REGION 13

Agusan River:

DREAM Ground Surveys Report

TRAINING CENTER FOR APPLIED GEODESY AND PHOTOGRAMMETRY

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List of Abbreviations

ADCP	Acoustic Doppler Current Profiler
AWLS	Automated Water Level Sensor
BM	Benchmark
DAC	Data Acquisition Component
DEM	Digital Elevation Model
DG	Depth Gauge
DOST	Department of Science and Technology
DPC	Data Processing Component
DREAM	Disaster Risk Exposure and Assessment for Mitigation
DVC	Data Validation Component
EGM 2008	Earth Gravitation Model 2008
FMC	Flood Modeling Component
GCP	Ground Control Point
GE	Geodetic Engineer
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
LGUs	Local Government Units
NAMRIA	National Mapping and Resource Information Authority
PCG	Philippine Coast Guard
PDRRMC	Provincial Disaster Risk Reduction Management Council
PPA	Philippine Ports Authority
PPK	Post Processed Kinematic
RG	Rain Gauge
TCAGP	Training Center for Applied Geodesy and Photogrammetry
UTM	Universal Transverse Mercator
WGS84	World Geodetic System 1984

Introduction

Introduction

1.1 DREAM Program Overview

The UP training Center for Applied Geodesy and Photogrammetry (UP TCAGP) conducts a research program entitled "Nationwide Disaster Risk and Exposure Assessment for Mitigation" supported by the Department of Science and Technology (DOST) Grant-in-Aide Program. The DREAM Program aims to produce detailed, up-to-date, national elevation dataset for 3D flood and hazard mapping to address disaster risk reduction and mitigation in the country.

The DREAM Program consists of four components that operationalize the various stages of implementation. The Data Acquisition Component (DAC) conducts aerial surveys to collect LiDAR data and aerial images in major river basins and priority areas. The Data Validation Component (DVC) implements ground surveys to validate acquired LiDAR data, along with bathymetric measurements to gather river discharge data. The Data Processing Component (DPC) processes and compiles all data generated by the DAC and DVC. Finally, the Flood Modeling Component (FMC) utilizes compiled data for flood modeling and simulation.

Overall, the target output is a national elevation dataset suitable for 1:5000 scale mapping, with 50 centimeter horizontal and vertical accuracies, respectively. These accuracies are achieved through the use of state-of-the-art airborne Light Detection and Ranging (LiDAR) Systems collects point cloud data at a rate of 100,000 to 500,000 points per second, and is capable of collecting elevation data at a rate of 300 to 400 square kilometer per day, per sensor.

1.2 Objectives and target outputs

The program aims to achieve the following objectives:

a. To acquire a national elevation and resource dataset at sufficient resolution to produce information necessary to support the different phases of disaster management,
b. 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,
c. To develop the capacity to process, produce and analyze various proven and potential thematic map layers from the 3D data useful for government agencies,
d. To transfer product development technologies to government agencies with geospatial information requirements, and,
e. To generate the following outputs
    1. flood hazard map
    2. digital surface model
    3. digital terrain model and
    4. orthophotograph

1.3 General methodological framework

The methodology employed to accomplish the project's expected outputs are subdivided into four (4) major components, as shown in Figure 1. Each component is described in detail in the following sections.

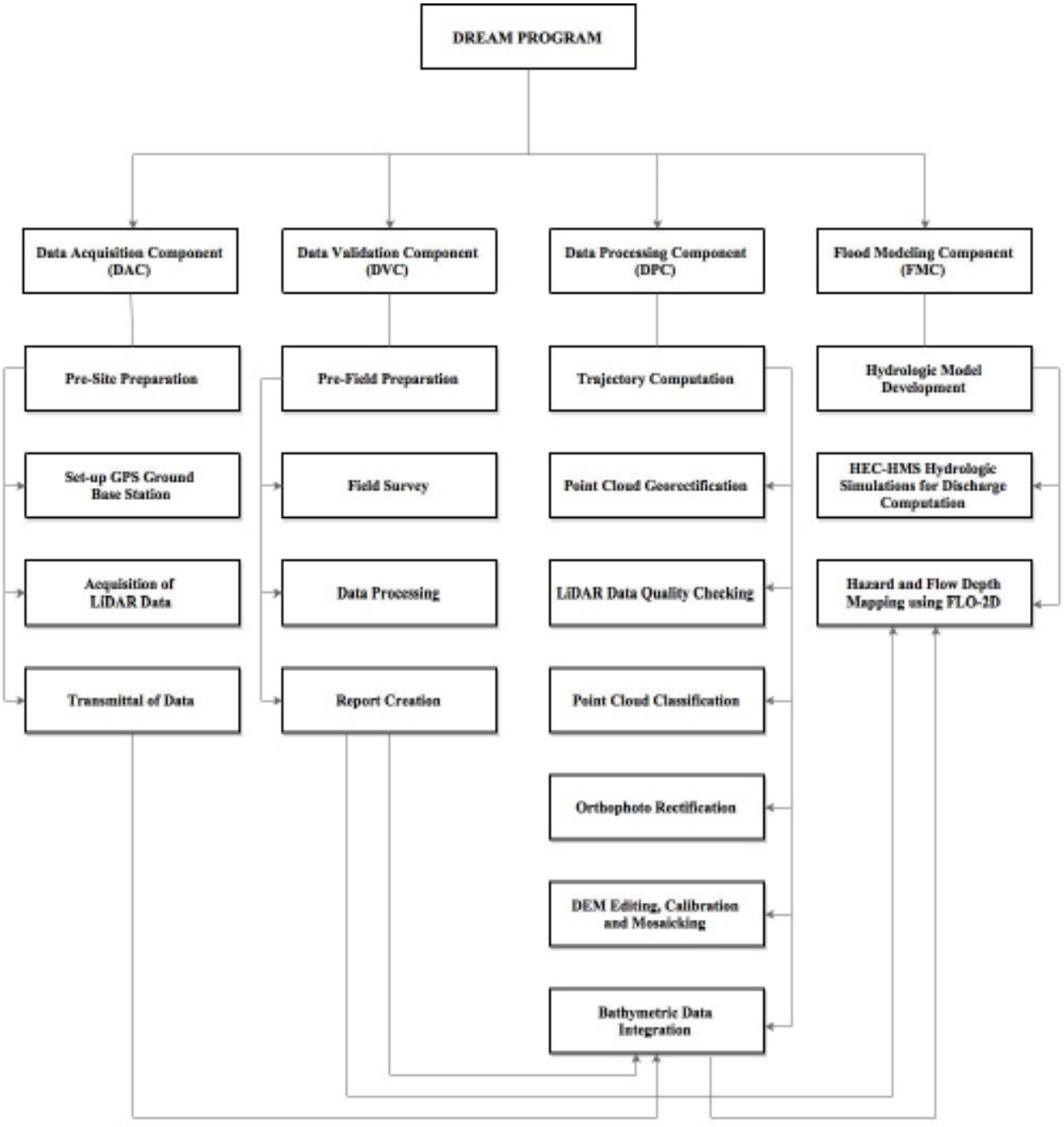


Figure 1. The General Methodological Framework of the Program

The Agusan River Basin

The Agusan River Basin

Located in the eastern part of Mindanao, the Agusan River Basin covers the provinces of Davao Oriental, Compostela Valley, Agusan del Sur, Agusan del Norte and Surigao del Norte. Draining an area of 10,921 square kilometers, it is the third largest river basin and also the third longest river in the Philippines. The location of Agusan River Basin is as shown in Figure 1.

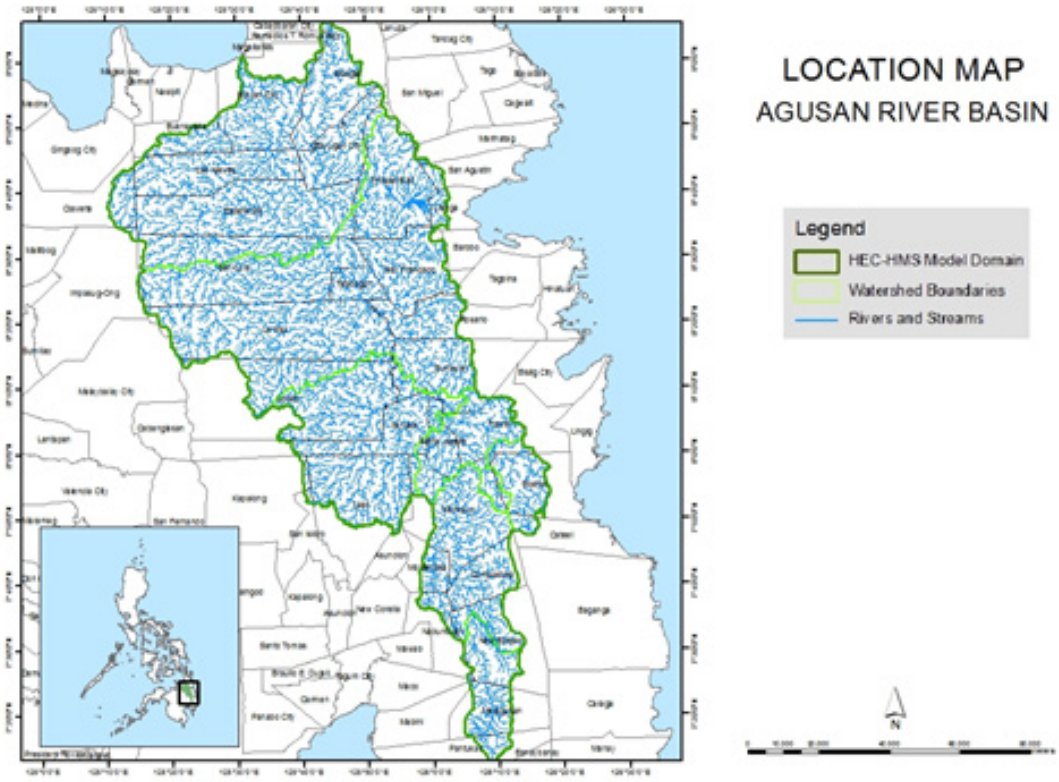


Figure 2. The Agusan River Basin Location Map

Upstream from the Compostela Valley, the river drains to the north and traverses Butuan City and Magallanes in Agusan del Norte. Three sub-basins comprise the Agusan River basin: The upper, middle, and lower Agusan River subbasins which traverses the river from the headwaters in Compostela Valley down to the mouth at Agusan del Norte.

The land and soil characteristics are important parameters used in assigning the roughness coefficient for different areas within the river basin. The roughness coefficient, also called Manning's coefficient, represents the variable flow of water in different land covers (i.e. rougher, restricted flow within vegetated areas, smoother flow within channels and fluvial environments).

The Agusan River Basin

The shape files of the soil and land cover were taken from the Bureau of Soils, which is under the Department of Environment and Natural Resources Management, and National Mapping and Resource Information Authority (NAMRIA). The soil and land cover of the Agusan River Basin are shown in Figure 3 and Figure 4, respectively.

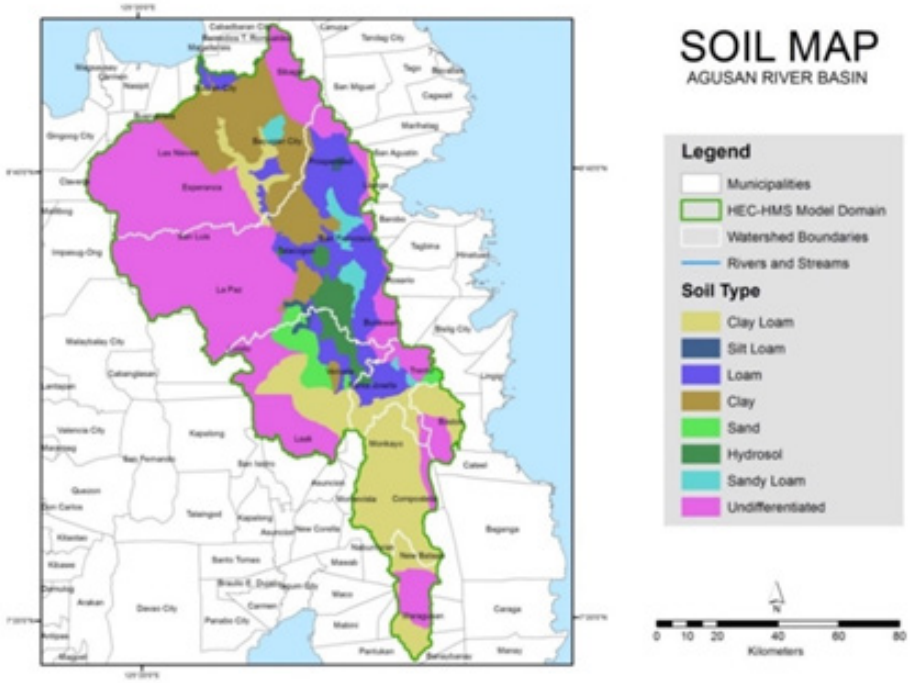


Figure 3. Agusan River Basin Soil Map

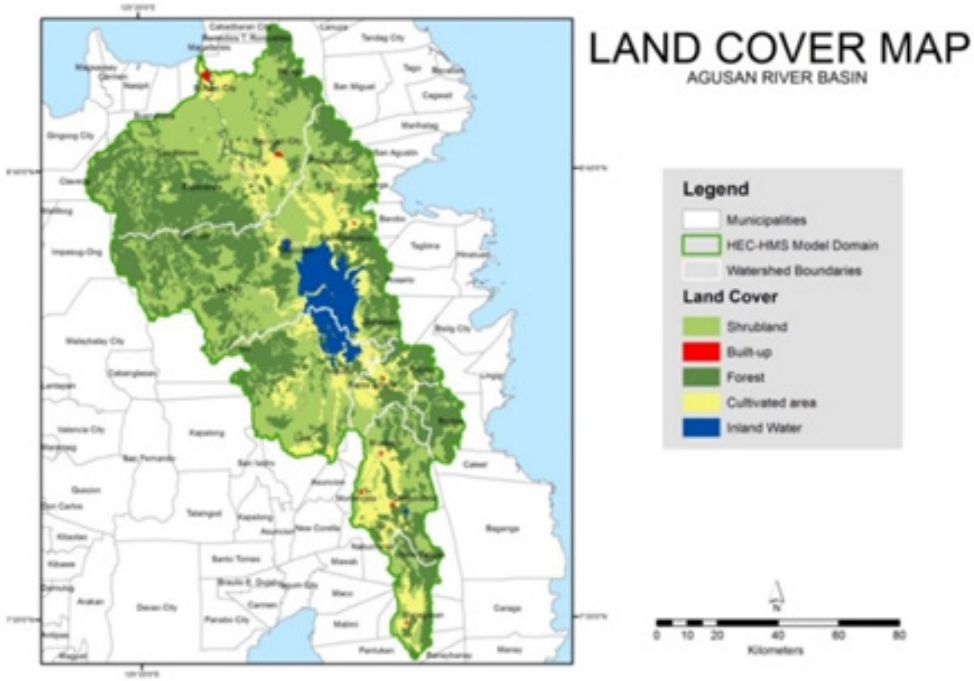
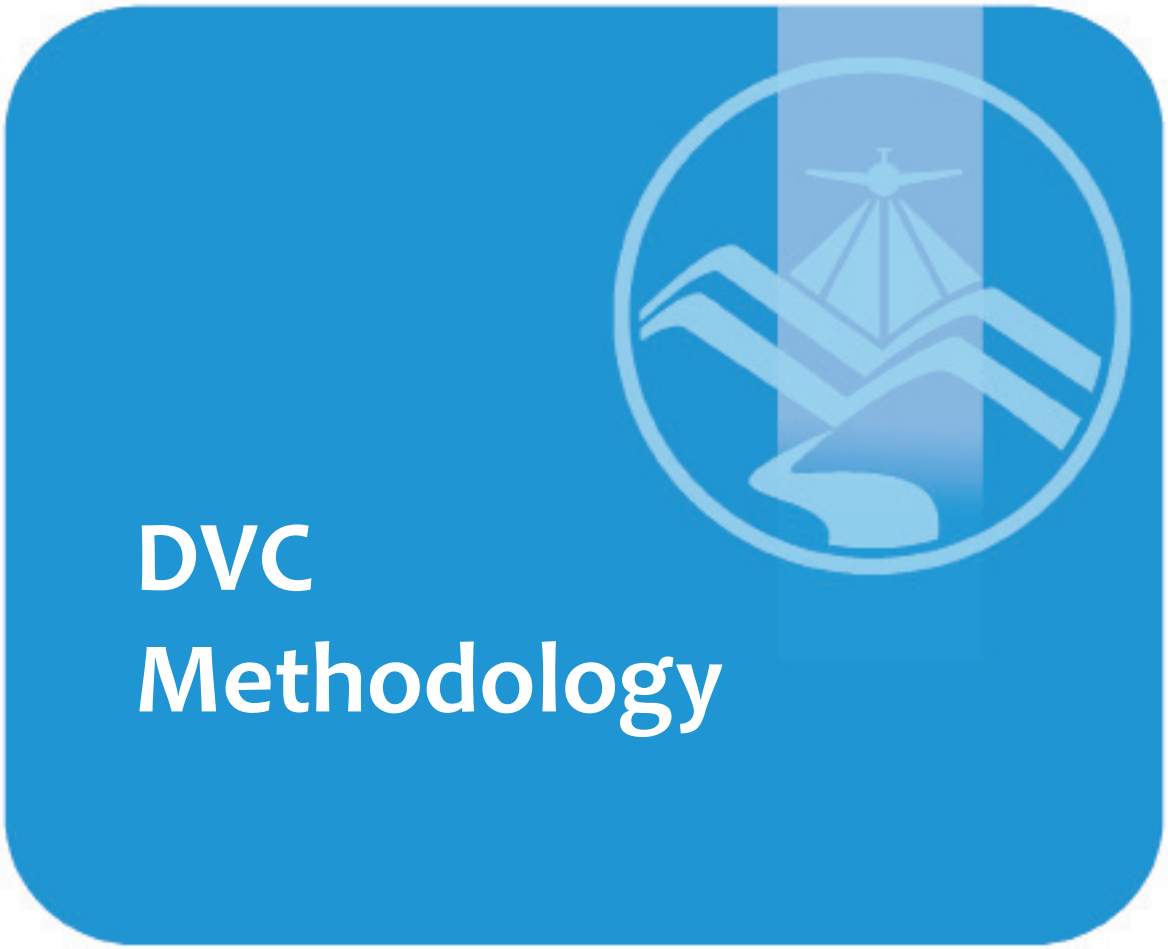


Figure 4. Agusan River Basin Land Cover Map



DVC Methodology

DVC Methodology

A set of activities were designed and implemented by DVC with four (4) main activities as shown in Figure 5.

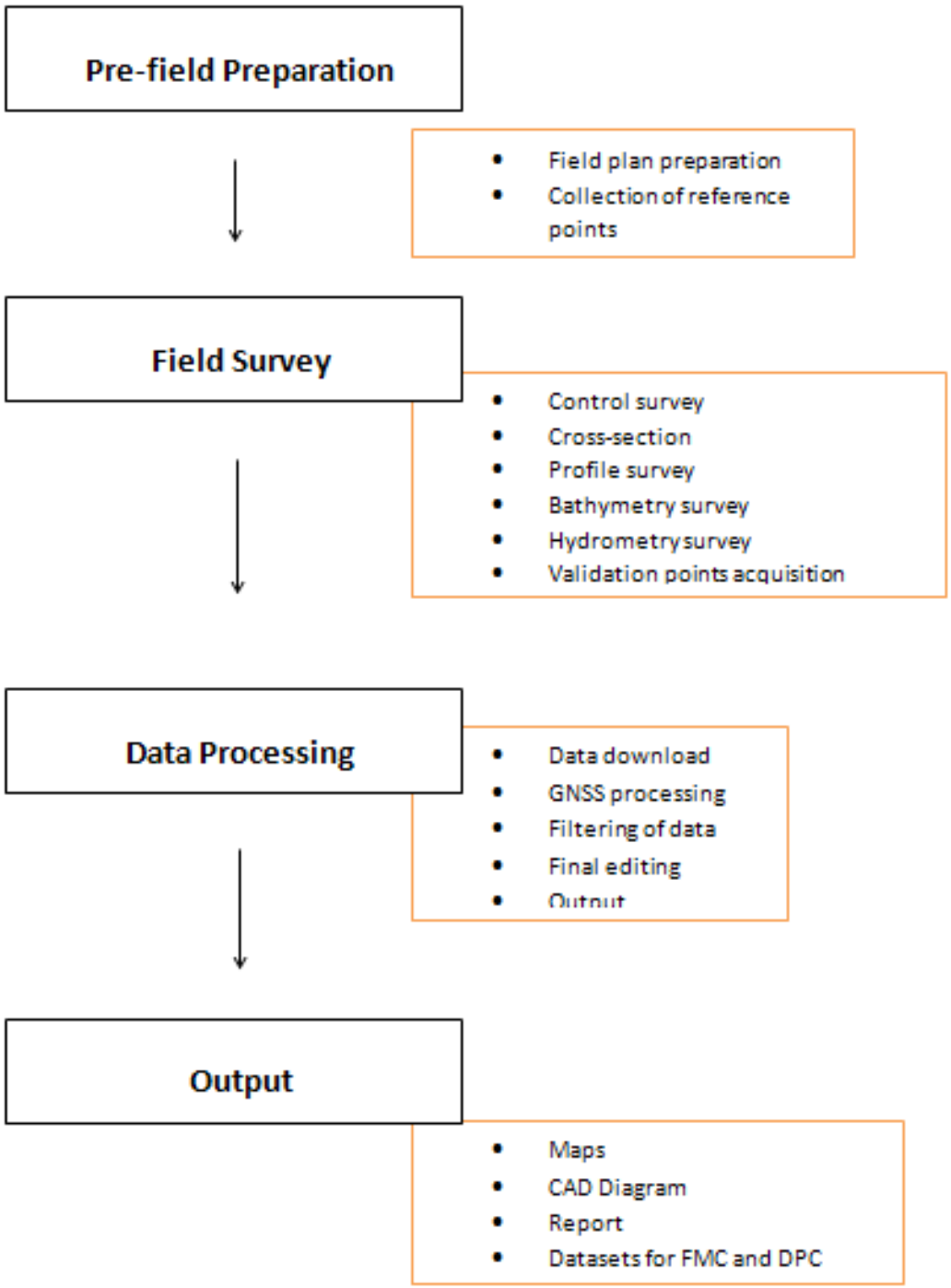


Figure 5. DVC Main Activities

3.1 Pre-field Preparation

3.1.1 Preparation of Field Plan

The planning for research fieldwork considers all the necessary technical and logistical concerns conceptualized in a field plan.

This serves as a basis and guide of the survey team in the implementation of the fieldwork activities and included the following activities:

- Delineation of bathymetry lines and determination of the river basin extent using Google Earth® images and available topographic maps;
- Listing and preparation of the survey equipment and other materials needed;
- Designation of tasks to DVC members for the field survey;
- Approximation of field duration and cost based on the delineated survey extent; and
- Assessment of the initial field plan by the program management for approval and implementation.

3.1.2 Collection of Reference Points

Technical data and other relevant information are collected from the National Mapping and Resource Information Authority (NAMRIA) such as locations and descriptions of established horizontal and vertical control points with a minimum of 2nd order accuracy. These ground control points and benchmarks are selected and occupied as primary reference points for the establishment of a GNSS network for the survey.

3.2 Field Surveys

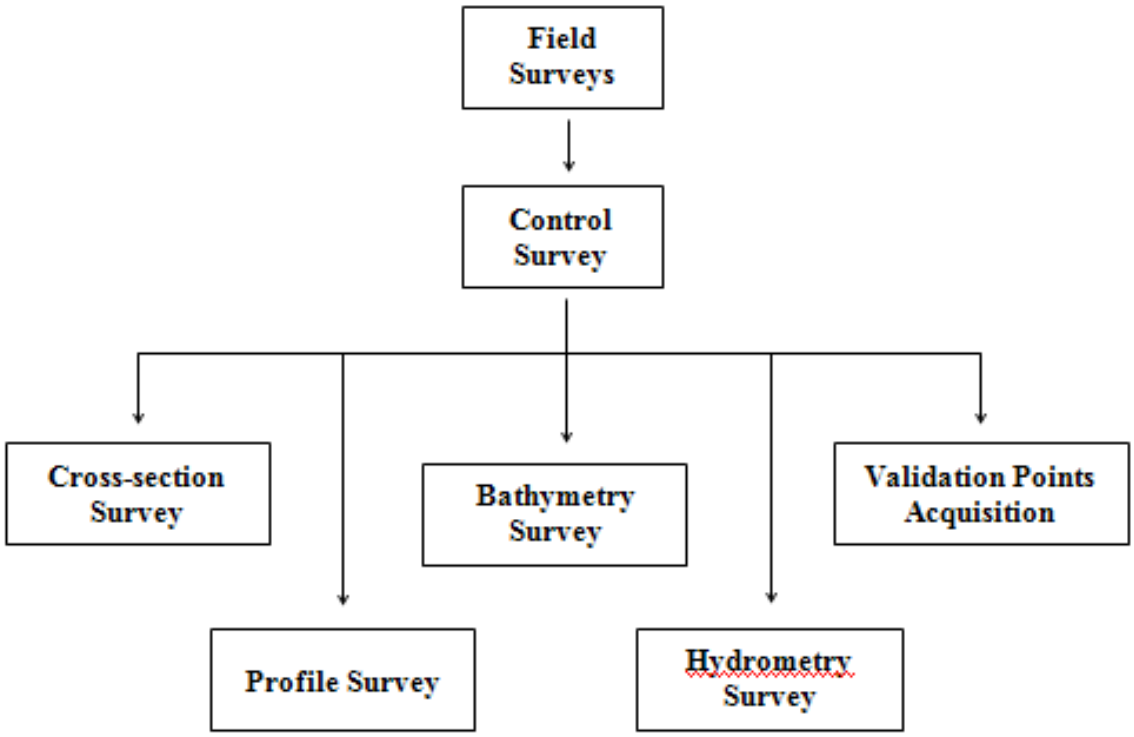


Figure 6. DVC Field Activities

3.2.1 Control Survey

A GNSS network is established through occupation of reference points with dual frequency GNSS receivers for four (4) hours. Reference points from NAMRIA only bear vertical coordinates (z or elevation value) and horizontal coordinates (x and y values) for benchmarks and ground control points, respectively.

Control survey aims to provide both the horizontal and vertical position for every control point established through network adjustment. Horizontal position is acquired through static survey while establishment of vertical position can be done either using a Total Station (TS) or digital level or through static survey.

For the vertical position control survey using a TS or Level, a double run is carried out connecting the nearest existing NAMRIA benchmarks (BMs) to the control point. A double run consists of a forward run (from BM to GCP) and backward run (from GCP to BM). The accuracy shall be assessed and accepted if it is within the third order differential leveling standard.

A benchmark may be used to refer elevation data to Mean Sea Level (MSL) within 20-km radius. Additional benchmarks are located for survey areas exceeding this 20-km radius.

Establishment of a GNSS network through control survey is pre-requisite for the conduct of other ground survey activities. Reference and control points occupied for the control survey may serve as base stations throughout the survey area.

3.2.2 Cross-section Survey

The objective of this activity is to derive a sectional view of the main river and the flood plain (right and left banks). Cross-sections are surveyed perpendicular to the riverbanks with an average length of 100 meters for each bank. The cross-section line shall follow the path of the nearby road or goat trails with a 10-meter interval for each point measurement. Additional points are obtained to describe apparent change in elevation along the cross-section line. Each cross-section is identified sequentially from upstream to downstream direction.

Cross-section surveys are done using dual frequency GNSS receivers and differential kinematic GNSS survey technique. The accuracy of the horizontal position and elevation of each individual cross-section surveys is within ±20 cm for horizontal and ±10 cm for vertical position residuals.

Areas where kinematic GNSS survey is not applicable due to the presence of obstructions such as tall structures and canopy of trees, conventional surveying techniques such as total stations and level are used to collect cross-sectional data.

3.2.3 Profile Surveys

Profile surveys are conducted to obtain the upper and lower banks of the river. This data is overlaid with LIDAR data to delineate the longitudinal extent of the river.

A profile survey consists of the Left Upper Bank (LUB) and Left Lower Bank (LLB), Right Upper Bank (RUB) and Right Lower Bank (RLB). An interval between successive profile points is approximately 10 meters. Additional points are gathered to describe apparent change in elevation along the profile line

Profile surveys are conducted using dual frequency GNSS receivers and kinematic survey technique with a prescribed vertical accuracies of ±20 cm for horizontal and ±10 cm for vertical position, respectively. Conventional surveying techniques such as total stations and level are used to collect profile data for areas where kinematic GNSS survey is not applicable due to obstructions such as tall structures and canopy of trees.

3.2.4 Bathymetric Survey

Bathymetric survey is performed using a survey-grade single beam echo sounder capable of logging time-stamped depth value in centimeter and dual frequency GNSS using kinematic survey technique, with prescribed vertical accuracies of ±20 cm for horizontal and ±10 cm for vertical position for rivers navigable by boat. Data acquisition is logged at one second intervals both for GPS positions and elevation and echo sounder depth reading

For portions of the river that is not navigable by boat due to shallow waterless than a meter, riverbed may be acquired using manual bathymetric survey. Manual bathymetric survey means manually acquiring riverbed points without the use of an echo sounder. It can be done using a GPS receiver, Total Station or Level.

3.2.5 Hydrometric Survey

Hydrometric survey consists of deployment of flow gathering sensors in order to produce a Stage-Discharge (HQ) computation for specific locations in the river such as in its upstream, tributaries, and downstream. This is done to determine the behavior of the river given specific precipitation levels.

The elements of discharge computation are the ff.:

- **River flow data –** river flow data can be acquired using an Acoustic Doppler Current Profiler (ADCP) or by mechanical or digital flow meters. River flow data sensors measure velocity of the river for a specific time period and interval.
- **Cross-section data –** cross section data is acquired using dual frequency GPS receivers to obtain the cross-section area of the river. Cross-section area of a river changes in time as influenced by water level change.
- **Water level change –** water level change is measured using either a depth gauge or an Automated Water Level Sensor (AWLS) installed by DOST. Depth gauges relates pressure to water level change while AWLS uses laser pulsed at specific time intervals for measurement.
- **Water surface elevation –** water surface elevation in MSL is measured near the banks of the river with dual frequency GPS receivers. This will refer the measured water level change to a corresponding elevation value in MSL in order to derive Stage or water level height a particular time.

Precipitation is the biggest factor influencing stage and river velocity. These two (2) sets of data must be synchronized by time in order to compute for its cross-section area, and subsequently, for discharge.

The element of time is crucial in determining the delay between the onset of precipitation and the time of significant water level change along key points of the river for early flood warning system of communities. The correlation of stage-discharge computation is used for calibrating flood-simulation programs utilized by the Flood Modeling Component (FMC).

The summary of elements for discharge computation is illustrated in Figure 7.

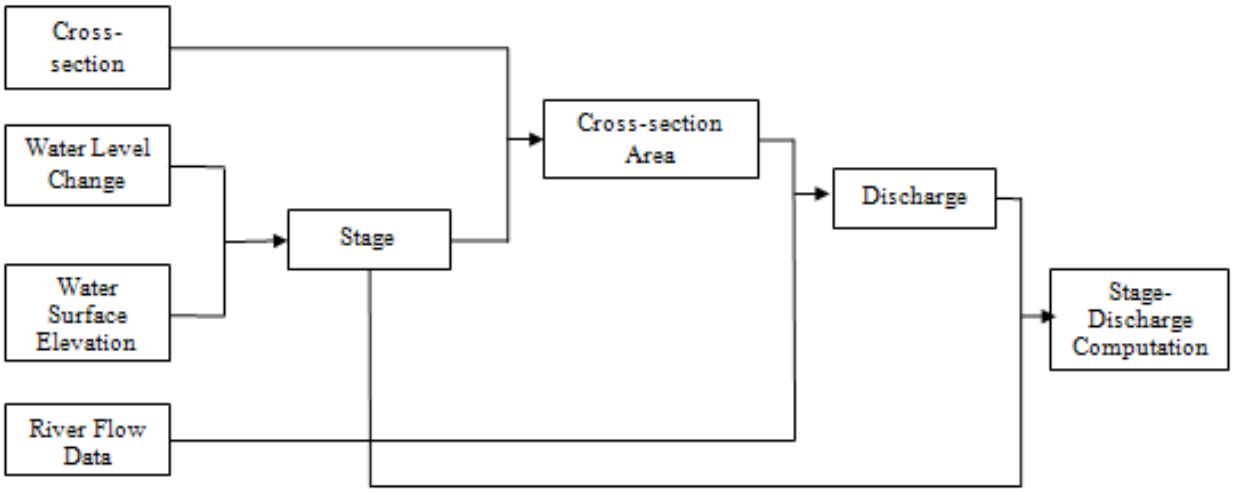


Figure 7. Flow Chart for Stage-Discharge Correlation Computation

3.2.5 Validation Points Acquisition Survey

Ground validation survey is conducted for quality checking purpose of the Aerial LiDAR data acquired by the Data Acquisition Component (DAC). A roving GNSS receiver is mounted on a range pole attached to a vehicle to gather points thru continuous topo method in a PPK Survey Technique. Points are measured along major roads and highway across the flight strips provided by DAC.

GNSS surveys setup used to accomplish DVC's field survey activities are illustrated in Figure 8.

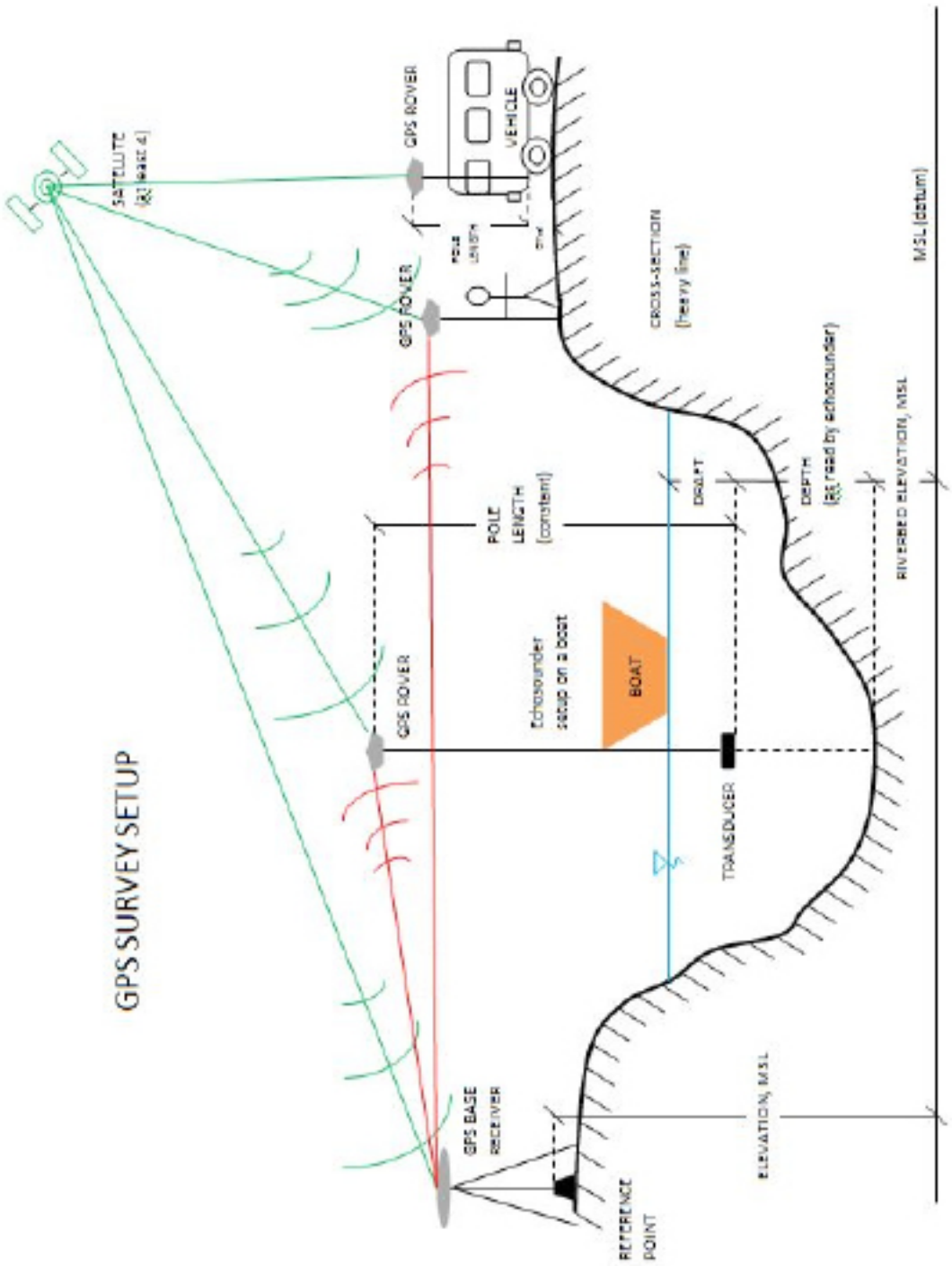


Figure 8. Set-up for GNSS Survey

3.3 Data Processing

Data processing procedures used by DVC are summarized in Figure 9.

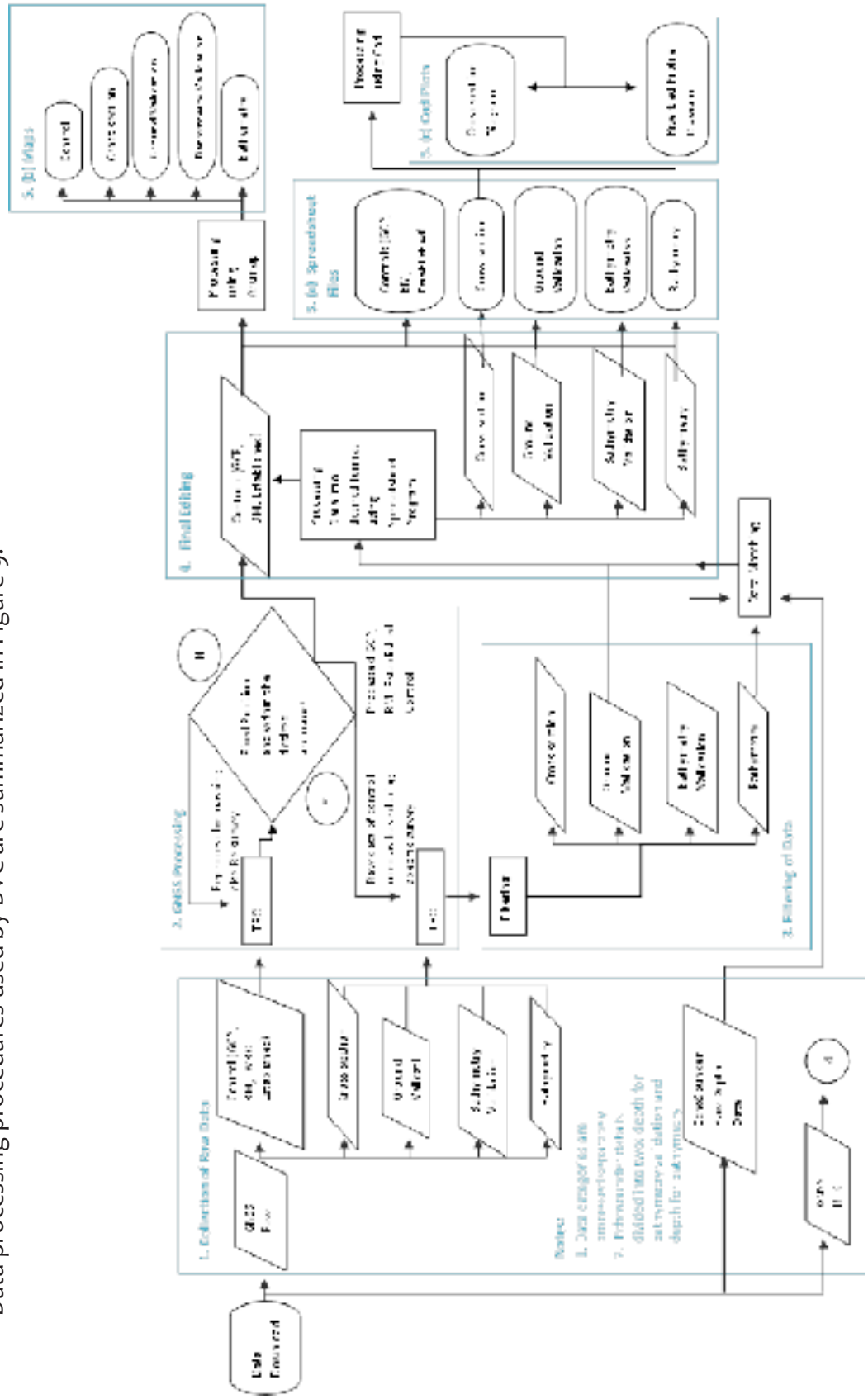


Figure 9. DVC Data Processing Methodology

3.3.1 Collection of Raw Data

GPS Raw data in (*.t02) format are downloaded from Trimble™ GPS receivers used in static, cross-section, LiDAR ground validation, and bathymetric surveys. Depth values in (*.som) files from bathymetric surveys are also downloaded from OHMEX® echo sounder.

3.3.2 Data Processing

Processing for GNSS Data

The horizontal and vertical coordinates of the reference point used as base station are held fixed, based on its NAMRIA certification, for the establishment of a GNSS network for the survey area. Coordinates of this fixed point is used to give horizontal and vertical coordinates for the other reference points occupied and control points established.

Data from GNSS control surveys are processed in Trimble™ Business Center (TBC) software and settings were set to the required accuracy of +/-10cm for vertical and +/-20cm for horizontal controls. The TBC coordinate system parameters were set to Universal Transverse Mercator (UTM) Zone 51 North, World Geodetic System of 1984 (WGS1984), and the geoid model EGM2008 for horizontal and vertical datum, respectively.

An offset is derived by comparing the MSL elevation of the benchmark stated in the NAMRIA certification and its elevation value that resulted from the processed and adjusted control survey. This offset is used to refer all elevation from other surveys into MSL (BM_Ortho).

The formulas used for offset and BM_Ortho computation are shown in Equations 1-2:

Computation for offset:

Equation 1:

$$OFFSET = BM - EGM$$

Computation for BM_ortho:

Equation 2:

$$BM_{\_ortho} = EGM_{\_ortho} \pm OFFSET$$

where:

OFFSET	= difference/offset between Geoid model, EGM 2008 and MSL datum. Can be a positive or negative value
BM	= MSL elevation of vertical control point certified by NAMRIA
EGM	= EGM2008 elevation of the same NAMRIA vertical control point derived from TBC software processing
EGM $_{Ortho}$	= elevation of points referred to geoid model, EGM 2008
BM $_{Ortho}$	= elevation of points referred to MSL

GNSS processing is also done for the other surveys with the coordinates from the occupied points for the control survey held fixed, depending on which base station is used for the survey.

Processed and adjusted data are exported to comma delimited (*.csv) file format with the ff. columns: Point Name, Latitude, Longitude, Ellipsoidal Height, Northing, Easting, and Elevation (EGM_Ortho). This file format can be accessed through Microsoft Excel/Spreadsheet program.

Depth Data Processing

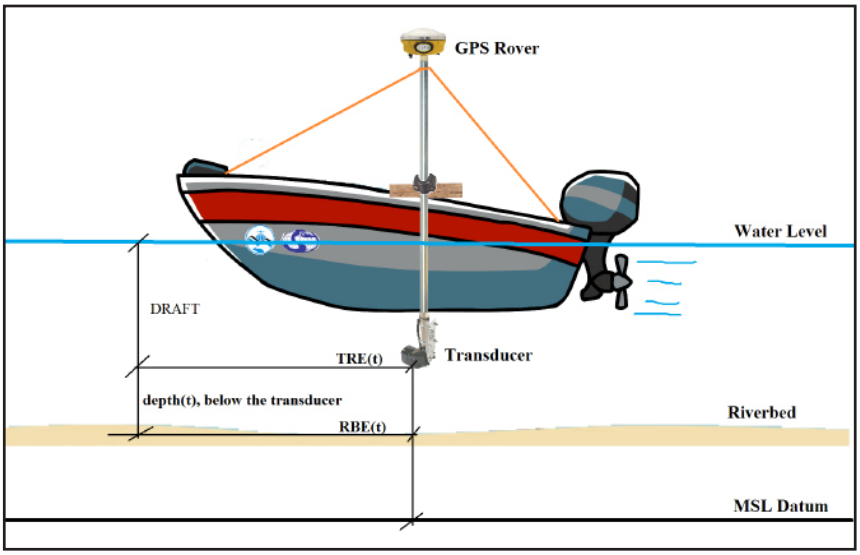


Figure 10. Illustration of Echo Sounder and GPS rover set-up for Bathymetric survey

There are two types of echo sounders used for bathymetric surveys – Hi-Target™ single beam echo sounder which is capable of recording depth data of one decimal place and the OHMEX™ single beam echo sounder capable of recording two-decimal places of depth data.

Raw depth data from Hi-Target™ single beam echo sounder is exported in (*.txt) file format with the ff. columns: Point No., Time, Depths H, Depths L, Draft, and Sound Velocity. This (*.txt) file is copied to a spreadsheet, retaining only the columns for Time and Depths H.

DVC Methodology

Raw depth data from OHMEX™ single beam echo sounder are exported in (*.som) file format. It is imported into SonarVista then exported into *.csv format with the ff. columns: Type, Date/Time, Sec, X/E, Y/N, Z/H, Tide, Depth and QA. SonarVista is used as file conversion tool only. The (*.csv) file opened using spreadsheet, making use of only the columns for Date/Time and Depth.

Data Matching for Bathymetric Data

Data matching is done by pairing an individual attribute of a bathymetric point to a depth data acquired using either OHMEX or HI-Target echo sounder. Matching is possible by ensuring that both bathymetric points and depth values acquisition has time stamp capability. These two sets of data are matched using VLOOKUP tool of a spreadsheet program, such that each point will have an accompanying (x,y,z) and depth data.

Below is the formula used for computing the elevation of the riverbed:

Equation 3:

$$RBE(t) = TRE(t) - Depth(t)$$

where:

RBE(t)	= elevation of the riverbed during time t,
TRE(t)	= transducer elevation (reckoned from EGM 2008)
Depth(t)	= depth recorded by the echo sounder at time t, with the assumption that depth is measured from the bottom of the transducer down to the riverbed

The resulting RBE(t) data are referred to MSL (BM_ortho) by applying the offset for the established network.

Final processed data are imported to Google Earth™ and Geographic Information Systems (GIS) software for viewing and checking horizontal position.

Hydrometry Data Processing

The processes done for Hydrometry data for HQ computation are described in the ff. steps:

1. **River Flow Data**

   a.) ADCP

   Data from the ADCP is logged internally and can be downloaded using either SonUtils™ or View Argonaut™ software. River velocity is recorded for a specified time duration and interval can be exported in a (*.csv) format.

   b.) Flow Meter

   Acquisition of river velocity using flow meters is done manually. Measurements for a specified time duration and interval is recorded in a field notebook and saved in a spreadsheet program.

2. **Cross Section and Water Surface Elevation Data**

   Cross Section data and water surface elevation data is acquired using GNSS receivers described in section 3.3.4 for GNSS data processing with a resulting file in (*.xls) format.

3. **Water Level Change-Stage**

   a.) Depth Gauge

   Data from depth gauge can be downloaded using HobowarePro™. Water level in meters are logged for a specific time interval and it can be exported in a (*.csv) format.

   b.) AWLS

   Data from installed AWLS can be accessed via the internet (http://repo.pscigrid.gov.ph/predict/). Water levels are logged in ten-minute time intervals and can be copied into a spreadsheet program.

4. **Discharge Computation**

   River flow data and water level change is synchronized by time. Parameters were preset in its respective programs so the deployment of each instrument will begin and end in the same time. All data in (*.csv) and (*.csv) format are combined in a single worksheet wherein the computation for the coefficient of determination or R2 are done.

The illustration in Figure 7 shows how each set of data from each instrument can be synchronized.

3.3.3 Filtering of Data

A processed point which resulted to float or did not meet the desired accuracy is filtered out. Resurveys are conducted immediately if data gaps are present for the ground surveys.

3.3.4 Final Editing

Final editing is performed to be able to come up with the desired data format: Point Value, Latitude, Longitude, Ellipsoidal Height, Northing, Easting, EGM_Ortho and BM_Ortho.

Processes discussed are valid for static, cross section, ground validation, and manual bathymetric surveys not employing echo sounders. For bathymetric surveys using a single beam echo sounder, the GPS rover is mounted on top of a 2m pole and a transducer at the bottom (see Figure 10). Figure is valid in both using OHMEX and HI-Target echo sounders. The GPS rover provides horizontal and vertical coordinates whereas the echo sounder transducer measures depth of the river from its bottom down to the riverbed.

3.3.5 Output

Filtered data are furthered processed into desired template using a spreadsheet program. Final data are generated into maps and CAD plots for cross-section, profile, and riverbed profiles. Cross-section, Profile, Validation Points, and Bathymetric data shall be turned-over to DPC while hydrometric data shall be turned-over to FMC.

Agusan River Basin Survey

Agusan River Basin Survey

The survey for Agusan River Basin was conducted on April 4 to 19, 2013 with the following activities: control and bathymetric survey, profile and cross-section lines reconnaissance for outsource.

Agusan River consists of 32 delineated cross-section lines with a total length of 62.34 km. For the left bank, the survey started from Brgy. Amparo, Naujan in the upstream down to Brgy. Lumbocan, Agusan del Norte and the right bank survey started from Brgy. Aupagan down to the Municipality of Magallanes. The total length of profile lines is about 19 km for both its left and right banks. Ground surveys for both cross-section and profile lines were conducted by LN Realty and Surveying Services on May 24 to June 7, 2013 as described in Annex F.

Another set of fieldwork was conducted on October 13-17, 2013 to acquire the cross-section and sensor elevation of the installed Automated Water Level Sensor (AWLS) and to perform flow data gathering in DRRM River Base Leon Kilat, Butuan City, Agusan del Norte; NIA Pumping Station, Butuan City, Agusan del Norte; Wawa Bridge, Bayugan City, Agusan del Sur; Adanan Bridge, Bayugan City, Agusan del Sur and Esperanza Bridge, Esperanza, Agusan del Sur.

Flow data gathering activities using an ADCP were also conducted for Agusan River in Las Nieves on November 9-17, 2013.

4.1 Control Survey

Two (2) NAMRIA established reference points and two (2) UP established control points were considered for the static GNSS observations in Agusan River. These include a first order benchmark AN-54 at Brgy. Antongalon; a second order reference point AGN-204 at Brgy. Taligaman; UP established control point "Tulay" in Magsaysay Bridge, Brgy. Ordoja and UP E-1 in Esperanza Bridge, Municipality of Esperanza, Agusan del Sur. The GNSS set-up for the four (4) base stations are shown in Figure 12, Figure 13, Figure 14 and Figure 15 while the location of these controls are shown in Figure 11.

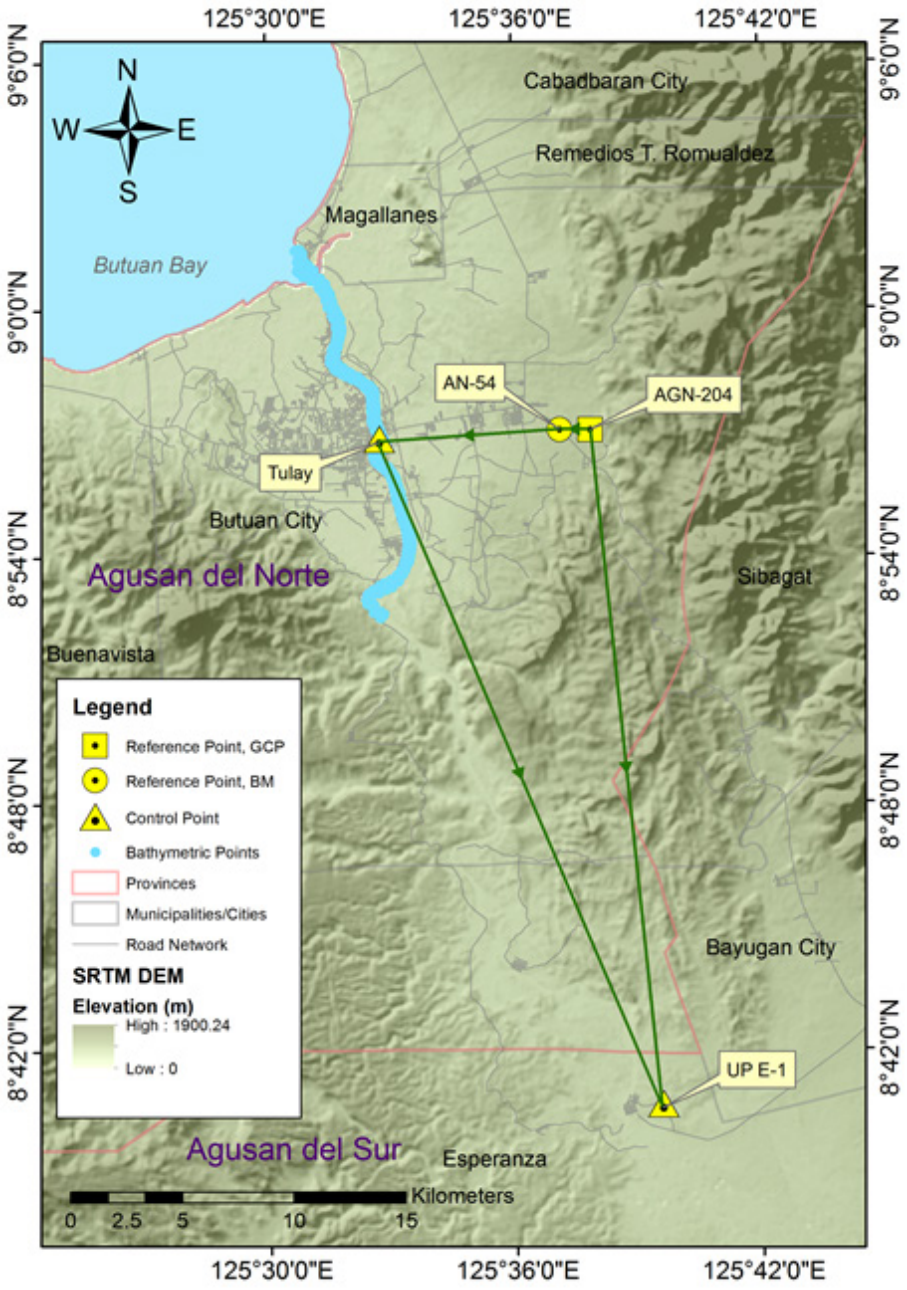


Figure 11. Location of control points

Continuous differential static observations were done simultaneously at these four stations for two hours to provide reference control points for the ground and bathymetric surveys. The horizontal coordinates and elevations of the four (4) control points were computed using Trimble ® Business Center GNSS processing software. The result of control survey for the control points are indicated in Table 1.

Table 1. Control points occupied during Agusan River Survey (Source: NAMRIA; UP-TCAGP)

Point Name	Order of Accuracy	WGS84 UTM Zone 51N					Elevation in MSL (m)
		Latitude	Longitude	Ellipsoidal Height (m)	Northing (m)	Easting (m)	
AN-54	1st	08°57'04.07" N	125°37'08.24" E	88.948	990473.811	787994.347	20.566
AGN-204	1st	08°56'16.03" N	125°37'53.34" E	96.874	989007.083	789383.684	28.435
Tulay	3rd	08°56'51.47" N	125°32'43.89" E	70.992	990029.969	779917.303	2.954
UP E-1	3rd	08°40'40.79" N	125°39'34.17" E	85.093	960278.351	792670.390	17.561

The GNSS setup for the three (3) control points are illustrated in Figure 12, Figure 13, Figure 14 and Figure 15:

Figure 12. Static GNSS observation at AGN-204 at Taligaman Elementary School in Brgy. Taligaman, Butuan City

Figure 13. Static observation at AN-54 at Brgy. Antongalon, Butuan City

Figure 14. Static observation at the established control at Brgy. Ordoja, Butuan City near Magsaysay Bridge

Figure 15. Static observation at UP E-1 at Esperanza Bridge, Municipality of Esperanza

Ground Surveys

The main objective of this activity is to perform reconnaissance to ensure the accessibility of the proposed cross-section and profile routes for the conduct of ground surveys by LN Realty and Surveying Services

Reconnaissance was conducted simultaneously with bathymetric and hydrometric measurements from April 4-19, 2013.

4.2 Reconnaissance of Cross-section and Profile Lines

Ocular inspection of the proposed cross-section and profile lines of Agusan River was the main objective of the team since cross-section and profile surveys were outsourced to LN Realty and Surveying Services.

Each cross-section lines were located using handheld GPS (Garmin Montana™ 650). Summary of reconnaissance for the 32 cross-sections are shown in detail in Annex E. Reconnaissance for profile lines were conducted simultaneously with the bathymetric surveys.

Features such as thick bushes, large tree canopy covers, tall grasses, etc. were noted and indicated on the field notebook and were relayed to the contractor prior the scheduled ground surveys.

4.3 Bathymetric Survey

The bathymetry of the river channel was surveyed using an echo sounding surveying technique. Differential GNSS surveying technique and an Ohmex™ single beam echo sounder were utilized in measuring the depth, eventually obtaining elevation with corresponding horizontal position. Bathymetry setup during the Agusan bathymetry survey is illustrated in Figure 16 while the location is shown in Figure 17.

The entire bathymetry survey took seven (7) days to accomplish from March 3-9, 2013. The Bathymetry Team executed the survey using a rigid boat borrowed from the City Disater Risk Reduction Management Office (CDRRMO). Centerline and zigzag sweep of the survey were performed in order to fully capture the topography of the river. In shallow portions of the river, manual data gathering was initiated, usually at the upstream of the river. The total length of the river is 18.82 km shown in Figure 17.

Figure 16. Bathymetry survey setup

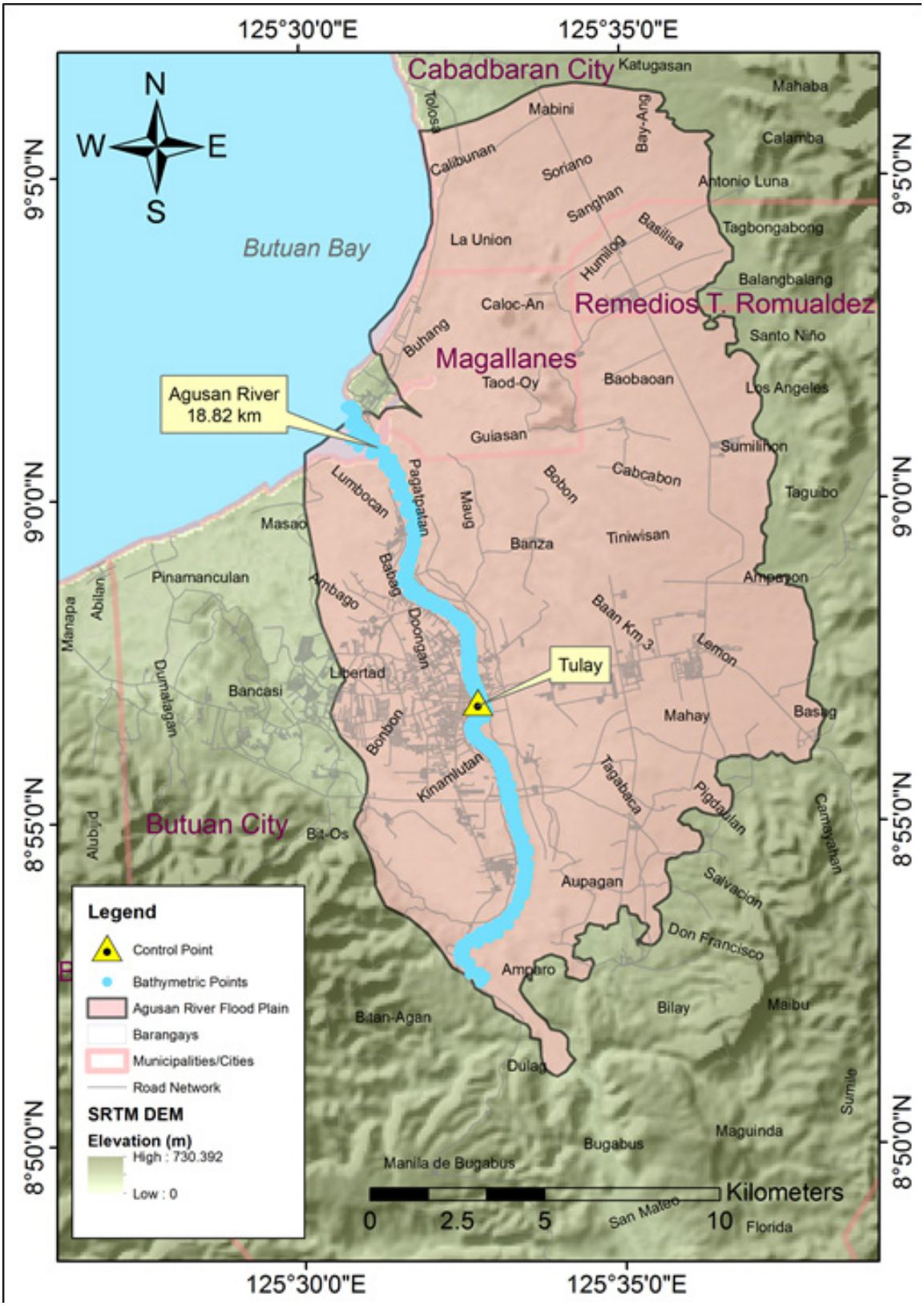


Figure 17. Bathymetry survey coverage of Agusan River

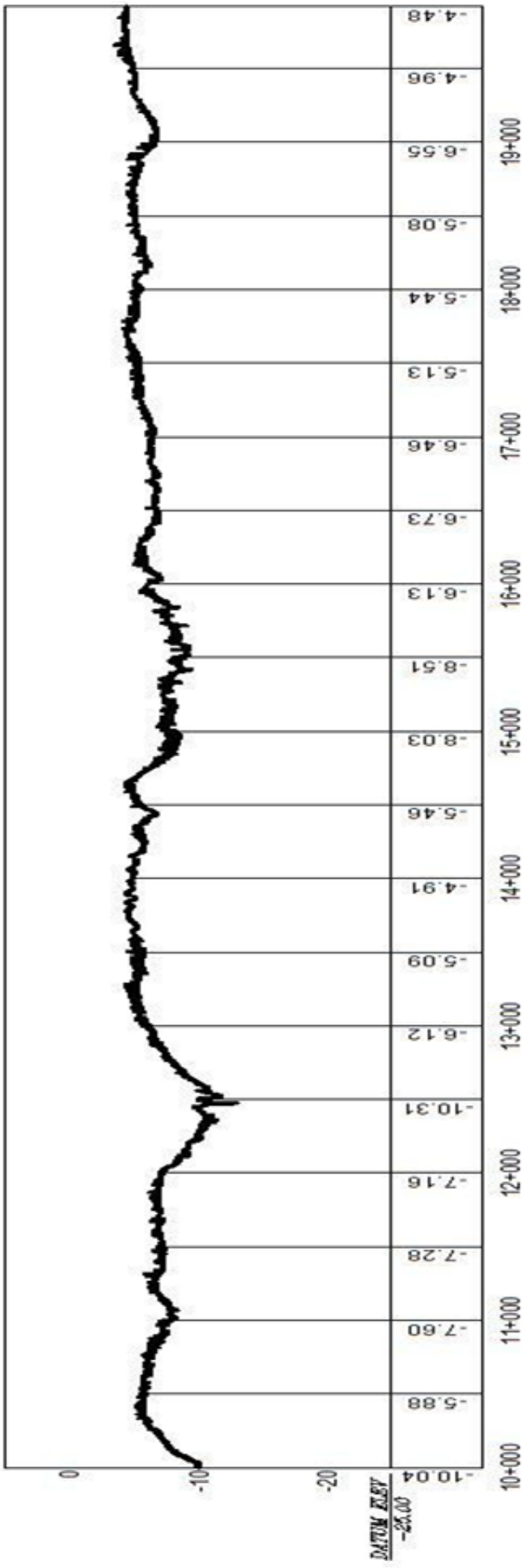


Figure 18. Riverbed centerline profile of Agusan River

4.4 Hydrometric Survey

4.4.1 Hydrometric Sensors Deployment with Stage Discharge Computation

Different sensors were deployed on the banks of Agusan River to obtain its physical characteristics such as cross-section elevation in MSL, velocity and elevation of water level in MSL at a particular time.

An ADCP sensor was deployed with a depth gauge and rain gauge in Brgy. Aupagan, Butuan City from April 7-18, 2013. Another survey was conducted and deployed an ADCP with depth gauge in Brgy. Mat-I, Las Nieves from October 13-17, 2013. One more survey was conducted and re-deployed the ADCP with depth gauge and rain gauge and in Brgy. Mat-I, Las Nieves from November 9-17, 2013.

The data gathered from the rain gauges shows the distribution of rainfall within the observation period from April 4-19, 2013 in Brgy. Aupagan, Butuan City, October 14-17 in Brgy. Mat-I, Las Nieves, Agusan del Norte and on November 9-17. Each sensor has a five (5)-minute interval

The summary of the location and deployment dates of the sensors used in Agusan River are shown in Table 2.

Table 2. Sensor location and deployment dates in Agusan River

Sensor	Location	Municipality	Deployment – Start	Deployment – End	LATITUDE	LONGITUDE
ADCP with Depth Gauge (1st)	Brgy. Aupagan	Butuan City	07-April 2013	18-April 201	08°52.619	125°32.817
Rain Gauge	Brgy. Aupagan	Butuan City	07-April 2013	18-April 2013	08°52.63	125°32.82
Depth Gauge	Brgy. Pagatpatan	Butuan City	07-April 2013	18-April 2013	08°59.52	125°31.70
ADCP with Depth Gauge (2nd)	Brgy. Mat-I	Las Nieves	13-October 2013	16-October-2013	8°43'54.22354"	125°36'00.80788"
ADCP with Depth Gauge (3rd)	Brgy. Mat-I	Las Nieves	10-November 2013	17-November-2013	8°43'54.22354"	125°36'00.80788"

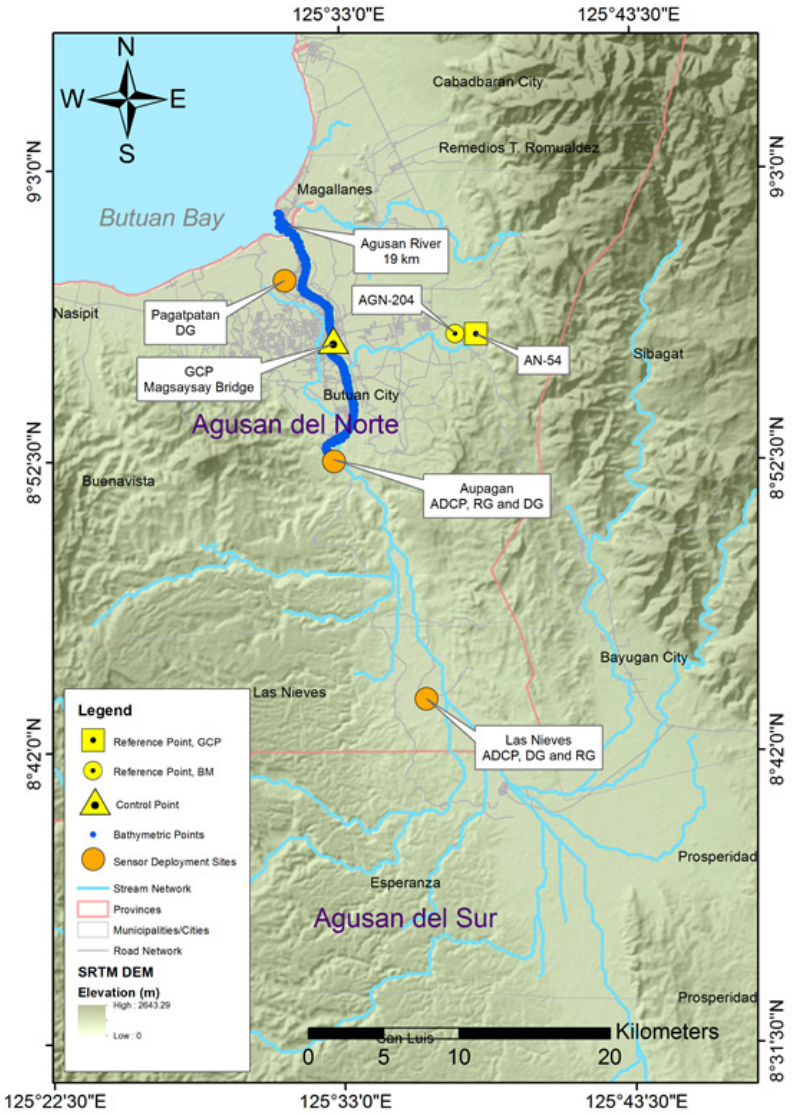


Figure 19. Agusan del Sur Sensor Locations

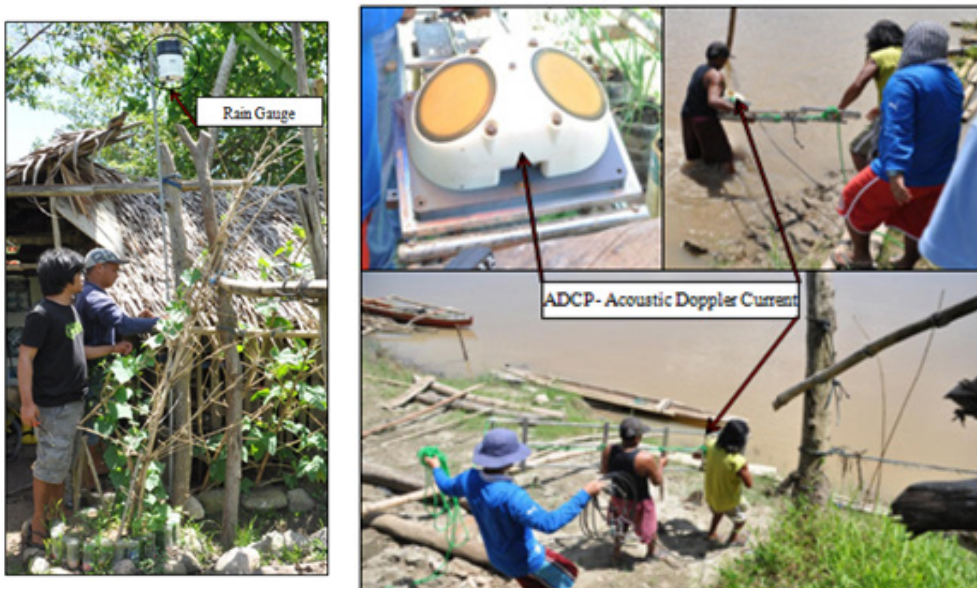


Figure 20. 1st deployment of Rain Gauge (left) and 1st deployment of ADCP with depth gauge (right) at Brgy. Aupagan, Butuan City

The image in Figure 20 shows the 1st deployment of rain gauge and ADCP with depth gauge for twelve days in Brgy. Aupagan, Butuan City, respectively. Another deployment of depth gauge is shown in Figure 20 at the downstream area of Agusan River in Brgy. Pagatpatan, Butuan City. The 2nd deployments of rain gauge and ADCP with depth gauge are shown in Figure 22 and Figure 23, respectively. The 3rd deployment of ADCP with depth gauge is shown in Figure 24 while the rain gauge data was obtained from repo.pscigrid.gov.ph. The nearest automated rain gauge was installed at Barangay Mat-I, Las Nieves, Agusan del Norte.

Figure 21. Deployment of depth gauge at Brgy. Pagatpatan, Butuan City

Figure 22. 2nd deployment of rain gauge at Brgy. Mar-I, Las Nieves

Figure 23. 2nd deployment of ADCP with depth gauge at Brgy. Mat-I, Las Nieves

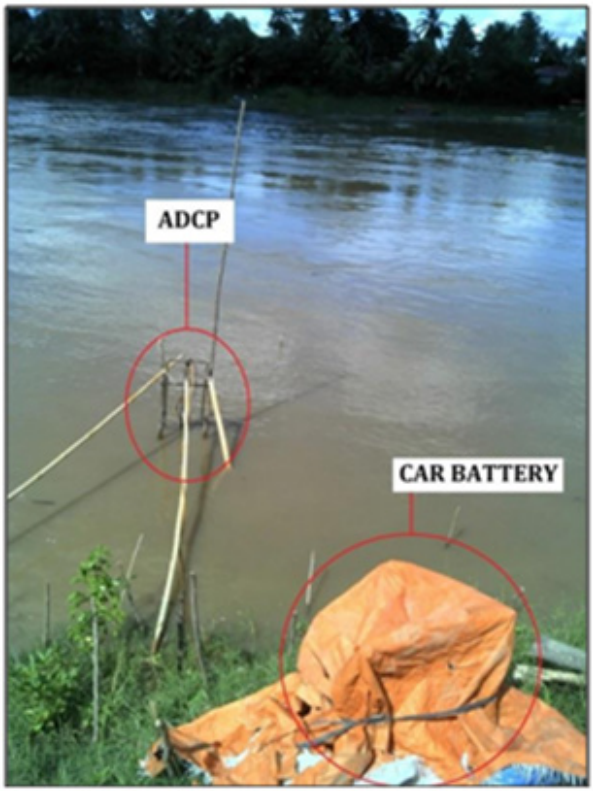


Figure 24. 3rd deployment of ADCP with depth gauge at Brgy. Mat-I, Las Nieves

The hydrometric properties of Agusan River for the 1st deployment last April 7-18, 2013 are illustrated in Figure 25-27. Rainfall data peaked on April 17, 2013 at 7.8 mm at 3:30 PM. Water level measurements showed pronounced variations in the first five days that have slightly lessened in the last five days. Abrupt changes in rainfall also corresponded with a more unstable water level. Discharge was computed by multiplying the velocity of the river, as measured by the ADCP, and the cross-sectional area within the polygon bounded by the stage and cross-section.

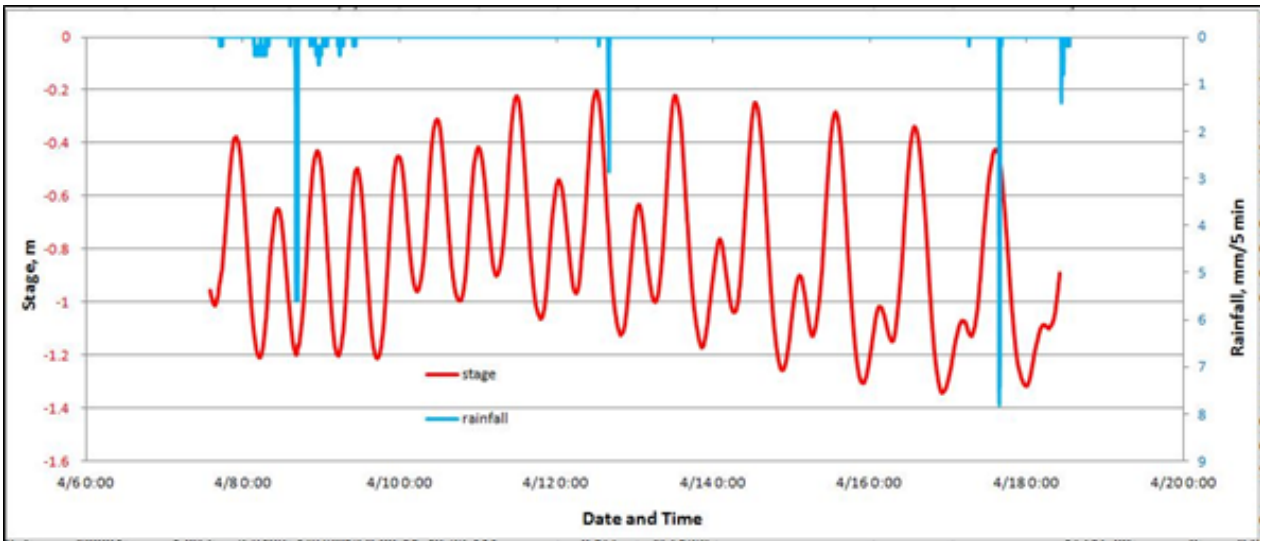


Figure 25. Stage vs Rainfall graph for Brgy. Aupagan, Butuan City

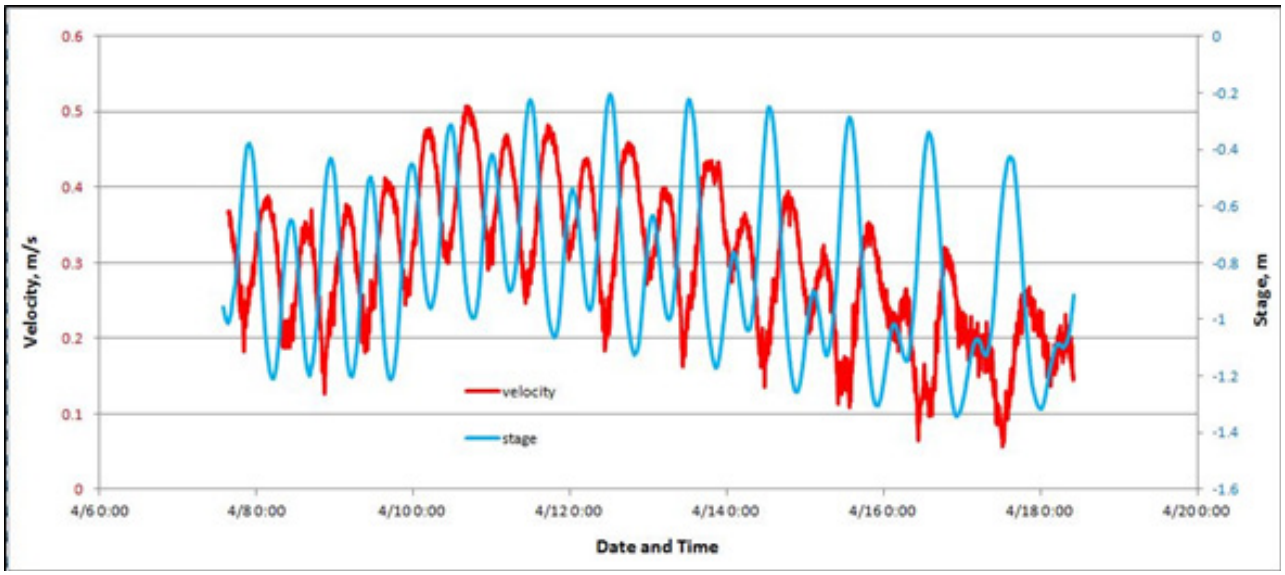


Figure 26. Stage vs Velocity graph for Brgy. Aupagan, Butuan City

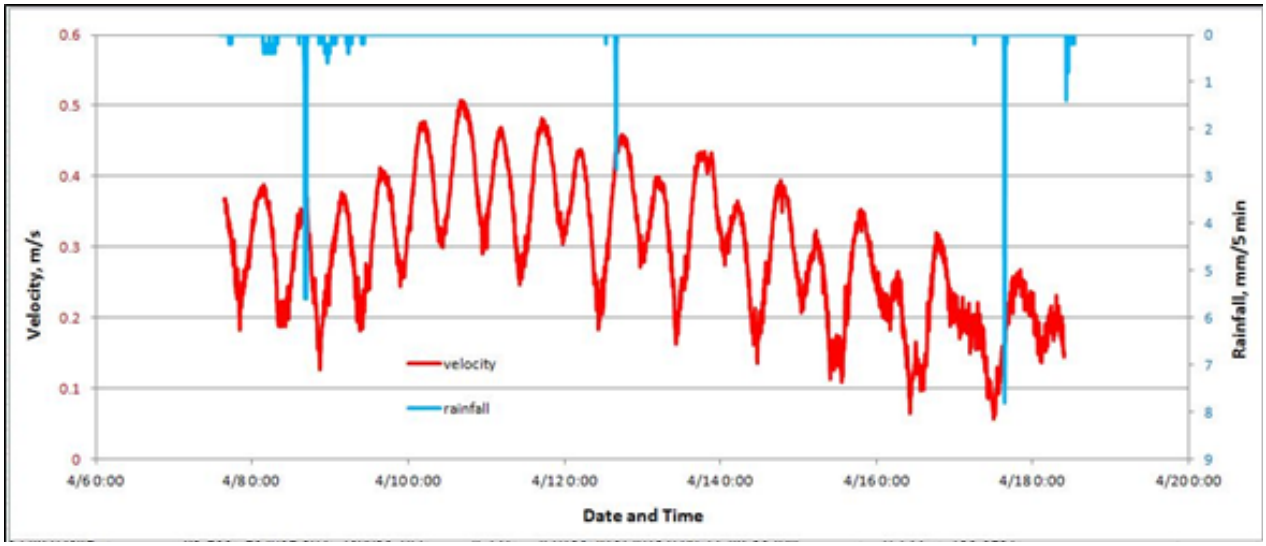


Figure 27. Velocity vs Rainfall graph for Brgy. Aupagan, Butuan City

The hydrometric properties of Agusan River for the 2nd deployment last October 13-16, 2013 are illustrated in Figure 28-31.

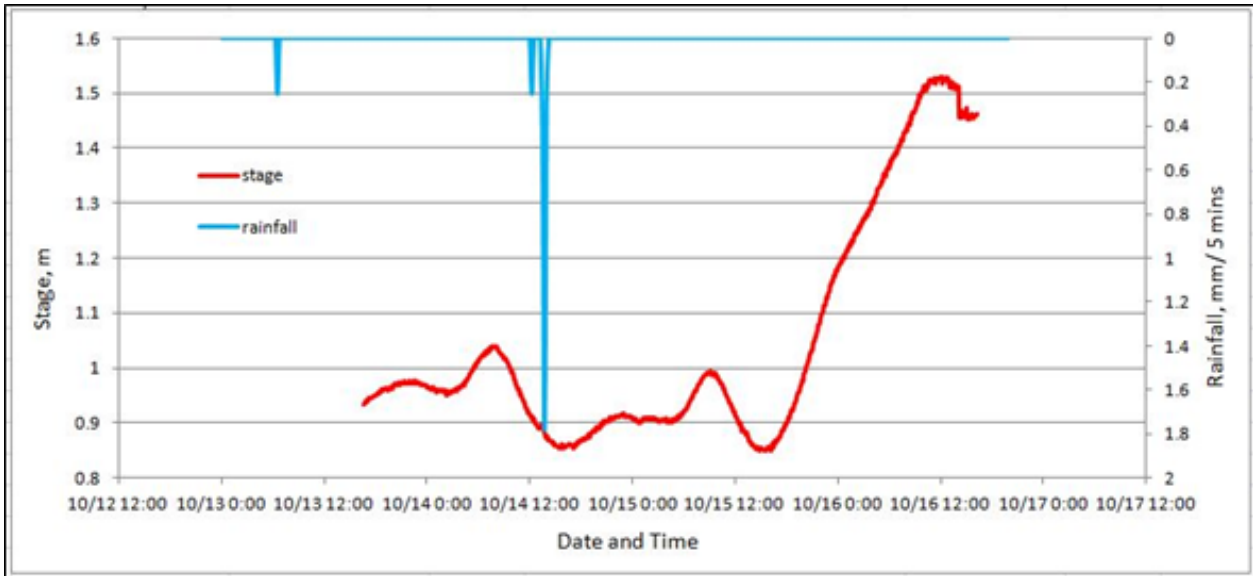


Figure 28. Stage vs Rainfall graph in Brgy. Mat-I, Las Nieves

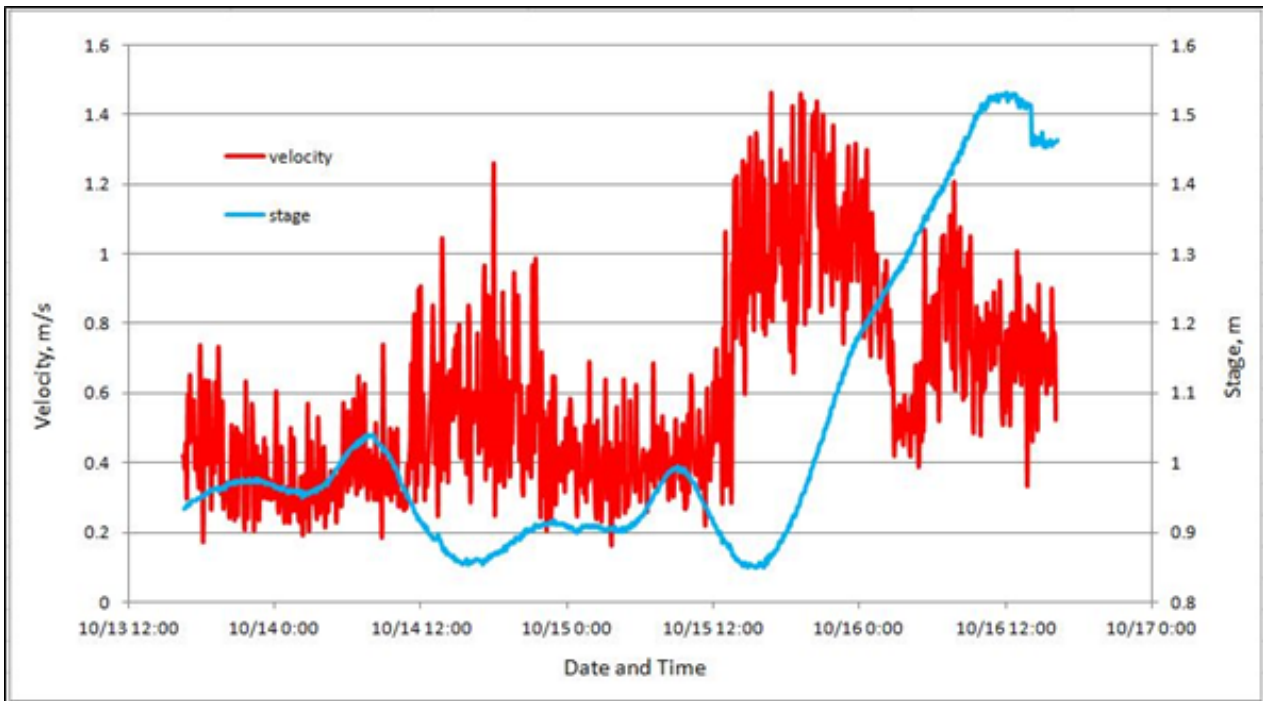


Figure 29. Stage vs Velocity graph in Brgy. Mat-I, Las Nieves

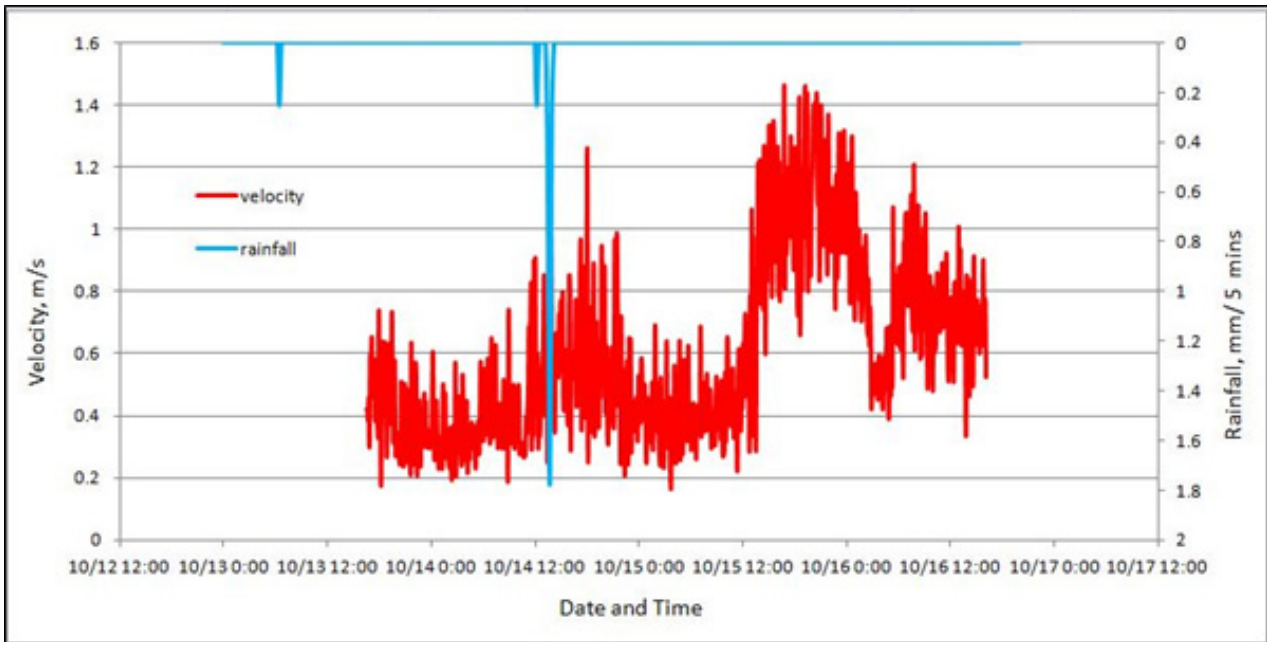


Figure 30. Velocity vs Rainfall graph in Brgy. Mat-I, Las Nieves

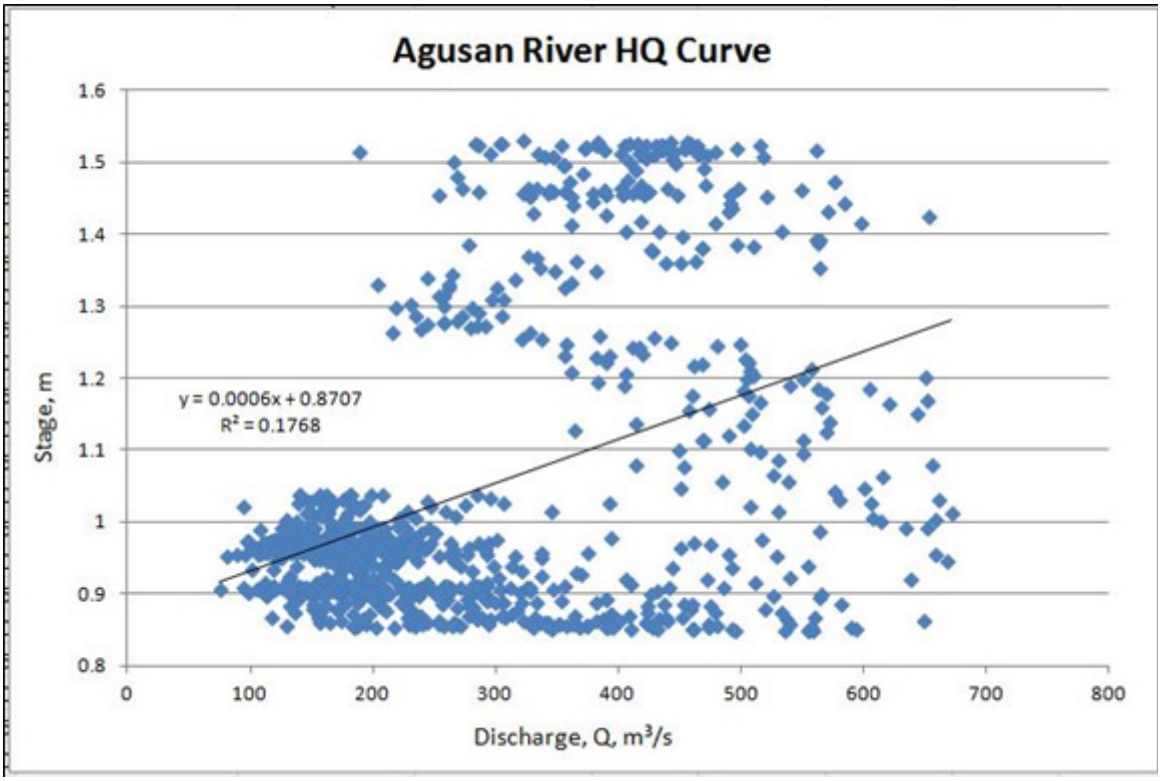


Figure 31. HQ Curve in Brgy. Mat-I, Las Nieves

The hydrometric properties of Agusan River for the 3rd deployment last November 10-17, 2013 are illustrated in Figures 32-35.

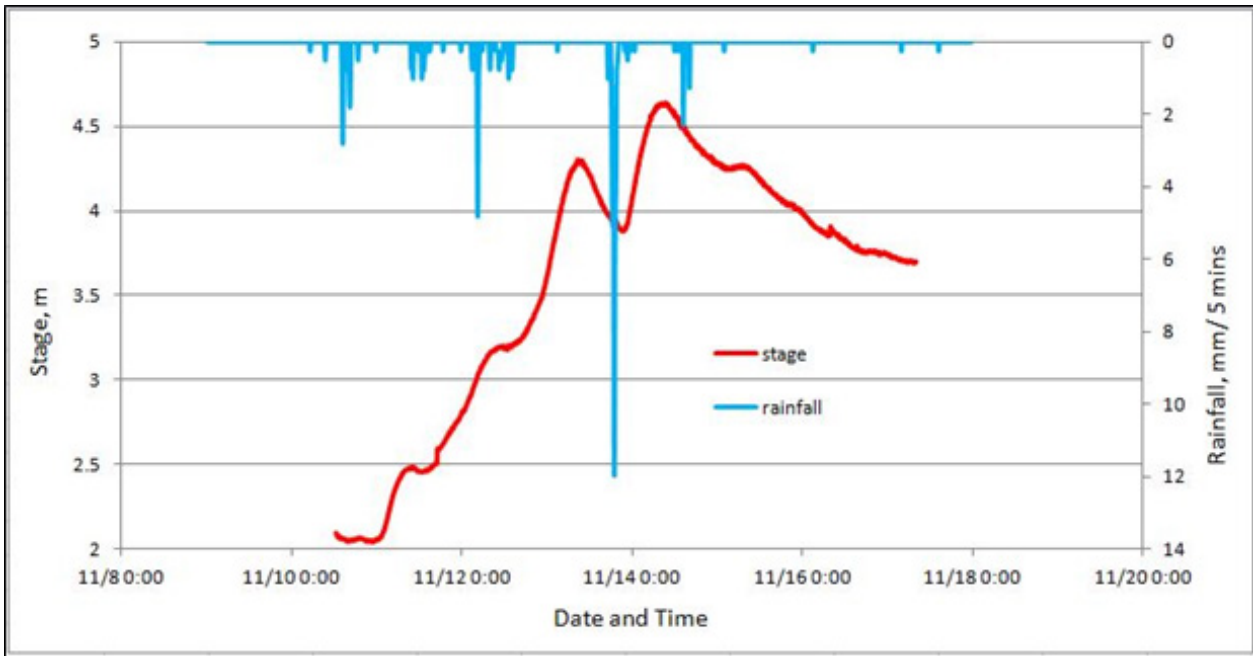


Figure 32. Stage vs Rainfall graph in Brgy. Mat-I, Las Nieves

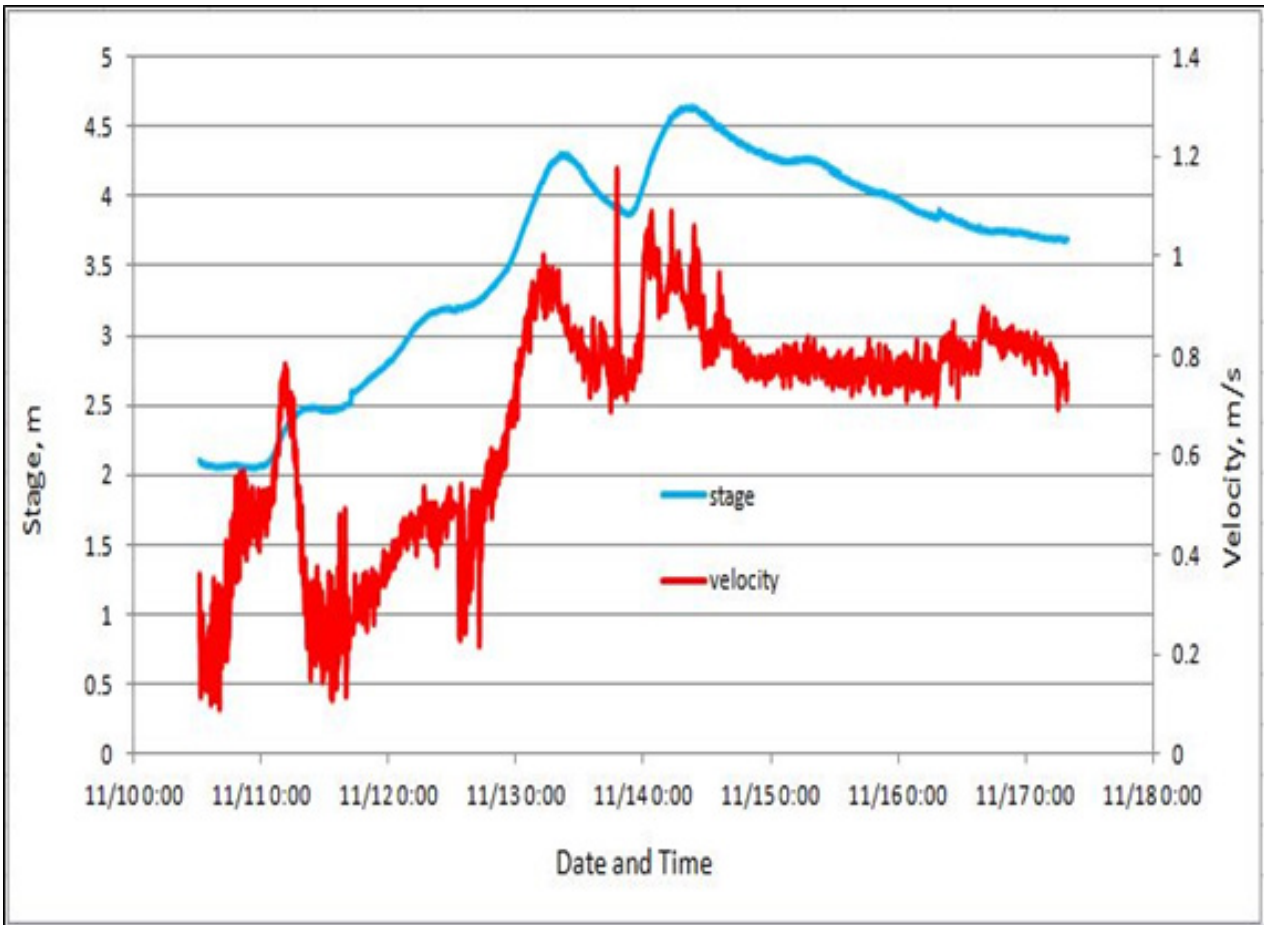


Figure 33. Stage vs Velocity graph in Brgy. Mat-I, Las Nieves

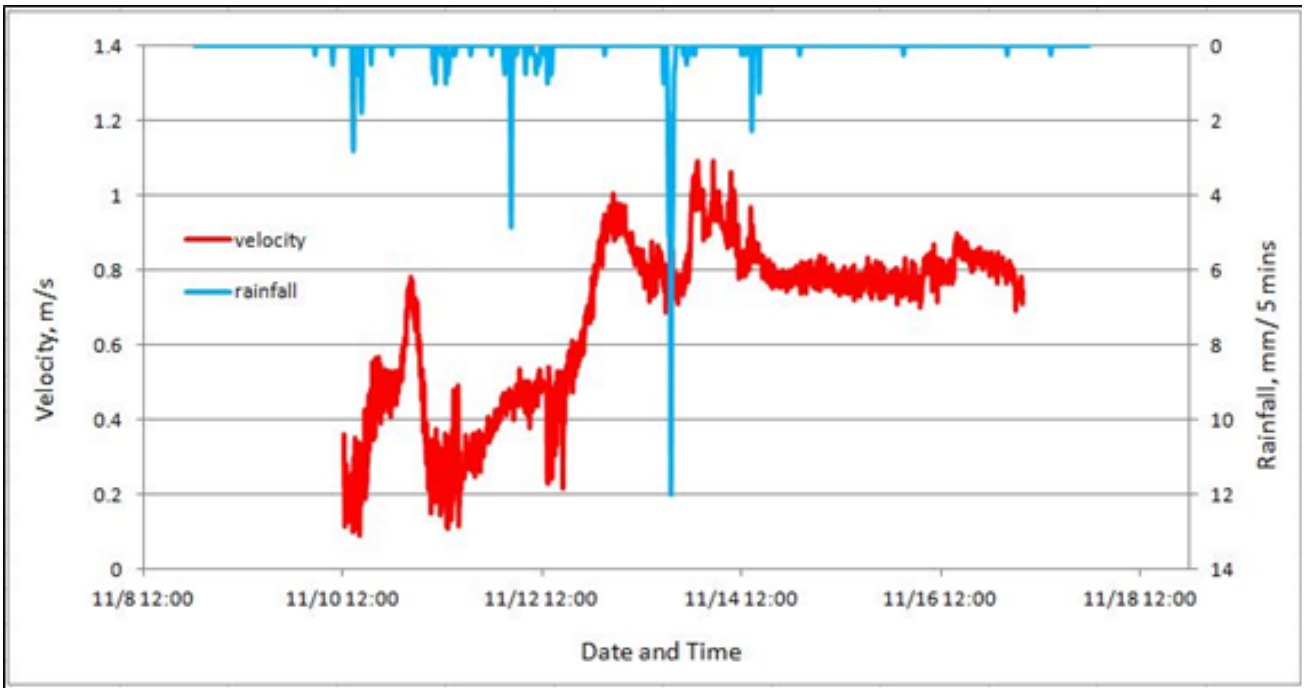


Figure 34. Velocity vs Rainfall graph in Brgy. Mat-I, Las Nieves

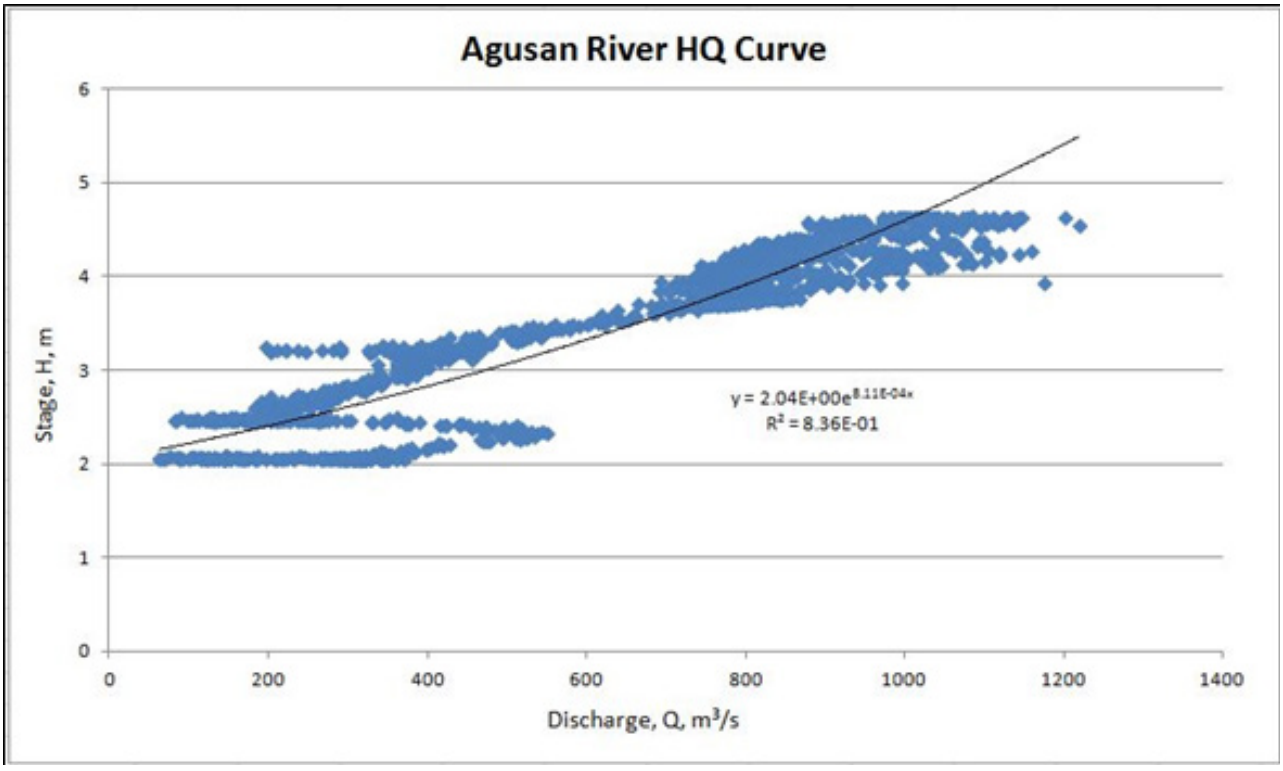


Figure 35. HQ Curve for Brgy. Mat-I, Las Nieves

4.4.2 Agusan del Norte AWLS Survey

Another survey was conducted for the installed AWLS in Agusan del Norte in order to get its cross-sectional area and water surface elevation in MSL on October 13-17, 2013. River velocity was also acquired using a mechanical flow meter.

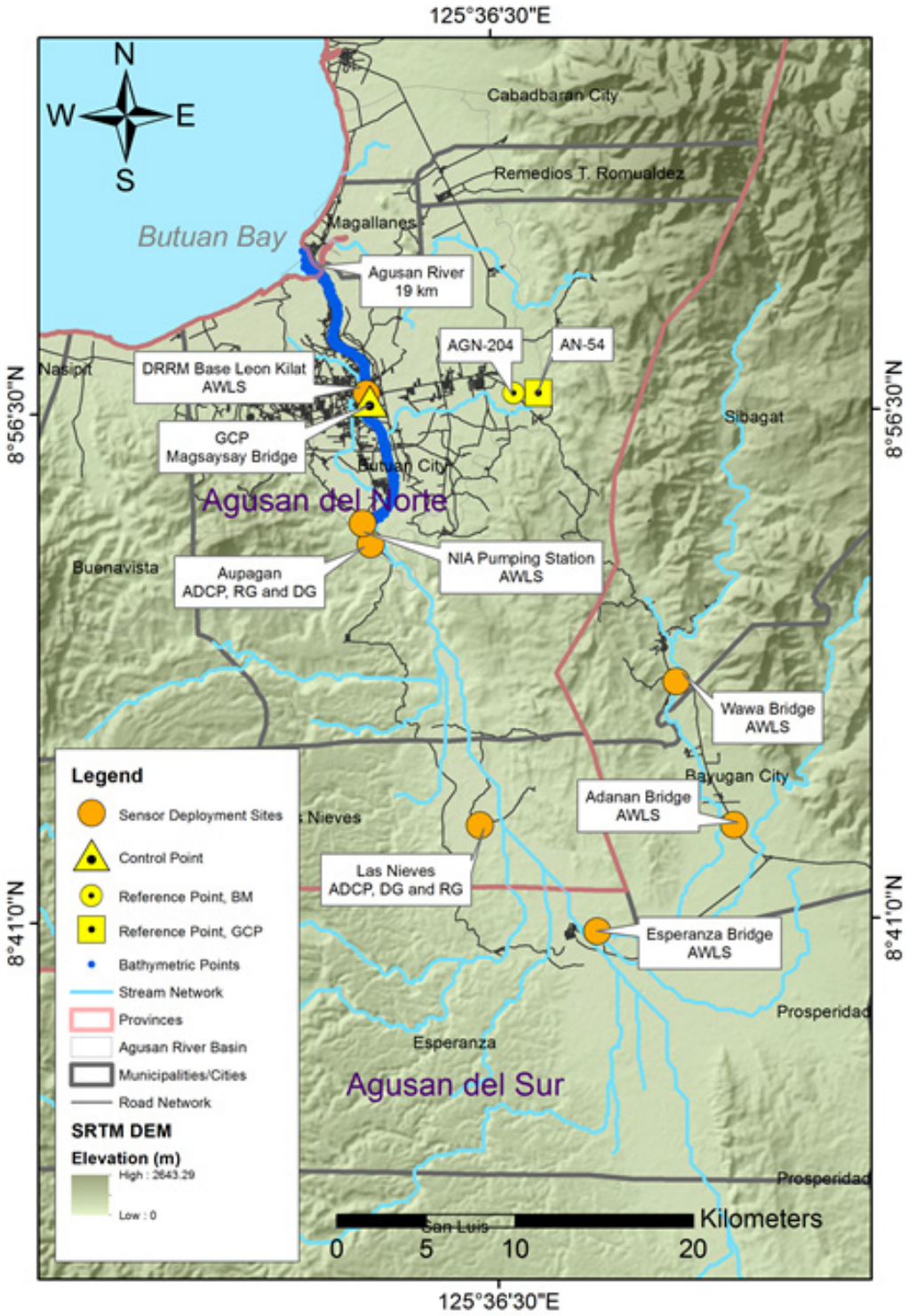


Figure 36. Agusan del Norte AWLS Survey Extent

4.4.2.1 AWLS Cross-section Survey

Another survey was conducted for the installed AWLS in Agusan del Norte in order to get its cross-sectional area and water surface elevation in MSL on October 13-17, 2013. River velocity was also acquired using a mechanical flow meter.

Table 3. AWLS sites in Agusan River System with its respective MSL value

AWLS	BARANGAY	LOCATION	AWLS ELEVATION m, (MSL)	Water Surface Elevation (m), MSL with Date& Time	IMAGE
DRRM River Base Leon Kilat	Agusan del Norte	Lat 8°57'04.34211"N Long 125°32'37.52101"E	2.828 m	-0.710 m, Oct. 14, 2013, 1:35 PM	
NIA Pumping Station	Agusan del Norte	Lat 8°53'07.62381"N Long 125°32'28.87528"E	2.686 m	0.137 m, Oct. 16, 2013, 10:37 AM	
Wawa Bridge	Bayugan City, Agusan del Norte	Lat 8°48'14.75762"N Long 125°42'3.09845"E	47.327 m	38.071 m, Oct. 16, 2013, 2:07 PM	

Agusan River Basin Survey

AWLS	BARANGAY	LOCATION	AWLS ELEVATION m, (MSL)	Water Surface Elevation (m), MSL with Date& Time	IMAGE
Andanan Bridge	Bayugan City, Agusan del Norte	Lat 8°43'52.02797"N Long 125°43'46.83912"E	26.046 m	17.408 m, Oct. 15, 2013, 1:56 PM	
Esperanza Bridge	Esperanza, Agusan del Sur	Lat 8°40'39.01990"N Long 125°39'34.61429"E	18.826 m	5.567 m, Oct. 15, 2013, 2:20 PM	

The diagram of cross-section data gathered for bridges with installed AWLS is illustrated in Figures 37-41.

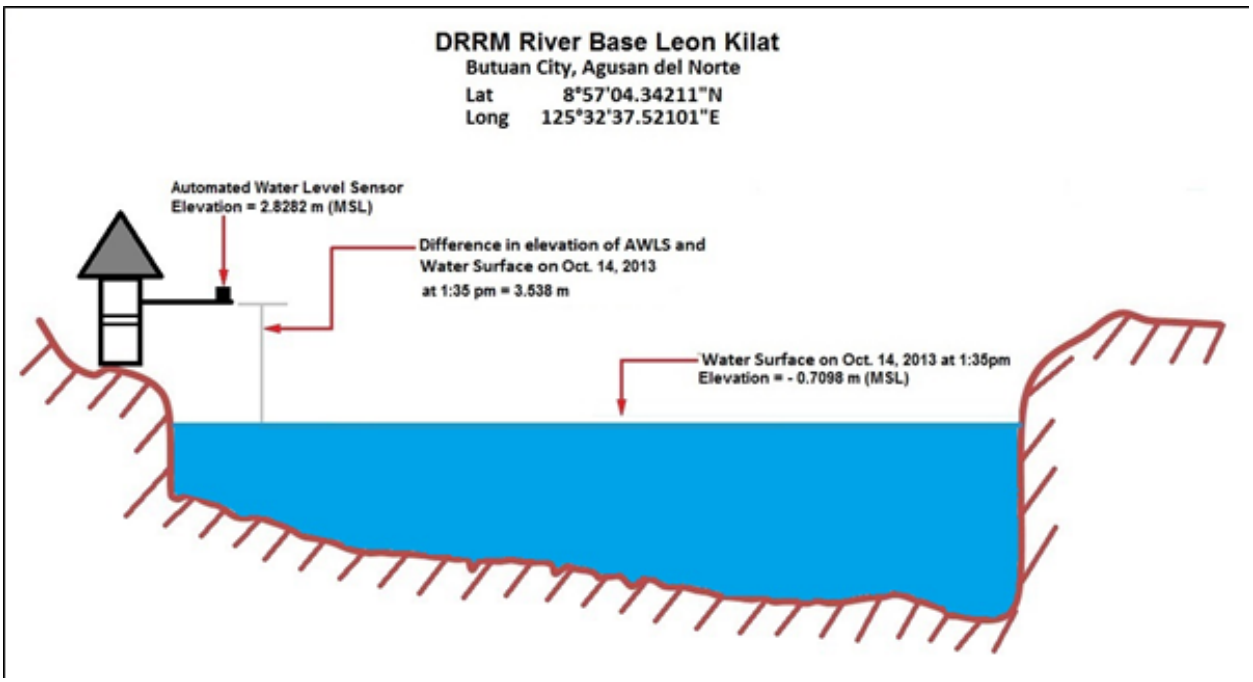


Figure 37. AWLS in DRRM River Base Leon Kilat, Agusan del Norte

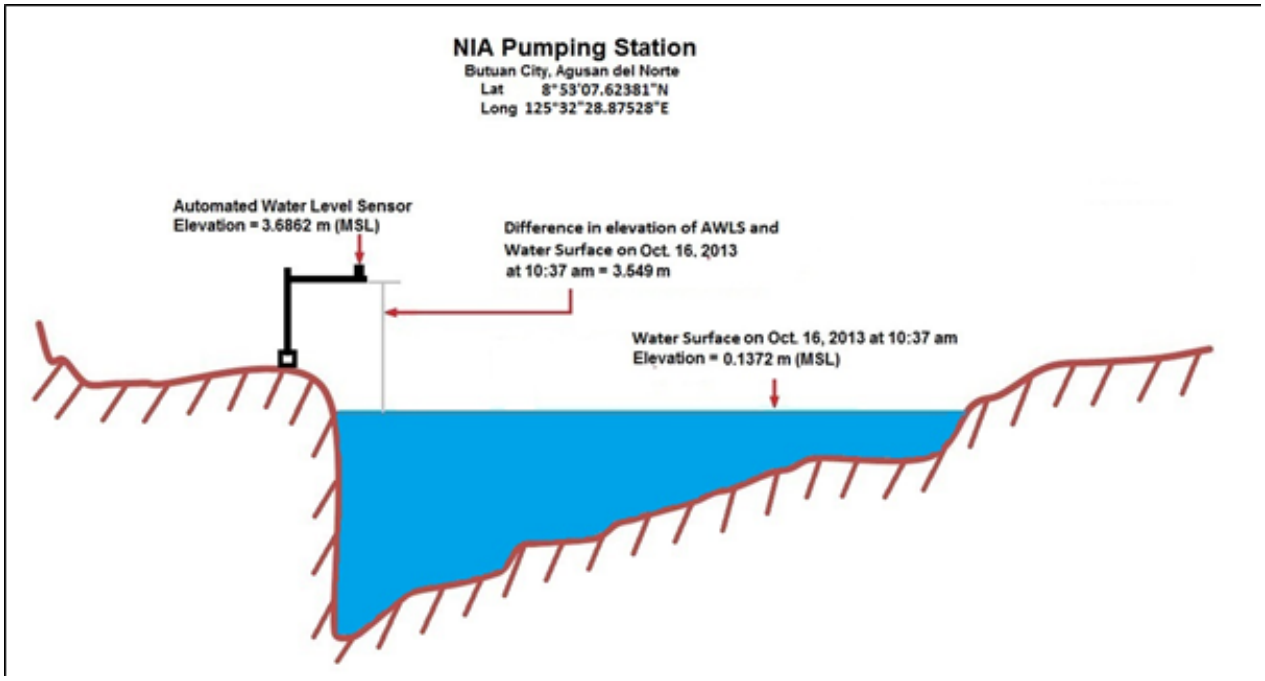


Figure 38. AWLS in NIA Pumping Station, Agusan del Norte

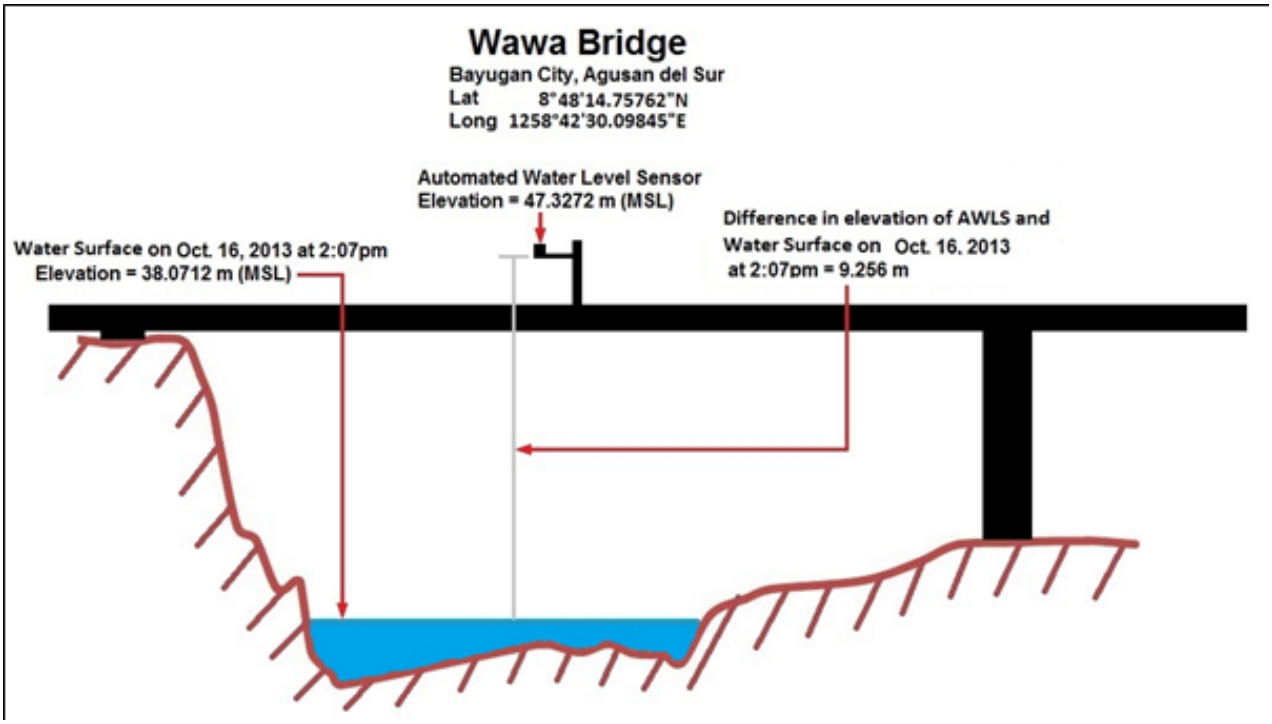


Figure 39. AWLS in Wawa Bridge, Bayugan City, Agusan del Norte

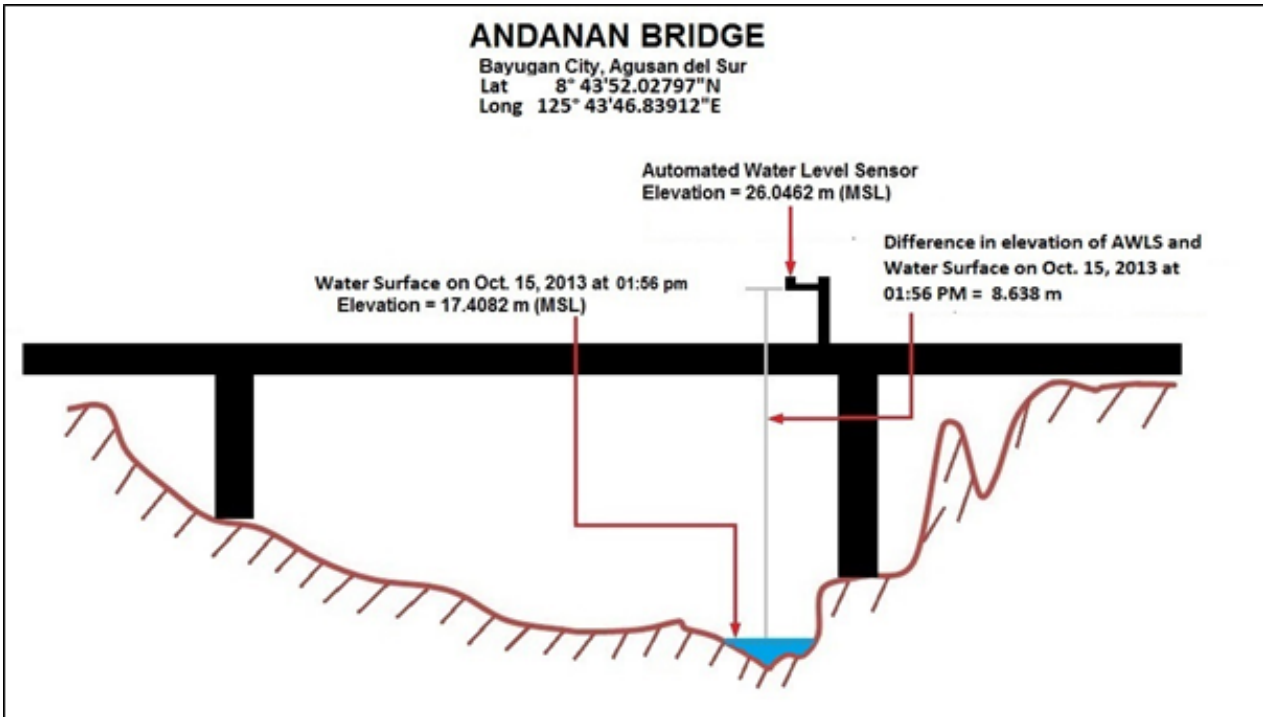


Figure 40. AWLS in Andanan Bridge, Bayugan City, Agusan del Norte

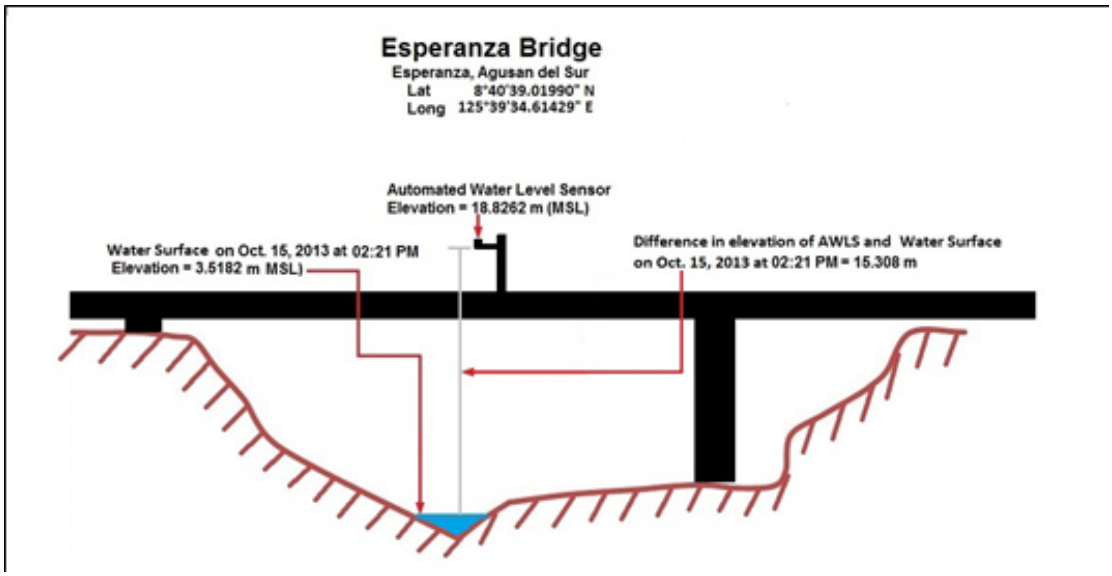


Figure 41. AWLS in Esperanza Bridge, Esperanza, Agusan del Norte

4.4.2.2 Flow Measurements and Stage Discharge Computation

Two (2) local hires living within the vicinity of the bridge were employed to gather flow measurements. Two types of events were recorded by the team – (1) base flow or the normal stream flow, without the influence of a precipitation. In this scenario, local hires were tasked to record the velocity of the river for two hours each in the morning and afternoon for a single day; and (2) the flow of the river during the occurrence of a rain event.

Two rainfall events were needed prior retrieval of the flow meters. In this type of event, the water velocity was recorded for six-hours straight while precipitation was on-going, day and night. Continuous recording of flow measurements were done until two rain events were observed. The summary of hydrometry data gathered per bridge location is summarized in Table 4.

Figure 42. Flow measurements using a rotor-type flow meter at Butuan Bridge for DRRM River Base Leon Kilat AWLS and Adanan Bridge

Table 4. Summary of AWLS Field Survey

Bridges	Cross Section	Water Level	Flow Measurement	Rainfall	Remarks
DRRM River Base Leon Kilat	✓	✓	✓	✓	flow measurement done in the Butuan Bridge
NIA Pumping Station	✓	✓	X	X	No rainfall data from repo.pscigrid.gov.ph within the observation period.
Wawa Bridge	✓	X	X	X	Flow measurement is not applicable within the observation period and also its affected by Andanan Wawa River Irrigation System No water level and rainfall data period from repo.pscigrid.gov.ph
Andanan Bridge	✓	✓	✓	✓	complete
Esperanza Bridge	✓	X	✓	X	No water level and rainfall data period from repo.pscigrid.gov.ph within the observation period

A. DRRM River Base Leon Kilat Stage Discharge Computation

River velocity data for DRMM River Base Leon Kilat, Agusan del Norte, was plotted against water level data from an Automatic Water Level Sensor (AWLS). Velocity measurements were recorded for one (1) day October 14, 2013 for two (2) hours observation. The summary of data gathered is illustrated in Figure 43-46.

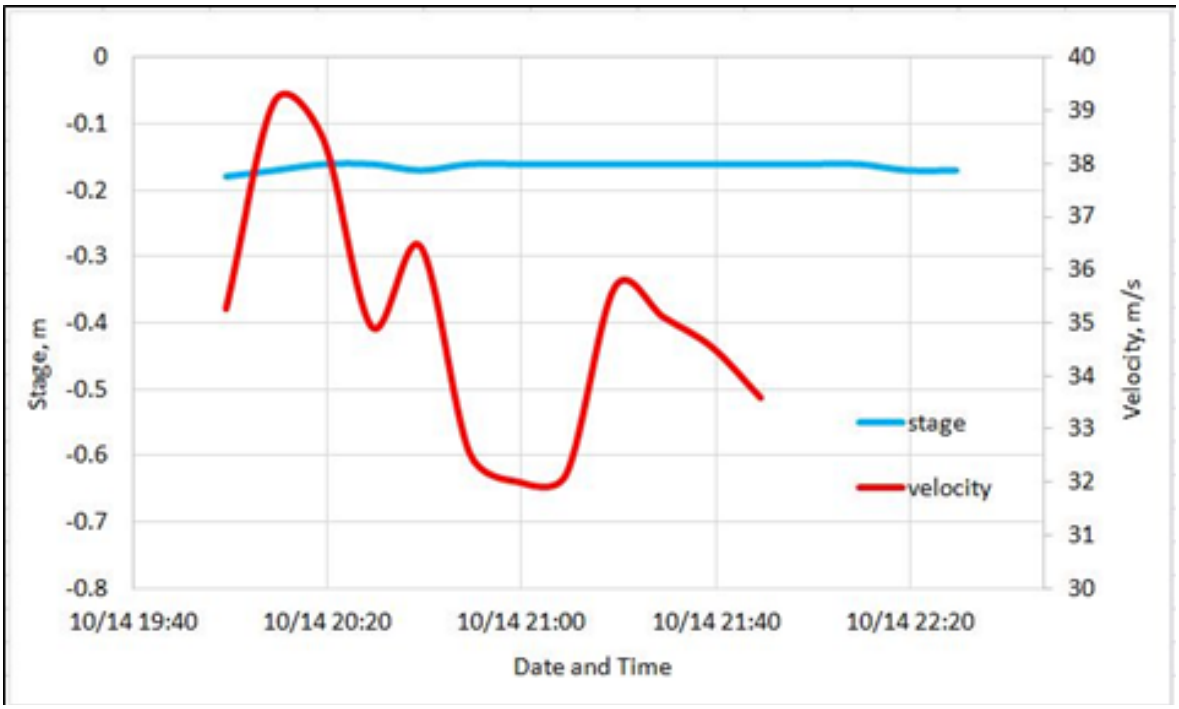


Figure 43. Stage vs Velocity graph for DRMM River Base Leon Kilat, Agusan del Norte

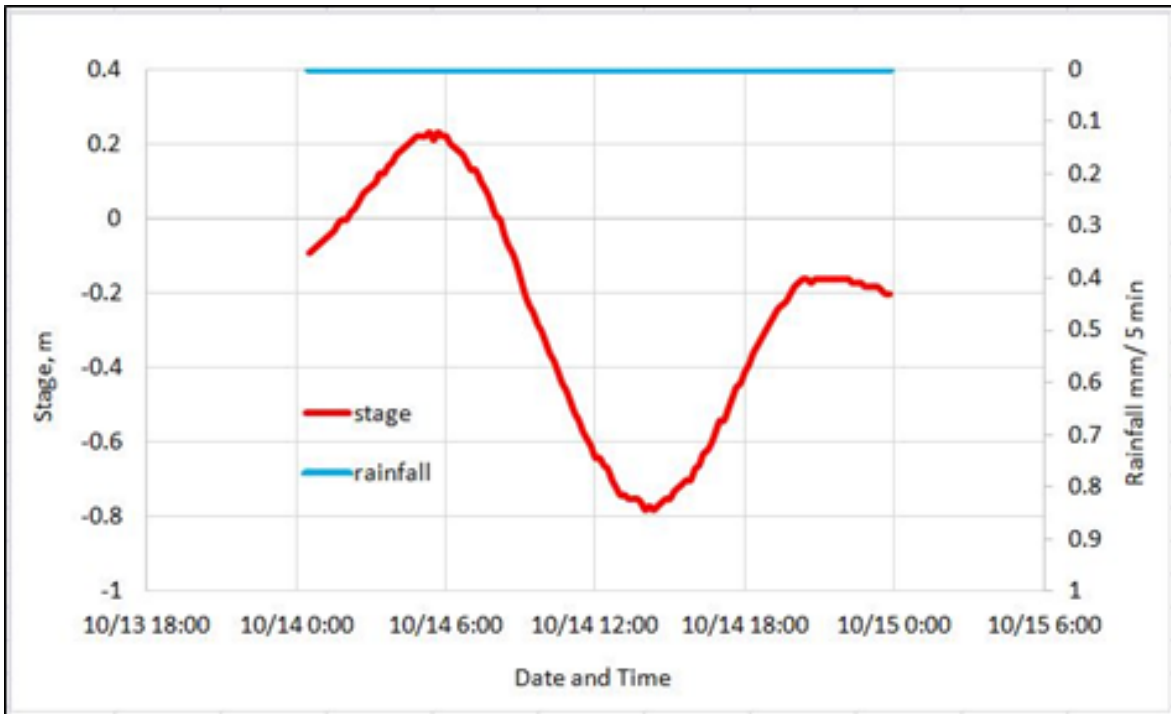


Figure 44. Stage vs Rainfall graph for DRMM River Base Leon Kilat, Agusan del Norte

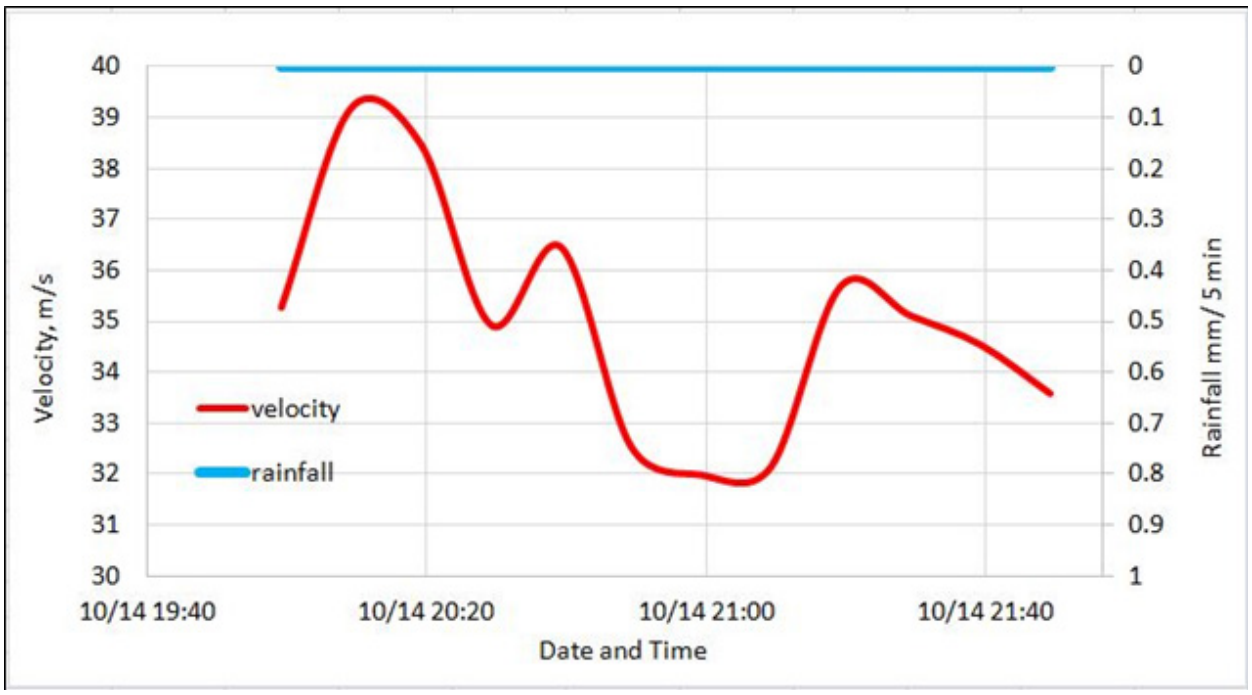


Figure 45. Velocity vs Rainfall graph for DRMM River Base Leon Kilat, Agusan del Norte

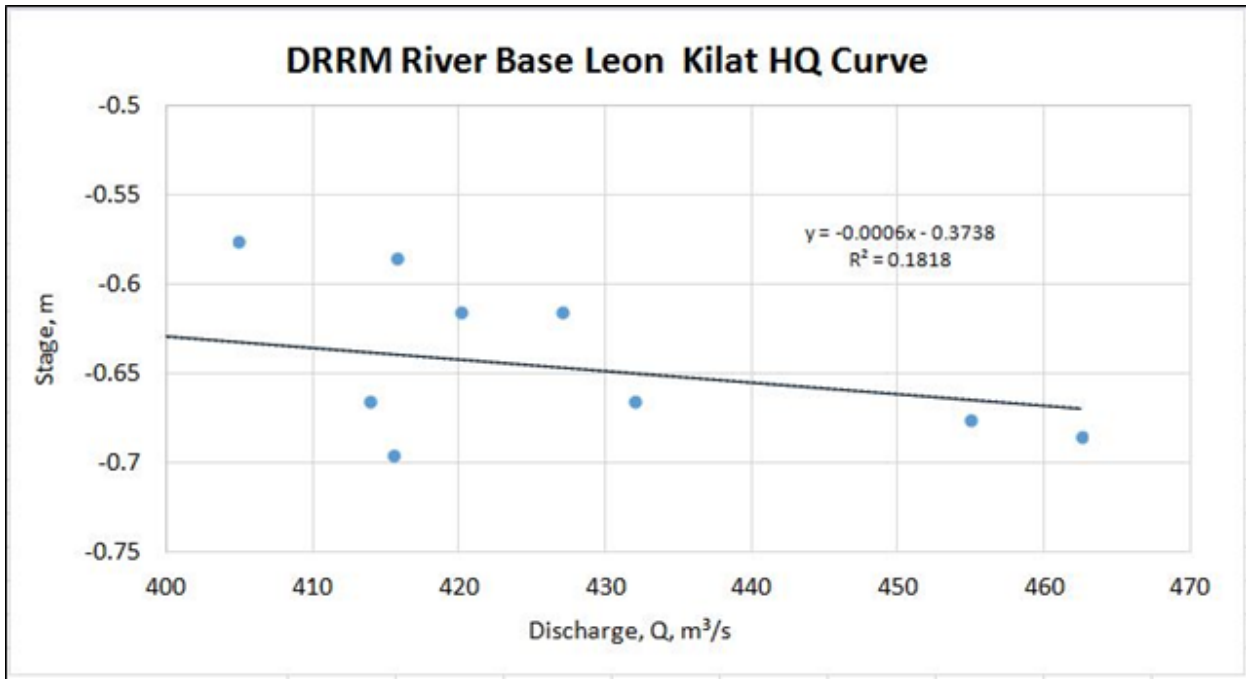


Figure 46. HQ Curve for DRMM River Base Leon Kilat, Agusan del Norte

B. NIA Pumping Station Stage Discharge Computation

Flow measurements were not recorded because there is no ideal location to establish the flow measurement instrument. Water Level data was extracted from repo.pscigrid.gov.ph. Water Level was recorded for one (1) day October 16, 2013 for twenty-four (24) hours observation. The summary of data gathered is illustrated in Figure 47.

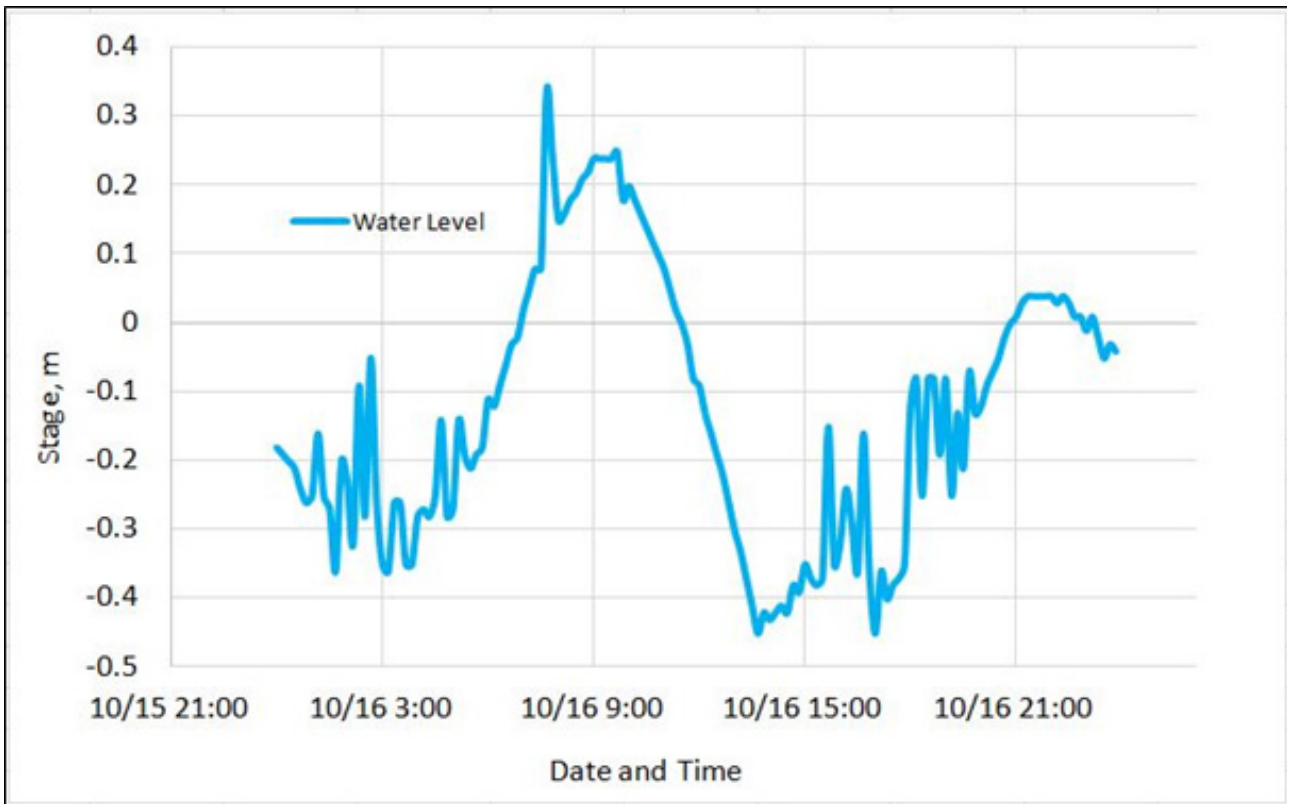


Figure 47. Stage in Mean Sea Level (MSL) of Agusan River

Note: No rainfall data available from repo.pscigrid.gov.ph at NIA Pumping station and flow measurement is not applicable due to unsuitable location to establish the flow measurement instrument.

C. Wawa Bridge Stage Discharge Computation

Flow measurements recorded were not applicable because the river flow condition is stagnant within the observation period. No rainfall and water level data were retrieved from repo.pscigrid.gov.ph.

D. Andanan Bridge Stage Discharge Computation

River velocity data for Andanan Bridge was plotted against water level data from an Automatic Water Level Sensor (AWLS) and rainfall from repo.pscigrid.gov.ph. Flow measurements were recorded for one (1) day October 15, 2013 for two (2) hours observation. The summary of data gathered is illustrated in Figure 48-51.

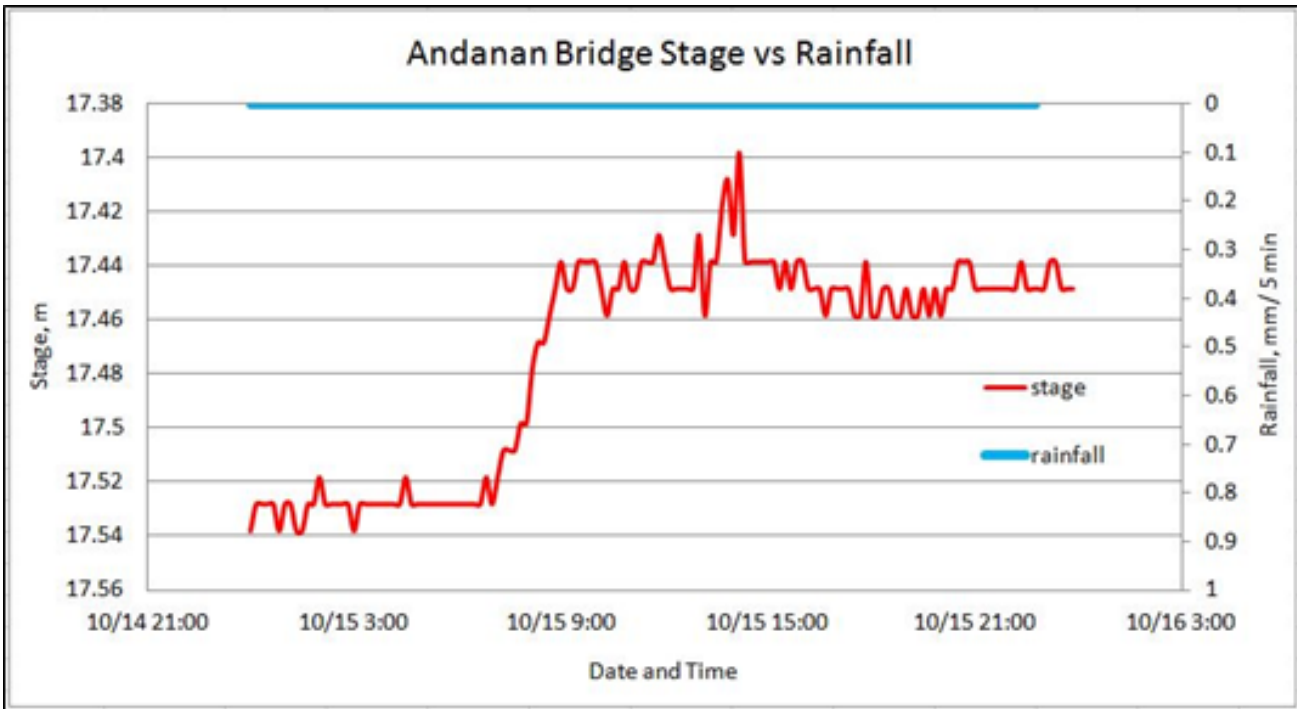


Figure 48. Stage vs Rainfall graph for Adanan Bridge

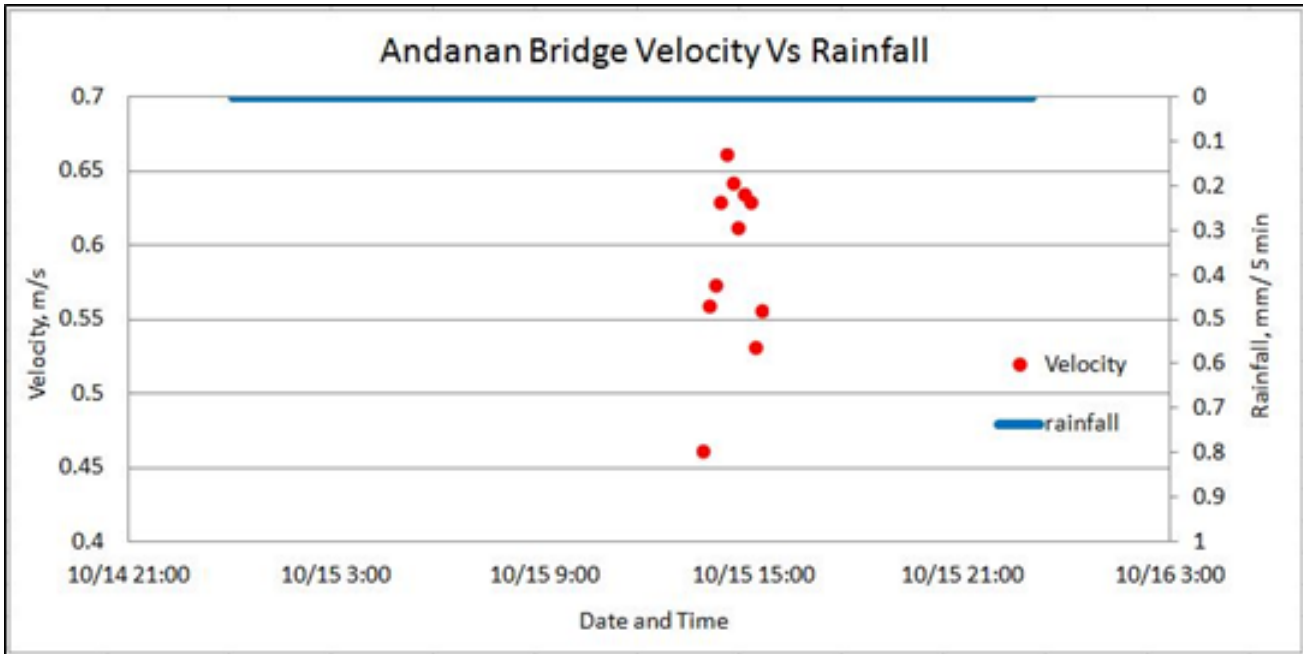


Figure 49. Velocity vs Rainfall graph for Adanan Bridge

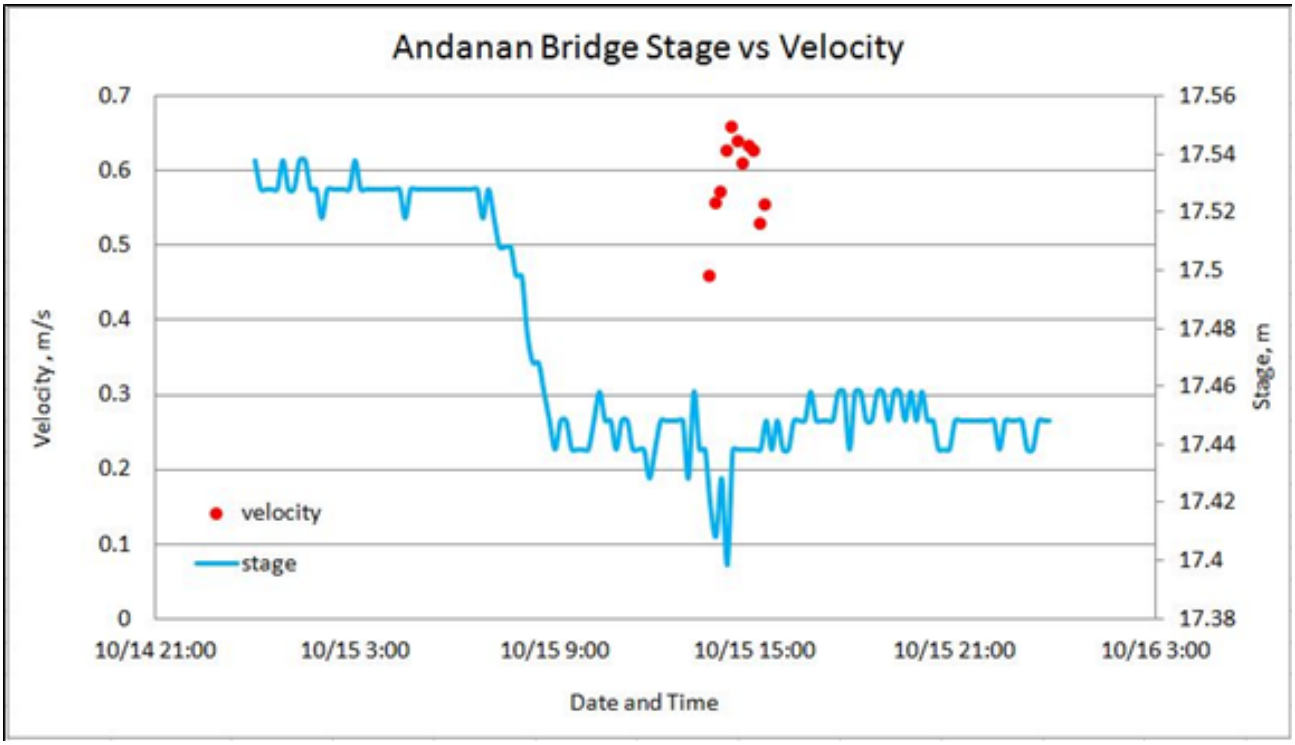


Figure 50. Stage vs Velocity graph for Adanan Bridge

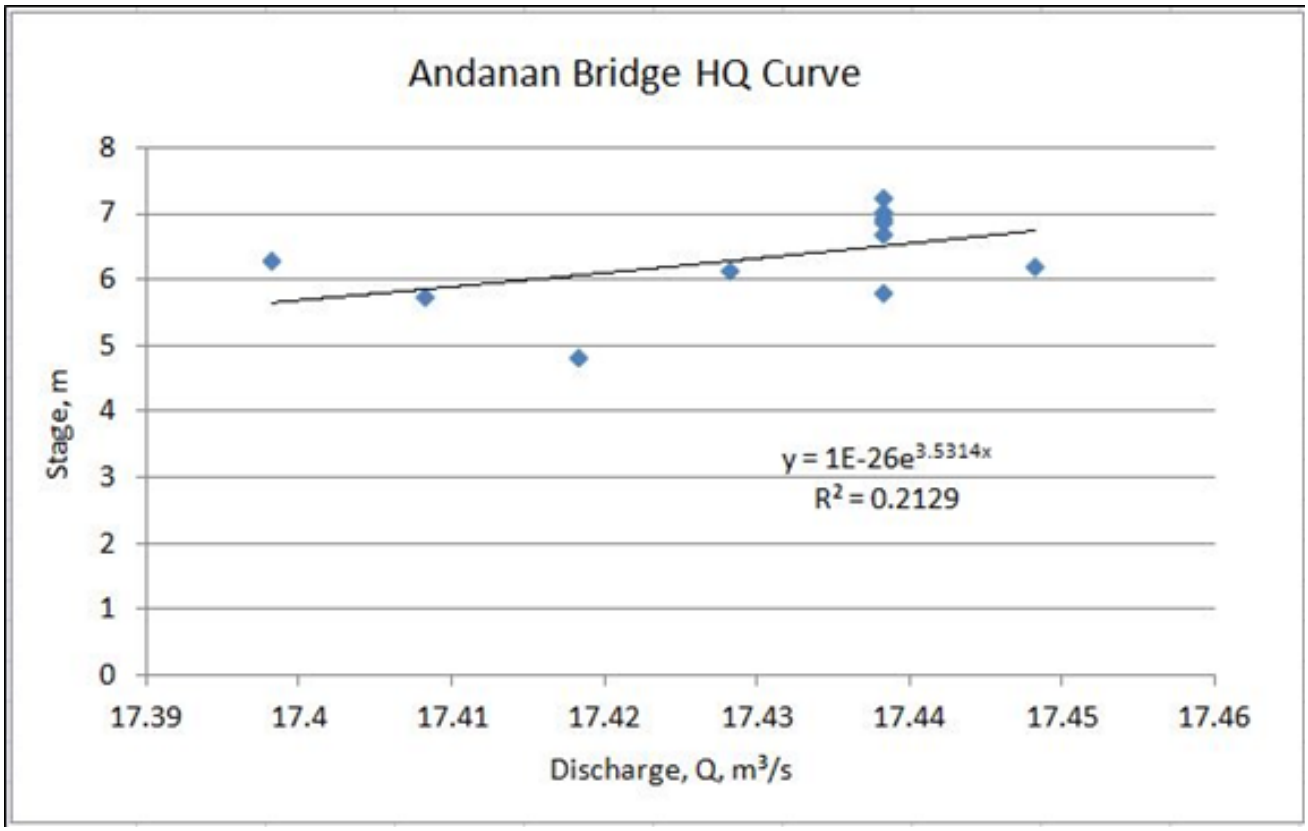


Figure 51. Adanan Bridge HQ Curve

E. Esperanza Bridge Stage Discharge Computation

No data of rainfall and water level from repo.pscigrid.gov.ph at Esperanza Bridge within the observation period. The summary of data gathered is illustrated in Figure 52.

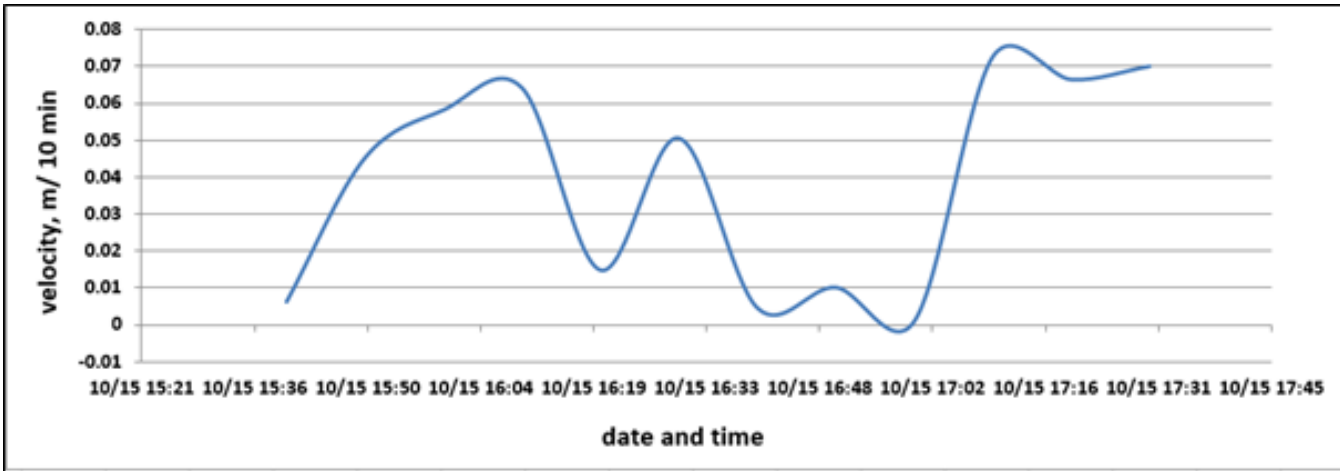


Figure 52. Water velocity of Esperanza Bridge within the observation period.

Annexes

Annexes

ANNEX A. PROBLEMS ENCOUNTERED AND RESOLUTIONS APPLIED

Problems	Solution
Generally, portions of the Agusan River made it difficult to conduct bathymetry survey in Butuan Bay	Extra caution has to be made to prevent the outboard motor and the transducer of the Echosounder from hitting the water lily, wood lumber and the river bed
Difficulties in measuring water velocity at DRMM and NIA Pumping Station because there is no bridge or other structure to set up the mechanical flow meter	Flow measurement was done in the upstream at Butuan Bridge which is 300m from DRMM River Base Leon Kilat
No AWLS was located at Hupas Bridge	Through the help of DOST AWLS was located at Wawa bridge
November 12-14, 2013: Agusan River swelled due to continuos rainfall brought by typhoon Zoraida	Re-deploy the sensor on shallow part of the river making sure that the sensor are still submerged under water
November 16, 2013: Swelling of the River subsided	Re-deploy the sensor on the deeper part of the river making sure that the sensor are still submerged under water

Figure 53. Problems encountered during bathymetric surveys

Annexes

ANNEX B. LIST OF EQUIPMENT AND INSTRUMENTS

Type	Brand	Serial Number	Owner	Quantity
GNSS Receiver (Base)	Trimble™ SPS852		UP-TCAGP	One (1) unit
GNSS Receiver (Rover)	Trimble™ SPS882		UP-TCAGP	Four (4) units
GNSS Controller	Trimble™ TSC3		UP-TCAGP	Four (4) units
Single beam Echo sounder	Hi-Target		UP-TCAGP	One (1) unit with accessories
Acoustic Doppler Current Profiler (ADCP Vertical)	Sontek™		UP- TCAGP	One (1) unit with accessories
Acoustic Doppler Current Profiler (ADCP Side looking)	Sontek™		UP- TCAGP	One (1) unit with accessories
Tripod	Trimble™		UP-TCAGP	One (1) units
Bipod	Trimble™		UP-TCAGP	Four (4) units
Range Pole	Trimble™		UP-TCAGP	Four (4) units
Tribrack			UP-TCAGP	Three (3) units
Laser Range Finder	Bushnell		UP-TCAGP	One (1) unit
Handheld GNSS	Garmin Oregon 650 Montana™		UP-TCAGP	Four (4) units
Laptops	Dell Latitude E6430		UP-TCAGP	Two (2) units
Laptops	Dell™ Latitude E6420		UP-TCAGP	One (1) unit
Rain Gauge	Hobo	F494	UP-TCAGP	One (1) unit
Depth gauge	Hobo		UP-TCAGP	Two (2) units
Coupler-2B			UP-TCAGP	One (1) unit
Flow Meter (rotor typer)			UP-TCAGP	Two (2) units
Trimble bag				
Toolbox			UP-TCAGP	One (1) unit
Battery chargers				

Annexes

ANNEX C. THE SURVEY TEAM

Data Validation Component Sub-Team	Designation	Name	Agency/Affiliation
Bathymetric Survey, Profile Reconnaissance and 1st Sensor Deployment Team	Senior Science Research Specialist (SSRS)	Engr. Dexter Lozano	UP TCAGP
	Research Associate	Mr. Jojo Morillo	UP TCAGP
	Senior Science Research Specialist (SSRS)	Engr. Bernard Paul Maramot	UP TCAGP
	Research Associate	Ms. Jeline Amante	UP TCAGP
AWLS Cross-section, 2nd Sensor Deployment and Flow Measurements	Senior Science Research Specialist (SSRS)	Engr. Dexter Lozano	UP TCAGP
	Research Associate	Engr. JMson Calalang	UP TCAGP
	Research Associate	Engr. Kristine Ailene Borromeo	UP TCAGP
	Research Associate	Regine Anne G. Faelga	UP TCAGP
3rd Sensor Deployment	Research Associate	Ms. Jeline Amante	UP TCAGP
	Research Associate	Engr. Mark Lester Rojas	UP TCAGP

Annexes

ANNEX D. NAMRIA CERTIFICATION

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

June 11, 2013

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: **AGUSAN DEL NORTE**
Station Name: **AGN-204**
Order: **2nd**

Island: **MINDANAO**
Municipality: **BUTUAN CITY (CAPITAL)**
Barangay: **TALIGAMAN**

PRS92 Coordinates

Latitude: **8° 56' 19.64993"** Longitude: **125° 37' 47.98982"** Ellipsoidal Hgt: **27.80400 m.**

WGS84 Coordinates

Latitude: **8° 56' 16.03323"** Longitude: **125° 37' 53.34384"** Ellipsoidal Hgt: **96.87400 m.**

PTM Coordinates

Northing: **988428.048 m.** Easting: **569283.505 m.** Zone: **5**

UTM Coordinates

Northing: **989,054.86** Easting: **789,222.64** Zone: **51**

Location Description

AGN-204
From Ampayon junction, travel 4 km E along the national road to Davao. The station is located on the concrete corner fence of Taligaman Elementary School, about 15 m away from the centerline of the road and 38.78 m west from the main gate. Mark is the head of a 3" copper nail flushed in a cement block embedded on the ground with inscriptions "AGN-204 2007 NAMRIA".

Requesting Party: **UP-TCAGP DREAM**
Pupose: **Reference**
OR Number: **3943775B**
T.N.: **2013-0558**

RUEL DM. BELEN, MNSA
Director, Mapping and Geodesy Department

9906112013150256

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

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

Annexes

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

April 05, 2013

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: **AGUSAN DEL NORTE**
Station Name: **AN-54**

Island: **Mindanao**	Municipality: **BUTUAN CITY (CAPITAL)**	Barangay: **ANTONGALON**
Elevation: **20.5662 m.**	Order: **1st Order**	Datum: **Mean Sea Level**

Location Description

ACCESS: "AN-54" is in Barangay Antongalon, Butuan City, Agusan Del Norte. Station is located 10 cm. south of the kilometer post KM. 1235 north of Iglesia Ni Kristo.

STATION MARK: Mark is the head of 4" copper nail embedded in 0.30x0.30x1.0 m. concrete monument with the inscription "AN-54 2007 NAMRIA".

Requesting Party: **UP-TCAGP**
Pupose: **Reference**
OR Number: **3943485 B**
T.N.: **2013-0269**

RUEL DM. BELEN, MNSA
Director, Mapping and Geodesy Department

9904052013155229

CIP/4701/12/09/814

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

Annexes

ANNEX E. RECONNAISSANCE SUMMARY

Reconnaissance of Cross-Section in Agusan River				
Remarks	Left	Cross-Section	Right	Remarks
Passable - private property with rough road.		1		Passable - grass and rice field
Passable - rough road.		2		Passable - rice field.
Passable, Start-End have a rice field and rough road.		3		Passable - Start/End pathway grass field.

Passable - Start have a private property, End Rice field		4		Passable - Start pathway grass field
Passable - Start rice field-private property open area, End rough road		5		Passable - Start pathway, End coconut trees with portion of grass field.
Start, have a private property, End rough road.		6		Passable - Start/End pathway.
Passable -rough road area.		7		Passable - Start/End pathway coconut trees.

Annexes

Passable – this cross-section have a pathway with grass field.		8		Passable - Start/End have a pathway.
Passable – have a rough road. Or pathway.		9		Passable – this cross-section have a grass field coconut tree.
Passable – have a rough road		10		Passable - pathway with private property.
Passable - Start, trees		11		Passable - Start many trees and grass field, End grass field.

Annexes

Passable -Ipil-Ipil tree and bamboo tree with pathway.		12		Passable –with rough road in the private property.
Passable - we have a small part of forest		13		Passable - pathway-rough road
Passable - Start, have a road End, street road		14		Passable – this cross-section have a portion of coconut plant.
Passable -private property		15		Passable - Start pathway, End rice field half rough road.

Annexes

Passable - have a road and open area.		16		Passable – have a pathway with concrete road.
Passable – have a private property inside.		17		Passable –have a pathway.
Passable - Start path way, End concrete road.		18		Passable – have a rough road.

Annexes

Passable - Start, private property		19		Passable - Start, rough road, End residence private property
Passable - Start have a residence, End grass field		20		Passable - Start grass field, End private property.
Passable - Start grass field, End private property		21		Passable - Start residence and have rough road, End
Passable - Start, have a residence, End concrete road		22		Passable - Start/End tall grass field.

Annexes

Passable - Start open area, End pathway		23		Passable - Start/End tall grass field.
Passable - Start century tree, End grass field-residence.		24		Passable - End half portion rough road and grass field.
Passable - Start,		25		Passable - Start path-way, End rough road

Annexes

Passable - Start concrete road and tree		26		Passable - Start tall grass field, End rough road
Start, open area-grass field		27		Passable - Start/End rough road.
Passable - Start, grass filed, End rough road		28		Passable - Start/End rice field and grass land.
Passable - Start, Nipa tree End rough road		29		Passable - Start nipa tree, End grass field.

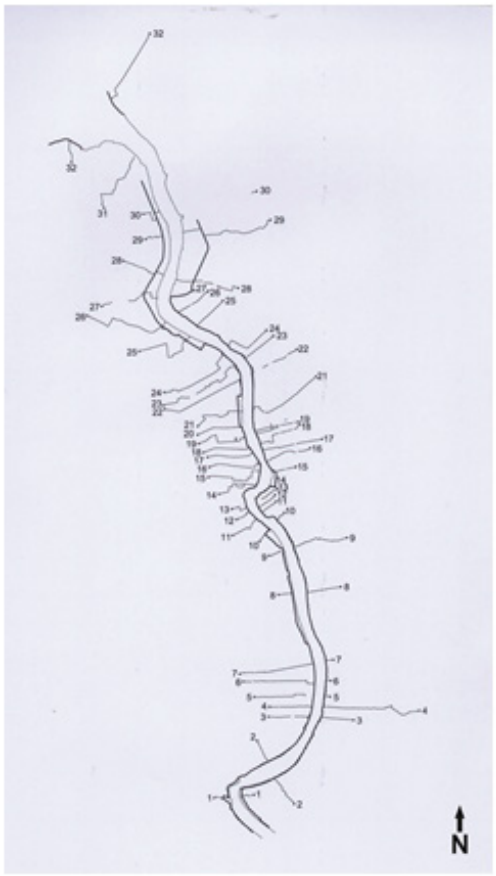
Annexes

Passable/Minor adjustment for pathway, Start/End rough road.		30		Passable - Start/End have a pathway and grass land.
Passable - Start/End nipa tree		31		Not Passable - Start/End nipa tree in the island.
Passable - Start, private property but have a existing pathway.		32		Passable - Start/End rough road

Annexes

ANNEX F. OUTSOURCE CROSS-SECTION AND PROFILE

PROFILE AND CROSS SECTION, SURVEYS IN AGUSAN RIVER, BUTUAN CITY



Prepared by:

LN Realty and Surveying Services
Ram City Homes cor. Employees Village Road,
Libertad, Butuan City

Survey Period: May 24, 2013 – June 07, 2013

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Introduction

Annexes

1.1 Background

1.1.1 LN Realty and Surveying Services is a contracting agency from Butuan City, Agusan del Norte that is engage in Real Estate Sales and Surveying Services since year 2000 to fulfill the flourishing demand in Land Surveying in the region and in the entire Philippines. It has completed various projects from different government agencies such as National Irrigation Administration (NIA), Department of Agrarian Reform (DAR), National Housing Authority (NHA), and Department of Environment and Natural Resources (DENR) Region XIII, Region VI and Region VIII.

1.1.2 1.1.2 In the later part of 2012, the UP-Training Center for Applied Geodesy and Photogrammetry (UP-TCAGP) conducted a public bidding for Profile and Cross-Section Surveys of the different river basins in the Philippines. Data gathered from these field works will be used by UP-TCAGP in their research program entitled "Nationwide Disaster Risk Exposure and Assessment for Mitigation (DREAM).

1.1.3 1.1.3 LN Realty and Surveying services is tasked to conduct Profile and Cross-section survey in Agusan River, the third largest river basin of the Philippines that has a total drainage area of 10,921 km2 and an estimated length of 350 kilometers from its origin. It is located in the eastern part of Mindanao Island, draining majority of the Caraga Region and some parts of Compostela Valley province. Agusan river valley measures 177 kilometers from south to north and varies from 32-48 kilometers in width. It finally drains into the Butuan Bay at its mouth in Butuan City. The Agusan river basin is divided into three sub-basins on the basis of topographic features: upper Agusan River basin, middle Agusan River basin and lower Agusan River basin. The upper Agusan river basin is the section from its headwaters in the mountains of Compostela Valley province to Santa Josefa, Agusan del Sur to Veruela, Agusan del Sur, the middle Agusan River basin is the section of the river from Sta. Josefa to Amparo, Agusan del Sur while the lower Agusan River basin is from Amparo to its mouth at Butuan City, Agusan del Norte.

1.2 Scope of Work

The scope of work includes the execution of the following activities:

1.2.1 Scope 1: Reconnaissance for Profile and Cross-Section Surveys

1.2.2 Scope 2: Recovery of NAMRIA Control Points and Observation of Established Control Points

1.2.3 Scope 3: Profile Survey of River. Survey of the approximately 19-km longitudinal profile along the banks of Agusan River from Barangay Aupagan downstream to The Municipality of Magallanes for the right bank and Barangay Amparo downstream to Barangay Lumbocan for the left bank.

1.2.4 Scope 4: Cross-section Survey. GPS survey on the 32 cross-sectional lines along Agusan River which has an approximate total length of 62.34 km.

1.2.5 Scope 5: Data Processing. It includes processing and adjustments of GNSS data and computations, corrections and plotting of surveyed cross-section and profile survey.

1.3. Professional Staffing and Implementation

The team tasked to carry out the survey is composed of survey personnel of LN Realty and Surveying Services. A licensed Geodetic Engineer acted as the project component leader. Another geodetic engineer acted as the project chief who supervises the entire survey. Five more members were assigned to conduct cross-section and profile surveys.

Prior to the actual fieldwork, the survey team conducted a reconnaissance in the area. As for the profile survey, the reconnaissance was conducted on the 21st and 22nd day of April 2013, and the actual profile survey was from April 23 to May 16, 2013. As for the cross-section survey, the cross-section data given by the UP-TCAGP was reconned on the ground from May 08-18, 2013. The actual field surveys were done for fifteen (15) days from May 24 to June 07, 2013.

Field Survey Methodology

Annexes

For the survey project to be accomplished, a step-by-step guide was followed.

2.1 Field Plan

Before the actual field survey, a field plan was prepared by the team. This field plan served as a guide in the implementation of the survey project.

2.2 Reconnaissance

The team conducted a reconnaissance for the cross-section and profile survey. The proposed cross-section and profile data of Agusan River provided by UP-TCAGP were inspected on the ground. It was done so to plan ahead on what to do in the actual field implementation. Also, available reference stations were located for it to be used in the cross-section and profile survey.

2.3 Recovery of NAMRIA Control Points and Observations of Established Control Points

NAMRIA established horizontal and vertical ground control points were recovered. Reconnaissance for the new control points to be established near the project site is also done. The NAMRIA recovered ground control points will be used as reference points in the GPS observation of the newly established control points. Also, certifications of the recovered ground control points were sought at the NAMRIA head office.

2.4 Profile Survey

The survey team then proceeded to conduct the profile survey along Agusan River. The left and right banks were measured separately.

The profile team is composed of five persons: one member stays and observes on the base station while the other four members form two profile teams with two members each team. In every team, one person holds the antenna while the other holds the GPS receiver that receives the GPS signal and correction radio signals for RTK surveying. Each team is deployed on each side of the river bank using a pump boat. For the left bank, the profile started upstream at Barangay Amparo and ended downstream at Barangay Lumbocan and for the right bank, it is from Barangay Aupagan down to Municipality of Magallanes. A distance of 10 meters is observed between successive profile points. Profiles of the Upper Left Bank, Upper Right Bank, Lower Left Bank and Lower Right Bank were gathered during the survey.

Figure 54. Profile team riding a pump boat during the profile survey of Agusan River

Figure 55. Profile team conducting a profile survey of Agusan River

2.5 Cross-Section Survey

Another set of ground survey was conducted along Agusan River. Cross-sections were surveyed perpendicular to the riverbanks of Agusan River. Just like in profile surveys, the cross-section survey also has two cross-section teams and one person mans the base station. Cross-section point interval is 10 meters.

The antenna used by every cross-section team was connected to a pole so that the reception to radio signals emitted by the RTK base station will be great. In areas, were the proposed cross section line cannot be followed due to some obstructions, alternate route was followed such as finding an alternate path that runs parallel to such cross section line.

Figure 56. Cross-section team conducting a profile survey of Agusan River

Figure 57. Cross-section team conducting a profile survey of Agusan River

2.6 Data Processing

2.6.1 Cross-Section Data

Another set of ground survey was conducted along Agusan River. Cross-sections were surveyed perpendicular to the riverbanks of Agusan River. Just like in profile surveys, the cross-section survey also has two cross-section teams and one person mans the base station. Cross-section point interval is 10 meters.

Processing of the cross-section data are as follows:

1. At the end of every field survey, data gathered from GPS receivers were downloaded and pre-processed. The GPS receiver is set first to download from its library.
2. The data from the library is then downloaded to the computer thru a copy paste process.
3. That .lib files are converted to comma delimited (.csv) file format with the following columns: Pt_Name, Longitude, Ellipsoidal Height, Northing, Easting and Elevation.
4. The data is then plotted to AutoCad.

2.6.2 Profile Data

Processing of profile data is the same as that of in processing of the cross-section data.

Results

Annexes

3.1 Actual Survey

The actual field works lasted for 15 days from May 24 to June 17, 2013. The figures below shows the actual result of the profile and cross-section survey of Agusan River.

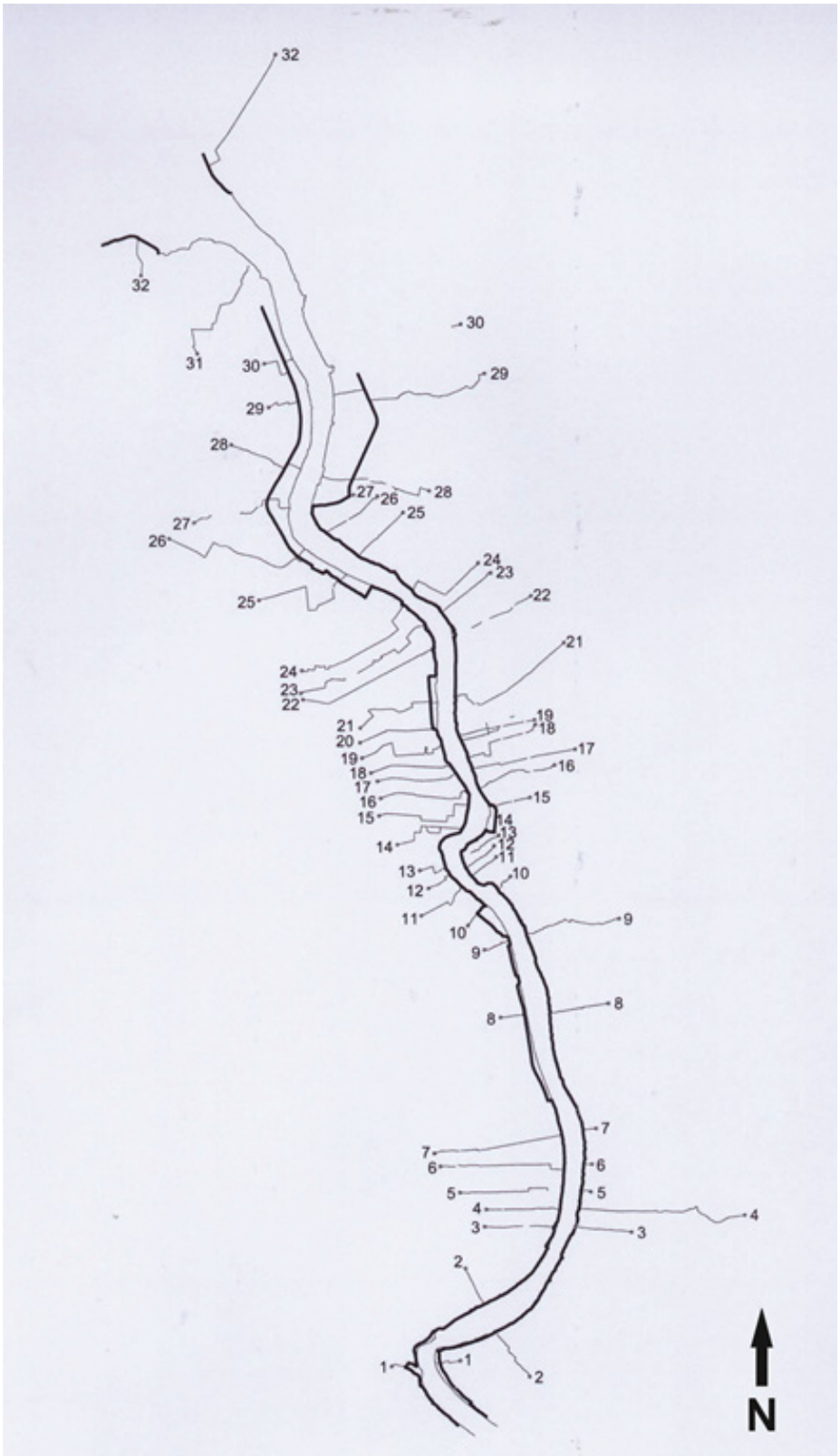

Figure 58. Actual Upper Bank Profile of Agusan River

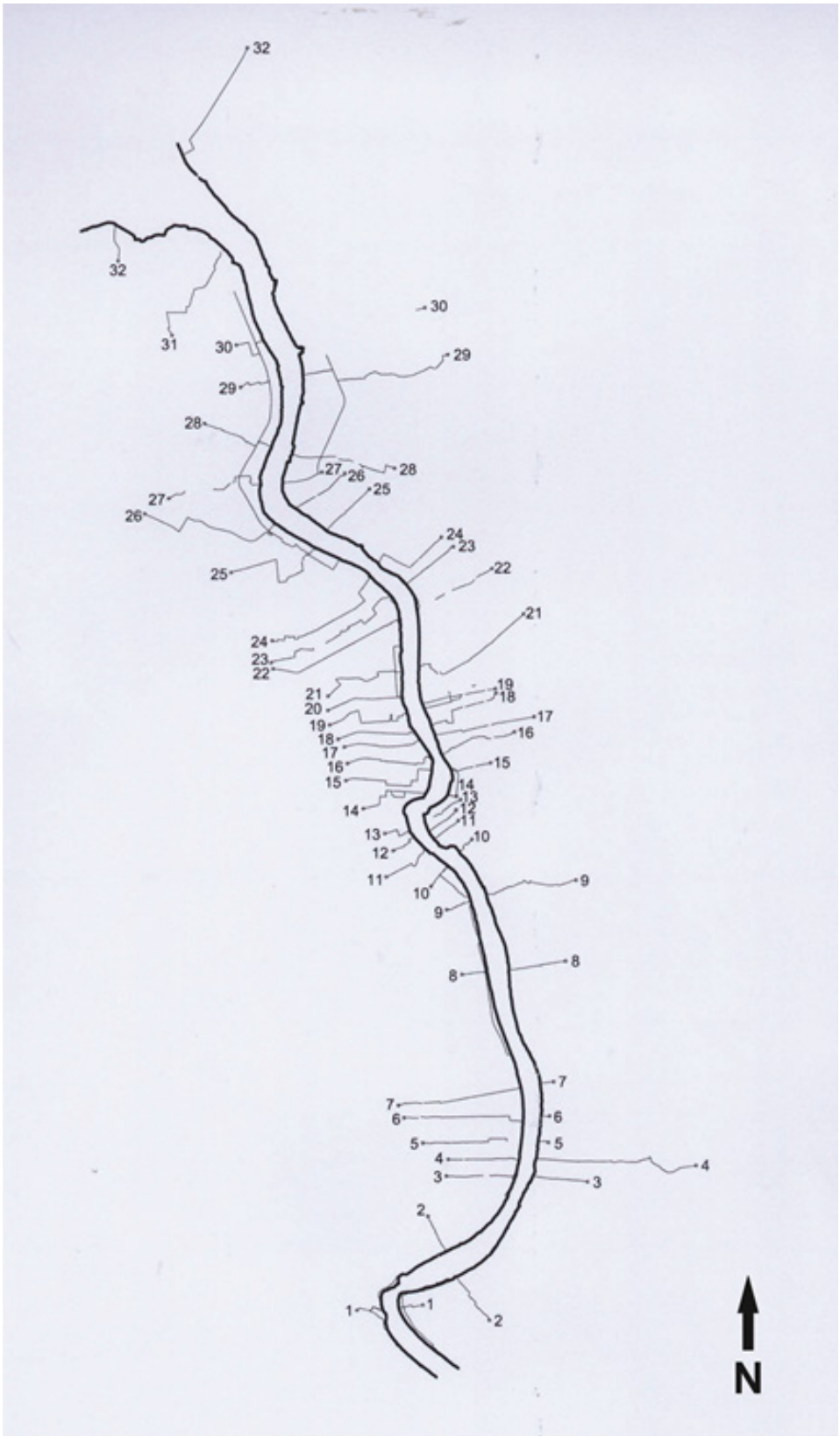

Figure 59. Actual Lower Bank Profile of Agusan River

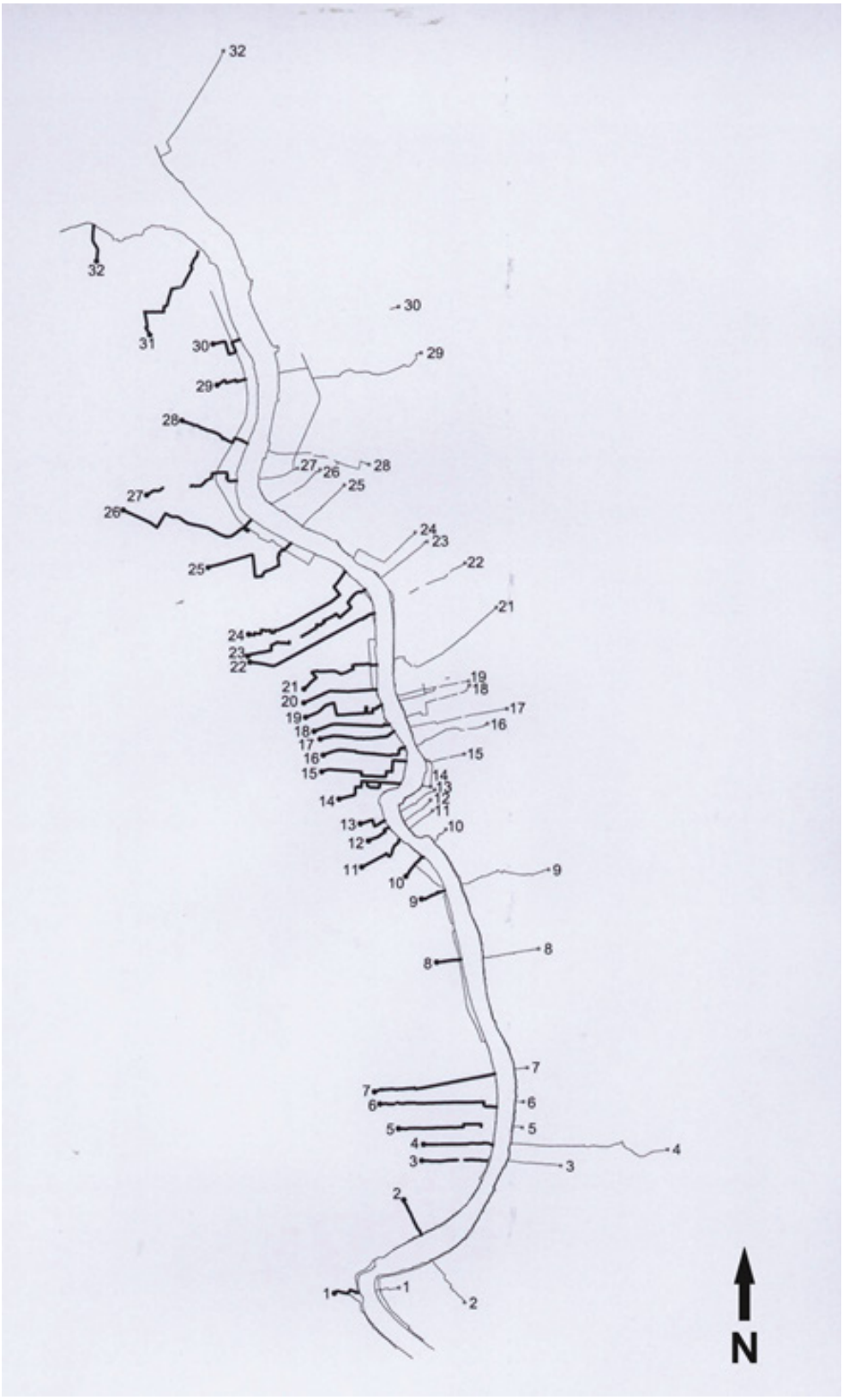

Figure 60. Actual Left Cross-Section of Agusan River

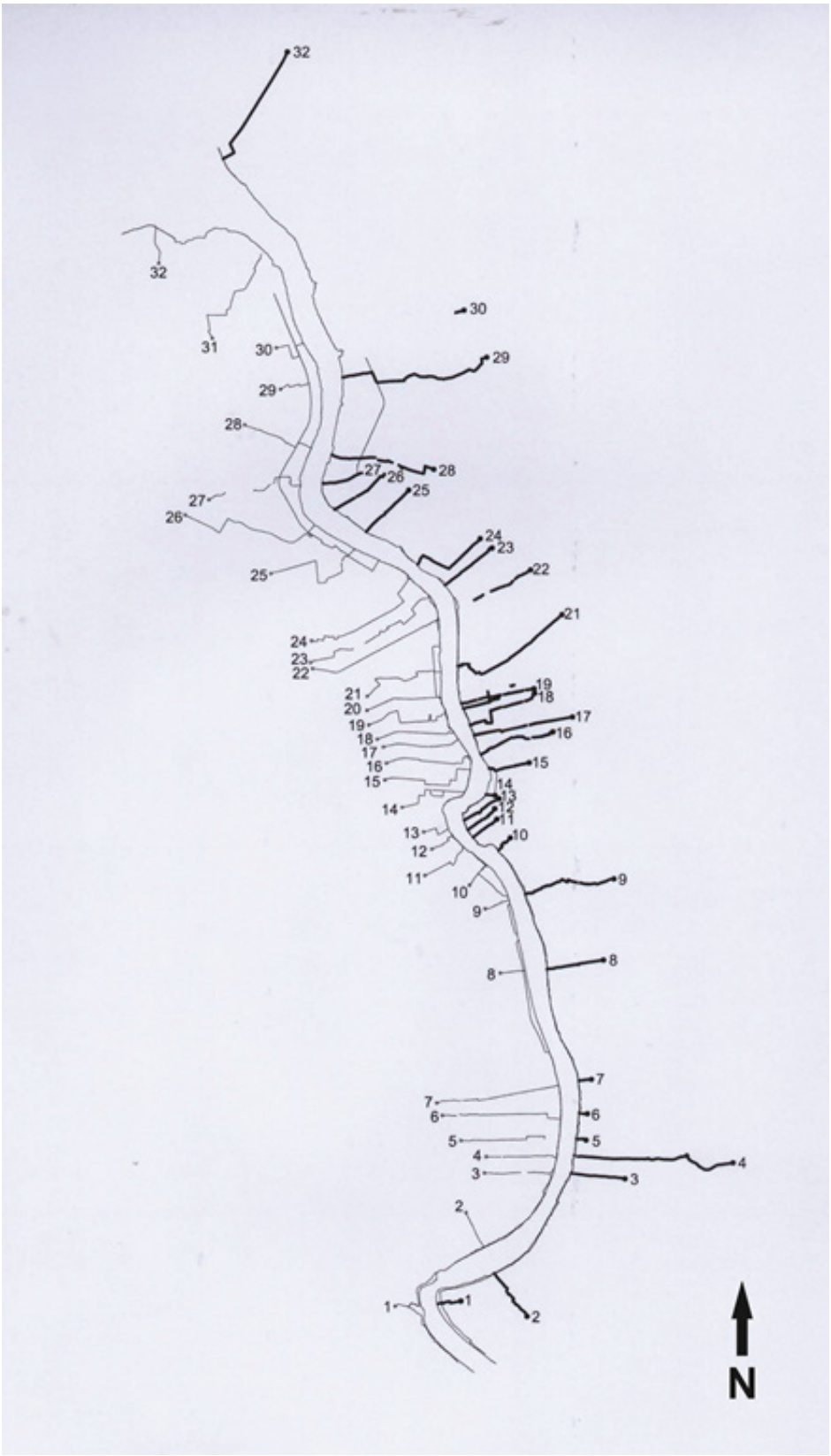

Figure 61. Actual Right Cross-Section of Agusan River

Annexes

Annexes

ANNEX A. PROBLEMS ENCOUNTERED AND SOLUTIONS APPLIED

The table below shows the problems encountered during the actual fieldwork and solutions undertaken by the survey team.

		LIMITATIONS/PROBLEMS	SOLUTIONS
1.	April 27	proposed profile line is beside a saw mill and lots of logs float in the river	the team walks on top of the floating logs.
2.	May 19	some points of XSL11 run through a residence	followed an alternate path tat ran parallel to XSL11.
3.	May 19	from the river approximately 180 meters of XSL05 was not observed because the saw mill won't allow team to enter the property	continue to next cross-section
4.	May 20	some points of XSL03 is in the swampy area	continue to next cross-section
5.	May 23	points that is about 380 meters from the river bank of XSR19 is in the swampy area	followed an alternate path parallel to XSR19
6.	May 23	also portion of XSR19 is in the rice field where there are newly planted seedlings were not accessed because the owner did not allow access	continue to next cross-section
7.	May 23	some points of XSR22 are in private properties and ricefield owner's won't allow access to their land	continue to next cross-section
8.	May 25	some points in the proposed XSL23 lines runs along houses and private properties	followed an alternate path that ran parallel to XSL23.
9.	May 25	also portion of XSL23 is in a polluted canal	continue to next cross-section
10.	May 26	some points in XSL27 run are in a protected nipa area, swampy and waist deep mud	continue to next cross-section
11.	May 26	end portion of XSL29 is in a swampy area	continue to next cross-section
12.	May 27	some points in XSL25 lines runs along a building and private properties	followed an alternate path that ran parallel to XSL25.
13.	May 29	XSR30 and XSR31 was not observed because of high water level	survey not pursued for it is not safe for the survey team

Figure 62. Cross-Section 30 and 31

Figure 63. Cross-Section line points that runs along private properties

Figure 64. Taken during the profile survey near a saw mill

Annexes

ANNEX B. THE SURVEY TEAM

Cross-Section and Profile Survey Team Members	Designation	Name	Agency/Affiliation
Survey Coordinator		ENGR. JHONNYLO P. ATABAY	LN Realty and Surveying Services
Cross-Section and Profile Team	Research Associate	BERNARD M. ALFARO	LN Realty and Surveying Services
	Research Associate	MEDARDO M. BONOTAN JR.	LN Realty and Surveying Services
	Research Associate	ROMEO A. DULFO JR.	LN Realty and Surveying Services
	Research Associate	JULIUS D. MATIAS JR.	LN Realty and Surveying Services
	Research Associate	YDJEL D. LOZANO	LN Realty and Surveying Services

Annexes

ANNEX C. SUMMARY OF ACTIVITIES

DAY	ACTIVITY	LOCATION	PERSONS INVOLVED/ PARTICIPATED
22-Apr-13	Reconnaissance on the area Recovery of NAMRIA Control Points and reference points	Butuan City	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
23-Apr-13	Reconnaissance on the area Recovery of NAMRIA Control Points and reference points	Butuan City	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
24-Apr-13	Continue Profile Survey Data Downloading and Processing Recovery of NAMRIA Control Points	Brgy. Amparo Brgy. Aupagan	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
25-Apr-13	Continue Profile Survey Data Downloading and Processing	Brgy. Amparo Brgy. Aupagan	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
26-Apr-13	Continue Profile Survey Data Downloading and Processing	Brgy. Bit-os Brgy. Aupagan	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
27-Apr-13	Continue Profile Survey Data Downloading and Processing	Brgy. San Vicente Brgy. Tagabaca	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
28-Apr-13	Continue Profile Survey Data Downloading and Processing	Brgy. Bingkilan Brgy. Tagabaca	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
29-Apr-13	Continue Profile Survey Data Downloading and Processing	Brgy. Maon Brgy. Tagabaca	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano

30-Apr-13	Continue Profile Survey Data Downloading and Processing	Brgy. Golden Ribbon Brgy. Mahay	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
1-May-13	Continue Profile Survey Data Downloading and Processing	Brgy. Agao Brgy. Mahay	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
2-May-13	Continue Profile Survey Data Downloading and Processing	Brgy. Datu Silongan Brgy. Mahay	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
3-May-13	Continue Profile Survey Data Downloading and Processing	Brgy. Rajah Humabon Brgy. Buhangin	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
4-May-13	Continue Profile Survey Data Downloading and Processing	Brgy. Urduja Brgy. Buhangin	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
5-May-13	Continue Profile Survey Data Downloading and Processing	Brgy. Leon Kilat Brgy. Buhangin	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
6-May-13	Continue Profile Survey Data Downloading and Processing	Brgy. Prot Poyohon Brgy. Baan Riverside	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
7-May-13	Continue Profile Survey Data Downloading and Processing	Brgy. Obrero Brgy. Baan Riverside	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
8-May-13	Continue Profile Survey Data Downloading and Processing	Brgy. Obrero Brgy. Mahogany	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano

9-May-13	Continue Profile Survey Data Downloading and Processing	Brgu. Bading Brgy. Mahogany	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
10-May-13	Continue Profile Survey Data Downloading and Processing	Brgy. Bading Brgy. Banza	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
11-May-13	Continue Profile Survey Data Downloading and Processing	Brgy. Agusan Pequeno Brgy. Banza	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
12-May-13	Continue Profile Survey Data Downloading and Processing	Brgy. Agusan Pequeno Brgy. Maug	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
13-May-13	Continue Profile Survey Data Downloading and Processing	Brgy. Pagatpatan Brgy. Maug	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
14-May-13	Continue Profile Survey Data Downloading and Processing	Brgy. Pagatpatan Mun. of Magallanes	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
15-May-13	Continue Profile Survey Data Downloading and Processing Courtesy Call to City Mayor Office	Brgy. Lumbocan Mun. of Magallanes	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
16-May-13	Continue Profile Survey Data Downloading and Processing	Brgy. Lumbocan Mun. of Magallanes	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
17-May-13	Start and completed Cross-Section Survey XSL17, XSL18, XSL19, XSL20, XSL22 Data downloading and processing	Butuan City Proper	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr.

18-May-13	Continuation of cross-section survey Completed cross-section Survey on XSL15, XSL16, XSL21 Data downloading and processing	Butuan City Proper	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr.
19-May-13	Continuation of cross-section survey Completed cross-section survey on XSL05, XSL09, XSL10, XSL11, XSL12, XSL14 Data downloading and processing	Brgy. San Vicente Brgy. Golden Ribbon Brgy. Bingkilan Brgy. Maon Brgy Agao	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
20-May-13	Coordination to City Mayor of Butuan Continuation of cross-section survey Completed cross-section survey on XSL03, XSL06, XSL07, XSR08, XSR10, XSR13 Data downloading and processing	Butuan City Hall Brgy. San Vicente Brgy. Bit-os Brgy. Golden Ribbon Brgy. Maon	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
21-May-12	Continuation of cross-section survey Completed cross-section survey on XSL01, XSL02, XSL04, XSR01, XSR05, XSR06, XSR07 Data downloading and processing	Brgy. Bit-os Brgy. San Vicente Brgy. Aupagan Brgy. Tagabaca Brgy. Mahay	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
22-May-13	Continuation of cross-section survey Completed cross-section survey on XSR02, XSR03, XSR17, XSR20, XSR21 Data downloading and processing	Brgy. Aupagan Brgy. Baan Riverside Brgy. Mahogany Brgy. Banza	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr.
23-May-13	Continuation of cross-section survey Completed cross-section survey on XSR04, XSR13, XSR14, XSR15, XSR16, XSR18, XSR19, XSR23, XSR27 Data downloading and processing	Brgy. Tagabaca Brgy. Buhangin Brgy. Baan Riverside Brgy. Mahogany Brgy. Banza	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
24-May-13	Continuation of cross-section survey Completed cross-section survey on XSR04, XSR13, XSR14, XSR15, XSR16, XSR18, XSR19, XSR23, XSR27 Data downloading and processing	Brgy. Banza Brgy. Maug	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano

25-May-13	Continuation of cross-section survey Completed cross-section survey on XSR29, XSL23, XSL26 Data downloading and processing	Brgy. Banza Brgy. Maug	Julius D. Matias Jr. Bernard M. Alfaro Romeo A. Dulfo Jr.
26-May-13	Continuation of cross-section survey Completed cross-section survey on XSL27, XSL28, XSL29, XSL30 Data downloading and processing	Brgy. Bading Brgy. Lower Doongan Brgy. Babag Brgy. Agusan Pequeño	Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
27-May-13	Continuation of cross-section survey Completed cross-section survey on XSL09, XSL13, XSL24, XSL25, XSL27, XSL28 Data downloading and processing	Brgy. Bading Brgy. Golden Ribbon Brgy. Agusan Pequeño Brgy. Pagatpatan Brgy. Bingkilan Brgy. Lower Doongan Brgy. Babag	Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
28-May-13	Continuation of cross-section survey Completed cross-section survey on XSR09, XSR25, XSR28, XSL11, XSL32 Data downloading and processing	Brgy. Maug Brgy. Mahay Brgy. Buhangin	Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano
29-May-13	Continuation of cross-section survey Completed cross-section survey on XSR30, XSL31 Data downloading and processing	Mun. of Magallanes Brgy. Lumbocan	Medardo Bonotan Sr. Ydjel D. Lozano
3-Jun-13	Continuation of cross-section survey Completed cross-section survey on XSR32 Data downloading and processing	Mun. of Magallanes	Bernard M. Alfaro Romeo A. Dulfo Jr.

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