REGION 10

Tagoloan 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.

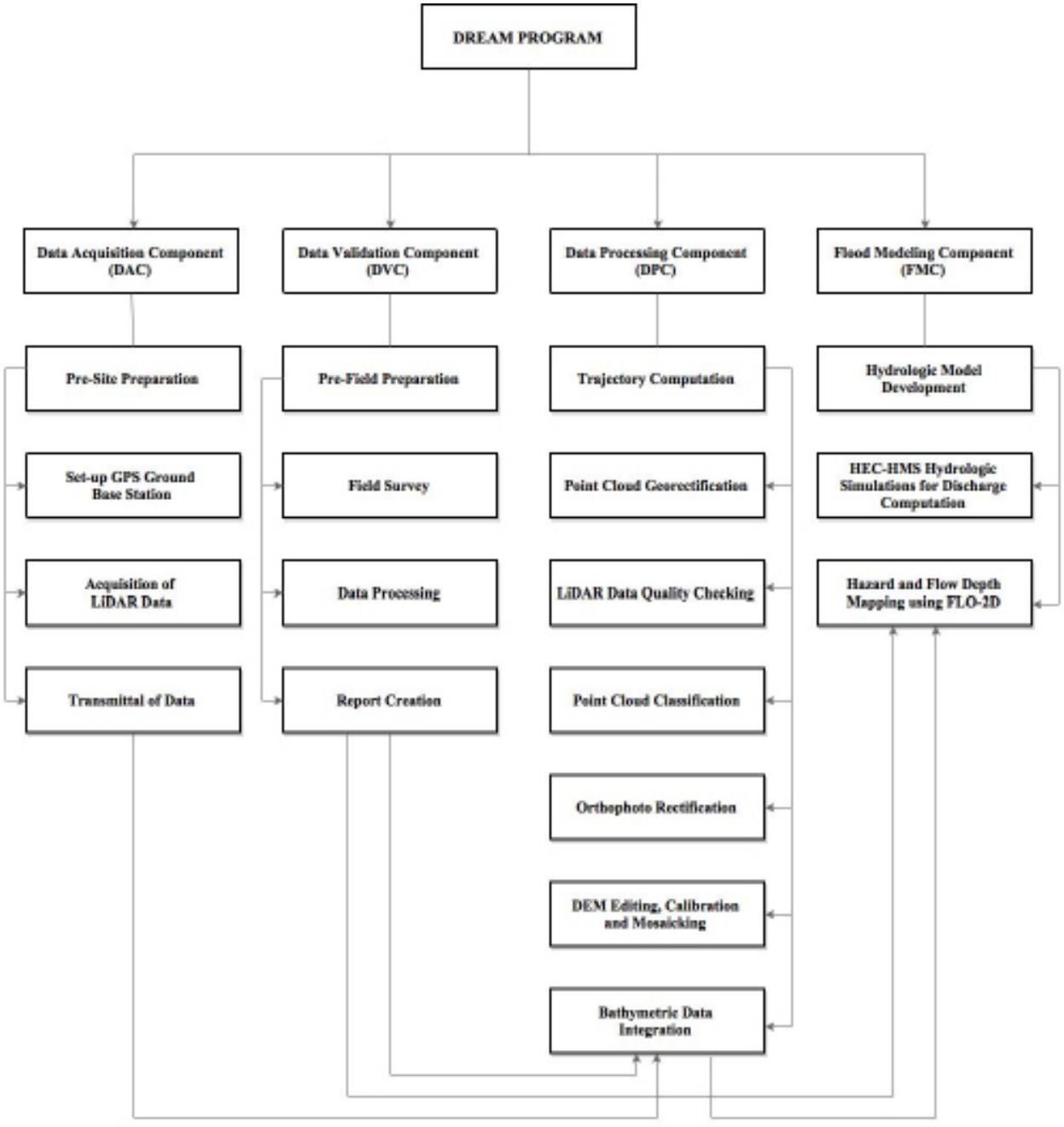


Figure 1. The General Methodological Framework of the Program

The Tagaloan River Basin

The Tagoloan River Basin

The area for the flood development in this study is the Tagoloan River Basin located in Misamis Oriental, north of Mindanao. The basin is as shown in Figure 2. The Tagoloan River Basin is considered as the 13th largest river system in the Philippines in terms of watershed size, as classified by the National Water Resources Board. It covers an area of 1,704 square kilometers and travels an approximate length of 106 kilometers. It traverses from as far as Malaybalay City, Bukidnon and flows outward through the province of Misamis Oriental. It opens westward and drains into Macajalar Bay. Large Scale Mining in the area has been threatening Tagoloan River. In 2013, a report, prepared by San Isidro College professor Fred Martinez, said that mud from chromite separator equipment used in large scale mining operations were flowing to the Dila Falls and then into Tagoloan River.

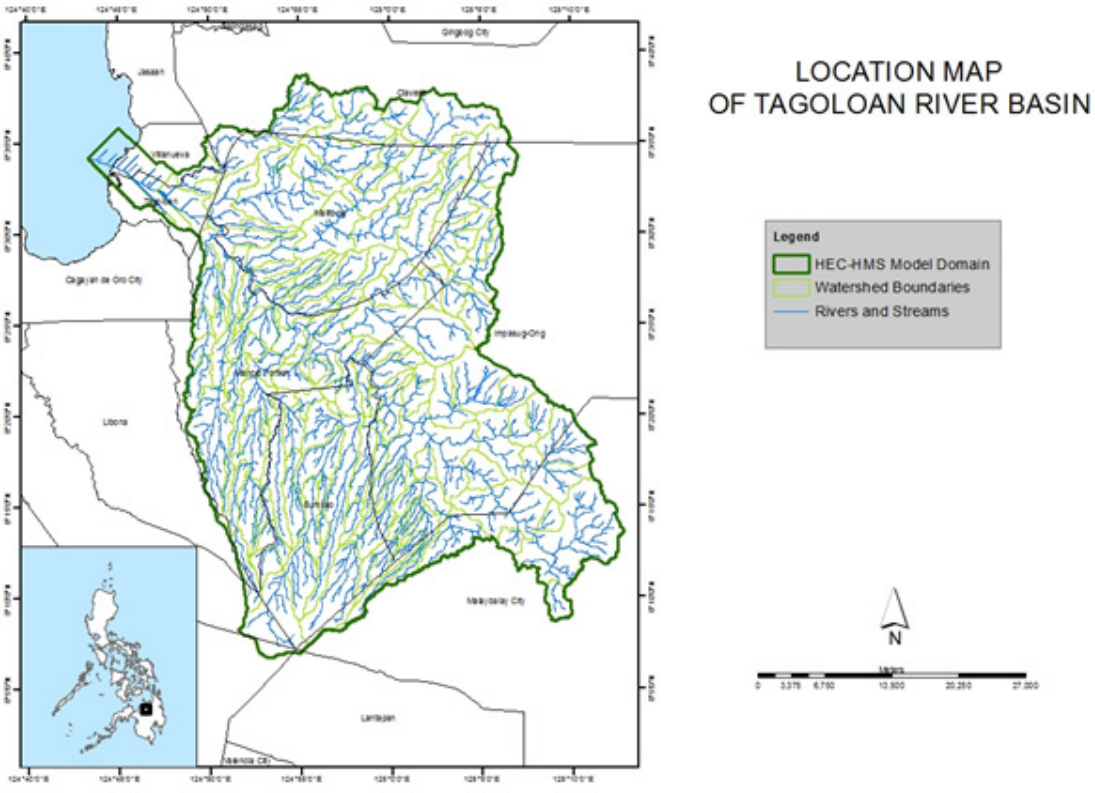


Figure 2. Davao River Basin Location Map

Some of the important parameters to be used in the characterization of the river basin (e.g. Manning's coefficient – a representation of the variable flow of water in different land covers) are the land cover and soil use. 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 land and soil cover of Tagoloan River Basin are as shown in Figure 2 and Figure 3.

The Tagoloan River Basin

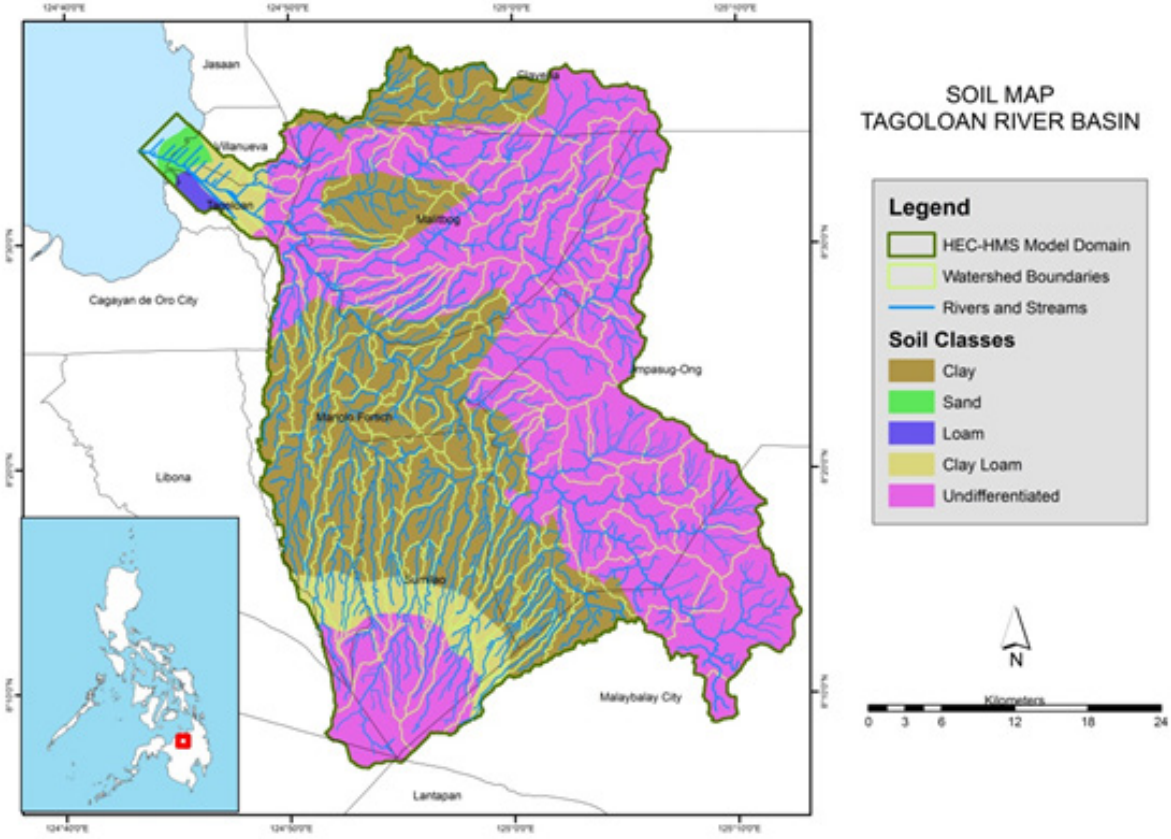


Figure 3. Tagoloan River Basin Soil Map

DVC Methodology

DVC Methodology

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

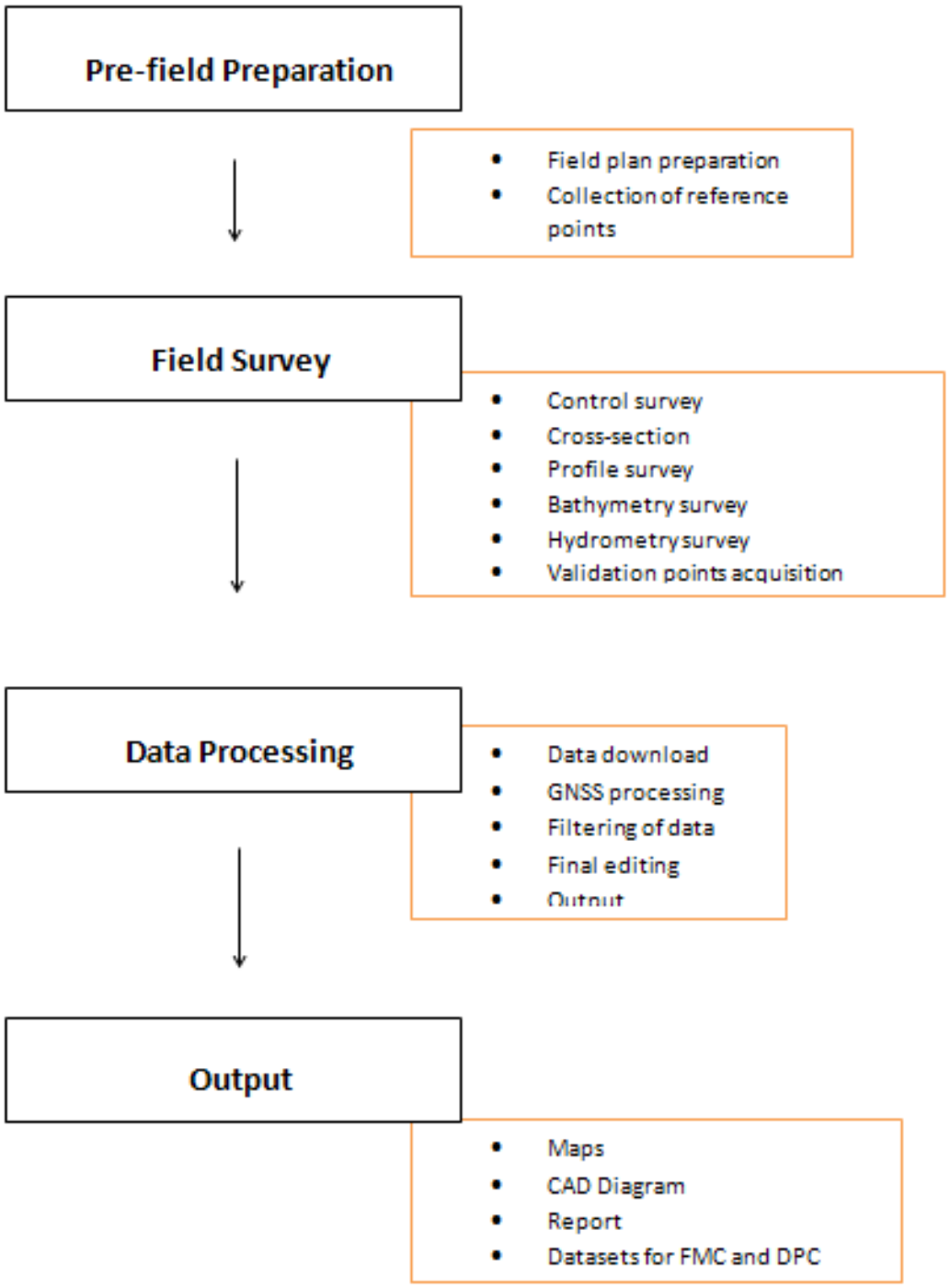


Figure 4. DVC Main Activities

DVC Methodology

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

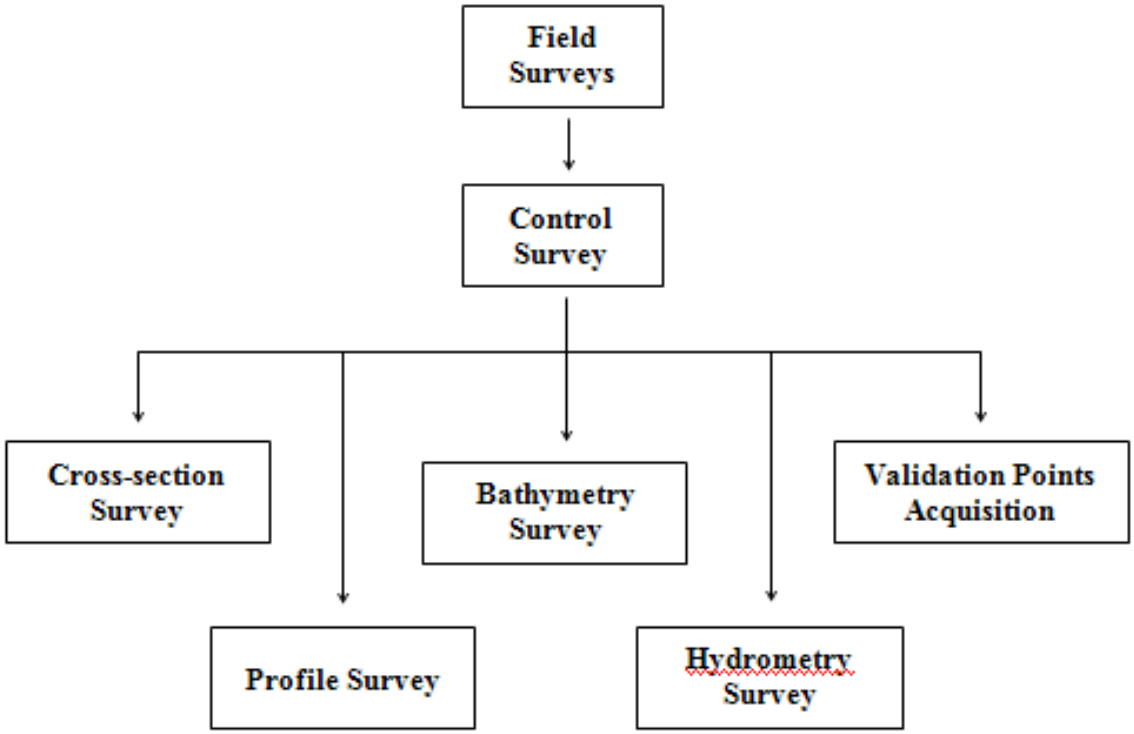


Figure 5. DVC Field Activities

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 6.

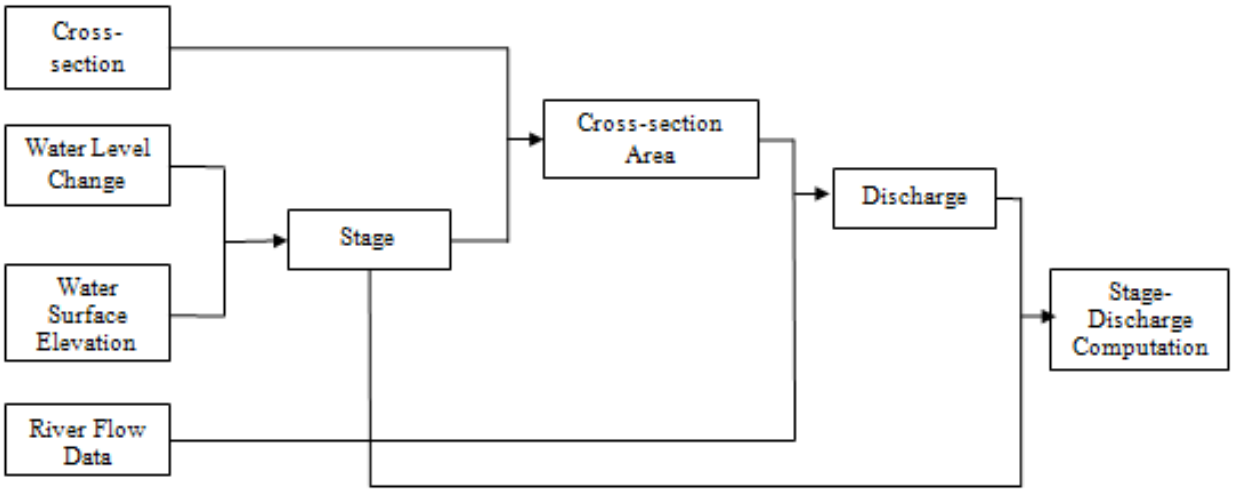


Figure 6. Flow Chart for Stage-Discharge Correlation Computation

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 7.

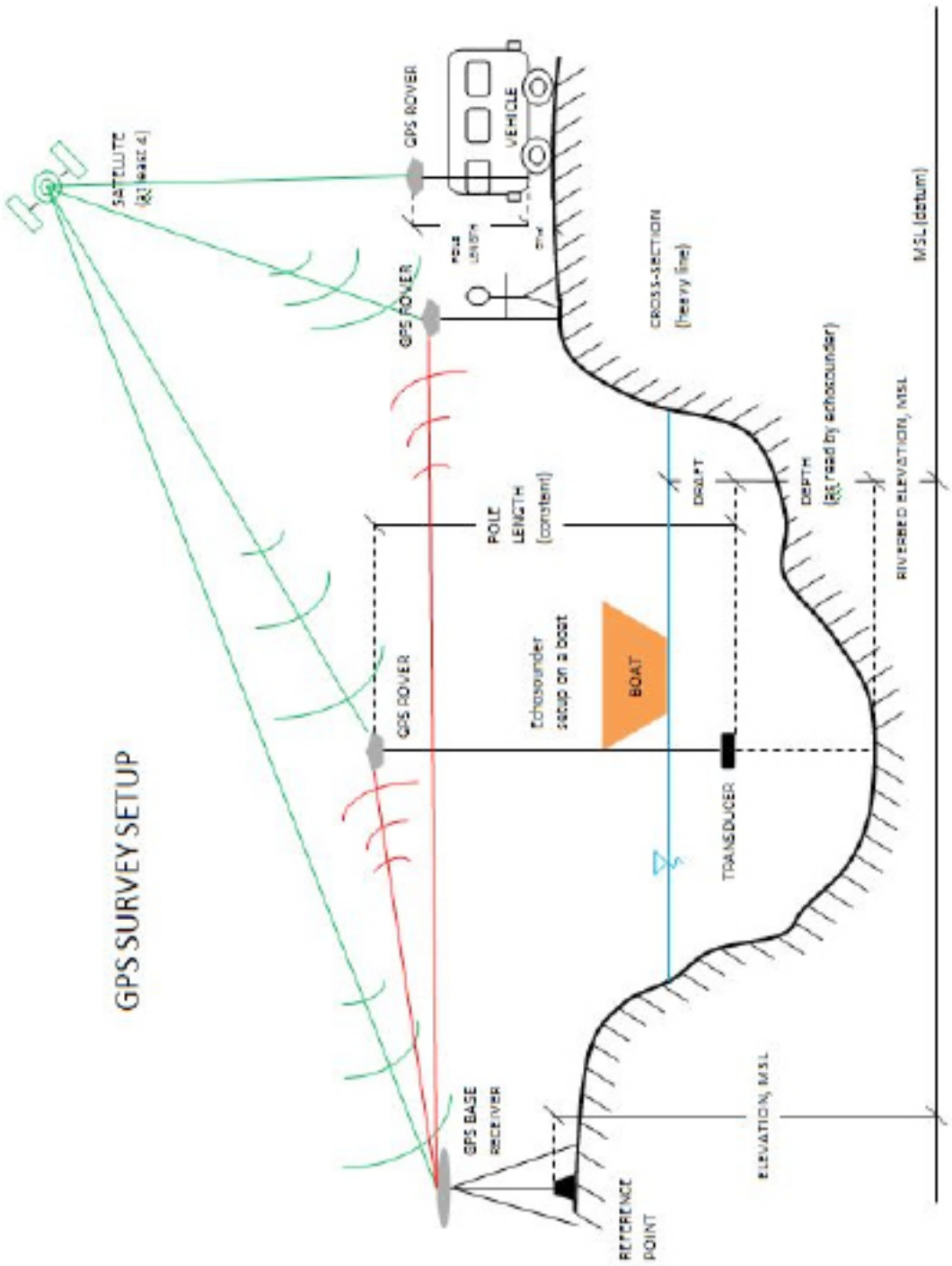


Figure 7. Set-up for GNSS Survey

3.3 Data Processing

Data processing procedures used by DVC are summarized in Figure 8.

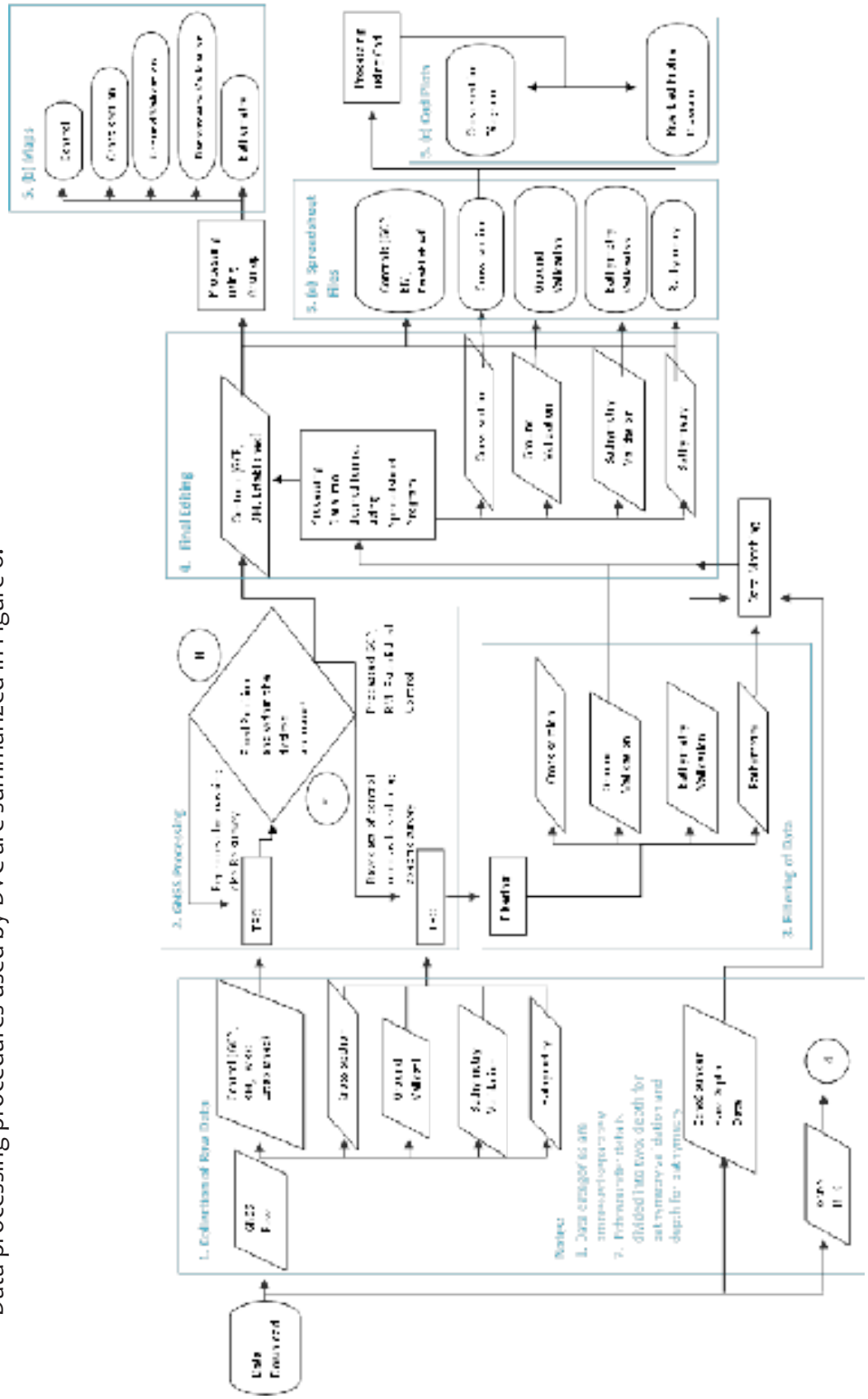


Figure 8. DVC Data Processing Methodology

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

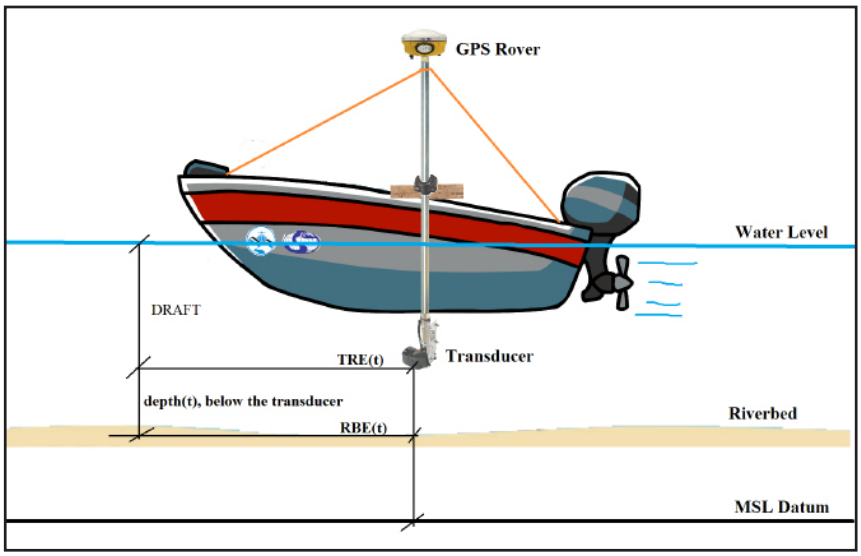


Figure 9. Illustration of Echo Sounder and GPS rover set-up for Bathymetric survey

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.

Tagoloan River Basin Survey

Tagoloan River Basin Survey

The survey for Tagoloan River Basin was conducted on May 16 to June 11, 2013 with the following activities: control, bathymetric and hydrometric surveys; profile and cross-section lines.

Tagoloan River consists of 23 delineated cross section lines with a total length of 45.6 km for both left and right banks starting from Brgy. Rosario in the upstream down to Brgy. Tambobong near the mouth of the river. The total length of profile lines is about 59 km for its both left and right banks.

Another set of fieldwork was conducted on October 8-12, 2013 to acquire the cross-section and sensor elevation of the installed AWLS and to perform flow data gathering in Mangima Bridge in Brgy. Mangima and Sabangan Bridge in Brgy. Sabangan in Manolo Fortich City, Tagoloan Bridge, Brgy. Poblacion in Tagoloan City, Arch Bridge, Brgy. Poblacion in Malitbog City and Pinaanan Bridge Brgy. Pinaanan in Impasungong City.

4.1 Control Survey

Three (3) NAMRIA established control points were considered for the static GNSS observations of Tagoloan River System. These include a benchmark, TGBM, which is located in Brgy. Macabalan, Cagayan De Oro City; a second-order reference point, MSE-25, situated in the center of a rice field near a concrete irrigational canal, Brgy. Poblacion I, Villanueva City; and a third-order reference point, MSE-3242, located at the foot of Umalag Bridge, Brgy. Tablon, Cagayan de Oro City. The GNSS set-up for the two (3) base stations and the UP Established point, UP-TAG, is shown in Figure 10.

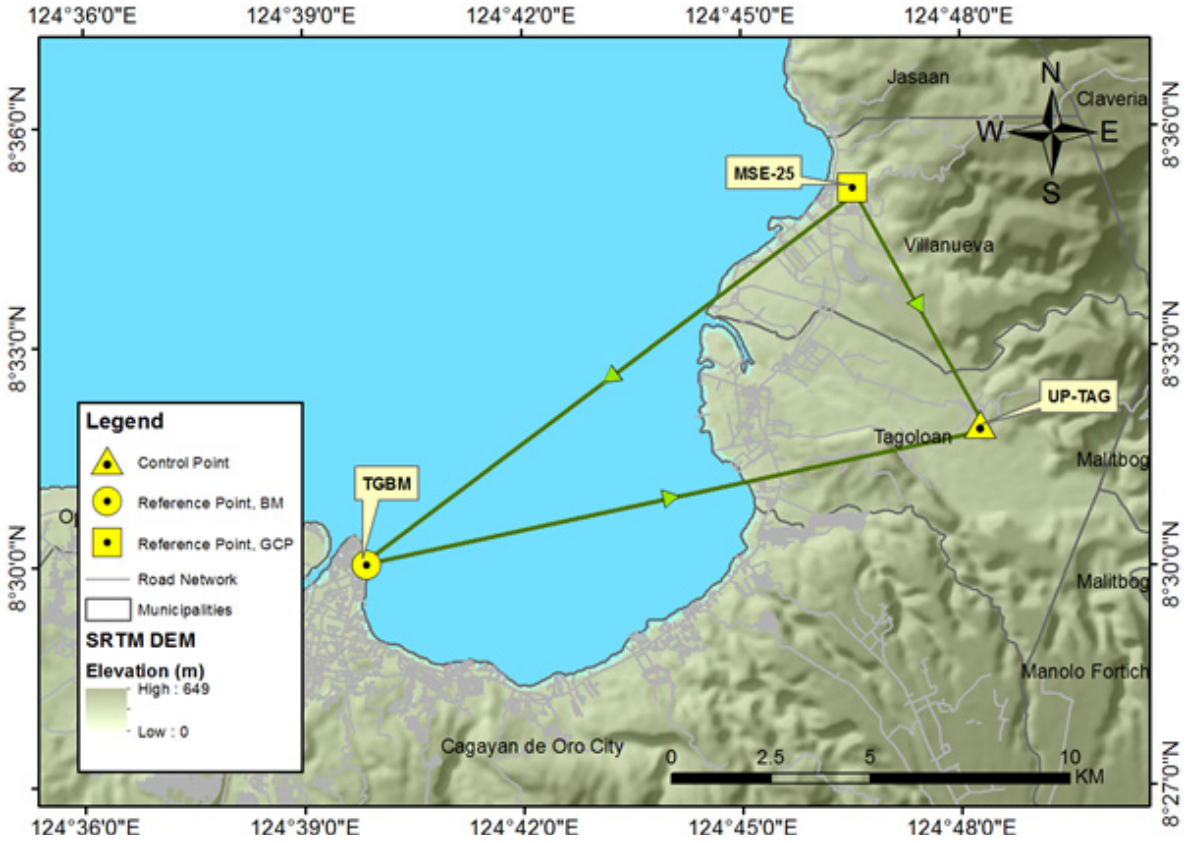


Figure 10. Location of control points

Continuous differential static observations were done simultaneously at these three stations for two hours to provide reference control points for the ground and bathymetric surveys. The horizontal coordinates and elevations of the three (3) 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 Tagoloan 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)	
MSE-25	2nd	8.58600148	124.775675	73.980	949534.35	695418.47	4.367
TGBM	1st	8.50060368	124.664291	70.923	940034.43	683197.72	1.090
UP Control		8.53181057	124.804607	131.519	943555.29	698631.61	61.323

The GNSS setup for the three (3) control points are illustrated in Figures 11 to 14:

Figure 11. Static GNSS observation on TGBM inside Macabalan Port

Figure 12. Static GNSS observation on MSE-25 beside a concrete irrigation canal in Brgy. Poblacion, Villanueva, Misamis Oriental

Figure 13. Static GNSS observation on UP established control point (UP-TAG)

Ground Surveys

The team which conducted the reconnaissance on the area reported that most of the proposed routes are passable. For those that are not passable, alternate routes were prepared. Control points that will be used during the survey were also identified.

The reference point MSE-25 in Tagoloan, which isone of the three control points used for static observation, was also used as a base station for differential kinematic GNSS survey.

4.2 Reconnaissance of Cross-section and Profile Lines

The topography of a river can be described using series of cross-sections that cut perpendicularly across the channel of the river. Bathymetric survey data of the river combined with ground survey data of the floodplain can produce a series of cross-sections along the stretch of the river.

Each cross-section lines were located using handheld GPS (Garmin Montana™ 650). Summary of reconnaissance for the 23 cross-sections are shown in detail in Annex E. Reconnaissance for profile lines were conducted simultaneously with the bathymetric surveys.

The team took pictures of both left and right banks of the river, with starting points of cross section lines as reference. Similar to cross section reconnaissance, profile reconnaissance was conducted to determine the terrain of the banks of the river for outsourcing. Contractors will determine horizontal (Northing and Easting) and vertical (Elevation) coordinates of points gathered for both left and right upper and lower banks of the river at a specific interval, while walking parallel the river, along the banks, from a predetermined starting and end points.

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 Validation Points Acquisition Survey

Validation Points Acquisition Survey was conducted for three (3) on April 7,10 and 14, 2013 using a survey-grade GNSS Rover receiver mounted on a pole which was attached in front of the vehicle. It was secured with a nylon rope to ensure that it was horizontally and vertically balanced. The antenna height was measured from the ground up to the bottom of notch of the GNSS Rover receiver. The survey was conducted using PPK technique on a continuous topo mode.

Ground Validation points acquired using UP-TAG as the base station is shown in the map in Figure 14.

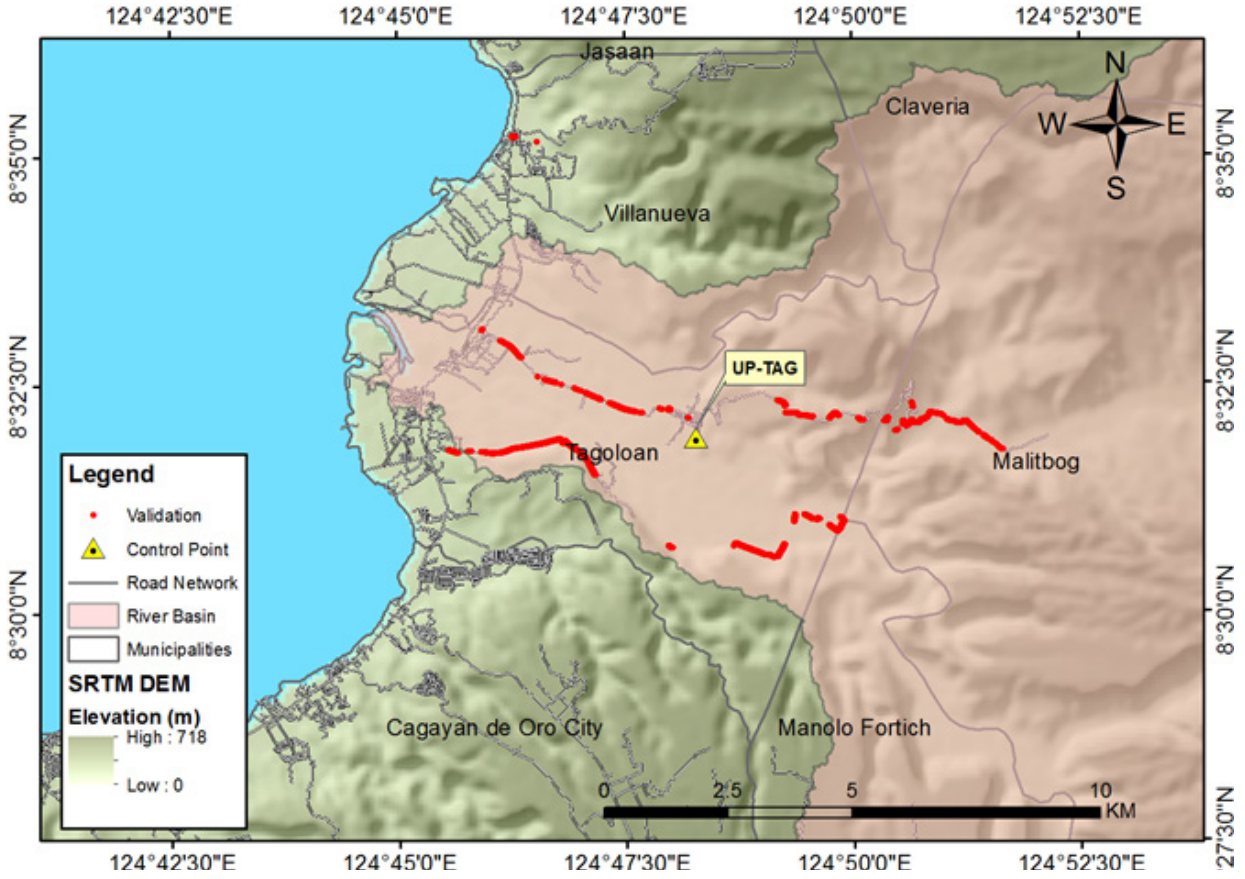


Figure 14. Acquired points for LiDAR validation of Tagoloan River Basin

4.4 Bathymetric Survey

The bathymetry of the river channel was surveyed using Differential GNSS surveying technique and a Hi-Target™ single beam echo sounder that were utilized in measuring the depth, eventually obtaining elevation with corresponding horizontal position. Bathymetry setup during the Tagoloan bathymetry survey is illustrated in Figure 15 and 16.

The entire bathymetry survey took four (4) days to accomplish from April 9 to 12, 2013. The Bathymetry Team executed the survey using a rubber boat. To cover the areas that the rubber boat cannot cross, the team also conducted bathymetry by traversing the length of the river by foot. Centerline and zigzag sweep of the survey were performed in order to fully capture the topography of the river.

An approximate centerline length of 16.5 km and a zigzag sweep length of 40.7 km were covered starting from downstream in Brgy. Tambobong up to Brgy. Rosano, Tagoloan City. Data gathered during the bathymetry survey is shown in map in Figure 17.

Figure 15. Bathymetric survey setup using Trimble SPS™ 882 mounted on top of the Hi-Target™ Transducer

Figure 16. Manual bathymetric survey using PPK GNSS technique along Brgy. Poblacion, Tagoloan City

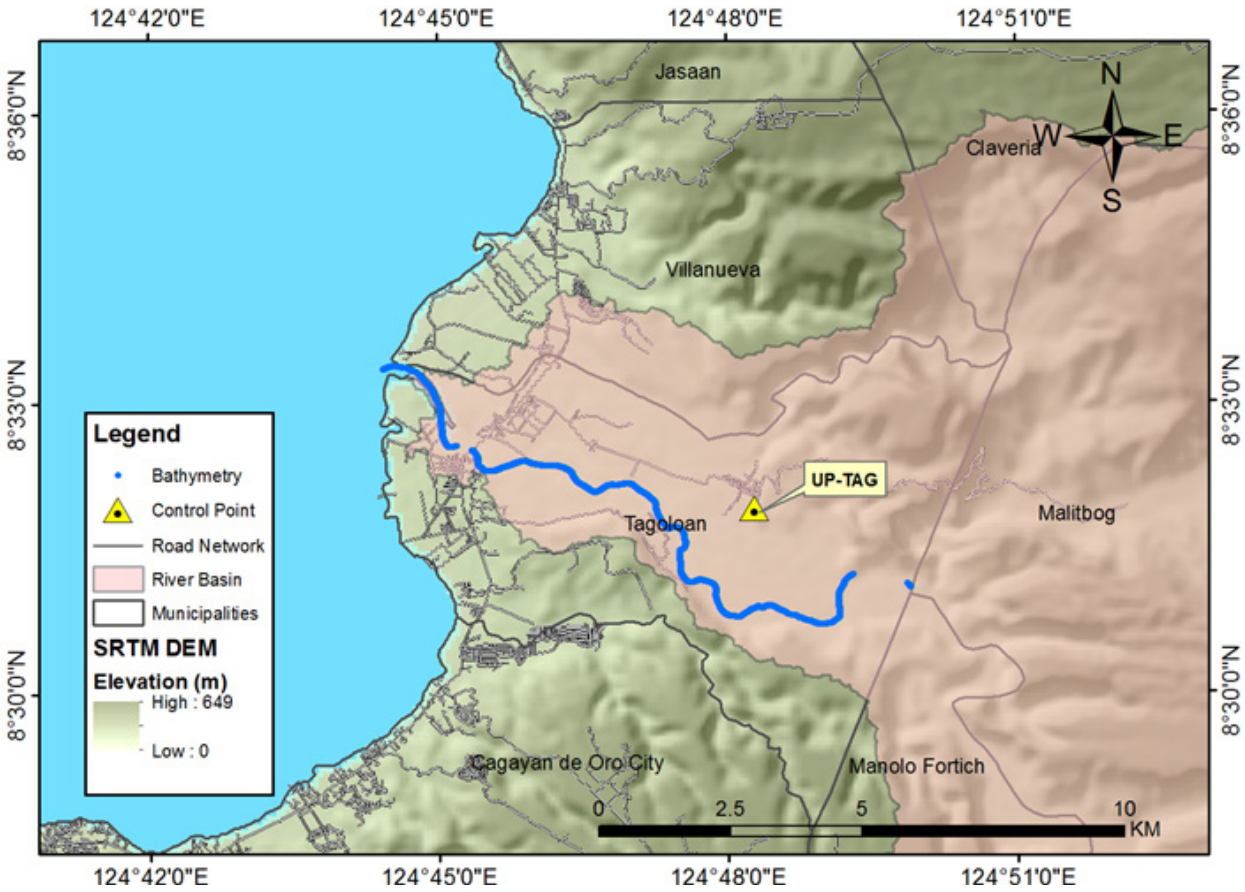


Figure 17. Bathymetry Survey along Tagoloan River

4.5 Hydrometric Survey

Different sensors were deployed on the banks of Tagoloan 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.

A velocity meter with depth gauge upstream in Brgy. Sta. Ines, Malitbog, Bukidnon for ten (10) days from April 6 to 15, 2013. Local hires were employed to monitor the depth gauge, rain gauge, and velocity meter. The velocity meter and depth gauge were also deployed in Pugaan River, a tributary of Tagoloan River, in Brgy. Sta. Ana, Tagoloan for an hour on April 15, 2013 as shown in Figure 24.

A rain gauge was installed in Brgy. Sta. Ines, Malitbog, Bukidnon about 300 meters away from the velocity meter deployment site (see Figure 23). Rainfall data observations started upon installation from April 6 to 15, 2013.

The data gathered from rain gauge shows the distribution of rainfall within the observation period from April 6 to 15, 2013. Each sensor has five (5)-minute interval. The first surge of rain, which reached 0.2mm, was observed on April 7, 2013. Highest amount of rain collected occurred on the 9th of April, 2013 at 1 mm. Relationships of data gathered within the observation period are illustrated Figure 18, 19, 20 and 21.

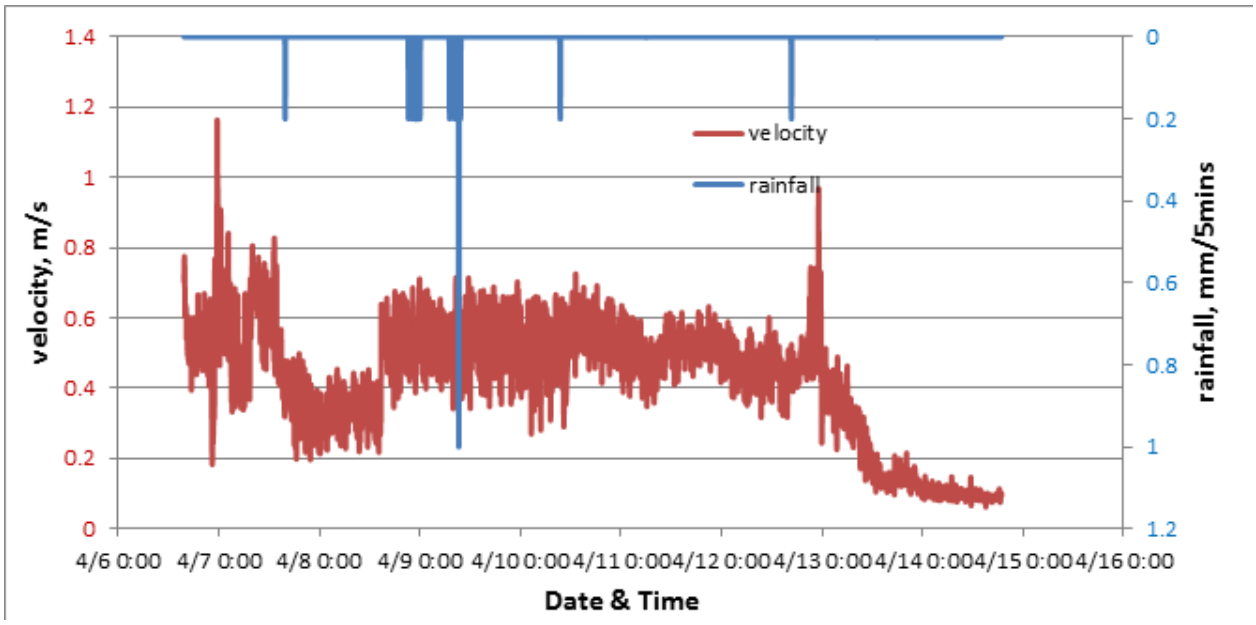


Figure 18. Relationship between velocity and rainfall in Brgy. Sta. Ines, Malitbog, Bukidnon

The relationship between rainfall and velocity data gathered using rain gauge and velocity meter deployed in Brgy. Sta. Ines, Malitbog, Bukidnon is shown in Figure 18.

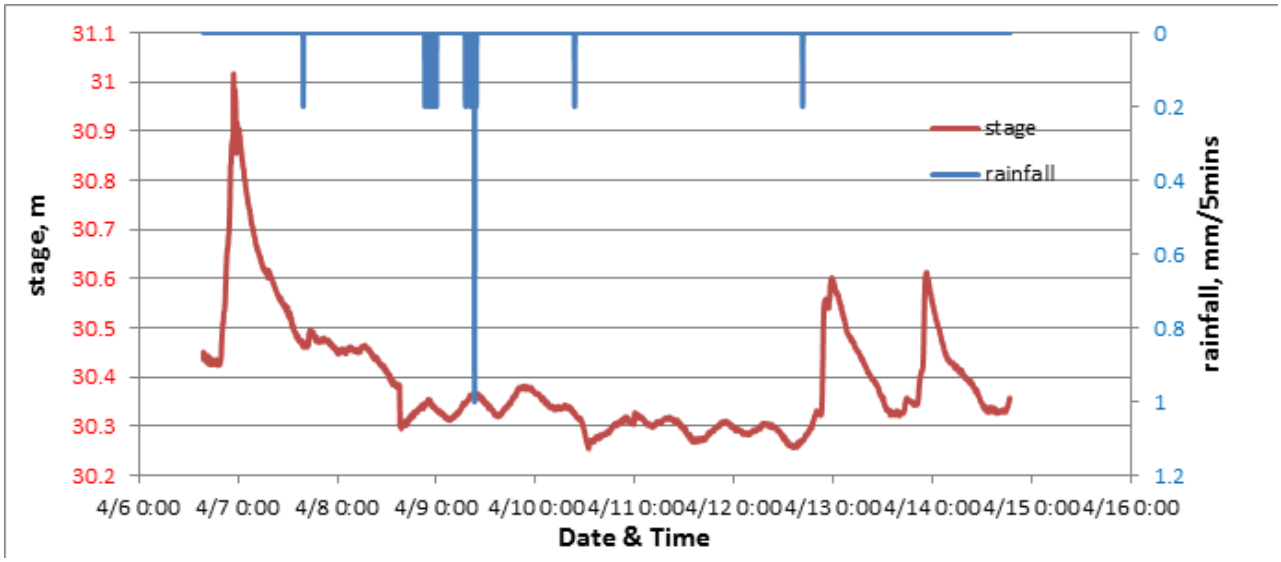


Figure 19. Relationship between stage and rainfall in Brgy. Sta. Ines, Malitbog, Bukidnon

The relationship between the rainfall and stage data gathered using rain gauge and depth gauge deployed in Brgy. Sta. Ines, Malitbog, Bukidnon is shown in Figure 19.

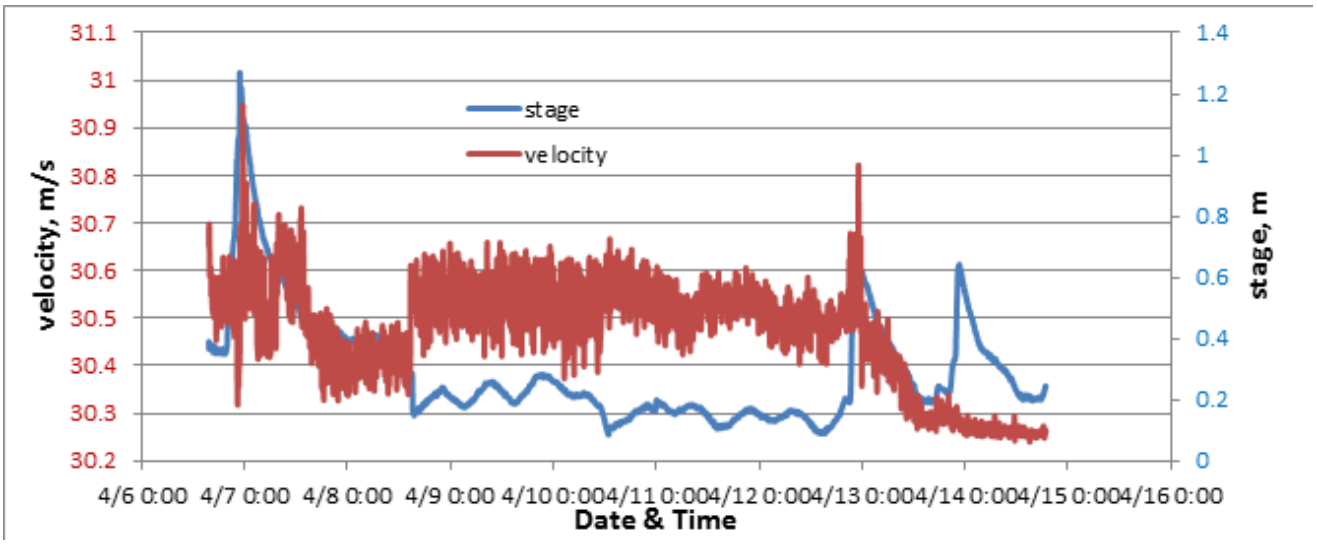


Figure 20. Relationship between stage and velocity in Brgy. Sta. Ana, Tagoloan City

The relationship between the velocity and stage data gathered using velocity meter and depth gauge deployed in Brgy. Sta. Ines, Malitbog, Bukidnon is shown in Figure 20

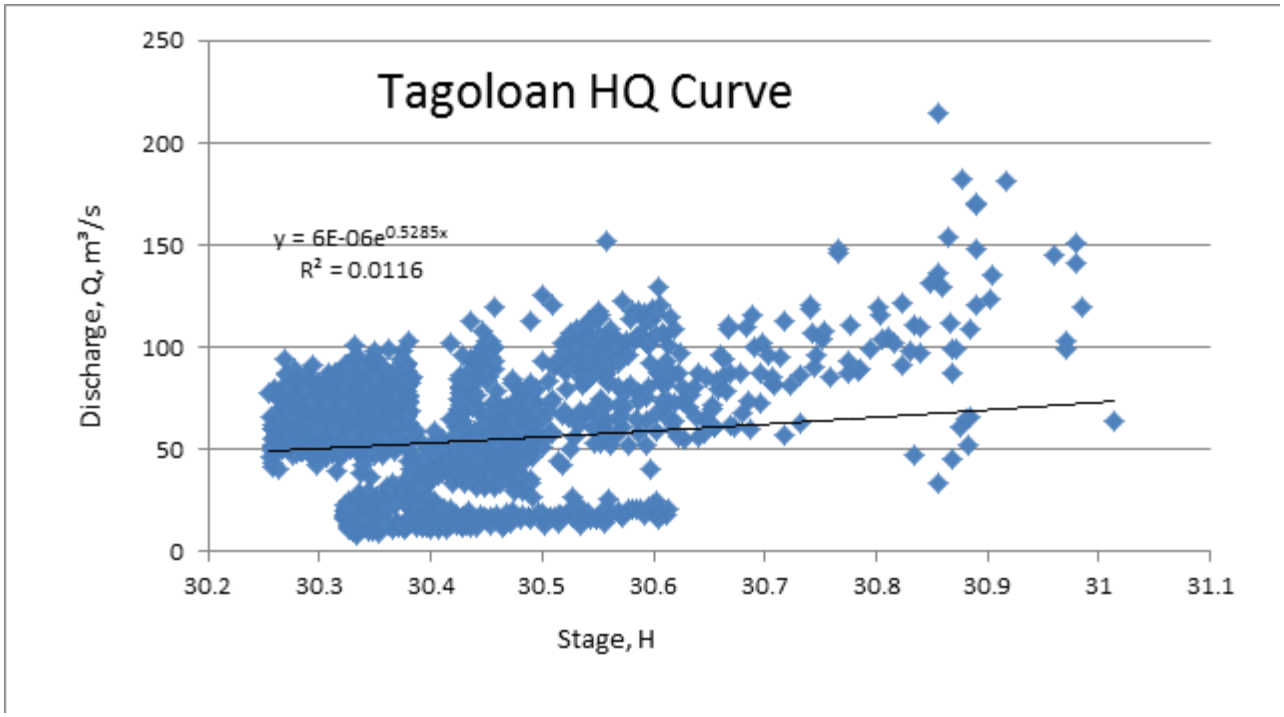


Figure 21. Relationship between stage and discharge in Brgy. Sta. Ana, Tagoloan City

The relationship between the stage or water surface elevation referred to MSL and river discharge on a specific area of the river resulted to an R2 = 0.01166 and is illustrated in Figure 21. A value approaching R2 = 1 indicates a good correlation.

Setup of sensors deployment is illustrated in Figures 22, 23 and 24.

Figure 22. A series of picture displaying the components and deployment of the velocity meter and depth gauge in Tagoloan River, Brgy. Sta Ana, Tagoloan City

Figure 23. Rain Gauge installation in Brgy. Sta. Ines, Malitbog, Bukidnon

Figure 24. Deployment of depth gauge and velocity meter in Pugaan River, Brgy. Sta Ana, Tagoloan City

Table 2. A summary of the location, start and end of deployment of all the sensors used for stream flow

Sensor	Location	City/ Municipality	Deployment - Start	Deployment - End	EASTING*	NORTHING*
Velocity Meter 1	Bgy.Sta. Ines	Malitbog	06-Apr 2013	15-Apr 2013	701718	942004
Velocity Meter 2	Brgy. Sta. Ana	Tagoloan	15-Apr 2013	15-Apr 2013	697392	943918
Rain Gauge	Brgy. Sta. Ines	Malitbog	06-Apr 2013	16-Apr 2013	701718	942004
Depth Gauge 1	Bgy.Sta. Ines	Malitbog	06-Apr 2013	16-Apr 2013	701718	942004
Depth Gauge 2	Brgy. Sta. Ana	Tagoloan	15-Apr 2013	15-Apr 2013	697392	943918

**Garmin Montana Handheld GPS coordinates*

Redeployment of sensors for hydrometric data in Tagoloan River System was initiated due to insufficiency of the gathered data on Oct. 8-12, 2013 for calibrating its flood model. An upcoming storm was approaching the area and a team was immediately assigned to re-deploy the sensors prior its landfall, but due to flight cancelations on the day of traveling the team was able to reach the area after the storm passed-by. Another storm "Zoraida", with international name "Typhoon Haiyan", was due to arrive days after the team reached the deployment site. The team took advantage of the bad weather to gather substantiate discharge data for a more accurate flood simulation for the area.

The ADCP and depth gauge was re-deployed in Brgy. Sta. Inez, Malitbog, Bukidnon for seven (7) days from November 9-12, 2013. Local hires were employed to watch over the sensors during its deployment. The established control point, UP-TAG was used as the base station to acquire the water surface elevation in MSL of the deployment site.

(a) (b)

Figure 25. (a) Setting up the ADCP. (b) Deploying the sensor on the bank of Tagoloan River.

Figure 26. (left) GNSS base station at UP-Tagoloan located in Brgy. Sta Ana, Tagoloan City (right) Measuring the Water Surface Elevation using a DGPS

4.5.1 AWLS Survey

Another survey was conducted on October 8-12, 2013 to get the cross-sectional area and water surface elevation in MSL of the installed AWLS along Tagoloan River and its tributaries as shown in map in Figure 28.

Installed AWLS were identified in Project NOAH's website and verified by coordinating with DOST Region X. The GPS base was set-up on three different sites depending on the coverage of survey namely, BLLM-2 in Manolo Fortich Municipal Hall Ground for the Mangima, Sabangan, and Pinaanan Bridge, and MSE-25 and UP-TAG for Tagoloan Bridge and Arch Bridge, respectively. The base stations were occupied in conducting cross-section survey on existing and proposed AWLS sites and for referring the elevation of the sensors and its respective water surface MSL.

Tagoloan River Basin Survey

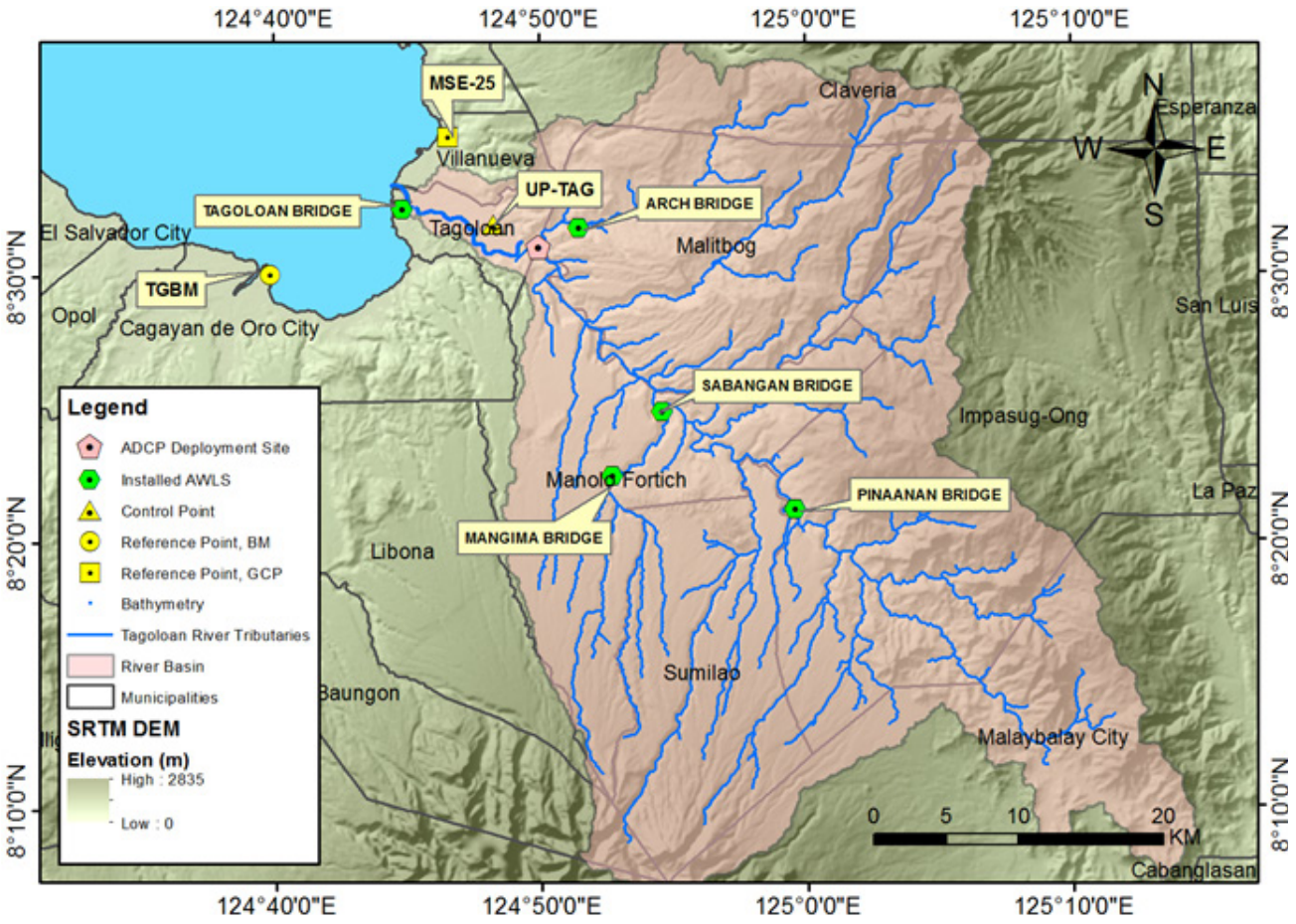


Figure 27. Tagoloan AWLS Survey Extent

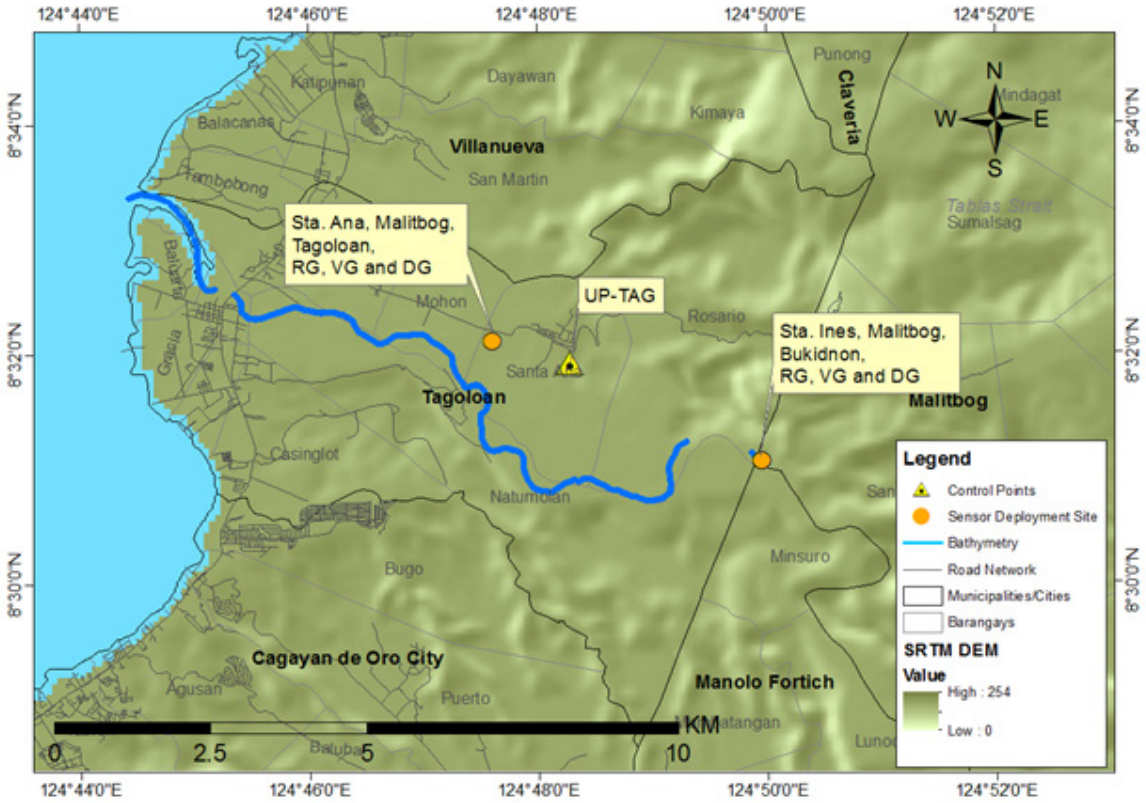


Figure 28. Sensor Locations

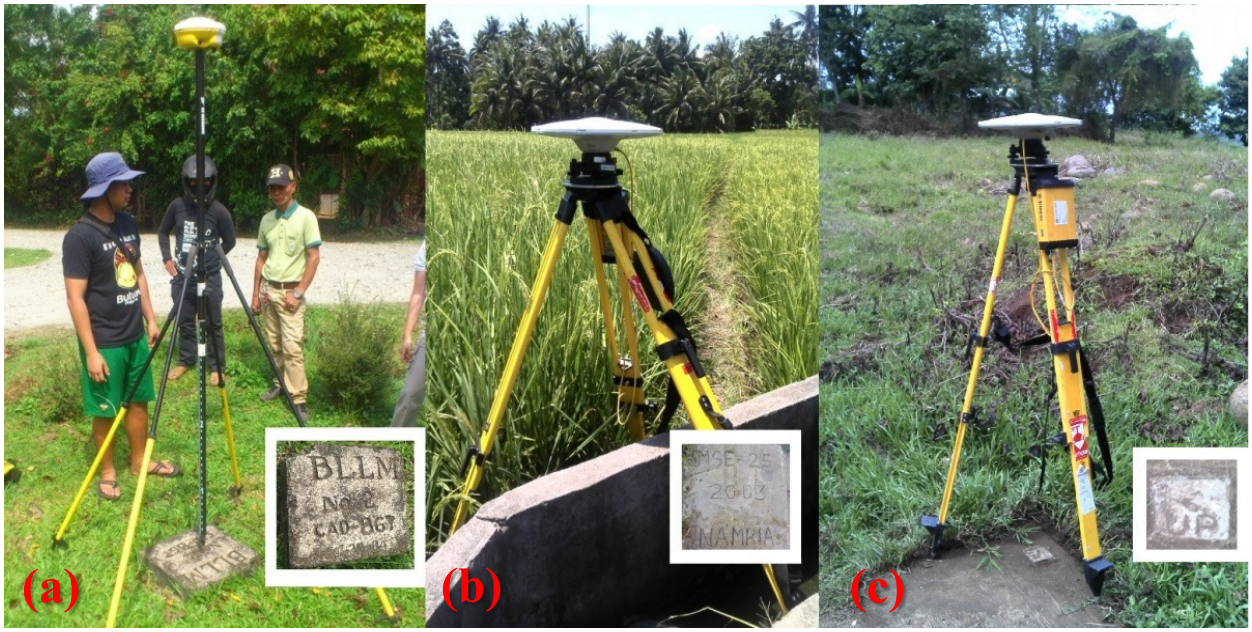


Figure 29. (a) PPK base at BLLM-2 at the back of Manolo Fortich Municipal Hall. (b) MSE-25 at Villanueva, Misamis Oriental. (c) Established point (UP-Tagoloan) in Brgy. Sta. Ana, Tagoloan.

4.5.1.1 Cross-section Survey

Summary of five (5) bridges with AWLS in Tagoloan River with corresponding coordinates, date and time of elevation determination and duration of flow data gathering, and images are shown below:

Table 3. MSL Elevations of AWLS installation sites in Tagoloan River, in the Provinces of Misamis Oriental and Bukidnon.

AWLS	BARANGAY	LOCATION	AWLS ELEVATION m, (MSL)	WATER SURFACE ELEVATION, m, (MSL)	DATE & TIME of Determining the Water Elevation	IMAGE	REMARKS
Mangima Bridge	Brgy. Mangima, Manolo Fortich	8°22'35.222"N 124°52'50.393"E	304.30	296.45	10/09/2013 2:44 PM		Installed and Working
Tagoloan Bridge	Poblacion, Tagoloan	8d 32' 32.511" N 124d 45' 21.177"E	10.53	1.89	10/12/2013 1:50 PM		Installed and working
Arch Bridge	Bgy. Poblacion, Malitbog	8d 32' 32.511" N 124d 45' 21.177"E	130.58 m	123.12 m	10/11/2013 11:05 am		Installed and Working

Tagoloan River Basin Survey

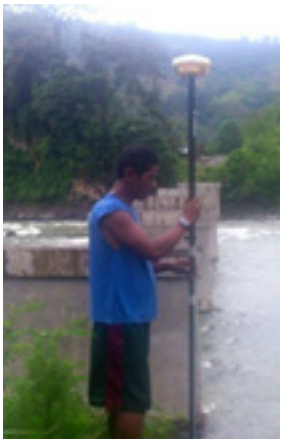
AWLS	BARANGAY	LOCATION	AWLS ELEVATION m, (MSL)	WATER SURFACE ELEVATION, m, (MSL)	DATE & TIME of Determining the Water Elevation	IMAGE	REMARKS
Sabangan	Sabangan, Manolo Fortich, Bukidnon	8°22'35.222"N 124°52'50.393"E	127.32 m (For reference)	-	-		Bridge was washed out by typhoon Sendong. Elevation mark for reference.
Pinaanan	Pinaanan, Impasungong, Bukidnon	8d20'31.518" N 125d00'39.496" E	358.1 m (For Reference)	-	-		Bridge was washed out by typhoon Sendong. Elevation mark for Reference.

Figure 30. Cross-section survey at Arch Bridge

Figure 31. Cross-section survey at Mangima Bridge

Figure 32. Cross-section survey at Sabangan Bridge

Figure 33. Installed AWLS and Cross-Section at Tagoloan Bridge

The images in Figure 34-36 shows the cross-sectional diagram of the AWLS site and its respective sensor and water surface elevation referred to MSL.

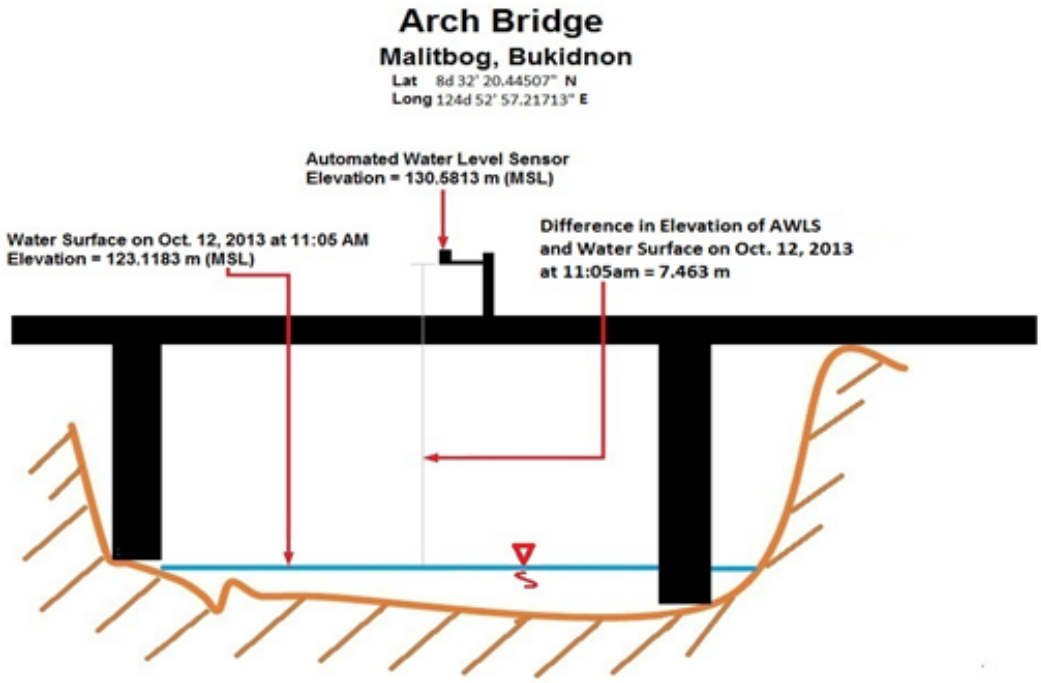


Figure 34. Cross-section diagram of Arch Bridge

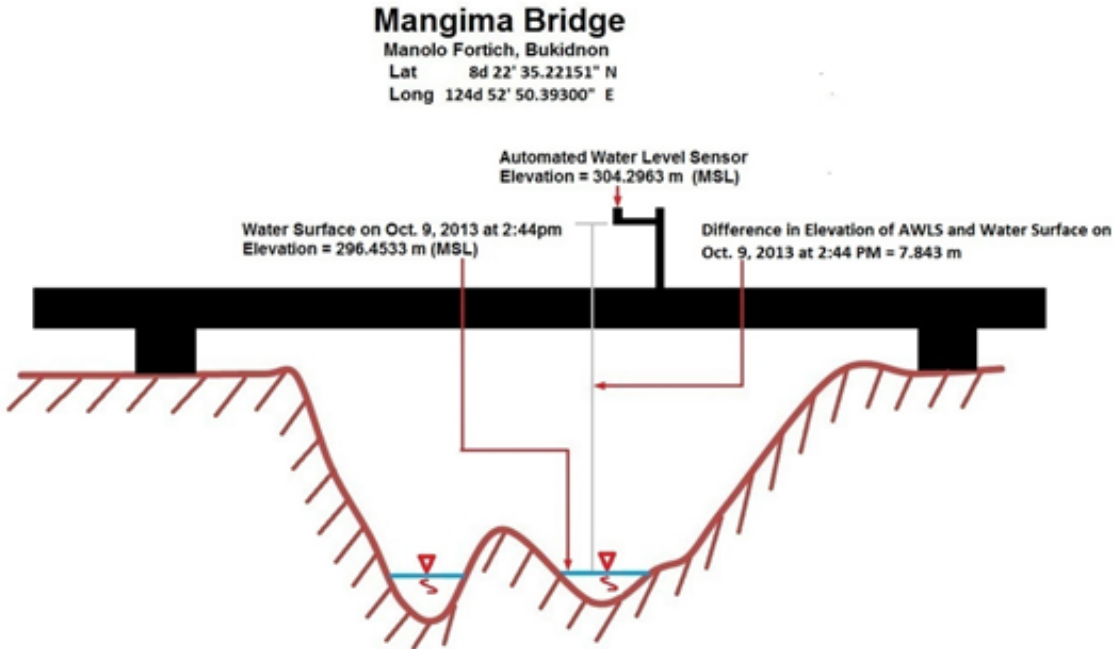


Figure 35. Cross-section diagram of Mangima Bridge

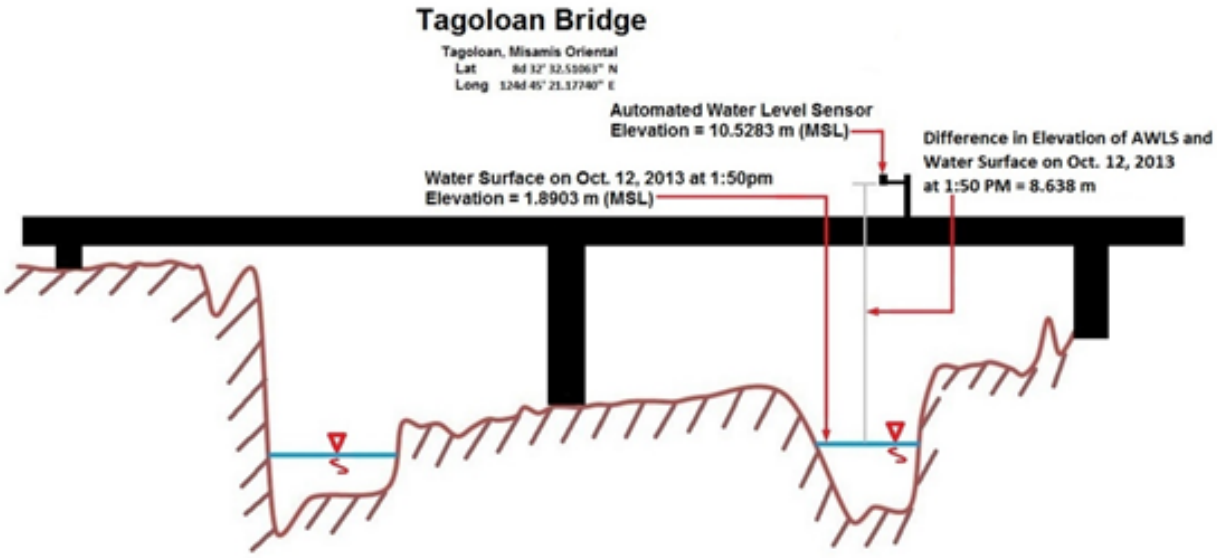


Figure 36. Cross-section diagram of Tagoloan Bridge

4.5.1.2 Flow Measurement

Flow measurements using Flow Probe FP 111 were done from October 8-12, 2014. Data are gathered from different bridges which have an installed AWLS. The relationships of river's flow data, stage and rainfall are shown in Figures 40-52.

Figure 37. Flow Measurement at Mangima Bridge

Figure 38. (a) Setting up of ADCP with depth gauge.
(b) Deployment of ADCP at Tagoloan River

Figure 39. Rain Gauge in Brgy. Sta. Inez, Malitbog

The following series of graphs shows the sensor data of the deployed ADCP, flow meter, depth gauge and rain gauge during the Tagoloan AWLS Cross-section Field Survey.

A. ADCP Deployment Site Sensor Graphs

The relationship between rainfall and velocity data gathered using rain gauge and flow meter deployed in Brgy. Sta. Inez, Malitbog, Bukidnon is shown in Figure 40. The first surge of rain was observed on October 10, 2013 which reached 0.25mm. The highest surge of rain was observed on October 12, 2013 which reached 2.25mm.

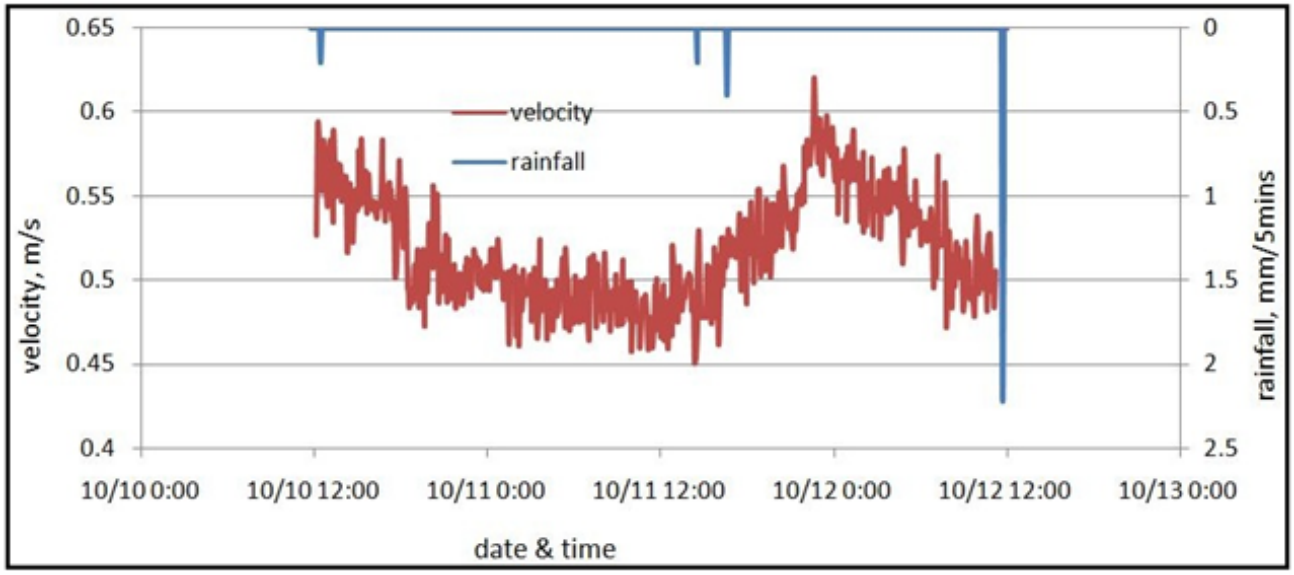


Figure 40. Rainfall vs Velocity in Brgy. Sta. Inez, Malitbog, Bukidnon

The relationship between the rainfall and stage data gathered using rain gauge and depth gauge deployed in Brgy. Sta. Inez, Malitbog, Bukidnon is shown in Figure 41.

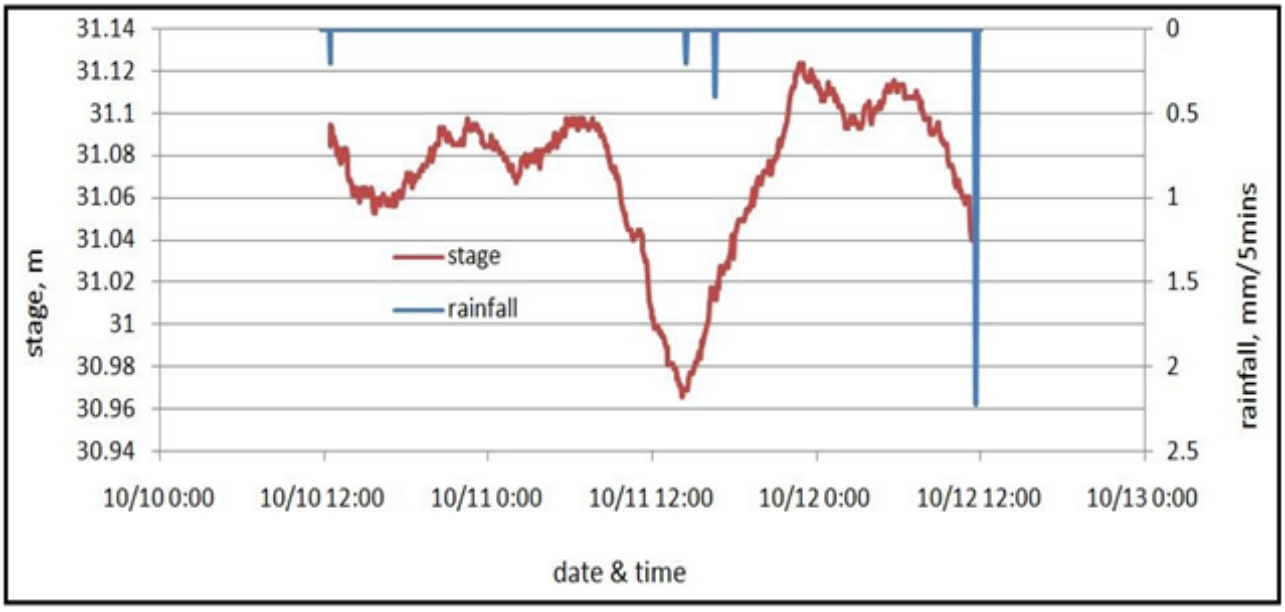


Figure 41. Stage vs Rainfall in Brgy. Sta. Inez, Malitbog, Bukidnon

The relationship between the velocity and stage data gathered using flow meter and depth gauge deployed in Brgy. Sta. Inez, Malitbog, Bukidnon is shown in Figure 42.

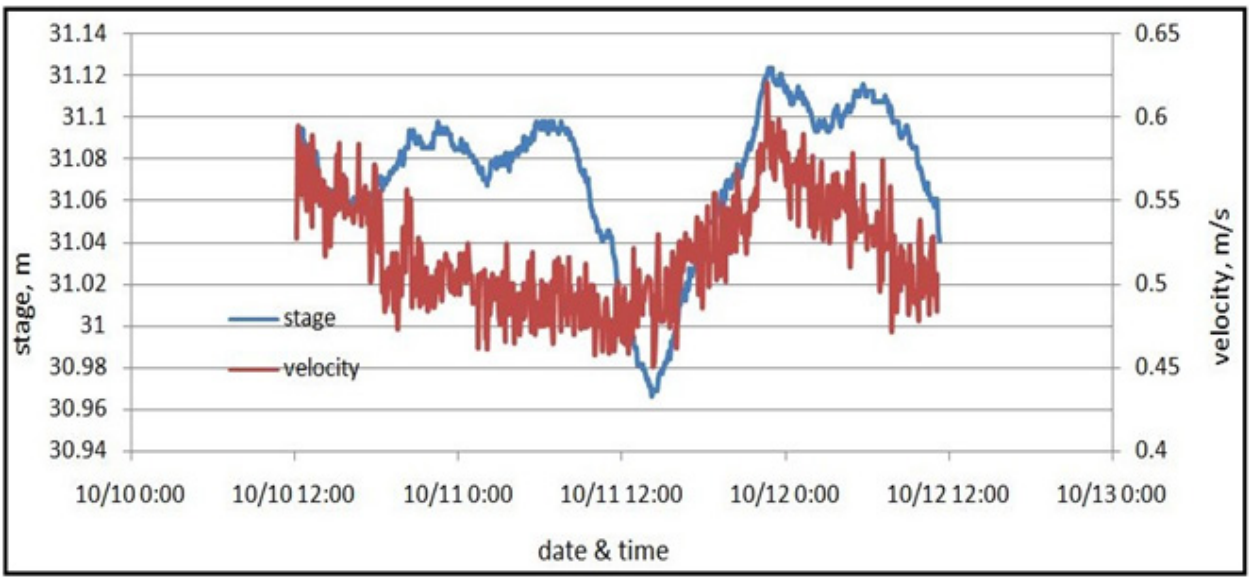


Figure 42. Stage vs Velocity in Brgy. Sta. Inez, Malitbog, Bukidnon

The relationship between the stage or water surface elevation referred to MSL and river discharge gathered in Brgy. Sta. Inez, Malitbog, Bukidnon for October 10-12 resulted to an R2 = 0.541 and is illustrated in Figure 43.

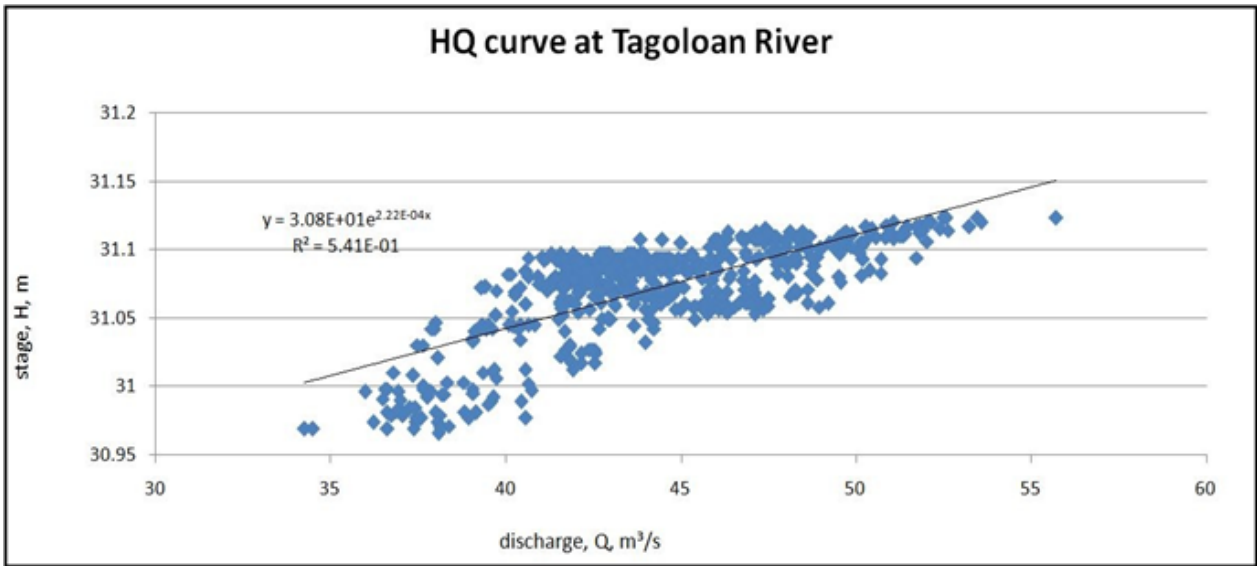


Figure 43. Stage-Discharge correlation of Tagoloan River in Brgy. Sta. Inez, Malitbog, Bukidnon

The relationship between stage and discharge for October 10 to 12 resulted to an R^2 of 0.541.

B. Arch Bridge Sensor Graph

The relationship between rainfall and velocity data gathered using rain gauge and flow meter deployed in Brgy. Sta. Inez, Malitbog, Bukidnon is shown in Figure 44. There is no observed surge of rain from October 11 to 12, 2013.

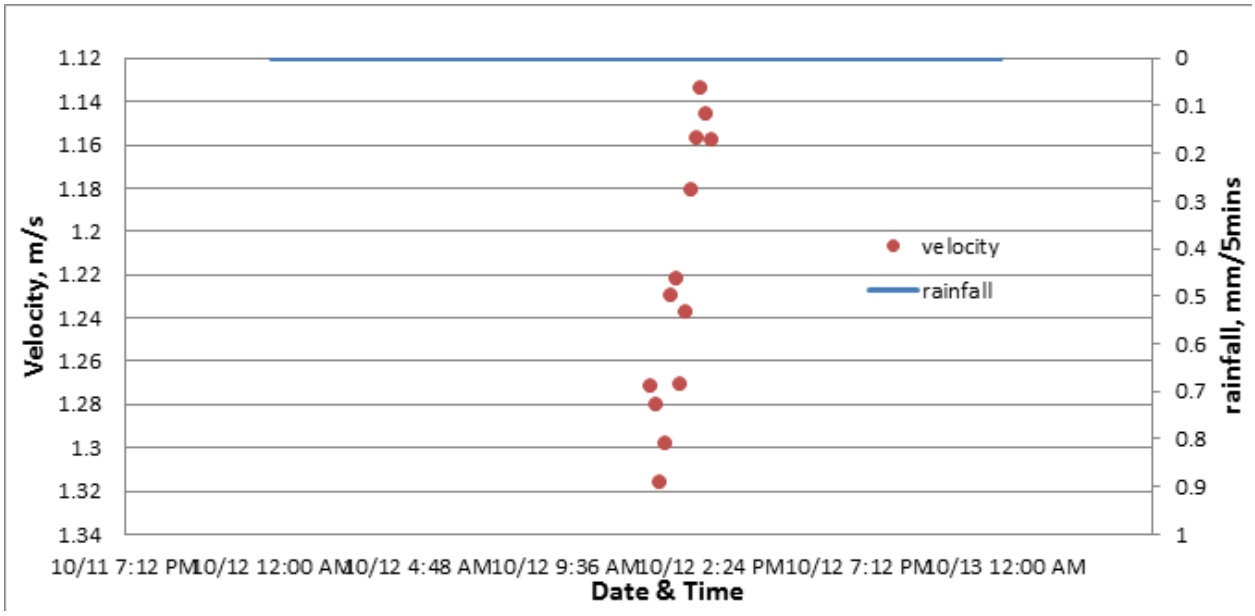


Figure 44. Velocity vs Rainfall in Arch Bridge, Brgy. Sta Inez, Malitbog City

The relationship between the velocity and stage data gathered using flow meter and depth gauge deployed in Brgy. Sta. Inez, Malitbog, Bukidnon is shown in Figure 45.

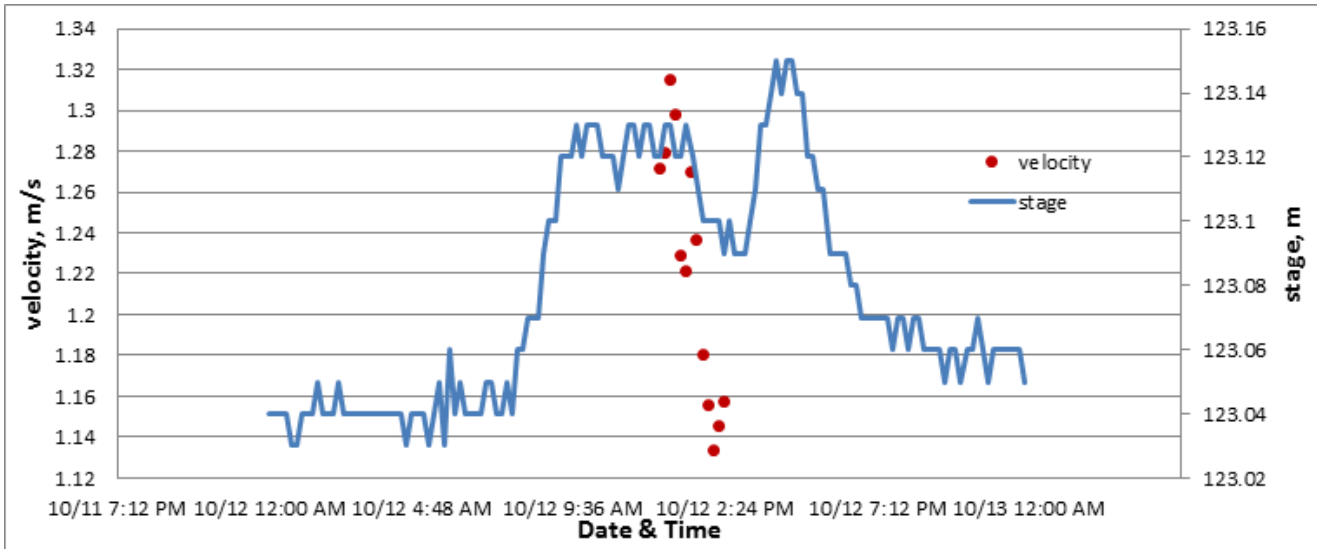


Figure 45. Velocity vs Stage in Arch Bridge, Brgy. Sta Inez, Malitbog City

The relationship between the rainfall and stage data gathered using rain gauge and depth gauge deployed in Brgy. Sta. Inez, Malitbog, Bukidnon is shown in Figure 46.

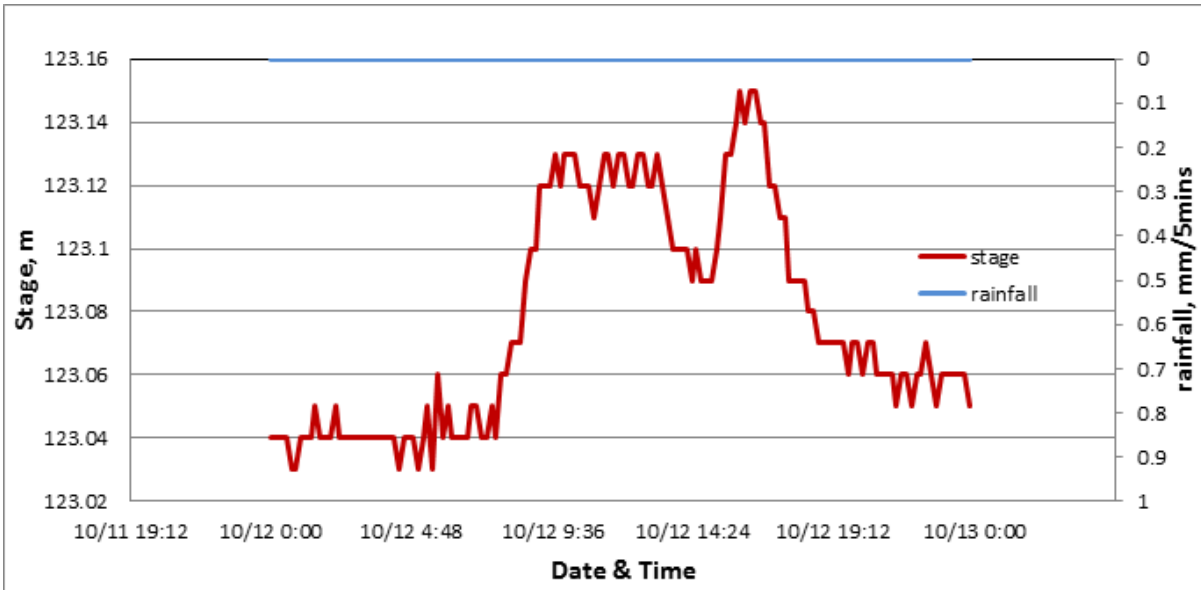


Figure 46. Stage vs Rainfall in Arch Bridge, Brgy. Sta Inez, Malitbog City

C. Mangima Bridge Sensor Graph

The relationship between rainfall and velocity data gathered using rain gauge deployed in Brgy. Sta. Inez, Malitbog, Bukidnon and flow meter deployed in Brgy. Tankulan, Manolo Fortich City is shown in Figure 47. The first and highest surge of rain was observed on October 9, 2013 that reached 0.3mm.

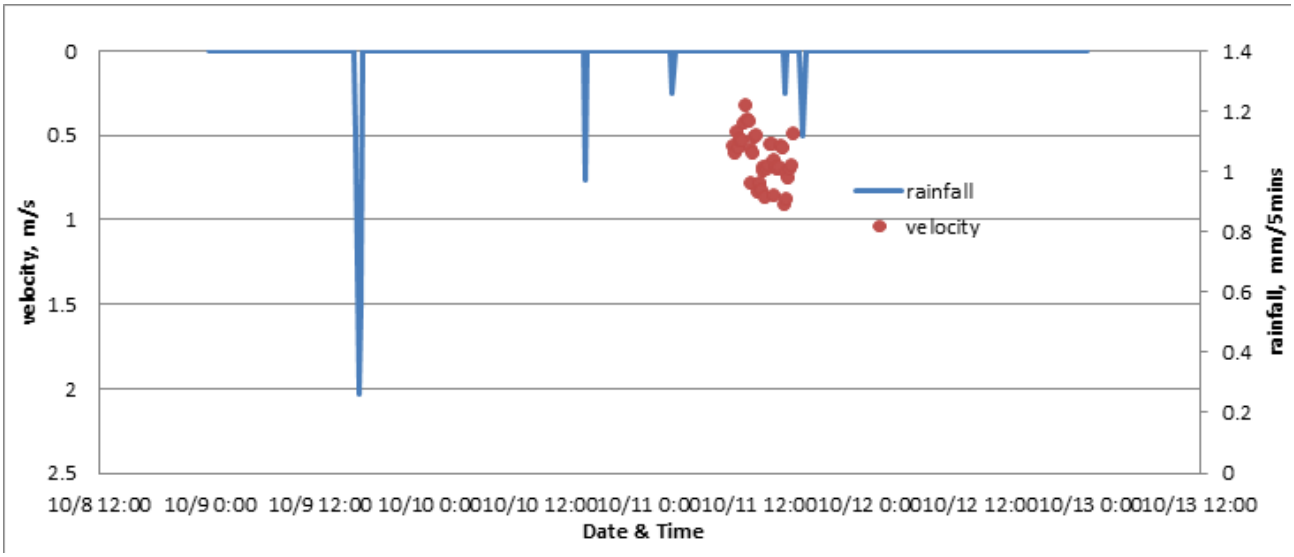


Figure 47. Velocity vs rainfall in Mangima Bridge, Brgy. Tankulan, Manolo Fortich City

The relationship between the velocity and stage data gathered using flow meter deployed in Brgy. Tankulan, Manolo Fortich City and depth gauge deployed in Brgy. Sta. Inez, Malitbog, Bukidnon is shown in Figure 48.

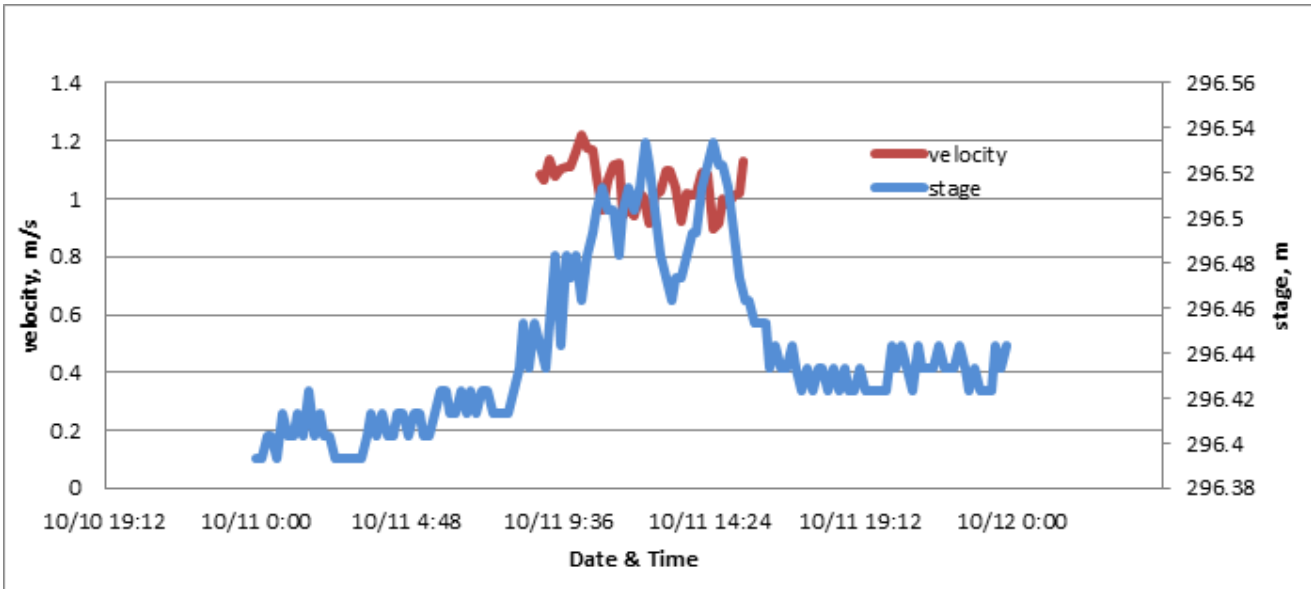


Figure 48. Velocity vs Stage in Mangima Bridge, Brgy. Tankulan, Manolo Fortich City

The relationship between the rainfall and stage data gathered using rain gauge deployed in Brgy. Sta. Inez, Malitbog, Bukidnon and depth gauge deployed in Brgy. Tankulan, Manolo Fortich City is shown in Figure 49.

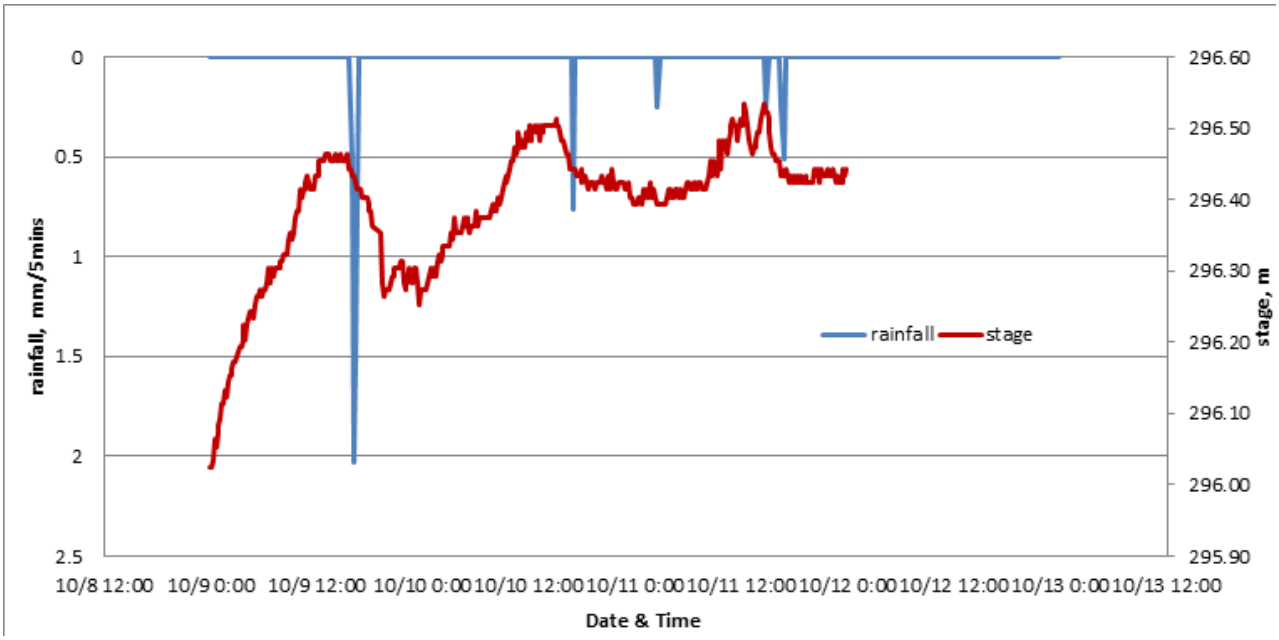


Figure 49. Rainfall vs Stage in Mangima Bridge, Brgy. Tankulan, Manolo Fortich City

D. Tagoloan Bridge Sensor Graph

The relationship between rainfall and velocity data gathered using rain gauge deployed in Brgy. Sta. Inez, Malitbog, Bukidnon and flow meter deployed in Brgy. Poblacion, Tagoloan City is shown in Figure 50. The first and highest surge of rain was observed on October 11, 2013 which reached 0.25mm.

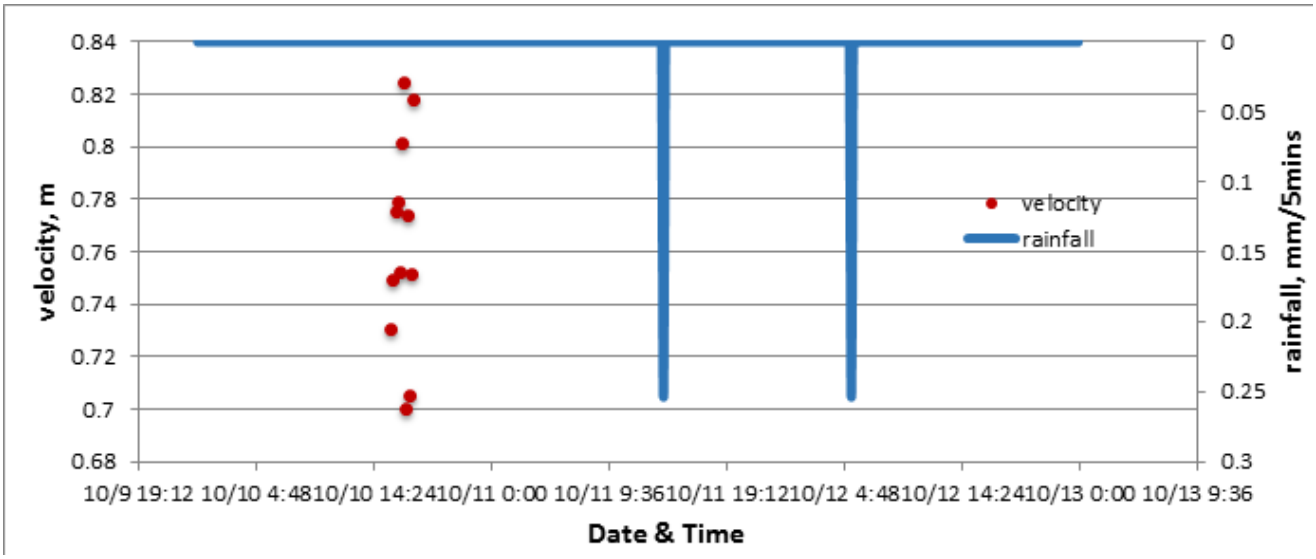


Figure 50. Velocity vs Rainfall in Tagoloan Bridge, Brgy. Poblacion, Tagoloan City

The relationship between velocity and stage data gathered using a flow meter deployed in Brgy. Poblacion, Tagoloan City and depth gauge deployed in Brgy. Sta. Inez, Malitbog, Bukidnon is shown in Figure 51.

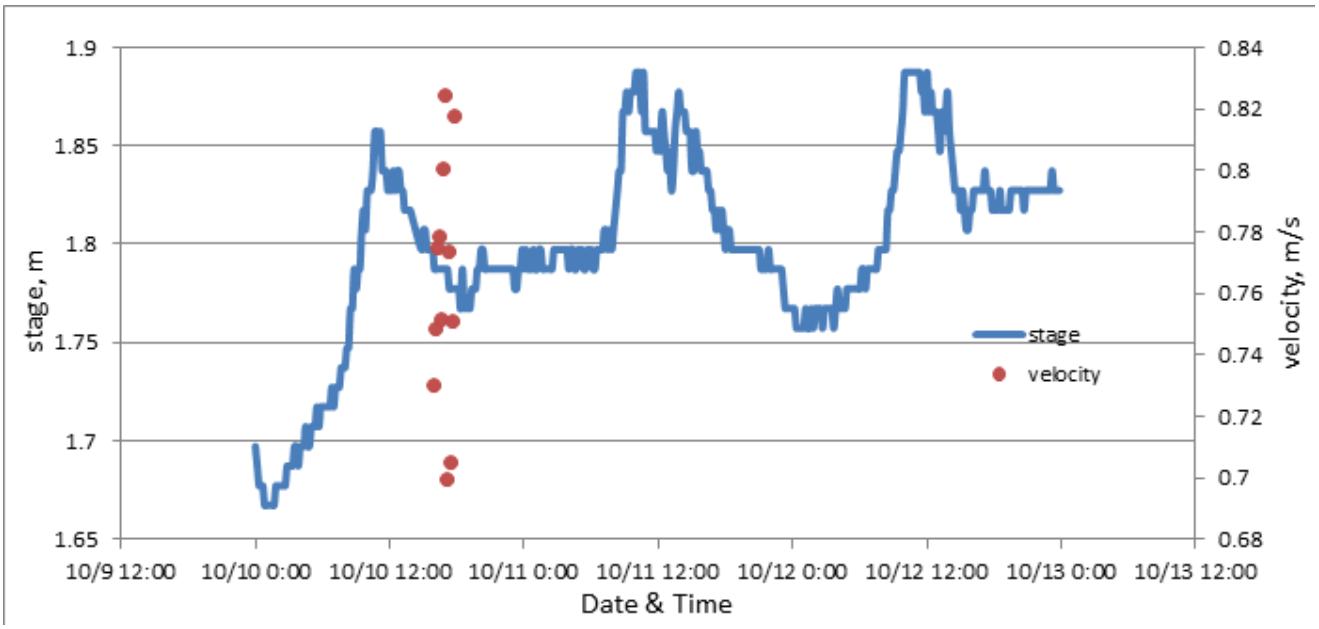


Figure 51. Velocity vs Stage in Tagoloan Bridge, Brgy. Poblacion, Tagoloan City

The relationship between the rainfall and stage data gathered using rain gauge deployed in Brgy. Sta. Inez, Malitbog, Bukidnon and depth gauge deployed in Brgy. Poblacion, Tagoloan City City is shown in Figure 52.

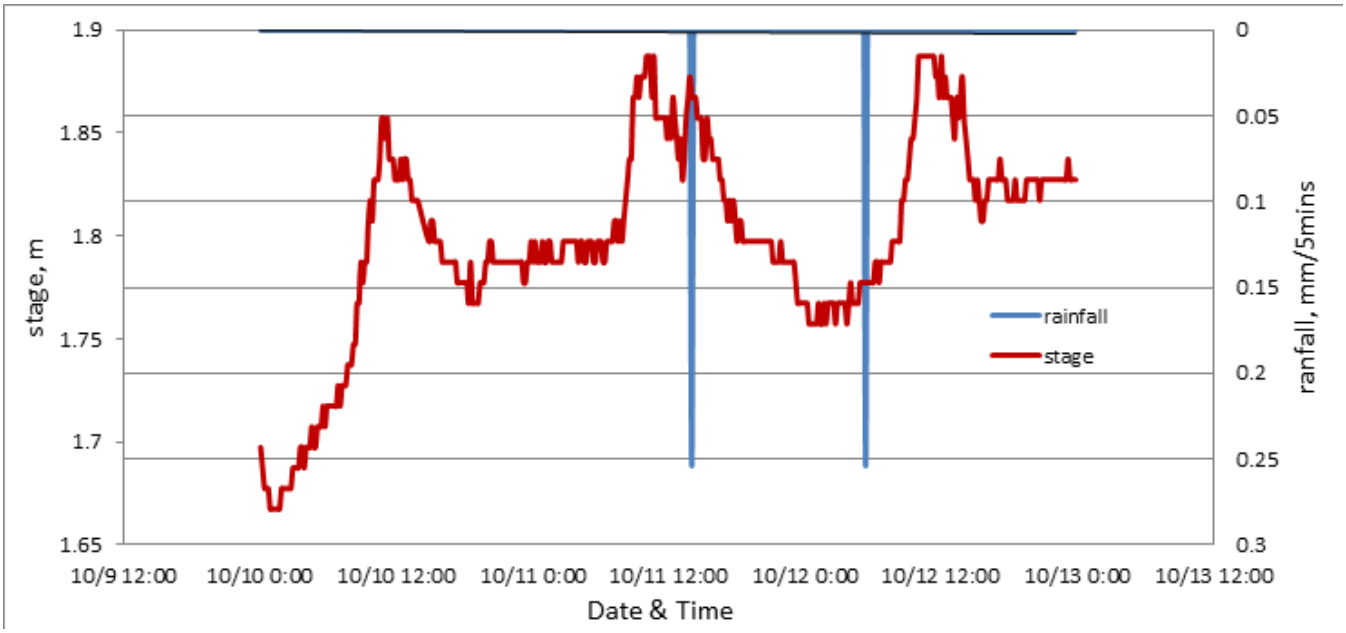


Figure 52. Rainfall vs Stage in Tagoloan Bridge, Brgy. Poblacion, Tagoloan City

Annexes

Annexes

ANNEX A. PROBLEMS ENCOUNTERED AND RESOLUTIONS APPLIED

The lack of available rubber boat delayed the bathymetric survey. Assistance for rubberboat and manpower were requested from the PDRRMO and PCG in Misamis Oriental, but the latter declined the request. This was resolved by renting a rubber boat from a private entity to be used on the whole duration of the survey.

Additionally, the team had difficulties conducting zigzag and bathymetric surveys from cross sections 01 to 13. Cross section lines are situated along rapids where the river is both shallow and rocky, making it unfeasible to conduct bathymetric zigzag and cross section survey using the echo sounder and manual bathymetric survey using PPK GNSS technique.

Manual bathymetry survey using PPK GNSS technique was conducted along cross sections 17 to 19 because of the shallow and rocky river. This spanned for two days, where profile survey for the island along these cross sections was also done.

Figure 50. Rapids along meandering parts of the river from cross section 01 to 13

Figure 51. Survey team conducting bathymetry survey using PPK GNSS technique along cross section 17 to 19

Figure 52. Canopy cover along roads made it difficult to conduct LiDAR validation survey using PPK GNSS technique on a continuous topo method

Annexes

ANNEX B. LIST OF EQUIPMENT AND INSTRUMENTS

Type	Brand	Owner	Quantity
GNSS Receiver (Base)	Trimble SPS852	UP-TCAGP	Three (3) units
GNSS Receiver (Rover)	Trimble SPS882	UP-TCAGP	Six (6) units
GNSS Controller	Trimble TSC3	UP-TCAGP	Six (6) units
High-Gain Antenna		UP- TCAGP	Three (3) units
RTK radio and antenna		UP-TCAGP	One (1) unit with battery
Singlebeam Echosounder	Hi-Target	UP-TCAGP	One (1) unit with accessories
Singlebeam Echosounder	Ohmex™ Echosounder	UP-TCAGP	One (1) unit with accessories
Acoustic Doppler Current Profiler (ADCP)	SonTek	UP- TCAGP	One (1) unit with accessories
Coupler-2B		UP- TCAGP	One (1) unit
Handheld GNSS	Montana 650	UP-TCAGP	Six (6) units
Laptop	Lenovo	UP-TCAGP	One (1) unit
	DellLatitude		Five (5) unit
	Panasonic Tough book (MDL)		One (1) unit
Depth Gauge	Onset Hobo wares	UP-TCAGP	Four (4) units
Rain Gauge		UP- TCAGP	Two (2) unit
Tripod	Trimble	UP-TCAGP	Three (3) units
Bipod	Trimble	UP-TCAGP	Six (6) units
Tribrach		UP-TCAGP	Three (3) unit
Laser Range Finder	Bushnell	UP-TCAGP	Two (2) units
Installers	SonTek	UP-TCAGP	One (1) unit
	Topcon		One (1) unit
	Trimble Business Center		One (1) unit
	Trimble Realworks		One (1) unit
Mobile Mapping Scanner (MMS)	MDL Dynascan	UP-TCAGP	One (1) unit with dual-GNSS antenna, one (1) interface adapter and accessories
Toolbox		UP-TCAGP	One (1) unit

Annexes

ANNEX C. THE SURVEY TEAM

Data Validation Component Sub-team	Designation	Name	Agency/Affiliation
	Project Leader	ENGR. LOUIE P. BALICANTA	UP TCAGP
Survey Coordinator	Chief Science Research Specialist (CSRS)	ENGR. JOEMARIE S. CABALLERO	UP TCAGP
Survey Head	Senior Science Research Specialist	ENGR. DEXTER T. LOZANO	UP TCAGP
Bathymetric Survey and Flow Measurement Team	Research Specialist	GIRLIE F. DAVID	UP TCAGP
Profile and Cross-Section Survey Team	Research Specialist	ENGR. KRISTINE AILENE B. BORROMEO	UP TCAGP
Cross Section Survey Team and Sensors Deployment Team	Research Specialist	ENGR. JMSON J. CALALANG	UP TCAGP
Cross Section Survey Team and Sensors Deployment Team	Research Specialist	PATRIZCIA MAE P. DELA CRUZ	UP TCAGP

Annexes

ANNEX D. NAMRIA CERTIFICATION

Republic of the Philippines
Department of Environment and Natural Resources
NATIONAL MAPPING AND RESOURCE INFORMATION AUTHORITY
Lawton Avenue, Fort Andres Bonifacio, 1634 Taguig City

17 June 2013

CERTIFICATION

Mr. Leonardo B. Nonan Jr.
LN Realty and Surveying Services
Butuan City

This is to certify that according to our records, the description and elevation of tidal benchmark TGBM at the Port of Cagayan de Oro is as follows:

TGBM – It is located inside the Port of Cagayan de Oro.It is set on the wharf floor, about 220 cm NE of the tide house and is about 45 cm NW of the concrete gutter. Mark is the head of a 2" bronze rod set flush on a 10" x 10" cement putty with inscriptions "TGBM 2011 NAMRIA".

Elevation: 2.2653 m above mean sea level
2.8553 m above mean lower low water

Values are based on 2007-2012 tidal series of observation.

Validated by:

Engr.RAUL S. CAPISTRANO
OIC, Oceanography Division

Commodore ROMEO I. HO
Director, Hydrography Department

www.namria.gov.ph osa@namria.gov.ph Fort Andres Bonifacio, Tel. No. (632) 810-4831 to 41 Binondo Branch, Tel. No. (632) 241-3494 to 96

04-18-08

Annexes

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

June 20, 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: **MISAMIS ORIENTAL**
Station Name: **MSE-3242**
Order: **3rd**

Island: **MINDANAO** Barangay: **TABLON**
Municipality: **CAGAYAN DE ORO CITY (CAPITAL)**

PRS92 Coordinates

Latitude: **8° 28' 55.37333"** Longitude: **124° 43' 33.63688"** Ellipsoidal Hgt: **8.50900 m.**

WGS84 Coordinates

Latitude: **8° 28' 51.79633"** Longitude: **124° 43' 39.04086"** Ellipsoidal Hgt: **76.30400 m.**

PTM Coordinates

Northing: **937869.408 m.** Easting: **469832.058 m.** Zone: **5**

UTM Coordinates

Northing: **937,952.73** Easting: **690,004.72** Zone: **51**

Location Description

MSE-3242
Is located at the foot of Umalag Bridge in Brgy. Tablon, Cagayan de Oro City. Mark is the head of a 4 in. copper nail embedded on a 25 cm. x 25 cm. concrete block, with inscriptions "MSE-3242 2007 NAMRIA".

Requesting Party: **LN Realty and Surveying Services**
Pupose: **Reference**
OR Number: **3943807 B**
T.N.: **2013-0593**

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

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

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

June 19, 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: **MISAMIS ORIENTAL**
Station Name: **MSE-25**
Order: **2nd**

Island: **MINDANAO**
Municipality: **VILLANUEVA**
Barangay: **POBLACION**

PRS92 Coordinates

Latitude:	**8° 35' 13.20618"**	Longitude:	**124° 46' 27.03667"**	Ellipsoidal Hgt:	**6.22900 m.**

WGS84 Coordinates

Latitude:	**8° 35' 9.60584"**	Longitude:	**124° 46' 32.43073"**	Ellipsoidal Hgt:	**73.92600 m.**

PTM Coordinates

Northing:	**949472.521 m.**	Easting:	**475142.313 m.**	Zone:	**5**

UTM Coordinates

Northing:	**949,584.36**	Easting:	**695,255.30**	Zone:	**51**

Location Description

MSE-25
From Cagayan de Oro travel E then N for about 24km to the municipality of Villanueva. About 100m past the municipal town hall is a road to the right (heading east) going to Claveria municipality. Follow this road for about 200m to a rice field at the right side. In the center of the rice field is a concrete irrigation canal. The station is about 150m S of the road centerline going to Claveria, beside the concrete irrigation canal, on the E side about 0.6m from the bend. Station mark is the head of a copper nail, top centered on a 30cm x 30cm x 60cm concrete block protruding by about 20cm with inscriptions, MSE-25, 2003 NAMRIA.

Requesting Party: **LN Realty and Surveying Services**
Pupose: **Reference**
OR Number: **3943777 B**
T.N.: **2013-0590**

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

9906192013155425

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

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Annexes

ANNEX E. RECONNAISSANCE SUMMARY

Cross Section Left	Image	Barangay	Municipality	Remarks	Comments
1		Natumolan	Tagoloan	Traversable	Located along dirt roads; banana plantations
2		Natumolan	Tagoloan	Traversable	Located along dirt roads; banana plantations
3		Natumolan	Tagoloan	Traversable	Located along dirt roads; banana plantations
4		Natumolan	Tagoloan	Traversable	Located along dirt roads; banana plantations
5		Natumolan	Tagoloan	Traversable	Located along dirt roads; banana plantations

Annexes

Cross Section Left	Image	Barangay	Municipality	Remarks	Comments
6		Natumolan	Tagoloan	Traversable	Located along dirt roads; banana plantations
7		Natumolan	Tagoloan	Traversable	Located along dirt roads; banana plantations
8		Natumolan	Tagoloan	Traversable	Located along dirt roads; banana plantations
9		Natumolan	Tagoloan	Traversable	Banana and coconut tree area; end points located in nearby mountain
10		Natumolan	Tagoloan	Traversable	Banana and coconut tree area; end points located in nearby mountain
11		Natumolan	Tagoloan	Traversable	Banana and coconut tree area; end points located in nearby mountain

Annexes

Cross Section Left	Image	Barangay	Municipality	Remarks	Comments
12		Natumolan	Tagoloan	Traversable	Banana and coconut tree area; end points located in nearby mountain
13		Natumolan	Tagoloan	Traversable	Banana and coconut tree area; end points located in nearby mountain
14		Natumolan	Tagoloan	Traversable	Banana and coconut tree area; end points located in nearby mountain
15		Natumolan	Tagoloan	Traversable	Banana and coconut tree area; end points located in nearby mountain
16		Natumolan	Tagoloan	Traversable	Banana and coconut tree area; end points located in nearby mountain
17		Natumolan	Tagoloan	Traversable	Built-up area; will pass through private properties

Annexes

Cross Section Left	Image	Barangay	Municipality	Remarks	Comments
18		Poblacion; Gracia	Tagoloan	Traversable	Located along Iligan-Cagayan de Oro-Butuan Road
19		Baluarte; Gracia	Tagoloan	Traversable	Will pass through few built up areas; generally traversable
20		Baluarte	Tagoloan	Traversable	Will pass through few built up areas; generally traversable
21		Baluarte	Tagoloan	Traversable	generally traversable
22		Baluarte	Tagoloan	Traversable	generally traversable
23		Baluarte	Tagoloan	Traversable	generally traversable

Cross Section Left	Barangay	Municipality	Remarks	Comments
1	Sta. Ines	Malitbog	Traversable	Generally traversable; coconut area
2	Rosario	Tagoloan	Traversable	Generally traversable; coconut area
3	Rosario	Tagoloan	Traversable	Generally traversable; coconut area
4	Rosario	Tagoloan	Traversable	Generally traversable; coconut area
5	Rosario	Tagoloan	Traversable	Generally traversable; coconut area
6	Rosario	Tagoloan	Traversable	Generally traversable
7	Rosario	Tagoloan	Traversable	Generally traversable
8	Santa Ana	Tagoloan	Traversable	Generally traversable
9	Santa Ana	Tagoloan	Traversable	Generally traversable
10	Santa Ana	Tagoloan	Traversable	Generally traversable
11	Santa Ana	Tagoloan	Traversable	Generally traversable; will pass through few built-up areas
12	Santa Ana	Tagoloan	Traversable	Generally traversable
13	Mohon	Tagoloan	Traversable	Generally traversable; will pass through few built-up areas
14	Mohon	Tagoloan	Traversable	Generally traversable; will pass through few built-up areas
15	Natumolan	Tagoloan	Traversable	Generally traversable; will pass through few built-up areas
16	Natumolan	Tagoloan	Traversable	Generally traversable; will pass through few built-up areas
17	Natumolan	Tagoloan	Traversable	Generally traversable; will pass through few built-up areas
18	Poblacion; Gracia	Tagoloan	Traversable	Located along Iligan-Cagayan de Oro-Butuan Road
19	Baluarte; Gracia	Tagoloan	Traversable	Generally traversable
20	Baluarte	Tagoloan	Traversable	Generally traversable
21	Baluarte	Tagoloan	Traversable	Generally traversable
22	Baluarte	Tagoloan	Traversable	Generally traversable
23	Baluarte	Tagoloan	Traversable	Generally traversable

ANNEX F. OUTSOURCE CROSS-SECTION AND PROFILE

PROFILE AND CROSS SECTION SURVEY IN DAVAO RIVER, DAVAO DEL SUR

DREAM
Disaster Risk and Exposure Assessment for Mitigation

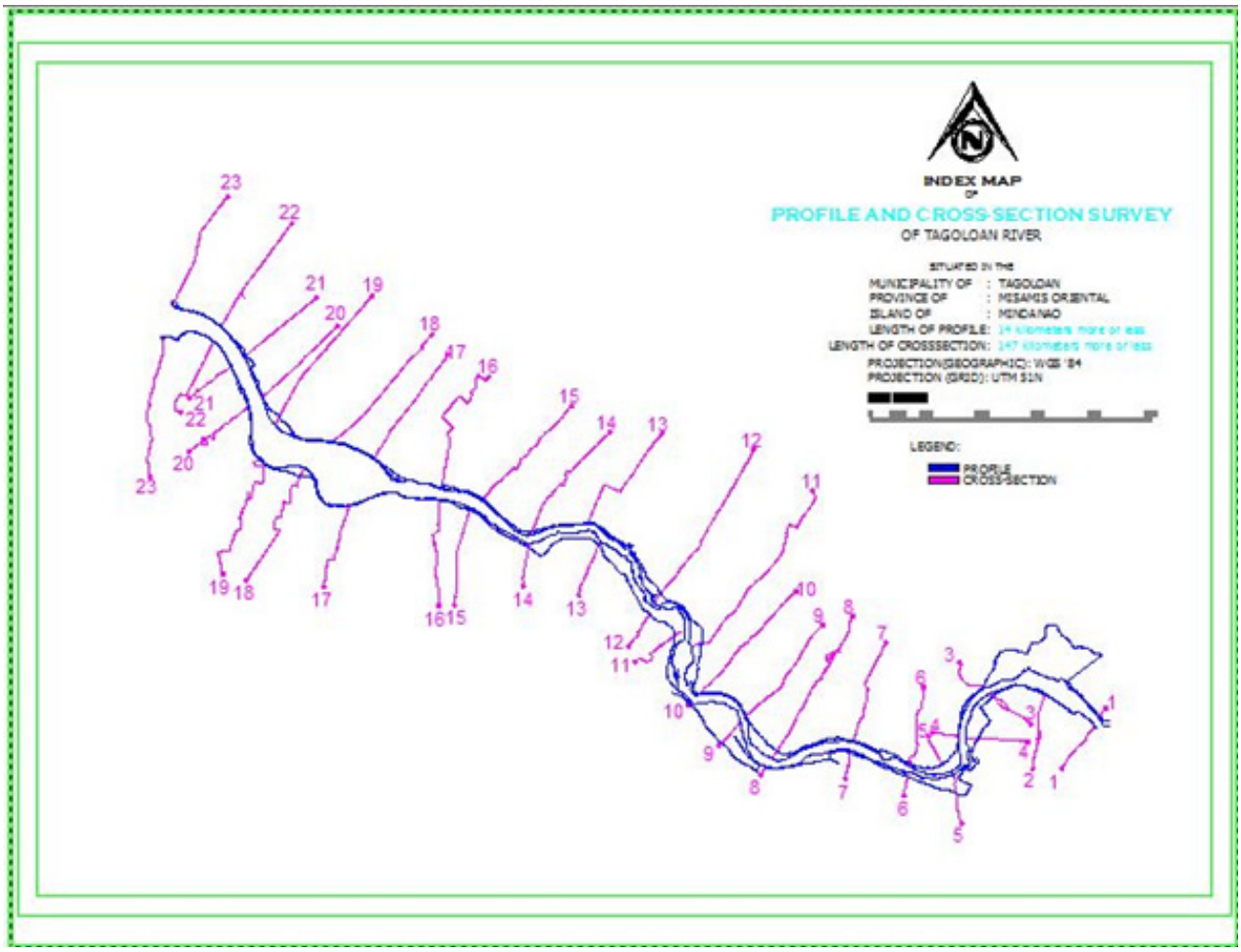


Figure 1: Index Map of the Profile and Cross-section Surveys in Tagoloan River

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

Annexes

Annexes

Annexes

Annexes

DAR	Department of Agrarian Reform
NIA	National Irrigation Administration
NHA	National Housing Authority
DENR	Department of Environment and Natural Resources
DREAM	Disaster Risk and Exposure Assessment for Mitigation
LiDaR	Light Detection and Ranging
TCAGP	Training Center for Applied Geodesy and Photogrammetry
NAMRIA	National Mapping and Resource Information Authority
GE	Geodetic Engineer
BM	benchmark
GCP	Ground Control Point
PT	Profile team
CST	Cross-section team
TBC	Trimble Business Center

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 The University of the Philippines-Training Center for Applied Geodesy and Photogrammetry (UP-TCAGP) is conducting a "Nationwide Disaster Risk Exposure and Assessment for Mitigation" (DREAM) research program which aims to acquire elevation and resource data set at sufficient resolution using Light Detection and Range (LiDAR) technology to produce information necessary to support the different phases of disaster management. In order to validate the accuracy of the gathered LiDAR data, ground validation surveys such as cross-section and profile survey, is needed.

1.1.3 Tagoloan River is the 13th largest river system in the Philippines in terms of watershed size. It has an estimated drainage area of 1,704 square kilometers covering the Province of Bukidnon and Misamis Oriental. It has a length of 106 kilometers from its source in Malaybalay City, Province of Bukidnon.

1.1.4 LN Realty and Surveying Services is tasked by University of the Philippines-Training Center for Applied Geodesy and Photogrammetry (UP-TCAGP) to conduct cross-section and profile survey on Tagoloan River.

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. It shall consist of the left bank and right bank surveys on the upper and lower part of the river with an extent of 14.983 km. each.

1.2.4 Scope 4: Cross-section Survey. GPS survey on the 23 cross-sectional lines along Tagoloan River which has a total distance of 147.63 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.

Figure 2: Members of the survey team

Prior to the actual fieldwork, the survey team conducted a reconnaissance in the area on April 05 to April 15, 2013. The actual field surveys were done for forty two (42) days from May 16 to June 11, 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. The items listed below were the tasks considered in the preparation of a field plan.

1. Scheduling of Activities
2. Assignment of each member of the survey team in the implementation of the survey project.
3. Enumeration of the instruments and equipments to be used in the survey project.
4. Processing of the data gathered.
5. Preparation of the reports to be submitted to UP-TCAGP.

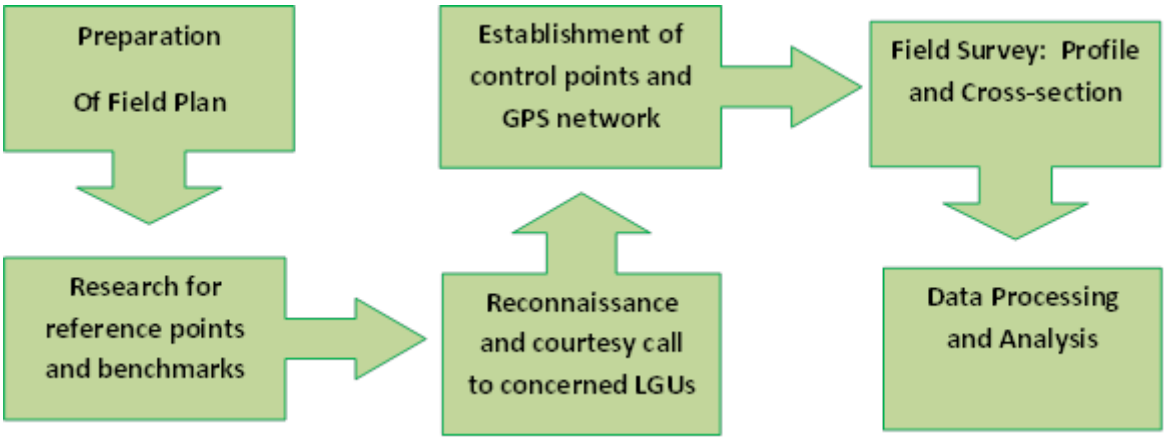


Figure 3: Flowchart of the field survey

2.2 Reconnaissance

The team conducted a reconnaissance for the cross-section and profile survey. The proposed cross-section and profile data of Tagoloan River provided by UP-TCAGP were inspected on the ground. Possible routes for the cross section lines and the bank profiles were inspected. The team also searched for previously established benchmarks which are in the proximity of the river that can be used as a reference point in the GPS observation of the newly established control points and in the establishment of base stations in the GPS 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 was also done. The NAMRIA recovered ground control points will be used as reference points in the GPS observation of the newly established control points and in the establishment of networks of base stations in the GPS survey. Also, certifications of the recovered ground control points were sought at the NAMRIA head office.

2.4 Establishment of control points and GNSS network

For the survey team to get accurate and precise measurements in the GPS surveying, a static GPS observation was performed. This is needed to establish the position of the reference base stations for the GPS survey in the conduct of the profile and cross-section survey along Tagoloan River. Four base stations were set up in three NAMRIA established control points; two reference points, one benchmark and a control point which was established primarily for this fieldwork. Static observations were simultaneously performed at these four base stations for an hour and a half. A South S86 and S66 Receiver were used for the static observation. The base stations for static observations are as follows:

- TGBM inside Macabalan Port (see Figure 4)
- MSE 25 beside a concrete irrigation canal at Poblacion, Villanueva, Misamis (see Figure 5)
- MSE 3242 at the foot of Umalag bridge, Tablopn, Cagayan de Oro City (see Figure 6)
- UP established control point (see Figure 7)

Figure 4: Static observation on TGBM inside Macabalan Port

Figure 5: Static observation on MSE-25 beside a concrete irrigation canal at Brgy. Poblacion, Villanueva, Misamis Oriental

Figure 6: MSE-3242 at the foot of Umalag Bridge, Brgy. Tablon, Cagayan de Oro City was used during the static observation

Figure 7: UP established control point

2.5 Ground Survey

2.5.1 Profile Survey

The survey team then proceeded to conduct the profile survey along Tagoloan River. The left and right banks were measured separately where the left and right banks were further divided into upper left bank, lower left bank and upper right bank and lower right bank.

The profile team is composed of five persons: one member stayed and observed on the base station while the other four members formed two profile teams with two members for each team. In every team, one person held the antenna while the other held 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 Sta. Ana, Sitio Maribuhok and ended downstream at Barangay Baluarte for both the left and right bank. An interval of 10 meters was observed in between profile points. Profiles of the upper left bank, upper right bank, lower left bank and lower right bank were gathered during the survey.

Figure 8: Profile survey on the right bank of Tagoloan River

Figure 9: PT member conducting a profile survey in Tagoloan River

2.5.2 Cross-Section Survey

Another set of ground survey was conducted along Tagoloan River. Cross-sections were surveyed perpendicular to the riverbanks of Tagoloan River. Just like in profile surveys, the cross-section survey also has two cross-section teams where one person manned the base station which was set up at a known location. Each cross-section team, using a handheld GPS receiver to locate the planned lines, started from the pre-determined starting point and from there, an approximate of 10 meter interval is observed in every point and measured using a survey grade GPS receivers.

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 would be good. In areas, where the proposed cross section line cannot be followed due to some obstructions, the team either looked for an alternate path which runs parallel to the planned cross section line or proceeded to the succeeding point of the cross-section line.

Figure 10: CST member holding an antenna during the conduct of cross-section survey inside a banana plantation

Figure 11: CST members conducting a cross-section survey of Tagoloan River

2.6 Data Processing and Analysis

2.6.1 Cross-Section Data

Processing of the cross-section data are as follows:

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

Annexes

3.1 Reconnaissance Survey

The team that conducted the reconnaissance on the area reported that most of the proposed routes are passable. For those that are not passable, alternate routes were prepared. Control points that will be used during the survey were also identified.

3.2 Actual Survey

The actual field works lasted for 42 days from May 16 to June 11, 2013. The figures below show the actual result of the profile and cross-section survey of Tagoloan River.

Table 1: Two control points, one benchmark and a ground point was occupied in the survey

Base Station	Order of Accuracy	WGS84 UTM Zone 51N					Elevation in MSL (m)
		Latitude	Longitude	Ellipsoidal Height (m)	Northing (m)	Easting (m)	
MSE-25	2nd	8.58600148	124.775675	73.980	949534.35	695418.47	4.367
MSE-3242	3rd	8.48105468	124.727511	76.236	937902.72	690168.26	5.913
TGBM	1st	8.50060368	124.664291	70.923	940034.43	683197.72	1.090
UP Control		8.53181057	124.804607	131.519	943555.29	698631.61	61.323

3.2.1 Profile Survey Results

The profile survey of Tagoloan River was conducted from May 17 to May 26, 2013. The total length covered during the profile survey on each side of the bank is tabulated below. During the conduct of survey, gaps were found upon process of data and those gaps were not included in the getting the total length of surveyed profile. Also the total number of points that were surveyed on each side of the banks can also be seen below.

Table 2: Total number of gathered points with corresponding

Profile	Total No. of Points Gathered	Length of Surveyed Profile (km)
Upper Left	2,118	14.983
Lower Left	2,244	14.890
Upper Right	2,862	14.038
Lower Right	2,664	15.100
TOTAL	**9,888**	

The total number of points gathered during the profile survey is 9,888, 4362 points for the left profile and 5526 points for the right profile of Tagoloan River.

The next two figures on the next page are index map of the left and right profile survey of Tagoloan River.

3.2.2 Cross-Section Survey Results

The cross-section survey was conducted from May 27 – June 08, 2013. The tables and figures in the next pages show the results during the cross-section survey.

Table 3: Total number of surveyed points and total length of cross-section

Cross-Section	Total No. of Points Surveyed		Total Length Surveyed (km)	
	Left	Right	Left	Right
1	78	10	0.581	0.104
2	128	-	0.836	-
3	109	68	0.581	0.508
4	89	38	0.663	0.289
5	80	46	0.561	0.351
6	36	106	0.256	0.897
7	53	158	0.311	1.146
8	19	314	0.136	1.789
9	41	192	0.327	1.195
10	3	221	0.036	1.512
11	89	333	0.751	2.327
12	63	301	0.442	1.933
13	105	195	0.643	1.378
14	61	223	0.487	1.494
15	135	240	1.059	1.467
16	166	252	1.227	1.828
17	120	184	1.041	1.373
18	244	234	1.621	1.595
19	276	295	1.913	1.863
20	165	173	1.057	1.127
21	79	153	0.572	1.023
22	117	208	0.983	1.410
23	233	160	1.597	1.310
TOTAL	**2,849**	**4,104**	**17.69018**	**27.929**

Table 3 shows the total number of points surveyed and the total length of surveyed on each cross-section line. The total number of points surveyed for the left cross section is 2849 while the right cross section has 4,104 points. Cross-section 19 has the most number of points while cross section 10 has the least for the right cross-section. As for the left cross-section, cross-section 11 as the most number of points while cross section 1 has the least.

3.3 Problems Encountered and Solutions Applied

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

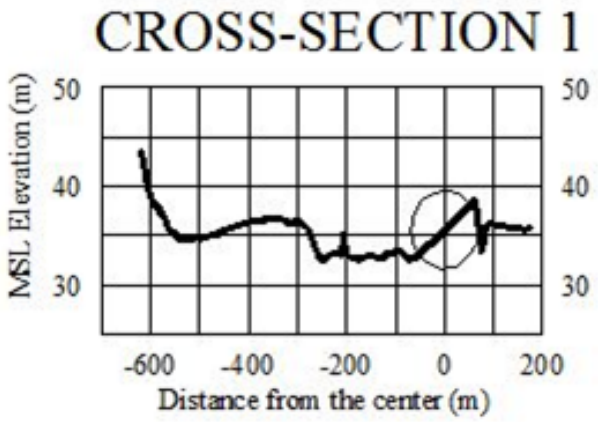
Table 4: Problems encountered by the survey teams and suitable solutions applied

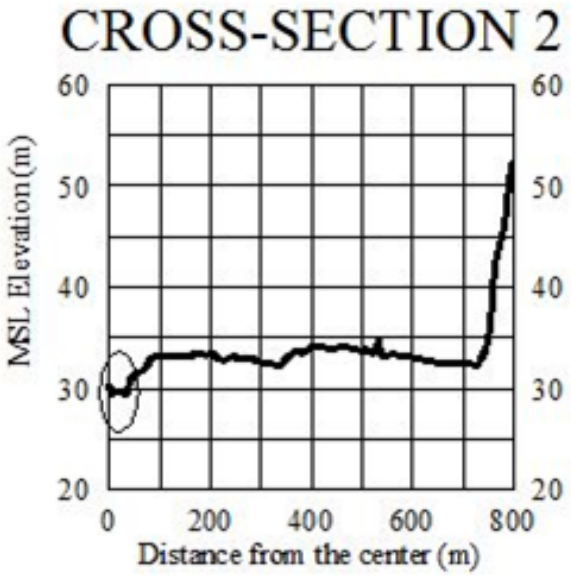
Limitation/Problems	Solutions
1.) May 18: cannot continue XSL01 and XSL02 due to the end points is in the cliff area already	continue to the next cross-section
2.) May 27: cannot continue XSL05, XSL06, XSL07 due to the end points is in the cliff area already	continue to the next cross-section
3.) June 07: cannot continue XSL14, XSL15, XSL16 due to the end points is in the cliff area already	continue to the next cross-section
4.) June 08: cannot continue XSL08 due to the end points is in the cliff area already	continue to the next cross-section
5.) May 18:Did not pursue XSR02 because the starting point is a cliff and ends on mountain	continue to the next cross-section

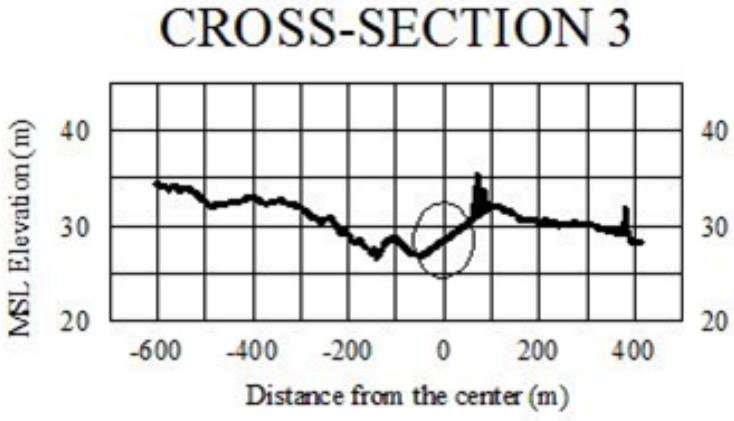
Figure 12: Cross-section on a cliff

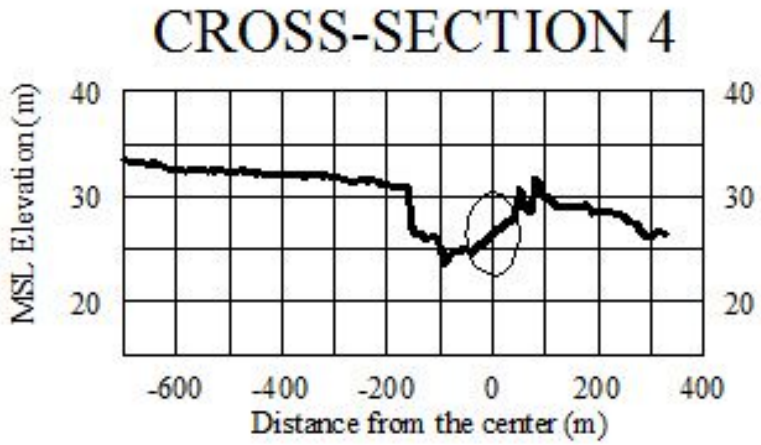
3.4 Processed Data

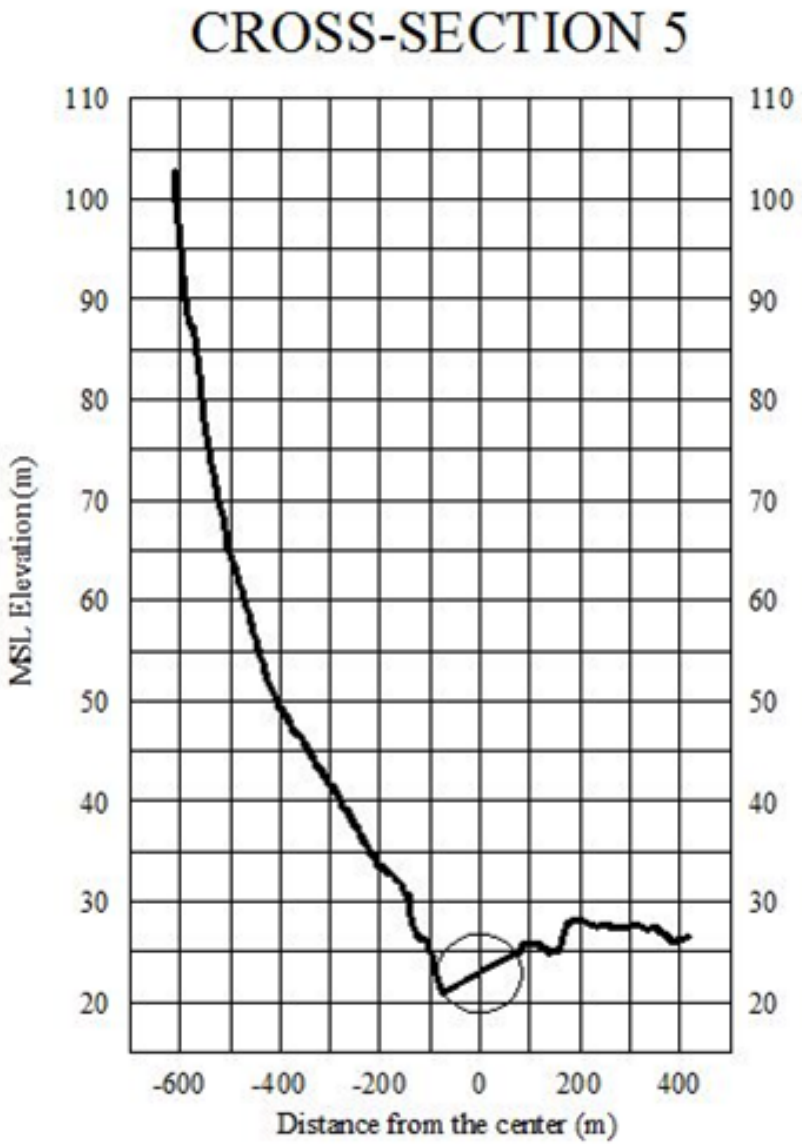
The following series of diagrams shows the respective cross-sections. Note that the encircled portion indicates no data since it is the bathymetry portion of the cross-section which the UP-DREAM already performed.

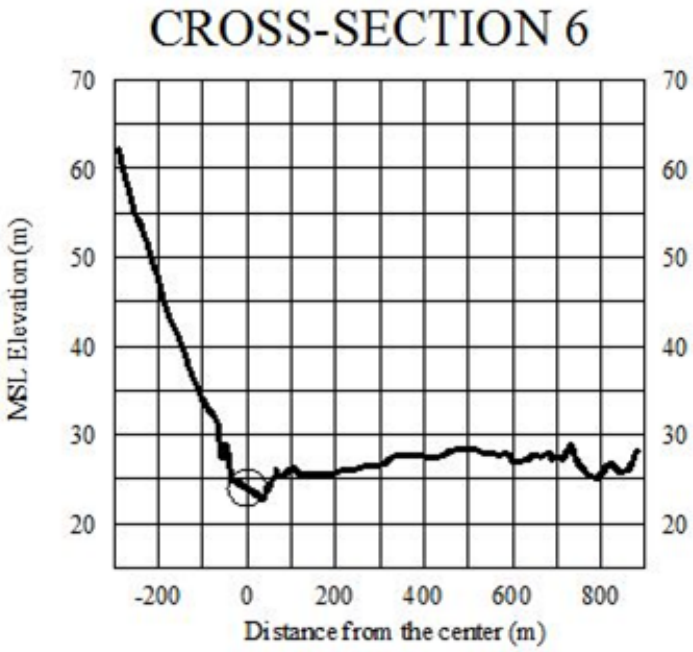


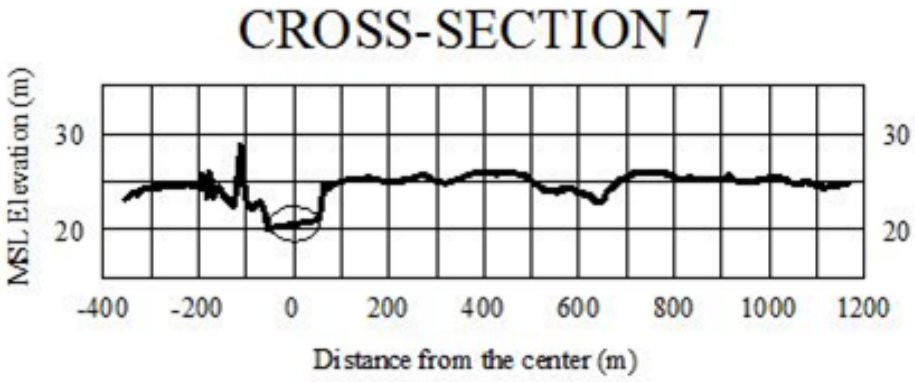


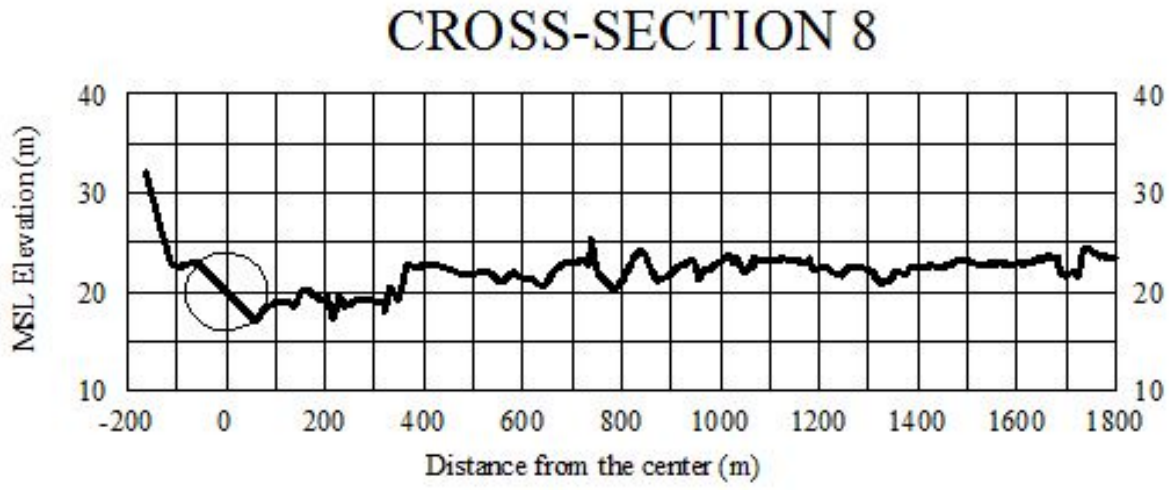


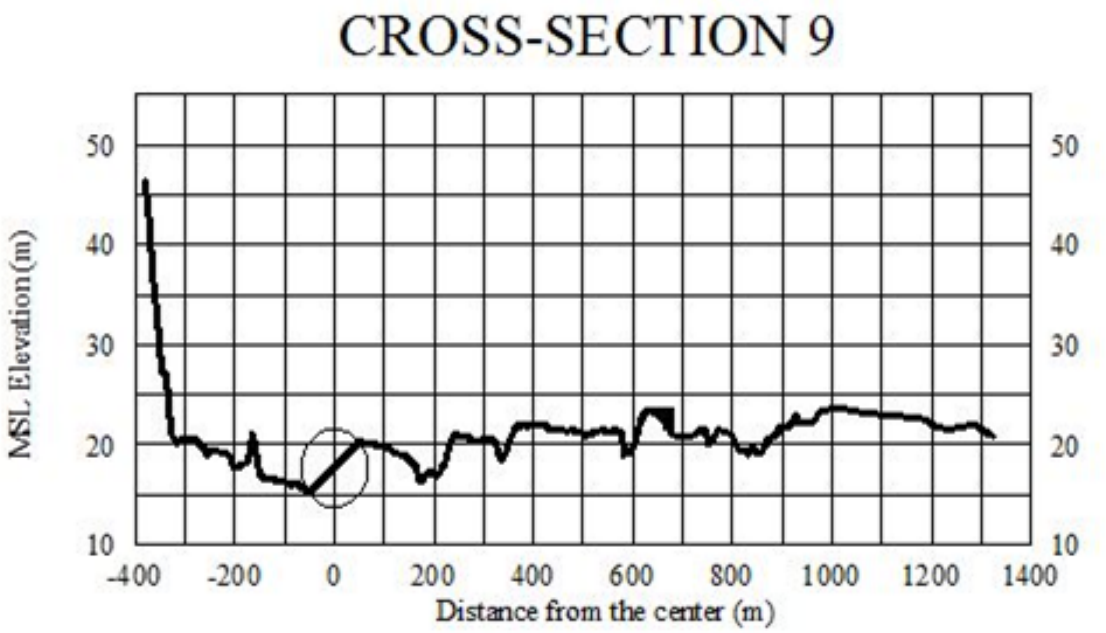

CROSS-SECTION 4
MSL Elevation (m)
40
30
20
-600
-400
-200
0
200
400
Distance from the center (m)

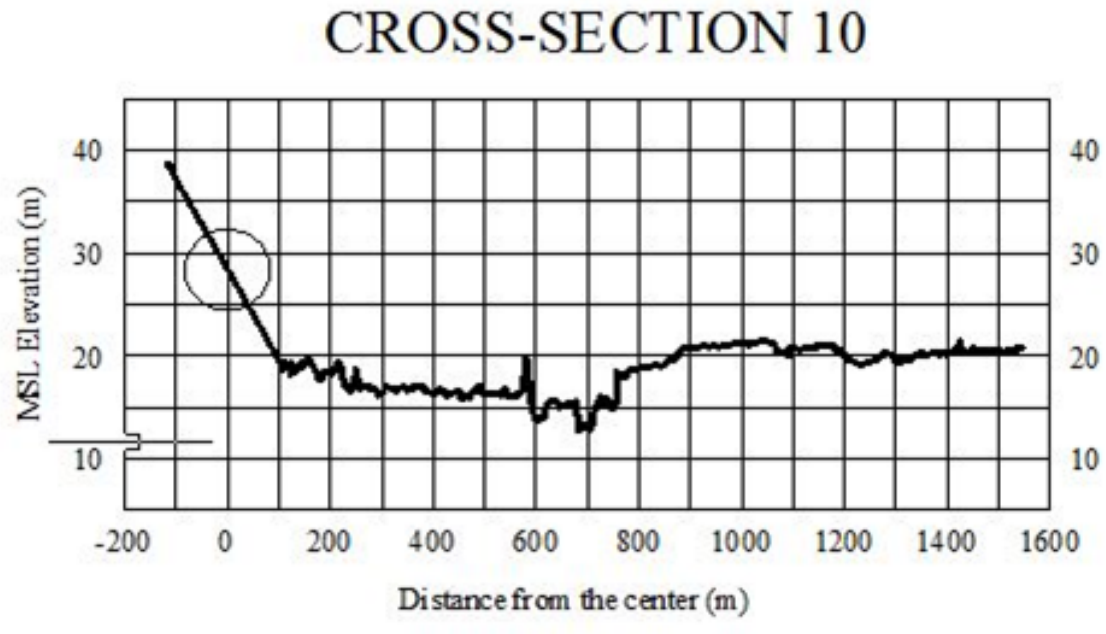

CROSS-SECTION 5
MSL Elevation (m)
110
100
90
80
70
60
50
40
30
20
-600
-400
-200
0
200
400
Distance from the center (m)

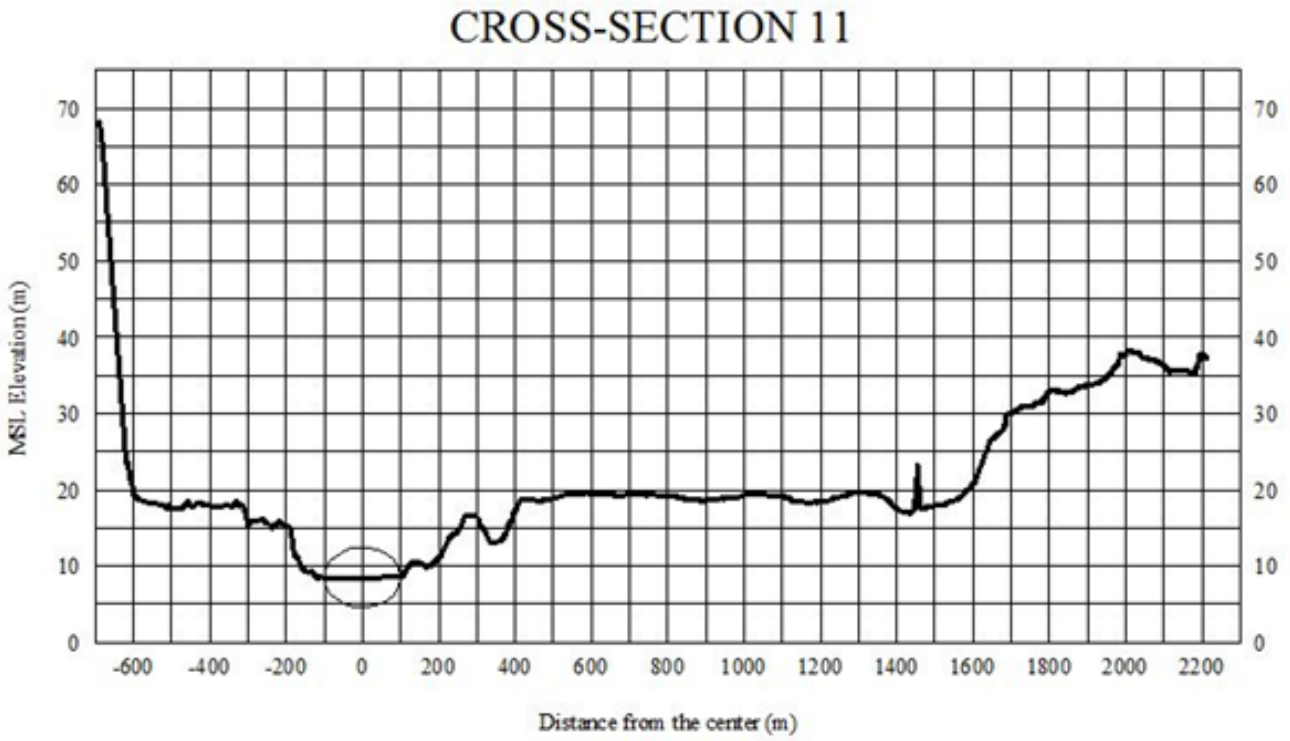

CROSS-SECTION 6
MSL Elevation (m)
70
60
50
40
30
20
-200
0
200
400
600
800
Distance from the center (m)

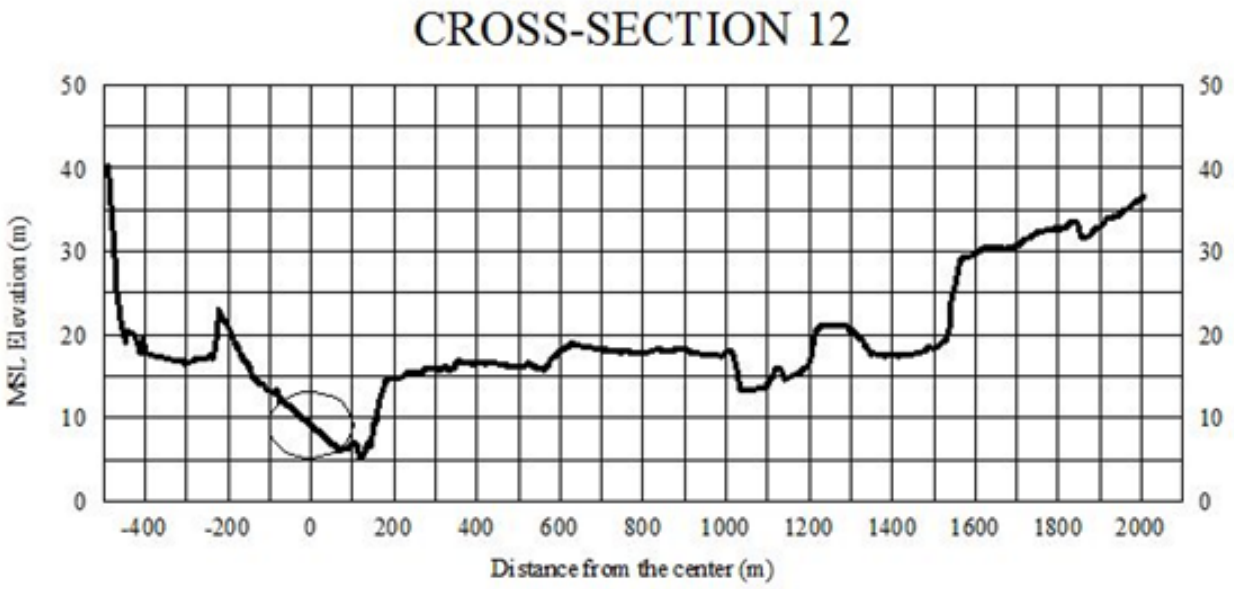

CROSS-SECTION 7
MSL Elevation (m)
30
20
-400
-200
0
200
400
600
800
1000
1200
Distance from the center (m)

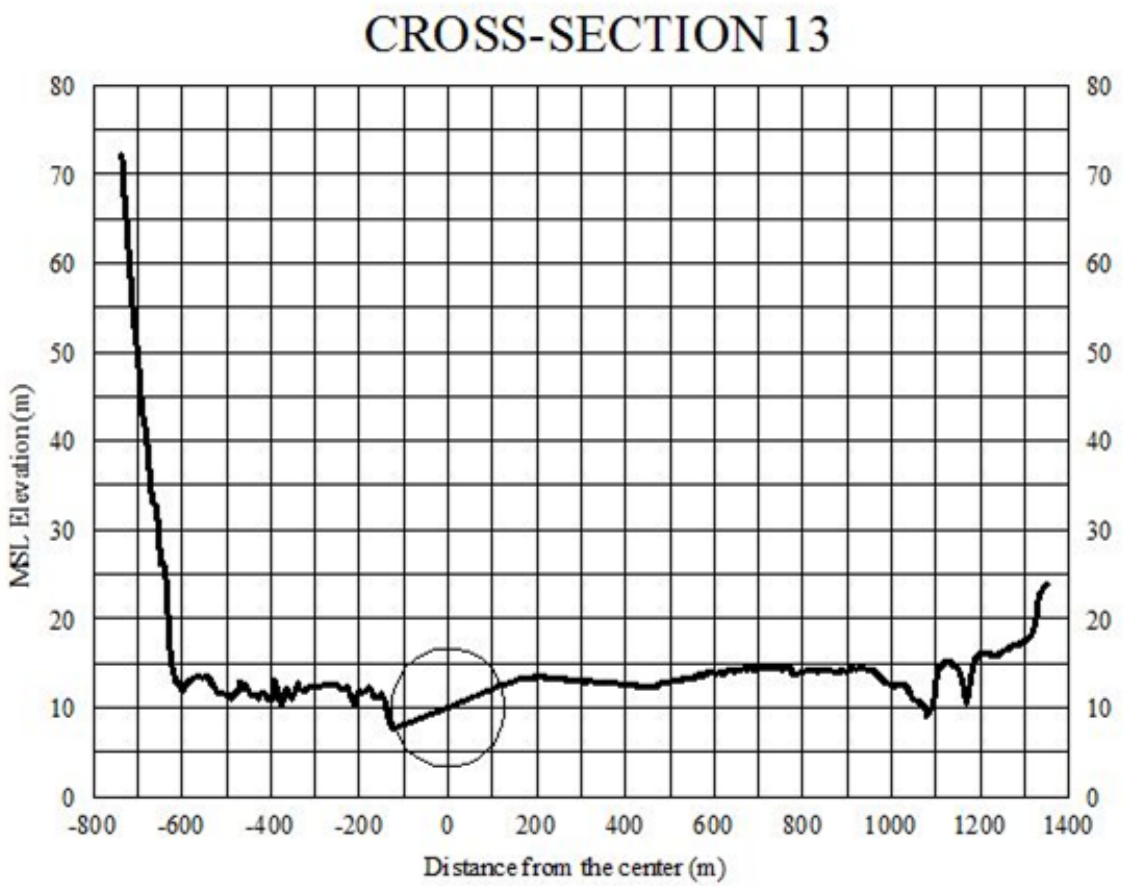

CROSS-SECTION 8
MSL Elevation (m)
40
30
20
10
-200
0
200
400
600
800
1000
1200
1400
1600
1800
Distance from the center (m)

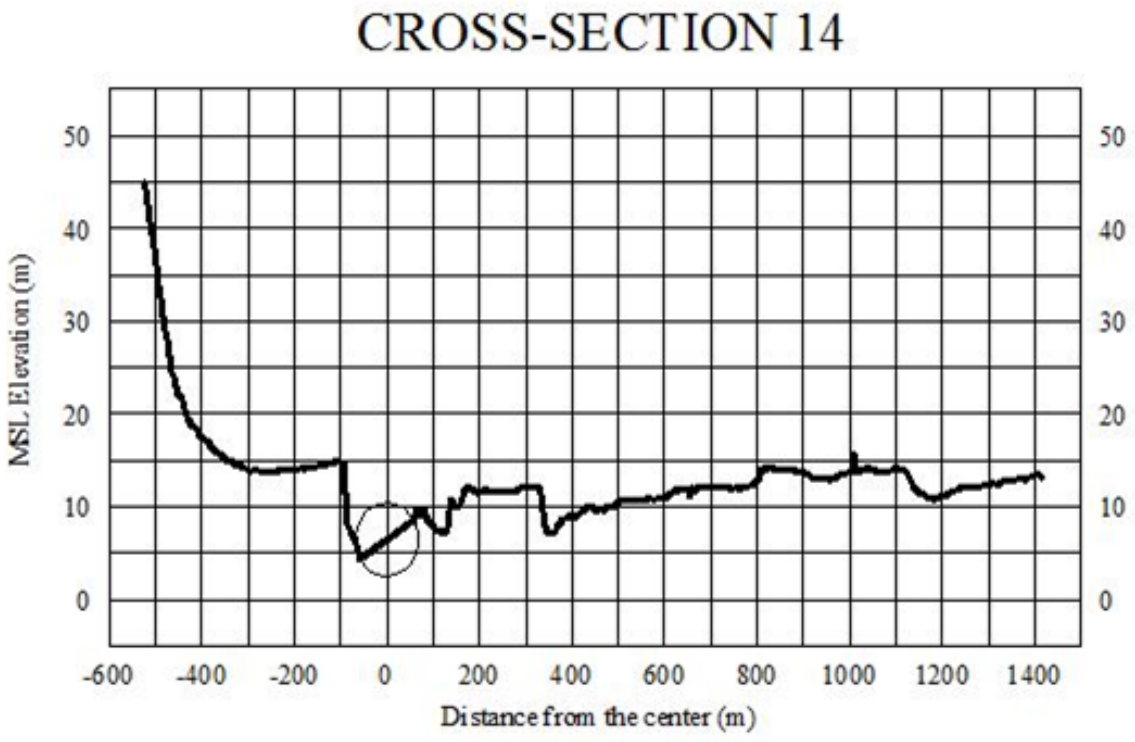

CROSS-SECTION 9
MSL Elevation (m)
50
40
30
20
10
-400
-200
0
200
400
600
800
1000
1200
1400
Distance from the center (m)

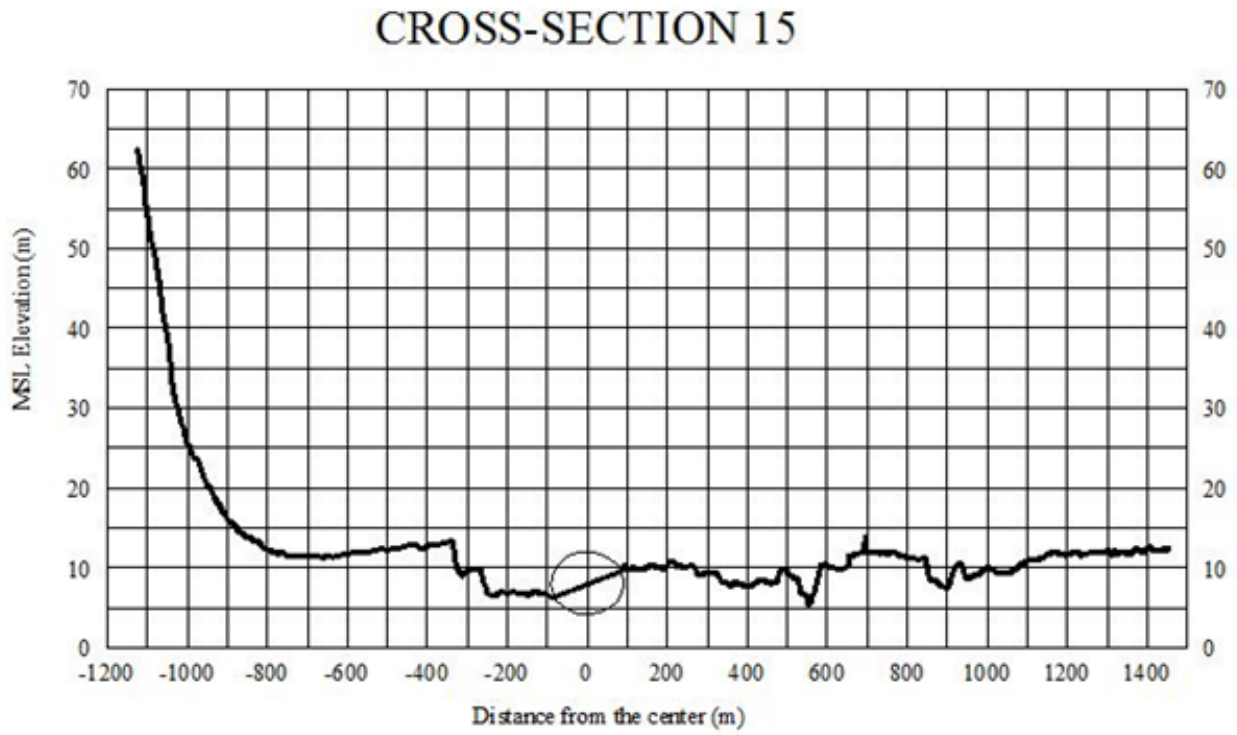

CROSS-SECTION 10
MSL Elevation (m)
40
30
20
10
-200
0
200
400
600
800
1000
1200
1400
1600
Distance from the center (m)

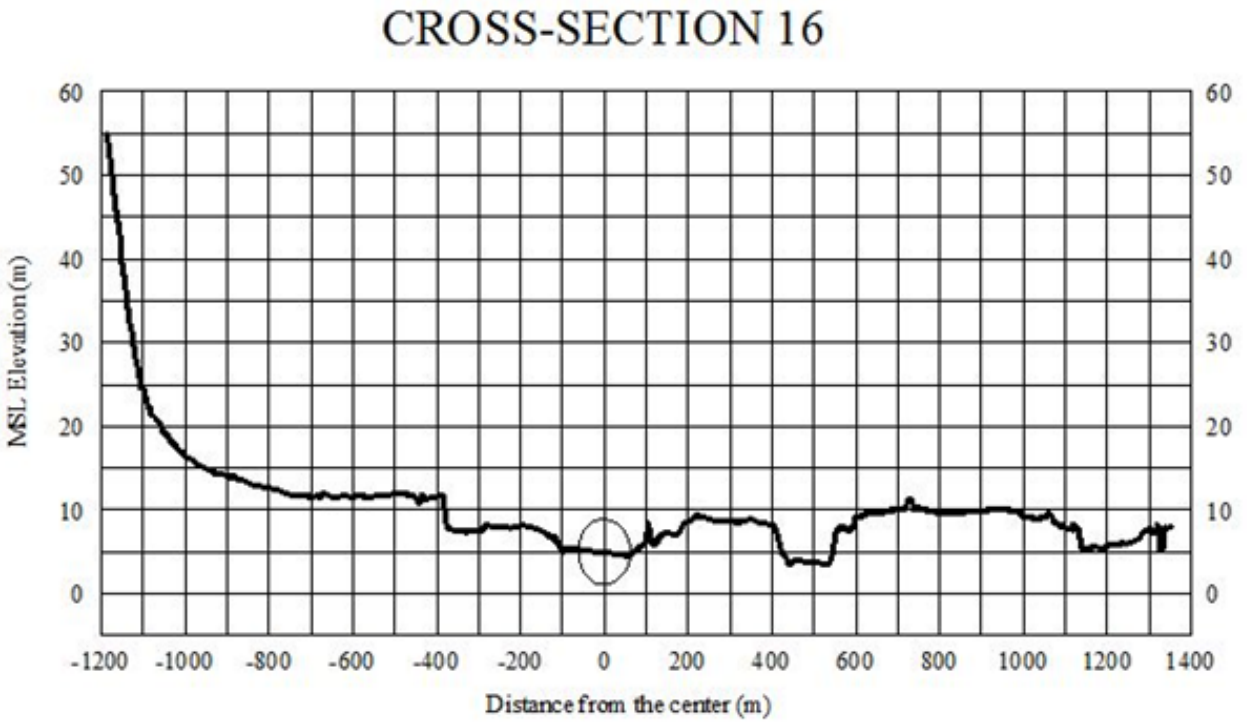

CROSS-SECTION 11
MSL Elevation (m)
70
60
50
40
30
20
10
0
-600
-400
-200
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
Distance from the center (m)


CROSS-SECTION 12
MSL Elevation (m)
50
40
30
20
10
0
-400
-200
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Distance from the center (m)


CROSS-SECTION 13
MSL Elevation (m)
Distance from the center (m)
80
70
60
50
40
30
20
10
0
-800
-600
-400
-200
0
200
400
600
800
1000
1200
1400


CROSS-SECTION 14
MSL Elevation (m)
Distance from the center (m)
50
40
30
20
10
0
-600
-400
-200
0
200
400
600
800
1000
1200
1400


CROSS-SECTION 15
MSL Elevation (m)
70
60
50
40
30
20
10
0
-1200 -1000 -800 -600 -400 -200 0 200 400 600 800 1000 1200 1400
Distance from the center (m)


CROSS-SECTION 16
MSL Elevation (m)
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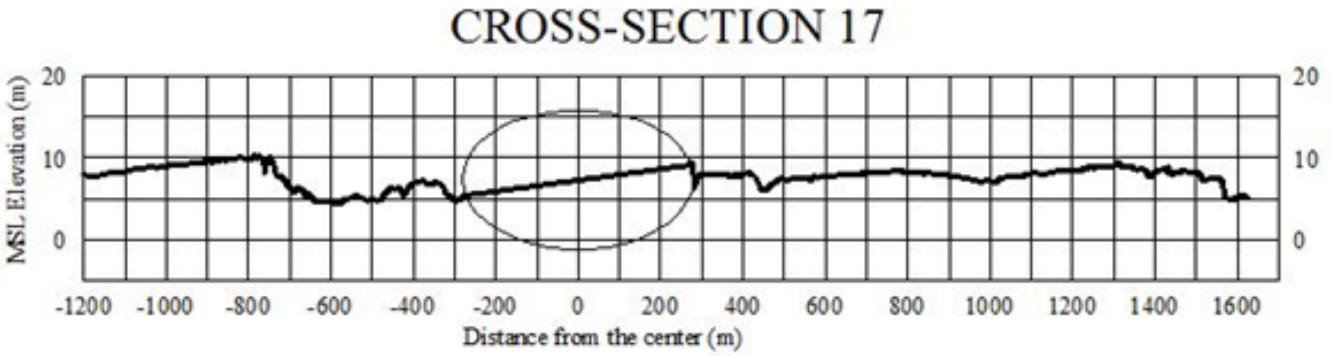
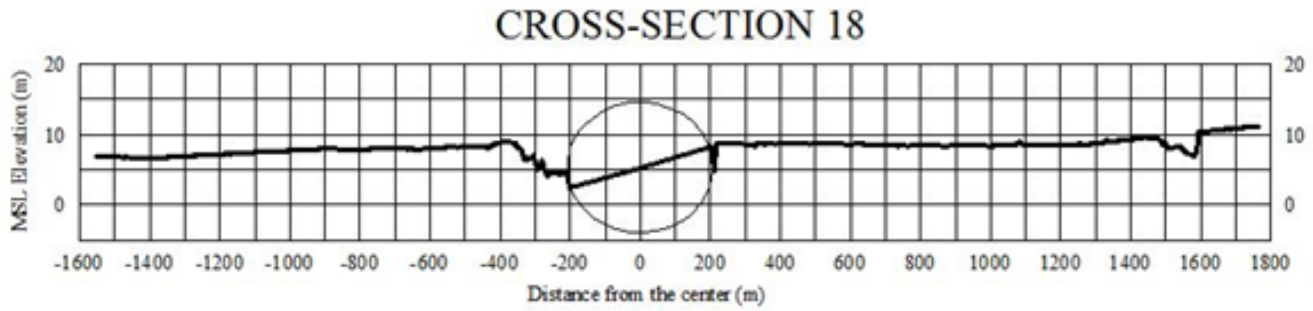
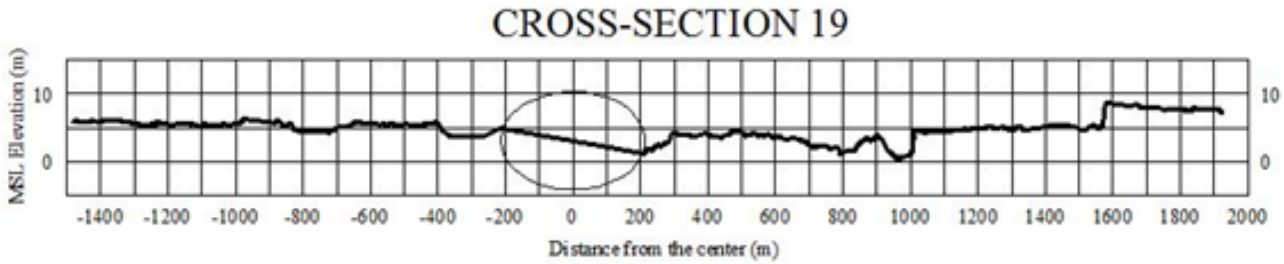
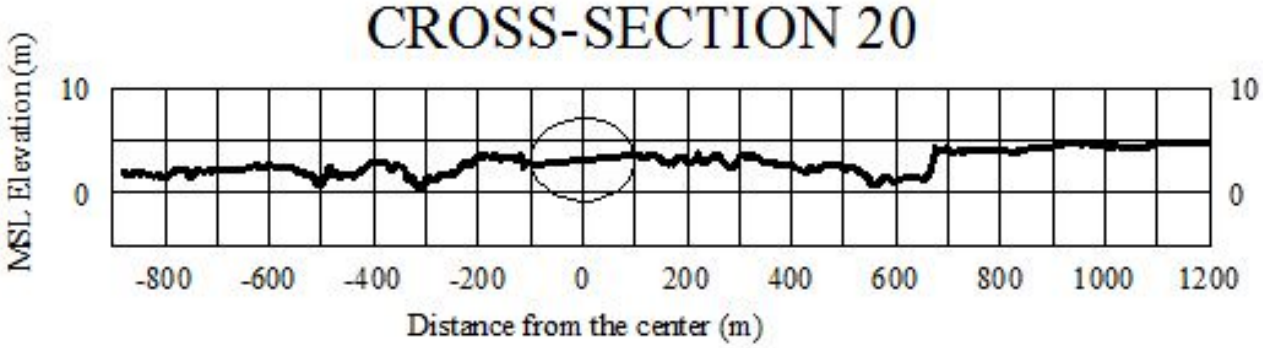
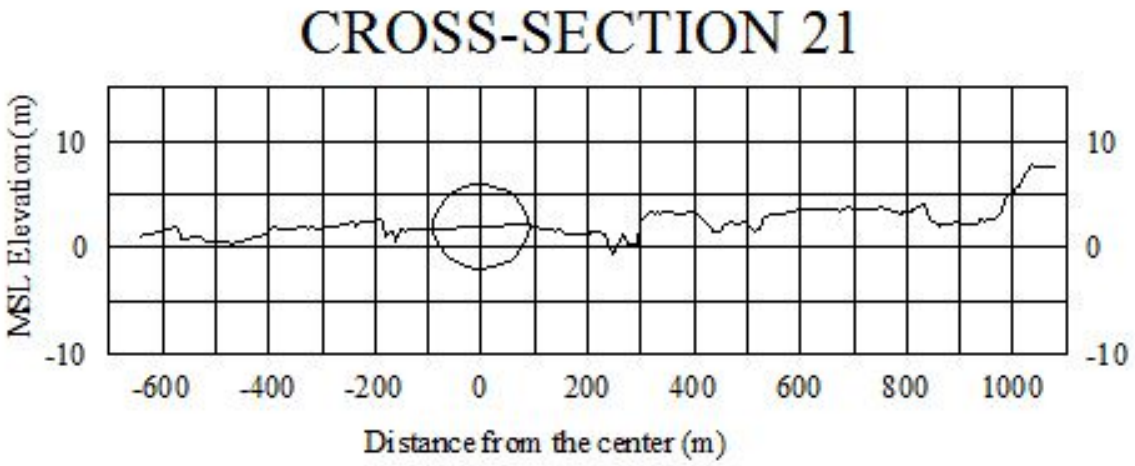
50
40
30
20
10
0
-1200 -1000 -800 -600 -400 -200 0 200 400 600 800 1000 1200 1400
Distance from the center (m)

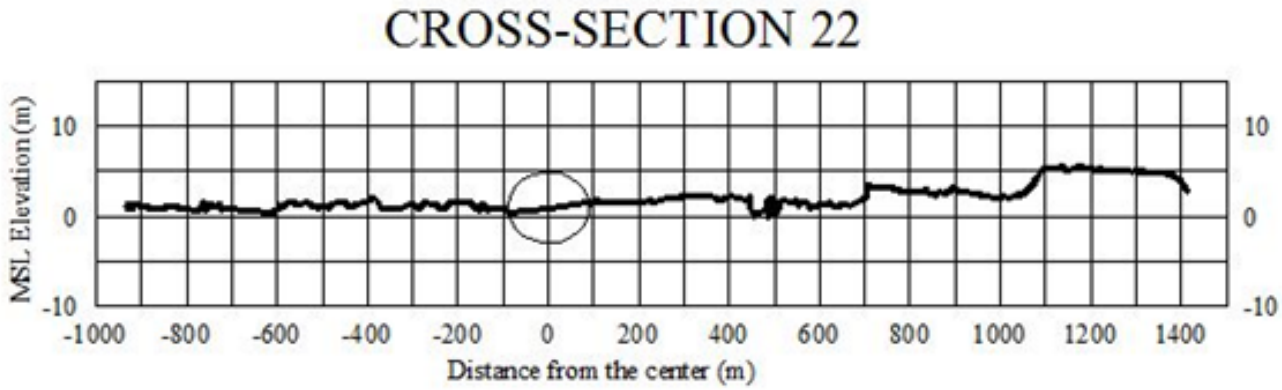

CROSS-SECTION 17
MSL Elevation (m)
20
10
0
-1200 -1000 -800 -600 -400 -200 0 200 400 600 800 1000 1200 1400 1600
Distance from the center (m)

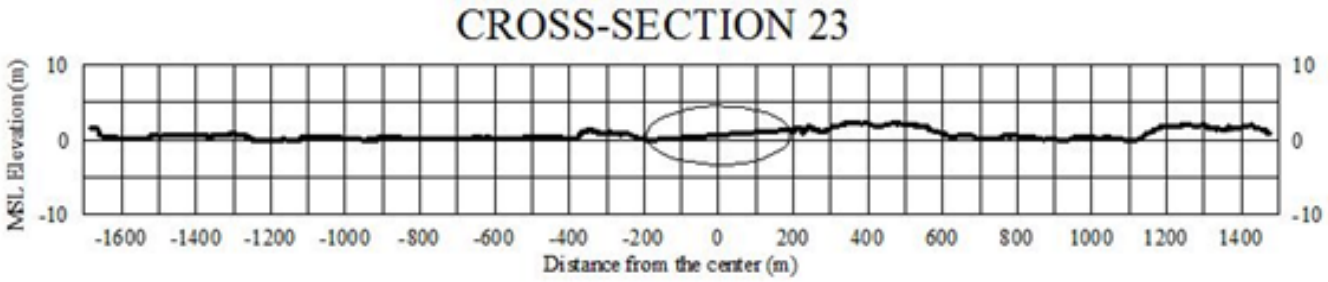

CROSS-SECTION 18
MSL Elevation (m)
20
10
0
-1600 -1400 -1200 -1000 -800 -600 -400 -200 0 200 400 600 800 1000 1200 1400 1600 1800
Distance from the center (m)


CROSS-SECTION 19
MSL Elevation (m)
10
0
-1400 -1200 -1000 -800 -600 -400 -200 0 200 400 600 800 1000 1200 1400 1600 1800 2000
Distance from the center (m)


CROSS-SECTION 20
MSL Elevation (m)
10
0
-800 -600 -400 -200 0 200 400 600 800 1000 1200
Distance from the center (m)

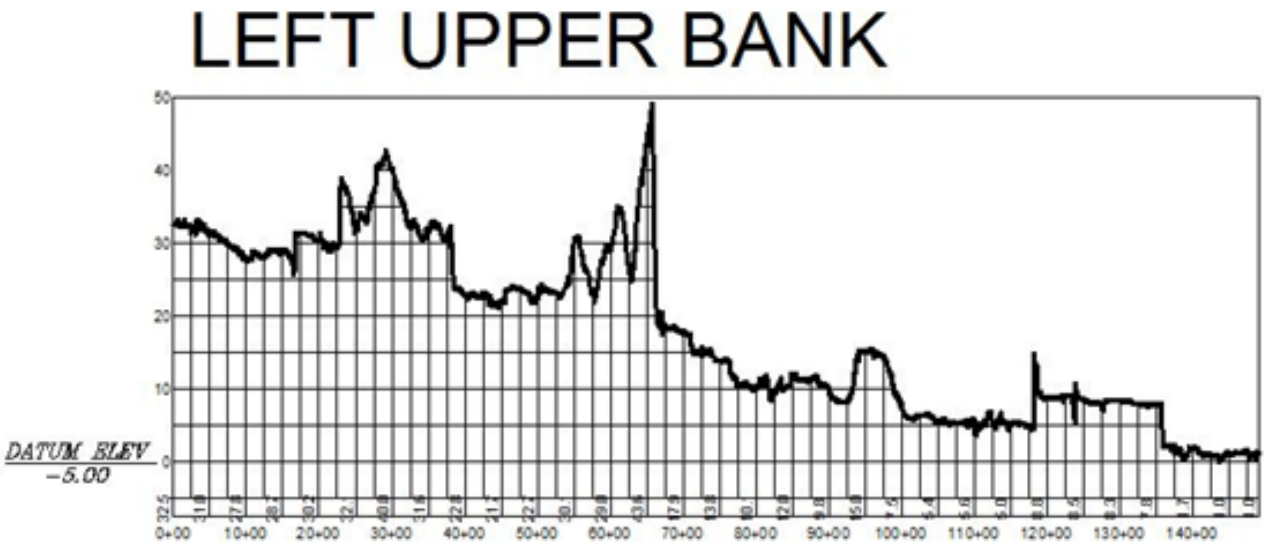

CROSS-SECTION 21
MSL Elevation (m)
10
0
-10
-600
-400
-200
0
200
400
600
800
1000
Distance from the center (m)

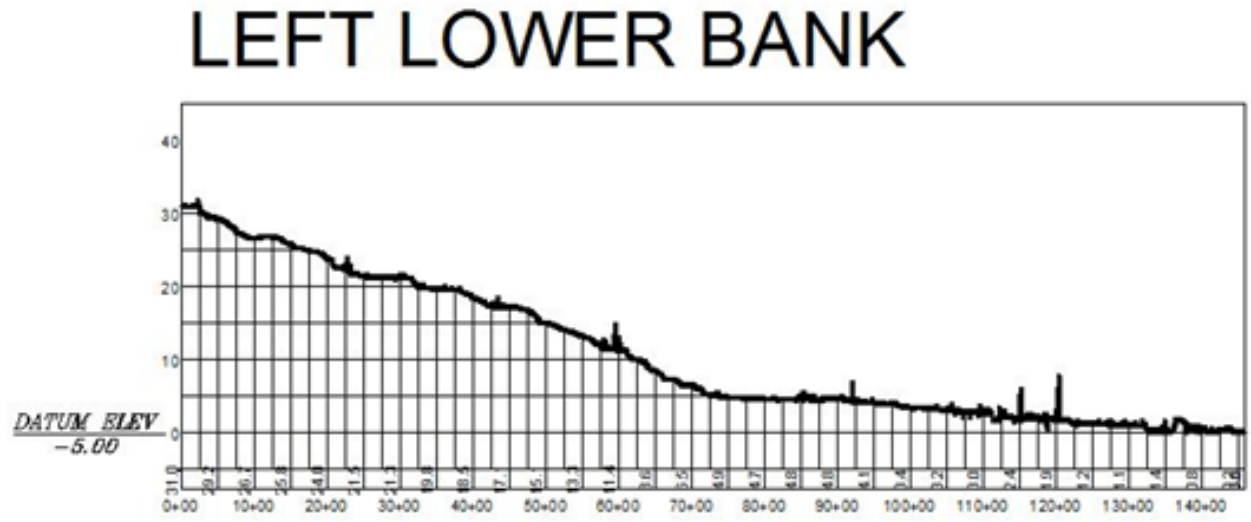

CROSS-SECTION 22
MSL Elevation (m)
10
0
-10
-1000
-800
-600
-400
-200
0
200
400
600
800
1000
1200
1400
Distance from the center (m)


CROSS-SECTION 23
MSL Elevation (m)
10
0
-10
-1600
-1400
-1200
-1000
-800
-600
-400
-200
0
200
400
600
800
1000
1200
1400
Distance from the center (m)

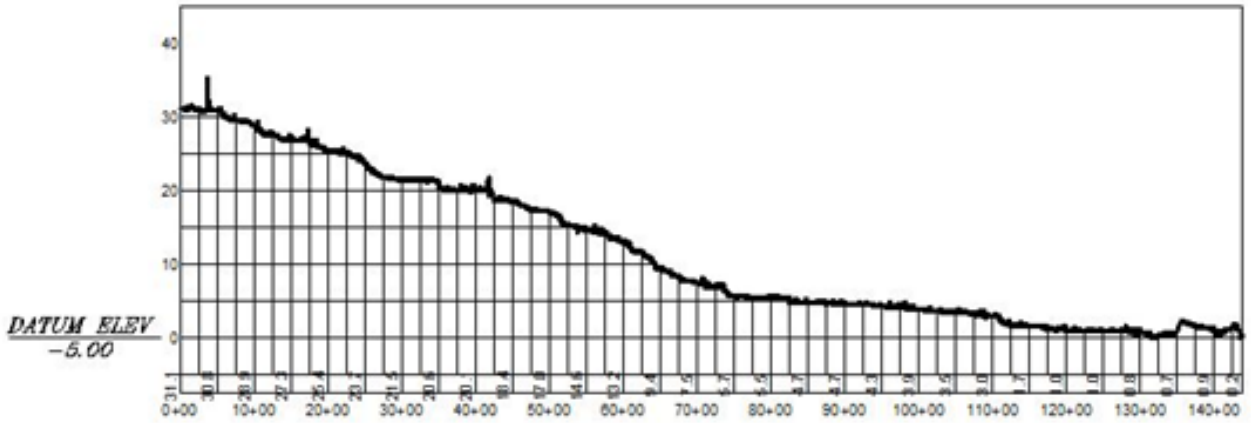
Annexes

The following images indicate the profile of the upper and lower banks on both sides of Tagoloan River:

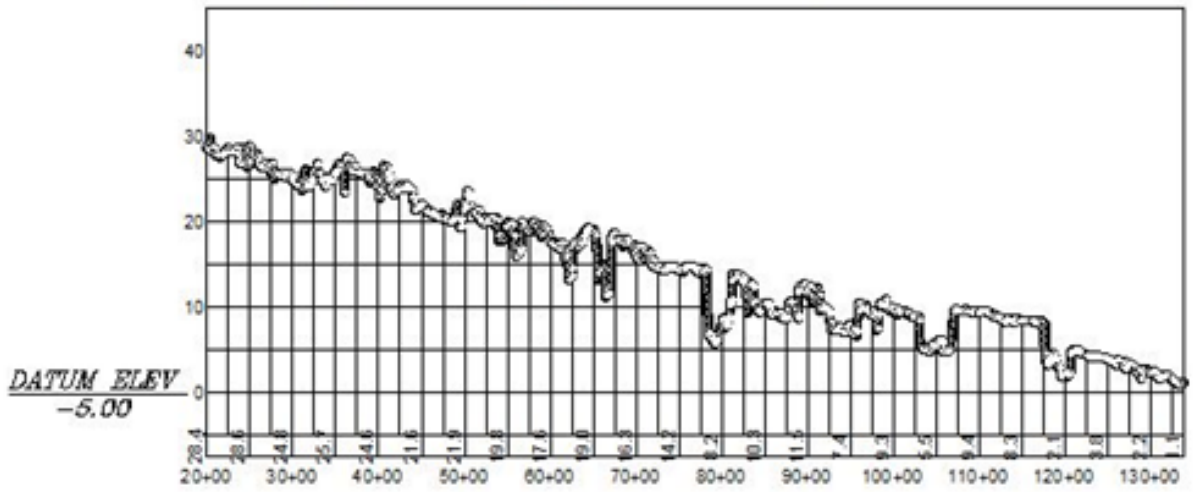




RIGHT LOWER BANK



RIGHT UPPER BANK



Annexes

ANNEX A. MAP OF THE RIVER SYSTEM

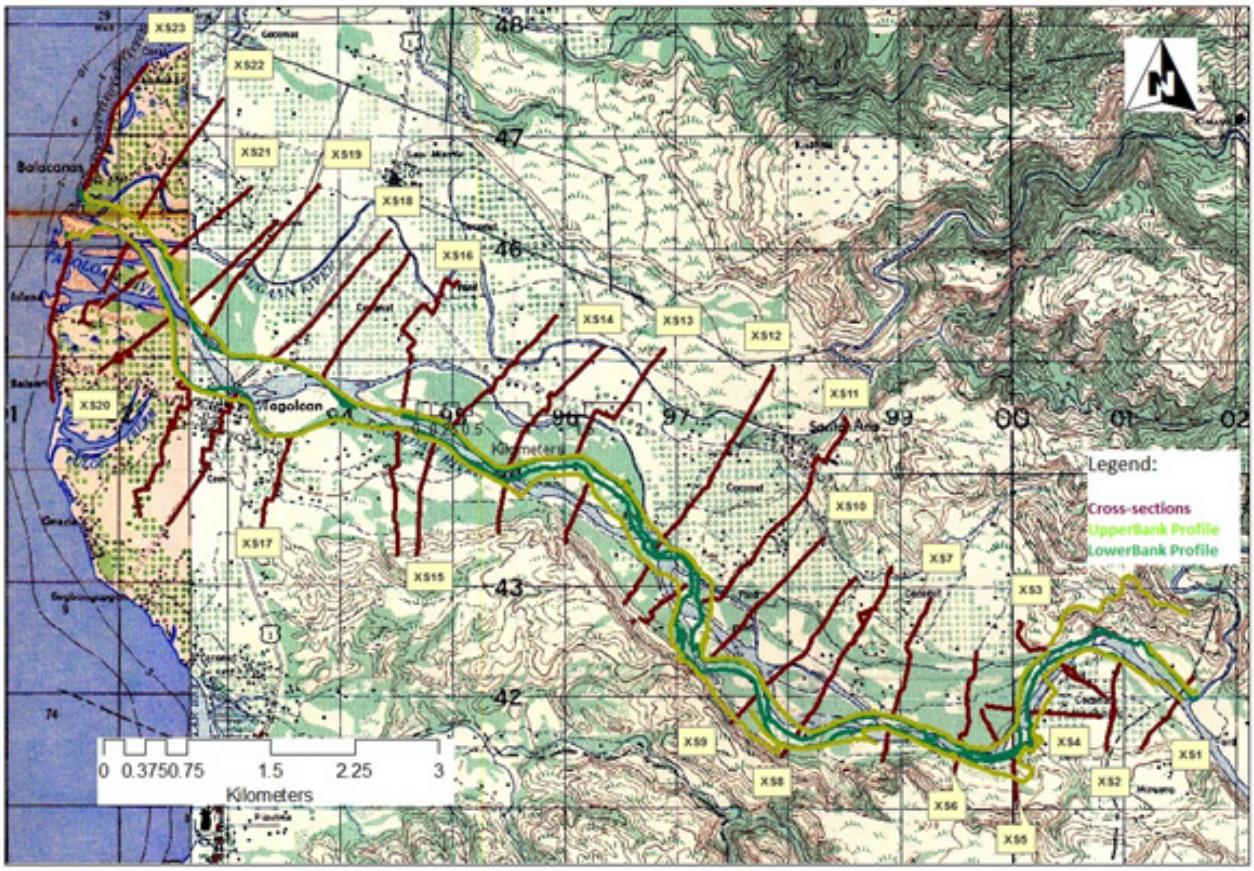


Figure 13: Actual cross-section and profile survey in Tagoloan River

ANNEX B. THE SURVEY TEAM

Table 5: Survey team composition

Cross-Section and Profile Survey Team Members	Designation	Name	Agency/Affiliation
Survey Coordinator			LN Realty and Surveying Services
Cross-Section and Profile Team	Research Associate	Andrew Cañeos	LN Realty and Surveying Services
	Research Associate	Jonas M. Busa	LN Realty and Surveying Services
	Research Associate	Judie Mel Apostol	LN Realty and Surveying Services
	Research Associate	Juney C. Aguiton	LN Realty and Surveying Services
	Research Associate	Medardo B. Bonotan Jr.	LN Realty and Surveying Services
	Research Associate	Zaldy Busa	LN Realty and Surveying Services

Annexes

ANNEX C. LIST OF ACTIVITIES

Table 6: Daily activities

DAY	ACTIVITY	LOCATION	PERSONS INVOLVED/ PARTICIPATED
16-May-13	Courtesy Call to Municipal Office of Tagoloan	Tagoloan	Jonas M. Busa Medardo B. Bonotan Jr. Ronielo R. Efren
17-May-13	- Start and completed Cross-Section Survey on XSR01, XSL01 - Start of Profile Survey - Data downloading and processing	Brgy. Sta Ines Sitio Maribuhok	Andrew Cañeos Jonas M. Busa Medardo B. Bonotan Jr. Ronielo R. Efren
18-May-13	- Continuation of cross-section survey - Completed cross-section Survey on XSL02 - Continuation of Profile Survey - Data downloading and processing	Brgy. Sta Ines Sitio Maribuhok	Andrew Cañeos Jonas M. Busa Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren
19-May-13	- Continuation of Profile Survey - Data downloading and processing	Brgy. Sta Ines Sitio Maribuhok	Andrew Cañeos Jonas M. Busa Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren
20-May-13	- Continuation of Profile Survey - Data downloading and processing	Brgy. Sta Cruz Brgy. Mohon	Andrew Cañeos Jonas M. Busa Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren
21-May-13	- Continuation of Profile Survey - Data downloading and processing	Brgy. Mohon	Andrew Cañeos Jonas M. Busa Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren
22-May-13	- Continuation of Profile Survey - Data downloading and processing	Brgy. Sta. Ana Sitio Salaban	Andrew Cañeos Jonas M. Busa Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren
23-May-13	- Continuation of Profile Survey - Data downloading and processing	Brgy. Maribuhok Brgy. Sta. Ana	Andrew Cañeos Jonas M. Busa Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren

24-May-13	- Continuation of Profile Survey - Data downloading and processing	Phividic	Andrew Cañeos Jonas M. Busa Judie Mel Apostol Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren Zaldy Busa
25-May-13	- Continuation of Profile Survey - Data downloading and processing	Brgy. Poblacion	Andrew Cañeos Jonas M. Busa Judie Mel Apostol Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren Zaldy Busa
26-May-13	- Continuation of Profile Survey - Data downloading and processing	Brgy. Natumu-lan Sitio Maribuhok	Andrew Cañeos Jonas M. Busa Judie Mel Apostol Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren Zaldy Busa
27-May-13	- Continuation of cross-section survey - Completed cross-section Survey on XSL05, XSL06, XSL07 - Continuation of Profile Survey - Data downloading and processing	Sitio Maribuhok	Andrew Cañeos Jonas M. Busa Judie Mel Apostol Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren Zaldy Busa
28-May-13	- Continuation of cross-section survey - Completed cross-section Survey on XSL06, XSL07 - Data downloading and processing	Brgy. Sta. Ana Sitio Salaban	Andrew Cañeos Jonas M. Busa Judie Mel Apostol Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren Zaldy Busa
29-May-13	- Continuation of cross-section survey Completed cross-section survey on XSR08, XSR09 - Data downloading and processing	Brgy. Sta. Ana Sitio Salaban	Andrew Cañeos Jonas M. Busa Judie Mel Apostol Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren Zaldy Busa

30-May-13	- Continuation of cross-section survey - Completed cross-section survey on XSR10, XSR11 - Data downloading and processing	Brgy. Sta. Ana	Andrew Cañeos Jonas M. Busa Judie Mel Apostol Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren Zaldy Busa
31-May-13	- Continuation of cross-section survey - Completed cross-section survey on XSR12, XSR13, XSR14 - Data downloading and processing	Brgy. Mohon	Andrew Cañeos Jonas M. Busa Judie Mel Apostol Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren Zaldy Busa
1-Jun-13	- Continuation of cross-section survey - Completed cross-section Survey on XSR15, XSR16 - Continuation of Profile Survey - Data downloading and processing	Brgy. Sta. Cruz	Andrew Cañeos Jonas M. Busa Judie Mel Apostol Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren Zaldy Busa
2-Jun-13	- Continuation of cross-section survey - Completed cross-section Survey on XSR17, XSR18, XSL18 - Data downloading and processing	Brgy. Poblacion	Andrew Cañeos Jonas M. Busa Judie Mel Apostol Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren Zaldy Busa
3-Jun-13	- Continuation of cross-section survey - Completed cross-section Survey on XSL19, XSL20, - Data downloading and processing	Brgy. Poblacion Brgy. Garcia	Andrew Cañeos Jonas M. Busa Judie Mel Apostol Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren Zaldy Busa
4-Jun-13	- Continuation of cross-section survey - Completed cross-section Survey on XSL21, XSL22, XSL23, XSR23 - Data downloading and processing	Brgy. Tambubong, Mun. of Villanueva Brgy. Nabulod Brgy. Baluarte	Andrew Cañeos Jonas M. Busa Judie Mel Apostol Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren Zaldy Busa

5-Jun-13	- Continuation of cross-section survey - Completed cross-section survey on XSR21, XSR22 - Data downloading and processing	Brgy. Nabulod Zone 1 river side	Andrew Cañeos Jonas M. Busa Judie Mel Apostol Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren Zaldy Busa
6-Jun-13	- Continuation of cross-section survey - Completed cross-section survey on XSR19, XSR20 - Data downloading and processing	Phividec Compound North Base	Andrew Cañeos Jonas M. Busa Judie Mel Apostol Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren Zaldy Busa
7-Jun-13	- Continuation of cross-section survey - Completed cross-section Survey on XSL13, XSL14, XSL15, SXL16, XSL17 - Data downloading and processing	Brgy. Natumulan	Andrew Cañeos Jonas M. Busa Judie Mel Apostol Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren Zaldy Busa
8-Jun-13	- Continuation of cross-section survey - Completed cross-section Survey on XSL02, XSL03,XSL08, XSL09, XSL11, XSL12 - Data downloading and processing	Sitio Maribuhok Brgy. Natumulan	Andrew Cañeos Jonas M. Busa Judie Mel Apostol Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren Zaldy Busa
9-Jun-13	- Continuation of Profile Survey - Data downloading and processing	Brgy. Sta Ana Sitio Salaban	Andrew Cañeos Jonas M. Busa Judie Mel Apostol Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren Zaldy Busa
11-Jun-13	- Continuation of Profile Survey - Data downloading and processing	Brgy. Sta Ana Sitio Salaban	Andrew Cañeos Jonas M. Busa Judie Mel Apostol Juney C. Aguiton Medardo B. Bonotan Jr. Ronielo R. Efren Zaldy Busa

Annexes

ANNEX D. INSTRUMENTS AND EQUIPMENTS USED

Table 7: List of Instruments and equipment

Type	Brand	Owner	No. of Units used
Dual Frequency RTK GPS Receiver	South	LN Realty and Surveying Services	One (1)
Dual Frequency RTK GPS Receiver	South	LN Realty and Surveying Services	Two (2)
handheld GPS	Garmin	LN Realty and Surveying Services	Four (4)
Single Frequency Static GPS	South	LN Realty and Surveying Services	Four (4) sets
Pumpboat		LN Realty and Surveying Services	Two (2)
Laptops	Acer, Asus	LN Realty and Surveying Services	Two (2)
Printer	Canon	LN Realty and Surveying Services	One (1)

Annexes

ANNEX E. CERTIFICATIONS OF BENCHMARK AND CONTROL POINTS USED

Republic of the Philippines
Department of Environment and Natural Resources
NATIONAL MAPPING AND RESOURCE INFORMATION AUTHORITY
Lawton Avenue, Fort Andres Bonifacio, 1634 Taguig City

2 of 2

17 June 2013

CERTIFICATION

Mr. Leonardo B. Nonan Jr.
LN Realty and Surveying Services
Butuan City

This is to certify that according to our records, the description and elevation of tidal benchmark TGBM at the Port of Cagayan de Oro is as follows:

TGBM – It is located inside the Port of Cagayan de Oro.It is set on the wharf floor, about 220 cm NE of the tide house and is about 45 cm NW of the concrete gutter. Mark is the head of a 2" bronze rod set flush on a 10" x 10" cement putty with inscriptions "TGBM 2011 NAMRIA".

Elevation: 2.2653 m above mean sea level
2.8553 m above mean lower low water

Values are based on 2007-2012 tidal series of observation.

Validated by:

Engr.RAUL S. CAPISTRANO
OIC, Oceanography Division

Commodore ROMEO I. HO
Director, Hydrography Department

www.namria.gov.ph osa@namria.gov.ph Fort Andres Bonifacio, Tel. No. (632) 810-4831 to 41 Binondo Branch, Tel. No. (632) 241-3494 to 96

04-18-08

Annexes

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

June 19, 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: **MISAMIS ORIENTAL**
Station Name: **MSE-25**
Order: **2nd**

Island: **MINDANAO** Barangay: **POBLACION**
Municipality: **VILLANUEVA**

PRS92 Coordinates

Latitude: **8° 35' 13.20618"** Longitude: **124° 46' 27.03667"** Ellipsoidal Hgt: **6.22900 m.**

WGS84 Coordinates

Latitude: **8° 35' 9.60584"** Longitude: **124° 46' 32.43073"** Ellipsoidal Hgt: **73.92600 m.**

PTM Coordinates

Northing: **949472.521 m.** Easting: **475142.313 m.** Zone: **5**

UTM Coordinates

Northing: **949,584.36** Easting: **695,255.30** Zone: **51**

Location Description

MSE-25
From Cagayan de Oro travel E then N for about 24km to the municipality of Villanueva. About 100m past the municipal town hall is a road to the right (heading east) going to Claveria municipality. Follow this road for about 200m to a rice field at the right side. In the center of the rice field is a concrete irrigation canal. The station is about 150m S of the road centerline going to Claveria, beside the concrete irrigation canal, on the E side about 0.6m from the bend. Station mark is the head of a copper nail, top centered on a 30cm x 30cm x 60cm concrete block protruding by about 20cm with inscriptions, MSE-25, 2003 NAMRIA.

Requesting Party: **LN Realty and Surveying Services**
Pupose: **Reference**
OR Number: **3943777 B**
T.N.: **2013-0590**

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

9906192013155425

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

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

June 20, 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: **MISAMIS ORIENTAL**
Station Name: **MSE-3242**
Order: **3rd**

Island: **MINDANAO**
Barangay: **TABLON**
Municipality: **CAGAYAN DE ORO CITY (CAPITAL)**

PRS92 Coordinates

Latitude: **8° 28' 55.37333"** Longitude: **124° 43' 33.63688"** Ellipsoidal Hgt: **8.50900 m.**

WGS84 Coordinates

Latitude: **8° 28' 51.79633"** Longitude: **124° 43' 39.04086"** Ellipsoidal Hgt: **76.30400 m.**

PTM Coordinates

Northing: **937869.408 m.** Easting: **469832.058 m.** Zone: **5**

UTM Coordinates

Northing: **937,952.73** Easting: **690,004.72** Zone: **51**

Location Description

MSE-3242
Is located at the foot of Umalag Bridge in Brgy. Tablon, Cagayan de Oro City. Mark is the head of a 4 in. copper nail embedded on a 25 cm. x 25 cm. concrete block, with inscriptions "MSE-3242 2007 NAMRIA".

Requesting Party: **LN Realty and Surveying Services**
Pupose: **Reference**
OR Number: **3943807 B**
T.N.: **2013-0593**

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

CIP/4701/12/09/814

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DREAM

Disaster Risk and Exposure Assessment for Mitigation