REGION 11

Davao River:

DREAM Ground Surveys Report

TRAINING CENTER FOR APPLIED GEODESY AND PHOTOGRAMMETRY

2015

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

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

UP TCAGP (2015), DREAM Ground Survey for Davao River, Disaster Risk and Exposure Assessment for Mitigation (DREAM) Program, DOST Grants-In-Aid Program, 110 pp.

For questions/queries regarding this report, contact:

Engr. Louie P. Balicanta, MAURP
Project Leader, Data Validation Component, DREAM Program
University of the Philippines Diliman
Quezon City, Philippines 1101
Email: louie_balicanta@yahoo.com

Enrico C. Paringit, Dr. Eng.
Program Leader, DREAM Program
University of the Philippines Diliman
Quezon City, Philippines 1101
E-mail: paringit@gmail.com

National Library of the Philippines
ISBN: 978-971-9695-40-0

Table of Contents

1 INTRODUCTION 1
1.1 DREAM Program Overview 2
1.2 Objectives and target outputs 2
1.3 General methodological framework 3
2 The Davao River Basin 5
3 DVC Methodology 9
3.1 Pre-field Preparation 11
3.1.1 Preparation of Field Plan 11
3.1.2 Collection of Reference Points 11
3.2 Field Surveys 12
3.2.1 Control Survey 12
3.2.2 Cross-Section Survey 13
3.2.3 Profile Surveys 14
3.2.4 Bathymetric Survey 14
3.2.5 Hydrometric Survey 15
3.2.6 Validation Points Acquisition Survey 16
3.3 Data Processing 18
3.3.1 Collection of Raw Data 19
3.3.2 Data Processing 19
3.3.3 Filtering of Data 23
3.3.4 Final Editing 23
3.3.5 Output 23
4 Davao River Basin Survey 25
4.1 Control Survey 26
4.2 Reconnaissance of Cross-section and Profile Lines 30
4.3 Bathymetric Survey 30
4.4 Hydrometric Survey 33

ANNEX A. PROBLEMS ENCOUNTERED AND RESOLUTIONS APPLIED 46
ANNEX B. LIST OF EQUIPMENT AND INSTRUMENTS 47
ANNEX C. THE SURVEY TEAM 48
ANNEX D NAMRIA CERTIFICATION 49
ANNEX E. RECONNAISSANCE SUMMARY 51
ANNEX F. OUTSOURCE CROSS-SECTION AND PROFILE 56

List of Figures

Figure 1.	The General Methodological Framework of the Program	3
Figure 2.	Davao River Basin Location Map	6
Figure 3.	Davao River Basin Soil Map	7
Figure 4.	DVC Main Activities	10
Figure 5.	DVC Field Activities	12
Figure 6.	Flow Chart for Stage-Discharge Correlation Computation	16
Figure 7.	Setup for GNSS Surveys	17
Figure 8.	DVC Data Processing Methodology	18
Figure 9.	Illustration of Echo Sounder and GPS rover set-up for Bathymetric survey	20
Figure 10.	Location of control points	27
Figure 11.	Static GNSS observation at DVS-1 in Port Area, Sta. Ana Wharf, Davao City	28
Figure 12.	Static GNSS observation at DV-76 in Guadalupe Bridge, Tagum City	29
Figure 13.	Static GNSS observation at COV-14 in front of Maco Municipal Hall in Barangay Poblacion, Maco, Compostela Valley	29
Figure 14.	Bathymetric survey setup	31
Figure 15.	Bathymetry team with the Philippine Coast Guard personnel	32
Figure 16.	Bathymetric data in Davao River	33
Figure 17.	Relationship between stage and rainfall	34
Figure 18.	Relationship between velocity and stage	34
Figure 19.	Relationship between velocity and rainfall	35
Figure 20.	Relationship between stage and discharge	35
Figure 21.	Deployment of ADCP with Depth Gauge on the bank of Davao River in Brgy. Waan, Davao City	36
Figure 22.	The Acoustic Doppler Current Profiler with Depth Gauge deployed in Brgy. Waan, Davao City	37
Figure 23.	Rain gauge deployment at Waan Bridge, Brgy. Waan, Davao City	37
Figure 24.	Location of Sensors in Davao River	39
Figure 25.	Matina Pangi AWLS Survey Extent	40
Figure 26.	Cross-section survey along Matina Pangi Bridge II	41
Figure 27.	Installed AWLS on Matina Pangi Bridge II	41
Figure 28.	AWLS diagram for Matina Pangi Bridge II in Brgy. Matina Pangi, Davao City	42
Figure 29.	Stage vs Velocity along Matina Pangi Bridge II	42
Figure 30.	Velocity vs Rainfall along Matina Pangi Bridge II	42
Figure 31.	Stage vs Rainfall along Matina Pangi Bridge II	43
Figure 32.	Stage-Discharge correlation along Matina Pangi Bridge II	43

List of Tables

Table 1. Control points occuiped during Davao River Survey (Source: NAMRIA, UP-TCAGP) 28

Table 2. Deployment of sensors along Davao River in Davao City 38

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.

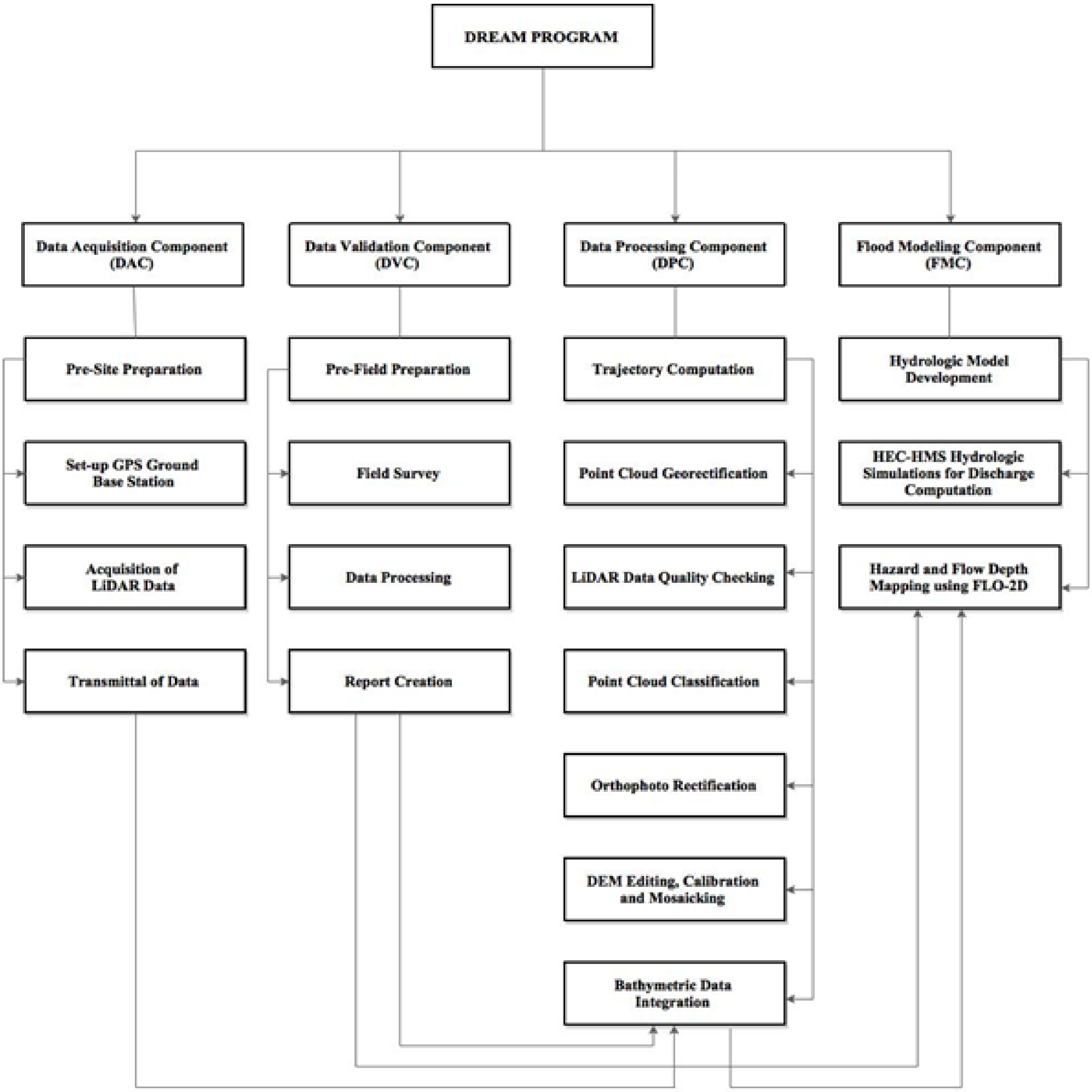


Figure 1. The General Methodological Framework of the Program

The Davao River Basin

The Davao River Basin

The area for the flood development in this study is the Davao River Basin located in the south of Mindanao. The basin is as shown in Figure 2. The Davao River Basin is considered as the third largest river catchment in the Southern Philippines. It is also considered as the largest of Davao City's nine (9) principal catchments, namely Lasang, Bunawan, Panacan, Matina, Davao, Talomo, Lipadas and portions of Inawayan and Sibulan. It covers an area of 1,623 square kilometers and travels an approximate length of 160 kilometers. It traverses from as far as the Salug River in San Fernando, Bukidnon and flows outward through the provinces of Bukidnon, Davao del Sur, Davao del Norte and North Cotabato. It opens eastward and drains into Gulf of Davao. Declared as a protected watershed by the government in 1903, the Davao River Basin serves as Davao city's main natural reservoir of aquifer, providing significant supply of water for drinking and irrigation.

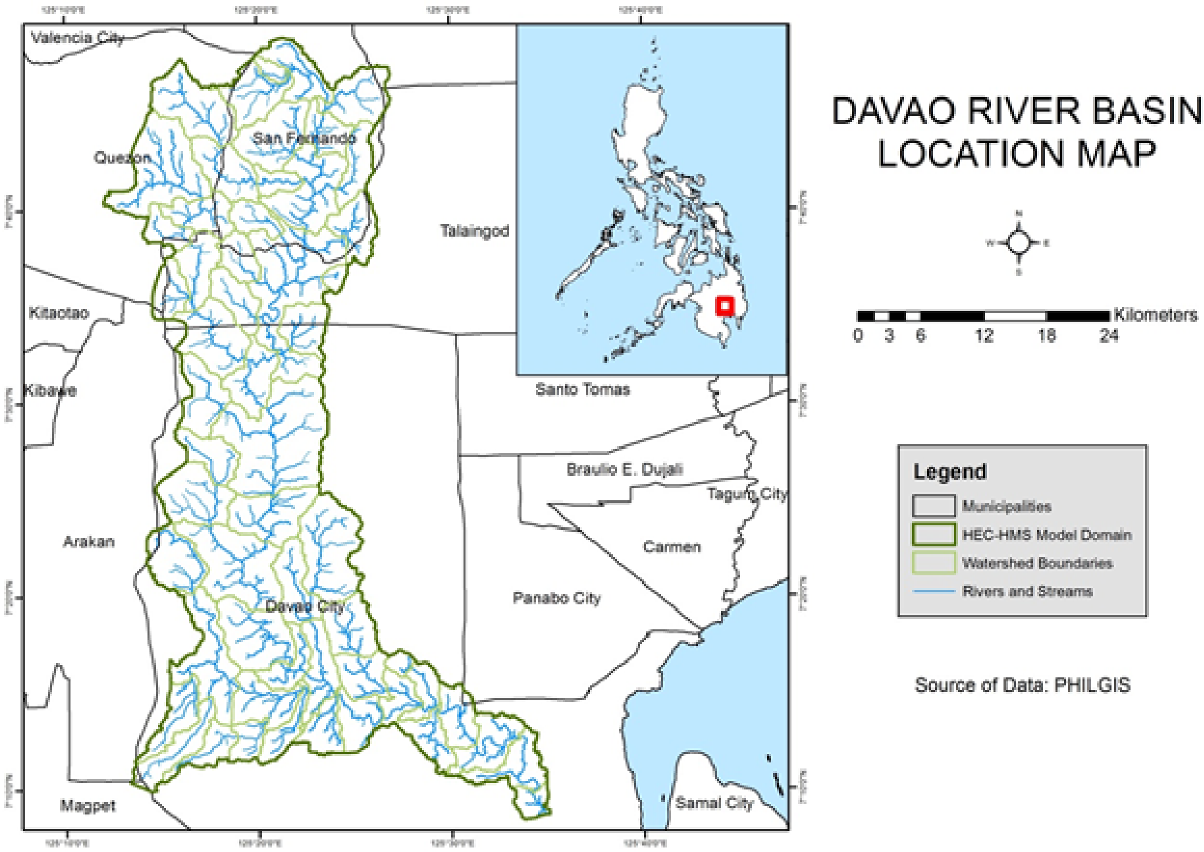


Figure 2. Davao River Basin Location Map

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). T

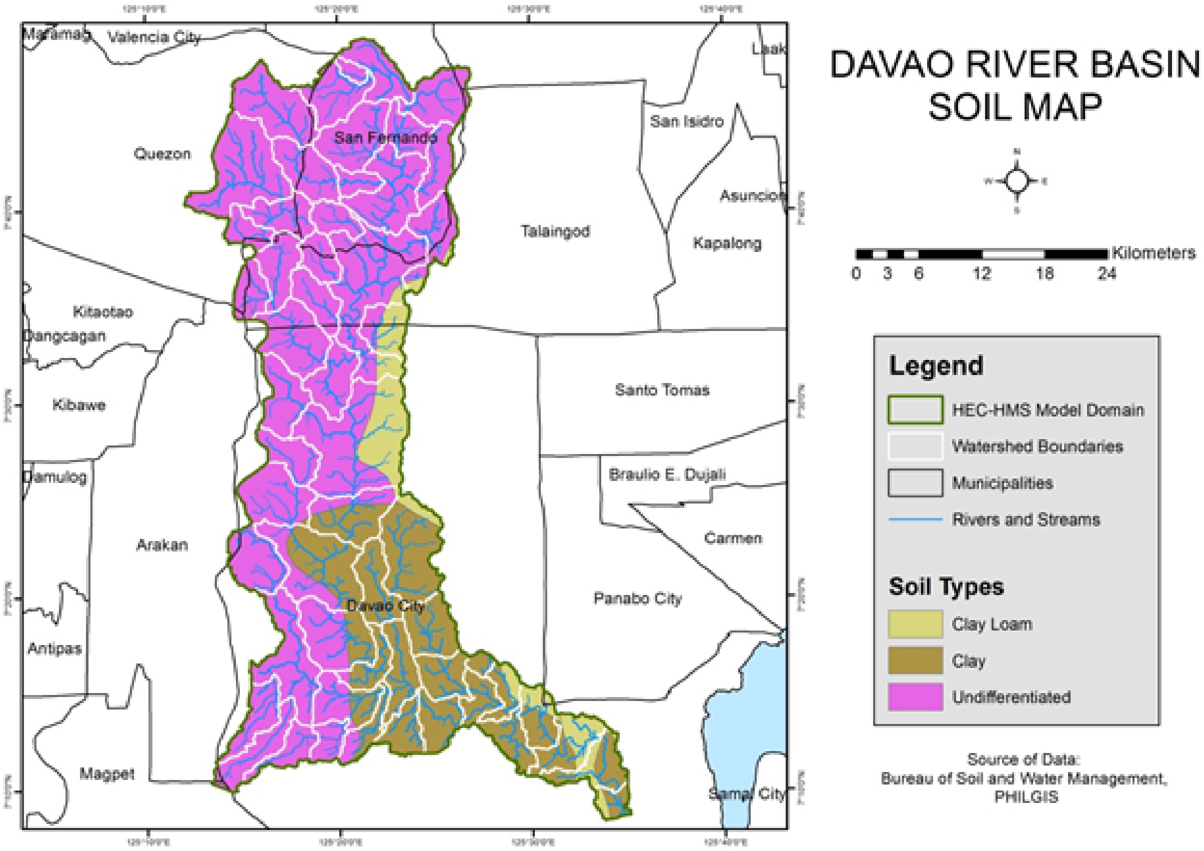


Figure 3. Davao River Basin Soil Map

DVC Methodology

DVC Methodology

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

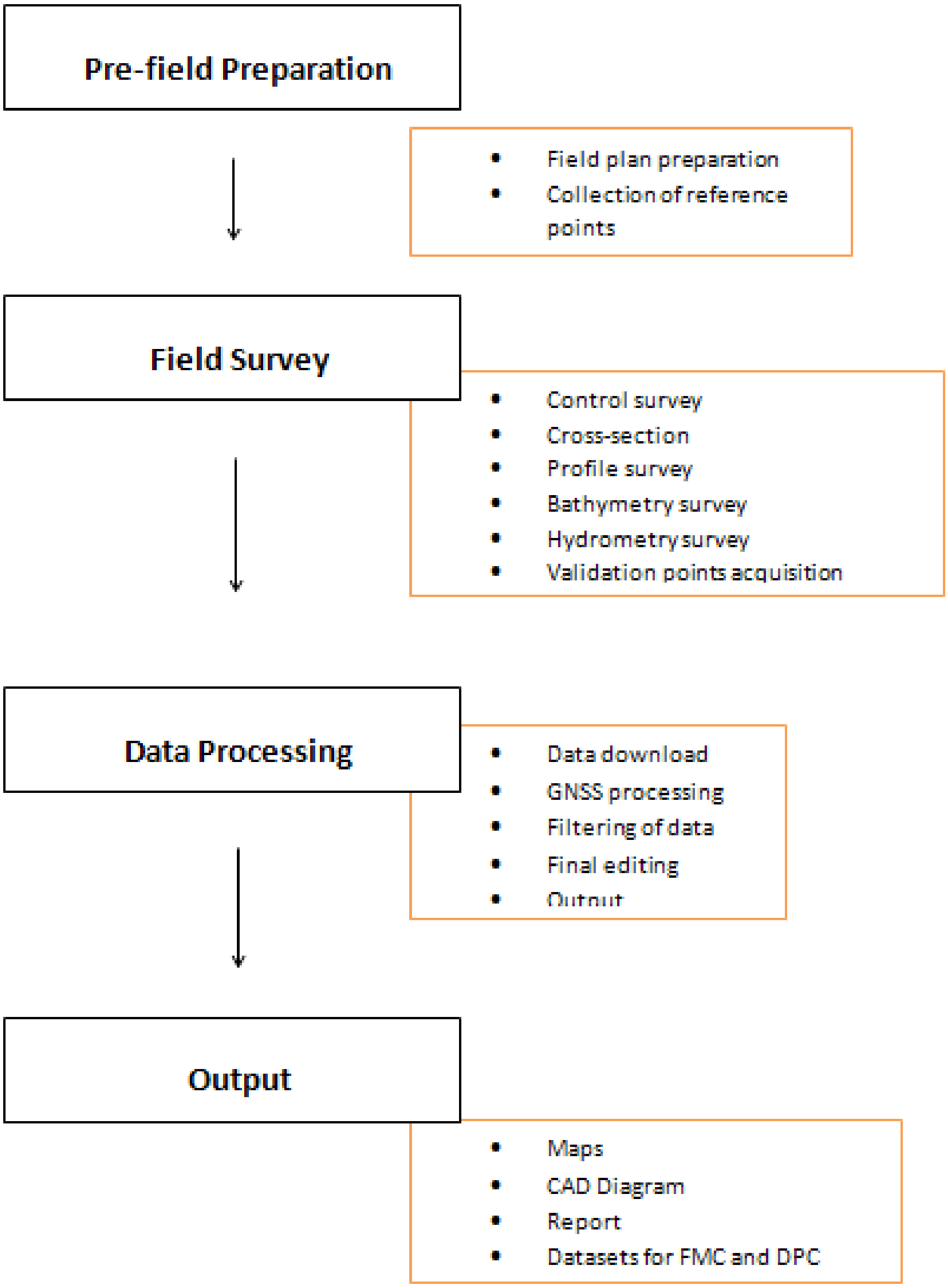


Figure 4. DVC Main Activities

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

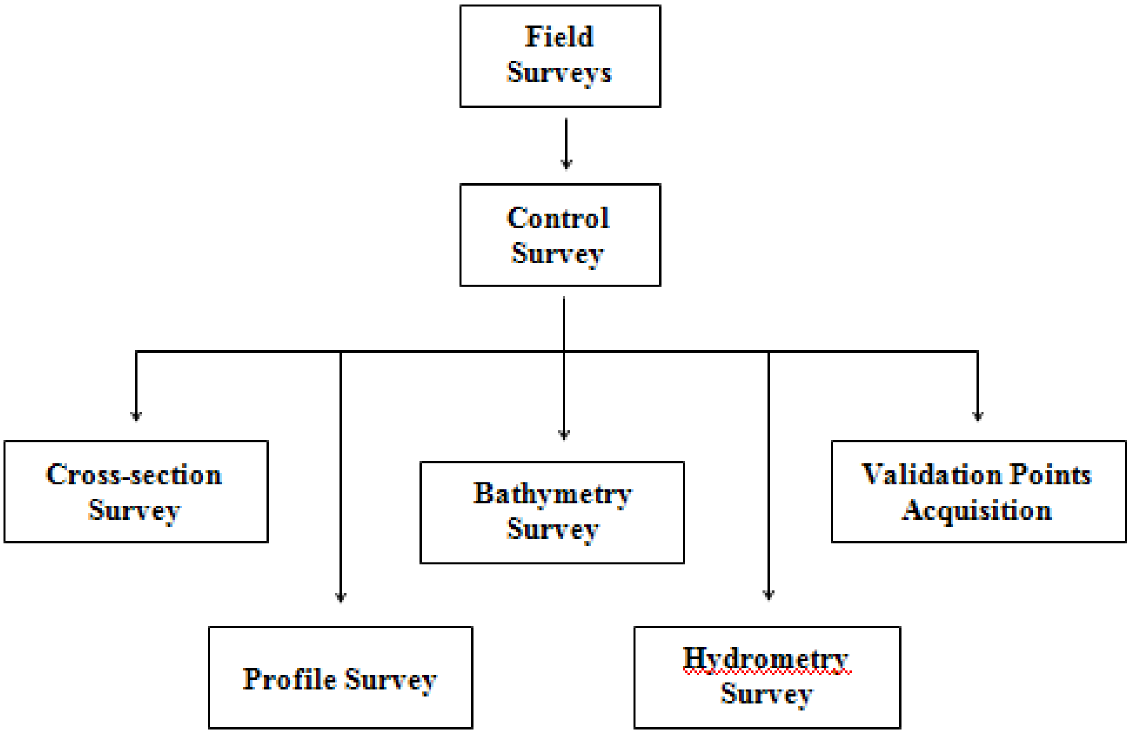


Figure 5. DVC Field Activities

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.

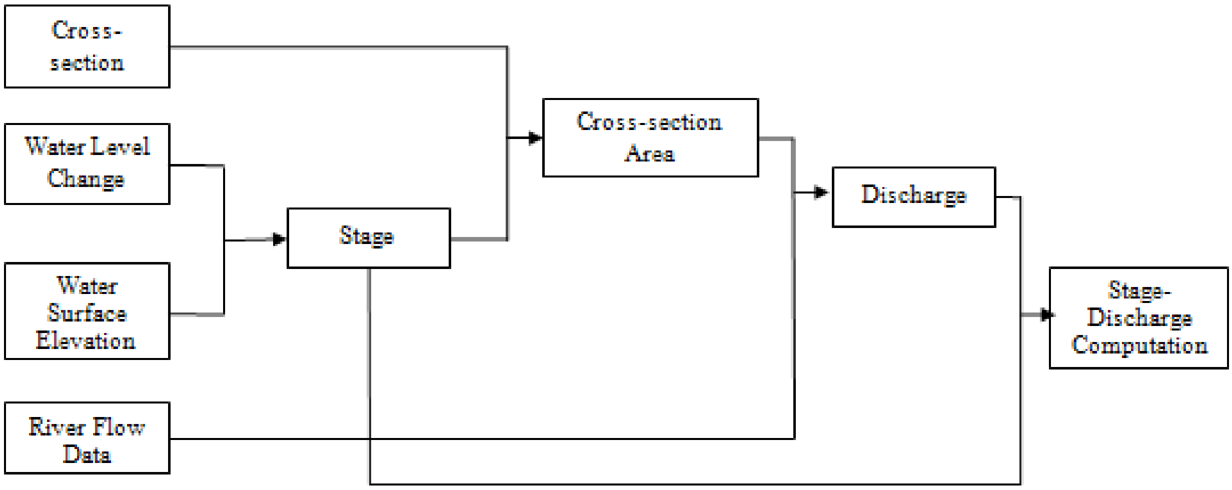


Figure 6. Flow Chart for Stage-Discharge Correlation Computation

3.2.6 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.

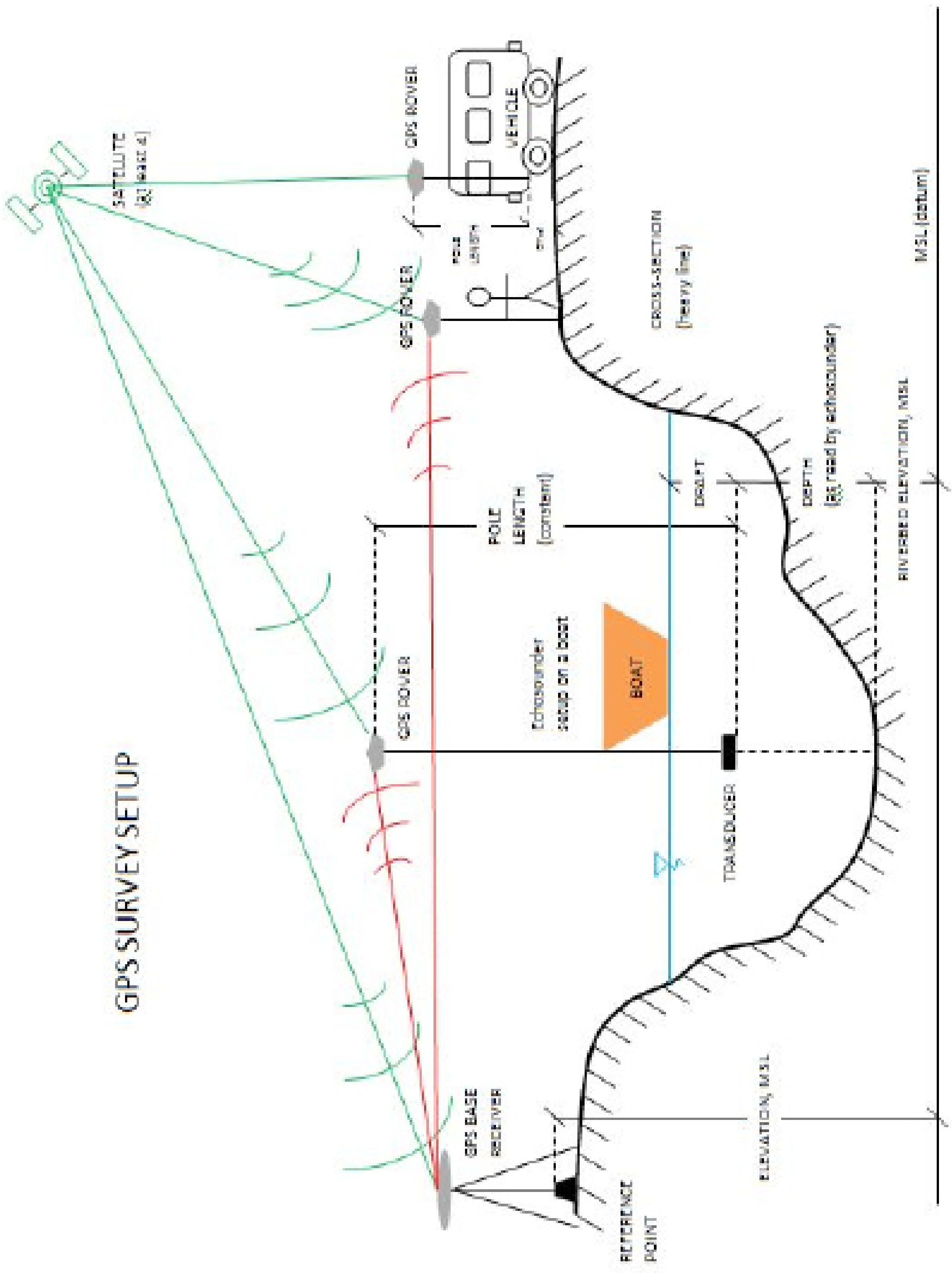


Figure 7. Set-up for GNSS Survey

3.3 Data Processing

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

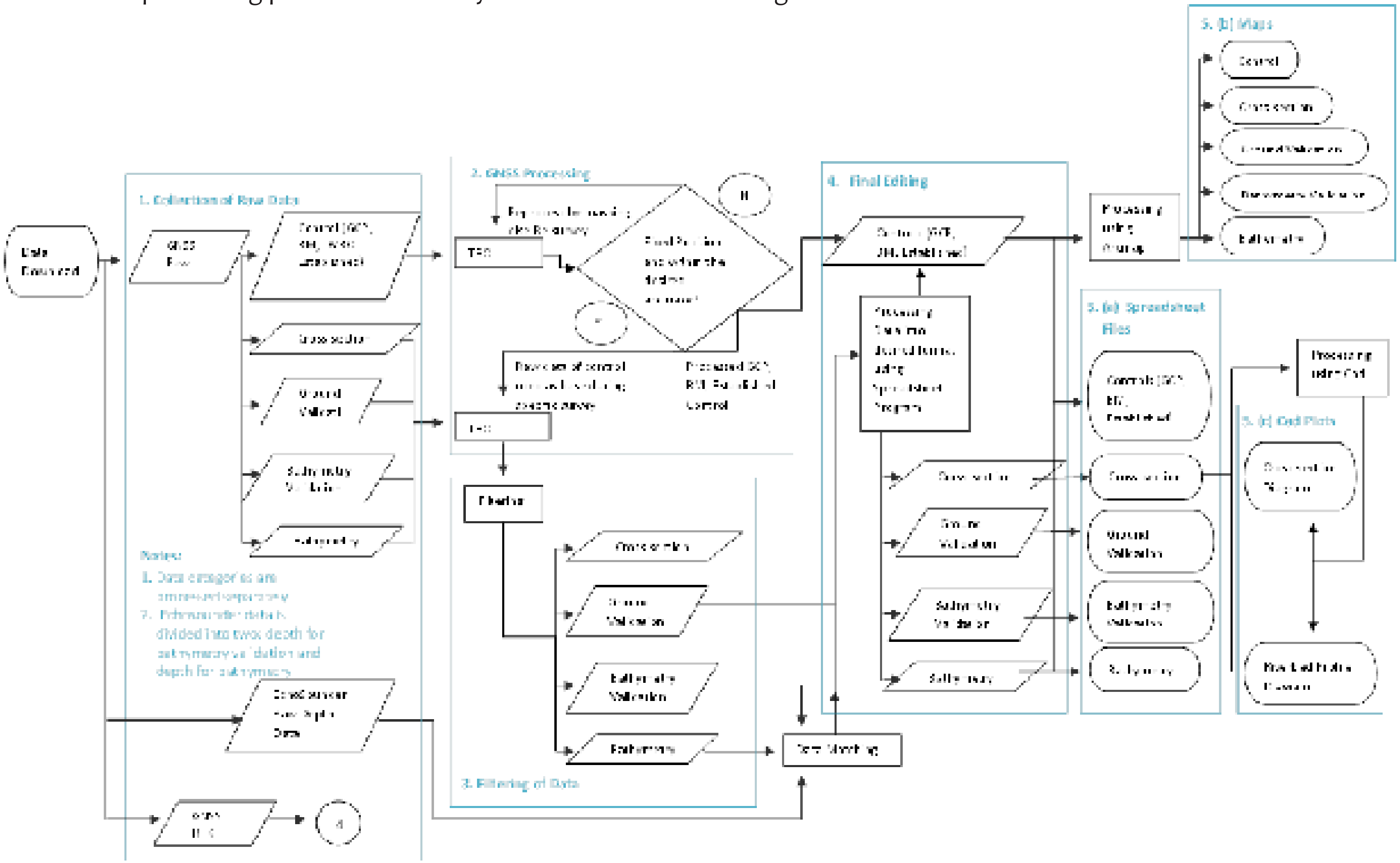


Figure 8. DVC Data Processing Methodology

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

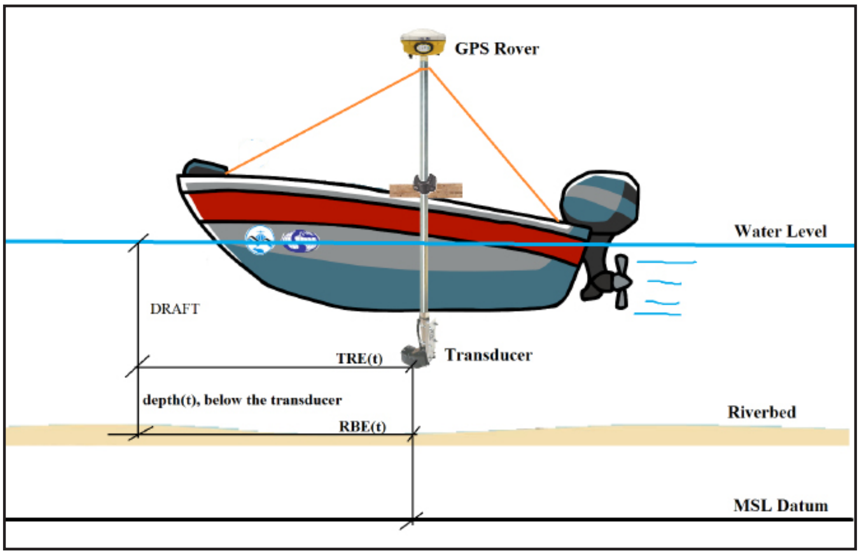


Figure 9. Illustration of Echo Sounder and GPS rover set-up for Bathymetric survey

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.

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.

DVC Methodology

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.

Davao River Basin Survey

Davao River Basin Survey

The survey for Davao River Basin was conducted on April 23 to May 8, 2013 with the following activities: control, bathymetric and hydrometric surveys; profile and cross-section lines reconnaissance for outsource.

Davao River consists of 23 delineated cross section lines with a total length of 52.9 km for both left and right banks starting from Brgy. Mandug in the upstream down to Brgy. Poblacion near the mouth of the river. The total length of profile lines is about 52.9 km for its both left and right banks. Ground surveys for both cross-section and profile lines were conducted by LN Realty and Surveying Services on May 24 to June 7, 2013 as described in Annex F.

Another set of fieldwork was conducted on January 23-24, 2014 to acquire the cross-section and sensor elevation of the installed Automated Water Level Sensor (AWLS) and to perform flow data gathering in Matina Pangi Bridge II in Brgy. Matina Pangi, Davao City.

4.1 Control Survey

Three (3) NAMRIA established control points were considered for the static GNSS observations of the three river systems namely: Davao, Hijo and Tagum-Libuganon Rivers. These include a benchmark, DV-76, which is located in Tagum City; a second-order reference point, COV-14, situated in front of Maco Municipal Hall, Compostela Valley; and a first-order reference point, DVS-1, located at Port Area, Sta. Ana Wharf, Davao City. The GNSS set-up for the three (3) base stations are shown in Figure 16, 17 and 18 while the location of these controls are shown in Figure 19. DVS-1 served as GNSS base station for Davao River bathymetry and ground validation survey for aerial LiDAR which is located in Port Area, Sta. Ana Wharf, Davao City. Locations of these controls are shown in Figure 10.

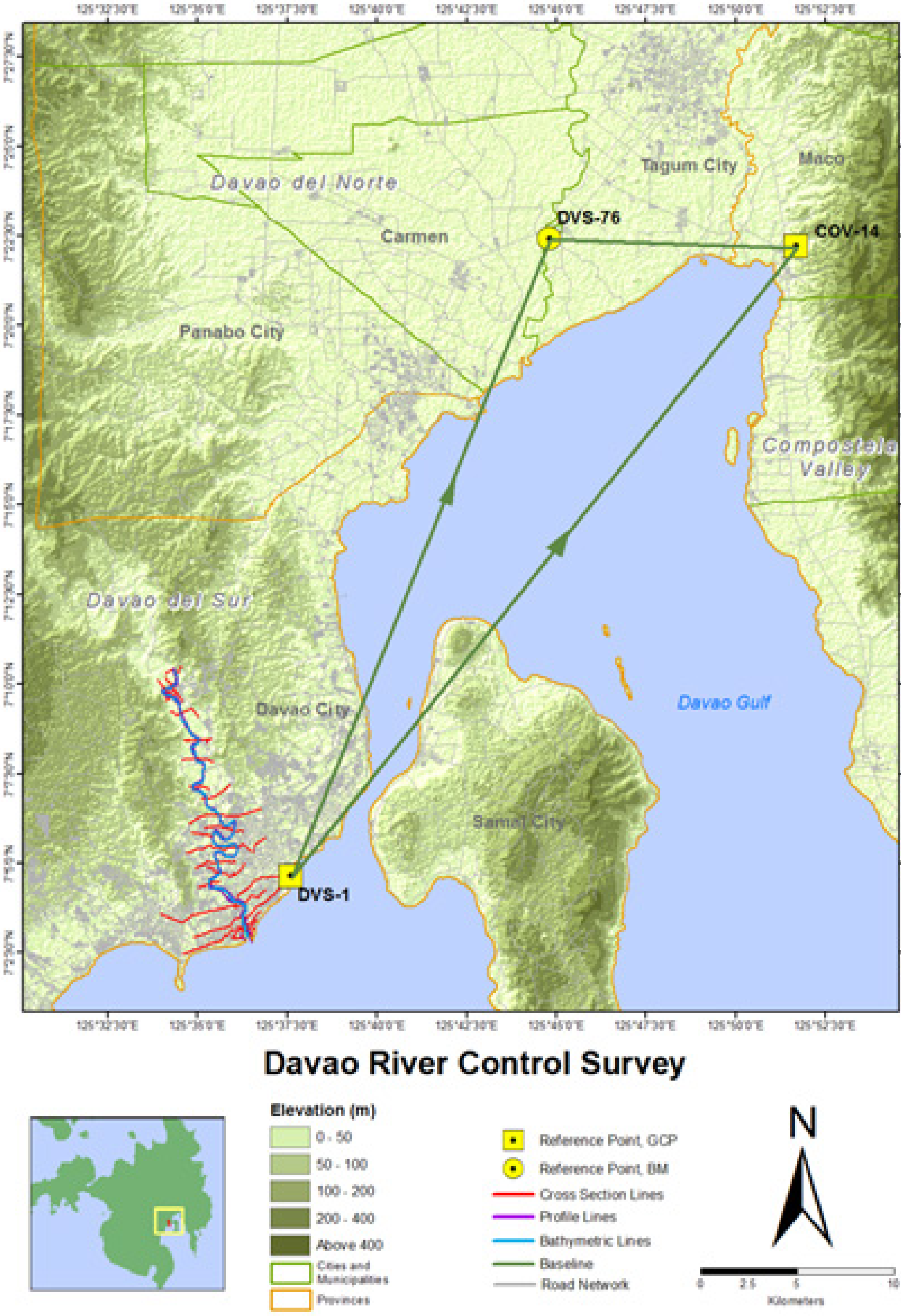


Figure 10. Location of control points

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 occuiped during Davao River Survey (Source: NAMRIA, UP-TCAGP)

Point Name	WGS84 UTM Zone 51N					Elevation in MSL (m)
	Latitude	Longitude	Ellipsoidal Height (m)	Northing (m)	Easting (m)	
COV-14	7022'13.38586" N	125051'41.73051" E	140.906	815706.706	815937.881	73.01
DV-76	7022'26.51282" N	125044'48.14113" E	75.907	816030.497	803241.596	8.112
DVS-1	7004'38.35565" N	125037'36.76595" E	68.456	783116.508	790192.769	0.727

The GNSS setup for the three (3) control points are illustrated in Figures 11 to 13:

Figure 11. Static GNSS observation at DVS-1 in Port Area, Sta. Ana Wharf, Davao City

Figure 12. Static GNSS observation at DV-76 in Guadalupe Bridge, Tagum City

Figure 13. Static GNSS observation at COV-14 in front of Maco Municipal Hall in Barangay Poblacion, Maco, Compostela Valley

Ground Surveys

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

Reconnaissance was conducted simultaneously with bathymetric and hydrometric measurements from April 23 to 30, 2013. The remaining days were allotted for the conduct of ground surveys for Hijo and Tagum-Libuganon rivers.

4.2 Reconnaissance of Cross-section and Profile Lines

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

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

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

4.3 Bathymetric Survey

The bathymetry of the river channel was surveyed using an echosounding surveying technique. Differential GNSS surveying technique and an Ohmex™ single beam echosounder were utilized in measuring the depth, eventually obtaining elevation with corresponding horizontal position. Bathymetry setup during the Davao bathymetry survey is illustrated in Figure 10 and 11.

The entire bathymetry survey took three (3) days to accomplish from April 29 to May 1, 2013. The Bathymetry Team executed the survey using a rubber boat borrowed from the Philippine Coast Guard (PCG) accompanied by two (2) coast guard personnel. Centerline and zigzag sweep of the survey were performed in order to fully capture the topography of the river as shown in Figure 14.

An approximate centerline length of 23.2 km and a zigzag sweep length of 45.6 km were covered starting from downstream in Brgy. Bucana up to Brgy. Mandug, Davao City.

Figure 14. Bathymetric survey setup

Figure 15. Bathymetry team with the Philippine Coast Guard personnel

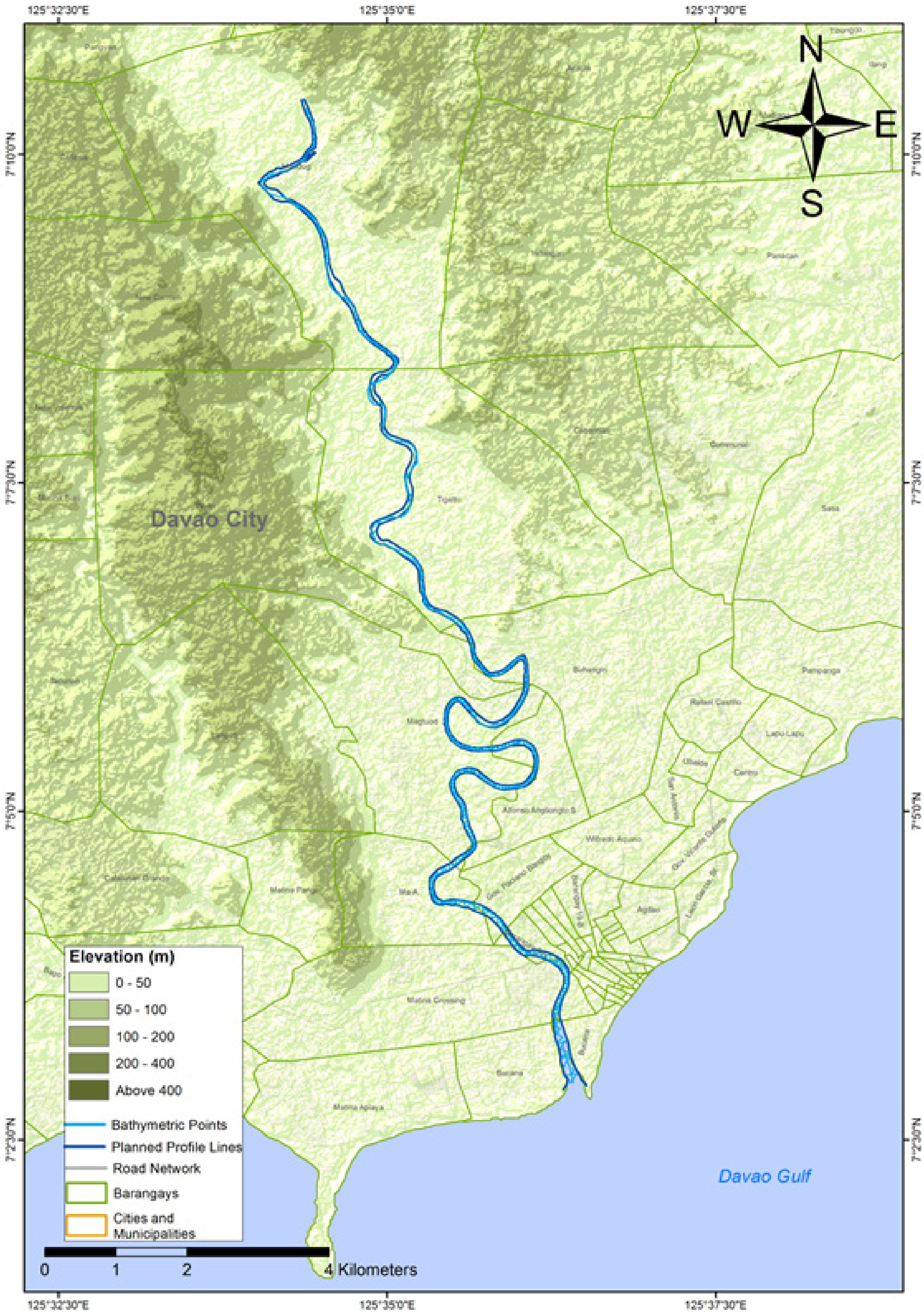


Figure 16. Bathymetric data in Davao River

4.4 Hydrometric Survey

Different sensors were deployed on the banks of Davao 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.

Data collection in Brgy Waan, Davao City using ADCP, Depth Gauge and Rain Gauge deployment started on the 24th of April, 2013 and retrieved on the 30th of April, 2013. The ADCP was monitored and its data downloaded every two (2) days while the depth gauge which was installed on the metal frame together with the ADCP and the Rain Gauge, installed in Waan Bridge continued gathering data until its retrieval.

Another depth gauge was installed at Bolton Bridge, Barangay Bucana, Davao City, at Lat 7° 7'55.98" N and Long 125°34'58.54" E.

The data gathered from rain gauge shows the distribution of rainfall within the observation period from April 24 to 30, 2013. Each sensor has five (5)-minute interval. The first surge of rain, which reached 1mm , was observed on April 24, 2013 at 1:35 pm. Highest amount of rain collected occurred on the 24th, 27th and 28th of April, 2013 at 2.2 mm. Relationships of data gathered within the observation period are illustrated Figure 17, 18, 19 and 20.

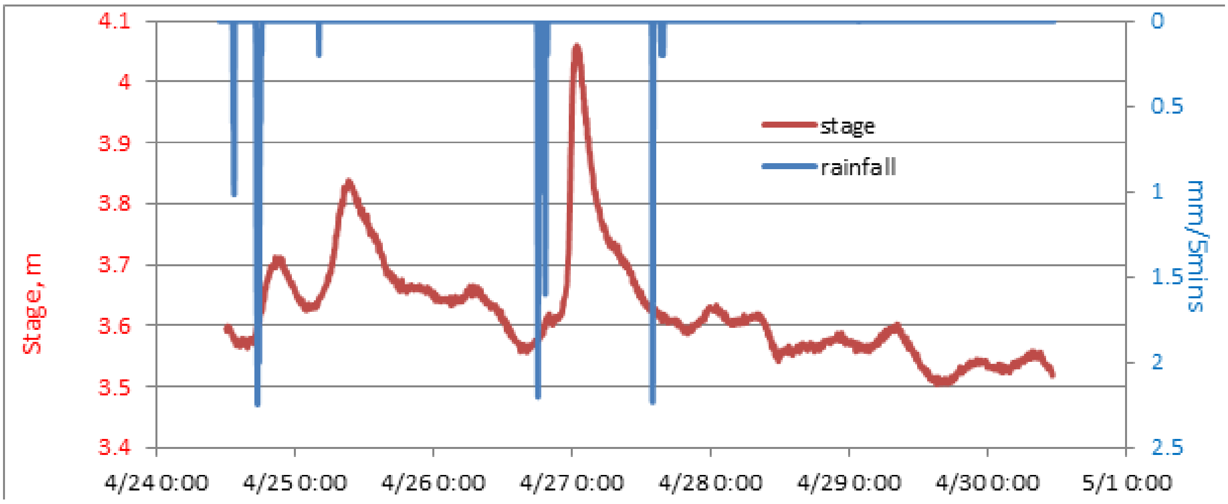


Figure 17. Relationship between stage and rainfall

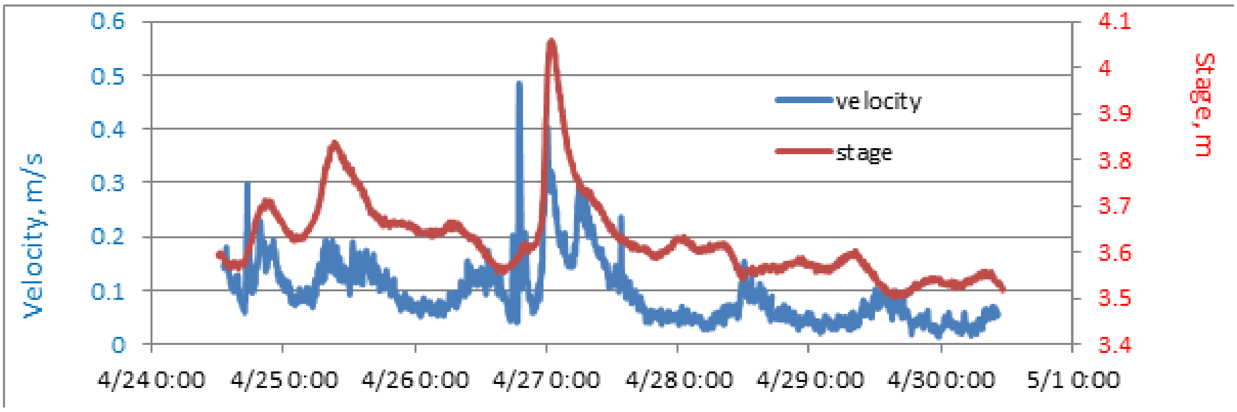


Figure 18. Relationship between velocity and stage

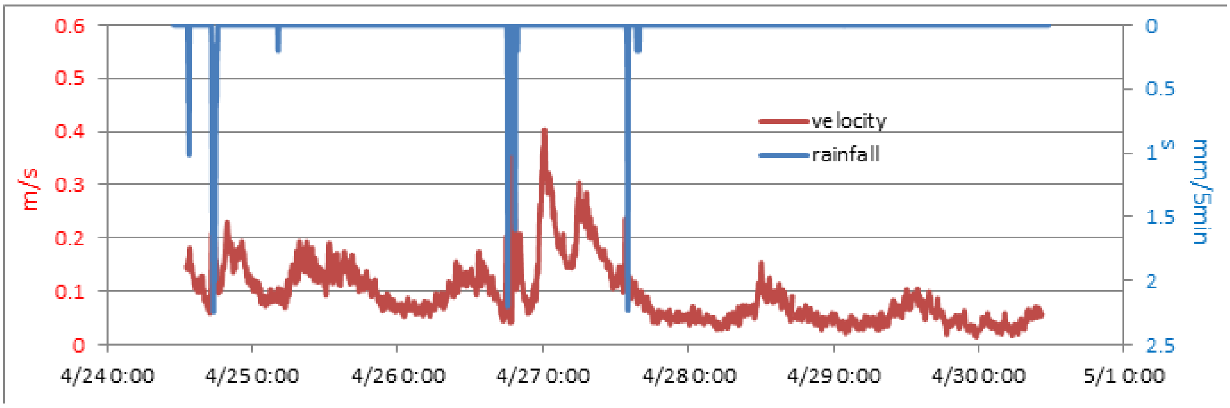


Figure 19. Relationship between velocity and rainfall

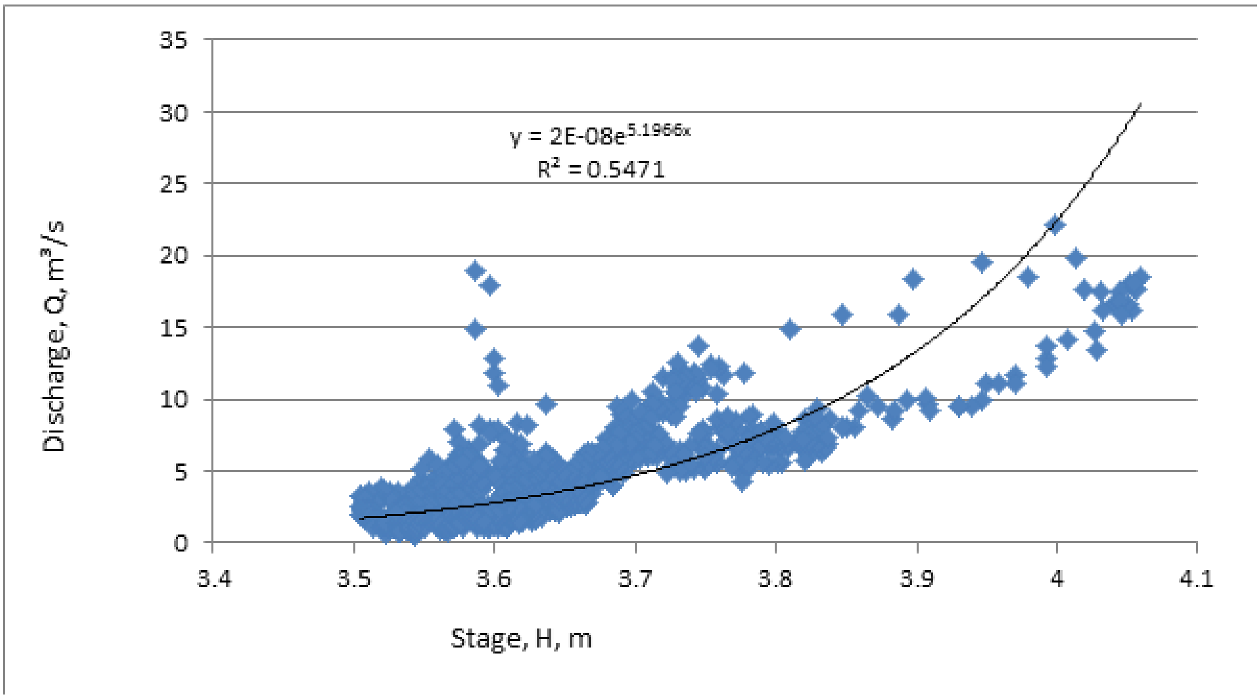


Figure 20. Relationship between stage and discharge

The relationship between the stage or water surface elevation referred to MSL and river discharge on a specific area of the river is illustrated in Figure 20. A value approaching $R^2 = 1$ indicates a good correlation.

Setup of sensors deployment is illustrated in Figures 21, 22 and 23.

Figure 21. Deployment of ADCP with Depth Gauge on the bank of Davao River in Brgy. Waan, Davao City

An ADCP with depth gauge was deployed near Waan Bridge while the rain gauge was installed at Waan Bridge in brgy. Waan, Davao City. The sensors were left on the site to continuously collect data while being monitored by a group of local hires. The sensors were checked every two to three days especially during and after the rainfalls events. The ADCP, depth gauge and rain gauge was then retrieved on April 30, after 6 days of continuous data gathering.

Figure 22. The Acoustic Doppler Current Profiler with Depth Gauge deployed in Brgy. Waan, Davao City

Figure 23. Rain gauge deployment at Waan Bridge, Brgy. Waan, Davao CitY

Table 2. Deployment of sensors along Davao River in Davao City

Sensor	Location	Deployment	Retrieval	Latitude	Longitude
ADCP and Depth Gauge (1)	Brgy. Waan,	25-Apr-13	30-Apr-13	7° 7'55.98"N	125°34'58.54"E
Rain Gauge	Brgy. Waan,	25-Apr-13	30-Apr-13	7° 7'54.83"N	125°34'59.02"E
Depth Gauge (2)	Bolton Bridge, Brgy. Bucana	24-Apr-13	30-Apr-13	7° 3'28.21"N	125°36'17.55"E

Summary of location of sensor deployment are shown in Table 2 and Figure 23.

Figure 24. Location of Sensors in Davao River

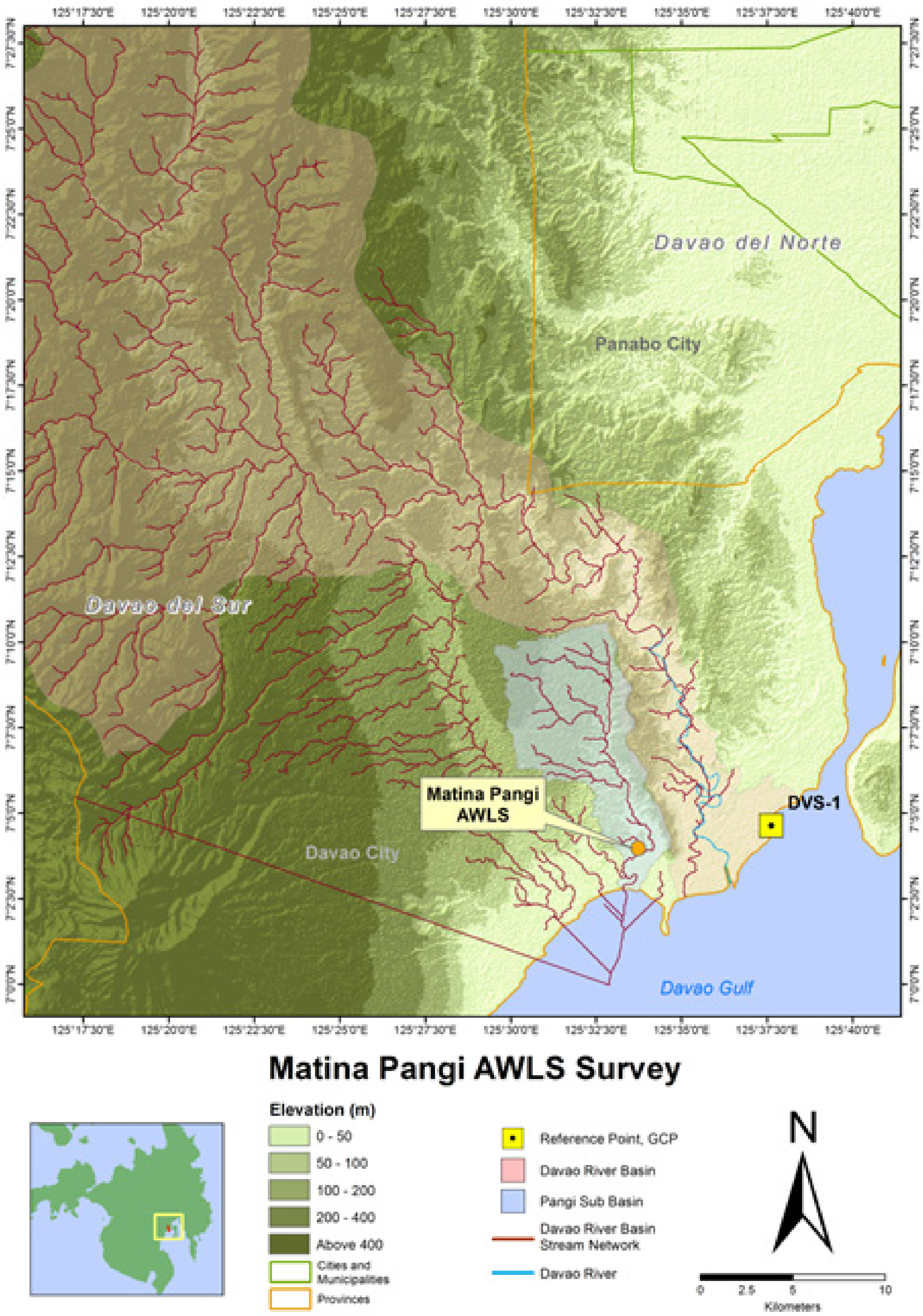


Figure 25. Matina Pangi AWLS Survey Extent

Another survey was conducted for the installed AWLS on Matina-Pangi Bridge in order to get its cross-sectional area and water surface elevation in MSL on January 23-24, 2014. Pangi River is a sub network of Davao river basin as show in Figure 25 and it also causes flood in the area.

River velocity was also acquired using FP 111 probe digital flow meter. The instrument was entrusted to a local living near the bridge to gather river velocity measurements from January 23 to February 24, 2014.

Figure 26. Cross-section survey along Matina Pangi Bridge II

Figure 27. Installed AWLS on Matina Pangi Bridge II

The reference point DVS-1 in Sta. Ana Wharf, Davao City was occupied as base station for the conduct of cross section survey. A GNSS rover using PPK Survey technique was used to acquire the cross survey of the bridge and sensor elevation as shown in Figures 26 and 27. The summary of data is illustrated in a diagram in Figure 28.

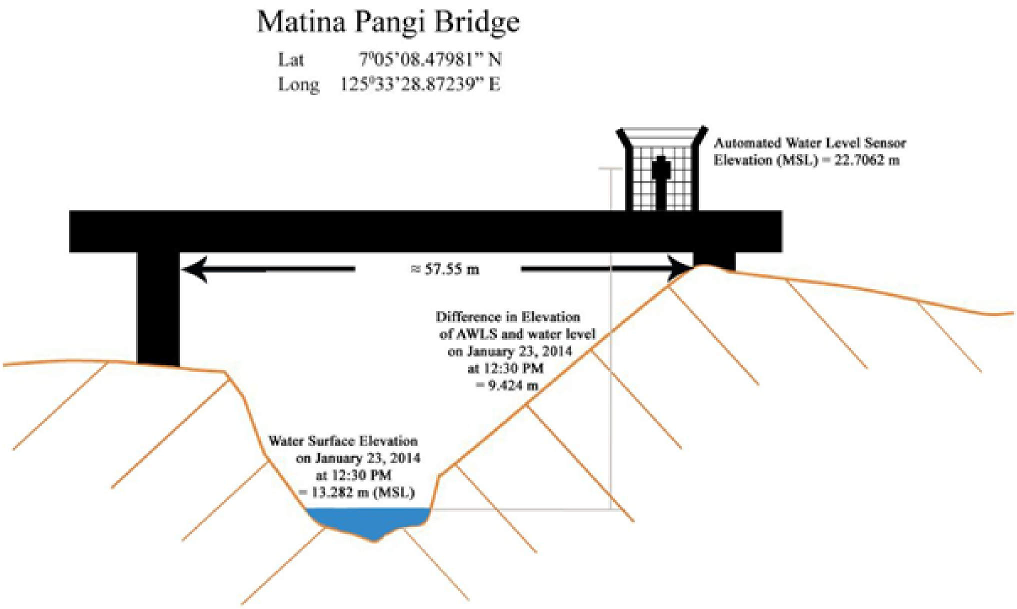


Figure 28. AWLS diagram for Matina Pangi Bridge II in Brgy. Matina Pangi, Davao City

Flow measurements using Flow Probe FP 111 were done from January 23 to February 24, 2014. The relationships of river's flow data, stage and rainfall are shown in Figures 29-32.

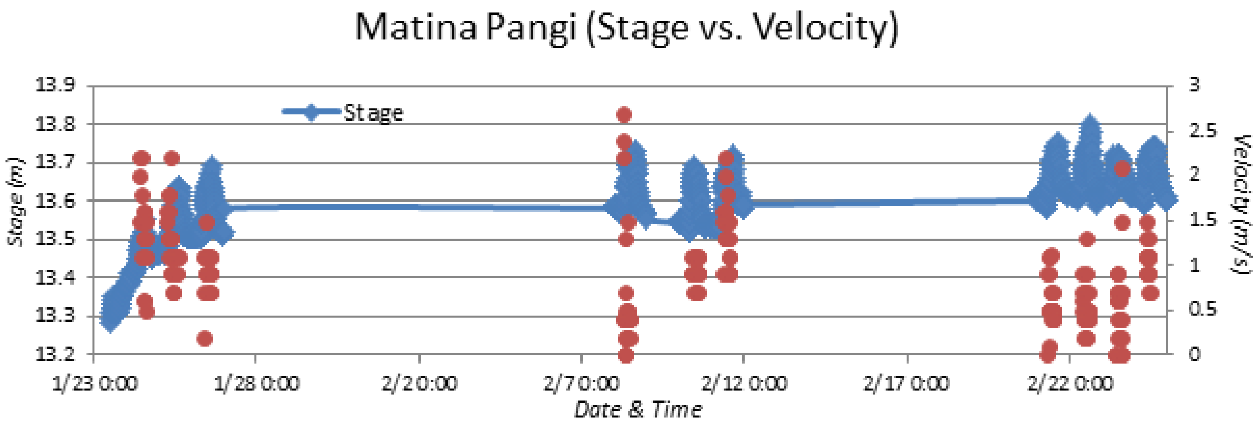


Figure 29. Stage vs Velocity along Matina Pangi Bridge II

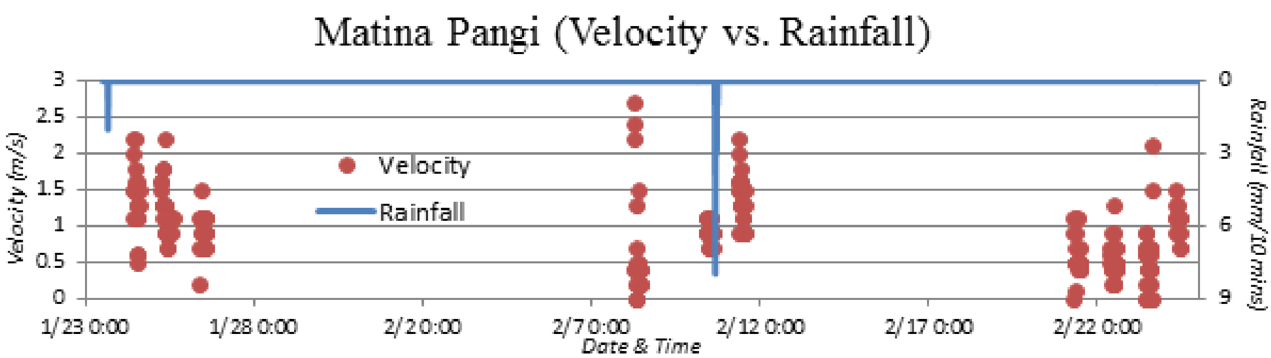


Figure 30. Velocity vs Rainfall along Matina Pangi Bridge II

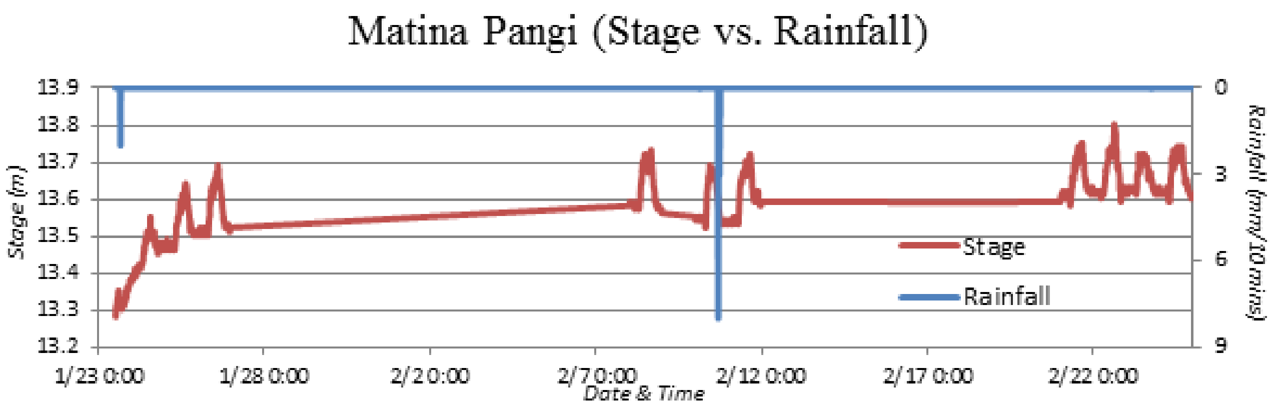


Figure 31 Stage vs Rainfall along Matina Pangi Bridge II

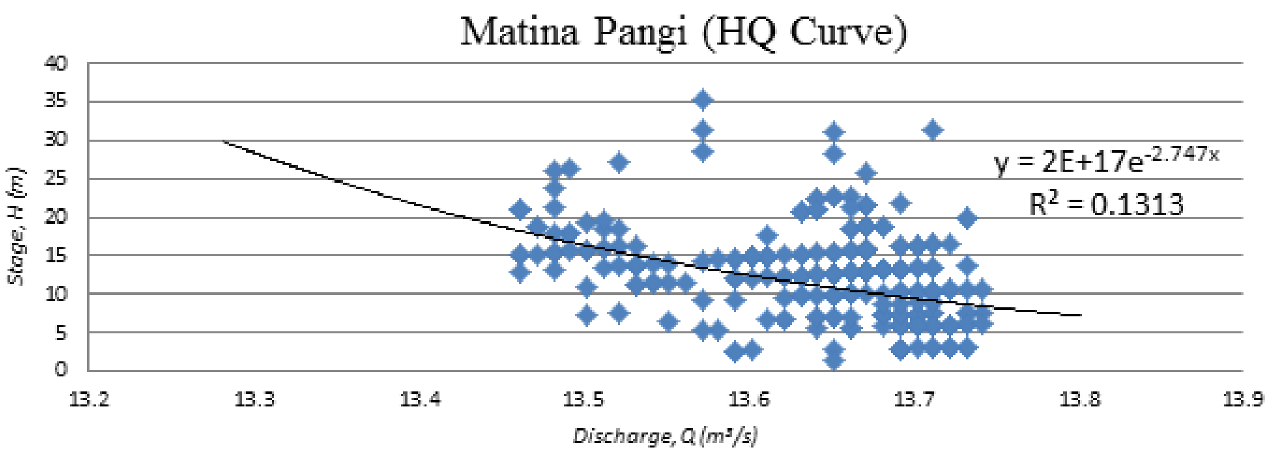


Figure 32. Stage-Discharge correlation along Matina Pangi Bridge II

The relationship between stage and discharge for January 23 to February 24, 2014 resulted to an R^2 of 0.1313.

Annexes

Annexes

ANNEX A. PROBLEMS ENCOUNTERED AND RESOLUTIONS APPLIED

In conducting reconnaissance for both profile and cross section, accessibility of the area is the major concern. Some of the proposed cross-section lines in Davao River are inside the private subdivisions while other lines are in areas which are not reachable by vehicles. Contractors must accomplish letters to have an access to perform data gathering inside the premises of the private subdivisions and considered necessary to hike in order to locate areas which are not reachable by vehicles.

The following shows the problems and limitations encountered during the fieldwork and the actions or solutions taken by the team.

Limitation/Problems		Solutions
1)	Proposed left cross-section lines (12-14) falls inside the private properties and subdivisions	Sent letters to the subdivision officials informing the purpose of such undertaking
2)	Proposed right cross-section lines (1-7 and 10) and left cross-section line (17) are not passable by vehicles	Traverse on foot in areas not passable by vehicles to reach the proposed cross-sections.
3)	Proposed left cross-section lines (1,6,7,9 and 17) were inspected and found to be hardly passable due to presence of trees and tall grasses	Contractors are opted to execute conventional method of surveying with the use of a total station and/or a level.

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
Laptops	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
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

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
Bathymetric Survey Team	Senior Science Research Specialist	ENGR. DEXTER T. LOZANO	UP TCAGP
	Research Associate	ENGR. JMSON J. CALALANG	UP TCAGP
Profile Survey Team	Senior Science Research Specialist	ENGR. BERNARD PAUL D. MARAMOT	UP TCAGP
	Senior Science Research Specialist	ENGR. MELCHOR REY M. NERY	UP TCAGP
Cross Section Survey Team and Sensors Deployment Team	Research Associate	JELINE M. AMANTE	UP TCAGP
	Research Associate	PATRIZCIA MAE P. DELACRUZ	UP TCAGP
	Research Associate	JOJO E. MORILLO	UP TCAGP
	Research Associate	JOJO E. MORILLO	UP TCAGP

ANNEX D. NAMRIA CERTIFICATION

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

April 26, 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: **DAVAO DEL SUR**	
	Station Name: **DVS-1**	
Island: **MINDANAO**	Order: **1st**	Barangay: **TOWN PROPER**
Municipality: **DAVAO CITY**		
	PRS92 Coordinates	
Latitude: **7° 4' 41.48387"**	Longitude: **125° 37' 31.24815"**	Ellipsoidal Hgt: **-4.50700 m.**
	WGS84 Coordinates	
Latitude: **7° 4' 38.36201"**	Longitude: **125° 37' 36.77094"**	Ellipsoidal Hgt: **68.27510 m.**
	PTM Coordinates	
Northing: **782663.345 m.**	Easting: **569084.935 m.**	Zone: **5**
	UTM Coordinates	
Northing: **783,162.17**	Easting: **790,026.11**	Zone: **51**

Location Description

DVS-1
From Davao City hall travel southeast along San Pedro street for 400 meters. Upon reaching the "T" intersection of San Pedro street and Quezon boulevard travel for 2.1 kms. up to the cross intersection of roads at Monteverde street, Leon Garcia street and Quezon boulevard. From this intersection turn right to Sta. Ana pier. The station is located on the east side of the new pier; 94 meters Northeast of coast guard house and north of the old pier. Station mark is 0.15 m x 0.01 m in diameter brass rod with cross cut on top, set in a drill hole, centered in a 30 cm x 30 cm cement patty on top of concrete pavement of wharf. Inscribed on top with the station name. All reference marks are 0.15 m x 0.01 m in diameter brass rods with cross cut on top, set in drill holes, centered in cement patty on concrete pavement of wharf. Inscribed on top with the reference mark numbers and arrow pointing to the station.

Requesting Party: **UP-TCAGP**
Pupose: **Reference**
OR Number: **3943584 B**
T.N.: **2013-0366**

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

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

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

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

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

June 11, 2013

CERTIFICATION

To whom it may concern:

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

Province: **DAVAO DEL NORTE**
Station Name: **DV-76**

Island: **Mindanao**	Municipality: **CARMEN**	Barangay: **TUGANAY**
Elevation: **8.3592 m.**	Order: **1st Order**	Datum: **Mean Sea Level**

Location Description

DV-76 is in the Province of Davao del Norte, City of Carmen, Barangay Tuganay taking the national highway until reaching the Gov. Miranda Bridge. Station is located at the NE abutment of Gov. Miranda at Kilometer Post KM 1456+881

Station mark is the head of 4" copper nail set on a drilled hole and cemented flushed on top of a 15x15cm. cement putty with inscriptions "DV-76, 2007 NAMRIA."

Requesting Party:	**UP-TCAGP DREAM**
Pupose:	**Reference**
OR Number:	**3943775B**
T.N.:	**2013-0563**

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

Annexes

ANNEX E. RECONNAISSANCE SUMMARY

Cross Section Reconnaissance				
Remarks	Left	Cross-Section	Right	Remarks
Traversable		1	No photo because the proposed line is not accessible by vehicle; must travel by footto reach the proposed line	Feasible
Falls within Brgy. Mandug with trees and cogon grasses				Falls in Brgy. Dalagdag with trees and tall cogon grasses
Traversable		2	No photo because the proposed line is not accessible by vehicle; must travel by foot to reach the proposed line	Feasible
Concrete road in DDF Village, Brgy. Mandug				Falls in Brgy. Dalagdag with trees and tall cogon grasses
Traversable		3	No photo because the proposed line is not accessible by vehicle; must travel by foot to reach the proposed line	Feasible
Concrete road in DDF Village, Brgy. Mandug				Falls in Brgy. Dalagdag with trees and tall cogon grasses
Traversable		4	No photo because the proposed line is not accessible by vehicle; must travel by foot to reach the proposed line	Feasible
Concrete road in DDF Village, Brgy. Mandug				Falls in Brgy. Dalagdag with trees and tall cogon grasses

Annexes

Remarks	Left	Cross-Section	Right	Remarks
Traversable Concrete road in DDF Village, Brgy. Mandug		5	No photo because the proposed line is not accessible by vehicle; must travel by foot to reach the proposed line	Feasible Falls in Brgy. Dalagdag with trees and tall cogon grasses
Traversable Trees and tall cogon grasses		6	No photo because the proposed line is not accessible by vehicle; must travel by foot to reach the proposed line	Feasible Falls in Brgy. Dalagdag with trees and tall cogon grasses
Traversable Trees and tall cogon grasses		7	No photo because the proposed line is not accessible by vehicle; must travel by foot to reach the proposed line	Feasible Falls in Brgy. Tigatto with trees and tall cogon grasses
Traversable Falls along Tigatto Bridge in Brgy. Tigatto and will pass national road		8		Traversable Falls in Brgy. Tigatto and will pass rough road
Traversable Trees, Corn and rice fields in Brgy. Tigatto		9		Traversable Falls in Brgy. Waan and will pass rough road

Annexes

Remarks	Left	Cross-Section	Right	Remarks
Traversable Falls along a rough road in Brgy. Tigatto and will end at Mandug road		10	No photo because the proposed line is not accessible by vehicle; must travel by foot to reach the proposed line	Feasible Falls in Brgy. Waan and will pass rough road
Traversable Falls at Diversion Bridge, pass a concrete highway and will end at Brgy. Buhangin underpass		11		Traversable Start at Diversion Bridge and will pass national road
Feasible Private property	No photo because it falls inside San Antonio subdivision, will pass Bacaca road and Rolling Hills Subdivision and ends at Ladislawa Garden Village	12		Feasible Falls in Brgy. Tigatto with trees and tall cogon grasses
Traversable Falls along Tigatto Bridge in Brgy. Tigatto and will pass national road	No photo because it falls inside private cemetery	13		Traversable Fall along the concrete road of Brgy. Maa
Traversable Falls inside AWHAG Village in Brgy. 19-B and pass J.P. Laurel Avenue Street		14		Traversable Must travel by foot to reach the starting point and will pass a concrete road in Brgy. Maa

Annexes

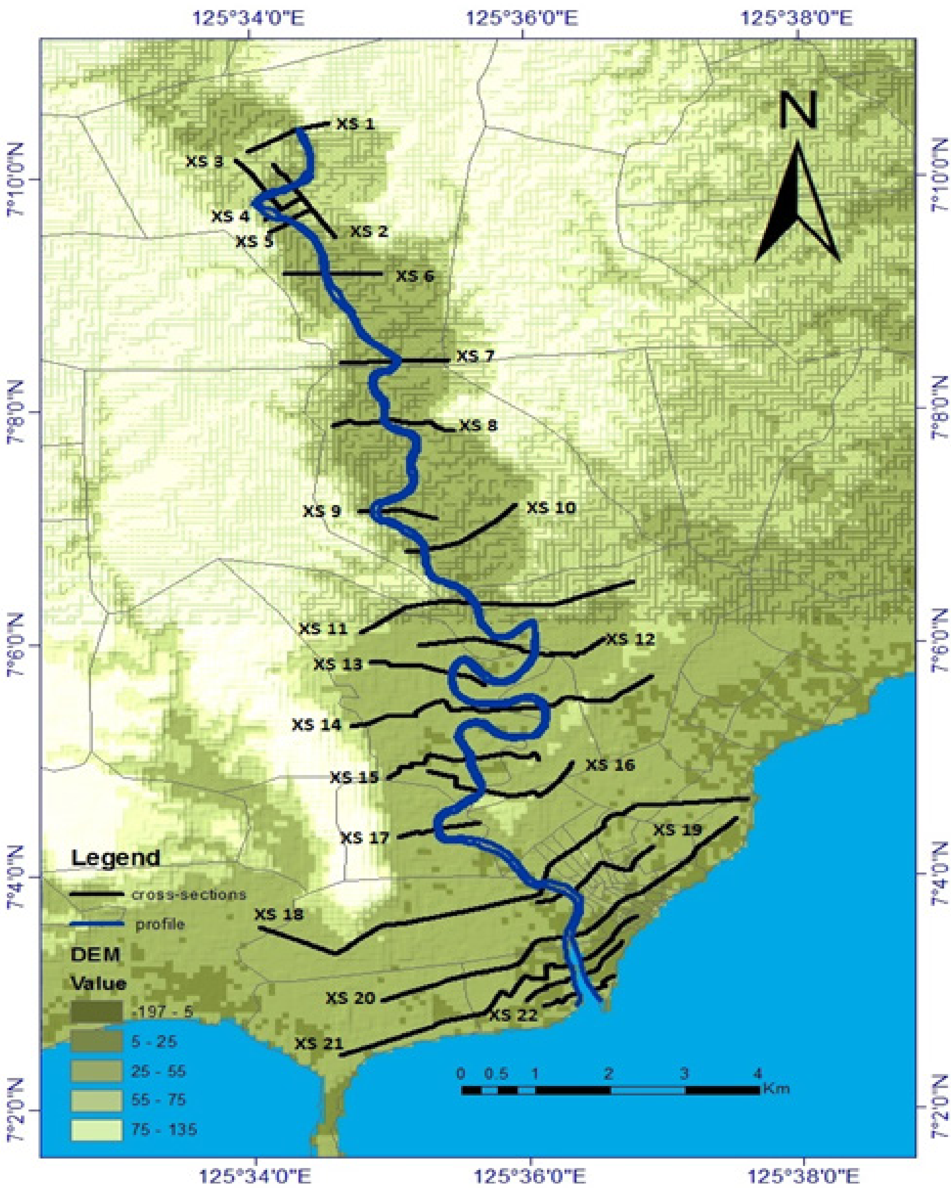
<table>
<tr><th>Remarks</th><th>Left</th><th>Cross-Section</th><th>Right</th><th>Remarks</th></tr>
<tr><td>Traversable</td><td rowspan="2">
</td><td rowspan="2">15</td><td rowspan="2"></td><td>Traversable</td></tr>
<tr><td>Falls at San Rafael Bridge, will pass concrete road and ends at Ruby Street Brgy. 9-A</td><td>Start at San Rafael Bridge, will pass along national highway and end at Don Julian Rodriguez Sr. Avenue</td></tr>
<tr><td>Traversable</td><td rowspan="2">
</td><td rowspan="2">16</td><td rowspan="2"></td><td>Traversable</td></tr>
<tr><td>From starting point will pass Davao Public cemetery, Marfori Heights II and J.A. Sarenas Avenue street</td><td>Falls in Don Julian Village and end at Gem Village</td></tr>
<tr><td>Feasible</td><td rowspan="2">No photo because the proposed line is not accessible by vehicle; must travel by foot to reach the proposed line</td><td rowspan="2">17</td><td rowspan="2">
</td><td>Traversable</td></tr>
<tr><td>Trees, tall cogon grasses and not accessible by vehicle</td><td>Will pass Don Julian Rodriguez Sr. Avenue road and ends at Midland Village</td></tr>
<tr><td>Traversable</td><td rowspan="2">
</td><td rowspan="2">18</td><td rowspan="2">
</td><td>Traversable</td></tr>
<tr><td>Falls in Gov. Generoso Bridge II and ends in Quirino Avenue highway</td><td>Start at Gov. Generoso Bridge and will end at Mcarthur Highway along Brgy. Matina Crossing</td></tr>
<tr><td>Traversable</td><td rowspan="2">
</td><td rowspan="2">19</td><td rowspan="2">
</td><td>Traversable</td></tr>
<tr><td>From starting point will pass Inigo Street Brgy. 2-A and will end in Brgy. 32-D</td><td>Falls in S.I.R.-Phase-1, Brgy. Bucana</td></tr>
</table>

<table>
<tr><th>Remarks</th><th>Left</th><th>Cross-Section</th><th>Right</th><th>Remarks</th></tr>
<tr><td>Traversable
Falls in Bolton Twin Bridge and will pass the highway</td><td>
</td><td>20</td><td>
</td><td>Traversable
Start at Bolton Twin Bridge and end at Quimpo Boulevard</td></tr>
<tr><td>Traversable
Falls in Brgy. Bucana and will pass a concrete road</td><td>
</td><td>21</td><td>
</td><td>Traversable
Falls along the concrete road of Brgy. Bucana and ends at Brgy. matina Aplaya Talomo Dist.</td></tr>
<tr><td>Traversable
Falls in Brgy. Bucana and will pass a concrete road</td><td>
</td><td>22</td><td>
</td><td>Traversable
Falls along the concrete road of Brgy. Bucana</td></tr>
<tr><td>Traversable
Falls at Brgy. Bucana and will pass a concrete road</td><td>
</td><td>23</td><td>
</td><td>Traversable
Falls at concrete road of Brgy. Bucana</td></tr>
</table>

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



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

1 **INTRODUCTION** 61
1.1 Background 62
1.2 Scope of Work 62
1.3 Professional Staffing and Implementation 64
2 **Field Survey Methodology** 65
2.1 Field Plan 66
2.2 Research for reference points and benchmarks 66
2.3 Establishment of control points and GNSS network 66
2.4 Ground Surveys 69
2.4.1 Cross-section Survey 70
2.4.2 Profile Survey 70
2.5 Data Processing and Analysis 71
2.4.1 Cross-section Data 71
2.4.2 Profile Data 71
3 **Results and Discussions** 73
3.1 Reconnaissance Survey and Actual Field Survey 74
3.2 Problems Encountered and Resolutions Applied 74
3.3 Processed Data 75
3.3.1 Cross-Section Data 76
3.3.2 Profile Surveys 84

ANNEX A. THE SURVEY TEAM 88
ANNEX B. INSTRUMENTS USED 89
ANNEX C. LIST OF ACTIVITIES 90
ANNEX D NAMRIA CERTIFICATION 91
ANNEX E. BASELINE PROCESSING 94
ACKNOWLEDGEMENTS 109

Figure 32.	Actual Profile and Cross section Survey	63
Figure 33.	Pictures of the members of the survey team	64
Figure 34.	Flow chart of field survey	66
Figure 35.	Static GNSS observation in DVS 3274 located at Brgy. Poblacion Davao City	67
Figure 36.	static GNSS survey at DVS-1 located at Sta Ana wharf, Davao City	67
Figure 37.	Office-IBSS used this base for entire Survey	68
Figure 38.	Bench mark DV-75 located at brgy. Guadalupe, Carmen City	68
Figure 39.	Location of Control points and Base Station used	75
Figure 40.	Cross section 1 of Davao survey area	76
Figure 41.	Cross section 2 of Davao survey area	76
Figure 42.	Cross section 3 of Davao survey area	77
Figure 43.	Cross section 4 of Davao survey area	77
Figure 44.	Cross section 5 of Davao survey area	78
Figure 45.	Cross section 6 of Davao survey area	78
Figure 46.	Cross section 7 of Davao survey area	79
Figure 47.	Cross section 8 of Davao survey area	79
Figure 48.	Cross section 9 of Davao survey area	80
Figure 49.	Cross section 7 of Davao survey area	80
Figure 50.	Cross section 11 of Davao survey area	80
Figure 51.	Cross section 12 of Davao survey area	81
Figure 52.	Cross section 14 of Davao survey area	81
Figure 53.	Cross section 15 of Davao survey area	81
Figure 54.	Cross section 16 of Davao survey area	82
Figure 55.	Cross section 17 of Davao survey area	82
Figure 56.	Cross section 18 of Davao survey area	82
Figure 57.	Cross section 19 of Davao survey area	83
Figure 58.	Cross section 20 of Davao survey area	83
Figure 59.	Cross section 21 of Davao survey area	83
Figure 60.	Cross section 22 of Davao survey area	84
Figure 61.	Cross section 23 of Davao survey area	84
Figure 62.	Upper right profile of Davao River	84
Figure 63.	Upper right profile of Davao river	85
Figure 64.	Upper left profile of Davao river	85
Figure 65.	Upper left profile of Davao river	85
Figure 66.	Lower right profile of Davao river	85
Figure 67.	Lower right profile of Davao river	85
Figure 68.	Lower left profile of Davao river	86
Figure 69.	Lower left profile of Davao river	86

Annexes

Table 3.	The three control points used to establish baselines and a GNSS network for the entire survey area	74
Table 4.	Problems encountered and solutions applied	74

Annexes

DREAM	Disaster Risk and Exposure Assessment for Mitigation
DOST	Department of Science and Technology
LiDAR	Light Detection and Ranging
GE	Geodetic Engineer
DVC	Data Validation Component, DREAM Program
NAMRIA	National Mapping and Resource Information Agency
BM	Bench Mark
GCP	Ground Control Point
GNSS	Global Navigation Satellite System
RTK	Real Time Kinematic
IBSS	Internet Base Station Service

Introduction

Annexes

1.1 Background

LN SURVEYING is the contractor for a ground validation survey for the Disaster Risk Exposure and Assessment for Mitigation (DREAM) Project under UP Training Center for Applied Geodesy and Photogrammetry which is supported by the Department of Science and Technology. The main objective of the project is to acquire ground data that can be used to develop flood hazard model for the` Davao River

The Davao River catchment is the third largest river catchment in the Southern Philippine Island of Mindanao. It is also the largest of Davao City's nine (9) principal watersheds, namely Lasang, Bunawan, Panacan, Matina, Davao, Talomo, Lipadas and portions of Inawayan and Sibulan. It drains an area of over 1700 km^2 with a river length of 160 km. Most of the areas are uplands. Average flows within the river near to the mouth are estimated at 70-80 cubic meters per second. The climate type is relatively uniform throughout the year with evenly distributed rainfall and humidity.

The LN Realty and surveying conducted a ground survey to conduct cross-section and profile surveys of Davao River. These datasets gathered from field surveys will pass to UP DREAM to validate the accuracy of airborne Light Detection and Ranging (LiDAR) data and input to flood modeling to provide flooding scenarios of different rainfall events.

1.2 Scope of Work

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

Scope 1: Establishment of ground control point survey connecting NAMRIA horizontal and vertical control points shall be done. Each control point that shall be used as reference point and must contain horizontal and vertical positions. An Internet Base Satellite System will be used for the project and a base station setup will be installed in a strategic location to cover the whole project area.

Scope 2: Reconnaissance survey of the approximately 23-km longitudinal profile and 23 cross sections along the banks of Davao River.

Scope 3: Cross section survey of 23 cross-sectional lines along Davao River which have an approximate total length of 52.9 km

Scope 4: Profile survey of left and right banks of Davao River with an approximate length of 23 km per bank

Scope 5: Processing of data and adjustment of network.

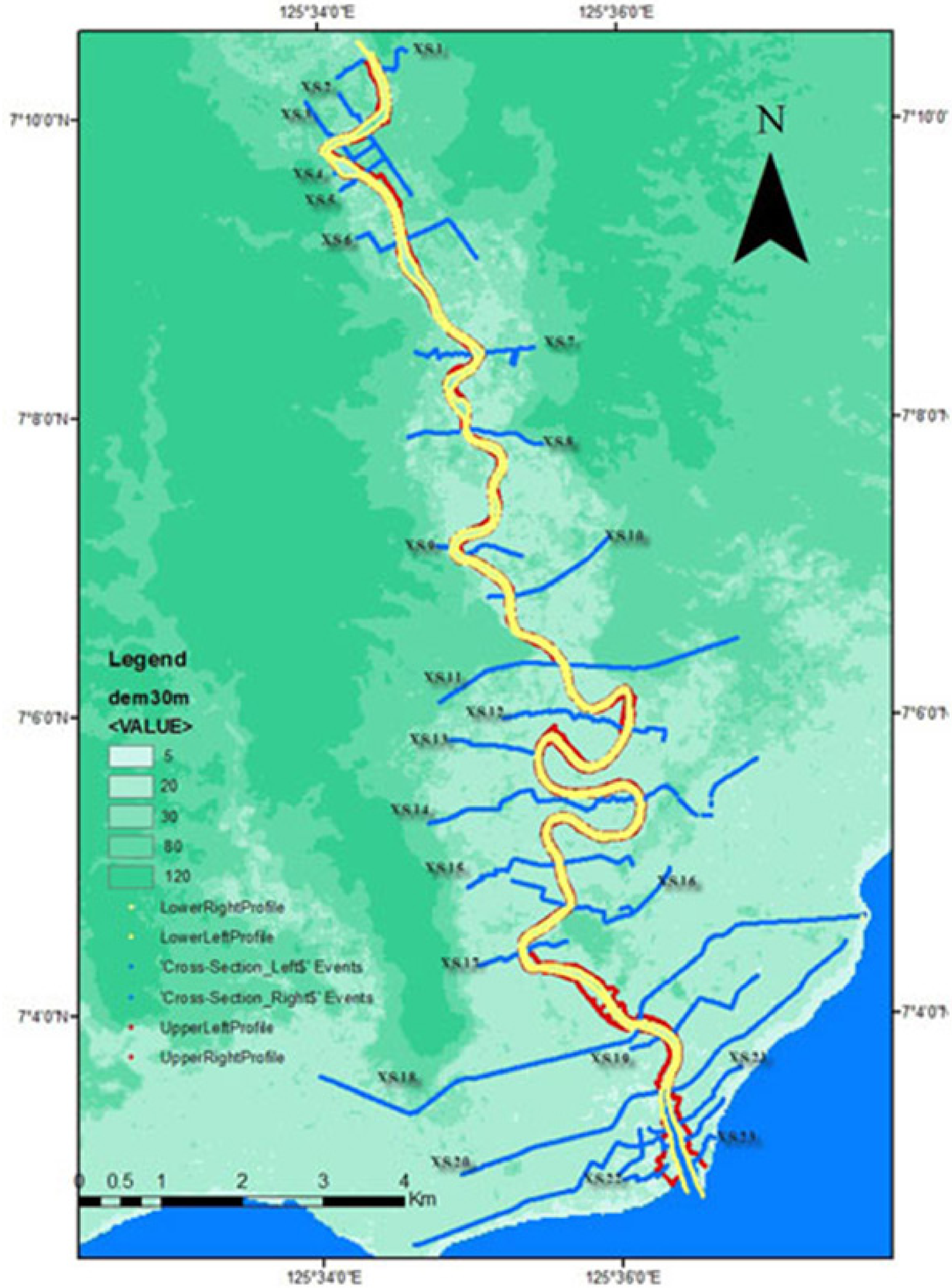


Figure 32. Actual Profile and Cross section Survey

1.3. Professional Staffing and Implementation

The survey team is composed of the following personnel: One (1) registered Senior Geodetic Engineer serves as chief of party and supervisor to oversee and manage the execution of surveys, instrument man, driver, AutoCAD operator and sufficient number of survey aides to perform cross sections and profile surveys.

Figure 33. 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

To ensure the success of the survey, considerable attention to the appropriate and tested methodology is required. For this survey, research of pertinent technical data, field and reconnaissance plan were prepared for the surveys.

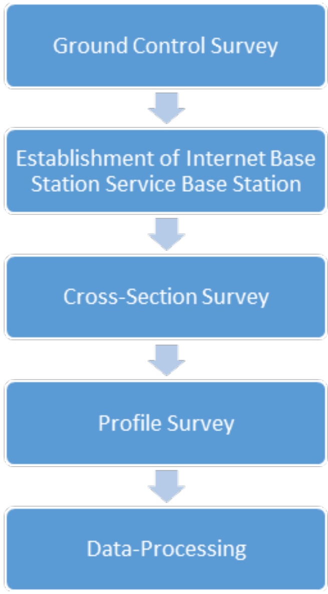


Figure 34. Flow chart of field survey

2.1 Field Plan

The UP DREAM provided maps and kmz file of the extent of cross section and profile along Davao River. From this data, a field plan was prepared by the survey team to serve as guide for the execution of the entire fieldwork activity. The team prepared the following tasks for making a field plan:

1. Enumerated and listed survey equipment needed for the survey;
2. Assigned tasks to team members for the actual field survey;
3. Estimated the approximate duration for actual field survey

2.2 Research for reference points and benchmarks

The UP DREAM provided reference points and benchmark to be used for the entire survey. These control points were obtained in establishment of the network of base stations for gathering of points. Aside from the reference point DVS-1 given by the UP DREAM, the team also searched for another reference point for checking namely DVS and DVS-1.

2.3 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 derive baselines and provide reference control to be used in the profile and cross-section survey along Davao River. Four base stations were set up at 2 control points; 1 reference point, a benchmark, and control points locally established to be used primarily for this fieldwork.DVS-1 located at Sta Ana wharf

Davao City, DVS 3274 located at brgy Poblacion Davao City, DV-75 located at brgy Guadalupe Carmen City, and the base used for the entire survey -IBSS is located at brgy Poblacion Davao City (see Annex E for Baseline Processing). Static observations were simultaneously performed at these four base stations for an hour and a half. The base stations for static observations were as follows:

Figure 35. Static GNSS observation in DVS 3274 located at brgy Poblacion Davao City

Figure 36. Static GNSS survey at DVS-1 located at Sta Ana wharf, Davao City

Figure 37. Office-IBSS used this base for entire Survey

Figure 38. Bench mark DV-75 located at brgy. Guadalupe, Carmen City

2.4 Ground Surveys

Internet Base Station Service (IBSS) made it easier and more economical to use GNSS based positioning systems on the construction site. Traditional GNSS correction methods rely solely on radios and repeaters to cover larger construction sites. IBSS is different because works by providing GNSS corrections over the Internet. In doing so, it extends the range of base station correction sources and is more reliable than using standard radio communications, which can be subject to range limitations and black spots. It also increases jobsite flexibility, improves coverage and reduces the time needed to get new job sites up and running.

All ground survey points were acquired in accordance with the Term of Reference for Outsourcing (TOR) the ground validation survey:

- Cross-sections were surveyed perpendicular to the riverbanks and has an average length of 100 meters on each bank, following the path of the nearby road or goat trails away from the bank. Cross-section point interval was 10 meters. Additional points were obtained to describe apparent change in elevation along the cross-section line. Each cross-section was identified sequentially with e.g. XS1, XS2…etc. from upstream to downstream. The route of cross sections may deviate up to 10 meters from the proposed cross section lines if it is not passable in the actual field implementation.

2.4.1 Cross-section Survey

Cross-section survey was 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 assessed and accepted if it passed the accuracy standard required: within ±20 cm for horizontal and ±10 cm for vertical position residuals. The result of the survey were assessed by the DREAM Program members.

Areas where kinematic GNSS survey was not applicable due to the presence of obstructions such as tall structures and canopy of trees, conventional surveying techniques (e.g. using total stations) was used to collect cross-sectional data.

The position of processed cross-sectional points was expressed in geographic coordinates (latitude and longitude) in the World Geodetic System of 1984 (WGS84), grid coordinates (Northing and Easting) expressed in WGS84 Universal Transverse Mercator Zone 51N (UTM51N) projection, elevation in WGS84 ellipsoidal heights and (EGM08) orthometric heights.

2.4.2 Profile Survey

Profile survey started from Brgy. Mandug Davao City at the upstream of Davao River then proceeded downstream to the flood plain at the town proper . An interval between successive profile points was 10 meters maximum. Additional points were provided to describe apparent change in elevation along the profile line. The profile survey consisted of the Left Upper Bank (LUB) and Left Lower Bank (LLB) survey, Right Upper Bank (RUB) and Right Lower Bank (RLB).

Similar to cross-section survey, profile survey was done using dual frequency GNSS receivers and kinematic survey technique. Accuracy is within ±20 cm for horizontal and ±10 cm for vertical position. The DREAM Validation Component evaluated the accuracy of the field survey by random checking of survey results. Areas where kinematic GNSS survey was not applicable due to obstructions such as tall structures and canopy of trees conventional surveying techniques (e.g. using total stations) were used to collect profile data.

The position of processed profile points was expressed in geographic coordinates (latitude and longitude) in the World Geodetic System of 1984 (WGS84), grid coordinates (Northing and Easting) expressed in WGS84 Universal Transverse Mercator Zone 51N (UTM51N) projection, elevation in WGS84 ellipsoidal heights and (EGM08) orthometric height.

2.5 Data Processing and Analysis

2.5.1 Cross-section Data

Processing of the cross-section data are as follows:

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

2.5.2 Profile Data

Processing of the profile data are as follows:

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

Results and Discussions

Annexes

3.1 Reconnaissance Survey and Actual Field Survey

The area covered by the project is an urban area from upstream to downstream. The cross-section lines mostly run through streets and residential areas. The terrain is relatively flat. The telephone company signal is also good with both Globe and Smart. The cross-section and profile survey were conducted using RTK-GPS using internet communication. Most of the cross section were acquired using RTK-GPS using IBSS but some part of the cross section that were not feasible to acquire using RTK-GPS so the team used a total station for the remaining of the areas.

Table 3. The three control points used to establish baselines and a GNSS network for the entire survey area.

Point ID	Latitude (Global)	Longitude (Global)	Ellipsoid Height (Global)	Northing	Easting	Elevation (MSL)
DVS-1	N7°04'38.36201"	E125°37'36.77094"	68.275	783116.705	790192.921	2.6442
DVS-3274	N7°05'59.63643"	E125°37'40.06397"	73.469	785615.574	790279.891	7.7732
DV-75	N7°22'30.70233"	E125°44'17.21483"	71.285	816153.45	802291.67	3.7959
Office(IBSS)	N7°05'27.44213"	E125°36'18.38203"	106.536	784611.803	787777.367	40.7202

3.2 Problems Encountered and Resolutions Applied

During the actual field work there was some incident that which were beyond the survey team like bad weather condition. Here are the problems that the survey team has encountered.

Table 4. Problems encountered and solutions applied

Limitation/Problems	Solutions
Cross-section 1 ,2 and 3 lines falls along sub-divisions and other private properties	The contractor explained the purpose of the project to the private entities within the survey extent, alternate routes were surveyed to connect the cross section lines
Some cross section lines fall along built-up areas and cannot be surveyed	Tried another route or deviate more than 10 m from the proposed cross section lines
RTK signal cannot be fixed due to canopy cover for some cross section and profile lines	The contractor used total station to gather points in these areas
Informal settlers along the left and right profile	Alternate routes were sought to connect the profile lines

3.3 Processed Data

The data was processed using Trimble Business Center. EGM2008-1' was applied as Geiod Model correction. The data were adjusted to MSL using the elevation of DVS-1 at Sta. Ana Wharf.

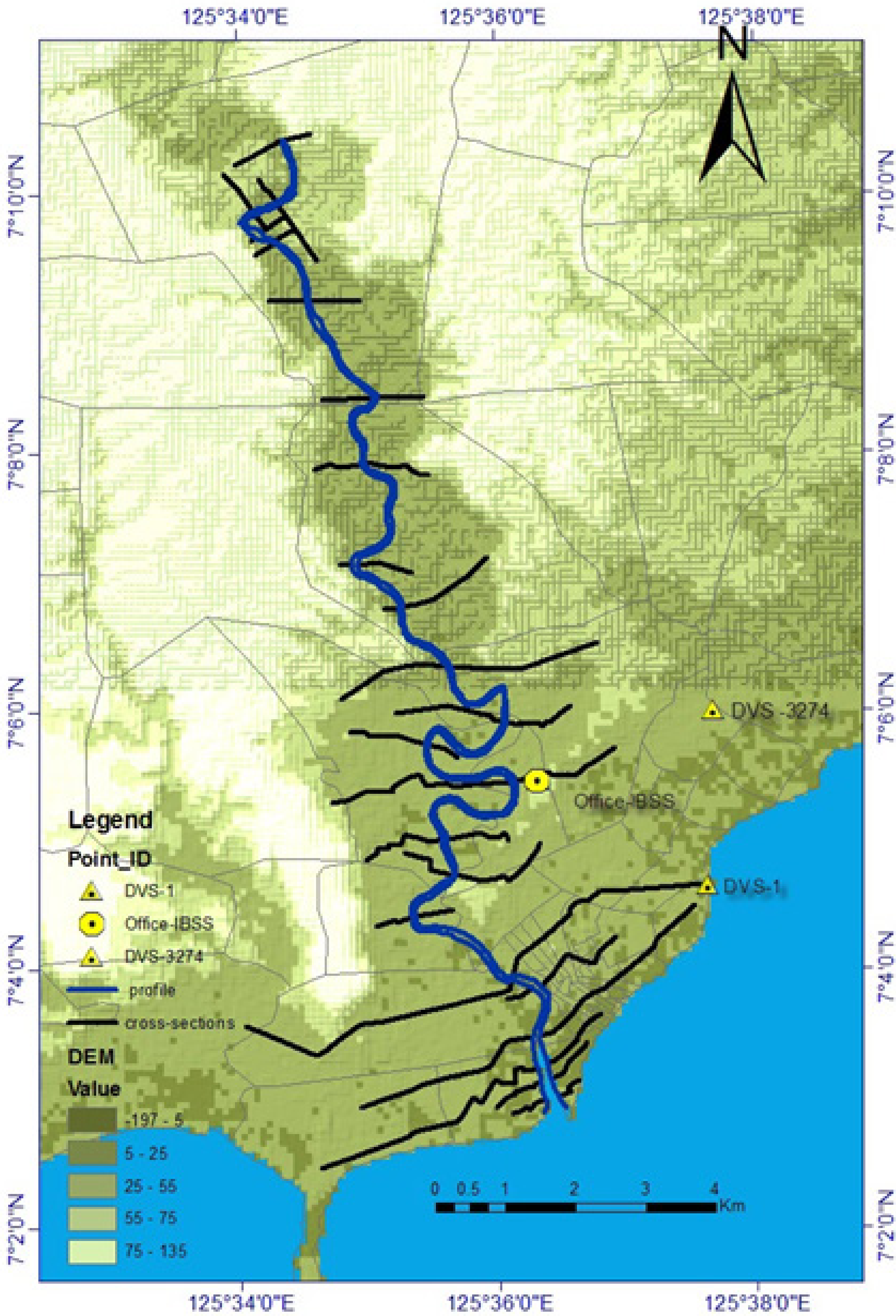


Figure 39. Location of Control points and Base Station used

3.3.1 Cross-Section Survey

The series of figures below shows the variation in the elevation of the cross-sections in Davao River Flood plain. The cross-sections were plotted from the left to right facing downstream.

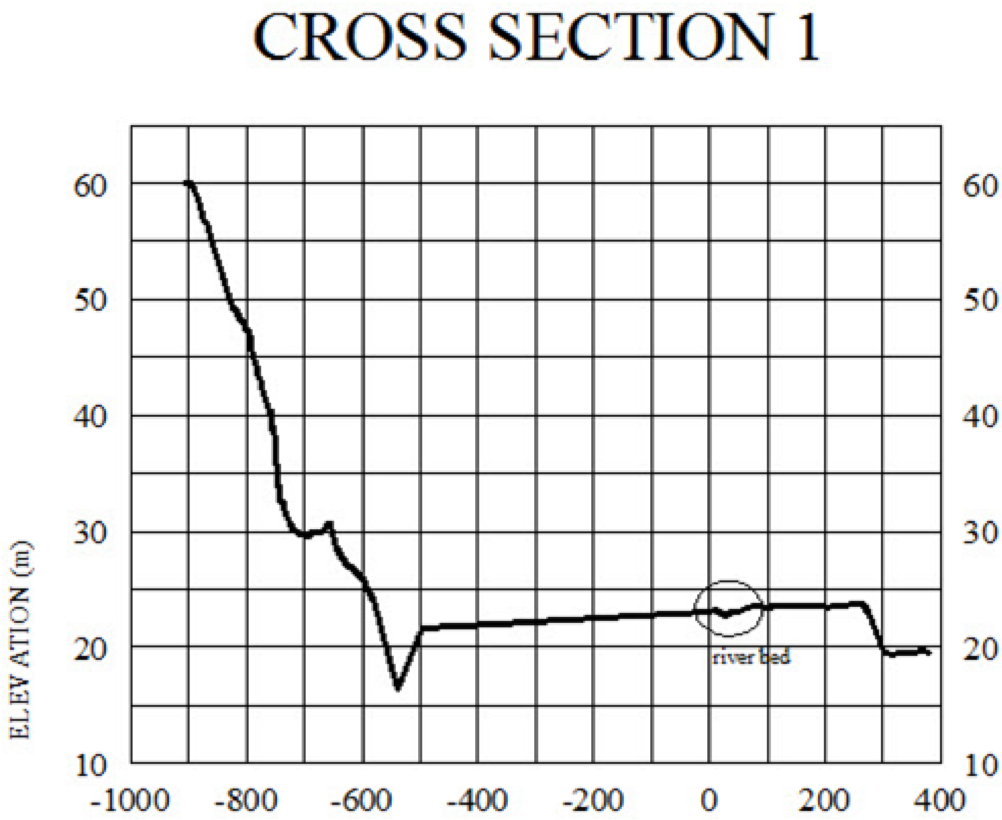


Figure 40. Cross section 1 of Davao survey area

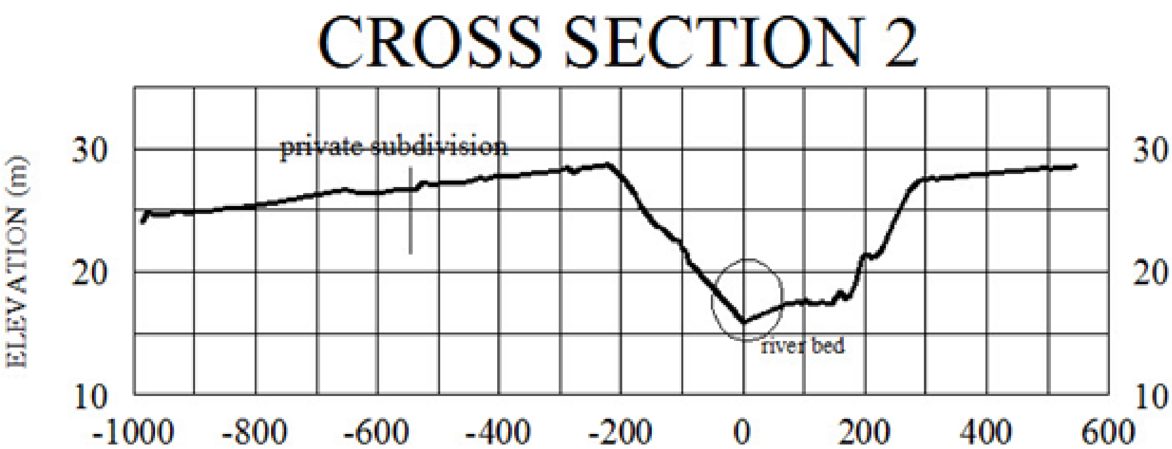


Figure 41. Cross section 2 of Davao survey area

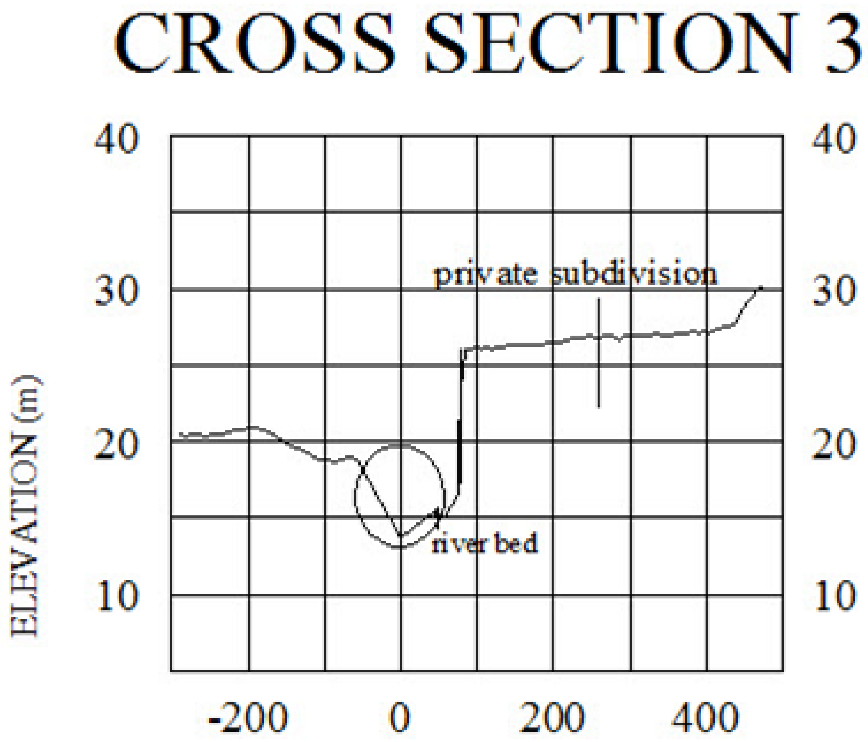


Figure 42. Cross section 3 of Davao survey area

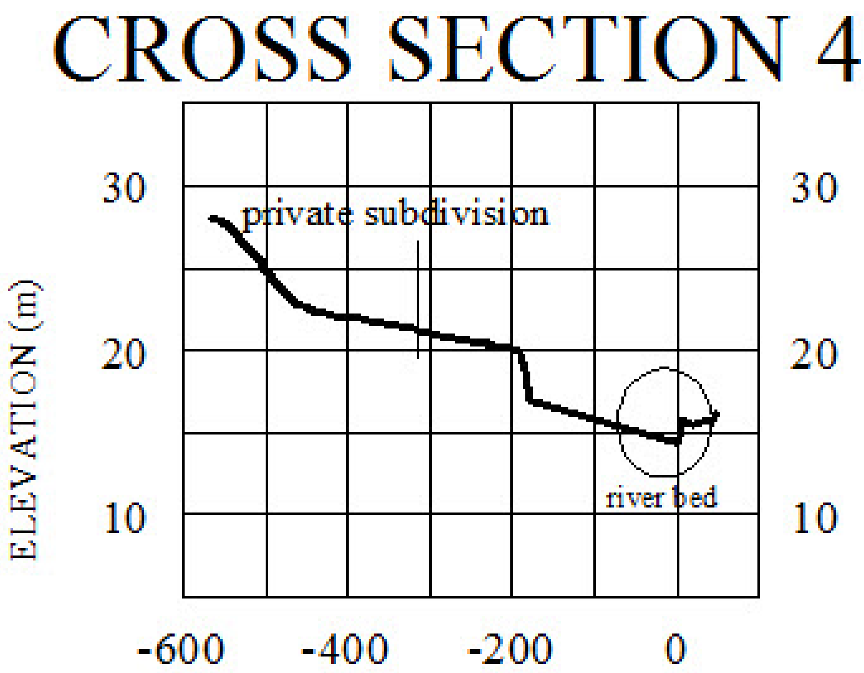


Figure 43. Cross section 4 of Davao survey area

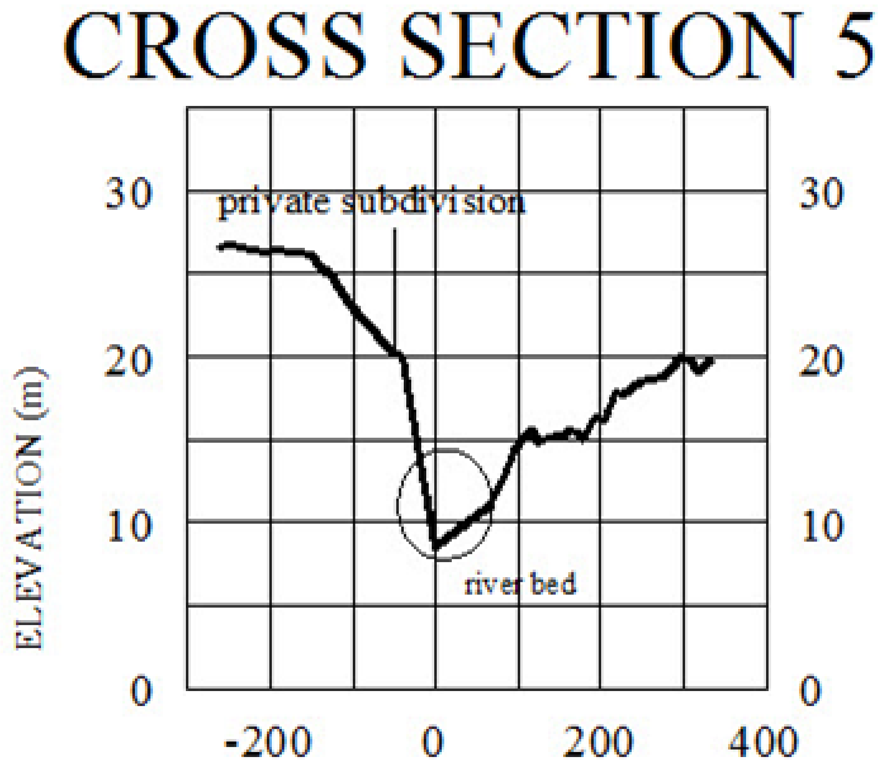


Figure 44. Cross section 5 of Davao survey area

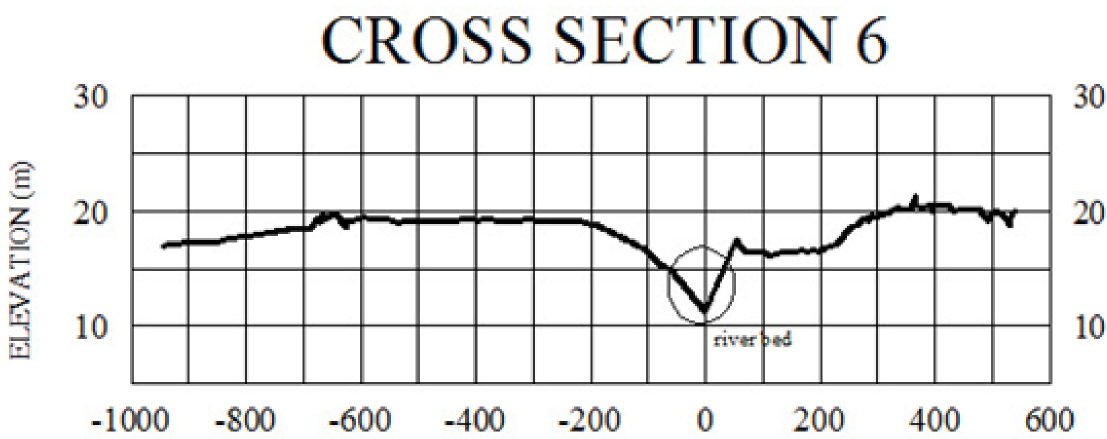


Figure 45. Cross section 6 of Davao survey area

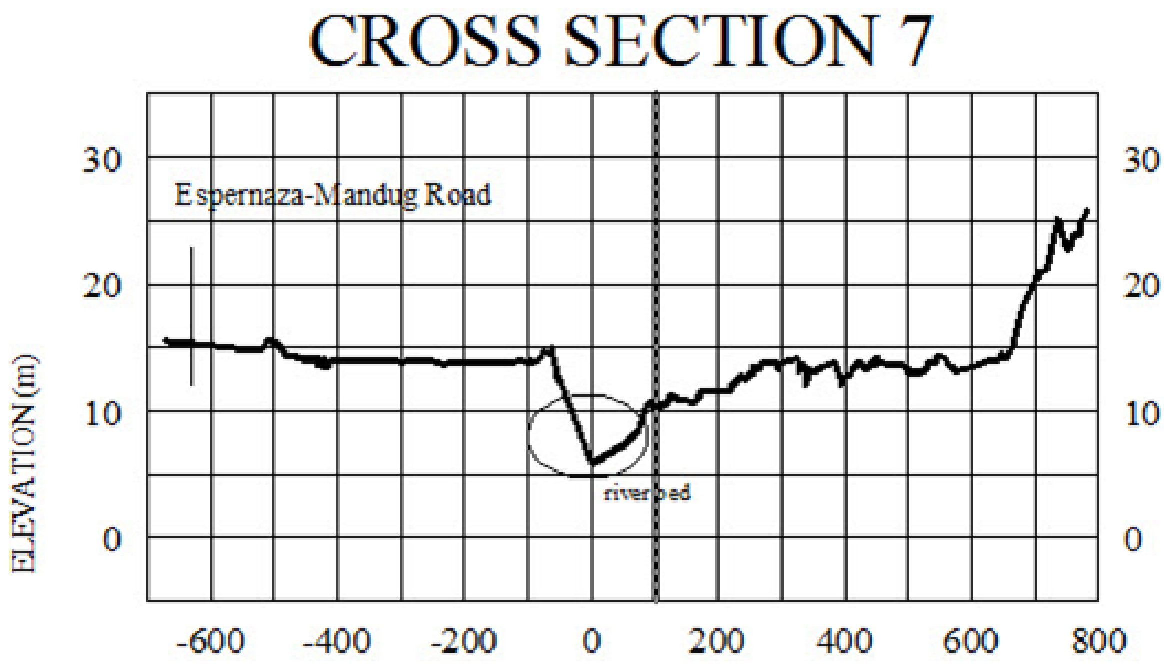


Figure 46. Cross section 7 of Davao survey area

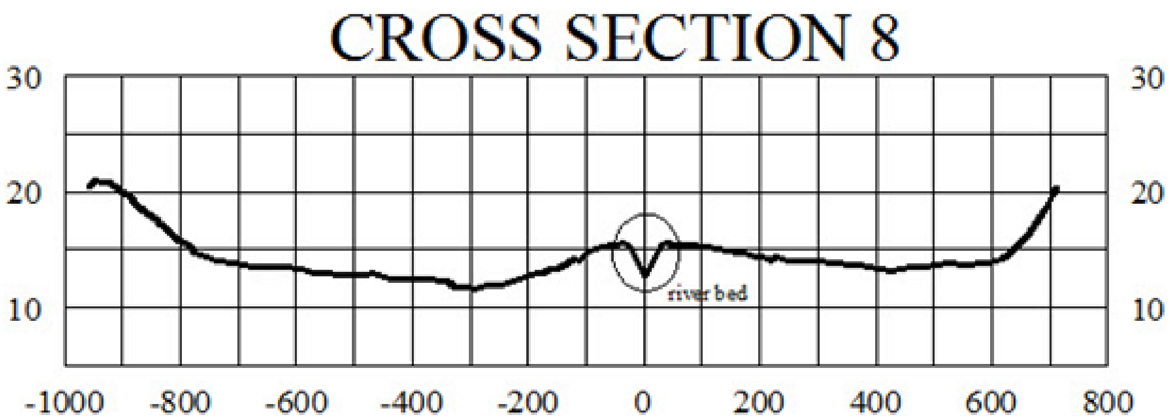


Figure 47. Cross section 8 of Davao survey area

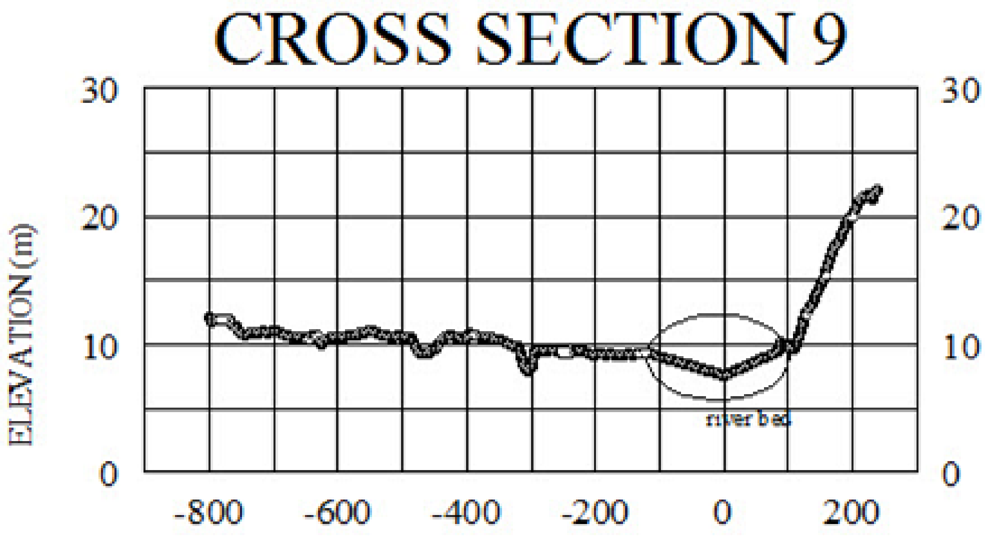


Figure 48. Cross section 9 of Davao survey area

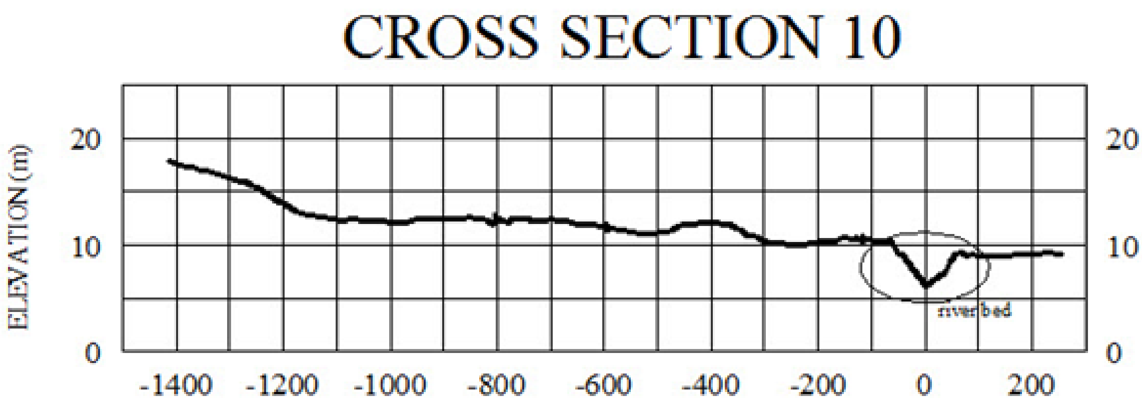


Figure 49. Cross section 7 of Davao survey area

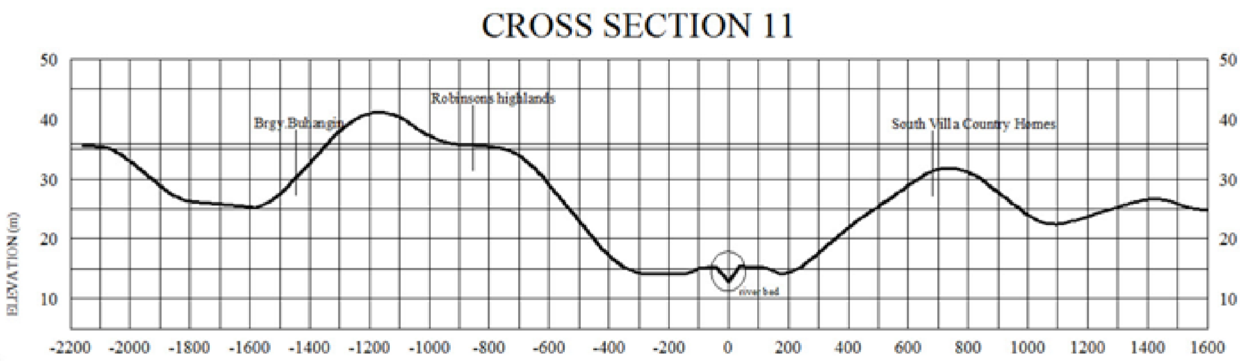


Figure 50. Cross section 11 of Davao survey area

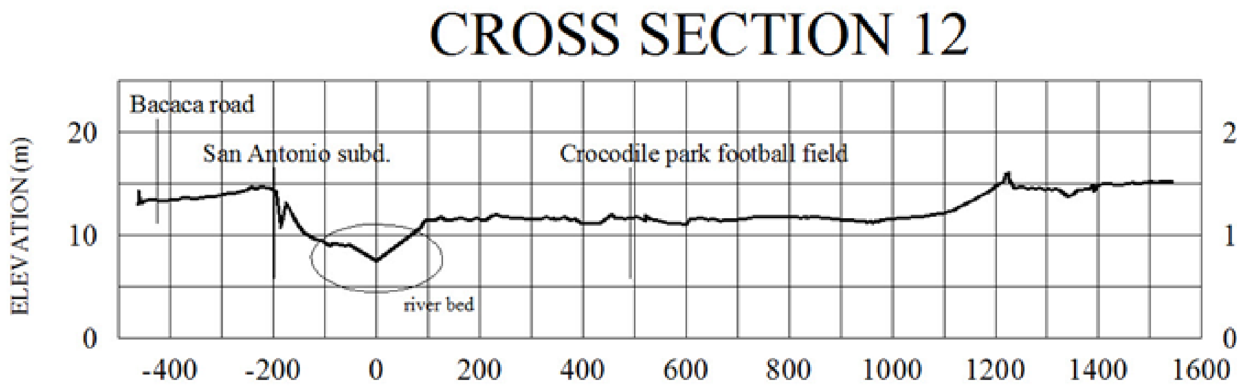


Figure 51. Cross section 12 of Davao survey area

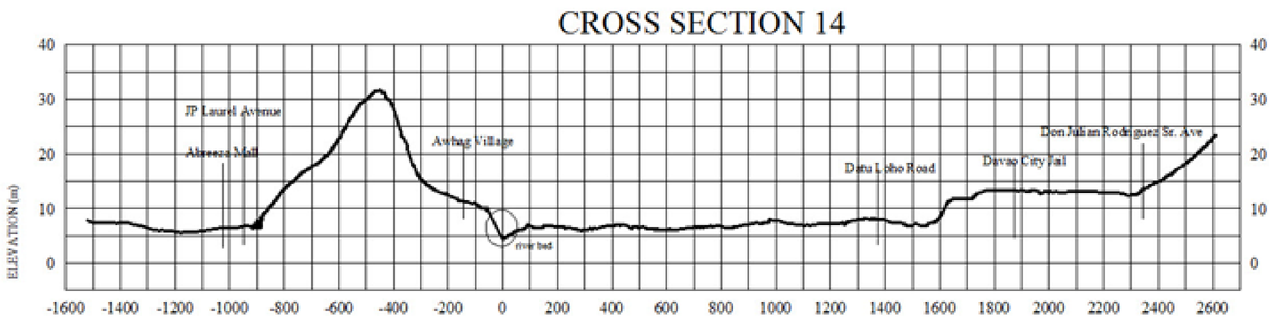


Figure 52. Cross section 14 of Davao survey area

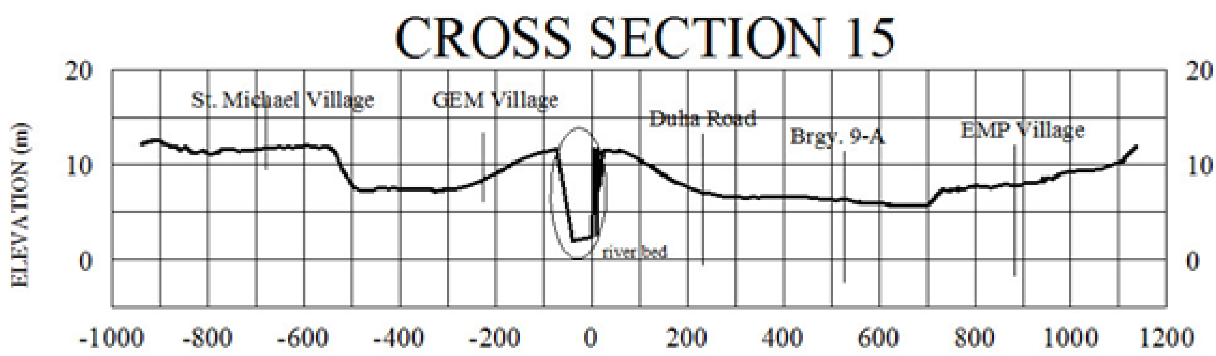


Figure 53. Cross section 15 of Davao survey area

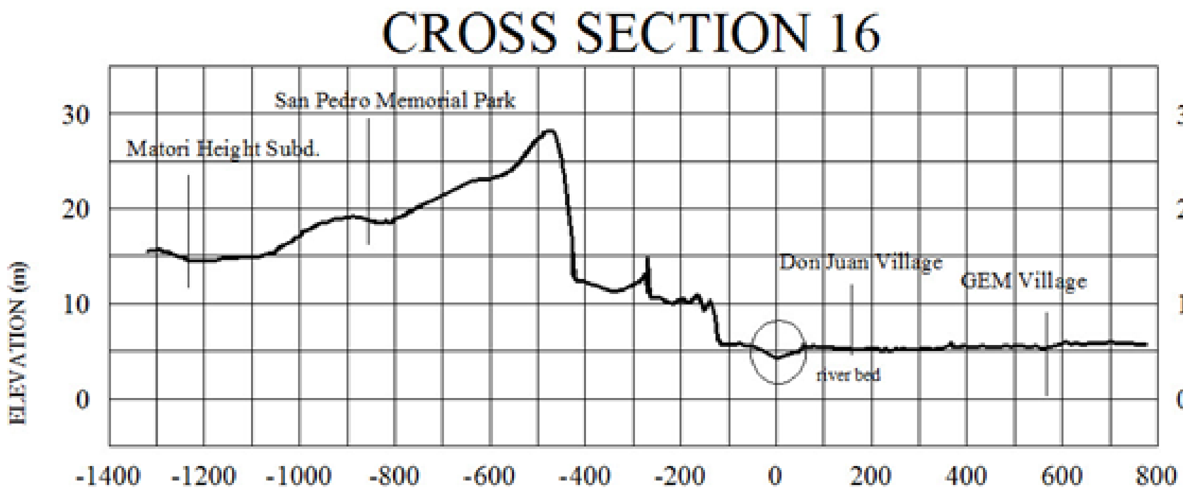


Figure 54. Cross section 16 of Davao survey area

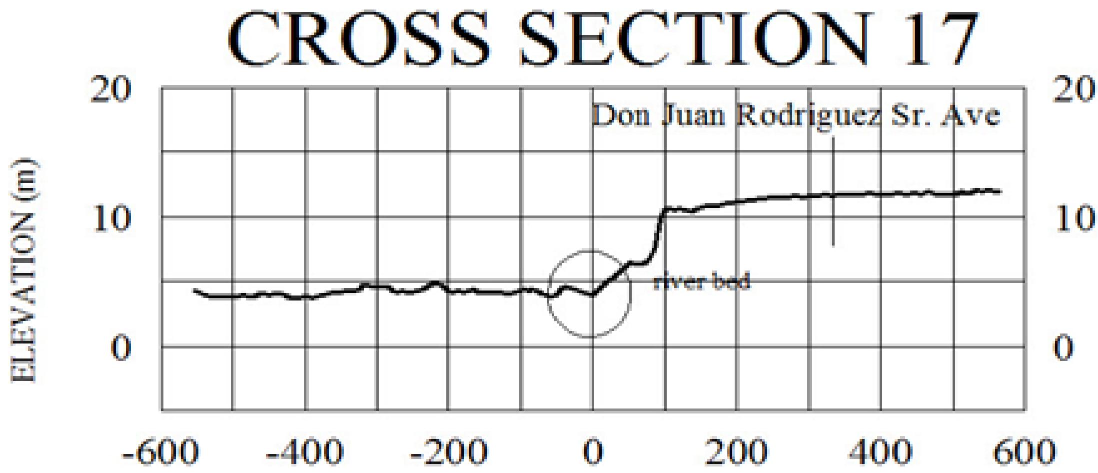


Figure 55. Cross section 17 of Davao survey area

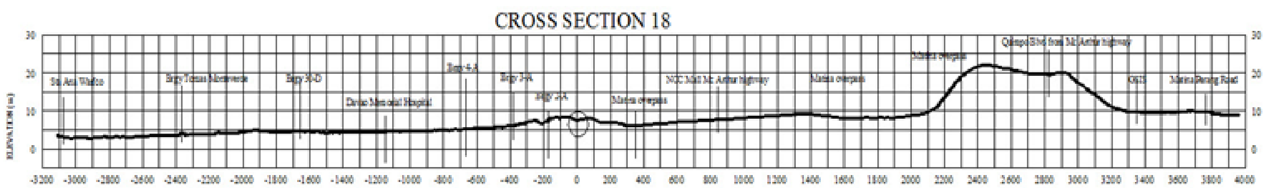


Figure 56. Cross section 18 of Davao survey area

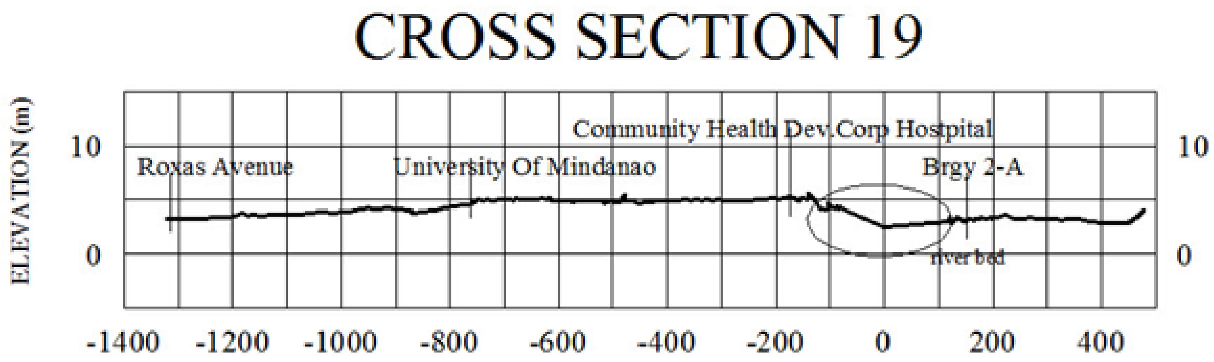


Figure 57. Cross section 19 of Davao survey area

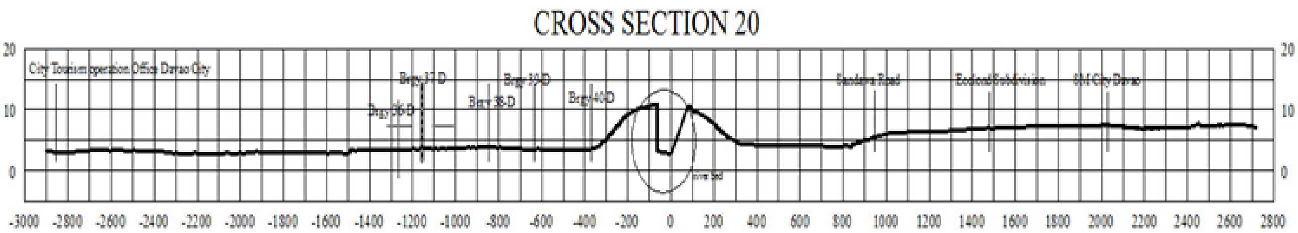


Figure 58. Cross section 20 of Davao survey area

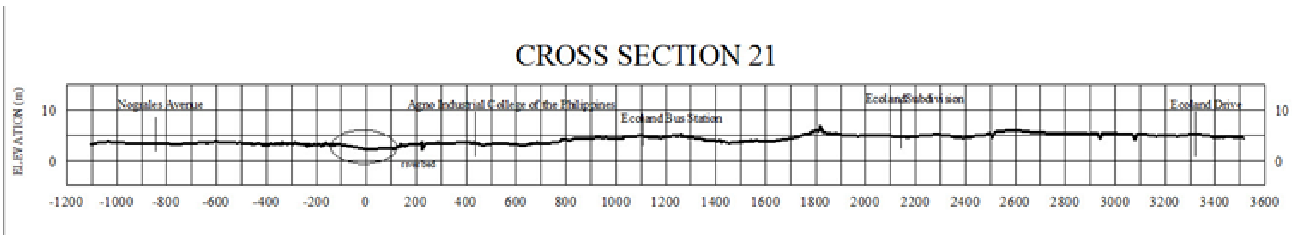


Figure 59 . Cross section 21 of Davao survey area

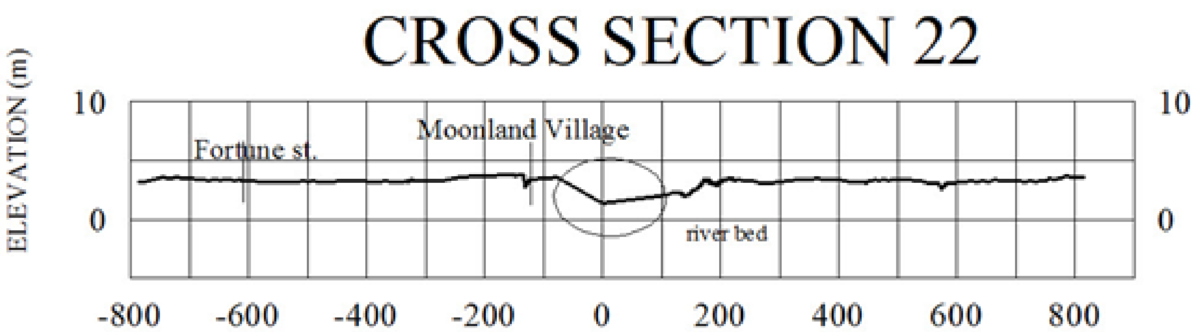


Figure 60. Cross section 22 of Davao survey area

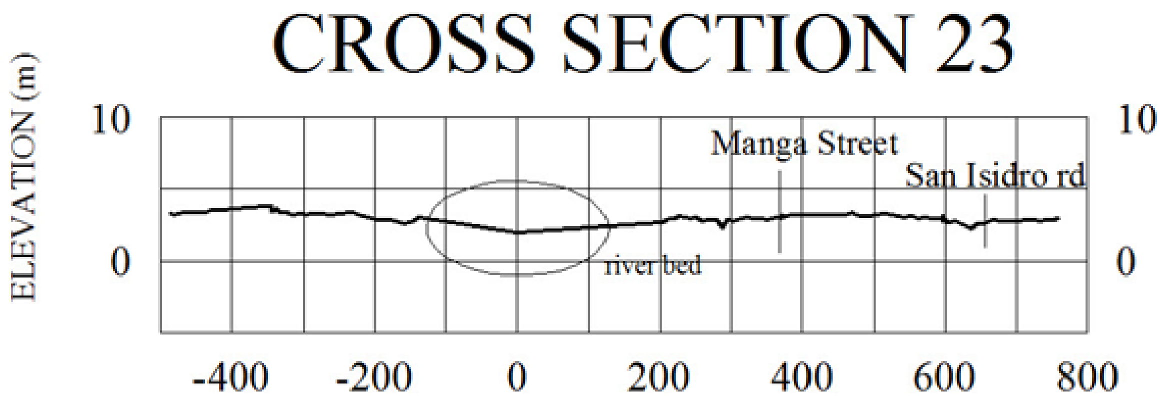


Figure 61. Cross section 23 of Davao survey area

3.3.2 Profile surveys

Graphs show the River profile of Davao river.

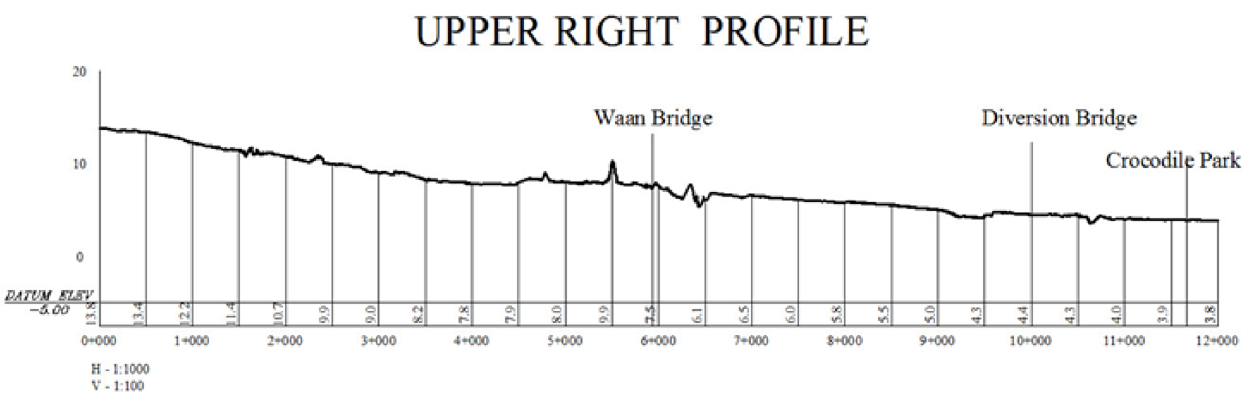


Figure 62. Upper right profile of Davao River

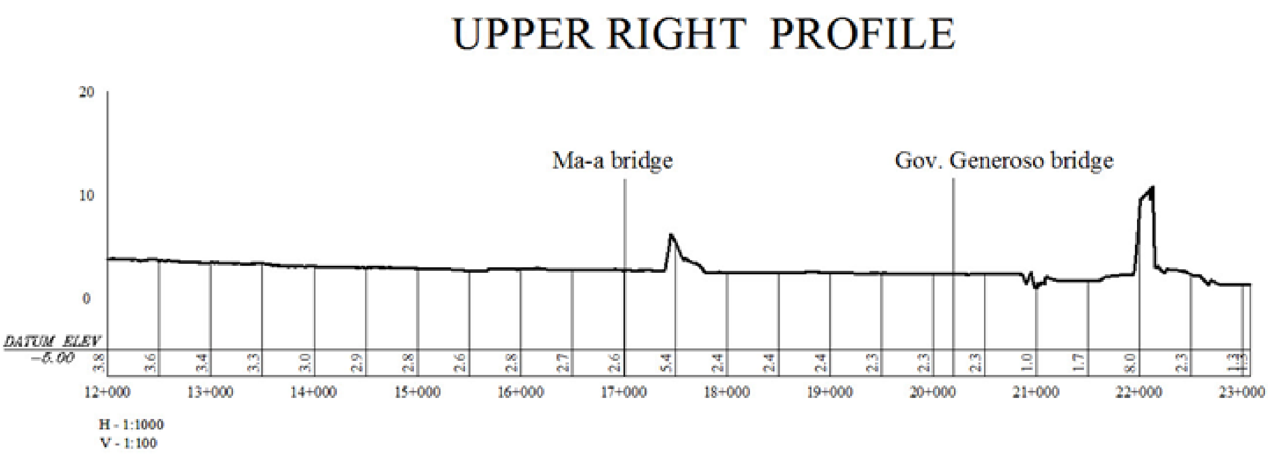


Figure 63. Upper right profile of Davao river

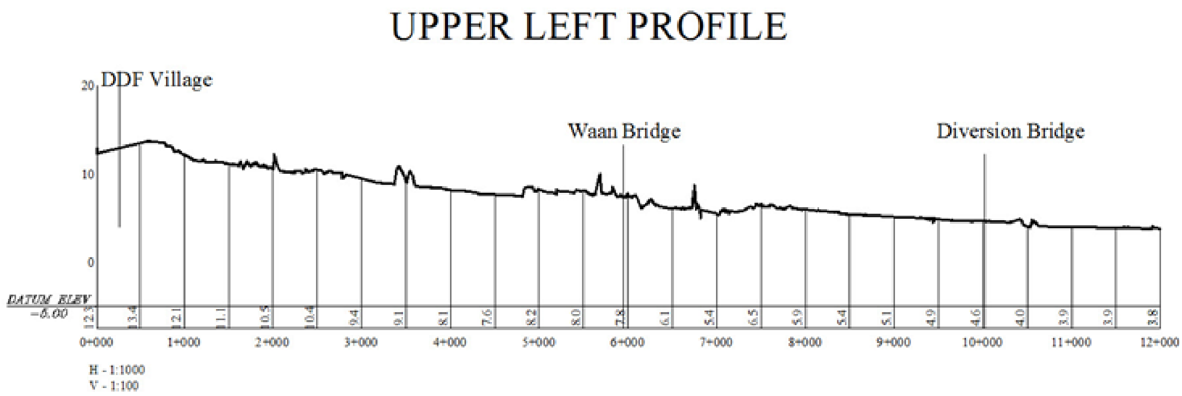


Figure 64. Upper left profile of Davao river

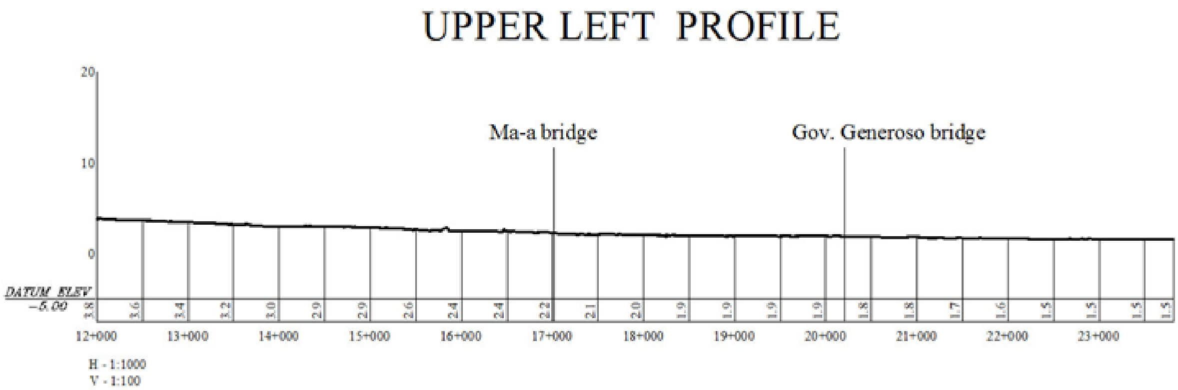


Figure 65. Upper left profile of Davao river

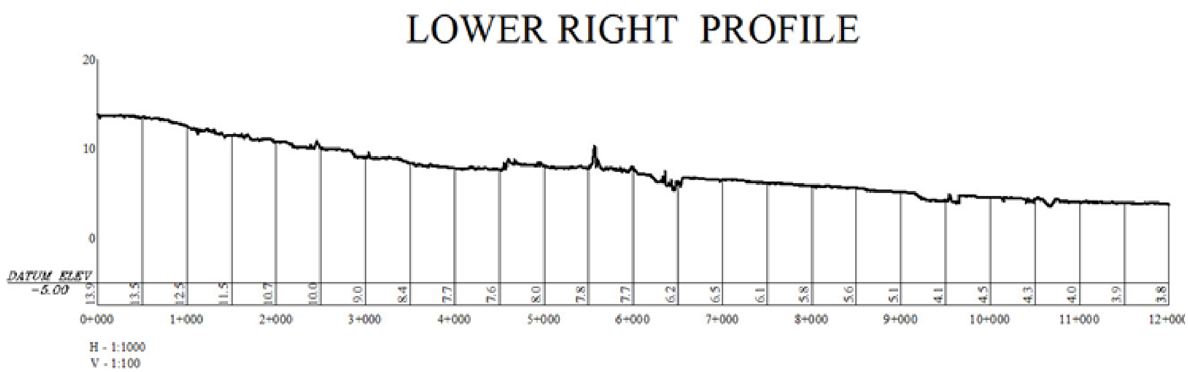


Figure 66. Lower right profile of Davao river

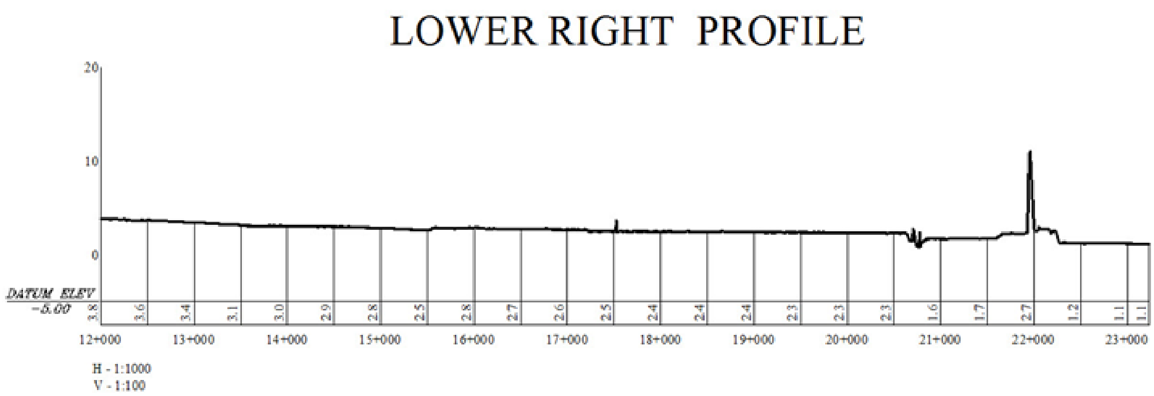


Figure 67. Lower right profile of Davao river

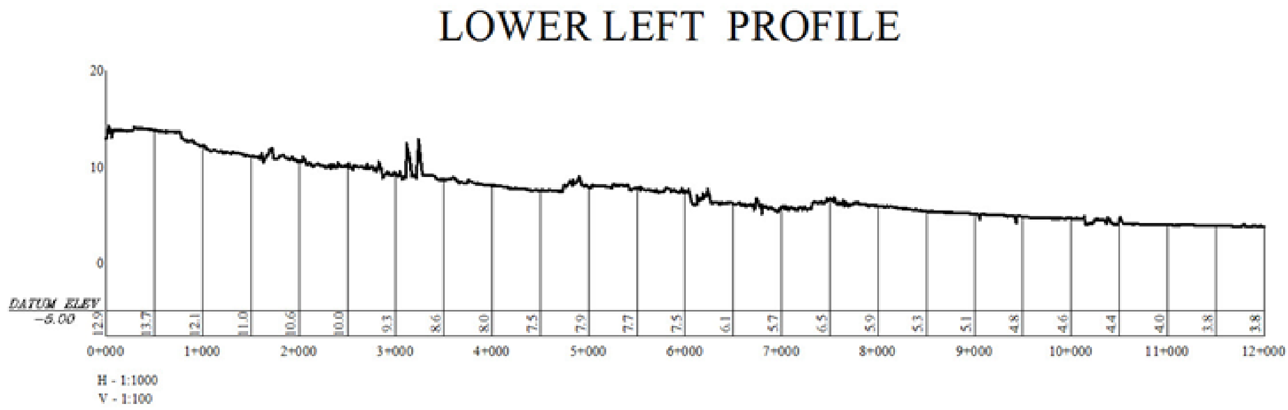


Figure 68. Lower left profile of Davao river

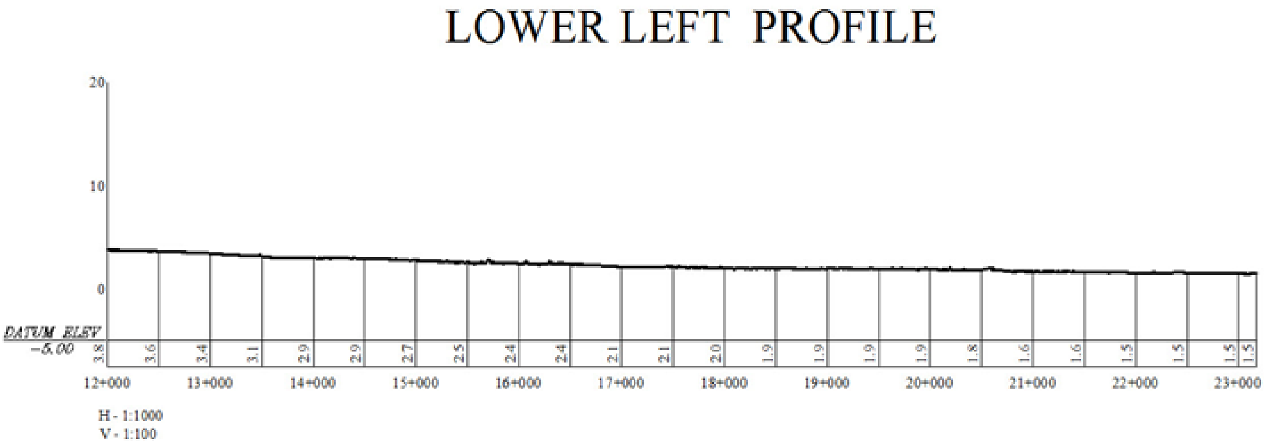


Figure 69. Lower left profile of Davao river

Annexes

Annexes

ANNEX A. THE SURVEY TEAM

TEAM	Name
Senior Geodetic Engineer	Engr. Ronielo Efren
Party Chief	Renato Capistrano
Driver	Luisito Dacara
Cross-Section	Jaycel Roy Dimaden
	Darwin Santos
	Lito Salvacion
	Arman Reyes
	Local Survey Aide
	Local Survey Aide
Profile	Arnel Cordano
	Babilito Pancho
	Houdini Abonal
	Eduard Cabrera
	Local Survey Aide
	Local Survey Aide
Autocadd Operator	Vanessa Sanchez

ANNEX B. INSTRUMENTS USED

Equipment	Quantity	Materials	Quantity
Trimble SPS 855	2	Concrete Nails	1 lot
Trimble SPS 852	1	Stakes	1 lot
Trimble SPS 882	1	Paint	1 lot
Trimble 5700	2	Brush	1 lot
TSCE Controller	2		
TSC2 Controller	1		
TSC3 Controller	2		
HPB High-Power External Radio	1		
Gowin Total Station	2		
Hand-Held GPS	2		
PPE equipment	1 lot		
Survey Vehicle	1		
Digital Level	1		
Field Computer (Lap-top)	2		
Plotter	1		

ANNEX C. LIST OF ACTIVITIES

DAY	ACTIVITY	LOCATION	PERSONS INVOLVED/PARTICIPATING
June 28 2013	• Static Survey	• Sta Ana Wharf • Stop House • Beside Convenience store	Houdini Abonal Bernard Alfaro Arnel Cordano
June 29 2013	• Static Survey	• Sta Ana Wharf • Stop House • Beside Convenience store	Houdini Abonal Bernard Alfaro Arnel Cordano Brian Koh
June 30 2013	• Start of Actual Survey of Profile and Cross section along Davao river	• Brgy. Mandug (Tigatto)	Team 1 Arnel Cordano, Lito Salvacion Team 2 Michael , Houdini Abonal Bernard Alfaro Team 3 Brian Koh, Darwin Santos
	• Continuation of Profile and Cross section along Davao River	• Brgy. Mandug (Near Lapanday food Corp.)	Team 1 Arnel Cordano, Lito Salvacion Team 2 Michael, Houdini Bernard Alfaro Team 3 Brian Koh, Darwin Santos
July 1 2013	• Continuation of Profile and Cross section along Davao River	• Brgy. Mandug (Callawa)	Team 1 Arnel Cordano, Lito Salvacion Team 2 Michael, Houdini Abonal Bernard Alfaro Team 3 Brian Koh, Darwin Santos
July 2 2013	• Continuation of Profile and Cross section along Davao River	• Brgy. Mandug (Callawa)	Team 1 Arnel Cordano, Lito Salvacion Team 2 Michael, Houdini Bernard ALfaro Team 3 Brian Koh, Darwin Santos
July 3 2013	• Continuation of Profile and Cross section along Davao River	• Brgy. Mandug (Callawa)	Team 1 Arnel Cordano, Lito Salvacion Team 2 Michael, Houdini Abonal Bernard Alfaro Team 3 Brian Koh, Darwin Santos
July 4 2013	• Continuation of Profile and Cross section along Davao River	• Brgy. Mandug (Callawa)	Team 1 Arnel Cordano, Lito Salvacion Team 2 Michael, Houdini Abonal Bernard Alfaro Team 3 Brian Koh, Darwin Santos
July 5 2013	• Continuation of Profile and Cross section along Davao River	• Brgy. Buhangin	Team 1 Arnel Cordano, Lito Salvacion Team 2 Michael, Houdini Abonal Bernard Alfaro Team 3 Brian Koh, Darwin Santos
July 6 2013	• Continuation of Profile and Cross section along Davao River	• Brgy. Ma-A	Team 1 Arnel Cordano, Lito Salvacion Team 2 Michael, Houdini Abonal Bernard ALfaro Team 3 Brian Koh, Darwin Santos
July 7 2013	• Continuation of Profile and Cross section along Davao River	• Brgy. Ma-A	Team 1 Arnel Cordano, Lito Salvacion Team 2 Michael, Houdini Abonal; Bernard ALfaro Team 3 Brian Koh, Darwin Santos
July 8 2013	• Continuation of Profile and Cross section along Davao River	• City Proper	Team 1 Arnel Cordano, Lito Salvacion Team 2 Michael, Houdini Abonal Bernard Alfaro Team 3 Brian Koh, Darwin Santos

ANNEX D. NAMRIA CERTIFICATION

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

July 25, 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: **DAVAO DEL SUR**
Station Name: **DVS-1**
Order: **1st**

Island: **MINDANAO** Municipality: **DAVAO CITY**		Barangay: **TOWN PROPER**
	PRS92 Coordinates	
Latitude: **7° 4' 41.48387"**	Longitude: **125° 37' 31.24815"**	Ellipsoidal Hgt: **-4.50700 m.**
	WGS84 Coordinates	
Latitude: **7° 4' 38.36201"**	Longitude: **125° 37' 36.77094"**	Ellipsoidal Hgt: **68.27500 m.**
	PTM Coordinates	
Northing: **782663.345 m.**	Easting: **569084.935 m.**	Zone: **5**
	UTM Coordinates	
Northing: **783,162.17**	Easting: **790,026.11**	Zone: **51**

Location Description

DVS-1
From Davao City hall travel southeast along San Pedro street for 400 meters. Upon reaching the "T" intersection of San Pedro street and Quezon boulevard travel for 2.1 kms. up to the cross intersection of roads at Monteverde street, Leon Garcia street and Quezon boulevard. From this intersection turn right to Sta. Ana pier. The station is located on the east side of the new pier; 94 meters Northeast of coast guard house and north of the old pier. Station mark is 0.15 m x 0.01 m in diameter brass rod with cross cut on top, set in a drill hole, centered in a 30 cm x 30 cm cement patty on top of concrete pavement of wharf. Inscribed on top with the station name. All reference marks are 0.15 m x 0.01 m in diameter brass rods with cross cut on top, set in drill holes, centered in cement patty on concrete pavement of wharf. Inscribed on top with the reference mark numbers and arrow pointing to the station.

Requesting Party:	**RAYMOND RAMA**
Pupose:	**Reference**
OR Number:	**3946574 B**
T.N.:	**2013-0723**

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

9 9 0 7 2 5 2 0 1 3 1 2 2 6 2 0

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

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

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

July 25, 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: **DAVAO DEL SUR**
Station Name: **DVS-3274**
Order: **4th**

Island: **MINDANAO**
Municipality: **DAVAO CITY**
Barangay: **POBLACION**

	PRS92 Coordinates	
Latitude: 7° 6' 2.76429"	Longitude: 125° 37' 34.54326"	Ellipsoidal Hgt: 0.72700 m.
	WGS84 Coordinates	
Latitude: 7° 5' 59.63643"	Longitude: 125° 37' 40.06397"	Ellipsoidal Hgt: 73.46900 m.
	PTM Coordinates	
Northing: 785160.263 m.	Easting: 569182.689 m.	Zone: 5
	UTM Coordinates	
Northing: 785,661.06	Easting: 790,113.15	Zone: 51

Location Description

DVS-3274
The station is at the parking area of Our Lady of Victory Enterprises along J. P. Laurel Ave., and Carmelite road leading to Hillside Subd. Station is S 45 E, 8m from the first concrete electrical post along Carmelite road. Mark is the head of a 4" copper nail embedded and centered on a 0.25 m x 0.25 m cement putty with inscription DVS-3274 2007 LMS II.

Requesting Party: **RAYMOND RAMA**
Pupose: **Reference**
OR Number: **3946573 B**
T.N.: **2013-0722**

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

99072520131213 12

CIP/4201/12/09/814

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: **DAVAO DEL NORTE**
Station Name: **DV-75**

Island: **Mindanao**	Municipality: **CARMEN**	Barangay: **GUADALUPE**
Elevation: **3.7959 m.**	Order: **1st Order**	Datum: **Mean Sea Level**

Location Description

DV-75 is in the Province of Davao del Norte, City of Carmen, Barangay Guadalupe taking the national highway fron Davao City going to Tagum City. Station is located 100 m. away from the Kilometer post KM.1468 along the nationa highway.

Station mark is the head of 4" copper nail set on a drilled hole and cemented flushed on top of a 15x15cm. cemer putty with inscriptions "DV-75, 2007 NAMRIA."

Requesting Party: **LN Realty and Surveying Services**
Pupose: **Reference**
OR Number: **3943807 B**
T.N.: **2013-0597**

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

CERTIFICATION INTERNATIONAL
CIP/4701/12/09/014

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

ANNEX E. BASELINE PROCESSING

Project information		Coordinate System	
Name:	C:\Users\LAPTOP518\Documents\Business Center - HCE\Davao_June 25.vce	Name:	UTM
Size:	147 KB	Datum:	WGS 1984
Modified:	7/26/2013 12:34:47 PM (UTC:8)	Zone:	51 North (123E)
Time zone:	China Standard Time	Geoid:	EGM08-1
Reference number:		Vertical datum:	
Description:			

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Metre)	V. Prec. (Metre)	Geodetic Az.	Ellipsoid Dist. (Metre)	Δ Height (Metre)
Office --- DVS-1 (B4)	DVS-1	Office	Fixed	0.003	0.013	302°04'46"	2839.014	38.261

Acceptance Summary

Processed	Passed	Flag	Fail
1	1	0	0

Office - DVS-1 (10:05:53 AM-11:19:44 AM) (S4)

Baseline observation:	Office --- DVS-1 (B4)
Processed:	7/31/2013 10:25:17 PM
Solution type:	Fixed
Frequency used:	Dual Frequency (L1, L2)
Horizontal precision:	0.003 m
Vertical precision:	0.013 m
RMS:	0.001 m
Maximum PDOP:	1.635
Ephemeris used:	Broadcast
Antenna model:	Trimble Relative
Processing start time:	6/25/2013 10:08:46 AM (Local: UTC+8hr)
Processing stop time:	6/25/2013 11:17:08 AM (Local: UTC+8hr)
Processing duration:	01:08:22
Processing interval:	1 second

Vector Components (Mark to Mark)

From:	DVS-1				
Grid		**Local**		**Global**	
Easting	790192.921 m	**Latitude**	N7°04'38.36201"	**Latitude**	N7°04'38.36201"
Northing	783116.705 m	**Longitude**	E125°37'36.77094"	**Longitude**	E125°37'36.77094"
Elevation	0.546 m	**Height**	68.275 m	**Height**	68.275 m

To:	Office				
Grid		**Local**		**Global**	
Easting	787777.367 m	**Latitude**	N7°05'27.44213"	**Latitude**	N7°05'27.44213"
Northing	784611.803 m	**Longitude**	E125°36'18.38203"	**Longitude**	E125°36'18.38203"
Elevation	38.622 m	**Height**	106.536 m	**Height**	106.536 m

Vector					
Δ Easting	-2415.554 m	**NS Fwd Azimuth**	302°04'46"	**Δ X**	2041.778 m
Δ Northing	1495.098 m	**Ellipsoid Dist.**	2839.014 m	**Δ Y**	1280.604 m
Δ Elevation	38.076 m	**Δ Height**	38.261 m	**Δ Z**	1500.959 m

Standard Errors

Vector errors:					
σ Δ Easting	0.001 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.004 m
σ Δ Northing	0.001 m	σ Ellipsoid Dist.	0.001 m	σ ΔY	0.006 m
σ Δ Elevation	0.007 m	σ Δ Height	0.007 m	σ ΔZ	0.001 m

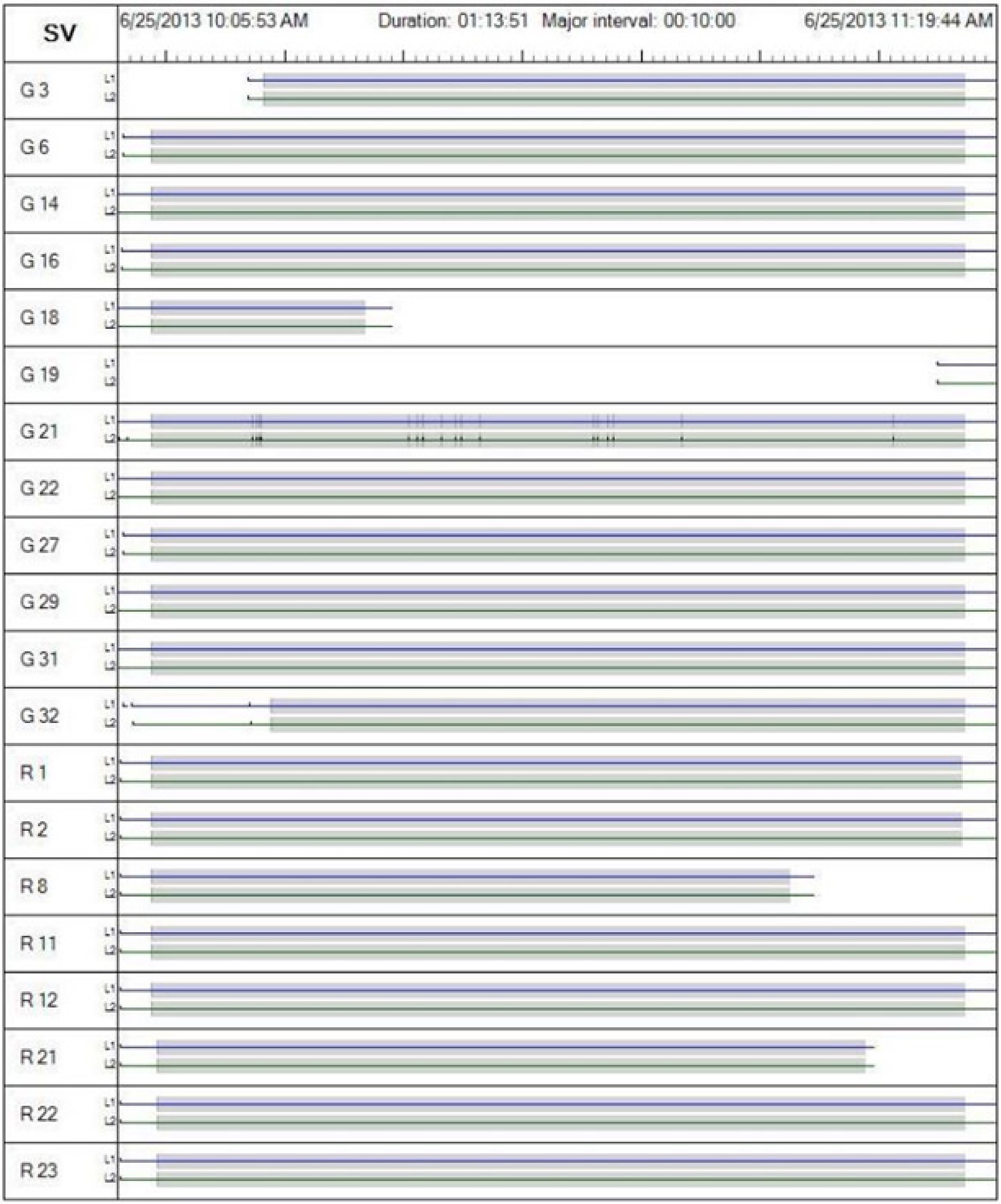
Aposteriori Covariance Matrix (Metre²)

	X	Y	Z
X	0.0000134360		
Y	-0.0000192490	0.0000311793	
Z	-0.0000022913	0.0000038041	0.0000015959

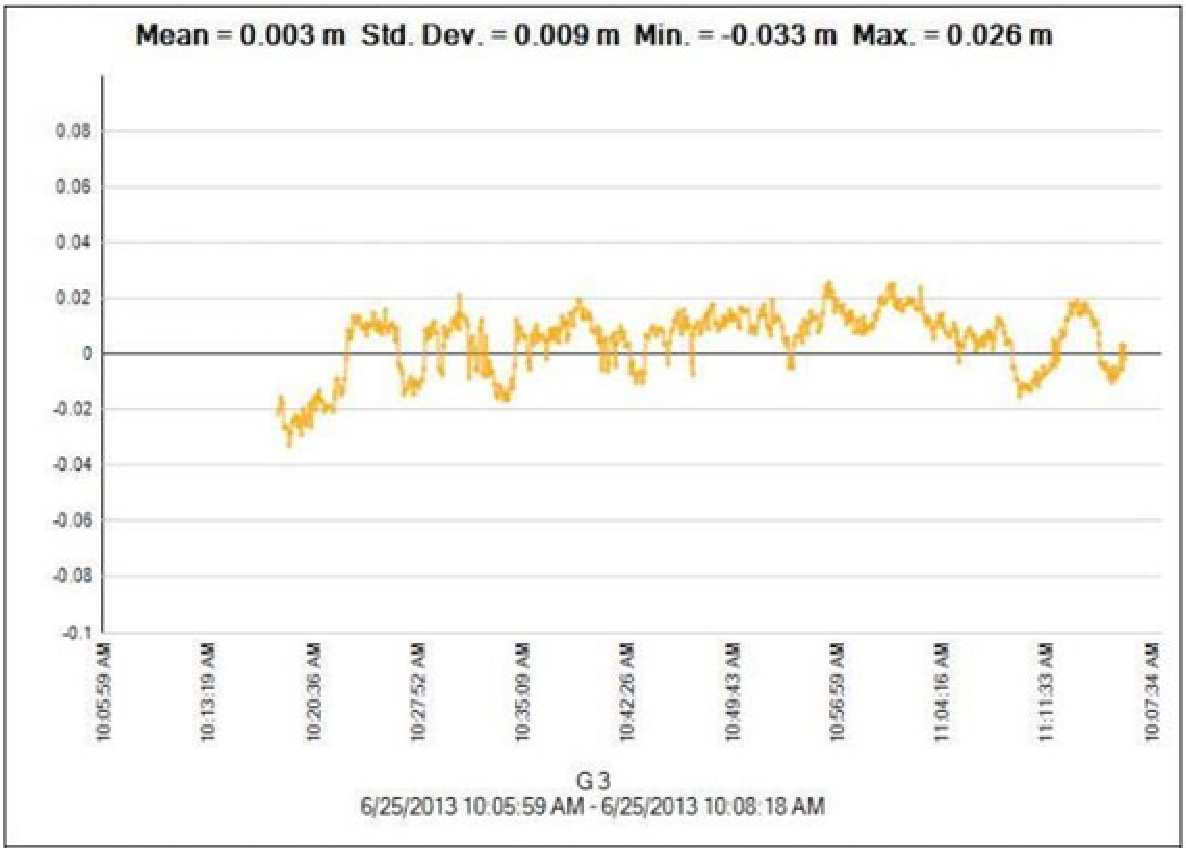
Occupations

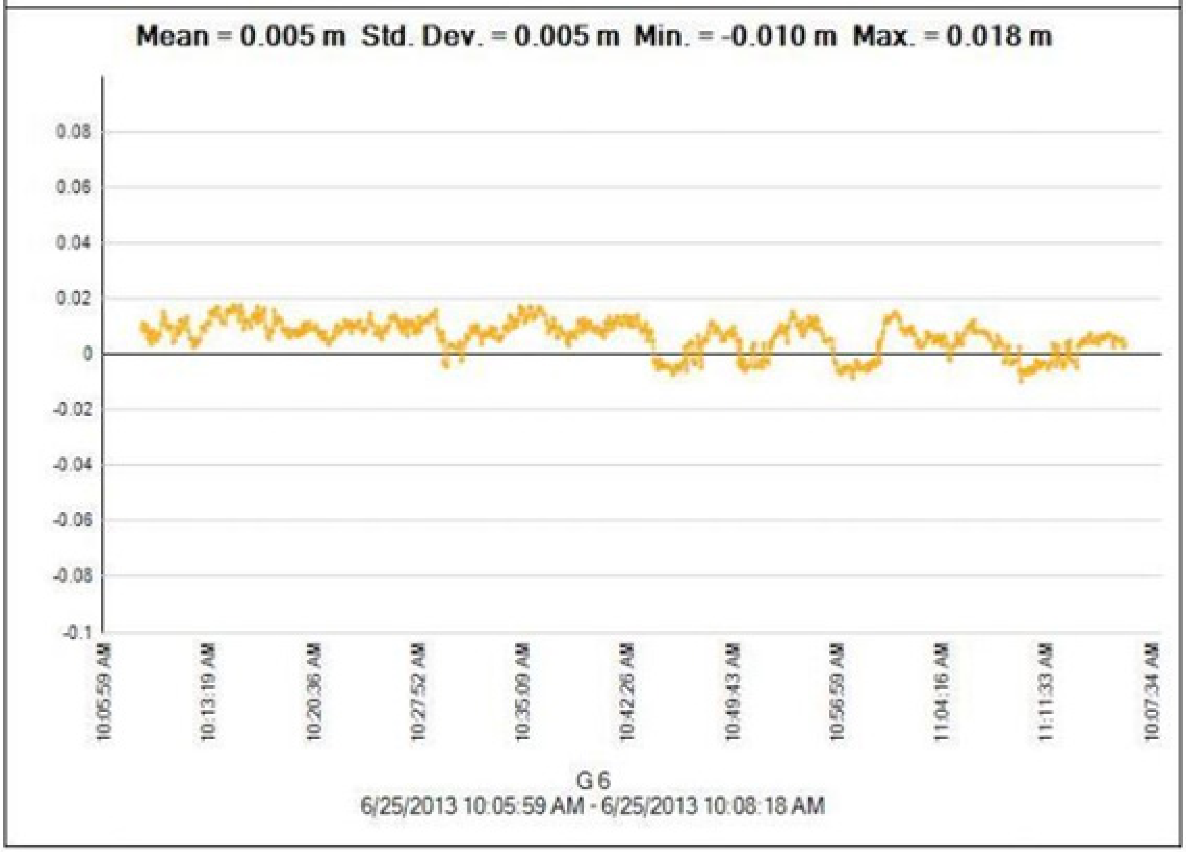
	From	To
Point ID:	DVS-1	Office
Data file:	C:\Users\LAPTOP518\Documents\Business Center - HCE\Davao_June 25\79661761.T02	C:\Users\LAPTOP518\Documents\Business Center - HCE\Davao_June 25\5044K71368201306250205.T02
Receiver type:	SPS882	SPS852
Receiver serial number:	5051457966	5044K71368
Antenna type:	R8 GNSS/SPS88x Internal	GA810
Antenna serial number:	--------	--------
Antenna height (measured):	1.580 m	0.000 m
Antenna method:	Bottom of antenna mount	Bottom of antenna mount

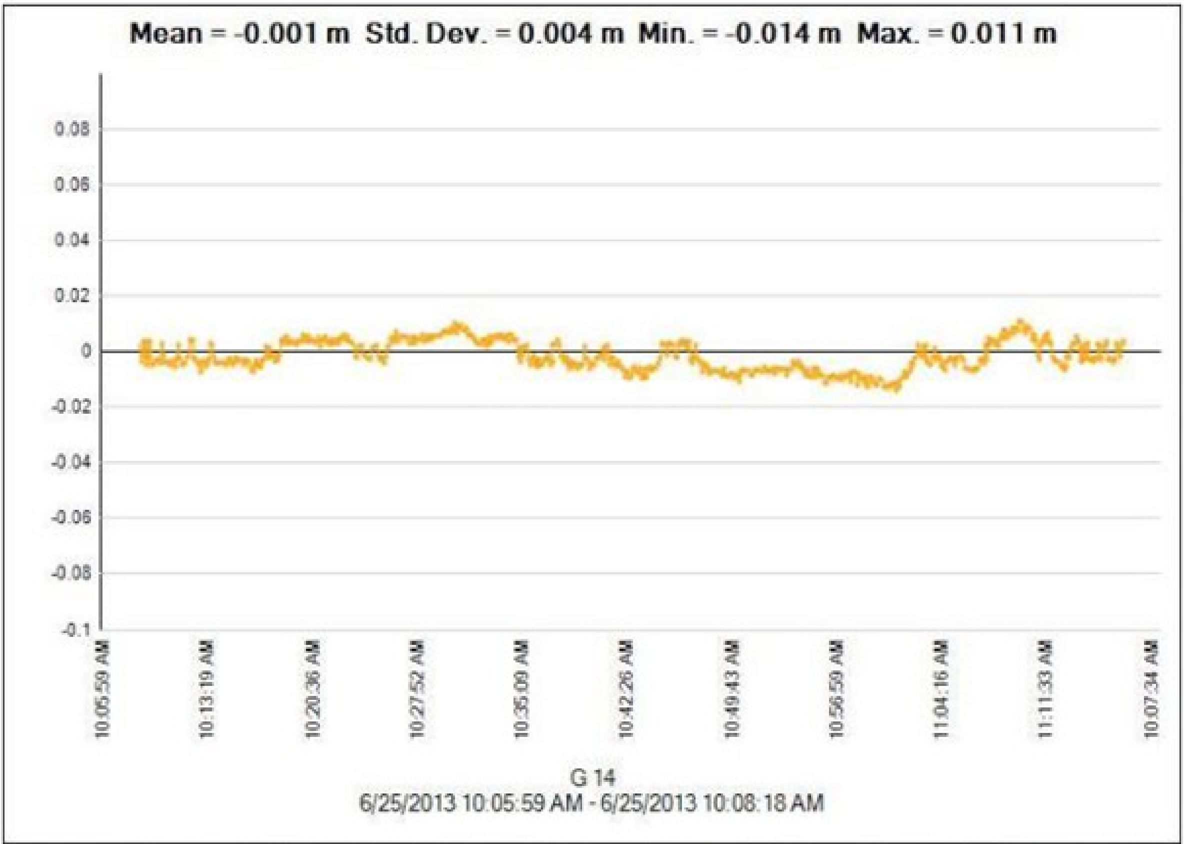
Tracking Summary

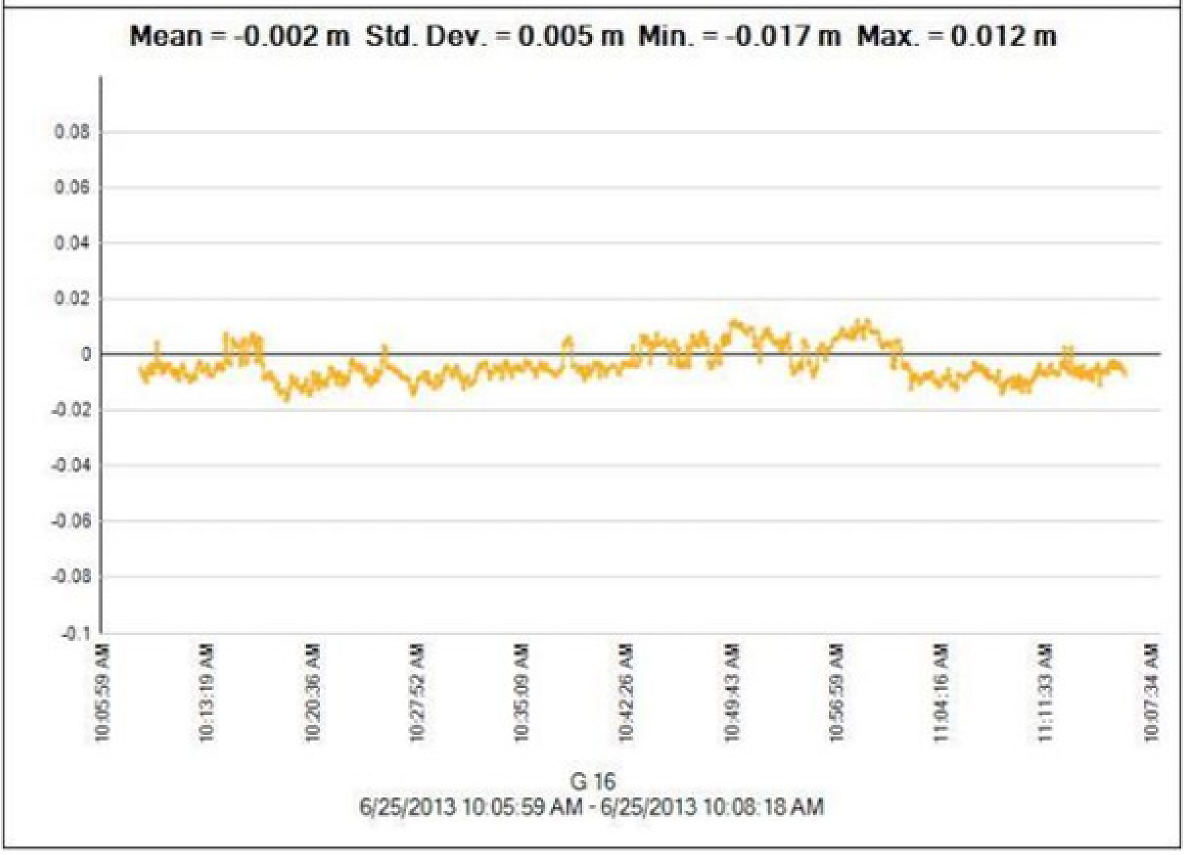


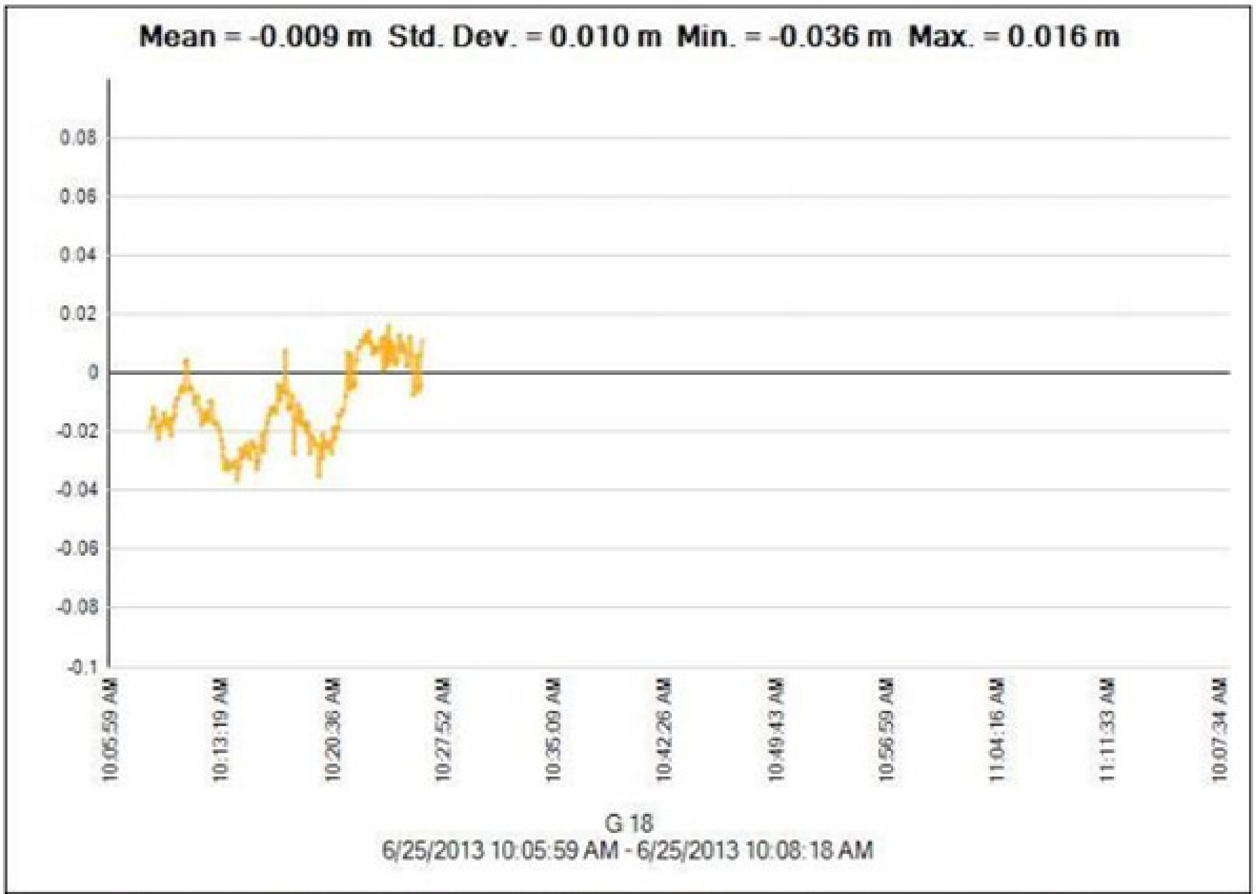
Residuals

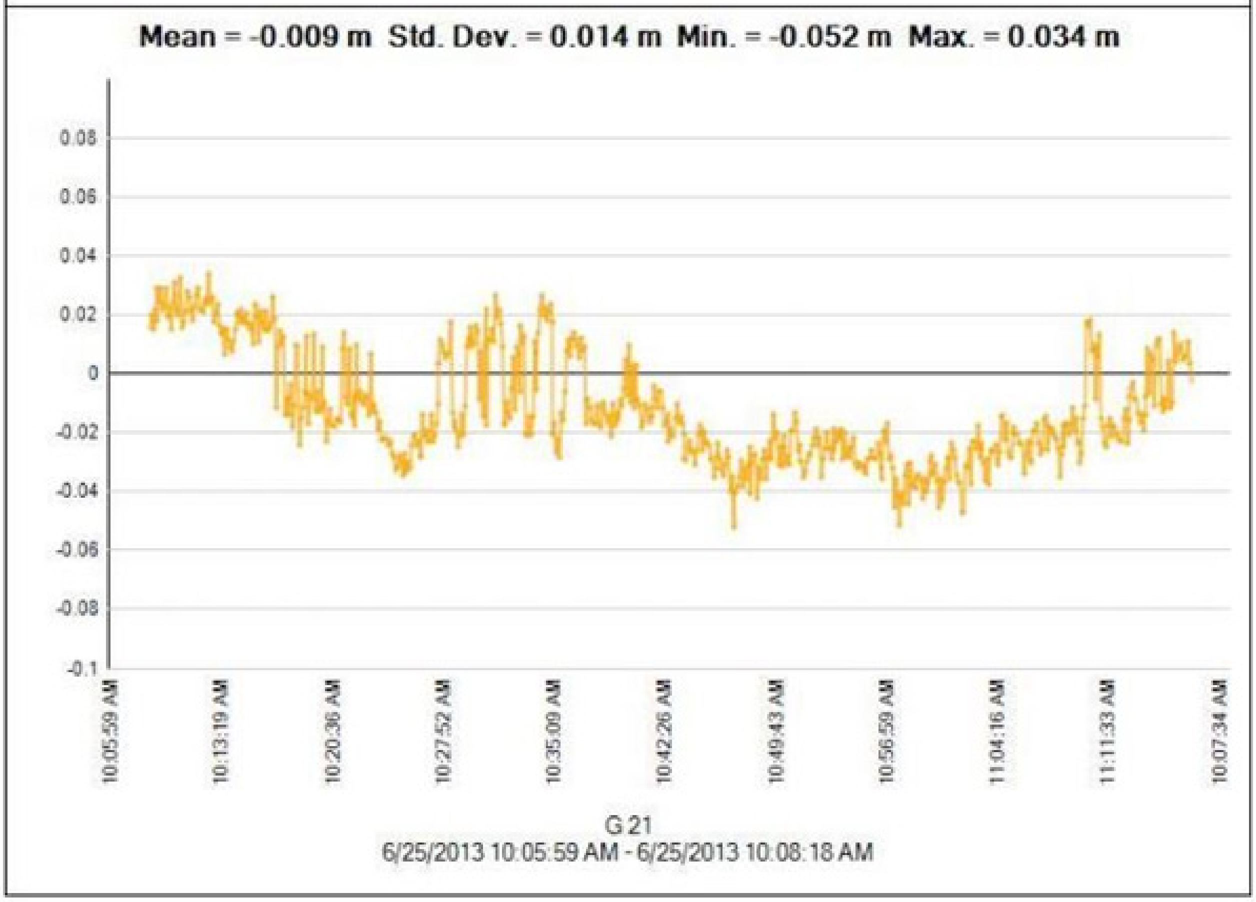

Mean = 0.003 m Std. Dev. = 0.009 m Min. = -0.033 m Max. = 0.026 m
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10:05:59 AM
10:13:19 AM
10:20:36 AM
10:27:52 AM
10:35:09 AM
10:42:26 AM
10:49:43 AM
10:56:59 AM
11:04:16 AM
11:11:33 AM
10:07:34 AM
G 3
6/25/2013 10:05:59 AM - 6/25/2013 10:08:18 AM

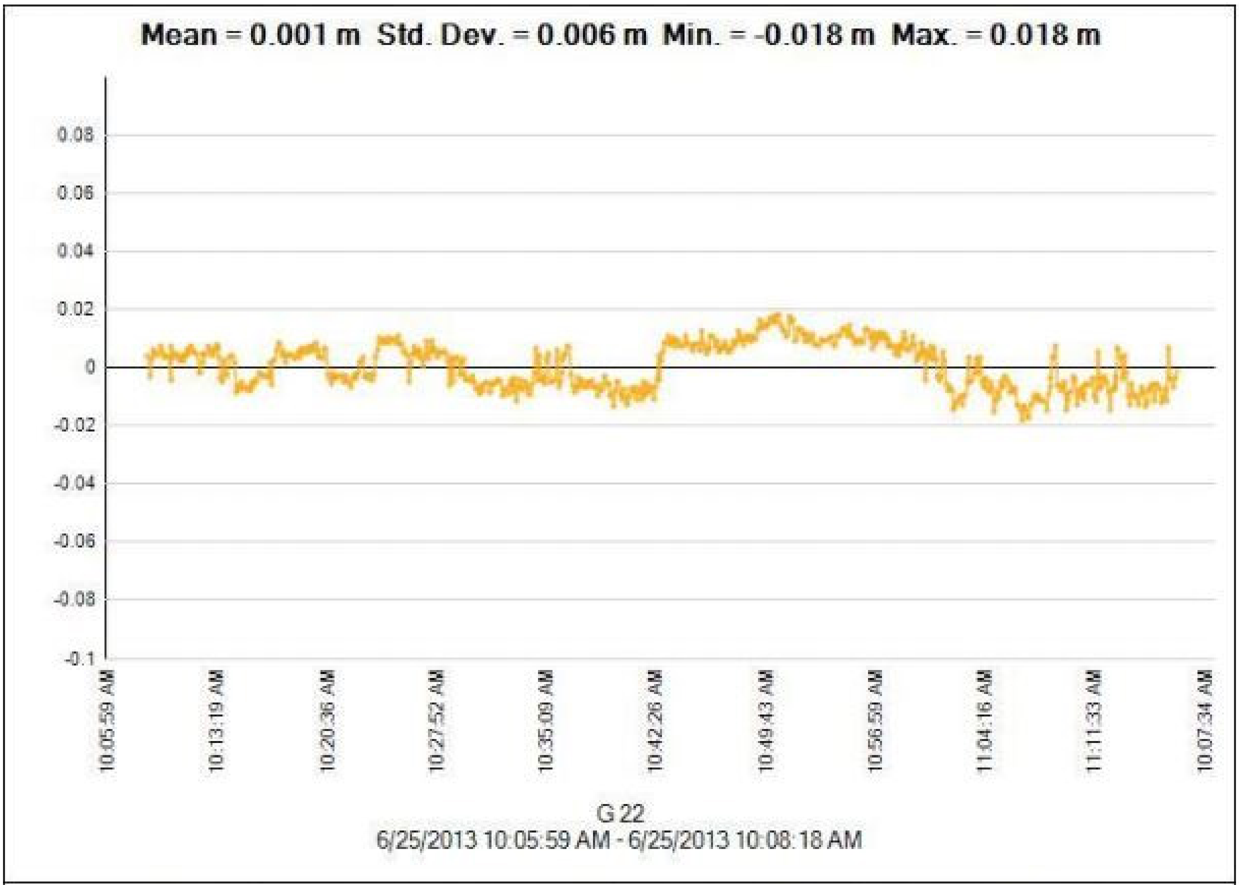

Mean = 0.005 m Std. Dev. = 0.005 m Min. = -0.010 m Max. = 0.018 m
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10:05:59 AM
10:13:19 AM
10:20:36 AM
10:27:52 AM
10:35:09 AM
10:42:26 AM
10:49:43 AM
10:56:59 AM
11:04:16 AM
11:11:33 AM
10:07:34 AM
G 6
6/25/2013 10:05:59 AM - 6/25/2013 10:08:18 AM

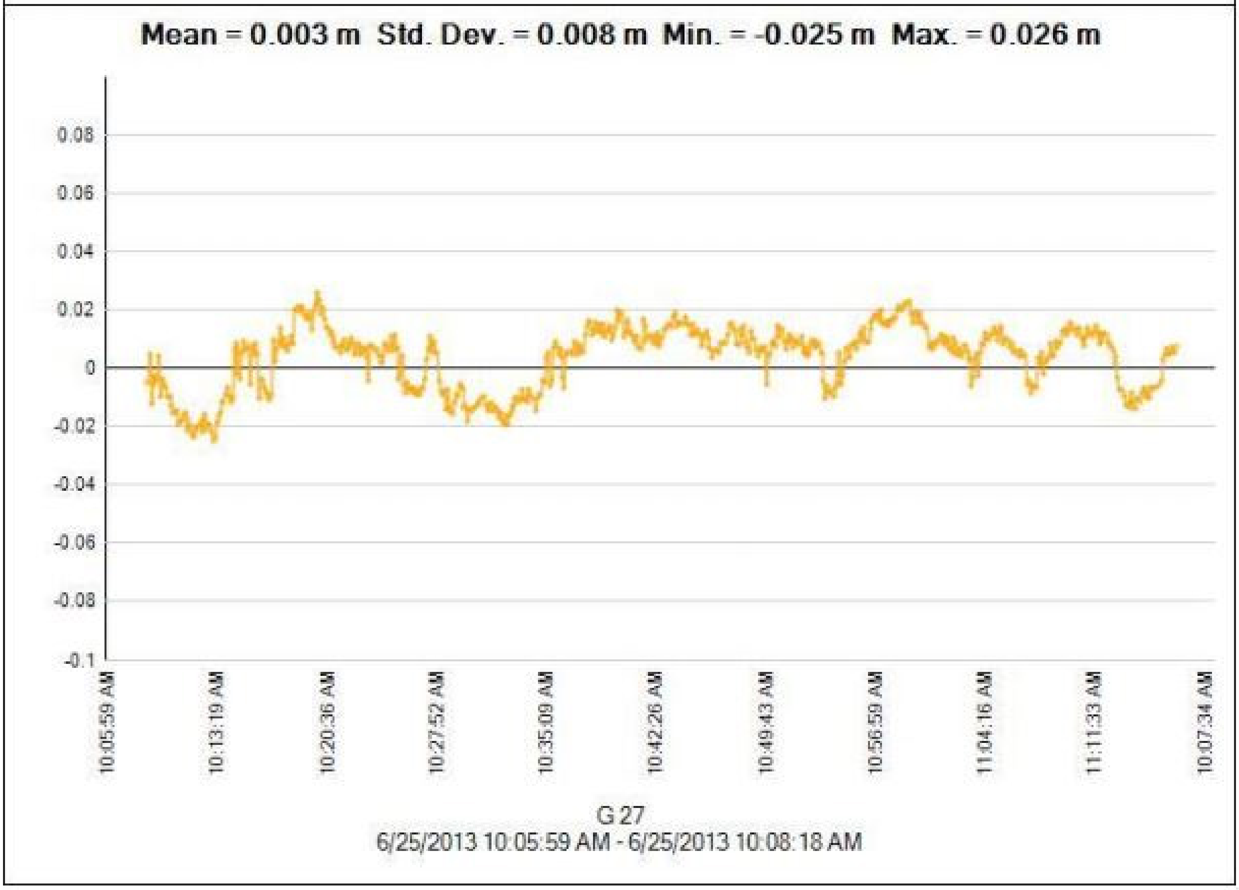

Mean = -0.001 m Std. Dev. = 0.004 m Min. = -0.014 m Max. = 0.011 m
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10:05:59 AM
10:13:19 AM
10:20:36 AM
10:27:52 AM
10:35:09 AM
10:42:26 AM
10:49:43 AM
10:56:59 AM
11:04:16 AM
11:11:33 AM
10:07:34 AM
G 14
6/25/2013 10:05:59 AM - 6/25/2013 10:08:18 AM


Mean = -0.002 m Std. Dev. = 0.005 m Min. = -0.017 m Max. = 0.012 m
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10:05:59 AM
10:13:19 AM
10:20:36 AM
10:27:52 AM
10:35:09 AM
10:42:26 AM
10:49:43 AM
10:56:59 AM
11:04:16 AM
11:11:33 AM
10:07:34 AM
G 16
6/25/2013 10:05:59 AM - 6/25/2013 10:08:18 AM


Mean = -0.009 m Std. Dev. = 0.010 m Min. = -0.036 m Max. = 0.016 m
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10:05:59 AM
10:13:19 AM
10:20:36 AM
10:27:52 AM
10:35:09 AM
10:42:26 AM
10:49:43 AM
10:56:59 AM
11:04:16 AM
11:11:33 AM
10:07:34 AM
G 18
6/25/2013 10:05:59 AM - 6/25/2013 10:08:18 AM


Mean = -0.009 m Std. Dev. = 0.014 m Min. = -0.052 m Max. = 0.034 m
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10:05:59 AM
10:13:19 AM
10:20:36 AM
10:27:52 AM
10:35:09 AM
10:42:26 AM
10:49:43 AM
10:56:59 AM
11:04:16 AM
11:11:33 AM
10:07:34 AM
G 21
6/25/2013 10:05:59 AM - 6/25/2013 10:08:18 AM


Mean = 0.001 m Std. Dev. = 0.006 m Min. = -0.018 m Max. = 0.018 m
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10:05:59 AM
10:13:19 AM
10:20:36 AM
10:27:52 AM
10:35:09 AM
10:42:26 AM
10:49:43 AM
10:56:59 AM
11:04:16 AM
11:11:33 AM
10:07:34 AM
G 22
6/25/2013 10:05:59 AM - 6/25/2013 10:08:18 AM

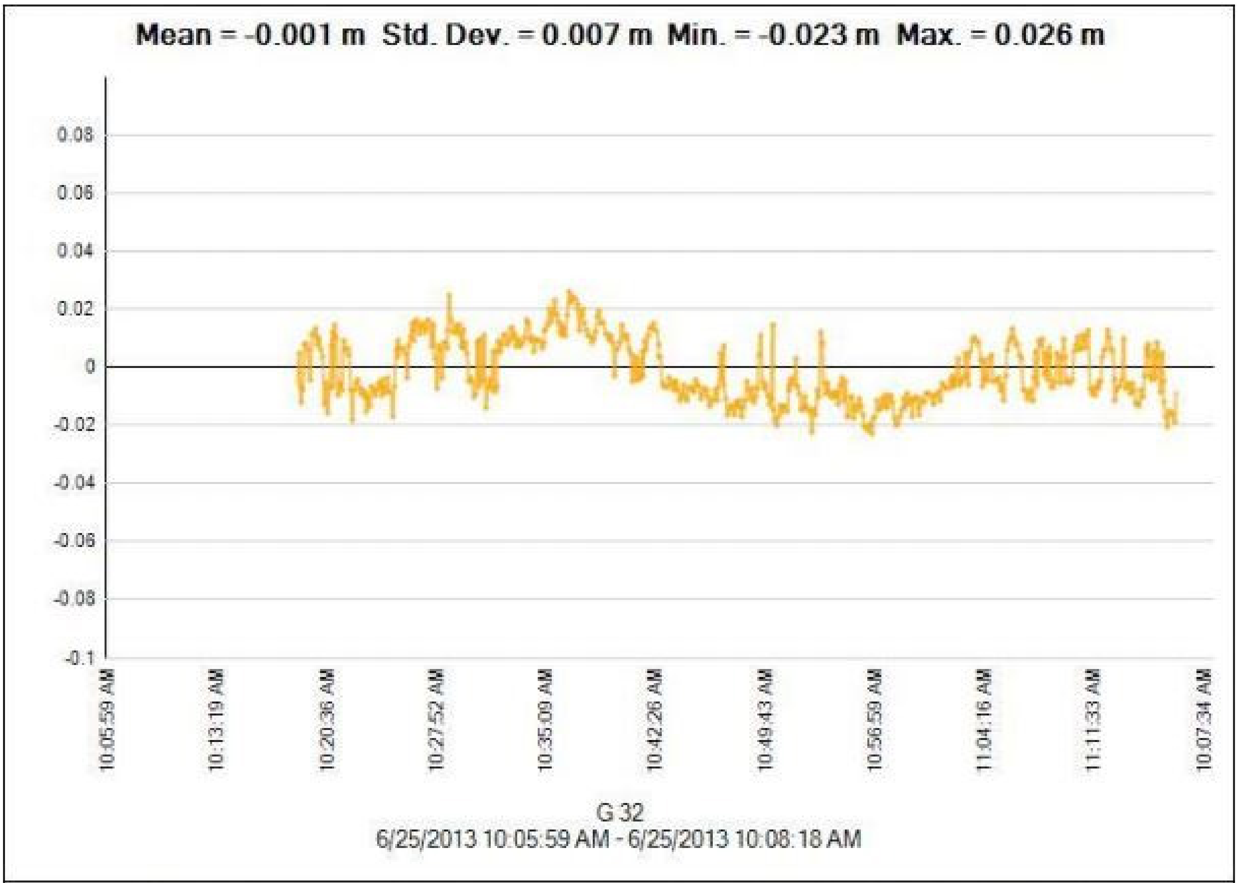

Mean = 0.003 m Std. Dev. = 0.008 m Min. = -0.025 m Max. = 0.026 m
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10:05:59 AM
10:13:19 AM
10:20:36 AM
10:27:52 AM
10:35:09 AM
10:42:26 AM
10:49:43 AM
10:56:59 AM
11:04:16 AM
11:11:33 AM
10:07:34 AM
G 27
6/25/2013 10:05:59 AM - 6/25/2013 10:08:18 AM

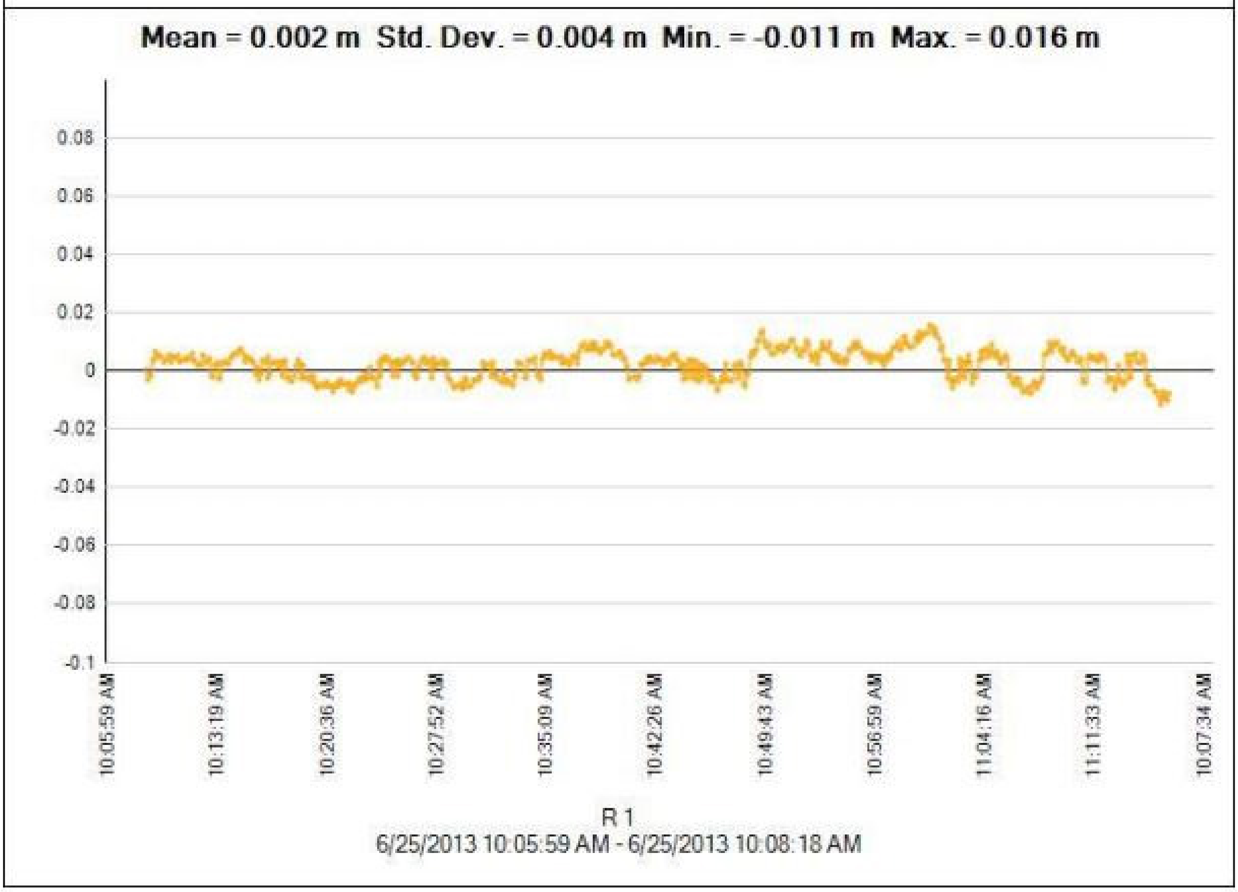
Mean = 0.003 m Std. Dev. = 0.007 m Min. = -0.022 m Max. = 0.026 m

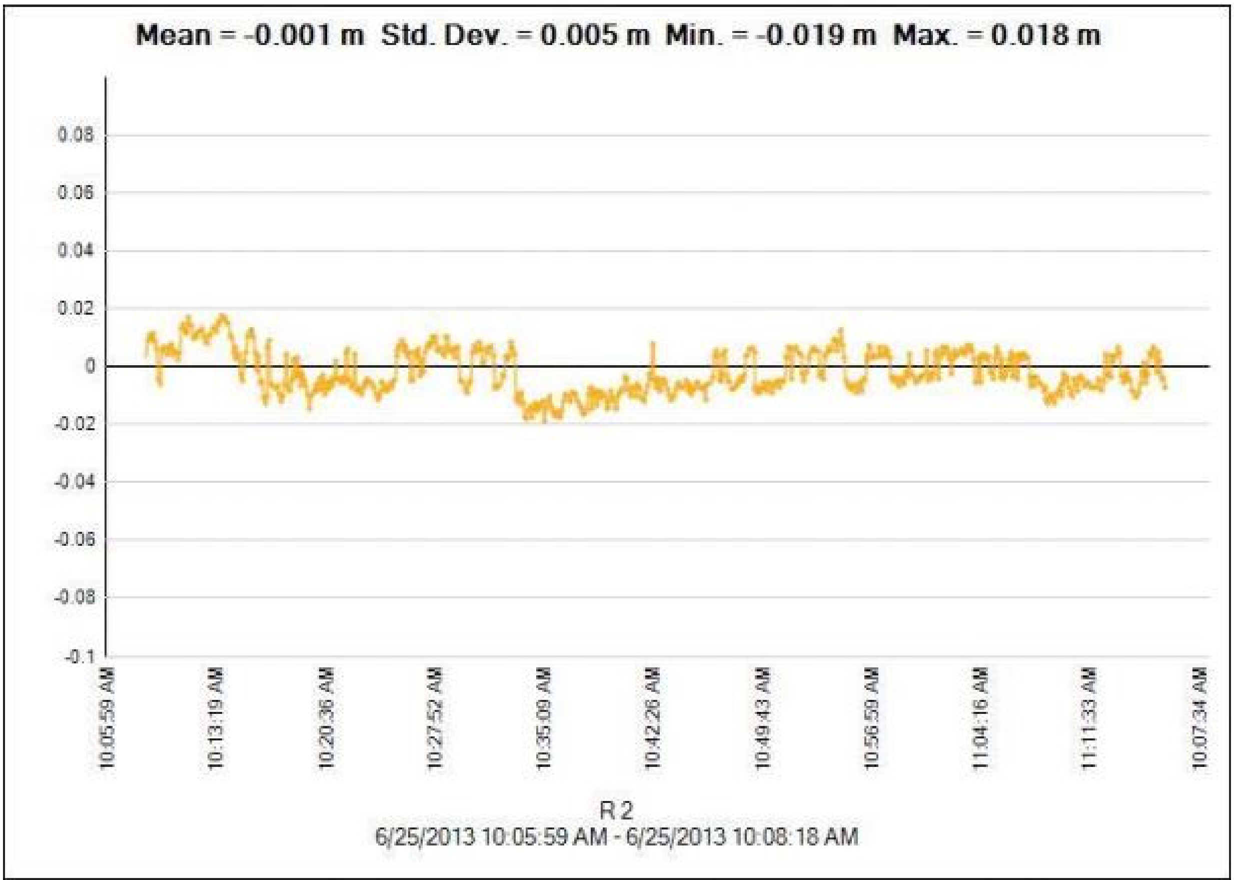
G 29
6/25/2013 10:05:59 AM - 6/25/2013 10:08:18 AM

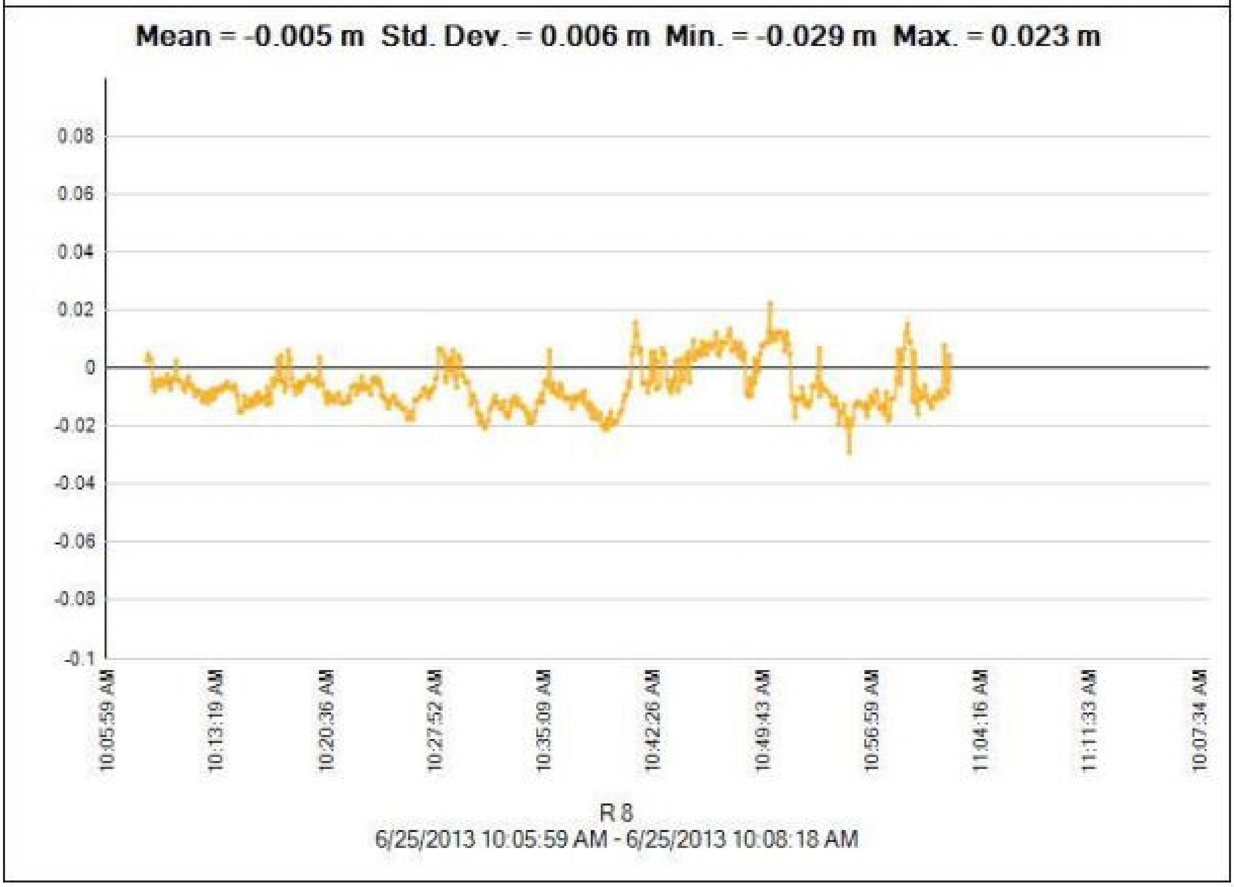
Mean = -0.003 m Std. Dev. = 0.006 m Min. = -0.022 m Max. = 0.016 m

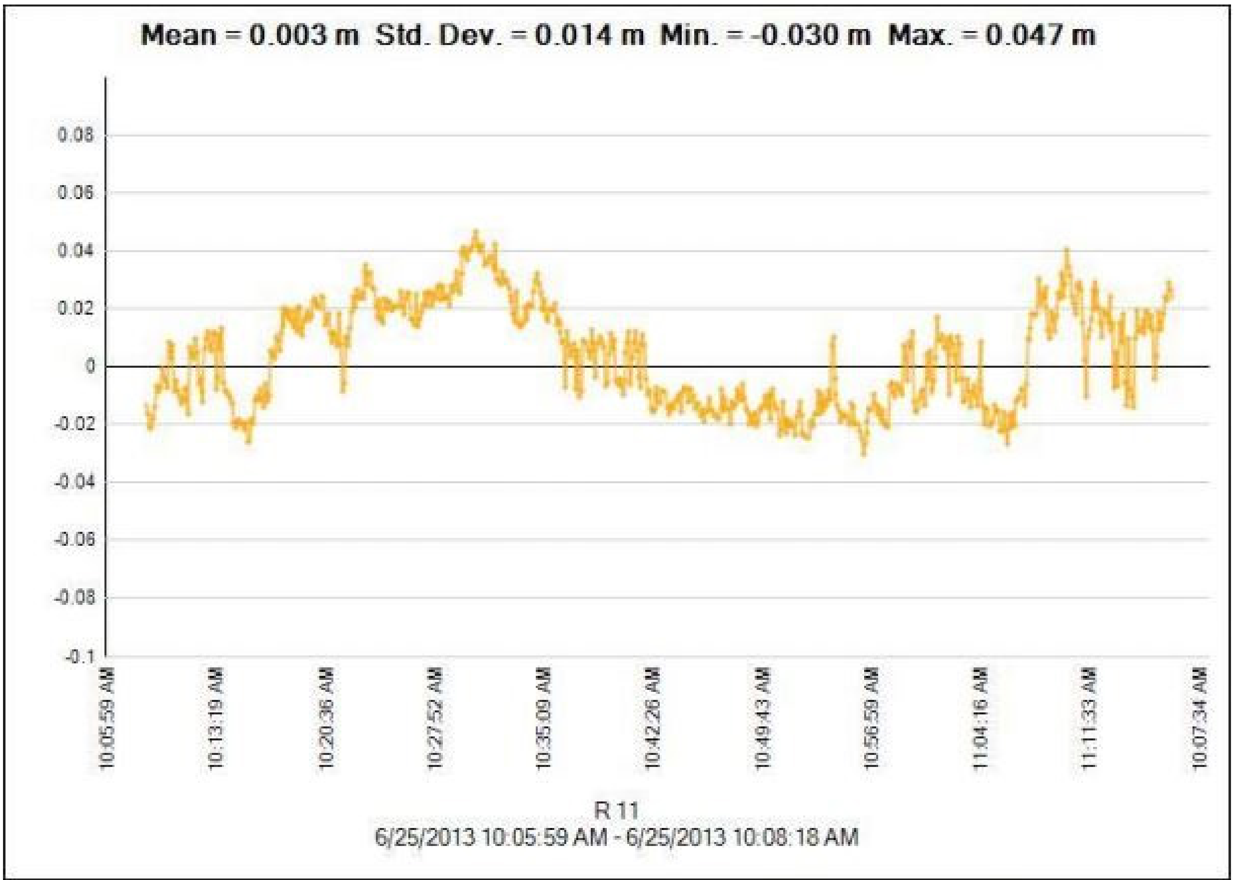
G 31
6/25/2013 10:05:59 AM - 6/25/2013 10:08:18 AM

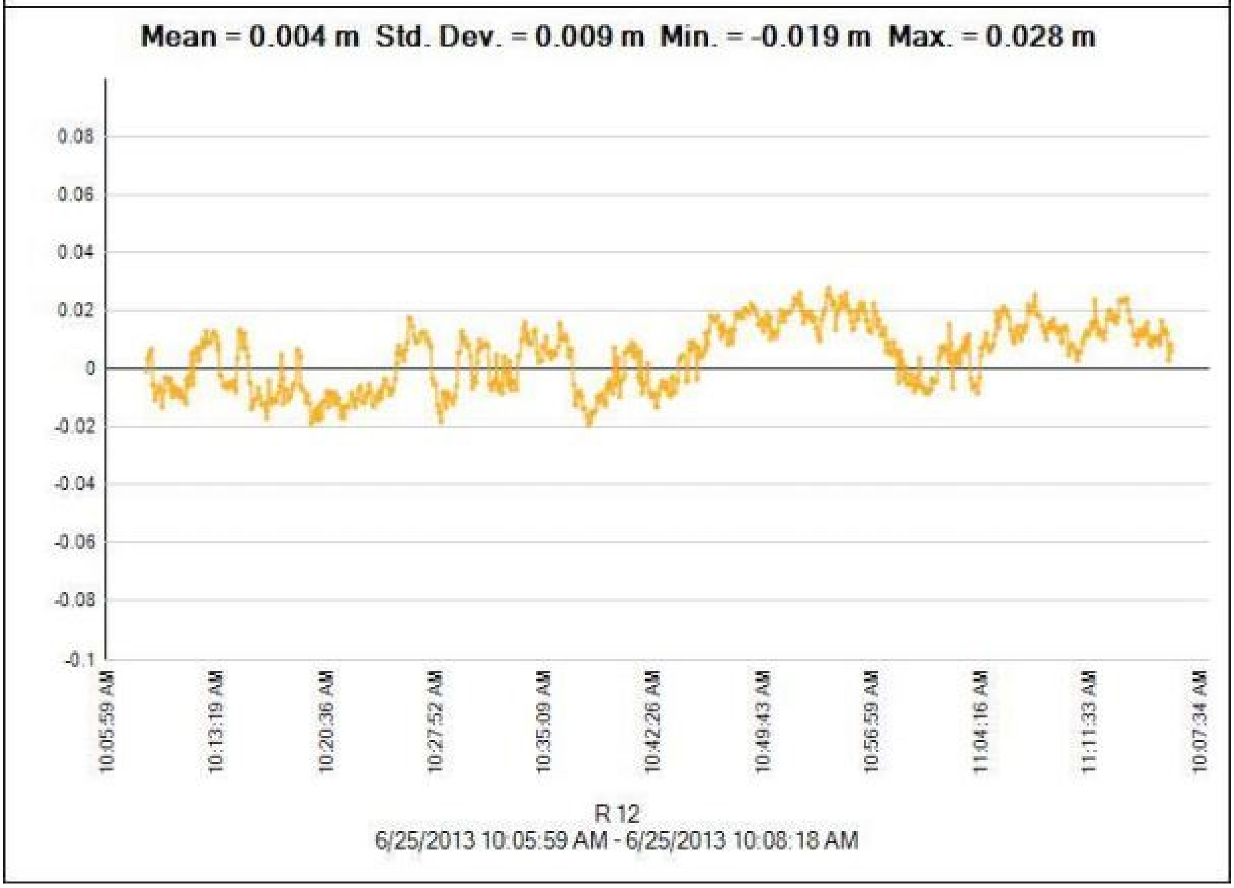

Mean = -0.001 m Std. Dev. = 0.007 m Min. = -0.023 m Max. = 0.026 m
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10:05:59 AM
10:13:19 AM
10:20:36 AM
10:27:52 AM
10:35:09 AM
10:42:26 AM
10:49:43 AM
10:56:59 AM
11:04:16 AM
11:11:33 AM
10:07:34 AM
G 32
6/25/2013 10:05:59 AM - 6/25/2013 10:08:18 AM

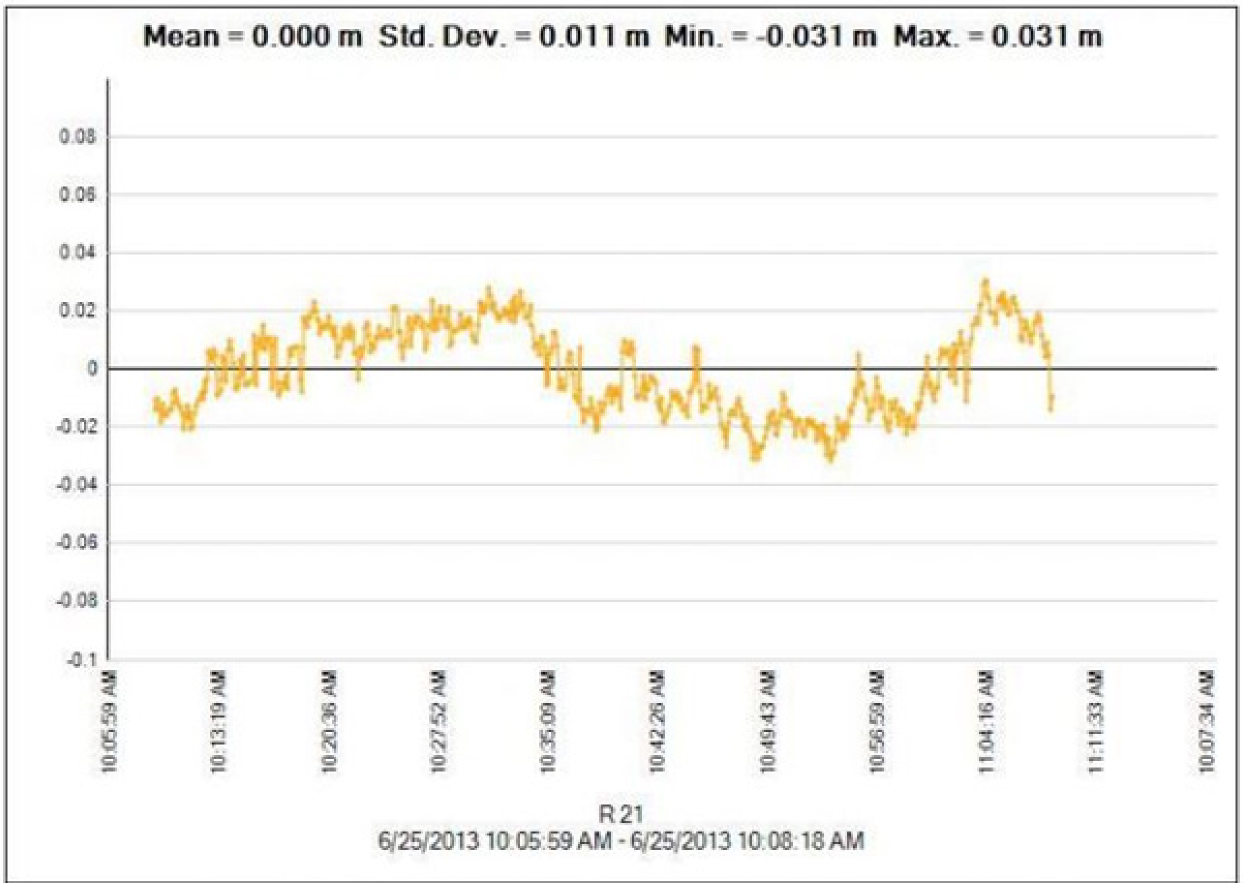

Mean = 0.002 m Std. Dev. = 0.004 m Min. = -0.011 m Max. = 0.016 m
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10:05:59 AM
10:13:19 AM
10:20:36 AM
10:27:52 AM
10:35:09 AM
10:42:26 AM
10:49:43 AM
10:56:59 AM
11:04:16 AM
11:11:33 AM
10:07:34 AM
R 1
6/25/2013 10:05:59 AM - 6/25/2013 10:08:18 AM

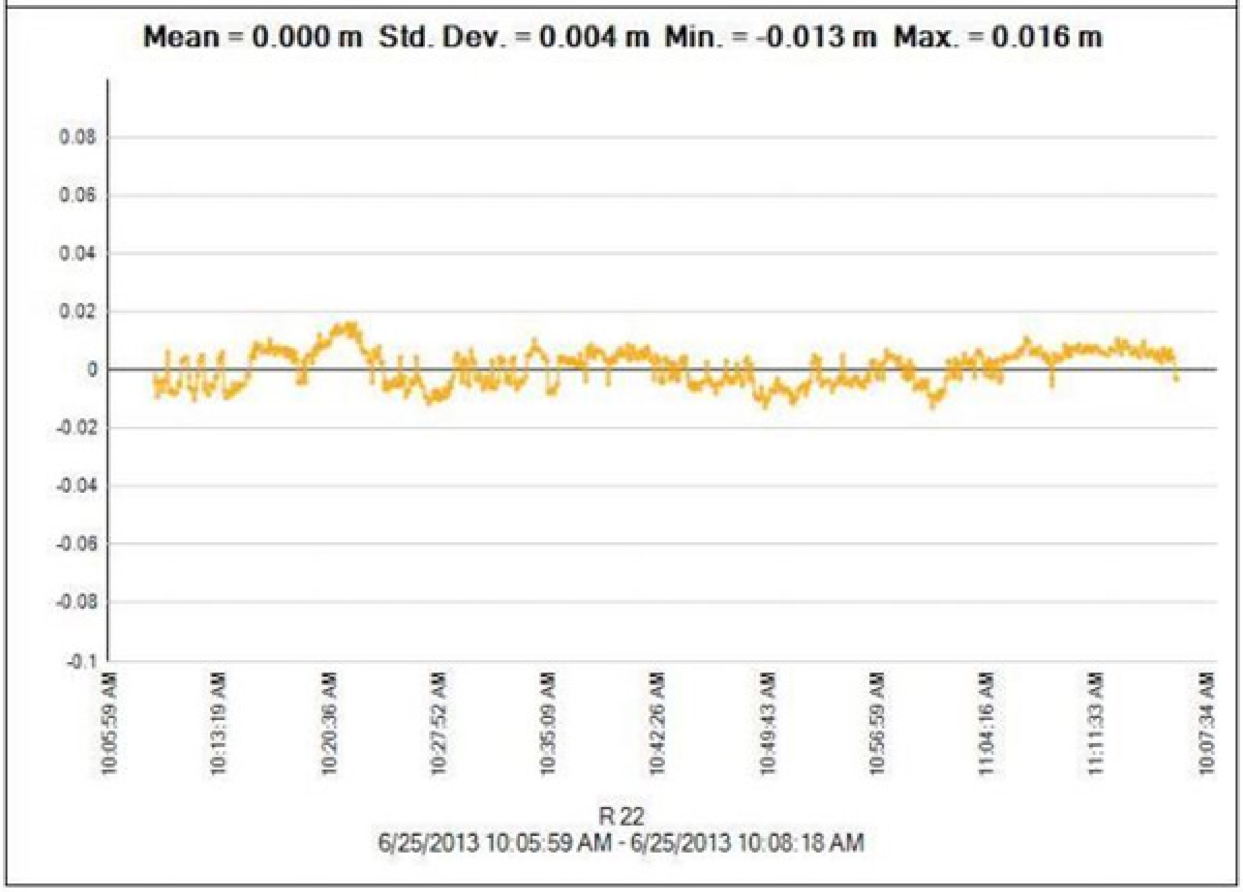

Mean = -0.001 m Std. Dev. = 0.005 m Min. = -0.019 m Max. = 0.018 m
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10:05:59 AM
10:13:19 AM
10:20:36 AM
10:27:52 AM
10:35:09 AM
10:42:26 AM
10:49:43 AM
10:56:59 AM
11:04:16 AM
11:11:33 AM
10:07:34 AM
R 2
6/25/2013 10:05:59 AM - 6/25/2013 10:08:18 AM

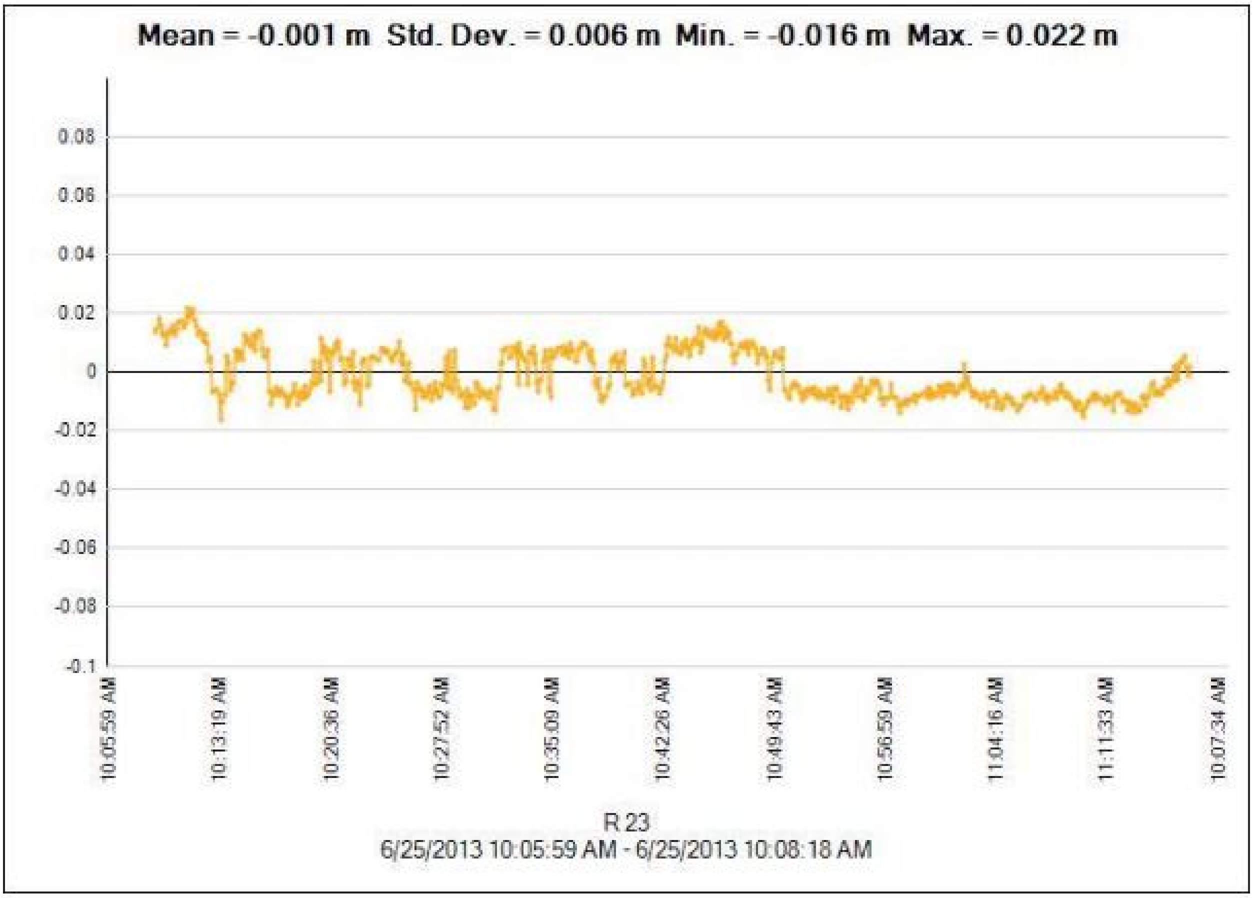

Mean = -0.005 m Std. Dev. = 0.006 m Min. = -0.029 m Max. = 0.023 m
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10:05:59 AM
10:13:19 AM
10:20:36 AM
10:27:52 AM
10:35:09 AM
10:42:26 AM
10:49:43 AM
10:56:59 AM
11:04:16 AM
11:11:33 AM
10:07:34 AM
R 8
6/25/2013 10:05:59 AM - 6/25/2013 10:08:18 AM


Mean = 0.003 m Std. Dev. = 0.014 m Min. = -0.030 m Max. = 0.047 m
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10:05:59 AM
10:13:19 AM
10:20:36 AM
10:27:52 AM
10:35:09 AM
10:42:26 AM
10:49:43 AM
10:56:59 AM
11:04:16 AM
11:11:33 AM
10:07:34 AM
R 11
6/25/2013 10:05:59 AM - 6/25/2013 10:08:18 AM


Mean = 0.004 m Std. Dev. = 0.009 m Min. = -0.019 m Max. = 0.028 m
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10:05:59 AM
10:13:19 AM
10:20:36 AM
10:27:52 AM
10:35:09 AM
10:42:26 AM
10:49:43 AM
10:56:59 AM
11:04:16 AM
11:11:33 AM
10:07:34 AM
R 12
6/25/2013 10:05:59 AM - 6/25/2013 10:08:18 AM


Mean = 0.000 m Std. Dev. = 0.011 m Min. = -0.031 m Max. = 0.031 m
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10:05:59 AM
10:13:19 AM
10:20:36 AM
10:27:52 AM
10:35:09 AM
10:42:26 AM
10:49:43 AM
10:56:59 AM
11:04:16 AM
11:11:33 AM
10:07:34 AM
R 21
6/25/2013 10:05:59 AM - 6/25/2013 10:08:18 AM


Mean = 0.000 m Std. Dev. = 0.004 m Min. = -0.013 m Max. = 0.016 m
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10:05:59 AM
10:13:19 AM
10:20:36 AM
10:27:52 AM
10:35:09 AM
10:42:26 AM
10:49:43 AM
10:56:59 AM
11:04:16 AM
11:11:33 AM
10:07:34 AM
R 22
6/25/2013 10:05:59 AM - 6/25/2013 10:08:18 AM


Mean = -0.001 m Std. Dev. = 0.006 m Min. = -0.016 m Max. = 0.022 m
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
10:05:59 AM
10:13:19 AM
10:20:36 AM
10:27:52 AM
10:35:09 AM
10:42:26 AM
10:49:43 AM
10:56:59 AM
11:04:16 AM
11:11:33 AM
10:07:34 AM
R 23
6/25/2013 10:05:59 AM - 6/25/2013 10:08:18 AM

Processing style

Elevation mask:	10.0 deg
Auto start processing:	Yes
Start automatic ID numbering:	AUTO0001
Continuous vectors:	No
Generate residuals:	Yes
Antenna model:	Automatic
Ephemeris type:	Automatic
Frequency:	Multiple Frequencies
Processing interval:	Use all data
Force float:	No

Acceptance Criteria

Vector Component	Flag	Fail
Horizontal Precision >	0.050 m + 1.000 ppm	0.100 m + 1.000 ppm
Vertical Precision >	0.100 m + 1.000 ppm	0.200 m + 1.000 ppm

7/31/2013 10:26:10 PM	C:\Users\LAPTOP518\Documents\Business Center - HCE\Davao_June 25.vce	Business Center - HCE

Acknowledgements

Annexes

We are very thankful to the following individuals and agencies for their generous support during the conduct of our field surveys:

LN Surveying would like to thank SITECH PHL Inc. for the support that they have given our team especially with the establishment of Internet Base Station Service.
The local residents of Davao City for guiding the survey team throughout the field surveys.

DREAM

Disaster Risk and Exposure Assessment for Mitigation