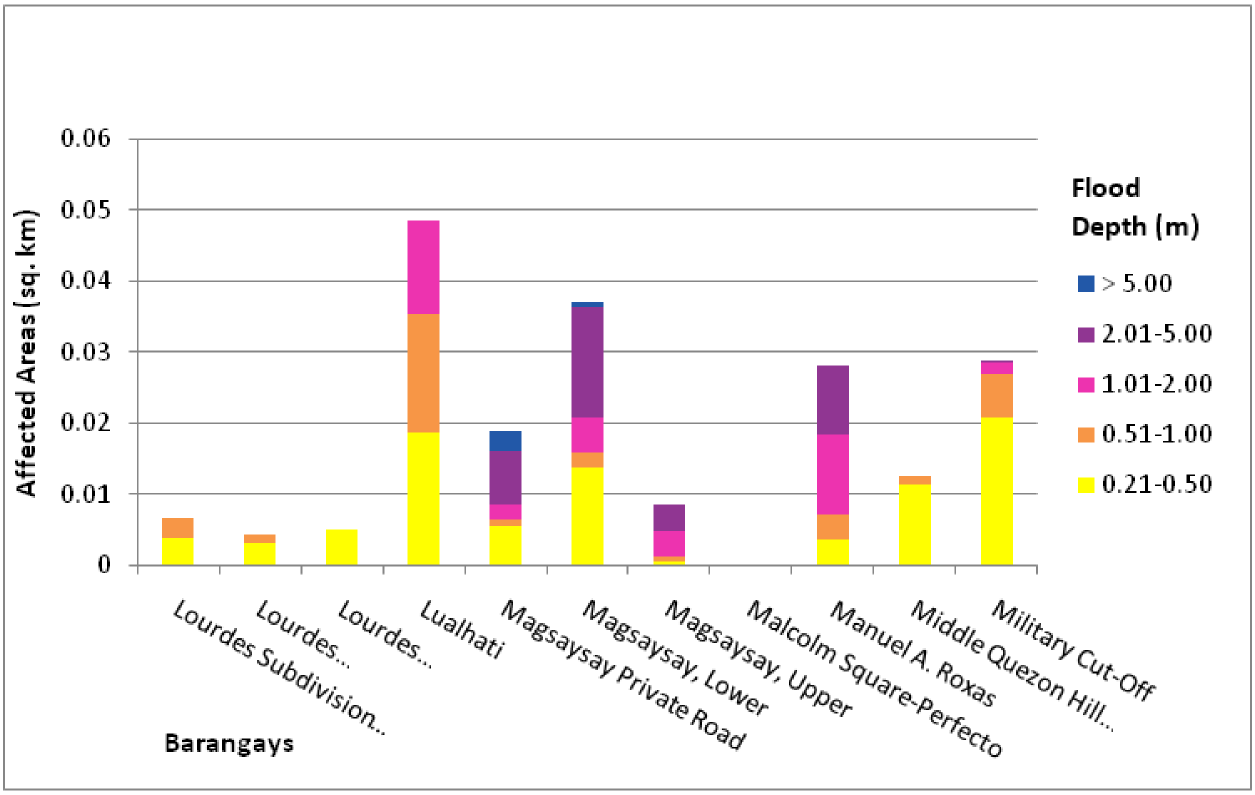


Figure 118. Affected areas in Baguio City, Benguet during a 25-year rainfall return period - F

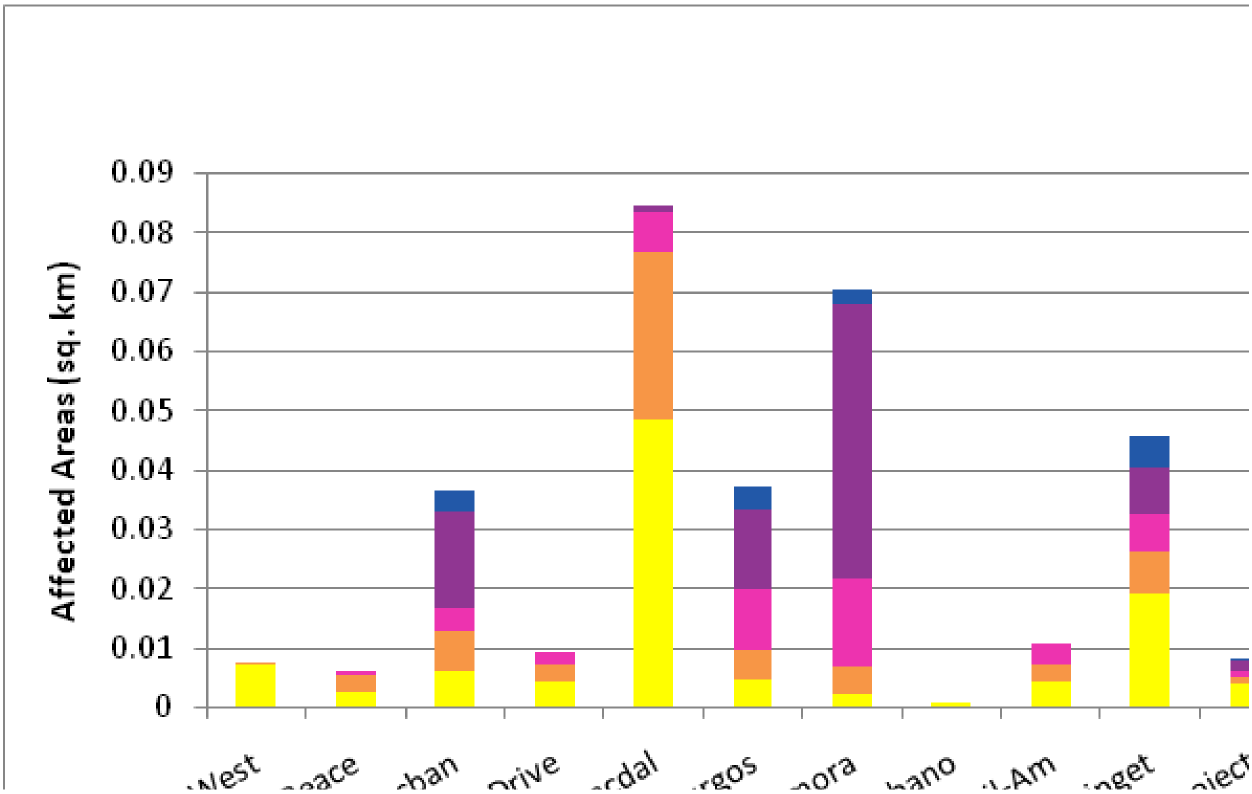


Figure 119. Affected areas in Baguio City, Benguet during a 25-year rainfall return period - G

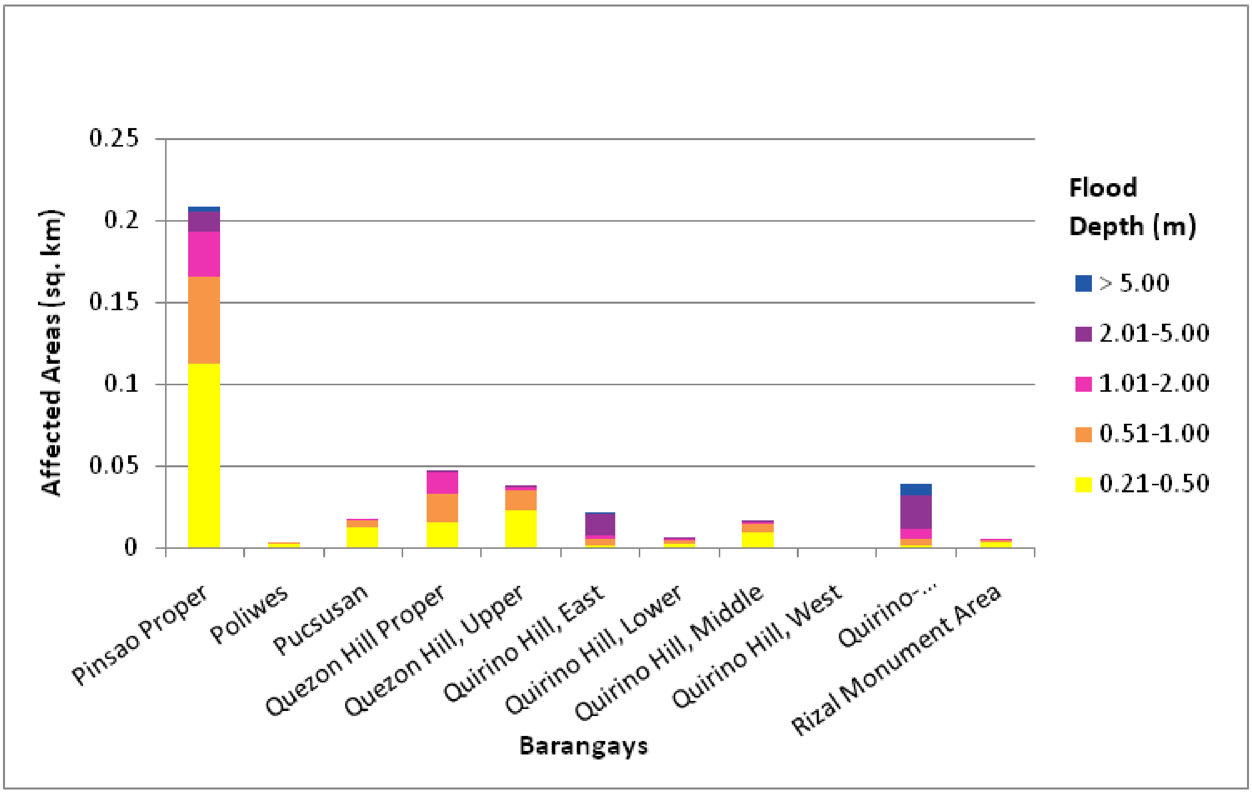


Figure 120. Affected areas in Baguio City, Benguet during a 25-year rainfall return period - H

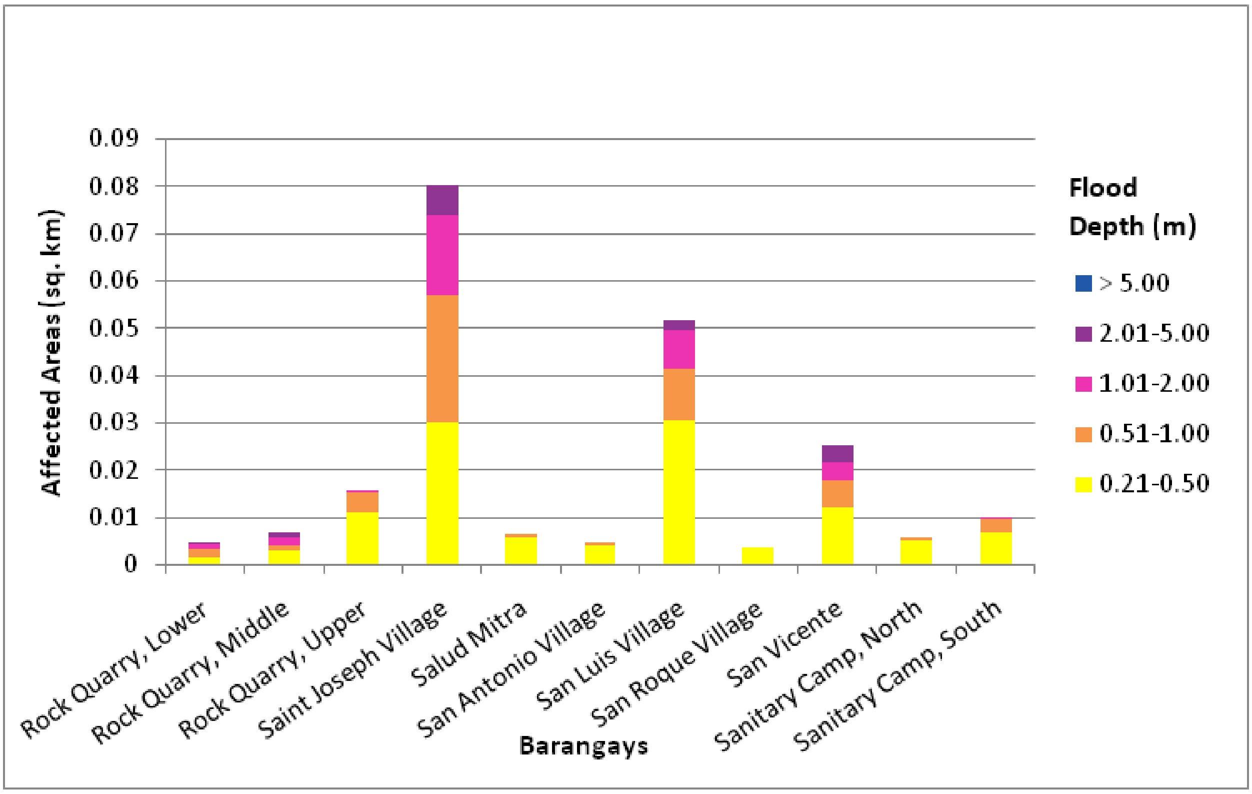


Figure 121. Affected areas in Baguio City, Benguet during a 25-year rainfall return period - I

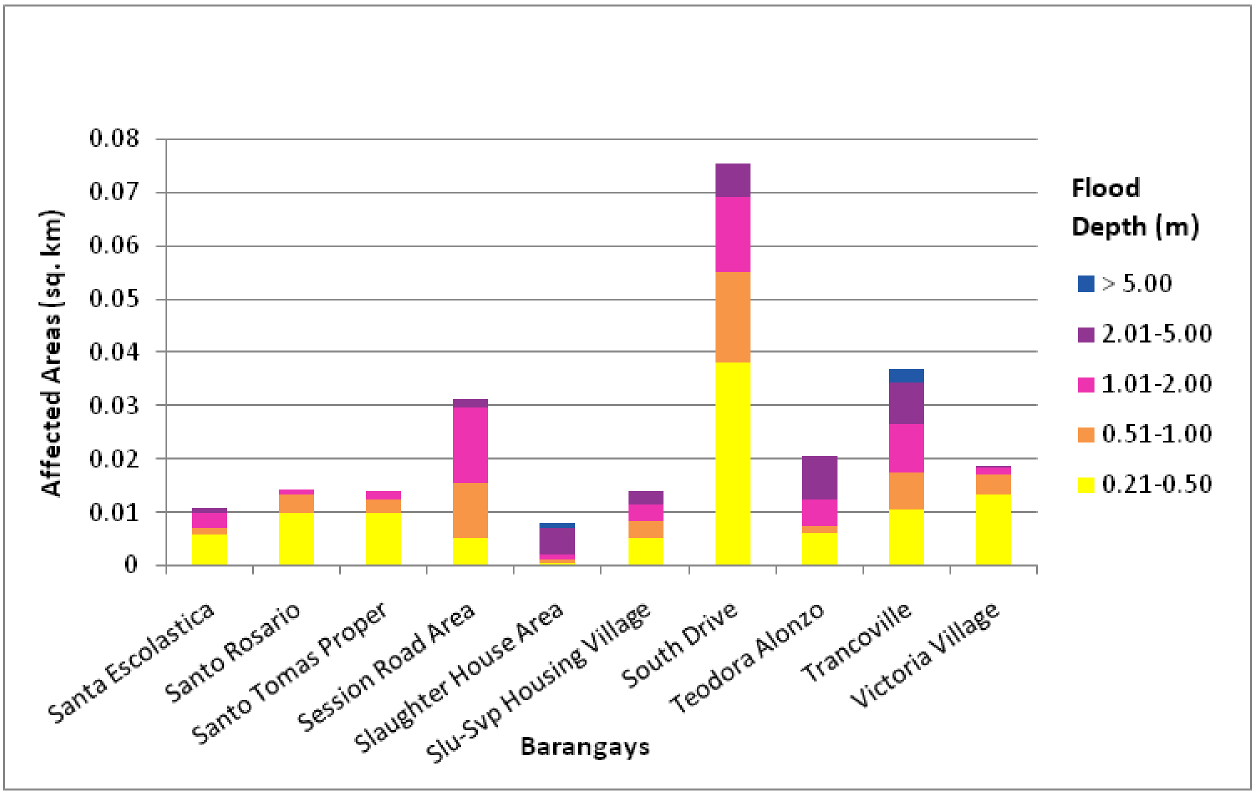


Figure 122. Affected areas in Baguio City, Benguet during a 25-year rainfall return period - J

For the 25-year return period, 30.44% of the Municipality of Kapangan, with an area of 133.9 square kilometers, will experience flood levels of less than 0.20 meters. 1.20% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 0.56%, 0.40%, 0.41%, and 0.30% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 82 are the affected areas, in square kilometers, by flood depth per barangay.

Table 82. Affected areas in Kapangan, Benguet during a 25-year rainfall return period

ARIN-GAY-BAU-ANG BASIN		Affected Barangays in Kapangan							
		Datakan	Gadang	Gasweling	Labueg	Paykek	Poblacion Central	Pongayan	Sagubo
Affected Area (sq. km.)	0-0.20	3.81	0.19	15.19	1.98	0.036	1.83	9.7	8.03
	0.21-0.50	0.16	0.0024	0.45	0.11	0.0018	0.077	0.42	0.38
	0.51-1.00	0.071	0	0.17	0.081	0	0.05	0.21	0.17
	1.01-2.00	0.046	0	0.14	0.078	0.000037	0.058	0.14	0.068
	2.01-5.00	0.054	0	0.16	0.1	0.000038	0.066	0.11	0.056
	> 5.00	0.13	0	0.21	0.037	0	0.0052	0.014	0.0013

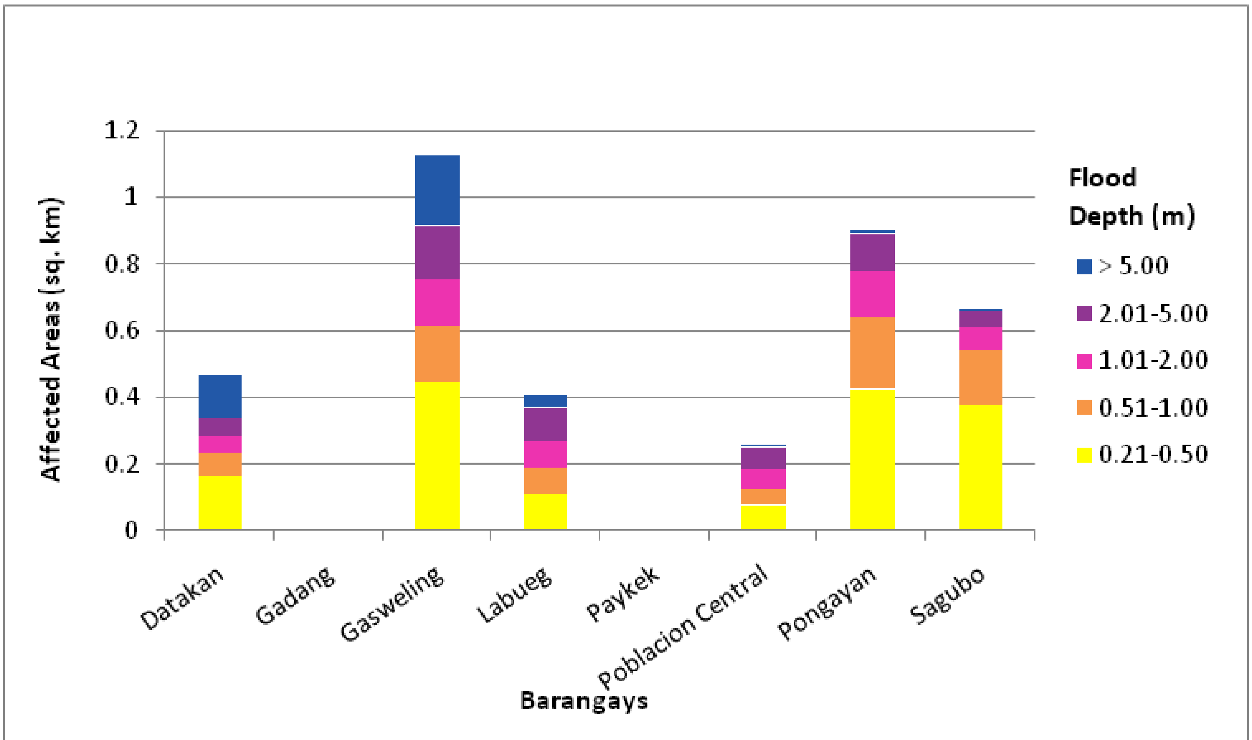


Figure 123. Affected areas in Kapangan, Benguet during a 25-year rainfall return period

For the 25-year return period, 71.44% of the Municipality of La Trinidad, with an area of 74.908 square kilometers, will experience flood levels of less than 0.20 meters. 4.06% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 2.16%, 2.16%, 3.04%, 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 Tables 83-84 are the affected areas, in square kilometers, by flood depth per barangay.

Table 83. Affected areas in La Trinidad, Benguet during a 25-year rainfall return period - A

ARINGAY-BAUANG BASIN		Affected Barangays in La Trinidad							
		Alapang	Alno	Ambiong	Bahong	Balili	Beckel	Betag	Bineng
Affected Area (sq. km.)	0-0.20	3.97	9.68	1.55	4.38	0.25	1.45	0.14	10.9
	0.21-0.50	0.25	0.41	0.063	0.34	0.076	0.067	0.056	0.59
	0.51-1.00	0.11	0.18	0.038	0.16	0.089	0.029	0.036	0.18
	1.01-2.00	0.11	0.11	0.052	0.1	0.26	0.015	0.26	0.089
	2.01-5.00	0.12	0.16	0.025	0.073	0.28	0.0041	0.93	0.047
	> 5.00	0.015	0.79	0.0028	0.013	0.017	0	0.14	0.14

Table 84. Affected areas in La Trinidad, Benguet during a 25-year rainfall return period - B

ARINGAY-BAUANG BASIN		Affected Barangays in La Trinidad							
		Cruz	Lubas	Pico	Poblacion	Puguis	Shilan	Tawang	Wangal
Affected Area (sq. km.)	0-0.20	0.46	1.39	0.96	1.79	3.5	6.55	2.24	4.31
	0.21-0.50	0.018	0.084	0.27	0.089	0.19	0.26	0.11	0.17
	0.51-1.00	0.0016	0.04	0.31	0.064	0.08	0.14	0.022	0.13
	1.01-2.00	0.0006	0.035	0.3	0.051	0.034	0.097	0.012	0.095
	2.01-5.00	0	0.038	0.25	0.17	0.015	0.069	0.0064	0.099
	> 5.00	0	0.0009	0.032	0	0	0.018	0.0005	0.027

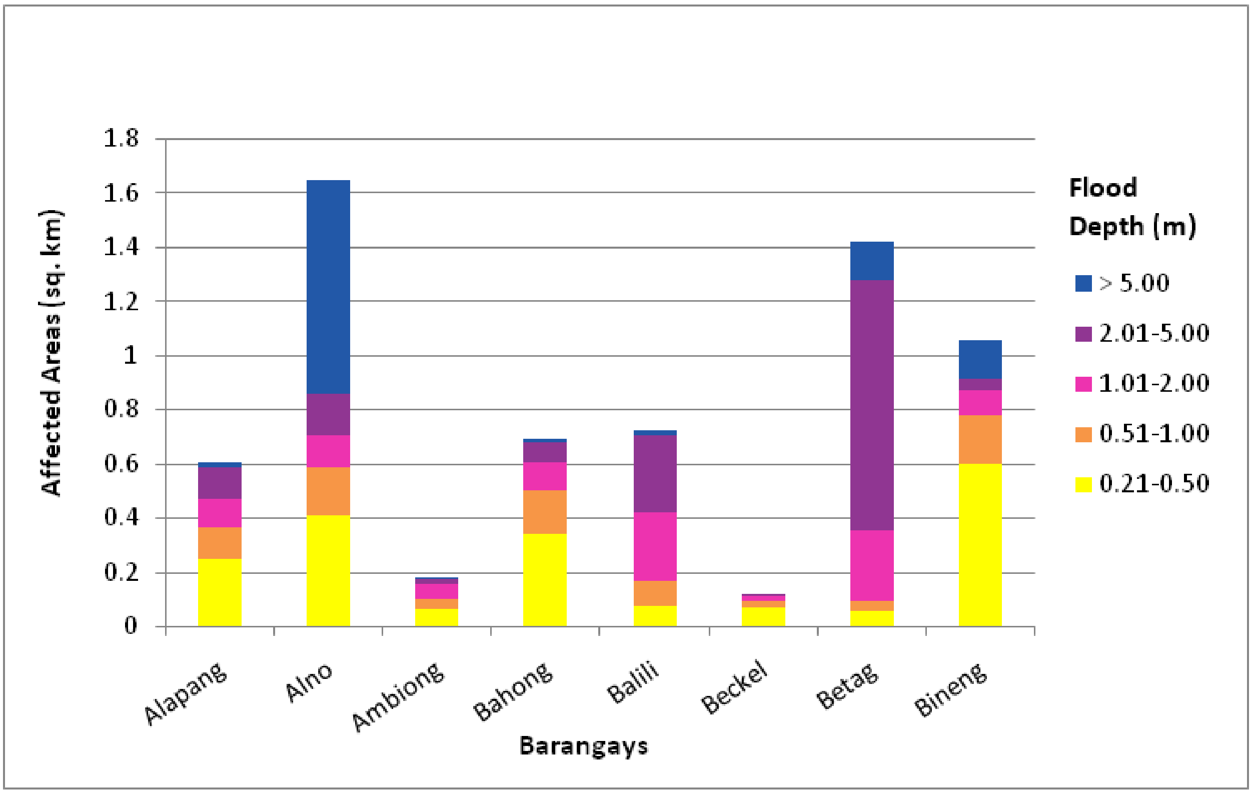


Figure 124. Affected areas in La Trinidad, Benguet during a 25-year rainfall return period - A

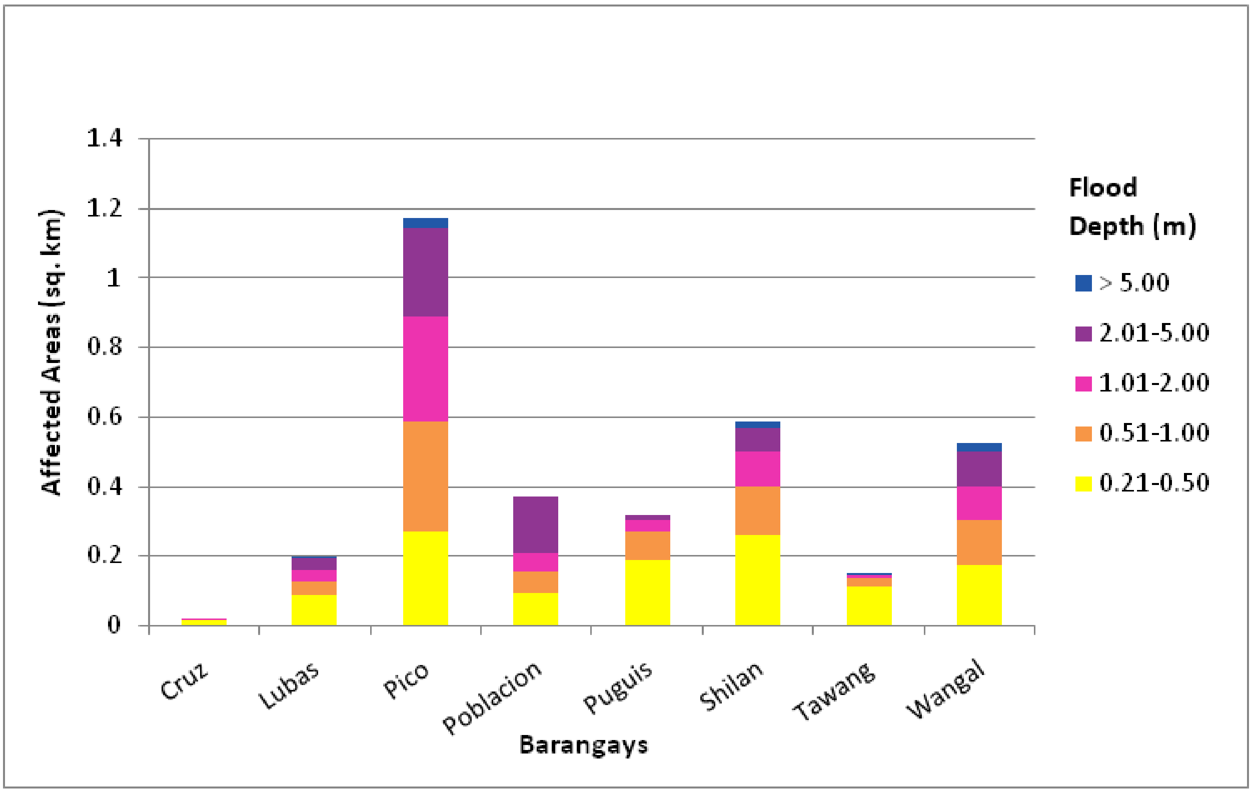


Figure 125. Affected areas in La Trinidad, Benguet during a 25-year rainfall return period - B

For the 25-year return period, 91.04% of the Municipality of Sablan, with an area of 90.22 square kilometers, will experience flood levels of less than 0.20 meters. 3.41% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 1.61%, 1.13%, 1.08%, and 1.74% 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 85 are the affected areas, in square kilometers, by flood depth per barangay.

Table 85. Affected areas in Sablan, Benguet during a 25-year rainfall return period

ARIN-GAY-BAU-ANG BASIN		Affected Barangays in Sablan							
		Bagong	Balluay	Banan-gan	Baneng-beng	Bayabas	Kamog	Pappa	Pobla-cion
Affected Area (sq. km.)	0-0.20	4.82	8.48	17.48	12.72	12.49	10.72	10.25	5.18
	0.21-0.50	0.1	0.36	0.67	0.48	0.57	0.34	0.34	0.23
	0.51-1.00	0.05	0.18	0.29	0.24	0.23	0.17	0.18	0.11
	1.01-2.00	0.036	0.12	0.22	0.13	0.17	0.13	0.13	0.092
	2.01-5.00	0.077	0.059	0.22	0.15	0.13	0.077	0.19	0.068
	> 5.00	0.87	0.1	0.052	0.42	0.024	0.056	0.039	0.004

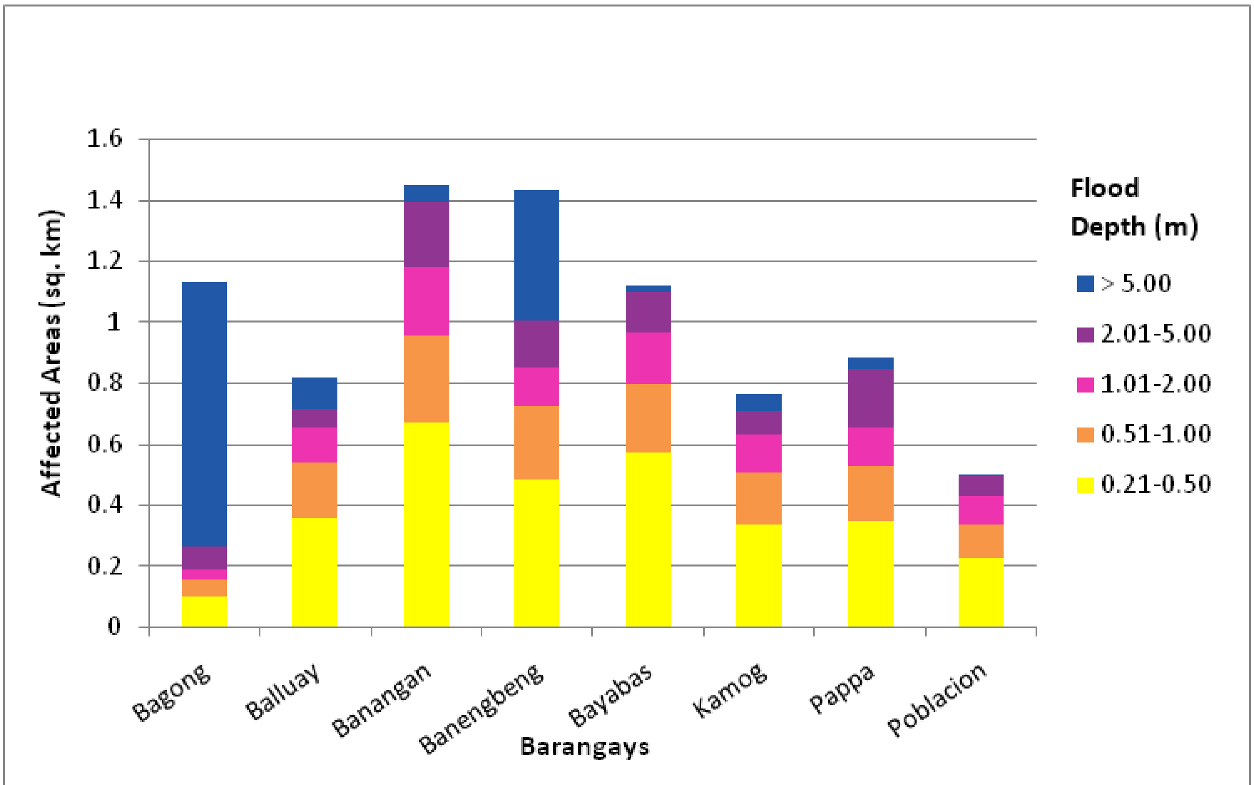


Figure 126. Affected areas in Sablan, Benguet during a 25-year rainfall return period

For the 25-year return period, 38.63% of the Municipality of Tuba, with an area of 322.02 square kilometers, will experience flood levels of less than 0.20 meters. 1.75% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 0.77%, 0.45%, 0.55%, and 0.58% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 86 are the affected areas, in square kilometers, by flood depth per barangay.

Table 86. Affected areas in Tuba, Benguet during a 25-year rainfall return period

ARIN-GAY-BAU-ANG BASIN		Affected Barangays in Tuba								
		Nan-galisan	Pobla-cion	San Pas-cual	Tabaan Norte	Tabaan Sur	Tadian-gan	Taloy Norte	Taloy Sur	Twin Peaks
Affected Area (sq. km.)	0-0.20	10.49	20.11	6.3	16.59	22.91	11.74	14.48	19.16	2.6
	0.21-0.50	0.47	1.07	0.26	0.69	1.03	0.59	0.61	0.78	0.14
	0.51-1.00	0.23	0.51	0.11	0.28	0.46	0.26	0.26	0.31	0.057
	1.01-2.00	0.18	0.25	0.085	0.13	0.26	0.17	0.16	0.22	0.0025
	2.01-5.00	0.35	0.3	0.11	0.14	0.27	0.21	0.15	0.24	0.0005
	> 5.00	0.81	0.12	0.021	0.18	0.32	0.17	0.094	0.14	0

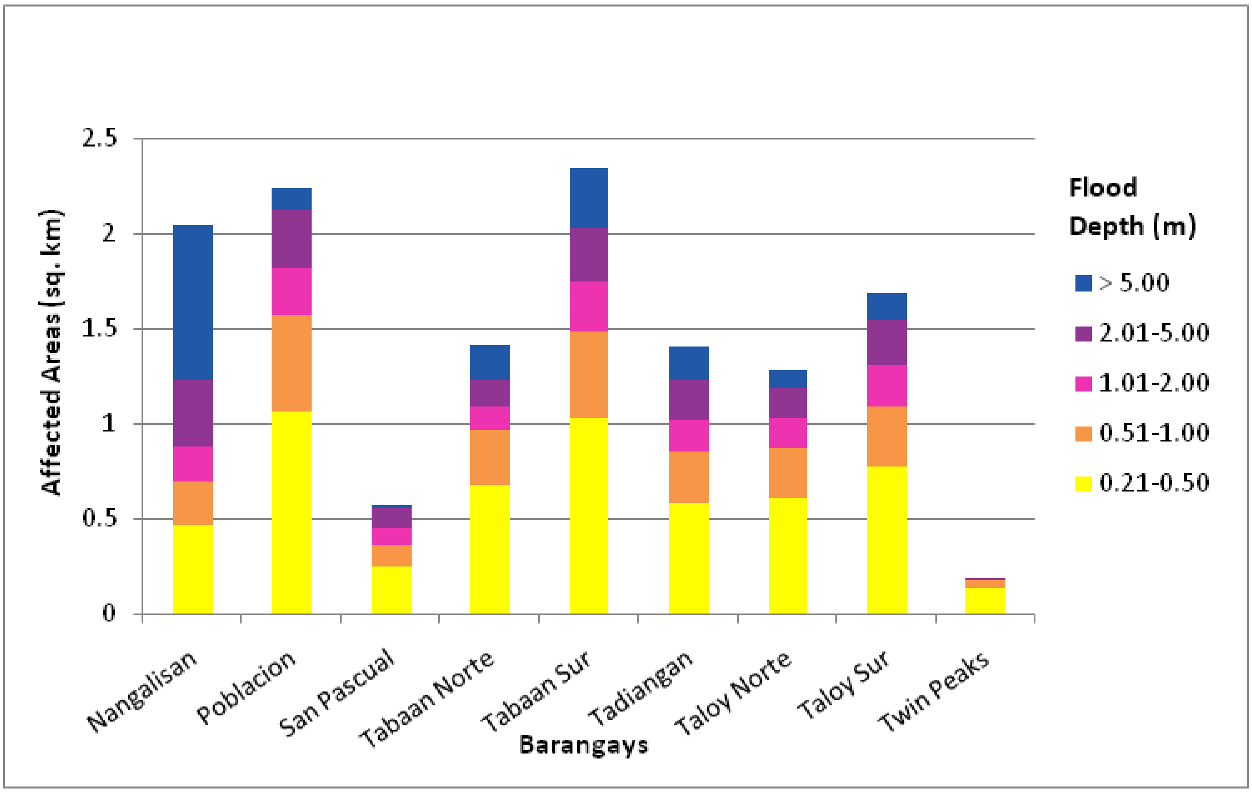


Figure 127. Affected areas in Tuba, Benguet during a 25-year rainfall return period

For the 25-year return period, 50.22% of the Municipality of Tublay, with an area of 63.21 square kilometers, will experience flood levels of less than 0.20 meters. 2.40% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 1.04%, 0.83%, 0.64%, and 0.60% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 87 are the affected areas, in square kilometers, by flood depth per barangay.

Table 87. Affected areas in Tublay, Benguet during a 25-year rainfall return period

ARIN-GAY-BAU-ANG BASIN		Affected Barangays in Tublay							
		Ambas-sador	Ambong-dolan	Ba-Ayan	Basil	Caponga	Daclan	Tublay Central	Tuel
Affected Area (sq. km.)	0-0.20	0.023	3.65	2	3.77	2.86	4.86	3.45	11.13
	0.21-0.50	0.0001	0.16	0.097	0.16	0.23	0.21	0.17	0.5
	0.51-1.00	0	0.08	0.028	0.074	0.085	0.087	0.094	0.21
	1.01-2.00	0	0.095	0.012	0.052	0.04	0.058	0.13	0.14
	2.01-5.00	0	0.05	0.0049	0.044	0.015	0.0098	0.12	0.16
	> 5.00	0	0.018	0	0.15	0	0	0.039	0.18

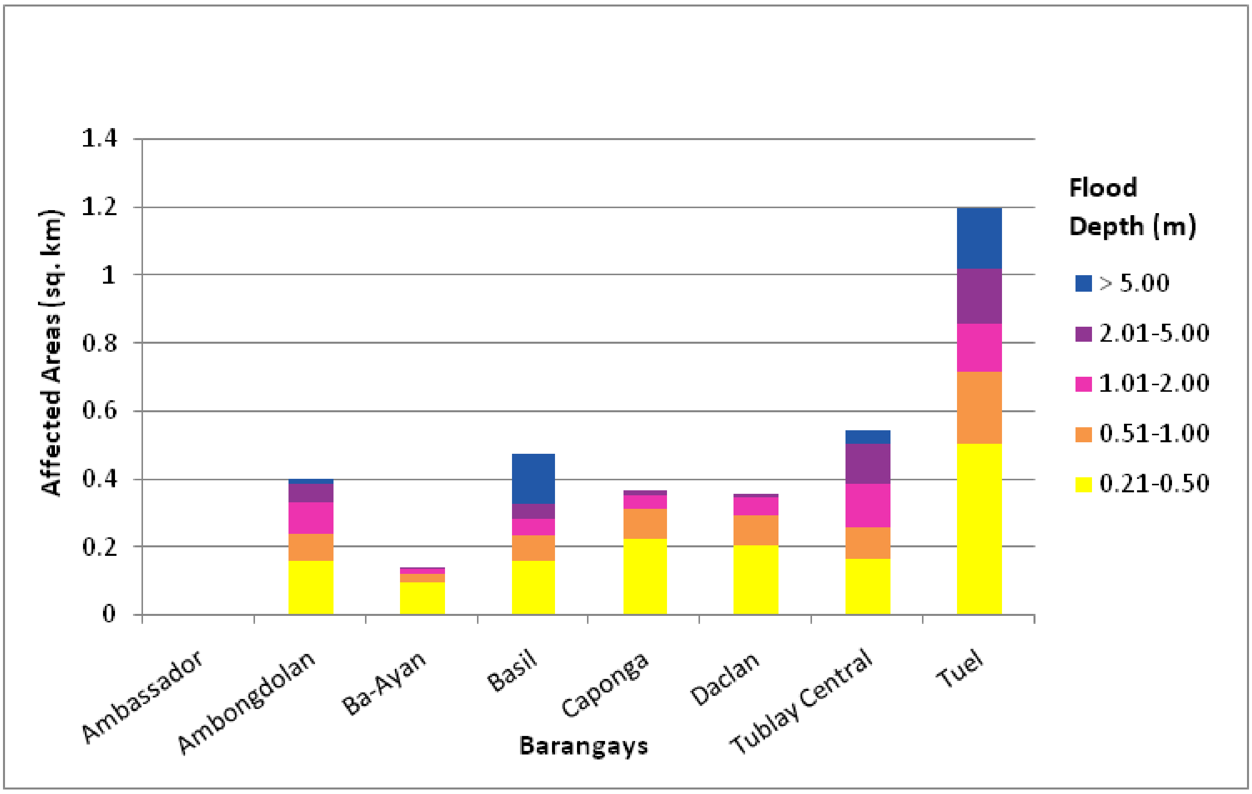


Figure 128. Affected areas in Tublay, Benguet during a 25-year rainfall return period

For the 25-year return period, 6.20% of the Municipality of Agoo, with an area of 33.71 square kilometers, will experience flood levels of less than 0.20 meters. 0.55% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 0.43%, 0.32%, 0.25%, 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 88 are the affected areas, in square kilometers, by flood depth per barangay.

Table 88. Affected areas in Agoo, La Union during a 25-year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in Agoo					
		Macalva Norte	Nazareno	Santa Ana	Santa Rita	Santa Rita East	Santa Rita Norte
Affected Area (sq. km.)	0-0.20	1.5	0.016	0.5	0.022	0.0093	0.037
	0.21-0.50	0.083	0.00046	0.05	0.022	0.002	0.028
	0.51-1.00	0.049	0	0.027	0.019	0.0029	0.048
	1.01-2.00	0.037	0	0.026	0.0065	0.0071	0.032
	2.01-5.00	0.017	0	0.05	0	0.0065	0.0095
	> 5.00	0	0	0.0017	0	0	0

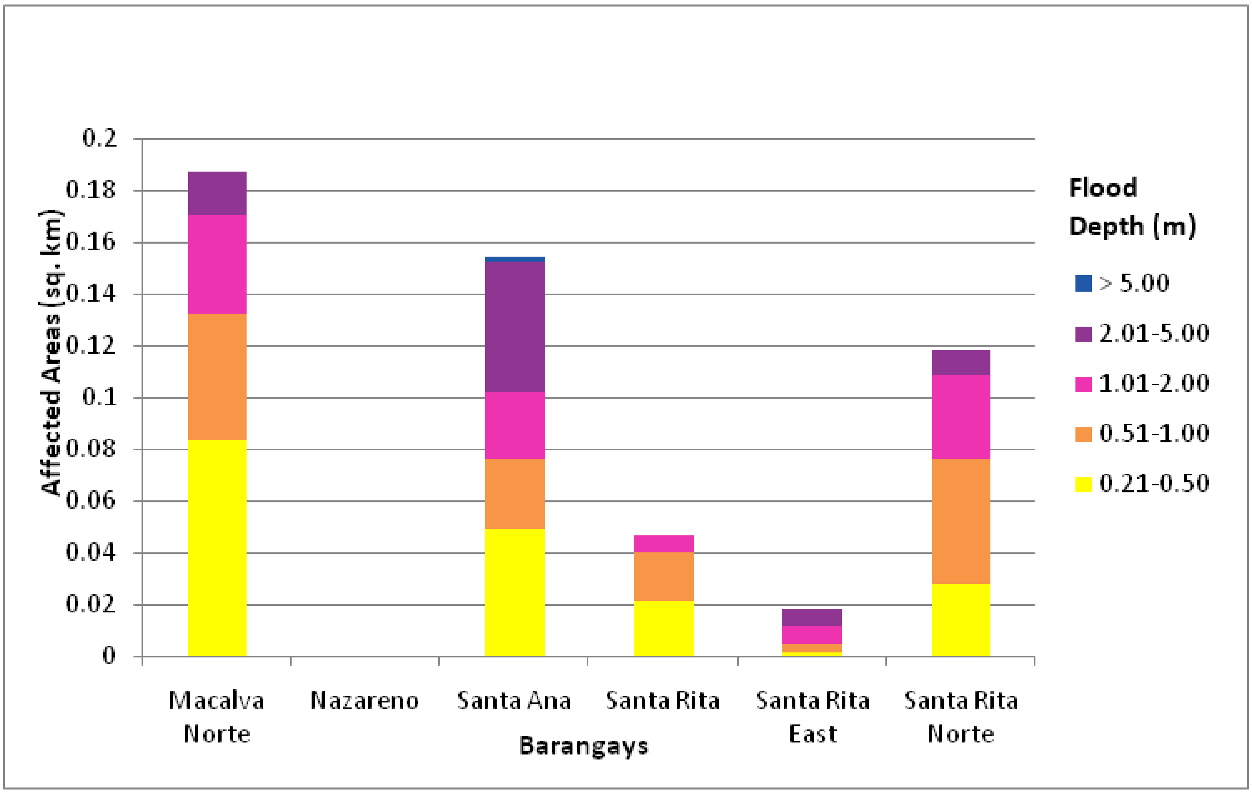


Figure 129. Affected areas in Agoo, La Union during a 25-year rainfall return period

For the 25-year return period, 64.69% of the Municipality of Aringay, with an area of 95.65 square kilometers, will experience flood levels of less than 0.20 meters. 4.57% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 3.33%, 6.37%, 9.75%, and 10.93% 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 Tables 89-90 are the affected areas, in square kilometers, by flood depth per barangay.

Table 89. Affected areas in Aringay, La Union during a 25-year rainfall return period - A

ARINGAY-BAUANG BASIN		Affected Barangays in Aringay											
		Alaska	Basca	Dulao	Gallano	Macaba-to	Manga	Pan-gao-Aoan East	Pan-gao-Aoan West	Pobla-cion	Samara	San An-tonio	San Beni-to Norte
Affected Area (sq. km.)	0-0.20	0.35	5.68	0.64	21.76	5.54	7.43	1.91	1.19	0.57	0.032	0.62	1.65
	0.21-0.50	0.14	0.28	0.46	1	0.24	0.3	0.097	0.16	0.031	0.052	0.063	0.22
	0.51-1.00	0.082	0.17	0.75	0.53	0.14	0.18	0.043	0.09	0.017	0.29	0.051	0.044
	1.01-2.00	0.4	0.11	1.42	0.34	0.12	0.13	0.045	0.12	0.025	1.7	0.15	0.031
	2.01-5.00	1.01	0.12	0.21	0.38	0.19	0.11	0.19	0.3	0.073	1.95	0.63	0.028
	> 5.00	0	0.26	0	2.1	0.048	0.0032	1.92	0.087	0.53	0.075	1.58	0.0003

Table 90. Affected areas in Aringay, La Union during a 25-year rainfall return period - B

ARINGAY-BAUANG BASIN		Affected Barangays in Aringay											
		San Beni-to Sur	San Eu-genio	San Juan East	San Juan West	San Simon East	San Simon West	Santa Cecilia	Santa Lucia	Santa Rita East	Santa Rita West	Santo Rosario East	Santo Rosario West
Affected Area (sq. km.)	0-0.20	0.54	5.1	1.91	1.8	1.21	1.59	0.21	0.14	1.59	0.26	0.14	0.0012
	0.21-0.50	0.041	0.34	0.21	0.096	0.068	0.14	0.013	0.15	0.073	0.068	0.13	0.013
	0.51-1.00	0.029	0.14	0.16	0.087	0.049	0.11	0.0099	0.091	0.048	0.012	0.035	0.035
	1.01-2.00	0.035	0.1	0.25	0.086	0.041	0.11	0.017	0.66	0.028	0.0096	0.054	0.11
	2.01-5.00	0.083	0.084	0.57	0.46	0.039	0.11	0.059	1.47	0.017	0.0069	0.05	1.21
	> 5.00	0.16	0.0003	0.18	1	0.11	0.0062	2.09	0.3	0.00088	0	0	0

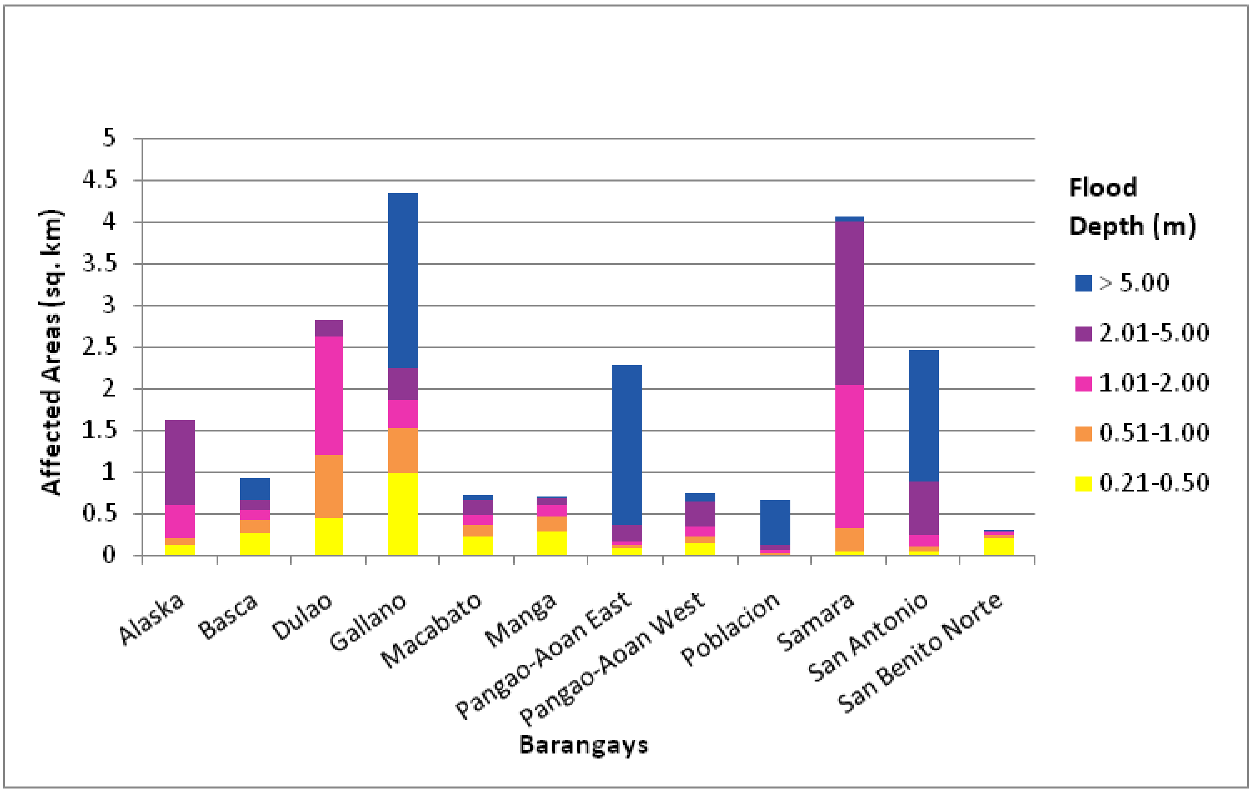


Figure 130. Affected areas in Aringay, La Union during a 25-year rainfall return period - A

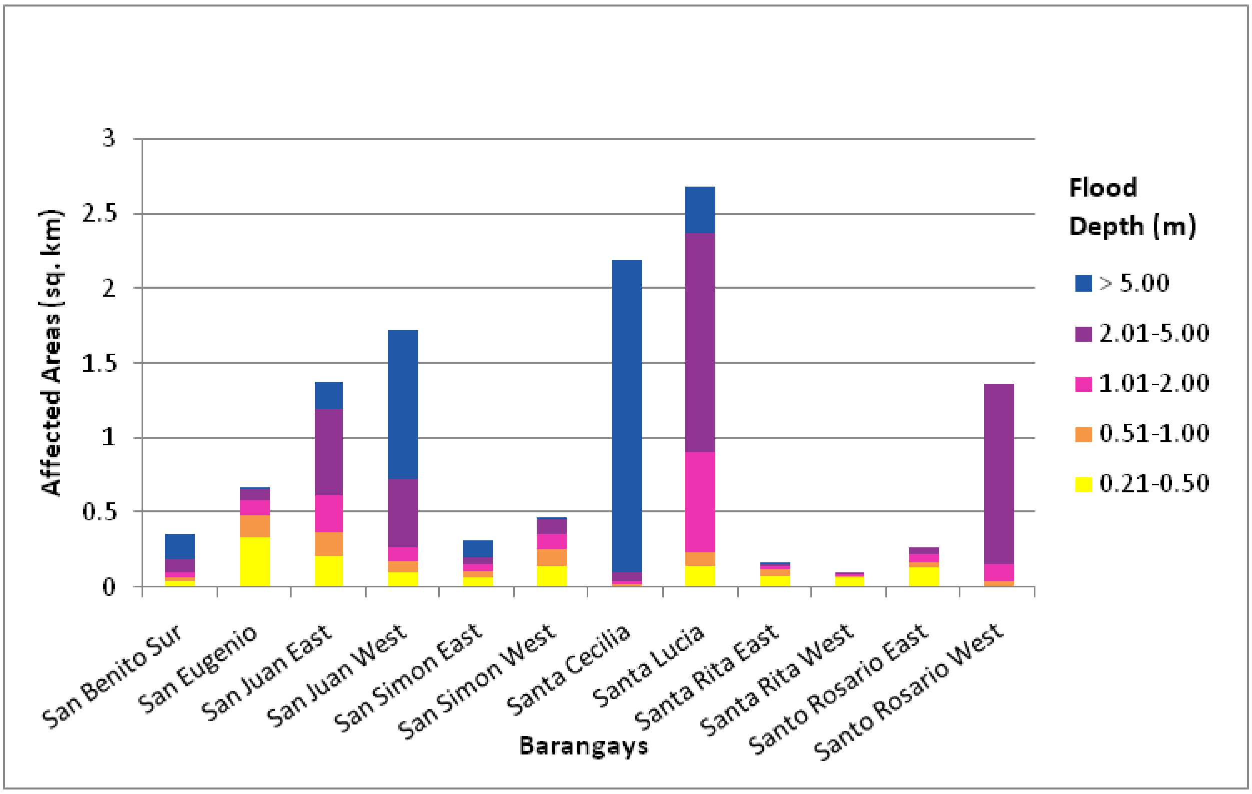


Figure 131. Affected areas in Aringay, La Union during a 25-year rainfall return period - B

For the 25-year return period, 72.84% of the Municipality of Bagulin, with an area of 77.97 square kilometers, will experience flood levels of less than 0.20 meters. 2.85% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 1.35%, 0.87%, 1.01%, and 5.30% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 91 are the affected areas, in square kilometers, by flood depth per barangay.

Table 91. Affected areas in Bagulin, La Union during a 25-year rainfall return period

ARIN-GAY-BAU-ANG BASIN		Affected Barangays in Bagulin									
		Alibang-say	Baay	Cam-baly		Dagup	Libbo	Suyo	Tagud-tud	Tio-An-gan	Wal-layan
Affected Area (sq. km.)	0-0.20	10.97	1.81	3.06	4.53	4.95	4.7	7.41	2.74	13.3	3.32
	0.21-0.50	0.35	0.079	0.13	0.15	0.22	0.17	0.39	0.12	0.46	0.14
	0.51-1.00	0.17	0.015	0.076	0.079	0.13	0.056	0.2	0.07	0.19	0.07
	1.01-2.00	0.12	0.006	0.051	0.03	0.097	0.03	0.14	0.035	0.13	0.039
	2.01-5.00	0.12	0.015	0.032	0.037	0.1	0.03	0.097	0.029	0.27	0.051
	> 5.00	1.03	0.36	0.066		0.69	0.14	0.49	0.16	0.49	0.69

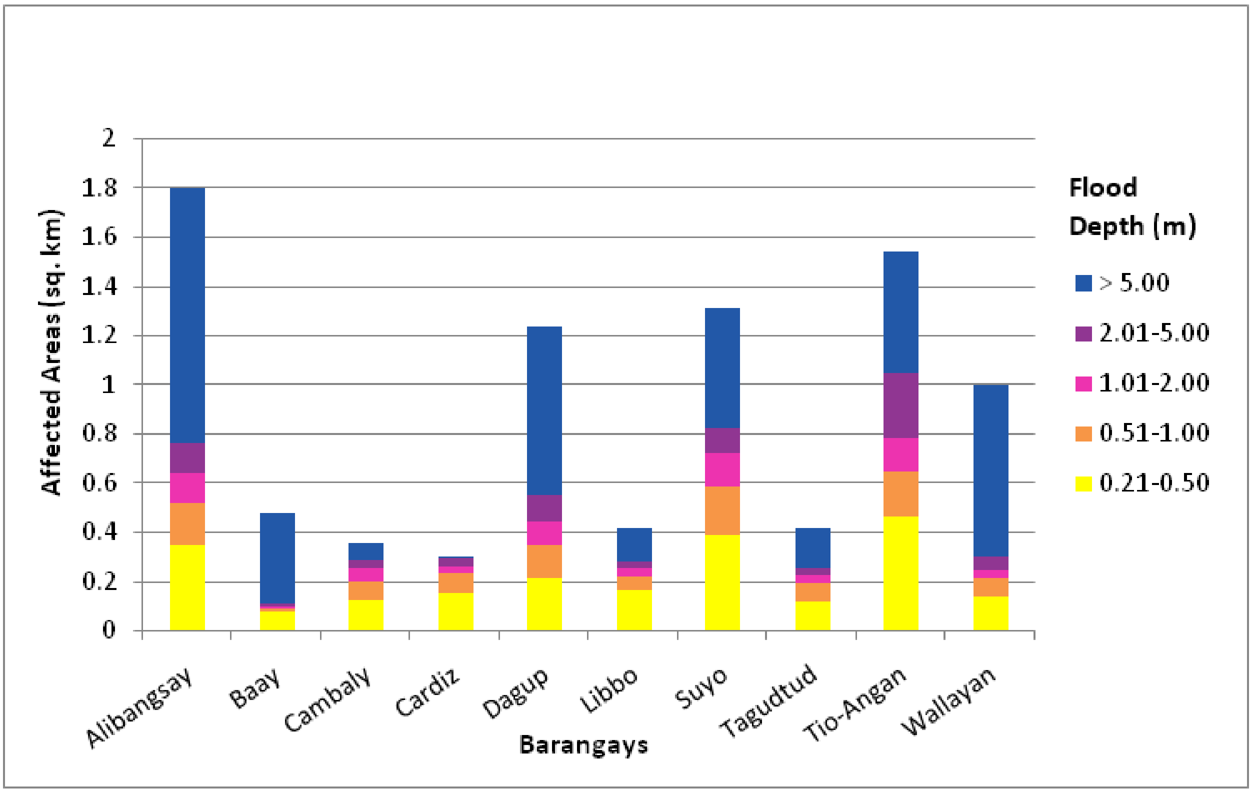


Figure 132. Affected areas in Bagulin, La Union during a 25-year rainfall return period

For the 25-year return period, 59.94% of the Municipality of Bauang, with an area of 85.26 square kilometers, will experience flood levels of less than 0.20 meters. 6.92% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 6.13%, 7.02%, 8.97%, and 9.82% 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 Tables 92-95 are the affected areas, in square kilometers, by flood depth per barangay.

Table 92. Affected areas in Bauang, La Union during a 25-year rainfall return period - A

ARINGAY-BAUANG BASIN		Affected Barangays in Bauang									
		Acao	Baccuit Norte	Baccuit Sur	Bagbag	Ballay	Bawanta	Boy-Utan	Bucayab	Cabalayan-gan	Cabisilan
Affected Area (sq. km.)	0-0.20	2.76	0.1	0.0062	0.44	0.25	0.75	3.08	2.9	4.55	1.73
	0.21-0.50	0.16	0.1	0.023	0.17	0.0033	0.041	0.32	0.18	0.3	0.16
	0.51-1.00	0.12	0.19	0.11	0.096	0.0065	0.021	0.19	0.1	0.2	0.086
	1.01-2.00	0.21	0.44	0.22	0.13	0.015	0.0089	0.12	0.13	0.31	0.047
	2.01-5.00	0.66	0.12	0.27	0.063	0.11	0.0022	0.15	0.17	0.32	0.095
	> 5.00	3.37	0	0	0.0017	1.91	0	0.83	0.028	0.94	0.045

Table 93. Affected areas in Bauang, La Union during a 25-year rainfall return period - B

ARINGAY-BAUANG BASIN		Affected Barangays in Bauang									
		Calumbaya	Carmay	Casilagan	Central East	Central West	Dili	Disso-Or	Guerrero	Lower San Agustin	Nagrebcan
Affected Area (sq. km.)	0-0.20	0.94	0.0037	5.66	0.28	0.0035	0.34	0.45	0.45	2.15	0.17
	0.21-0.50	0.18	0.019	0.46	0.025	0.0011	0.056	0.12	0.16	0.12	0.027
	0.51-1.00	0.17	0.073	0.32	0.013	0.0015	0.061	0.064	0.022	0.065	0.02
	1.01-2.00	0.12	0.1	0.34	0.02	0.0061	0.046	0.037	0.0054	0.057	0.017
	2.01-5.00	0.034	0.11	0.35	0.19	0.21	0.0005	0.027	0.0004	0.12	0.14
	> 5.00	0.00038	0.0017	0.034	0.38	0.047	0	0	0	0.096	0.52

Table 94. Affected areas in Bauang, La Union during a 25-year rainfall return period - C

ARINGAY-BAUANG BASIN		Affected Barangays in Bauang									
		Pagdalagan Sur	Palintucang	Palug-si-Limman-sangan	Parian Este	Parian Oeste	Paringao	Payocpoc Norte Este	Payocpoc Norte Oeste	Payocpoc Sur	Pilar
Affected Area (sq. km.)	0-0.20	0	0.44	4.99	0.28	0.072	0.0029	1.51	0.4	0.37	0.028
	0.21-0.50	0	0.061	0.35	0.22	0.078	0.02	0.2	0.47	0.17	0.025
	0.51-1.00	0	0.066	0.23	0.6	0.29	0.062	0.18	0.55	0.12	0.025
	1.01-2.00	0.000003	0.1	0.15	0.15	1.18	0.25	0.11	0.35	0.093	0.00037
	2.01-5.00	0	0.068	0.05	0.28	0.24	0.17	0.13	0.021	0.0049	0
	> 5.00	0	0.0043	0.0003	0.068	0	0	0.0097	0	0	0

Table 95. Affected areas in Bauang, La Union during a 25-year rainfall return period - D

ARINGAY-BAUANG BASIN		Affected Barangays in Bauang								
		Pottot	Pudoc	Pugo	Quinavite	Santa Mon-ica	Santiago	Taberna	Upper San Agustin	Urayong
Affected Area (sq. km.)	0-0.20	0.5	0.01	0	0.5	5.68	1.09	0.0056	7.84	0.39
	0.21-0.50	0.12	0.027	0.0003	0.14	0.3	0.28	0.0013	0.63	0.18
	0.51-1.00	0.13	0.11	0.009	0.05	0.2	0.12	0.02	0.41	0.12
	1.01-2.00	0.055	0.22	0.15	0.025	0.16	0.07	0.13	0.36	0.037
	2.01-5.00	0.0002	0.64	1.21	0.07	0.11	0.013	1.03	0.47	0.002
	> 5.00	0	0	0.064	0	0.0053	0	0.0015	0.013	0

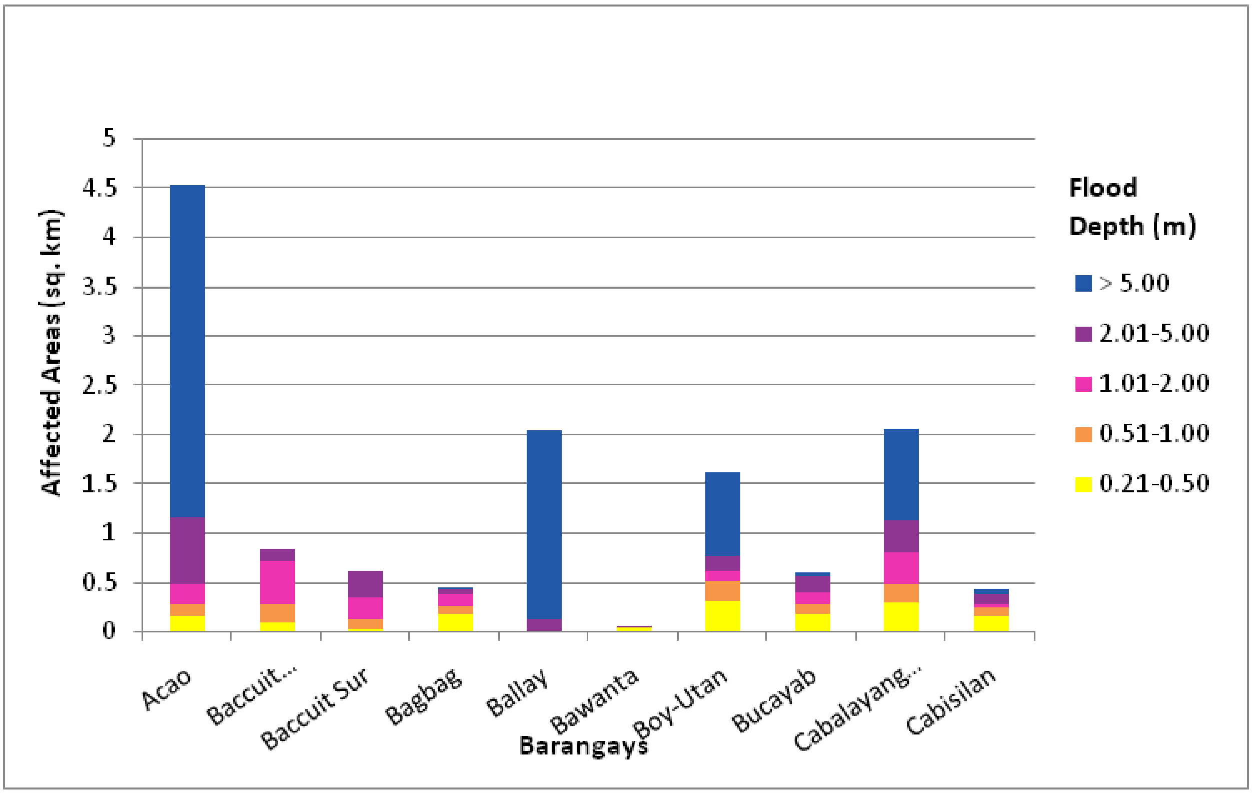


Figure 133. Affected areas in Bauang, La Union during a 25-year rainfall return period - A

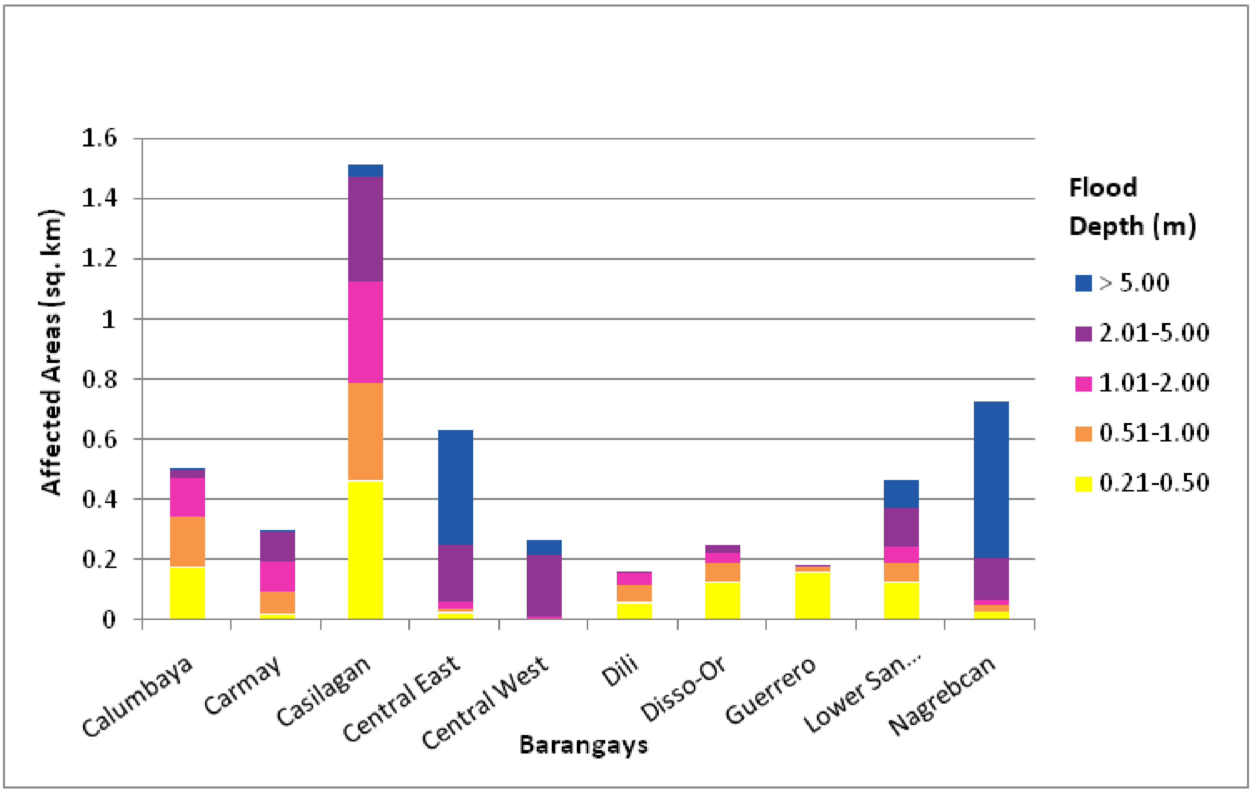


Figure 134. Affected areas in Bauang, La Union during a 25-year rainfall return period - B

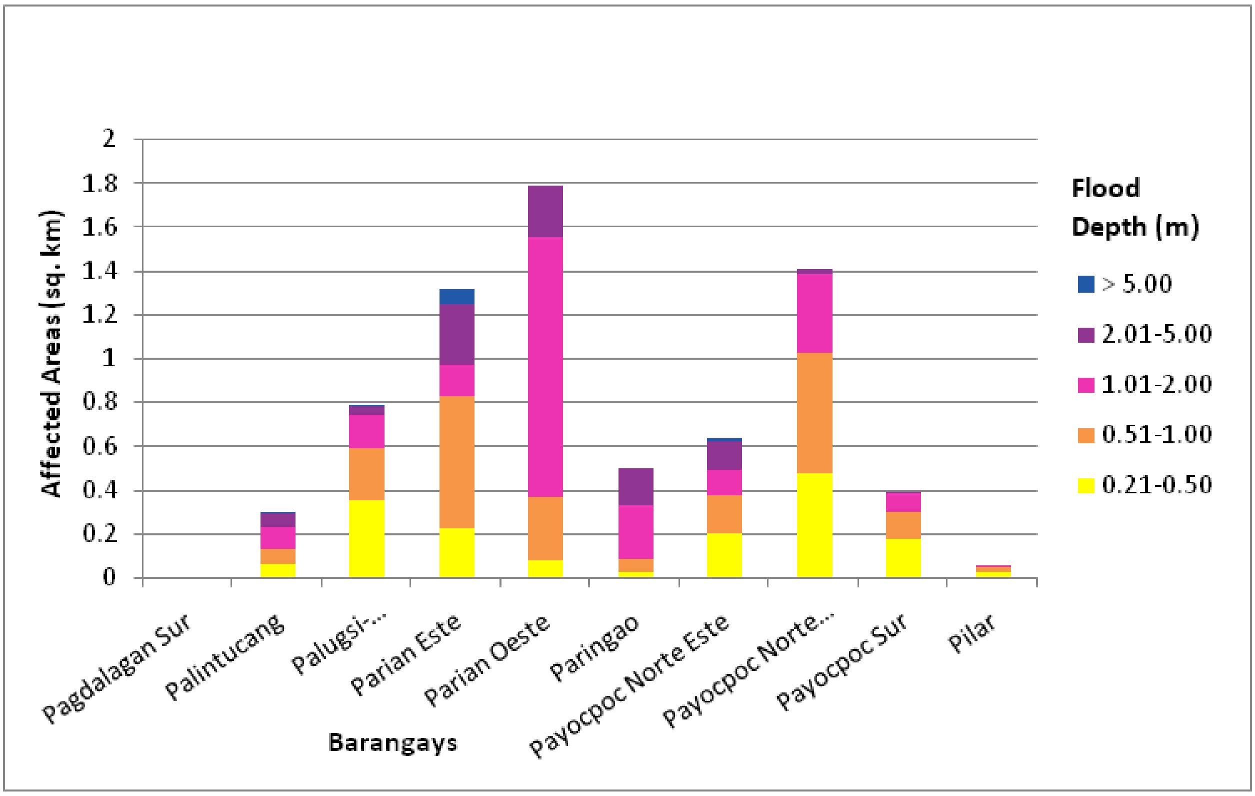


Figure 135. Affected areas in Bauang, La Union during a 25-year rainfall return period - C

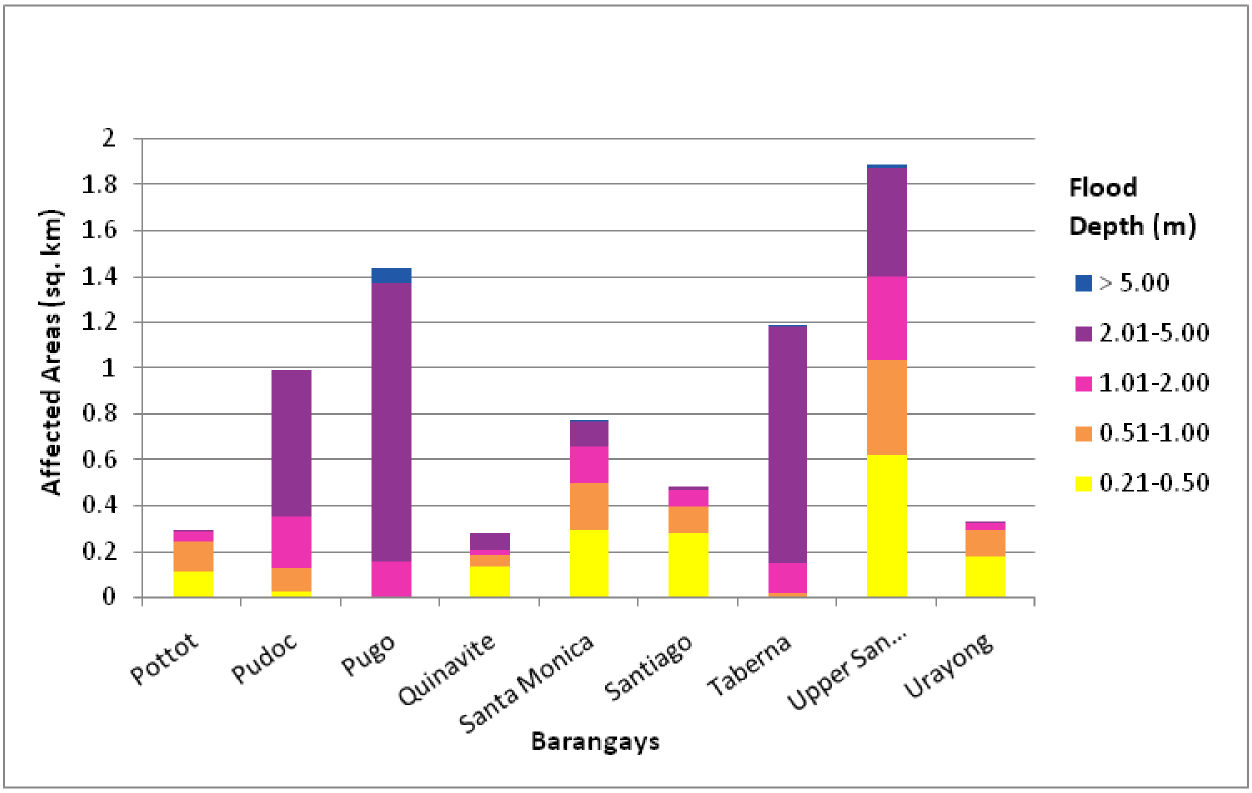


Figure 136 - Affected areas in Bauang, La Union during a 25-year rainfall return period - D

For the 25-year return period, 89.12% of the Municipality of Burgos, with an area of 51.92 square kilometers, will experience flood levels of less than 0.20 meters. 3.74% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 1.58%, 1.05%, 1.29%, and 3.22% 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 96 are the affected areas, in square kilometers, by flood depth per barangay.

Table 96. Affected areas in Burgos, La Union during a 25-year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in Burgos											
		Agpay	Bilis	Caoayan	Dalacdac	Delles	Imelda	Libtong	Linuan	Lower Tumapoc	New Po-blacion	Old Po-blacion	Upper Tumapoc
Affected Area (sq. km.)	0-0.20	2.98	4.64	0.36	2.24	11.51	3.82	4.64	3.97	1.06	3.3	1.31	6.44
	0.21-0.50	0.14	0.18	0.0083	0.08	0.45	0.19	0.23	0.094	0.041	0.2	0.067	0.26
	0.51-1.00	0.067	0.058	0.013	0.046	0.22	0.093	0.082	0.056	0.022	0.037	0.025	0.1
	1.01-2.00	0.036	0.045	0.0084	0.029	0.13	0.066	0.054	0.037	0.013	0.032	0.019	0.071
	2.01-5.00	0.036	0.046	0.01	0.067	0.09	0.067	0.057	0.041	0.054	0.028	0.044	0.13
	> 5.00	0.1	0.053	0.076	0.41	0.015	0.099	0.064	0.55	0.022	0.0091	0.097	0.17

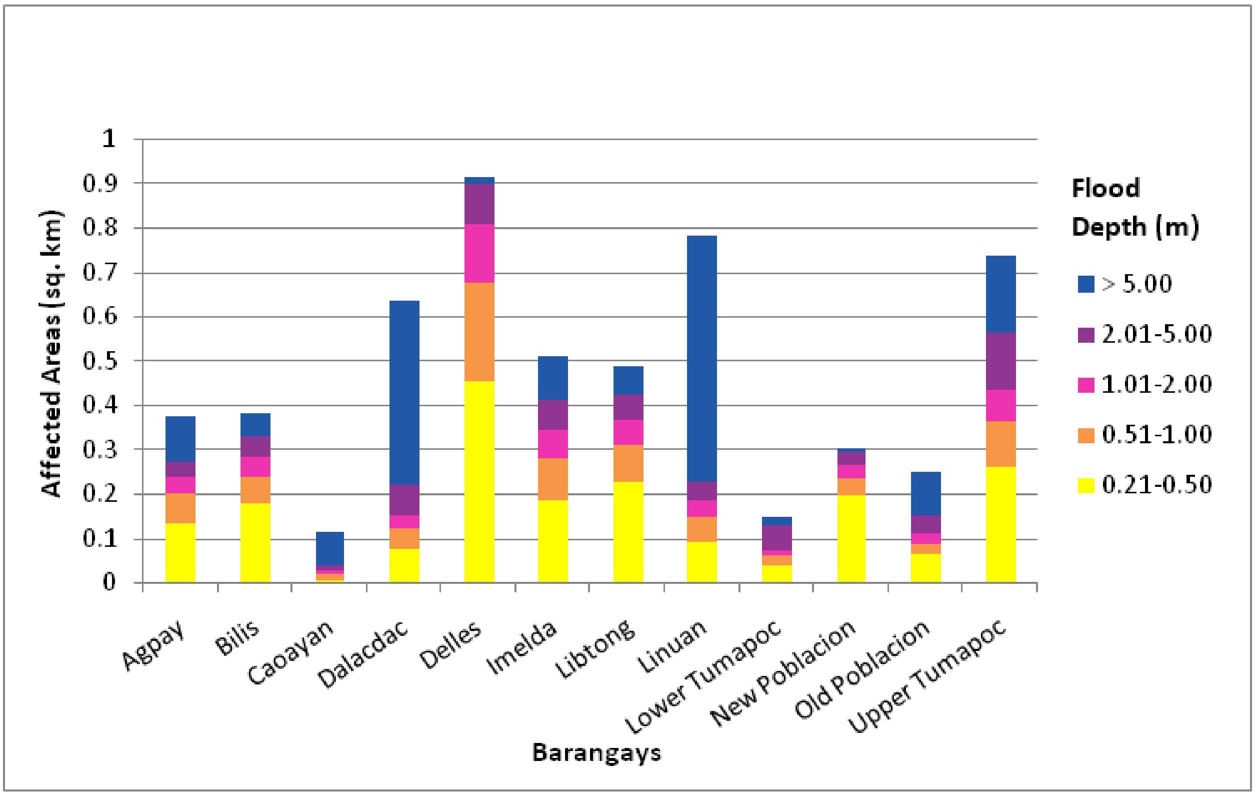


Figure 137. Affected areas in Burgos, La Union during a 25-year rainfall return period

For the 25-year return period, 69.01% of the Municipality of Caba, with an area of 56.19 square kilometers, will experience flood levels of less than 0.20 meters. 7.78% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 5.46%, 5.84%, 8.02%, and 3.86% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Tables 97-98 are the affected areas, in square kilometers, by flood depth per barangay.

Table 97. Affected areas in Caba, La Union during a 25-year rainfall return period - A

ARINGAY-BAUANG BASIN		Affected Barangays in Caba								
		Bautista	Gana	Juan Cartas	Las-Ud	Liquicia	Poblacion Norte	Pobla-cion Sur	San Carlos	San Cor-nelio
Affected Area (sq. km.)	0-0.20	2.47	0.89	2.35	0.097	12.94	0.33	0.31	0.2	4.94
	0.21-0.50	0.44	0.76	0.19	0.045	0.61	0.088	0.14	0.3	0.4
	0.51-1.00	0.2	0.3	0.11	0.042	0.42	0.073	0.042	0.31	0.29
	1.01-2.00	0.086	0.11	0.048	0.047	0.41	0.19	0.025	0.41	0.26
	2.01-5.00	0.041	0.095	0.024	0.012	0.74	0.25	0.016	0.082	0.31
	> 5.00	0.001	0	0.0011	0	1.13	0.02	0	0	0.23

Table 98. Affected areas in Caba, La Union during a 25-year rainfall return period - B

ARINGAY-BAUANG BASIN		Affected Barangays in Caba							
		San Fer-min	San Gre-gorio	San Jose	Santiago Norte	Santiago Sur	Sobredillo	Urayong	Wenceslao
Affected Area (sq. km.)	0-0.20	4.7	1.8	2.11	0.015	0.02	3.71	1.79	0.11
	0.21-0.50	0.34	0.12	0.24	0.073	0.048	0.18	0.26	0.13
	0.51-1.00	0.24	0.11	0.15	0.17	0.24	0.1	0.12	0.14
	1.01-2.00	0.19	0.12	0.14	0.29	0.84	0.067	0.022	0.025
	2.01-5.00	0.29	0.18	0.56	0.11	1.74	0.035	0.0052	0
	> 5.00	0.41	0.15	0.2	0	0	0.029	0	0

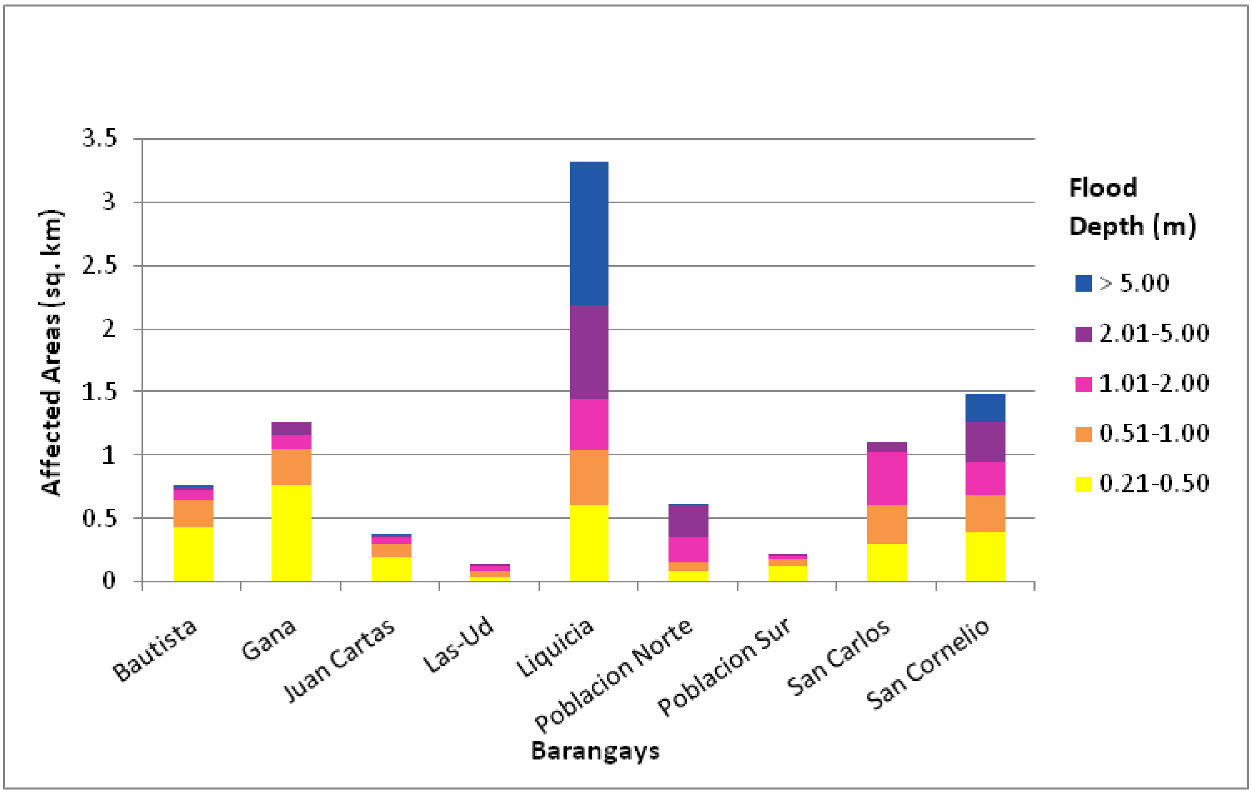


Figure 138. Affected areas in Caba, La Union during a 25-year rainfall return period - A

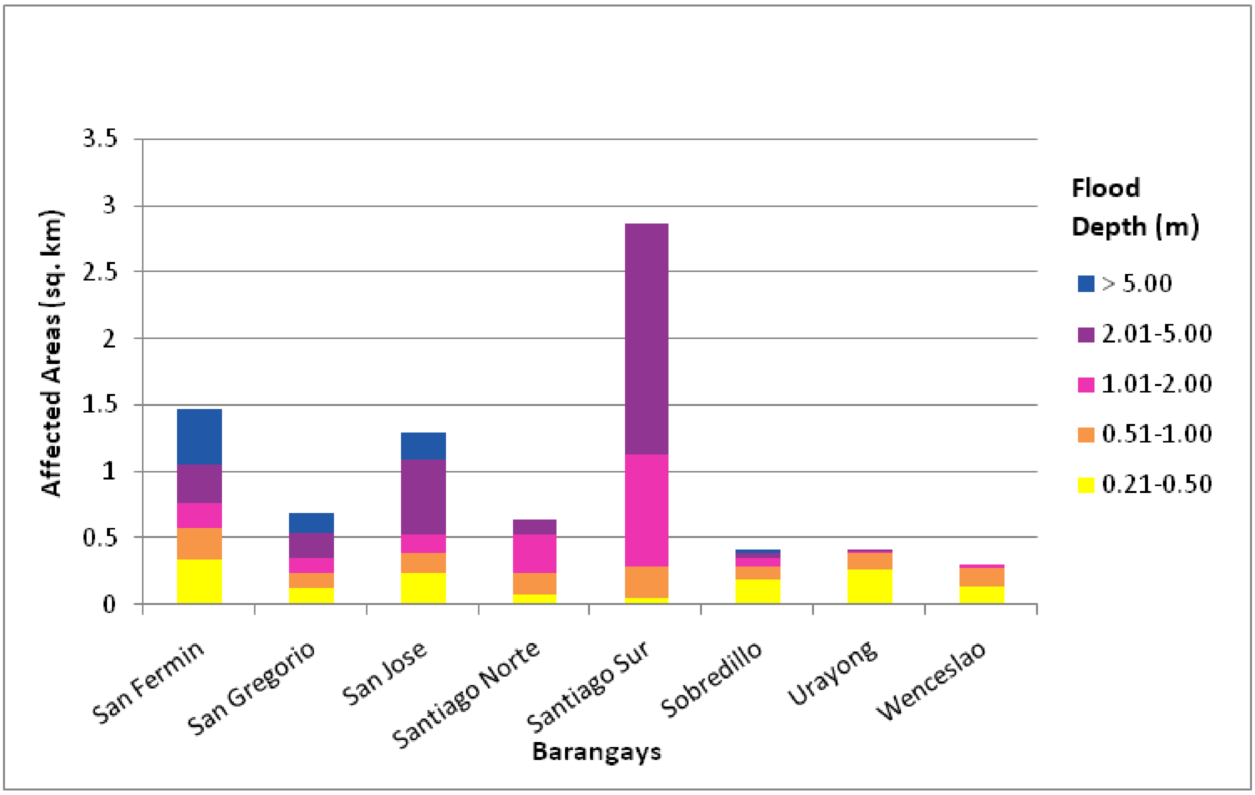


Figure 139. Affected areas in Caba, La Union during a 25-year rainfall return period - B

For the 25-year return period, 66.21% of the Municipality of Naguilian, with an area of 86.39 square kilometers, will experience flood levels of less than 0.20 meters. 3.41% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 2.28%, 1.95%, 4.29%, and 21.89% 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 Tables 99-102 are the affected areas, in square kilometers, by flood depth per barangay.

Table 99. Affected areas in Naguilian, La Union during a 25-year rainfall return period - A

ARINGAY-BAUANG BASIN		Affected Barangays in Naguilian									
		Aguioas	Al-Alinao Norte	Al-Alinao Sur	Ambaracao Norte	Ambaracao Sur	Angin	Balecbec	Bancagan	Baraoas Norte	Baraoas Sur
Affected Area (sq. km.)	0-0.20	0.47	1.92	3.01	2.19	1.64	0.23	3.52	0.38	0.000051	0.041
	0.21-0.50	0.016	0.15	0.13	0.18	0.14	0.013	0.17	0.0057	0.000043	0.00091
	0.51-1.00	0.012	0.14	0.054	0.24	0.14	0.0049	0.1	0.006	0.00016	0.0023
	1.01-2.00	0.019	0.23	0.028	0.17	0.062	0.0022	0.092	0.01	0.00074	0.0036
	2.01-5.00	0.062	0.32	0.047	0.41	0.079	0.00065	0.19	0.11	0.25	0.092
	> 5.00	0.68	1.04	0.3	1.97	0.044	0.000085	0.21	1.45	0.4	0.34

Table 100. Affected areas in Naguilian, La Union during a 25-year rainfall return period - B

ARINGAY-BAUANG BASIN		Affected Barangays in Naguilian									
		Bariquir	Bato	Bimmoto-bot	Cabaritan Norte	Cabaritan Sur	Casilagan	Dal-Li-paoen	Daramuan-gan	Guesset	Gusing Norte
Affected Area (sq. km.)	0-0.20	1.03	1.58	4.05	0.00051	0.03	5.35	0.0073	0.091	0.42	3.54
	0.21-0.50	0.034	0.086	0.19	0	0.0008	0.23	0.0002	0.0055	0.027	0.14
	0.51-1.00	0.015	0.074	0.11	0	0.0013	0.14	0.0001	0.0083	0.02	0.076
	1.01-2.00	0.0072	0.058	0.072	0.00035	0.0044	0.11	0.00067	0.016	0.0043	0.064
	2.01-5.00	0.01	0.03	0.069	0.0045	0.046	0.19	0.0013	0.033	0.0001	0.074
	> 5.00	0.027	0.017	0.03	0.29	0.26	0.37	0.47	0.74	0	0.73

Table 101. Affected areas in Naguilian, La Union during a 25-year rainfall return period - C

ARINGAY-BAUANG BASIN		Affected Barangays in Naguilian									
		Gusing Sur	Imelda	Lioac Norte	Lioac Sur	Magungu-nay	Mamat-Ing Norte	Mamat-Ing Sur	Nagsido-risan	Natividad	Ortiz
Affected Area (sq. km.)	0-0.20	1.9	0.26	0.5	0.48	2.74	1.15	1.15	0.53	1.07	0.00019
	0.21-0.50	0.079	0.011	0.013	0.031	0.18	0.03	0.05	0.043	0.12	0.0016
	0.51-1.00	0.047	0.0054	0.0073	0.013	0.13	0.015	0.022	0.028	0.065	0.0037
	1.01-2.00	0.064	0.0043	0.0099	0.015	0.14	0.016	0.023	0.016	0.046	0.0088
	2.01-5.00	0.1	0.0006	0.042	0.035	0.45	0.041	0.065	0.028	0.1	0.045
	> 5.00	1.43	0	0.46	0.054	0.43	0.84	1.81	0.013	0.37	0.43

Table 102. Affected areas in Naguilian, La Union during a 25-year rainfall return period - D

ARINGAY-BAUANG BASIN		Affected Barangays in Naguilian						
		Ribsuan	San Anto-nio	San Isidro	Sili	Suguidan Norte	Suguidan Sur	Tuddingan
Affected Area (sq. km.)	0-0.20	0.99	4.64	7.23	0.7	0.31	1.99	2.05
	0.21-0.50	0.052	0.24	0.31	0.057	0.014	0.12	0.08
	0.51-1.00	0.014	0.13	0.18	0.04	0.008	0.065	0.048
	1.01-2.00	0.0052	0.083	0.12	0.012	0.0072	0.1	0.063
	2.01-5.00	0.013	0.071	0.16	0.017	0.021	0.37	0.13
	> 5.00	0.19	0.0055	0.093	0.13	0.55	2.34	0.4

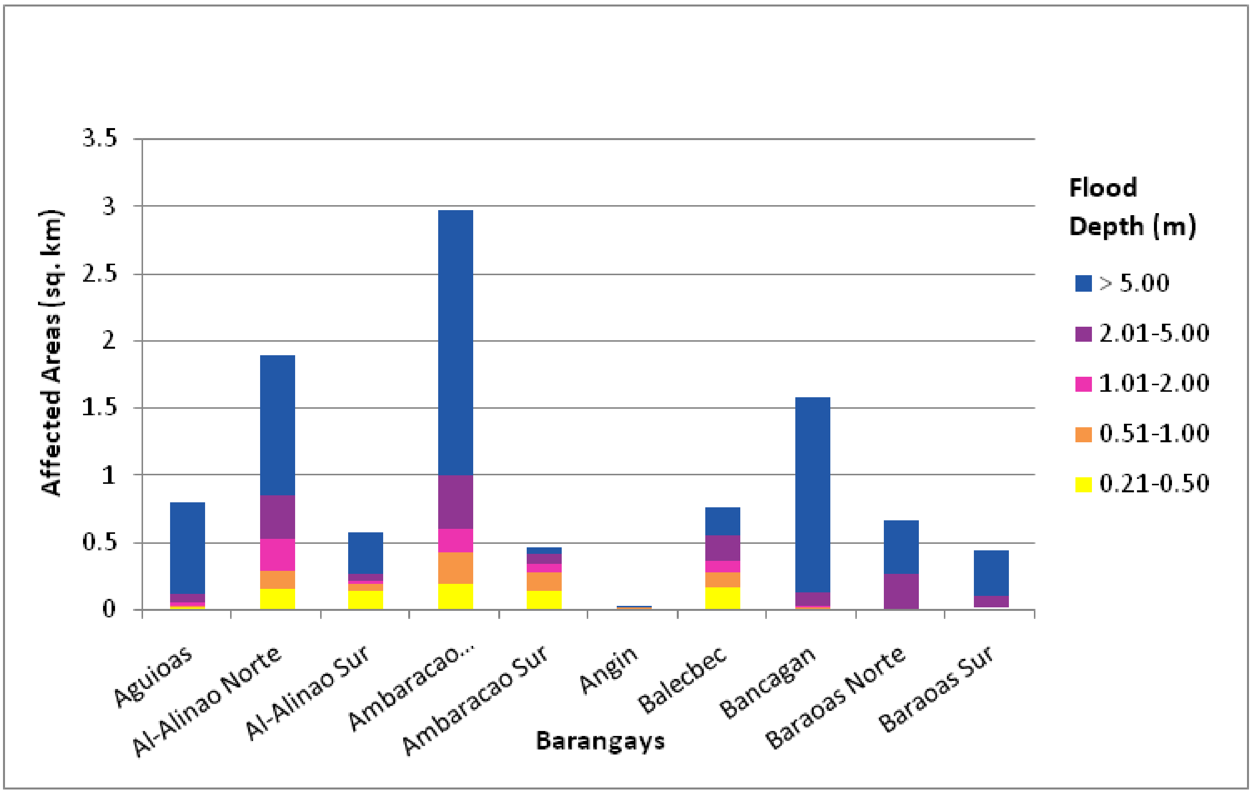


Figure 140. Affected areas in Naguilian, La Union during a 25-year rainfall return period - A

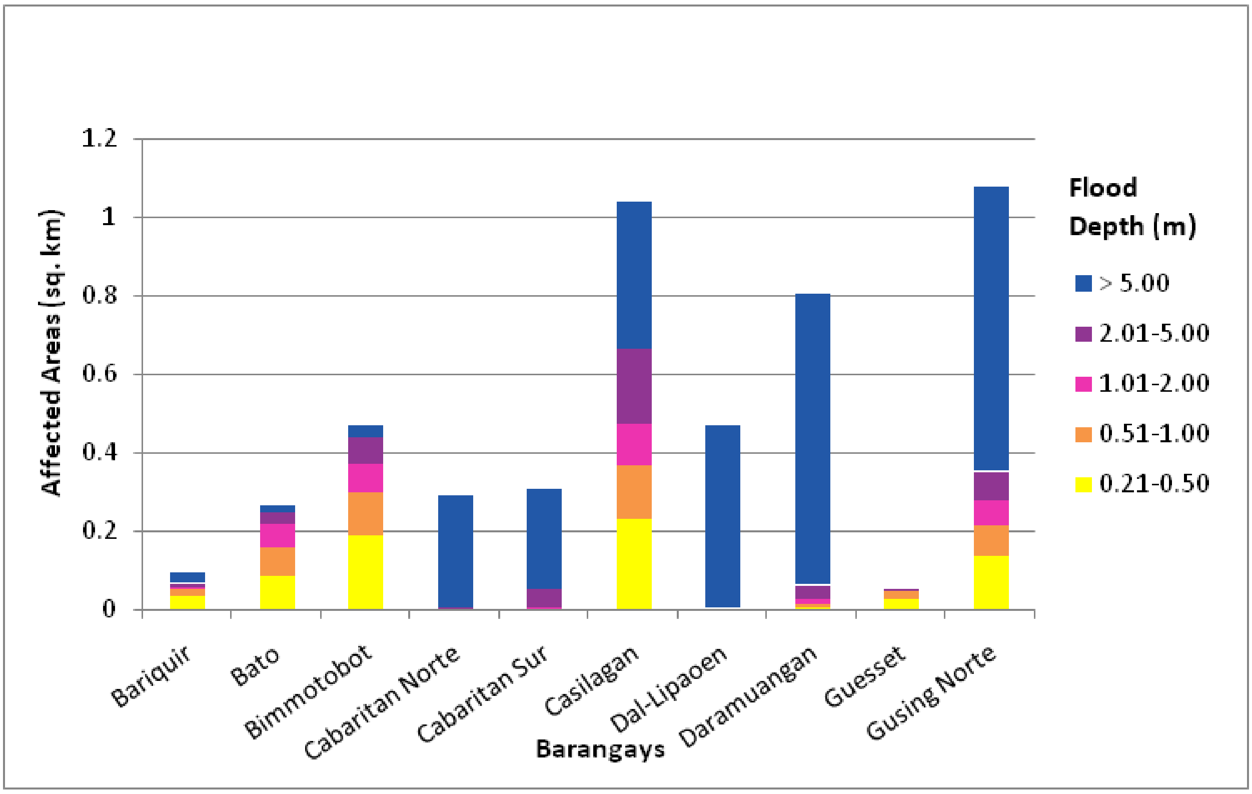


Figure 141. Affected areas in Naguilian, La Union during a 25-year rainfall return period - B

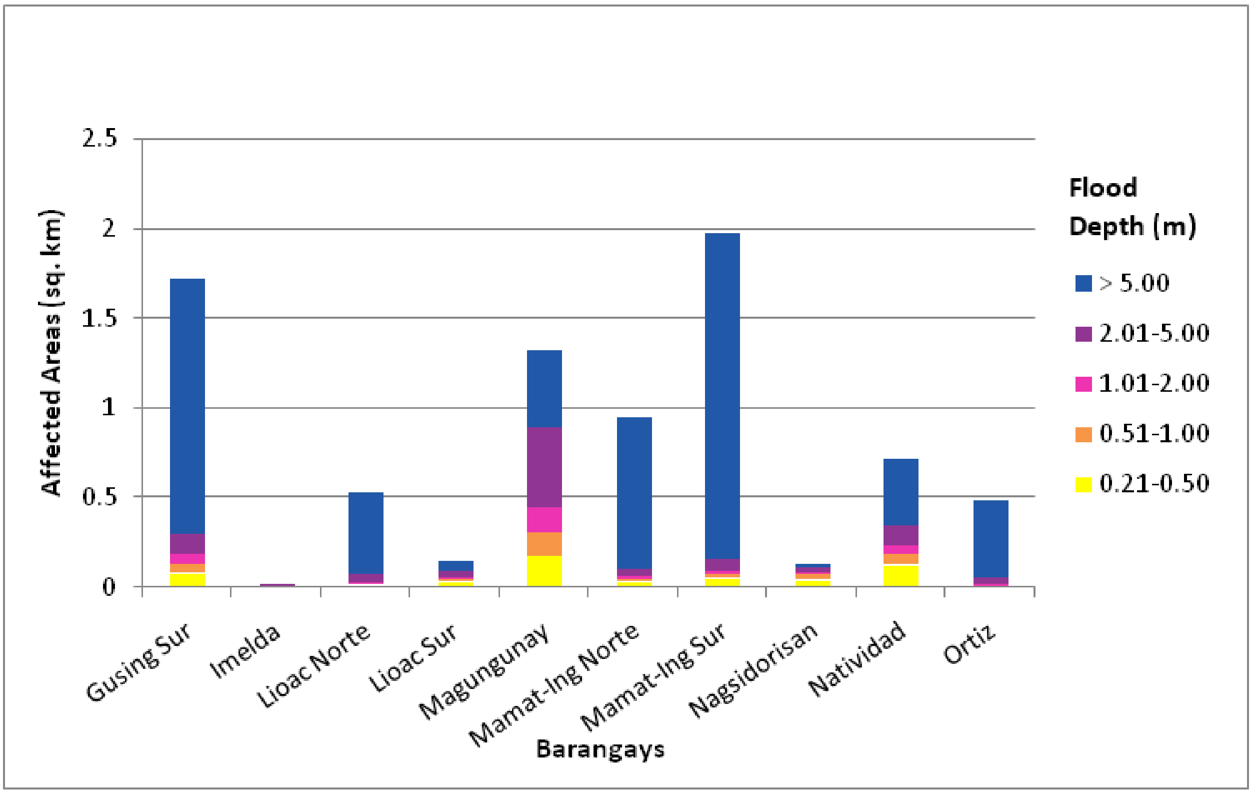


Figure 142. Affected areas in Naguilian, La Union during a 25-year rainfall return period - C

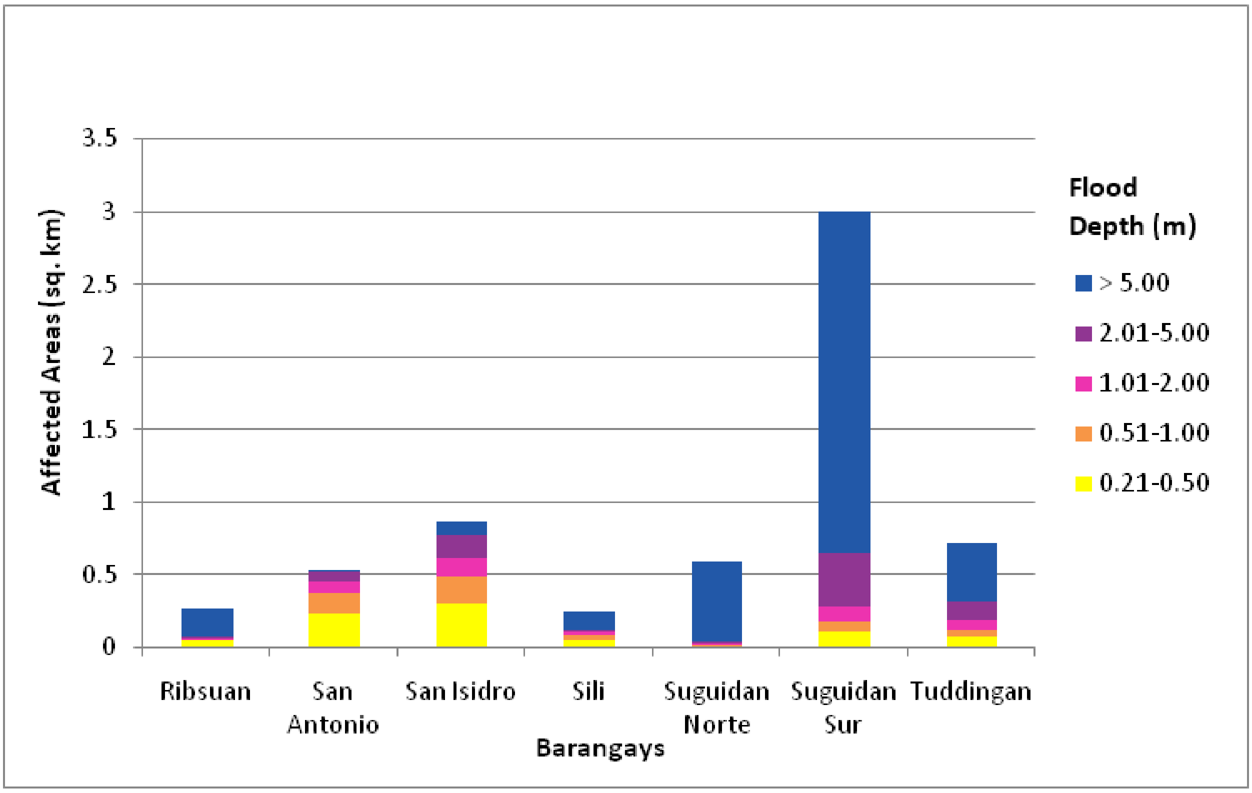


Figure 143. Affected areas in Naguilian, La Union during a 25-year rainfall return period - D

For the 25-year return period, 67.28% of the Municipality of Pugo, with an area of 60.54 square kilometers, will experience flood levels of less than 0.20 meters. 3.67% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 2.50%, 3.21%, 4.84%, and 1.40% 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 103 are the affected areas, in square kilometers, by flood depth per barangay.

Table 103. Affected areas in Pugo, La Union during a 25-year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in Pugo											
		Ambalite	Amban-gonan	Cares	Duplas	Mao-asoas Norte	Mao-asoas Sur	Palina	Pobla-cion East	Pobla-cion West	San Luis	Tavora East	Tavora Proper
Affected Area (sq. km.)	0-0.20	2.56	4.09	3.1	0.88	1.14	1.57	19.93	2.95	2.09	1.1	0.23	1.08
	0.21-0.50	0.15	0.21	0.23	0.041	0.1	0.084	0.94	0.16	0.15	0.05	0.015	0.094
	0.51-1.00	0.11	0.13	0.22	0.032	0.098	0.069	0.47	0.095	0.082	0.025	0.069	0.11
	1.01-2.00	0.27	0.15	0.25	0.028	0.16	0.047	0.26	0.073	0.12	0.015	0.24	0.33
	2.01-5.00	0.4	0.2	0.35	0.073	0.16	0.033	0.26	0.032	0.18	0.0031	0.67	0.56
	> 5.00	0.03	0.011	0.16	0.0068	0.13	0.074	0.12	0.041	0.098	0	0.12	0.059

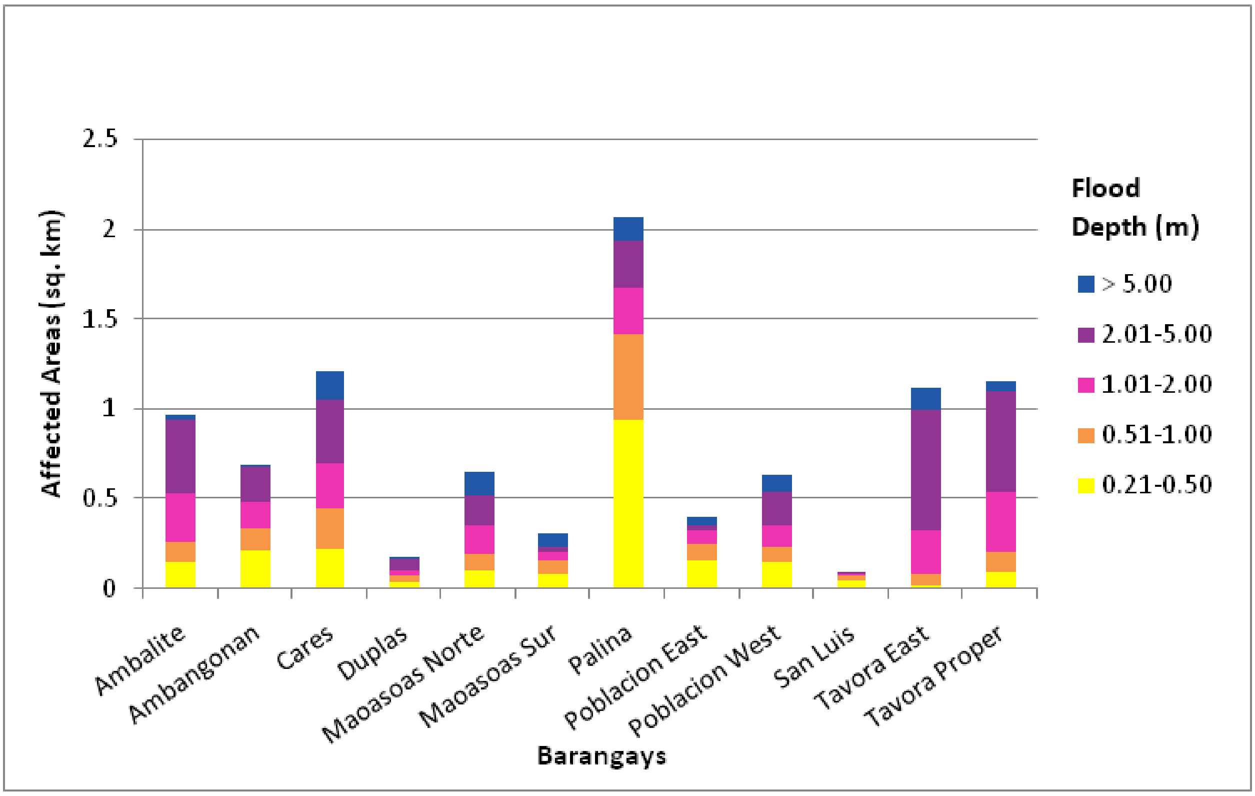


Figure 144. Affected areas in Pugo, La Union during a 25-year rainfall return period

For the 25-year return period, 6.31% of the Municipality of Rosario, with an area of 64.33 square kilometers, will experience flood levels of less than 0.20 meters. 0.32% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 0.19%, 0.14%, and 0.10% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and 2.01 to 5 meters, respectively. Listed in Table 104 are the affected areas, in square kilometers, by flood depth per barangay.

Table 104. Affected areas in Rosario, La Union during a 25-year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in Rosario				
		Ambango-nan	Inabaan Norte	Marcos	Parasapas	San Jose
Affected Area (sq. km.)	0-0.20	0.25	0.75	1.22	1.22	0.62
	0.21-0.50	0.014	0.022	0.066	0.067	0.034
	0.51-1.00	0.0059	0.014	0.051	0.035	0.016
	1.01-2.00	0.0045	0.0083	0.041	0.023	0.01
	2.01-5.00	0.0011	0.0018	0.036	0.018	0.0052
	> 5.00	0	0	0	0	0

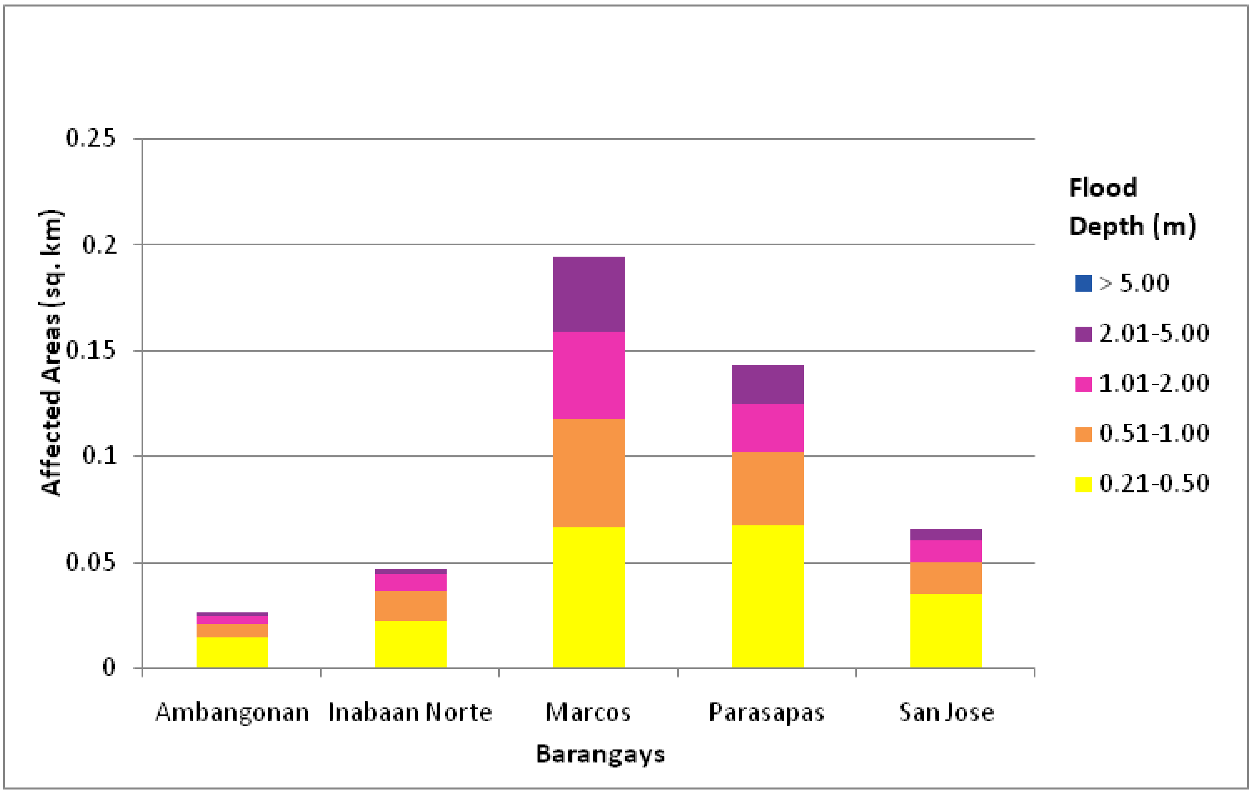


Figure 145. Affected areas in Rosario, La Union during a 25-year rainfall return period

For the 25-year return period, 36.05% of the Municipality of San Fernando City, with an area of 121.05 square kilometers, will experience flood levels of less than 0.20 meters. 2.36% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 1.46%, 1.18%, 1.48%, and 4.43% 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 Tables 105-106 are the affected areas, in square kilometers, by flood depth per barangay.

Table 105. Affected areas in San Fernando City, La Union during a 25-year rainfall return period - A

ARINGAY-BAUANG BASIN		Affected Barangays in San Fernando City											
		Apaleng	Bacsil	Bangbangolan	Birunget	Bungro	Cabarsican	Cadaclan	Calabugao	Langcuas	Masicong	Nagyubuyuban	Namtutan
Affected Area (sq. km.)	0-0.20	4.04	5.37	0.87	2.94	0.2	1.31	2.22	1.61	0.21	1.31	0.73	0.15
	0.21-0.50	0.22	0.32	0.068	0.19	0.11	0.047	0.12	0.085	0.012	0.05	0.035	0.011
	0.51-1.00	0.15	0.22	0.028	0.17	0.067	0.024	0.069	0.063	0.005	0.027	0.021	0.0029
	1.01-2.00	0.16	0.19	0.0075	0.1	0.087	0.032	0.041	0.035	0.0013	0.014	0.011	0.0028
	2.01-5.00	0.3	0.21	0.0011	0.04	0.074	0.11	0.058	0.019	0.0002	0.025	0.0022	0
	> 5.00	0.25	0.089	0	0.0006	0.0003	1.07	0.011	0.0004	0	1.6	0	0

Table 106. Affected areas in San Fernando City, La Union during a 25-year rainfall return period - B

ARINGAY-BAUANG BASIN		Affected Barangays in San Fernando City											
		Narra Este	Narra Oeste	Pacpaco	Pao Norte	Pao Sur	Pias	Puspus	Sacyud	Sagayad	Sevilla	Sibo-an-Otong	Tanquigan
Affected Area (sq. km.)	0-0.20	3.87	2.3	0.72	2.49	3.12	0.92	0.64	3.34	0.43	0.37	2.91	1.57
	0.21-0.50	0.21	0.26	0.041	0.11	0.22	0.1	0.031	0.15	0.052	0.03	0.21	0.16
	0.51-1.00	0.15	0.13	0.018	0.066	0.12	0.074	0.021	0.1	0.057	0.022	0.12	0.05
	1.01-2.00	0.11	0.12	0.012	0.024	0.087	0.017	0.011	0.081	0.081	0.085	0.098	0.03
	2.01-5.00	0.1	0.15	0.0044	0.0071	0.12	0.0098	0.0009	0.17	0.076	0.21	0.079	0.011
	> 5.00	0.00014	0.02	0.0001	0	0.17	0.0013	0	2.13	0.0006	0.015	0	0

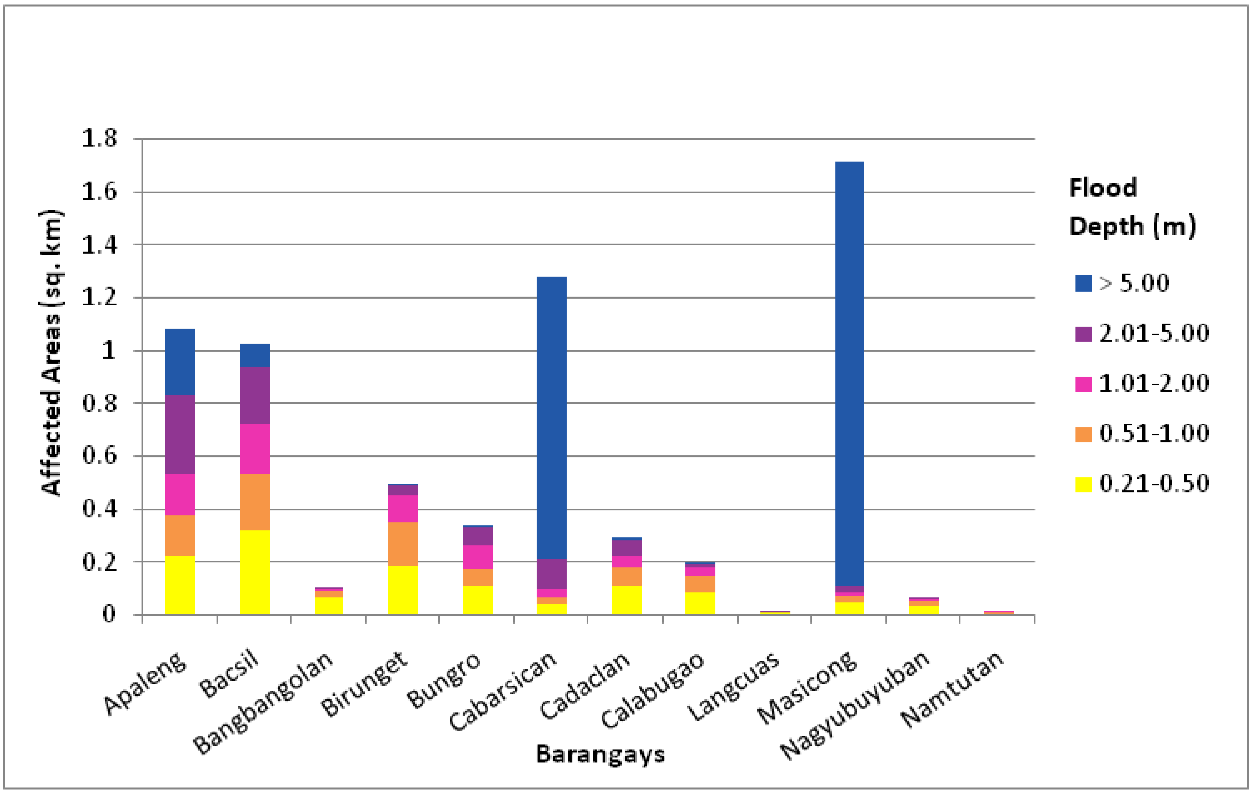


Figure 146. Affected areas in San Fernando City, La Union during a 25-year rainfall return period - A

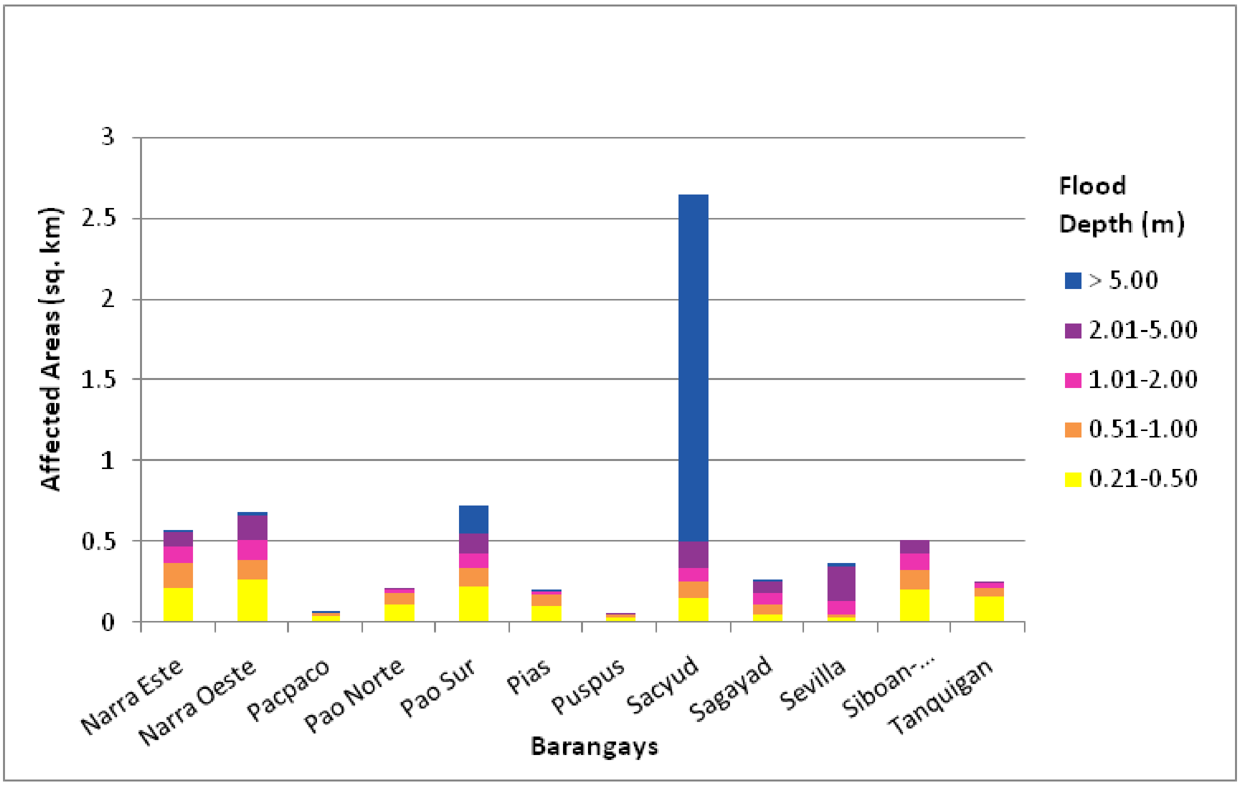


Figure 147. Affected areas in San Fernando City, La Union during a 25-year rainfall return period - B

For the 25-year return period, 10.01% of the Municipality of San Gabriel, with an area of 154.19 square kilometers, will experience flood levels of less than 0.20 meters. 0.48% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 0.19%, 0.11%, 0.11%, 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 107 are the affected areas, in square kilometers, by flood depth per barangay.

Table 107. Affected areas in San Gabriel, La Union during a 25-year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in San Gabriel		
		Amontoc	Apayao	Bayabas
Affected Area (sq. km.)	0-0.20	3.29	11.73	0.42
	0.21-0.50	0.11	0.63	0.0002
	0.51-1.00	0.03	0.27	0.0001
	1.01-2.00	0.02	0.16	0
	2.01-5.00	0.015	0.16	0
	> 5.00	0.014	0.1	0

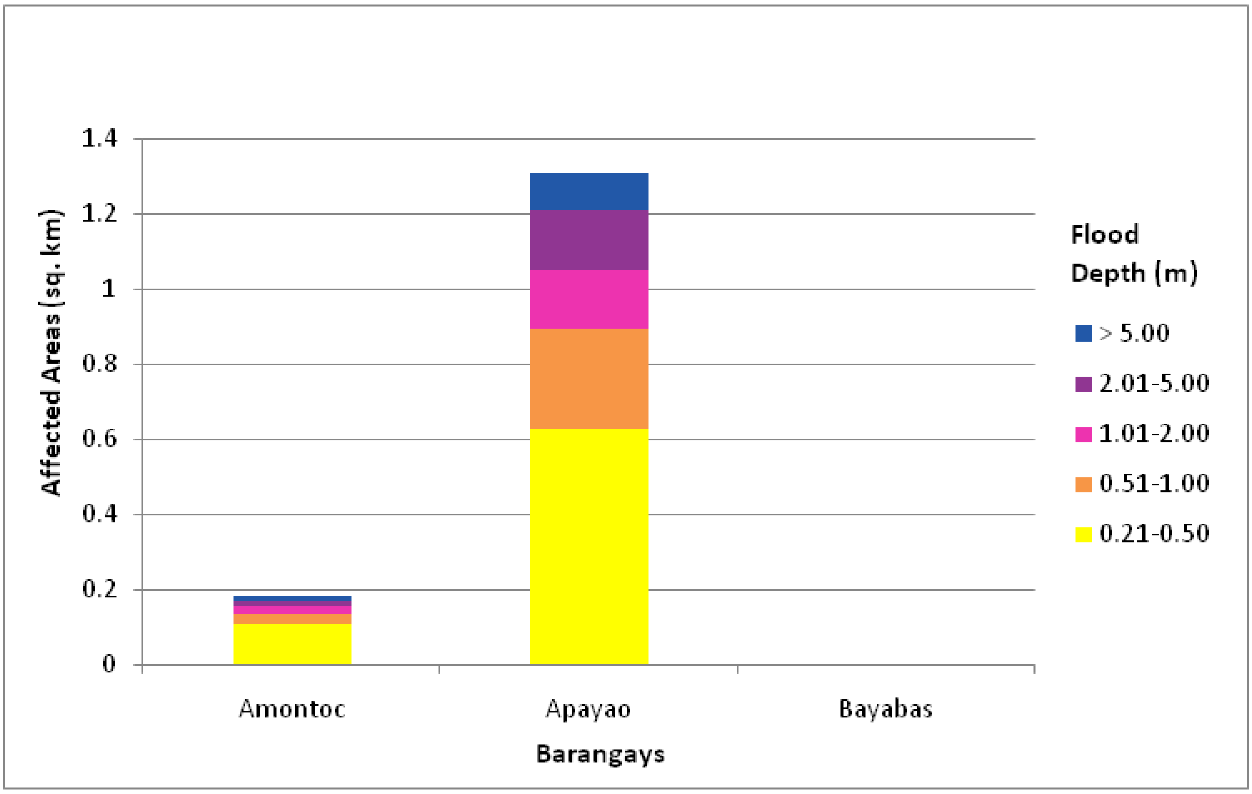


Figure 148. Affected areas in San Gabriel, La Union during a 25-year rainfall return period

For the 25-year return period, 7.97% of the Municipality of Santo Tomas, with an area of 58.53 square kilometers, will experience flood levels of less than 0.20 meters. 0.38% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 0.23%, 0.20%, 0.12%, 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 108 are the affected areas, in square kilometers, by flood depth per barangay.

Table 108. Affected areas in Santo Tomas, La Union during a 25-year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in Santo Tomas		
		Ambitacay	Bail	Pongpong
Affected Area (sq. km.)	0-0.20	0.36	0.14	4.17
	0.21-0.50	0.011	0.0097	0.2
	0.51-1.00	0.0081	0.0042	0.12
	1.01-2.00	0.0055	0.0024	0.11
	2.01-5.00	0.0032	0	0.065
	> 5.00	0.0002	0	0.0062

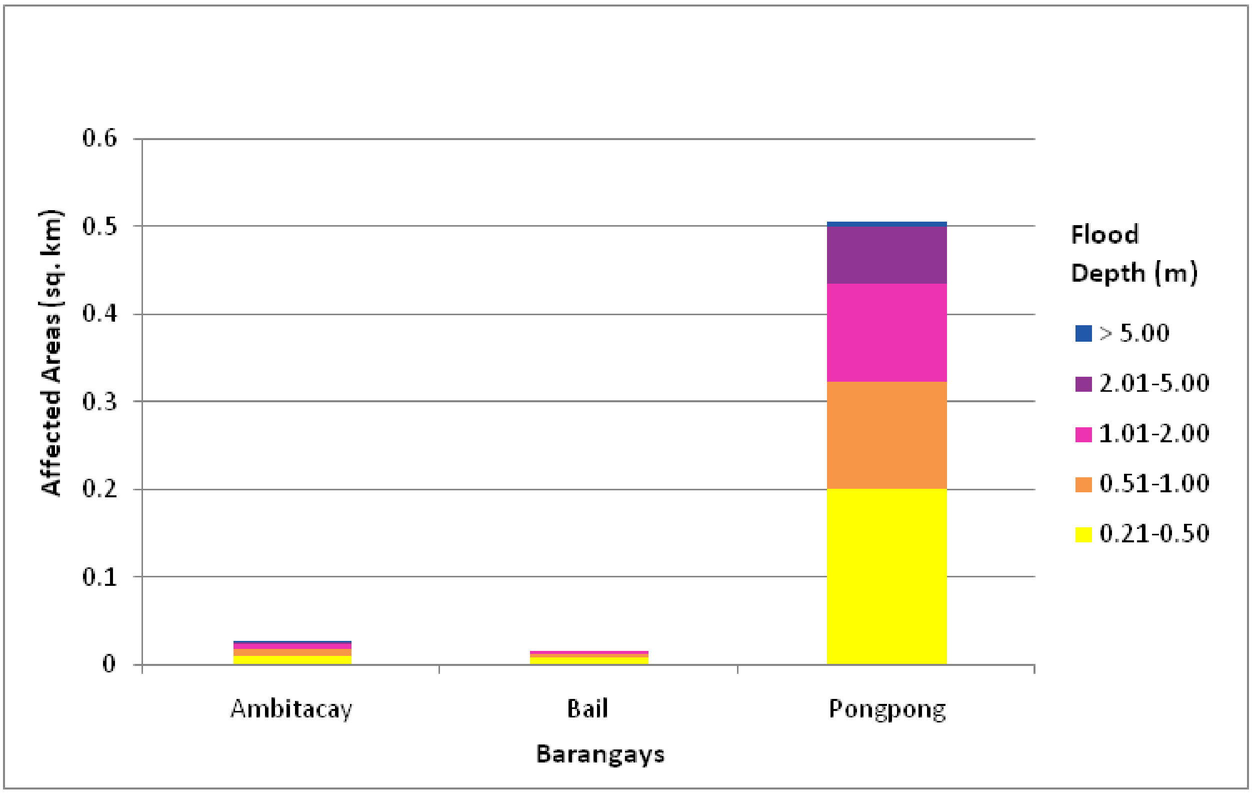


Figure 149. Affected areas in Santo Tomas, La Union during a 25-year rainfall return period

For the 25-year return period, 48.49% of the Municipality of Tubao, with an area of 53.87 square kilometers, will experience flood levels of less than 0.20 meters. 2.99% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 1.72%, 1.47%, 3.61%, and 25.64% 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 Tables 109-110 are the affected areas, in square kilometers, by flood depth per barangay.

Table 109. Affected areas in Tubao, La Union during a 25-year rainfall return period - A

ARINGAY-BAUANG BASIN		Affected Barangays in Tubao								
		Anduyan	Caoigue	Francia Sur	Francia West	Garcia	Gonzales	Halog East	Halog West	Leones East
Affected Area (sq. km.)	0-0.20	5.07	1.3	0.87	0.34	0.46	0.12	0.081	0.033	0
	0.21-0.50	0.43	0.086	0.044	0.015	0.021	0.0033	0.0036	0.0052	0
	0.51-1.00	0.24	0.057	0.023	0.0092	0.012	0.0033	0.0065	0.0083	0
	1.01-2.00	0.15	0.076	0.023	0.007	0.0079	0.0052	0.0083	0.017	0
	2.01-5.00	0.27	0.29	0.052	0.015	0.018	0.022	0.012	0.08	0
	> 5.00	1.49	0.015	0.057	0.029	0.61	0.92	0.76	0.74	0.93

Table 110. Affected areas in Tubao, La Union during a 25-year rainfall return period - B

ARINGAY-BAUANG BASIN		Affected Barangays in Tubao							
		Leones West	Linapew	Lloren	Magsay-say	Pideg	Pobla-cion	Rizal	Santa Teresa
Affected Area (sq. km.)	0-0.20	0.79	1.96	2.52	0.34	2.4	0.26	4.35	5.23
	0.21-0.50	0.055	0.093	0.24	0.016	0.12	0.013	0.23	0.24
	0.51-1.00	0.034	0.035	0.12	0.0085	0.093	0.01	0.14	0.12
	1.01-2.00	0.051	0.009	0.11	0.012	0.085	0.0077	0.13	0.095
	2.01-5.00	0.2	0.0027	0.27	0.033	0.15	0.031	0.3	0.19
	> 5.00	0.51	0.0015	0.48	0.85	0.039	0.75	3.12	2.51

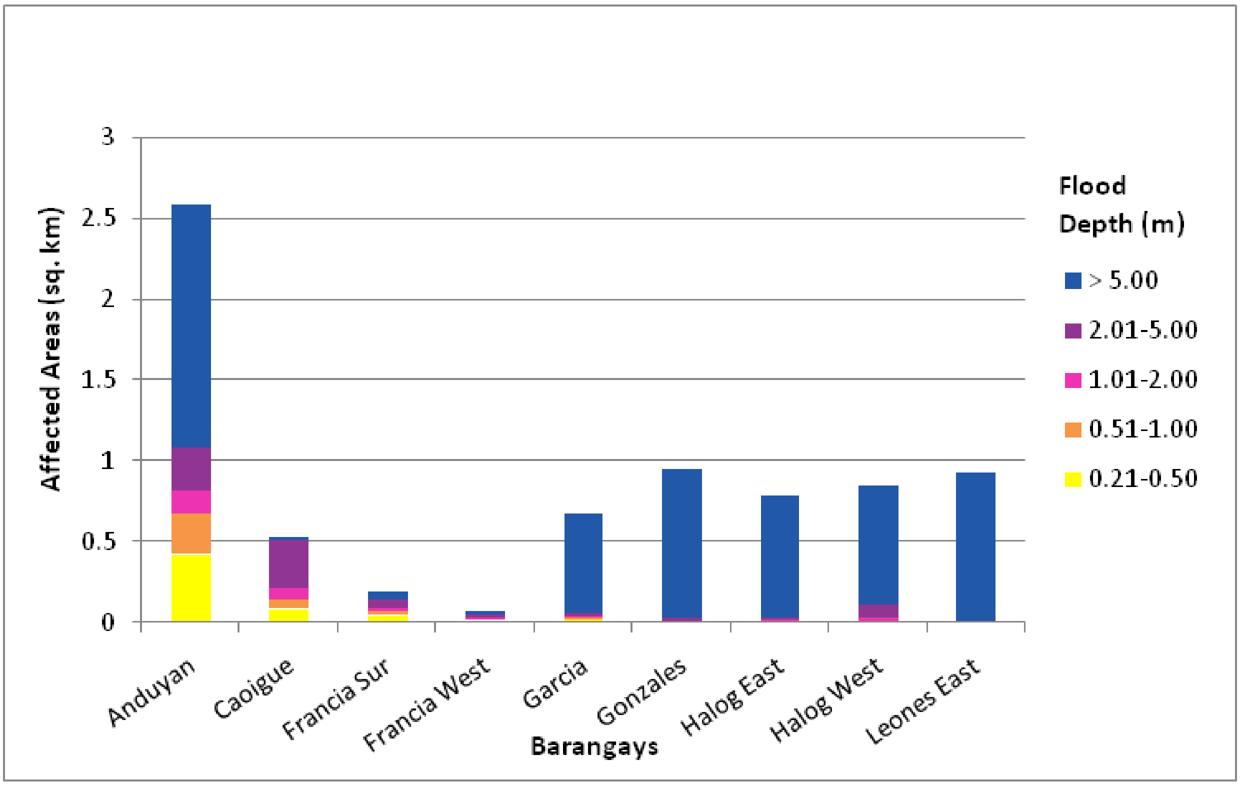


Figure 150. Affected areas in Tubao, La Union during a 25-year rainfall return period - A

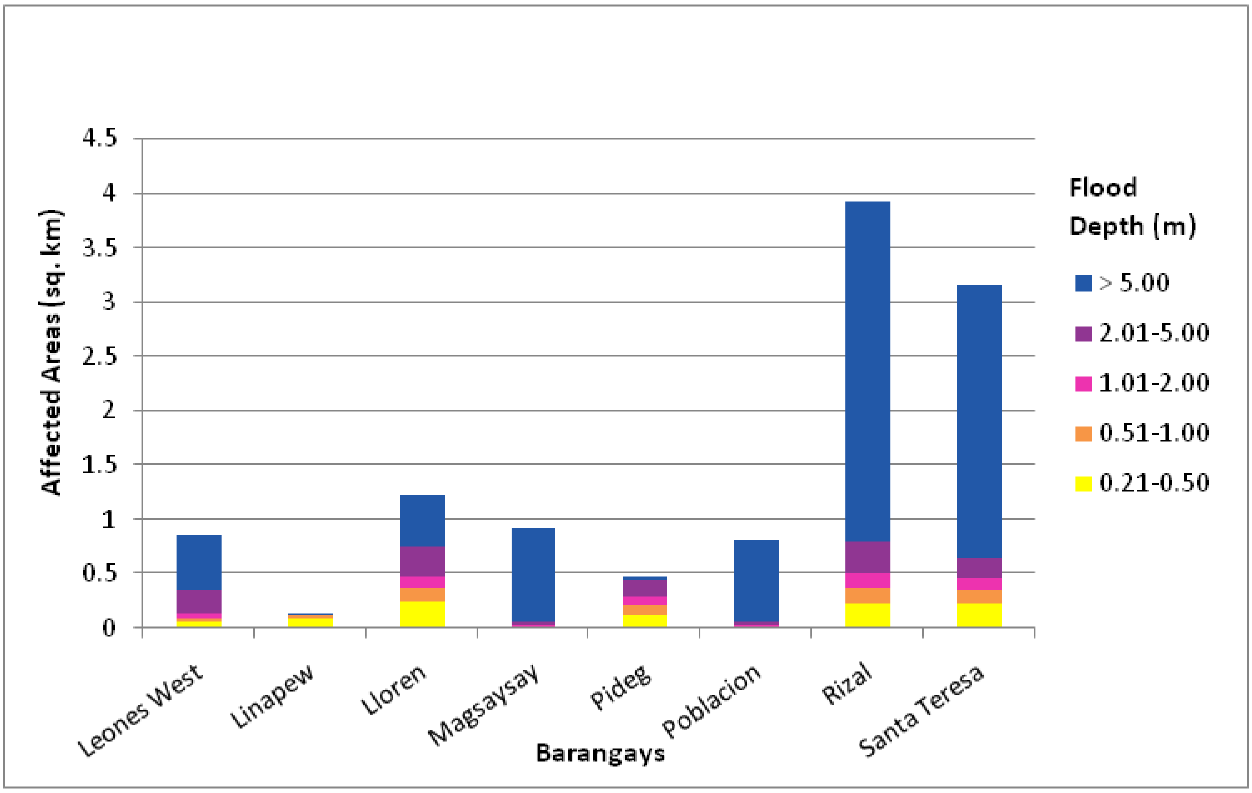


Figure 151. Affected areas in Tubao, La Union during a 25-year rainfall return period - B

For the 100-year return period, 46.61% of the Municipality of Baguio City, with an area of 60.8979 square kilometers, will experience flood levels of less than 0.20 meters. 2.82% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 1.54%, 1.28%, 1.45%, and 0.50% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Tables 111-120 are the affected areas, in square kilometers, by flood depth per barangay.

Table 111. Affected areas in Baguio City, Benguet during a 100-year rainfall return period - A

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City										
		A. Bonifacio-Caguioa-Rimando	Aban-ao-Zandueta-Kayong-Chugum-Otek	Alfonso Tabora	Ambiong	Andres Bonifacio	Asin Road	Aurora Hill Proper	Aurora Hill, North Central	Aurora Hill, South Central	Bakakeng Central	Bakakeng North
Affected Area (sq. km.)	0-0.20	0.046	0.031	0.072	0.24	0.072	4.13	0.023	0.04	0.068	0.7	0.081
	0.21-0.50	0.0093	0.0065	0.0027	0.01	0.0055	0.28	0.0008	0.0035	0.0025	0.033	0.0061
	0.51-1.00	0.001	0.0059	0.002	0.008	0.0007	0.12	0.0004	0.0014	0.0001	0.025	0.00087
	1.01-2.00	0.00052	0.00046	0.0077	0.0052	0	0.089	0.0017	0.0033	0	0.024	0
	2.01-5.00	0.00094	0	0.014	0	0	0.087	0.0043	0.0026	0	0.015	0
	> 5.00	0	0	0.0062	0	0	0.0094	0.0004	0	0	0.0076	0

Table 112. Affected areas in Baguio City, Benguet during a 100-year rainfall return period - B

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City										
		Bal-Marcoville	Balsigan	Bayan Park East	Bayan Park Village	Bayan Park West	Bgh Compound	Brookside	Brookspoint	Cabinet Hill-Teacher's Camp	Camdas Subdivision	Camp 8	Camp Allen
Affected Area (sq. km.)	0-0.20	0.12	0.054	0.17	0.075	0.016	0.089	0.095	0.34	0.16	0.084	0.12	0.124508
	0.21-0.50	0.0021	0.00017	0.0075	0.0016	0.00042	0.0049	0.0089	0.016	0.0028	0.0085	0.0055	0.005502
	0.51-1.00	0.0049	0.00018	0.0056	0.0023	0.00094	0.0029	0.0044	0.0057	0.0013	0.0005	0.0064	0.006351
	1.01-2.00	0.0069	0.00011	0.0073	0.002	0.0022	0.00021	0.0062	0.0078	0.00073	0	0.0091	0.00911
	2.01-5.00	0.00082	0	0.0013	0	0	0	0.0044	0.023	0.00098	0	0.0029	0.002882
	> 5.00	0	0	0	0	0	0	0	0.00031	0.00091	0	0.000038	0.000038

Table 113. Affected areas in Baguio City, Benguet during a 100-year rainfall return period - C

ARINGAY-BAU-ANG BASIN		Affected Barangays in Baguio City										
		Campo Filipino	City Camp Central	City Camp Proper	Country Club Village	Cresencia Village	Dizon Sub-division	Dominican Hill-Mirador	Dontogan	Dps Area	Engineers' Hill	Fairview Village
Affected Area (sq. km.)	0-0.20	0.11	0.068	0.082	0.19	0.16	0.25	1.15	0.54	0.12	0.1	0.24
	0.21-0.50	0.015	0.0023	0.0033	0.017	0.0045	0.0056	0.055	0.022	0.0028	0.0033	0.017
	0.51-1.00	0.018	0.0015	0	0.0088	0.0059	0.0015	0.029	0.0097	0.0016	0.0001	0.019
	1.01-2.00	0.034	0	0	0.008	0.012	0.0019	0.023	0.0077	0.0049	0	0.023
	2.01-5.00	0.038	0	0	0.0019	0.013	0.0011	0.058	0.01	0.021	0	0.011
	> 5.00	0	0	0	0	0	0	0.1	0.00051	0.0055	0	0

Table 114. Affected areas in Baguio City, Benguet during a 100-year rainfall return period - D

ARINGAY-BAU-ANG BASIN		Affected Barangays in Baguio City										
		Ferdinand	General Emilio F. Aguinaldo	General Luna, Lower	General Luna, Upper	Gibraltar	Greenwater Village	Guisad Central	Guisad Sorong	Happy Hol-low	Happy Homes	Holy Ghost Extension
Affected Area (sq. km.)	0-0.20	0.088	0.06	0.026	0.033	0.2	0.13	0.077	0.29	0.71	0.18	0.29
	0.21-0.50	0.0079	0.0039	0.0013	0.0017	0.0038	0.0061	0.0006	0.017	0.076	0.0022	0.0081
	0.51-1.00	0.0059	0.0013	0.0028	0.00024	0.00051	0.0013	0.0002	0.0087	0.028	0.0018	0.0061
	1.01-2.00	0.0056	0.0027	0.0011	0	0.000071	0.00039	0	0.0029	0.02	0.0019	0.0074
	2.01-5.00	0.0014	0.0058	0.003	0	0	0.000037	0	0.00049	0.014	0.0094	0.024
	> 5.00	0	0	0.0023	0	0	0	0	0	0.0024	0.012	0.0017

Table 115. Affected areas in Baguio City, Benguet during a 100-year rainfall return period - E

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City										
		Holy Ghost Proper	Honey-moon	Imelda R. Marcos	Imelda Village	Irisan	Kabayani-han	Kagitingan	Kayang Extension	Kayang-Hill-top	Legar-da-Burn-ham-Kisad	Lopez Jaena
Affected Area (sq. km.)	0-0.20	0.04	0.07	0.023	0.072	5.5	0.06	0.029	0.089	0.0097	0.34	0.046
	0.21-0.50	0.0034	0.0058	0.0012	0.0083	0.32	0.0017	0.00089	0.0046	0.0005	0.022	0.002
	0.51-1.00	0.0019	0.0027	0	0.0041	0.19	0.0032	0.0014	0.0016	0.00028	0.027	0.0013
	1.01-2.00	0.0015	0.0013	0	0.0067	0.15	0.0054	0.0022	0.00032	0.000001	0.037	0
	2.01-5.00	0.0079	0.0002	0	0.0072	0.15	0.0003	0.009	0	0	0.073	0
	> 5.00	0.0071	0	0	0	0.07	0	0.0012	0	0	0.012	0

Table 116. Affected areas in Baguio City, Benguet during a 100-year rainfall return period - F

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City										
		Lourdes Subdi-vision Extension	Lourdes Subdivision, Lower	Lourdes Subdivision, Proper	Lualhati	Magsaysay Private Road	Magsaysay, Lower	Magsaysay, Upper	Malcolm Square-Per-fecto	Manuel A. Roxas	Middle Quezon Hill Subdivision	Military Cut-Off
Affected Area (sq. km.)	0-0.20	0.026	0.029	0.076	0.31	0.02	0.084	0.0082	0.044	0.091	0.14	0.28
	0.21-0.50	0.0029	0.0032	0.007	0.021	0.0062	0.014	0.0002	0.00013	0.0054	0.013	0.023
	0.51-1.00	0.0043	0.002	0.0001	0.015	0.0009	0.0035	0.00082	0.00019	0.0028	0.0024	0.0078
	1.01-2.00	0	0	0	0.017	0.0019	0.0032	0.0031	0	0.0098	0	0.0024
	2.01-5.00	0	0	0	0.0018	0.0071	0.018	0.0048	0	0.014	0	0.00018
	> 5.00	0	0	0	0	0.0053	0.0024	0	0	0	0	0

Table 117. Affected areas in Baguio City, Benguet during a 100-year rainfall return period - G

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City										
		Modern Site, West	Mrr-Queen Of Peace	New Lucban	Outlook Drive	Pacdal	Padre Burgos	Padre Zamora	Palma-Urbano	Phil-Am	Pinget	Pinsao Pilot Project
Affected Area (sq. km.)	0-0.20	0.093	0.06	0.11	0.14	1.07	0.099	0.019	0.075	0.031	0.34	0.089
	0.21-0.50	0.0086	0.0033	0.0059	0.0053	0.055	0.0058	0.0018	0.0019	0.0042	0.024	0.0057
	0.51-1.00	0.0013	0.0027	0.0075	0.003	0.03	0.0034	0.003	0	0.0033	0.0088	0.00087
	1.01-2.00	0.00015	0.00092	0.0037	0.0029	0.012	0.0082	0.008	0	0.0041	0.0061	0.00098
	2.01-5.00	0	0.0001	0.017	0	0.0012	0.02	0.048	0	0.0001	0.0095	0.0019
	> 5.00	0	0	0.0057	0	0	0.0071	0.015	0	0	0.006	0.00033

Table 118. Affected areas in Baguio City, Benguet during a 100-year rainfall return period - H

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City										
		Pinsao Proper	Poliwes	Pucsusan	Quezon Hill Proper	Quezon Hill, Upper	Quirino Hill, East	Quirino Hill, Lower	Quirino Hill, Middle	Quirino Hill, West	Quirino-Magsaysay, Upper	Rizal Monument Area
Affected Area (sq. km.)	0-0.20	2.11	0.061	0.14	0.16	0.31	0.05	0.032	0.05	0.095	0.07	0.034
	0.21-0.50	0.12	0.0038	0.017	0.015	0.026	0.0019	0.003	0.011	0.0036	0.0046	0.0016
	0.51-1.00	0.062	0.0009	0.005	0.018	0.013	0.0034	0.0024	0.0071	0.0036	0.0024	0.00077
	1.01-2.00	0.033	0	0.0008	0.018	0.0043	0.0027	0.0013	0.0018	0.0064	0.0005	0.0014
	2.01-5.00	0.015	0	0	0.0017	0.0011	0.012	0.0009	0.0003	0.022	0	0.0032
	> 5.00	0.0034	0	0	0	0	0.0041	0	0	0.0079	0	0.000006

Table 119. Affected areas in Baguio City, Benguet during a 100-year rainfall return period - I

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City										
		Rock Quarry, Lower	Rock Quarry, Middle	Rock Quarry, Upper	Saint Joseph Village	Salud Mitra	San Antonio Village	San Luis Village	San Roque Village	San Vicente	Sanitary Camp, North	Sanitary Camp, South
Affected Area (sq. km.)	0-0.20	0.051	0.058	0.63	0.14	0.13	0.6	0.053	0.19	0.15	0.08	0.076
	0.21-0.50	0.0029	0.0098	0.031	0.0075	0.0043	0.034	0.0061	0.015	0.0069	0.0083	0.0072
	0.51-1.00	0.0015	0.007	0.028	0.00096	0.0011	0.014	0	0.006	0.00087	0.0039	0.0014
	1.01-2.00	0.0025	0.0013	0.021	0	0	0.0086	0	0.0045	0.000052	0.0002	0.0029
	2.01-5.00	0.0041	0.00029	0.0092	0	0	0.0043	0	0.004	0	0	0.0011
	> 5.00	0.000014	0	0	0	0	0	0	0	0	0	0

Table 120. Affected areas in Baguio City, Benguet during a 100-year rainfall return period - J

ARINGAY-BAUANG BASIN		Affected Barangays in Baguio City										
		Santa Escolastica	Santo Rosario	Santo Tomas Proper	Session Road Area	Slaughter House Area	Slu-Svp Housing Village	South Drive	Teodora Alonzo	Trancoville	Victoria Village	Santa Escolastica
Affected Area (sq. km.)	0-0.20	0.076	0.19	0.21	0.2	0.023	0.2	0.32	0.054	0.22	0.18	1.673953
	0.21-0.50	0.0072	0.012	0.011	0.0077	0.00031	0.006	0.034	0.006	0.012	0.012	0.10784
	0.51-1.00	0.0014	0.0042	0.0038	0.0089	0.0004	0.0038	0.027	0.0023	0.0079	0.0067	0.065944
	1.01-2.00	0.0029	0.0012	0.0021	0.016	0.001	0.0031	0.014	0.0033	0.0066	0.0011	0.05135
	2.01-5.00	0.0011	0	0	0.0035	0.0049	0.003	0.0087	0.011	0.012	0.0003	0.044057
	> 5.00	0	0	0	0	0.0024	0	0	0	0.0037	0	0.006074

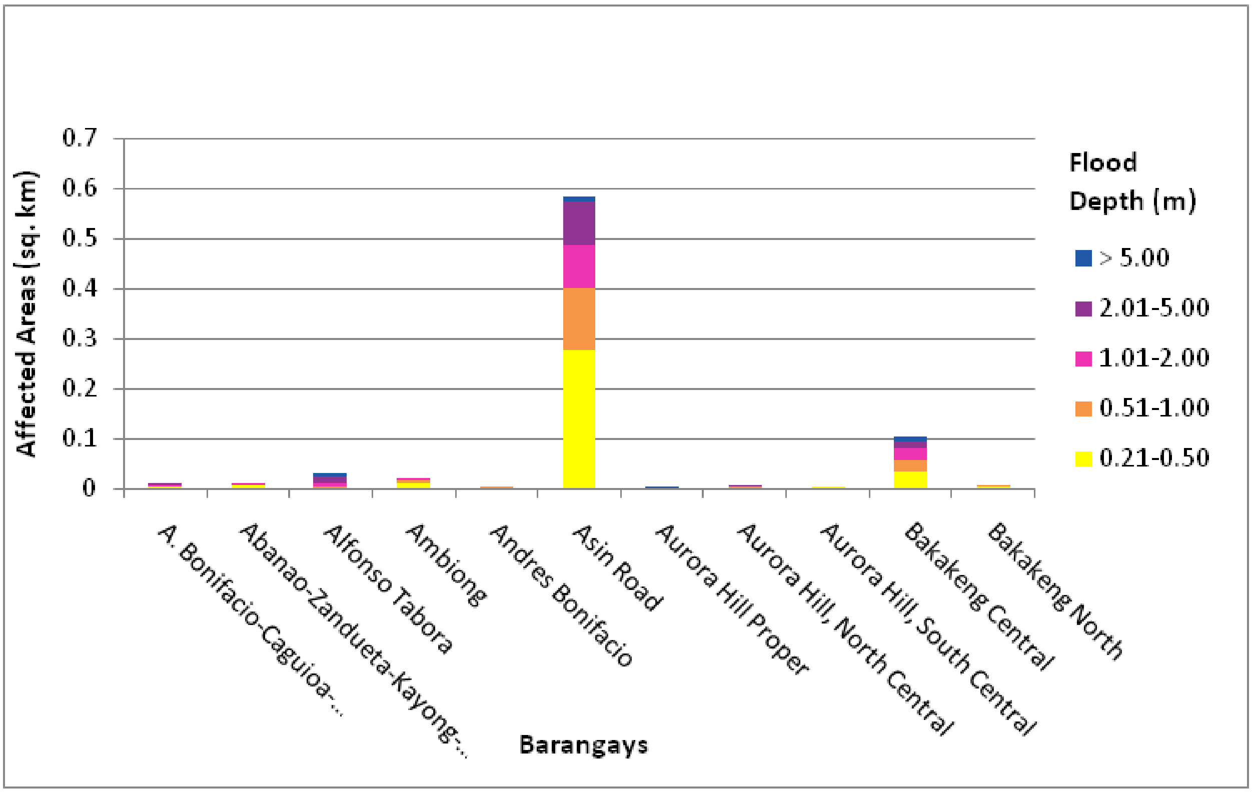


Figure 152. Affected areas in Baguio City, Benguet during a 100-year rainfall return period - A

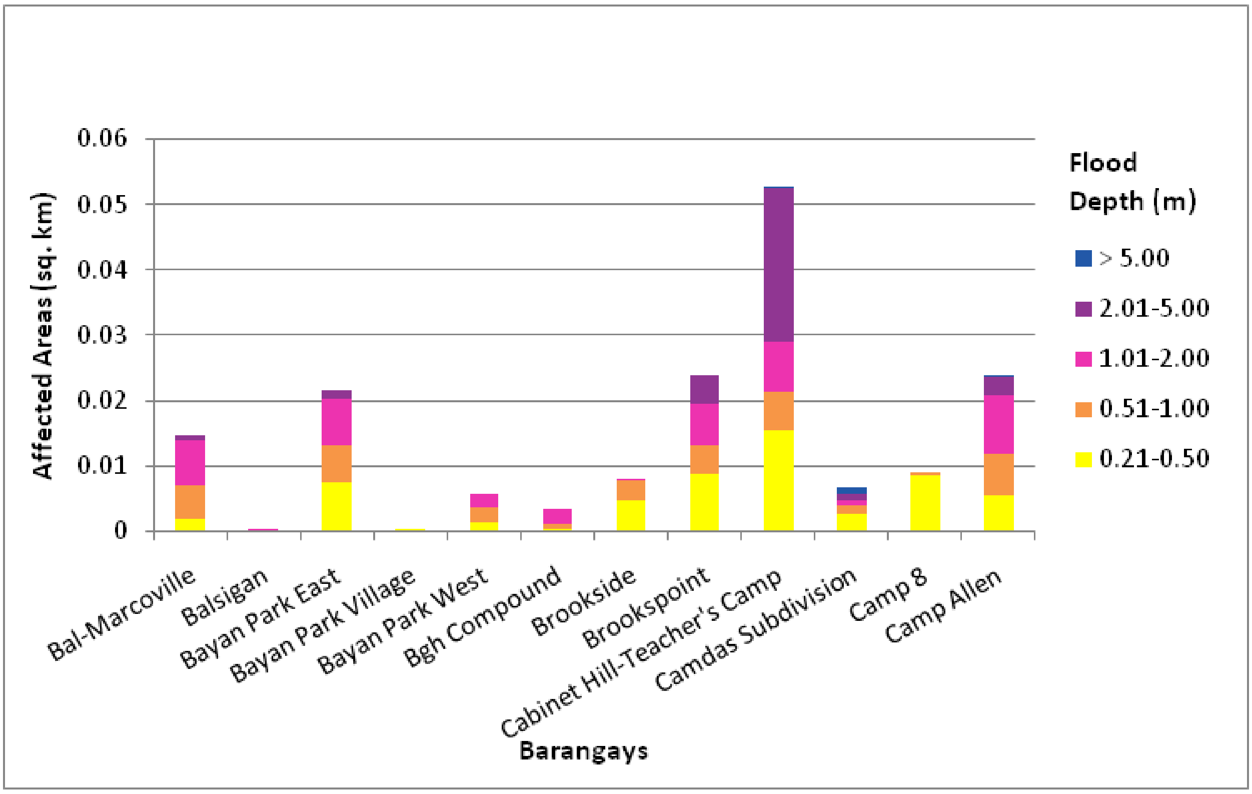


Figure 153. Affected areas in Baguio City, Benguet during a 100-year rainfall return period - B

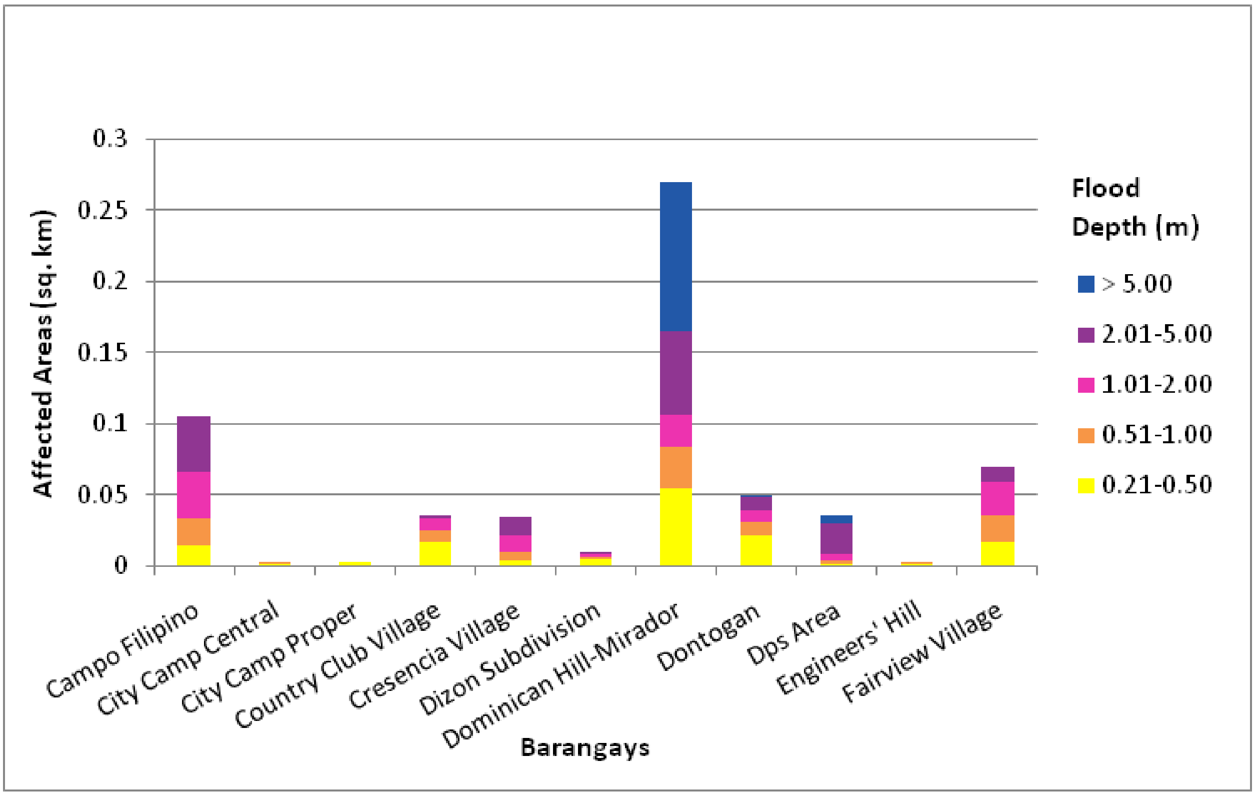


Figure 154. Affected areas in Baguio City, Benguet during a 100-year rainfall return period - C

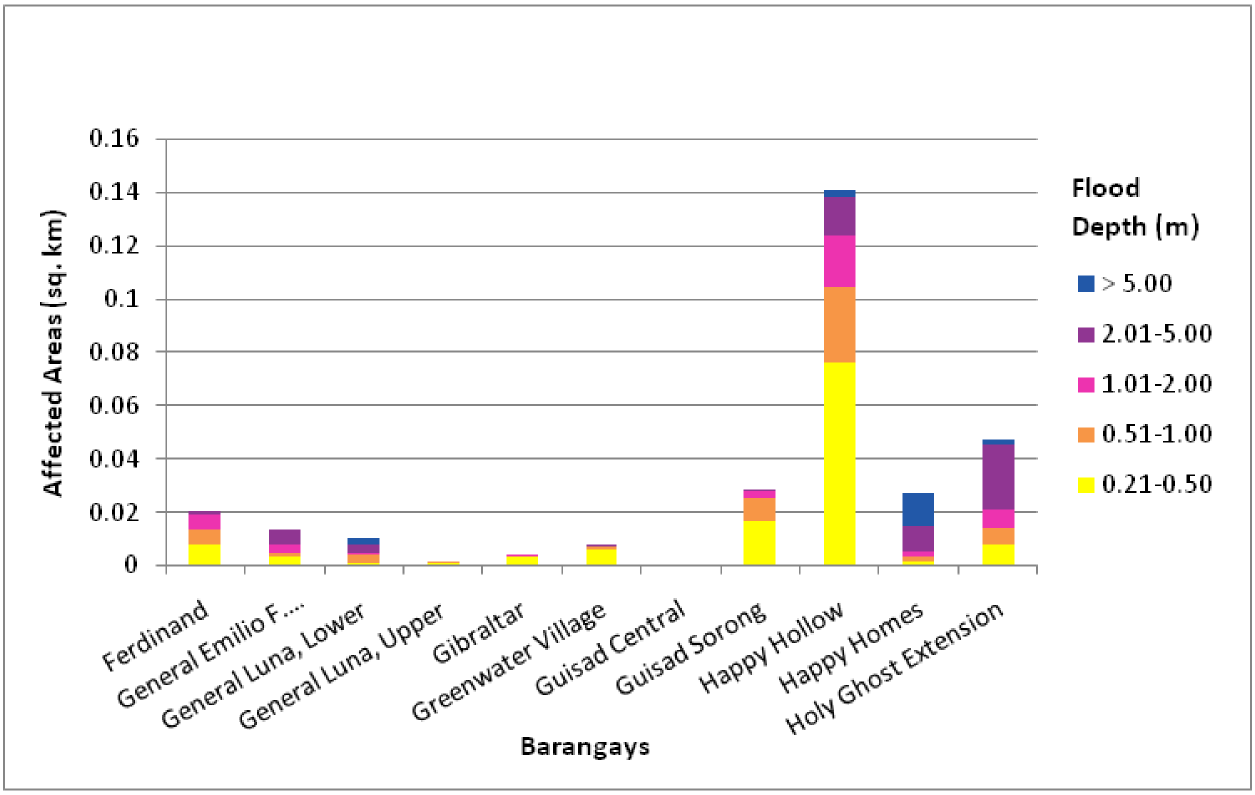


Figure 155. Affected areas in Baguio City, Benguet during a 100-year rainfall return period - D

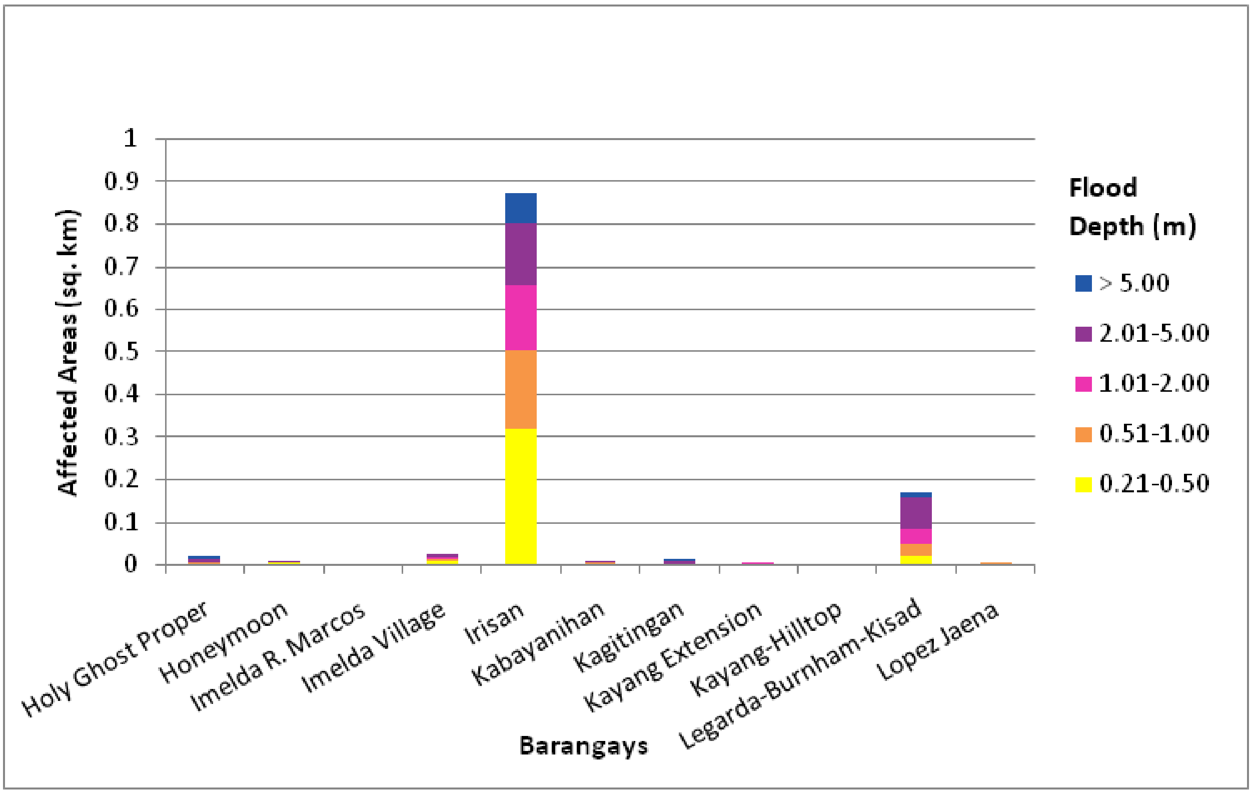


Figure 156. Affected areas in Baguio City, Benguet during a 100-year rainfall return period - E

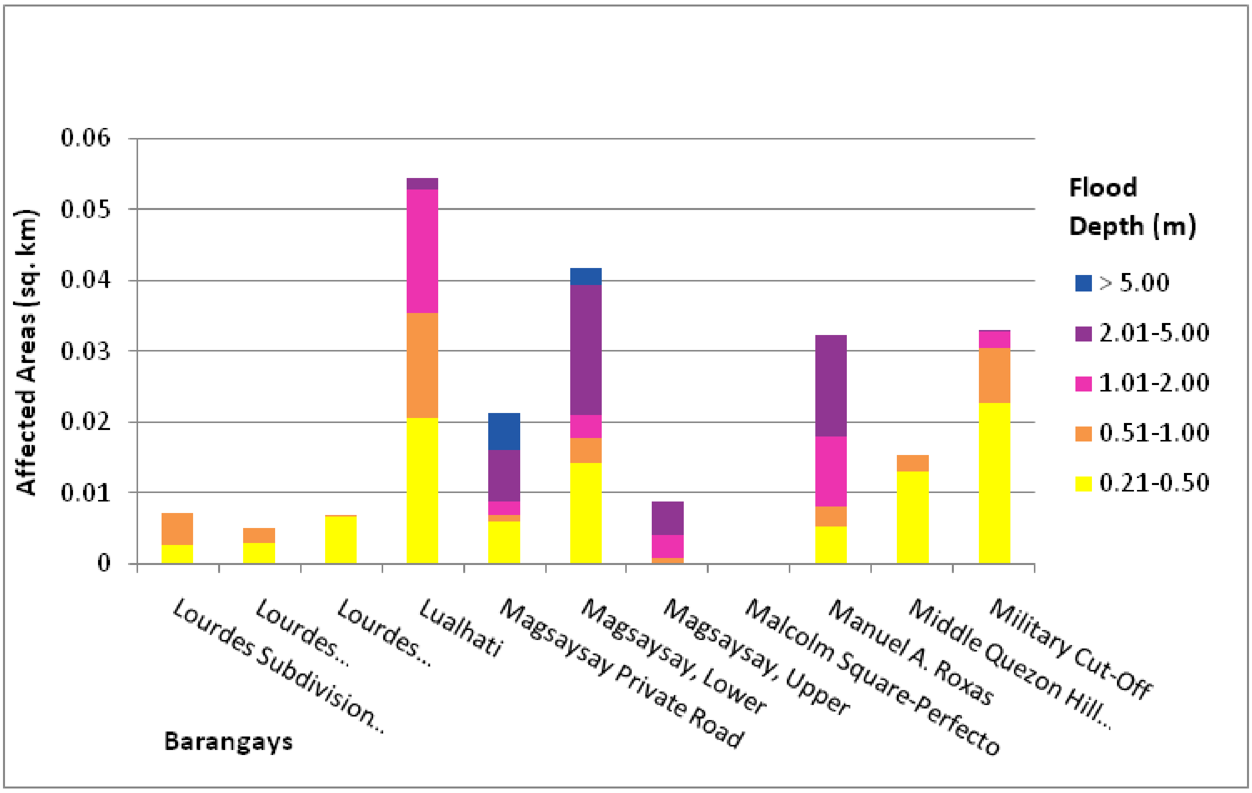


Figure 157. Affected areas in Baguio City, Benguet during a 100-year rainfall return period - F

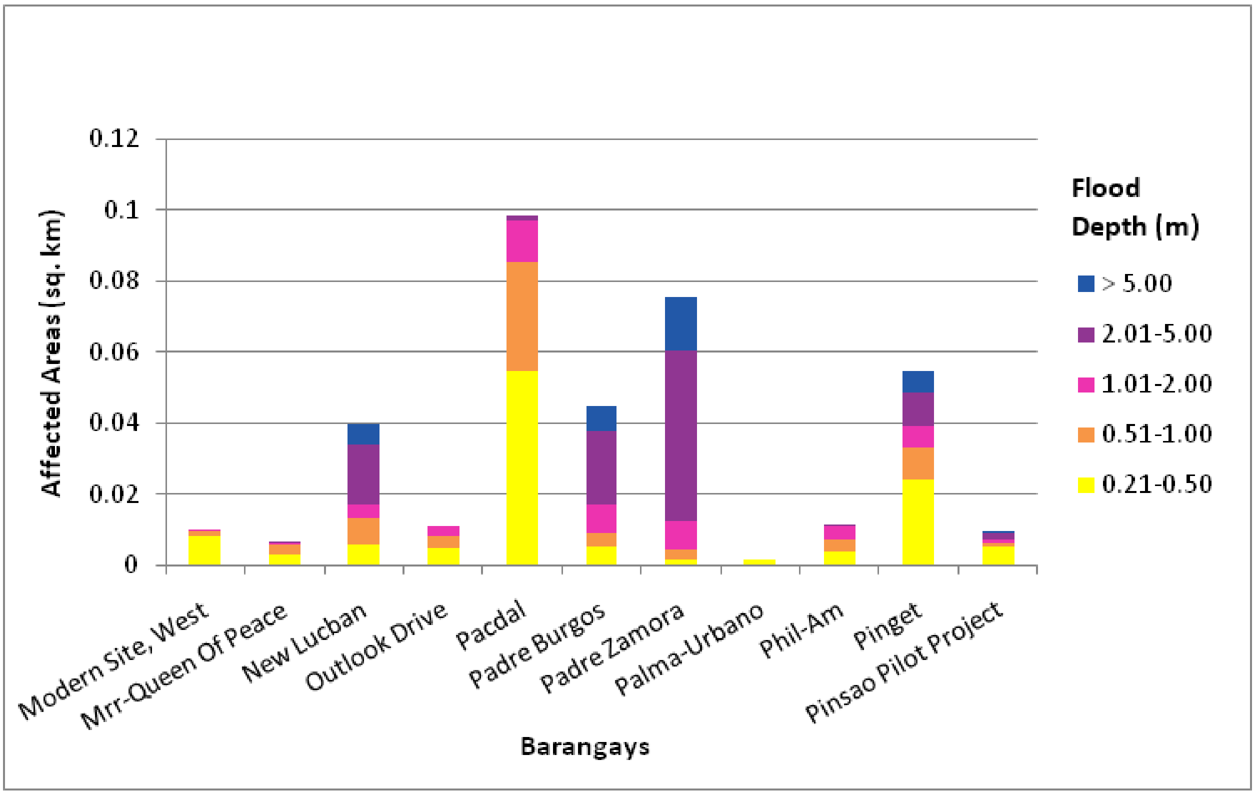


Figure 158. Affected areas in Baguio City, Benguet during a 100-year rainfall return period - G

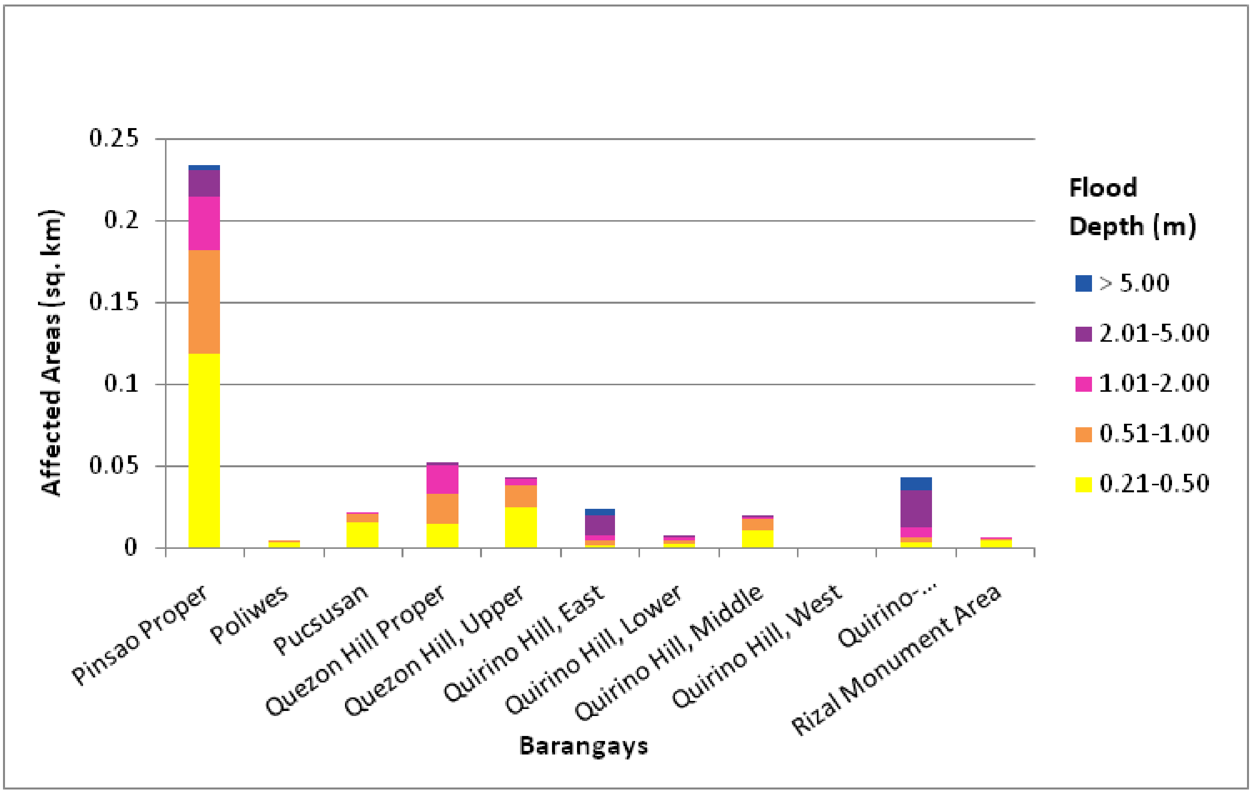


Figure 159. Affected areas in Baguio City, Benguet during a 100-year rainfall return period - H

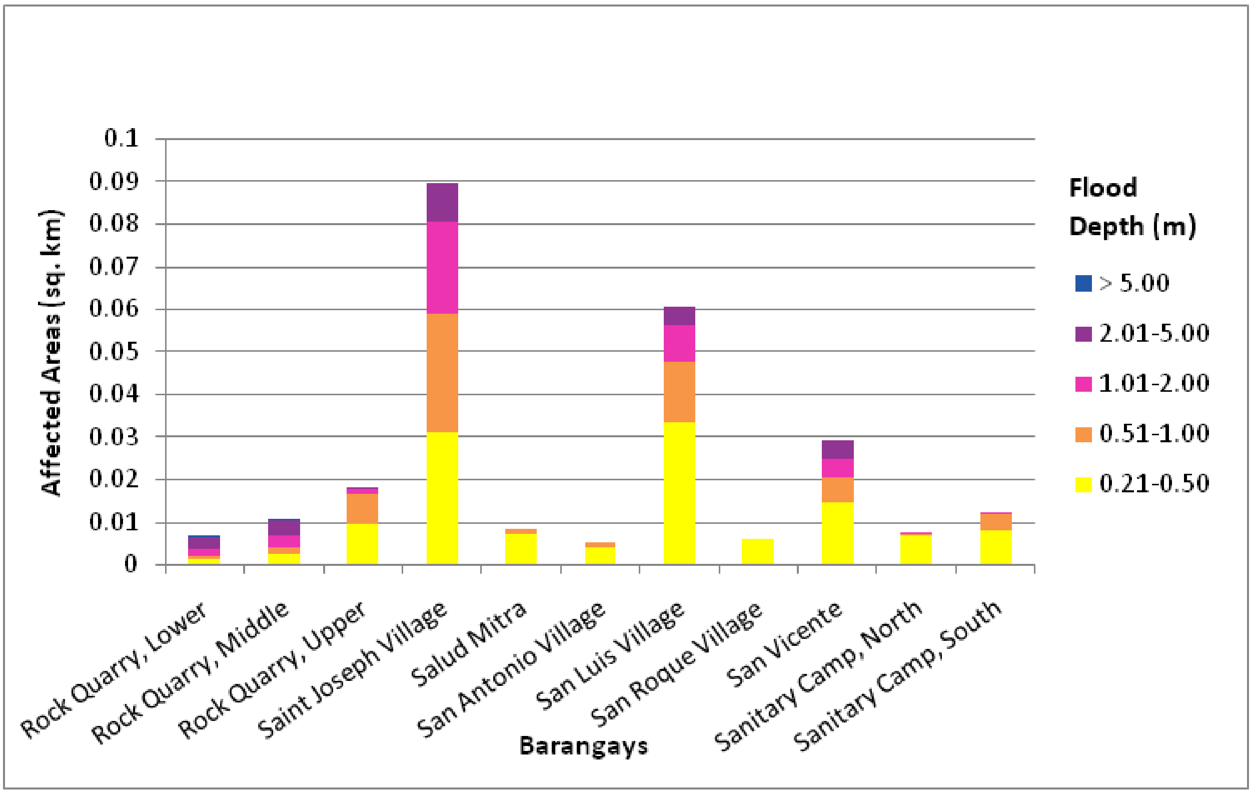


Figure 160. Affected areas in Baguio City, Benguet during a 100-year rainfall return period - I

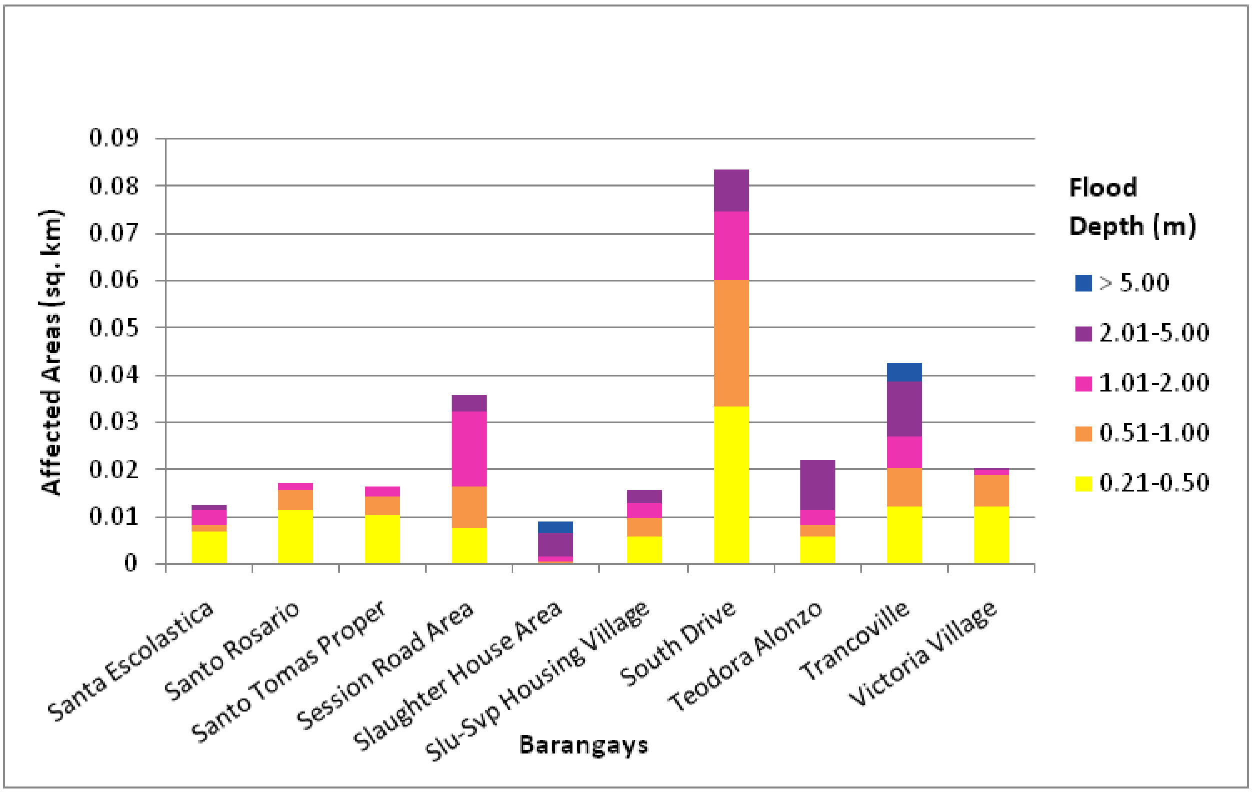


Figure 161. Affected areas in Baguio City, Benguet during a 100-year rainfall return period - J

For the 100-year return period, 30.02% of the Municipality of Kapangan, with an area of 133.9 square kilometers, will experience flood levels of less than 0.20 meters. 1.34% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 0.63%, 0.43%, 0.49%, and 0.38% 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 Tables 121 are the affected areas, in square kilometers, by flood depth per barangay.

Table 121. Affected areas in Kapangan, Benguet during a 100-year rainfall return period

ARIN-GAY-BAUANG BASIN		Affected Barangays in Kapangan							
		Datakan	Gadang	Gaswel-ing	Labueg	Paykek	Pobla-cion Central	Pongayan	Sagubo
Affected Area (sq. km.)	0-0.20	3.75	0.19	15.01	1.93	0.035	1.8	9.57	7.91
	0.21-0.50	0.18	0.0037	0.53	0.11	0.0023	0.086	0.45	0.43
	0.51-1.00	0.08	0	0.19	0.08	0.0002	0.056	0.25	0.19
	1.01-2.00	0.057	0	0.14	0.076	0	0.055	0.16	0.087
	2.01-5.00	0.056	0	0.18	0.12	0.000075	0.081	0.14	0.07
	> 5.00	0.16	0	0.25	0.06	0	0.013	0.029	0.0038

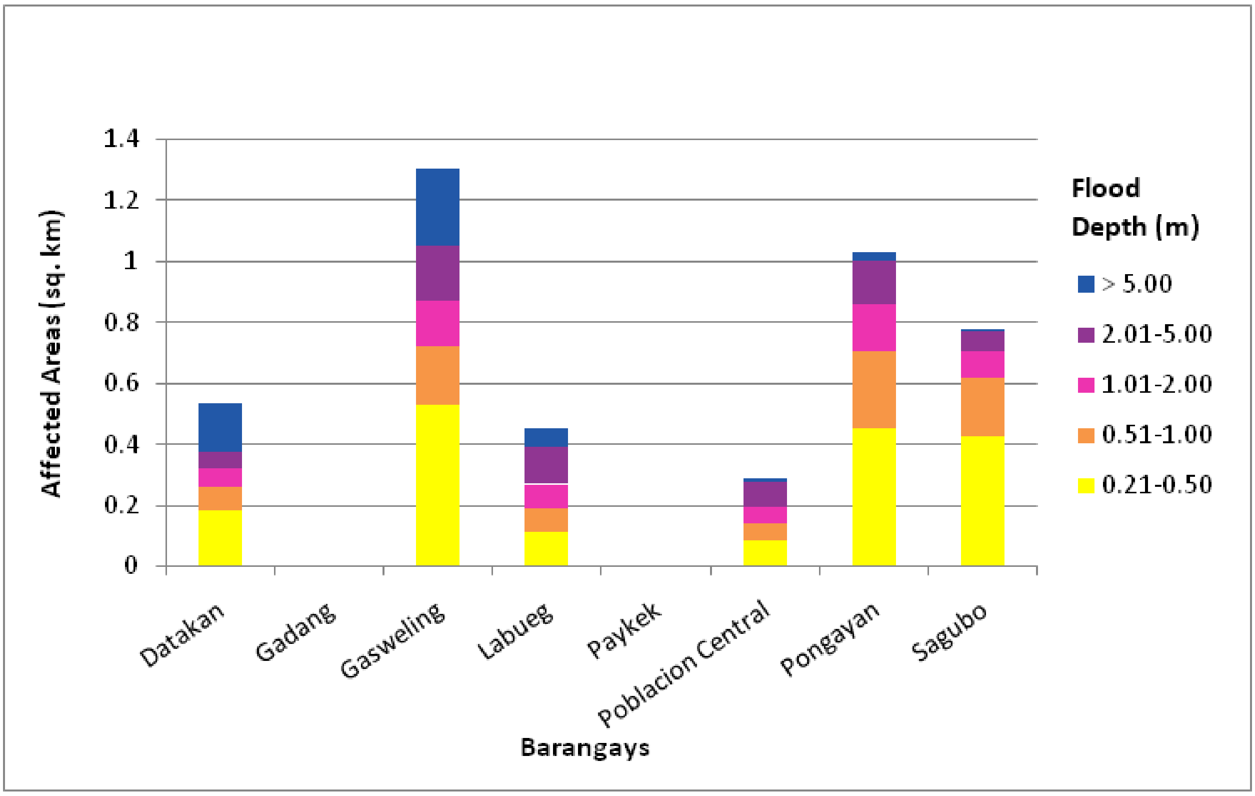


Figure 162. Affected areas in Kapangan, Benguet during a 100-year rainfall return period

For the 100-year return period, 69.90% of the Municipality of La Trinidad, with an area of 74.908 square kilometers, will experience flood levels of less than 0.20 meters. 4.39% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 2.30%, 1.97%, 3.54%, and 2.37% 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 Tables 122-123 are the affected areas, in square kilometers, by flood depth per barangay.

Table 122. Affected areas in La Trinidad, Benguet during a 100-year rainfall return period - A

ARINGAY-BAUANG BASIN		Affected Barangays in La Trinidad							
		Alapang	Alno	Ambiong	Bahong	Balili	Beckel	Betag	Bineng
Affected Area (sq. km.)	0-0.20	3.87	9.44	1.53	4.26	0.22	1.43	0.1	10.7
	0.21-0.50	0.29	0.45	0.07	0.38	0.05	0.076	0.048	0.69
	0.51-1.00	0.12	0.21	0.04	0.19	0.07	0.035	0.027	0.23
	1.01-2.00	0.1	0.13	0.048	0.11	0.18	0.015	0.06	0.1
	2.01-5.00	0.16	0.16	0.04	0.1	0.41	0.0079	0.93	0.066
	> 5.00	0.029	0.95	0.0058	0.022	0.041	0	0.39	0.17

Table 123. Affected areas in La Trinidad, Benguet during a 100-year rainfall return period - B

ARINGAY-BAUANG BASIN		Affected Barangays in La Trinidad							
		Cruz	Lubas	Pico	Poblacion	Puguis	Shilan	Tawang	Wangal
Affected Area (sq. km.)	0-0.20	0.45	1.35	0.9	1.75	3.46	6.45	2.19	4.25
	0.21-0.50	0.026	0.096	0.19	0.092	0.2	0.31	0.14	0.18
	0.51-1.00	0.0027	0.049	0.28	0.068	0.096	0.14	0.026	0.13
	1.01-2.00	0.0007	0.036	0.36	0.052	0.041	0.12	0.015	0.1
	2.01-5.00	0	0.044	0.34	0.17	0.022	0.087	0.008	0.11
	> 5.00	0	0.0054	0.053	0.026	0	0.031	0.0005	0.049

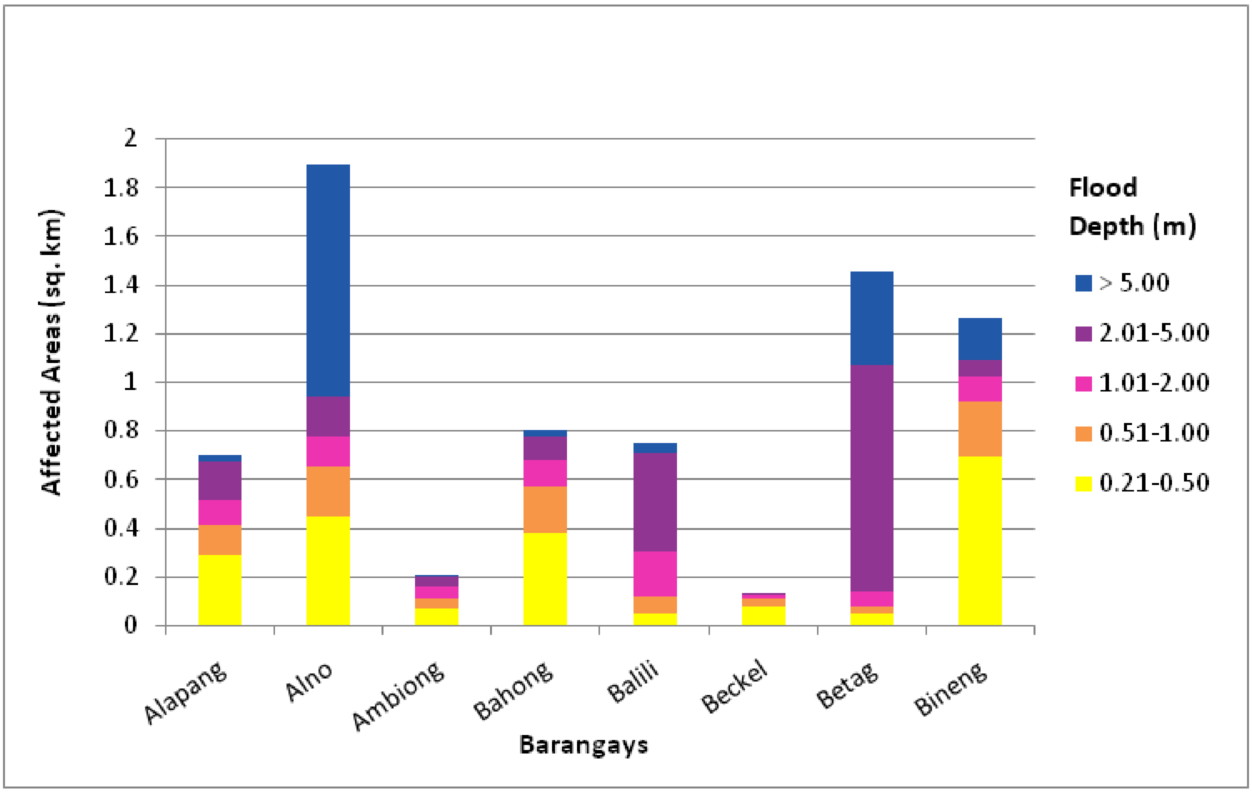


Figure 163. Affected areas in La Trinidad, Benguet during a 100-year rainfall return period - A

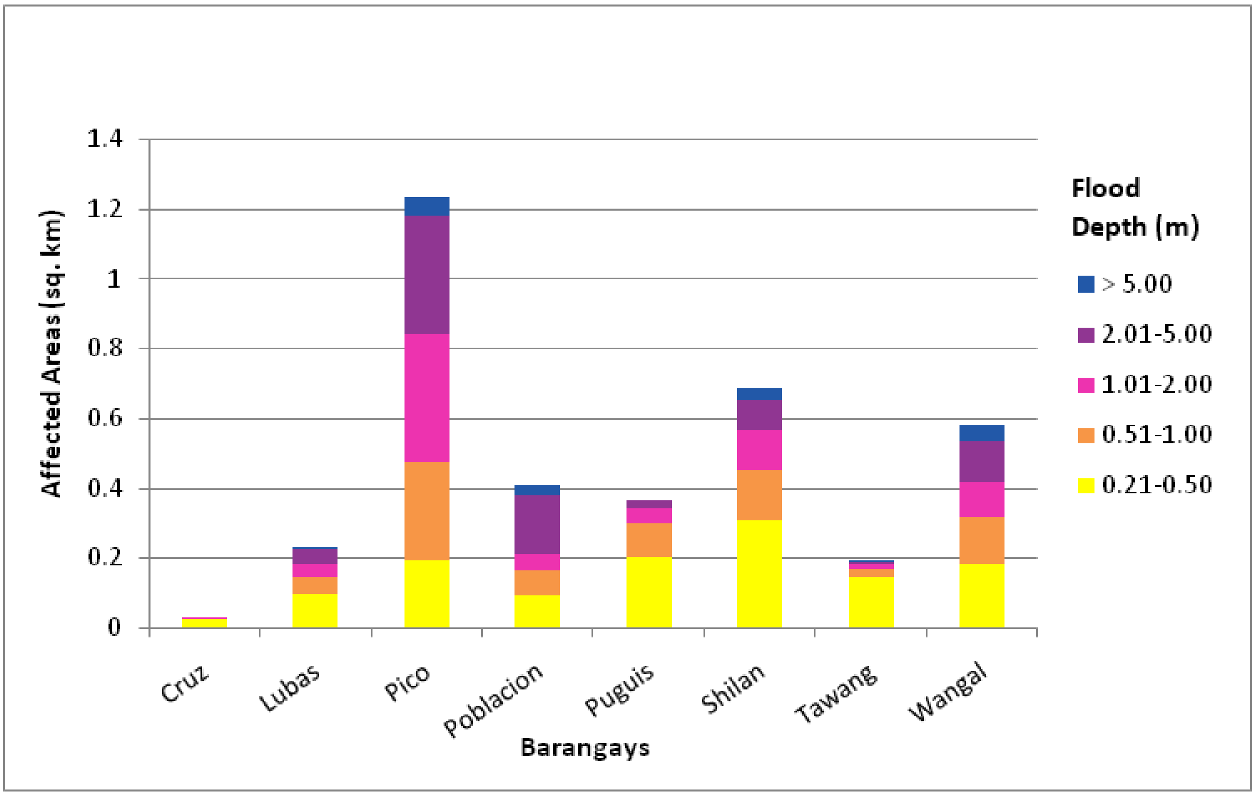


Figure 164. Affected areas in La Trinidad, Benguet during a 100-year rainfall return period - B

For the 100-year return period, 89.56% of the Municipality of Sablan, with an area of 90.22 square kilometers, will experience flood levels of less than 0.20 meters. 3.98% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 1.79%, 1.27%, 1.29%, and 2.10% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 124 are the affected areas, in square kilometers, by flood depth per barangay.

Table 124. Affected areas in Sablan, Benguet during a 100-year rainfall return period

ARIN-GAY-BAUANG BASIN		Affected Barangays in Sablan							
		Bagong	Balluay	Banangan	Baneng-beng	Bayabas	Kamog	Pappa	Pobla-cion
Affected Area (sq. km.)	0-0.20	4.71	8.35	17.23	12.48	12.27	10.58	10.1	5.09
	0.21-0.50	0.11	0.41	0.8	0.55	0.68	0.39	0.4	0.25
	0.51-1.00	0.052	0.21	0.32	0.27	0.26	0.18	0.2	0.13
	1.01-2.00	0.041	0.13	0.24	0.15	0.2	0.14	0.14	0.11
	2.01-5.00	0.079	0.074	0.26	0.17	0.17	0.11	0.21	0.092
	> 5.00	0.95	0.12	0.093	0.53	0.042	0.071	0.076	0.0091

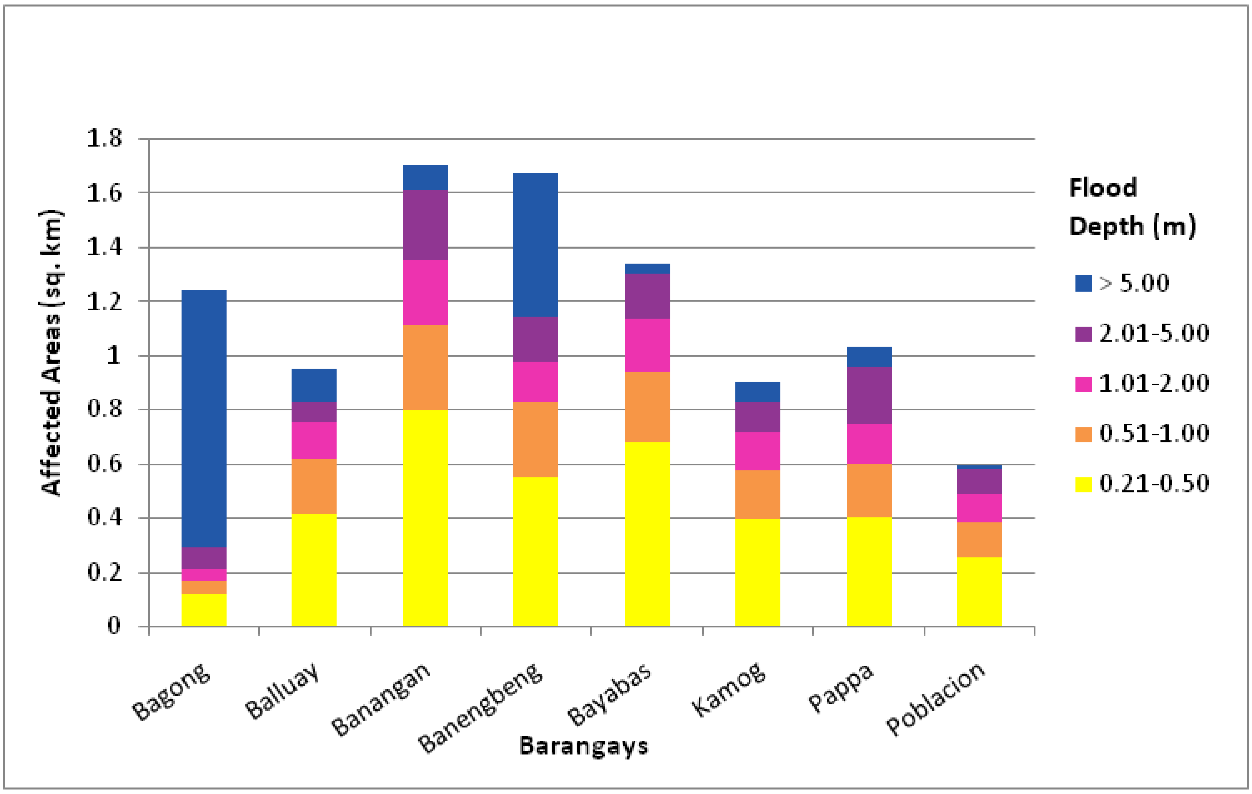


Figure 165. Affected areas in Sablan, Benguet during a 100-year rainfall return period

For the 100-year return period, 37.96% of the Municipality of Tuba, with an area of 322.02 square kilometers, will experience flood levels of less than 0.20 meters. 2.00% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 0.89%, 0.52%, 0.58%, and 0.78% 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 125 are the affected areas, in square kilometers, by flood depth per barangay.

Table 125. Affected areas in Tuba, Benguet during a 100-year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in Tuba								
		Nangalisan	Poblacion	San Pascual	Tabaan Norte	Tabaan Sur	Tadiangan	Taloy Norte	Taloy Sur	Twin Peaks
Affected Area (sq. km.)	0-0.20	10.24	19.73	6.21	16.34	22.53	11.5	14.24	18.88	2.56
	0.21-0.50	0.49	1.22	0.3	0.78	1.18	0.68	0.72	0.88	0.16
	0.51-1.00	0.25	0.59	0.12	0.36	0.52	0.3	0.29	0.36	0.069
	1.01-2.00	0.19	0.31	0.09	0.16	0.31	0.19	0.19	0.25	0.0071
	2.01-5.00	0.31	0.31	0.13	0.15	0.29	0.23	0.19	0.27	0.0006
	> 5.00	1.05	0.2	0.036	0.23	0.43	0.25	0.13	0.21	0

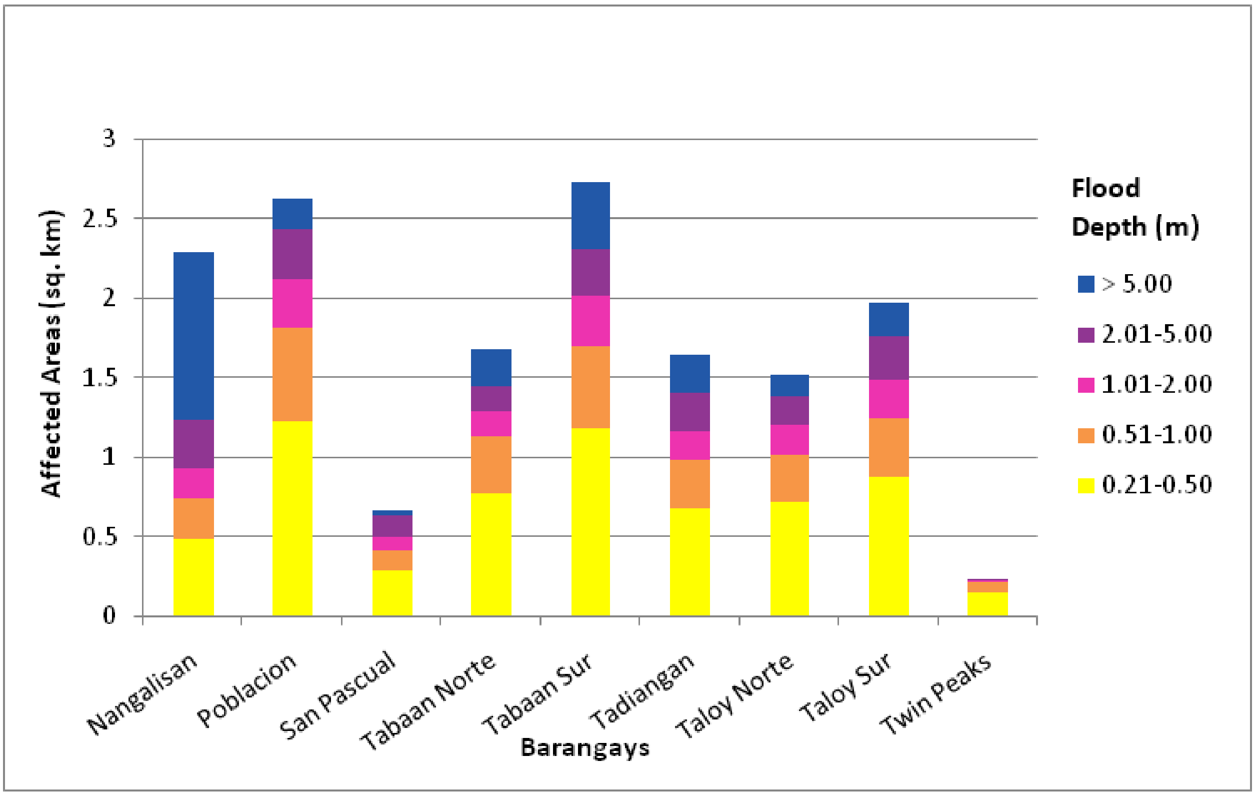


Figure 166. Affected areas in Tuba, Benguet during a 100-year rainfall return period

For the 100-year return period, 49.35% of the Municipality of Tublay, with an area of 63.21 square kilometers, will experience flood levels of less than 0.20 meters. 2.74% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 1.17%, 0.84%, 0.84%, and 0.79% 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 126 are the affected areas, in square kilometers, by flood depth per barangay.

Table 126. Affected areas in Tublay, Benguet during a 100-year rainfall return period

ARIN-GAY-BAU-ANG BASIN		Affected Barangays in Tublay							
		Ambas-sador	Ambong-dolan	Ba-Ayan	Basil	Caponga	Daclan	Tublay Central	Tuel
Affected Area (sq. km.)	0-0.20	0.023	3.59	1.97	3.69	2.79	4.8	3.38	10.94
	0.21-0.50	0.0001	0.18	0.12	0.18	0.26	0.23	0.19	0.58
	0.51-1.00	0	0.087	0.034	0.082	0.098	0.099	0.093	0.24
	1.01-2.00	0	0.098	0.014	0.047	0.051	0.07	0.11	0.15
	2.01-5.00	0	0.075	0.0079	0.07	0.022	0.019	0.16	0.18
	> 5.00	0	0.021	0	0.18	0.0008	0.0001	0.066	0.23

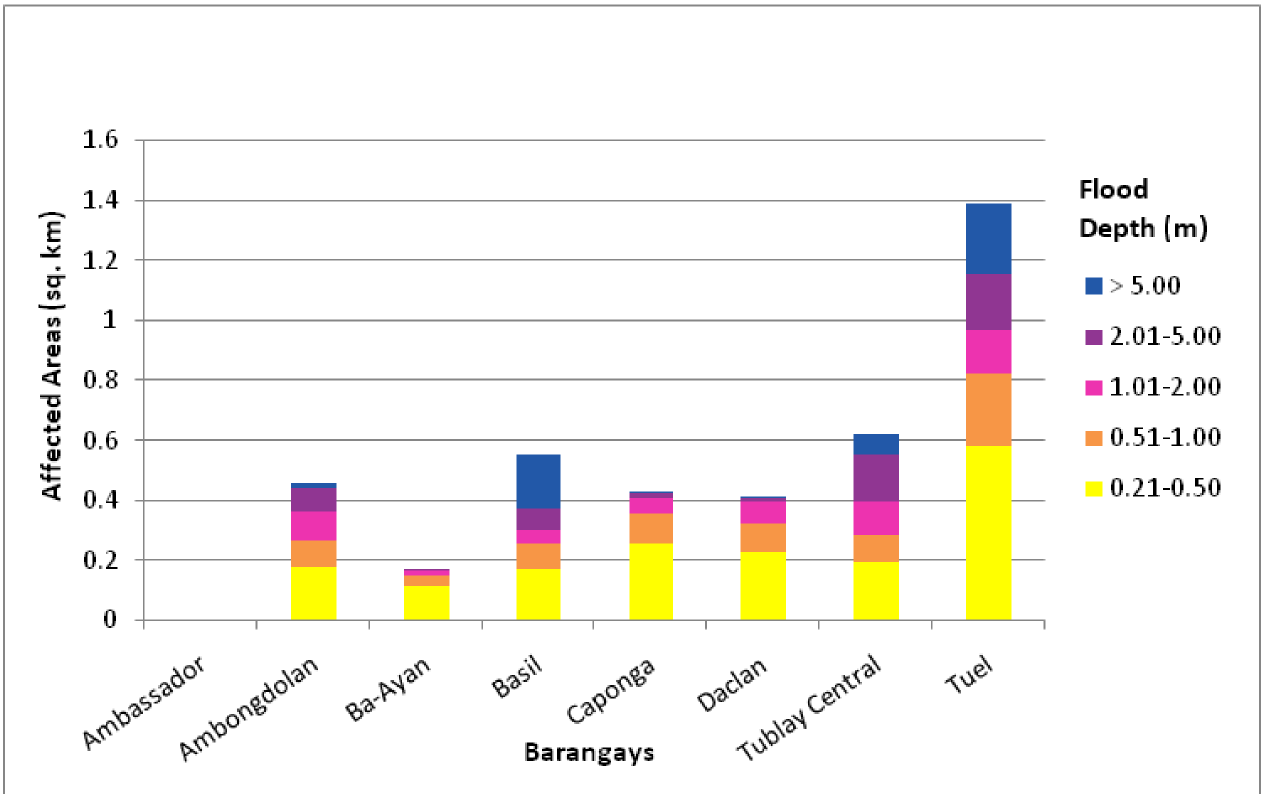


Figure 167. Affected areas in Tublay, Benguet during a 100-year rainfall return period

For the 100-year return period, 6.00% of the Municipality of Agoo, with an area of 33.71 square kilometers, will experience flood levels of less than 0.20 meters. 0.59% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 0.45%, 0.40%, 0.31%, 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 127 are the affected areas, in square kilometers, by flood depth per barangay.

Table 127. Affected areas in Agoo, La Union during a 100-year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in Agoo					
		Macalva Norte	Nazareno	Santa Ana	Santa Rita	Santa Rita East	Santa Rita Norte
Affected Area (sq. km.)	0-0.20	1.48	0.015	0.48	0.017	0.0081	0.023
	0.21-0.50	0.092	0.00068	0.053	0.021	0.00084	0.03
	0.51-1.00	0.055	0	0.033	0.021	0.0027	0.041
	1.01-2.00	0.041	0	0.027	0.0096	0.0074	0.05
	2.01-5.00	0.026	0	0.058	0	0.0087	0.011
	> 5.00	0.0001	0	0.0045	0	0	0

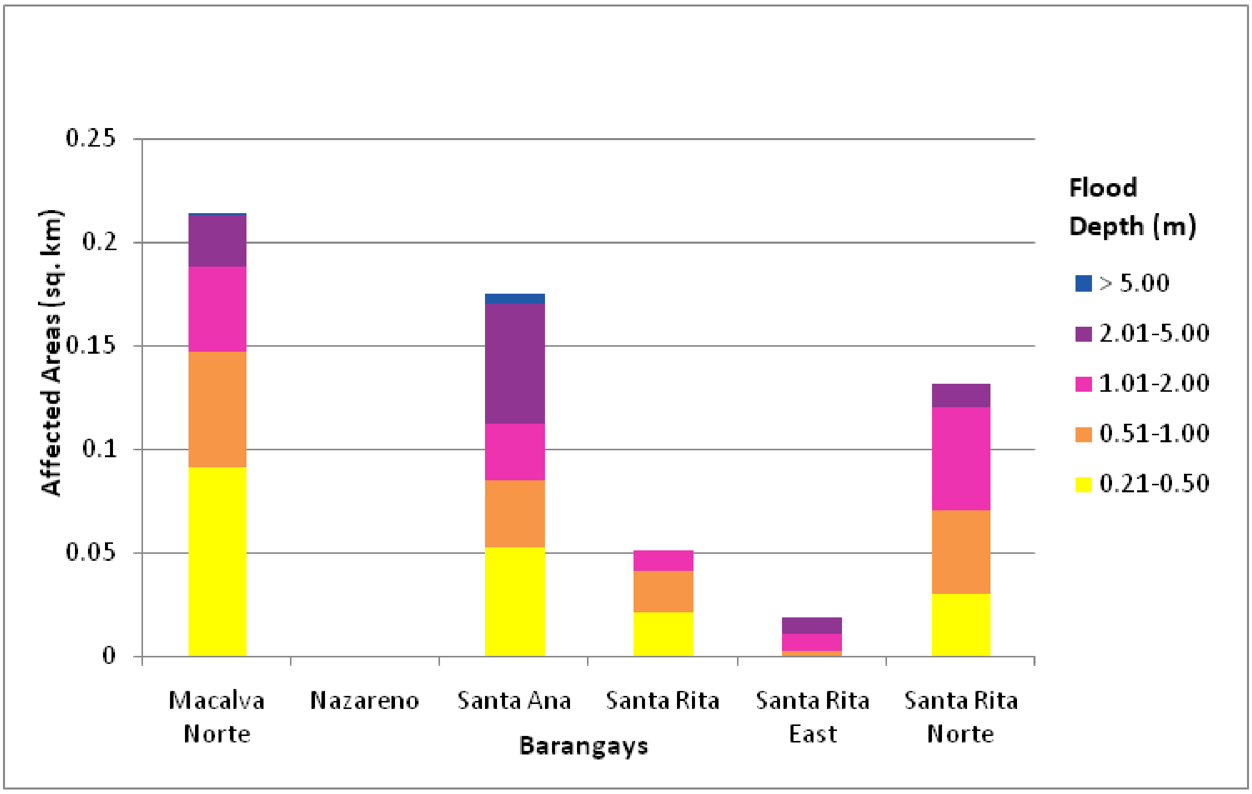


Figure 168. Affected areas in Agoo, La Union during a 100-year rainfall return period

For the 100-year return period, 62.16% of the Municipality of Aringay, with an area of 95.65 square kilometers, will experience flood levels of less than 0.20 meters. 4.80% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 3.29%, 5.56%, 10.81%, and 13.03% 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 Tables 128-129 are the affected areas, in square kilometers, by flood depth per barangay.

Table 128. Affected areas in Aringay, La Union during a 100-year rainfall return period - A

ARINGAY-BAUANG BASIN		Affected Barangays in Aringay											
		Alaska	Basca	Dulao	Gallano	Macaba-to	Manga	Pan-gao-Aoan East	Pan-gao-Aoan West	Pobla-cion	Samara	San An-tonio	San Beni-to Norte
Affected Area (sq. km.)	0-0.20	0.28	5.52	0.51	21.16	5.44	7.33	1.79	0.91	0.55	0.021	0.55	1.58
	0.21-0.50	0.17	0.3	0.39	1.08	0.26	0.34	0.1	0.14	0.035	0.024	0.064	0.27
	0.51-1.00	0.088	0.18	0.69	0.58	0.14	0.19	0.046	0.1	0.017	0.17	0.035	0.055
	1.01-2.00	0.3	0.13	1.39	0.37	0.13	0.14	0.042	0.12	0.027	1.4	0.063	0.032
	2.01-5.00	1.14	0.12	0.49	0.4	0.19	0.15	0.1	0.3	0.071	2.38	0.55	0.037
	> 5.00	0	0.36	0	2.51	0.09	0.011	2.12	0.37	0.55	0.11	1.84	0.0018

Table 129. Affected areas in Aringay, La Union during a 100-year rainfall return period - B

ARINGAY-BAUANG BASIN		Affected Barangays in Aringay											
		San Beni-to Sur	San Eu-genio	San Juan East	San Juan West	San Simon East	San Simon West	Santa Cecilia	Santa Lucia	Santa Rita East	Santa Rita West	Santo Rosario East	Santo Rosario West
Affected Area (sq. km.)	0-0.20	0.51	4.98	1.73	1.73	1.16	1.54	0.17	0.095	1.57	0.22	0.096	0
	0.21-0.50	0.042	0.38	0.2	0.094	0.069	0.14	0.013	0.15	0.076	0.094	0.13	0.0041
	0.51-1.00	0.031	0.17	0.15	0.074	0.055	0.12	0.01	0.077	0.055	0.019	0.059	0.032
	1.01-2.00	0.038	0.12	0.24	0.081	0.049	0.1	0.013	0.34	0.034	0.0086	0.051	0.082
	2.01-5.00	0.092	0.11	0.57	0.21	0.064	0.15	0.045	1.82	0.023	0.0097	0.068	1.25
	> 5.00	0.18	0.0031	0.38	1.34	0.12	0.012	2.14	0.33	0.0019	0	0	0

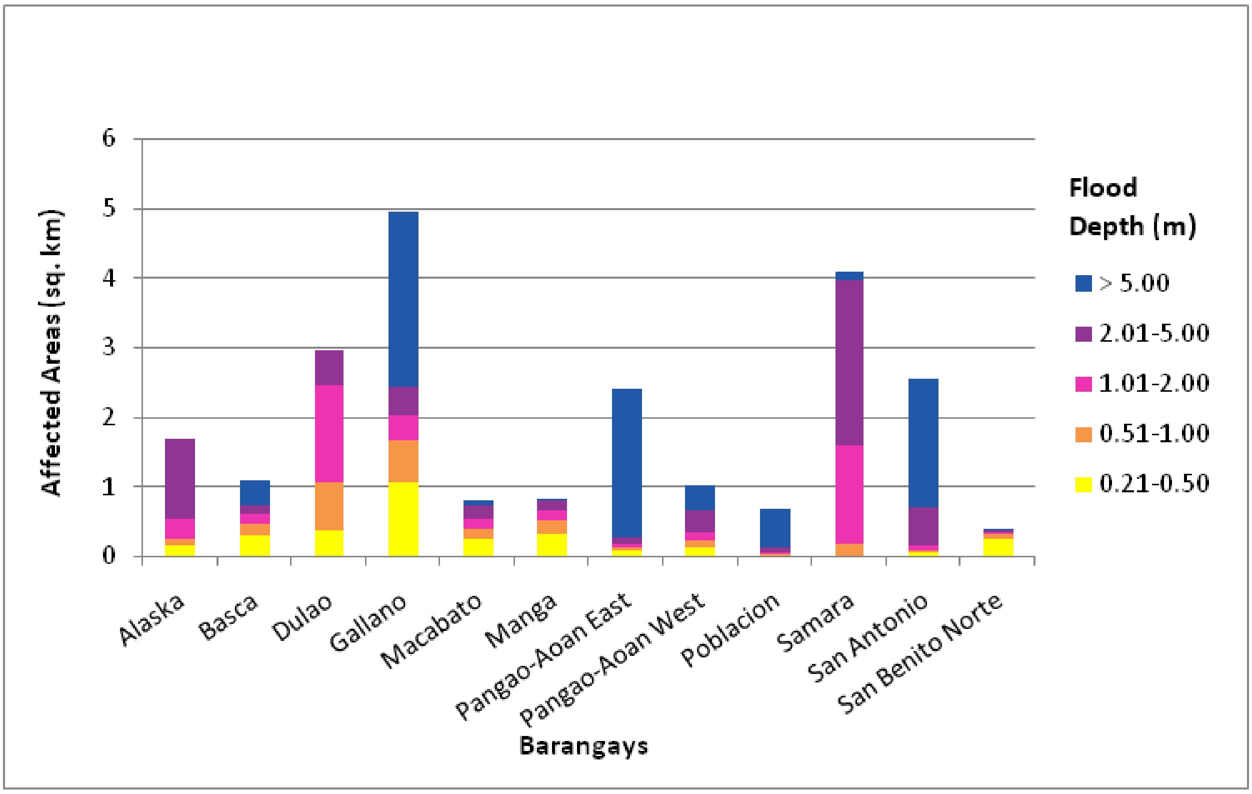


Figure 169. Affected areas in Aringay, La Union during a 100-year rainfall return period - A

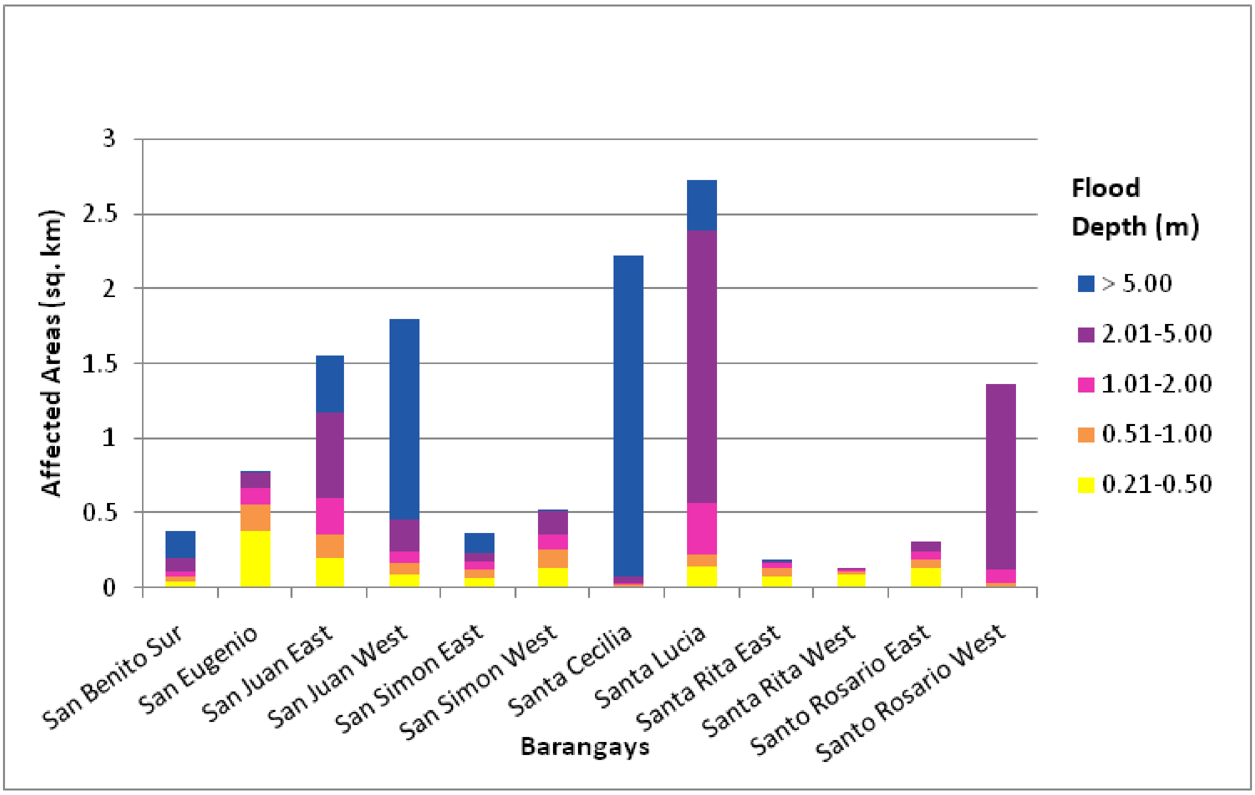


Figure 170. Affected areas in Aringay, La Union during a 100-year rainfall return period - B

For the 100-year return period, 71.15% of the Municipality of Bagulin, with an area of 77.97 square kilometers, will experience flood levels of less than 0.20 meters. 3.26% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 1.54%, 0.99%, 1.14%, and 6.14% 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 130 are the affected areas, in square kilometers, by flood depth per barangay.

Table 130. Affected areas in Bagulin, La Union during a 100-year rainfall return period

ARINGAY-BAU-ANG BASIN		Affected Barangays in Bagulin									
		Alibang-say	Baay	Cam-baly	Cardiz	Dagup	Libbo	Suyo	Tagudtud	Tio-An-gan	Wal-layan
Affected Area (sq. km.)	0-0.20	10.73	1.76	3.01	4.48	4.8	4.59	7.18	2.69	13.05	3.2
	0.21-0.50	0.41	0.092	0.15	0.18	0.24	0.19	0.44	0.14	0.54	0.16
	0.51-1.00	0.18	0.022	0.082	0.092	0.15	0.071	0.23	0.08	0.22	0.081
	1.01-2.00	0.14	0.0068	0.06	0.04	0.11	0.036	0.16	0.039	0.14	0.044
	2.01-5.00	0.15	0.015	0.045	0.044	0.11	0.039	0.13	0.037	0.27	0.056
	> 5.00	1.17	0.39	0.077	0.0032	0.79	0.2	0.59	0.18	0.63	0.77

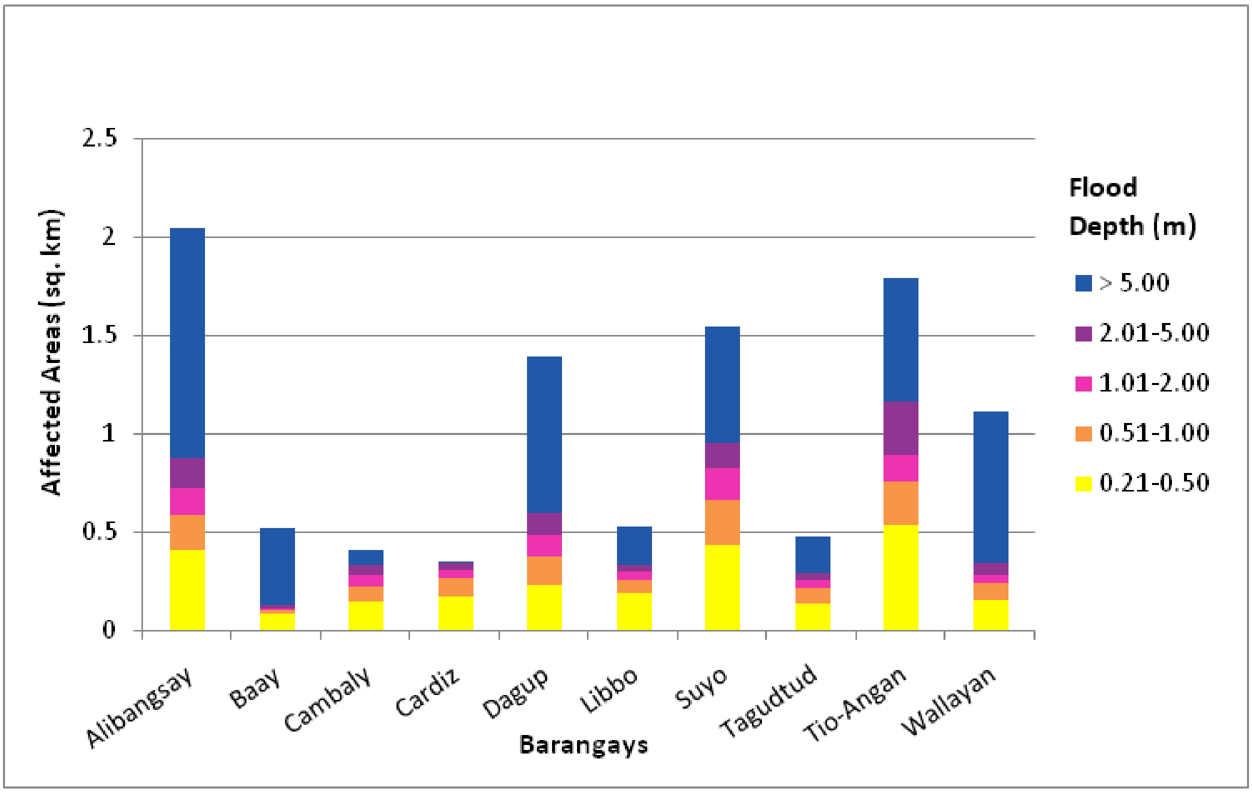


Figure 171. Affected areas in Bagulin, La Union during a 100-year rainfall return period

For the 100-year return period, 57.26% of the Municipality of Bauang, with an area of 85.26 square kilometers, will experience flood levels of less than 0.20 meters. 7.08% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 6.19%, 7.18%, 10.06%, and 11.04% 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 Tables 131-134 are the affected areas, in square kilometers, by flood depth per barangay.

Table 131. Affected areas in Bauang, La Union during a 100-year rainfall return period - A

ARINGAY-BAUANG BASIN		Affected Barangays in Bauang									
		Acao	Baccuit Norte	Baccuit Sur	Bagbag	Ballay	Bawanta	Boy-Utan	Bucayab	Cabalayan-gan	Cabisilan
Affected Area (sq. km.)	0-0.20	2.6	0.075	0.0028	0.37	0.24	0.74	2.94	2.83	4.44	1.67
	0.21-0.50	0.16	0.098	0.0099	0.18	0.0019	0.045	0.33	0.19	0.29	0.16
	0.51-1.00	0.12	0.15	0.078	0.11	0.0024	0.024	0.21	0.11	0.2	0.11
	1.01-2.00	0.17	0.47	0.23	0.15	0.011	0.013	0.13	0.13	0.28	0.054
	2.01-5.00	0.68	0.16	0.3	0.083	0.055	0.003	0.16	0.21	0.4	0.086
	> 5.00	3.56	0	0	0.0028	1.99	0.000075	0.92	0.038	1.02	0.086

Table 132. Affected areas in Bauang, La Union during a 100-year rainfall return period - B

ARINGAY-BAUANG BASIN		Affected Barangays in Bauang									
		Calumbaya	Carmay	Casilagan	Central East	Central West	Dili	Disso-Or	Guerrero	Lower San Agustin	Nagrebcan
Affected Area (sq. km.)	0-0.20	0.89	0.00059	5.5	0.26	0.0022	0.32	0.4	0.41	2.06	0.14
	0.21-0.50	0.17	0.0051	0.47	0.029	0.00088	0.065	0.14	0.18	0.14	0.033
	0.51-1.00	0.2	0.046	0.34	0.013	0.0012	0.06	0.08	0.036	0.069	0.029
	1.01-2.00	0.11	0.13	0.35	0.021	0.004	0.058	0.042	0.0073	0.066	0.013
	2.01-5.00	0.061	0.11	0.44	0.1	0.18	0.0018	0.035	0.0006	0.12	0.091
	> 5.00	0.0098	0.0058	0.069	0.48	0.078	0	0	0	0.16	0.59

Table 133. Affected areas in Bauang, La Union during a 100-year rainfall return period - C

ARINGAY-BAUANG BASIN		Affected Barangays in Bauang									
		Pagdalagan Sur	Palintucang	Palug-si-Limman-sangan	Parian Este	Parian Oeste	Paringao	Payocpoc Norte Este	Payocpoc Norte Oeste	Payocpoc Sur	Pilar
Affected Area (sq. km.)	0-0.20	0	0.41	4.88	0.19	0.051	0.0004	1.37	0.26	0.33	0.021
	0.21-0.50	0	0.068	0.38	0.18	0.049	0.007	0.26	0.48	0.17	0.025
	0.51-1.00	0	0.05	0.24	0.61	0.18	0.047	0.19	0.55	0.15	0.031
	1.01-2.00	0.000003	0.13	0.19	0.26	1.01	0.2	0.15	0.44	0.094	0.00078
	2.01-5.00	0	0.076	0.075	0.23	0.58	0.25	0.15	0.072	0.017	0
	> 5.00	0	0.008	0.0004	0.13	0	0	0.019	0	0	0

Table 134. Affected areas in Bauang, La Union during a 100-year rainfall return period - D

ARINGAY-BAUANG BASIN		Affected Barangays in Bauang								
		Pottot	Pudoc	Pugo	Quinavite	Santa Mon-ica	Santiago	Taberna	Upper San Agustin	Urayong
Affected Area (sq. km.)	0-0.20	0.48	0.0001	0	0.45	5.58	0.99	0.0043	7.58	0.35
	0.21-0.50	0.1	0.0096	0	0.15	0.31	0.33	0.0006	0.65	0.17
	0.51-1.00	0.13	0.063	0.0031	0.065	0.22	0.15	0.01	0.45	0.15
	1.01-2.00	0.092	0.22	0.095	0.026	0.17	0.075	0.085	0.38	0.052
	2.01-5.00	0.0004	0.71	1.22	0.079	0.15	0.03	1.09	0.57	0.0065
	> 5.00	0	0.00035	0.12	0	0.019	0	0.0076	0.11	0

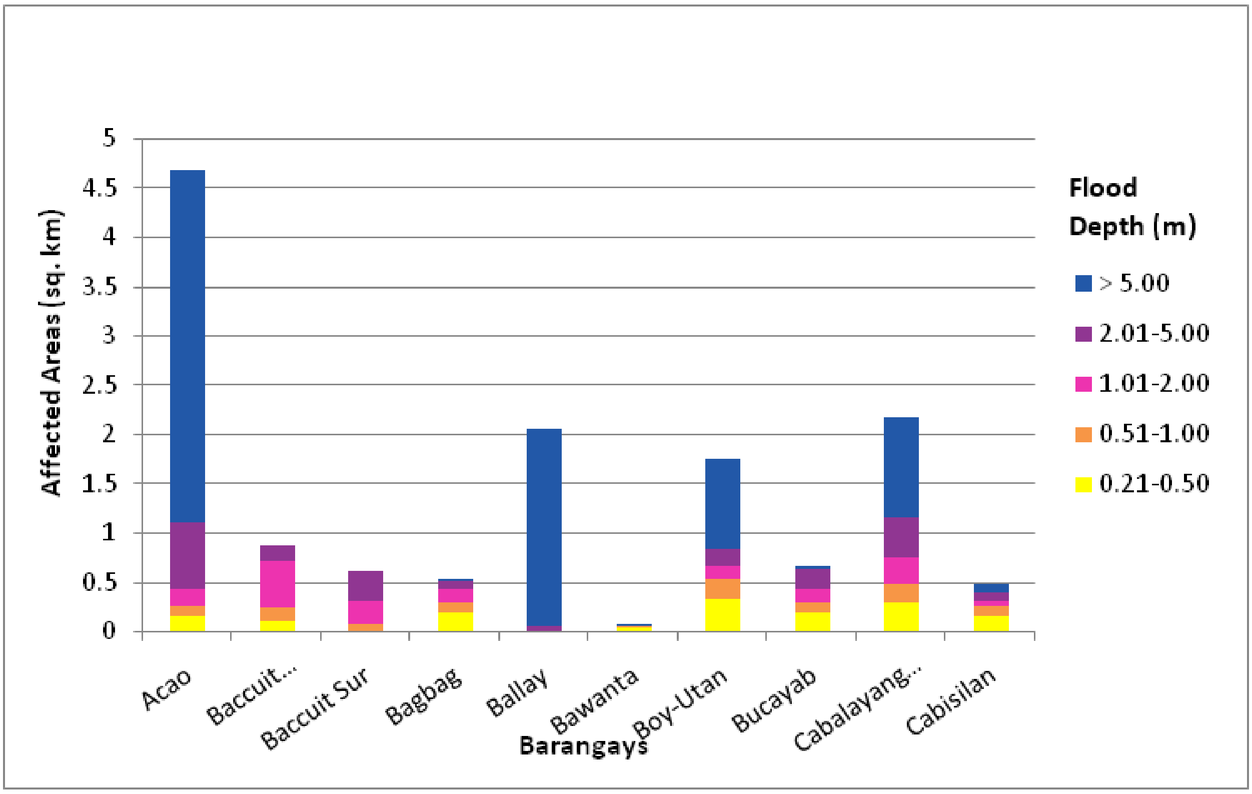


Figure 172. Affected areas in Bauang, La Union during a 100-year rainfall return period - A

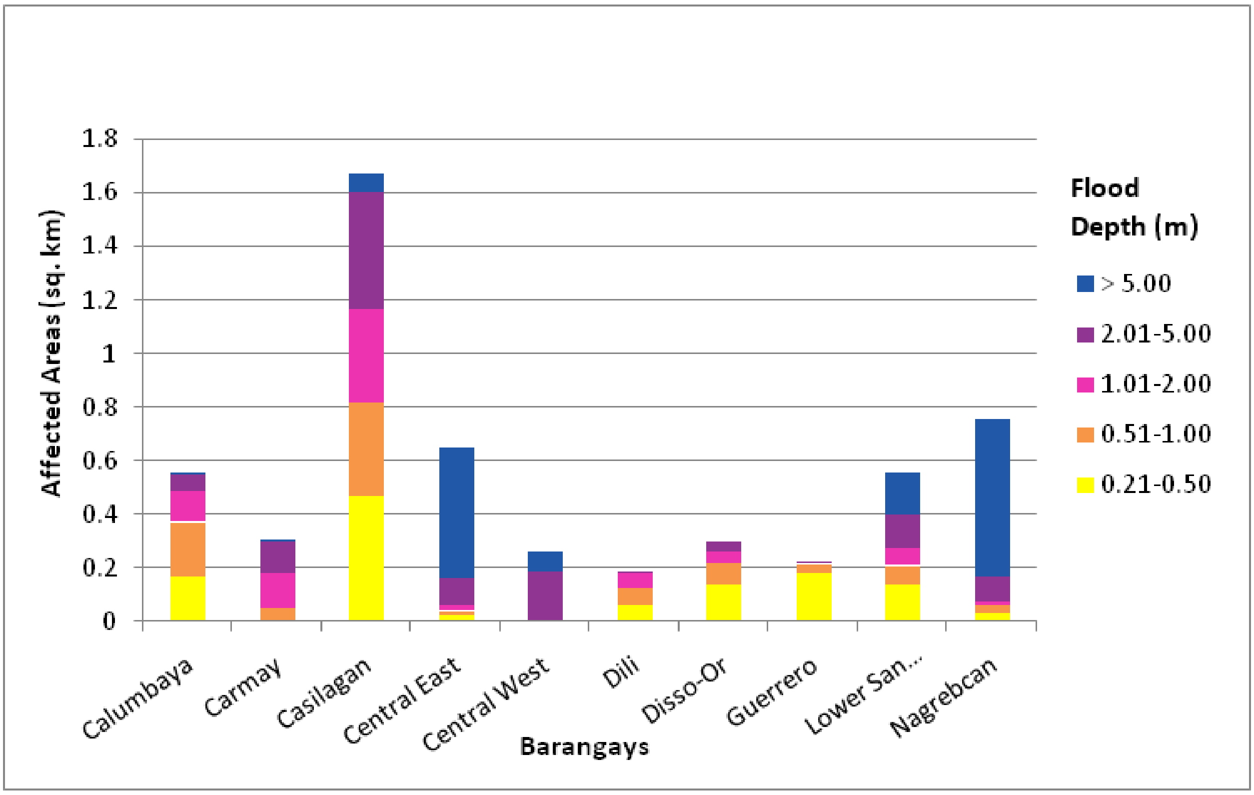


Figure 173. Affected areas in Bauang, La Union during a 100-year rainfall return period - B

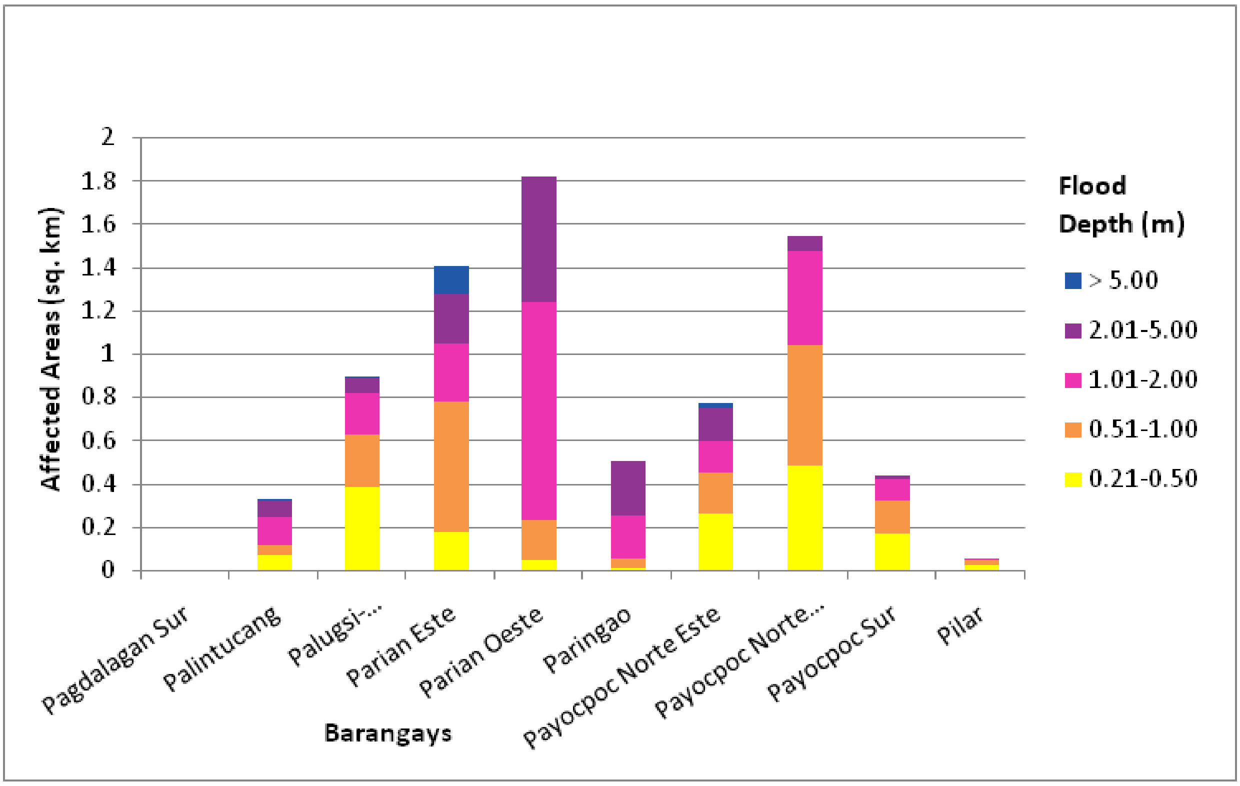


Figure 174. Affected areas in Bauang, La Union during a 100-year rainfall return period - C

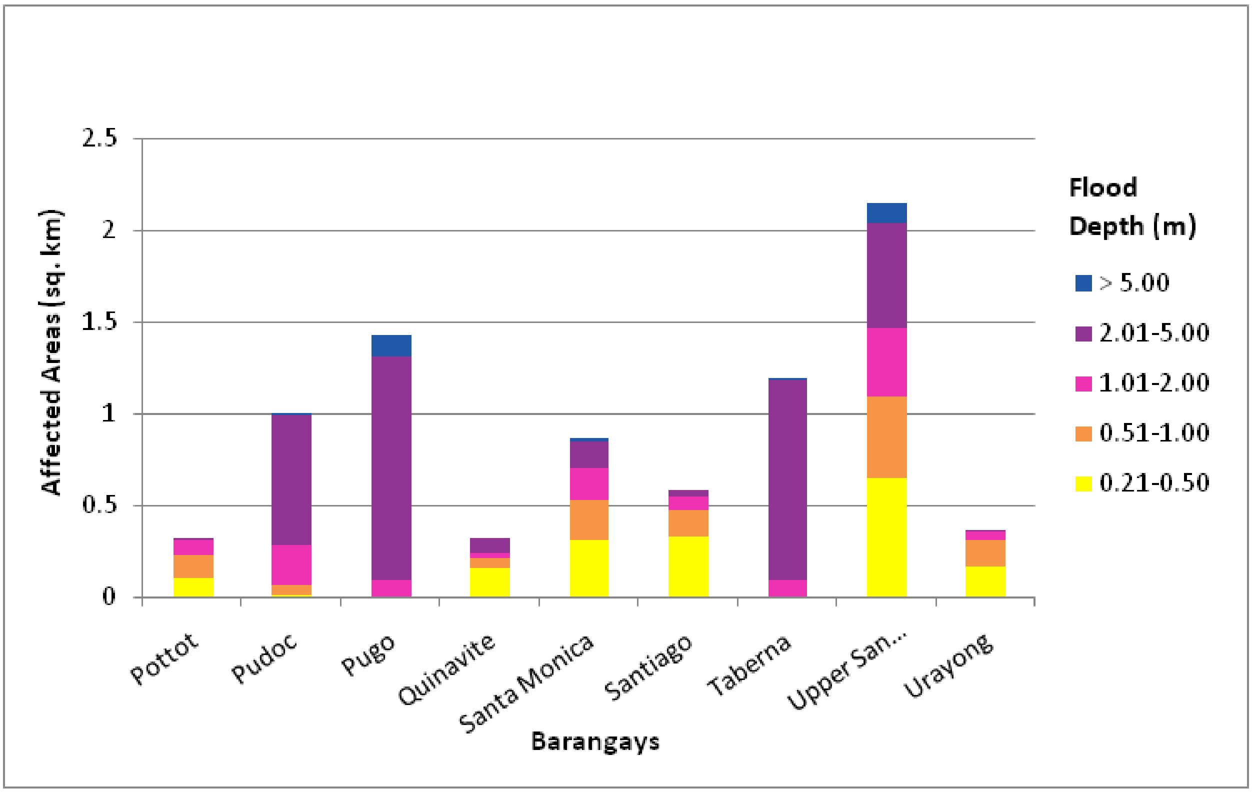


Figure 175. Affected areas in Bauang, La Union during a 100-year rainfall return period - D

For the 100-year return period, 87.39% of the Municipality of Burgos, with an area of 51.92 square kilometers, will experience flood levels of less than 0.20 meters. 4.44% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 1.80%, 1.19%, 1.43%, and 3.76% 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 135 are the affected areas, in square kilometers, by flood depth per barangay.

Table 135. Affected areas in Burgos, La Union during a 100-year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in Burgos											
		Agpay	Bilis	Caoayan	Dalacdac	Delles	Imelda	Libtong	Linuan	Lower Tumapoc	New Poblacion	Old Poblacion	Upper Tumapoc
Affected Area (sq. km.)	0-0.20	2.92	4.57	0.35	2.17	11.34	3.74	4.54	3.9	1.04	3.21	1.28	6.32
	0.21-0.50	0.16	0.22	0.007	0.093	0.52	0.22	0.28	0.097	0.048	0.25	0.078	0.31
	0.51-1.00	0.074	0.071	0.011	0.053	0.25	0.1	0.1	0.059	0.025	0.052	0.03	0.11
	1.01-2.00	0.046	0.047	0.012	0.034	0.16	0.078	0.062	0.04	0.015	0.033	0.017	0.08
	2.01-5.00	0.041	0.052	0.012	0.07	0.12	0.078	0.064	0.038	0.047	0.037	0.045	0.13
	> 5.00	0.12	0.069	0.086	0.45	0.037	0.11	0.086	0.61	0.041	0.013	0.12	0.21

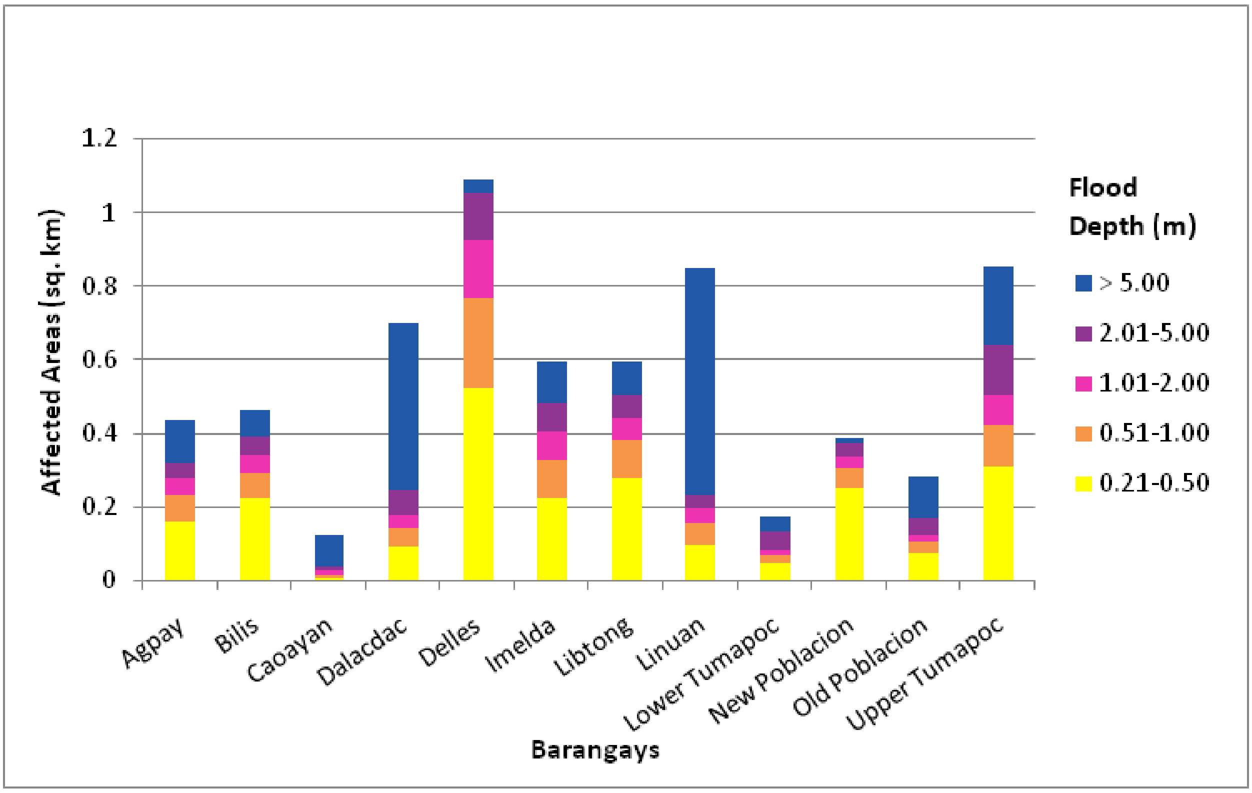


Figure 176. Affected areas in Burgos, La Union during a 100-year rainfall return period

For the 100-year return period, 66.27% of the Municipality of Caba, with an area of 56.19 square kilometers, will experience flood levels of less than 0.20 meters. 7.67% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 5.87%, 6.28%, 8.86%, and 5.00% 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 Tables 136-137 are the affected areas, in square kilometers, by flood depth per barangay.

Table 136. Affected areas in Caba, La Union during a 100-year rainfall return period - A

ARINGAY-BAUANG BASIN		Affected Barangays in Caba								
		Bautista	Gana	Juan Cartas	Las-Ud	Liquicia	Poblacion Norte	Poblacion Sur	San Carlos	San Cornelio
Affected Area (sq. km.)	0-0.20	2.36	0.73	2.3	0.062	12.63	0.27	0.27	0.13	4.79
	0.21-0.50	0.45	0.77	0.2	0.044	0.65	0.054	0.14	0.28	0.4
	0.51-1.00	0.26	0.4	0.13	0.059	0.43	0.073	0.073	0.32	0.29
	1.01-2.00	0.11	0.12	0.068	0.063	0.45	0.19	0.035	0.47	0.28
	2.01-5.00	0.057	0.13	0.03	0.014	0.74	0.31	0.02	0.12	0.38
	> 5.00	0.0028	0	0.002	0	1.37	0.046	0	0	0.29

Table 137. Affected areas in Caba, La Union during a 100-year rainfall return period - B

ARINGAY-BAUANG BASIN		Affected Barangays in Caba							
		San Fermin	San Gregorio	San Jose	Santiago Norte	Santiago Sur	Sobredillo	Urayong	Wenceslao
Affected Area (sq. km.)	0-0.20	4.54	1.73	1.96	0.0022	0.007	3.64	1.73	0.078
	0.21-0.50	0.34	0.12	0.21	0.023	0.032	0.21	0.27	0.12
	0.51-1.00	0.25	0.1	0.17	0.15	0.18	0.11	0.16	0.16
	1.01-2.00	0.2	0.11	0.21	0.33	0.74	0.081	0.033	0.043
	2.01-5.00	0.33	0.22	0.5	0.15	1.93	0.045	0.007	0.0002
	> 5.00	0.51	0.2	0.35	0	0	0.038	0	0

For the 100-year return period, 64.07% of the Municipality of Naguilian, with an area of 86.39 square kilometers, 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. Meanwhile, 2.36%, 2.11%, 3.44%, and 24.53% 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 Tables 138-141 are the affected areas, in square kilometers, by flood depth per barangay.

Table 138. Affected areas in Naguilian, La Union during a 100-year rainfall return period - A

ARINGAY-BAUANG BASIN		Affected Barangays in Naguilian									
		Aguioas	Al-Alinao Norte	Al-Alinao Sur	Ambaracao Norte	Ambaracao Sur	Angin	Balecbec	Bancagan	Baraoas Norte	Baraoas Sur
Affected Area (sq. km.)	0-0.20	0.43	1.8	2.94	2.08	1.59	0.23	3.43	0.36	0	0.015
	0.21-0.50	0.016	0.11	0.15	0.15	0.13	0.012	0.18	0.005	0	0.0089
	0.51-1.00	0.013	0.11	0.066	0.21	0.13	0.0058	0.11	0.0035	0	0.0072
	1.01-2.00	0.019	0.21	0.033	0.19	0.089	0.0032	0.089	0.014	0	0.007
	2.01-5.00	0.054	0.31	0.038	0.26	0.092	0.0033	0.2	0.029	0.0019	0.012
	> 5.00	0.73	1.27	0.34	2.27	0.065	0.00017	0.28	1.54	0.66	0.43

Table 139. Affected areas in Naguilian, La Union during a 100-year rainfall return period - B

ARINGAY-BAUANG BASIN		Affected Barangays in Naguilian									
		Bariquir	Bato	Bimmoto-bot	Cabaritan Norte	Cabaritan Sur	Casilagan	Dal-Li-paoen	Daramuan-gan	Guesset	Gusing Norte
Affected Area (sq. km.)	0-0.20	1.02	1.55	3.96	0.00024	0.027	5.23	0.0067	0.02	0.42	3.48
	0.21-0.50	0.039	0.095	0.21	0.000076	0.00052	0.25	0.0001	0.0072	0.026	0.15
	0.51-1.00	0.015	0.065	0.12	0.0002	0.0015	0.16	0.0004	0.024	0.023	0.084
	1.01-2.00	0.011	0.077	0.086	0	0.002	0.12	0.0002	0.028	0.0075	0.068
	2.01-5.00	0.0099	0.034	0.075	0.002	0.016	0.17	0.0016	0.048	0.0035	0.078
	> 5.00	0.034	0.028	0.06	0.29	0.29	0.47	0.47	0.77	0	0.76

Table 140. Affected areas in Naguilian, La Union during a 100-year rainfall return period - C

ARINGAY-BAUANG BASIN		Affected Barangays in Naguilian									
		Gusing Sur	Imelda	Lioac Norte	Lioac Sur	Magungu-nay	Mamat-Ing Norte	Mamat-Ing Sur	Nagsido-risan	Natividad	Ortiz
Affected Area (sq. km.)	0-0.20	1.84	0.25	0.47	0.45	2.6	1.09	1.1	0.5	1	0
	0.21-0.50	0.089	0.014	0.013	0.036	0.17	0.033	0.054	0.038	0.11	0
	0.51-1.00	0.052	0.0059	0.0093	0.0091	0.14	0.016	0.025	0.026	0.076	0
	1.01-2.00	0.054	0.004	0.0096	0.013	0.15	0.013	0.024	0.022	0.055	0.00019
	2.01-5.00	0.1	0.0019	0.031	0.039	0.4	0.029	0.049	0.041	0.097	0.029
	> 5.00	1.49	0	0.49	0.079	0.61	0.92	1.86	0.028	0.44	0.46

Table 141. Affected areas in Naguilian, La Union during a 100-year rainfall return period - D

ARINGAY-BAUANG BASIN		Affected Barangays in Naguilian						
		Ribsuan	San Anto-nio	San Isidro	Sili	Suguidan Norte	Suguidan Sur	Tuddingan
Affected Area (sq. km.)	0-0.20	0.97	4.55	7.11	0.67	0.3	1.88	2
	0.21-0.50	0.056	0.27	0.35	0.054	0.015	0.12	0.09
	0.51-1.00	0.022	0.15	0.2	0.045	0.0094	0.057	0.048
	1.01-2.00	0.0049	0.1	0.14	0.024	0.0067	0.077	0.062
	2.01-5.00	0.013	0.092	0.17	0.018	0.019	0.3	0.12
	> 5.00	0.2	0.0099	0.14	0.14	0.56	2.56	0.46

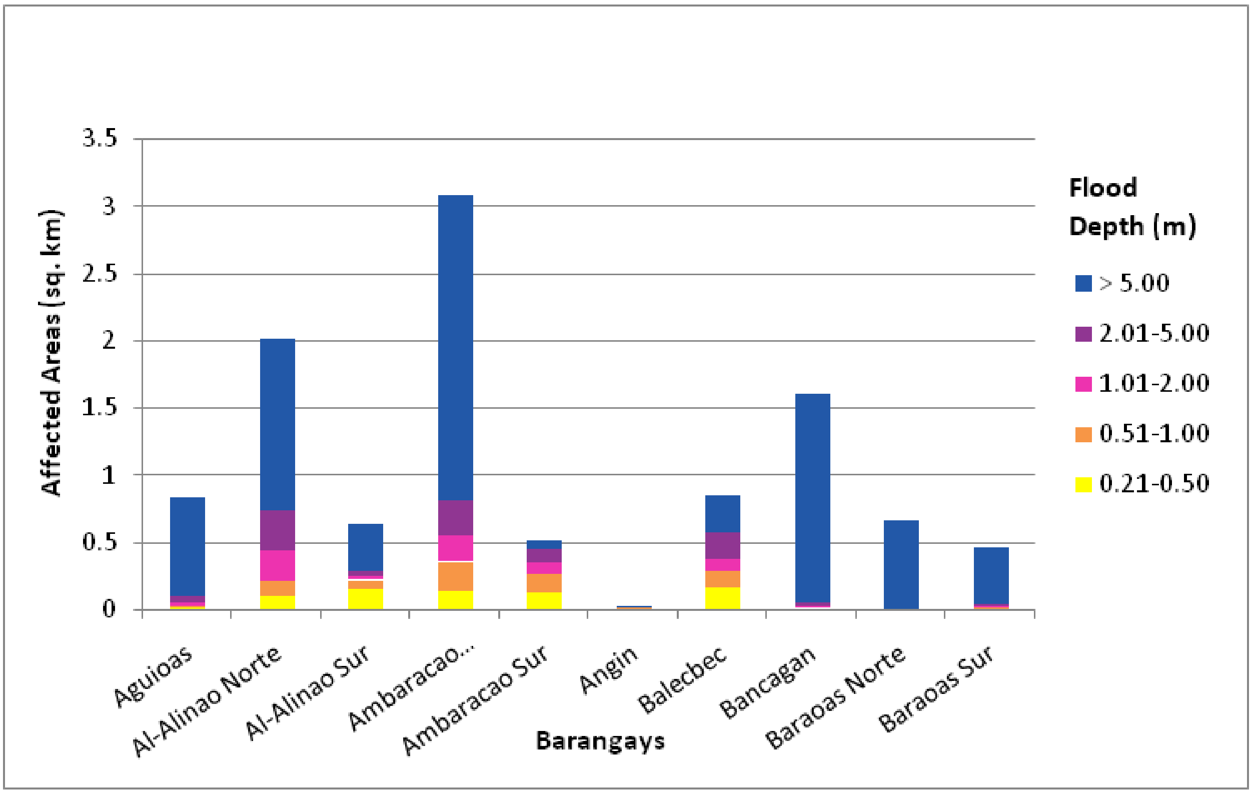


Figure 179. Affected areas in Naguilian, La Union during a 100-year rainfall return period - A

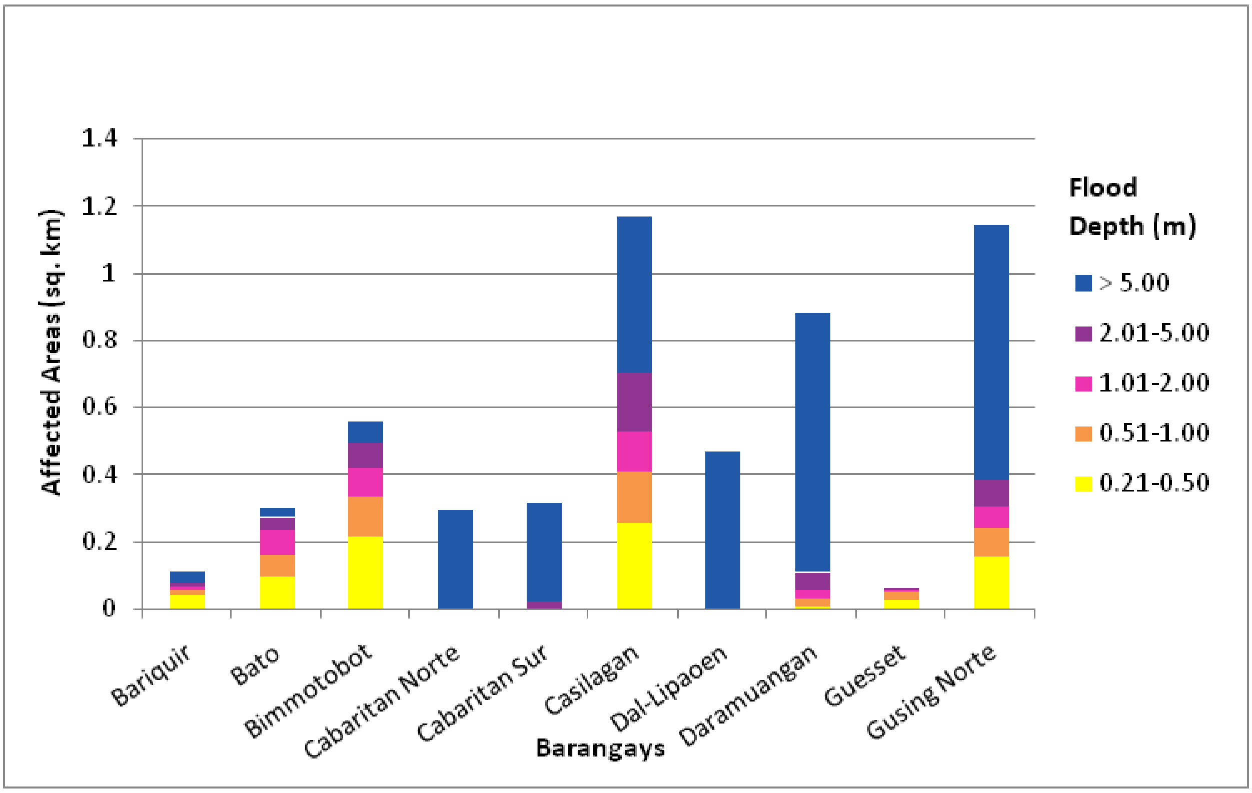


Figure 180. Affected areas in Naguilian, La Union during a 100-year rainfall return period - B

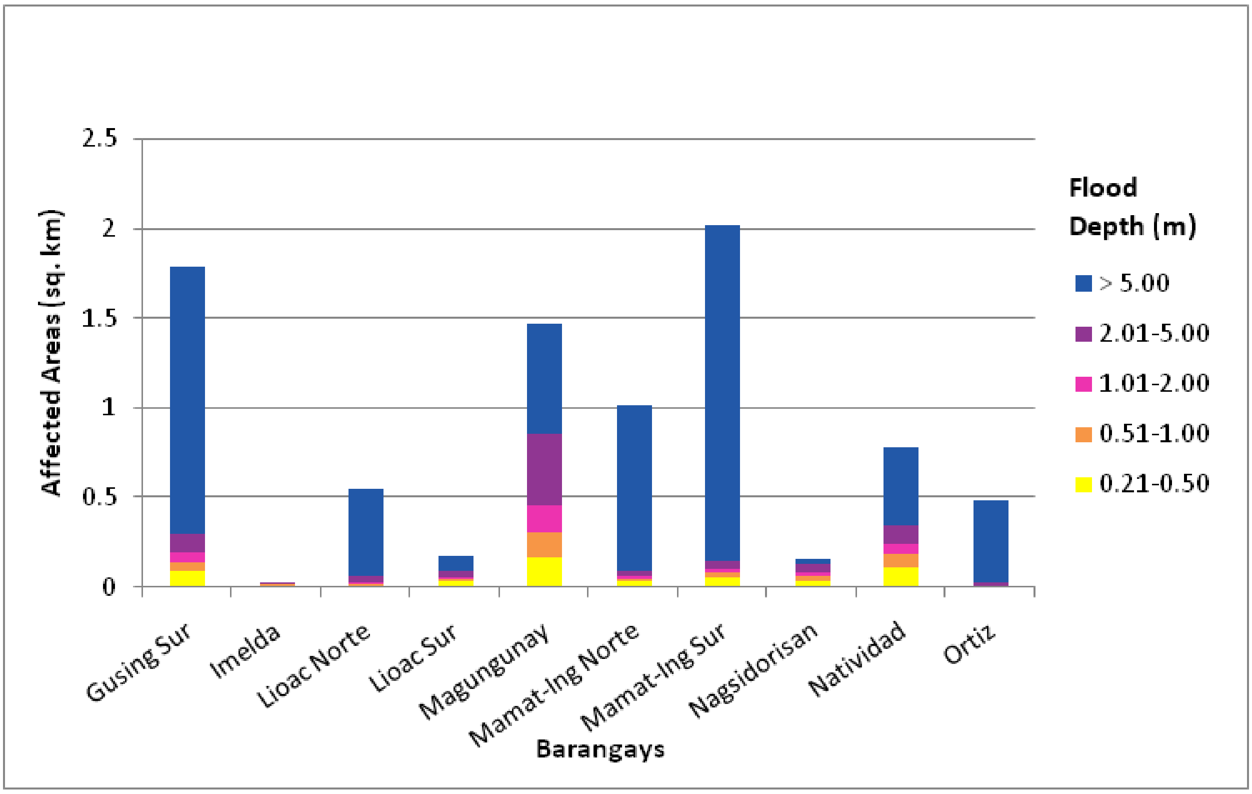


Figure 181. Affected areas in Naguilian, La Union during a 100-year rainfall return period - C

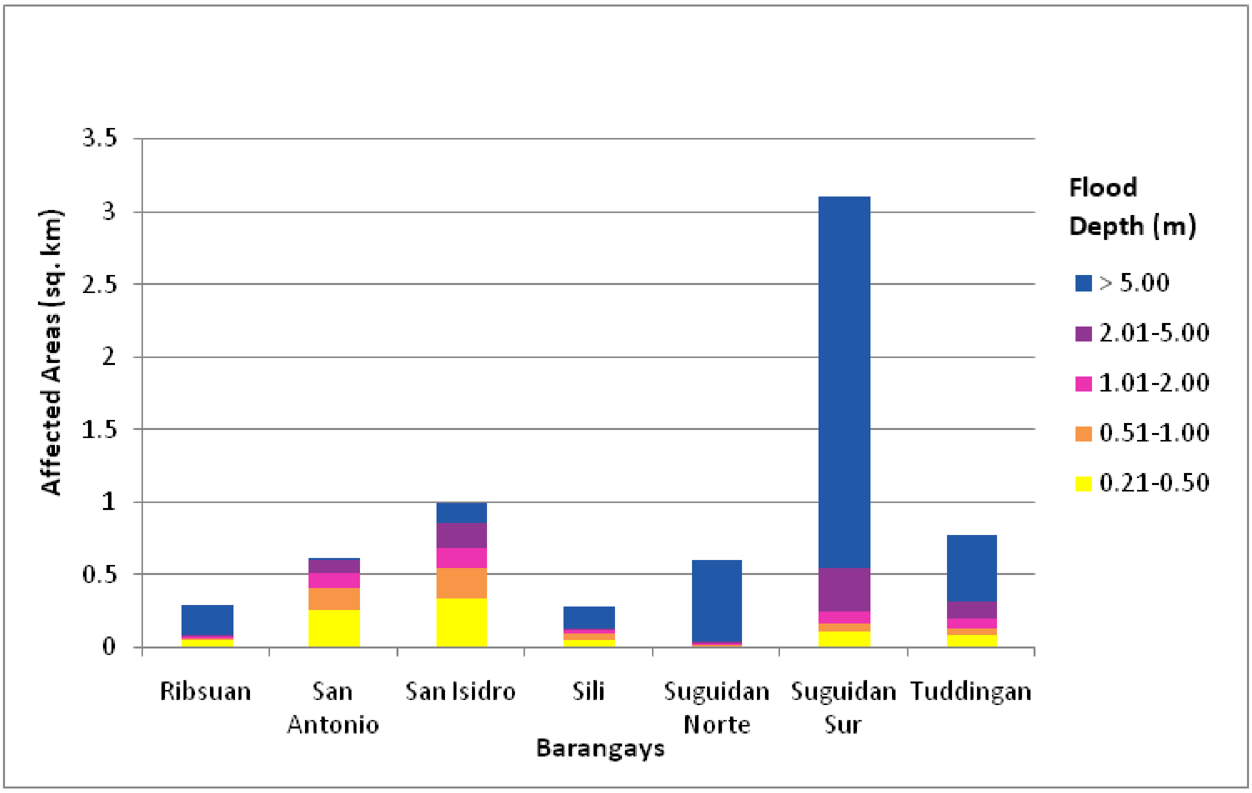


Figure 182. Affected areas in Naguilian, La Union during a 100-year rainfall return period - D

For the 100-year return period, 65.67% of the Municipality of Pugo, with an area of 60.54 square kilometers, will experience flood levels of less than 0.20 meters. 3.87% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 2.40%, 2.42%, 5.22%, and 3.33% 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 142 are the affected areas, in square kilometers, by flood depth per barangay.

Table 142. Affected areas in Pugo, La Union during a 100-year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in Pugo											
		Ambalite	Amban-gonan	Cares	Duplas	Mao-asoas Norte	Mao-asoas Sur	Palina	Pobla-cion East	Pobla-cion West	San Luis	Tavora East	Tavora Proper
Affected Area (sq. km.)	0-0.20	2.49	4.03	2.99	0.86	1.07	1.53	19.61	2.89	1.97	1.08	0.2	1.02
	0.21-0.50	0.17	0.22	0.2	0.044	0.11	0.084	1.05	0.17	0.16	0.058	0.0062	0.075
	0.51-1.00	0.098	0.14	0.19	0.032	0.087	0.077	0.54	0.1	0.095	0.028	0.0075	0.055
	1.01-2.00	0.17	0.13	0.28	0.031	0.12	0.054	0.31	0.08	0.11	0.019	0.013	0.15
	2.01-5.00	0.54	0.25	0.44	0.077	0.25	0.043	0.31	0.049	0.24	0.0055	0.27	0.68
	> 5.00	0.063	0.025	0.21	0.015	0.15	0.085	0.18	0.054	0.15	0	0.84	0.25

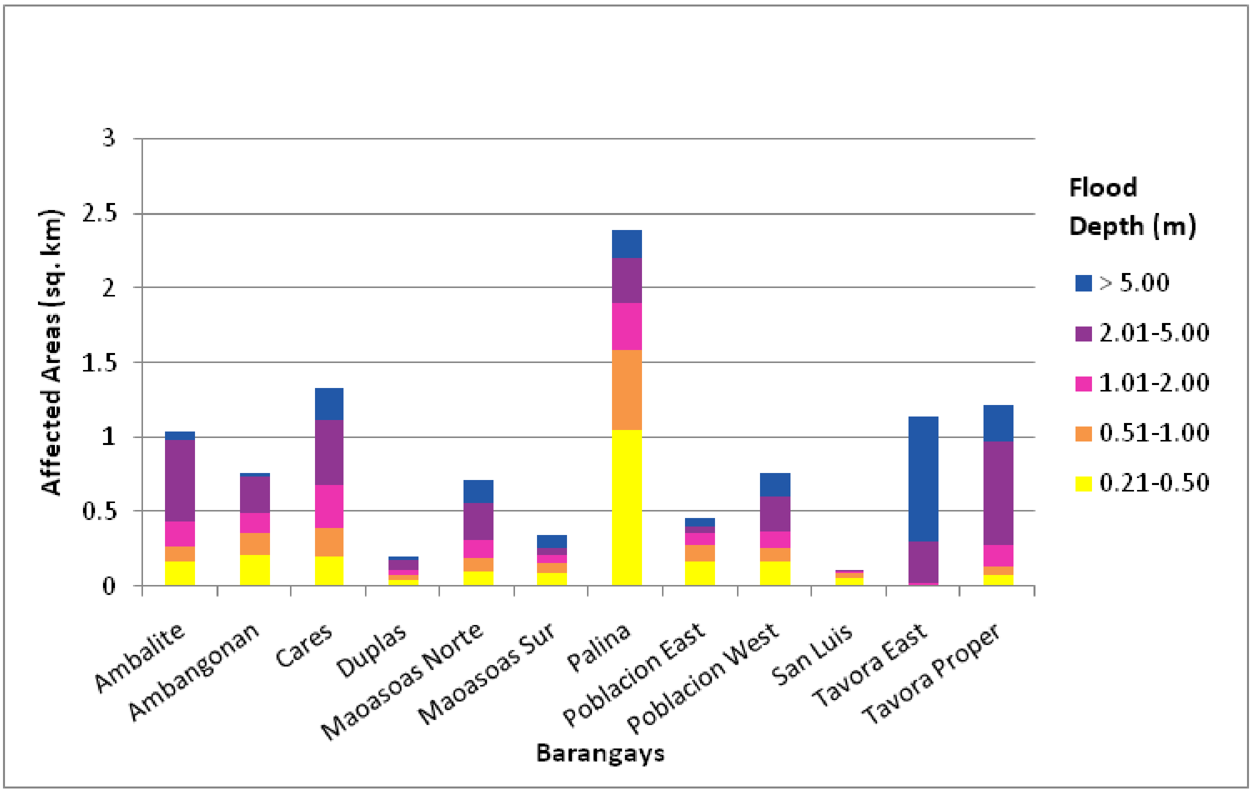


Figure 183. Affected areas in Pugo, La Union during a 100-year rainfall return period

For the 100-year return period, 6.20% of the Municipality of Rosario, with an area of 64.33 square kilometers, will experience flood levels of less than 0.20 meters. 0.35% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 0.20%, 0.16%, and 0.13% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and 2.01 to 5 meters, respectively. Listed in Table 143 are the affected areas, in square kilometers, by flood depth per barangay.

Table 143. Affected areas in Rosario, La Union during a 100-year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in Rosario				
		Ambango-nan	Inabaan Norte	Marcos	Parasapas	San Jose
Affected Area (sq. km.)	0-0.20	0.25	0.74	1.2	1.19	0.61
	0.21-0.50	0.017	0.027	0.071	0.076	0.036
	0.51-1.00	0.0065	0.016	0.053	0.037	0.019
	1.01-2.00	0.0052	0.01	0.048	0.028	0.012
	2.01-5.00	0.0021	0.0028	0.05	0.024	0.0071
	> 5.00	0	0	0	0	0

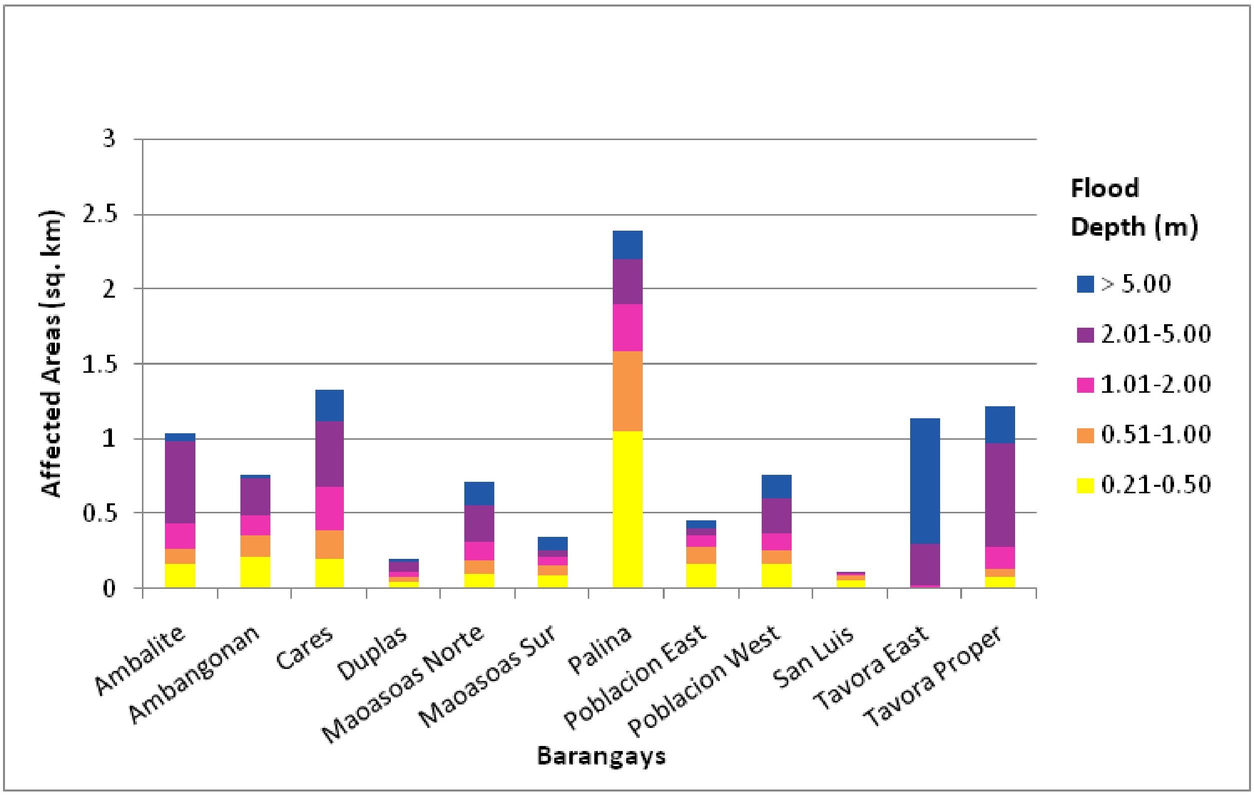


Figure 184. Affected areas in Rosario, La Union during a 100-year rainfall return period

For the 100-year return period, 34.84% of the Municipality of San Fernando City, with an area of 121.05 square kilometers, will experience flood levels of less than 0.20 meters. 2.52% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 1.58%, 1.28%, 1.74%, and 5.00% 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 Tables 144-145 are the affected areas, in square kilometers, by flood depth per barangay.

Table 144. Affected areas in San Fernando City, La Union during a 100-year rainfall return period - A

ARINGAY-BAUANG BASIN		Affected Barangays in San Fernando City											
		Apaleng	Bacsil	Bangbangolan	Birunget	Bungro	Cabarsican	Cadaclan	Calabugao	Langcuas	Masicong	Nagyubuyuban	Namtutan
Affected Area (sq. km.)	0-0.20	3.91	5.2	0.85	2.87	0.17	1.25	2.17	1.58	0.2	1.28	0.72	0.15
	0.21-0.50	0.24	0.35	0.073	0.19	0.084	0.051	0.13	0.093	0.012	0.057	0.038	0.012
	0.51-1.00	0.15	0.22	0.037	0.17	0.089	0.027	0.076	0.069	0.0057	0.032	0.022	0.0045
	1.01-2.00	0.16	0.21	0.011	0.12	0.09	0.027	0.056	0.046	0.0024	0.016	0.015	0.0031
	2.01-5.00	0.3	0.26	0.0022	0.087	0.11	0.084	0.063	0.026	0.0002	0.023	0.0034	0
	> 5.00	0.37	0.13	0	0.0054	0.002	1.15	0.024	0.0015	0	1.62	0.00018	0

Table 145. Affected areas in San Fernando City, La Union during a 100-year rainfall return period - B

ARINGAY-BAUANG BASIN		Affected Barangays in San Fernando City											
		Narra Este	Narra Oeste	Pacpaco	Pao Norte	Pao Sur	Pias	Puspus	Sacyud	Sagayad	Sevilla	Sibo-an-Otong	Tanquigan
Affected Area (sq. km.)	0-0.20	3.8	2.2	0.7	2.45	3	0.9	0.62	3.08	0.39	0.35	2.83	1.52
	0.21-0.50	0.22	0.29	0.047	0.13	0.24	0.097	0.034	0.15	0.056	0.028	0.24	0.19
	0.51-1.00	0.16	0.15	0.022	0.075	0.13	0.087	0.023	0.094	0.053	0.021	0.14	0.063
	1.01-2.00	0.13	0.13	0.014	0.034	0.078	0.027	0.015	0.079	0.092	0.048	0.1	0.035
	2.01-5.00	0.13	0.18	0.0065	0.013	0.14	0.013	0.0015	0.16	0.1	0.26	0.11	0.021
	> 5.00	0.0023	0.034	0.0002	0	0.26	0.0022	0	2.42	0.0029	0.026	0.0005	0

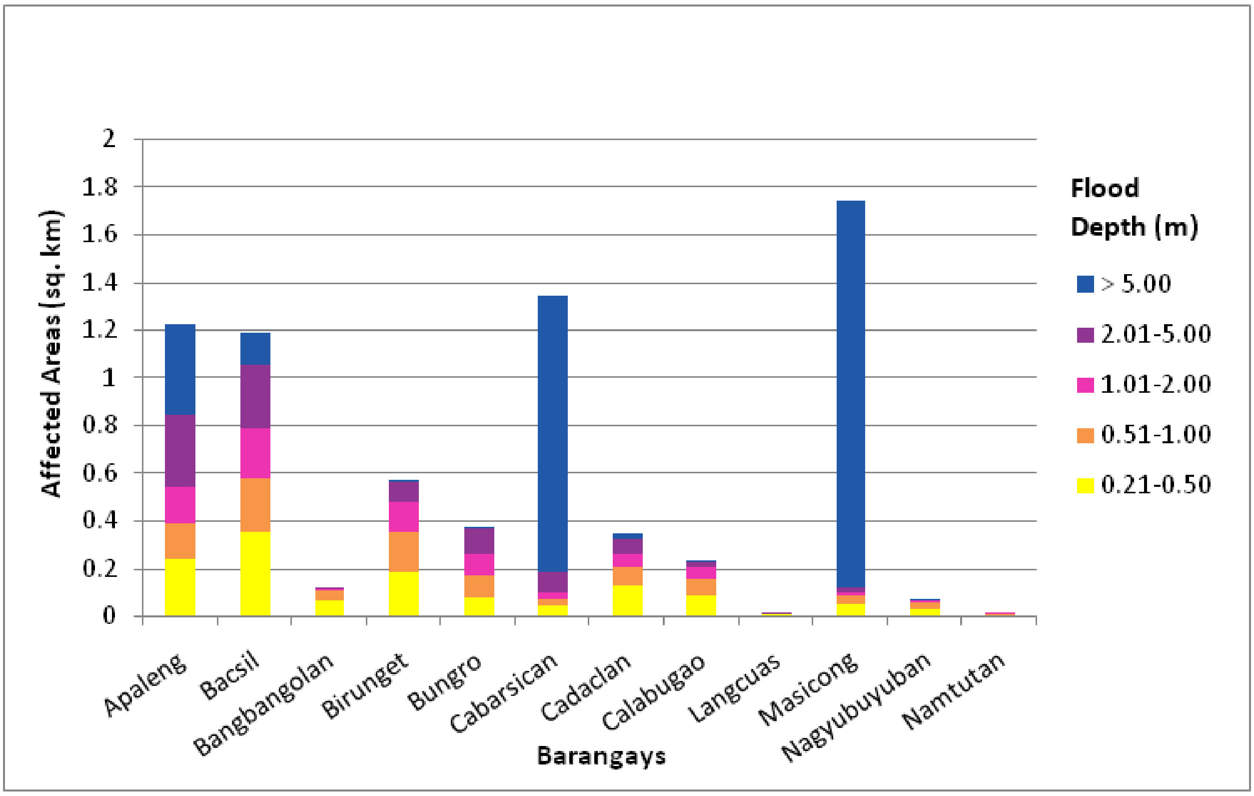


Figure 185. Affected areas in San Fernando City, La Union during a 100-year rainfall return period - A

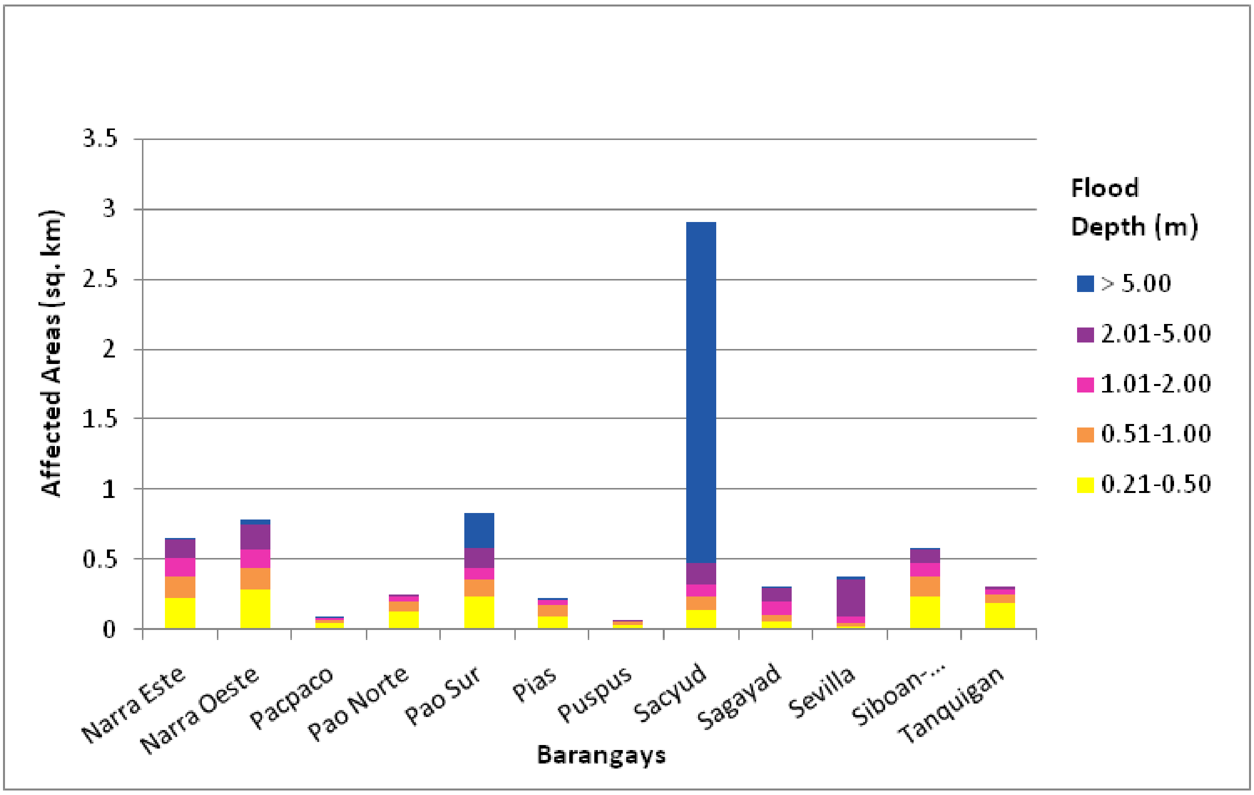


Figure 186. Affected areas in San Fernando City, La Union during a 100-year rainfall return period - B

For the 100-year return period, 9.84% of the Municipality of San Gabriel, with an area of 154.19 square kilometers, will experience flood levels of less than 0.20 meters. 0.55% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 0.22%, 0.13%, 0.13%, and 0.10% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 146 are the affected areas, in square kilometers, by flood depth per barangay.

Table 146. Affected areas in San Gabriel, La Union during a 100-year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in San Gabriel		
		Amontoc	Apayao	Bayabas
Affected Area (sq. km.)	0-0.20	3.25	11.51	0.42
	0.21-0.50	0.13	0.72	0.0003
	0.51-1.00	0.034	0.31	0.0001
	1.01-2.00	0.018	0.17	0
	2.01-5.00	0.021	0.18	0
	> 5.00	0.019	0.14	0

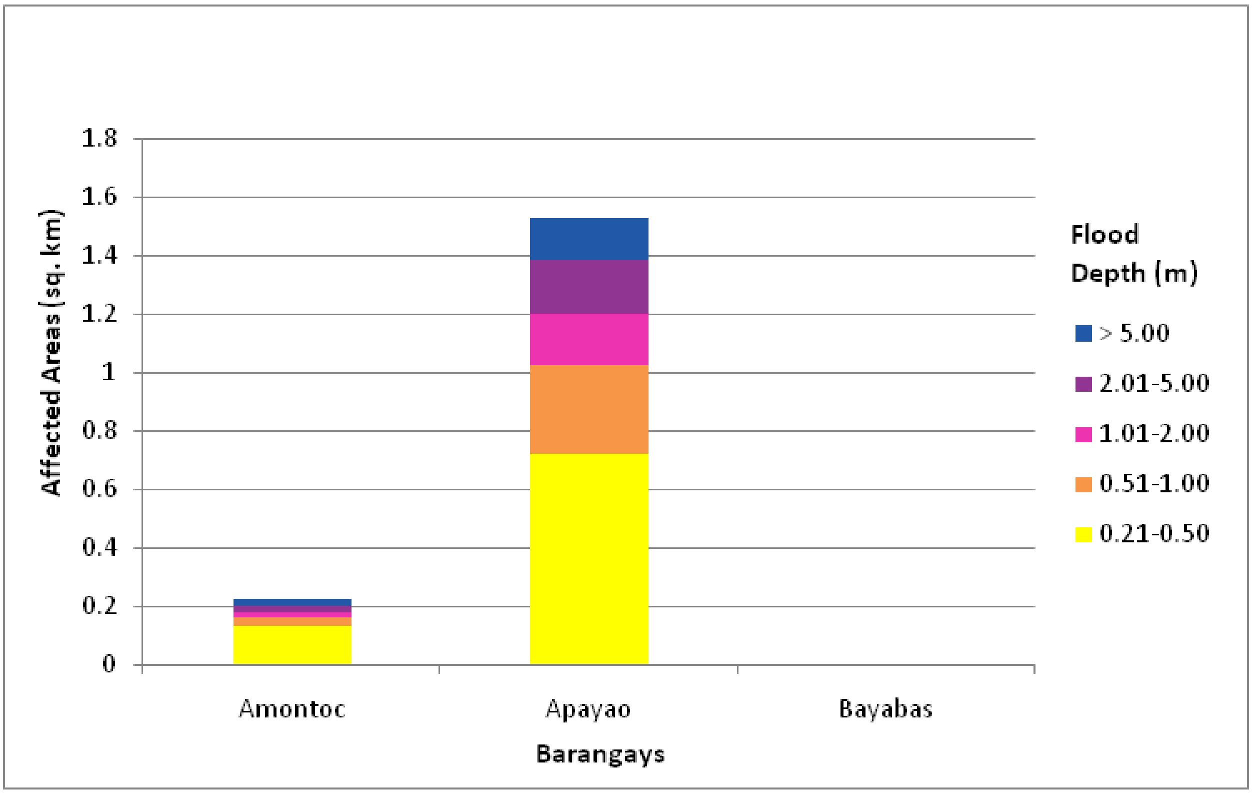


Figure 187. Affected areas in San Gabriel, La Union during a 100-year rainfall return period

For the 100-year return period, 7.84% of the Municipality of Santo Tomas, with an area of 58.53 square kilometers, will experience flood levels of less than 0.20 meters. 0.41% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 0.25%, 0.22%, 0.17%, and 0.02% 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 147 are the affected areas, in square kilometers, by flood depth per barangay.

Table 147. Affected areas in Santo Tomas, La Union during a 100-Year rainfall return period

ARINGAY-BAUANG BASIN		Affected Barangays in Santo Tomas		
		Ambitacay	Bail	Pongpong
Affected Area (sq. km.)	0-0.20	0.35	0.14	4.1
	0.21-0.50	0.0098	0.011	0.22
	0.51-1.00	0.01	0.0056	0.13
	1.01-2.00	0.0062	0.0028	0.12
	2.01-5.00	0.0042	0.0001	0.096
	> 5.00	0.0003	0	0.0097

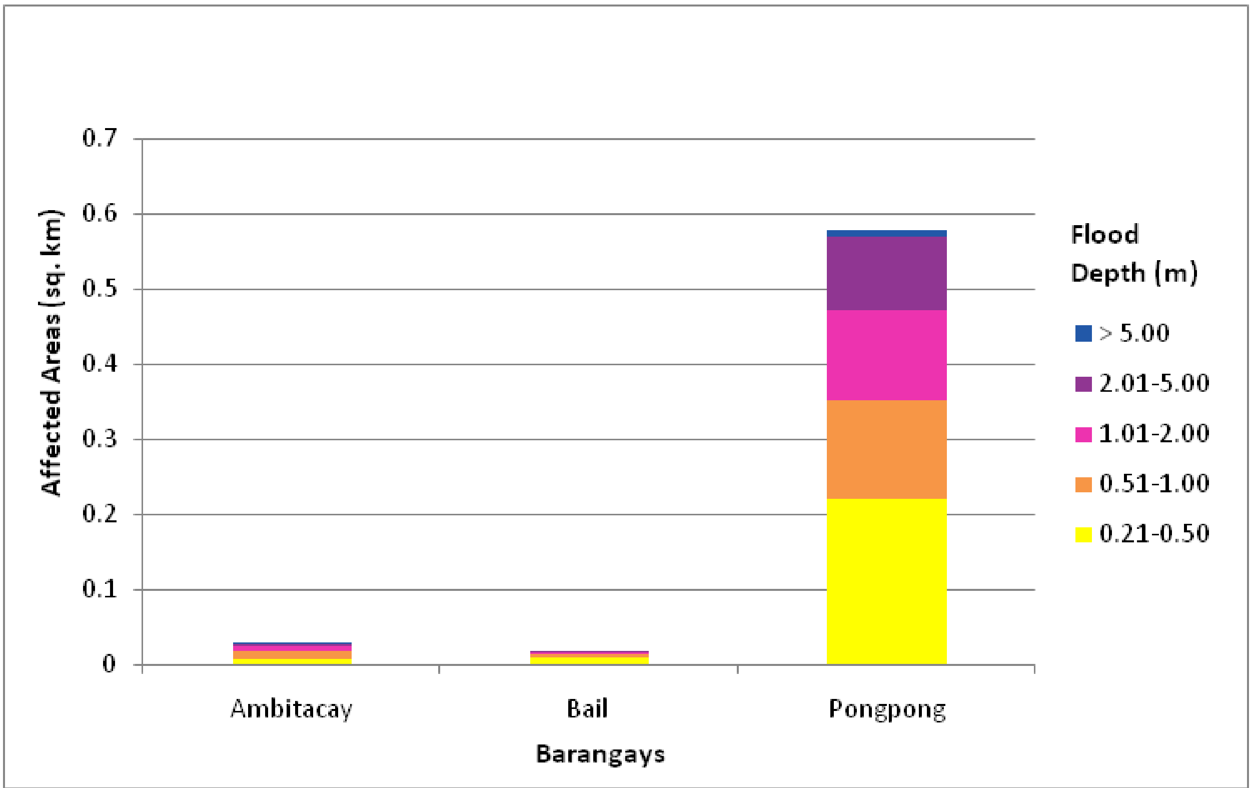


Figure 188. Affected areas in Santo Tomas, La Union during a 100-Year rainfall return period

For the 100-year return period, 46.42% of the Municipality of Tubao, with an area of 53.87 square kilometers, will experience flood levels of less than 0.20 meters. 3.15% of the area will experience flood levels of 0.21 to 0.50 meters. Meanwhile, 1.89%, 1.47%, 3.06%, and 27.92% 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 Tables 148-149 are the affected areas, in square kilometers, by flood depth per barangay.

Table 148. Affected areas in Tubao, La Union during a 100-year rainfall return period - A

ARINGAY-BAUANG BASIN		Affected Barangays in Tubao								
		Anduyan	Caoigue	Francia Sur	Francia West	Garcia	Gonzales	Halog East	Halog West	Leones East
Affected Area (sq. km.)	0-0.20	4.84	1.26	0.84	0.33	0.45	0.12	0.049	0.0005	0
	0.21-0.50	0.46	0.083	0.048	0.016	0.022	0.004	0.0021	0.0033	0
	0.51-1.00	0.29	0.062	0.024	0.0094	0.013	0.003	0.0039	0.0045	0
	1.01-2.00	0.17	0.062	0.026	0.0074	0.0088	0.0034	0.01	0.011	0
	2.01-5.00	0.14	0.28	0.057	0.017	0.014	0.018	0.039	0.036	0
	> 5.00	1.76	0.084	0.076	0.036	0.63	0.93	0.77	0.83	0.93

Table 149. Affected areas in Tubao, La Union during a 100-year rainfall return period - B

ARINGAY-BAUANG BASIN		Affected Barangays in Tubao							
		Leones West	Linapew	Lloren	Magsay-say	Pideg	Pobla-cion	Rizal	Santa Teresa
Affected Area (sq. km.)	0-0.20	0.67	1.93	2.41	0.33	2.35	0.24	4.18	5.03
	0.21-0.50	0.044	0.11	0.25	0.017	0.12	0.016	0.25	0.25
	0.51-1.00	0.029	0.042	0.15	0.0096	0.099	0.0098	0.14	0.13
	1.01-2.00	0.044	0.015	0.11	0.012	0.083	0.009	0.14	0.088
	2.01-5.00	0.13	0.0026	0.22	0.03	0.17	0.026	0.29	0.18
	> 5.00	0.72	0.0023	0.62	0.87	0.064	0.76	3.27	2.7

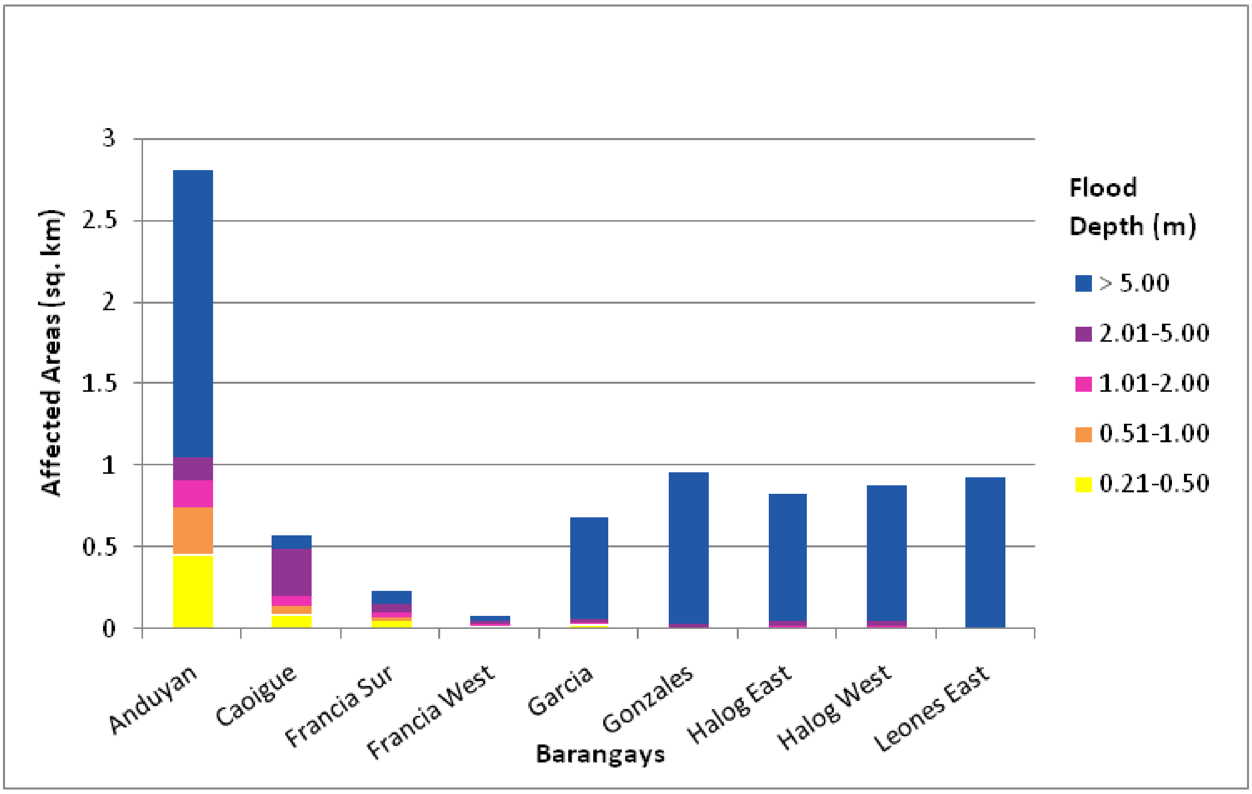


Figure 189. Affected areas in Tubao, La Union during a 100-year rainfall return period - A

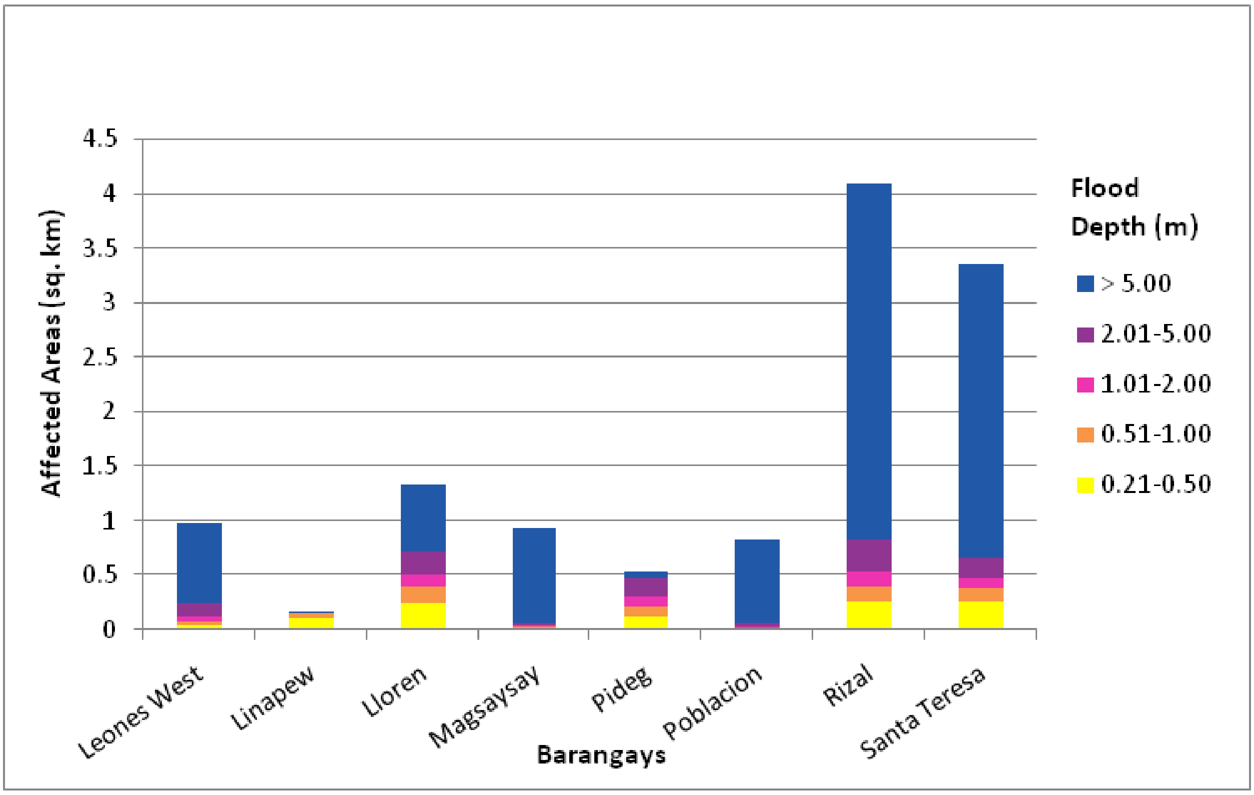


Figure 190. Affected areas in Tubao, La Union during a 100-year rainfall return period - B

Among the barangays in the Municipality of Baguio City in Benguet, Irisan is projected to have the highest percentage of area that will experience flood levels, at 10.46%. Meanwhile, Asin Road posted the second highest percentage of area that may be affected by flood depths, at 7.75%.

Among the barangays in the Municipality of Kapangan in Benguet, Gasweling is projected to have the highest percentage of area that will experience flood levels, at 12.18%. Meanwhile, Pongayan posted the second highest percentage of area that may be affected by flood depths, at 7.92%.

Among the barangays in the Municipality of La Trinidad in Benguet, Bineng is projected to have the highest percentage of area that will experience flood levels, at 15.96%. Meanwhile, Alno posted the second highest percentage of area that may be affected by flood depths, at 15.12%.

Among the barangays in the Municipality of Sablan in Benguet, Banangan is projected to have the highest percentage of area that will experience flood levels, at 20.98%. Meanwhile, Banengbeng posted the second highest percentage of area that may be affected by flood depths, at 15.69%.

Among the barangays in the Municipality of Tuba in Benguet, Tabaan Sur is projected to have the highest percentage of area that will experience flood levels, at 7.84%. Meanwhile, Poblacion posted the second highest percentage of area that may be affected by flood depths, at 6.94%.

Among the barangays in the Municipality of Tublay in Benguet, Tuel is projected to have the highest percentage of area that will experience flood levels, at 19.50%. Meanwhile, Daclan posted the second highest percentage of area that may be affected by flood depths, at 8.26%.

Among the barangays in the Municipality of Agoo in La Union, Macalva Norte is projected to have the highest percentage of area that will experience flood levels, at 5.02%. Meanwhile, Santa Ana posted the second highest percentage of area that may be affected by flood depths, at 1.95%.

Among the barangays in the Municipality of Aringay in La Union, Gallano is projected to have the highest percentage of area that will experience flood levels, at 27.30%. Meanwhile, Manga posted the second highest percentage of area that may be affected by flood depths, at 8.53%.

Among the barangays in the Municipality of Bagulin in La Union, Tio-Angan is projected to have the highest percentage of area that will experience flood levels, at 19.03%. Meanwhile, Alibangsay posted the second highest percentage of area that may be affected by flood depths, at 16.38%.

Among the barangays in the Municipality of Bauang in La Union, Upper San Agustin is projected to have the highest percentage of area that will experience flood levels, at 11.41%. Meanwhile, Acao posted the second highest percentage of area that may be affected by flood depths, at 8.54%.

Among the barangays in the Municipality of Burgos in La Union, Delles is projected to have the highest percentage of area that will experience flood levels, at 23.94%. Meanwhile, Upper Tumapoc posted the second highest percentage of area that may be affected by flood depths, at 13.82%.

Among the barangays in the Municipality of Caba in La Union, Liquicia is projected to have the highest percentage of area that will experience flood levels, at 28.94%. Meanwhile, San Cornelio posted the second highest percentage of area that may be affected by flood depths, at 11.43%.

Among the barangays in the Municipality of Naguilian in La Union, San Isidro is projected to have the highest percentage of area that will experience flood levels, at 9.38%. Meanwhile, Casilagan posted the second highest percentage of area that may be affected by flood depths, at 7.40%.

Among the barangays in the Municipality of Pugo in La Union, Palina is projected to have the highest percentage of area that will experience flood levels, at 36.33%. Meanwhile, Ambangonan posted the second highest percentage of area that may be affected by flood depths, at 7.91%.

Among the barangays in the Municipality of Rosario in La Union, Marcos is projected to have the highest percentage of area that will experience flood levels, at 2.21%. Meanwhile, Parasapas posted the second highest percentage of area that may be affected by flood depths, at 2.11%.

Among the barangays in the Municipality of San Fernando City in La Union, Bacsil is projected to have the highest percentage of area that will experience flood levels, at 5.28%. Meanwhile, Sacyud posted the second highest percentage of area that may be affected by flood depths, at 4.94%.

Among the barangays in the Municipality of San Gabriel in La Union, Apayao is projected to have the highest percentage of area that will experience flood levels, at 8.45%. Meanwhile, Amontoc posted the second highest percentage of area that may be affected by flood depths, at 2.25%.

Among the barangays in the Municipality of Santo Tomas in La Union, Pongpong is projected to have the highest percentage of area that will experience flood levels, at 7.99%. Meanwhile, Ambitacay posted the second highest percentage of area that may be affected by flood depths, at 0.66%.

Among the barangays in the Municipality of Tubao in La Union, Santa Teresa is projected to have the highest percentage of area that will experience flood levels, at 15.56%. Meanwhile, Rizal posted the second highest percentage of area that may be affected by flood depths, at 15.35%.

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

Table 150. Area covered by each warning level, with respect to the rainfall scenario

Warning Level	Area Covered in sq. km.		
	5 year	25 year	100 year
Low	37.57	42.03	45.01
Medium	40.35	42.10	43.74
High	108.03	135.46	151.95
TOTAL	185.95	219.59	240.7

Of the fifty-five (55) identified educational institutions in the Bauang floodplain, eighteen (18) were assessed to be exposed to High-level flooding for all three (3) rainfall return scenarios. Three (3) other schools were found to be susceptible to flooding, projected to experience Medium-level flooding in the 5-year return period, and High-level flooding in the 25-year and 100-year rainfall scenarios. See Annex 12 for a detailed enumeration of schools in the Bauang floodplain.

Six (6) medical institutions were identified in the Bauang floodplain. Naguilian Health Center in Barangay Cabaritan Sur and Naguilian District Hospital in Barangay Suguidan Norte were found to be highly prone to flooding, computed to have High-level flooding in all three (3) rainfall scenarios. See Annex 13 for a detailed enumeration of hospitals and clinics in the Bauang floodplain.

5.11 Flood Validation

In order to check and validate the extent of flooding in the different river systems, there is a need to perform validation survey work. For this purpose, field personnel gathered secondary data regarding flood occurrences in the respective areas within the major river systems in the Philippines.

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

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

After which, the actual data from the field were compared with the simulated data to assess the accuracy of the flood depth maps produced, and to improve on the results of the flood map. The points in the flood map versus the corresponding validation depths are illustrated in Figure 192.

The flood validation survey was conducted in January 2017. The flood validation consists of one hundred and ninety-seven (197) points randomly selected all over the Bauang floodplain. It attained an RMSE value of 2.97. Table 151 presents a contingency matrix of the comparison. The validation points are found in Annex 11.

The validation data were obtained on January 2017

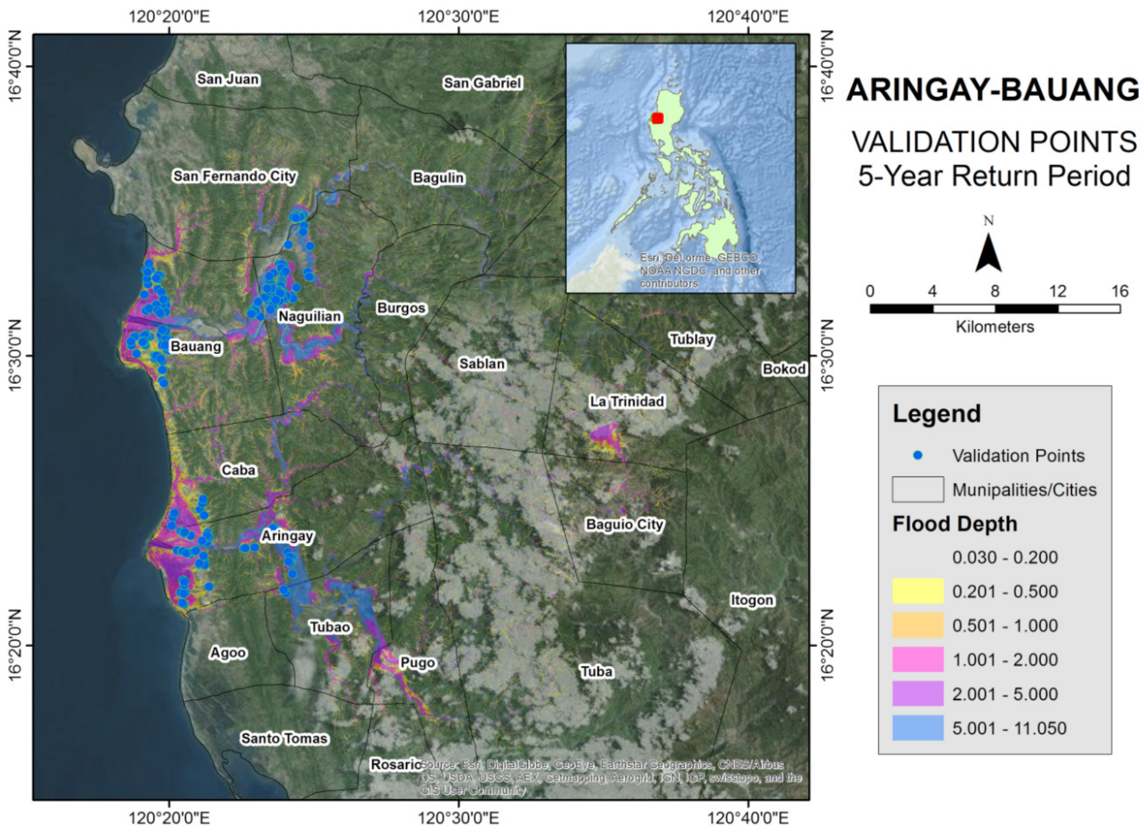


Figure 191. Flood validation points of the Bauang River Basin

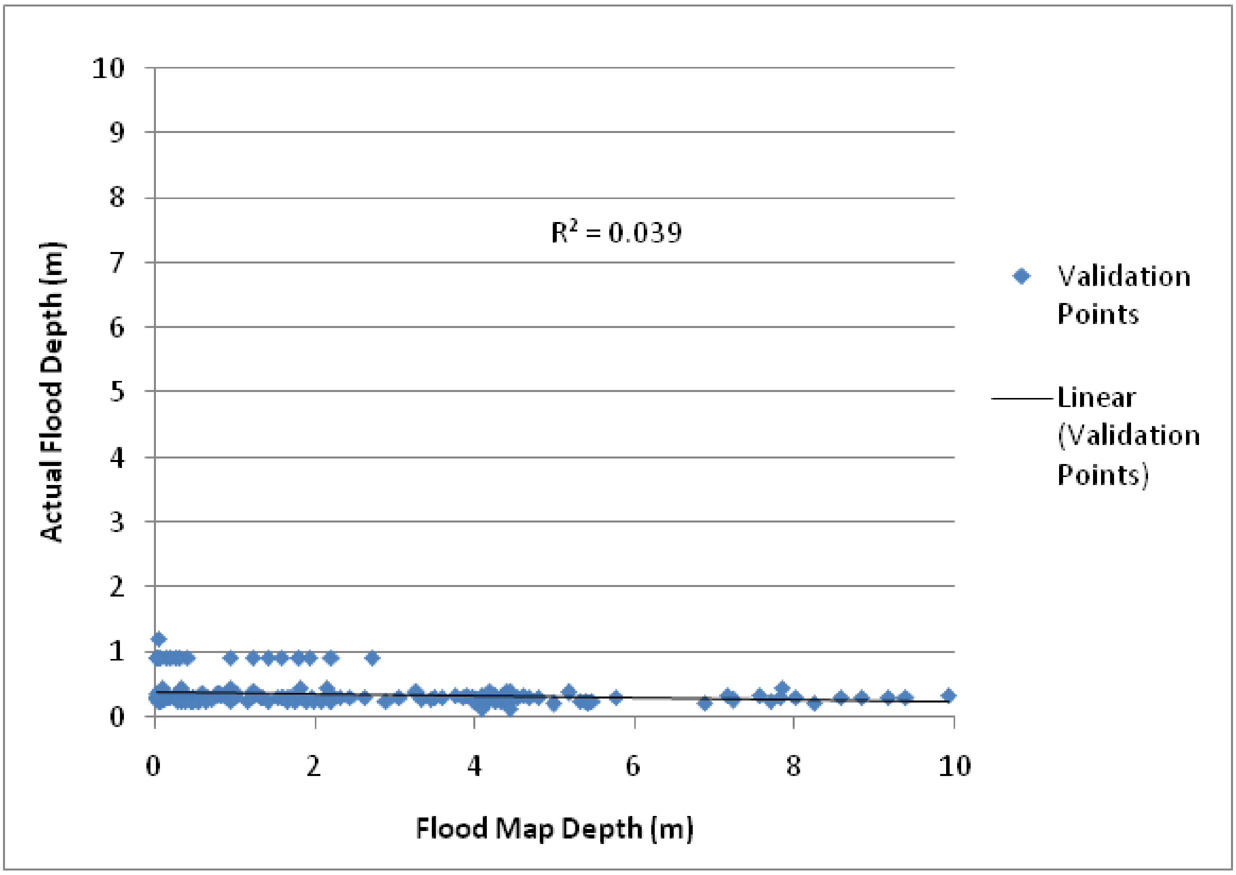


Figure 192. Flood map depth vs. actual flood depth for Bauang

Table 151. Actual flood depth vs. simulated flood depth in the Bauang River Basin

ARINGAY-BAU-ANG BASIN		Modeled Flood Depth (m)						
		0-0.20	0.21-0.50	0.51-1.00	1.01-2.00	2.01-5.00	> 5.00	Total
Actual Flood Depth (m)	0-0.20	0	0	0	0	2	0	2
	0.21-0.50	39	21	20	25	50	20	175
	0.51-1.00	7	3	1	6	2	0	19
	1.01-2.00	1	0	0	0	0	0	1
	2.01-5.00	0	0	0	0	0	0	0
	> 5.00	0	0	0	0	0	0	0
	Total	47	24	21	31	54	20	197

The overall accuracy generated by the flood model is estimated at 11.17%, with twenty-two (22) points correctly matching the actual flood depths. In addition, there were sixty-eight (68) points estimated one (1) level above and below the correct flood depths. Meanwhile, there were thirty-four (34) points and seventy-three (73) points estimated two (2) levels above and below, and three (3) or more levels above and below the correct flood depths, respectively. A total of one hundred and twenty-five (125) points were overestimated, while a total of fifty (50) points were underestimated in the modeled flood depths of Bauang.

Table 152. Summary of Accuracy Assessment in the Bauang River Basin

	No. of Points	%
Correct	22	11.17
Overestimated	125	63.45
Underestimated	50	25.38
Total	197	100

REFERENCES

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

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

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

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

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

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

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

ANNEXES

Annex 1. Technical Specifications of the Pegasus LiDAR Sensor used in the Bauang Floodplain Survey

Table A-1.1. Technical specifications of the Pegasus 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 Certification of Reference Points used in the LiDAR Survey

1. LUN-62

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

March 04, 2014

CERTIFICATION

To whom it may concern:

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

Province: **LA UNION**
Station Name: **LUN-62**
Order: **2nd**

Island: **LUZON**
Municipality: **NAGUILIAN**
Barangay: **BARAOAS NORTE**

	PRS92 Coordinates	
Latitude: **16° 33' 19.98115"**	Longitude: **120° 23' 28.76004"**	Ellipsoidal Hgt: **33.18400 m.**
	WGS84 Coordinates	
Latitude: **16° 33' 14.07106"**	Longitude: **120° 23' 33.49149"**	Ellipsoidal Hgt: **69.44500 m.**
	PTM Coordinates	
Northing: **1831016.667 m.**	Easting: **435034.926 m.**	Zone: **3**
	UTM Coordinates	
Northing: **1,832,084.35**	Easting: **221,592.72**	Zone: **51**

Location Description

LUN-62
From Naguilian Town Hall, travel N to Brgy. Baraoas Norte until reaching the rough road and the river control. Station is located 15 m. S from the first access ladder of the river control and about 100 m. N from the end. It is also situated 300 m. S of a hanging bridge. Mark is the head of a 4 in. copper nail centered and embedded in a 0.3 m. x 0.3 m. cement putty, with inscriptions "LUN-62 2007 NAMRIA".

Requesting Party: **UP-DREAM**
Pupose: **Reference**
OR Number: **8795470 A**
T.N.: **2014-451**

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

9 9 0 3 0 4 2 0 1 4 1 6 0 9 4 3

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

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

Figure A-2.1. LUN-62

2. LUN-176

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

March 04, 2014

CERTIFICATION

To whom it may concern:

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

Province: **LA UNION**
Station Name: **LUN-176**
Order: **2nd**

Island: **LUZON**
Municipality: **BALAOAN**
Barangay: **BUNGOL**

PRS92 Coordinates

Latitude: **16° 46' 14.35394"**	Longitude: **120° 24' 5.41918"**	Ellipsoidal Hgt: **35.63300 m.**

WGS84 Coordinates

Latitude: **16° 46' 8.39718"**	Longitude: **120° 24' 10.13252"**	Ellipsoidal Hgt: **71.25300 m.**

PTM Coordinates

Northing: **1854816.574 m.**	Easting: **436193.115 m.**	Zone: **3**

UTM Coordinates

Northing: **1,855,884.60**	Easting: **222,990.04**	Zone: **51**

Location Description

LUN-176 (FNSP-DENR)

From Candon City, Ilocos Sur, travel S to the province of La Union passing through Balaoan town proper until reaching Km. Post No. 292 on the left side of the highway. Travel more for about 300 m. until reaching a concrete waiting shed on the right side of the highway, before reaching a highway curve and the road leading to Magic Star Fireworks Factory. Beside the concrete shed is a trail, follow this trail until reaching a house with an artesian well beside a series of Coconut trees. It is located on a corner of a farm dike, about 15 m. SE of the well and about 20 m. SW of the nearest house.

Mark is the head of a 3 in. concrete nail embedded and centered on a 30 cm. x 30 cm. concrete monument protruding by about 5 cm., with inscriptions "LUN-176, 2004, PRS-92, FNSP-DENR-I".

Requesting Party:	**UP-DREAM**
Pupose:	**Reference**
OR Number:	**8795470 A**
T.N.:	**2014-453**

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

9 9 0 3 0 4 2 0 1 4 1 6 1 1 3 2

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

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

Figure A-2.2. LUN-176

3. LUN-3062

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

March 04, 2014

CERTIFICATION

To whom it may concern:

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

Province: **LA UNION**
Station Name: **LUN-3062**
Order: **4th**

Island: **LUZON**
Municipality: **NAGUILIAN**
Barangay: **NATIVIDAD (POB.)**

PRS92 Coordinates

Latitude: **16° 31' 55.00993"**	Longitude: **120° 23' 12.50504"**	Ellipsoidal Hgt: **25.32100 m.**

WGS84 Coordinates

Latitude: **16° 31' 49.10470"**	Longitude: **120° 23' 17.23850"**	Ellipsoidal Hgt: **61.64400 m.**

PTM Coordinates

Northing: **1828406.255 m.**	Easting: **434545.028 m.**	Zone: **3**

UTM Coordinates

Northing: **1,829,477.48**	Easting: **221,076.59**	Zone: **51**

Location Description

LUN-3062

Is located at barangay Natividad, Naguilian, La Union. The station is erected at the top of a dike. It is approximately 100 m north of Philippine Central College of Arts Science & Technology and 80 m north of Naguilian emission testing center.
Mark in the head of a 3 inches concrete nail embedded and centered on a 30 cm x 30 cm x 100 cm standard concrete monument protruding by about 20 cm, with the inscription LUN-3062 PRS-92 DENR-FNSP R-1.

Requesting Party: **UP-DREAM**
Pupose: **Reference**
OR Number: **8795470 A**
T.N.: **2014-455**

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

9 9 0 3 0 4 2 0 1 4 1 6 1 5 3 6

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

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

Figure A-2.3. LUN-3062

4. LUN-3047

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

March 04, 2014

CERTIFICATION

To whom it may concern:

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

	Province: **LA UNION**	
	Station Name: **LUN-3047**	
Island: **LUZON**	Order: **4th**	Barangay: **NAZARENO**
Municipality: **AGOO**		
	PRS92 Coordinates	
Latitude: **16° 20' 55.96430"**	Longitude: **120° 21' 47.08672"**	Ellipsoidal Hgt: **43.62100 m.**
	WGS84 Coordinates	
Latitude: **16° 20' 50.09786"**	Longitude: **120° 21' 51.83567"**	Ellipsoidal Hgt: **80.44800 m.**
	PTM Coordinates	
Northing: **1808156.256 m.**	Easting: **431948.446 m.**	Zone: **3**
	UTM Coordinates	
Northing: **1,809,242.68**	Easting: **218,278.33**	Zone: **51**

Location Description

LUN-3047

It is located at Barangay Nazareno, Agoo, La Union.

Mark in the head of a 3 inches concrete nail embedded and centered on a 30 cm x 30 cm x 100 cm standard concrete monument protruding by about 20 cm, with the inscription LUN-3047 PRS-92 DENR-FNSP R-1.

Requesting Party: **UP-DREAM**
Pupose: **Reference**
OR Number: **8795470 A**
T.N.: **2014-454**

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

9903042014161304

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

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

Figure A-2.4. LUN-3047

5. LUN-3129

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

March 04, 2014

CERTIFICATION

To whom it may concern:

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

Province: **LA UNION**
Station Name: **LUN-3129 (BLLM-9)**
Order: **4th**

Island: **LUZON**		Barangay: **BUNGOL**
Municipality: **BALAOAN**		
	PRS92 Coordinates	
Latitude: **16° 46' 13.75662"**	Longitude: **120° 24' 16.12821"**	Ellipsoidal Hgt: **37.03000 m.**
	WGS84 Coordinates	
Latitude: **16° 46' 7.80013"**	Longitude: **120° 24' 20.84154"**	Ellipsoidal Hgt: **72.65800 m.**
	PTM Coordinates	
Northing: **1854797.26 m.**	Easting: **436510.212 m.**	Zone: **3**
	UTM Coordinates	
Northing: **1,855,862.08**	Easting: **223,307.10**	Zone: **51**

Location Description

LUN-3129 (BLLM-9)

The station is located of National road about 50 meters northeast of the house of Engr. Whitney Valdez.

Station mark is the head of a 3" concrete nail embedded and centered on a 30cm. x 30cm. x 100 cm. standard concrete monument protruding about 20cm. with inscription "LUN-3129 (BLLM-9); 2008; DENR/LMS I."

Requesting Party: **UP-DREAM**
Pupose: **Reference**
OR Number: **8795470 A**
T.N.: **2014-456**

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

9903042014161706

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

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

Figure A-2.5. LUN-3129

6. LU-94

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

March 04, 2014

CERTIFICATION

To whom it may concern:

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

Province: **LA UNION**
Station Name: **LU-94**

Island: **LUZON**	Municipality: **BACNOTAN**	Barangay: **BARORO**
Elevation: **7.3488 m.**	Order: **1st Order**	Datum: **Mean Sea Level**

Location Description

BM LU-94
Station is located in Brgy. Baroro, Bacnotan, La Union along the national highway set on the S edge of Baroro bridge, 4 m SE of the centerline of the national highway, 30 m SE of Baroro national memorial monument.

Mark is the head of a 4" copper nail set on a drilled hole and cemented flushed on top of a 10 cm x 10 cm cement putty with inscription LU-94 2007 NAMRIA.

Requesting Party: **UP-DREAM**
Pupose: **Reference**
OR Number: **8795470 A**
T.N.: **2014-449**

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

9903042014160555

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

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

Figure A-2.6. LU-94

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

Table A-3.1. LU-94

Vector Components (Mark to Mark)

From:	LUN-176				
Grid		Local		Global	
Easting	223129.137 m	Latitude	N16°46'08.61931"	Latitude	N16°46'08.61931"
Northing	1855819.084 m	Longitude	E120°24'10.06092"	Longitude	E120°24'10.06092"
Elevation	31.168 m	Height	70.997 m	Height	70.997 m

To:	LU-94				
Grid		Local		Global	
Easting	216672.143 m	Latitude	N16°42'38.64674"	Latitude	N16°42'38.64674"
Northing	1849445.472 m	Longitude	E120°20'35.05091"	Longitude	E120°20'35.05091"
Elevation	9.967 m	Height	49.582 m	Height	49.582 m

Vector					
ΔEasting	-6456.994 m	NS Fwd Azimuth	224°37'26"	ΔX	4564.890 m
ΔNorthing	-6373.612 m	Ellipsoid Dist.	9067.628 m	ΔY	4806.440 m
ΔElevation	-21.201 m	ΔHeight	-21.415 m	ΔZ	-6187.390 m

Standard Errors

Vector errors:					
σ ΔEasting	0.002 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.004 m
σ ΔNorthing	0.001 m	σ Ellipsoid Dist.	0.002 m	σ ΔY	0.006 m
σ ΔElevation	0.007 m	σ ΔHeight	0.007 m	σ ΔZ	0.003 m

Aposteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.0000159225		
Y	-0.0000194629	0.0000365086	
Z	-0.0000081542	0.0000147591	0.0000075754

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
FIELD TEAM			
LiDAR Operation	Senior Science Research Specialist (SSRS)	LOVELY GRACIA ACUNA	UP-TCAGP
	Research Associate (RA)	RENAN PUNTO	UP-TCAGP
	RA	FAITH JOY SABLE	UP-TCAGP
Ground Survey, Data Download and Transfer	RA	KENNETH QUISADO	UP-TCAGP
LiDAR Operation	Airborne Security	SSG. OLIVER SACLOT	PHILIPPINE AIR FORCE (PAF)
	Pilot	CAPT. MARK LAWRENCE TAN-GONAN	ASIAN AEROSPACE CORPORATION (AAC)
		CAPT. NEIL ACHILLES AGAWIN	AAC

Annex 5. Data Transfer Sheets for the Bauang Floodplain Flights

CLA 4/4/2014

DATA TRANSFER SHEET
Mar 17, 2014

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS	POS	RAW IMAGES	MISSION LOG FILE	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
2/25/2014	1151P	1BLK10A056A	PEGASUS	3.03GB	NA	12.3MB	229MB	N/A	N/A	19.8	N/A	6.5	1KB	459B	35	NA	X:\Airborne_Raw\1151P
2/25/2014	1153P	1BLK10AS056B	PEGASUS	836MB	NA	3.57MB	84.5MB	N/A	N/A	8.02	N/A	6.51	1KB	244B	38	N/A	X:\Airborne_Raw\1153P
2/26/2014	1155P	1BLK10C057A	PEGASUS	2.64GB	NA	11MB	220MB	33.1GB	289KB	26.4	N/A	6.95	1KB	610B	44	N/A	X:\Airborne_Raw\1155P
2/26/2014	1157P	1BLK10B057B	PEGASUS	1.85GB	NA	6.62MB	129MB	25.6GB	229KB	17.4	N/A	6.95	1KB	485B	45	N/A	X:\Airborne_Raw\1157P
2/27/2014	1159P	1BLK10GD058A	PEGASUS	2.76GB	NA	11.4MB	221MB	4.7GB	148KB	27.9	N/A	6.55	1KB	669B	29	N/A	X:\Airborne_Raw\1159P
2/27/2014	1161P	1BLK10DS058B	PEGASUS	1.28GB	NA	7.08MB	152MB	22.3GB	186KB	15.6	N/A	6.55	1KB	474B	50	N/A	X:\Airborne_Raw\1161P
2/28/2014	1163P	1BLK10F059A	PEGASUS	3.42GB	NA	12MB	216MB	53.2GB	416KB	31.7	N/A	6.05	1KB	328B	31	N/A	X:\Airborne_Raw\1163P
2/28/2014	1165P	1BLK10E059B	PEGASUS	1.41GB	NA	7.12MB	143MB	25.6GB	208KB	16.7	N/A	6.05	1KB	502B	n/a	N/A	X:\Airborne_Raw\1165P
3/1/2014	1167P	1BLK10H060A	PEGASUS	831MB	NA	7.42MB	170MB	17.5GB	145KB	8.66	N/A	6.64	1KB	318B	20	N/A	X:\Airborne_Raw\1167P
3/1/2014	1169P	1BLK10ES060B	PEGASUS	2.05GB	NA	7.17MB	133MB	28.6GB	224KB	19.1	N/A	6.64	1KB	304B	45	N/A	X:\Airborne_Raw\1169P
3/2/2014	1171P	1BLK10CDS061A	PEGASUS	1.72GB	NA	9.73MB	206MB	21GB	170KB	17	N/A	7.08	1KB	310B	32	N/A	X:\Airborne_Raw\1171P
3/2/2014	1173P	1BLK10DS061B	PEGASUS	1.52GB	NA	5.95MB	116MB	20.3GB	169KB	14.5	N/A	7.08	1KB	481B	50	N/A	X:\Airborne_Raw\1173P
3/3/2014	1175P	1BLK10BS062A	PEGASUS	3.14GB	NA	11.8MB	214MB	43.1GB	341KB	29.5	N/A	6.74	1KB	305B	38	N/A	X:\Airborne_Raw\1175P
3/3/2014	1177P	1BLK10CS062B	PEGASUS	1.18GB	NA	8.31MB	157MB	30GB	254KB	11.3	N/A	6.74	1KB	741B	42	N/A	X:\Airborne_Raw\1177P
Mar 4, 2014	1179P	1BLK27B063A	PEGASUS	3.54GB	NA	14MB	260MB	39.3GB	361KB	34.5	N/A	5.86	1KB	1KB	38	N/A	X:\Airborne_Raw\1179P
Mar 5, 2014	1183P	1BLK12AC064A	PEGASUS	1.5GB	NA	10.3MB	206MB	35.6GB	304KB	22.5GB	N/A	5.94	1KB	1KB	42/38/33/4234	N/A	X:\Airborne_Raw\1183P
Mar 5, 2014	1185P	1BLK10D064B	PEGASUS	1.18GB	NA	5.86MB	151MB	16.4GB	142KB	11.7GB	N/A	5.94	1KB	1KB	n/a	N/A	X:\Airborne_Raw\1185P
Mar 6, 2014	1187P	1BLK12DS065A	PEGASUS	2.34GB	NA	11MB	212MB	35.3GB	302KB	24.4GB	N/A	6.62	1KB	1KB	36	N/A	X:\Airborne_Raw\1187P
Mar 6, 2014	1189P	1BLK12CS065B	PEGASUS	2.06GB	NA	8.08MB	151MB	37.7GB	332KB	19.7GB	N/A	6.62	1KB	1KB	42	N/A	X:\Airborne_Raw\1189P
Mar 8, 2014	1195P	1BLK27ABS067A	PEGASUS	915MB	NA	4.91MB	110MB	16.1GB	130KB	10.2GB	N/A	From Ilocos	1KB	1KB	36	N/A	X:\Airborne_Raw\1195P
Mar 8, 2014	1197P	1BLK10CGS067B	PEGASUS	714MB	NA	4.95MB	112MB	14.5GB	131KB	8.16GB	N/A	1.44MB	1KB	1KB	27	N/A	X:\Airborne_Raw\1197P

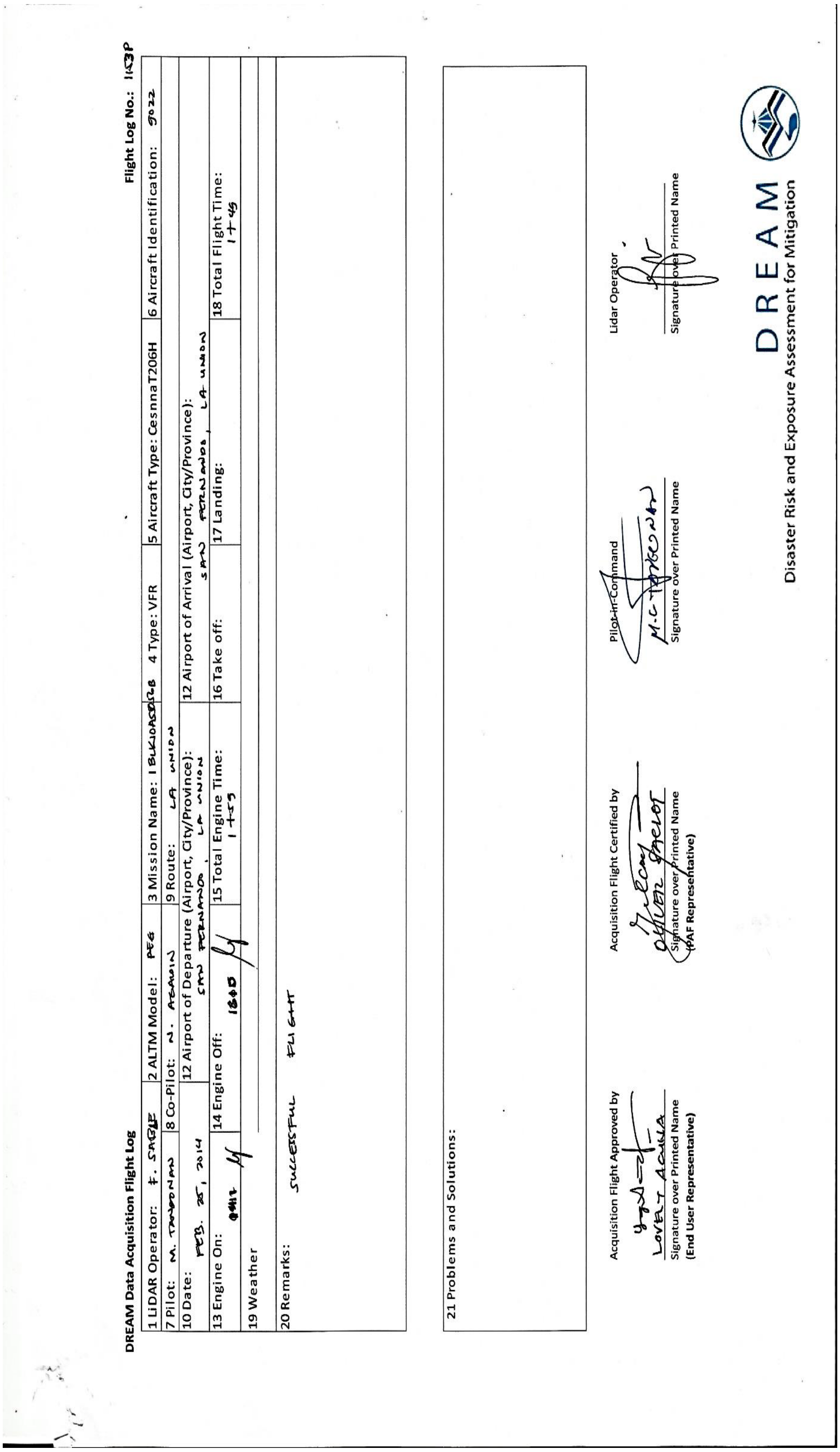
Received from
Name CHRIS JOAQUIN
Position RA
Signature

Received by
Name JOIDA F. PRIETO
Position SSRS
Signature

Figure A-5.1. Data Transfer Sheet for the Bauang Floodplain

Annex 6. Flight Logs for the Flight Missions

1. Flight Log for 1153P Mission


DREAM Data Acquisition Flight Log

Flight Log No.: 1153P

1 LiDAR Operator: F. SAGUE	2 ALTM Model: PEG	3 Mission Name: 1BLK10ACD? 26B	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9022
7 Pilot: M. TANGONAN	8 Co-Pilot: N. ACAYKIN	9 Route: LA UNION			
10 Date: FEB. 25, 2014	12 Airport of Departure (Airport, City/Province): SAN FERNANDO, LA UNION		12 Airport of Arrival (Airport, City/Province): SAN FERNANDO, LA UNION		
13 Engine On: 0912	14 Engine Off: 1840	15 Total Engine Time: 1+53	16 Take off:	17 Landing:	18 Total Flight Time: 1+45
19 Weather					
20 Remarks: SUCCESSFUL FLIGHT					

21 Problems and Solutions:

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

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

Pilot-in-Command — M.C. TANGONAN — Signature over Printed Name

Lidar Operator — Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.1. Flight Log for Mission 1153P

2. Flight Log for 1155P Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 1155P

1 LiDAR Operator: R. PUNTO	2 ALTM Model: PEG	3 Mission Name: 1BLK10CS57A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9022
7 Pilot: M. TANGONAN	8 Co-Pilot: N. AGAWIN	9 Route: LA UNION			
10 Date: FEB. 26, 2014	12 Airport of Departure (Airport, City/Province): SAN FERNANDO, LA UNION		12 Airport of Arrival (Airport, City/Province): SAN FERNANDO, LA UNION		
13 Engine On: 0901	14 Engine Off: 1242	15 Total Engine Time: 3+41	16 Take off:	17 Landing:	18 Total Flight Time: 3+31
19 Weather					
20 Remarks: SUCCESSFUL FLIGHT					

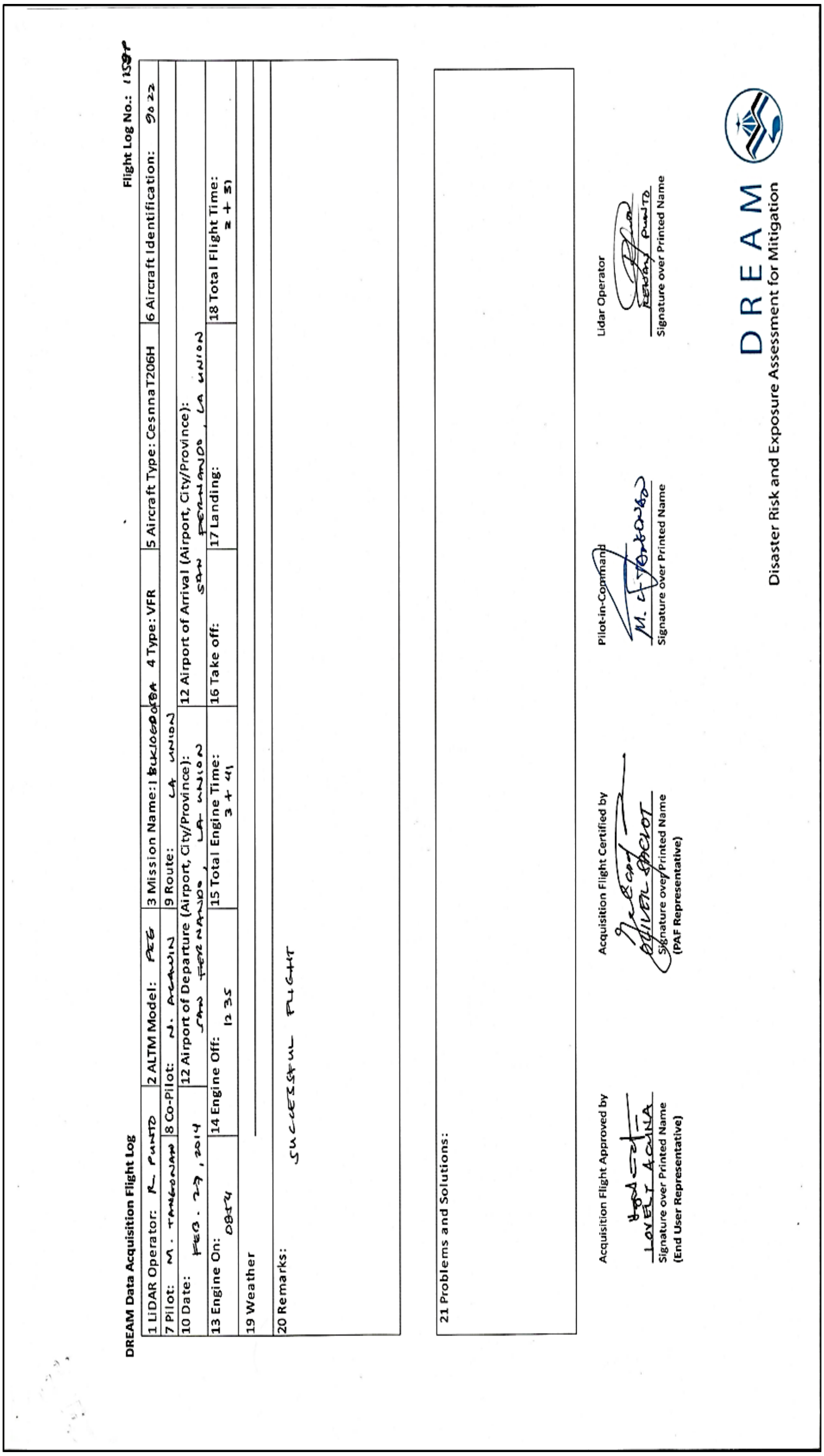
21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
LOVELY ACUÑA	OLIVER SACLOT	M. C. TANGONAN	RENAN PUNTO
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.2. Flight Log for Mission 1155P

3. Flight Log for 1159P Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 1159P

1 LiDAR Operator: R. PUNTO	2 ALTM Model: PEG	3 Mission Name: 1BLK10BDOE58A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9022
7 Pilot: M. TANGONAN	8 Co-Pilot: N. ACAWIN	9 Route: LA UNION			
10 Date: FEB. 27, 2014	12 Airport of Departure (Airport, City/Province): SAN FERNANDO, LA UNION		12 Airport of Arrival (Airport, City/Province): SAN FERNANDO, LA UNION		
13 Engine On: 0854	14 Engine Off: 1235	15 Total Engine Time: 3 + 41	16 Take off:	17 Landing:	18 Total Flight Time: 2 + 51
19 Weather					
20 Remarks: SUCCESSFUL FLIGHT					

21 Problems and Solutions:

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

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

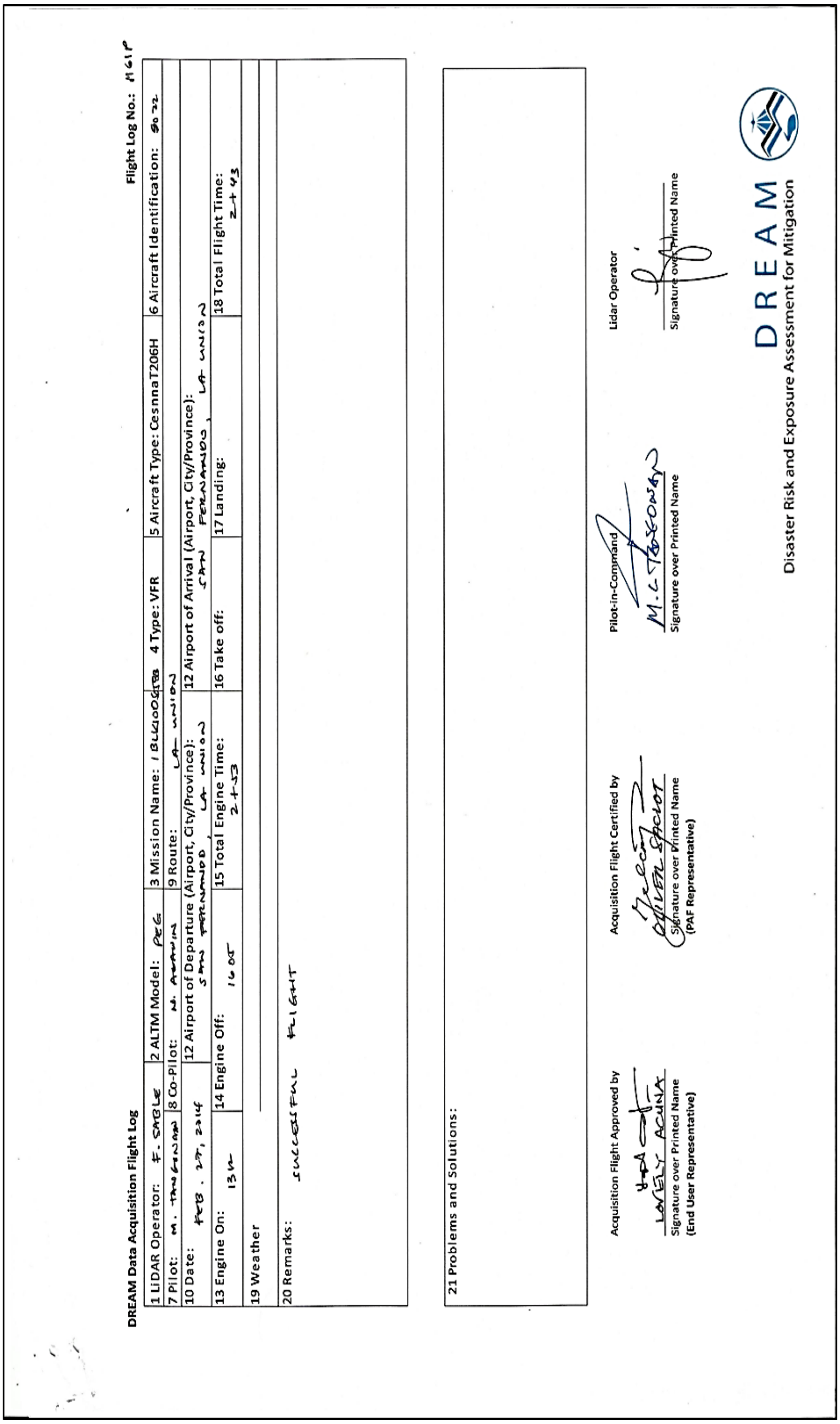
Pilot-in-Command
M. C. TANGONAN
Signature over Printed Name

Lidar Operator
RENAN PUNTO
Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.3. Flight Log for Mission 1159P

4. Flight Log for 1161P Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 1161P

1 LiDAR Operator: F. SABLE	2 ALTM Model: PEG	3 Mission Name: 1BLK10OGTB	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9022
7 Pilot: M. TANGONAN	8 Co-Pilot: N. ADAWIN	9 Route: LA UNION			
10 Date: FEB. 27, 2014	12 Airport of Departure (Airport, City/Province): SAN FERNANDO, LA UNION		12 Airport of Arrival (Airport, City/Province): SAN FERNANDO, LA UNION		
13 Engine On: 1312	14 Engine Off: 1605	15 Total Engine Time: 2+53	16 Take off:	17 Landing:	18 Total Flight Time: 2+43
19 Weather					
20 Remarks: SUCCESSFUL FLIGHT					

21 Problems and Solutions:

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

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

Pilot-in-Command
M.C TANGONAN
Signature over Printed Name

Lidar Operator
Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.4. Flight Log for Mission 1161P

5. Flight Log for 1163P Mission

DREAM Data Acquisition Flight Log — Flight Log No.: 1163P

1 LiDAR Operator: R. PUNTO	2 ALTM Model: PEG	3 Mission Name: 1BLK10F059A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9022
7 Pilot: M. TANGONAN	8 Co-Pilot: N. AGAWIN	9 Route: LA UNION			
10 Date: FEB. 28, 2014	12 Airport of Departure (Airport, City/Province): SAN FERNANDO, LA UNION		12 Airport of Arrival (Airport, City/Province): SAN FERNANDO, LA UNION		
13 Engine On: 0853	14 Engine Off: 1240	15 Total Engine Time: 3 + 47	16 Take off:	17 Landing:	18 Total Flight Time: 3 + 37
19 Weather					
20 Remarks: SUCCESSFUL FLIGHT					

21 Problems and Solutions:

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

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

Pilot-in-Command
M. TANGONAN
Signature over Printed Name

Lidar Operator
Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.5. Flight Log for Mission 1163P

6. Flight Log for 1171P Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 1171P

1 LiDAR Operator: R. PUNTO	2 ALTM Model: PEG	3 Mission Name: 1BLK10CDS061A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9022
7 Pilot: M. TANGONAN	8 Co-Pilot: N. ARENAS	9 Route: LA UNION			
10 Date: MAR. 2, 2014	12 Airport of Departure (Airport, City/Province): SAN FERNANDO, LA UNION		12 Airport of Arrival (Airport, City/Province): SAN FERNANDO, LA UNION		
13 Engine On: 0912	14 Engine Off: 1241	15 Total Engine Time: 3+29	16 Take off:	17 Landing:	18 Total Flight Time: 3+23
19 Weather					
20 Remarks: SUCCESSFUL FLIGHT					

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
LOVELY ACUÑA	OLIVER BACLOT	M. I. TANGONAN	R. PUNTO
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.6. Flight Log for Mission 1171P

7. Flight Log for 1173P Mission

DREAM Data Acquisition Flight Log — Flight Log No.: 1173P

1 LiDAR Operator: F. SABLE	2 ALTM Model: PEG	3 Mission Name: 1BLK1DSDG1B	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9022
7 Pilot: M. TANGONAN	8 Co-Pilot: B. AGAWIN	9 Route: LA UNION			
10 Date: MAR. 2, 2014	12 Airport of Departure (Airport, City/Province): SAN FERNANDO, LA UNION		12 Airport of Arrival (Airport, City/Province): SAN FERNANDO, LA UNION		
13 Engine On: 1324	14 Engine Off: 1547	15 Total Engine Time: 2+23	16 Take off:	17 Landing:	18 Total Flight Time: 2+13
19 Weather					
20 Remarks: SUCCESSFUL FLIGHT					

21 Problems and Solutions:

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

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

Pilot-in-Command — M.C. TANGONAN — Signature over Printed Name

Lidar Operator — Signature over Printed Name

DREAM Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.7. Flight Log for Mission 1173P

8. Flight Log for 1177P Mission

DREAM Data Acquisition Flight Log Flight Log No.: 1177P

1 LIDAR Operator: F. Sabue	2 ALTM Model: PEG	3 Mission Name: 1BLK1CS061B	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9022
7 Pilot: M. Tangonan	8 Co-Pilot: B. Dongines	9 Route: La Union			
10 Date: Mar. 8, 2014	12 Airport of Departure (Airport, City/Province): San Fernando, La Union		12 Airport of Arrival (Airport, City/Province): San Fernando, La Union		
13 Engine On: 815	14 Engine Off: 1108	15 Total Engine Time: 2+53	16 Take off:	17 Landing:	18 Total Flight Time: 2+43
19 Weather					
20 Remarks: Successful Flight					

21 Problems and Solutions:

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

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

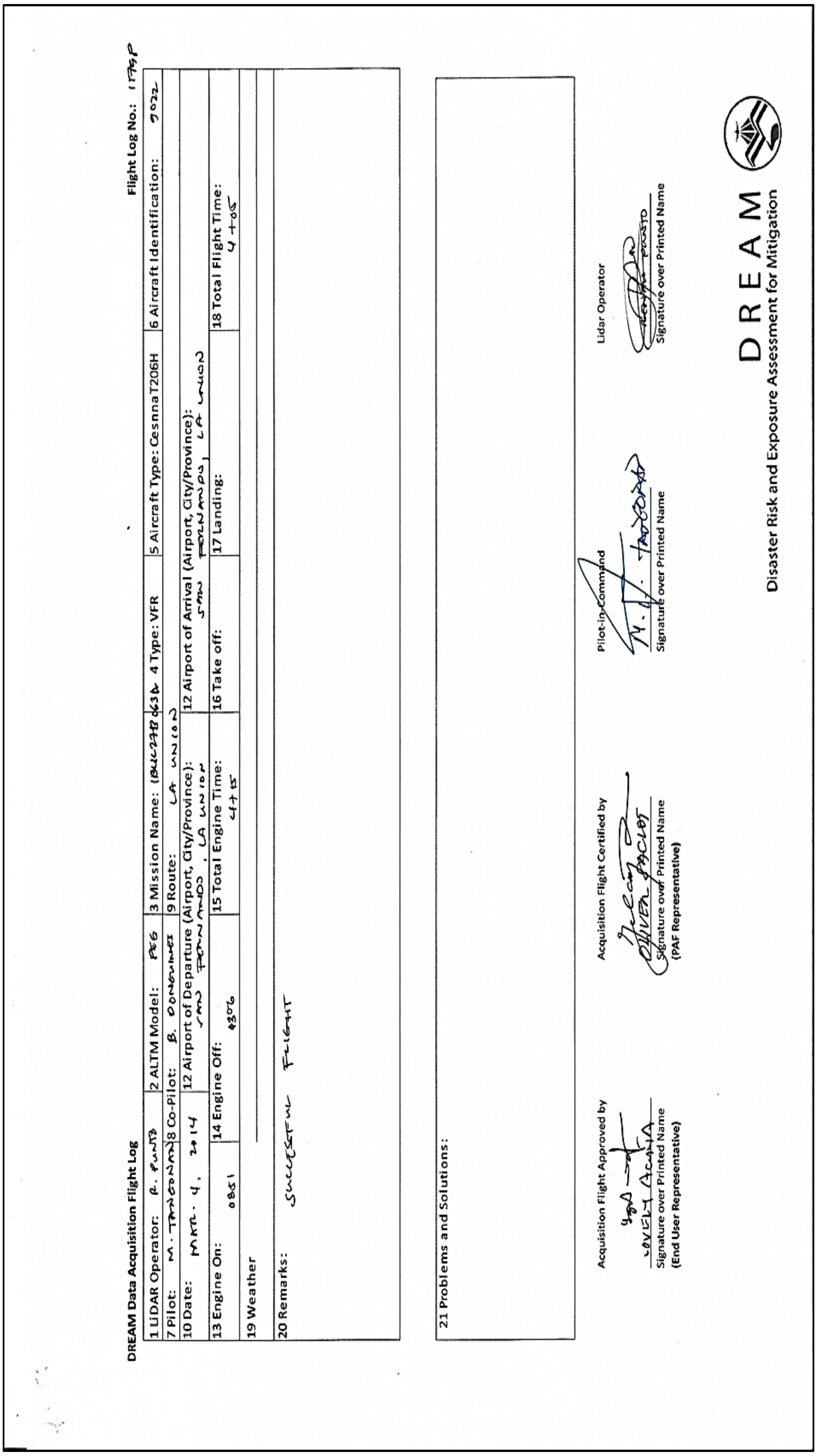
Pilot-in-Command
M.C. Tangonan
Signature over Printed Name

Lidar Operator
Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.8. Flight Log for Mission 1177P

9. Flight Log for 1197P Mission



DREAM Data Acquisition Flight Log — Flight Log No.: 1197P

1 LiDAR Operator: R. PUNTO	2 ALTM Model: PEG	3 Mission Name: 1BLK27B063A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9022
7 Pilot: M. TANGONAN	8 Co-Pilot: B. DONGUINES	9 Route: LA UNION			
10 Date: MAR. 4, 2014	12 Airport of Departure (Airport, City/Province): SAN FERNANDO, LA UNION		12 Airport of Arrival (Airport, City/Province): SAN FERNANDO, LA UNION		
13 Engine On: 0851	14 Engine Off: 1306	15 Total Engine Time: 4+15	16 Take off:	17 Landing:	18 Total Flight Time: 4+05
19 Weather					
20 Remarks: SUCCESSFUL FLIGHT					

21 Problems and Solutions:

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

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

Pilot-in-Command: M. J. TANGONAN — Signature over Printed Name

Lidar Operator: PUNTO — Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.9. Flight Log for Mission 1197P

Annex 7. Flight Status Reports

Table A-7.1. Flight Status Report

NORTHERN MINDANAO
(February 25 – March 8, 2014)

FLIGHT NO	AREA	MISSION	OPERATOR	DATE FLOWN	REMARKS
1153P	BLOCK 10A	1BLK10AS056B	F. SABLE	February 25, 2014	Survey voids of Block10A and 1 line Blk10B; renamed from 1151P
1155P	BLOCK 10C	1BLK10C057A	R. PUNTO	February 26, 2014	Survey Block 10C with data voids due to eye safety, laser sets off; renamed from 1153P
1159P	BLOCK 10GD	1BLK10GD058A	R. PUNTO	February 27, 2014	Survey Block 10G and 10D with data voids due to eye safety, laser sets off; renamed from 1157P
1161P	BLK10D	1BLK10D058B	F SABLE	February 27, 2014	Survey Block 10D
1163P	BLK10F	1BLK10F059A	R PUNTO	February 28, 2014	Finished Survey
1171P	BLOCK 10D & BLOCK 10C	1BLK10CDS061A	R. PUNTO	March 2, 2014	Supplementary flight to cover voids for Block10D & Block10C; renamed from 1169P
1173P	BLOCK 10D	1BLK10DGS061B	F. SABLE	March 2, 2014	Supplementary flight to complete Block 10D; renamed from 1171P
1177P	BLOCK 10C	1BLK10CS062B	F. SABLE	March 3, 2014	Supplementary flight to cover voids in Block 10C; renamed from 1175P
1197P	BLOCK 10G,10C	1BLK10GCS067B	R.PUNTO	March 8, 2014	Mission Complete

LAS BOUNDARIES PER FLIGHT

Flight No. :	1153P		
Area:	BLK 10A		
Mission Name:	1BLK10BAS056B		
Parameters:	Altitude: 1200m;		Scan Frequency: 30Hz;
	Scan Angle: 25deg;		Overlap: 30%

LAS

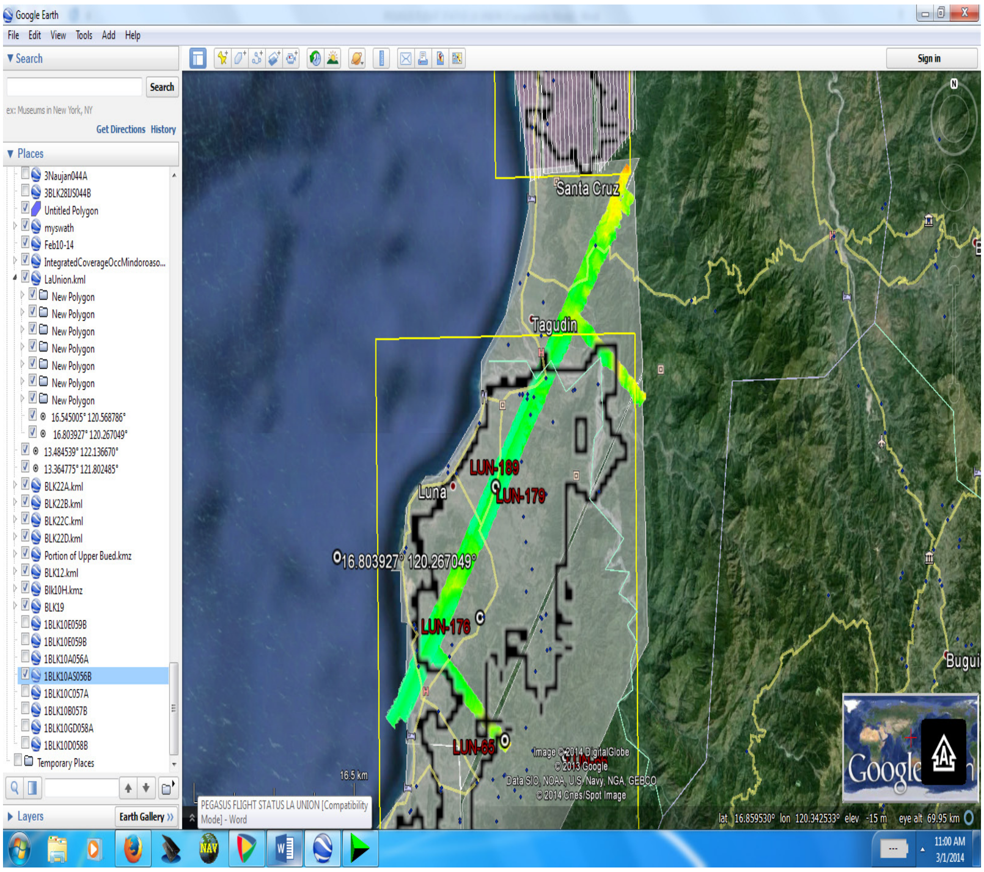


Figure A-7.1. Swath for Flight No. 1153P

Flight No. : 1155P

Area:	BLK 10C		
Mission Name:	1BLK10C057A		
Parameters:	Altitude:	1200 m;	Scan Frequency: 30Hz;
	Scan Angle:	25deg;	Overlap: 30%

LAS

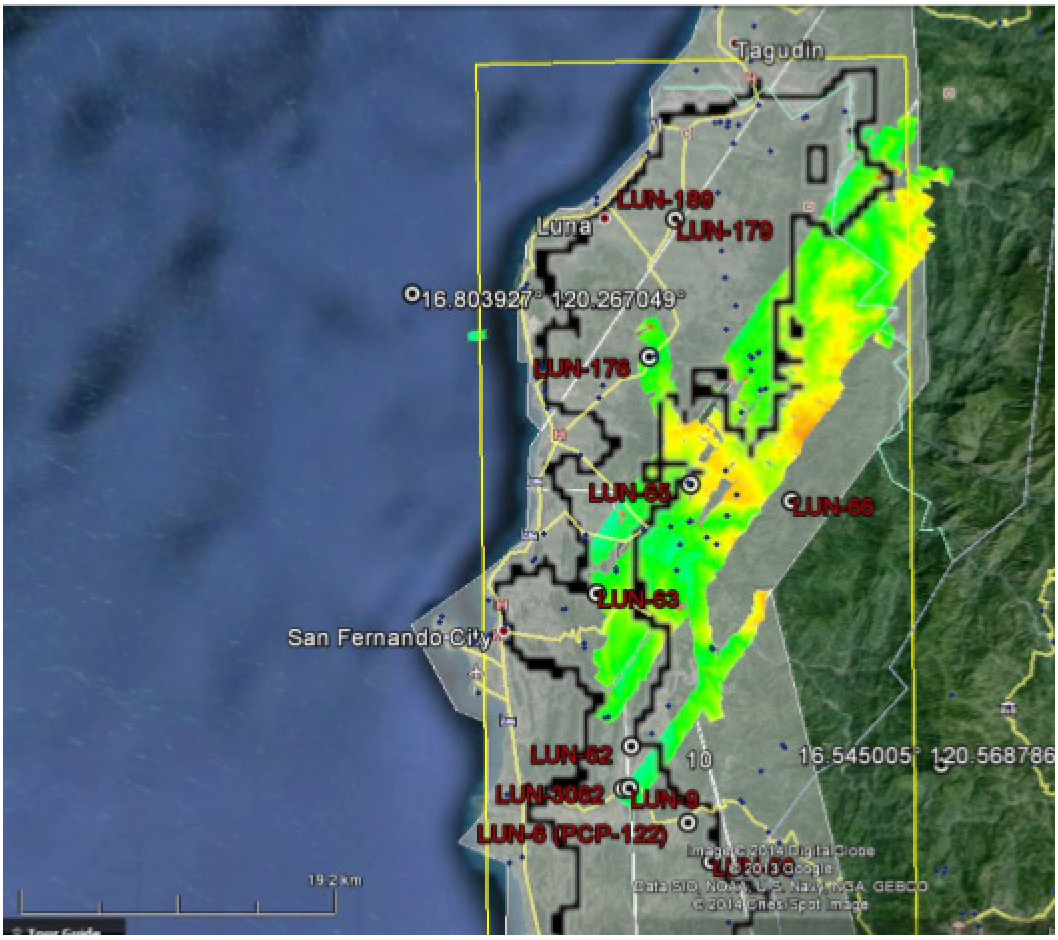


Figure A-7.2. Swath for Flight No. 1155P

Flight No. :	1159P
Area:	BLK 10G
Mission Name:	1BLK10GD058A
Parameters:	Altitude: 1200m; Scan Frequency: 30Hz;
	Scan Angle: 25 deg; Overlap: 30%

LAS

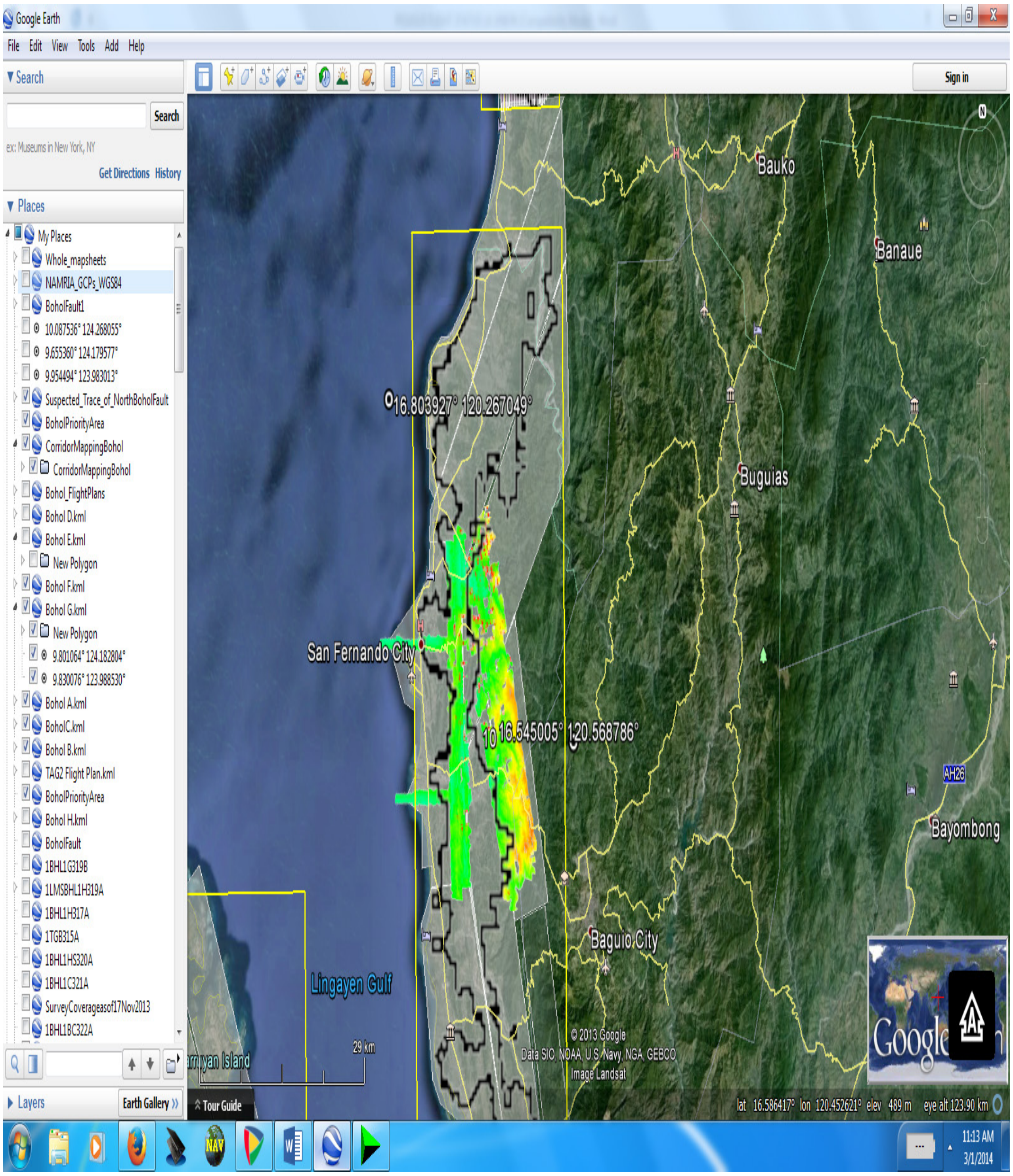


Figure A-7.3. Swath for Flight No. 1159P

Flight No. :	1161P	
Area:	BLK10D	
Mission name:	1BLK10D058B	
Parameters:	Altitude: 1200 m;	Scan Frequency: 50 Hz;
	Scan Angle: 15 deg;	Overlap: %
Area covered:	188.09 km^2	

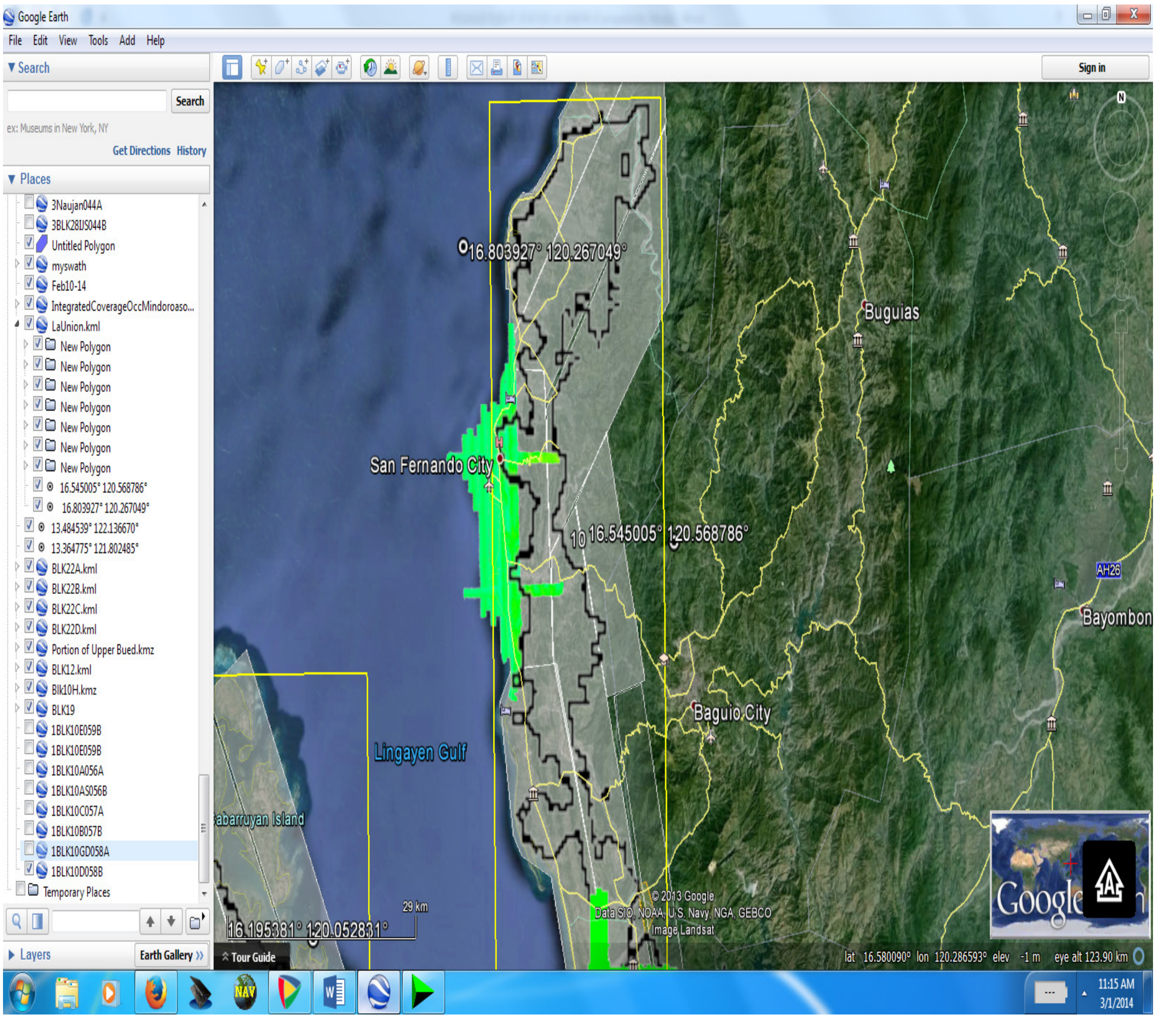


Figure A-7.4. Swath for Flight No. 1161P

Flight No. :	1163P	
Area:	BLK10F	
Mission name:	1BLK10F059A	
Parameters:	Altitude: 1200 m;	Scan Frequency: 50 Hz;
	Scan Angle: 15 deg;	Overlap: 50 %
Area covered:	341.41 km^2	

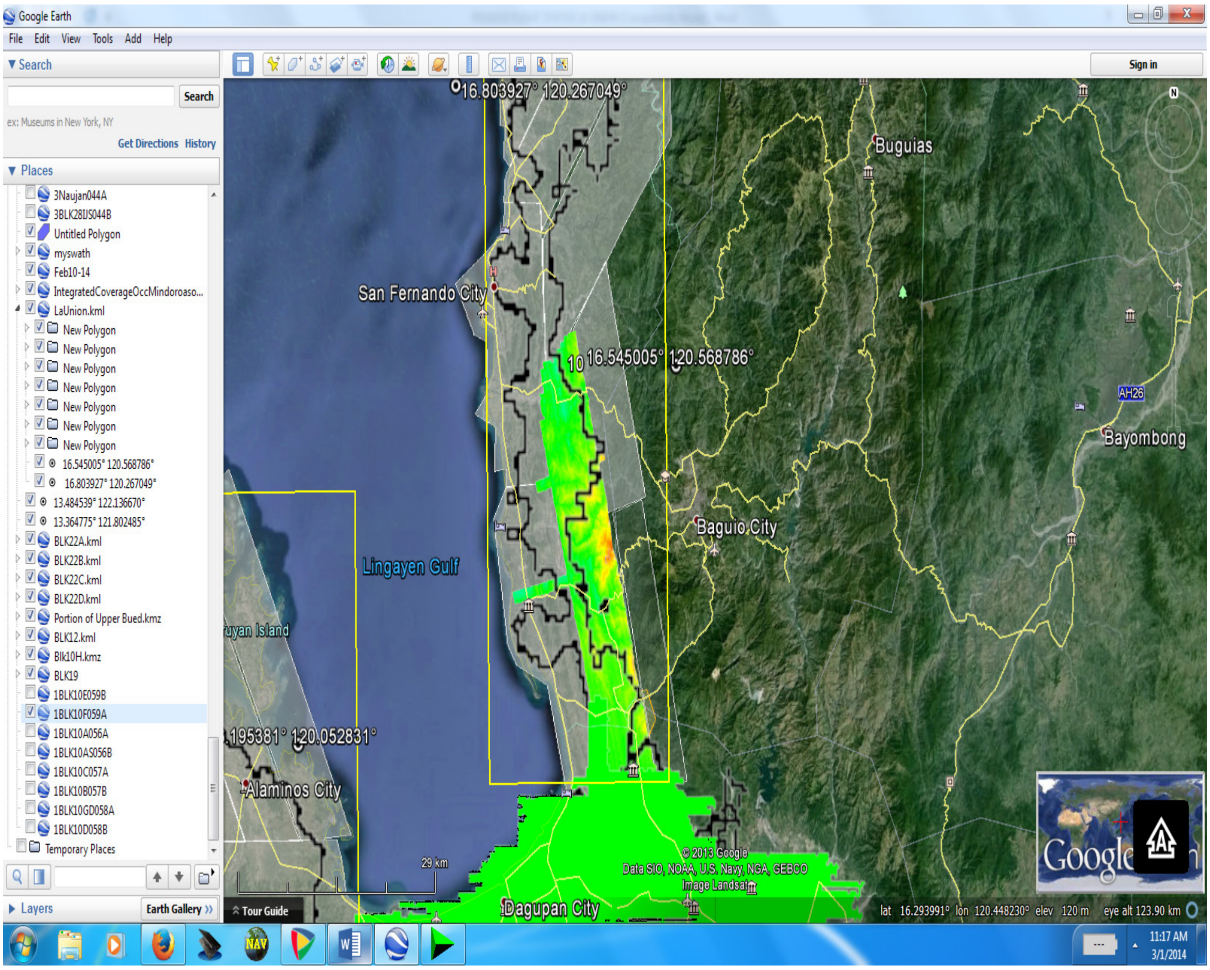


Figure A-7.5. Swath for Flight No. 1163P

Flight No. :	1171P	
Area:	BLK 10C	
Mission Name:	1BLK10CDS061A	
Parameters:	Altitude: 1500m;	Scan Frequency: 30Hz;
	Scan Angle:	25 deg; Overlap: 30%

LAS

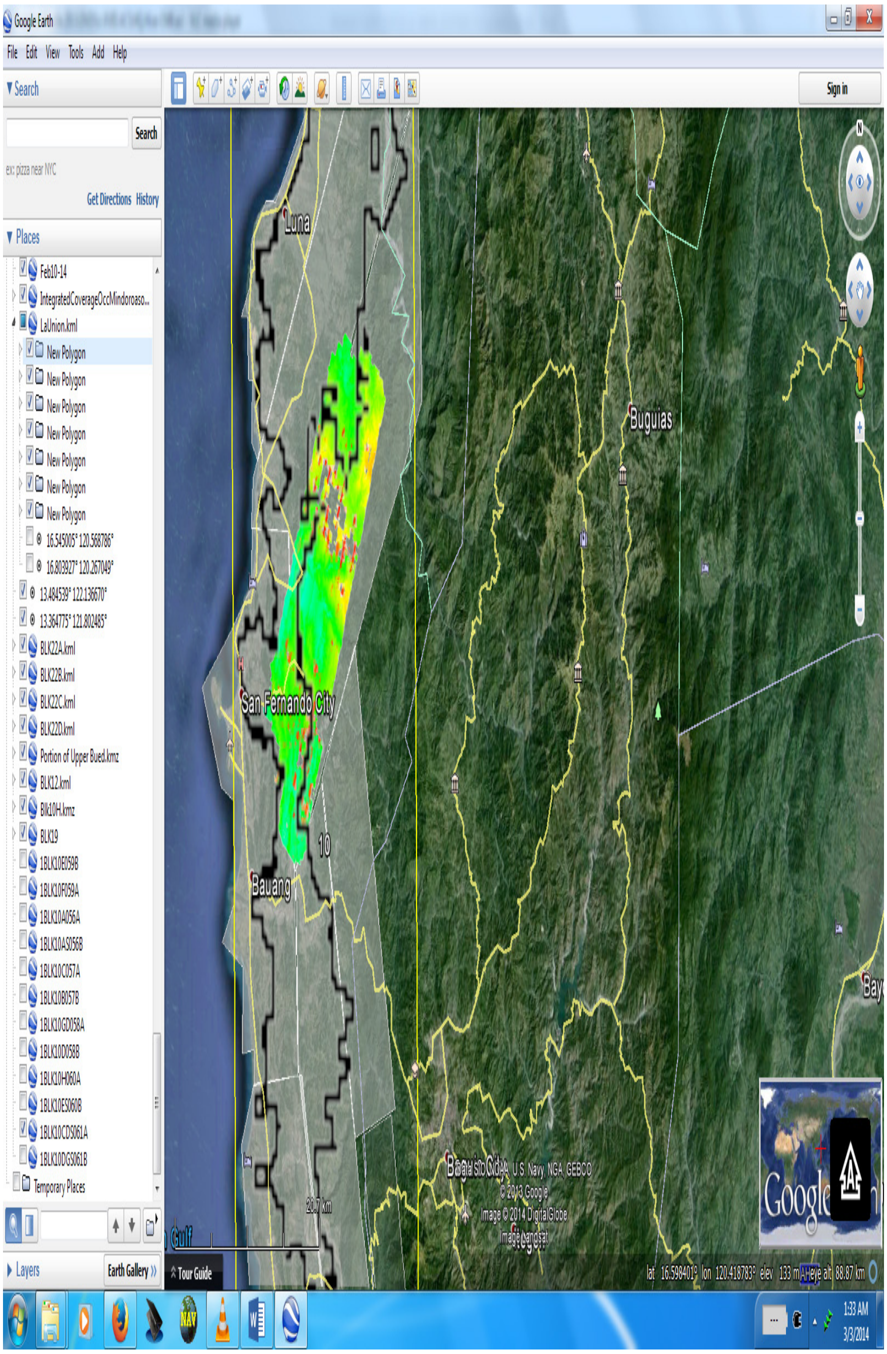


Figure A-7.6. Swath for Flight No. 1171P

Flight No. : 1173P
Area: BLK 10D
Mission Name: 1BLK10DS061B
Parameters: Altitude: 1200m; Scan Frequency: 30Hz;
Scan Angle: 25 deg; Overlap: 30%

LAS

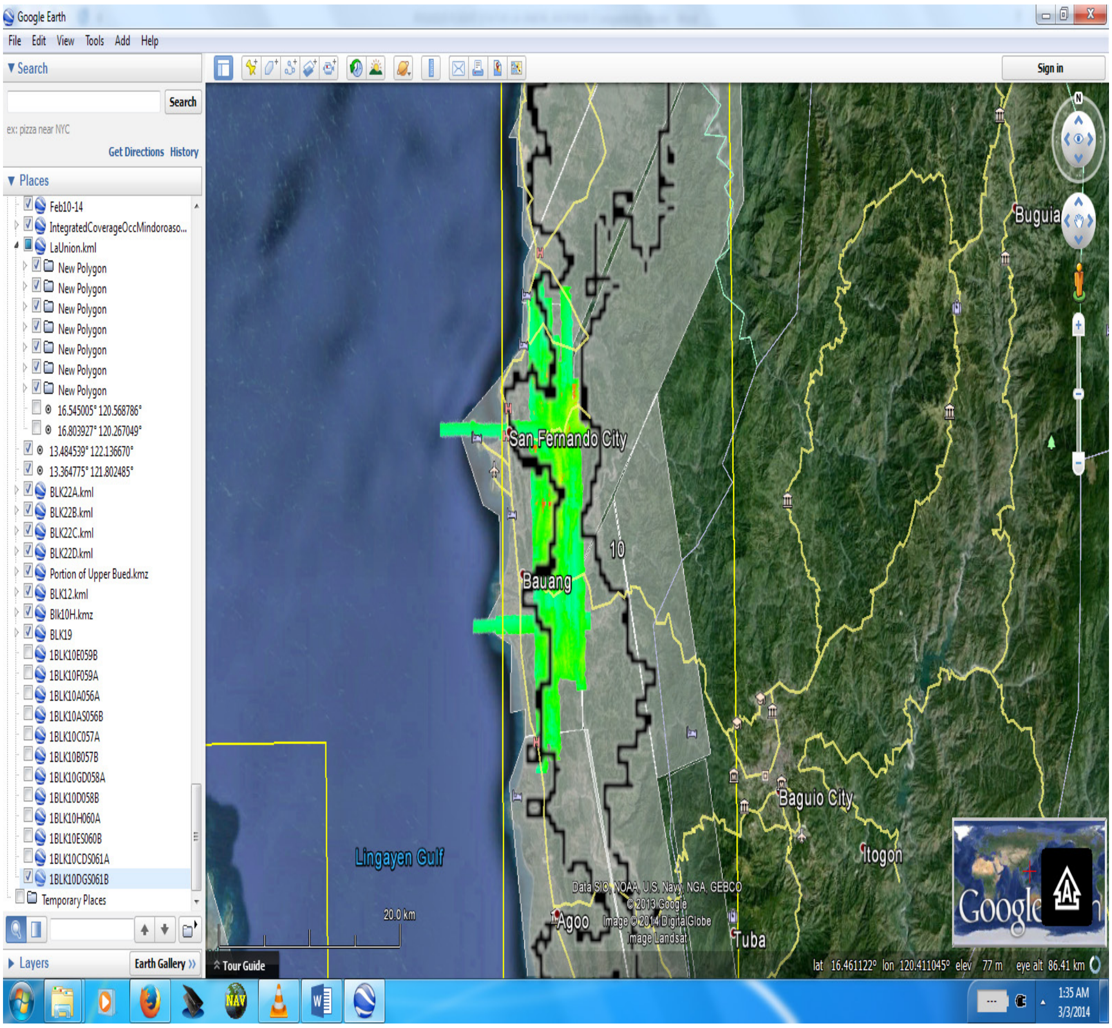


Figure A-7.7. Swath for Flight No. 1173P

Flight No. :	1177P	
Area:	BLK 10C	
Mission Name:	1BLK10CS062B	
Parameters:	Altitude: 1800m;	Scan Frequency: 30Hz;
	Scan Angle:	25 deg; Overlap: 30%

LAS

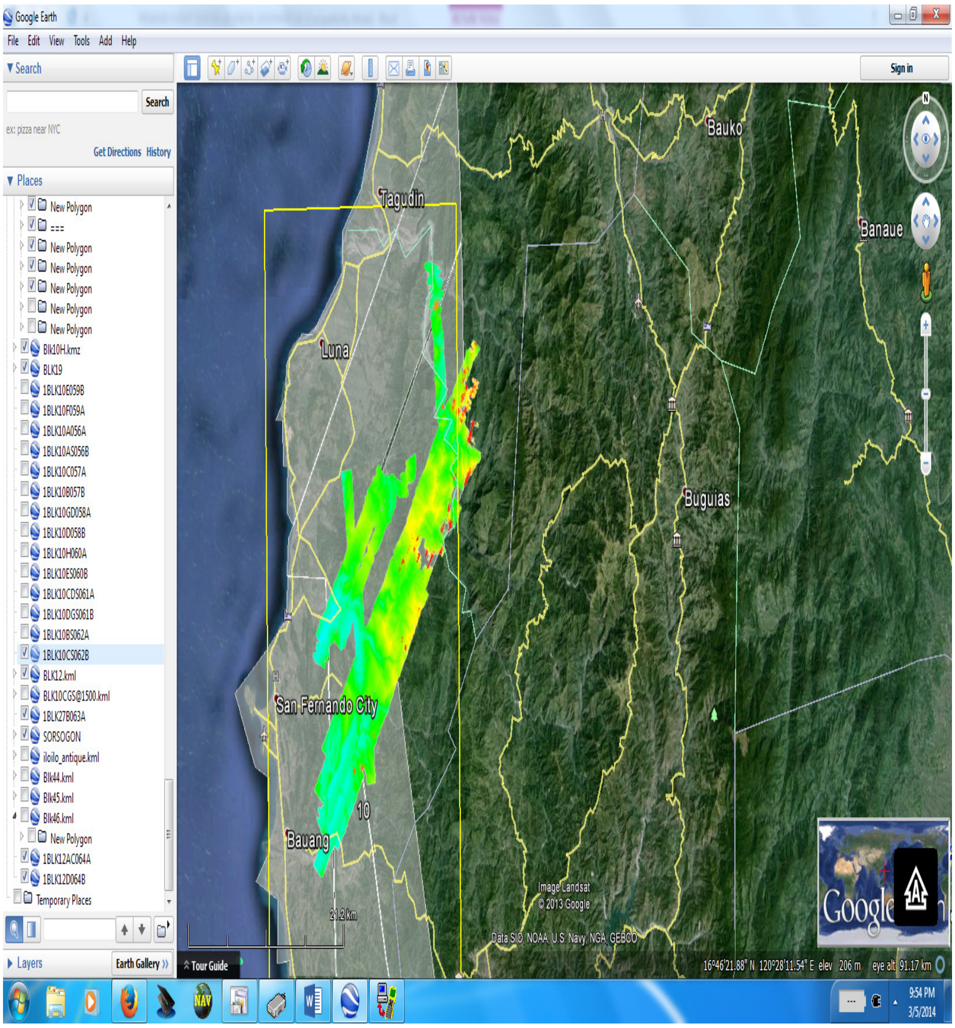


Figure A-7.8. Swath for Flight No. 1177P

Flight No. :	1197P	
Area:	BLK10GC	
Mission name:	1BLK10GCS067B	
Parameters:	Altitude: 1500 m;	Scan Frequency: 50 Hz;
	Scan Angle: 15 deg;	Overlap: 50 %
Area covered:	108.87 km^2	

LAS

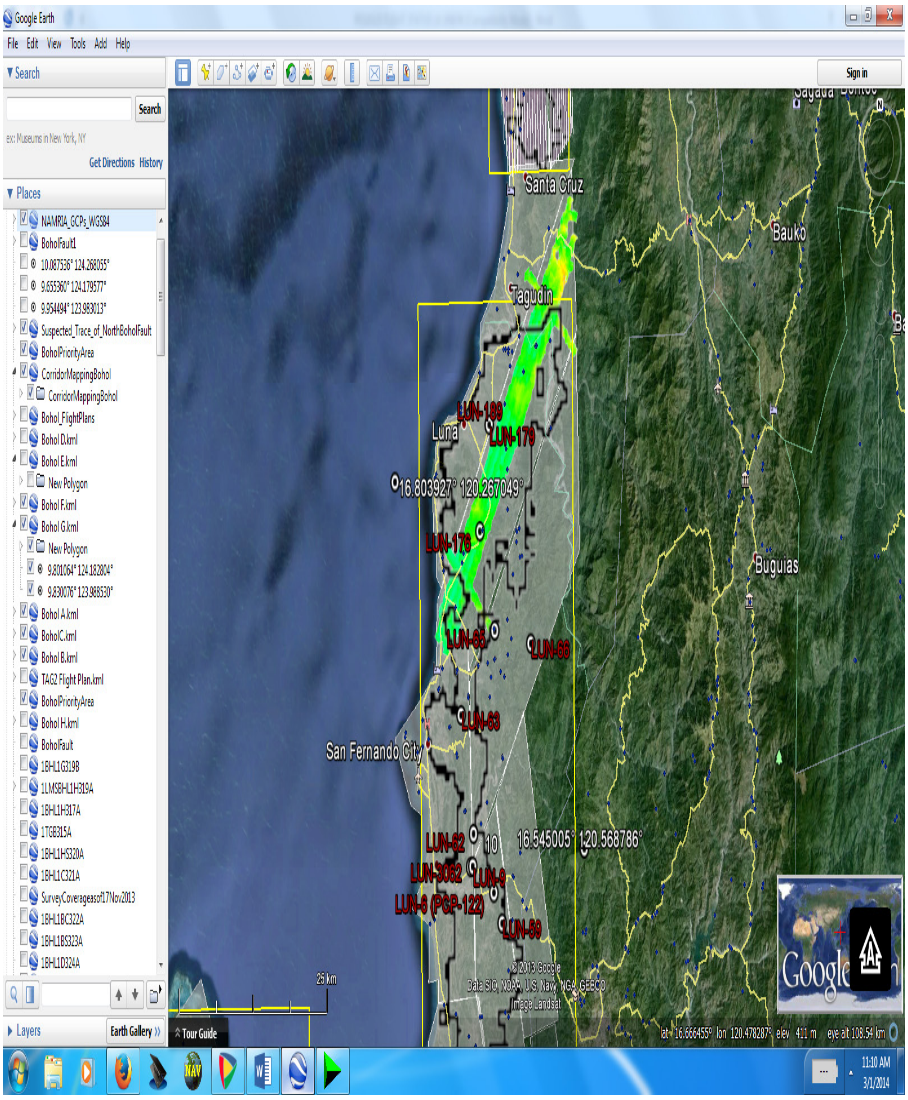


Figure A-7.9. Swath for Flight No. 1197P

Annex 8. Mission Summary Reports

Table A-8.1. Mission Summary Report for Mission Blk10C

Flight Area	**La Union**
Mission Name	**Blk10C**
Inclusive Flights	1155P, 1171P, 1177P, 1197P
Range data size	62.86 GB
Base data size	22.2 MB
POS	695 MB
Image	98.6 GB
Transfer date	March 08, 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)	3.62
RMSE for East Position (<4.0 cm)	4.3
RMSE for Down Position (<8.0 cm)	6.55
Boresight correction stdev (<0.001deg)	0.000398
IMU attitude correction stdev (<0.001deg)	0.017218
GPS position stdev (<0.01m)	0.0267
Minimum % overlap (>25)	35.05%
Ave point cloud density per sq.m. (>2.0)	3.75
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	505
Maximum Height	1038.87 m
Minimum Height	45.5 m
Classification (# of points)	
Ground	270,659,389
Low vegetation	232,081,137
Medium vegetation	638,506,120
High vegetation	737,644,888
Building	23,046,935
Orthophoto	Yes
Processed by	Engr. Kenneth Solidum, Engr. Melanie Hingpit, Ailyn Biñas

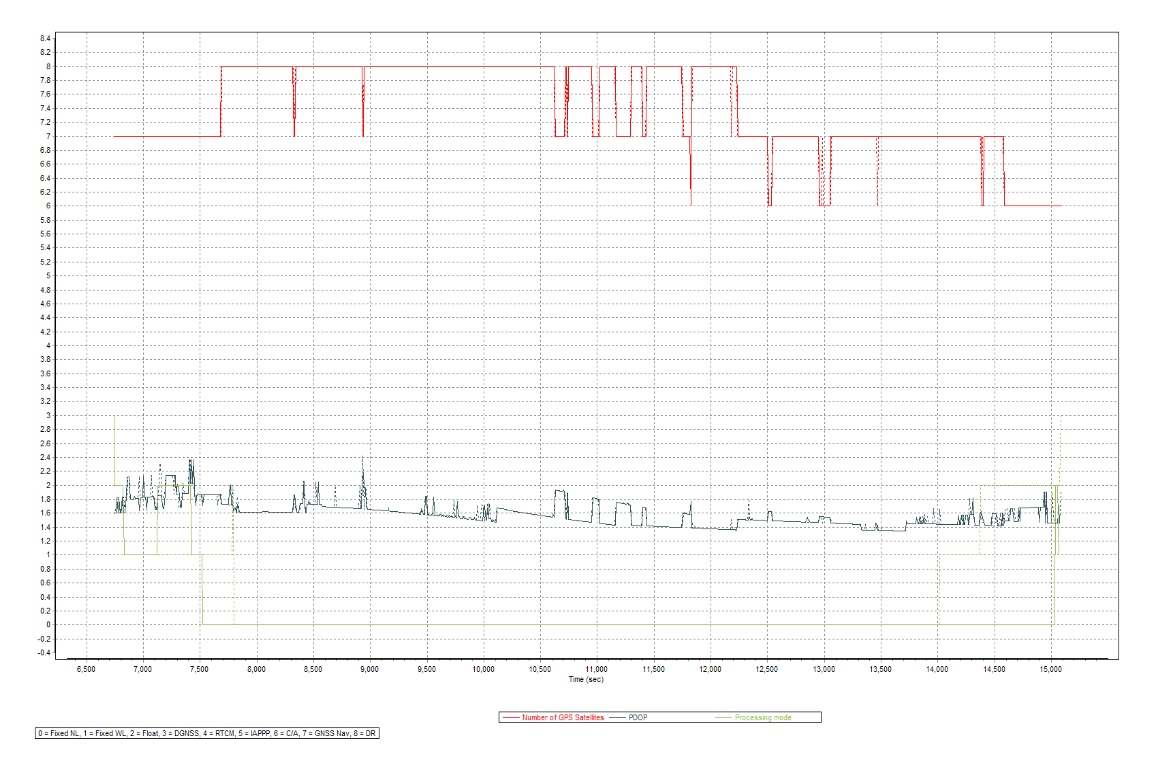


Figure A-8.1. Solution Status

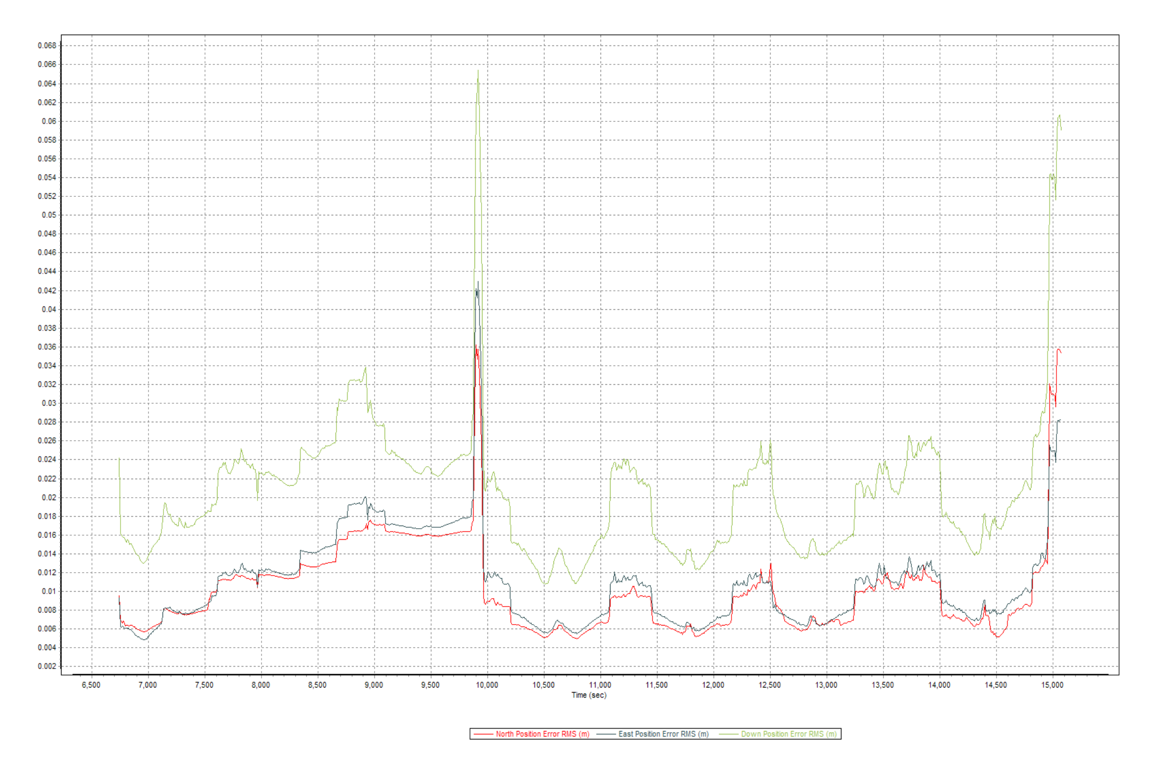


Figure A-8.2. Smoothed Performance Metric Parameters

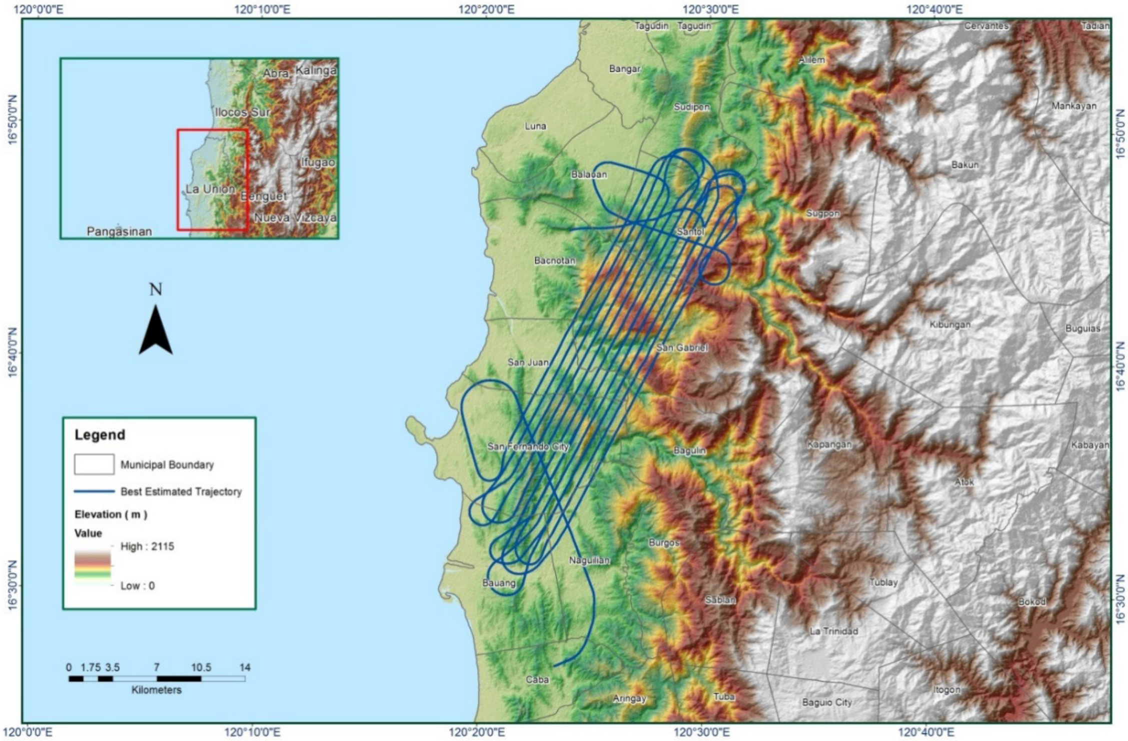


Figure A-8.3. Best Estimated Trajectory

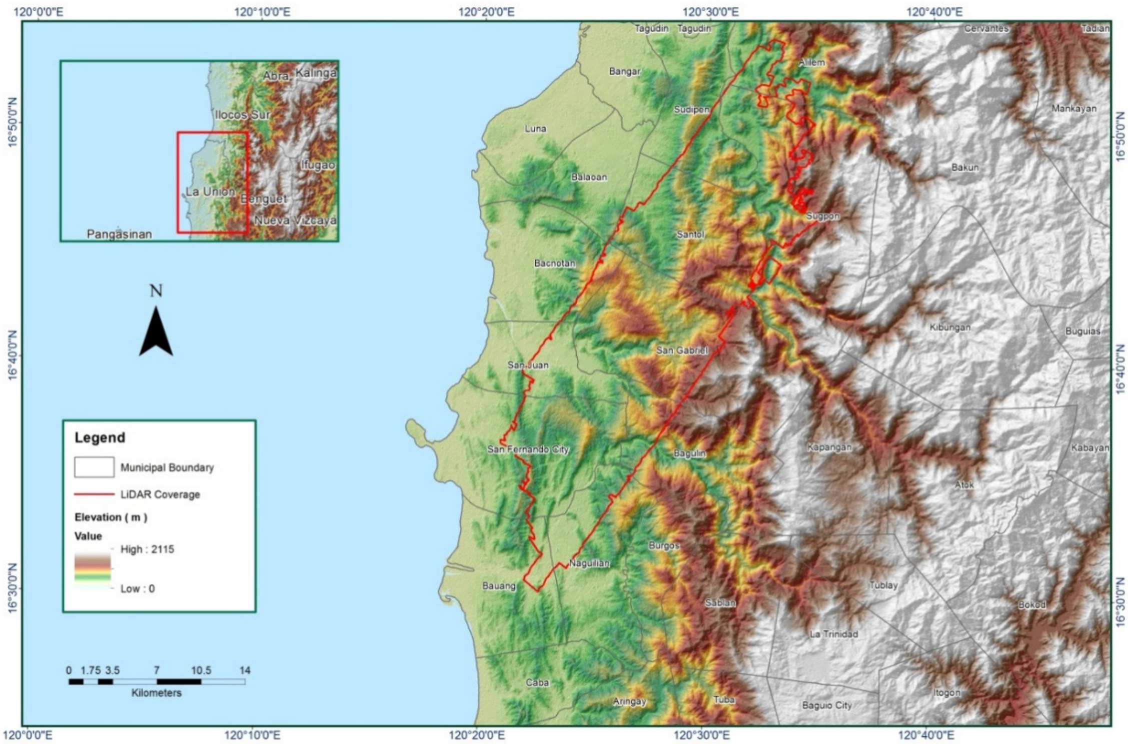


Figure A-8.4. Coverage of LIDAR data

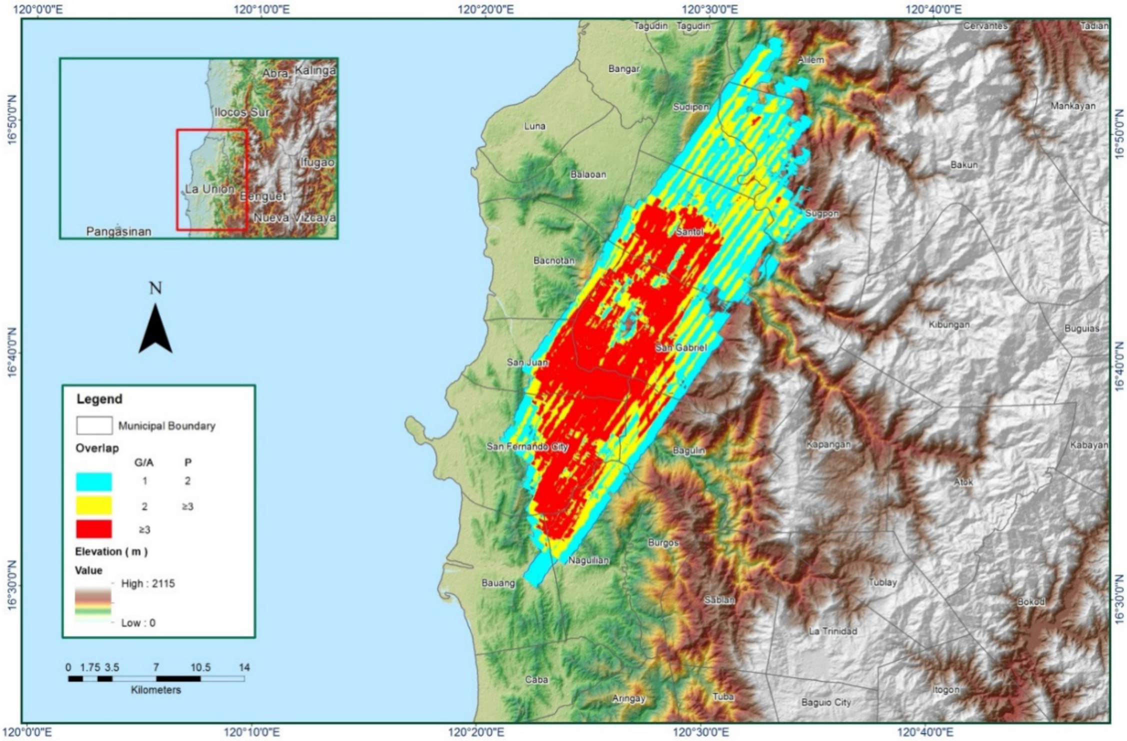


Figure A-8.5. Image of Data Overlap

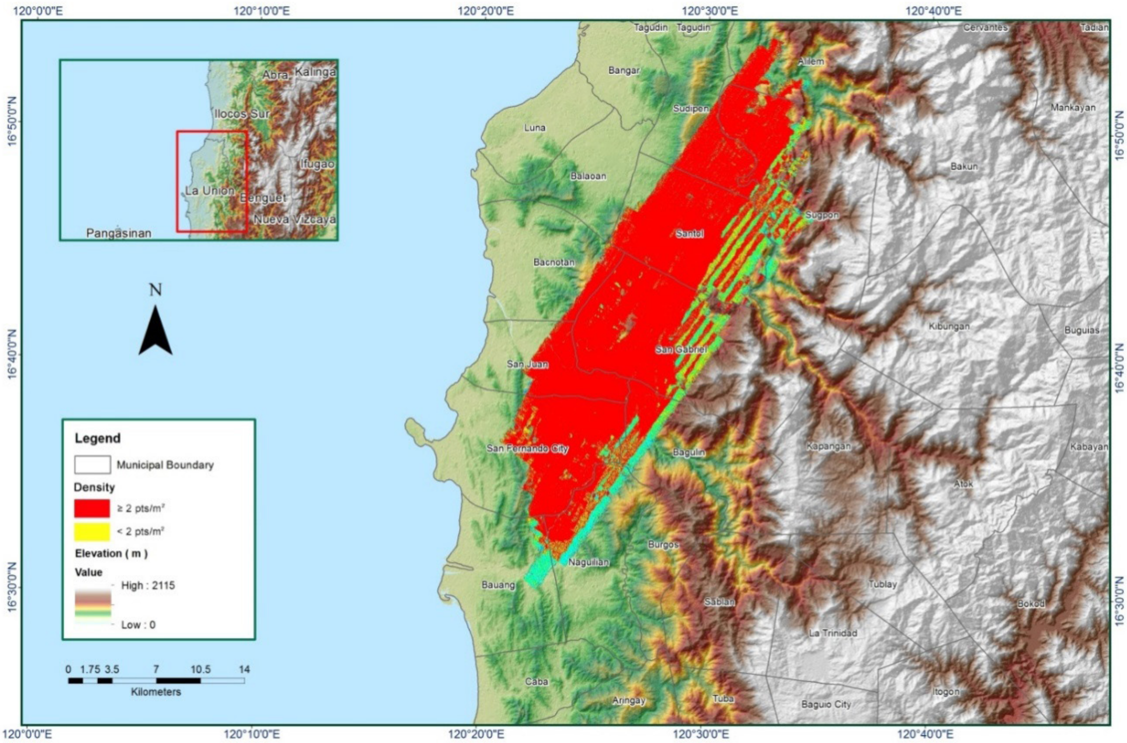


Figure A-8.6. Density map of merged LIDAR data

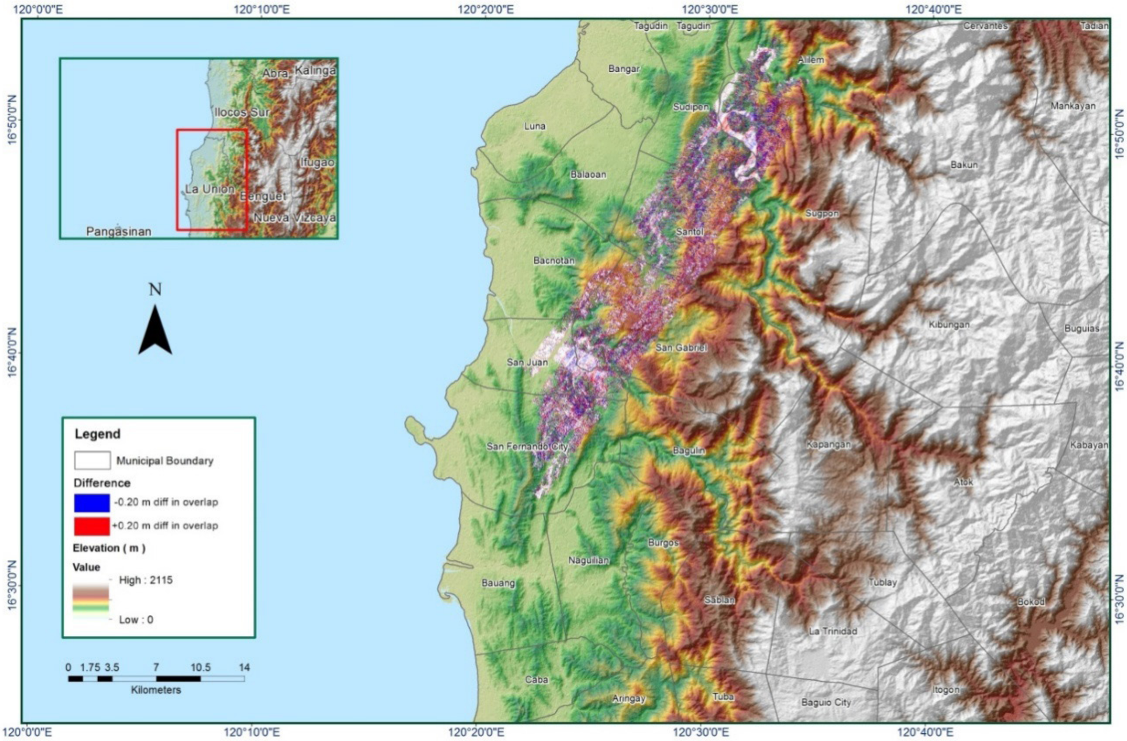


Figure A-8.7. Elevation difference between flight lines

Table A-8.2. Mission Summary Report for Mission Blk10D

Flight Area	La Union
Mission Name	**Blk10D**
Inclusive Flights	1159P, 1161P, 1171P, 1173P
Range data size	75 GB
Base data size	27.3 MB
POS	695 MB
Image	68.3 GB
Transfer date	March 02, 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)	1.4
RMSE for East Position (<4.0 cm)	1.4
RMSE for Down Position (<8.0 cm)	2.4
Boresight correction stdev (<0.001deg)	0.000325
IMU attitude correction stdev (<0.001deg)	0.006754
GPS position stdev (<0.01m)	0.0029
Minimum % overlap (>25)	68.41%
Ave point cloud density per sq.m. (>2.0)	2.78
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	394
Maximum Height	401.8
Minimum Height	42.44
Classification (# of points)	
Ground	301,413,519
Low vegetation	230,161,400
Medium vegetation	317,034,224
High vegetation	336,165,453
Building	30,496,828
Orthophoto	
Processed by	Engr. Kenneth Solidum, Engr. Angelo Carlo Bongat, Engr. Benjamin Jonah Magallon, Engr. Harmond Santos, Engr. Jeffrey Delica

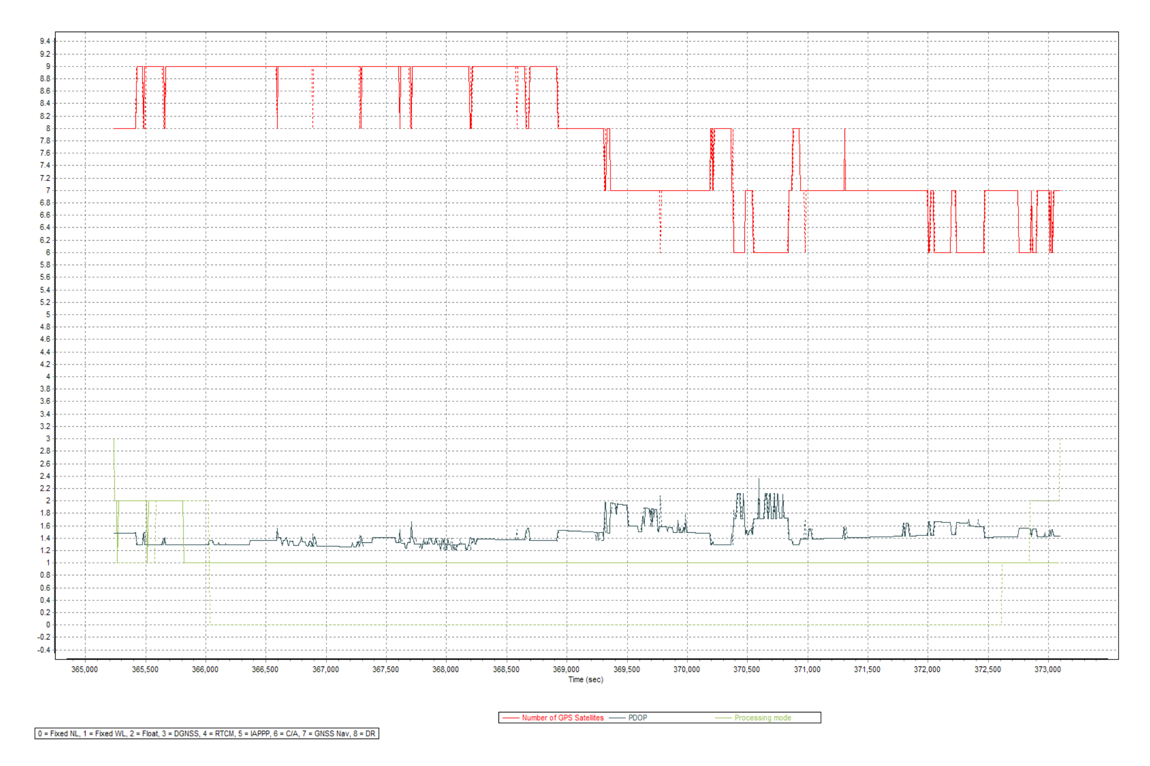


Figure A-8.8. Solution Status

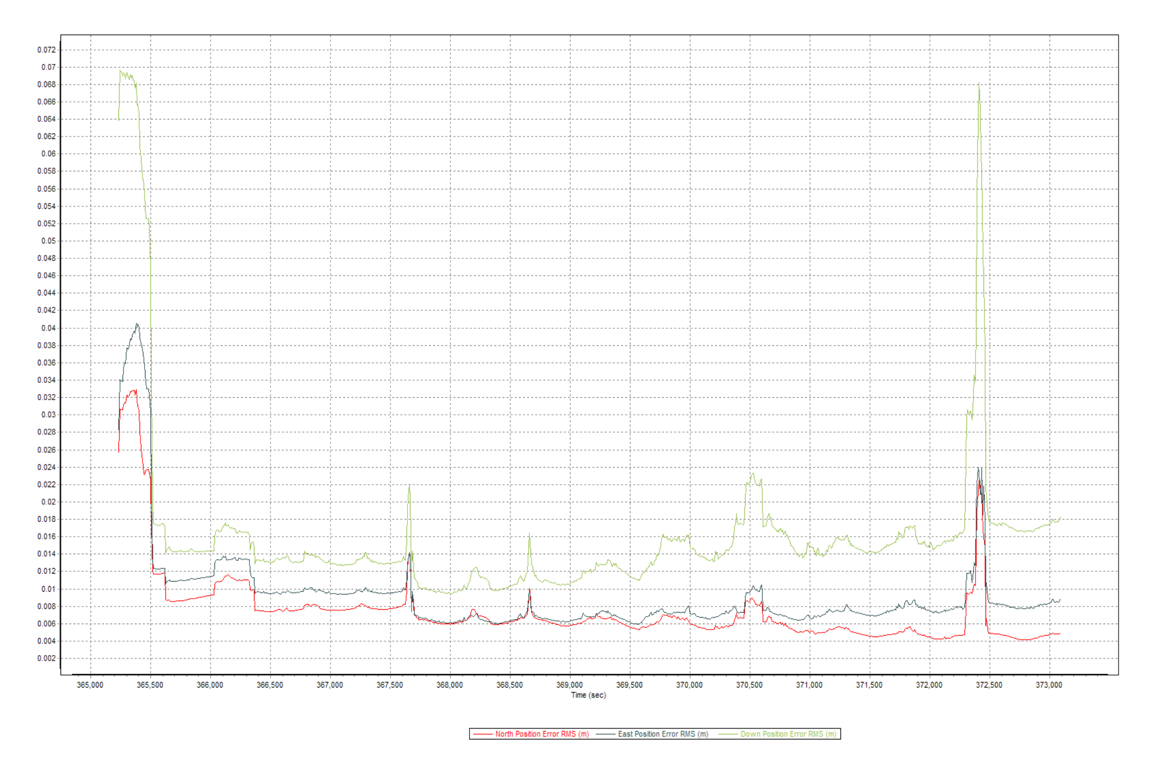


Figure A-8.9. Smoothed Performance Metric Parameters

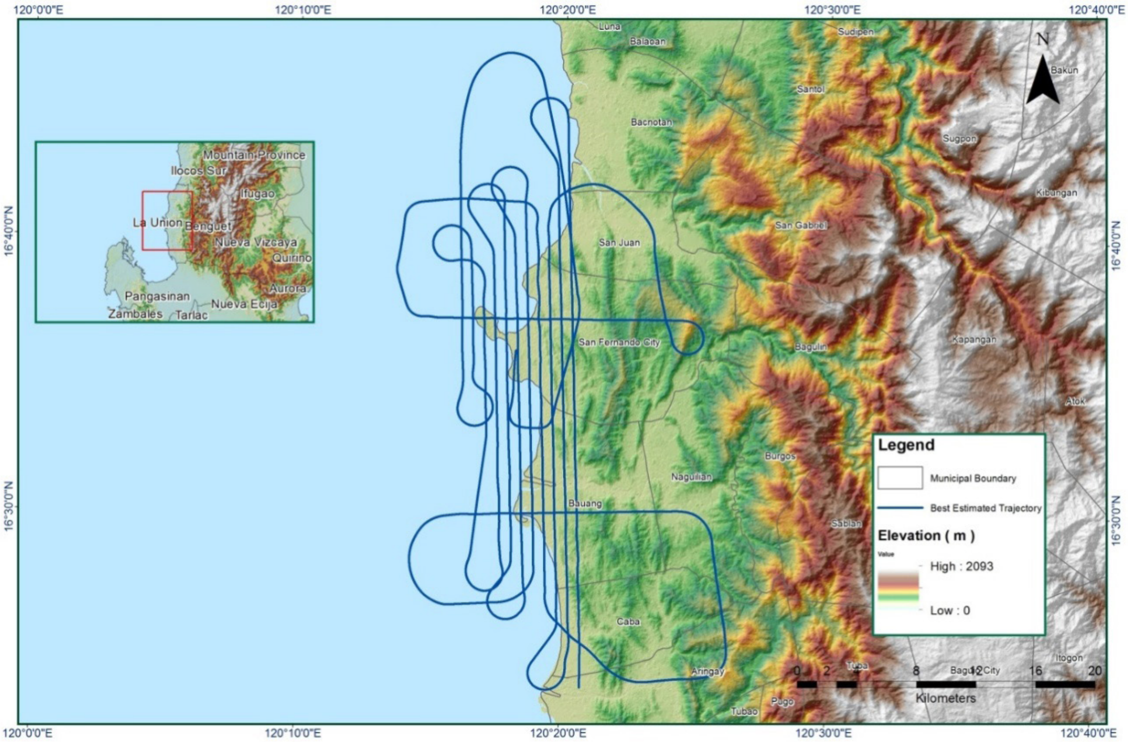


Figure A-8.10. Best Estimated Trajectory

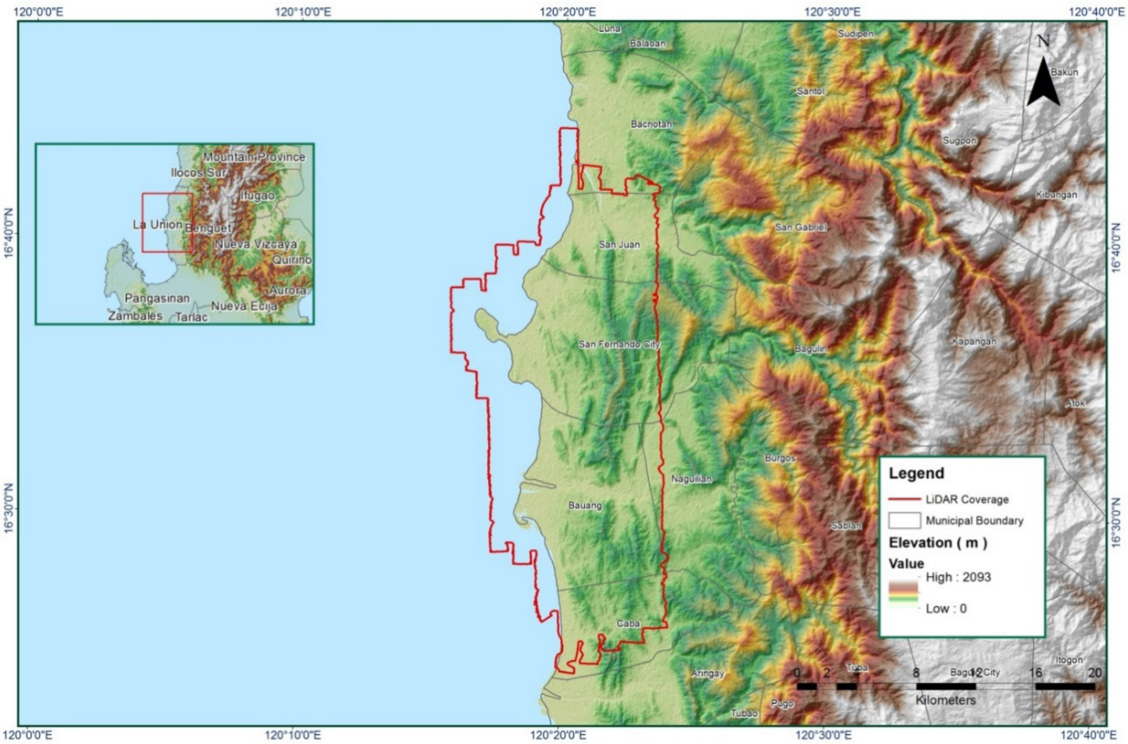


Figure A-8.11. Coverage of LIDAR data

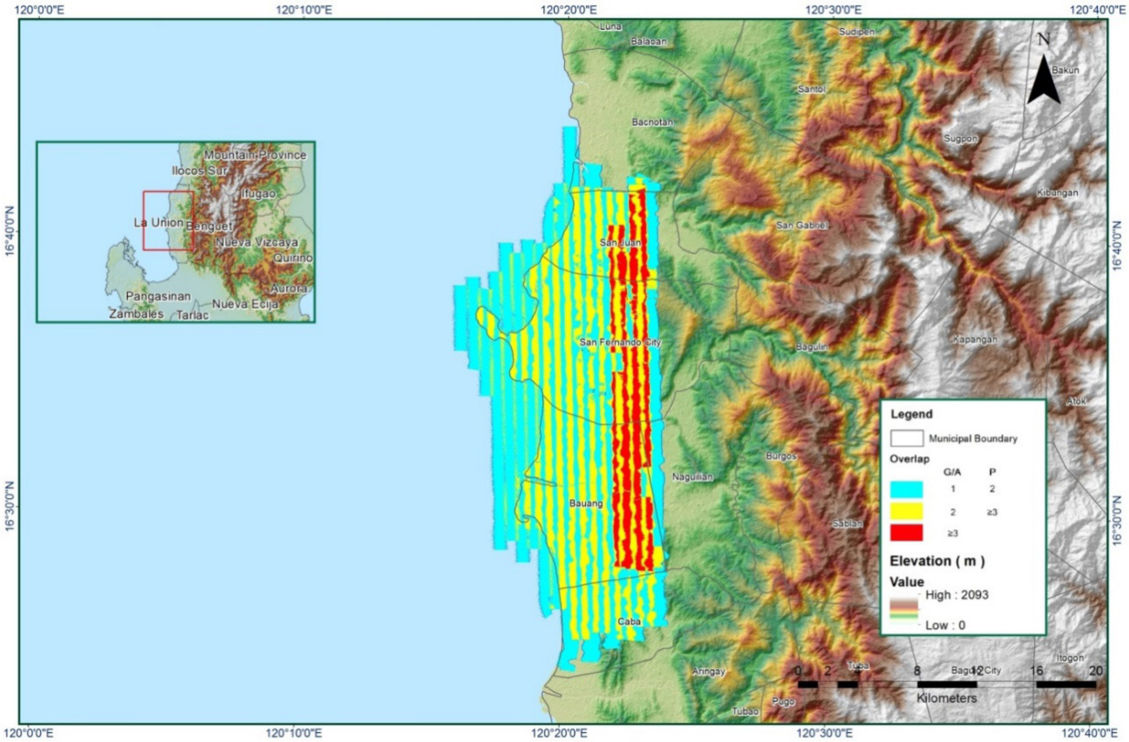


Figure A-8.12. Image of Data Overlap

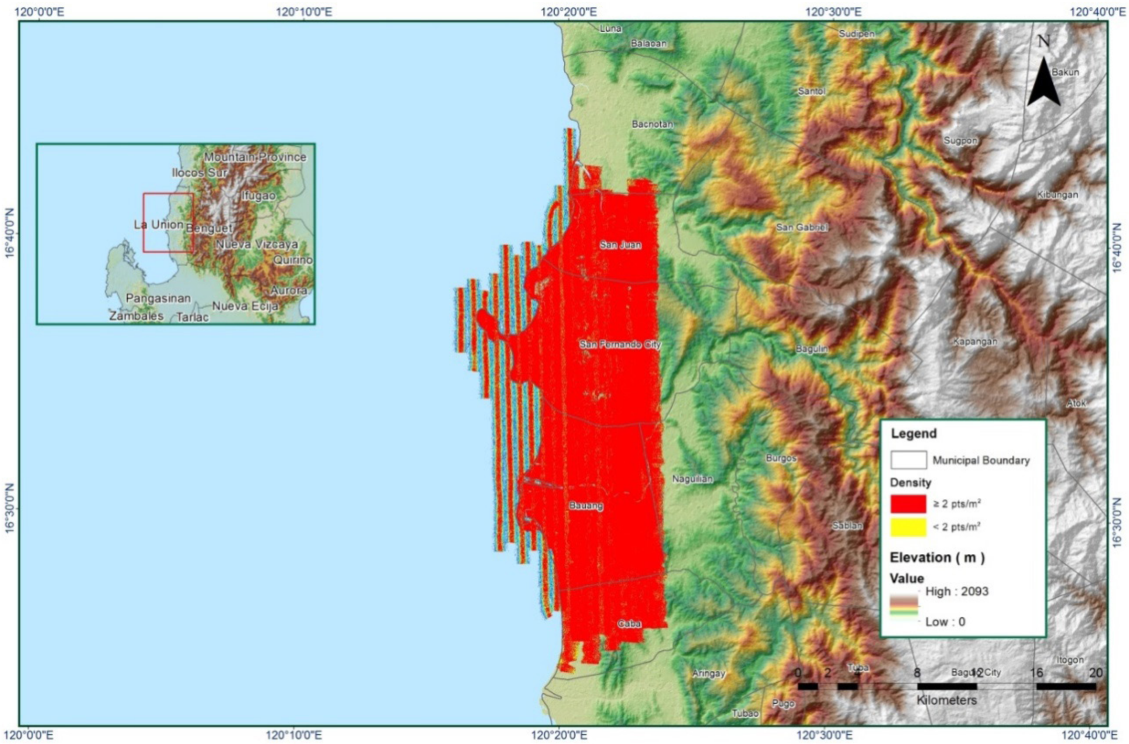


Figure A-8.13. Density map of merged LIDAR data

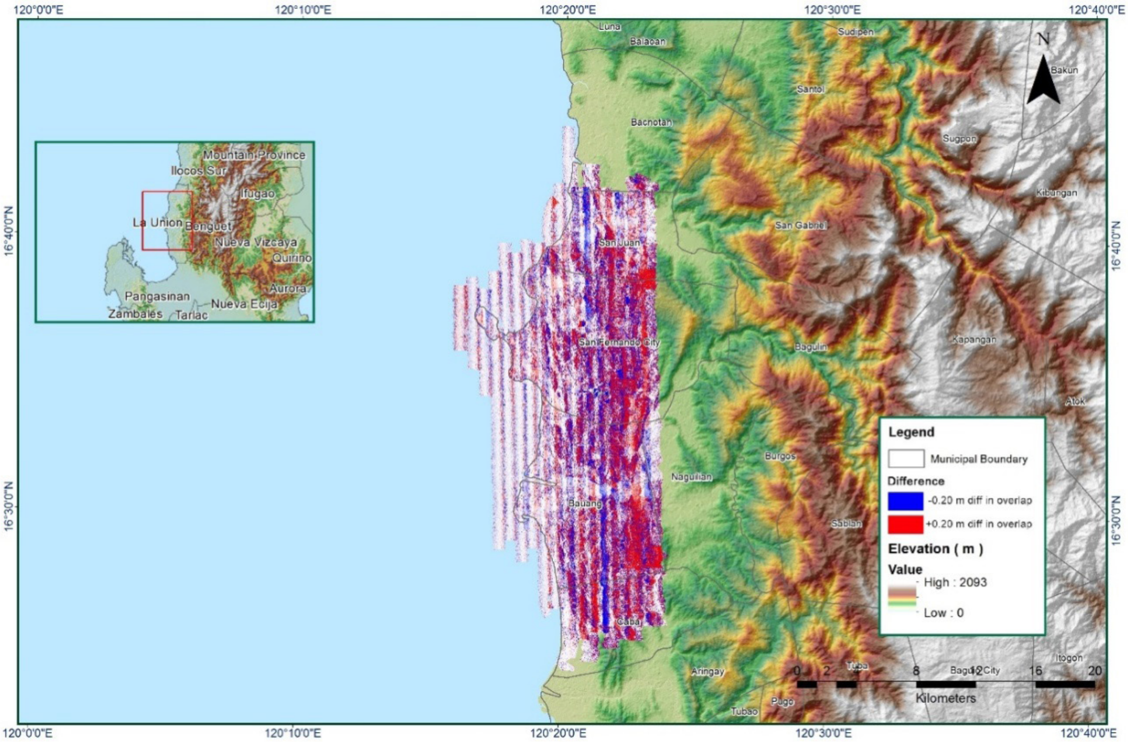


Figure A-8.14 Elevation difference between flight lines

Table A-8.3. Mission Summary Report for Mission Blk10F

Flight Area	La Union
Mission Name	**Blk10F**
Inclusive Flights	1163P
Range data size	31.7 GB
Base data size	6.1 MB
POS	216 MB
Image	26.6 GB
Transfer date	February 28, 2014
Solution Status	
Number of Satellites (>6)	No
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	4.0
RMSE for East Position (<4.0 cm)	1.7
RMSE for Down Position (<8.0 cm)	4.55
Boresight correction stdev (<0.001deg)	0.000412
IMU attitude correction stdev (<0.001deg)	0.001085
GPS position stdev (<0.01m)	0.0015
Minimum % overlap (>25)	51.30%
Ave point cloud density per sq.m. (>2.0)	2.89
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	397
Maximum Height	917.14
Minimum Height	54.72
Classification (# of points)	
Ground	313,178,442
Low vegetation	207,472,770
Medium vegetation	359,082,600
High vegetation	352,450,264
Building	16,826,260
Orthophoto	
Processed by	Engr. Irish Cortez, Engr. Edgardo Gubatanga, Jr., Ailyn Biñas

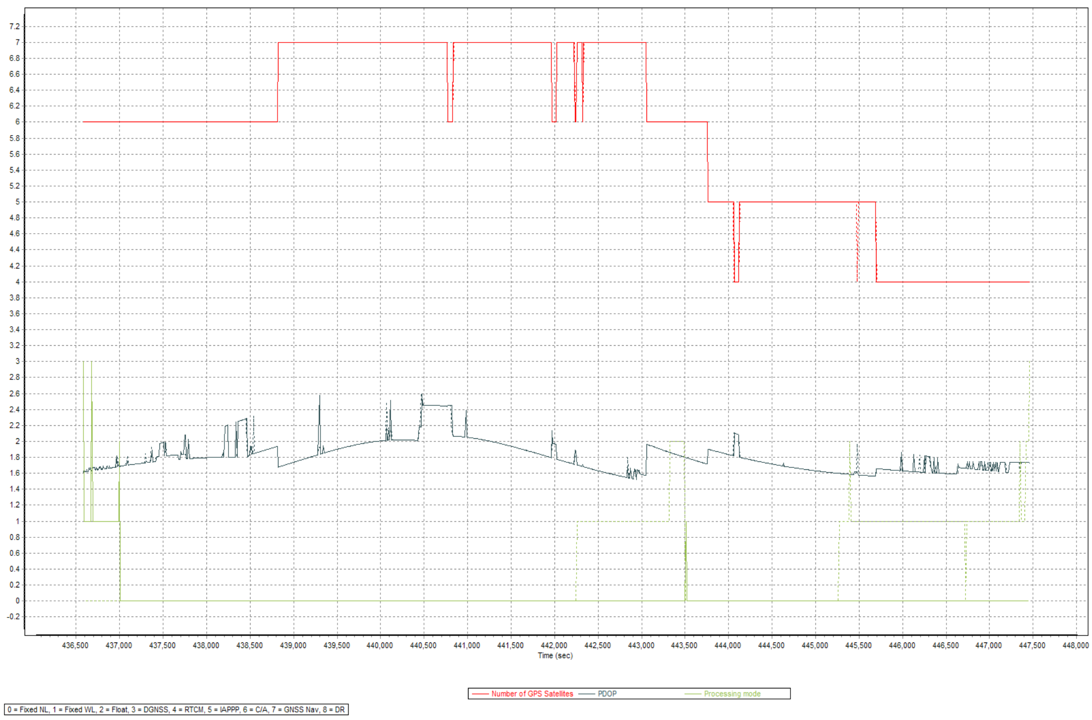


Figure A-8.15. Solution Status

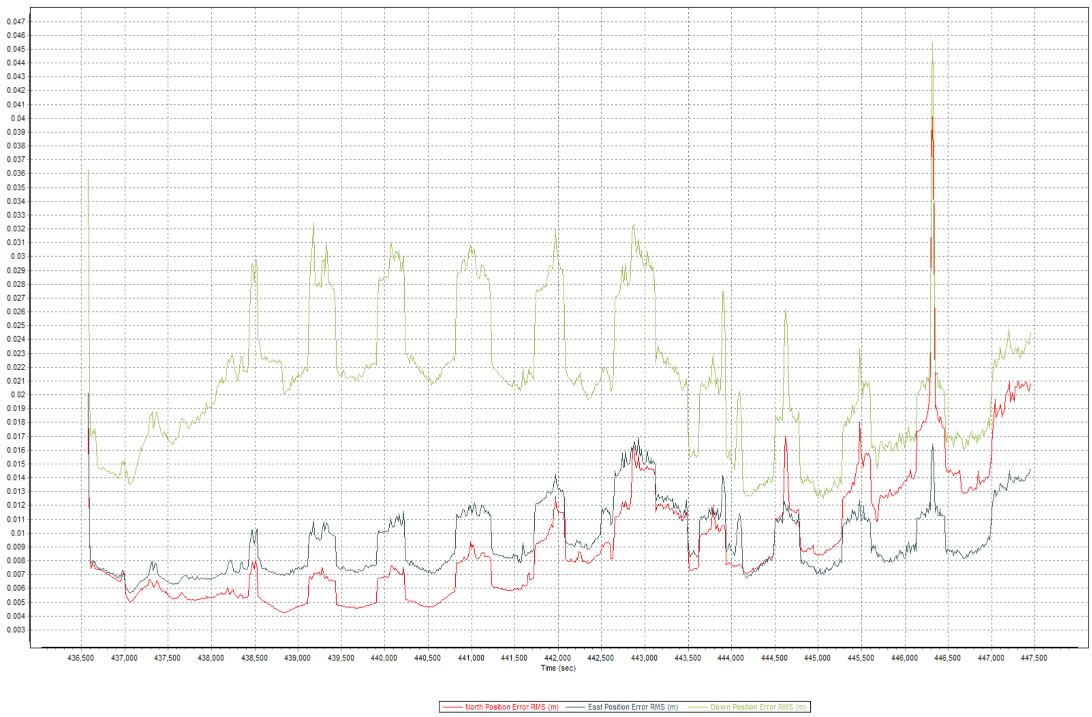


Figure A-8.16. Smoothed Performance Metric Parameters

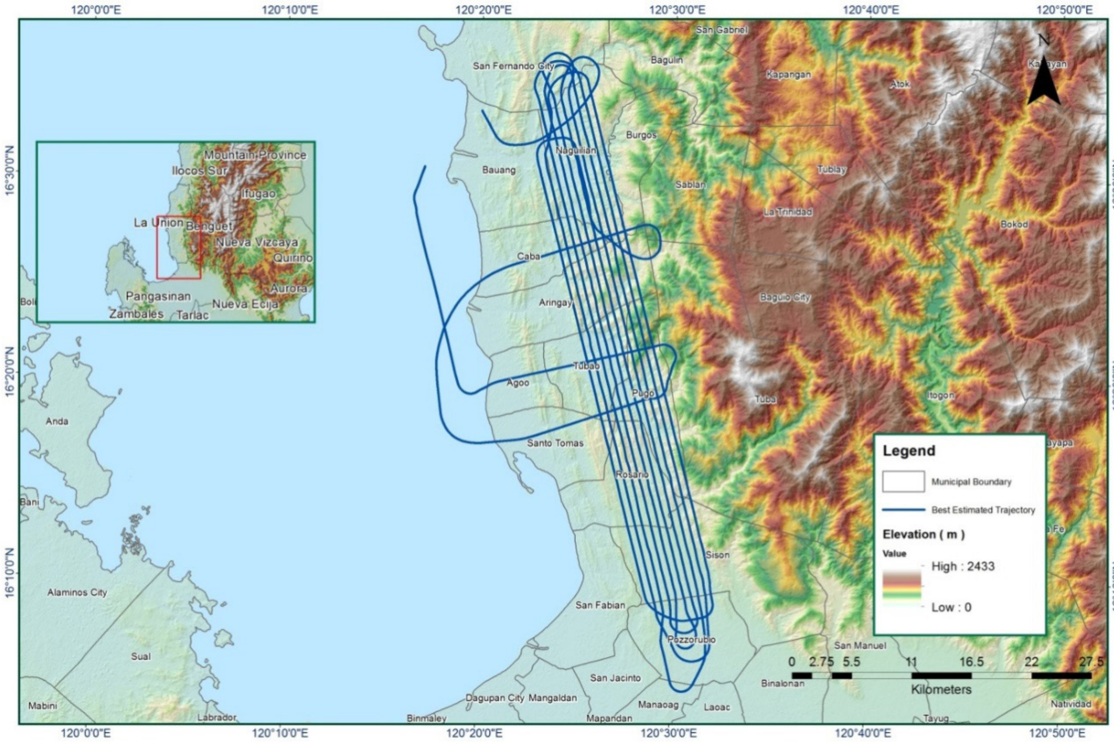


Figure A-8.17. Best Estimated Trajectory

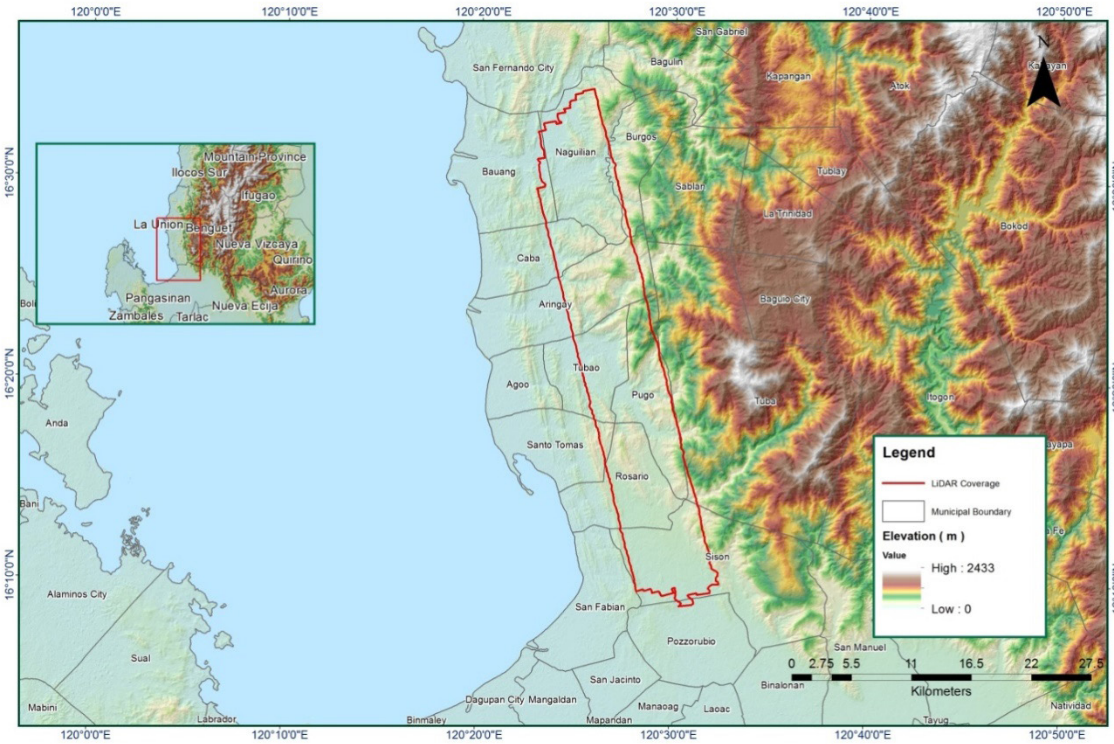


Figure A-8.18. Coverage of LIDAR data

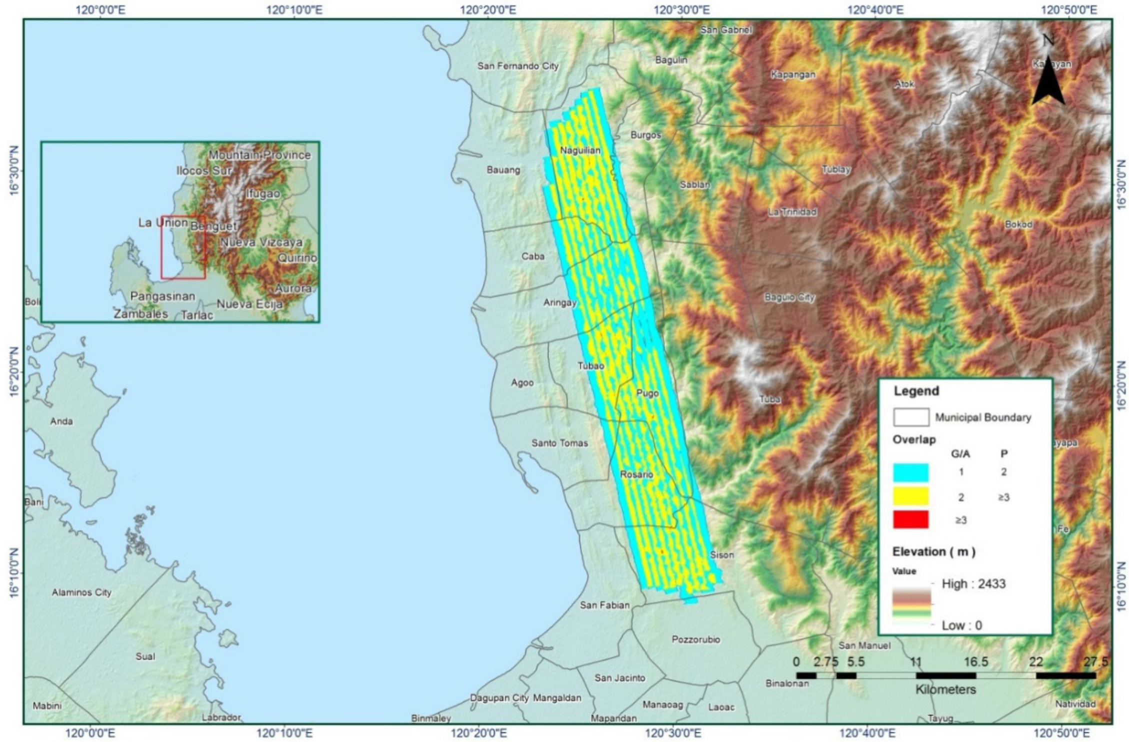


Figure A-8.19. Image of Data Overlap

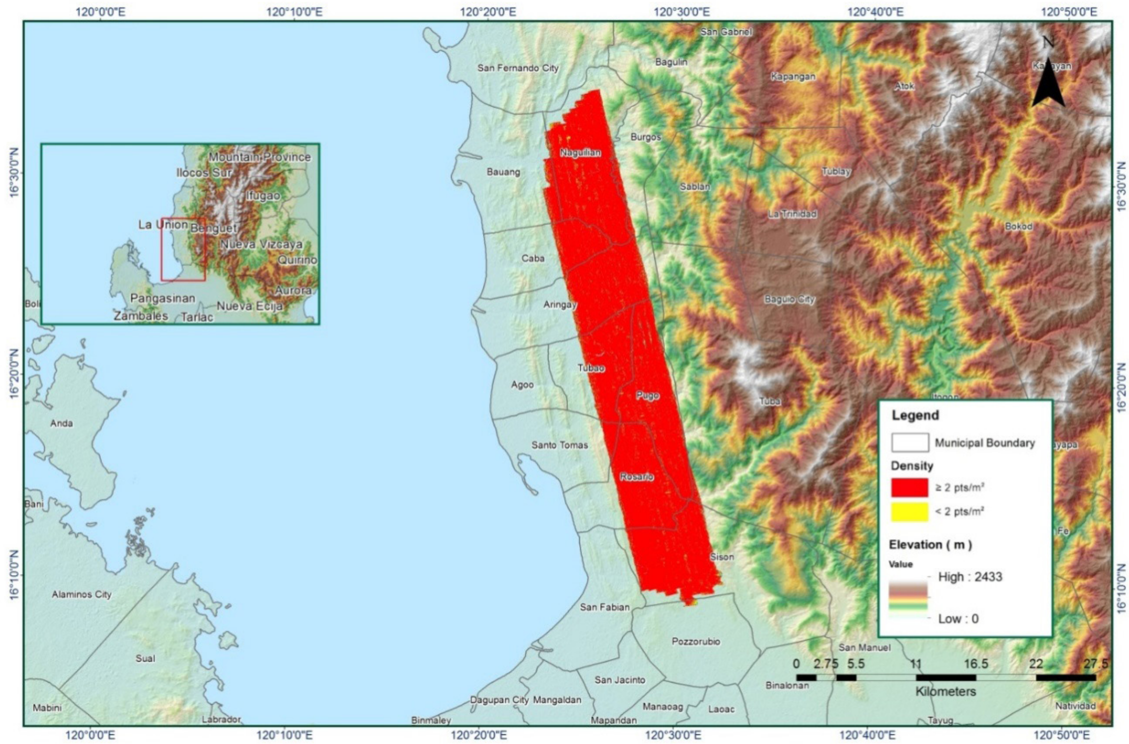


Figure A-8.20. Density map of merged LIDAR data

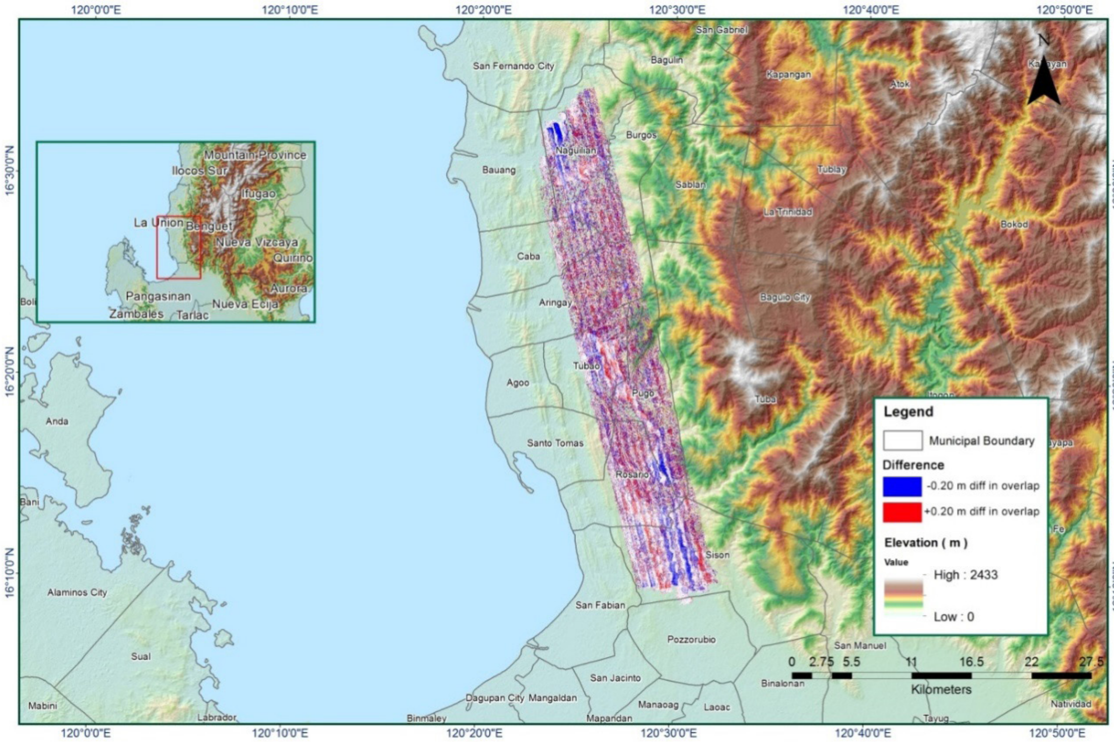


Figure A-8.21. Elevation difference between flight lines

Table A-8.4. Mission Summary Report for Mission Blk10G

Flight Area	La Union
Mission Name	**Blk10G**
Inclusive Flights	1159P, 1197P
Range data size	36.06 GB
Base data size	8.0 MB
POS	333 MB
Image	19.2 GB
Transfer date	March 08, 2014
Solution Status	
Number of Satellites (>6)	No
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.8
RMSE for East Position (<4.0 cm)	1.45
RMSE for Down Position (<8.0 cm)	3.7
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)	49.64%
Ave point cloud density per sq.m. (>2.0)	3.07
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	169
Maximum Height	907.57 m
Minimum Height	63.17 m
Classification (# of points)	
Ground	87,019,657
Low vegetation	52,606,940
Medium vegetation	177,544,572
High vegetation	232,589,835
Building	6,668,084
Orthophoto	Yes
Processed by	Engr. Angelo Carlo Bongat, Engr. Kenneth Solidum, Engr. Harmond Santos, Simonette Lat

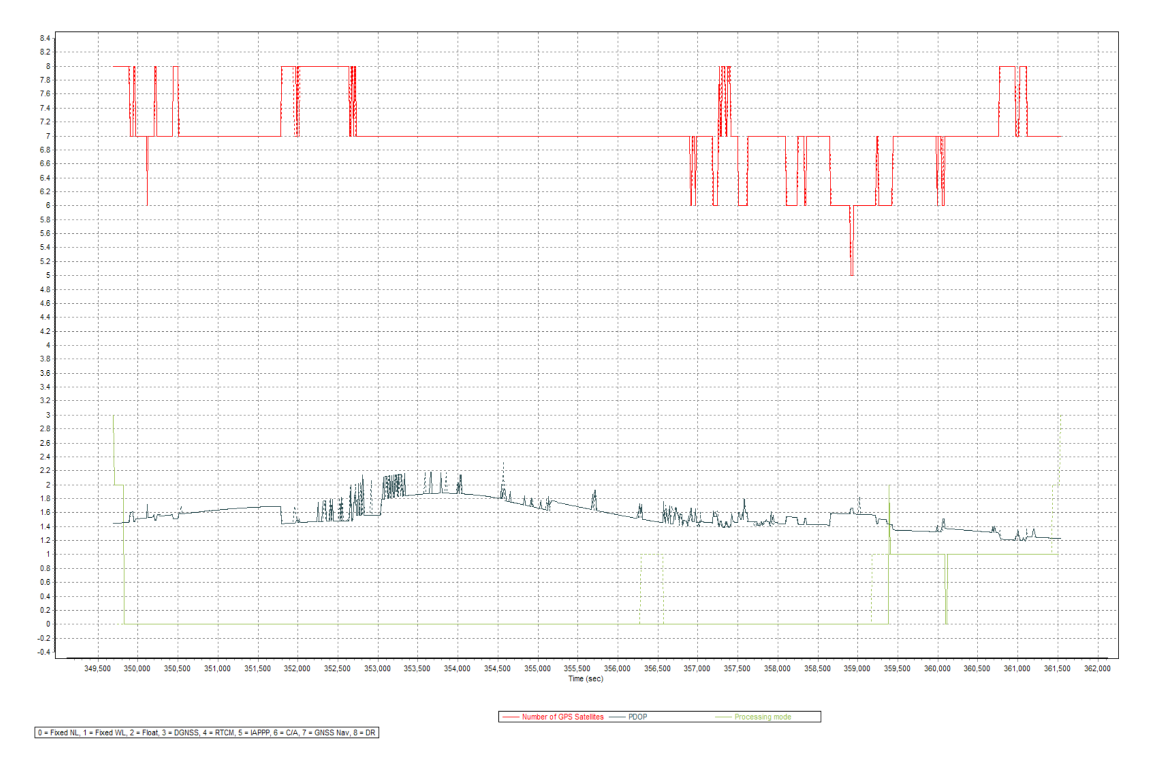


Figure A-8.22. Solution Status

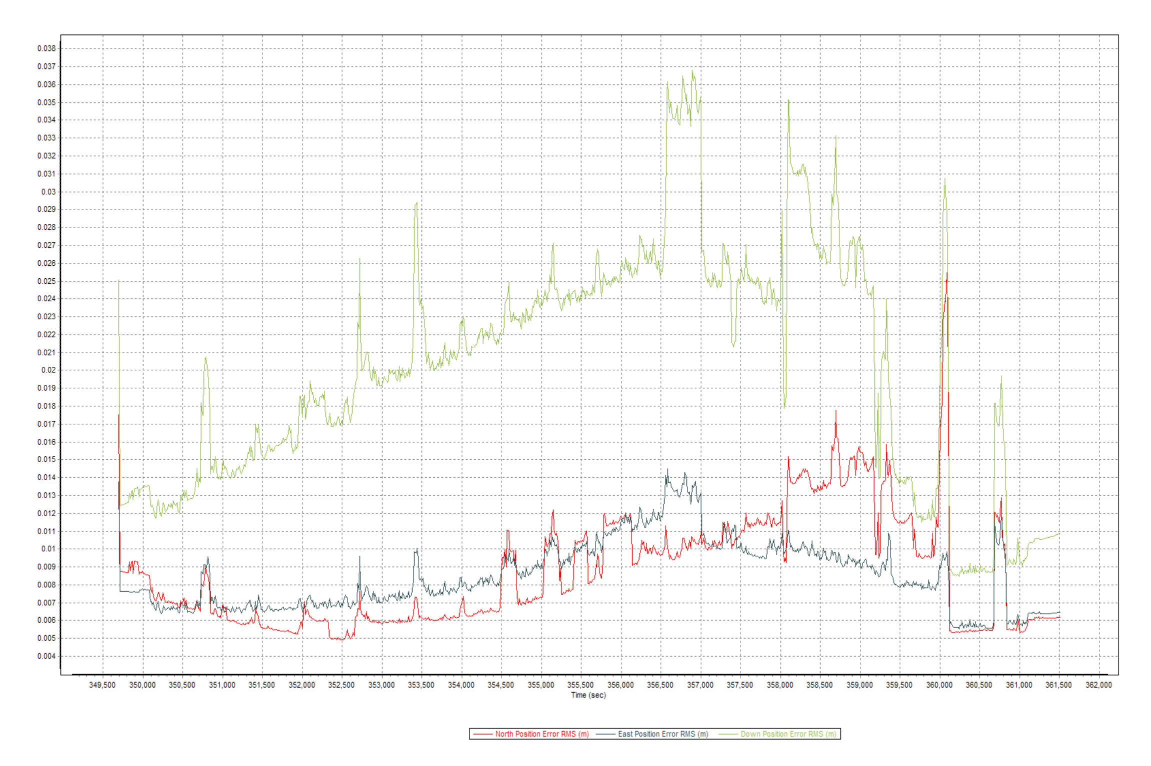


Figure A-8.23. Smoothed Performance Metric Parameters

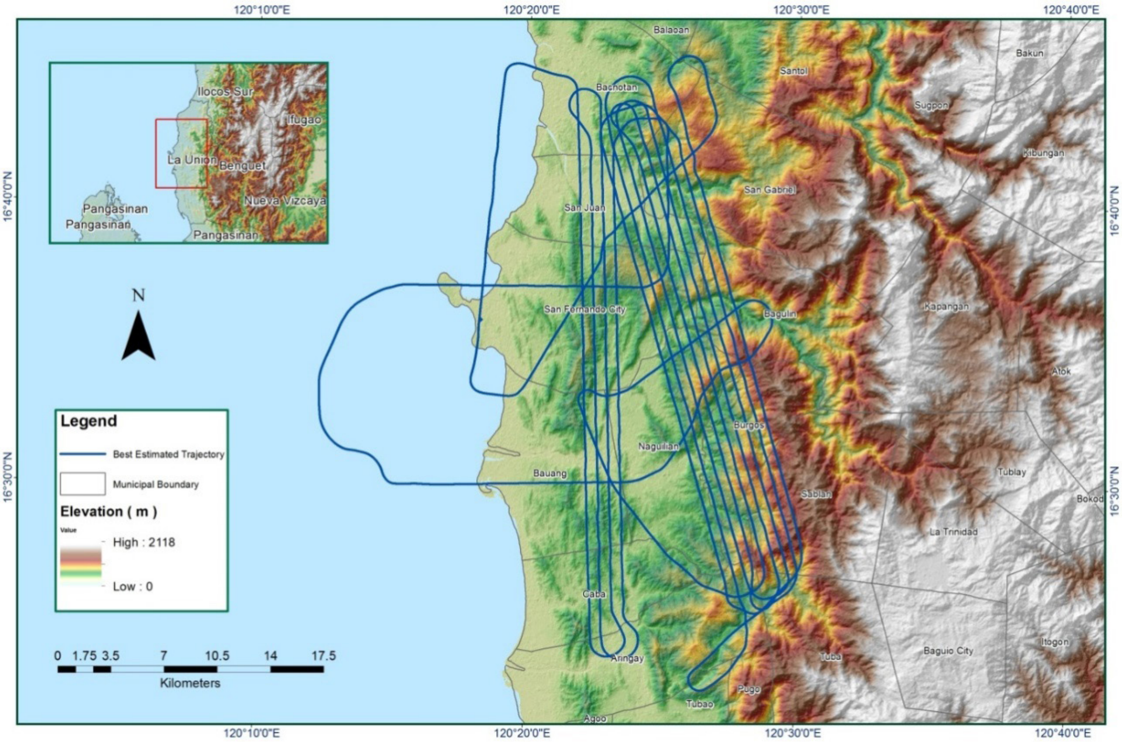


Figure A-8.24. Best Estimated Trajectory

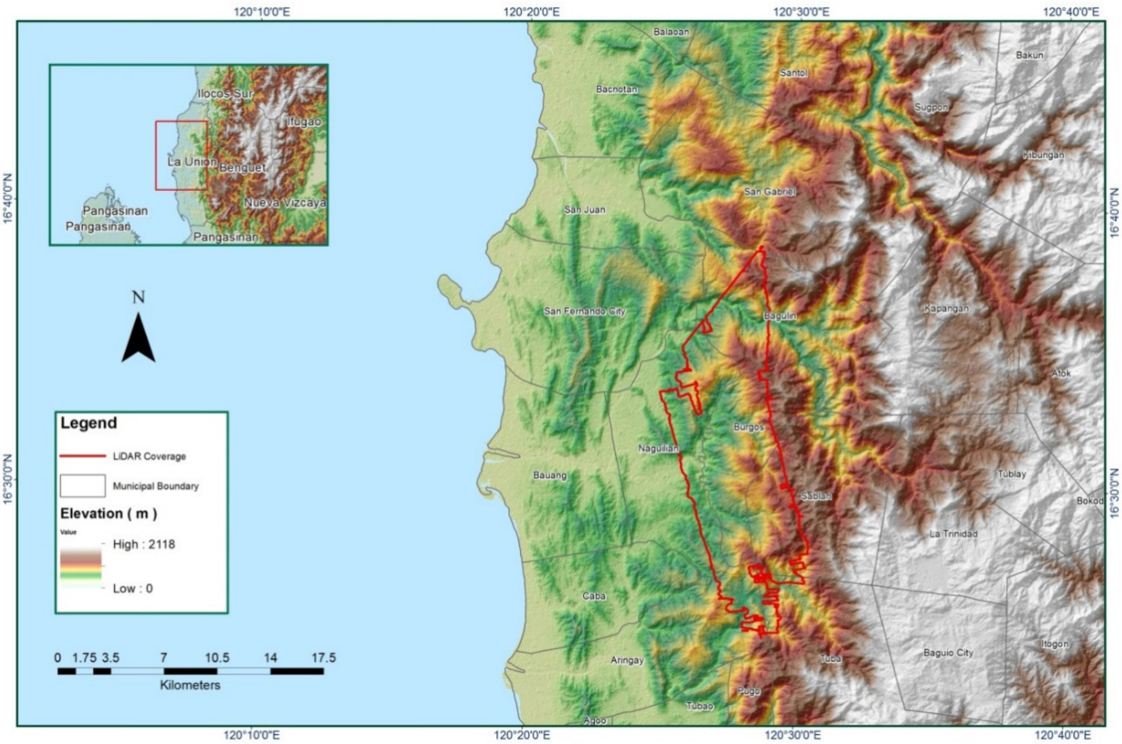


Figure A-8.25. Coverage of LIDAR data

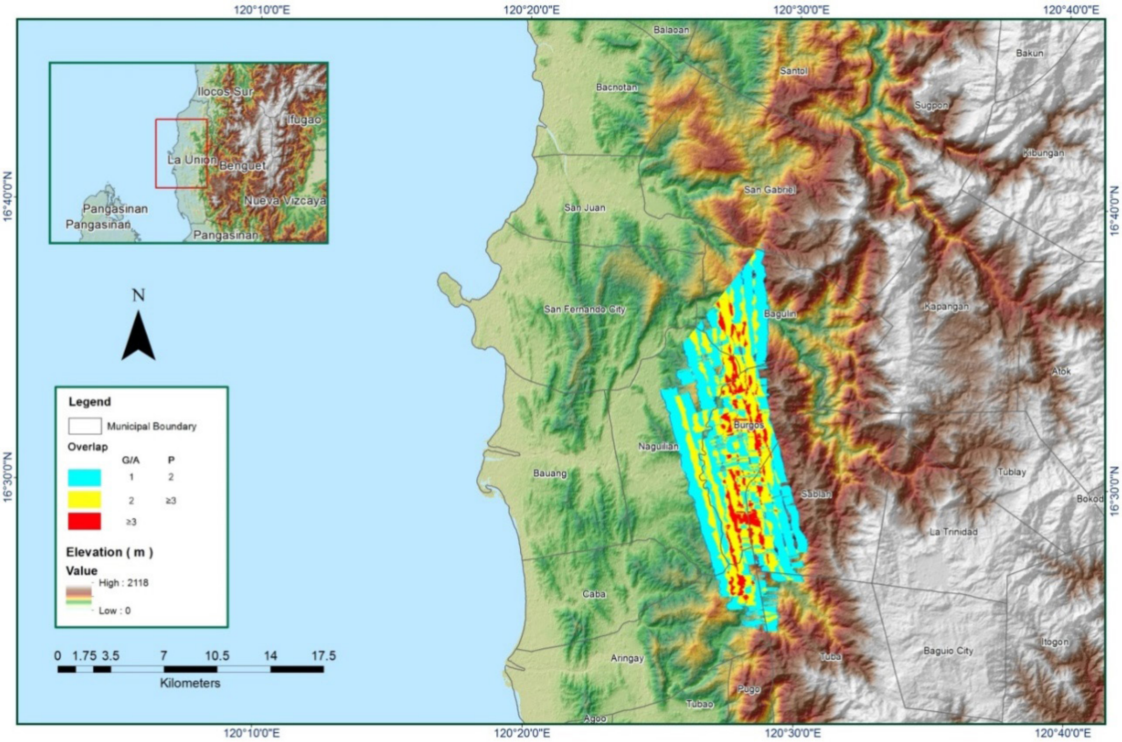


Figure A-8.26. Image of Data Overlap

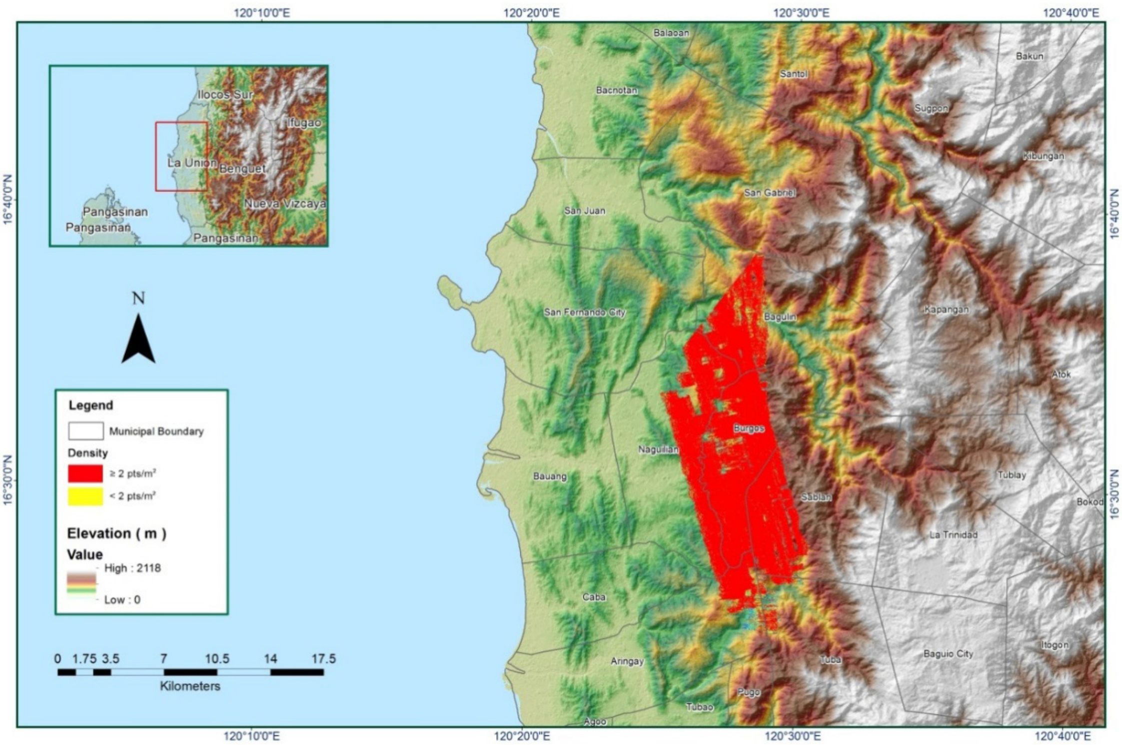


Figure A-8.27. Density map of merged LIDAR data

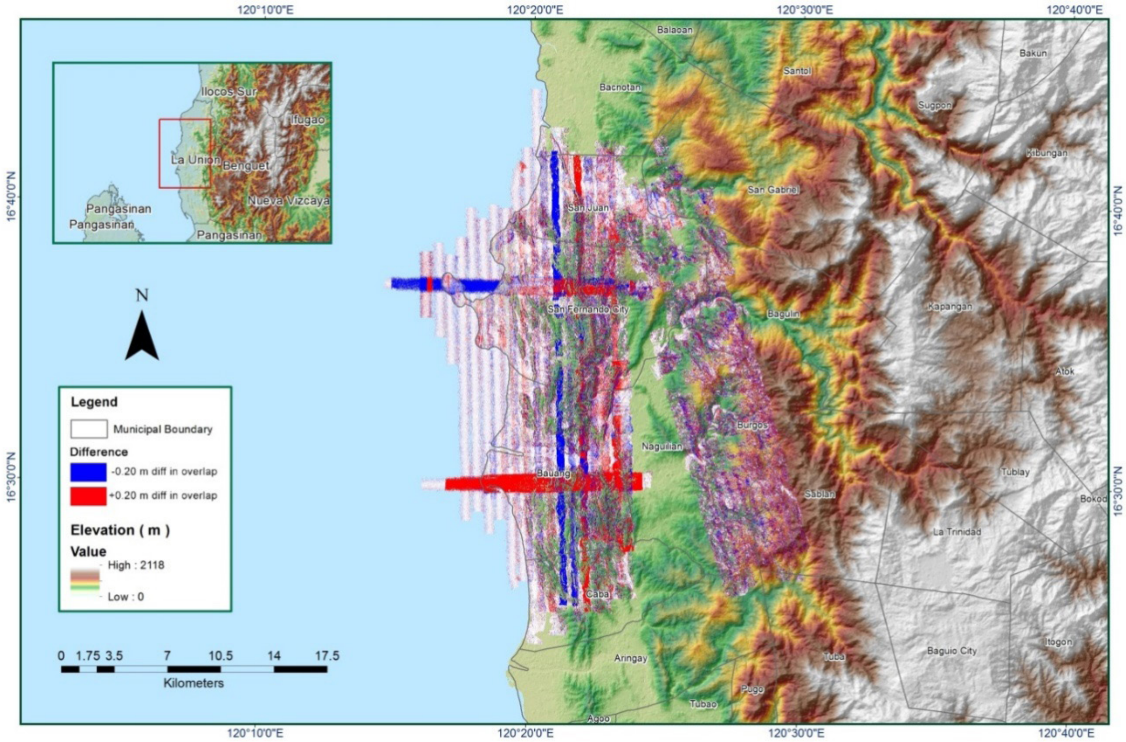


Figure A-8.28. Elevation difference between flight lines

Annex 9. Bauang Model Basin Parameters

Table A-9.1. Bauang Model Basin Parameters

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (cms)	Recession Constant	Threshold Type	Ratio to Peak
W1000	426.92	52.5	0	4.1347	2.9943	Discharge	0.7729	0.77141	Ratio to Peak	0.22199
W1010	397.91	52.5	0	2.4364	3.9763	Discharge	0.39896	0.94681	Ratio to Peak	0.23
W1020	365.77	51.45	0	3.1982	3.4949	Discharge	1.1178	0.96345	Ratio to Peak	0.2254
W1030	424.45	52.937	0	3.6847	6.1081	Discharge	1.4758	0.94909	Ratio to Peak	0.21083
W1040	422.71	52.5	0	4.613	4.9194	Discharge	0.43701	0.65802	Ratio to Peak	0.23329
W1050	386.57	37.083	0	2.3547	3.8404	Discharge	0.68777	0.77301	Ratio to Peak	0.2254
W1060	80.855	89.497	0	1.346	0.38687	Discharge	0.47027	0.588	Ratio to Peak	0.2116
W1070	348.315	35	0	2.0717	3.3811	Discharge	0.58396	1	Ratio to Peak	0.23
W1080	371.547	35	0	1.6096	2.6268	Discharge	0.42883	1	Ratio to Peak	0.23
W1090	11.847	40.82	0	4.1982	1.4944	Discharge	0.54568	0.59058	Ratio to Peak	0.33222
W1100	398.75	40.467	0	0.22153	2.8015	Discharge	0.10226	1	Ratio to Peak	0.15253
W1120	45.094	46.789	0	3.4107	2.1217	Discharge	0.98428	1	Ratio to Peak	0.15114
W1130	14.703	59.922	0	0.82372	1.1766	Discharge	0.51775	0.98	Ratio to Peak	0.3153
W1140	8.8367	66.58	0	3.1129	2.3757	Discharge	0.48839	1	Ratio to Peak	0.21108
W1160	111.0417	49.21112	0	1.4997	2.4475	Discharge	0.41147	1	Ratio to Peak	0.23
W1170	98.063	43.473	0	0.23392	0.2545	Discharge	0.79974	0.90616	Ratio to Peak	0.22173
Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (cms)	Recession Constant	Threshold Type	Ratio to Peak
W1210	292.9839	36.63786	0	2.2628	3.6929	Discharge	0.45951	1	Ratio to Peak	0.23

W1220	279.4011	37.35	0	1.6872	2.7535	Discharge	0.41506	1	Ratio to Peak	0.23
W1260	193.63	35	0	0.29194	3.5736	Discharge	0.036556	1	Ratio to Peak	0.15177
W1270	127.75	35	0	2.829	10.647	Discharge	0.49971	1	Ratio to Peak	0.22213
W580	370.1	52.5	0	4.0786	6.6563	Discharge	1.5918	1	Ratio to Peak	0.23
W590	454.01	52.5	0	1.6185	2.6414	Discharge	0.45151	1	Ratio to Peak	0.23
W600	109.9824	49.31009	0	1.7339	2.8298	Discharge	0.62745	1	Ratio to Peak	0.23
W610	174	40.336	0	9.1514	5.4524	Discharge	2.7478	1	Ratio to Peak	0.21316
W620	454.01	52.5	0	1.6993	2.7733	Discharge	0.18684	1	Ratio to Peak	0.23
W630	402.9	52.5	0	3.0562	4.9877	Discharge	1.0706	1	Ratio to Peak	0.23
W640	194.56	56.611	0	3.3964	3.7105	Discharge	1.2108	1	Ratio to Peak	0.15559
W650	453.68	52.5	0	2.0404	3.3299	Discharge	0.19391	1	Ratio to Peak	0.23
W660	155.0109	45.4425	0	2.2775	3.7168	Discharge	0.64257	1	Ratio to Peak	0.23
W670	132.6072	47.28759	0	2.8886	4.7142	Discharge	0.95227	1	Ratio to Peak	0.23
W680	454.01	52.5	0	0.77019	1.257	Discharge	0.065698	1	Ratio to Peak	0.23
W690	217.21	60.047	0	1.4745	8.0759	Discharge	0.48623	1	Ratio to Peak	0.15638
W710	366.99	52.5	0	3.494	5.7022	Discharge	1.0211	1	Ratio to Peak	0.23
W720	416.26	52.5	0	6.1889	10.1	Discharge	2.7377	0.79105	Ratio to Peak	0.23
Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (cms)	Recession Constant	Threshold Type	Ratio to Peak
W730	95.2248	50.72504	0	2.4122	3.9367	Discharge	1.346	1	Ratio to Peak	0.23
W740	399.37	52.5	0	4.2002	6.8547	Discharge	1.4536	1	Ratio to Peak	0.23
W750	116.8167	48.68137	0	2.0371	3.3246	Discharge	0.35059	1	Ratio to Peak	0.23
W760	397.29	52.5	0	3.3648	5.4913	Discharge	0.79662	1	Ratio to Peak	0.23
W770	149.7738	45.86082	0	1.4698	2.3987	Discharge	0.76564	1	Ratio to Peak	0.23
W780	150.7935	45.77865	0	3.0714	5.0124	Discharge	1.2696	1	Ratio to Peak	0.23

W790	123.0636	48.11987	0	2.1949	3.582	Discharge	0.70158	1	Ratio to Peak	0.23
W800	152.4369	45.6473	0	1.9466	3.1769	Discharge	0.90735	1	Ratio to Peak	0.23
W810	137.9565	46.83379	0	0.38796	0.63314	Discharge	0.026565	1	Ratio to Peak	0.23
W820	123.8193	48.05327	0	2.466	4.0246	Discharge	0.20348	1	Ratio to Peak	0.23
W840	343.068	35	0	2.2556	3.6811	Discharge	0.43307	1	Ratio to Peak	0.23
W850	100.1517	50.24322	0	1.648	2.6895	Discharge	0.48525	1	Ratio to Peak	0.23
W860	351.32	52.5	0	3.2196	5.2543	Discharge	1.2641	1	Ratio to Peak	0.23
W870	167.2275	44.49568	0	0.84319	1.3761	Discharge	0.049354	1	Ratio to Peak	0.23
W880	419.79	52.5	0	2.7753	4.5292	Discharge	1.3093	0.69844	Ratio to Peak	0.23
W890	102.1119	50.0546	0	0.70422	1.1493	Discharge	0.14968	1	Ratio to Peak	0.23
W900	95.8716	50.66092	0	2.8553	4.6599	Discharge	1.1964	1	Ratio to Peak	0.23
W910	45.8106	56.11589	0	1.1987	1.9563	Discharge	0.13839	1	Ratio to Peak	0.23
Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (cms)	Recession Constant	Threshold Type	Ratio to Peak
W920	85.5591	51.69614	0	2.4243	3.9565	Discharge	0.56583	1	Ratio to Peak	0.23
W930	117.3942	48.62846	0	4.1035	6.6969	Discharge	1.5355	1	Ratio to Peak	0.23
W940	84.4404	51.8113	0	0.90625	1.479	Discharge	0.015614	1	Ratio to Peak	0.23
W950	117.3249	48.63468	0	1.8319	2.9897	Discharge	0.59199	1	Ratio to Peak	0.23
W960	175.164	43.90119	0	3.254	5.3105	Discharge	0.83282	1	Ratio to Peak	0.23
W970	338.25	52.5	0	1.7193	2.8059	Discharge	0.14144	1	Ratio to Peak	0.23
W980	129.5217	47.5534	0	1.9726	3.2192	Discharge	0.42932	1	Ratio to Peak	0.23
W990	408.01	52.5	0	1.6798	2.7414	Discharge	0.42102	1	Ratio to Peak	0.23

Annex 10. Bauang Model Reach Parameters

Table A-10.1. Bauang Model Reach Parameters

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
R1190	Automatic Fixed Interval	3354.8	0.004709	0.002321	Trapezoid	406	1
R120	Automatic Fixed Interval	5522.1	0.018676	0.002573	Trapezoid	99	1
R130	Automatic Fixed Interval	2553.2	0.01112	0.004	Trapezoid	201	1
R170	Automatic Fixed Interval	7003.8	0.004856	0.004	Trapezoid	72.6	1
R180	Automatic Fixed Interval	2825	0.004294	0.004	Trapezoid	209	1
R200	Automatic Fixed Interval	672.43	0.005511	0.004	Trapezoid	214	1
R210	Automatic Fixed Interval	6419.1	0.010809	0.002218	Trapezoid	128	1
R220	Automatic Fixed Interval	5997.8	0.030139	0.004	Trapezoid	54	1
R250	Automatic Fixed Interval	1909.4	0.00042	0.004	Trapezoid	319	1
R260	Automatic Fixed Interval	416.98	0.007377	0.004	Trapezoid	90	1
R270	Automatic Fixed Interval	597.9	0.024835	0.004	Trapezoid	540	1
R280	Automatic Fixed Interval	4843.5	0.002694	0.004	Trapezoid	261	1
R290	Automatic Fixed Interval	8260.9	0.007637	0.004	Trapezoid	113	1
R310	Automatic Fixed Interval	1688.7	0.002826	0.004	Trapezoid	375	1
R320	Automatic Fixed Interval	1419.9	0.004629	0.004	Trapezoid	370	1
R350	Automatic Fixed Interval	2503	0.062015	0.00164	Trapezoid	47	1

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
R370	Automatic Fixed Interval	5357.7	0.044187	0.002589	Trapezoid	99	1
R380	Automatic Fixed Interval	1831	0.001279	0.001615	Trapezoid	63	1
R390	Automatic Fixed Interval	3707.4	0.042046	0.045922	Trapezoid	46	1
R400	Automatic Fixed Interval	9143.5	0.001858	0.001289	Trapezoid	201	1
R430	Automatic Fixed Interval	4923.1	0.052421	0.004	Trapezoid	38	1
R440	Automatic Fixed Interval	3380.2	0.047798	0.00251	Trapezoid	34	1
R460	Automatic Fixed Interval	7485.8	0.014169	0.004	Trapezoid	67	1
R50	Automatic Fixed Interval	2644.4	0.021782	0.002535	Trapezoid	72	1
R500	Automatic Fixed Interval	5328.7	0.083476	0.001764	Trapezoid	58	1
R530	Automatic Fixed Interval	1598.9	0.21569	0.001795	Trapezoid	58	1
R540	Automatic Fixed Interval	185.56	0.047255	0.001203	Trapezoid	28	1

R550	Automatic Fixed Interval	4754.6	0.009935	0.000747	Trapezoid	39	1
R60	Automatic Fixed Interval	2313.1	0.027551	0.0001	Trapezoid	63	1
R70	Automatic Fixed Interval	971.54	0.056669	0.004243	Trapezoid	51	1
R90	Automatic Fixed Interval	9905.1	0.008136	0.001732	Trapezoid	301	1

Annex 11. Bauang Field Validation Points

Table A-11.1. Bauang Field Validation Points

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error (m)	Event/Date	Rain Return/ Scenario
	Lat	Long					
1	16.51108	120.32204	0.320	0.305	0.000	Mario/ September 18-22, 2014	5-Year
2	16.503304	120.33216	0.350	0.330	0.000	Mario/ September 18-22, 2014	5-Year
3	16.411791	120.35121	0.280	0.305	0.001	Mario/ September 18-22, 2014	5-Year
4	16.396607	120.34572	0.940	0.914	0.001	Mario/ September 18-22, 2014	5-Year
5	16.51044	120.32898	0.280	0.254	0.001	Mario/ September 18-22, 2014	5-Year
6	16.548766	120.39744	0.340	0.305	0.001	Mario/ September 18-22, 2014	5-Year
7	16.485764	120.32932	0.260	0.305	0.002	Mario/ September 18-22, 2014	5-Year
8	16.511446	120.31343	0.350	0.305	0.002	Mario/ September 18-22, 2014	5-Year
9	16.508774	120.32994	0.300	0.356	0.003	Mario/ September 18-22, 2014	5-Year
10	16.512486	120.32846	0.390	0.330	0.004	Mario/ September 18-22, 2014	5-Year
11	16.498321	120.32491	0.320	0.381	0.004	Mario/ September 18-22, 2014	5-Year
12	16.526291	120.33113	0.230	0.305	0.006	Mario/ September 18-22, 2014	5-Year
13	16.50613	120.31974	0.380	0.305	0.006	Mario/ September 18-22, 2014	5-Year
14	16.552791	120.39646	0.380	0.305	0.006	Mario/ September 18-22, 2014	5-Year
15	16.548769	120.39948	0.330	0.254	0.006	Mario/ September 18-22, 2014	5-Year
16	16.363723	120.3399	0.420	0.305	0.013	Mario/ September 18-22, 2014	5-Year
17	16.511512	120.31418	0.180	0.305	0.016	Mario/ September 18-22, 2014	5-Year
18	16.541629	120.32045	0.380	0.254	0.016	Mario/ September 18-22, 2014	5-Year
19	16.381372	120.35388	0.330	0.457	0.016	Mina/ November 24-27, 2007	5-Year
20	16.538313	120.32686	0.160	0.305	0.021	Mina/ November 24-27, 2007	5-Year
21	16.528534	120.32905	0.140	0.305	0.027	Mario/ September 18-22, 2014	5-Year
22	16.551601	120.39777	0.110	0.279	0.029	Mario/ September 18-22, 2014	5-Year
23	16.512359	120.33145	0.130	0.305	0.031	Mario/ September 18-22, 2014	5-Year
24	16.374575	120.40435	0.480	0.305	0.031	Mario/ September 18-22, 2014	5-Year
25	16.552634	120.39921	0.480	0.305	0.031	Mario/ September 18-22, 2014	5-Year
26	16.35708	120.3417	0.070	0.254	0.034	Mario/ September 18-22, 2014	5-Year
27	16.549322	120.31993	0.070	0.254	0.034	Mario/ September 18-22, 2014	5-Year
28	16.532295	120.33134	0.120	0.305	0.034	Mario/ September 18-22, 2014	5-Year
29	16.509823	120.3314	0.060	0.254	0.038	Mario/ September 18-22, 2014	5-Year
30	16.500438	120.32479	0.100	0.305	0.042	Mario/ September 18-22, 2014	5-Year
31	16.536744	120.32905	0.100	0.305	0.042	Pepeng/ October 2-5, 2009	5-Year
32	16.511306	120.32075	0.460	0.254	0.042	Mario/ September 18-22, 2014	5-Year
33	16.503199	120.33332	0.040	0.254	0.046	Mario/ September 18-22, 2014	5-Year
34	16.491931	120.32937	0.090	0.305	0.046	Mario/ September 18-22, 2014	5-Year
35	16.398289	120.35557	0.080	0.305	0.051	Mario/ September 18-22, 2014	5-Year
36	16.546205	120.32813	0.080	0.305	0.051	Mario/ September 18-22, 2014	5-Year
37	16.552816	120.39804	0.080	0.305	0.051	Mario/ September 18-22, 2014	5-Year
38	16.51094	120.31329	0.480	0.254	0.051	Mario/ September 18-22, 2014	5-Year
39	16.512607	120.31981	0.070	0.305	0.055	Mario/ September 18-22, 2014	5-Year

40	16.534652	120.40393	0.070	0.305	0.055	Mario/ September 18-22, 2014	5-Year
41	16.498986	120.32711	0.600	0.356	0.060	Mario/ September 18-22, 2014	5-Year
42	16.379924	120.35056	0.060	0.305	0.060	Mario/ September 18-22, 2014	5-Year
43	16.392663	120.35501	0.060	0.305	0.060	Mario/ September 18-22, 2014	5-Year
44	16.484272	120.33031	0.060	0.305	0.060	Mario/ September 18-22, 2014	5-Year
45	16.514342	120.33126	0.060	0.305	0.060	Mario/ September 18-22, 2014	5-Year
46	16.508775	120.33435	0.550	0.305	0.060	Mario/ September 18-22, 2014	5-Year
47	16.52886	120.3314	0.050	0.305	0.065	Mario/ September 18-22, 2014	5-Year
48	16.529613	120.32909	0.050	0.305	0.065	Mario/ September 18-22, 2014	5-Year
49	16.539349	120.40664	0.050	0.305	0.065	Mario/ September 18-22, 2014	5-Year
50	16.389155	120.37613	0.040	0.305	0.070	Mario/ September 18-22, 2014	5-Year
51	16.544139	120.3268	0.040	0.305	0.070	Mario/ September 18-22, 2014	5-Year
52	16.363751	120.34257	0.030	0.305	0.076	Mario/ September 18-22, 2014	5-Year
53	16.367221	120.35628	0.030	0.305	0.076	Mario/ September 18-22, 2014	5-Year
54	16.379545	120.35388	0.030	0.305	0.076	Mario/ September 18-22, 2014	5-Year
55	16.389477	120.37707	0.030	0.305	0.076	Mario/ September 18-22, 2014	5-Year
56	16.389855	120.38242	0.030	0.305	0.076	Mario/ September 18-22, 2014	5-Year
57	16.497003	120.32944	0.030	0.305	0.076	Mario/ September 18-22, 2014	5-Year
58	16.500168	120.32509	0.030	0.305	0.076	Mario/ September 18-22, 2014	5-Year
59	16.5318	120.39052	0.030	0.305	0.076	Mario/ September 18-22, 2014	5-Year
60	16.55045	120.39799	0.030	0.305	0.076	Mario/ September 18-22, 2014	5-Year
61	16.563239	120.41443	0.030	0.305	0.076	Mario/ September 18-22, 2014	5-Year
62	16.500193	120.32673	0.580	0.305	0.076	Mario/ September 18-22, 2014	5-Year
63	16.533048	120.40464	0.580	0.305	0.076	Mario/ September 18-22, 2014	5-Year
64	16.498988	120.32563	0.540	0.254	0.082	Mario/ September 18-22, 2014	5-Year
65	16.506502	120.31905	0.540	0.254	0.082	Mario/ September 18-22, 2014	5-Year
66	16.407248	120.33538	1.220	0.914	0.093	Mario/ September 18-22, 2014	5-Year
67	16.50004	120.32586	0.620	0.305	0.099	Mario/ September 18-22, 2014	5-Year
68	16.506142	120.32941	0.030	0.356	0.106	Mario/ September 18-22, 2014	5-Year
69	16.380686	120.35075	0.100	0.457	0.128	Pepeng/ October 2-5, 2009	5-Year
70	16.546513	120.32679	0.670	0.305	0.133	Mario/ September 18-22, 2014	5-Year
71	16.541242	120.3211	0.640	0.254	0.149	Mario/ September 18-22, 2014	5-Year
72	16.50764	120.31845	0.780	0.356	0.180	Mario/ September 18-22, 2014	5-Year
73	16.547416	120.39939	0.720	0.279	0.194	Mario/ September 18-22, 2014	5-Year
74	16.501205	120.3145	0.800	0.356	0.197	Mario/ September 18-22, 2014	5-Year
75	16.363181	120.34163	0.830	0.343	0.237	Mario/ September 18-22, 2014	5-Year
76	16.3881	120.33801	0.950	0.457	0.243	Mario/ September 18-22, 2014	5-Year
77	16.511837	120.31923	0.410	0.914	0.254	Mario/ September 18-22, 2014	5-Year
78	16.385993	120.34569	1.420	0.914	0.256	Pepeng/ October 2-5, 2009	5-Year
79	16.498267	120.3284	0.890	0.356	0.286	Mario/ September 18-22, 2014	5-Year
80	16.40828	120.35338	0.320	0.914	0.353	Mario/ September 18-22, 2014	5-Year
81	16.535374	120.31901	0.910	0.305	0.366	Mario/ September 18-22, 2014	5-Year
82	16.504699	120.33389	0.980	0.356	0.390	Mario/ September 18-22, 2014	5-Year
83	16.549544	120.3224	0.940	0.305	0.403	Mario/ September 18-22, 2014	5-Year
84	16.395854	120.35625	0.270	0.914	0.415	Pepeng/ October 2-5, 2009	5-Year
85	16.508635	120.31907	1.010	0.356	0.428	Mario/ September 18-22, 2014	5-Year

86	16.387309	120.3468	1.580	0.914	0.443	Pepeng/ October 2-5, 2009	5-Year
87	16.386625	120.34401	0.940	0.254	0.471	Mario/ September 18-22, 2014	5-Year
88	16.508008	120.31811	1.000	0.305	0.483	Mario/ September 18-22, 2014	5-Year
89	16.41515	120.3524	0.200	0.914	0.510	Mario/ September 18-22, 2014	5-Year
90	16.544755	120.32596	0.180	0.914	0.539	Pepeng/ October 2-5, 2009	5-Year
91	16.38495	120.35309	0.140	0.914	0.600	Mina/ November 24-27, 2007	5-Year
92	16.417631	120.35279	0.070	0.914	0.713	Mario/ September 18-22, 2014	5-Year
93	16.396743	120.35524	0.060	0.914	0.730	Pepeng/ October 2-5, 2009	5-Year
94	16.532781	120.40024	1.240	0.381	0.738	Mario/ September 18-22, 2014	5-Year
95	16.398415	120.34053	1.790	0.914	0.767	Mina/ November 24-27, 2007	5-Year
96	16.525333	120.33128	0.030	0.914	0.782	Pepeng/ October 2-5, 2009	5-Year
97	16.532616	120.32998	0.030	0.914	0.782	Mina/ November 24-27, 2007	5-Year
98	16.402373	120.3347	1.800	0.914	0.784	Mario/ September 18-22, 2014	5-Year
99	16.506263	120.33103	1.150	0.254	0.803	Mario/ September 18-22, 2014	5-Year
100	16.387464	120.34045	1.260	0.356	0.818	Mario/ September 18-22, 2014	5-Year
101	16.387612	120.34138	1.210	0.305	0.819	Mario/ September 18-22, 2014	5-Year
102	16.386583	120.34326	1.320	0.305	1.031	Mario/ September 18-22, 2014	5-Year
103	16.398986	120.33992	1.940	0.914	1.052	Mina/ November 24-27, 2007	5-Year
104	16.544506	120.32059	1.350	0.305	1.092	Pepeng/ October 2-5, 2009	5-Year
105	16.357738	120.34087	1.420	0.254	1.360	Mario/ September 18-22, 2014	5-Year
106	16.514998	120.32929	0.050	1.219	1.367	Typhoon Juan (Oct. 17-20, 2010)	5-Year
107	16.409695	120.33635	1.540	0.305	1.526	Mario/ September 18-22, 2014	5-Year
108	16.5081	120.31136	1.580	0.305	1.626	Mario/ September 18-22, 2014	5-Year
109	16.398624	120.34122	1.590	0.305	1.652	Mario/ September 18-22, 2014	5-Year
110	16.39964	120.39538	1.600	0.305	1.678	Mario/ September 18-22, 2014	5-Year
111	16.52629	120.32139	2.210	0.914	1.679	Mina/ November 24-27, 2007	5-Year
112	16.387525	120.3477	1.810	0.457	1.830	Pepeng/ October 2-5, 2009	5-Year
113	16.506114	120.31121	1.660	0.305	1.837	Mario/ September 18-22, 2014	5-Year
114	16.39361	120.35221	1.670	0.305	1.864	Mario/ September 18-22, 2014	5-Year
115	16.368146	120.3421	1.710	0.305	1.975	Mario/ September 18-22, 2014	5-Year
116	16.543112	120.39797	1.660	0.254	1.977	Mario/ September 18-22, 2014	5-Year
117	16.506098	120.31162	1.730	0.305	2.031	Mario/ September 18-22, 2014	5-Year
118	16.370944	120.34115	1.750	0.305	2.089	Mario/ September 18-22, 2014	5-Year
119	16.370107	120.34211	1.800	0.305	2.236	Mario/ September 18-22, 2014	5-Year
120	16.397804	120.34191	1.760	0.254	2.268	Mario/ September 18-22, 2014	5-Year
121	16.529418	120.32595	1.850	0.305	2.388	Pepeng/ October 2-5, 2009	5-Year
122	16.548582	120.40037	1.900	0.254	2.709	Mario/ September 18-22, 2014	5-Year
123	16.38788	120.34858	1.960	0.305	2.740	Mario/ September 18-22, 2014	5-Year
124	16.398618	120.34218	2.150	0.457	2.866	Mina/ November 24-27, 2007	5-Year
125	16.50843	120.31122	1.980	0.254	2.979	Mario/ September 18-22, 2014	5-Year
126	16.401535	120.39411	2.720	0.914	3.260	Mario/ September 18-22, 2014	5-Year
127	16.548289	120.32095	2.170	0.356	3.292	Mario/ September 18-22, 2014	5-Year
128	16.526032	120.3199	2.070	0.254	3.298	Lawin/ October 18-22, 2016	5-Year
129	16.526105	120.3267	2.170	0.305	3.479	Mario/ September 18-22, 2014	5-Year
130	16.55314	120.32169	2.190	0.305	3.554	Mario/ September 18-22, 2014	5-Year

131	16.542177	120.3981	2.190	0.254	3.748	Mario/ September 18-22, 2014	5-Year
132	16.53452	120.40075	2.250	0.305	3.784	Mario/ September 18-22, 2014	5-Year
133	16.52746	120.32172	2.200	0.254	3.787	Typhoon Juan (Oct. 17-20, 2010)	5-Year
134	16.523961	120.32862	2.310	0.305	4.021	Mina/ November 24-27, 2007	5-Year
135	16.524765	120.32802	2.440	0.305	4.559	Mario/ September 18-22, 2014	5-Year
136	16.542988	120.3914	2.620	0.305	5.360	Mario/ September 18-22, 2014	5-Year
137	16.531262	120.39277	2.890	0.254	6.948	Mario/ September 18-22, 2014	5-Year
138	16.547687	120.39322	3.060	0.305	7.591	Mario/ September 18-22, 2014	5-Year
139	16.541131	120.39754	3.270	0.381	8.346	Mario/ September 18-22, 2014	5-Year
140	16.540895	120.39223	3.330	0.279	9.306	Mario/ September 18-22, 2014	5-Year
141	16.545858	120.39097	3.440	0.279	9.989	Mario/ September 18-22, 2014	5-Year
142	16.522614	120.38573	3.500	0.305	10.209	Mario/ September 18-22, 2014	5-Year
143	16.529913	120.39351	3.500	0.305	10.209	Mario/ September 18-22, 2014	5-Year
144	16.528049	120.38279	3.590	0.305	10.793	Mario/ September 18-22, 2014	5-Year
145	16.363453	120.40046	3.760	0.343	11.677	Mario/ September 18-22, 2014	5-Year
146	16.528985	120.38422	3.890	0.343	12.582	Mario/ September 18-22, 2014	5-Year
147	16.382054	120.40334	3.860	0.305	12.639	Mario/ September 18-22, 2014	5-Year
148	16.400218	120.39443	3.960	0.305	13.360	Mario/ September 18-22, 2014	5-Year
149	16.526364	120.38147	3.960	0.305	13.360	Mario/ September 18-22, 2014	5-Year
150	16.540155	120.39747	3.980	0.305	13.507	Mario/ September 18-22, 2014	5-Year
151	16.527021	120.38266	3.990	0.254	13.958	Mario/ September 18-22, 2014	5-Year
152	16.525947	120.38288	4.010	0.267	14.012	Mario/ September 18-22, 2014	5-Year
153	16.539322	120.39334	4.000	0.254	14.033	Mario/ September 18-22, 2014	5-Year
154	16.531348	120.39426	4.090	0.343	14.041	Mario/ September 18-22, 2014	5-Year
155	16.384447	120.4039	4.190	0.381	14.508	Mario/ September 18-22, 2014	5-Year
156	16.524397	120.38144	4.150	0.254	15.179	Mario/ September 18-22, 2014	5-Year
157	16.531442	120.39563	4.150	0.254	15.179	Mario/ September 18-22, 2014	5-Year
158	16.53285	120.39861	4.250	0.330	15.365	Mario/ September 18-22, 2014	5-Year
159	16.400822	120.39291	4.250	0.305	15.565	Mario/ September 18-22, 2014	5-Year
160	16.532553	120.39306	4.090	0.127	15.705	Mario/ September 18-22, 2014	5-Year
161	16.535291	120.39319	4.260	0.254	16.048	Mario/ September 18-22, 2014	5-Year
162	16.533592	120.39377	4.390	0.381	16.072	Mario/ September 18-22, 2014	5-Year
163	16.534631	120.39228	4.350	0.330	16.159	Mario/ September 18-22, 2014	5-Year
164	16.537782	120.39651	4.360	0.330	16.239	Mario/ September 18-22, 2014	5-Year
165	16.365543	120.39929	4.440	0.381	16.475	Mario/ September 18-22, 2014	5-Year
166	16.537606	120.39402	4.320	0.254	16.532	Mario/ September 18-22, 2014	5-Year
167	16.535123	120.39479	4.410	0.305	16.853	Mario/ September 18-22, 2014	5-Year
168	16.380699	120.40287	4.380	0.267	16.919	Mario/ September 18-22, 2014	5-Year
169	16.533858	120.38846	4.470	0.305	17.349	Mario/ September 18-22, 2014	5-Year
170	16.387019	120.40165	4.490	0.305	17.516	Mario/ September 18-22, 2014	5-Year
171	16.574923	120.41091	4.450	0.254	17.606	Mario/ September 18-22, 2014	5-Year
172	16.537365	120.39082	4.530	0.305	17.852	Mario/ September 18-22, 2014	5-Year
173	16.384314	120.40273	4.600	0.343	18.123	Mario/ September 18-22, 2014	5-Year
174	16.538683	120.3924	4.440	0.127	18.602	Mario/ September 18-22, 2014	5-Year
175	16.537209	120.39673	4.690	0.305	19.230	Mario/ September 18-22, 2014	5-Year

176	16.531553	120.39679	4.790	0.305	20.117	Mario/ September 18-22, 2014	5-Year
177	16.528943	120.39297	4.980	0.203	22.818	Mario/ September 18-22, 2014	5-Year
178	16.53591	120.39814	5.170	0.381	22.935	Mario/ September 18-22, 2014	5-Year
179	16.536062	120.39717	5.310	0.254	25.563	Mario/ September 18-22, 2014	5-Year
180	16.532305	120.39457	5.400	0.254	26.481	Mario/ September 18-22, 2014	5-Year
181	16.381677	120.40202	5.420	0.229	26.951	Mario/ September 18-22, 2014	5-Year
182	16.524187	120.38059	5.470	0.254	27.207	Mario/ September 18-22, 2014	5-Year
183	16.52671	120.39157	5.770	0.305	29.868	Mario/ September 18-22, 2014	5-Year
184	16.538789	120.38985	6.870	0.229	44.108	Mario/ September 18-22, 2014	5-Year
185	16.580871	120.41054	7.160	0.343	46.473	Mario/ September 18-22, 2014	5-Year
186	16.580175	120.40951	7.230	0.267	48.488	Mario/ September 18-22, 2014	5-Year
187	16.548133	120.41312	7.560	0.330	52.270	Mario/ September 18-22, 2014	5-Year
188	16.545377	120.41473	7.840	0.457	54.506	Mina/ November 24-27, 2007	5-Year
189	16.531125	120.38452	7.700	0.254	55.443	Mario/ September 18-22, 2014	5-Year
190	16.579328	120.4082	7.810	0.305	56.328	Mario/ September 18-22, 2014	5-Year
191	16.571292	120.41033	8.010	0.305	59.370	Mario/ September 18-22, 2014	5-Year
192	16.579912	120.40863	8.250	0.229	64.343	Mario/ September 18-22, 2014	5-Year
193	16.545459	120.4138	8.580	0.305	68.479	Mario/ September 18-22, 2014	5-Year
194	16.580824	120.4057	8.840	0.305	72.850	Mario/ September 18-22, 2014	5-Year
195	16.579739	120.40483	9.160	0.305	78.415	Mario/ September 18-22, 2014	5-Year
196	16.579363	120.40612	9.390	0.305	82.541	Mario/ September 18-22, 2014	5-Year
197	16.563974	120.40191	9.920	0.330	91.964	Mario/ September 18-22, 2014	5-Year
				RMSE	2.971563		

Annex 12. Educational Institutions Affected by Flooding in Bauang Floodplain

Table A-12.1. Educational Institutions Affected by Flooding in the Bauang Floodplain

La Union				
Bagulin				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
BAGULIN CENTRAL ELEMENTARYSCHOOL	Dagup	Medium	High	High
SUYO NATIONAL HIGHSCHOOL	Dagup	High	High	High
Bauang				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
BALLAY COMMUNITYSCHOOL / BALLAY NATIONAL HIGH SCHOOL	Acao	High	High	High
BACCUIT ELEMEMTARYSCHOOL	Baccuit Sur	Medium	High	High
BACCUIT NATIONAL HIGHSCHOOL	Baccuit Sur	Medium	Medium	High
CABARITAN ELEMENTARYSCHOOL	Ballay	High	High	High
BOY-UTAN ELEMENTARYSCHOOL	Boy-Utan	High	High	High
CABALAYANGAN ELEMENTARYSCHOOL	Bucayab			
SUGUIDAN INTEGRATEDSCHOOL	Cabalayangan		Medium	High
CALUMBAYA ELEM.SCHOOL	Calumbaya			
DON EULOGIO MEMORIAL NATIONAL HIGHSCHOOL	Calumbaya			
BAUANG LIBRARY	Central East			
BAUANG NORTH CENTRALSCHOOL	Central East			
SACRED HEARTSCHOOL	Central East			
STS. PETER AND PAUL LEARNING CENTER	Central East			
QUINAVITE ELEMENTARYSCHOOL	Disso-Or			Low
TUBAO CREDIT COOPERATIVE	Disso-Or			Low
YESHUAH THE MESIAH CHRISTIAN ACAD-EMY	Disso-Or			Low
YESHUAH THE MESSIAH CHRISTIAN ACADEMY	Disso-Or		Low	Low
DAY CARE CENTER	Parian Este	Low	Medium	Medium
PARIAN ELEMENTARYSCHOOL	Parian Este	Low	Medium	Medium
PARIAN ESTE ELEMENTARYSCHOOL	Parian Este	Low	Medium	Medium
PUDOK PRIMARYSCHOOL	Parian Este	Low	Medium	Medium
GUERRERO ELEMENTARYSCHOOL	Payocpoc Norte Este			
PAYOCPOC ELEMENTARYSCHOOL	Payocpoc Norte Este		Low	Low
LA UNION COLLEGES OFSCIENCE AND TECHNOLOGY	Pugo	High	High	High
KIDDIE CAMP PLAYSCHOOL	Quinavite			Low

ST. ANTHONY MONTESSORI EDUCATIONAL NETWORK	Quinavite			
SANTIAGO ELEMENTARYSCHOOL	Santiago		Low	Low
BEEHIVE LEARNING CENTER	Taberna	High	High	High
PUGO ELEMENTARYSCHOOL	Taberna	High	High	High
Burgos				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
AGPAY ELEMENTARYSCHOOL	Agpay			
Naguilian				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
EASTERN NAGUILIAN NATIONAL HIGHSCHOOL	Ambaracao Norte			
GUESSET ELEMENTARYSCHOOL	Ambaracao Norte			
GUESSET ELEMENTARYSCHOOL	Ambaracao Norte			
DR. HERMOGGENES BELEN ELEMENTARYSCHOOL	Cabaritan Sur			
GIRLSCOUT OF THE PHILIPPINES REGIONAL OFFICE	Cabaritan Sur	High	High	High
NAGUILIAN DISTRICT OFFICE	Cabaritan Sur	High	High	High
NAGUILIAN ELEMENTARYSCHOOL	Cabaritan Sur	High	High	High
BARIQUIR ELEMENTARYSCHOOL	Casilagan	Low	Medium	High
UNIONSCHOOLS OF LA UNION	Dal-Lipaoen	High	High	High
BARAOAS SUR ELEMENTARYSCHOOL	Daramuangan	High	High	High
CASILAGAN ELEMENTARYSCHOOL	Gusing Sur	High	High	High
LOWER BIMMOTOBOT ELEMENTARYSCHOOL	Mamat-Ing Norte	High	High	High
GUSING ELEMENTARYSCHOOL	Mamat-Ing Sur	High	High	High
GUSING NATIONAL HIGHSCHOOL	Mamat-Ing Sur	High	High	High
TUDDINGAN ELEMENTARYSCHOOL	Mamat-Ing Sur		High	High
NAGUILIAN NATIONAL HIGHSCHOOL	Natividad	High	High	High
BURGOS CENTRALSCHOOL	Sili			
DON TOMAS R. MENDOZA ELEMENTARYSCHOOL	Sili			
HOLY INFANT NINO MONTESSORI	Suguidan Norte	Medium	High	High
BATO ELEMENTARYSCHOOL	Suguidan Sur			
NAGSIDORISAN ELEMENTARYSCHOOL	Suguidan Sur		High	High
San Fernando City				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
MASICONG ELEMENTARYSCHOOL	Birunget		Low	Low
MAMAT-ING SUR ELEMENTARYSCHOOL	Sacyud	High	High	High

Annex 13. Medical Institutions Affected by Flooding in Bauang Floodplain

Table A-13.1. Medical Institutions Affected by Flooding in the Bauang Floodplain

La Union				
Bauang				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
BAUANG RURAL HEALTH UNIT	Central East			
MUNICIPAL HEALTH CENTER	Central East			
GENERIKA DRUG STORE	Quinavite	Low	Low	Low
BARANGAY TABEMA HEALTH CENTER (TL)	Taberna	Medium	High	High
Naguilian				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
NAGUILIAN HEALTH CENTER	Cabaritan Sur	High	High	High
NAGUILIAN DISTRICT HOSPITAL	Suguidan Norte	High	High	High