REGION 2

Cagayan River Basin:
DREAM Flood Forecasting and Flood Hazard Mapping

TRAINING CENTER FOR APPLIED GEODESY AND PHOTOGRAMMETRY
2015

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Table of Contents

Table of Contents

List of Figures

List of Figures

List of Figures

List of Tables

List of Equations

List of Abbreviations

ACDP	Acoustic Doppler Current Profiler
AOI	Area of Interest
ARG	Automated Rain Gauge
AWLS	Automated Water Level Sensor
DAC	Data Acquisition Component
DEM	Digital Elevation Model
DOST	Department of Science and Technology
DPC	Data Processing Component
DREAM	Disaster Risk Exposure and Assessment for Mitigation
DTM	Digital Terrain Model
DVC	Data Validation Component
FMC	Flood Modelling Component
GDS	Grid Developer System
HEC-HMS	Hydrologic Engineering Center – Hydrologic Modeling System
LiDAR	Light Detecting and Ranging
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
RIDF	Rainfall Intensity Duration Frequency
SCS	Soil Conservation Service
SRTM	Shuttle Radar Topography Mission
UP-TCAGP	UP Training Center for Applied Geodesy and Photogrammetry

Introduction

Introduction

1.1 About the DREAM Program

The UP Training Center for Applied Geodesy and Photogrammetry (UP TCAGP) conducts a research program entitled "Nationwide Disaster Risk and Exposure Assessment for Mitigation (DREAM) Program" funded by the Department of Science and Technology (DOST) Grants-in-Aid 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 Light Detecting and Ranging (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. These accuracies are achieved through the use of state-of-the-art airborne Light Detection and Ranging (LiDAR) technology and appended with Synthetic-aperture radar (SAR) in some areas. It 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 kilometers 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 to accomplish the program's expected outputs are subdivided into four (4) major components, as shown in Figure 1. Each component is described in detail in the following section.

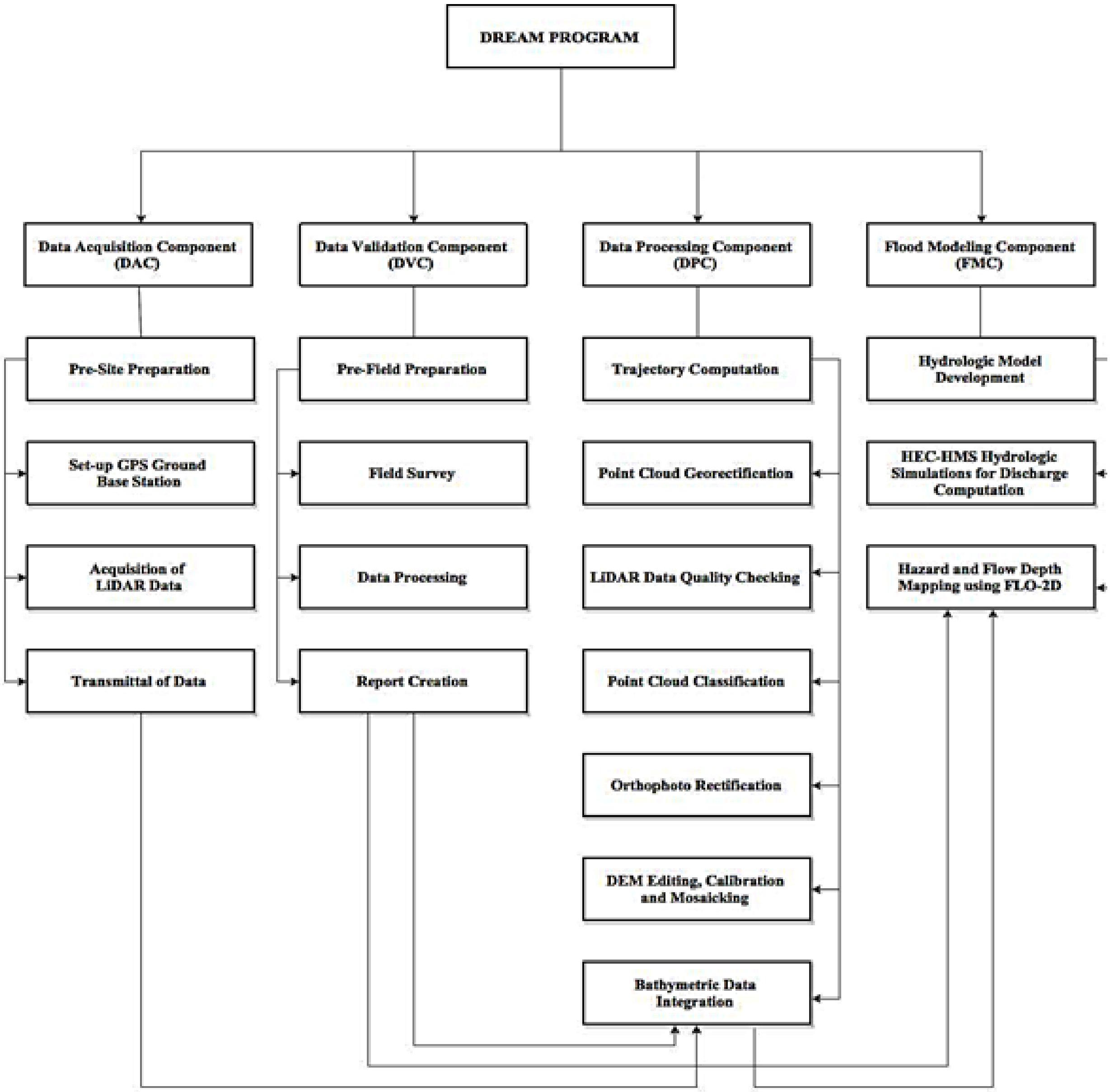


Figure 1. The general methodological framework of the program

1.4 Scope of Work of the Flood Modeling Component

The scope of work of the Flood Modeling Component is listed as the following:

a) To develop the watershed hydrologic model of the Cagayan River Basin;
b) To compute the discharge values quantifying the amount of water entering the floodplain using HEC-HMS;
c) To create flood simulations using hydrologic models of the Cagayan floodplain using FLO-2D GDS Pro; and
d) To prepare the static flood hazard and flow depth maps for the Cagayan river basin.

1.5 Limitations

This research is limited to the usage of the available data, such as the following:

1. Digital Elevation Models (DEM) surveyed by the Data Acquisition Component (DAC) and processed by the Data Processing Component (DPC)
2. Outflow data surveyed by the Data Validation and Bathymetric Component (DVC)
3. Observed Rainfall from ASTI sensors

While the findings of this research could be further used in related-studies, the accuracy of such is dependent on the accuracy of the available data. Also, this research adapts the limitations of the software used: ArcGIS 10.2, HEC-GeoHMS 10.2 extension, WMS 9.1, HEC-HMS 3.5 and FLO-2D GDS Pro.

1.6 Operational Framework

The flow for the operational framework of the Flood Modeling Component is shown in Figure 2.

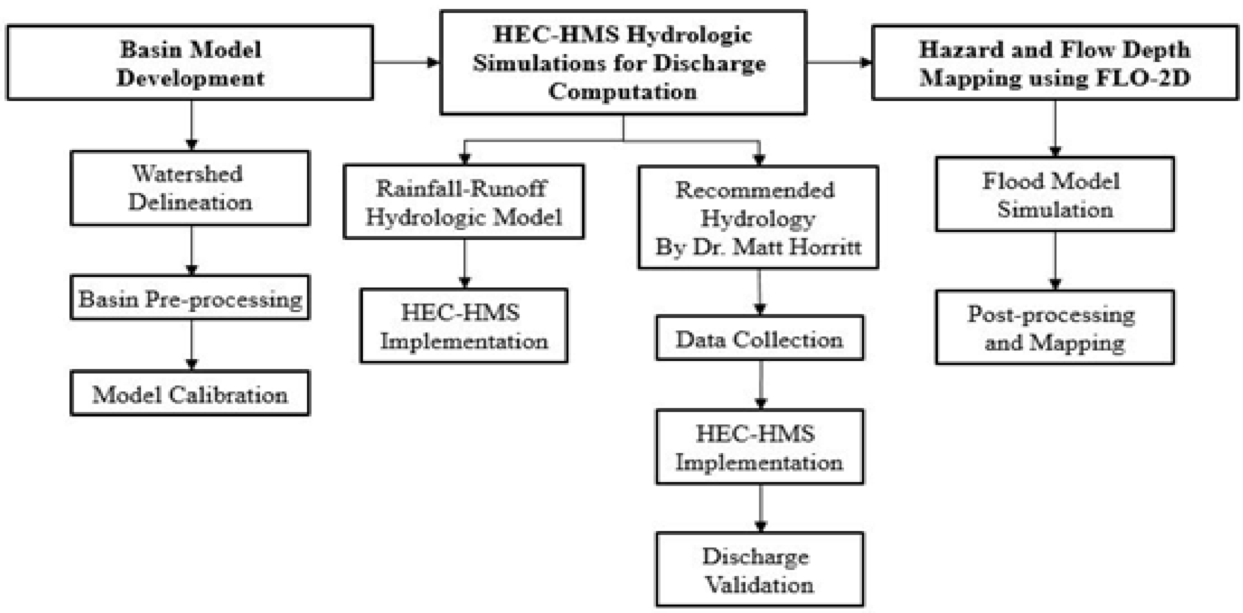


Figure 2. The operational framework and specific work flow of the Flood Modeling Component

The Cagayan River Basin

The Cagayan River Basin

The Cagayan River Basin is located in the north eastern part of Luzon. It is considered as the largest river catchment in the Philippines with an area of 25,649 square kilometers. The location of Cagayan River Basin is as shown in Figure 3.

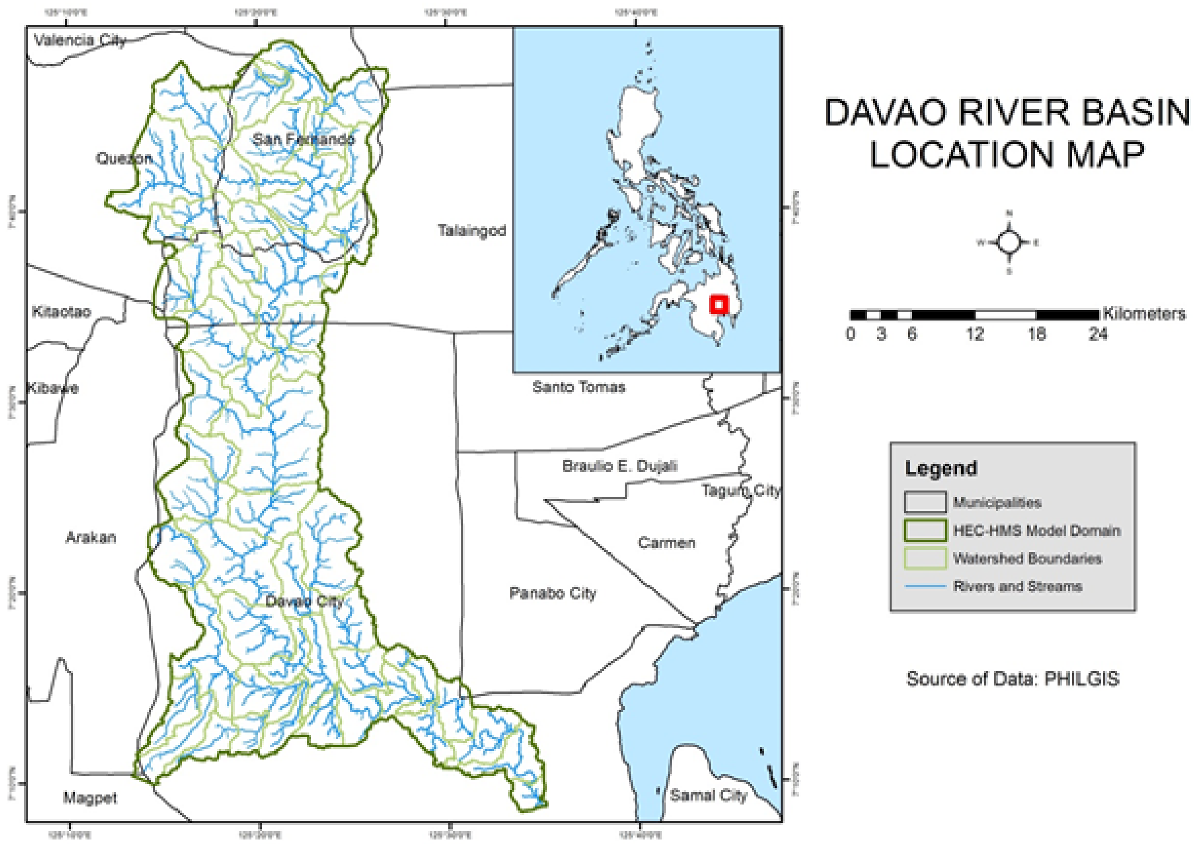


Figure 3. Cagayan River Basin Location Map

It is characterized by a valley oriented north to south. The valley is bounded on the east by the Sierra Madre Mountains, on the west by the Cordillera Mountains, on the south by the Caraballo Mountains, and on the north by the coastline of the Babuyan Channel. The basin covers the provinces Quirino, Nueva Vizcaya, Ifugao, Mountain Province, Kalinga, Apayao, Isabela, and Cagayan.

It drains the northern portion of the island and traverses through Tuguegarao City and Cauayan City and the towns of Natipunan and Maddela in Quirino; San Mateo in Ifugao; San Agustin, Jones, Echague, Angadanan, Naguilian, San Mariano, Gamu, Benito Soliven and Ilagan, Tumauini, Santo, Tomas, Cabagan, Santa Maria and San Pablo in Isabela; and, Enrile, Solana, Iguig, Samulung, Alcala, Santo Niño, Gattaran, Lasam, Lal-lo, Camalaniugan and Aparri in Cagayan.

The average annual rainfall ranges from 1,000 millimeters in the northern part up to 3,000 millimeters in the southern mountains. Floods caused by the Cagayan River flow slowly because of surface retention over the floodplain. Cagayan Valley is relatively flat and basin coverage has a gentle slope. Also, there are retardations of flooding due to several river meanders and gorges.

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 Cagayan River Basin are shown in Figures 4 and 5, respectively.

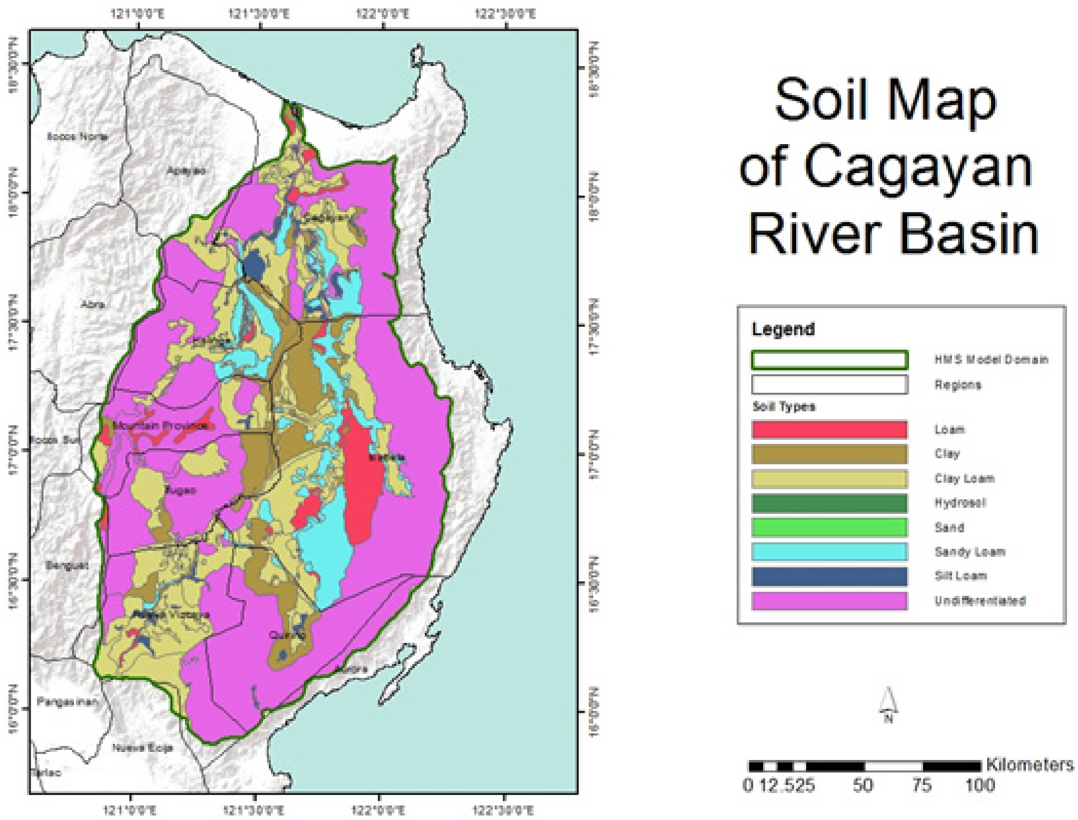


Figure 4. Cagayan River Basin Soil Map

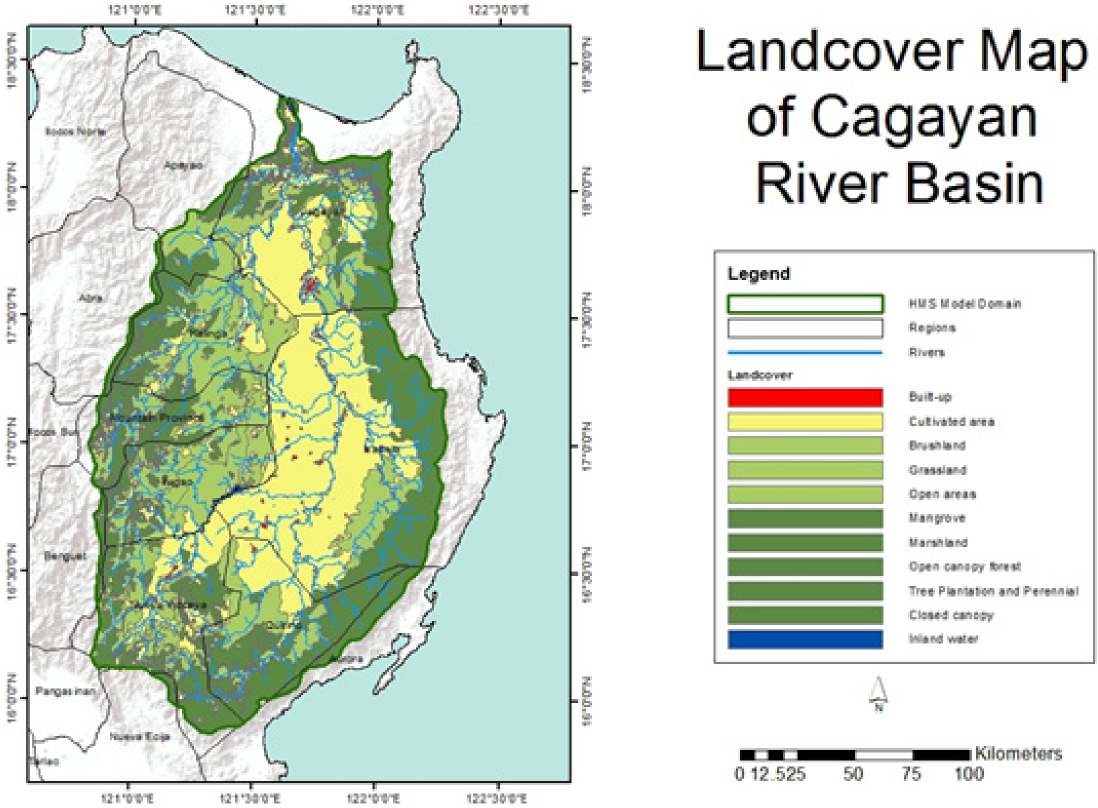


Figure 5. Cagayan River Basin Land Cover Map

Methodology

Methodology

3.1 Pre-processing and Data Used

Flood modeling involved several data and parameters to achieve realistic simulations and outputs. Figure 6 shows a summary of the data needed to for the research.

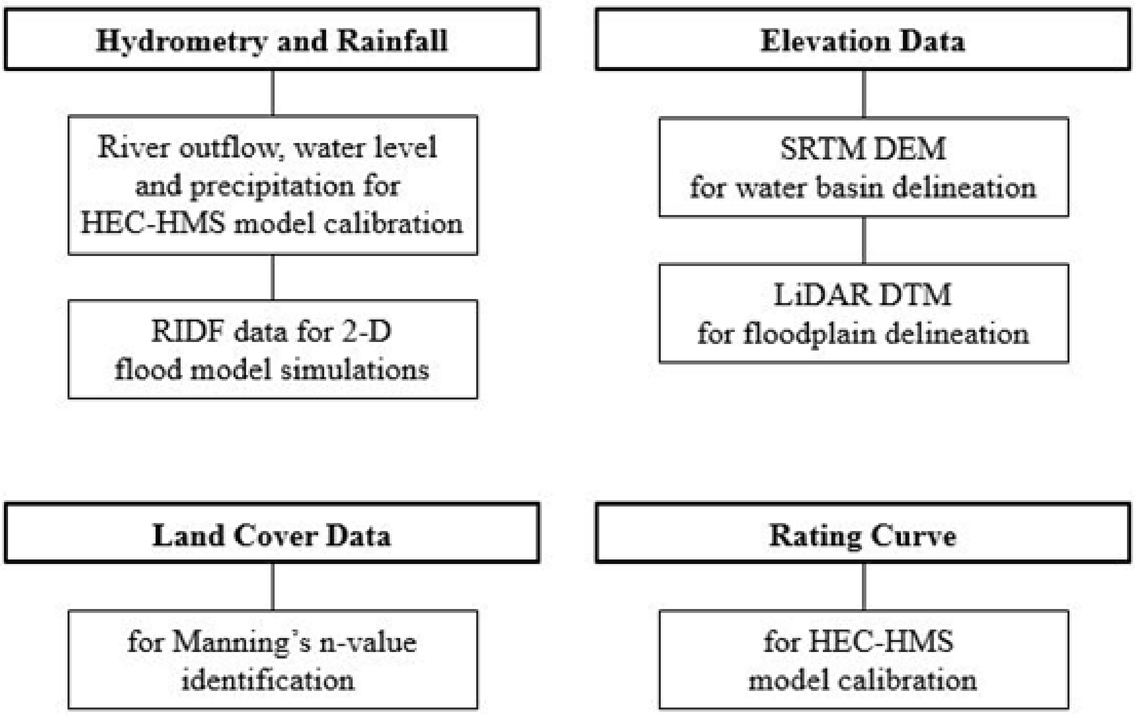


Figure 6. Summary of data needed for the purpose of flood modeling

3.1.1 Elevation Data

3.1.1.1 Hydro Corrected SRTM DEM

With the Shuttle Radar Topography Mission Digital Elevation Model (SRTM DEM) data as an input in determining the extent of the delineated water basin, the model was set-up. The Digital Elevation Model (DEM) is a set of elevation values for a range of points within a designated area. SRTM DEM has a 90 meter spatial mosaic of the entire country. Survey data of cross sections and profile points were integrated to the SRTM DEM for the hydro-correction.

3.1.1.2 LiDAR DEM

LiDAR was used to generate the Digital Elevation Model (DEM) of the different floodplains. DEMs used for flood modeling were already converted to digital terrain models (DTMs) which only show topography, and are thus cleared of land features such as trees and buildings. These terrain features would allow water to flow realistically in the models.

Figure 7 shows an image of the DEM generated through LiDAR.

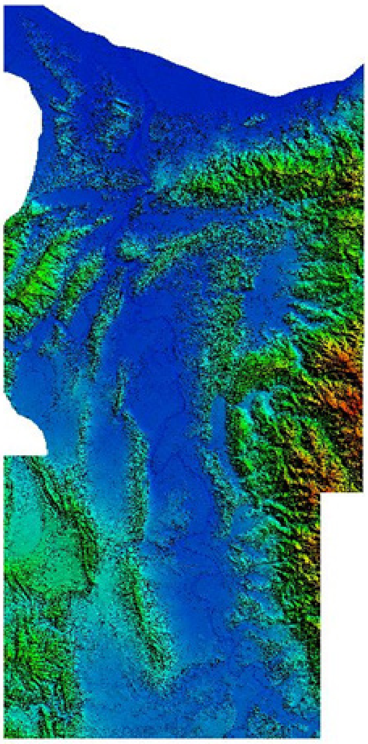


Figure 7. Digital Elevation Model (DEM) of the Cagayan River Basin using Light Detection and Ranging (LiDAR) technology

Elevation points were created from LiDAR DTMs. Since DTMs were provided as 1-meter spatial resolution rasters (while flood models for Cagayan were created using a 10-meter grid), the DTM raster had to be resampled to a raster grid with a 10-meter cell size using ArcGIS.

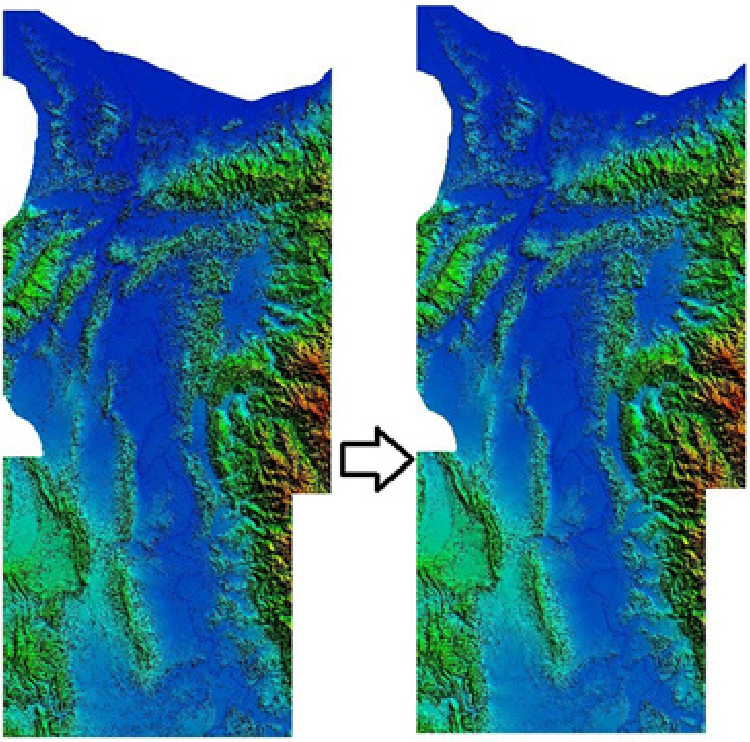


Figure 8. The 1-meter resolution LiDAR data resampled to a 10-meter raster grid in GIS software to ensure that values are properly adjusted.

3.1.2 Land Cover and Soil Type

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).

A general approach was done for the Cagayan floodplain. Streams were identified against built-up areas and rice fields. Identification was done visually using stitched Quickbird images from Google Earth. Areas with different land covers are shown on Figure 9. Different Manning n-values are assigned to each grid element coinciding with these main classifications during the modeling phase.

Figure 9. Stitched Quickbird images for the Cagayan floodplain.

3.1.3 Hydrometry and Rainfall Data

3.1.3.1 Hydrometry for different discharge points

3.1.3.1.1 Gamu Bridge, Isabela

River outflow from the Data Validation Component was used to calibrate the Gamu HEC-HMS model. This was taken from Gamu-Roxas Bridge, District II, Gamu, Isabela (17° 4' 2.95''N, 121° 50' 34.95''E). The hydrograph is shown in Figure 10. This was recorded on 24-29 September 2011.

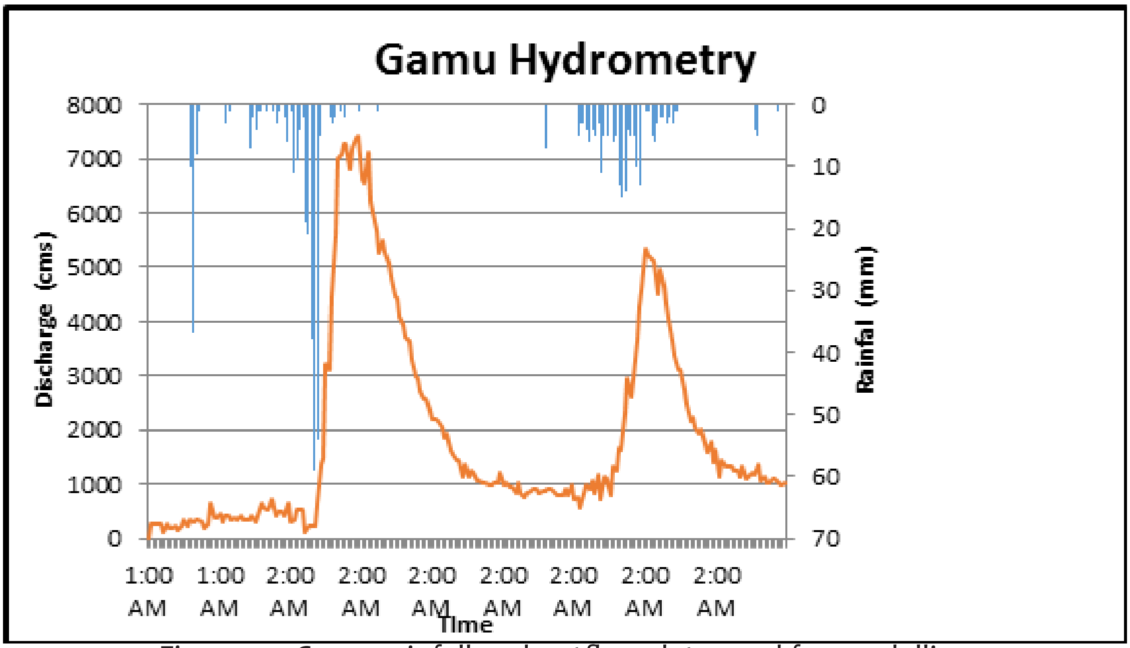


Figure 10. Gamu rainfall and outflow data used for modelling

3.1.3.1.2 Arkon Bridge, Isabela

The river outflow was computed using the derived rating curve equation. This discharge was used to calibrate the HEC-HMS model. It was taken from Arkon Bridge, Isabela (17°16'25.76"N, 121°49'36.34"E). The hydrograph is shown in Figure 11. The recorded peak discharge is 183.51 cms at 4:10 AM, November 10, 2013.

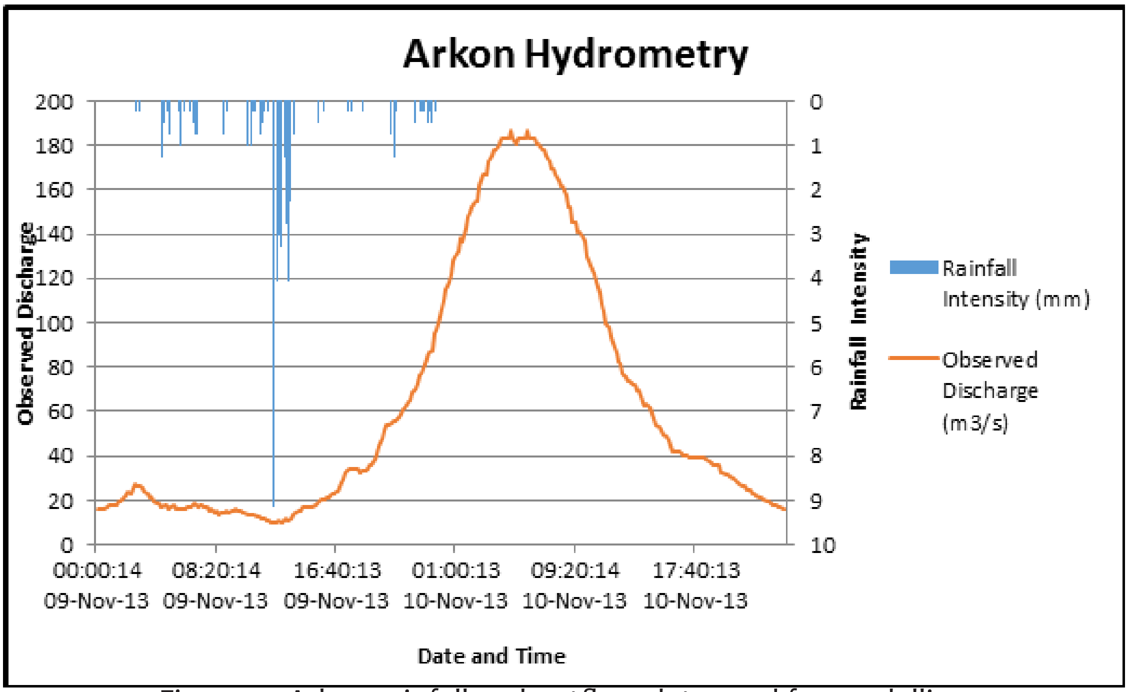


Figure 11. Arkon rainfall and outflow data used for modelling

3.1.3.1.3 Buntun Bridge, Cagayan

The river outflow was computed using the derived rating curve equation. This discharge was used to calibrate the HEC-HMS model. It was taken from Buntun Bridge, Tuguegarao (17°36'50.67"N, 121°41'17.46"E). The hydrograph is shown in Figure 12. The recorded peak discharge is 3373.9 cms at 2:00 PM, March 27 2014.

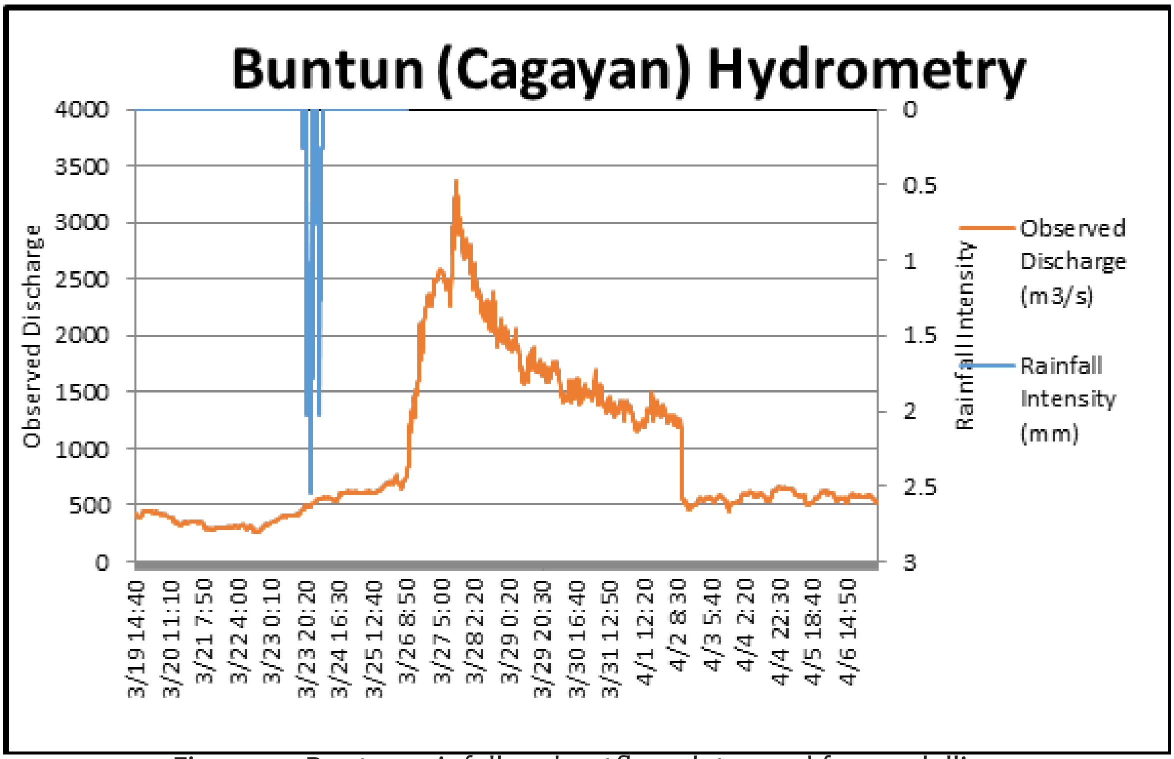


Figure 12. Buntun rainfall and outflow data used for modelling

3.1.3.1.4 Sangbay Bridge, Isabela

The river outflow was computed using the derived rating curve equation. This discharge was used to calibrate the HEC-HMS model. It was taken from Sangbay Bridge, Nagtipunan, Quirino (16°15'27.95"N, 121°39'5.67"E). The hydrograph is shown in Figure 13. The recorded peak discharge is 635.30 cms at 08:00 AM, October 12, 2013.

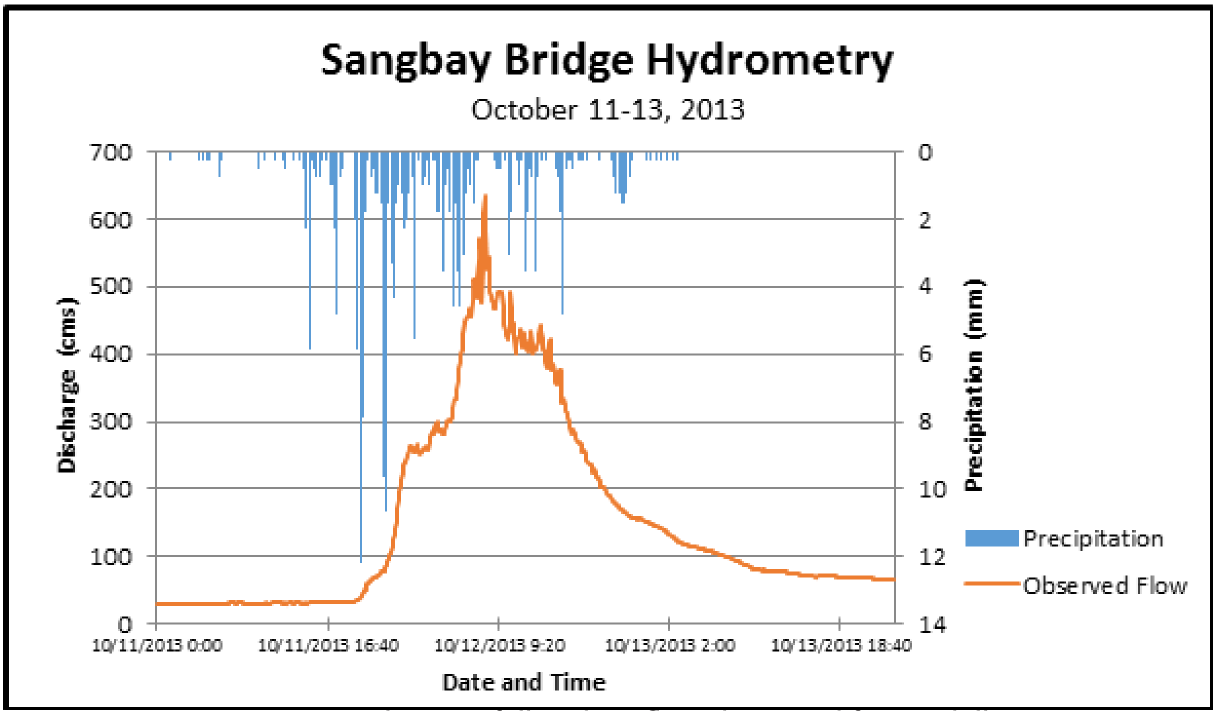


Figure 13. Sangbay rainfall and outflow data used for modelling

3.1.3.1.5 Santiago City Bridge, Isabela

The river outflow was computed using the derived rating curve equation. This discharge was used to calibrate the HEC-HMS model. It was taken from Santiago City Bridge, Isabela (16°41'40.57"N, 121°33'24.80"E). The hydrograph is shown in Figure 14. The recorded peak discharge is 11.5 cms at 01:00 AM, August 22, 2014.

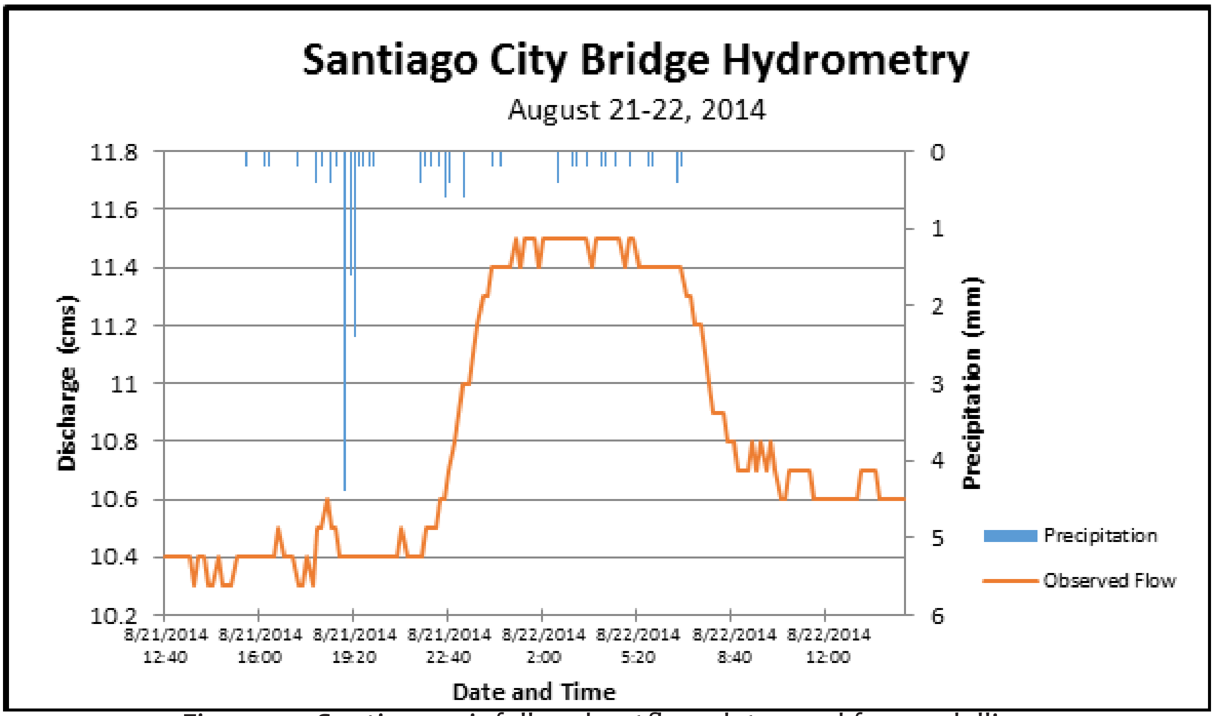


Figure 14. Santiago rainfall and outflow data used for modelling

3.1.3.1.6 Siffu Bridge, Isabela

The river outflow was computed using the derived rating curve equation. This discharge was used to calibrate the HEC-HMS model. It was taken from Siffu Bridge, Isabela (17° 7'47.02"N, 121°36'52.15"E). The hydrograph is shown in Figure 15.The recorded peak discharge is 492.70 cms at 03:30 AM, October 13, 2013.

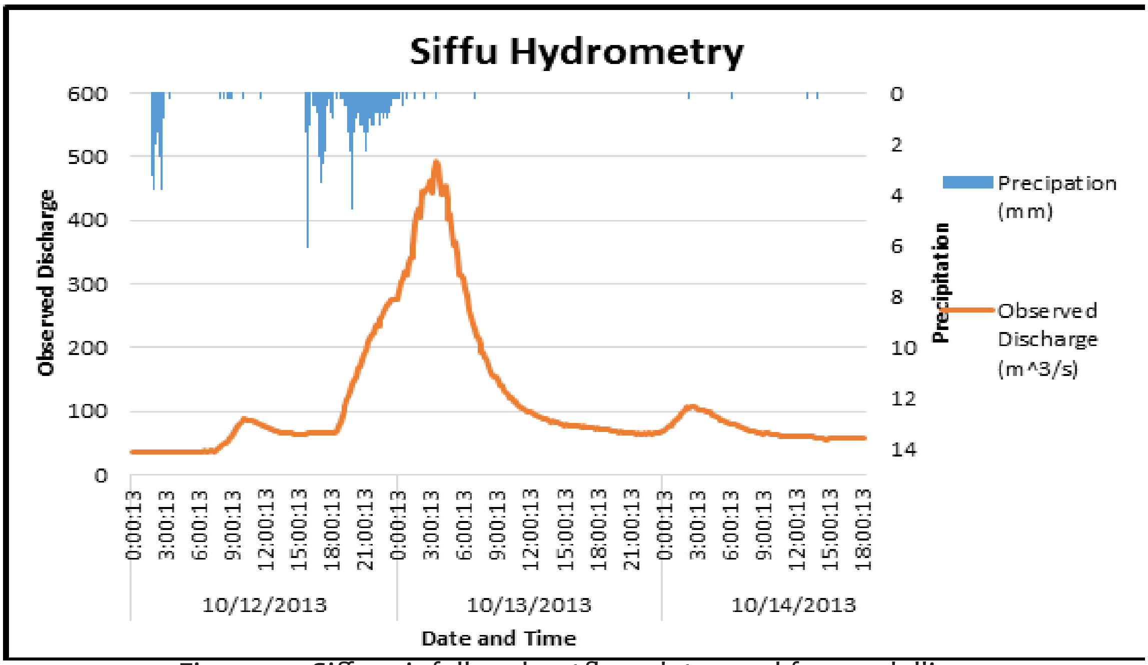


Figure 15. Siffu rainfall and outflow data used for modelling

3.1.3.2 Rainfall Intensity Duration Frequency

The Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) computed Rainfall Intensity Duration Frequency (RIDF) values for the Tuguegarao Rain Gauge. This station was chosen based on its proximity to the Cagayan watershed. The extreme values for this watershed were computed based on a 26-year record.

The thiessen polygon shown in Figure 16 was used to designate the corresponding RIDFs for each water level sensors within the Cagayan watershed. For Gamu Bridge, Arkon Bridge, Buntun Bridge, and Siffu Bridge, Tuguegarao RIDF was used; while for the rest, Sangbay Bridge and Santiago City Bridge, Casiguran RIDF was used.

Five return periods were used, namely, 5-, 10-, 25-, 50-, and 100-year RIDFs. All return periods are 24 hours long and peaks after 12 hours.

Figure 16. Thiessen Polygon of Rain Intensity Duration Frequency (RIDF) Stations for the whole Philippines.

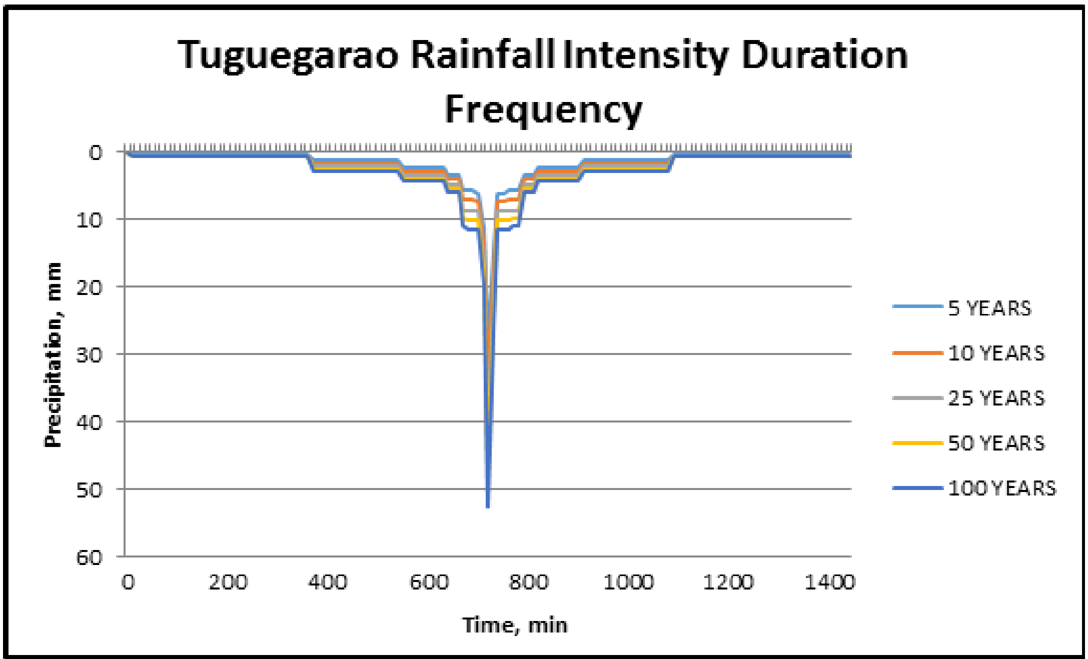


Figure 17. Tuguegarao Rainfall-Intensity Duration Frequency (RIDF) curves.

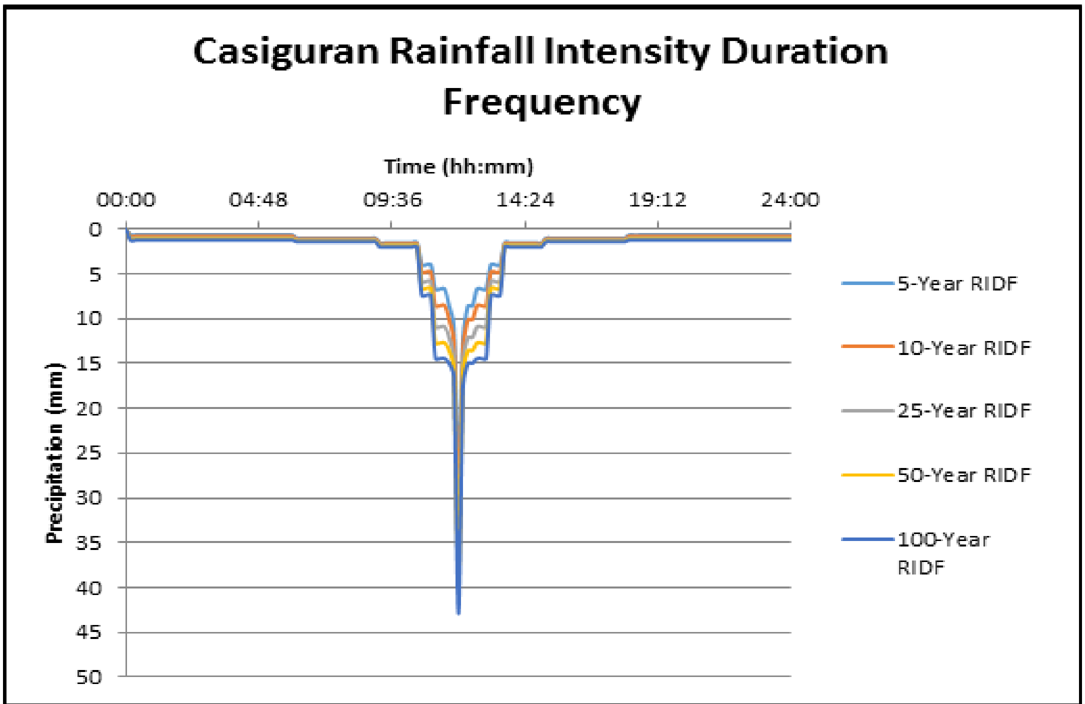


Figure 18. Casiguran Rainfall-Intensity Duration Frequency (RIDF) curves.

The Cagayan outflow was computed for the five return periods, namely, 5-, 10-, 25-, 50-, and 100-year RIDFs.

3.1.4 Rating Curves

Rating curves were provided by DVC. This curve gives the relationship between the observed water levels from the AWLS used and outflow watershed at the said locations.

Rating curves are expressed in the form of Equation 1 with the discharge (Q) as a function of the gauge height (h) readings from CDO Bridge AWLS and constants (a and n).

$$Q = a^{nh}$$

Equation 1. Rating Curve

3.1.4.1 Arkon Bridge, Isabela Rating Curve

For Arkon Bridge, the rating curve is expressed as $Q = 9E\text{-}17e^{1.5658h}$ as shown in Figure 19.

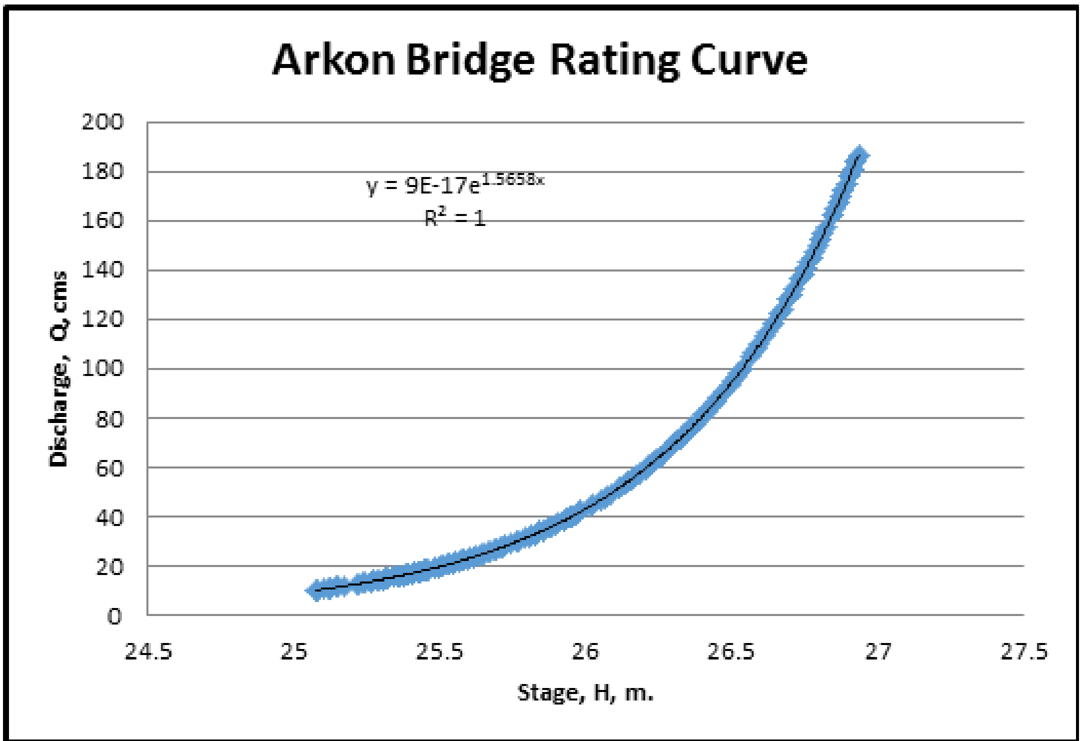


Figure 19. Water level vs. Discharge Curve for Arkon Bridge, Isabela

3.1.4.2 Buntun Bridge, Isabela Rating Curve

For Buntun Bridge, the rating curve is expressed as $Q = 8.7578e^{7E\text{-}05h}$ as shown in Figure 20.

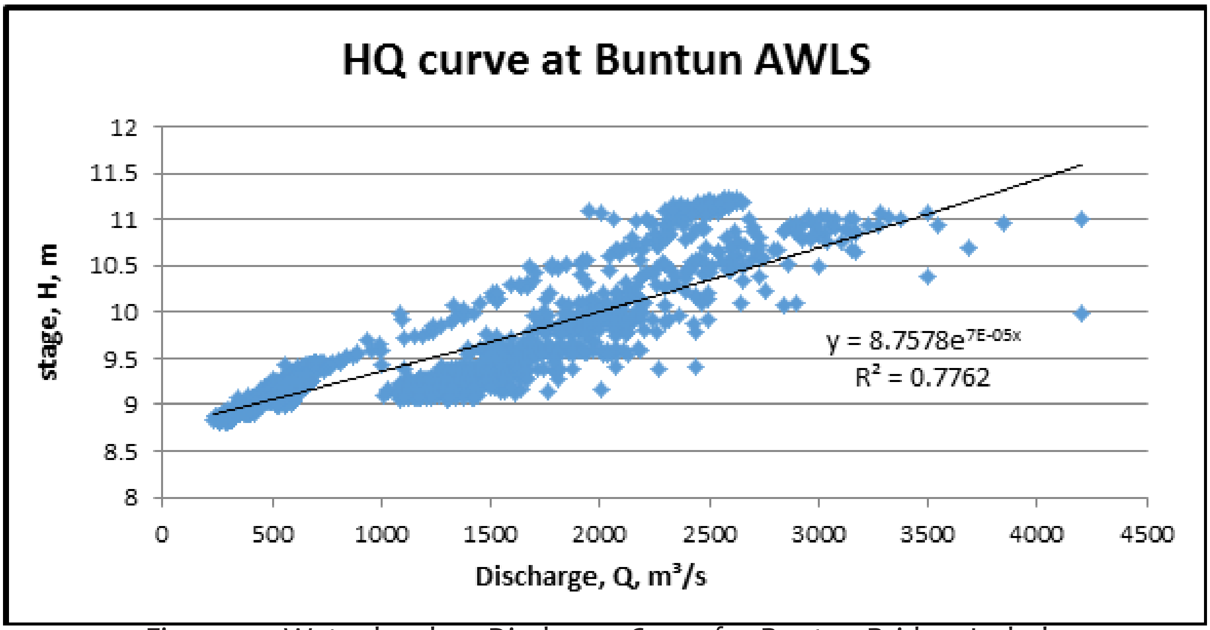


Figure 20. Water level vs. Discharge Curve for Buntun Bridge, Isabela

3.1.4.3 Sangbay Bridge, Quirino Rating Curve

For Sangbay Bridge, the rating curve is expressed as $Q = 6E\text{-}61e^{0.908h}$ as shown in Figure 21.

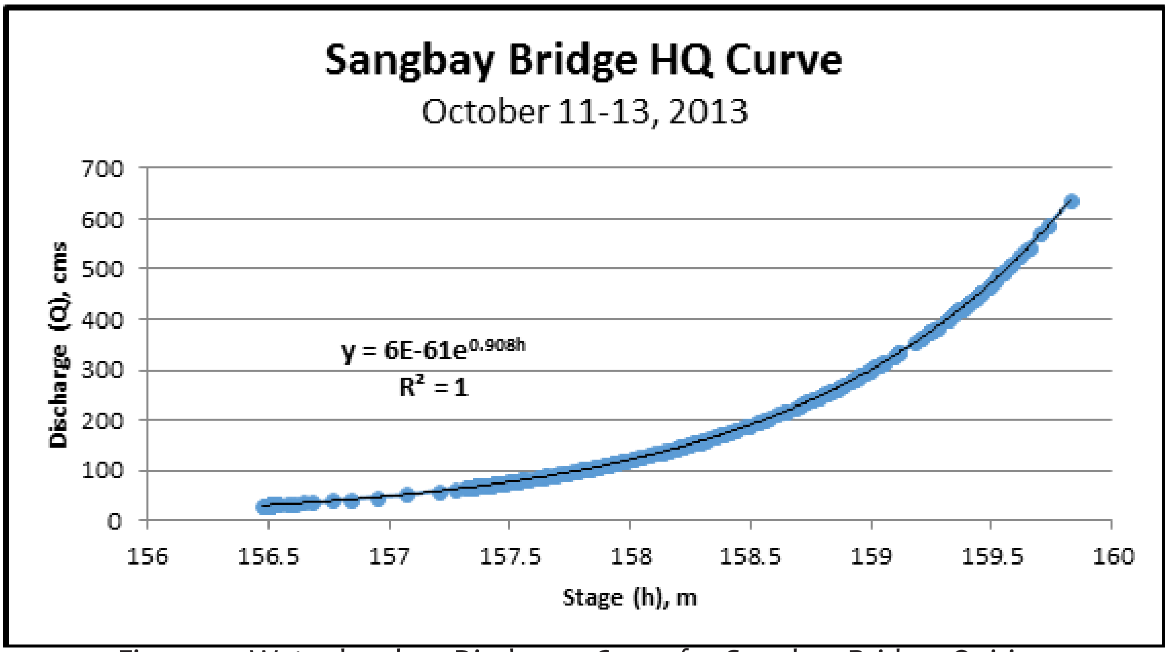


Figure 21. Water level vs. Discharge Curve for Sangbay Bridge, Quirino

3.1.4.4 Santiago City Bridge, Isabela Rating Curve

For Santiago City Bridge, the rating curve is expressed as $Q=7.644e^{0.504h}$ as shown in Figure 22.

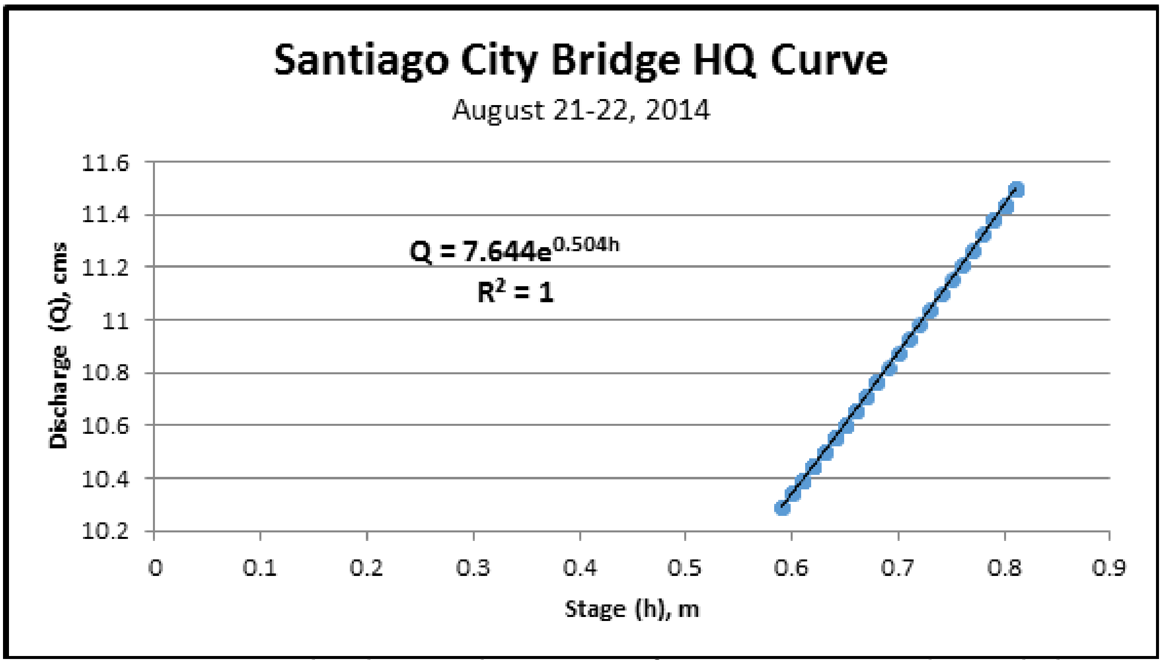


Figure 22. Water level vs. Discharge Curve for Santiago City Bridge, Isabela

3.1.4.5 Siffu Bridge, Isabela Rating Curve

For Siffu Bridge, the rating curve is expressed as $Q = 3E\text{-}13e^{0.6586h}$ as shown in Figure 23.

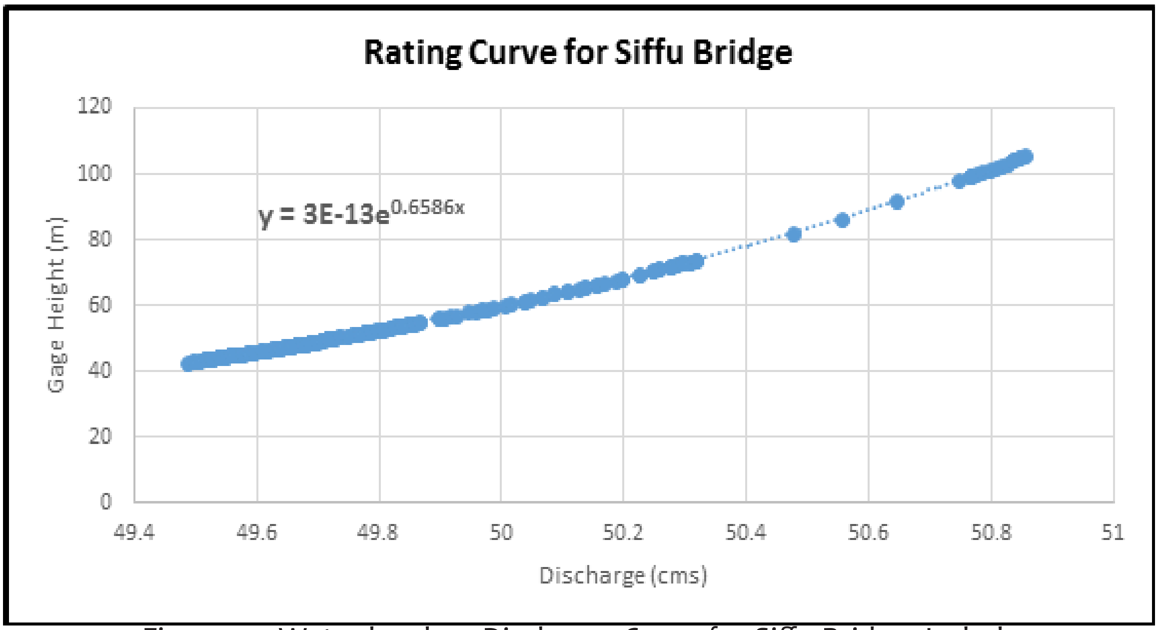


Figure 23. Water level vs. Discharge Curve for Siffu Bridge, Isabela

3.2 Rainfall-Runoff Hydrologic Model Development

3.2.1 Watershed Delineation and Basin Model Pre-processing

The hydrologic model of Cagayan River Basin was developed using Watershed Modeling System (WMS) version 9.1. The software was developed by Aquaveo, a water resources engineering consulting firm in United States. WMS is a program capable of various watershed computations and hydrologic simulations. The hydrologic model development follows the scheme shown in the Figure 24.

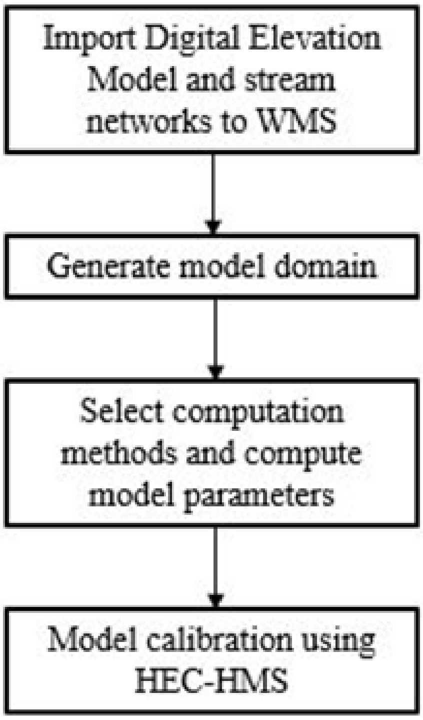


Figure 24. The Rainfall-Runoff Basin Model Development Scheme

Hydro-corrected SRTM DEM was used as the terrain for the basin model. The watershed delineation and its hydrologic elements, namely the subbasins, junctions and reaches, were generated using WMS after importing the elevation data and stream networks.

The parameters for the subbasins and reaches were computed after the model domain was created. There are several methods available for different calculation types for each subbasin and reach hydrologic elements. The methods used for this study is shown in Table 1. The necessary parameter values are determined by the selected methods. The initial abstraction, curve number, percentage impervious and manning's coefficient of roughness, n, for each subbasin were computed based on the soil type, land cover and land use data. The subbasin time of concentration and storage coefficient were computed based on the analysis of the topography of the basin.

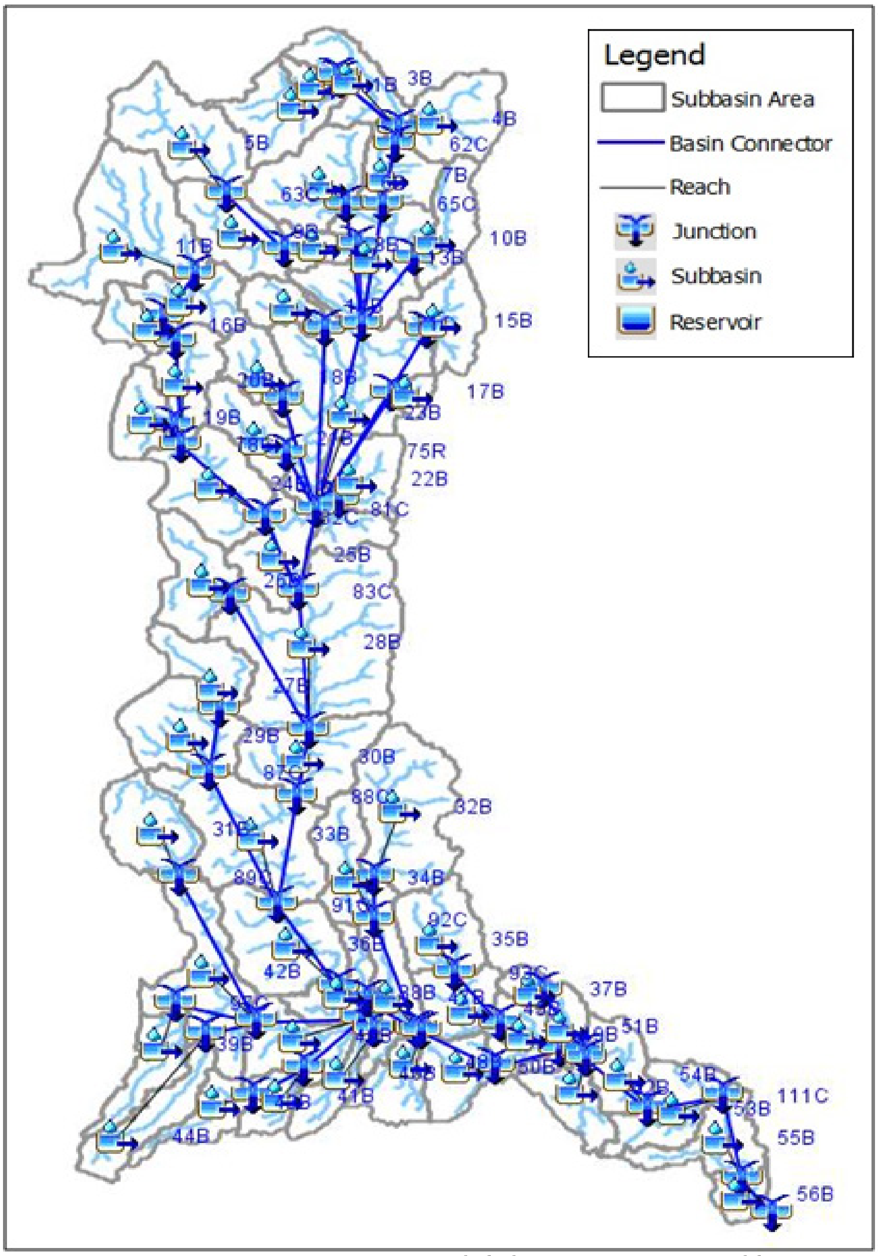


Figure 25. Cagayan HEC-HMS Model domain generated by WMS

Table 1. Methods used for the different calculation types for the hydrologic elements

Hydrologic Element	Calculation Type	Method
Subbasin	Loss Rate	SCS Curve Number
	Transform	Clark’s unit hydrograph
	Baseflow	Bounded recession
Reach	Routing	Muskingum-Cunge

3.2.2 Basin Model Calibration

The basin model made using WMS was exported to Hydrologic Modeling System (HEC-HMS) version 3.5, a software made by the Hydrologic Engineering Center of the US Army Corps of Engineers, to create the final rainfall-runoff model. The developers described HEC-HMS as a program designed to simulate the hydrologic processes of a dendritic watershed systems. In this study, the rainfall-runoff model was developed to calculate inflow from the watershed to the floodplain.

Precipitation data was taken from automatic rain gauges (ARGs) installed by the Department of Science and Technology – Advanced Science and Technology Institute (DOST-ASTI) which covers the proximity of the subbasins upstream of the discharge point being considered.

For the calibration of Gamu Bridge, Naguilian, Santiago, and Nagtipunan ARGs were used. The locations of the rain gauges are shown in Figure 26. Total rain from Nagtipunan rain gauge is 148.59 mm. It peaked to 11.938mm on 24 September 2013, 21:20. For Santiago, total rain for this event is 55.066 mm. Peak rain of 30 mm was recorded on 24 September 2013, 15:10. For Naguilian, total rain is 22.606mm. It peaked to 2.54 mm at 25 September 2012, 18:00. The lag time between the peak rainfall and discharge is 11 hours and 50 minutes.

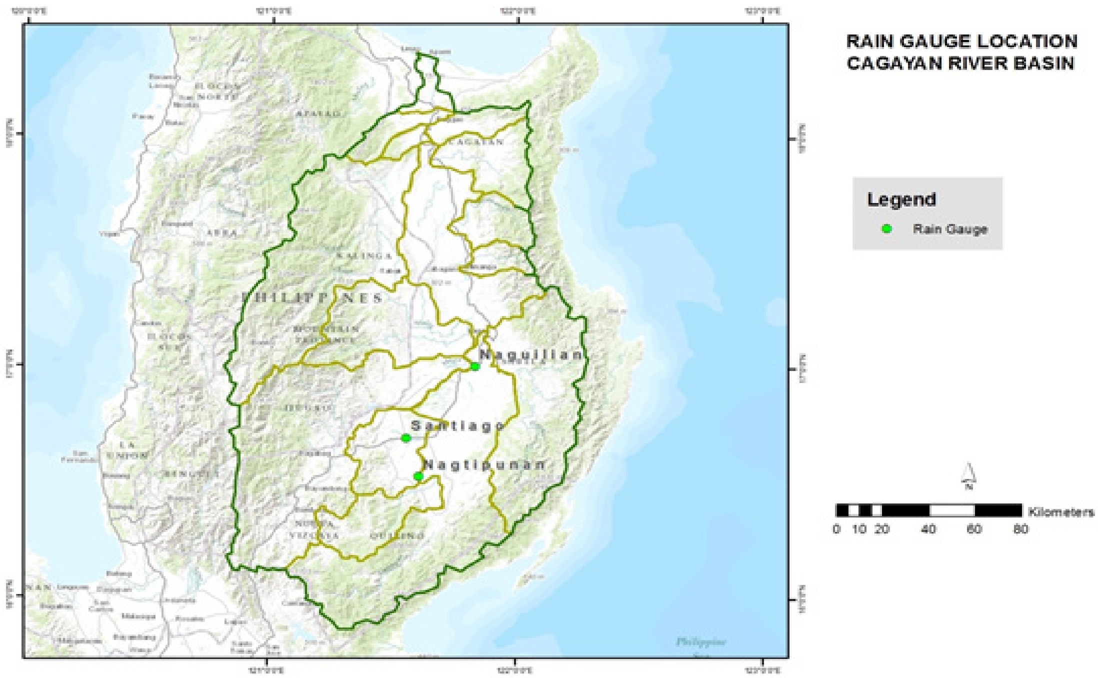


Figure 26. Location of rain gauge used for the calibration of Cagayan HEC-HMS Model

The outflow hydrograph for the downstream-most discharge point with field data was also encoded to the model as a basis for the calibration. Using the said data, HEC-HMS could perform rainfall-runoff simulation and the resulting outflow hydrograph was compared with the observed hydrograph. The values of the parameters were adjusted and optimized in order for the calculated outflow hydrograph to appear like the observed hydrograph. Acceptable values of the subbasin and reach parameters from the manual and past literatures were considered in the calibration.

3.3 HEC-HMS Hydrologic Simulations for Discharge Computations using PAGASA RIDF Curves

3.3.1 Discharge Computation using Rainfall-Runoff Hydrologic Model

The calibrated rainfall-Runoff Hydrologic Model for the Cagayan River Basin using WMS and HEC-HMS was used to simulate the flow for for the five return periods, namely, 5-, 10-, 25-, 50-, and 100-year RIDFs. Time-series data of the precipitation data using the Tuguegarao or Casiguran RIDF curves were encoded to HEC-HMS for the aforementioned return periods, wherein each return period corresponds to a scenario. This process was performed for all discharge points. The output for each simulation was an outflow hydrograph from that result, the total inflow to the floodplain and time difference between the peak outflow and peak precipitation could be determined.

3.3.2 Discharge Computation using Dr. Horritt's Recommended Hydrological Method

The required data to be accumulated for the implementation of Dr. Horrit's method is shown on Figure 27.

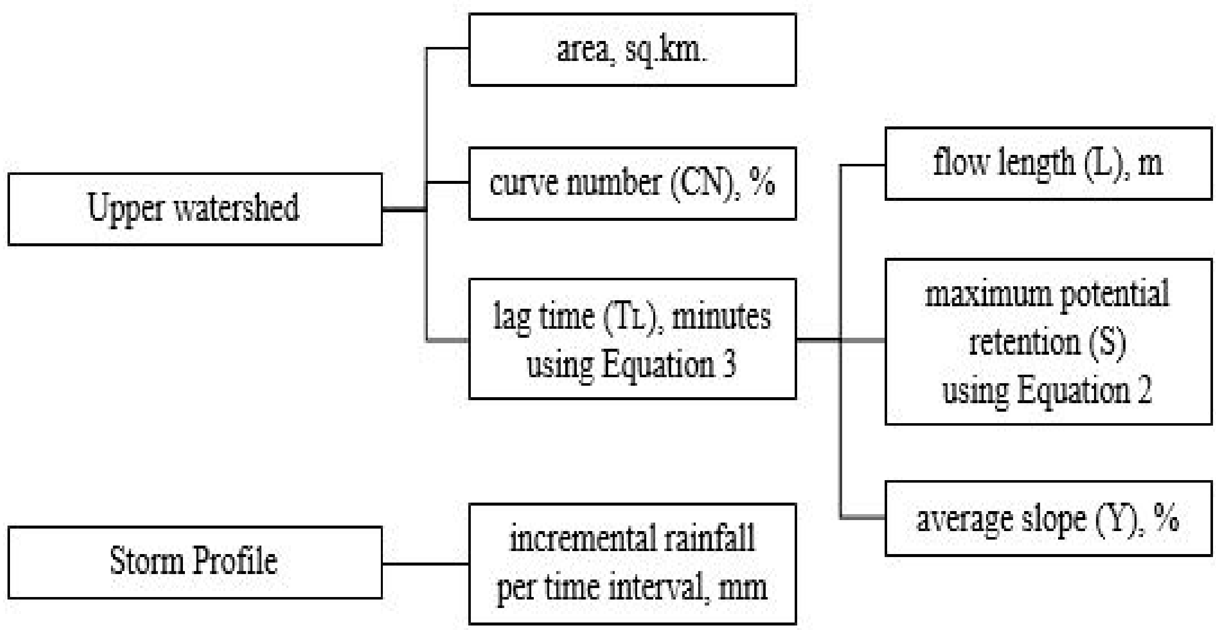


Figure 27. Different data needed as input for HEC-HMS discharge simulation using Dr. Horritt's recommended hydrology method.

Flows from streams were computed using the hydrology method developed by the flood modeling component with Dr. Matt Horritt, a British hydrologist that specializes in flood research. The methodology was based on an approach developed by CH2M Hill and Horritt Consulting for Taiwan which has been successfully validated in a region with meteorology and hydrology similar to the Philippines. The method utilizes the SCS curve number and unit hydrograph method to have an accurate approximation of river discharge data from measurable catchment parameters.

3.3.2.1 Determination of Catchment Properties

RADARSAT DTM data for the different areas of the Philippines were compiled with the aid of ArcMap. RADARSAT satellites provide advance geospatial information and these were processed in the forms of shapefiles and layers that are readable and can be analyzed by ArcMap. These shapefiles are digital vectors that store geometric locations.

The watershed flow length is defined as the longest drainage path within the catchment, measured from the top of the watershed to the point of the outlet. With the tools provided by the ArcMap program and the data from RADARSAT DTM, the longest stream was selected and its geometric property, flow length, was then calculated in the program.

The area of the watershed is determined with the longest stream as the guide. The compiled RADARSAT data has a shapefile with defined small catchments based on mean elevation. These parameters were used in determining which catchments, along with the area, belong in the upper watershed.

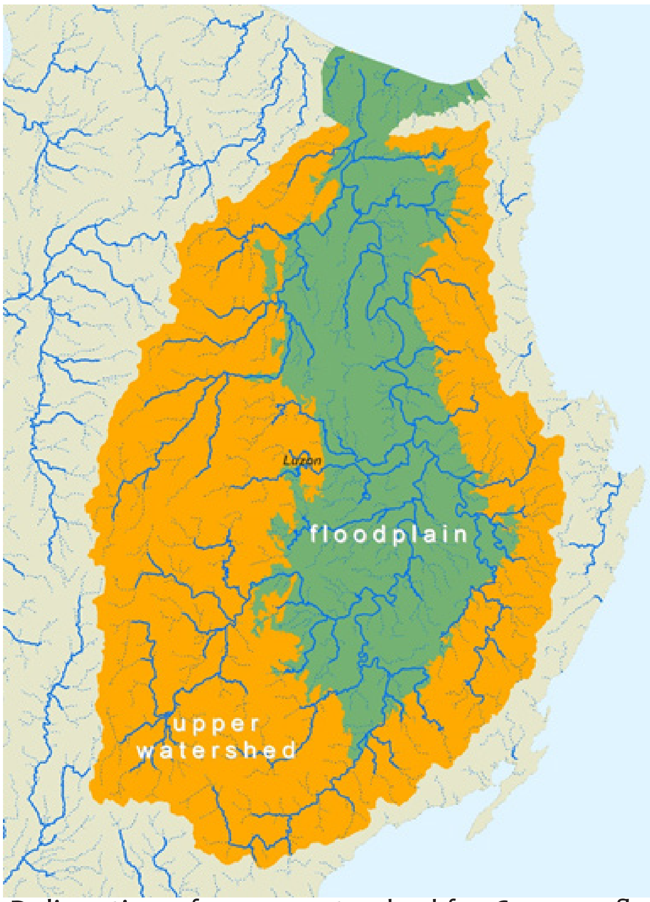


Figure 28. Delineation of upper watershed for Cagayan floodplain discharge computation

The value of the curve number was obtained using the RADARSAT data that contains information of the Philippine national curve number map. An ArcMap tool was used to determine the average curve number of the area bounded by the upper watershed shapefile. The same method was implemented in determining the average slope using RADARSAT with slope data for the whole country.

After determining the curve number (CN), the maximum potential retention (S) was determined by Equation 2.

$$S = \frac{1000}{CN} - 10$$

Equation 2. Determination of maximum potential retention using the average curve number of the catchment

The watershed length (L), average slope (Y) and maximum potential retention (S) are used to estimate the lag time of the upper watershed as illustrated in Equation 3.

$$T_L = \frac{L^{0.8}(S+1)^{0.7}}{560Y^{0.5}}$$

Equation 3. Lag Time Equation Calibrated for Philippine Setting

Finally, the final parameter that will be derived is the storm profile. The synoptic station which covers the majority of the upper watershed was identified. Using the RIDF data, the incremental values of rainfall in millimeter per 0.1 hour was used as the storm profile.

3.3.2.2 HEC-HMS Implementation

With all the parameters available, HEC-HMS was then utilized. Obtained values from the previous section were used as input and a brief simulation would result in the tabulation of discharge results per time interval. The maximum discharge and time-to-peak for the whole simulation as well as the river discharge hydrograph were used for the flood simulation process. The time series results (discharge per time interval) were stored as HYD files for input in FLO-2D GDS Pro.

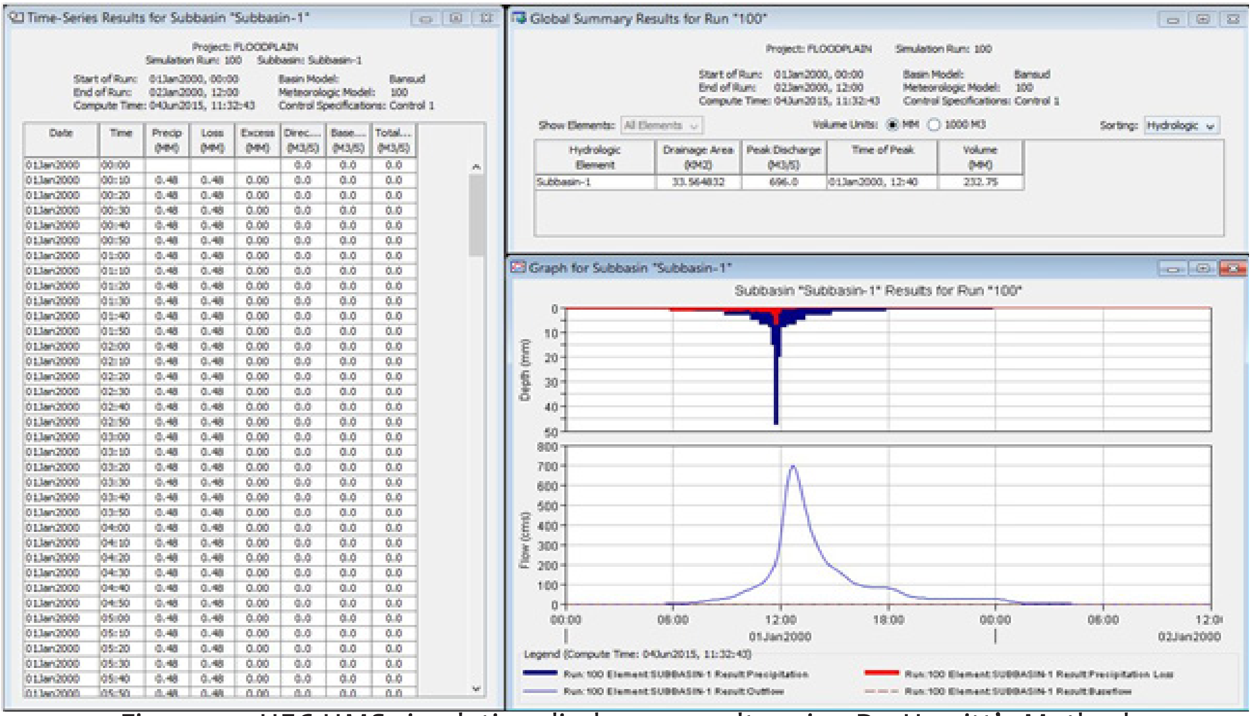


Figure 29. HEC-HMS simulation discharge results using Dr. Horritt's Method

3.3.2.3 Discharge validation against other estimates

As a general rule, the river discharge of a 2-year rain return, Q_{MED}, should approximately be equal to the bankful discharge, $Q_{bankful}$, of the river. This assumes that the river is in equilibrium, with its deposition being balanced by erosion. Since the simulations of the river discharge are done for 5-, 25-, and 100-year rainfall return scenarios, a simple ratio for the 2-year and 5-year return was computed with samples from actual discharge data of different rivers. It was found out to have a constant of 0.88. This constant, however, should still be continuously checked and calibrated when necessary.

$$Q_{MED} = 0.88Q_{5yr}$$

Equation 4. Ratio of river discharge of a 5-year rain return to a 2-year rain return scenario from measured discharge data

For the discharge calculation to pass the validation using the bankful method, Equation 5 must be satisfied.

$$50\% \, Q_{bankful} \leq Q_{MED} \leq 150\% \, Q_{bankful}$$

Equation 5. Discharge validation equation using bankful method

The bankful discharge was estimated using channel width (w), channel depth (h), bed slope (S) and Manning's constant (n). Derived from the Manning's Equation, the equation for the bankful discharge is by Equation 6.

$$Q_{bankful} = \frac{(wh)^{\frac{5}{3}} S^{\frac{1}{2}}}{n(w+2h)^{\frac{2}{3}}}$$

Equation 6. Bankful discharge equation using measurable channel parameters

3.4 Hazard and Flow Depth Mapping using FLO-2D

3.4.1 Floodplain Delineation

The boundaries of subbasins within the floodplain were delineated based on elevation values given by the DEM. Each subbasin is marked by ridges dividing catchment areas. These catchments were delineated using a set of ArcMap tools compiled by Al Duncan, a UK Geomatics Specialist, into a single processing model. The tool allows ArcMap to compute for the flow direction and acceleration based on the elevations provided by the DEM.

Running the tool creates features representing large, medium-sized, and small streams, as well as large, medium-sized, and small catchments. For the purpose of this particular model, the large, medium-sized, and small streams were set to have an area threshold of 100,000sqm, 50,000sqm, and 10,000sqm respectively. These thresholds define the values where the algorithm refers to in delineating a trough in the DEM as a stream feature, i.e. a large stream feature should drain a catchment area totalling 100,000 sqm to be considered as such. These values differ from the standard values used (10,000sqm, 1,000 sqm and 100sqm) to limit the detail of the project, as well as the file sizes, allowing the software to process the data faster.

The tool also shows the direction in which the water is going to flow across the catchment area. This information was used as the basis for delineating the floodplain. The entire area of the floodplain was subdivided into several zones in such a way that it can be processed properly. This was done by grouping the catchments together, taking special account of the inflows and outflows of water across the entire area. To be able to simulate actual conditions, all the catchments comprising a particular computational domain were set to have outflows that merged towards a single point. The area of each subdivision was limited to 250,000 grids or less to allow for an optimal simulation in FLO-2D GDS Pro. Larger models tend to run longer, while smaller models may not be as accurate as a large one.

3.4.2 Flood Model Generation

The software used to run the simulation is FLO-2D GDS Pro. It is a GIS integrated software tool that creates an integrated river and floodplain model by simulating the flow of the water over a system of square grid elements.

After loading the shapefile of the subcatchment onto FLO-2D, 10 meter by 10 meter grids that encompassed the entire area of interest were created.

The boundary for the area was set by defining the boundary grid elements. This can either be done by defining each element individually, or by drawing a line that traces the boundaries of the subcatchment. The grid elements inside of the defined boundary were considered as the computational area in which the simulation will be run.

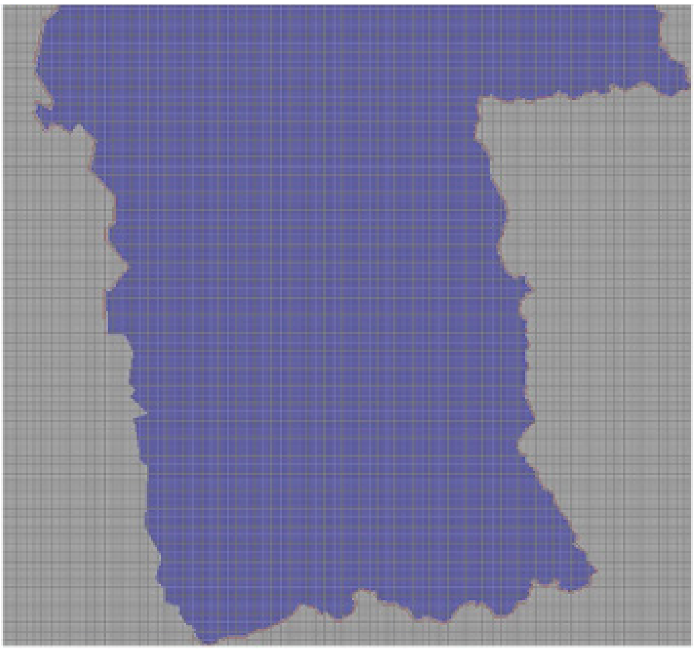


Figure 30. Screenshot showing how boundary grid elements are defined by line

Elevation data was imported in the form of the DEM gathered through LiDAR. These elevation points in PTS format were extrapolated into the model, providing an elevation value for each grid element.

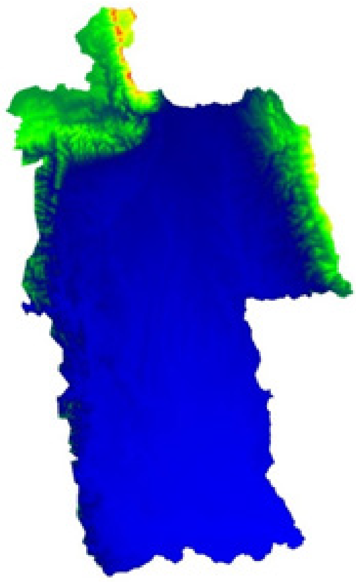


Figure 31. Screenshots of PTS files when loaded into the FLO-2D program

The floodplain is predominantly composed of rice fields, which have a Manning coefficient of 0.15. All the inner grid elements were selected and the Manning coefficient of 0.15 was assigned. To differentiate the streams from the rest of the floodplain, a shapefile containing all the streams and rivers in the area were imported into the software. The shapefile was generated using Al Duncan's catchment tool for ArcMap. The streams were then traced onto their corresponding grid elements.

These grid elements were all selected and assigned a Manning coefficient of 0.03. The DEM and aerial imagery were also used as bases for tracing the streams and rivers.

Figure 32. Areal image of Cagayan floodplain

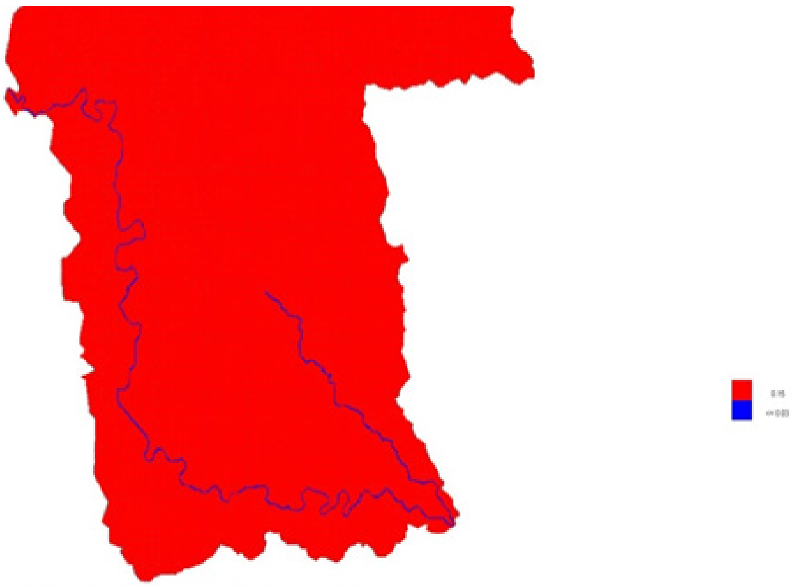


Figure 33. Screenshot of Manning's n-value rendering

After assigning Manning coefficients for each grid, the infiltration parameters were identified. Green-Ampt infiltration method by W. Heber Green and G.S Ampt were used for all the models. The initial saturations applied to the model were 0.99, 0.8, and 0.7 for 100-year, 25-year, and 5-year rain return periods respectively. These initial saturations were used in the computation of the infiltration value.

The Green-Ampt infiltration method by W. Heber Green and G.S Ampt method is based on a simple physical model in which the equation parameter can be related to physical properties of the soil. Physically, Green and Ampt assumed that the soil was saturated behind the wetting front and that one could define some "effective" matric potential at the wetting front (Kirkham, 2005). Basically, the system is assumed to consist of a uniformly wetted near-saturated transmission zone above a sharply defined wetting front of constant pressure head (Diamond & Shanley, 2003).

The next step was to allocate inflow nodes based on the locations of the outlets of the streams from the upper watershed. The inflow values came from the computed discharges that were input as hyd files.

Outflow nodes were allocated for the model. These outflow nodes show the locations where the water received by the watershed is discharged. The water that will remain in the watershed will result to flooding on low lying areas.

For the models to be able to simulate actual conditions, the inflow and outflow of each computational domain should be indicated properly. In situations wherein water flows from one subcatchment to the other, the corresponding models are processed one after the other. The outflow generated by the source subcatchment was used as inflow for the subcatchment area that it flows into.

The standard simulation time used to run each model is the time-to-peak (TP) plus an additional 12 hours. This gives enough time for the water to flow into and out of the model area, illustrating the complete process from entry to exit as shown in the hydrograph. The additional 12 hours allows enough time for the water to drain fully into the next subcatchment. After all the parameters were set, the model was run through FLO-2D GDS Pro.

3.4.3 Flow Depth and Hazard Map Simulation

After running the flood map simulation in FLO-2D GDS Pro, FLO-2D Mapper Pro was used to read the resulting hazard and flow depth maps. The standard input values for reading the simulation results are shown on Figure 34.

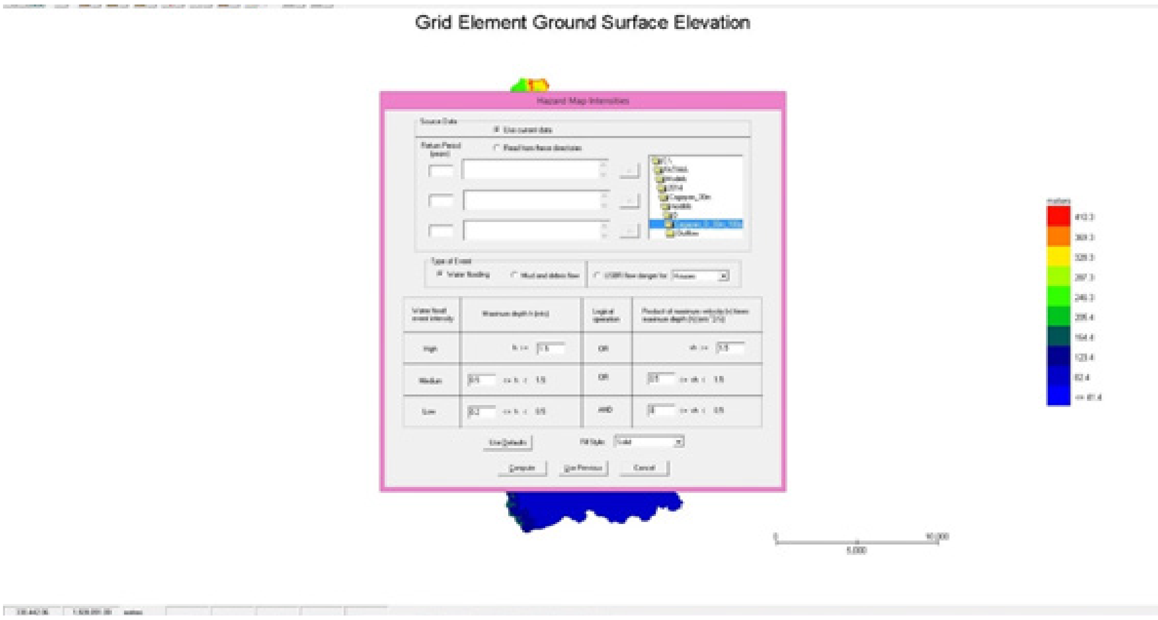


Figure 34. FLO-2D Mapper Pro General Procedure

In order to produce the hazard maps, set input for low maximum depth as 0.2 m, and vh, product of maximum velocity and maximum depth (m^2/s), as greater than or equal to zero. The program will then compute for the flood inundation and will generate shapefiles for the hazard and flow depth scenario. A sample screenshot of the results are shown in Figure 35 and Figure 36.

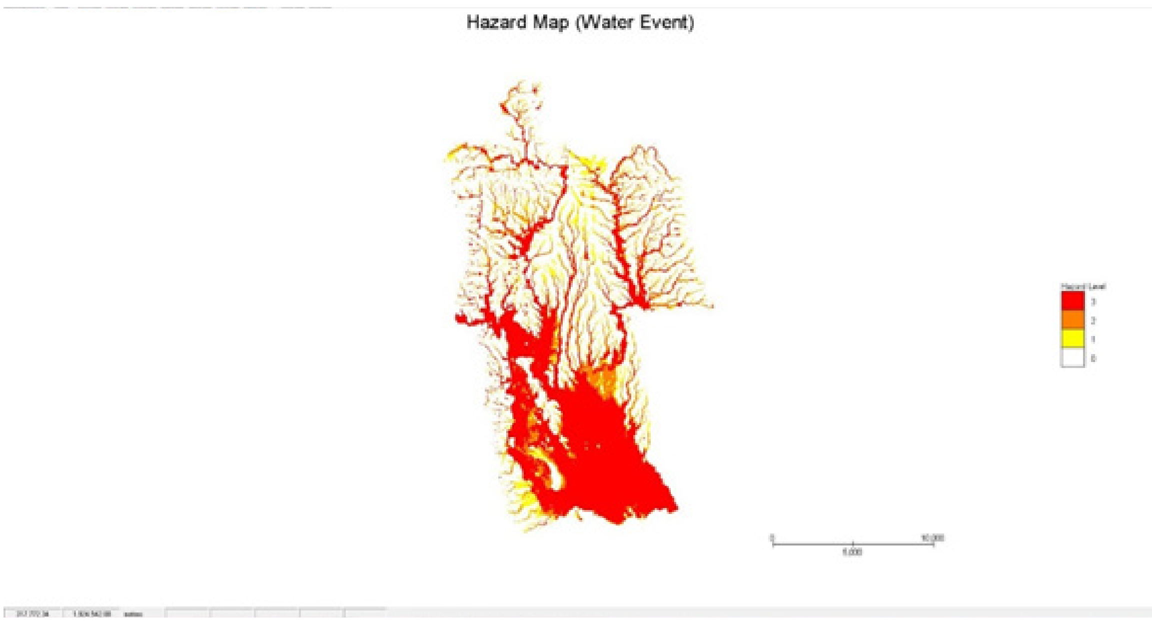


Figure 35. Cagayan Floodplain Generated Hazard Maps using FLO-2D Mapper

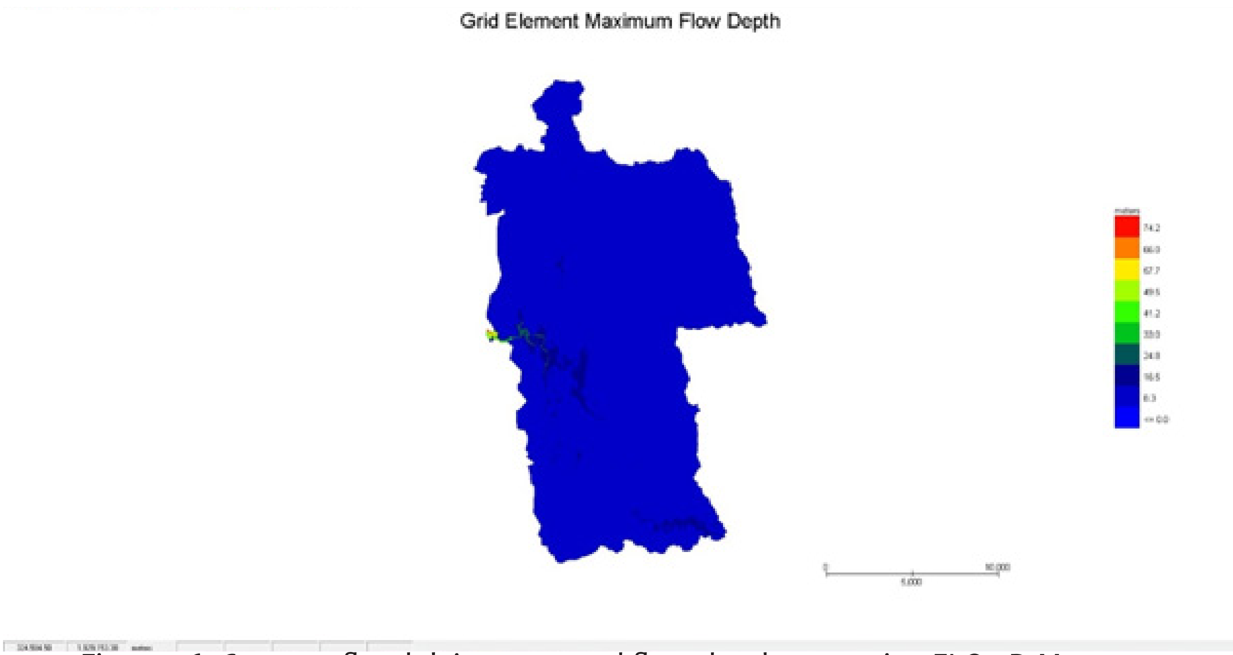
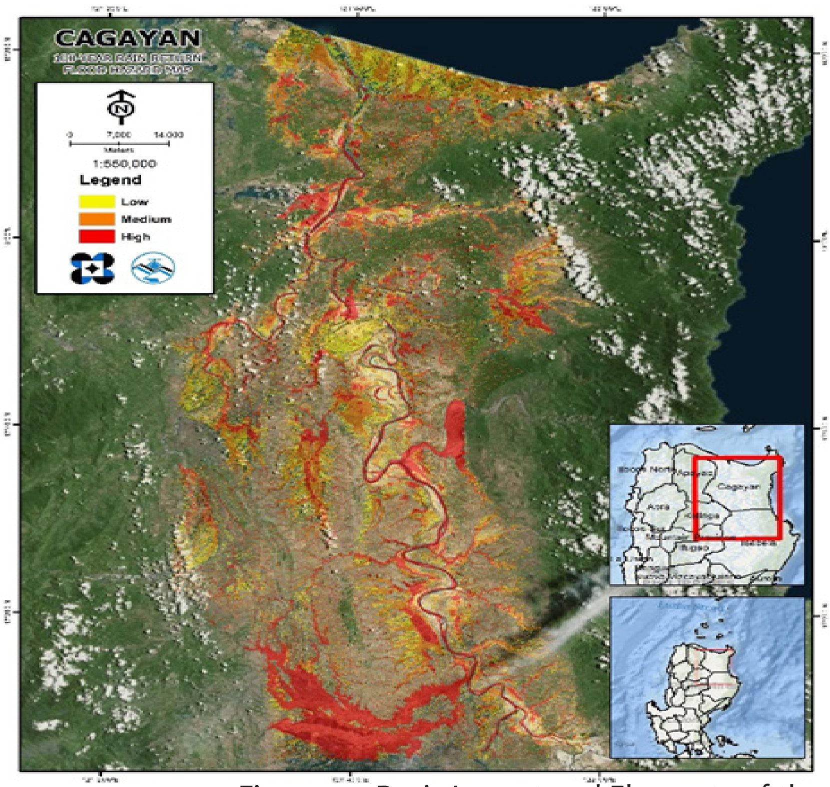


Figure 36. Cagayan floodplain generated flow depth map using FLO-2D Mapper

3.4.4 Hazard Map and Flow Depth Map Creation

The final procedure in creating the maps is to prepare them with the aid of ArcMap. The generated shapefiles from FLO-2D Mapper Pro were opened in ArcMap. The basic layout of a hazard map is shown in Figure 37. The same map elements are also found in a flow depth map.



ELEMENTS
1. River Basin Name
2. Hazard/Flow Depth Shapefile
3. Provincial Inset
4. Philippine Inset
5. Hi-Res image of the area
6. North Arrow
7. Scale text and Bar

Figure 37. Basic Layout and Elements of the Hazard Maps

Results and Discussion

4.1 Efficiency of HEC-HMS Rainfall-Runoff Models calibrated based on field survey and gauges data

4.1.1 Gamu Bridge, Isabela HMS Calibration Results

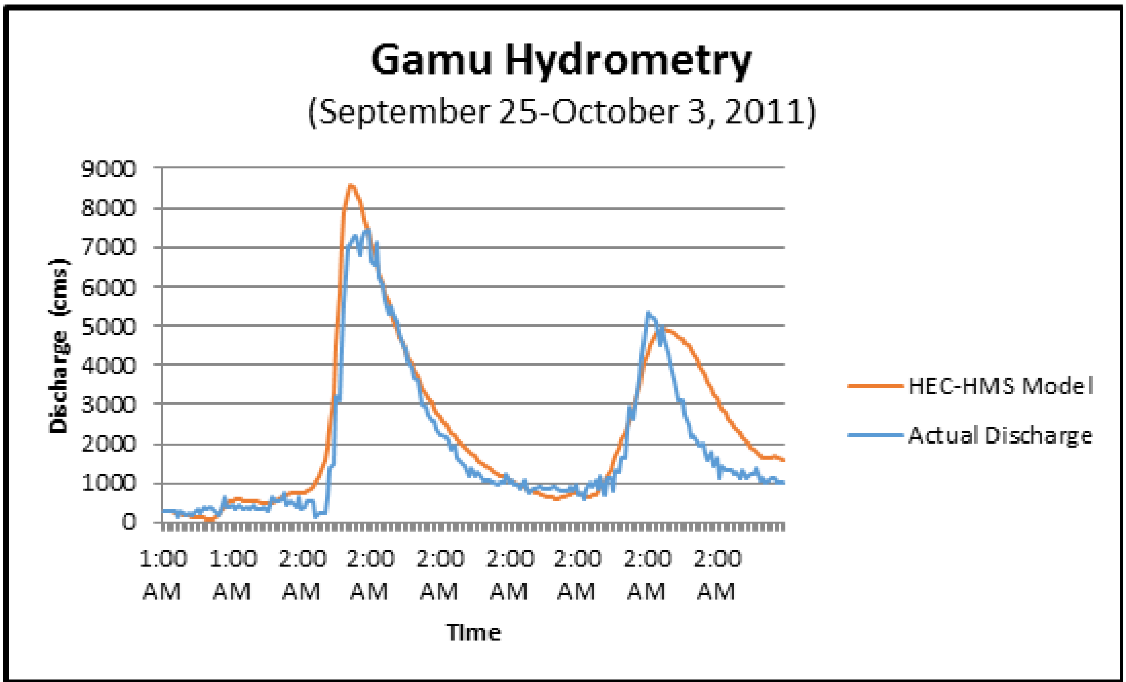


Figure 38. Gamu Outflow Hydrograph produced by the HEC-HMS model compared with observed outflow

After calibrating the Gamu HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 38 shows the comparison between the two discharge data.

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was identified at 23.

The Pearson correlation coefficient (r2) assesses the strength of the linear relationship between the observations and the model. This value being close to 1 corresponds to an almost perfect match of the observed discharge and the resulting discharge from the HEC HMS model. Here, it measured 0.84.

The Nash-Sutcliffe (E) method was also used to assess the predictive power of the model. Here the optimal value is 1. The model attained an efficiency coefficient of 0.71.

A positive Percent Bias (PBIAS) indicates a model's propensity towards under-prediction. Negative values indicate bias towards over-prediction. Again, the optimal value is 0. In the model, the PBIAS is -0.81.

The Observation Standard Deviation Ratio, RSR, is an error index. A perfect model attains a value of 0 when the error in the units of the valuable a quantified. The model has an RSR value of 0.54.

4.1.2 Arkon Bridge, Isabela HMS Calibration Results

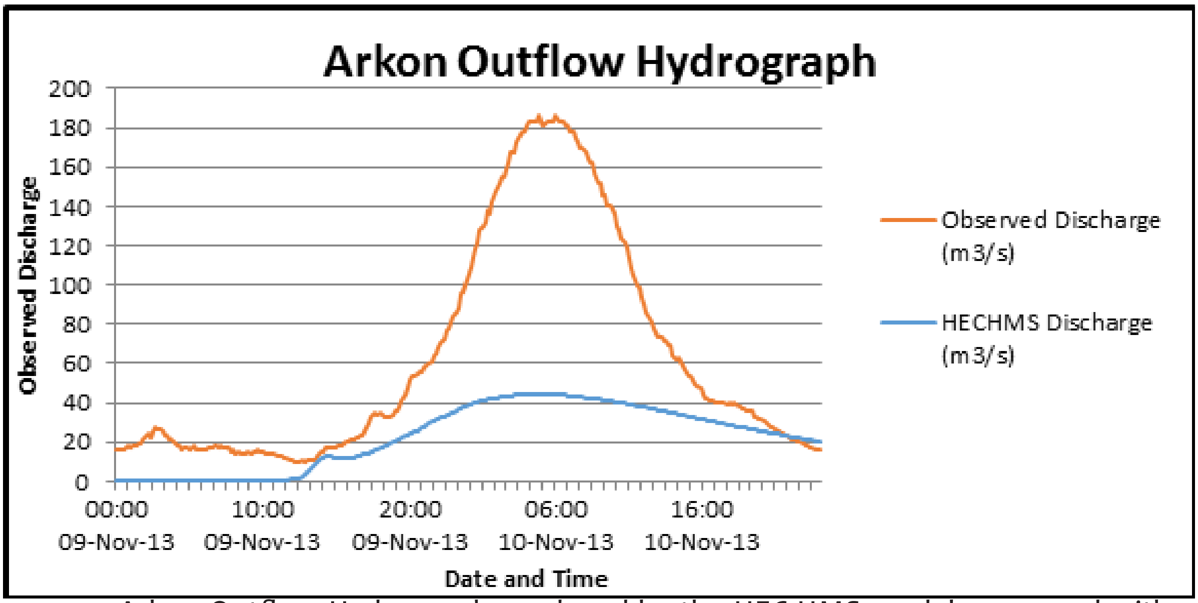


Figure 39. Arkon Outflow Hydrograph produced by the HEC-HMS model compared with observed outflow

After calibrating the Arkon HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 39 shows the comparison between the two discharge data.

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was identified at 59.79.

The Pearson correlation coefficient (r2) assesses the strength of the linear relationship between the observations and the model. This value being close to 1 corresponds to an almost perfect match of the observed discharge and the resulting discharge from the HEC HMS model. Here, it measured 0.84.

The Nash-Sutcliffe (E) method was also used to assess the predictive power of the model. Here the optimal value is 1. The model attained an efficiency coefficient of 0.1.

A positive Percent Bias (PBIAS) indicates a model's propensity towards under-prediction. Negative values indicate bias towards over-prediction. Again, the optimal value is 0. In the model, the PBIAS is 178.75.

The Observation Standard Deviation Ratio, RSR, is an error index. A perfect model attains a value of 0 when the error in the units of the valuable a quantified. The model has an RSR value of 1.05.

4.1.3 Buntun Bridge, Cagayan HMS Calibration Results

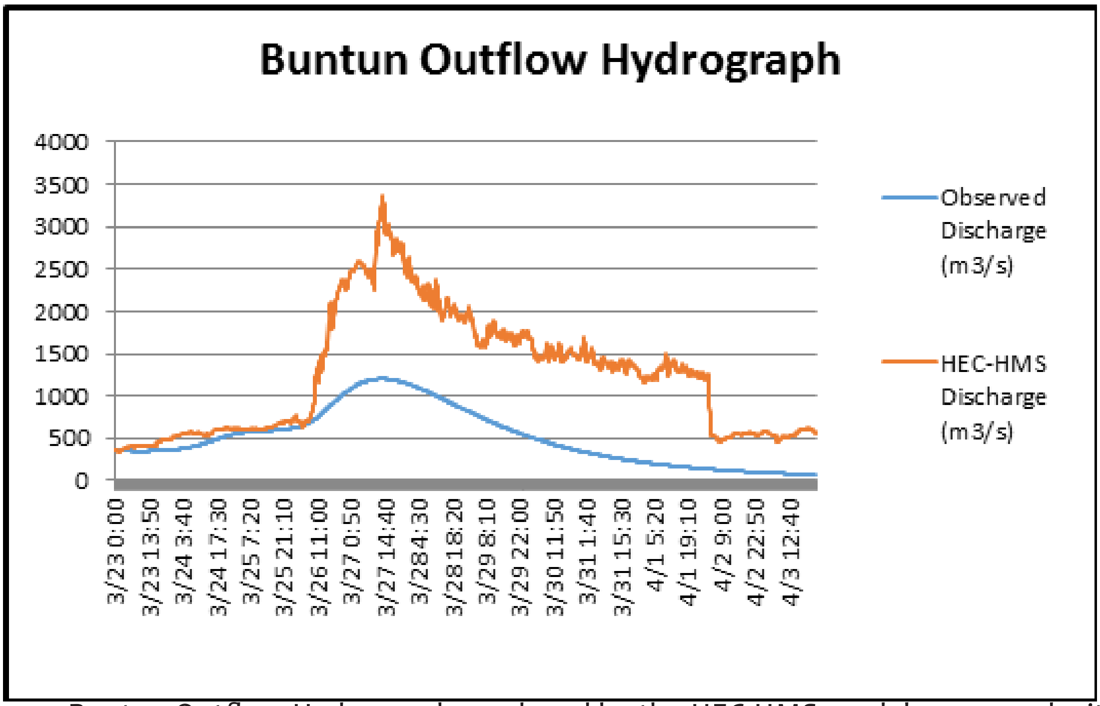


Figure 40. Buntun Outflow Hydrograph produced by the HEC-HMS model compared with observed outflow

After calibrating the Buntun HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 40 shows the comparison between the two discharge data.

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was identified at 943.42.

The Pearson correlation coefficient (r2) assesses the strength of the linear relationship between the observations and the model. This value being close to 1 corresponds to an almost perfect match of the observed discharge and the resulting discharge from the HEC HMS model. Here, it measured 0.7638.

The Nash-Sutcliffe (E) method was also used to assess the predictive power of the model. Here the optimal value is 1. The model attained an efficiency coefficient of -6.1057.

A positive Percent Bias (PBIAS) indicates a model's propensity towards under-prediction. Negative values indicate bias towards over-prediction. Again, the optimal value is 0. In the model, the PBIAS is -48.64.

The Observation Standard Deviation Ratio, RSR, is an error index. A perfect model attains a value of 0 when the error in the units of the valuable a quantified. The model has an RSR value of 3.1083.

4.1.4 Sangbay Bridge, Quirino HMS Calibration Results

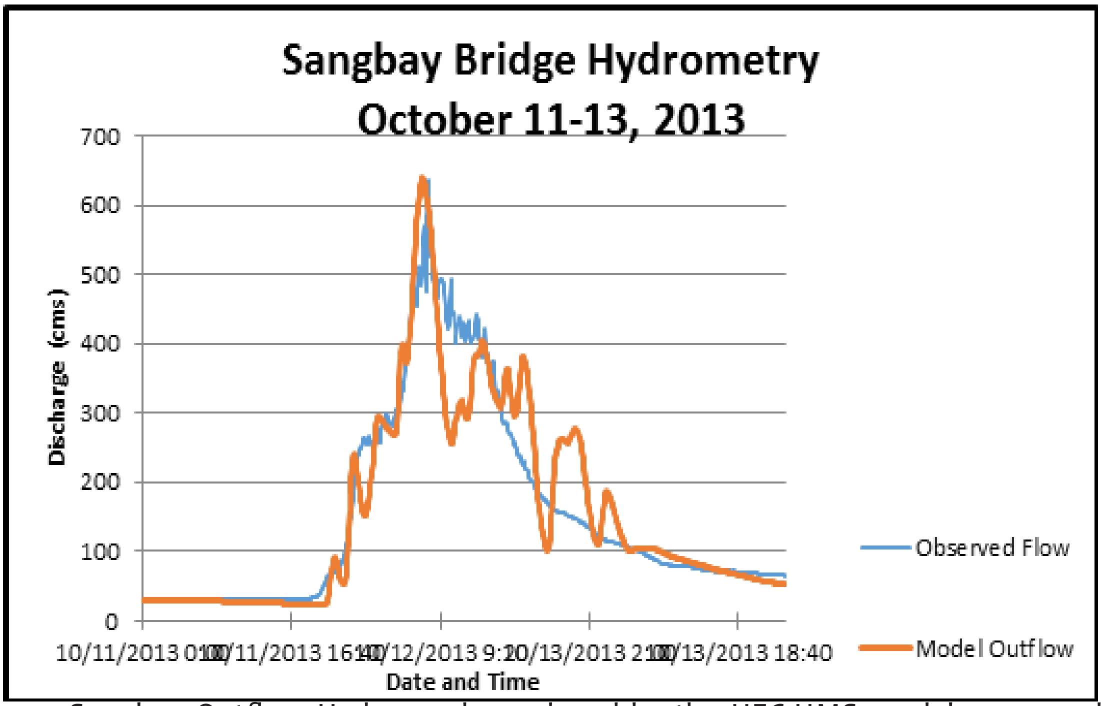


Figure 41. Sangbay Outflow Hydrograph produced by the HEC-HMS model compared with observed outflow

After calibrating the Sangbay HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 41 shows the comparison between the two discharge data.

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was identified at 52.5.

The Pearson correlation coefficient (r2) assesses the strength of the linear relationship between the observations and the model. This value being close to 1 corresponds to an almost perfect match of the observed discharge and the resulting discharge from the HEC HMS model. Here, it measured 0.93.

The Nash-Sutcliffe (E) method was also used to assess the predictive power of the model. Here the optimal value is 1. The model attained an efficiency coefficient of 0.86.

A positive Percent Bias (PBIAS) indicates a model's propensity towards under-prediction. Negative values indicate bias towards over-prediction. Again, the optimal value is 0. In the model, the PBIAS is -1.47.

The Observation Standard Deviation Ratio, RSR, is an error index. A perfect model attains a value of 0 when the error in the units of the valuable a quantified. The model has an RSR value of 0.37.

4.1.5 Santiago City Bridge, Isabela HMS Calibration Results

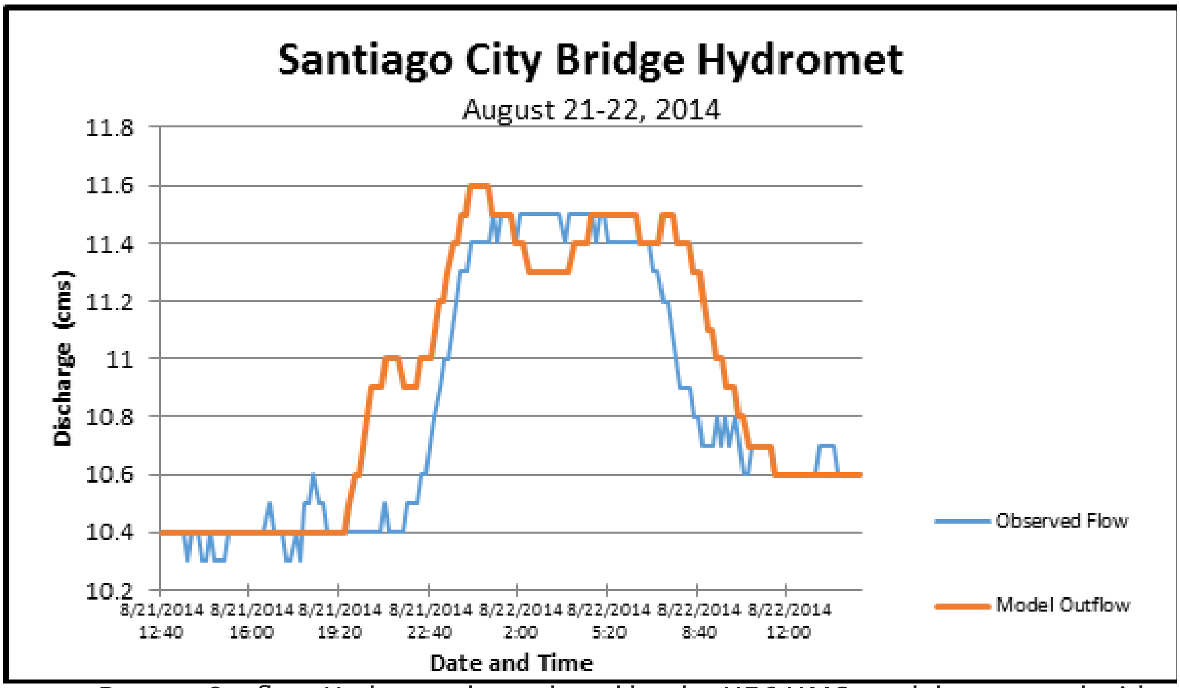


Figure 42. Buntun Outflow Hydrograph produced by the HEC-HMS model compared with observed outflow

After calibrating the Santiago HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 42 shows the comparison between the two discharge data.

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was identified at 0.2.

The Pearson correlation coefficient (r2) assesses the strength of the linear relationship between the observations and the model. This value being close to 1 corresponds to an almost perfect match of the observed discharge and the resulting discharge from the HEC HMS model. Here, it measured 0.90.

The Nash-Sutcliffe (E) method was also used to assess the predictive power of the model. Here the optimal value is 1. The model attained an efficiency coefficient of 0.74.

A positive Percent Bias (PBIAS) indicates a model's propensity towards under-prediction. Negative values indicate bias towards over-prediction. Again, the optimal value is 0. In the model, the PBIAS is -0.92.

The Observation Standard Deviation Ratio, RSR, is an error index. A perfect model attains a value of 0 when the error in the units of the valuable a quantified. The model has an RSR value of 0.51.

4.1.6 Siffu Bridge, Isabela HMS Calibration Results

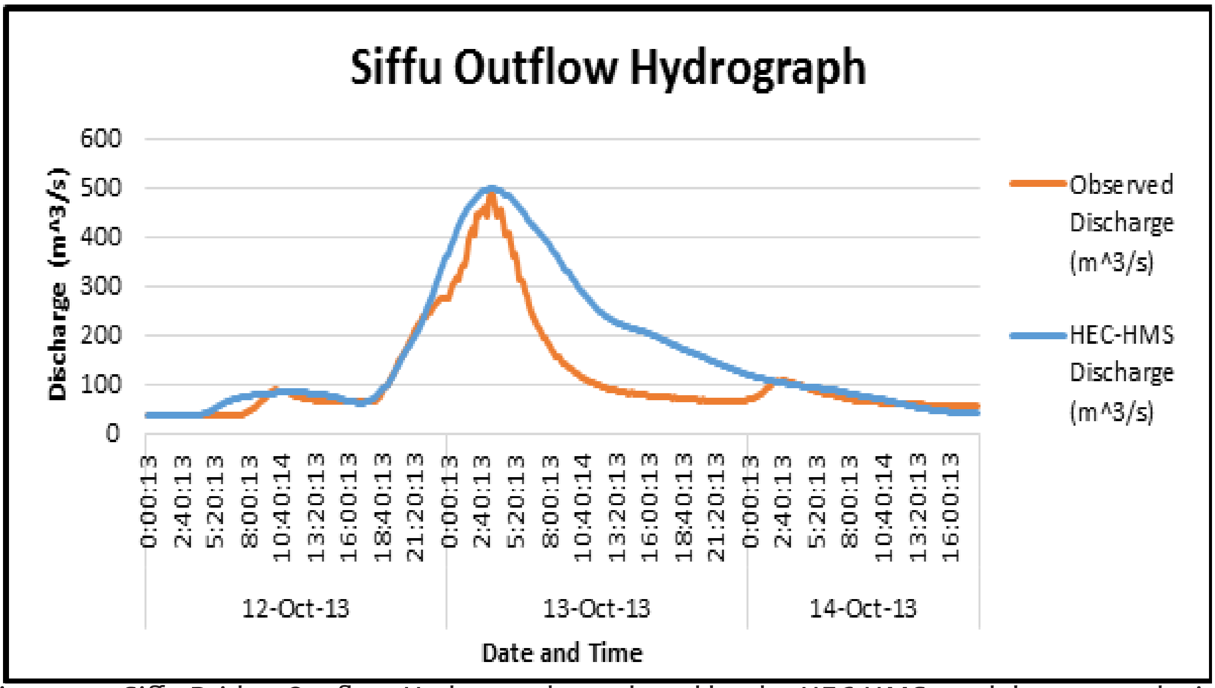


Figure 43. Siffu Bridge Outflow Hydrograph produced by the HEC-HMS model compared with observed outflow

After calibrating the Siffu HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 43 shows the comparison between the two discharge data.

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was identified at 77.6.

The Pearson correlation coefficient (r2) assesses the strength of the linear relationship between the observations and the model. This value being close to 1 corresponds to an almost perfect match of the observed discharge and the resulting discharge from the HEC HMS model. Here, it measured 0.43.

The Nash-Sutcliffe (E) method was also used to assess the predictive power of the model. Here the optimal value is 1. The model attained an efficiency coefficient of 0.74.

A positive Percent Bias (PBIAS) indicates a model's propensity towards under-prediction. Negative values indicate bias towards over-prediction. Again, the optimal value is 0. In the model, the PBIAS is -28.71.

The Observation Standard Deviation Ratio, RSR, is an error index. A perfect model attains a value of 0 when the error in the units of the valuable a quantified. The model has an RSR value of 0.75.

The calibrated models of the other discharge points are used in flood forecasting. DREAM Program offers the LGUs and other disaster mitigation agencies a water level forecast tool, which can be found on the DREAM website.

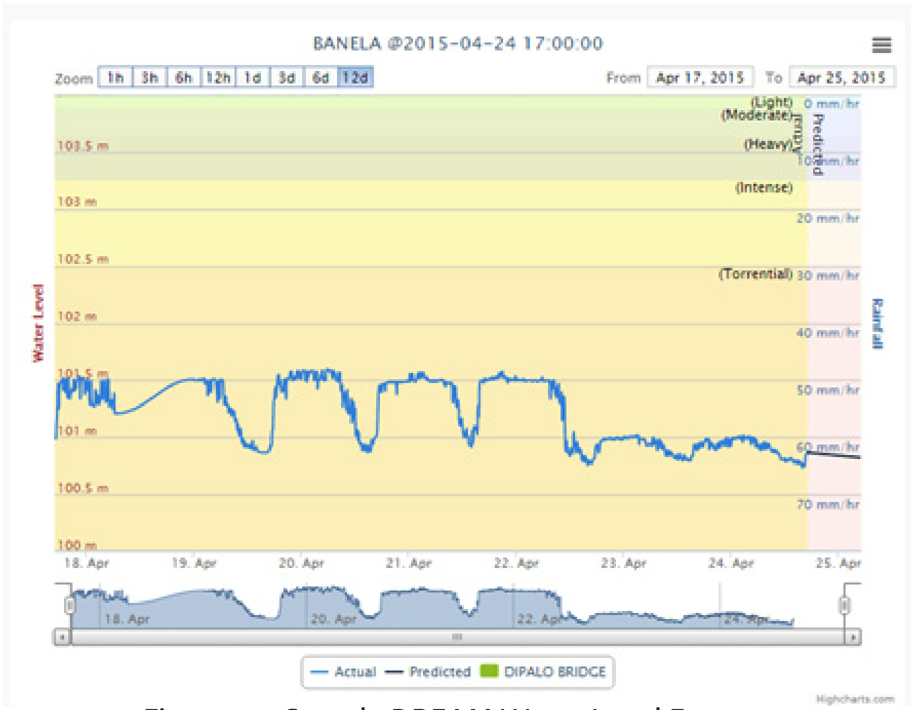


Figure 44. Sample DREAM Water Level Forecast

Given the predicted and real-time actual water level on specific AWLS, possible river flooding can be monitored and information can be disseminated to LGUs. This will help in the early evacuation of the probable affected communities. The calibrated models can also be used for flood inundation mapping.

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

4.2.1 Hydrograph using the Rainfall-Runoff Model

4.2.1.1 Gamu Bridge, Isabela

The outflow of Gamu Bridge using the Tuguegarao station Rainfall Intensity-Duration-Frequency curves (RIDF) in 5 different return periods (5-year, 10-year, 25-year, 50-year, and 100-year rainfall time series) based on PAGASA data are shown in Figures 45-49. The simulation results reveal significant increase in outflow magnitude as the rainfall intensity increases for a range of durations and return periods.

In the 5-year return period graph shown in Figure 45, the peak outflow is 7,686 cms. This occurs after 11 hours and 50 minutes after the peak precipitation of 28.5 mm.

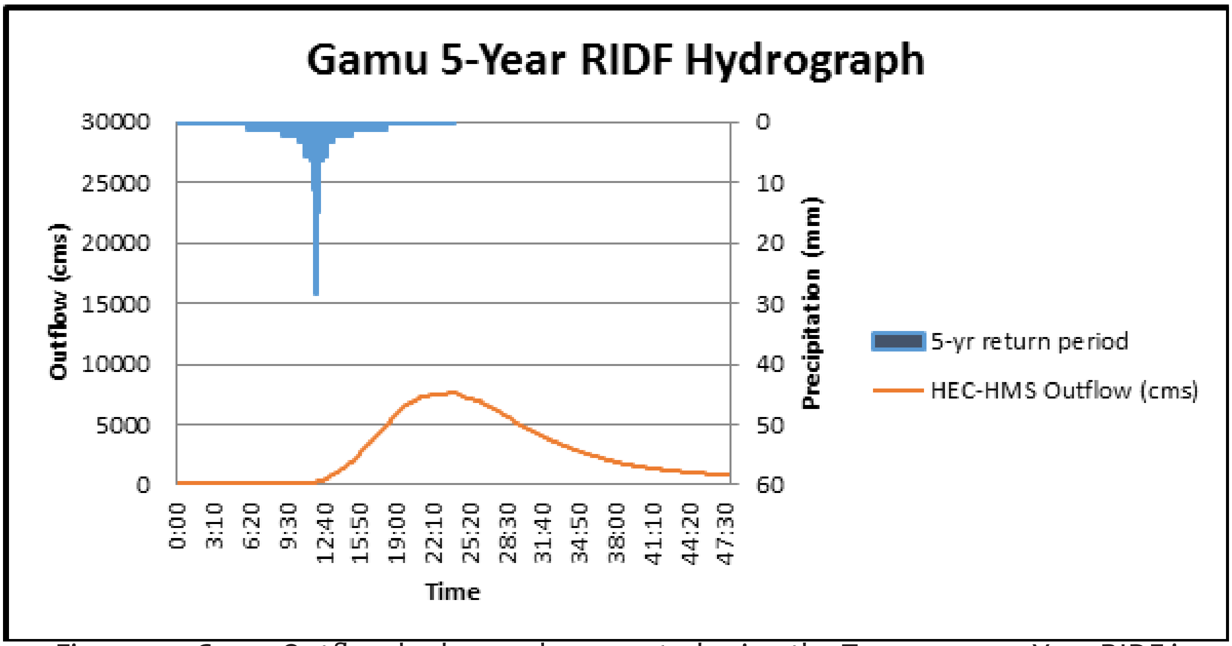


Figure 45. Gamu Outflow hydrograph generated using the Tuguegarao 5-Year RIDF in HEC-HMS

In the 10-year return period graph shown in Figure 46, the peak outflow is 11,021 cms. This occurs after 11 hours and 50 minutes after the peak precipitation of 34.3 mm.

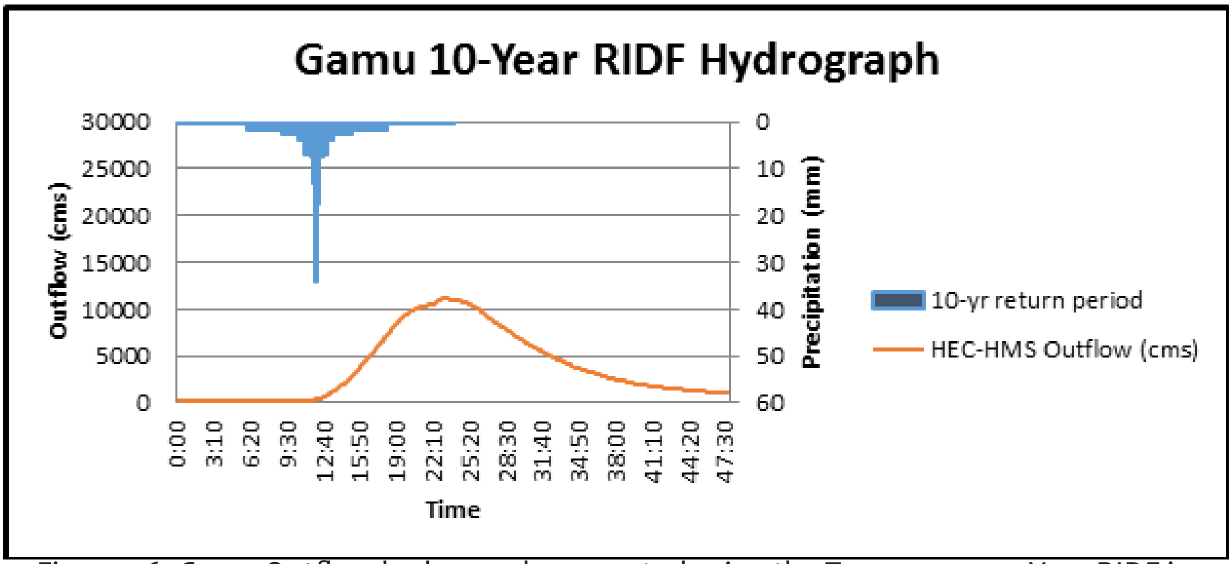


Figure 46. Gamu Outflow hydrograph generated using the Tuguegarao 10-Year RIDF in HEC-HMS

In the 25-year return period graph shown in Figure 47, the peak outflow is 16162 cms. This occurs after 11 hours and 50 minutes after the peak precipitation of 41.7 mm.

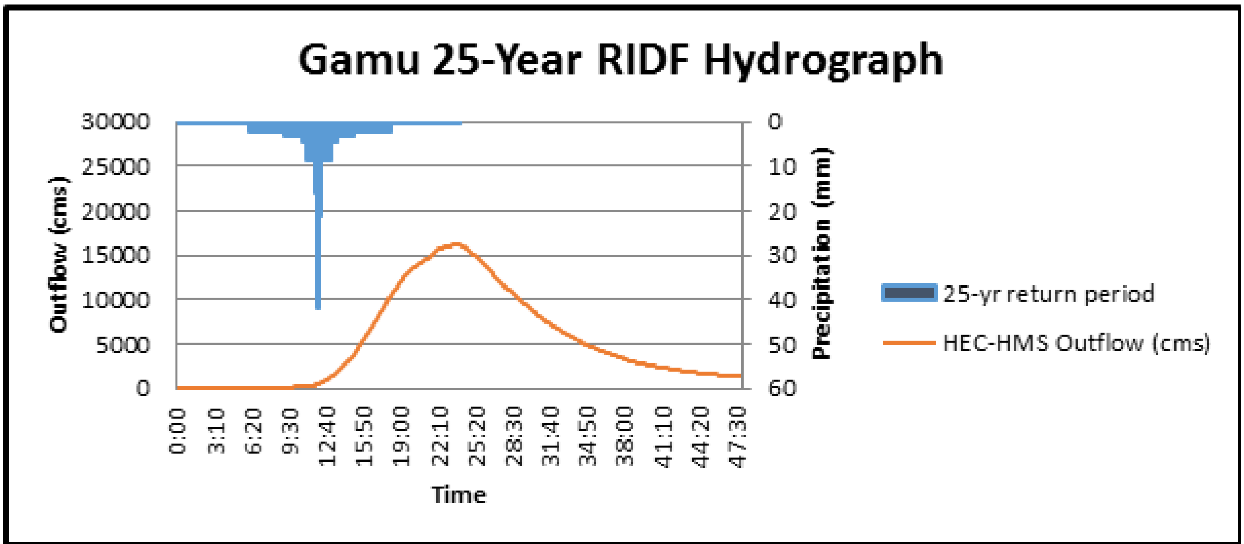


Figure 47. Gamu Outflow hydrograph generated using the Tuguegarao 25-Year RIDF in HEC-HMS

In the 50-year return period graph shown in Figure 48, the peak outflow is 20,222 cms. This occurs after 11 hours and 50 minutes after the peak precipitation of 47.1 mm.

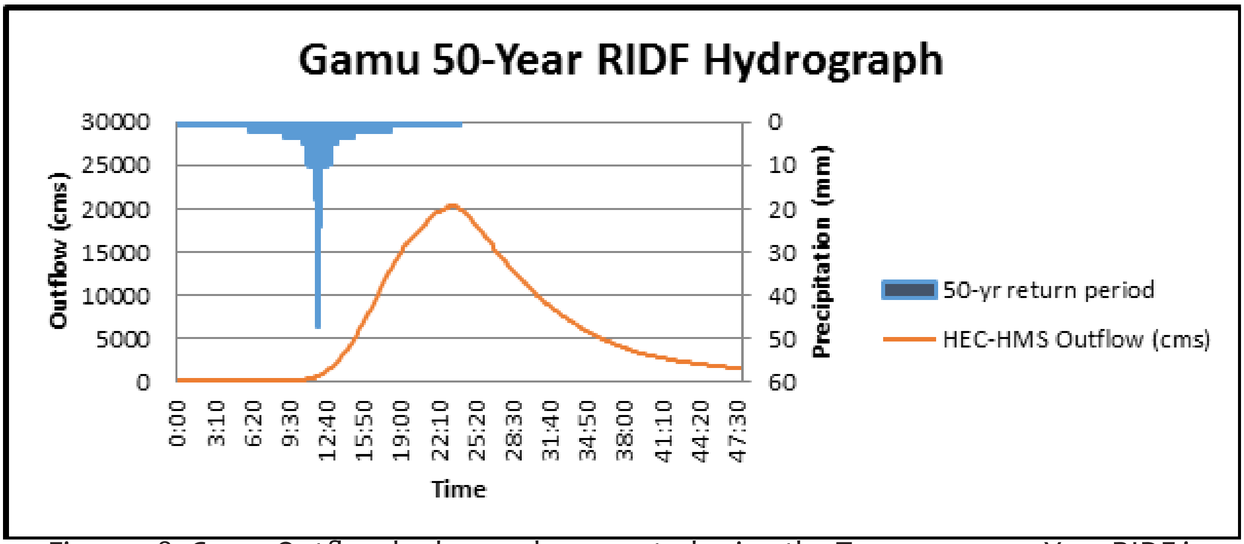


Figure 48. Gamu Outflow hydrograph generated using the Tuguegarao 50-Year RIDF in HEC-HMS

In the 100-year return period graph showin in Figure 49, the peak outflow is 24,147 cms. This occurs after 11 hours and 50 minutes after the peak precipitation of 52.6 mm.

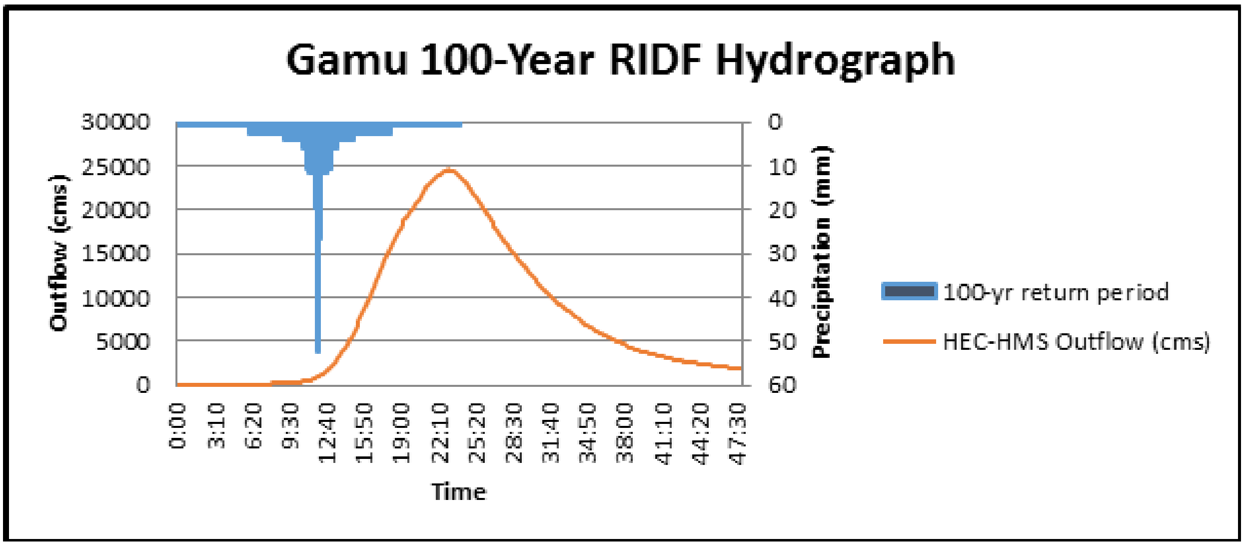


Figure 49. Gamu Outflow hydrograph generated using the Tuguegarao 100-Year RIDF in HEC-HMS

A summary of the total precipitation, peak rainfall, peak outflow and time to peak of Gamu discharge using Tuguegarao Rainfall Intensity Duration Frequency curves in five different return periods is shown in Table 2.

Table 2. Summary of Gamu outflow using Tuguegarao Station Rainfall Intensity Duration Frequency (RIDF)

RIDF Period	Total Precipitation (mm)	Peak rainfall (mm)	Peak outflow (cms)	Time to Peak
5-Year	248	28.5	7,686	11 hours, 50 minutes
10-Year	301	34.3	11,021	11 hours, 50 minutes
25-Year	367	41.7	16,162	11 hours, 50 minutes
50-Year	417	47.1	20,222	11 hours, 50 minutes
100-Year	466	52.6	24,148	11 hours, 50 minutes

4.2.1.2 Arkon Bridge, Isabela

The outflow of Arkon Bridge using the Tuguegarao station Rainfall Intensity-Duration-Frequency curves (RIDF) in 5 different return periods (5-year, 10-year, 25-year, 50-year, and 100-year rainfall time series) based on PAGASA data are shown in Figures 50-54. The simulation results reveal significant increase in outflow magnitude as the rainfall intensity increases for a range of durations and return periods.

In the 5-year return period graph shown in Figure 50, the peak outflow is 477.4 cms. This occurs after 10 hours and 10 minutes after the peak precipitation of 28.5 mm.

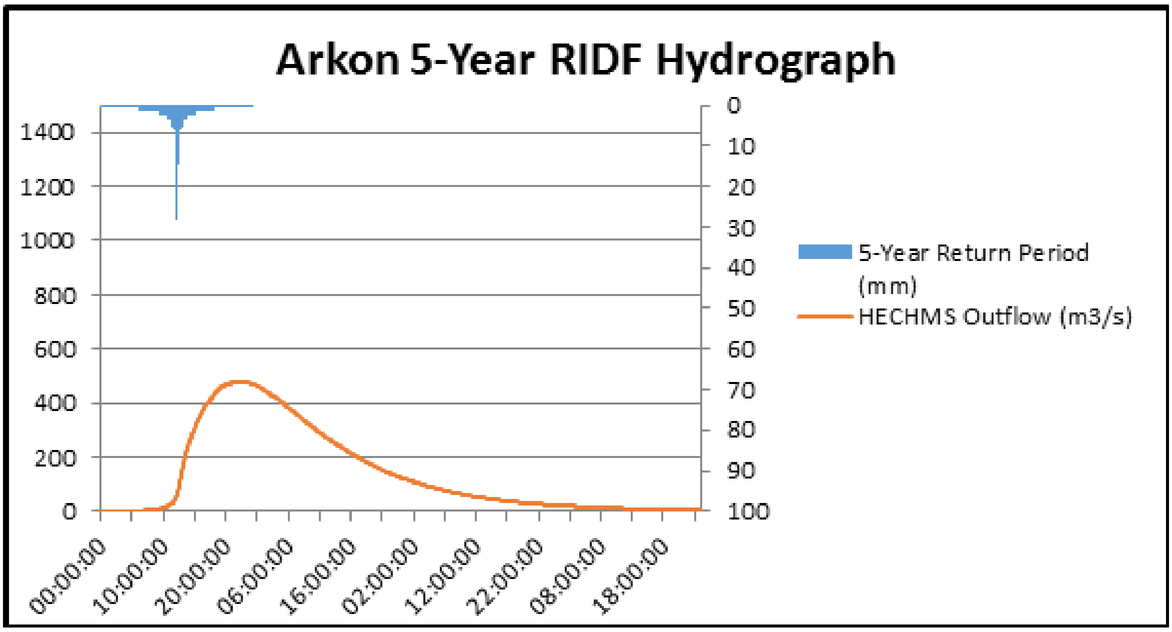


Figure 50. Arkon Outflow hydrograph generated using the Tuguegarao 5-Year RIDF in HEC-HMS

In the 10-year return period graph shown in Figure 51, the peak outflow is 534 cms. This occurs after 11 hours after the peak precipitation of 34.3 mm.

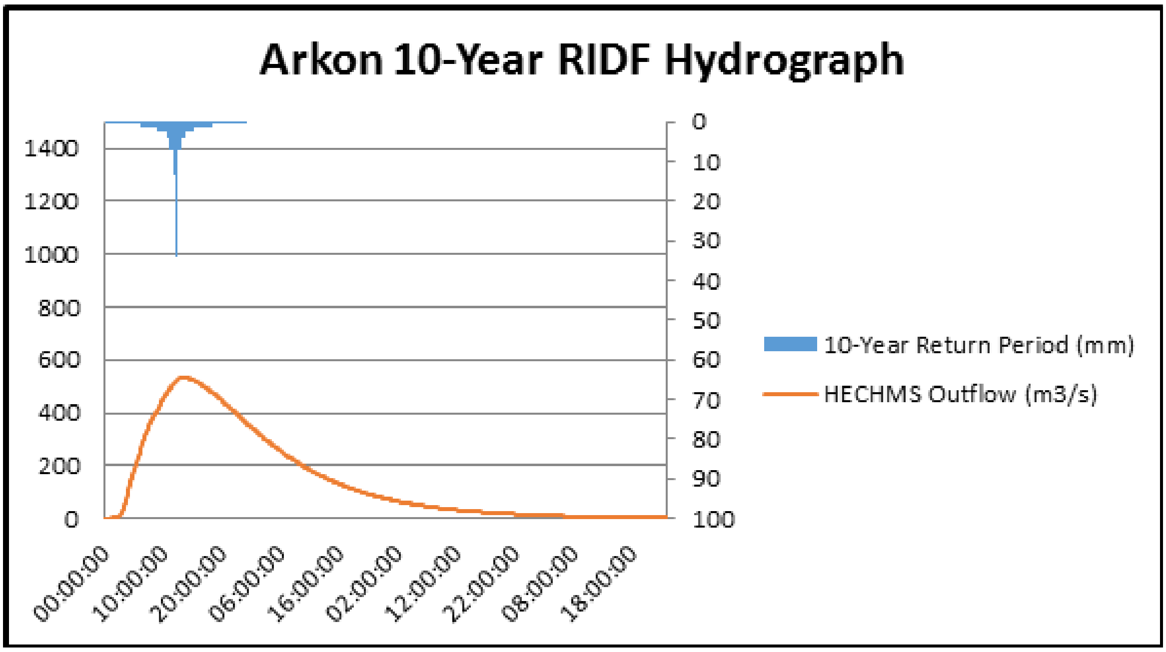


Figure 51. Arkon Outflow hydrograph generated using the Tuguegarao 10-Year RIDF in HEC-HMS

In the 25-year return period graph shown in Figure 52, the peak outflow is 696.3 cms. This occurs after 11 hours after the peak precipitation of 41.7 mm.

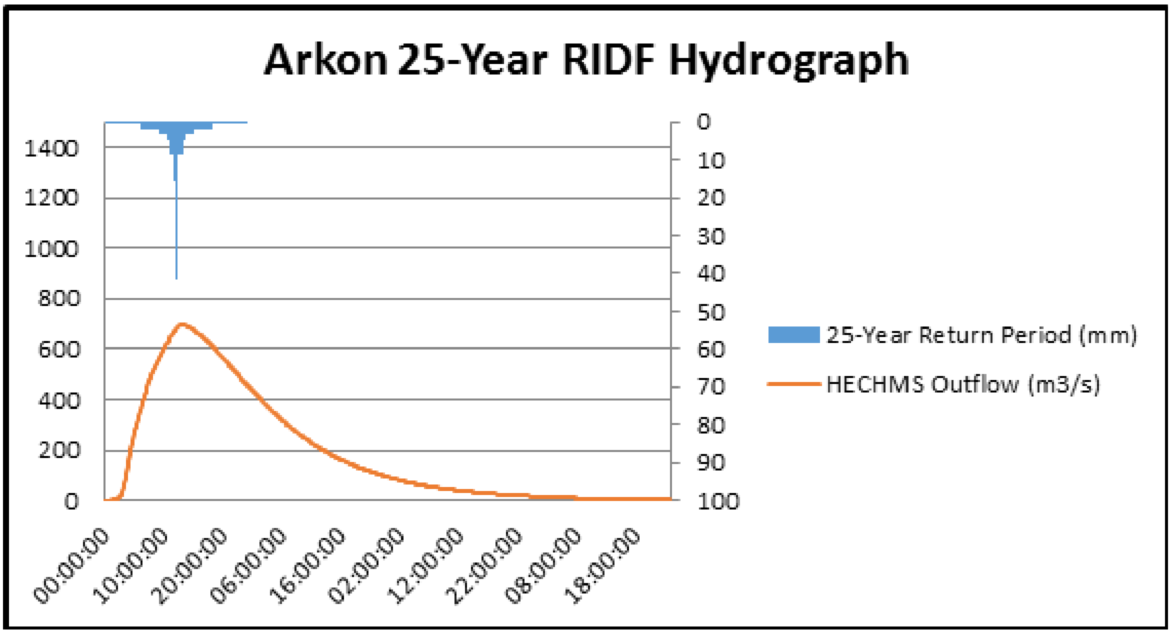


Figure 52. Arkon Outflow hydrograph generated using the Tuguegarao 25-Year RIDF in HEC-HMS

In the 50-year return period graph shown in Figure 53, the peak outflow is 819.2 cms. This occurs after 11 hours after the peak precipitation of 47.1 mm.

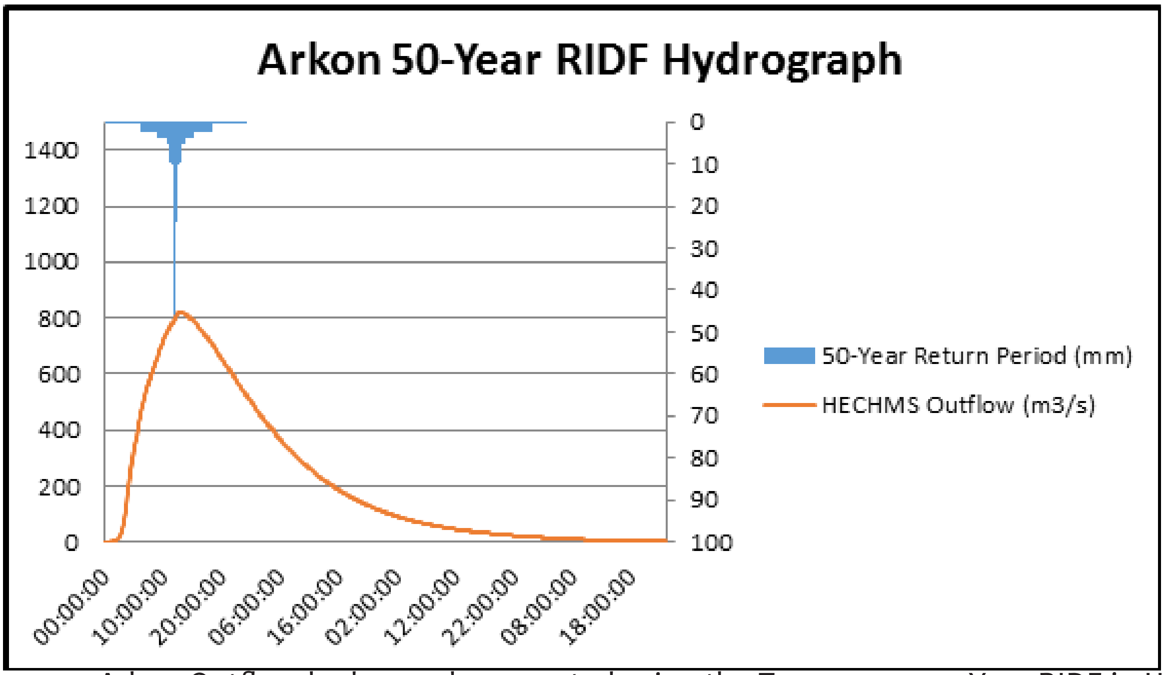


Figure 53. Arkon Outflow hydrograph generated using the Tuguegarao 50-Year RIDF in HEC-HMS

In the 100-year return period graph showin in Figure 54, the peak outflow is 941.3 cms. This occurs after 11 hours after the peak precipitation of 52.6 mm.

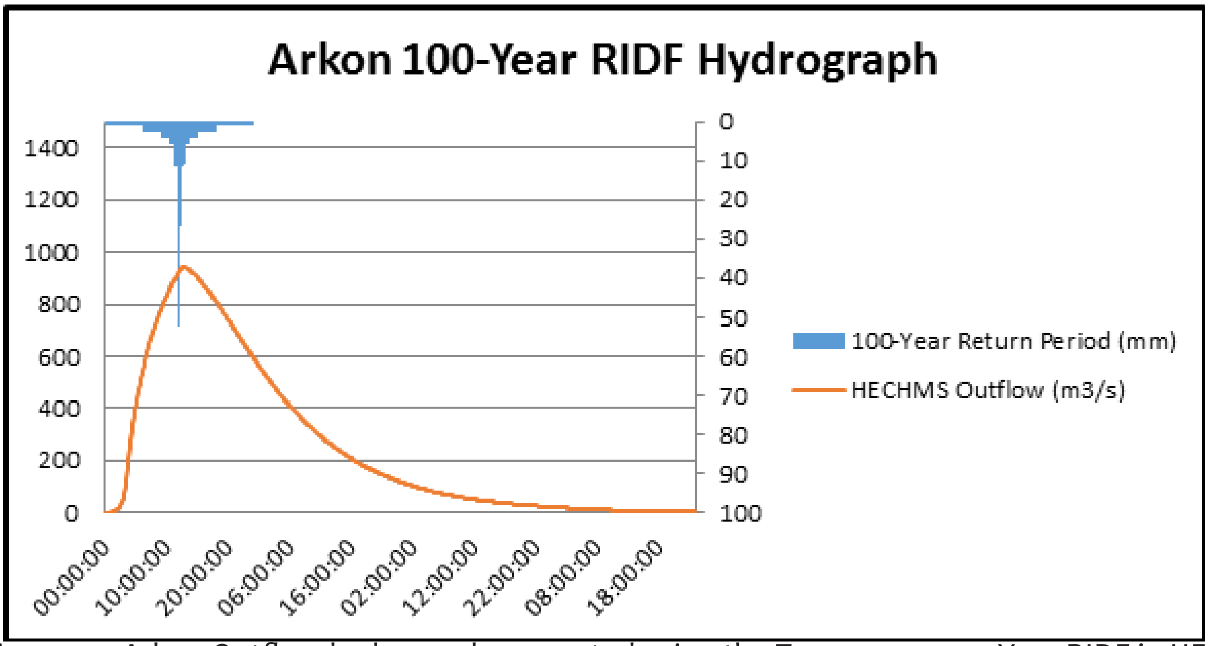


Figure 54. Arkon Outflow hydrograph generated using the Tuguegarao 100-Year RIDF in HEC-HMS

A summary of the total precipitation, peak rainfall, peak outflow and time to peak of Arkon discharge using the Tuguegarao Rainfall Intensity-Duration-Frequency curves (RIDF) curves in five different return periods is shown in Table 3.

Table 3. Summary of Arkon outflow using Tuguegarao Station Rainfall Intensity Duration Frequency (RIDF)

RIDF Period	Total Precipitation (mm)	Peak rainfall (mm)	Peak outflow (cms)	Time to Peak
5-Year	214.9	28.5	477.4	10 hours, 10 minutes
10-Year	262.7	34.3	534	11 hours
25-Year	323	41.7	636.3	11 hours
50-Year	367.8	47.1	819.2	11 hours
100-Year	412.2	52.6	941.3	11 hours

4.2.1.3 Buntun Bridge, Cagayan

The outflow of Buntun Bridge using the Tuguegarao station Rainfall Intensity-Duration-Frequency curves (RIDF) in 5 different return periods (5-year, 10-year, 25-year, 50-year, and 100-year rainfall time series) based on PAGASA data are shown in Figures 55-59. The simulation results reveal significant increase in outflow magnitude as the rainfall intensity increases for a range of durations and return periods.

In the 5-year return period graph shown in Figure 55, the peak outflow is 13087.8 cms. This occurs after 76 hours and 10 minutes after the peak precipitation of 28.5 mm.

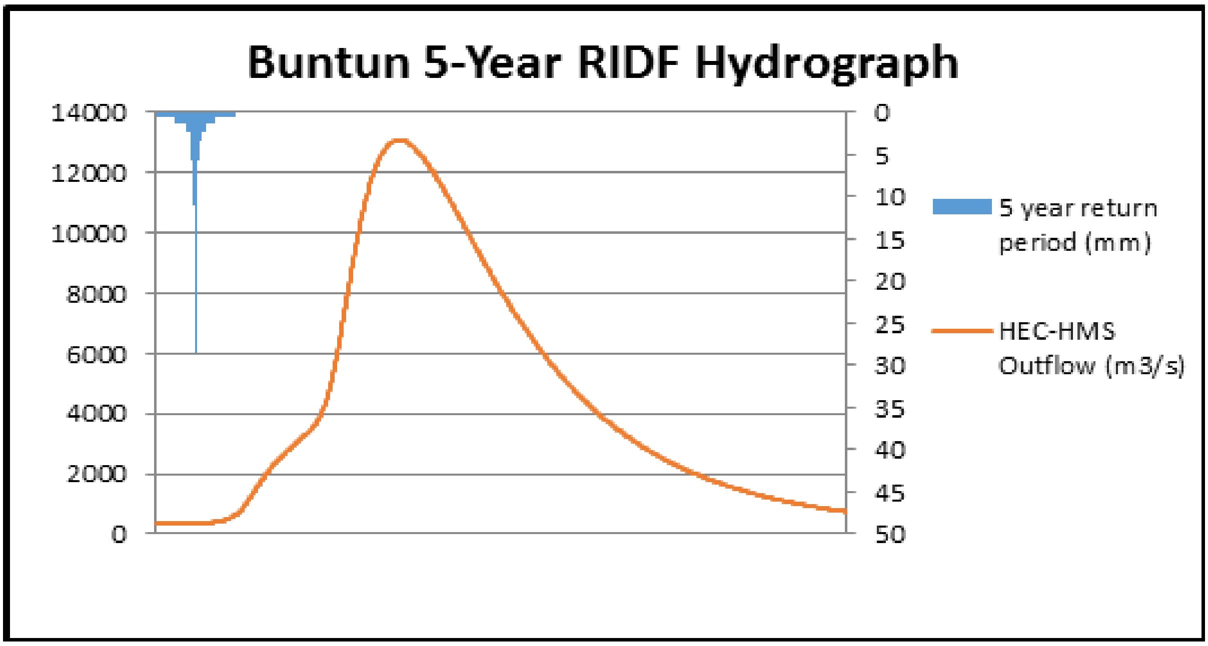


Figure 55. Buntun Outflow hydrograph generated using the Tuguegarao 5-Year RIDF in HEC-HMS

In the 10-year return period graph shown in Figure 56, the peak outflow is 16928.9 cms. This occurs after 73 hours after the peak precipitation of 34.3 mm.

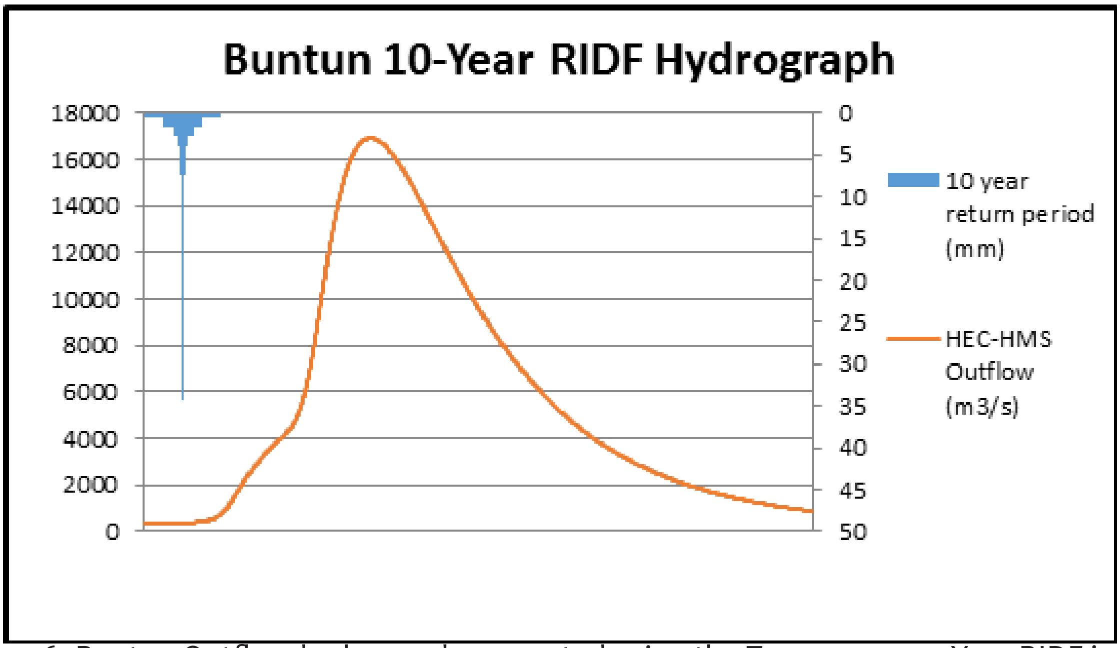


Figure 56. Buntun Outflow hydrograph generated using the Tuguegarao 10-Year RIDF in HEC-HMS

In the 25-year return period graph shown in Figure 57, the peak outflow is 21930.7 cms. This occurs after 58 hours 10 minutes after the peak precipitation of 41.7 mm.

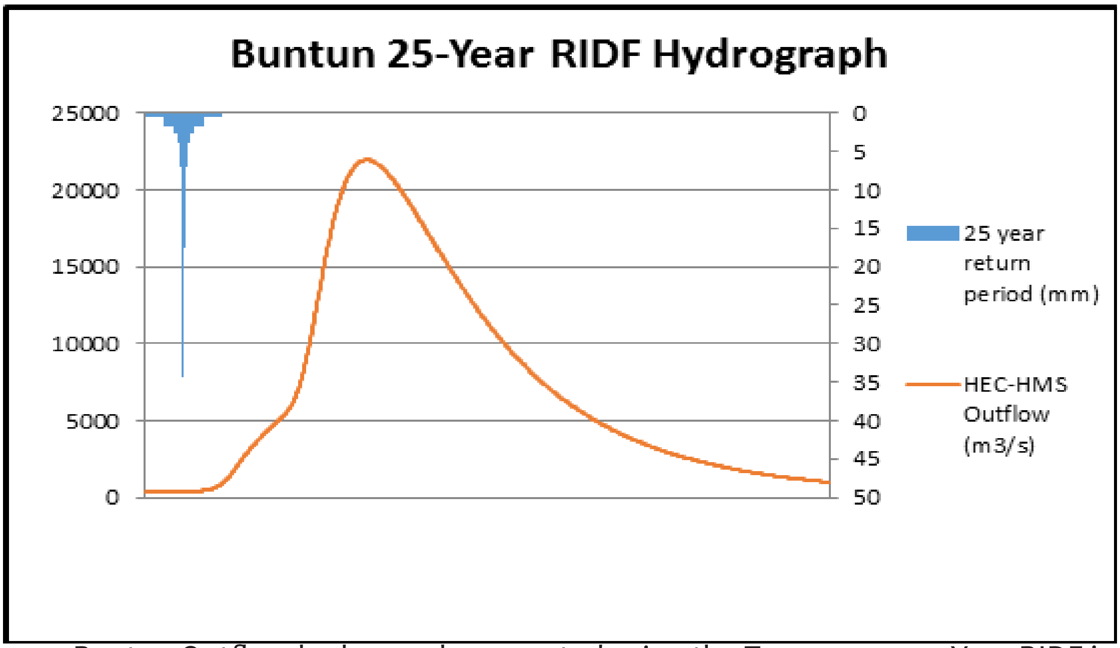


Figure 57. Buntun Outflow hydrograph generated using the Tuguegarao 25-Year RIDF in HEC-HMS

In the 50-year return period graph shown in Figure 58, the peak outflow is 25795.1 cms. This occurs after 56 hours 20 minutes after the peak precipitation of 47.1 mm.

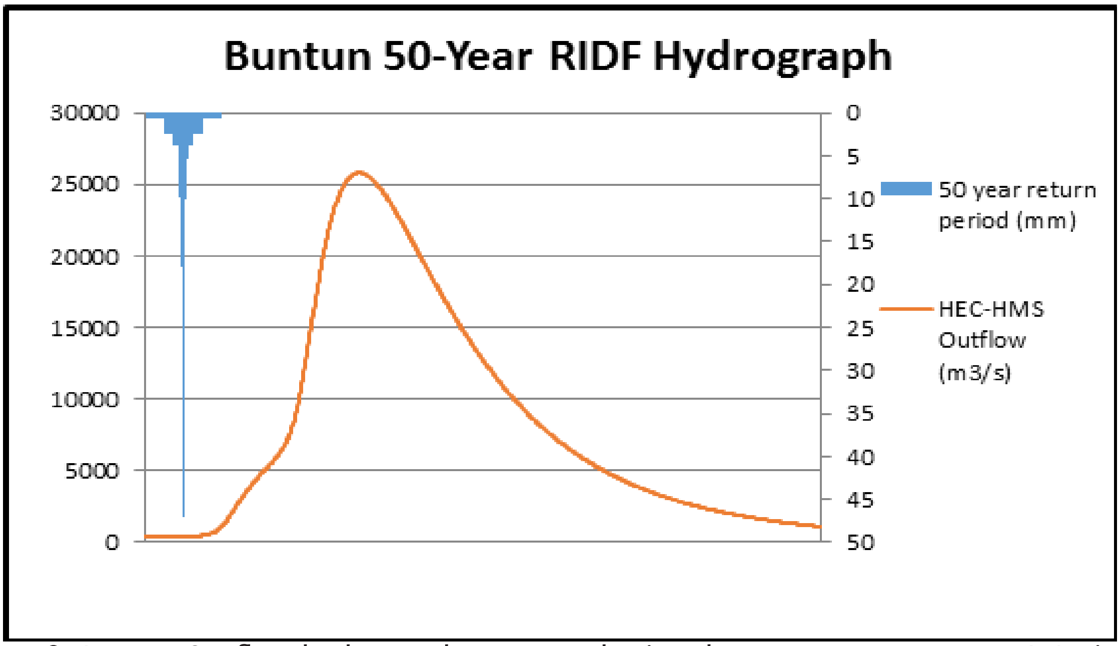


Figure 58. Buntun Outflow hydrograph generated using the Tuguegarao 50-Year RIDF in HEC-HMS

In the 100-year return period graph shown in Figure 59, the peak outflow is 29620.7 cms. This occurs after 55 hours after the peak precipitation of 52.6 mm.

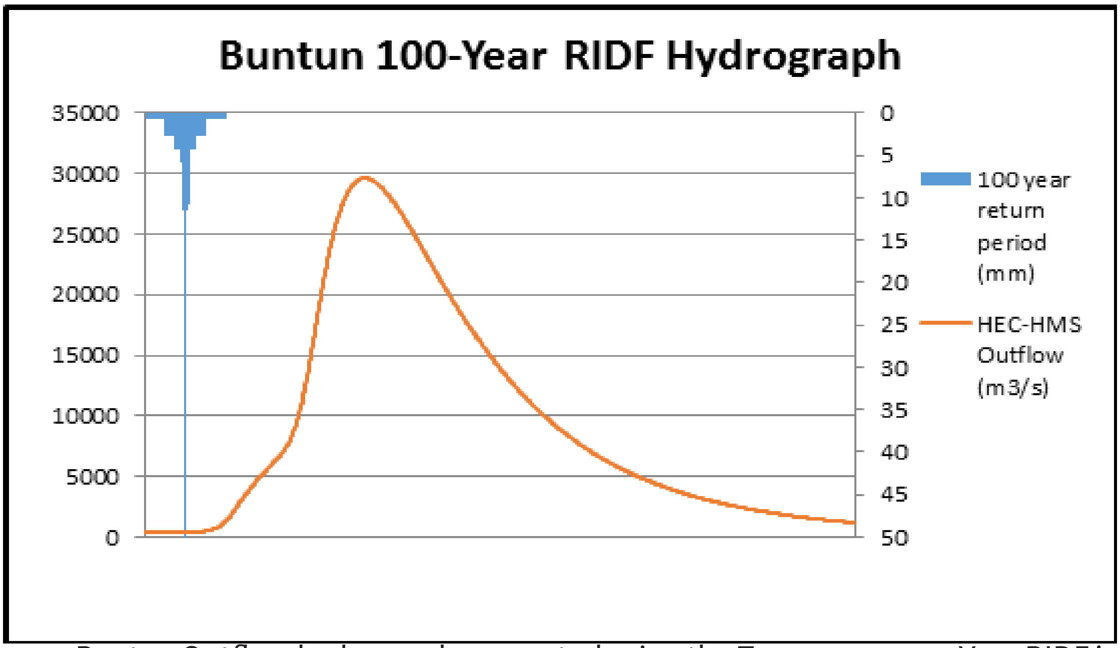


Figure 59. Buntun Outflow hydrograph generated using the Tuguegarao 100-Year RIDF in HEC-HMS

Results and Discussion

A summary of the total precipitation, peak rainfall, peak outflow and time to peak of Buntun discharge using the Tuguegarao Rainfall Intensity-Duration-Frequency curves (RIDF) in five different return periods is shown in Table 4.

Table 4. Summary of Buntun outflow using Tuguegarao Station Rainfall Intensity Duration Frequency (RIDF)

RIDF Period	Total Precipitation (mm)	Peak rainfall (mm)	Peak outflow (cms)	Time to Peak
5-Year	214.9	28.5	13,087.8	76 hours 10 minutes
10-Year	262.7	34.3	16,928.9	73 hours
25-Year	323	41.7	21,930.7	58 hours 10 minutes
50-Year	367.8	47.1	25,795.1	56 hours 20 minutes
100-Year	412.2	52.6	29,620.7	55 hours

4.2.1.4 Siffu Bridge, Isabela

The outflow of Siffu Bridge using the Tuguegarao station Rainfall Intensity-Duration-Frequency curves (RIDF) in 5 different return periods (5-year, 10-year, 25-year, 50-year, and 100-year rainfall time series) based on PAGASA data are shown in Figures 60-64. The simulation results reveal significant increase in outflow magnitude as the rainfall intensity increases for a range of durations and return periods.

In the 5-year return period graph shown in Figure 60, the peak outflow is 1,850.0 cms. This occurs after 8 hours after the peak precipitation of 25.52 mm.

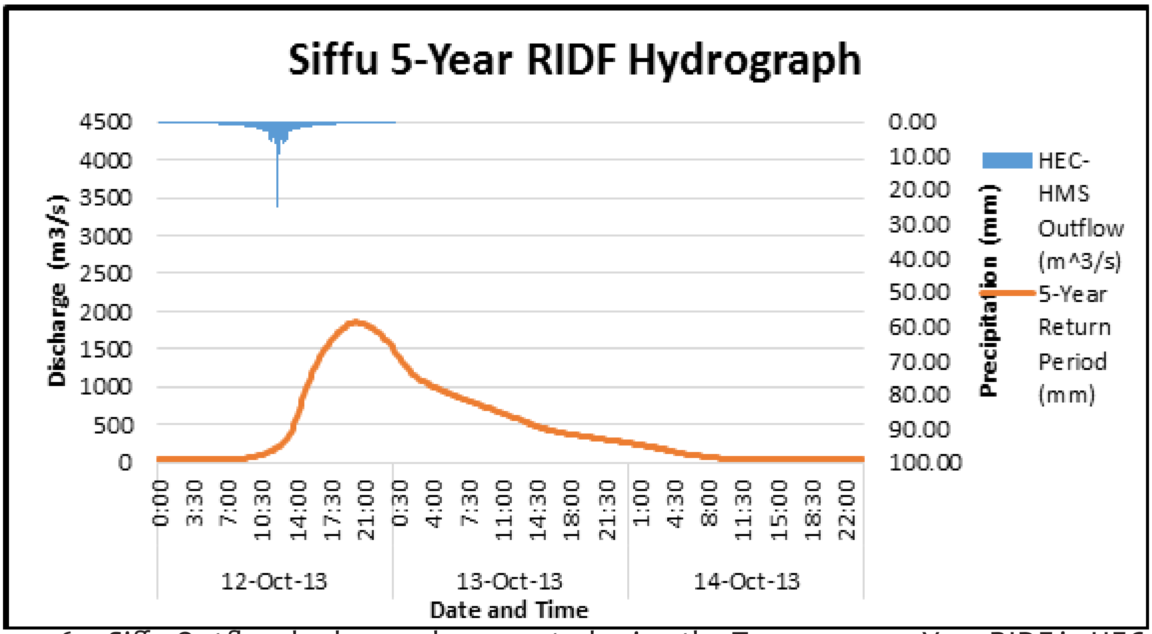


Figure 60. Siffu Outflow hydrograph generated using the Tuguegarao 5-Year RIDF in HEC-HMS

In the 10-year return period graph shown in Figure 61, the peak outflow is 2,439.9 cms. This occurs after 7 hours and 50 minutes after the peak precipitation of 280.04 mm.

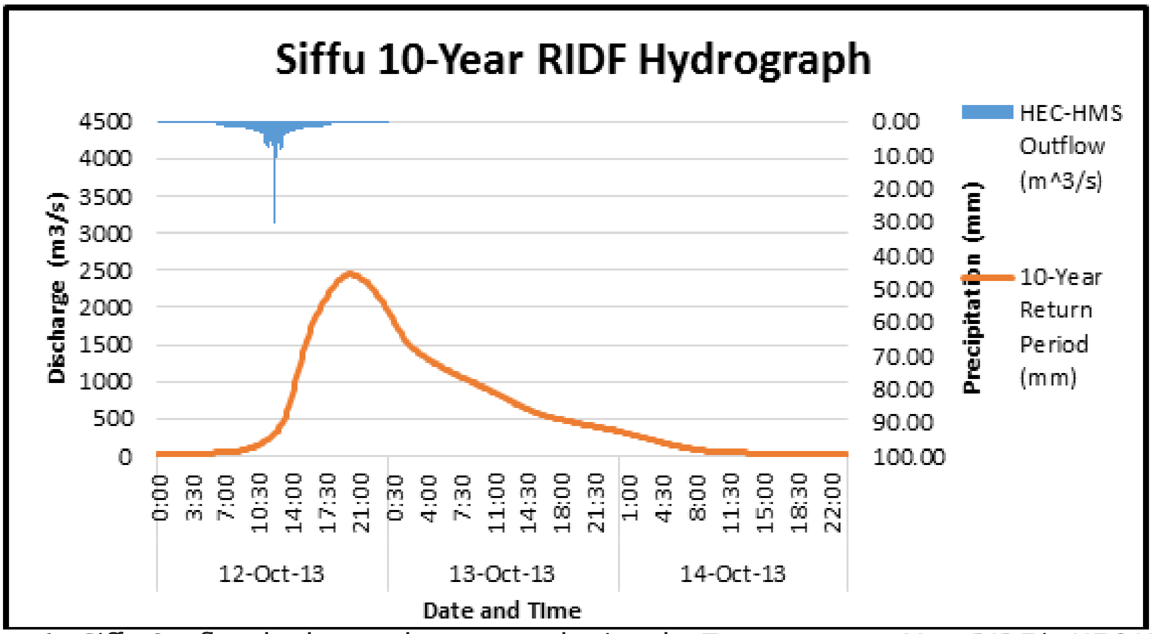


Figure 61. Siffu Outflow hydrograph generated using the Tuguegarao 10-Year RIDF in HEC-HMS

In the 25-year return period graph shown in Figure 62, the peak outflow is 3,140.3 cms. This occurs after 7 hours and 50 minutes after the peak precipitation of 36.73 mm.

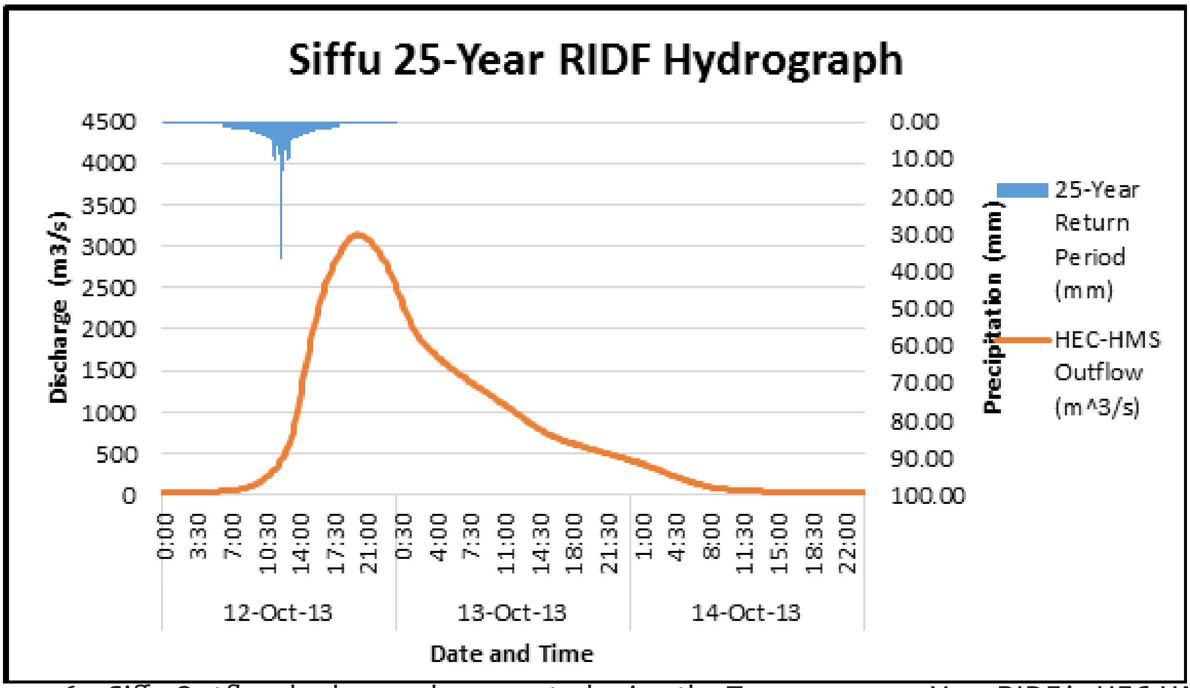


Figure 62. Siffu Outflow hydrograph generated using the Tuguegarao 25-Year RIDF in HEC-HMS

In the 50-year return period graph shown in Figure 63, the peak outflow is 3,639.4 cms. This occurs after 7 hours and 50 minutes after the peak precipitation of 40.96 mm.

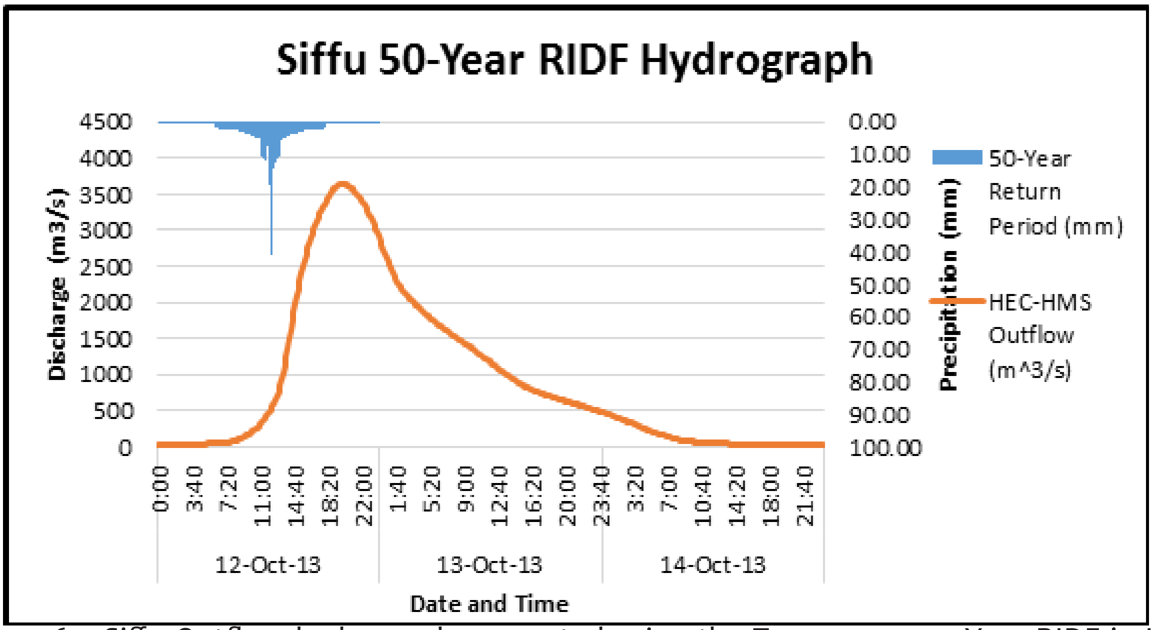


Figure 63. Siffu Outflow hydrograph generated using the Tuguegarao 50-Year RIDF in HEC-HMS

In the 100-year return period graph shown in Figure 64, the peak outflow is 4,140.3 cms. This occurs after 7 hours and 50 minutes after the peak precipitation of 45.14 mm.

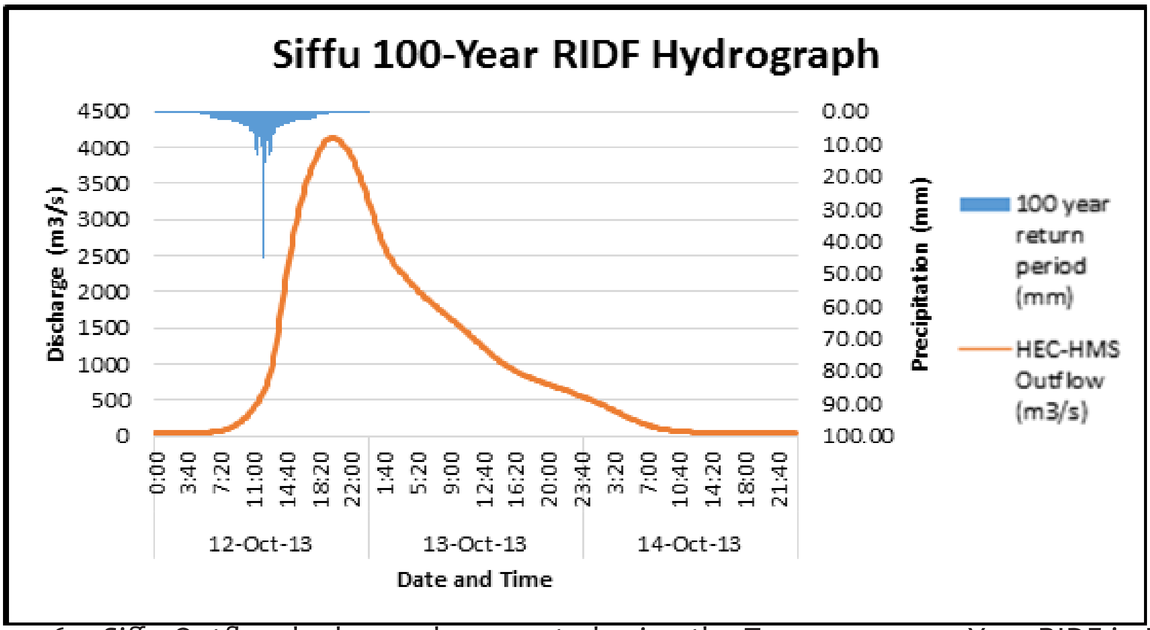


Figure 64. Siffu Outflow hydrograph generated using the Tuguegarao 100-Year RIDF in HEC-HMS

A summary of the total precipitation, peak rainfall, peak outflow and time to peak of Siffu discharge using the Tuguegarao Rainfall Intensity-Duration-Frequency curves (RIDF) in five different return periods is shown in Table 5.

Table 5. Summary of Siffu outflow using Tuguegarao Station Rainfall Intensity Duration Frequency (RIDF)

RIDF Period	Total Precipitation (mm)	Peak rainfall (mm)	Peak outflow (cms)	Time to Peak
5-Year	221.72	25.52	1,850.00	8 hours
10-Year	280.04	30.74	2,439.90	7 hours, 50 mins.
25-Year	348.87	36.73	3,140.30	7 hours, 50 mins.
50-Year	397.88	40.96	3,639.40	7 hours, 50 mins.
100-Year	446.50	45.15	4,140.30	7 hours, 50 mins.

4.2.1.5 Sangbay Bridge, Quirino

The outflow of Sangbay Bridge using the Casiguran station Rainfall Intensity-Duration-Frequency curves (RIDF) in 5 different return periods (5-year, 10-year, 25-year, 50-year, and 100-year rainfall time series) based on PAGASA data are shown in Figures 65-69. The simulation results reveal significant increase in outflow magnitude as the rainfall intensity increases for a range of durations and return periods.

In the 5-year return period graph showin in Figure 65, the peak outflow is 2998 cms. This occurs 3 hours and 20 minutes after the peak precipitation of 27 mm.

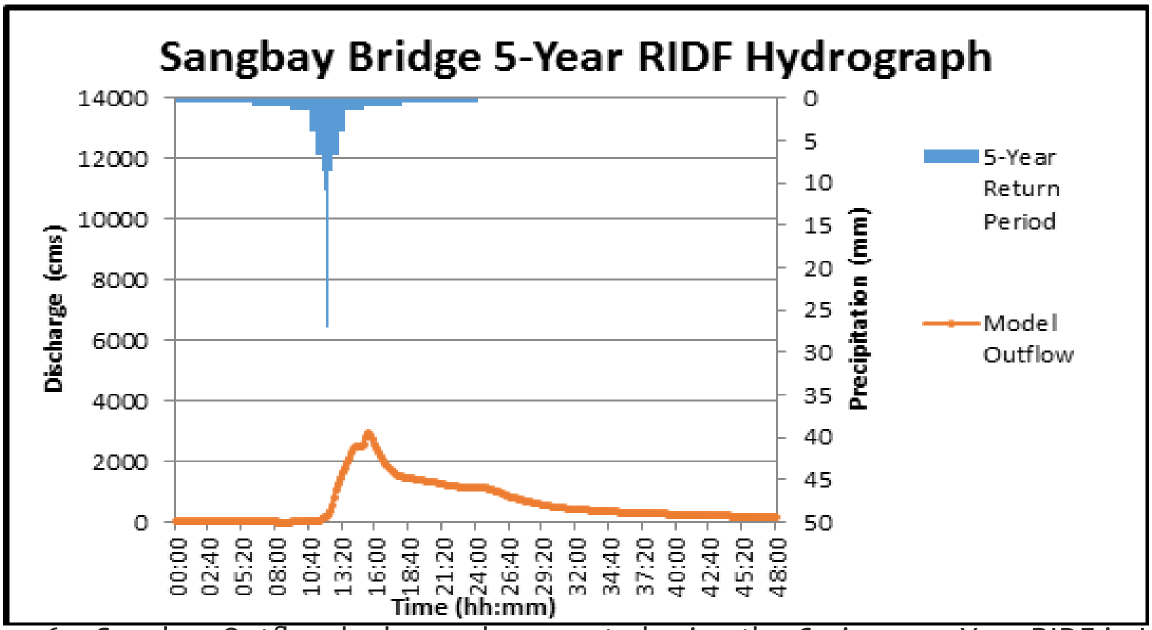


Figure 65. Sangbay Outflow hydrograph generated using the Casiguran 5-Year RIDF in HEC-HMS

In the 10-year return period graph shown in Figure 66, the peak outflow is 4828 cms. This occurs 3 hours after the peak precipitation of 30.9 mm.

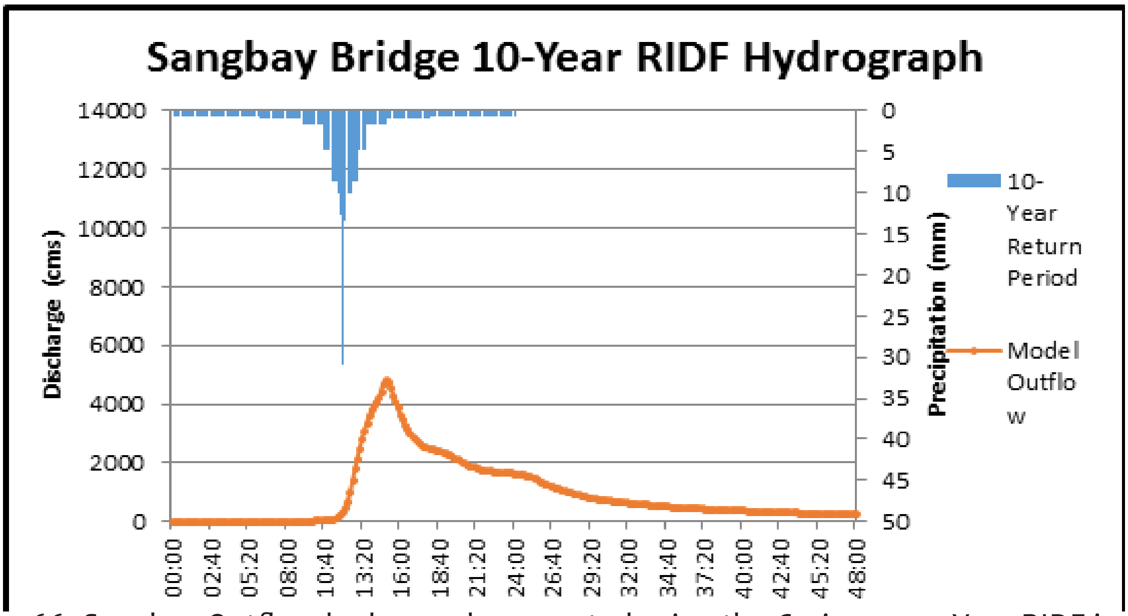


Figure 66. Sangbay Outflow hydrograph generated using the Casiguran 10-Year RIDF in HEC-HMS

In the 25-year return period graph showin in Figure 67, the peak outflow is 7446.1 cms. This occurs 2 hours and 40 minutes after the peak precipitation of 35.7 mm.

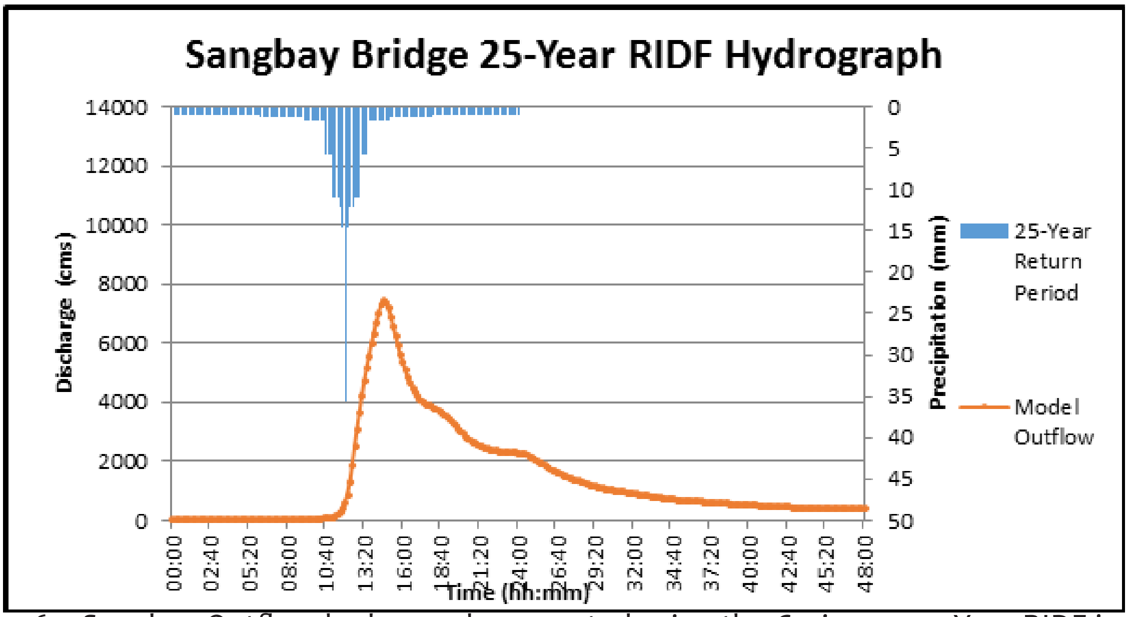


Figure 67. Sangbay Outflow hydrograph generated using the Casiguran 25-Year RIDF in HEC-HMS

In the 50-year return period graph shown in Figure 68, the peak outflow is 9565.3 cms. This occurs 2 hours and 30 minutes after the peak precipitation of 39.3 mm.

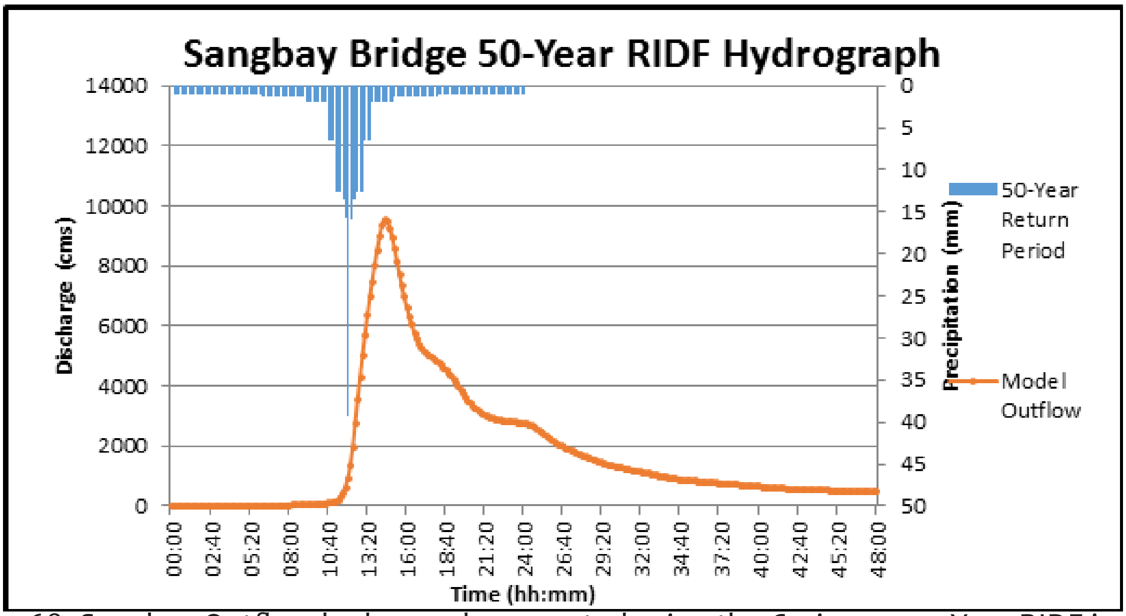


Figure 68. Sangbay Outflow hydrograph generated using the Casiguran 50-Year RIDF in HEC-HMS

In the 100-year return period graph shown in Figure 69, the peak outflow is 11741.7 cms. This occurs 2 hours and 20 minutes after the peak precipitation of 42.9 mm.

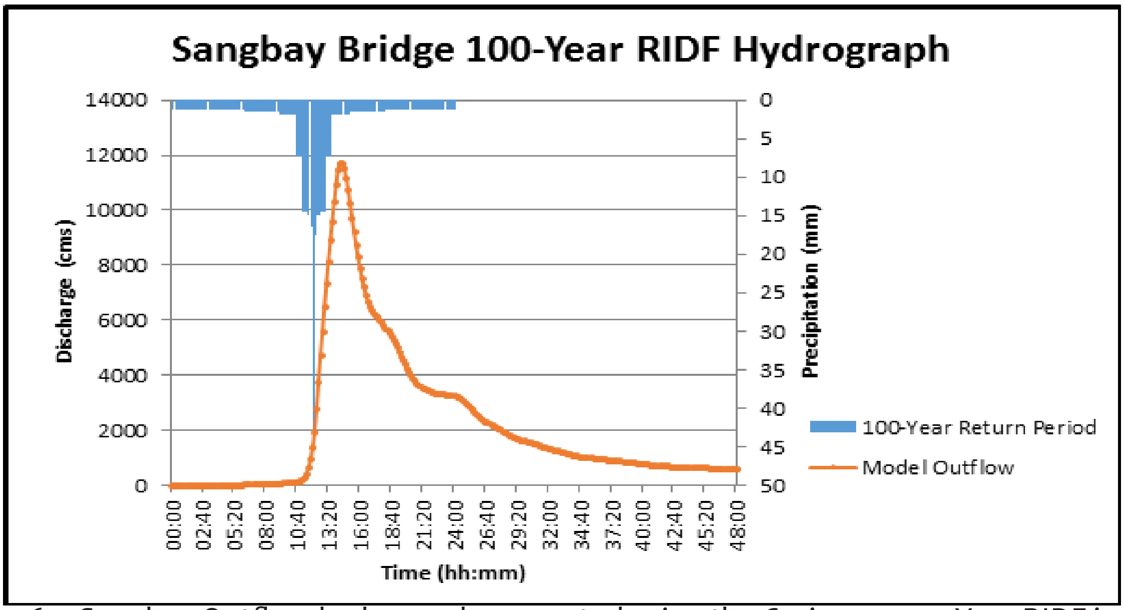


Figure 69. Sangbay Outflow hydrograph generated using the Casiguran 100-Year RIDF in HEC-HMS

Results and Discussion

A summary of the total precipitation, peak rainfall, peak outflow and time to peak of Sangbay Bridge discharge using the Casiguran Rainfall Intensity-Duration-Frequency curves (RIDF) in five different return periods is shown in Table 6.

Table 6. Summary of Sangbay outflow using Casiguran Station Rainfall Intensity Duration Frequency (RIDF)

RIDF Period	Total Precipitation (mm)	Peak rainfall (mm)	Peak outflow (cms)	Time to Peak
5-Year	245.6	27	2998	3 hours and 20 minutes
10-Year	289.8	30.9	4828	3 hours
25-Year	345.5	35.7	7446.1	2 hours and 40 minutes
50-Year	386.9	39.3	9565.3	2 hours and 30 minutes
100-Year	427.9	42.9	11741.7	2 hours and 20 minutes

4.2.1.6 Santiago City Bridge, Isabela

The outflow of Santiago City Bridge using the Casiguran station Rainfall Intensity-Duration-Frequency curves (RIDF) in 5 different return periods (5-year, 10-year, 25-year, 50-year, and 100-year rainfall time series) based on PAGASA data are shown in Figures 70-74. The simulation results reveal significant increase in outflow magnitude as the rainfall intensity increases for a range of durations and return periods.

In the 5-year return period graph shown in Figure 70, the peak outflow is 946.9 cms. This occurs 2 hours after the peak precipitation of 27 mm.

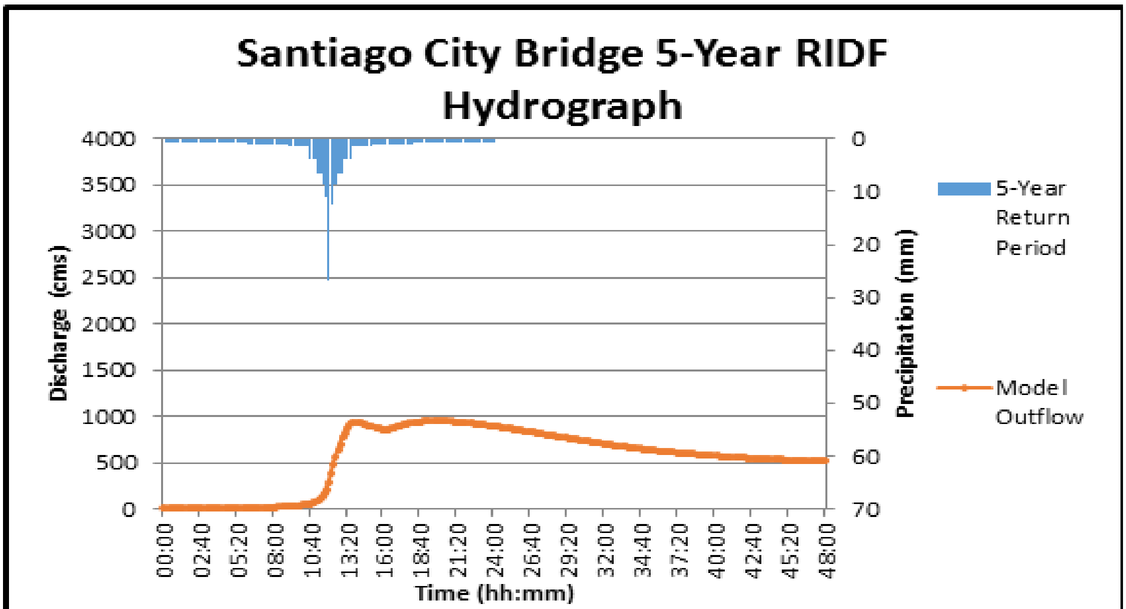


Figure 70. Santiago City outflow hydrograph generated using the Casiguran 5-Year RIDF in HEC-HMS

In the 10-year return period graph shown in Figure 71, the peak outflow is 1321.8 cms. This occurs 1 hour and 50 minutes after the peak precipitation of 30.9 mm.

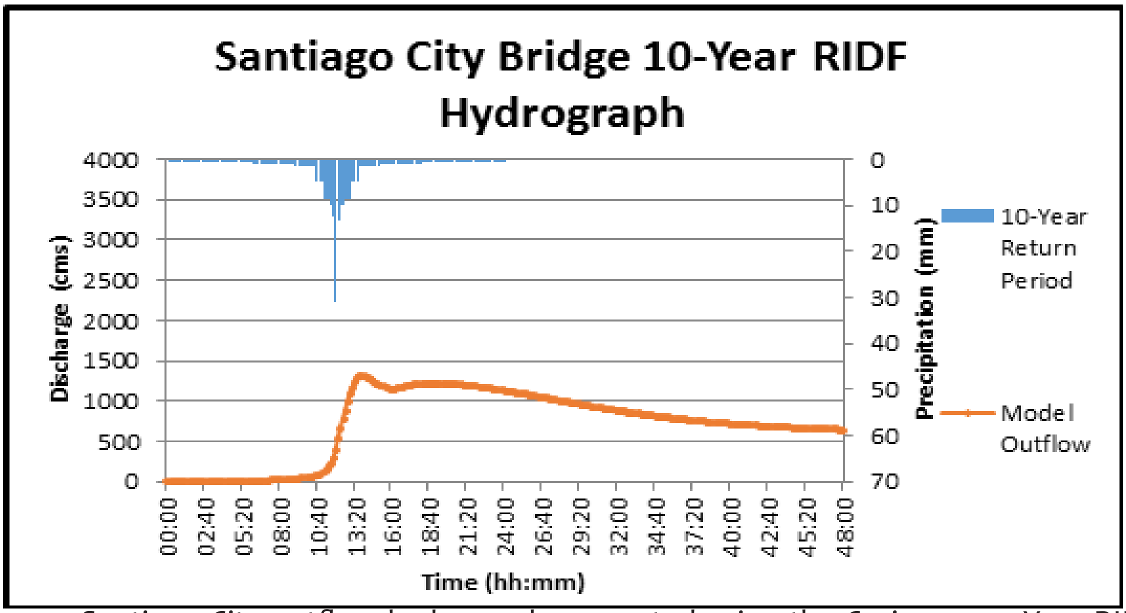


Figure 71. Santiago City outflow hydrograph generated using the Casiguran 10-Year RIDF in HEC-HMS

In the 25-year return period graph shown in Figure 72, the peak outflow is 1850 cms. This occurs 1 hour and 50 minutes after the peak precipitation of 35.7 mm.

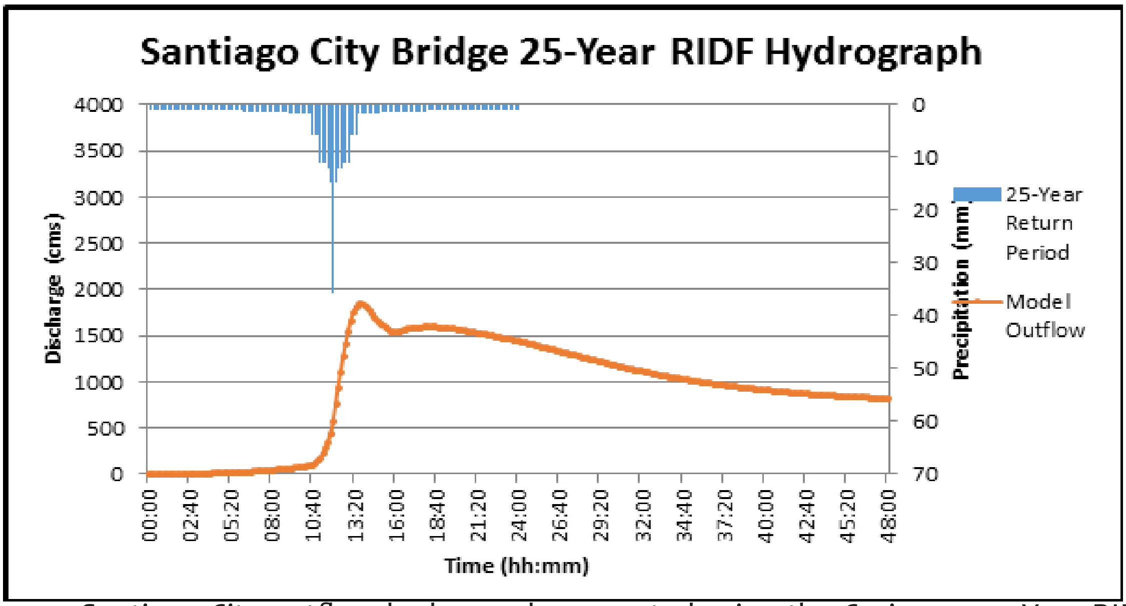


Figure 72. Santiago City outflow hydrograph generated using the Casiguran 25-Year RIDF in HEC-HMS

Results and Discussion

In the 50-year return period graph shown in Figure 73, the peak outflow is 2269.8 cms. This occurs 1 hour and 40 minutes after the peak precipitation of 39.3 mm.

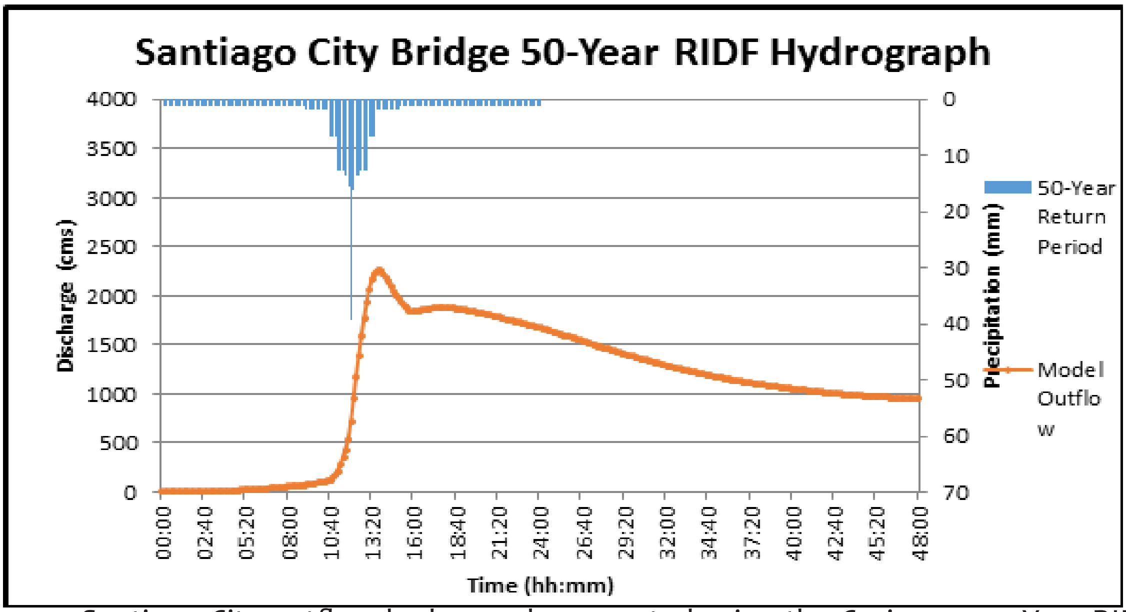


Figure 73. Santiago City outflow hydrograph generated using the Casiguran 50-Year RIDF in HEC-HMS

In the 100-year return period graph shown in Figure 74, the peak outflow is 2712.7 cms. This occurs 1 hour and 40 minutes after the peak precipitation of 42.9 mm.

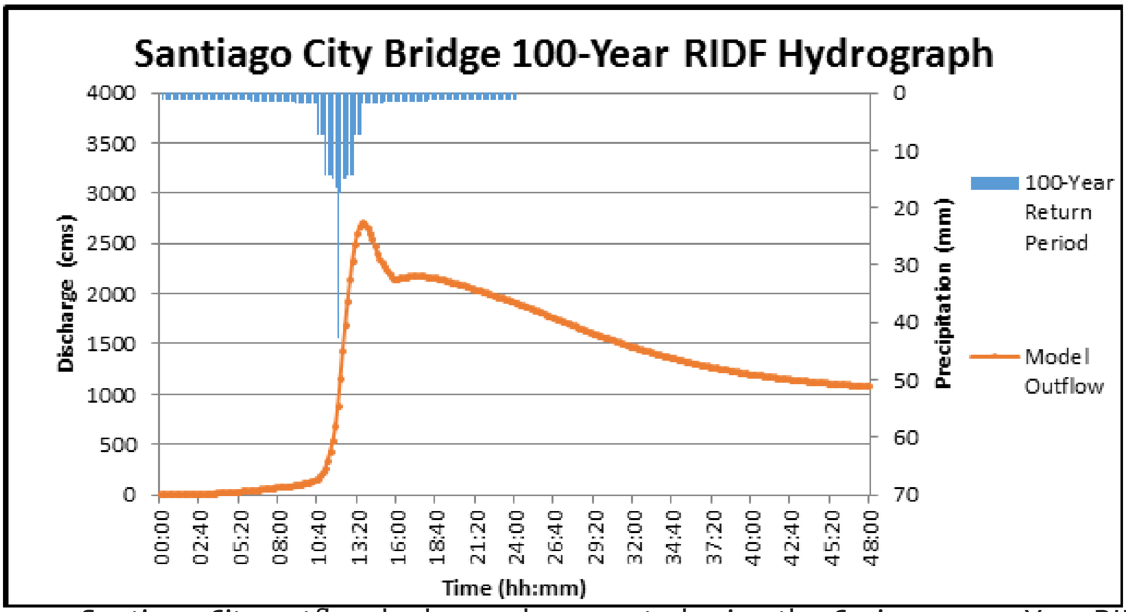


Figure 74. Santiago City outflow hydrograph generated using the Casiguran 100-Year RIDF in HEC-HMS

A summary of the total precipitation, peak rainfall, peak outflow and time to peak of Santiago City Bridge discharge using the Casiguran Rainfall Intensity-Duration-Frequency curves (RIDF) in five different return periods is shown in Table 7.

Table 7. Summary of Santiago City Bridge outflow using Casiguran Station Rainfall Intensity Duration Frequency (RIDF)

RIDF Period	Total Precipitation (mm)	Peak rainfall (mm)	Peak outflow (cms)	Time to Peak
5-Year	245.6	27	946.9	2 hours
10-Year	289.8	30.9	1321.8	1 hour and 50 minutes
25-Year	345.5	35.7	1850	1 hour and 50 minutes
50-Year	386.9	39.3	2269.8	1 hour and 40 minutes
100-Year	427.9	42.9	2712.7	1 hour and 40 minutes

4.2.2 Discharge Data using Dr. Horritt's Recommended Hydrological Method

The river discharge values using Dr. Horritt's recommended hydrological method are shown in Figure 75 and the peak discharge values are summarized in Table 8.

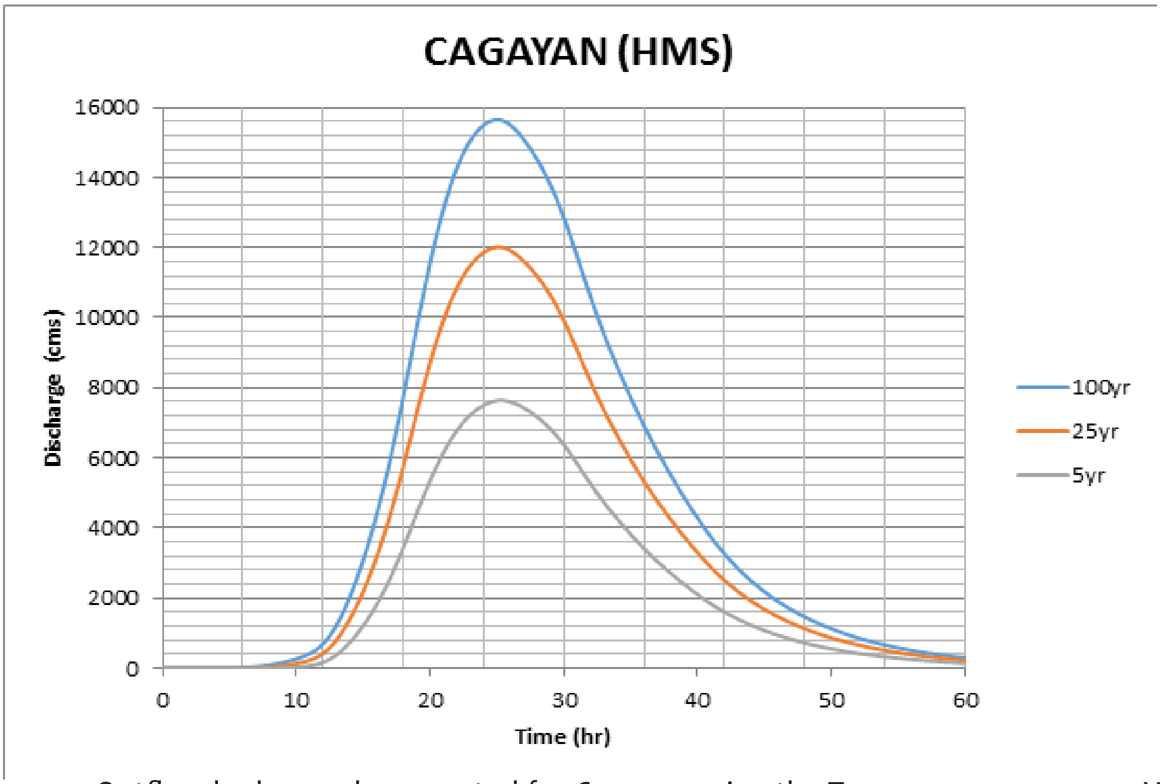


Figure 75. Outflow hydrograph generated for Cagayan using the Tuguegarao 5-, 25-, 100-Year RIDF in HEC-HMS

Table 8. Summary of Cagayan river discharge using the recommended hydrological method by Dr. Horritt

RIDF Period	Peak discharge (cms)	Time-to-peak
5-Year	7,642.4	25 hours, 10 minutes
25-Year	12,018.5	25 hours, 10 minutes
100-Year	15,655.3	25 hours

The comparison of discharge values obtained from HEC-HMS, QMED, and from the bankful discharge method, Qbankful, are shown in Table 9. Using values from the DTM of Cagayan, the bankful discharge for the river was computed.

Table 9. Validation of river discharge estimate using the bankful method

Discharge Point	Qbankful, cms	QMED, cms	Validation
Cagayan	7,122.41	7,642.4	Pass

The value from the HEC-HMS discharge estimate was able to satisfy the condition for validating the computed discharge using the bankful method. The computed value was used for the discharge point that did not have actual discharge data. The actual discharge data were also used for some areas in the floodplain that were modelled. It is recommended, therefore, to use the actual value of the river discharge for higher-accuracy modeling.

4.3 Flood Hazard and Flow Depth Maps

The following images are the hazard and flow depth maps for the 5-, 25-, and 100-year rain return scenarios of the Cagayan river basin.

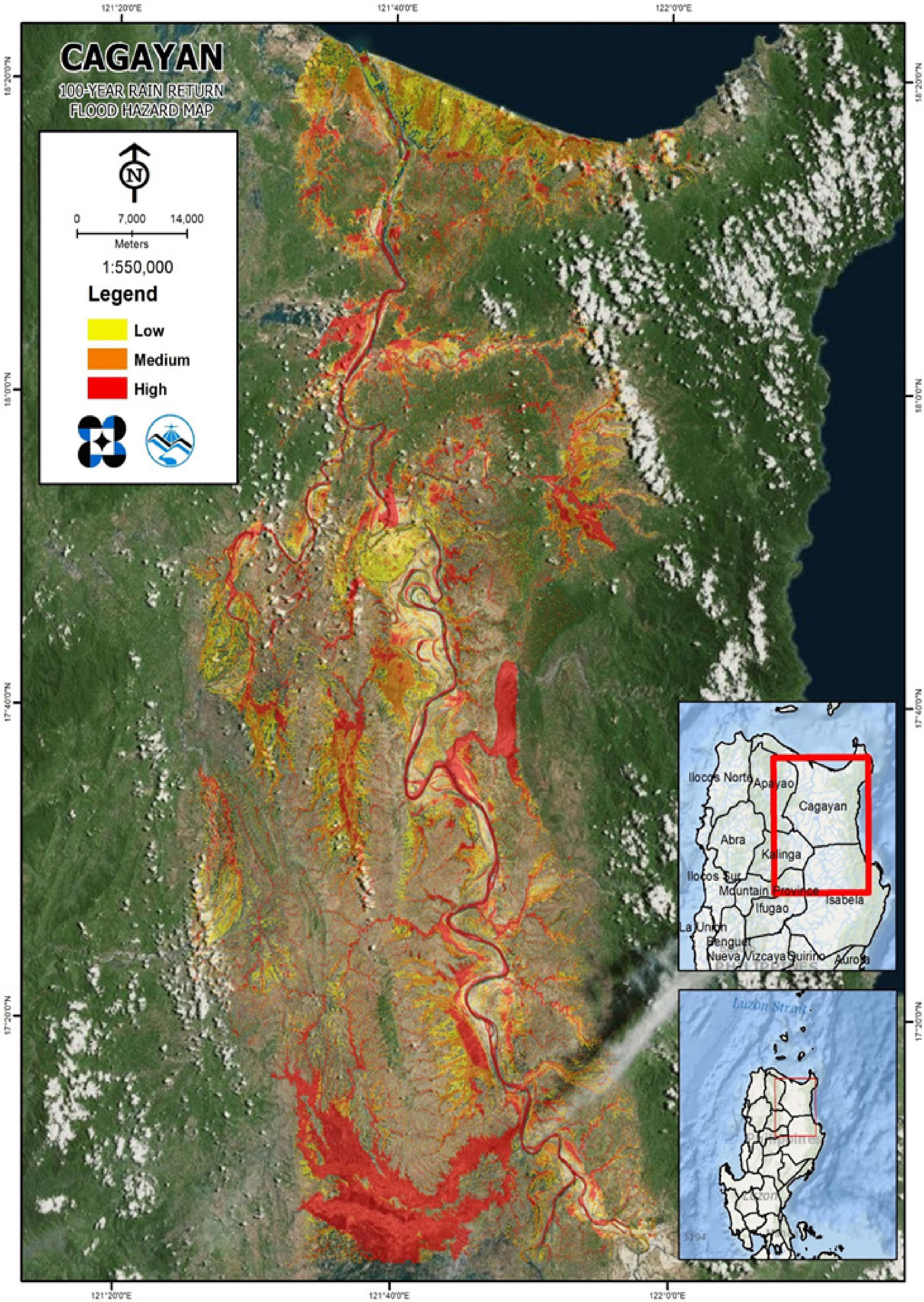


Figure 76. 100-year Flood Hazard Map for Cagayan River Basin

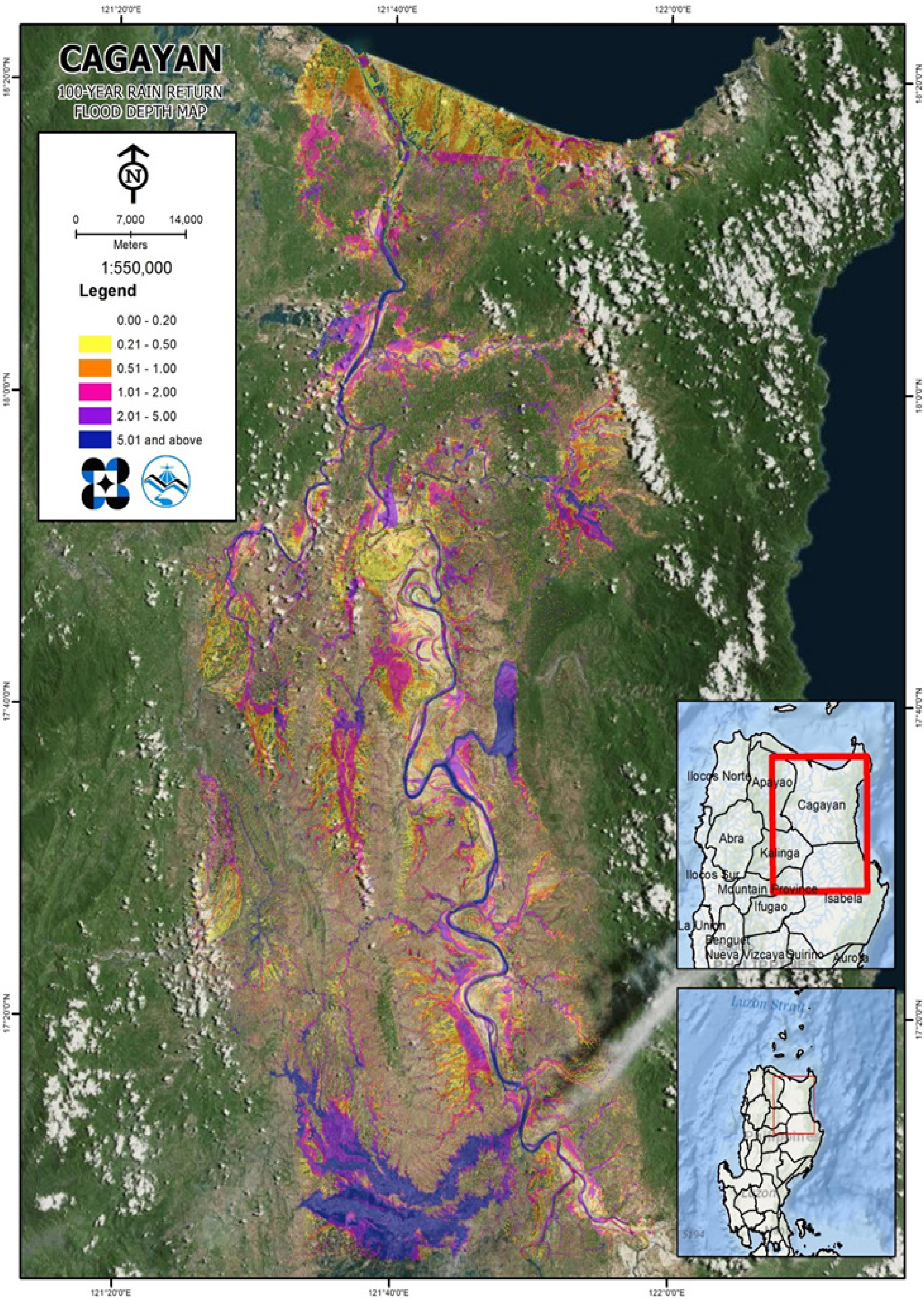


Figure 77. 100-year Flow Depth Map for Cagayan River Basin

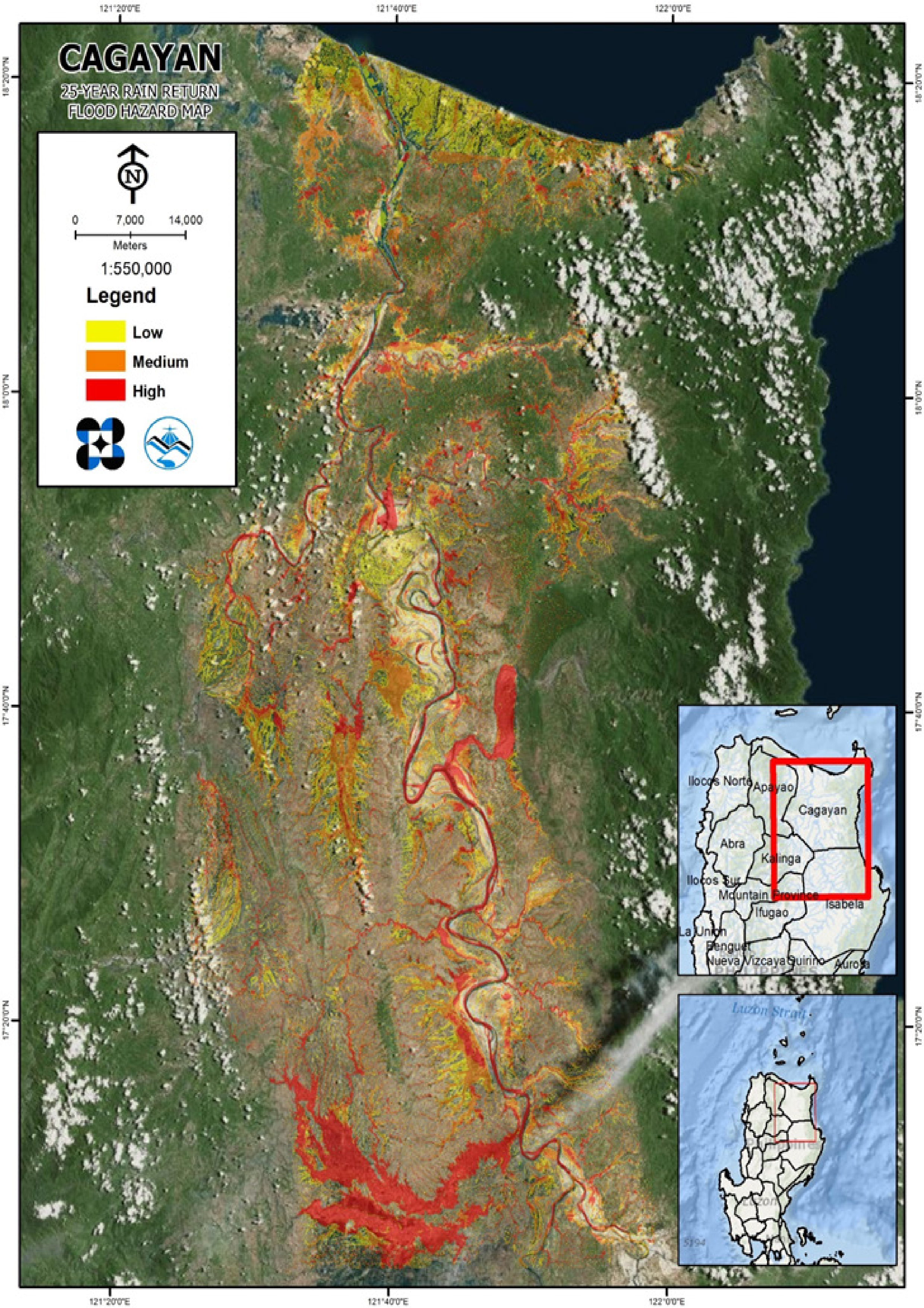


Figure 78. 25-year Flood Hazard Map for Cagayan River Basin

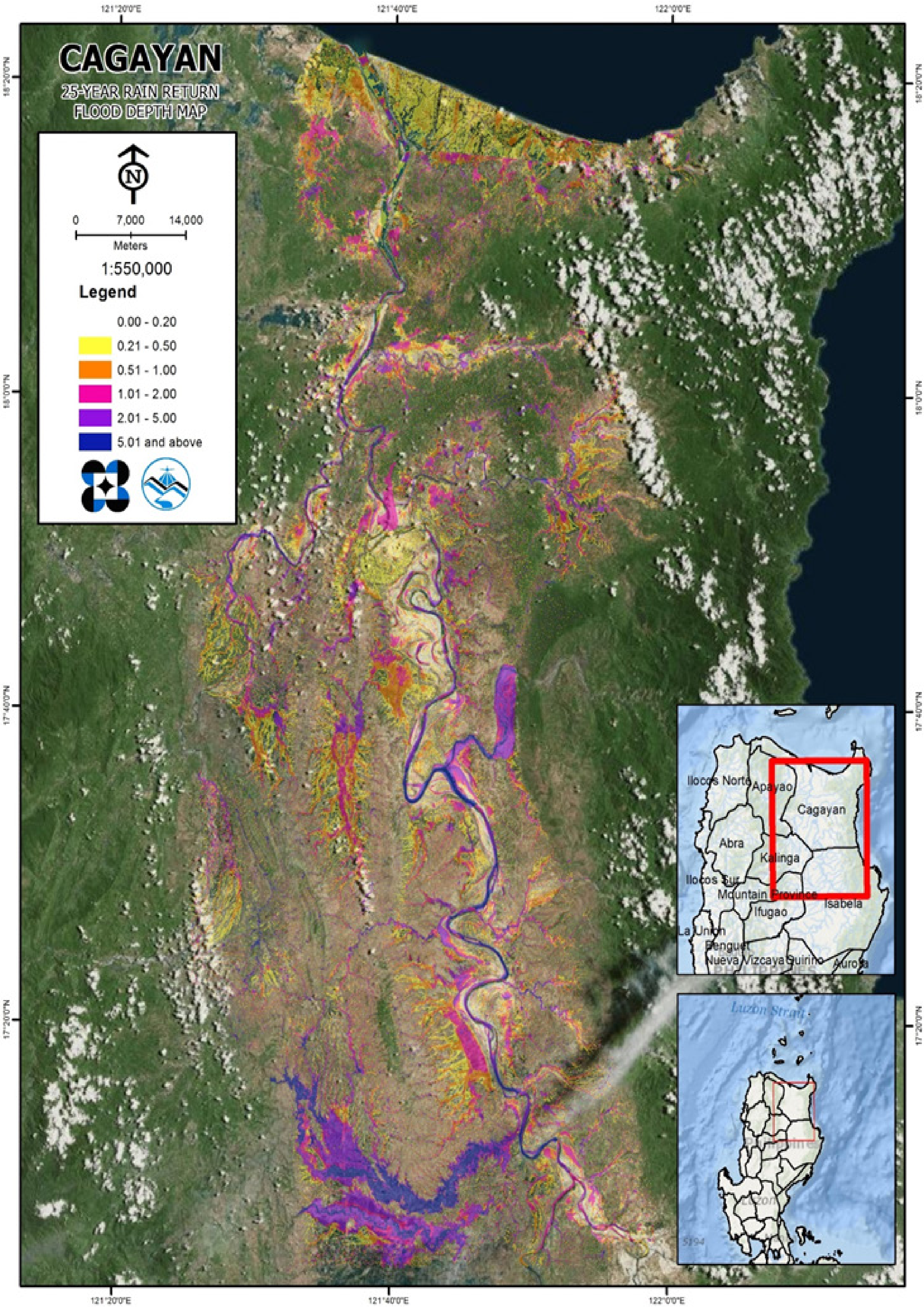


Figure 79. 25-year Flow Depth Map for Cagayan River Basin

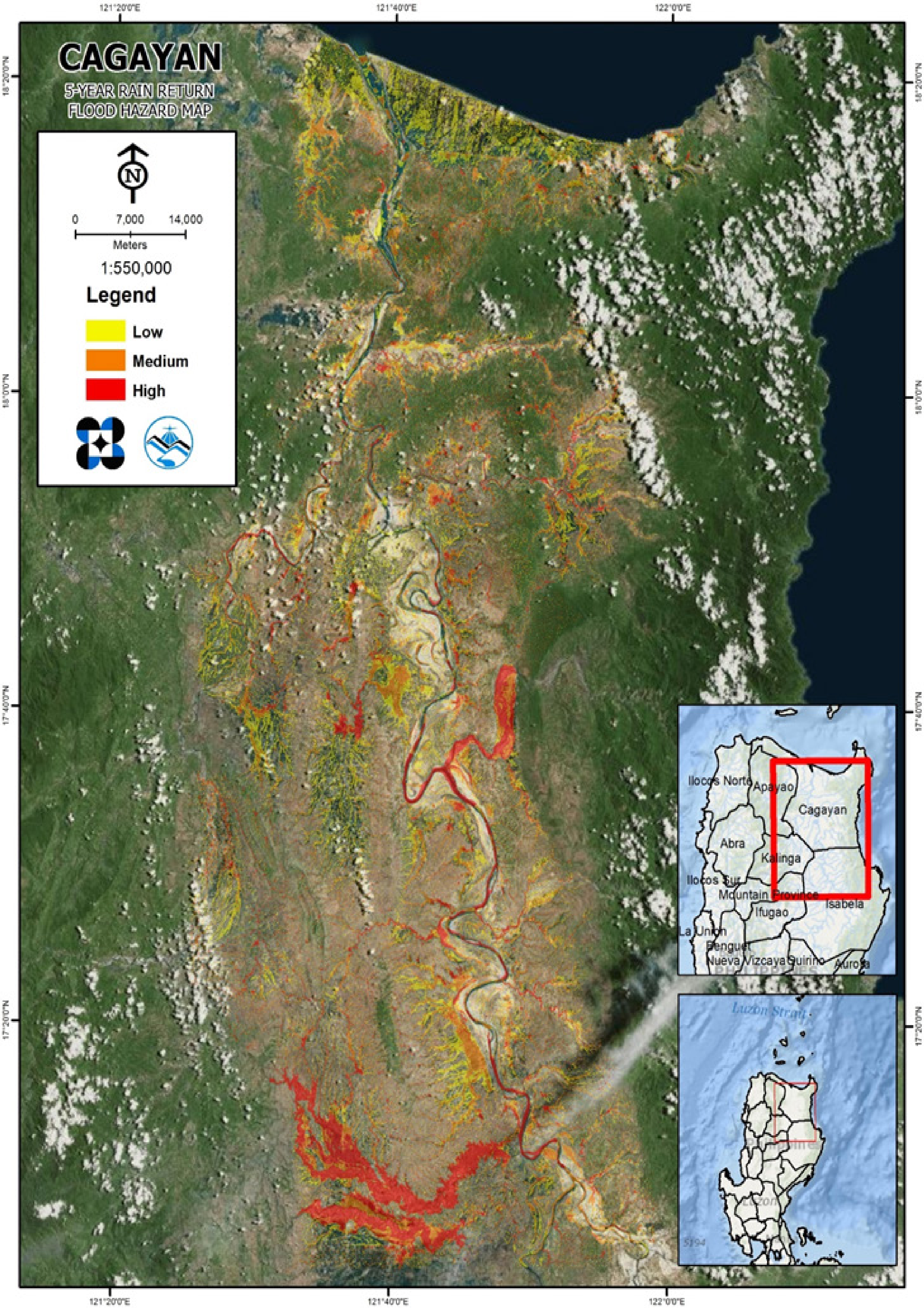


Figure 80. 5-year Flood Hazard Map for Cagayan River Basin

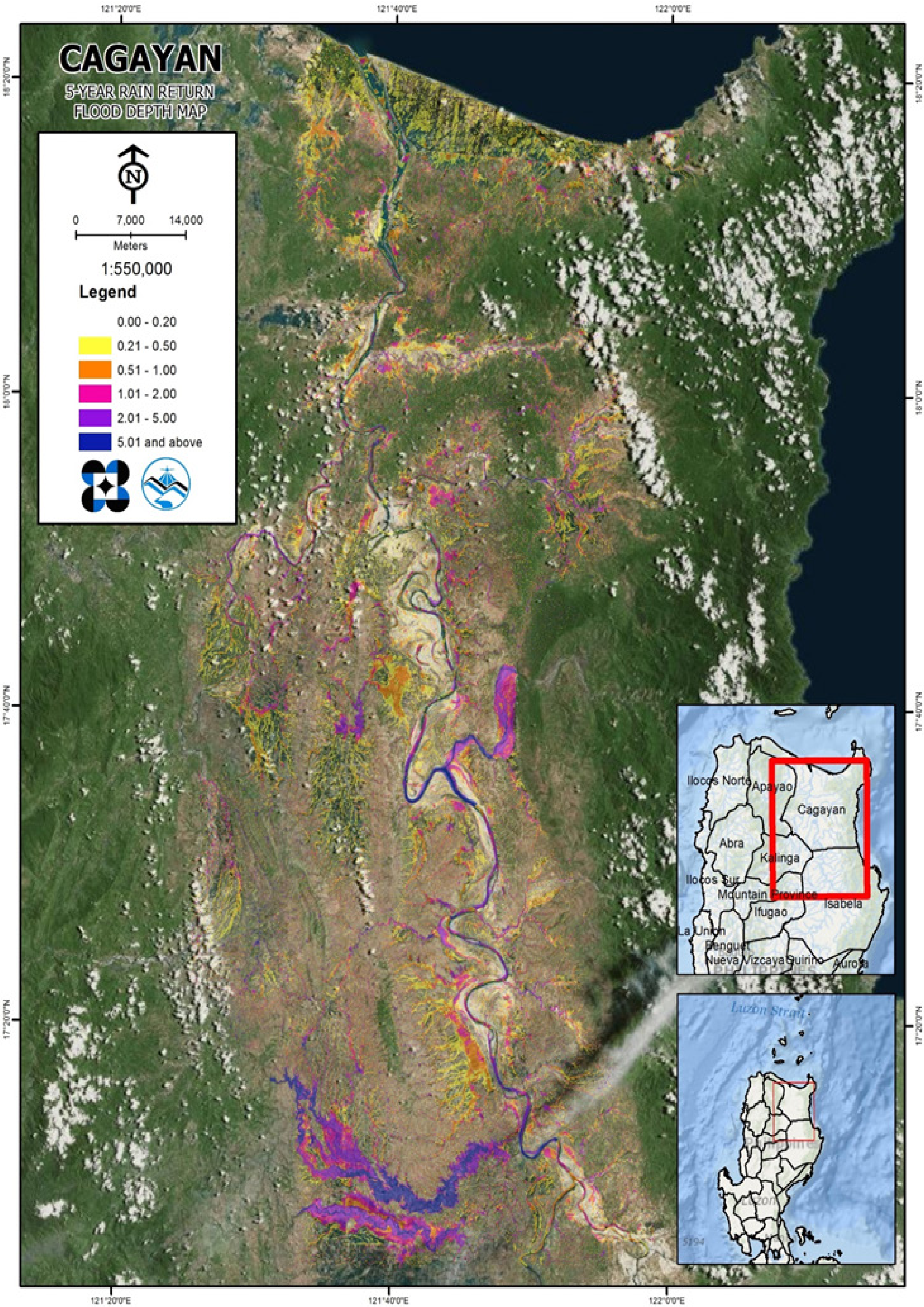


Figure 81. 5-year Flow Depth Map for Cagayan River Basin

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Appendix

Appendix A. Gamu Model Basin Parameters

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1434B	180.222	48.65595	0	5.5688	0.9153	Discharge	0.011471	0.0240899	Ratio to Peak	0.01
1435B	26.91	46.87515	0	3.5428	0.450342	Discharge	0.017207	0.0361349	Ratio to Peak	0.01
1436B	59.079	12.19995	0	4.1453	0.286074	Discharge	0.037183	0.0780847	Ratio to Peak	0.01
1437B	19.416	53.53635	0	0.25176	0.60834	Discharge	0.017207	0.0361349	Ratio to Peak	0.01
1438B	26.806	52.1283	0	26.887	2.1312	Discharge	0.017207	0.0361349	Ratio to Peak	0.01
1439B	27.348	52.3236	0	8.2567	1.5837	Discharge	0.017207	0.0361349	Ratio to Peak	0.01
1440B	19.442	52.59975	0	8.5556	1.49148	Discharge	0.025294	0.053117	Ratio to Peak	0.01
1441B	38.95	53.07435	0	3.8605	0.236592	Discharge	0.017207	0.0361349	Ratio to Peak	0.01
1442B	26.1	23.96625	0	3.6163	0.2223	Discharge	0.017207	0.0361349	Ratio to Peak	0.01
1443B	49.064	48.5268	0	3.6246	0.356934	Discharge	0.017207	0.0361349	Ratio to Peak	0.01
1444B	19.474	36.9768	0	1.463	0.476376	Discharge	0.017207	0.0361349	Ratio to Peak	0.01

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1445B	96.468	51.99075	0	14.255	1.48668	Discharge	0.017207	0.0361349	Ratio to Peak	0.01
1446B	19.479	46.08135	0	8.1976	0.95712	Discharge	0.017207	0.0361349	Ratio to Peak	0.01
1447B	43.601	50.60895	0	3.073	0.330426	Discharge	0.017207	0.0361349	Ratio to Peak	0.01
1448B	43.135	37.00515	0	5.4045	0.88404	Discharge	0.087111	0.18293	Ratio to Peak	0.01
1449B	19.54	46.76595	0	27.082	1.4322	Discharge	0.025295	0.0531184	Ratio to Peak	0.01
1450B	41.583	37.23405	0	2.4525	0.52452	Discharge	0.087111	0.18293	Ratio to Peak	0.01
1451B	28.402	36.8319	0	19.529	0.75108	Discharge	0.060435	0.12691	Ratio to Peak	0.01
1452B	42.138	39.5493	0	12.23	2.37582	Discharge	0.017207	0.0361349	Ratio to Peak	0.01
1453B	28.006	36.9579	0	2.5212	0.5658	Discharge	0.087111	0.18293	Ratio to Peak	0.01
1454B	19.672	16.4073	0	1.8599	0.56784	Discharge	0.087111	0.18293	Ratio to Peak	0.01
1455B	29.972	36.9348	0	5.4863	0.72588	Discharge	0.060431	0.1269	Ratio to Peak	0.01

Appendix

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1456B	19.203	18.3771	0	6.6952	0.461034	Discharge	0.025295	0.0531184	Ratio to Peak	0.01
1457B	42.8	18.53355	0	6.5488	0.361272	Discharge	0.017207	0.0361349	Ratio to Peak	0.01
1458B	41.397	36.93375	0	1.5027	0.40116	Discharge	0.12805	0.268905	Ratio to Peak	0.01
1459B	27.916	36.9348	0	3.4279	0.5112	Discharge	0.12805	0.268905	Ratio to Peak	0.01
1460B	18.447	36.93585	0	4.3982	0.65388	Discharge	0.19208	0.403368	Ratio to Peak	0.01
1461B	15.084	39.49995	0	5.0472	0.7308	Discharge	0.13067	0.274407	Ratio to Peak	0.01
1462B	93.702	38.82795	0	0.59805	0.2658	Discharge	0.441	0.9261	Ratio to Peak	0.01
1463B	24.476	44.9253	0	1.4235	0.31848	Discharge	0.441	0.9261	Ratio to Peak	0.01
1464B	64.62	36.8445	0	0.2	0.10692	Discharge	0.11701	0.245721	Ratio to Peak	0.01
1465B	64.62	36.8445	0	0.2	0.10692	Discharge	0.26328	0.552888	Ratio to Peak	0.01
1466B	18.657	38.27775	0	2.7821	0.46236	Discharge	0.087111	0.18293	Ratio to Peak	0.01

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1467B	18.317	37.09755	0	3.0168	0.47496	Discharge	0.28268	0.593628	Ratio to Peak	0.01
1468B	27.454	37.5837	0	8.013	0.97656	Discharge	0.441	0.9261	Ratio to Peak	0.01
1469B	71.784	36.89595	0	13.162	0.55824	Discharge	0.2646	0.55566	Ratio to Peak	0.01
1470B	21.481	36.9348	0	33.645	1.14792	Discharge	0.294	0.6174	Ratio to Peak	0.01
1471B	28.172	36.93585	0	2.1467	0.38652	Discharge	0.441	0.9261	Ratio to Peak	0.01
1472B	32.248	36.93585	0	8.4508	0.45348	Discharge	0.294	0.6174	Ratio to Peak	0.01
1473B	28.097	40.22655	0	9.4276	1.08804	Discharge	0.441	0.9261	Ratio to Peak	0.01
1474B	28.084	36.9348	0	2.9623	0.60696	Discharge	0.441	0.9261	Ratio to Peak	0.01
1475B	18.683	37.0083	0	6.6656	0.46368	Discharge	0.441	0.9261	Ratio to Peak	0.01
1476B	18.833	36.9117	0	4.2279	0.59436	Discharge	0.441	0.9261	Ratio to Peak	0.01
1477B	28.18	36.93585	0	8.769	0.55584	Discharge	0.3	0.63	Ratio to Peak	0.01

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1478B	28.086	37.11435	0	15.136	0.6144	Discharge	0.294	0.6174	Ratio to Peak	0.01
1479B	62.613	36.9348	0	6.6561	0.67596	Discharge	0.441	0.9261	Ratio to Peak	0.01
1480B	28.179	37.1028	0	2.0692	0.30924	Discharge	0.441	0.9261	Ratio to Peak	0.01
1481B	10.929	37.1385	0	14.037	0.783	Discharge	0.28812	0.605052	Ratio to Peak	0.01
1482B	32.03	40.1898	0	4.0337	0.79356	Discharge	0.441	0.9261	Ratio to Peak	0.01
1483B	27.348	60.8265	0	5.7267	0.55476	Discharge	0.441	0.9261	Ratio to Peak	0.01
1484B	42.042	39.7887	0	6.885	0.37524	Discharge	0.45	0.945	Ratio to Peak	0.01
1485B	27.791	36.87075	0	6.8891	0.57252	Discharge	0.45	0.945	Ratio to Peak	0.01
1486B	62.468	39.80865	0	3.5508	0.40668	Discharge	0.44775	0.940275	Ratio to Peak	0.01
1487B	41.929	38.8122	0	7.2403	0.45096	Discharge	0.44775	0.940275	Ratio to Peak	0.01
1488B	18.756	40.0071	0	6.53	0.45756	Discharge	0.45	0.945	Ratio to Peak	0.01

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1489B	62.516	37.296	0	3.0414	0.37356	Discharge	0.45	0.945	Ratio to Peak	0.01

Appendix B. Gamu Model Reach Parameters

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
908R	Automatic Fixed Interval	52105.14	0.1322	0.51758	Trapezoid	30	45
909R	Automatic Fixed Interval	33143.37	0.1482	0.14593	Trapezoid	30	45
910R	Automatic Fixed Interval	4541.102	0.143	0.36493	Trapezoid	30	45
911R	Automatic Fixed Interval	17658.37	0.1679	0.0129075	Trapezoid	30	45
912R	Automatic Fixed Interval	41044.55	0.1868	0.0583198	Trapezoid	30	45
913R	Automatic Fixed Interval	58307.61	0.01834	0.0257314	Trapezoid	30	45
914R	Automatic Fixed Interval	3678.926	0.5475	0.16116	Trapezoid	30	45
915R	Automatic Fixed Interval	3085.722	0.5393	0.0964029	Trapezoid	30	45
916R	Automatic Fixed Interval	27502.19	0.2057	0.032599	Trapezoid	30	45
917R	Automatic Fixed Interval	26217.71	0.2116	0.16228	Trapezoid	30	45
918R	Automatic Fixed Interval	1225.716	0.062	0.012923	Trapezoid	30	45
919R	Automatic Fixed Interval	3361.405	0.1541	0.16218	Trapezoid	30	45
920R	Automatic Fixed Interval	3604.334	0.2008	0.0622848	Trapezoid	30	45
921R	Automatic Fixed Interval	2648.707	0.0996	0.40264	Trapezoid	30	45
922R	Automatic Fixed Interval	32126.11	0.0484	1	Trapezoid	30	45
923R	Automatic Fixed Interval	27656.05	0.1403	0.0331806	Trapezoid	30	45
924R	Automatic Fixed Interval	2026.455	0.1915	0.12201	Trapezoid	30	45
925R	Automatic Fixed Interval	3268.213	0.1626	0.089933	Trapezoid	30	45
926R	Automatic Fixed Interval	1201.095	0.8	0.10165	Trapezoid	30	45
927R	Automatic Fixed Interval	2377.086	0.4985	0.0445988	Trapezoid	30	45
928R	Automatic Fixed Interval	21346.58	0.1359	0.10106	Trapezoid	30	45
929R	Automatic Fixed Interval	3618.808	0.2258	0.0141271	Trapezoid	30	45
930R	Automatic Fixed Interval	8337.668	0.1351	0.14252	Trapezoid	30	45
931R	Automatic Fixed Interval	9937.166	0.4501	0.0711747	Trapezoid	30	45
932R	Automatic Fixed Interval	6606.517	0.2801	0.24419	Trapezoid	30	45
933R	Automatic Fixed Interval	3962.694	0.461	0.10584	Trapezoid	30	45
934R	Automatic Fixed Interval	4472.585	0.0173	0.10824	Trapezoid	30	45
935R	Automatic Fixed Interval	8494.313	0.2412	0.0666753	Trapezoid	30	45
936R	Automatic Fixed Interval	2569.065	0.2613	0.0427846	Trapezoid	30	45
937R	Automatic Fixed Interval	3958.792	0.0745	0.0724078	Trapezoid	30	45
938R	Automatic Fixed Interval	2129.473	0.1806	0.0708996	Trapezoid	30	45
939R	Automatic Fixed Interval	1515.696	0.1863	0.0715752	Trapezoid	30	45
940R	Automatic Fixed Interval	8446.354	0.0001	0.11028	Trapezoid	30	45
941R	Automatic Fixed Interval	71352.06	0.2146	0.11463	Trapezoid	30	45
942R	Automatic Fixed Interval	18306.43	0.1506	0.0224857	Trapezoid	30	45

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
943R	Automatic Fixed Interval	40479.43	0.2375	0.0858422	Trapezoid	30	45
944R	Automatic Fixed Interval	1389.935	0.8	0.31426	Trapezoid	30	45
945R	Automatic Fixed Interval	10605.6	0.0965	0.24046	Trapezoid	30	45
946R	Automatic Fixed Interval	12120.06	0.3439	0.0686921	Trapezoid	30	45
947R	Automatic Fixed Interval	46779.03	0.1718	0.36279	Trapezoid	30	45
948R	Automatic Fixed Interval	865.2062	0.2133	0.11192	Trapezoid	30	45
949R	Automatic Fixed Interval	9059.753	0.2077	0.0001	Trapezoid	30	45
950R	Automatic Fixed Interval	27419.59	0.2081	0.0450158	Trapezoid	30	45
951R	Automatic Fixed Interval	22693.72	0.0363	0.0468937	Trapezoid	30	45
952R	Automatic Fixed Interval	21166.23	0.0924	0.13579	Trapezoid	30	45
953R	Automatic Fixed Interval	11966.26	0.1394	0.12071	Trapezoid	30	45
954R	Automatic Fixed Interval	5333.186	0.0016	0.3156	Trapezoid	30	45
955R	Automatic Fixed Interval	15459.52	0.1227	0.0561444	Trapezoid	30	45

Appendix C. Arkon Model Basin Parameters

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1363B	0.01	63.43	0	1.43049	10.1139	Discharge	0.09	0.09	Ratio to Peak	0
1364B	0.01	70.34	0	2.801445	19.807	Discharge	0.09	0.09	Ratio to Peak	0
1365B	0.01	75.6	0	1.201215	8.4929	Discharge	0.09	0.09	Ratio to Peak	0
1367B	0.01	79.36	0	1.72701	12.2104	Discharge	0.09	0.09	Ratio to Peak	0
1370B	0.01	78.15	0	4.837995	34.206	Discharge	0.09	0.09	Ratio to Peak	0
1371B	0.01	84	0	5.065005	35.811	Discharge	0.09	0.09	Ratio to Peak	0
1373B	0.01	82.63	0	0.987165	6.97951	Discharge	0.09	0.09	Ratio to Peak	0
1376B	0.01	84	0	1.21278	8.57467	Discharge	0.09	0.09	Ratio to Peak	0
1378B	0.01	78	0	1.314645	9.29487	Discharge	0.09	0.09	Ratio to Peak	0
1379B	0.01	82.6	0	0.60516	4.27869	Discharge	0.09	0.09	Ratio to Peak	0
1380B	0.01	84	0	1.73007	12.232	Discharge	0.09	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1381B	0.01	85.5	0	0.53571	3.78768	Discharge	0.09	0.09	Ratio to Peak	0
1382B	0.01	30	0	1.28277	9.06952	Discharge	0.09	0.09	Ratio to Peak	0
1383B	0.01	78.96	0	1.326675	9.37996	Discharge	0.09	0.09	Ratio to Peak	0
1385B	0.01	82.55	0	2.37684	16.805	Discharge	0.09	0.09	Ratio to Peak	0
1386B	0.01	82.67	0	3.49521	24.7121	Discharge	0.09	0.09	Ratio to Peak	0
1387B	0.01	72.21	0	1.776465	12.5601	Discharge	0.09	0.09	Ratio to Peak	0
1388B	0.01	78.8	0	1.534035	10.846	Discharge	0.09	0.09	Ratio to Peak	0
1389B	0.01	84	0	0.873345	6.17474	Discharge	0.09	0.09	Ratio to Peak	0
1390B	0.01	81.12	0	1.98954	14.0666	Discharge	0.09	0.09	Ratio to Peak	0
1392B	0.01	84	0	1.557825	11.0143	Discharge	0.09	0.09	Ratio to Peak	0
1393B	0.01	75.43	0	2.203005	15.5759	Discharge	0.09	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1395B	0.01	84	0	0.44109	3.11857	Discharge	0.09	0.09	Ratio to Peak	0
1396B	0.01	82.89	0	3.93885	27.8487	Discharge	0.09	0.09	Ratio to Peak	0
1397B	0.01	30	0	0.052155	0.36875	Discharge	0.09	0.09	Ratio to Peak	0
1398B	0.01	84	0	0.990915	7.00603	Discharge	0.09	0.09	Ratio to Peak	0
1399B	0.01	81.27	0	2.65953	18.8035	Discharge	0.09	0.09	Ratio to Peak	0
1400B	0.01	73.05	0	1.72077	12.1664	Discharge	0.09	0.09	Ratio to Peak	0
1402B	0.01	72.09	0	2.928555	20.7057	Discharge	0.09	0.09	Ratio to Peak	0
1404B	0.01	84.21	0	3.462285	24.4793	Discharge	0.09	0.09	Ratio to Peak	0
1405B	0.01	78.5	0	0.65406	4.62436	Discharge	0.09	0.09	Ratio to Peak	0
1406B	0.01	73.67	0	1.19511	8.44974	Discharge	0.09	0.09	Ratio to Peak	0
1407B	0.01	30	0	0.774435	5.47541	Discharge	0.09	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1408B	0.01	71.33	0	1.57482	11.1344	Discharge	0.09	0.09	Ratio to Peak	0
1410B	0.01	84.21	0	3.178965	22.4761	Discharge	0.09	0.09	Ratio to Peak	0
1411B	0.01	84	0	1.408125	9.95579	Discharge	0.09	0.09	Ratio to Peak	0
1412B	0.01	74.66	0	2.41242	17.0565	Discharge	0.09	0.09	Ratio to Peak	0
1413B	0.01	74.36	0	1.770315	12.5165	Discharge	0.09	0.09	Ratio to Peak	0
1414B	0.01	30	0	0.05754	0.4069	Discharge	0.09	0.09	Ratio to Peak	0
1415B	0.01	84.9	0	0.824025	5.82602	Discharge	0.09	0.09	Ratio to Peak	0
1416B	0.01	61.85	0	1.21869	8.6164	Discharge	0.09	0.09	Ratio to Peak	0
1418B	0.01	82.67	0	1.670805	11.813	Discharge	0.09	0.09	Ratio to Peak	0
1419B	0.01	84	0	0.03225	0.22802	Discharge	0.09	0.09	Ratio to Peak	0
1420B	0.01	76.36	0	0.52416	3.70598	Discharge	0.09	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1421B	0.01	77.67	0	2.463945	17.4207	Discharge	0.09	0.09	Ratio to Peak	0
1422B	0.01	69.81	0	2.927025	20.6948	Discharge	0.09	0.09	Ratio to Peak	0
1423B	0.01	30	0	0.6678	4.72154	Discharge	0.09	0.09	Ratio to Peak	0
1424B	0.01	81.73	0	1.777005	12.5639	Discharge	0.09	0.09	Ratio to Peak	0
1425B	0.01	82.07	0	2.029875	14.3517	Discharge	0.09	0.09	Ratio to Peak	0
1426B	0.01	72.8	0	0.9402	6.64749	Discharge	0.09	0.09	Ratio to Peak	0
1428B	0.01	66.33	0	1.59447	11.2734	Discharge	0.09	0.09	Ratio to Peak	0
1429B	0.01	77	0	1.127745	7.97349	Discharge	0.09	0.09	Ratio to Peak	0
1430B	0.01	73.15	0	1.75914	12.4376	Discharge	0.09	0.09	Ratio to Peak	0
1431B	0.01	83.22	0	0.43869	3.10167	Discharge	0.09	0.09	Ratio to Peak	0
1432B	0.01	61.09	0	1.549035	10.9521	Discharge	0.09	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1434B	0.01	78	0	1.480725	10.4691	Discharge	0.09	0.09	Ratio to Peak	0
1435B	0.01	77	0	0.618855	4.37548	Discharge	0.09	0.09	Ratio to Peak	0
1436B	0.01	79.07	0	1.615635	11.423	Discharge	0.09	0.09	Ratio to Peak	0
1439B	0.01	85.29	0	0.80226	15.925	Discharge	0.09	0.09	Ratio to Peak	0
1440B	0.01	78.05	0	1.09749	7.75951	Discharge	0.09	0.09	Ratio to Peak	0
1441B	0.01	30	0	0.197415	1.39581	Discharge	0.09	0.09	Ratio to Peak	0
1442B	9.4827	84	0	1.276845	9.02759	Discharge	0.09	0.09	Ratio to Peak	0
1443B	0.01	84	0	2.471985	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1445B	0.01	84	0	1.98627	15.925	Discharge	0.09	0.09	Ratio to Peak	0
1446B	0.01	84	0	0.68718	4.85862	Discharge	0.09	0.09	Ratio to Peak	0
1448B	0.01	30	0	0.39357	2.78265	Discharge	0.09	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1449B	0.01	30	0	0.48948	3.46073	Discharge	0.09	0.09	Ratio to Peak	0
1450B	0.01	60.33	0	0.77781	5.49933	Discharge	0.09	0.09	Ratio to Peak	0
1451B	0.01	77	0	0.92238	6.52145	Discharge	0.09	0.09	Ratio to Peak	0
1453B	0.01	84	0	0.600375	4.24483	Discharge	0.09	0.09	Ratio to Peak	0
1455B	0.01	76.46	0	0.927555	6.55805	Discharge	0.09	0.09	Ratio to Peak	0
1456B	0.01	30	0	0.29811	2.10769	Discharge	0.09	0.09	Ratio to Peak	0
1457B	0.01	61.29	0	1.88061	13.2964	Discharge	0.09	0.09	Ratio to Peak	0
1458B	0.01	69.98	0	1.00857	7.13083	Discharge	0.09	0.09	Ratio to Peak	0
1459B	0.01	30	0	0.0402	0.28425	Discharge	0.09	0.09	Ratio to Peak	0
1460B	0.01	78.25	0	3.733905	26.3997	Discharge	0.09	0.09	Ratio to Peak	0
1461B	0.01	78.75	0	1.383615	9.78257	Discharge	0.09	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1464B	0.01	84.25	0	2.43042	17.1837	Discharge	0.09	0.09	Ratio to Peak	0
1465B	0.01	84.21	0	2.261745	15.9912	Discharge	0.09	0.09	Ratio to Peak	0
1466B	0.01	77.88	0	0.618105	4.37015	Discharge	0.09	0.09	Ratio to Peak	0
1467B	0.01	77	0	0.29508	2.08631	Discharge	0.09	0.09	Ratio to Peak	0
1468B	0.01	77	0	0.85965	6.07796	Discharge	0.09	0.09	Ratio to Peak	0
1469B	0.01	77	0	1.00182	7.08312	Discharge	0.09	0.09	Ratio to Peak	0
1470B	0.01	30	0	0.43425	3.07034	Discharge	0.09	0.09	Ratio to Peak	0
1471B	0.01	78.27	0	0.699015	4.94215	Discharge	0.09	0.09	Ratio to Peak	0
1472B	0.01	77.05	0	0.653445	4.62007	Discharge	0.09	0.09	Ratio to Peak	0
1473B	0.01	77	0	0.91026	6.43585	Discharge	0.09	0.09	Ratio to Peak	0
1474B	0.01	84.53	0	0.9105	6.43747	Discharge	0.09	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1475B	0.01	30	0	0.30456	2.15339	Discharge	0.09	0.09	Ratio to Peak	0
1476B	0.01	30	0	0.237015	1.67583	Discharge	0.09	0.09	Ratio to Peak	0
1477B	0.01	85.8	0	1.030065	7.2828	Discharge	0.09	0.09	Ratio to Peak	0
1478B	0.01	77.21	0	1.91652	13.5504	Discharge	0.09	0.09	Ratio to Peak	0
1479B	15.395	76.38	0	1.770285	12.5163	Discharge	0.09	0.09	Ratio to Peak	0
1480B	0.01	77	0	1.770285	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1481B	0.01	30	0	0.03801	0.26878	Discharge	0.09	0.09	Ratio to Peak	0
1482B	0.01	84	0	0.36351	2.57017	Discharge	0.09	0.09	Ratio to Peak	0
1483B	0.01	79.4	0	1.82547	12.9066	Discharge	0.09	0.09	Ratio to Peak	0
1484B	0.01	79.75	0	0.95271	6.73595	Discharge	0.09	0.09	Ratio to Peak	0
1485B	0.01	83.71	0	1.339065	9.46758	Discharge	0.09	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1486B	0.01	77	0	0.858675	6.071	Discharge	0.09	0.09	Ratio to Peak	0
1487B	0.01	30	0	0.129225	0.91371	Discharge	0.09	0.09	Ratio to Peak	0
1488B	0.01	79	0	0.872085	6.1659	Discharge	0.09	0.09	Ratio to Peak	0
1489B	0.01	30	0	0.1791	1.26627	Discharge	0.09	0.09	Ratio to Peak	0
1490B	0.01	81.28	0	1.458435	10.3115	Discharge	0.09	0.09	Ratio to Peak	0
1491B	9.4827	84	0	0.10284	0.72716	Discharge	0.09	0.09	Ratio to Peak	0
1492B	55.246	47.4	0	0.10284	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1493B	10.116	77	0	0.64416	15.9653	Discharge	0.09	0.09	Ratio to Peak	0
1494B	0.01	75.62	0	0.81603	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1495B	0.01	79.8	0	1.738695	12.2931	Discharge	0.09	0.09	Ratio to Peak	0
1496B	0.01	81.92	0	1.77108	12.5221	Discharge	0.09	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1497B	0.01	30	0	0.094545	0.66853	Discharge	0.09	0.09	Ratio to Peak	0
1498B	0.01	69	0	0.57669	4.07732	Discharge	0.09	0.09	Ratio to Peak	0
1499B	0.01	30	0	0.144825	1.02395	Discharge	0.09	0.09	Ratio to Peak	0
1500B	0.01	67	0	0.50589	3.57676	Discharge	0.09	0.09	Ratio to Peak	0
1501B	0.01	77.49	0	1.11036	7.85051	Discharge	0.09	0.09	Ratio to Peak	0
1502B	0.01	69.76	0	1.231305	8.70565	Discharge	0.09	0.09	Ratio to Peak	0
1503B	0.01	30	0	0.085035	0.60125	Discharge	0.09	0.09	Ratio to Peak	0
1504B	0.01	77	0	0.685515	4.84679	Discharge	0.09	0.09	Ratio to Peak	0
1505B	14.871	77	0	0.260085	1.83885	Discharge	0.09	0.09	Ratio to Peak	0
1506B	15.25	77	0	0.260085	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1507B	0.01	84	0	1.1781	15.925	Discharge	0.09	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1508B	0.01	84	0	0.803505	5.681	Discharge	0.09	0.09	Ratio to Peak	0
1509B	0.01	30	0	0.49968	3.53295	Discharge	0.09	0.09	Ratio to Peak	0
1510B	0.01	82.33	0	0.698175	4.93623	Discharge	0.09	0.09	Ratio to Peak	0
1511B	0.01	79.15	0	1.197975	8.47002	Discharge	0.09	0.09	Ratio to Peak	0
1512B	10.042	83.56	0	0.73617	5.20494	Discharge	0.09	0.09	Ratio to Peak	0
1513B	9.4827	84	0	0.73617	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1514B	12.446	80	0	0.061905	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1515B	0.01	77.04	0	0.450675	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1516B	14.871	77	0	0.12963	0.9165	Discharge	0.09	0.09	Ratio to Peak	0
1517B	10.957	82.33	0	0.12963	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1518B	0.01	30	0	0.72999	10.8336	Discharge	0.09	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1519B	0.01	76.05	0	1.377855	9.74181	Discharge	0.09	0.09	Ratio to Peak	0
1520B	0.01	76	0	0.58122	4.1093	Discharge	0.09	0.09	Ratio to Peak	0
1521B	0.01	77.91	0	0.41295	2.91961	Discharge	0.09	0.09	Ratio to Peak	0
1522B	0.01	78.33	0	0.523935	3.70442	Discharge	0.09	0.09	Ratio to Peak	0
1523B	0.01	82.16	0	0.50295	3.55596	Discharge	0.09	0.09	Ratio to Peak	0
1524B	0.01	77.88	0	0.69588	4.92005	Discharge	0.09	0.09	Ratio to Peak	0
1525B	9.4827	84	0	0.177225	1.25301	Discharge	0.09	0.09	Ratio to Peak	0
1526B	0.01	77.98	0	0.177225	15.925	Discharge	0.09	0.09	Ratio to Peak	0
1527B	9.7243	84	0	0.40713	2.87859	Discharge	0.09	0.09	Ratio to Peak	0
1528B	22.211	77.43	0	0.40713	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1529B	14.514	84	0	1.5282	15.925	Discharge	0.09	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1530B	0.01	30	0	0.79809	15.925	Discharge	0.09	0.09	Ratio to Peak	0
1531B	0.01	73.12	0	0.77808	5.50121	Discharge	0.09	0.09	Ratio to Peak	0
1532B	15.25	77	0	0.52152	3.68732	Discharge	0.09	0.09	Ratio to Peak	0
1533B	10.176	83.38	0	0.52152	15.925	Discharge	0.09	0.09	Ratio to Peak	0
1534B	0.01	30	0	0.572175	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1535B	0.01	77.92	0	0.354945	2.50959	Discharge	0.09	0.09	Ratio to Peak	0
1536B	0.01	79.12	0	1.89489	13.3974	Discharge	0.09	0.09	Ratio to Peak	0
1537B	10.583	82.83	0	0.425085	3.00541	Discharge	0.09	0.09	Ratio to Peak	0
1538B	15.25	77	0	0.425085	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1539B	22.761	77	0	0.20622	15.925	Discharge	0.09	0.09	Ratio to Peak	0
1540B	21.455	78.03	0	0.867795	10.8336	Discharge	0.09	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1541B	22.761	77	0	0.73437	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1542B	14.514	84	0	0.5172	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1543B	18.423	80.53	0	0.054045	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1544B	0.01	79	0	0.84798	15.925	Discharge	0.09	0.09	Ratio to Peak	0
1545B	0.01	78.95	0	0.884235	6.25177	Discharge	0.09	0.09	Ratio to Peak	0
1546B	17.285	81.51	0	0.86766	6.13464	Discharge	0.09	0.09	Ratio to Peak	0
1547B	0.01	69.5	0	0.86766	15.925	Discharge	0.09	0.09	Ratio to Peak	0
1548B	29.005	72.43	0	1.02306	7.23327	Discharge	0.09	0.09	Ratio to Peak	0
1549B	0.01	30	0	1.02306	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1550B	0.01	30	0	0.04017	0.28405	Discharge	0.09	0.09	Ratio to Peak	0
1551B	0.01	66.1	0	0.66789	4.72219	Discharge	0.09	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1552B	0.01	65.96	0	0.685845	4.84907	Discharge	0.09	0.09	Ratio to Peak	0
1553B	0.01	73.8	0	0.944835	6.68031	Discharge	0.09	0.09	Ratio to Peak	0
1554B	0.01	77.74	0	0.36882	2.60761	Discharge	0.09	0.09	Ratio to Peak	0
1555B	22.761	77	0	0.234645	1.65906	Discharge	0.09	0.09	Ratio to Peak	0
1556B	16.354	82.33	0	0.234645	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1557B	22.761	77	0	0.47328	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1558B	0.01	77	0	0.37857	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1559B	22.761	77	0	0.361065	2.55281	Discharge	0.09	0.09	Ratio to Peak	0
1560B	22.761	77	0	0.361065	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1561B	14.108	78.33	0	0.27516	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1562B	24.66	75.55	0	0.742965	16.1168	Discharge	0.09	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1563B	21.555	77.95	0	1.05129	24.375	Discharge	0.09	0.09	Ratio to Peak	0
1564B	0.01	77.44	0	0.976845	24.375	Discharge	0.09	0.09	Ratio to Peak	0
1565B	34.235	69	0	0.115785	0.81868	Discharge	0.09	0.09	Ratio to Peak	0
1566B	22.761	77	0	0.115785	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1567B	22.761	77	0	0.347505	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1568B	0.01	69.72	0	0.321285	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1569B	0.01	78.49	0	0.95157	6.72789	Discharge	0.09	0.09	Ratio to Peak	0
1570B	22.761	77	0	0.343815	2.43087	Discharge	0.09	0.09	Ratio to Peak	0
1571B	21.367	77	0	0.343815	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1572B	20.969	78.1	0	0.299175	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1573B	0.01	77	0	0.780975	15.925	Discharge	0.09	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1574B	0.01	78.52	0	0.634335	4.48494	Discharge	0.09	0.09	Ratio to Peak	0
1575B	0.01	80.17	0	1.27923	9.04449	Discharge	0.09	0.09	Ratio to Peak	0
1576B	0.01	78.2	0	0.455415	3.21997	Discharge	0.09	0.09	Ratio to Peak	0
1577B	14.029	78.42	0	0.39141	2.76738	Discharge	0.09	0.09	Ratio to Peak	0
1578B	13.946	78.36	0	0.39141	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1579B	0.01	78.64	0	0.712575	10.8336	Discharge	0.09	0.09	Ratio to Peak	0
1580B	0.01	77	0	0.16746	1.18404	Discharge	0.09	0.09	Ratio to Peak	0
1581B	0.01	79.44	0	0.96087	6.79354	Discharge	0.09	0.09	Ratio to Peak	0
1582B	0.01	78.5	0	0.404475	2.85974	Discharge	0.09	0.09	Ratio to Peak	0
1583B	22.761	78.46	0	0.77094	5.45077	Discharge	0.09	0.09	Ratio to Peak	0
1584B	0.01	75.71	0	0.77094	10.8336	Discharge	0.09	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1585B	20.747	77	0	0.157815	1.11579	Discharge	0.09	0.09	Ratio to Peak	0
1586B	19.301	78.6	0	0.157815	24.375	Discharge	0.09	0.09	Ratio to Peak	0
1587B	22.761	79.79	0	1.178865	16.3241	Discharge	0.09	0.09	Ratio to Peak	0
1588B	0.01	30	0	0.69693	24.375	Discharge	0.09	0.09	Ratio to Peak	0
1589B	0.01	77	0	0.14013	0.99073	Discharge	0.09	0.09	Ratio to Peak	0
1590B	0.01	30	0	0.13983	0.98865	Discharge	0.09	0.09	Ratio to Peak	0
1591B	0.01	78.5	0	0.36594	2.58733	Discharge	0.09	0.09	Ratio to Peak	0
1592B	0.01	78.13	0	0.996585	7.04613	Discharge	0.09	0.09	Ratio to Peak	0
1593B	20.402	77	0	0.320745	2.26772	Discharge	0.09	0.09	Ratio to Peak	0
1594B	15.174	78.88	0	0.320745	16.328	Discharge	0.09	0.09	Ratio to Peak	0
1595B	18.316	77	0	0.611415	16.3261	Discharge	0.09	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1596B	11.121	73.5	0	0.01821	24.375	Discharge	0.09	0.09	Ratio to Peak	0
1597B	33.656	82.04	0	0.367785	24.375	Discharge	0.09	0.09	Ratio to Peak	0
1598B	0.01	78.45	0	0.67812	16.3293	Discharge	0.09	0.09	Ratio to Peak	0
1599B	11.402	60.15	0	0.526815	3.72476	Discharge	0.09	0.09	Ratio to Peak	0
1600B	13.749	81.67	0	0.526815	24.375	Discharge	0.09	0.09	Ratio to Peak	0
1601B	13.996	78.7	0	0.237855	24.375	Discharge	0.09	0.09	Ratio to Peak	0
1602B	13.741	78.4	0	0.709605	24.375	Discharge	0.09	0.09	Ratio to Peak	0
1603B	15.174	78.71	0	0.550155	24.375	Discharge	0.09	0.09	Ratio to Peak	0
1604B	13.236	77	0	0.611205	16.315	Discharge	0.09	0.09	Ratio to Peak	0
1605B	9.6762	79.33	0	0.10257	16.3306	Discharge	0.09	0.09	Ratio to Peak	0
1606B	15.174	84	0	0.396825	24.375	Discharge	0.09	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1607B	20.071	77	0	0.180135	0.065	Discharge	0.09	0.09	Ratio to Peak	0
1608B	17.516	71.68	0	0.02535	16.3306	Discharge	0.09	0.09	Ratio to Peak	0
1609B	13.374	74.36	0	0.823095	24.375	Discharge	0.09	0.09	Ratio to Peak	0
1610B	0.01	30	0	0.76839	24.375	Discharge	0.09	0.09	Ratio to Peak	0
1611B	0.01	71.64	0	1.02102	7.2189	Discharge	0.09	0.09	Ratio to Peak	0
1612B	14.07	79.16	0	0.78867	5.57616	Discharge	0.09	0.09	Ratio to Peak	0
1613B	14.909	78.31	0	0.78867	24.375	Discharge	0.09	0.09	Ratio to Peak	0
1614B	15.174	77.31	0	0.913005	16.3189	Discharge	0.09	0.09	Ratio to Peak	0
1615B	15.174	77	0	0.9483	16.2962	Discharge	0.09	0.09	Ratio to Peak	0
1616B	15.174	77	0	0.107055	16.3306	Discharge	0.09	0.09	Ratio to Peak	0
1617B	14.571	77	0	0.05802	16.3306	Discharge	0.09	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1618B	14.782	77.71	0	0.08928	16.3306	Discharge	0.09	0.09	Ratio to Peak	0
1619B	0.01	77	0	0.693075	24.375	Discharge	0.09	0.09	Ratio to Peak	0
1620B	0.01	78.87	0	0.596175	24.375	Discharge	0.09	0.09	Ratio to Peak	0
1621B	0.01	75.05	0	0.68376	4.83438	Discharge	0.09	0.09	Ratio to Peak	0
1622B	0.01	30	0	0.033405	0.23615	Discharge	0.09	0.09	Ratio to Peak	0
1623B	0.01	78.35	0	0.481305	3.40295	Discharge	0.09	0.09	Ratio to Peak	0
1624B	0.01	77.46	0	0.978855	6.92075	Discharge	0.09	0.09	Ratio to Peak	0
1625B	0.01	78.27	0	0.978855	24.375	Discharge	0.09	0.09	Ratio to Peak	0
1979B	0.01	30	0	0.15	0.65	Discharge	0.09	0.09	Ratio to Peak	0

Appendix D. Arkon Model Reach Parameters

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
1000R	Automatic Fixed Interval	1089.4	0.0354	0.7	Trapezoid	0.3	0.45
1001R	Automatic Fixed Interval	80026	0.003	0.0233	Trapezoid	0.3	0.45
1002R	Automatic Fixed Interval	28095	0.0004	0.7	Trapezoid	0.3	0.45
1003R	Automatic Fixed Interval	1389.2	0.0054	0.7	Trapezoid	0.3	0.45
1004R	Automatic Fixed Interval	2005.9	0.0034	0.0233	Trapezoid	0.3	0.45
1005R	Automatic Fixed Interval	86790	0.0034	0.7	Trapezoid	0.3	0.45
1006R	Automatic Fixed Interval	14043	0.0021	0.0525	Trapezoid	0.3	0.45
1007R	Automatic Fixed Interval	6745.9	0.0098	0.7	Trapezoid	0.3	0.45
1008R	Automatic Fixed Interval	1330.8	0.0012	0.7	Trapezoid	0.3	0.45
1009R	Automatic Fixed Interval	94262	0.0022	0.7	Trapezoid	0.3	0.45
1010R	Automatic Fixed Interval	38102	0.0023	0.7	Trapezoid	0.3	0.45
1011R	Automatic Fixed Interval	1165.7	0.0353	0.0343	Trapezoid	0.3	0.45
1012R	Automatic Fixed Interval	59266	0.0023	0.7	Trapezoid	0.3	0.45
1013R	Automatic Fixed Interval	5683.9	0.0017	0.0352	Trapezoid	0.3	0.45
1014R	Automatic Fixed Interval	25521	0.0019	0.7	Trapezoid	0.3	0.45
1015R	Automatic Fixed Interval	245.02	0.1104	0.0343	Trapezoid	0.3	0.45
1016R	Automatic Fixed Interval	17903	0.0034	0.7	Trapezoid	0.3	0.45
1017R	Automatic Fixed Interval	933.69	0.0099	0.0233	Trapezoid	0.3	0.45
1018R	Automatic Fixed Interval	10924	0.0021	0.0233	Trapezoid	0.3	0.45
1019R	Automatic Fixed Interval	73296	0.0033	0.0343	Trapezoid	0.3	0.45
1020R	Automatic Fixed Interval	2273.7	0.0105	0.035	Trapezoid	0.3	0.45
1023R	Automatic Fixed Interval	9879.9	0.012	0.7	Trapezoid	0.3	0.45
1024R	Automatic Fixed Interval	1021.2	0.0204	0.0525	Trapezoid	0.3	0.45
1025R	Automatic Fixed Interval	8705.1	0.0414	0.7	Trapezoid	0.3	0.45
1026R	Automatic Fixed Interval	1699.1	0.0428	0.0343	Trapezoid	0.3	0.45
1027R	Automatic Fixed Interval	3980.7	0.0122	0.0315	Trapezoid	0.3	0.45
1028R	Automatic Fixed Interval	17631	0.0017	0.0525	Trapezoid	0.3	0.45
1029R	Automatic Fixed Interval	24436	0.0345	0.7	Trapezoid	0.3	0.45
1030R	Automatic Fixed Interval	1125.4	0.003	0.035	Trapezoid	0.3	0.45
1031R	Automatic Fixed Interval	1277.9	0.0565	0.035	Trapezoid	0.3	0.45
1032R	Automatic Fixed Interval	24590	0.0076	0.035	Trapezoid	0.3	0.45
1033R	Automatic Fixed Interval	1378	0.0181	0.7	Trapezoid	0.3	0.45
1034R	Automatic Fixed Interval	22715	0.0044	0.7	Trapezoid	0.3	0.45
1035R	Automatic Fixed Interval	25524	0.0024	0.7	Trapezoid	0.3	0.45
1038R	Automatic Fixed Interval	8064.6	0.0024	0.7	Trapezoid	0.3	0.45

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Man-ning's n	Shape	Width	Side Slope
1039R	Automatic Fixed Interval	1713.5	0.0328	0.0351	Trapezoid	0.3	0.45
1040R	Automatic Fixed Interval	324.6	0.3123	0.7	Trapezoid	0.3	0.45
1041R	Automatic Fixed Interval	603.08	0.0013	0.7	Trapezoid	0.3	0.45
1042R	Automatic Fixed Interval	7356.2	0.0147	0.7	Trapezoid	0.3	0.45
1043R	Automatic Fixed Interval	20555	0.0041	0.0525	Trapezoid	0.3	0.45
1044R	Automatic Fixed Interval	671.56	0.0129	0.0349	Trapezoid	0.3	0.45
1045R	Automatic Fixed Interval	1263.7	0.0435	0.0351	Trapezoid	0.3	0.45
1046R	Automatic Fixed Interval	7910.1	0.0034	0.035	Trapezoid	0.3	0.45
1047R	Automatic Fixed Interval	54446	0.0044	0.7	Trapezoid	0.3	0.45
1048R	Automatic Fixed Interval	22585	0.0021	0.0525	Trapezoid	0.3	0.45
1049R	Automatic Fixed Interval	48120	0.0074	0.0351	Trapezoid	0.3	0.45
1050R	Automatic Fixed Interval	405.62	0.2233	0.0525	Trapezoid	0.3	0.45
1051R	Automatic Fixed Interval	23067	0.0092	0.0525	Trapezoid	0.3	0.45
1052R	Automatic Fixed Interval	12057	0.0017	0.035	Trapezoid	0.3	0.45
1053R	Automatic Fixed Interval	820.39	0.0233	0.7	Trapezoid	0.3	0.45
1054R	Automatic Fixed Interval	735.31	0.0766	0.0352	Trapezoid	0.3	0.45
1055R	Automatic Fixed Interval	235.14	0.1652	0.0525	Trapezoid	0.3	0.45
1056R	Automatic Fixed Interval	8073.2	0.0079	0.7	Trapezoid	0.3	0.45
1057R	Automatic Fixed Interval	266.78	0.0471	0.7	Trapezoid	0.3	0.45
1058R	Automatic Fixed Interval	48072	0.014	0.7	Trapezoid	0.3	0.45
1059R	Automatic Fixed Interval	18499	0.001	0.7	Trapezoid	0.3	0.45
1060R	Automatic Fixed Interval	25055	0.0004	0.7	Trapezoid	0.3	0.45
1061R	Automatic Fixed Interval	1091.5	0.0042	0.7	Trapezoid	0.3	0.45
1062R	Automatic Fixed Interval	10256	0.0012	0.7	Trapezoid	0.3	0.45
1063R	Automatic Fixed Interval	17592	0.0008	0.7	Trapezoid	0.3	0.45
1064R	Automatic Fixed Interval	19848	0.0007	0.7	Trapezoid	0.3	0.45
1065R	Automatic Fixed Interval	37630	0.0033	0.7	Trapezoid	0.3	0.45
1068R	Automatic Fixed Interval	97762	0.004	0.7	Trapezoid	0.3	0.45
1069R	Automatic Fixed Interval	20109	0.0004	0.7	Trapezoid	0.3	0.45
1070R	Automatic Fixed Interval	13350	0.0072	0.7	Trapezoid	0.3	0.45
1071R	Automatic Fixed Interval	8283.2	0.0062	0.7	Trapezoid	0.3	0.45
1072R	Automatic Fixed Interval	23177	0.0063	0.7	Trapezoid	0.3	0.45
1073R	Automatic Fixed Interval	95284	0.0013	0.7	Trapezoid	0.3	0.45
1074R	Automatic Fixed Interval	21673	0.0019	0.7	Trapezoid	0.3	0.45
1075R	Automatic Fixed Interval	1359.5	0.0056	0.7	Trapezoid	0.3	0.45

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
1076R	Automatic Fixed Interval	22029	0.0042	0.7	Trapezoid	0.3	0.45
1077R	Automatic Fixed Interval	22735	0.0008	0.7	Trapezoid	0.3	0.45
1078R	Automatic Fixed Interval	6630.9	0.0029	0.7	Trapezoid	0.3	0.45
1079R	Automatic Fixed Interval	62138	0.0028	0.7	Trapezoid	0.3	0.45
1080R	Automatic Fixed Interval	910.49	0.0198	0.7	Trapezoid	0.3	0.45
1081R	Automatic Fixed Interval	3616.2	0.0189	0.7	Trapezoid	0.3	0.45
1082R	Automatic Fixed Interval	50311	0.0087	0.7	Trapezoid	0.3	0.45
1083R	Automatic Fixed Interval	3733.1	0.0044	0.7	Trapezoid	0.3	0.45
1119R	Automatic Fixed Interval	4297.5	0.0005	0.7	Trapezoid	0.3	0.45
1120R	Automatic Fixed Interval	33164	0.001	0.7	Trapezoid	0.3	0.45
1121R	Automatic Fixed Interval	34448	0.0012	0.7	Trapezoid	0.3	0.45
1122R	Automatic Fixed Interval	39291	0.001	0.7	Trapezoid	0.3	0.45
1123R	Automatic Fixed Interval	36176	0.0003	0.7	Trapezoid	0.3	0.45
1124R	Automatic Fixed Interval	53806	0.0001	0.7	Trapezoid	0.3	0.45
1125R	Automatic Fixed Interval	65019	0.0004	0.7	Trapezoid	0.3	0.45
1126R	Automatic Fixed Interval	1765.7	0.0249	0.7	Trapezoid	0.3	0.45
1127R	Automatic Fixed Interval	77678	0.0003	0.7	Trapezoid	0.3	0.45
1128R	Automatic Fixed Interval	77475	0.0004	0.7	Trapezoid	0.3	0.45
1129R	Automatic Fixed Interval	18603	5E-05	0.7	Trapezoid	0.3	0.45
1130R	Automatic Fixed Interval	367.42	0.0126	0.7	Trapezoid	0.3	0.45
1131R	Automatic Fixed Interval	5098.5	0.0018	0.7	Trapezoid	0.3	0.45
1132R	Automatic Fixed Interval	25863	0.0008	0.7	Trapezoid	0.3	0.45
1133R	Automatic Fixed Interval	7283.7	0.0013	0.7	Trapezoid	0.3	0.45
1134R	Automatic Fixed Interval	32532	0.0016	0.7	Trapezoid	0.3	0.45
1135R	Automatic Fixed Interval	19560	0.0012	0.7	Trapezoid	0.3	0.45
1136R	Automatic Fixed Interval	46549	0.002	0.7	Trapezoid	0.3	0.45
1137R	Automatic Fixed Interval	1042.1	0.0588	0.7	Trapezoid	0.3	0.45
1138R	Automatic Fixed Interval	789.57	0.0292	0.7	Trapezoid	0.3	0.45
1139R	Automatic Fixed Interval	9782.5	0.0013	0.7	Trapezoid	0.3	0.45
1141R	Automatic Fixed Interval	60068	0.0025	0.7	Trapezoid	0.3	0.45
1142R	Automatic Fixed Interval	599.34	0.0205	0.7	Trapezoid	0.3	0.45
1143R	Automatic Fixed Interval	14483	0.0015	0.035	Trapezoid	0.3	0.45
1144R	Automatic Fixed Interval	48366	0.0037	0.7	Trapezoid	0.3	0.45
1145R	Automatic Fixed Interval	65874	0.0025	0.7	Trapezoid	0.3	0.45
1146R	Automatic Fixed Interval	370.08	0.2428	0.7	Trapezoid	0.3	0.45

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Man-ning's n	Shape	Width	Side Slope
1147R	Automatic Fixed Interval	9746.2	0.0094	0.7	Trapezoid	0.3	0.45
1148R	Automatic Fixed Interval	493.69	0.0246	0.7	Trapezoid	0.3	0.45
1149R	Automatic Fixed Interval	19119	0.0008	0.7	Trapezoid	0.3	0.45
1150R	Automatic Fixed Interval	144045	0.0032	0.7	Trapezoid	0.3	0.45
1151R	Automatic Fixed Interval	1393.9	0.0138	0.7	Trapezoid	0.3	0.45
1152R	Automatic Fixed Interval	15061	0.0075	0.7	Trapezoid	0.3	0.45
1153R	Automatic Fixed Interval	6944.7	0.0031	0.7	Trapezoid	0.3	0.45
1154R	Automatic Fixed Interval	394.55	0.0286	0.7	Trapezoid	0.3	0.45
1155R	Automatic Fixed Interval	15400	6E-05	0.7	Trapezoid	0.3	0.45
1156R	Automatic Fixed Interval	8631.5	0.0023	0.7	Trapezoid	0.3	0.45
1157R	Automatic Fixed Interval	28892	0.0082	0.0233	Trapezoid	0.3	0.45
1158R	Automatic Fixed Interval	1022.4	0.0204	0.7	Trapezoid	0.3	0.45
1159R	Automatic Fixed Interval	1309.2	0.0242	0.7	Trapezoid	0.3	0.45
1160R	Automatic Fixed Interval	35588	0.0019	0.7	Trapezoid	0.3	0.45
1161R	Automatic Fixed Interval	753.91	0.0143	0.7	Trapezoid	0.3	0.45
1162R	Automatic Fixed Interval	12158	0.0033	0.7	Trapezoid	0.3	0.45
1164R	Automatic Fixed Interval	6606.5	0.002	0.0233	Trapezoid	0.3	0.45
1165R	Automatic Fixed Interval	587.93	0.0711	0.0525	Trapezoid	0.3	0.45
1166R	Automatic Fixed Interval	12676	0.0042	0.0343	Trapezoid	0.3	0.45
1167R	Automatic Fixed Interval	924.33	0.0646	0.7	Trapezoid	0.3	0.45
1168R	Automatic Fixed Interval	4078.1	0.0098	0.0233	Trapezoid	0.3	0.45
1169R	Automatic Fixed Interval	564.2	0.0196	0.7	Trapezoid	0.3	0.45
1170R	Automatic Fixed Interval	807.99	0.035	0.7	Trapezoid	0.3	0.45
1171R	Automatic Fixed Interval	962.35	0.0198	0.0233	Trapezoid	0.3	0.45
1172R	Automatic Fixed Interval	72845	0.0038	0.0233	Trapezoid	0.3	0.45
1173R	Automatic Fixed Interval	9986.5	0.0069	0.7	Trapezoid	0.3	0.45
1174R	Automatic Fixed Interval	1544.5	0.0538	0.7	Trapezoid	0.3	0.45
1175R	Automatic Fixed Interval	27641	0.0029	0.0525	Trapezoid	0.3	0.45
1177R	Automatic Fixed Interval	40371	0.0066	0.0233	Trapezoid	0.3	0.45
1178R	Automatic Fixed Interval	75087	0.0073	0.0343	Trapezoid	0.3	0.45
1179R	Automatic Fixed Interval	1482.2	0.0031	0.0343	Trapezoid	0.3	0.45
1180R	Automatic Fixed Interval	31209	0.0036	0.7	Trapezoid	0.3	0.45
1181R	Automatic Fixed Interval	24003	0.0144	0.7	Trapezoid	0.3	0.45
1182R	Automatic Fixed Interval	21938	0.0135	0.0343	Trapezoid	0.3	0.45
1183R	Automatic Fixed Interval	13463	0.0012	0.7	Trapezoid	0.3	0.45

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
1184R	Automatic Fixed Interval	17416	0.0031	0.7	Trapezoid	0.3	0.45
1185R	Automatic Fixed Interval	5494.5	0.0186	0.7	Trapezoid	0.3	0.45
1187R	Automatic Fixed Interval	23574	0.0094	0.035	Trapezoid	0.3	0.45
1188R	Automatic Fixed Interval	889.72	0.0895	0.0525	Trapezoid	0.3	0.45
1189R	Automatic Fixed Interval	33715	0.0041	0.7	Trapezoid	0.3	0.45
1190R	Automatic Fixed Interval	34736	0.0105	0.0525	Trapezoid	0.3	0.45
1191R	Automatic Fixed Interval	39099	0.0111	0.0351	Trapezoid	0.3	0.45
1192R	Automatic Fixed Interval	6899	0.016	0.7	Trapezoid	0.3	0.45
579R	Automatic Fixed Interval	394.58	0.0318	0.7	Trapezoid	0.3	0.45
612R	Automatic Fixed Interval	746.36	0.082	0.7	Trapezoid	0.3	0.45
627R	Automatic Fixed Interval	1325.2	0.0279	0.7	Trapezoid	0.3	0.45
658R	Automatic Fixed Interval	74755	0.0005	0.7	Trapezoid	0.3	0.45
890R	Automatic Fixed Interval	7449.7	0.0018	0.7	Trapezoid	0.3	0.45
891R	Automatic Fixed Interval	30369	0.0009	0.7	Trapezoid	0.3	0.45
892R	Automatic Fixed Interval	13128	0.0021	0.7	Trapezoid	0.3	0.45
893R	Automatic Fixed Interval	87919	0.0003	0.7	Trapezoid	0.3	0.45
894R	Automatic Fixed Interval	33098	0.0001	0.7	Trapezoid	0.3	0.45
895R	Automatic Fixed Interval	38916	0.0002	0.7	Trapezoid	0.3	0.45
896R	Automatic Fixed Interval	9220.4	0.0039	0.7	Trapezoid	0.3	0.45
897R	Automatic Fixed Interval	1452.9	0.0204	0.7	Trapezoid	0.3	0.45
898R	Automatic Fixed Interval	30187	0.0019	0.7	Trapezoid	0.3	0.45
899R	Automatic Fixed Interval	10122	0.0026	0.7	Trapezoid	0.3	0.45
900R	Automatic Fixed Interval	55279	0.0056	0.7	Trapezoid	0.3	0.45
901R	Automatic Fixed Interval	37531	0.0005	0.0351	Trapezoid	0.3	0.45
902R	Automatic Fixed Interval	37130	0.0066	0.7	Trapezoid	0.3	0.45
903R	Automatic Fixed Interval	29683	0.0012	0.7	Trapezoid	0.3	0.45
904R	Automatic Fixed Interval	54368	0.0097	0.7	Trapezoid	0.3	0.45
905R	Automatic Fixed Interval	18581	0.0051	0.7	Trapezoid	0.3	0.45
906R	Automatic Fixed Interval	67778	0.0014	0.0348	Trapezoid	0.3	0.45
907R	Automatic Fixed Interval	40191	0.0033	0.0525	Trapezoid	0.3	0.45
908R	Automatic Fixed Interval	24469	0.0115	0.0525	Trapezoid	0.3	0.45
909R	Automatic Fixed Interval	43520	0.0099	0.7	Trapezoid	0.3	0.45
910R	Automatic Fixed Interval	41033	0.0025	0.7	Trapezoid	0.3	0.45
949R	Automatic Fixed Interval	27115	0.0018	0.7	Trapezoid	0.3	0.45
950R	Automatic Fixed Interval	3045.8	0.0004	0.7	Trapezoid	0.3	0.45

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Man-ning's n	Shape	Width	Side Slope
951R	Automatic Fixed Interval	58234	0.0035	0.7	Trapezoid	0.3	0.45
952R	Automatic Fixed Interval	9724	0.011	0.0351	Trapezoid	0.3	0.45
953R	Automatic Fixed Interval	6247.7	0.0176	0.0352	Trapezoid	0.3	0.45
954R	Automatic Fixed Interval	27061	0.0011	0.0352	Trapezoid	0.3	0.45
955R	Automatic Fixed Interval	30542	0.0009	0.0525	Trapezoid	0.3	0.45
956R	Automatic Fixed Interval	32207	0.0108	0.0352	Trapezoid	0.3	0.45
957R	Automatic Fixed Interval	3247	0.0661	0.0525	Trapezoid	0.3	0.45
958R	Automatic Fixed Interval	22750	0.0071	0.0525	Trapezoid	0.3	0.45
959R	Automatic Fixed Interval	48956	0.003	0.0296	Trapezoid	0.3	0.45
960R	Automatic Fixed Interval	30902	0.0027	0.0233	Trapezoid	0.3	0.45
961R	Automatic Fixed Interval	15942	0.0028	0.0233	Trapezoid	0.3	0.45
962R	Automatic Fixed Interval	23404	0.0266	0.035	Trapezoid	0.3	0.45
963R	Automatic Fixed Interval	23624	0.0103	0.035	Trapezoid	0.3	0.45
964R	Automatic Fixed Interval	22174	0.0064	0.0233	Trapezoid	0.3	0.45
965R	Automatic Fixed Interval	10204	0.0208	0.035	Trapezoid	0.3	0.45
966R	Automatic Fixed Interval	2794.9	0.0147	0.0351	Trapezoid	0.3	0.45
967R	Automatic Fixed Interval	3672.5	0.004	0.035	Trapezoid	0.3	0.45
968R	Automatic Fixed Interval	111744	0.0016	0.0343	Trapezoid	0.3	0.45
969R	Automatic Fixed Interval	10667	0.002	0.0343	Trapezoid	0.3	0.45
970R	Automatic Fixed Interval	105260	0.0022	0.0343	Trapezoid	0.3	0.45
971R	Automatic Fixed Interval	6219.4	0.0046	0.7	Trapezoid	0.3	0.45
972R	Automatic Fixed Interval	812.88	0.031	0.7	Trapezoid	0.3	0.45
973R	Automatic Fixed Interval	21912	0.0012	0.7	Trapezoid	0.3	0.45
974R	Automatic Fixed Interval	15669	0.0004	0.7	Trapezoid	0.3	0.45
975R	Automatic Fixed Interval	1017.3	0.0008	0.7	Trapezoid	0.3	0.45
976R	Automatic Fixed Interval	30064	0.0011	0.7	Trapezoid	0.3	0.45
977R	Automatic Fixed Interval	625.62	0.0413	0.7	Trapezoid	0.3	0.45
978R	Automatic Fixed Interval	33018	0.0006	0.7	Trapezoid	0.3	0.45
979R	Automatic Fixed Interval	8228.1	0.0116	0.7	Trapezoid	0.3	0.45
980R	Automatic Fixed Interval	615.11	0.0353	0.7	Trapezoid	0.3	0.45
981R	Automatic Fixed Interval	20365	0.0018	0.7	Trapezoid	0.3	0.45
982R	Automatic Fixed Interval	46066	0.0007	0.7	Trapezoid	0.3	0.45
983R	Automatic Fixed Interval	15629	0.0012	0.0343	Trapezoid	0.3	0.45
984R	Automatic Fixed Interval	16808	0.0016	0.7	Trapezoid	0.3	0.45
985R	Automatic Fixed Interval	629.06	0.1229	0.7	Trapezoid	0.3	0.45

Reach Number	Muskingum Cunge Channel Routing							
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
986R	Automatic Fixed Interval	9690.6	0.0149	0.7	Trapezoid	0.3	0.45
987R	Automatic Fixed Interval	33528	0.0002	0.7	Trapezoid	0.3	0.45
990R	Automatic Fixed Interval	60336	0.0007	0.7	Trapezoid	0.3	0.45
991R	Automatic Fixed Interval	1525.1	0.0033	0.7	Trapezoid	0.3	0.45
992R	Automatic Fixed Interval	15601	0.0008	0.7	Trapezoid	0.3	0.45
993R	Automatic Fixed Interval	84057	0.001	0.7	Trapezoid	0.3	0.45
994R	Automatic Fixed Interval	576.41	0.0271	0.7	Trapezoid	0.3	0.45
995R	Automatic Fixed Interval	1422.5	0.0131	0.0233	Trapezoid	0.3	0.45
996R	Automatic Fixed Interval	115562	0.0008	0.7	Trapezoid	0.3	0.45
997R	Automatic Fixed Interval	612.47	0.0532	0.7	Trapezoid	0.3	0.45
998R	Automatic Fixed Interval	30257	0.001	0.7	Trapezoid	0.3	0.45
999R	Automatic Fixed Interval	28646	0.0021	0.7	Trapezoid	0.3	0.45
166R	Automatic Fixed Interval	7027.9	0.0116	0.0553	Trapezoid	30	45

Appendix E. Buntun Model Basin Parameters

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1311B	0.5	74.35	0	26.64795	14.90712	Discharge	1.6863	0.09	Ratio to Peak	0
1314B	0.5	71.2	0	35.0336	19.59792	Discharge	0.60977	0.09	Ratio to Peak	0
1318B	0.5	69.21	0	81.8251	45.7734	Discharge	1.9261	0.09	Ratio to Peak	0
1329B	0.5	77	0	2.99985	1.6782	Discharge	0.026146	0.09	Ratio to Peak	0
1333B	0.5	77	0	3.5	1.2	Discharge	0.000443	0.09	Ratio to Peak	0
1334B	0.5	77	0	16.7888	9.3918	Discharge	1.1689	0.09	Ratio to Peak	0
1335B	0.5	76	0	31.059	17.37468	Discharge	0.89072	0.09	Ratio to Peak	0
1336B	0.5	74.82	0	14.2051	7.9464	Discharge	1.1903	0.09	Ratio to Peak	0
1338B	0.5	71.68	0	45.62915	25.5252	Discharge	0.8244	0.09	Ratio to Peak	0
1339B	0.5	65.57	0	17.73485	9.92088	Discharge	0.34846	0.09	Ratio to Peak	0
1342B	0.5	80	0	17.1689	9.60444	Discharge	0.46338	0.09	Ratio to Peak	0

Appendix

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1343B	0.5	62.73	0	27.65315	15.46932	Discharge	0.49706	0.09	Ratio to Peak	0
1344B	0.5	67.17	0	53.2308	29.77764	Discharge	2.3819	0.09	Ratio to Peak	0
1346B	0.5	72.69	0	13.9461	7.80144	Discharge	0.57712	0.09	Ratio to Peak	0
1347B	0.5	78.39	0	30.4703	17.04528	Discharge	4.3289	0.09	Ratio to Peak	0
1348B	0.5	82.55	0	15.0773	8.43444	Discharge	1.3576	0.09	Ratio to Peak	0
1350B	0.5	66.5	0	7.70245	4.30872	Discharge	0.098821	0.09	Ratio to Peak	0
1353B	0.5	77	0	5.1527	2.88252	Discharge	0.18642	0.09	Ratio to Peak	0
1354B	0.5	77	0	22.4273	12.54588	Discharge	1.6888	0.09	Ratio to Peak	0
1355B	0.5	80.04	0	26.0799	14.58936	Discharge	5.186	0.09	Ratio to Peak	0
1356B	0.5	77	0	11.22275	6.27804	Discharge	1.3241	0.09	Ratio to Peak	0
1358B	0.5	72.63	0	61.98185	34.67292	Discharge	3.9855	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1359B	0.5	77.08	0	18.0096	10.07472	Discharge	2.4216	0.09	Ratio to Peak	0
1363B	0.5	63.43	0	33.3781	18.67188	Discharge	0.26736	0.09	Ratio to Peak	0
1364B	0.5	70.34	0	65.36705	36.56676	Discharge	1.1523	0.09	Ratio to Peak	0
1365B	0.5	75.6	0	28.02835	15.6792	Discharge	0.56028	0.09	Ratio to Peak	0
1367B	0.5	79.36	0	40.2969	22.54224	Discharge	4.0427	0.09	Ratio to Peak	0
1368B	0.5	77	0	12.69485	7.10148	Discharge	1.7339	0.09	Ratio to Peak	0
1370B	0.5	78.15	0	112.8866	63.14952	Discharge	1.9342	0.09	Ratio to Peak	0
1371B	0.5	84	0	118.1835	66.11256	Discharge	1.962	0.09	Ratio to Peak	0
1373B	0.5	82.63	0	23.03385	12.88524	Discharge	4.5657	0.09	Ratio to Peak	0
1376B	0.5	84	0	28.2982	15.83016	Discharge	0.97625	0.09	Ratio to Peak	0
1378B	0.5	78	0	30.67505	17.15976	Discharge	1.2693	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1379B	0.5	82.6	0	14.1204	7.89912	Discharge	0.68643	0.09	Ratio to Peak	0
1380B	0.5	84	0	40.3683	22.5822	Discharge	0.87418	0.09	Ratio to Peak	0
1381B	0.5	85.5	0	12.4999	6.99264	Discharge	0.29543	0.09	Ratio to Peak	0
1382B	0.5	77	0	29.9313	16.74372	Discharge	0.052143	0.09	Ratio to Peak	0
1383B	0.5	78.96	0	30.95575	17.31684	Discharge	2.2175	0.09	Ratio to Peak	0
1385B	0.5	82.55	0	55.4596	31.02456	Discharge	2.7437	0.09	Ratio to Peak	0
1386B	0.5	82.67	0	81.5549	45.62232	Discharge	3.7128	0.09	Ratio to Peak	0
1387B	0.5	72.21	0	41.45085	23.18796	Discharge	1.2153	0.09	Ratio to Peak	0
1388B	0.5	78.8	0	35.79415	20.02344	Discharge	3.0961	0.09	Ratio to Peak	0
1389B	0.5	84	0	20.37805	11.39952	Discharge	0.46309	0.09	Ratio to Peak	0
1390B	0.5	81.12	0	46.4226	25.96908	Discharge	2.1442	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1392B	0.5	84	0	36.34925	20.334	Discharge	0.67048	0.09	Ratio to Peak	0
1393B	0.5	75.43	0	51.40345	28.75548	Discharge	2.1634	0.09	Ratio to Peak	0
1395B	0.5	84	0	10.2921	5.75736	Discharge	0.089663	0.09	Ratio to Peak	0
1396B	0.5	82.89	0	91.9065	51.41292	Discharge	2.6954	0.09	Ratio to Peak	0
1397B	0.5	77	0	1.21695	0.68076	Discharge	0.000295	0.09	Ratio to Peak	0
1398B	0.5	84	0	23.12135	12.9342	Discharge	0.34477	0.09	Ratio to Peak	0
1399B	0.5	81.27	0	62.0557	34.7142	Discharge	3.6	0.09	Ratio to Peak	0
1400B	0.5	73.05	0	40.1513	22.461	Discharge	1.8859	0.09	Ratio to Peak	0
1402B	0.5	72.09	0	68.33295	38.22588	Discharge	1.9998	0.09	Ratio to Peak	0
1404B	0.5	84.21	0	80.78665	45.1926	Discharge	1.8538	0.09	Ratio to Peak	0
1405B	0.5	78.5	0	15.2614	8.53728	Discharge	1.1894	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1406B	0.5	73.67	0	27.8859	15.59952	Discharge	0.68717	0.09	Ratio to Peak	0
1407B	0.5	77	0	18.07015	10.10844	Discharge	0.001329	0.09	Ratio to Peak	0
1408B	0.5	71.33	0	36.7458	20.55588	Discharge	0.49337	0.09	Ratio to Peak	0
1410B	0.5	84.21	0	74.17585	41.49432	Discharge	1.8902	0.09	Ratio to Peak	0
1411B	0.5	84	0	32.85625	18.37992	Discharge	0.40459	0.09	Ratio to Peak	0
1412B	0.5	74.66	0	56.2898	31.48884	Discharge	4.1418	0.09	Ratio to Peak	0
1413B	0.5	74.36	0	41.30735	23.10744	Discharge	1.8354	0.09	Ratio to Peak	0
1414B	0.5	77	0	1.3426	0.7512	Discharge	0.001329	0.09	Ratio to Peak	0
1415B	0.5	84.9	0	19.22725	10.75572	Discharge	0.47712	0.09	Ratio to Peak	0
1416B	0.5	61.85	0	28.4361	15.9072	Discharge	0.60962	0.09	Ratio to Peak	0
1418B	0.5	82.67	0	38.98545	21.80868	Discharge	2.5416	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1419B	0.5	84	0	0.7525	0.42096	Discharge	0.079471	0.09	Ratio to Peak	0
1420B	0.5	76.36	0	12.2304	6.8418	Discharge	0.5334	0.09	Ratio to Peak	0
1421B	0.5	77.67	0	57.49205	32.16132	Discharge	1.9868	0.09	Ratio to Peak	0
1422B	0.5	69.81	0	68.29725	38.20584	Discharge	1.5572	0.09	Ratio to Peak	0
1423B	0.5	77	0	15.582	8.71668	Discharge	0.008715	0.09	Ratio to Peak	0
1424B	0.5	81.73	0	41.46345	23.1948	Discharge	1.7837	0.09	Ratio to Peak	0
1425B	0.5	82.07	0	47.36375	26.49552	Discharge	3.7009	0.09	Ratio to Peak	0
1426B	0.5	72.8	0	21.938	12.27228	Discharge	0.20429	0.09	Ratio to Peak	0
1428B	0.5	66.33	0	37.2043	20.81244	Discharge	0.93105	0.09	Ratio to Peak	0
1429B	0.5	77	0	26.31405	14.72028	Discharge	3.901	0.09	Ratio to Peak	0
1430B	0.5	73.15	0	41.0466	22.96176	Discharge	2.5887	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1431B	0.5	83.22	0	10.2361	5.72616	Discharge	0.42217	0.09	Ratio to Peak	0
1432B	0.5	61.09	0	36.14415	20.21928	Discharge	0.4622	0.09	Ratio to Peak	0
1434B	0.5	78	0	34.55025	19.32756	Discharge	2.6193	0.09	Ratio to Peak	0
1435B	0.5	77	0	14.43995	8.0778	Discharge	1.169	0.09	Ratio to Peak	0
1436B	0.5	79.07	0	37.69815	21.08856	Discharge	6.5588	0.09	Ratio to Peak	0
1439B	0.5	85.29	0	18.7194	29.4	Discharge	0.32497	0.09	Ratio to Peak	0
1440B	0.5	78.05	0	25.6081	14.32524	Discharge	4.7193	0.09	Ratio to Peak	0
1441B	0.5	77	0	4.60635	2.57688	Discharge	0.00192	0.09	Ratio to Peak	0
1442B	0.5	84	0	29.79305	16.66632	Discharge	2.7996	0.09	Ratio to Peak	0
1443B	0.5	84	0	57.67965	20.0004	Discharge	1.2958	0.09	Ratio to Peak	0
1445B	0.5	84	0	46.3463	29.4	Discharge	0.65526	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1446B	0.5	84	0	16.0342	8.96976	Discharge	0.11537	0.09	Ratio to Peak	0
1448B	0.5	77	0	9.1833	5.1372	Discharge	0.018169	0.09	Ratio to Peak	0
1449B	0.5	77	0	11.4212	6.38904	Discharge	0.003102	0.09	Ratio to Peak	0
1450B	0.5	60.33	0	18.1489	10.1526	Discharge	0.1226	0.09	Ratio to Peak	0
1451B	0.5	77	0	21.5222	12.0396	Discharge	1.9451	0.09	Ratio to Peak	0
1453B	0.5	84	0	14.00875	7.8366	Discharge	0.27534	0.09	Ratio to Peak	0
1455B	0.5	76.46	0	21.64295	12.10716	Discharge	3.3589	0.09	Ratio to Peak	0
1456B	0.5	77	0	6.9559	3.89112	Discharge	0.00192	0.09	Ratio to Peak	0
1457B	0.5	61.29	0	43.8809	24.5472	Discharge	2.2054	0.09	Ratio to Peak	0
1458B	0.5	69.98	0	23.5333	13.1646	Discharge	3.6938	0.09	Ratio to Peak	0
1459B	0.5	77	0	0.938	0.52476	Discharge	0.001329	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1460B	0.5	78.25	0	87.12445	48.73788	Discharge	3.1245	0.09	Ratio to Peak	0
1461B	0.5	78.75	0	32.28435	18.06012	Discharge	0.6755	0.09	Ratio to Peak	0
1464B	0.5	84.25	0	56.7098	31.72368	Discharge	1.6102	0.09	Ratio to Peak	0
1465B	0.5	84.21	0	52.77405	29.52216	Discharge	1.8178	0.09	Ratio to Peak	0
1466B	0.5	77.88	0	14.42245	8.06796	Discharge	1.3585	0.09	Ratio to Peak	0
1467B	0.5	77	0	6.8852	3.85164	Discharge	0.39292	0.09	Ratio to Peak	0
1468B	0.5	77	0	20.0585	11.22084	Discharge	1.2813	0.09	Ratio to Peak	0
1469B	0.5	77	0	23.3758	13.07652	Discharge	1.3309	0.09	Ratio to Peak	0
1470B	0.5	77	0	10.1325	5.66832	Discharge	0.029248	0.09	Ratio to Peak	0
1471B	0.5	78.27	0	16.31035	9.12396	Discharge	2.9482	0.09	Ratio to Peak	0
1472B	0.5	77.05	0	15.24705	8.52936	Discharge	1.8198	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1473B	0.5	77	0	21.2394	11.88156	Discharge	0.95542	0.09	Ratio to Peak	0
1474B	0.5	84.53	0	21.245	11.88456	Discharge	0.69145	0.09	Ratio to Peak	0
1475B	0.5	77	0	7.1064	3.97548	Discharge	0.005022	0.09	Ratio to Peak	0
1476B	0.5	77	0	5.53035	3.09384	Discharge	0.003693	0.09	Ratio to Peak	0
1477B	0.5	85.8	0	24.03485	13.44516	Discharge	0.44905	0.09	Ratio to Peak	0
1478B	0.5	77.21	0	44.7188	25.01604	Discharge	4.3682	0.09	Ratio to Peak	0
1479B	0.5	76.38	0	41.30665	23.10708	Discharge	3.5871	0.09	Ratio to Peak	0
1480B	0.5	77	0	41.30665	20.0004	Discharge	0.56294	0.09	Ratio to Peak	0
1481B	0.5	77	0	0.8869	0.4962	Discharge	0.000886	0.09	Ratio to Peak	0
1482B	0.5	84	0	8.4819	4.74492	Discharge	0.093504	0.09	Ratio to Peak	0
1483B	0.5	79.4	0	42.5943	23.82756	Discharge	3.7007	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1484B	0.5	79.75	0	22.2299	12.4356	Discharge	2.342465	0.09	Ratio to Peak	0
1485B	0.5	83.71	0	31.24485	17.4786	Discharge	3.9332	0.09	Ratio to Peak	0
1486B	0.5	77	0	20.03575	11.208	Discharge	4.3867	0.09	Ratio to Peak	0
1487B	0.5	77	0	3.01525	1.68684	Discharge	0.00192	0.09	Ratio to Peak	0
1488B	0.5	79	0	20.34865	11.3832	Discharge	0.49795	0.09	Ratio to Peak	0
1489B	0.5	77	0	4.179	2.33772	Discharge	0.003988	0.09	Ratio to Peak	0
1490B	0.5	81.28	0	34.03015	19.03656	Discharge	3.0053	0.09	Ratio to Peak	0
1491B	0.5	84	0	2.3996	1.34244	Discharge	0.015362	0.09	Ratio to Peak	0
1492B	0.5	47.4	0	2.3996	20.0004	Discharge	0.26589	0.09	Ratio to Peak	0
1493B	0.5	77	0	15.0304	29.4744	Discharge	1.5278	0.09	Ratio to Peak	0
1494B	0.5	75.62	0	19.0407	20.0004	Discharge	4.0425	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1495B	0.5	79.8	0	40.56955	22.69488	Discharge	0.93622	0.09	Ratio to Peak	0
1496B	0.5	81.92	0	41.3252	23.11764	Discharge	1.4966	0.09	Ratio to Peak	0
1497B	0.5	77	0	2.20605	1.2342	Discharge	0.001034	0.09	Ratio to Peak	0
1498B	0.5	69	0	13.4561	7.52736	Discharge	0.19838	0.09	Ratio to Peak	0
1499B	0.5	77	0	3.37925	1.89036	Discharge	0.001182	0.09	Ratio to Peak	0
1500B	0.5	67	0	11.8041	6.60324	Discharge	0.7368	0.09	Ratio to Peak	0
1501B	0.5	77.49	0	25.9084	14.49324	Discharge	2.8141	0.09	Ratio to Peak	0
1502B	0.5	69.76	0	28.73045	16.07196	Discharge	1.5101	0.09	Ratio to Peak	0
1503B	0.5	77	0	1.98415	1.11	Discharge	0.003102	0.09	Ratio to Peak	0
1504B	0.5	77	0	15.99535	8.94792	Discharge	0.6885	0.09	Ratio to Peak	0
1505B	0.5	77	0	6.06865	3.3948	Discharge	0.14048	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1506B	0.5	77	0	6.06865	20.0004	Discharge	1.2974	0.09	Ratio to Peak	0
1507B	0.5	84	0	27.489	29.4	Discharge	0.008863	0.09	Ratio to Peak	0
1508B	0.5	84	0	18.74845	10.488	Discharge	1.4351	0.09	Ratio to Peak	0
1509B	0.5	77	0	11.6592	6.52236	Discharge	0.002659	0.09	Ratio to Peak	0
1510B	0.5	82.33	0	16.29075	9.11304	Discharge	0.48436	0.09	Ratio to Peak	0
1511B	0.5	79.15	0	27.95275	15.63696	Discharge	4.3901	0.09	Ratio to Peak	0
1512B	0.5	83.56	0	17.1773	9.60912	Discharge	1.546872	0.09	Ratio to Peak	0
1513B	0.5	84	0	17.1773	20.0004	Discharge	0.01359	0.09	Ratio to Peak	0
1514B	0.5	80	0	1.44445	20.0004	Discharge	0.35599	0.09	Ratio to Peak	0
1515B	0.5	77.04	0	10.51575	20.0004	Discharge	1.0662	0.09	Ratio to Peak	0
1516B	0.5	77	0	3.0247	1.692	Discharge	0.001329	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1517B	0.5	82.33	0	3.0247	20.0004	Discharge	0.78909	0.09	Ratio to Peak	0
1518B	0.5	77	0	17.0331	20.0004	Discharge	0.000739	0.09	Ratio to Peak	0
1519B	0.5	76.05	0	32.14995	17.98488	Discharge	5.6495	0.09	Ratio to Peak	0
1520B	0.5	76	0	13.5618	7.5864	Discharge	0.60622	0.09	Ratio to Peak	0
1521B	0.5	77.91	0	9.6355	5.39004	Discharge	0.48185	0.09	Ratio to Peak	0
1522B	0.5	78.33	0	12.22515	6.83892	Discharge	0.95823	0.09	Ratio to Peak	0
1523B	0.5	82.16	0	11.7355	6.56484	Discharge	0.76841	0.09	Ratio to Peak	0
1524B	0.5	77.88	0	16.2372	9.08316	Discharge	1.9866	0.09	Ratio to Peak	0
1525B	0.5	84	0	4.13525	2.31324	Discharge	0.024225	0.09	Ratio to Peak	0
1526B	0.5	77.98	0	4.13525	29.4	Discharge	2.172	0.09	Ratio to Peak	0
1527B	0.5	84	0	9.4997	5.31432	Discharge	0.23959	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1528B	0.5	77.43	0	9.4997	20.0004	Discharge	3.358	0.09	Ratio to Peak	0
1529B	0.5	84	0	35.658	29.4	Discharge	0.48066	0.09	Ratio to Peak	0
1530B	0.5	77	0	18.6221	29.4	Discharge	0.003397	0.09	Ratio to Peak	0
1531B	0.5	73.12	0	18.1552	10.15608	Discharge	1.6368	0.09	Ratio to Peak	0
1532B	0.5	77	0	12.1688	6.80736	Discharge	0.002511	0.09	Ratio to Peak	0
1533B	0.5	83.38	0	12.1688	29.4	Discharge	0.38155	0.09	Ratio to Peak	0
1534B	0.5	77	0	13.35075	20.0004	Discharge	0.002807	0.09	Ratio to Peak	0
1535B	0.5	77.92	0	8.28205	4.63308	Discharge	0.53443	0.09	Ratio to Peak	0
1536B	0.5	79.12	0	44.2141	24.73368	Discharge	4.1233	0.09	Ratio to Peak	0
1537B	0.5	82.83	0	9.91865	5.54844	Discharge	0.86251	0.09	Ratio to Peak	0
1538B	0.5	77	0	9.91865	20.0004	Discharge	0.001034	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1539B	0.5	77	0	4.8118	29.4	Discharge	1.582	0.09	Ratio to Peak	0
1540B	0.5	78.03	0	20.24855	20.0004	Discharge	1.3319	0.09	Ratio to Peak	0
1541B	0.5	77	0	17.1353	20.0004	Discharge	0.95217	0.09	Ratio to Peak	0
1542B	0.5	84	0	12.068	20.0004	Discharge	0.017283	0.09	Ratio to Peak	0
1543B	0.5	80.53	0	1.26105	20.0004	Discharge	3.4116	0.09	Ratio to Peak	0
1544B	0.5	79	0	19.7862	29.4	Discharge	3.7305	0.09	Ratio to Peak	0
1545B	0.5	78.95	0	20.63215	11.54172	Discharge	1.9525	0.09	Ratio to Peak	0
1546B	0.5	81.51	0	20.2454	11.32548	Discharge	3.005	0.09	Ratio to Peak	0
1547B	0.5	69.5	0	20.2454	29.4	Discharge	0.071199	0.09	Ratio to Peak	0
1548B	0.5	72.43	0	23.8714	13.35372	Discharge	3.153	0.09	Ratio to Peak	0
1549B	0.5	77	0	23.8714	20.0004	Discharge	0.005022	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1550B	0.5	77	0	0.9373	0.5244	Discharge	0.009158	0.09	Ratio to Peak	0
1551B	0.5	66.1	0	15.5841	8.71788	Discharge	0.8891	0.09	Ratio to Peak	0
1552B	0.5	65.96	0	16.00305	8.95212	Discharge	1.1887	0.09	Ratio to Peak	0
1553B	0.5	73.8	0	22.04615	12.33288	Discharge	1.5156	0.09	Ratio to Peak	0
1554B	0.5	77.74	0	8.6058	4.81404	Discharge	0.84567	0.09	Ratio to Peak	0
1555B	0.5	77	0	5.47505	3.06288	Discharge	0.00192	0.09	Ratio to Peak	0
1556B	0.5	82.33	0	5.47505	20.0004	Discharge	0.1551	0.09	Ratio to Peak	0
1557B	0.5	77	0	11.0432	20.0004	Discharge	0.02585	0.09	Ratio to Peak	0
1558B	0.5	77	0	8.8333	20.0004	Discharge	0.73976	0.09	Ratio to Peak	0
1559B	0.5	77	0	8.42485	4.71288	Discharge	0.37785	0.09	Ratio to Peak	0
1560B	0.5	77	0	8.42485	20.0004	Discharge	0.27298	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1561B	0.5	78.33	0	6.4204	20.0004	Discharge	2.1909	0.09	Ratio to Peak	0
1562B	0.5	75.55	0	17.33585	29.754	Discharge	1.8918	0.09	Ratio to Peak	0
1563B	0.5	77.95	0	24.5301	45	Discharge	2.7478	0.09	Ratio to Peak	0
1564B	0.5	77.44	0	22.79305	45	Discharge	0.76871	0.09	Ratio to Peak	0
1565B	0.5	69	0	2.70165	1.5114	Discharge	0.017283	0.09	Ratio to Peak	0
1566B	0.5	77	0	2.70165	20.0004	Discharge	0.6111	0.09	Ratio to Peak	0
1567B	0.5	77	0	8.10845	20.0004	Discharge	0.005909	0.09	Ratio to Peak	0
1568B	0.5	69.72	0	7.49665	20.0004	Discharge	0.73001	0.09	Ratio to Peak	0
1569B	0.5	78.49	0	22.2033	12.42072	Discharge	2.7029	0.09	Ratio to Peak	0
1570B	0.5	77	0	8.02235	4.48776	Discharge	0.25865	0.09	Ratio to Peak	0
1571B	0.5	77	0	8.02235	20.0004	Discharge	0.54433	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1572B	0.5	78.1	0	6.98075	20.0004	Discharge	3.9958	0.09	Ratio to Peak	0
1573B	0.5	77	0	18.22275	29.4	Discharge	0.01167	0.09	Ratio to Peak	0
1574B	0.5	78.52	0	14.80115	8.27988	Discharge	1.9986	0.09	Ratio to Peak	0
1575B	0.5	80.17	0	29.8487	16.69752	Discharge	4.1561	0.09	Ratio to Peak	0
1576B	0.5	78.2	0	10.62635	5.94456	Discharge	1.2599	0.09	Ratio to Peak	0
1577B	0.5	78.42	0	9.1329	5.109	Discharge	1.029	0.09	Ratio to Peak	0
1578B	0.5	78.36	0	9.1329	20.0004	Discharge	2.8383	0.09	Ratio to Peak	0
1579B	0.5	78.64	0	16.62675	20.0004	Discharge	1.8255	0.09	Ratio to Peak	0
1580B	0.5	77	0	3.9074	2.18592	Discharge	0.065438	0.09	Ratio to Peak	0
1581B	0.5	79.44	0	22.4203	12.54192	Discharge	2.0309	0.09	Ratio to Peak	0
1582B	0.5	78.5	0	9.43775	5.27952	Discharge	0.58687	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1583B	0.5	78.46	0	17.9886	10.06296	Discharge	3.0926	0.09	Ratio to Peak	0
1584B	0.5	75.71	0	17.9886	20.0004	Discharge	1.587	0.09	Ratio to Peak	0
1585B	0.5	77	0	3.68235	2.05992	Discharge	0.003988	0.09	Ratio to Peak	0
1586B	0.5	78.6	0	3.68235	45	Discharge	0.6399	0.09	Ratio to Peak	0
1587B	0.5	79.79	0	27.50685	30.1368	Discharge	2.1339	0.09	Ratio to Peak	0
1588B	0.5	77	0	16.2617	45	Discharge	0.000443	0.09	Ratio to Peak	0
1589B	0.5	77	0	3.2697	1.82904	Discharge	0.075335	0.09	Ratio to Peak	0
1590B	0.5	77	0	3.2627	1.8252	Discharge	0.003988	0.09	Ratio to Peak	0
1591B	0.5	78.5	0	8.5386	4.7766	Discharge	0.6755	0.09	Ratio to Peak	0
1592B	0.5	78.13	0	23.25365	13.00824	Discharge	3.9815	0.09	Ratio to Peak	0
1593B	0.5	77	0	7.48405	4.18656	Discharge	0.002511	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1594B	0.5	78.88	0	7.48405	30.144	Discharge	1.1833	0.09	Ratio to Peak	0
1595B	0.5	77	0	14.26635	30.1404	Discharge	0.003988	0.09	Ratio to Peak	0
1596B	0.5	73.5	0	0.4249	45	Discharge	0.48982	0.09	Ratio to Peak	0
1597B	0.5	82.04	0	8.58165	45	Discharge	1.0412	0.09	Ratio to Peak	0
1598B	0.5	78.45	0	15.8228	30.1464	Discharge	1.8173	0.09	Ratio to Peak	0
1599B	0.5	60.15	0	12.29235	6.87648	Discharge	0.53296	0.09	Ratio to Peak	0
1600B	0.5	81.67	0	12.29235	45	Discharge	0.31818	0.09	Ratio to Peak	0
1601B	0.5	78.7	0	5.54995	45	Discharge	2.3908	0.09	Ratio to Peak	0
1602B	0.5	78.4	0	16.55745	45	Discharge	1.0501	0.09	Ratio to Peak	0
1603B	0.5	78.71	0	12.83695	45	Discharge	1.6995	0.09	Ratio to Peak	0
1604B	0.5	77	0	14.26145	30.12	Discharge	0.001034	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow					
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1605B	0.5	79.33	0	2.3933	30.1488	Discharge	0.54241	0.09	Ratio to Peak	0
1606B	0.5	84	0	9.25925	45	Discharge	0.14417	0.09	Ratio to Peak	0
1607B	0.5	77	0	4.20315	0.12	Discharge	0.000591	0.09	Ratio to Peak	0
1608B	0.5	71.68	0	0.5915	30.1488	Discharge	1.3439	0.09	Ratio to Peak	0
1609B	0.5	74.36	0	19.20555	45	Discharge	1.7574	0.09	Ratio to Peak	0
1610B	0.5	77	0	17.9291	45	Discharge	0.003841	0.09	Ratio to Peak	0
1611B	0.5	71.64	0	23.8238	13.3272	Discharge	1.5062	0.09	Ratio to Peak	0
1612B	0.5	79.16	0	18.4023	10.29444	Discharge	2.1024	0.09	Ratio to Peak	0
1613B	0.5	78.31	0	18.4023	45	Discharge	2.7208	0.09	Ratio to Peak	0
1614B	0.5	77.31	0	21.30345	30.1272	Discharge	3.4539	0.09	Ratio to Peak	0
1615B	0.5	77	0	22.127	30.0852	Discharge	0.005466	0.09	Ratio to Peak	0

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1616B	0.5	77	0	2.49795	30.1488	Discharge	0.020385	0.09	Ratio to Peak	0
1617B	0.5	77	0	1.3538	30.1488	Discharge	0.002068	0.09	Ratio to Peak	0
1618B	0.5	77.71	0	2.0832	30.1488	Discharge	2.1986	0.09	Ratio to Peak	0
1619B	0.5	77	0	16.17175	45	Discharge	0.98319	0.09	Ratio to Peak	0
1620B	0.5	78.87	0	13.91075	45	Discharge	0.66575	0.09	Ratio to Peak	0
1621B	0.5	75.05	0	15.9544	8.925	Discharge	1.0634	0.09	Ratio to Peak	0
1622B	0.5	77	0	0.77945	0.43596	Discharge	0.000443	0.09	Ratio to Peak	0
1623B	11.23045	6.28236	0	11.23045	6.28236	Discharge	1.1393	0.09	Ratio to Peak	0
1624B	22.83995	12.77676	0	22.83995	12.77676	Discharge	3.5109	0.09	Ratio to Peak	0
1625B	22.83995	45	0	22.83995	45	Discharge	4.5561	0.09	Ratio to Peak	0
1979B	3.5	1.2	0	3.5	1.2	Discharge	0.000443	0.09	Ratio to Peak	0

Appendix F. Buntun Model Reach Parameters

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
1000R	Automatic Fixed Interval	1089.438	0.03536	0.050174	Trapezoid	0.3	0.45
1001R	Automatic Fixed Interval	80025.52	0.00295	0.050225	Trapezoid	0.3	0.45
1002R	Automatic Fixed Interval	28095.05	0.00036	0.049	Trapezoid	0.3	0.45
1003R	Automatic Fixed Interval	1389.152	0.00542	0.033333	Trapezoid	0.3	0.45
1004R	Automatic Fixed Interval	2005.898	0.0034	0.05023	Trapezoid	0.3	0.45
1005R	Automatic Fixed Interval	86790.32	0.00339	0.033333	Trapezoid	0.3	0.45
1006R	Automatic Fixed Interval	14043.31	0.00211	0.033333	Trapezoid	0.3	0.45
1007R	Automatic Fixed Interval	6745.905	0.00975	0.075	Trapezoid	0.3	0.45
1008R	Automatic Fixed Interval	1330.784	0.00122	0.050116	Trapezoid	0.3	0.45
1009R	Automatic Fixed Interval	94262.11	0.00215	0.033333	Trapezoid	0.3	0.45
1010R	Automatic Fixed Interval	38102.17	0.0023	0.033333	Trapezoid	0.3	0.45
1011R	Automatic Fixed Interval	1165.656	0.03525	0.050246	Trapezoid	0.3	0.45
1012R	Automatic Fixed Interval	59265.57	0.00233	0.049	Trapezoid	0.3	0.45
1013R	Automatic Fixed Interval	5683.886	0.00173	0.05	Trapezoid	0.3	0.45
1014R	Automatic Fixed Interval	25521.11	0.00189	0.049	Trapezoid	0.3	0.45
1015R	Automatic Fixed Interval	245.021	0.11041	0.050249	Trapezoid	0.3	0.45
1016R	Automatic Fixed Interval	17902.7	0.00343	0.033333	Trapezoid	0.3	0.45
1017R	Automatic Fixed Interval	933.694	0.00985	0.050246	Trapezoid	0.3	0.45
1018R	Automatic Fixed Interval	10923.64	0.0021	0.050211	Trapezoid	0.3	0.45
1019R	Automatic Fixed Interval	73296.27	0.00332	0.05	Trapezoid	0.3	0.45
1020R	Automatic Fixed Interval	2273.718	0.01049	0.049	Trapezoid	0.3	0.45
1023R	Automatic Fixed Interval	9879.938	0.01199	0.033333	Trapezoid	0.3	0.45
1024R	Automatic Fixed Interval	1021.208	0.0204	0.033333	Trapezoid	0.3	0.45
1025R	Automatic Fixed Interval	8705.138	0.04143	0.075	Trapezoid	0.3	0.45
1026R	Automatic Fixed Interval	1699.066	0.04276	0.075	Trapezoid	0.3	0.45
1027R	Automatic Fixed Interval	3980.694	0.01224	0.049422	Trapezoid	0.3	0.45
1028R	Automatic Fixed Interval	17631.04	0.00169	0.033333	Trapezoid	0.3	0.45
1029R	Automatic Fixed Interval	24435.55	0.03446	0.033333	Trapezoid	0.3	0.45
1030R	Automatic Fixed Interval	1125.371	0.00301	0.050187	Trapezoid	0.3	0.45
1031R	Automatic Fixed Interval	1277.925	0.0565	0.075	Trapezoid	0.3	0.45
1032R	Automatic Fixed Interval	24590.18	0.00762	0.075	Trapezoid	0.3	0.45
1033R	Automatic Fixed Interval	1378.005	0.01808	0.033333	Trapezoid	0.3	0.45
1034R	Automatic Fixed Interval	22714.8	0.00439	0.050195	Trapezoid	0.3	0.45
1035R	Automatic Fixed Interval	25523.63	0.00235	0.049	Trapezoid	0.3	0.45
1038R	Automatic Fixed Interval	8064.553	0.00238	0.049	Trapezoid	0.3	0.45

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
1039R	Automatic Fixed Interval	1713.463	0.03277	0.033333	Trapezoid	0.3	0.45
1040R	Automatic Fixed Interval	324.604	0.31229	0.033333	Trapezoid	0.3	0.45
1041R	Automatic Fixed Interval	603.081	0.00126	0.050249	Trapezoid	0.3	0.45
1042R	Automatic Fixed Interval	7356.182	0.01469	0.033333	Trapezoid	0.3	0.45
1043R	Automatic Fixed Interval	20554.87	0.00405	0.033333	Trapezoid	0.3	0.45
1044R	Automatic Fixed Interval	671.555	0.01292	0.033333	Trapezoid	0.3	0.45
1045R	Automatic Fixed Interval	1263.657	0.04346	0.049	Trapezoid	0.3	0.45
1046R	Automatic Fixed Interval	7910.083	0.00338	0.033333	Trapezoid	0.3	0.45
1047R	Automatic Fixed Interval	54446.13	0.00436	0.049	Trapezoid	0.3	0.45
1048R	Automatic Fixed Interval	22585.24	0.00209	0.033333	Trapezoid	0.3	0.45
1049R	Automatic Fixed Interval	48120.26	0.00742	0.033333	Trapezoid	0.3	0.45
1050R	Automatic Fixed Interval	405.621	0.22327	0.033333	Trapezoid	0.3	0.45
1051R	Automatic Fixed Interval	23067.39	0.00924	0.049	Trapezoid	0.3	0.45
1052R	Automatic Fixed Interval	12057.27	0.00172	0.033333	Trapezoid	0.3	0.45
1053R	Automatic Fixed Interval	820.394	0.02329	0.033333	Trapezoid	0.3	0.45
1054R	Automatic Fixed Interval	735.308	0.07659	0.05	Trapezoid	0.3	0.45
1055R	Automatic Fixed Interval	235.135	0.16521	0.05	Trapezoid	0.3	0.45
1056R	Automatic Fixed Interval	8073.233	0.00788	0.05	Trapezoid	0.3	0.45
1057R	Automatic Fixed Interval	266.778	0.0471	0.05	Trapezoid	0.3	0.45
1058R	Automatic Fixed Interval	48072.42	0.01402	0.05	Trapezoid	0.3	0.45
1059R	Automatic Fixed Interval	18498.99	0.00101	0.05	Trapezoid	0.3	0.45
1060R	Automatic Fixed Interval	25054.54	0.00037	0.05	Trapezoid	0.3	0.45
1061R	Automatic Fixed Interval	1091.456	0.00419	0.05	Trapezoid	0.3	0.45
1062R	Automatic Fixed Interval	10255.79	0.00118	0.05	Trapezoid	0.3	0.45
1063R	Automatic Fixed Interval	17592.03	0.00075	0.05	Trapezoid	0.3	0.45
1064R	Automatic Fixed Interval	19848.4	0.00069	0.05	Trapezoid	0.3	0.45
1065R	Automatic Fixed Interval	37629.8	0.00327	0.05	Trapezoid	0.3	0.45
1068R	Automatic Fixed Interval	97761.61	0.00404	0.05	Trapezoid	0.3	0.45
1069R	Automatic Fixed Interval	20108.61	0.00044	0.05	Trapezoid	0.3	0.45
1070R	Automatic Fixed Interval	13350.39	0.00715	0.05	Trapezoid	0.3	0.45
1071R	Automatic Fixed Interval	8283.209	0.00619	0.05	Trapezoid	0.3	0.45
1072R	Automatic Fixed Interval	23176.66	0.00634	0.05	Trapezoid	0.3	0.45
1073R	Automatic Fixed Interval	95284.36	0.00129	0.05	Trapezoid	0.3	0.45
1074R	Automatic Fixed Interval	21672.89	0.00192	0.05	Trapezoid	0.3	0.45
1075R	Automatic Fixed Interval	1359.518	0.00559	0.05	Trapezoid	0.3	0.45

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Man-ning's n	Shape	Width	Side Slope
1076R	Automatic Fixed Interval	22028.75	0.00417	0.05	Trapezoid	0.3	0.45
1077R	Automatic Fixed Interval	22735.28	0.00075	0.05	Trapezoid	0.3	0.45
1078R	Automatic Fixed Interval	6630.927	0.00289	0.05	Trapezoid	0.3	0.45
1079R	Automatic Fixed Interval	62137.54	0.0028	0.05	Trapezoid	0.3	0.45
1080R	Automatic Fixed Interval	910.491	0.01984	0.05	Trapezoid	0.3	0.45
1081R	Automatic Fixed Interval	3616.245	0.01886	0.05	Trapezoid	0.3	0.45
1082R	Automatic Fixed Interval	50310.85	0.00866	0.05	Trapezoid	0.3	0.45
1083R	Automatic Fixed Interval	3733.065	0.00437	0.05	Trapezoid	0.3	0.45
1104R	Automatic Fixed Interval	4893.627	0.00252	0.05	Trapezoid	0.3	0.45
1105R	Automatic Fixed Interval	18917.28	0.00059	0.05	Trapezoid	0.3	0.45
1106R	Automatic Fixed Interval	696.054	0.01546	0.05	Trapezoid	0.3	0.45
1107R	Automatic Fixed Interval	5553.186	0.00893	0.05	Trapezoid	0.3	0.45
1108R	Automatic Fixed Interval	59322.96	0.00016	0.05	Trapezoid	0.3	0.45
1109R	Automatic Fixed Interval	14593.97	0.00023	0.05	Trapezoid	0.3	0.45
1110R	Automatic Fixed Interval	16018.86	0.00028	0.05	Trapezoid	0.3	0.45
1111R	Automatic Fixed Interval	22361.01	0.0013	0.05	Trapezoid	0.3	0.45
1113R	Automatic Fixed Interval	17089.2	0.00295	0.05	Trapezoid	0.3	0.45
1114R	Automatic Fixed Interval	53445.17	0.00086	0.05	Trapezoid	0.3	0.45
1116R	Automatic Fixed Interval	7144.197	0.00063	0.05	Trapezoid	0.3	0.45
1117R	Automatic Fixed Interval	19008.78	0.00217	0.05	Trapezoid	0.3	0.45
1118R	Automatic Fixed Interval	6183.175	0.00225	0.05	Trapezoid	0.3	0.45
1119R	Automatic Fixed Interval	4297.545	0.00049	0.05	Trapezoid	0.3	0.45
1120R	Automatic Fixed Interval	33164.31	0.00095	0.05	Trapezoid	0.3	0.45
1121R	Automatic Fixed Interval	34447.66	0.00122	0.05	Trapezoid	0.3	0.45
1122R	Automatic Fixed Interval	39290.74	0.00101	0.05	Trapezoid	0.3	0.45
1123R	Automatic Fixed Interval	36176.46	0.00032	0.05	Trapezoid	0.3	0.45
1124R	Automatic Fixed Interval	53806.22	0.00012	0.05	Trapezoid	0.3	0.45
1125R	Automatic Fixed Interval	65019.46	0.00044	0.05	Trapezoid	0.3	0.45
1126R	Automatic Fixed Interval	1765.721	0.02489	0.05	Trapezoid	0.3	0.45
1127R	Automatic Fixed Interval	77677.9	0.00029	0.05	Trapezoid	0.3	0.45
1128R	Automatic Fixed Interval	77474.89	0.0004	0.05	Trapezoid	0.3	0.45
1129R	Automatic Fixed Interval	18603.48	0.00005	0.05	Trapezoid	0.3	0.45
1130R	Automatic Fixed Interval	367.415	0.01256	0.05	Trapezoid	0.3	0.45
1131R	Automatic Fixed Interval	5098.452	0.00182	0.05	Trapezoid	0.3	0.45
1132R	Automatic Fixed Interval	25862.84	0.00084	0.05	Trapezoid	0.3	0.45

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
1133R	Automatic Fixed Interval	7283.678	0.00127	0.05	Trapezoid	0.3	0.45
1134R	Automatic Fixed Interval	32531.64	0.00164	0.05	Trapezoid	0.3	0.45
1135R	Automatic Fixed Interval	19560.33	0.00124	0.05	Trapezoid	0.3	0.45
1136R	Automatic Fixed Interval	46549.45	0.00196	0.05	Trapezoid	0.3	0.45
1137R	Automatic Fixed Interval	1042.079	0.0588	0.05	Trapezoid	0.3	0.45
1138R	Automatic Fixed Interval	789.567	0.02917	0.05	Trapezoid	0.3	0.45
1139R	Automatic Fixed Interval	9782.518	0.00131	0.05	Trapezoid	0.3	0.45
1141R	Automatic Fixed Interval	60068.21	0.00247	0.05	Trapezoid	0.3	0.45
1142R	Automatic Fixed Interval	599.343	0.02049	0.05	Trapezoid	0.3	0.45
1143R	Automatic Fixed Interval	14482.83	0.00153	0.05	Trapezoid	0.3	0.45
1144R	Automatic Fixed Interval	48366.27	0.00367	0.05	Trapezoid	0.3	0.45
1145R	Automatic Fixed Interval	65874.03	0.00248	0.05	Trapezoid	0.3	0.45
1146R	Automatic Fixed Interval	370.084	0.24281	0.05	Trapezoid	0.3	0.45
1147R	Automatic Fixed Interval	9746.236	0.00942	0.05	Trapezoid	0.3	0.45
1148R	Automatic Fixed Interval	493.688	0.02457	0.05	Trapezoid	0.3	0.45
1149R	Automatic Fixed Interval	19118.6	0.00077	0.05	Trapezoid	0.3	0.45
1150R	Automatic Fixed Interval	144045.4	0.00318	0.05	Trapezoid	0.3	0.45
1151R	Automatic Fixed Interval	1393.907	0.01383	0.05	Trapezoid	0.3	0.45
1152R	Automatic Fixed Interval	15060.63	0.00747	0.05	Trapezoid	0.3	0.45
1153R	Automatic Fixed Interval	6944.727	0.00308	0.05	Trapezoid	0.3	0.45
1154R	Automatic Fixed Interval	394.545	0.02862	0.05	Trapezoid	0.3	0.45
1155R	Automatic Fixed Interval	15399.54	0.00006	0.05	Trapezoid	0.3	0.45
1156R	Automatic Fixed Interval	8631.509	0.00226	0.05	Trapezoid	0.3	0.45
1157R	Automatic Fixed Interval	28891.55	0.00818	0.05	Trapezoid	0.3	0.45
1158R	Automatic Fixed Interval	1022.359	0.02039	0.05	Trapezoid	0.3	0.45
1159R	Automatic Fixed Interval	1309.203	0.0242	0.05	Trapezoid	0.3	0.45
1160R	Automatic Fixed Interval	35587.6	0.00193	0.05	Trapezoid	0.3	0.45
1161R	Automatic Fixed Interval	753.905	0.01425	0.05	Trapezoid	0.3	0.45
1162R	Automatic Fixed Interval	12158.11	0.00334	0.05	Trapezoid	0.3	0.45
1164R	Automatic Fixed Interval	6606.52	0.00199	0.05	Trapezoid	0.3	0.45
1165R	Automatic Fixed Interval	587.934	0.07107	0.05	Trapezoid	0.3	0.45
1166R	Automatic Fixed Interval	12675.71	0.00419	0.05	Trapezoid	0.3	0.45
1167R	Automatic Fixed Interval	924.328	0.06462	0.05	Trapezoid	0.3	0.45
1168R	Automatic Fixed Interval	4078.101	0.00983	0.05	Trapezoid	0.3	0.45
1169R	Automatic Fixed Interval	564.203	0.01957	0.05	Trapezoid	0.3	0.45

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Man-ning's n	Shape	Width	Side Slope
1170R	Automatic Fixed Interval	807.992	0.03498	0.05	Trapezoid	0.3	0.45
1171R	Automatic Fixed Interval	962.353	0.01981	0.05	Trapezoid	0.3	0.45
1172R	Automatic Fixed Interval	72845.12	0.00378	0.05	Trapezoid	0.3	0.45
1173R	Automatic Fixed Interval	9986.494	0.00689	0.05	Trapezoid	0.3	0.45
1174R	Automatic Fixed Interval	1544.542	0.0538	0.05	Trapezoid	0.3	0.45
1175R	Automatic Fixed Interval	27641.34	0.00293	0.05	Trapezoid	0.3	0.45
1177R	Automatic Fixed Interval	40370.62	0.00663	0.05	Trapezoid	0.3	0.45
1178R	Automatic Fixed Interval	75087.12	0.00726	0.05	Trapezoid	0.3	0.45
1179R	Automatic Fixed Interval	1482.218	0.00311	0.05	Trapezoid	0.3	0.45
1180R	Automatic Fixed Interval	31208.65	0.00359	0.05	Trapezoid	0.3	0.45
1181R	Automatic Fixed Interval	24002.83	0.01437	0.05	Trapezoid	0.3	0.45
1182R	Automatic Fixed Interval	21938.3	0.0135	0.05	Trapezoid	0.3	0.45
1183R	Automatic Fixed Interval	13462.73	0.0012	0.05	Trapezoid	0.3	0.45
1184R	Automatic Fixed Interval	17416.5	0.00312	0.05	Trapezoid	0.3	0.45
1185R	Automatic Fixed Interval	5494.477	0.01863	0.05	Trapezoid	0.3	0.45
1187R	Automatic Fixed Interval	23573.64	0.00936	0.05	Trapezoid	0.3	0.45
1188R	Automatic Fixed Interval	889.715	0.08946	0.05	Trapezoid	0.3	0.45
1189R	Automatic Fixed Interval	33715.21	0.00409	0.05	Trapezoid	0.3	0.45
1190R	Automatic Fixed Interval	34736.11	0.01045	0.05	Trapezoid	0.3	0.45
1191R	Automatic Fixed Interval	39098.72	0.01112	0.05	Trapezoid	0.3	0.45
1192R	Automatic Fixed Interval	6898.952	0.01604	0.05	Trapezoid	0.3	0.45
579R	Automatic Fixed Interval	394.583	0.03179	0.05	Trapezoid	0.3	0.45
612R	Automatic Fixed Interval	746.361	0.082	0.05	Trapezoid	0.3	0.45
627R	Automatic Fixed Interval	1325.231	0.02789	0.05	Trapezoid	0.3	0.45
658R	Automatic Fixed Interval	74754.65	0.0005	0.05	Trapezoid	0.3	0.45
887R	Automatic Fixed Interval	43958.58	0.00037	0.05	Trapezoid	0.3	0.45
888R	Automatic Fixed Interval	10164.26	0.00062	0.05	Trapezoid	0.3	0.45
889R	Automatic Fixed Interval	56834.17	0.00097	0.05	Trapezoid	0.3	0.45
890R	Automatic Fixed Interval	7449.696	0.00184	0.05	Trapezoid	0.3	0.45
891R	Automatic Fixed Interval	30369.27	0.00092	0.05	Trapezoid	0.3	0.45
892R	Automatic Fixed Interval	13128.12	0.00206	0.05	Trapezoid	0.3	0.45
893R	Automatic Fixed Interval	87918.52	0.00029	0.05	Trapezoid	0.3	0.45
894R	Automatic Fixed Interval	33098.34	0.00011	0.05	Trapezoid	0.3	0.45
895R	Automatic Fixed Interval	38916.25	0.00023	0.05	Trapezoid	0.3	0.45
896R	Automatic Fixed Interval	9220.416	0.00393	0.05	Trapezoid	0.3	0.45

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
897R	Automatic Fixed Interval	1452.88	0.02037	0.05	Trapezoid	0.3	0.45
898R	Automatic Fixed Interval	30187.03	0.00188	0.05	Trapezoid	0.3	0.45
899R	Automatic Fixed Interval	10122.18	0.0026	0.05	Trapezoid	0.3	0.45
900R	Automatic Fixed Interval	55278.82	0.00562	0.05	Trapezoid	0.3	0.45
901R	Automatic Fixed Interval	37531.01	0.00049	0.05	Trapezoid	0.3	0.45
902R	Automatic Fixed Interval	37130.18	0.00662	0.05	Trapezoid	0.3	0.45
903R	Automatic Fixed Interval	29683.36	0.00115	0.05	Trapezoid	0.3	0.45
904R	Automatic Fixed Interval	54368.33	0.00971	0.05	Trapezoid	0.3	0.45
905R	Automatic Fixed Interval	18580.51	0.0051	0.05	Trapezoid	0.3	0.45
906R	Automatic Fixed Interval	67778.32	0.0014	0.05	Trapezoid	0.3	0.45
907R	Automatic Fixed Interval	40190.76	0.0033	0.05	Trapezoid	0.3	0.45
908R	Automatic Fixed Interval	24469.15	0.01146	0.05	Trapezoid	0.3	0.45
909R	Automatic Fixed Interval	43520.42	0.00993	0.05	Trapezoid	0.3	0.45
910R	Automatic Fixed Interval	41033.48	0.00247	0.05	Trapezoid	0.3	0.45
924R	Automatic Fixed Interval	55381.09	0.01136	0.05	Trapezoid	0.3	0.45
925R	Automatic Fixed Interval	17875.6	0.00154	0.05	Trapezoid	0.3	0.45
926R	Automatic Fixed Interval	10037.94	0.00805	0.05	Trapezoid	0.3	0.45
927R	Automatic Fixed Interval	28050.39	0.00408	0.05	Trapezoid	0.3	0.45
928R	Automatic Fixed Interval	48859.09	0.00107	0.05	Trapezoid	0.3	0.45
929R	Automatic Fixed Interval	28574.32	0.0011	0.05	Trapezoid	0.3	0.45
949R	Automatic Fixed Interval	27115.27	0.00181	0.05	Trapezoid	0.3	0.45
950R	Automatic Fixed Interval	3045.834	0.0004	0.05	Trapezoid	0.3	0.45
951R	Automatic Fixed Interval	58234.03	0.00353	0.05	Trapezoid	0.3	0.45
952R	Automatic Fixed Interval	9723.996	0.011	0.05	Trapezoid	0.3	0.45
953R	Automatic Fixed Interval	6247.725	0.01755	0.05	Trapezoid	0.3	0.45
954R	Automatic Fixed Interval	27060.82	0.00113	0.05	Trapezoid	0.3	0.45
955R	Automatic Fixed Interval	30542.15	0.00094	0.05	Trapezoid	0.3	0.45
956R	Automatic Fixed Interval	32206.97	0.01075	0.05	Trapezoid	0.3	0.45
957R	Automatic Fixed Interval	3247.044	0.06606	0.05	Trapezoid	0.3	0.45
958R	Automatic Fixed Interval	22750.3	0.00705	0.05	Trapezoid	0.3	0.45
959R	Automatic Fixed Interval	48956.06	0.00295	0.05	Trapezoid	0.3	0.45
960R	Automatic Fixed Interval	30902.11	0.00266	0.05	Trapezoid	0.3	0.45
961R	Automatic Fixed Interval	15942.07	0.00275	0.05	Trapezoid	0.3	0.45
962R	Automatic Fixed Interval	23404.42	0.02662	0.05	Trapezoid	0.3	0.45
963R	Automatic Fixed Interval	23624.04	0.01029	0.05	Trapezoid	0.3	0.45

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Man-ning's n	Shape	Width	Side Slope
964R	Automatic Fixed Interval	22173.71	0.00641	0.05	Trapezoid	0.3	0.45
965R	Automatic Fixed Interval	10203.61	0.02081	0.05	Trapezoid	0.3	0.45
966R	Automatic Fixed Interval	2794.92	0.01473	0.05	Trapezoid	0.3	0.45
967R	Automatic Fixed Interval	3672.487	0.00401	0.05	Trapezoid	0.3	0.45
968R	Automatic Fixed Interval	111743.9	0.00161	0.05	Trapezoid	0.3	0.45
969R	Automatic Fixed Interval	10667.34	0.00202	0.05	Trapezoid	0.3	0.45
970R	Automatic Fixed Interval	105260	0.00218	0.05	Trapezoid	0.3	0.45
971R	Automatic Fixed Interval	6219.409	0.00464	0.05	Trapezoid	0.3	0.45
972R	Automatic Fixed Interval	812.878	0.03096	0.05	Trapezoid	0.3	0.45
973R	Automatic Fixed Interval	21912.12	0.00117	0.05	Trapezoid	0.3	0.45
974R	Automatic Fixed Interval	15668.54	0.00039	0.05	Trapezoid	0.3	0.45
975R	Automatic Fixed Interval	1017.332	0.00076	0.05	Trapezoid	0.3	0.45
976R	Automatic Fixed Interval	30064.33	0.00109	0.05	Trapezoid	0.3	0.45
977R	Automatic Fixed Interval	625.624	0.04126	0.05	Trapezoid	0.3	0.45
978R	Automatic Fixed Interval	33017.58	0.00056	0.05	Trapezoid	0.3	0.45
979R	Automatic Fixed Interval	8228.058	0.0116	0.05	Trapezoid	0.3	0.45
980R	Automatic Fixed Interval	615.108	0.03528	0.05	Trapezoid	0.3	0.45
981R	Automatic Fixed Interval	20365.44	0.00178	0.05	Trapezoid	0.3	0.45
982R	Automatic Fixed Interval	46065.81	0.0007	0.05	Trapezoid	0.3	0.45
983R	Automatic Fixed Interval	15629.27	0.00121	0.05	Trapezoid	0.3	0.45
984R	Automatic Fixed Interval	16807.73	0.00157	0.05	Trapezoid	0.3	0.45
985R	Automatic Fixed Interval	629.062	0.12287	0.05	Trapezoid	0.3	0.45
986R	Automatic Fixed Interval	9690.623	0.0149	0.05	Trapezoid	0.3	0.45
987R	Automatic Fixed Interval	33528.45	0.0002	0.05	Trapezoid	0.3	0.45
990R	Automatic Fixed Interval	60336.06	0.00068	0.05	Trapezoid	0.3	0.45
991R	Automatic Fixed Interval	1525.147	0.00327	0.05	Trapezoid	0.3	0.45
992R	Automatic Fixed Interval	15600.79	0.00082	0.05	Trapezoid	0.3	0.45
993R	Automatic Fixed Interval	84057.46	0.001	0.05	Trapezoid	0.3	0.45
994R	Automatic Fixed Interval	576.414	0.02708	0.05	Trapezoid	0.3	0.45
995R	Automatic Fixed Interval	1422.537	0.01313	0.05	Trapezoid	0.3	0.45
996R	Automatic Fixed Interval	115561.8	0.00079	0.05	Trapezoid	0.3	0.45
997R	Automatic Fixed Interval	612.469	0.05319	0.05	Trapezoid	0.3	0.45
998R	Automatic Fixed Interval	30256.97	0.00095	0.05	Trapezoid	0.3	0.45
999R	Automatic Fixed Interval	28645.76	0.00209	0.05	Trapezoid	0.3	0.45

Appendix G. Sangbay Bridge Model Basin Parameters

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1547B	124.87	60.843	0	38.319	0.02	Discharge	0.0789495	0.75037	Ratio to Peak	0.05
1549B	182.81	68.784	0	17.296	0.02	Discharge	0.0055691	0.76569	Ratio to Peak	0.05
1550B	172.31	92.456	0	0.08226	0.02	Discharge	0.0101553	0.16398	Ratio to Peak	0.05
1551B	181.37	59.047	0	3.3834	0.02	Discharge	0.98589	0.76569	Ratio to Peak	0.05
1552B	34.588	43.163	0	7.4518	0.02	Discharge	1.3181	0.76569	Ratio to Peak	0.05
1553B	182.08	65.925	0	3.0918	0.02	Discharge	1.6805	0.76569	Ratio to Peak	0.05
1568B	181.75	62.281	0	7.7603	0.02	Discharge	0.80948	0.53423	Ratio to Peak	0.05
1569B	183.45	99	0	7.1934	0.02	Discharge	2.9971	0.52088	Ratio to Peak	0.05
1576B	33.874	67.995	0	1.2679	0.02	Discharge	1.397	0.78374	Ratio to Peak	0.05
1579B	183.14	99	0	7.7437	0.02	Discharge	2.0242	0.35434	Ratio to Peak	0.05
1582B	72.938	35.183	0	0.2555	0.02	Discharge	0.65076	0.35434	Ratio to Peak	0.05

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1584B	182.05	75.702	0	5.1974	0.02	Discharge	1.7598	0.78251	Ratio to Peak	0.05
1588B	124.22	68.784	0	26.065	0.02	Discharge	0.00049139	0.76569	Ratio to Peak	0.05
1589B	181.83	68.784	0	2.3469	0.02	Discharge	0.0835358	0.77436	Ratio to Peak	0.05
1590B	181.52	68.784	0	0.090135	0.02	Discharge	0.0044225	0.78251	Ratio to Peak	0.05
1591B	270.97	70.124	0	1.8	0.02	Discharge	0.74904	0.52088	Ratio to Peak	0.05
1592B	77.522	79.872	0	2.865	0.02	Discharge	4.4149	0.76569	Ratio to Peak	0.05
1598B	180.29	99	0	11.184	0.02	Discharge	2.0152	0.76569	Ratio to Peak	0.05
1610B	124.22	68.784	0	26.069	0.02	Discharge	0.0042587	0.76569	Ratio to Peak	0.05
1611B	179.54	88.835	0	7.6521	0.02	Discharge	1.6702	0.5264	Ratio to Peak	0.05
1620B	124.52	70.455	0	26.185	0.02	Discharge	0.73823	0.78131	Ratio to Peak	0.05
1621B	183.18	45.114	0	16.923	0.02	Discharge	1.1792	0.53151	Ratio to Peak	0.05

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1622B	181.64	68.784	0	0.0465218	0.02	Discharge	0.00049139	0.76569	Ratio to Peak	0.05
1623B	60.123	78.835	0	1.5385	0.02	Discharge	1.2634	0.76569	Ratio to Peak	0.05
1625B	123.75	35.301	0	17.456	0.02	Discharge	5.0521	0.52088	Ratio to Peak	0.05

Appendix H. Sangbay Bridge Model Reach Parameters

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
1023R	Automatic Fixed Interval	9879.938	0.01199	0.000853689	Trapezoid	300	1
1034R	Automatic Fixed Interval	22714.796	0.00439	0.000838323	Trapezoid	300	1
1035R	Automatic Fixed Interval	25523.627	0.00235	0.0012549	Trapezoid	300	1
1038R	Automatic Fixed Interval	8064.553	0.00238	0.0013035	Trapezoid	300	1
1040R	Automatic Fixed Interval	324.604	0.31229	0.000580741	Trapezoid	300	1
1041R	Automatic Fixed Interval	603.081	0.00126	0.0029574	Trapezoid	300	1
1042R	Automatic Fixed Interval	7356.182	0.01469	0.000879322	Trapezoid	300	1
1047R	Automatic Fixed Interval	54446.129	0.00436	0.0018879	Trapezoid	300	1
1053R	Automatic Fixed Interval	820.394	0.02329	0.002967	Trapezoid	300	1
1056R	Automatic Fixed Interval	8073.233	0.00788	0.0019264	Trapezoid	300	1
1057R	Automatic Fixed Interval	266.778	0.0471	0.0013067	Trapezoid	300	1
1058R	Automatic Fixed Interval	48072.417	0.01402	0.0068058	Trapezoid	300	1
1173R	Automatic Fixed Interval	9986.494	0.00689	0.0030432	Trapezoid	300	1
1174R	Automatic Fixed Interval	1544.542	0.0538	0.000853689	Trapezoid	300	1
1180R	Automatic Fixed Interval	31208.65	0.00359	0.000580741	Trapezoid	300	1
1184R	Automatic Fixed Interval	17416.498	0.00312	0.001251	Trapezoid	300	1
1185R	Automatic Fixed Interval	5494.477	0.01863	0.0029988	Trapezoid	300	1
1189R	Automatic Fixed Interval	33715.212	0.00409	0.002598	Trapezoid	300	1
1192R	Automatic Fixed Interval	6898.952	0.01604	0.00441	Trapezoid	300	1
612R	Automatic Fixed Interval	746.361	0.082	0.0020388	Trapezoid	300	1
905R	Automatic Fixed Interval	18580.514	0.0051	0.0012549	Trapezoid	300	1
909R	Automatic Fixed Interval	43520.424	0.00993	0.00196	Trapezoid	300	1

Appendix I. Santiago Bridge Model Basin Parameters

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1476B	7.1824	92	0	5.0998	2.0816	Discharge	0.0057073	0.9	Ratio to Peak	0.76157
1477B	7.44917	78	0	1.5207	2.333	Discharge	0.694	0.9	Ratio to Peak	0.62693
1481B	5.73108	79	0	3.2165	3.2075	Discharge	0.0013697	0.9	Ratio to Peak	0.2305
1484B	3.5135	65	0	0.21498	3.277	Discharge	3.6202	0.9	Ratio to Peak	0.62619
1485B	3.10304	57	0	0.8015	1.3053	Discharge	6.0787	0.01	Ratio to Peak	0.51884

Appendix J. Santiago Bridge Model Reach Parameters

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
1154R	Automatic Fixed Interval	394.545	0.02862	0.038416	Trapezoid	30	1
1155R	Automatic Fixed Interval	15399.536	0.00006	0.0549715	Trapezoid	30	1
897R	Automatic Fixed Interval	1452.88	0.02037	0.0877951	Trapezoid	30	1
992R	Automatic Fixed Interval	15600.792	0.00082	0.26656	Trapezoid	30	1

Appendix K. Siffu Bridge Model Basin Parameters

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
1406B	0.5	75.06973	0.0	19.52013	1.169964	Discharge	4.9245	0.99	Ratio to Peak	0
1412B	0.5	76.07854	0.0	39.40286	2.361663	Discharge	7.9780	0.99	Ratio to Peak	0
1434B	0.5	79.482	0.0	24.185175	1.449567	Discharge	0.0791445	0.99	Ratio to Peak	0
1467B	0.5	78.463	0.0	4.81964	0.288873	Discharge	1.0633	0.99	Ratio to Peak	0
1470B	0.5	78.463	0.0	7.09275	0.425124	Discharge	7.0878	0.99	Ratio to Peak	0
1471B	0.5	79.75713	0.0	11.417245	0.684297	Discharge	11.208	0.99	Ratio to Peak	0
1472B	0.5	78.51395	0.0	10.672935	0.639702	Discharge	1.8595	0.99	Ratio to Peak	0

Appendix L. Siffu Bridge Model Reach Parameters

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
1133R	Automatic Fixed Interval	1089.438	0.03536	4.9245	Trapezoid	.3	.45
1141R	Automatic Fixed Interval	80025.515	0.00295	7.9780	Trapezoid	.3	.45
1150R	Automatic Fixed Interval	28095.053	0.00036	0.0791445	Trapezoid	.3	.45
1151R	Automatic Fixed Interval	1389.152	0.00542	1.0633	Trapezoid	.3	.45
1152R	Automatic Fixed Interval	2005.898	0.0034	7.0878	Trapezoid	.3	.45

Appendix M. Cagayan River Discharge HEC-HMS Simulation

DIRECT FLOW (cms)							
Time (hr)	100-yr	25-yr	5-year	Time (hr)	100-yr	25-yr	5-year
0	0	0	0	6	0	0	0
0.1666667	0	0	0	6.1666667	0	0	0
0.3333333	0	0	0	6.3333333	0	0	0
0.5	0	0	0	6.5	0	0	0
0.6666667	0	0	0	6.6666667	0	0	0
0.8333333	0	0	0	6.8333333	0	0	0
1	0	0	0	7	0	0	0
1.1666667	0	0	0	7.1666667	0	0	0
1.3333333	0	0	0	7.3333333	0	0	0
1.5	0	0	0	7.5	0	0	0
1.6666667	0	0	0	7.6666667	0	0	0
1.8333333	0	0	0	7.8333333	0	0	0
2	0	0	0	8	0	0	0
2.1666667	0	0	0	8.1666667	0	0	0
2.3333333	0	0	0	8.3333333	0	0	0
2.5	0.1	0	0	8.5	0	0	0
2.6666667	0.1	0	0	8.6666667	0	0	0
2.8333333	0.2	0	0	8.8333333	0	0	0
3	0.3	0	0	9	0	0	0
3.1666667	0.5	0	0	9.1666667	0	0	0
3.3333333	0.8	0.1	0	9.3333333	0.1	0	0
3.5	1.1	0.1	0	9.5	0.1	0	0
3.6666667	1.5	0.2	0	9.6666667	0.3	0.1	0
3.8333333	2	0.3	0	9.8333333	0.7	0.3	0
4	2.6	0.5	0	10	1.3	0.6	0.1
4.1666667	3.3	0.7	0	10.166667	2.8	1.4	0.4
4.3333333	4.2	0.9	0	10.333333	6.1	3.5	1.3
4.5	5.3	1.3	0	10.5	14	9	4.2
4.6666667	6.5	1.7	0	10.666667	25	16.7	8.5
4.8333333	7.9	2.1	0	10.833333	38	26	13.7
5	9.6	2.7	0	11	53.2	36.7	19.7
5.1666667	11.4	3.4	0.1	11.166667	69.8	48.5	26.2
5.3333333	13.5	4.1	0.1	11.333333	88.9	62	33.6
5.5	15.9	5	0.2	11.5	113.3	79.3	43.3
5.6666667	18.5	6.1	0.2	11.666667	142.7	100.5	55.3
5.8333333	21.4	7.2	0.3	11.833333	175.5	124.1	68.8

DIRECT FLOW (cms)							
Time (hr)	100-yr	25-yr	5-year	Time (hr)	100-yr	25-yr	5-year
12	698.7	422.8	171.1	18.333333	8418.5	6273.4	3771.7
12.166667	768.1	472.1	198	18.5	8746.4	6527.3	3934.7
12.333333	844.5	526.6	227.9	18.666667	9074.8	6781.7	4098.5
12.5	927.8	586.1	260.6	18.833333	9403.4	7036.5	4262.6
12.666667	1018.3	651.1	296.5	19	9730.9	7290.4	4426.3
12.833333	1116.6	722.2	336.2	19.166667	10051	7538.6	4586.5
13	1226.2	802.3	381.9	19.333333	10366.6	7783.5	4744.6
13.166667	1345.4	890.1	433	19.5	10677.8	8025.3	4901.1
13.333333	1471.8	983.5	487.8	19.666667	10982.5	8262.6	5055.2
13.5	1604.5	1081.9	545.9	19.833333	11280.5	8495.3	5207.2
13.666667	1743.7	1185.2	606.9	20	11571.5	8723	5356.5
13.833333	1889.2	1293.3	670.9	20.166667	11854.9	8944.9	5502.6
14	2041.3	1406.6	738.1	20.333333	12126.1	9157.4	5642.6
14.166667	2200.7	1525.7	809.1	20.5	12384.4	9359.9	5776.1
14.333333	2368.3	1651.4	884.7	20.666667	12634.4	9556.1	5905.5
14.5	2541.9	1781.8	963.5	20.833333	12875.3	9745.6	6031.1
14.666667	2721.1	1916.8	1045.2	21	13107.3	9928.7	6153.1
14.833333	2905.8	2055.9	1129.7	21.166667	13330.2	10105.3	6271.6
15	3095.8	2199.1	1216.7	21.333333	13543.5	10274.8	6386
15.166667	3291.3	2346.6	1306.6	21.5	13746	10435.8	6495.2
15.333333	3493	2499.2	1399.9	21.666667	13931.4	10583.5	6595.5
15.5	3705.5	2660.5	1499.2	21.833333	14107.1	10723.6	6690.6
15.666667	3924.8	2827.3	1602.4	22	14273.1	10856.5	6781.3
15.833333	4150.8	2999.3	1709.2	22.166667	14429.6	10982.3	6867.8
16	4383.6	3176.6	1819.3	22.333333	14576.8	11101.4	6950.6
16.166667	4623.1	3359	1932.6	22.5	14714.3	11213.3	7029.1
16.333333	4869.4	3546.6	2049.1	22.666667	14841.7	11317.2	7102.8
16.5	5122.8	3740	2169.4	22.833333	14954	11409.2	7168.4
16.666667	5386.9	3942	2295.6	23	15055.1	11492.2	7227.7
16.833333	5661	4152.1	2427.6	23.166667	15147.4	11568.4	7282.4
17	5942	4367.8	2563.5	23.333333	15232.3	11638.7	7333.2
17.166667	6229.7	4588.6	2702.9	23.5	15309.8	11703.5	7380.6
17.333333	6523.9	4814.5	2845.5	23.666667	15380.1	11762.8	7424.8
17.5	6824.6	5045.3	2991.1	23.833333	15443	11816.4	7465.3
17.666667	7131.7	5281.1	3140	24	15497	11863	7501.4
17.833333	7444.8	5522	3292.4	24.166667	15541.8	11902.4	7532.6
18	7766.1	5769.6	3449.7	24.333333	15579.4	11936.1	7559.9
18.166667	8091.4	6020.6	3609.9	24.5	15609.4	11964	7583.6

DIRECT FLOW (cms)							
Time (hr)	100-yr	25-yr	5-year	Time (hr)	100-yr	25-yr	5-year
24.666667	15632	11986.3	7603.8	31	11730.8	9056.9	5824.8
24.833333	15647.4	12003.3	7620.8	31.166667	11536	8906.8	5728.6
25	15655.3	12014.3	7634	31.333333	11341.4	8756.9	5632.6
25.166667	15655	12018.5	7642.4	31.5	11149.8	8609.4	5538.1
25.333333	15638.4	12009.6	7641.9	31.666667	10958.6	8462.2	5444
25.5	15613.5	11994	7636.3	31.833333	10769.2	8316.1	5350.3
25.666667	15581.2	11972.4	7626.7	32	10581.9	8171.5	5257.2
25.833333	15541.8	11945.2	7613.1	32.166667	10397	8028.5	5164.8
26	15495.4	11912.7	7596.2	32.333333	10214.6	7887.2	5073.3
26.166667	15442.2	11874.9	7576	32.5	10035.3	7748.3	4983.1
26.333333	15381.8	11831.5	7552.3	32.666667	9863	7615	4896.8
26.5	15315.1	11783.2	7525.2	32.833333	9694.5	7484.7	4812.7
26.666667	15242.7	11730.2	7494.8	33	9528.7	7356.5	4729.8
26.833333	15165.2	11673.1	7461.6	33.166667	9365.2	7230	4648
27	15084	11613	7426.3	33.333333	9204	7105.1	4567.1
27.166667	14999.3	11550.1	7389.1	33.5	9045.2	6981.9	4487
27.333333	14910.9	11484.3	7349.8	33.666667	8888.9	6860.6	4408.1
27.5	14819	11415.5	7308.4	33.833333	8735.5	6741.6	4330.6
27.666667	14722.3	11342.9	7264.3	34	8584.9	6624.7	4254.6
27.833333	14620.3	11266	7217.2	34.166667	8436.3	6509.5	4179.7
28	14514.2	11185.8	7167.8	34.333333	8289	6395.2	4105.4
28.166667	14403.6	11102	7116	34.5	8142.9	6281.7	4031.6
28.333333	14288.5	11014.7	7061.9	34.666667	7997.8	6169.1	3958.3
28.5	14169	10924.2	7005.7	34.833333	7854	6057.4	3885.5
28.666667	14045.2	10830.1	6947.3	35	7712	5947.2	3813.8
28.833333	13916.4	10732.1	6886.1	35.166667	7573.2	5839.5	3743.8
29	13779.4	10627.5	6820.6	35.333333	7436.2	5733.3	3674.8
29.166667	13636.9	10518.7	6752	35.5	7301.1	5628.5	3606.8
29.333333	13489.2	10405.7	6680.7	35.666667	7167.8	5525.1	3539.6
29.5	13336.1	10288.7	6606.9	35.833333	7036.4	5423	3473.2
29.666667	13177.6	10167.6	6530.6	36	6906.8	5322.4	3407.7
29.833333	13013.8	10042.4	6451.8	36.166667	6779.1	5223.3	3343.2
30	12844.6	9913.1	6370.3	36.333333	6655	5127.1	3280.7
30.166667	12669	9778.5	6285.3	36.5	6533.4	5032.9	3219.7
30.333333	12487.6	9639.3	6196.9	36.666667	6413.4	4940	3159.7
30.5	12302.1	9496.8	6106.2	36.833333	6294.7	4848.3	3100.5
30.666667	12114	9352.1	6013.8	37	6177.3	4757.5	3042
30.833333	11923.6	9205.5	5920	37.166667	6061.2	4667.7	2984.1

DIRECT FLOW (cms)							
Time (hr)	100-yr	25-yr	5-year	Time (hr)	100-yr	25-yr	5-year
37.333333	5946.3	4579	2926.9	43.666667	2605.1	2005.7	1281.6
37.5	5832.8	4491.3	2870.5	43.833333	2547.9	1961.8	1253.6
37.666667	5720.5	4404.6	2814.6	44	2492.1	1918.8	1226.2
37.833333	5609.5	4318.8	2759.5	44.166667	2437.6	1876.9	1199.5
38	5499.6	4233.9	2704.9	44.333333	2384.4	1836	1173.4
38.166667	5390.7	4149.9	2650.8	44.5	2332.5	1796.1	1148
38.333333	5282.9	4066.6	2597.3	44.666667	2281.8	1757.1	1123.1
38.5	5176.1	3984.2	2544.4	44.833333	2232.2	1718.8	1098.7
38.666667	5070.6	3902.8	2492.3	45	2183.4	1681.3	1074.6
38.833333	4967.3	3823.3	2441.4	45.166667	2135.5	1644.4	1051.1
39	4865.4	3744.9	2391.3	45.333333	2088.5	1608.2	1027.9
39.166667	4764.6	3667.3	2341.9	45.5	2042.4	1572.6	1005.1
39.333333	4664.9	3590.7	2293.1	45.666667	1997.2	1537.8	982.7
39.5	4566.4	3515	2244.8	45.833333	1953	1503.6	960.8
39.666667	4469	3440.1	2197.1	46	1909.6	1470.2	939.4
39.833333	4372.9	3366.2	2149.9	46.166667	1867.8	1438	918.8
40	4277.9	3293.1	2103.4	46.333333	1827	1406.6	898.7
40.166667	4184.1	3220.9	2057.3	46.5	1787	1375.9	879.2
40.333333	4091.6	3149.7	2011.9	46.666667	1748	1345.9	860
40.5	4000.5	3079.6	1967.1	46.833333	1709.8	1316.5	841.3
40.666667	3910.8	3010.5	1922.9	47	1672.4	1287.8	823
40.833333	3822.6	2942.5	1879.3	47.166667	1635.9	1259.7	805.1
41	3736	2875.7	1836.6	47.333333	1600.1	1232.1	787.5
41.166667	3651.6	2810.8	1795.1	47.5	1565	1205.1	770.2
41.333333	3570.3	2748.3	1755.2	47.666667	1530.5	1178.5	753.2
41.5	3490.8	2687.2	1716.4	47.833333	1496.8	1152.5	736.6
41.666667	3413	2627.5	1678.5	48	1463.7	1127	720.2
41.833333	3337	2569.1	1641.4	48.166667	1431.3	1102	704.2
42	3262.6	2512	1605.1	48.333333	1399.7	1077.6	688.5
42.166667	3189.9	2456.1	1569.5	48.5	1368.8	1053.8	673.2
42.333333	3119	2401.6	1534.8	48.666667	1339.1	1030.9	658.6
42.5	3049.6	2348.2	1500.7	48.833333	1310	1008.5	644.3
42.666667	2981.7	2295.9	1467.4	49	1281.6	986.7	630.4
42.833333	2915.3	2244.8	1434.7	49.166667	1253.8	965.3	616.8
43	2850.4	2194.8	1402.7	49.333333	1226.6	944.4	603.5
43.166667	2786.8	2145.8	1371.3	49.5	1200	924	590.4
43.333333	2724.6	2097.8	1340.6	49.666667	1174	904	577.6
43.5	2663.9	2051.1	1310.6	49.833333	1148.6	884.3	565.1

DIRECT FLOW (cms)							
Time (hr)	100-yr	25-yr	5-year	Time (hr)	100-yr	25-yr	5-year
50	1123.6	865.1	552.8	56.333333	486.1	374.1	239
50.166667	1099.1	846.2	540.7	56.5	475.4	366	233.8
50.333333	1075.1	827.7	528.9	56.666667	465	357.9	228.6
50.5	1051.5	809.5	517.2	56.833333	454.8	350.1	223.6
50.666667	1028.4	791.7	505.8	57	444.7	342.4	218.7
50.833333	1005.8	774.3	494.6	57.166667	434.9	334.8	213.9
51	983.8	757.3	483.7	57.333333	425.3	327.4	209.2
51.166667	962.5	740.9	473.2	57.5	415.9	320.1	204.5
51.333333	941.6	724.8	463	57.666667	406.6	313	200
51.5	921.1	709.1	453	57.833333	397.6	306.1	195.5
51.666667	901.1	693.7	443.2	58	388.8	299.3	191.1
51.833333	881.5	678.7	433.6	58.166667	380.2	292.6	186.9
52	862.4	663.9	424.2	58.333333	371.8	286.2	182.7
52.166667	843.6	649.5	415	58.5	363.8	280	178.8
52.333333	825.2	635.3	405.9	58.666667	355.9	273.9	174.9
52.5	807.2	621.5	397.1	58.833333	348.2	268	171.2
52.666667	789.6	607.9	388.4	59	340.7	262.3	167.5
52.833333	772.3	594.6	379.8	59.166667	333.4	256.7	163.9
53	755.4	581.5	371.5	59.333333	326.3	251.2	160.4
53.166667	738.9	568.8	363.3	59.5	319.3	245.8	157
53.333333	722.7	556.3	355.3	59.666667	312.5	240.6	153.7
53.5	707.1	544.2	347.6	59.833333	305.9	235.5	150.4
53.666667	691.8	532.5	340.1	60	299.4	230.5	147.2
53.833333	676.9	521	332.8				
54	662.2	509.8	325.6				
54.166667	647.9	498.7	318.6				
54.333333	633.9	487.9	311.7				
54.5	620.1	477.4	305				
54.666667	606.7	467	298.4				
54.833333	593.4	456.8	291.9				
55	580.5	446.9	285.5				
55.166667	567.8	437.1	279.2				
55.333333	555.3	427.5	273.1				
55.5	543.1	418	267				
55.666667	531.1	408.8	261.1				
55.833333	519.4	399.8	255.3				
56	508.1	391	249.7				
56.166667	497	382.5	244.3				

D R E A M

Disaster RIsk and Exposure Assessment for Mitigation