REGION 12 AND ARMM

Mindanao River:

DREAM Ground Surveys Report

TRAINING CENTER FOR APPLIED GEODESY AND PHOTOGRAMMETRY

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List of Abbreviations

ADCP	Acoustic Doppler Current Profiler
AWLS	Automated Water Level Sensor
BM	Benchmark
CAD	Computer Aided Designs
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.

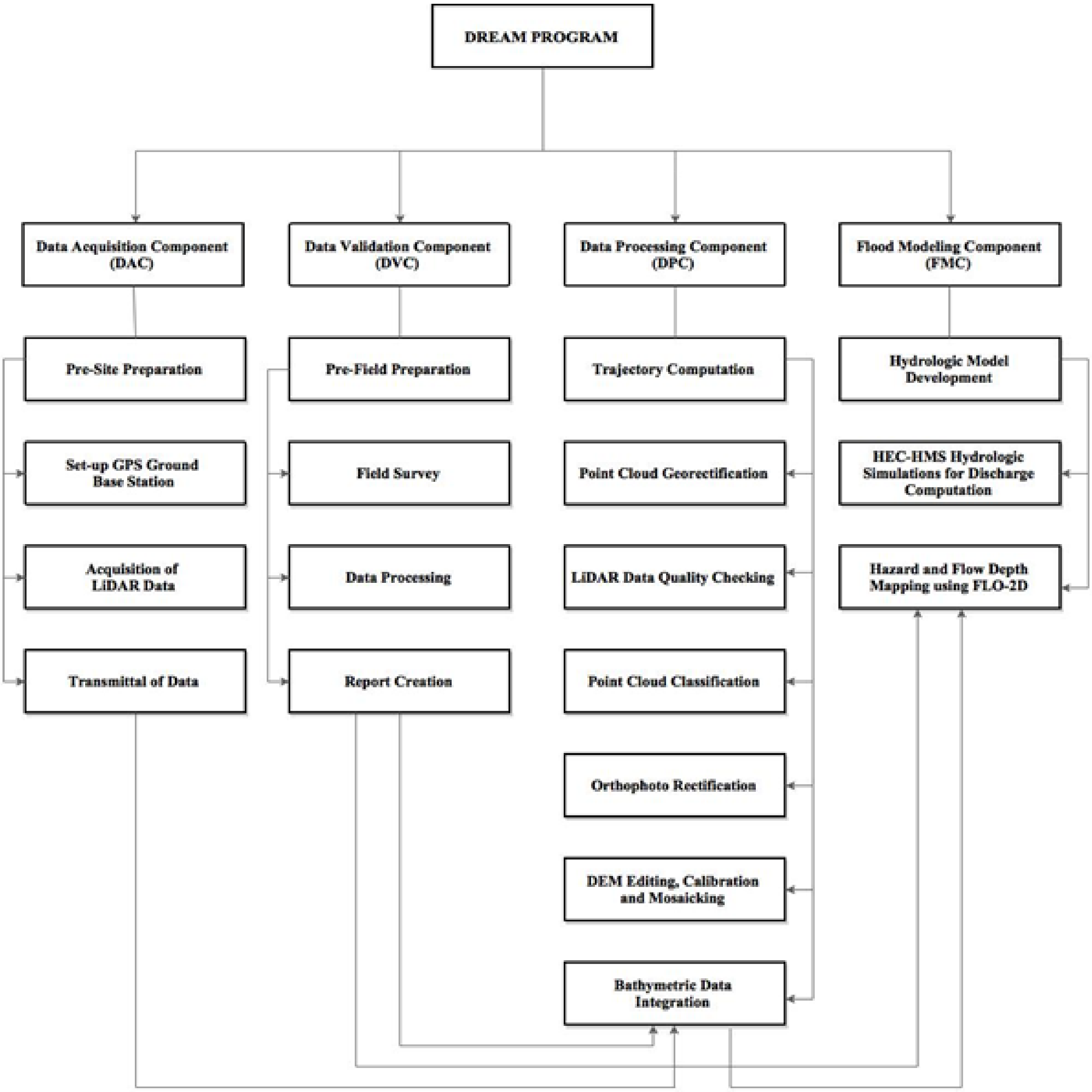


Figure 1. The General Methodological Framework of the Program

The Mindanao River Basin

The Mindanao River Basin

The Mindanao River Basin covers the provinces of Shariff Kabunsuan, Maguindanao, Agusan del Sur, Bukidnon, Davao del Norte, Davao del Sur, Lanao del Sur, North Cotabato, South Cotabato, and Sultan Kudarat. It is the second largest river system in the Philippines. It has an estimate basin area of 23,169 square kilometers.

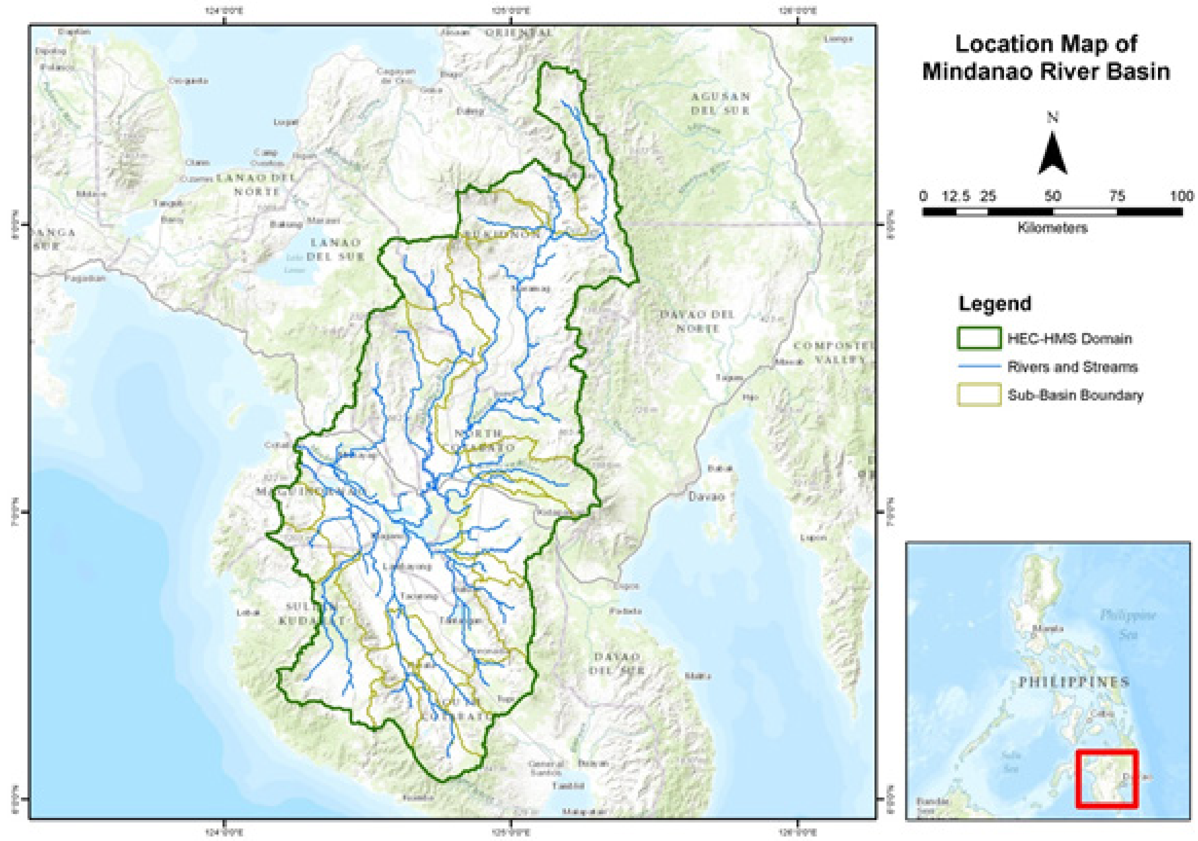


Figure 2. Location Map of the Mindanao River Basin

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

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

The Mindanao River Basin

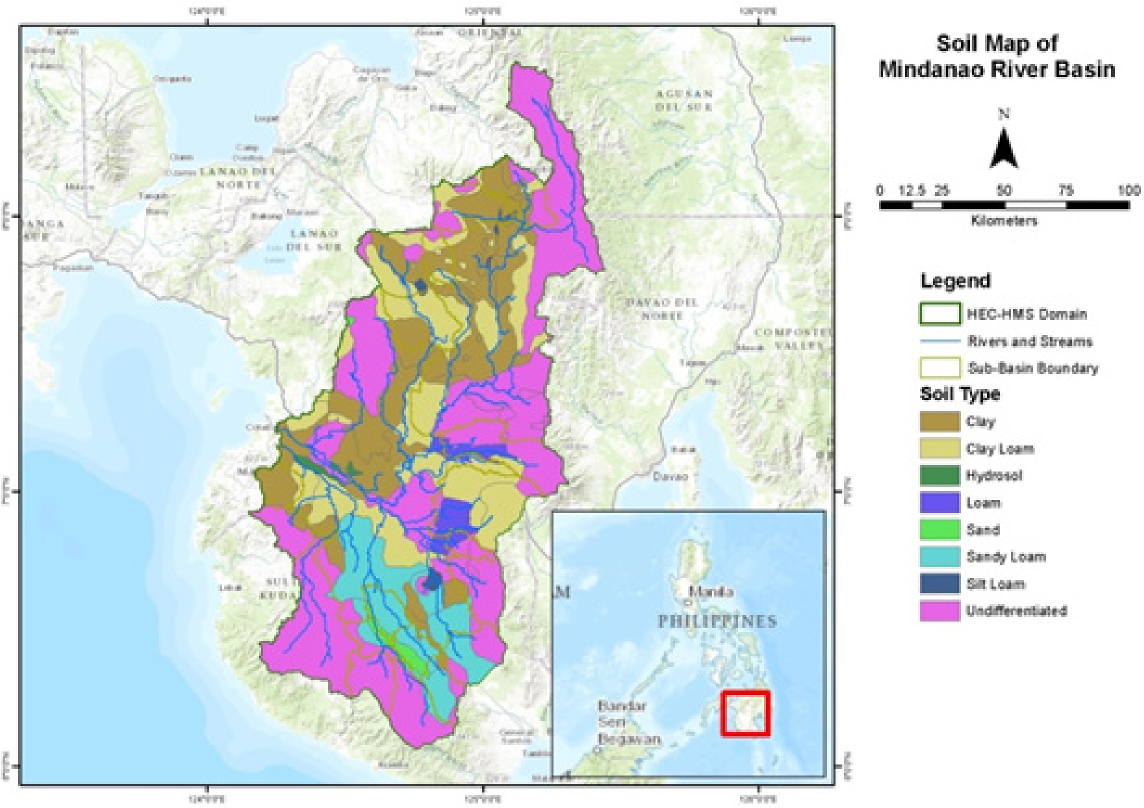


Figure 3. The soil map of Mindanao river basin

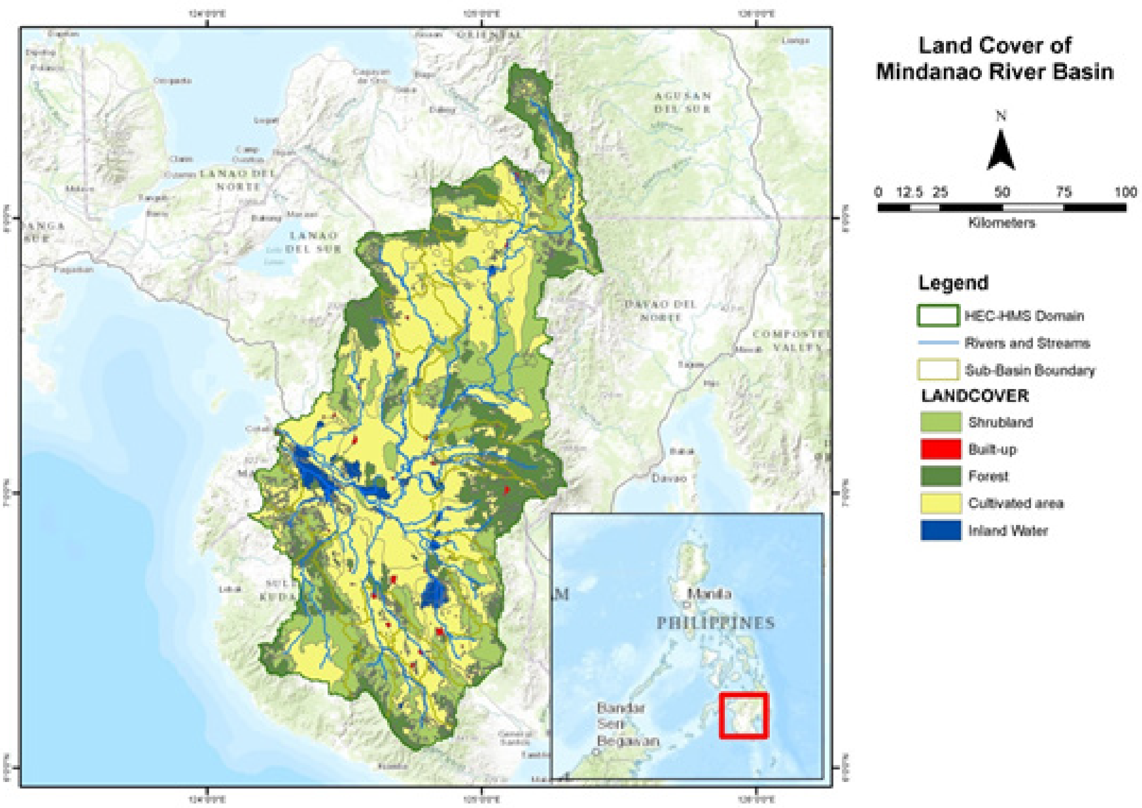


Figure 4. The land cover map of Mindanao river basin

DVC Methodology

DVC Methodology

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

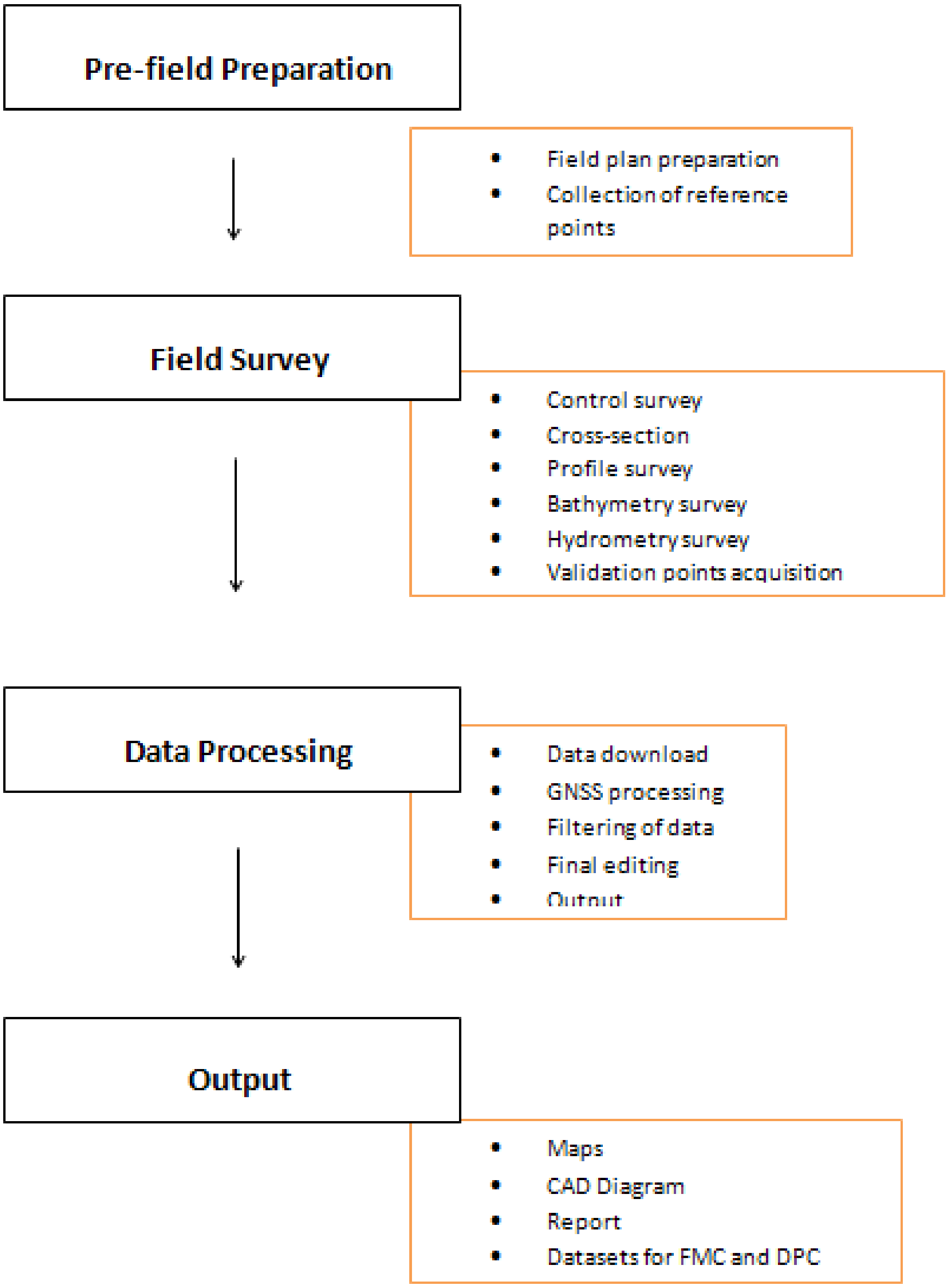


Figure 5. DVC Main Activities

3.1 Pre-field Preparation

3.1.1 Preparation of Field Plan

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

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

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

3.1.2 Collection of Reference Points

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

3.2 Field Surveys

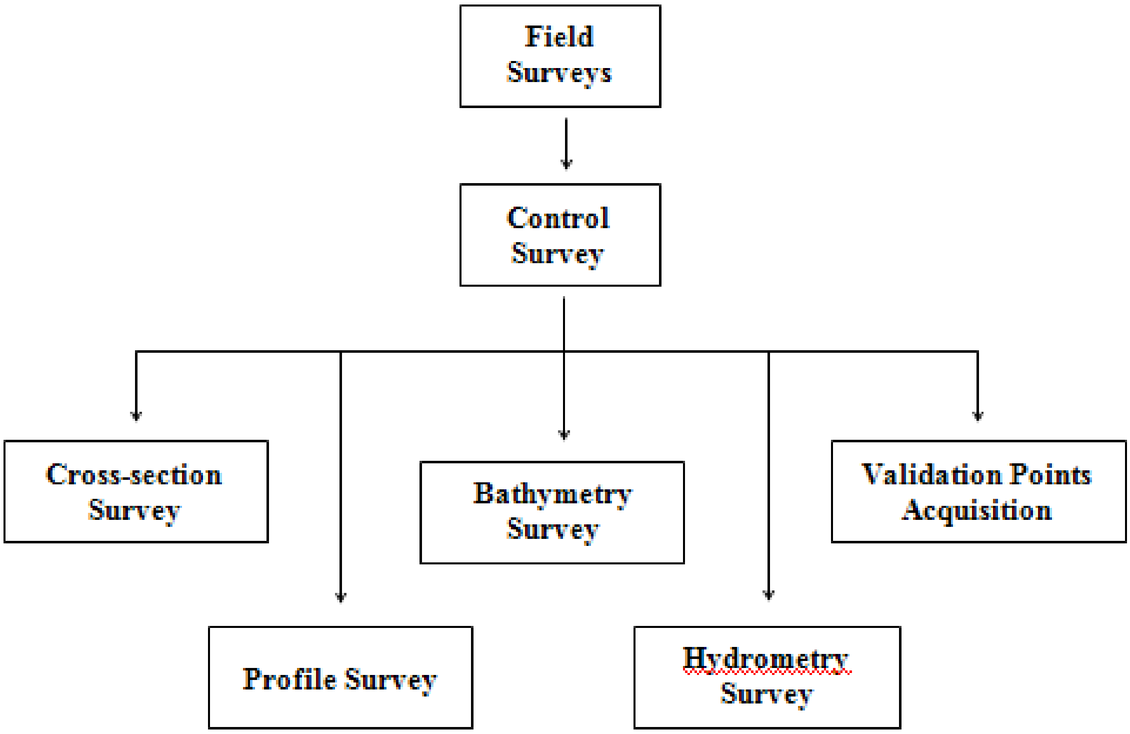


Figure 6. DVC Field Activities

3.2.1 Control Survey

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

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

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

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

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

3.2.2 Cross-section Survey

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

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

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

3.2.3 Profile Surveys

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

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

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

3.2.4 Bathymetric Survey

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

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

3.2.5 Hydrometric Survey

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

The elements of discharge computation are the ff.:

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

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

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

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

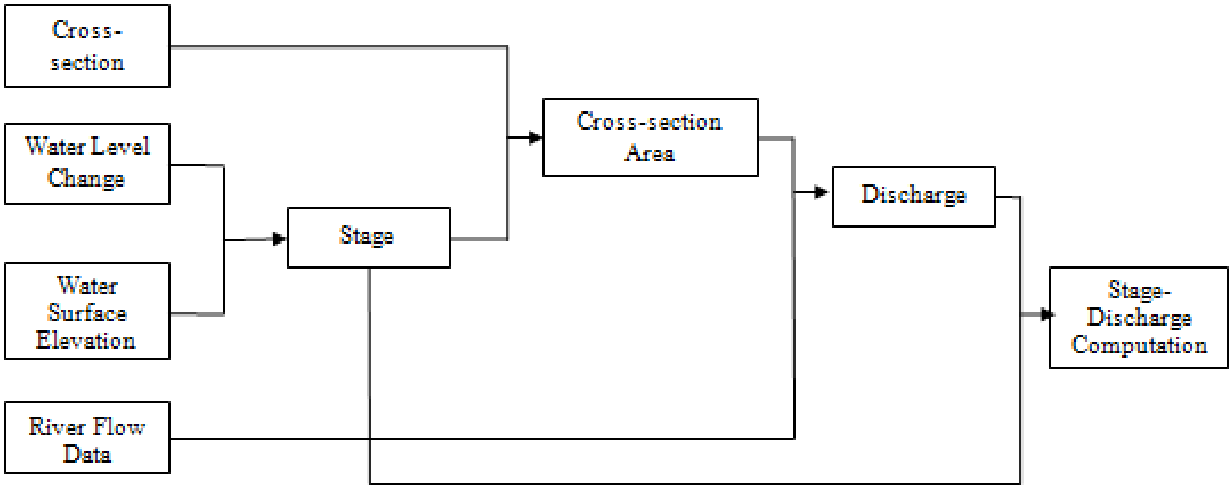


Figure 7. Flow Chart for Stage-Discharge Correlation Computation

3.2.6 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 8.

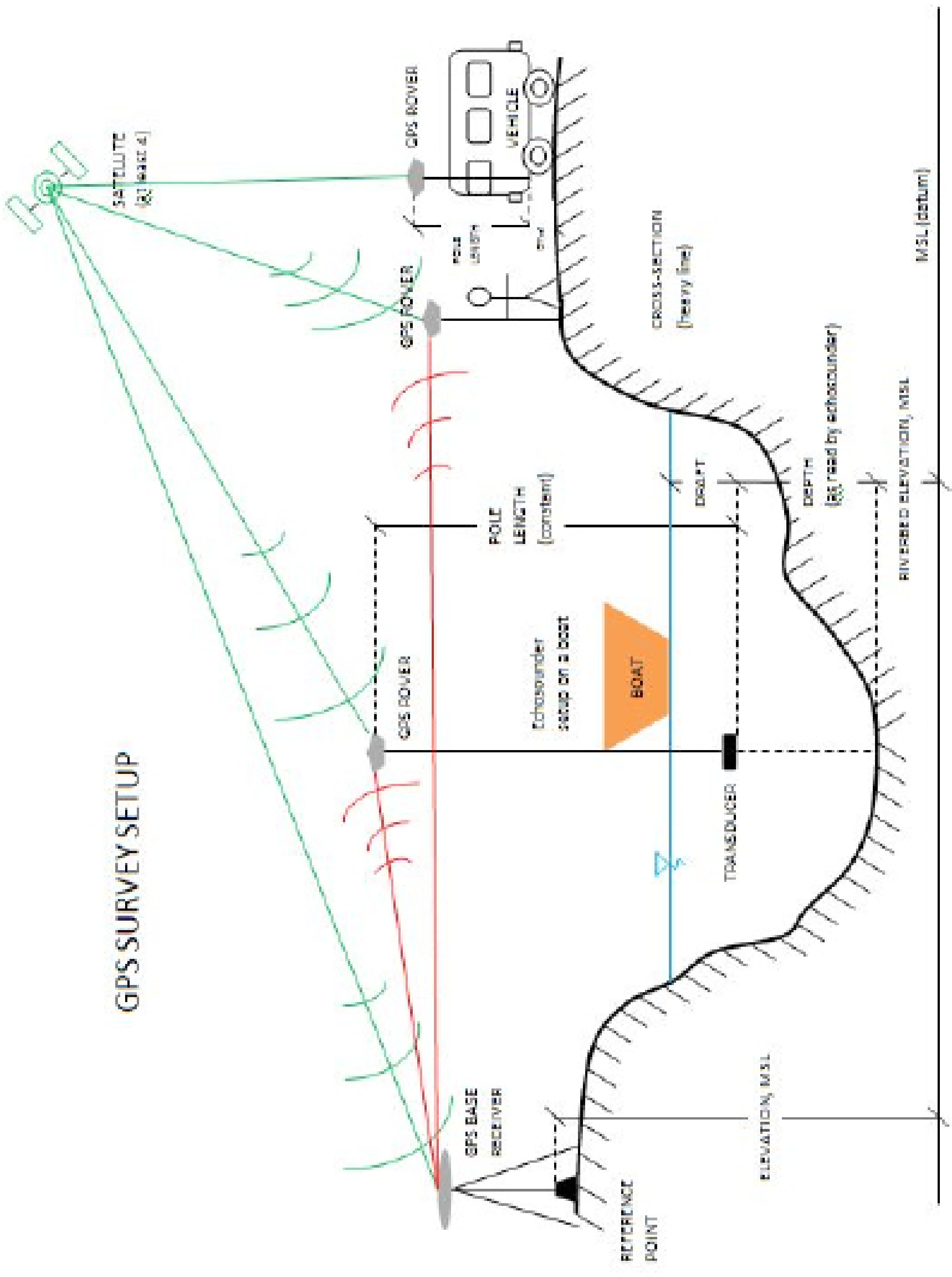


Figure 8. Set-up for GNSS Survey

3.3 Data Processing

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

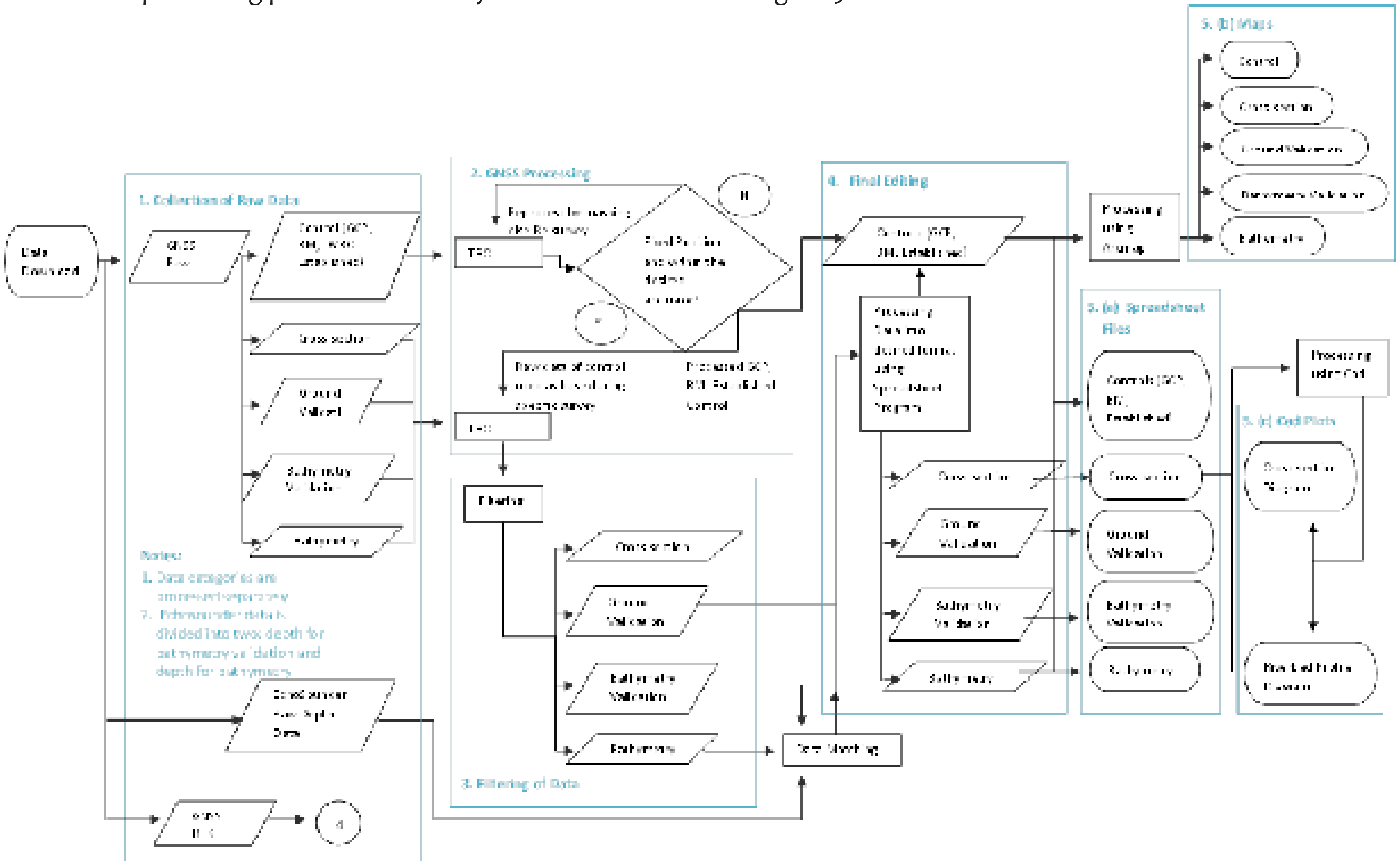


Figure 9. DVC Data Processing Methodology

3.3.1 Collection of Raw Data

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

3.3.2 Data Processing

Processing for GNSS Data

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

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

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

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

Computation for offset:

Equation 1:

$$OFFSET = BM - EGM$$

Computation for BM_ortho:

Equation 2:

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

where:

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

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

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

Depth Data Processing

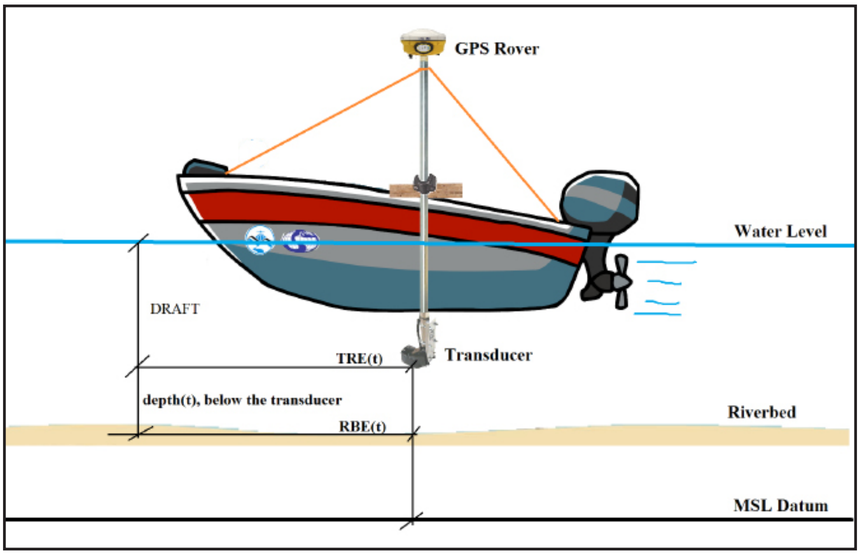


Figure 10. Illustration of Echo Sounder and GPS rover set-up for Bathymetric survey

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

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

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.

Mindanao River Basin Survey

Mindanao River Basin Survey

The survey for Mindanao River Basin was conducted on December 13-19, 2013 with the following activities: control survey, cross-section and flow data gathering along bridges with installed AWLS such as Lumayong (Carmen), Dicalungan, Simuay, Kalawag, and Tunggol Bridges.

Mindanao River consists of 52 delineated cross section lines with an estimate length of 52.7 km for both left and right banks starting from Datu Piang in the upstream down to Moro Gulf near the mouth of the river. The total length of profile lines is about 52.7 km for its both left and right banks. Ground surveys for both cross-section and profile lines were conducted by RASA Surveying on 2013, December 4, to 2014, February 28 as described in Annex E.

Another set of fieldwork was conducted on July 1-15, 2014 with the following activities: bathymetric survey along Mindanao River; bridge as-built survey, in Dicalungan, Simuay, Kalawag, Tunggol, Talisawa and Carmen Bridges; and flow measurement in Simuay and Kalawag Bridges.

4.1 Control Survey

Five (5) control points were considered for the static GNSS observations of the Mindanao River for the December 13-19, 2-013 survey. These include UP established IBM-58A located in front of Kabacan Elementary School, which was leveled from a NAMRIA benchmark IBM-58, a first order reference point located in Brgy. Poblacion, Kabacan, North Cotabato; another UP established, BM-2, at Tunggol Bridge, Datu Montawal, Maguindanao; NAMRIA established MGD-2, situated at the top of the water tank in PC Hill Compound, Cotabato City; an occupied NAMRIA established, BMMG-59, at Dicalungan Bridge, Ampatuan, Maguindanao; and an occupied LMS established, SKT-3200, at Kalawag Bridge, Isulan, Sultan Kudarat (see Figure 11).

Baseline survey was conducted using MGD-2 as reference point and an established control point, UP DREAM, situated in front of the Datu Piang Municipal Hall in Maguindanao for the July 1-15, 2014 survey.

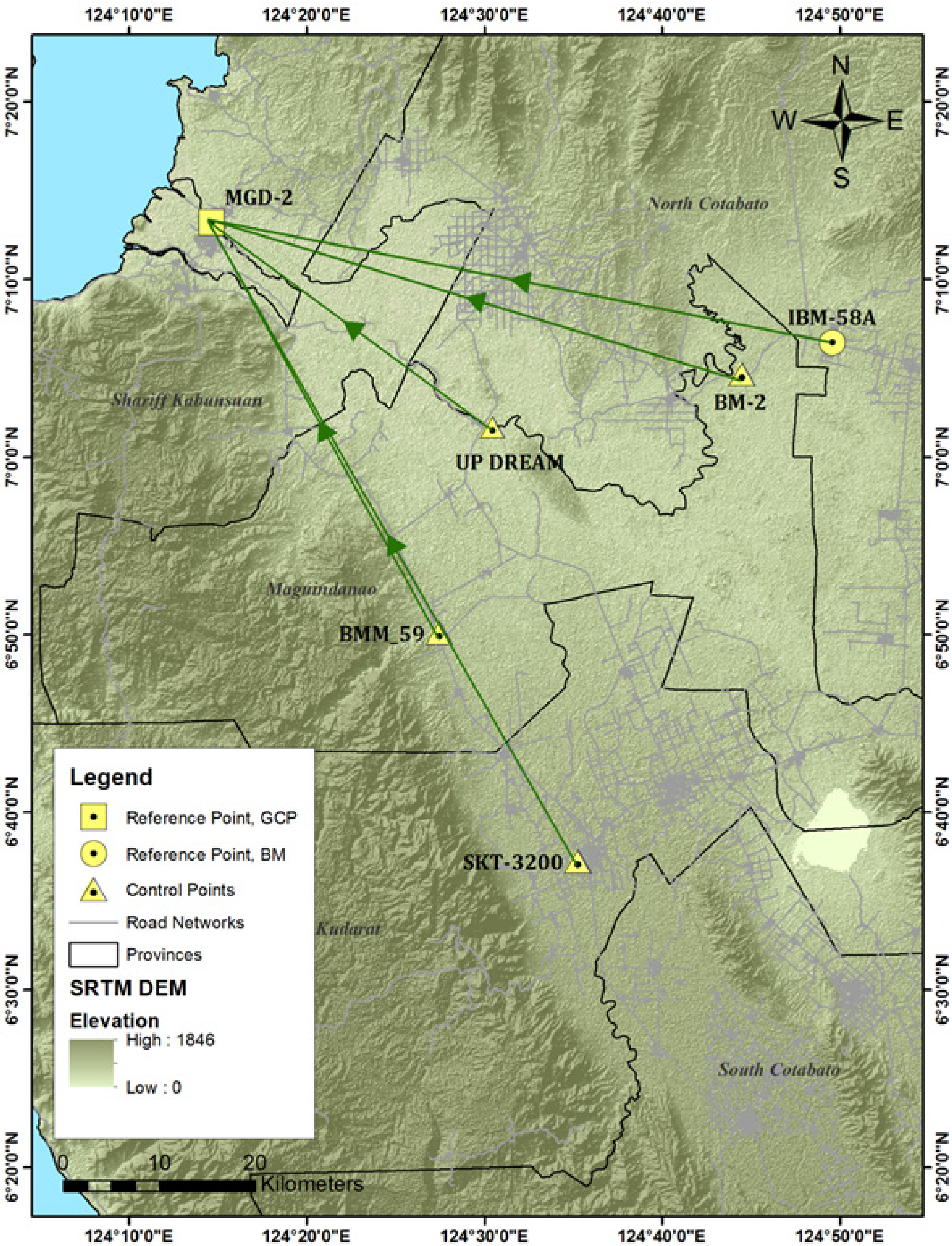


Figure 11. Location of control points

Continuous differential static observations were done simultaneously at these five stations for two hours to provide reference control points for the ground and bathymetric surveys. The horizontal coordinates and elevations of the six (6) control points were computed using Trimble® Business Center GNSS processing software. The result of control survey for the control points are indicated in Table 1.

Table 1. Control points occupied during Mindanao 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)	
MGD-2	7°13'12.35957"N	124°14'39.13820"E	132.256	798267.737	637368.854	55.0701
IBM-58-A	7°06'26.31703"N	124°49'36.19306"E	92.810	786009.700	701750.048	15.0251
BMMG-59	6°50'05.72316"N	124°27'22.73011"E	100.949	755743.681	660924.183	21.999
SKT-3200	6d37'14.69672"N	124d35'10.11245"E	141.093	732104.221	675350.631	62.1201
BM-2	7d04'39.33906"N	124d44'25.80492"E	89.704	782686.495	692237.097	11.8921
UP DREAM	6d37'14.69672"N	124d35'10.11245"E	141.093	732104.221	675350.631	62.1201
IBM-58						14.7694

The GNSS setup for the five (5) control points are illustrated in Figure 12 to Figure 17; while Figures 18 and 19 shows differential levelling survey:

Figure 12. Static GNSS observation at MGD-2 on top of the PC Hill Compound water tank in Cotabato City

Figure 13. Static GNSS observation at IBM-58A in front of Kabacan Elementary School in Brgy. Poblacion, Kabacan, Cotabato

Figure 14. Static GNSS observation at BMMG-59 at Dicalungan Bridge, at Dicalungan Bridge, Ampatuan, Maguindanao

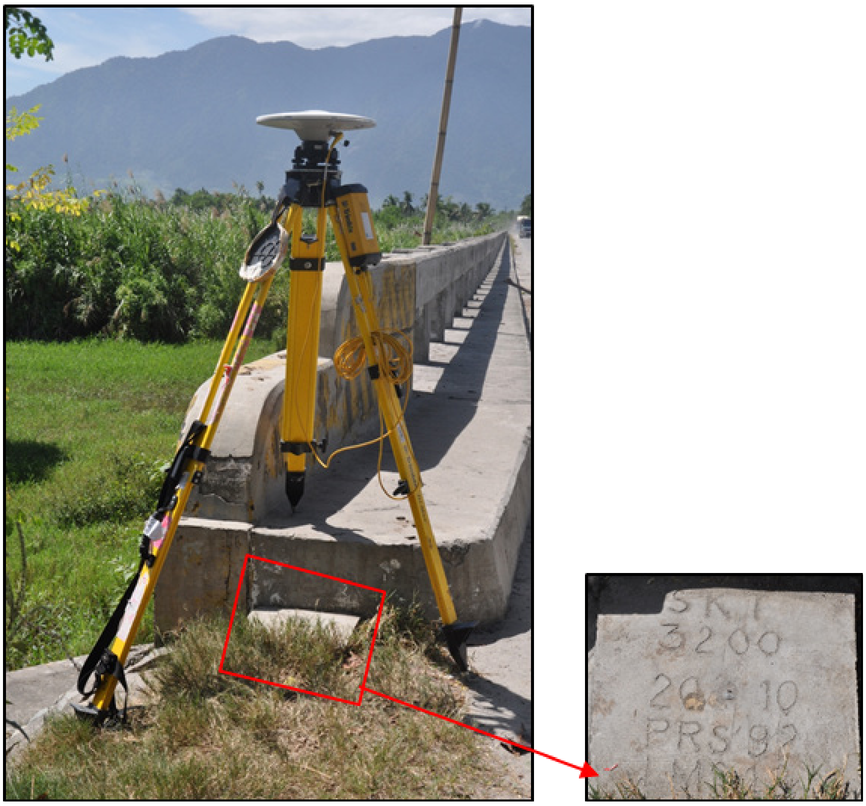


Figure 15. Static GNSS observation at SKT-3200 at Kalawag Bridge Isulan, Sultan Kudarat

Figure 16. Static GNSS observation at BM-2 at Tunggol Bridge in Datu Montawal, Maguindanao

Figure 17. Static GNSS observation at UP DREAM in front of Municipality Hall of Datu Piang, Maguindanao

Figure 18. Differential levelling survey at IBM 58 in Brgy. Poblacion, Kabacan, Cotabato

Figure 19. Differential Levelling execution in front of Kabacan Elementary School in Brgy. Poblacion, Kabacan, Cotabato

4.2 LiDAR Ground Validation

LiDAR Ground Validation survey, last December 18, 2014, conducted by the team using a survey-grade GPS Rover receiver mounted on a pole which was attached in front of the vehicle as shown in Figure 18. It was secured with a nylon rope to ensure that it was horizontally and vertically balanced. The antenna height was measured from the ground up to the bottom of notch of the GNSS Rover receiver. The survey was conducted using PPK technique on a continuous topo mode. The survey team covered Shariff Aguak Cotabato City Road and Maharlika Highway.

Figure 20. Validation Points Acquisition Survey

A map was produced using a GIS software showing the extent of the survey which passed along the Shariff Aguak Cotabato City Road and Maharlika Highway as shown in Figure 21. An approximate length of 55.32 km were covered with a total of 4,678 ground validation points using the base station MGD 2.

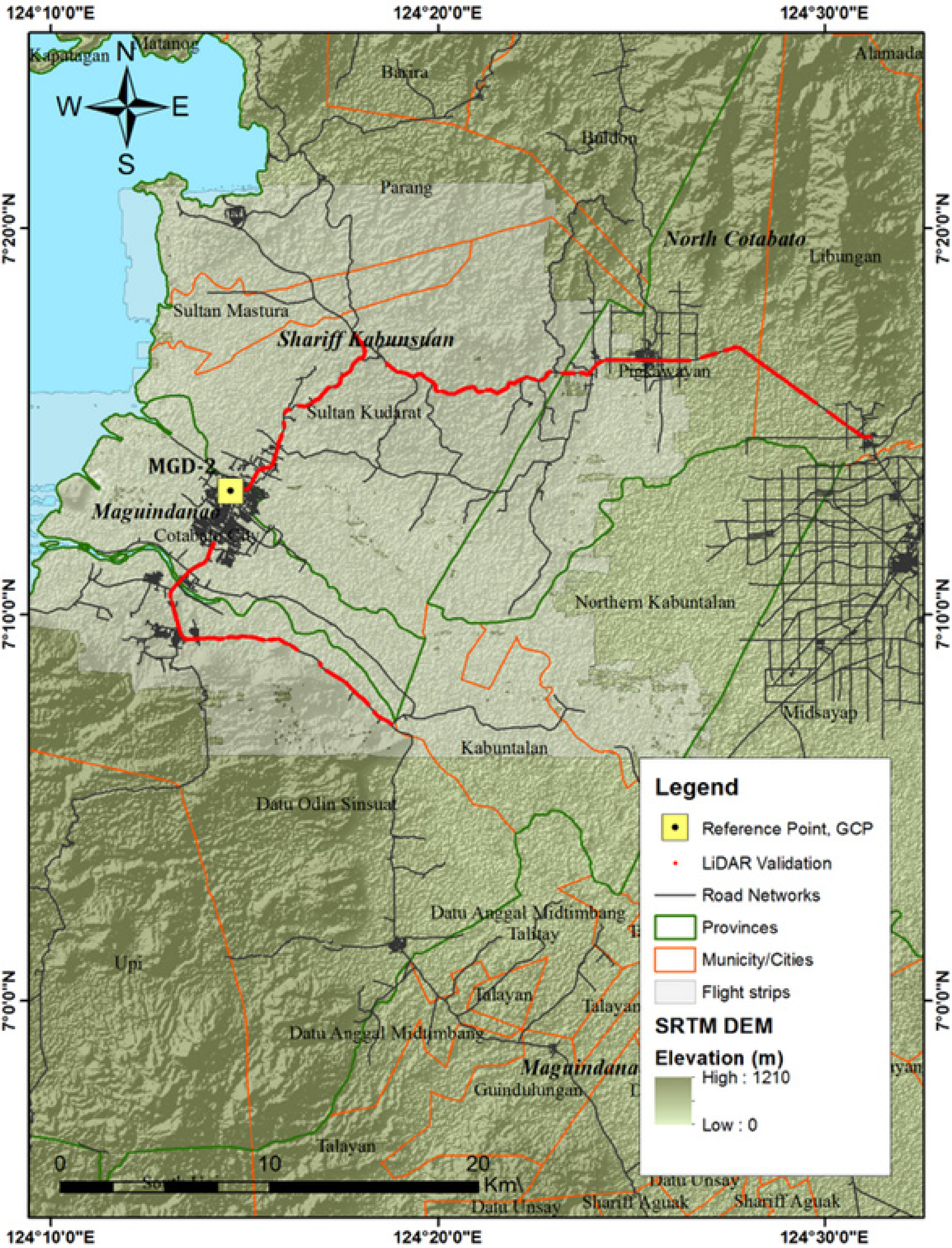


Figure 21. LiDAR ground validation survey along Mindanao Region

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 Mindanao bathymetry survey is illustrated in Figure 22 and Figure 23.

The entire bathymetry survey took three (3) days to accomplish from July 9, 10 and 12, 2014. The Bathymetry Team executed the survey using a rigid boat borrowed from ARMM HEART, accompanied by three (3) response team personnel. The first day of the survey started upstream from the Municipality of Datu Piang to down to Kabuntalan, Maguindanao. The succeeding days of bathymetry started upstream to downstream from the Municipality of Kabuntalan down to Moro Gulf, including the bathymetry of the Tamontaka River, a parallel tributary. The entire survey covered the centreline and cross section of the Mindanao River from the Municipality of Datu Piang to Moro Gulf with estimated length of 52.7 km. The reference point MGD-2 served as the base station for the entire bathymetric survey.

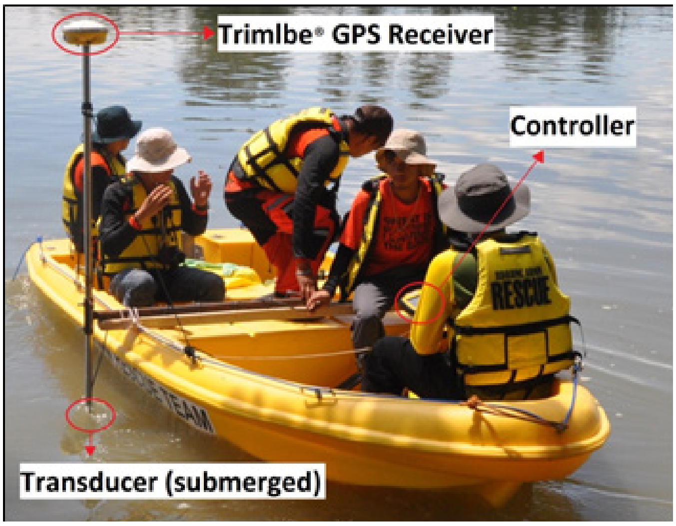


Figure 22. Bathymetric survey setup

Figure 23. Bathymetry team with the ARMM HEART personnel

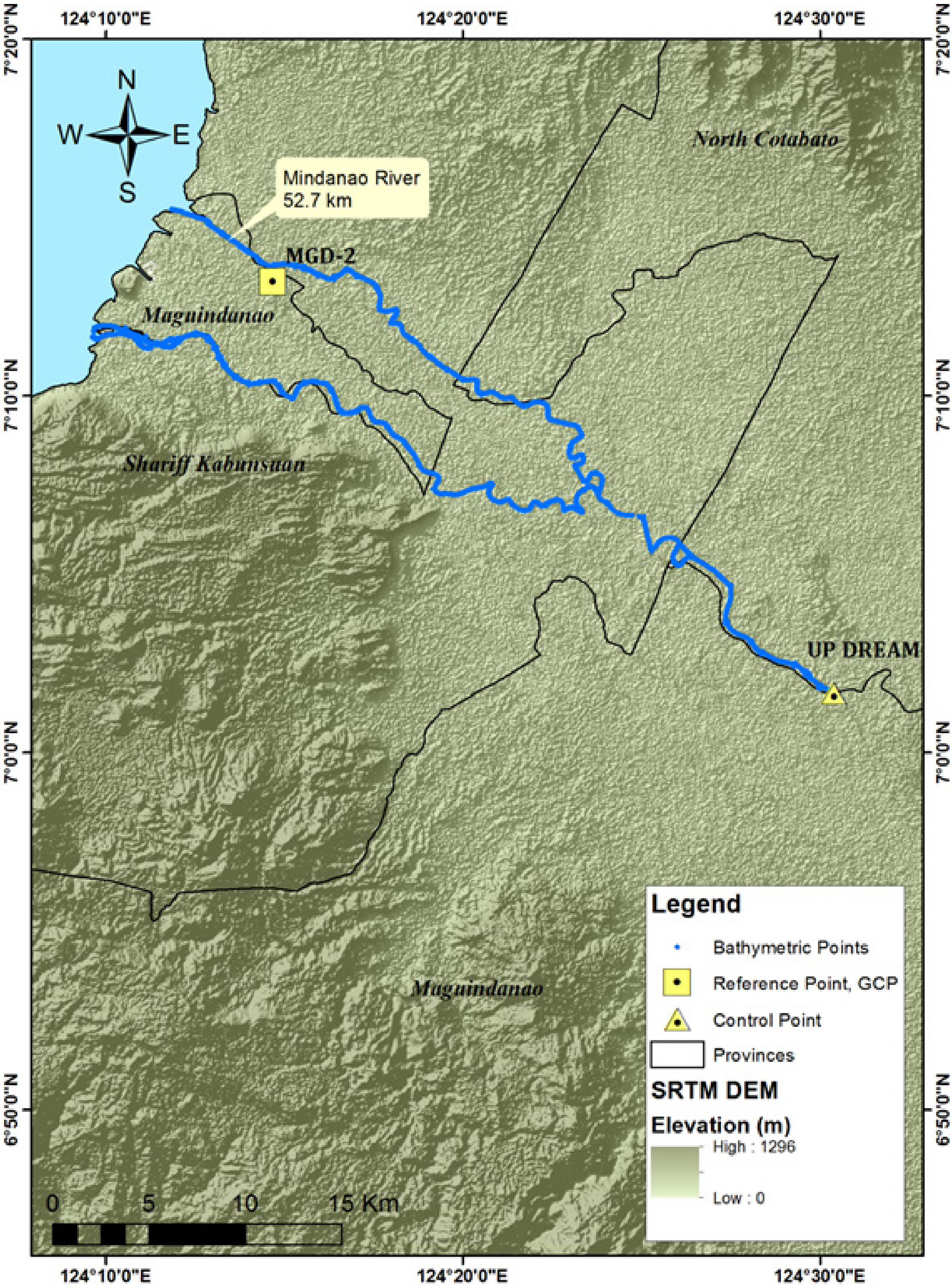


Figure 24. Bathymetric data in Mindanao River

4.3.1 Mindanao River Centerline Profile

A CAD drawing was also produced to illustrate the Mindanao riverbed profile as shown in Figures 25-29. Lowest elevation was 10m in between XS9 and XS10 was observed from its upstream in Brgy. Reina Regente, Datu Piang Maguindanao down to Brgy. Poblacion V, Cotabato City.

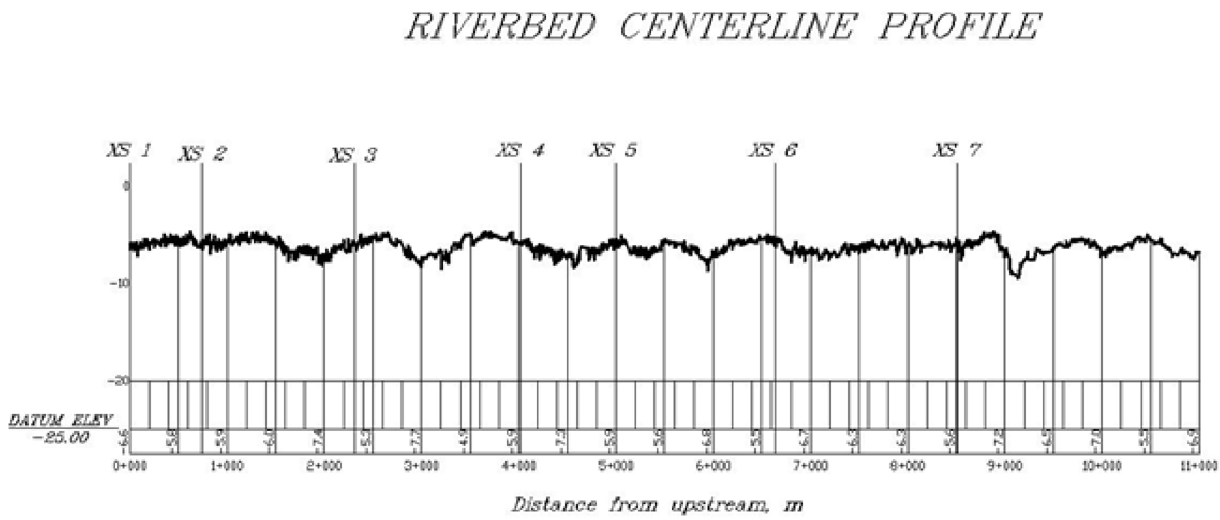


Figure 25. Mindanao Riverbed Profile from cross-section 1 to 7

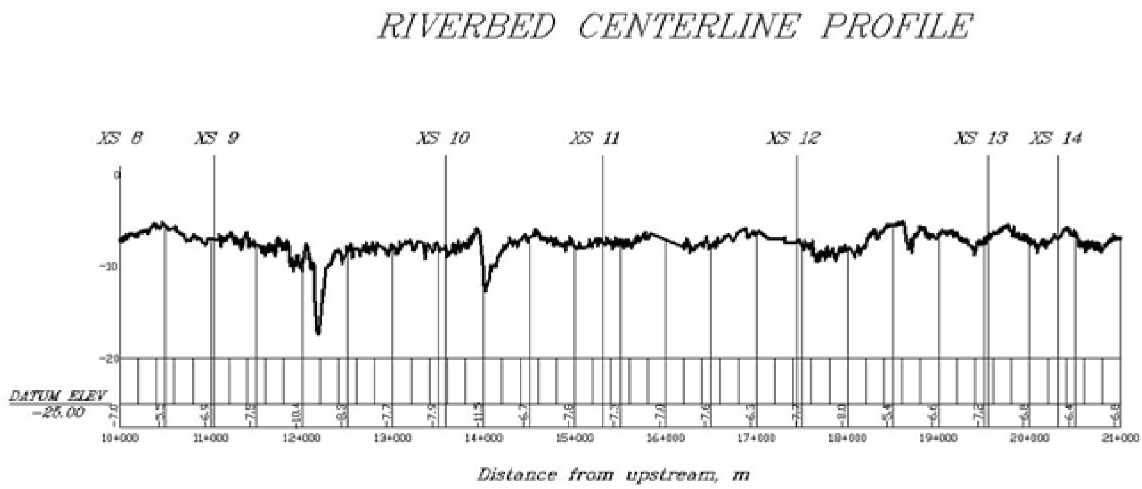


Figure 26. Mindanao Riverbed Profile from cross-section 8 to 14

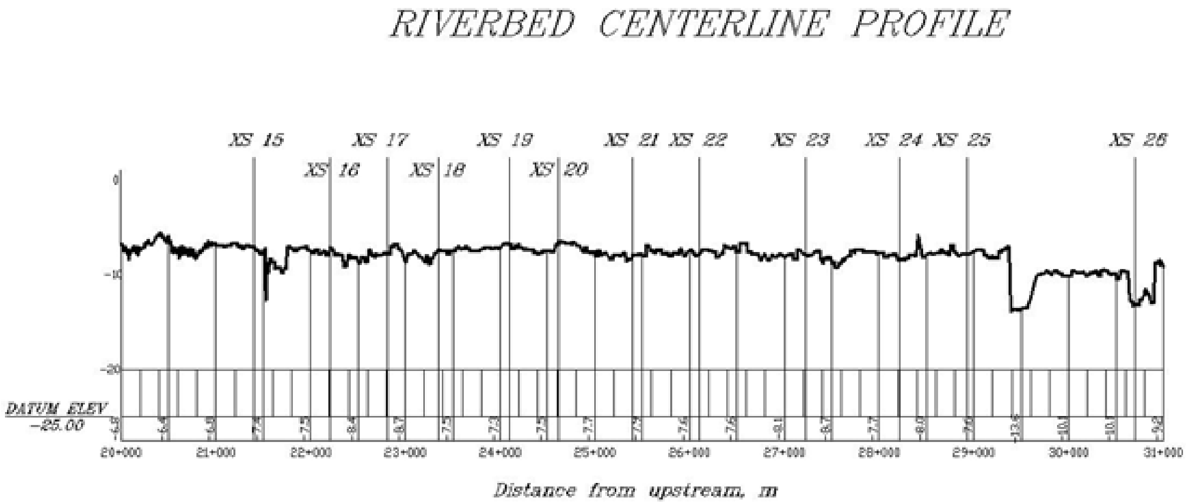


Figure 27. Mindanao Riverbed Profile from cross-section 15 to 26

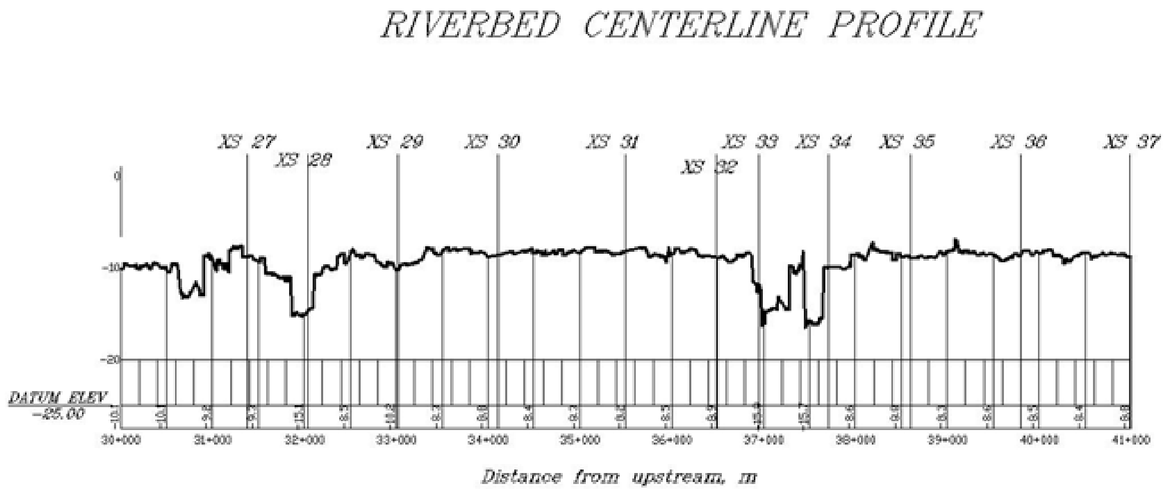


Figure 28. Mindanao Riverbed Profile from cross-section 27 to 37

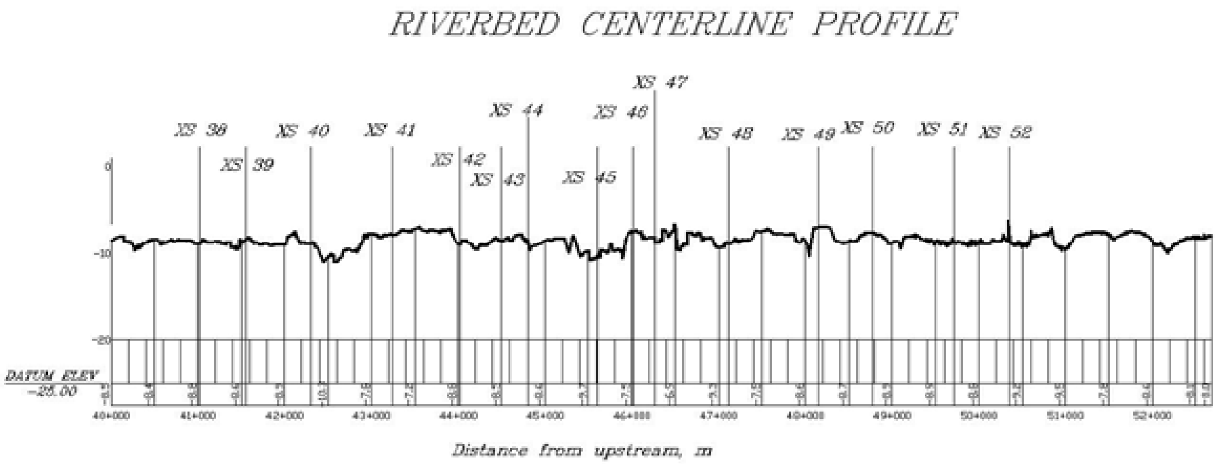


Figure 29. Mindanao Riverbed Profile from cross-section 38 to 52

4.4 Hydrometric Survey

4.4.1 Hydrometric Sensors Deployment with Stage Discharge Computation

Different sensors were deployed on the banks of Mindanao 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.

The survey team deployed Acoustic Doppler Current Profilers (ADCP), velocity meters, depth gauges, and rain gauges and to gathered data for velocity, stage and rainfall. The summary of the location and deployment dates of the sensors used in Mindanao River are shown in the Table 2 below.

Table 2. Sensor location and deployment dates in Mindanao River System

Sensor	Location	Municipality	Deployment –Start	Deployment –End	Bridge Location	
					Latitude	Longitude
ADCP Rain Gauge and Depth Gauge	Lumayong (Carmen) Bridge	Kabacan	Dec. 15, 2013	Dec. 17, 2013	7°08'38.130"N	124°48'09.372"E
ADCP and Depth Gauge	Dicalungan Bridge	Ampatuan	Dec. 16, 2013	Dec. 18, 2013	6°50'06.027"N	124°27'22.919"E
Velocity Meter	Simuay Bridge	Sultan Mas-tura	Dec. 16, 2013 at 10:10 AM	Dec. 16, 2013 at 4:10 PM	7°17'12.669"N	124°17'53.811"E
Velocity Meter Rain Gauge and Depth Gauge			July 6, 2014 at 7:00 AM	July 13, 2014 at 7:00 AM		
Velocity Meter	Kalawag Bridge	Isulan	Dec. 15, 2013 at 12:05 PM	Dec. 15, 2013 at 4:05 PM	6°37'13.600"N	124°35'6.435"E
			July 7, 2014 at 6:00 AM	July 13, 2014 at 4:00 PM		
Velocity Meter	Tunggol Bridge	Datu Mon-tawal	Dec. 17, 2013 at 11:05 AM	Dec. 17, 2013 at 6:05 PM	7°4'40.140"N	124°44'25.590"E

The data gathered at Lumayong(Carmen) Bridge in Kabacan, North Cotabato from rain gauge shows the distribution of rainfall within the observation period from December 15-18, 2013. Each sensor has five (5)-minute interval. The first surge of rain, which reached 0.2 mm, was observed on December 15, 2013 at 4:15 PM. The highest amount of rain collected occurred was on the 18th of December, 2013 at 2:35 PM with 3.6 mm. Setup of sensors deployment in Lumayong is illustrated in Figure 30 and Figure 31. While relationships of data gathered within the observation period are illustrated in Figure 32-Figure 35.

Figure 30. Deployment of ADCP with depth gauge in Lumayong (Carmen) Bridge, Brgy. Kaya, Kabacan, North Cotabato

Figure 31. The Acoustic Doppler Current Profiler with depth gauge deployed in Lumayong (Carmen) Bridge, Brgy. Kaya, Kabacan, North Cotabato

The relationship of water level data from the deployed depth gauge and rainfall data from the deployed rain gauge from December 15-19, 2013 is shown in Figure 32.

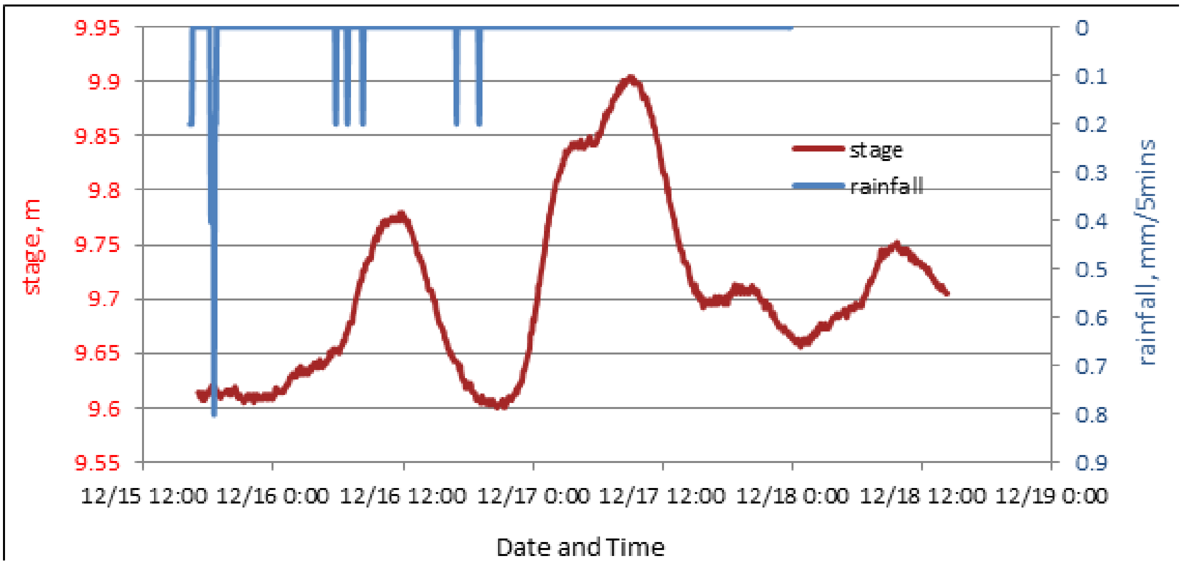


Figure 32. Relationship between stage and rainfall in Lumayong (Carmen) Bridge, Brgy. Kaya, Kabacan, North Cotabato

The relationship of water velocity data using ADCP and water level from the deployed depth gauge from December 15-18, 2013 is shown in Figure 33.

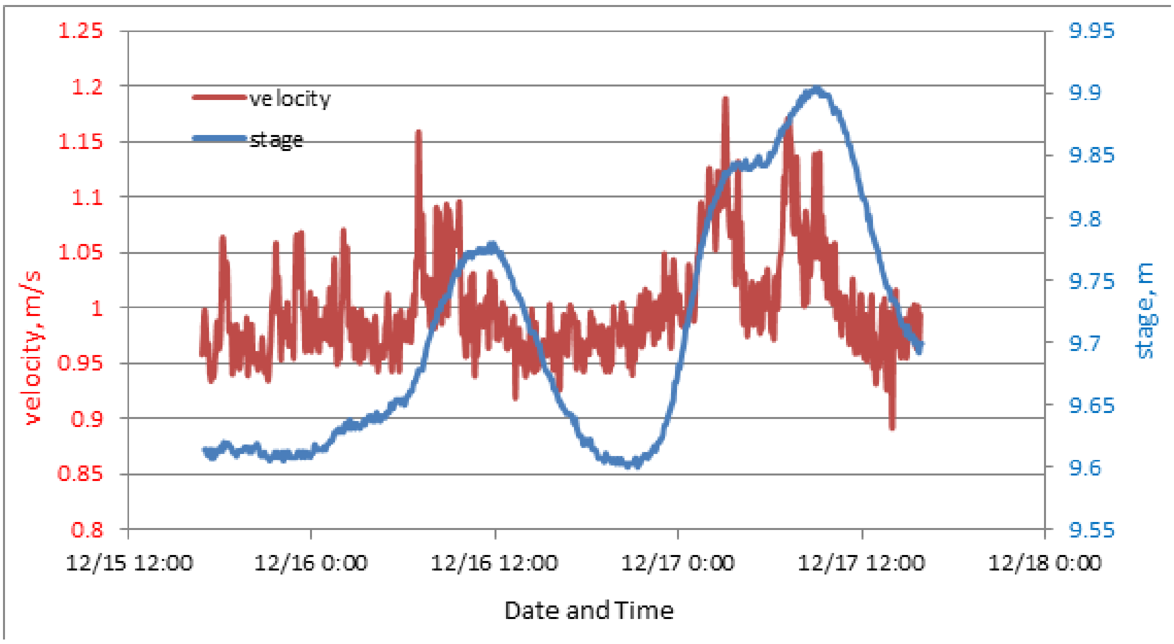


Figure 33. Relationship between velocity and stage in Lumayong (Carmen) Bridge, Brgy. Kaya, Kabacan, North Cotabato

The relationship of water velocity data from the deployed ADCP and rainfall from the deployed rain gauge from December 15-18, 2013 is shown in Figure 34.

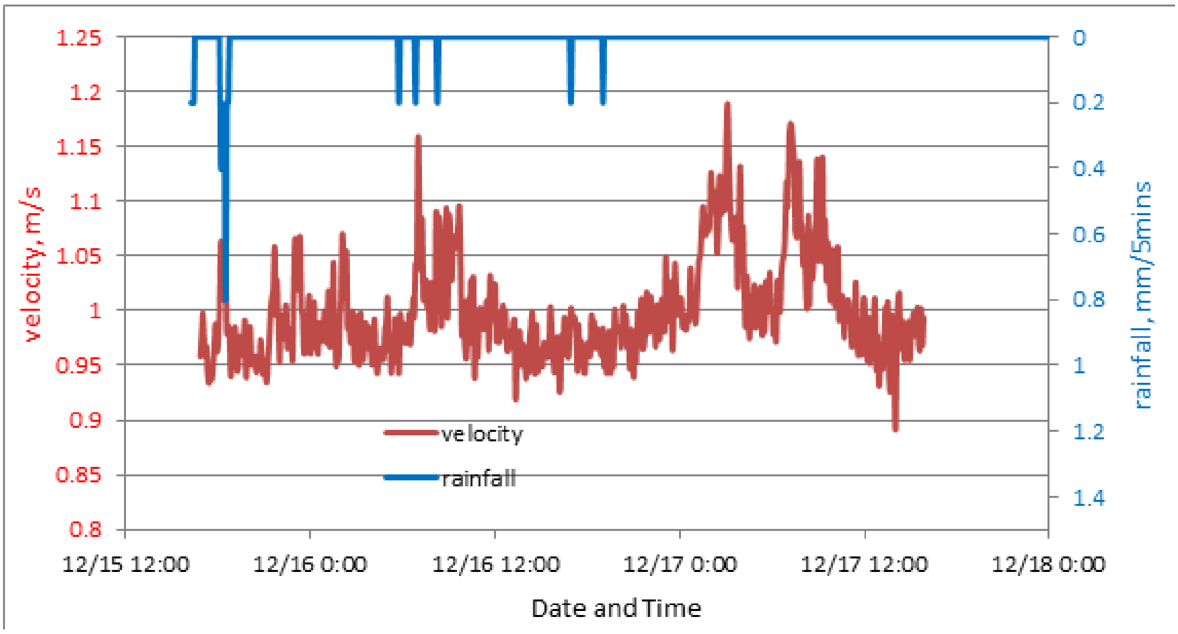


Figure 34. Relationship between velocity and rainfall in Lumayong (Carmen) Bridge, Brgy. Kaya, Kabacan, North Cotabato

The relationship between stage and discharge for December 13-19, 2013 survey resulted in an R^2 of 0.757 shown in Figure 33. A value approaching $R^2 = 1$ indicates a good correlation.

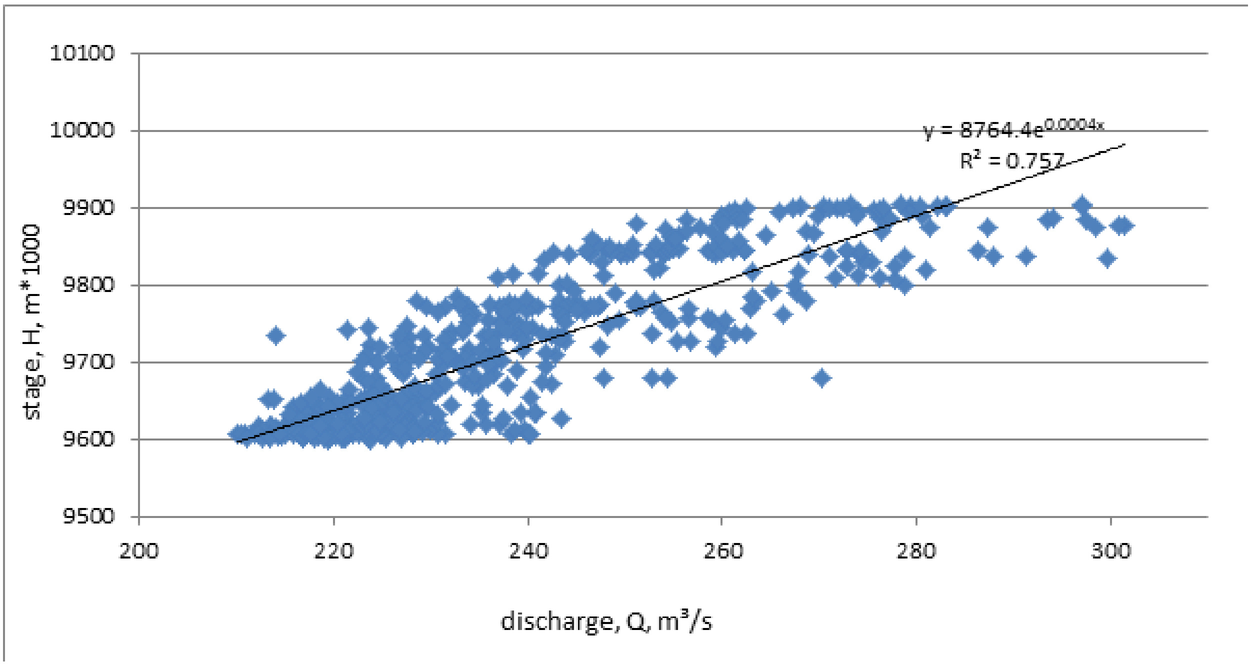


Figure 35. Relationship between stage and discharge near Lumayong (Carmen) Bridge, Brgy. Kaya, Kabacan, North Cotabato

The set up sensors for data gathering in Dicalungan Bridge, Ampatuan, Maguindanao Cotabato are shown in Figure 36 and Figure 37 while the relationships of data gathered within the observation period on December 13-15, 2013 presented in graphs in Figure 38-Figure 41.

Figure 36. Deployment of ADCP with Depth Gauge on the bank of Mindoro River in Dicalungan Bridge, Ampatuan, Maguindanao Cotabato

Figure 37. The Acoustic Doppler Current Profiler with depth gauge deployed along Dicalungan Bridge, Ampatuan, Maguindanao Cotabato

The relationship of stage from the deployed depth gauge and rainfall data from the deployed rain gauge from December 15-19, 2013 is shown in Figure 38.

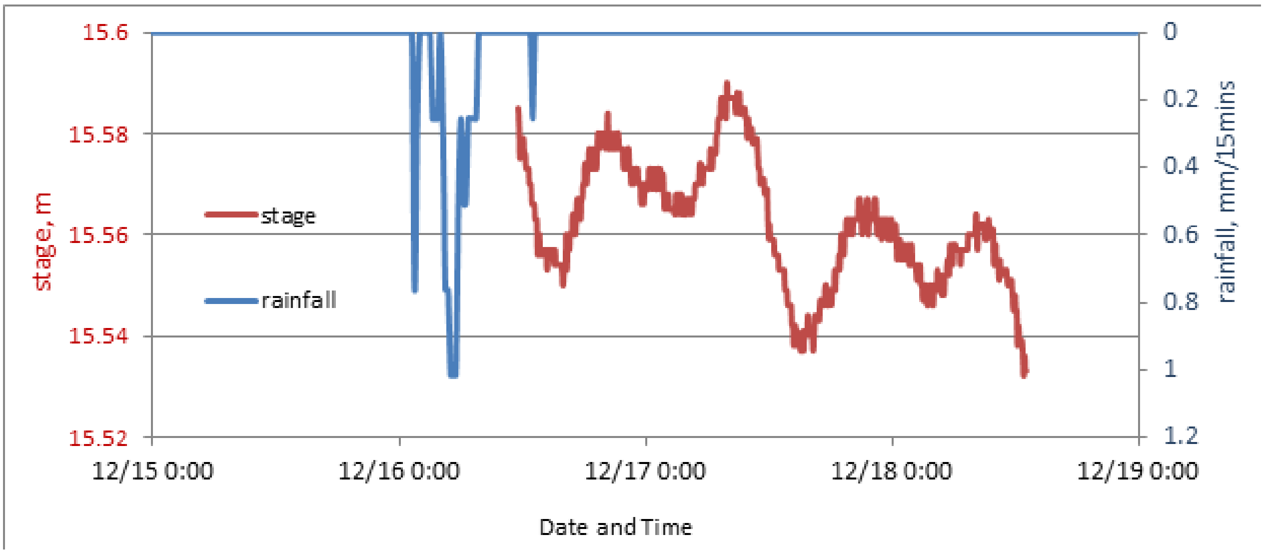


Figure 38. Relationship between stage and rainfall in Dicalungan Bridge, Ampatuan, Maguindanao Cotabato

The relationship of water velocity data using ADCP and stage from the deployed depth gauge from December 16-19, 2013 is shown in Figure 39.

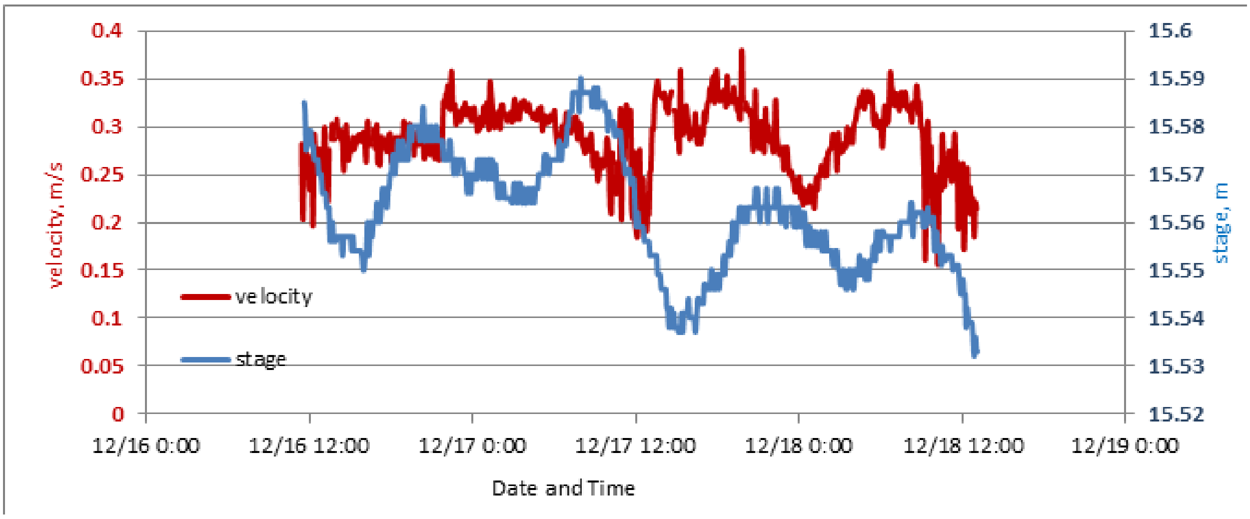


Figure 39. Relationship between velocity and stage in Dicalungan Bridge, Ampatuan, Maguindanao Cotabato

The relationship of water velocity data from the deployed ADCP and rainfall from the deployed rain gauge from December 15-18, 2013 is shown in Figure 40.

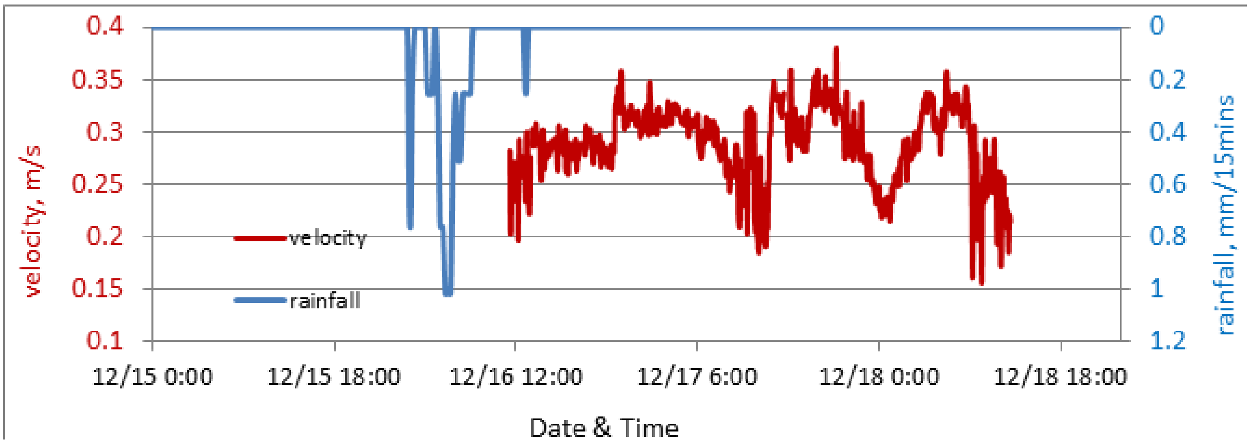


Figure 40. Relationship between velocity and rainfall in Dicalungan Bridge, Ampatuan, Maguindanao Cotabato

The relationship between stage and discharge for December 13-19, 2013 survey resulted in an R^2 of 0.0131 is shown in Figure 41.

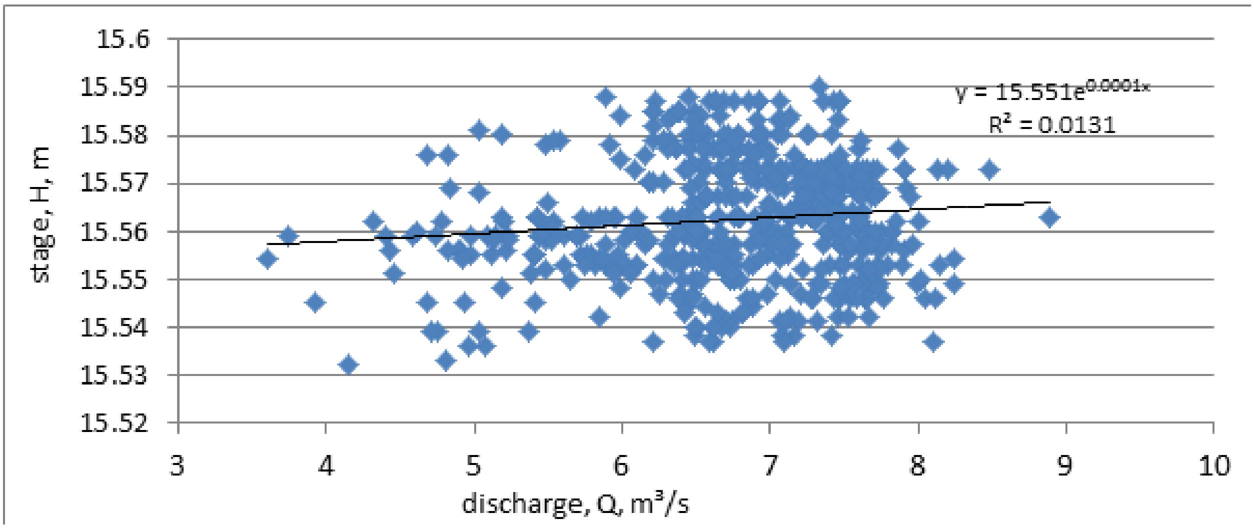


Figure 41. Relationship between stage and discharge in Dicalungan Bridge, Ampatuan, Maguindanao Cotabato

Mindanao River Basin Survey

4.4.2 Mindanao AWLS Survey

Cross-section survey along bridges with installed AWLS was conducted on December 14-17, 2013 along the Mindanao River System using GNSS PPK survey technique. The elevation of the installed AWLS and the water surface elevation along the banks near the sensor were acquired as well. The summary of data gathered is shown in Table 3.

As-built surveys were also done on July 5-13, 2014 for the bridges with installed AWLS as additional data for the cross-section survey, which is needed for the refinement of the Mindanao River flood models refinement. The as-built forms are located in Annex E.

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

AWLS	Location	Coordinates	AWLS Elevation (m), MSL	Water Surface Elevation (m), MSL with Date& Time	Image
Lumayong Bridge	Lumayong Bridge, Brgy. Kaya, Kabacan, North Cotabato	Lat 7° 8'34.44524"N Long 124°48'9.54763"E	20.921 m	10.0331 m *(Dec. 14, 2013 at 9:12 AM)*	
Dicalungan Bridge	Dicalungan Bridge, Ampatuan, Maguindanao Cotabato	Lat 6°50'6.73911"N Long 124°27'22.68011"E	23.152 m	15.5731 m *(Dec. 16, 2013 at 12:20 PM)*	
Simuay Bridge	Simuay Bridge, Sultan Mastura, Maguindanao	Lat 7°17'12.66857"N Long 124°17'53.81059"E	20.921 m	10.0331 m *(Dec. 14, 2013 at 9:12 AM)*	
Kalawag Bridge	Kalawag Bridge, Isulan, Sultan Kudarat	Lat 6°37'13.60020"N Long 124°35'6.43523"E	69.452 m	64.6511 m *(Dec. 15, 2013 at 3:52 PM)*	

AWLS	Location	Coordinates	AWLS Elevation (m), MSL	Water Surface Elevation (m), MSL with Date& Time	Image
Tunggol Bridge	Tunggol Bridge, Datu Montawal, Maguindanao	Lat 7° 4’40.14”N Long 124°44’25.59”E	12.980 m	3.8521 m *(Dec. 17, 2013 at 10:51 AM)*	
Talisawa Bridge	Talisawa Bridge, Datu Abdulah Sangki, Maguindanao	Lat 6°46’20.54866”N Long 124°28’49.04935”E	40.304 m	64.6511 m *(Dec. 15, 2013 at 3:52 PM)*	

The diagram of cross-section data gathered for bridges with installed AWLS is illustrated in Figure 42-Figure 47. The location of theses bridges is illustrated in the map in Figure 48.

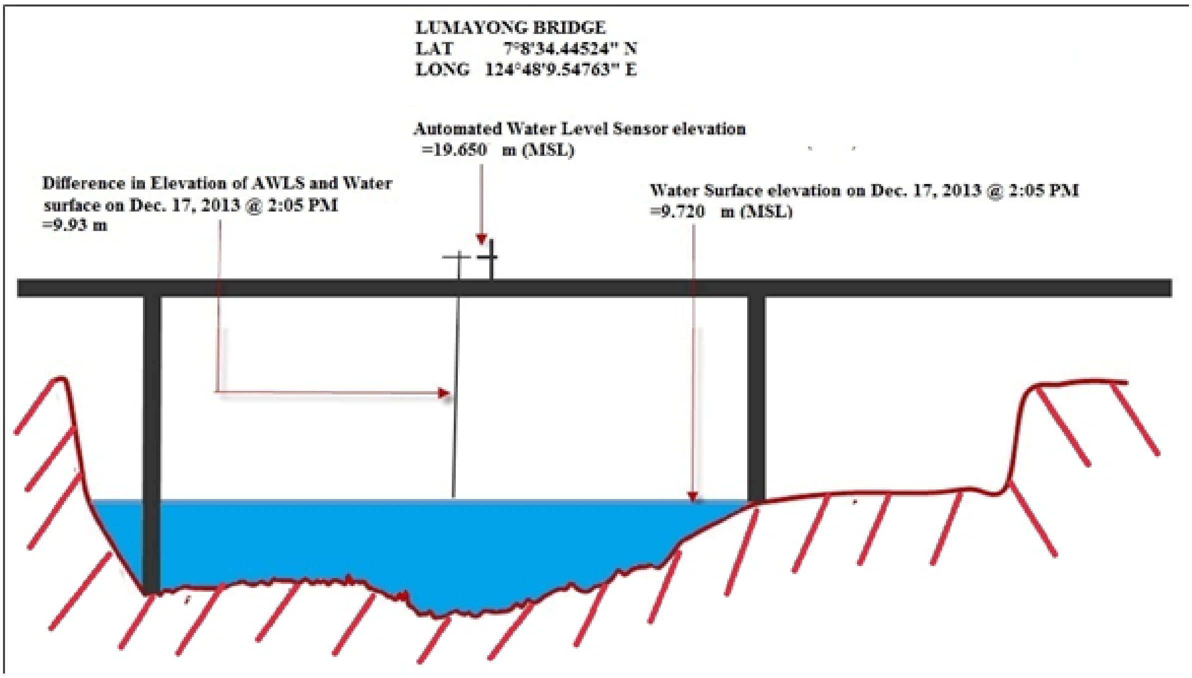


Figure 42. AWLS diagram for Lumayong Bridge in Brgy. Kaya, Kabacan, North Cotabato

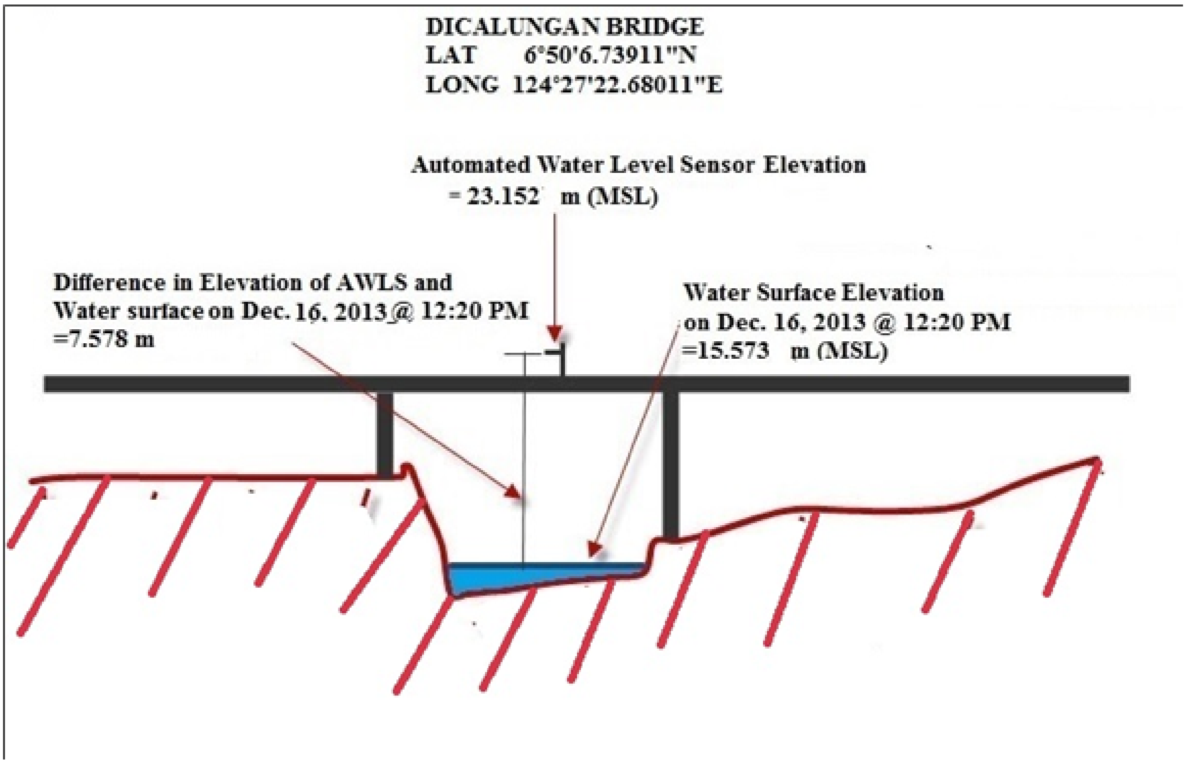


Figure 43. AWLS diagram of Dicalungan Bridge in Ampatuan, Maguindanao Cotabato

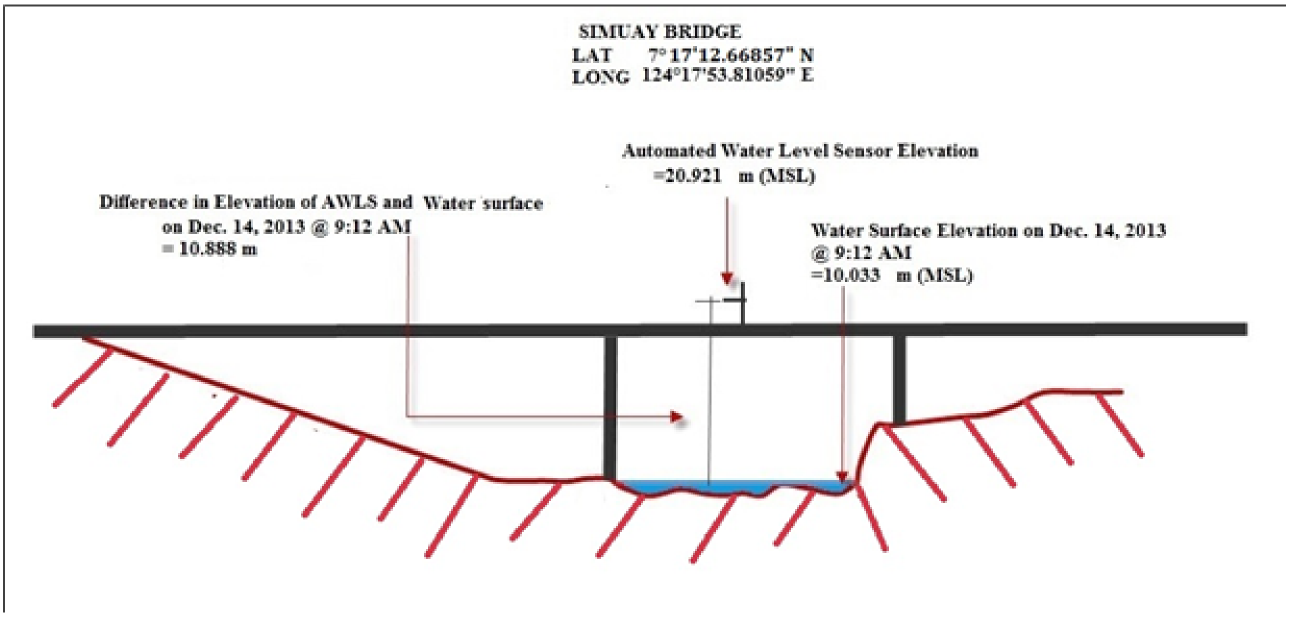


Figure 44. AWLS diagram of Simuay Bridge in Sultan Mastura, Maguindanao

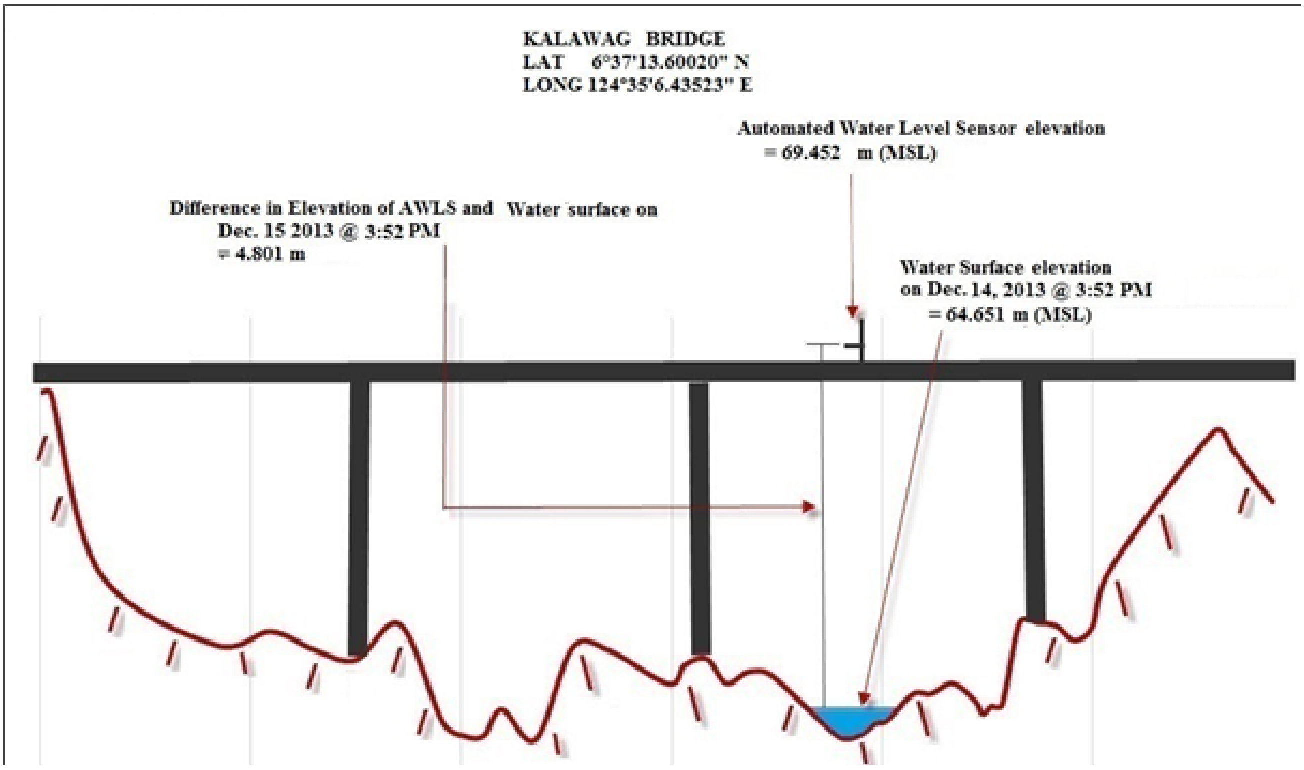


Figure 45. AWLS diagram of Kalawag Bridge in Isulan, Sultan Kudarat

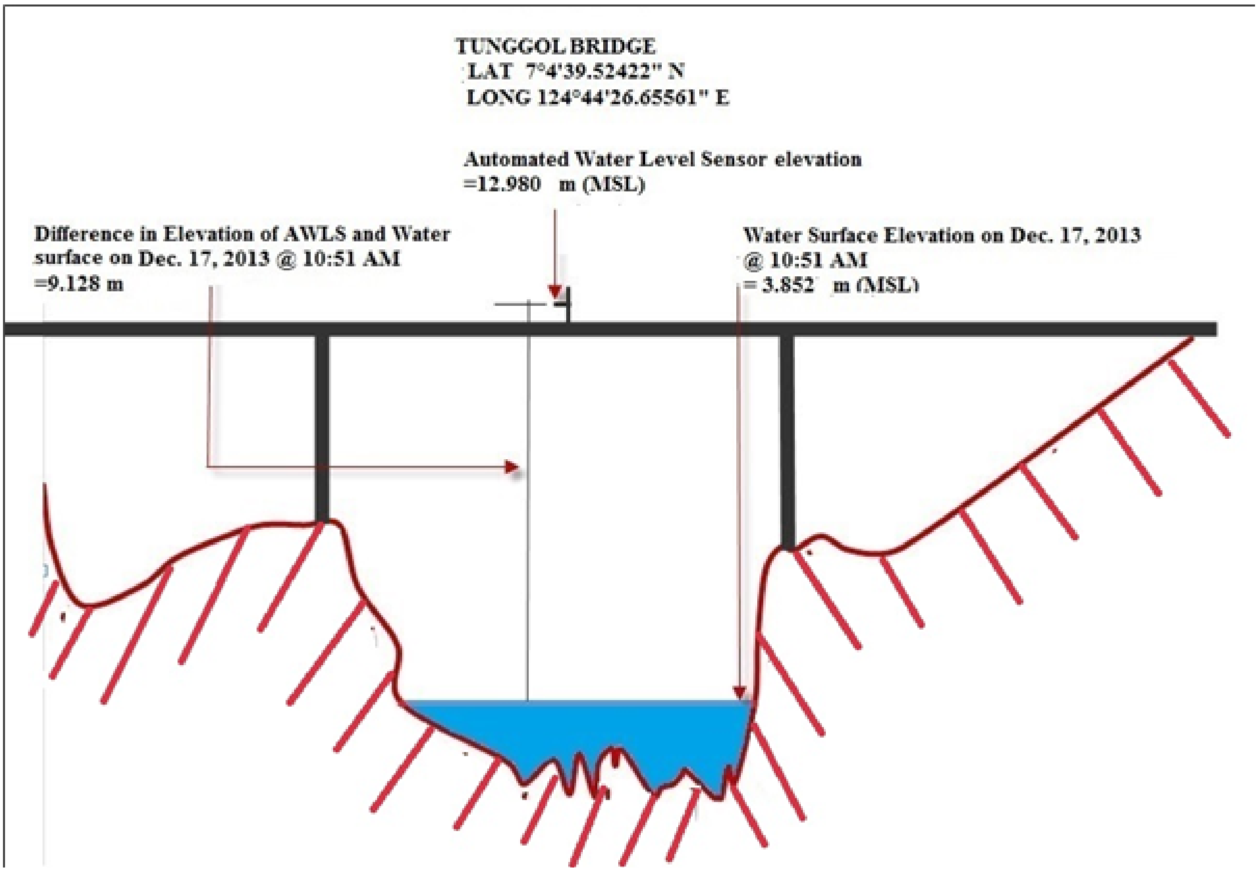


Figure 46. AWLS diagram of Tunggol Bridge in Datu Montawal, Maguindanao

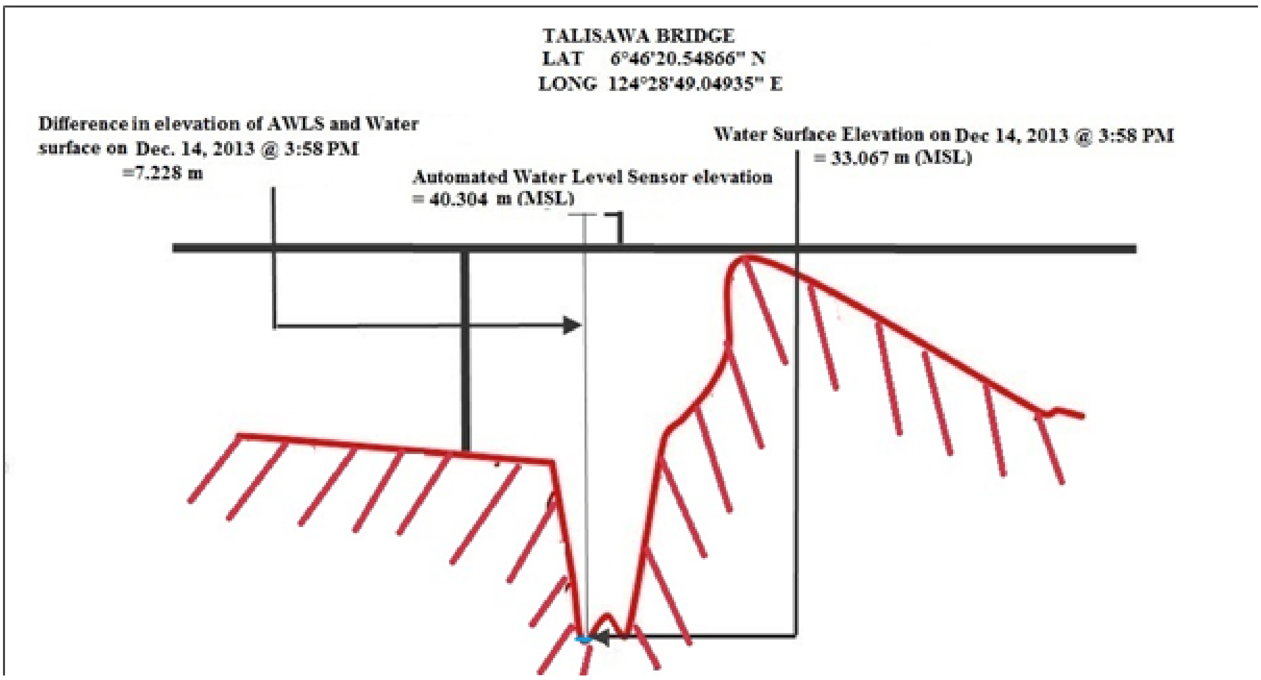


Figure 47. AWLS diagram of Talisawa Bridge in Datu Abdulah Sangki, Maguindanao

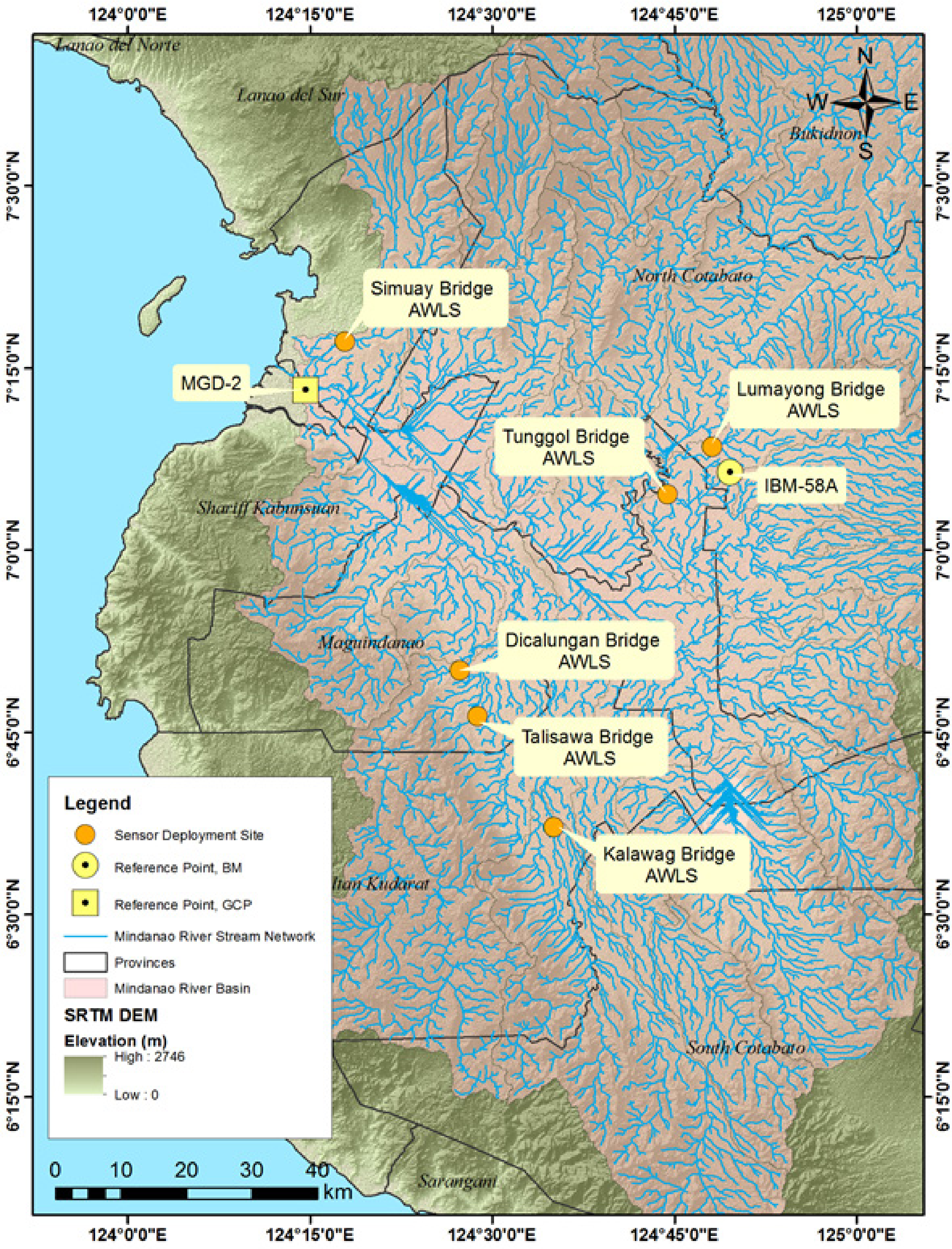


Figure 48. **Location of AWLS in Mindanao River**

4.4.3 Mindanao AWLS Flow Measurements and Stage-Discharge Computation

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

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

Figure 49. Flow measurement in Kalawag Bridge in Isulan, Sultan Kudarat on December 13-19, 2013 survey (A) and on July 1-15, 2014 survey (B) using digital flow meter.

Table 4. Summary of Mindanao River System AWLS Field Survey

Bridges	Cross Section	Water Level	Flow Measurement	Rainfall	Remarks
Simuay	✓	✓	✓	✓	complete
Kalawag	✓	✓	✓	No data from repo.pscigrid.gov.ph	No rainfall data from repo.pscigrid.gov.ph within the observation period.
Tunggol	✓	✓	✓	✓	complete
Lumayong	✓	✓	✓	✓	complete
Dicalungan	✓	✓	✓	✓	complete
Talisawa	✓	No data from repo.pscigrid.gov.ph	Not applicable within the observation period	No data from repo.pscigrid.gov.ph	Flow measurement is not applicable within the observation period No water level and rainfall data from repo.pscigrid.gov.ph

A. Simuay Bridge Stage-Discharge Computation

Flow measurements were recorded for one (1) day December 14, 2013 for two (2) hours observation and for eight (8) days on July 6-13, 2014 for four (4) hours observation along Simuay Bridge. No rainfall was observed throughout the duration of survey on December 13-19, 2013. Relationships of data gathered within the observation period are illustrated in Figure 50-Figure 55.

On the July 1-15, 2014 survey, from the deployed rain gauge, the data shows that first surge of rain, which reached 0.2 mm, was observed on July 5, 2014 at 10:48 PM. The highest amount of rain collected occurred was on the 13th of July, 2014 at 4:57 PM and 5:04 PM with 9.8 mm.

The relationship of stage data and rainfall data from the deployed rain gauge is shown in Figure 50.

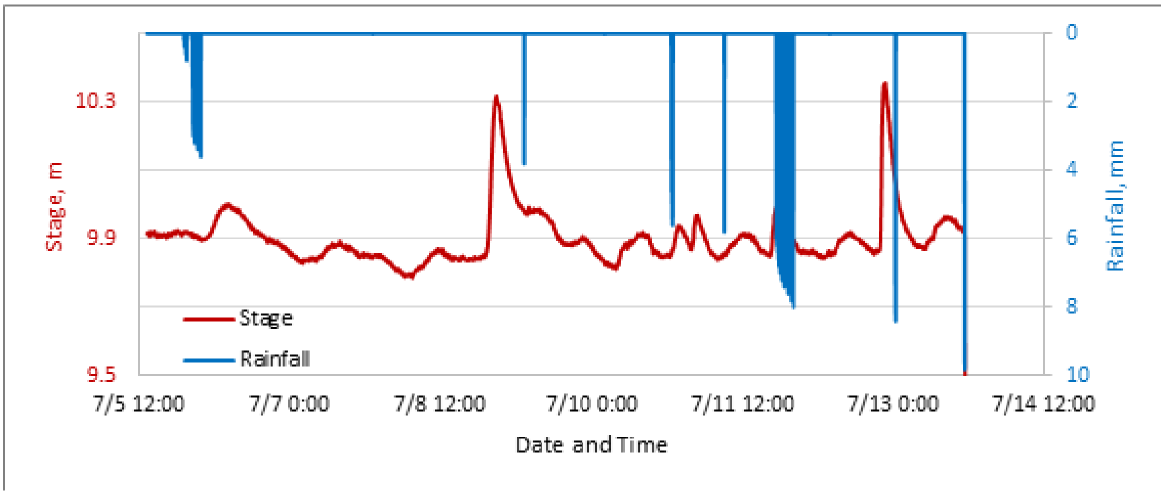


Figure 50. Relationship between stage and rainfall in Simuay Bridge, Sultan Mastura, Maguindanao

The relationship of water velocity data using the flow meter and water level on December 13-19, 2013 is shown in Figure 51.

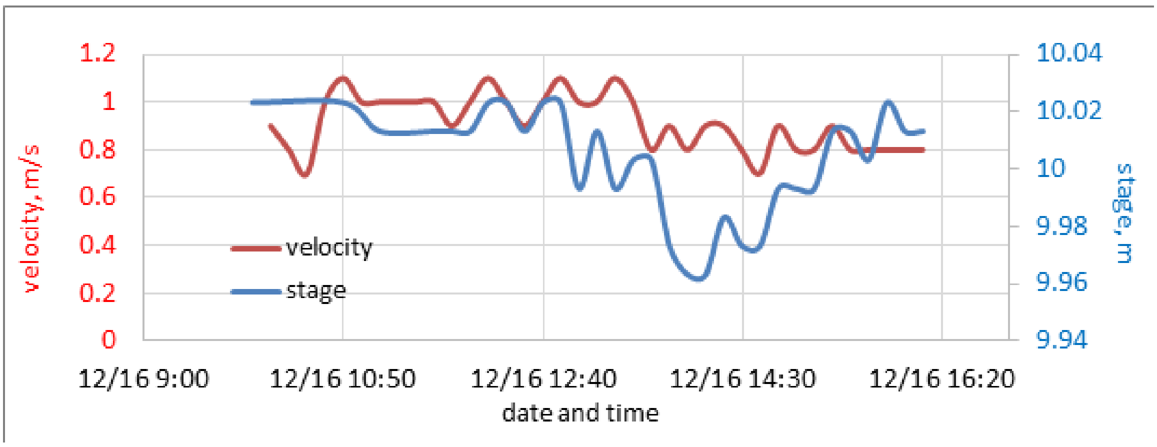


Figure 51. Relationship between velocity and stage in Simuay Bridge, Sultan Mastura, Maguindanao

The relationship of water velocity data using the flow meter and water level from July 5-14, 2014 is shown in Figure 52.

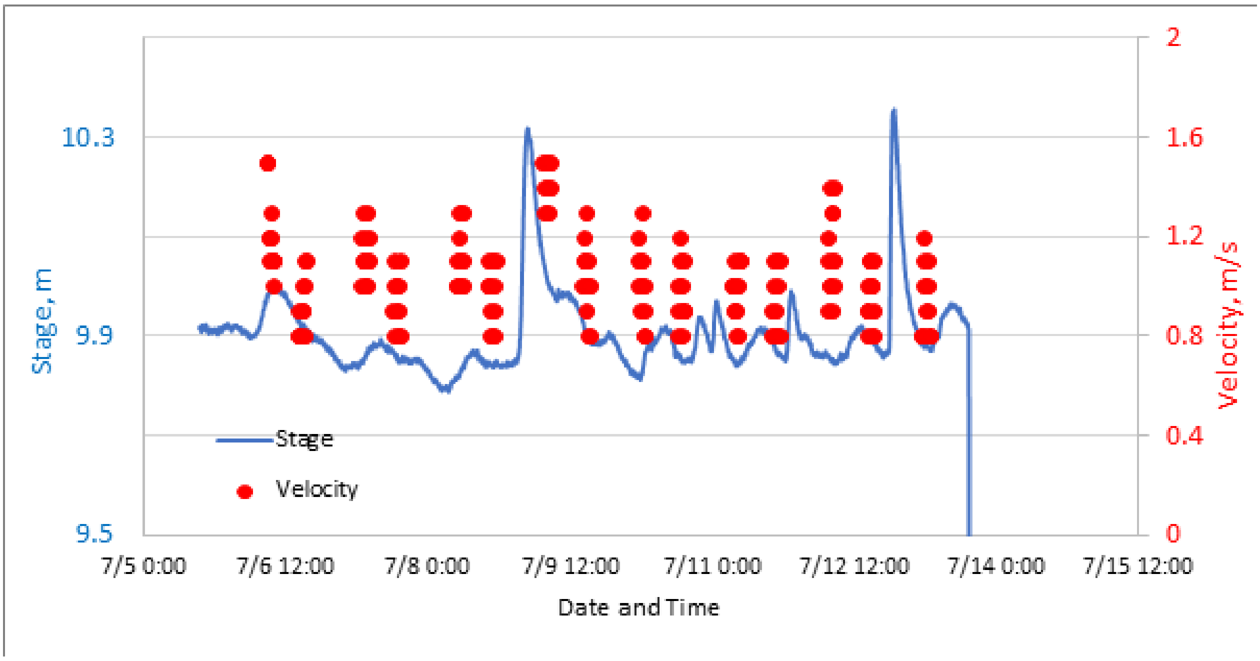


Figure 52. Relationship between velocity and stage in Simuay Bridge, Sultan Mastura, Maguindanao

The relationship of water velocity data using flow meter and rainfall data using the deployed rain gauge data from July 5 to July 13, 2014 and the water level during the sensor deployment is shown in Figure 53.

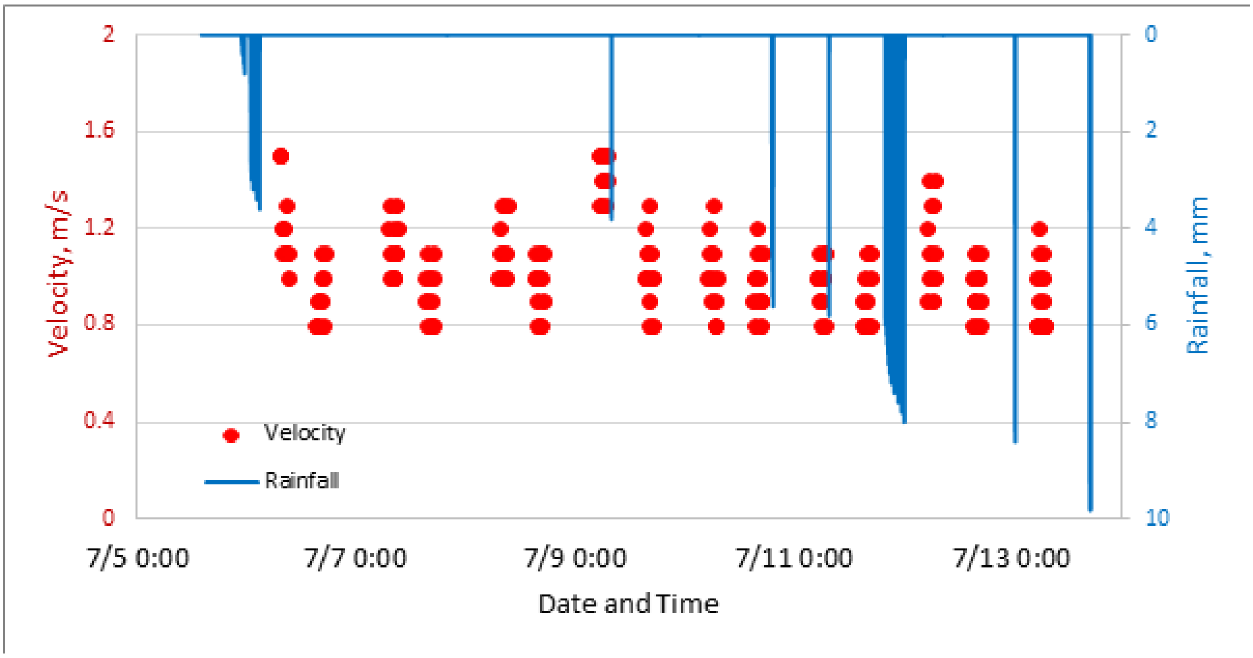


Figure 53. Relationship between velocity and rainfall in Simuay Bridge, Sultan Mastura, Maguindanao

The relationship between stage and discharge for December 13-19, 2013 survey resulted in an R^2 of 0.0418 (see Figure 54) while for July 1-15, 2014 survey, R2 is equal to 0.0133 (see Figure 55).

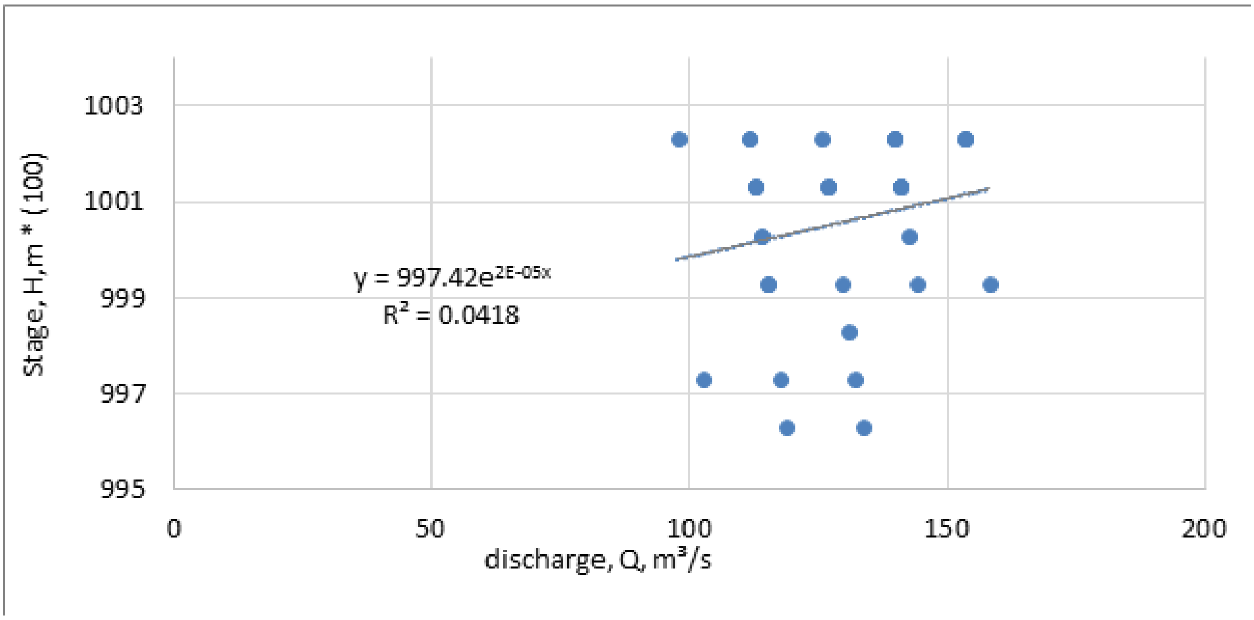


Figure 54. Relationship between stage and discharge in Simuay Bridge, Sultan Mastura, Maguindanao

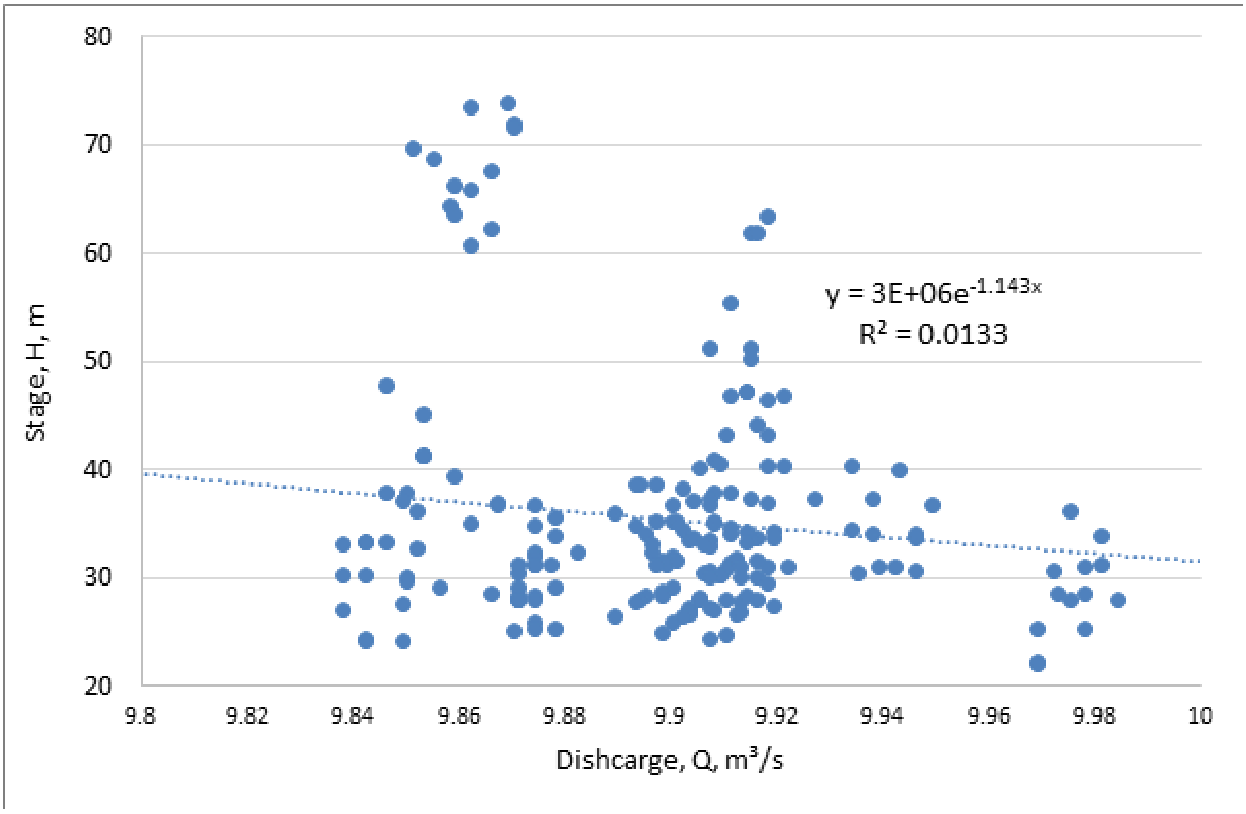


Figure 55. Relationship between stage and discharge in Simuay Bridge, Sultan Mastura, Maguindanao

B. Kalawag Bridge Stage Discharge Computation

Flow measurements were recorded for one (1) day December 15, 2013 for four (4) hours observation and for seven (7) days on July 7-13, 2014 for four (4) hours observation along Kalawag Bridge. No rainfall data extracted from repo.pscigrid.gov.ph at Kalawag Bridge. The relationships of data gathered within the observation period are illustrated in Figure 56-Figure 59.

The relationship of water velocity data using the flow meter and water level from December 15, 2013 is shown in Figure 56.

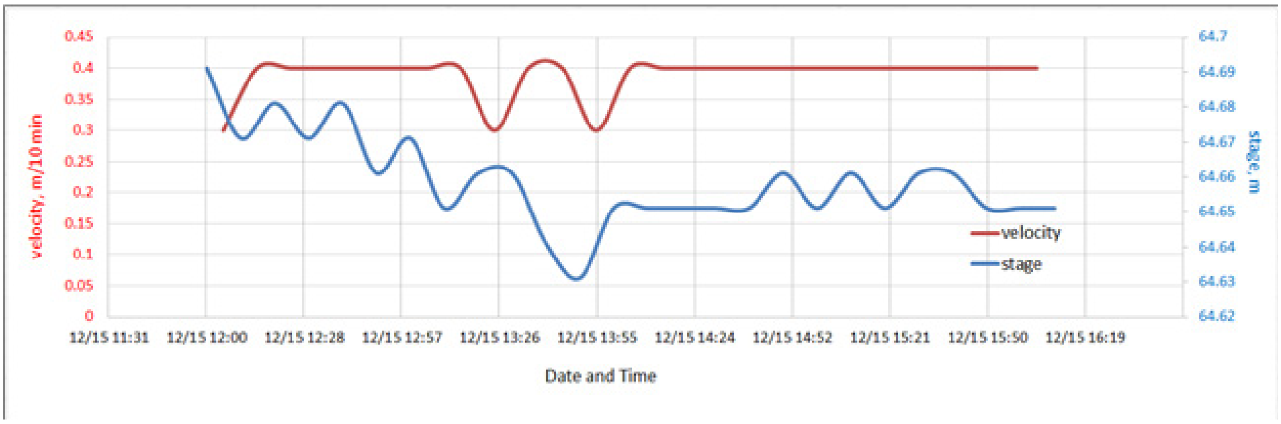


Figure 56. Relationship between velocity and stage in Kalawag Bridge, Isulan, Sultan Kudarat

The relationship of water velocity data using the flow meter and water level from July 6-15, 2014 is shown in Figure 57.

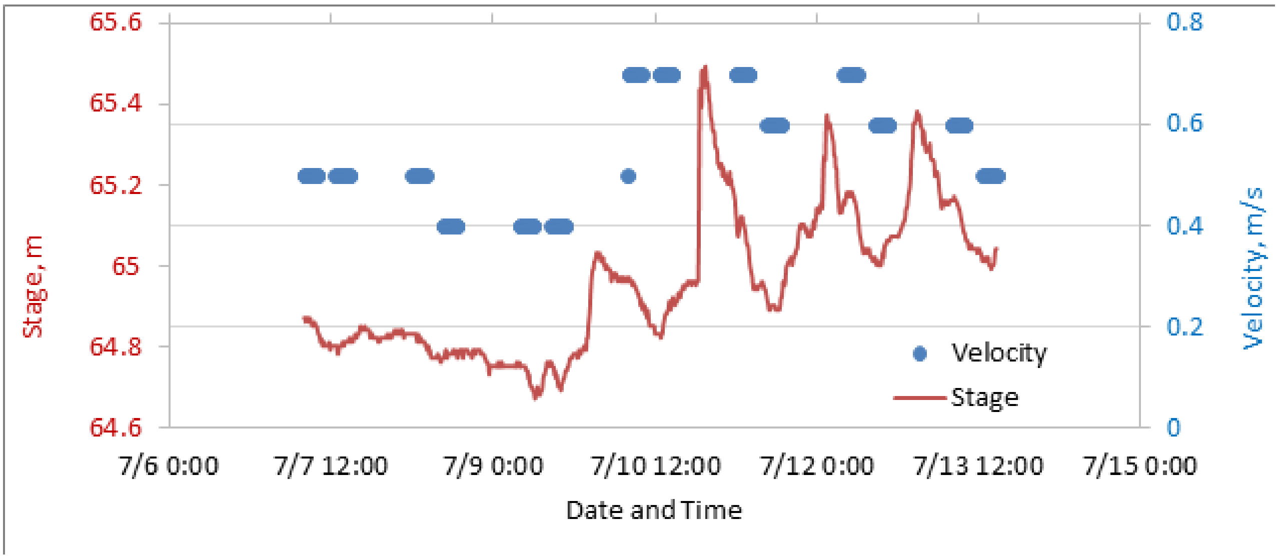


Figure 57. Relationship between velocity and stage in Kalawag Bridge, Isulan, Sultan Kudarat

The relationship between stage and discharge for December 15, 2013 survey resulted in an R2 of 0.391 (see Figure 58) while for July 6-15, 2014 survey, R^2 is equal to 0.9441 (see Figure 59). A value approaching R^2 = 1 indicates a good correlation.

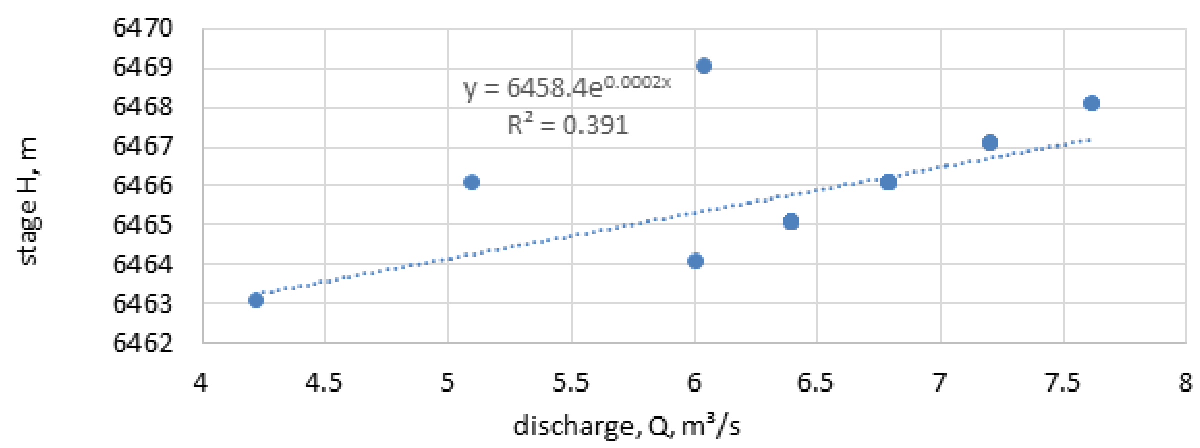


Figure 58. Relationship between stage and discharge in Kalawag Bridge, Isulan, Sultan Kudarat

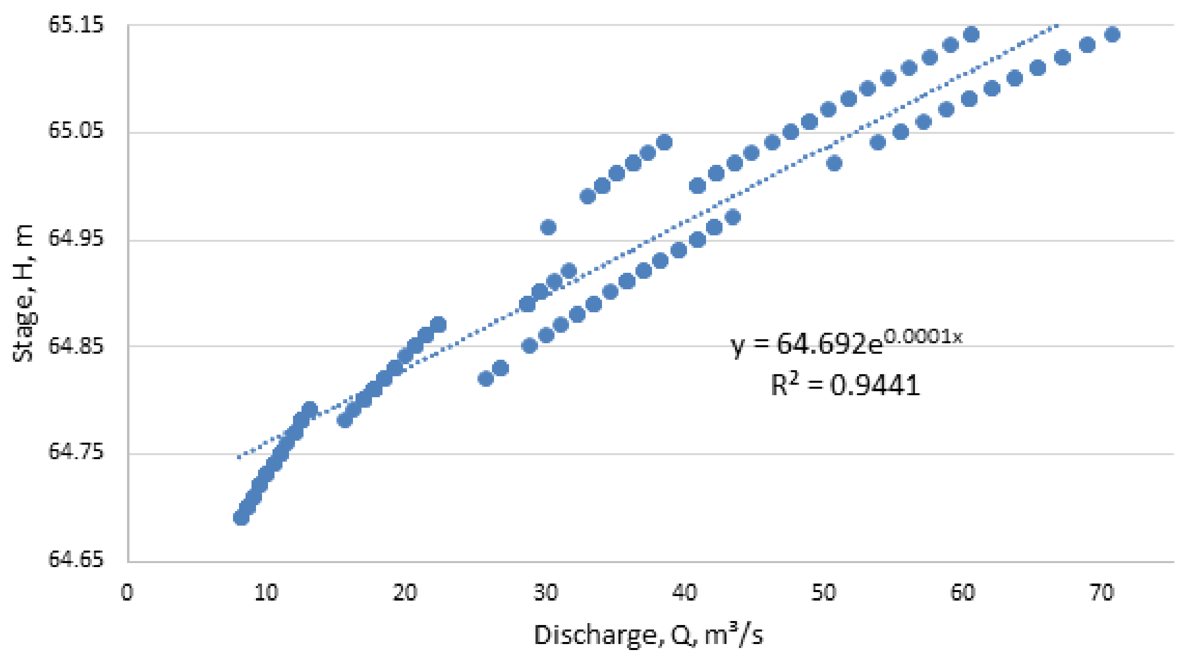


Figure 59. Relationship between stage and discharge in Kalawag Bridge, Isulan, Sultan Kudarat

C. Tunggol Bridge Stage Discharge Computation

Flow measurements were recorded for one (1) day December 17, 2013 for seven (7) hours observation along Tunggol Bridge. While rainfall data was extracted from repo.pscigrid.gov.ph. Based on the data gathered the first surge of rain, which reached 0.508 mm, was observed on December 15, 2013 at 6:20 PM. The highest amount of rain collected occurred was also on December 15, 2013 at 6:30 PM with 2.794 mm. The relationships of data gathered within the observation period are illustrated in Figure 60-Figure 63.

The relationship of water level data and rainfall from repo.pscigrid.gov.ph from December 15-16, 2013 is shown in Figure 60.

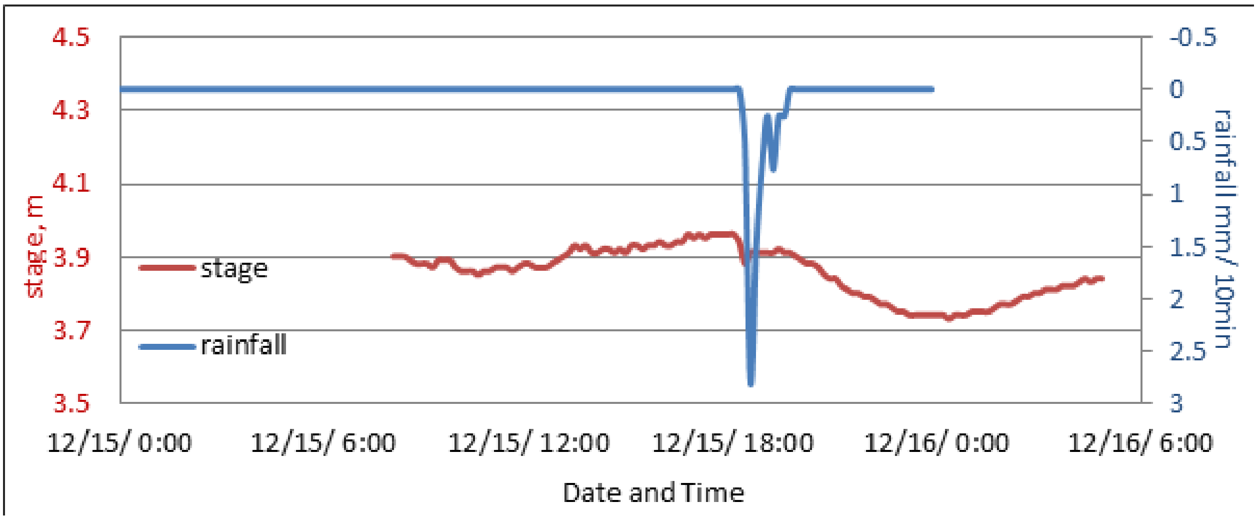


Figure 60. Relationship between stage and rainfall in Tunggol Bridge, Datu Montawal, Maguindanao

The relationship of water velocity data using the flow meter and water level from December 15-16, 2013 is shown in Figure 61.

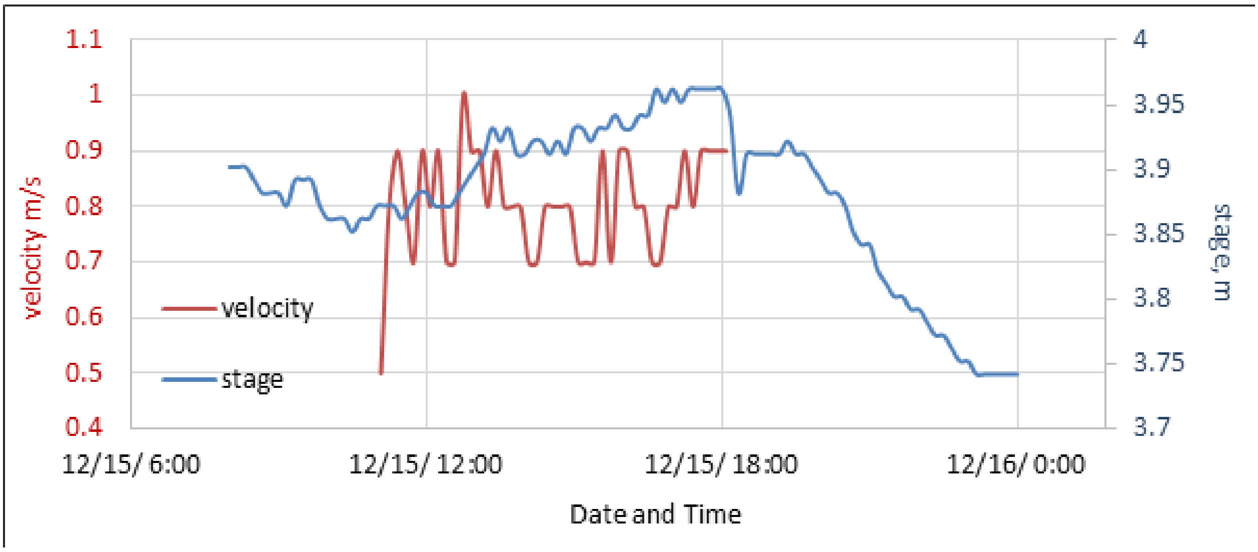


Figure 61. Relationship between velocity and stage in Tunggol Bridge, Datu Montawal, Maguindanao

The relationship of water velocity and rainfall from repo.pscigrid.gov.ph from December 15-16, 2013 is shown in Figure 62.

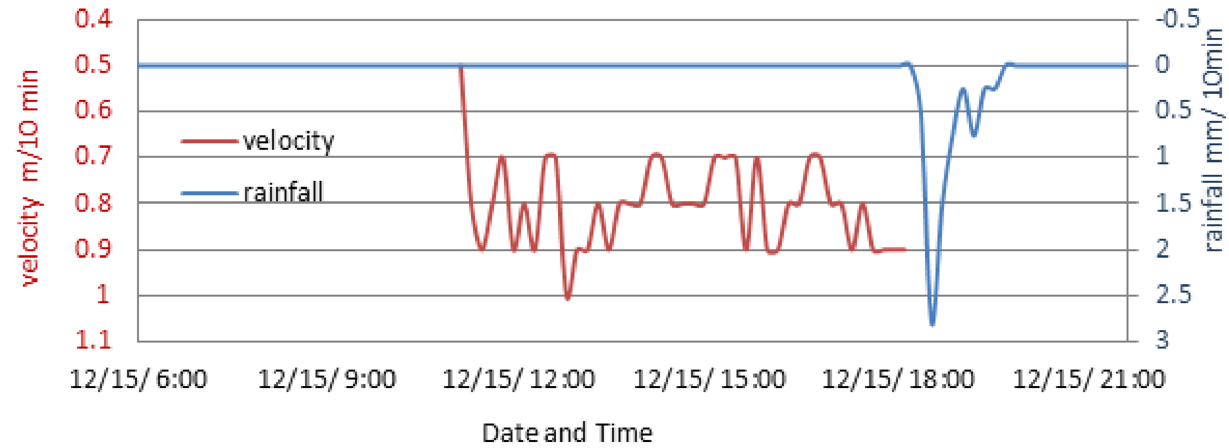


Figure 62. Relationship between velocity and rainfall in Tunggol Bridge, Datu Montawal, Maguindanao

The relationship between stage and discharge for December 15-16, 2013 survey resulted in an R^2 of 0.0514 is shown in Figure 63.

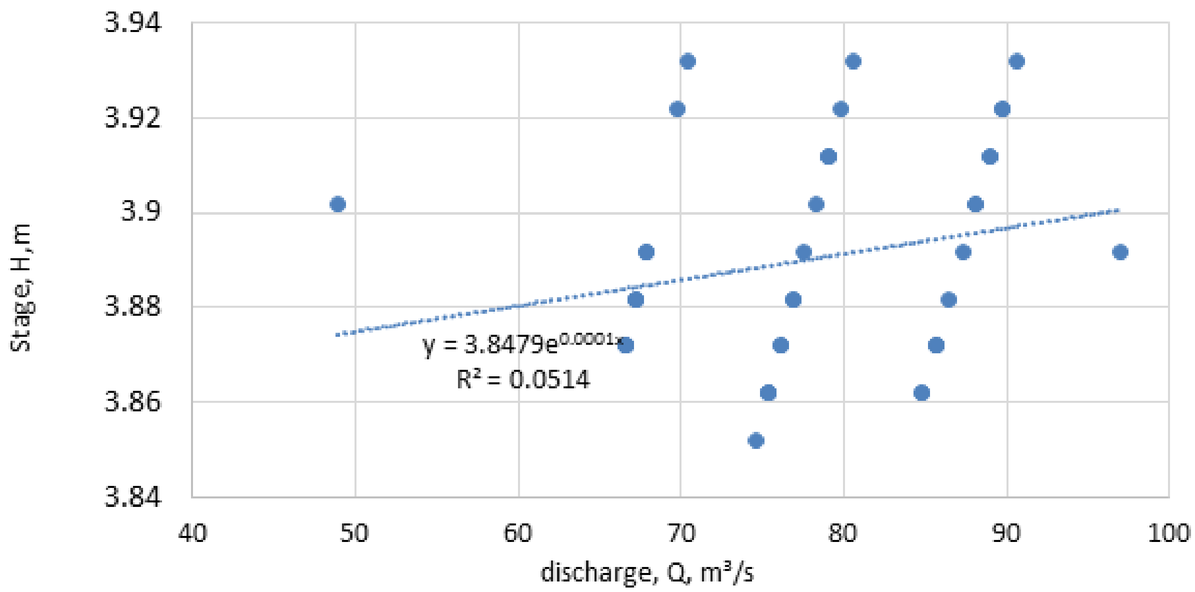


Figure 63. Relationship between stage and discharge in Tunggol Bridge, Datu Montawal, Maguindanao

Annexes

Annexes

ANNEX A. PROBLEMS ENCOUNTERED AND RESOLUTIONS APPLIED

In conducting flow measurement, cross section, and bathymetric survey accessibility of peace and order of the area is the main issue. The survey team and Contractors must coordinate with different organizations in the area to ensure the success of the survey.

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

Limitation/Problems		Solutions
1)	The location of IBM 58 is not suitable for GPS observation because of presence of electrical post and near building	Established IBM 58 A through differential levelling
2)	Echosounder malfunction on the first day of the bathymetry. The cable connecting the transducer and main unit was damaged/broken	Brought the echosounder to an electronic shop and fixed the cable socket connection. Informed the supplier after the fieldwork.
3)	The installed AWLS at Simuay Bridge got lost	Deployed a depth gauge and a rain gauge within the vicinity of the bridge.

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	Three (3) units
GNSS Receiver (Rover/Base)	Trimble SPS985	UP-TCAGP	One (1) unit with accessories
GNSS Controller	Trimble TSC3	UP-TCAGP	Three (3) units
Single beam			
Echosounder	Ohmex™ Echosounder	UP-TCAGP	One (1) unit with accessories
Acoustic Doppler Current Profiler (ADCP)	SonTek	UP- TCAGP	Two (2) units with accessories
Coupler-2B		UP- TCAGP	One (1) unit
Handheld GNSS	Montana 650	UP-TCAGP	Three(3) units
Laptops	DellLatitude	UP-TCAGP	Two (2) units
Level Road		UP-TCAGP	Four (4) units
Depth Gauge	Onset Hobo wares	UP-TCAGP	Four (4) units
Depth Sounder		UP-TCAGP	One (1) unit
Flow meter		UP-TCAGP	Four (4) units
Rain Gauge		UP- TCAGP	Three (3) unit
Rover Batteries	Trimble	UP- TCAGP	Ten (10) pcs
Tripod	Trimble	UP-TCAGP	Five (5) units
Bipod	Trimble	UP-TCAGP	Six (6) units
Nikon d90 with charger		UP-TCAGP	Two (2) units
Toolbox		UP-TCAGP	One (1) unit
Range Finder		UP-TCAGP	One (1) unit
Digital Level		UP-TCAGP	One (1) unit
Trimble Bag	Trimble	UP-TCAGP	Three (3) units

ANNEX C. THE SURVEY TEAM

Data Validation Component	Designation	Name	Agency/Affiliation
Survey Coordinator	Chief Science Research Specialist (CSRS)	ENGR. JOEMARIE S. CABALLERO	UP TCAGP
Supervising	Senior Science Research Specialist	ENGR. BERNARD PAUL D. MARAMOT	UP TCAGP
Bathymetric Survey Team	Research Associate	ENGR. JMSON J. CALALANG	UP TCAGP
	Research Associate	FORESTER RODEL C. ALBERTO	UP TCAGP
As-Built and Flow	Research Associate	GEOGRAPHER JON CARLO B. GARCIA	UP TCAGP
Cross Section Survey Team and Sensors Deployment Team	Research Associate	ENGR. EDJIE M. ABALOS	UP TCAGP
	Research Associate	FORESTER MARIDEL P. MIRAS	UP TCAGP
	Research Associate	GEOGRAPHER MAX HENRY AFICIAL	UP TCAGP

ANNEX D. NAMRIA CERTIFICATION

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

December 17, 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: **MAGUINDANAO**
Station Name: **MGD-2**
Order: **1st**

Island: **MINDANAO**		Barangay:
Municipality: **COTABATO CITY**		
	PRS92 Coordinates	
Latitude: **7° 13' 15.64595"**	Longitude: **124° 14' 33.61529"**	Ellipsoidal Hgt: **63.17200 m.**
	WGS84 Coordinates	
Latitude: **7° 13' 12.35957"**	Longitude: **124° 14' 39.13820"**	Ellipsoidal Hgt: **132.25570 m.**
	PTM Coordinates	
Northing: **798479.586 m.**	Easting: **416359.591 m.**	Zone: **5**
	UTM Coordinates	
Northing: **798,317.68**	Easting: **637,200.75**	Zone: **51**

Location Description

MGD-2 = COTABATO WATER TANK
From Cotabato City Plaza, along Sinsuat Ave., travel SW for 230 m. to Quezon Ave. Then turn right and travel W uphill for 0.7 km. to the gate of the Cotabato City Internal Defense Command and park on the left side of Cotabato City Metropolitan District Command (COMDISCOM). Walk for 100 m. to COMDISCOM parade ground up to the iron stair at the N side of the water tank. Station is located at Colina Hill on top of a concrete water tank, about 400 m. S of the poblacion, 80 m. NW of and 20 m. higher than the parade ground. Station mark is a drill hole at the center of a 3 in. triangle chiseled 0.87 m. N of the highest portion, and on the 16th step from the 0.305 m. parapet wall of the concrete water tank.

Requesting Party:	**UP-DREAM**
Pupose:	**Reference**
OR Number:	**8794950 A**
T.N.:	**2013-1589**

for: **RUEL DM. BELEN, MNSA**
Director, Mapping And Geodesy Branch

9 9 1 2 1 7 2 0 1 3 1 1 1 3 8 3 4

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

December 17, 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: **COTABATO (NORTH COTABATO)**
Station Name: **IBM-58**

Island: **Mindanao**	Municipality: **KABACAN**	Barangay: **POBLACION**
Elevation: **14.7694 m.**	Order: **1st Order**	Datum: **Mean Sea Level**

Location Description

IBM-58 is in the Brgy. Poblacion, Kabacan, North Cotabato along Kidapawan-Cotabato Highway. Station is located 60 cm. north KM Post 1649 and about 15 cm east of Simuay Hardware.

Mark is the head of a 4" copper nail embedded in a 20x20 cm concrete monument with the inscription "DPWH, IBM-58, 2006".

Requesting Party: **UP-DREAM**
Pupose: **Reference**
OR Number: **8794950 A**
T.N.: **2013-1590**

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

9 9 1 2 1 7 2 0 1 3 1 1 1 3 9 1 0

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. AS-BUILT FORM

Bridge Data Form

Bridge Name: ___________Carmen Bridge___________________________ **Date:** _____07/13/2014________

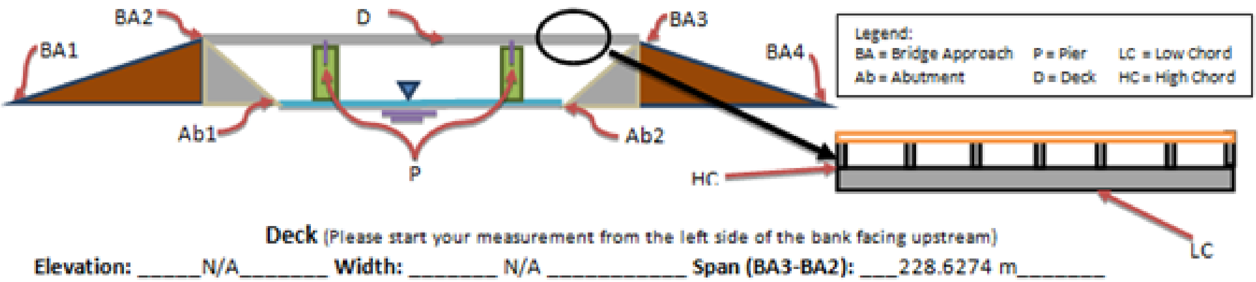
River Name: _______________N/A__________________________________ **Time:** ______2:13 PM_________

Location (Brgy, City,Region):___________Kabacan, South Cotabato_______________________________

Survey Team:__________Mindanao River Phase II Survey Team__________________________________

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

Latitude:_______7d8'34.44524" N _______________ **Longitude:** ________124d48'9.54763" E _________



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

Elevation: _____N/A_______ **Width:** _______ N/A ___________ **Span (BA3-BA2):** ___228.6274 m_______

	Station	High Chord Elevation	Low Chord Elevation
1	N/A	17.9711 m	16.7201 m
2	N/A	N/A	N/A
3	N/A	N/A	N/A
4	N/A	N/A	N/A
5	N/A	N/A	N/A

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

	Station(Distance from BA1)	Elevation		Station(Distance from BA1)	Elevation
BA1	0	15.3551 m	BA3	406.7037 m	18.0281 m
BA2	178.0763 m	17.9851 m	BA4	N/A	N/A

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

	Station (Distance from BA1)	Elevation
Ab1	206.3147 m	11.0441 m
Ab2	N/A	N/A

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

Shape: __Round_____________ Number of Piers: ____4______ Height of column footing: __submerged____

	Station (Distance from BA1)	Elevation	Pier Width
Pier 1	181.5314 m	18.0021 m	N/A
Pier 2	N/A	N/A	N/A
Pier 3	329.3001 m	17.9711 m	N/A
Pier 4	403.0893 m	17.9991 m	N/A

Bridge Data Form

Bridge Name: ___________Dicalungan Bridge_________________________ **Date:** _____07/11/2014_______

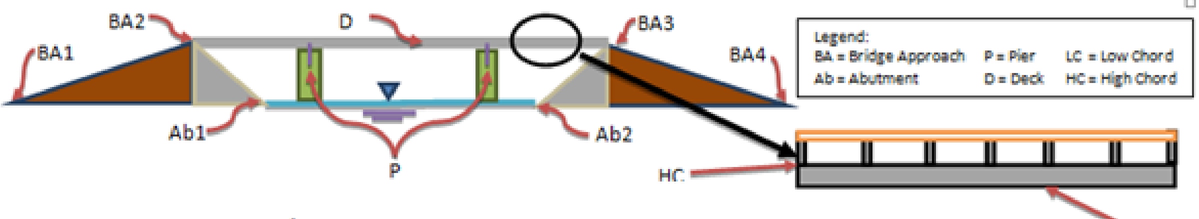
River Name: ______________N/A________________________________ **Time:** _____11:42 AM_______

Location (Brgy, City,Region):___________Ampatuan, Maguindanao___________________________

Survey Team:__________Mindanao River Phase II Survey Team_____________________________

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

Latitude:_______6d50'6.73911" N_______________ **Longitude:** ________124d27'22.68011" E_________



LC

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

Elevation: _____N/A_______ **Width:** _______ N/A ___________ **Span (BA3-BA2):** ___95.16526 m_______

	Station	High Chord Elevation	Low Chord Elevation
1	N/A	21.8121 m	20.4751 m
2	N/A	N/A	N/A
3	N/A	N/A	N/A
4	N/A	N/A	N/A
5	N/A	N/A	N/A

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

	Station(Distance from BA1)	Elevation		Station(Distance from BA1)	Elevation
BA1	0	N/A	**BA3**	N/A	21.4281 m
BA2	N/A	21.7121 m	**BA4**	N/A	N/A

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

	Station (Distance from BA1)	Elevation
Ab1	N/A	16.1921 m
Ab2	N/A	18.9011 m

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

Shape: __Round_____________ Number of Piers: ____7______ Height of column footing: __submerged____

	Station (Distance from BA1)	Elevation	Pier Width
Pier 1	N/A	21.9821 m	N/A
Pier 2	N/A	21.9581 m	N/A
Pier 3	N/A	22.0241 m	N/A
Pier 4	N/A	22.0081 m	N/A
Pier 5	N/A	21.9591 m	N/A
Pier 6	N/A	21.8271 m	N/A

Bridge Data Form

Bridge Name: ___________Simuay Bridge__________________________ **Date:** _____07/05/2014_______

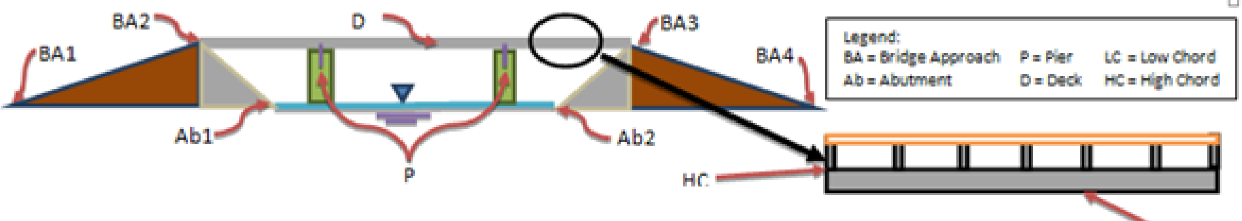
River Name: _______________N/A______________________________ **Time:** ______2:34 PM________

Location (Brgy, City,Region):___________Sultan Mastura, Maguindanao__________________________

Survey Team:__________Mindanao River Phase II Survey Team______________________________

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

Latitude:_______7d17'12.66857" N_____________ **Longitude:** ________124d17'53.81059" E__________



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

Elevation: _______________ **Width:** ______________________ **Span (BA3-BA2):** ___228.87541 m______

	Station	High Chord Elevation	Low Chord Elevation
1	N/A	N/A	N/A
2	N/A	N/A	N/A
3	N/A	N/A	N/A
4	N/A	N/A	N/A
5	N/A	N/A	N/A

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

	Station(Distance from BA1)	Elevation		Station(Distance from BA1)	Elevation
BA1	0	N/A	**BA3**	N/A	19.5521 m
BA2	N/A	20.0761 m	**BA4**	N/A	N/A

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

	Station (Distance from BA1)	Elevation
Ab1	N/A	15.4381 m
Ab2	N/A	20.2851 m

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

Shape: __Rectangular_________ Number of Piers: ____8______ Height of column footing: _____3.49 m_____

	Station (Distance from BA1)	Elevation	Pier Width
Pier 1	N/A	19.9281 m	.70 m
Pier 2	N/A	20.0181 m	.70 m
Pier 3	N/A	20.0321 m	.70 m
Pier 4	N/A	20.3131 m	.70 m
Pier 5	N/A	20.3511 m	.70 m
Pier 6	N/A	20.3711 m	.70 m

Bridge Data Form

Bridge Name: ___________Kalawag Bridge___________________________ **Date:** _____07/06/2014_________

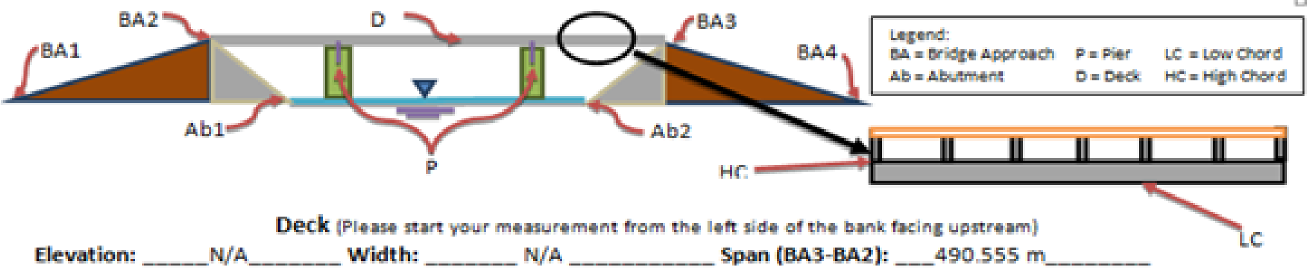
River Name: _______________N/A________________________________ **Time:** _______1:31 PM__________

Location (Brgy, City, Region):___________Isulan, Sultan Kudarat______________________________

Survey Team:__________Mindanao River Phase II Survey Team_____________________________

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

Latitude: _______6d37'13.60020" N_____________ **Longitude:** ________124d35'6.43523" E__________



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

Elevation: _____N/A_______ **Width:** _______ N/A ___________ **Span (BA3-BA2):** ___490.555 m________

	Station	High Chord Elevation	Low Chord Elevation
1	N/A	N/A	N/A
2	N/A	N/A	N/A
3	N/A	N/A	N/A
4	N/A	N/A	N/A
5	N/A	N/A	N/A

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

	Station(Distance from BA1)	Elevation		Station(Distance from BA1)	Elevation
BA1	**0**	N/A	**BA3**	N/A	62.3641 m
BA2	N/A	62.1381 m	**BA4**	N/A	N/A

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

	Station (Distance from BA1)	Elevation
Ab1	N/A	59.9221 m
Ab2	N/A	N/A

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

Shape: __Rectangular_________ Number of Piers: ____24_____ Height of column footing: __submerged____

	Station (Distance from BA1)	Elevation	Pier Width
Pier 1	N/A	62.3371 m	N/A
Pier 2	N/A	62.3491 m	N/A
Pier 3	N/A	62.3241 m	N/A
Pier 4	N/A	62.3481 m	N/A
Pier 5	N/A	62.3941 m	N/A
Pier 6	N/A	62.4151 m	N/A

Bridge Data Form

Bridge Name: ___________Tunggol Bridge_____________________________ **Date:** _____07/13/2014______

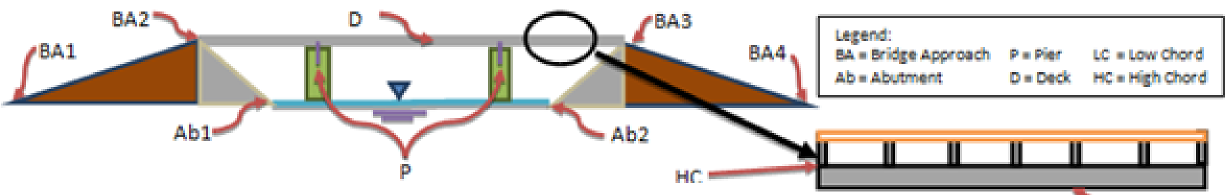
River Name: _______________N/A________________________________ **Time:** ______11:45 PM________

Location (Brgy, City,Region):___________Datu Montawal Maguindanao_________________________________

Survey Team:__________Mindanao River Phase II Survey Team____

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

Latitude:_______7d4'40.14" N _________________ **Longitude:**________124d44'25.59" E ____________



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

Elevation: _____N/A_______ **Width:** _______ N/A ___________ **Span (BA3-BA2):** ___113.9157 m_______

	Station	High Chord Elevation	Low Chord Elevation
1	N/A	11.8591 m	9.6691 m
2	N/A	N/A	N/A
3	N/A	N/A	N/A
4	N/A	N/A	N/A
5	N/A	N/A	N/A

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

	Station(Distance from BA1)	Elevation		Station(Distance from BA1)	Elevation
BA1	0	8.4351 m	**BA3**	344.3557 m	11.8451 m
BA2	230.44 m	11.8631 m	**BA4**	457.4199 m	9.9521 m

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

	Station (Distance from BA1)	Elevation
Ab1	234.8425 m	6.1211 m
Ab2	336.0881 m	5.3001 m

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

Shape: __Oval_______________ Number of Piers: ____4______ Height of column footing: __submerged____

	Station (Distance from BA1)	Elevation	Pier Width
Pier 1	233.6006 m	11.8241 m	N/A
Pier 2	263.5413 m	11.8701 m	N/A
Pier 3	310.1833 m	11.9021 m	N/A
Pier 4	341.2845 m	11.7671 m	N/A

Bridge Data Form

Bridge Name: ___________Talisawa Bridge___________________________ Date: _____07/11/2014________

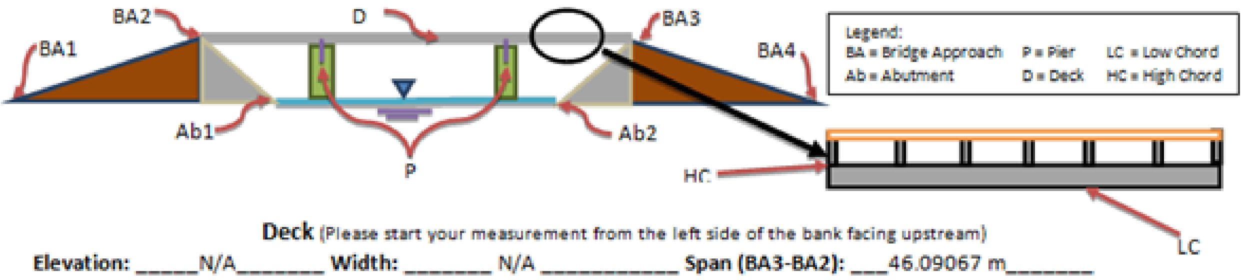
River Name: _______________N/A_________________________________ Time: ______12:45 PM________

Location (Brgy, City,Region):___________Datu Abdulah Sangki, Maguindanao______________________________

Survey Team:__________Mindanao River Phase II Survey Team_____________________________________

Flow condition: low normal high Weather Condition: fair rainy

Latitude: _______6d46'20.54866" N _____________ Longitude: ________124d28'49.04935" E _________



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

Elevation: _____N/A_______ Width: _______ N/A ___________ Span (BA3-BA2): ___46.09067 m_______

	Station	High Chord Elevation	Low Chord Elevation
1	N/A	39.2921 m	38.5211 m
2	N/A	N/A	N/A
3	N/A	N/A	N/A
4	N/A	N/A	N/A
5	N/A	N/A	N/A

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

	Station(Distance from BA1)	Elevation		Station(Distance from BA1)	Elevation
BA1	0	N/A	BA3	N/A	38.9161 m
BA2	N/A	38.8811 m	BA4	N/A	N/A

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

	Station (Distance from BA1)	Elevation
Ab1	N/A	35.5061 m
Ab2	N/A	35.5061 m

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

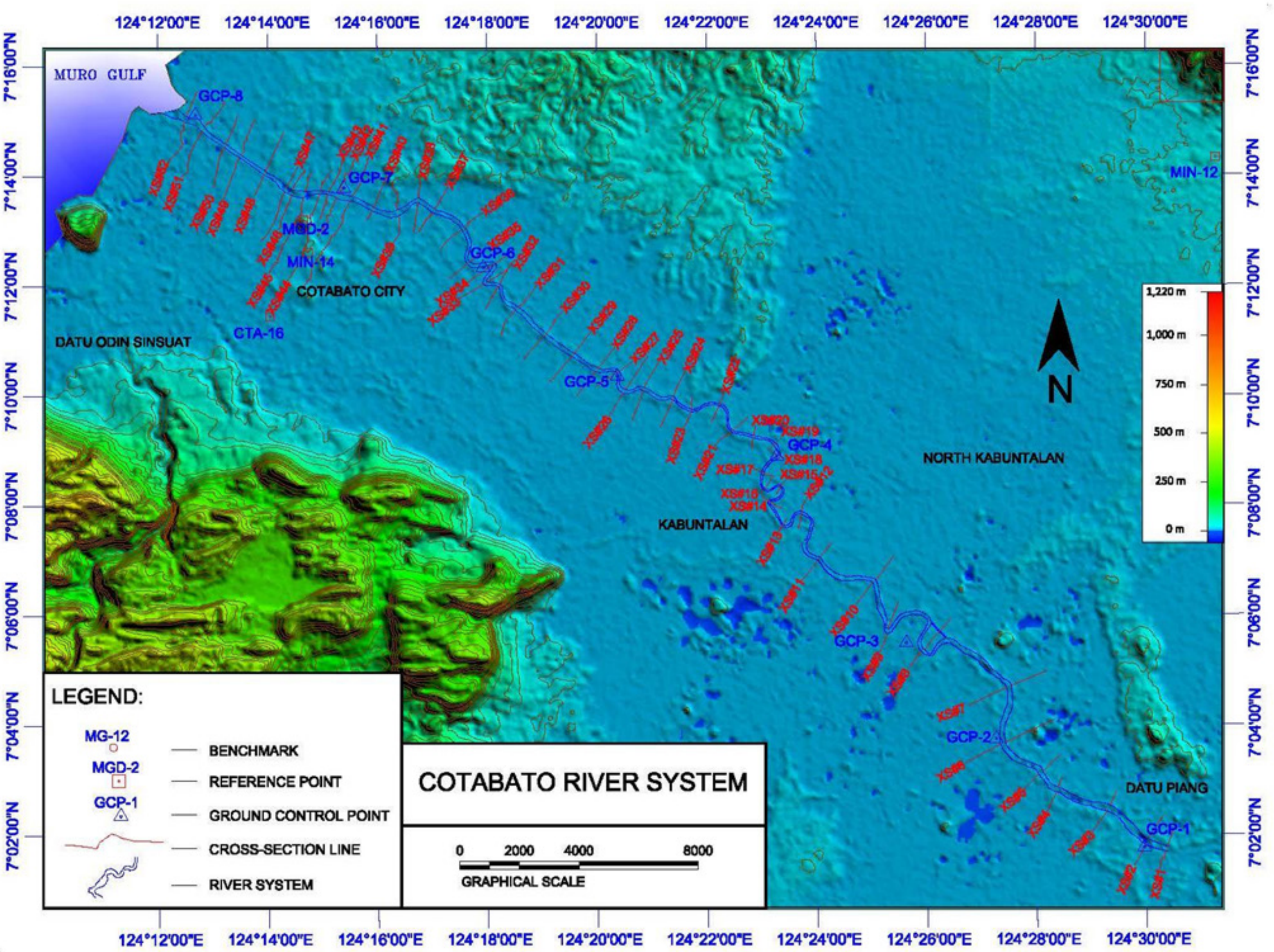
Shape: __Square_____________ Number of Piers: ____5______ Height of column footing: __submerged____

	Station (Distance from BA1)	Elevation	Pier Width
Pier 1	N/A	39.2501 m	N/A
Pier 2	N/A	39.2291 m	N/A
Pier 3	N/A	39.2691 m	N/A
Pier 4	N/A	39.3021 m	N/A
Pier 5	N/A	38.5121 m	N/A

ANNEX F. OUTSOURCE CROSS-SECTION AND PROFILE

PROFILE AND CROSS SECTION SURVEYS OF COTABATO RIVER SYSTEM, MAGUINDANAO

DREAM
Disaster Risk and Exposure Assessment for Mitigation



Prepared by:

RASA SURVEYING LAND SURVEY CONSULTANTS

`In joint venture with:

HONS H.O. NOVELOSO SURVEYING ENGINEERS·SURVEYORS·CONSULTANTS Accept all kinds of surveys, Rental of Total Station and GPS

Survey Period: December 4, 2013 to February 28, 2014

Annexes

Annexes

Annexes

DAO	DENR Administrative Order
DOST	Department of Science and Technology
DREAM	Disaster Risk and Exposure Assessment for Mitigation
EGM08	Earth Gravitational Model of 2008
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GCP	Ground Control Point
KM	Kilometer
LMB	Land Management Bureau
LiDAR	Light Detection and Ranging
LGU	Local government unit
MM	Millimeter
NAMRIA	National Mapping and Resource Information Authority
PRS92	Philippine Reference System of 1992
LUB	Left Upper Bank
RUB	Right Upper Bank
LLB	Left Lower Bank
RLB	Right Lower Bank
MILF	Moro Islamic Liberation Front
BIFF	Bangsamoro Islamic Freedom Fighter

Introduction

Annexes

1.1 Background

The Disaster Risk and Exposure Assessment for Mitigation (DREAM) Program funded by the Department of Science and Technology Grant-in-Aid (DOST-GIA) and undertaken by the University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP) aims to acquire elevation and resource dataset at information necessary to support the different phases of disaster management.

Disasters bring negative impacts on the socio-economic aspects of a nation. In the Philippines, the effects of disasters include loss of lives and economic opportunities, damages and destructions on infrastructure developments.

Proper Planning and disaster management that provides early warning systems, appropriate policies and procedures are needed to minimize the destructive effects of the different disasters hitting the country. However, this requires sufficient and accurate spatial datasets.

The outputs of the acquired LiDAR data must be within the accuracy standard needed for understanding disaster events such as flood modeling. Because of this, there is a need to conduct validation surveys in order to verify the accuracy of gathered LiDAR data.

1.2 Scope of Work

There are eighteen (18) major river systems that are identified to be flood-prone in the country. One of these river systems is the Cotabato River System wherein the main stream is the Rio Grande River that passes thru the Municipalities of Datu Piang, Kabuntalan, North Kabuntalan and in the City of Cotabato.

The work shall include the following:

1.2.1. **Ground Control Survey.** Ground control survey connecting to NAMRIA horizontal and vertical control points shall be done. Each control point that shall be used as reference points must contain horizontal and vertical positions.

1.2.2. **Cross Section Survey.** There are 18 cross-sectional lines with a total distance of 37.92 km.

1.2.3. **Profile Survey.** Profile survey shall consist of left bank and right bank surveys on the upper and the lower part of the river with an extent of 22.84 km and 23.13 km, respectively.

1.2.4. **Data Processing.** This includes processing and adjustments of GNSS data and computations, corrections, and plotting of surveyed cross-sections and profiles.

1.3 Professional Staffing and Implementation

The following are the proposed qualified personnel to be assigned in the project:

Table 1: Proposed Project Leader and Team Leaders for the DREAM project

Name of Personnel with picture	Position	Qualification	Official Function
 Engr. Raymund Arnold S. Alberto	Project Engineer	Licensed Geodetic Engineer with experience as Project Engineer	• Over-all Project management and supervision • Reviews reports and documentations • Coordinates with LGUs and other Stakeholders
 Renato S. Dacono	Technical Staff	College Graduate	• Monitors field operations and prepares progress report • Evaluates outputs of Field Operations Management Group
 Engr. Marvin Andrew A. Caliolio	Chief of Party	Licensed Geodetic Engineer with experience as Chief of Party	• Works at full time for the Project • Deals directly with the End-User • Manages Field Office operations and related activities • Evaluates outputs and consolidate reports
 Bernie Revamonte	Team Leader for Profile Survey	B. S. G. E. Graduate with experience in field operation and Team Management	• Manages Field operations and related activities • Review and validate the output of the profile survey works

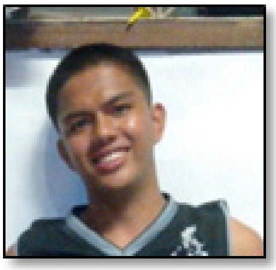
Name of Personnel with picture	Position	Qualification	Official Function
 Franie T. Reyes	Team Leader for Cross-section Survey	B. S. G. E. Graduate with experience in field operation and Team Management	• Manages Field operations and related activities • Review and validate the output of the profile survey works

Table 2: Proposed staff as Instrument Men for the surveying team

Instrument Men with competent skill in operating survey-grade GPS and levelling Instruments. Responsible for Field data gathering and evaluation.			
 Jay Borja	 Nelson Acosta	 Gregorio Costelo	 Julio Balensona
 Marlon Garina	 Ramil Olimpiada	 Dennis Refugia	 Anselor Dumpac
 Joemel Sierra	 Ryan Audrey Basco	 Jeffrey Orbillo	 Jerry D. Domingo

Field Survey Methodology

Annexes

For the completion of the profile and cross section survey of the Mag-Asawang Tubig, the team followed necessary procedure to ensure the effective delivery of survey reports. Figure No. 49 shows the workflow for the completion of the project. From planning stage, field acquisition, and data processing, a standard practice was implemented.

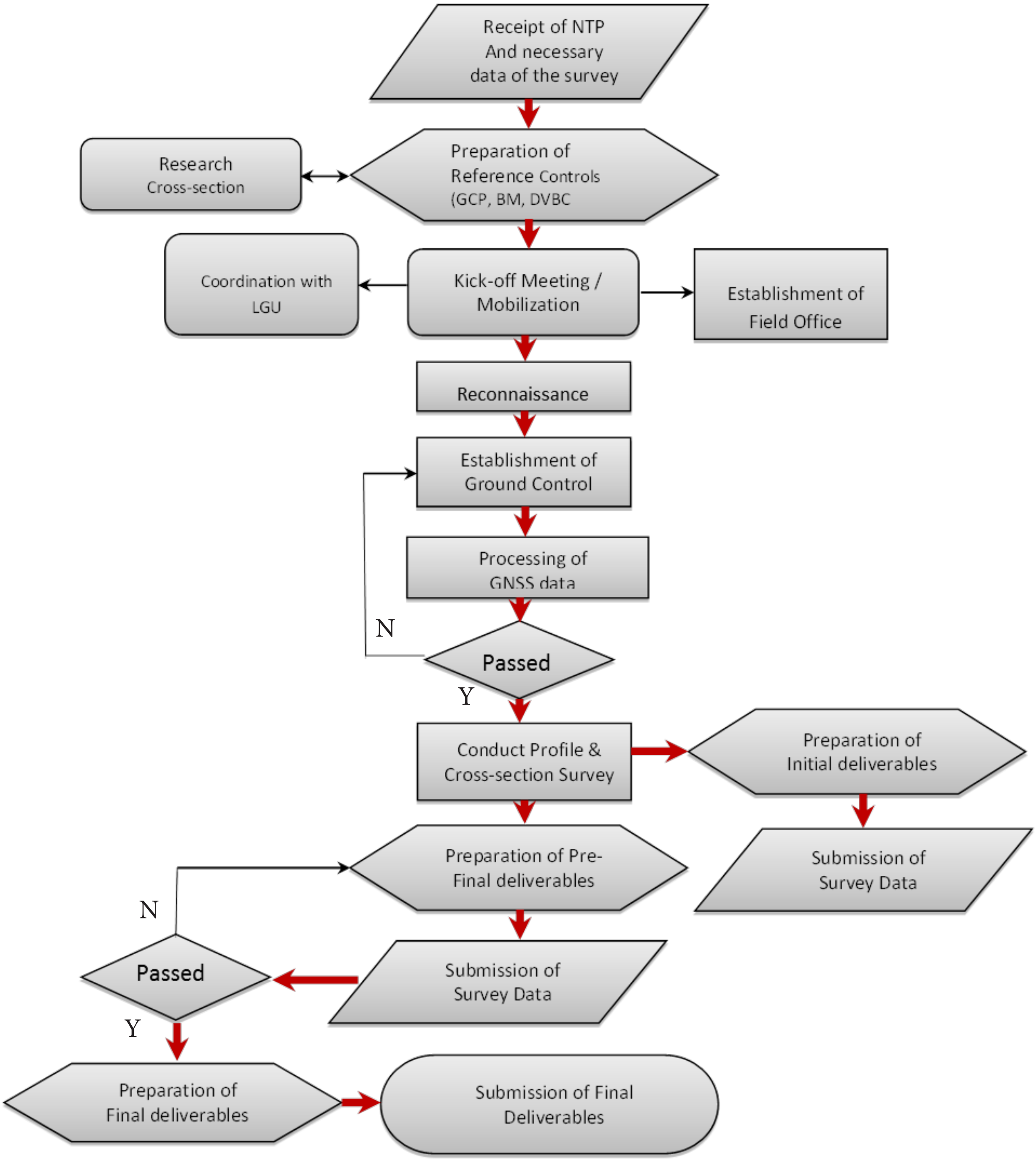
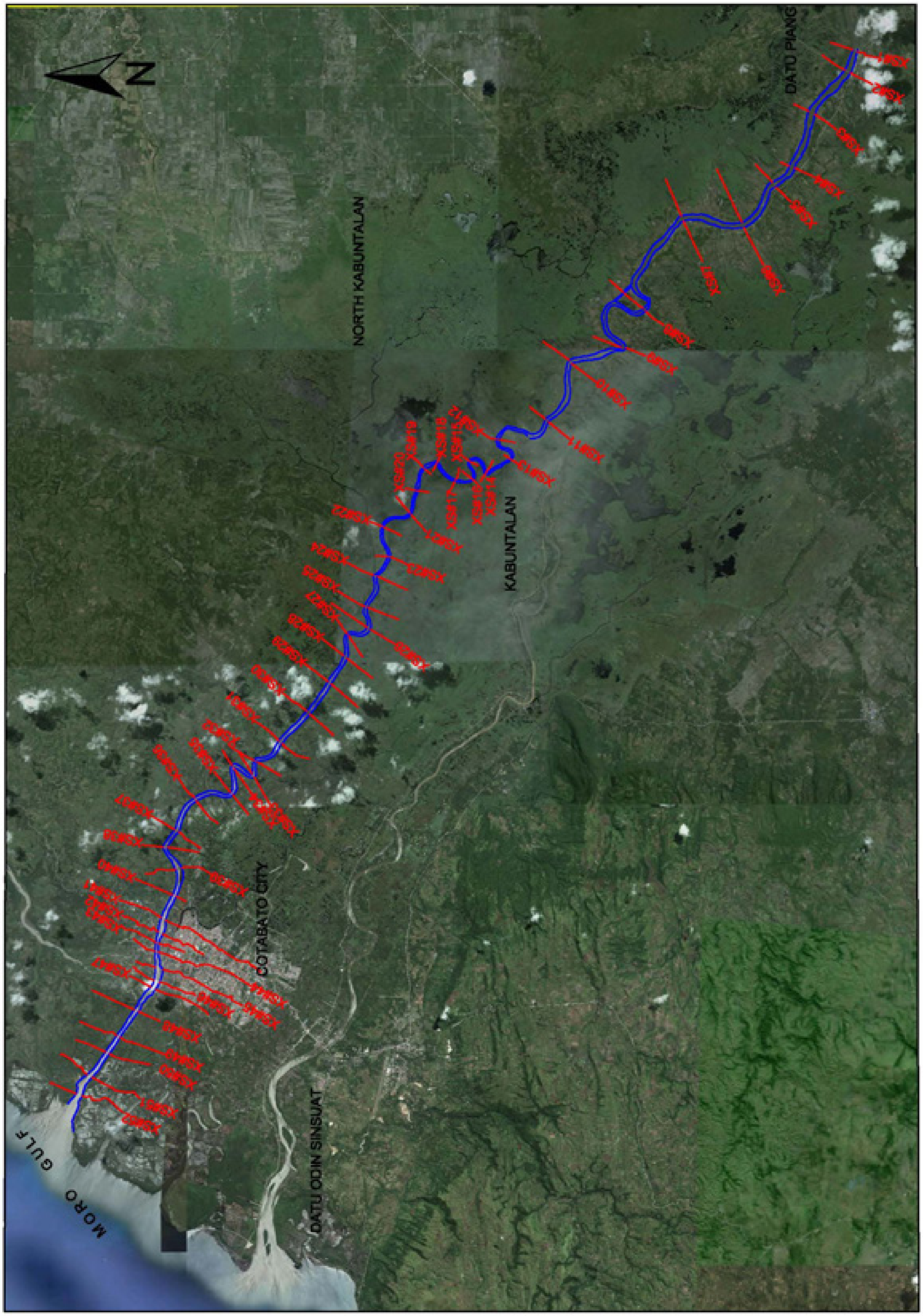


Figure 1: Flowchart showing the processes and overall activities for the field survey of Cotabato River System

Annexes

2.1 Field Plan

Upon receipt of preliminary data e.g. coordinates of the profile and cross-section lines, extent of the project area and endorsement letter for the LGUs dated November 19, 2013, proposed work schedule was prepared. Survey equipment such as survey grade GPS, total stations and digital level were calibrated and checked to ensure it complies with operational standard. Survey teams assigned for the project were briefed about the execution and importance of the project. Preliminary network design of additional Ground Control Points was created using Google earth image.



LOCATION MAP

Figure 2: The Project Site, map of the river system, which was overlayed on Google earth satellite image

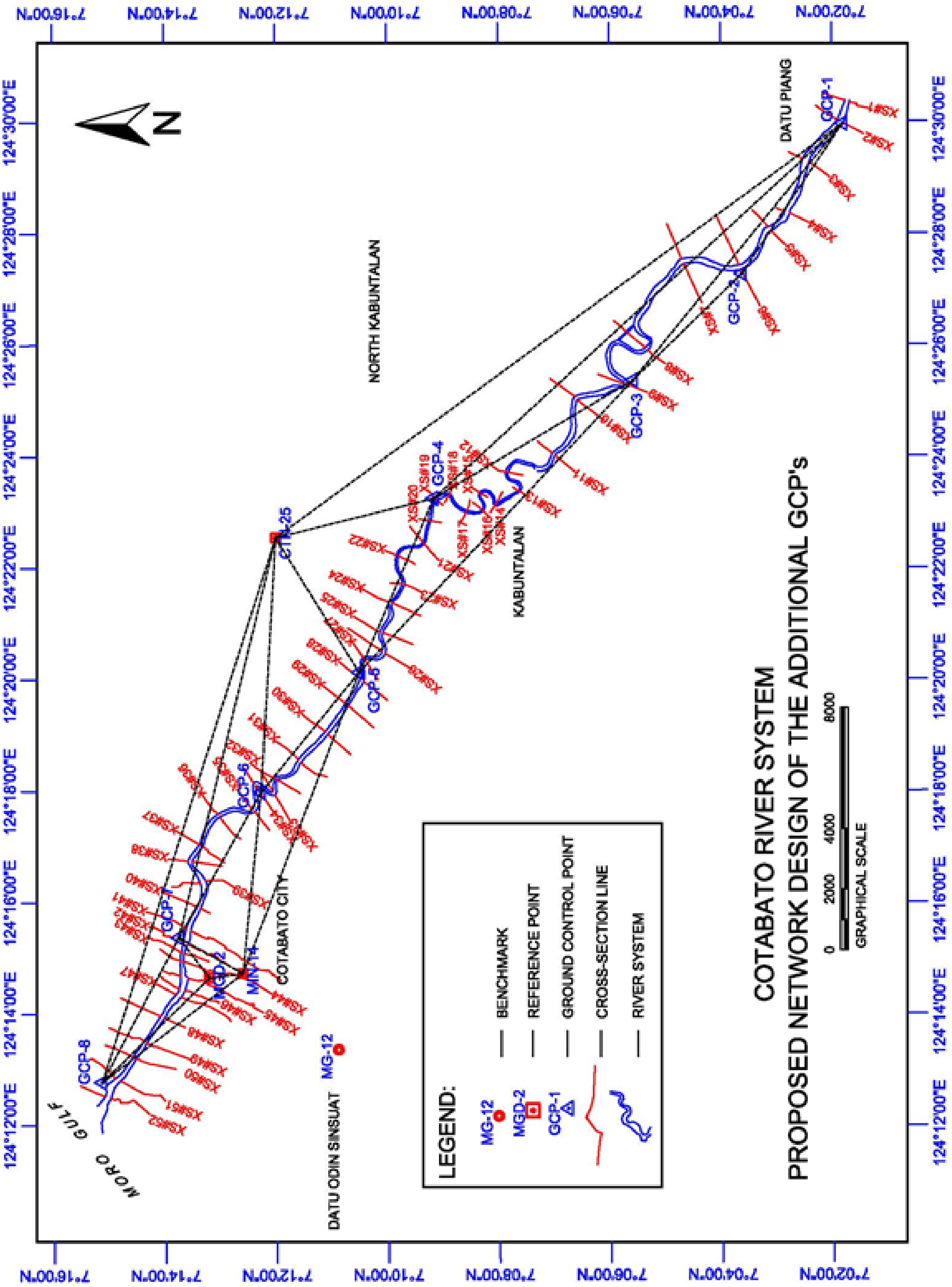


Figure 3: Preliminary Network Design for establishing GCPs

2.2 Research for reference points and benchmarks.

To have a better implementation of field survey of the project area, National Mapping and Resource Information Authority (NAMRIA) controls points with at least 2nd order horizontal accuracy and at least 3rd order vertical accuracy were used as reference points in establishing project controls. These specifications are required, to meet the mapping standard of the government pursuant to the DENR Administrative Order 2007-29 (DAO 07-29) Section 28 and the DENR Memorandum Circular 2010-13 (DMC 10-13) Manual on Land Survey Procedures.

These reference points were used to control the propagation of systematic error in the adjustment process of establishing ground control points and GNSS network. Higher order reference points provide better accuracy and minimal variances in the positioning of project control.

Using the monuments description sheets from the NAMRIA as the reference guide, the team collected the nearest reference control points from the project area based on its sketch and description using the selection process.

Certifications of reference points were acquired from NAMRIA, See Annex D. These were used to locate NAMRIA established reference points and benchmarks within the survey area during reconnaissance and to determine the geographic coordinates and elevations of recovered reference points for processing.

2.3 Reconnaissance

With the point description secured from NAMRIA, preliminary map, and endorsement letter, the team mobilized to the project area. Reconnaissance was performed to locate available NAMRIA reference points and benchmark within the vicinity of the project area. Unfortunately, there is only one available NAMRIA control point with higher accuracy found within the subject municipalities. Also, the available NAMRIA benchmark in the area was already disturbed. UP DVC team had located one benchmark in the Municipality of Kabacan and used as vertical reference for the project. A sub-control point was established by the DVC team in an open area and transferred its vertical data using geodetic level to avoid such obstruction during GNSS observation. It is about 47kms away from the project area. Location of the proposed GCPs were determined using Navigational GPS and was ensured that it is within the mapping standard as per DAO 07-29. Proposed profile and cross-section lines were verified whether it is passable for RTK survey or it needs clearing activity, in case that designed lines fell in impassable densely vegetated areas. With this process the Team Leader will make any adjustment of the preliminary network design and schedule of GNSS observation.

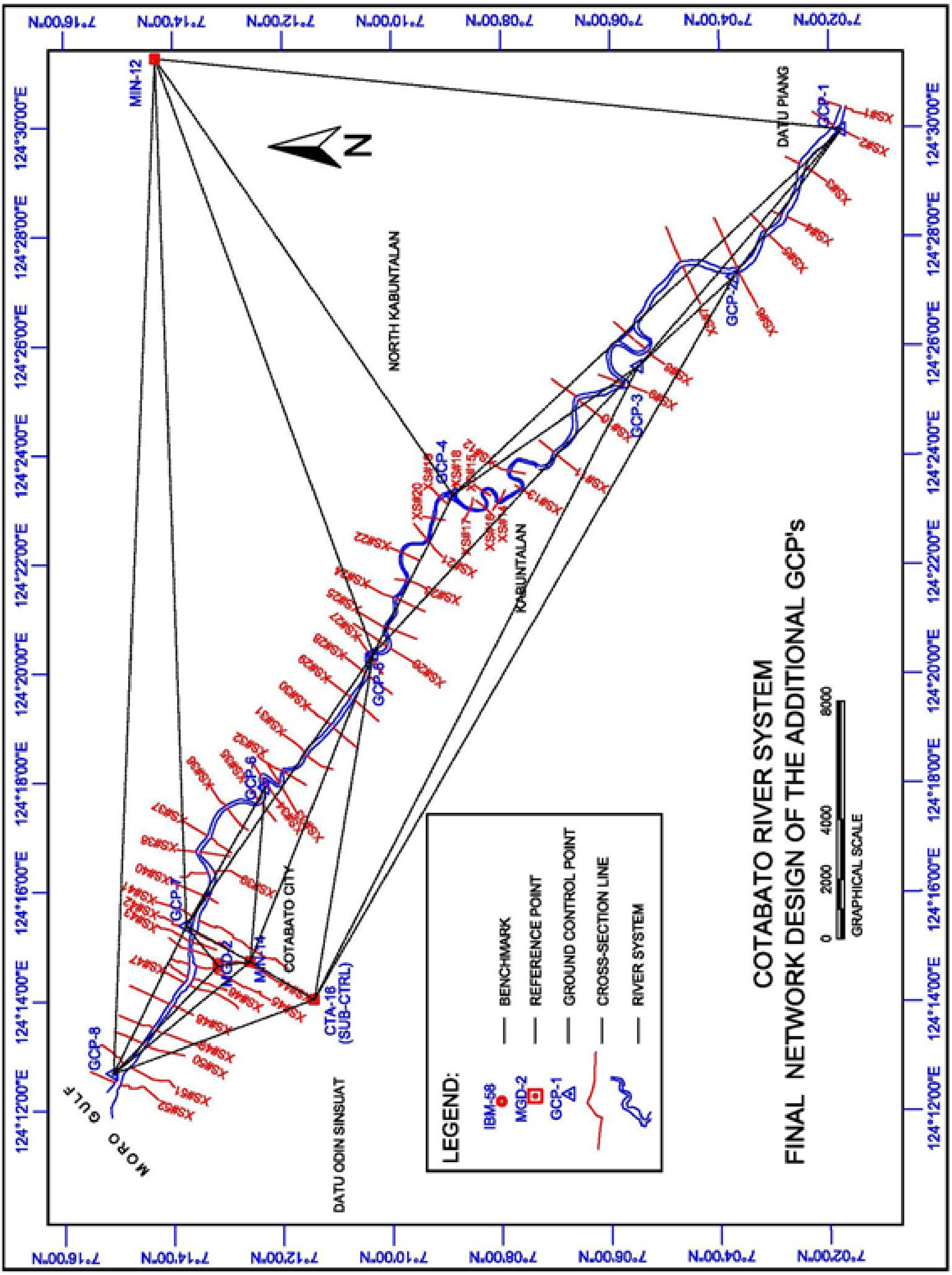


Figure 4: **Revised Network Design for establishing GCPs**

2.4 Establishment of control points and GNSS network

The revised network design created during reconnaissance was used in the implementation of field survey for establishing ground control points. The GNSS network was created in such a way that ground control points were positioned not more than 10 km away from each other. They were also selected based on criteria such as clear satellite visibility; stable foundation and negligible ground movement, preferably at a distant from tall natural and man-made obstructions and interferences such as buildings, trees, houses and transmission lines. Previously established GCPs were also observed to check the accuracy of the additional GCPs.

Reference Control

Horizontal Reference Point

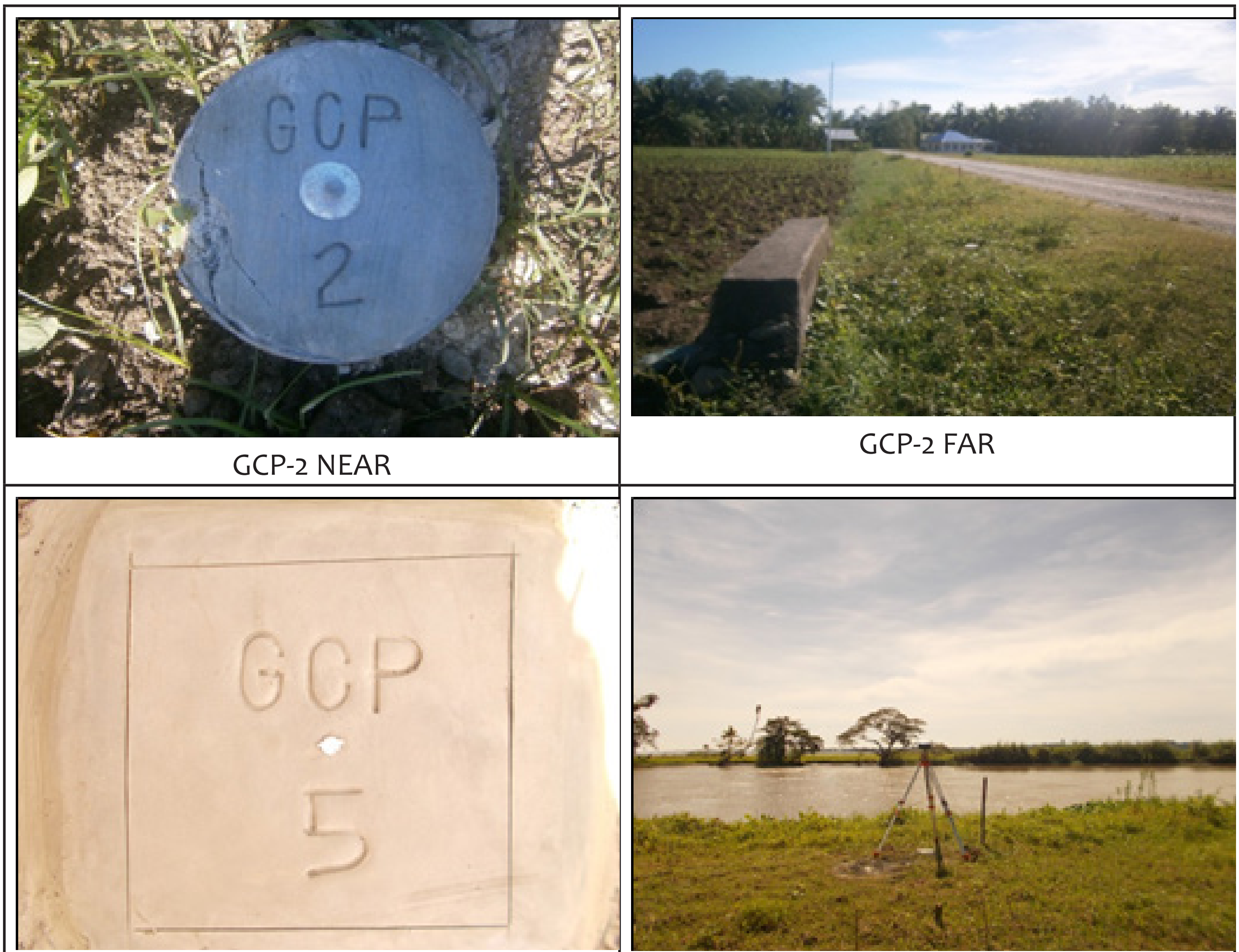
Table 3: List of 2nd order Horizontal Reference Point from NAMRIA

List of Reference Points											
	WGS-84						UTM				
Sta. Name	Latitude			Longitude			Ellipsoidal Ht.	Elev. (EGM08)	MSL	Vert. Acc.	Hor. Acc.
	dd	mm	ss.ssss	dd	mm	ss.ssss	mmmm.mm	mmmm.mm	mmmm.mm		
MIN-25	7	12	16.4298	124	47	46.0522	109.862	37.346	32.062	FIXED	FIXED
MGD-2	7	13	12.3596	124	14	39.1382	132.256	60.356	55.072	FIXED	FIXED

Vertical Reference point

Table 4: List of Benchmark used in the project

List of Benchmarks											
	WGS-84						UTM				
Sta. Name	Latitude			Longitude			Ellipsoidal Ht.	Elev. (EGM08)	MSL	Vert. Acc.	Hor. Acc.
	dd	mm	ss.ssss	dd	mm	ss.ssss	mmmm.mm	mmmm.mm	mmmm.mm		
IBM-58A	7	6	26.3076	124	49	36.1911	92.755	20.309	15.025	0.033	0.020
IBM-58									14.769		



GCP-2 NEAR | GCP-2 FAR

GCP-5 NEAR | GCP-5 FAR

Figure 5: Sample Photographs of the Established Ground Control Points

Each control point was documented and included in the field survey activities as attachments in "ANNEX I". Information such as control point name, geographic coordinates, elevation, sketch, description, monument and panoramic photographs were included in the field sheet.

For the establishment of ground control points, static GPS survey technique was implemented. The available control point from NAMRIA was used as reference station which provided a closed geometric figure, as a basic requirement of static GPS survey technique. Each session of GNSS survey was conducted with three (3) hours of observation using dual frequency GNSS receivers, with data logging of every five (5) seconds, and having an elevation mask of fifteen (15) degrees to ensure that the GNSS receiver resulted to a fixed solution.

Additional sub-control points were also established using GPS static survey to serve as reckoning points for traditional survey using total station in the areas not suitable for RTK survey.

The established ground control points were used as the local control within the project area during the ground survey of profile and cross-section. This is to provide accessible reference control with relative high positional accuracy for the ground survey.

2.5 Ground Surveys

Using the pre-established control points, profile survey was conducted from the predetermined upstream of the river down to its mouth (downstream). Profile survey consists of traversing the Left Upper Bank (LUB), Left Lower Bank (LLB), Right Upper Bank (RUB), and Right Lower Bank (RLB) portions of the river where points was measured at a 10m interval using dual frequency GNSS receivers and kinematic survey technique. The route for profile lines may deviate up to 10m from the proposed lines if the planned lines were not passable. Additional points were also observed to describe apparent changes in elevation. Conventional surveying technique using an electronic total station was used for areas with obstructed satellite signals. Required accuracy of ±20 cm for horizontal and ±10 cm for vertical position must be observed.

The position of the proposed 53 cross-sectional lines was determined using navigational GPS. Provided coordinates were marked with stake or paint to serve as guide for the surveyor during the actual survey. Cross-section started from the upper bank of the river going left side or right side following the path of the nearby roads or goat trails. Similar to profile survey, cross-section points shall not exceed 10m interval between successive points and additional points shall be observed to describe apparent changes in elevation along the designed line. Each cross-section was identified sequentially with e.g. XS1, XS2…etc. from upstream to downstream direction. Points for cross-section lines were measured at a 10m interval using dual frequency GNSS receivers and kinematic survey technique. The route for sectional lines may deviate up to 10m from the proposed lines if the planned lines are not passable and additional points were observed to describe apparent changes in elevation. Conventional surveying technique using an electronic total station was used for areas with obstructed satellite signals. Required accuracy of ±20 cm for horizontal and ±10 cm for vertical position must be observed.

2.6. Data Processing

2.6.1 GNSS survey

Data obtained from the field for static survey were downloaded and processed immediately using Trimble Business Center Software. GNSS raw data was converted to receiver independent exchange format (RINEX) data. Cycle slips and noise on the observed satellites were disabled. Observed reference points were fixed using the certified data from NAMRIA and baseline adjustment was perform to minimize random errors. Geographical coordinates in WGS-84 and PRS-92 as well as UTM coordinates were extracted after the successful baseline adjustment. Mean Sea Level elevations for each GCPs were computed base from the EGM2008 elevation and the certified MSL data of the recovered NAMRIA benchmark. The following accuracy and precision were observed in the final baseline adjustment:

Horizontal Precision <= ±3mm + 0.5ppm x D
Vertical Precision <= ±5mm + 0.5ppm x D

Where: D is the baseline distance from GNSS base station to the established ground control points

2.6.2 Cross-section Survey

After each day of observation, data from the total stations and RTK controller were downloaded and processed to validate and monitor the accuracy and completeness of the survey. Downloaded data was sent thru email to the main office for finalization.

Point data received from the field were imported to Civil3D software to generate cross-section graphs with the required scale 1:2000 for horizontal and 1:100 for vertical. All major structures traversed by the section lines were indicated in the cross-section plan to serve as landmark.

2.6.3 Profile Survey

Same with the cross-section data, Profile point data was imported to Civil3D software to generate Profile Plan with the required scale 1:10,000 for horizontal and 1:100 for vertical. Upper bank profile line was generated following the topmost portion of the river bank, while the lower bank profile line was based on the existing water level during the time of actual field survey. All major structures along the river banks were indicated in the plan like bridges, riprap, etc.

Results and Discussions

Annexes

3.1 Reconnaissance Survey

Reconnaissance Survey started on December 4, 2014. Representatives from the survey team dropped by at the local government Cotabato City for courtesy call and presented the endorsement letter provided by UP DREAM for requisition of necessary permit to initiate the field survey. The other group proceeds to the Municipalities of Kabuntalan, Northern Kabuntalan and Datu Piang and secure work permits. team met Congressman Manny Pacquiao in his hometown. They discussed to him the objective of the project and he gave his best support for the execution of the said project. Twelve (12) teams, where a team is composed of an instrument man and two (2) survey aids, were deployed to investigate and provide preliminary information of the actual working environment of the project area.

Based on the initial assessment, the project area is relatively flat and about 80 percent is under water. Most of the areas of the river banks were used as residential areas especially in the part of Cotabato City. About 60% of Kabuntalan area is swampy or underwater as well as in some part of Datu Piang. About 50% of the neighboring properties are agricultural area and the rest is marsh land or underwater and residential area as seen in the pictures below

Figure 6: Photos showing the topography of the actual project area.

3.2 Actual Field Survey

Additional Ground Control Points were connected to the existing NAMRIA control point MGD-2 located on top of the concrete water tank in Colina Hill in the City of Cotabato. Previously established ground control points namely; MIN-12, MIN-14 & MIN-25 were also observed to checked the accuracy of the survey. Due to the absence of approved benchmark in the area, vertical datum was connected to the NAMRIA benchmark IBM-58 located in the municipality of Kabacan. UP DREAM DVC team established sub-control point named IBM-58A to avoid such obstruction during GNSS observation.
Cross-section survey was conducted using the planned cross-section provided by UP DREAM. Coordinates of the points for staking out were extracted from the digital file. Each point was surveyed using a RTK GNSS receiver.

Figure 7 shows the proposed or designed cross-section and profile lines of the river.

Figure 8 shows the actual cross-section and profile lines as surveyed.

And figure 9 shows the comparison between the proposed and actual cross-section and profile lines wherein section lines 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 41m 42, 43, 44, 45, 46, 47, 48, 49, 50, 51 & 52 have a minimal deviation due to some obstructions and actual conditions on site. About 990 meters length of section line #6 on the left side and about 1.2 kms length on the left end of xs line # 41 are inaccessible due to resistance of the local residents. Same with left and right portion of section lines 20, 21, 22, 23, 24, 25, 26, 26 & 27, left portion of xs line # 28 & 29 and right of xs line 31 due to high level of water during the execution of actual survey. Portion of the river alignment differ from the proposed line maybe due to the continues rainfall in the area that caused minor erosion of the river banks.

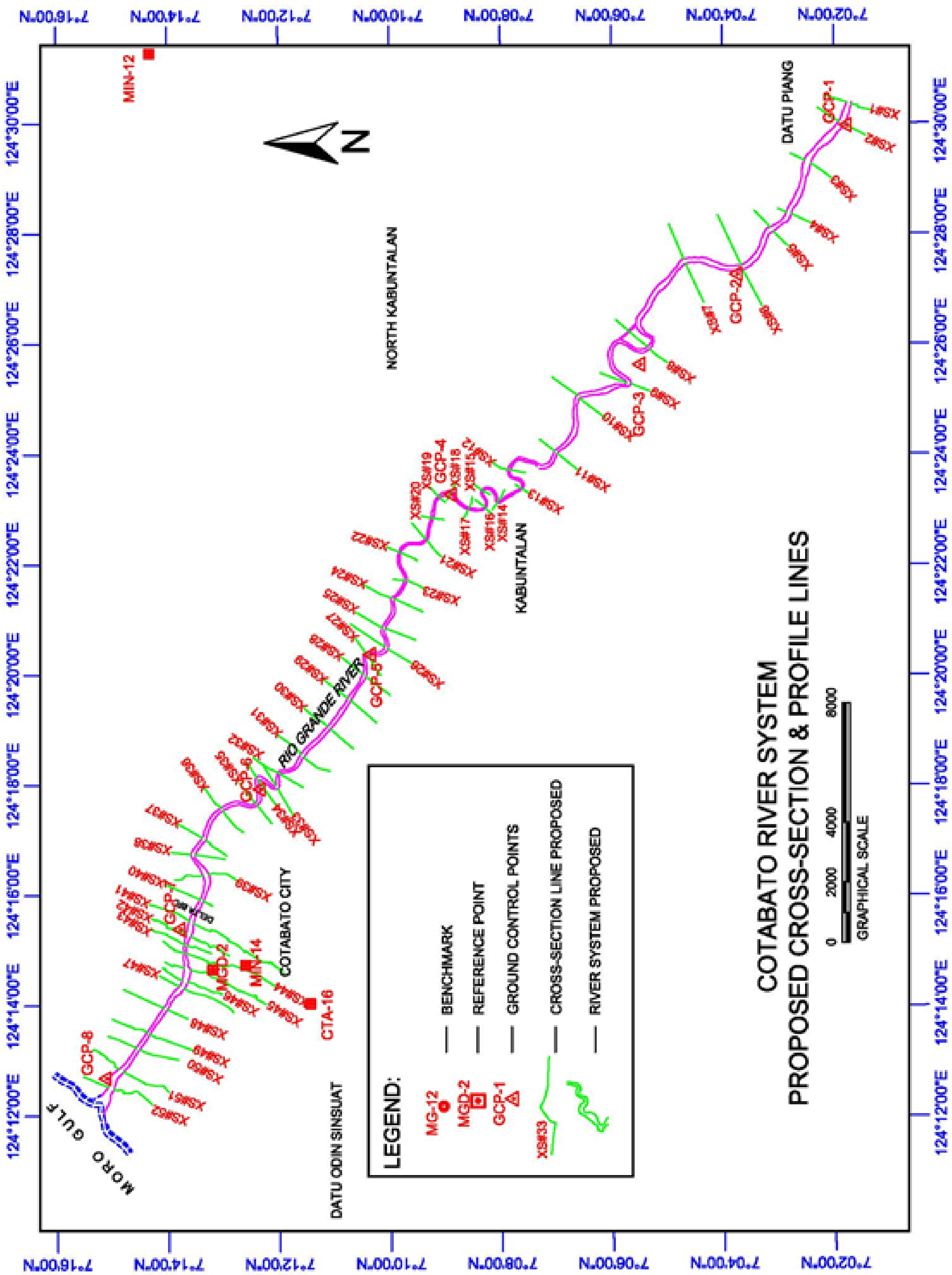


Figure 7 : Proposed Cross-Section and Profile line of the River

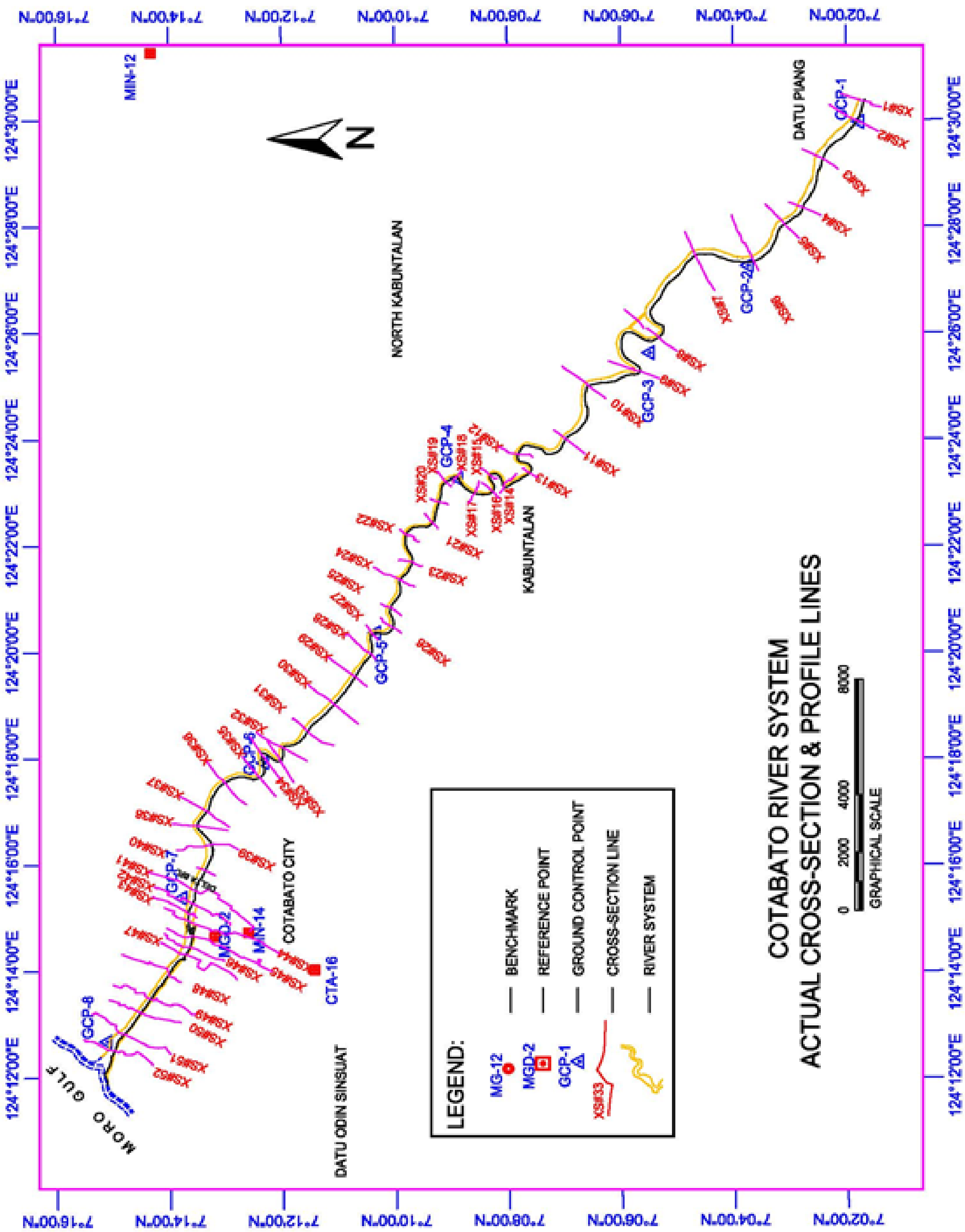


Figure 8 : Actual Cross-section and Profile line

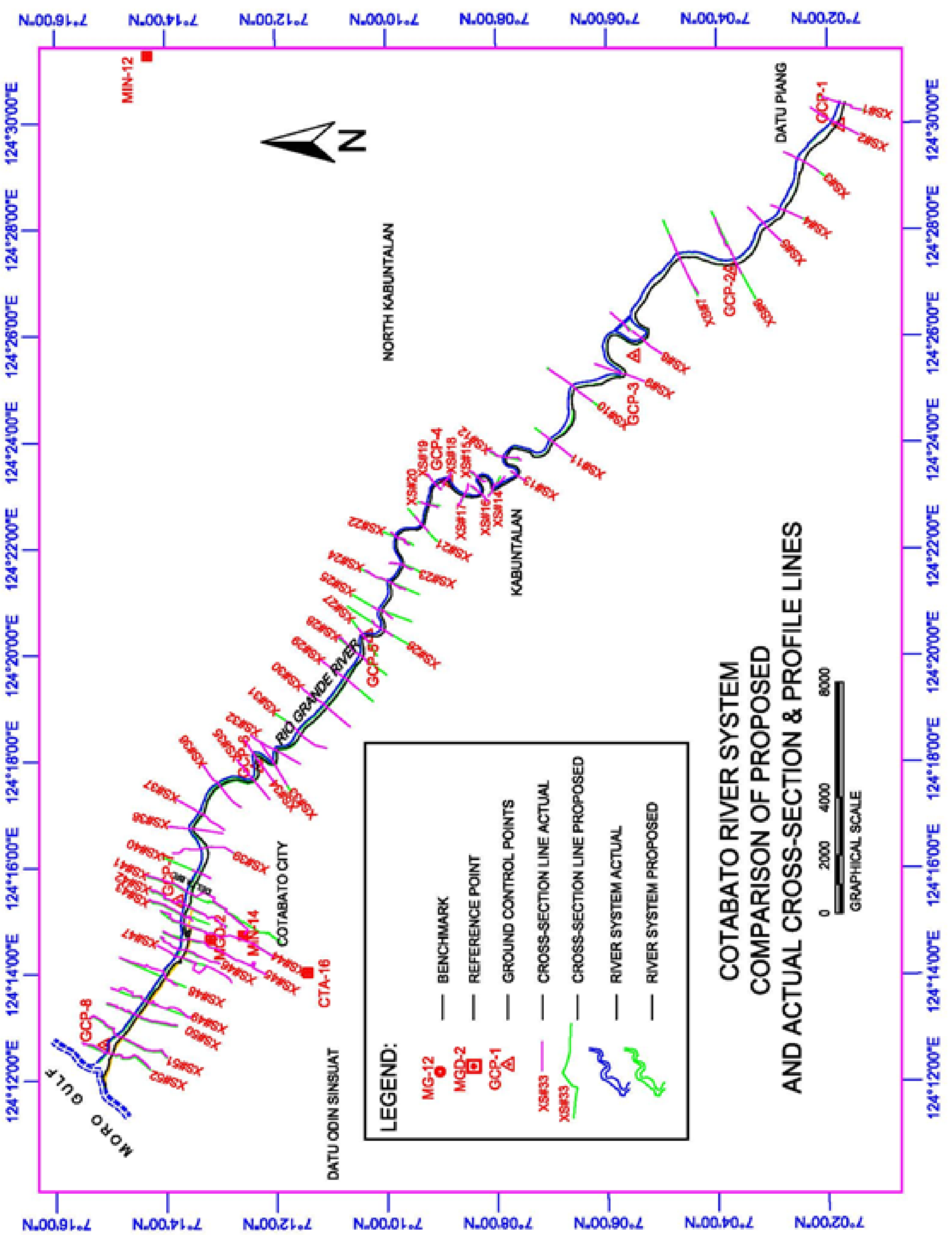


Figure 9 : Comparison of the proposed and actual survey lines

3.3 Problems Encountered and Resolutions Applied.

Based on the field survey, from reconnaissance up to the actual field survey, problems encountered by the surveying team are as follows:

Table 5: Problem Encountered and Solution Applied

Problems Encountered		Action Taken
1.	A lot of areas were hard to access due to dense vegetation coverage causing delay and changing of survey approach.	Additional manpower hired to clear heavily vegetated areas. In conjunction with the additional manpower, machineries and materials such grass cutter and jungle bolo were also provided.
2.	Hard to secure permits from Local Government Units and local residents	While waiting for their preferred schedule, the team performs other task for the project.
3.	Delay in the projected field work because of unfavorable weather condition in the area.	Overtime on Sundays and extend working hours
4.	River banks and section lines were not visible because of the high water level.	Adjustment in the work schedule to extend the duration of field survey.
5.	Land owners did not allow our survey team to enter their property even we had secured permits from the barangay officials.	The team hired barangay kagawad who is well-known in the respective areas to serve as guide during the survey.
6.	Most of the time the barangay officials are not available to accompany the survey team to conduct survey works.	Wait for the availability of the barangay officials before conducting survey work on site.
7.	MILF & BIFF encounter against the Government forces during the peace talk agreement.	The team assigned in the affected area waits for the advised of the military for their own safety.
8.	No access road on most of the project area in Kabuntalan	Rent two motor boats daily for easy access along the river

The report chart showing the weather during the entire survey implementation of the project can be seen in Figure 10. This is documented by the team to as reference for the delay of the survey.

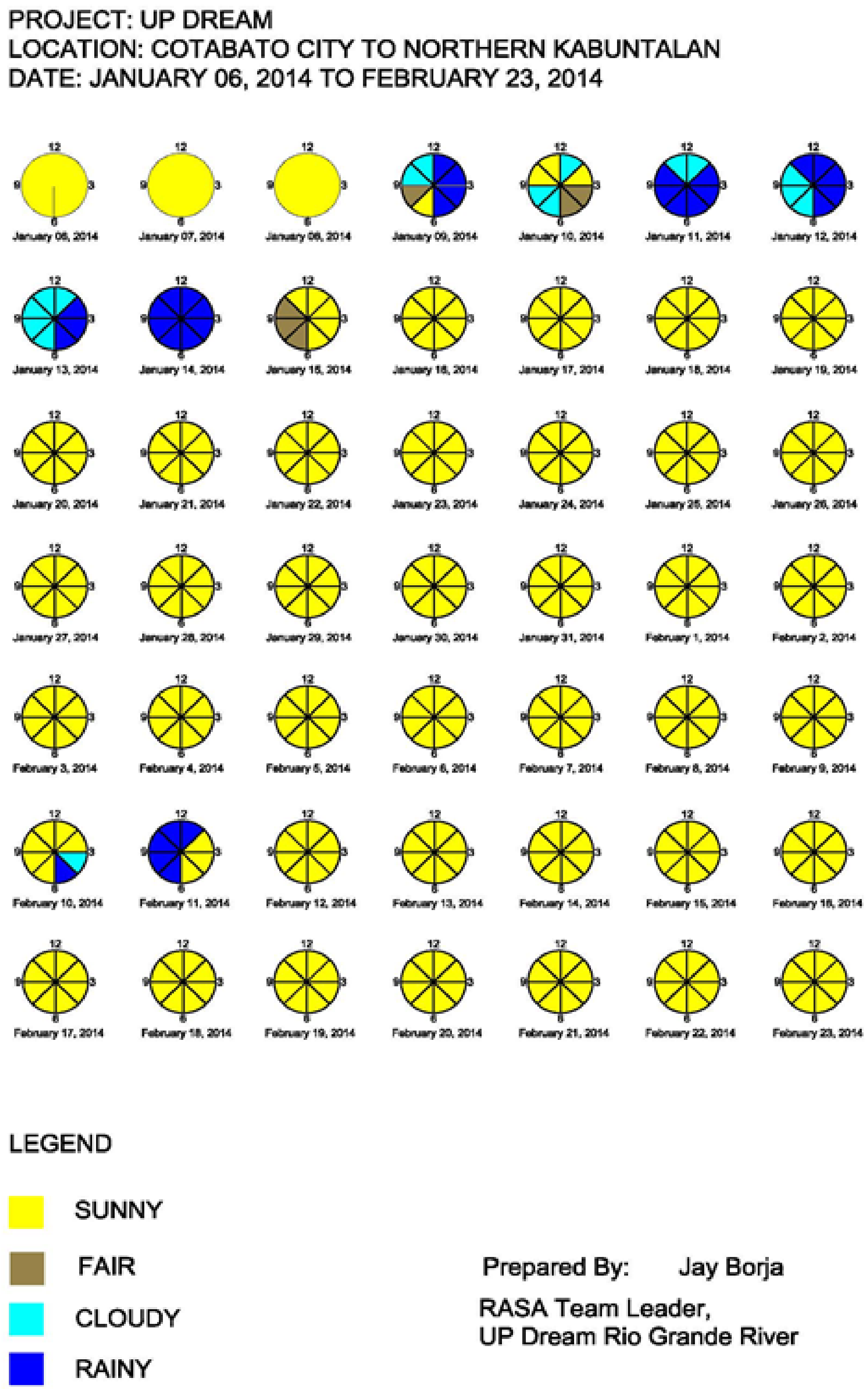
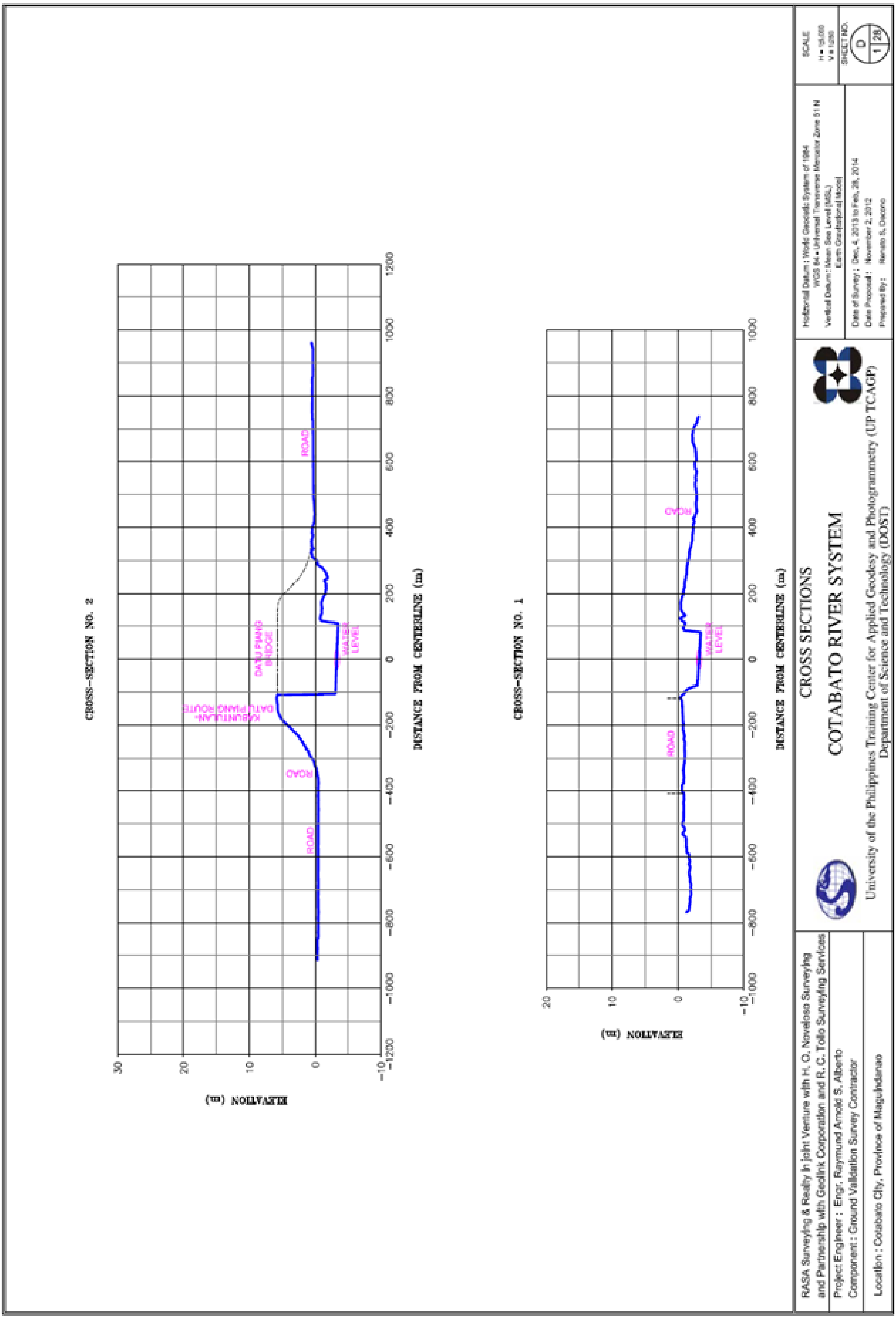


Figure 10 : Chart showing the weather on the project during the entire survey

3.4 Processed Data

Tables and Figures showing the summary of all the processed data: the established GCPs, cross section and profile survey data. Copy of all processed and raw data were compiled and were also submitted in digital format.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DATU PIANG BRIDGE
WATER LEVEL
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CROSS SECTIONS
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Horizontal Datum : World Geodetic System of 1984
WGS 84 • Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : Dec. 4, 2013 to Feb. 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Dacono
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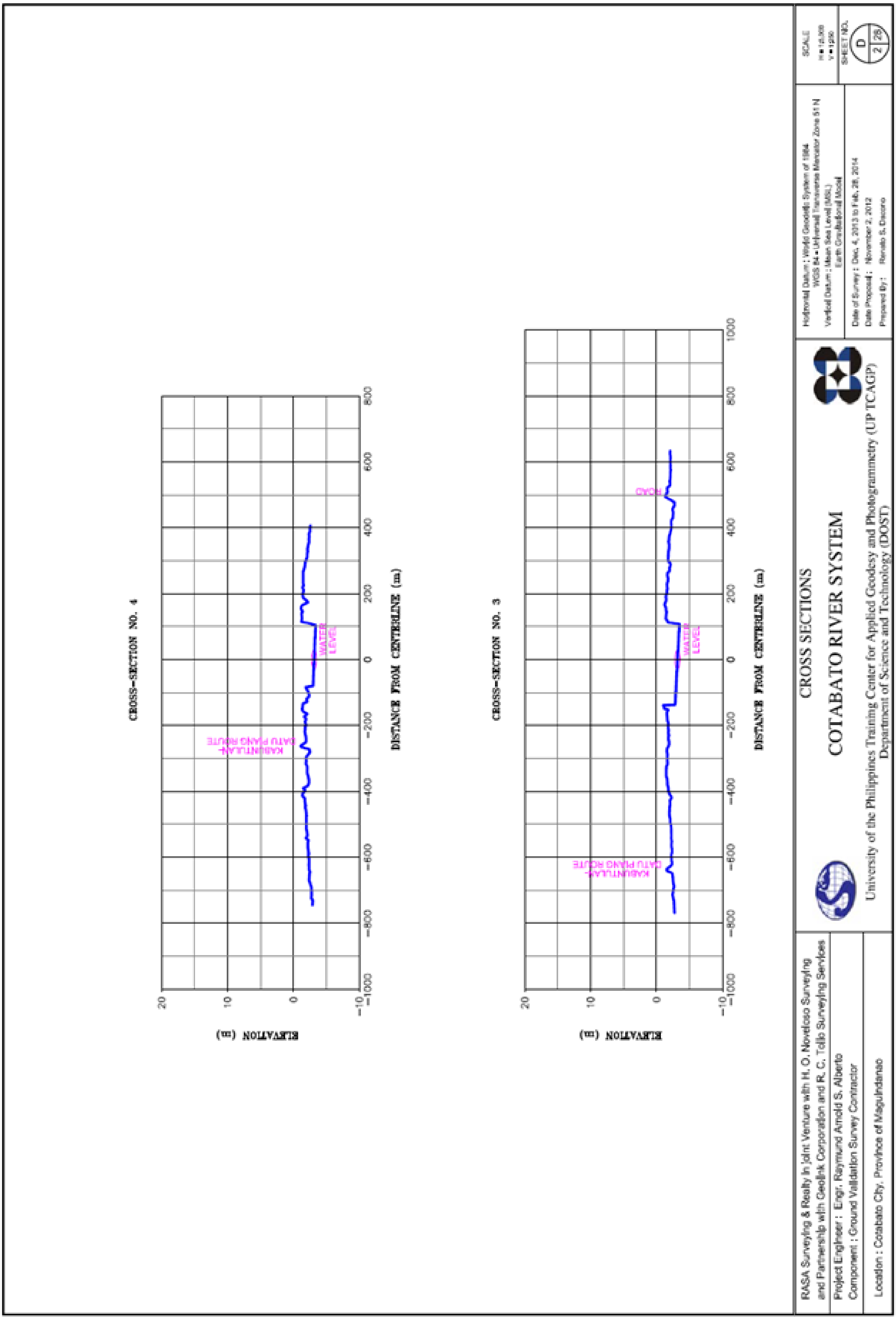
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DISTANCE FROM CENTERLINE (m)
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WATER LEVEL
ROAD
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
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University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
WGS 84 = Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
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Date Proposal : November 2, 2012
Prepared By : Renato S. Dacono
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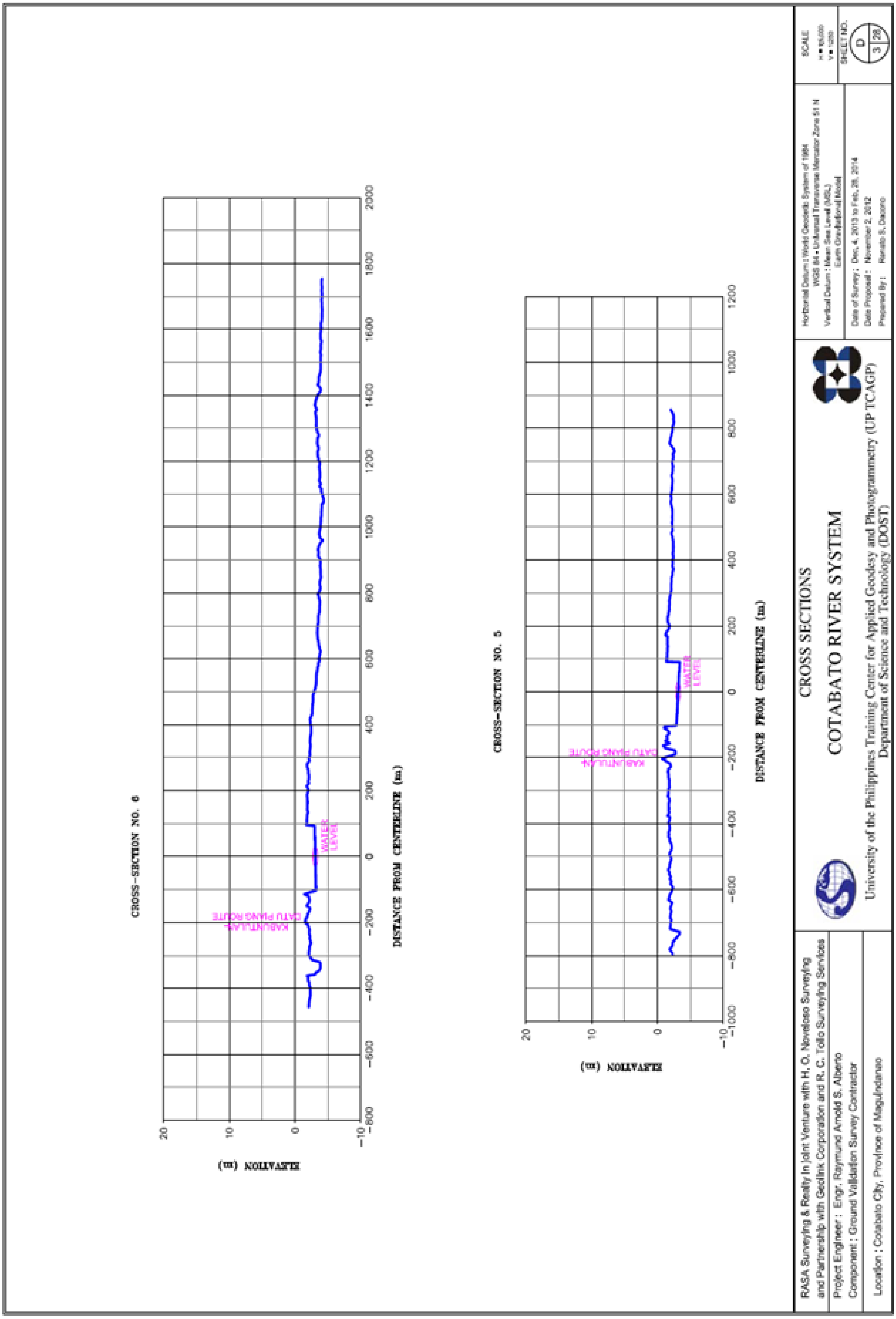

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DISTANCE FROM CENTERLINE (m)
WATER LEVEL
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RASA Surveying & Realty In Joint Venture with H. O. Novelloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
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University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
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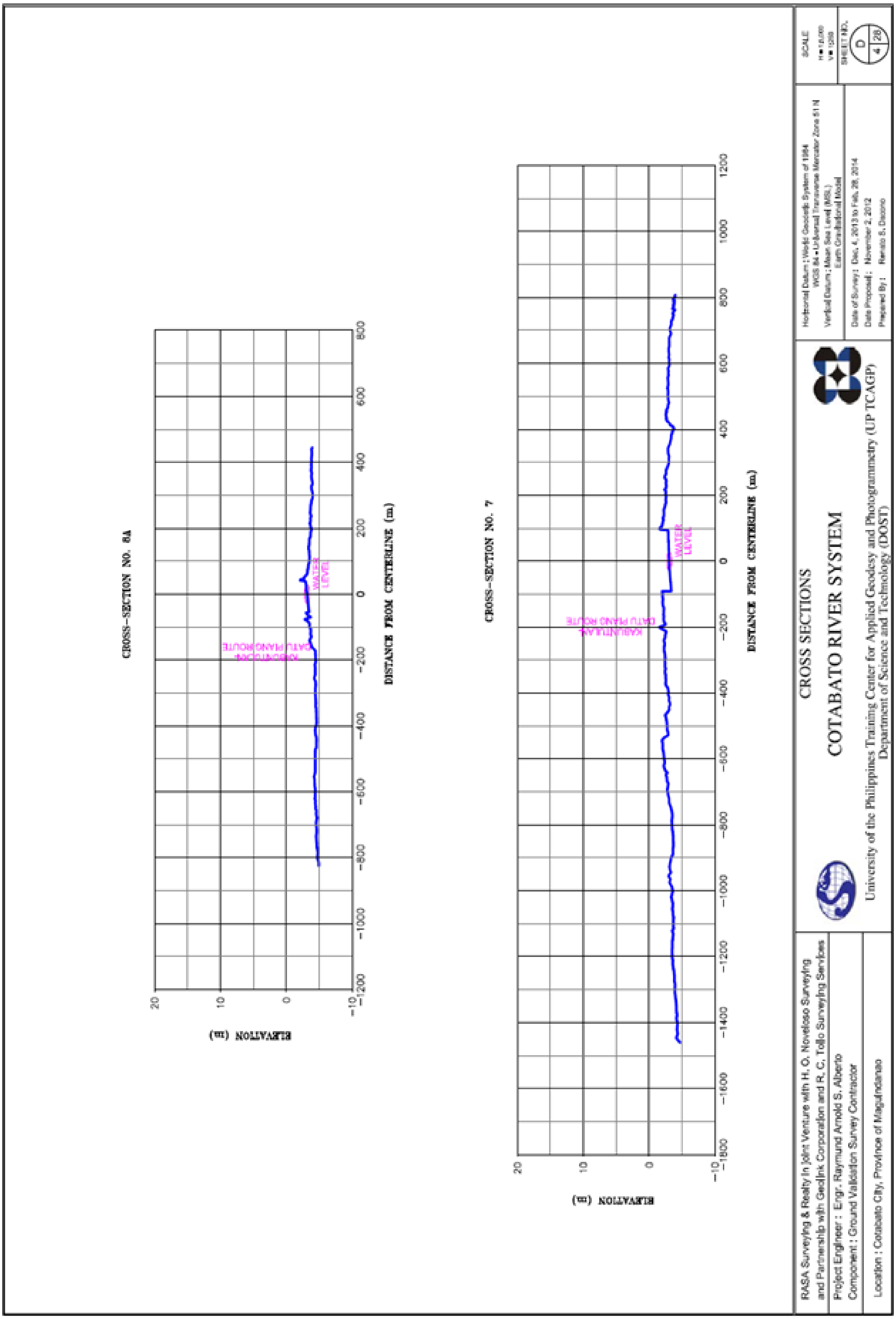
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WATER LEVEL
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KABUNTULAN
CROSS SECTIONS
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University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying and Partnership with GeoInk Corporation and R. C. Tolijo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
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Date Proposed : November 2, 2012
Prepared By : Renato S. Dacono
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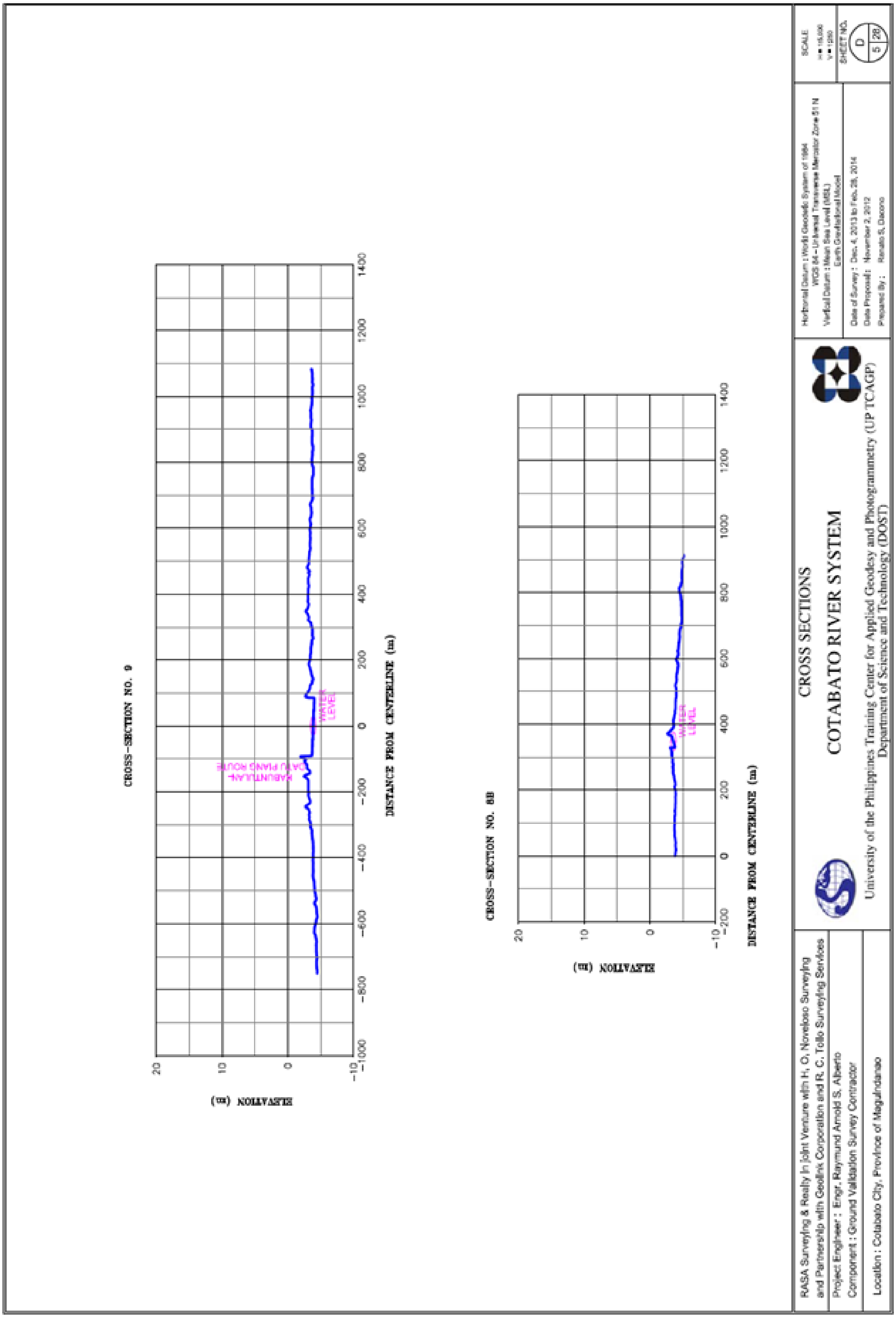
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ELEVATION (m)
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WATER LEVEL
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
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Project Engineer : Engr. Raymund Arnold S. Alberto
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University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
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Horizontal Datum : World Geodetic System of 1984
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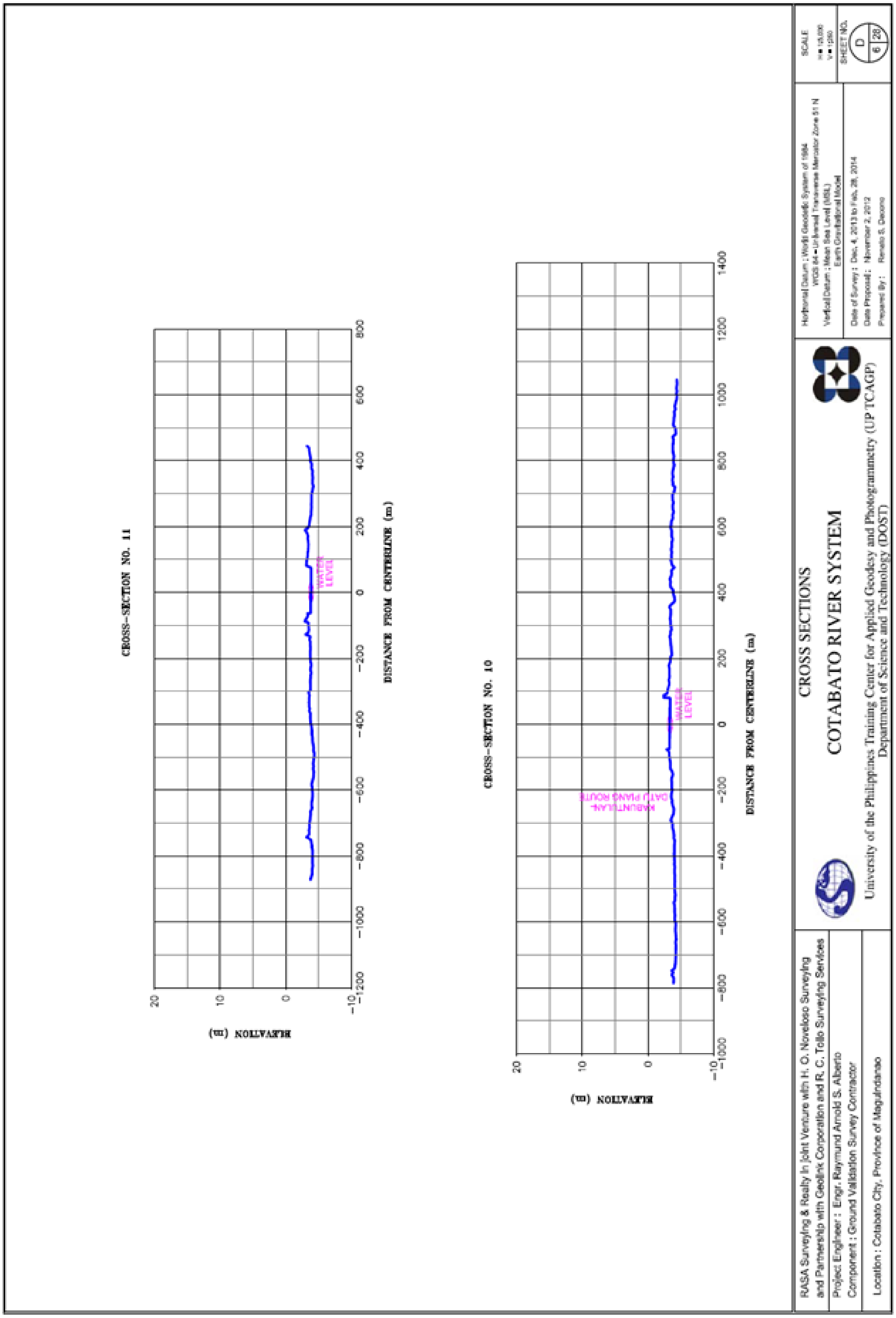
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WATER LEVEL
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University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tello Surveying Services
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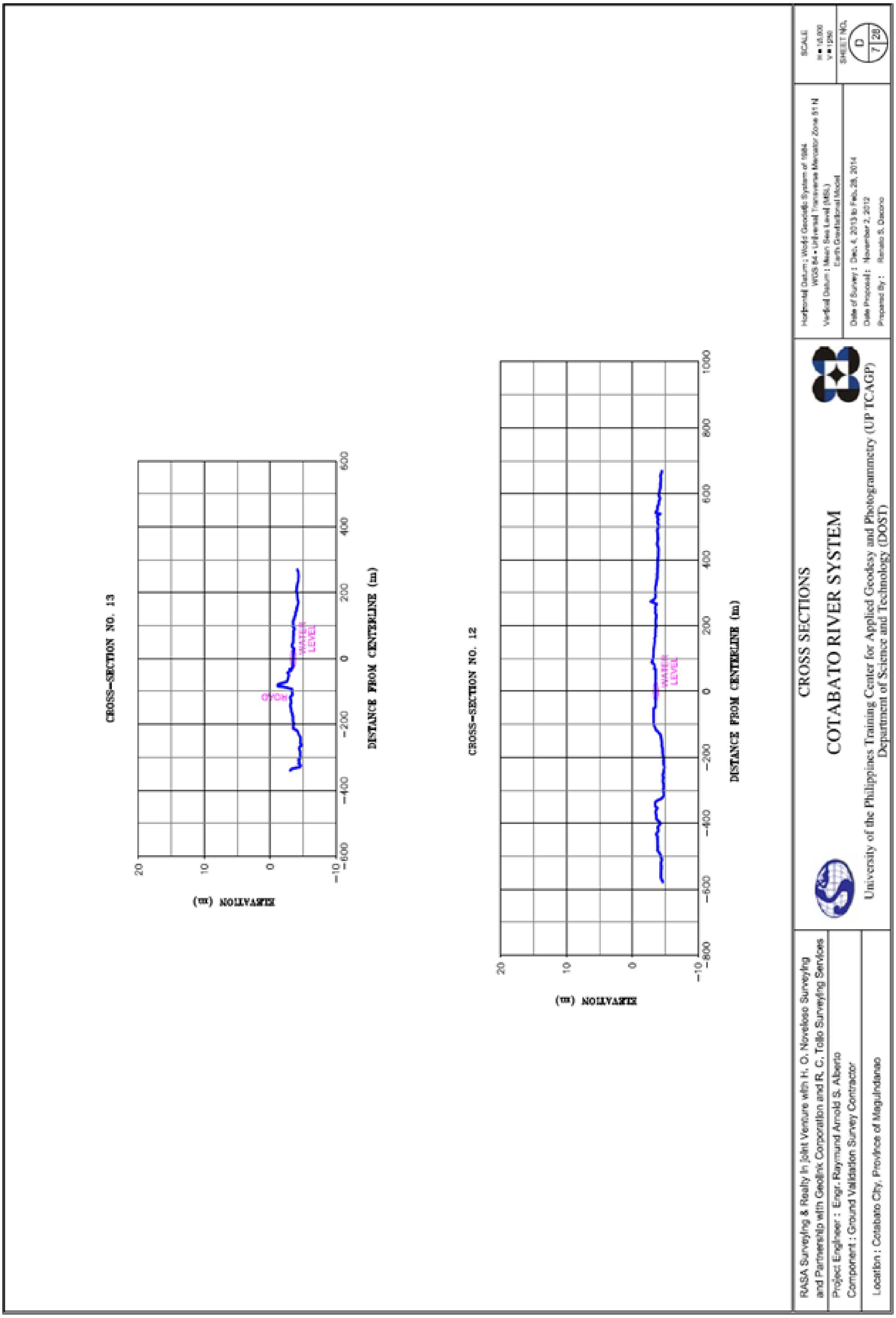

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CROSS-SECTION NO. 12
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DISTANCE FROM CENTERLINE (m)
WATER LEVEL
ROAD
CROSS SECTIONS
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University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
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Date of Survey : Dec. 4, 2013 to Feb. 28, 2014
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Prepared By : Renato S. Dacono
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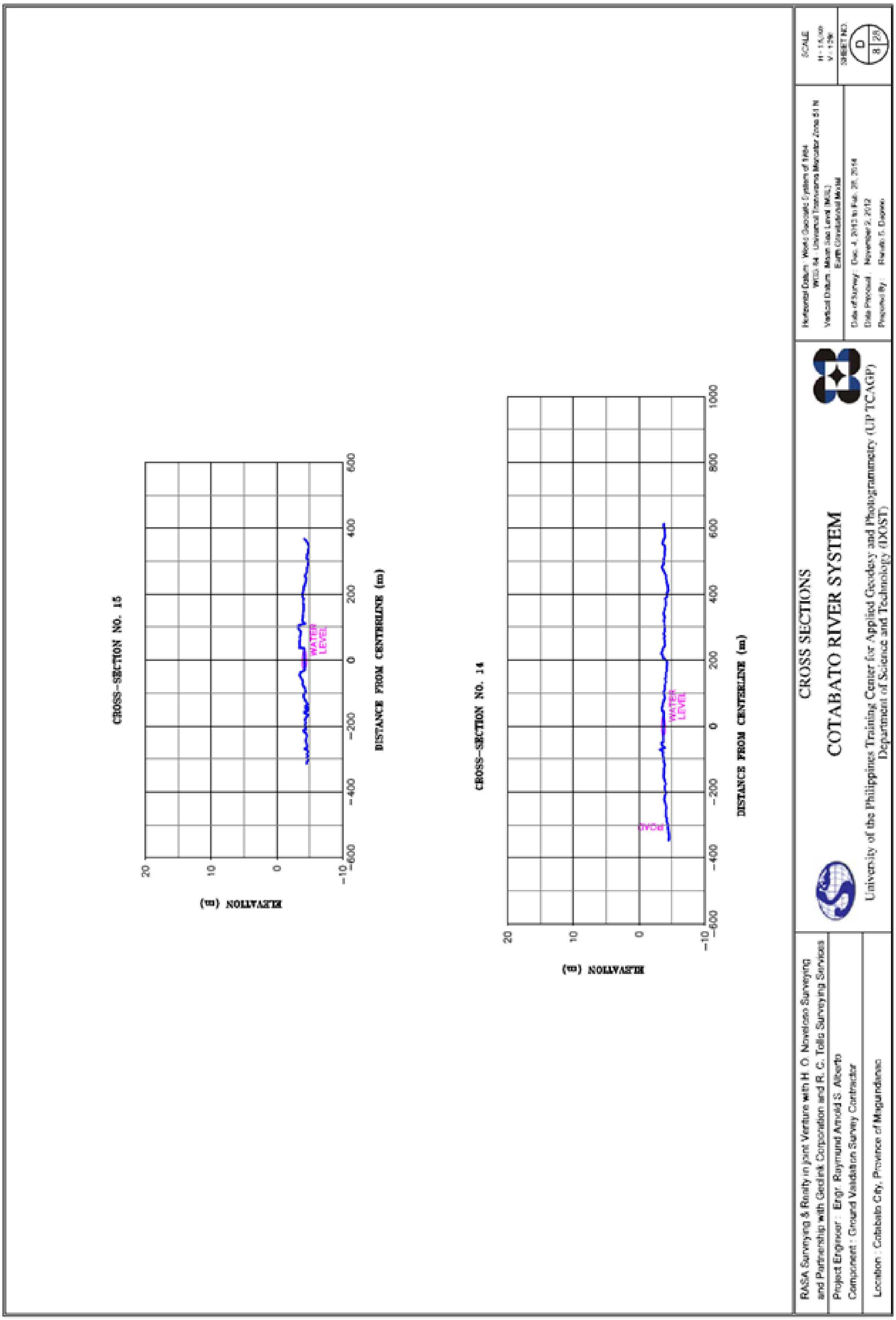
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ROAD
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University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
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RASA Surveying & Realty in joint Venture with H. O. Navelosa Surveying and Partnership with Geodink Corporation and R. C. Tolla Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
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Vertical Datum : Mean Sea Level (MSL)
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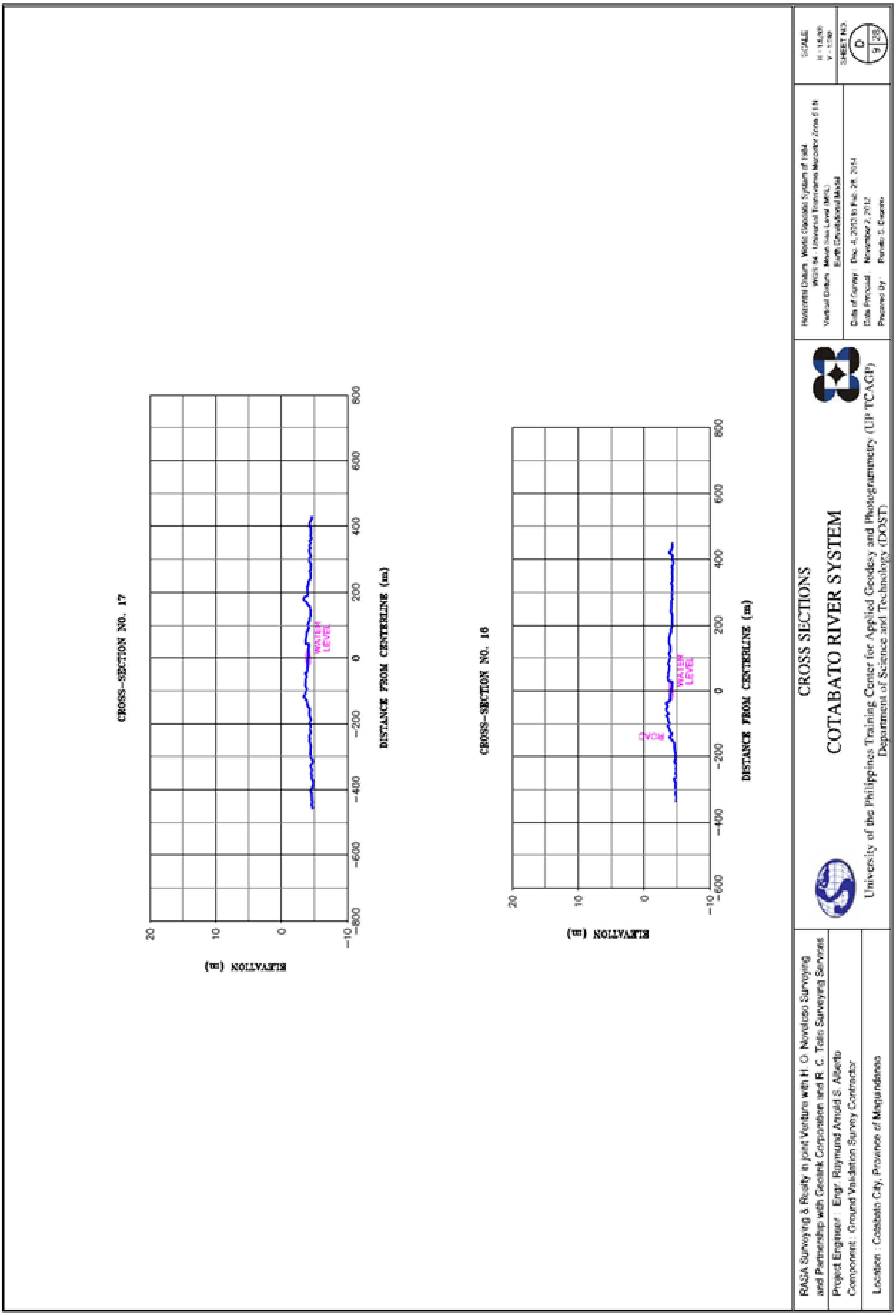
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ROAD
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University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in joint Venture with H. O. Nowalobo Surveying and Partnership with Geolink Corporation and R. C. Tallo Surveying Services
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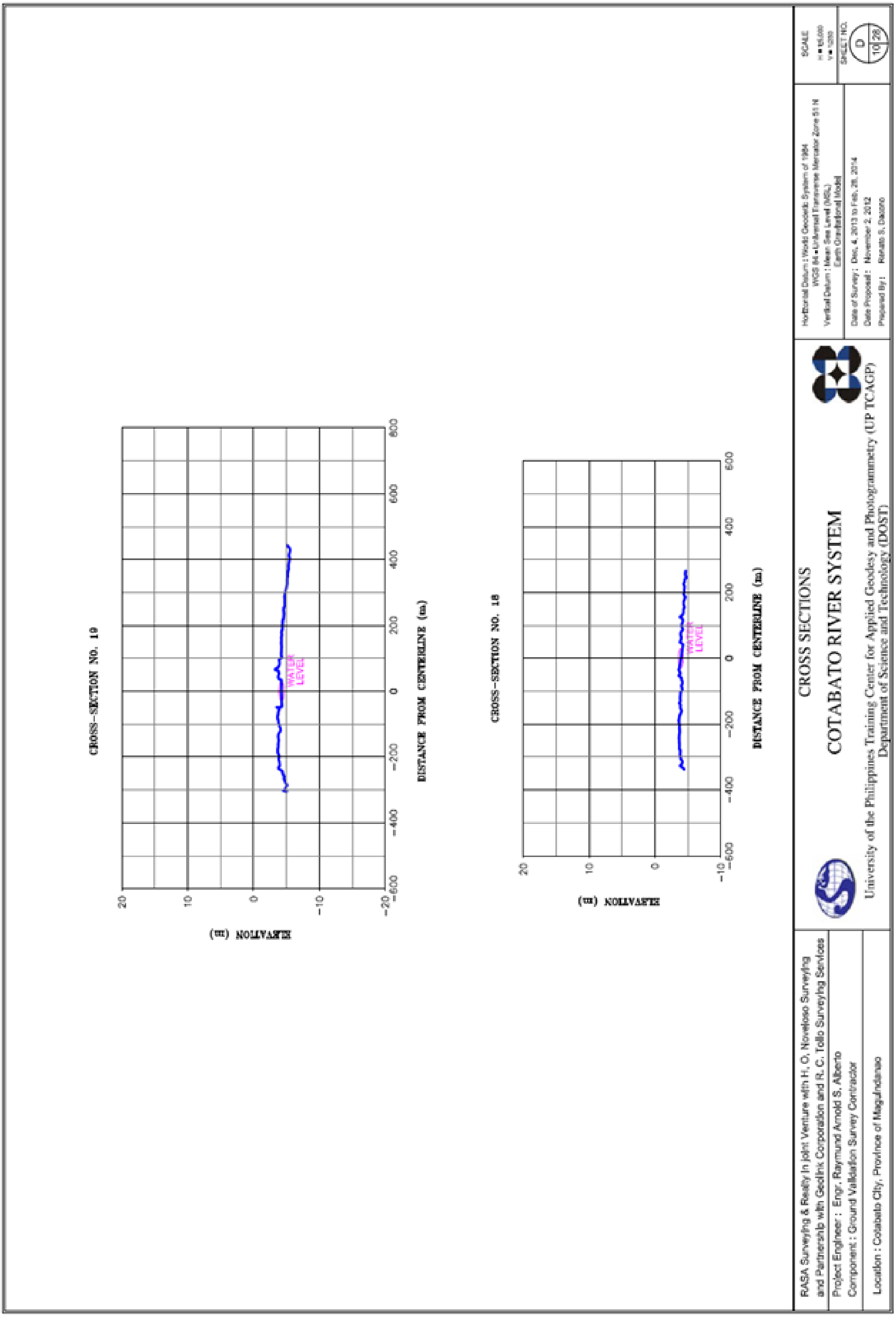
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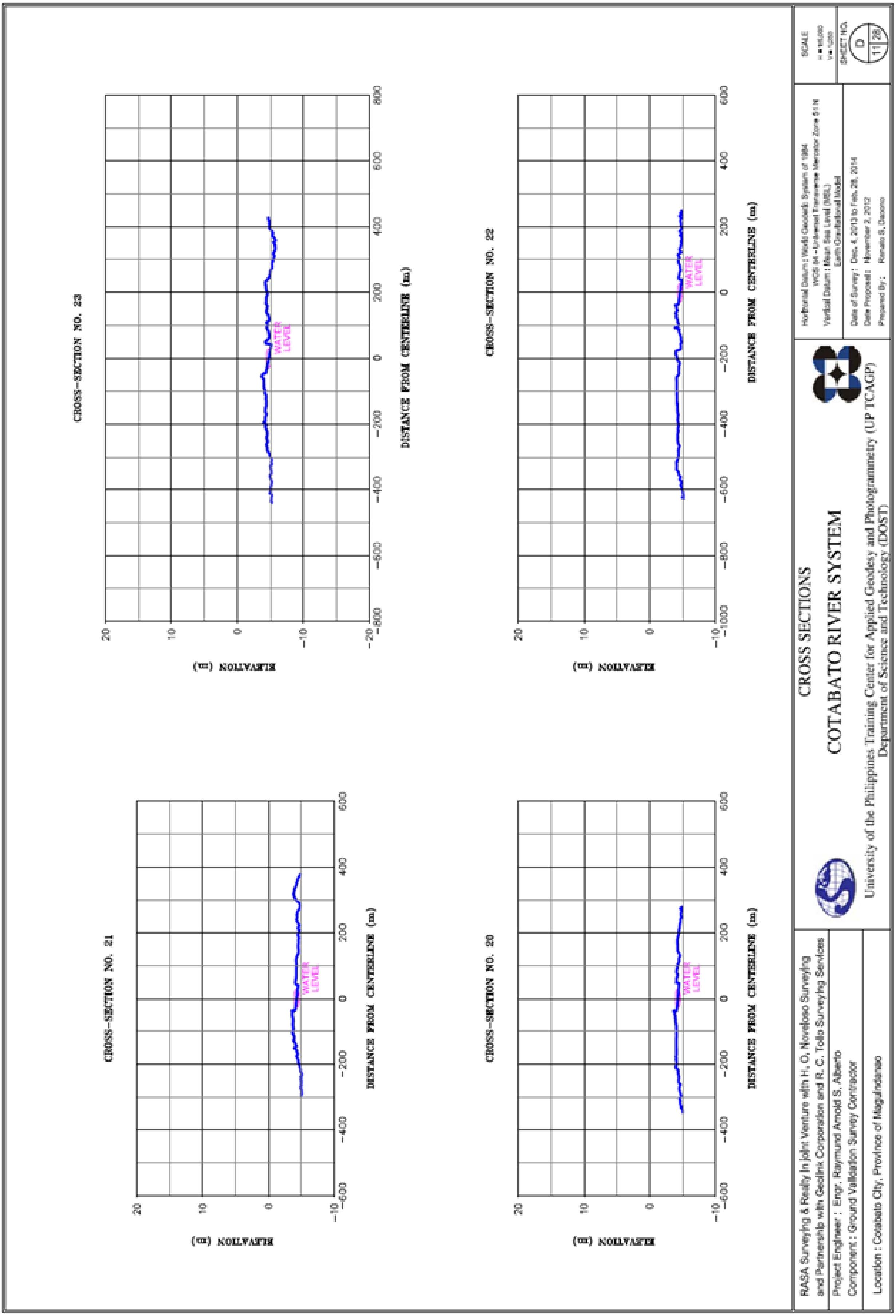
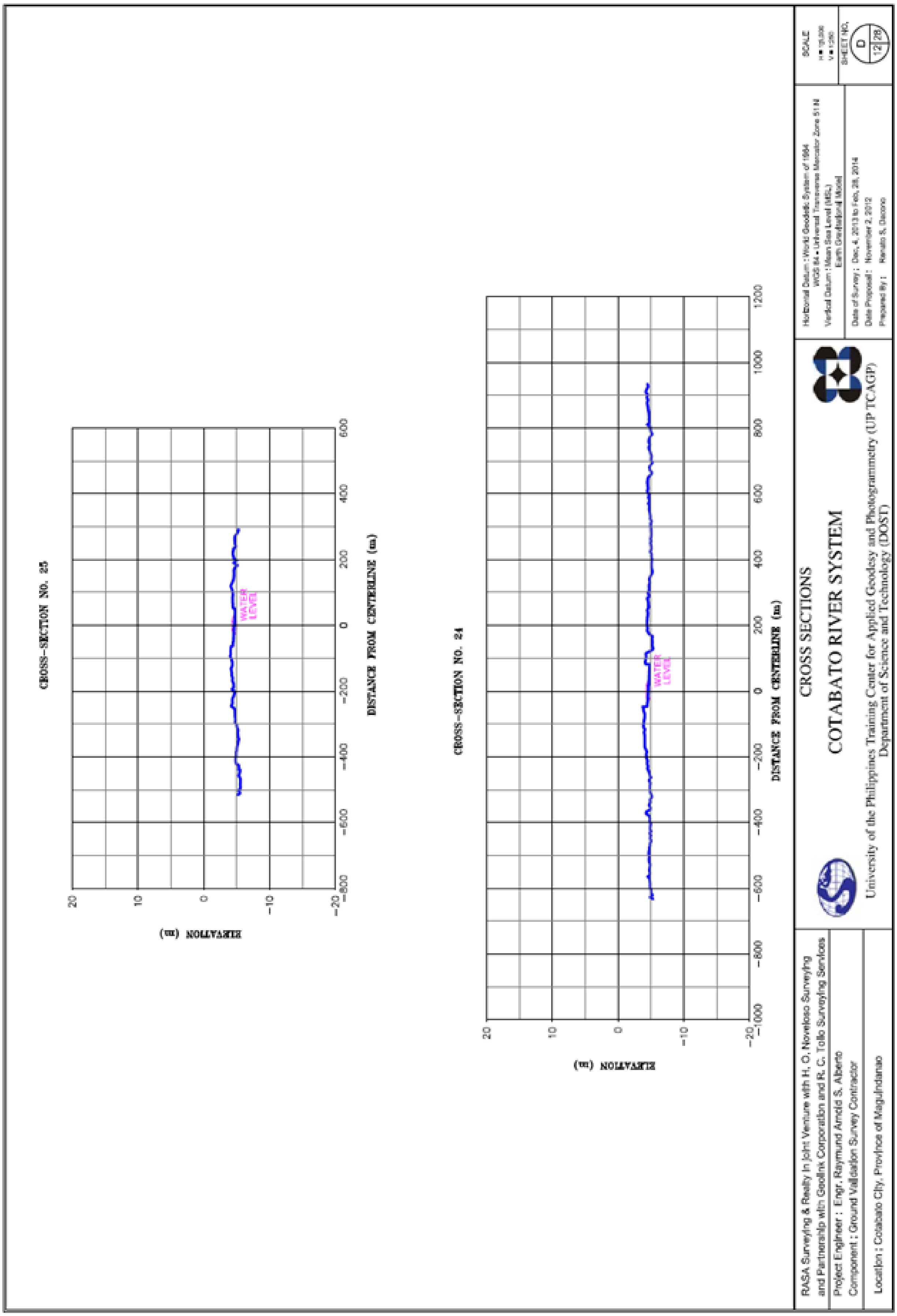
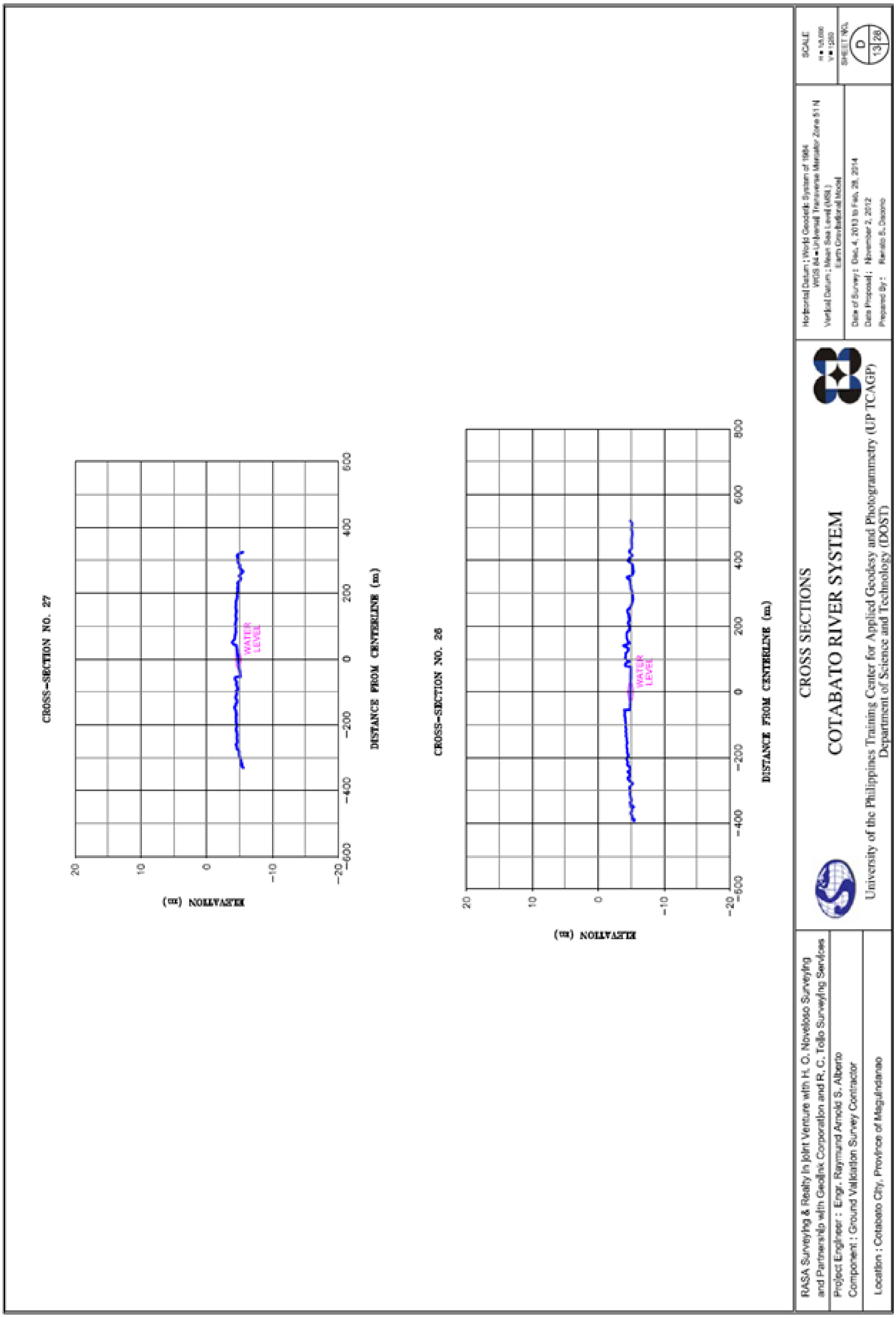
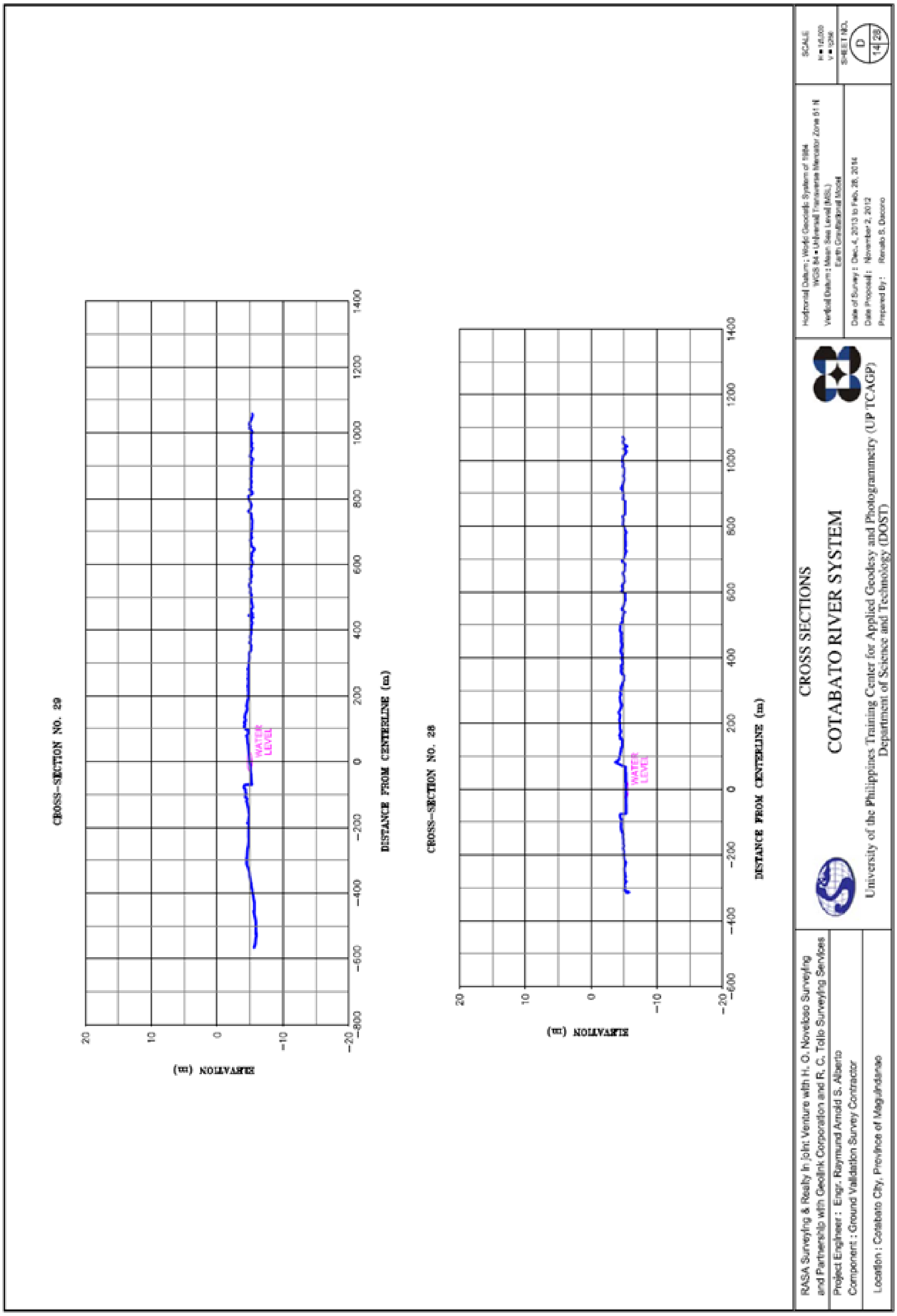
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
WATER LEVEL
CROSS SECTIONS
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Date of Survey : Dec. 4, 2013 to Feb. 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Dacono
SCALE
SHEET NO.
D
10
28

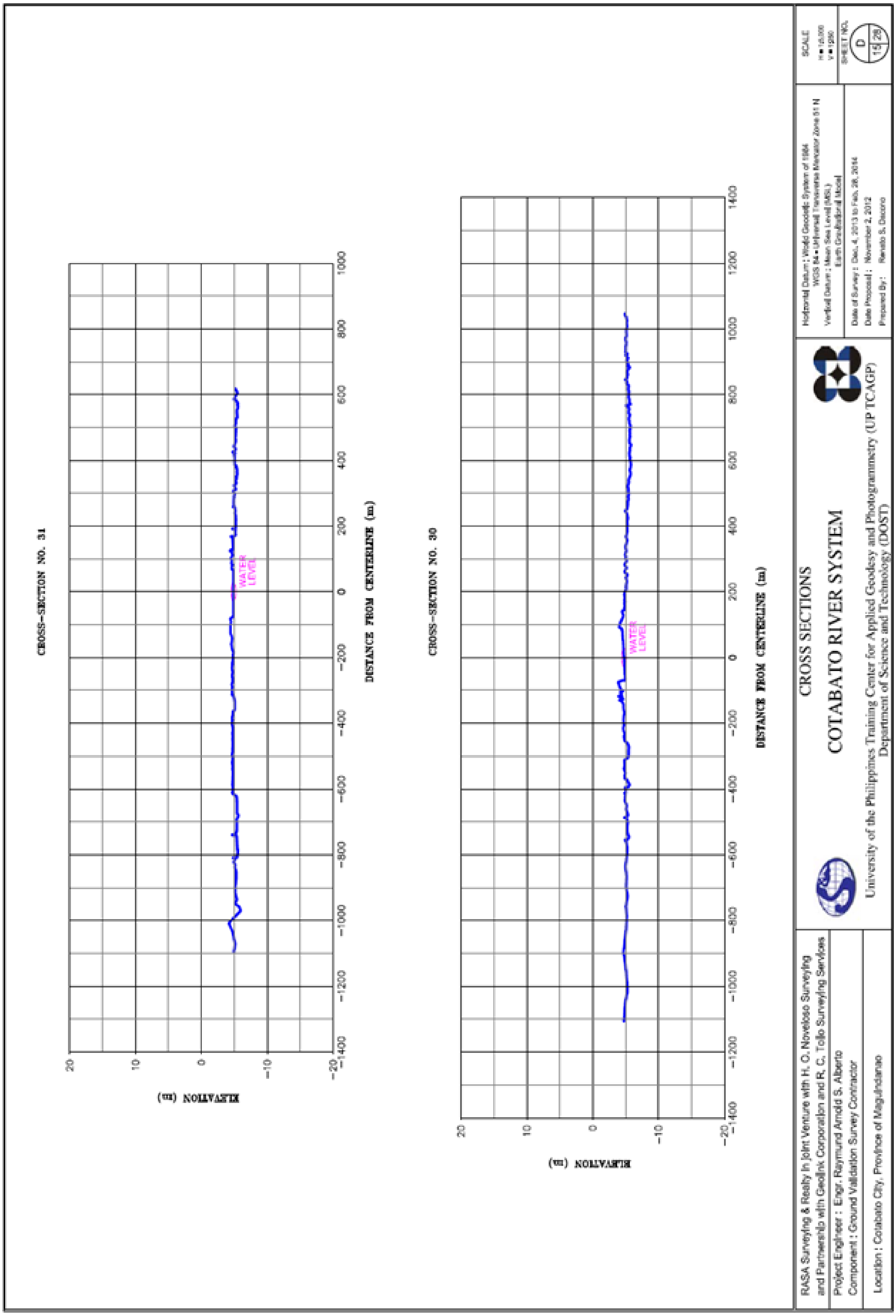

CROSS-SECTION NO. 23
CROSS-SECTION NO. 22
CROSS-SECTION NO. 21
CROSS-SECTION NO. 20
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
WATER LEVEL
CROSS SECTIONS
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Date of Survey : Dec. 4, 2013 to Feb. 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Dacono
SHEET NO.
D
11
28

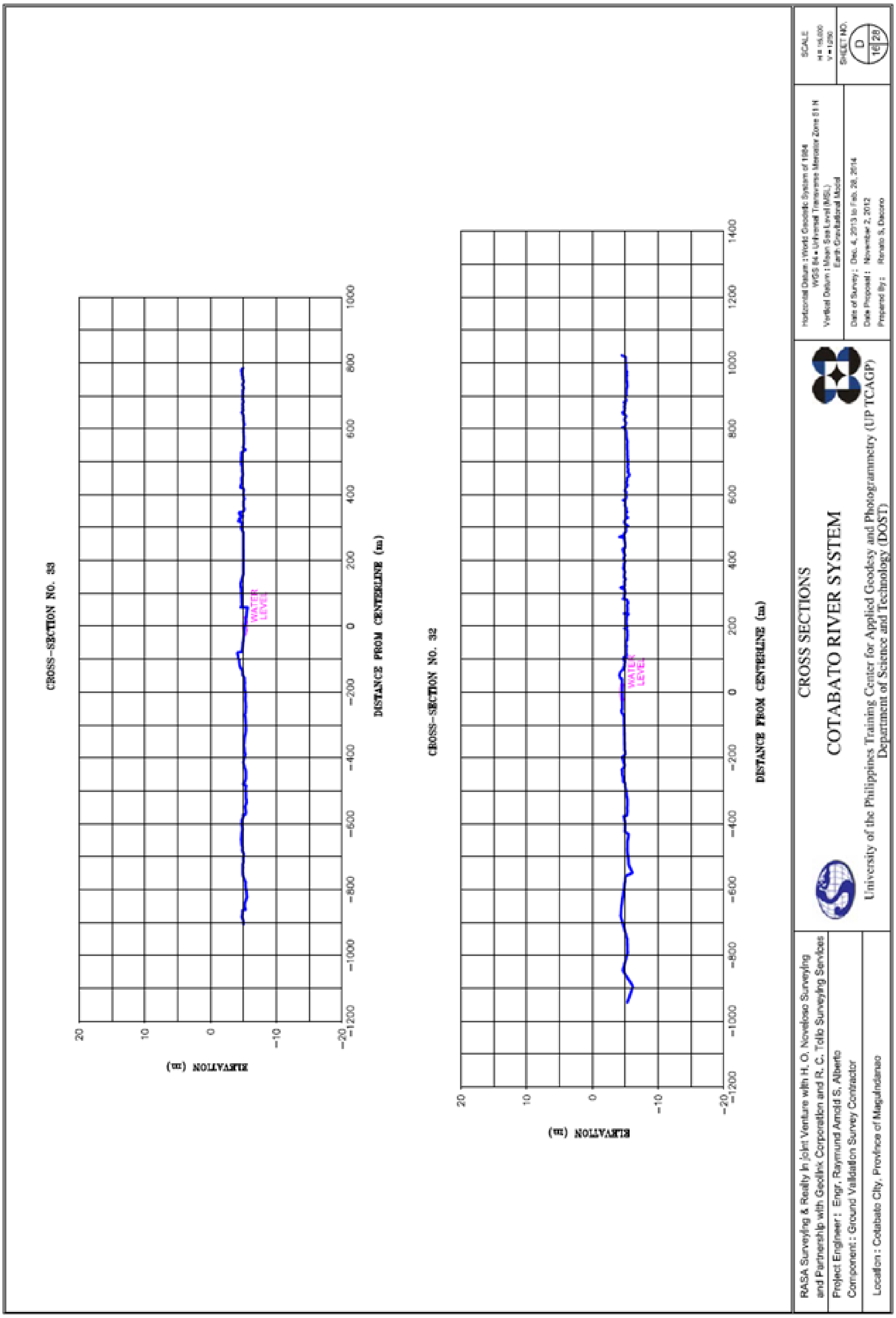

CROSS-SECTION NO. 25
CROSS-SECTION NO. 24
WATER LEVEL
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
CROSS SECTIONS
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Horizontal Datum : World Geodetic System of 1984
WGS 84 • Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : Dec. 4, 2013 to Feb. 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Decono
SCALE
SHEET NO.
D
12
28

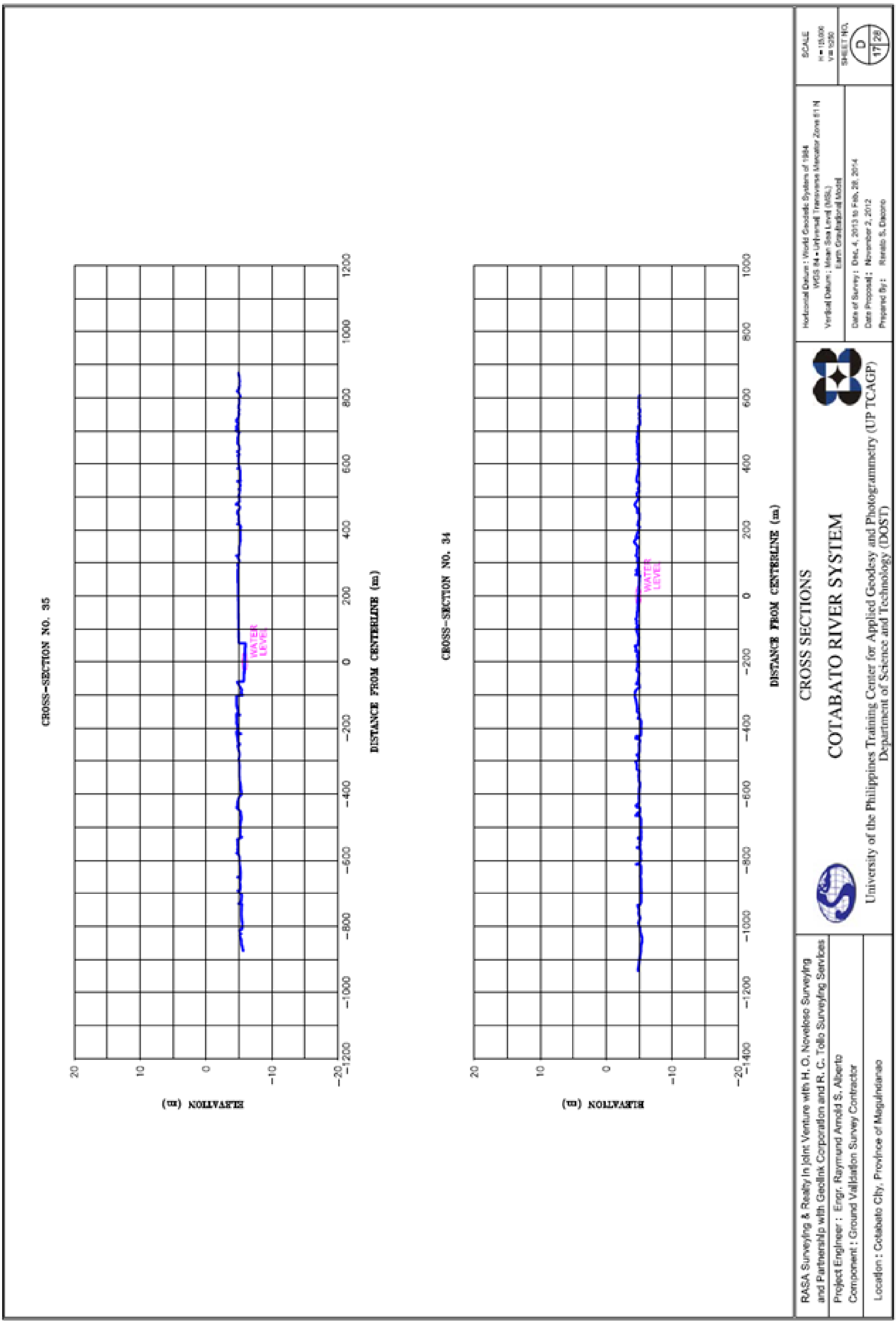

CROSS-SECTION NO. 27
CROSS-SECTION NO. 28
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
WATER LEVEL
CROSS SECTIONS
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying
and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Horizontal Datum : World Geodetic System of 1984
WGS 84 • Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : Dec. 4, 2013 to Feb. 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Dacono
SCALE
SHEET NO.
D
13
28

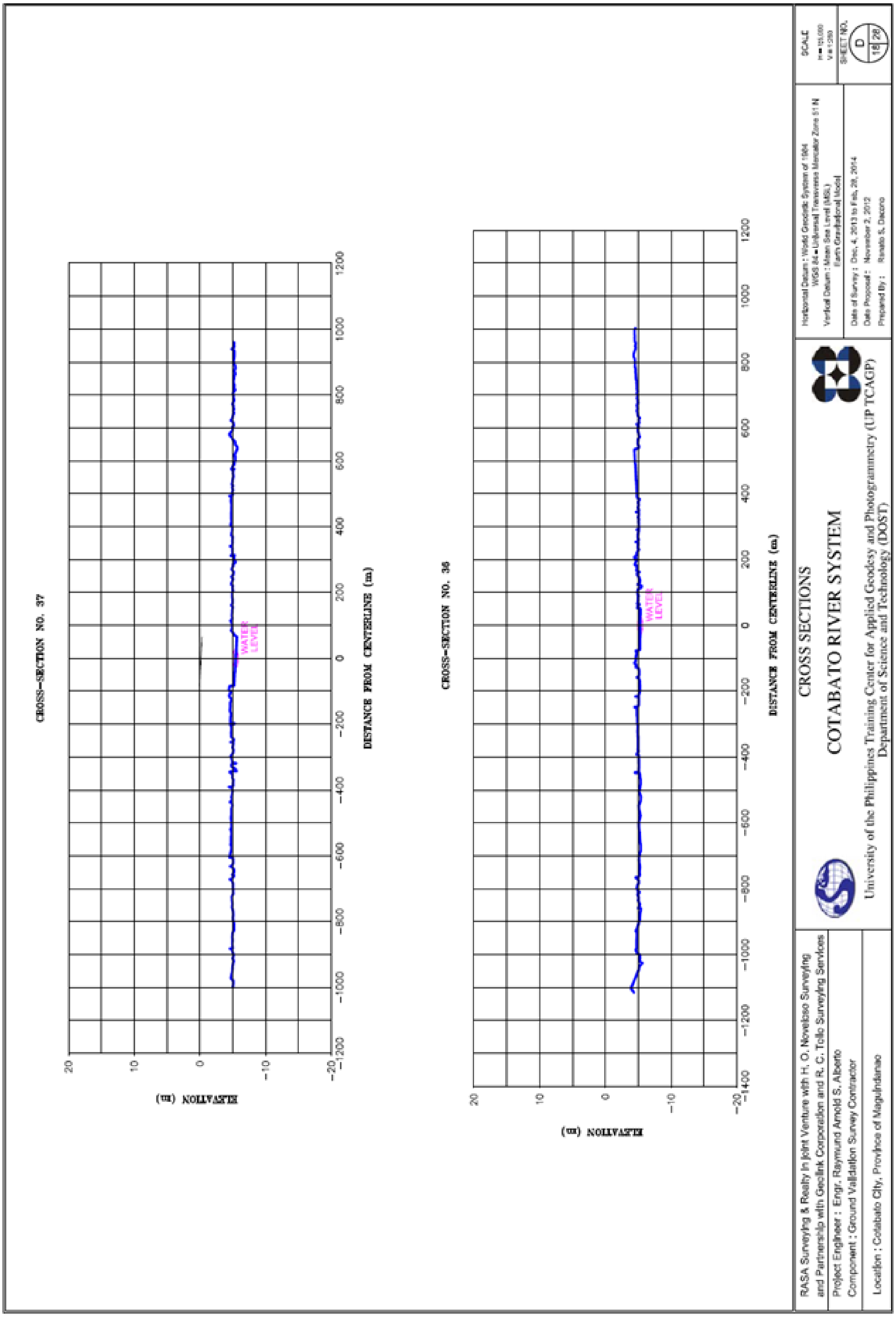


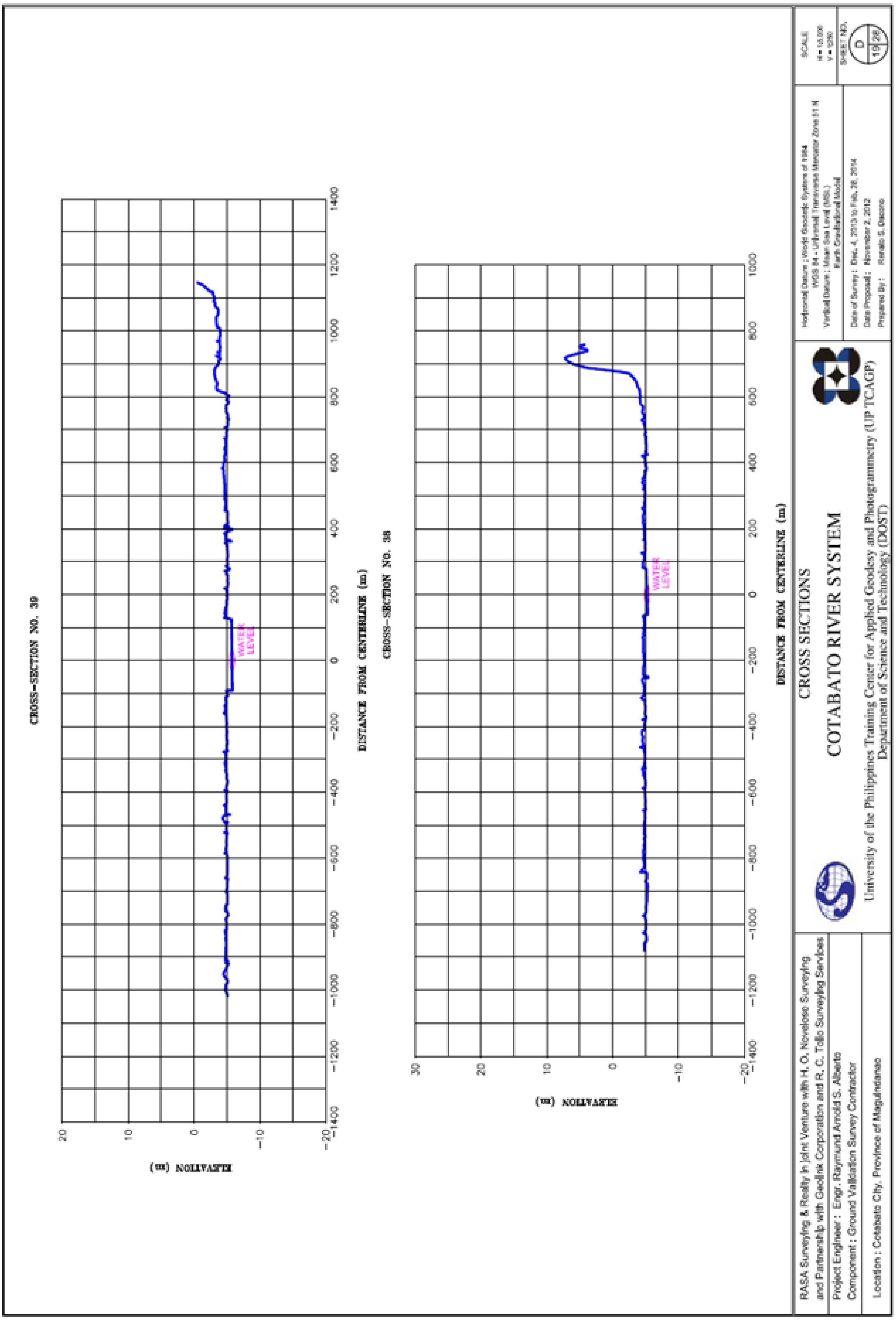
CROSS-SECTION NO. 29
ELEVATION (m)
WATER LEVEL
DISTANCE FROM CENTERLINE (m)
CROSS-SECTION NO. 28
ELEVATION (m)
WATER LEVEL
DISTANCE FROM CENTERLINE (m)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
CROSS SECTIONS
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
WGS 84 • Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : Dec. 4, 2013 to Feb. 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Dacono
SCALE
SHEET NO.
D
14
28

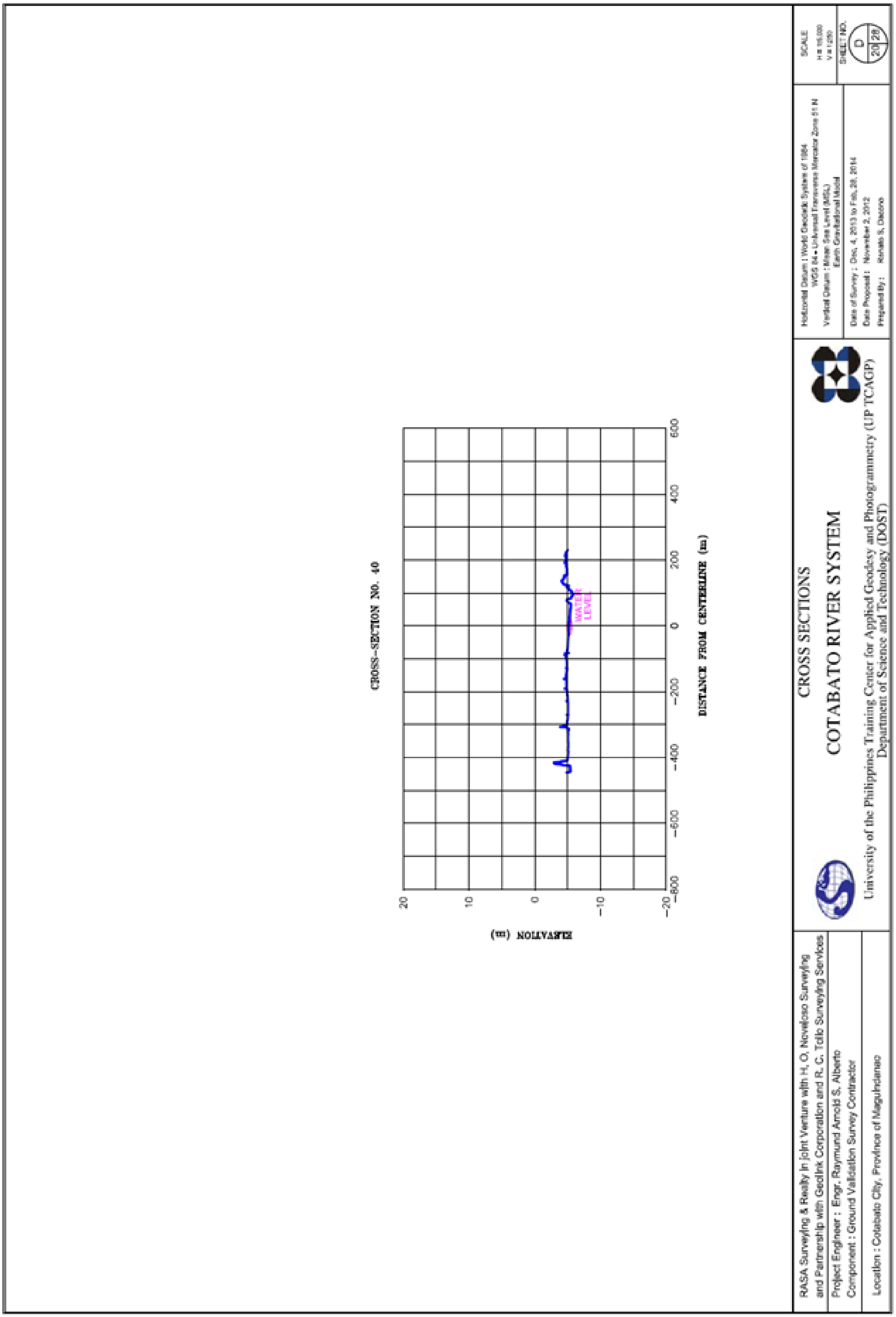

CROSS-SECTION NO. 31
CROSS-SECTION NO. 30
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
WATER LEVEL
CROSS SECTIONS
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Horizontal Datum : World Geodetic System of 1984
WGS 84 • Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : Dec. 4, 2013 to Feb. 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Discoro
SCALE
SHEET NO.
D
15
28

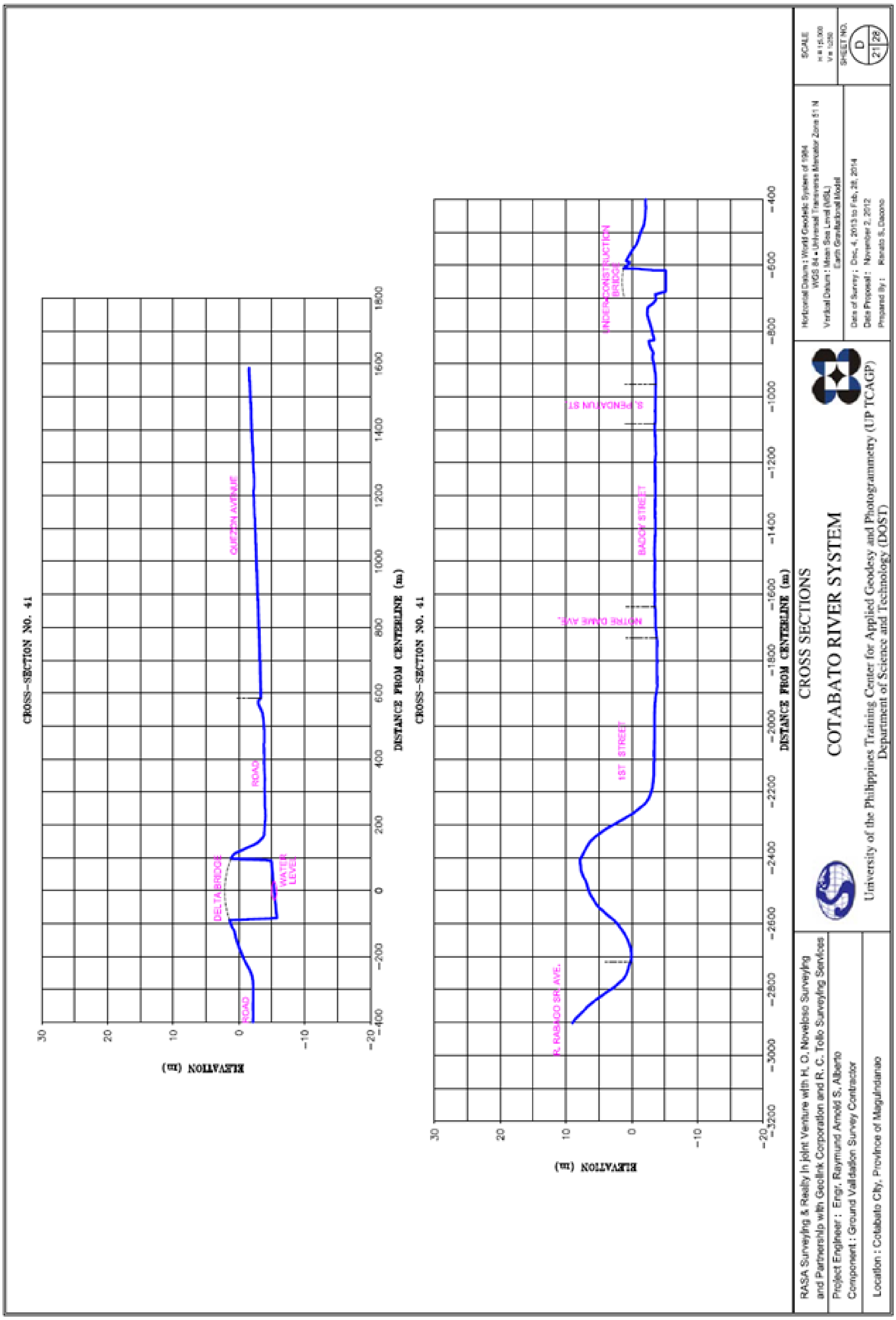

CROSS-SECTION NO. 33
CROSS-SECTION NO. 32
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
WATER LEVEL
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying
and Partnership with Geolink Corporation and R. C. Tolio Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
CROSS SECTIONS
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Date of Survey : Dec. 4, 2013 to Feb. 28, 2014
Date Proposed : November 2, 2012
Prepared By : Renato S. Dacono
SCALE
SHEET NO.

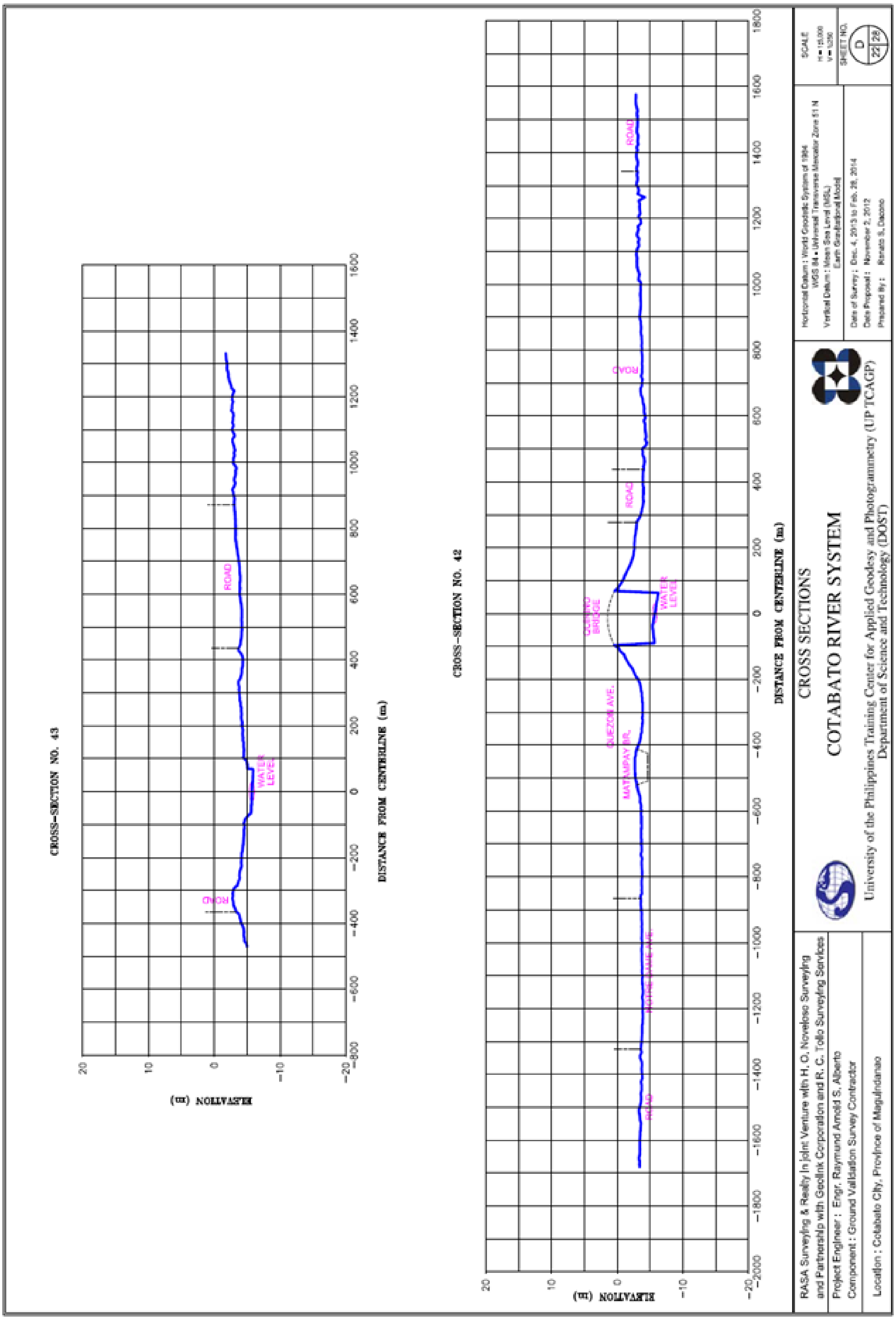

CROSS-SECTION NO. 35
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
WATER LEVEL
CROSS-SECTION NO. 34
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
WATER LEVEL
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
CROSS SECTIONS
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : Dec. 4, 2013 to Feb. 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Dacono
SCALE
SHEET NO.
D
17
28

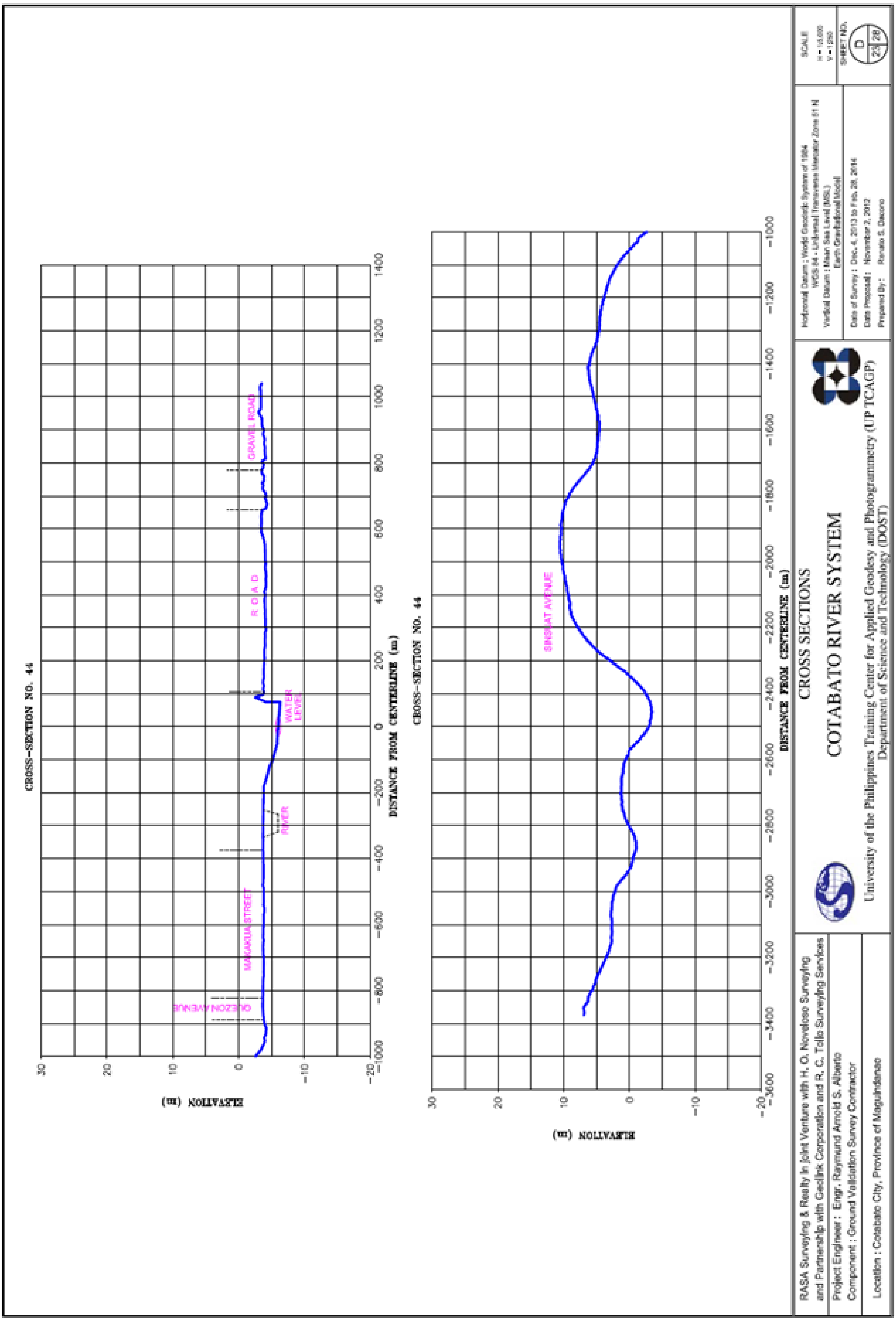

CROSS-SECTION NO. 37
ELEVATION (m)
WATER LEVEL
DISTANCE FROM CENTERLINE (m)
CROSS-SECTION NO. 36
ELEVATION (m)
WATER LEVEL
DISTANCE FROM CENTERLINE (m)
RASA Surveying & Realty in joint Venture with H. O. Novelciso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
CROSS SECTIONS
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : Dec. 4, 2013 to Feb. 28, 2014
Date Proposed : November 2, 2012
Prepared By : Renato S. Dacono
SCALE
SHEET NO.
D
18
28

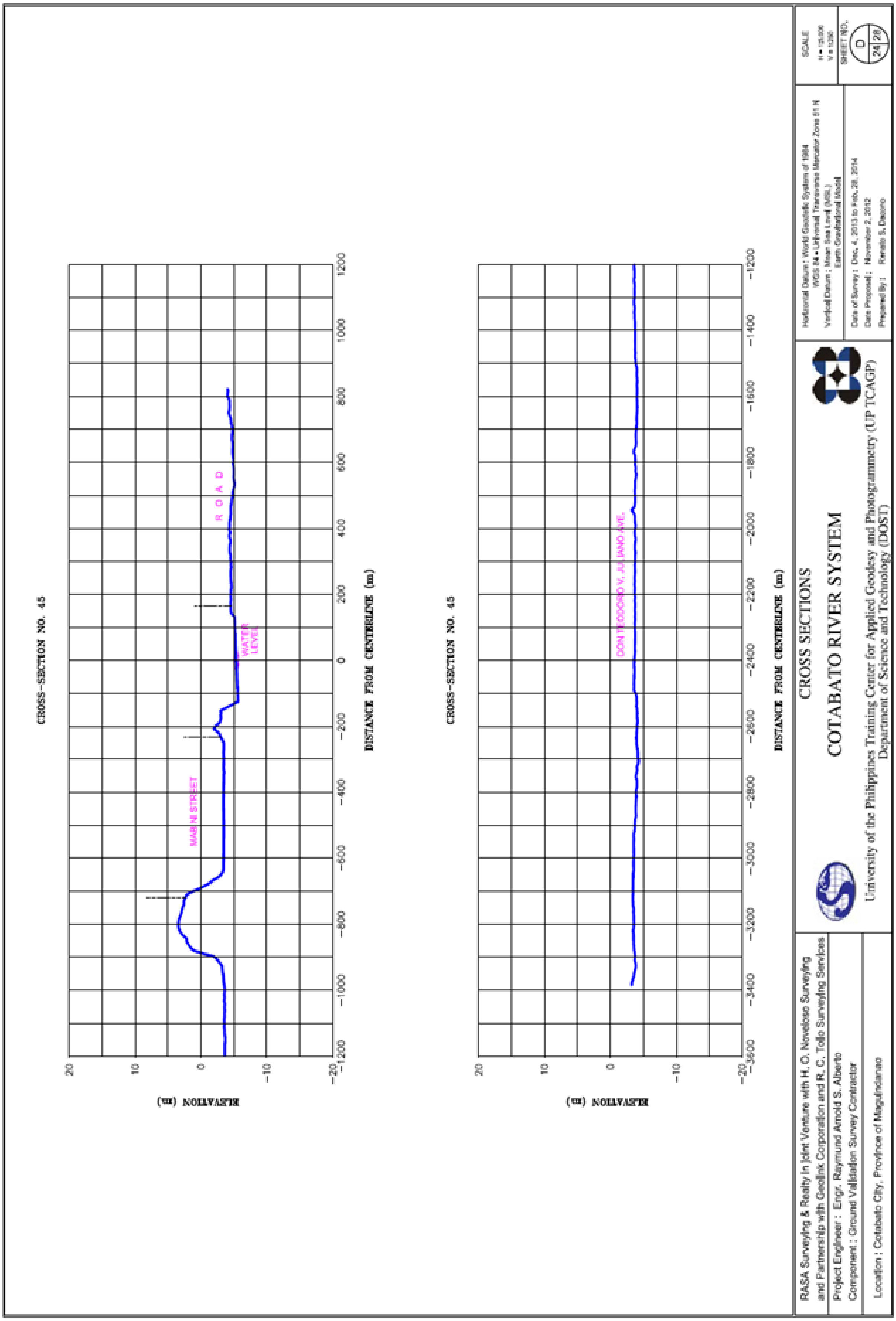

CROSS-SECTION NO. 39
CROSS-SECTION NO. 38
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
WATER LEVEL
CROSS SECTIONS
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tolio Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Date of Survey : Dec. 4, 2013 to Feb. 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Dacono
SCALE
SHEET NO.

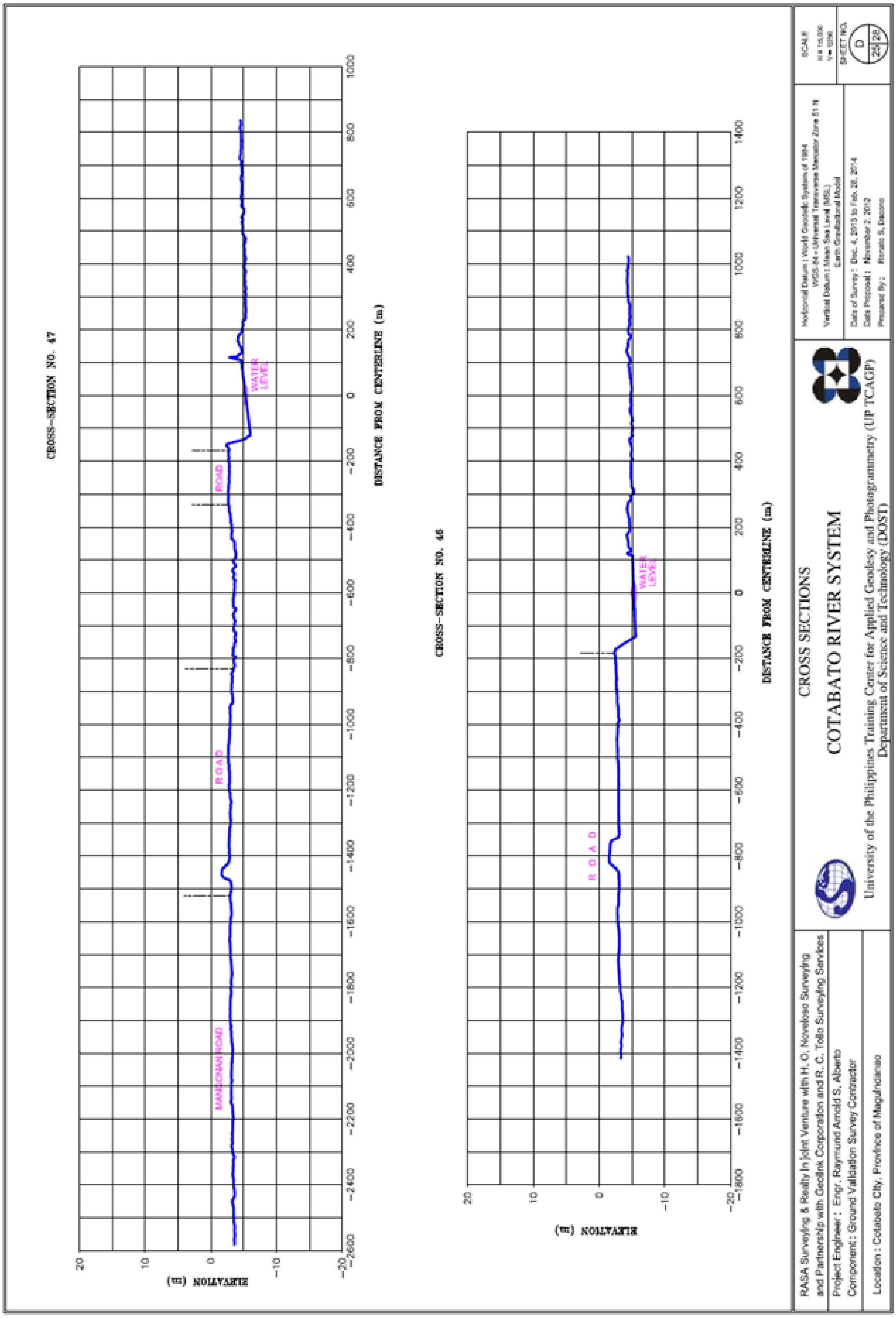

CROSS-SECTION NO. 40
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
WATER LEVEL
20
10
0
−10
−20
−800
−600
−400
−200
0
200
400
600
CROSS SECTIONS
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : Dec. 4, 2013 to Feb. 28, 2014
Date Proposed : November 2, 2012
SCALE
SHEET NO.
D
20
28
RASA Surveying & Realty in joint Venture with H. O. Novilloso Surveying
and Partnership with Geolink Corporation and R. C. Tolib Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao

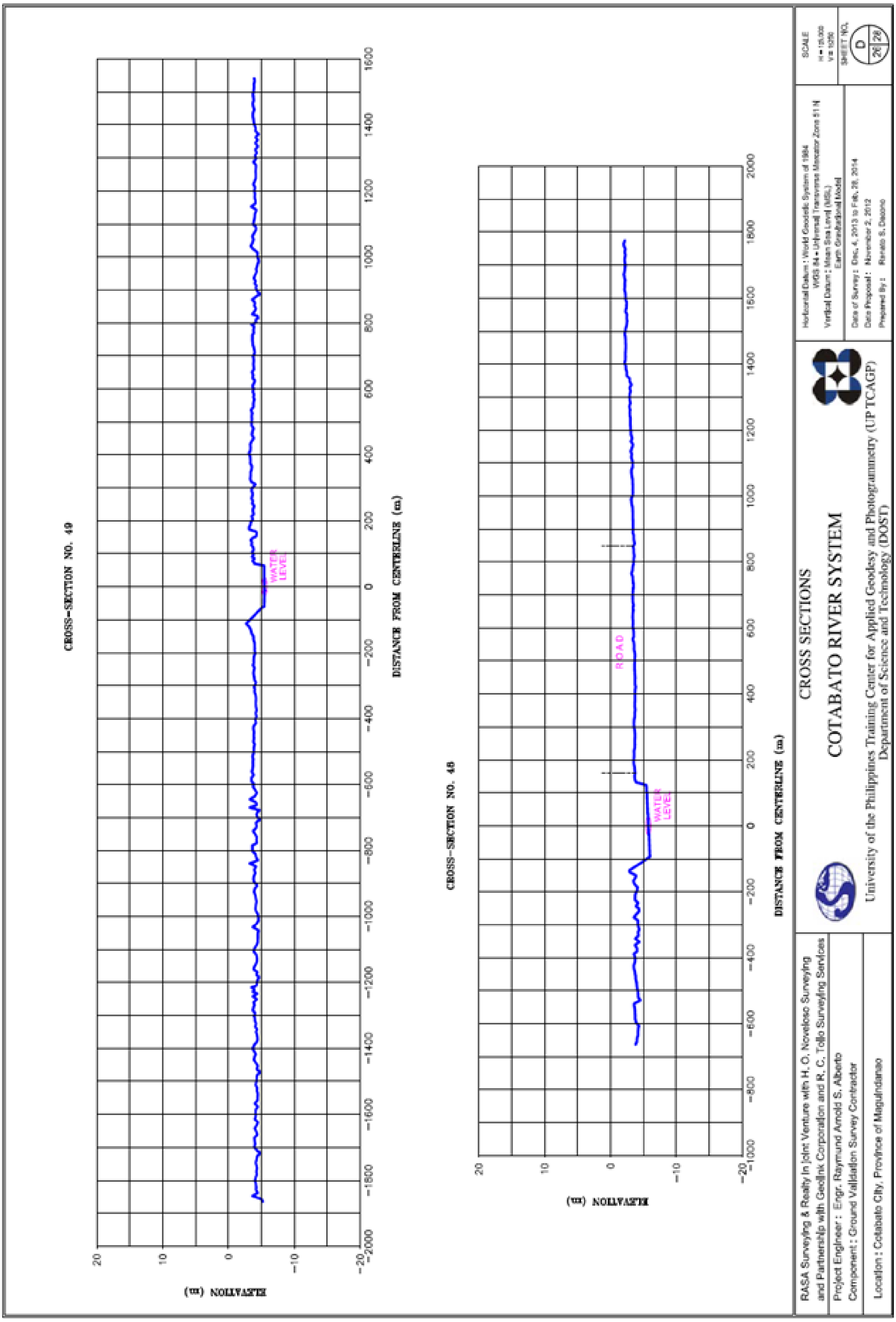

CROSS-SECTION NO. 41
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
ROAD
DELTA BRIDGE
WATER LEVEL
ROAD
QUEZON AVENUE
CROSS-SECTION NO. 41
R. RABACO SR. AVE.
1ST STREET
NOTRE DAME AVE.
BADOY STREET
S. PENDATUN ST
UNDER CONSTRUCTION BRIDGE
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
CROSS SECTIONS
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
WGS 84 ◆ Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : Dec. 4, 2013 to Feb. 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Dacono
SCALE
SHEET NO.
D
21
28

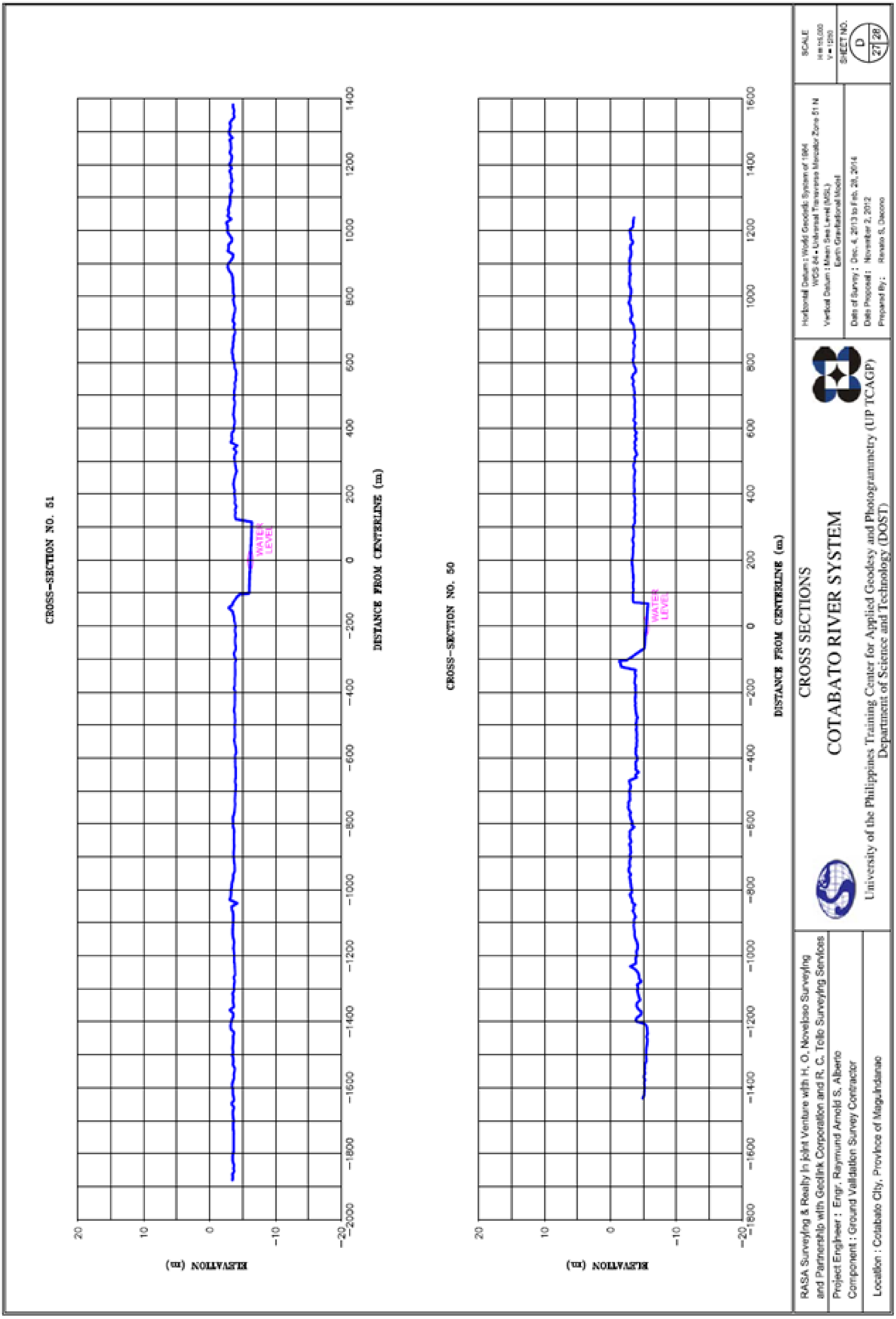

CROSS-SECTION NO. 43
CROSS-SECTION NO. 42
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
ROAD
WATER LEVEL
QUEZON AVE.
MATAMPAY BR.
NOTRE DAME AVE.
CROSS SECTIONS
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
SCALE
SHEET NO.

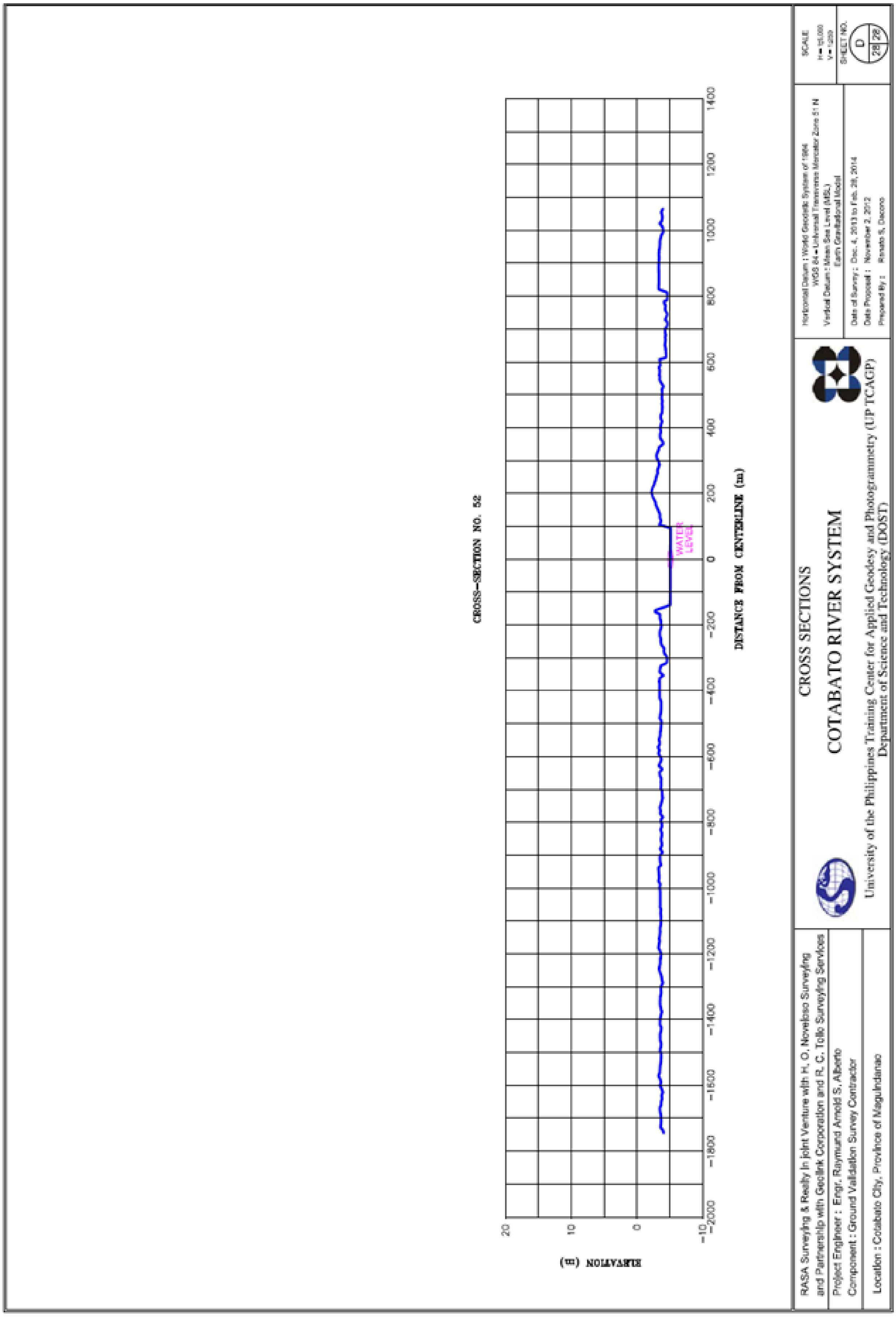

CROSS-SECTION NO. 44
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
QUEZON AVENUE
MAKAKUA STREET
RIVER
WATER LEVEL
R O A D
GRAVEL ROAD
SINSUAT AVENUE
CROSS SECTIONS
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in joint Venture with H. O. Novelloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Date of Survey : Dec. 4, 2013 to Feb. 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Dacono
SCALE
SHEET NO.


CROSS-SECTION NO. 45
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
MABINI STREET
WATER LEVEL
R O A D
CROSS-SECTION NO. 45
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
DON TEODORO V. JULIANO AVE.
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
CROSS SECTIONS
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : Dec. 4, 2013 to Feb. 28, 2014
Date Proposal : November 2, 2012
SCALE
SHEET NO.
D
24
28

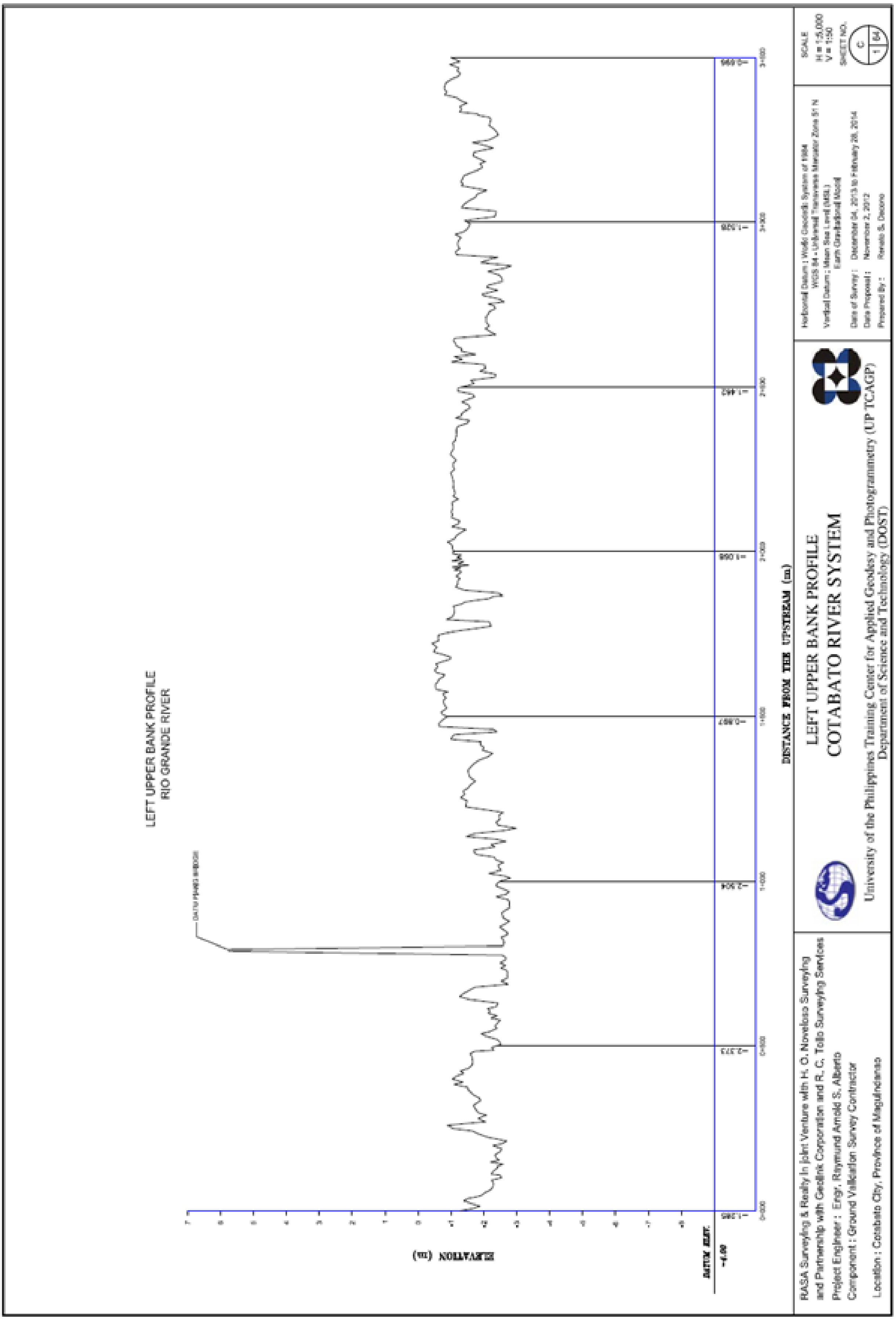

CROSS-SECTION NO. 47
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
WATER LEVEL
ROAD
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
WATER LEVEL
R O A D
CROSS SECTIONS
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty In Joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao

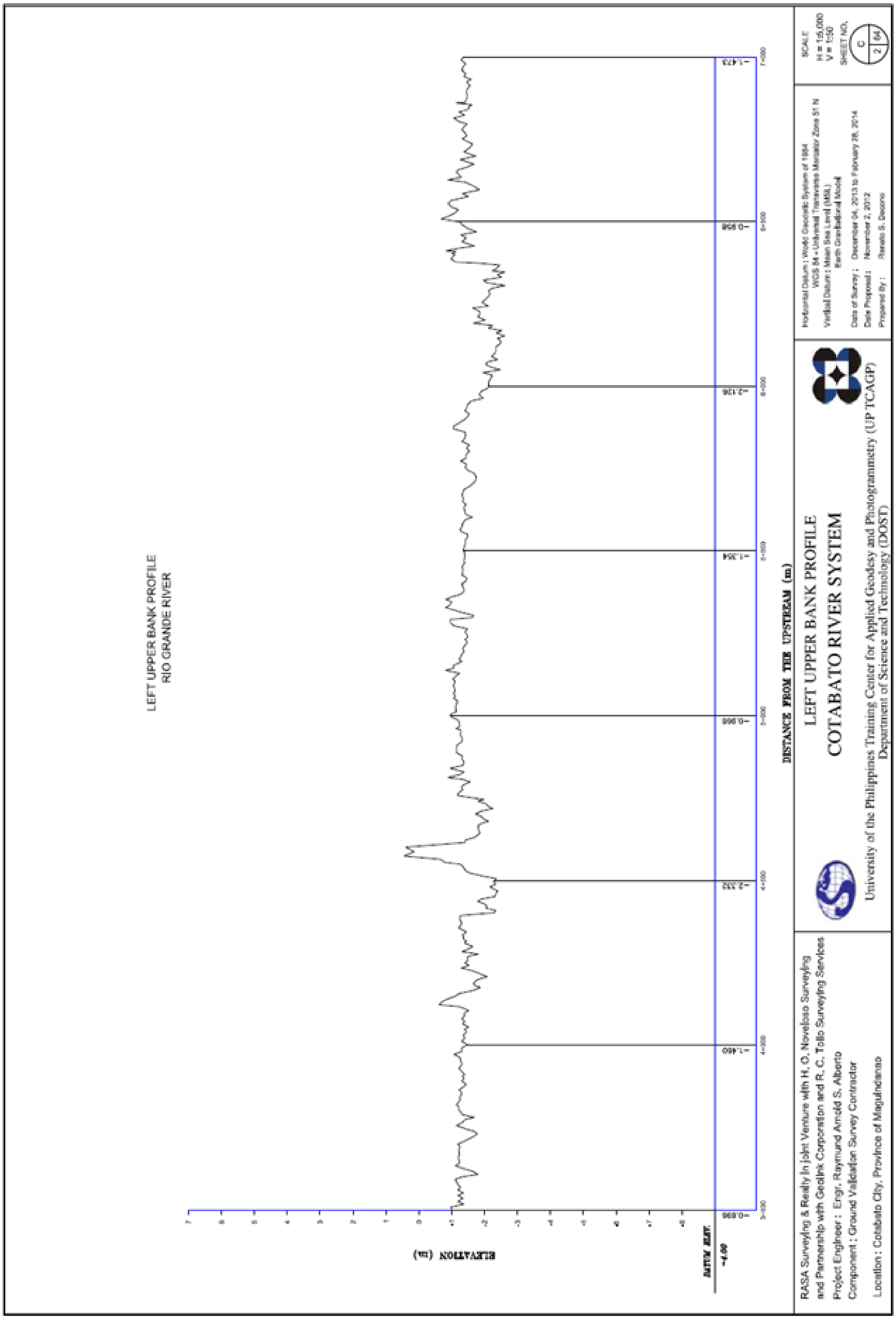

CROSS-SECTION NO. 49
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
WATER LEVEL
CROSS-SECTION NO. 48
ROAD
WATER LEVEL
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
CROSS SECTIONS
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Toljo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
SCALE
SHEET NO.
D

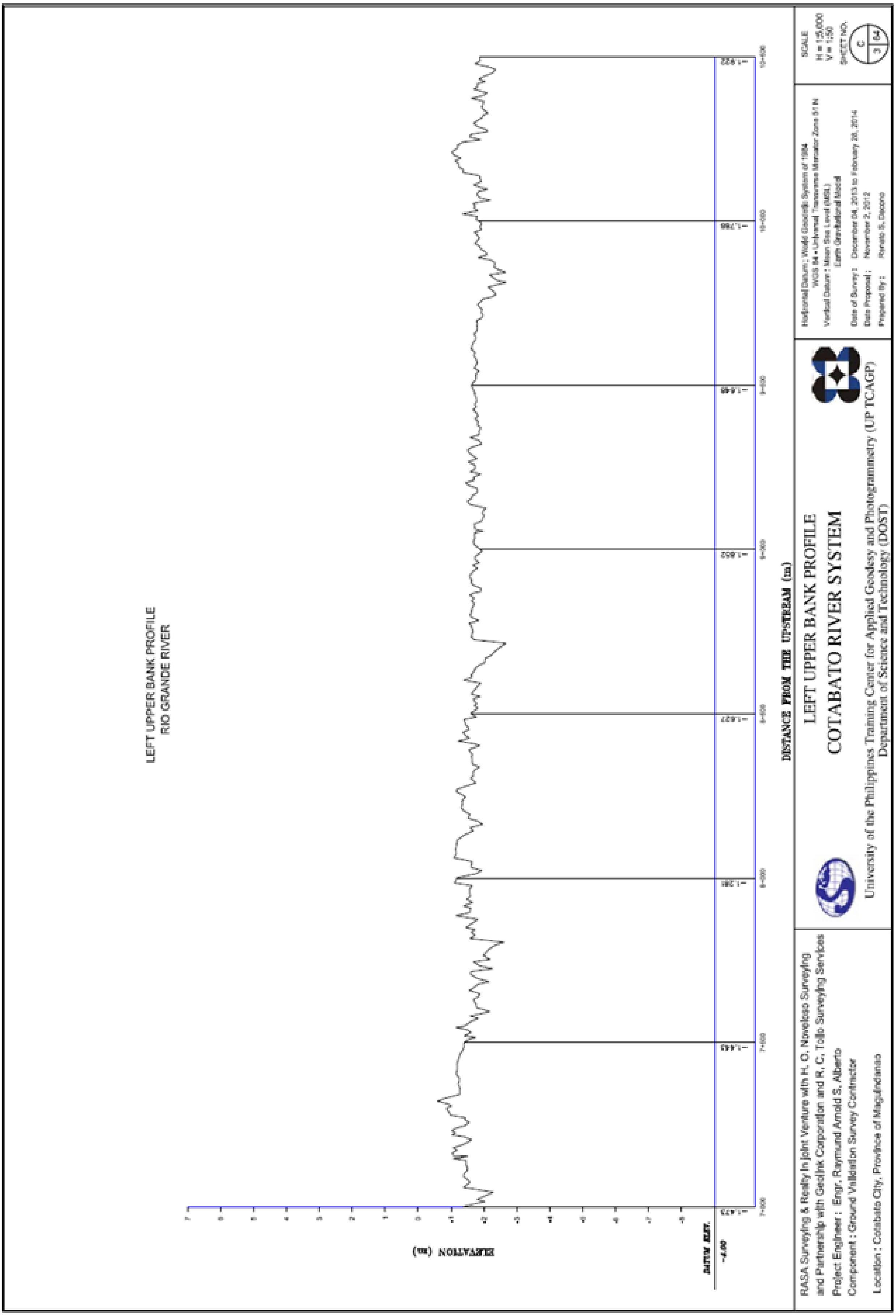

CROSS-SECTION NO. 51
CROSS-SECTION NO. 50
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
WATER LEVEL
CROSS SECTIONS
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in joint Venture with H. O. Novelozo Surveying and Partnership with Geolink Corporation and R. C. Tello Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
SCALE
SHEET NO.
D
27
28


CROSS-SECTION NO. 52
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
WATER LEVEL
CROSS SECTIONS
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Horizontal Datum : World Geodetic System of 1984
WGS 84 – Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : Dec. 4, 2013 to Feb. 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Dacono
SCALE
SHEET NO.
D
28 28

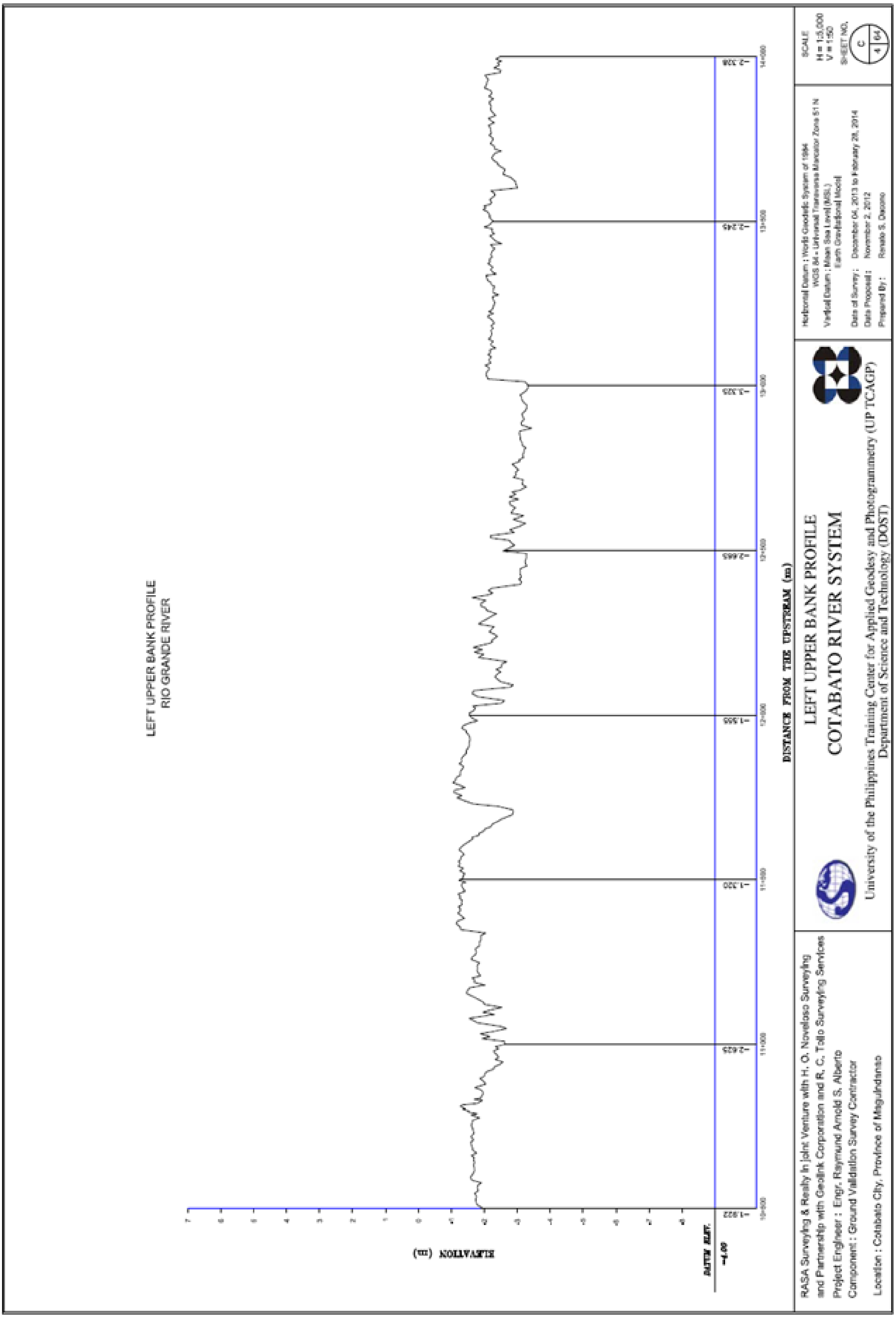
RIVER PROFILE

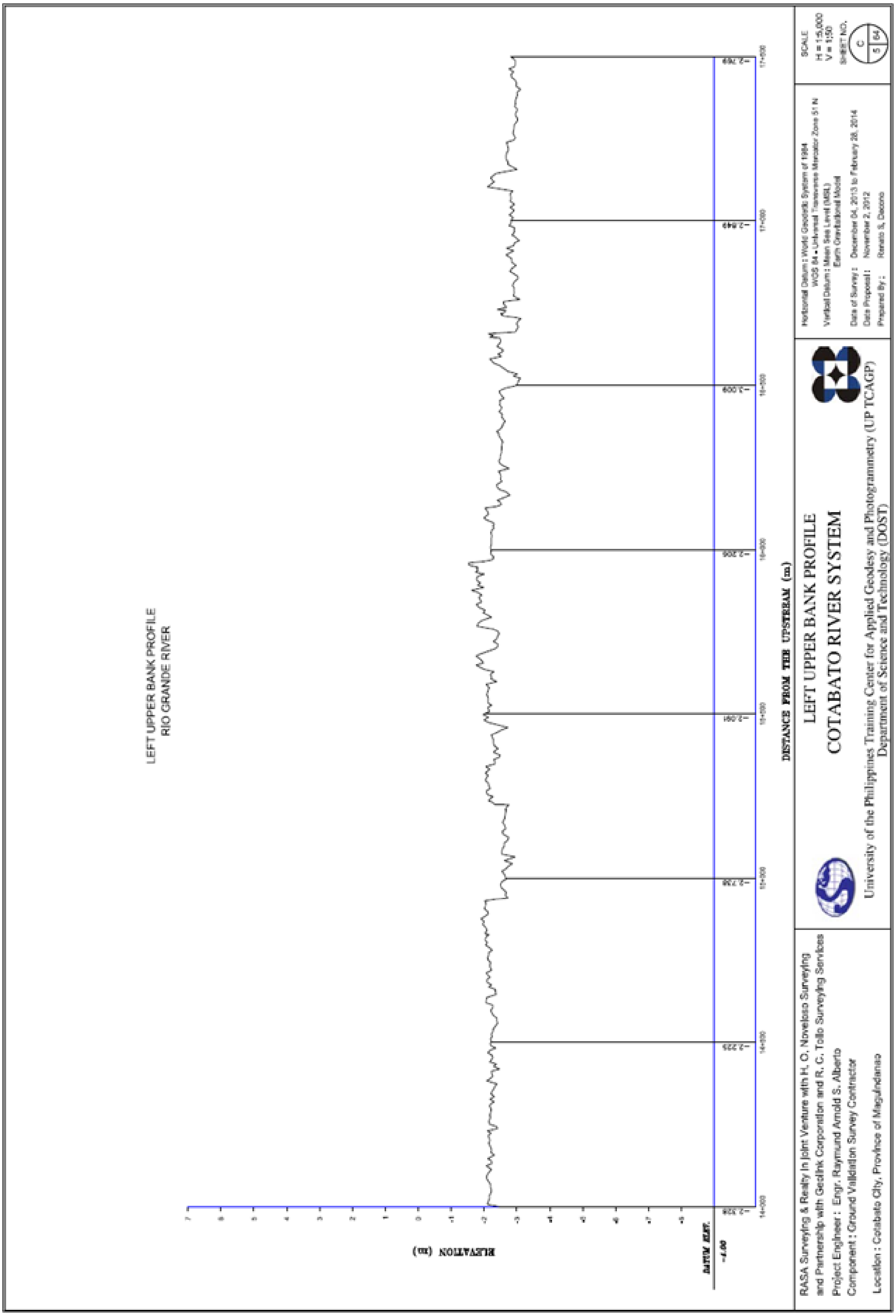



LEFT UPPER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DISTANCE FROM THE UPSTREAM (m)
LEFT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Navelbso Surveying
and Partnership with Geolink Corporation and R. C. Tolib Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
SCALE
H = 1:5,000
V = 1:50
SHEET NO.



LEFT UPPER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
DISTANCE FROM THE UPSTREAM (m)
LEFT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Novelozo Surveying and Partnership with Geolink Corporation and R. C. Tolja Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Diocono
SCALE
H = 1:5,000
V = 1:50
SHEET NO.


LEFT UPPER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
-4.00
DISTANCE FROM THE UPSTREAM (m)
LEFT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Data Proposal : November 2, 2012
Prepared By : Renato S. Dacono
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
C
4
64


LEFT UPPER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
-4.00
DISTANCE FROM THE UPSTREAM (m)
LEFT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty In Joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Horizontal Datum : World Geodetic System of 1984
WGS 84 • Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Decono
SCALE
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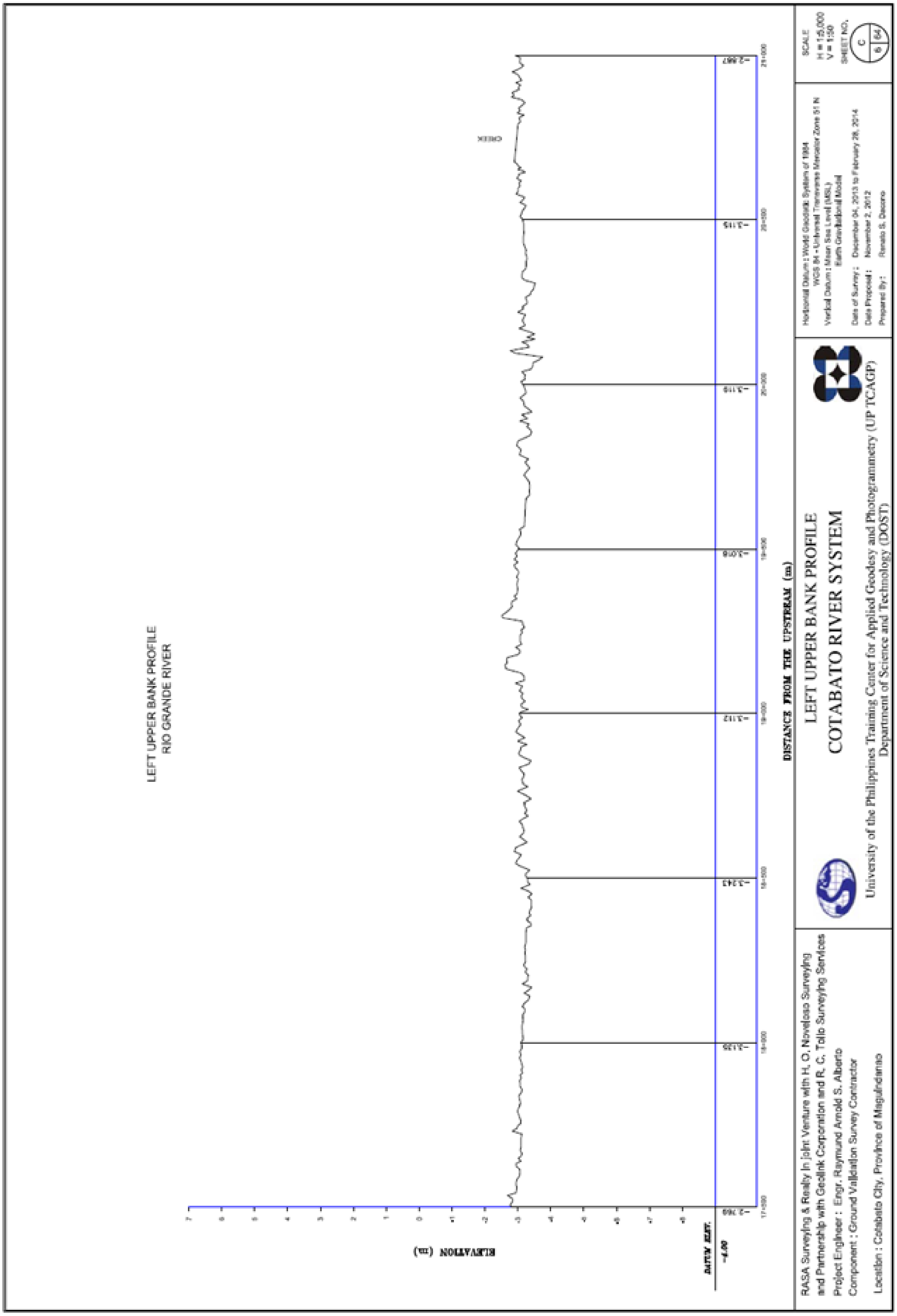
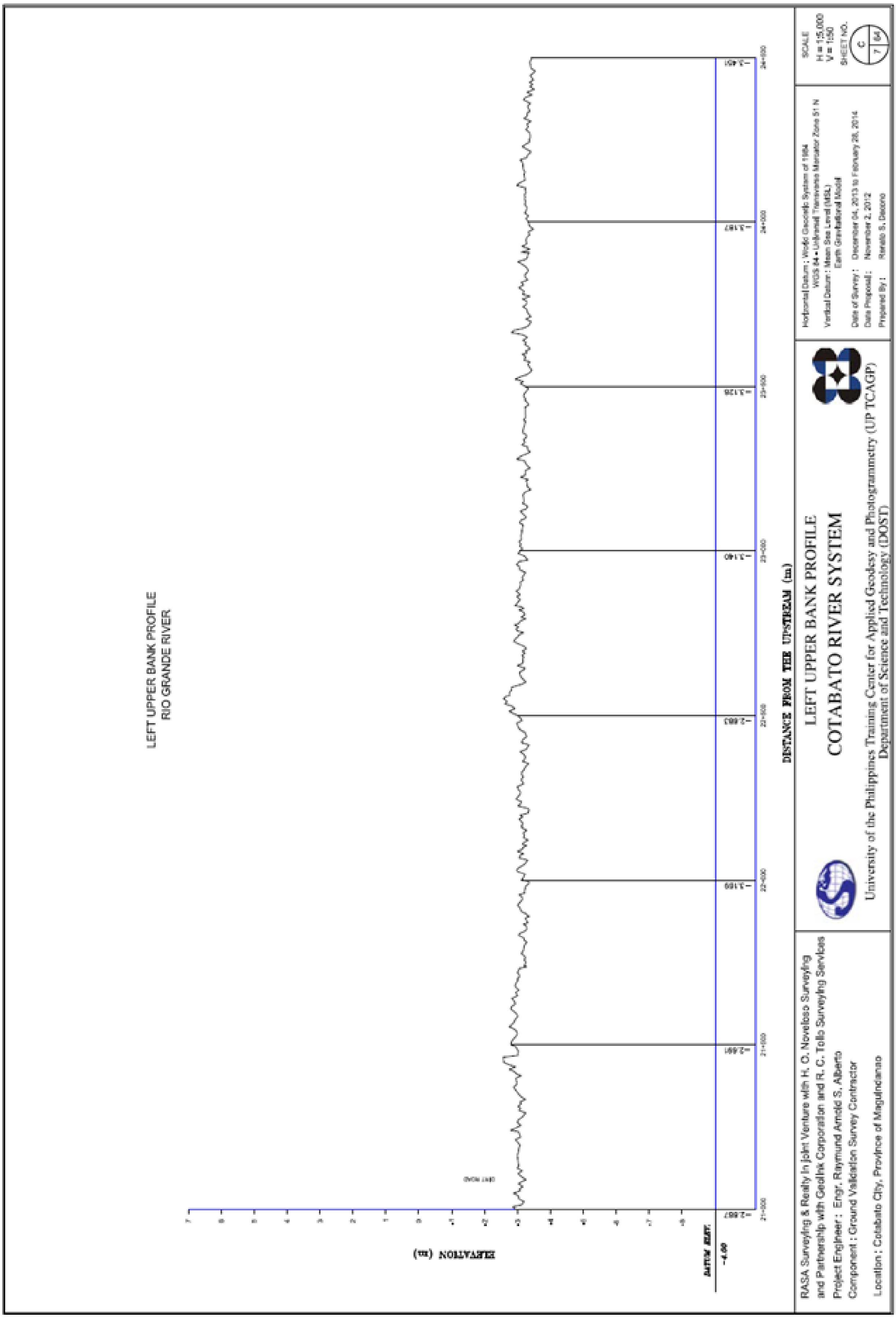
V = 150
SHEET NO.



LEFT UPPER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
-4.00
CREEK
-2.769
-3.135
-3.243
-3.112
-3.018
-3.119
-3.115
-2.887
17+500
18+000
18+500
19+000
19+500
20+000
20+500
21+000
DISTANCE FROM THE UPSTREAM (m)
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tolio Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
LEFT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Dacono
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
C
6
64


LEFT UPPER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
-4.00
DISTANCE FROM THE UPSTREAM (m)
LEFT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty In joint Venture with H. O. Noveloso Surveying
and Partnership with Geolink Corporation and R. C. Tello Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Data Proposal : November 2, 2012
Prepared By : Renato S. Dicono
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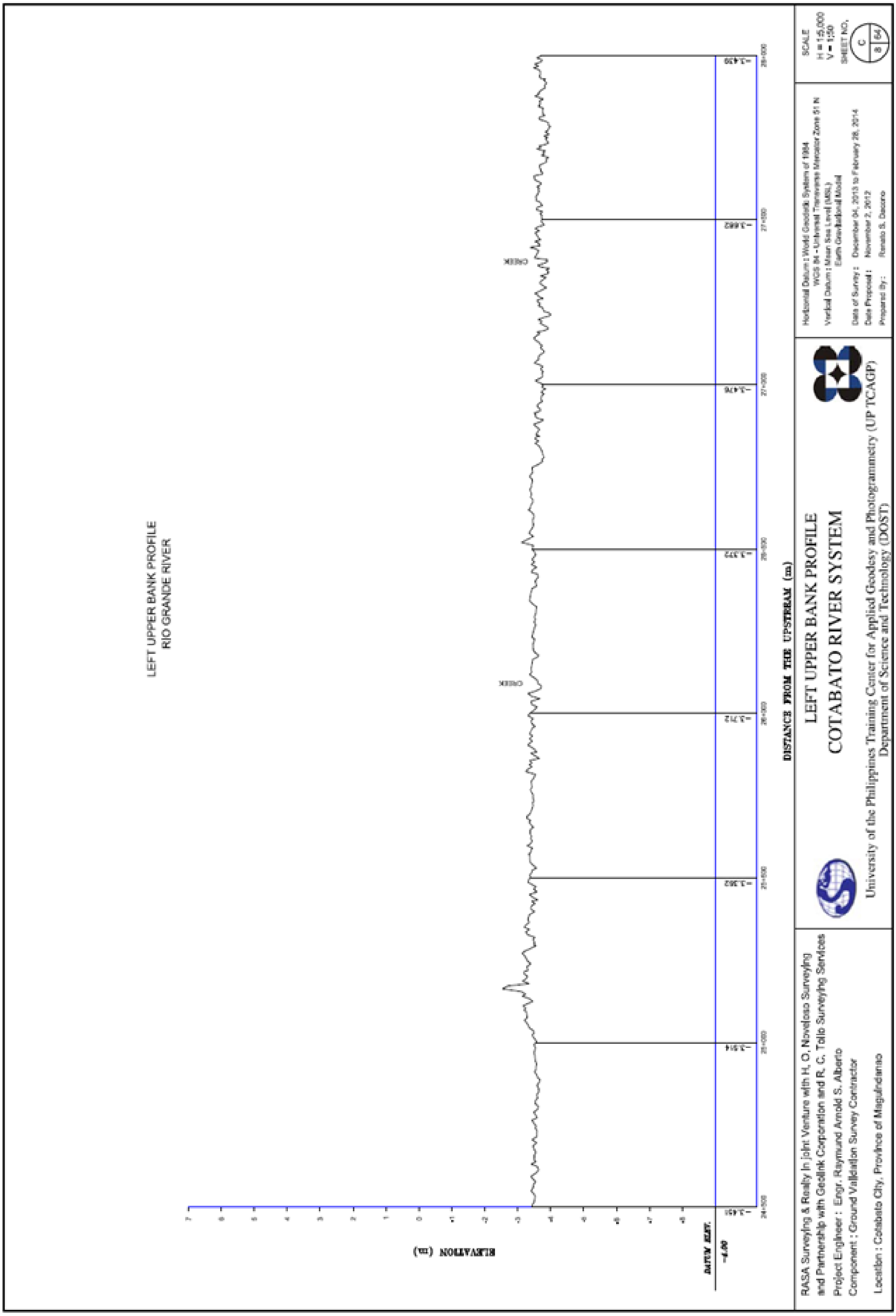
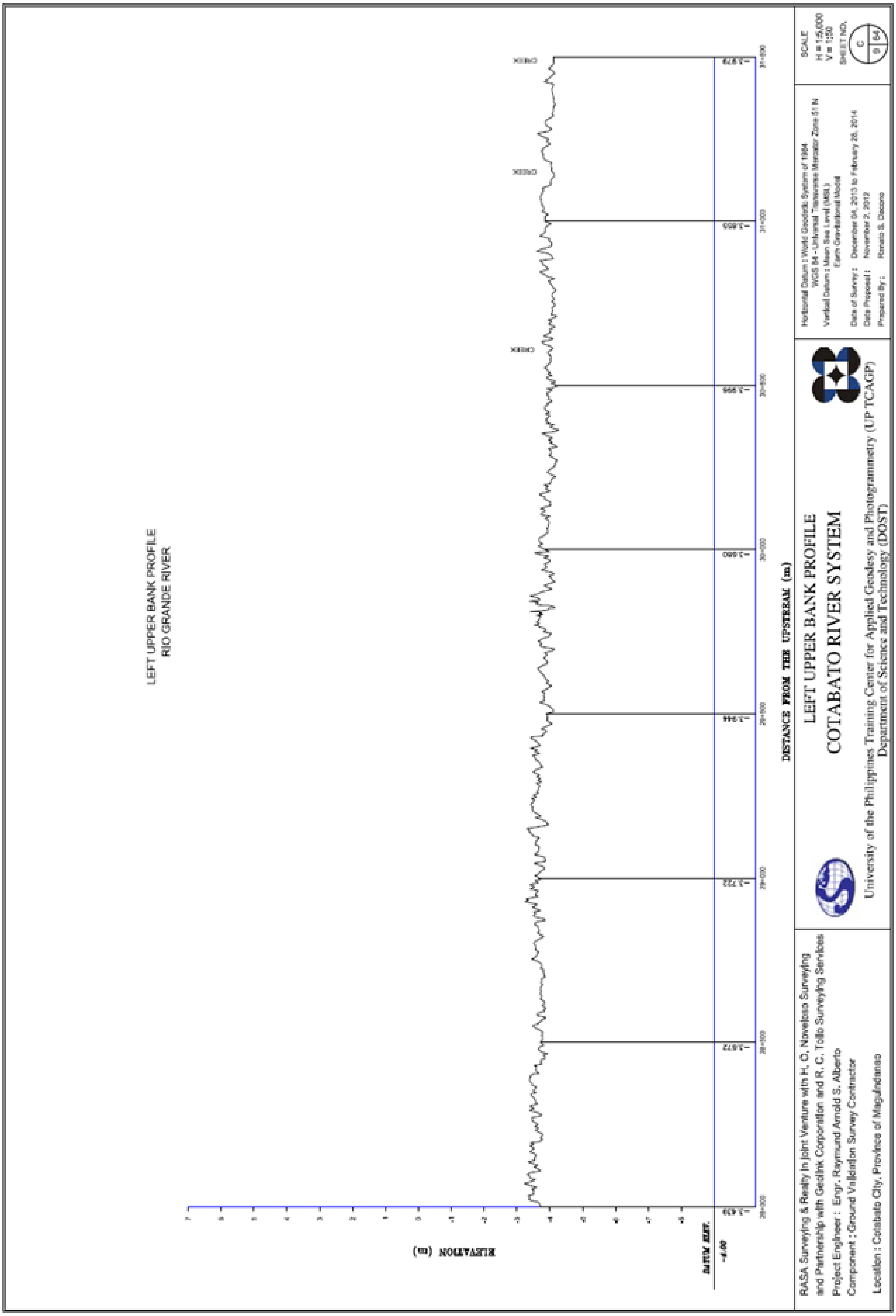
SHEET NO.


LEFT UPPER BANK PROFILE
RIO GRANDE RIVER
CREEK
CREEK
ELEVATION (m)
DATUM ELEV.
-4.00
DISTANCE FROM THE UPSTREAM (m)
LEFT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying
and Partnership with Geolink Corporation and R. C. Tallo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Dacono
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
C
8 | 54


LEFT UPPER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
-4.00
CREEK
CREEK
CREEK
DISTANCE FROM THE UPSTREAM (m)
LEFT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. C. Novelozo Surveying
and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Date Proposed : November 2, 2012
Prepared By : Renato B. Dacono
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
C
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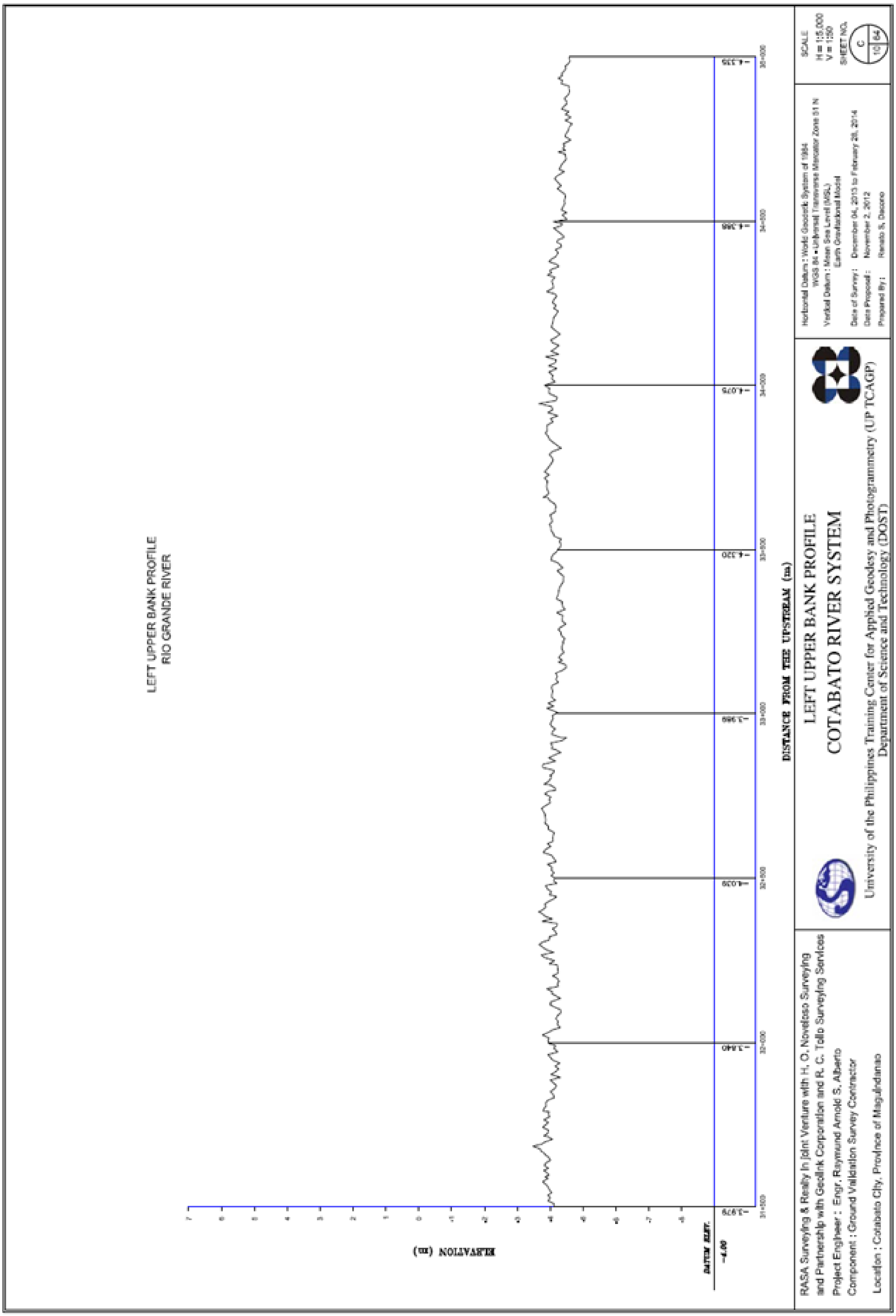
LEFT UPPER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
-4.00
DISTANCE FROM THE UPSTREAM (m)
LEFT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Novelozo Surveying and Partnership with GeoInk Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
C
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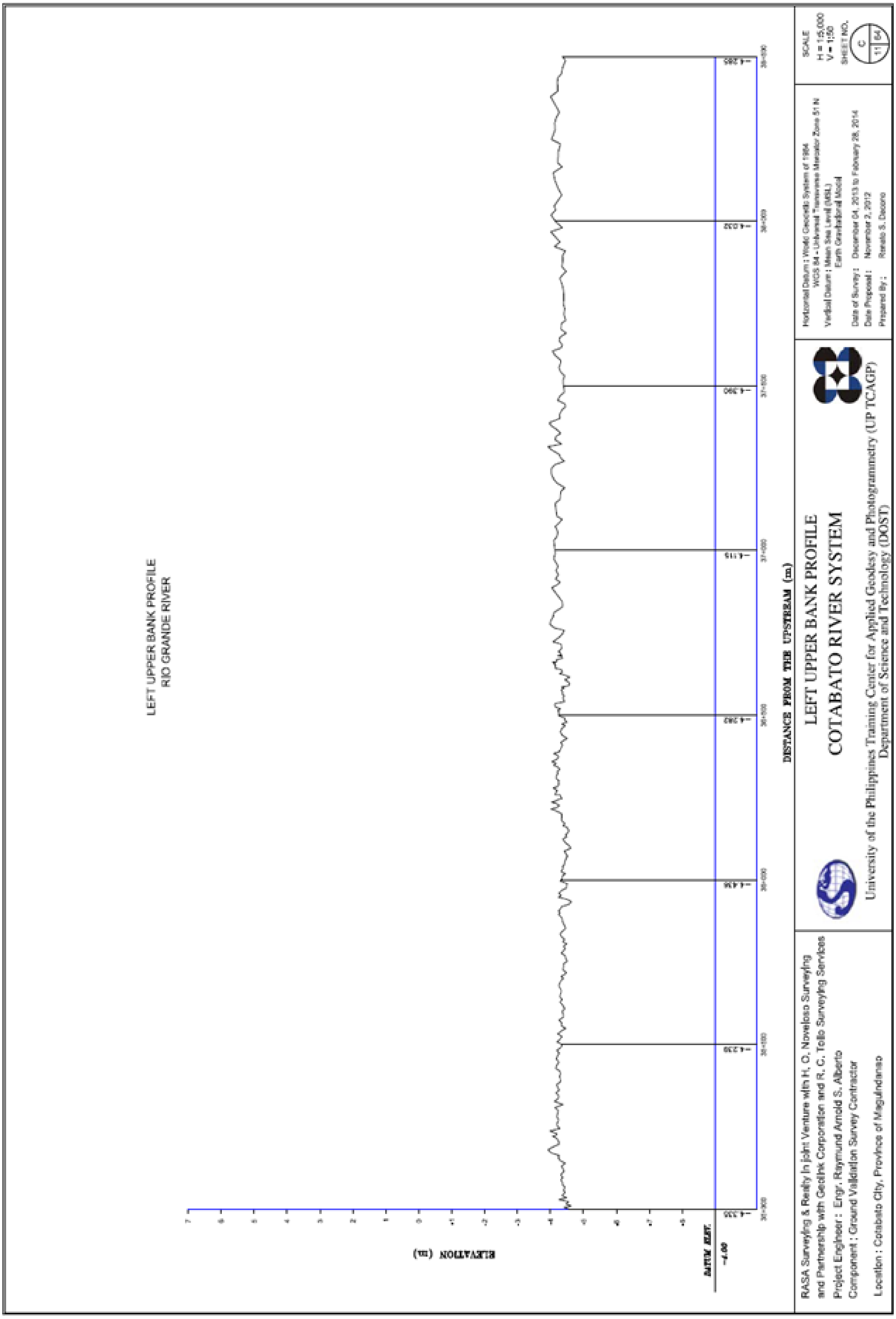
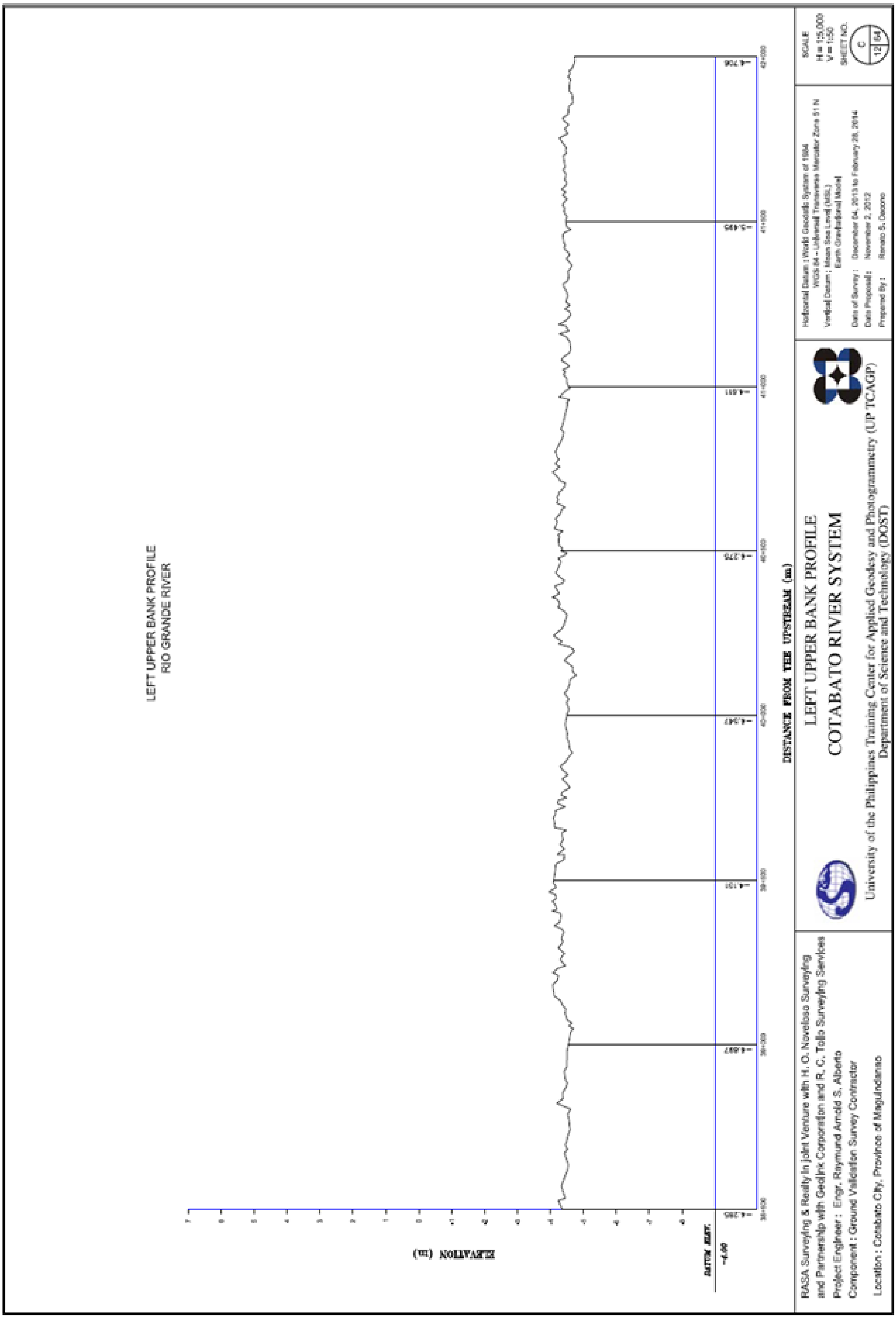
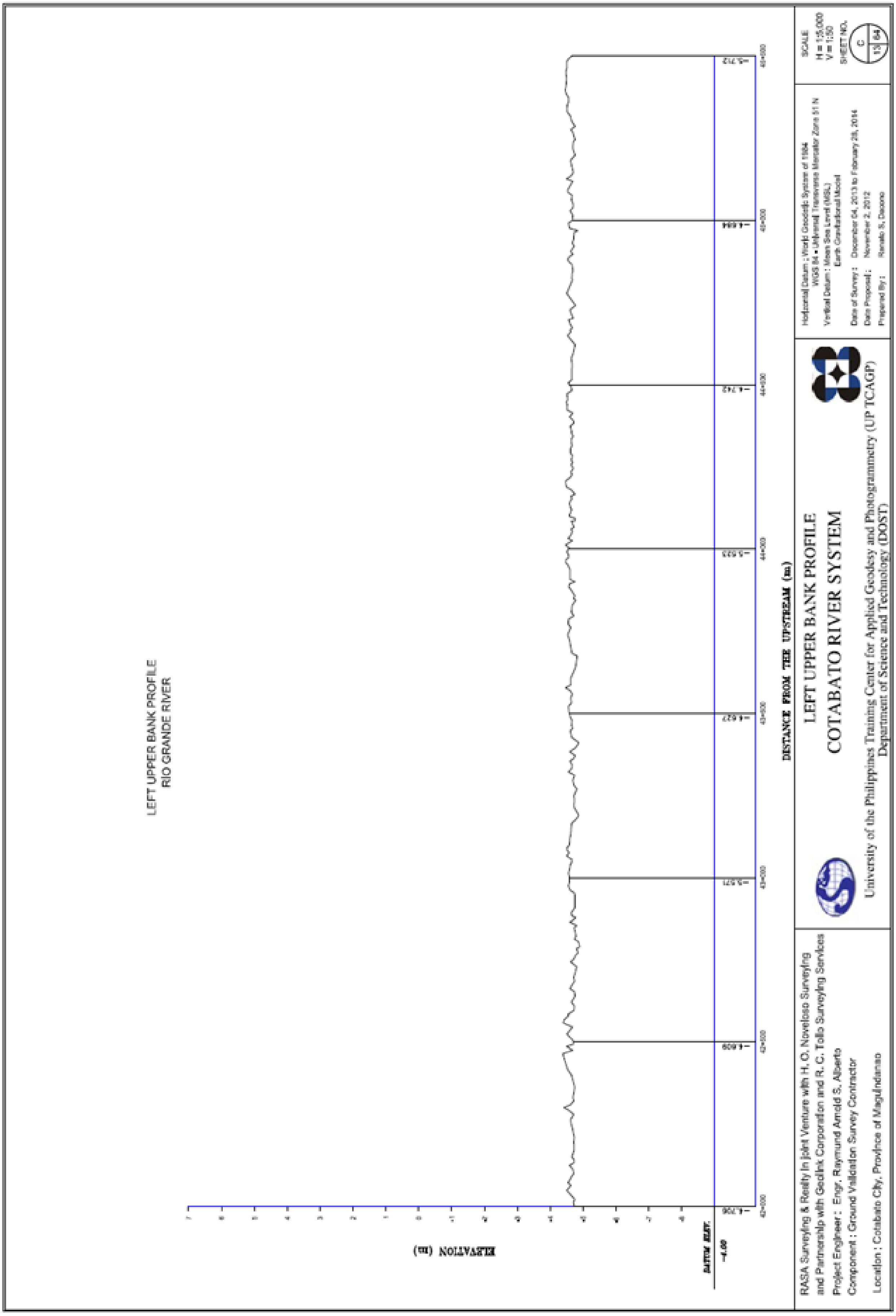
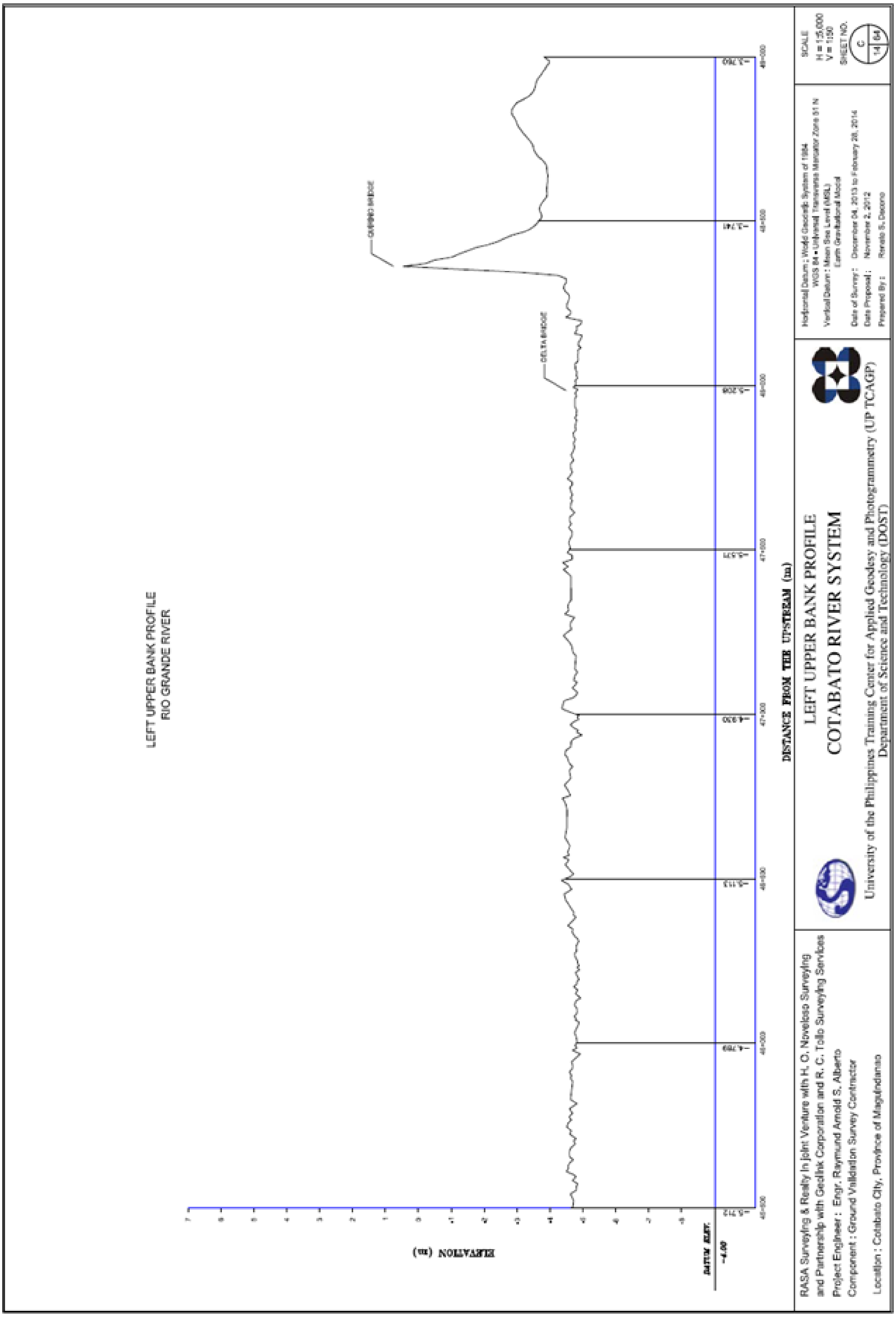
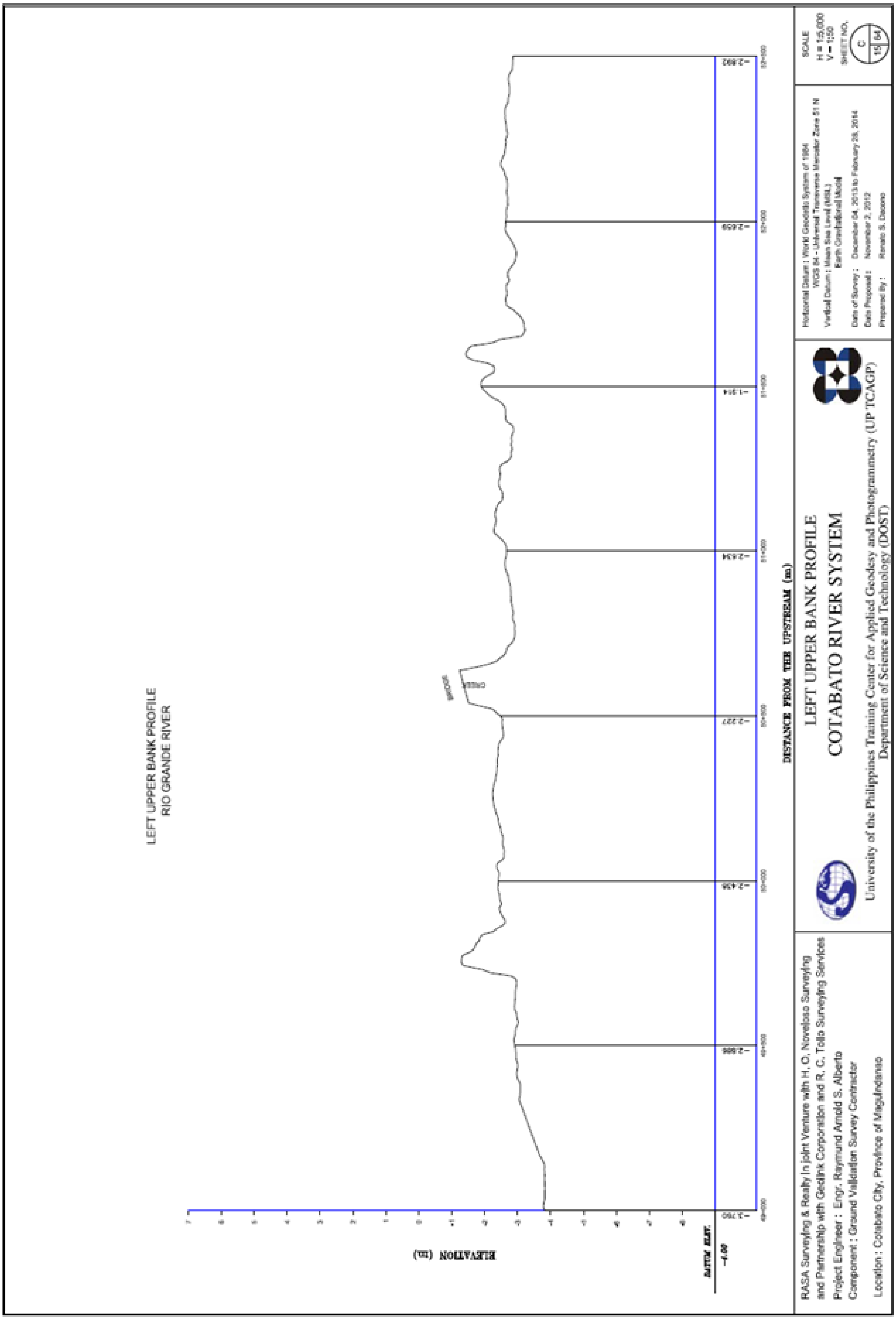

LEFT UPPER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
DISTANCE FROM THE UPSTREAM (m)
LEFT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying
and Partnership with Geolink Corporation and R. C. Tello Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Date of Survey : December 04, 2013 to February 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Decono
SCALE
SHEET NO.

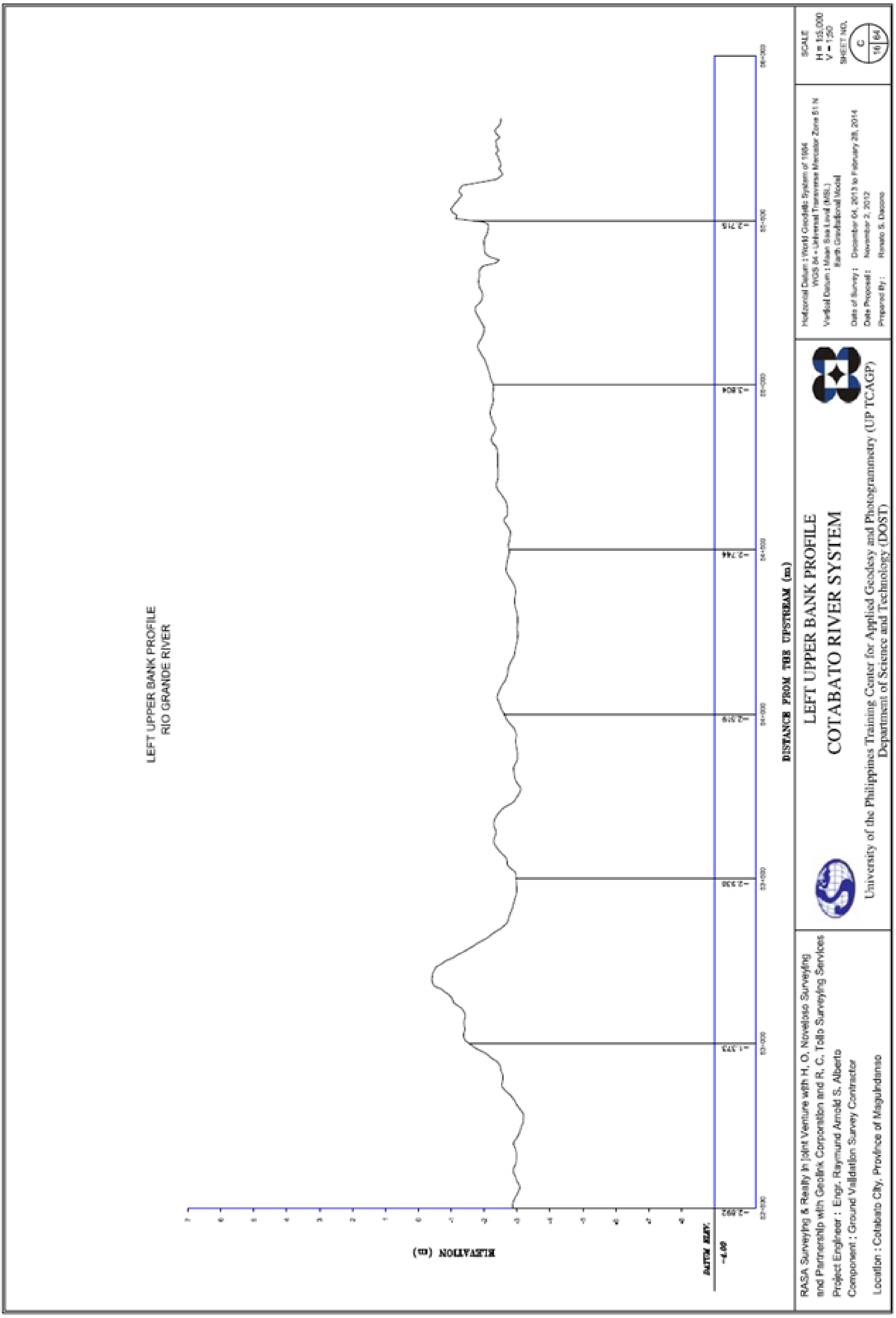

LEFT UPPER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
DISTANCE FROM THE UPSTREAM (m)
RASA Surveying & Realty in joint Venture with H. O. Novelozo Surveying
and Partnership with Geolink Corporation and R. C. Tolib Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
LEFT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Dacono
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
C
12
54

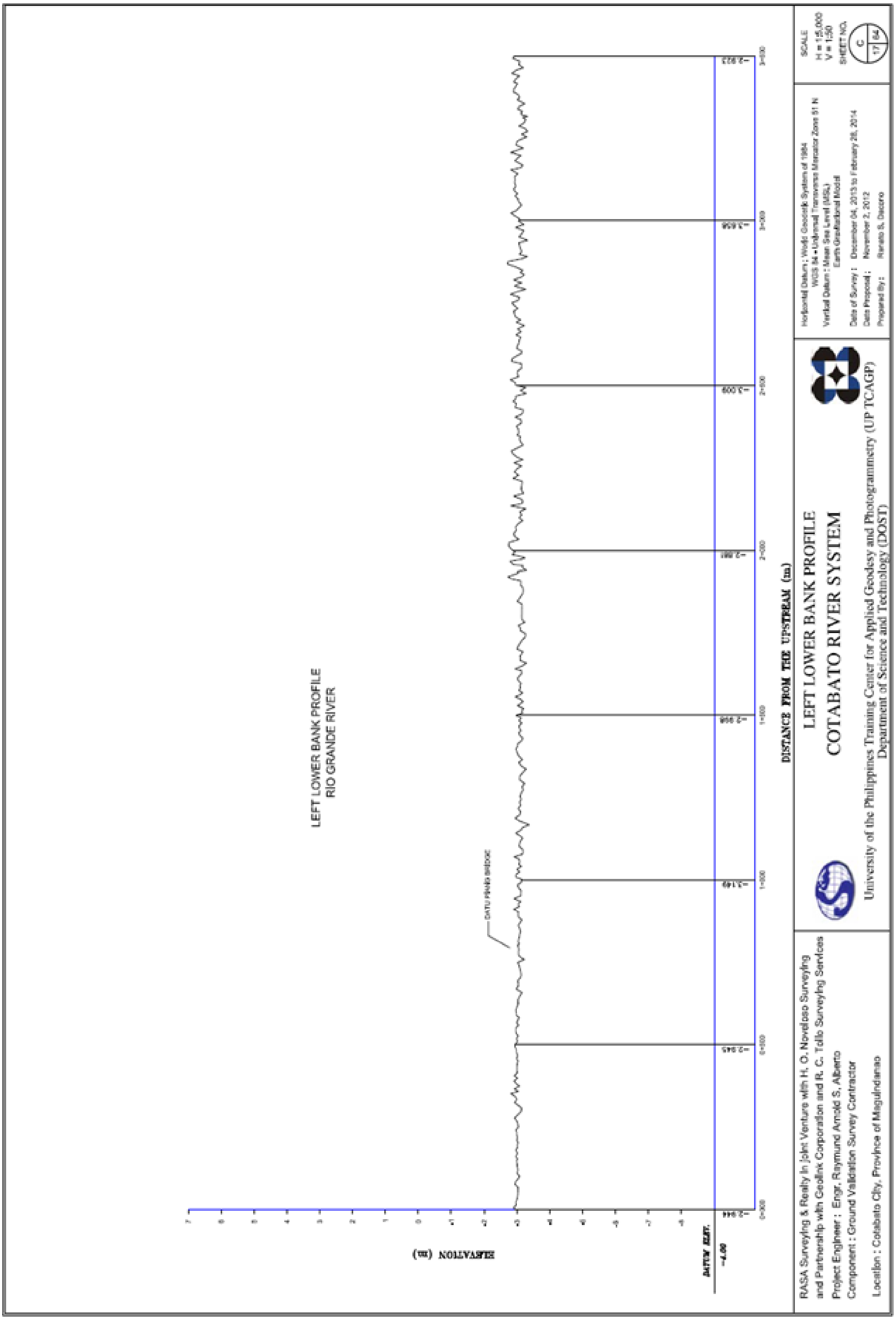

LEFT UPPER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DISTANCE FROM THE UPSTREAM (m)
LEFT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty In Joint Venture with H. O. Noveloso Surveying
and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao



LEFT UPPER BANK PROFILE
RIO GRANDE RIVER
DELTA BRIDGE
DATUM ELEV.
-4.00
ELEVATION (m)
DISTANCE FROM THE UPSTREAM (m)
LEFT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in joint Venture with H. O. Novelozo Surveying
and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Horizontal Datum : World Geodetic System of 1984
WGS 84 • Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Decena
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
C
14
64


LEFT UPPER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
-4.00
DISTANCE FROM THE UPSTREAM (m)
RASA Surveying & Realty In joint Venture with H. O. Novelozo Surveying
and Partnership with Geolink Corporation and R. C. Tello Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
LEFT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Date Proposed : November 2, 2012
Prepared By : Renato S. Dacono
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
C
15
64


LEFT UPPER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DISTANCE FROM THE UPSTREAM (m)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying
and Partnership with Geolink Corporation and R. C. Tolib Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
LEFT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
SCALE
SHEET NO.


LEFT LOWER BANK PROFILE
RIO GRANDE RIVER
DATU PIANG BRIDGE
ELEVATION (m)
DATUM ELEV.
-4.00
DISTANCE FROM THE UPSTREAM (m)
LEFT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Novelozo Surveying
and Partnership with Geolink Corporation and R. C. Tolio Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
SCALE
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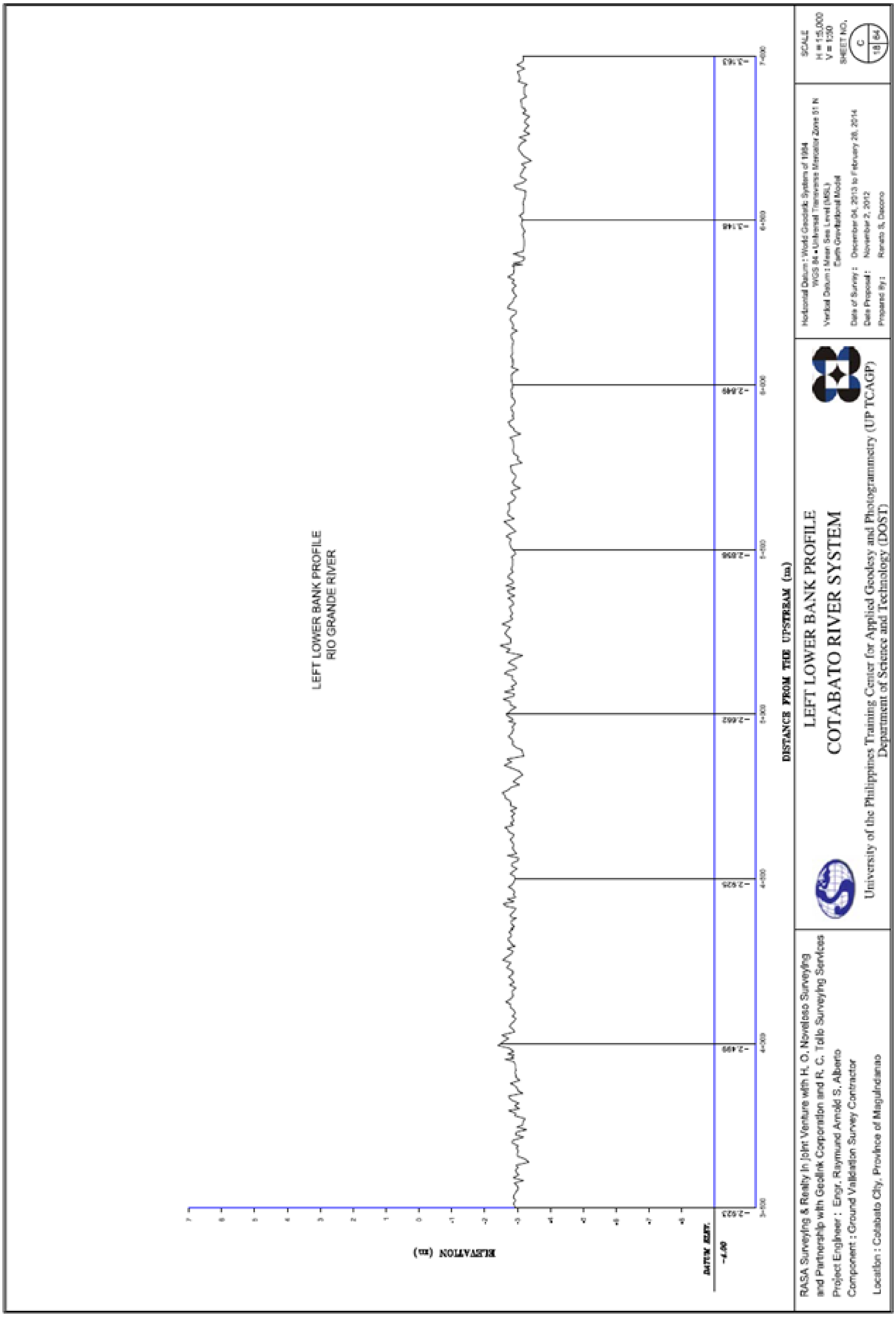
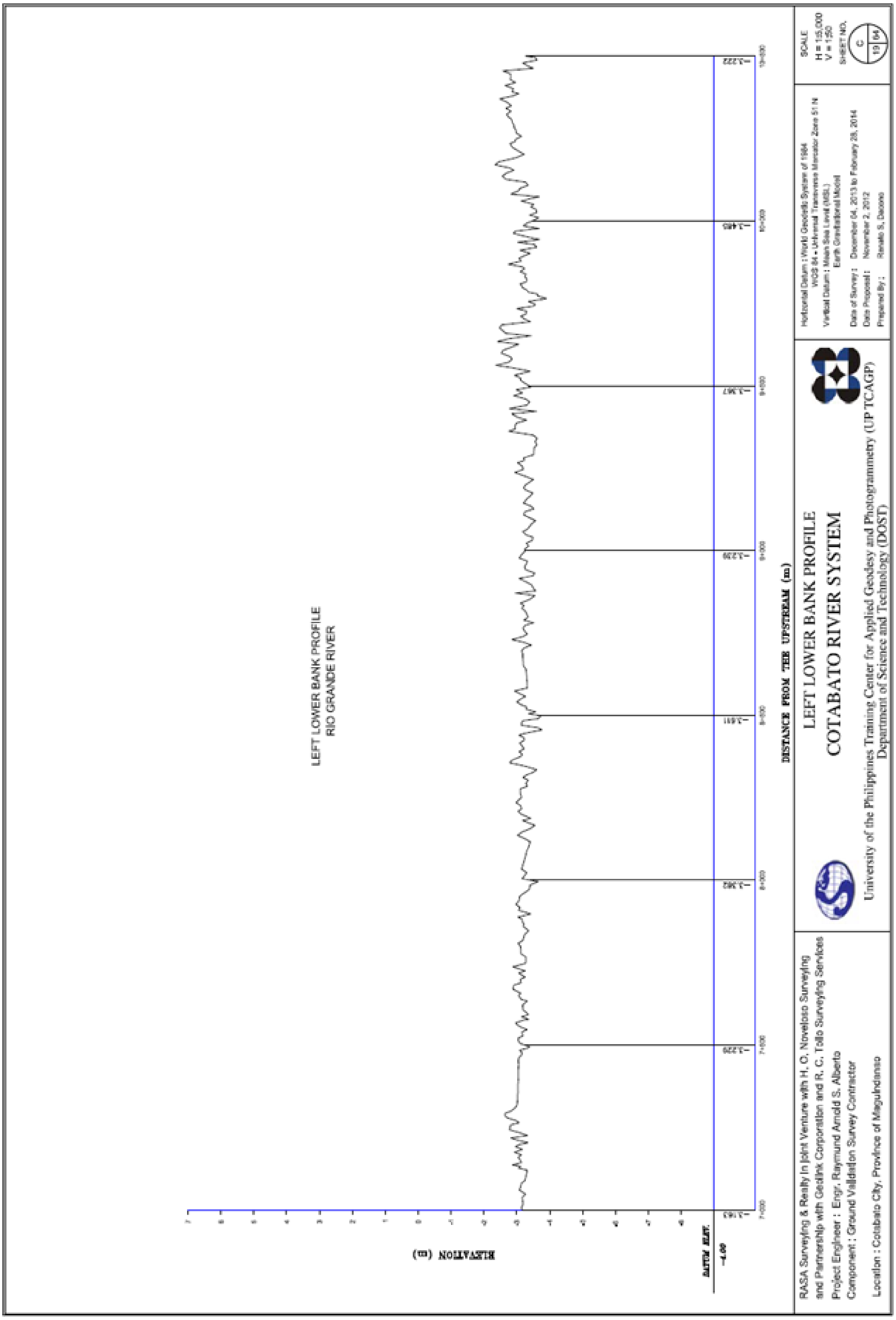
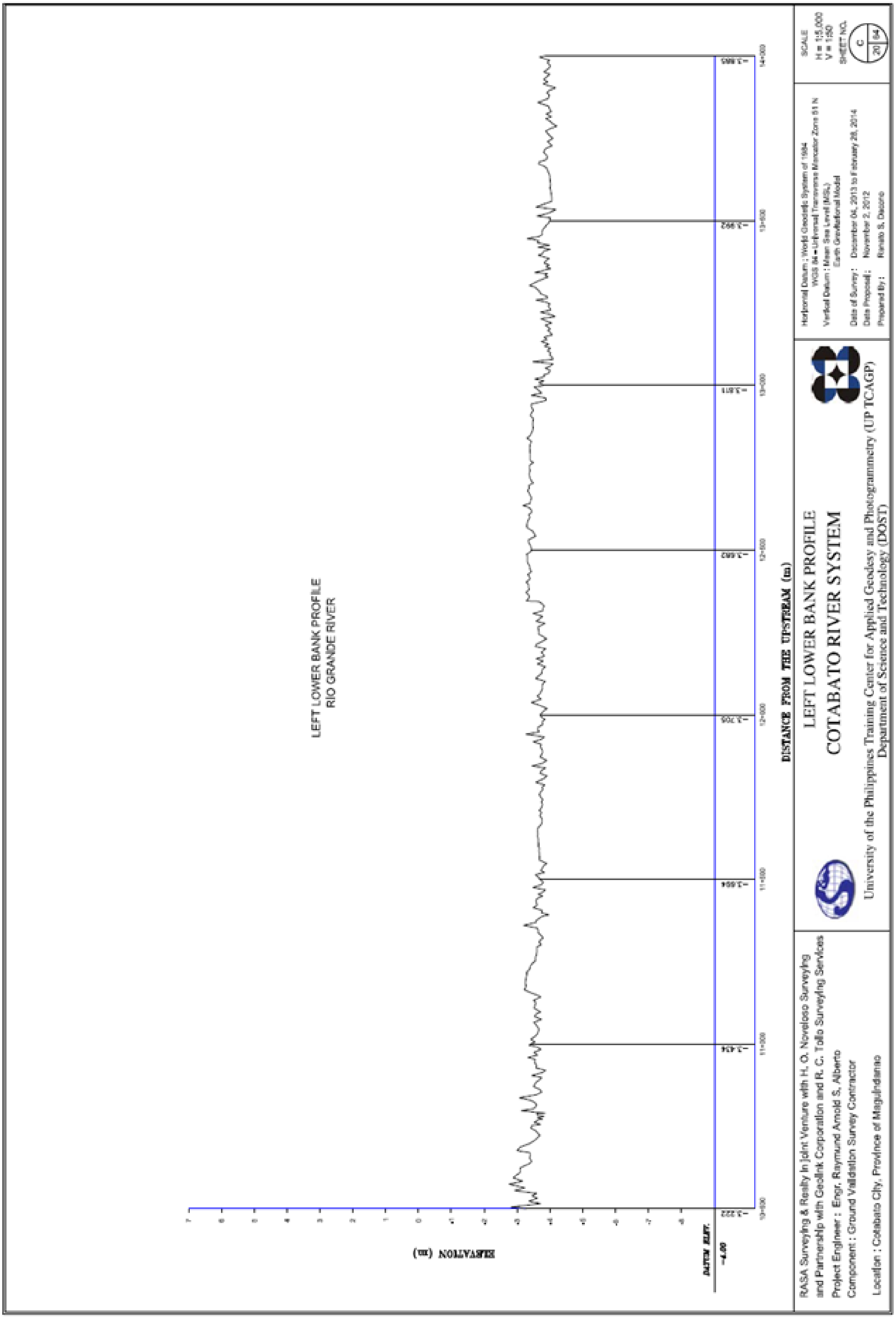
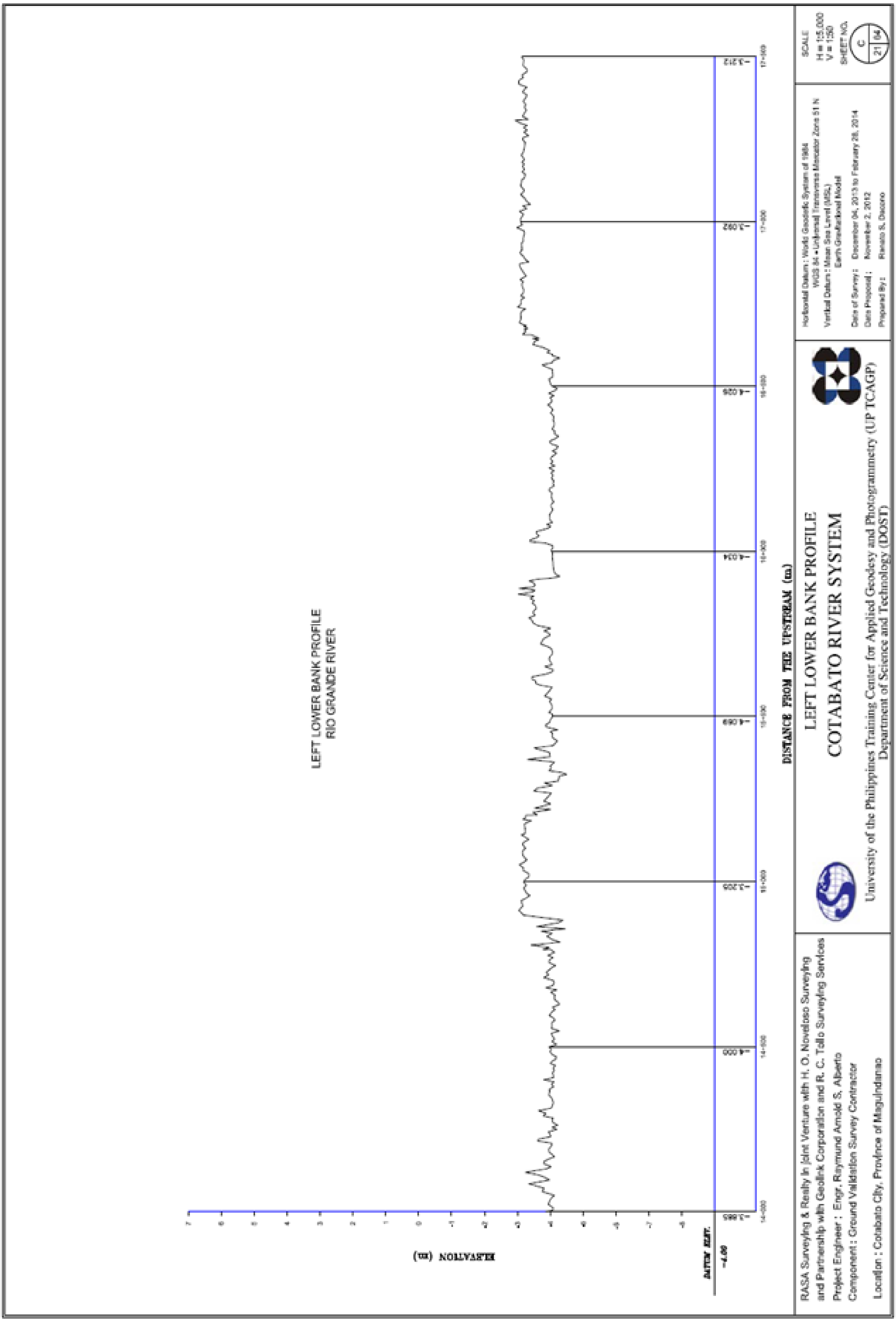
V = 1:50
SHEET NO.

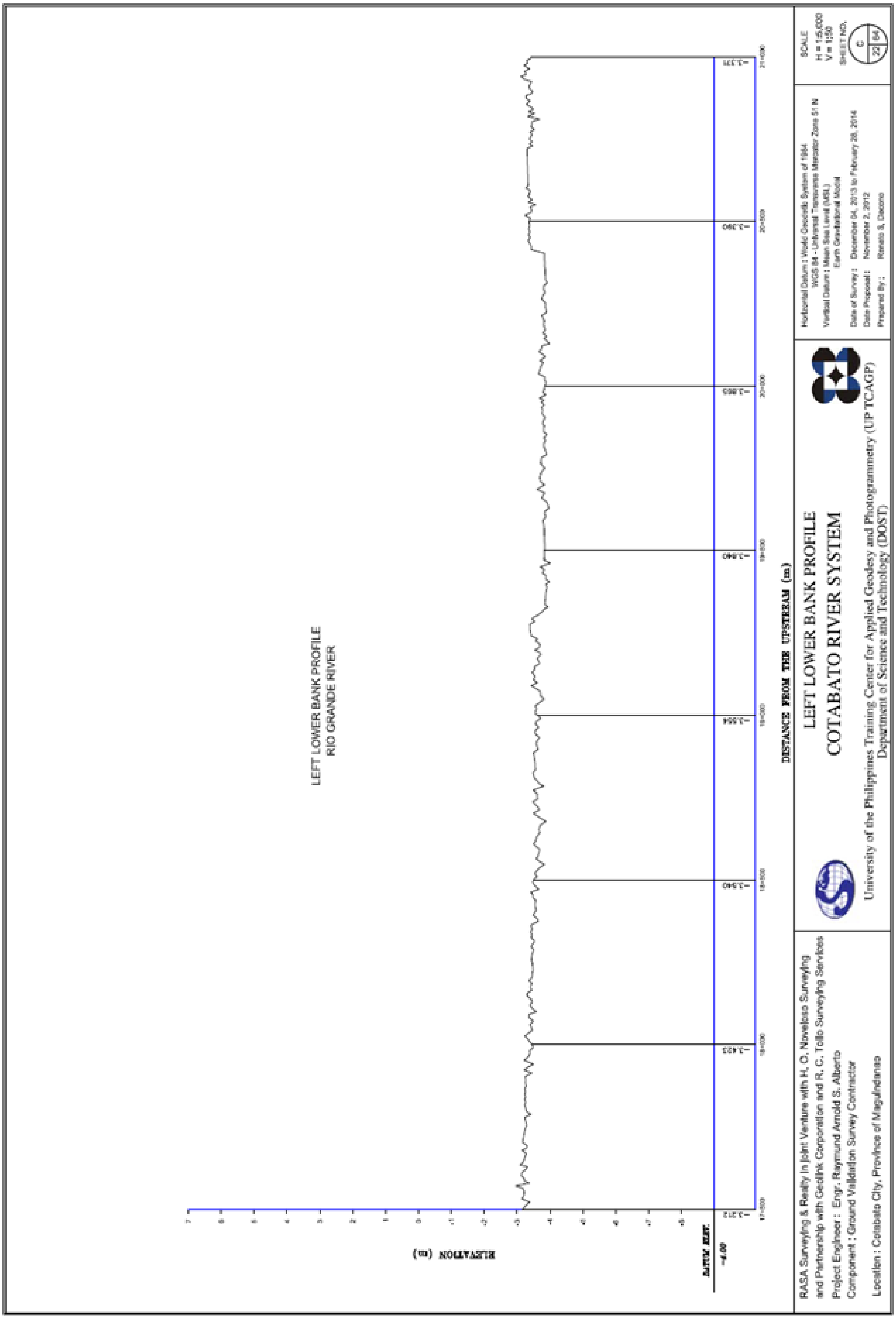

LEFT LOWER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
-4.00
DISTANCE FROM THE UPSTREAM (m)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying
and Partnership with Geolink Corporation and R. C. Tallo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
LEFT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
WGS 84 • Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Date Proposed : November 2, 2012
Prepared By : Renato S. Dacono
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
C
18 | 64


LEFT LOWER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DISTANCE FROM THE UPSTREAM (m)
LEFT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying
and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao


LEFT LOWER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
-4.00
DISTANCE FROM THE UPSTREAM (m)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying
and Partnership with GeoInk Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
LEFT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Date Proposed : November 2, 2012
Prepared By : Renato S. Dacono
SCALE
H = 1:5,000
V = 1:50
SHEET NO.



LEFT LOWER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DISTANCE FROM THE UPSTREAM (m)
LEFT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Novelboso Surveying
and Partnership with Geolink Corporation and R. C. Tello Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
SCALE
SHEET NO.


LEFT LOWER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
DISTANCE FROM THE UPSTREAM (m)
LEFT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Navejoso Surveying and Partnership with Geolink Corporation and R. C. Tolib Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Decano
SCALE
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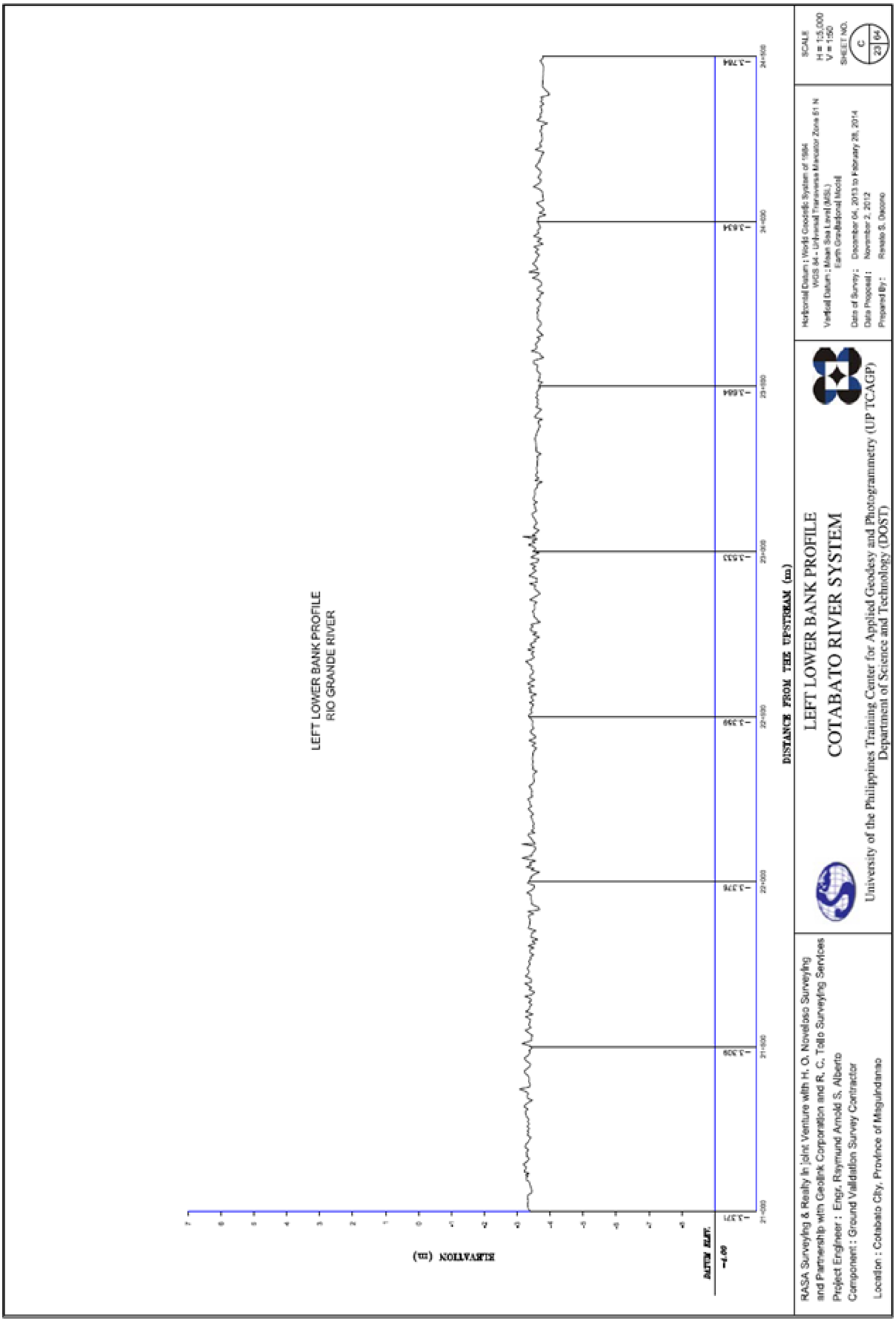
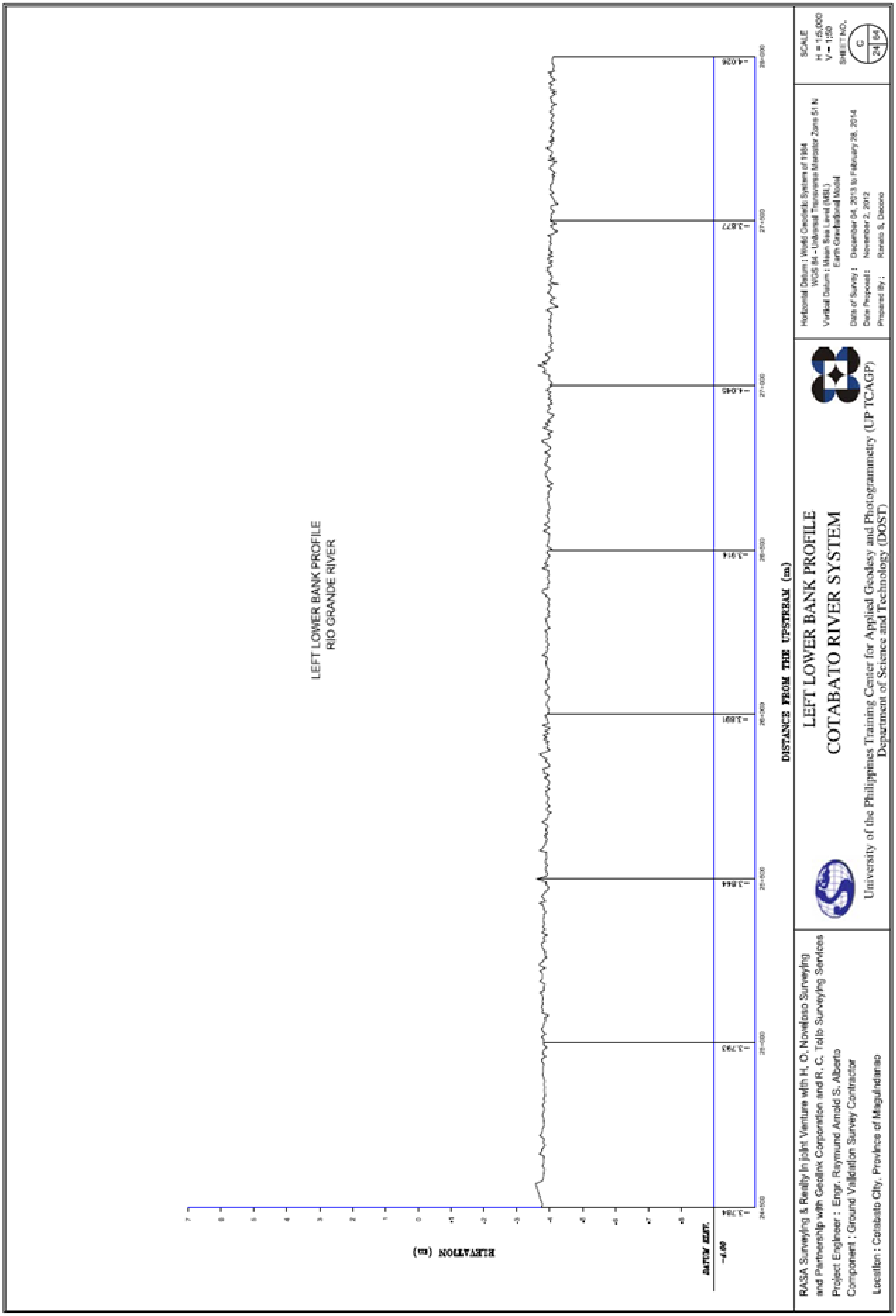
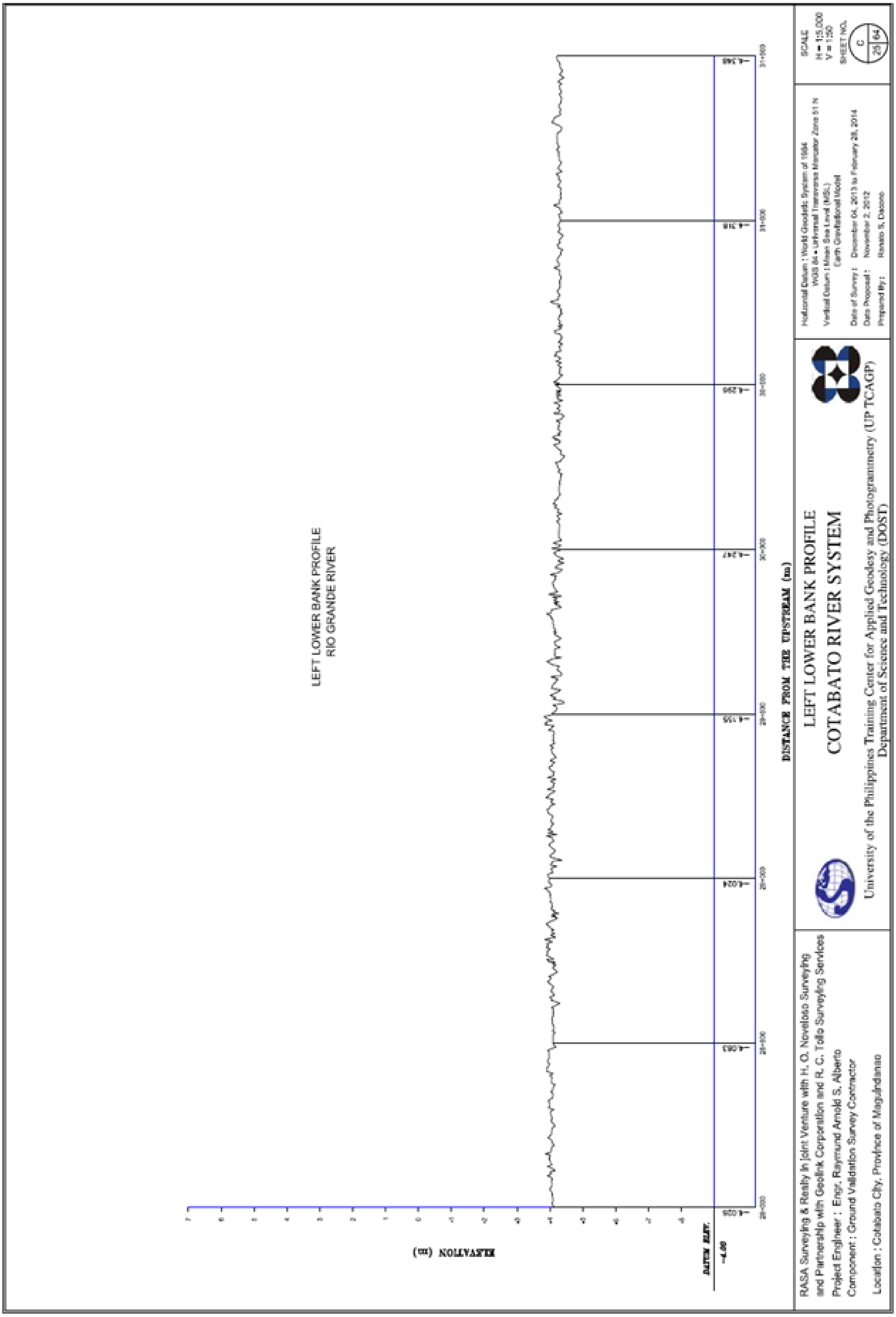
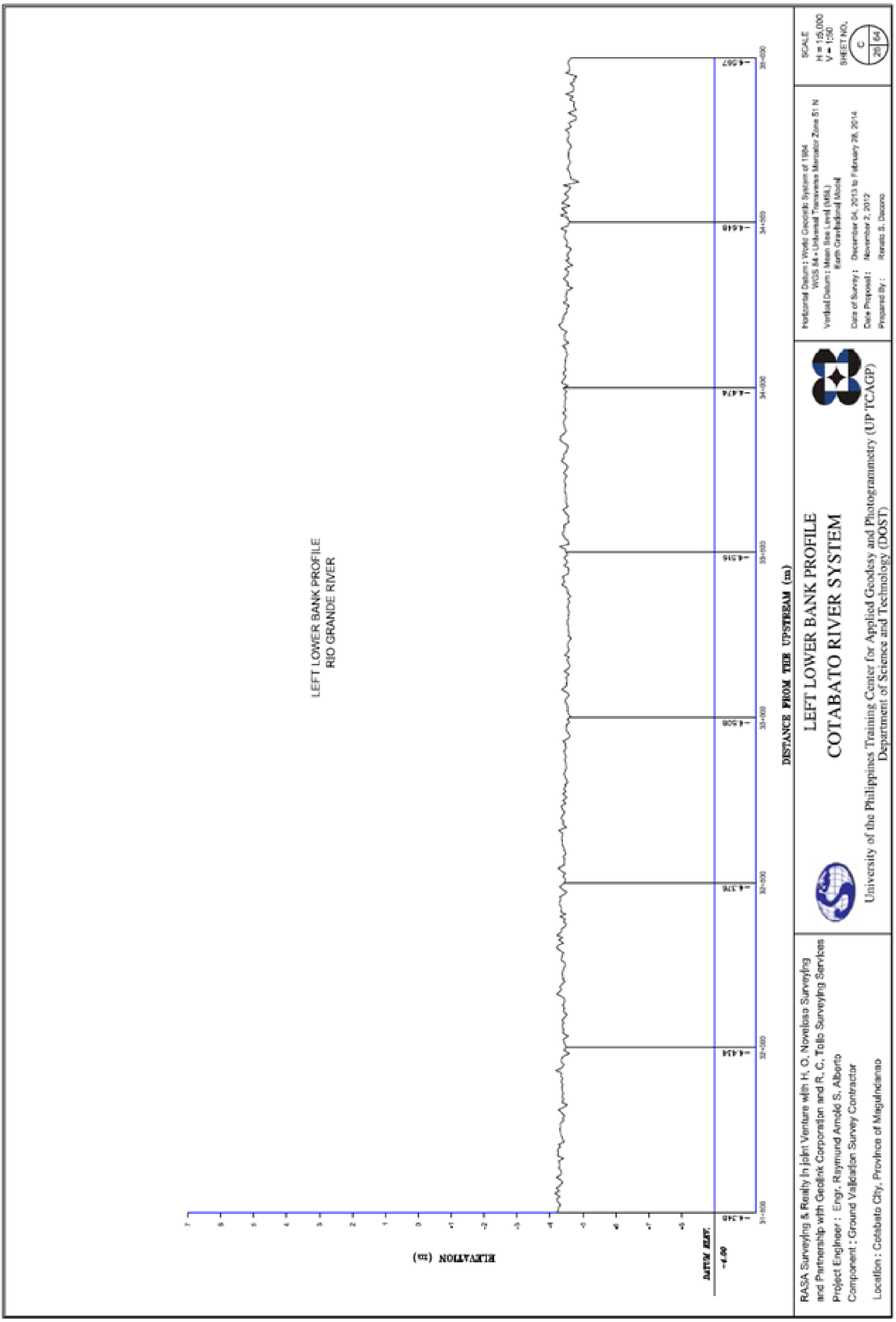
V = 1:50
SHEET NO.

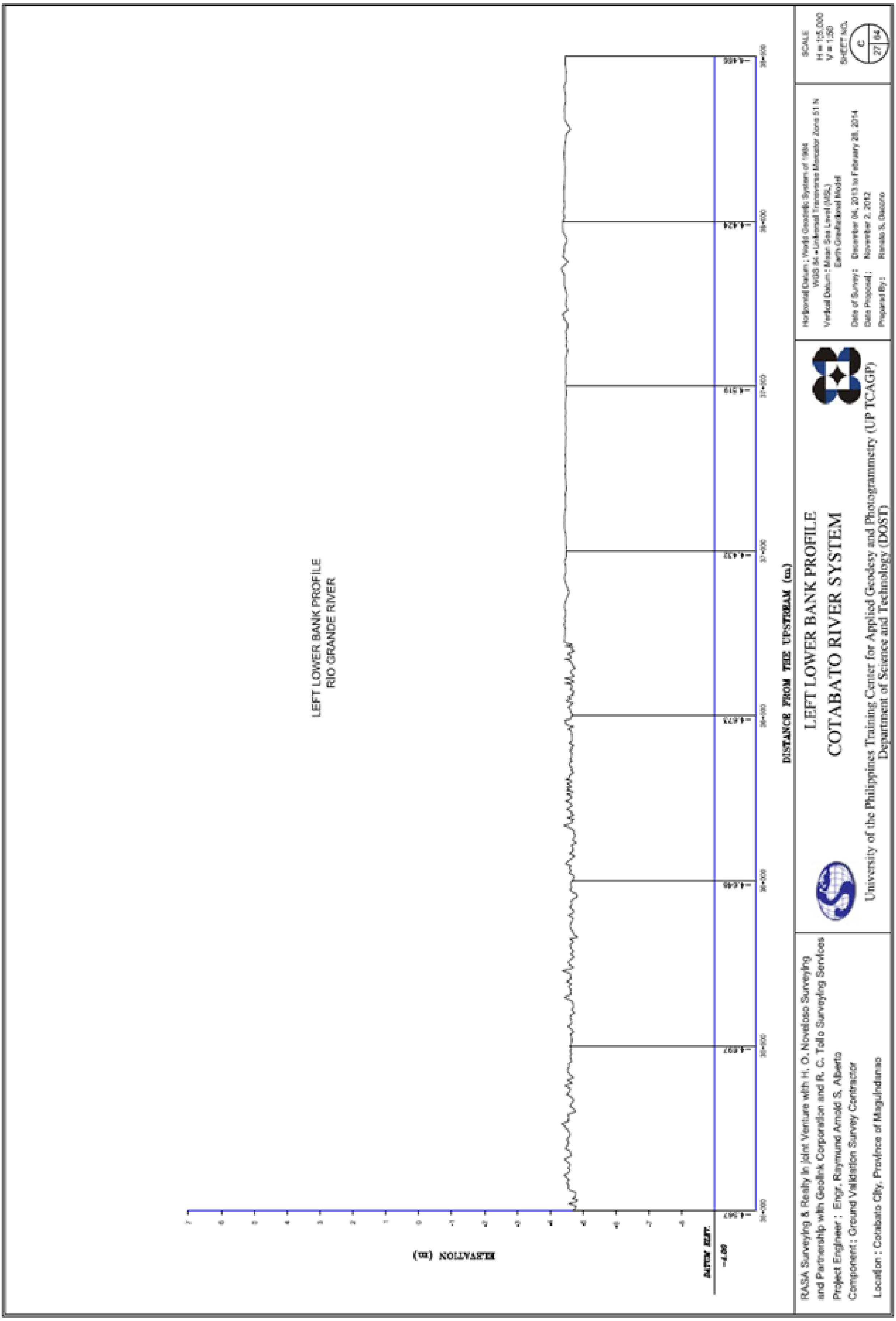

LEFT LOWER BANK PROFILE
RIO GRANDE RIVER
DISTANCE FROM THE UPSTREAM (m)
ELEVATION (m)
LEFT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in joint Venture with H. O. Novelboo Surveying and Partnership with Geolink Corporation and R. C. Tolib Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Date of Survey : December 04, 2013 to February 28, 2014
Prepared By : Renato S. Dacono
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
C
23
64

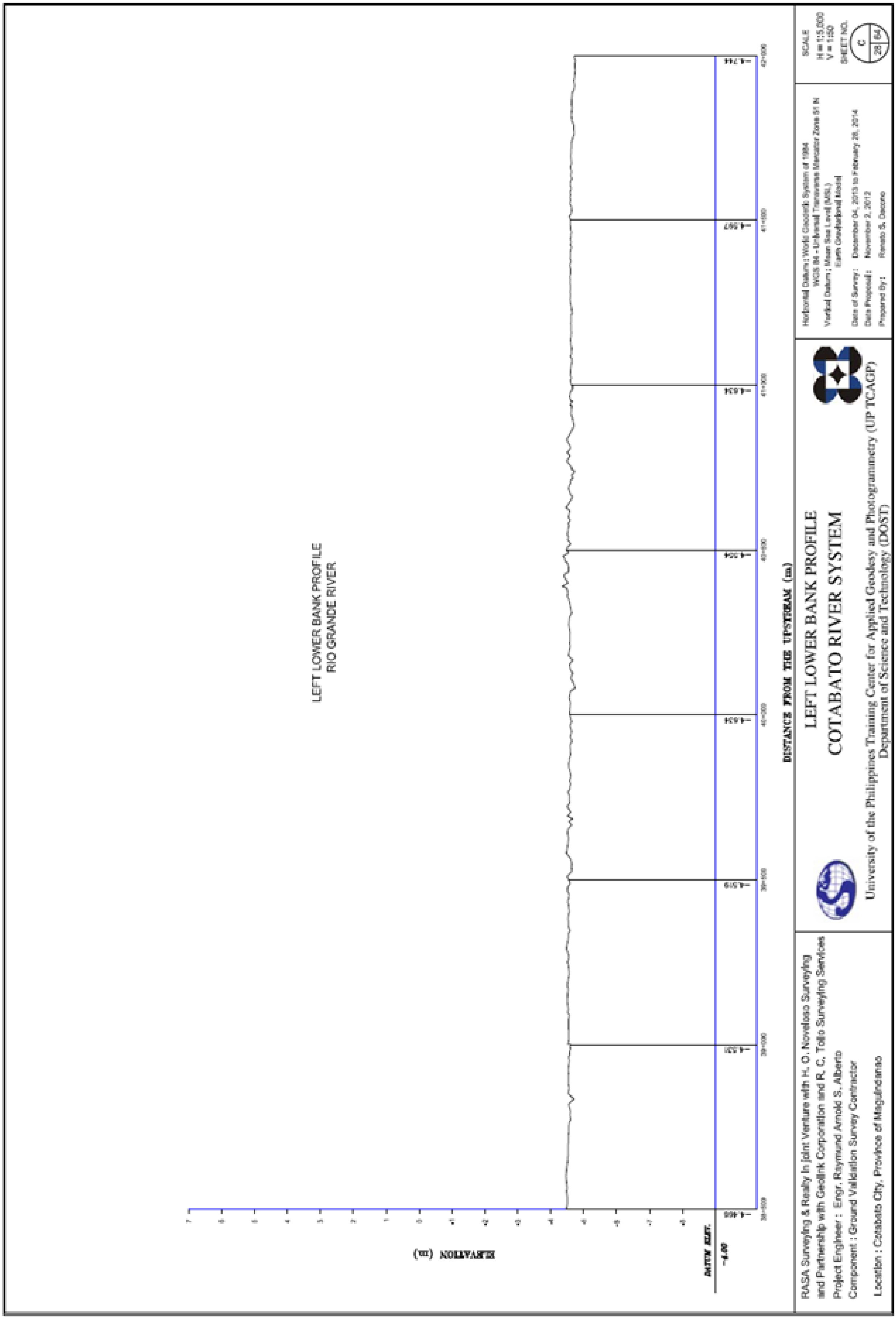

LEFT LOWER BANK PROFILE
RIO GRANDE RIVER
DISTANCE FROM THE UPSTREAM (m)
ELEVATION (m)
DATUM ELEV.
LEFT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in joint Venture with H. O. Novelboo Surveying and Partnership with Geolink Corporation and R. C. Tello Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Date Proposed : November 2, 2012
Prepared By : Renato S. Dacono
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
C
24
54

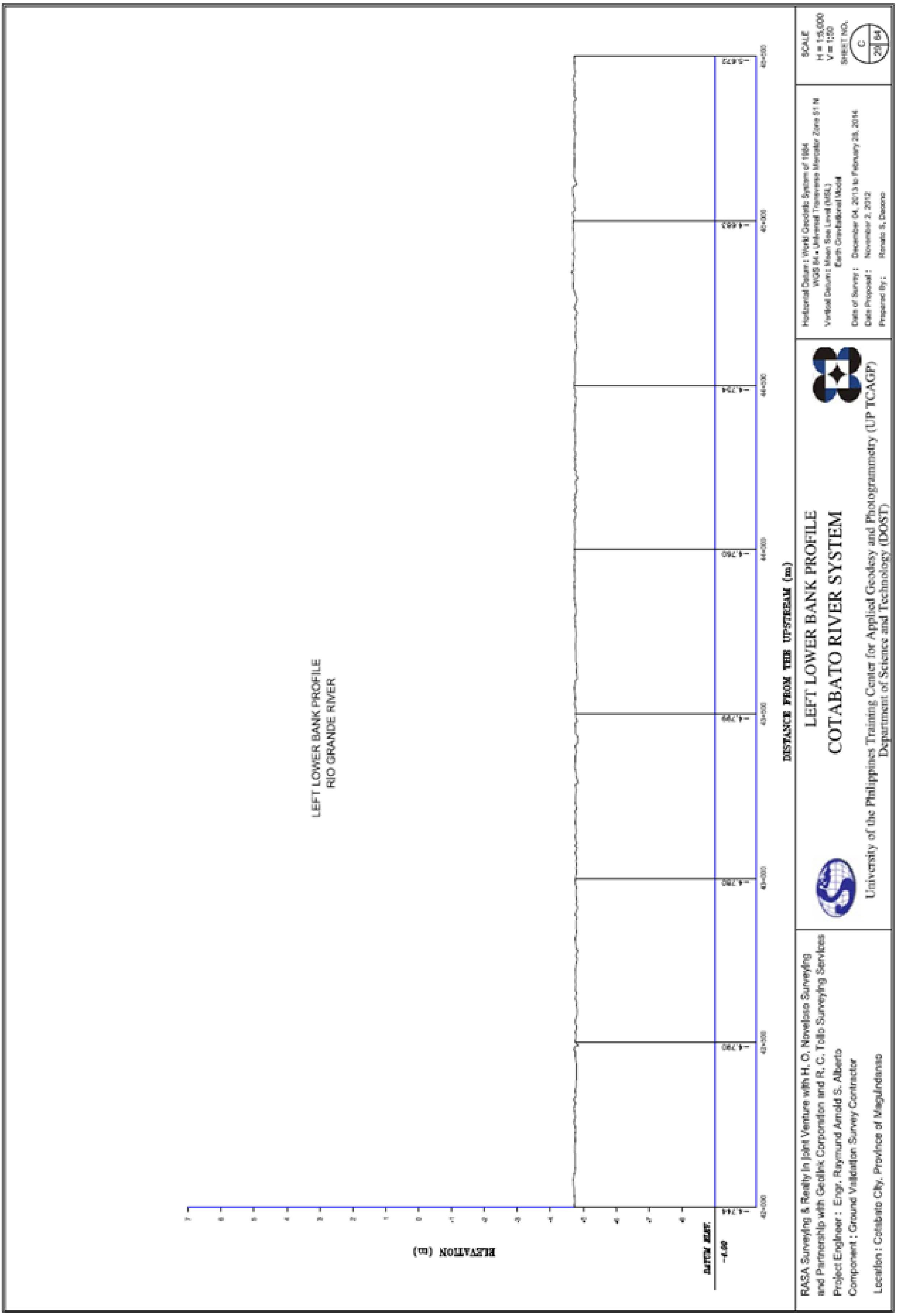

LEFT LOWER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
-4.00
DISTANCE FROM THE UPSTREAM (m)
LEFT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tello Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
SCALE
H = 1:5,000
V = 1:50
SHEET NO.

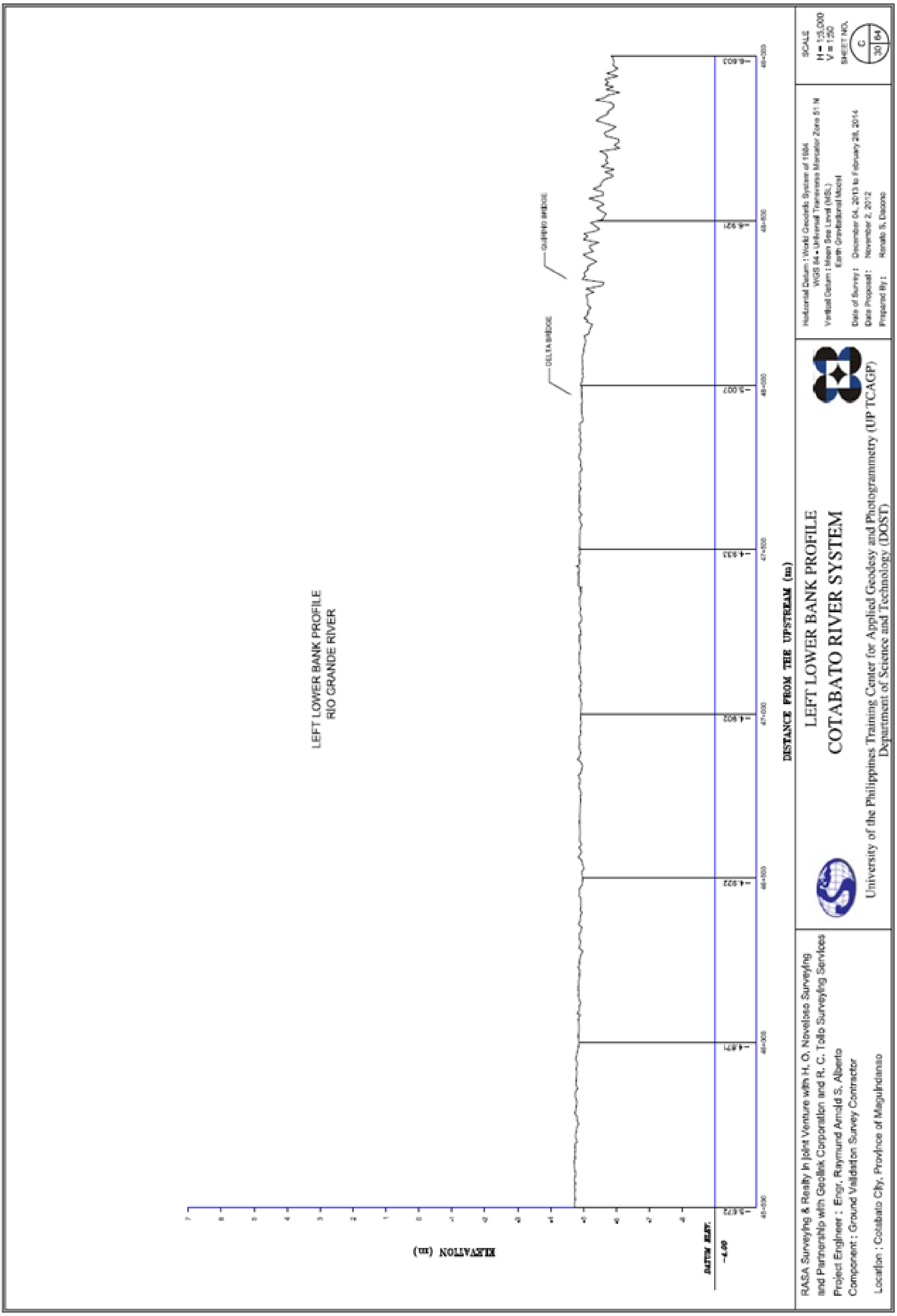
Annexes

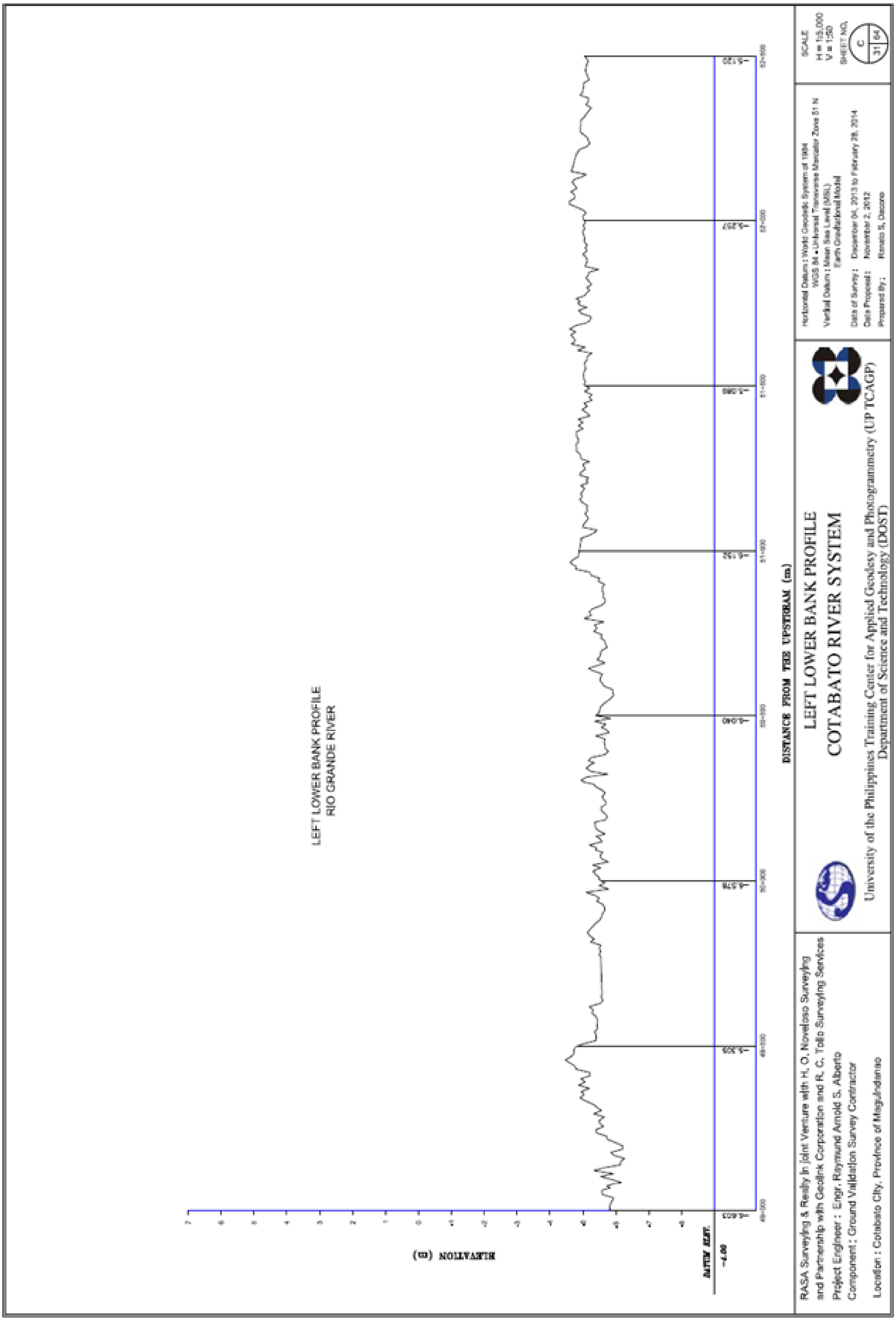

LEFT LOWER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
DISTANCE FROM THE UPSTREAM (m)
LEFT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying
and Partnership with Geolink Corporation and R. C. Tolle Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
SCALE
SHEET NO.


LEFT LOWER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DISTANCE FROM THE UPSTREAM (m)
LEFT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Novelloso Surveying
and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao


LEFT LOWER BANK PROFILE
RIO GRANDE RIVER
DISTANCE FROM THE UPSTREAM (m)
ELEVATION (m)
DATUM ELEV. -4.00
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tello Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
LEFT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Prepared By : Renato S. Decono
SCALE
SHEET NO.
C


LEFT LOWER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
-4.00
DISTANCE FROM THE UPSTREAM (m)
42+000
42+500
43+000
43+500
44+000
44+500
45+000
45+500
-4.744
-4.790
-4.780
-4.799
-4.760
-4.704
-4.683
-5.672
LEFT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. C. Novelozo Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Decena
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
C
25 64


LEFT LOWER BANK PROFILE
RIO GRANDE RIVER
DELTA BRIDGE
ELEVATION (m)
DISTANCE FROM THE UPSTREAM (m)
LEFT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)


LEFT LOWER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DISTANCE FROM THE UPSTREAM (m)
LEFT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Date Proposed : November 2, 2012
Prepared By : Renato S. Discono
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SHEET NO.
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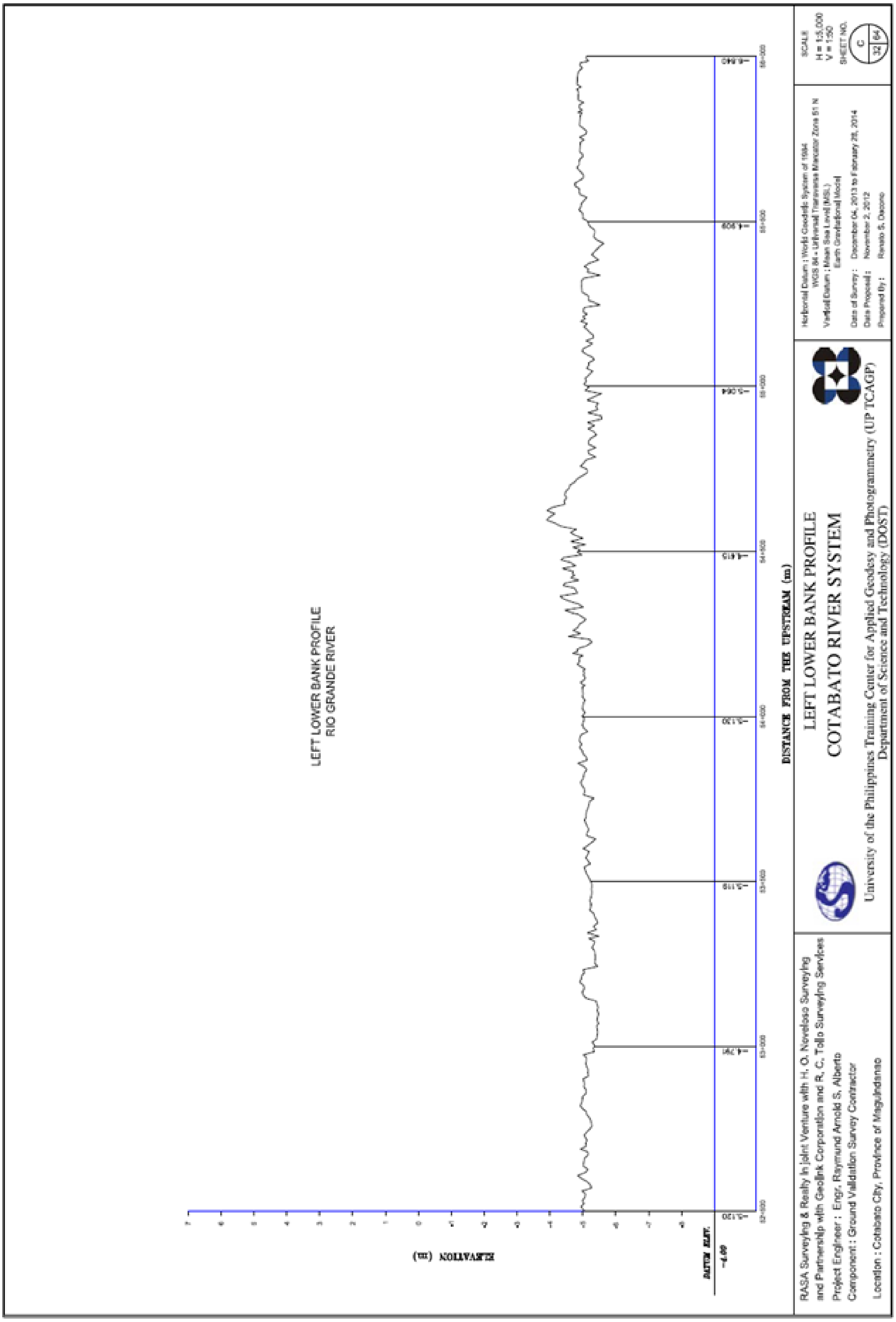
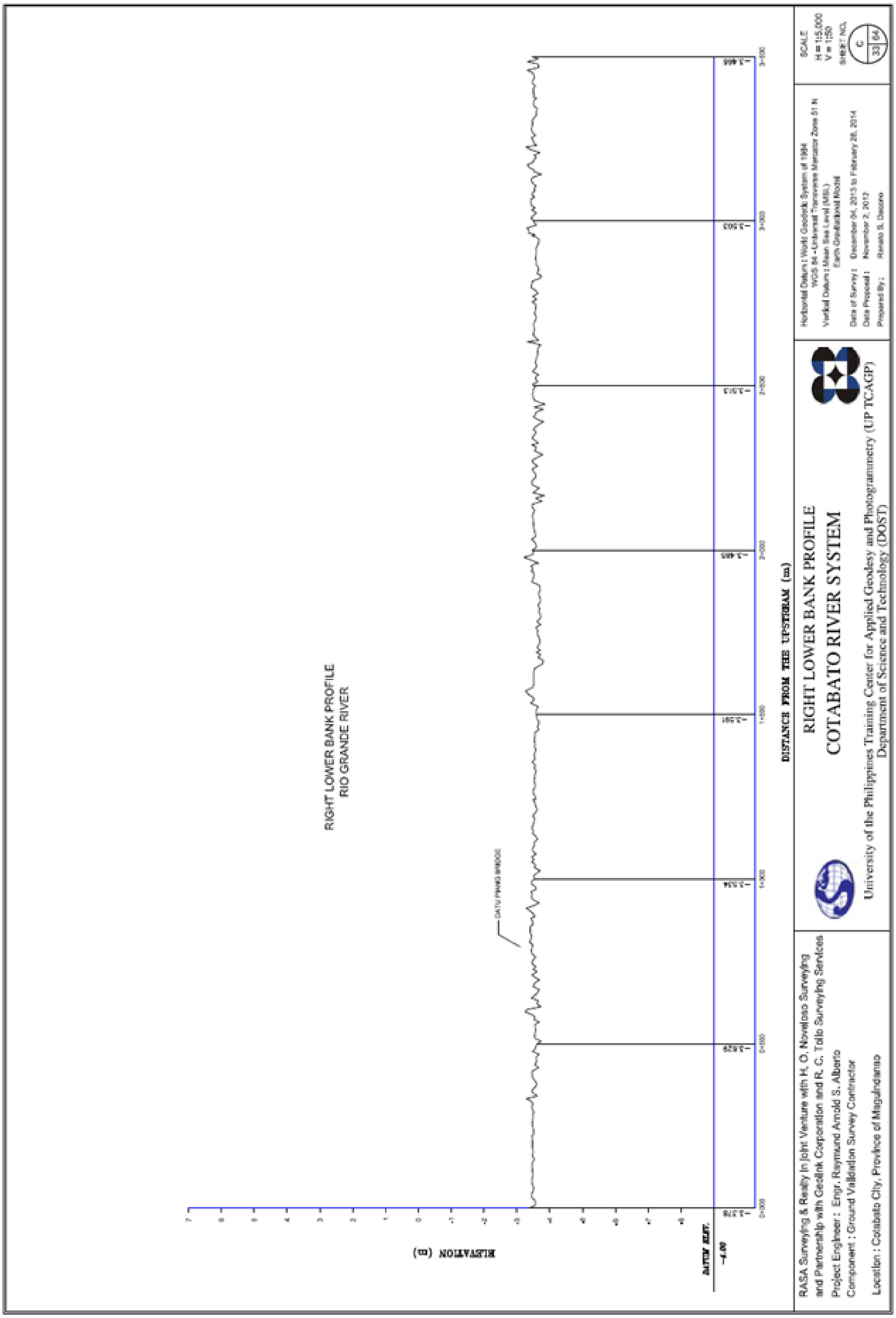
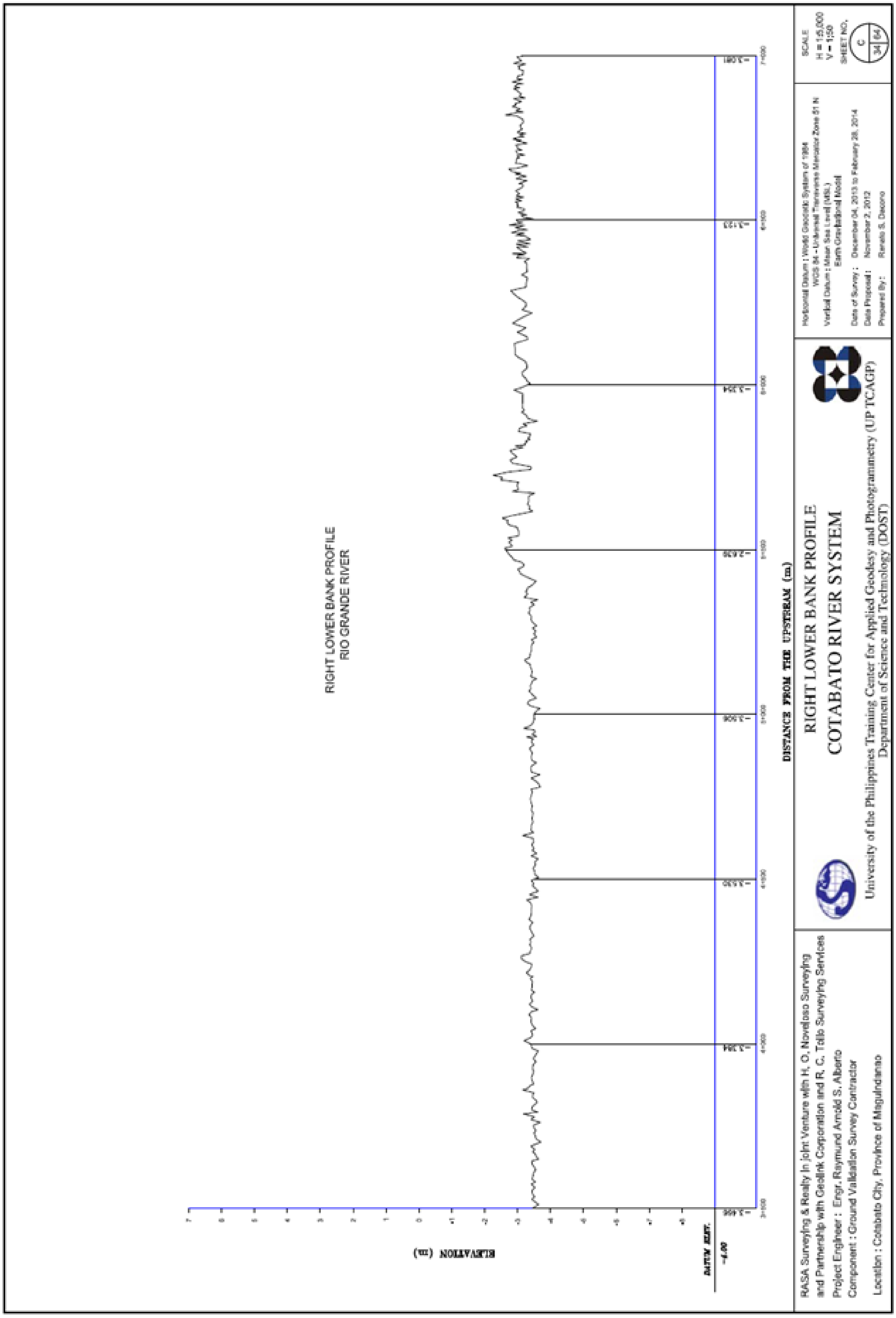
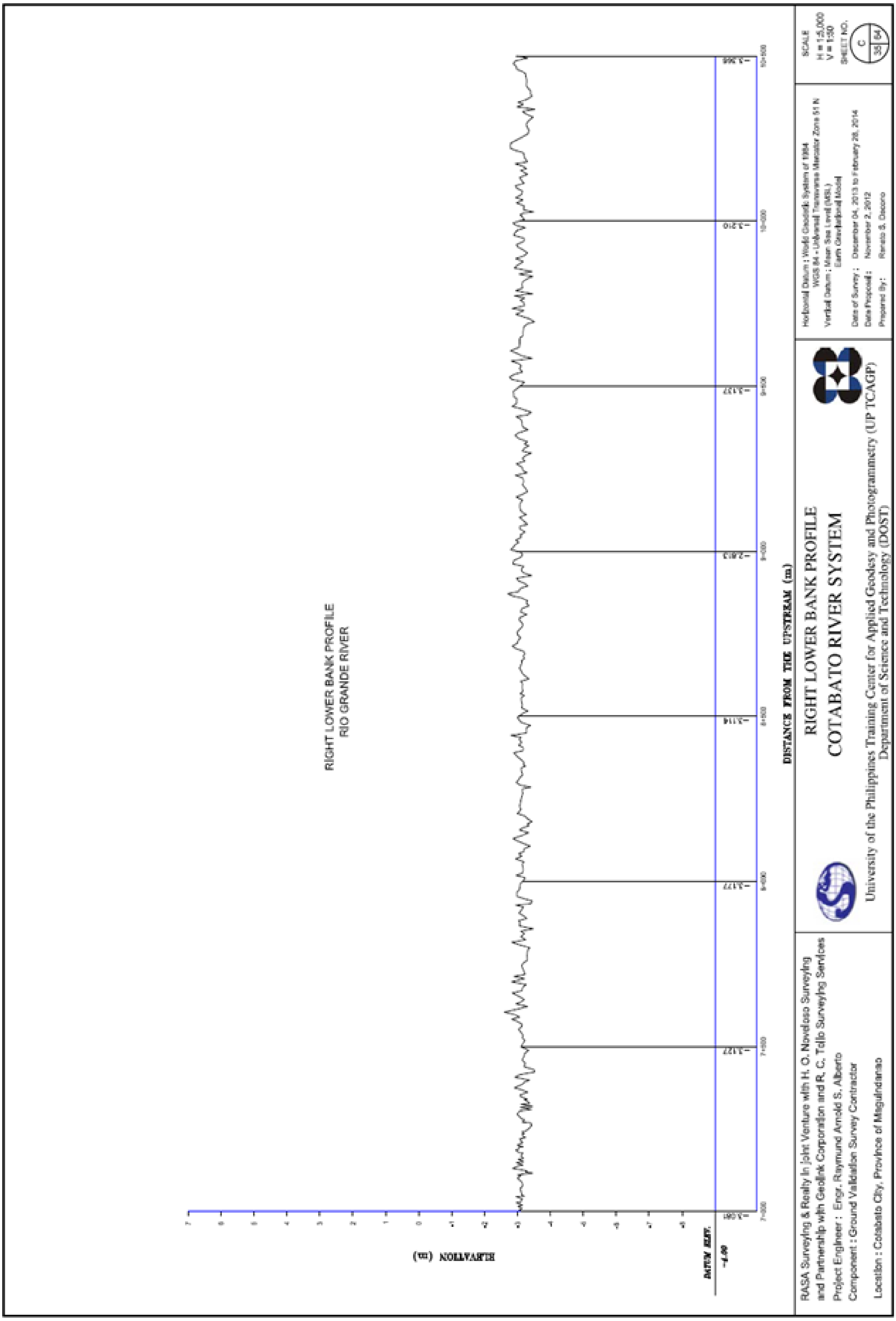
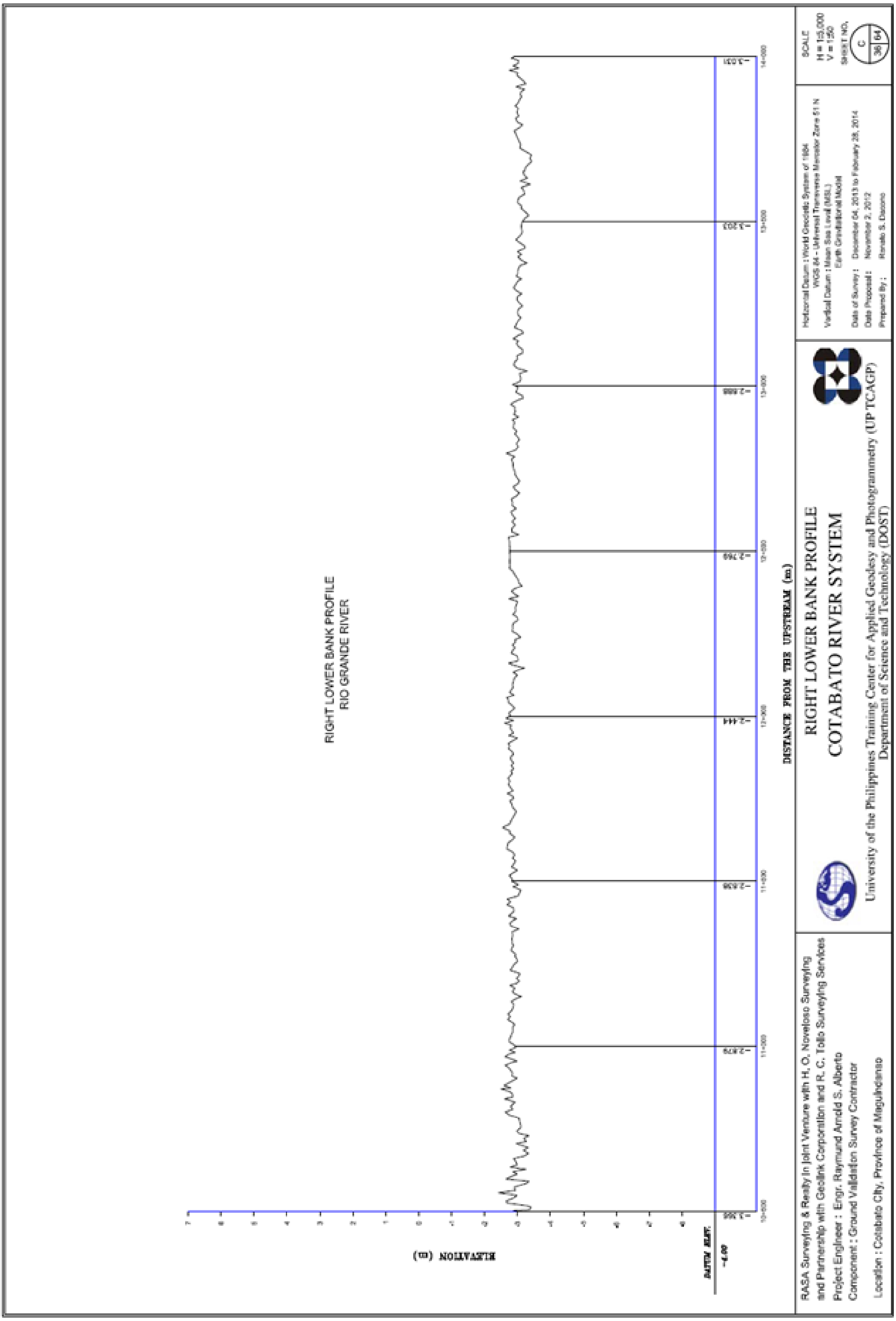
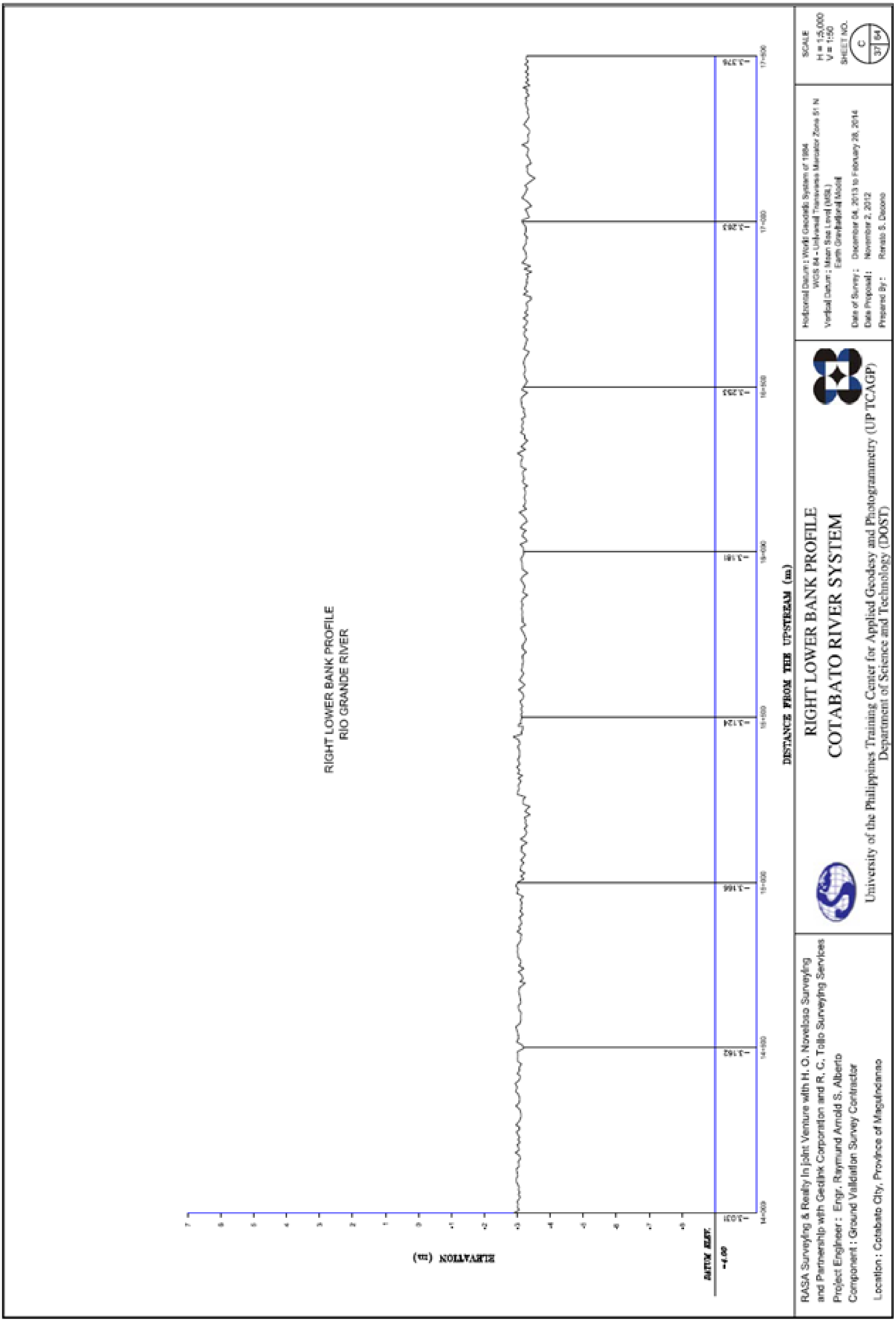

LEFT LOWER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DISTANCE FROM THE UPSTREAM (m)
LEFT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao

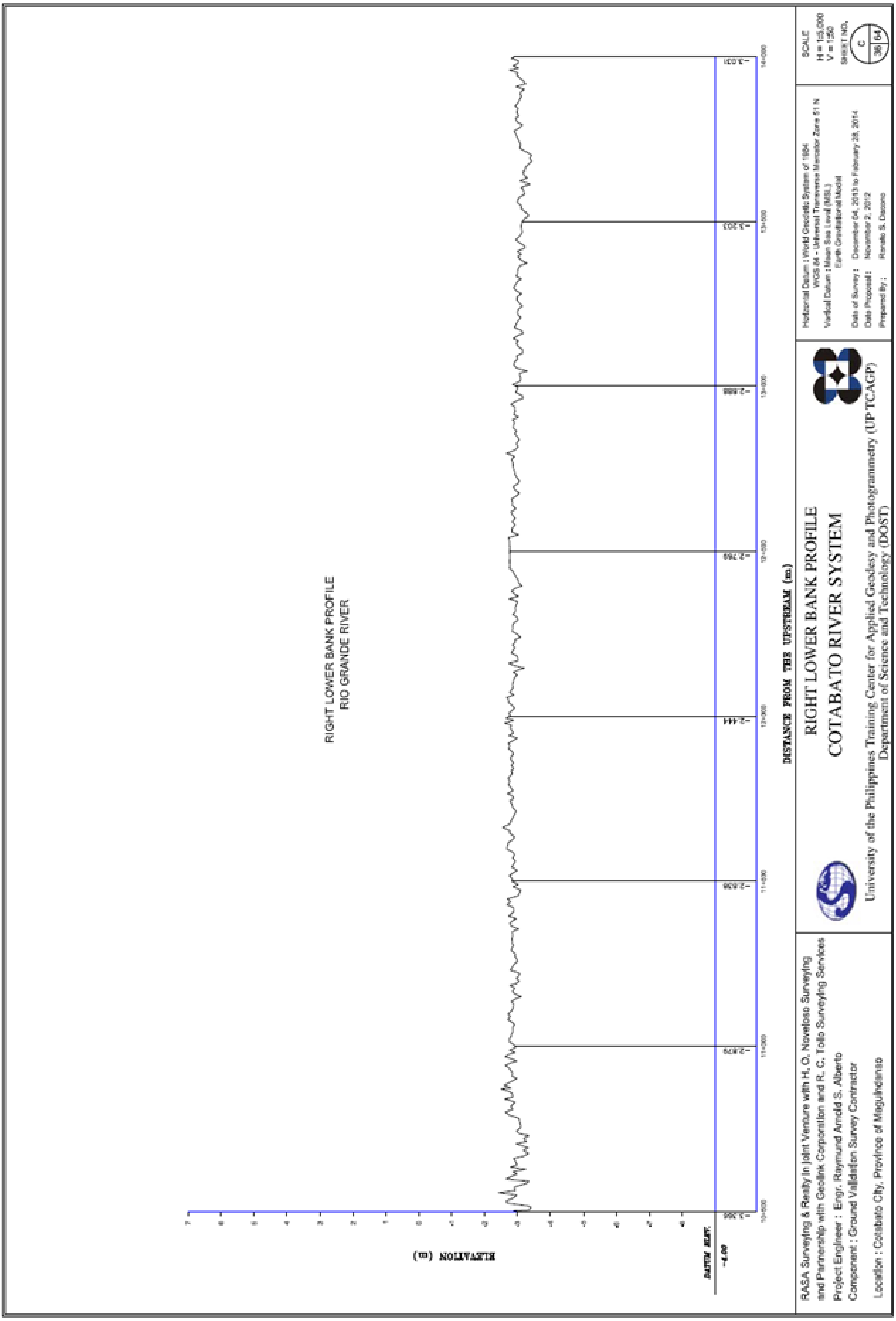

RIGHT LOWER BANK PROFILE
RIO GRANDE RIVER
DATU PIANG BRIDGE
ELEVATION (m)
DATUM ELEV.
-4.00
DISTANCE FROM THE UPSTREAM (m)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying
and Partnership with Geolink Corporation and R. C. Tallo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
RIGHT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
Vertical Datum : Mean Sea Level (MSL)
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
C
33
64

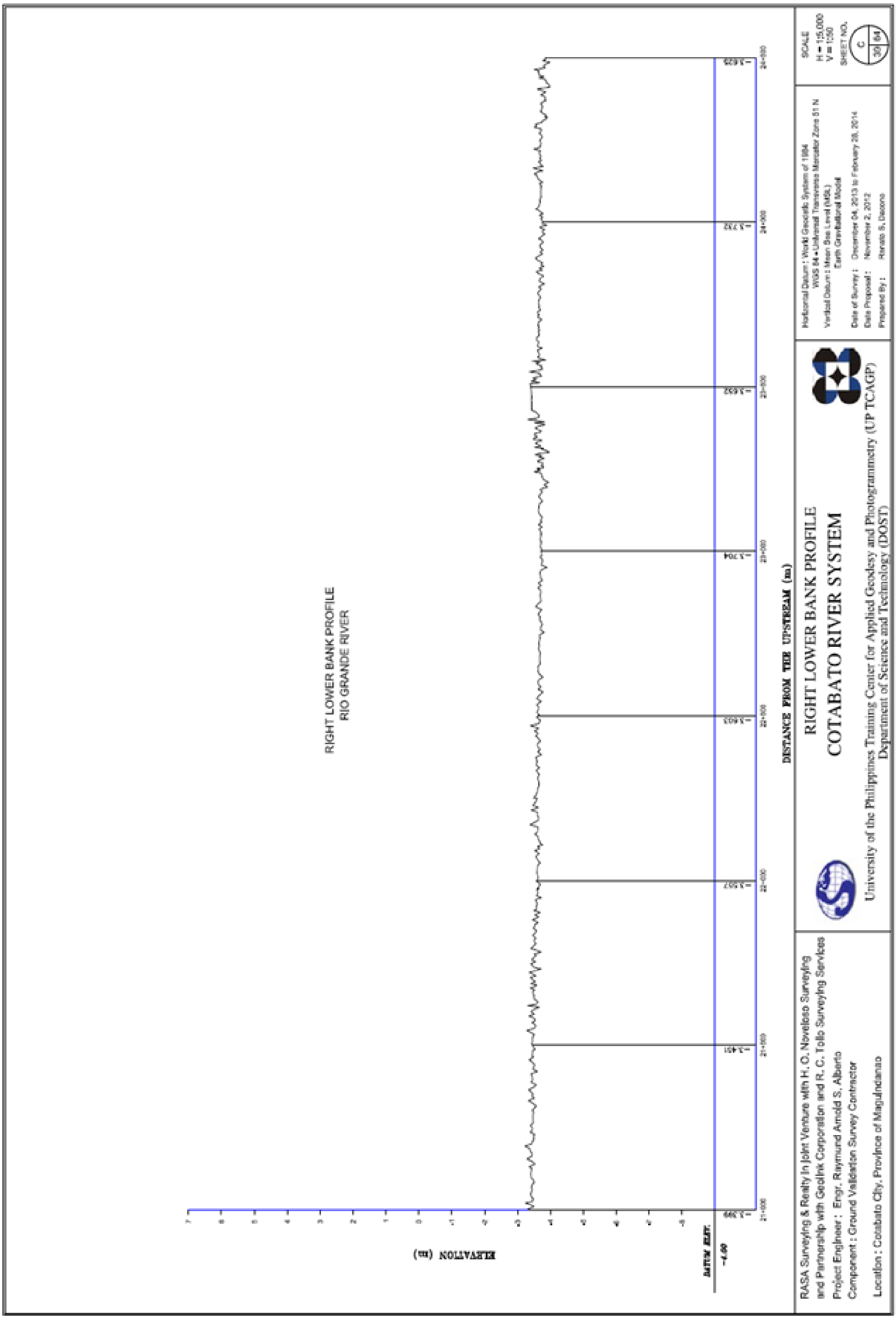

RIGHT LOWER BANK PROFILE
RIO GRANDE RIVER
DISTANCE FROM THE UPSTREAM (m)
ELEVATION (m)
RIGHT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)

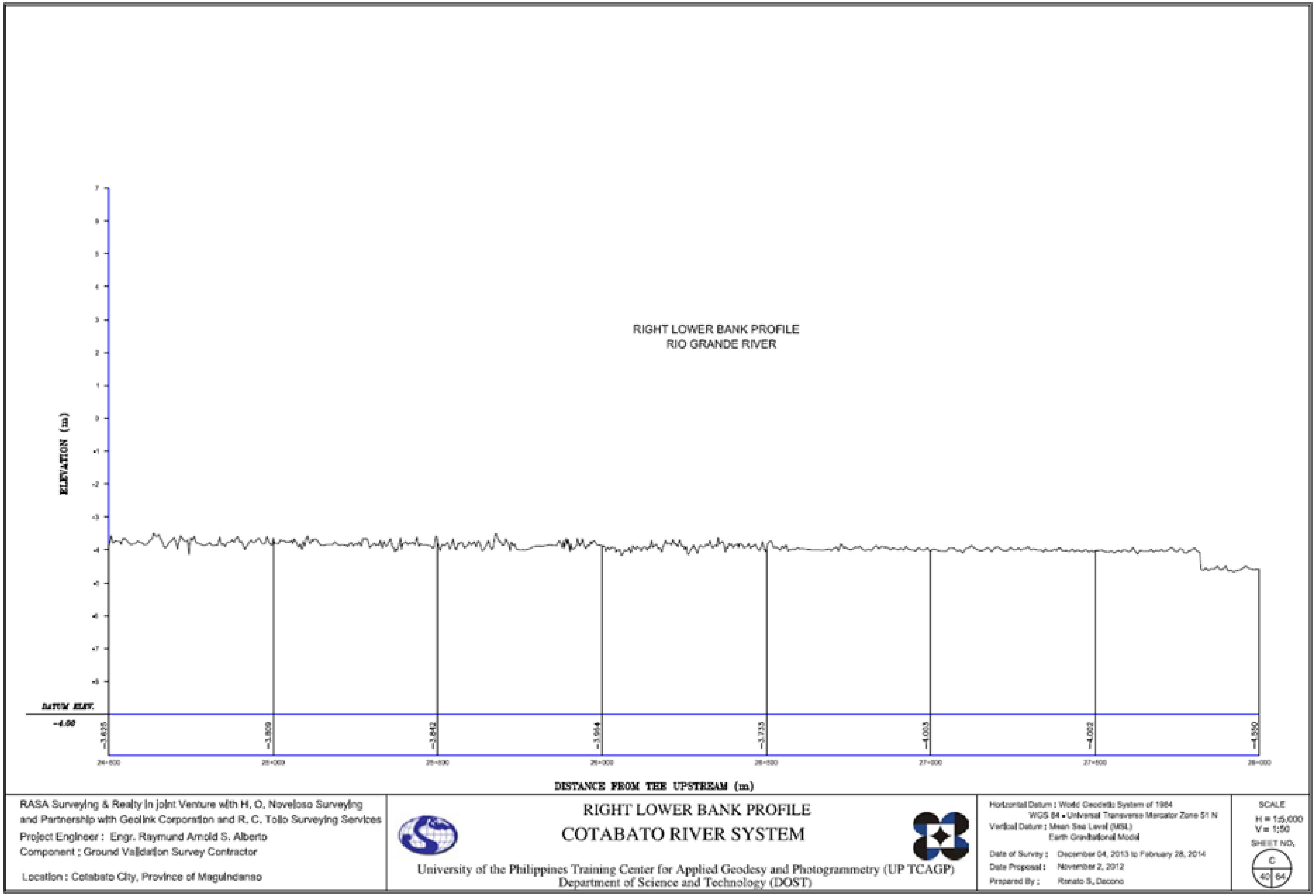

RIGHT LOWER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
DISTANCE FROM THE UPSTREAM (m)
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tello Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
RIGHT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Date Prepared : November 2, 2012
Prepared By : Renato S. Dacono
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
C
35
54


RIGHT LOWER BANK PROFILE
RIO GRANDE RIVER
DISTANCE FROM THE UPSTREAM (m)
ELEVATION (m)
RIGHT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)


RIGHT LOWER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
-4.00
-3.031
-3.162
-3.166
-3.124
-3.181
-3.233
-3.263
-3.376
DISTANCE FROM THE UPSTREAM (m)
RASA Surveying & Realty In joint Venture with H. O. Noveloso Surveying
and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
RIGHT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Date of Survey : December 04, 2013 to February 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Decono
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
C
37
54


RIGHT LOWER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
-4.00
DISTANCE FROM THE UPSTREAM (m)
RIGHT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying
and Partnership with Geolink Corporation and R. C. Tolib Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
C
36 64


RIGHT LOWER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
-4.00
DISTANCE FROM THE UPSTREAM (m)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying
and Partnership with GeoInk Corporation and R. C. Tolo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
RIGHT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Dacono
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
C
30 64


RIGHT LOWER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
-4.00
-3.635
-3.809
-3.842
-3.964
-3.733
-4.003
-4.002
-4.550
24+500
25+000
25+500
26+000
26+500
27+000
27+500
28+000
DISTANCE FROM THE UPSTREAM (m)
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tolb Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
RIGHT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
WGS 84 • Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Decono
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
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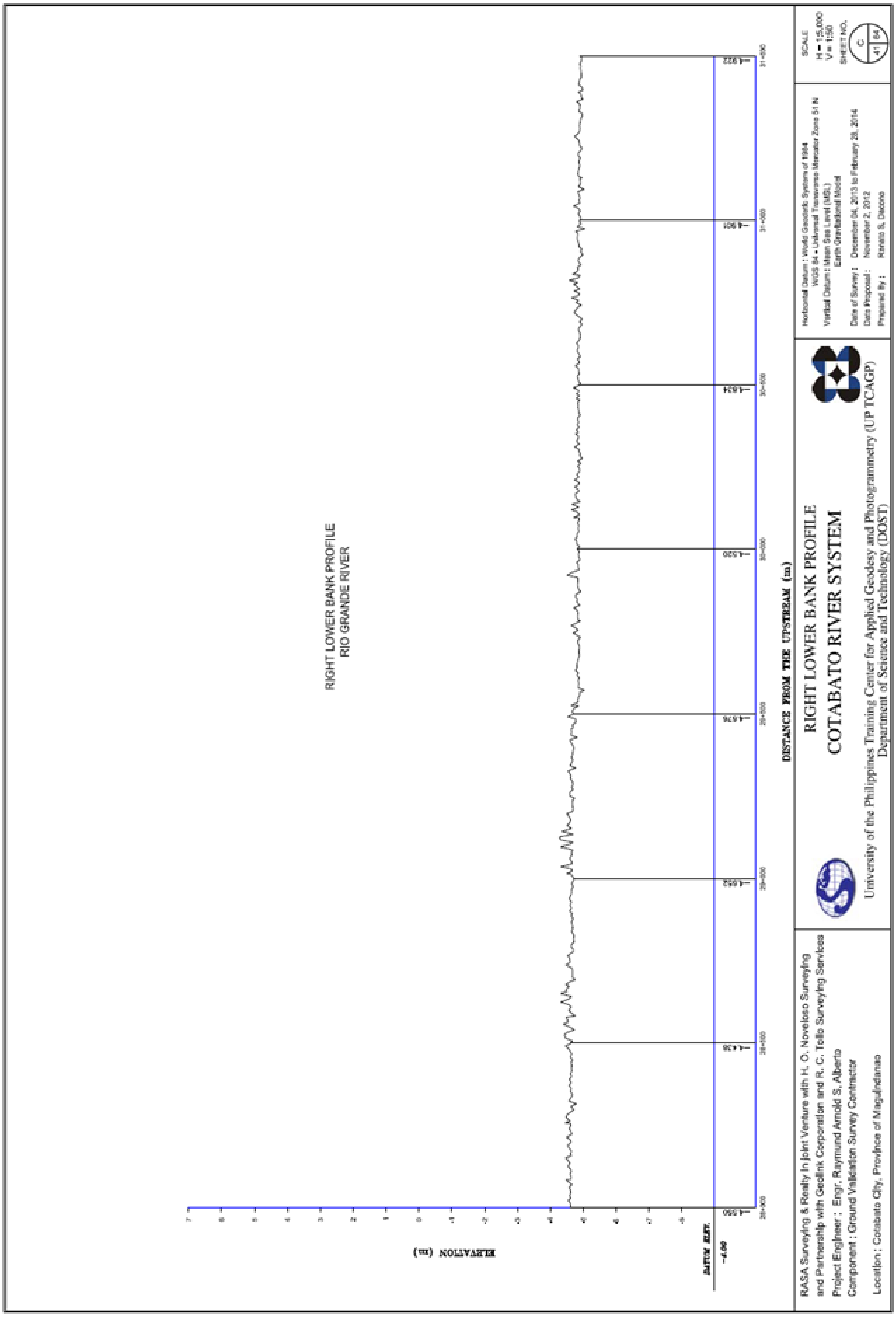
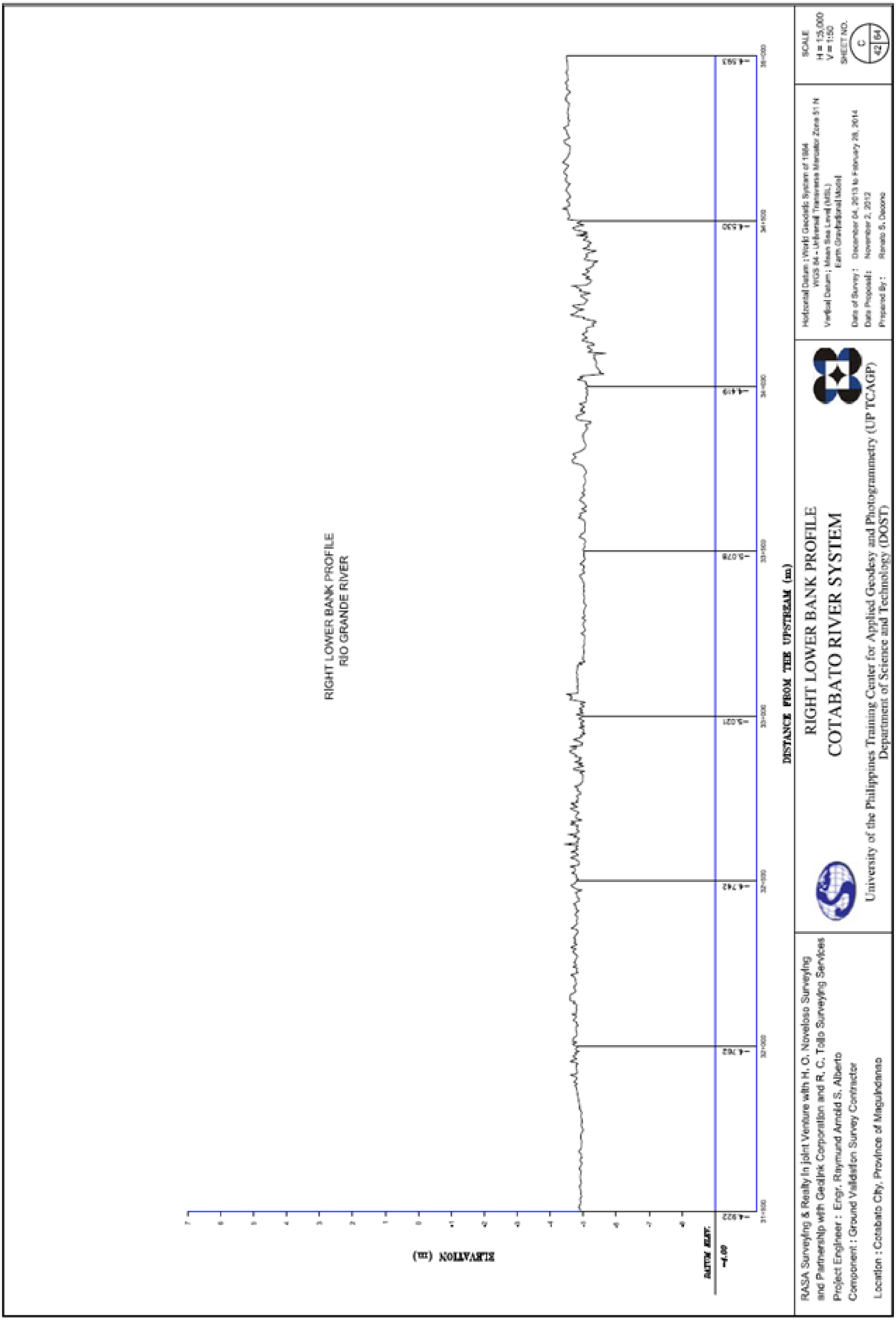
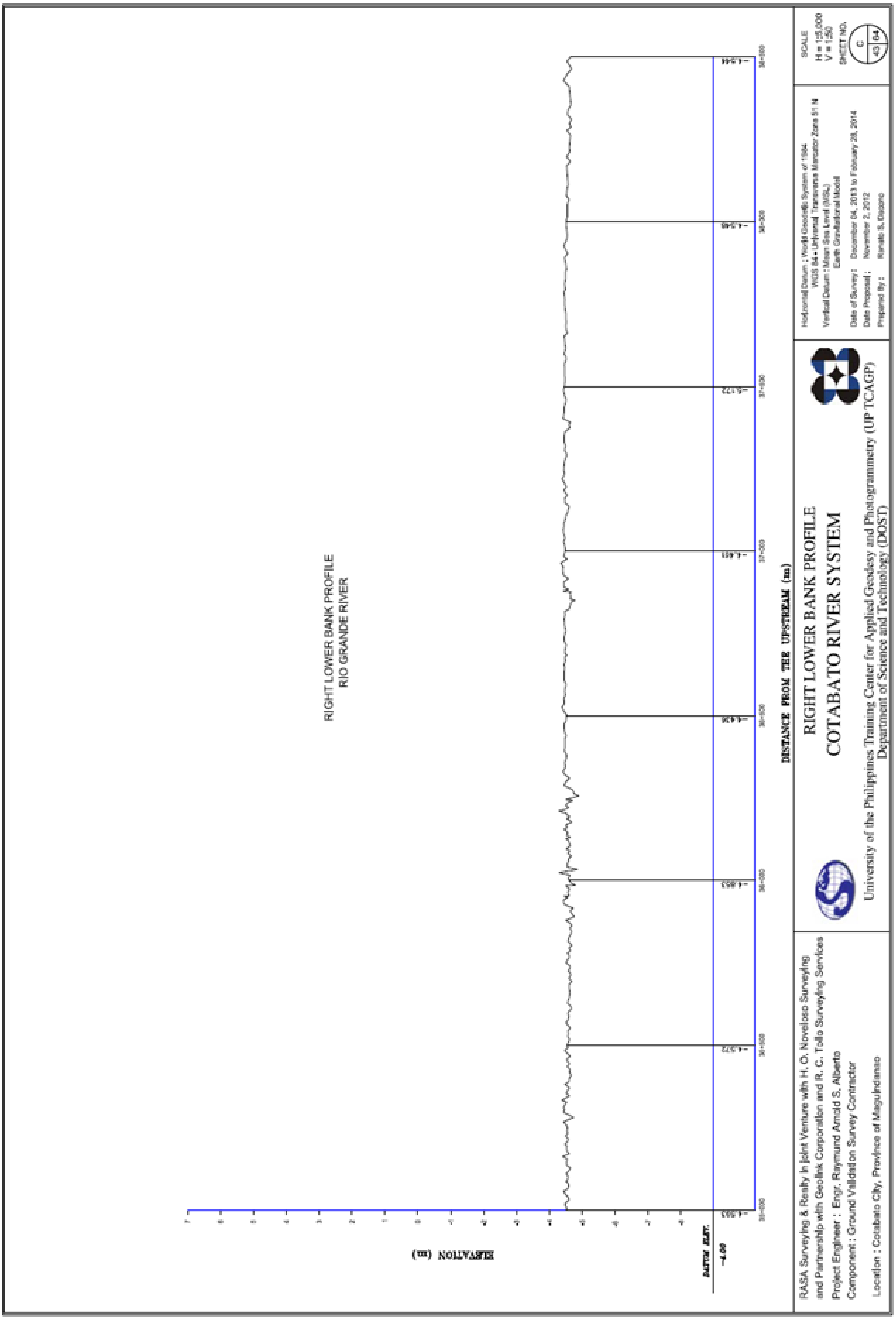
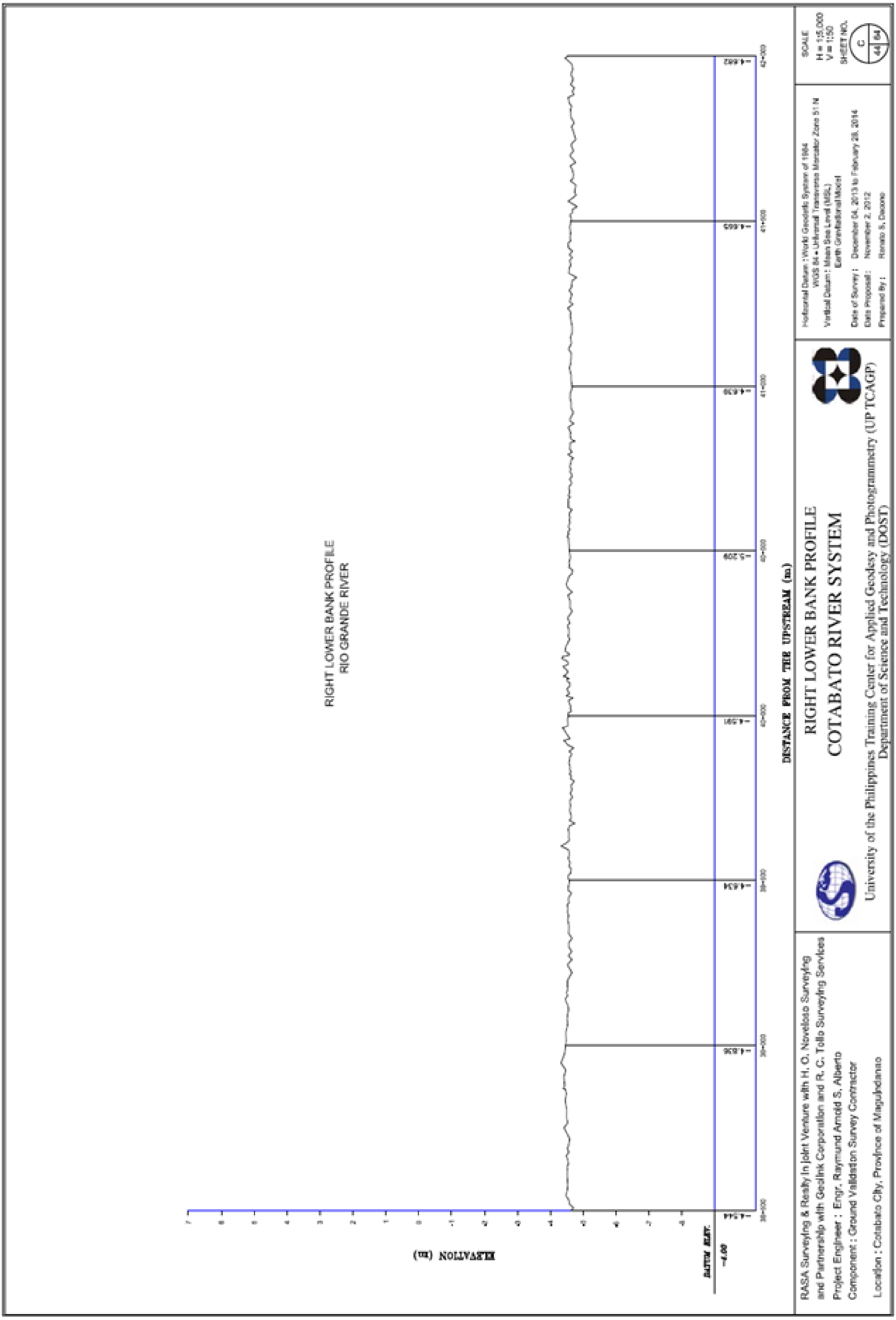
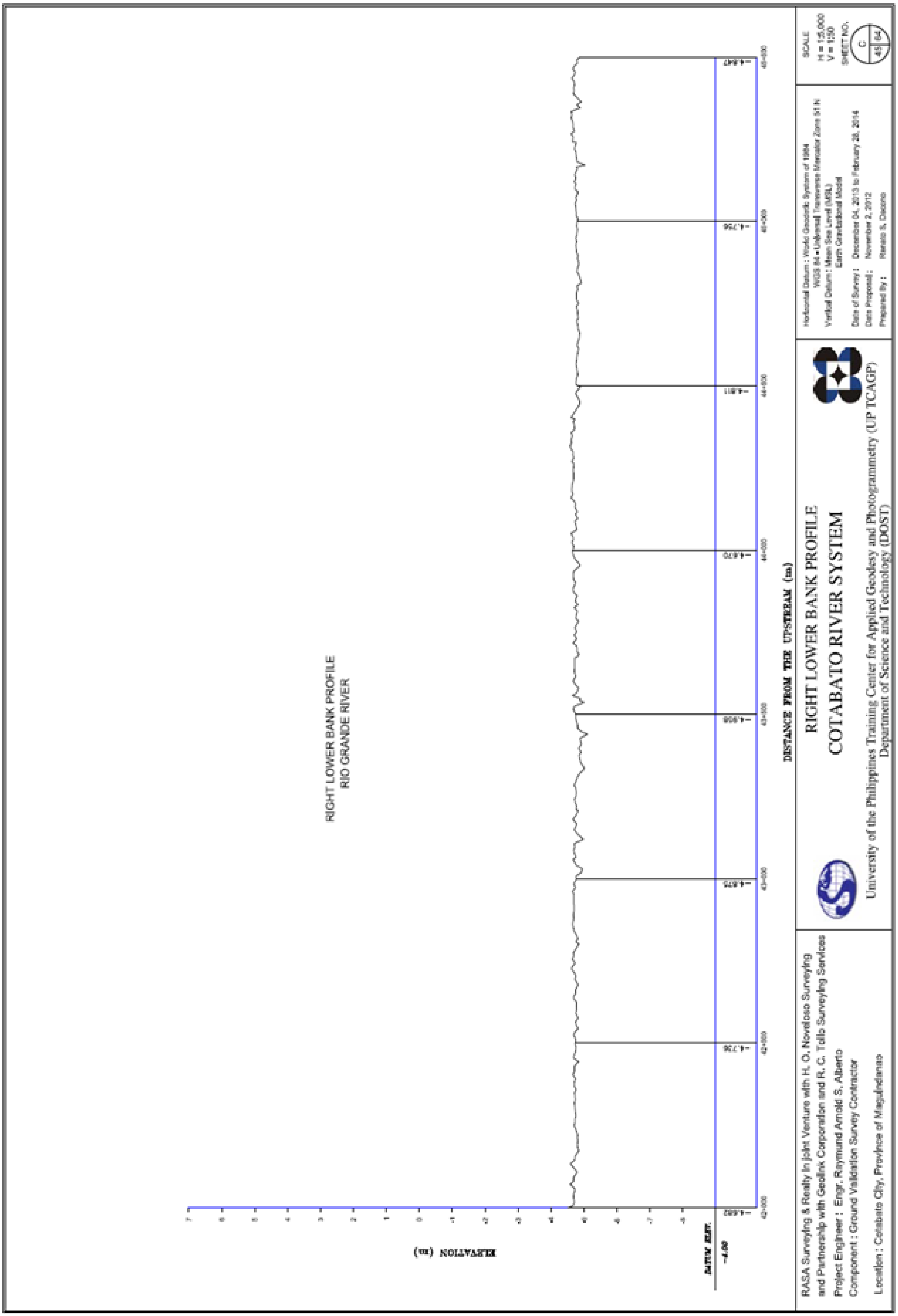

RIGHT LOWER BANK PROFILE
RIO GRANDE RIVER
DISTANCE FROM THE UPSTREAM (m)
ELEVATION (m)
RIGHT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)


RIGHT LOWER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DISTANCE FROM THE UPSTREAM (m)
RIGHT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tolo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
SCALE
H = 1:5,000
V = 1:50
SHEET NO.

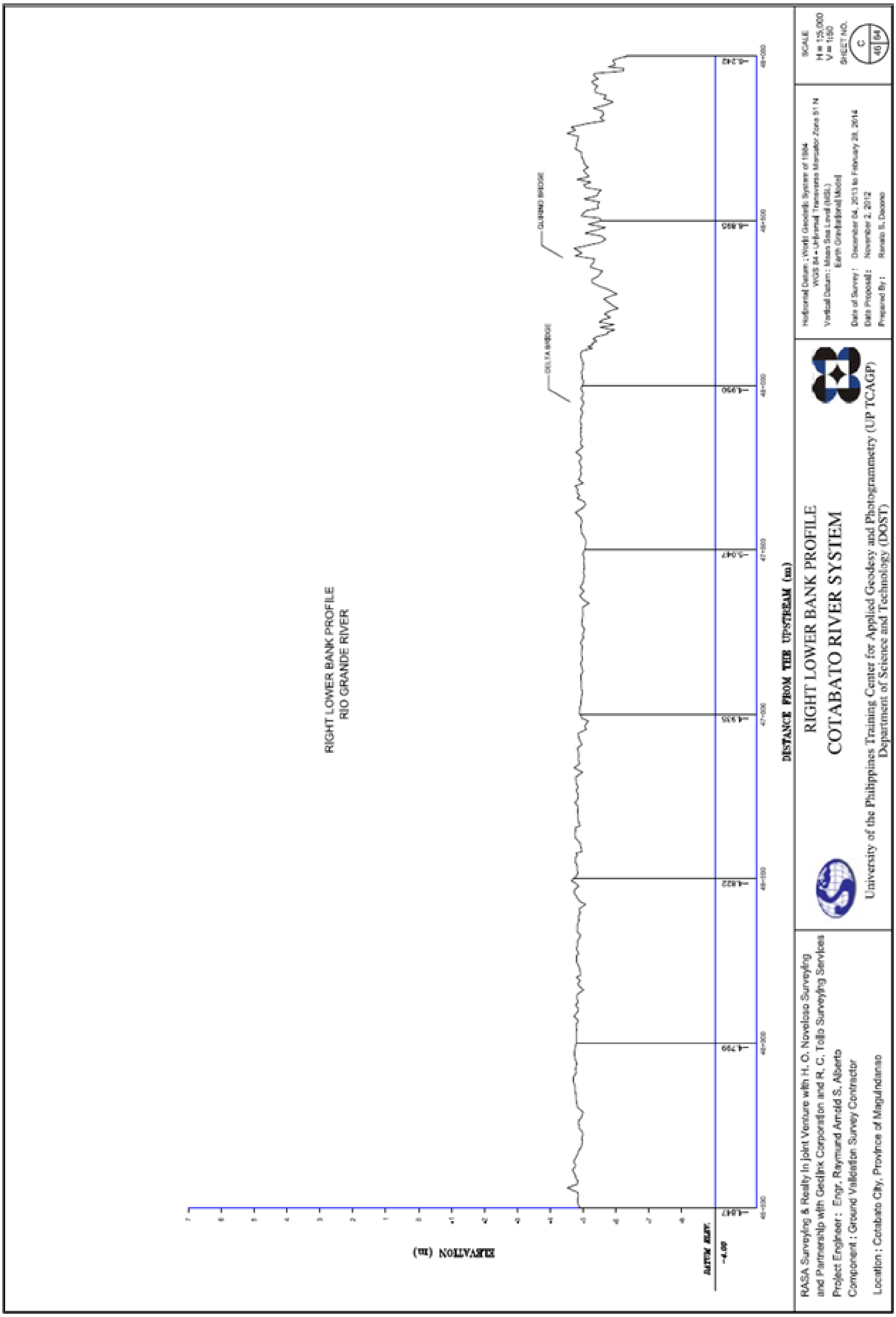

RIGHT LOWER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DISTANCE FROM THE UPSTREAM (m)
RIGHT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Novelozo Surveying
and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao



RIGHT LOWER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
-4.00
DISTANCE FROM THE UPSTREAM (m)
RIGHT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty In Joint Venture with H. O. Novelboo Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Date Proposal : November 2, 2012
Prepared By : Ronato S. Dacone
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
C
44 64



RIGHT LOWER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DISTANCE FROM THE UPSTREAM (m)
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying
and Partnership with Geolink Corporation and R. C. Tallo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
RIGHT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)


RIGHT LOWER BANK PROFILE
RIO GRANDE RIVER
DELTA BRIDGE
ELEVATION (m)
DISTANCE FROM THE UPSTREAM (m)
RIGHT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
SCALE
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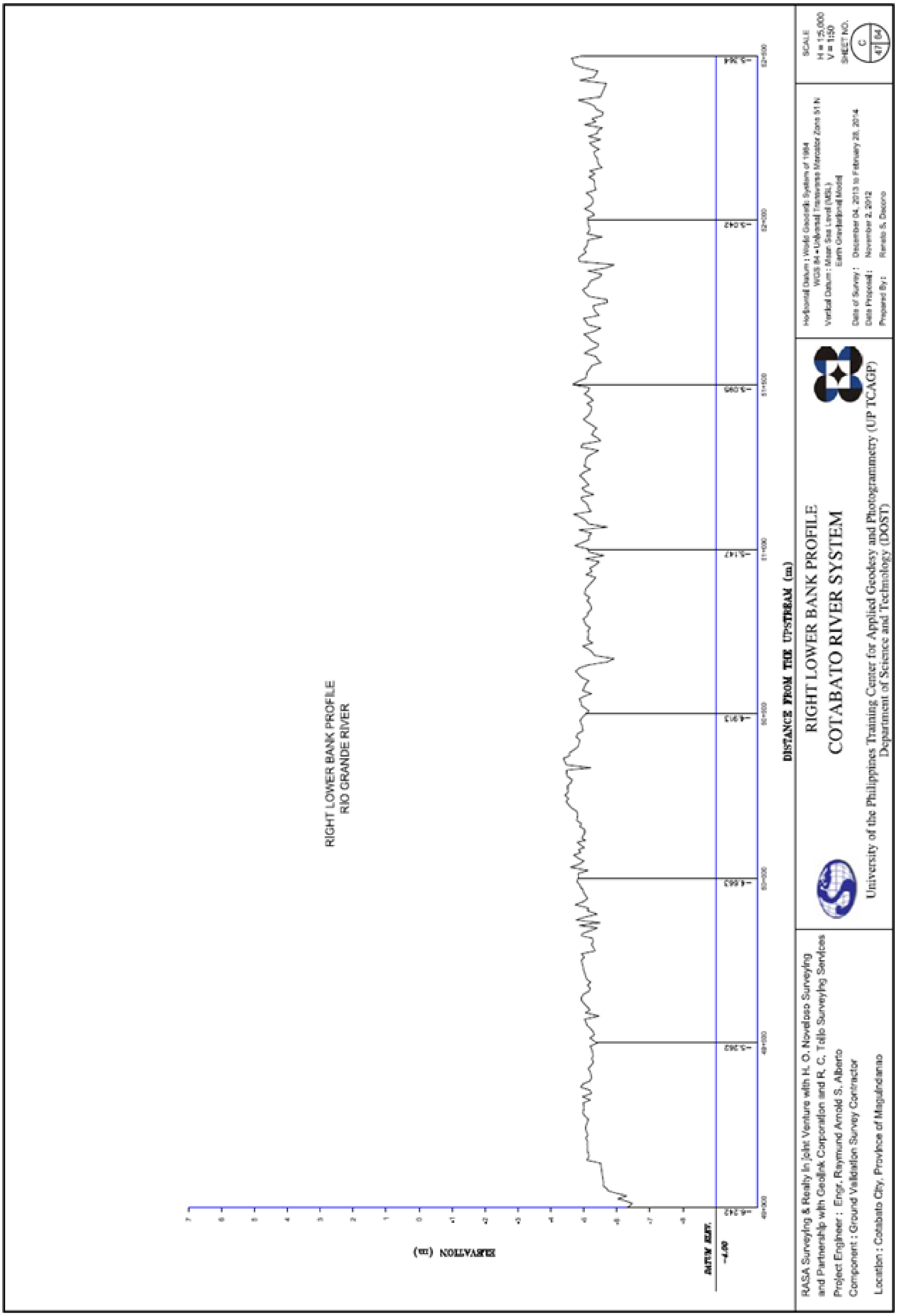
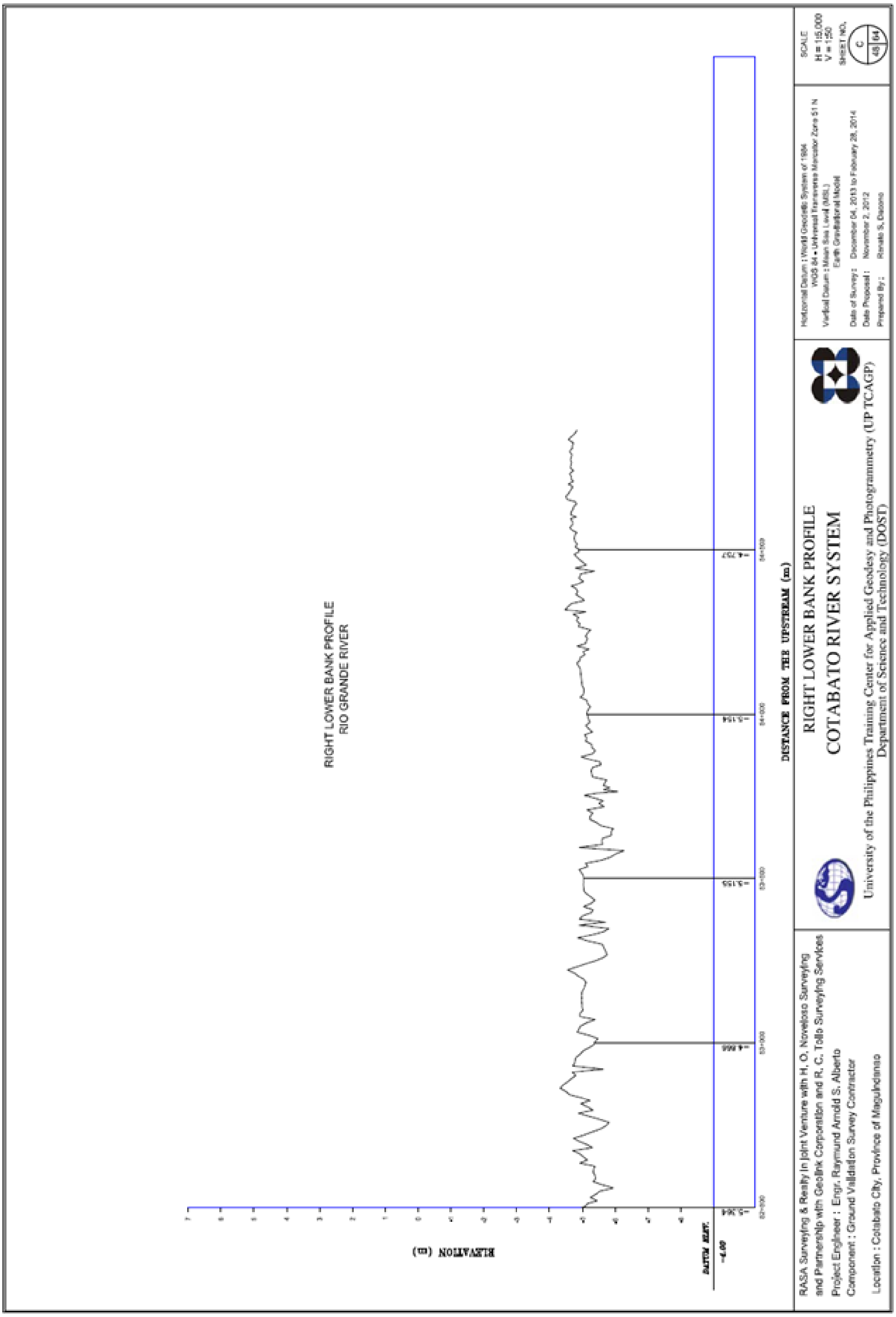
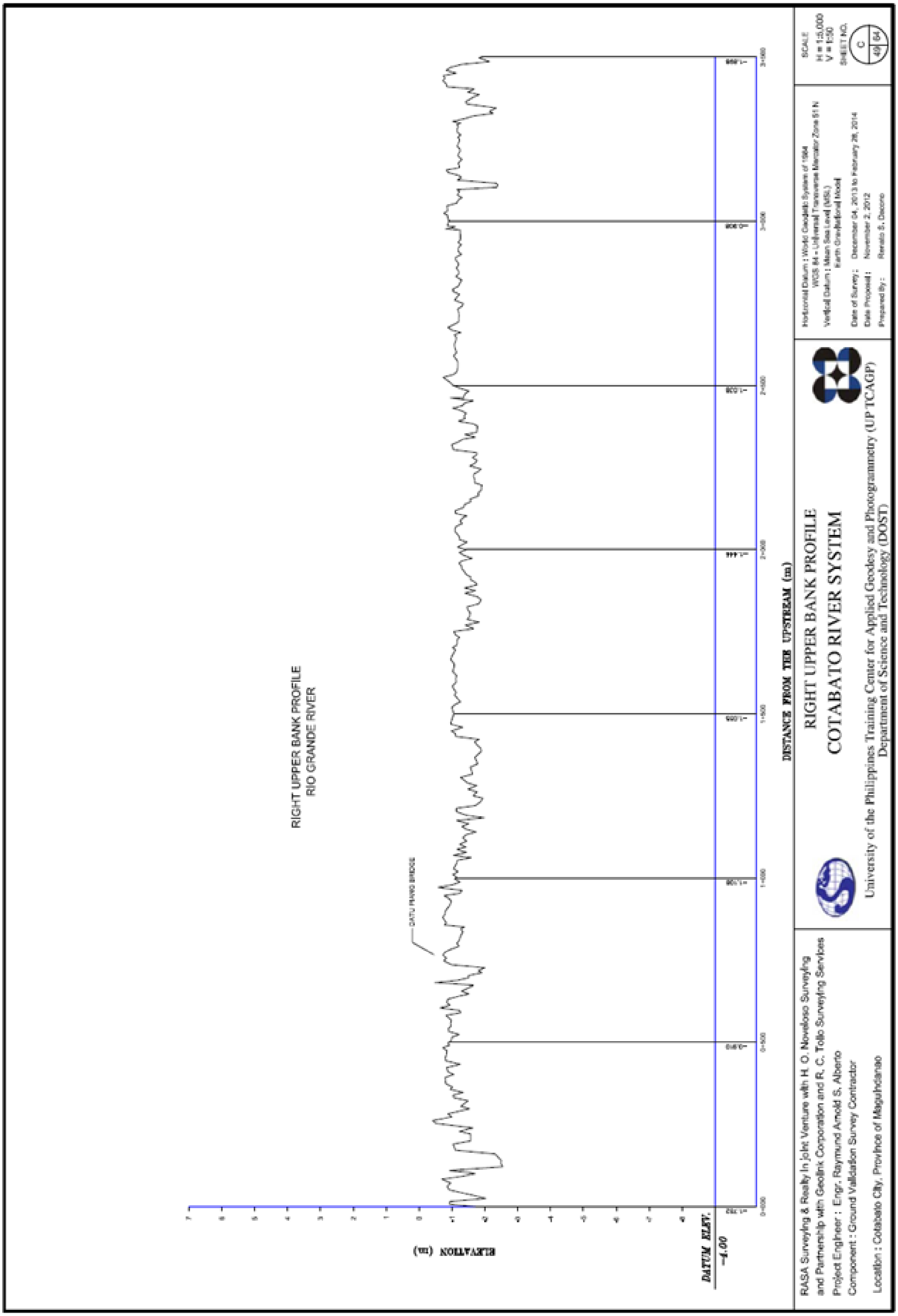
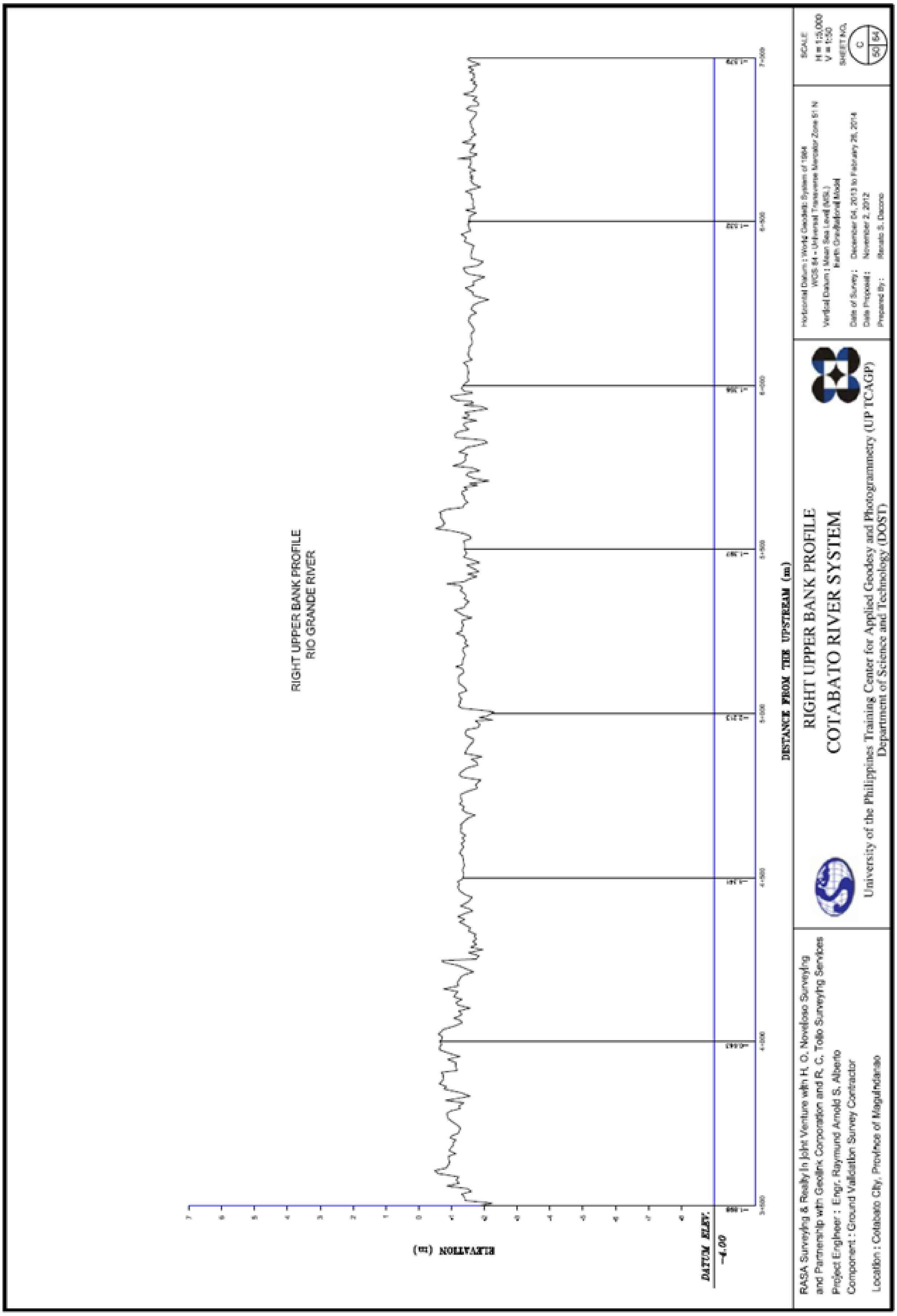
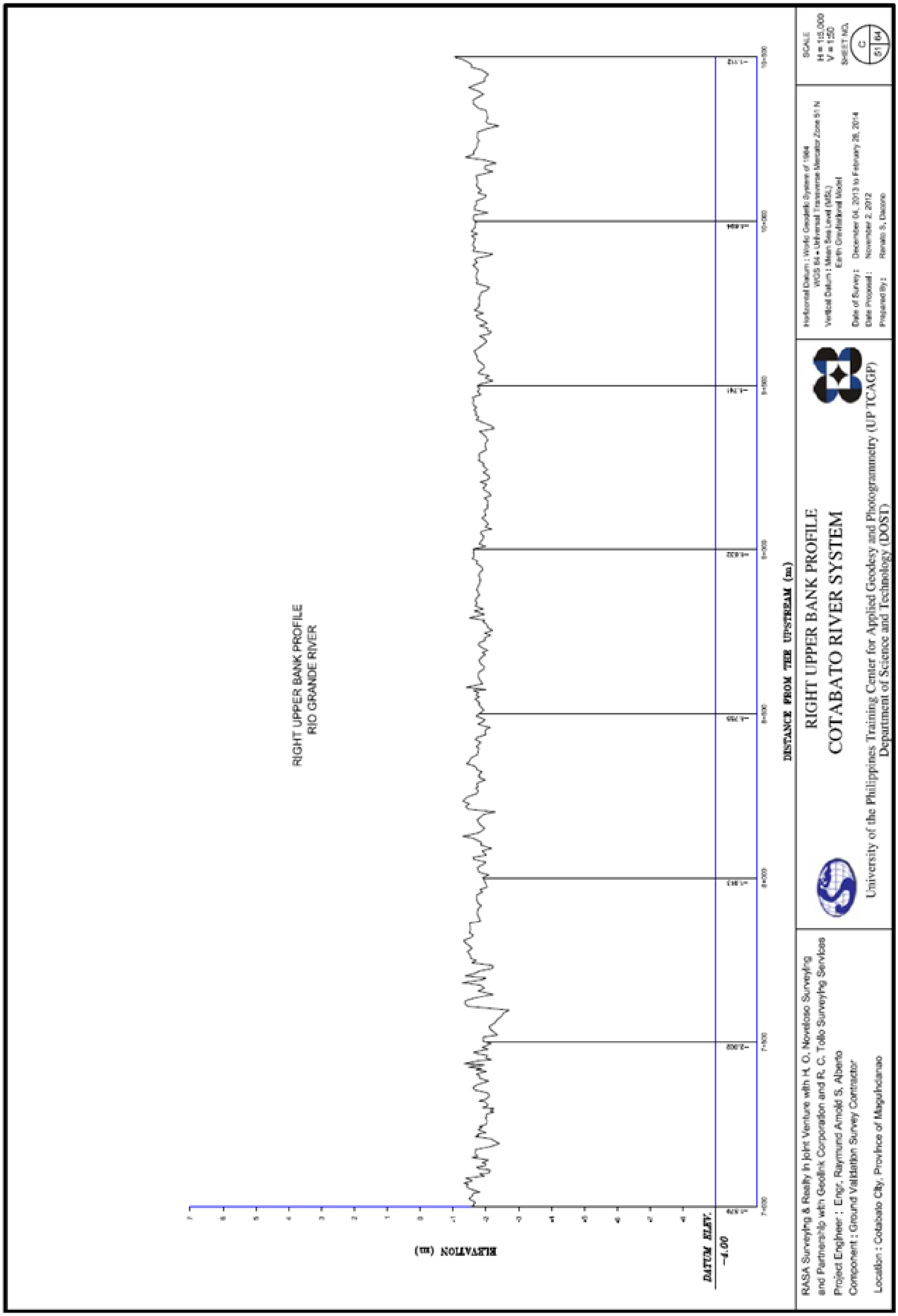
V = 1:50
SHEET NO.


RIGHT LOWER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
-4.00
DISTANCE FROM THE UPSTREAM (m)
RIGHT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Novelozo Surveying and Partnership with Geolink Corporation and R. C. Tolilo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberio
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Horizontal Datum : World Geodetic System of 1984
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Date Proposal : November 2, 2012
Prepared By : Renato S. Decano
SCALE
H = 1:5,000
V = 1:50
SHEET NO.


RIGHT LOWER BANK PROFILE
RIO GRANDE RIVER
DISTANCE FROM THE UPSTREAM (m)
ELEVATION (m)
DATUM ELEV. -6.00
RIGHT LOWER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying and Partnership with GeoLink Corporation and R. C. Tello Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
SCALE
H = 1:5,000
V = 1:50
SHEET NO.


RIGHT UPPER BANK PROFILE
RIO GRANDE RIVER
DATU PIANG BRIDGE
ELEVATION (m)
DATUM ELEV.
-4.00
DISTANCE FROM THE UPSTREAM (m)
RIGHT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying
and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Date Prepared : November 2, 2012
Prepared By : Renato S. Decano
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
C
49
64


RIGHT UPPER BANK PROFILE
RIO GRANDE RIVER
DISTANCE FROM THE UPSTREAM (m)
ELEVATION (m)
DATUM ELEV.
-4.00
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying
and Partnership with Geolink Corporation and R. C. Tolio Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
RIGHT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
Vertical Datum : Mean Sea Level (MSL)
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
C


RIGHT UPPER BANK PROFILE
RIO GRANDE RIVER
DATUM ELEV.
-4.00
ELEVATION (m)
DISTANCE FROM THE UPSTREAM (m)
RIGHT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tolio Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Date Proposed : November 2, 2012
Prepared By : Renato S. Dacono
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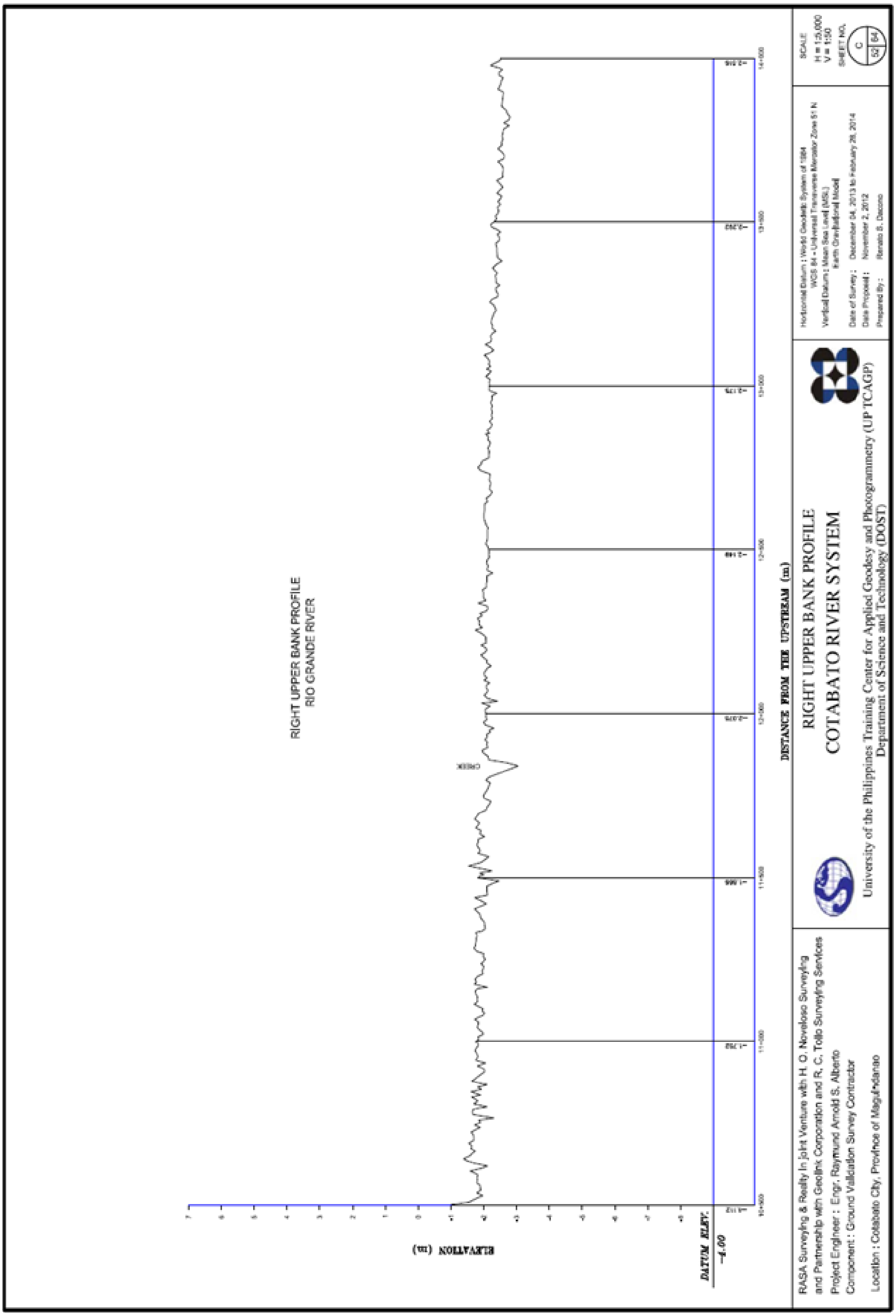
V = 1:50
SHEET NO.
C
51 64



RIGHT UPPER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
-4.00
CREEK
10+500
11+000
11+500
12+000
12+500
13+000
13+500
14+000
DISTANCE FROM THE UPSTREAM (m)
RASA Surveying & Realty In Joint Venture with H. O. Noveloso Surveying
and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Cotabato City, Province of Maguindanao
RIGHT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
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Horizontal Datum : World Geodetic System of 1984
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Date Proposed : November 2, 2012
Prepared By : Renato S. Dacono
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SHEET NO.
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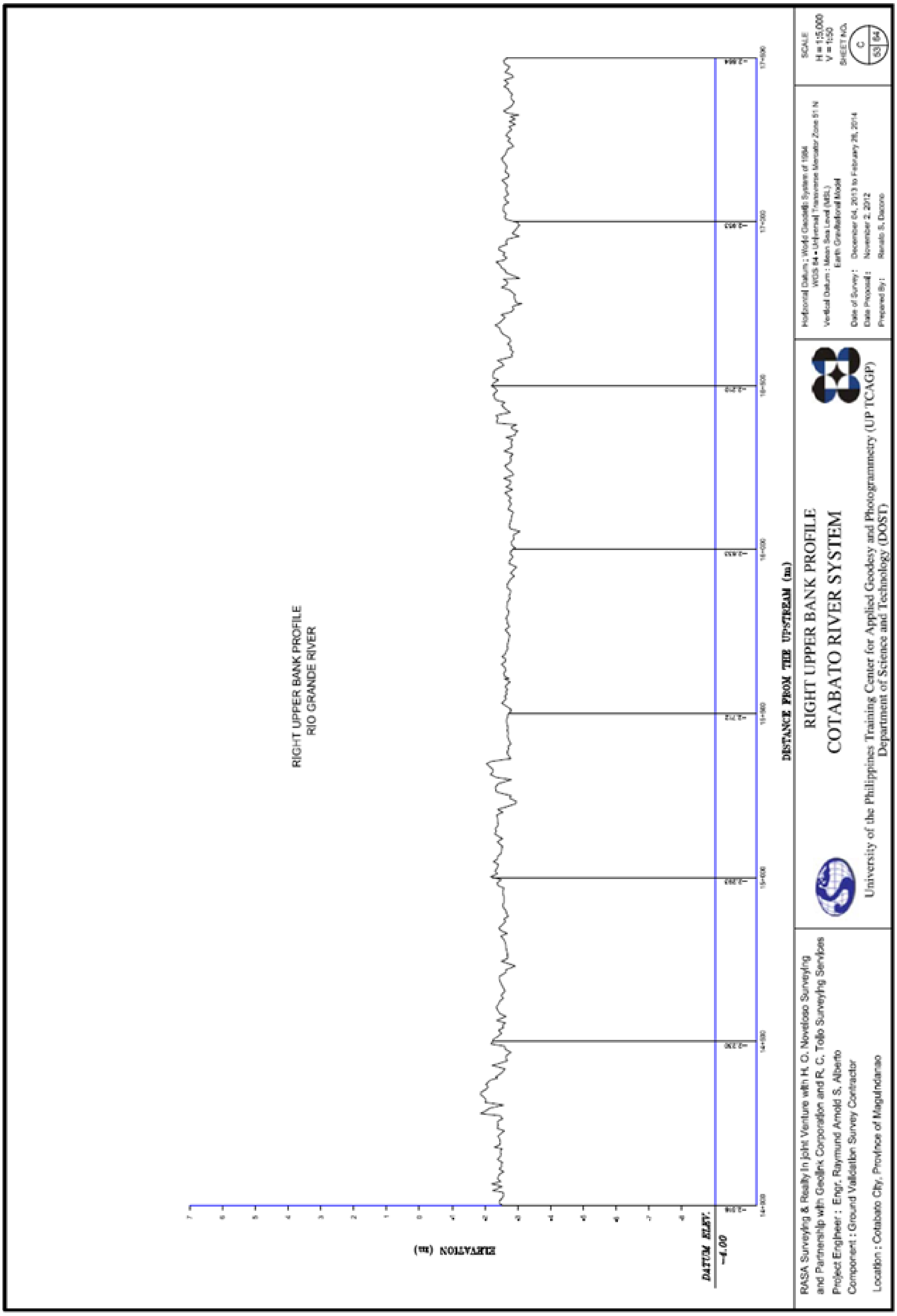
84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RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
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DISTANCE FROM THE UPSTREAM (m)
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying and Partnership with Geollinx Corporation and R. C. Tollo Surveying Services
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Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
Date Proposal : November 2, 2012
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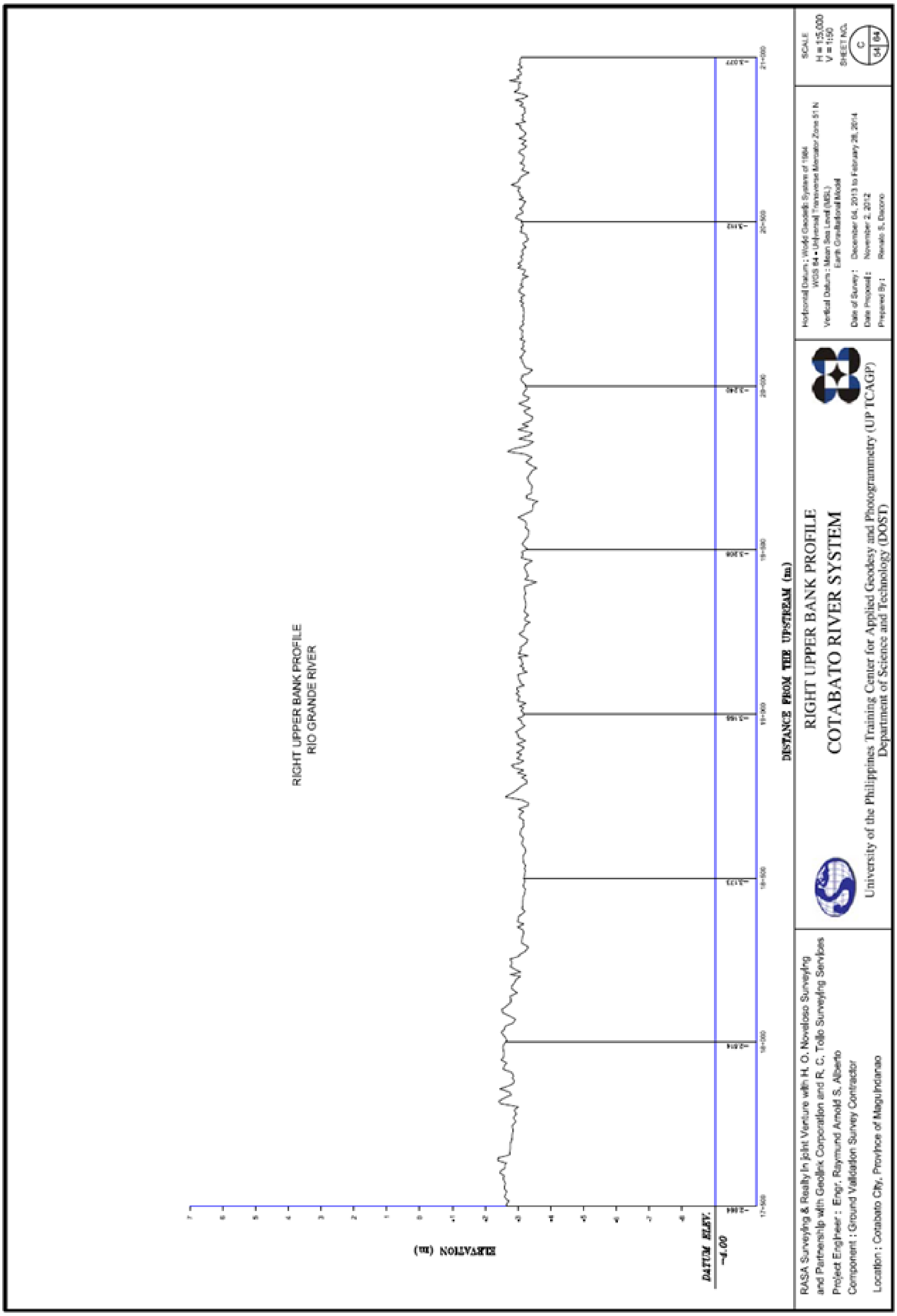
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DISTANCE FROM THE UPSTREAM (m)
RIGHT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
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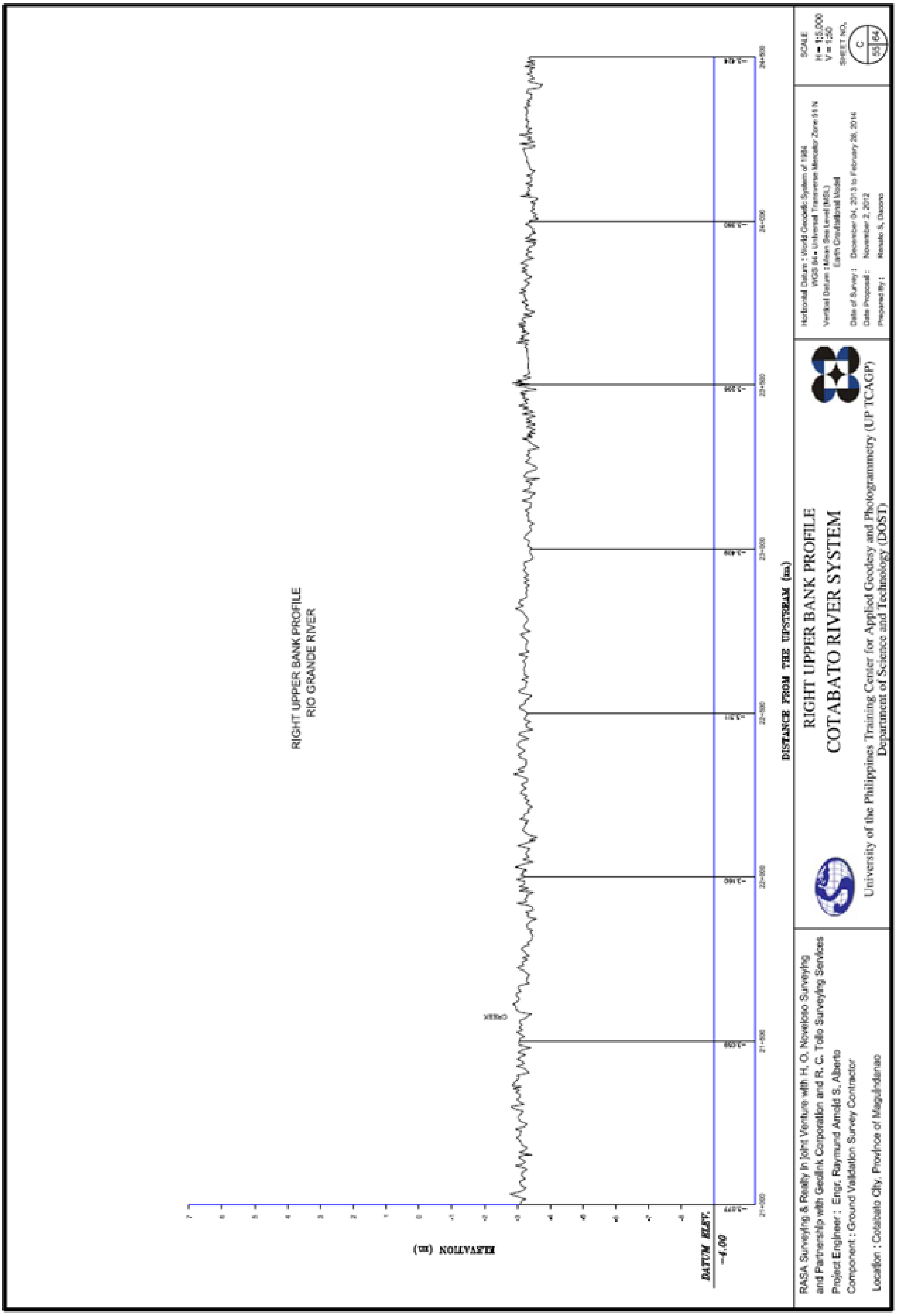
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CREEK
ELEVATION (m)
DATUM ELEV.
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DISTANCE FROM THE UPSTREAM (m)
RIGHT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
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SHEET NO.
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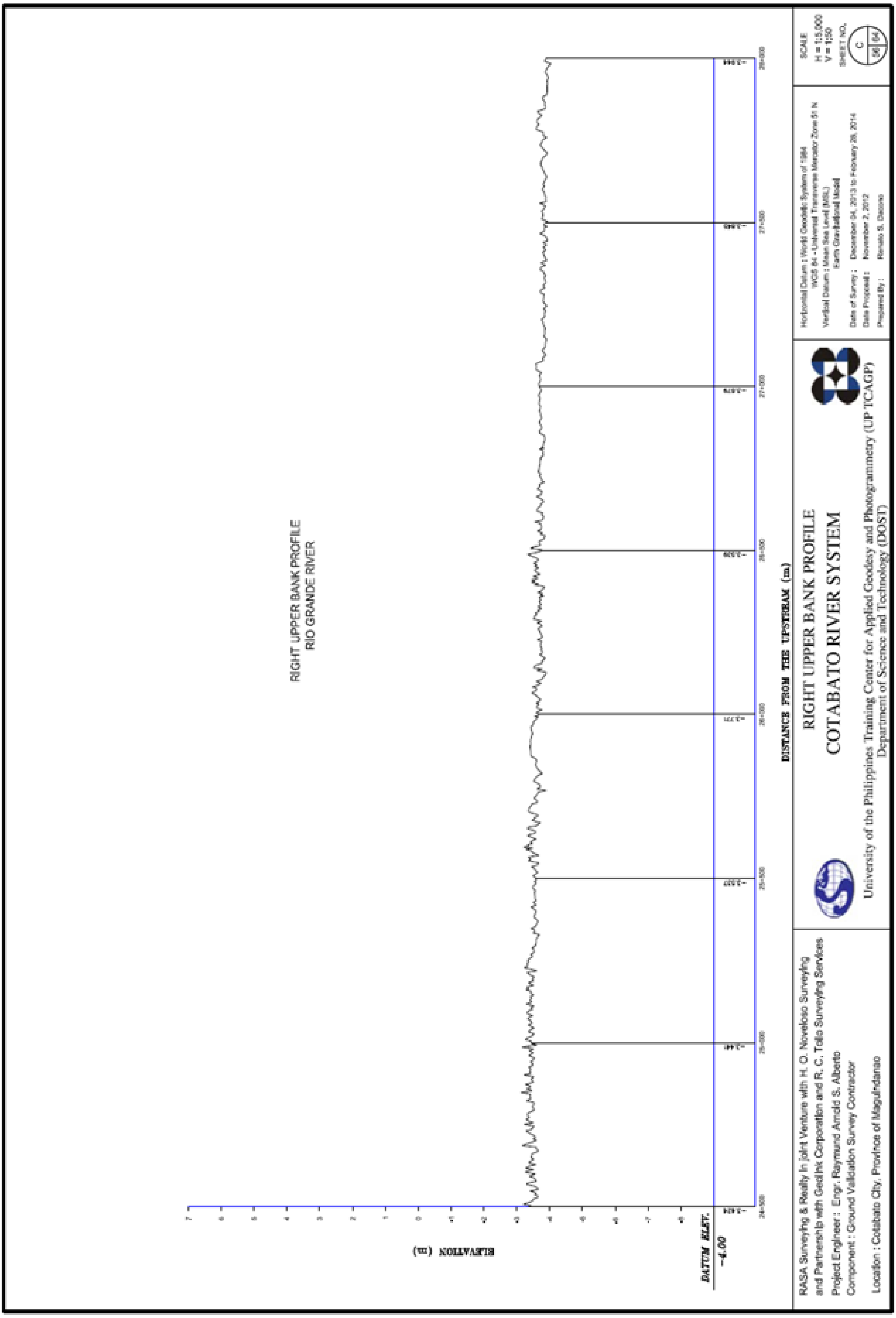

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RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
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DISTANCE FROM THE UPSTREAM (m)
RIGHT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
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V = 1:50
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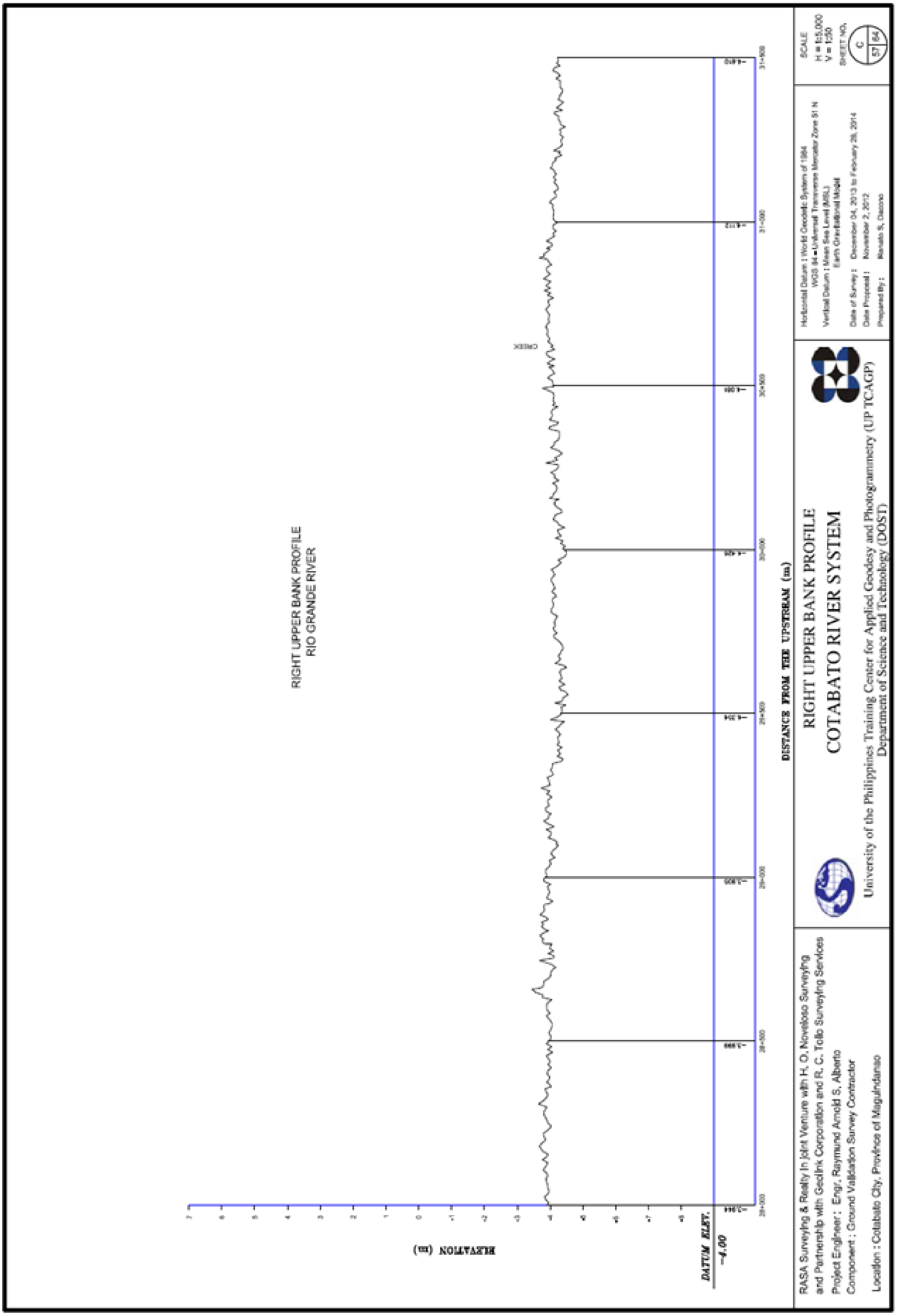
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ELEVATION (m)
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DISTANCE FROM THE UPSTREAM (m)
RIGHT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
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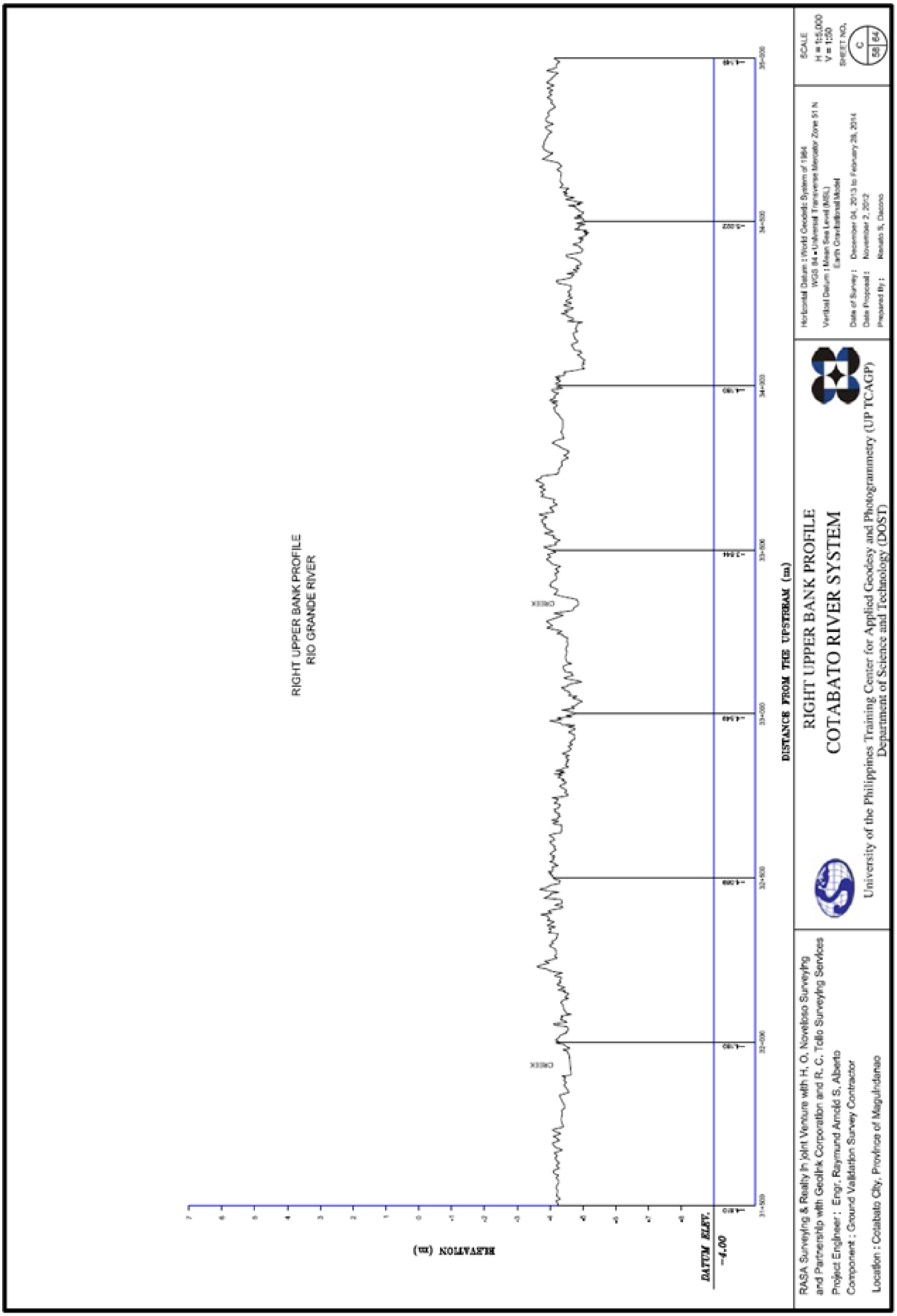
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RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
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DISTANCE FROM THE UPSTREAM (m)
CREEK
RIGHT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
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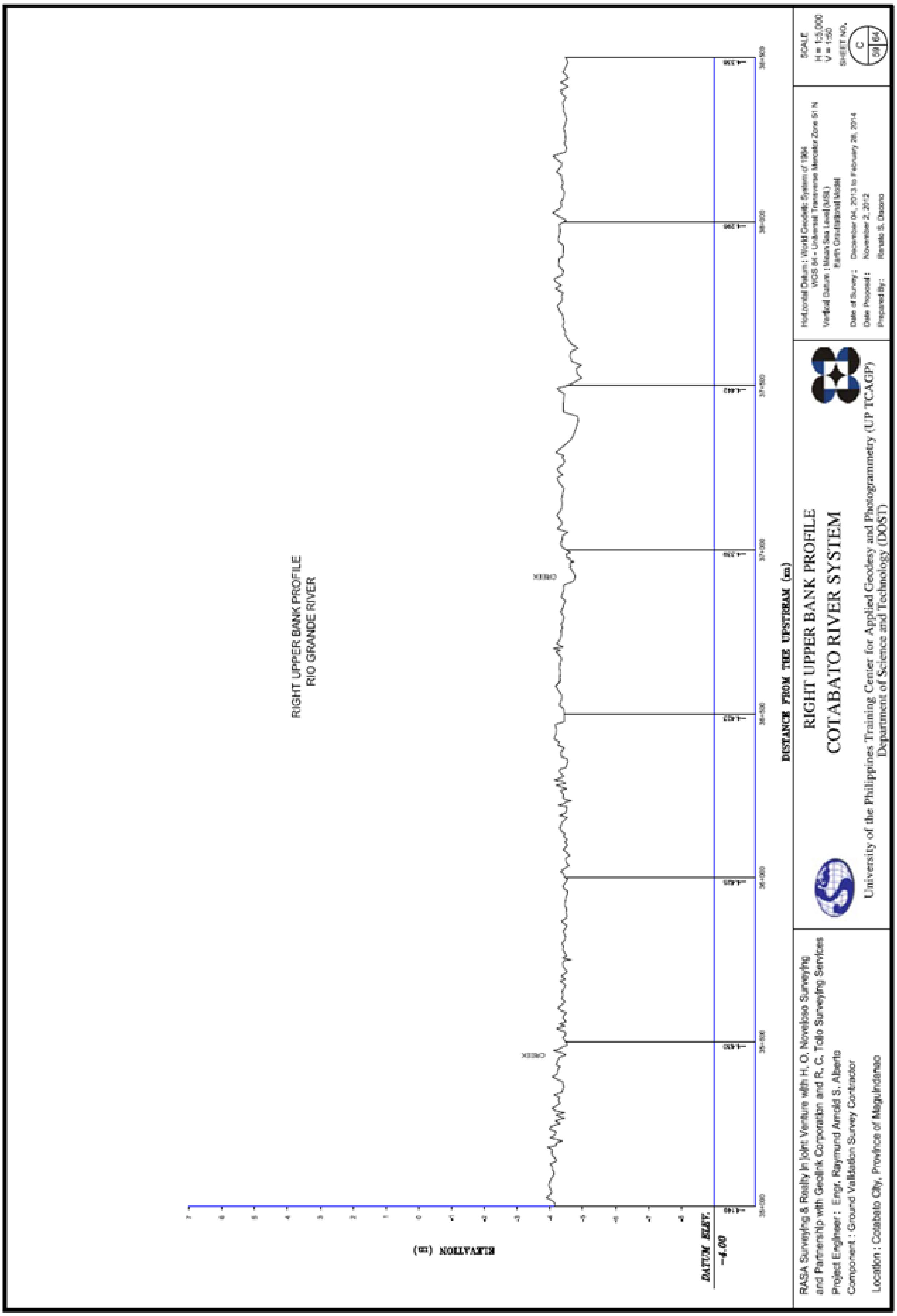
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RIO GRANDE RIVER
CREEK
CREEK
ELEVATION (m)
DATUM ELEV.
-4.00
DISTANCE FROM THE UPSTREAM (m)
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Prepared By :
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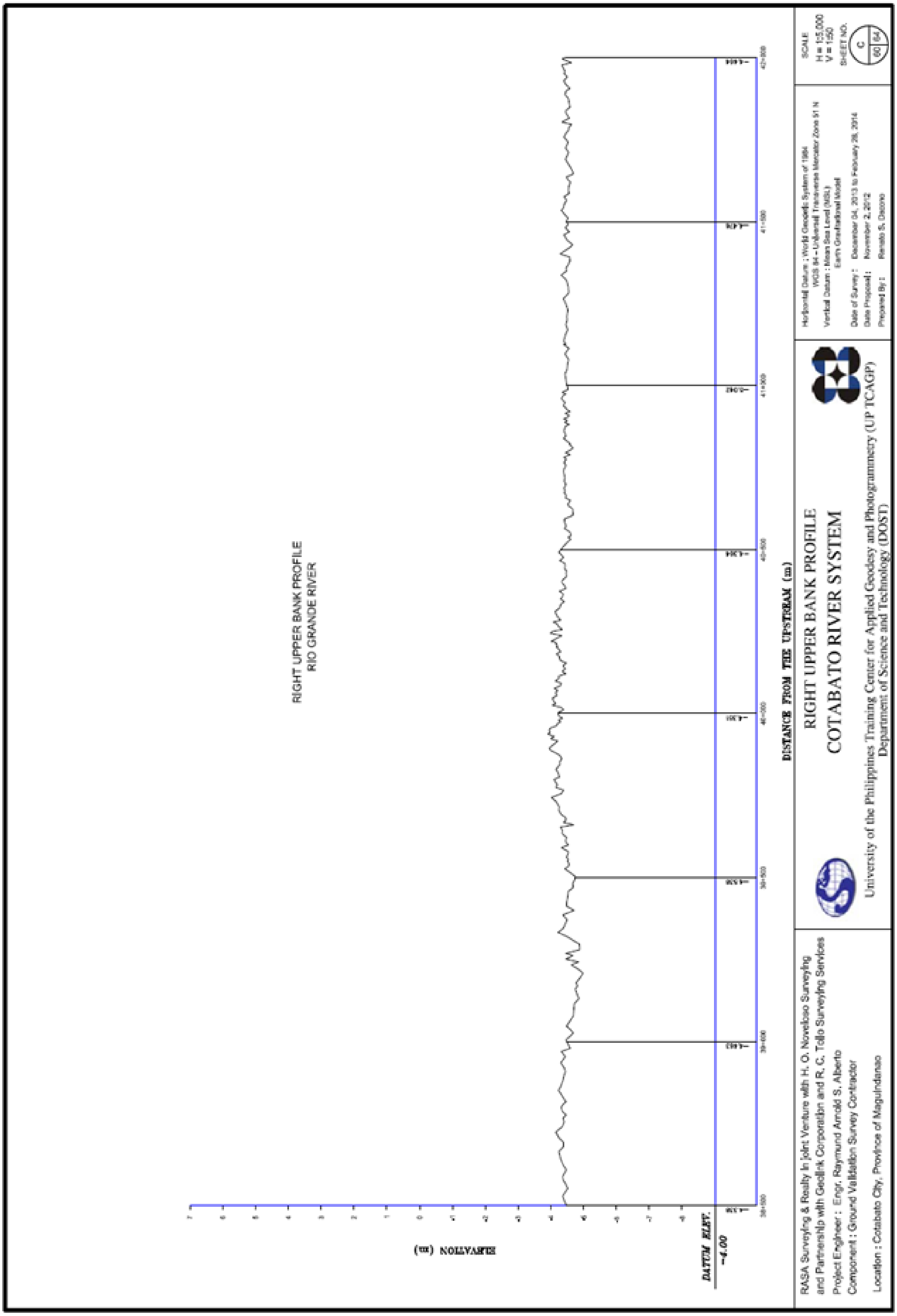
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RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
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DISTANCE FROM THE UPSTREAM (m)
RASA Surveying & Realty in joint Venture with H. O. Novelloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
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RIGHT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
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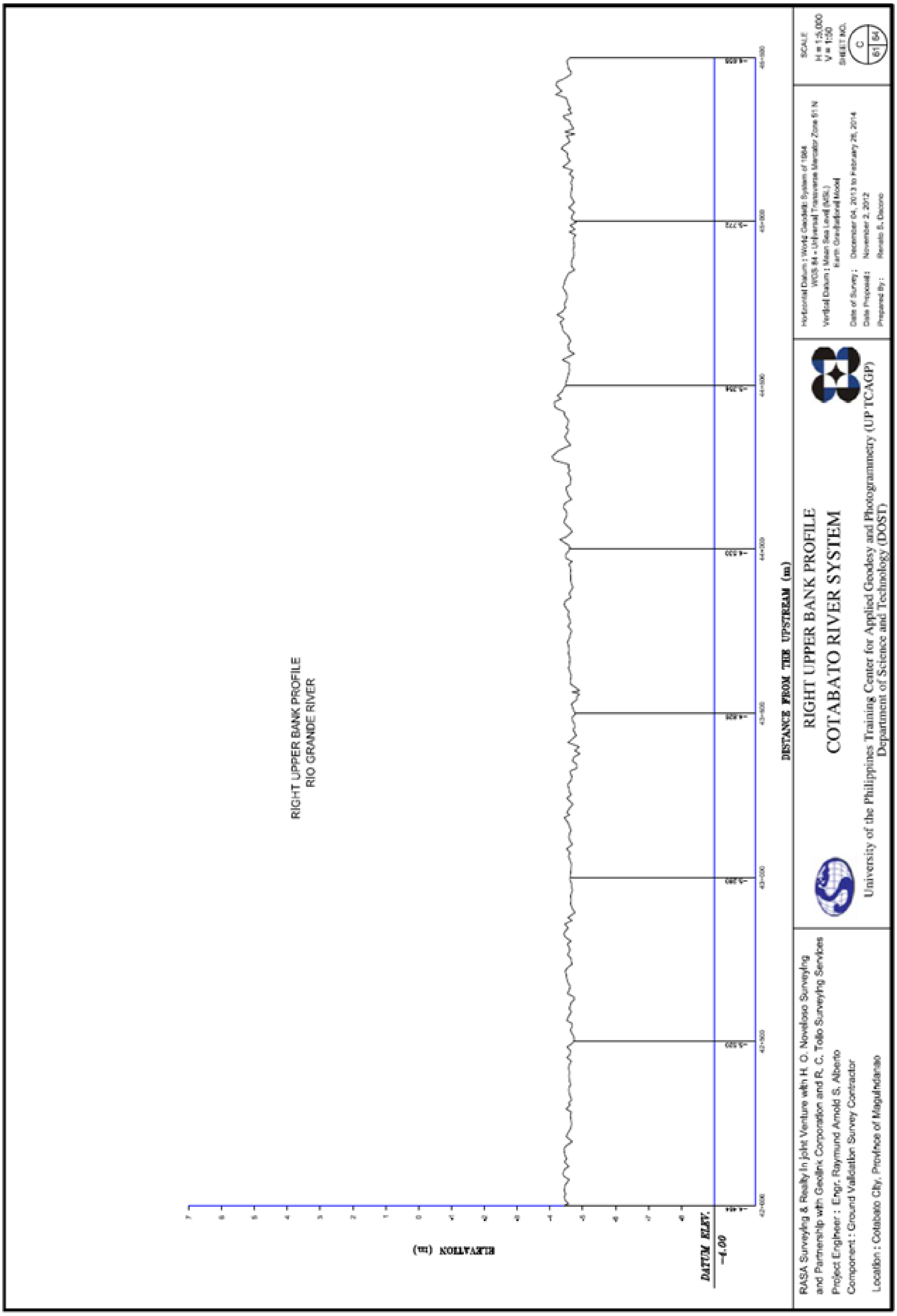
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RIO GRANDE RIVER
DATUM ELEV.
-4.00
ELEVATION (m)
DISTANCE FROM THE UPSTREAM (m)
RIGHT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
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Prepared By : Renato S. Dicono
SCALE
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V = 1:50
SHEET NO.
C
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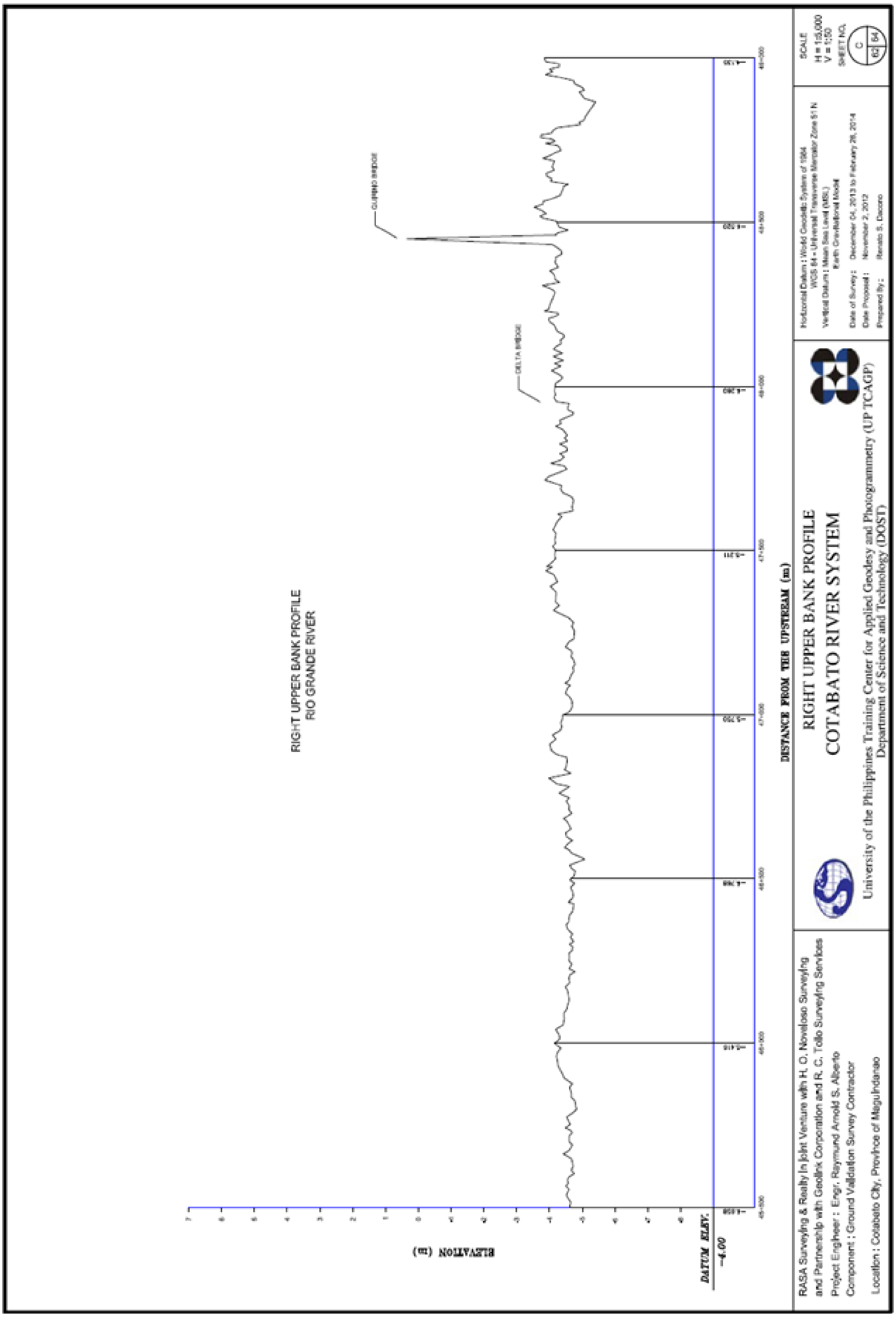
RIGHT UPPER BANK PROFILE
RIO GRANDE RIVER
QUIRINO BRIDGE
DELTA BRIDGE
DATUM ELEV.
-4.00
ELEVATION (m)
DISTANCE FROM THE UPSTREAM (m)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying
and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
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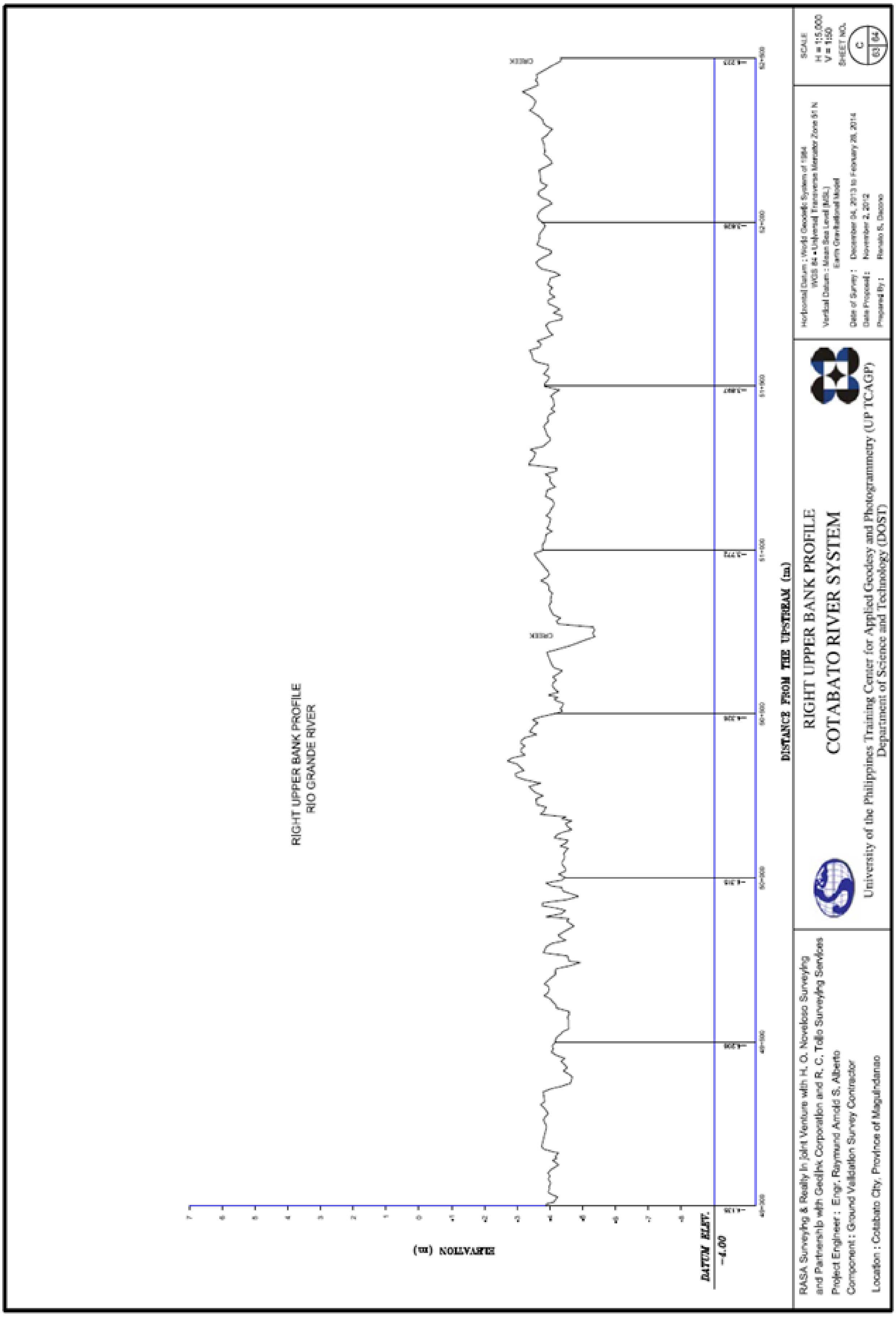
Earth Gravitational Model
Date of Survey : December 04, 2013 to February 28, 2014
SCALE
SHEET NO.


RIGHT UPPER BANK PROFILE
RIO GRANDE RIVER
CREEK
CREEK
ELEVATION (m)
DATUM ELEV.
-4.00
DISTANCE FROM THE UPSTREAM (m)
RIGHT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
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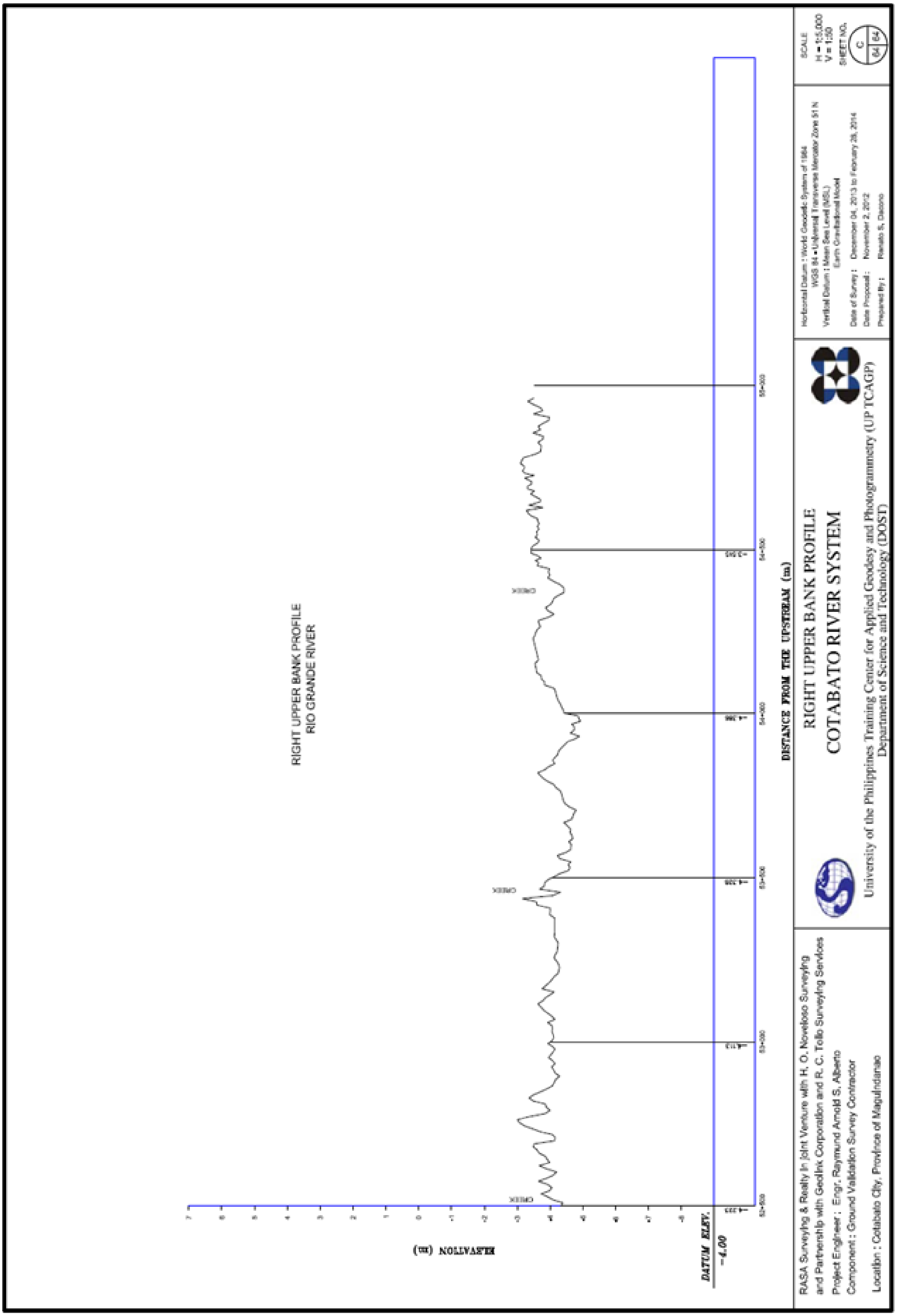
RIGHT UPPER BANK PROFILE
RIO GRANDE RIVER
ELEVATION (m)
DATUM ELEV.
-4.00
DISTANCE FROM THE UPSTREAM (m)
CREEK
RIGHT UPPER BANK PROFILE
COTABATO RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
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H = 1:5,000
V = 1:50
SHEET NO.
C
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84

Table 6 shows the processed ground control points which are adjusted using the Trimble Business Center, GNSS processing and adjustment report can be seen in "Annex E".

Table 6: Adjusted Ground Control Points.

List of Ground Control Points													
	WGS-84						UTM						
Sta. Name	Latitude			Longitude			Northing	Easting	Ellipsoidal Ht.	Elev. (EGM08)	MSL	Vert. Acc.	Hor. Acc.
	dd	mm	ss.ssss	dd	mm	ss.ssss	mmmmmmm. mmmm	mmmmmmm. mmmm	mmmm.mm	mmmm.mm	mmmm. mm		
CTA-16	7	11	26.6570	124	14	2.2232	795018.0470	636245.3210	74.240	2.246	-3.038	0.015	0.0099
MIN-12	7	14	18.7200	124	31	16.4615	800399.0200	667954.9110	98.585	26.127	20.843	0.015	0.0092
MIN-14	7	12	36.9019	124	14	43.9653	797179.0690	637519.8920	86.483	14.531	9.247	0.012	0.0120
GCP-1	7	1	45.3621	124	29	57.1568	777249.4370	665597.4250	82.234	9.634	4.350	0.025	0.0142
GCP-2	7	3	44.0309	124	27	15.3284	780878.9290	660619.7430	75.734	3.153	-2.131	0.018	0.0120
GCP-3	7	5	28.8338	124	25	37.1752	784088.8250	657597.9110	74.704	2.160	-3.124	0.016	0.0099
GCP-4	7	8	53.0394	124	23	15.9942	790348.1290	653247.0960	74.209	1.765	-3.519	0.016	0.0092
GCP-5	7	10	20.6258	124	20	22.0449	793022.6060	647902.5720	73.670	1.313	-3.971	0.035	0.0120
GCP-6	7	12	19.7932	124	17	55.6357	796669.9570	643400.7360	72.845	0.630	-4.654	0.019	0.0110
GCP-7	7	13	46.7867	124	15	23.2691	799328.8750	638719.5790	73.402	1.484	-3.800	0.011	0.0099
GCP-8	7	15	6.8650	124	12	41.0616	801774.9450	633737.7090	72.910	1.368	-3.916	0.017	0.0113

Annexes

Annexes

ANNEX A. THE SURVEY TEAM

THE SURVEY TEAM		
ITEM #	NAME	DESIGNATION
1	ENGR. RAYMUND ARNOLD S. ALBERTO	PROJECT ENGINEER
2	RENATO S. DACONO	TECHNICAL STAFF
3	ENGR. MARVIN ANDREW A. CALIOLIO	CHIEF OF PARTY
4	BERNIE REVAMONTE	TEAM LEADER FOR GROUP 1 (RASA)
5	FRANIE T. REYES	TEAM LEADER FOR GROUP 2 (RCT)
6	JULIETO G. CABILIN	TEAM LEADER FOR GROUP 3 (HONS)
7	JULIO BALENSONA	TEAM LEADER FOR GROUP 4 (GEOLINK)
8	JAY BORJA	INSTRUMENT MAN
9	NELSO ACOSTA	INSTRUMENT MAN
10	GREGORIO COSTELO	INSTRUMENT MAN
11	RAMIL OLIMPIADA	INSTRUMENT MAN
12	DENNIS REFUGIA	INSTRUMENT MAN
13	BRYAN URMENETA	INSTRUMENT MAN/DRIVER
14	RYAN AUDREY BASCO	INSTRUMENT MAN/CADD OPERATOR
15	JEFFERSON F. ORBILLO	INSTRUMENT MAN
16	JAYPEE NOVELOSO	INSTRUMENT MAN
17	RICHARD QUINES	INSTRUMENT MAN
18	JORGE RENE GUERRERO	INSTRUMENT MAN
19	JOHN BRYAN ESCAMILLA	INSTRUMENT MAN
20	HAROLD ARGAO	DRIVER
21	ERWIN TOLLO	DRIVER
22	JERRY D. DOMINGO	DRIVER
		24 SURVEY AIDS

ANNEX B. LIST OF EQUIPMENT AND INSTRUMENTS

ITEM #	EQUIPMENT NAME	SERIAL #
1	HI-TARGET V30ST L1/L2	3000608
2	HI-TARGET V30ST L1/L2	3005333
3	HI-TARGET V30ST L1/L2	3006440
4	HI-TARGET V30ST L1/L2	3011059
5	HI-TARGET V30ST L1/L2	3011154
6	HI-TARGET V30ST L1/L2	3000614
7	HI-TARGET V30ST L1/L2	3000762
8	HI-TARGET V30ST L1/L2	3004252
9	HI-TARGET V30ST L1/L2	3004203
10	SOKKIA GSX2	107310035
11	SOKKIA GSX2	107310052
12	SOKKIA GSX2	107310007
13	EPOCH 25 L1/L2	0726J36433
14	EPOCH 25 L1/L2	0746J55231
15	EPOCH 25 L1/L2	0813J55299
16	EPOCH 25 L1/L2	0813J55657
17	HI-TARGET ZTS 120R	Z 10220
18	HI-TARGET ZTS 120	Z 10553
19	SOKKIA SET 3030R3	35980
20	SOKKIA SET 630R	157615
21	SOKKIA SET 610	206709
22	SANDING STS 755L	SD 12344
23	4 UNITS HANDHELD GPS	NA
24	8 UNITS DIGITAL CAMERA	NA
25	4 UNITS LAPTOP	NA
26	4 UNITS SERVICE VEHICLE	NA

ANNEX C. ACTUAL FIELD SURVEY ACTIVITIES

DATE	ACTIVITY	LOCATION
4-Dec-13	Mobilization	Manila to Cotabato City
5-Dec-13	Courtesy Call to Local Government Units	Cotabato City
6-Dec-13	Kick-off meeting of the whole team	Field office
7-Dec-13	Establishment of Project control	Cotabato City
8-Dec-13	Courtesy Call to Local Government Units	Kabuntalan
9-Dec-13	Courtesy Call to Local Government Units	Datu Piang
10-Dec-13	Courtesy Call to Local Government Units	North Kabuntalan
11-Dec-13	Establishment of GCPs	Project area
12-Dec-13	Establishment of GCPs	Project area
13-Dec-13	GNSS observation	Project area
14-Dec-13	Profile survey	Cotabato City
15-Dec-13	Coordination to other concerned LGUs & Local Residents	Cotabato City
16-Dec-13	Coordination to other concerned LGUs & Local Residents	Cotabato City
17-Dec-13	Profile survey	Rio Grande River
18-Dec-13	Profile survey	Rio Grande River
19-Dec-13	Profile survey	Rio Grande River
20-Dec-13	Courtesy Call to Local Government Units & Military	North Kabuntalan
21-Dec-13	Profile survey	Rio Grande River
22-Dec-13	Other teams went back to Manila due to some of the concern LGUs were already on leave	Cotabato City to Manila
23-Dec-13	Secure permit from the available LGUs	North Kabuntalan
24-Dec-13	Profile survey	Project area
25-Dec-13	No work	
26-Dec-13	Profile survey	Rio Grande River
27-Dec-13	Profile survey	Rio Grande River
28-Dec-13	Profile survey	Rio Grande River
29-Dec-13	Profile survey	Rio Grande River
30-Dec-13	Profile survey	Rio Grande River
31-Dec-13	Profile survey	Rio Grande River
2-Jan-14	Travel to Cotabato City/ Profile survey	Project area
3-Jan-14	Profile survey	Rio Grande River
4-Jan-14	Profile survey	Rio Grande River
5-Jan-14	Profile survey /Coordination with the available LGUs	Cotabato City
6-Jan-14	Profile survey	Rio Grande River
7-Jan-14	Profile survey	Rio Grande River
8-Jan-14	Profile survey	Rio Grande River
9-Jan-14	Profile survey	Rio Grande River
10-Jan-14	Profile survey	Rio Grande River
11-Jan-14	Rainy no activity	Project area

12-Jan-14	**Rainy no activity**	**Project area**
13-Jan-14	Rainy no activity	Project area
14-Jan-14	Rainy no activity	Project area
15-Jan-14	Cross-section and profile survey	Rio Grande River
16-Jan-14	Cross-section and profile survey	Rio Grande River
17-Jan-14	Cross-section and profile survey	Rio Grande River
18-Jan-14	Cross-section and profile survey	Rio Grande River
19-Jan-14	Cross-section and profile survey	Rio Grande River
20-Jan-14	Cross-section and profile survey	Rio Grande River
21-Jan-14	Cross-section and profile survey	Rio Grande River
22-Jan-14	Cross-section and profile survey	Rio Grande River
23-Jan-14	Cross-section and profile survey	Rio Grande River
24-Jan-14	Cross-section and profile survey	Rio Grande River
25-Jan-14	Cross-section & Profile Survey	Rio Grande River
26-Jan-14	Cross-section & Profile Survey	Rio Grande River
27-Jan-14	Cross-section & Profile Survey	Rio Grande River
28-Jan-14	No activity / Cross-section	Datu Piang / Kabuntalan
29-Jan-14	Cross-section Survey	Rio Grande River
30-Jan-14	Cross-section Survey	Rio Grande River
31-Jan-14	Cross-section Survey	Rio Grande River
1-Feb-14	Cross-section Survey	Rio Grande River
2-Feb-14	Cross-section Survey	Rio Grande River
3-Feb-14	Cross-section Survey	Rio Grande River
4-Feb-14	Cross-section Survey	Rio Grande River
5-Feb-14	Cross-section Survey	Rio Grande River
6-Feb-14	Cross-section Survey	Rio Grande River
7-Feb-14	Cross-section Survey	Rio Grande River
8-Feb-14	Cross-section Survey	Rio Grande River
9-Feb-14	Cross-section Survey	Rio Grande River
10-Feb-14	Cross-section Survey	Rio Grande River
11-Feb-14	Rainy no activity	Project area
12-Feb-14	Cross-section Survey	Rio Grande River
13-Feb-14	Cross-section Survey	Rio Grande River
14-Feb-14	Cross-section Survey	Rio Grande River
15-Feb-14	Cross-section Survey	Rio Grande River
16-Feb-14	Cross-section Survey	Rio Grande River
17-Feb-14	Cross-section Survey	Rio Grande River
18-Feb-14	Cross-section Survey	Rio Grande River
19-Feb-14	Cross-section Survey	Rio Grande River
20-Feb-14	Cross-section Survey	Rio Grande River
21-Feb-14	Cross-section Survey	Rio Grande River

22-Feb-14	Cross-section Survey	Rio Grande River
23-Feb-14	Cross-section Survey	Rio Grande River
24-Feb-14	Cross-section Survey	Rio Grande River
25-Feb-14	Cross-section Survey	Rio Grande River
26-Feb-14	Cross-section Survey	Rio Grande River
27-Feb-14	Cross-section Survey	Rio Grande River
28-Feb-14	UP-DVC field validation	Rio Grande River
1-Mar-14	UP-DVC field validation	Rio Grande River
2-Mar-14	UP-DVC field validation	Rio Grande River

ANNEX D. CERTIFIED REFERENCE POINTS AND BENCHMARK

Republic of the Philippines
Department of Environment and Natural Resources
NATIONAL MAPPING AND RESOURCE INFORMATION AUTHORITY
Lawton Avenue, Fort Andres Bonifacio, 1202 Makati City

August 28, 2009

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: **MAGUINDANAO**

Station Name: **MGD-2 = COTABATO WATER TANK**

Island:	**MINDANAO**			Order:	**1st**
Municipality:	**COTABATO CITY**			Barangay:	
		PRS92 Coordinates			
Latitude:	**7° 13' 15.64595"**	Longitude:	**124° 14' 33.61529"**	Ellipsoidal Hgt:	**63.17200 m.**
		WGS84 Coordinates			
Latitude:	**7° 13' 12.35957"**	Longitude:	**124° 14' 39.13820"**	Ellipsoidal Hgt:	**132.25570 m.**
		PTM Coordinates			
Northing:	**798,479.586 m.**	Easting:	**416,359.591 m.**	Zone:	**5**

Location Description

MGD-2 = COTABATO WATER TANK
From Cotabato City Plaza, along Sinsuat Ave., travel SW for 230 m. to Quezon Ave. Then turn right and travel W uphill for 0.7 km. to the gate of the Cotabato City Internal Defense Command and park on the left side of Cotabato City Metropolitan District Command (COMDISCOM). Walk for 100 m. to COMDISCOM parade ground up to the iron stair at the N side of the water tank. Station is located at Colina Hill on top of a concrete water tank, about 400 m. S of the poblacion, 80 m. NW of and 20 m. higher than the parade ground. Station mark is a drill hole at the center of a 3 in. triangle chiseled 0.87 m. N of the highest portion, and on the 16th step from the 0.305 m. parapet wall of the concrete water tank.

Requesting Party: **RASA Surveying**
Pupose: **Reference**
OR Number: **8456557 M**
T.N.: **0252-2009**

JOSE GALO P. ISADA, JR.
Director, MGD

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

February 25, 2014

CERTIFICATION

To whom it may concern:

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

Province: **COTATBATO (NORTH COTABATO)**
Station Name: **IBM-58**

Island: **Mindanao**	Municipality: **KABACAN**	Barangay: **POBLACION**
Elevation: **14.7694 m.**	Order: **1st Order**	Datum: **Mean Sea Level**

Location Description

IBM-58 is in the Brgy. Poblacion, Kabacan, North Cotabato along Kidapawan-Cotabato Highway. Station is located 60 cm. north KM Post 1649 and about 15 cm east of Simuay Hardware.

Mark is the head of a 4" copper nail embedded in a 20x20 cm concrete monument with the inscription "DPWH, IBM-58, 2006".

Requesting Party:	**RASA Surveying**
Pupose:	**Reference**
OR Number:	**8795428 A**
T.N.:	**2014-384**

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

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

NAMRIA OFFICES:

ANNEX E. ENDORSEMENT LETTER

TRAINING CENTER FOR APPLIED GEODESY AND PHOTOGRAMMETRY
National Engineering Center, University of the Philippines, Quezon City 1101
Tel. Nos.: (+63-2) 981-8770 / (+63-2) 981-8771; Telefax: (+63-2) 920-8924

November 19, 2013

TO WHOM IT MAY CONCERN

Dear **Maam/Sir:**

The Training Center for Applied Geodesy & Photogrammetry of the University of the Philippines-Diliman (UP-TCAGP) is conducting a research program entitled **"Nationwide Disaster Risk and Exposure Assessment for Mitigation (DREAM)"** supported by the Department of Science and Technology (DOST) Grant-in-Aid Program. It generally aims to acquire a national elevation and resource information dataset in 3D at sufficient detail and resolution from which various base and thematic map features can be extracted. Particularly, we aim to operationalize the development of flood hazard models that would produce updated and detailed flood hazard maps for the major watersheds and river systems in the country.

The Nationwide DREAM Program contracted the Joint Venture of RASA Surveying & Realty and H.O. Noveloso Surveying to conduct the ground validation surveys for LiDAR Mapping. They are tasked to perform the following:

1. Recover the NAMRIA established reference points and benchmarks; and

2. Conduct cross-sectional and profile surveys along the Mindanao River.

With this, we are endorsing herewith the said contractors to your good office the smooth conduct of their surveys.

Thank you very much for your cooperation and generous support to our project. If you have questions about the project, please do not hesitate to contact any of the following:

Engr. Joemarie S. Caballero	Chief Science Research Specialist	0917-546-0346
Engr. Dexter T. Lozano	Supervising Science Research Specialist	0917-456-8675

Yours truly,

ENGR. LOUIE P. BALICANTA
Project Leader
Nationwide DREAM Program

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Endorsement letter from UP TCAGP for DREAM Project

ANNEX F. REFERENCE PHOTOGRAPHS

Coordination with the LGUs

Actual Field Survey

MGD-2

NAMRIA 1st Order Horizontal Control

Establishment of Ground Control Points



Some Pictures for Profile Survey






Some Pictures for Cross Section Survey











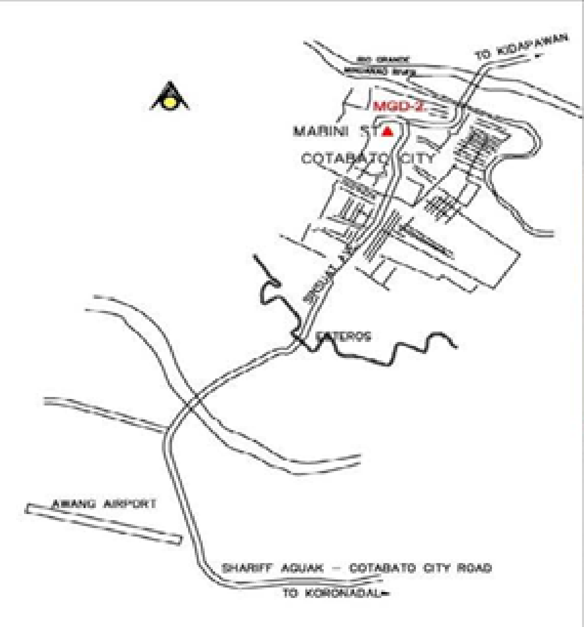
Actual validation survey with UP-DVC Engineers


RASA
FILA

ANNEX G. RECOVERED NAMRIA REFERENCE POINTS

Control Number: MGD-2

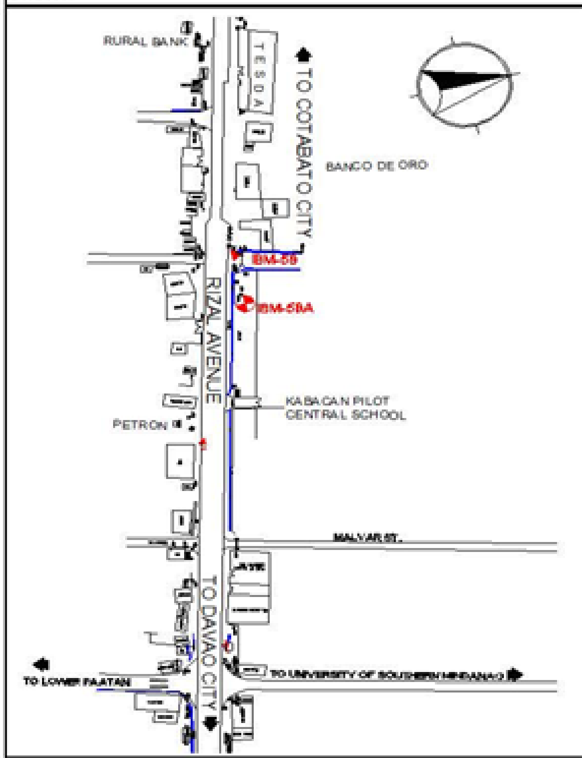
Station Name	MGD-2	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	N7°13'15.645964"
	Longitude	E124°14'33.615291"
	Ellipsoidal Height	63.172 m.
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	N7°13'12.359570"
	Longitude	E124°14'39.138200"
	Ellipsoidal Height	132.256 m.
Elevation	meters above Mean Sea Level (MSL)	
Description	MGD-2 = COTABATO WATER TANK From Cotabato Airport travel About 9.5 km. Northeast towards Cotabato City Plaza, along Sinsuat Ave., travel SW for 230 m. to Quezon Ave. Then turn right and travel W uphill for 0.7 km. to the gate of the Cotabato City Internal Defense Command and park on the left side of Cotabato City Metropolitan District Command (COMDISCOM). Walk for 100 m. to COMDISCOM parade ground up to the iron stair at the N side of the water tank. Station is located at Colina Hill on top of a concrete water tank, about 400 m. S of the poblacion, 80 m. NW of and 20 m. higher than the parade ground. Station mark is a drill hole at the center of a 3 in. triangle chiseled 0.87 m. N of the highest portion, and on the 16th step from the 0.305 m. parapet wall of the concrete water tank.	
Sketch	Picture	



ANNEX H. RECOVERED NAMRIA BENCHMARK

Control Number: IBM-58A

Station Name	**IBM-58A**	
Order of Accuracy	**2nd**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	**Latitude**	N7°06'29.510637"
	Longitude	E124°49'30.663148"
	Ellipsoidal Height	22.014 m.
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	**Latitude**	N7°06'26.307581"
	Longitude	E124°49'36.191120"
	Ellipsoidal Height	92.755 m.
Elevation	15.025 meters above Mean Sea Level (MSL)	
Description	**IBM-58** Located in the Brgy. Poblacion, Kabacan, North Cotabato along Kidapawan - Cotabato Highway (Rizal Avenue). Station is located 60cm North of KM post 1649 and about 15 cm east of Simuay Hardware. Mark is the head of a 4" copper nail embedded in a 20x20x80cm concrete monument with th inscription "DPWH, IBM-58, 2006". **IBM-58A** is located about 35.75m South of IBM-58, beside the pathwalk of Kabacan Pilot Central School.	
Sketch	**Picture**	



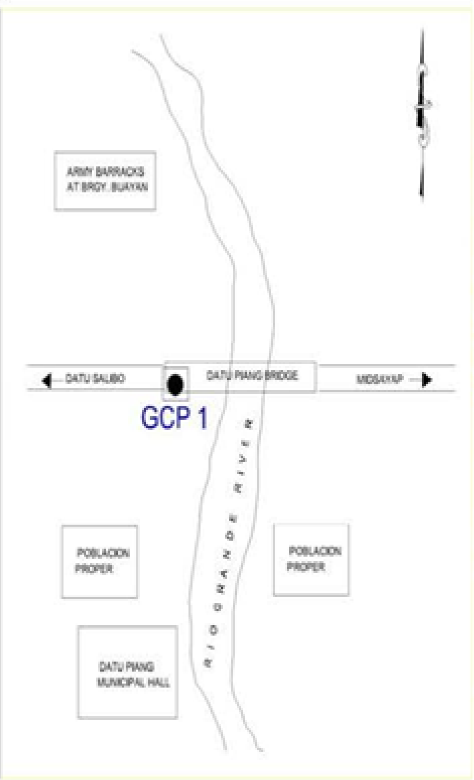
Station Name	CTA-16		
Order of Accuracy	2nd		
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	N7°11'29.936488"	
	Longitude	E124°13'56.697427"	
	Ellipsoidal Height	5.127	
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	N7°11'26.656956"	
	Longitude	E124°14'02.223156"	
	Ellipsoidal Height	74.24	
Elevation	-3.038 meters above Mean Sea Level (MSL)		
Description	The station is located in Brgy. Tamontaka 1, City of Cotabato. Along Sinsuat Avenue about 3kms travel from the Ciy proper going to the airport. Mark is a head of copper nail centered on top of a 30x30cm cement putty with the inscriptn "CTA-16, 1958, BPH".		
Sketch	**Picture**		

ANNEX I. ESTABLISHED GROUND CONTROL POINTS

Control Number: GCP-1

Station Name	GCP 1	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	N7°01'48.574209"
	Longitude	E124°29'51.618625"
	Ellipsoidal Height	12.160 m.
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	N7°01'45.362070"
	Longitude	E124°29'57.156789"
	Ellipsoidal Height	82.234 m.
Elevation	meters above sea level	
Description	GCP 1 is located in between the boundaries of Brgys. Poblacion and Kanguan at Datu Piang Maguindanao. It is placed on the approach of Datu Piang Bridge (rightside), about 500m South of the Municipal Plaza and 800m South of Datu Piang Municipal Hall.	

Sketch	Picture



Control Number: GCP-2

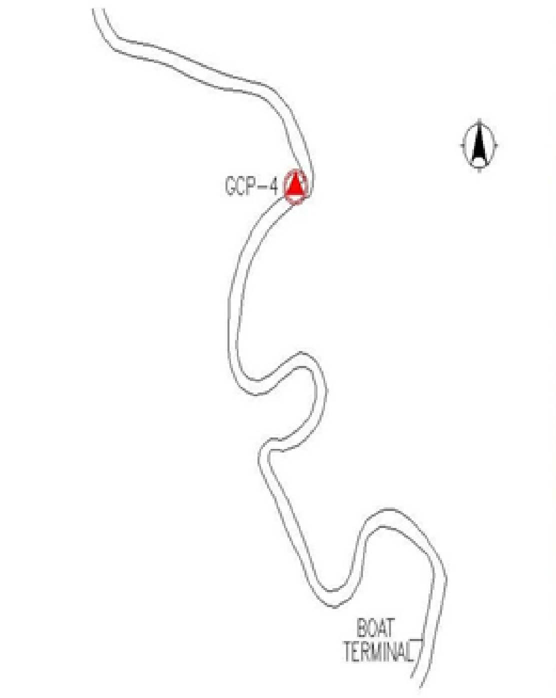
Station Name	GCP 2	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	N7°03'47.255955"
	Longitude	E124°27'09.792868"
	Ellipsoidal Height	5.833 m.
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	N7°03'44.030882"
	Longitude	E124°27'15.328419"
	Ellipsoidal Height	75.734 m.
Elevation	meters above sea level	
Description	GCP 2 is located at Brgy. Dado, Datu Piang Maguindanao, it is placed beside a culvert along the Municipal road. About 70m East from Dado Elementary School, 70m North of Dado Primary School, and about 6 kms. From Datu Piang Town Proper.	
Sketch	**Picture**	

Annexes

Control Number: GCP-3

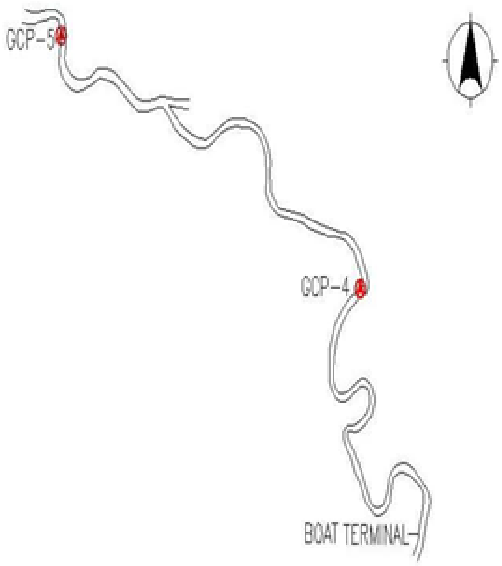
Station Name	GCP 3	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	N7°05'32.069192"
	Longitude	E124°25'31.642078"
	Ellipsoidal Height	4.925 m.
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	N7°05'28.833842"
	Longitude	E124°25'37.175206"
	Ellipsoidal Height	74.704 m,
Elevation	meters above sea level	
Description	GCP 3 is located at Brgy. Montay Datu Piang, Maguindanao. From the Town Proper, approximately 6 kms. Travel Northbound at the Municipal road passing Brgys. Kaguan, Buaya, Balanaken, Montay and Dado. It is located on the right side of the road, 5m East of a pipe culvert and about 30m North of a wooden bridge.	
Sketch	**Picture**	

Control Number: GCP-4

Station Name	GCP-4	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	N7°08'56.293500"
	Longitude	E124°23'10.465892"
	Ellipsoidal Height	4.633
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	N7°08'53.039410"
	Longitude	E124°23'15.994173"
	Ellipsoidal Height	74.209
Elevation	meters above Mean Sea Level (MSL)	
Description	The station is located at Brgy. Pagalungan, Kabuntalan, 2 meters from the river bank. To reach the location you have to rent a boat at the boat terminal in Brgy. Ganta, Kabuntalan. From there the ride will be approximately 20minutes. The Station Mark is the head of a 4 in. concrete nail driven in a 20x20x30 cm. concrete block embedded in the ground with inscriptions, "GCP-4".	
Sketch	**Picture**	
		

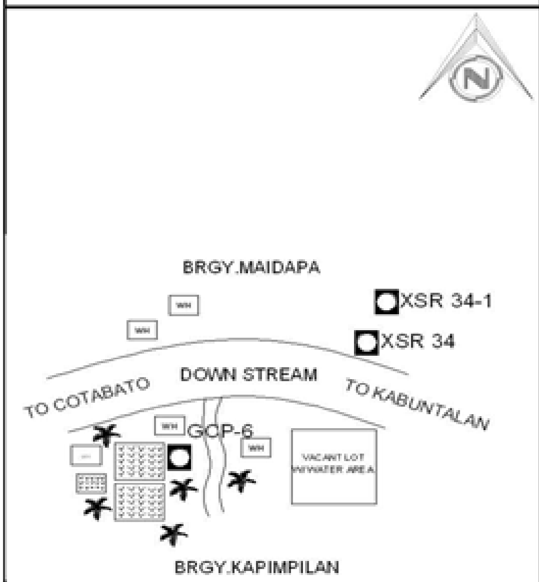
Control Number: GCP-5

Station Name	GCP-5	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	N7°10'23.890831"
	Longitude	E124°20'16.518455"
	Ellipsoidal Height	4.260
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	N7°10'20.625830"
	Longitude	E124°20'22.044937"
	Ellipsoidal Height	73.670
Elevation	195.8585 meters above Mean Sea Level (MSL)	
Description	The station is located at Brgy. Katidtuan, Kabuntalan, About 4 meters from the river bank. To reach the location you have to rent a boat at the boat terminal in Brgy. Ganta, Kabuntalan. From there the ride will be approximately 1hr, you will notice a reference written on the body of coconut tree. The Station Mark is the head of a 4 in. concrete nail driven in a 20x20x30 cm. concrete block embedded in the ground with inscriptions, "GCP-5".	
Sketch	**Picture**	



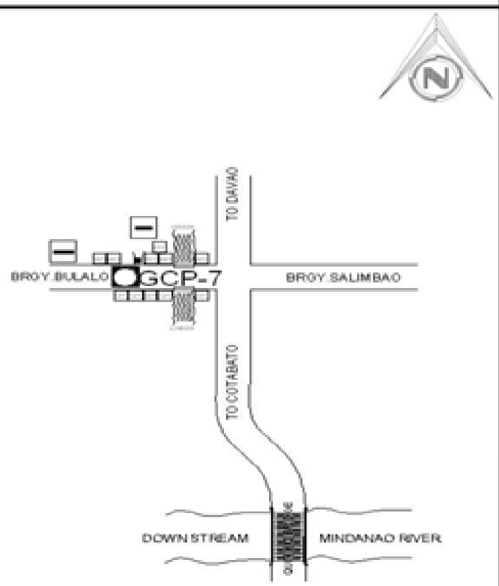
Control Number: GCP-6

Station Name	**GCP 6**	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	**Latitude**	
	Longitude	
	Ellipsoidal Height	
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	**Latitude**	7°12'19.79324" North
	Longitude	124°17'55.63568" East
	Ellipsoidal Height	72.845 meters
Elevation	meters above Mean Sea Level (MSL)	
Description	From Barangay Hall of Maidapa travel 1 km to east to reach the house of an Imam, the house of the Imam is at the right side of the river going to Kabuntalan. From the Imam's house go directly southeast, at the side of the river you can see a small Banca's passage and from there go east, at the right portion of the bank of the river, approximately 10 meters going to GCP 6.	
Sketch	**Picture**	



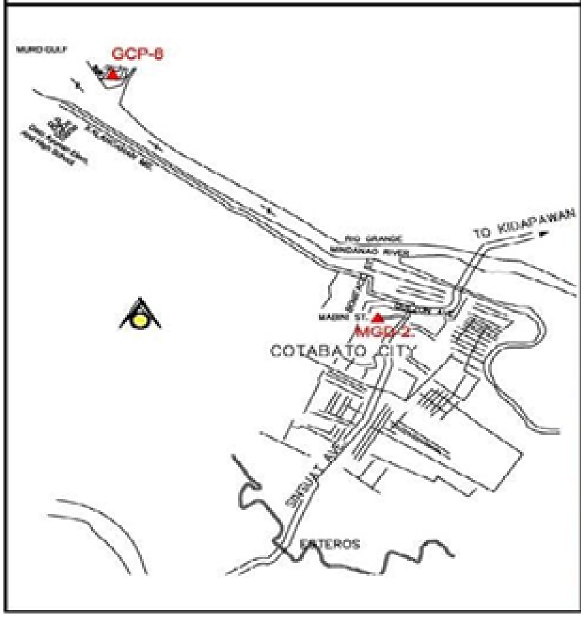
Control Number: GCP-7

Station Name	**GCP 7**	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	**Latitude**	N7°13'50.074572"
	Longitude	E124°15'17.747117"
	Ellipsoidal Height	4.306 m.
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	**Latitude**	N7°13'46.786714"
	Longitude	E124°15'23.269087"
	Ellipsoidal Height	73.402 m.
Elevation	meters above Mean Sea Level (MSL)	
Description	The station is located in Barangay **Bulalo, City of Cotabato. Along the National Road, bout 100meters East of Barangay Hall. Mark is a head of concrete nail centered on top of a 20cm x 20cm x 30cm concrete block with the inscription "GCP-7".**	
Sketch	**Picture**	



Control Number: GCP-8

Station Name	**GCP-8**	
Order of Accuracy	**2nd**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	**Latitude**	N7°15'10.162934"
	Longitude	E124°12'35.541250"
	Ellipsoidal Height	3.968 m.
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	**Latitude**	N7°15'06.865034"
	Longitude	E124°12'41.061578"
	Ellipsoidal Height	72.910 m.
Elevation	meters above Mean Sea Level (MSL)	
Description	From MGD-2 = COTABATO WATER TANK, Travel Northwest along Mabini St for about 1.6 km until reacing Jose Lim Street. Turn left and continue travel along Kalangan MB road for about 3.9 km liding to Dato Ayunan Elem. And High School. From take a boat ride Accross the Rio Grande, mindanao River going to Brgy. Kalaganan-1. from Kalaganan Proper, proceed travel east for about 380 m along the dirt road. The Station is located 10 m Southeast away from tree, and about 25 m north away from existing dirt road. Mark is the head of a copper nail embedded and set flush to a concrete monument 0.30m x 0.30m x 1m protruding 0.20m above the ground with inscriptions "GCP-8, 2013."	
Sketch	**Picture**	



ANNEX J. GNSS PROCESSING REPORT

RASA SURVEYING
#9 Anlacan Compound, Philand Drive,
TandangSora
Quezon City
Philippines

Phone: 029357296
Fax: 029357297
www.rasasurvey.com
technical@rasasurvey.com

Project Information		Coordinate System	
Name:	D:\COTABATO GPS\TBC COTABATO.vce	Name:	UTM
Size:	945 KB	Datum:	WGS 1984
Modified:	2/22/2014 4:32:06 PM (UTC:8)	Zone:	51 North (123E)
Time zone:	Taipei Standard Time	Geoid:	EGM2008
Reference number:		Vertical datum:	
Description:			

NETWORK ADJUSTMENT REPORT

Adjustment Settings

Set-Up Errors	
GNSS	
Error in Height of Antenna:	0.002 m
Centering Error:	0.003 m
Covariance Display	
Horizontal:	
Propagated Linear Error [E]:	U.S.
Constant Term [C]:	0.000 m
Scale on Linear Error [S]:	1.960
Three-Dimensional	
Propagated Linear Error [E]:	U.S.
Constant Term [C]:	0.000 m
Scale on Linear Error [S]:	1.960

Adjustment Statistics

Number of Iterations for Successful Adjustment:	2
Network Reference Factor:	1.00
Chi Square Test (95%):	Passed
Precision Confidence Level:	95%
Degrees of Freedom:	94
Post Processed Vector Statistics	
Reference Factor:	1.00
Redundancy Number:	94.00
A Priori Scalar:	1.62

Control Coordinate Comparisons

Values shown are control coordinates minus adjusted coordinates.

Point ID	ΔNorthing (Meter)	ΔEasting (Meter)	ΔElevation (Meter)	ΔHeight (Meter)
MIN-12	-0.157	0.184	?	0.024
MIN-14	-0.121	0.331	?	0.34

Control Point Constraints

Point ID	Type	North σ (Meter)	East σ (Meter)	Height σ (Meter)	Elevation σ (Meter)
MIN-12	-0.157	0.184	?	0.024	
MIN-14	-0.121	0.331	?	0.34	
Fixed = 0.000001(Meter)					

Adjusted Grid Coordinates

Point ID	Northing (m)	Northing Error (m)	Easting (m)	Easting Error (m)	Elevation (m)	Elevation Error (m)	Constraint
CTA-16	795018.047	0.007	636245.321	0.007	2.246	0.015	
GCP-1	777249.437	0.009	665597.425	0.011	9.634	0.025	
GCP-2	780878.929	0.008	660619.743	0.009	3.153	0.018	
GCP-3	784088.825	0.007	657597.911	0.007	2.160	0.016	
GCP-4	790348.129	0.006	653247.096	0.007	1.765	0.016	
GCP-5	793022.606	0.008	647902.572	0.009	1.313	0.035	
GCP7	799328.875	0.007	638719.579	0.007	1.484	0.011	
GCP-8	801774.945	0.008	633737.709	0.008	1.368	0.017	
MGD-2	798267.737	?	637368.854	?	60.356	?	LLh
MIN-12	800399.020	0.006	667954.911	0.007	26.127	0.015	
MIN-14	797179.069	0.008	637519.892	0.009	14.531	0.012	
MIN-25	796752.743	?	698327.946	?	37.346	?	LLh
UP DREAM 2013	786009.409	0.013	701749.989	0.015	20.253	0.033	

Adjusted Geodetic Coordinates

Point ID	Latitude	Longitude	Height (m)	Height Error (m)	Constraint
CTA-16	N7°11'26.656956"	E124°14'02.223156"	74.240	0.015	
GCP-1	N7°01'45.362070"	E124°29'57.156789"	82.234	0.025	
GCP-2	N7°03'44.030882"	E124°27'15.328419"	75.734	0.018	
GCP-3	N7°05'28.833842"	E124°25'37.175206"	74.704	0.016	
GCP-4	N7°08'53.039410"	E124°23'15.994173"	74.209	0.016	
GCP-5	N7°10'20.625830"	E124°20'22.044937"	73.670	0.035	
GCP7	N7°13'46.786714"	E124°15'23.269087"	73.402	0.011	
GCP-8	N7°15'06.865034"	E124°12'41.061578"	72.910	0.017	
MGD-2	N7°13'12.359570"	E124°14'39.138200"	132.256	?	LLh
MIN-12	N7°14'18.719985"	E124°31'16.461501"	98.585	0.015	
MIN-14	N7°12'36.901932"	E124°14'43.965325"	86.483	0.012	
MIN-25	N7°12'16.429820"	E124°47'46.052230"	109.862	?	LLh
UP DREAM 2013	N7°06'26.307581"	E124°49'36.191120"	92.755	0.033	

Adjusted ECEF Coordinates

Point ID	X (m)	X Error (m)	Y (m)	Y Error (m)	Z (m)	Z Error (m)	3D Error (m)	Constraint
CTA-16	-3560177.034	0.010	5231969.975	0.013	793075.914	0.007	0.018	
GCP-1	-3585617.375	0.017	5217259.718	0.021	775356.743	0.010	0.028	
GCP-2	-3581266.354	0.013	5219697.223	0.015	778973.934	0.008	0.022	
GCP-3	-3578557.278	0.011	5221072.798	0.014	782168.840	0.007	0.019	
GCP-4	-3574543.384	0.011	5222878.929	0.014	788393.639	0.007	0.019	
GCP-5	-3569948.018	0.020	5225614.224	0.030	791063.263	0.009	0.037	
GCP7	-3561927.913	0.009	5230123.442	0.010	797346.595	0.007	0.015	
GCP-8	-3557639.215	0.012	5232666.125	0.014	799786.947	0.008	0.020	
MGD-2	-3560916.536	?	5231043.624	?	796304.777	?	?	LLh
MIN-12	-3586003.429	0.010	5213526.052	0.013	798322.960	0.006	0.017	
MIN-14	-3561090.388	0.010	5231035.840	0.011	795218.378	0.008	0.017	
MIN-25	-3611250.727	?	5196658.648	?	794597.369	?	?	LLh
UP DREAM 2013	-3614780.560	0.023	5195815.550	0.027	783923.139	0.014	0.038	

Error Ellipse Components

Point ID	Semi-major axis (m)	Semi-minor axis (m)	Azimuth
CTA-16	0.009	0.009	103°
GCP-1	0.013	0.011	90°
GCP-2	0.011	0.01	105°
GCP-3	0.009	0.008	99°
GCP-4	0.009	0.008	103°
GCP-5	0.012	0.011	80°
GCP7	0.009	0.009	107°
GCP-8	0.01	0.01	105°
MIN-12	0.008	0.007	88°
MIN-14	0.011	0.01	89°
UP DREAM 2013	0.019	0.016	101°

Adjusted GPS Observations

Transformation Parameters			
Azimuth Rotation:	-0.852 sec	(95%)	0.027 sec
Scale Factor:	1.00000379	(95%)	0.00000016

Observation ID		**Observation**	**A-posteriori Error**	**Residual**	**Standardized Residual**
MGD-2 --> MIN-14 (PV78)	**Az.**	172°15'27"	1.596 sec	1.213 sec	1.108
	ΔHt.	-45.773 m	0.012 m	-0.009 m	-3.165
		1099.273 m	0.008 m	-0.004 m	-0.621
GCP7 --> GCP-4 (PV70)	**Az.**	121°52'51"	0.089 sec	-0.016 sec	-0.205
	ΔHt.	0.806 m	0.018 m	0.055 m	2.943
	Ellip Dist.	17081.560 m	0.008 m	-0.005 m	-0.716
GCP-3 --> GCP-2 (PV5)	**Az.**	136°54'15"	0.380 sec	-0.275 sec	-1.039
	ΔHt.	1.030 m	0.017 m	0.021 m	2.617
	Ellip Dist.	4408.868 m	0.008 m	0.009 m	1.613
CTA-16 --> GCP-2 (PV33)	**Az.**	120°16'12"	0.059 sec	-0.013 sec	-0.316
	ΔHt.	1.493 m	0.017 m	-0.022 m	-2.421
	Ellip Dist.	28181.950 m	0.009 m	0.003 m	0.481
MIN-14 --> CTA-16 (PV31)	**Az.**	210°41'17"	0.708 sec	0.580 sec	1.105
	ΔHt.	-12.242 m	0.019 m	-0.051 m	-2.112
	Ellip Dist.	2509.306 m	0.008 m	0.005 m	0.837
MGD-2 --> GCP-3 (PV82)	**Az.**	125°10'55"	0.061 sec	-0.017 sec	-0.306
	ΔHt.	-57.552 m	0.016 m	0.027 m	2.052
	Ellip Dist.	24706.494 m	0.008 m	0.000 m	-0.018
MIN-12 --> GCP-1 (PV43)	**Az.**	186°00'13"	0.084 sec	0.054 sec	1.104
	ΔHt.	-16.352 m	0.025 m	-0.037 m	-2.039
	Ellip Dist.	23270.523 m	0.009 m	0.005 m	0.862

MGD-2 --> CTA-16 (PV75)	**Az.**	199°13'40"	0.435 sec	0.161 sec	0.409
	ΔHt.	-58.015 m	0.015 m	-0.025 m	-2.035
	Ellip Dist.	3438.997 m	0.007 m	0.006 m	1
MIN-25 --> GCP-4 (PV28)	**Az.**	262°08'18"	0.036 sec	-0.063 sec	-1.964
	ΔHt.	-35.653 m	0.016 m	0.040 m	0.966
	Ellip Dist.	45534.058 m	0.010 m	-0.005 m	-0.699
MGD-2 --> GCP-4 (PV76)	**Az.**	116°39'51"	0.080 sec	-0.091 sec	-1.252
	ΔHt.	-58.047 m	0.016 m	0.001 m	0.074
	Ellip Dist.	17746.086 m	0.007 m	0.013 m	1.949
MIN-25 --> GCP-2 (PV6)	**Az.**	247°23'37"	0.044 sec	0.068 sec	1.863
	ΔHt.	-34.128 m	0.018 m	0.049 m	1.421
	Ellip Dist.	40912.998 m	0.010 m	0.012 m	1.215
MIN-12 --> GCP7 (PV41)	**Az.**	268°05'42"	0.051 sec	-0.018 sec	-0.420
	ΔHt.	-25.183 m	0.016 m	0.030 m	1.843
	Ellip Dist.	29257.964 m	0.008 m	0.006 m	0.984
MIN-12 --> CTA-16 (PV37)	**Az.**	260°33'35"	0.042 sec	-0.006 sec	-0.141
	ΔHt.	-24.345 m	0.018 m	0.004 m	0.148
	Ellip Dist.	32166.414 m	0.007 m	-0.012 m	-1.646
MIN-14 --> GCP-5 (PV16)	**Az.**	111°58'24"	0.181 sec	-0.061 sec	-0.350
	ΔHt.	-12.813 m	0.037 m	-0.074 m	-1.596
	Ellip Dist.	11185.360 m	0.010 m	0.006 m	0.744
MIN-14 --> MIN-12 (PV40)	**Az.**	84°07'02"	0.054 sec	0.092 sec	1.331
	ΔHt.	12.103 m	0.019 m	-0.029 m	-0.438
	Ellip Dist.	30608.138 m	0.009 m	0.072 m	1.575
MIN-12 --> MIN-25 (PV45)	**Az.**	97°02'12"	0.051 sec	-0.051 sec	-1.158
	ΔHt.	11.276 m	0.015 m	0.016 m	0.455
	Ellip Dist.	30590.511 m	0.010 m	0.014 m	1.526
GCP-2 --> GCP-1 (PV4)	**Az.**	126°16'33"	0.316 sec	-0.267 sec	-1.478
	ΔHt.	6.500 m	0.023 m	0.012 m	1.308
	Ellip Dist.	6160.813 m	0.010 m	0.005 m	0.853
GCP-4 --> CTA-16 (PV29)	**Az.**	285°31'54"	0.082 sec	-0.006 sec	-0.080
	ΔHt.	0.031 m	0.018 m	0.021 m	1.468
	Ellip Dist.	17633.872 m	0.008 m	-0.001 m	-0.164
MIN-25 --> GCP-1 (PV3)	**Az.**	239°25'58"	0.054 sec	-0.098 sec	-1.353
	ΔHt.	-27.628 m	0.025 m	0.040 m	0.617
	Ellip Dist.	38100.174 m	0.012 m	-0.049 m	-1.433
MIN-12 --> GCP-8 (PV46)	**Az.**	272°29'40"	0.046 sec	-0.027 sec	-0.759
	ΔHt.	-25.676 m	0.018 m	-0.002 m	-0.205
	Ellip Dist.	34248.738 m	0.008 m	-0.008 m	-1.405

UP DREAM 2013 --> GCP-4 (PV72)	**Az.**	275°20'17"	0.046 sec	-0.002 sec	-0.106
	ΔHt.	-18.547 m	0.032 m	0.002 m	0.121
	Ellip Dist.	48696.749 m	0.012 m	0.006 m	1.351
CTA-16 --> GCP-5 (PV30)	**Az.**	99°52'03"	0.151 sec	0.120 sec	0.882
	ΔHt.	-0.570 m	0.036 m	0.046 m	1.339
	Ellip Dist.	11828.533 m	0.009 m	-0.001 m	-0.140
UP DREAM 2013 --> GCP7 (PV71)	**Az.**	282°09'35"	0.035 sec	0.003 sec	0.214
	ΔHt.	-19.354 m	0.032 m	0.000 m	0.031
	Ellip Dist.	64424.516 m	0.012 m	-0.009 m	-1.319
GCP-4 --> GCP-3 (PV27)	**Az.**	145°22'08"	0.201 sec	-0.171 sec	-1.025
	ΔHt.	0.495 m	0.019 m	0.020 m	1.17
	Ellip Dist.	7623.633 m	0.007 m	0.008 m	1.29
GCP7 --> GCP-5 (PV17)	**Az.**	124°38'09"	0.177 sec	-0.211 sec	-1.242
	ΔHt.	0.267 m	0.036 m	-0.015 m	-0.315
	Ellip Dist.	11141.437 m	0.010 m	0.005 m	0.493
MIN-14 --> GCP-8 (PV50)	**Az.**	320°42'14"	0.321 sec	0.045 sec	0.14
	ΔHt.	-13.572 m	0.020 m	-0.033 m	-1.145
	Ellip Dist.	5953.059 m	0.009 m	0.004 m	0.473
CTA-16 --> GCP-3 (PV35)	**Az.**	117°15'31"	0.062 sec	0.040 sec	0.745
	ΔHt.	0.463 m	0.018 m	-0.023 m	-1.127
	Ellip Dist.	23990.185 m	0.008 m	0.000 m	0.061
MIN-14 --> GCP7 (PV11)	**Az.**	29°19'11"	0.732 sec	-0.205 sec	-0.383
	ΔHt.	-13.080 m	0.016 m	-0.031 m	-1.079
	Ellip Dist.	2462.287 m	0.008 m	0.007 m	1.023
MIN-25 --> GCP-3 (PV1)	**Az.**	252°57'06"	0.039 sec	0.009 sec	0.299
	ΔHt.	-35.158 m	0.016 m	0.011 m	0.511
	Ellip Dist.	42653.484 m	0.009 m	-0.006 m	-1.040
MGD-2 --> MIN-25 (PV83)	**Az.**	91°34'47"	0.027 sec	0.024 sec	1.018
	ΔHt.	-22.395 m	0.000 m	0.000 m	-0.003
	Ellip Dist.	60980.579 m	0.010 m	-0.007 m	-0.637
CTA-16 --> GCP-8 (PV47)	**Az.**	339°47'39"	0.234 sec	0.034 sec	0.198
	ΔHt.	-1.330 m	0.019 m	0.011 m	0.887
	Ellip Dist.	7208.434 m	0.008 m	0.002 m	0.404
MIN-12 --> GCP-4 (PV38)	**Az.**	235°50'34"	0.079 sec	0.057 sec	0.722
	ΔHt.	-24.377 m	0.019 m	-0.018 m	-0.646
	Ellip Dist.	17815.413 m	0.007 m	0.003 m	0.541
MGD-2 --> GCP-8 (PV73)	**Az.**	314°09'43"	0.317 sec	-0.115 sec	-0.467
	ΔHt.	-59.345 m	0.017 m	0.007 m	0.476
	Ellip Dist.	5049.190 m	0.008 m	0.004 m	0.708

MGD-2 --> GCP7 (PV79)	**Az.**	52°00'10"	0.883 sec	-0.184 sec	-0.255
	ΔHt.	-58.853 m	0.011 m	0.002 m	0.662
	Ellip Dist.	1717.970 m	0.007 m	0.002 m	0.3
GCP-4 --> GCP-5 (PV22)	**Az.**	296°45'25"	0.321 sec	-0.120 sec	-0.186
	ΔHt.	-0.539 m	0.037 m	-0.016 m	-0.244
	Ellip Dist.	5977.041 m	0.010 m	0.008 m	0.594
GCP-4 --> GCP-1 (PV26)	**Az.**	136°51'19"	0.110 sec	0.024 sec	0.311
	ΔHt.	8.025 m	0.026 m	0.007 m	0.372
	Ellip Dist.	18004.422 m	0.009 m	-0.004 m	-0.594
GCP7 --> GCP-8 (PV51)	**Az.**	296°18'32"	0.300 sec	-0.066 sec	-0.305
	ΔHt.	-0.492 m	0.018 m	-0.007 m	-0.496
	Ellip Dist.	5550.905 m	0.008 m	0.001 m	0.227
MGD-2 --> GCP-5 (PV77)	**Az.**	116°37'34"	0.156 sec	-0.021 sec	-0.134
	ΔHt.	-58.586 m	0.035 m	0.020 m	0.49
	Ellip Dist.	11769.052 m	0.009 m	0.003 m	0.298
MIN-12 --> GCP-3 (PV44)	**Az.**	212°36'19"	0.078 sec	0.032 sec	0.472
	ΔHt.	-23.882 m	0.018 m	0.001 m	0.034
	Ellip Dist.	19322.029 m	0.007 m	0.003 m	0.421
GCP-3 --> GCP-5 (PV20)	**Az.**	312°50'10"	0.150 sec	-0.023 sec	-0.173
	ΔHt.	-1.034 m	0.036 m	-0.016 m	-0.442
	Ellip Dist.	13185.195 m	0.009 m	0.002 m	0.206
MIN-12 --> GCP-2 (PV42)	**Az.**	200°47'03"	0.083 sec	-0.013 sec	-0.167
	ΔHt.	-22.852 m	0.019 m	-0.007 m	-0.416
	Ellip Dist.	20854.080 m	0.008 m	0.000 m	0.044
MGD-2 --> MIN-12 (PV74)	**Az.**	86°10'13"	0.043 sec	-0.014 sec	-0.337
	ΔHt.	-33.670 m	0.015 m	-0.001 m	-0.102
	Ellip Dist.	30663.498 m	0.007 m	0.001 m	0.18
MIN-12 --> GCP-5 (PV39)	**Az.**	249°59'39"	0.084 sec	0.019 sec	0.17
	ΔHt.	-24.916 m	0.037 m	0.015 m	0.214
	Ellip Dist.	21367.904 m	0.010 m	-0.010 m	-0.308

Covariance Terms

From Point	To Point		Components	A-posteriori Error	Horiz. Precision (Ratio)	3D Precision (Ratio)
CTA-16	GCP-8	**Az.**	339°47'39"	0.235 sec	1 : 894709	1 : 894846
		ΔHt.	-1.330 m	0.019 m		
		ΔElev.	-0.878 m	0.019 m		
		Ellip Dist.	7208.461 m	0.008 m		
CTA-16	MGD-2	**Az.**	19°13'37"	0.439 sec	1 : 503871	1 : 503144
		ΔHt.	58.016 m	0.015 m		
		ΔElev.	58.110 m	0.015 m		
		Ellip Dist.	3439.010 m	0.007 m		
CTA-16	MIN-12	**Az.**	80°31'26"	0.048 sec	1 : 3751901	1 : 3751624
		ΔHt.	24.345 m	0.018 m		
		ΔElev.	23.880 m	0.018 m		
		Ellip Dist.	32166.536 m	0.009 m		
GCP-1	GCP-2	**Az.**	306°16'54"	0.318 sec	1 : 629943	1 : 630134
		ΔHt.	-6.500 m	0.023 m		
		ΔElev.	-6.481 m	0.023 m		
		Ellip Dist.	6160.837 m	0.010 m		
GCP-1	GCP-4	**Az.**	316°52'10"	0.112 sec	1 : 1873963	1 : 1874805
		ΔHt.	-8.025 m	0.026 m		
		ΔElev.	-7.869 m	0.026 m		
		Ellip Dist.	18004.490 m	0.010 m		
GCP-1	MIN-12	**Az.**	6°00'04"	0.089 sec	1 : 2495561	1 : 2495025
		ΔHt.	16.352 m	0.025 m		
		ΔElev.	16.493 m	0.025 m		
		Ellip Dist.	23270.611 m	0.009 m		
GCP-2	CTA-16	**Az.**	300°17'51"	0.060 sec	1 : 3085085	1 : 3085400
		ΔHt.	-1.493 m	0.017 m		
		ΔElev.	-0.907 m	0.017 m		
		Ellip Dist.	28182.056 m	0.009 m		
GCP-2	MIN-12	**Az.**	20°46'34"	0.089 sec	1 : 2482654	1 : 2482277
		ΔHt.	22.852 m	0.019 m		
		ΔElev.	22.973 m	0.019 m		
		Ellip Dist.	20854.159 m	0.008 m		
GCP-3	CTA-16	**Az.**	297°16'58"	0.065 sec	1 : 3019899	1 : 3019916
		ΔHt.	-0.464 m	0.018 m		
		ΔElev.	0.087 m	0.018 m		
		Ellip Dist.	23990.276 m	0.008 m		

From Point	To Point		Components	A-posteriori Error	Horiz. Precision (Ratio)	3D Precision (Ratio)
GCP-3	GCP-2	**Az.**	136°54'16"	0.380 sec	1 : 527671	1 : 527784
		ΔHt.	1.030 m	0.017 m		
		ΔElev.	0.994 m	0.017 m		
		Ellip Dist.	4408.885 m	0.008 m		
GCP-3	GCP-4	**Az.**	325°22'26"	0.203 sec	1 : 1014129	1 : 1014314
		ΔHt.	-0.495 m	0.019 m		
		ΔElev.	-0.395 m	0.019 m		
		Ellip Dist.	7623.662 m	0.008 m		
GCP-3	GCP-5	**Az.**	312°50'10"	0.150 sec	1 : 1400868	1 : 1401203
		ΔHt.	-1.034 m	0.036 m		
		ΔElev.	-0.846 m	0.036 m		
		Ellip Dist.	13185.245 m	0.009 m		
GCP-3	MGD-2	**Az.**	305°12'18"	0.057 sec	1 : 3486147	1 : 3485909
		ΔHt.	57.552 m	0.016 m		
		ΔElev.	58.197 m	0.016 m		
		Ellip Dist.	24706.587 m	0.007 m		
GCP-3	MIN-12	**Az.**	32°35'37"	0.083 sec	1 : 2470817	1 : 2470093
		ΔHt.	23.882 m	0.018 m		
		ΔElev.	23.967 m	0.018 m		
		Ellip Dist.	19322.103 m	0.008 m		
GCP-4	CTA-16	**Az.**	285°31'55"	0.085 sec	1 : 2211283	1 : 2211264
		ΔHt.	0.031 m	0.018 m		
		ΔElev.	0.482 m	0.018 m		
		Ellip Dist.	17633.939 m	0.008 m		
GCP-4	MGD-2	**Az.**	296°40'56"	0.074 sec	1 : 2606522	1 : 2606245
		ΔHt.	58.047 m	0.016 m		
		ΔElev.	58.592 m	0.016 m		
		Ellip Dist.	17746.153 m	0.007 m		
GCP-4	MIN-12	**Az.**	55°49'35"	0.084 sec	1 : 2354146	1 : 2353463
		ΔHt.	24.377 m	0.019 m		
		ΔElev.	24.362 m	0.019 m		
		Ellip Dist.	17815.481 m	0.008 m		
GCP-4	UP DREAM 2013	**Az.**	95°17'02"	0.055 sec	1 : 3341917	1 : 3341813
		ΔHt.	18.546 m	0.032 m		
		ΔElev.	18.489 m	0.032 m		
		Ellip Dist.	48696.933 m	0.015 m		

From Point	To Point		Components	A-posteriori Error	Horiz. Precision (Ratio)	3D Precision (Ratio)
GCP-5	CTA-16	**Az.**	279°52'52"	0.155 sec	1 : 1215726	1 : 1215743
		ΔHt.	0.570 m	0.036 m		
		ΔElev.	0.933 m	0.036 m		
		Ellip Dist.	11828.578 m	0.010 m		
GCP-5	GCP-4	**Az.**	116°45'04"	0.321 sec	1 : 624659	1 : 624861
		ΔHt.	0.539 m	0.037 m		
		ΔElev.	0.452 m	0.037 m		
		Ellip Dist.	5977.064 m	0.010 m		
GCP-5	MGD-2	**Az.**	296°38'18"	0.153 sec	1 : 1308895	1 : 1307753
		ΔHt.	58.586 m	0.035 m		
		ΔElev.	59.043 m	0.035 m		
		Ellip Dist.	11769.097 m	0.009 m		
GCP-5	MIN-12	**Az.**	69°58'18"	0.086 sec	1 : 2088568	1 : 2089640
		ΔHt.	24.915 m	0.037 m		
		ΔElev.	24.813 m	0.037 m		
		Ellip Dist.	21367.985 m	0.010 m		
GCP7	GCP-4	**Az.**	121°52'52"	0.090 sec	1 : 2175564	1 : 2175714
		ΔHt.	0.807 m	0.018 m		
		ΔElev.	0.281 m	0.018 m		
		Ellip Dist.	17081.625 m	0.008 m		
GCP7	GCP-5	**Az.**	124°38'10"	0.179 sec	1 : 1152756	1 : 1153005
		ΔHt.	0.268 m	0.036 m		
		ΔElev.	-0.170 m	0.036 m		
		Ellip Dist.	11141.479 m	0.010 m		
GCP7	GCP-8	**Az.**	296°18'33"	0.302 sec	1 : 654595	1 : 654630
		ΔHt.	-0.492 m	0.018 m		
		ΔElev.	-0.115 m	0.018 m		
		Ellip Dist.	5550.926 m	0.008 m		
GCP7	MGD-2	**Az.**	232°00'17"	0.881 sec	1 : 237498	1 : 237755
		ΔHt.	58.853 m	0.011 m		
		ΔElev.	58.873 m	0.011 m		
		Ellip Dist.	1717.977 m	0.007 m		
GCP7	MIN-12	**Az.**	88°03'43"	0.054 sec	1 : 3443979	1 : 3443791
		ΔHt.	25.183 m	0.016 m		
		ΔElev.	24.643 m	0.016 m		
		Ellip Dist.	29258.074 m	0.008 m		

From Point	To Point		Components	A-posteriori Error	Horiz. Precision (Ratio)	3D Precision (Ratio)
GCP7	MIN-14	**Az.**	209°19'17"	0.733 sec	1 : 290923	1 : 290833
		ΔHt.	13.080 m	0.016 m		
		ΔElev.	13.047 m	0.016 m		
		Ellip Dist.	2462.296 m	0.008 m		
GCP7	UP DREAM 2013	**Az.**	102°05'19"	0.043 sec	1 : 4059936	1 : 4059819
		ΔHt.	19.353 m	0.032 m		
		ΔElev.	18.770 m	0.032 m		
		Ellip Dist.	64424.760 m	0.016 m		
GCP-8	MGD-2	**Az.**	134°09'29"	0.323 sec	1 : 618973	1 : 619310
		ΔHt.	59.346 m	0.017 m		
		ΔElev.	58.988 m	0.017 m		
		Ellip Dist.	5049.209 m	0.008 m		
MIN-12	GCP-8	**Az.**	272°29'40"	0.050 sec	1 : 3698952	1 : 3698893
		ΔHt.	-25.675 m	0.018 m		
		ΔElev.	-24.758 m	0.018 m		
		Ellip Dist.	34248.867 m	0.009 m		
MIN-12	MGD-2	**Az.**	266°12'20"	0.039 sec	1 : 4526215	1 : 4526088
		ΔHt.	33.670 m	0.015 m		
		ΔElev.	34.230 m	0.015 m		
		Ellip Dist.	30663.614 m	0.007 m		
MIN-14	CTA-16	**Az.**	210°41'18"	0.710 sec	1 : 302933	1 : 302905
		ΔHt.	-12.242 m	0.019 m		
		ΔElev.	-12.284 m	0.019 m		
		Ellip Dist.	2509.316 m	0.008 m		
MIN-14	GCP-5	**Az.**	111°58'25"	0.183 sec	1 : 1110083	1 : 1110099
		ΔHt.	-12.813 m	0.037 m		
		ΔElev.	-13.217 m	0.037 m		
		Ellip Dist.	11185.403 m	0.010 m		
MIN-14	GCP-8	**Az.**	320°42'15"	0.323 sec	1 : 650393	1 : 650676
		ΔHt.	-13.572 m	0.020 m		
		ΔElev.	-13.162 m	0.020 m		
		Ellip Dist.	5953.082 m	0.009 m		
MIN-14	MGD-2	**Az.**	352°15'28"	1.595 sec	1 : 141821	1 : 142056
		ΔHt.	45.773 m	0.012 m		
		ΔElev.	45.826 m	0.012 m		
		Ellip Dist.	1099.277 m	0.008 m		

From Point	To Point		Components	A-posteriori Error	Horiz. Precision (Ratio)	3D Precision (Ratio)
MIN-14	MIN-12	**Az.**	84°07'03"	0.057 sec	1 : 3076761	1 : 3076690
		ΔHt.	12.103 m	0.019 m		
		ΔElev.	11.596 m	0.019 m		
		Ellip Dist.	30608.254 m	0.010 m		
MIN-25	GCP-1	**Az.**	239°25'59"	0.052 sec	1 : 3705258	1 : 3703122
		ΔHt.	-27.628 m	0.025 m		
		ΔElev.	-27.712 m	0.025 m		
		Ellip Dist.	38100.318 m	0.010 m		
MIN-25	GCP-2	**Az.**	247°23'38"	0.042 sec	1 : 4780963	1 : 4778487
		ΔHt.	-34.128 m	0.018 m		
		ΔElev.	-34.193 m	0.018 m		
		Ellip Dist.	40913.153 m	0.009 m		
MIN-25	GCP-4	**Az.**	262°08'19"	0.029 sec	1 : 6723993	1 : 6722751
		ΔHt.	-35.653 m	0.016 m		
		ΔElev.	-35.581 m	0.016 m		
		Ellip Dist.	45534.230 m	0.007 m		
MIN-25	MGD-2	**Az.**	271°38'57"	0.000 sec	1:00	1:00
		ΔHt.	22.394 m	0.000 m		
		ΔElev.	23.010 m	0.000 m		
		Ellip Dist.	60980.810 m	0.000 m		
MIN-25	MIN-12	**Az.**	277°04'17"	0.039 sec	1 : 4527499	1 : 4528212
		ΔHt.	-11.277 m	0.015 m		
		ΔElev.	-11.220 m	0.015 m		
		Ellip Dist.	30590.627 m	0.007 m		

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ANNEX K. SUB-CONTROL POINTS

List of Sub-Control Points											
	WGS-84						UTM				
Sta. Name	Latitude			Longitude			Northing	Easting	Ellipsoidal Ht.	Elev. (EGM08)	MSL
	dd	mm	ss.ssss	dd	mm	ss.ssss	mmmmmmmm. mmmm	mmmmmmmm. mmmm	mmmm.mm	mmmm.mm	mmmm. mm
XSL32	7	11	59.8176	124	18	11.5386	796057.9070	643889.9760	73.520	1.015	-4.269
XSL32-A	7	11	56.3045	124	18	14.4657	795950.2580	643980.0720	73.504	0.993	-4.291
XSL33	7	12	2.1964	124	17	56.9698	796129.7010	643442.8660	73.728	1.235	-4.049
XSL33-A	7	12	0.1160	124	17	57.7036	796065.8640	643465.5560	73.547	1.051	-4.233
XSL35	7	12	28.0199	124	17	37.4573	796921.1800	642842.0690	73.410	0.956	-4.328
XSL35-A	7	12	23.6276	124	17	39.6457	796786.4600	642909.5790	73.220	0.760	-4.524
XSL37	7	13	22.4817	124	16	58.9826	798590.6520	641657.1660	73.246	0.887	-4.397
XSL40	7	13	23.4694	124	15	52.4278	798615.2830	639615.6160	73.002	0.723	-4.561
XSL40-A	7	13	22.4530	124	15	54.8702	798584.2730	639690.6210	72.939	0.655	-4.629
XSR29	7	10	45.7544	124	19	37.5856	793790.6020	646536.1050	73.671	1.052	-4.232
XSR29-A	7	10	46.5224	124	19	35.7908	793814.0320	646480.9760	73.814	1.196	-4.088
XSR30	7	11	10.1828	124	19	3.3634	794537.9060	645484.1120	73.869	1.288	-3.996
XSR30-A	7	11	11.7588	124	19	4.1903	794586.3860	645509.3410	73.659	1.078	-4.206
XSR31	7	11	36.7565	124	18	35.1722	795351.6470	644616.9750	73.513	0.971	-4.313
XSR31-A	7	11	35.6325	124	18	37.0028	795317.2840	644673.2280	73.734	1.190	-4.094
XSR34	7	12	25.7766	124	18	9.0794	796855.0330	643812.2640	72.999	0.520	-4.764
XSR34-A	7	12	27.0889	124	18	10.0760	796895.4290	643842.7200	73.390	0.912	-4.372
XSR36	7	13	5.4006	124	17	35.6839	798069.1850	642784.4170	73.018	0.601	-4.683
XSR36-A	7	13	6.7845	124	17	36.6572	798111.7770	642814.1500	72.979	0.563	-4.721
XSR37	7	13	25.0987	124	17	4.9902	798671.5530	641841.2130	73.400	1.037	-4.247
XSR38	7	13	35.9638	124	16	44.7804	799003.5320	641220.3710	73.017	0.689	-4.595
XSR38-A	7	13	35.2350	124	16	43.0860	798981.0010	641168.4630	73.022	0.696	-4.588
XSR39	7	13	22.6812	124	16	21.8383	798593.5830	640517.8050	72.983	0.668	-4.616
XSR39-A	7	13	23.8314	124	16	20.6455	798628.8100	640481.1180	73.252	0.940	-4.344
XSR41	7	13	38.3438	124	15	34.3414	799070.6100	639059.5840	78.453	6.213	0.929
XSR41-A	7	13	32.1813	124	15	31.0105	798881.0490	638957.9400	78.613	6.370	1.086

From Point	To Point		Components	A-posteriori Error	Horiz. Precision (Ratio)	3D Precision (Ratio)
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		ΔHt.	-11.277 m	0.015 m		
		ΔElev.	-11.220 m	0.015 m		
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	dd	mm	ss.ssss	dd	mm	ss.ssss	mmmmmmm. mmmm	mmmmmmm. mmmm	mmmm.mm	mmmm.mm	mmmm. mm
XSL32	7	11	59.8176	124	18	11.5386	796057.9070	643889.9760	73.520	1.015	-4.269
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In behalf of the whole surveying team under the joint venture of RASA SURVEYING AND LAND SURVEY CONSULTANTS and H.O. NOVELOSO SURVEYING we would like take this opportunity to express my profound gratitude and deep regards to all who provide support and significant contribution for the accomplishment of this project.

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For the Local Government of Cotabato City, Kabuntalan, Northern Kabuntalan and Datu Piang, South Cotabato, who play the very vital role in the assistance and security of the team during field surveys.

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and

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DREAM

Disaster Risk and Exposure Assessment for Mitigation