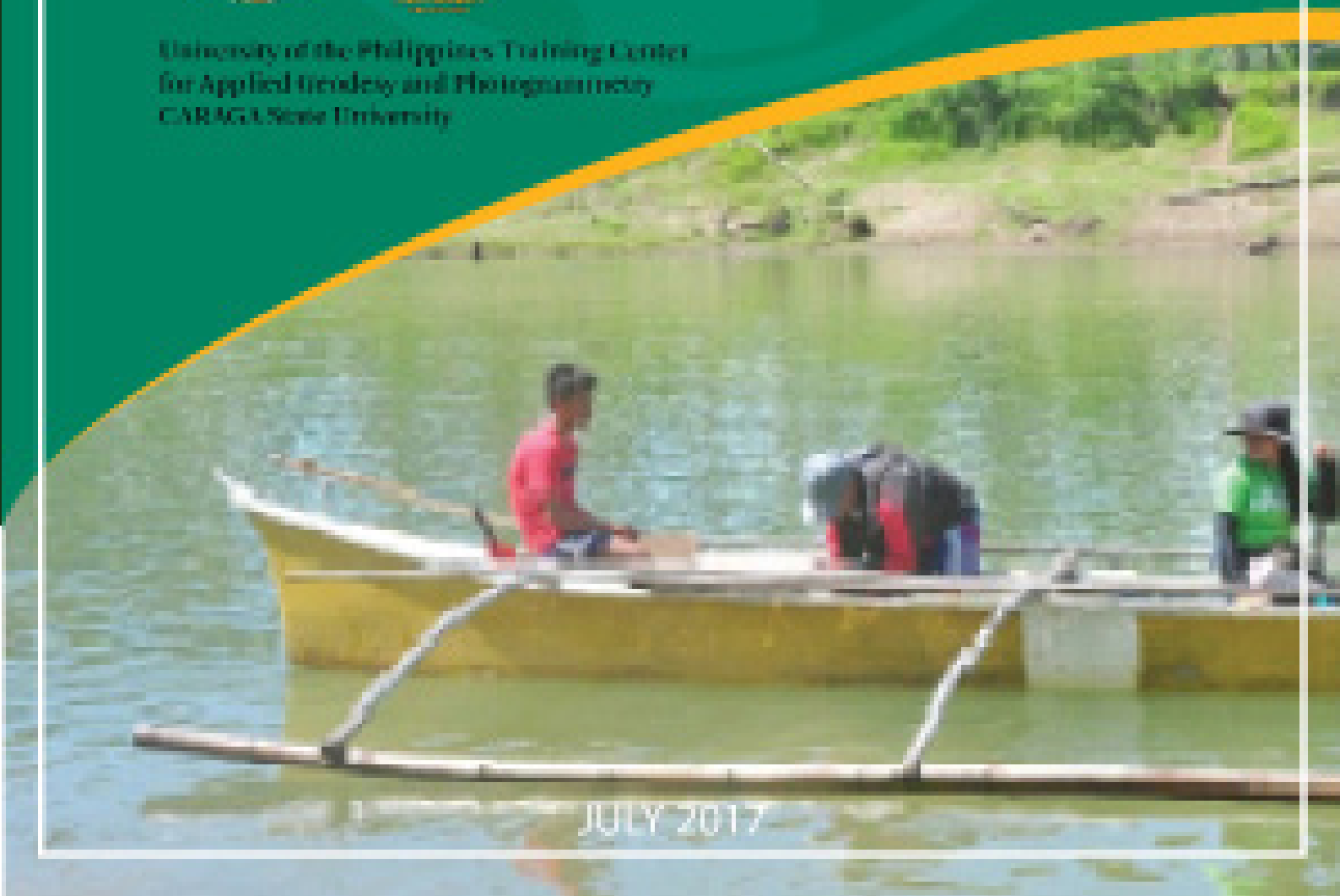
HAZARD MAPPING OF THE PHILIPPINES USING LIDAR (PHIL-LIDAR 1)

LiDAR Surveys and Flood Mapping of Tago River

University of the Philippines Training Center
for Applied Geodesy and Photogrammetry
CARAGA State University



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

Enrico C. Paringit, Dr. Eng., Meriam Makinano-Santillan, Edsel Matt O. Morales, Jojene R. Santillan, and Arthur A. Amora

1.1 Background of the Phil-LIDAR 1 Program

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

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

The implementing partner university for the Phil-LiDAR 1 Program is the Caraga State University (CSU). CSU 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 11 river basins in the CARAGA Region. The university is located in Butuan City in the province of Agusan del Norte.

1.2 Overview of the Tago River Basin

The Tago River Basin is composed of the province of Surigao del Sur and Agusan del Sur in Mindanao. It lies at 125°43' to 126°16' east longitude and 8°44' to 9°11' north latitude. It traverses the municipality of Sibagat of Agusan del Sur and the municipalities of Cantilan, Lanuza, Tandag, San Miguel, Cagwait, and Tago of Surigao del Sur. The basin has an estimated drainage area of 1,448 square kilometers, and is about 50 kilometers long and 60 kilometers wide.

The Tago River is the principal drainageway of the basin. It originates in the City of Cabadbaran, Agusan del Norte and traverses the entire length of the basin in an easterly direction and discharges into the Philippine Sea. The river channel is wide and is navigable by motor boats up to about 45 kilometers from its outlet. Several tributaries, such as Maitum and Umalag Rivers that pass Barangay Poblacion in San Miguel, Surigao del Sur and the Bagyang River which traverses from Barangay Bitaugan down to Barangay Calatngan of the same municipality, contribute directly to the Tago River.

The climate on the basin is usually classified as tropical according to the Köppen-Geiger climate classification in which there is no dry season—all months have an average precipitation value of at least 60 mm (Climate: Surigao del Sur, n.d.). Rainy season occurs from November to March.
The basin's highest point is at 1,611 meters above mean sea level located in Barangay del Pilar, City of Cabadbaran, Agusan del Norte (NAMRIA, n.d.). The most abundant soil type in the river basin based on the soil type maps published by the Department of Agriculture is clay having an area of 1,191 square kilometers which almost covers the entire river basin.

One of the municipalities situated within the basin is Tago, which is in the central part of Surigao del Sur facing the Pacific Ocean. It is bounded by its neighboring cities and municipalities like Tandag City on the north, Municipality of Lanuza on the northwest, San Miguel on the west, the Municipality of Bayabas on the southeast, and the Municipalities of Cagwait and Marihatag on the south. It has a land area of 343.52 square kilometers which takes up 7.55% of the total area of the province and composed of 24 barangays, Cabangahan being the largest and Purisima as the smallest (Tago, Surigao del Sur, n.d.). According to the 2015 Census, Tago has a population of 35,329 people (PSA, 2015).

The basin's economy thrived because of the agriculture and aqua-culture sectors of the Tago Municipality which provide livelihood of its people through farming and selling marine resources such as fish, crabs and prawns. Its eco-tourism is also on its way for a spot in the tourism industry for their Haguisan Kalipayan Hill, which is good for eco-retreats, dining, and various events (Tago, Surigao del Sur, n.d.).

In December 2014, about 20,858 people in Tago were affected by Tropical Storm Seniang. TS Seniang stayed inside the Philippine Area of Responsibility for four days from December 28 to 31. It made landfall over Hinatuan, Surigao del Sur, then tracked across Visayas and weakened into Tropical Depression (NDRRMC, 2014).

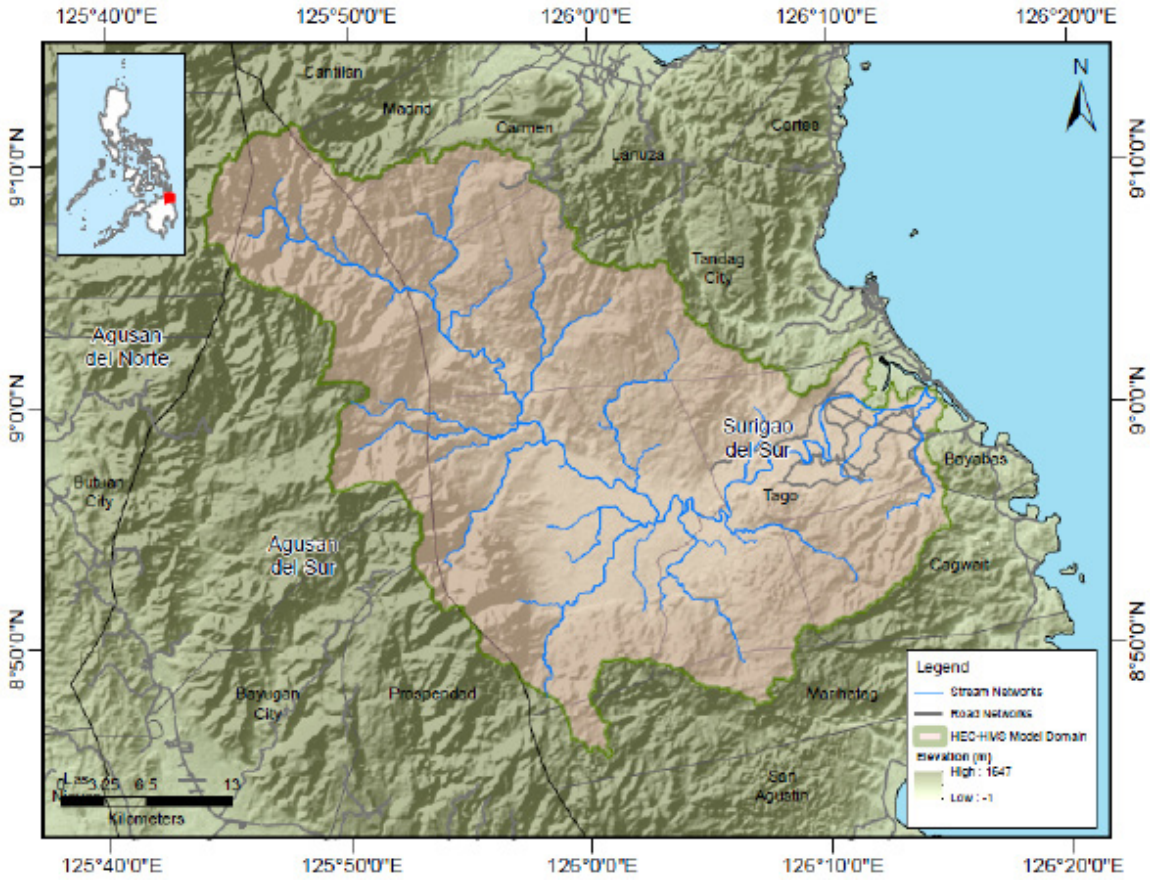

Figure 1. Map of the Tago River Basin (in brown)

CHAPTER 2: LIDAR DATA ACQUISITION OF THE TAGO FLOODPLAIN

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

2.1 Flight Plans

Plans were made to acquire LiDAR data within the delineated priority area for Tago Floodplain in Surigao del Sur. These missions were planned for 14 lines that run for at most four and a half (4.5) hours including take-off, landing, and turning time. The flight planning parameters for the LiDAR system are found in Table 1 and Table 2. Figure 2 shows the flight plan for Tago Floodplain survey.

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Table 1. Flight planning parameters for Aquarius LiDAR System

Block Name	Flying Height (m AGL)	Overlap (%)	Max Field of View (θ)	Pulse Repetition Frequency (PRF) (kHz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
BLK61A	500	25,50,60	36	50	45	120	5
BLK61B	500,600	60	36	50	45	120	5
BLK61C	600	60	36	50	45	120	5
BLK61D	600	60,65	36	50	45	120	5
BLK61E	600	25,35,40,45	36	50	45	120	5
BLK61F	600	70	36	50	45	120	5
BLK61G	600	25,35,45,70	36	50	45	120	5
BLK61H	600	60,65,70	36	50	45	120	5
BLK61I	600	40,45,60,65	36	50	45	120	5
BLK61J	600	70	36	50	45	120	5
BLK61K	500,600	60,70	36	50	45	120	5
BLK61L	600	65	36	50	45	120	5
BLK61M	500,600	70	36	50	45	120	5
BLK61N	600	70	36	50	45	120	5

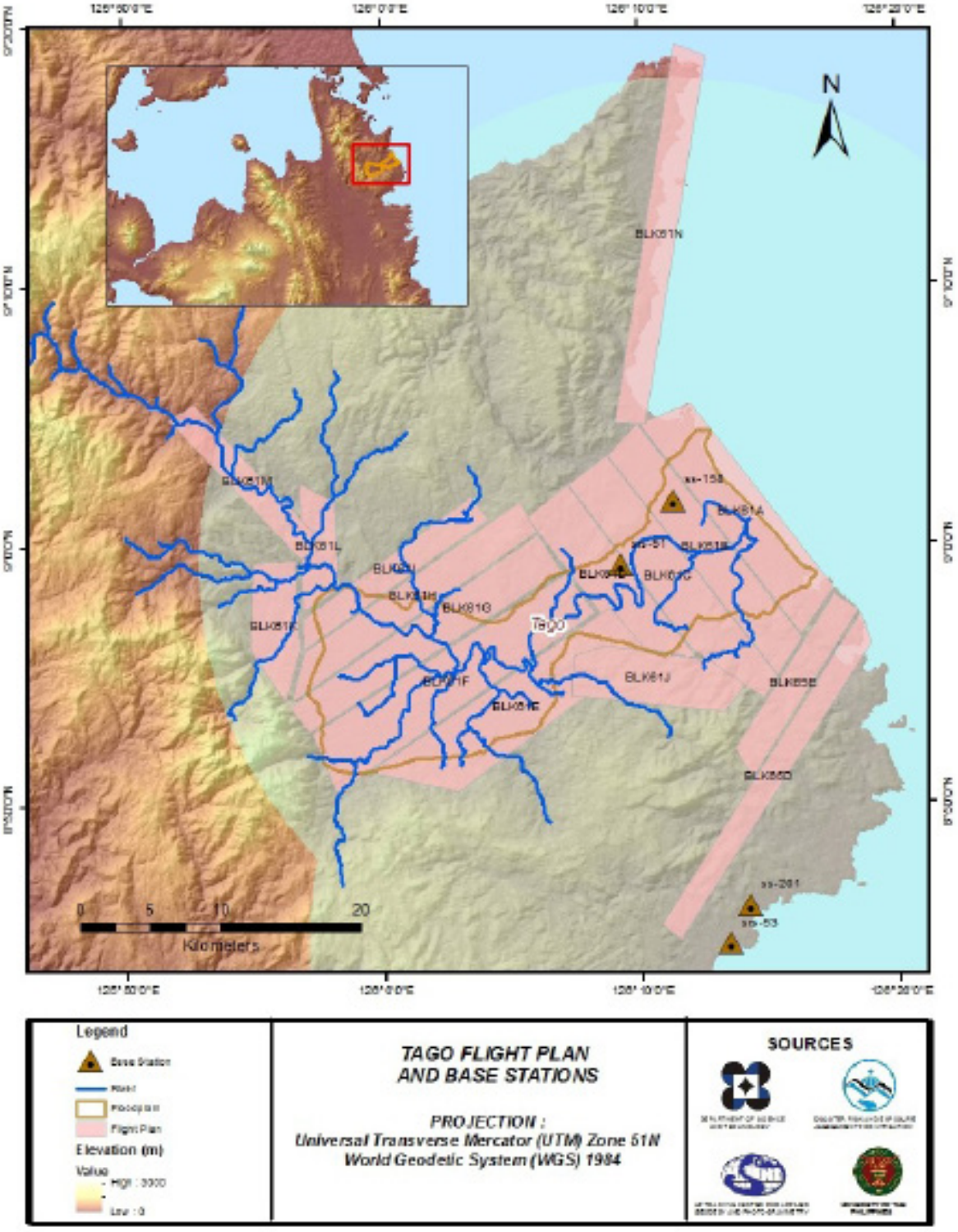


Figure 2. Flight plan and base stations used to cover Tago Floodplain

2.2 Ground Base Station

The project team was able to recover two (2) NAMRIA ground control points: SRS-51 and SRS-53 which are of second (2nd)-order accuracy and two (2) NAMRIA benchmarks, BMSS-158 and BMSS-201. These benchmarks were used as vertical reference points and were also established as ground control points.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 points were used as base stations during flight operations for the entire duration of the survey (July 5–29, 2014). Base stations were observed using dual frequency GPS receivers, TRIMBLE SPS 852 and SPS 985. The flight plans and location of base stations used during the aerial LiDAR acquisition in Tago Floodplain are shown in Figure 2.

Figure 3 to Figure 6 show the recovered NAMRIA reference points within the area. Table 2 to Table 5 summarize the details about the following NAMRIA control stations and established points, while Table 6 shows the list of all ground control points occupied during the acquisition with the corresponding dates of utilization.

(a) (b)

Figure 3. GPS set-up over BMSS-158 located at Batang Bridge in Brgy. Dayo-an, Surigao del Sur (a) and NAMRIA reference point SM-286 (b) as recovered by the field team

Table 2. Details of the recovered NAMRIA benchmark BMSS-158 used as base station for the LiDAR acquisition with established coordinates

Station Name	SS-158	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1:50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	9°01'43.29494" North 126°11'10.19014" East 1.842 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	850353.357 meters 999491.438 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	9°01'39.70405" North 126°11'15.53082" East 76.97 meters

(a) (b)

Figure 4. GPS set-up over SRS-51 recovered inside the compound of the barangay hall, beside the basketball court in Brgy. Bajao, Tandag, Surigao del Sur (a) and NAMRIA reference point SMR-33 (b) as recovered by the field team

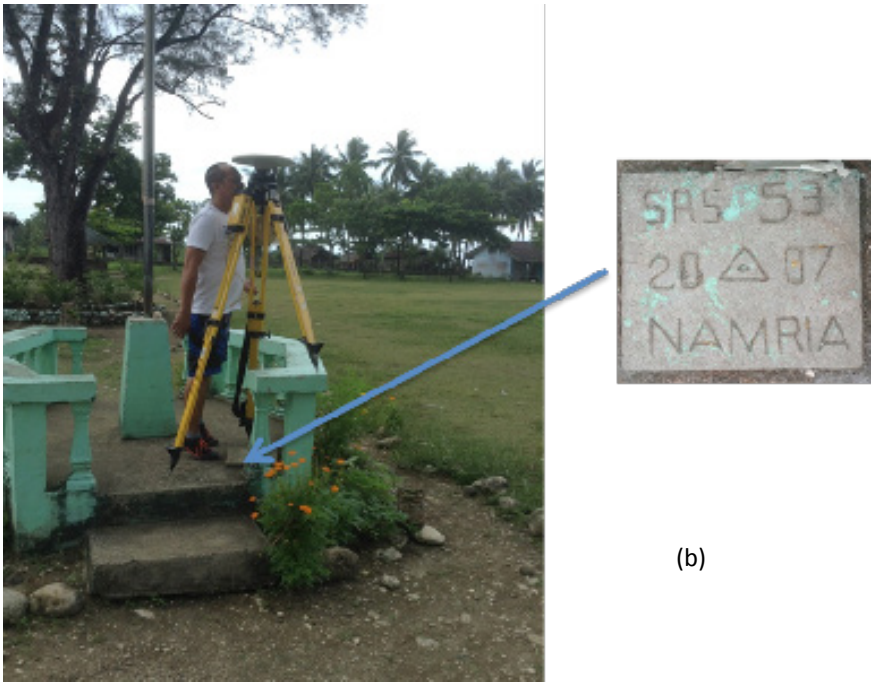
Table 3. Table 3. Details of the recovered NAMRIA horizontal control point SRS-51 used as base station for the LiDAR acquisition

Station Name	SRS-51	
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	8° 59' 14.14996" North 126° 9' 6.83415" East 3.97000 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	406741.509 meters 99387.182 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	8°59' 10.56678" North 126° 9' 12.17833" East 74.22300 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS92)	Easting Northing	186815.64 meters 994598.26 meters

Figure 5. GPS set-up over BMSS-201 located in Sto. Nino Bridge in San Agustin, Surigao del Sur (a) and NAMRIA reference point SM-201 (b) as recovered by the field team

Table 4. Details of the recovered NAMRIA benchmark BMSS-201 used as base station for the LiDAR acquisition with established coordinates

Station Name	BMSS-201	
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	8°46'03.02195" North 126°14'07.03352" East 72.180 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	856009.096 meters 970681.752 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	8°46'03.02195" North 126°14'07.03352" East 72.180 meters



(a) (b)

Figure 6. GPS set-up over SRS-53 located in the NE corner of the flagpole of San Agustin Central Elementary School in Brgy. San Agustin, Surigao del Sur (a) and NAMRIA reference point SMR-53 (b) as recovered by the field team

Table 5. Details of the recovered NAMRIA horizontal control point SRS-53 used as base station for the LiDAR acquisition

Station Name	SRS-53	
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	8° 44' 37.87784" North 126° 13' 16.64511" East -1.34900 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	414316.026 meters 966899.682 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	8° 44' 34.36515" North 126° 13' 22.01039" East 69.59300 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 92)	Easting Northing	194250.44 meters 967600.49 meters

Table 6. Ground control points used during LiDAR data acquisition

Date Surveyed	Flight Number	Mission Name	Ground Control Points
July 5, 2014	**1664A**	**3BLK61A186A**	**BMSS-158, SRS-51**
July 6, 2014	1666A	3BLK61ASB187A	BMSS-158, SRS-51
July 7, 2014	1670A	3BLK61BSC188A	BMSS-158, SRS-51
July 8, 2014	1674A	3BLK61CSD189A	BMSS-158, SRS-51
July 9, 2014	1678A	3BLK61DSG190A	BMSS-158, SRS-51
July 10, 2014	1682A	3BLK61GSE191A	BMSS-158, SRS-51
July 10, 2014	1684A	3BLK61E191B	BMSS-158, SRS-51
July 11, 2014	1686A	3BLK61ESHI192A	BMSS-158, SRS-51
July 12, 2014	1690A	3BLK61IS193A, 3BLK65E193A	BMSS-158, SRS-51
July 13, 2014	1694	3BLK65ES194A	BMSS-201, SRS-53
July 22, 2014	1732A	3LMSCALIB203B & 3BLK61J203B	BMSS-158, BMSS-201, SRS-51, SRS-53
July 23, 2014	1736A	3BLK61JS204B	BMSS-158, BMSS-201, SRS-51, SRS-53
July 23, 2014	1742A	3BLK61K206A, 3BLK61BCDES206A	BMSS-201, SRS-51
July 27, 2014	1750A	3BLK61L208A	BMSS-158, SRS-51
July 27, 2014	1752A	3BLK61L208B	BMSS-158, SRS-51
July 28, 2014	1754A	3BLK61KSM209A	BMSS-158, SRS-51
July 29, 2014	1758A	3BLK61FGHKMSN210A	BMSS-158, SRS-51

2.3 Flight Missions

Seventeen (17) missions were conducted complete the LiDAR Data Acquisition in Tago Floodplain, for a total of sixty hours and forty-two minutes (60+42) for RP-C9122. All missions were acquired using the Aquarius LiDAR system. Table 7 shows the total area of actual coverage per mission and the corresponding flying hours per mission, while Table 8 shows the actual parameters used during the LiDAR data acquisition.

Table 7. Flight missions for LiDAR data acquisition in Tago Floodplain

Date Surveyed	Flight Number	Flight Plan Area (km^2)	Surveyed Area (km^2)	Area Surveyed within the Floodplain (km^2)	Area Surveyed Outside the Floodplain (km^2)	No. of Images (Frames)	Flying Hours	
							Hr	Min
5 JULY 14	1664A	68	31.10	7.19	23.91	365	1	59
6 JULY 14	1666A	134.478	82.44	45.91	36.52	704	4	88
7 JULY 14	1670A	131.649	96.81	41.05	55.76	428	4	5
8 JULY 14	1674A	115.94	93.17	40.27	52.90	393	4	23
9 JULY 14	1678A	102.348	88.48	51.57	36.90	672	4	17
10 JULY 14	1682A	82	102.81	97.19	5.62	1098	3	35
10 JULY 14	1684A	60	54.82	39.61	15.21	666	2	35
11 JULY 14	1686A	144.126	78.44	38.12	40.32	1072	4	23
12 JULY 14	1690A	32.973	60.54	6.87	53.67	NA	4	23
13 JULY 14	1694A	86	78.98	NA	78.98	1034	4	23
22 JULY 14	1732A	28.142	19.88	0.97	18.91	255	2	35
23 JULY 14	1736A	26	28.22	0.14	28.08	288	3	11
23 JULY 14	1742A	283.319	61.32	17.58	43.74	514	2	53
27 JULY 14	1750A	27	29.21	1.14	28.07	306	2	35
27 JULY 14	1752A	27	18.24	2.97	15.27	93	2	23
28 JULY 14	1754A	55.726	28.93	NA	28.93	231	3	11
29 JULY 14	1758A	213.44	112.42	8.39	104.03	218	4	23
TOTAL		1618.14	1065.81	398.97	666.82	8337	60	42

Table 8. Actual parameters used during LiDAR data acquisition

Flight Number	Flying Height (m AGL)	Overlap (%)	FOV (θ)	PRF (kHz)	Scan Frequency (Hz)	Average Speed (kts)
1664A	500	25-50	36	50	45	120
1666A	500	60	36	50	45	120
1670A	600	60	36	50	45	120
1674A	600	60	36	50	45	120
1678A	600	60, 65	36	50	45	120
1682A	600	25, 35	36	50	45	120
1684A	600	45	36	50	45	120
1686A	600	45	36	50	45	120
1690A	600	60, 65	36	50	45	120
1694A	600	40	36	50	45	120
1732A	600	70	36	50	45	120
1736A	600	70	36	50	45	120
1742A	600	60	36	50	45	120
1750A	600	65	36	50	45	120
1752A	600	65	36	50	45	120
1754A	500	70	36	50	45	120
1758A	600	70	36	50	45	120

2.4 Survey Coverage

Tago Floodplain is located in the province of Surigao del Sur, with majority of the floodplain situated within the municipality of Tago. Municipalities of Bayabas and Tago are mostly covered by the survey. The list of municipalities and cities surveyed, with at least one (1) square kilometer coverage, is found in Table 9. The actual coverage of the LiDAR acquisition for Tago Floodplain is presented in Figure 7. The flight status reports are found in Annex 7.

Table 9. List of municipalities and cities surveyed during Tago Floodplain LiDAR survey

Province	Municipality/City	Area of Municipality/City	Surveyed Area (km^2)	Percentage of Area Surveyed
Lanao del Norte	Bayabas	48.29	48.2	99%
	Tago	293.49	213.47	73%
	San Miguel	410.02	258.20	63%
	Cagwait	200.13	96.26	48%
	Tandag	392.39	113.80	29%
	Cortes	82.48	21.4	26%
	San Agustin	231.99	15.24	7%
	Marihatag	272.4	12.78	5%
	Lanuza	231.62	9.88	4%
Agusan del Sur	Sibagat	640.31	2.42	1%
TOTAL		2,803.12	791.65	28.24%

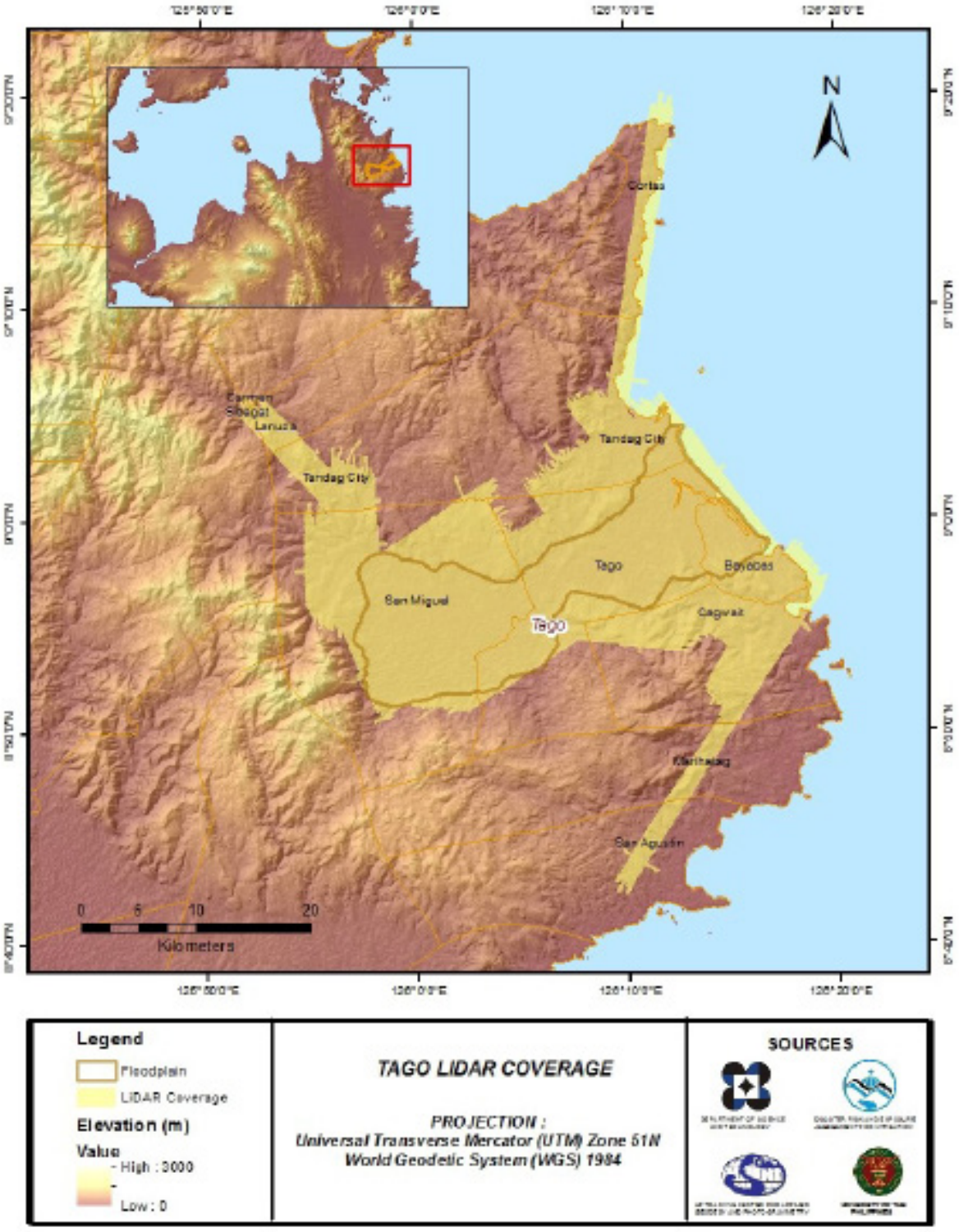


Figure 7. Actual LiDAR survey coverage for Tago Floodplain

CHAPTER 3: LIDAR DATA PROCESSING OF THE TAGO FLOODPLAIN

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

3.1 Overview of the LiDAR Data Pre-Processing

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

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

These processes are summarized in the flowchart shown in Figure 8.

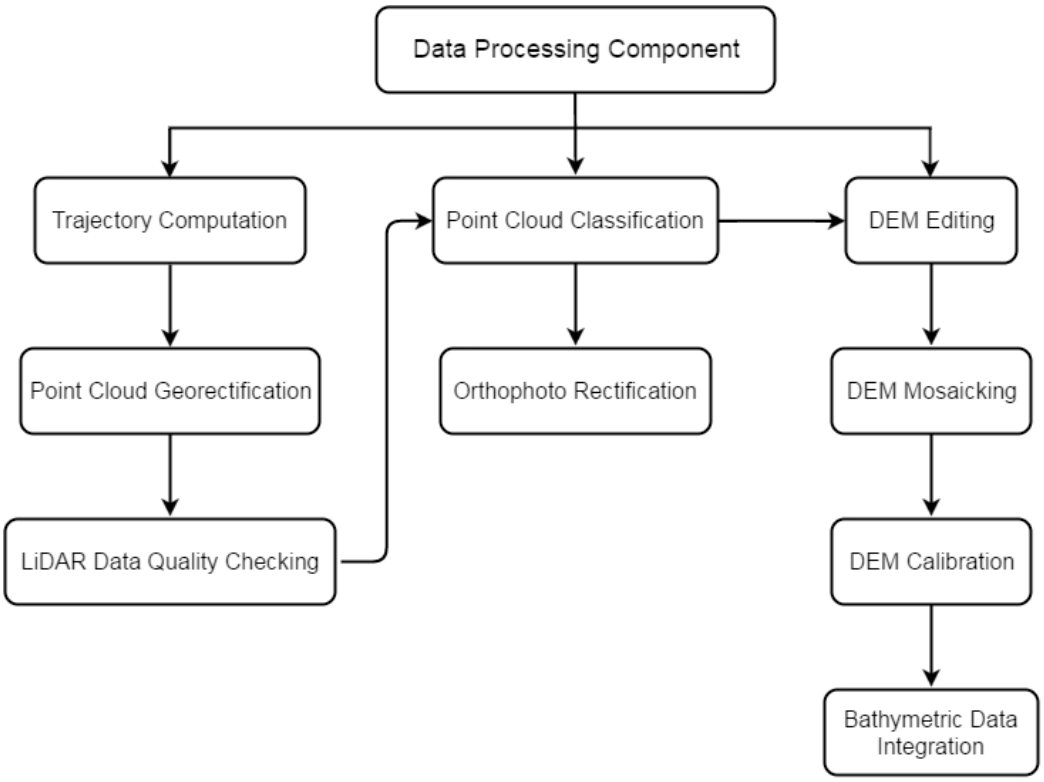

Figure 8. Schematic diagram for Data Pre-Processing Component

3.2 Transmittal of Acquired LiDAR Data

Data transfer sheets for all the LiDAR missions for Tago Floodplain can be found in ANNEX 5. Missions flown during the first survey conducted on May 2014 used the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.) Aquarius system over Surigao del Sur. The Data Acquisition Component (DAC) transferred a total of 144.75 Gigabytes of Range data, 3.31 Gigabytes of POS data, 173.48 Megabytes of GPS base station data, and 443.7 Gigabytes of raw image data to the data server on July 3, 2014 for the first survey and August 17, 2014 for the second survey. The Data Pre-Processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for Tago was fully transferred on September 1, 2014, as indicated on the data transfer sheets for Tago Floodplain.

3.3 Trajectory Computation

The Smoothed Performance Metrics of the computed trajectory for flight 1752A, one of the Tago flights, which is the North, East, and Down position RMSE values are shown in Figure 9. The x-axis corresponds to the time of flight, which is measured by the number of seconds from the midnight of the start of the GPS week, which on that week fell on July 27, 2014 00:00 AM. The y-axis is the RMSE value for that particular position.

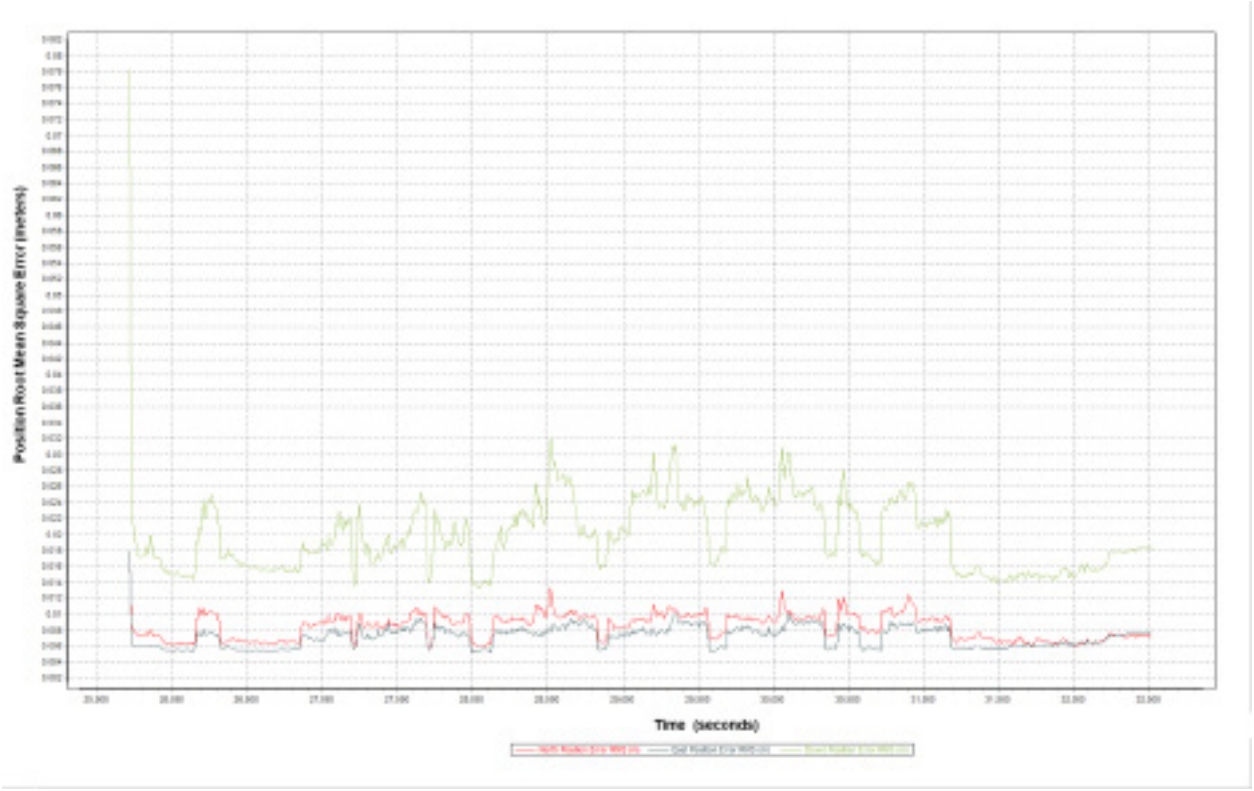

Figure 9. Smoothed Performance Metrics of Tago Flight 1752A

The time of flight was from 25400 seconds to 32500 seconds, which corresponds to afternoon of July 27, 2014. The initial spike that is seen on the data corresponds to the time that the aircraft was getting into position to start the acquisition, and the POS system starts computing for the position and orientation of the aircraft. Redundant measurements from the POS system quickly minimized the RMSE value of the positions. The periodic increase in RMSE values from an otherwise smoothly curving RMSE values correspond to the turn-around period of the aircraft, when the aircraft makes a turn to start a new flight line. Figure 9 shows that the North position RMSE peaks at 1.00 centimeters, the East position RMSE peaks at 1. 30 centimeters, and the Down position RMSE peaks at 3.20 centimeters, which are within the prescribed accuracies described in the methodology.

Figure 10. Solution Status parameters of Tago Flight 1752A

The Solution Status parameters of flight 1752A,one of the Tago flights, which are the number of GPS satellites, Positional Dilution of Precision (PDOP), and the GPS processing mode used, are shown in Figure 10. The graphs indicate that the number of satellites during the acquisition did not go down to 8. Majority of the time, the number of satellites tracked was between 8 and 12. The PDOP value also did not go above the value of 3, which indicates optimal GPS geometry. The processing mode stayed at the value of 0 for majority of the survey with some peaks up to 2 attributed to the turns performed by the aircraft. The value of 0 corresponds to a Fixed, Narrow-Lane mode, which is the optimum carrier-cycle integer ambiguity resolution technique available for POSPAC MMS. All of the parameters adhered to the accuracy requirements for optimal trajectory solutions, as indicated in the methodology. The computed best estimated trajectory for all Tago flights is shown in Figure 11.

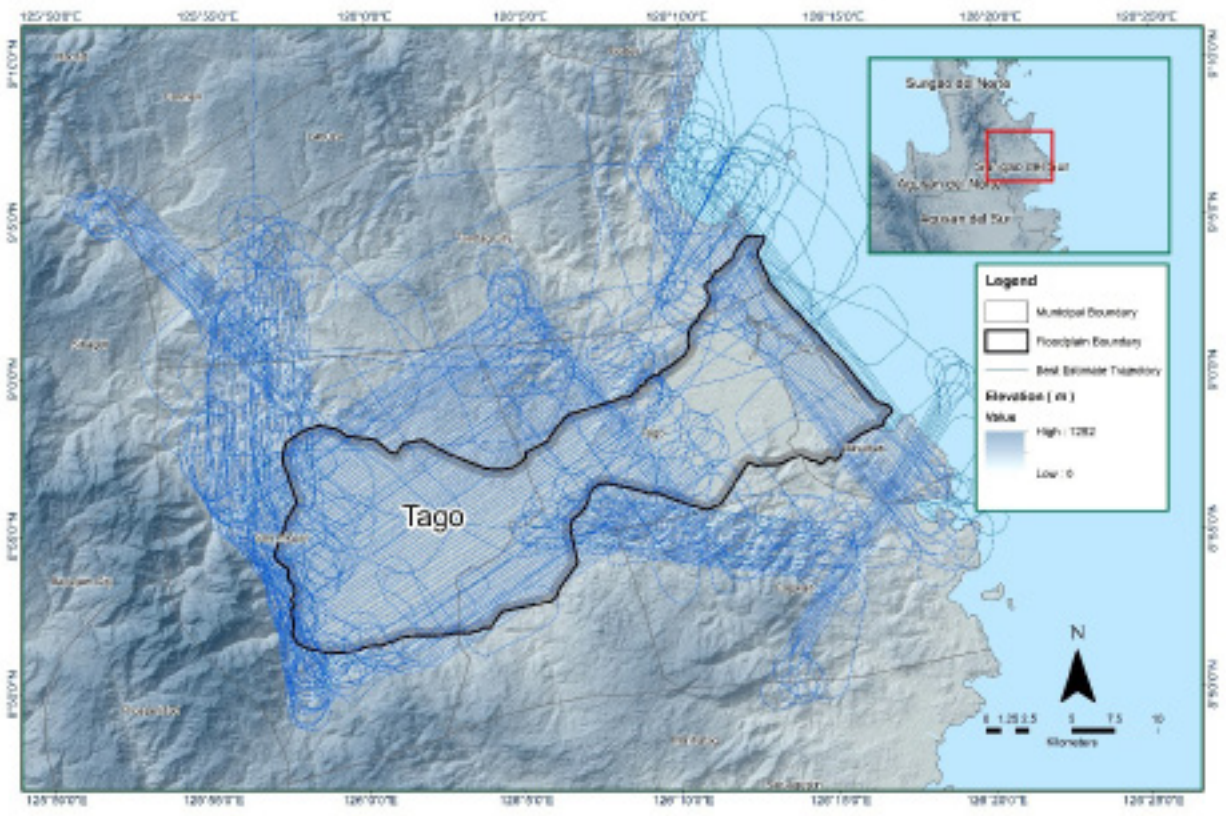

Figure 11. Best estimated trajectory of the LiDAR missions conducted over the Tago Floodplain

3.4 LiDAR Point Cloud Computation

The produced LAS data contains 234 flight lines, with each flight line containing one channel, since the Aquarius system contains one channel only. The summary of the self-calibration results obtained from LiDAR processing in LiDAR Mapping Suite (LMS) software for all flights over Tago Floodplain are given in Table 10.

Table 10. Self-calibration results values for Tago flights

Parameter		Value
Boresight Correction stdev	(<0.001degrees)	0.000689
IMU Attitude Correction Roll and Pitch Corrections stdev	(<0.001degrees)	0.000818
GPS Position Z-correction stdev	(<0.01meters)	0.0114

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

3.5 LiDAR Data Quality Checking

The boundary of the processed LiDAR data on top of a SAR Elevation Data over Tago Floodplain is shown in Figure 12. The map shows gaps in the LiDAR coverage that are attributed to cloud coverage.

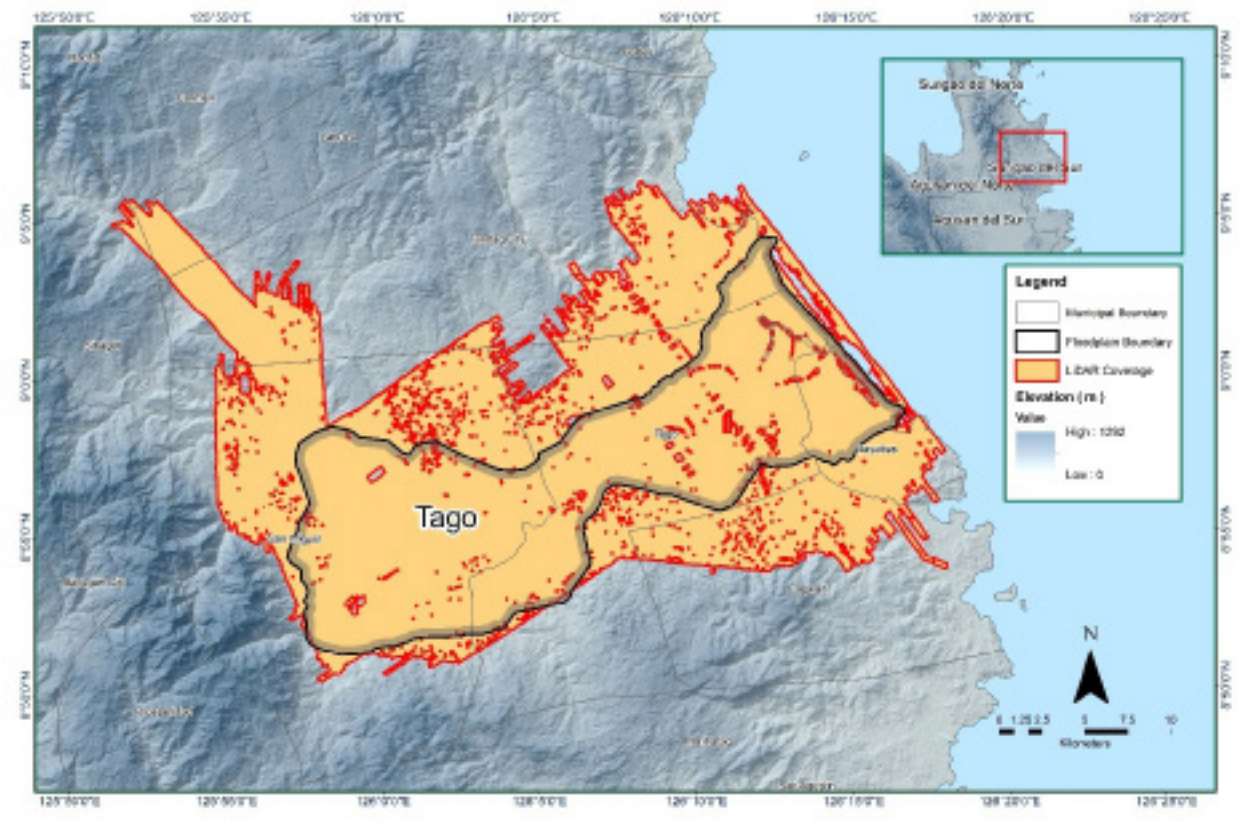

Figure 12. Boundary of the processed LiDAR data over Tago Floodplain

The total area covered by the Tago missions is 807.76 sq km that is comprised of sixteen (16) flight acquisitions grouped and merged into fourteen (14) blocks as shown in Table 11.

Table 11. List of LiDAR blocks for Tago Floodplain

LiDAR Blocks	Flight Numbers	Area (sq.km)
SurigaoDelSur_Blk61M	1754A	32.48
	1758A	
SurigaoDelSur_Blk61L	1752A	40.14
	1750A	
SurigaoDelSur_Blk61K	1754A	32.95
	1758A	
	1742A	
SurigaoDelSur_Blk61I	1690A	31.12
SurigaoDelSur_Blk61H	1686A	71.03
	1758A	
SurigaoDelSur_Blk61H_additional	1758A	17.04
SurigaoDelSur_Blk61G	1678A	66.68
	1686A	
SurigaoDelSur_Blk61F	1682A	100.82
SurigaoDelSur_Blk61E	1684A	70.79
	1686A	
SurigaoDelSur_Blk61E_additional	1742A	16.14
SurigaoDelSur_Blk61J	1736A	39.87
	1732A	
SurigaoDelSur_Blk61B	1670A	94.84
SurigaoDelSur_Blk61A	1664A	91.35
	1666A	
SurigaoDelSur_Blk61CD	1674A	102.49
	1678A	
SurigaoDelSur_Blk61CD_additional	1674A	0.47
	1678A	
TOTAL		**808.21 sq km**

The overlap data for the merged LiDAR blocks, showing the number of channels that pass through a particular location, is shown in Figure 13. Since the Aquarius system employs one channel only, an average value of 1 (blue) would be expected for areas where there is limited overlap, and a value of 2 (yellow) or more (red) for areas with three or more overlapping flight lines.

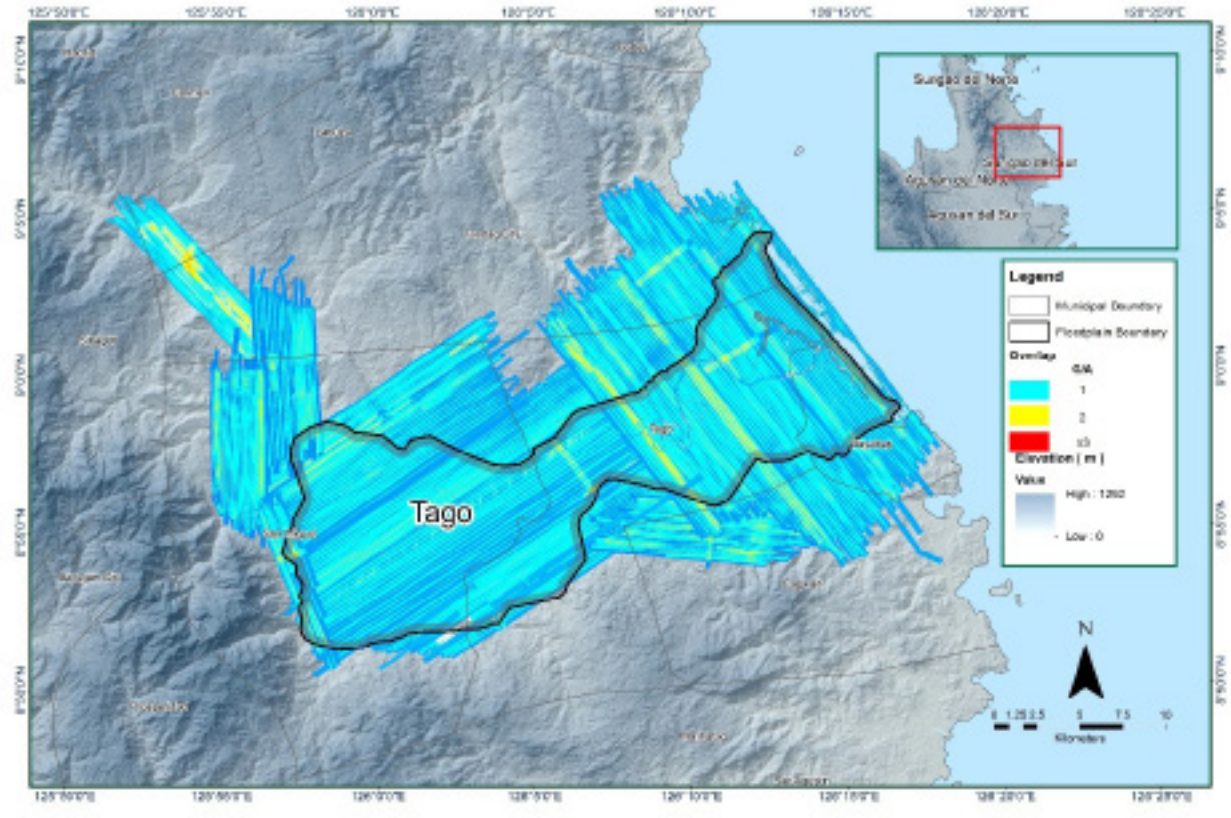

Figure 13. Image of data overlap for Tago Floodplain

The overlap statistics per block for the Tago Floodplain can be found in ANNEX 8. It should be noted that one pixel corresponds to 25.0 square meters on the ground. For this area, the minimum and maximum percent overlaps are 46.73% and 71.21% respectively, which passed the 25% requirement.

The pulse density map for the merged LiDAR data, with the red parts showing the portions of the data that satisfy the 2 points per square meter criterion, is shown in Figure 14. It was determined that all LiDAR data for Tago Floodplain satisfy the point density requirement, and the average density for the entire survey area is 4.27 points per square meter.

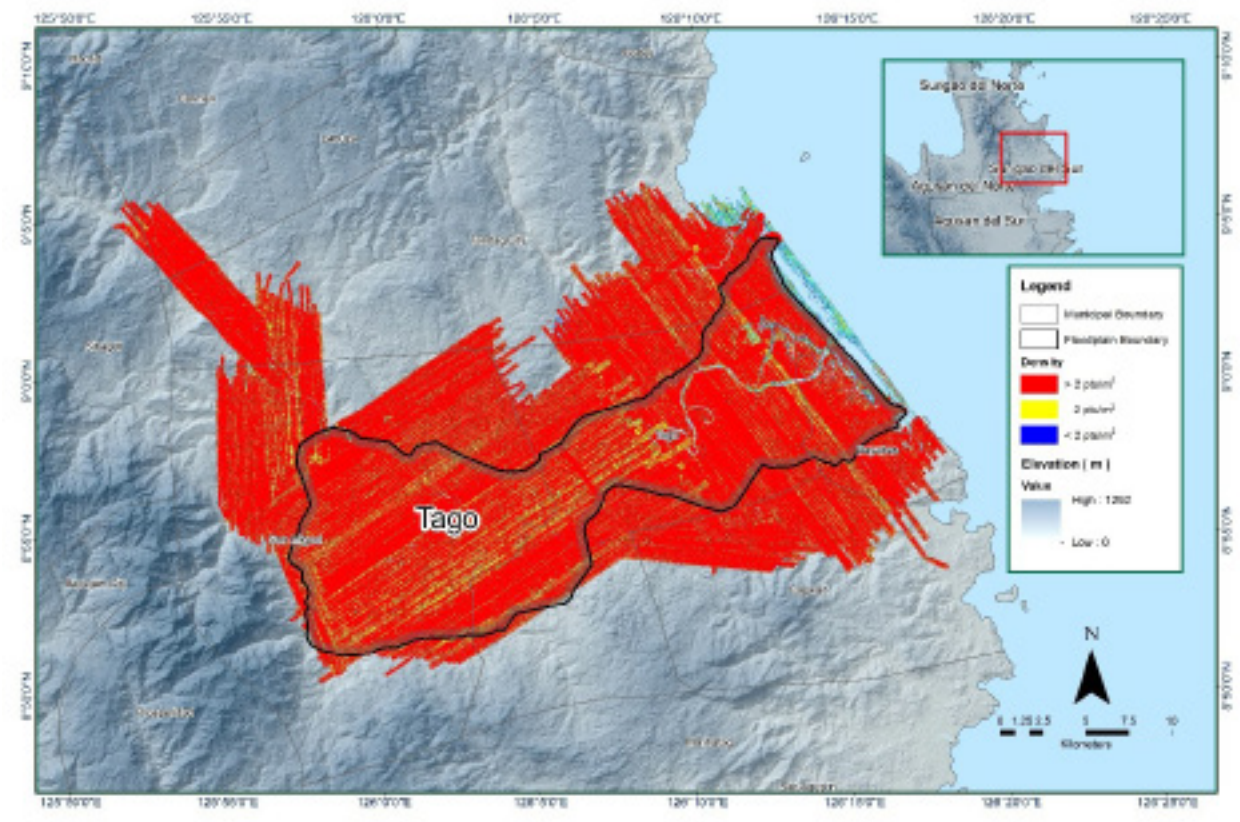

Figure 14. Pulse density map of merged LiDAR

The elevation difference between overlaps of adjacent flight lines is shown in Figure 15. The default color range is from blue to red, where bright blue areas correspond to portions where elevations of a previous flight line, identified by its acquisition time, are higher by more than 0.20 m relative to elevations of its adjacent flight line. Bright red areas indicate portions where elevations of a previous flight line are lower by more than 0.20 m relative to elevations of its adjacent flight line. Areas with bright red or bright blue need to be investigated further using Quick Terrain Modeler software.

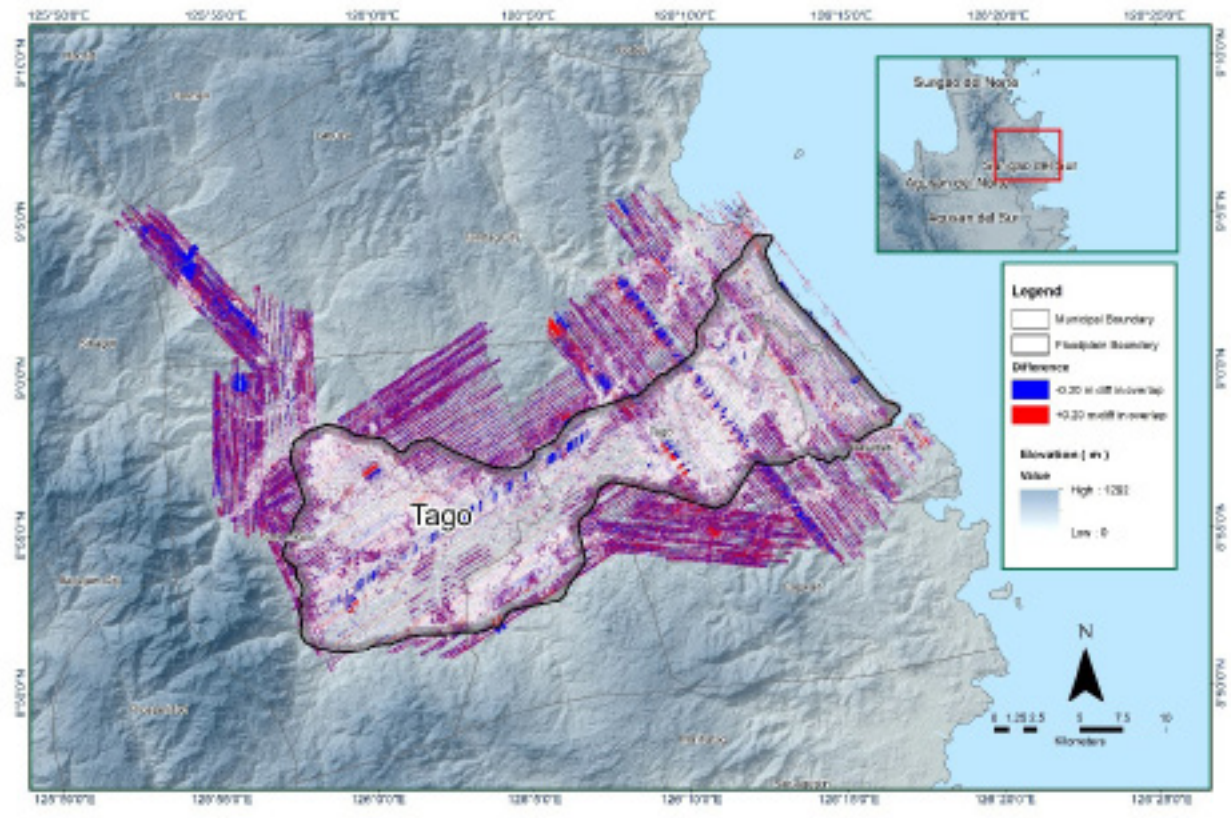

Figure 15. Elevation difference map between flight lines for Tago Floodplain

A screen capture of the processed LAS data from a Tago flight 1752A loaded in QT Modeler is shown in Figure 16. The upper left image shows the elevations of the points from two overlapping flight strips traversed by the profile, illustrated by a dashed yellow line. The x-axis corresponds to the length of the profile. It is evident that there are differences in elevation, but the differences do not exceed the 20-centimeter mark. This profiling was repeated until the quality of the LiDAR data becomes satisfactory. No reprocessing was done for this LiDAR dataset.

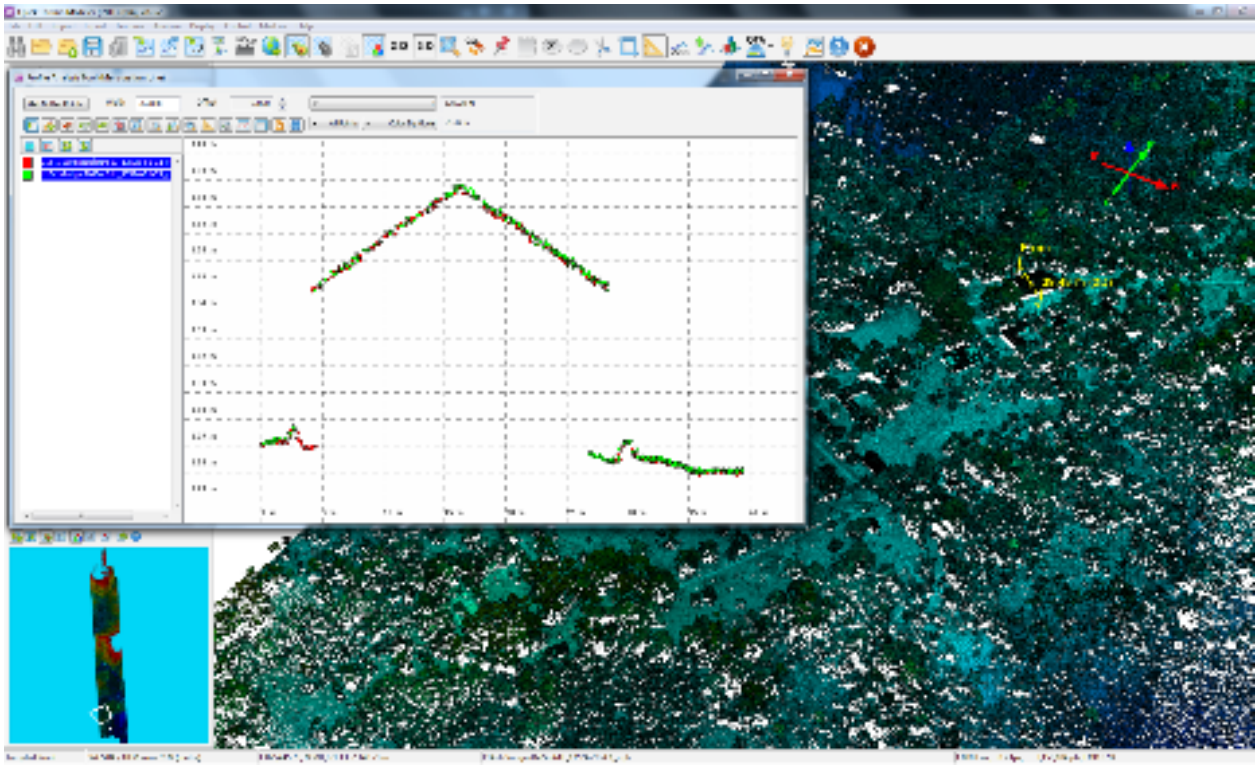

Figure 16. Quality checking for a Tago flight 1752A using the Profile Tool of QT Modeler

3.6 LiDAR Point Cloud Classification and Rasterization

Table 12. Tago classification results in TerraScan

Pertinent Class	Total Number of Points
Ground	331,390,337
Low Vegetation	405,579,680
Medium Vegetation	513,977,872
High Vegetation	1,403,571,531
Building	50,956,540

The tile system that TerraScan employed for the LiDAR data and the final classification image for a block in Tago Floodplain is shown in Figure 17. A total of 1,305 1 km by 1 km tiles were produced. The number of points classified to the pertinent categories is illustrated in Table 12. The point cloud has a maximum and minimum height of 564.88 meters and 55.44 meters, respectively.

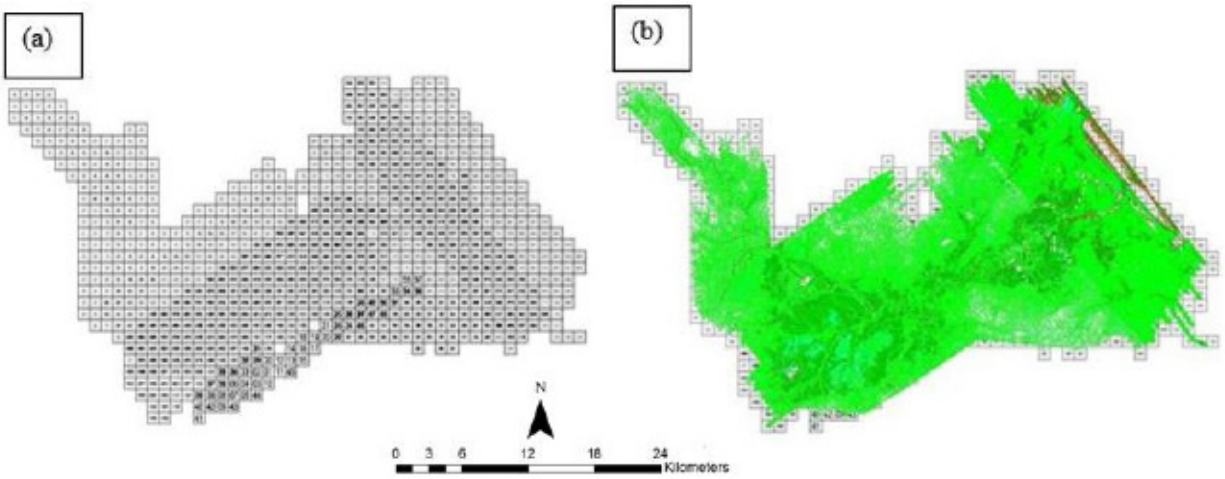

Figure 17. Tiles for Tago Floodplain (a) and classification results (b) in TerraScan

An isometric view of an area before and after running the classification routines is shown in Figure 18. The ground points are in orange, the vegetation is in different shades of green, and the buildings are in cyan. It can be seen that residential structures adjacent or even below canopy are classified correctly due to the density of the LiDAR data.

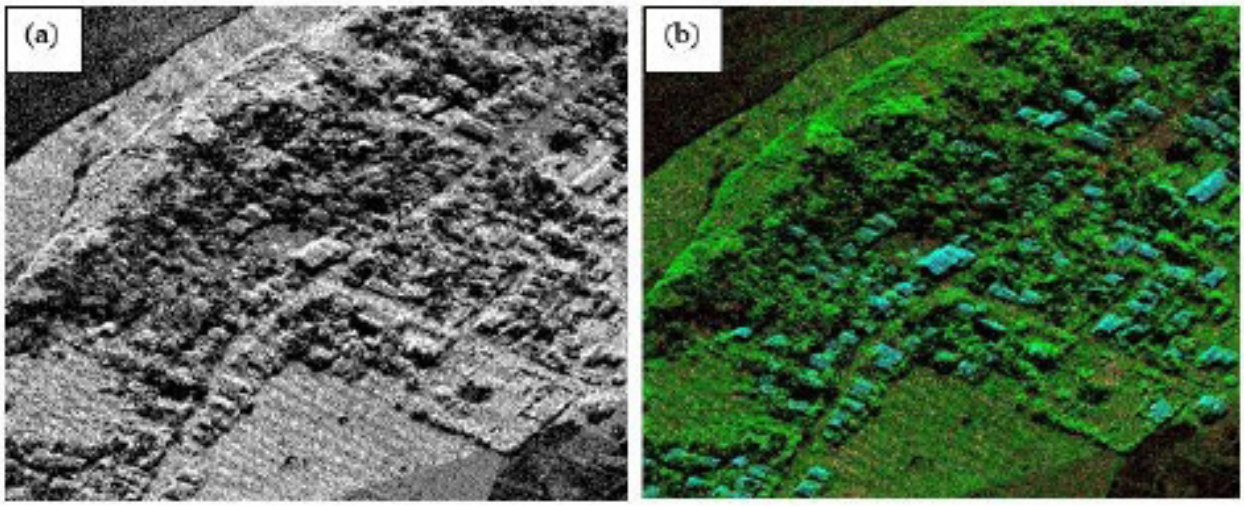

Figure 18. Point cloud before (a) and after (b) classification

The production of last return (V_ASCII) and the secondary (T_ ASCII) DTM, first (S_ ASCII) and last (D_ ASCII) return DSM of the area in top view display are shown in Figure 19. It shows that DTMs are the representation of the bare earth while on the DSMs, all features such as buildings and vegetation are present.

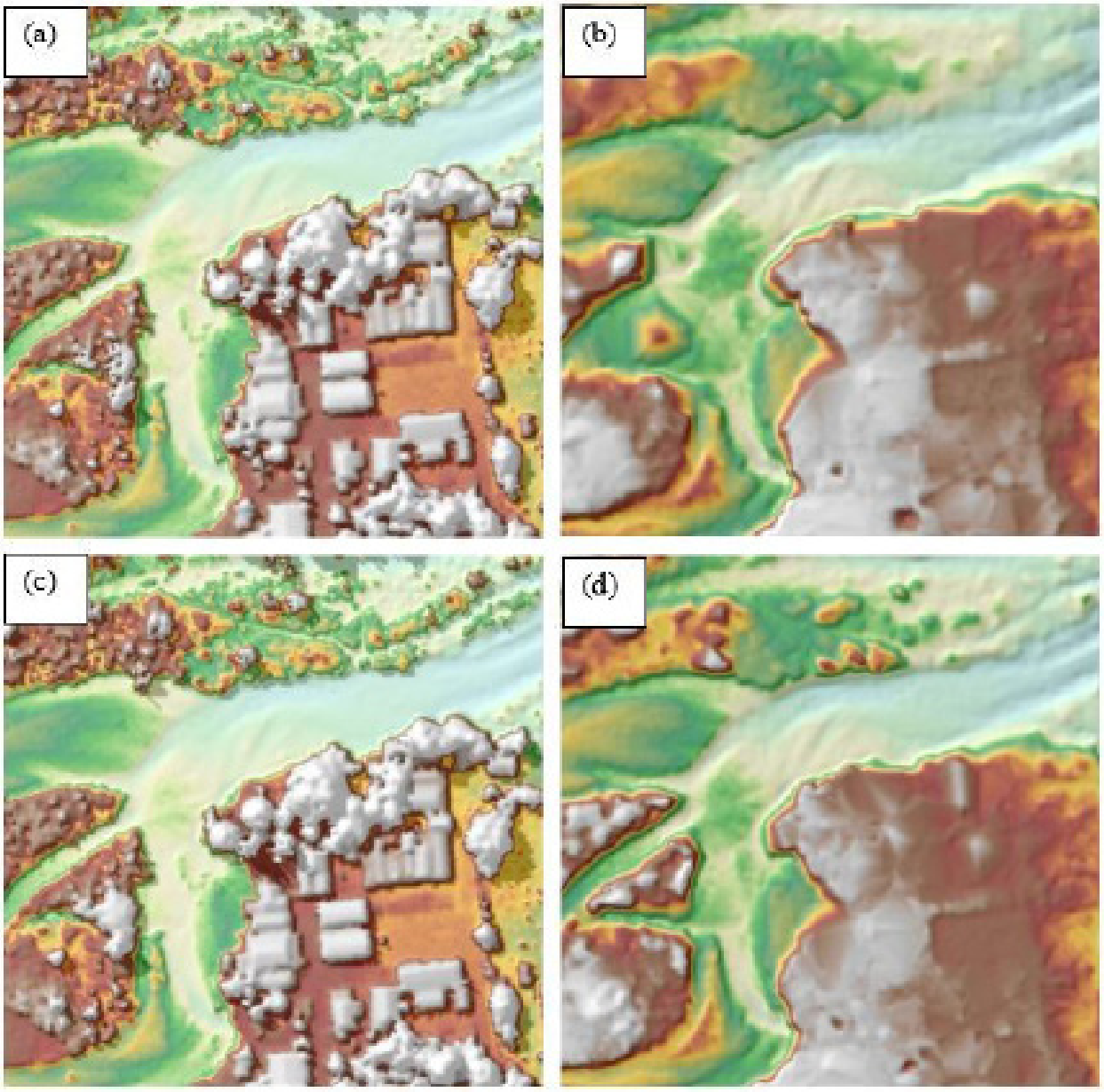

Figure 19. The production of last return DSM (a) and DTM (b); first return DSM (c) and secondary DTM (d) in some portion of Tago Floodplain

3.7 LiDAR Image Processing and Orthophotograph Rectification

The 950 1 km by 1 km tiles area covered by Tago Floodplain is shown in Figure 20. After tie point selection to fix photo misalignments, color points were added to smoothen out visual inconsistencies along the seamlines where photos overlap. The Tago Floodplain survey attained a total of 823.2 sq km in orthophotogaph coverage comprised of 11,848 images. A zoomed in version of sample orthophotographs named in reference to its tile number is shown in Figure 21..

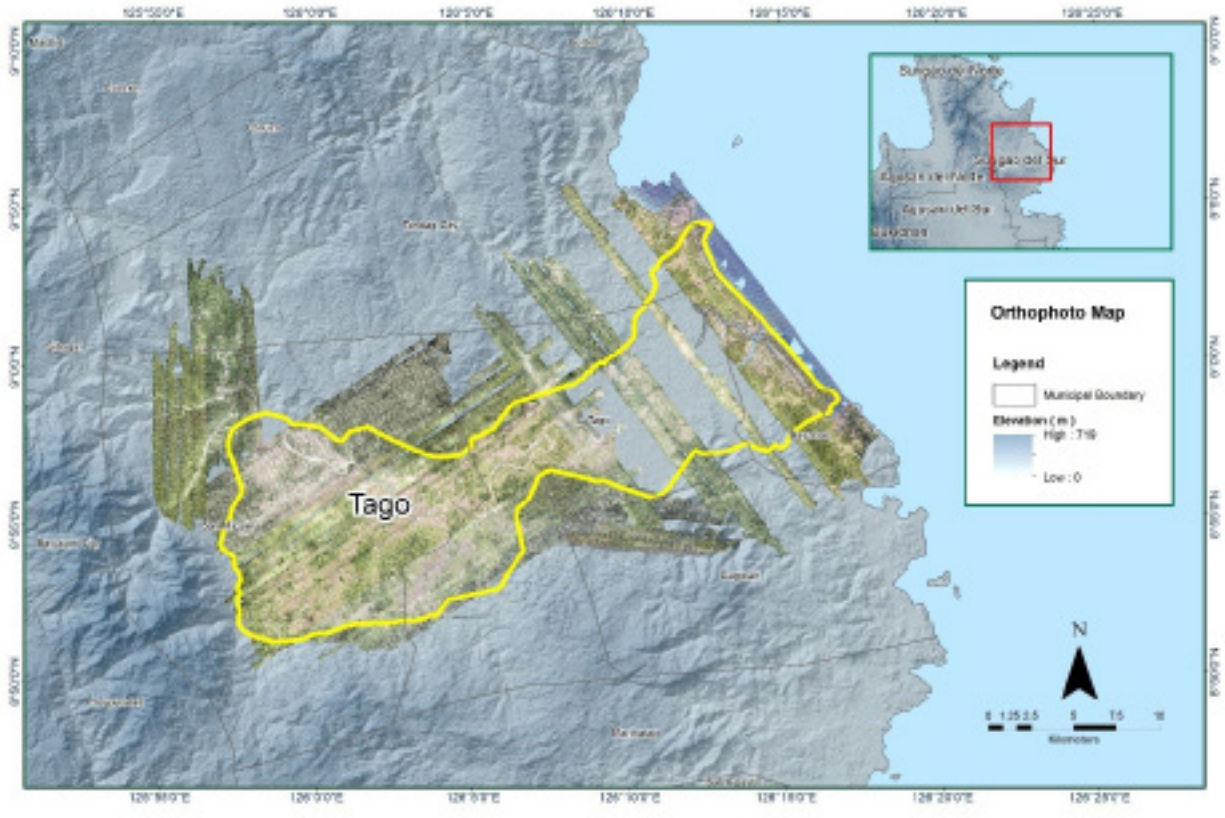

Figure 20. Tago Floodplain with available orthophotographs

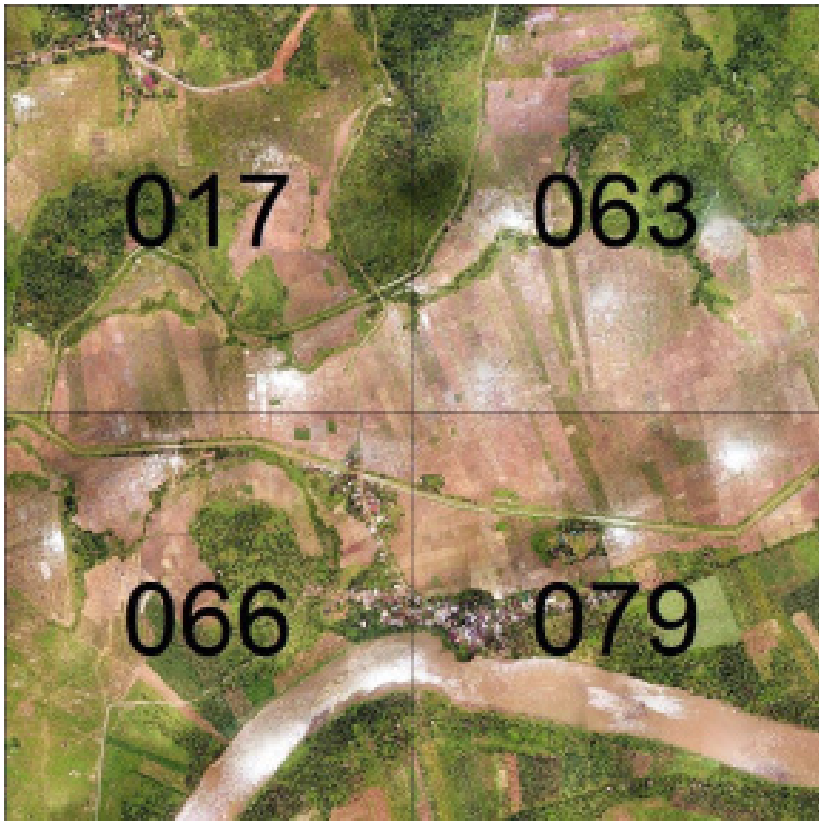

Figure 21. Sample orthophotograph tiles for Tago Floodplain

3.8 DEM Editing and Hydro-Correction

Fifteen (15) mission blocks were processed for Tago Floodplain. These are composed of SurigaoDelSur blocks with a total area of 808.21 square kilometers. Table 13 shows the name and corresponding area of each block in square kilometers.

Table 13. LiDAR blocks with the corresponding area

LiDAR Blocks	Area (sq.km)
SurigaoDelSur_Blk61CD	102.49
SurigaoDelSur_Blk61B	94.84
SurigaoDelSur_Blk61A	91.35
SurigaoDelSur_Blk61E	70.79
SurigaoDelSur_Blk61F	100.82
SurigaoDelSur_Blk61G	66.68
SurigaoDelSur_Blk61H	71.03
SurigaoDelSur_Blk61I	31.12
SurigaoDelSur_Blk61L	40.14
SurigaoDelSur_Blk61M	32.48
SurigaoDelSur_Blk61K	32.95
SurigaoDelSur_Blk61H_additional	17.04
SurigaoDelSur_Blk61E_additional	16.14
SurigaoDelSur_Blk61J	39.87
SurigaoDelSur_Blk61CD_additional	0.47
TOTAL	**808.21 sq km**

Portions of DTM before and after manual editing are shown in Figure 22. A portion of a mountain (Figure 22a) had been misclassified and removed during classification process and had to be retrieved to complete the surface (Figure 22b) to allow the correct flow of water. The bridge (Figure 22c) was also considered to be an impedance to the flow of water along the river and had to be removed (Figure 22d) in order to hydrologically correct the river.

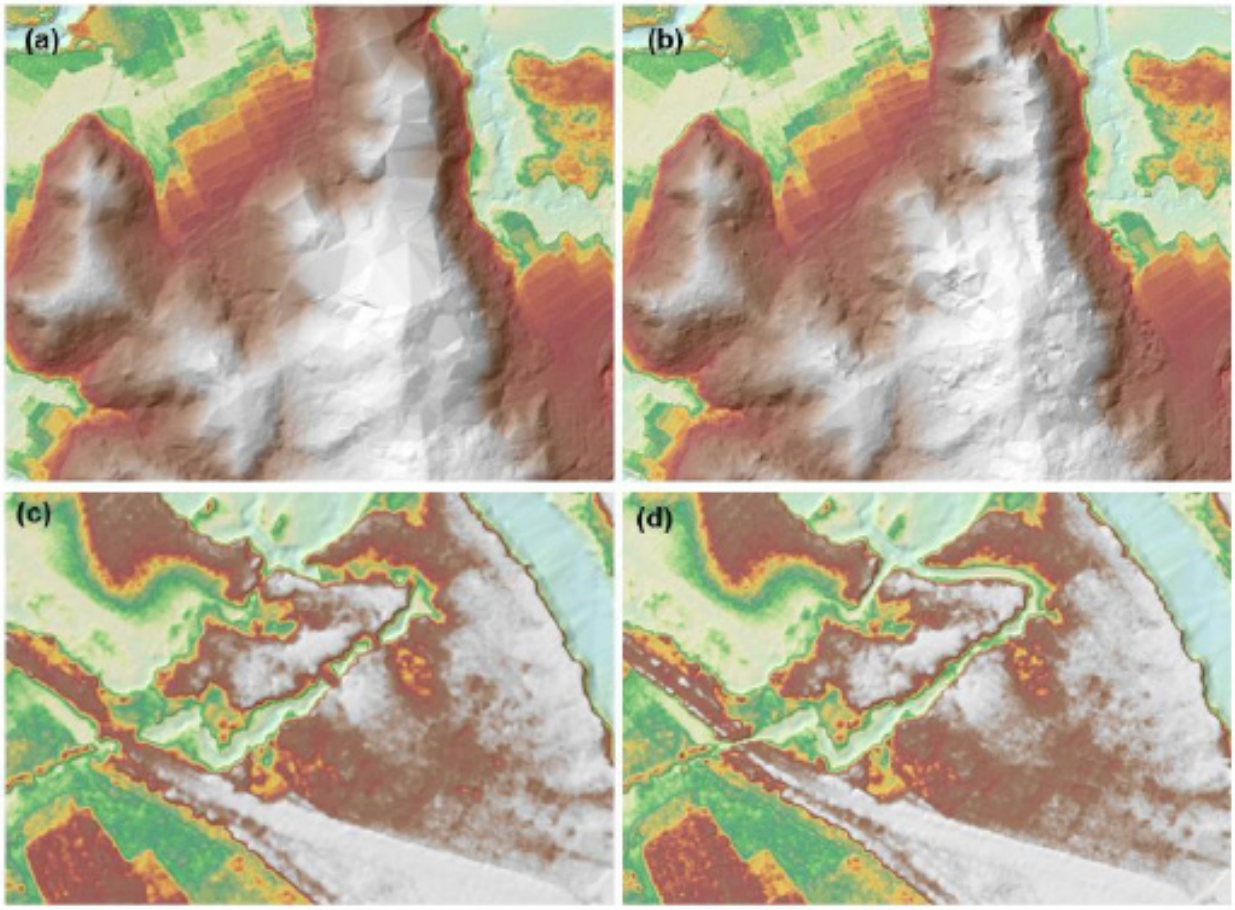

Figure 22. Portions in the DTM of Tago Floodplain—mountainous portion (a) and after (b) data retrieval; and a bridge before (c) and after (d) manual editing

3.9 Mosaicking of Blocks

SurigaodelSur_Blk61CD was used as the reference block at the start of mosaicking because this block contained national highway on which the validation surveys passed through. Table 14 shows the shift values applied to each LiDAR block during mosaicking.

Mosaicked LiDAR DTM for Tago Floodplain is shown in Figure 23. It can be seen that the entire Tago Floodplain is 92.06% covered by LiDAR data.

Table 14. Shift values of each LiDAR Block of Tago Floodplain

Mission Blocks	Shift Values (meters)		
	x	y	Z
SurigaoDelSur_Blk61B	0.00	0.00	0.06
SurigaoDelSur_Blk61A	0.00	3.00	-1.11
SurigaoDelSur_Blk61E	13.00	0.00	0.19
SurigaoDelSur_Blk61F	11.00	-1.00	-0.02
SurigaoDelSur_Blk61G	0.00	0.00	-0.02
SurigaoDelSur_Blk61H	9.00	-2.00	-0.03
SurigaoDelSur_Blk61I	9.00	-1.00	-0.79
SurigaoDelSur_Blk61L	8.00	0.00	-0.62
SurigaoDelSur_Blk61M	7.00	0.00	-0.89
SurigaoDelSur_Blk61K	8.00	0.00	-0.72
SurigaoDelSur_Blk61H_additional	11.00	-1.00	-0.02
SurigaoDelSur_Blk61E_additional	12.00	0.00	0.03
SurigaoDelSur_Blk61J	10.00	-1.00	0.25
SurigaoDelSur_Blk61CD_additional	9.00	0.00	0.12

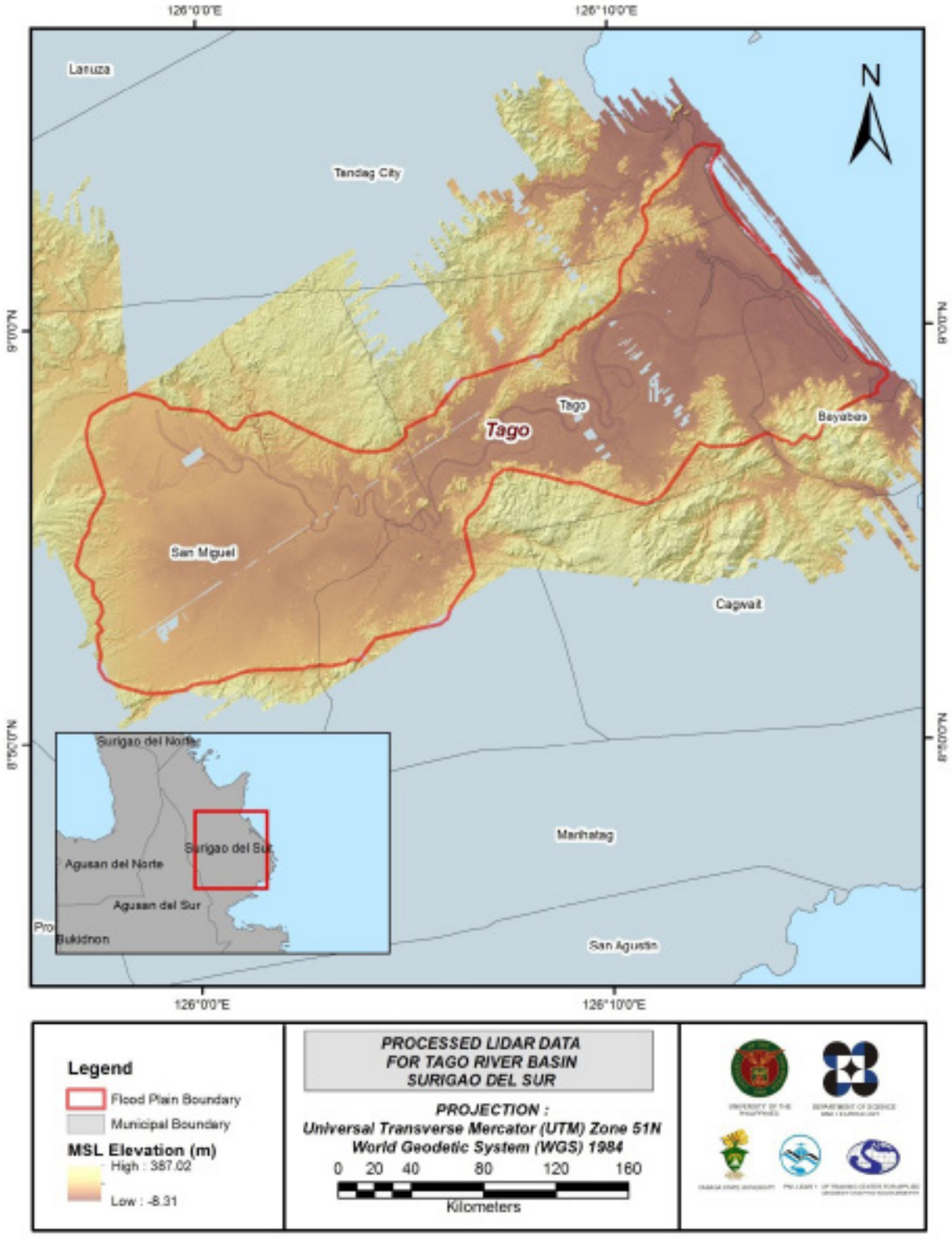

Figure 23. Map of processed LiDAR data for Tago Floodplain

3.10 Calibration and Validation of Mosaicked LiDAR Digital Elevation Model

The extent of the validation survey done by the Data Validation and Bathymetry Component (DVBC) in Tago to collect points with which the LiDAR dataset is validated is shown in Figure 24. A total of 3,800 survey points were used for calibration and validation of Tago LiDAR data. Eighty percent of the survey points, which were randomly selected, resulting in 3,040 points, were used for calibration. A good correlation between the uncalibrated mosaicked LiDAR elevation values and the ground survey elevation values is shown in Figure 25. Statistical values were computed from extracted LiDAR values using the selected points to assess the quality of data and obtain the value for vertical adjustment. The computed height difference between the LiDAR DTM and calibration elevation values is 0.75 meters with a standard deviation of 0.17 meters. Calibration of Tago LiDAR data was done by adding the height difference value, 0.75 meters, to Tago mosaicked LiDAR data. Table 15 shows the statistical values of the compared elevation values between LiDAR data and calibration data.

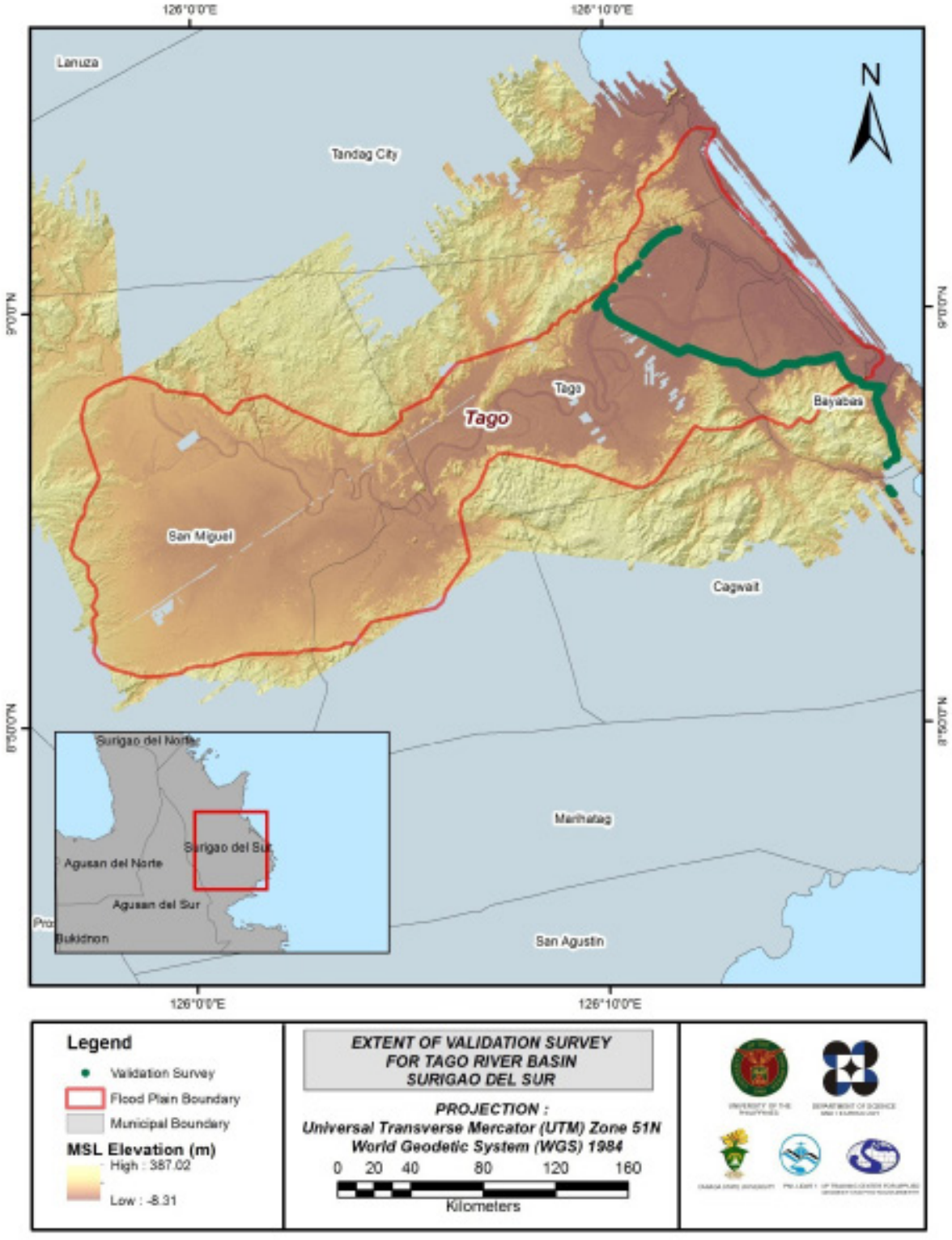

Figure 24. Map of Tago Floodplain with validation survey points in green

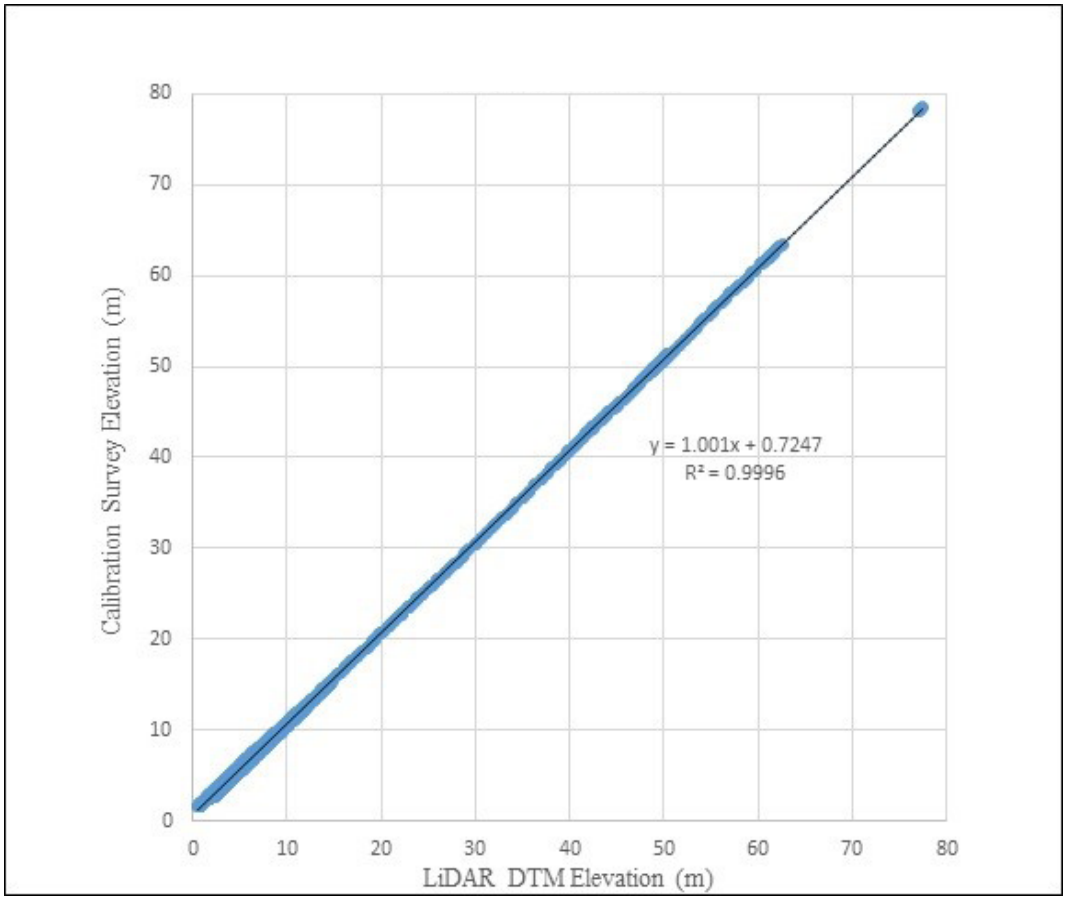

Figure 25. Correlation plot between calibration survey points and LiDAR data

Table 15. Calibration statistical measures

Calibration Statistical Measures	Value (meters)
Height Difference	0.75
Standard Deviation	0.17
Average	0.73
Minimum	0.39
Maximum	1.07

The remaining 20% of the total survey points, resulting in 760 points, were used for the validation of calibrated Tago DTM. A good correlation between the calibrated mosaicked LiDAR elevation values and the ground survey elevation, which reflects the quality of the LiDAR DTM is shown in Figure 26. The computed RMSE between the calibrated LiDAR DTM and validation elevation values is 0.17 meters with a standard deviation of 0.17 meters, as shown in Table 16.

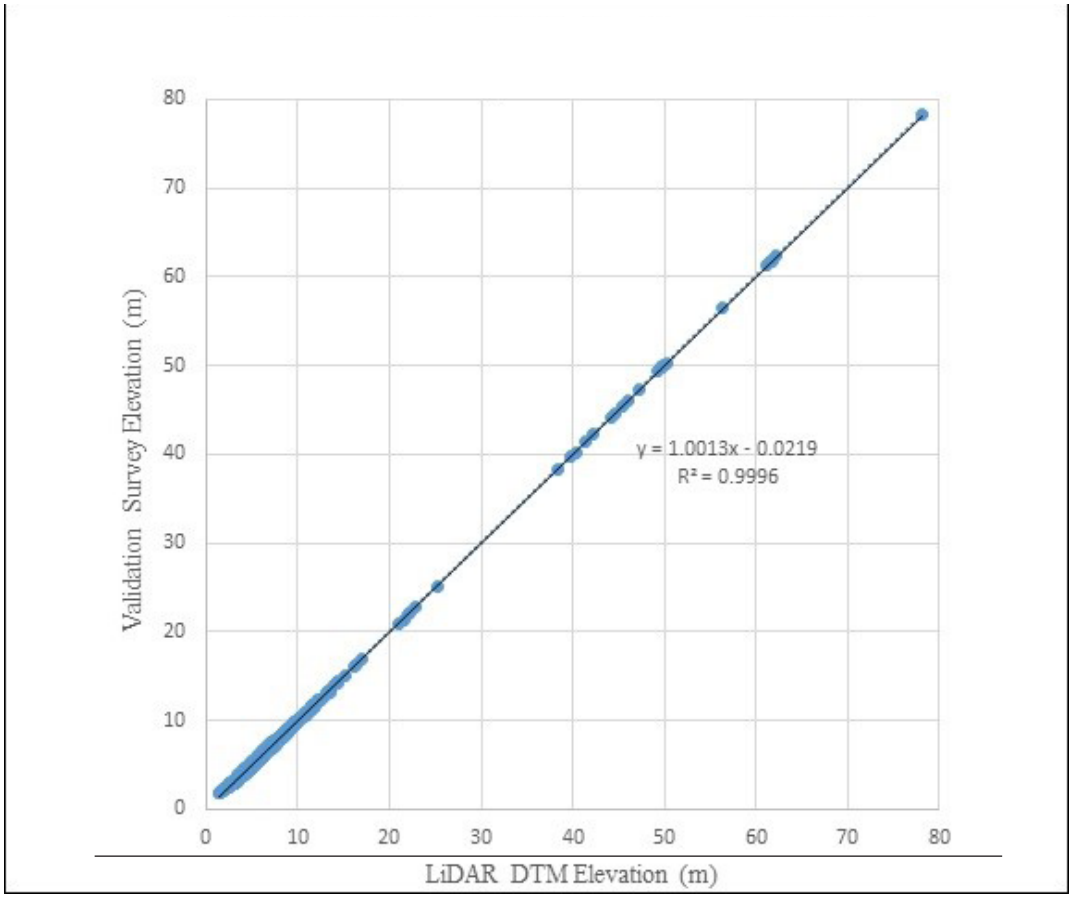

Figure 26. Correlation plot between validation survey points and LiDAR data

Table 16. Validation statistical measures

Validation Statistical Measures	Value (meters)
RMSE	0.17
Standard Deviation	0.17
Average	-0.01
Minimum	-0.35
Maximum	0.32

3.11 Integration of Bathymetric Data into the LiDAR Digital Terrain Model

For bathy integration, centerline and zigzag data were available for Tago with 55,045 bathymetric survey points. The resulting raster surface produced was done by Inverse Distance Weighted (IDW) interpolation method. After burning the bathymetric data to the calibrated DTM, assessment of the interpolated surface was represented by the computed RMSE value of 0.15 meters. The extent of the bathymetric survey done by the Data Validation and Bathymetry Component (DVBC) in Tago integrated with the processed LiDAR DEM is shown in Figure 27.

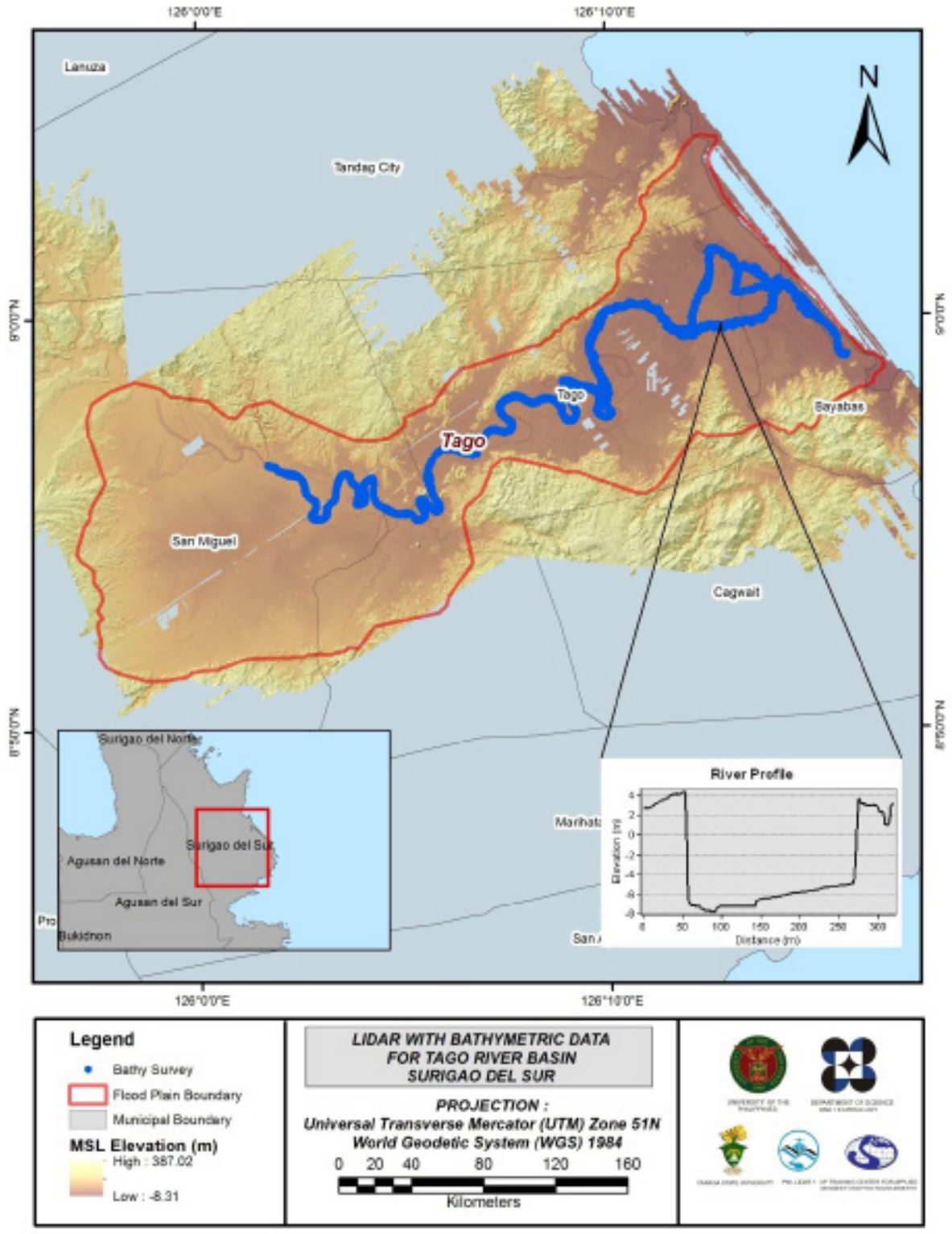

Figure 27. Map of Tago Floodplain with bathymetric survey points shown in blue

3.12 Feature Extraction

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

3.12.1 Quality Checking of Digitized Features' Boundary

Tago Floodplain, including its 200 m buffer, has a total area of 346.98 sq km. For this area, a total of 11.0 sq km, corresponding to a total of 3,055 building features, weere considered for QC. Figure 28 shows the QC blocks for Tago Floodplain.

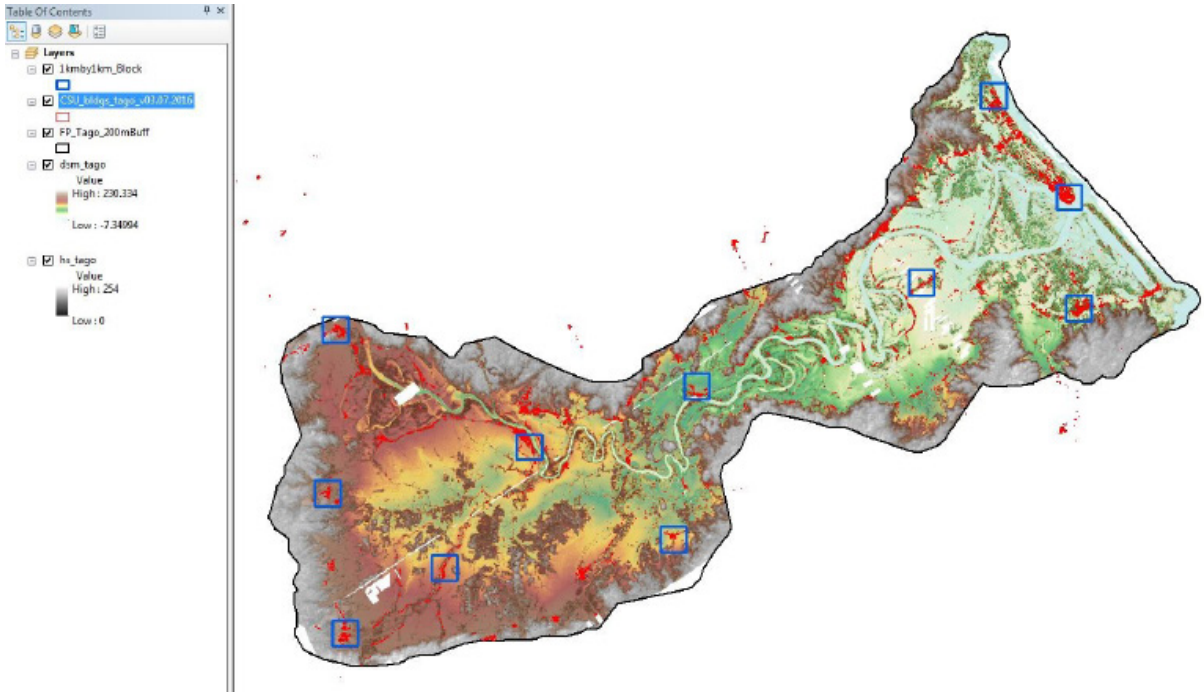

Figure 28. Blocks (in blue) of Tago building features subjected to QC

Quality checking of Tago building features resulted in the ratings shown in Table 17.

Table 17. Quality checking ratings for Tago building features.

FLOODPLAIN	COMPLETENESS	CORRECTNESS	QUALITY	REMARKS
Tago	99.38	99.94	92.96	PASSED

3.12.2 Height Extraction

Height extraction was done for 14,829 building features in Tago Floodplain. Of these building features, 748 buildings were filtered out after height extraction, resulting in 14,081 buildings with height attributes. The lowest building height is at 2.00 m, while the highest building is at 4.92 m.

3.12.3 Feature Attribution

Field surveys, familiarity with the area, and free online web maps such as Wikimapia (http://wikimapia.org/) and Google Map (https://www.google.com/maps) were used to gather information such as name and type of the features within the river basin.

Table 18 summarizes the number of building features per type. On the other hand, Table 19 shows the total length of each road type, while Table 20 presents the number of water features extracted per type.

Table 18. Building features extracted for Tago Floodplain

Facility Type	No. of Features
Residential	13,809
School	193
Market	15
Agricultural/Agro-Industrial Facilities	1
Medical Institutions	6
Barangay Hall	3
Military Institution	1
Sports Center/Gymnasium/Covered Court	8
Telecommunication Facilities	0
Transport Terminal	1
Warehouse	7
Power Plant/Substation	0
NGO/CSO Offices	0
Police Station	0
Water Supply/Sewerage	0
Religious Institutions	14
Bank	1
Factory	0
Gas Station	5
Fire Station	0
Other Government Offices	17
Other Commercial Establishments	0
Total	**14,081**

Table 19. Total length of extracted roads for Tago Floodplain

Floodplain	Road Network Length (km)					Total
	Barangay Road	City/ Municipal Road	Provincial Road	National Road	Others	
Tago	27.54	10.32	291.56	22.68	0.00	**352.09**

Table 20. Number of extracted water bodies for Tago Floodplain

Floodplain	Water Body Type					Total
	Rivers/ Streams	Lakes/ Ponds	Sea	Dam	Fish Pen	
Tago	33	0	0	1	0	**34**

A total of 93 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 29 shows the Digital Surface Model (DSM) of Tago Floodplain overlaid with its ground features.

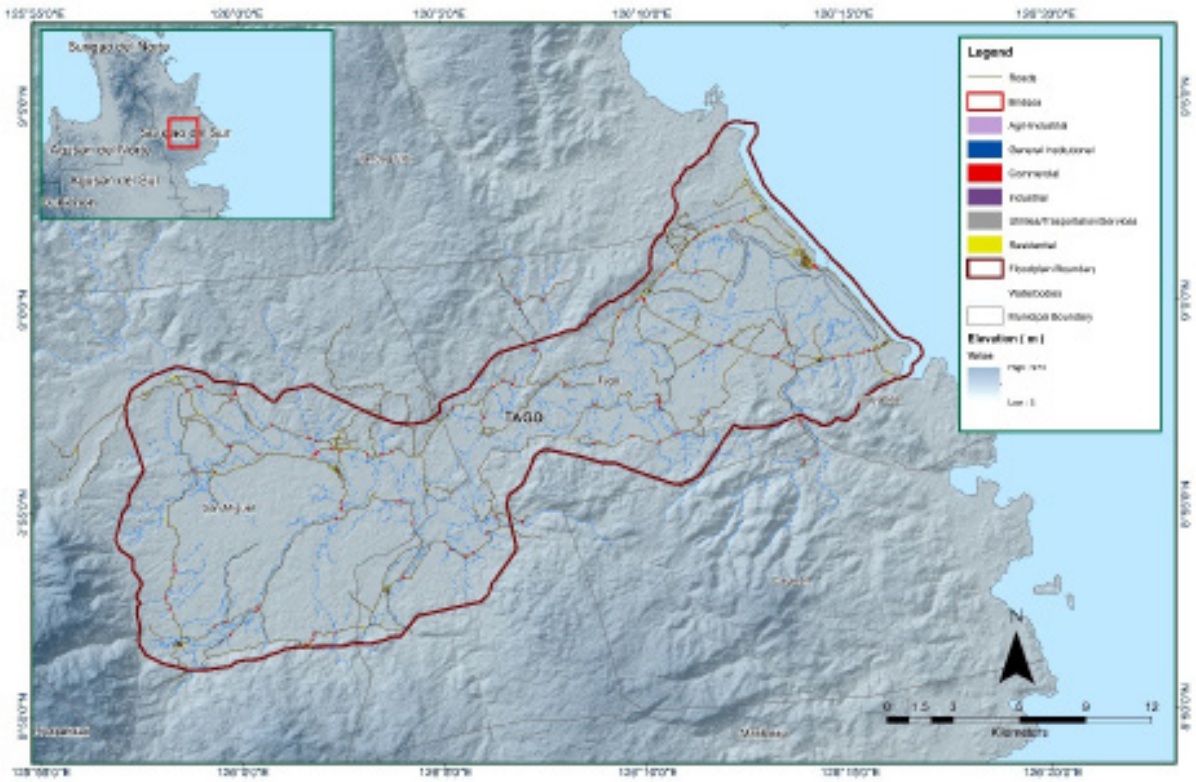

Figure 29. Extracted features for Tago Floodplain

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

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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

DVBC conducted field survey in Tago River on August 24–September 7, 2015 with the following scope of work: reconnaissance; control survey for the establishment of a control point; as-built survey of Tago-San Miguel Bridge in Brgy. Poblacion, Municipality of San Miguel, Surigao del Sur; validation points acquisition of about 166 km; and bathymetric survey from Brgy. Poblacion in San Miguel down to the mouth of the river in Brgy. La Paz in Bayabas, with an estimated length of 54.02 km using an OHMEX™ Single Beam Echo Sounder and GNSS PPK survey technique. Cross-section survey was earlier conducted by CSU – PHIL-LiDAR 1 on November 3–7, 2014 during their fieldwork in Tago River Basin that also involved flow-gathering, leveling, and establishing GNSS network.

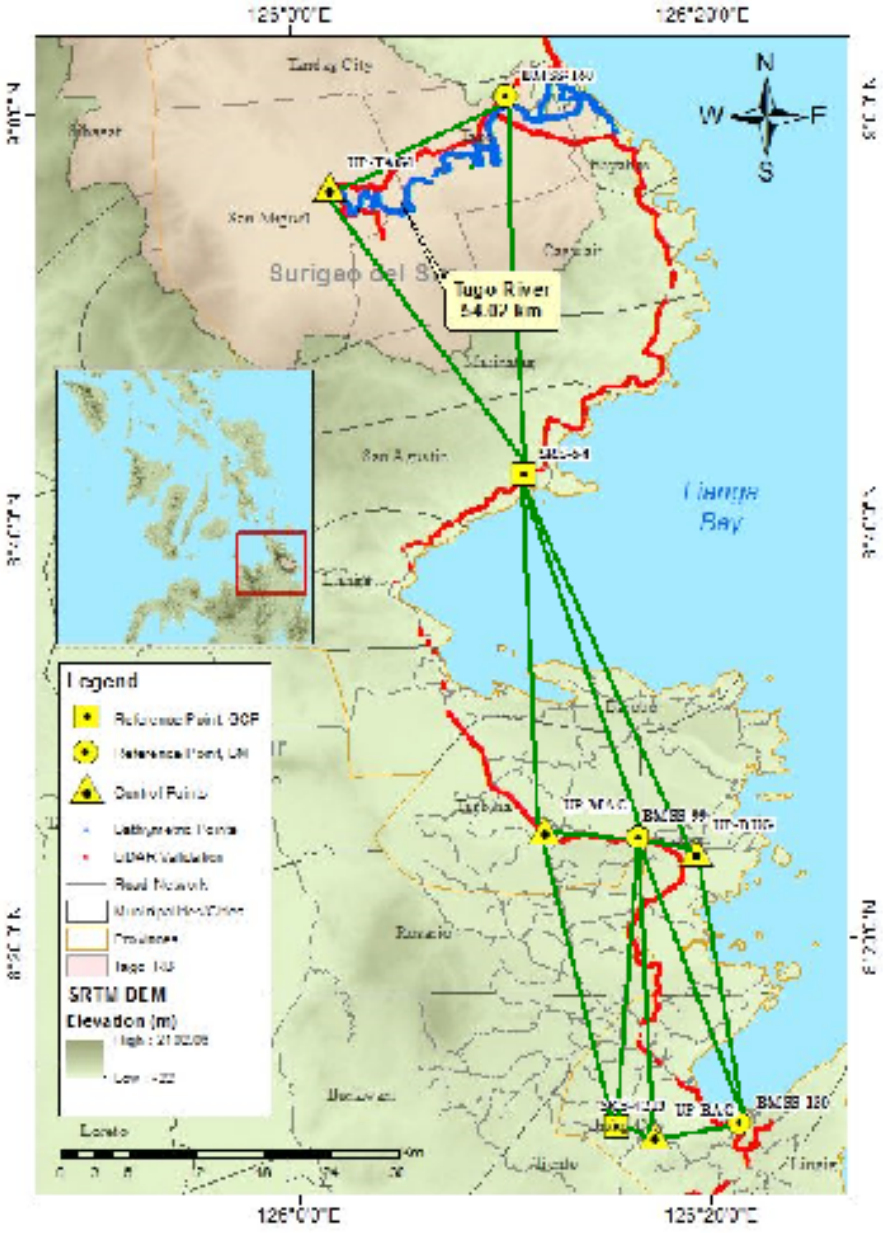


Figure 30. Extent of the bathymetric survey (in blue) in Tago River and the LiDAR data validation survey

4.2 Control Survey

The GNSS network used for Tago River Basin is composed of seven (7) loops established on August 27, September 5 and 6, 2015 occupying the following reference points: SRS-54, a second-order GCP in Brgy. Gata, Municipality of San Agustin; SS-130, a first-order BM in Brgy. Mangagoy, Bislig City; and SS-160, a first-order BM in Brgy. Gamut, Municipality of Tago, all in Surigao del Sur.

Four control points were established along the approach of bridges, namely: UP-BAG, located at the approach of Bagnan Bridge in Brgy. Mone, Bislig City; UP-DUG, at Dugmanon Bridge in Brgy, Dugmanon, Municipality of Hinatuan; UP-MAG at Maglambing Bridge in Brgy. Maglambing, Municipality of Tagbina; and UP-TAG1 located at Tago-San Miguel Bridge, Municipality of San Miguel, all in Surigao del Sur. NAMRIA established control points, namely: SS-99, in Brgy. Mahayhay, Municipality of Hinatuan; and SS-4213, at Burboanan Bridge in Brgy. Burboanan, Bislig City, were also occupied to use as marker during the survey.

The summary of references and control points and their respective locations is summarized in Table 21 while the GNSS network established is illustrated in Figure 31.

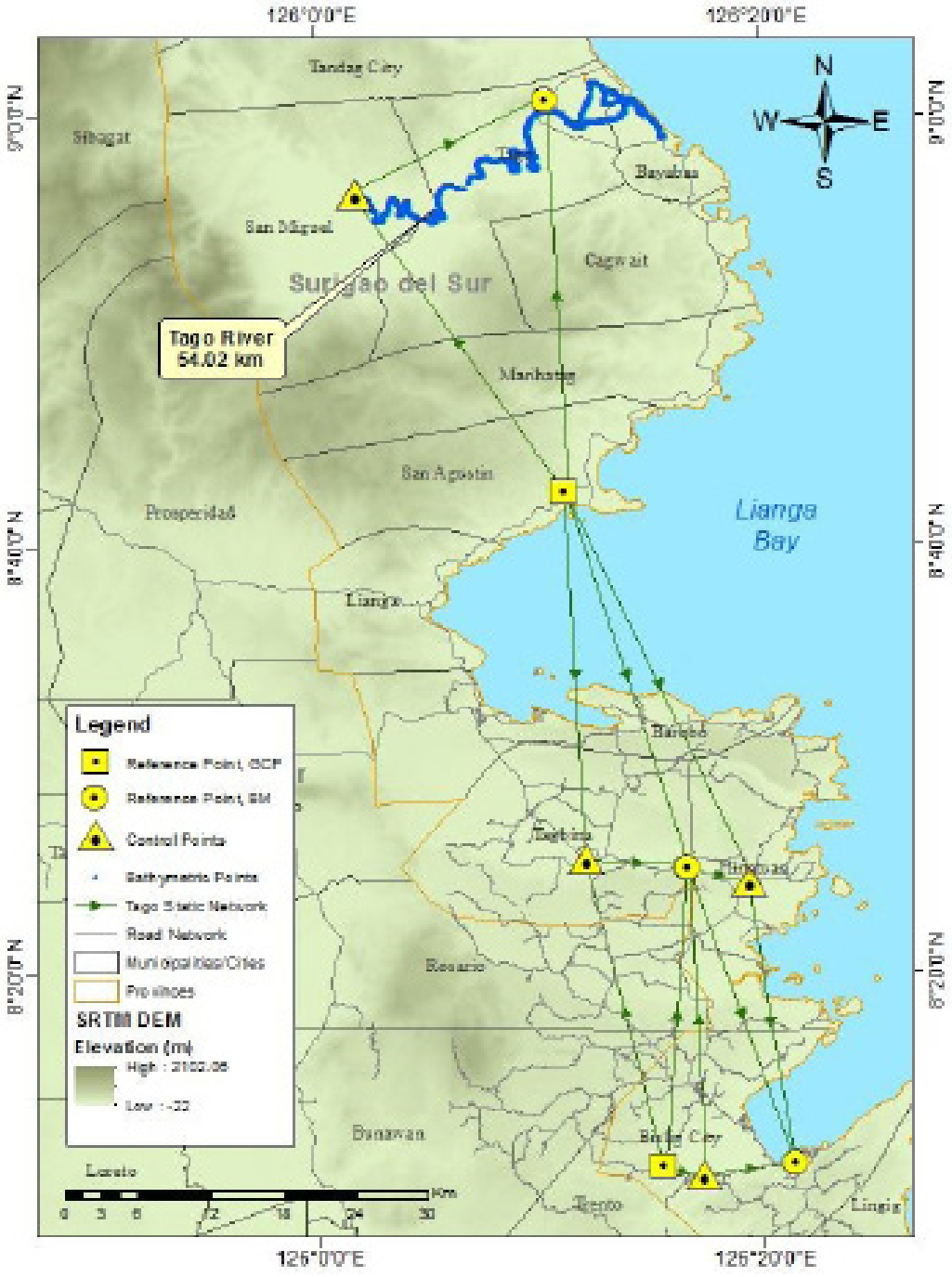


Figure 31. GNSS Network of Tago River field survey

Table 21. List of references and control points used in Surigao del Sur survey (Source: NAMRIA and UP-TCAGP)

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)				
		Latitude	Longitude	Ellipsoidal Height (m)	Elevation in MSL (m)	Date Established
SRS-54	2nd order, GCP	8°42'29.12518"	126°11'07.08070"	71.938	3.335	2007
SS-130	1st order, BM	8°11'01.30897"	126°21'23.49960"	73.969	5.237	2008
SS-160	1st order, BM	9°00'44.86640"	126°10'25.53097"	75.213	7.065	2009
SS-99	Used as Marker	8°24'53.51089"	126°16'34.96716"	98.350	29.782	2008
SRS-4213	Used as Marker	8°10'56.27507"	126°15'21.74124"	72.222	2.959	2012
UP-BAG	UP Established	8°10'28.76338"	126°17'14.48487"	71.368	2.211	Sep 5, 2015
UP-DUG	UP Established	8°24'10.91693"	126°19'18.89585"	72.157	4.035	Sep 6, 2015
UP-MAG	UP Established	8°25'15.48835"	126°12'01.07825"	82.586	13.509	Sep 6, 2015
UP-TAG1	UP Established	8°56'22.49905"	126°01'48.98421"	85.888	16.502	Aug 27, 2015

The GNSS set-ups made in the location of the reference and control points are exhibited in Figure 32 to Figure 40.

Figure 32. Trimble® SPS 852 set-up at SRS-54 near the flag pole of Gata Integrated School in San Agustin, Surigao del Sur

Figure 33. GNSS base set-up, Trimble® SPS 852 at BMSS-130, located on one end of a concrete barrier along Surigao-Davao Coastal Road in Brgy. Mangagoy, Bislig City, Surigao del Sur

Figure 34. GNSS base set-up, Trimble® SPS 852 at BMSS-160, located at Pamuksukan Bridge in Brgy. Gamut, Tago, Surigao del Sur

Figure 35. GNSS receiver set-up, Trimble® SPS 882 at BMSS-99, located inside Mahayhay Primary School in the Municipality of Hinatuan, Surigao del Sur

Figure 36. GNSS receiver set-up, Trimble® SPS 882 at BMSS-4213, located near Burboanan Bridge in Brgy. Burboanan, Bislig City, Surigao del Sur

Figure 37. GNSS base set-up, Trimble® SPS 852 at UP-BAG, located near Bagnan Bridge in Brgy. Mone, Bislig City, Surigao del Sur

Figure 38. Trimble® SPS 882 set-up at UP-DUG, located near Dugmanon Bridge in the Municipality of Hinatuan, Surigao del Sur

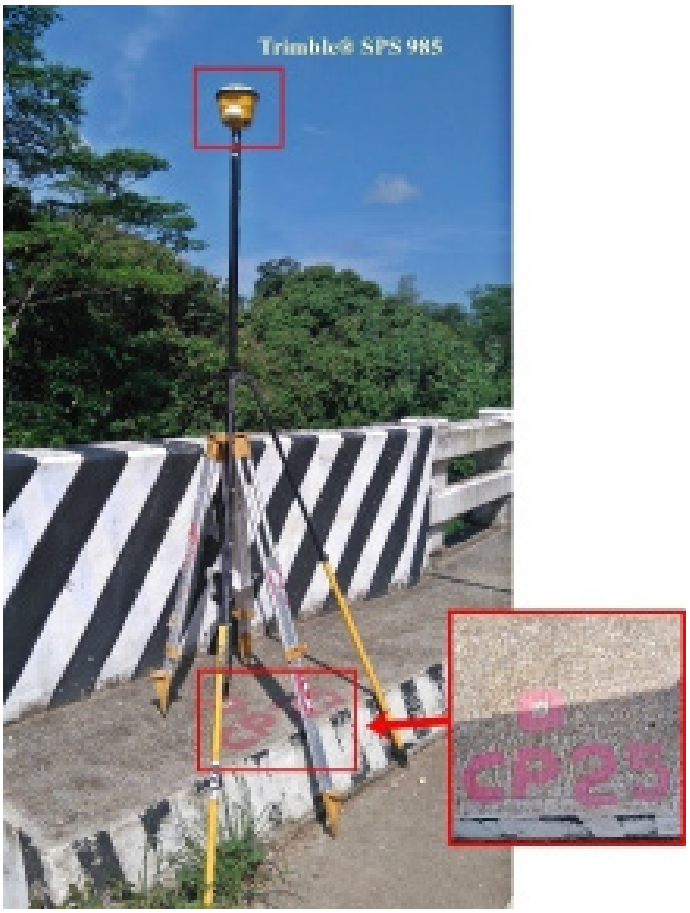


Figure 39. GNSS base set-up, Trimble® SPS 985 at UP-MAG, located at Maglambing Bridge along Surigao-Davao Coastal Road in Brgy. Maglambing in the Municipality of Tagbina, Surigao del Sur

Figure 40. GNSS base set-up, Trimble® SPS 882 at UP-TAG1, located at Tago-San Miguel Bridge, Municipality of San Miguel, Surigao del Sur

4.3 Baseline Processing

GNSS baselines were processed simultaneously in TBC by observing that all baselines have fixed solutions with horizontal and vertical precisions within +/-20cm and +/-10cm requirement, respectively. In case where one or more baselines did not meet all of these criteria, masking was performed. Masking is done by removing/masking portions of these baseline data using the same processing software. It is repeatedly processed until all baseline requirements are met. If the reiteration yields out of the required accuracy, resurvey is initiated. Baseline processing result of control points in Bislig River Basin is summarized in Table 22 generated by TBC software.

Table 22. Baseline processing report for Tago river survey

Observation	Date of Observation	Solution Type	H. Prec. (m)	V. Prec (m)	Geodetic Az.	Ellipsoid Dist. (m)	ΔHeight (Meter)
SRS-4213 --- UP-MAG	09-06-2015	Fixed	0.006	0.028	346°54'31"	27101.111	10.348
UP-BAG --- SRS-4213	09-05-2015	Fixed	0.003	0.016	283°45'49"	3553.032	0.870
SS-99 --- SS-130	09-06-2015	Fixed	0.004	0.025	160°56'32"	27048.109	-24.369
UP-BAG --- SS-130	09-05-2015	Fixed	0.007	0.030	82°31'19"	7687.540	2.595
SS-99 --- UP-BAG	09-06-2015	Fixed	0.005	0.028	177°23'35"	26593.869	-26.916
SS-99 --- SRS-4213	09-06-2015	Fixed	0.008	0.030	184°58'49"	25818.568	-26.099
SS-130 --- UP-DUG	09-06-2015	Fixed	0.004	0.026	351°04'11"	24555.772	-1.865
SS-99 --- UP-DUG	09-06-2015	Fixed	0.005	0.017	104°37'16"	5182.796	-26.175
SS-160 --- SRS-54	08-27-2015	Fixed	0.009	0.042	357°50'28"	33687.727	3.259
SS-99 --- UP-MAG	09-06-2015	Fixed	0.006	0.020	274°36'46"	8405.733	-15.761
UP-TAG1 --- SRS-54	08-27-2015	Fixed	0.005	0.037	326°20'38"	30763.333	13.888
UP-DUG --- BMSS-99	09-06-2015	Fixed	0.003	0.019	284°37'40"	5182.793	26.194
SS-99 --- UP-MAG	09-06-2015	Fixed	0.005	0.023	274°36'46"	8405.736	-15.773
SS-99 --- SRS-54	09-06-2015	Fixed	0.011	0.031	162°48'46"	33945.127	26.544
SRS-54 --- UP-MAG	09-06-2015	Fixed	0.014	0.058	177°01'20"	31798.307	10.764
UP-DUG --- SRS-54	09-06-2015	Fixed	0.005	0.025	155°57'50"	36939.414	0.268
SS-160 --- UP-TAG1	08-27-2015	Fixed	0.008	0.017	242°57'01"	17718.093	10.680

As shown in Table 22, a total of 17 baselines were processed and all of them passed the required accuracy set by the project.

4.4 Network Adjustment

After the baseline processing procedure, network adjustment was performed using TBC. Looking at the Adjusted Grid Coordinates (Table 24) of the TBC generated Network Adjustment Report, it can be observed that the square root of the sum of the squares of x and y must be less than 20cm and z less than 10cm in equation from:
$\sqrt{((x_e)^2 + (y_e)^2)} < 20$ cm

Where:

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

The nine (9) control points, SRS-54, SS-130, SS-160, SS-99, SRS-4213, UP-BAG, UP-DUG, UP-MAG, and UP-TAG1, were occupied and observed simultaneously to form a GNSS loop. Coordinates of SRS-54 and elevation values of SS-130 and SS-160 were held fixed during the processing of the control points as presented in Table 23. Through these reference points, the corrdinates and elevation of the unknown control points were computed.

Table 23. Control Point Constraints

Point ID	Type	East σ (Meter)	North σ (Meter)	Height σ (Meter)	Elevation σ (Meter)
BMSS-130	Grid				Fixed
BMSS-160	Grid				Fixed
SRS-54	Local	Fixed	Fixed		
Fixed = 0.000001(Meter)					

The list of adjusted grid coordinates, i.e., Northing, Easting, Elevation, and computed standard errors of the control points in the network, is indicated in Table 24. All fixed control points have no values for grid and elevation errors.

Table 24. Adjusted grid coordinates

Point ID	Easting (Meter)	Easting Error (Meter)	Northing (Meter)	Northing Error (Meter)	Elevation (Meter)	Elevation Error (Meter)	Constraint
BMSS-130	869923.595	0.025	906149.656	0.019	5.237	?	e
BMSS-160	848999.411	0.009	997745.370	0.008	7.065	?	e
BMSS-99	860869.543	0.023	931673.348	0.017	29.782	0.069	
SRS-4213	858838.293	0.024	905903.658	0.019	2.959	0.088	
SRS-54	850558.697	?	964056.168	?	3.335	0.072	LL
UP-BAG	862300.278	0.025	905085.566	0.019	2.211	0.083	
UP-DUG	865901.481	0.023	930405.547	0.017	4.035	0.075	
UP-MAG	852475.815	0.023	932279.823	0.018	13.509	0.085	
UP-TAG1	833273.403	0.007	989543.115	0.007	16.502	0.064	

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

SRS-54
Horizontal accuracy = Fixed
Vertical accuracy = 7.2 cm < 10 cm

SS-130
Horizontal accuracy = $\sqrt{((2.50)^2 + (1.90)^2)}$
= $\sqrt{(6.25 + 3.61)}$
= 3.14 cm< 10 cm
Vertical accuracy = Fixed

SS-160
Horizontal accuracy = $\sqrt{((0.9)^2 + (0.8)^2)}$
= $\sqrt{(0.81 + 0.64)}$
= 1.20 cm < 10 cm
Vertical accuracy = Fixed

SS-99
Horizontal accuracy = $\sqrt{((2.30)^2 + (1.70)^2)}$
= $\sqrt{(5.29 + 2.89)}$
= 2.86 cm < 20 cm
Vertical accuracy = 6.90 cm < 10 cm

SRS-4213
Horizontal accuracy = $\sqrt{((2.40)^2 + (1.90)^2)}$
= $\sqrt{(5.76 + 3.61)}$
= 3.06 cm < 20 cm
Vertical accuracy = 8.80 cm < 10 cm

UP-BAG
Horizontal accuracy = $\sqrt{((2.50)^2 + (1.90)^2)}$
= $\sqrt{(6.25 + 3.61)}$
= 3.14 cm < 20 cm
Vertical accuracy = 8.30 cm < 10 cm

UP-DUG
Horizontal accuracy = $\sqrt{((2.30)^2 + (1.70)^2)}$
= $\sqrt{(5.29 + 2.89)}$
= 2.86 cm < 20 cm
Vertical accuracy = 7.50 cm < 10 cm

UP-MAG
Horizontal accuracy = $\sqrt{((2.30)^2 + (1.80)^2)}$
= $\sqrt{(5.29 + 3.24)}$
= 2.92 cm < 20 cm
Vertical accuracy = 8.50 cm < 10 cm

UP-TAG1
Horizontal accuracy = $\sqrt{((0.70)^2 + (0.70)^2)}$
= $\sqrt{(0.49 + 0.49)}$
= 0.99 cm < 20 cm
Vertical accuracy = 6.40 cm < 10 cm

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

Table 25. Adjusted geodetic coordinates

Point ID	Latitude	Longitude	Height (Meter)	Height Error (Meter)	Constraint
BMSS-130	N8°11'01.30897"	E126°21'23.49960"	73.969	?	e
BMSS-160	N9°00'44.86640"	E126°10'25.53097"	75.213	?	e
BMSS-99	N8°24'53.51089"	E126°16'34.96716"	98.292	0.069	
SRS-4213	N8°10'56.27507"	E126°15'21.74124"	72.265	0.088	
SRS-54	N8°42'29.12518"	E126°11'07.08070"	71.864	0.072	LL
UP-BAG	N8°10'28.76338"	E126°17'14.48487"	71.388	0.083	
UP-DUG	N8°24'10.91693"	E126°19'18.89585"	72.120	0.075	
UP-MAG	N8°25'15.48835"	E126°12'01.07825"	82.582	0.085	
UP-TAG1	N8°56'22.49905"	E126°01'48.98421"	85.877	0.064	

The corresponding geodetic coordinates of the observed points are within the required accuracy as shown in Table 25. Based on the result of the computation, the accuracy condition is satisfied; hence, the required accuracy for the program was met.

The summary of reference and control points used is indicated in Table 26.

Table 26. Reference and control points used and their location (Source: NAMRIA, UP-TCAGP)

Point ID	Order of Accuracy	Geographic Coordinates (WGS 84)			UTM ZONE 51 N		
		Latitude	Longitude	Ellipsoidal Height (m)	Northing (m)	Easting (m)	BM Ortho (m)
SRS-54	2nd Order, GCP	8°42'29.12518"	126°11'07.08070"	71.864	964056.168	850558.697	3.335
SS-130	1st Order, BM	8°11'01.30897"	126°21'23.49960"	73.969	906149.656	869923.595	5.237
SS-160	1st Order, BM	9°00'44.86640"	126°10'25.53097"	75.213	997745.370	848999.411	7.065
SS-99	Used as Marker	8°24'53.51089"	126°16'34.96716"	98.292	931673.348	860869.543	29.782
SRS-4213	Used as Marker	8°10'56.27507"	126°15'21.74124"	72.265	905903.658	858838.293	2.959
UP-BAG	UP Established	8°10'28.76338"	126°17'14.48487"	71.388	905085.566	862300.278	2.211
UP-DUG	UP Established	8°24'10.91693"	126°19'18.89585"	72.120	930405.547	865901.481	4.035
UP-MAG	UP Established	8°25'15.48835"	126°12'01.07825"	82.582	932279.823	852475.815	13.509
UP-TAG1	UP Established	8°56'22.49905"	126°01'48.98421"	85.877	989543.115	833273.403	16.502

4.5 Cross-section and Bridge-as-built survey and Water Level Marking

Cross-section survey of Tago-San Miguel Bridge was conducted by Caraga State University PHIL-LiDAR during their fieldwork on November 3–7, 2014. The values gathered from this survey was validated and adjusted by DVBC to be fit with the data of as-built survey.

As-built survey was performed on August 25, 2015 at Tago-San Miguel Bridge, in Brgy. Poblacion, Municipality of San Miguel, Surigao del Sur. The survey was conducted with the application of PPK technique using a survey grade GPS, Trimble® SPS 882 as shown in Figure 41.

Figure 41. (a) As-built survey on the upper dike using Trimble® SPS 882
(b) measuring the width of one of the piers in Tago-San Miguel Bridge

As-built features of the bridge were determined to get the distance of piers and abutments from the bridge approach. The location map, cross-section diagram, and bridge as-built form are shown in Figure 42 to Figure 44, respectively. Cross-section data was incorporated with as-built data to create a cross-section diagram of Tago-San Miguel bridge.

The water surface elevation of Tago River at its left bank was acquired using PPK survey technique on September 01, 2015 at 12:14 pm. The resulting water surface elevation data was translated to 4.950 m MSL.

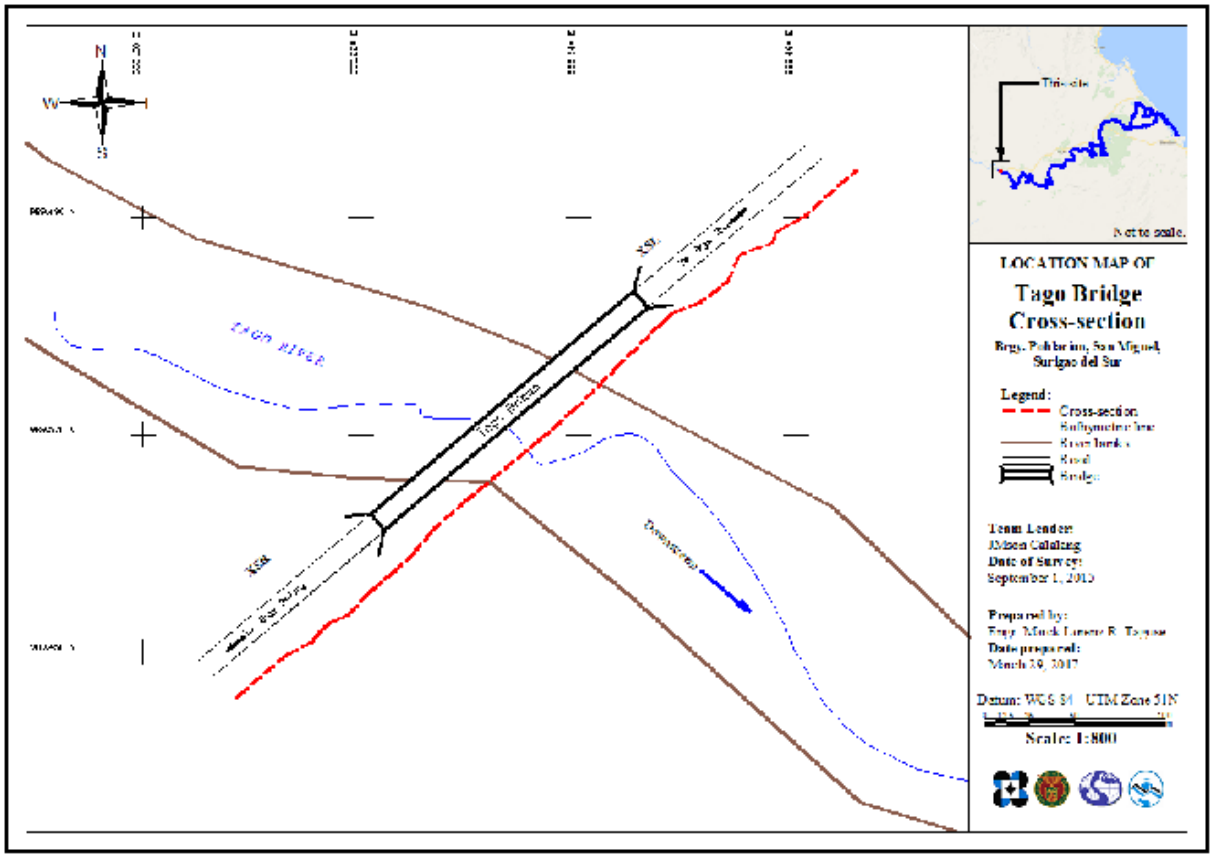


Figure 42. Tago bridge cross-section location map

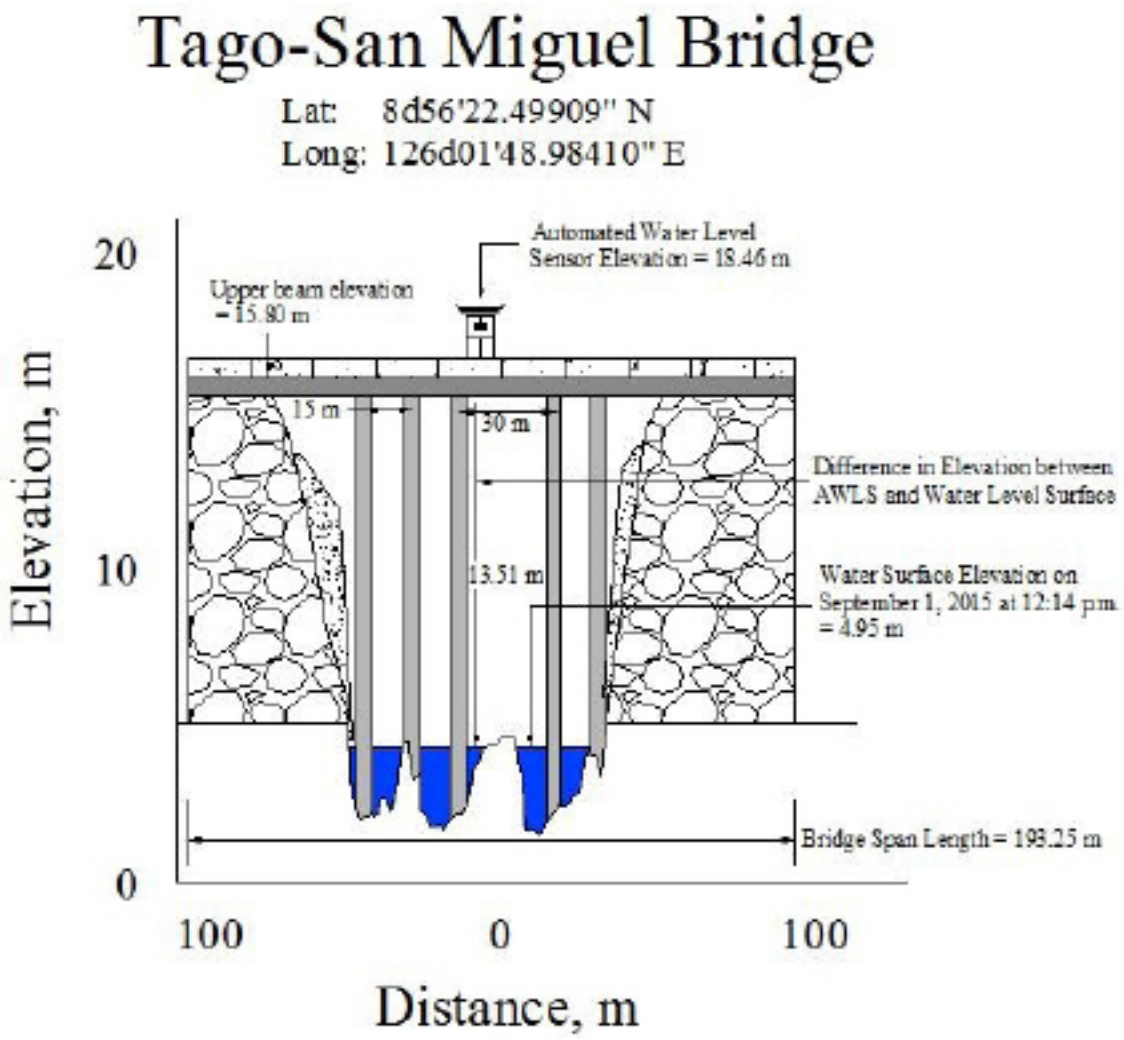


Figure 43. Tago Bridge cross-section diagram

Bridge Data Form

Bridge Name: TAGO-SAN MIGUEL BRIDGE **Date:** September 1, 2015

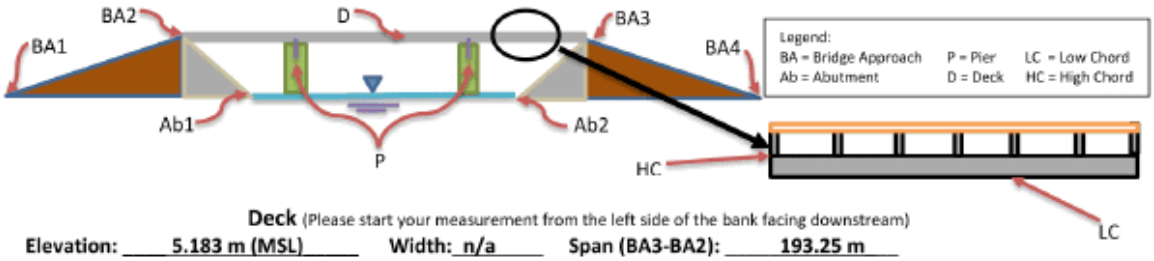
River Name: TAGO RIVER **Time:** 12:14 pm

Location (Brgy, City, Region): Brgy. Poblacion, San Miguel, Surigao del Sur

Survey Team: DVBC/DVC Surigao del Sur Team Survey – Team JM

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

Latitude: 8°56'22.49909"N **Longitude:** 126°01'48.98410" E



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

Elevation: 5.183 m (MSL) **Width:** n/a **Span (BA3-BA2):** 193.25 m

	Station	High Chord Elevation	Low Chord Elevation
1	Pier 1	15.785 m	
2	Pier 2	15.767 m	
3	Pier 3	15.709 m	
4	Pier 4	15.821 m	
5	Pier 5	15.767 m	

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	16.288	BA3	110.421	16.264
BA2	36.483	16.339	BA4	n/a	n/a

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

	Station (Distance from BA1)	Elevation
Ab1	36.446	14.265
Ab2	50.947	5.183

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

Shape: ___ __ **Number of Piers:** 5 **Height of column footing:** _____

	Station (Distance from BA1)	Elevation	Pier Width
Pier 1	54.299	15.785	
Pier 2	69.698	15.767	
Pier 3	84.841	16.368	
Pier 4	115.101	16.480	
Pier 5	129.667	16.426	

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

Figure 44. Tago Bridge as-built survey data form

4.6 Validation Points Acquisition Survey

Validation points acquisition survey was conducted for 3 days on August 25, 26, and 31, 2015. A Trimble® SPS 882 was attached on the side of a vehicle, as shown in Figure 45, to measure points utilizing continuous topo method in a PPK survey technique. The height of instrument was measured and a 2.404-meter distance from the ground up to the bottom of notch was noted. Points were gathered along major concrete roads with the aid of a vehicle which moved at a speed of 20–40 kph, cutting across the flight strips of the DAC with the aid of available topographic maps and Google EarthTM images.

On August 25, ground validation survey covered the roads from the Municipality of Tago going east towards Brgy. Poblacion in San Miguel. An established point, UP-TAG1, was used as base station. The second day of this survey started also in the Municipality of Tago going to Lanuza in the North via national road using BMSS-160 as base station. The ground validation on August 31 ran from the Municipality of Tago going south towards the Municipality of Barobo via Surigao-Davao Coastal Road. The GCP SRS-54 was used as based for the last route.

Figure 45. Validation points acquisition survey set-up: A Trimble® SPS 882, mounted in a 2-meter pole and attached in front of the vehicle

The map in Figure 46 shows the extent of the ground validation survey which acquired 27,314 ground validation points with an approximate length of 166 km.

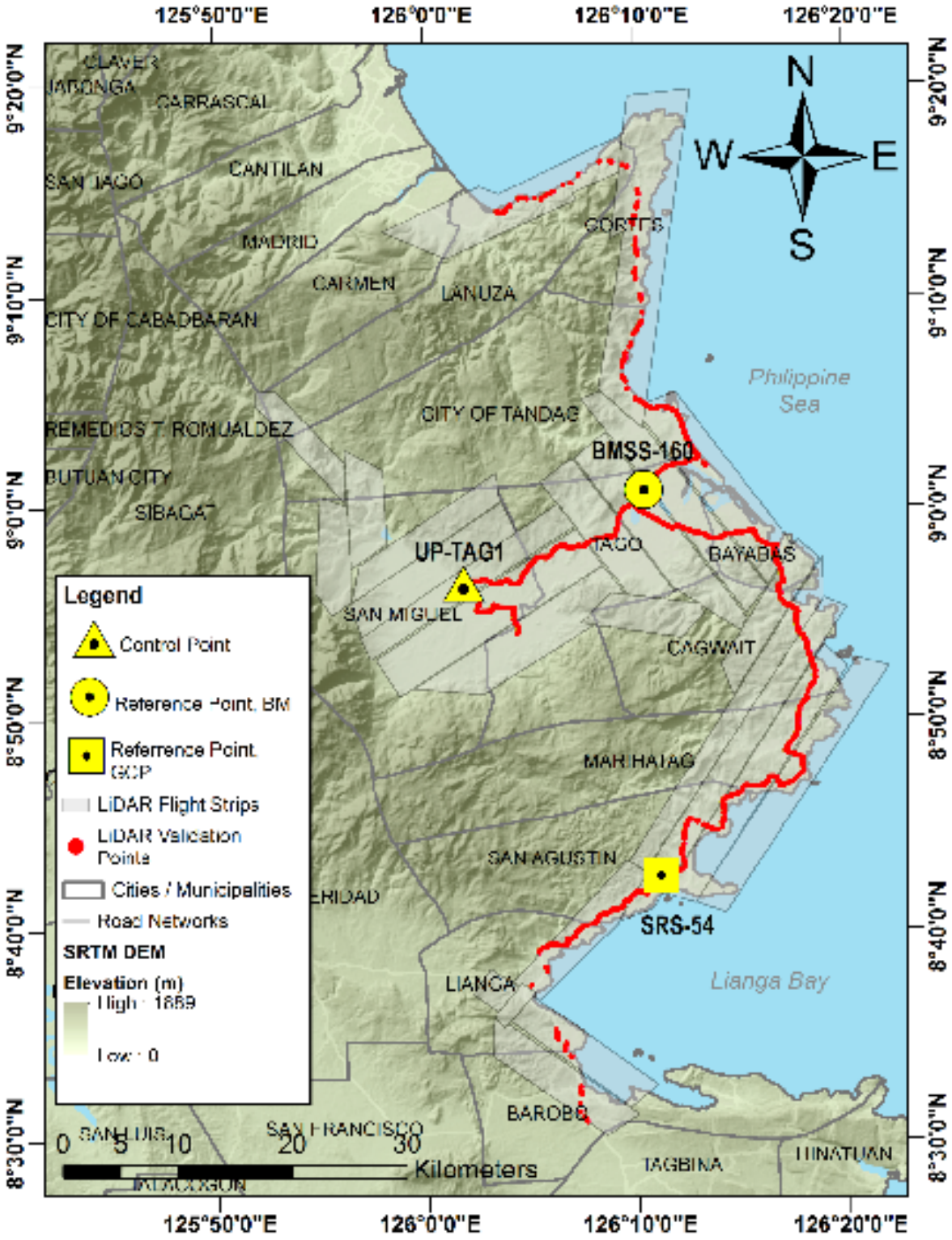


Figure 46. LiDAR validation points acquisition survey extent in Tago River Basin

4.7 Bathymetric Survey

Bathymetric survey was conducted on August 26–29, 2015 at Tago River using Trimble® SPS 882 in GNSS PPK survey technique and an installed Ohmex™ Single Beam echo sounder mounted at the side of a boat as shown in Figure 47.

Figure 47. Bathymetry set-up using OHMEX™ single beam echo sounder with a Trimble® SPS 882

The survey started at the upstream part of the river in Brgy. Poblacion, Municipality of San Miguel with coordinates 8°56'24.62195"N, 126°01'44.43002"E down to the mouth of the river in Brgy. La Paz, Municipality of Bayabas, both in Surigao Del Surin Brgy. Kahayag, also in Bislig City with coordinates 8°59'02.14683"N, 126°15'45.21483"E as shown in Figure 48. The NAMRIA-established control point SS-160 and UP-established control point UP-TAG1 were used as base station all throughout the bathymetric survey.

Figure 48. Bathymetric survey of Tago River

A CAD drawing was also produced to illustrate the Tago riverbed profile. As shown in Figure 49 to Figure 51, the highest and lowest elevation garnered a 14-meter difference. The highest elevation observed was 5.07 meters located in Brgy. Poblacion, Municipality of San Miguel, while the lowest elevation value observed was -16.564 below MSL located in Brgy. Cagdapao, Municipality of Tago. The bathymetric survey gathered 57,945 points and produced a centerline profile covering 46.69 km of the river.

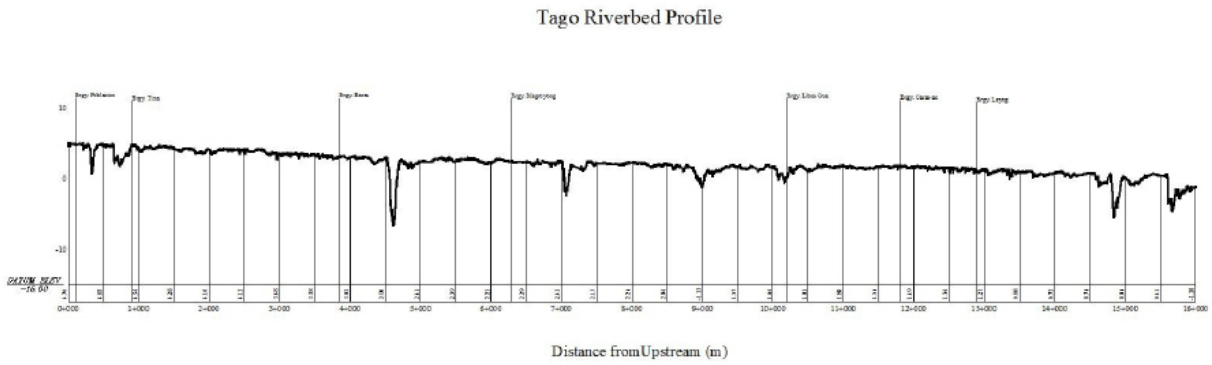


Figure 49. Riverbed profile of Tago River (Part 1)

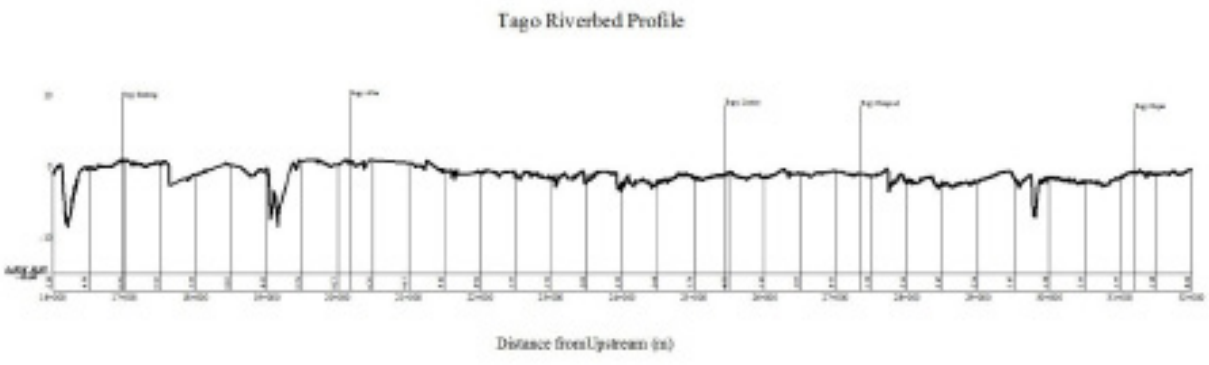


Figure 50. Riverbed profile of Tago River (Part 2)

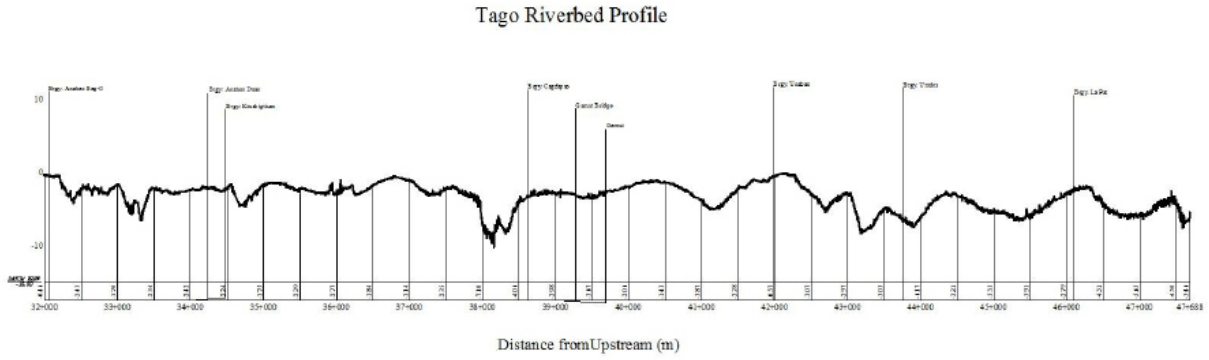


Figure 51. Riverbed profile of Tago River (Part 3)

CHAPTER 5: FLOOD MODELING AND MAPPING

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

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

5.1 Data Used for Hydrologic Modeling

5.1.1 Hydrometry and Rating Curves

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

5.1.2 Precipitation

Precipitation data was taken from one automatic rain gauge (ARG) installed by the Department of Science and Technology – Advanced Science and Technology Institute (DOST-ASTI). This is the Tina ARG which is being installed in the Municipality of San Miguel. The location of the rain gauge is shown in Figure 52.

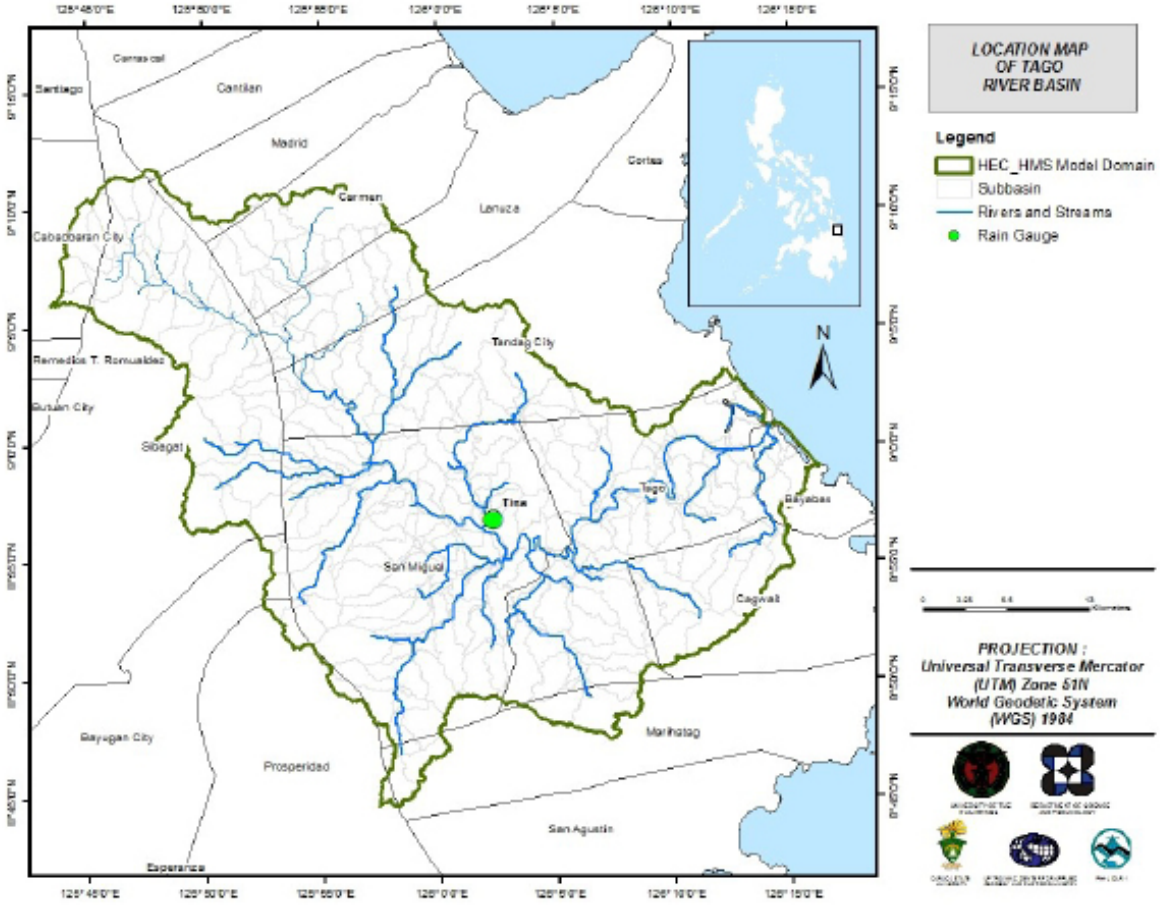


Figure 52. Location map of rain gauge used for the calibration of the Tago HEC-HMS model

The total rain recorded from Tina rain gauge from 15 December 2014 00:00 to 29 December 2014 23:45 is 465 mm. It peaked to 10.6 mm on 17 December 2014 16:00. The lag time between the peak rainfall and its corresponding peak discharge at Cabtic Bridge is 7 hours and 50 minutes.

5.1.3 Rating Curves and River Outflow

A rating curve was developed at Cabtic Bridge, San Miguel, Surigao del Sur (8°56'23.32"N, 126°01'50.13"E). It gives the relationship between the observed water levels from the Cabtic Bridge Automated Water Level Sensor (AWLS) and outflow of the watershed at this location.

For Cabtic Bridge, the rating curve is expressed as Q = 245.83H + 1374.2 as shown in Figure 54.

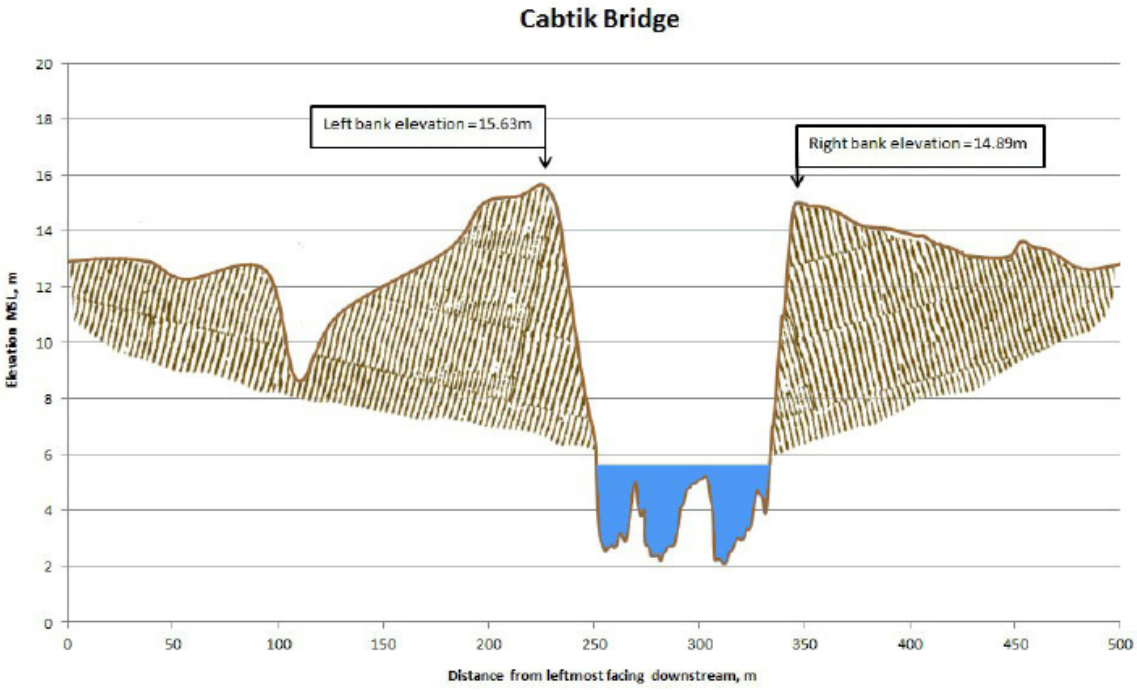


Figure 53. Cross-section plot of the Tago Bridge

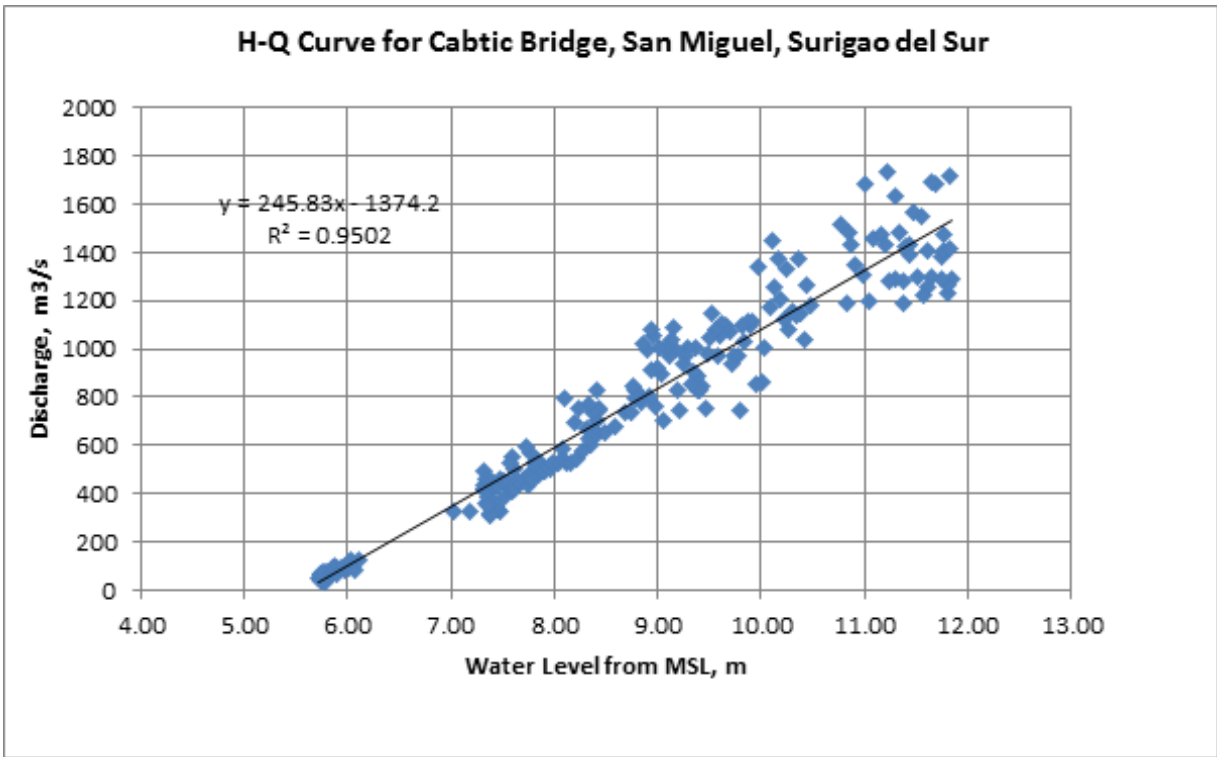


Figure 54. Rating curve at Cabtic Bridge, San Miguel, Surigao del Sur

The river outflow measured at Cabtic Bridge (Figure 55) was utilized for the calibration of the HEC-HMS model. Peak discharge is 1,538.73 cubic meter per second (cms) at 9:40 AM, December 19, 2014.

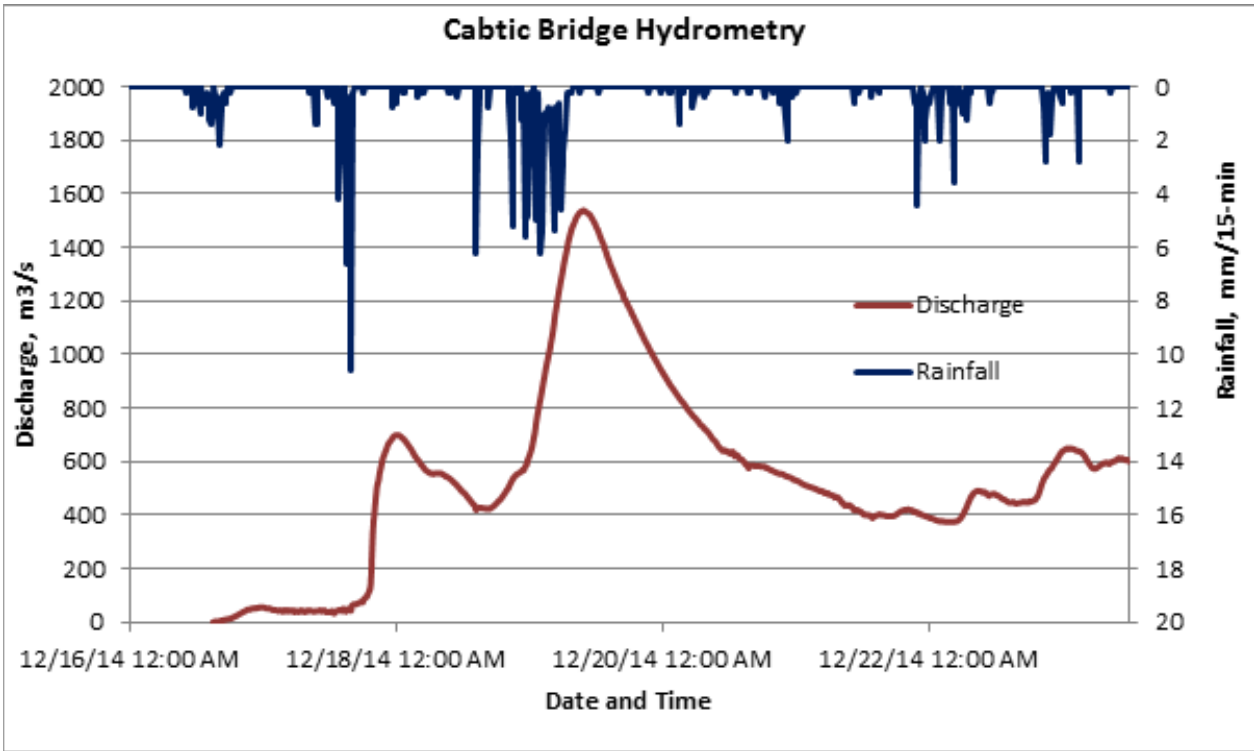


Figure 55. Rainfall at TinaARG and outflow data at Cabtic Bridge used for modeling

5.2 RIDF Station

The Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) computed Rainfall Intensity Duration Frequency (RIDF) values for the Hinatuan Rain Gauge. This station was chosen based on its proximity to the Tago watershed. The extreme values (Table 27) for this watershed were computed based on a 42-year record.

Table 27. Computed extreme values (in mm) of precipitation at Tago River Basin based on average RIDF data of Hinatuan station

COMPUTED EXTREME VALUES (in mm) OF PRECIPITATION									
T (yrs)	5 mins	10 mins	15 mins	1 hr	2 hrs	3 hrs	6 hrs	12 hrs	24 hrs
5	15.9	31.9	35.9	82.8	116.9	141.9	190.6	230.6	276.5
10	18.5	36.9	41.7	96.6	137.5	167.2	228.9	274.4	326.5
25	21.7	43.3	49	114.2	163.5	199.1	277.3	329.8	389.7
50	24.1	48.1	54.4	127.2	182.8	222.8	313.2	370.9	436.6
100	26.4	52.8	59.8	140.1	202	246.3	348.8	411.7	483.1

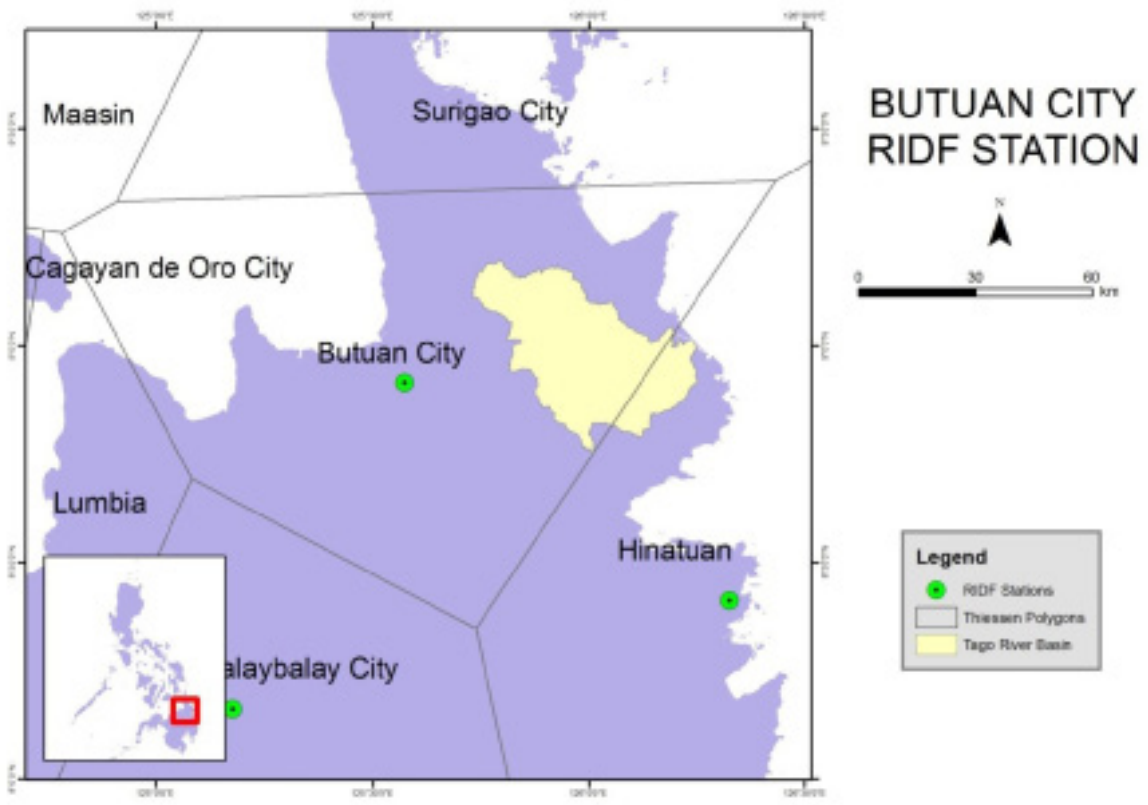


Figure 56. Location of Hinatuan RIDF Station relative to Tago River Basin

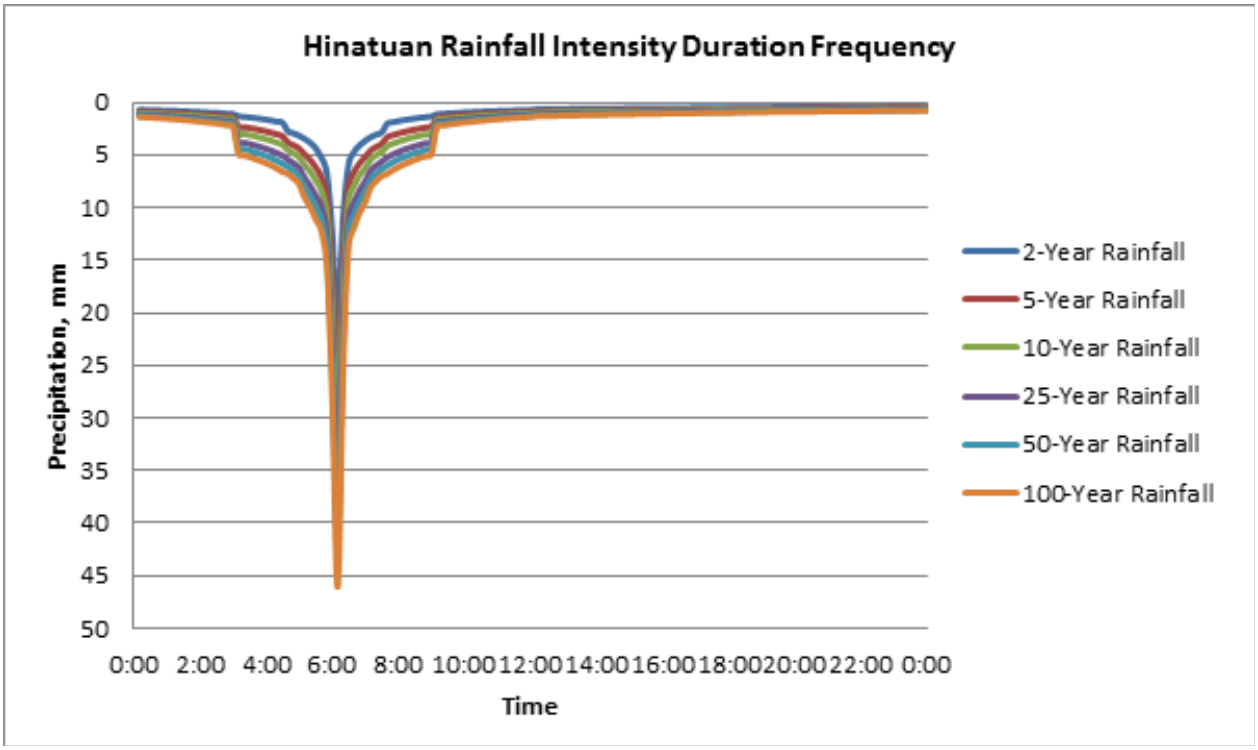


Figure 57. Hinatuan RIDF curves

5.3 HMS Model

The soil dataset (dated 2004) was obtained from the Department of Agriculture – Bureau of Soils and Water Management (DA-BSWM). The land cover dataset was taken from the National Mapping and Resource information Authority (NAMRIA).

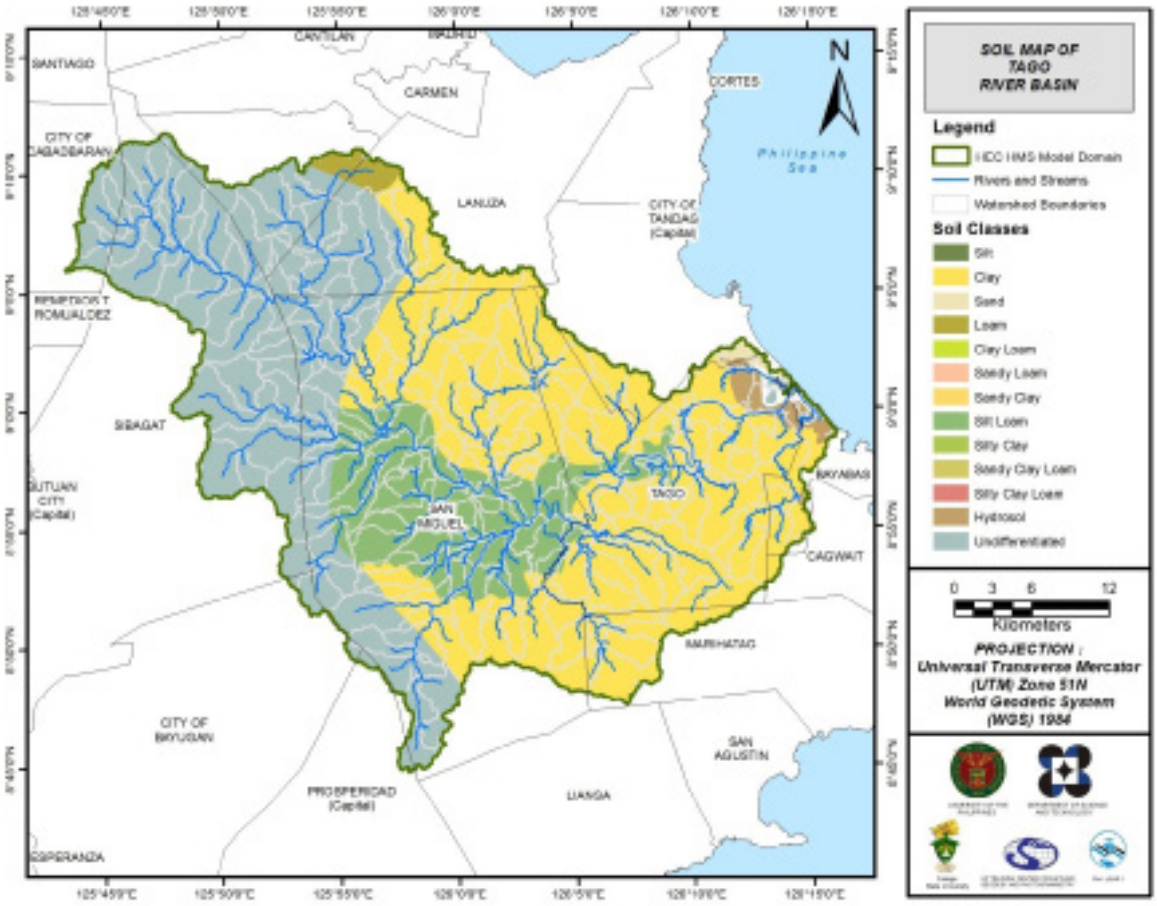


Figure 58. The soil map of the Tago River Basin used for the estimation of the CN parameter. (Source: DA-BSWM)

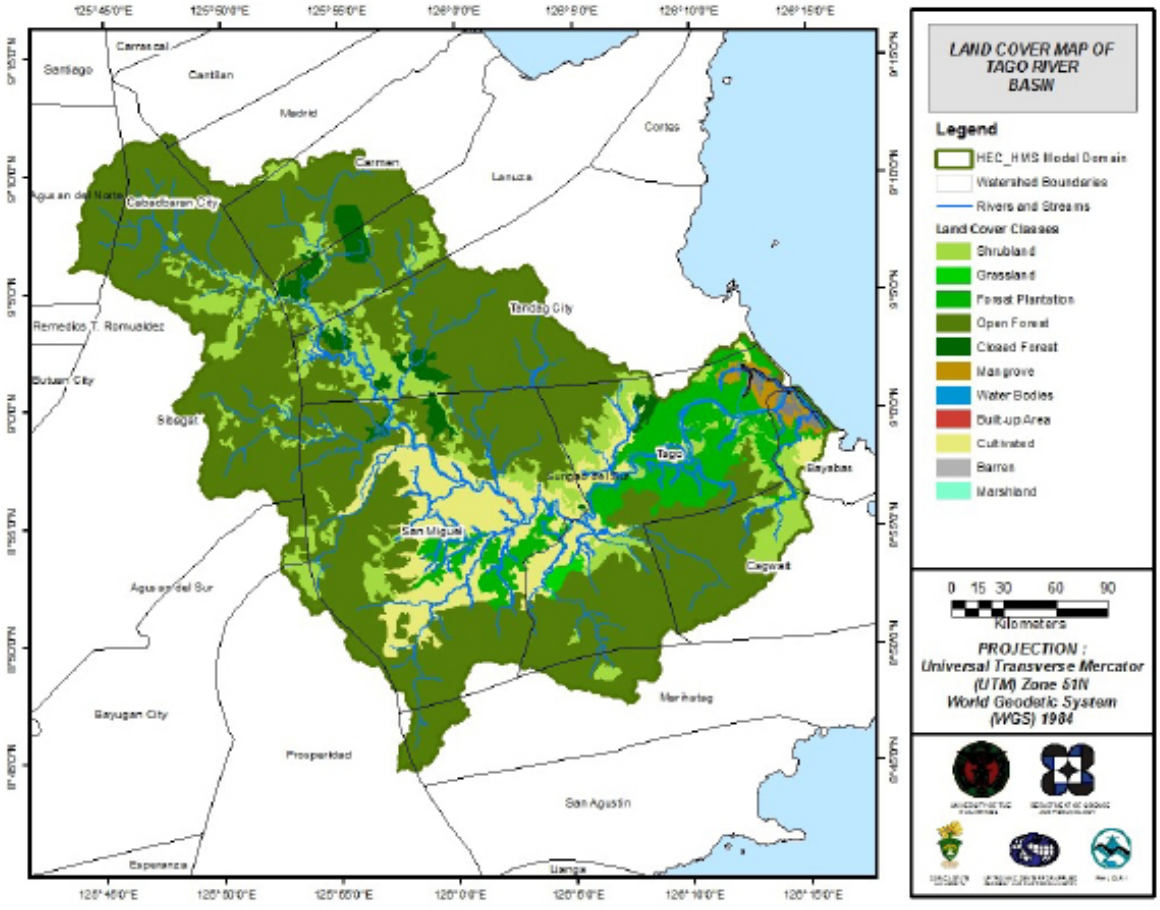


Figure 59. Land cover map of the Tago River Basin used for the estimation of the CN and watershed lag parameters of the rainfall-runoff model (Source: NAMRIA)

For Tago, the soil classes identified weremostly clay, silt clay, and undifferentiated soil. The land cover types identified were cultivated land, shrublands, grassland, mangrove, and open canopy forest.

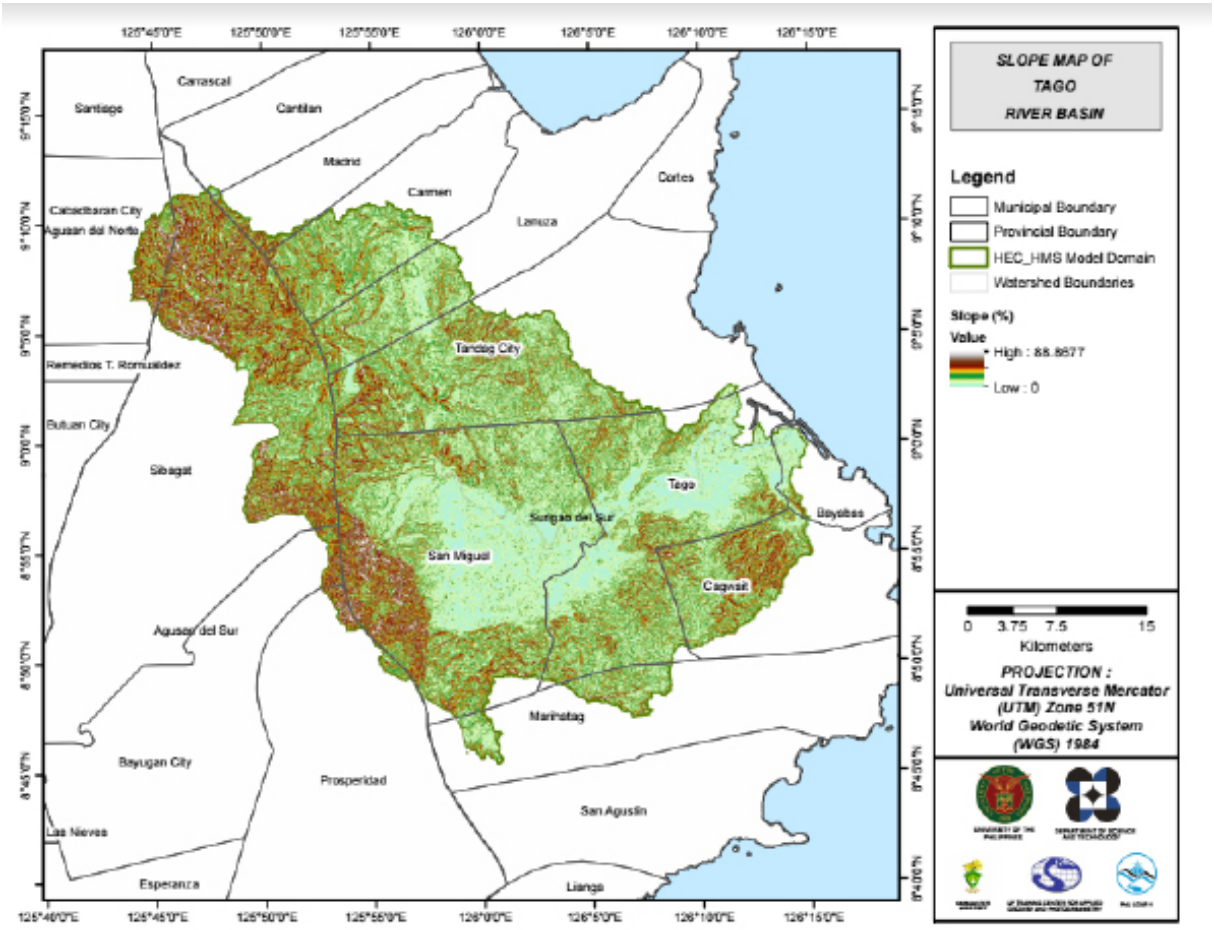


Figure 60. Slope map of the Tago River Basin

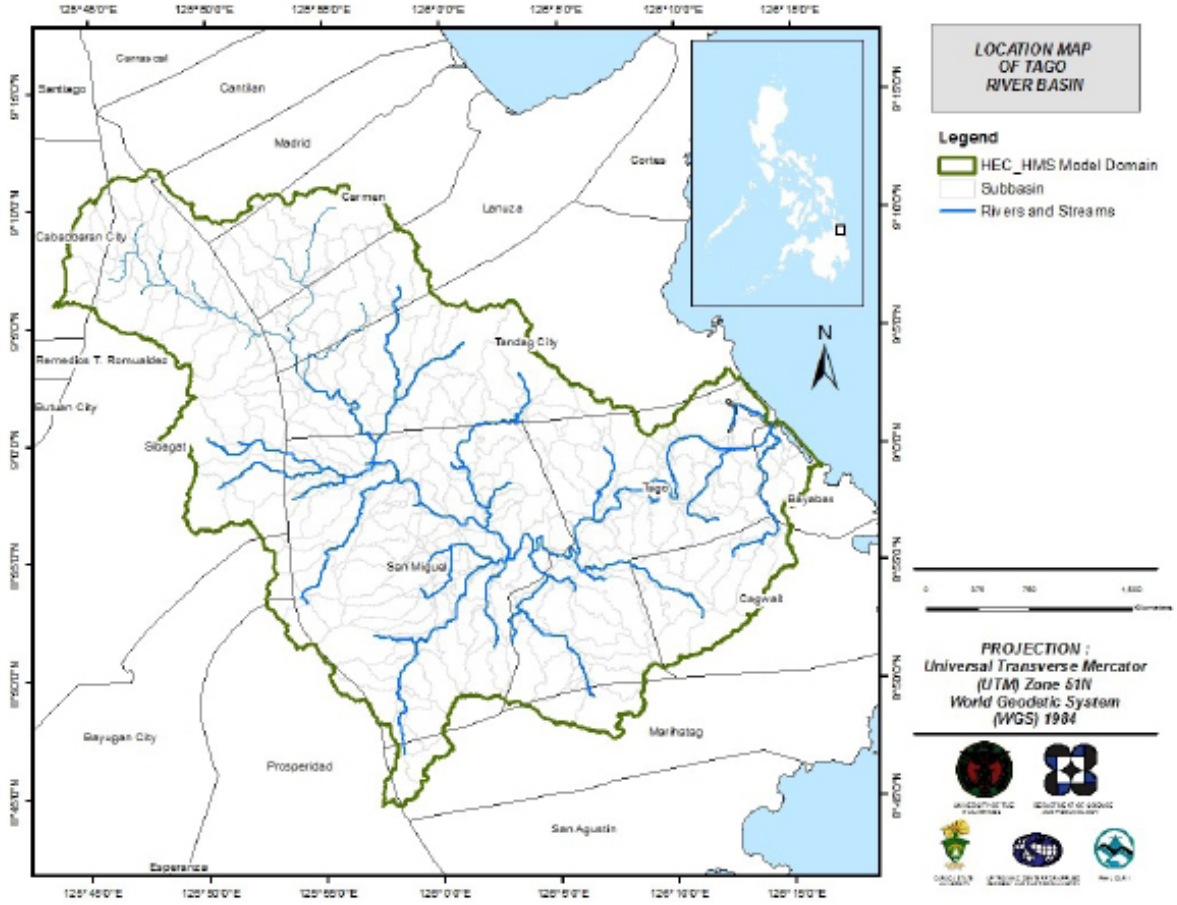


Figure 61. Stream delineation map of Tago River Basin

The Tago basin model consists of 296 subbasins, 158 reaches, and 157 junctions. This basin model is illustrated in Figure 62. The basins were identified based on the delineation using the 10 meter SAR DEM and the resampled 10 meter LiDAR DTM. Precipitation was taken from DOST rain gauges. Finally, it was calibrated using data from Cabtic Bridge Automated Water Level Station (AWLS) as shown in Figure 63.

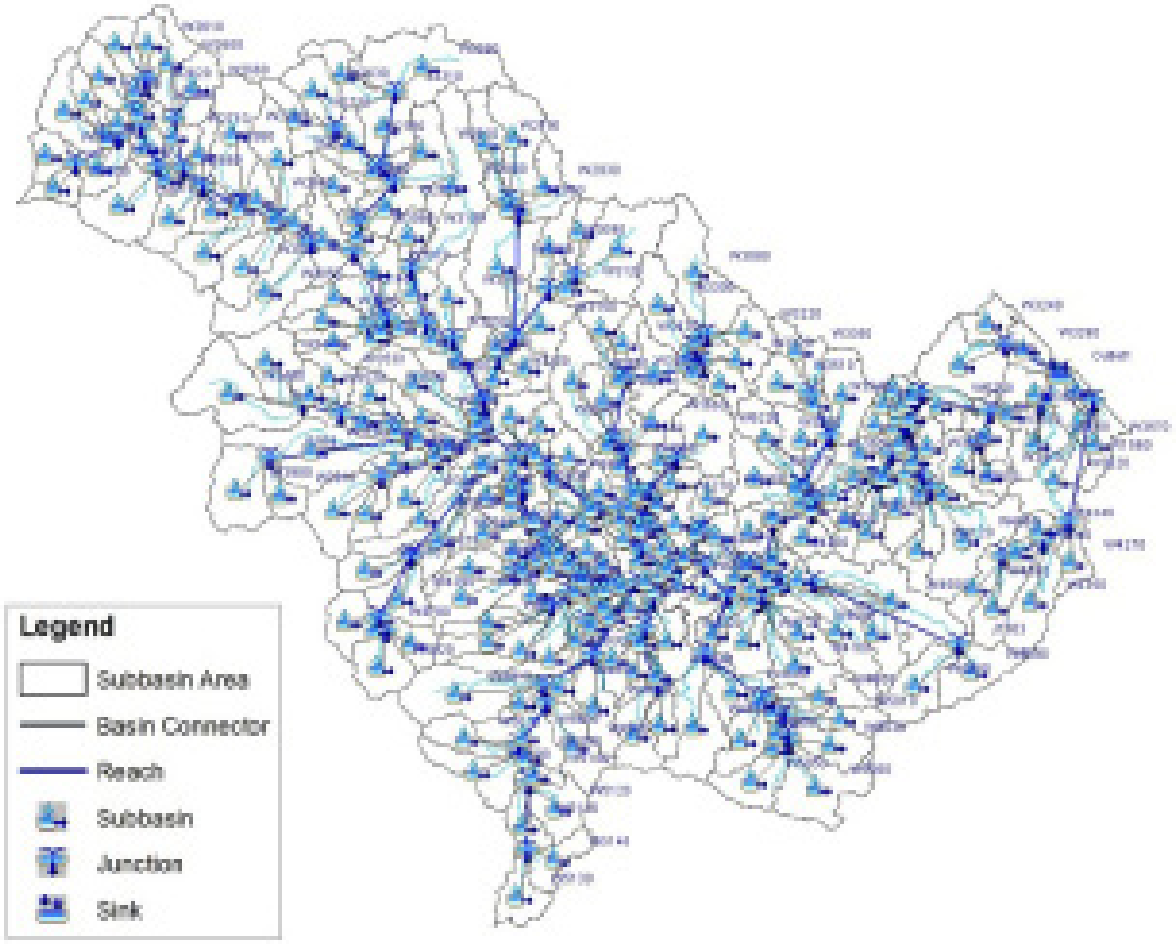


Figure 62. The Tago River Basin model generated using HEC-HMS

5.4 Cross-section Data

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

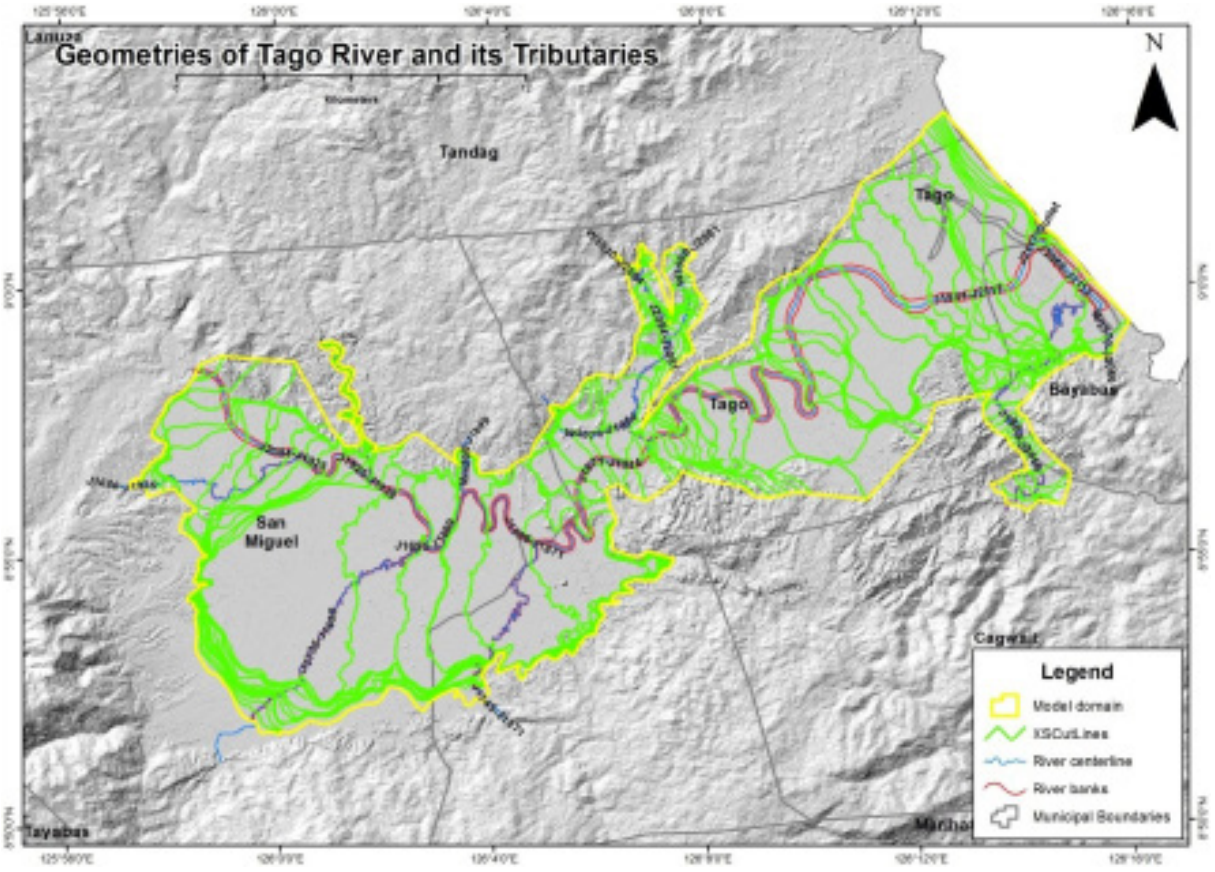


Figure 63. Created geometries of Tago HEC RAS model

5.5 Flo 2D Model

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

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

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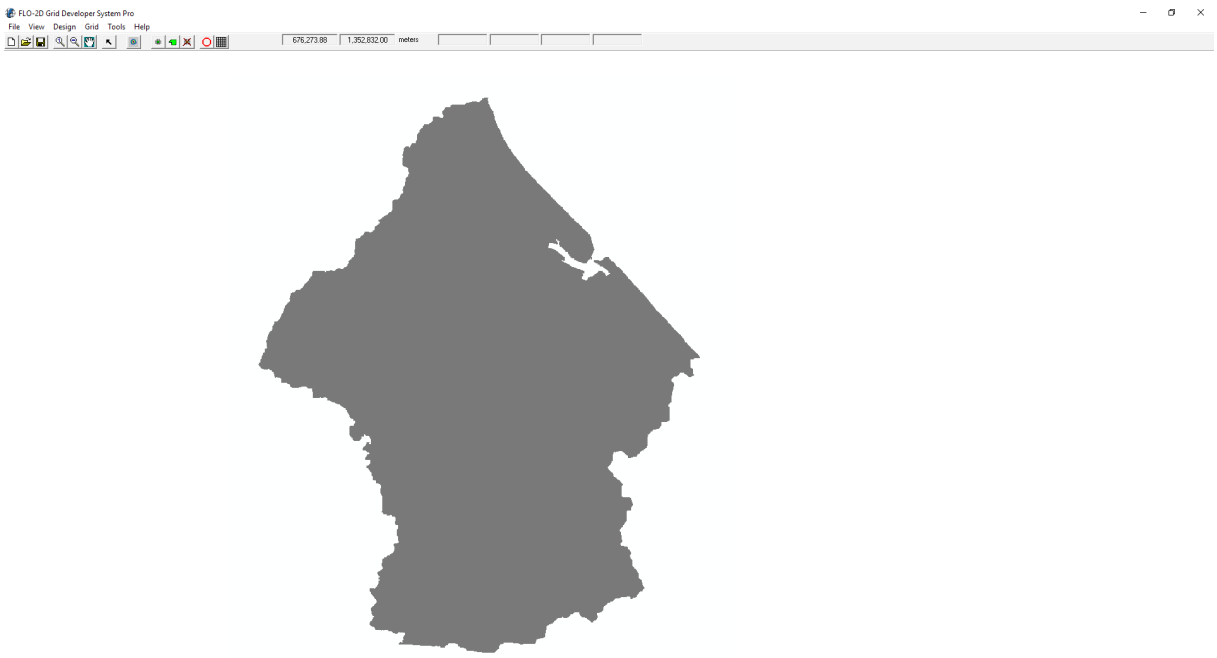

Figure 64. Screenshot of subcatchment with the computational area to be modeled in FLO-2D GDS Pro

5.6 Results of HMS Calibration

After calibrating the Tago HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 65 shows the comparison between the two discharge data. ANNEX 9 lists the Tago model basin parameters.

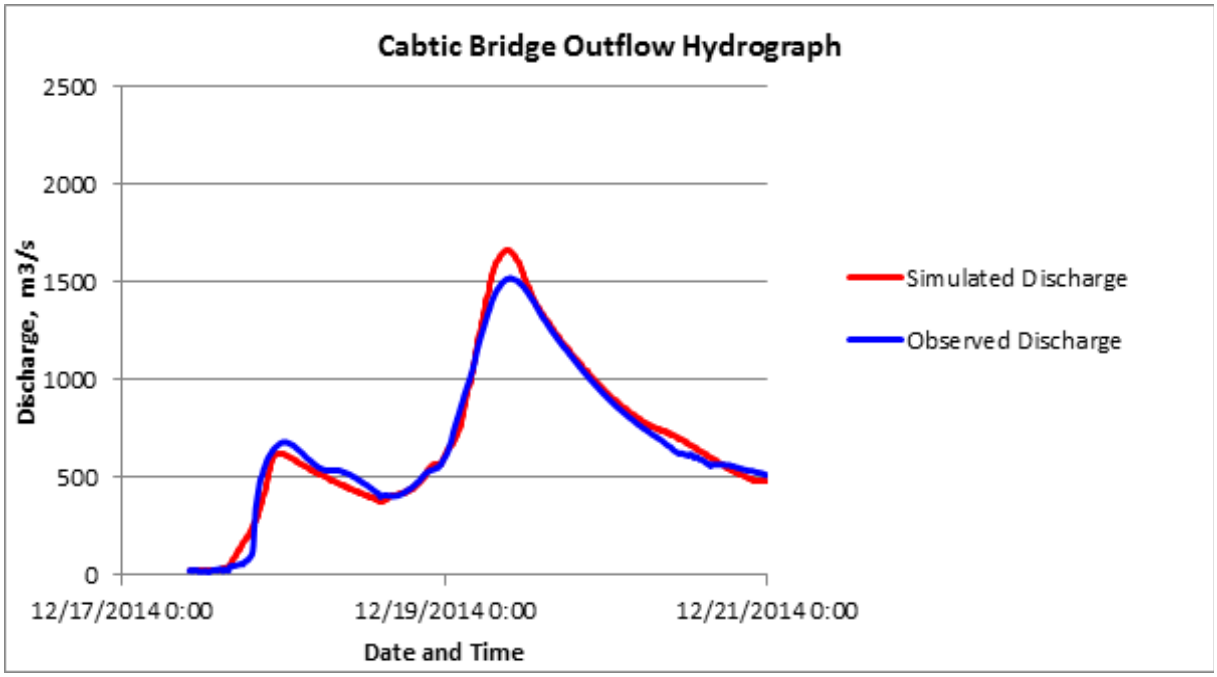

Figure 65. Outflow hydrograph of Cabtic Bridge produced by the HEC-HMS model compared with observed outflow

Enumerated in Table 28 are the adjusted ranges of values of the parameters used in calibrating the model.

Table 28. Range of calibrated values for Tago River Basin

Hydrologic Element	Calculation Type	Method	Parameter	Range of Calibrated Values
Basin	Loss	SCS Curve number	Initial Abstraction (mm)	0
			Curve Number	75-98
	Transform	Clark Unit Hydrograph	Time of Concentration (hr)	0.34-10.73
			Storage Coefficient (hr)	0.60-18.78
	Baseflow	Recession	Recession Constant	0.4
			Ratio to Peak	0.8
Reach	Routing	Muskingum-Cunge	Manning's Coefficient	0.06-0.261

Curve number is the estimate of the precipitation excess of soil cover, land use, and antecedent moisture. The magnitude of the outflow hydrograph increases as curve number increases. The range of 75–98 for curve number is advisable for Philippine watersheds depending on the soil and land cover of the area.

Time of concentration and storage coefficient are the travel time and index of temporary storage of runoff in a watershed. The range of calibrated values from 0.34 to 10.73 hours determines the reaction time of the model with respect to the rainfall. The peak magnitude of the hydrograph also decreases when these parameters are increased.

Recession constant is the rate at which baseflow recedes between storm events and ratio to peak is the ratio of the baseflow discharge to the peak discharge. A recession constant of 0.4 indicates that the basin will quickly go back to its initial discharge.

Manning's roughness coefficient of 0.06 to 0.261 corresponds to the common roughness of Philippine watersheds. Tago River Basin is determined to be cultivated with mature field crops.

Table 29. Summary of the efficiency test of Tago HMS Model

Accuracy Measure	Value
r^2	0.9839
NSE	0.98
PBIAS	-0.76
RSR	0.15

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was identified to be 55.8 m3/s.

The Pearson correlation coefficient (r2) assesses the strength of the linear relationship between the observations and the model. A value close to 1 corresponds to an almost perfect match of the observed discharge and the resulting discharge from the HEC HMS model. Here, it measured 0.9839.

The Nash-Sutcliffe (E) method was also used to assess the predictive power of the model, with E = 1 being the optimal value. The model attained an efficiency coefficient of 0.98.

A positive Percent Bias (PBIAS) indicates a model's propensity towards under-prediction. Negative values indicate bias towards over-prediction. The optimal value is 0. In the model, the PBIAS is -0.76.

The Observation Standard Deviation Ratio (RSR) is an error index. A perfect model attains a value of 0 when the error in the units of the valuable a quantified. The model has an RSR value of 0.15.

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

5.7.1 Hydrograph using the Rainfall Runoff Model

The summary graph (Figure 66) shows the Tago outflow using the Hinatuan RIDF curves in 5 different return periods (5-year, 10-year, 25-year, 50-year, and 100-year rainfall time series) based on the PAGASA data. The simulation results reveal significant increase in outflow magnitude as the rainfall intensity increases for a range of durations and return periods.

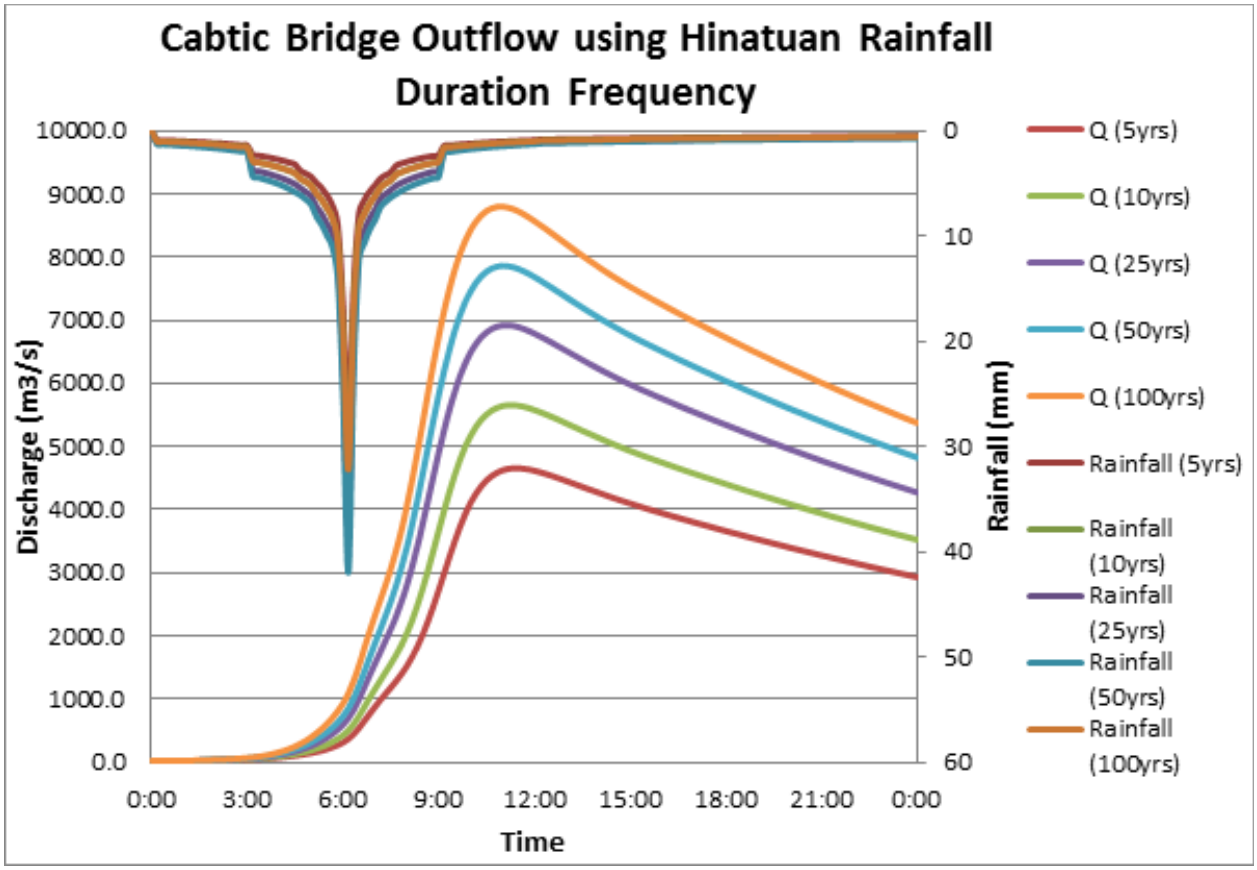

Figure 66. Outflow hydrograph at the Tago Station, generated using the simulated rain events for 24-hour period for Hinatuan station

Table 30. Peak outflows of the Tago HECHMS Model at Cabtic Bridge using the Hinatuan RIDF

RIDF Period	Total Precipitation (mm)	Peak rainfall (mm)	Peak outflow	Range of Calibrated Values
2-Year	176.88	18.49	2710.3	6 hours
5-Year	265.44	26.59	4446.2	5 hours, 30 min
10-Year	323.23	31.87	5593.6	5 hours, 20 min
25-Year	389.7	37.81	6921.1	5 hours, 10 min
50-Year	436.6	41.98	7860	5 hours
100-Year	483.1	46.11	8799.9	5 hours

5.8 River Analysis (RAS) Model Simulation

The HEC-RAS flood model produced a simulated water level at every cross-section for every time step for every flood simulation created. The resulting model will be used in determining the flooded areas within the model. The simulated model will be an integral part in determining real-time flood inundation extent of the river after it has been automated and uploaded on the DREAM website. The maximum flood extent and inundation levels due to typhoon "Agaton" last January 2014 is shown in Figure 67.

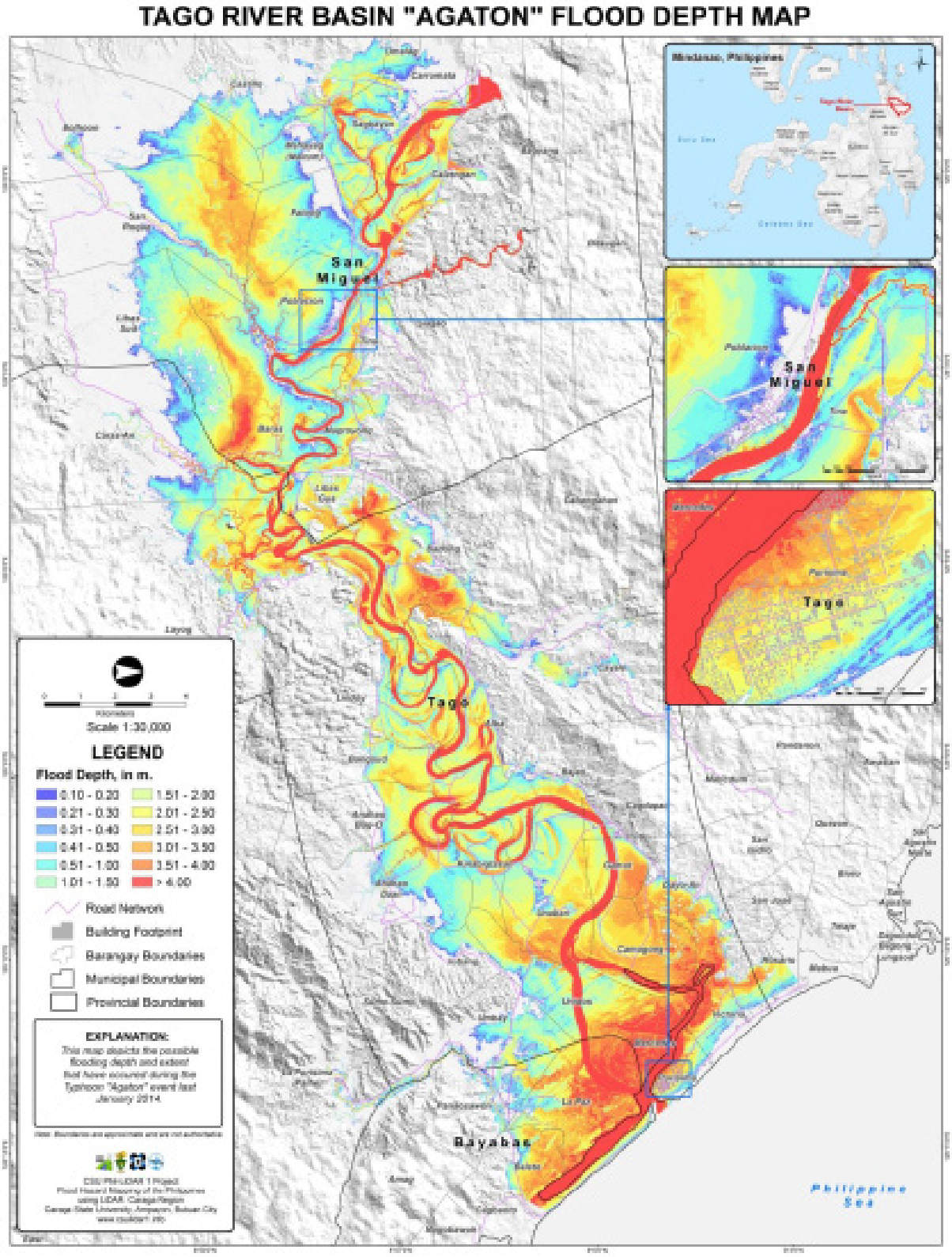

Figure 67. Flood depth and extent at Tago River basin during typhoon “Agaton”

5.9 Flood Hazard and Flow Depth Map

The resulting hazard and flow depth maps have a 10 m resolution. The 5-, 25-, and 100-year rain return scenarios of the Tago Floodplain are shown in Figure 68 to Figure 73. The floodplain, with an area of 2,388.57 sq km, covers eight municipalities, namely Bayabas, Cagwait, Carmen, Lanuza, San Miguel, Sibagat, Tago, and Tandag City. Table 31 shows the percentage of area affected by flooding per municipality.

Table 31. Municipalities affected in Tago Floodplain

City / Municipality	Total Area	Area Flooded	% Flooded
Bayabas	48.29	41.64	86%
Cagwait	200.13	47.16	24%
Carmen	172.33	0.17	0%
Lanuza	231.62	8.25	4%
San Miguel	410.02	247.92	60%
Sibagat	640.31	1.99	0.31%
Tago	293.49	210.94	72%
Tandag City	392.39	78.33	20%

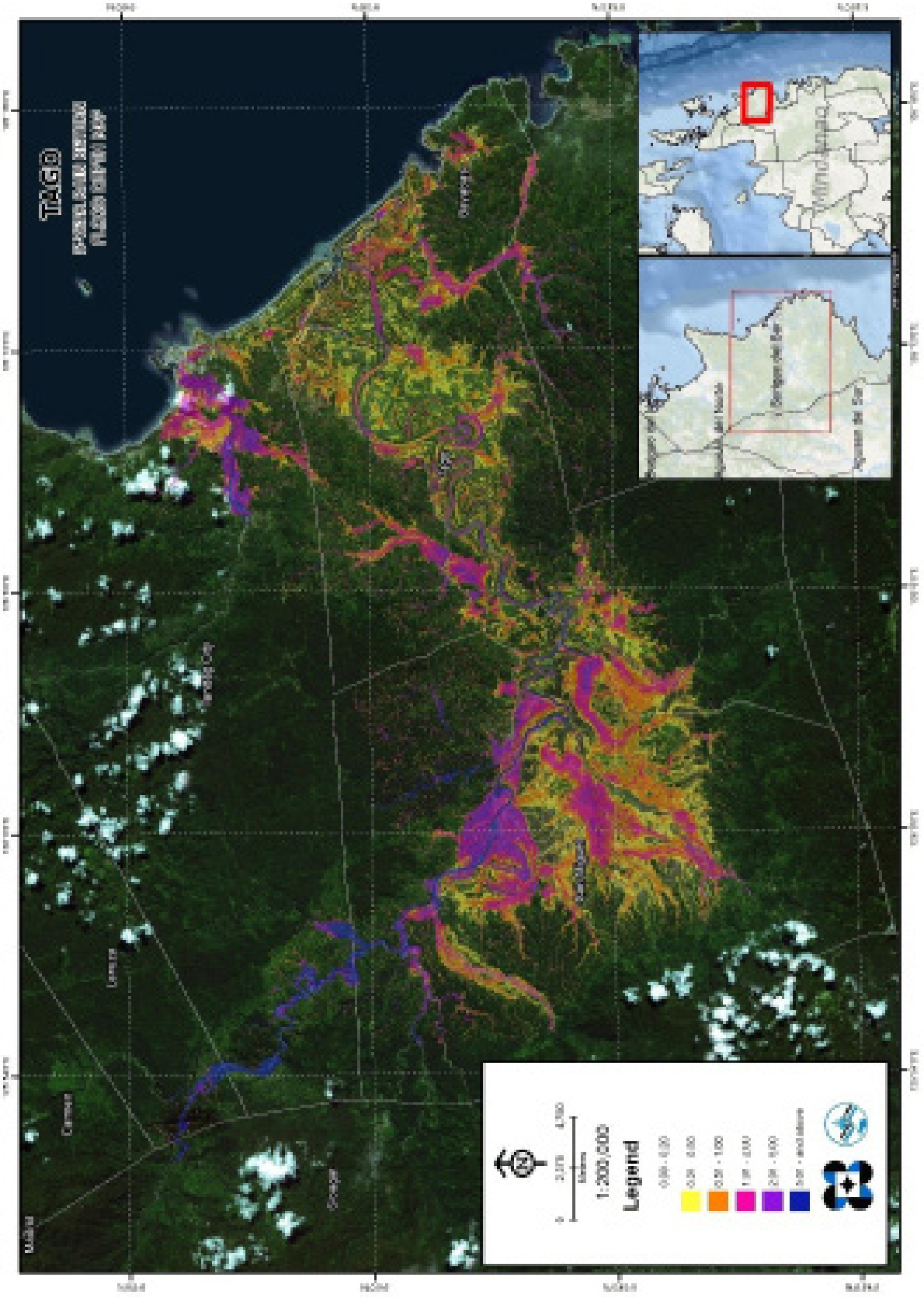

Figure 68. A 5-year flow depth map for the Tago Floodplain

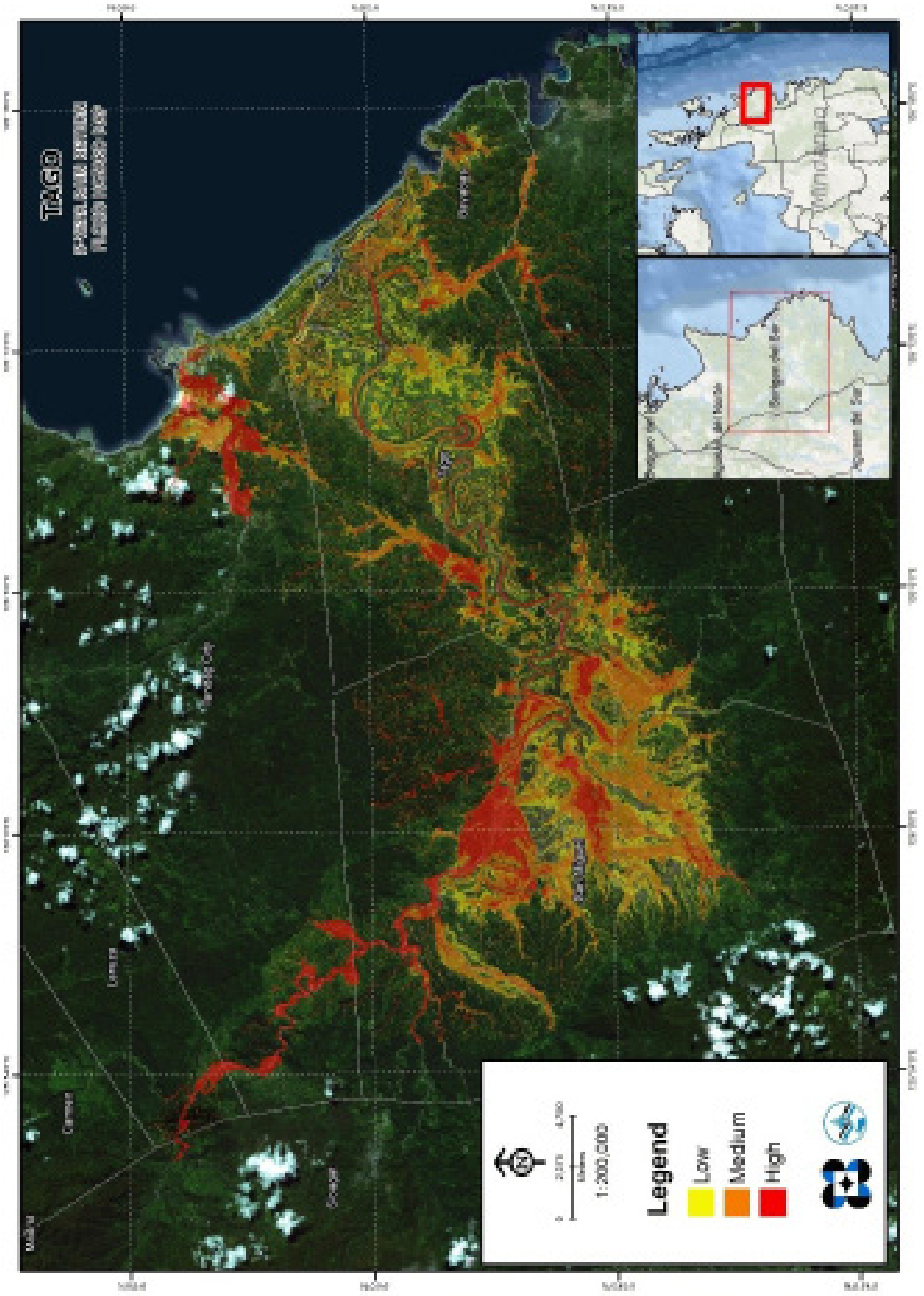

Figure 69. A 5-year flood hazard map for the Tago Floodplain

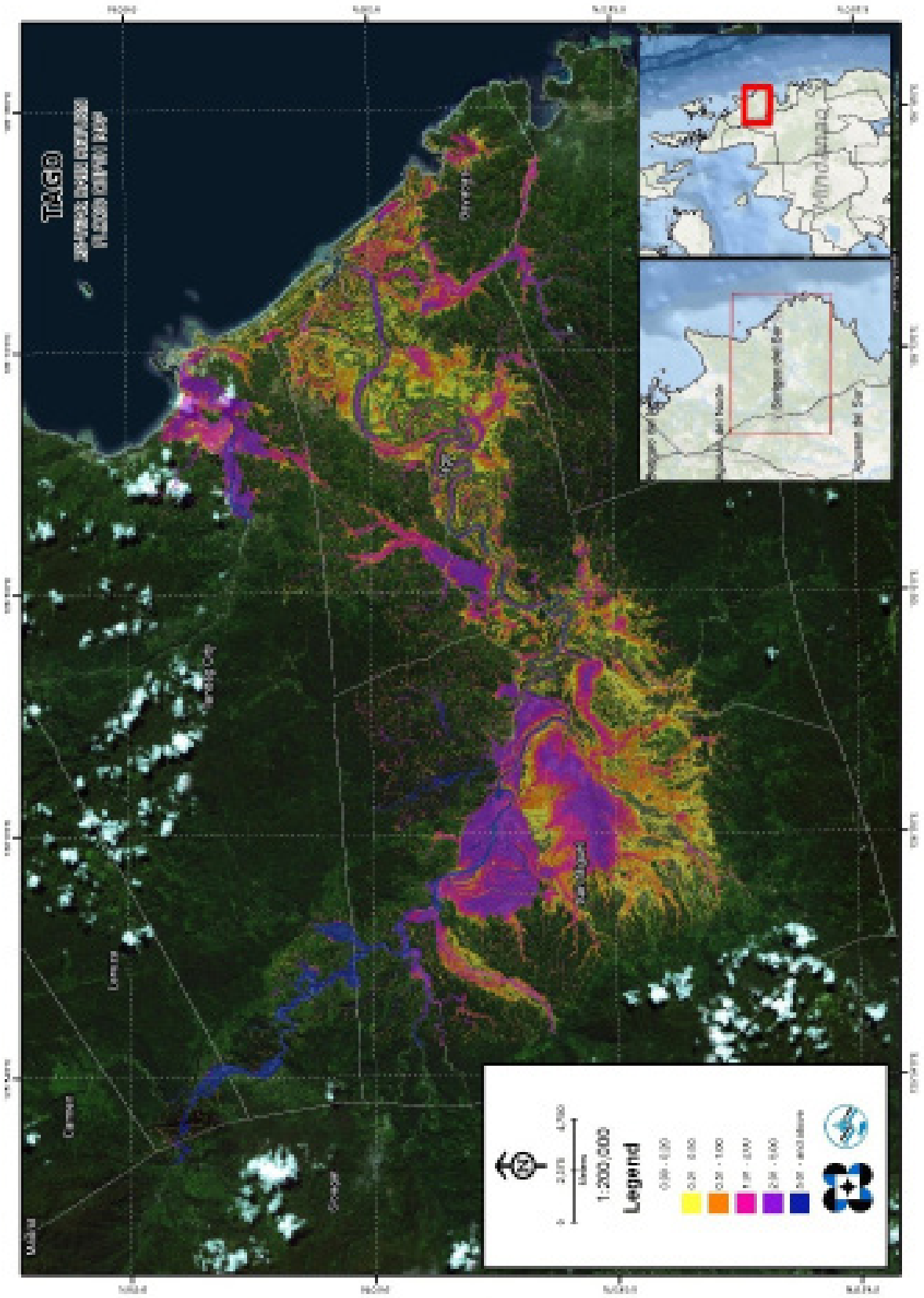

Figure 70. A 25-year flow depth map for the Tago Floodplain

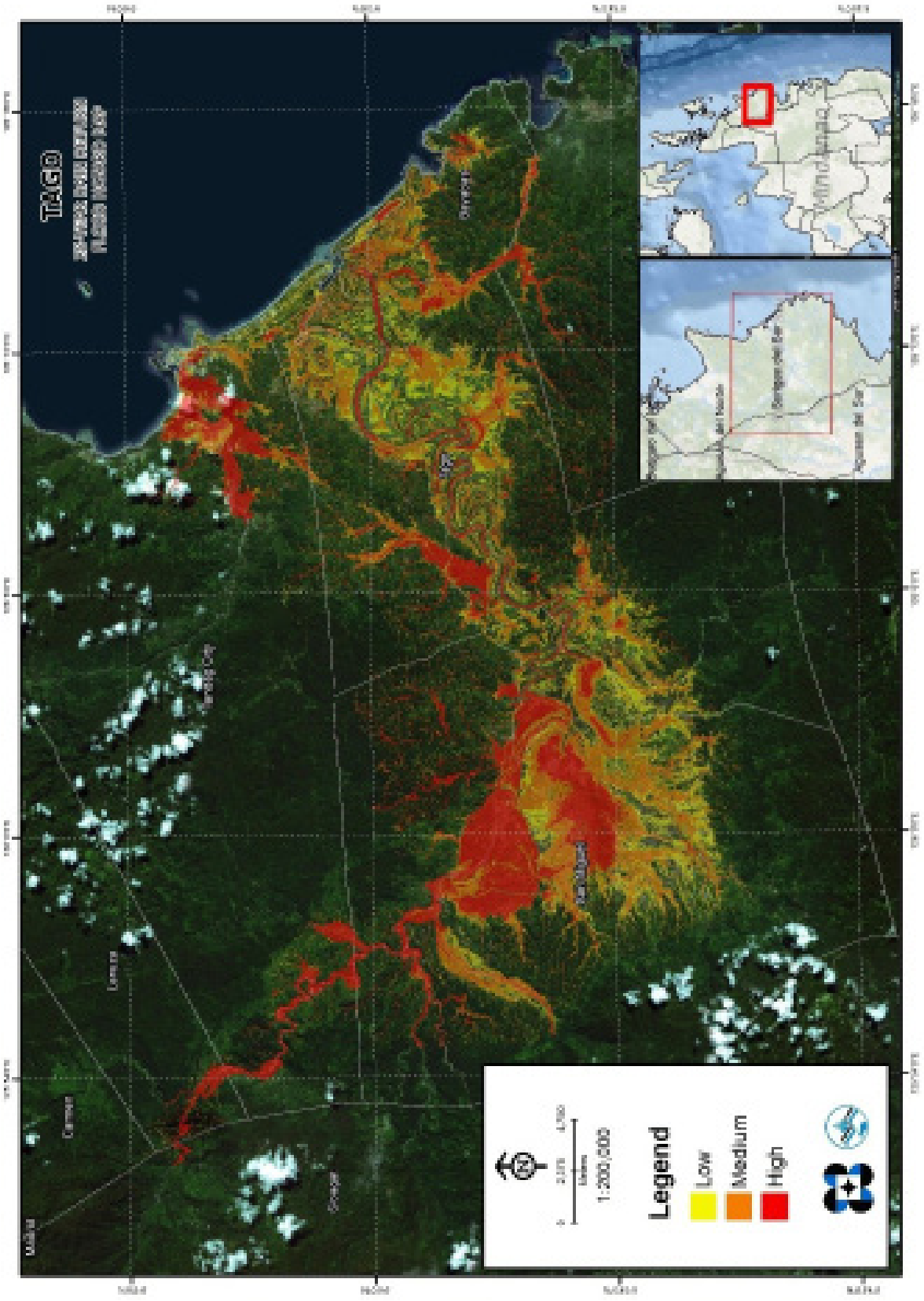

Figure 71. A 25-year flood hazard map for the Tago Floodplain

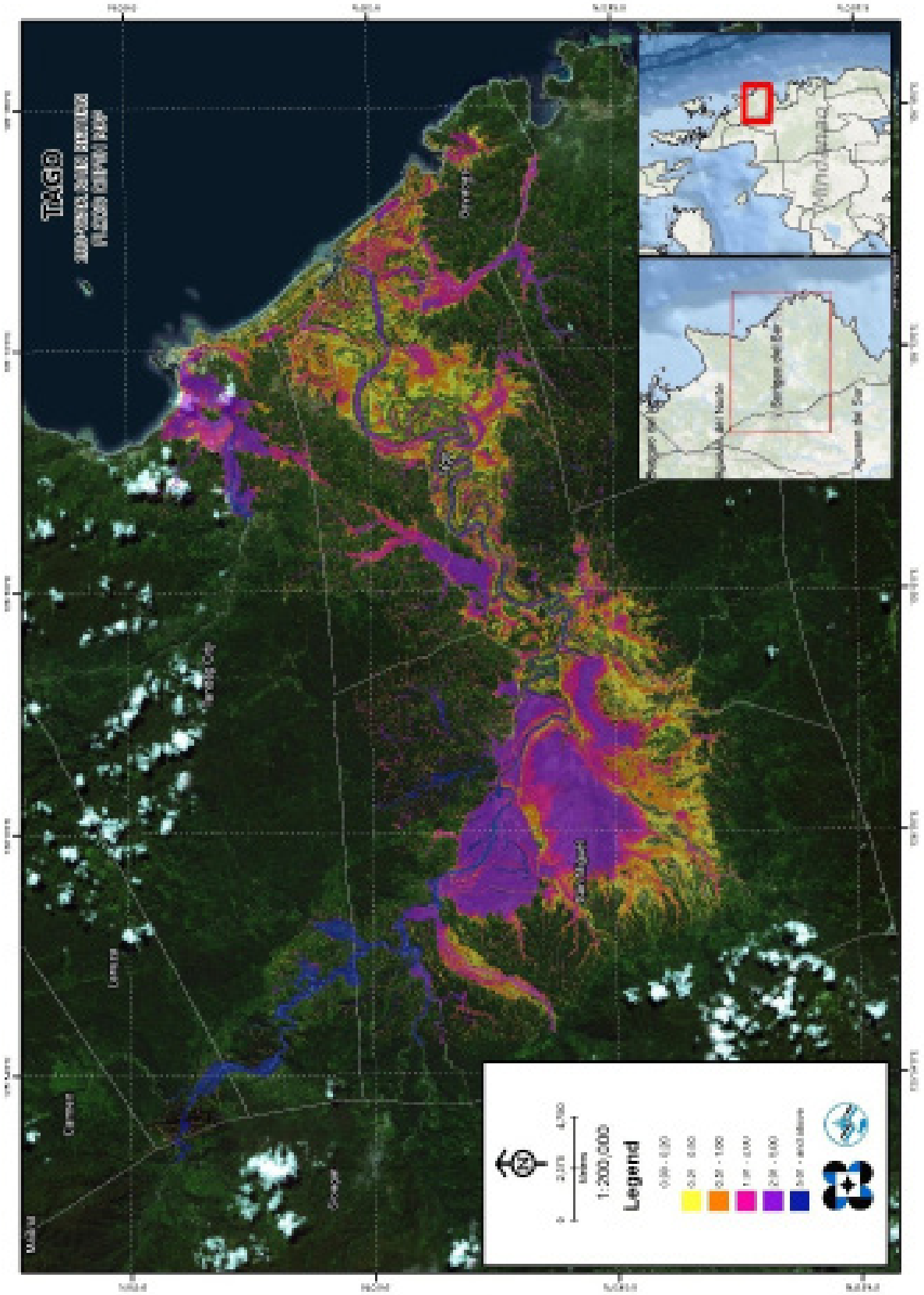

Figure 72. A 100-year flow depth map for the Tago Floodplain

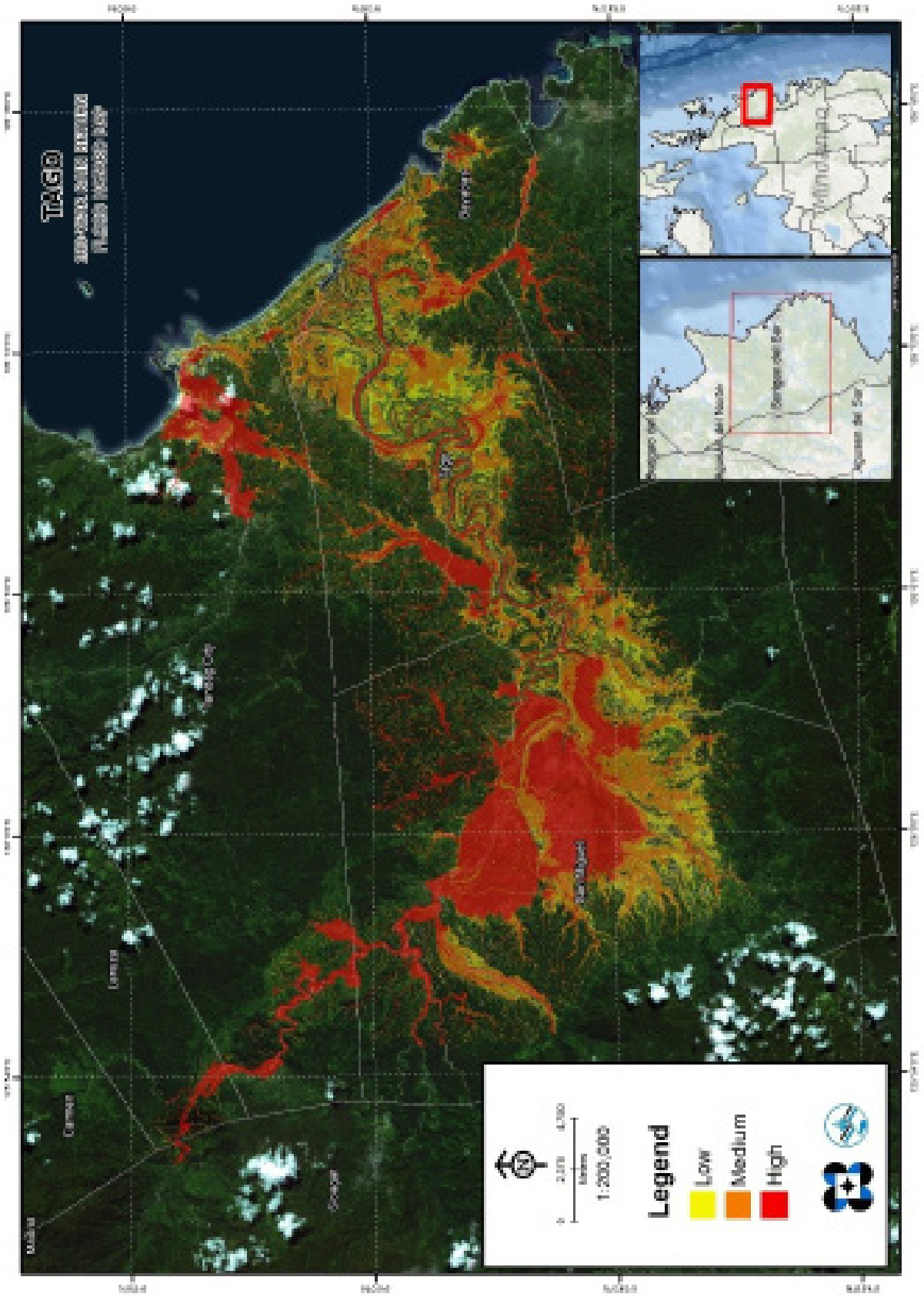

Figure 73. A 100-year flood hazard map for the Tago Floodplain

5.10 Inventory of Areas Exposed to Flooding

Affected barangays in the Tago river basin, grouped by municipality, are listed below. For the said basin, eight municipalities consisting of 74 barangays are expected to experience flooding when subjected to 5-year rainfall return period.

For the 5-year return period, 41.15% of the municipality of Bayabas, with an area of 117.84 sq km, will experience flood levels of less 0.20 meters; 3.82% of the area will experience flood levels of 0.21 to 0.50 meters; while 3.37%, 2.94%, 0.5%, 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 32 are the affected areas in square kilometres by flood depth per barangay.

Table 32. Affected Areas in Labangan, Zamboanga del Sur during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Bayabas (in sq km.)						
	Amag	Balete	Cabugo	Cagbaoto	La Paz	Magobawok	Panaosawon
0.03-0.20	10.39	2.33	1.93	2	4.49	12.71	14.64
0.21-0.50	0.39	0.77	0.33	0.36	1.69	0.36	0.6
0.51-1.00	0.29	0.78	0.27	0.37	1.31	0.4	0.55
1.01-2.00	0.38	0.3	0.23	0.14	1.24	0.3	0.88
2.01-5.00	0.13	0.023	0.053	0.031	0.13	0.05	0.18
> 5.00	0.013	0.0018	0	0.0003	0.0033	0	0.00067

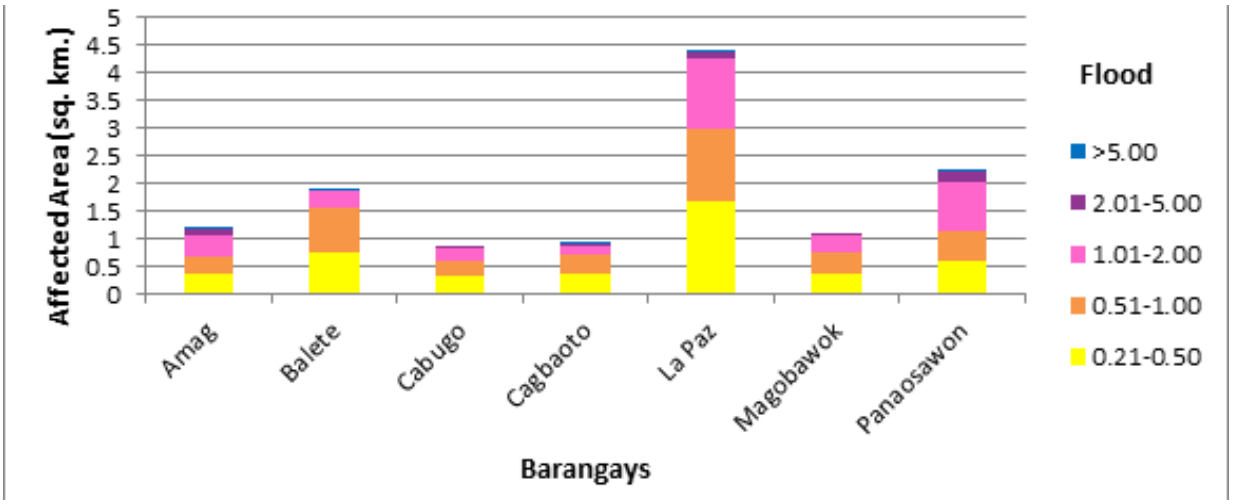

Figure 74. Affected areas in Bayabas, Surigao del Sur during a 5-year rainfall return period

For the municipality of Cagwait, with an area of 78.45 sq km, 26.28% will experience flood levels of less 0.20 meters; 0.87% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.73%, 1.02%, 0.84%, and 0.1% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 33 are the affected areas in square kilometres by flood depth per barangay.

Table 33. Affected areas in Cagwait, Surigao del Sur during a 5-year rainfall return period

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Cagwait (in sq km.)	
	La Purisima	Tubo-Tubo
0.03-0.20	25.87	15.77
0.21-0.50	0.92	0.46
0.51-1.00	0.9	0.26
1.01-2.00	1.38	0.23
2.01-5.00	1.08	0.25
> 5.00	0.094	0.069

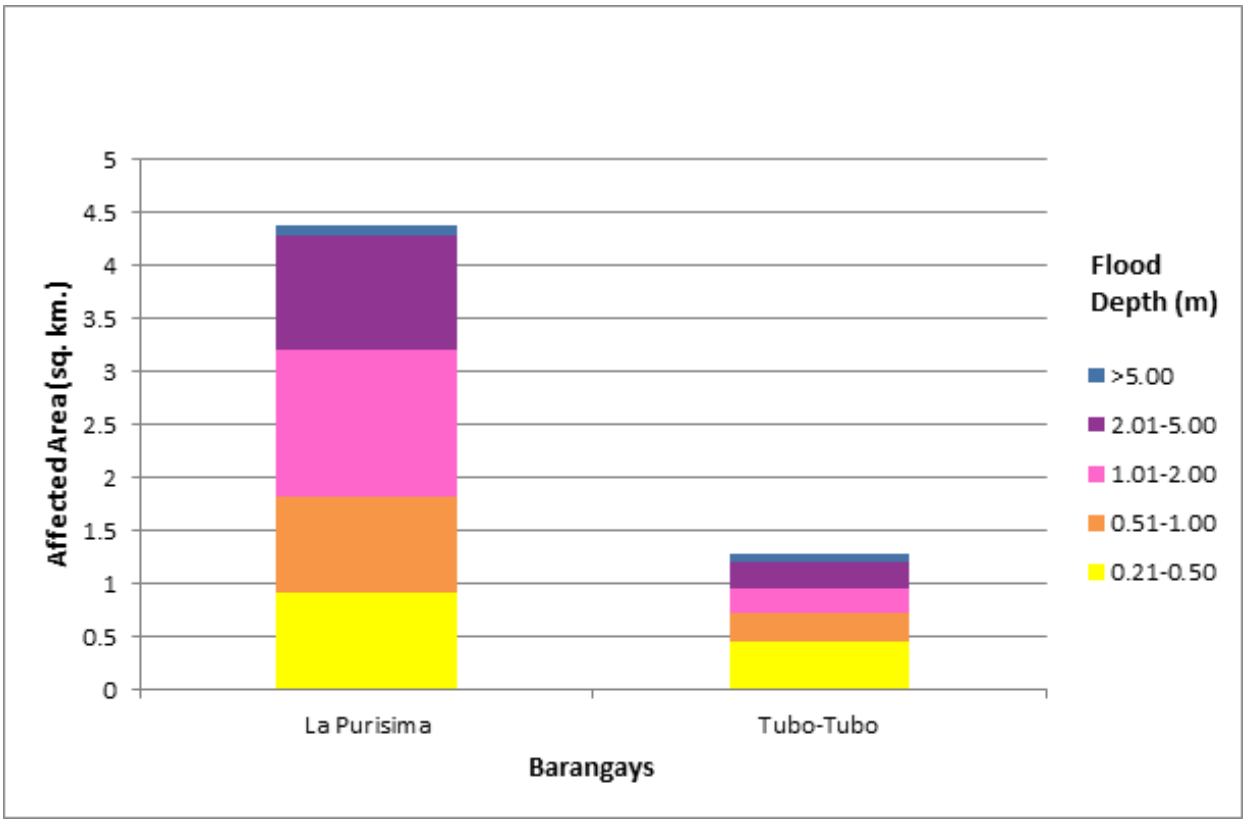

Figure 75. Affected areas in Cagwait, Surigao del Sur during a 5-year rainfall return period

For the municipality of Carmen, with an area of 158.4 sq km, 4.09% will experience flood levels of less 0.20 meters; 0.14% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.06%, 0.07%, 0.22%, and 0.75% 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 34 are the affected areas in square kilometres by flood depth per barangay.

Table 34. Affected areas in Carmen, Surigao del Sur during a 5-year rainfall return period

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Carmen (in sq km.)		
	Cancavan	**Puyat**	**Pakwan**
0.03-0.20	0.13	0.032	6.31
0.21-0.50	0.0046	0.00057	0.21
0.51-1.00	0.0011	0.00071	0.1
1.01-2.00	0	0	0.11
2.01-5.00	0	0	0.35
> 5.00	0	0	1.18

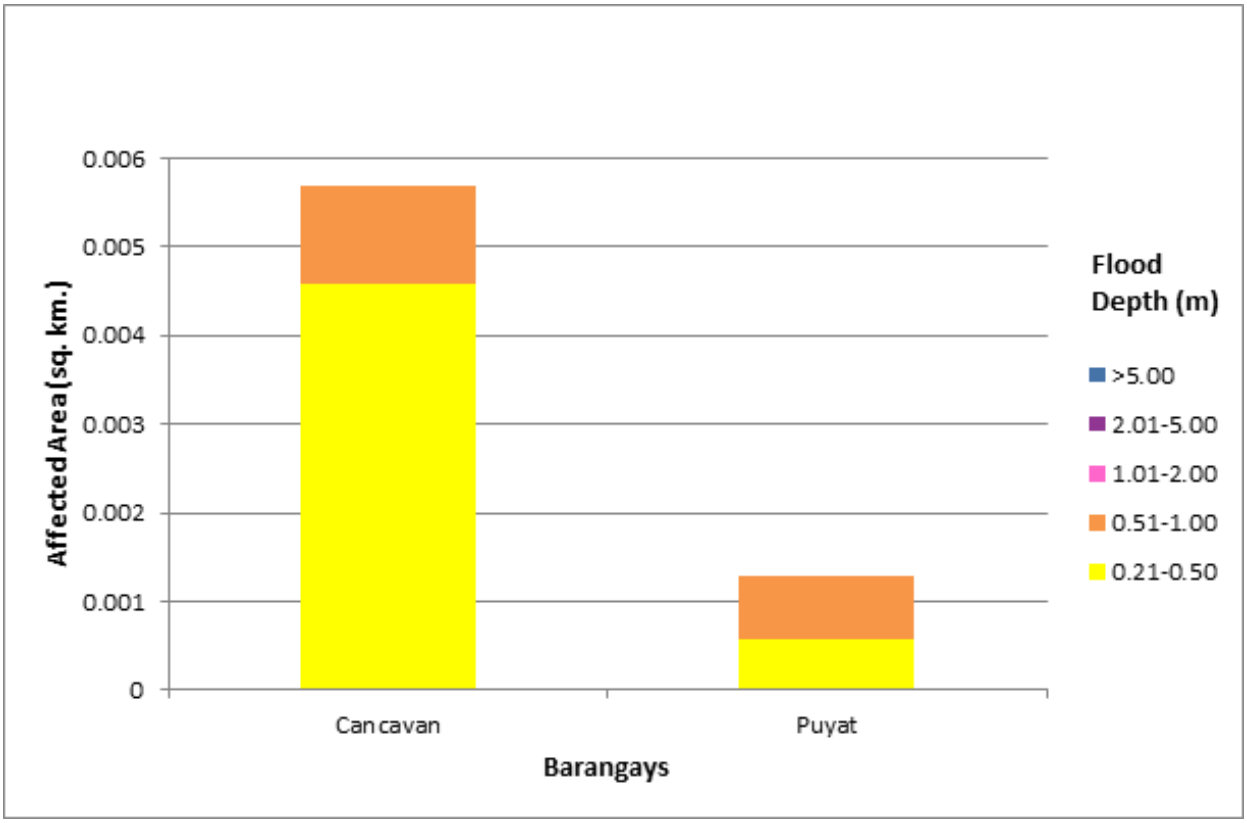

Figure 76. Affected areas in Carmen, Surigao del Sur during a 5-year rainfall return period

For the municipality of Lanuza, with an area of 317.09 sq km, 1.99% will experience flood levels of less 0.20 meters; 0.07% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.03%, 0.03%, 0.11%, and 0.37% 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 Table 35 are the affected areas in square kilometres by flood depth per barangay.

Table 35. Affected areas in Lanuza, Surigao del Sur during a 5-year rainfall return period

Affected Area (sq. km.) by flood depth (in m.)	**Area of affected barangays in Lanuza (in sq km.)**
	Pakwan
0.03-0.20	6.31
0.21-0.50	0.21
0.51-1.00	0.1
1.01-2.00	0.11
2.01-5.00	0.35
> 5.00	1.18

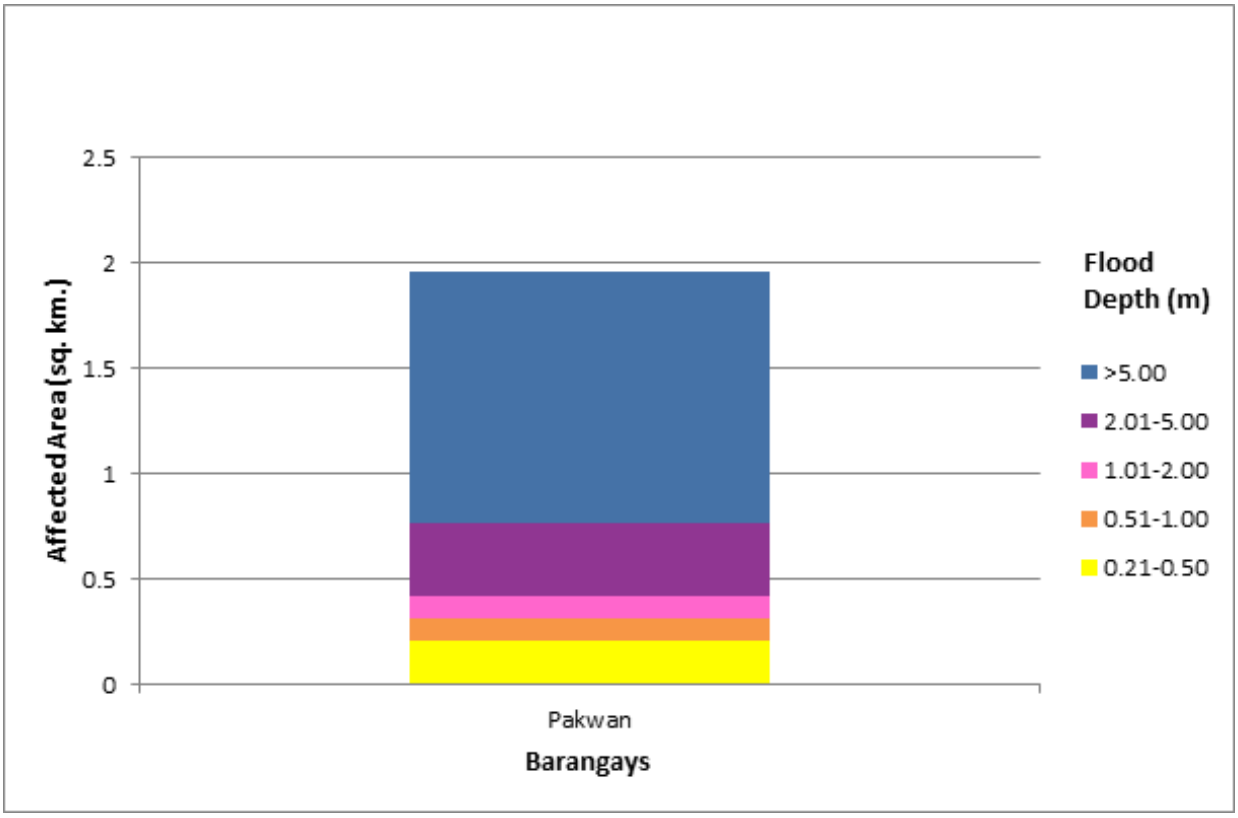

Figure 77. Affected areas in Lanuza, Surigao del Sur during a 5-year rainfall return period

For the municipality of San Miguel, with an area of 654.52 sq km, 22.64% will experience flood levels of less 0.20 meters; 4.29% of the area will experience flood levels of 0.21 to 0.50 meters; while 4.56%, 3.8%, 2.05%, and 0.68% 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 Table 36 and Table 37 are the affected areas in square kilometres by flood depth per barangay.

Table 36. Affected areas in San Miguel, Surigao del Sur during a 5-year rainfall return period

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Miguel (in sq km.)								
	Bagyang	**Baras**	**Bitaugan**	**Bolhoon**	**Calatngan**	**Carromata**	**Castillo**	**Libas Gua**	**Libas Sud**
0.03-0.20	11.51	3.65	12.21	8.09	28.65	2.26	23.99	3.55	8.92
0.21-0.50	0.4	1.73	0.32	3.51	1.77	1.16	3.73	0.69	3.41
0.51-1.00	0.39	1.85	0.2	3.97	1.99	0.7	3.91	0.54	4.12
1.01-2.00	0.53	1.89	0.2	2.79	2.75	0.27	2.3	0.22	1.43
2.01-5.00	0.88	0.91	0.26	0.49	3.55	0.13	0.46	0.13	0.08
> 5.00	0.64	0.19	0.72	0.018	1.35	0.007	0.0019	0.082	0.0026

Table 37. Affected areas in San Miguel, Surigao del Sur during a 5-year rainfall return period

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Miguel (in sq km.)								
	Magroyong	Mahayag	Patong	Poblacion	Sagbayan	San Roque	Siagao	Tina	Umalag
0.03-0.20	3.4	1.66	2.49	2.25	0.23	6.73	8.42	7.39	12.76
0.21-0.50	0.5	0.84	1.78	1.42	0.33	3.68	0.31	0.65	1.82
0.51-1.00	0.49	0.57	1.7	1.12	0.64	4.83	0.29	1.08	1.47
1.01-2.00	0.94	0.56	1.72	1.17	1.01	4.2	0.76	1.22	0.93
2.01-5.00	0.5	0.18	1.05	0.21	1.2	0.51	1.67	1.01	0.23
> 5.00	0.04	0.001	0.13	0.05	0.14	0.0018	0.6	0.46	0.0014

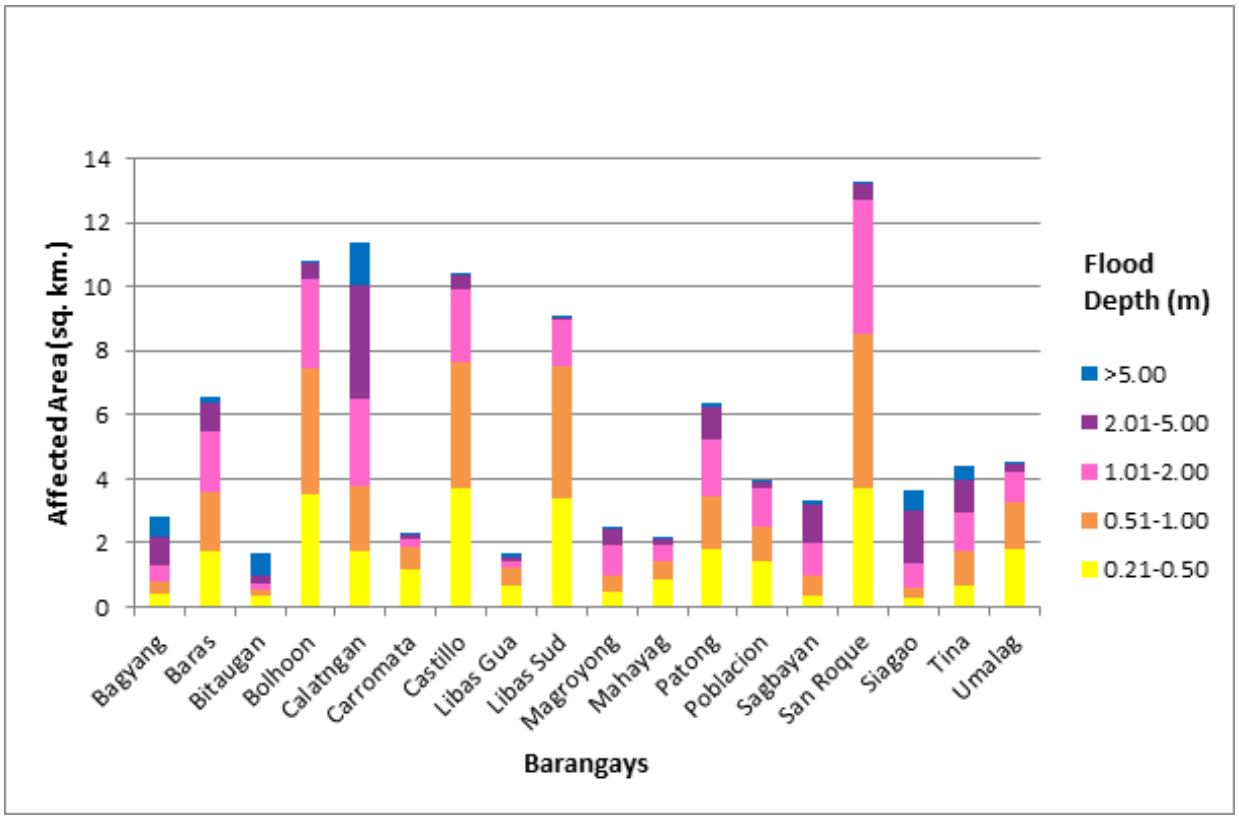

Figure 78. Affected areas in San Miguel, Surigao del Sur during a 5-year rainfall return period

For the municipality of Sibagat, with an area of 728.8 sq km, 0.24% will experience flood levels of less 0.20 meters; 0.005% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.001%, 0.002%, 0.004%, 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 38 are the affected areas in square kilometres by flood depth per barangay.

Table 38. Affected areas in Sibagat, Agusan del Sur during a 5-year rainfall return period

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Sibagat (in sq km.)
	Kolambugan
0.03-0.20	1.71
0.21-0.50	0.036
0.51-1.00	0.011
1.01-2.00	0.012
2.01-5.00	0.026
> 5.00	0.19

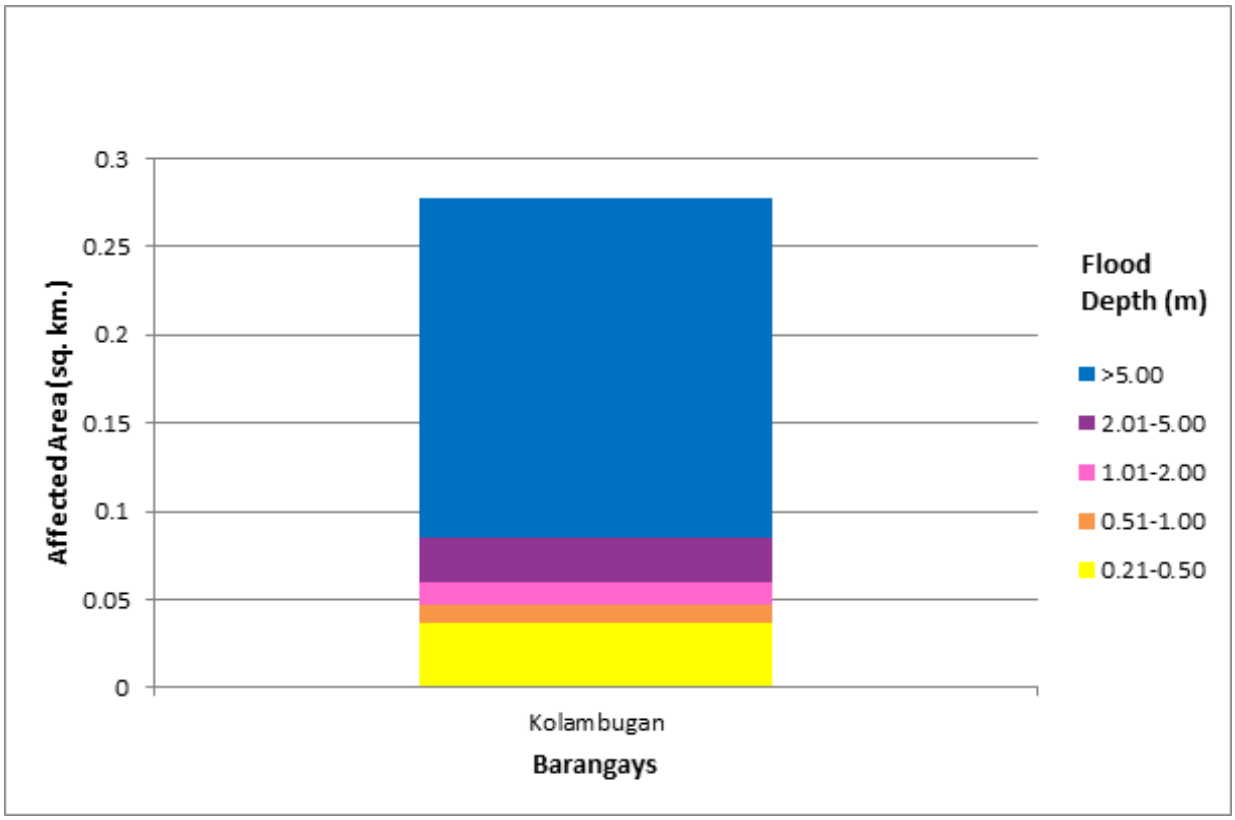

Figure 79. Affected areas in Sibagat, Agusan del Sur during a 5-year rainfall return period

For the municipality of Tago, with an area of 321.22 sq km, 44.6% will experience flood levels of less 0.20 meters; 8.25% of the area will experience flood levels of 0.21 to 0.50 meters; while 6.8%, 4.35%, 1.65%, and 0.18% 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 39 and Table 40 are the affected areas in square kilometres by flood depth per barangay.

Table 39. Affected areas in Tago, Surigao del Sur during a 5-year rainfall return period

Affected area (sq km.) by flood depth (in m.)	Area of affected barangays in Tago (in sq km.)											
	Alba	Anahao Bag-O	Anahao Daan	Badong	Bajao	Bangsud	Cabangahan	Cagdapao	Camagong	Caras-An	Cayale	Dayo-An
0.03-0.20	6.75	5.45	5.54	12.06	8.14	5.2	9.7	4.84	3.52	8.54	9.51	2.64
0.21-0.50	1.01	0.71	2.3	1.19	1	0.8	0.38	0.25	1.74	3.07	0.62	0.71
0.51-1.00	0.67	0.43	1.57	1.37	0.85	0.62	0.48	0.15	0.54	3.86	0.99	0.72
1.01-2.00	0.75	0.34	0.68	2.29	0.69	0.34	0.41	0.15	0.082	1.72	1.25	0.19
2.01-5.00	0.5	0.44	0.35	1.24	0.11	0.16	0.14	0.1	0.0077	0.39	0.25	0.015
> 5.00	0.0046	0.0059	0.0041	0.036	0.0018	0.013	0.017	0.014	0	0.083	0.0051	0

Table 40. Affected areas in Tago, Surigao del Sur during a 5-year rainfall return period

Affected area (sq km.) by flood depth (in m.)	Area of affected barangays in Tago (in sq km.)											
	Gamut	Jubang	Kinabigtasan	Layog	Lindoy	Mercedes	Purisima	Sumo-Sumo	Umbay	Unaban	Unidos	Victoria
0.03-0.20	1.94	2.36	2	19.84	8.39	0.51	1.41	7.69	3.3	5.21	4.88	3.83
0.21-0.50	0.67	0.49	0.6	2.52	0.87	0.15	0.34	0.37	1.02	2.16	2.3	1.23
0.51-1.00	0.57	0.55	0.48	2.96	0.7	0.078	0.064	0.6	0.76	1.24	0.95	0.65
1.01-2.00	0.19	0.06	0.11	2.09	0.3	0.0046	0.0018	0.54	0.8	0.26	0.57	0.15
2.01-5.00	0.046	0.02	0.017	0.86	0.16	0	0	0.22	0.1	0.028	0.13	0.024
> 5.00	0	0.0001	0	0.32	0.05	0	0	0.0039	0.00055	0.0002	0.0035	0

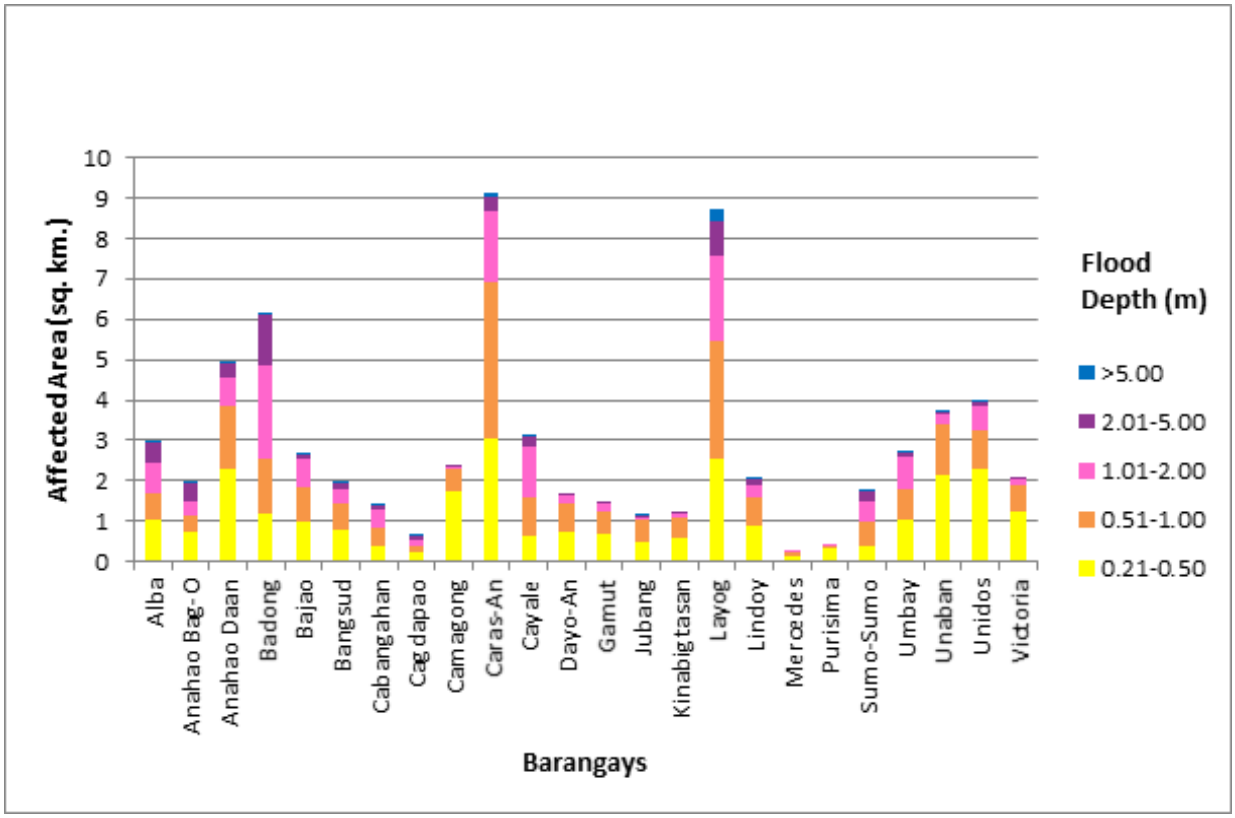

Figure 80. Affected areas in Tago, Surigao del Sur during a 5-year rainfall return period

For the city of Tandag, with an area of 181.51sq km, 29.62% will experience flood levels of less 0.20 meters; 2.07% of the area will experience flood levels of 0.21 to 0.50 meters; while 2.46%, 3.45%, 3.35%, and 2.29% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 41 and Table 42 are the affected areas in square kilometres by flood depth per barangay.

Table 41. Affected areas in Tandag City, Surigao del Sur during a 5-year rainfall return period

Affected area (sq km.) by flood depth (in m.)	Area of affected barangays in Tandag City (in sq km.)								
	Awasian	Bagong Lungsod	Bioto	Bongtod Poblacion	Dagocdoc	Mabua	Mabuhay	Maitum	Maticdum
0.03-0.20	6.26	0.22	0.51	0.38	0.14	1.19	23.44	2.6	2.9
0.21-0.50	0.48	0.031	0.12	0.02	0.02	0.36	0.65	0.12	0.28
0.51-1.00	0.96	0.0078	0.34	0.0001	0.0054	0.13	0.4	0.081	0.52
1.01-2.00	1.37	0	1.04	0	0.011	0.04	0.44	0.21	0.77
2.01-5.00	0.41	0	0.86	0	0.0083	0.013	1.35	0.64	0.1
> 5.00	0.015	0	0.000054	0	0	0	3.66	0.26	0.0013

Table 42. Affected areas in Tandag City, Surigao del Sur during a 5-year rainfall return period

Affected area (sq km.) by flood depth (in m.)	Area of affected barangays in Tandag City (in sq km.)							
	Pandanon	Quezon	Rosario	San Agustin Norte	San Agustin Sur	San Isidro	San Jose	Telaje
0.03-0.20	2.7	0.41	1.87	1.67	0.15	3.97	2.72	2.62
0.21-0.50	0.13	0.14	0.51	0.11	0.054	0.28	0.13	0.34
0.51-1.00	0.14	0.48	0.38	0.11	0.059	0.29	0.14	0.4
1.01-2.00	0.3	0.62	0.05	0.18	0.11	0.52	0.17	0.44
2.01-5.00	0.52	0.65	0.0022	0.051	0.11	0.89	0.25	0.21
> 5.00	0.1	0.098	0	0	0	0.016	0	0

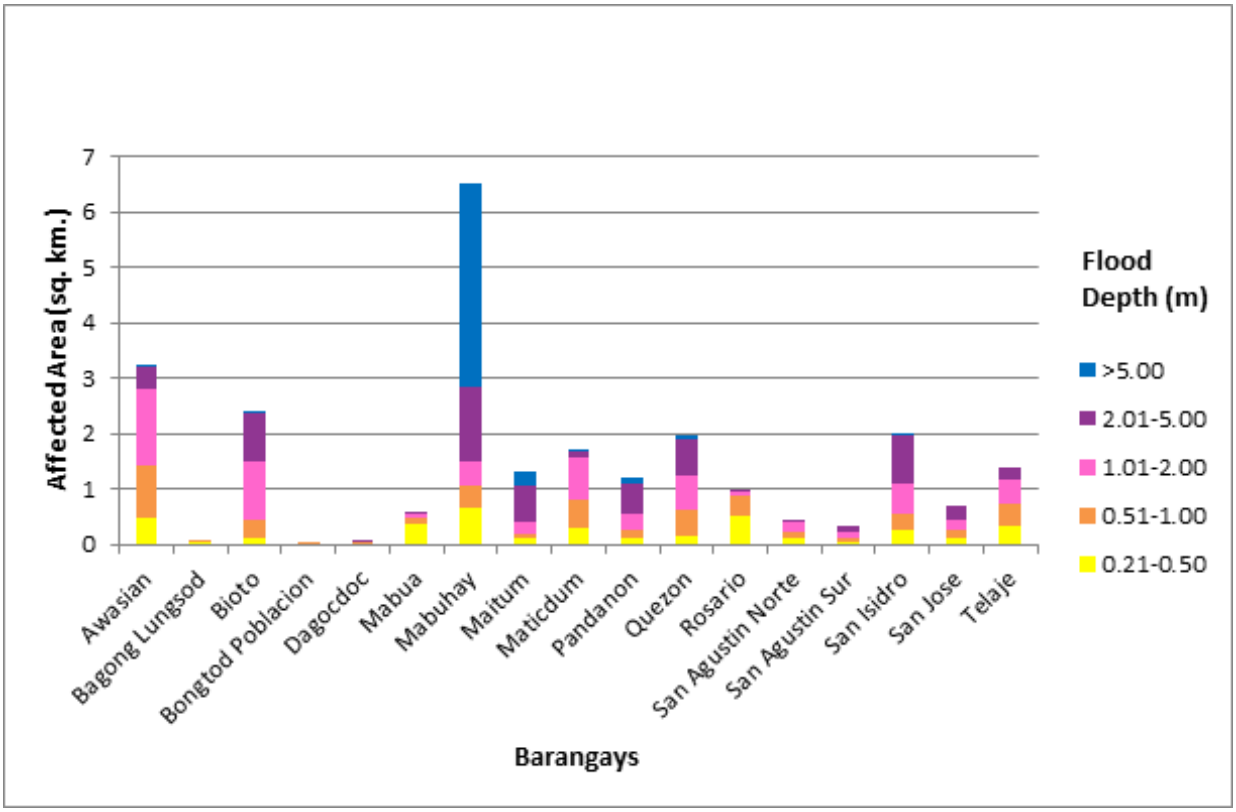

Figure 81. Affected areas in Tandag City, Surigao del Sur during a 5-year rainfall return period

For the 25-year return period, 22.93% of the municipality of Bayabas, with an area of 117.84 sq km, will experience flood levels of less 0.20 meters; 3.8% of the area will experience flood levels of 0.21 to 0.50 meters; while 3.86%, 3.79%, 1.07%, 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 43 are the affected areas in square kilometres by flood depth per barangay.

Table 43. Affected areas in Bayabas, Surigao del Sur during a 25-year rainfall return period

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Bayabas (in sq km.)						
	Amag	Balete	Cabugo	Cagbaoto	La Paz	Magobawok	Panaosawon
0.03-0.20	10.23	1.96	1.81	1.85	3.51	2.49	5.16
0.21-0.50	0.41	0.73	0.33	0.34	1.67	0.37	0.63
0.51-1.00	0.26	0.94	0.28	0.43	1.7	0.38	0.55
1.01-2.00	0.41	0.54	0.31	0.23	1.52	0.43	1.04
2.01-5.00	0.25	0.03	0.086	0.043	0.46	0.083	0.31
> 5.00	0.017	0.003	0	0.0012	0.013	0	0.0014

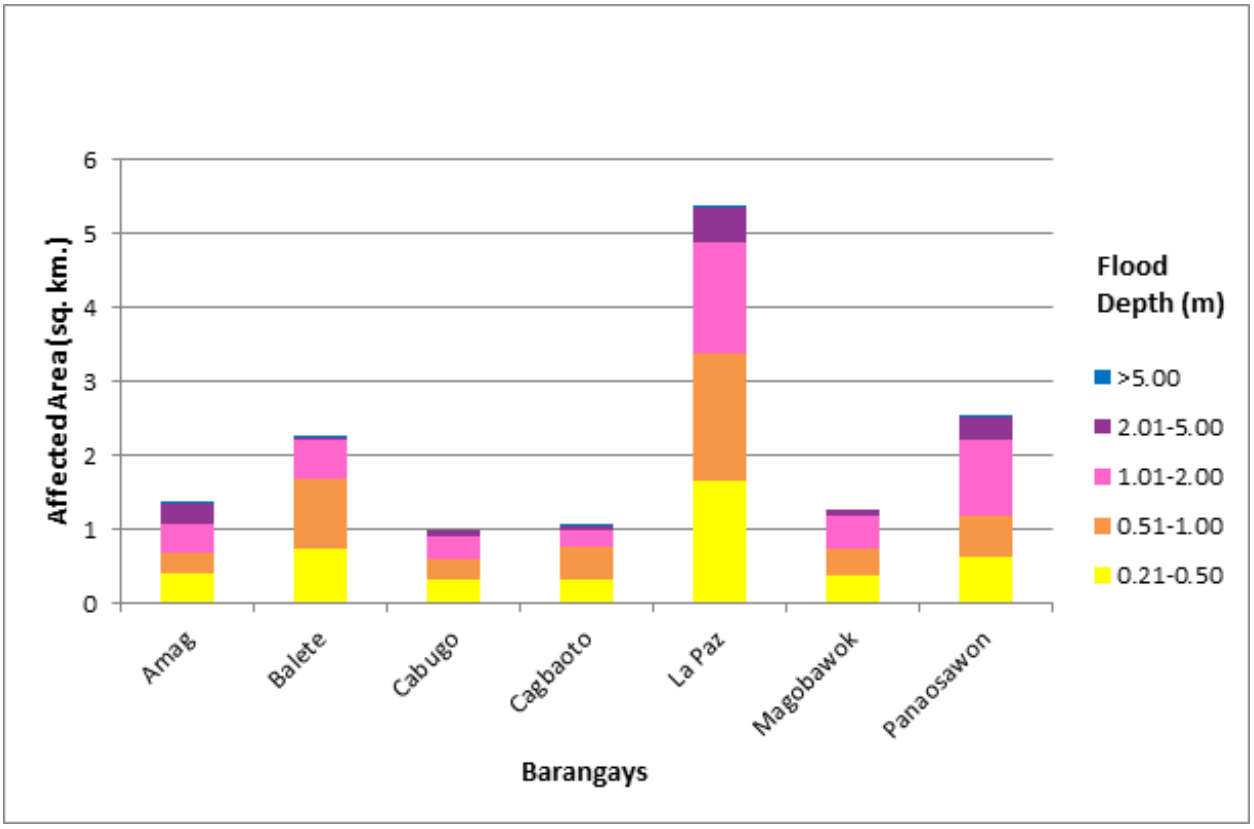

Figure 82. Affected areas in Bayabas, Surigao del Sur during a 25-year rainfall return period

For the municipality of Cagwait, with an area of 78.45 sq km, 25.83% will experience flood levels of less 0.20 meters; 0.93% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.64%, 1.03%, 1.2%, and 0.23% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 44 are the affected areas in square kilometres by flood depth per barangay.

Table 44. Affected areas in Cagwait, Surigao del Sur during a 25-year rainfall return period

Affected Area (sq. km.) by flood depth (in m.)	**Area of affected barangays in Cagwait (in sq km.)**	
	La Purisima	**Tubo-Tubo**
0.03-0.20	25.42	15.5
0.21-0.50	0.93	0.54
0.51-1.00	0.72	0.3
1.01-2.00	1.36	0.27
2.01-5.00	1.59	0.3
> 5.00	0.23	0.13

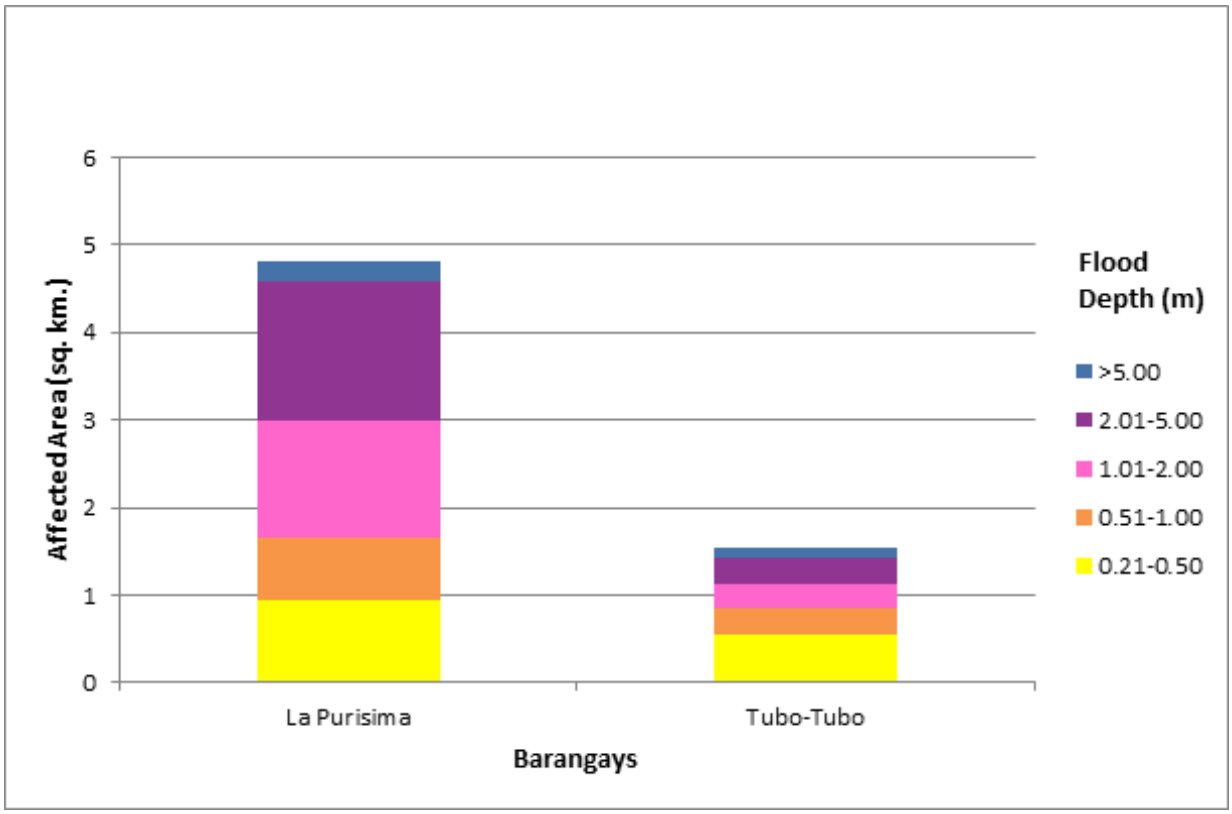

Figure 83. Affected areas in Cagwait, Surigao del Sur during a 25-year rainfall return period

For the municipality of Carmen, with an area of 158.4 sq km, 3.93% will experience flood levels of less 0.20 meters; 0.16% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.07%, 0.06%, 0.11%, and 1% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 45 are the affected areas in square kilometres by flood depth per barangay.

Table 45. Affected areas in Carmen, Surigao del Sur during a 25-year rainfall return period

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Carmen (in sq km.)		
	Cancavan	**Puyat**	**Pakwan**
0.03-0.20	0.13	0.032	6.06
0.21-0.50	0.0062	0.00055	0.24
0.51-1.00	0.0016	0.00097	0.11
1.01-2.00	0	0.0001	0.095
2.01-5.00	0	0	0.17
> 5.00	0	0	1.58

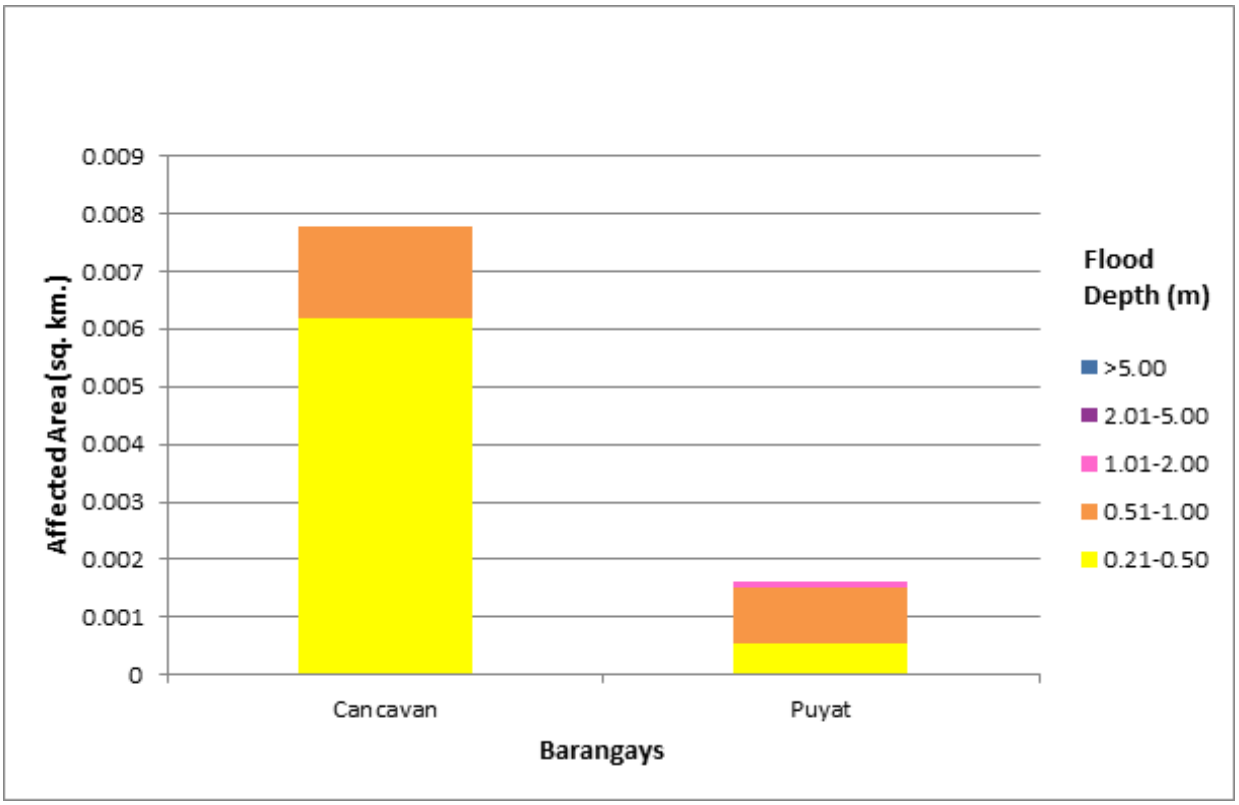

Figure 84. Affected areas in Carmen, Surigao del Sur during a 25-year rainfall return period

For the municipality of Lanuza, with an area of 317.09 sq km, 1.91% will experience flood levels of less 0.20 meters; 0.08% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.04%, 0.03%, 0.06%, and 0.5% 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 kilometres by flood depth per barangay.

Table 46. Affected areas in Lanuza, Surigao del Sur during a 25-year rainfall return period

Affected Area (sq. km.) by flood depth (in m.)	**Area of affected barangays in Lanuza (in sq km.)**
	Pakwan
0.03-0.20	6.06
0.21-0.50	0.24
0.51-1.00	0.11
1.01-2.00	0.095
2.01-5.00	0.17
> 5.00	1.58

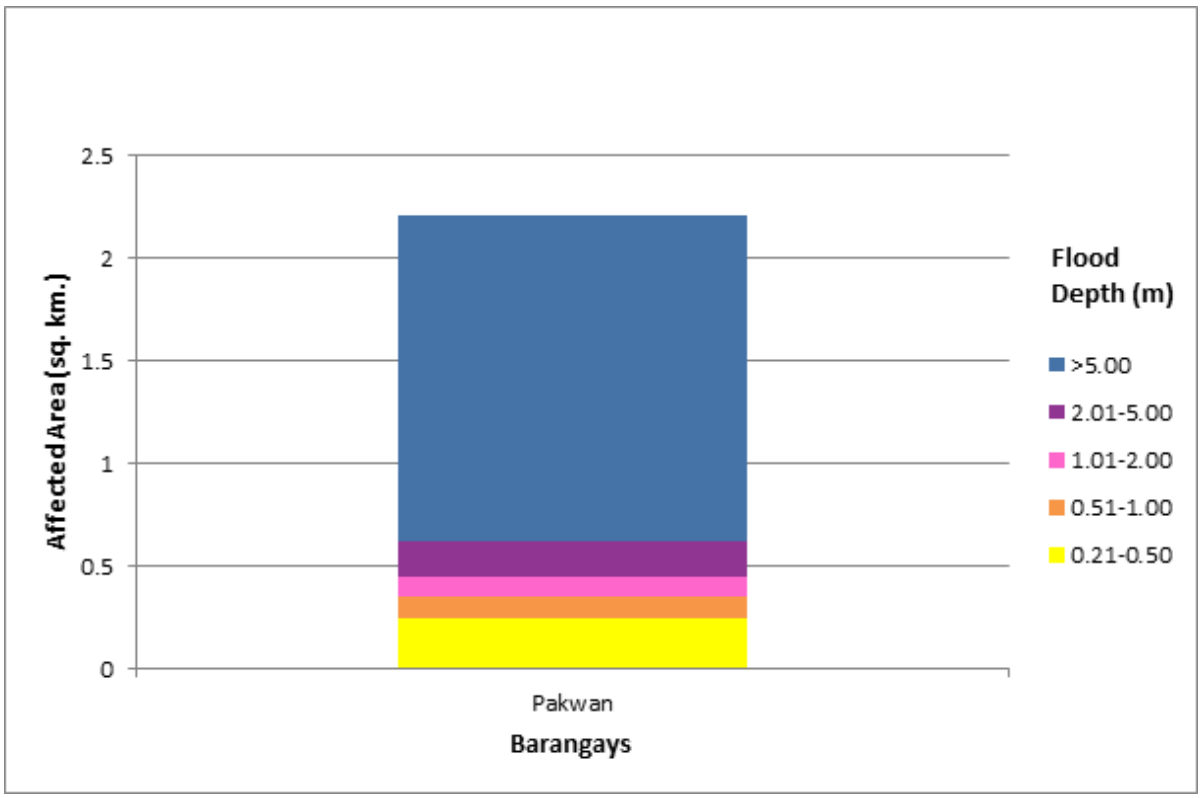

Figure 85. Affected areas in Lanuza, Surigao del Sur during a 25-year rainfall return period

For the municipality of San Miguel, with an area of 654.52 sq km, 20.83% will experience flood levels of less 0.20 meters; 3.79% of the area will experience flood levels of 0.21 to 0.50 meters; while 4.15%, 4.19%, 4.21%, 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 Table 47 and Table 48 are the affected areas in square kilometres by flood depth per barangay.

Table 47. Affected areas in San Miguel, Surigao del Sur during a 25-year rainfall return period

Affected area (sq km.) by flood depth (in m.)	Area of affected barangays in San Miguel (in sq km.)								
	Bagyang	Baras	Bitaugan	Bolhoon	Calatngan	Carromata	Castillo	Libas Gua	Libas Sud
0.03-0.20	11.15	3.54	11.98	8.52	27.46	1.03	22.7	3.23	8.63
0.21-0.50	0.42	1.84	0.37	3.87	1.54	0.24	3.11	0.68	3.7
0.51-1.00	0.32	1.93	0.22	3.29	1.77	0.45	3.59	0.63	3.98
1.01-2.00	0.49	2.14	0.22	1.96	2.62	1.58	2.96	0.43	1.56
2.01-5.00	1.07	0.73	0.26	1.23	4.66	1.22	2.02	0.17	0.089
> 5.00	0.9	0.18	0.85	0.0002	2	0.0073	0.0037	0.061	0.0048

Table 48. Affected areas in San Miguel, Surigao del Sur during a 25-year rainfall return period

Affected area (sq km.) by flood depth (in m.)	Area of affected barangays in San Miguel (in sq km.)								
	Magroyong	Mahayag	Patong	Poblacion	Sagbayan	San Roque	Siagao	Tina	Umalag
0.03-0.20	3.1	0.45	0.39	0.49	0.012	6.69	8.12	6.86	11.94
0.21-0.50	0.53	0.37	1.32	0.54	0.015	3.79	0.32	0.47	1.67
0.51-1.00	0.42	0.92	1.89	1.19	0.083	3.83	0.28	0.73	1.62
1.01-2.00	0.5	1.57	2.51	2.25	0.91	2.53	0.54	1.51	1.13
2.01-5.00	1.27	0.48	2.62	1.74	2.25	3.1	2.06	1.76	0.85
> 5.00	0.046	0.013	0.15	0.055	0.3	0.0034	0.74	0.48	0.0028

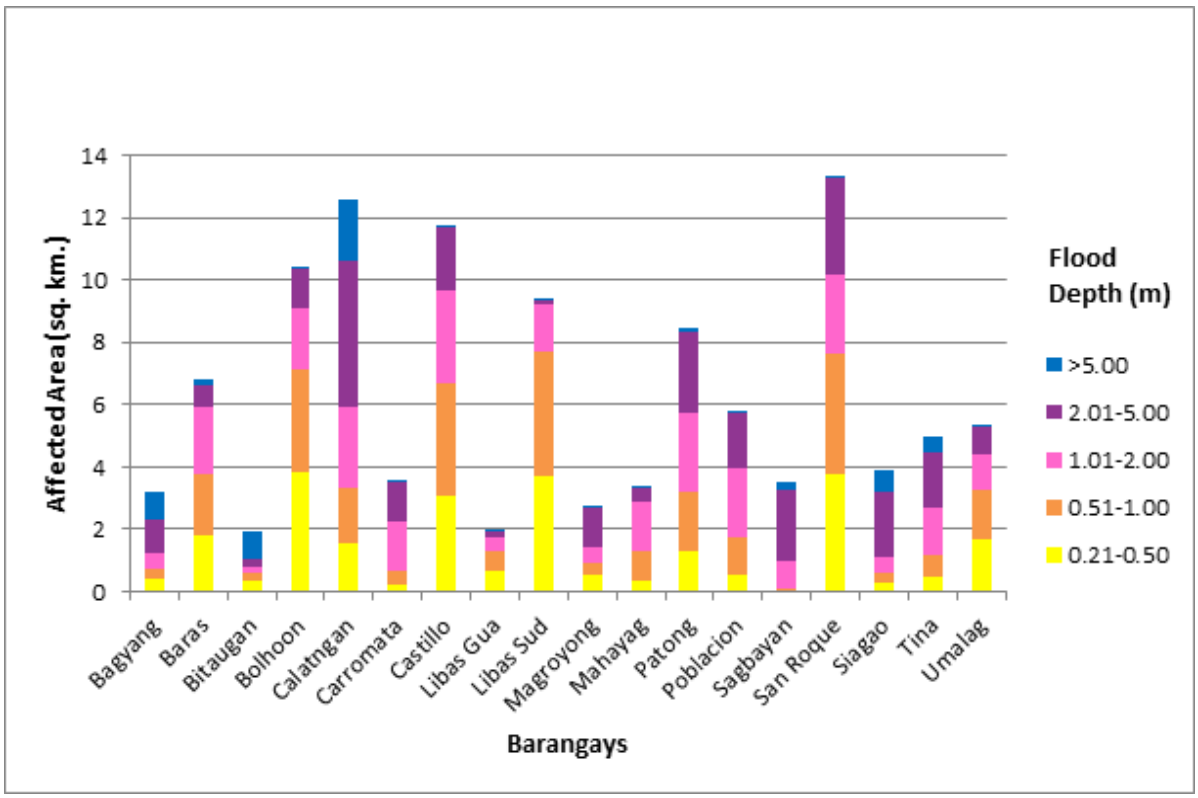

Figure 86. Affected areas in San Miguel, Surigao del Sur during a 25-year rainfall return period

For the municipality of Sibagat, with an area of 728.8 sq km, 0.23% will experience flood levels of less 0.20 meters; 0.006% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.002%, 0.002%, 0.006%, 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 49 are the affected areas in square kilometres by flood depth per barangay.

Table 49. Affected areas in Sibagat, Agusan del Sur during a 25-year rainfall return period

Affected Area (sq. km.) by flood depth (in m.)	**Area of affected barangays in Sibagat (in sq km.)**
	Kolambugan
0.03-0.20	1.65
0.21-0.50	0.042
0.51-1.00	0.012
1.01-2.00	0.016
2.01-5.00	0.042
> 5.00	0.23

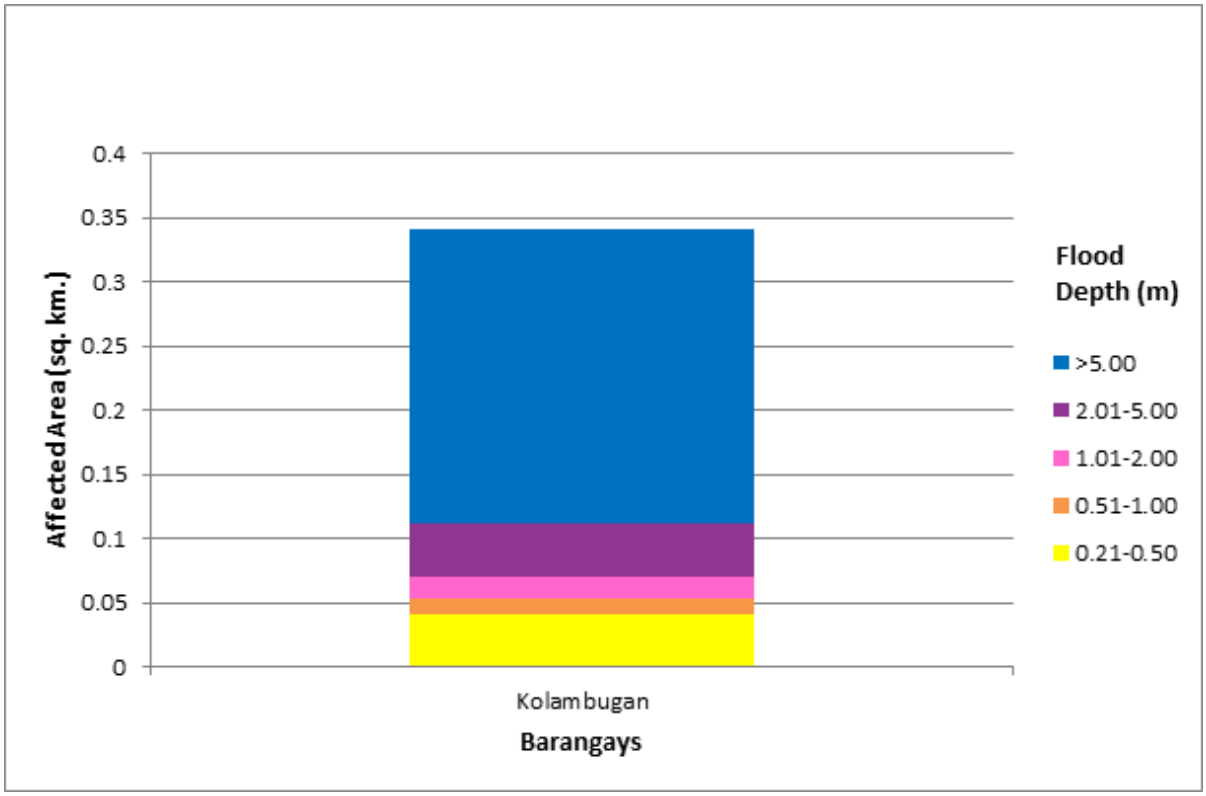

Figure 87. Affected areas in Sibagat, Agusan del Sur during a 25-year rainfall return period

For the municipality of Tago, with an area of 321.22 sq km, 41.33% will experience flood levels of less 0.20 meters; 8.75% of the area will experience flood levels of 0.21 to 0.50 meters; while 7.26%, 5.24%, 2.91%, and 0.35% 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 50 and Table 51 are the affected areas in square kilometres by flood depth per barangay.

Table 50. Affected areas in Tago, Surigao del Sur during a 25-year rainfall return period

Affected area (sq km.) by flood depth (in m.)	Area of affected barangays in Tago (in sq km.)											
	Alba	Anahao Bag-O	Anahao Daan	Badong	Bajao	Bangsud	Cabangahan	Cagdapao	Camagong	Caras-An	Cayale	Dayo-An
0.03-0.20	6.1	4.84	4.39	11.22	7.5	4.57	9.53	4.72	2.39	10.39	9.26	2.38
0.21-0.50	1.03	0.92	2.38	0.96	0.96	0.96	0.4	0.28	1.98	4.22	0.52	0.6
0.51-1.00	0.81	0.61	1.94	1.18	0.93	0.74	0.35	0.17	1.33	2.08	0.71	0.89
1.01-2.00	0.54	0.45	1.25	2.02	1.17	0.43	0.63	0.15	0.12	0.62	1.63	0.38
2.01-5.00	0.96	0.54	0.47	2.65	0.22	0.39	0.19	0.16	0.073	0.29	0.49	0.026
> 5.00	0.24	0.015	0.014	0.16	0.0029	0.035	0.031	0.026	0	0.063	0.01	0

Table 51. Affected areas in Tago, Surigao del Sur during a 25-year rainfall return period

Affected area (sq km.) by flood depth (in m.)	Area of affected barangays in Tago (in sq km.)											
	Gamut	Jubang	Kinabigtasan	Layog	Lindoy	Mercedes	Purisima	Sumo-Sumo	Umbay	Unaban	Unidos	Victoria
0.03-0.20	1.53	2.24	1.71	19.02	7.81	0.45	1.24	7.55	2.65	3.91	4.03	3.34
0.21-0.50	0.69	0.38	0.63	2.68	0.95	0.14	0.44	0.33	0.75	2.42	2.26	1.2
0.51-1.00	0.64	0.68	0.47	3.15	0.79	0.11	0.13	0.45	0.99	1.72	1.44	0.99
1.01-2.00	0.27	0.15	0.37	2.32	0.55	0.035	0.0033	0.76	1.31	0.68	0.67	0.33
2.01-5.00	0.3	0.026	0.026	1.02	0.28	0	0	0.31	0.28	0.19	0.4	0.031
> 5.00	0	0.0002	0	0.4	0.099	0	0	0.0071	0.00064	0.003	0.03	0.0016

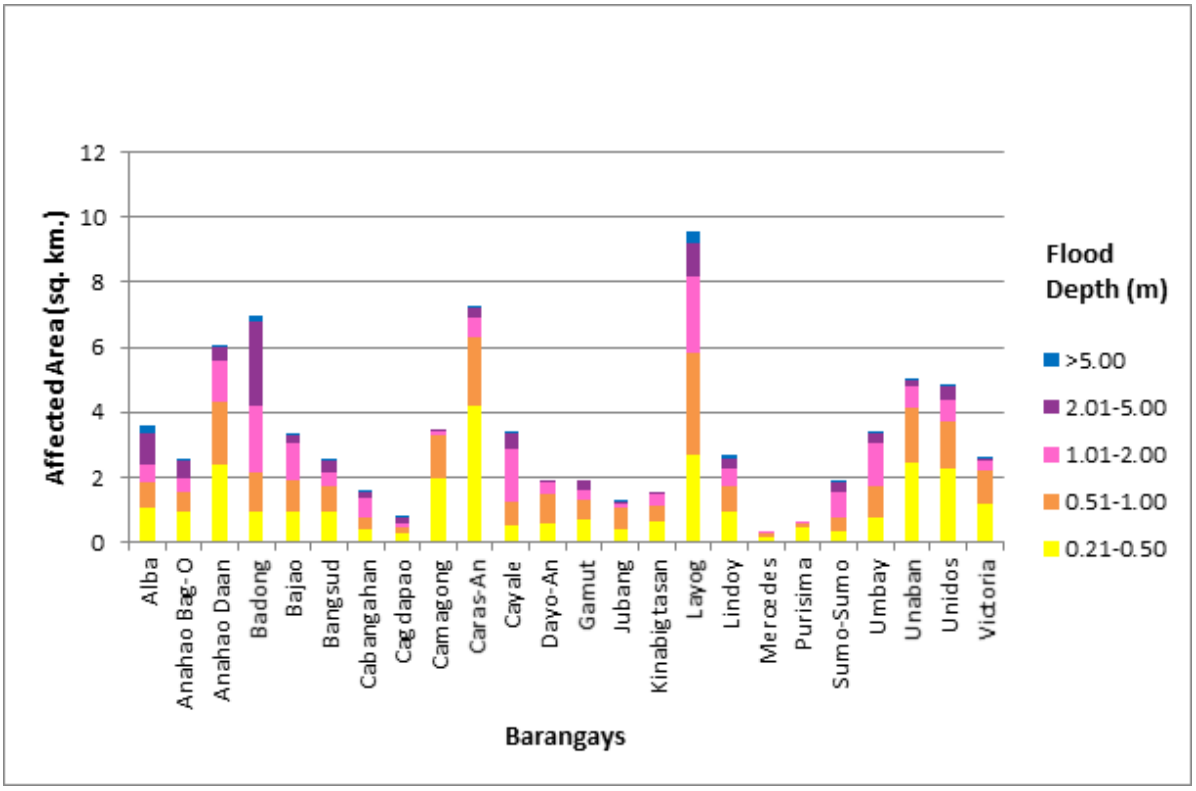

Figure 88. Affected areas in Tago, Surigao del Sur during a 25-year rainfall return period

For the city of Tandag, with an area of 181.51 sq km, 28.39% will experience flood levels of less 0.20 meters; 1.84% of the area will experience flood levels of 0.21 to 0.50 meters; while 1.92%, 3.55%, 4.4%, and 3.14% 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 52 and Table 53 are the affected areas in square kilometres by flood depth per barangay.

Table 52. Affected areas in Tandag City, Surigao del Sur during a 25-year rainfall return period

Affected area (sq km.) by flood depth (in m.)	Area of affected barangays in Tandag City (in sq km.)								
	Awasian	Bagong Lungsod	Bioto	Bongtod Poblacion	Dagocdoc	Mabua	Mabuhay	Maitum	Maticdum
0.03-0.20	6.05	0.18	0.44	0.37	0.13	0.94	22.71	2.53	2.81
0.21-0.50	0.29	0.059	0.045	0.03	0.03	0.43	0.71	0.12	0.23
0.51-1.00	0.48	0.018	0.14	0.0005	0.0072	0.26	0.41	0.073	0.35
1.01-2.00	1.62	0.0023	0.88	0	0.0064	0.088	0.38	0.084	0.88
2.01-5.00	1.03	0	1.35	0	0.016	0.022	0.72	0.74	0.31
> 5.00	0.028	0	0.01	0	0	0	5	0.37	0.002

Table 53. Affected areas in Tandag City, Surigao del Sur during a 25-year rainfall return period

Affected area (sq km.) by flood depth (in m.)	Area of affected barangays in Tandag City (in sq km.)							
	Pandanon	Quezon	Rosario	San Agustin Norte	San Agustin Sur	San Isidro	San Jose	Telaje
0.03-0.20	2.62	0.35	1.71	1.6	0.11	3.87	2.68	2.42
0.21-0.50	0.1	0.046	0.45	0.095	0.031	0.22	0.12	0.34
0.51-1.00	0.12	0.18	0.5	0.11	0.071	0.28	0.14	0.34
1.01-2.00	0.18	0.78	0.16	0.21	0.1	0.44	0.15	0.51
2.01-5.00	0.72	0.92	0.0031	0.12	0.17	1.13	0.32	0.4
> 5.00	0.14	0.12	0	0.0001	0	0.018	0	0

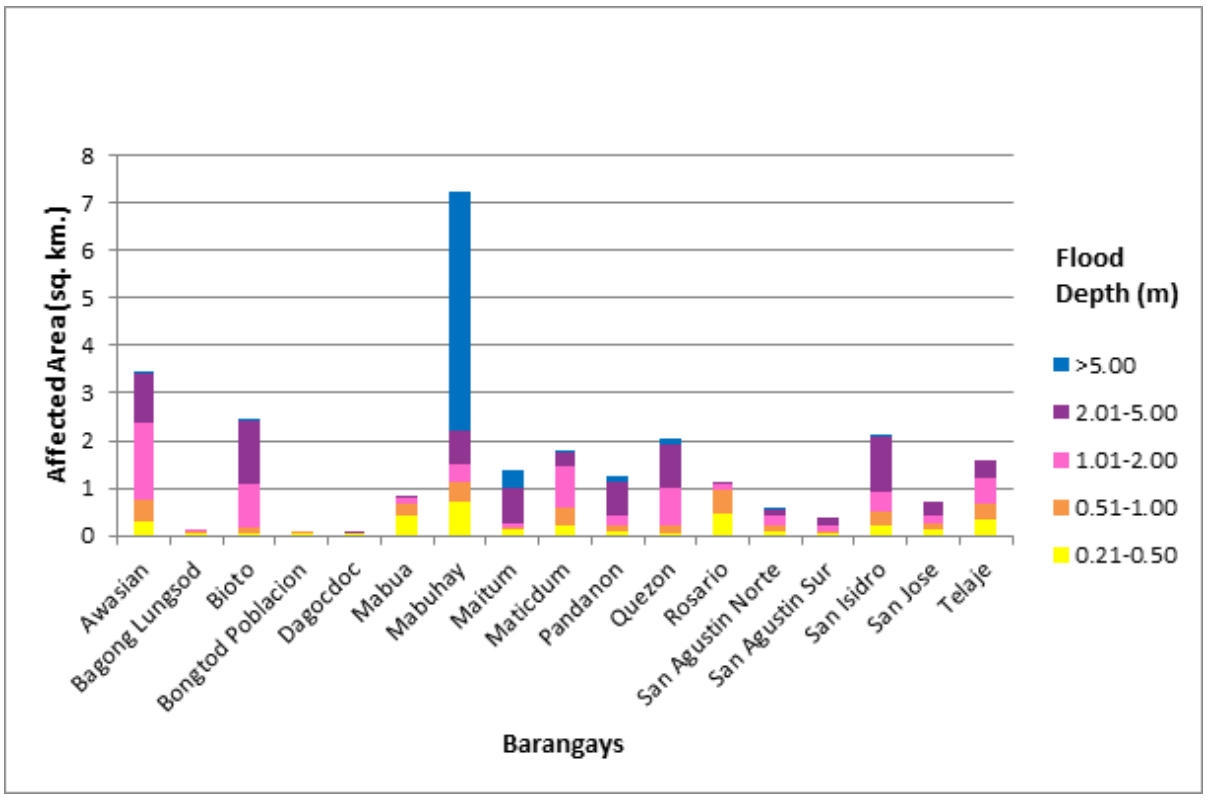

Figure 89. Affected areas in Tandag City, Surigao del Sur during a 25-year rainfall return period

For the 100-year return period, 21.83% of the municipality of Bayabas, with an area of 117.84 sq km, will experience flood levels of less 0.20 meters; 3.69% of the area will experience flood levels of 0.21 to 0.50 meters; while 4.2%, 4.24%, 1.46%, and 0.05% 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 54 are the affected areas in square kilometres by flood depth per barangay.

Table 54. Affected areas in Bayabas, Surigao del Sur during a 100-year rainfall return period

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Bayabas (in sq km.)						
	Amag	Balete	Cabugo	Cagbaoto	La Paz	Magobawok	Panaosawon
0.03-0.20	10.12	1.77	1.72	1.77	2.99	2.41	4.95
0.21-0.50	0.44	0.69	0.33	0.32	1.55	0.36	0.65
0.51-1.00	0.27	1.01	0.28	0.47	1.96	0.39	0.58
1.01-2.00	0.39	0.69	0.34	0.28	1.75	0.48	1.07
2.01-5.00	0.36	0.042	0.13	0.056	0.59	0.11	0.43
> 5.00	0.023	0.0041	0	0.0023	0.022	0	0.0025

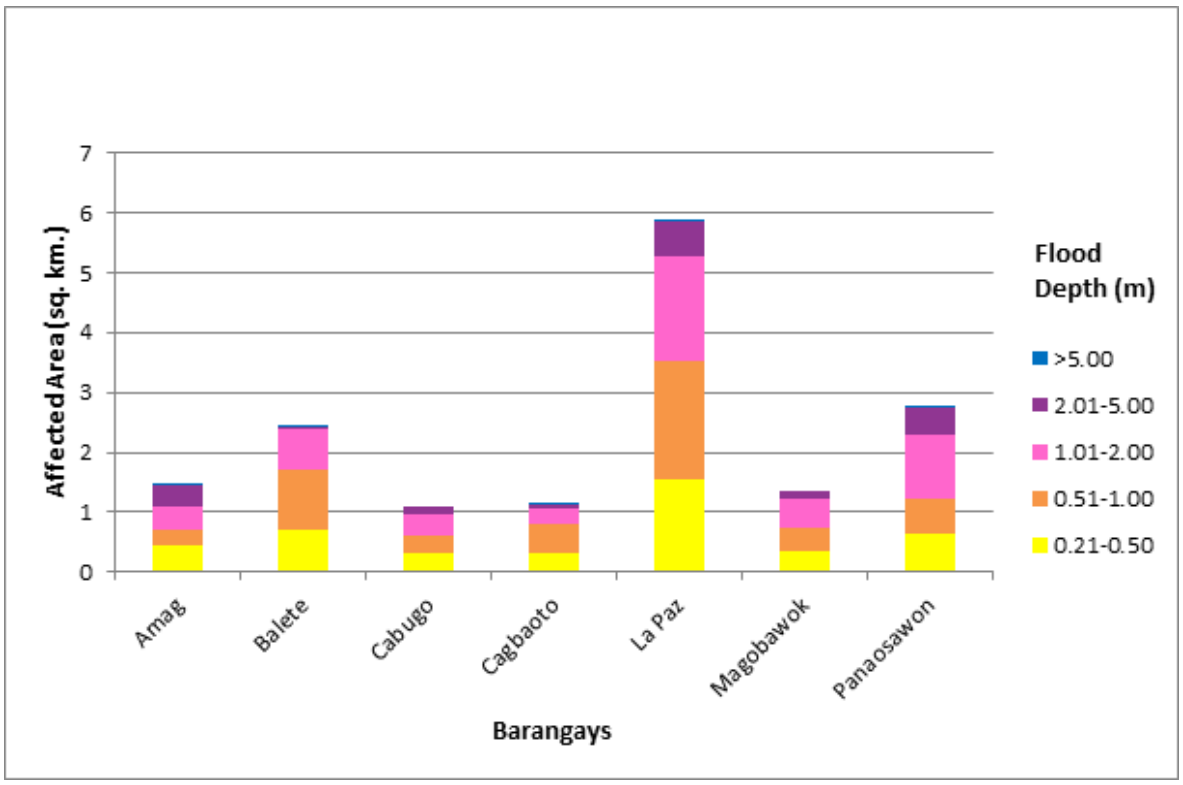

Figure 90. Affected areas in Bayabas, Surigao del Sur during a 100-year rainfall return period

For the municipality of Cagwait, with an area of 78.45 sq km, 25.5% will experience flood levels of less 0.20 meters; 1.01% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.62%, 0.91%, 1.49%, 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 55 are the affected areas in square kilometres by flood depth per barangay.

Table 55. Affected areas in Cagwait, Surigao del Sur during a 100-year rainfall return period

Affected Area (sq. km.) by flood depth (in m.)	**Area of affected barangays in Cagwait (in sq km.)**	
	La Purisima	**Tubo-Tubo**
0.03-0.20	25.12	15.28
0.21-0.50	0.98	0.62
0.51-1.00	0.65	0.33
1.01-2.00	1.15	0.29
2.01-5.00	2.02	0.34
> 5.00	0.32	0.19

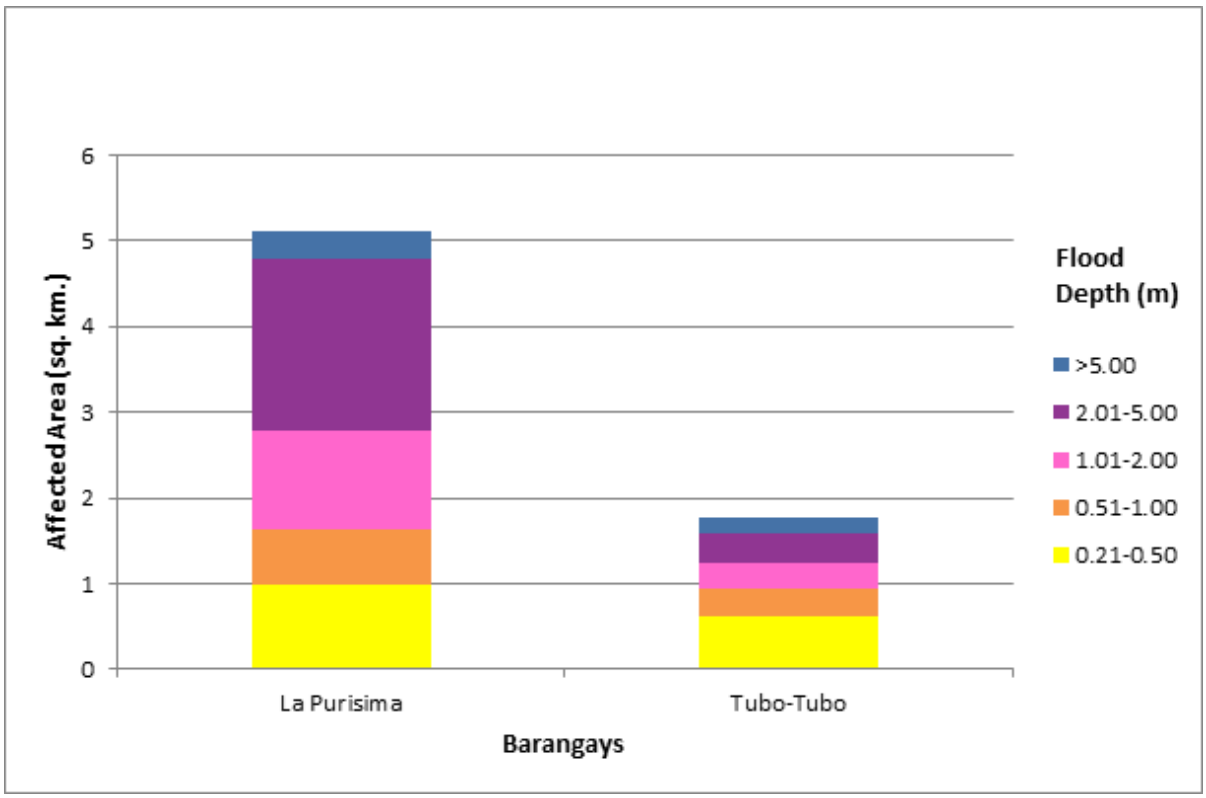

Figure 91. Affected areas in Cagwait, Surigao del Sur during a 100-year rainfall return period

For the municipality of Carmen, with an area of 158.4 sq km, 3.81% will experience flood levels of less 0.20 meters; 0.17% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.08%, 0.07%, 0.11%, and 1.1% 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 56 are the affected areas in square kilometres by flood depth per barangay.

Table 56. Affected areas in Carmen, Surigao del Sur during a 100-year rainfall return period

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Carmen (in sq km.)		
	Cancavan	**Puyat**	**Pakwan**
0.03-0.20	0.12	0.031	5.87
0.21-0.50	0.007	0.00075	0.27
0.51-1.00	0.002	0.0011	0.12
1.01-2.00	0.0001	0.0001	0.1
2.01-5.00	0	0	0.17
> 5.00	0	0	1.73

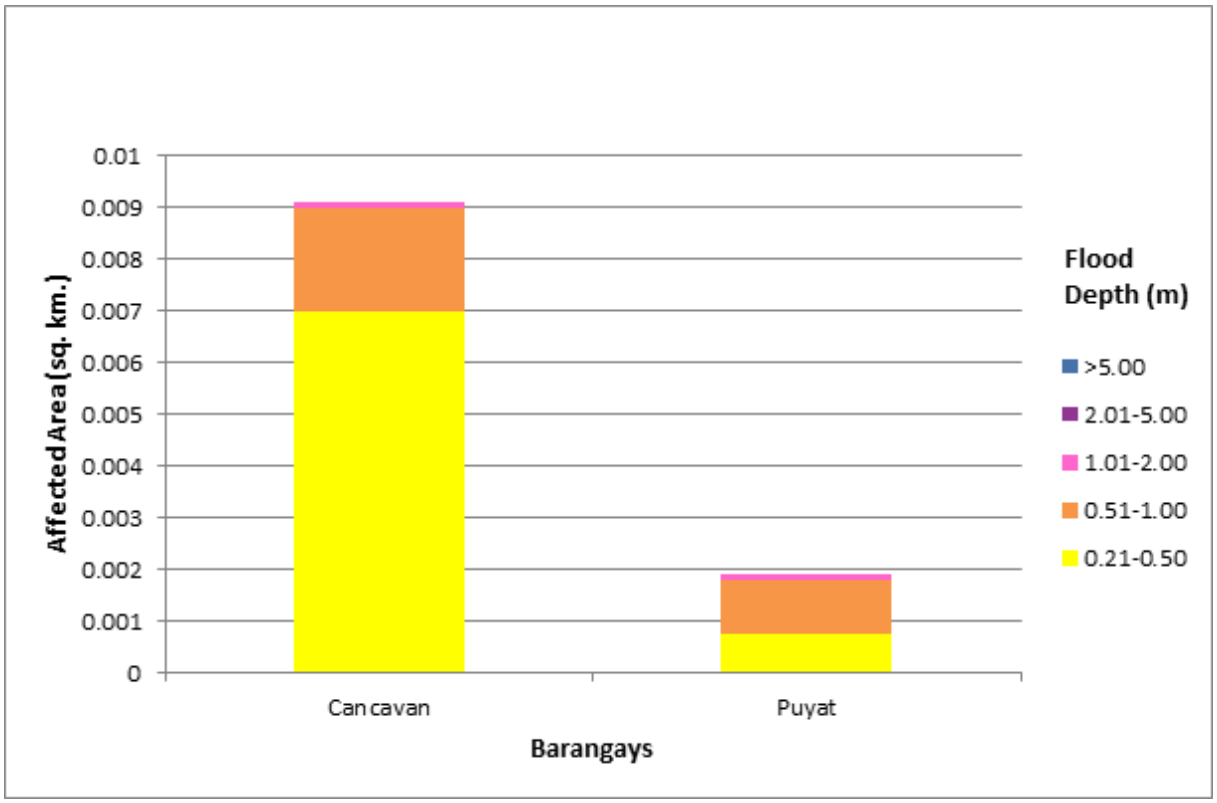

Figure 92. Affected areas in Carmen, Surigao del Sur during a 100-year rainfall return period

For the municipality of Lanuza, with an area of 317.09 sq km, 1.91% will experience flood levels of less 0.20 meters; 0.08% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.04%, 0.03%, 0.06%, and 0.5% 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 kilometres by flood depth per barangay.

Table 57. Affected areas in Lanuza, Surigao del Sur during a 100-year rainfall return period

Affected Area (sq. km.) by flood depth (in m.)	**Area of affected barangays in Lanuza (in sq km.)**
	Pakwan
0.03-0.20	5.87
0.21-0.50	0.27
0.51-1.00	0.12
1.01-2.00	0.1
2.01-5.00	0.17
> 5.00	1.73

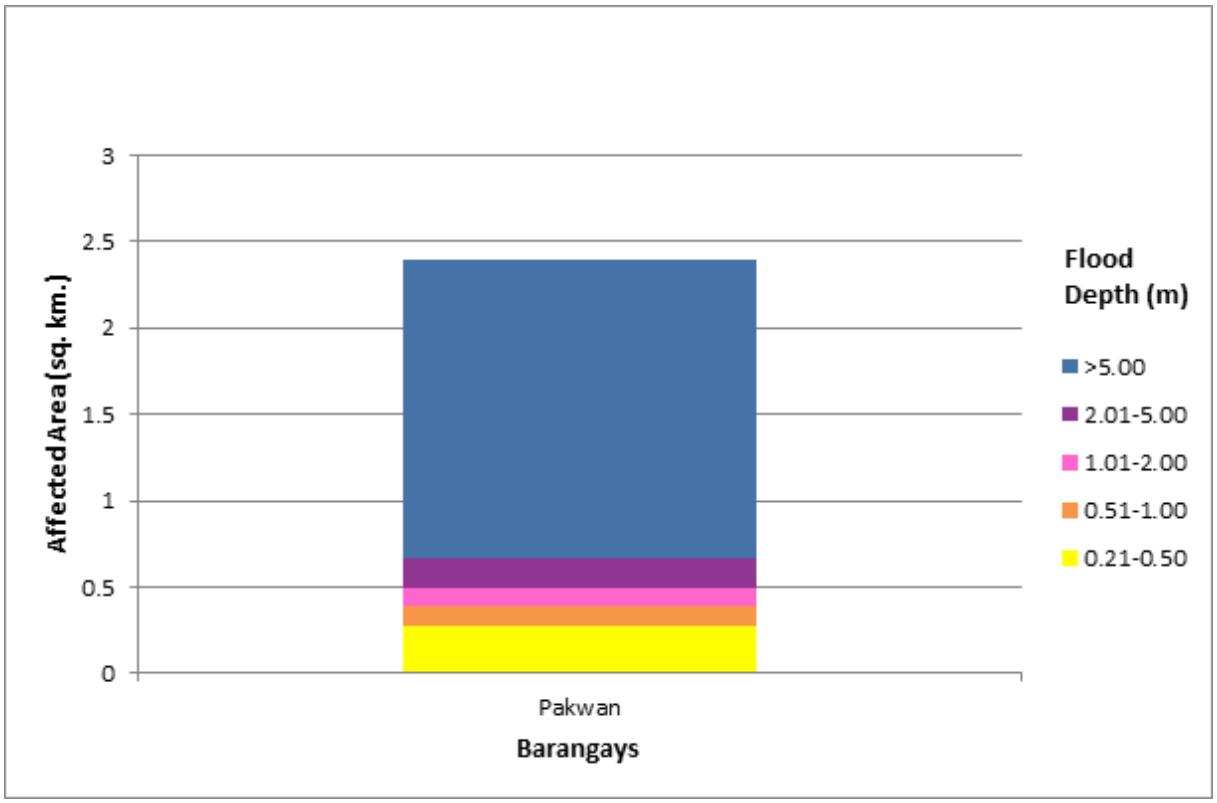

Figure 93. Affected areas in Lanuza, Surigao del Sur during a 100-year rainfall return period

For the municipality of San Miguel, with an area of 654.52 sq km, 19.32% will experience flood levels of less 0.20 meters; 3.01% of the area will experience flood levels of 0.21 to 0.50 meters; while 3.52%, 4.24%, 6.78%, and 1.21% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 58 and Table 59 are the affected areas in square kilometres by flood depth per barangay.

Table 58. Affected areas in San Miguel, Surigao del Sur during a 100-year rainfall return period

Affected area (sq km.) by flood depth (in m.)	Area of affected barangays in San Miguel (in sq km.)								
	Bagyang	Baras	Bitaugan	Bolhoon	Calatngan	Carromata	Castillo	Libas Gua	Libas Sud
0.03-0.20	10.89	1.58	11.83	7.47	26.76	0.94	21.9	2.95	7.18
0.21-0.50	0.44	1	0.41	3.63	1.47	0.083	2.74	0.67	2.92
0.51-1.00	0.29	1.71	0.24	3.54	1.56	0.15	3.22	0.72	3.69
1.01-2.00	0.36	3.13	0.23	1.64	2.45	0.78	3.12	0.59	3
2.01-5.00	0.92	2.72	0.29	2.58	5.12	2.55	3.36	0.14	1.18
> 5.00	1.46	0.31	0.91	0.0002	2.7	0.024	0.04	0.13	0.0051

Table 59. Affected areas in San Miguel, Surigao del Sur during a 100-year rainfall return period

Affected area (sq km.) by flood depth (in m.)	Area of affected barangays in San Miguel (in sq km.)								
	Magroyong	Mahayag	Patong	Poblacion	Sagbayan	San Roque	Siagao	Tina	Umalag
0.03-0.20	2.93	0.18	0.13	0.24	0.0018	5.32	7.93	6.68	11.51
0.21-0.50	0.5	0.15	0.18	0.1	0.0044	3.02	0.32	0.41	1.62
0.51-1.00	0.49	0.24	0.81	0.39	0.013	3.39	0.26	0.6	1.71
1.01-2.00	0.45	1.21	2.53	1.7	0.28	3.02	0.45	1.45	1.32
2.01-5.00	1.28	2	5.07	3.73	2.79	5.2	2.2	2.17	1.05
> 5.00	0.2	0.027	0.17	0.062	0.47	0.0042	0.89	0.49	0.0081

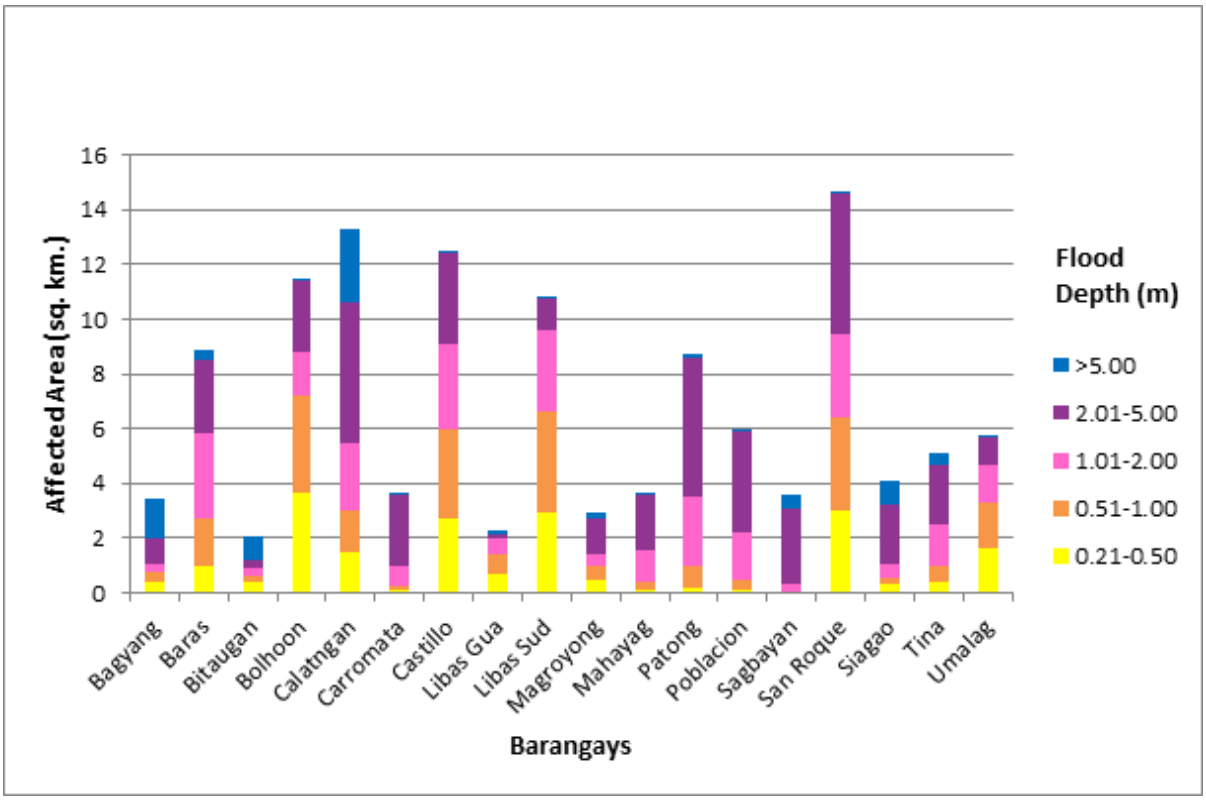

Figure 94. Affected areas in San Miguel, Surigao del Sur during a 100-year rainfall return period

For the municipality of Sibagat, with an area of 728.8 sq km, 0.22% will experience flood levels of less 0.20 meters; 0.006% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.002%, 0.002%, 0.004%, and 0.04% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 60 are the affected areas in square kilometres by flood depth per barangay.

Table 60. Affected areas in Sibagat, Agusan del Sur during a 100-year rainfall return period

Affected Area (sq. km.) by flood depth (in m.)	**Area of affected barangays in Sibagat (in sq km.)**
	Kolambugan
0.03-0.20	1.62
0.21-0.50	0.047
0.51-1.00	0.015
1.01-2.00	0.012
2.01-5.00	0.032
> 5.00	0.26

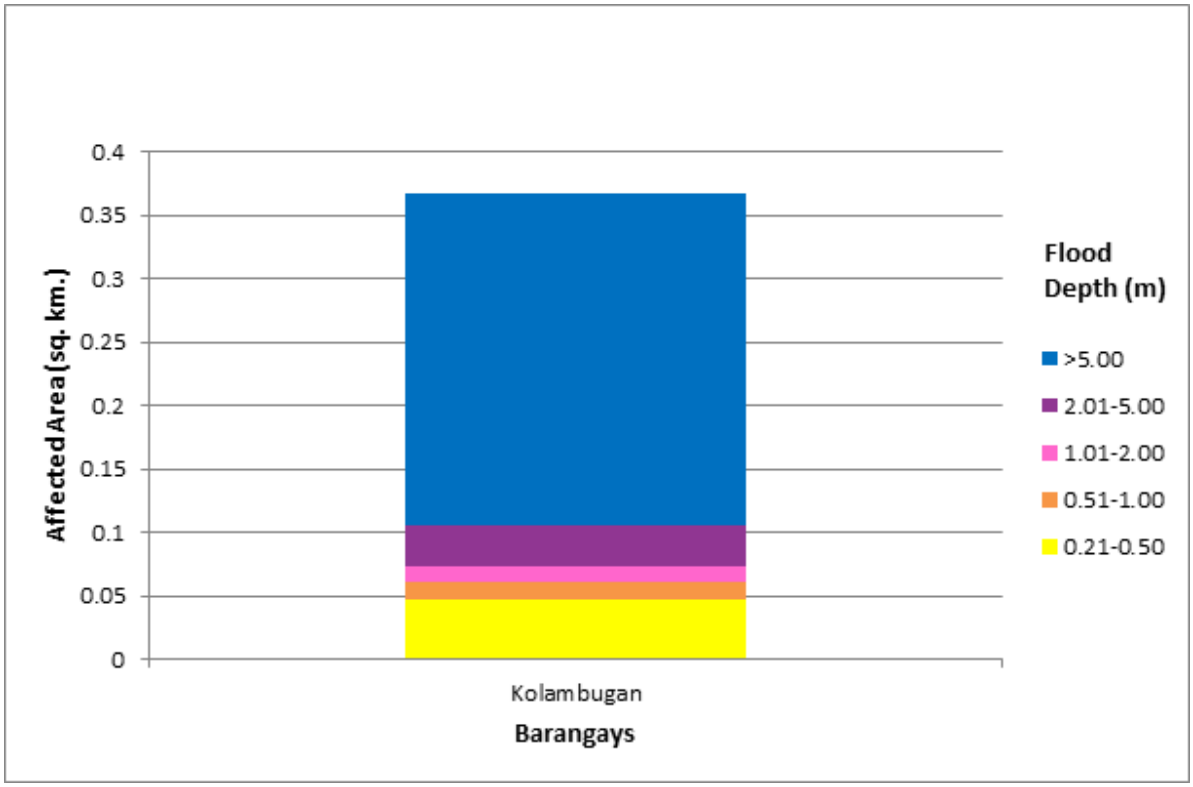

Figure 95. Affected areas in Sibagat, Agusan del Sur during a 100-year rainfall return period

For the municipality of Tago, with an area of 321.22 sq km, 38.51% will experience flood levels of less 0.20 meters; 8.5% of the area will experience flood levels of 0.21 to 0.50 meters; while 8.17%, 6.26%, 3.84%, and 0.57% 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 61 and Table 62 are the affected areas in square kilometres by flood depth per barangay.

Table 61. Affected areas in Tago, Surigao del Sur during a 100-year rainfall return period

Affected area (sq km.) by flood depth (in m.)	Area of affected barangays in Tago (in sq km.)											
	Alba	Anahao Bag-O	Anahao Daan	Badong	Bajao	Bangsud	Cabangahan	Cagdapao	Camagong	Caras-An	Cayale	Dayo-An
0.03-0.20	5.53	4.48	3.86	10.74	7.24	4.24	9.41	4.63	1.87	8.83	9.12	2.26
0.21-0.50	1.02	0.94	2.27	0.89	0.84	0.95	0.43	0.32	1.88	4.43	0.5	0.5
0.51-1.00	1.03	0.8	2.15	1.05	0.88	0.88	0.32	0.19	1.79	2.93	0.58	0.91
1.01-2.00	0.61	0.54	1.59	1.84	1.28	0.5	0.69	0.15	0.28	1.05	1.61	0.57
2.01-5.00	1.09	0.6	0.55	3.47	0.54	0.48	0.23	0.17	0.091	0.33	0.79	0.033
> 5.00	0.41	0.021	0.024	0.21	0.0038	0.094	0.042	0.046	0	0.11	0.016	0.0001

Table 62. Affected areas in Tago, Surigao del Sur during a 100-year rainfall return period

Affected area (sq km.) by flood depth (in m.)	Area of affected barangays in Tago (in sq km.)											
	Gamut	Jubang	Kinabigtasan	Layog	Lindoy	Mercedes	Purisima	Sumo-Sumo	Umbay	Unaban	Unidos	Victoria
0.03-0.20	1.35	2.18	1.51	17.9	7.38	0.42	1.13	7.46	2.37	3.18	3.54	3.05
0.21-0.50	0.68	0.33	0.6	2.47	0.98	0.15	0.49	0.33	0.7	2.25	2.22	1.15
0.51-1.00	0.65	0.7	0.6	3.41	0.85	0.13	0.18	0.39	0.85	2.2	1.63	1.16
1.01-2.00	0.33	0.24	0.37	3	0.69	0.049	0.009	0.82	1.57	0.94	0.95	0.43
2.01-5.00	0.4	0.031	0.12	1.25	0.39	0	0	0.41	0.49	0.32	0.44	0.089
> 5.00	0.0049	0.0005	0	0.57	0.18	0	0	0.01	0.00074	0.013	0.065	0.0047

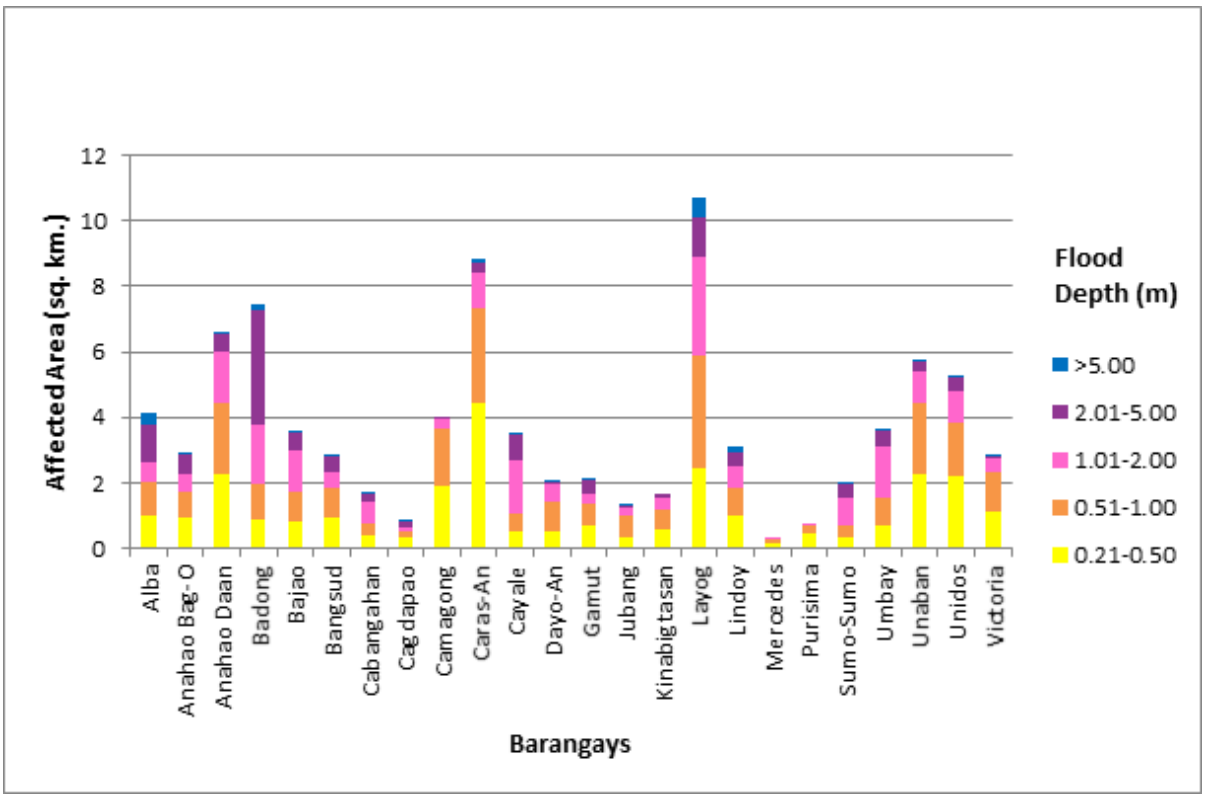

Figure 96. Affected areas in Tago, Surigao del Sur during a 100-year rainfall return period

For the city of Tandag, with an area of 181.51 sq km, 27.66% will experience flood levels of less 0.20 meters; 1.83% of the area will experience flood levels of 0.21 to 0.50 meters; while 1.74%, 3.25%, 5.17%, and 3.59% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 63 and Table 64 are the affected areas in square kilometres by flood depth per barangay.

Table 63. Affected areas in Tandag City, Surigao del Sur during a 100-year rainfall return period

Affected area (sq km.) by flood depth (in m.)	Area of affected barangays in Tandag City (in sq km.)								
	Awasian	Bagong Lungsod	Bioto	Bongtod Poblacion	Dagocdoc	Mabua	Mabuhay	Maitum	Maticdum
0.03-0.20	5.96	0.14	0.43	0.37	0.11	0.8	22.21	2.5	2.76
0.21-0.50	0.27	0.086	0.034	0.037	0.04	0.43	0.75	0.12	0.2
0.51-1.00	0.3	0.03	0.074	0.0009	0.016	0.35	0.41	0.072	0.3
1.01-2.00	1.4	0.0063	0.63	0	0.0062	0.13	0.37	0.073	0.86
2.01-5.00	1.52	0	1.66	0	0.017	0.028	0.66	0.62	0.46
> 5.00	0.052	0	0.045	0	0	0	5.55	0.54	0.0027

Table 64. Affected areas in Tandag City, Surigao del Sur during a 100-year rainfall return period

Affected area (sq km.) by flood depth (in m.)	Area of affected barangays in Tandag City (in sq km.)							
	Pandanon	Quezon	Rosario	San Agustin Norte	San Agustin Sur	San Isidro	San Jose	Telaje
0.03-0.20	2.58	0.34	1.61	1.56	0.079	3.82	2.65	2.31
0.21-0.50	0.1	0.023	0.44	0.11	0.039	0.21	0.12	0.34
0.51-1.00	0.11	0.1	0.51	0.085	0.051	0.27	0.14	0.33
1.01-2.00	0.15	0.62	0.24	0.21	0.11	0.4	0.14	0.56
2.01-5.00	0.77	1.18	0.024	0.17	0.2	1.25	0.36	0.47
> 5.00	0.18	0.13	0	0.0002	0	0.019	0	0

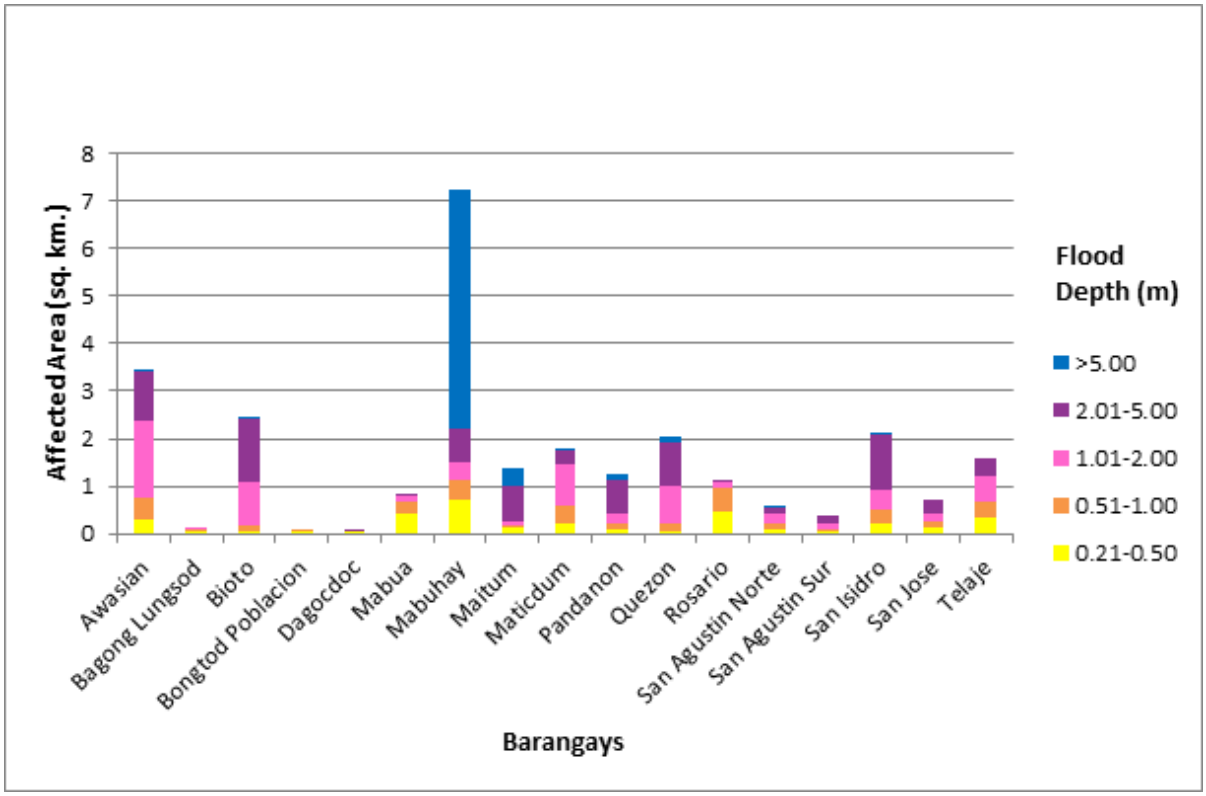

Figure 97. Affected areas in Tandag City, Surigao del Sur during a 100-year rainfall return period

Among the barangays in the municipality of Bayabas, Panosawon is projected to have the highest percentage of area that will experience flood levels at 14.3%. Meanwhile, Magobawok posted the second highest percentage of area that may be affected by flood depths at 11.73%.

Among the barangays in the municipality of Cagwait, La Purisima is projected to have the highest percentage of area that will experience flood levels at 38.55%. Meanwhile, Tubo-Tubo posted the second highest percentage of area that may be affected by flood depths at 21.73%.

Among the barangays in the municipality of Carmen, Pakwan is projected to have the highest percentage of area that will experience flood levels at 5.22%. Meanwhile, Cancavan posted the second highest percentage of area that may be affected by flood depths at 0.084%.

Among the barangays in the municipality of Lanuza, Pakwan is projected to have the highest percentage of area that will experience flood levels at 2.6%.

Among the barangays in the municipality of San Miguel, Calatngan is projected to have the highest percentage of area that will experience flood levels at 6.15%. Meanwhile, San Roque posted the second highest percentage of area that may be affected by flood depths at 3.05%.

Among the barangays in the municipality of Sibagat, Kolambugan is projected to have the highest percentage of area that will experience flood levels at 0.63%.

Among the barangays in the municipality of Tago, Layog is projected to have the highest percentage of area that will experience flood levels at 8.9%. Meanwhile, Badong posted the second highest percentage of area that may be affected by flood depths at 5.66%.

Among the barangays in the municipality of Tandag City, Mabuhay is projected to have the highest percentage of area that will experience flood levels at 16.5%. Meanwhile, Awasian posted the second highest percentage of area that may be affected by flood depths at 5.23%.

Moreover, the generated flood hazard maps for the Tago Floodplain were used to assess the vulnerability of the educational and medical institutions in the floodplain. Using the flood depth units of PAG-ASA for hazard maps—"Low," "Medium," and "High"—the affected institutions were given their individual assessment for each flood hazard scenario (5-year, 25-year, and 100-year).

Table 65. 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	65.83	63.45	57.07
Medium	94.26	94.76	94.49
High	57.99	88.19	117.11
TOTAL	218.08	246.4	268.67

Of the identified education institutions in the Tago Floodplain, 4 schools were assessed to be exposed to low-level flooding during a 5 year scenario. See ANNEX 12 for a detailed enumeration of schools in the Tago Floodplain.

Of the identified medical institutions in the TagoFloodplain, no schools were assessed to be exposed to any of the flooding scenarios. See ANNEX 13 for a detailed enumeration of hospitals and clinics in the Tago Floodplain.

The flood validation consisted of 606 points randomly selected all over the Tago Floodplain. It has an RMSE value of 1.48.

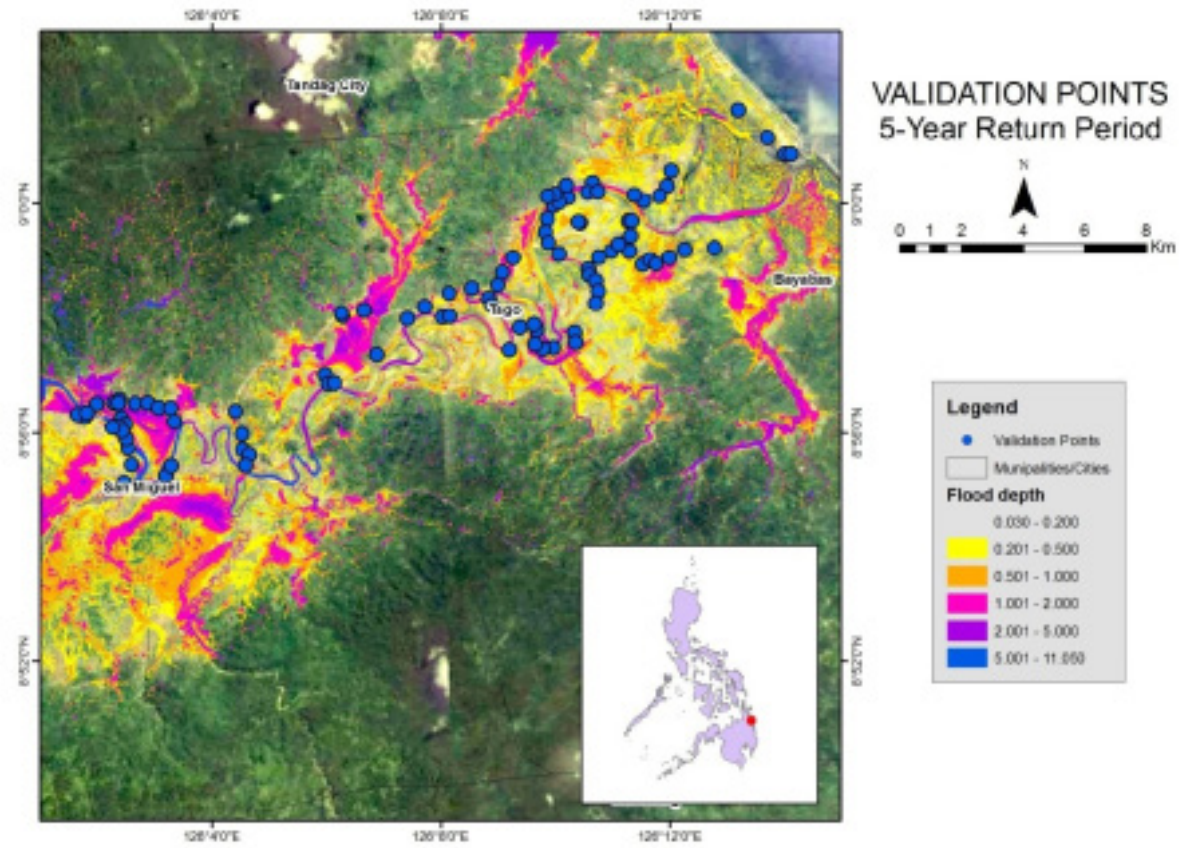

Figure 98. Flood validation points of Tago River Basin

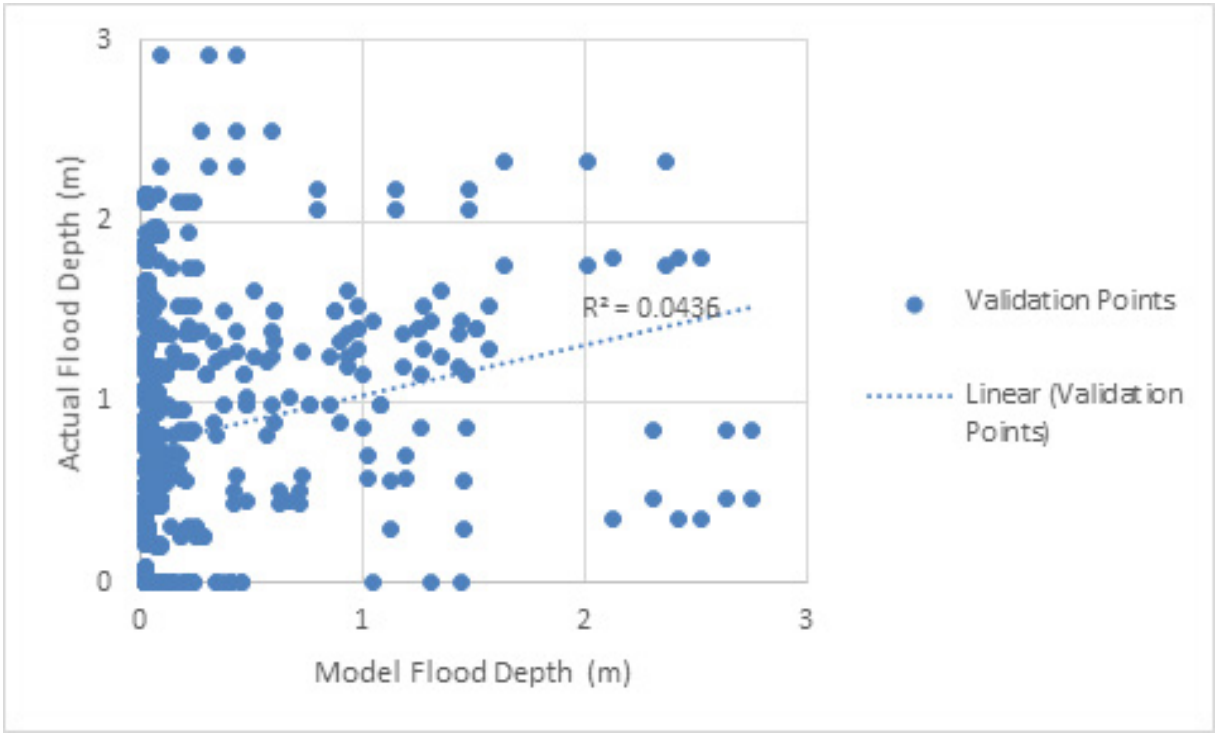

Figure 99. Flood map depth vs. actual flood depth

Table 66. Actual flood depth vs. simulated flood depth

Actual Flood Depth (m)	Modeled Flood Depth (m)						
	0-0.20	0.21-0.50	0.51-1.00	1.01-2.00	2.01-5.00	> 5.00	Total
0-0.20	118	14	0	3	0	0	135
0.21-0.50	61	9	3	2	6	0	81
0.51-1.00	108	12	11	10	3	0	144
1.01-2.00	142	23	23	20	5	0	213
2.01-5.00	15	8	3	5	2	0	33
> 5.00	0	0	0	0	0	0	0
Total	444	66	40	40	16	0	606

The overall accuracy generated by the flood model is estimated at 26.40% with 160 points correctly matching the actual flood depths. In addition, there were 121 points estimated one level above and below the correct flood depths while there were 139 points and 174 points estimated two levels above and below, and three or more levels above and below the correct flood. A total of 4 points were overestimated while a total of 400 points were underestimated in the modeled flood depths of Tago.

Table 67. Summary of accuracy assessment in Tago River Basin survey

DARAGA	No. of Points	%
Correct	160	**26.40**
Overestimated	46	**7.59**
Underestimated	400	**66.01**
Total	606	**100.00**

REFERENCES

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ANNEXES

Annex 1. OPTECH Technical Specification of the Aquarius Sensor

Parameter	Specification
Operational altitude	300-600 m AGL
Laser pulse repetition rate	33, 50. 70 kHz
Scan rate	0-70 Hz
Scan half-angle	0 to ± 25 °
Laser footprint on water surface	30-60 cm
Depth range	0 to > 10 m (for k < 0.1/m)
Topographic mode	
Operational altitiude	300-2500
Range Capture	Up to 4 range measurements, including 1st, 2nd, 3rd, and last returns
Intensity capture	12-bit dynamic measurement range
Position and orientation system	POS AVTM 510 (OEM) includes embedded 72-channel GNSS receiver (GPS and GLONASS)
Data Storage	Ruggedized removable SSD hard disk (SATA III)
Power	28 V, 900 W, 35 A
Image capture	5 MP interline camera (standard); 60 MP full frame (optional)
Full waveform capture	12-bit Optech IWD-2 Intelligent Waveform Digitizer (optional)
Dimensions and weight	Sensor:250 x 430 x 320 mm; 30 kg; Control rack: 591 x 485 x 578 mm; 53 kg
Operating Temperature	0-35˚C
Relative humidity	0-95% no-condensing

Annex 2. NAMRIA Certification of Reference Points Used in the LIDAR Survey

1. SRS-51

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

July 11, 2014

CERTIFICATION

To whom it may concern

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

Province: **SURIGAO DEL SUR**
Station Name: **SRS-51**
Order: **2nd**

Island: **MINDANAO**
Municipality: **TAGO**
Barangay: **BAJAO**
MSL Elevation:

PRS92 Coordinates

Latitude: **8° 59' 14.14996"** Longitude: **126° 9' 6.63416"** Ellipsoidal Hgt: **3.97000 m.**

WGS84 Coordinates

Latitude: **8° 59' 10.56678"** Longitude: **126° 9' 12.17833"** Ellipsoidal Hgt: **74.22300 m.**

PTM / PRS92 Coordinates

Northing: **993837.182 m.** Easting: **406741.609 m.** Zone: **6**

UTM / PRS92 Coordinates

Northing: **994,558.26** Easting: **186,815.64** Zone: **52**

Location Description

SRS-51
From Tandag City travel to Brgy. Bajao municipality of Tago for 13 km south. The station is located inside the compound of Bajao Brgy. hall, beside the SW side of the basketball court. The basketball court is about 20 m after the main gate of barangay. Mark is the head of a 3" copper nail set at the corner of a cement block embedded on the ground with inscriptions SRS-51 2007 NAMRIA.

Requesting Party: **UP TCAGP / Engr. Christopher Cruz**
Pupose: **Reference**
OR Number: **8796507 A**
T.N.: **2014-1584**

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

2. SRS-53

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

July 11, 2014

CERTIFICATION

To whom it may concern:

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

Province: SURIGAO DEL SUR
Station Name: SRS-53
Order: 2nd

Island: MINDANAO
Municipality: SAN AGUSTIN
Barangay: POBLACION
MSL Elevation:

PRS92 Coordinates

Latitude: 8° 44' 37.67704" Longitude: 126° 13' 16.64011" Ellipsoidal Hgt: -1.34900 m.

WGS84 Coordinates

Latitude: 8° 44' 34.36515" Longitude: 126° 13' 22.01039" Ellipsoidal Hgt: 69.59300 m.

PTM / PRS92 Coordinates

Northing: 966899.682 m. Easting: 414316.026 m. Zone: 5

UTM / PRS92 Coordinates

Northing: 967,600.49 Easting: 194,250.44 Zone: 52

Location Description

SRS-53
From Tandag City travel for 68 km south to municipality of San Agustin; then turn left on the national road about 70 m leading to San Agustin school. Station is located inside the compound of San Agustin Central Elementary School, 52 m from stage on the NE corner of the flagpole. Mark is the head of a 3. copper nail set at the center of cement block embedded on the ground with inscriptions SRS-53 2007 NAMRIA.

Requesting Party: UP TCAGP / Engr. Christopher Cruz
Purpose: Reference
OR Number: 8796607 A
T.N.: 2014-1693

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

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

NAMRIA OFFICES
Main: Lawton Avenue, Fort Bonifacio, 1634 Taguig City, Philippines Tel. Nos. 532-1653 to 61
Annex: 421 Barraca St. San Nicolas, 1010 Manila, Philippines, Tel. No. 832-3489 to 93
www.namria.gov.ph

ISO 9001:2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

Annex 3. Baseline Processing Reports of Reference Points Used in the LiDAR Survey

1.BMSS-158

Project Information		Coordinate System	
Name:		Name:	UTM
Size:		Datum:	PRS 92
Modified:	10/12/2012 4:40:11 PM (UTC+0)	Zone:	51 North (123E)
Time zone:	Mountain Standard Time	Geoid:	EGM PH
Reference number:		Vertical datum:	
Description:			

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
SRS-51 — BMSS-158 (B1)	SRS-51	BMSS-158	Fixed	0.004	0.012	39°25'42"	5832.043	-2.128
SRS-51 — BMSS-158 (B2)	SRS-51	BMSS-158	Fixed	0.004	0.015	39°25'07"	5832.058	-2.183

Acceptance Summary

Processed	Passed	Flag	Fail
2	2	0	0

SRS-51 - BMSS-158 (9:24:42 AM-2:08:07 PM) (B1)

Baseline observation:	SRS-51 — BMSS-158 (B1)
Processed:	8/15/2014 4:24:54 PM
Solution type:	Fixed
Frequency used:	Dual Frequency (L1, L2)
Horizontal precision:	0.004 m
Vertical precision:	0.012 m
RMS:	0.003 m
Maximum PDOP:	2.892
Ephemeris used:	Broadcast
Antenna model:	Trimble Relative
Processing start time:	7/28/2014 9:24:57 AM (Local: UTC+8hr)
Processing stop time:	7/28/2014 2:08:07 PM (Local: UTC+8hr)
Processing duration:	04:43:10
Processing interval:	1 second

Vector Components (Mark to Mark)

From:	SRS-51				
Grid		Local		Global	
Easting	848621.372 m	Latitude	N8°59'14.14999"	Latitude	N8°59'10.59078"
Northing	994872.010 m	Longitude	E126°9'06.89415"	Longitude	E126°9'12.17692"
Elevation	5.793 m	Height	3.970 m	Height	74.223 m

To:	BMSS-158				
Grid		Local		Global	
Easting	850263.357 m	Latitude	N8°9'43.29484"	Latitude	N8°9'38.70387"
Northing	999491.438 m	Longitude	E126°11'10.19014"	Longitude	E126°11'15.53033"
Elevation	4.177 m	Height	1.842 m	Height	72.090 m

Vector					
ΔEasting	3731.985 m	NS Fwd Azimuth	39°25'42"	ΔX	+2810.650 m
ΔNorthing	4618.427 m	Ellipsoid Dist.	5932.043 m	ΔY	+2804.382 m
ΔElevation	-1.586 m	Δ-Height	-2.128 m	ΔZ	4525.185 m

Standard Errors

Vector errors:					
σ ΔEasting	0.000 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.001 m
σ ΔNorthing	0.001 m	σ Ellipsoid Dist.	0.002 m	σ ΔY	0.005 m
σ ΔElevation	0.006 m	σ ΔHeight	0.006 m	σ ΔZ	0.001 m

Aposteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.000012538		
Y	-0.000014304	0.000024058	
Z	-0.000003593	0.000004454	0.000002185

Occupations

	From	To
Point ID:	SRS-51	BMSS-158
Data file:	C:\Users\Francis\Documents\Business Center - HCE\Unnamed\SRS51 (Modular) 7-28-14 [1.754m].T02	C:\Users\Francis\Documents\Business Center - HCE\Unnamed\BMSS158 (Rover) 7-28-14 [1.797m].T02
Receiver type:	SPS852	SPS985
Receiver serial number:	5203K81512	5245F15374
Antenna type:	Zephyr Geodetic 2	SPS985 Internal
Antenna serial number:	--------	--------
Antenna height (measured):	1.754 m	1.694 m
Antenna method:	Bottom of notch	Bottom of antenna mount

Tracking Summary

2.BMSS-201

Project Information		Coordinate System	
Name:		Name:	UTM
Size:		Datum:	WGS 1984
Modified:	10/12/2012 4:40:11 PM (UTC:-6)	Zone:	51 North (123E)
Time zone:	Mountain Standard Time	Geoid:	EGM96 (Global)
Reference number:		Vertical datum:	
Description:			

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
SRS53 --- BMSS201 (B1)	SRS53	BMSS201	Fixed	0.004	0.012	38°48'11"	3051.816	2.587
SRS53 --- BMSS201 (B2)	SRS53	BMSS201	Fixed	0.003	0.010	38°48'11"	3051.816	2.570
SRS53 --- BMSS201 (B3)	SRS53	BMSS201	Fixed	0.005	0.013	38°48'11"	3051.806	3.061

Acceptance Summary

Processed	Passed	Flag	Fail
3	3	0	0

SRS53 - BMSS201 (11:01:12 AM-3:26:18 PM) (S1)

Baseline observation:	SRS53 --- BMSS201 (B1)
Processed:	8/2/2014 3:33:43 PM
Solution type:	Fixed
Frequency used:	Dual Frequency (L1, L2)
Horizontal precision:	0.004 m
Vertical precision:	0.012 m
RMS:	0.003 m
Maximum PDOP:	2.308
Ephemeris used:	Broadcast
Antenna model:	Trimble Relative
Processing start time:	7/16/2014 11:01:27 AM (Local: UTC+8hr)
Processing stop time:	7/16/2014 3:26:18 PM (Local: UTC+8hr)
Processing duration:	04:24:51
Processing interval:	1 second

Vector Components (Mark to Mark)

From:	SRS53				
Grid		Local		Global	
Easting	854654.870 m	Latitude	N8°44'34.36515"	Latitude	N8°44'34.36515"
Northing	967943.120 m	Longitude	E126°13'22.01030"	Longitude	E126°13'22.01030"
Elevation	3.274 m	Height	69.593 m	Height	69.593 m

To:	BMSS201				
Grid		Local		Global	
Easting	856009.096 m	Latitude	N8°46'03.02195"	Latitude	N8°46'03.02195"
Northing	970681.752 m	Longitude	E126°14'07.03352"	Longitude	E126°14'07.03352"
Elevation	6.036 m	Height	72.186 m	Height	72.186 m

Vector					
ΔEasting	1354.226 m	NS Fwd Azimuth	26°48'11"	ΔX	-866.334 m
ΔNorthing	2738.632 m	Ellipsoid Dist.	3051.818 m	ΔY	-1145.673 m
ΔElevation	2.740 m	ΔHeight	2.587 m	ΔZ	2692.429 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.	0.001 m	σ ΔY	0.005 m
σ ΔElevation	0.006 m	σ ΔHeight	0.006 m	σ ΔZ	0.002 m

Aposteriori Coveriance Matrix (Meter²)

	X	Y	Z
X	0.0000139315		
Y	-0.0000161276	0.0000265278	
Z	-0.0000041845	0.0000058211	0.0000027776

Occupations

	From	To
Point ID:	SRS53	BMSS201
Data file:	C:\Users\DAC\Documents\Business Center - HCE\Unnamed(1)\SRS53 (Modular) 7-16-14 [1.775m].T02	C:\Users\DAC\Documents\Business Center - HCE\Unnamed(1)\BMSS201 (Rover0 7-16-14 [1.755m].T02
Receiver type:	SPS852	SPS985
Receiver serial number:	5203K81512	5245F15374
Antenna type:	Zephyr Geodetic 2	SPS985 Internal
Antenna serial number:	--------	--------
Antenna height (measured):	1.775 m	1.755 m
Antenna method:	Bottom of notch	Bottom of antenna mount

Tracking Summary

Annex 4. The LiDAR Survey Team Composition

Data Acquisition Component Sub-Team	Designation	Name	Agency/ Affiliation
PHIL-LIDAR 1	Program Leader	ENRICO C. PARINGIT, D.ENG	UP-TCAGP
Data Acquisition Component Leader	Data Component Project Leader – I	ENGR. CZAR JAKIRI SARMIENTO	UP-TCAGP
		ENGR. LOUIE BALICANTA	UP-TCAGP
Survey Supervisor	Chief Science Research Specialist (CSRS)	ENGR. CHRISTOPHER CRUZ	UP-TCAGP
	Supervising Science Research Specialist (Supervising SRS)	ENGR. LOVELYN ASUNCION	UP-TCAGP
		LOVELY GRACIA ACUNA	UP-TCAGP
FIELD TEAM			
LiDAR Operation, Ground Survey, Data Download and Transfer	Research Associate (RA)	MARY CATHERINE ELIZABETH BALIGUAS	UP-TCAGP
		MA. REMEDIOS VILLANUEVA	
		JONATHAN ALMALVEZ	
LiDAR Operation	Airborne Security	TSG. MICHAEL BERONILLA	PHILIPPINE AIR FORCE (PAF)
	Pilot	CAPT. JEFFREY JEREMY ALAJAR	ASIAN AEROSPACE CORPORATION (AAC)
	Pilot	CAPT. NEIL ACHILLES AGAWIN	
	Pilot	CAPT. ANGELO GARCHITORENA	

Annex 5. Data Transfer Sheet for Tago Floodplain

DATA TRANSFER SHEET
7/23/2014(Surigao del Sur- study)

DATE	FLIGHT NO	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	POS	RAW IMAGES/CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
/5/2014	1564A	3BLK61A186A	Aquarius	NA	224/8	386	102	20.7	185	4.49	31.8	5.67	1KB	1KB	4	224/8	Z:\Airborne_Raw
/5/2014	1566A	3BLK61ASB187A	Aquarius	NA	595/128	1.51	224	54.1	312	12.7	140	10.0	1KB	1KB	4	596/128	Z:\Airborne_Raw
/7/2014	1670A	3BLK61BSC185A	Aquarius	NA	261/83/376/11	592	241	6.28	12	13	NA	6.58	1KB	1KB	4/4	261/83/376/11	Z:\Airborne_Raw
/8/2014	1674A	3BLK61CSD185A	Aquarius	NA	317/250/11	1.06	254	28.7	200	14.9	NA	3.49	1KB	1KB	4/4	317/250/11	Z:\Airborne_Raw
/9/2014	1678A	3BLK61DS3190A	Aquarius	NA	159/159/383/12/9	804	251	46.3	323	15.2	NA	3.45	1KB	1KB	3/3	159/159/383/12/9	Z:\Airborne_Raw

Received from

Name TJ Malaomo
Position
Signature

Received by

Name JOIDA PRIETO
Position SSRS
Signature
7/23/2014

DATA TRANSFER SHEET
08/29/2014(Surigao del Sur(Tandag/Bislig)- ready)

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	POS	RAW IMAGES/CASI	MISSION LOG FILES/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
7/25/2014	1742A	3BLK61K206A, 3BLK61BCDES206A	Aquarius	NA	290	721	258	34.1	260	8.78	NA	8.53	1KB	1KB	5/14	37	Z:\AIRBORNE_RAW
7/27/2014	1750A	3BLK61L208A	Aquarius	NA	283	385	144	20	96	4.23	NA	15	1KB	1KB	4	197	Z:\DAC\RAW\DATA
7/27/2014	1752A	3BLK61L208B	Aquarius	NA	283	322	136	6.41	46	3.35	NA	15	1KB	1KB	5/4	12	Z:\DAC\RAW\DATA
7/29/2014	1758A	3BLK61FGHKMSN210A	Aquarius	NA	158/371/255	1.01	271	15.7	0	12.7	NA	8.76	1KB	1KB	6/7/5	5/17	Z:\DAC\RAW\DATA
8/4/2014	1794A	3BLK66HSI216B	Aquarius	NA	81	2.06	191	41/17.9	318/166	10.7	NA	17.4	1KB	1KB	4/4	8/9	Z:\DAC\RAW\DATA
8/8/2014	1798A	3BLK66SN220A	Aquarius	NA	641	1.03	236	75.7	399	11.4	522	15.5	1KB	1KB	6	6	Z:\DAC\RAW\DATA
8/8/2014	1800A	3BLK66O220B	Aquarius	NA	385	645	162	42.2	329	7.27	944	15.5	1KB	1KB	6	11	Z:\DAC\RAW\DATA
8/8/2014	1804A	3BLK66OSP221B	Aquarius	NA	168/276	893	231	58.9	463	10.1	NA	14.1	1KB	1KB	6/6	11/11	Z:\DAC\RAW\DATA
8/11/2014	1812A	3BLK66QS223B	Aquarius	NA	359	593	143	26.9	237	6.66	NA	18.3	1KB	1KB	6	13	Z:\DAC\RAW\DATA
8/12/2014	1814A	3BLK66KR224A	Aquarius	NA	528/71	1	257	87.1	366	10.3	459	16.9	1KB	1KB	6/7	12/15	Z:\DAC\RAW\DATA
8/12/2014	1816A	3BLK66RS234B	Aquarius	NA	212	457	169	NA	NA	9.21	NA	16.9	1KB	1KB	6	13	Z:\DAC\RAW\DATA
8/12/2014	1818A	3BLK66D225A	Aquarius	NA	382	644	257	32.1	166	10.3	NA	9.12	1KB	1KB	7	15	Z:\DAC\RAW\DATA
8/17/2014	1834A	3BLK66ASB229A	Aquarius	NA	170	405	175	NA	NA	7.71	NA	16.5	1KB	1KB	6	NA	Z:\DAC\RAW\DATA
8/17/2014	1836A	3BLK66DS229B	Aquarius	NA	430	686	178	30.7	180	9.01	NA	16.5	1KB	1KB	7	8	Z:\DAC\RAW\DATA

Received from

Name KRISTINE ANDAYA
Position EA
Signature

Received by

Name JOIDA PRIETO
Position SSRS
Signature 9/1/14

14-16

DATA TRANSFER SHEET

[illegible]

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	POS	RAW IMAGES/CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
7/10/2014	1682A	3BLK61GSE191A	Aquarius	NA	666	1.05	210	81.2	312	12	NA	14.1	1KB	1KB	3	8	Z:\Airborne_Raw
7/10/2014	1684A	3BLK61E191B	Aquarius	NA	415	007	152	25.7/10	227/101	7.65	NA	14.1	1KB	1KB	4	NA	Z:\Airborne_Raw
7/11/2014	1686A	3BLK61ESHI192A	Aquarius	NA	134/430	1.33	268	73	308	12.3	NA	8.12	1KB	1KB	4/3/3	9	Z:\Airborne_Raw
7/12/2014	1690A	3BLK61IS193A & 3BLK65E193A	Aquarius	NA	154/113	512	248	NA	NA	11	NA	6.09	1KB	1KB	10/3	154/113/7	Z:\Airborne_Raw
7/13/2014	1694A	3BLK65ESD194A	Aquarius	NA	615	0.98	258	69.7	522	11.7	NA	10.6	1KB	1KB	5	12	Z:\Airborne_Raw
7/14/2014	1698A	3BLK65SC195A	Aquarius	NA	520	795	184	48.5	369	11.5	NA	7.55	1KB	1KB	3	520	Z:\Airborne_Raw

Received from

Name TIN ANDAYA

Position RA

Signature

Received by

Name JOIDA F. PRIETO

Position SSRS

Signature 8/5/14

DATA TRANSFER SHEET

03/03/2014 (Cartago del Sur - mostly)

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOG(MB)	POS	RAW IMAGERIES	MISSION LOG FILE/SOD LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OP_LOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (meets)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
Jul 29, 2014	1690C	2NEJFG02RA	Gemini	NA	82	173	384	NA	NA	6.46	NA	417	1KM	9KB	4/4	82	Z:\Airborne_Raw
7/15/2014	1702A	3BLK65BCSD5196A	Aquarius	NA	173	786	193	49.9	367	18.6	NA	8.44	1KB	9KB	3/3/10/6	9/16/2012	Z:\Airborne_Raw
7/16/2014	1706A	3BLK65BSA197A	Aquarius	NA	279	1	253	67.5	495	12.2	NA	8.66	1KB	1KB	3/5	382/629	Z:\Airborne_Raw
7/16/2014	1714A	3BLK65FC199A	Aquarius	NA	704	1.29	253	74.6	581	13.1	NA	8.09	1KB	1KB	3/3/5/6	10/11	Z:\Airborne_Raw
7/21/2014	1726A	3BLK65AS5CS202A	Aquarius	NA	117	2.6	238	69.2	509	13	NA	18.9	1KB	1KB	5/6/6/3	117/9/1691/173/117/173/535/112	Z:\Airborne_Raw
7/21/2014	1728A	3BLK65H202B	Aquarius	NA	145	254	114	10.2	109	3.14	NA	18.9	1KB	1KB	3	145	Z:\Airborne_Raw
7/22/2014	1730A	3BLK65HS203A	Aquarius	NA	351	646	202	43.5	201	7.84	NA	14	1KB	1KB	3	NA	Z:\Airborne_Raw
7/22/2014	1732A	3BLK5CALIB203B & 2BLK65LI2C3B	Aquarius	NA	110/6	334	137	18	131	4.21	NA	14	1KB	1KB	6/4	110/6	Z:\Airborne_Raw
7/23/2014	1734A	3BLK65JSGS204A	Aquarius	NA	219/141/14 1	603	177	40.4	295	8.98	NA	15	1KB	1KB	5/5	11-Sep	Z:\Airborne_Raw
7/23/2014	1736A	3BLK61J5204B	Aquarius	NA	225	397	185	14.7	147	5.77	NA	15	1KB	1KB	6	225	Z:\Airborne_Raw

Received from

Name: TIN ANDAYA
Position: RA
Signature:

Received by

Name: JOIDA PRIETO
Position: ASRS
Signature: 7/31/14

DATA TRANSFER SHEET

Surigao del Sur(Tandag/Bislig)- ready)

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	POS	RAW IMAGES/CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
28/2014	1754A	3BLK61KSV209A	Aquarius	NA	23	497	173	15.1	0	5.87	NA	9.3	1KB	1KB	5/4	23/273	Z:\DAC\RAWDATA
30/2014	1762A	3BLK61NS211A	Aquarius	NA	680	1.11	232	82.3	385	11.6	137	7.56	1KB	1KB	6	14	Z:\DAC\RAWDATA
31/2014	1766A	3BLK61NSO212A	Aquarius	NA	890/232/850	1.91	209	68.6	467	9.95	NA	17.8	1KB	1KB	6/5	922/13	Z:\DAC\RAWDATA
31/2014	1768A	3BLK61CSB213B	Aquarius	NA	850	1.1	247	49.5	468	9.21	31.6	17.8	1KB	1KB	5	13	Z:\DAC\RAWDATA

Received from

Name TIN ANDAYA
Position RA
Signature

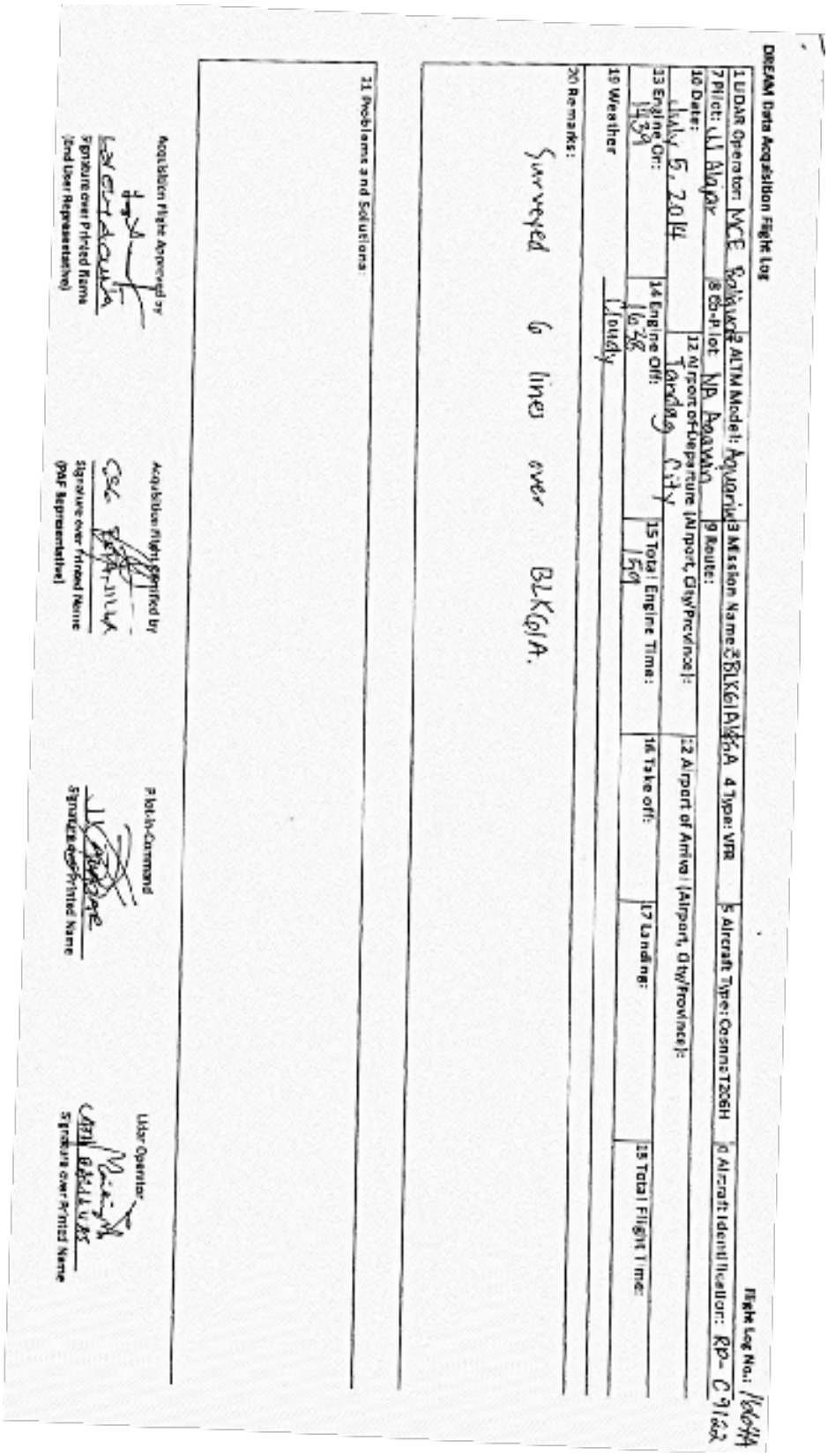
Received by

Name JOIDA F. PRIETO
Position SSRS
Signature

3/14/14

Annex 6. Flight Logs for the Flight Missions

Flight Log for 3BLK61A186A Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 186A

1 LiDAR Operator: NCE 2 ALTM Model: Aquarius 3 Mission Name: 3BLK61A186A 4 Type: VFR 5 Aircraft Type: Cessna T206H 6 Aircraft Identification: RP- C9162

7 Pilot: [illegible] 8 Co-Pilot: NA 9 Route: [illegible]

10 Date: July 5, 2014 11 Airport of Departure (Airport, City/Province): Tanauan City 12 Airport of Arrival (Airport, City/Province):

13 Engine On: 14:39 14 Engine Off: 16:26 15 Total Engine Time: 1:50 16 Take off: 17 Landing: 18 Total Flight Time:

19 Weather: Cloudy

20 Remarks: Surveyed 6 lines over BLK61A.

31 Problems and Solutions

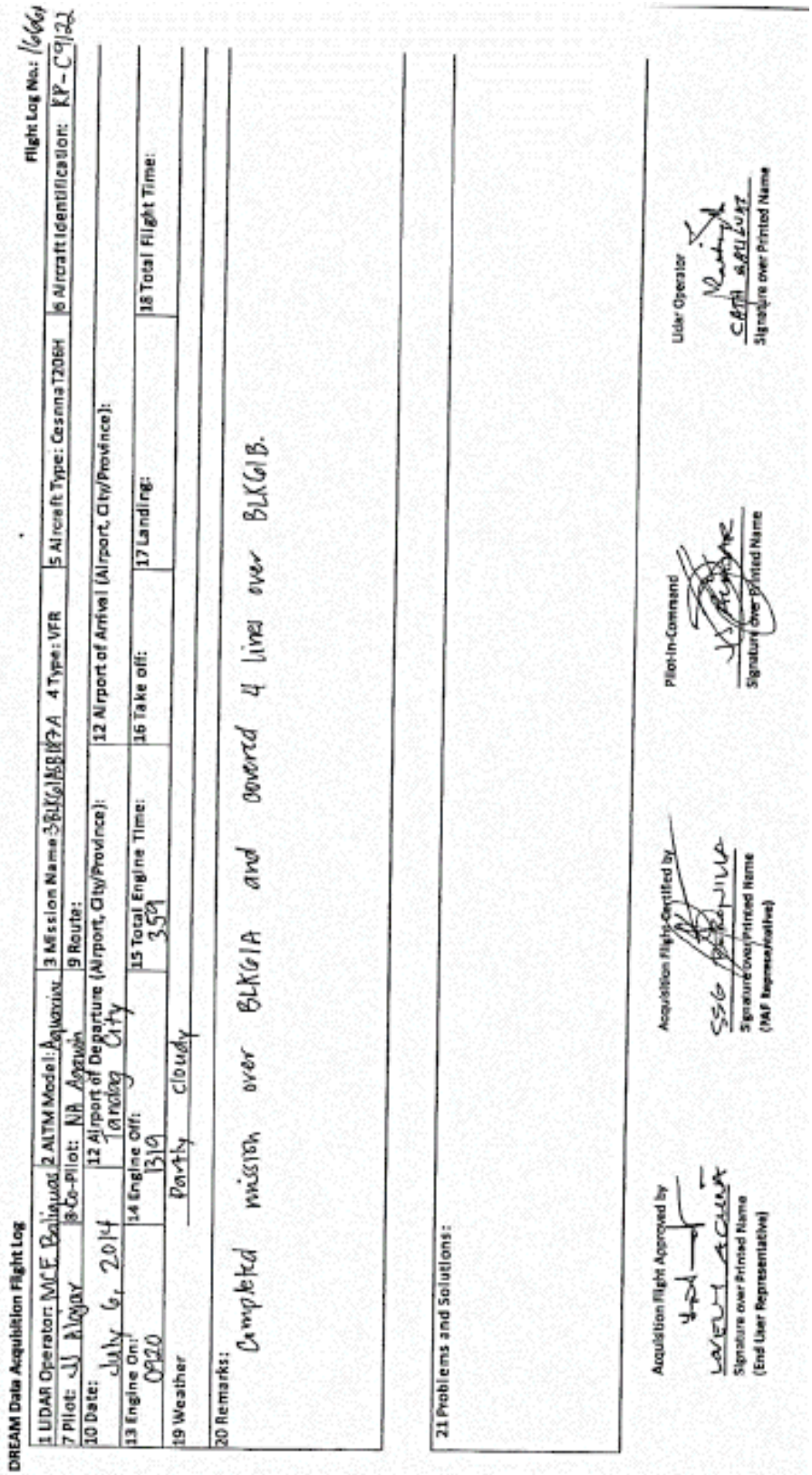
Acquisition Flight Approved by: (Signature over Printed Name / End User Representative)

Acquisition Flight Certified by: (Signature over Printed Name / DAC Representative)

Pilot-in-Command: (Signature over Printed Name)

LiDar Operator: (Signature over Printed Name)

Flight Log for 3BLK61ASB187A Mission.



DREAM Data Acquisition Flight Log

Flight Log No.: 16661

1 LiDAR Operator: NCE Baliuag	2 ALTM Model: Aquarius	3 Mission Name: 3BLK61ASB187A	4 Type: VFR
5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C9122		
7 Pilot: JJ Alguay	8 Co-Pilot: NA Agguin	9 Route:	
10 Date: July 6, 2014	11 Airport of Departure (Airport, City/Province): Tarlac City	12 Airport of Arrival (Airport, City/Province):	
13 Engine On: 0920	14 Engine Off: 1310	15 Total Engine Time: 3.59	16 Take off:
17 Landing:	18 Total Flight Time:		
19 Weather: Partly cloudy			

20 Remarks:

Completed mission over BLK61A and covered 4 lines over BLK61B.

21 Problems and Solutions:

Acquisition Flight Approved by

Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by

Signature over Printed Name
(PAF Representative)

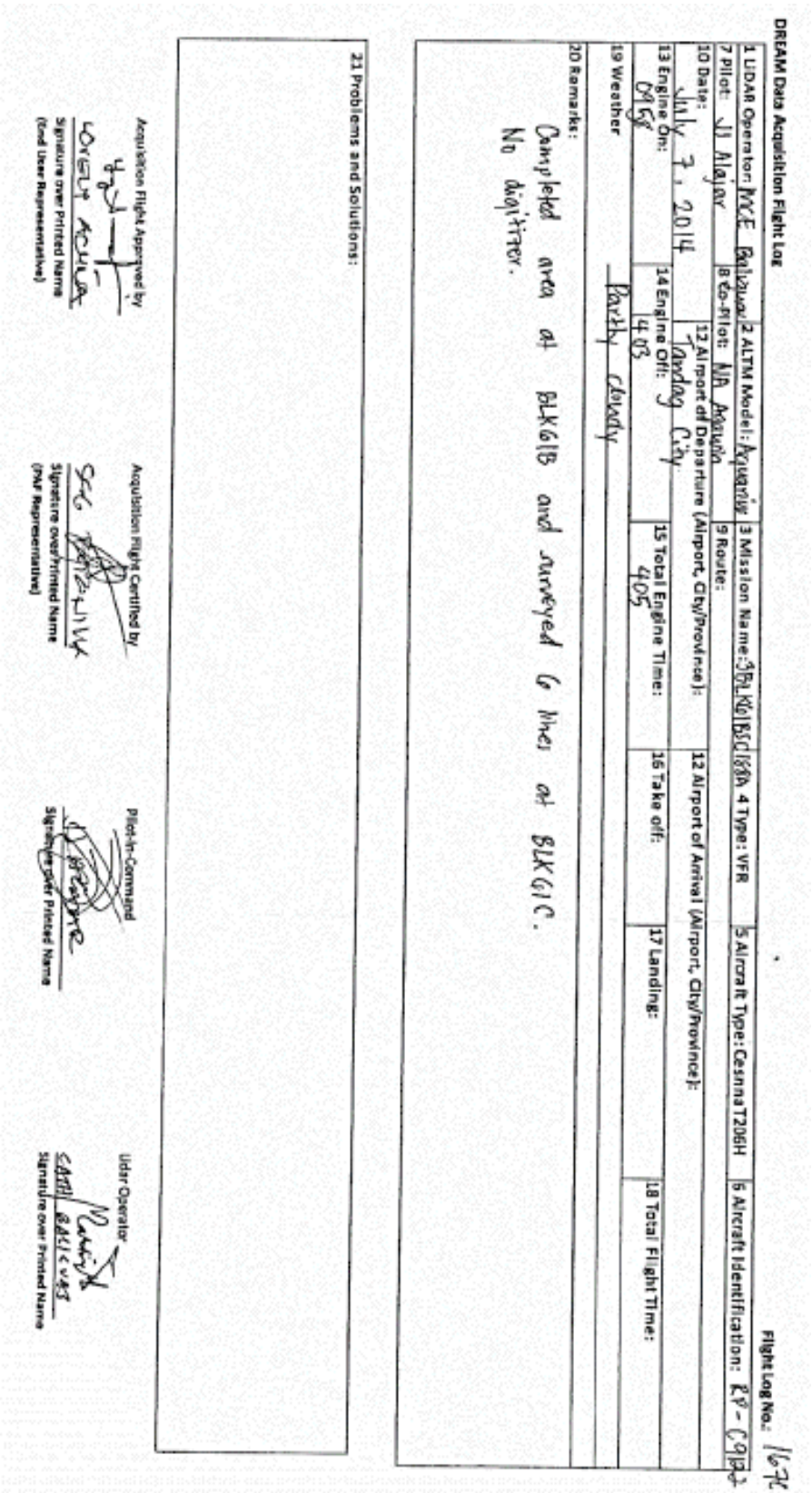
Pilot-in-Command

Signature over Printed Name

Lidar Operator

Signature over Printed Name

Flight Log for 3BLK61BSC188A Mission.



DREAM Data Acquisition Flight Log

Flight Log No.: 16-74

1 LIDAR Operator: MCE Baluyut	2 ALTM Model: Aquarius	3 Mission Name: 3BLK61BSC188A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C9136
7 Pilot: JJ Alajar	8 Co-Pilot: NA Arevalo	9 Route:			
10 Date: July 7, 2014	11 Airport of Departure (Airport, City/Province): Tandag City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0956	14 Engine Off: 1405	15 Total Engine Time: 4.05	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Partly cloudy					

20 Remarks:

Completed area at BLK61B and surveyed 6 hrs at BLK61C.
No additional.

21 Problems and Solutions:

Acquisition Flight Approved by:

Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by:

Signature over Printed Name
(PAF Representative)

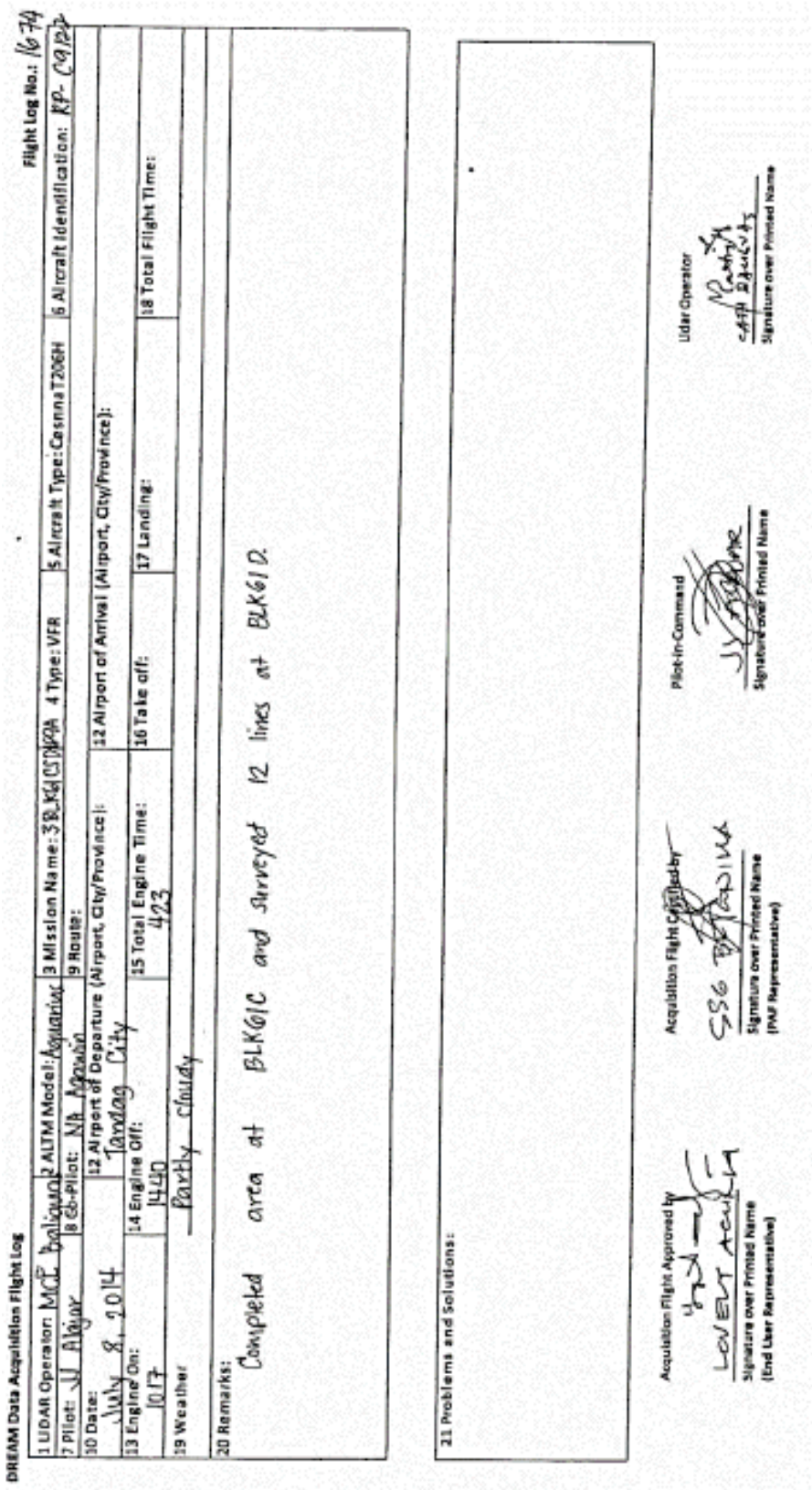
Pilot-in-Command

Signature over Printed Name

Lidar Operator

Signature over Printed Name

Flight Log for 3BLK61CSD189A Mission.



DREAM Data Acquisition Flight Log

Flight Log No.: 16-74

1 LiDAR Operator: MAE Baliguat	2 ALTM Model: Aquarius	3 Mission Name: 3BLK61CSP189A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C9123
7 Pilot: JJ Alejar	8 Co-Pilot: NA Agcaoili	9 Route:			
10 Date: July 8, 2014	12 Airport of Departure (Airport, City/Province): Tandag City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1017	14 Engine Off: 1440	15 Total Engine Time: 4.23	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Partly cloudy					

20 Remarks:
Completed area at BLK61C and surveyed 12 lines at BLK61D

21 Problems and Solutions:

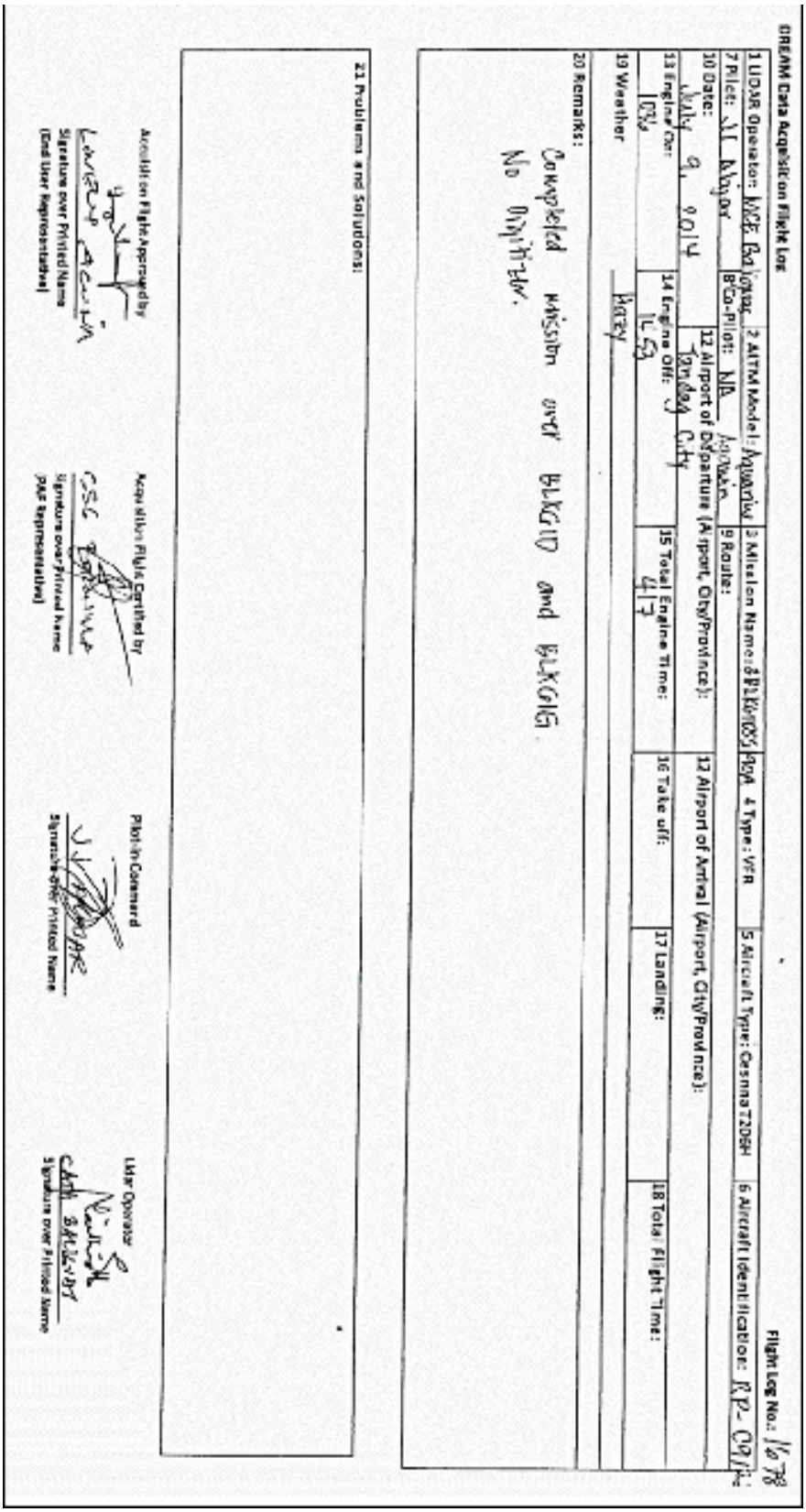
Acquisition Flight Approved by
LOVELY ACUÑA
Signature over Printed Name
(End User Representative)

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

Pilot-in-Command
Signature over Printed Name

Lidar Operator
Signature over Printed Name

Flight Log for 3BLK61DSG190A Mission.



GREAM Data Acquisition Flight Log — Flight Log No.: 178

1 LIDAR Operator: [illegible] 2 ATTM Model: Aquarius 3 Mission Name: 3BLK61DSG190A 4 Type: VFR 5 Aircraft Type: Cessna T206H 6 Aircraft Identification: RP-C8716

7 Pilot: [illegible] 8 Co-Pilot: NA

10 Date: July 9, 2014 12 Airport of Departure (Airport, City/Province): Tandag City 13 Engine On: 10:14 14 Engine Off: 15:53 15 Total Engine Time: 4.7 16 Take off: Hazy 17 Landing: 18 Total Flight Time:

19 Weather

20 Remarks:

Completed mission over BLK61D and BLK61G.
No Problem.

21 Problems and Solutions:

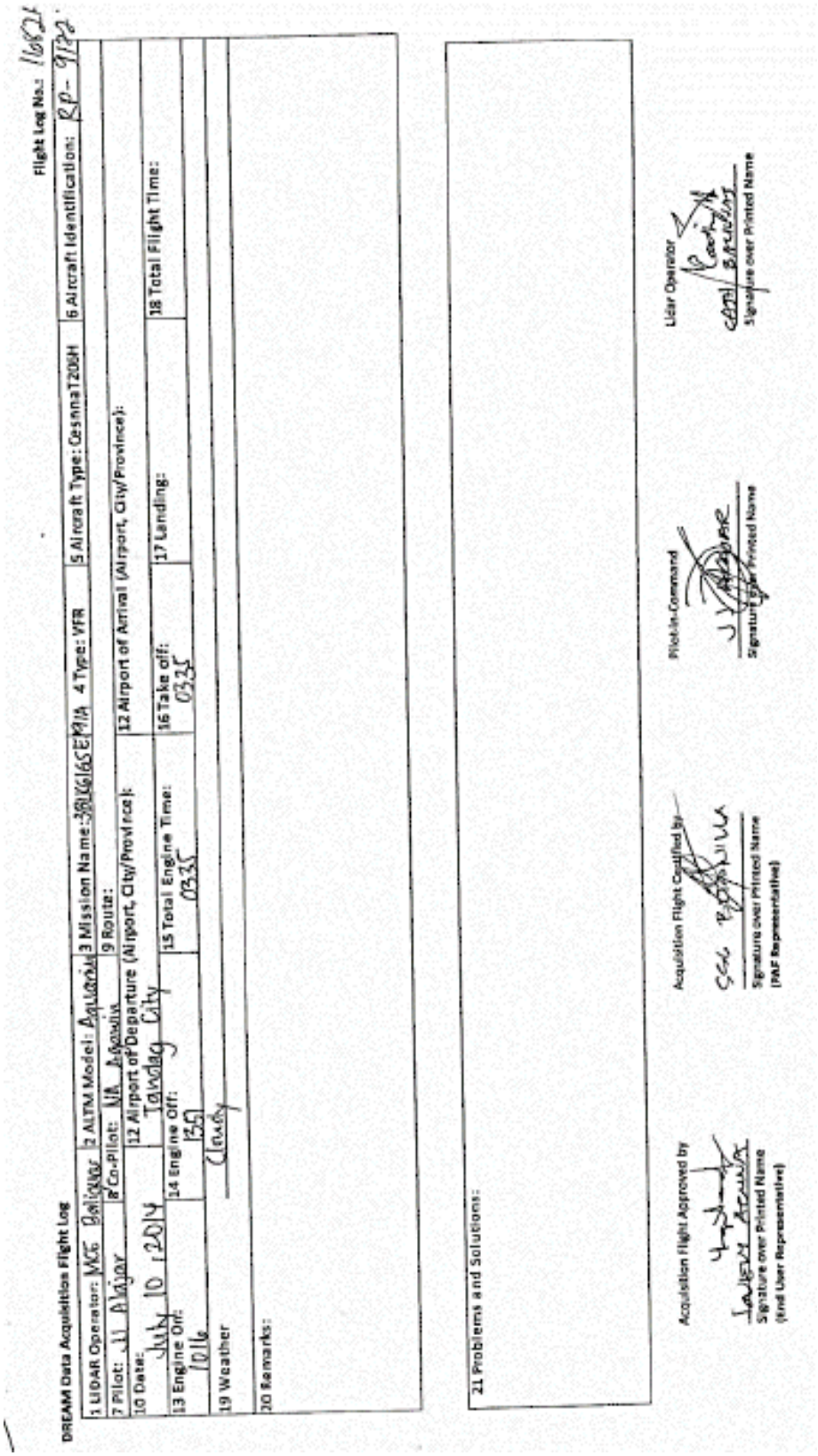
Accomplished Flight Approved by
Signature over Printed Name
(End User Representative)

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

Pilot-in-Command
Signature over Printed Name

LiMa Operator
Signature over Printed Name

Flight Log for 3BLK61GSE191A Mission.



DREAM Data Acquisition Flight Log

Flight Log No.: 1682

1 LiDAR Operator: MGB	2 ALTM Model: Aquarius	3 Mission Name: 3BLK61GSE191A	4 Type: VFR	5 Aircraft Type: CessnaT206H
6 Aircraft Identification: RP- 9132				
7 Pilot: JL Alejar	8 Co-Pilot: VA Amanila	9 Route:		
10 Date: July 10 2019	11 Airport of Departure (Airport, City/Province): Tandag City		12 Airport of Arrival (Airport, City/Province):	
13 Engine On: 1016	14 Engine Off: 1350	15 Total Engine Time: 0335	16 Take off: 0335	17 Landing:
18 Total Flight Time:				
19 Weather: Cloudy				
20 Remarks:				
21 Problems and Solutions:				

Acquisition Flight Approved by

Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by

Signature over Printed Name
(PAF Representative)

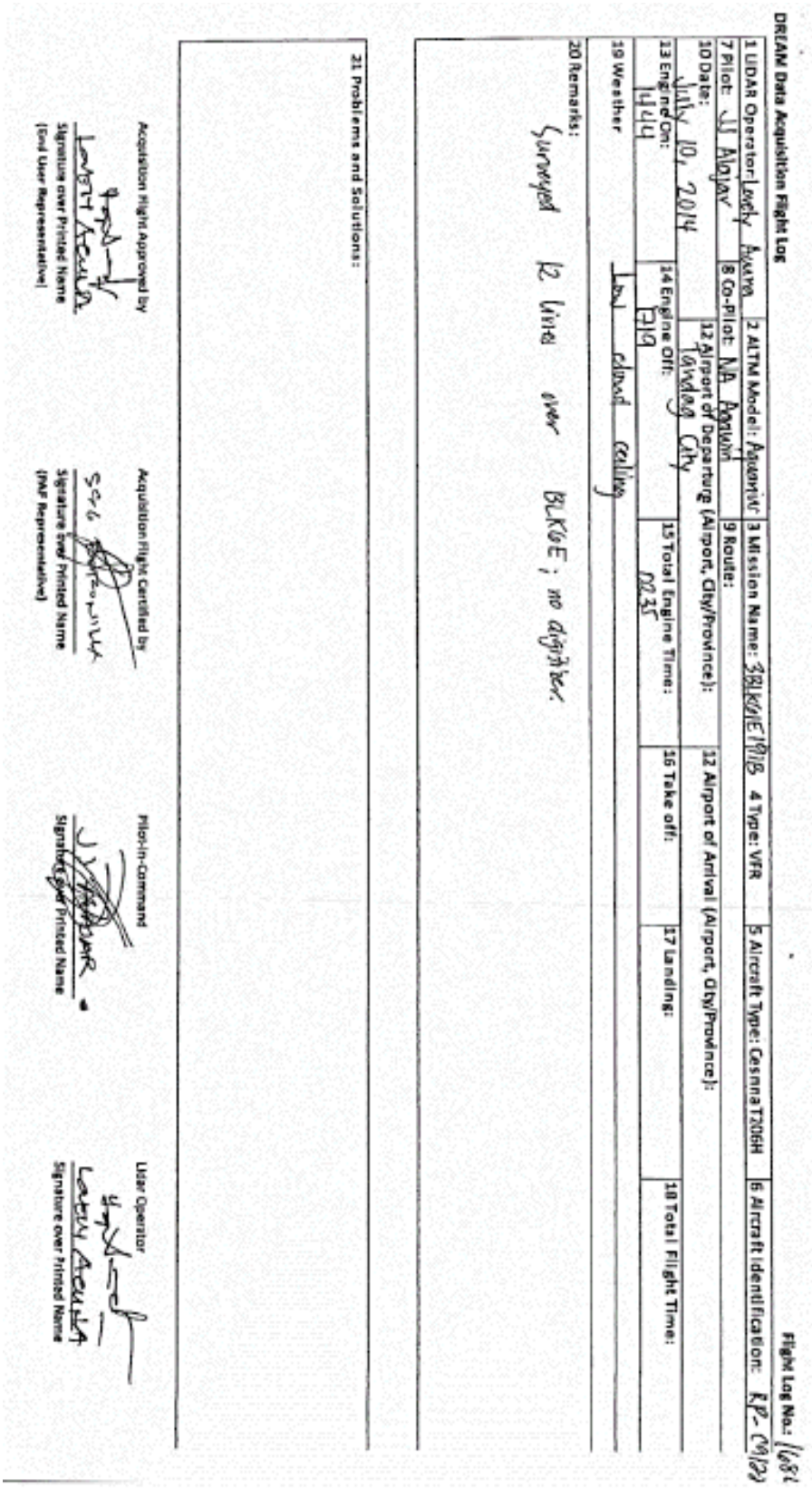
Pilot-in-Command

Signature over Printed Name

Lidar Operator

Signature over Printed Name

Flight Log for 3BLK61E191B Mission.



DREAM Data Acquisition Flight Log — Flight Log No.: 1681

1 LiDAR Operator: Lovely Ayuyao	2 ALTM Model: Aquarius	3 Mission Name: 3BLK61E191B	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C9122
7 Pilot: JJ Alojar	8 Co-Pilot: NA Aquino	9 Route:			
10 Date: July 10, 2014	11 Airport of Departure (Airport, City/Province): Tandag City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1414	14 Engine Off: 1919	15 Total Engine Time: 02.35	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Low cloud ceiling					

20 Remarks: Surveyed 12 kms over BLK61E; no digitizer.

21 Problems and Solutions:

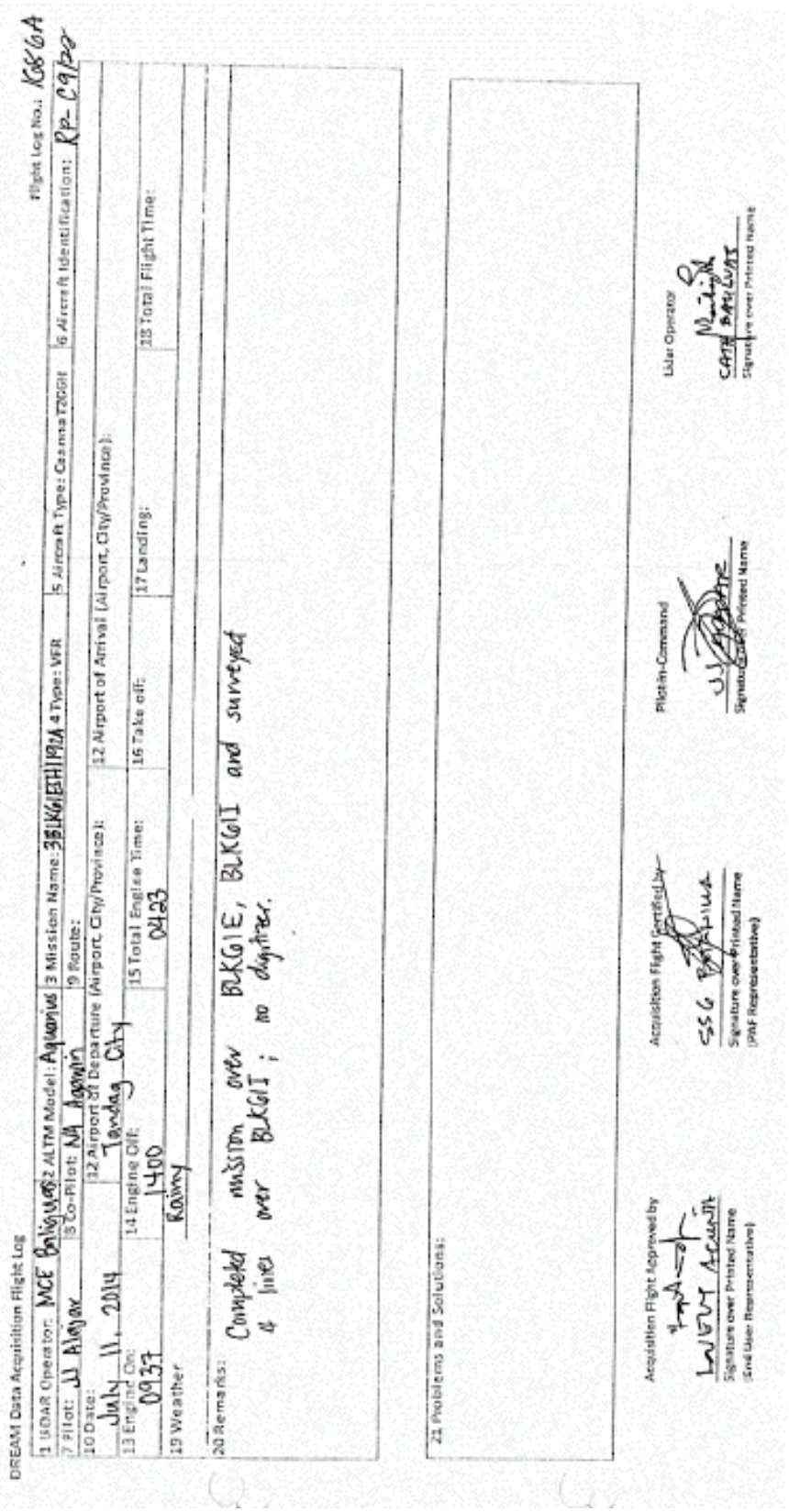
Acquisition Flight Approved by
Signature over Printed Name
(End User Representative)

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

Pilot-in-Command
Signature over Printed Name

LiDAR Operator
Signature over Printed Name

Flight Log for 3BLK61ESHI192A Mission.



DREAM Data Acquisition Flight Log

Flight Log No.: K66GA

1 LiDAR Operator: MCE Bringuez 2 ALTM Model: Aquarius 3 Mission Name: 3BLK61ESHI192A 4 Type: VFR 5 Aircraft Type: Cessna T206H 6 Aircraft Identification: RP-C9160

7 Pilot: JJ Alegre 8 Co-Pilot: NA Aggarwal 9 Route:

10 Date: July 11, 2014 11 Airport of Departure (Airport, City/Province): Tandag City 12 Airport of Arrival (Airport, City/Province):

13 Engine On: 0937 14 Engine Off: 1400 15 Total Engine Time: 04.23 16 Take off: 17 Landing: 18 Total Flight Time:

19 Weather: Rainy

20 Remarks: Completed mission over BLK61E, BLK61I and surveyed 4 lines over BLK61I ; no diagnostics.

21 Problems and Solutions:

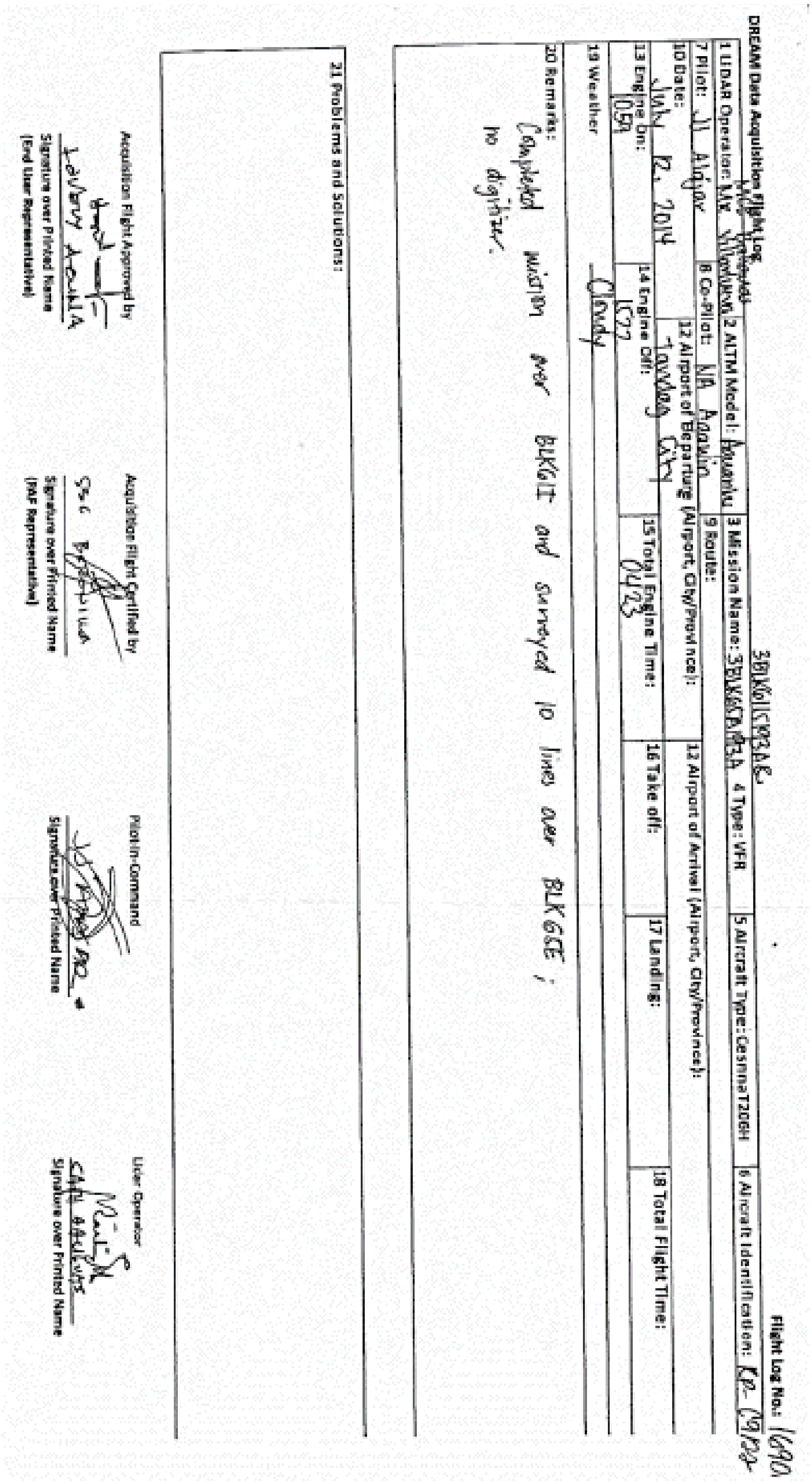
Acquisition Flight Approved by
Signature over Printed Name
(End User Representative)

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

Pilot-in-Command
Signature over Printed Name

Lidar Operator
Signature over Printed Name

Flight Log for 3BLK61IS193A & 3BLK65E193A Mission.


DREAM Data Acquisition Flight Log

Flight Log No.: 1690

1 LIDAR Operator: MR Villanueva	2 ALTM Model: Aquarius	3 Mission Name: 3BLK65E193A / 3BLK61IS193A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C9022
7 Pilot: JJ Alajar	8 Co-Pilot: JB Agawin	9 Route:			
10 Date: July 12, 2014	12 Airport of Departure (Airport, City/Province): Tacloban City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1054	14 Engine Off: 1527	15 Total Engine Time: 0423	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Cloudy					

20 Remarks:

Completed mission over BLK61I and surveyed 10 lines over BLK65E;
no digitizer.

21 Problems and Solutions:

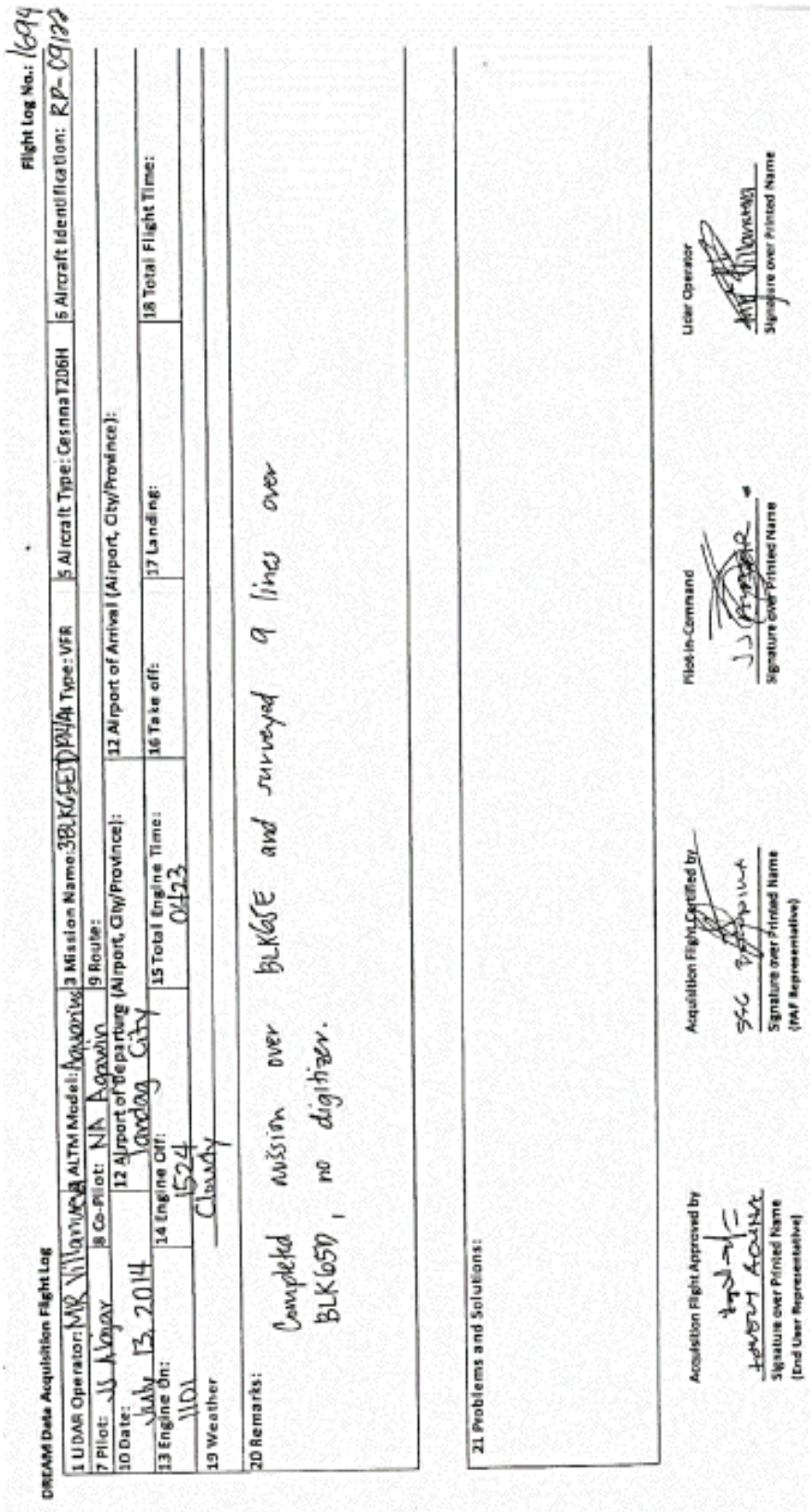
Acquisition Flight Approved by — Lovely Acuna — Signature over Printed Name (End User Representative)

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

Pilot-in-Command — Signature over Printed Name

Lidar Operator — Signature over Printed Name

Flight Log for 3BLK65ESD194A Mission.



DREAM Data Acquisition Flight Log

Flight Log No.: 1694

1 LiDAR Operator: MR Aboy	2 ALTM Model: Aquarius	3 Mission Name: 3BLK65ESD194A Type: VFR	5 Aircraft Type: Cessna T206H	5 Aircraft Identification: RP-C9132
7 Pilot: JJ Aboy	8 Co-Pilot: NA Agawin	9 Route:		
10 Date: July 13, 2014	12 Airport of Departure (Airport, City/Province): Tandag City		12 Airport of Arrival (Airport, City/Province):	
13 Engine On: 1101	14 Engine Off: 1524	15 Total Engine Time: 0423	16 Take off:	17 Landing:
19 Weather: Cloudy				18 Total Flight Time:

20 Remarks:

Completed mission over BLK65E and surveyed 9 lines over BLK65D, no digitizer.

21 Problems and Solutions:

Acquisition Flight Approved by

Signature over Printed Name
[End User Representative]

Acquisition Flight Certified by

Signature over Printed Name
(PAF Representative)

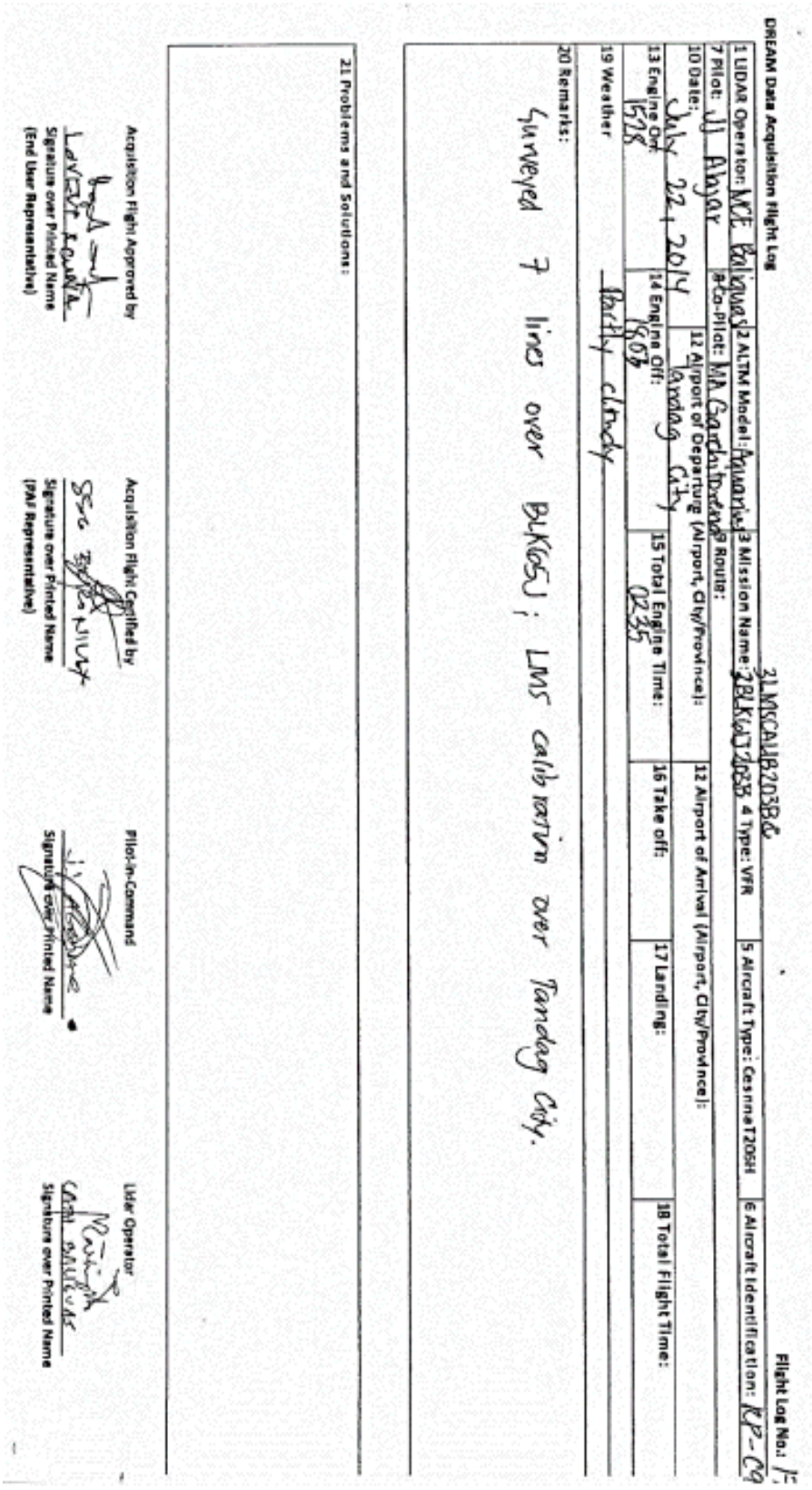
Pilot-in-Command

Signature over Printed Name

Lidar Operator

Signature over Printed Name

Flight Log for 3LMSCALIB203B & 2BLK61J203B Mission.



DREAM Data Acquisition Flight Log — Flight Log No.: 15

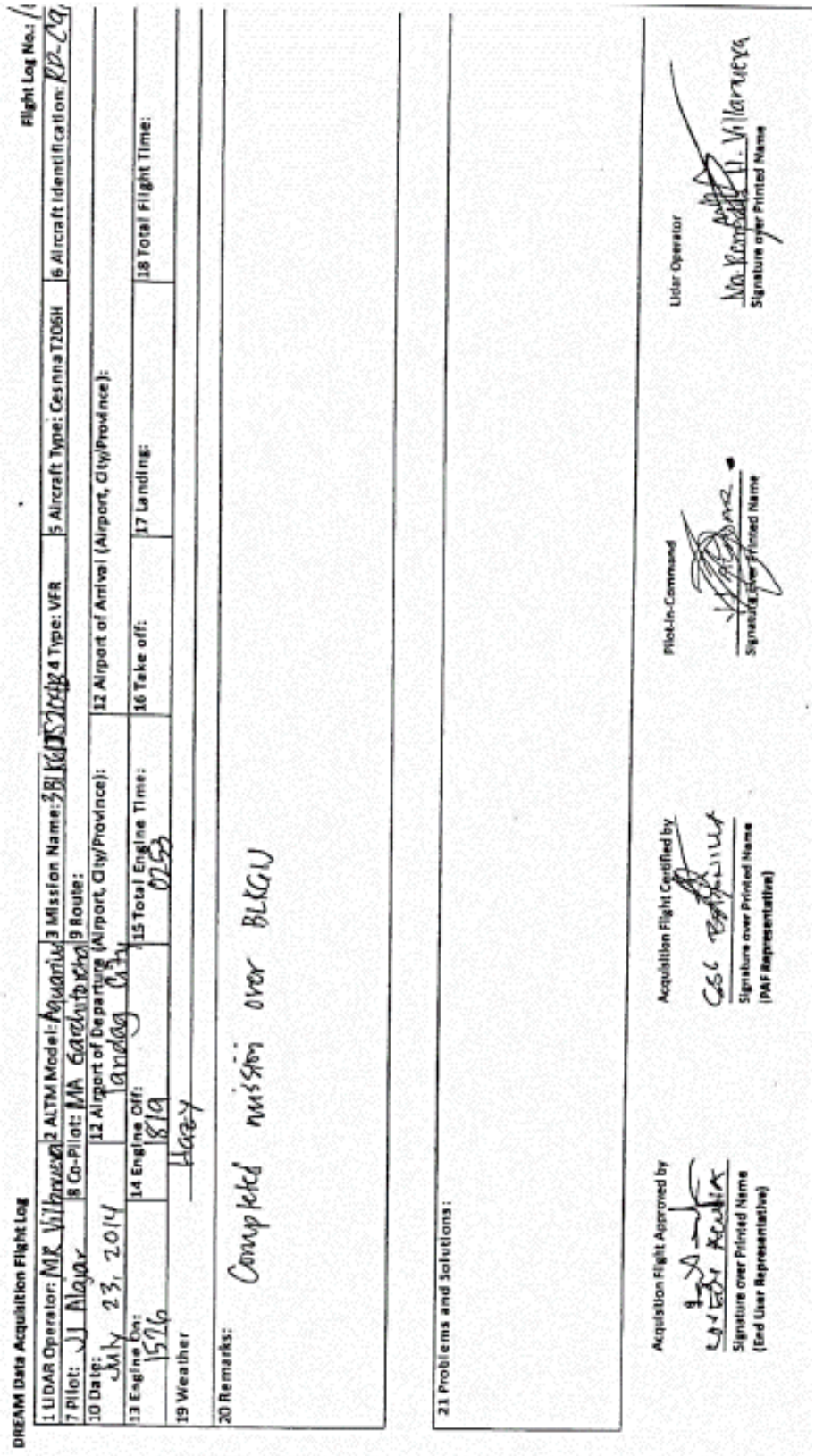
1 LiDAR Operator: MCE Balquin	2 ALTM Model: Aquarius	3 Mission Name: 3LMSCALIB203B & 2BLK61J203B	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C9
7 Pilot: JJ Alejar	8 Co-Pilot: MA Gaerlan	9 Route:			
10 Date: July 22, 2014	11 Airport of Departure (Airport, City/Province): Tandag City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1528	14 Engine Off: 1607	15 Total Engine Time: 0235	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Partly cloudy					

20 Remarks: Surveyed 7 lines over BLK61J ; LMS calibration over Tandag City.

21 Problems and Solutions:

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

Flight Log for 3BLK61JS204B Mission.



DREAM Data Acquisition Flight Log

Flight Log No.: 1

1 LiDAR Operator: MR Wilhelm	2 ALTM Model: Aquarius	3 Mission Name: 3BLK61JS204B	4 Type: VFR
5 Aircraft Type: CessnaT206H	6 Aircraft Identification: RP-C79		
7 Pilot: JJ Alajar	8 Co-Pilot: MA Garantacha	9 Route:	
10 Date: July 23, 2014	11 Airport of Departure (Airport, City/Province): Lanuza City	12 Airport of Arrival (Airport, City/Province):	
13 Engine On: 1516	14 Engine Off: 1819	15 Total Engine Time: 0253	16 Take off:
17 Landing:	18 Total Flight Time:		
19 Weather: Hazy			

20 Remarks: Completed mission over BLKU

21 Problems and Solutions:

Acquisition Flight Approved by

Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by

Signature over Printed Name
(PAF Representative)

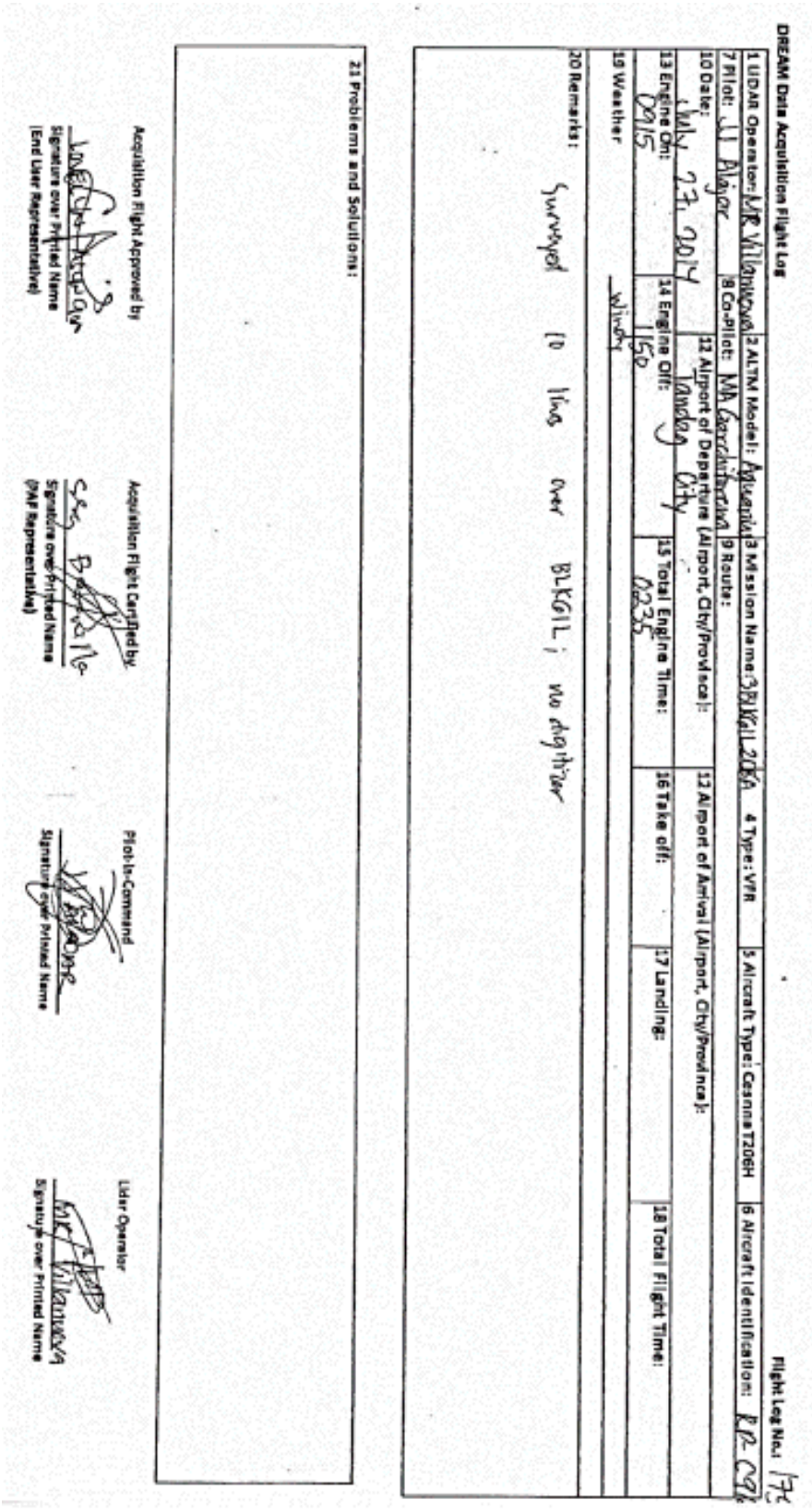
Pilot-In-Command

Signature over Printed Name

Lidar Operator

Signature over Printed Name

Flight Log for 3BLK61L208A Mission.



DREAM Data Acquisition Flight Log — Flight Log No.: 175

1 LIDAR Operator: MR Villanueva	2 ALTM Model: Aquarius	3 Mission Name: 3BLK61L208A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C9[illegible]
7 Pilot: LL Alajar	8 Co-Pilot: MA Garcia/Ibarra	9 Route:			
10 Date: July 23, 2014	11 Airport of Departure (Airport, City/Province): Tandag City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0915	14 Engine Off: 1550	15 Total Engine Time: 0235	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: windy					
20 Remarks: Surveyed 10 lines over BLK61L; no alterations					

21 Problems and Solutions:

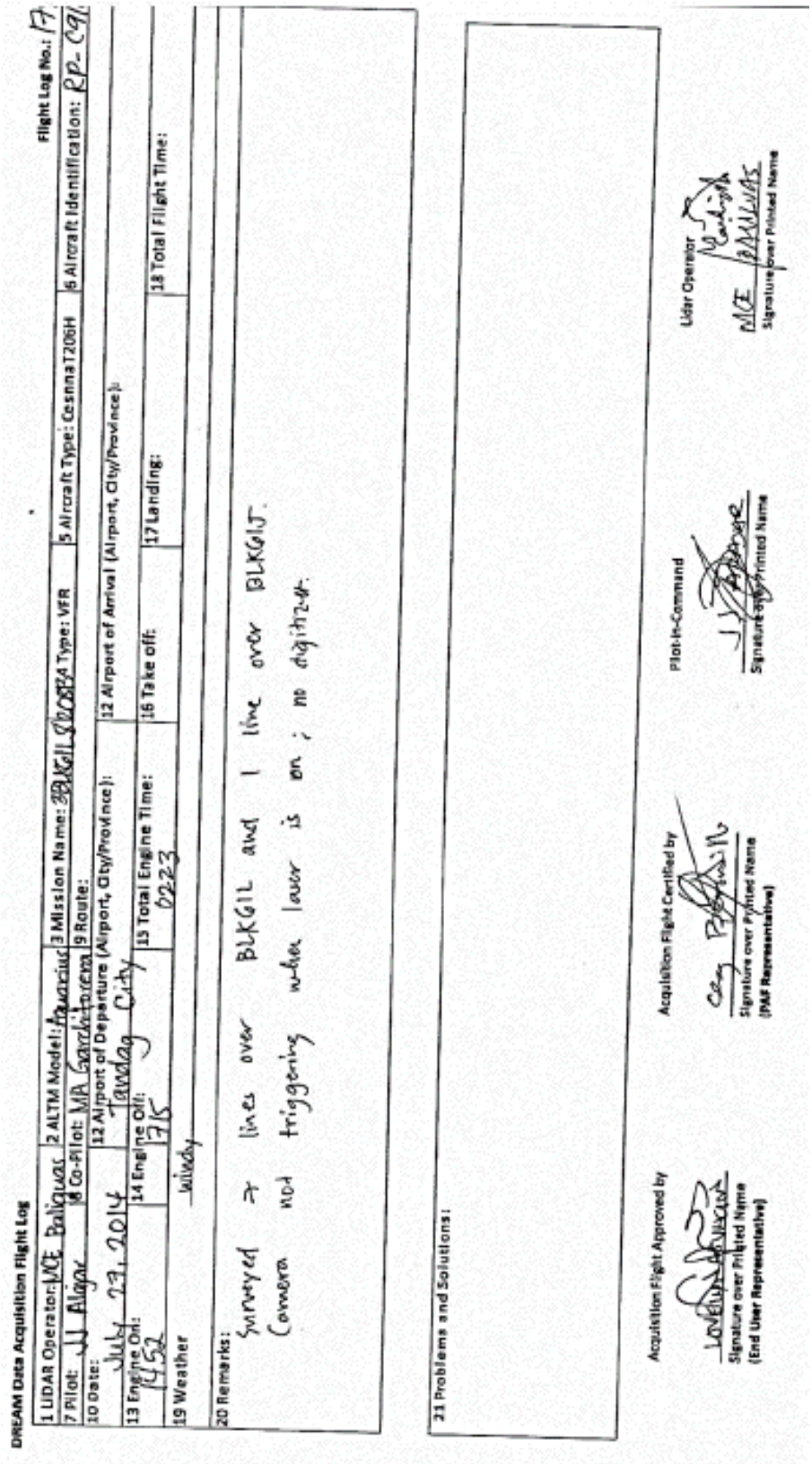
Acquisition Flight Approved by:
Signature over Printed Name
(End User Representative)

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

Pilot-in-Command
Signature over Printed Name

Lidar Operator
Signature over Printed Name

Flight Log for 3BLK61L208B Mission.



DREAM Data Acquisition Flight Log

Flight Log No.: 17

1 LiDAR Operator: MCE Baliguas	2 ALTM Model: Aquarius	3 Mission Name: 3BLK61L208B	4 Type: VFR	5 Aircraft Type: CessnaT206H	6 Aircraft Identification: RP-C91
7 Pilot: JJ Alagar	8 Co-Pilot: MA Gardiatorem	9 Route:			
10 Date: July 23, 2014	12 Airport of Departure (Airport, City/Province): Tandag City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1452	14 Engine Off: 1715	15 Total Engine Time: 0223	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: windy					

20 Remarks:
Surveyed 2 lines over BLK61L and 1 line over BLK61J.
Camera not triggering when laser is on ; no digitize.

21 Problems and Solutions:

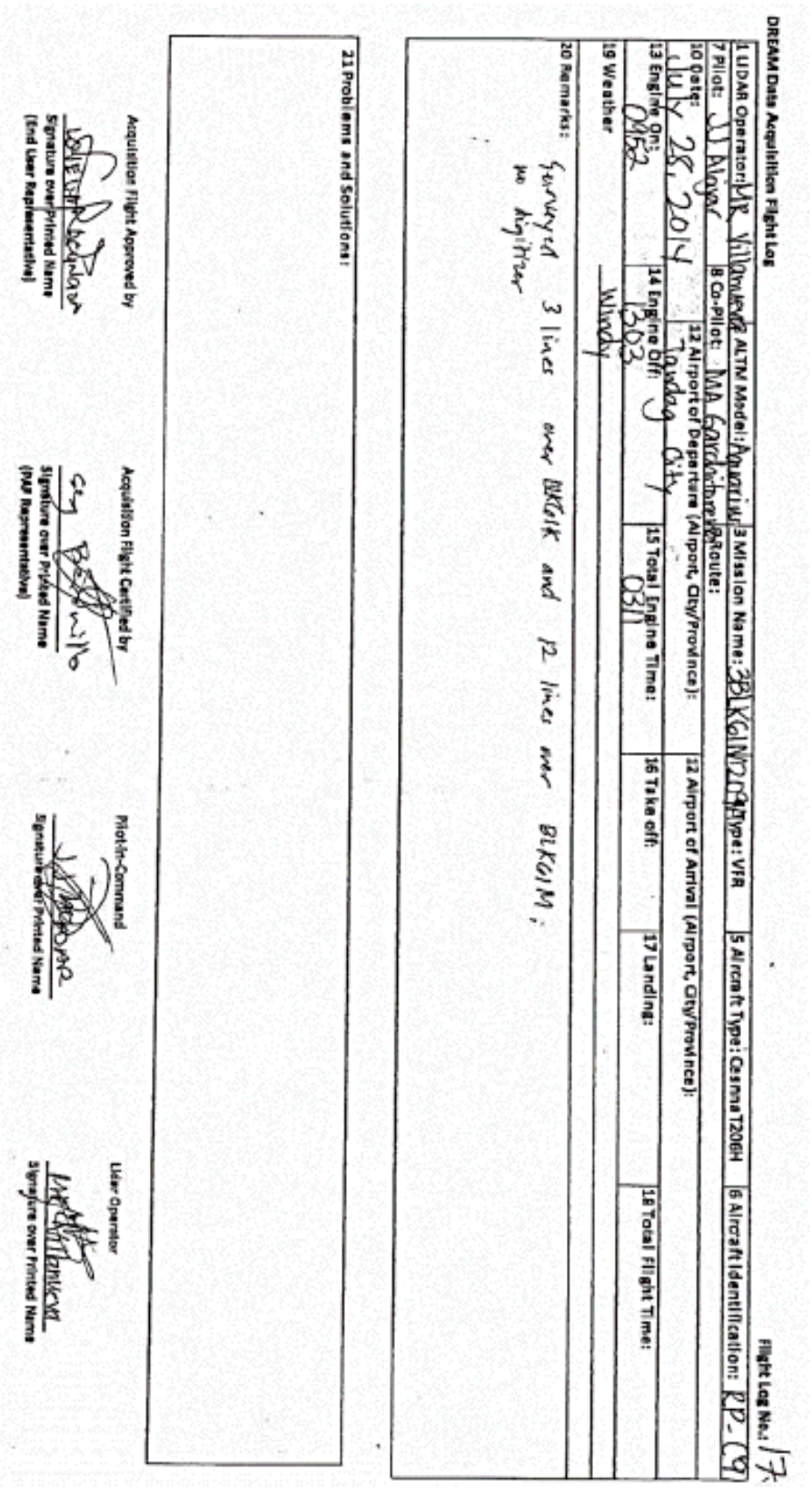
Acquisition Flight Approved by
Signature over Printed Name
(End User Representative)

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

Pilot-in-Command
Signature over Printed Name

Lidar Operator
Signature over Printed Name

Flight Log for 3BLK61KSM209A Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 17

1 LIDAR Operator: DR Villamor	2 ALTM Model: Aquarius	3 Mission Name: 3BLK61M209A	Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C91
7 Pilot: JJ Alejar	8 Co-Pilot: MA Garcia	Route:			
10 Date: July 28, 2014	11 Airport of Departure (Airport, City/Province): Tandag City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0952	14 Engine Off: 1303	15 Total Engine Time: 0311	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Windy					

20 Remarks: Surveyed 3 lines over BLK61K and 12 lines over BLK61M; no flight/ear

21 Problems and Solutions:

Acquisition Flight Approved by

Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by

Signature over Printed Name
(PAF Representative)

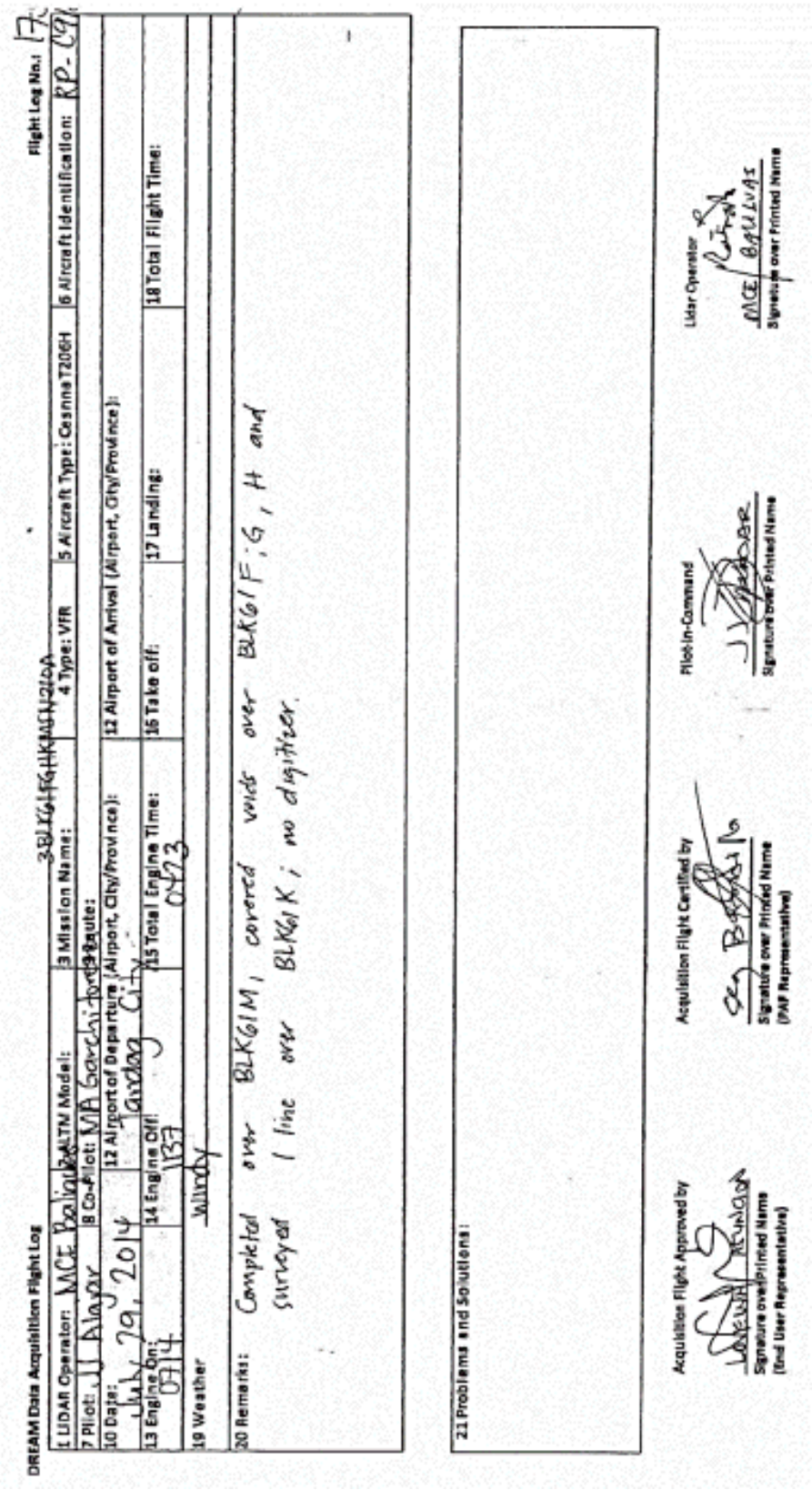
Pilot-in-Command

Signature over Printed Name

Lidar Operator

Signature over Printed Name

Flight Log for 3BLK61KSM210A Mission.



DREAM Data Acquisition Flight Log

Flight Log No.: 17

1 LIDAR Operator: MCE Balicat	2 ALTM Model:	3 Mission Name: 3BLK61FG1HKSM210A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C[illegible]
7 Pilot: JJ Alagar	8 Co-Pilot: MR Garcia	9 Route:		
10 Date: July 29, 2014	11 Airport of Departure (Airport, City/Province): Tarlac City		12 Airport of Arrival (Airport, City/Province):	
13 Engine On: 0714	14 Engine Off: 1137	15 Total Engine Time: 0423	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: windy				

20 Remarks: Completed over BLK61M, covered voids over BLK61F, G, H and surveyed 1 line over BLK61K; no digitizer.

21 Problems and Solutions:

Acquisition Flight Approved by

Signature over Printed Name (End User Representative)

Acquisition Flight Certified by

Signature over Printed Name (PAF Representative)

Pilot-in-Command

Signature over Printed Name

Lidar Operator

MCE BALICAT

Signature over Printed Name

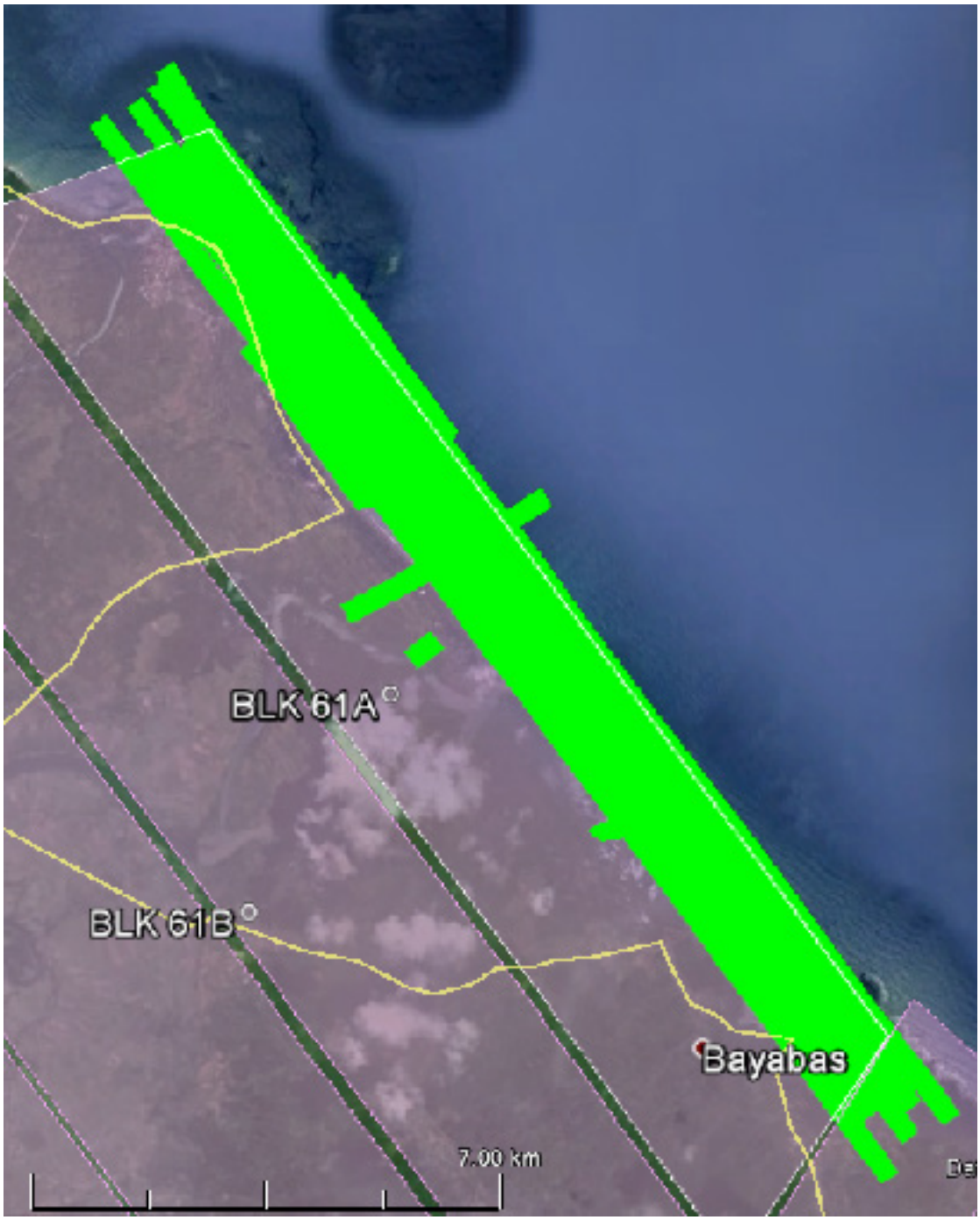
Annex 7. Flight Status Report

Northern Mindanao
June 4-July 9, 2014

FLIGHT NO	AREA	MISSION	OPERATOR	DATE FLOWN	REMARKS
1664	BLK61A	3BLK61A186A	MCE BALIGUAS	5 JULY 14	Surveyed 6 lines over BLK61A
1666	BLK61A, BLK61B	3BLK61ASB187A	MCE BALIGUAS	6 JULY 14	Completed mission over BLK61A and covered 4 lines over BLK61B
1670	BLK 61B, BLK61C	3BLK61BSC188A	MCE BALIGUAS	7 JULY 14	Completed area at BLK61B and surveyed 6 lines at BLK61C. No digitizer
1674	BLK61C, BLK61D	3BLK61CSD189A	MCE BALIGUAS	8 JULY 14	Completed area at BLK61C and surveyed 12 lines at BLK61D
1678	BLK61D, BLK61G	3BLK61DSG190A	MCE BALIGUAS	9 JULY 14	Completed mission over BLK61D and BLK61G. No digitize
1682	BLK 61G, BLK61E	3BLK61GSE191A	MCE BALIGUAS	10 JULY 14	Mission completed
1684	BLK61E	3BLK61E191B	LOVELY ACUNA	10 JULY 14	Surveyed 12 lines over BLK61E
1686	BLK61E, BLK61H, BLK61I	3BLK61ESHI192A	MCE BALIGUAS	11 JULY 14	Completed mission over BLK61E, BLK61I and surveyed 4 lines over BLK61I.
1690	BLK61I, BLK65E	3BLK61IS193A, 3BLK65E193A	MCE BALIGUAS, MR VILLANUEVA	12 JULY 14	Completed mission over BLK61I. Surveyed 10 lines over BLKK65E
1694	BLK61E, BLK61D	3BLK65ESD194A	MR VILLANUEVA	13 JULY 14	Completed mission over BLK65E. Surveyed 9 lines over BLK65D
1732	BLK61J	MCE BALIGUAS	3LMSCALIB203B, 2BLK61J203B	22 JULY 14	Surveyed 7 lines over BLK65J; LMS Calibration over Tandag City
1736	BLK61J	MR VILLANUEVA	3BLK61JS204B	23 JULY 14	Completed mission over BLK65J
1742	BLK61K, BLK61B, BLK61C, BLK61D, BLK61E	MCE BALIGUAS	3BLK61K206A, 3BLK61BCDES206A	25 JULY 14	Surveyed 15 lines over BLK61K and covered voids over BLK61B, Blk61C, BLK61E; no digitizer
1750	BLK61K	MR VILLANUEVA	3BLK61L208A	27 JULY 14	Surveyed 10 lines over BLK61L; no digitizer
1752	BLK61L	MCE BALIGUAS	3BLK61L208B	27 JULY 14	Surveyed 7 lines over BLK61L and 1 line over BLK61K. Camera not triggering when laser is on; no digitizer
1754	BLK61K, BLK61M	MR VILLANUEVA	3BLK61KSM209A	28 JULY 14	Surveyed 3 lines over BLK61K and 12 lines over BLK61M; no digitizer
1758	BLK61F, BLK61G, BLK61H, BLK61K, BLK61M, BLK61N	MCE BALIGUAS	3BLK61FGHKMSN210A	29 JULY 14	Completed over BLK61M, covered voids over BLK61F,G,H and surveyed 1 line over BLK61K; no digitizer

1. Swath Coverage of Mission 3BLK61A186A

Flight No. :	1664	
Area:	BLK61A	
Mission name:	3BLK61A186A	
Parameters:	Altitude: 500 m	Scan Frequency: 40 kHz
	Scan Angle: 25 degrees	
Total Area Surveyed:	**31.1 sq km**	

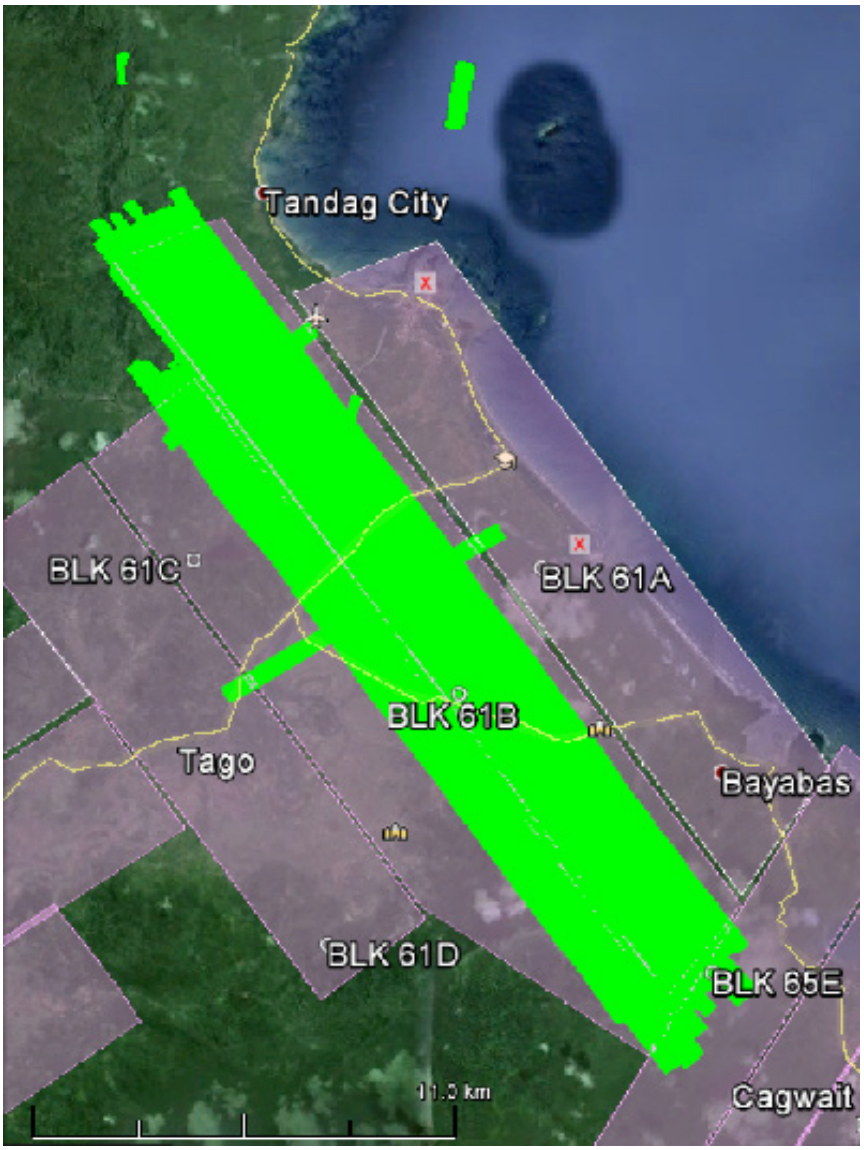


2. Swath Coverage of Mission 3BLK61ASB187A

Flight No. :	1666	
Area:	BLK61A, BLK61B	
Mission name:	3BLK61ASB187A	
Parameters:	Altitude: 500 m	Scan Frequency: 40 kHz
	Scan Angle: 25 degrees	
Total Area Surveyed:	**79.2 sq km**	

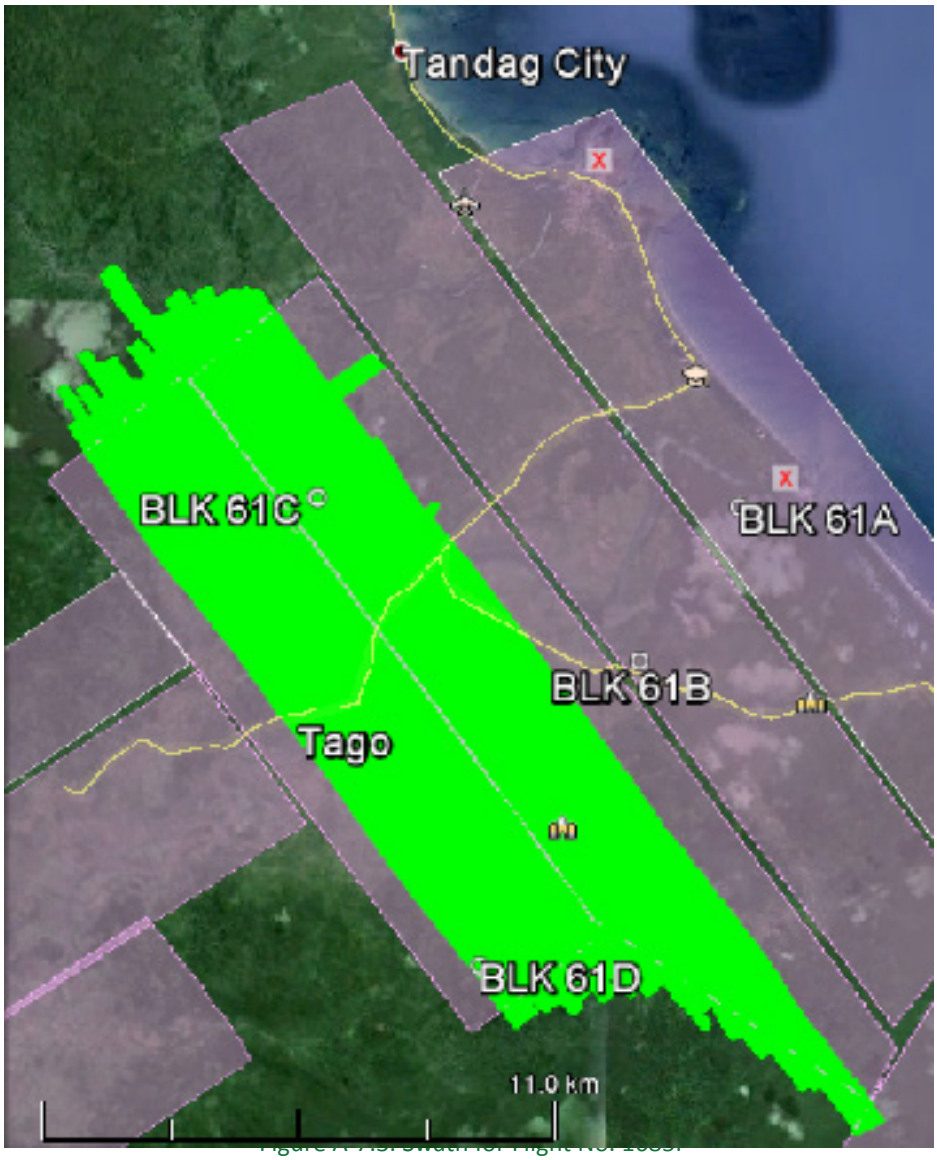
3. Swath Coverage of Mission 3BLK61BSC188A

Flight No. :	1670	
Area:	BLK61B, BLK61C	
Mission name:	3BLK61BSC188A	
Parameters:	Altitude:600 m	Scan Frequency: 40 kHz
	Scan Angle: 25 degrees	
Total Area Surveyed:	**93.4 sq km**	



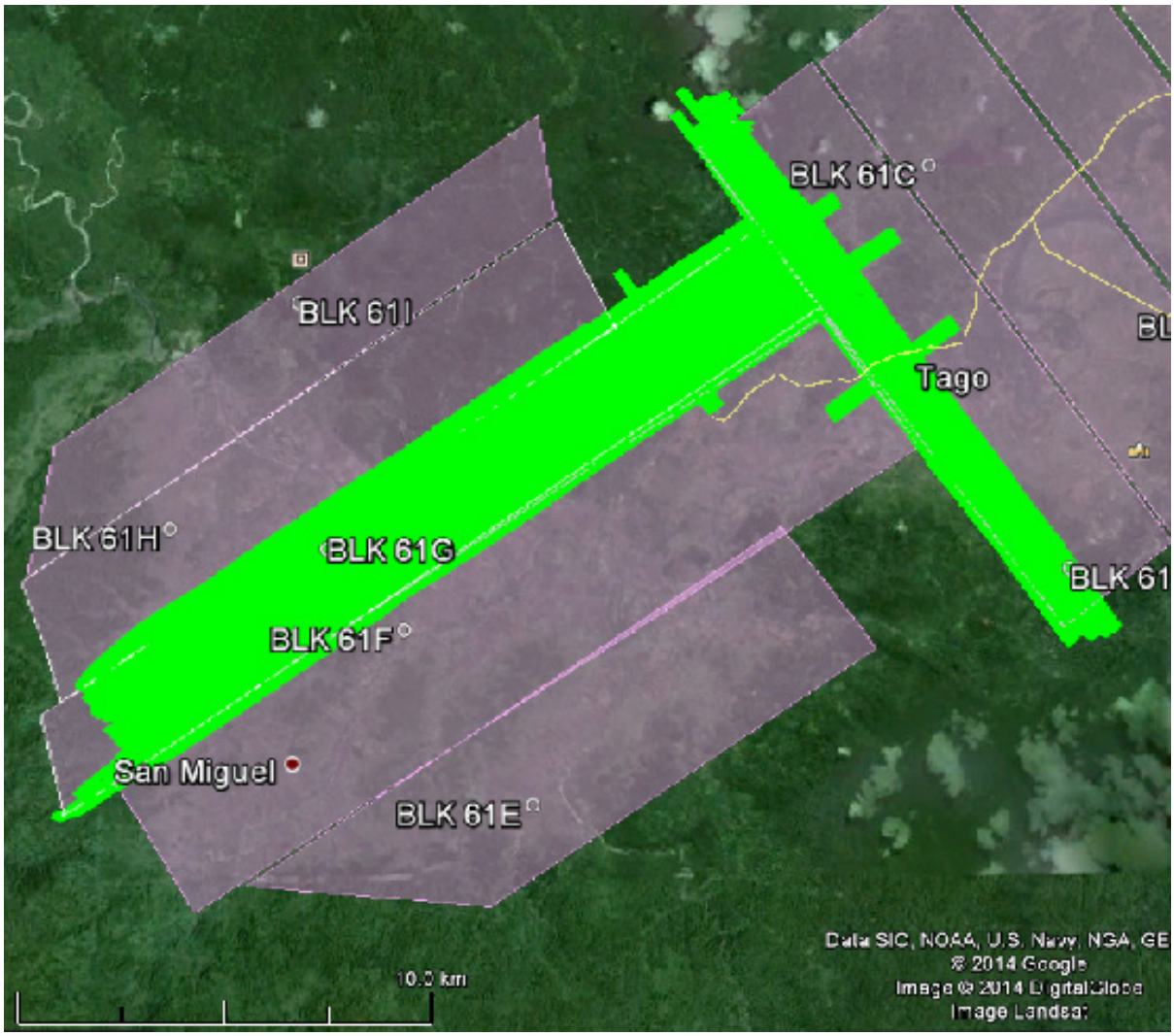
4. Swath Coverage of Mission 3BLK61CSD189A

Flight No. : 1674
Area: BLK61C, BLK61D
Mission name: 3BLK61ASB187A
Parameters: Altitude: 600 m Scan Frequency: 40 kHz
Scan Angle: 25 degrees
Total Area Surveyed: **91.3 sq km**



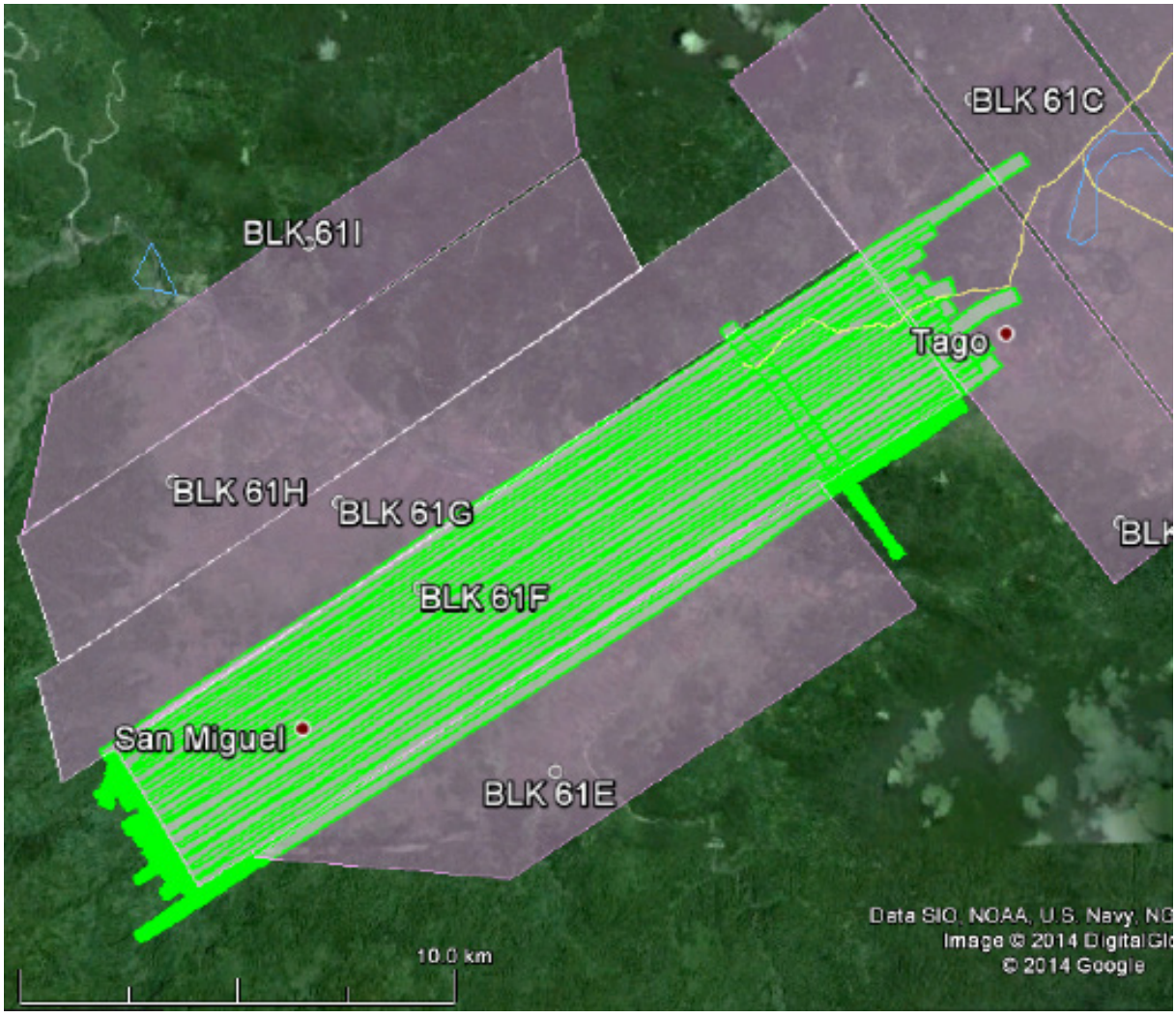
5.Swath Coverage of Mission 3BLK61DSG190A

Flight No. :	1678	
Area:	BLK61D, BLK61G	
Mission name:	3BLK61DSG190A	
Parameters:	Altitude:600 m	Scan Frequency: 40 kHz
	Scan Angle: 25 degrees	
Total Area Surveyed:	**84.5 sq km**	



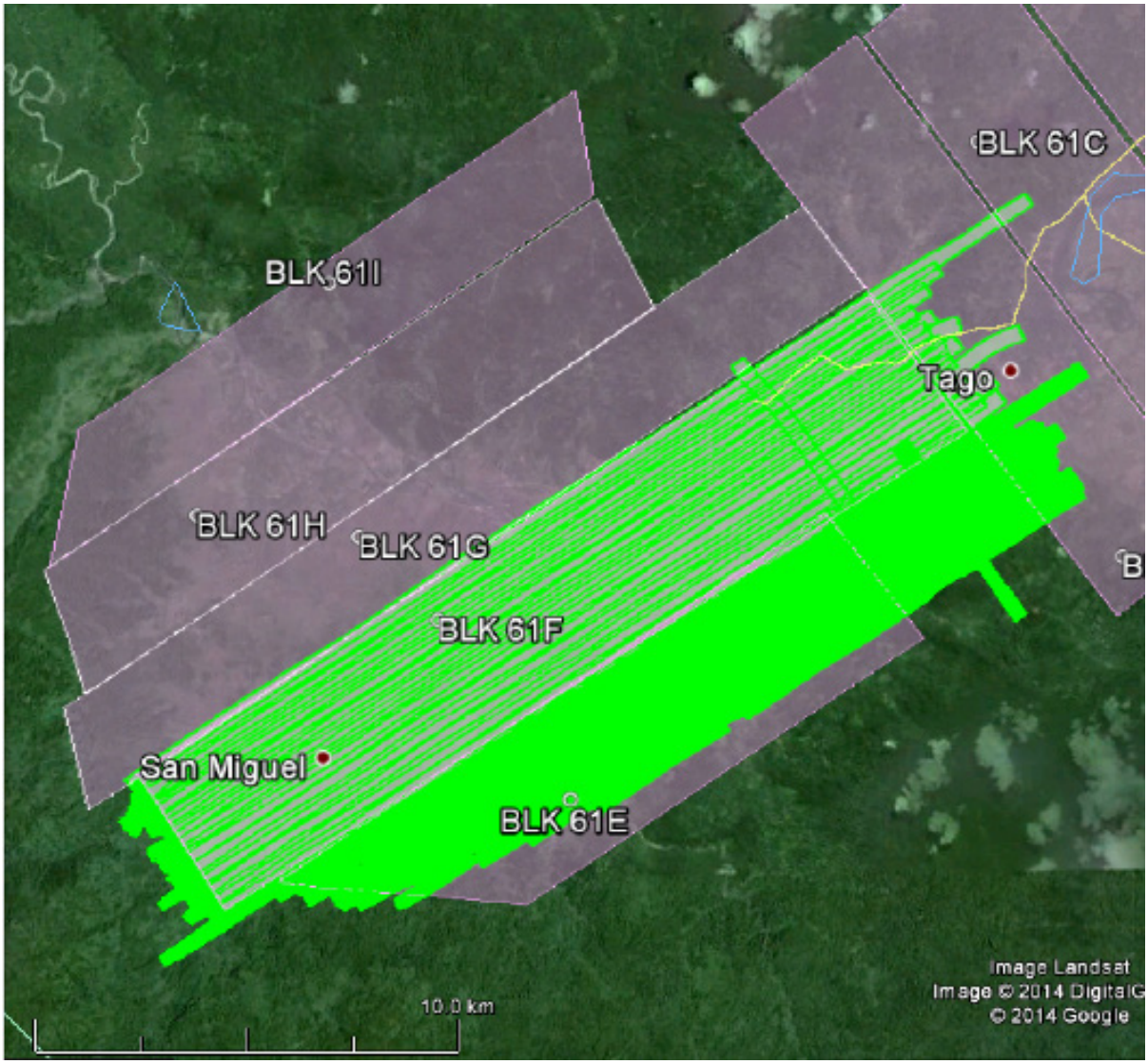
6. Swath Coverage of Mission 3BLK61GSE191A

Flight No. : 1682
Area: BLK61G, BLK61E
Mission name: 3BLK61GSE191A
Parameters: Altitude: 600 m Scan Frequency: 40 kHz
Scan Angle: 25 degrees
Total Area Surveyed: 99.3 sq km



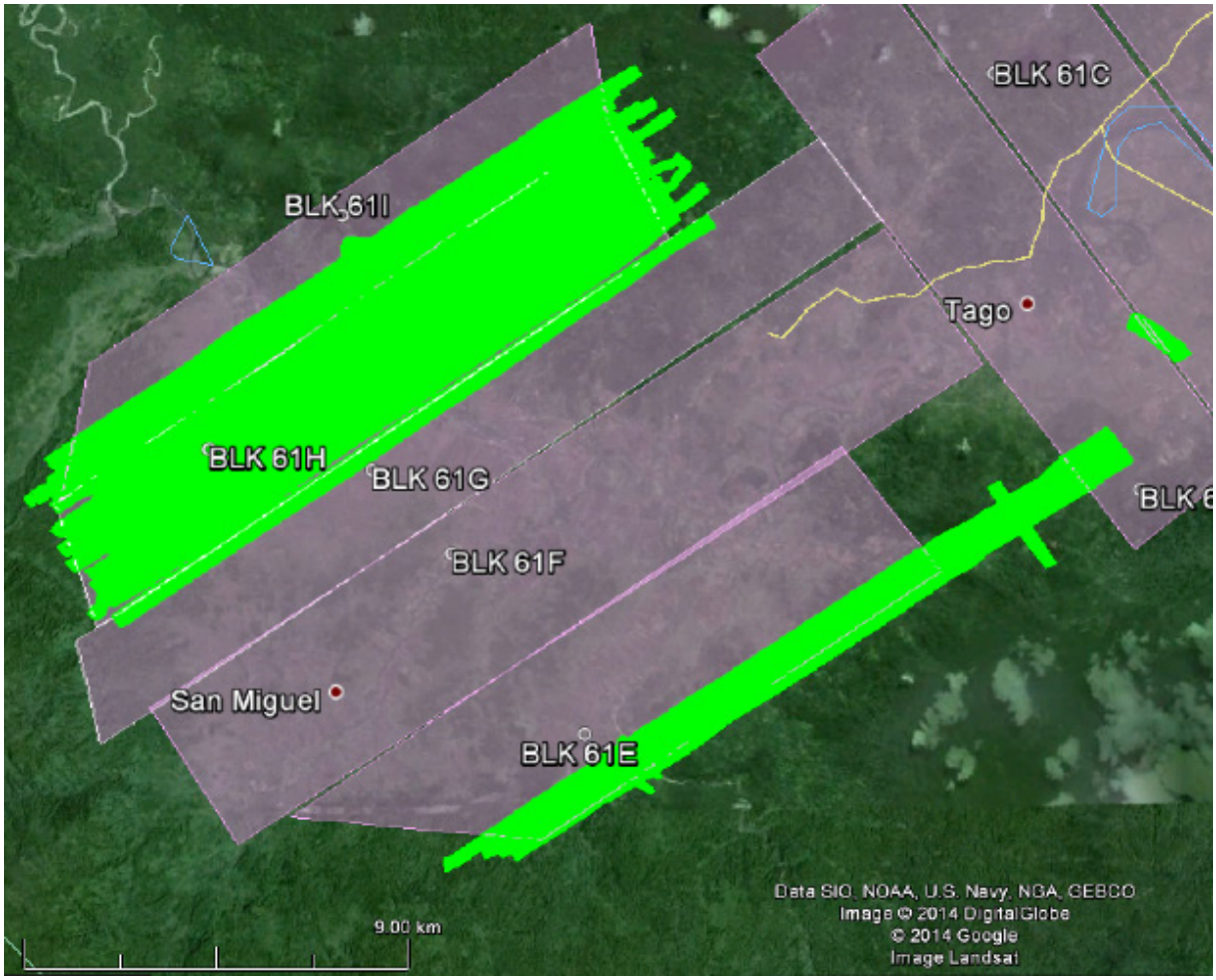
7.Swath Coverage of Mission 3BLK61E191B

Flight No. :	1684	
Area:	BLK61E	
Mission name:	3BLK61E191B	
Parameters:	Altitude:600 m	Scan Frequency: 40 kHz
	Scan Angle: 25 degrees	
Total Area Surveyed:	**54.45 sq km**	



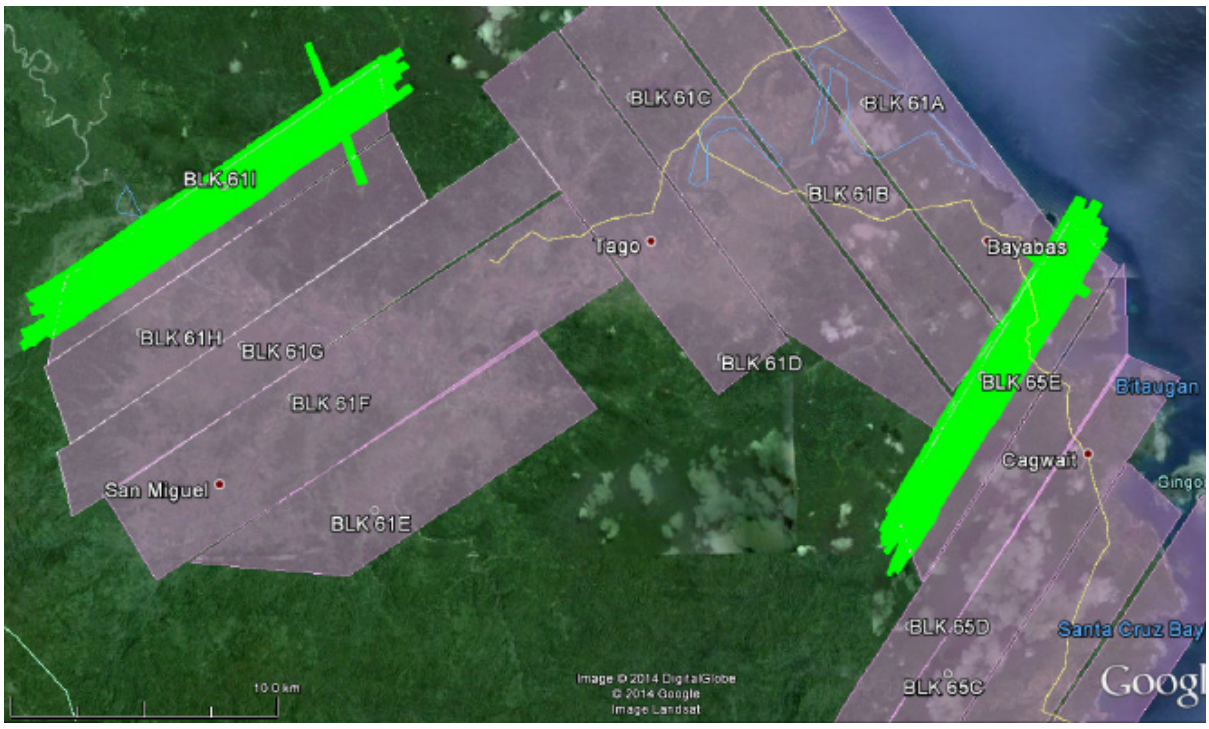
8. Swath Coverage of Mission 3BLK61ESHI192A

Flight No. : 1686
Area: BLK61E, BLK61H, BLK61I
Mission name: 3BLK61ESHI192A
Parameters: Altitude: 600 m Scan Frequency: 40 kHz
Scan Angle: 25 degrees
Total Area Surveyed: 74.2 sq km



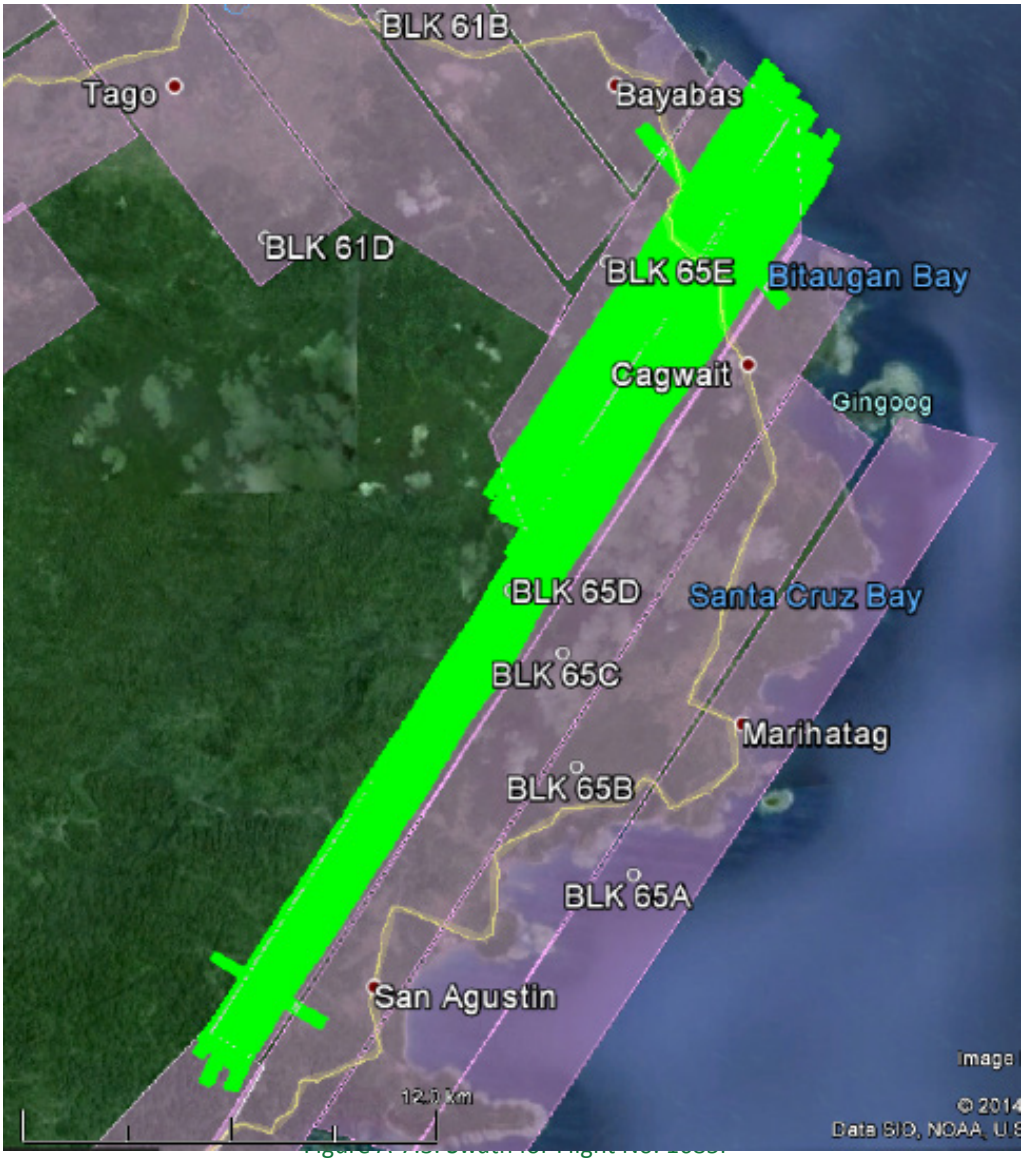
9.Swath Coverage of Mission 3BLK61ISE193A, 3BLK65E193A

Flight No. :	1690	
Area:	BLK61I, BLK65E	
Mission name:	3BLK61ISE193A, 3BLK65E193A	
Parameters:	Altitude:600 m	Scan Frequency: 40 kHz
	Scan Angle: 25 degrees	
Total Area Surveyed:	**57.5 sq km**	



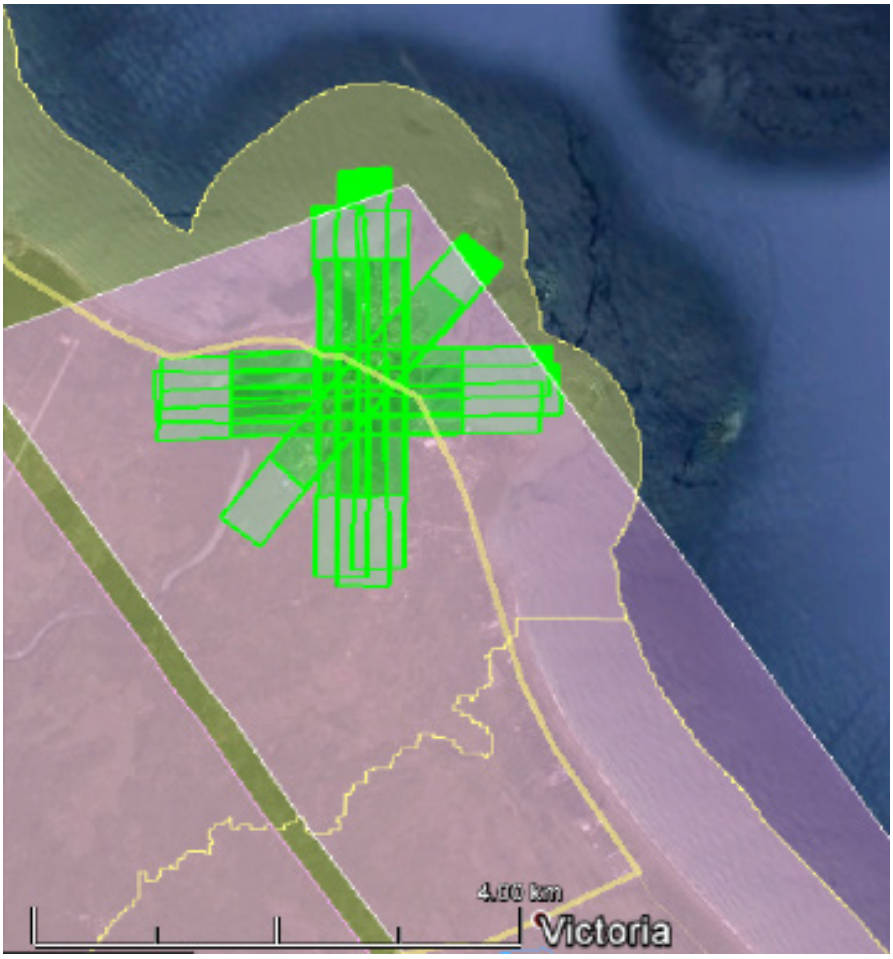
10. Swath Coverage of Mission of 3BLK65ESD194A

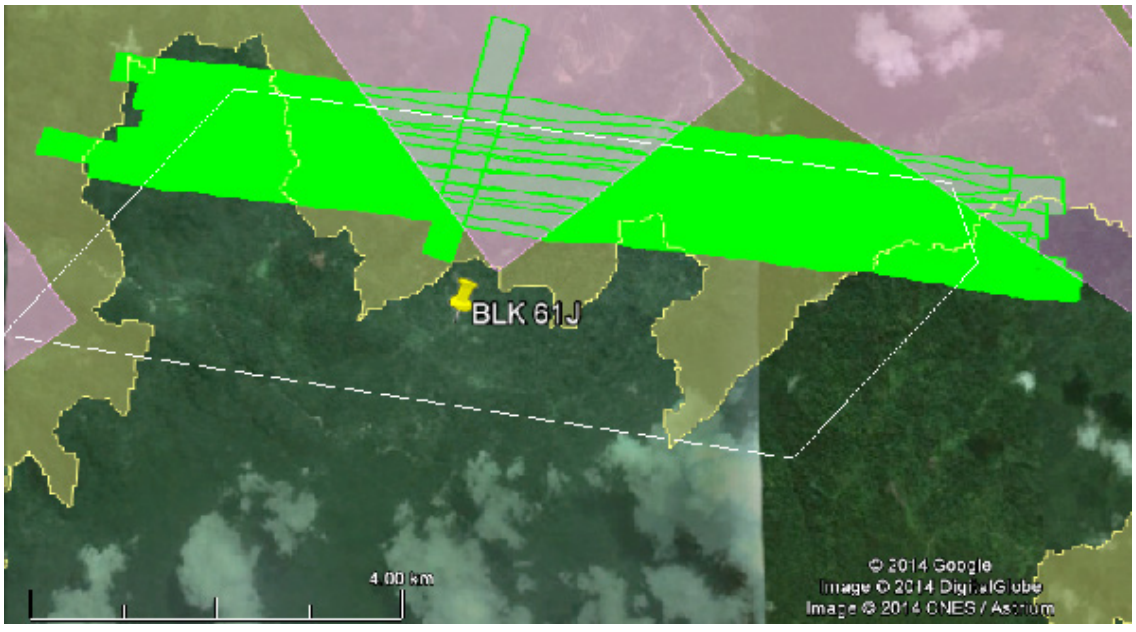
Flight No. : 1694
Area: BLK65E, BLK65D
Mission name: 3BLK65ESD194A
Parameters: Altitude: 600 m Scan Frequency: 40 kHz
Scan Angle: 25 degrees
Total Area Surveyed: 80.1 sq km



11. Swath Coverage of Mission 3LMSCALIB203B, 3BLK61J203B

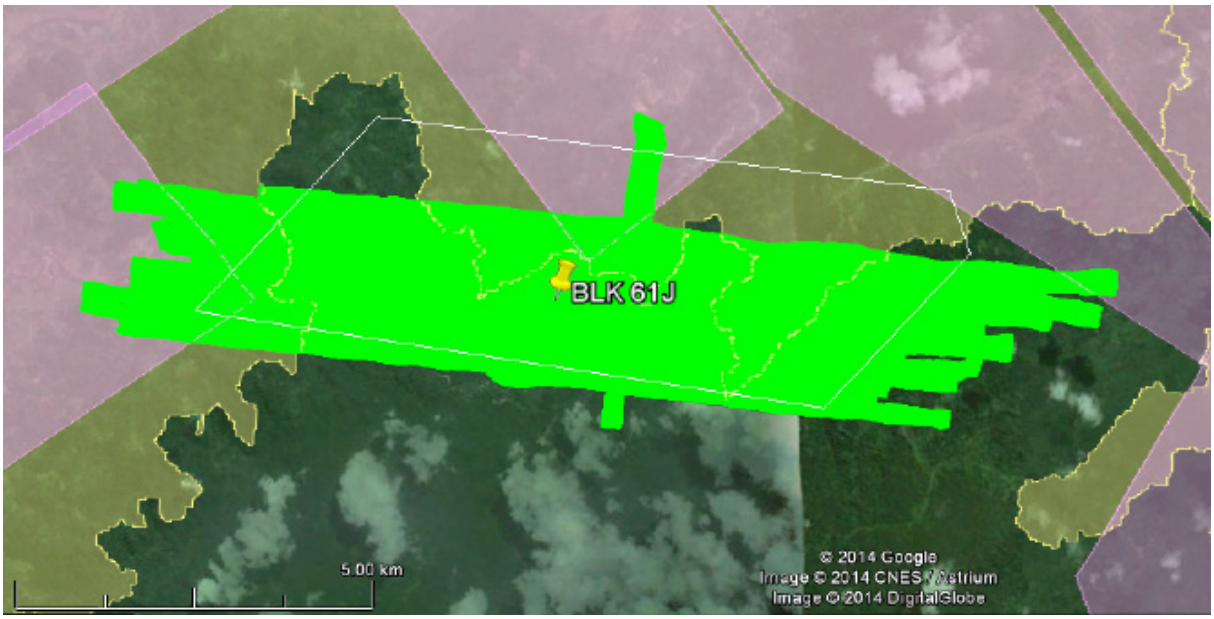
Flight No. :	1732	
Area:	BLK65J	
Mission name:	3LMSCALIB203B, 3BLK61J203B	
Parameters:	Altitude:600 m	Scan Frequency: 40 kHz
	Scan Angle: 25 degrees	
Total Area Surveyed:	**14.6 sq km**	





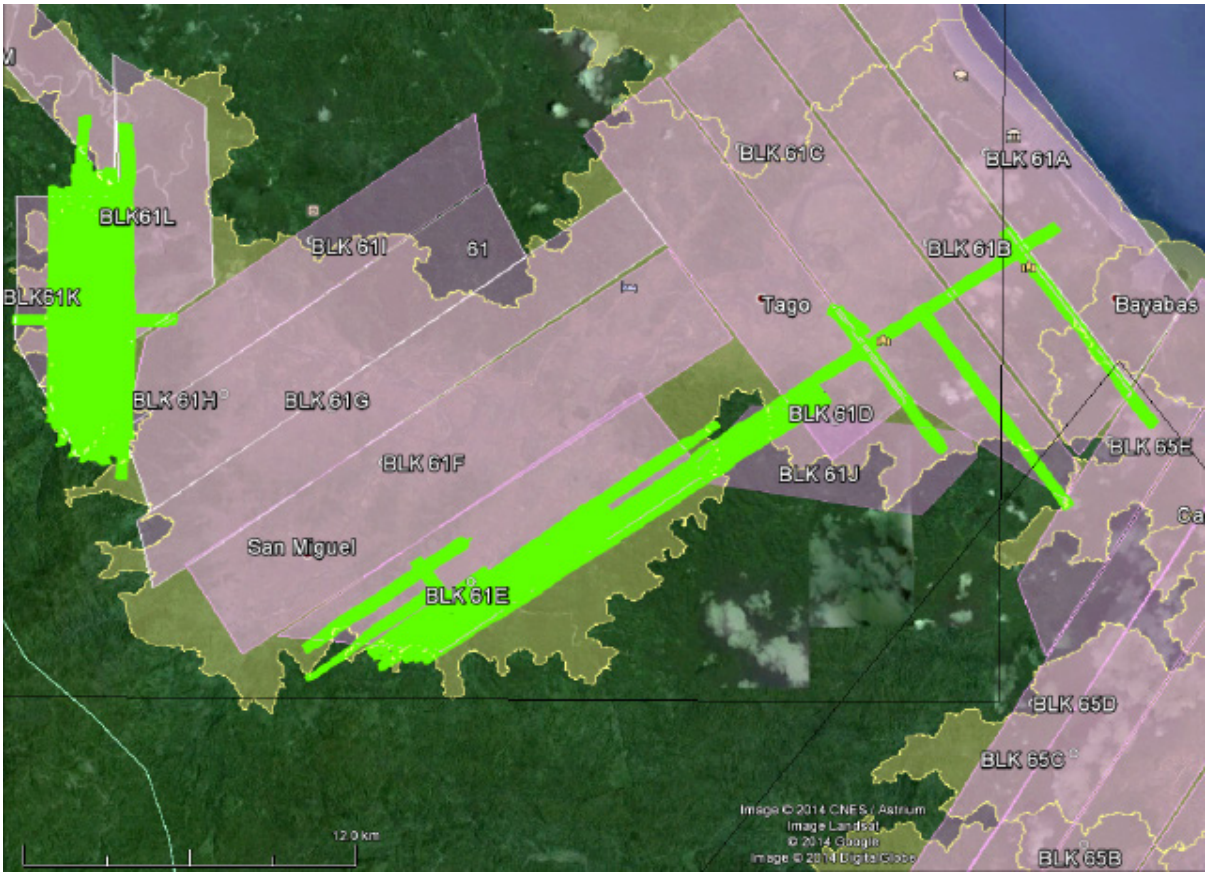
12. Swath Coverage of Mission 3BLK61JS204B

Flight No. : 1736
Area: BLK65J
Mission name: 3BLK61JS204B
Parameters: Altitude: 600 m Scan Frequency: 40 kHz
Scan Angle: 25 degrees
Total Area Surveyed: 27.6 sq km



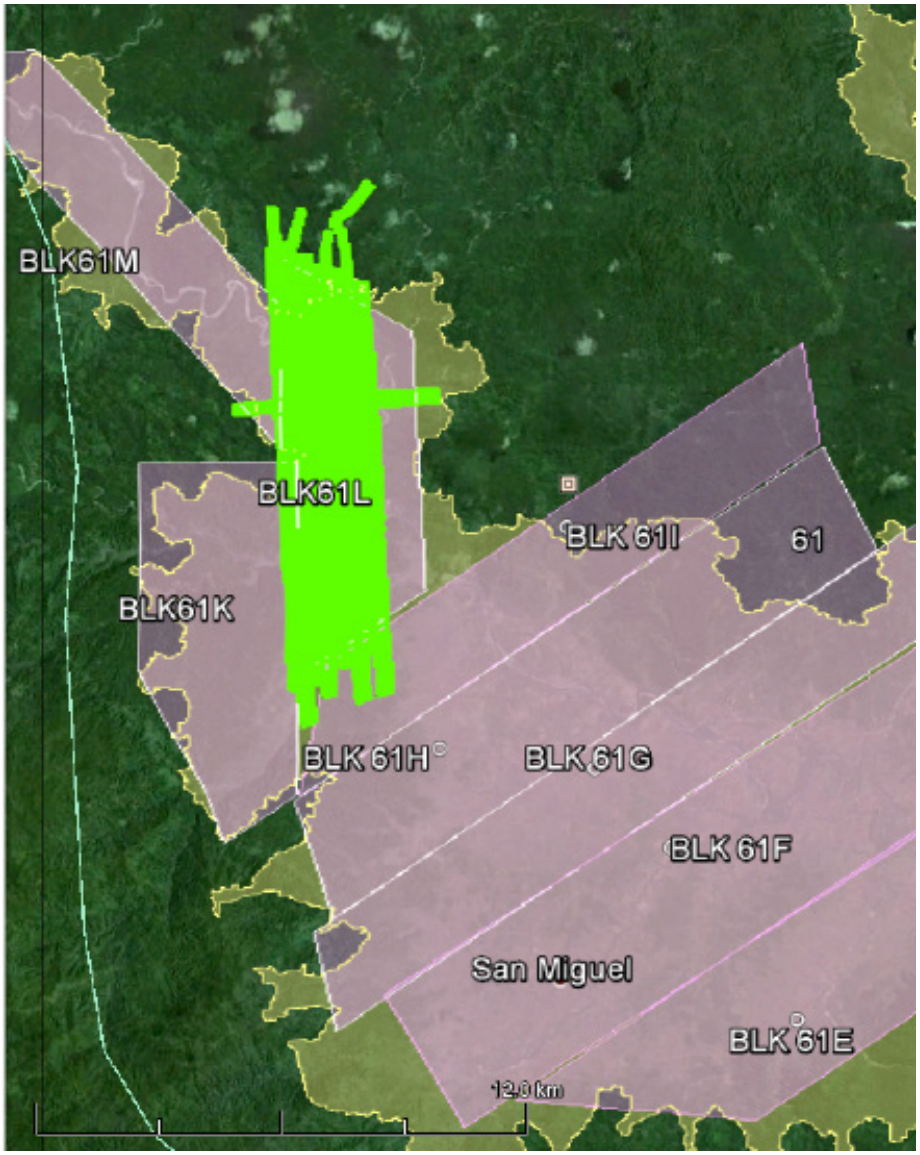
13. Swath Coverage of Mission 3BLK61K206A & 3BLK61BCDES206A

Flight No. : 1742
Area: BLK61B, BLK61C, BLK61D, BLK61E, BLK61K
Mission name: 3BLK61K206A & 3BLK61BCDES206A
Parameters: Altitude:600 m Scan Frequency: 40 kHz
Scan Angle: 25 degrees
Total Area Surveyed: 62.8 sq km



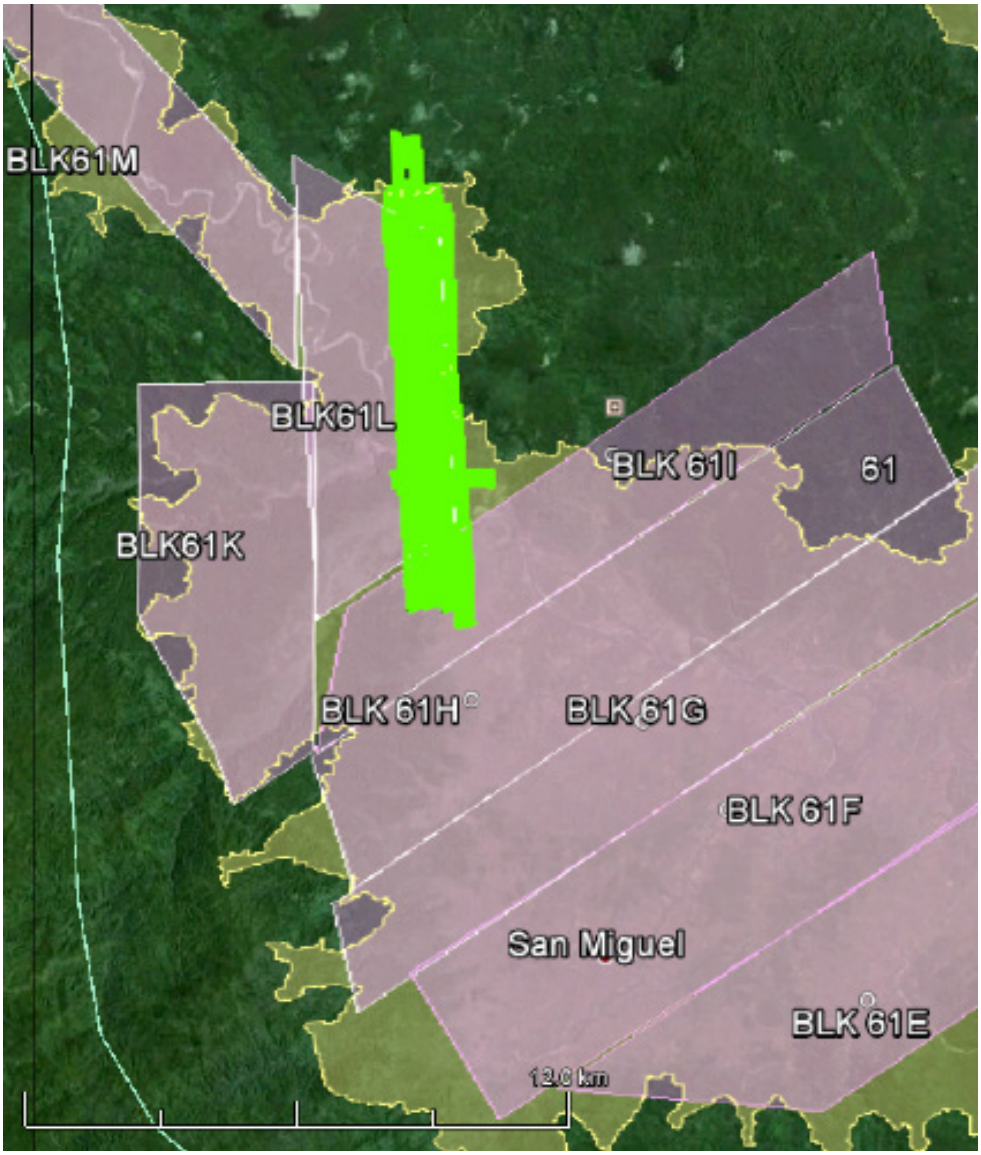
14. Swath Coverage of Mission 3BLK61L208A

Flight No. : 1750
Area: BLK61L
Mission name: 3BLK61L208A
Parameters: Altitude: 600 m Scan Frequency: 40 kHz
Scan Angle: 25 degrees
Total Area Surveyed: 28.11 sq km



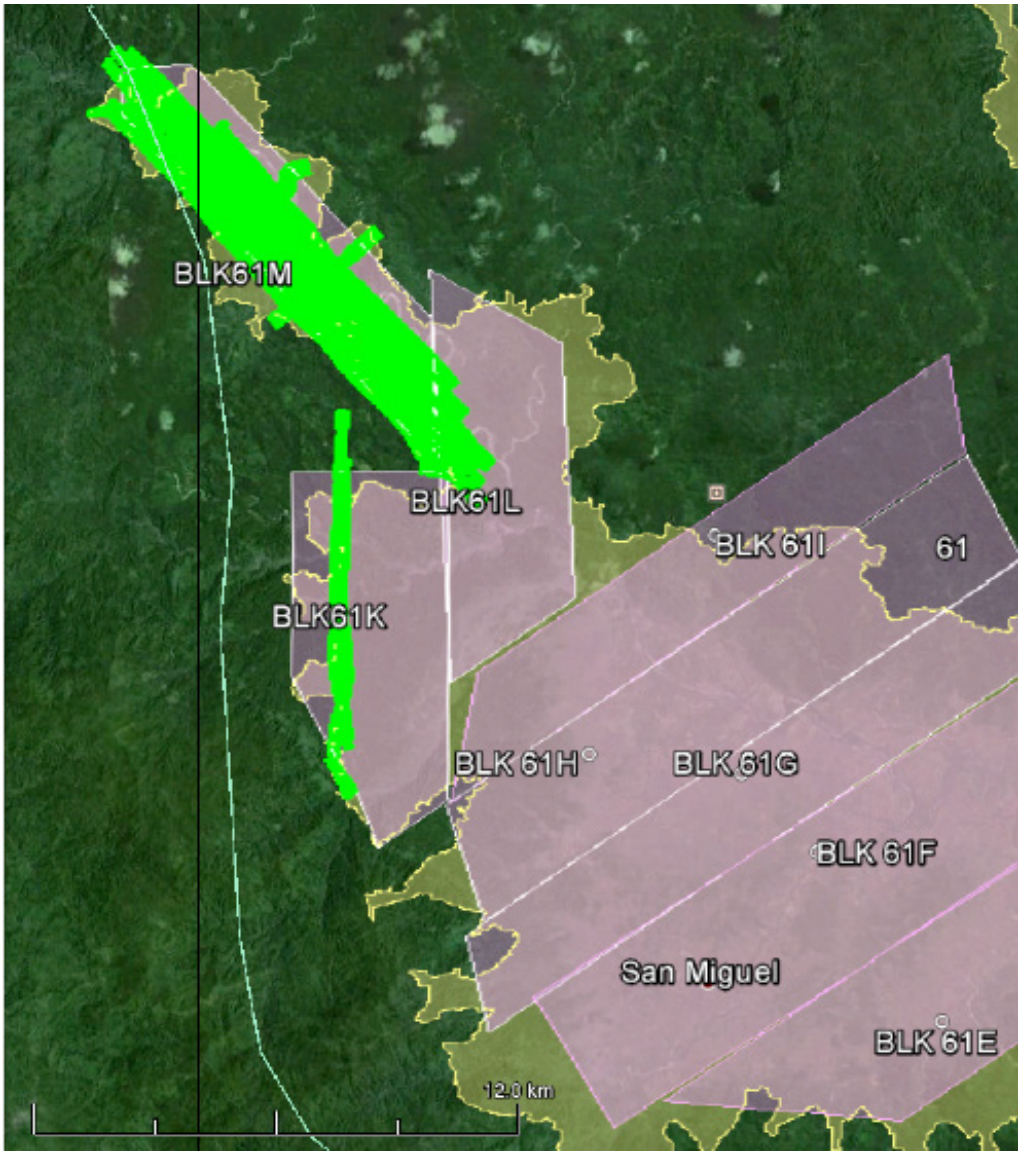
15. Swath Coverage of Mission 3BLK61LS208B

Flight No. :	1752	
Area:	BLK61L	
Mission name:	3BLK61LS208B	
Parameters:	Altitude:600 m	Scan Frequency: 40 kHz
	Scan Angle: 25 degrees	
Total Area Surveyed:	**12.15 sq km**	



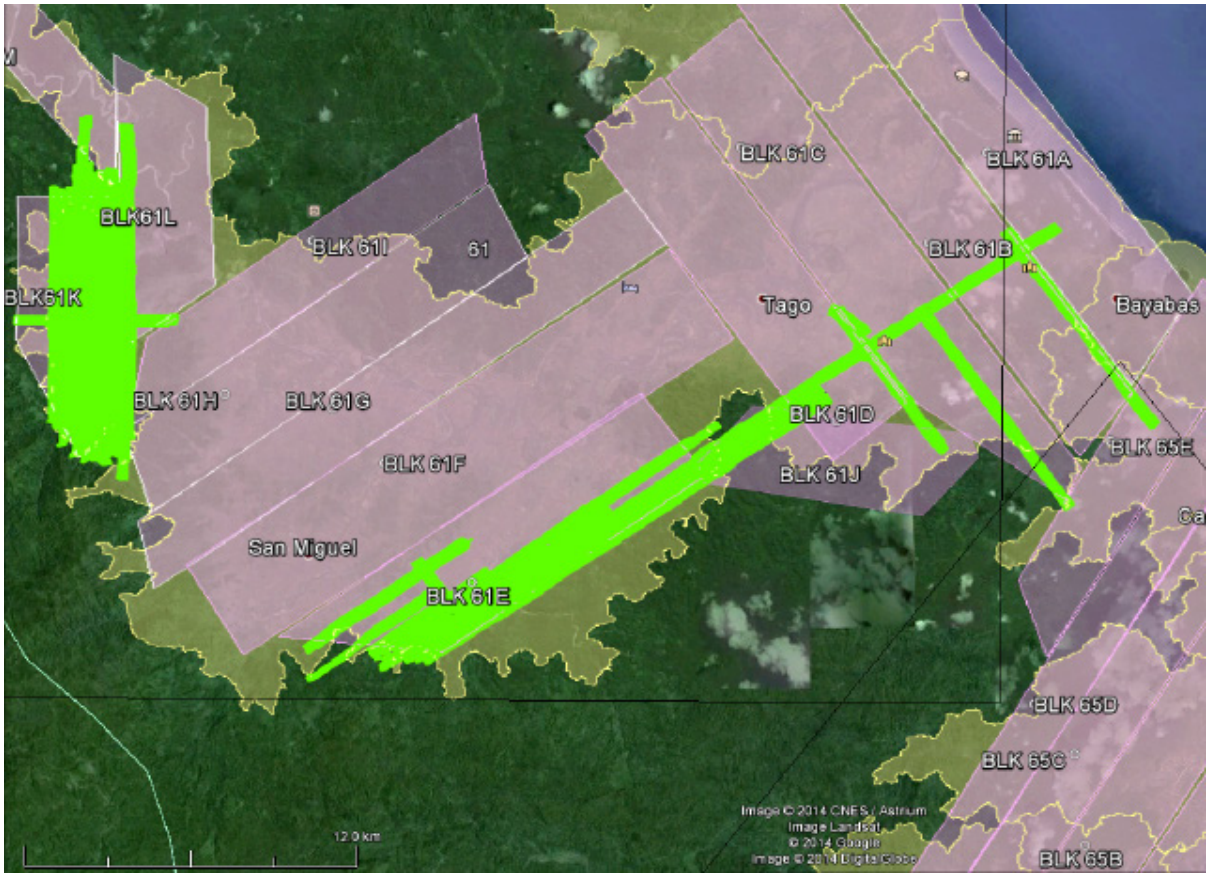
16. Swath Coverage of Mission 3BLK61KSM209A

Flight No. : 1754
Area: BLK61LK, BLK61M
Mission name: 3BLK61KSM209A
Parameters: Altitude: 500 m Scan Frequency: 40 kHz
Scan Angle: 25 degrees
Total Area Surveyed: 28.14 sq km



17. Swath Coverage of Mission 3BLK61FGHKMSN210A

Flight No. :	1678	
Area:	BLK61D, BLK61G	
Mission name:	3BLK61DSG190A	
Parameters:	Altitude:600 m	Scan Frequency: 40 kHz
	Scan Angle: 25 degrees	
Total Area Surveyed:	**84.5 sq km**	



Annex 8. Mission Summary Reports

Flight Area	Tandag (Surigao Del Sur)
Mission Name	Block 61M
Inclusive Flights	1754A, & 1758A
Range data size	1.97 GB
Base data size	18.06 MB
POS	444 MB
Image	30.80 MB
Transfer date	August 14, 2014 & September 1, 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)	3.00
RMSE for East Position (<4.0 cm)	3.60
RMSE for Down Position (<8.0 cm)	8.50
Boresight correction stdev (<0.001deg)	0.000689
IMU attitude correction stdev (<0.001deg)	0.003118
GPS position stdev (<0.01m)	0.0098
Minimum % overlap (>25)	71.12
Ave point cloud density per sq.m. (>2.0)	6.46
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	58
Maximum Height	564.88 m
Minimum Height	93.53 m
Classification (# of points)	
Ground	7,431,428
Low vegetation	6,196,484
Medium vegetation	26,501,322
High vegetation	118,863,587
Building	2,592,219
Orthophoto	No
Processed by	Engr. Analyn Naldo, Engr. Chelou Prado, Jovy Narisma

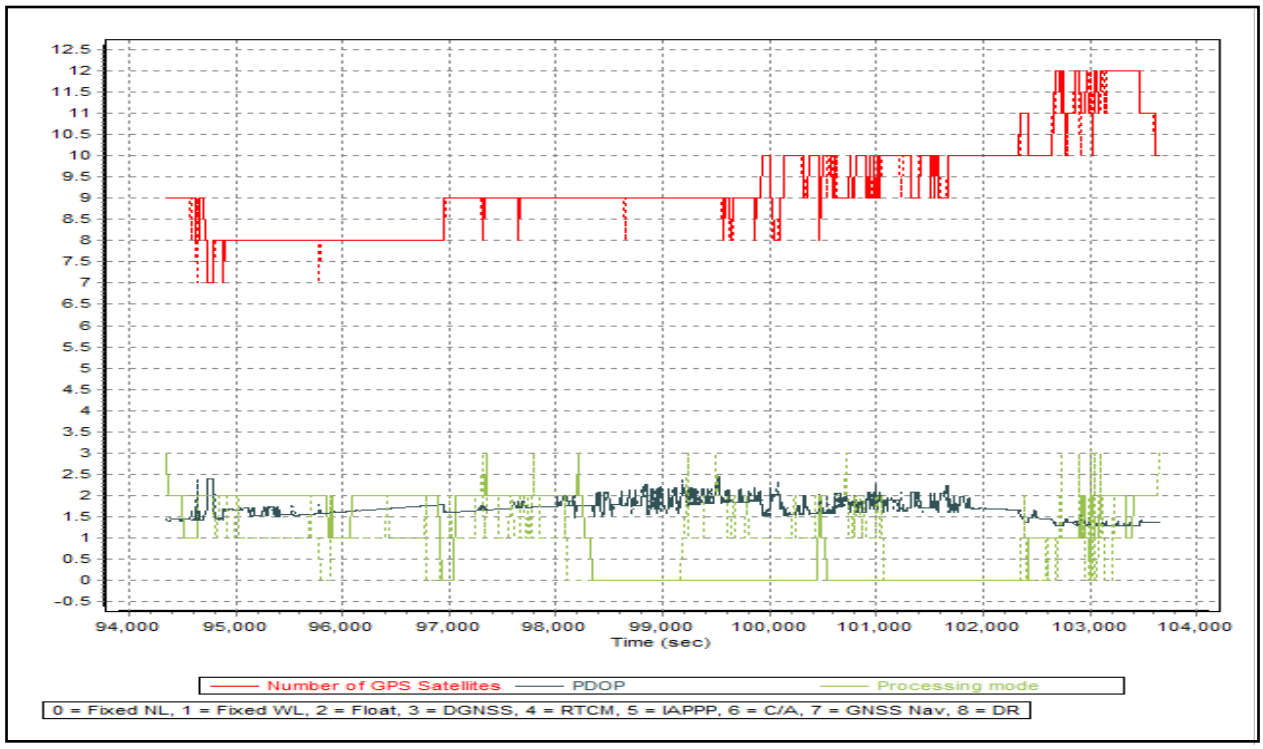


Figure 1.1.1 Solution Status

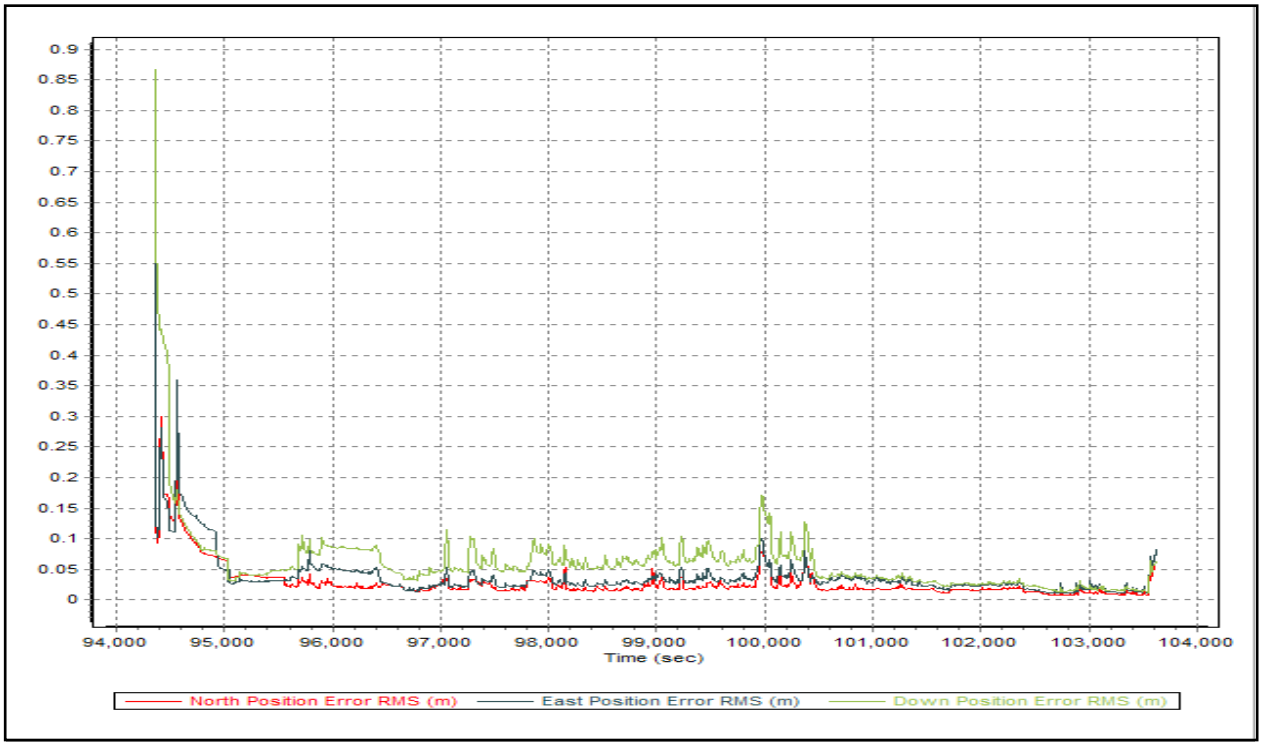


Figure 1.1.2 Smoothed Performance Metric Parameters

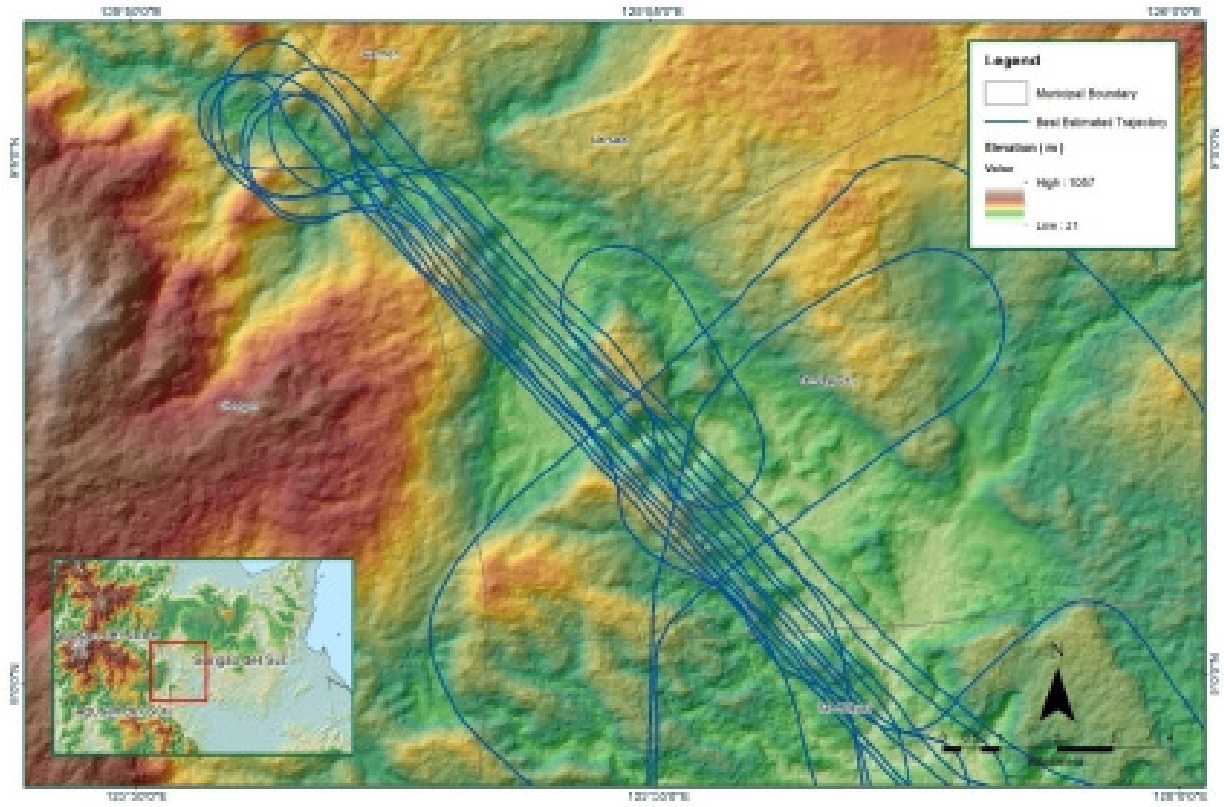


Figure 1.1.3 Best Estimated Trajectory

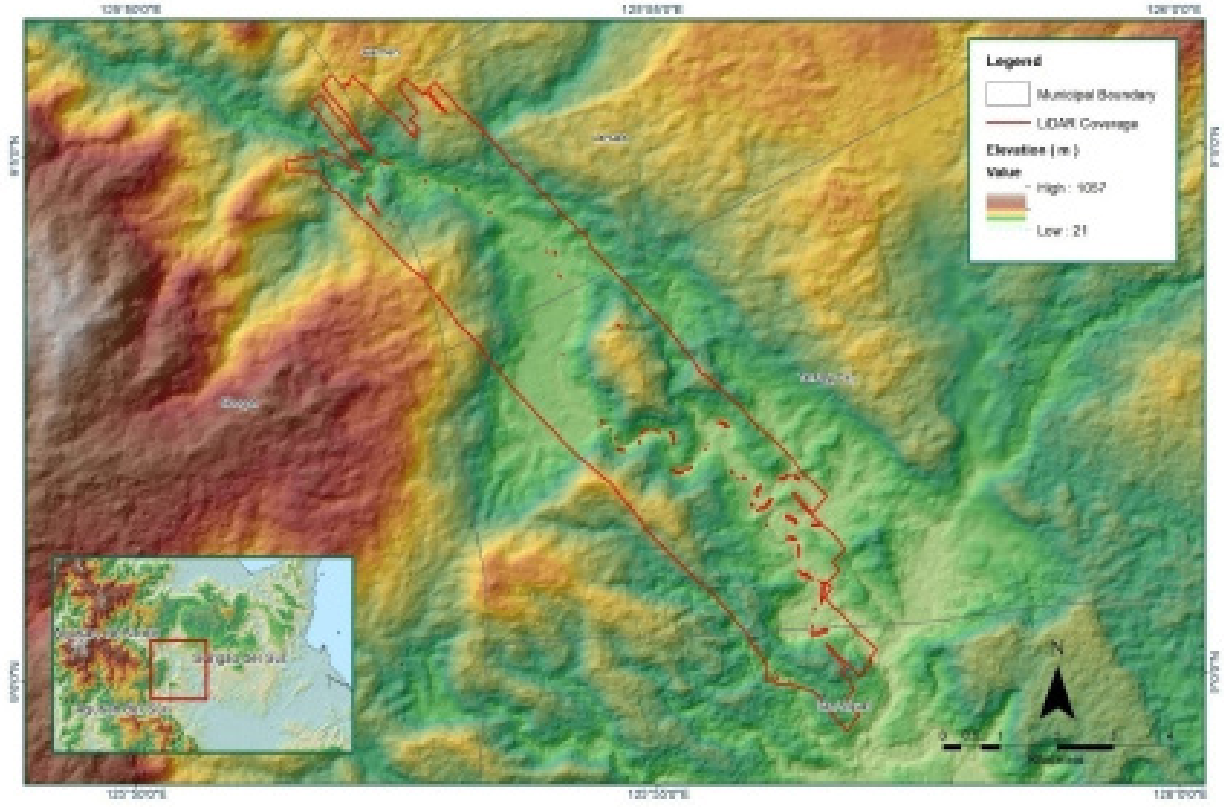


Figure 1.1.4 Coverage of LiDAR data

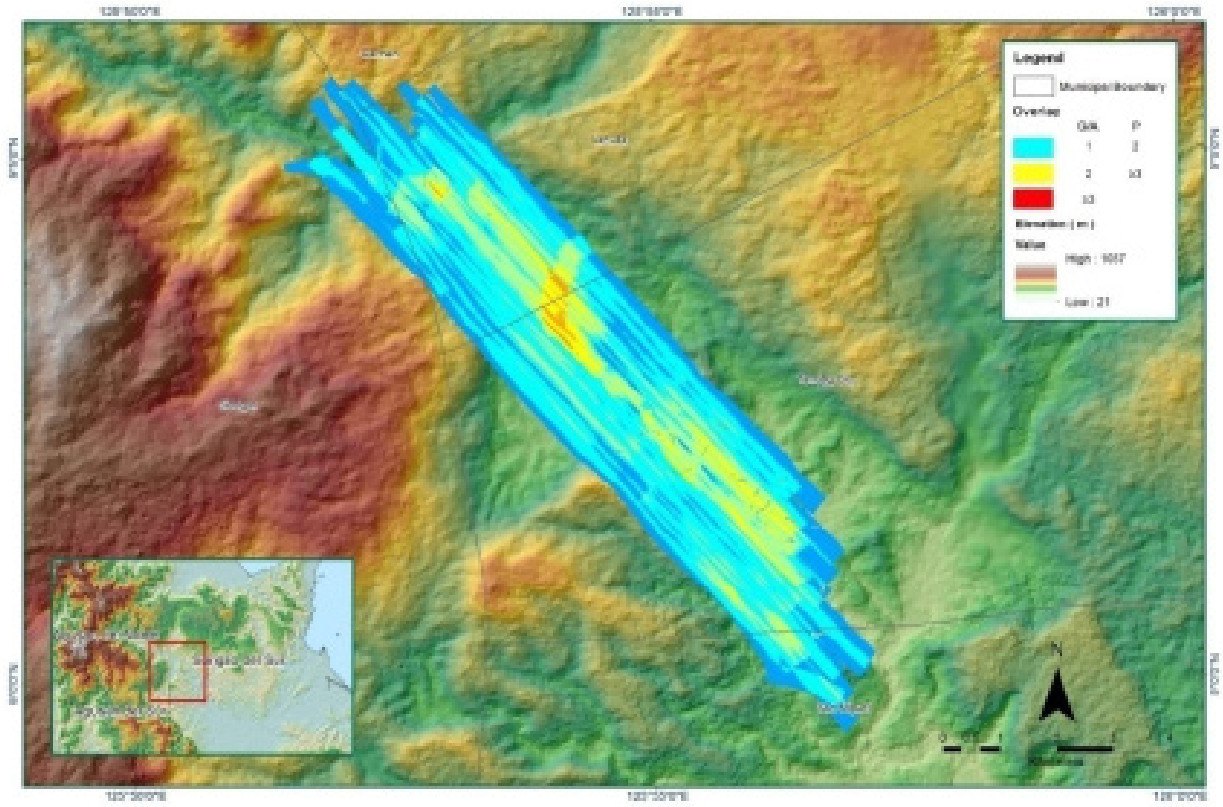


Figure 1.1.5 Image of data overlap

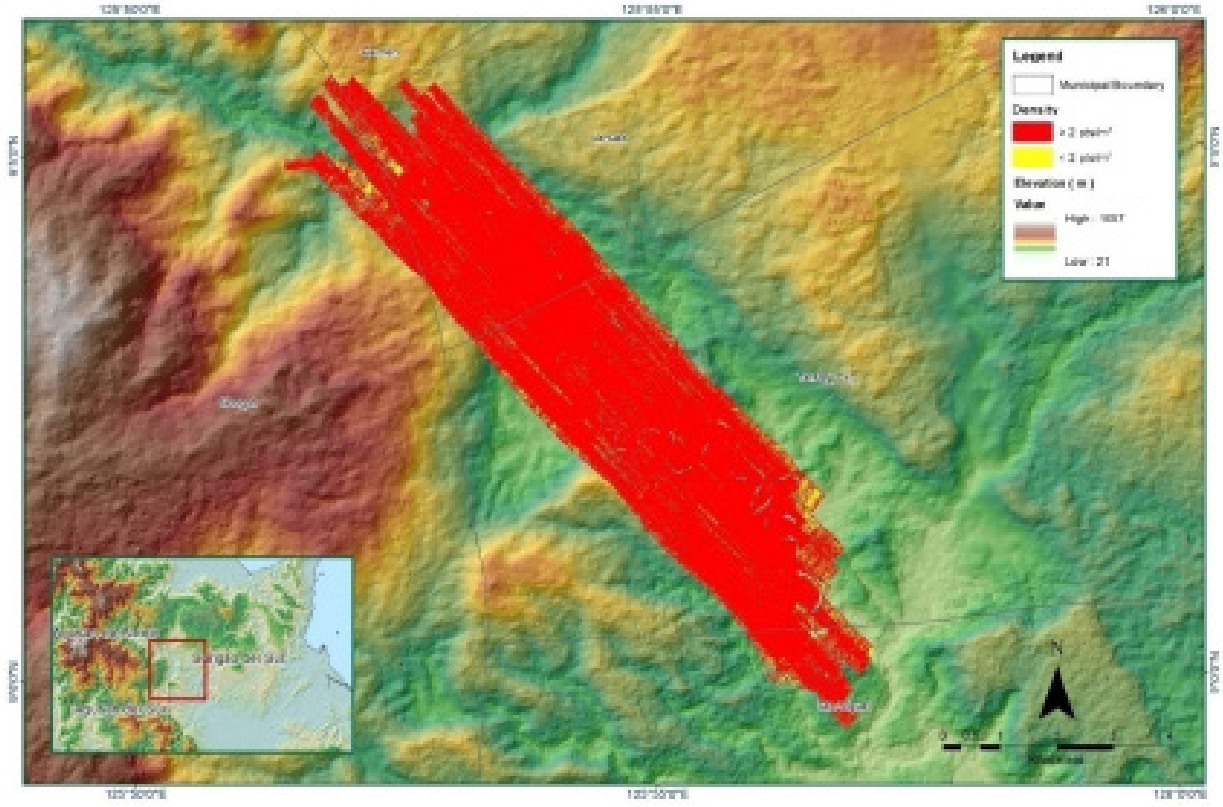


Figure 1.1.6 Density map of merged LiDAR data

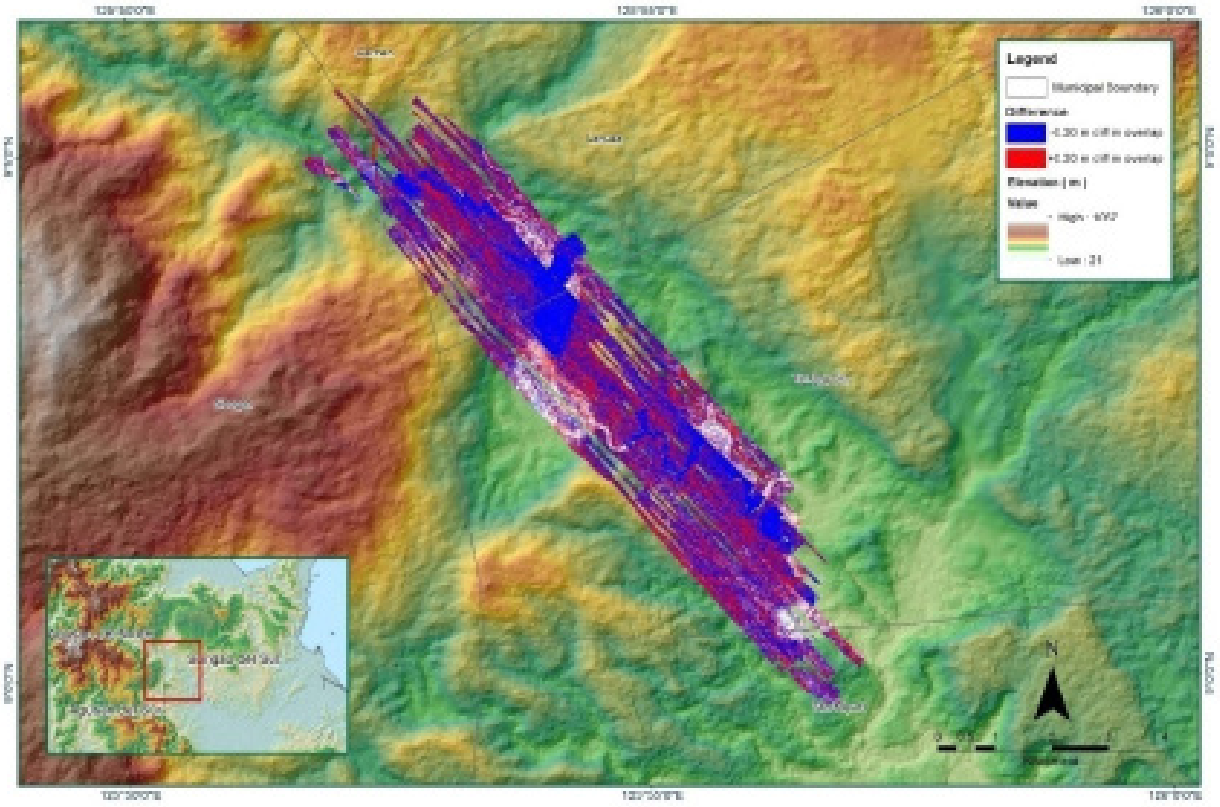


Figure 1.1.7 Elevation difference between flight lines

Flight Area	Tandag (Surigao Del Sur)
Mission Name	Block 61L
Inclusive Flights	1750A, & 1752A
Range data size	7.58 GB
Base data size	30 MB
POS	274 MB
Image	25.41 MB
Transfer date	September 1, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	No
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.60
RMSE for East Position (<4.0 cm)	1.50
RMSE for Down Position (<8.0 cm)	2.50
Boresight correction stdev (<0.001deg)	0.000553
IMU attitude correction stdev (<0.001deg)	0.006531
GPS position stdev (<0.01m)	0.0085
Minimum % overlap (>25)	46.73
Ave point cloud density per sq.m. (>2.0)	3.91
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	63
Maximum Height	499.20 m
Minimum Height	82.29 m
Classification (# of points)	
Ground	12,161,496
Low vegetation	11,849,313
Medium vegetation	28,825,460
High vegetation	74,418,746
Building	2,561,136
Orthophoto	Yes
Processed by	Engr. Jommer Medina, Engr. Christy Lubiano, Engr. Melissa Fernandez

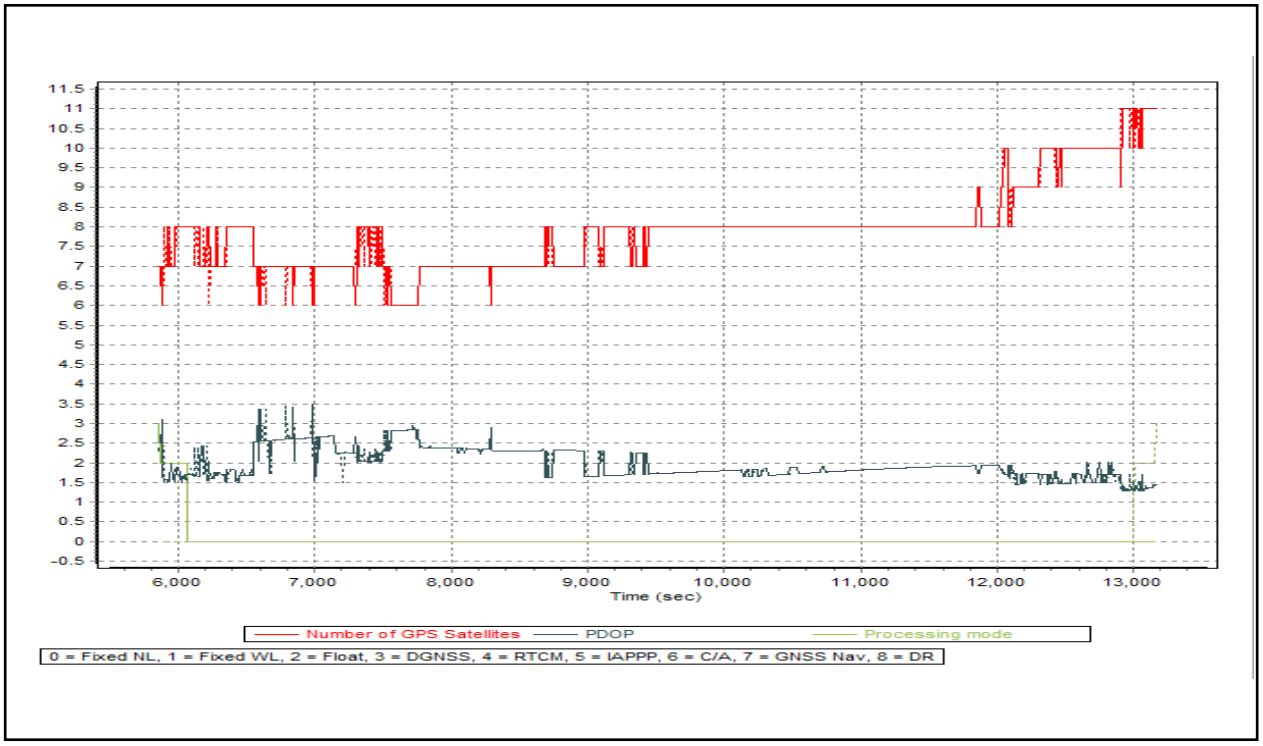


Figure 1.2.1 Solution Status

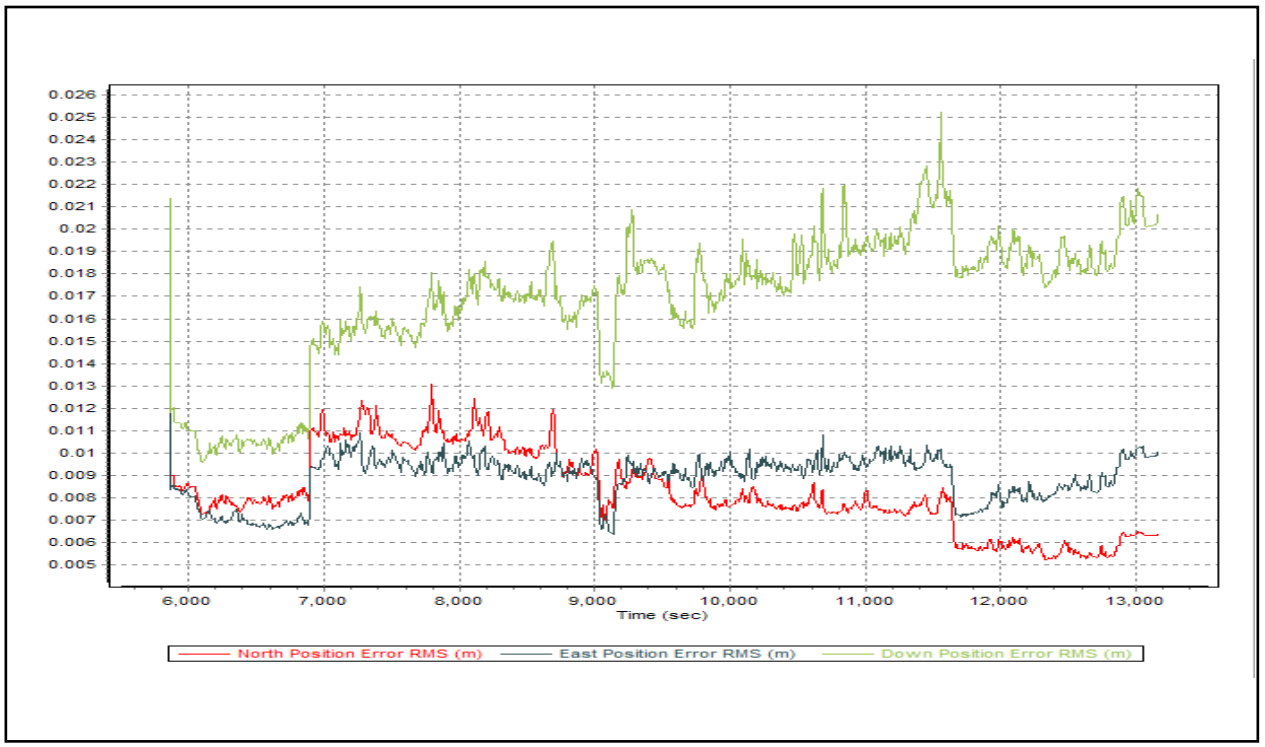


Figure 1.2.2 Smoothed Performance Metric Parameters

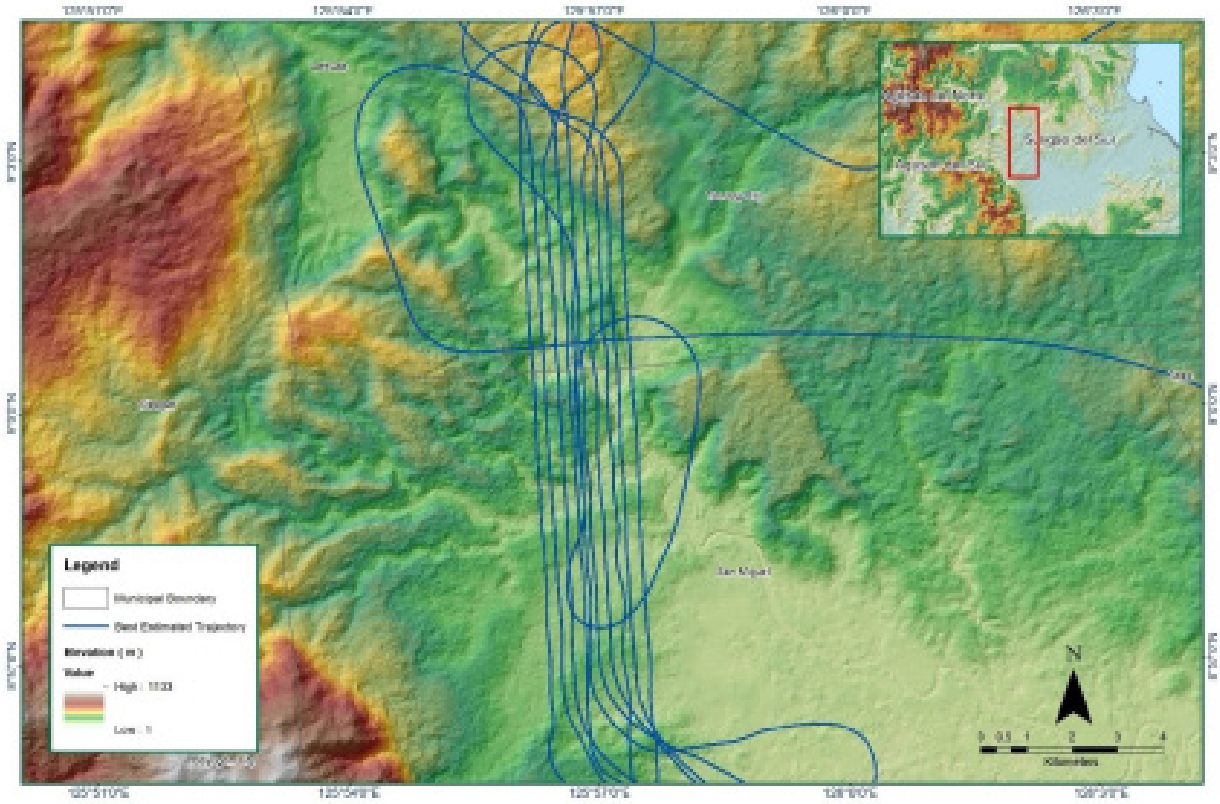


Figure 1.2.3 Best Estimated Trajectory

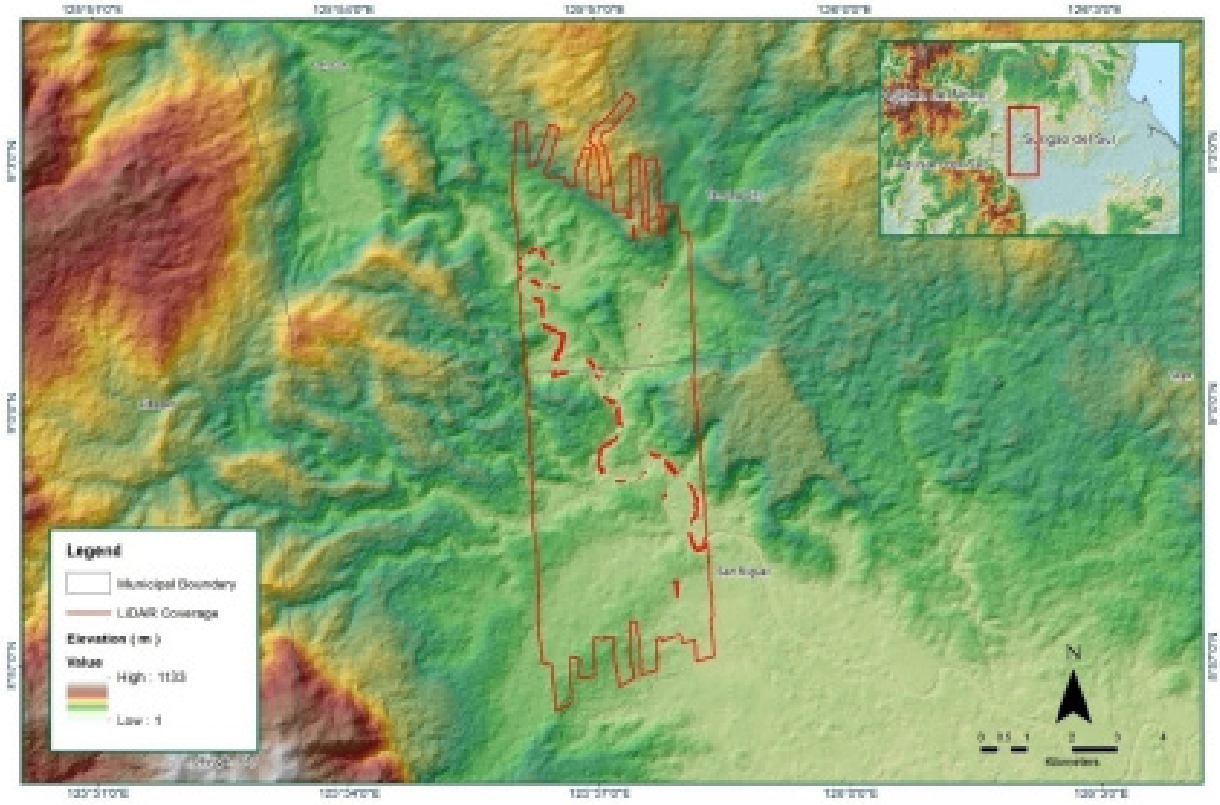


Figure 1.2.4 Coverage of LiDAR data

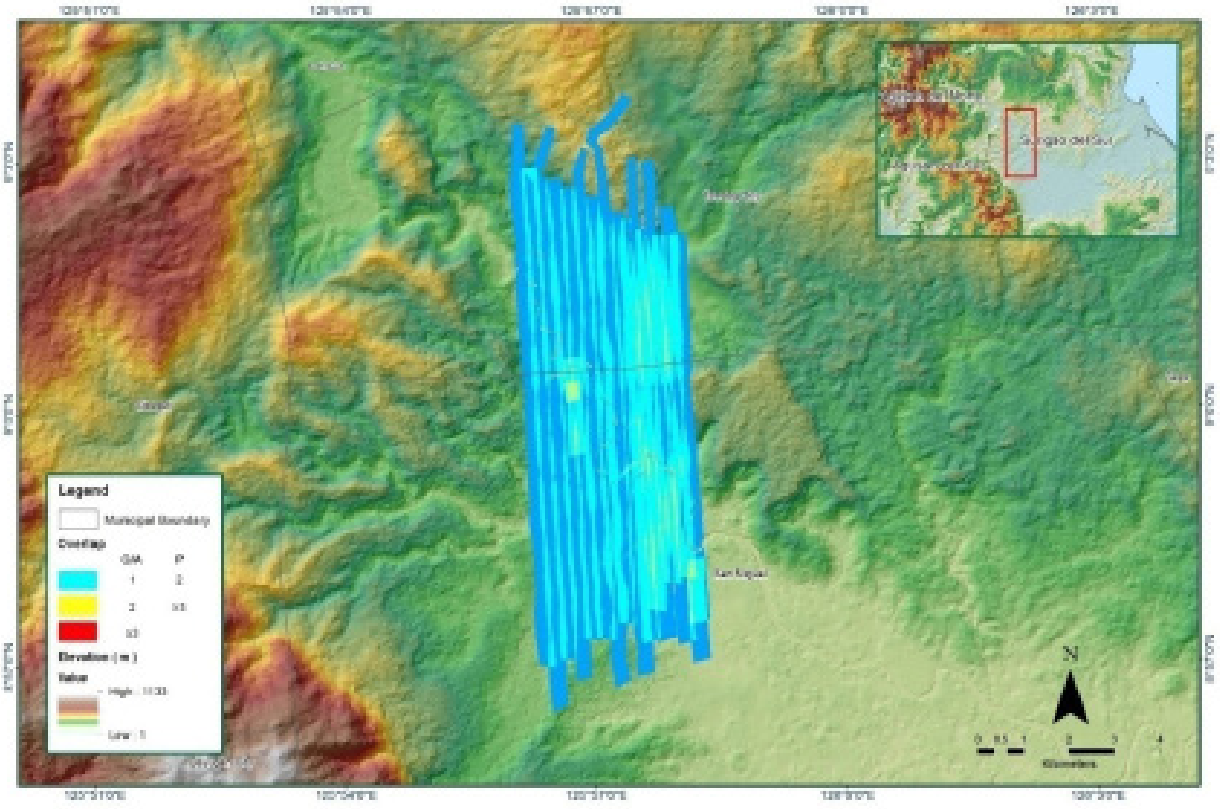


Figure 1.2.5 Image of data overlap

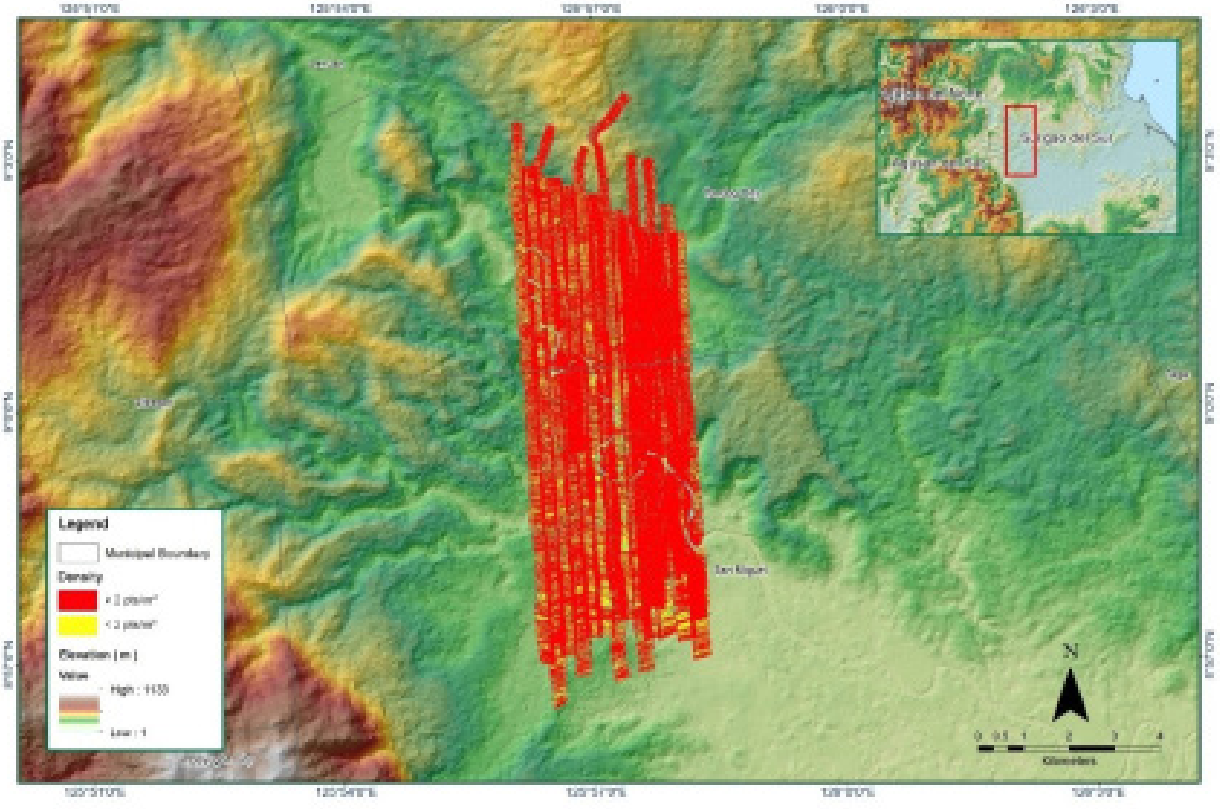


Figure 1.2.6 Density map of merged LiDAR data

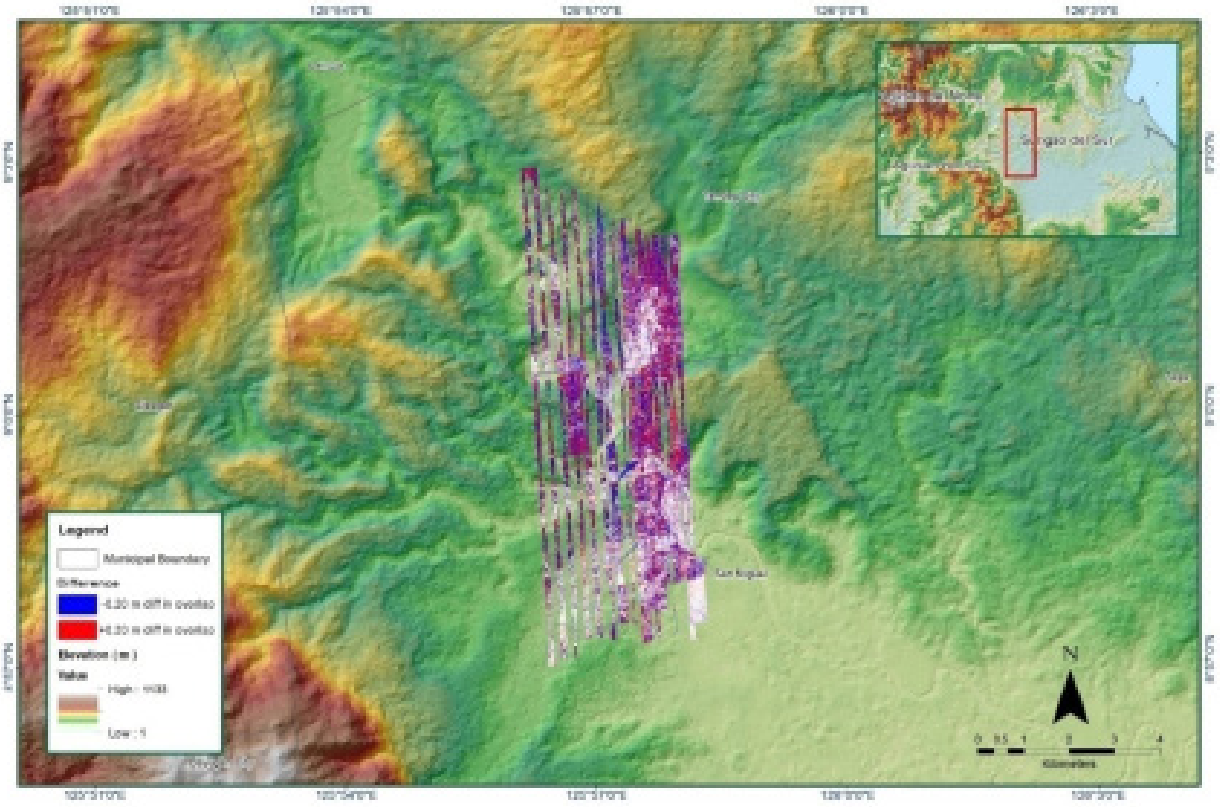


Figure 1.2.7Elevation difference between flight lines

Flight Area	Tandag (Surigao Del Sur)
Mission Name	Block 61K
Inclusive Flights	1742A, 1754A, & 1758A
Range data size	27.35 GB
Base data size	26.59 MB
POS	702 MB
Image	64.90 MB
Transfer date	August 14, 2014 & September 1, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	2.00
RMSE for East Position (<4.0 cm)	2.10
RMSE for Down Position (<8.0 cm)	3.70
Boresight correction stdev (<0.001deg)	0.001028
IMU attitude correction stdev (<0.001deg)	0.004358
GPS position stdev (<0.01m)	0.0161
Minimum % overlap (>25)	64.37
Ave point cloud density per sq.m. (>2.0)	4.88
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	50
Maximum Height	447.32 m
Minimum Height	97.17 m
Classification (# of points)	
Ground	5,072,096
Low vegetation	4,688,992
Medium vegetation	14,976,239
High vegetation	102,601,104
Building	2,821,828
Orthophoto	Yes
Processed by	Engr. Jommer Medina, Engr. Mark Joshua Salvacion, Engr. Melissa Fernandez

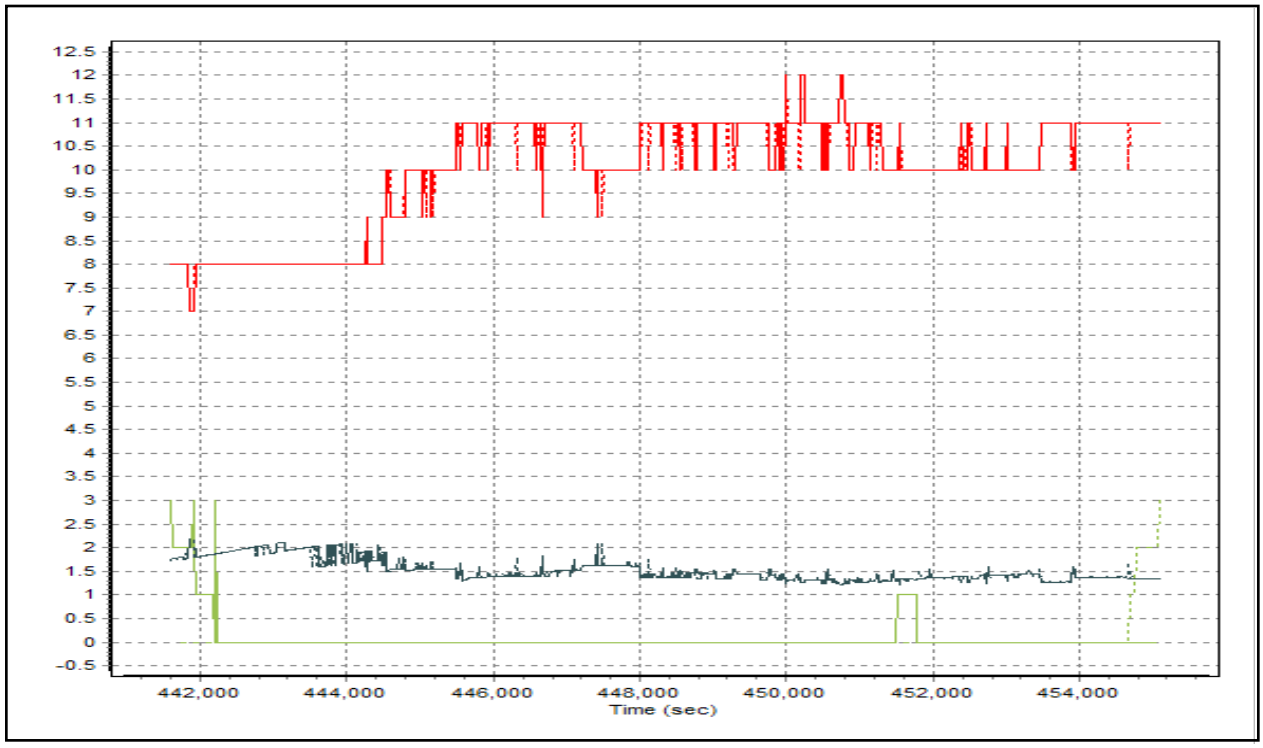


Figure 1.3.1 Solution Status

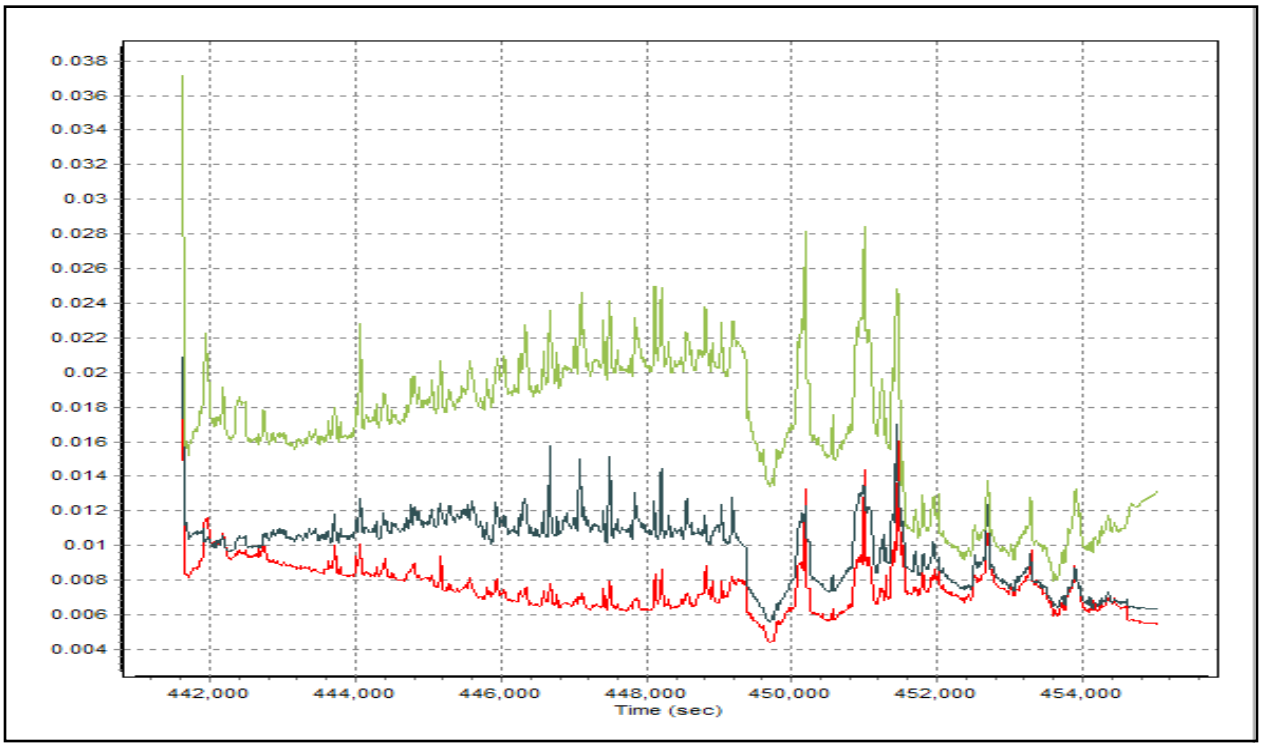


Figure 1.3.2 Smoothed Performance Metric Parameters

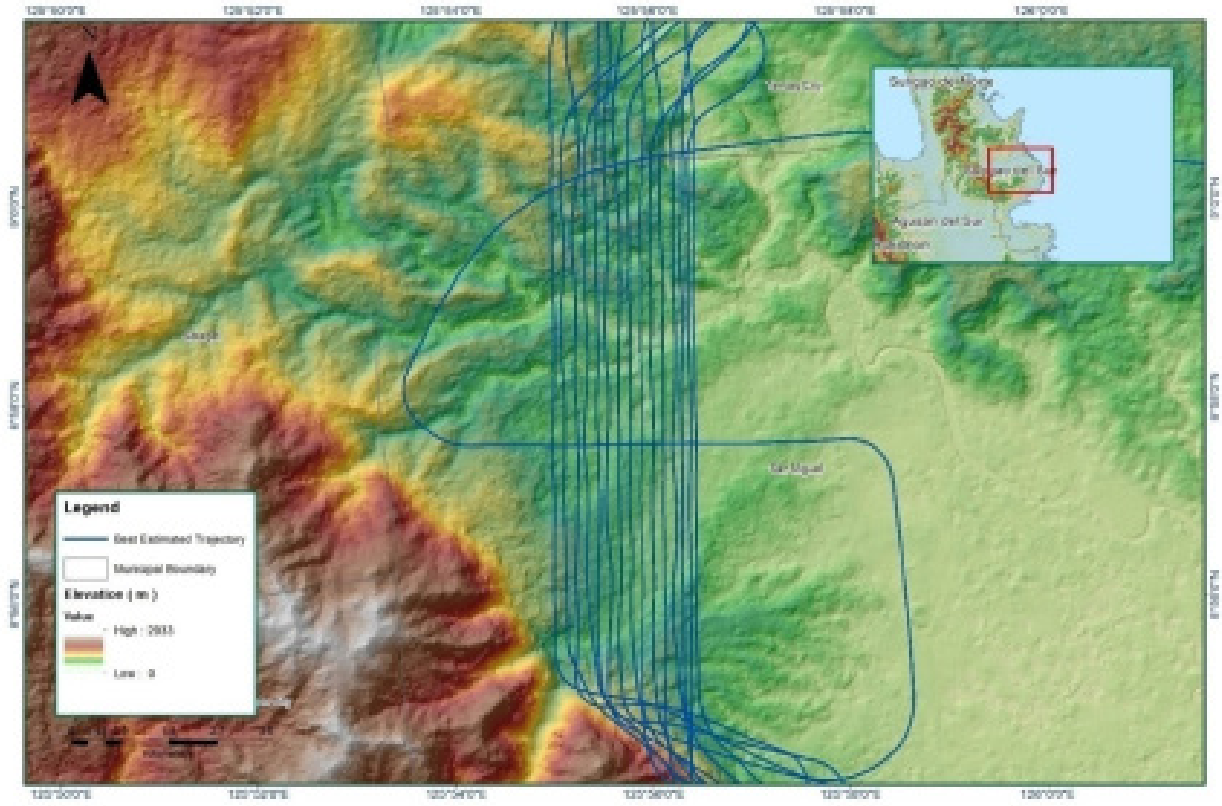


Figure 1.3.3 Best Estimated Trajectory

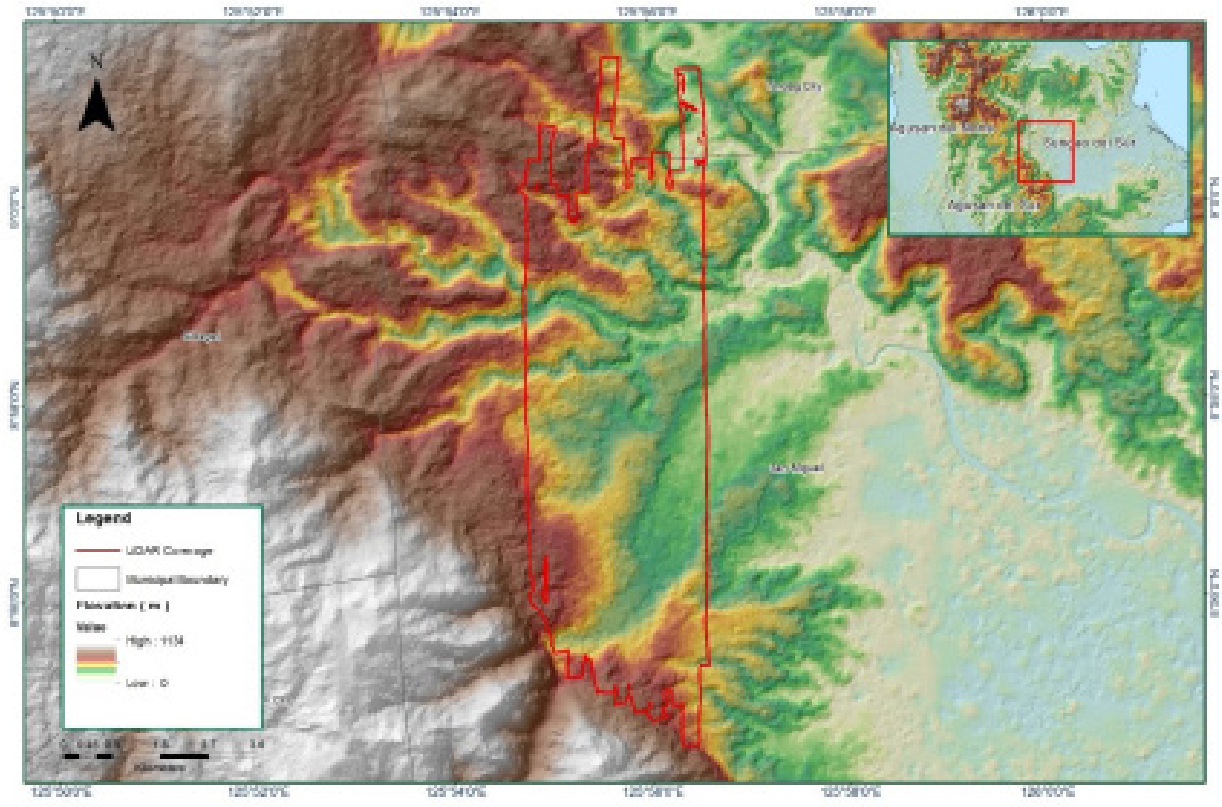


Figure 1.3.4 Coverage of LiDAR data

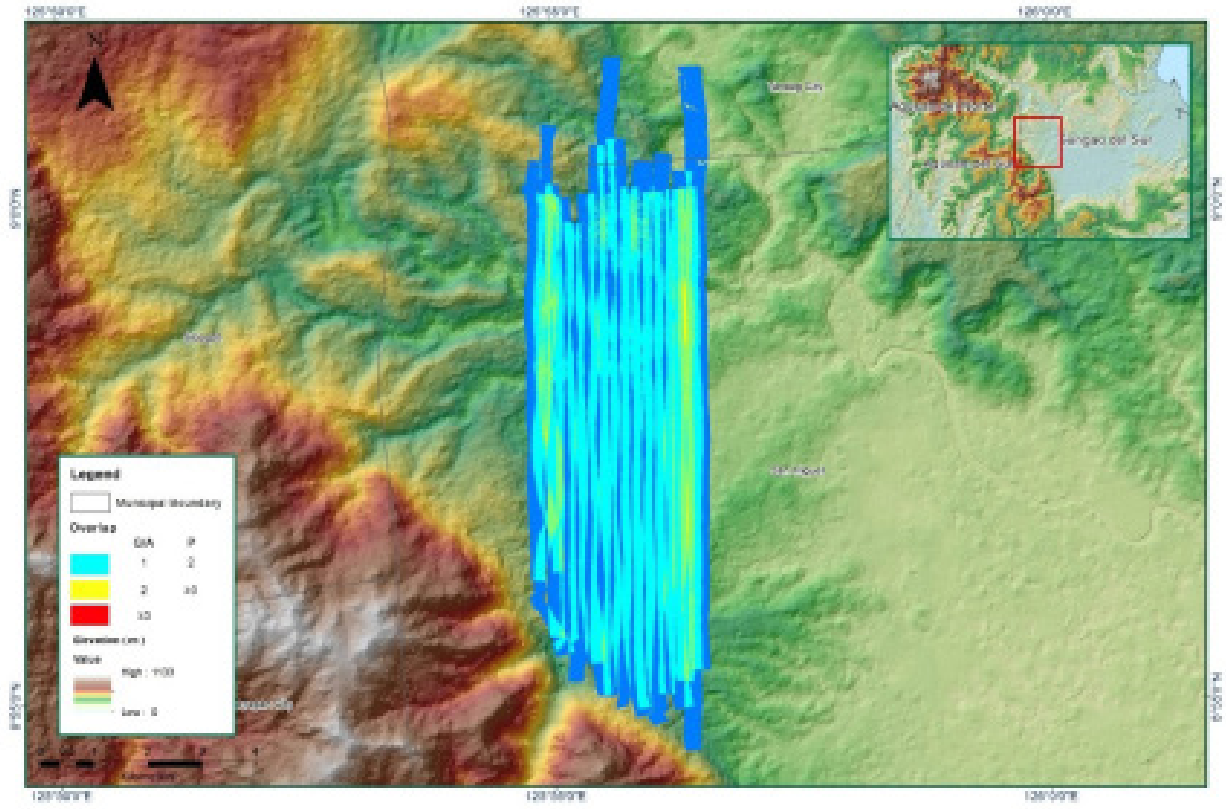


Figure 1.3.5 Image of data overlap

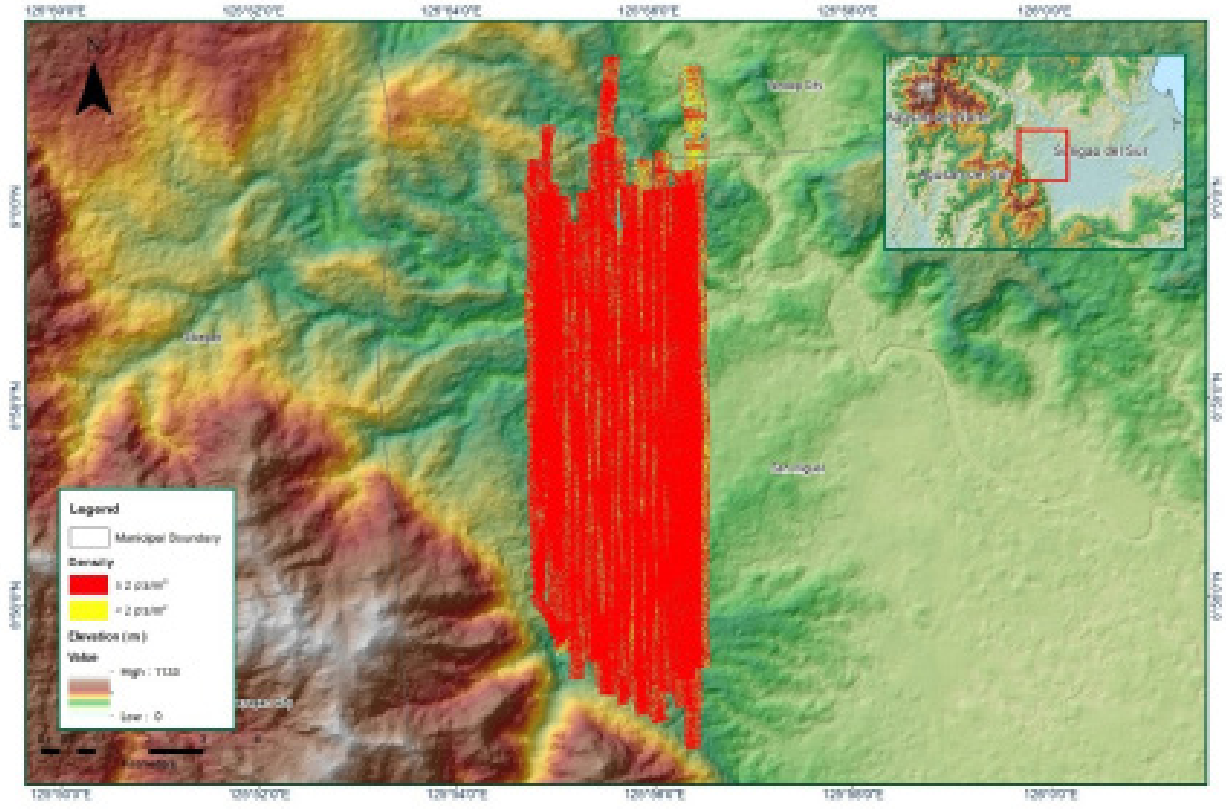


Figure 1.3.6 Density map of merged LiDAR data

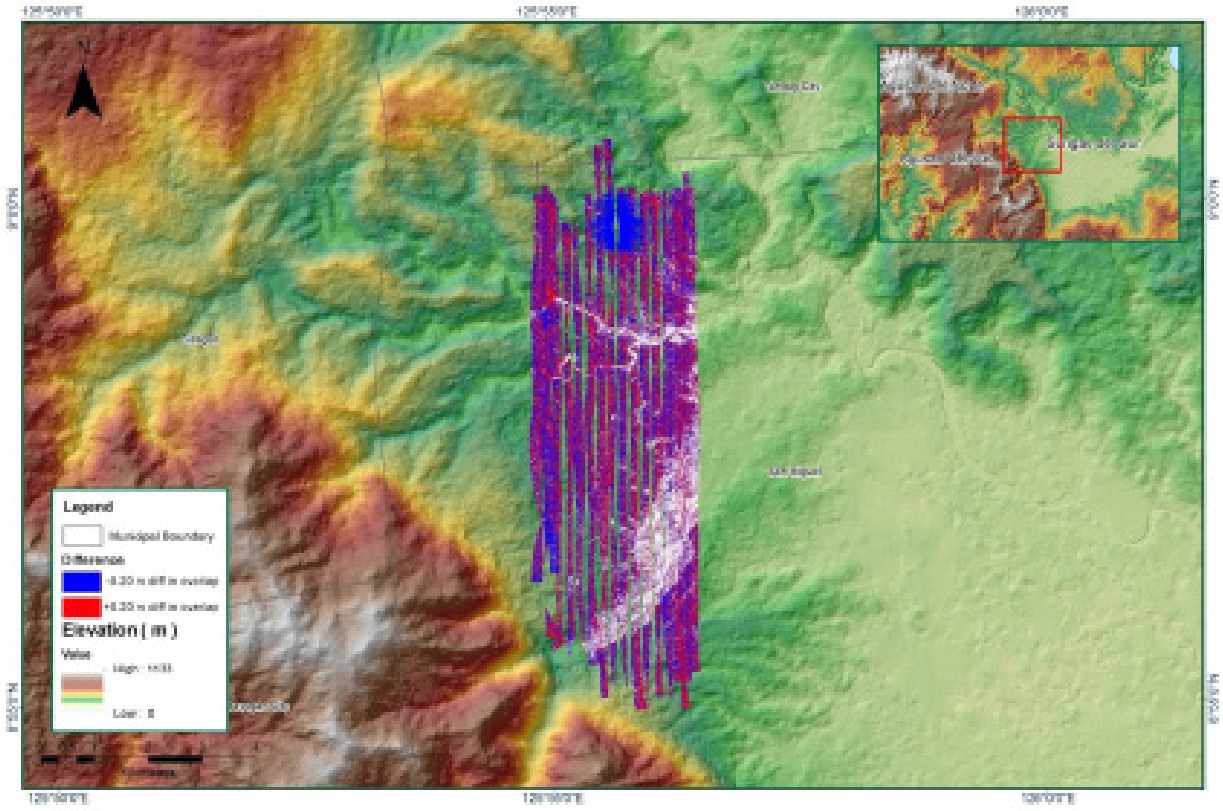


Figure 1.3.7 Elevation difference between flight lines

Flight Area	Tandag (Surigao Del Sur)
Mission Name	Block 61I
Inclusive Flights	1690A
Range data size	12.70 GB
Base data size	9.69 MB
POS	271 MB
Image	15.70 MB
Transfer date	September 1, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	2.22
RMSE for East Position (<4.0 cm)	2.60
RMSE for Down Position (<8.0 cm)	6.80
Boresight correction stdev (<0.001deg)	0.000944
IMU attitude correction stdev (<0.001deg)	0.114061
GPS position stdev (<0.01m)	0.0153
Minimum % overlap (>25)	66.66
Ave point cloud density per sq.m. (>2.0)	5.02
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	61
Maximum Height	351.14 m
Minimum Height	80.36 m
Classification (# of points)	
Ground	8,766,089
Low vegetation	11,046,424
Medium vegetation	17,620,937
High vegetation	102,989,150
Building	3,722,988
Orthophoto	No
Processed by	Engr. Kenneth Solidum, Engr. Antonio Chua, Jr., Jovy Narisma

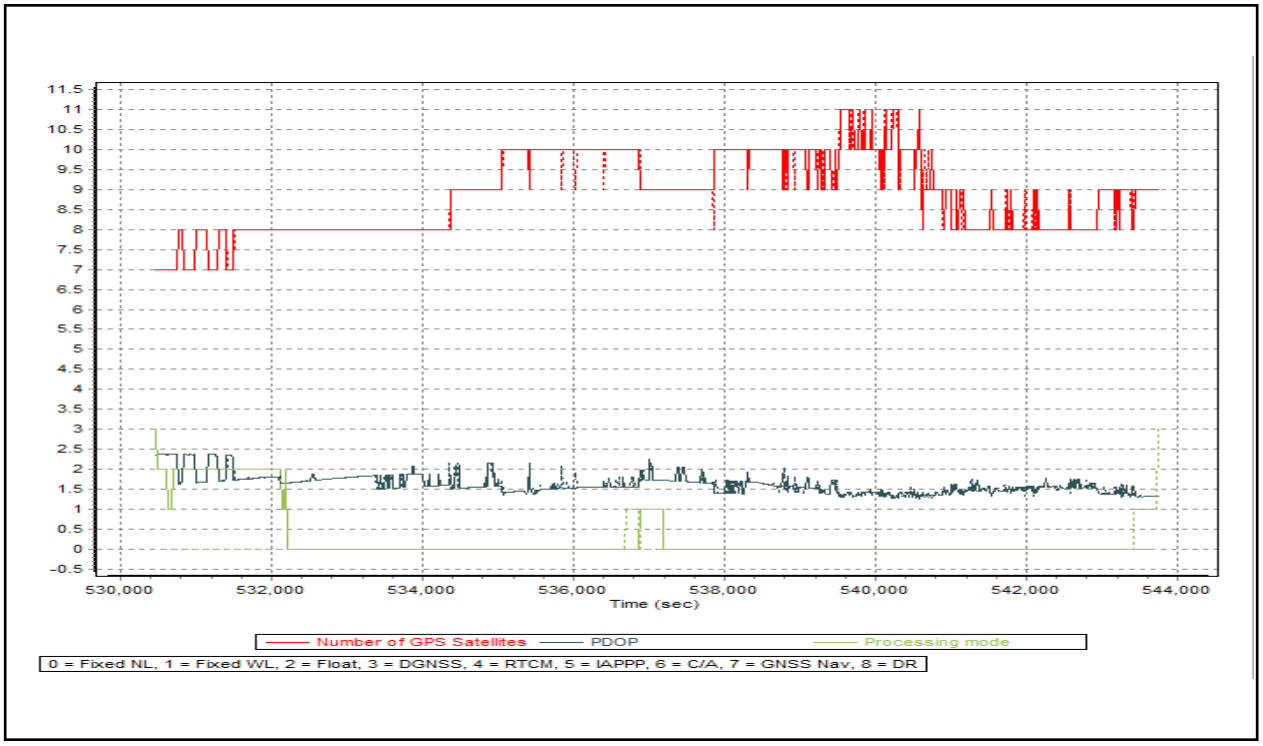


Figure 1.4.1 Solution Status

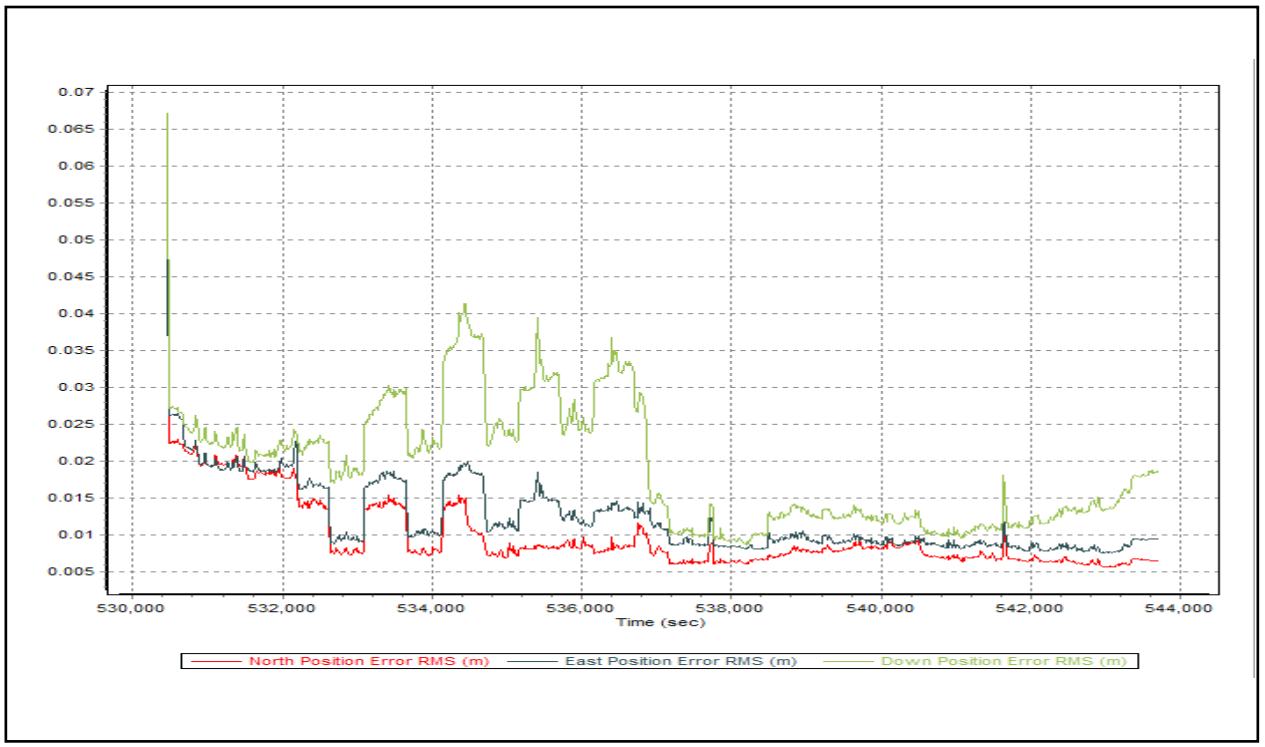


Figure 1.4.2 Smoothed Performance Metric Parameters

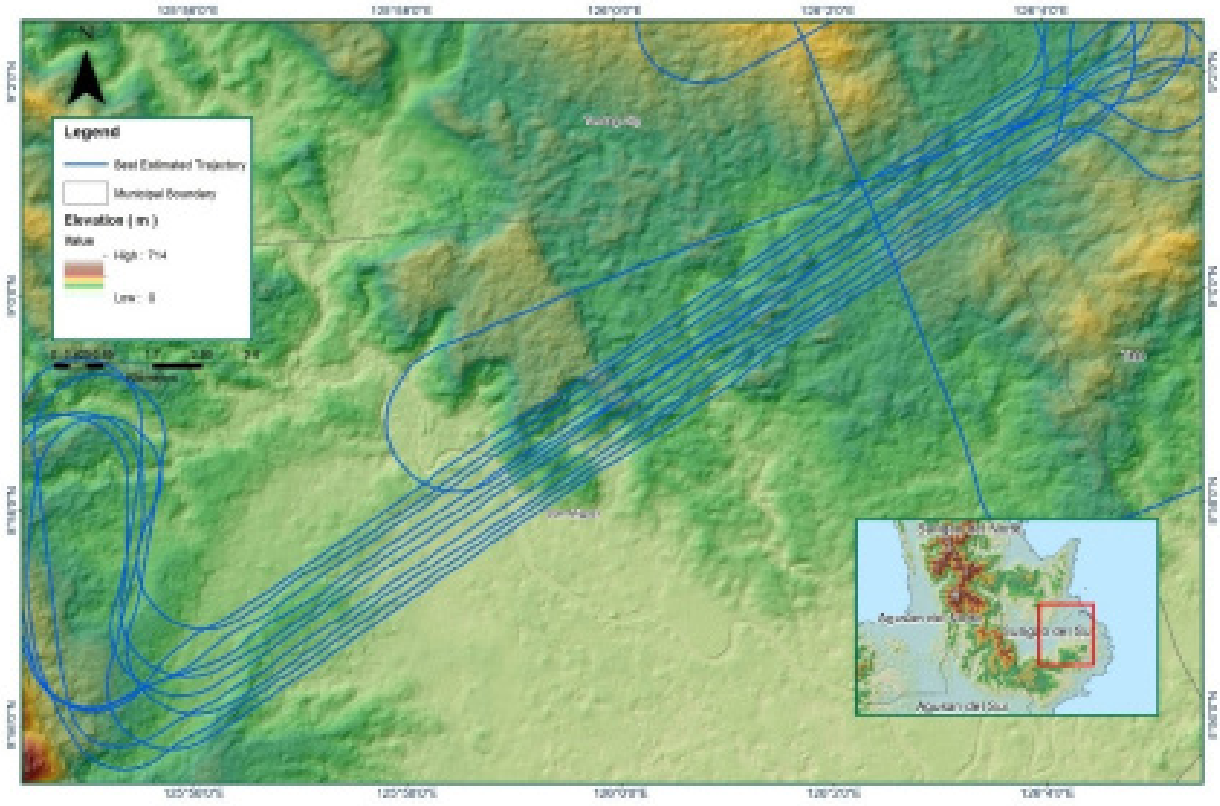


Figure 1.4.3 Best Estimated Trajectory

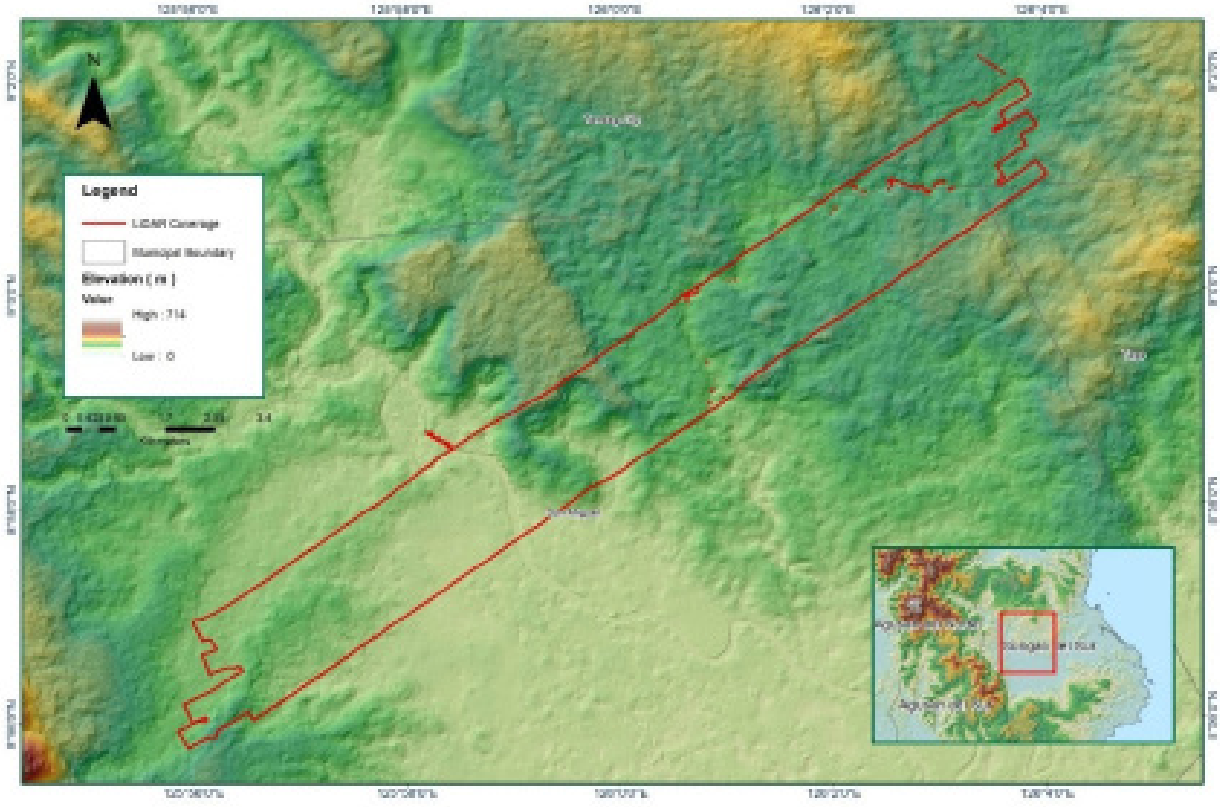


Figure 1.4.4 Coverage of LiDAR data

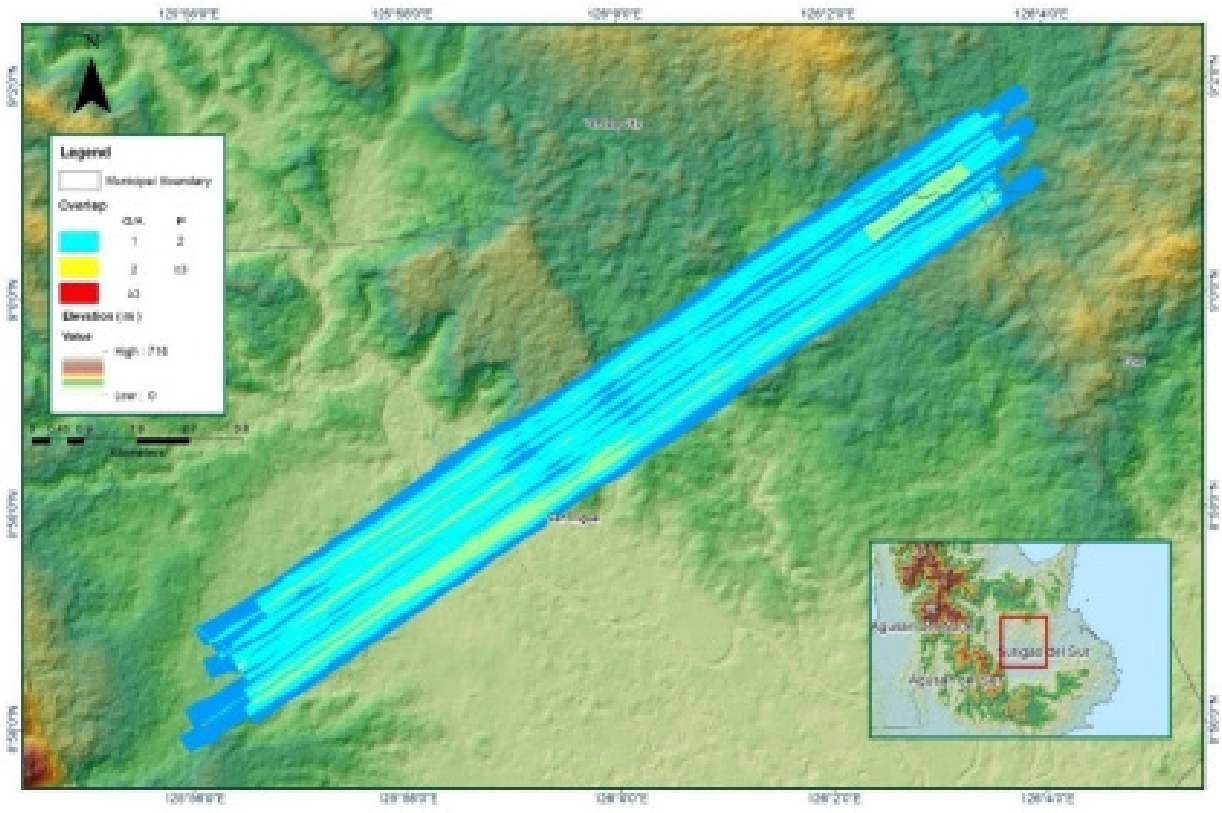


Figure 1.4.5 Image of data overlap

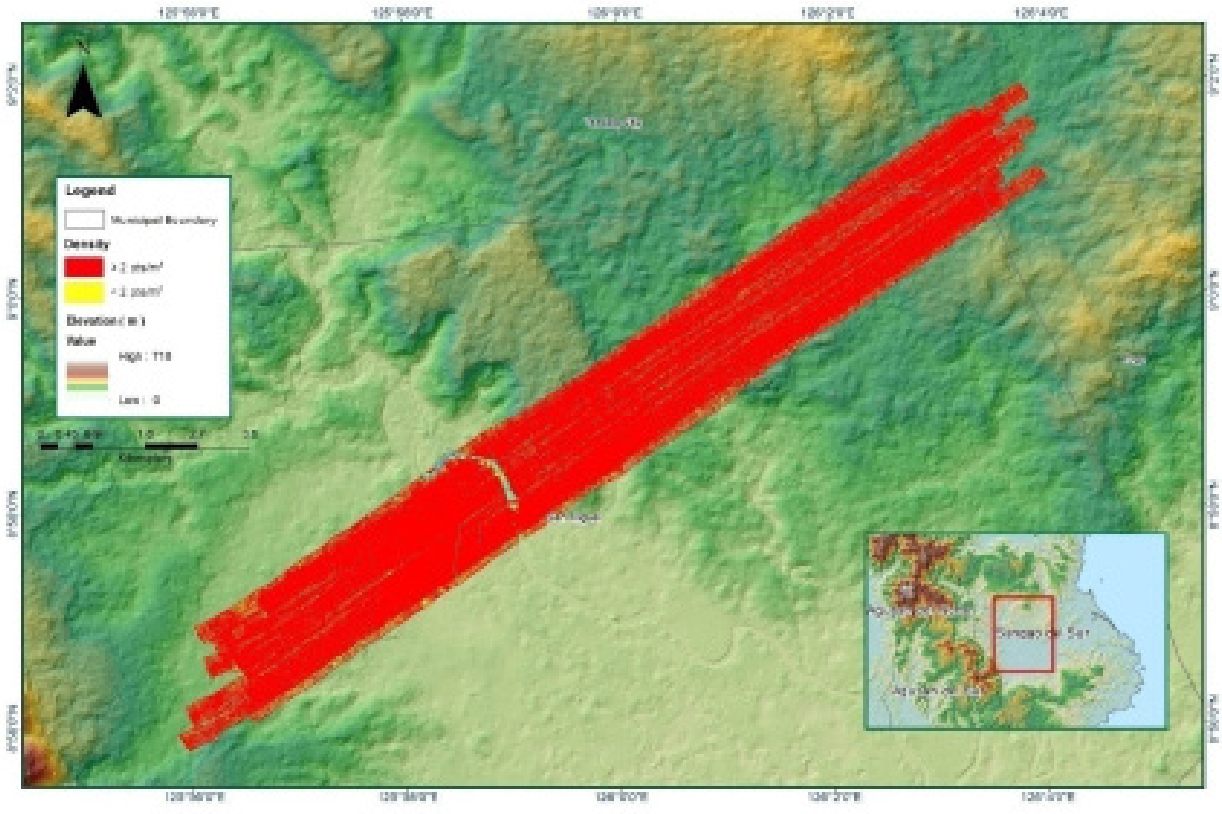


Figure 1.4.6 Density map of merged LiDAR data

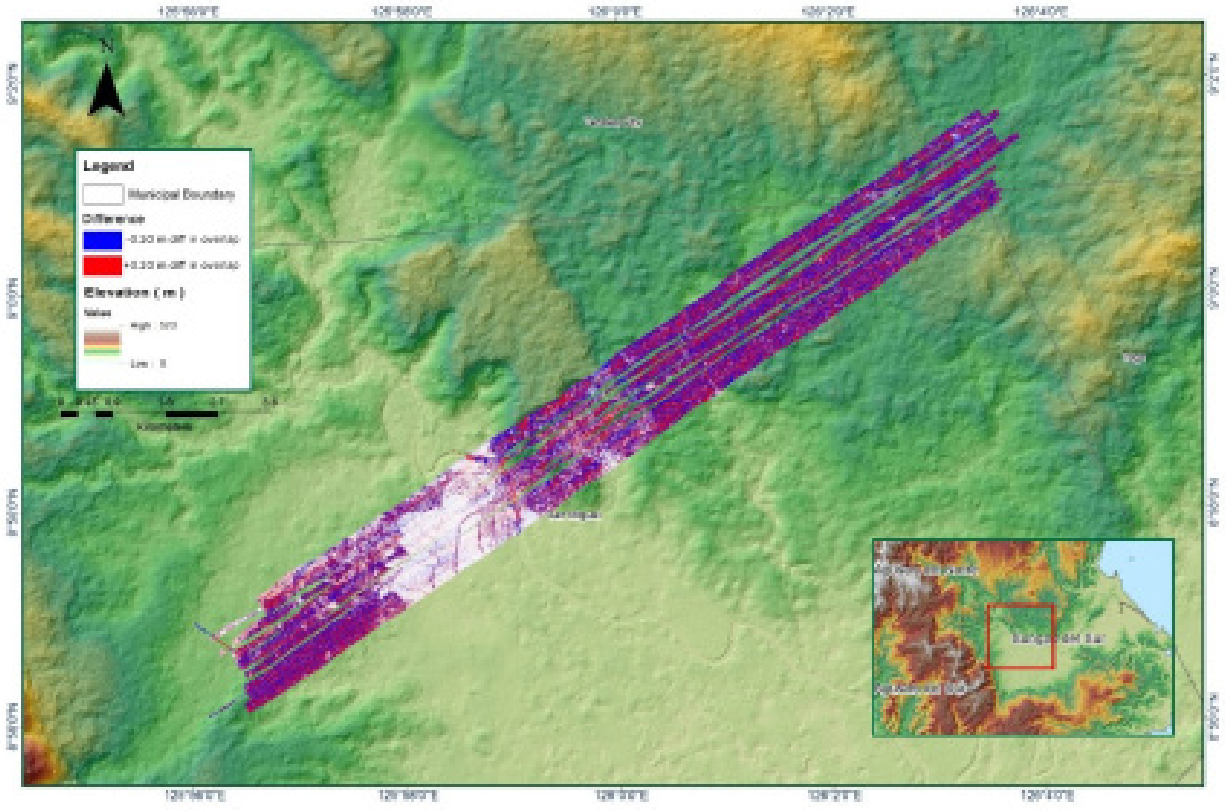


Figure 1.4.7 Elevation difference between flight lines

Flight Area	Tandag (Surigao Del Sur)
Mission Name	Block 61H
Inclusive Flights	1686A
Range data size	12.90 GB
Base data size	8.12 MB
POS	266 MB
Image	73 MB
Transfer date	August 5, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.80
RMSE for East Position (<4.0 cm)	1.95
RMSE for Down Position (<8.0 cm)	3.40
Boresight correction stdev (<0.001deg)	0.000693
IMU attitude correction stdev (<0.001deg)	0.004578
GPS position stdev (<0.01m)	0.0101
Minimum % overlap (>25)	51.56
Ave point cloud density per sq.m. (>2.0)	3.97
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	109
Maximum Height	454.91 m
Minimum Height	66.4 m
Classification (# of points)	
Ground	20,914,420
Low vegetation	31,446,222
Medium vegetation	36,113,880
High vegetation	137,965,847
Building	2,326,691
Orthophoto	YES
Processed by	Engr. Carlyn Ibañez, Engr. Christy Lubiano, Engr. Melissa Fernandez

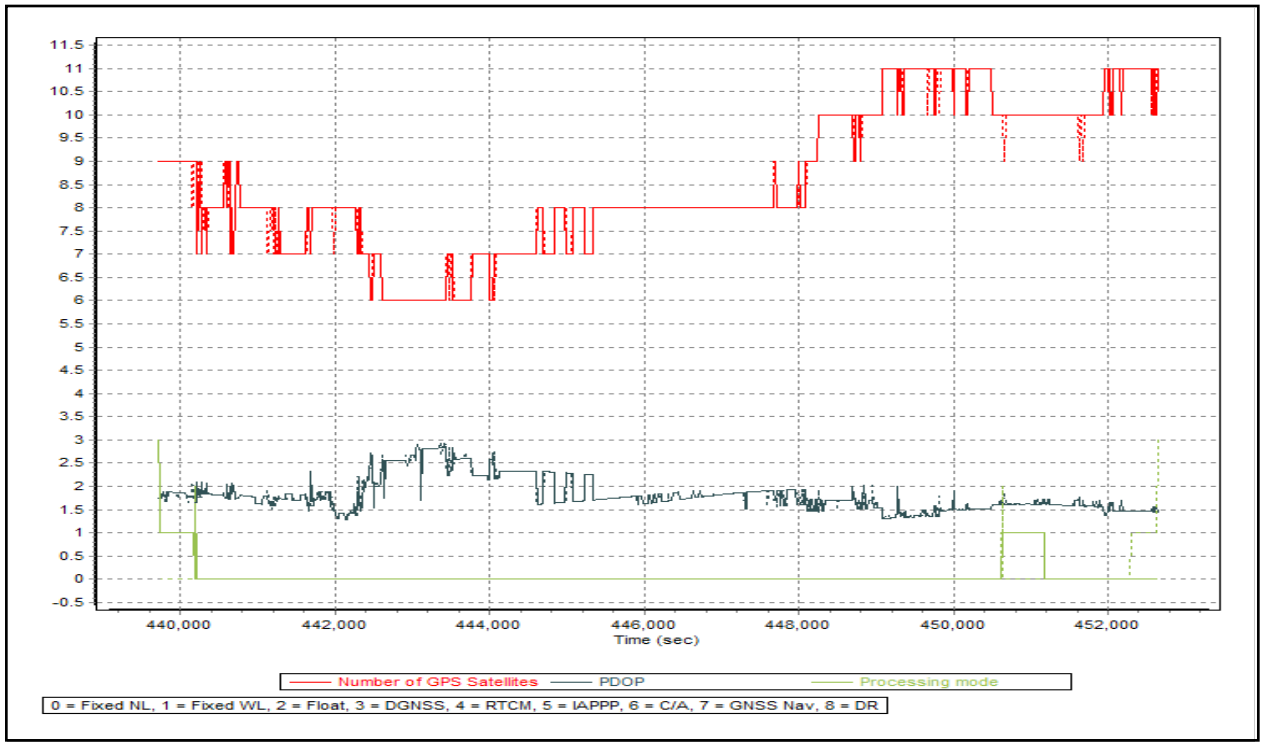


Figure 1.5.1 Solution Status

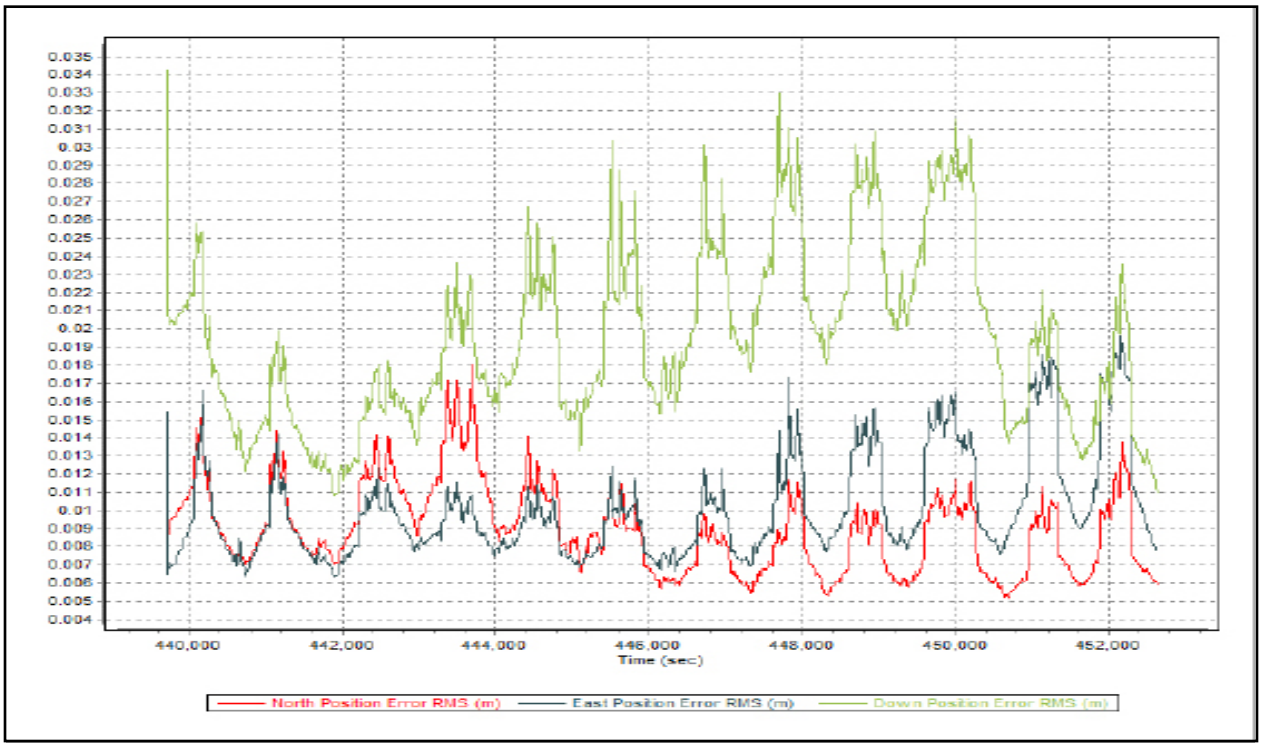


Figure 1.5.2 Smoothed Performance Metric Parameters

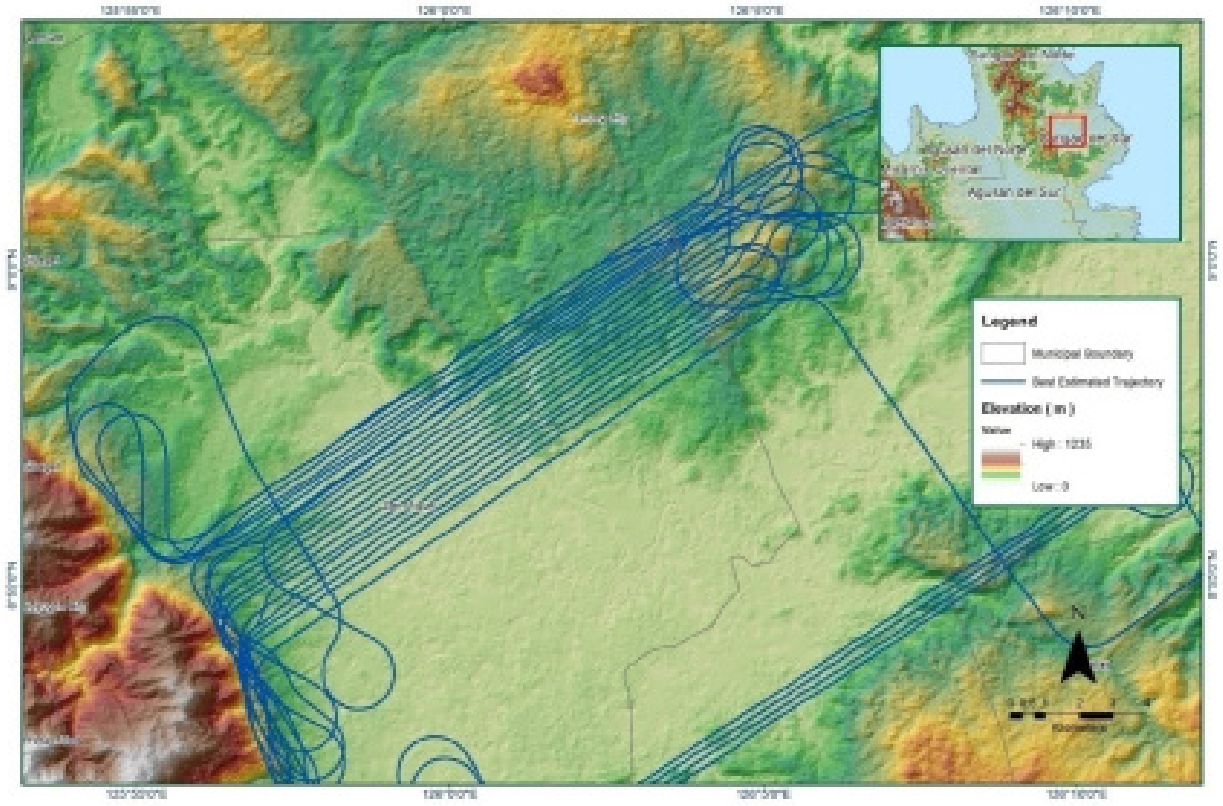


Figure 1.5.3 Best Estimated Trajectory

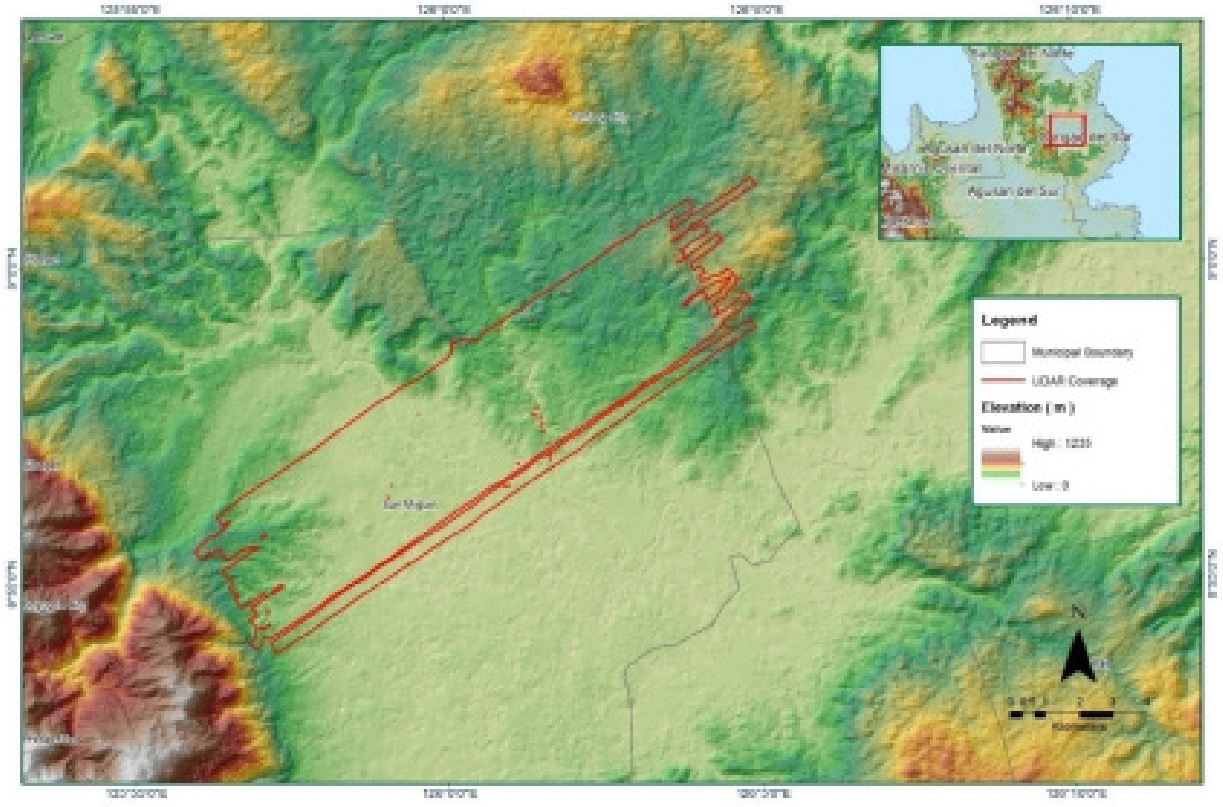


Figure 1.5.4 Coverage of LiDAR data

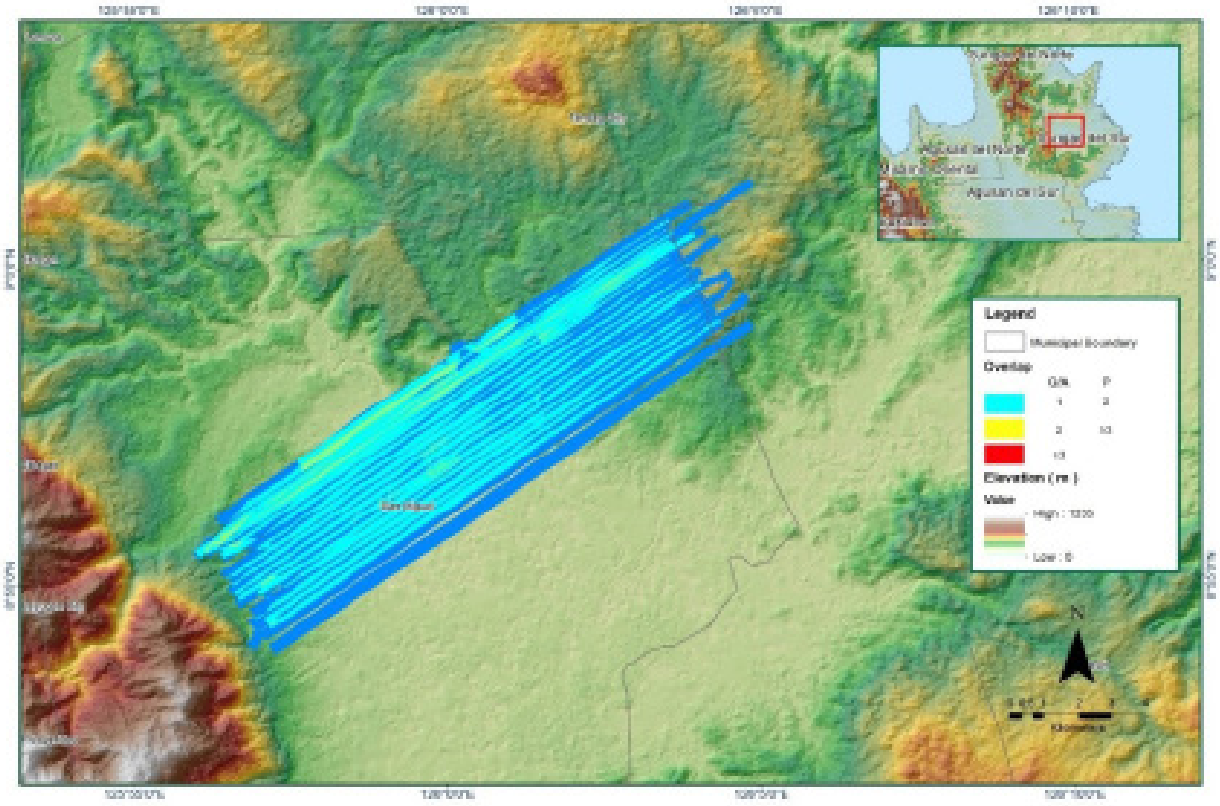


Figure 1.5.5 Image of data overlap

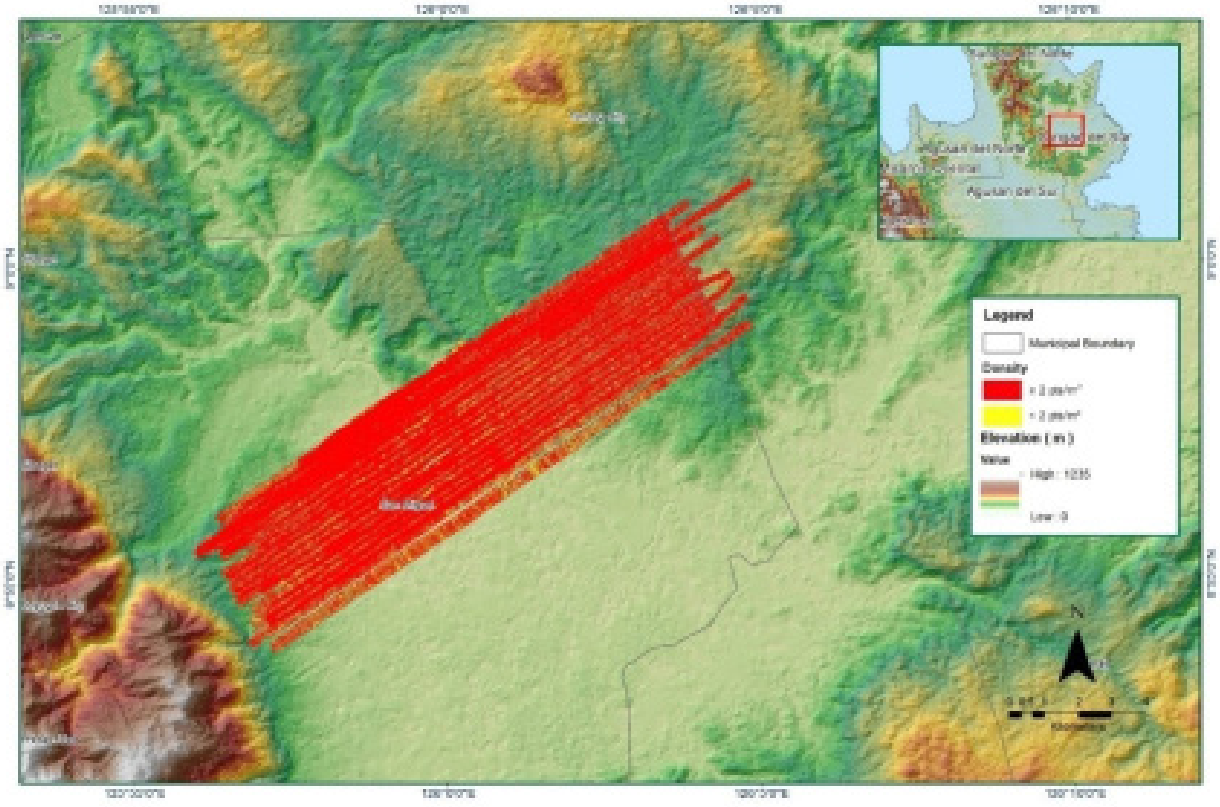


Figure 1.5.6 Density map of merged LiDAR data

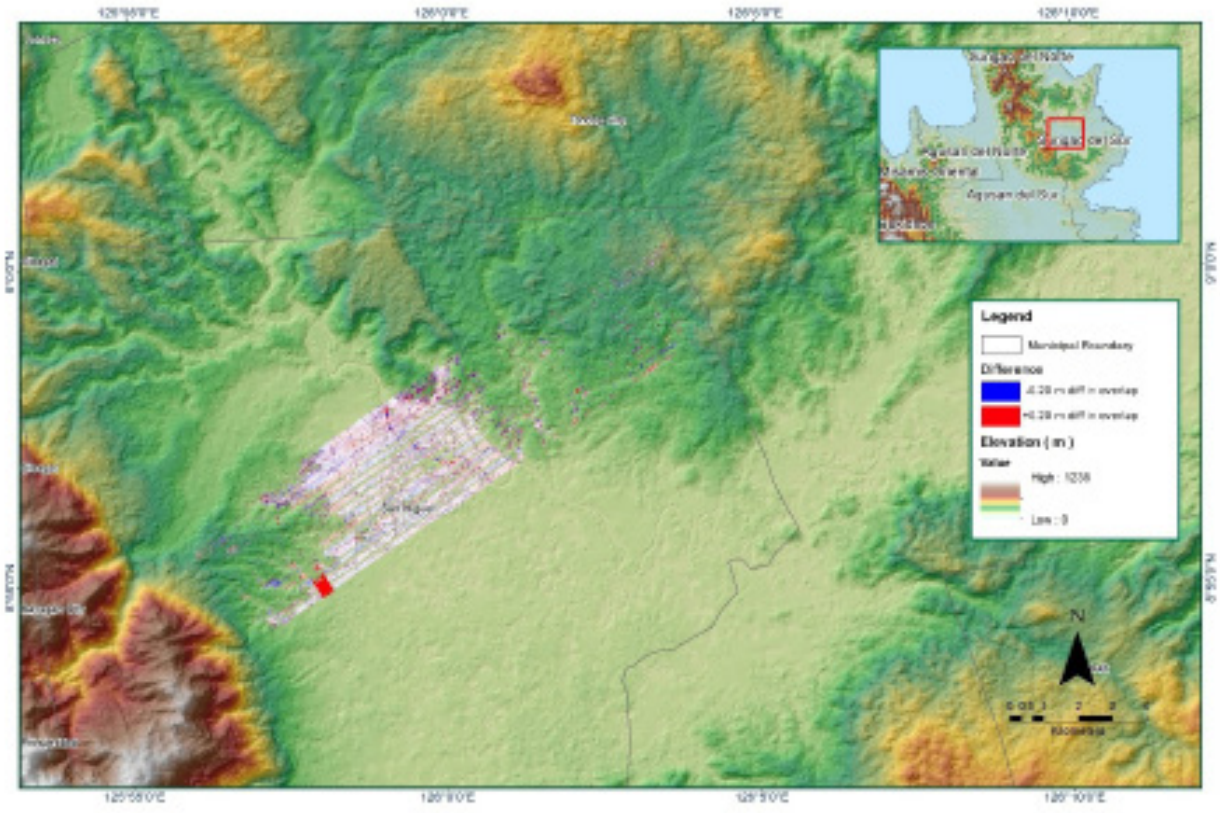


Figure 1.5.7 Elevation difference between flight lines

Flight Area	Tandag (Surigao Del Sur)
Mission Name	Block 61H Additional
Inclusive Flights	1758A
Range data size	12.70 GB
Base data size	8.76 MB
POS	271 MB
Image	15.70 MB
Transfer date	September 1, 2014
Solution Status	
Number of Satellites (>6)	No
PDOP (<3)	No
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	2.70
RMSE for East Position (<4.0 cm)	2.15
RMSE for Down Position (<8.0 cm)	7.50
Boresight correction stdev (<0.001deg)	0.001222
IMU attitude correction stdev (<0.001deg)	0.004524
GPS position stdev (<0.01m)	0.0138
Minimum % overlap (>25)	51.23
Ave point cloud density per sq.m. (>2.0)	4.24
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	37
Maximum Height	340.16 m
Minimum Height	89.25 m
Classification (# of points)	
Ground	3,798,108
Low vegetation	3,250,606
Medium vegetation	11,774,557
High vegetation	38,510,400
Building	1,107,217
Orthophoto	No
Processed by	Engr. Jennifer Saguran, Engr. Chelou Prado, Engr. Melissa Fernandez

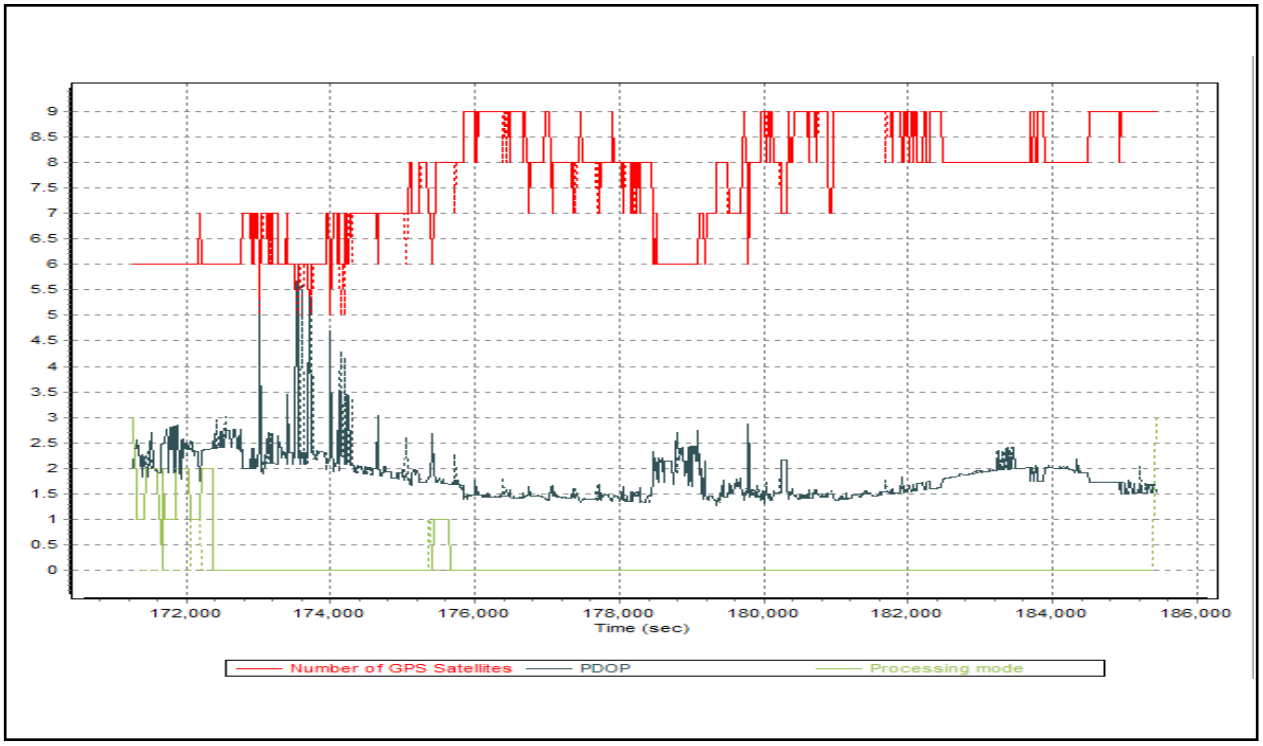


Figure 1.6.1 Solution Status

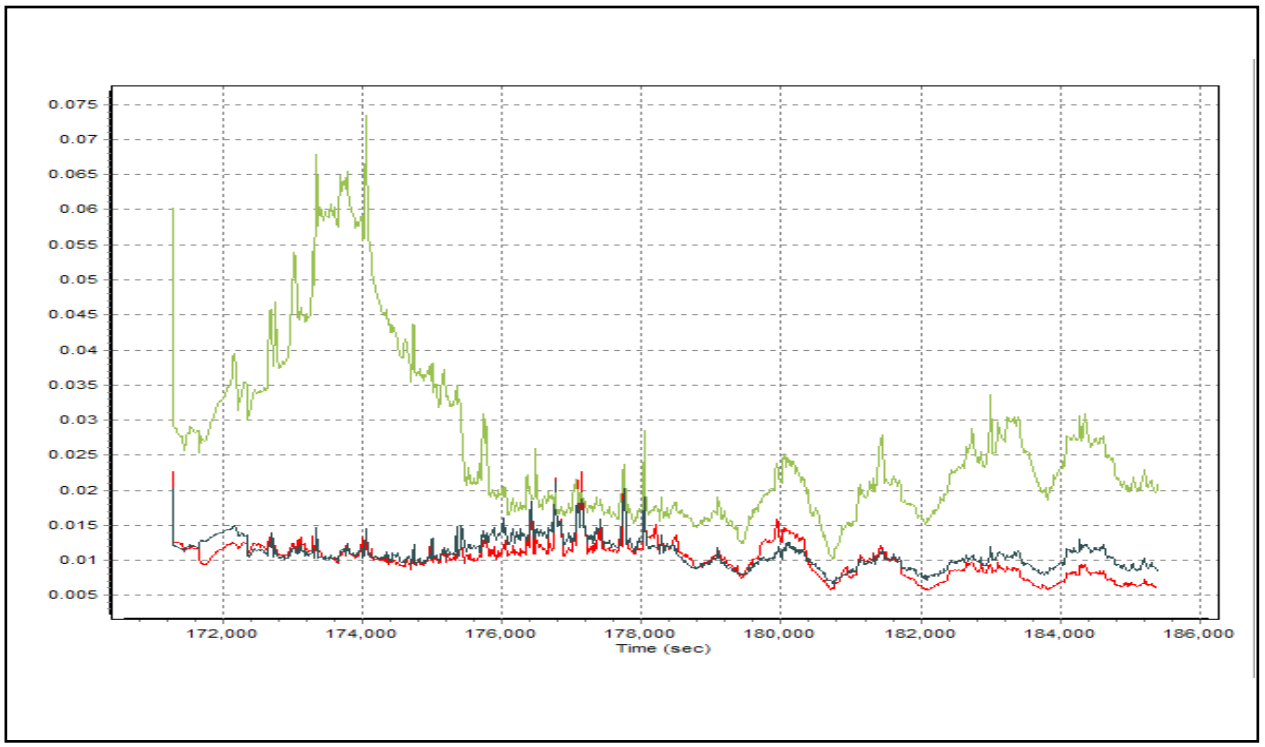


Figure 1.6.2 Smoothed Performance Metric Parameters

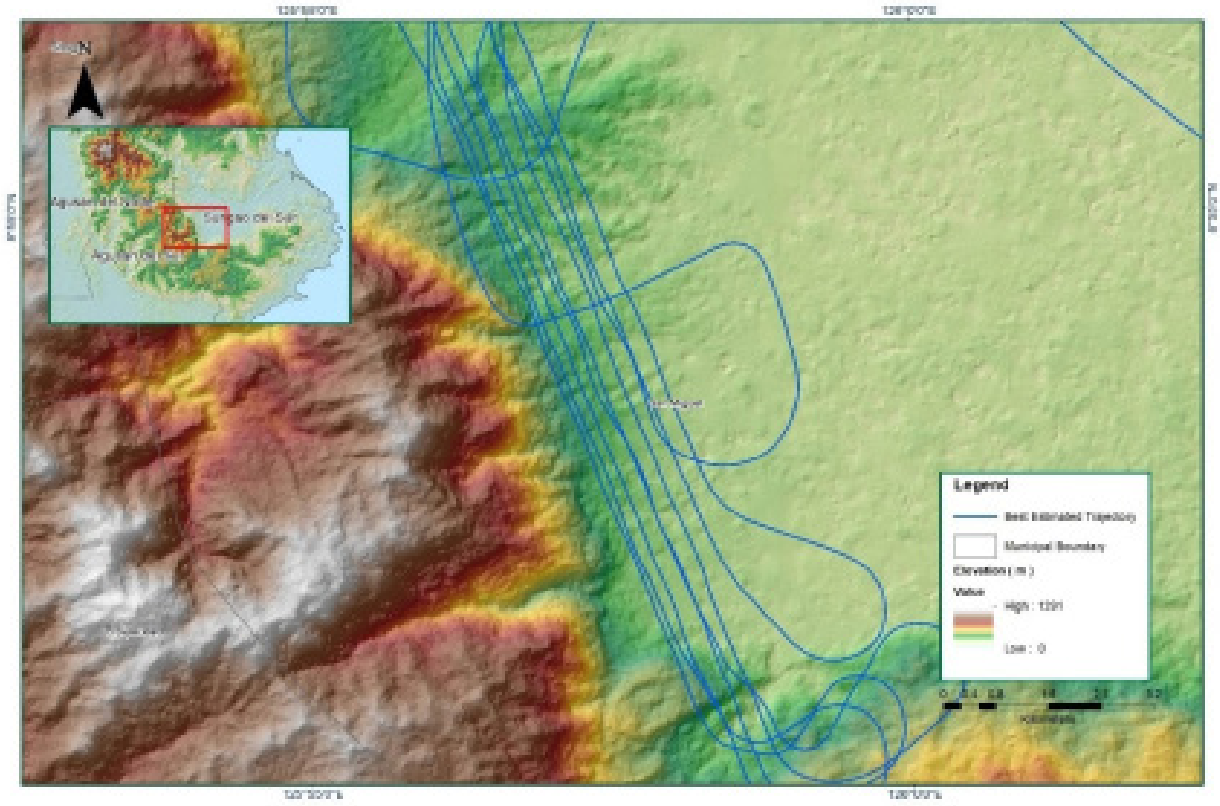


Figure 1.6.3 Best Estimated Trajectory

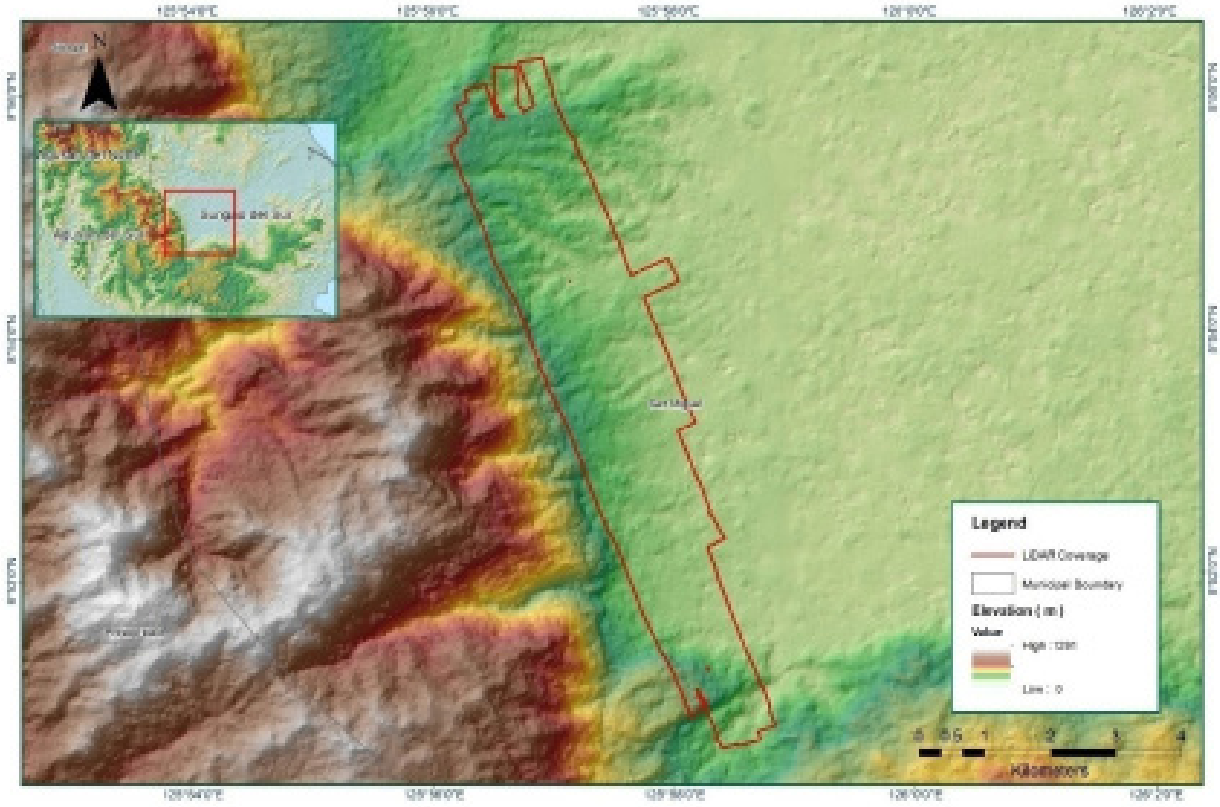


Figure 1.6.4 Coverage of LiDAR data

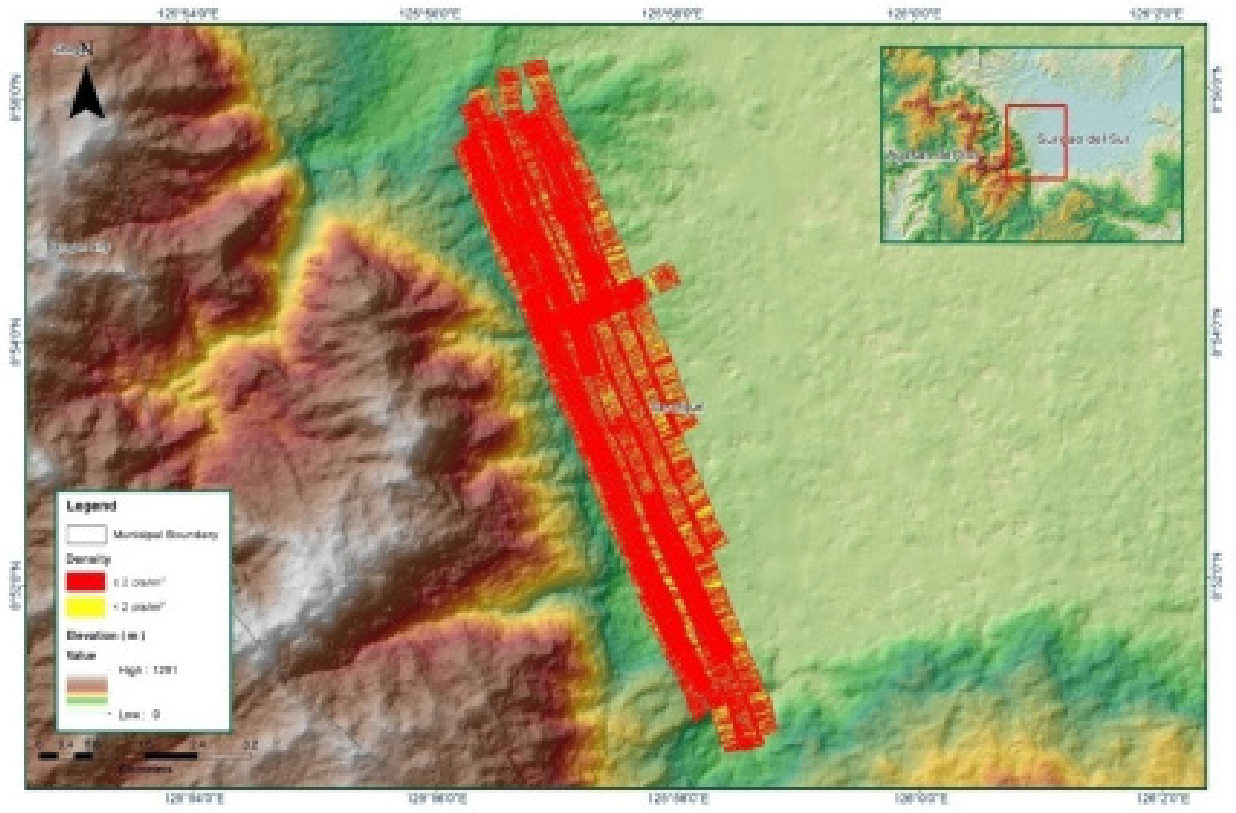


Figure 1.6.5 Image of data overlap

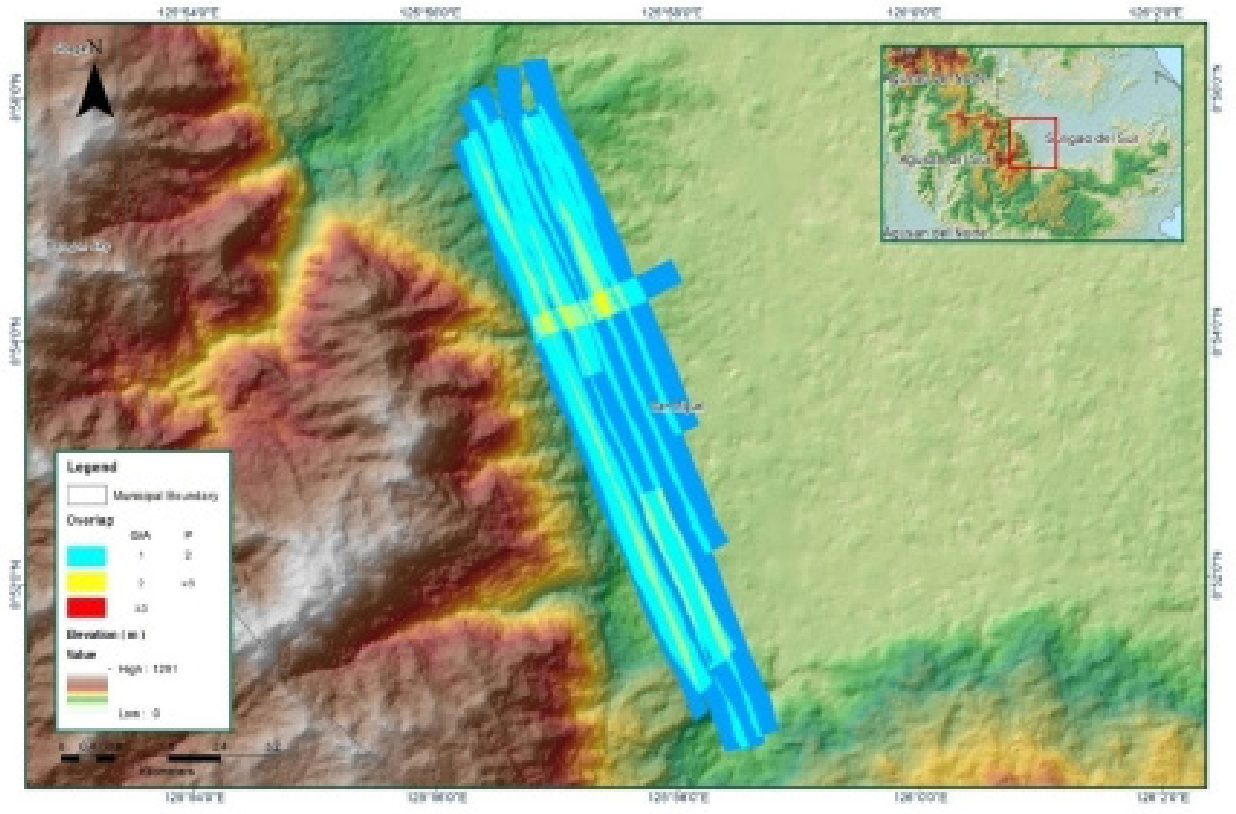


Figure 1.6.6 Density map of merged LiDAR data

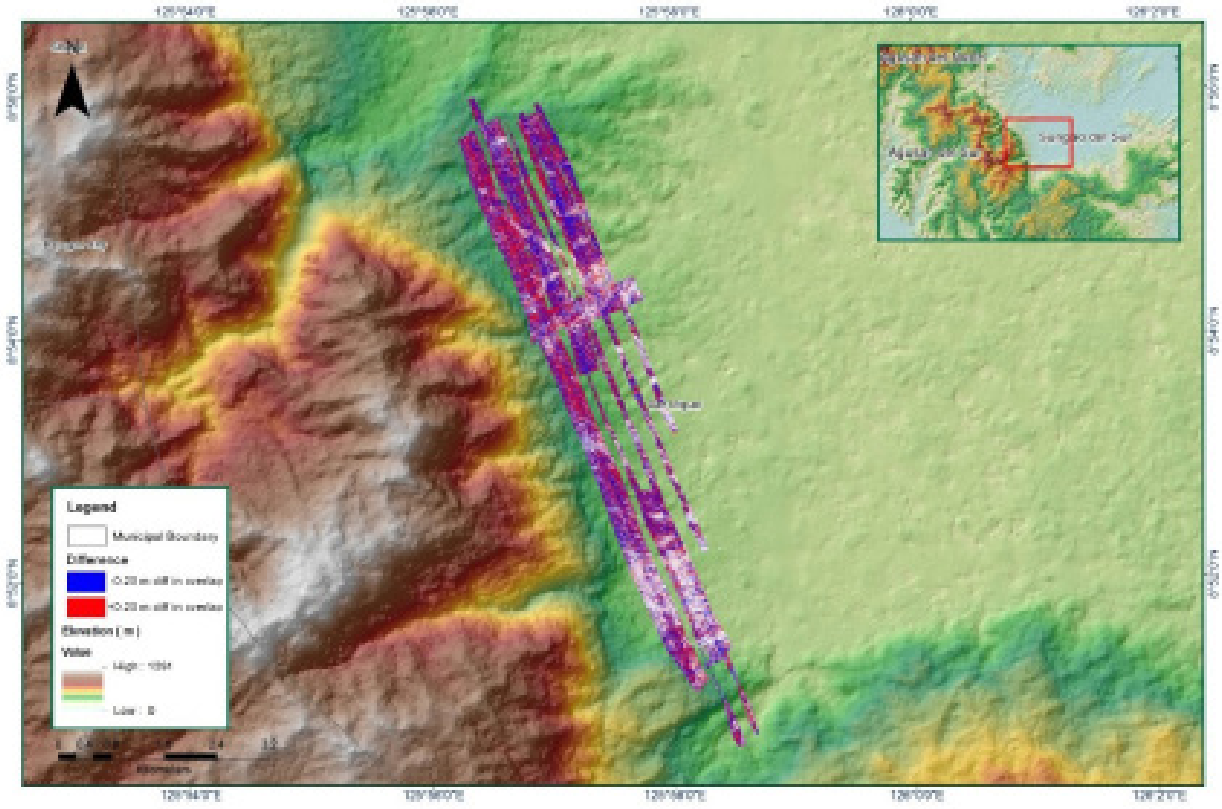


Figure 1.6.7 Elevation difference between flight lines

Flight Area	Tandag (Surigao Del Sur)
Mission Name	Block 61G
Inclusive Flights	1678A
Range data size	13.20 GB
Base data size	8.45 MB
POS	251 MB
Image	46.30 MB
Transfer date	July 23, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.50
RMSE for East Position (<4.0 cm)	1.70
RMSE for Down Position (<8.0 cm)	3.60
Boresight correction stdev (<0.001deg)	0.000641
IMU attitude correction stdev (<0.001deg)	0.012275
GPS position stdev (<0.01m)	0.0166
Minimum % overlap (>25)	63.31
Ave point cloud density per sq.m. (>2.0)	3.70
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	106
Maximum Height	482.93 m
Minimum Height	72.18 m
Classification (# of points)	
Ground	26,970,703
Low vegetation	42,800,536
Medium vegetation	52,653,788
High vegetation	82,256,262
Building	3,409,452
Orthophoto	YES
Processed by	Engr. Jommer Medina, Engr. Harmond Santos, Engr. John Dill Macapagal

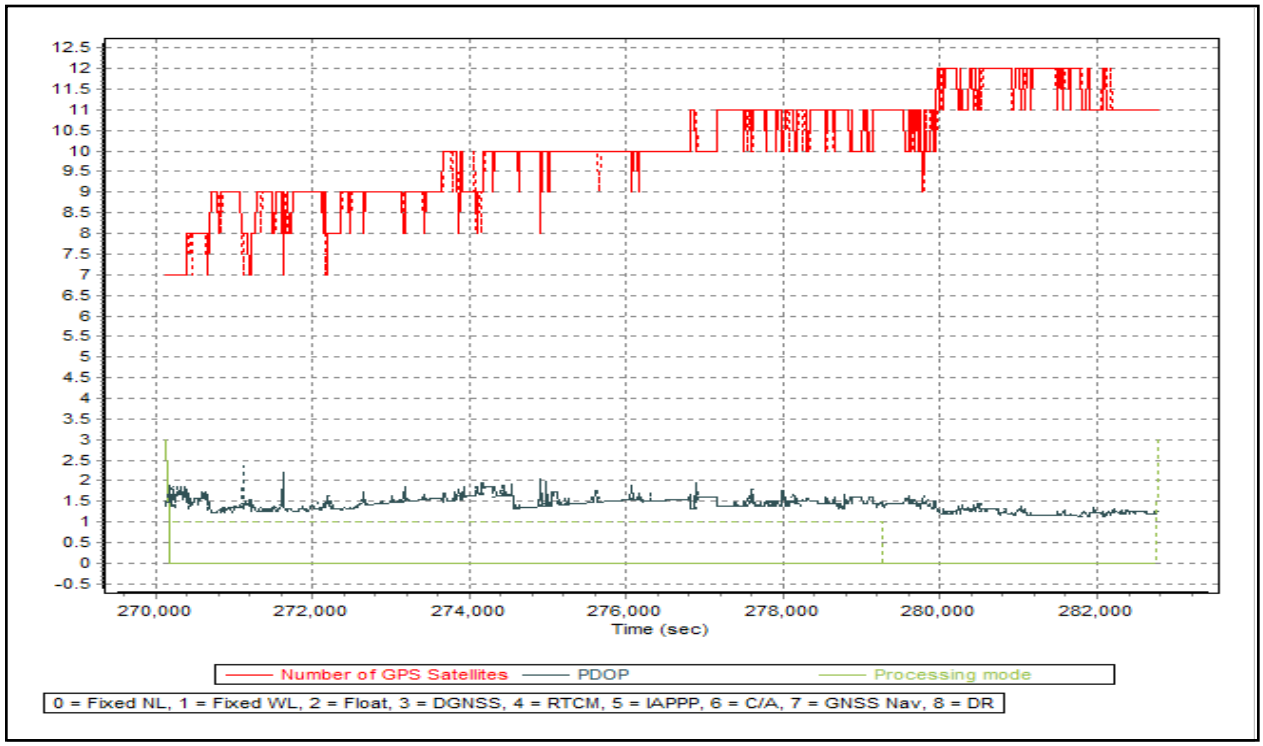


Figure 1.7.1 Solution Status

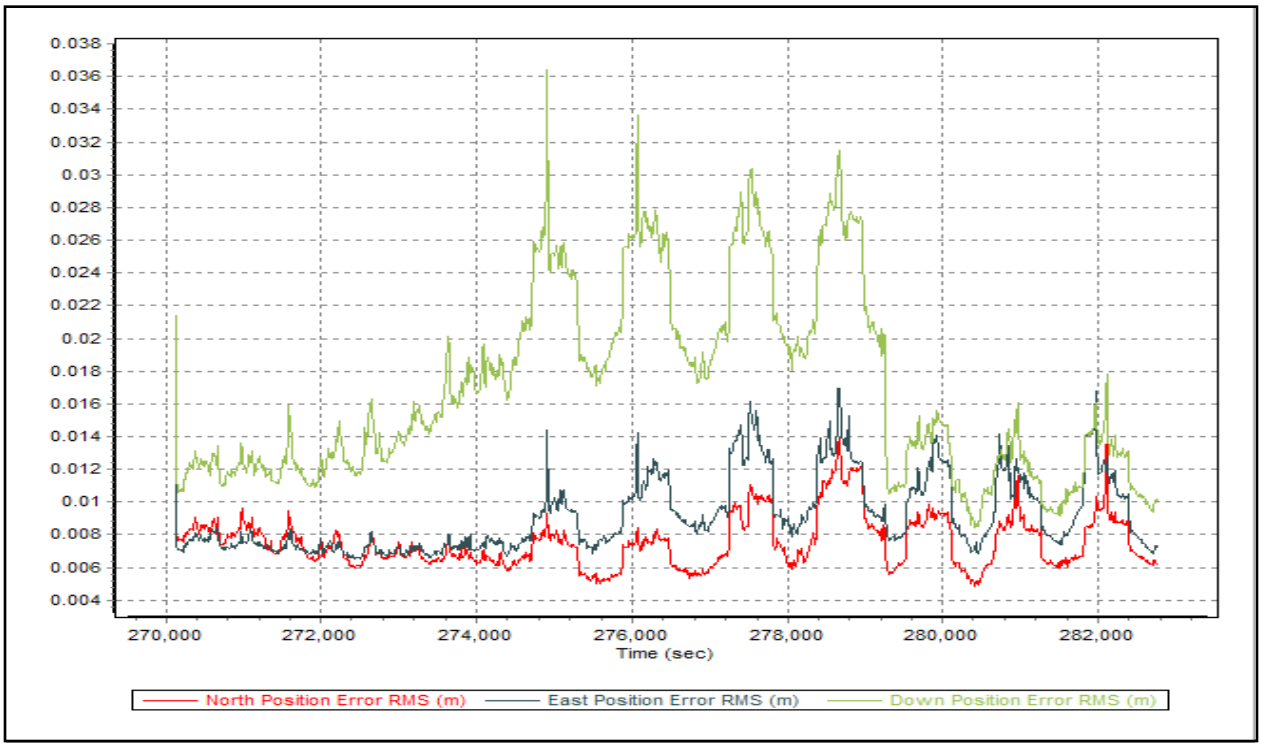


Figure 1.7.2 Smoothed Performance Metric Parameters

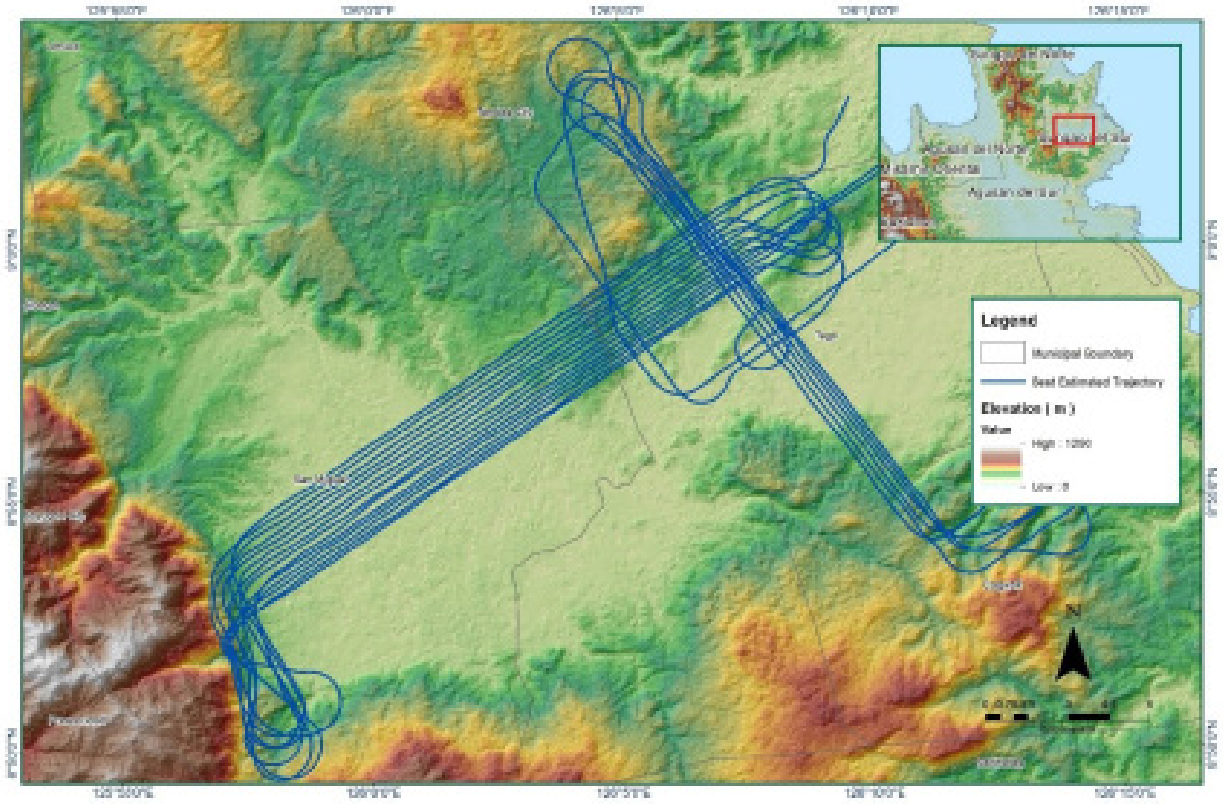


Figure 1.7.3 Best Estimated Trajectory

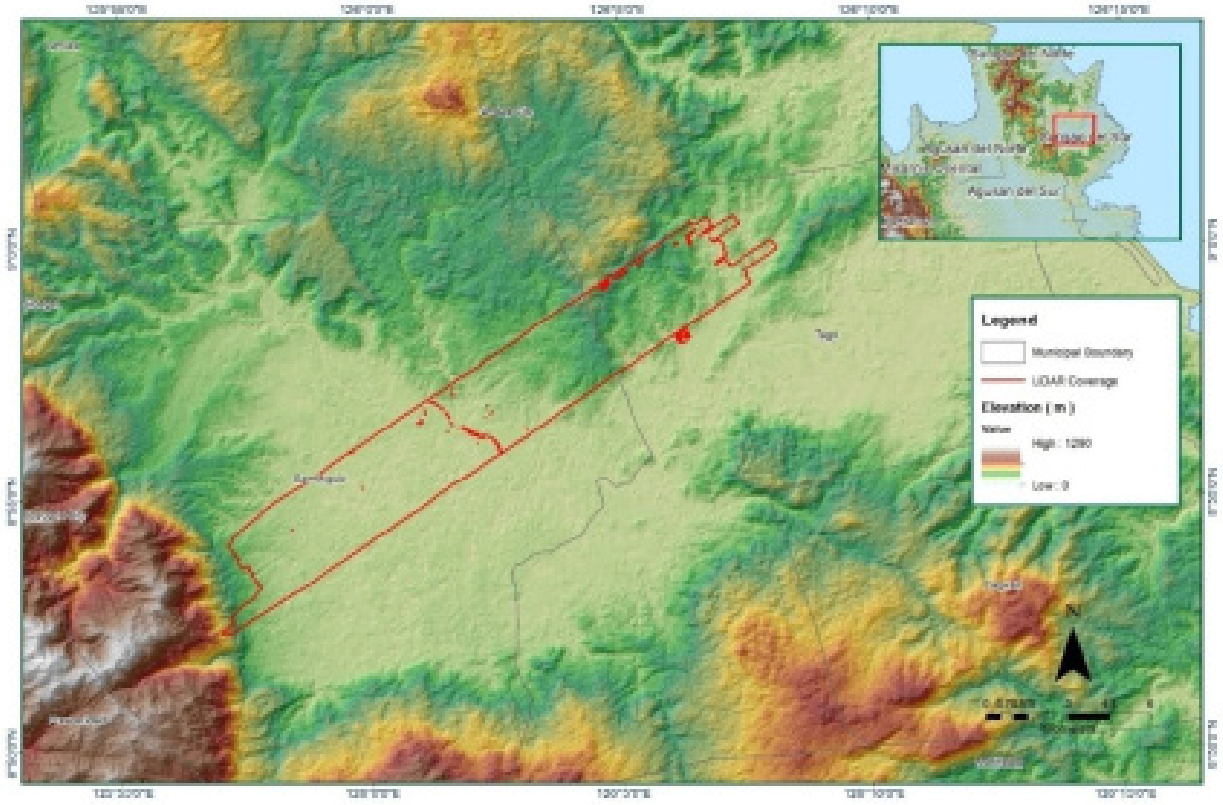


Figure 1.7.4 Coverage of LiDAR data

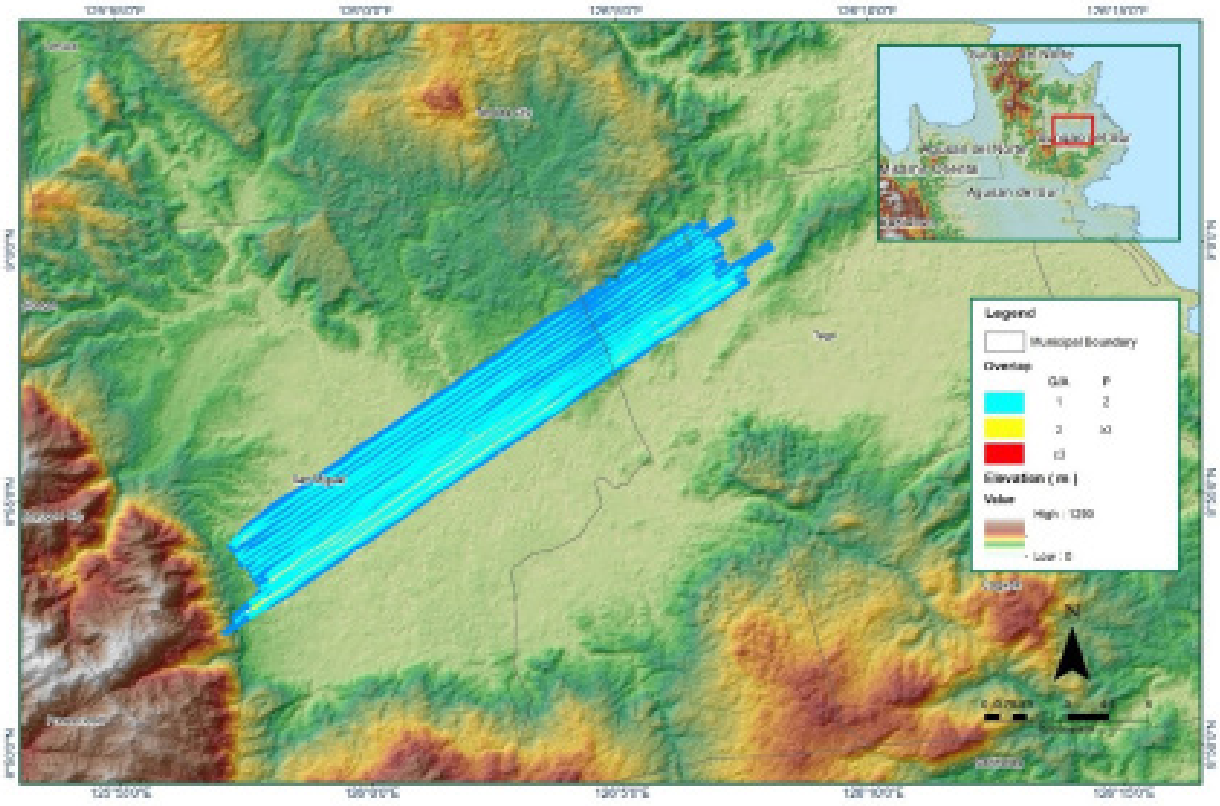


Figure 1.7.5 Image of data overlap

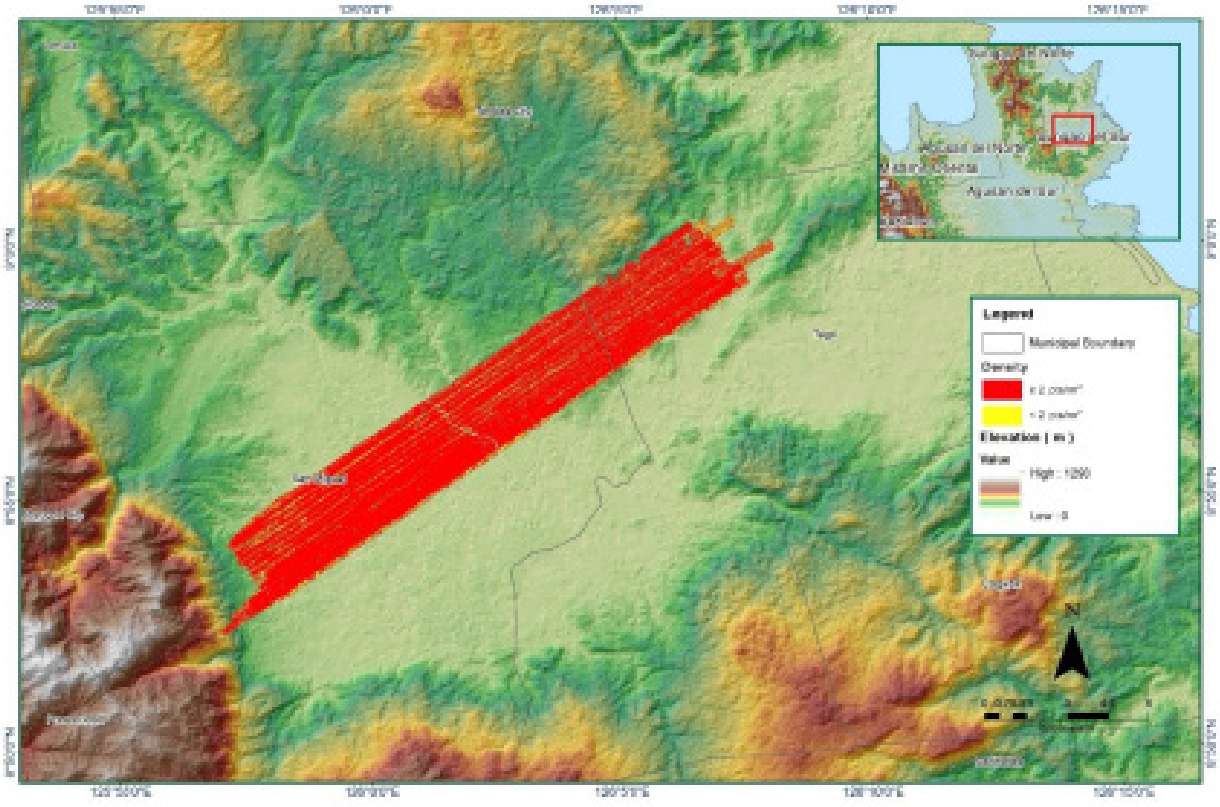


Figure 1.7.6 Density map of merged LiDAR data

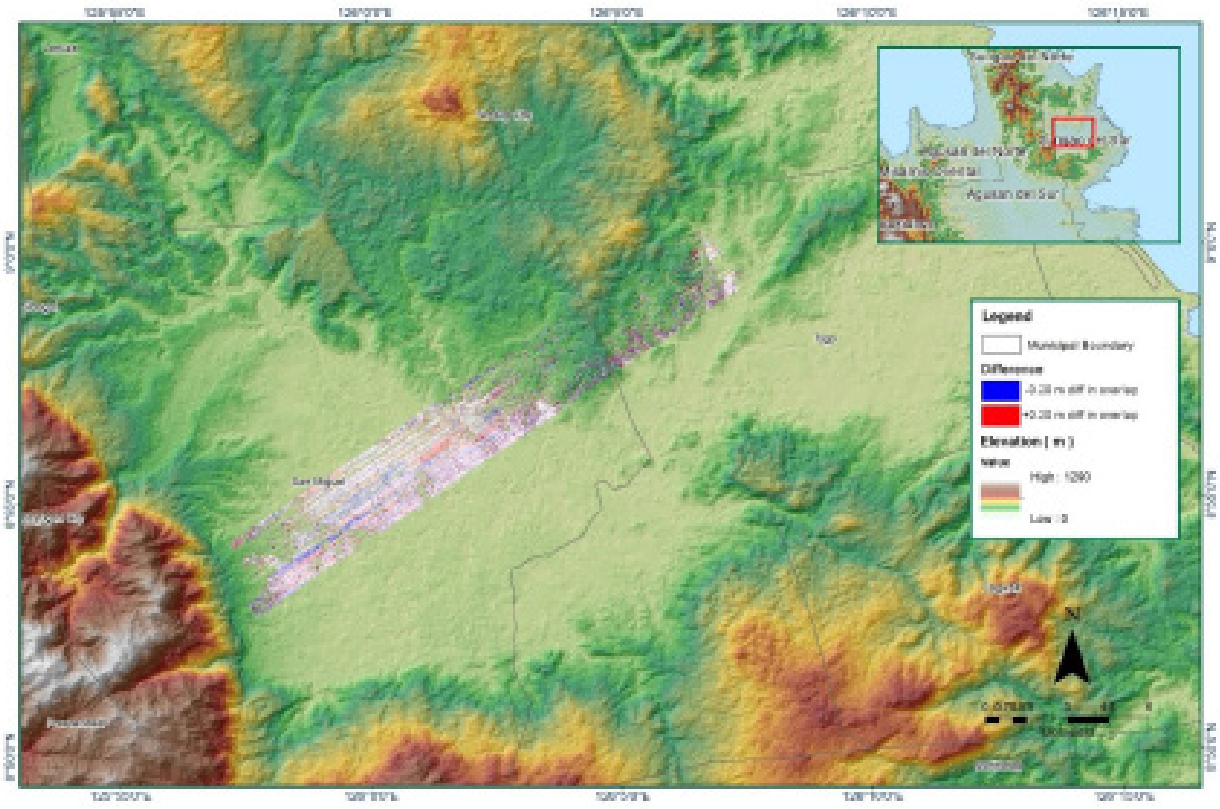


Figure 1.7.7 Elevation difference between flight lines

Flight Area	Tandag (Surigao Del Sur)
Mission Name	Block 61F
Inclusive Flights	1682A
Range data size	12.00 GB
Base data size	14.1 MB
POS	210MB
Image	81.20 MB
Transfer date	August 5, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	No
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.30
RMSE for East Position (<4.0 cm)	1.30
RMSE for Down Position (<8.0 cm)	3.20
Boresight correction stdev (<0.001deg)	0.000626
IMU attitude correction stdev (<0.001deg)	0.002838
GPS position stdev (<0.01m)	0.0036
Minimum % overlap (>25)	47.14
Ave point cloud density per sq.m. (>2.0)	3.00
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	149
Maximum Height	378.07 m
Minimum Height	66.86 m
Classification (# of points)	
Ground	50,865,700
Low vegetation	73,914,300
Medium vegetation	67,817,872
High vegetation	52,119,664
Building	4,995,362
Orthophoto	YES
Processed by	Engr. Irish Cortez, Engr. Harmond Santos, Engr. Jeffrey Delica

Figure 1.8.1 Solution Status

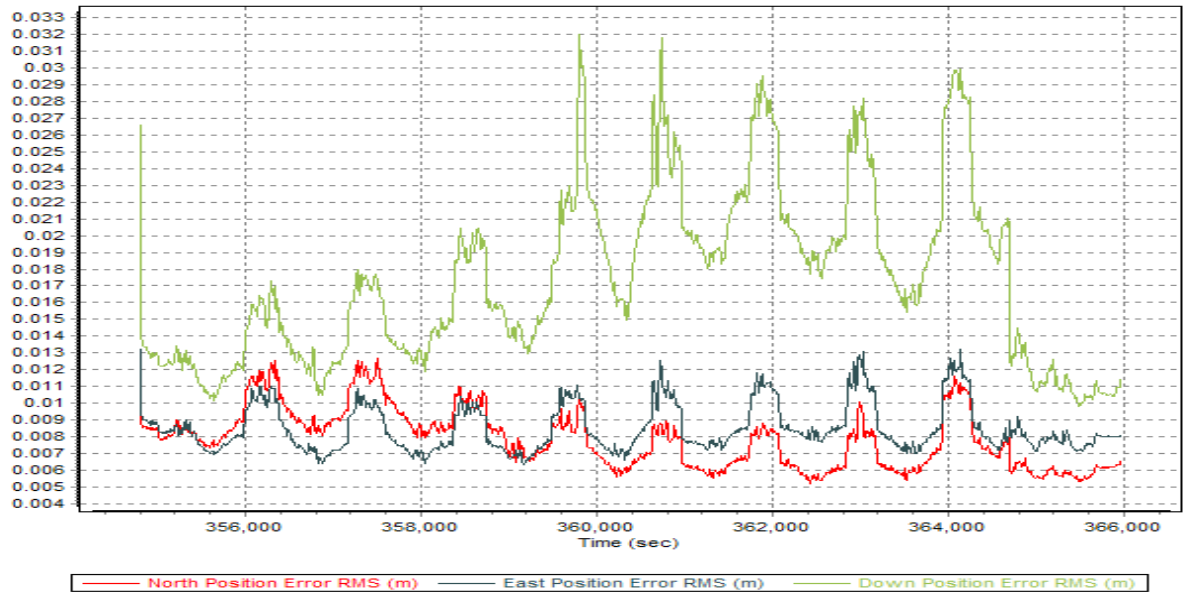


Figure 1.8.2 Smoothed Performance Metric Parameters

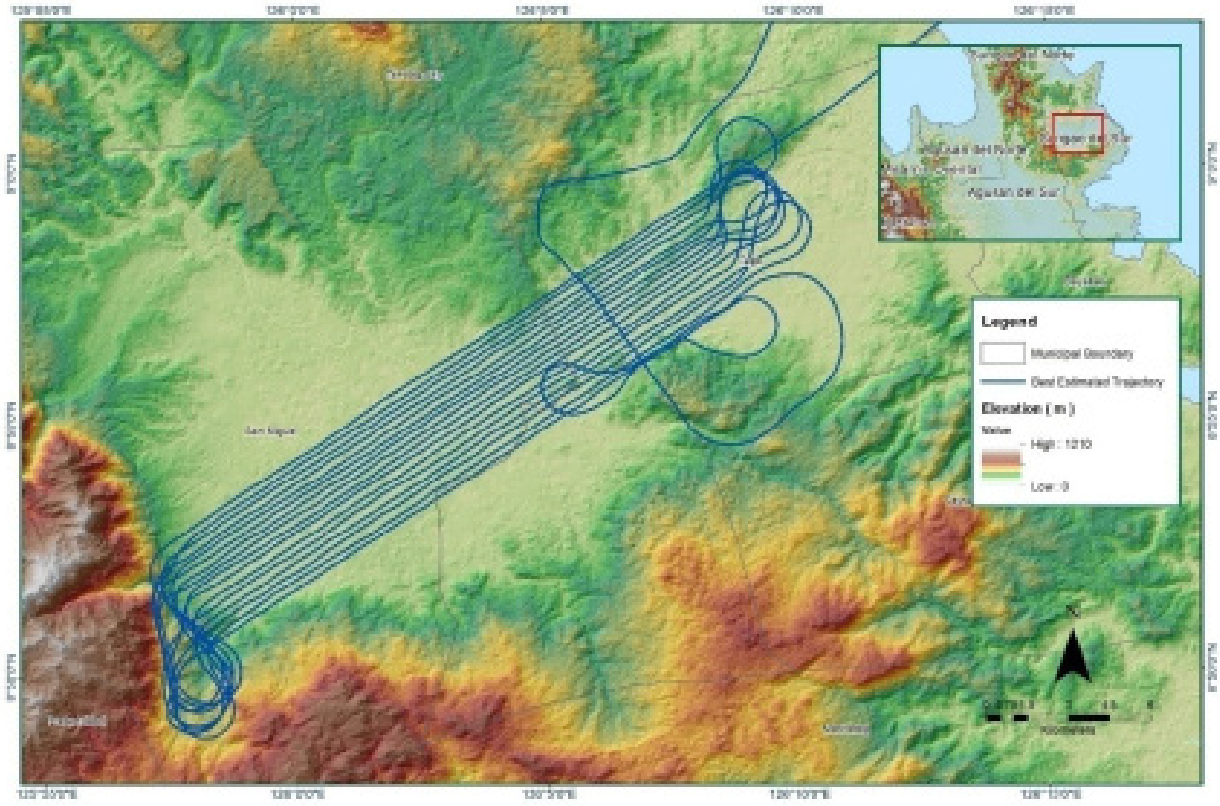


Figure 1.8.3 Best Estimated Trajectory

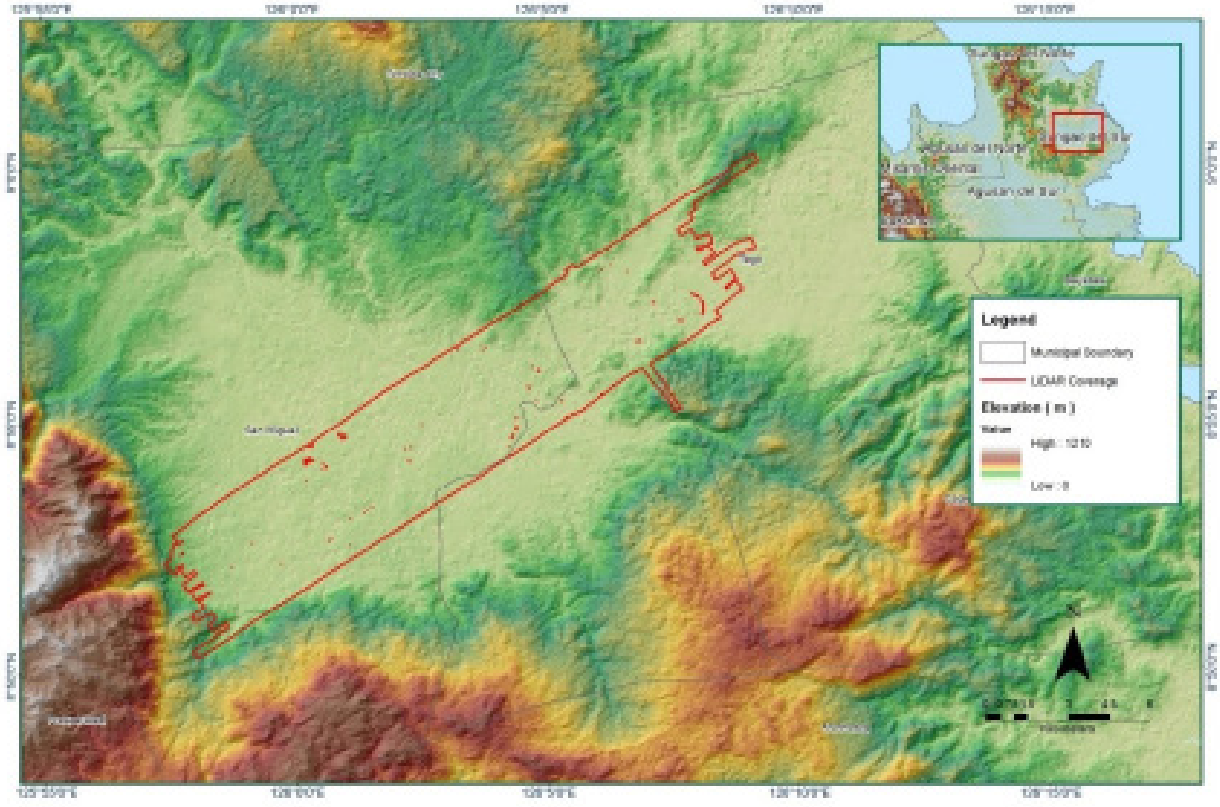


Figure 1.8.4 Coverage of LiDAR data

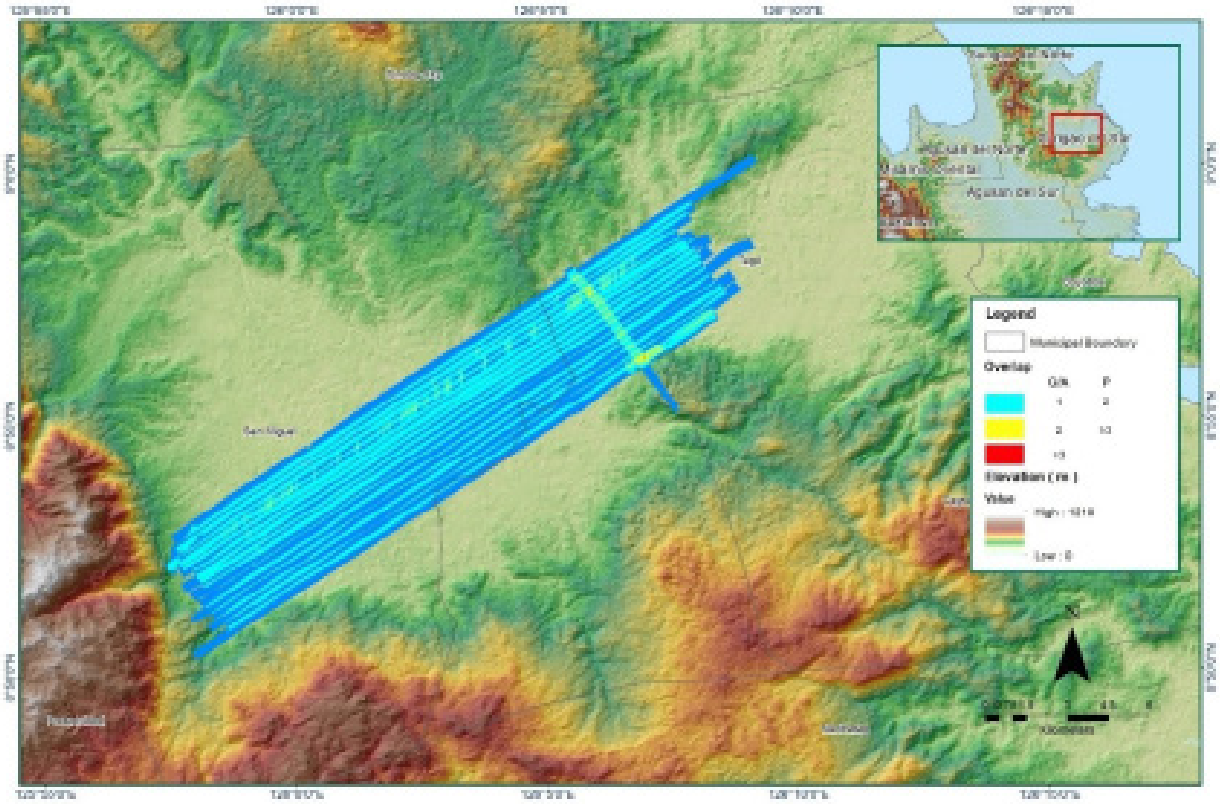


Figure 1.8.5 Image of data overlap

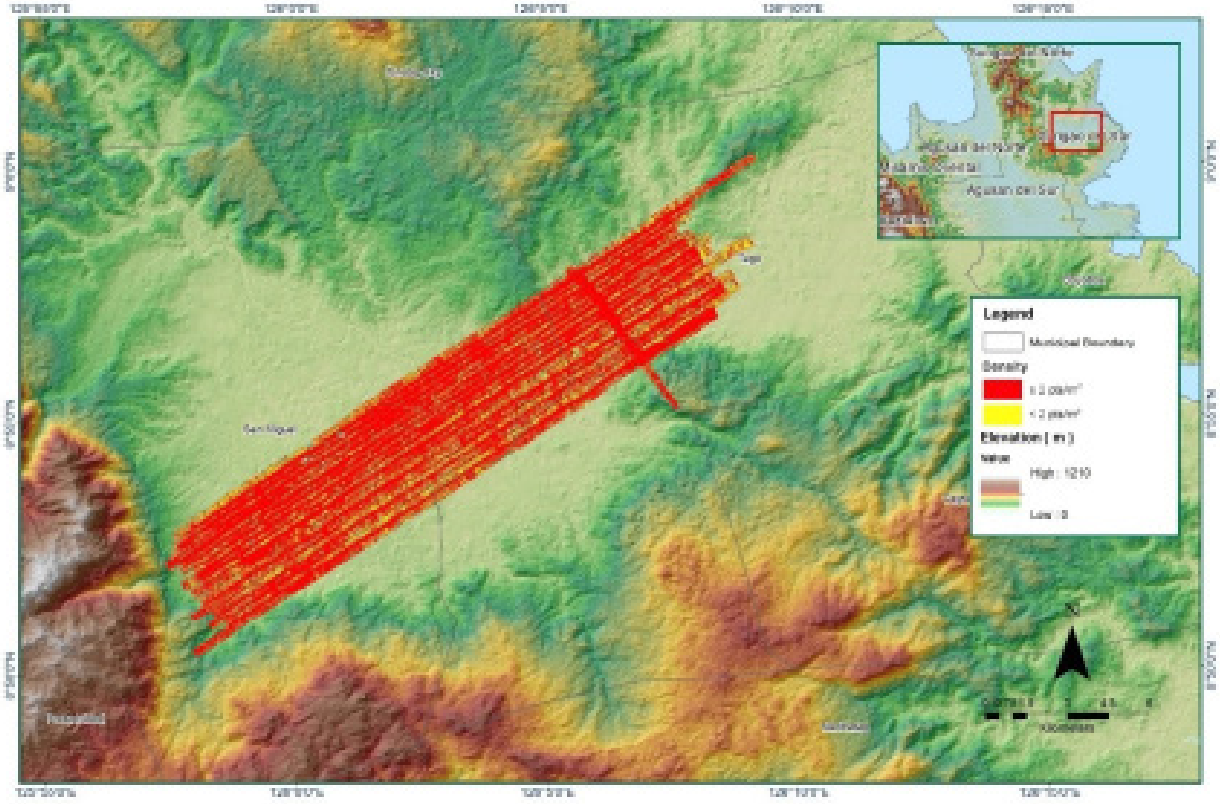


Figure 1.8.6 Density map of merged LiDAR data

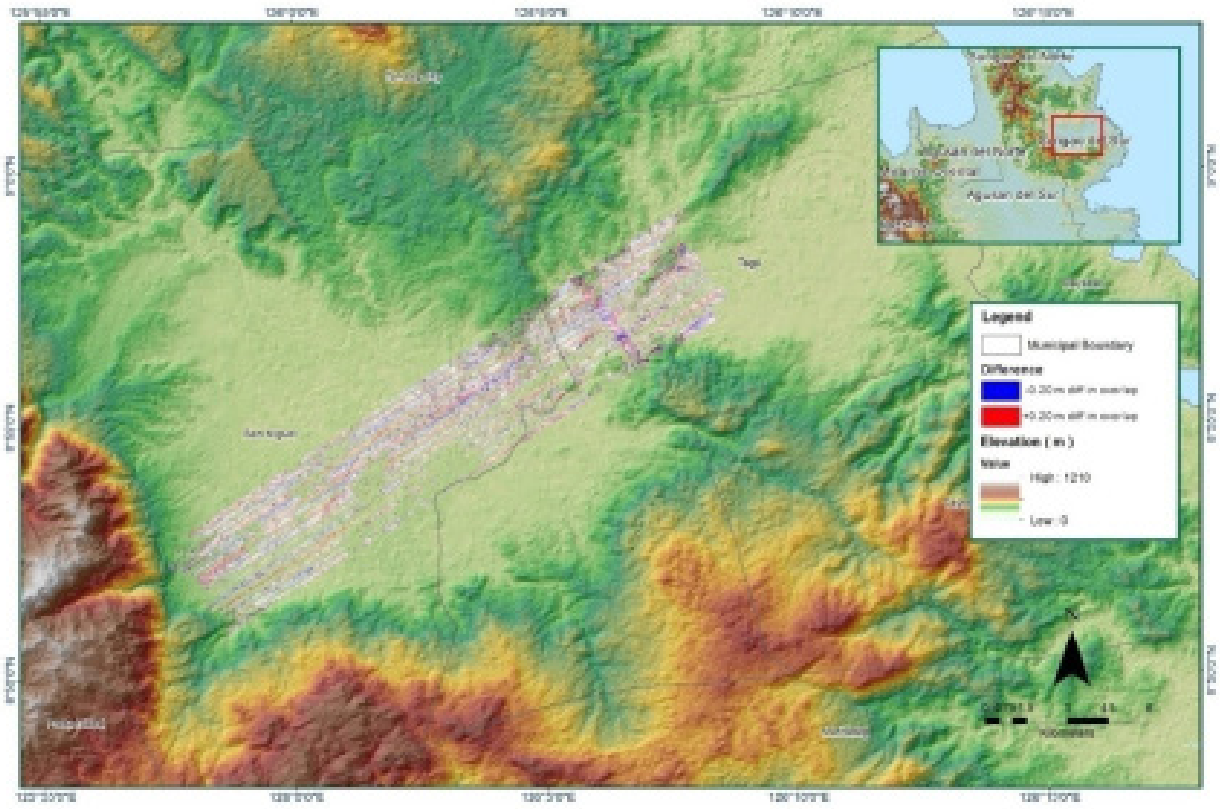


Figure 1.8.7 Elevation difference between flight lines

Flight Area	Tandag (Surigao Del Sur)
Mission Name	Block 61E
Inclusive Flights	1684A &1686A
Range data size	22.45 GB
Base data size	22.22 MB
POS	418 MB
Image	98.70 MB
Transfer date	August 5, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	2.00
RMSE for East Position (<4.0 cm)	2.10
RMSE for Down Position (<8.0 cm)	3.40
Boresight correction stdev (<0.001deg)	0.000887
IMU attitude correction stdev (<0.001deg)	0.002708
GPS position stdev (<0.01m)	0.0287
Minimum % overlap (>25)	57.57
Ave point cloud density per sq.m. (>2.0)	3.70
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	108
Maximum Height	427.08 m
Minimum Height	67.35 m
Classification (# of points)	
Ground	26,301,518
Low vegetation	40,924,666
Medium vegetation	44,851,896
High vegetation	106,307,085
Building	2,949,641
Orthophoto	YES
Processed by	Engr. Carlyn Ibañez, Engr. Chelou Prado, Engr. Gladys Apat

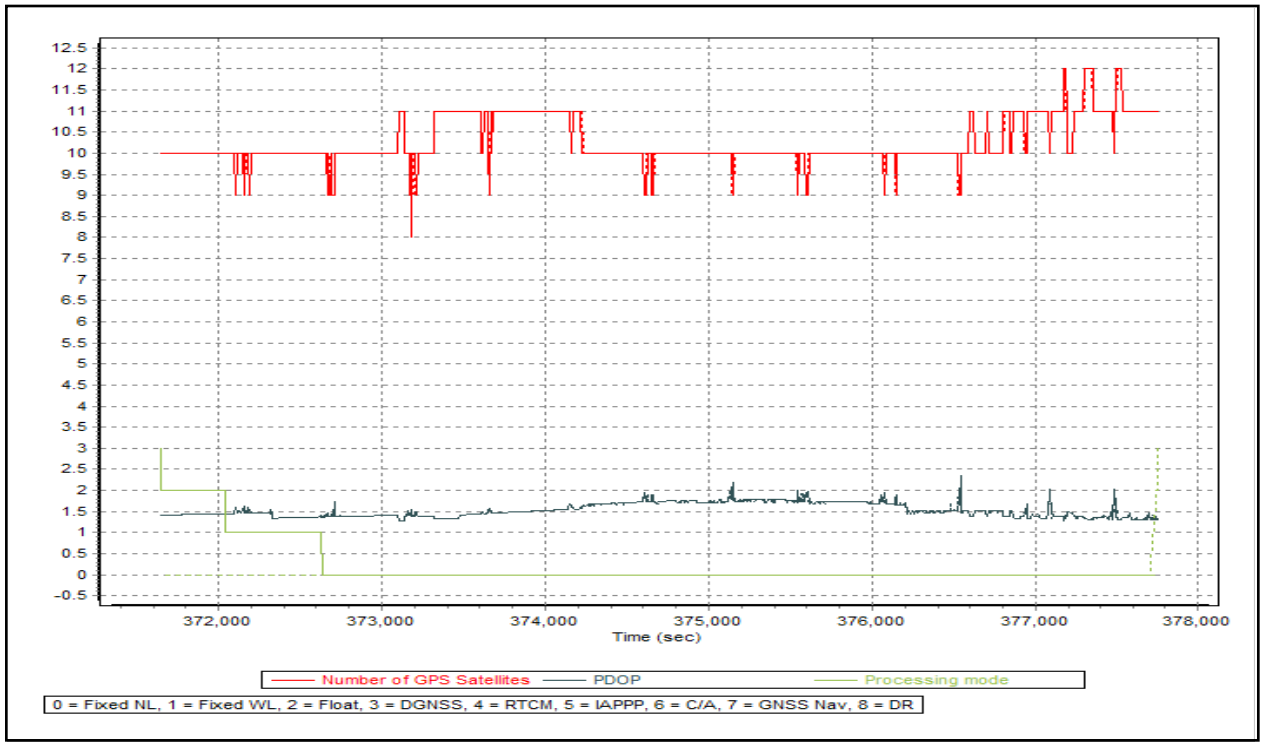


Figure 1.9.1 Solution Status

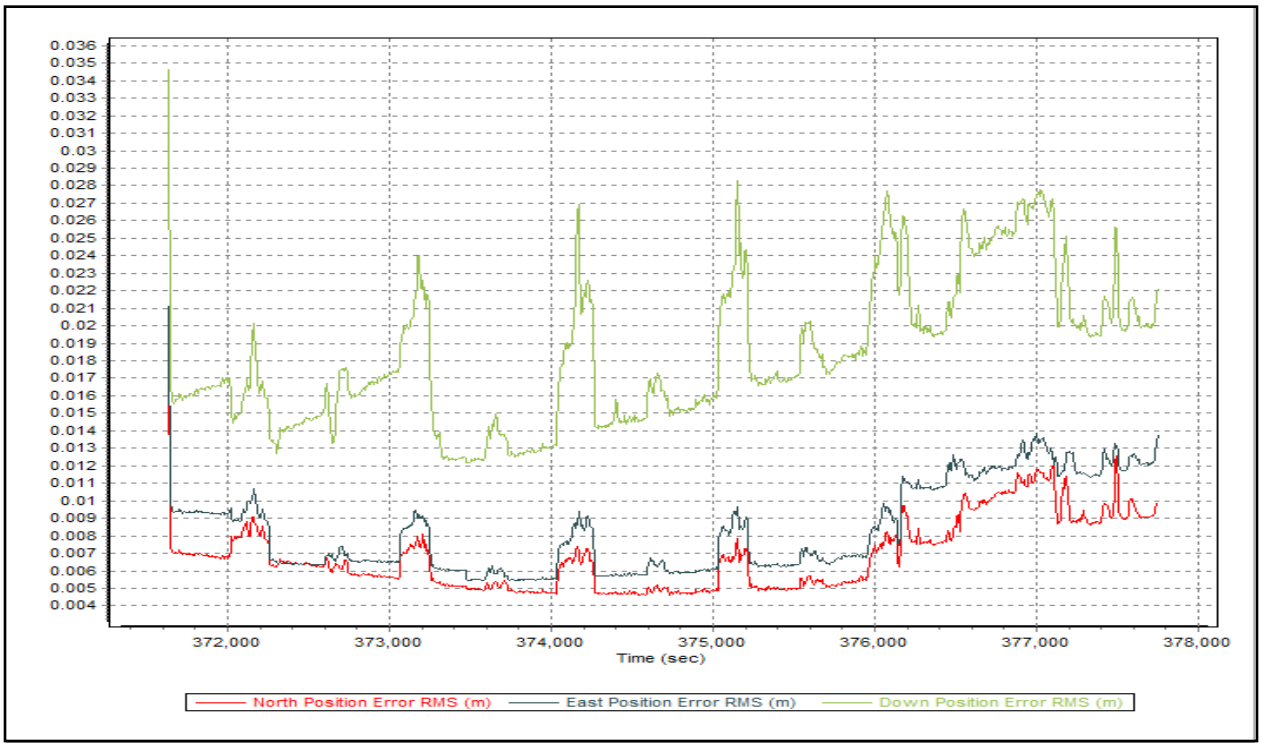


Figure 1.9.2 Smoothed Performance Metric Parameters

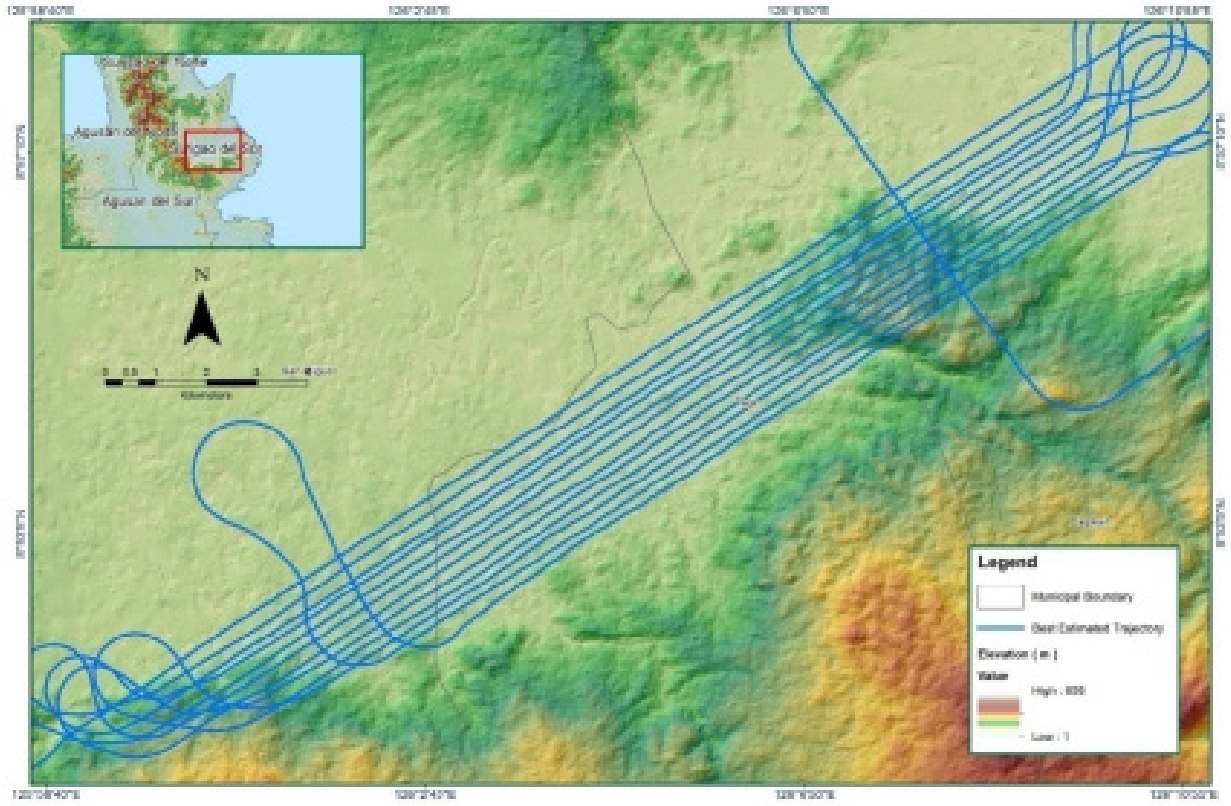


Figure 1.9.3 Best Estimated Trajectory

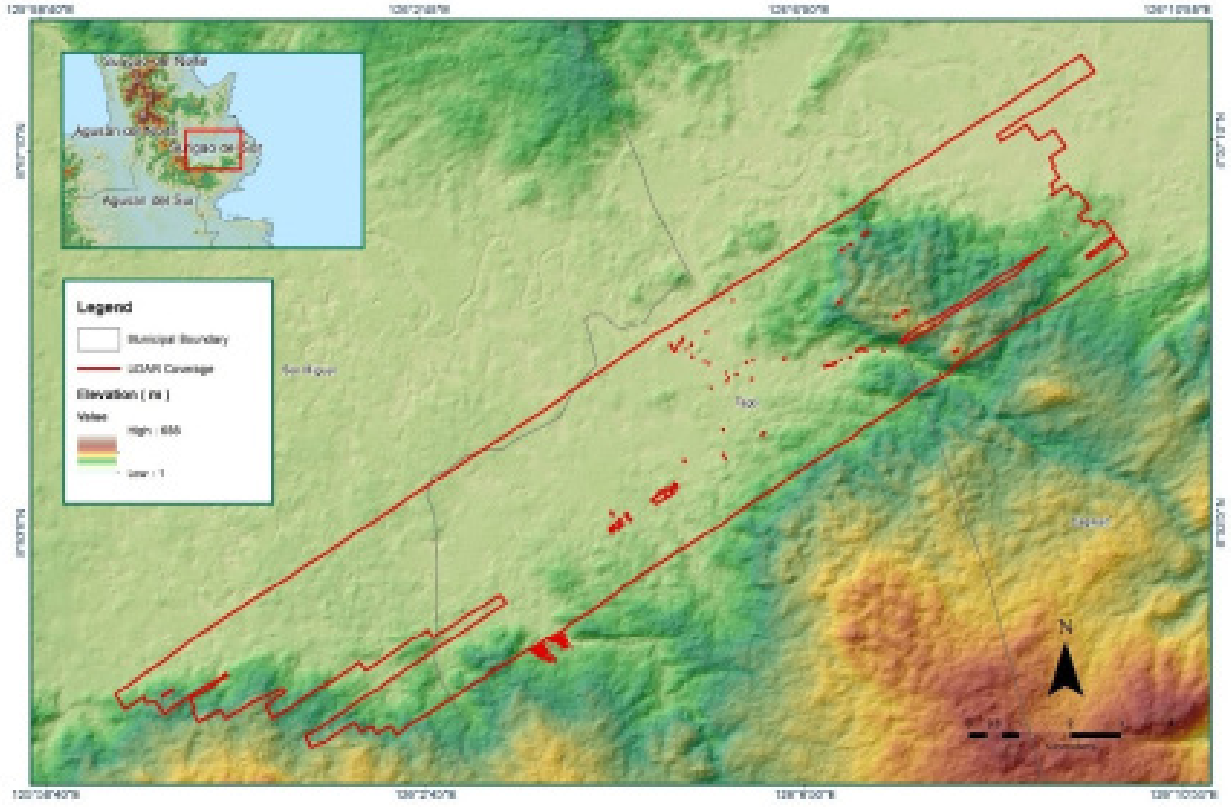


Figure 1.9.4 Coverage of LiDAR data

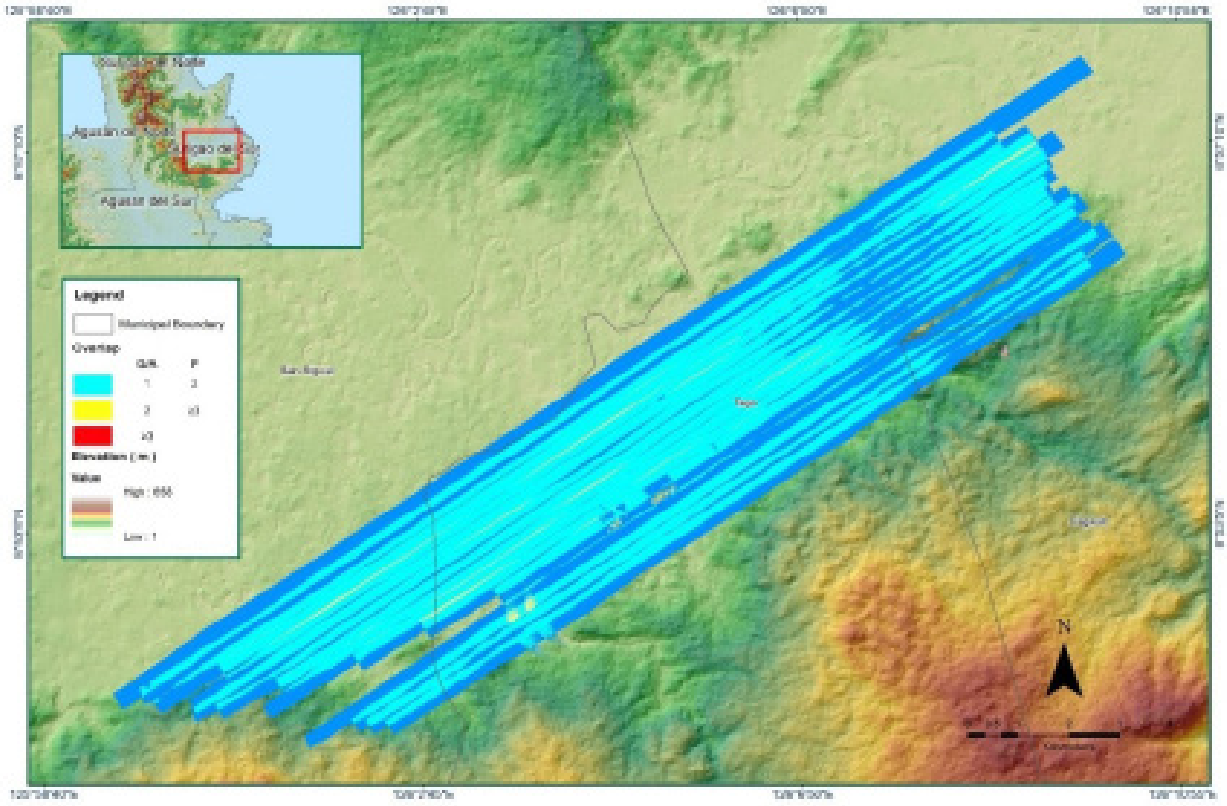


Figure 1.9.5 Image of data overlap

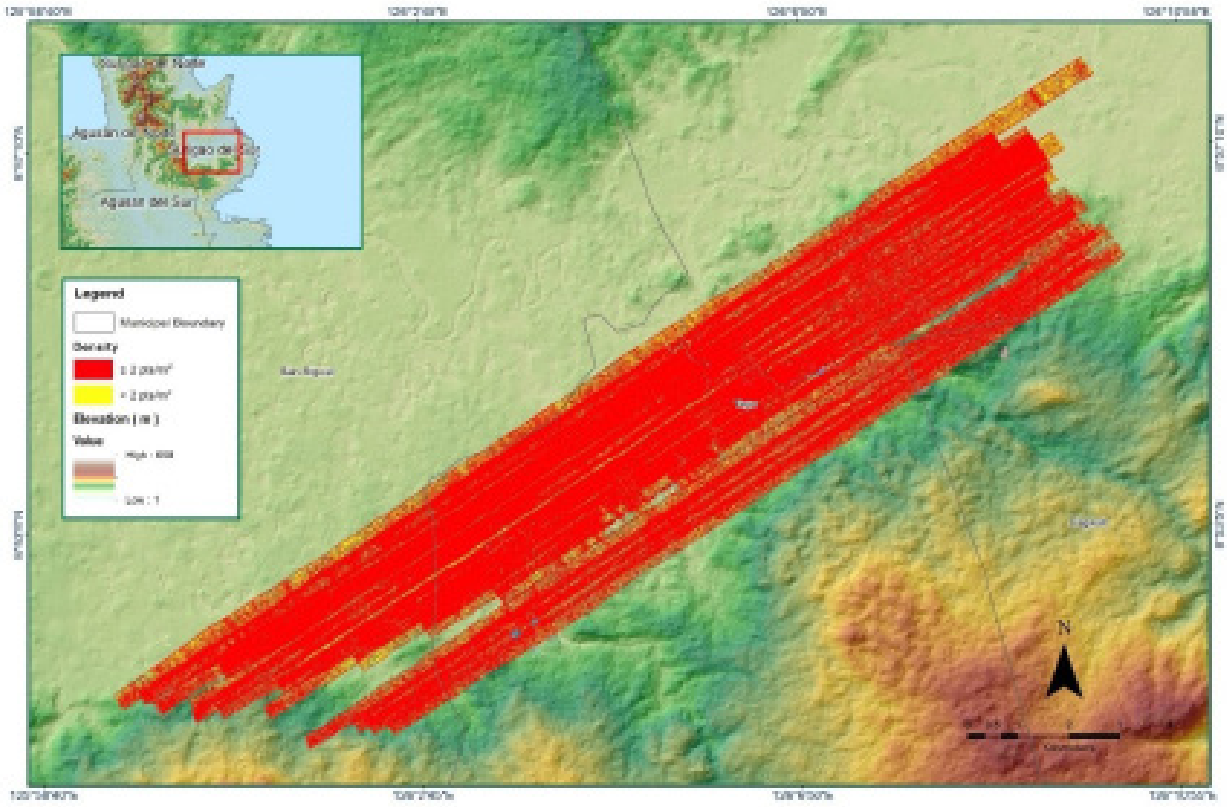


Figure 1.9.6 Density map of merged LiDAR data

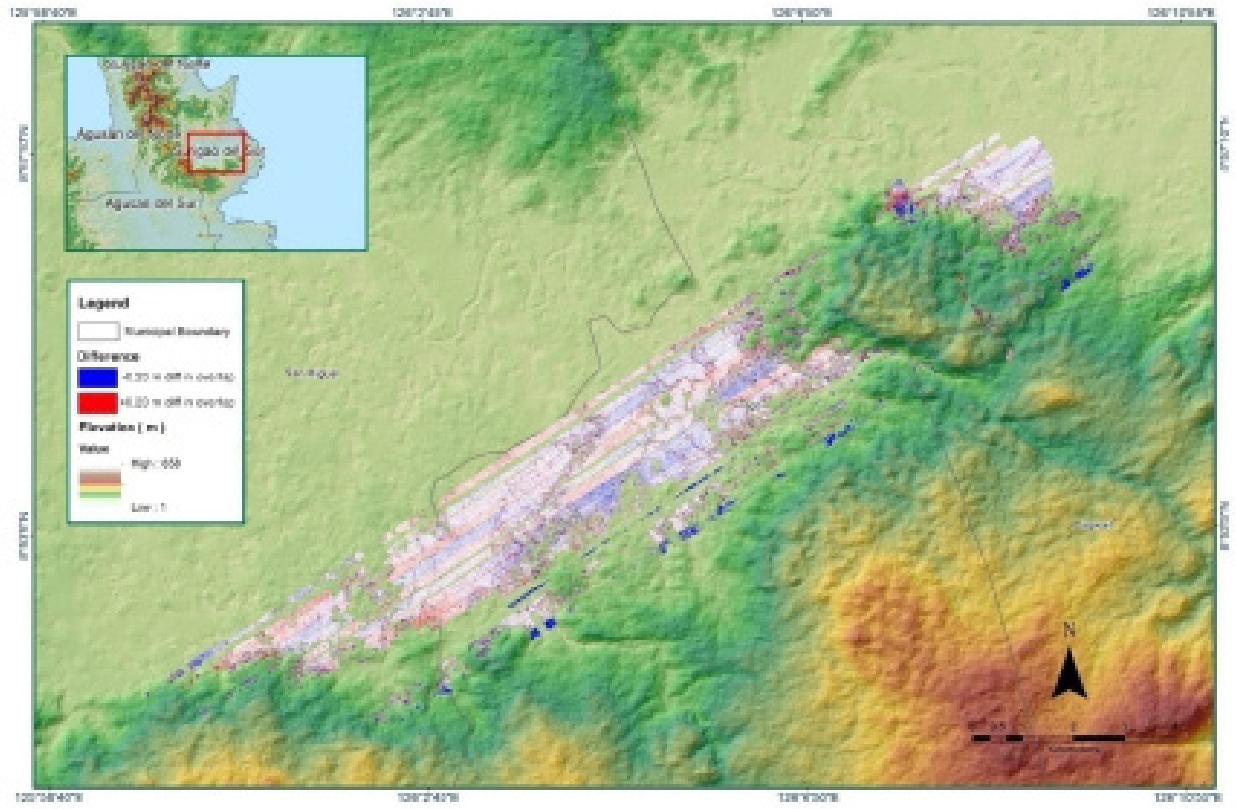


Figure 1.9.7 Elevation difference between flight lines

Flight Area	Tandag (Surigao Del Sur)
Mission Name	Block 61E Additional
Inclusive Flights	1742A
Range data size	8.78 GB
Base data size	8.53 MB
POS	258 MB
Image	260 MB
Transfer date	September 1, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	2.00
RMSE for East Position (<4.0 cm)	2.10
RMSE for Down Position (<8.0 cm)	3.60
Boresight correction stdev (<0.001deg)	0.001060
IMU attitude correction stdev (<0.001deg)	0.016490
GPS position stdev (<0.01m)	0.0230
Minimum % overlap (>25)	11.23
Ave point cloud density per sq.m. (>2.0)	2.79
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	56
Maximum Height	472.26 m
Minimum Height	69.88 m
Classification (# of points)	
Ground	8,367,359
Low vegetation	7,565,819
Medium vegetation	11,051,516
High vegetation	30,305,790
Building	836,628
Orthophoto	YES
Processed by	Engr. Jommer Medina, Aljon Araneta, Engr. Jeffrey Delica

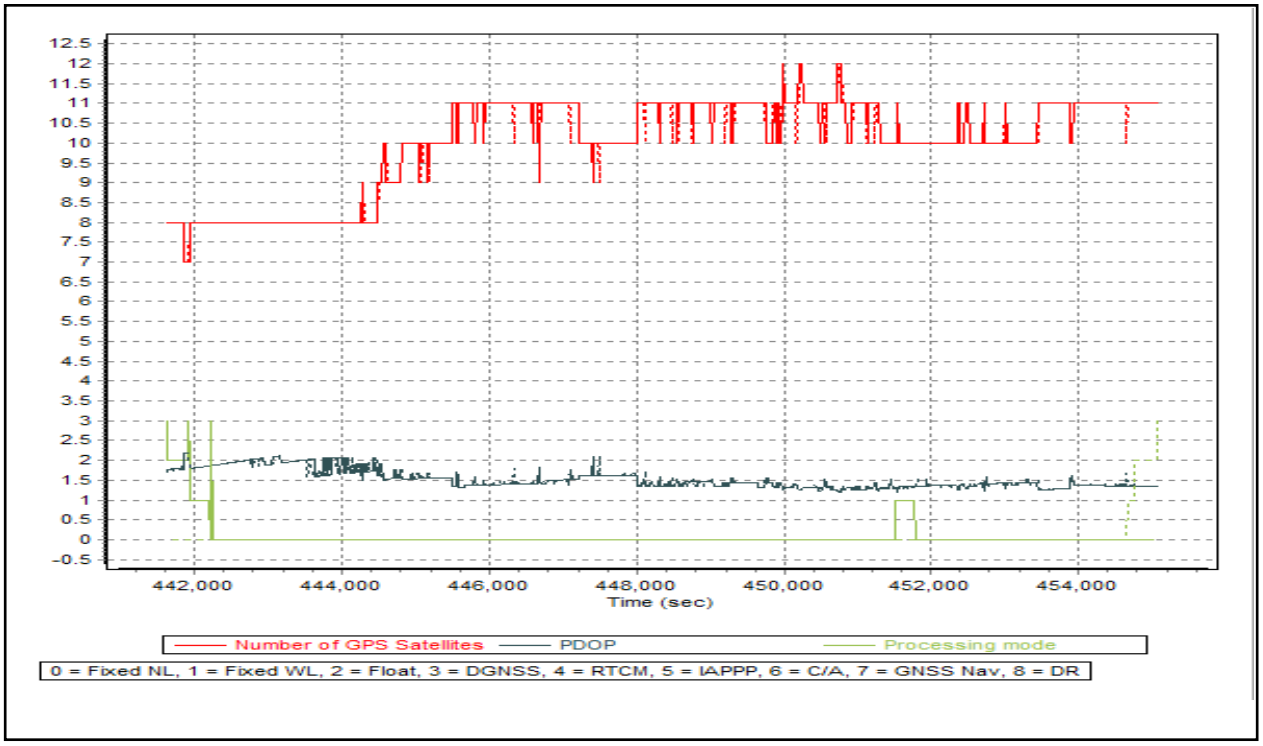


Figure 1.10.1 Solution Status

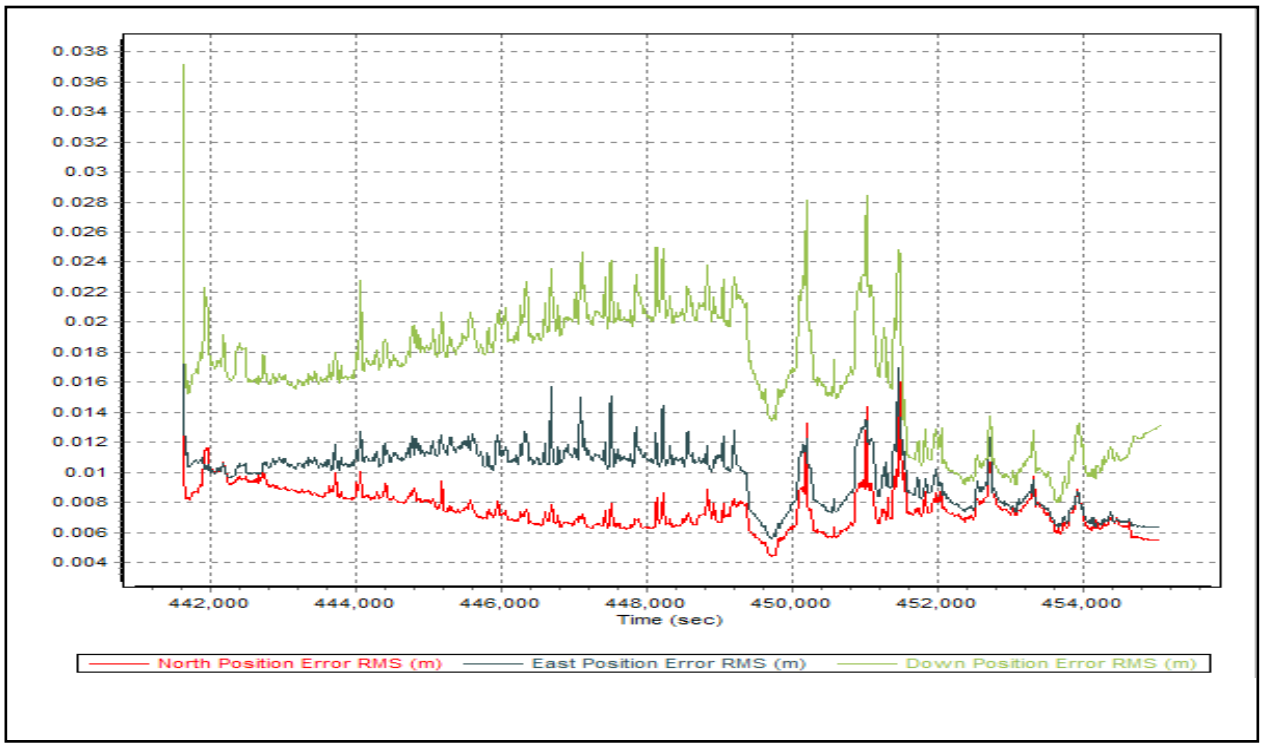


Figure 1.10.2 Smoothed Performance Metric Parameters

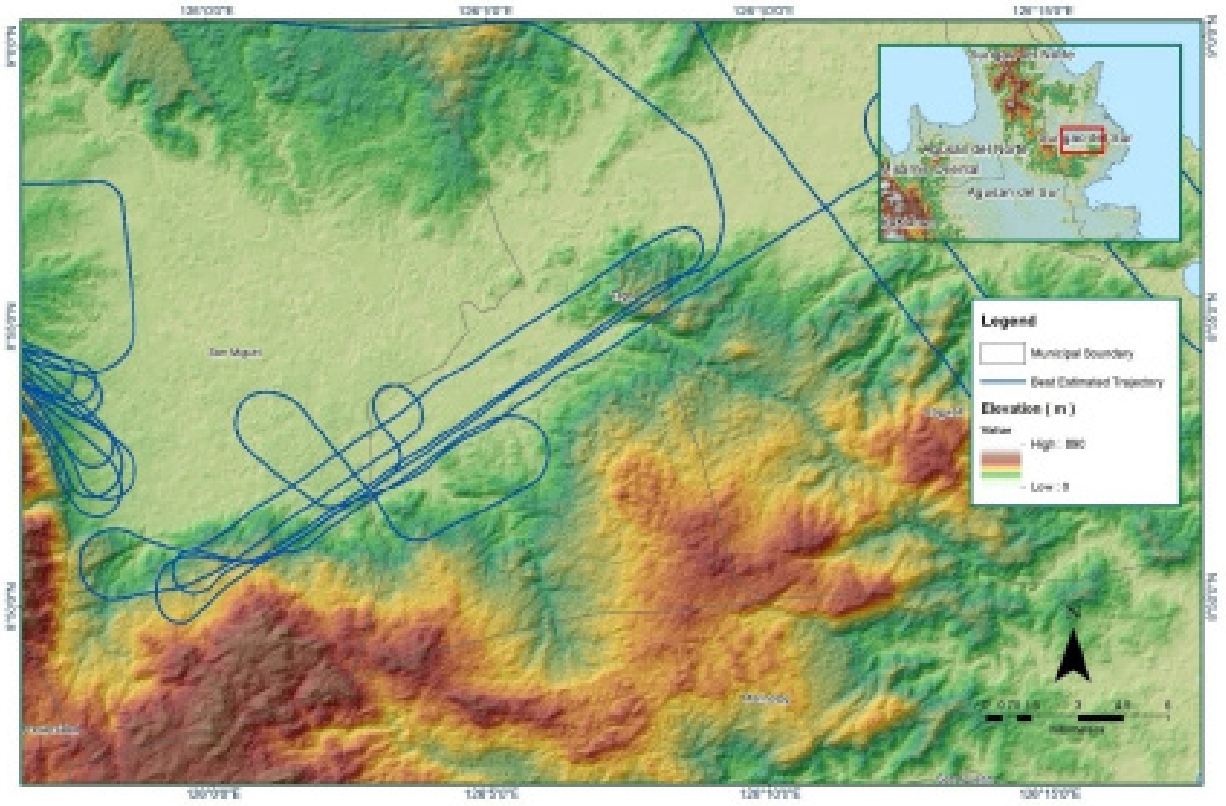


Figure 1.10.3 Best Estimated Trajectory

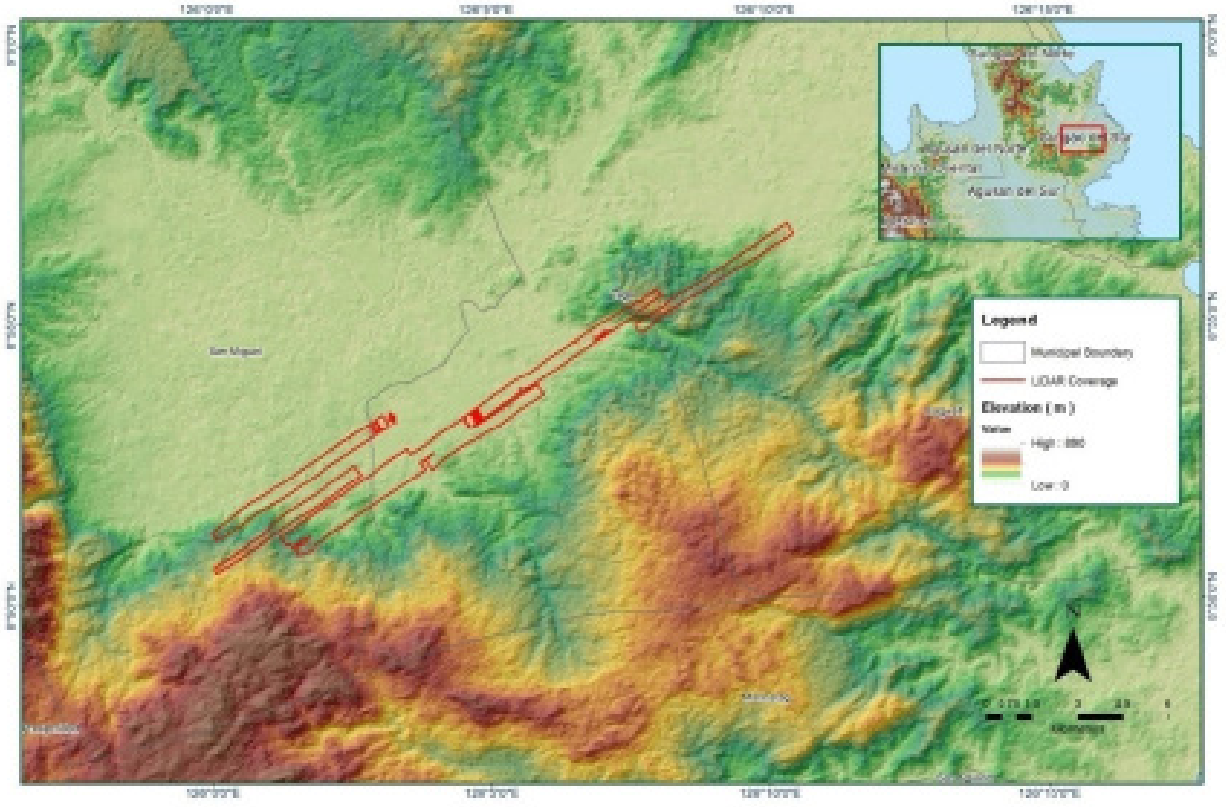


Figure 1.10.4 Coverage of LiDAR data

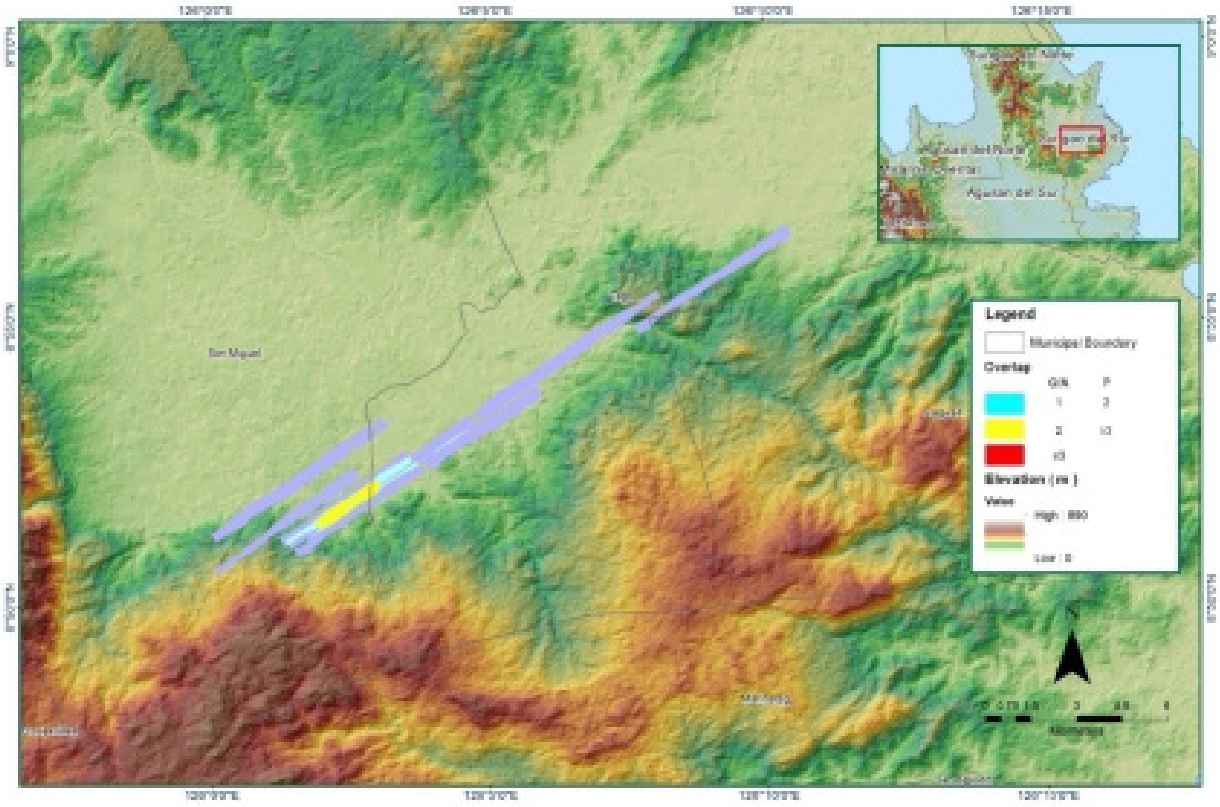


Figure 1.10.5 Image of data overlap

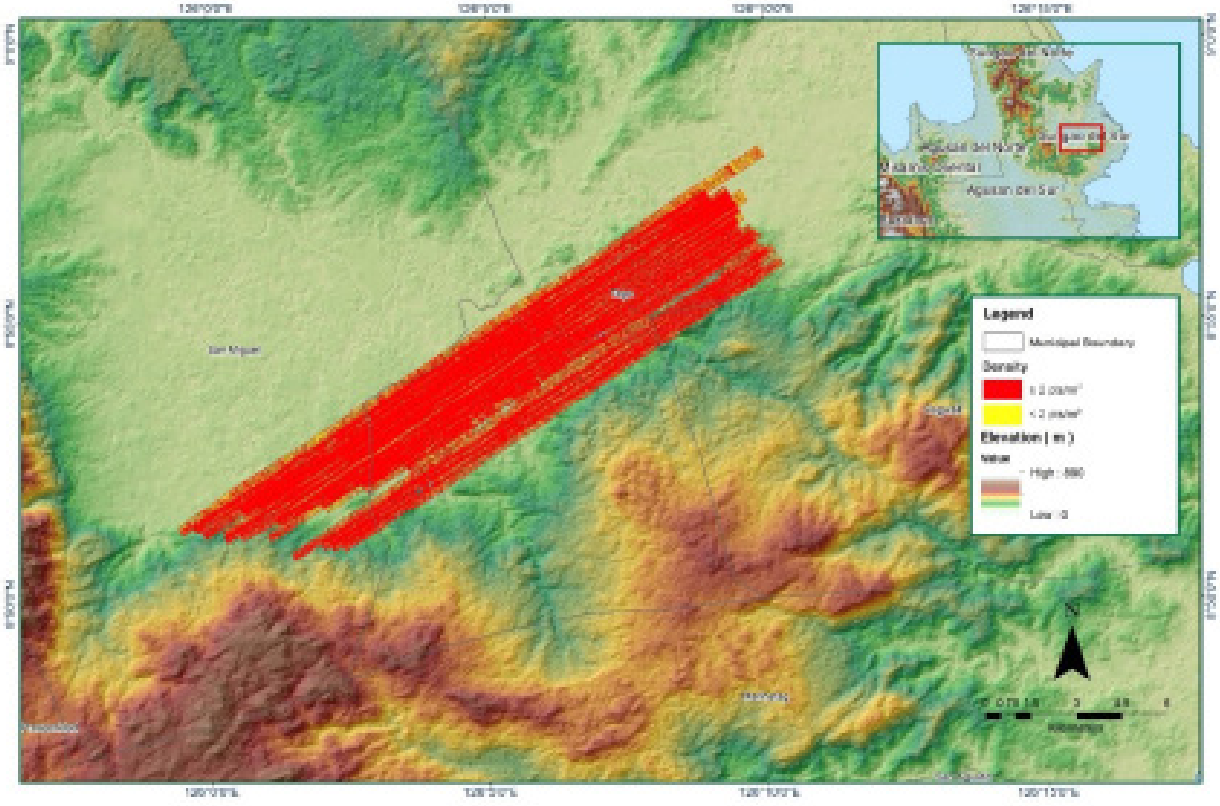


Figure 1.10.6 Density map of merged LiDAR data

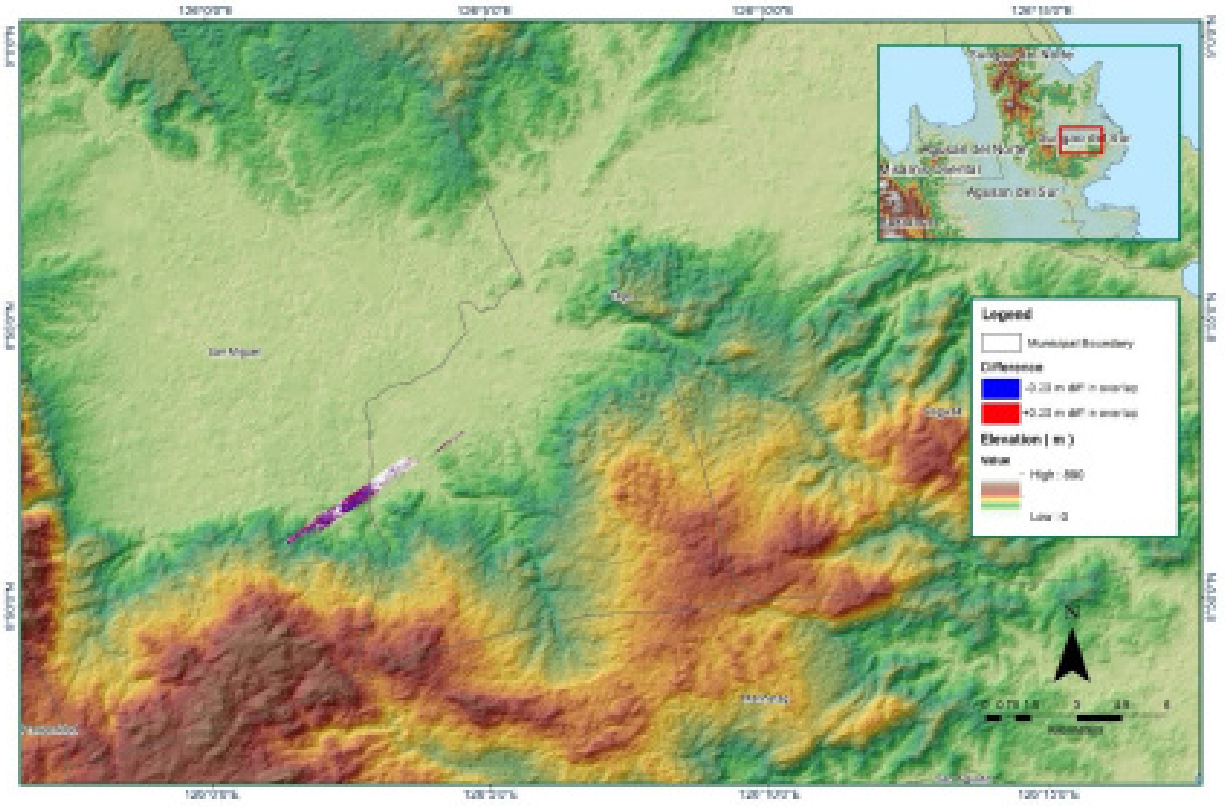


Figure 1.10.7Elevation difference between flight lines

Flight Area	Tandag (Surigao Del Sur)
Mission Name	Block 61J
Inclusive Flights	1732A & 1736A
Range data size	9.98 GB
Base data size	29 MB
POS	302 MB
Image	29.70 MB
Transfer date	July 31, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.50
RMSE for East Position (<4.0 cm)	1.35
RMSE for Down Position (<8.0 cm)	5.80
Boresight correction stdev (<0.001deg)	--
IMU attitude correction stdev (<0.001deg)	--
GPS position stdev (<0.01m)	--
Minimum % overlap (>25)	67.96
Ave point cloud density per sq.m. (>2.0)	6.14
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	62
Maximum Height	473.33 m
Minimum Height	71.35 m
Classification (# of points)	
Ground	4,228,635
Low vegetation	2,835,524
Medium vegetation	16,040,466
High vegetation	159,502,765
Building	8,212,686
Orthophoto	Yes
Processed by	Engr. Carlyn Ibañez, Engr. Harmond Santos, Engr. Jeffrey Delica

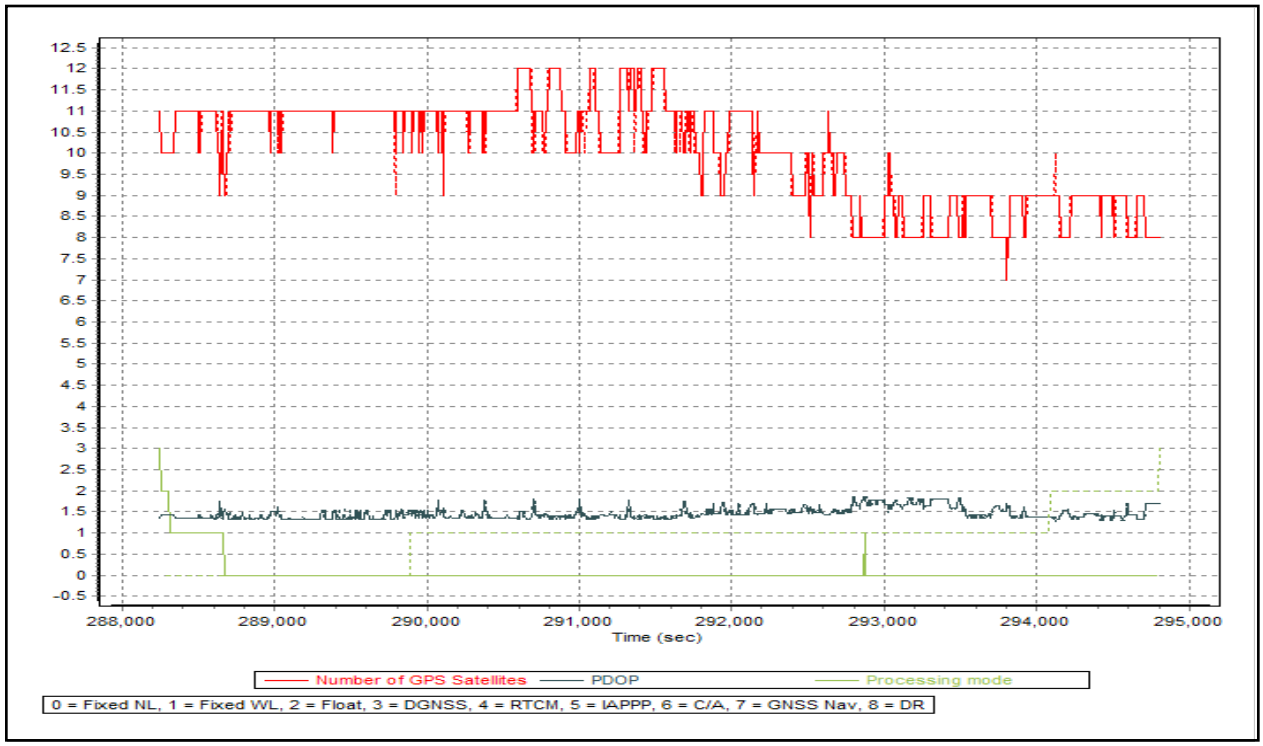


Figure 1.11.1 Solution Status

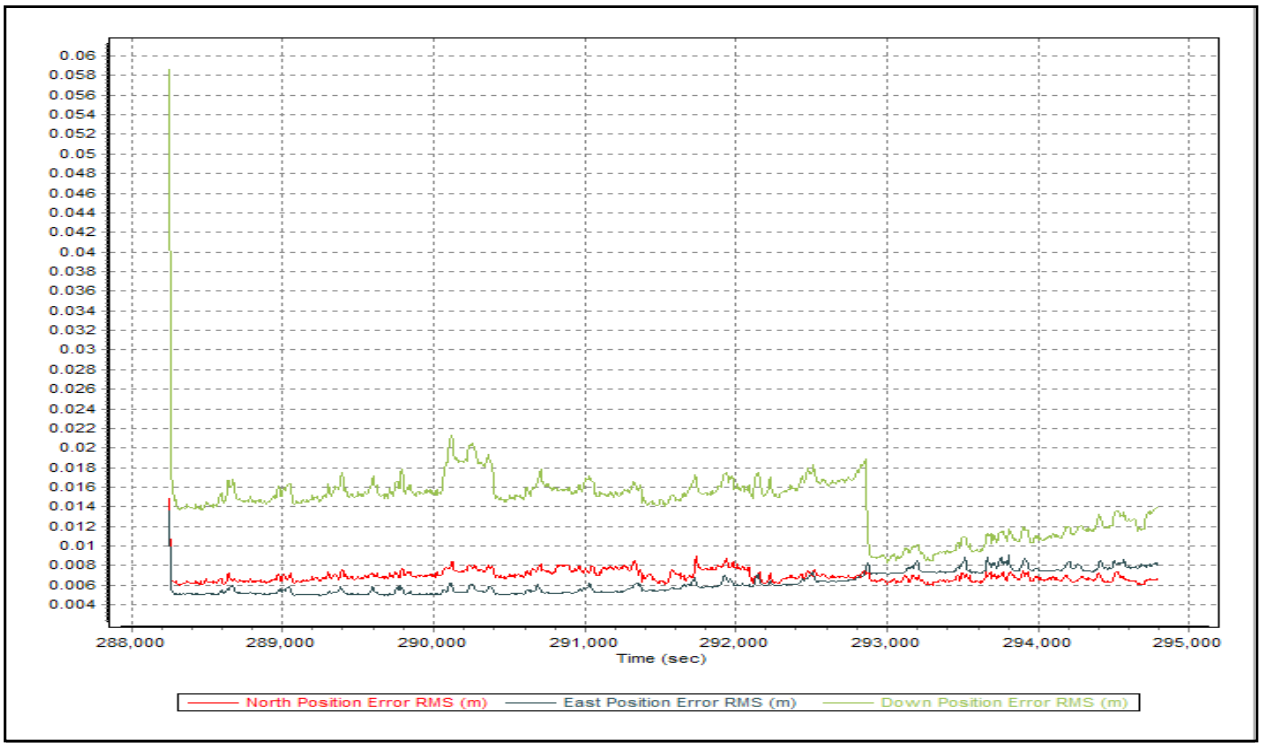


Figure 1.11.2 Smoothed Performance Metric Parameters

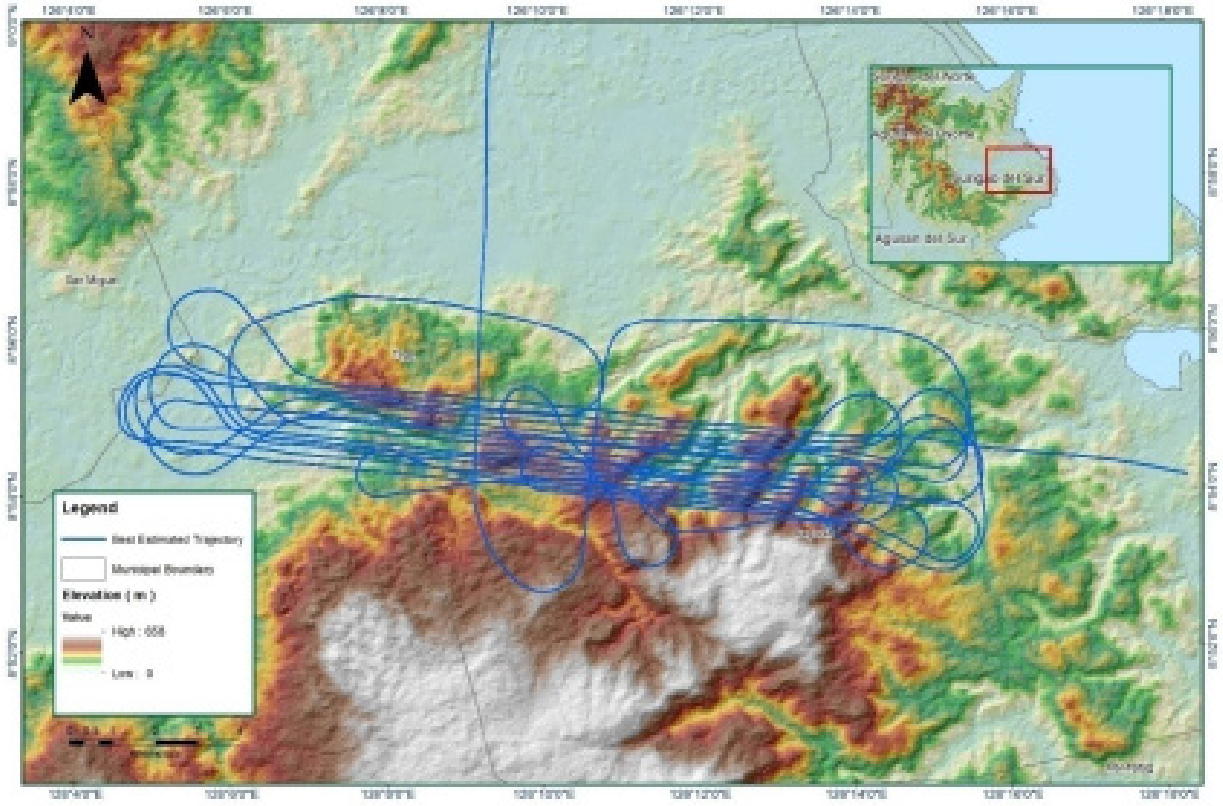


Figure 1.11.3 Best Estimated Trajectory

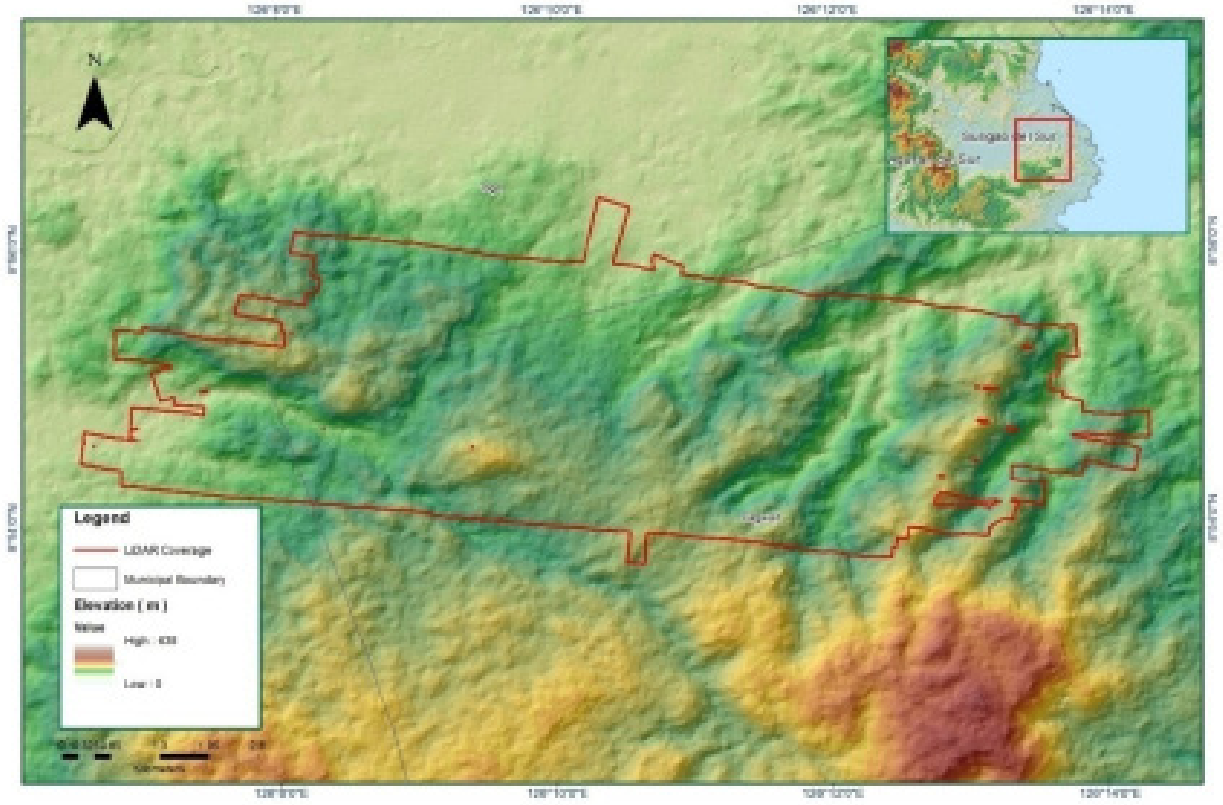


Figure 1.11.4 Coverage of LiDAR data

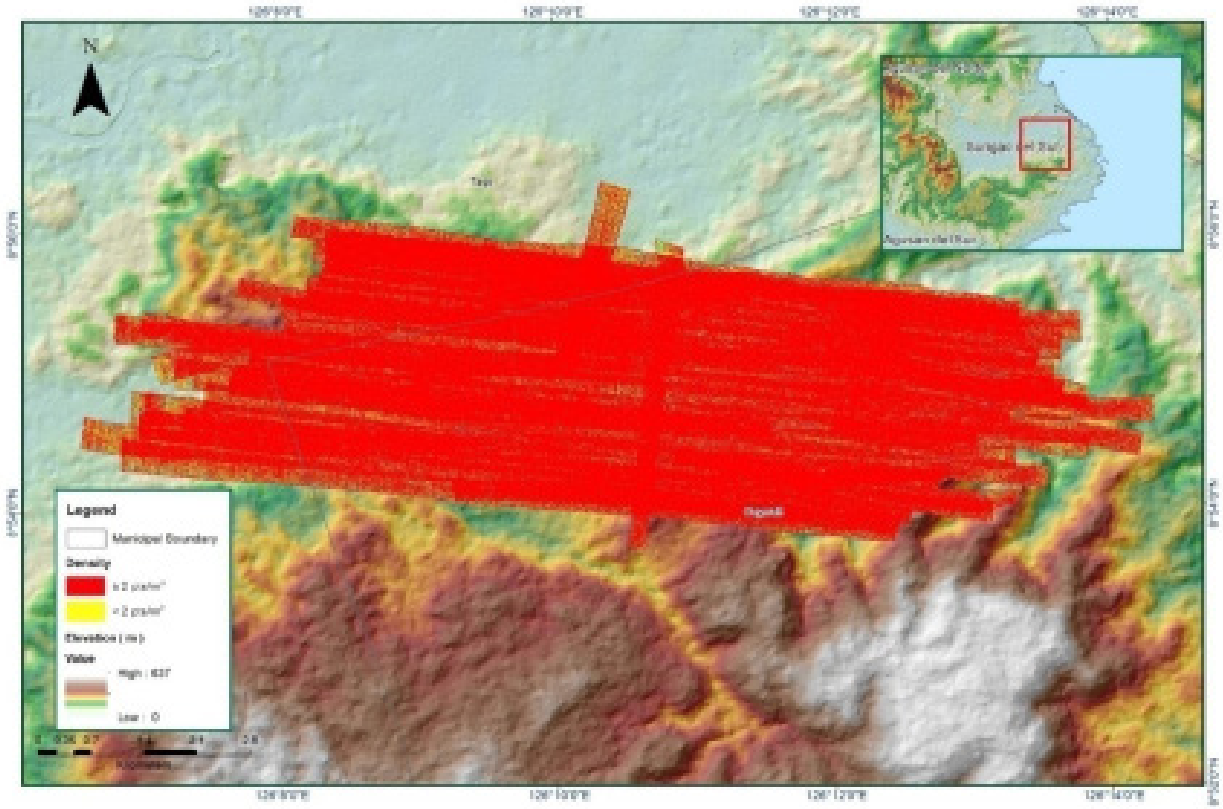


Figure 1.11.5 Image of data overlap

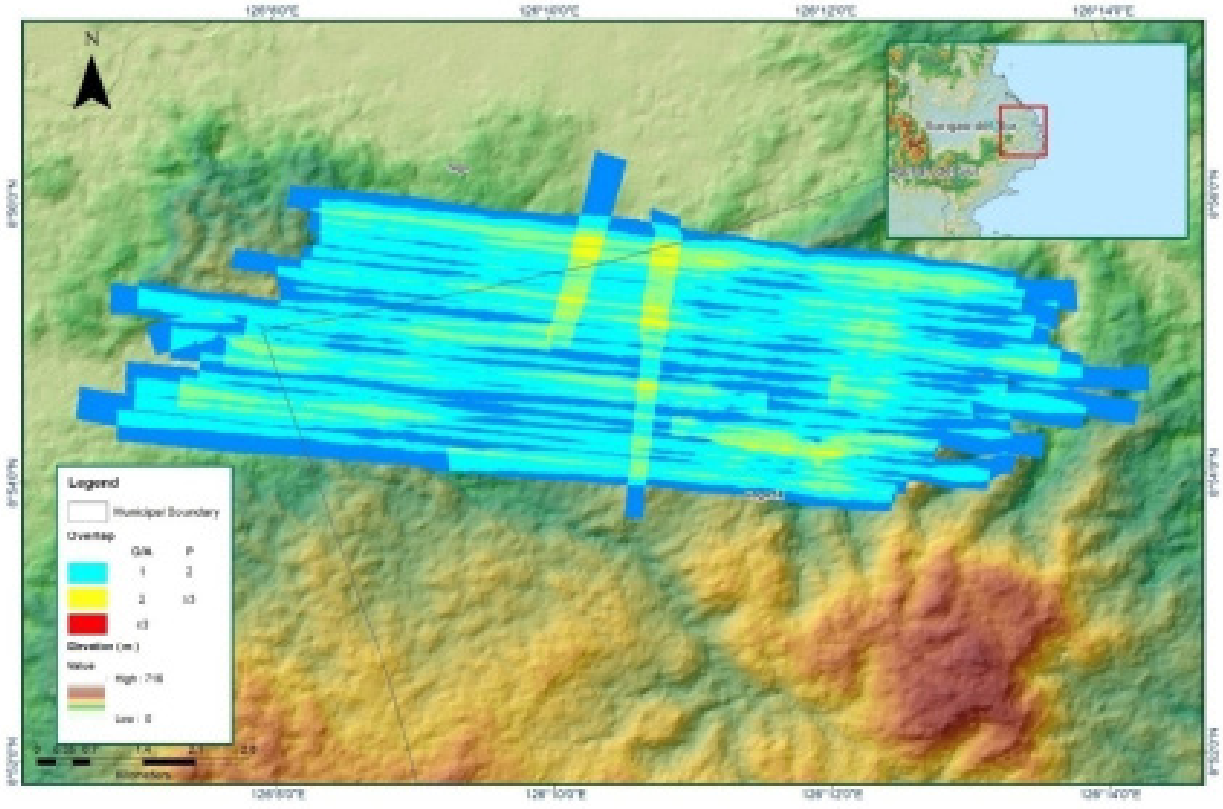


Figure 1.11.6 Density map of merged LiDAR data

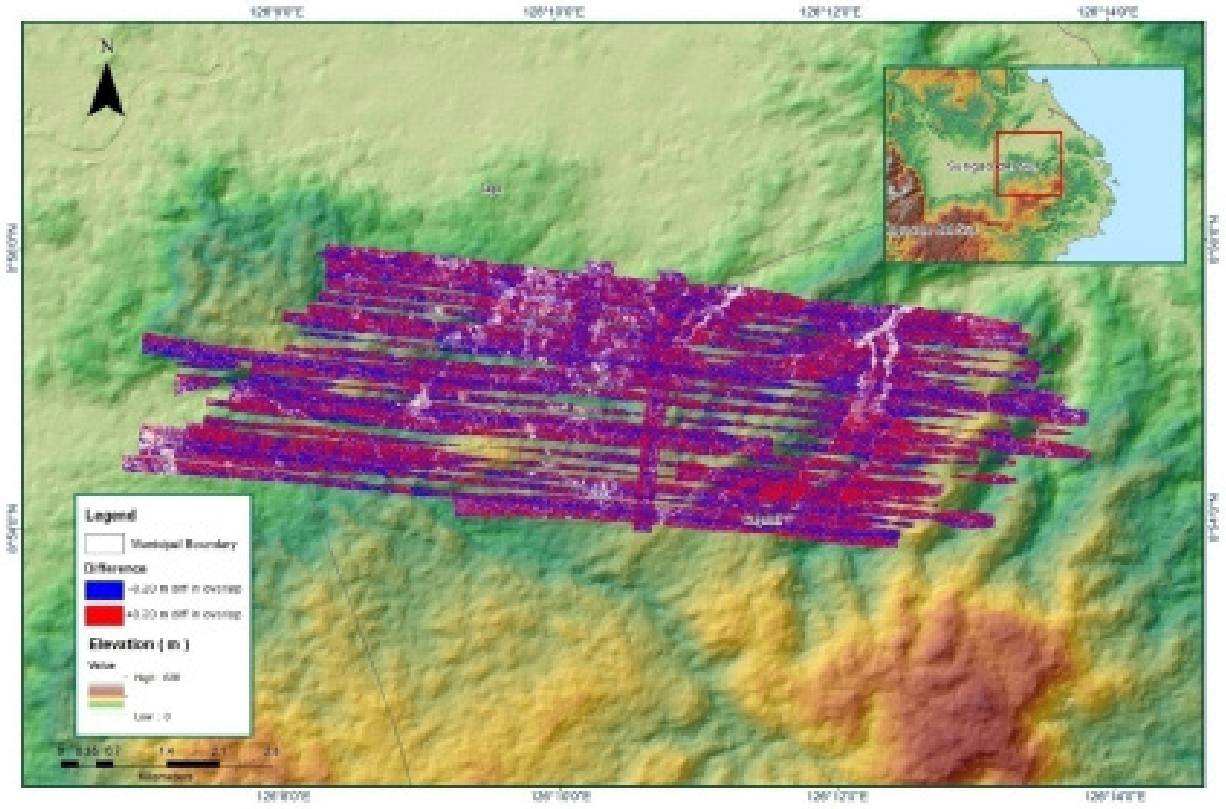


Figure 1.11.7 Elevation difference between flight lines

Flight Area	Tandag (Surigao Del Sur)
Mission Name	Block 61B
Inclusive Flights	1670A
Range data size	13.00 GB
Base data size	8.58 MB
POS	241 MB
Image	6.28 MB
Transfer date	July 23, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	2.50
RMSE for East Position (<4.0 cm)	3.10
RMSE for Down Position (<8.0 cm)	3.00
Boresight correction stdev (<0.001deg)	0.000449
IMU attitude correction stdev (<0.001deg)	0.001114
GPS position stdev (<0.01m)	0.0023
Minimum % overlap (>25)	56.75
Ave point cloud density per sq.m. (>2.0)	3.49
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	143
Maximum Height	527.31 m
Minimum Height	61.67 m
Classification (# of points)	
Ground	71,379,929
Low vegetation	49,277,234
Medium vegetation	45,969,458
High vegetation	118,976,653
Building	3,318,983
Orthophoto	YES
Processed by	Engr. Irish Cortez, Engr. Christy Lubiano, Engr. Melissa Fernandez

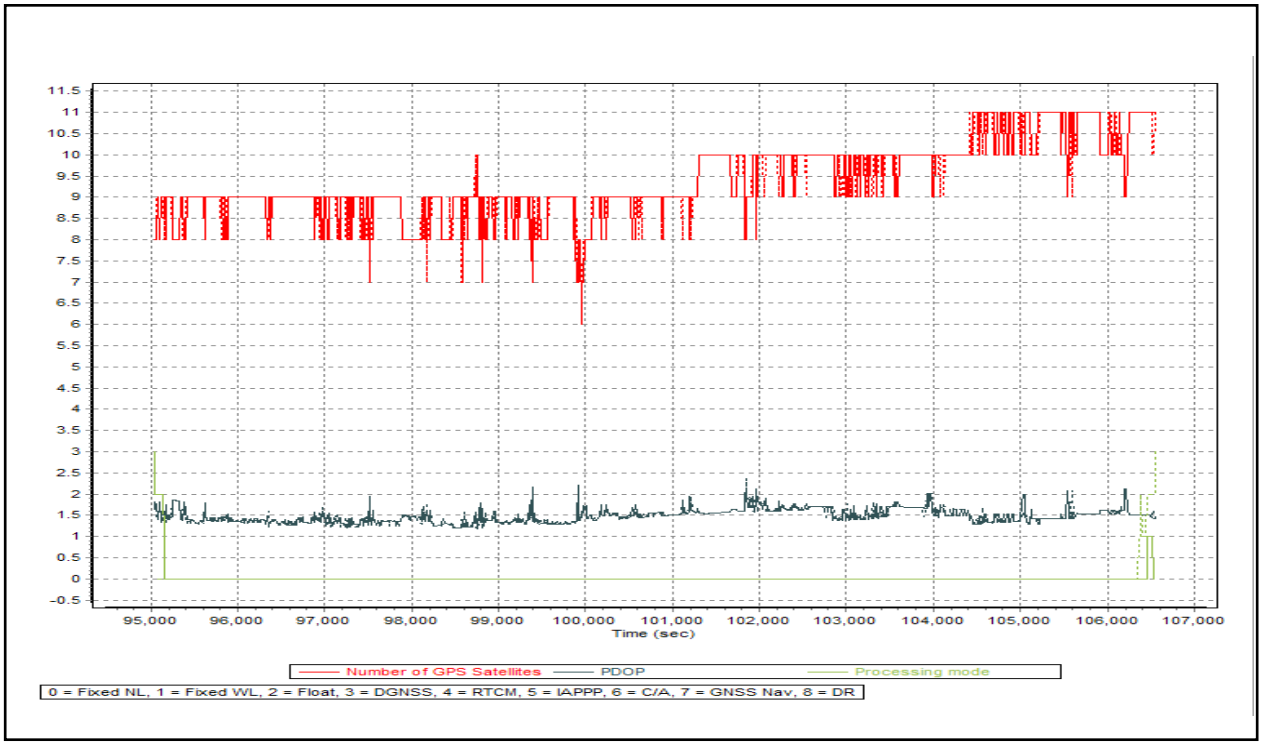


Figure 1.12.1 Solution Status

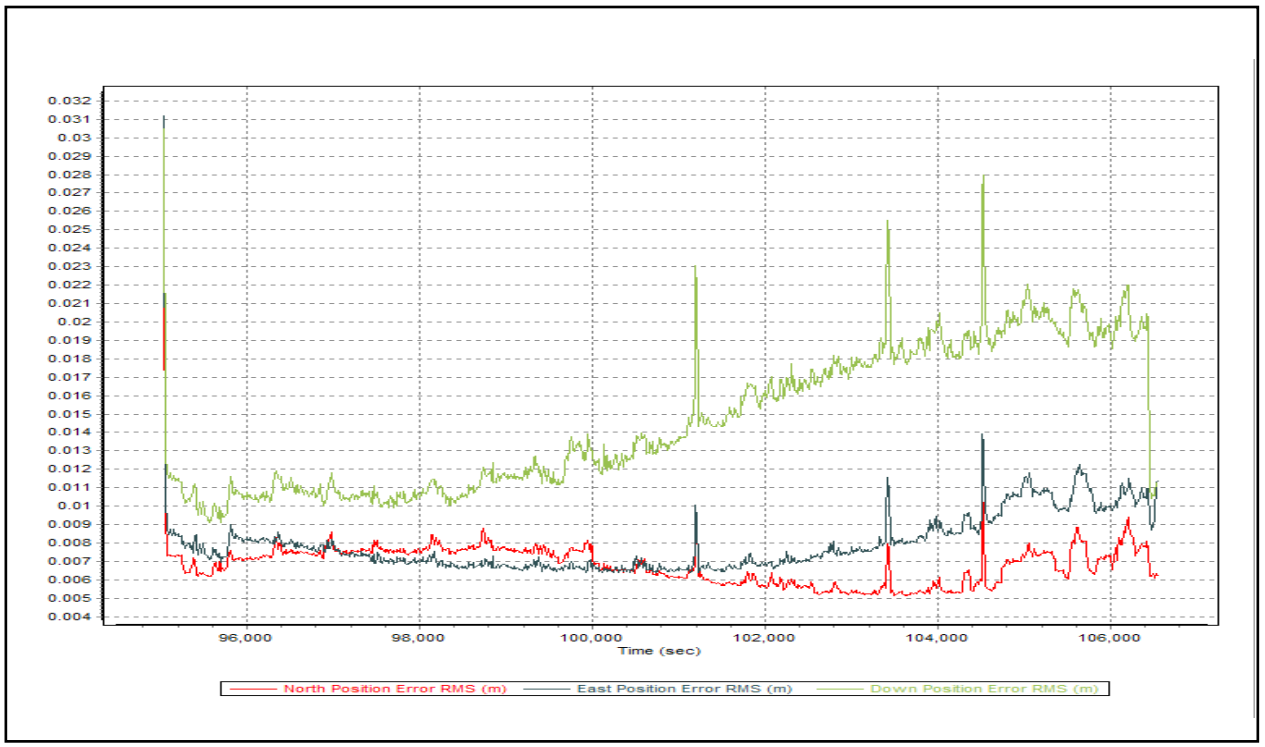


Figure 1.12.2 Smoothed Performance Metric Parameters

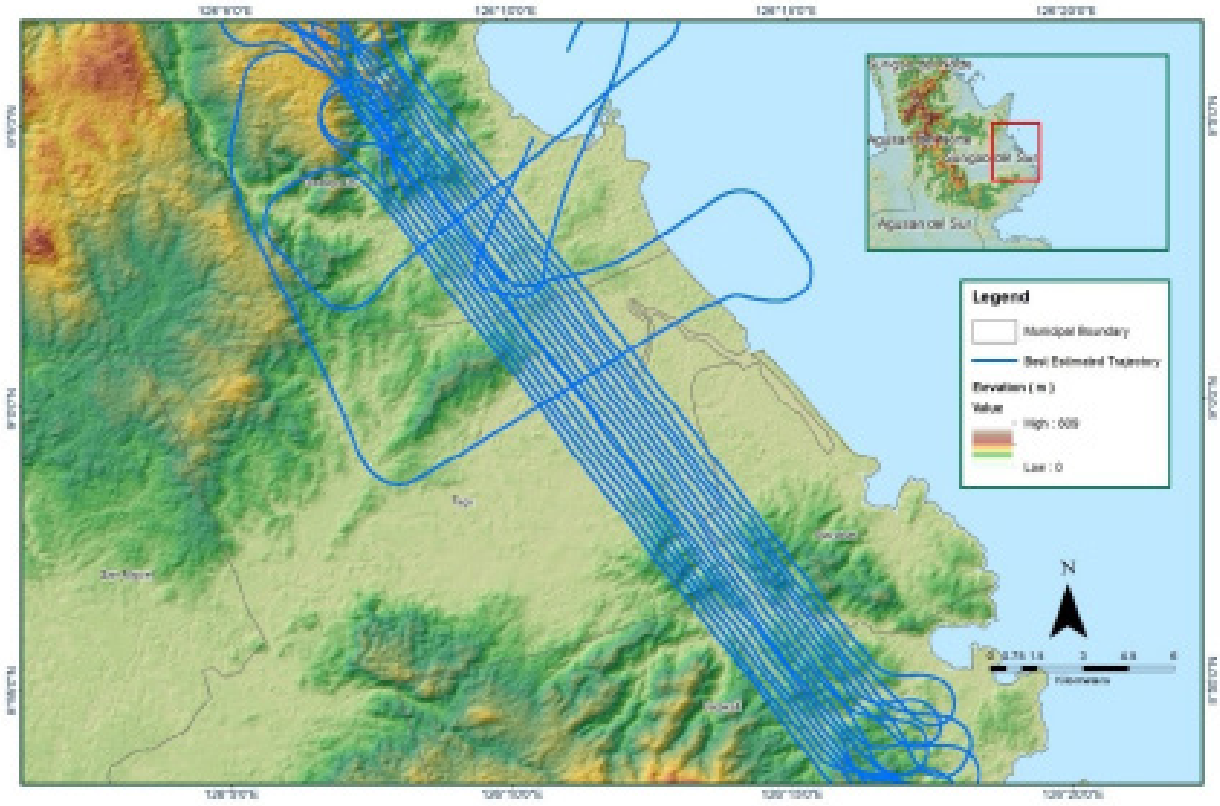


Figure 1.12.3 Best Estimated Trajectory

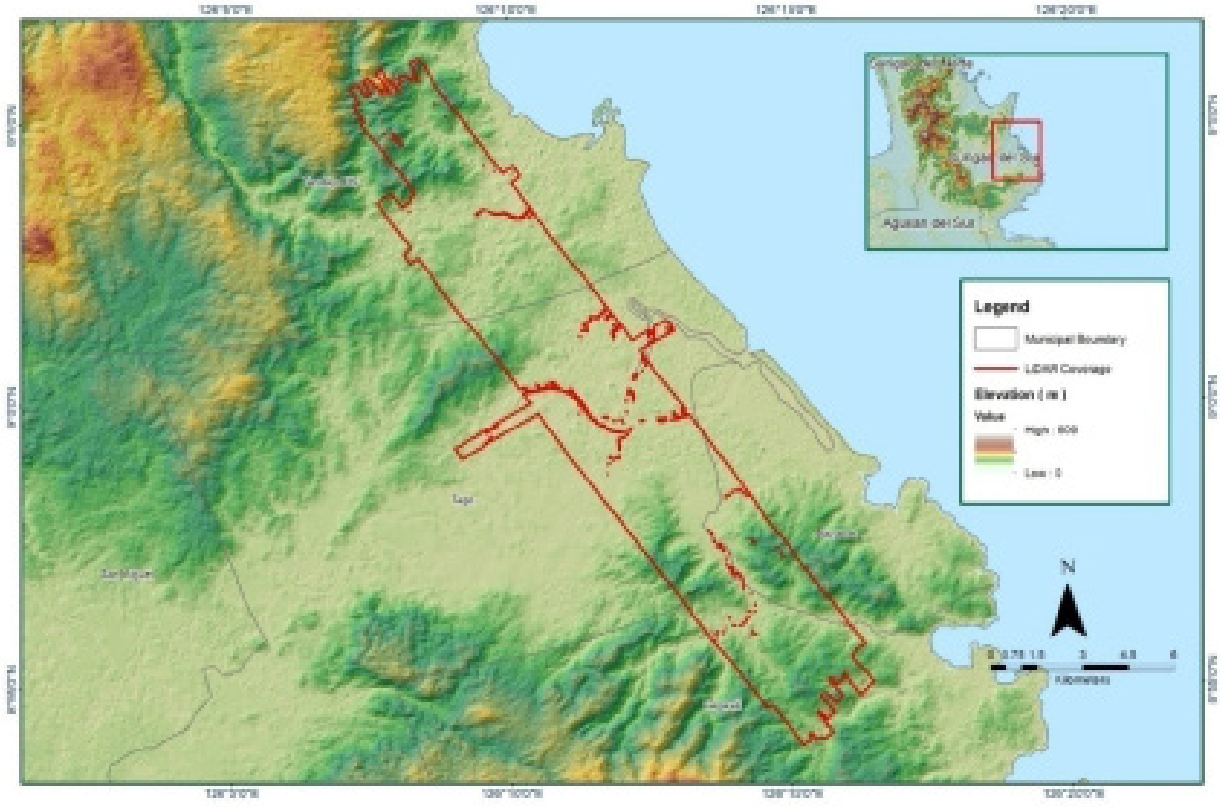


Figure 1.12.4 Coverage of LiDAR data

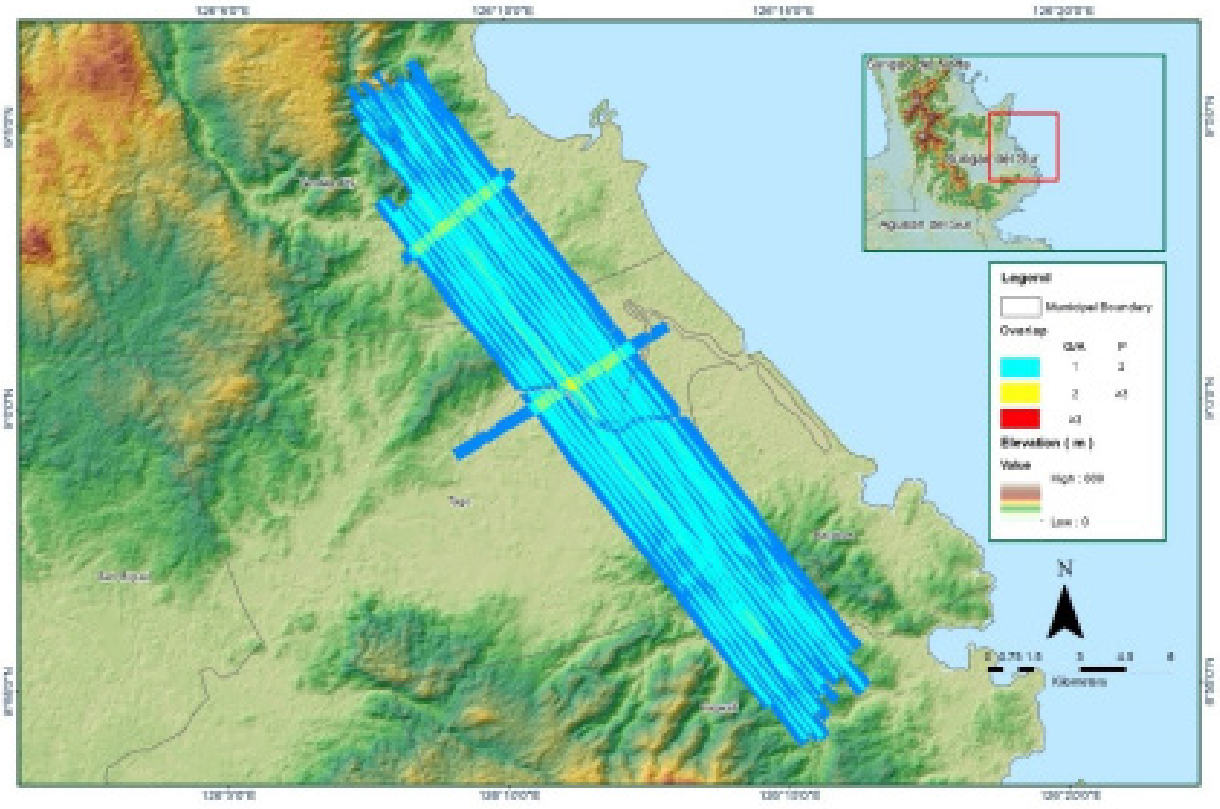


Figure 1.12.5 Image of data overlap

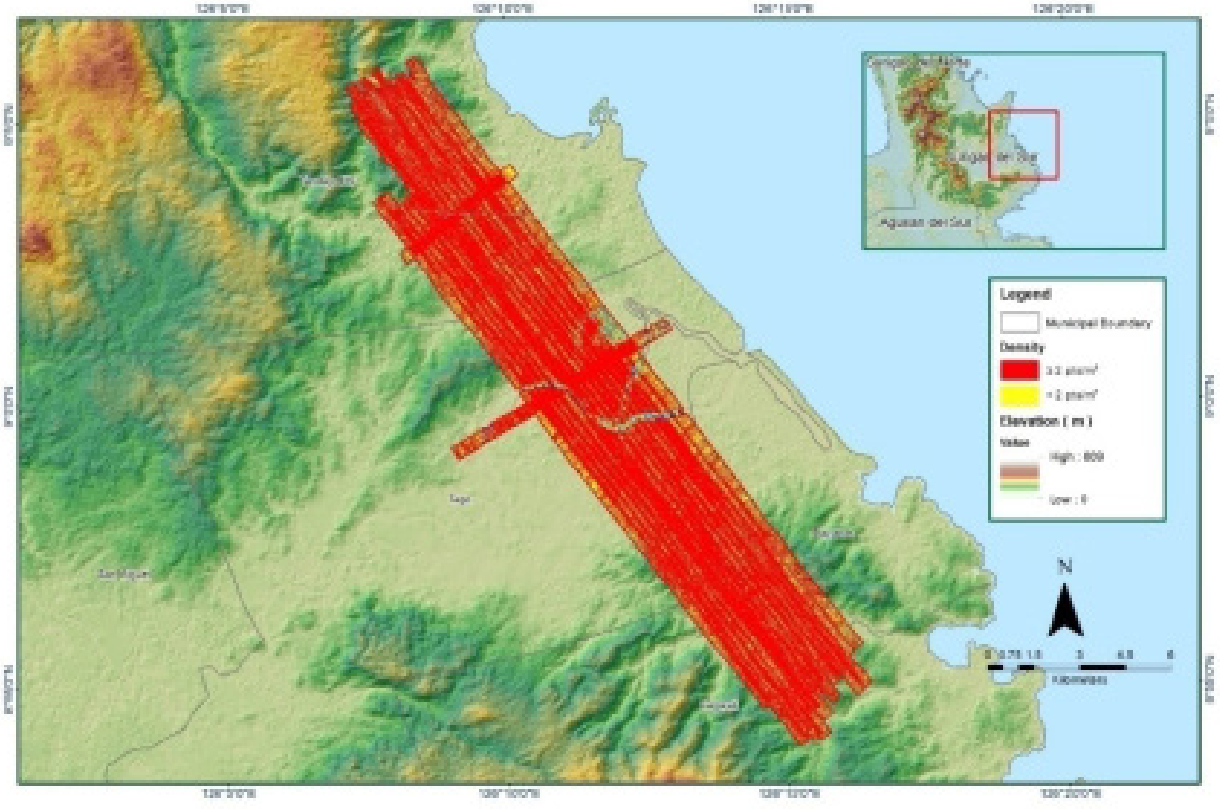


Figure 1.12.6 Density map of merged LiDAR data

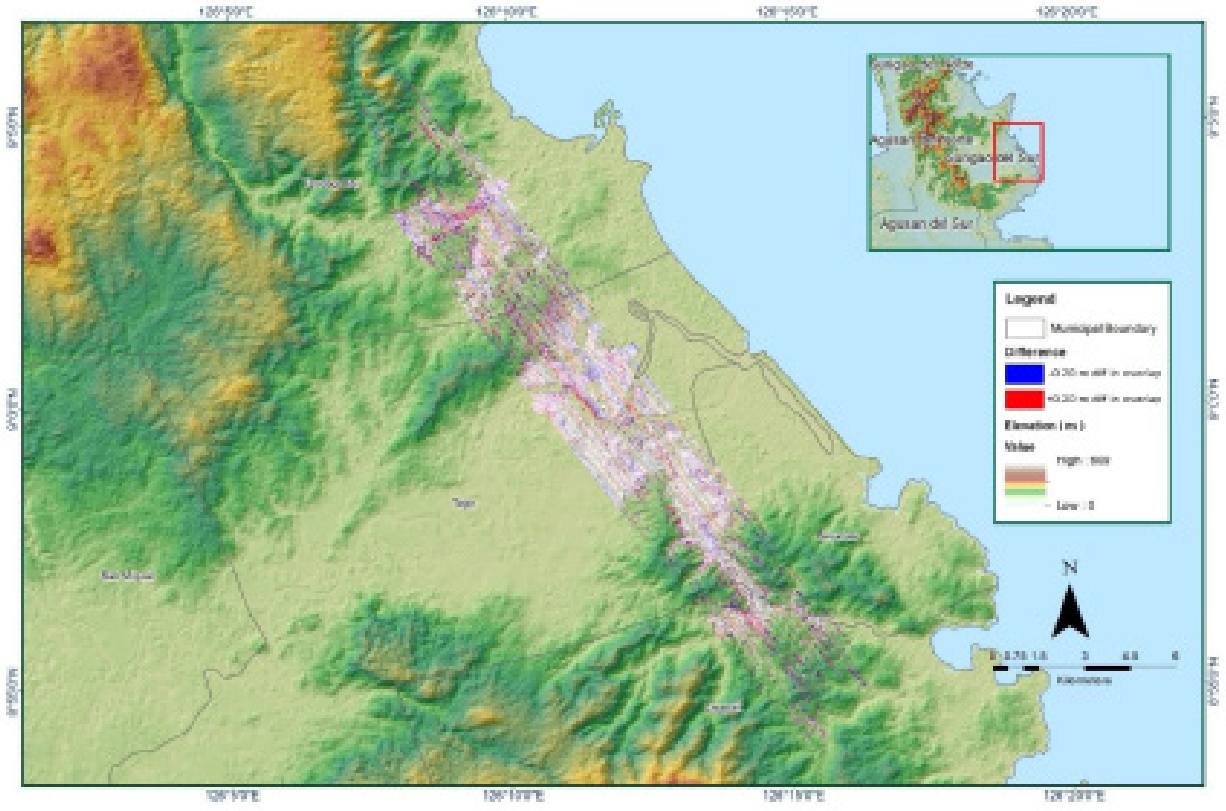


Figure 1.12.7Elevation difference between flight lines

Flight Area	Tandag (Surigao Del Sur)
Mission Name	Block 61A
Inclusive Flights	1664A & 1666A
Range data size	17.19 GB
Base data size	16.27 MB
POS	336 MB
Image	74.80 MB
Transfer date	July 23, 2014
Solution Status	
Number of Satellites (>6)	No
PDOP (<3)	No
Baseline Length (<30km)	Yes
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	6.00
RMSE for East Position (<4.0 cm)	5.00
RMSE for Down Position (<8.0 cm)	10.50
Boresight correction stdev (<0.001deg)	0.000668
IMU attitude correction stdev (<0.001deg)	0.012522
GPS position stdev (<0.01m)	0.0190
Minimum % overlap (>25)	47.47
Ave point cloud density per sq.m. (>2.0)	4.01
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	152
Maximum Height	391.02 m
Minimum Height	55.44 m
Classification (# of points)	
Ground	41,603,699
Low vegetation	52,174,302
Medium vegetation	70,177,534
High vegetation	113,371,103
Building	4,387,894
Orthophoto	YES
Processed by	Engr. Analyn Naldo, Engr. Chelou Prado, Engr. Jeffrey Delica

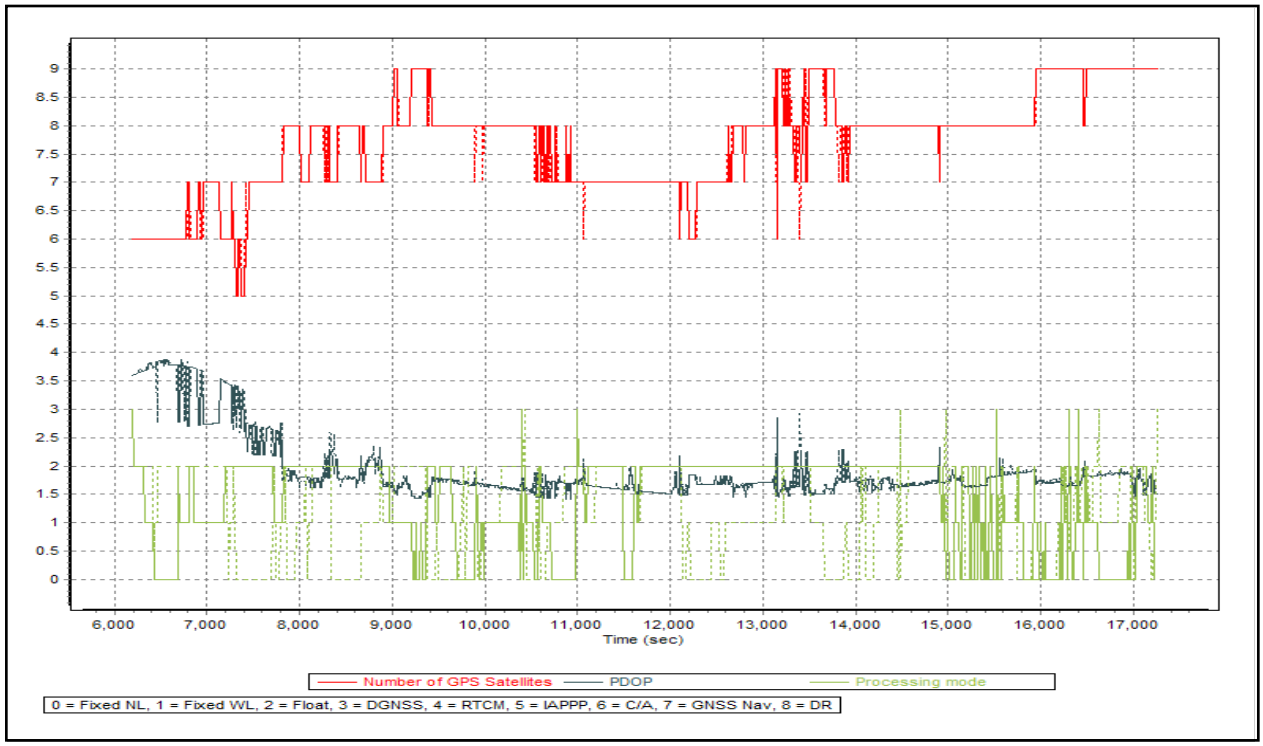


Figure 1.13.1 Solution Status

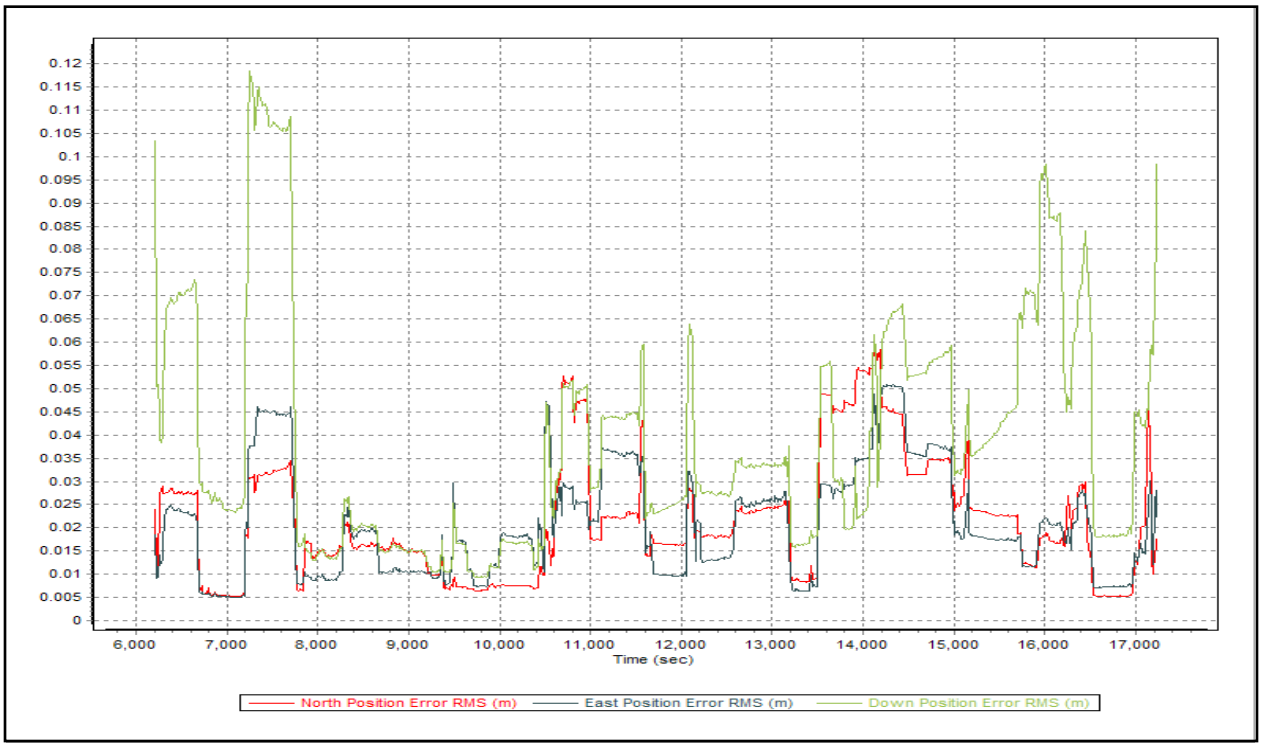


Figure 1.13.2 Smoothed Performance Metric Parameters

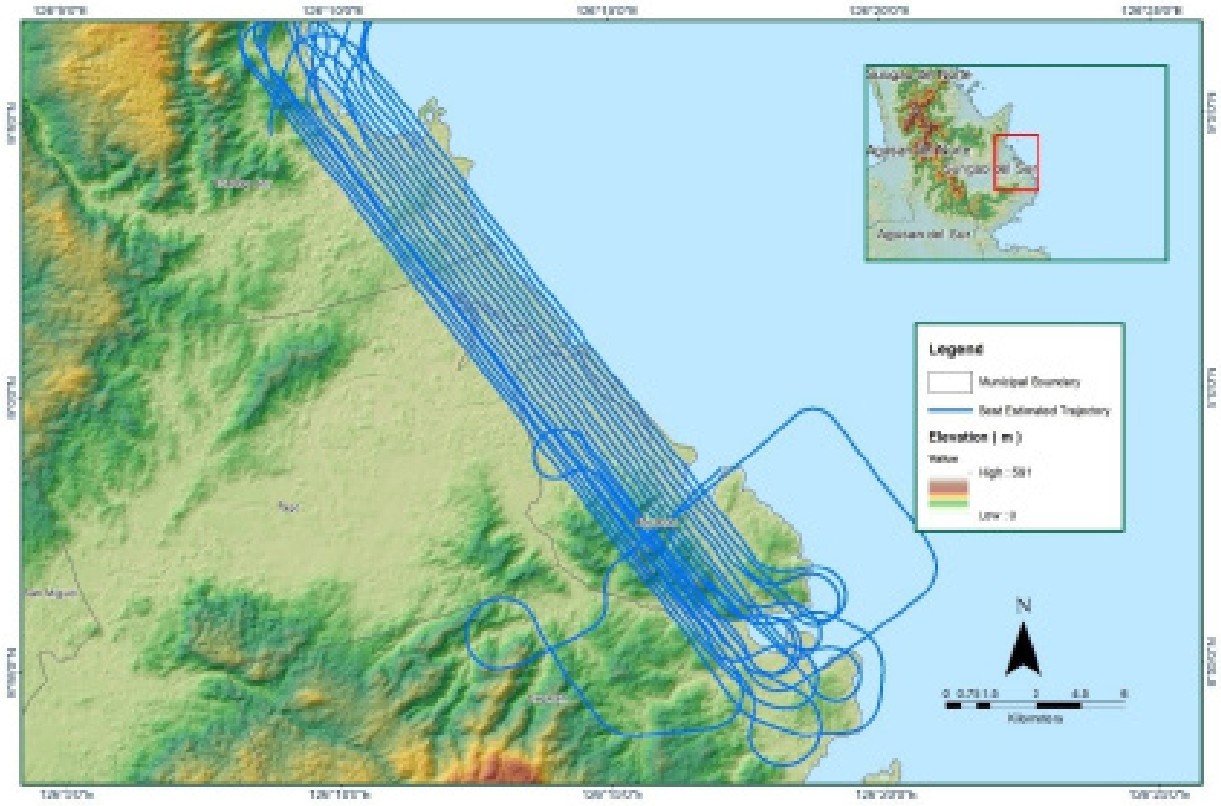


Figure 1.13.3 Best Estimated Trajectory

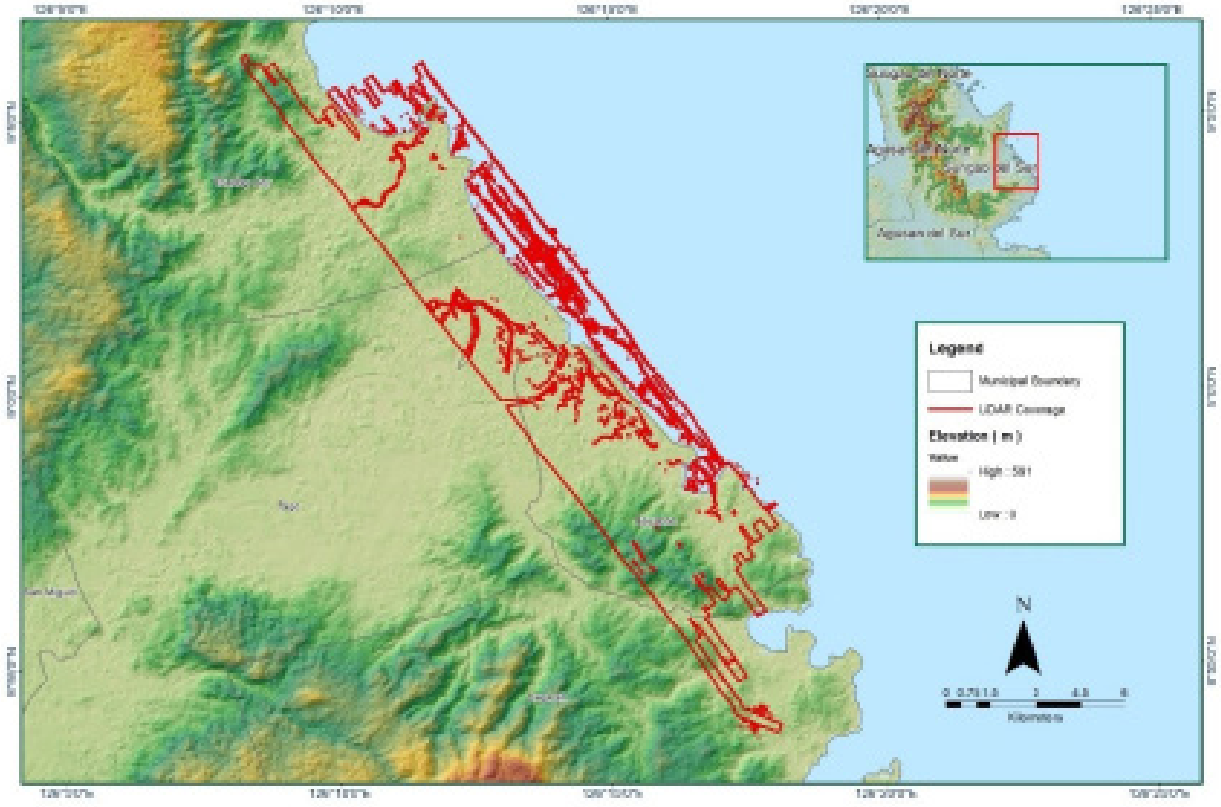


Figure 1.13.4 Coverage of LiDAR data

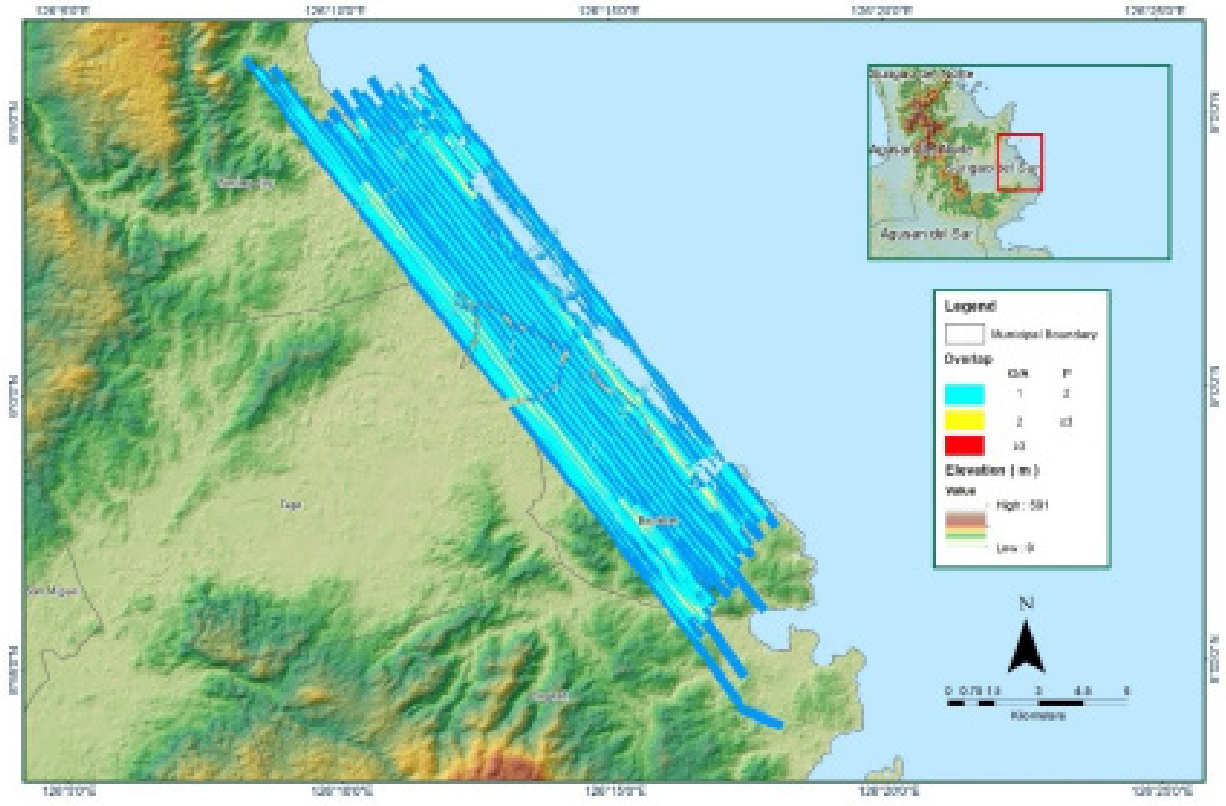


Figure 1.13.5 Image of data overlap

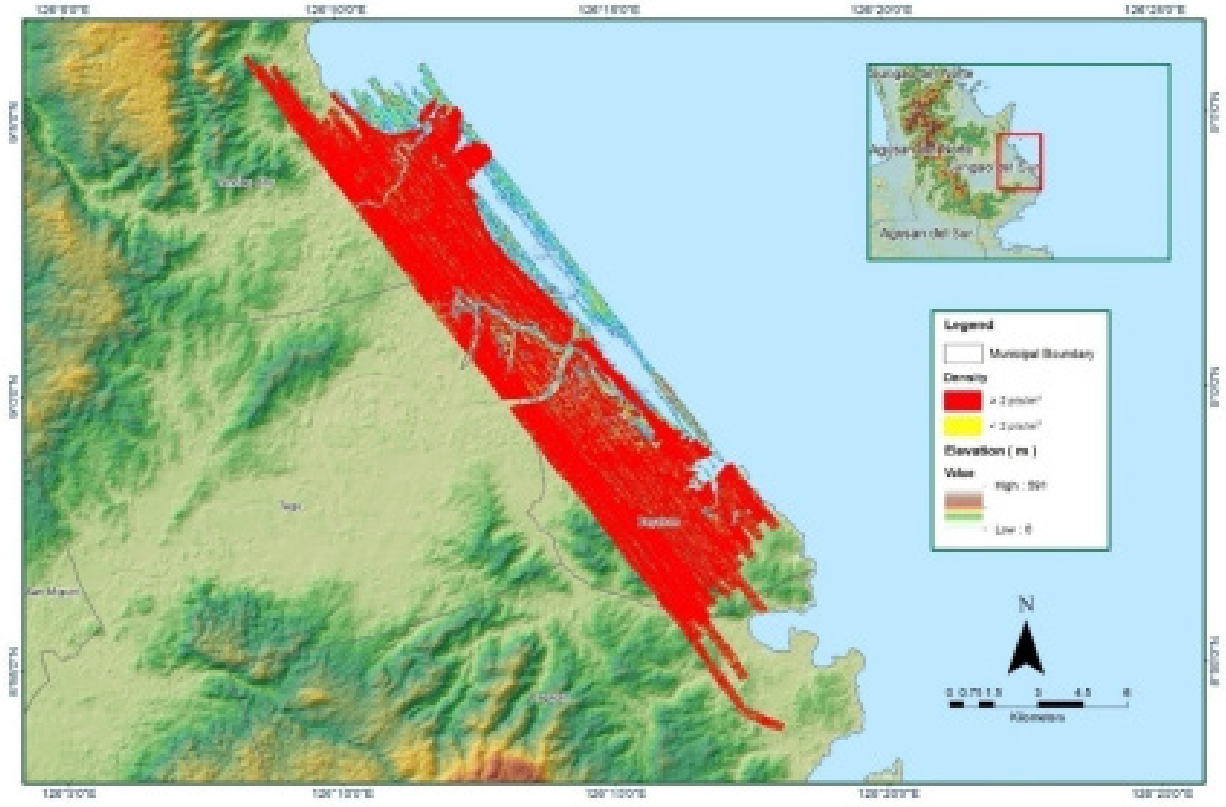


Figure 1.13.6 Density map of merged LiDAR data

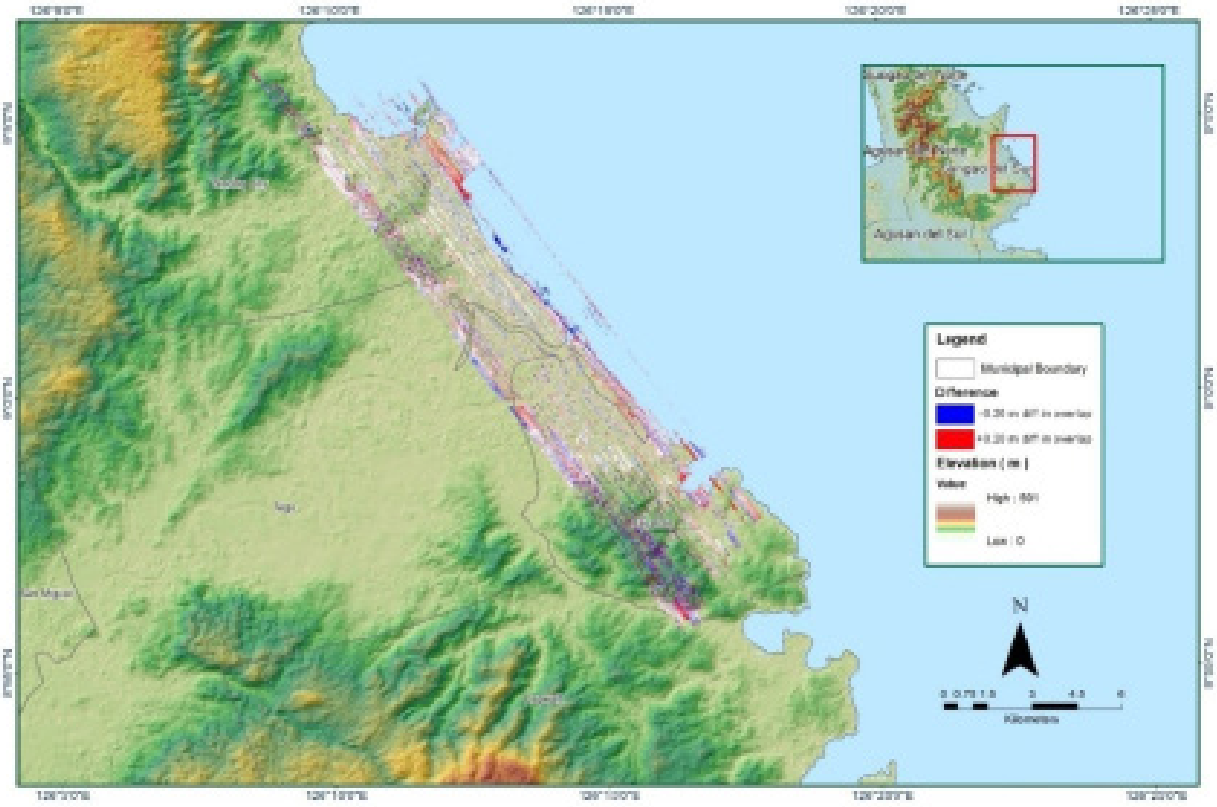


Figure 1.13.7 Elevation difference between flight lines

Flight Area	Tandag (Surigao Del Sur)
Mission Name	Block 61CD
Inclusive Flights	1674A &1678A
Range data size	22.69 GB
Base data size	17.94 MB
POS	395 MB
Image	37.90 MB
Transfer date	July 23, 2014 & August 6, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.50
RMSE for East Position (<4.0 cm)	1.85
RMSE for Down Position (<8.0 cm)	2.70
Boresight correction stdev (<0.001deg)	0.000606
IMU attitude correction stdev (<0.001deg)	0.005630
GPS position stdev (<0.01m)	0.0085
Minimum % overlap (>25)	68.11
Ave point cloud density per sq.m. (>2.0)	4.48
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	151
Maximum Height	437.79 m
Minimum Height	63.78 m
Classification (# of points)	
Ground	46,043,085
Low vegetation	71,460,073
Medium vegetation	73,450,888
High vegetation	178,625,360
Building	8,063,567
Orthophoto	YES
Processed by	Engr. Jommer Medina, Engr. Melanie Hingpit, Engr. Elainne Lopez

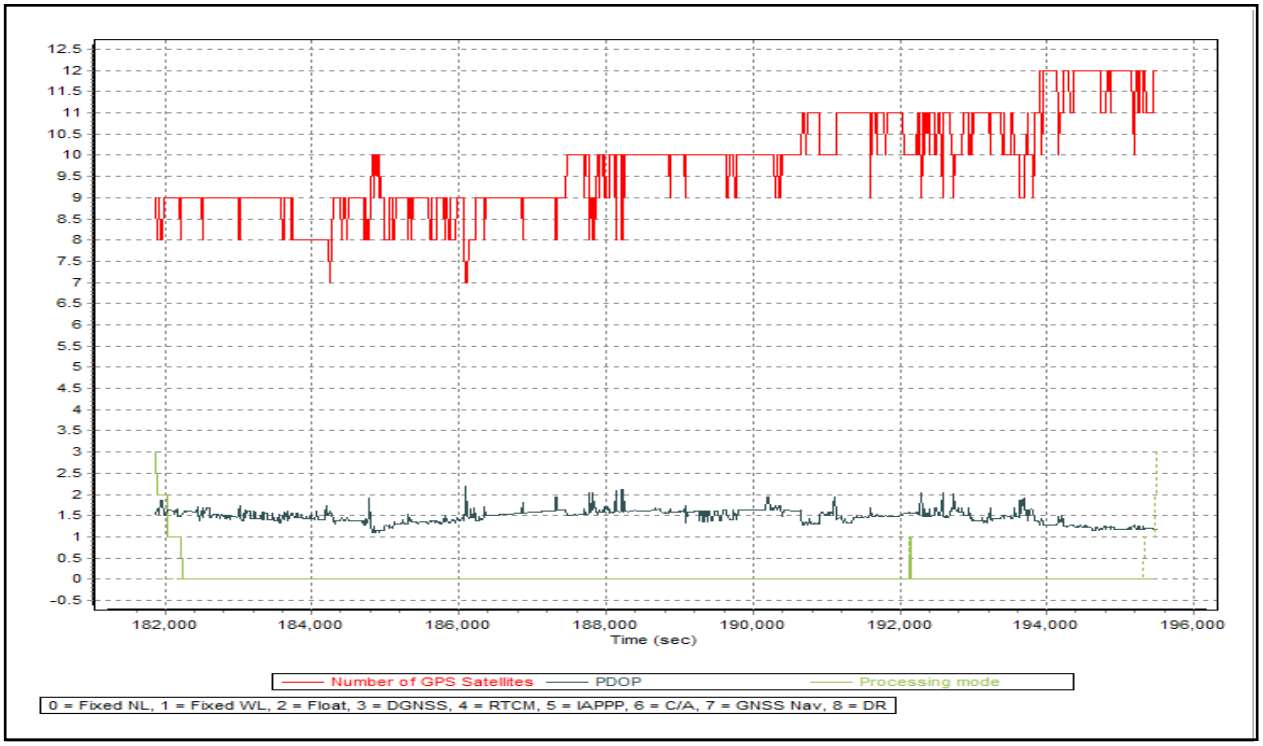


Figure 1.14.1 Solution Status

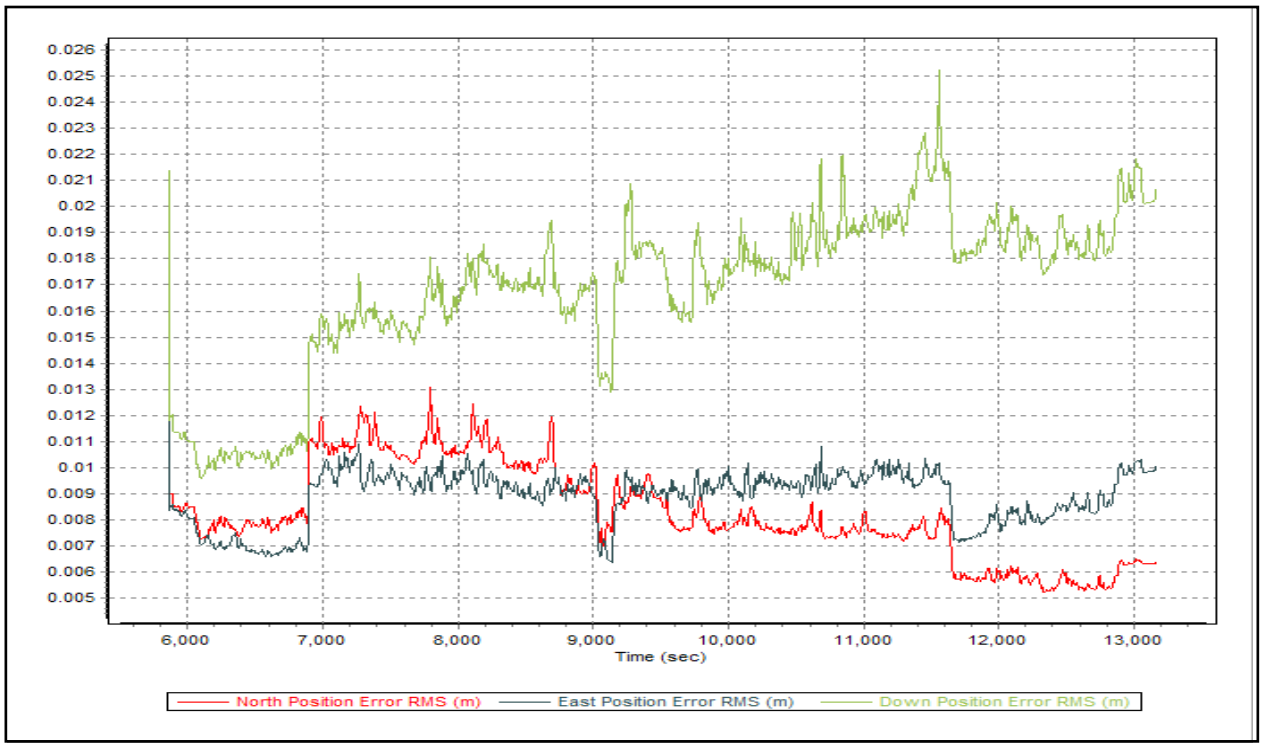


Figure 1.14.2 Smoothed Performance Metric Parameters

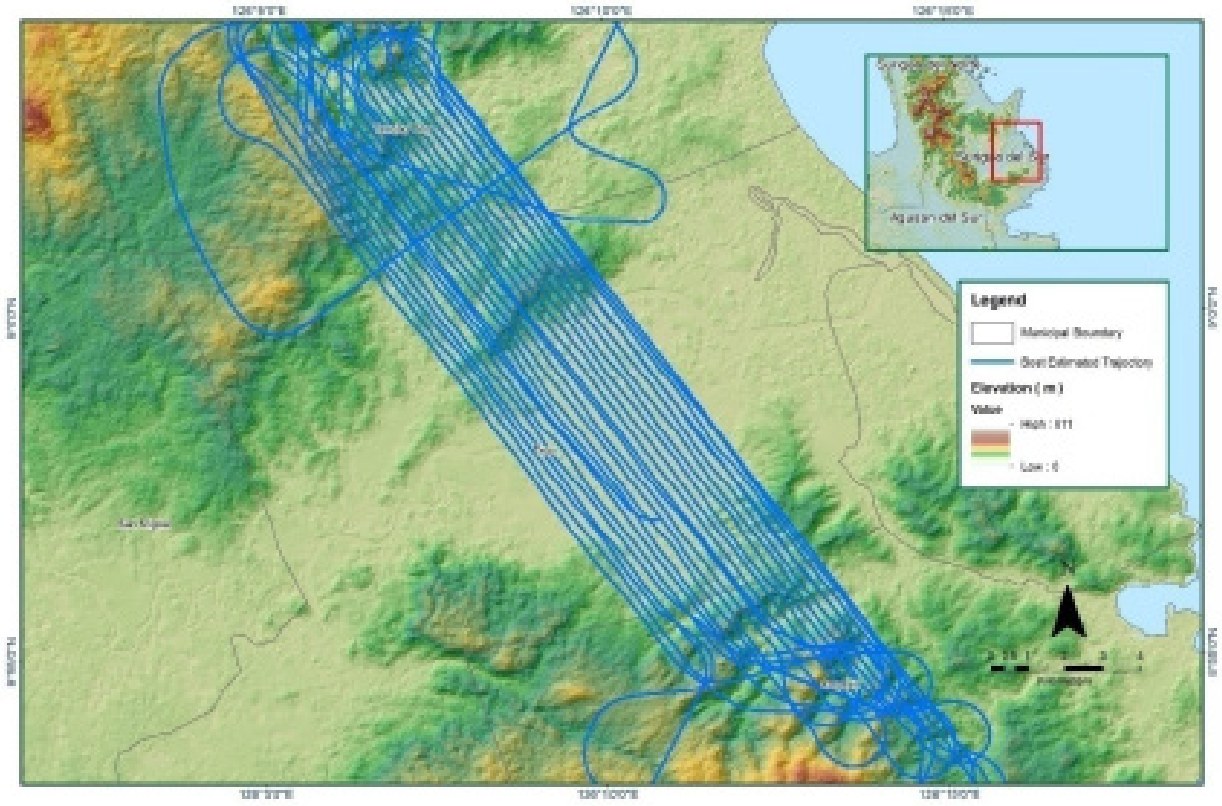


Figure 1.14.3 Best Estimated Trajectory

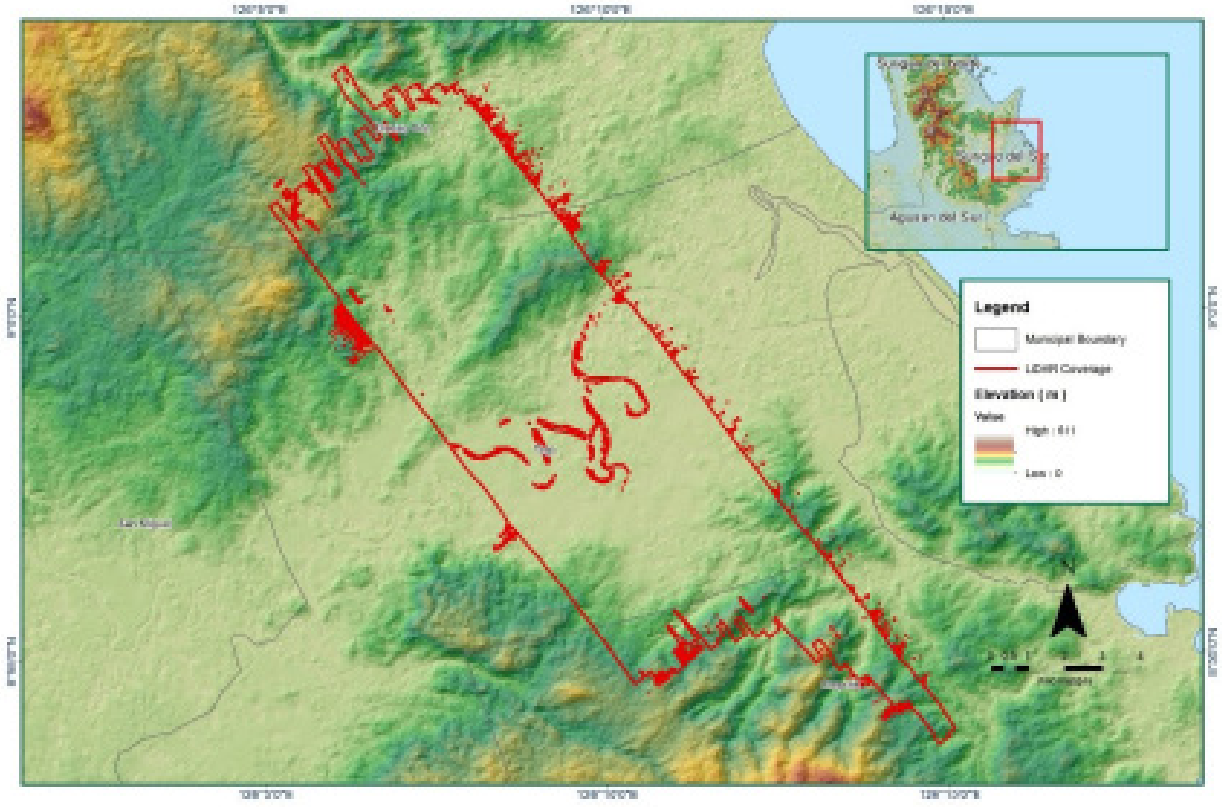


Figure 1.14.4 Coverage of LiDAR data

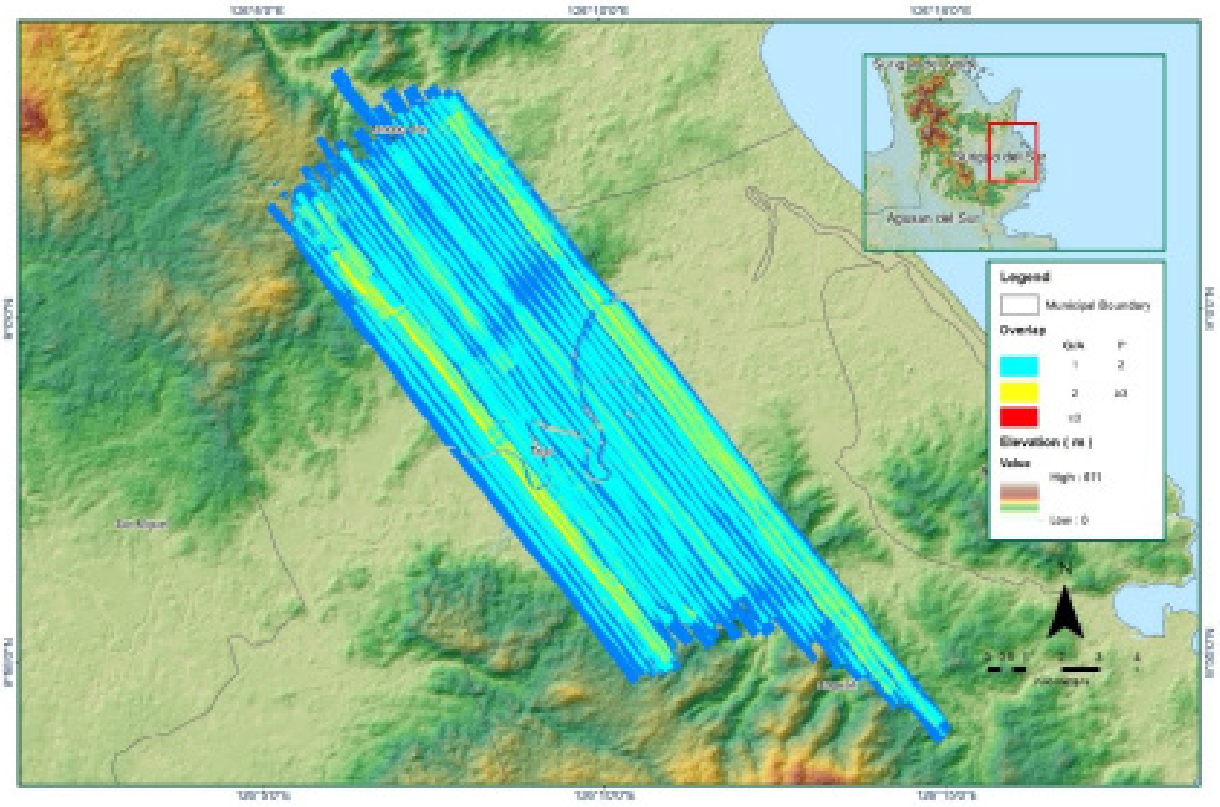


Figure 1.14.5 Image of data overlap

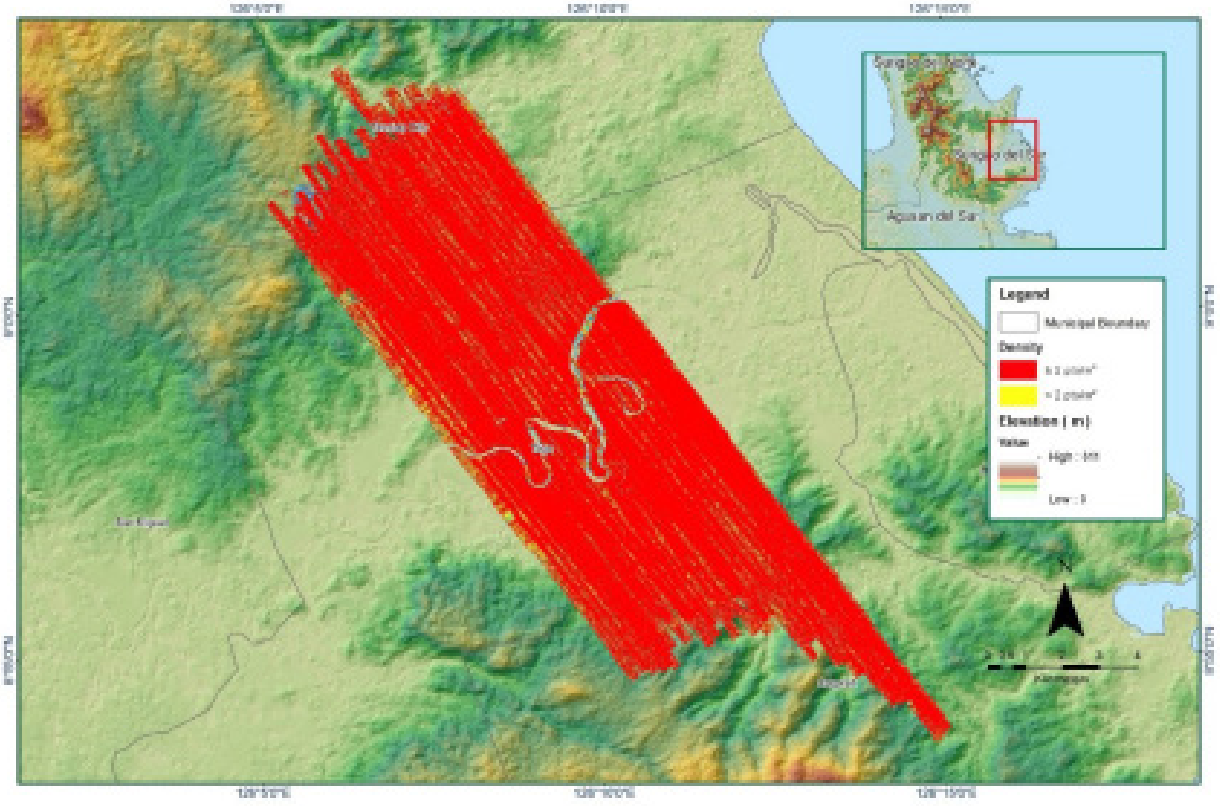


Figure 1.14.6 Density map of merged LiDAR data

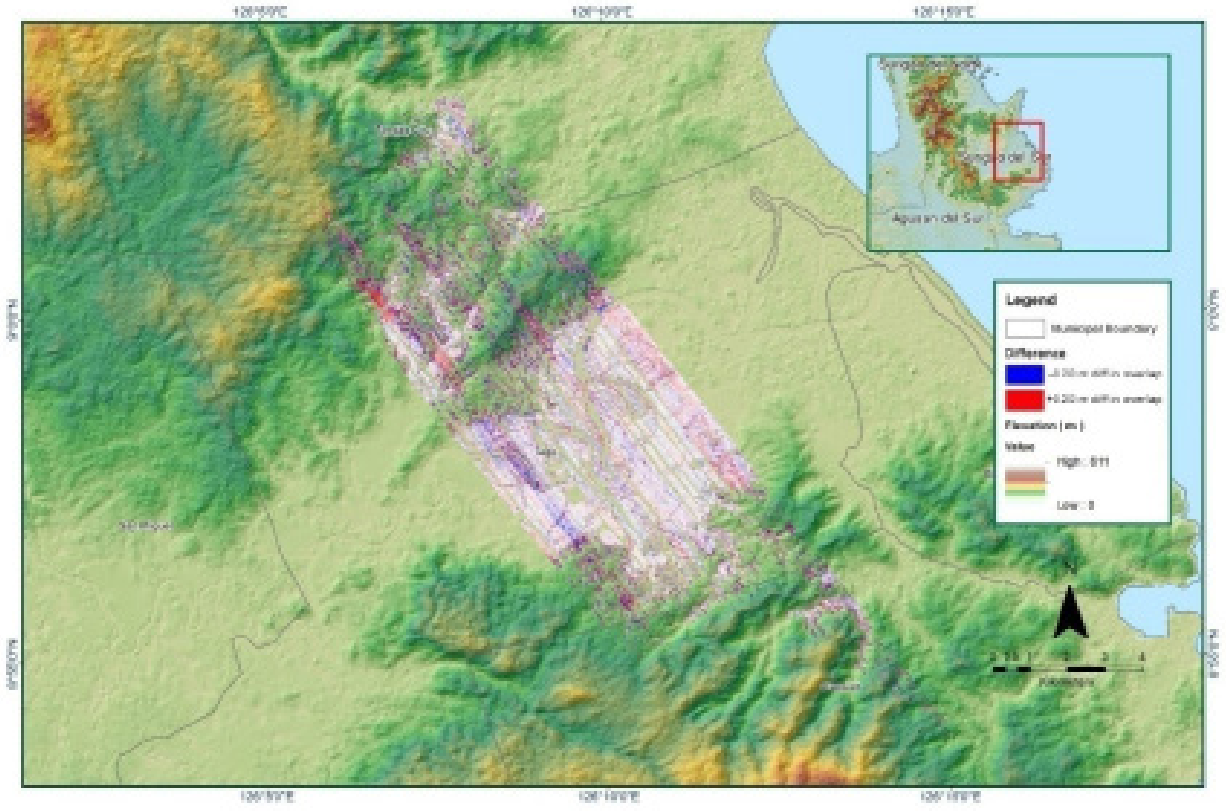


Figure 1.14.7 Elevation difference between flight lines

Flight Area	Tandag (Surigao Del Sur)
Mission Name	Block 61CD Additional
Inclusive Flights	1742A
Range data size	8.78 GB
POS	258 MB
Image	260 MB
Transfer date	September 1, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	2.00
RMSE for East Position (<4.0 cm)	2.10
RMSE for Down Position (<8.0 cm)	3.60
Boresight correction stdev (<0.001deg)	0.005403
IMU attitude correction stdev (<0.001deg)	0.009075
GPS position stdev (<0.01m)	0.0297
Minimum % overlap (>25)	NA
Ave point cloud density per sq.m. (>2.0)	2.53
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	6
Maximum Height	346.71 m
Minimum Height	119.91 m
Classification (# of points)	
Ground	31,216
Low vegetation	11,639
Medium vegetation	96,673
High vegetation	773,269
Building	1,724
Orthophoto	NO
Additional Remarks	Lasdiff and lasoverlap are not available on this block
Processed by	Engr. Jommer Medina, Engr. Antonio Chua Jr.

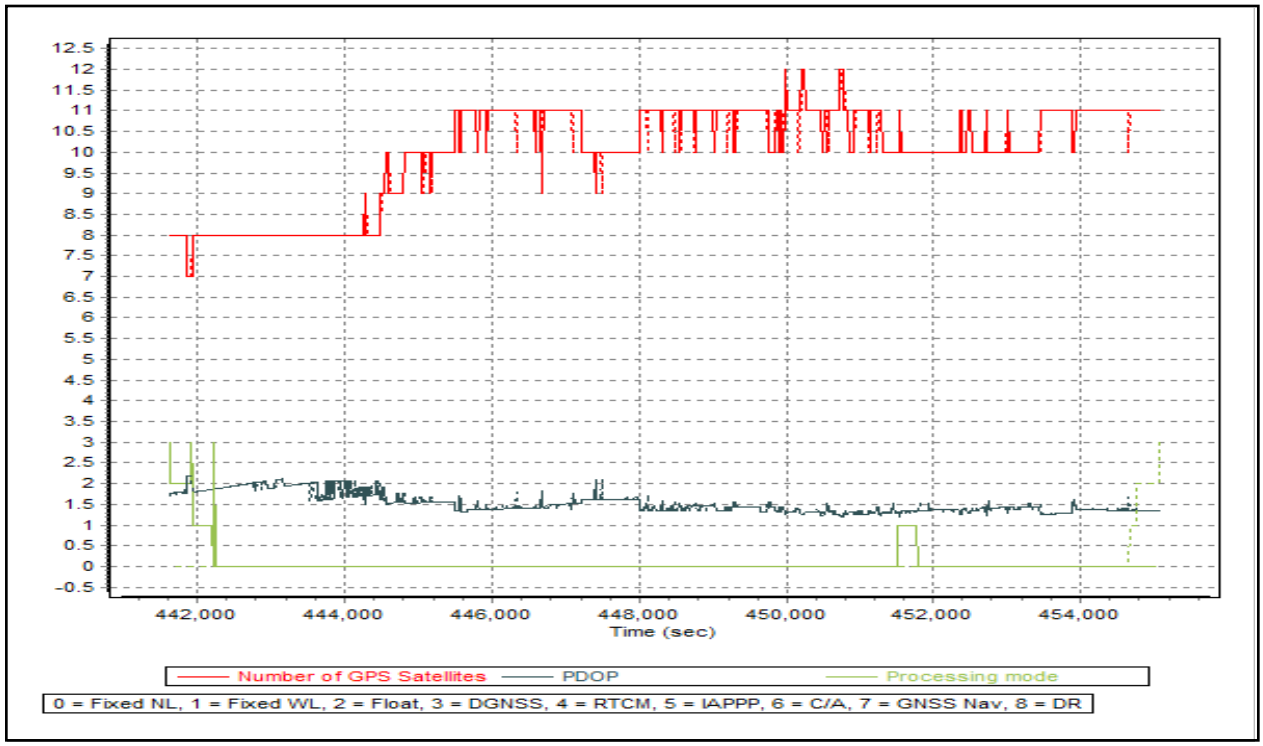


Figure 1.15.1 Solution Status

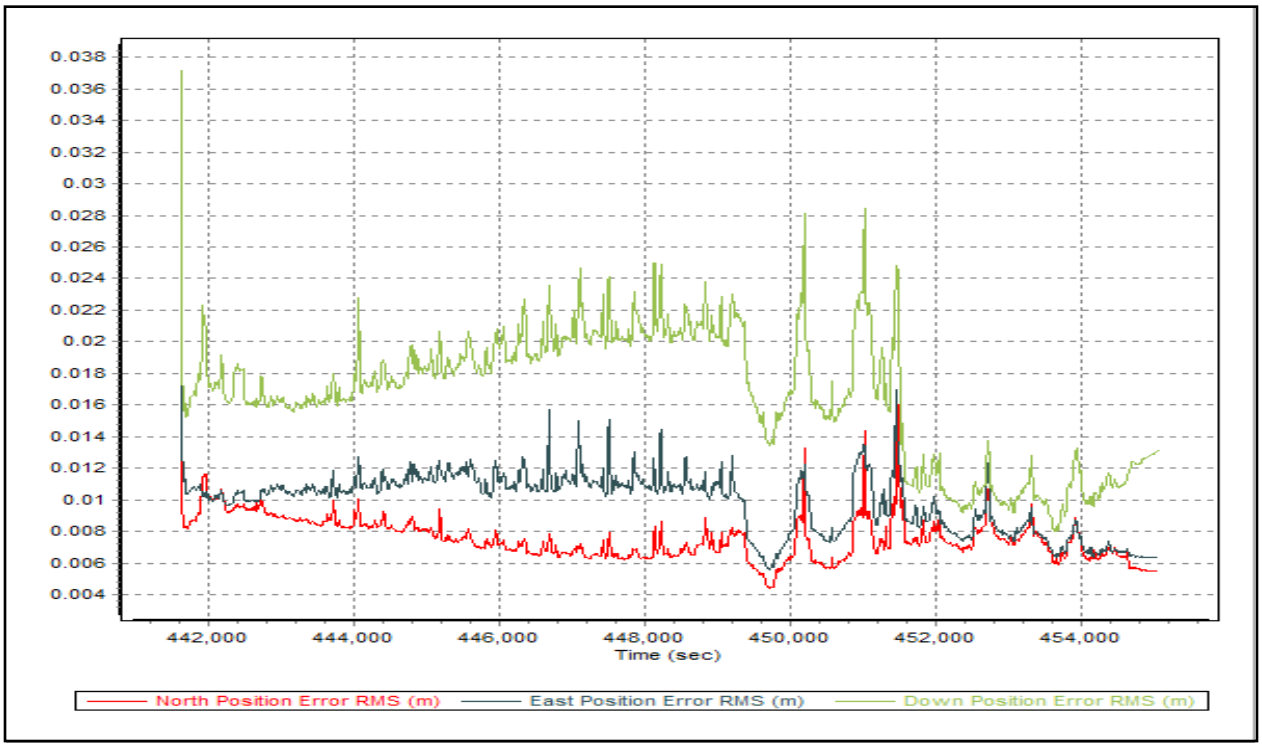


Figure 1.15.2 Smoothed Performance Metric Parameters

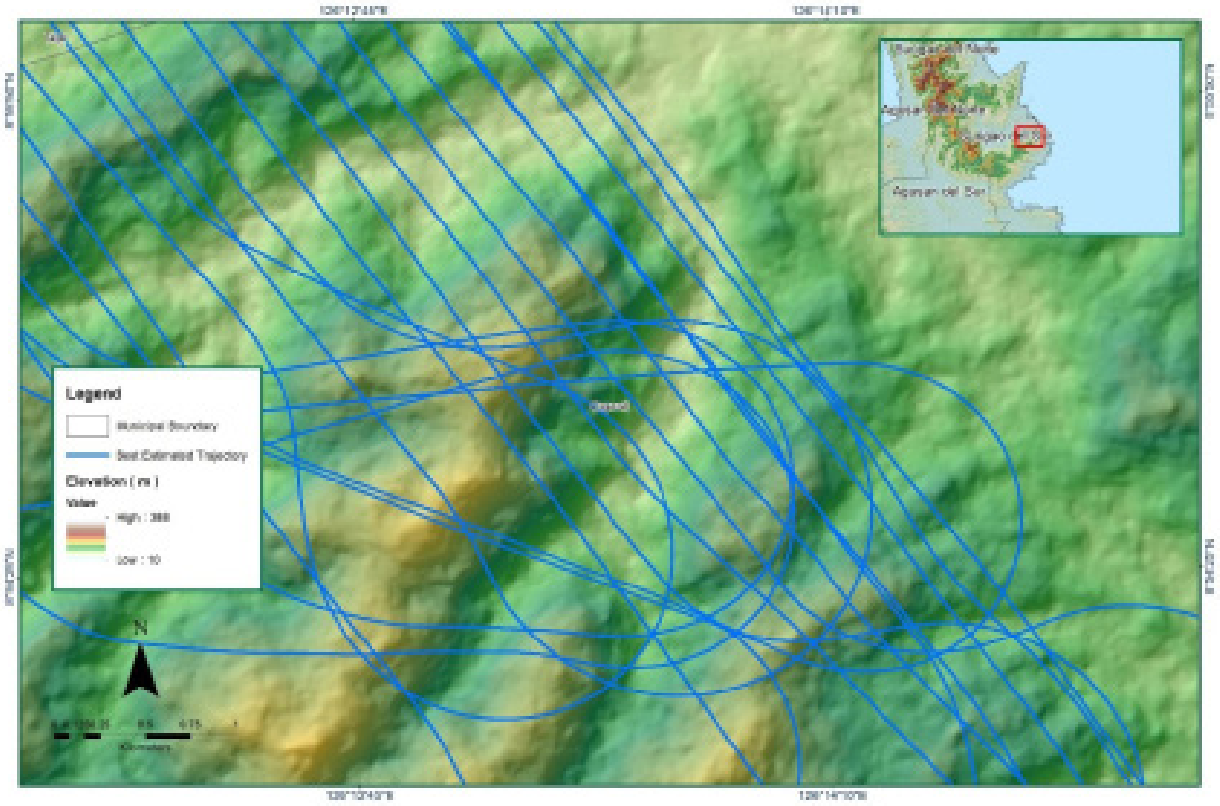


Figure 1.15.3 Best Estimated Trajectory

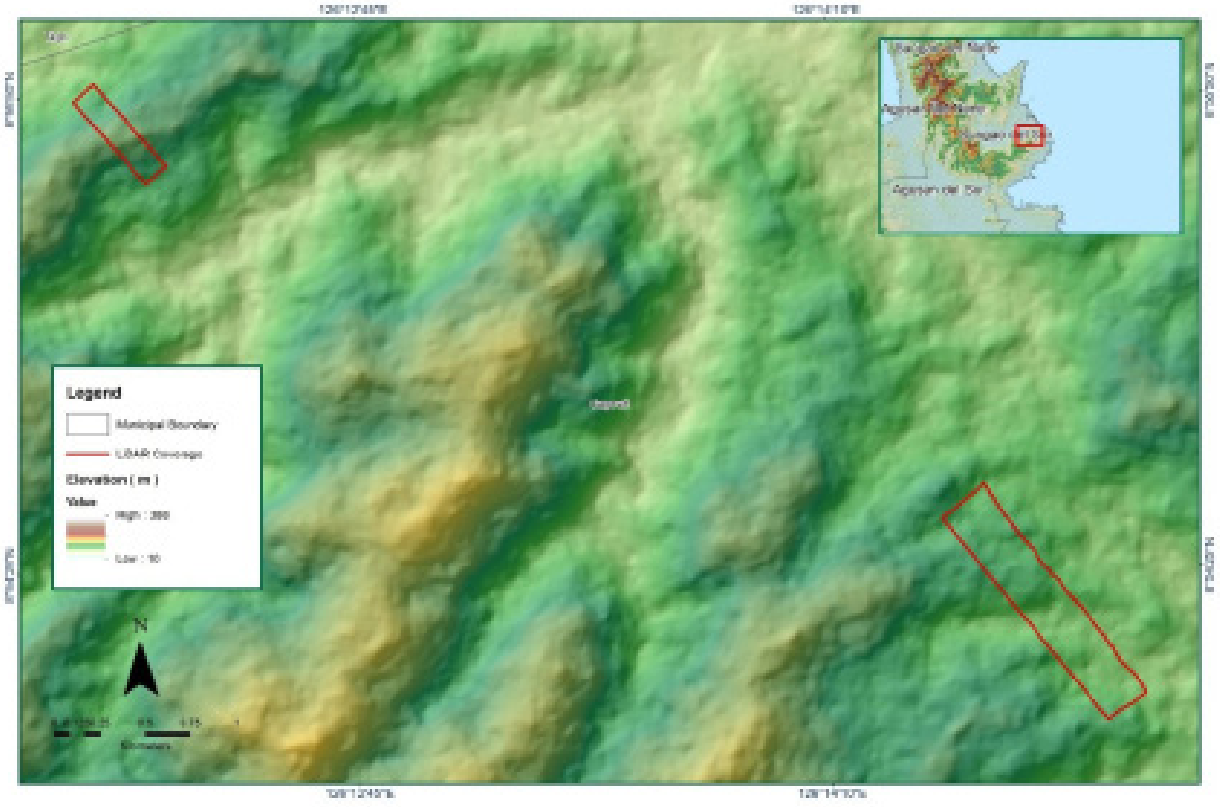


Figure 1.15.4 Coverage of LiDAR data

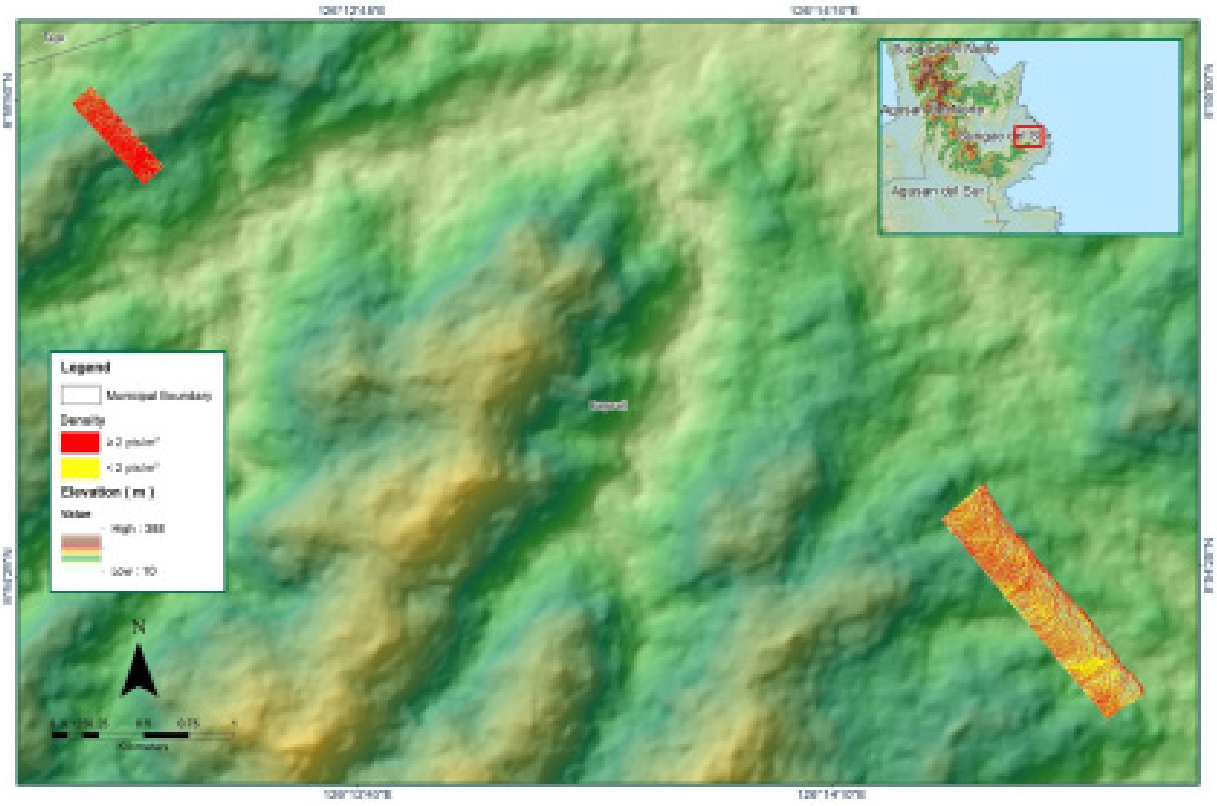


Figure 1.15.5 Image of data overlap

Flight Area	Tandag (Surigao Del Sur)
Mission Name	Block 61B
Inclusive Flights	1670A
Range data size	13.00 GB
POS	241 MB
Image	6.28 MB
Transfer date	July 23, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	2.50
RMSE for East Position (<4.0 cm)	3.10
RMSE for Down Position (<8.0 cm)	3.00
Boresight correction stdev (<0.001deg)	0.000449
IMU attitude correction stdev (<0.001deg)	0.001114
GPS position stdev (<0.01m)	0.0023
Minimum % overlap (>25)	56.75
Ave point cloud density per sq.m. (>2.0)	3.49
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	143
Maximum Height	527.31 m
Minimum Height	61.67 m
Classification (# of points)	
Ground	71,379,929
Low vegetation	49,277,234
Medium vegetation	45,969,458
High vegetation	118,976,653
Building	3,318,983
Orthophoto	YES
Processed by	Engr. Jennifer Saguran

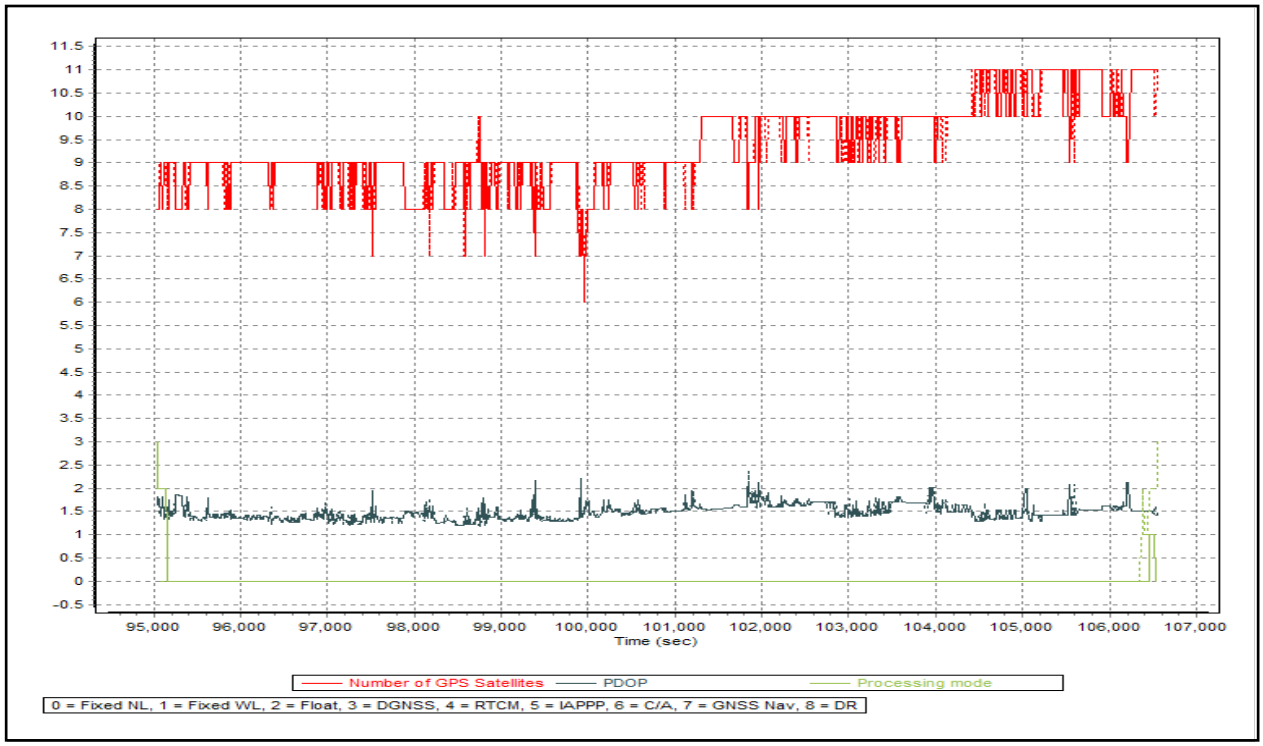


Figure 1.16.1 Solution Status

Figure 1.16.2 Smoothed Performance Metric Parameters

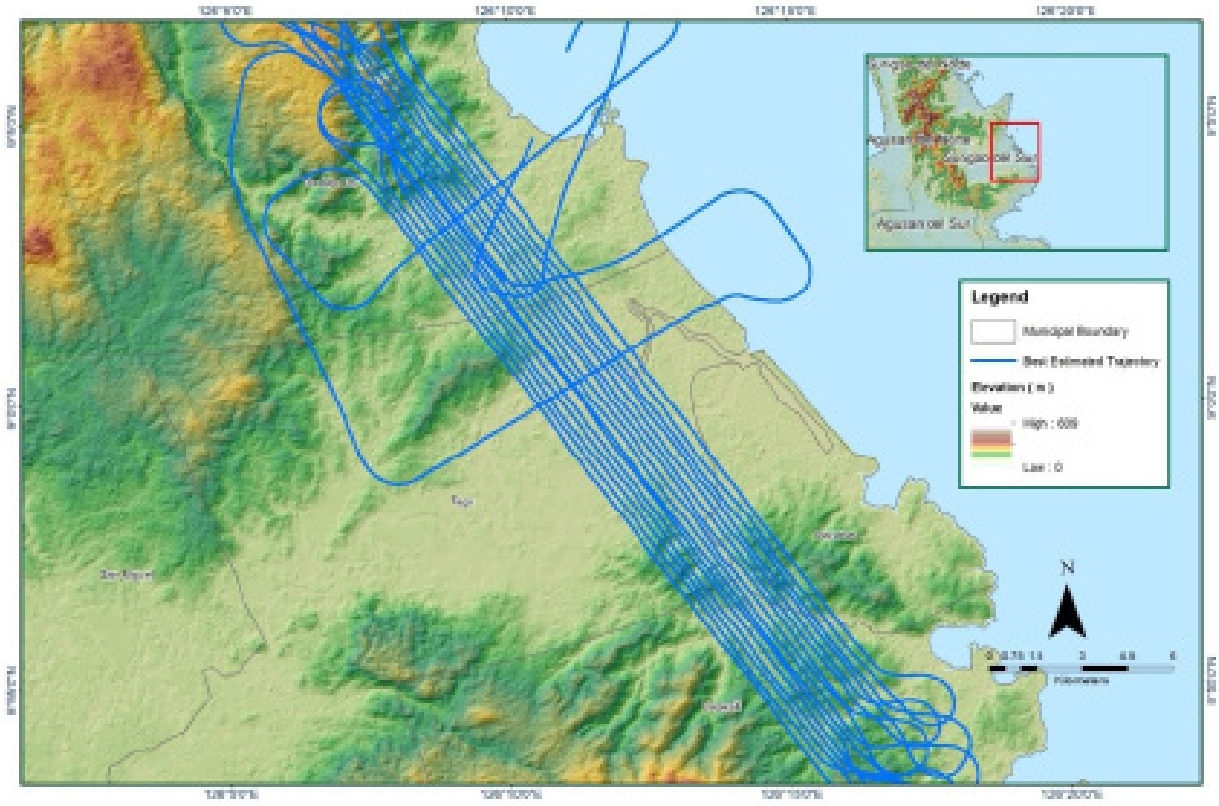


Figure 1.16.3 Best Estimated Trajectory

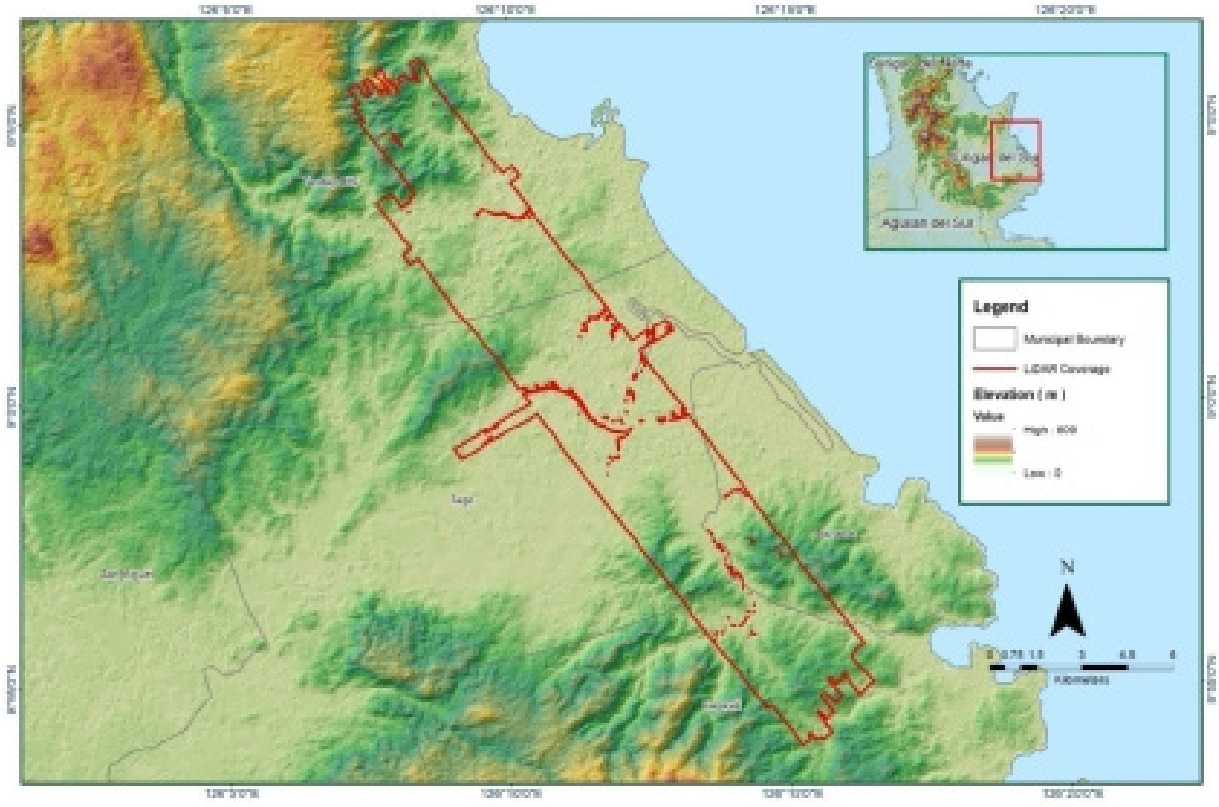


Figure 1.16.4 Coverage of LiDAR data

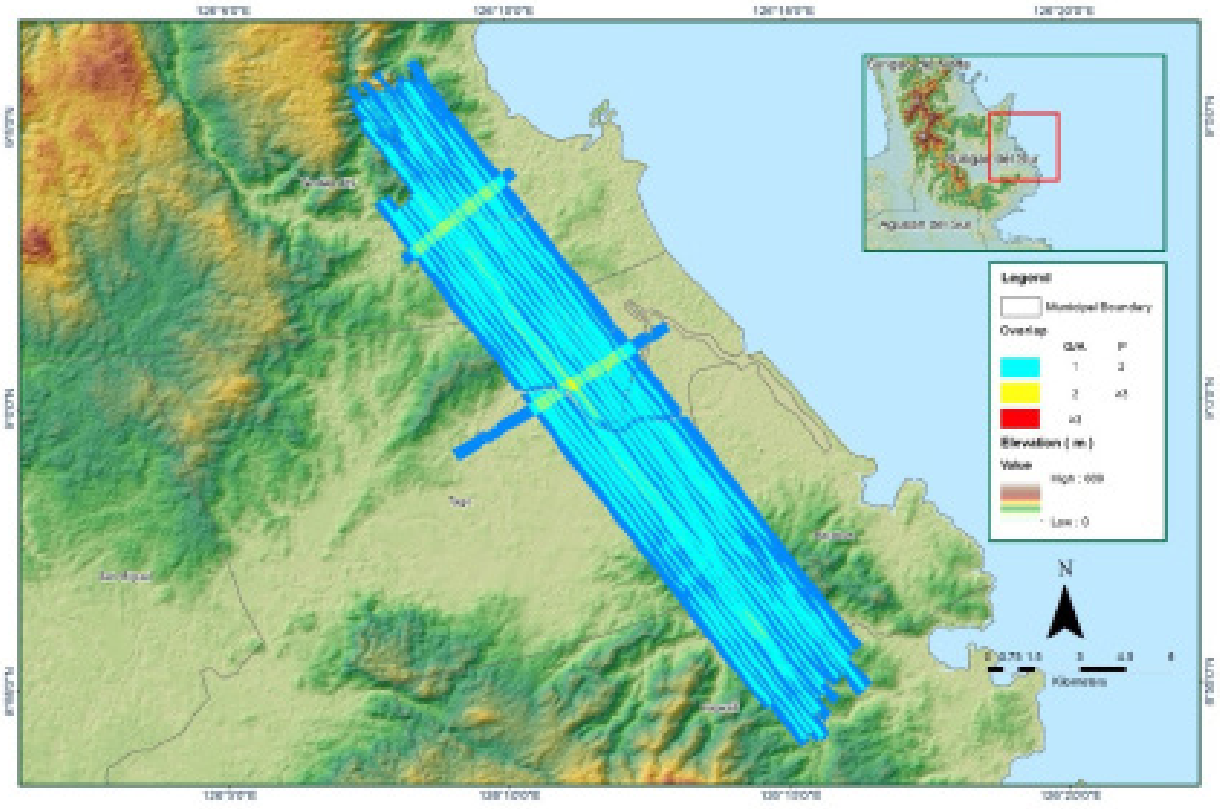


Figure 1.16.5 Image of data overlap

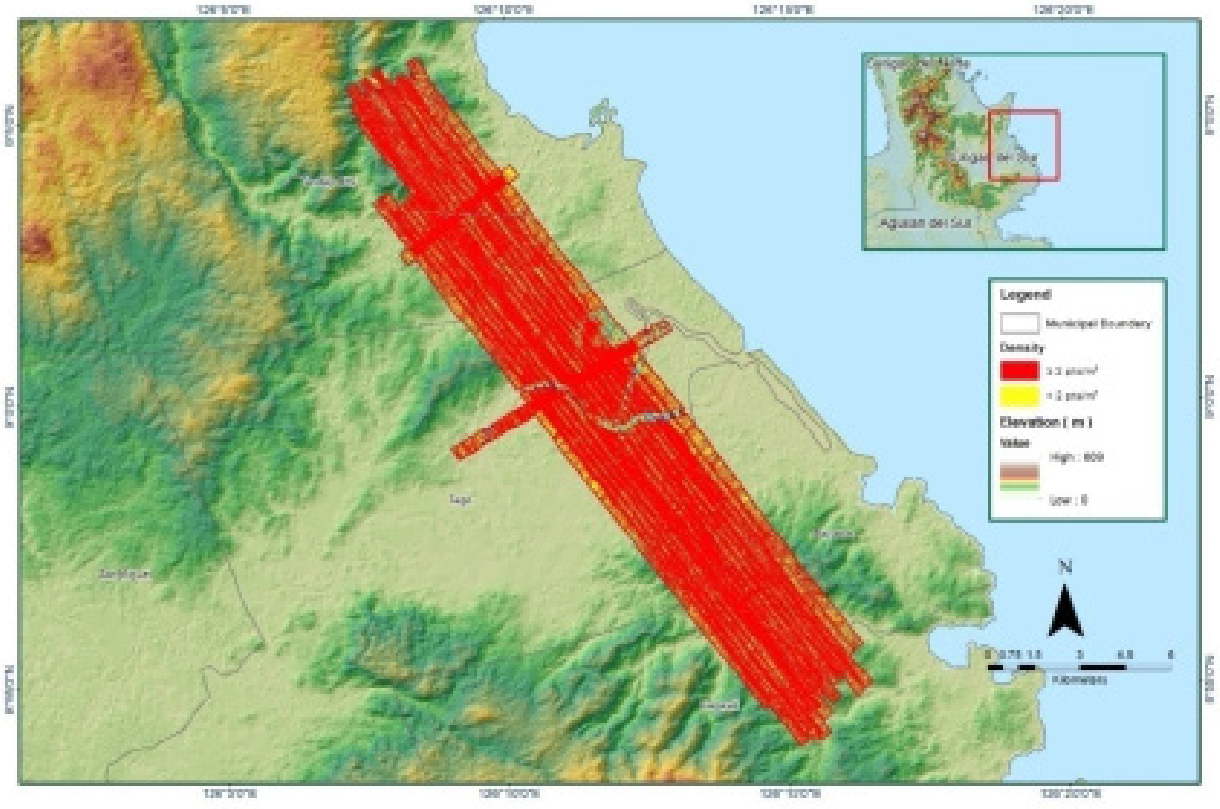


Figure 1.16.6 Density map of merged LiDAR data

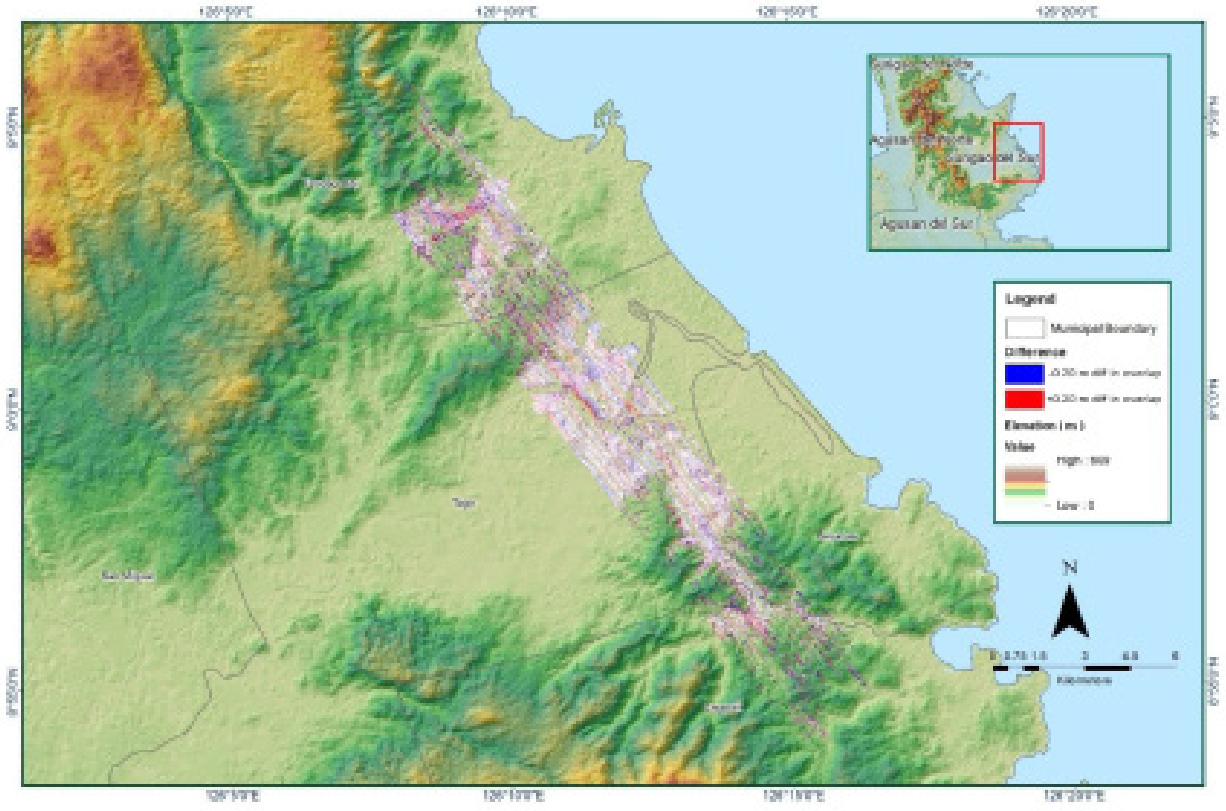


Figure 1.16.7 Elevation difference between flight lines

Flight Area	Tandag (Surigao Del Sur)
Mission Name	Block 61G
Inclusive Flights	1678A
Range data size	13.20 GB
POS	251 MB
Image	46.30 MB
Transfer date	July 23, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.50
RMSE for East Position (<4.0 cm)	1.70
RMSE for Down Position (<8.0 cm)	3.60
Boresight correction stdev (<0.001deg)	0.000641
IMU attitude correction stdev (<0.001deg)	0.012275
GPS position stdev (<0.01m)	0.0166
Minimum % overlap (>25)	63.31
Ave point cloud density per sq.m. (>2.0)	3.70
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	106
Maximum Height	482.93 m
Minimum Height	72.18 m
Classification (# of points)	
Ground	26,970,703
Low vegetation	42,800,536
Medium vegetation	52,653,788
High vegetation	82,256,262
Building	3,409,452
Orthophoto	YES
Processed by	Engr. Jennifer Saguran

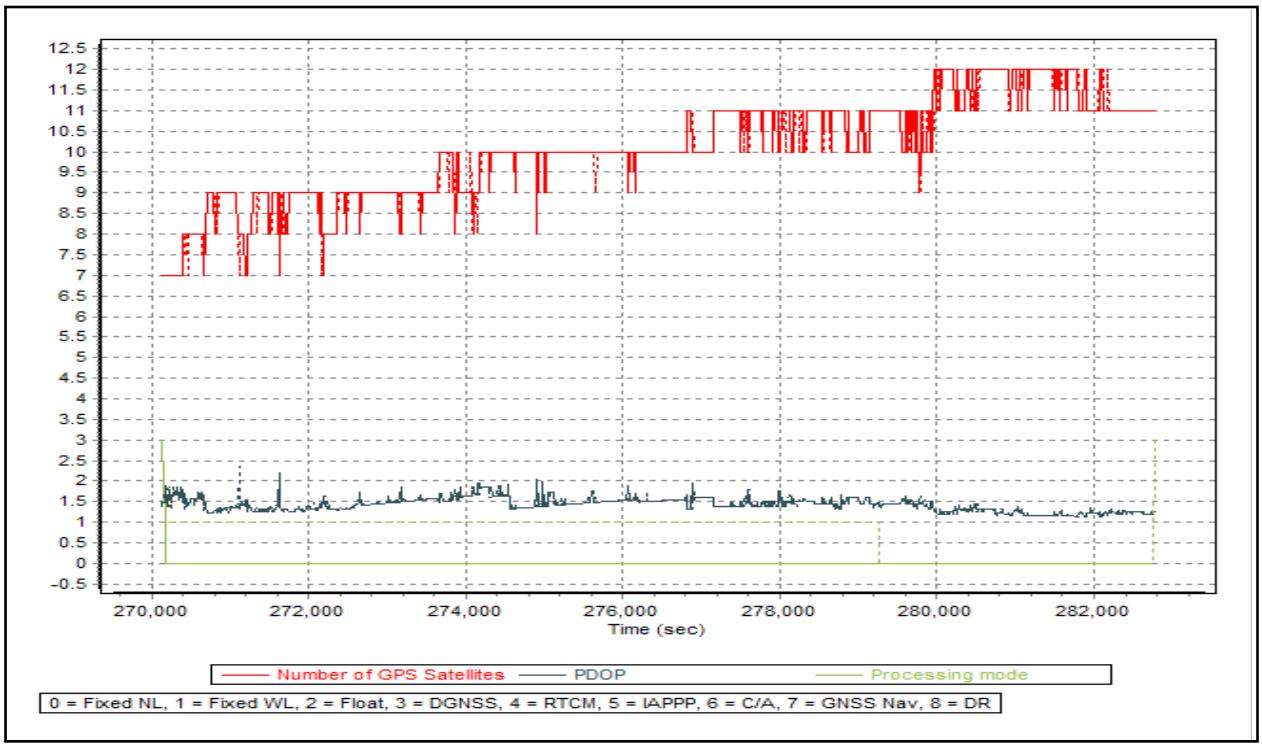


Figure 1.17.1 Solution Status

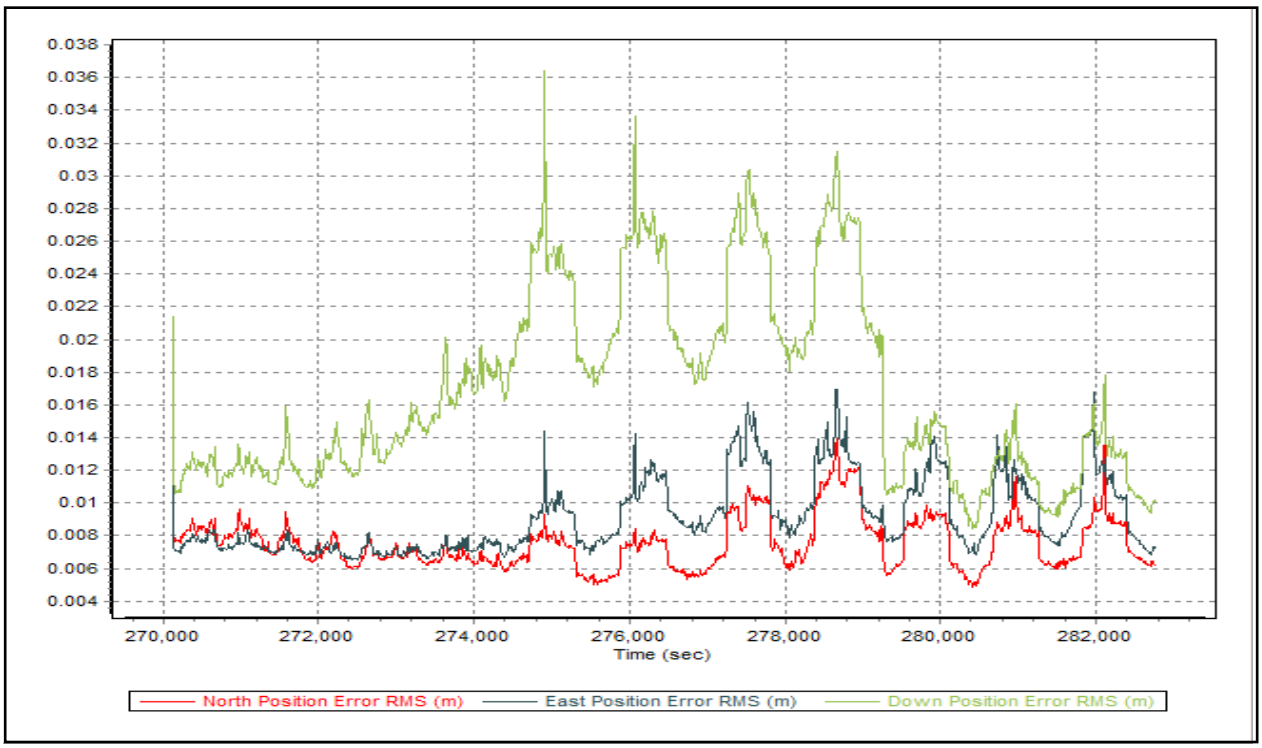


Figure 1.17.2 Smoothed Performance Metric Parameters

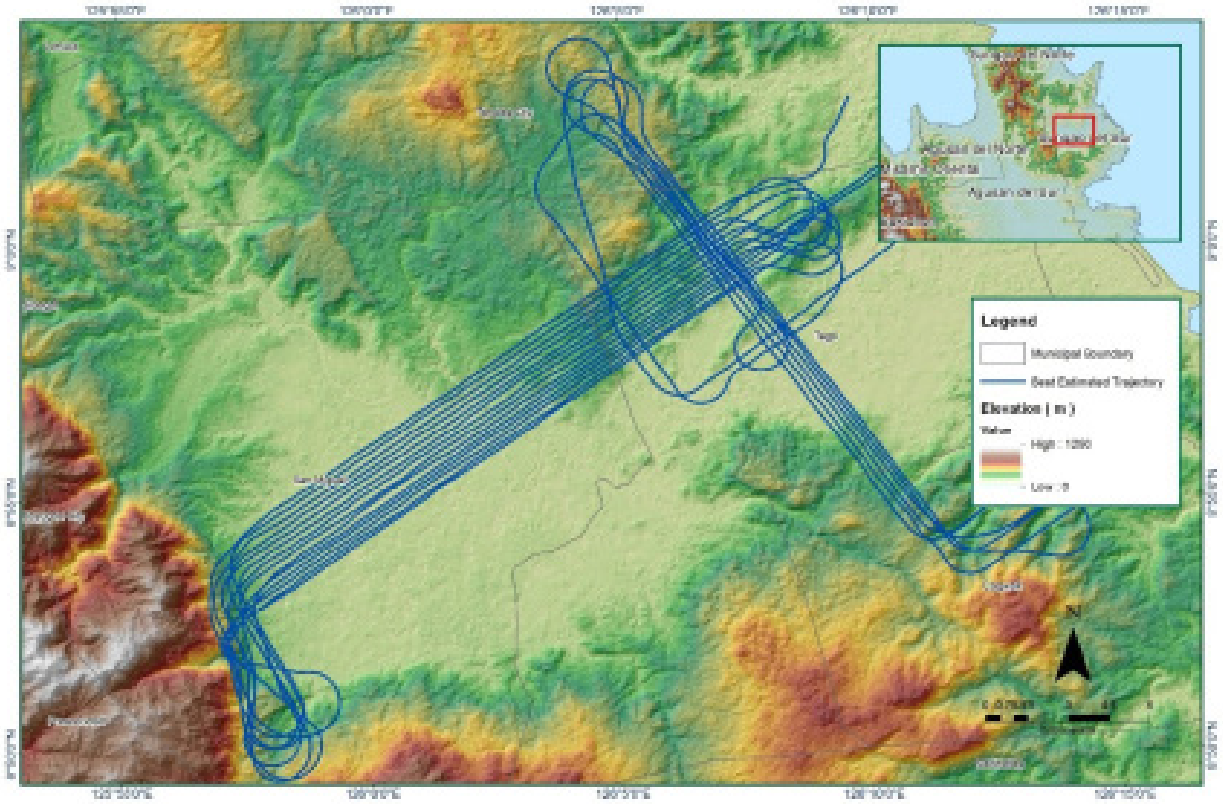


Figure 1.17.3 Best Estimated Trajectory

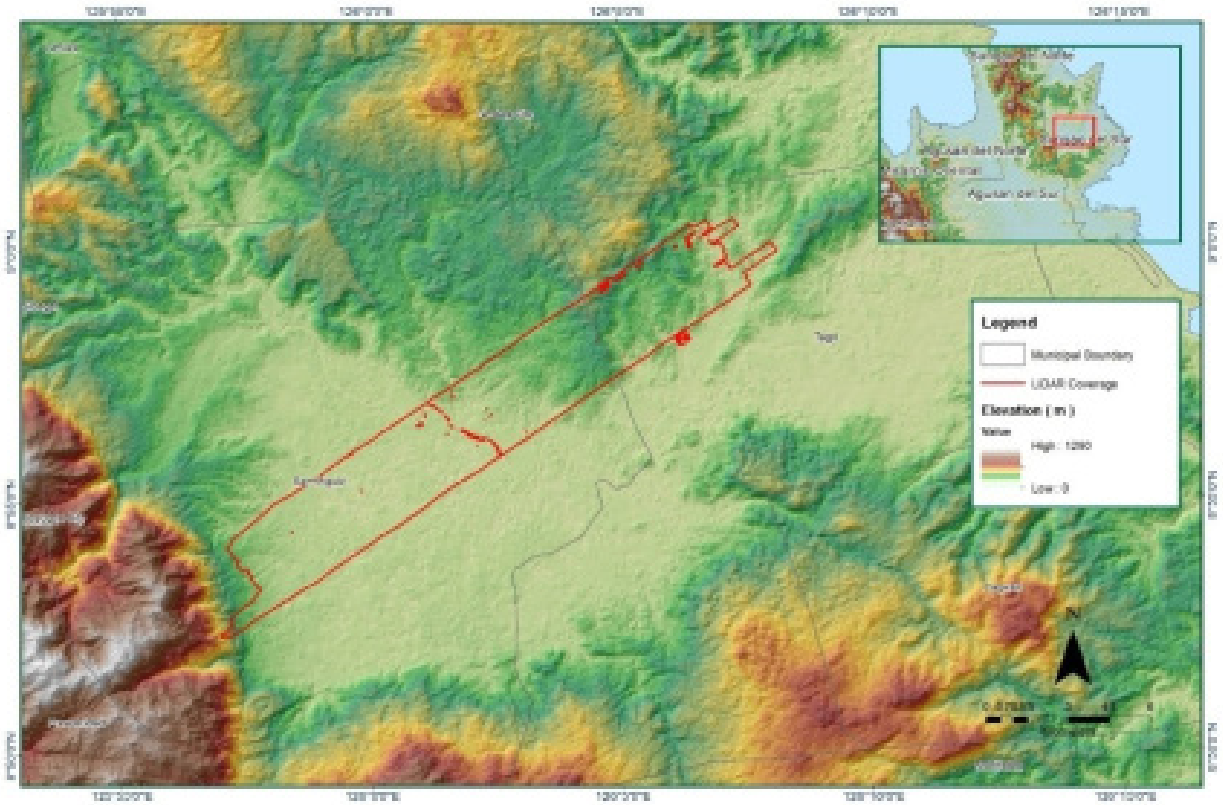


Figure 1.17.4 Coverage of LiDAR data

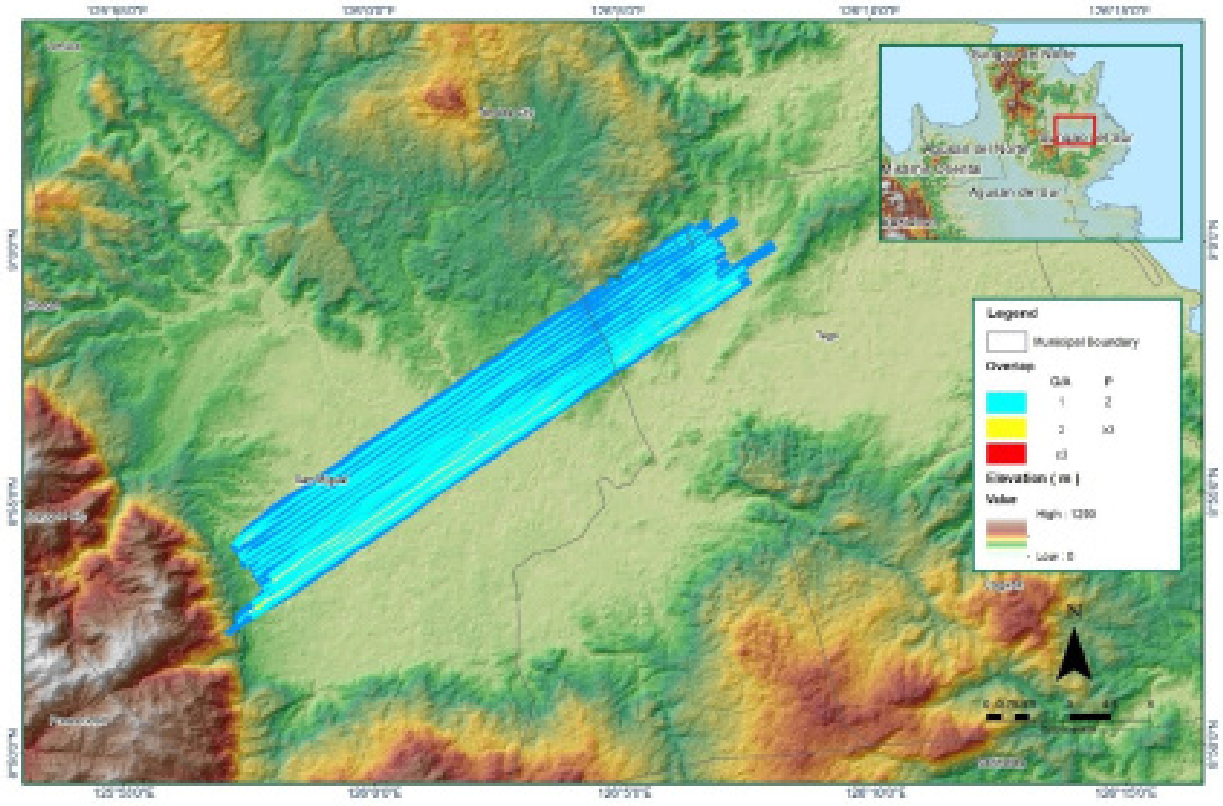


Figure 1.17.5 Image of data overlap

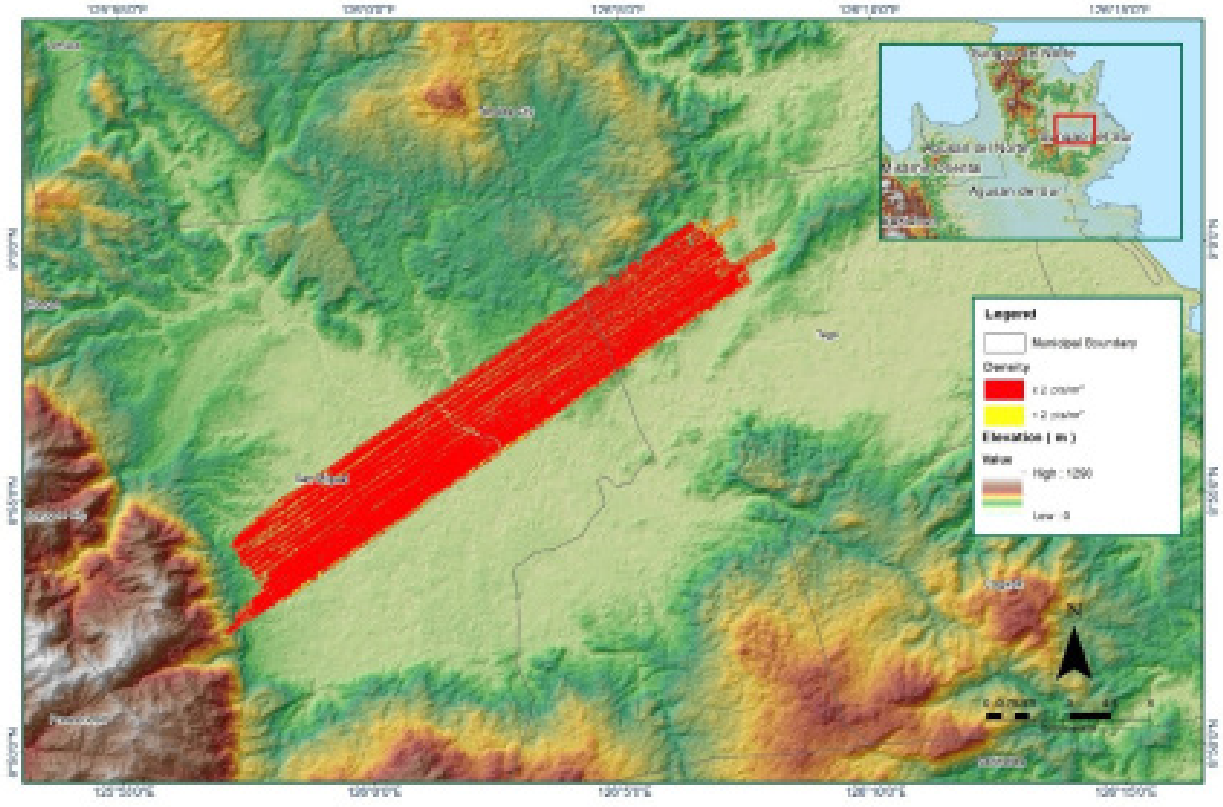


Figure 1.17.6 Density map of merged LiDAR data

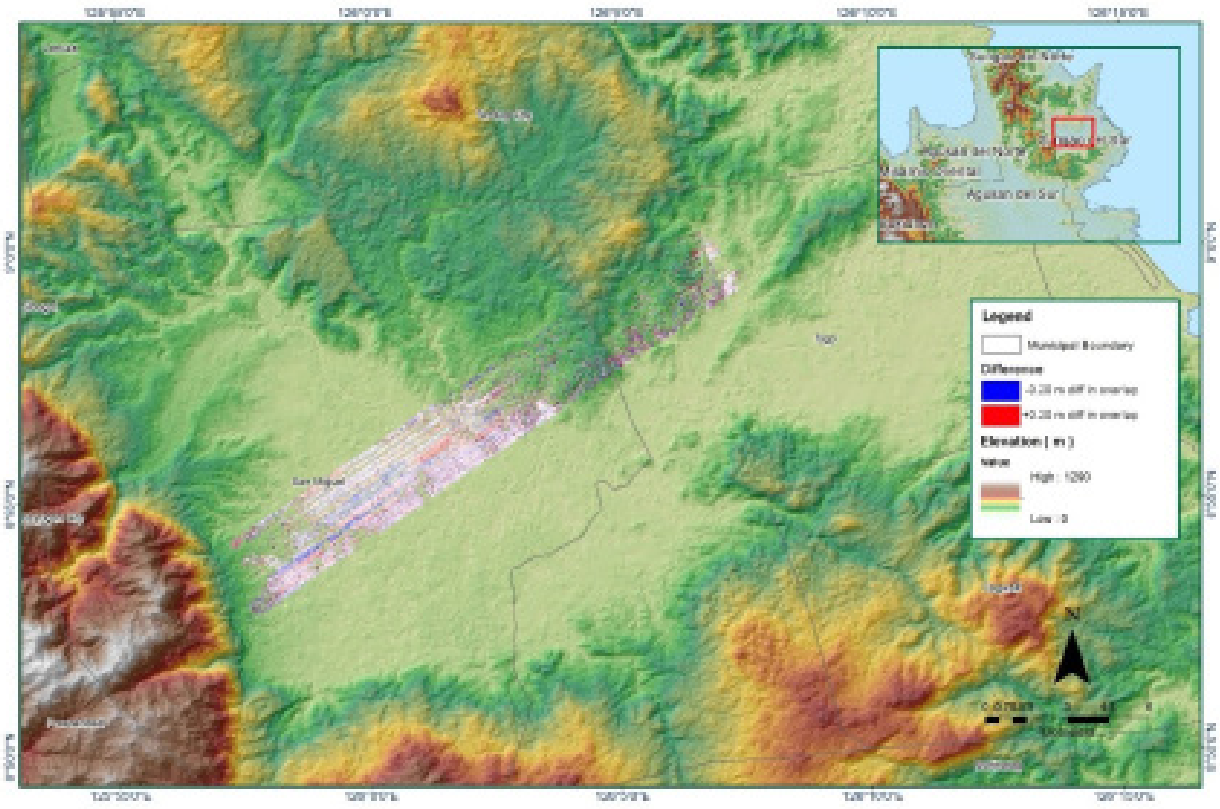


Figure 1.17.7 Elevation difference between flight lines

Flight Area	Tandag (Surigao Del Sur)
Mission Name	Blk61C
Inclusive Flights	23610P
Range data size	13.7 GB
Base data size	369 MB
POS	480 MB
Image	NA
Transfer date	January 3, 2017
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.27
RMSE for East Position (<4.0 cm)	1.25
RMSE for Down Position (<8.0 cm)	3.3
Boresight correction stdev (<0.001deg)	0.000257
IMU attitude correction stdev (<0.001deg)	0.000441
GPS position stdev (<0.01m)	0.0072
Minimum % overlap (>25)	31.42
Ave point cloud density per sq.m. (>2.0)	3.87
Elevation difference between strips (<0.20 m)	YES
Number of 1km x 1km blocks	179
Maximum Height	834.4 m
Minimum Height	57.55 m
Classification (# of points)	
Ground	139,523,754
Low vegetation	71,702,105
Medium vegetation	116,146,930
High vegetation	188,868,056
Building	1,173,534
Orthophoto	No
Processed by	Engr. Analyn Naldo, Engr. Harmond Santos, Engr. Gladys Mae Apat

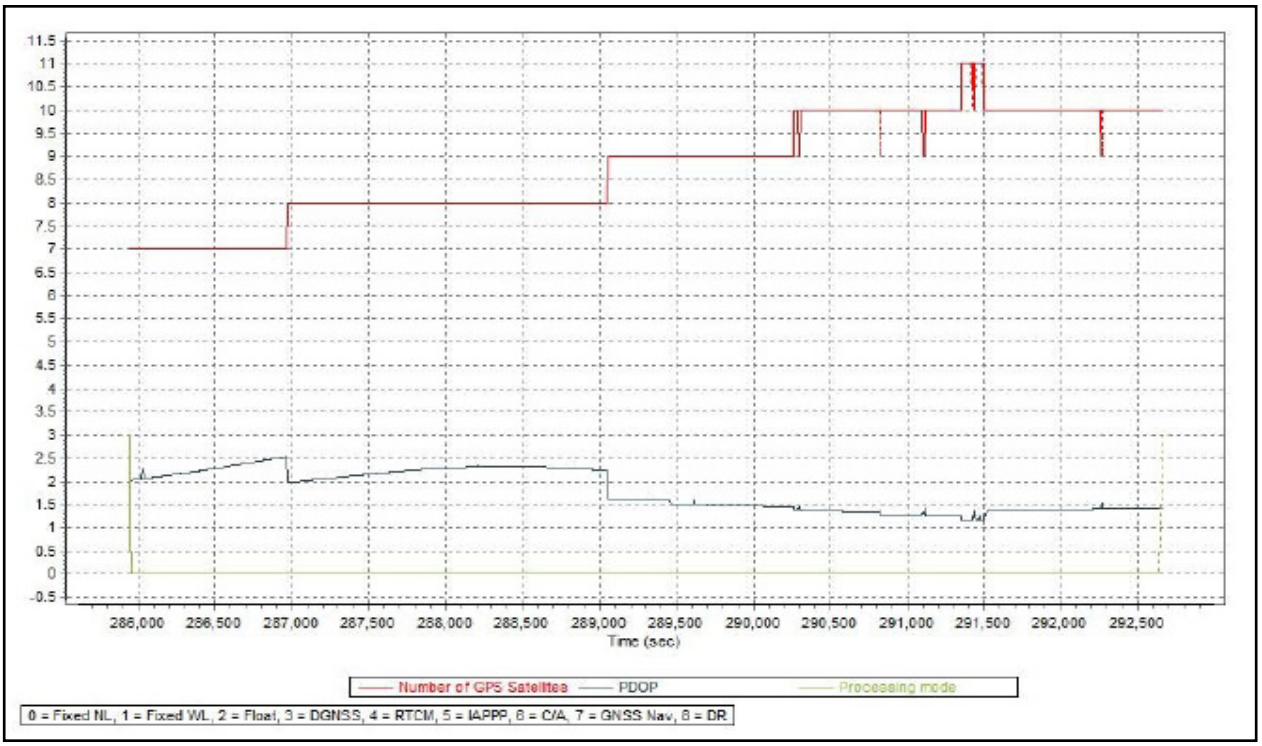


Figure 1.18.1 Solution Status

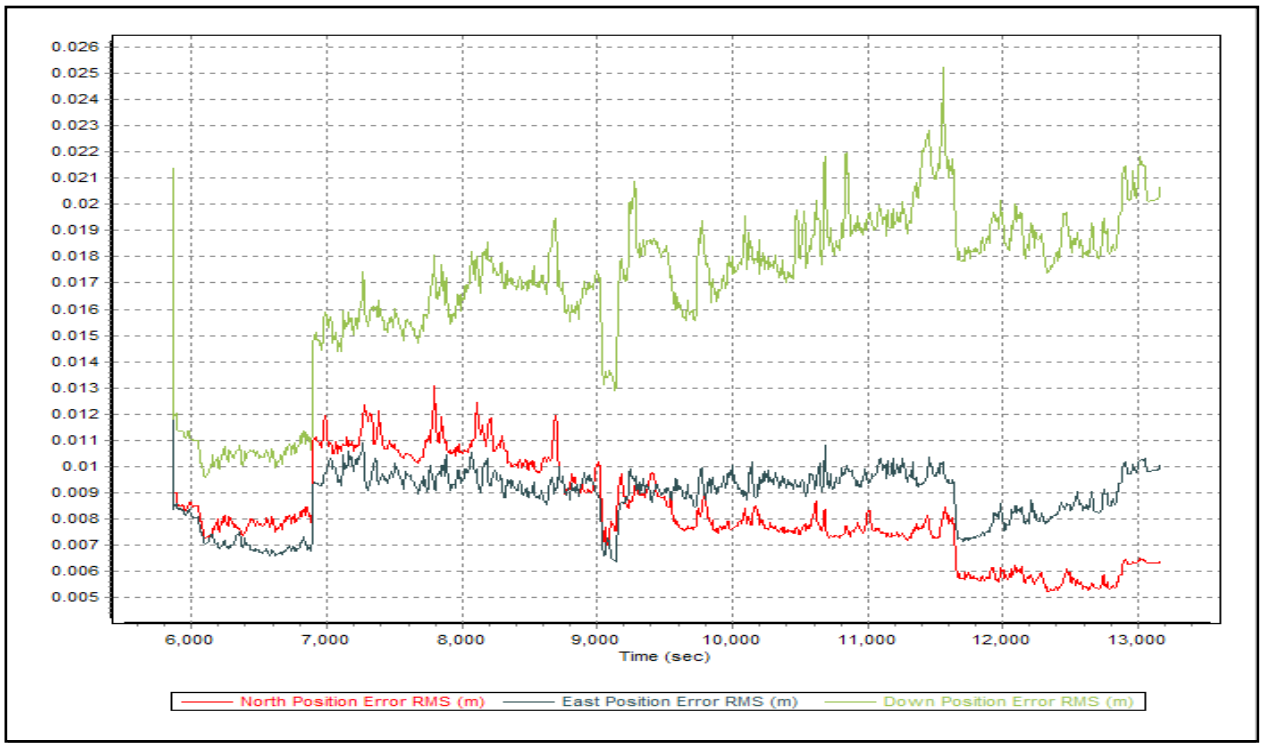


Figure 1.18.2 Smoothed Performance Metric Parameters

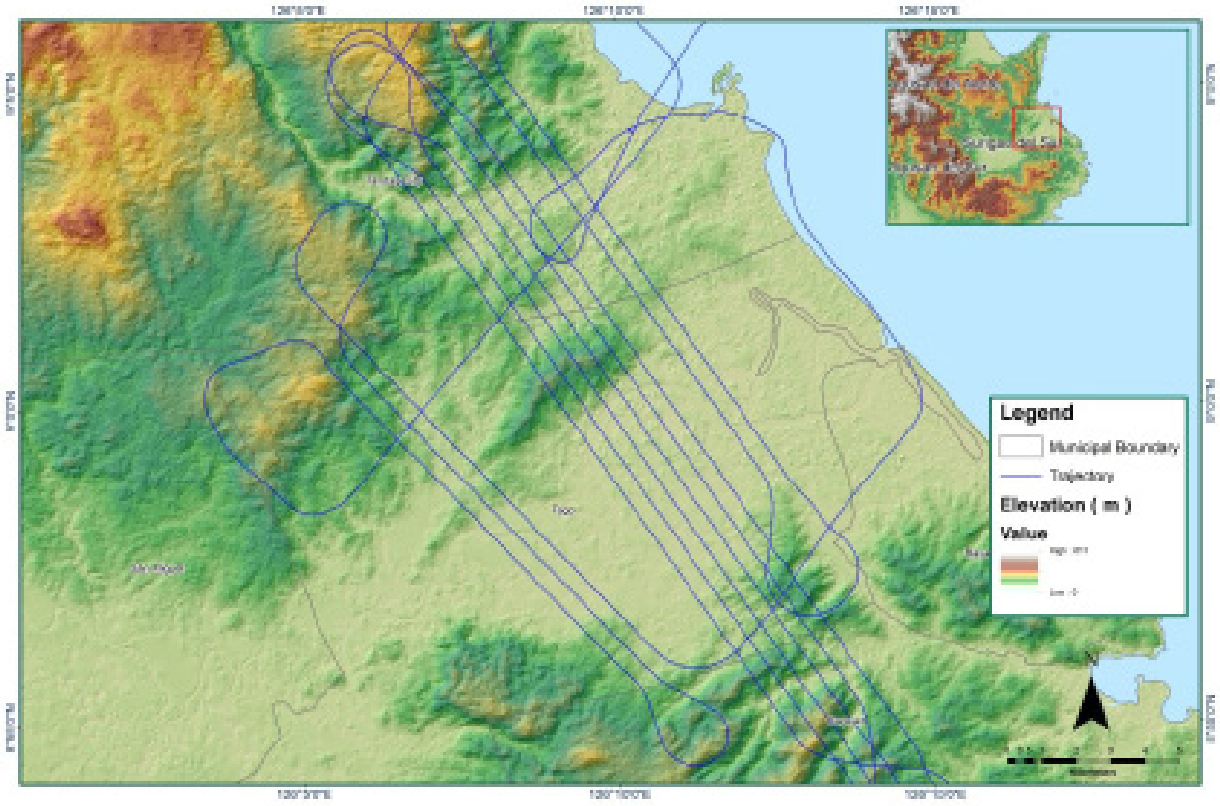


Figure 1.18.3 Best Estimated Trajectory

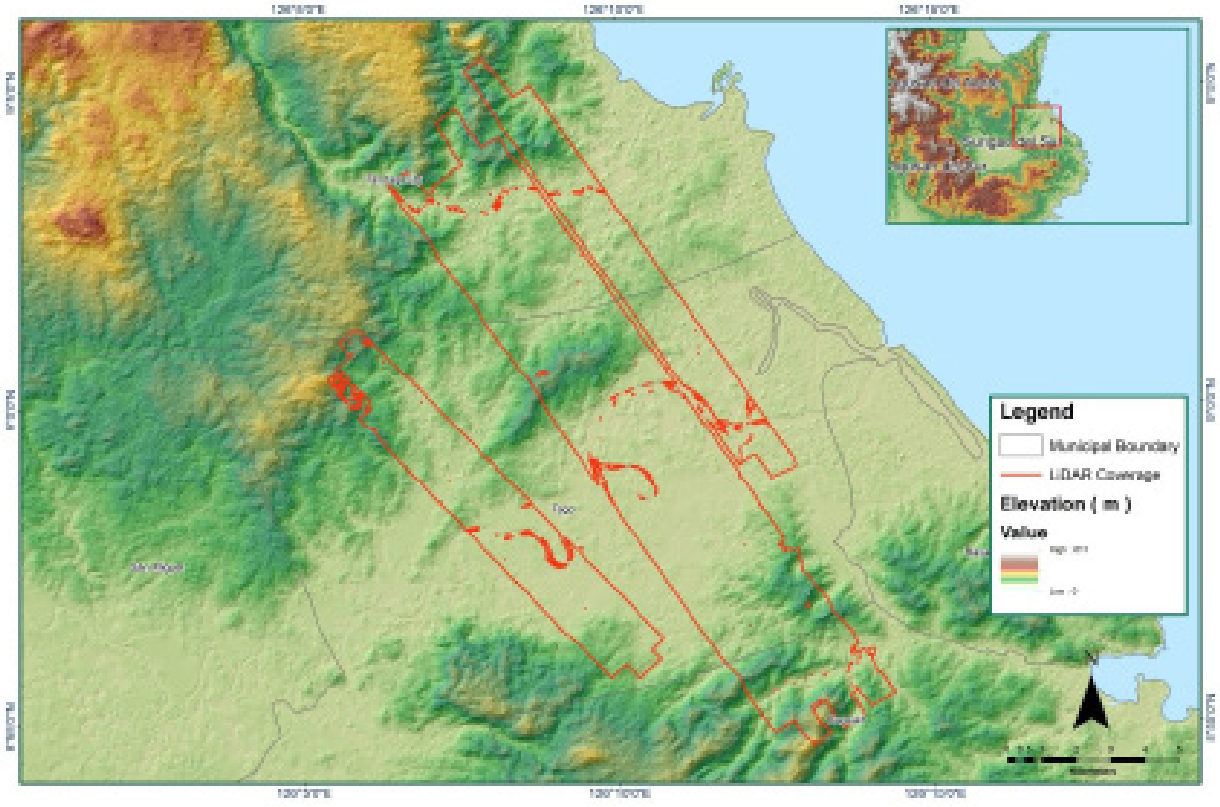


Figure 1.18.4 Coverage of LiDAR data

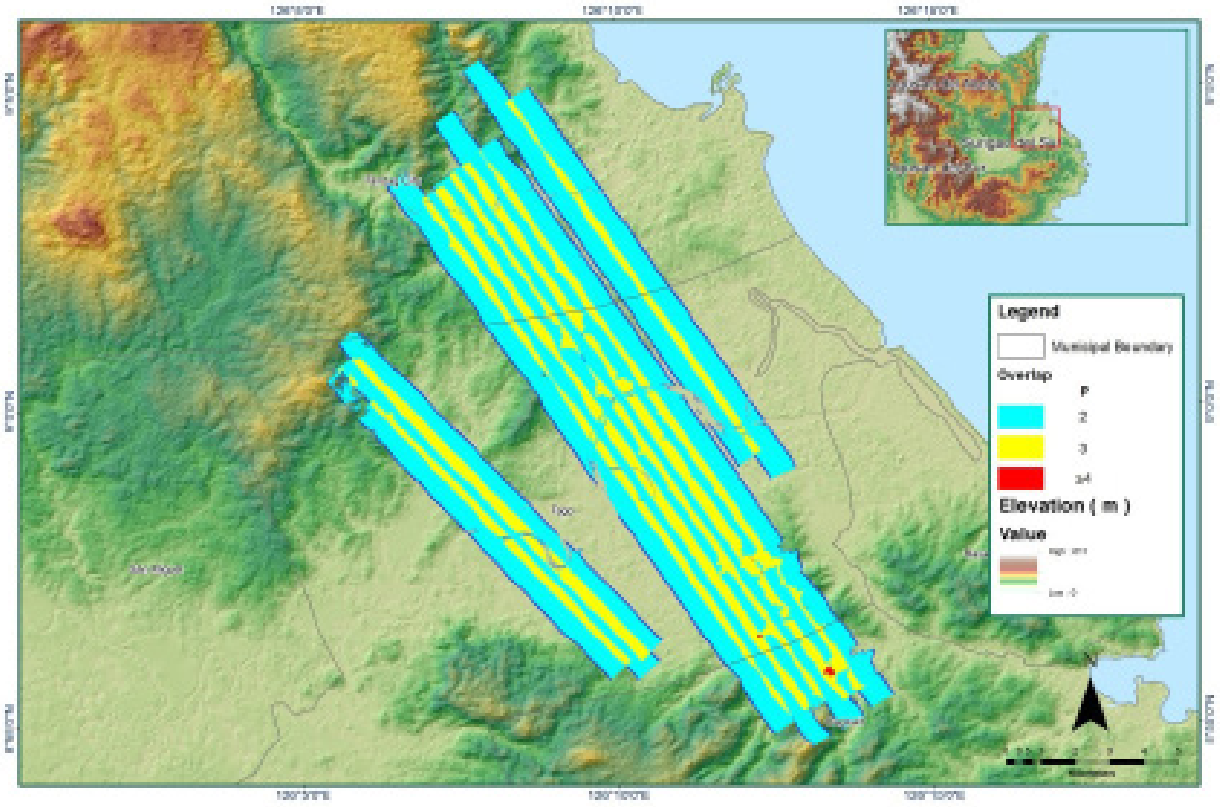


Figure 1.18.5 Image of data overlap

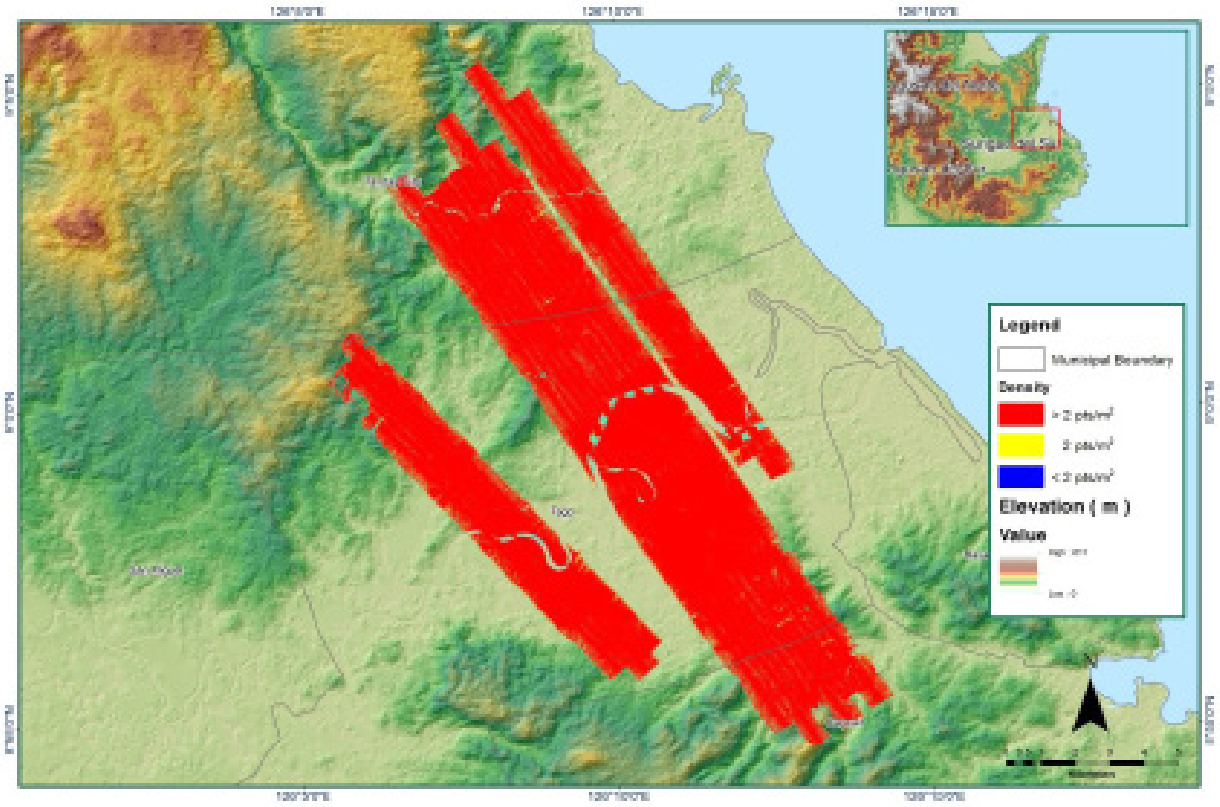


Figure 1.18.6 Density map of merged LiDAR data

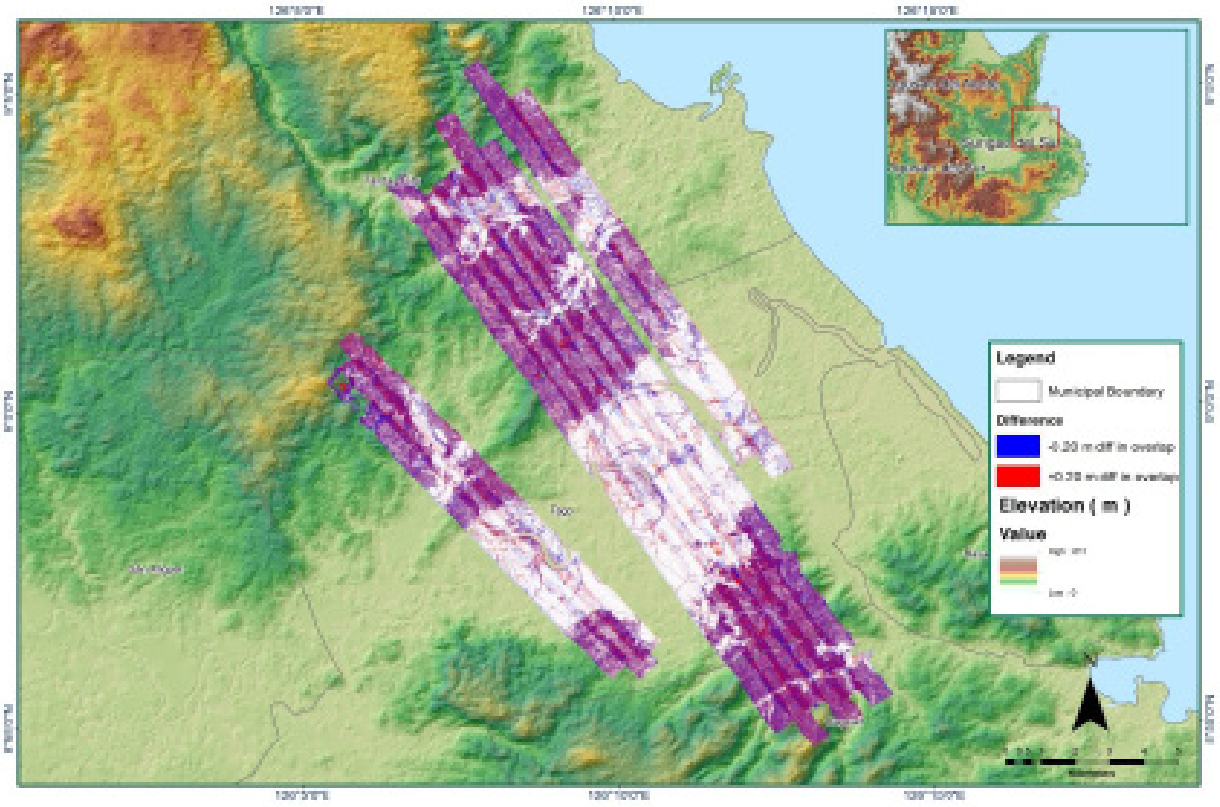


Figure 1.18.7Elevation difference between flight lines

Annex 9. Tago Model Basin Parameters

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Base flow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W2580	0	88.8290	0.0000	1.7480	3.0590	Discharge	0.1793	0.4	Ratio to Peak	0.8
W2590	0	81.7610	0.3610	6.1940	10.8395	Discharge	0.6616	0.4	Ratio to Peak	0.8
W2600	0	88.7020	0.0000	2.9636	5.1863	Discharge	0.1964	0.4	Ratio to Peak	0.8
W2610	0	88.7315	0.0000	2.0060	3.5105	Discharge	0.1387	0.4	Ratio to Peak	0.8
W2620	0	88.8050	0.0000	1.1677	2.0435	Discharge	0.0638	0.4	Ratio to Peak	0.8
W2630	0	89.4350	0.0000	2.4528	4.2924	Discharge	0.2376	0.4	Ratio to Peak	0.8
W2640	0	89.6840	0.0000	3.9144	6.8502	Discharge	0.2109	0.4	Ratio to Peak	0.8
W2650	0	89.7410	0.0000	2.2074	3.8630	Discharge	0.2554	0.4	Ratio to Peak	0.8
W2660	0	88.6863	0.0000	1.9746	3.4555	Discharge	0.2348	0.4	Ratio to Peak	0.8
W2670	0	88.6800	0.0000	1.8785	3.2874	Discharge	0.1917	0.4	Ratio to Peak	0.8
W2680	0	89.0850	0.0000	0.8374	1.4654	Discharge	0.0357	0.4	Ratio to Peak	0.8
W2690	0	88.5880	0.0000	2.6640	4.6620	Discharge	0.2863	0.4	Ratio to Peak	0.8
W2700	0	88.9110	0.0000	3.1046	5.4331	Discharge	0.4261	0.4	Ratio to Peak	0.8
W2710	0	88.8430	0.0000	1.7244	3.0178	Discharge	0.1404	0.4	Ratio to Peak	0.8
W2720	0	88.9690	0.0000	0.8530	1.4927	Discharge	0.0546	0.4	Ratio to Peak	0.8
W2730	0	88.6230	0.0000	1.6316	2.8553	Discharge	0.1206	0.4	Ratio to Peak	0.8
W2740	0	89.1600	0.5155	4.0318	7.0557	Discharge	0.3747	0.4	Ratio to Peak	0.8
W2750	0	89.0250	0.0000	2.8462	4.9809	Discharge	0.2056	0.4	Ratio to Peak	0.8
W2760	0	89.9220	0.0000	1.8096	3.1668	Discharge	0.1539	0.4	Ratio to Peak	0.8
W2770	0	89.0440	0.0000	1.4670	2.5673	Discharge	0.1138	0.4	Ratio to Peak	0.8
W2780	0	88.9070	0.0000	0.5777	1.0110	Discharge	0.0162	0.4	Ratio to Peak	0.8

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Base flow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W2790	0	88.7450	0.5547	3.9974	6.9955	Discharge	0.2293	0.4	Ratio to Peak	0.155
W2800	0	88.8020	0.1296	7.2284	12.6497	Discharge	0.6114	0.4	Ratio to Peak	0.155
W2810	0	88.6300	0.0000	4.6112	8.0696	Discharge	0.2615	0.4	Ratio to Peak	0.155
W2820	0	88.9330	0.0000	3.1880	5.5790	Discharge	0.3544	0.4	Ratio to Peak	0.155
W2830	0	88.5560	0.0000	1.3230	2.3153	Discharge	0.1300	0.4	Ratio to Peak	0.155
W2840	0	88.8445	0.0000	1.7762	3.1084	Discharge	0.1887	0.4	Ratio to Peak	0.155
W2850	0	88.5540	0.0000	1.6639	2.9118	Discharge	0.1234	0.4	Ratio to Peak	0.155
W2860	0	89.2070	0.0000	1.0539	1.8443	Discharge	0.0676	0.4	Ratio to Peak	0.155
W2870	0	88.6090	0.0000	2.1234	3.7160	Discharge	0.3716	0.4	Ratio to Peak	0.155
W2880	0	89.0080	0.0000	2.0070	3.5123	Discharge	0.1197	0.4	Ratio to Peak	0.155
W2890	0	89.5800	0.0000	2.6110	4.5693	Discharge	0.1253	0.4	Ratio to Peak	0.155
W2900	0	89.2360	0.0000	2.5638	4.4867	Discharge	0.2065	0.4	Ratio to Peak	0.155
W2910	0	88.9420	0.0000	1.8772	3.2851	Discharge	0.2238	0.4	Ratio to Peak	0.155
W2920	0	89.6594	0.0000	1.3173	2.3052	Discharge	0.1604	0.4	Ratio to Peak	0.155
W2930	0	89.7340	0.4473	3.4636	6.0613	Discharge	0.2155	0.4	Ratio to Peak	0.155
W2940	0	89.8280	0.0000	1.7304	3.0281	Discharge	0.1537	0.4	Ratio to Peak	0.155
W2950	0	90.8060	0.0000	0.3400	0.5950	Discharge	0.0009	0.4	Ratio to Peak	0.155
W2960	0	89.1720	0.0000	0.7506	1.3135	Discharge	0.0204	0.4	Ratio to Peak	0.155
W2970	0	89.1680	0.0000	2.5934	4.5385	Discharge	0.2522	0.4	Ratio to Peak	0.155
W2980	0	89.0360	0.0000	2.9870	5.2273	Discharge	0.1634	0.4	Ratio to Peak	0.155
W2990	0	89.2340	0.0000	4.1722	7.3014	Discharge	0.6135	0.4	Ratio to Peak	0.155
W3000	0	91.4190	0.0000	0.3400	0.5950	Discharge	0.0022	0.4	Ratio to Peak	0.155
W3010	0	90.4120	0.0000	1.1711	2.0495	Discharge	0.0784	0.4	Ratio to Peak	0.155
W3020	0	89.6880	0.0000	2.4404	4.2707	Discharge	0.2744	0.4	Ratio to Peak	0.155
W3030	0	88.7340	0.0000	3.7604	6.5807	Discharge	0.5463	0.4	Ratio to Peak	0.155

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Base flow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W3040	0	89.9680	0.0000	2.2596	3.9543	Discharge	0.2651	0.4	Ratio to Peak	0.8
W3050	0	90.0950	0.0464	2.9806	5.2161	Discharge	0.4107	0.4	Ratio to Peak	0.8
W3060	0	89.2900	0.0000	1.3580	2.3764	Discharge	0.0817	0.4	Ratio to Peak	0.8
W3070	0	91.3990	0.0000	1.8273	3.1978	Discharge	0.1834	0.4	Ratio to Peak	0.8
W3080	0	88.8550	0.0000	4.4798	7.8397	Discharge	0.5390	0.4	Ratio to Peak	0.8
W3090	0	89.1580	0.0000	2.7870	4.8773	Discharge	0.1996	0.4	Ratio to Peak	0.8
W3100	0	88.8600	0.0000	2.5728	4.5024	Discharge	0.1498	0.4	Ratio to Peak	0.8
W3110	0	88.9810	0.0000	2.2668	3.9669	Discharge	0.1189	0.4	Ratio to Peak	0.8
W3120	0	88.9470	0.0000	2.0062	3.5109	Discharge	0.1227	0.4	Ratio to Peak	0.8
W3130	0	89.8580	0.0000	1.6427	2.8747	Discharge	0.1395	0.4	Ratio to Peak	0.8
W3140	0	90.1420	0.0125	3.3118	5.7957	Discharge	0.2170	0.4	Ratio to Peak	0.8
W3150	0	88.7670	0.0000	2.4266	4.2466	Discharge	0.2348	0.4	Ratio to Peak	0.8
W3160	0	89.6870	0.0000	3.0348	5.3109	Discharge	0.2407	0.4	Ratio to Peak	0.8
W3170	0	91.3930	0.1561	0.6746	1.1806	Discharge	0.0174	0.4	Ratio to Peak	0.8
W3180	0	89.2030	0.0000	2.9982	5.2469	Discharge	0.1461	0.4	Ratio to Peak	0.8
W3190	0	90.5510	0.0000	1.5575	2.7257	Discharge	0.1275	0.4	Ratio to Peak	0.8
W3200	0	90.0800	0.1057	0.9249	1.6185	Discharge	0.0258	0.4	Ratio to Peak	0.8
W3210	0	89.5550	0.0000	2.4226	4.2396	Discharge	0.1883	0.4	Ratio to Peak	0.8
W3220	0	89.0290	0.0000	2.8346	4.9606	Discharge	0.1577	0.4	Ratio to Peak	0.8
W3230	0	90.1060	0.0000	0.9277	1.6234	Discharge	0.0612	0.4	Ratio to Peak	0.8
W3240	0	79.7580	4.6296	4.1360	7.2380	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3250	0	93.5118	0.0000	1.0394	1.8189	Discharge	0.0547	0.4	Ratio to Peak	0.8
W3260	0	88.7710	0.0000	3.5314	6.1800	Discharge	0.1710	0.4	Ratio to Peak	0.8
W3270	0	89.3510	0.0000	0.8630	1.5103	Discharge	0.0285	0.4	Ratio to Peak	0.8
W3280	0	93.5010	1.1441	4.5800	8.0150	Discharge	0.0000	0.4	Ratio to Peak	0.8

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Base flow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W3290	0	90.7790	4.4873	5.5838	9.7717	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3300	0	88.6340	0.0000	3.4800	6.0900	Discharge	0.3049	0.4	Ratio to Peak	0.8
W3310	0	88.8030	0.0000	0.9021	1.5786	Discharge	0.0271	0.4	Ratio to Peak	0.8
W3320	0	88.7590	0.0000	2.7734	4.8535	Discharge	0.1357	0.4	Ratio to Peak	0.8
W3330	0	89.5100	0.0000	1.5775	2.7607	Discharge	0.1255	0.4	Ratio to Peak	0.8
W3340	0	90.0544	0.0000	2.2218	3.8882	Discharge	0.1248	0.4	Ratio to Peak	0.8
W3350	0	90.0390	0.0000	2.2974	4.0205	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3360	0	88.5800	0.0000	1.0812	1.8921	Discharge	0.0257	0.4	Ratio to Peak	0.8
W3370	0	88.7850	0.0000	2.2430	3.9253	Discharge	0.1491	0.4	Ratio to Peak	0.8
W3380	0	88.8370	0.0000	2.7080	4.7390	Discharge	0.2974	0.4	Ratio to Peak	0.8
W3390	0	98.0000	0.0000	0.3400	0.5950	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3400	0	97.2848	2.0035	2.4178	4.2312	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3410	0	98.0000	0.0000	0.3400	0.5950	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3420	0	95.4800	0.0000	4.1422	7.2489	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3430	0	88.6960	0.0000	2.8250	4.9438	Discharge	0.1496	0.4	Ratio to Peak	0.8
W3440	0	89.2050	0.0000	3.2092	5.6161	Discharge	0.3122	0.4	Ratio to Peak	0.8
W3450	0	89.2060	0.0000	0.3400	0.5950	Discharge	0.0004	0.4	Ratio to Peak	0.8
W3460	0	86.5056	0.0000	3.8942	6.8149	Discharge	0.3140	0.4	Ratio to Peak	0.8
W3470	0	88.8430	0.0000	2.4302	4.2529	Discharge	0.2189	0.4	Ratio to Peak	0.8
W3480	0	89.3200	0.0000	3.6634	6.4110	Discharge	0.5458	0.4	Ratio to Peak	0.8
W3490	0	91.4490	0.0000	2.6688	4.6704	Discharge	0.2948	0.4	Ratio to Peak	0.8
W3510	0	90.2770	3.7024	3.3238	5.8167	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3520	0	89.6801	0.0000	1.8075	3.1631	Discharge	0.1536	0.4	Ratio to Peak	0.8
W3530	0	89.4820	0.0000	2.0354	3.5620	Discharge	0.1607	0.4	Ratio to Peak	0.8
W3540	0	92.2940	0.0000	2.5934	4.5385	Discharge	0.0000	0.4	Ratio to Peak	0.8

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Base flow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W3550	0	79.6970	0.0000	1.7713	3.0998	Discharge	0.0582	0.4	Ratio to Peak	0.8
W3560	0	91.3250	0.0000	1.4844	2.5976	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3570	0	93.7397	0.0515	2.6358	4.6127	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3580	0	94.9210	2.6559	2.8418	4.9732	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3590	0	89.3490	1.5781	4.2286	7.4001	Discharge	0.1502	0.4	Ratio to Peak	0.8
W3600	0	93.3290	0.0000	1.9168	3.3544	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3610	0	93.7010	2.2859	4.3720	7.6510	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3620	0	92.2740	3.8593	2.8628	5.0099	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3630	0	90.3980	0.8604	4.6748	8.1809	Discharge	0.1094	0.4	Ratio to Peak	0.8
W3640	0	82.4860	0.0000	1.7247	3.0182	Discharge	0.0028	0.4	Ratio to Peak	0.8
W3650	0	81.2960	0.0000	0.4604	0.8058	Discharge	0.1905	0.4	Ratio to Peak	0.8
W3660	0	88.7510	0.0000	2.9358	5.1377	Discharge	0.1681	0.4	Ratio to Peak	0.8
W3670	0	87.4150	0.0000	2.9856	5.2248	Discharge	0.0154	0.4	Ratio to Peak	0.8
W3680	0	96.4960	0.0000	1.1984	2.0972	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3690	0	94.2930	0.0000	2.0920	3.6610	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3700	0	89.7450	2.8696	5.3208	9.3114	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3710	0	81.8680	0.4141	3.4846	6.0981	Discharge	0.1283	0.4	Ratio to Peak	0.8
W3730	0	79.5530	0.0000	3.5384	6.1922	Discharge	0.0643	0.4	Ratio to Peak	0.8
W3740	0	88.7920	0.0000	0.4594	0.8040	Discharge	0.0474	0.4	Ratio to Peak	0.8
W3750	0	90.9090	0.0000	1.9708	3.4490	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3760	0	81.9130	0.0000	0.9886	1.7301	Discharge	0.0450	0.4	Ratio to Peak	0.8
W3770	0	90.7430	0.6892	3.6474	6.3830	Discharge	0.0229	0.4	Ratio to Peak	0.8
W3780	0	89.4860	0.0000	2.2554	3.9470	Discharge	0.5914	0.4	Ratio to Peak	0.8
W3790	0	88.8800	0.0000	0.7314	1.2800	Discharge	0.3450	0.4	Ratio to Peak	0.8
W3800	0	93.7700	0.0000	4.0352	7.0616	Discharge	0.0000	0.4	Ratio to Peak	0.8

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Base flow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W3810	0	91.7950	0.0000	4.6716	8.1753	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3820	0	82.7140	0.8658	4.3614	7.6325	Discharge	0.0084	0.4	Ratio to Peak	0.8
W3830	0	88.5560	1.0353	1.8613	3.2572	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3840	0	84.3370	0.0000	0.7541	1.3197	Discharge	0.1161	0.4	Ratio to Peak	0.8
W3850	0	95.5580	2.8129	2.3722	4.1514	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3860	0	96.1560	0.0000	2.8422	4.9739	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3870	0	88.3270	2.8677	2.3364	4.0887	Discharge	0.0138	0.4	Ratio to Peak	0.8
W3880	0	82.5220	2.6157	2.4304	4.2532	Discharge	0.2044	0.4	Ratio to Peak	0.8
W3890	0	85.2230	3.1430	1.0821	1.8937	Discharge	0.1209	0.4	Ratio to Peak	0.8
W3900	0	88.9940	0.0000	5.1646	9.0381	Discharge	0.3826	0.4	Ratio to Peak	0.8
W3910	0	89.1370	0.0000	2.5748	4.5059	Discharge	0.1396	0.4	Ratio to Peak	0.8
W3920	0	81.4650	0.0000	1.9392	3.3935	Discharge	0.2797	0.4	Ratio to Peak	0.8
W3930	0	79.9160	0.0000	1.4733	2.5783	Discharge	0.2788	0.4	Ratio to Peak	0.8
W3940	0	81.8110	0.0000	7.1470	12.5073	Discharge	0.1480	0.4	Ratio to Peak	0.8
W3950	0	89.1810	0.0000	5.4290	9.5008	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3960	0	89.3090	0.0000	4.5464	7.9562	Discharge	0.1426	0.4	Ratio to Peak	0.8
W3970	0	94.2150	0.1799	5.2460	9.1805	Discharge	0.0000	0.4	Ratio to Peak	0.8
W3980	0	89.3600	0.0000	2.1578	3.7762	Discharge	0.3307	0.4	Ratio to Peak	0.8
W3990	0	88.9870	6.5819	4.0192	7.0336	Discharge	0.1164	0.4	Ratio to Peak	0.8
W4000	0	86.7430	0.0000	2.2714	3.9750	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4010	0	89.3580	0.0000	1.9246	3.3680	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4020	0	89.9620	0.0000	5.8544	10.2452	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4030	0	90.4140	1.3740	2.9260	5.1205	Discharge	0.1357	0.4	Ratio to Peak	0.8
W4040	0	92.1340	0.9115	2.6062	4.5609	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4050	0	84.0010	1.1918	2.4056	4.2098	Discharge	0.0000	0.4	Ratio to Peak	0.8

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Base flow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W4060	0	90.7330	1.6130	4.5926	8.0371	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4070	0	88.2340	0.0000	0.3400	0.5950	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4080	0	94.2870	0.4282	3.9114	6.8450	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4090	0	82.9176	0.9046	3.5130	6.1478	Discharge	0.0235	0.4	Ratio to Peak	0.8
W4100	0	91.4980	0.7499	1.9461	3.4056	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4110	0	96.0730	0.0000	1.4492	2.5360	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4120	0	90.1530	0.9265	1.7896	3.1318	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4140	0	92.3681	0.2719	0.9510	1.6643	Discharge	0.0022	0.4	Ratio to Peak	0.8
W4160	0	87.0770	0.3671	3.5750	6.2563	Discharge	0.1218	0.4	Ratio to Peak	0.8
W4170	0	88.0210	0.8597	3.9222	6.8639	Discharge	0.0793	0.4	Ratio to Peak	0.8
W4180	0	89.4960	1.2121	0.5846	1.0230	Discharge	0.0357	0.4	Ratio to Peak	0.8
W4190	0	85.6160	0.3258	2.5098	4.3922	Discharge	0.0895	0.4	Ratio to Peak	0.8
W4200	0	80.3840	3.1788	5.4816	9.5928	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4210	0	92.3730	5.3695	3.4644	6.0627	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4220	0	90.2440	0.0727	8.1442	14.2524	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4230	0	78.1470	1.1672	4.1906	7.3336	Discharge	0.1617	0.4	Ratio to Peak	0.8
W4240	0	92.0019	0.5500	3.3322	5.8314	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4250	0	88.5770	0.0000	2.2260	3.8955	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4260	0	86.7160	0.0000	5.1088	8.9404	Discharge	0.0416	0.4	Ratio to Peak	0.8
W4270	0	90.2370	0.5484	1.5727	2.7523	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4290	0	87.0060	0.2434	3.9832	6.9706	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4300	0	95.9450	0.0000	4.8424	8.4742	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4310	0	91.5890	0.0000	2.3990	4.1983	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4320	0	87.1490	4.4304	3.6082	6.3144	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4330	0	80.3510	0.0000	0.3400	0.5950	Discharge	0.1184	0.4	Ratio to Peak	0.8

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Base flow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W4340	0	90.1420	2.0222	1.9608	3.4314	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4350	0	89.2270	1.8939	4.7740	8.3545	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4360	0	93.2168	0.2261	4.7024	8.2292	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4370	0	88.3030	0.0579	1.4368	2.5144	Discharge	0.1848	0.4	Ratio to Peak	0.8
W4380	0	89.1380	0.0000	2.7734	4.8535	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4390	0	85.7880	0.1237	2.7702	4.8479	Discharge	0.2519	0.4	Ratio to Peak	0.8
W4400	0	88.9240	0.0147	1.8109	3.1690	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4420	0	89.4940	0.0000	1.7997	3.1495	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4430	0	84.2500	0.7131	2.0852	3.6491	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4440	0	88.7390	0.0000	2.1840	3.8220	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4460	0	83.8170	0.3662	2.3224	4.0642	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4470	0	92.3340	0.0000	3.0262	5.2959	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4480	0	75.9370	0.0000	0.3673	0.6428	Discharge	0.1525	0.4	Ratio to Peak	0.8
W4490	0	77.6600	0.0098	10.7300	18.7775	Discharge	0.2853	0.4	Ratio to Peak	0.8
W4500	0	88.9970	0.2701	1.8480	3.2339	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4510	0	92.4880	0.0000	1.8482	3.2343	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4520	0	84.4210	0.0000	4.9290	8.6258	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4550	0	84.3080	0.0000	3.9178	6.8562	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4560	0	90.2440	0.0000	3.7278	6.5237	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4570	0	87.3970	0.0473	1.9420	3.3985	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4580	0	88.7570	0.0000	2.2060	3.8605	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4590	0	84.8510	0.0000	2.7642	4.8374	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4600	0	93.8320	0.0000	3.0912	5.4096	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4610	0	75.9000	0.0000	3.0990	5.4233	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4620	0	89.3260	0.0000	3.9926	6.9871	Discharge	0.0000	0.4	Ratio to Peak	0.8

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Base flow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W4630	0	82.2110	0.0000	4.7506	8.3136	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4640	0	89.6770	0.0000	2.4528	4.2924	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4650	0	82.7520	0.0000	0.7674	1.3430	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4660	0	82.9740	0.0000	2.0954	3.6670	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4680	0	88.1500	0.0000	4.5016	7.8778	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4690	0	89.8300	0.0000	2.3344	4.0852	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4700	0	93.9284	1.0673	5.7712	10.0996	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4710	0	81.5290	0.0000	5.6386	9.8676	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4720	0	84.1640	0.0000	5.2632	9.2106	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4730	0	90.6502	0.0000	5.5350	9.6863	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4740	0	83.4550	0.0210	3.5282	6.1744	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4750	0	88.9210	0.0000	0.6778	1.1862	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4760	0	89.3700	0.0000	9.1022	15.9289	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4770	0	89.1730	0.0130	8.4446	14.7781	Discharge	0.1993	0.4	Ratio to Peak	0.8
W4780	0	89.2200	0.0000	3.5934	6.2885	Discharge	0.0258	0.4	Ratio to Peak	0.8
W4790	0	88.6500	0.0000	3.8464	6.7312	Discharge	0.1440	0.4	Ratio to Peak	0.8
W4800	0	87.2380	0.0000	3.5710	6.2493	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4810	0	81.9150	0.0889	4.6036	8.0563	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4820	0	89.0990	0.0000	1.3712	2.3996	Discharge	0.2520	0.4	Ratio to Peak	0.8
W4830	0	86.8700	0.0000	0.6736	1.1788	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4840	0	88.2050	0.0000	1.8643	3.2625	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4850	0	88.6300	0.0000	5.6076	9.8133	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4860	0	89.5300	0.0000	3.7970	6.6448	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4870	0	91.6380	0.0000	1.5382	2.6919	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4880	0	89.7070	0.0000	3.9066	6.8366	Discharge	0.0000	0.4	Ratio to Peak	0.8

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Base flow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W4890	0	88.6460	0.0000	2.5308	4.4289	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4900	0	89.9070	0.0000	3.8888	6.8054	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4910	0	90.0910	0.0000	4.2022	7.3539	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4920	0	89.2840	0.0557	2.9156	5.1023	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4930	0	89.2993	0.0108	3.3348	5.8359	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4940	0	91.3656	0.0000	2.4658	4.3152	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4950	0	89.1071	0.0000	2.8566	4.9991	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4960	0	93.1401	0.4947	2.7278	4.7737	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4970	0	89.7290	0.0779	2.8998	5.0747	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4980	0	89.1340	0.0000	2.4642	4.3124	Discharge	0.0000	0.4	Ratio to Peak	0.8
W4990	0	89.3910	0.0020	1.7428	3.0499	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5000	0	90.4170	0.0000	3.9814	6.9675	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5010	0	88.7820	0.0000	0.3400	0.5950	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5020	0	89.2860	0.0000	1.0011	1.7519	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5030	0	88.8308	0.0000	3.1826	5.5696	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5040	0	89.1650	0.0000	2.9222	5.1139	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5050	0	88.9550	0.0000	2.0610	3.6068	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5060	0	88.8850	0.0000	3.7282	6.5244	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5070	0	89.3950	0.0000	1.3615	2.3827	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5080	0	91.0160	0.0000	3.3864	5.9262	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5090	0	89.6030	0.0000	1.1536	2.0189	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5100	0	89.3660	0.0000	3.2740	5.7295	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5110	0	89.6750	0.0000	3.8176	6.6808	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5120	0	89.2370	0.0000	2.5058	4.3852	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5130	0	88.8600	0.0000	0.8330	1.4578	Discharge	0.0000	0.4	Ratio to Peak	0.8

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Base flow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W5140	0	88.9000	0.0000	3.0286	5.3001	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5170	0	94.9040	0.0000	1.6230	2.8403	Discharge	0.0004	0.4	Ratio to Peak	0.8
W5210	0	91.4220	0.0000	2.4872	4.3526	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5230	0	93.1910	0.0000	2.3478	4.1087	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5250	0	87.8300	0.0000	2.9284	5.1247	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5270	0	87.7510	0.0000	2.9738	5.2042	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5310	0	86.5230	17.9890	0.3400	0.5950	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5330	0	87.6280	11.9230	2.8446	4.9781	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5360	0	86.2900	13.0720	0.7003	1.2255	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5380	0	87.7322	2.6949	2.2618	3.9582	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5410	0	86.9919	1.2341	2.7354	4.7870	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5530	0	87.5810	0.8051	8.7240	15.2670	Discharge	0.0085	0.4	Ratio to Peak	0.8
W5560	0	77.5280	0.1039	4.8510	8.4893	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5580	0	86.7180	0.0000	9.9308	17.3789	Discharge	0.0134	0.4	Ratio to Peak	0.8
W5600	0	87.1640	0.0024	6.3990	11.1983	Discharge	0.0084	0.4	Ratio to Peak	0.8
W5620	0	88.0080	0.0000	2.7512	4.8146	Discharge	0.0091	0.4	Ratio to Peak	0.8
W5660	0	87.9280	0.0000	0.3400	0.5950	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5680	0	87.0380	0.0000	2.2264	3.8962	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5700	0	87.7293	0.0000	1.3500	2.3626	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5720	0	87.6470	10.0000	1.2763	2.2336	Discharge	0.0212	0.4	Ratio to Peak	0.8
W5780	0	78.5410	0.0000	0.3400	0.5950	Discharge	0.0292	0.4	Ratio to Peak	0.8
W5810	0	84.1710	0.0000	5.4132	9.4731	Discharge	0.1521	0.4	Ratio to Peak	0.8
W5830	0	86.9650	0.0000	4.4576	7.8008	Discharge	0.0008	0.4	Ratio to Peak	0.8
W5850	0	84.6710	0.0214	2.6226	4.5896	Discharge	0.0140	0.4	Ratio to Peak	0.8
W5870	0	84.3450	0.0000	2.7834	4.8710	Discharge	0.0479	0.4	Ratio to Peak	0.8

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Base flow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W5910	0	84.3020	0.6171	4.5576	7.9758	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5930	0	89.4430	0.0000	2.7412	4.7971	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5950	0	84.5070	0.0000	2.3762	4.1584	Discharge	0.0000	0.4	Ratio to Peak	0.8
W5970	0	86.5130	0.0000	1.8120	3.1710	Discharge	0.0000	0.4	Ratio to Peak	0.8
W6010	0	87.3250	0.0000	6.1266	10.7216	Discharge	0.1361	0.4	Ratio to Peak	0.8
W6020	0	86.4000	0.2164	7.4588	13.0529	Discharge	0.0328	0.4	Ratio to Peak	0.8
W6060	0	88.2460	0.0000	8.3800	14.6650	Discharge	0.0084	0.4	Ratio to Peak	0.8
W6110	0	89.6400	0.0781	8.3650	14.6388	Discharge	0.0000	0.4	Ratio to Peak	0.8
W6150	0	84.9420	1.1796	1.2227	2.1397	Discharge	0.0067	0.4	Ratio to Peak	0.8
W6170	0	88.6990	0.0000	0.3400	0.5950	Discharge	0.0779	0.4	Ratio to Peak	0.8
W6210	0	89.0840	0.0000	2.6952	4.7166	Discharge	0.1379	0.4	Ratio to Peak	0.8
W6220	0	88.8052	0.0000	0.8229	1.4401	Discharge	0.3287	0.4	Ratio to Peak	0.8
W6260	0	95.0110	0.0000	2.1400	3.7450	Discharge	0.0000	0.4	Ratio to Peak	0.8
W6330	0	94.8080	0.0000	2.8040	4.9070	Discharge	0.0000	0.4	Ratio to Peak	0.8
W6350	0	94.8950	0.0000	3.1628	5.5349	Discharge	0.0000	0.4	Ratio to Peak	0.8
W6370	0	90.8270	5.3711	1.0981	1.9217	Discharge	0.0000	0.4	Ratio to Peak	0.8
W6410	0	94.5418	0.7293	1.4892	2.6062	Discharge	0.0000	0.4	Ratio to Peak	0.8
W6430	0	96.9220	9.0362	0.5544	0.9702	Discharge	0.0000	0.4	Ratio to Peak	0.8
W6470	0	90.1890	3.8845	1.4031	2.4554	Discharge	0.0000	0.4	Ratio to Peak	0.8
W6510	0	93.8450	0.1907	0.9151	1.6014	Discharge	0.0000	0.4	Ratio to Peak	0.8
W6530	0	94.0860	4.4272	0.5788	1.0130	Discharge	0.0000	0.4	Ratio to Peak	0.8
W6550	0	94.4720	1.6431	0.4259	0.7454	Discharge	0.0000	0.4	Ratio to Peak	0.8
W6570	0	91.4080	0.7937	1.3513	2.3648	Discharge	0.0000	0.4	Ratio to Peak	0.8
W6610	0	85.5340	1.6407	0.8332	1.4581	Discharge	0.0000	0.4	Ratio to Peak	0.8
W6620	0	85.1110	0.4457	8.8474	15.4830	Discharge	0.0000	0.4	Ratio to Peak	0.8

Annex 10. Tago Model Reach Parameters

Muskingum-Cunge Channel Routing							
Reach Number	Time Step Method	Length (m)	Slope (m/m)	Manning's n	Shape	Width (m)	Side Slope
R1000	Automatic Fixed Interval	4885.70	0.001142	0.0317	Trapezoid	255.58	1
R1030	Automatic Fixed Interval	3513.50	0.001833	0.0346	Trapezoid	13.24	1
R1060	Automatic Fixed Interval	5276.70	0.009574	0.0300	Trapezoid	16.81	1
R1070	Automatic Fixed Interval	1581.40	0.003971	0.0600	Trapezoid	356.18	1
R1080	Automatic Fixed Interval	1922.70	0.008348	0.0600	Trapezoid	94.49	1
R1100	Automatic Fixed Interval	3287.70	0.000639	0.0300	Trapezoid	20.40	1
R1130	Automatic Fixed Interval	2642.10	0.005980	0.0600	Trapezoid	105.38	1
R1140	Automatic Fixed Interval	2252.10	0.005288	0.0600	Trapezoid	253.35	1
R1150	Automatic Fixed Interval	1719.60	0.014463	0.0300	Trapezoid	19.57	1
R1190	Automatic Fixed Interval	4004.10	0.001531	0.0436	Trapezoid	144.81	1
R1200	Automatic Fixed Interval	10650.00	0.017736	0.0350	Trapezoid	87.96	1
R1210	Automatic Fixed Interval	1212.40	0.007151	0.0600	Trapezoid	133.36	1
R1220	Automatic Fixed Interval	911.90	0.000395	0.0350	Trapezoid	122.01	1
R1240	Automatic Fixed Interval	2630.70	0.005155	0.0600	Trapezoid	54.66	1
R1250	Automatic Fixed Interval	2812.30	0.000601	0.0310	Trapezoid	186.17	1
R1260	Automatic Fixed Interval	5258.20	0.014513	0.0600	Trapezoid	112.26	1
R1280	Automatic Fixed Interval	310.56	0.008243	0.0450	Trapezoid	14.81	1
R130	Automatic Fixed Interval	2045.10	0.042727	0.0350	Trapezoid	15.00	1
R1300	Automatic Fixed Interval	3168.60	0.000107	0.0307	Trapezoid	165.15	1
R1310	Automatic Fixed Interval	2915.40	0.001183	0.0300	Trapezoid	158.12	1
R1330	Automatic Fixed Interval	1339.30	0.003382	0.0300	Trapezoid	25.43	1
R1340	Automatic Fixed Interval	62.43	0.051421	0.0300	Trapezoid	12.35	1
R1350	Automatic Fixed Interval	6088.80	0.000338	0.0326	Trapezoid	11.24	1
R1360	Automatic Fixed Interval	3035.40	0.000425	0.0261	Trapezoid	23.46	1
R1370	Automatic Fixed Interval	481.48	0.000395	0.0300	Trapezoid	9.53	1
R1390	Automatic Fixed Interval	756.63	0.002207	0.0350	Trapezoid	19.24	1
R1420	Automatic Fixed Interval	1500.30	0.001280	0.0300	Trapezoid	16.97	1
R1430	Automatic Fixed Interval	5990.50	0.000147	0.0308	Trapezoid	132.59	1
R1470	Automatic Fixed Interval	3888.30	0.001731	0.0393	Trapezoid	167.91	1
R1490	Automatic Fixed Interval	377.84	0.000159	0.0393	Trapezoid	116.20	1
R150	Automatic Fixed Interval	779.91	0.052878	0.0350	Trapezoid	15.00	1
R1510	Automatic Fixed Interval	938.76	0.000788	0.0300	Trapezoid	152.59	1
R1540	Automatic Fixed Interval	2161.90	0.000370	0.0362	Trapezoid	97.78	1
R1550	Automatic Fixed Interval	2425.70	0.000820	0.0325	Trapezoid	144.27	1
R1560	Automatic Fixed Interval	17679.00	0.000435	0.0401	Trapezoid	25.38	1
R1580	Automatic Fixed Interval	1943.80	0.003349	0.0264	Trapezoid	32.19	1
R1590	Automatic Fixed Interval	1689.10	0.000521	0.0333	Trapezoid	109.96	1
R1650	Automatic Fixed Interval	162.43	0.010651	0.0300	Trapezoid	103.28	1
R1670	Automatic Fixed Interval	1684.00	0.000576	0.0300	Trapezoid	15.70	1
R1680	Automatic Fixed Interval	4123.50	0.000929	0.0300	Trapezoid	20.74	1

Muskingum-Cunge Channel Routing							
Reach Number	Time Step Method	Length (m)	Slope (m/m)	Manning's n	Shape	Width (m)	Side Slope
R170	Automatic Fixed Interval	4138.80	0.044708	0.0350	Trapezoid	17.52	1
R1700	Automatic Fixed Interval	3073.80	0.001308	0.0340	Trapezoid	31.22	1
R1720	Automatic Fixed Interval	8893.30	0.009648	0.0600	Trapezoid	117.91	1
R1730	Automatic Fixed Interval	4250.20	0.002183	0.0368	Trapezoid	28.33	1
R1740	Automatic Fixed Interval	5992.20	0.000117	0.0363	Trapezoid	92.65	1
R1760	Automatic Fixed Interval	321.92	0.004535	0.0333	Trapezoid	41.45	1
R1780	Automatic Fixed Interval	4278.50	0.000524	0.0313	Trapezoid	118.82	1
R1790	Automatic Fixed Interval	1173.60	0.000409	0.0300	Trapezoid	122.13	1
R180	Automatic Fixed Interval	4916.90	0.030328	0.0350	Trapezoid	16.35	1
R1800	Automatic Fixed Interval	3054.40	0.000268	0.0350	Trapezoid	81.86	1
R1820	Automatic Fixed Interval	3923.70	0.002449	0.0300	Trapezoid	21.98	1
R1850	Automatic Fixed Interval	1230.90	0.001016	0.0350	Trapezoid	34.30	1
R1860	Automatic Fixed Interval	1866.00	0.000911	0.0400	Trapezoid	29.62	1
R1870	Automatic Fixed Interval	2384.50	0.000700	0.0350	Trapezoid	24.50	1
R1890	Automatic Fixed Interval	1646.80	0.000838	0.0300	Trapezoid	19.19	1
R190	Automatic Fixed Interval	4475.30	0.046884	0.0350	Trapezoid	15.00	1
R1900	Automatic Fixed Interval	3964.90	0.001110	0.0405	Trapezoid	26.13	1
R1910	Automatic Fixed Interval	549.06	0.001293	0.0400	Trapezoid	29.13	1
R1920	Automatic Fixed Interval	1967.90	0.001204	0.0300	Trapezoid	28.85	1
R1930	Automatic Fixed Interval	3.54	0.000100	0.0500	Trapezoid	17.14	1
R1960	Automatic Fixed Interval	767.70	0.000404	0.0300	Trapezoid	11.37	1
R1970	Automatic Fixed Interval	732.34	0.000328	0.0300	Trapezoid	3.62	1
R1990	Automatic Fixed Interval	1554.10	0.000193	0.0300	Trapezoid	5.18	1
R200	Automatic Fixed Interval	3905.70	0.026899	0.0350	Trapezoid	15.00	1
R2000	Automatic Fixed Interval	3098.30	0.001340	0.0500	Trapezoid	13.34	1
R2010	Automatic Fixed Interval	2194.80	0.001030	0.0600	Trapezoid	12.88	1
R2020	Automatic Fixed Interval	815.83	0.001753	0.0500	Trapezoid	13.47	1
R2040	Automatic Fixed Interval	1706.40	0.001231	0.0300	Trapezoid	6.78	1
R2070	Automatic Fixed Interval	4769.00	0.047894	0.0350	Trapezoid	83.96	1
R2110	Automatic Fixed Interval	3862.00	0.001054	0.0300	Trapezoid	9.14	1
R2120	Automatic Fixed Interval	1260.00	0.047546	0.0350	Trapezoid	20.00	1
R2170	Automatic Fixed Interval	895.69	0.000447	0.0300	Trapezoid	7.26	1
R220	Automatic Fixed Interval	3445.80	0.033394	0.0350	Trapezoid	15.00	1
R2220	Automatic Fixed Interval	11217.00	0.021166	0.0428	Trapezoid	34.70	1
R2230	Automatic Fixed Interval	7728.50	0.001184	0.0319	Trapezoid	32.91	1
R2240	Automatic Fixed Interval	6592.30	0.000840	0.0365	Trapezoid	25.21	1
R2280	Automatic Fixed Interval	4576.70	0.002390	0.0331	Trapezoid	22.97	1
R2290	Automatic Fixed Interval	4608.60	0.000853	0.0388	Trapezoid	72.86	1
R230	Automatic Fixed Interval	2302.80	0.009506	0.0350	Trapezoid	15.00	1
R2340	Automatic Fixed Interval	6180.30	0.008284	0.0398	Trapezoid	50.81	1

Muskingum-Cunge Channel Routing							
Reach Number	Time Step Method	Length (m)	Slope (m/m)	Manning's n	Shape	Width (m)	Side Slope
R2350	Automatic Fixed Interval	105.00	0.027238	0.0500	Trapezoid	77.45	1
R2360	Automatic Fixed Interval	1282.10	0.003697	0.0388	Trapezoid	75.99	1
R2380	Automatic Fixed Interval	1833.20	0.036461	0.0600	Trapezoid	87.75	1
R2440	Automatic Fixed Interval	1723.20	0.015755	0.0350	Trapezoid	120.35	1
R2460	Automatic Fixed Interval	486.78	0.004355	0.0350	Trapezoid	50.00	1
R2470	Automatic Fixed Interval	3864.50	0.035379	0.0500	Trapezoid	41.38	1
R2490	Automatic Fixed Interval	606.98	0.100200	0.0350	Trapezoid	15.00	1
R250	Automatic Fixed Interval	1544.70	0.008999	0.0350	Trapezoid	20.59	1
R2520	Automatic Fixed Interval	2029.40	0.056101	0.0350	Trapezoid	15.00	1
R2550	Automatic Fixed Interval	4567.40	0.056995	0.0350	Trapezoid	15.00	1
R260	Automatic Fixed Interval	2066.60	0.032106	0.0350	Trapezoid	15.00	1
R300	Automatic Fixed Interval	151.57	0.026787	0.0350	Trapezoid	15.00	1
R310	Automatic Fixed Interval	3292.90	0.005758	0.0350	Trapezoid	15.00	1
R340	Automatic Fixed Interval	1437.50	0.010581	0.0350	Trapezoid	15.00	1
R370	Automatic Fixed Interval	225.21	0.016207	0.0350	Trapezoid	25.40	1
R390	Automatic Fixed Interval	2696.10	0.010252	0.0350	Trapezoid	29.93	1
R400	Automatic Fixed Interval	4343.30	0.012391	0.0350	Trapezoid	37.52	1
R420	Automatic Fixed Interval	2424.30	0.007936	0.0450	Trapezoid	53.47	1
R430	Automatic Fixed Interval	4219.00	0.005492	0.0439	Trapezoid	87.23	1
R440	Automatic Fixed Interval	2829.00	0.017144	0.0350	Trapezoid	45.15	1
R510	Automatic Fixed Interval	2395.40	0.006325	0.0350	Trapezoid	15.00	1
R5180	Automatic Fixed Interval	141.57	0.012644	0.0300	Trapezoid	93.06	1
R5220	Automatic Fixed Interval	3179.80	0.001343	0.0388	Trapezoid	121.25	1
R5240	Automatic Fixed Interval	492.84	0.008197	0.0300	Trapezoid	100.63	1
R5260	Automatic Fixed Interval	485.77	0.001153	0.0300	Trapezoid	8.57	1
R530	Automatic Fixed Interval	5095.00	0.003784	0.0335	Trapezoid	123.37	1
R5320	Automatic Fixed Interval	2934.80	0.001608	0.0600	Trapezoid	17.55	1
R5370	Automatic Fixed Interval	1253.20	0.000415	0.0300	Trapezoid	8.49	1
R5440	Automatic Fixed Interval	1397.30	0.000909	0.0300	Trapezoid	8.70	1
R550	Automatic Fixed Interval	4879.40	0.015848	0.0350	Trapezoid	20.89	1
R5570	Automatic Fixed Interval	5.00	0.076000	0.0300	Trapezoid	25.00	1
R5590	Automatic Fixed Interval	1452.60	0.002024	0.0300	Trapezoid	9.12	1
R560	Automatic Fixed Interval	1429.10	0.000812	0.0350	Trapezoid	15.73	1
R5610	Automatic Fixed Interval	251.07	0.001036	0.0300	Trapezoid	19.49	1
R5690	Automatic Fixed Interval	2508.00	0.000275	0.0300	Trapezoid	13.24	1
R5710	Automatic Fixed Interval	1295.00	0.000100	0.0300	Trapezoid	5.95	1
R580	Automatic Fixed Interval	1161.30	0.004185	0.0350	Trapezoid	15.60	1
R5820	Automatic Fixed Interval	2509.00	0.001192	0.0300	Trapezoid	8.31	1
R5840	Automatic Fixed Interval	674.41	0.004448	0.0300	Trapezoid	5.16	1
R5860	Automatic Fixed Interval	660.12	0.000100	0.0300	Trapezoid	6.15	1

Muskingum-Cunge Channel Routing							
Reach Number	Time Step Method	Length (m)	Slope (m/m)	Manning's n	Shape	Width (m)	Side Slope
R5920	Automatic Fixed Interval	1195.90	0.000284	0.0300	Trapezoid	28.66	1
R5960	Automatic Fixed Interval	1914.80	0.000621	0.0300	Trapezoid	5.07	1
R60	Automatic Fixed Interval	1936.30	0.065465	0.0350	Trapezoid	15.00	1
R6030	Automatic Fixed Interval	1567.00	0.003070	0.0300	Trapezoid	138.59	1
R610	Automatic Fixed Interval	10335.00	0.028402	0.0350	Trapezoid	33.28	1
R6120	Automatic Fixed Interval	17.07	0.034561	0.0350	Trapezoid	12.00	1
R6140	Automatic Fixed Interval	3101.00	0.019010	0.0350	Trapezoid	22.74	1
R6160	Automatic Fixed Interval	327.63	0.011171	0.0350	Trapezoid	19.40	1
R620	Automatic Fixed Interval	4509.80	0.002331	0.0435	Trapezoid	114.42	1
R630	Automatic Fixed Interval	3715.20	0.023218	0.0350	Trapezoid	25.02	1
R6340	Automatic Fixed Interval	799.02	0.000726	0.0300	Trapezoid	216.35	1
R6360	Automatic Fixed Interval	708.14	0.006086	0.0300	Trapezoid	21.00	1
R6420	Automatic Fixed Interval	586.21	0.007438	0.0300	Trapezoid	173.66	1
R6440	Automatic Fixed Interval	1274.20	0.000345	0.0300	Trapezoid	223.87	1
R6520	Automatic Fixed Interval	1227.30	0.002607	0.0300	Trapezoid	17.02	1
R6540	Automatic Fixed Interval	282.63	0.005307	0.0300	Trapezoid	5.00	1
R6560	Automatic Fixed Interval	508.14	0.003031	0.0300	Trapezoid	5.00	1
R6640	Automatic Fixed Interval	2938.10	0.001297	0.0345	Trapezoid	15.60	1
R670	Automatic Fixed Interval	1648.50	0.002390	0.0300	Trapezoid	15.20	1
R690	Automatic Fixed Interval	3639.90	0.002088	0.0450	Trapezoid	147.95	1
R700	Automatic Fixed Interval	1715.30	0.004337	0.0332	Trapezoid	78.26	1
R740	Automatic Fixed Interval	1955.50	0.002046	0.0300	Trapezoid	15.43	1
R750	Automatic Fixed Interval	28.71	0.418730	0.0300	Trapezoid	300.00	1
R760	Automatic Fixed Interval	3665.70	0.000360	0.0300	Trapezoid	301.77	1
R770	Automatic Fixed Interval	7.07	0.035355	0.0300	Trapezoid	300.00	1
R780	Automatic Fixed Interval	1272.50	0.006931	0.0300	Trapezoid	15.00	1
R820	Automatic Fixed Interval	120.71	0.018971	0.0300	Trapezoid	15.00	1
R830	Automatic Fixed Interval	5365.00	0.007419	0.0300	Trapezoid	23.23	1
R860	Automatic Fixed Interval	6592.40	0.001963	0.0450	Trapezoid	122.02	1
R870	Automatic Fixed Interval	3260.60	0.001877	0.0312	Trapezoid	63.68	1
R880	Automatic Fixed Interval	2572.80	0.000875	0.0300	Trapezoid	386.26	1
R90	Automatic Fixed Interval	1217.40	0.081296	0.0350	Trapezoid	15.00	1
R900	Automatic Fixed Interval	2216.70	0.000406	0.0350	Trapezoid	237.81	1
R910	Automatic Fixed Interval	2900.20	0.001303	0.0300	Trapezoid	228.77	1
R940	Automatic Fixed Interval	3323.50	0.034295	0.0350	Trapezoid	15.00	1
R960	Automatic Fixed Interval	1465.40	0.001106	0.0450	Trapezoid	113.84	1
R980	Automatic Fixed Interval	294.85	0.003968	0.0500	Trapezoid	147.25	1
R990	Automatic Fixed Interval	5392.10	0.004026	0.0350	Trapezoid	77.58	1

Annex 11. Tago Field Validation Points

Point Number	Validation Coordinates		Validation Points (m)	Model Var (m)	Error	Event/Date	Rain Return /Scenario
	Latitude	Longitude					
1	8.987243	126.2131	0.47	0.03	0.44	5-yr	Agaton
2	8.986686	126.2045	0	0.08	-0.08	5-yr	Agaton
3	8.98444	126.1999	0	0.03	-0.03	5-yr	Agaton
4	8.98847	126.1863	0.59	0.09	0.5	5-yr	Agaton
5	8.990777	126.1886	1.06	0.06	1	5-yr	Agaton
6	8.995146	126.1881	1.15	0.04	1.11	5-yr	Agaton
7	8.995113	126.1889	0.8	0.03	0.77	5-yr	Agaton
8	8.994449	126.1739	1.2	0.03	1.17	5-yr	Agaton
9	8.994743	126.1734	1.88	0.03	1.85	5-yr	Agaton
10	8.986201	126.183	0.73	0.07	0.66	5-yr	Agaton
11	8.984548	126.1792	1.08	0.03	1.05	5-yr	Agaton
12	8.981118	126.1763	2.13	0.03	2.1	5-yr	Agaton
13	8.979275	126.1766	1.4	0.05	1.35	5-yr	Agaton
14	8.977572	126.1783	0	0.21	-0.21	5-yr	Agaton
15	8.974599	126.1791	1.84	0.03	1.81	5-yr	Agaton
16	8.971062	126.1783	1.23	0.03	1.2	5-yr	Agaton
17	8.962589	126.1724	0	0.09	-0.09	5-yr	Agaton
18	8.959635	126.1727	0.66	0.03	0.63	5-yr	Agaton
19	8.958162	126.1662	2.5	0.28	2.22	5-yr	Agaton
20	8.957875	126.1629	1.51	0.04	1.47	5-yr	Agaton
21	8.959261	126.1607	0	0.07	-0.07	5-yr	Agaton
22	8.96328	126.1612	0.87	0.03	0.84	5-yr	Agaton
23	8.9649	126.1604	1.87	0.03	1.84	5-yr	Agaton
24	8.964039	126.1563	2.1	0.17	1.93	5-yr	Agaton
25	8.957624	126.1533	1.94	0.03	1.91	5-yr	Agaton
26	8.982393	126.192	1.23	0.15	1.08	5-yr	Agaton
27	8.983856	126.1942	1.59	0.03	1.56	5-yr	Agaton
28	8.982644	126.1959	1.02	0.07	0.95	5-yr	Agaton
29	8.986179	126.1883	0	0.13	-0.13	5-yr	Agaton
30	8.988316	126.1851	0.81	0.03	0.78	5-yr	Agaton
31	8.999416	126.1662	1.45	0.03	1.42	5-yr	Agaton
32	8.995739	126.1644	1.2	0.04	1.16	5-yr	Agaton
33	8.991732	126.1637	1.31	0.03	1.28	5-yr	Agaton
34	8.988714	126.1646	0	0.03	-0.03	5-yr	Agaton
35	8.985435	126.1678	2.15	0.03	2.12	5-yr	Agaton
36	8.980234	126.1512	0.3	0.03	0.27	5-yr	Agaton
37	8.976411	126.1499	1.63	0.03	1.6	5-yr	Agaton
38	8.975439	126.1423	0	0.18	-0.18	5-yr	Agaton
39	8.973954	126.1357	0	0.03	-0.03	5-yr	Agaton
40	8.970028	126.1286	0	0.35	-0.35	5-yr	Agaton
41	9.0019	126.1703	1.22	0.2	1.02	5-yr	Agaton
42	9.00055	126.1678	1.38	0.09	1.29	5-yr	Agaton
43	9.0055	126.1699	0	0.03	-0.03	5-yr	Agaton
44	9.006217	126.1774	1.2	0.03	1.17	5-yr	Agaton
45	9.001017	126.1924	0.45	0.03	0.42	5-yr	Agaton

Point Number	Validation Coordinates		Validation Points (m)	Model Var (m)	Error	Event/Date	Rain Return /Scenario
	Latitude	Longitude					
46	9.009733	126.2006	0.82	0.08	0.74	5-yr	Agaton
47	9.005333	126.1993	0.52	0.06	0.46	5-yr	Agaton
48	9.002367	126.197	0.75	0.03	0.72	5-yr	Agaton
49	9.002667	126.1897	0.99	0.09	0.9	5-yr	Agaton
50	9.0029	126.1666	0.8	0.03	0.77	5-yr	Agaton
51	9.002267	126.1643	0	0.06	-0.06	5-yr	Agaton
52	8.969006	126.1109	1.45	1.05	0.4	5-yr	Agaton
53	8.967397	126.1046	1.8	2.13	-0.33	5-yr	Agaton
54	8.968336	126.1043	0.85	2.31	-1.46	5-yr	Agaton
55	8.950165	126.0995	1.03	0.03	1	5-yr	Agaton
56	8.947682	126.1005	0	0.03	-0.03	5-yr	Agaton
57	8.94771	126.1023	0.62	0.14	0.48	5-yr	Agaton
58	8.956248	126.1145	2.1	0.03	2.07	5-yr	Agaton
59	8.966545	126.1236	0.31	0.14	0.17	5-yr	Agaton
60	8.967036	126.1338	1.92	0.06	1.86	5-yr	Agaton
61	9.014512	126.2336	0	0.03	-0.03	5-yr	Agaton
62	9.014526	126.2354	0	0.03	-0.03	5-yr	Agaton
63	9.019414	126.2285	0.42	0.05	0.37	5-yr	Agaton
64	9.027417	126.2199	0.25	0.18	0.07	5-yr	Agaton
65	9.003451	126.1761	1.97	0.06	1.91	5-yr	Agaton
66	9.003467	126.179	1.54	0.06	1.48	5-yr	Agaton
67	8.98434	126.1544	0	0.03	-0.03	5-yr	Agaton
68	8.97242	126.1472	2.92	0.09	2.83	5-yr	Agaton
69	8.970455	126.1481	2.15	0.03	2.12	5-yr	Agaton
70	8.94202	126.038	1.28	0.15	1.13	5-yr	Agaton
71	8.943124	126.0395	0	0.06	-0.06	5-yr	Agaton
72	8.943111	126.0395	1.13	0.06	1.07	5-yr	Agaton
73	8.941692	126.0331	1.61	0.52	1.09	5-yr	Agaton
74	8.941998	126.0393	0.56	0.21	0.35	5-yr	Agaton
75	8.937714	126.0401	0.99	0.48	0.51	5-yr	Agaton
76	8.935884	126.0413	1.33	0.33	1	5-yr	Agaton
77	8.941816	126.0442	0	0.07	-0.07	5-yr	Agaton
78	8.942082	126.0479	1.25	0.38	0.87	5-yr	Agaton
79	8.940701	126.051	0.37	0.03	0.34	5-yr	Agaton
80	8.940487	126.0544	0	0.03	-0.03	5-yr	Agaton
81	8.936624	126.0556	0.06	0.03	0.03	5-yr	Agaton
82	8.939608	126.0585	0	0.03	-0.03	5-yr	Agaton
83	8.932968	126.0754	0.55	0.03	0.52	5-yr	Agaton
84	8.933012	126.0754	0	0.03	-0.03	5-yr	Agaton
85	8.928399	126.0756	1.06	0.03	1.03	5-yr	Agaton
86	8.926952	126.0775	0	0.03	-0.03	5-yr	Agaton
87	8.923962	126.0765	1.34	0.03	1.31	5-yr	Agaton
88	8.939645	126.0735	0.51	0.42	0.09	5-yr	Agaton
89	8.935182	126.0395	1.4	0.98	0.42	5-yr	Agaton
90	8.928854	126.0421	1.15	0.12	1.03	5-yr	Agaton

Point Number	Validation Coordinates		Validation Points (m)	Model Var (m)	Error	Event/Date	Rain Return /Scenario
	Latitude	Longitude					
91	8.924146	126.0431	1.51	0.03	1.48	5-yr	Agaton
92	8.918743	126.0408	1.07	0.03	1.04	5-yr	Agaton
93	8.917449	126.0473	0.31	0.03	0.28	5-yr	Agaton
94	8.92091	126.053	0.6	0.1	0.5	5-yr	Agaton
95	8.923741	126.0546	0.7	0.19	0.51	5-yr	Agaton
96	8.931652	126.0415	1.15	1	0.15	5-yr	Agaton
97	8.933935	126.0403	1.38	0.93	0.45	5-yr	Agaton
98	8.934971	126.0376	1.53	0.98	0.55	5-yr	Agaton
99	8.937934	126.0296	1.34	0.03	1.31	5-yr	Agaton
100	8.938769	126.0274	2.33	1.64	0.69	5-yr	Agaton
101	8.939188	126.0301	2.06	0.8	1.26	5-yr	Agaton
102	8.987243	126.2131	0.47	0.03	0.44	25-yr	Agaton
103	8.986686	126.2045	0	0.12	-0.12	25-yr	Agaton
104	8.98444	126.1999	0	0.03	-0.03	25-yr	Agaton
105	8.98847	126.1863	0.59	0.1	0.49	25-yr	Agaton
106	8.990777	126.1886	1.06	0.07	0.99	25-yr	Agaton
107	8.995146	126.1881	1.15	0.05	1.1	25-yr	Agaton
108	8.995113	126.1889	0.8	0.03	0.77	25-yr	Agaton
109	8.994449	126.1739	1.2	0.03	1.17	25-yr	Agaton
110	8.994743	126.1734	1.88	0.03	1.85	25-yr	Agaton
111	8.986201	126.183	0.73	0.08	0.65	25-yr	Agaton
112	8.984548	126.1792	1.08	0.03	1.05	25-yr	Agaton
113	8.981118	126.1763	2.13	0.03	2.1	25-yr	Agaton
114	8.979275	126.1766	1.4	0.06	1.34	25-yr	Agaton
115	8.977572	126.1783	0	0.23	-0.23	25-yr	Agaton
116	8.974599	126.1791	1.84	0.03	1.81	25-yr	Agaton
117	8.971062	126.1783	1.23	0.03	1.2	25-yr	Agaton
118	8.962589	126.1724	0	0.11	-0.11	25-yr	Agaton
119	8.959635	126.1727	0.66	0.03	0.63	25-yr	Agaton
120	8.958162	126.1662	2.5	0.44	2.06	25-yr	Agaton
121	8.957875	126.1629	1.51	0.04	1.47	25-yr	Agaton
122	8.959261	126.1607	0	0.08	-0.08	25-yr	Agaton
123	8.96328	126.1612	0.87	0.04	0.83	25-yr	Agaton
124	8.9649	126.1604	1.87	0.03	1.84	25-yr	Agaton
125	8.964039	126.1563	2.1	0.21	1.89	25-yr	Agaton
126	8.957624	126.1533	1.94	0.09	1.85	25-yr	Agaton
127	8.982393	126.192	1.23	0.35	0.88	25-yr	Agaton
128	8.983856	126.1942	1.59	0.03	1.56	25-yr	Agaton
129	8.982644	126.1959	1.02	0.48	0.54	25-yr	Agaton
130	8.986179	126.1883	0	0.14	-0.14	25-yr	Agaton
131	8.988316	126.1851	0.81	0.03	0.78	25-yr	Agaton
132	8.999416	126.1662	1.45	0.03	1.42	25-yr	Agaton
133	8.995739	126.1644	1.2	0.05	1.15	25-yr	Agaton
134	8.991732	126.1637	1.31	0.03	1.28	25-yr	Agaton
135	8.988714	126.1646	0	0.03	-0.03	25-yr	Agaton

Point Number	Validation Coordinates		Validation Points (m)	Model Var (m)	Error	Event/Date	Rain Return /Scenario
	Latitude	Longitude					
136	8.985435	126.1678	2.15	0.03	2.12	25-yr	Agaton
137	8.980234	126.1512	0.3	0.04	0.26	25-yr	Agaton
138	8.976411	126.1499	1.63	0.03	1.6	25-yr	Agaton
139	8.975439	126.1423	0	0.22	-0.22	25-yr	Agaton
140	8.973954	126.1357	0	0.03	-0.03	25-yr	Agaton
141	8.970028	126.1286	0	0.41	-0.41	25-yr	Agaton
142	9.0019	126.1703	1.22	0.22	1	25-yr	Agaton
143	9.00055	126.1678	1.38	0.12	1.26	25-yr	Agaton
144	9.0055	126.1699	0	0.04	-0.04	25-yr	Agaton
145	9.006217	126.1774	1.2	0.03	1.17	25-yr	Agaton
146	9.001017	126.1924	0.45	0.03	0.42	25-yr	Agaton
147	9.009733	126.2006	0.82	0.09	0.73	25-yr	Agaton
148	9.005333	126.1993	0.52	0.07	0.45	25-yr	Agaton
149	9.002367	126.197	0.75	0.03	0.72	25-yr	Agaton
150	9.002667	126.1897	0.99	0.11	0.88	25-yr	Agaton
151	9.0029	126.1666	0.8	0.03	0.77	25-yr	Agaton
152	9.002267	126.1643	0	0.08	-0.08	25-yr	Agaton
153	8.969006	126.1109	1.45	1.31	0.14	25-yr	Agaton
154	8.967397	126.1046	1.8	2.42	-0.62	25-yr	Agaton
155	8.968336	126.1043	0.85	2.64	-1.79	25-yr	Agaton
156	8.950165	126.0995	1.03	0.03	1	25-yr	Agaton
157	8.947682	126.1005	0	0.03	-0.03	25-yr	Agaton
158	8.94771	126.1023	0.62	0.15	0.47	25-yr	Agaton
159	8.956248	126.1145	2.1	0.04	2.06	25-yr	Agaton
160	8.966545	126.1236	0.31	0.22	0.09	25-yr	Agaton
161	8.967036	126.1338	1.92	0.08	1.84	25-yr	Agaton
162	9.014512	126.2336	0	0.03	-0.03	25-yr	Agaton
163	9.014526	126.2354	0	0.07	-0.07	25-yr	Agaton
164	9.019414	126.2285	0.42	0.06	0.36	25-yr	Agaton
165	9.027417	126.2199	0.25	0.25	0	25-yr	Agaton
166	9.003451	126.1761	1.97	0.07	1.9	25-yr	Agaton
167	9.003467	126.179	1.54	0.07	1.47	25-yr	Agaton
168	8.98434	126.1544	0	0.03	-0.03	25-yr	Agaton
169	8.97242	126.1472	2.92	0.31	2.61	25-yr	Agaton
170	8.970455	126.1481	2.15	0.04	2.11	25-yr	Agaton
171	8.94202	126.038	1.28	0.44	0.84	25-yr	Agaton
172	8.943124	126.0395	0	0.06	-0.06	25-yr	Agaton
173	8.943111	126.0395	1.13	0.06	1.07	25-yr	Agaton
174	8.941692	126.0331	1.61	0.94	0.67	25-yr	Agaton
175	8.941998	126.0393	0.56	1.13	-0.57	25-yr	Agaton
176	8.937714	126.0401	0.99	0.77	0.22	25-yr	Agaton
177	8.935884	126.0413	1.33	0.61	0.72	25-yr	Agaton
178	8.941816	126.0442	0	0.08	-0.08	25-yr	Agaton
179	8.942082	126.0479	1.25	0.59	0.66	25-yr	Agaton
180	8.940701	126.051	0.37	0.03	0.34	25-yr	Agaton

Point Number	Validation Coordinates		Validation Points (m)	Model Var (m)	Error	Event/Date	Rain Return /Scenario
	Latitude	Longitude					
181	8.940487	126.0544	0	0.03	-0.03	25-yr	Agaton
182	8.936624	126.0556	0.06	0.03	0.03	25-yr	Agaton
183	8.939608	126.0585	0	0.06	-0.06	25-yr	Agaton
184	8.932968	126.0754	0.55	0.03	0.52	25-yr	Agaton
185	8.933012	126.0754	0	0.03	-0.03	25-yr	Agaton
186	8.928399	126.0756	1.06	0.03	1.03	25-yr	Agaton
187	8.926952	126.0775	0	0.03	-0.03	25-yr	Agaton
188	8.923962	126.0765	1.34	0.03	1.31	25-yr	Agaton
189	8.939645	126.0735	0.51	0.63	-0.12	25-yr	Agaton
190	8.935182	126.0395	1.4	1.25	0.15	25-yr	Agaton
191	8.928854	126.0421	1.15	0.3	0.85	25-yr	Agaton
192	8.924146	126.0431	1.51	0.6	0.91	25-yr	Agaton
193	8.918743	126.0408	1.07	0.03	1.04	25-yr	Agaton
194	8.917449	126.0473	0.31	0.03	0.28	25-yr	Agaton
195	8.92091	126.053	0.6	0.11	0.49	25-yr	Agaton
196	8.923741	126.0546	0.7	1.03	-0.33	25-yr	Agaton
197	8.931652	126.0415	1.15	1.26	-0.11	25-yr	Agaton
198	8.933935	126.0403	1.38	1.19	0.19	25-yr	Agaton
199	8.934971	126.0376	1.53	1.27	0.26	25-yr	Agaton
200	8.937934	126.0296	1.34	0.03	1.31	25-yr	Agaton
201	8.938769	126.0274	2.33	2.01	0.32	25-yr	Agaton
202	8.939188	126.0301	2.06	1.15	0.91	25-yr	Agaton
203	8.987243	126.2131	0.47	0.03	0.44	100-yr	Agaton
204	8.986686	126.2045	0	0.21	-0.21	100-yr	Agaton
205	8.98444	126.1999	0	0.03	-0.03	100-yr	Agaton
206	8.98847	126.1863	0.59	0.11	0.48	100-yr	Agaton
207	8.990777	126.1886	1.06	0.08	0.98	100-yr	Agaton
208	8.995146	126.1881	1.15	0.06	1.09	100-yr	Agaton
209	8.995113	126.1889	0.8	0.03	0.77	100-yr	Agaton
210	8.994449	126.1739	1.2	0.03	1.17	100-yr	Agaton
211	8.994743	126.1734	1.88	0.03	1.85	100-yr	Agaton
212	8.986201	126.183	0.73	0.09	0.64	100-yr	Agaton
213	8.984548	126.1792	1.08	0.04	1.04	100-yr	Agaton
214	8.981118	126.1763	2.13	0.03	2.1	100-yr	Agaton
215	8.979275	126.1766	1.4	0.07	1.33	100-yr	Agaton
216	8.977572	126.1783	0	0.24	-0.24	100-yr	Agaton
217	8.974599	126.1791	1.84	0.04	1.8	100-yr	Agaton
218	8.971062	126.1783	1.23	0.03	1.2	100-yr	Agaton
219	8.962589	126.1724	0	0.12	-0.12	100-yr	Agaton
220	8.959635	126.1727	0.66	0.03	0.63	100-yr	Agaton
221	8.958162	126.1662	2.5	0.59	1.91	100-yr	Agaton
222	8.957875	126.1629	1.51	0.05	1.46	100-yr	Agaton
223	8.959261	126.1607	0	0.09	-0.09	100-yr	Agaton
224	8.96328	126.1612	0.87	0.05	0.82	100-yr	Agaton
225	8.9649	126.1604	1.87	0.03	1.84	100-yr	Agaton

Point Number	Validation Coordinates		Validation Points (m)	Model Var (m)	Error	Event/Date	Rain Return /Scenario
	Latitude	Longitude					
316	8.979275	126.1766	1.04	0.05	0.99	5-yr	Seniang
317	8.977572	126.1783	1.38	0.21	1.17	5-yr	Seniang
318	8.974599	126.1791	1.67	0.03	1.64	5-yr	Seniang
319	8.971062	126.1783	0.86	0.03	0.83	5-yr	Seniang
320	8.962589	126.1724	0.68	0.09	0.59	5-yr	Seniang
321	8.959635	126.1727	1.26	0.03	1.23	5-yr	Seniang
322	8.958162	126.1662	1.39	0.28	1.11	5-yr	Seniang
323	8.957875	126.1629	0.82	0.04	0.78	5-yr	Seniang
324	8.959261	126.1607	1.2	0.07	1.13	5-yr	Seniang
325	8.96328	126.1612	0.63	0.03	0.6	5-yr	Seniang
326	8.9649	126.1604	1.53	0.03	1.5	5-yr	Seniang
327	8.964039	126.1563	1.53	0.17	1.36	5-yr	Seniang
328	8.957624	126.1533	1.42	0.03	1.39	5-yr	Seniang
329	8.982393	126.192	0.82	0.15	0.67	5-yr	Seniang
330	8.983856	126.1942	1.01	0.03	0.98	5-yr	Seniang
331	8.982644	126.1959	0.45	0.07	0.38	5-yr	Seniang
332	8.986179	126.1883	0	0.13	-0.13	5-yr	Seniang
333	8.988316	126.1851	0.09	0.03	0.06	5-yr	Seniang
334	8.999416	126.1662	1.23	0.03	1.2	5-yr	Seniang
335	8.995739	126.1644	0	0.04	-0.04	5-yr	Seniang
336	8.991732	126.1637	1.05	0.03	1.02	5-yr	Seniang
337	8.988714	126.1646	0.78	0.03	0.75	5-yr	Seniang
338	8.985435	126.1678	1.62	0.03	1.59	5-yr	Seniang
339	8.980234	126.1512	0.3	0.03	0.27	5-yr	Seniang
340	8.976411	126.1499	1.2	0.03	1.17	5-yr	Seniang
341	8.975439	126.1423	0.84	0.18	0.66	5-yr	Seniang
342	8.973954	126.1357	0.54	0.03	0.51	5-yr	Seniang
343	8.970028	126.1286	0	0.35	-0.35	5-yr	Seniang
344	9.001892	126.1703	0.83	0.2	0.63	5-yr	Seniang
345	9.000543	126.1678	0.95	0.15	0.8	5-yr	Seniang
346	9.005544	126.1699	0	0.03	-0.03	5-yr	Seniang
347	9.006223	126.1774	0.39	0.03	0.36	5-yr	Seniang
348	9.001021	126.1924	0.25	0.03	0.22	5-yr	Seniang
349	9.009736	126.2006	0.46	0.08	0.38	5-yr	Seniang
350	9.005328	126.1993	0	0.03	-0.03	5-yr	Seniang
351	9.002366	126.197	0.76	0.03	0.73	5-yr	Seniang
352	9.002663	126.1897	0.6	0.09	0.51	5-yr	Seniang
353	9.002897	126.1666	0	0.03	-0.03	5-yr	Seniang
354	9.002263	126.1643	1.18	0.06	1.12	5-yr	Seniang
355	8.969006	126.1109	0	1.05	-1.05	5-yr	Seniang
356	8.967397	126.1046	0.35	2.13	-1.78	5-yr	Seniang
357	8.968336	126.1043	0.46	2.31	-1.85	5-yr	Seniang
358	8.950165	126.0995	0	0.03	-0.03	5-yr	Seniang
359	8.947682	126.1005	0.62	0.03	0.59	5-yr	Seniang
360	8.94771	126.1023	0.72	0.14	0.58	5-yr	Seniang

Point Number	Validation Coordinates		Validation Points (m)	Model Var (m)	Error	Event/Date	Rain Return /Scenario
	Latitude	Longitude					
361	8.956248	126.1145	0.31	0.03	0.28	5-yr	Seniang
362	8.966545	126.1236	1.74	0.14	1.6	5-yr	Seniang
363	8.967036	126.1338	0.22	0.06	0.16	5-yr	Seniang
364	9.014512	126.2336	0	0.03	-0.03	5-yr	Seniang
365	9.014526	126.2354	0	0.03	-0.03	5-yr	Seniang
366	9.019414	126.2285	0	0.05	-0.05	5-yr	Seniang
367	9.027417	126.2199	0.25	0.18	0.07	5-yr	Seniang
368	9.003451	126.1761	0.94	0.06	0.88	5-yr	Seniang
369	9.003467	126.179	0.98	0.06	0.92	5-yr	Seniang
370	8.98434	126.1544	0	0.03	-0.03	5-yr	Seniang
371	8.97242	126.1472	2.3	0.09	2.21	5-yr	Seniang
372	8.970455	126.1481	1.79	0.03	1.76	5-yr	Seniang
373	8.94202	126.038	0.59	0.15	0.44	5-yr	Seniang
374	8.943124	126.0395	1.05	0.06	0.99	5-yr	Seniang
375	8.943111	126.0395	0.77	0.06	0.71	5-yr	Seniang
376	8.941692	126.0331	1.25	0.52	0.73	5-yr	Seniang
377	8.941998	126.0393	0.3	0.21	0.09	5-yr	Seniang
378	8.937714	126.0401	0.99	0.48	0.51	5-yr	Seniang
379	8.935884	126.0413	0.88	0.33	0.55	5-yr	Seniang
380	8.941816	126.0442	0.42	0.07	0.35	5-yr	Seniang
381	8.942082	126.0479	0.98	0.38	0.6	5-yr	Seniang
382	8.940701	126.051	0.22	0.03	0.19	5-yr	Seniang
383	8.940487	126.0544	0	0.03	-0.03	5-yr	Seniang
384	8.936624	126.0556	0	0.03	-0.03	5-yr	Seniang
385	8.939608	126.0585	1.51	0.03	1.48	5-yr	Seniang
386	8.932968	126.0754	0	0.03	-0.03	5-yr	Seniang
387	8.933012	126.0754	0	0.03	-0.03	5-yr	Seniang
388	8.928399	126.0756	0.92	0.03	0.89	5-yr	Seniang
389	8.926952	126.0775	0	0.03	-0.03	5-yr	Seniang
390	8.923962	126.0765	0.52	0.03	0.49	5-yr	Seniang
391	8.939645	126.0735	0.44	0.42	0.02	5-yr	Seniang
392	8.935182	126.0395	1.4	0.98	0.42	5-yr	Seniang
393	8.928854	126.0421	1.15	0.12	1.03	5-yr	Seniang
394	8.924146	126.0431	1.51	0.03	1.48	5-yr	Seniang
395	8.918743	126.0408	1.07	0.03	1.04	5-yr	Seniang
396	8.917449	126.0473	0.31	0.03	0.28	5-yr	Seniang
397	8.92091	126.053	0.55	0.1	0.45	5-yr	Seniang
398	8.923741	126.0546	0.58	0.19	0.39	5-yr	Seniang
399	8.931652	126.0415	0.86	1	-0.14	5-yr	Seniang
400	8.933935	126.0403	1.2	0.93	0.27	5-yr	Seniang
401	8.934971	126.0376	1.3	0.98	0.32	5-yr	Seniang
402	8.937934	126.0296	0.65	0.03	0.62	5-yr	Seniang
403	8.938769	126.0274	1.76	1.64	0.12	5-yr	Seniang
404	8.939188	126.0301	2.18	0.8	1.38	5-yr	Seniang
405	8.987243	126.2131	0.32	0.03	0.29	25-yr	Seniang

Point Number	Validation Coordinates		Validation Points (m)	Model Var (m)	Error	Event/Date	Rain Return /Scenario
	Latitude	Longitude					
406	8.986686	126.2045	0	0.12	-0.12	25-yr	Seniang
407	8.98444	126.1999	0	0.03	-0.03	25-yr	Seniang
408	8.98847	126.1863	0	0.1	-0.1	25-yr	Seniang
409	8.990777	126.1886	0.82	0.07	0.75	25-yr	Seniang
410	8.995146	126.1881	0.49	0.05	0.44	25-yr	Seniang
411	8.995113	126.1889	0.38	0.03	0.35	25-yr	Seniang
412	8.994449	126.1739	1	0.03	0.97	25-yr	Seniang
413	8.994743	126.1734	1.16	0.03	1.13	25-yr	Seniang
414	8.986201	126.183	0.2	0.08	0.12	25-yr	Seniang
415	8.984548	126.1792	0.42	0.03	0.39	25-yr	Seniang
416	8.981118	126.1763	1.8	0.03	1.77	25-yr	Seniang
417	8.979275	126.1766	1.04	0.06	0.98	25-yr	Seniang
418	8.977572	126.1783	1.38	0.23	1.15	25-yr	Seniang
419	8.974599	126.1791	1.67	0.03	1.64	25-yr	Seniang
420	8.971062	126.1783	0.86	0.03	0.83	25-yr	Seniang
421	8.962589	126.1724	0.68	0.11	0.57	25-yr	Seniang
422	8.959635	126.1727	1.26	0.03	1.23	25-yr	Seniang
423	8.958162	126.1662	1.39	0.44	0.95	25-yr	Seniang
424	8.957875	126.1629	0.82	0.04	0.78	25-yr	Seniang
425	8.959261	126.1607	1.2	0.08	1.12	25-yr	Seniang
426	8.96328	126.1612	0.63	0.04	0.59	25-yr	Seniang
427	8.9649	126.1604	1.53	0.03	1.5	25-yr	Seniang
428	8.964039	126.1563	1.53	0.21	1.32	25-yr	Seniang
429	8.957624	126.1533	1.42	0.09	1.33	25-yr	Seniang
430	8.982393	126.192	0.82	0.35	0.47	25-yr	Seniang
431	8.983856	126.1942	1.01	0.03	0.98	25-yr	Seniang
432	8.982644	126.1959	0.45	0.48	-0.03	25-yr	Seniang
433	8.986179	126.1883	0	0.14	-0.14	25-yr	Seniang
434	8.988316	126.1851	0.09	0.03	0.06	25-yr	Seniang
435	8.999416	126.1662	1.23	0.03	1.2	25-yr	Seniang
436	8.995739	126.1644	0	0.05	-0.05	25-yr	Seniang
437	8.991732	126.1637	1.05	0.03	1.02	25-yr	Seniang
438	8.988714	126.1646	0.78	0.03	0.75	25-yr	Seniang
439	8.985435	126.1678	1.62	0.03	1.59	25-yr	Seniang
440	8.980234	126.1512	0.3	0.04	0.26	25-yr	Seniang
441	8.976411	126.1499	1.2	0.03	1.17	25-yr	Seniang
442	8.975439	126.1423	0.84	0.22	0.62	25-yr	Seniang
443	8.973954	126.1357	0.54	0.03	0.51	25-yr	Seniang
444	8.970028	126.1286	0	0.41	-0.41	25-yr	Seniang
445	9.001892	126.1703	0.83	0.22	0.61	25-yr	Seniang
446	9.000543	126.1678	0.95	0.18	0.77	25-yr	Seniang
447	9.005544	126.1699	0	0.04	-0.04	25-yr	Seniang
448	9.006223	126.1774	0.39	0.03	0.36	25-yr	Seniang
449	9.001021	126.1924	0.25	0.03	0.22	25-yr	Seniang
450	9.009736	126.2006	0.46	0.09	0.37	25-yr	Seniang

Point Number	Validation Coordinates		Validation Points (m)	Model Var (m)	Error	Event/Date	Rain Return /Scenario
	Latitude	Longitude					
451	9.005328	126.1993	0	0.03	-0.03	25-yr	Seniang
452	9.002366	126.197	0.76	0.03	0.73	25-yr	Seniang
453	9.002663	126.1897	0.6	0.11	0.49	25-yr	Seniang
454	9.002897	126.1666	0	0.03	-0.03	25-yr	Seniang
455	9.002263	126.1643	1.18	0.08	1.1	25-yr	Seniang
456	8.969006	126.1109	0	1.31	-1.31	25-yr	Seniang
457	8.967397	126.1046	0.35	2.42	-2.07	25-yr	Seniang
458	8.968336	126.1043	0.46	2.64	-2.18	25-yr	Seniang
459	8.950165	126.0995	0	0.03	-0.03	25-yr	Seniang
460	8.947682	126.1005	0.62	0.03	0.59	25-yr	Seniang
461	8.94771	126.1023	0.72	0.15	0.57	25-yr	Seniang
462	8.956248	126.1145	0.31	0.04	0.27	25-yr	Seniang
463	8.966545	126.1236	1.74	0.22	1.52	25-yr	Seniang
464	8.967036	126.1338	0.22	0.08	0.14	25-yr	Seniang
465	9.014512	126.2336	0	0.03	-0.03	25-yr	Seniang
466	9.014526	126.2354	0	0.07	-0.07	25-yr	Seniang
467	9.019414	126.2285	0	0.06	-0.06	25-yr	Seniang
468	9.027417	126.2199	0.25	0.25	0	25-yr	Seniang
469	9.003451	126.1761	0.94	0.07	0.87	25-yr	Seniang
470	9.003467	126.179	0.98	0.07	0.91	25-yr	Seniang
471	8.98434	126.1544	0	0.03	-0.03	25-yr	Seniang
472	8.97242	126.1472	2.3	0.31	1.99	25-yr	Seniang
473	8.970455	126.1481	1.79	0.04	1.75	25-yr	Seniang
474	8.94202	126.038	0.59	0.44	0.15	25-yr	Seniang
475	8.943124	126.0395	1.05	0.06	0.99	25-yr	Seniang
476	8.943111	126.0395	0.77	0.06	0.71	25-yr	Seniang
477	8.941692	126.0331	1.25	0.94	0.31	25-yr	Seniang
478	8.941998	126.0393	0.3	1.13	-0.83	25-yr	Seniang
479	8.937714	126.0401	0.99	0.77	0.22	25-yr	Seniang
480	8.935884	126.0413	0.88	0.61	0.27	25-yr	Seniang
481	8.941816	126.0442	0.42	0.08	0.34	25-yr	Seniang
482	8.942082	126.0479	0.98	0.59	0.39	25-yr	Seniang
483	8.940701	126.051	0.22	0.03	0.19	25-yr	Seniang
484	8.940487	126.0544	0	0.03	-0.03	25-yr	Seniang
485	8.936624	126.0556	0	0.03	-0.03	25-yr	Seniang
486	8.939608	126.0585	1.51	0.06	1.45	25-yr	Seniang
487	8.932968	126.0754	0	0.03	-0.03	25-yr	Seniang
488	8.933012	126.0754	0	0.03	-0.03	25-yr	Seniang
489	8.928399	126.0756	0.92	0.03	0.89	25-yr	Seniang
490	8.926952	126.0775	0	0.03	-0.03	25-yr	Seniang
491	8.923962	126.0765	0.52	0.03	0.49	25-yr	Seniang
492	8.939645	126.0735	0.44	0.63	-0.19	25-yr	Seniang
493	8.935182	126.0395	1.4	1.25	0.15	25-yr	Seniang
494	8.928854	126.0421	1.15	0.3	0.85	25-yr	Seniang
495	8.924146	126.0431	1.51	0.6	0.91	25-yr	Seniang

Point Number	Validation Coordinates		Validation Points (m)	Model Var (m)	Error	Event/Date	Rain Return /Scenario
	Latitude	Longitude					
496	8.918743	126.0408	1.07	0.03	1.04	25-yr	Seniang
497	8.917449	126.0473	0.31	0.03	0.28	25-yr	Seniang
498	8.92091	126.053	0.55	0.11	0.44	25-yr	Seniang
499	8.923741	126.0546	0.58	1.03	-0.45	25-yr	Seniang
500	8.931652	126.0415	0.86	1.26	-0.4	25-yr	Seniang
501	8.933935	126.0403	1.2	1.19	0.01	25-yr	Seniang
502	8.934971	126.0376	1.3	1.27	0.03	25-yr	Seniang
503	8.937934	126.0296	0.65	0.03	0.62	25-yr	Seniang
504	8.938769	126.0274	1.76	2.01	-0.25	25-yr	Seniang
505	8.939188	126.0301	2.18	1.15	1.03	25-yr	Seniang
506	8.987243	126.2131	0.32	0.03	0.29	100-yr	Seniang
507	8.986686	126.2045	0	0.21	-0.21	100-yr	Seniang
508	8.98444	126.1999	0	0.03	-0.03	100-yr	Seniang
509	8.98847	126.1863	0	0.11	-0.11	100-yr	Seniang
510	8.990777	126.1886	0.82	0.08	0.74	100-yr	Seniang
511	8.995146	126.1881	0.49	0.06	0.43	100-yr	Seniang
512	8.995113	126.1889	0.38	0.03	0.35	100-yr	Seniang
513	8.994449	126.1739	1	0.03	0.97	100-yr	Seniang
514	8.994743	126.1734	1.16	0.03	1.13	100-yr	Seniang
515	8.986201	126.183	0.2	0.09	0.11	100-yr	Seniang
516	8.984548	126.1792	0.42	0.04	0.38	100-yr	Seniang
517	8.981118	126.1763	1.8	0.03	1.77	100-yr	Seniang
518	8.979275	126.1766	1.04	0.07	0.97	100-yr	Seniang
519	8.977572	126.1783	1.38	0.24	1.14	100-yr	Seniang
520	8.974599	126.1791	1.67	0.04	1.63	100-yr	Seniang
521	8.971062	126.1783	0.86	0.03	0.83	100-yr	Seniang
522	8.962589	126.1724	0.68	0.12	0.56	100-yr	Seniang
523	8.959635	126.1727	1.26	0.03	1.23	100-yr	Seniang
524	8.958162	126.1662	1.39	0.59	0.8	100-yr	Seniang
525	8.957875	126.1629	0.82	0.05	0.77	100-yr	Seniang
526	8.959261	126.1607	1.2	0.09	1.11	100-yr	Seniang
527	8.96328	126.1612	0.63	0.05	0.58	100-yr	Seniang
528	8.9649	126.1604	1.53	0.03	1.5	100-yr	Seniang
529	8.964039	126.1563	1.53	0.24	1.29	100-yr	Seniang
530	8.957624	126.1533	1.42	0.22	1.2	100-yr	Seniang
531	8.982393	126.192	0.82	0.57	0.25	100-yr	Seniang
532	8.983856	126.1942	1.01	0.05	0.96	100-yr	Seniang
533	8.982644	126.1959	0.45	0.67	-0.22	100-yr	Seniang
534	8.986179	126.1883	0	0.15	-0.15	100-yr	Seniang
535	8.988316	126.1851	0.09	0.03	0.06	100-yr	Seniang
536	8.999416	126.1662	1.23	0.03	1.2	100-yr	Seniang
537	8.995739	126.1644	0	0.06	-0.06	100-yr	Seniang
538	8.991732	126.1637	1.05	0.04	1.01	100-yr	Seniang
539	8.988714	126.1646	0.78	0.03	0.75	100-yr	Seniang
540	8.985435	126.1678	1.62	0.03	1.59	100-yr	Seniang

Point Number	Validation Coordinates		Validation Points (m)	Model Var (m)	Error	Event/Date	Rain Return /Scenario
	Latitude	Longitude					
541	8.980234	126.1512	0.3	0.04	0.26	100-yr	Seniang
542	8.976411	126.1499	1.2	0.04	1.16	100-yr	Seniang
543	8.975439	126.1423	0.84	0.24	0.6	100-yr	Seniang
544	8.973954	126.1357	0.54	0.04	0.5	100-yr	Seniang
545	8.970028	126.1286	0	0.46	-0.46	100-yr	Seniang
546	9.001892	126.1703	0.83	0.23	0.6	100-yr	Seniang
547	9.000543	126.1678	0.95	0.2	0.75	100-yr	Seniang
548	9.005544	126.1699	0	0.05	-0.05	100-yr	Seniang
549	9.006223	126.1774	0.39	0.03	0.36	100-yr	Seniang
550	9.001021	126.1924	0.25	0.04	0.21	100-yr	Seniang
551	9.009736	126.2006	0.46	0.1	0.36	100-yr	Seniang
552	9.005328	126.1993	0	0.03	-0.03	100-yr	Seniang
553	9.002366	126.197	0.76	0.03	0.73	100-yr	Seniang
554	9.002663	126.1897	0.6	0.13	0.47	100-yr	Seniang
555	9.002897	126.1666	0	0.03	-0.03	100-yr	Seniang
556	9.002263	126.1643	1.18	0.08	1.1	100-yr	Seniang
557	8.969006	126.1109	0	1.45	-1.45	100-yr	Seniang
558	8.967397	126.1046	0.35	2.52	-2.17	100-yr	Seniang
559	8.968336	126.1043	0.46	2.75	-2.29	100-yr	Seniang
560	8.950165	126.0995	0	0.03	-0.03	100-yr	Seniang
561	8.947682	126.1005	0.62	0.03	0.59	100-yr	Seniang
562	8.94771	126.1023	0.72	0.17	0.55	100-yr	Seniang
563	8.956248	126.1145	0.31	0.04	0.27	100-yr	Seniang
564	8.966545	126.1236	1.74	0.25	1.49	100-yr	Seniang
565	8.967036	126.1338	0.22	0.09	0.13	100-yr	Seniang
566	9.014512	126.2336	0	0.03	-0.03	100-yr	Seniang
567	9.014526	126.2354	0	0.09	-0.09	100-yr	Seniang
568	9.019414	126.2285	0	0.06	-0.06	100-yr	Seniang
569	9.027417	126.2199	0.25	0.29	-0.04	100-yr	Seniang
570	9.003451	126.1761	0.94	0.08	0.86	100-yr	Seniang
571	9.003467	126.179	0.98	0.08	0.9	100-yr	Seniang
572	8.98434	126.1544	0	0.03	-0.03	100-yr	Seniang
573	8.97242	126.1472	2.3	0.43	1.87	100-yr	Seniang
574	8.970455	126.1481	1.79	0.08	1.71	100-yr	Seniang
575	8.94202	126.038	0.59	0.73	-0.14	100-yr	Seniang
576	8.943124	126.0395	1.05	0.07	0.98	100-yr	Seniang
577	8.943111	126.0395	0.77	0.07	0.7	100-yr	Seniang
578	8.941692	126.0331	1.25	1.36	-0.11	100-yr	Seniang
579	8.941998	126.0393	0.3	1.46	-1.16	100-yr	Seniang
580	8.937714	126.0401	0.99	1.08	-0.09	100-yr	Seniang
581	8.935884	126.0413	0.88	0.9	-0.02	100-yr	Seniang
582	8.941816	126.0442	0.42	0.1	0.32	100-yr	Seniang
583	8.942082	126.0479	0.98	0.85	0.13	100-yr	Seniang
584	8.940701	126.051	0.22	0.03	0.19	100-yr	Seniang
585	8.940487	126.0544	0	0.03	-0.03	100-yr	Seniang

Point Number	Validation Coordinates		Validation Points (m)	Model Var (m)	Error	Event/Date	Rain Return /Scenario
	Latitude	Longitude					
586	8.936624	126.0556	0	0.03	-0.03	100-yr	Seniang
587	8.939608	126.0585	1.51	0.38	1.13	100-yr	Seniang
588	8.932968	126.0754	0	0.03	-0.03	100-yr	Seniang
589	8.933012	126.0754	0	0.03	-0.03	100-yr	Seniang
590	8.928399	126.0756	0.92	0.03	0.89	100-yr	Seniang
591	8.926952	126.0775	0	0.03	-0.03	100-yr	Seniang
592	8.923962	126.0765	0.52	0.04	0.48	100-yr	Seniang
593	8.939645	126.0735	0.44	0.72	-0.28	100-yr	Seniang
594	8.935182	126.0395	1.4	1.51	-0.11	100-yr	Seniang
595	8.928854	126.0421	1.15	0.47	0.68	100-yr	Seniang
596	8.924146	126.0431	1.51	0.88	0.63	100-yr	Seniang
597	8.918743	126.0408	1.07	0.03	1.04	100-yr	Seniang
598	8.917449	126.0473	0.31	0.03	0.28	100-yr	Seniang
599	8.92091	126.053	0.55	0.12	0.43	100-yr	Seniang
600	8.923741	126.0546	0.58	1.2	-0.62	100-yr	Seniang
601	8.931652	126.0415	0.86	1.47	-0.61	100-yr	Seniang
602	8.933935	126.0403	1.2	1.43	-0.23	100-yr	Seniang
603	8.934971	126.0376	1.3	1.57	-0.27	100-yr	Seniang
604	8.937934	126.0296	0.65	0.03	0.62	100-yr	Seniang
605	8.938769	126.0274	1.76	2.36	-0.6	100-yr	Seniang
606	8.939188	126.0301	2.18	1.48	0.7	100-yr	Seniang

Annex 12. Educational Institutions Affected by Flooding in Tago Floodplain

SURIGAO DEL SUR				
BAYABAS				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-YR	**25-YR**	**100-YR**
Lapaz Elementary School	Balete	Medium	Medium	Medium
Cagbaoto Elementary School	Cagbaoto	Medium	Medium	Medium
Sumo-sumo Elementary School	Panaosawon	Low	Low	Low

SURIGAO DEL SUR				
CAGWAIT				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-YR	**25-YR**	**100-YR**
Panaosawon Elementary School	La Purisima	Medium	Medium	High

SURIGAO DEL SUR				
SAN MIGUEL				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-YR	**25-YR**	**100-YR**
Baras Elementary School	Baras	Low	Medium	Medium
Bolhoon Elementary School	Bolhoon			
Bolhoon National High School	Bolhoon			
Carromata Elementary School	Carromata	Low	High	High
Sagbayan Elementary School	Carromata	Medium	High	High
San Miguel National Central High School Annex	Carromata	Medium	High	High
Castillo Elementary School	Castillo			
Haguimitan Elementary School	Castillo			
Libas Gua Elementary School	Libas Gua			
Catabadan Elementary School	Libas Sud			Low
Magroyong Elementary School	Magroyong			
San Miguel National Central High School	Magroyong			
Mahayag Elementary School	Mahayag	Medium	High	High
Patong Elementary School	Patong	Medium	Medium	High
San Miguel Central Elementary School	Poblacion	Low	Medium	Medium
San Miguel National Central High School Annex	Poblacion	Low	Low	Medium
San Roque Elementary School	San Roque			
Siagao Elementary School	Siagao	High	High	High
San Miguel National Central High School	Tina			
Tina Elementary School	Tina			

SURIGAO DEL SUR				
TAGO				
Building Name	Barangay	Rainfall Scenario		
		5-YR	25-YR	100-YR
Alba Elementary School	Alba			
Anahao Bag-o Elementary School	Anahao Bag-O			
Anahao Daan Elementary School	Anahao Daan			
Badong Elementary School	Badong			
Badong National High School	Badong			
C.M. Pimentel Memorial Elementary School	Badong			Low
Cayale Elementary School	Badong			
Bajao Elementary School	Bajao			
Anahao Bag-o Elementary School	Bangsud			
Bangsud Elementary School	Bangsud			
Mat-e Elementary School	Cabangahan	Medium	Medium	Medium
Gamut Elementary School	Cagdapao			
Gamut National High School	Cagdapao			Low
Rosario Elementary School	Cagdapao		Low	Low
Camagong Elementary School	Camagong		Low	Low
Libas Sud Elementary School	Caras-An	Medium	Medium	Medium
Mabuhay Elementary School	Cayale			
Dayoan Elementary School	Dayo-An	Medium	Medium	High
Caras-an Elementary School	Layog	Low	Low	Low
Layog Elementary School	Layog			Low
Bangsud Elementary School	Lindoy			
Lindoy Elementary School	Lindoy			
Falcon M. Elementary School	Purisima	Low	Low	Low
Mga Bayani ng Pilipinas Elementary School	Purisima	Low	Low	Medium
Kinabigtasan Elementary School	Unaban			
Unaban Elementary School	Unaban			
Unidus Elementary School	Unidos			
Surigao del Sur State University Main Campus	Victoria	Low	Medium	Medium
Victoria Elementary School	Victoria	Low	Low	Low

SURIGAO DEL SUR				
TAGO				
Building Name	Barangay	Rainfall Scenario		
		5-YR	25-YR	100-YR
Rosario Elementary School	Rosario	Medium	Medium	Medium

Annex 13. Health Institutions Affected by Flooding in Tago Floodplain

SURIGAO DEL SUR				
SAN MIGUEL				
Building Name	Barangay	Rainfall Scenario		
		5-YR	25-YR	100-YR
San Miguel Community Hospital	Tina			
Tina Health Center	Tina			