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# BICOL RIVER BASIN FLOOD CONTROL INVESTIGATION

## VOLUME II
## RESEARCH REPORT

Norbert L. Ackermann
Subin Pinkayan
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Tawatchai Tingsanchali
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In cooperation with
BICOL RIVER BASIN COUNCIL
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VOLUME II – RESEARCH REPORT

# BICOL RIVER BASIN FLOOD CONTROL INVESTIGATION

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# I INTRODUCTION

The research report on the Bicol River Basin flood control investigation is presented in two volumes. Volume I is a summary of the results of the investigation which excludes many of the technical details which have been included in Volume II. In this volume, Chapter II provides a description of the various basin modifications that could serve as possible measures to reduce the effects of flooding in the basin.

Chapter III describes the method used to determine the design rainfall throughout the basin for various return periods. Rainfall-runoff relationships for any design storm were determined for each of the 79 subcatchments that provided independent discharges into the river system of the Bicol Basin. The hydrologic inputs used for the model calibration are also determined.

Chapter IV describes the method by which the water levels in San Miguel Bay and Ragay Gulf were determined. The design water levels were obtained by superimposing the astronomical and the meteorological tides. The meteorological tides, produced by the typhoon selected as the design storm, were determined from an analysis of the wind and pressure conditions existing over San Miguel Bay and Ragay Gulf as the typhoon moved along a selected storm path. The astronomical tides were estimated from an analysis based on approximately one month of tidal records.

Chapter V describes the Flood Control Simulation model which uses as its inputs the hydrologic and water level information described in detail in Chapters III and IV. The simulation model is a hydrodynamic representation of the river system which includes the effects of the various flood control measures. The effects of the flood control measures upon the response of the river flows can be determined individually or in combination. The computer program and its complete description is also presented.

The detailed results indicating the computed water levels at 31 locations along the Bicol and Sipocot Rivers are presented in tabular form for the 13 and 50 year design storms. These figures provide the maximum daily water level for the period prior to as well as during the storm and its recession period. This information is contained in Tables 5.2 thru 5.23 of Chapter V.

# II FLOOD CONTROL MEASURES

This chapter supplements the descriptive presentation of the various proposed flood control measures for the Bicol River Basin in Volume I. Herein are presented the technical description of the flood control measures.

The proposed flood control measures can be classified as:
(1) structures to prevent flood waters from reaching protected areas and (2) schemes designed to promote rapid removal or conveyance of potential flood waters to minimize flood peaks and duration of inundation. The proposed Pulantuna reservoir and tidal barrier at the Bicol Estuary belong to classification (1), while the Sipocot-San Miguel diversion, Bicol-Ragay diversions, Cutoff Channel No.3 and channel deepening downstream of Lake Bato belong to classification (2).

Fig.2.1 shows the Bicol River Basin and the proposed flood control schemes.

## 2.1 Pulantuna Reservoir

The Pulantuna reservoir is proposed to store the flood waters of the Pulantuna River, the upstream tributary of the Sipocot River. The proposed reservoir has the surface area and capacity characteristic shown in Fig.2.2

## 2.2 Tidal Barrier

Several concepts of salinity and tidal barrier in the Bicol Estuary had been proposed by Caldwell (1973). The form of barrier that was utilized in this investigation was the proposed barrier at the vicinity of the ferry crossing at Balongay. It has the following hydraulic features: (1) fifteen gates each at 3.5 m high and 21 m wide; (2) four skimming weirs each 25 m wide; and (3) navigation lock of 52 m long x 10 m wide x 3.6 m deep.

Caldwell reports that the barrier concept would block tide water and storm surge and will pass a design river flood of 3000 $m^3$/sec with a backwater effect of less than 10 cm.

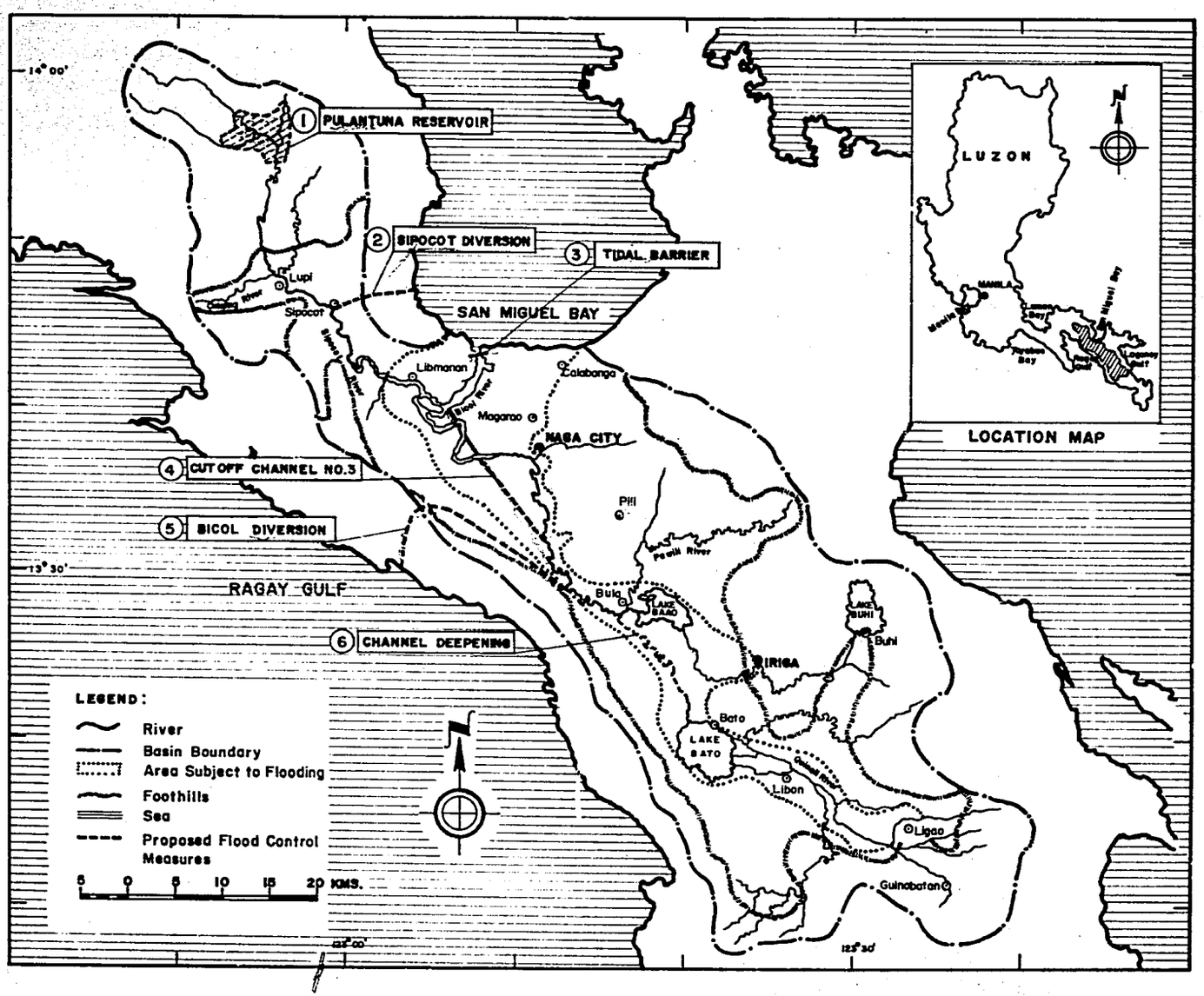



Fig.2.1 - Proposed Flood Control Measures for the Bicol River Basin

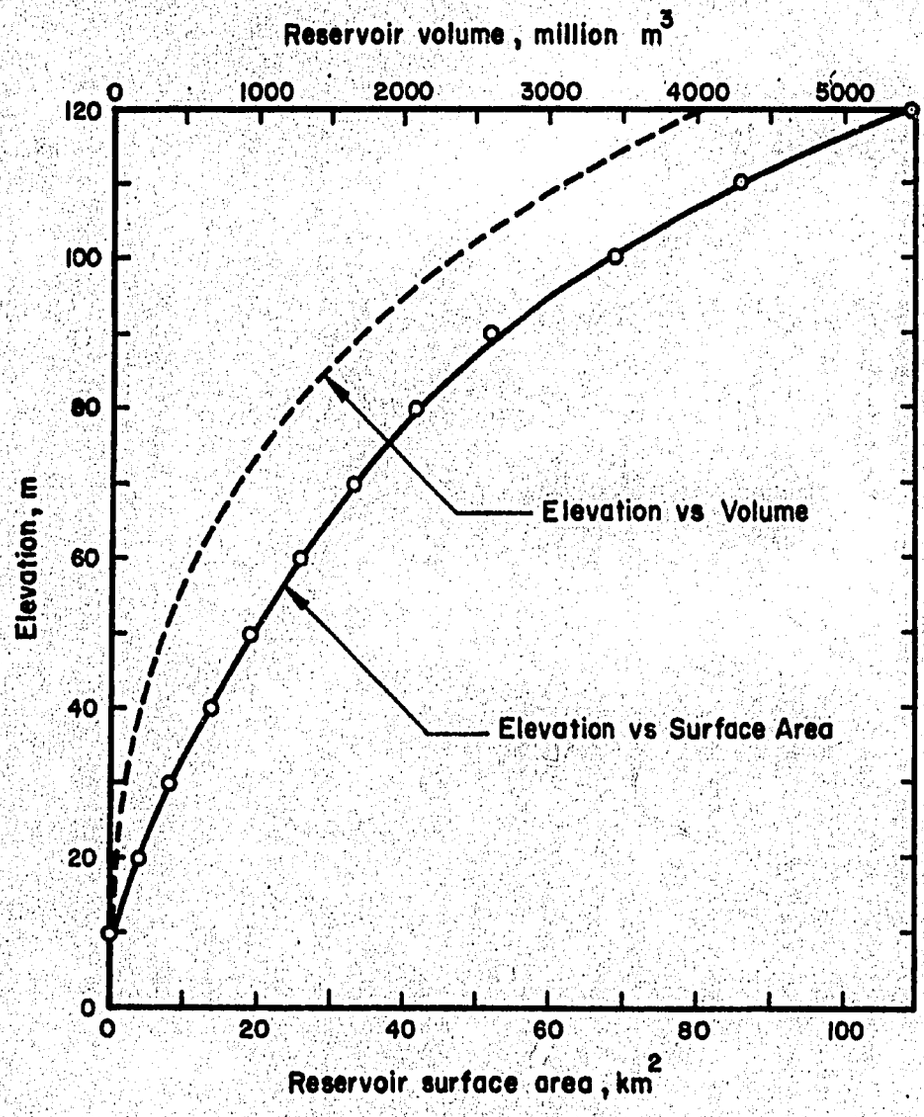



**Fig. 2.2 Elevation – surface area – volume relationships for the Pulantuna reservoir**

## 2.3 Sipocot-San Miguel Diversion

To minimize flooding on the populated lower reaches of the Sipocot River, a diversion channel originating at the town of Sipocot is proposed to divert part of the flow of the Sipocot River directly into San Miguel Bay. The proposed channel is trapezoidal in shape having a 1:1 side slope and topwidth of 8.8 m. On the average, the channel depth is about 10 m on its 8.7 km length. A profile and typical section of the Sipocot-San Miguel diversion is shown in Fig.2.3a.

In this investigation, the hydrodynamic effect of control structures at the point of diversion from the river and at the diversion channel outlet at San Miguel Bay were not considered.

## 2.4 Bicol-Ragay Diversion

As a flood control scheme, a diversion of the flow of the Bicol River near Ombao to the Ragay Gulf has been proposed. This diversion would have the additional purpose of providing irrigation water to a large area on the lower central part of the basin. At the point of diversion from the Bicol River, the canal is downstream of approximately one half of the drainage area of the Bicol River.

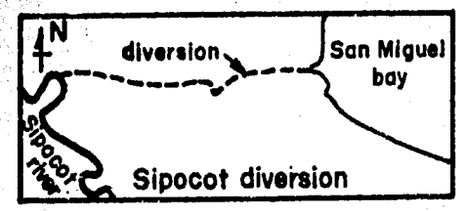
The proposed diversion is about 26 km long, the upstream end being near Ombao and the channel outlet at Pasacao in the Ragay Gulf. The diversion channel gradually increases in cross-section from its departure from the Bicol River to its outlet. The upstream and downstream ends have topwidths of 40 m and 70 m respectively.

The location, typical channel sections and profile of the diversion channel are shown in Fig.2.3b.

Like the Sipocot diversion, no hydraulic controls at the upstream and downstream ends of the channel were considered in this study.

## 2.5 Cutoff Channel No.3

Cutoff No.3 is the third cutoff in a proposed series of cutoff channels on the meandering course of the Bicol River. The series of cutoffs would shorten the course of the river, thus increasing the hydraulic gradient and the river's conveyance capacity. It seems intuitive that periods of

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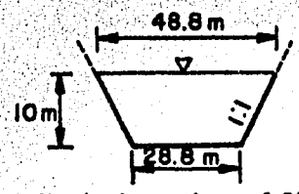
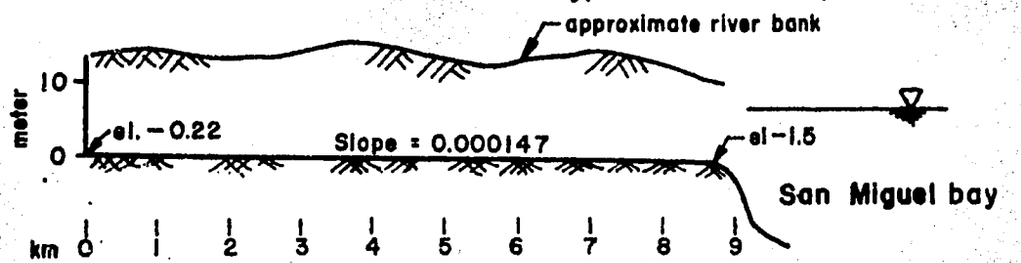
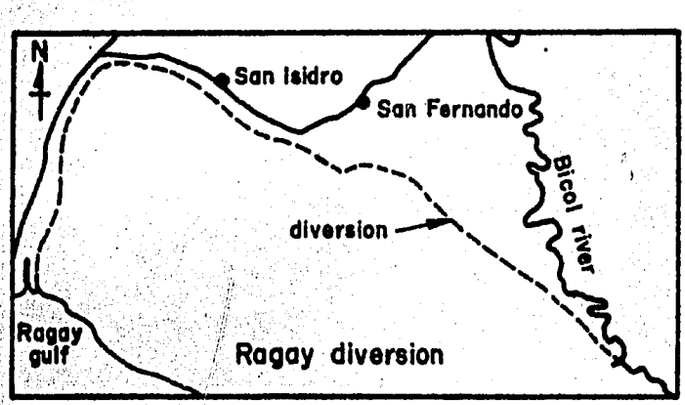



Typical section of Sipocot diversion

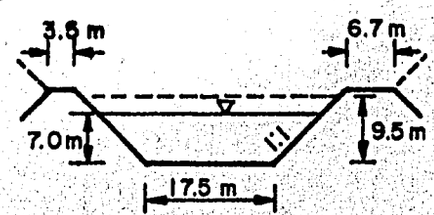



Longitudinal section of Sipocot diversion

(a)




Plan

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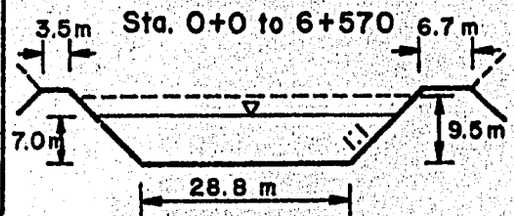


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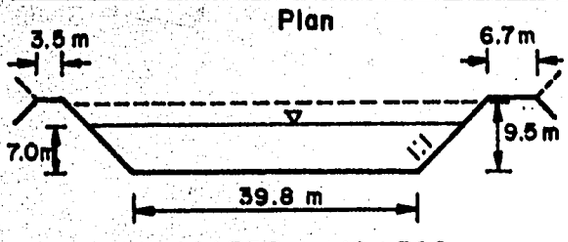


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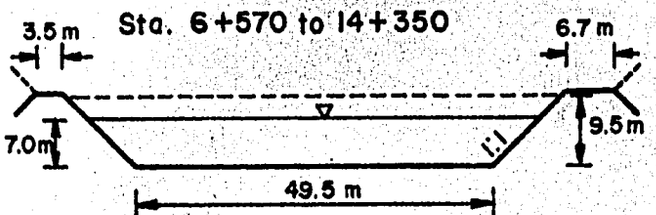


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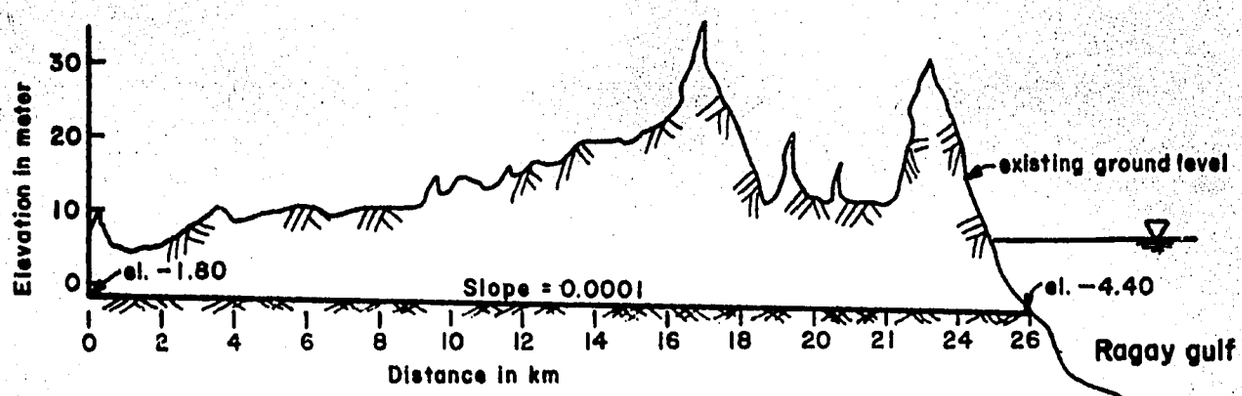
Typical cross-sections of Bicol - Ragay diversion




Longitudinal section of Bicol - Ragay diversion

(b)

Fig. 2.3 Plan, section and profile of the Sipocot-San Miguel and Bicol-Ragay diversions

inundation by flood waters will be shortened on the upper reaches of the Bicol River by the construction of Cutoff No.3.

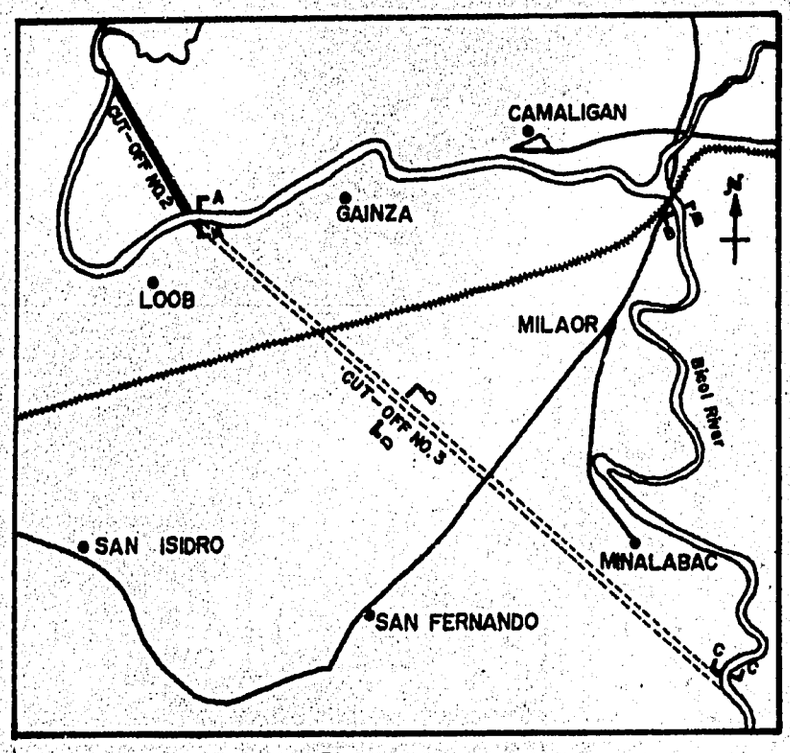
The two cutoffs downstream of Cutoff No.3 have been constructed, while Cutoff No.3, the longest of the series of cutoffs, is completed for approximately one half its proposed length.

The plan view, typical sections and profile of Cutoff No.3 are shown in Fig.2.4.

## 2.6 Channel Deepening

An examination of the Bicol River bed profile indicates the existence of a hump on a reach immediately downstream from Lake Bato. This hump acts as a control for the flow from the lake thereby making the lake somewhat similar to a natural reservoir. With the deepening of the channel, flood waters impounded in this natural reservoir could be drained more readily.

Fig.2.5 shows the location and bed profile of the 15 km reach to be deepened. With an improved channel depth at elevation 2.0 m, the average depth of cut on the river channel is about 2.0 m.

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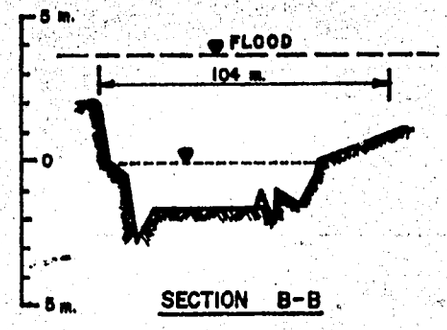


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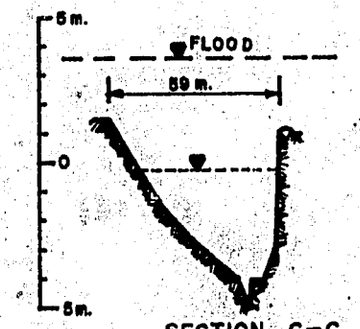


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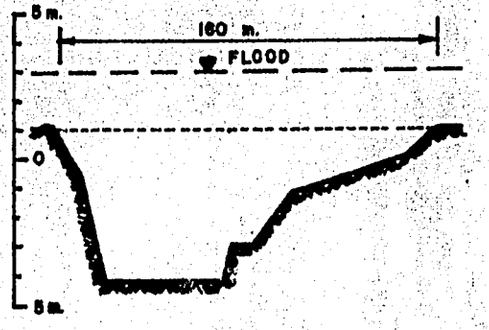


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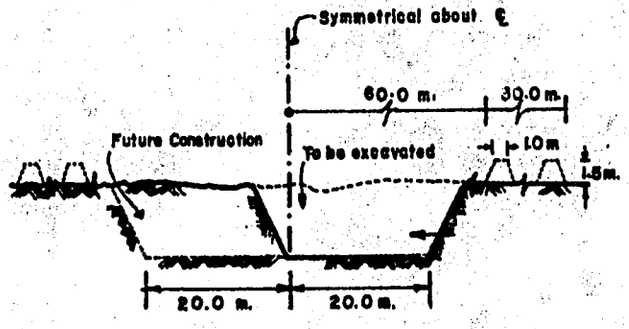
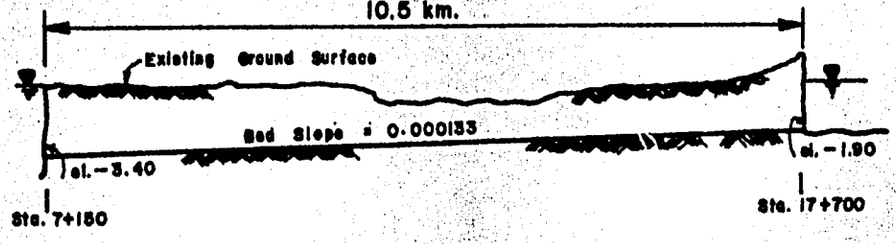
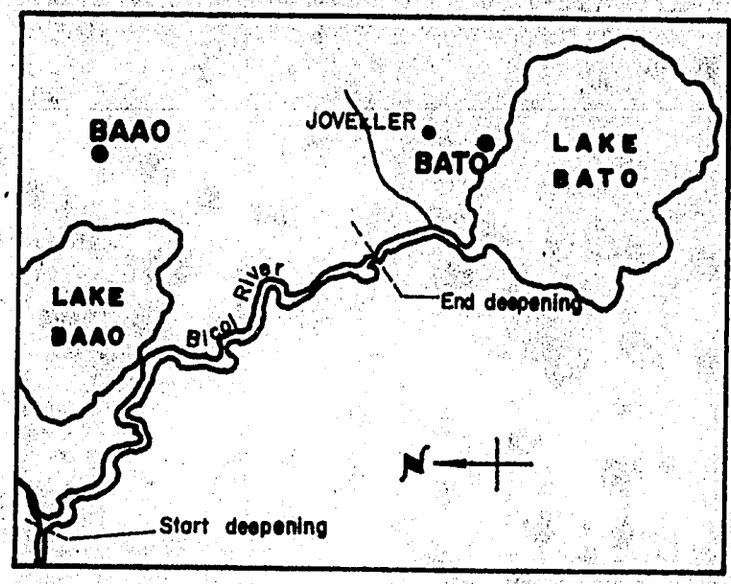



SECTION D-D




Longitudinal Section of Proposed Cut-off No.3

**Fig. 2.4 Plan, section and profile of cut-off No. 3**



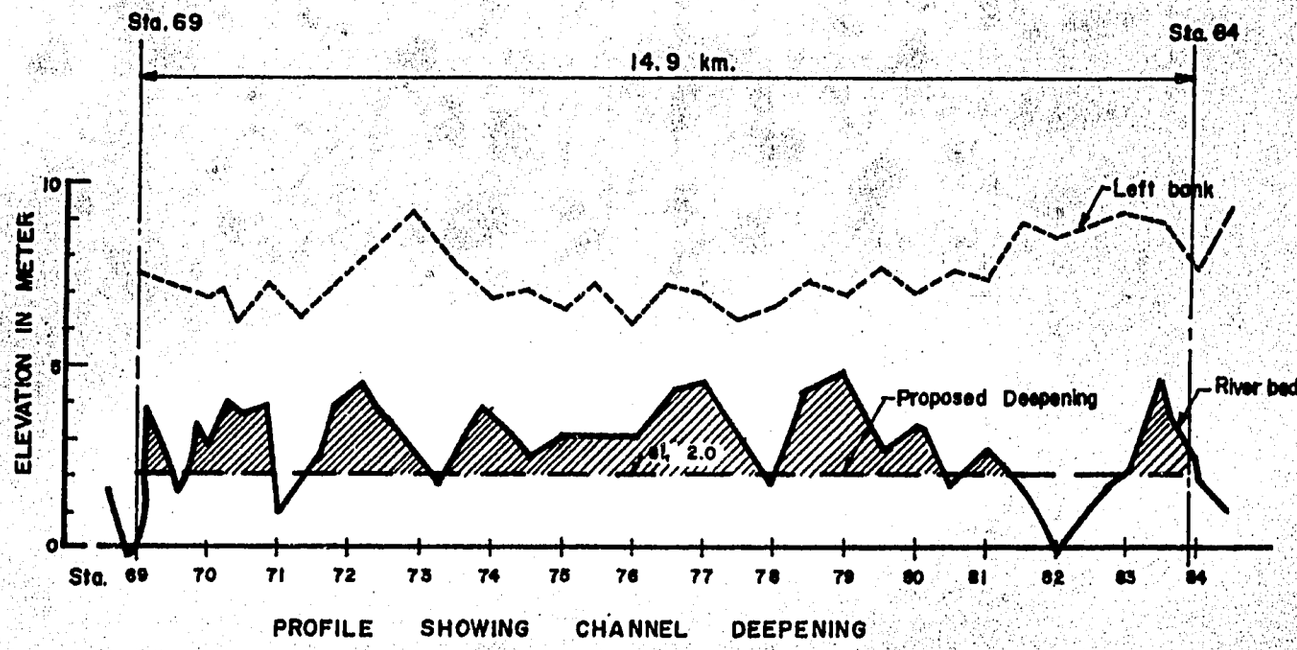




**Fig. 2.5 Channel improvement on the Bicol river**

# III HYDROLOGIC INVESTIGATION

## 3.1 Introduction

In this study, the objective is to provide the hydrologic input required by the mathematical (flood control simulation) model. The methods used to estimate these inputs were partly determined by the available hydrologic data and partly by the level of accuracy expected in the mathematical model.

3.1.1 Objectives The requisite inputs to the mathematical model are rainfall and runoff values, either observed or estimated. It is the objective of this study to estimate these inputs which are namely: (1) catchment runoff from the October 1970 typhoon to be used jointly for model calibration and as inputs for the 13 year design storm; and (2) runoff from a 50-year design basin rainfall to be used in the flood control study.

3.1.2 Available Hydrologic Data Observed hydrologic data in the basin that are available are: (1) daily discharge and staff gage readings; and (2) daily rainfall measured at stations within and nearby the basin. Data from two synoptic stations nearby the basin are also available. A listing of streamflow and raingage stations and corresponding length of records are shown in Tables 3.1 and 3.2. The location of each of these stations in the basin is shown in Fig.3.1.

## 3.2 Distribution Graph

The unit hydrograph method is the commonly used method to obtain the runoff from a design rainfall. In this study, the unit hydrograph method could not be used since rainfall and runoff data, taken at intervals shorter than one day, were not available. The distribution graph method was used instead. This method, though the peak runoff is roughly estimated, the total volume of runoff, which is the main problem in drainage lasting several days, could be satisfactorily estimated.

3.2.1 Principle of Distribution Graph The distribution graph is simply a graph showing the distribution of the total volume of the direct runoff at the catchment outlet, produced by a storm falling during a

Table 3.1 - Streamflow Gaging Station in the Basin

| No. Sta. | Stream Gaging Station | Drainage Area Sq.Km | Available Record |
|---|---|---|---|
| 1 | San Francisco River, Bobongsuran | 131 | |
| 2 | Cabilogan River, Bobongsuran | 164 | |
| 3 | Ugsong River, Benanuan | 11 | |
| 4 | Nasisi River | 39 | |
| 5 | Iraya River | 217 | |
| 6 | Talisay River | 90 | |
| 7 | Quinali River | 232 | |
| 8 | San Agustin River | 262 | |
| 9 | Agus River | 111 | |
| 10 | Naporog (Lal-lo) | 22 | |
| 11 | Lake Bato | 874 | |
| 12 | Bicol River, Sto. Domingo | 905 | |
| 13 | Barit River | 142 | |
| 14 | Pawili River, San Vicente | 112 | |
| 15 | Pawili River, San Roque | 240 | |
| 16 | Bicol River, Ombao | 1630 | |
| 17 | Anayan River | 17 | |
| 18 | Bicol River, Baliwag Nue. Vo. | 1720 | |
| 19 | Bicol River, Mobulo, Naga City | 1930 | |
| 20 | Yabo River | 20 | |
| 21 | Pulantuna River | 172 | |
| 22 | Culacling River | 64 | |
| 23 | Pulantuna, Greek | 55 | |
| 24 | Sipocot River | 447 | |
| 25 | Aslong River | 12 | |
| 26 | Libmanan River | 596 | |
| 27 | Bicol River, Cuyapi | 2717 | |

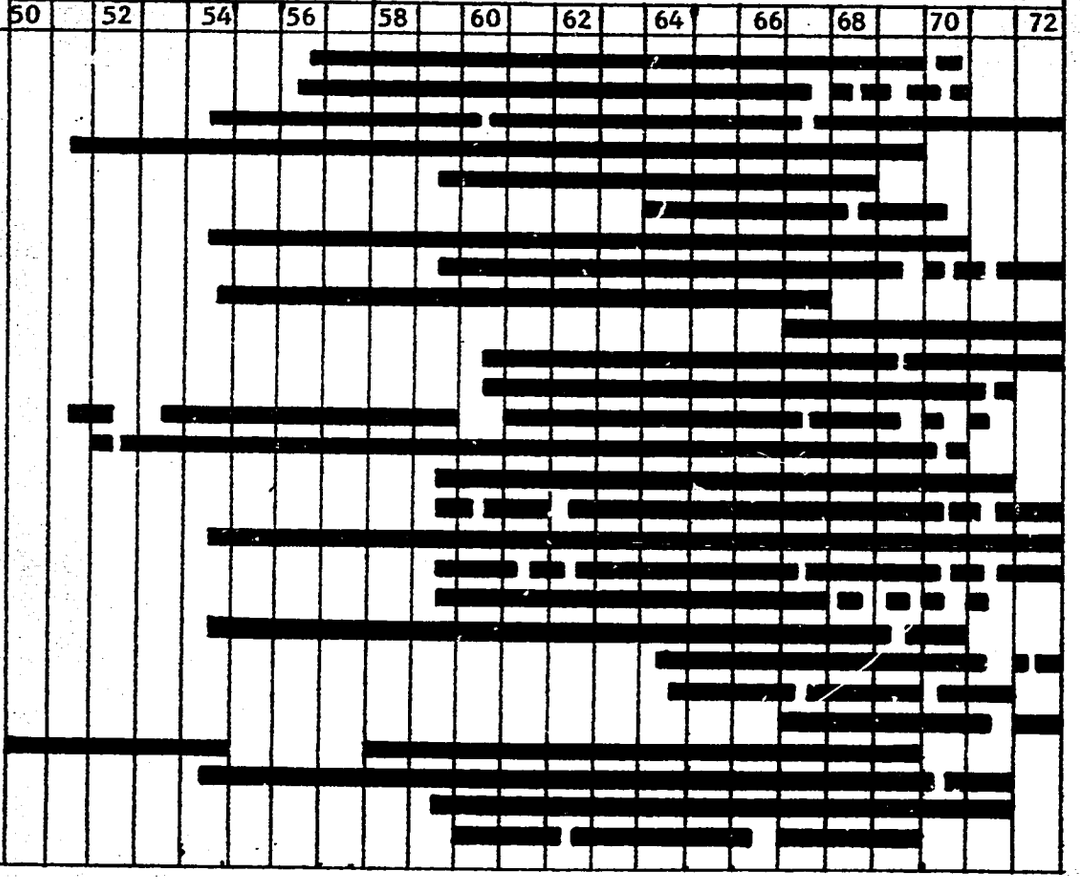
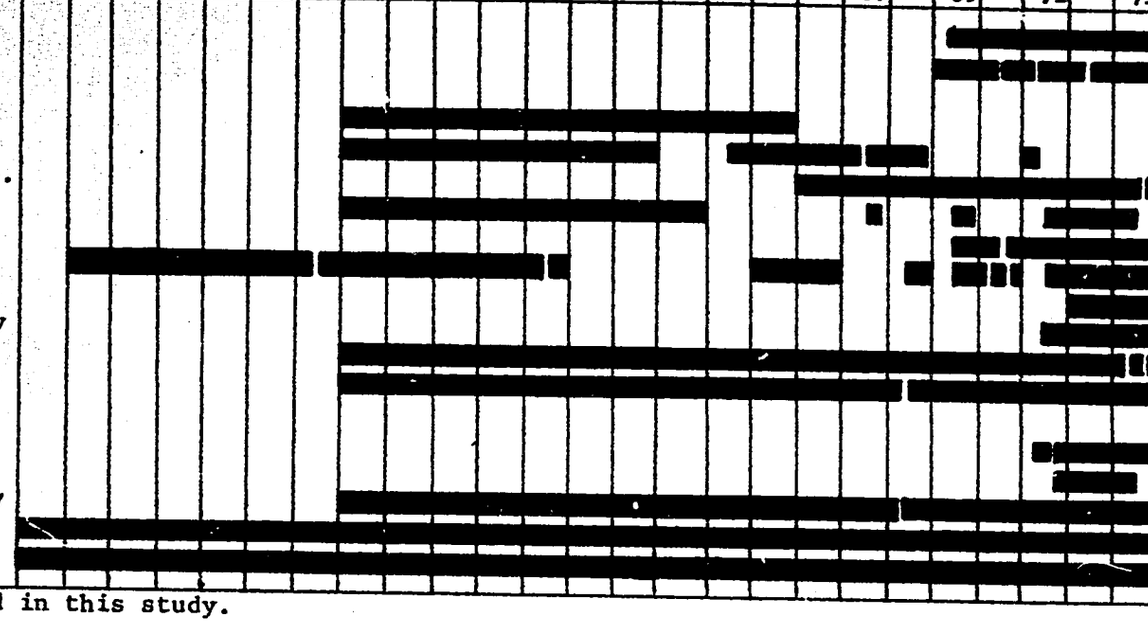


Table 3.2 - Rainfall Stations in the Bicol River Basin and Vicinity

| | Station No. and Name | Years of Record | Record Length (years) |
|---|---|---|---|
| 2 | Sabang, Sipocot, Camarines Sur | | 5 |
| 3 | Inarihan River Irrig. Syst., Calabanga, C.S. | | 5 |
| 4 | Yabo Farm, Naga City, C.S. | | 10 |
| 5 | Concepcion, Naga City, C.S. | | 13 |
| 6 | B.R.C.E.S., San Agustin, Pili, C.S. | | 8 |
| 7 | S.C.P. #9, San Jose, Banasi, C.S. | | 13 |
| 9 | Sta. Crug, Baao, C.S. | | 5 |
| 10 | Buhi, Buhi, C.S. | | 19 |
| 11 | Bato Central School, Bato, C.S. | | 2 |
| 12 | Libon Central School, Libon, Albay | | 3 |
| 13 | S.C.P. #4, Ligao, Albay | | 18 |
| 14 | Guinobatan Exp. Sta., Guinobatan, Alb. | | 18 |
| 15 | Sta. Malama, Ligao, Albay | | |
| 16 | *Pantao, Libon, Albay | | 3 |
| 18 | *Sto. Domingo, Sto. Domingo, Albay | | 3 |
| 19 | *Legaspi City, Albay | | 18 |
| 21 | *Daet, Camarines Norte | | 25 |
| | | | 25 |




* Stations outside the river basin used in this study.

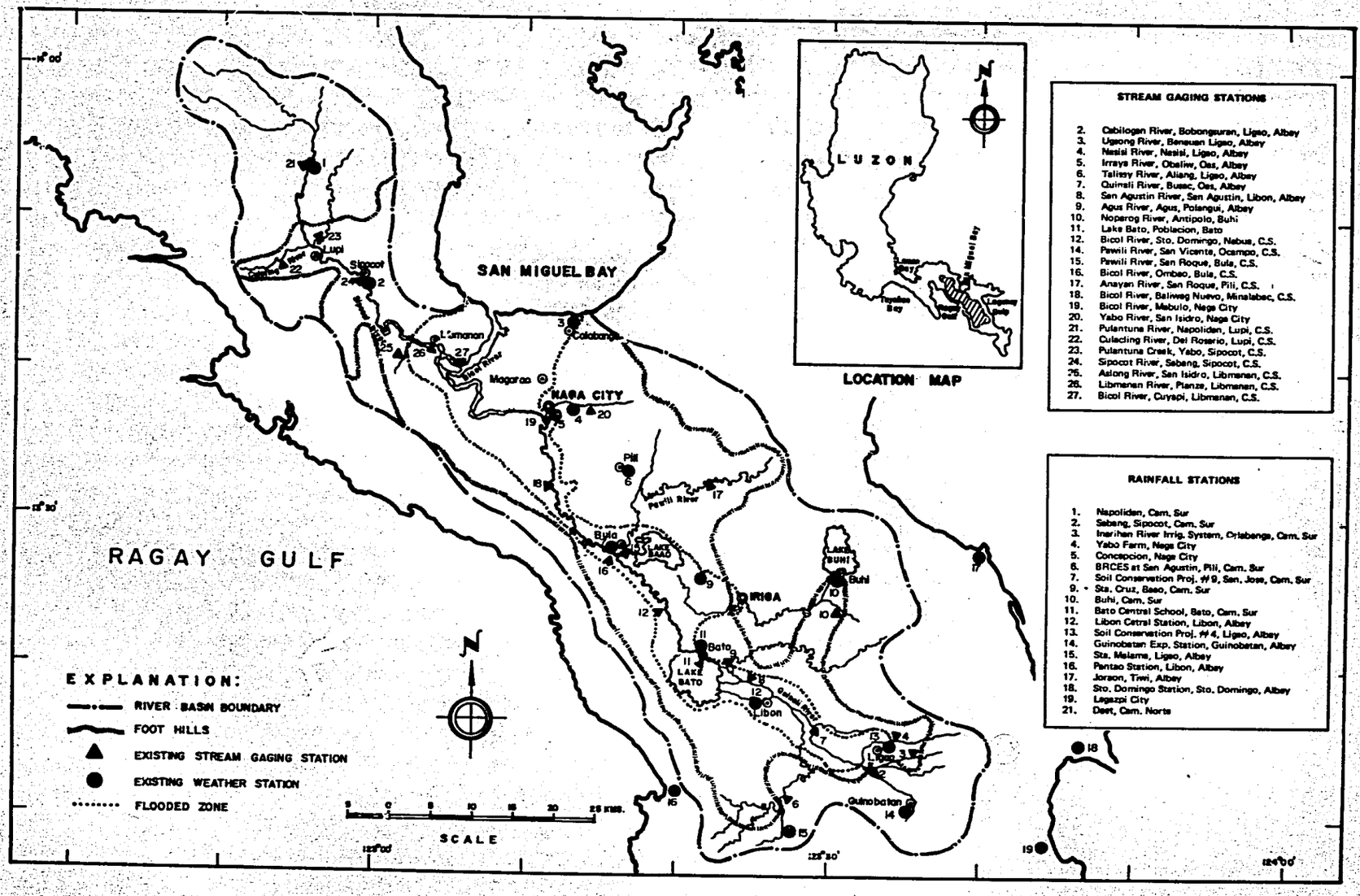



Fig.3.1 - Location of Streamflow and Raingage Stations in the Bicol River Basin

period uninfluenced by a preceeding and subsequent rainfalls. The distribution graph principle is based on a concept of the unit graph, described first by Bernard (1935).

3.2.2 Storm Characteristics A storm period to produce the distribution graph of a watershed must have the following characteristics: (1) the rain must have fallen within the recording time interval, or the time unit, as day or hour; (2) the storm must have been well distributed over the watershed, all stations showing an appreciable depth of rainfall; and (3) the storm period must occupy a place of comparative isolation in the record, i.e. it should follow a period of low streamflow and there should be no further rainfall until the flood peak is well passed.

## 3.3 Distribution Graphs for the Bicol River Basin

3.3.1 October 1970 Storm An examination of all the recorded rainfalls due to major storms in the basin occurring from 1950 to 1973 indicated that two days is the predominant storm duration, hence two-days was taken as the storm duration to be used in the distribution graph. Further, it was found that the storm of October 12-13, 1970 satisfied the required storm characteristics for the distribution graph. As will be shown later (section 3.7), this storm was the second largest basin storm in terms of two-day total rainfall and has a recurrence interval of once every 13 years. Thus this storm was used in deriving the distribution graph since aside from satisfying the storm characteristic, it has, in comparison with other storms, fairly reliable streamflow data for the period of the storm.

The rainfall hyetographs for the October 1970 storms for 3 stations in the basin are shown in Fig.3.2.

3.3.2 Streamflow Data Used Streamflow data of eleven catchments namely Station Nos.1, 3, 7, 8, 14, 15, 17, 20, 21, 22 and 23 were available for the period of October 11-21, 1970. An examination of the streamflow records of the above mentioned stations indicated the following: (1) for Station No.23, the record of the peak discharge on the 13th is of doubtful accuracy because of its unreasonably low value; (2) for Station No.8, the peak discharge is missing; and (3) Station No.15 is reported to be

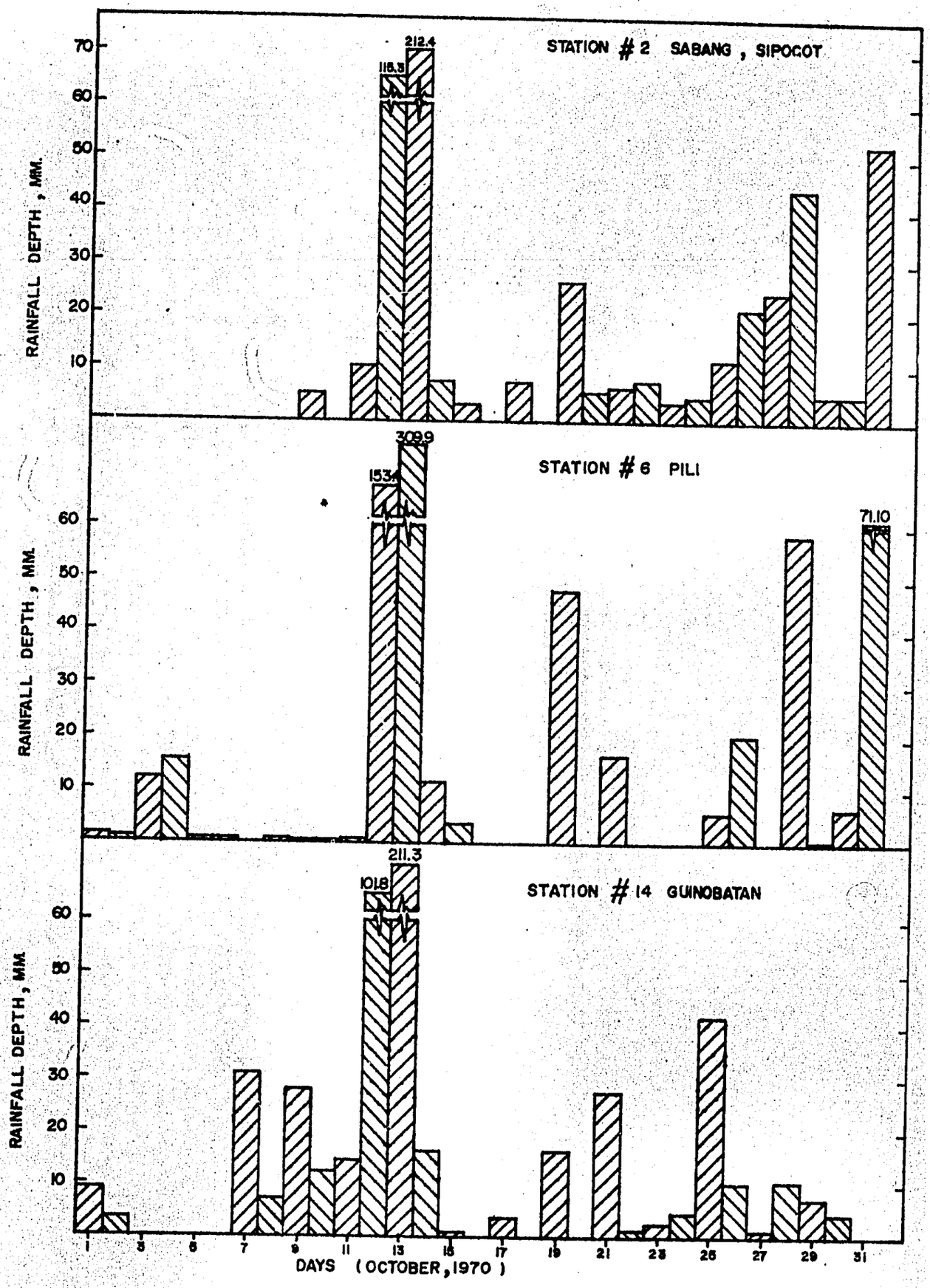



Fig. 3.2 October 1970 rainfall hyetographs for stations # 2 Sabang, # 6 Pili, and # 14 Guinobatan in the basin

affected by tide. Hence, for the above mentioned reasons, Station Nos.8, 23 and 15 were not used in the derivation of the distribution graph.

The plots of the observed hydrograph for Station Nos.1, 3, 7, 14, 17, 20, 21 and 22 for the period of October 11-21, 1970 are shown in Fig.3.3. Where some corrections on the hydrograph have to be made due to the effect of an appreciable rainfall subsequent to the two-day storm, they are indicated in the plots in Fig.3.3.

3.3.3 Calculations and Results Table 3.3 shows the calculation of the distribution graph for Station No.3, Ugsong River at Ligao, Albay.

The calculations were as follows: (1) Necessary corrections were made on the observed hydrograph, e.g. for the effect of subsequent rainfall on the isolated storm (Col.3); (2) Base flow was estimated (Col.4); (3) Segregated flow was obtained, i.e. modified flow less base flow (Col.5); (4) The percentage of flow for the time interval with respect to the total flow was calculated (Col.6); and (5) The percentage flow was cumulated to get the distribution graph mass curve. Calculations for the remaining 7 stations and comments on modification of the observed hydrographs are shown in Section A1 of Appendix A.

A plot of the cumulative percentages of the distribution graph for each of the eleven catchments as shown in Fig.3.4, indicated that the distribution graphs can be classified into two, namely: one for catchments whose drainage area is less than 50 sq.km. and the other for area greater than or equal to 50 sq.km. From the eye-fitted line of the cumulative percentages or mass curve, the distribution graph can be obtained as shown in Fig.3.4.

Certain unavoidable sources of error and inaccuracy must be recognized and accepted in the data that was used for deriving the distribution graphs. It is highly probable that at many raingage stations, the readings are taken at irregular intervals. A continuous storm of 24 hours or less may be divided by the recording hour, appearing in the record as a 2-day storm. Streamflow is recorded as a 24-hour average, obscuring true instantaneous maximum values, particularly on small watersheds. Also on small watersheds, it is possible that the entire rainfall may have

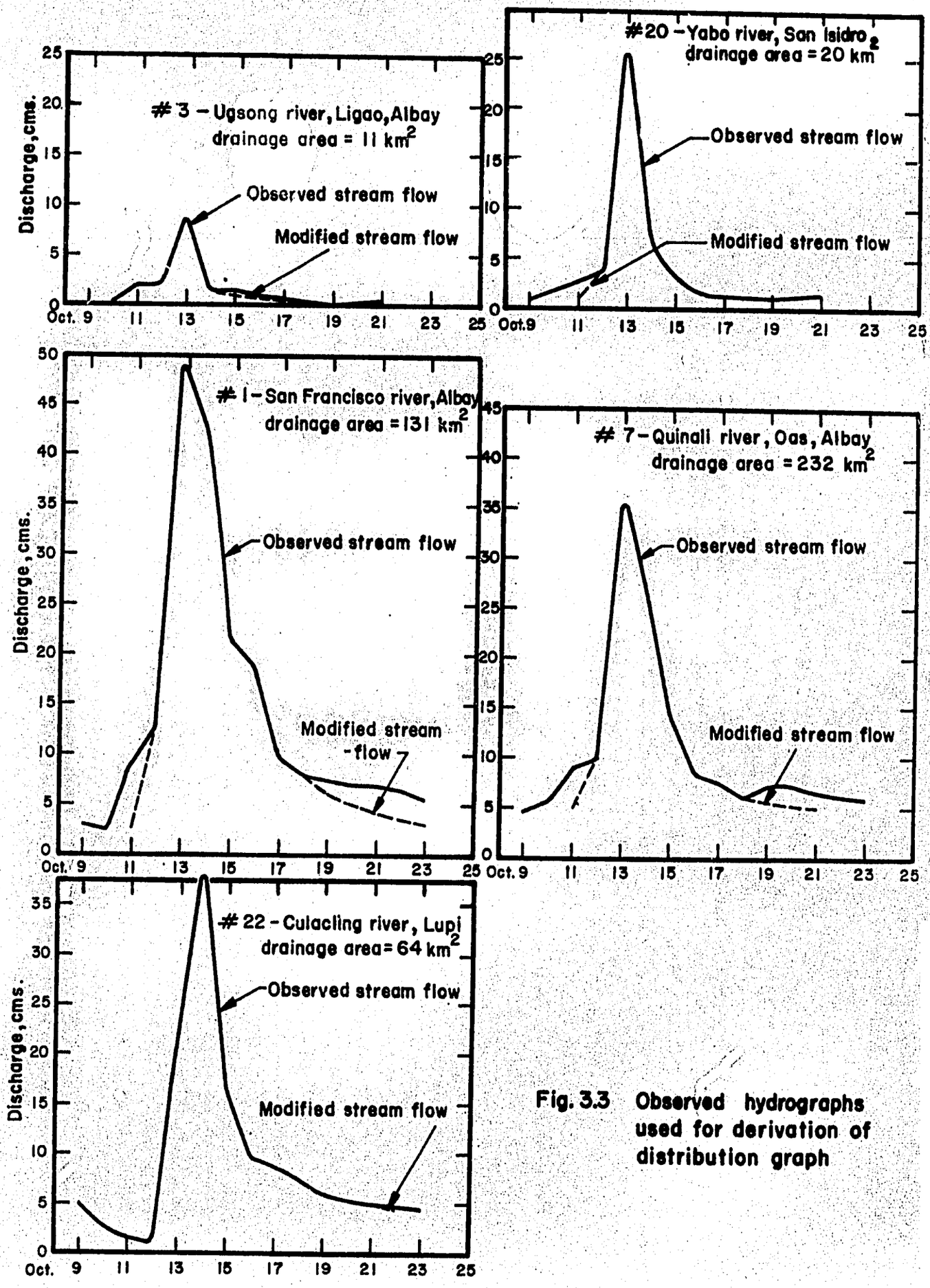
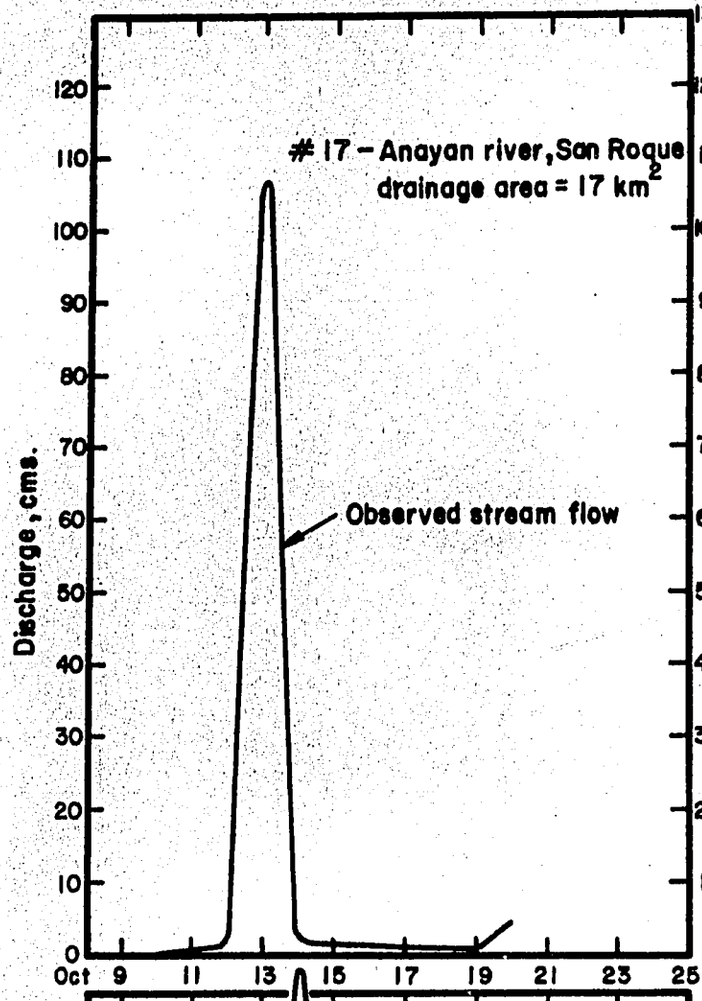
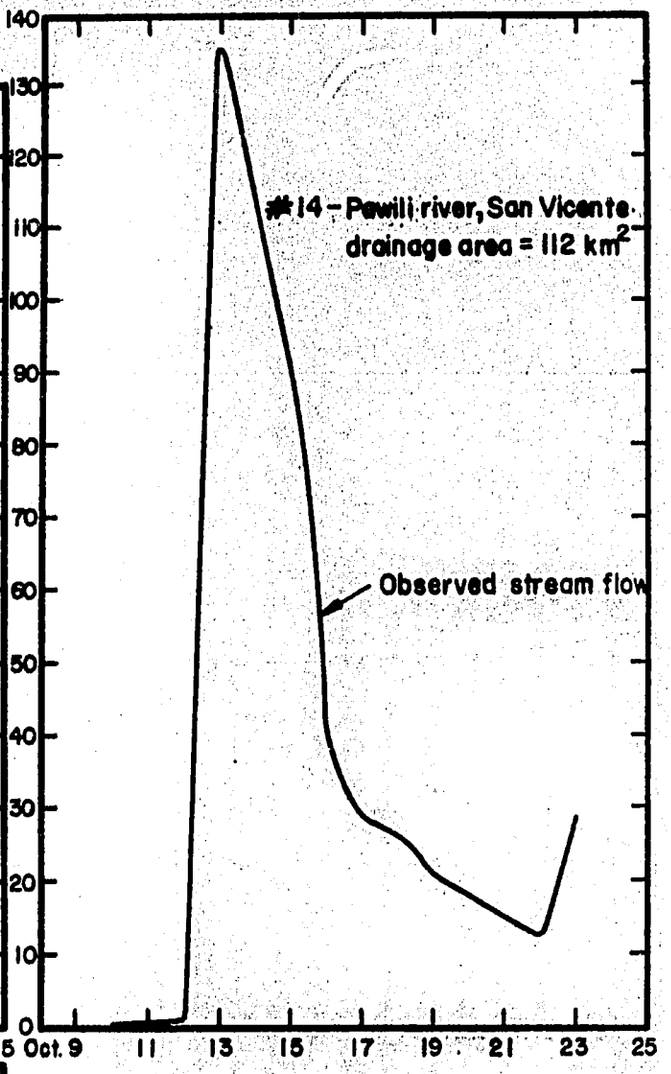



**Fig. 3.3** Observed hydrographs used for derivation of distribution graph



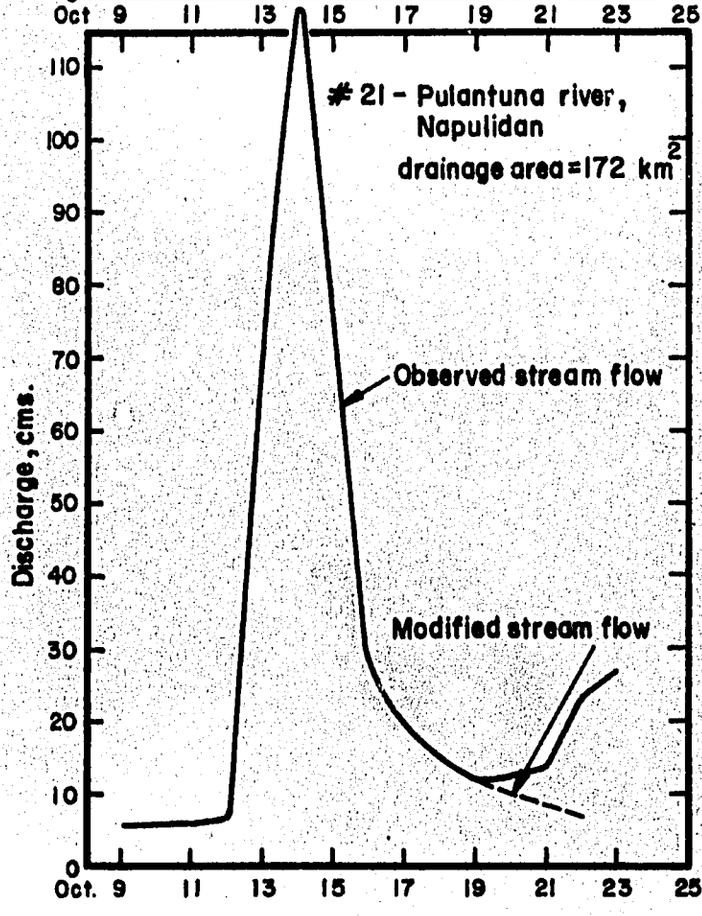




Fig. 3.3 Observed hydrographs (cont.)

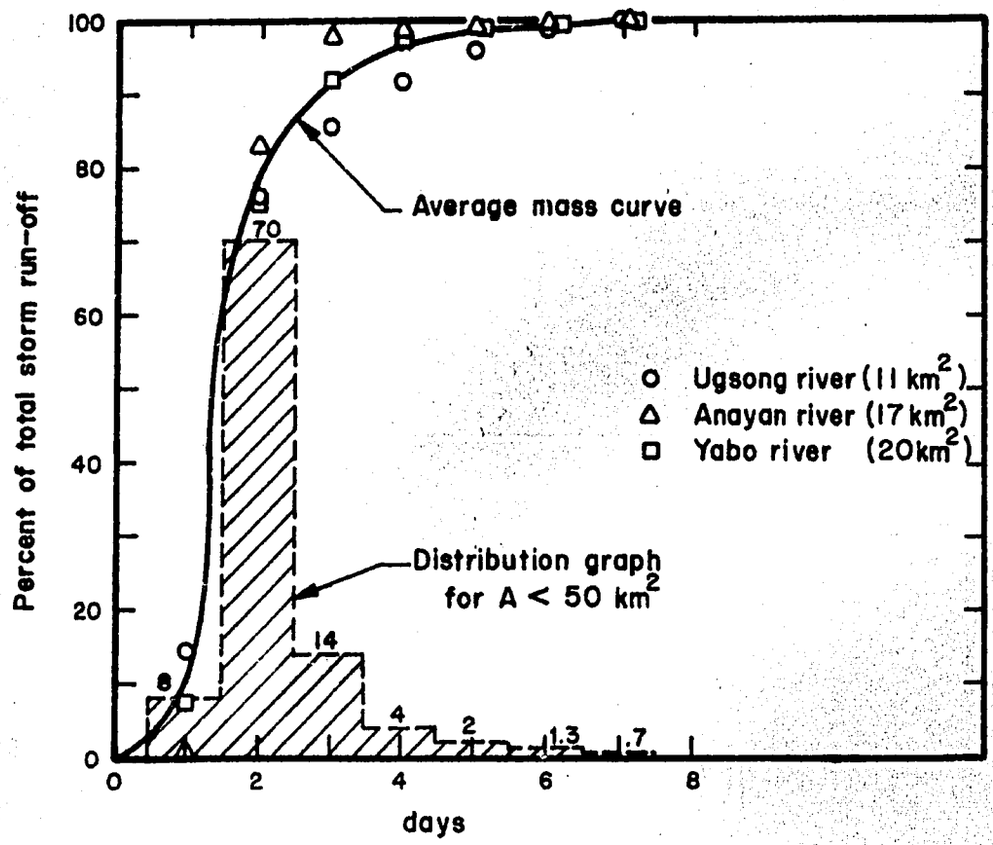
Table 3.3 - Derivation of Distribution Graph of Ugsong River (Units in CMS)

| 3 - Ugsong River, Ligao, Albay (Area = 11 km$^2$) | | | | | | |
|---|---|---|---|---|---|---|
| Date | Observed Stream Flow | Modified Stream Flow | Base Flow | Segregated Flow | Dist. Percentage | Cumulative Percentage |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Oct. 1970 | | | | | | |
| 9 | | | | | | |
| 10 | 0.037 | | | | | |
| 11 | 1.81 | 0.00 | 0.00 | 0.00 | 0.0 | 0 |
| 12 | 2.02 | 2.02 | 0.00 | 2.02 | 14.4 | 14.4 |
| 13 | 8.64 | 8.64 | 0.00 | 8.64 | 61.5 | 75.9 |
| 14 | 1.38 | 1.38 | 0.00 | 1.38 | 9.8 | 85.7 |
| 15 | 1.49* | 0.80 | 0.00 | 0.80 | 5.7 | 91.4 |
| 16 | 0.90 | 0.60 | 0.00 | 0.60 | 4.3 | 95.7 |
| 17 | 0.76 | 0.40 | 0.00 | 0.40 | 2.8 | 98.5 |
| 18 | 0.30 | 0.20 | 0.00 | 0.20 | 1.5 | 100.0 |
| 19 | 0.15 | 0.00 | 0.00 | 0.00 | 0.0 | 0 |
| 20 | 0.35 | | | | | |
| 21 | 0.54 | | | | | |
| 22 | | | | | | |
| Total | | | | 14.04 | 100.0 | |

*Day record abandoned

Table 3.4 - Data Used in Obtaining the Base Flow as a Function of Watershed Area

| Stream Gaging Station No. | River | Drainage Area (km$^2$) | Estimated Base Flow (cms) |
|---|---|---|---|
| 1 | 2 | 3 | 4 |
| 1 | San Francisco | 131 | 4.5 |
| 3 | Ugsong | 11 | 0.5 |
| 14 | Pawili | 112 | 4.0 |
| 20 | Yabo | 20 | 1.0 |
| 21 | Pulantuna | 172 | 6.0 |
| 22 | Culacling | 64 | 2.5 |



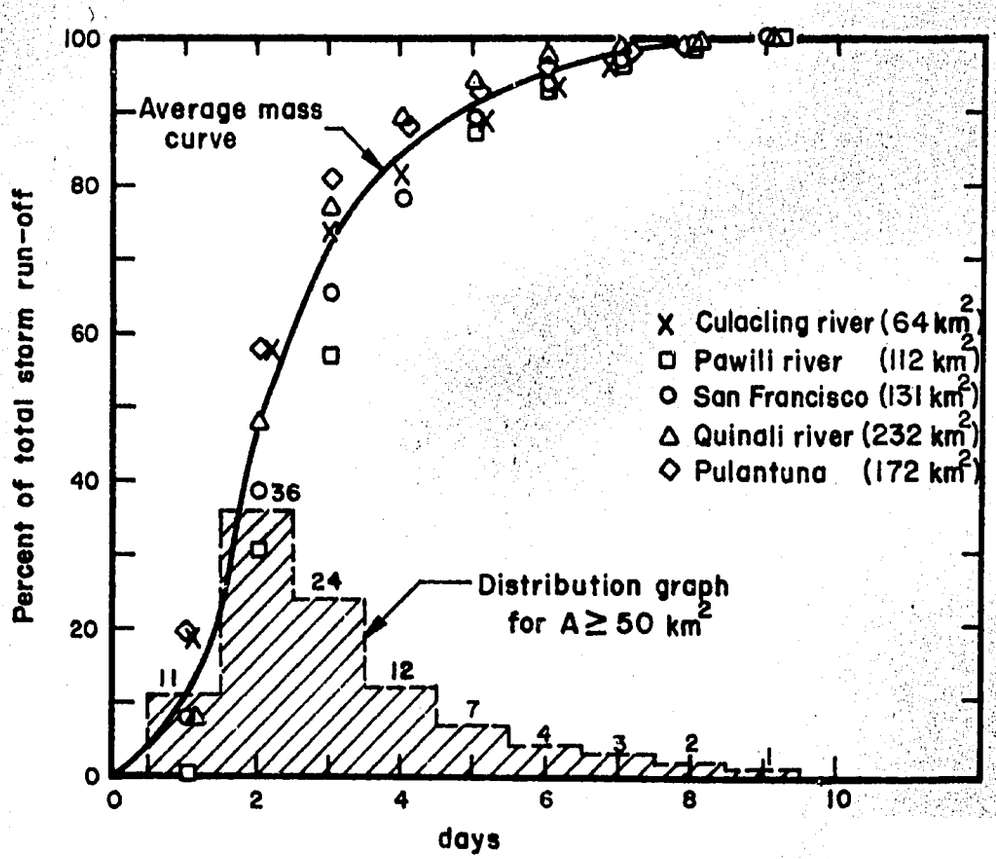




Fig. 3.4 Distribution graphs

fallen in the first hour, the flood peak on the 12th hour and the 24-hour average flow, officially recorded as the mean of first and 24-hour, may be only a small fraction of the maximum flow.

## 3.4 Calculation of Base Flow

Hydrographs of six watersheds (Station Nos.1, 3, 14, 20, 21 and 22) were plotted for the period of September 20 to November 10, 1970. The hydrographs are shown in Fig.3.5. A value of base flow was estimated for each of the watershed from these hydrographs. The areas of the watersheds and the base flow values selected are listed in Table 3.4. The base flow was correlated with the area of the catchment. The regression equation so obtained was

$$Q_B = 0.063\ A^{0.87} \qquad (3.1)$$

where $Q_B$ = base flow is in cubic meter/sec and A is catchment area in sq.km.

The correlation coefficient of Eq.(3.1) was 0.9982 and standard error of estimate was 0.0649.

A plot of the relationship of base flow and catchment area is shown in Fig.3.6.

## 3.5 Estimation of Runoff Coefficients

The basin catchment was divided into three Thiessen polygon based on raingage Station Nos.2, 6, and 14 as shown in Fig.3.7. Since the two-day rainfall of the October 12-13, 1970 storm was fairly uniform over the basin and since no other station rainfall measurements are available, the observed rainfall of the raingage station was considered to be the rainfall falling on any catchment within the polygon of the raingage station.

Seven catchments (Station Nos.1, 3, 14, 17, 20, 21 and 22) were used in the calculation of runoff coefficients. The data used and calculations are shown in Table 3.5. The runoff coefficient of Station No.17 was found to be impossibly large since the value was greater than one and hence data from this station was later removed.

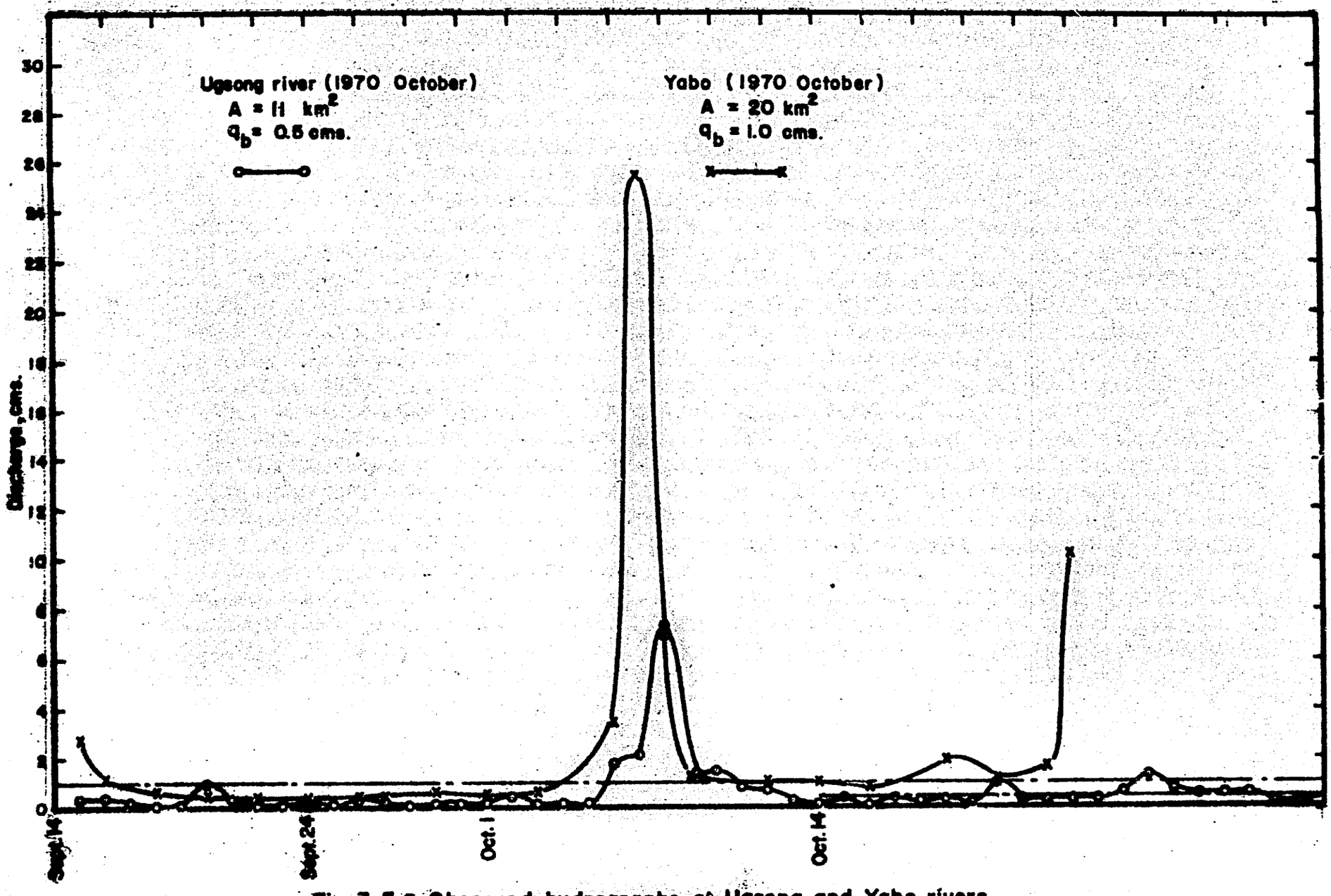



Fig. 3.5 a Observed hydrographs at Ugsong and Yabo rivers

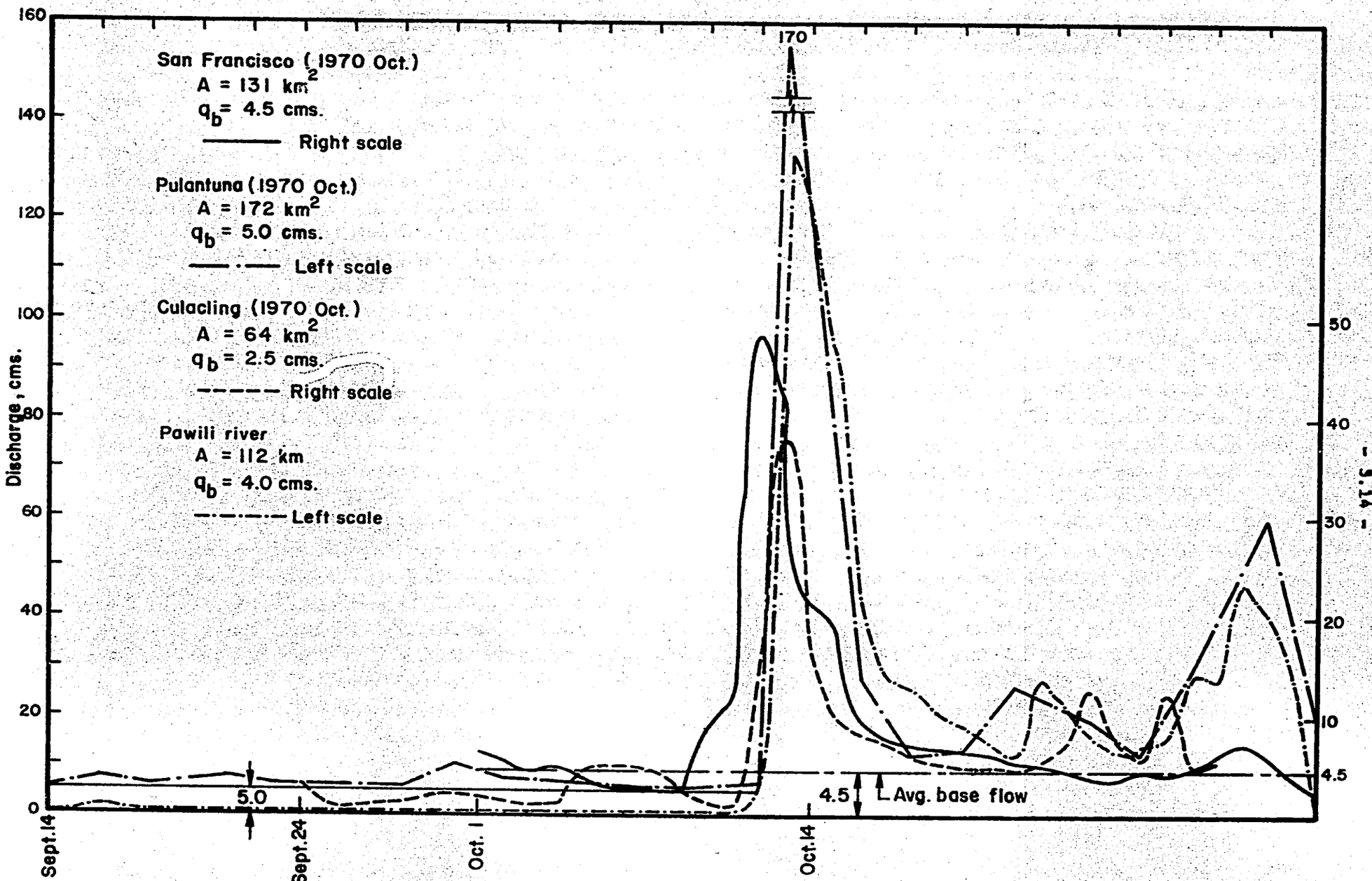



Fig. 3.5 b Observed hydrographs at San Francisco, Pulantuna and Culacling rivers

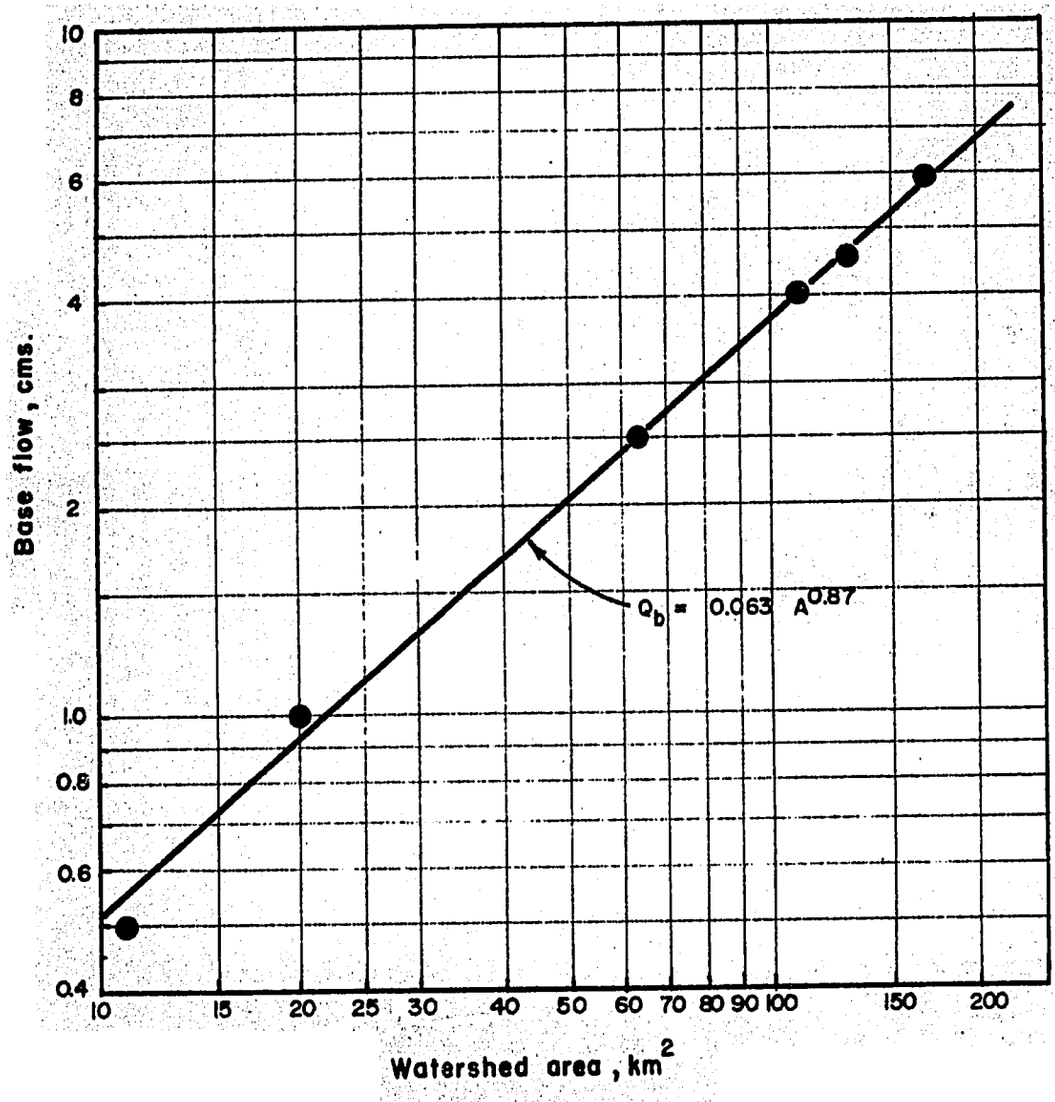



Fig. 3.6 Area-base flow relationship of catchments in the basin

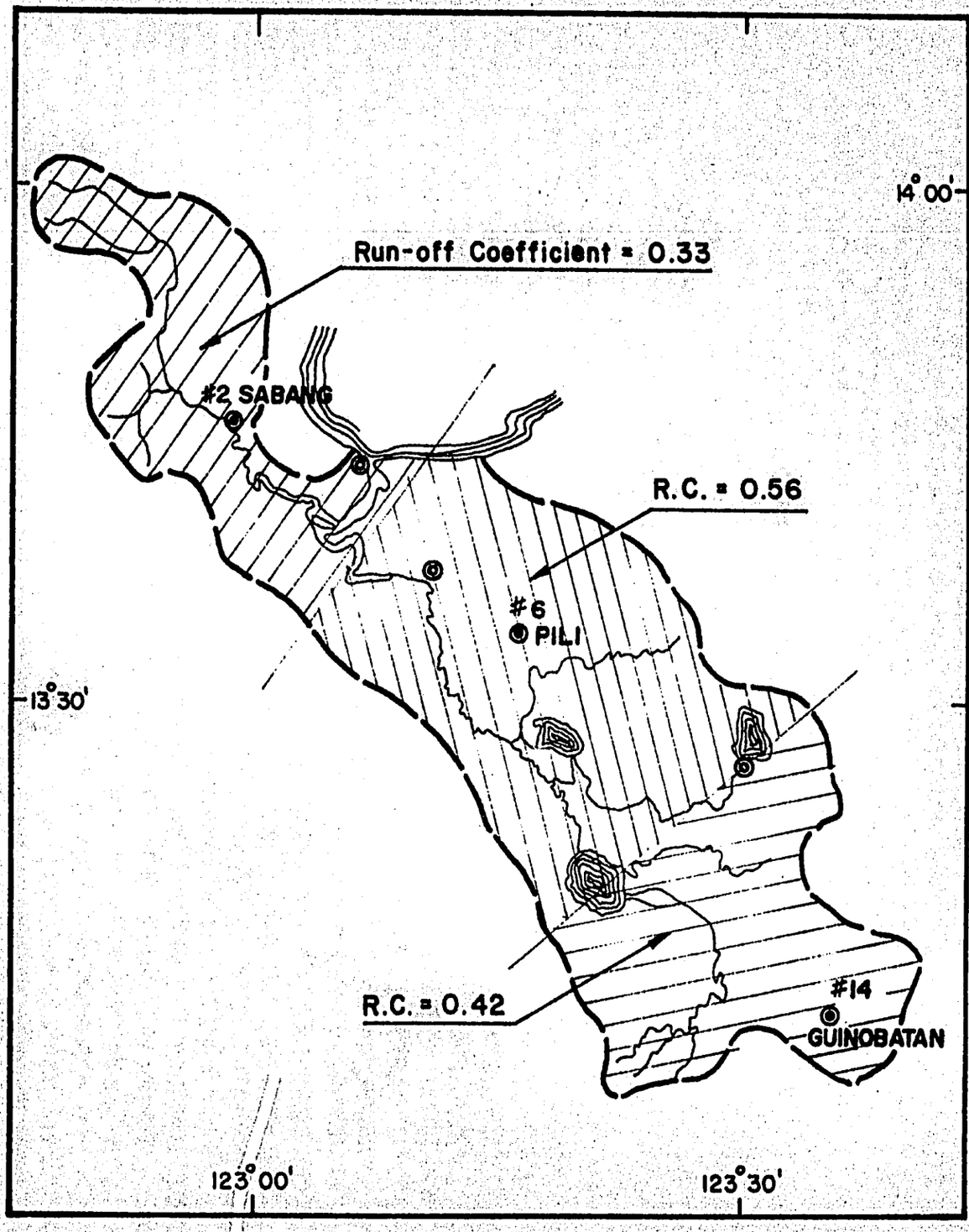



Fig. 3.7 Division of the basin into Thiessen polygons

Table 3.5 -- Calculation of Runoff Coefficients

| Stream Gaging Station No. | Gaging Station | Drainage Area of Watershed ($km^2$) | Two-Day Rainfall (mm) | Total Runoff (cms) | Total Runoff Depth (mm) | Runoff Coefficient | Average Runoff Coefficient for the Polygon |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1 | San Francisco | 131 | 313 | 149 | 98.3 | 0.314 | 0.33 |
| 3 | Ugsong | 11 | 313 | 14 | 109.7 | 0.351 | |
| 14 | Pawili | 112 | 463 | 464 | 357.9 | 0.773 | 0.56 |
| 20 | Yabo | 20 | 463 | 37 | 159.8 | 0.345 | |
| 17 | Anayan | 17 | 463 | 129 | 655.6 | 1.416 | discard |
| 21 | Pulantuna | 172 | 328 | 292 | 146.7 | 0.447 | 0.42 |
| 22 | Culacling | 64 | 328 | 95 | 128.6 | 0.391 | |

The average of the runoff coefficients in the polygon was taken as the representative value for the polygon. These runoff coefficients are 0.33, 0.56 and 0.42 respectively for polygons 1, 2 and 3 as shown in Fig.3.7.

## 3.6 Application of the Derived Distribution Graph

To verify the accuracy of the derived distribution graphs, the graphs were used to compute the discharge hydrographs of some catchments where measured data are available. The estimated and observed hydrographs are shown in Figs.3.8 to 3.10 for the catchment of the Ugsong, Yabo and Pawili Rivers respectively. The value of the runoff coefficients used were those derived in Section 3.5 and the base flows were calculated using Eq.(3.1).

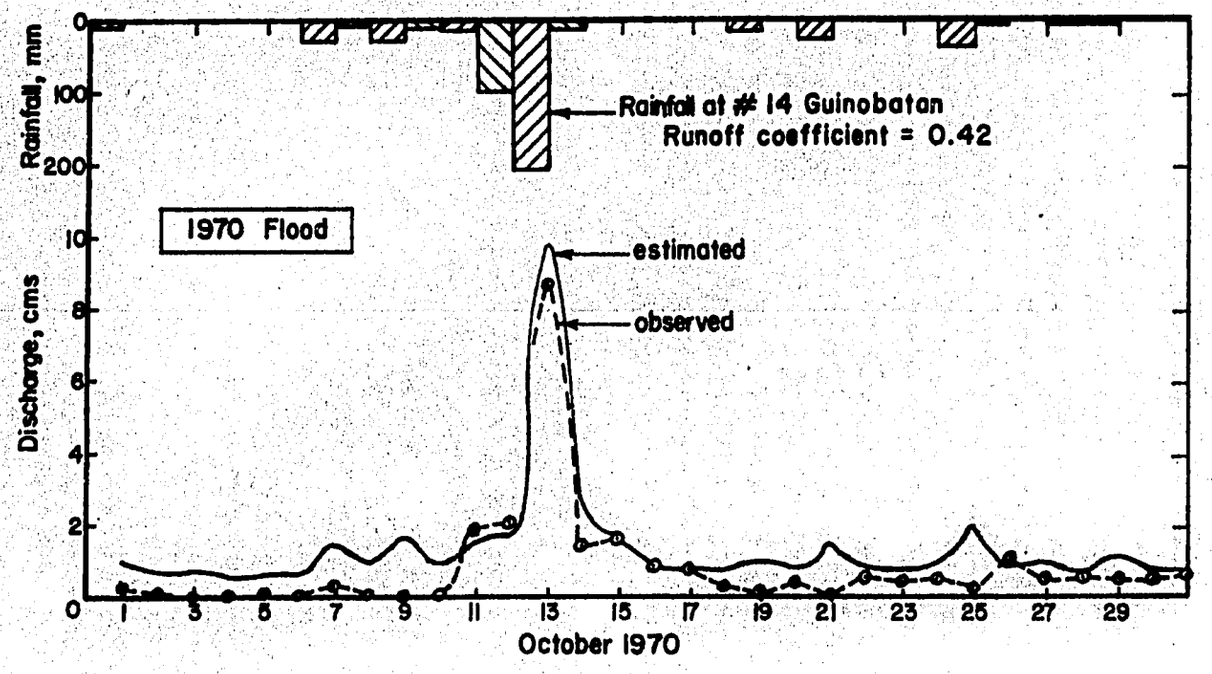
Using two flood events namely: October 1958 and October 1970 storms, the results indicate good agreement between the estimated and observed hydrographs, as shown by Figs.3.8 to 3.10.

## 3.7 Design Storm for the Basin

The 50-year design storm for input to the model is a two-day storm preceded and followed by a daily rainfall whose amount is equal to the average of the annual storms that had been observed in the basin. In this section are discussed the determination of: (1) design average basin rainfall caused by the two-day storm; (2) average basin rainfall preceding and following the two-day storm; and (3) distribution of the computed average basin rainfalls into station rainfalls.

3.7.1 Average Basin Rainfall Caused by the Two-Day Storm A total of 16 rainfall stations inside and outside the basin have daily accumulated rainfall data ranging from 2 to 25 years length of record. In some years for some stations records are fragmented. Table 3.1 shows the rainfall station with their corresponding years when data is available.

To estimate the average basin rainfall during the maximum annual two-day storm, two methods used were: (1) averaging the design storm of individual stations which were obtained by frequency analysis; and (2) computing the maximum average basin rainfall for each year.



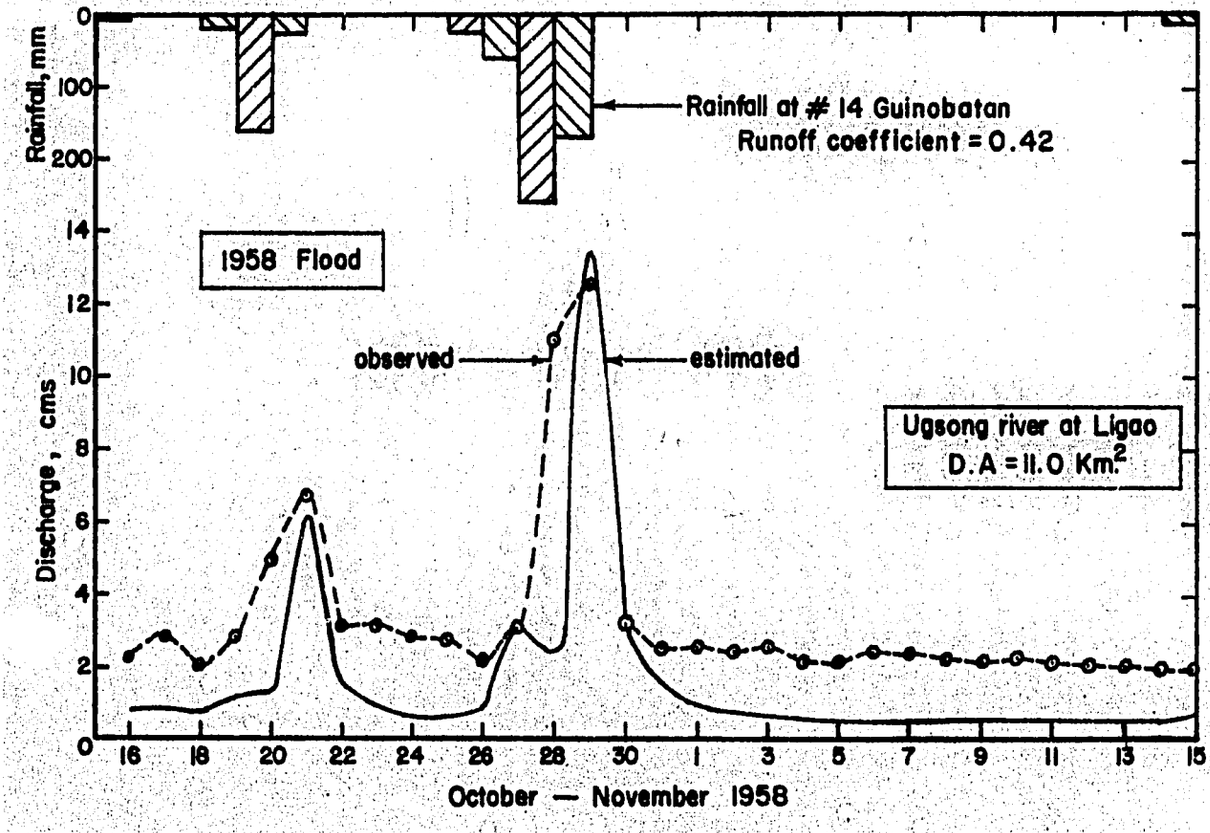




Fig. 3.8 Observed and estimated hydrographs of Ugsong river at Ligao

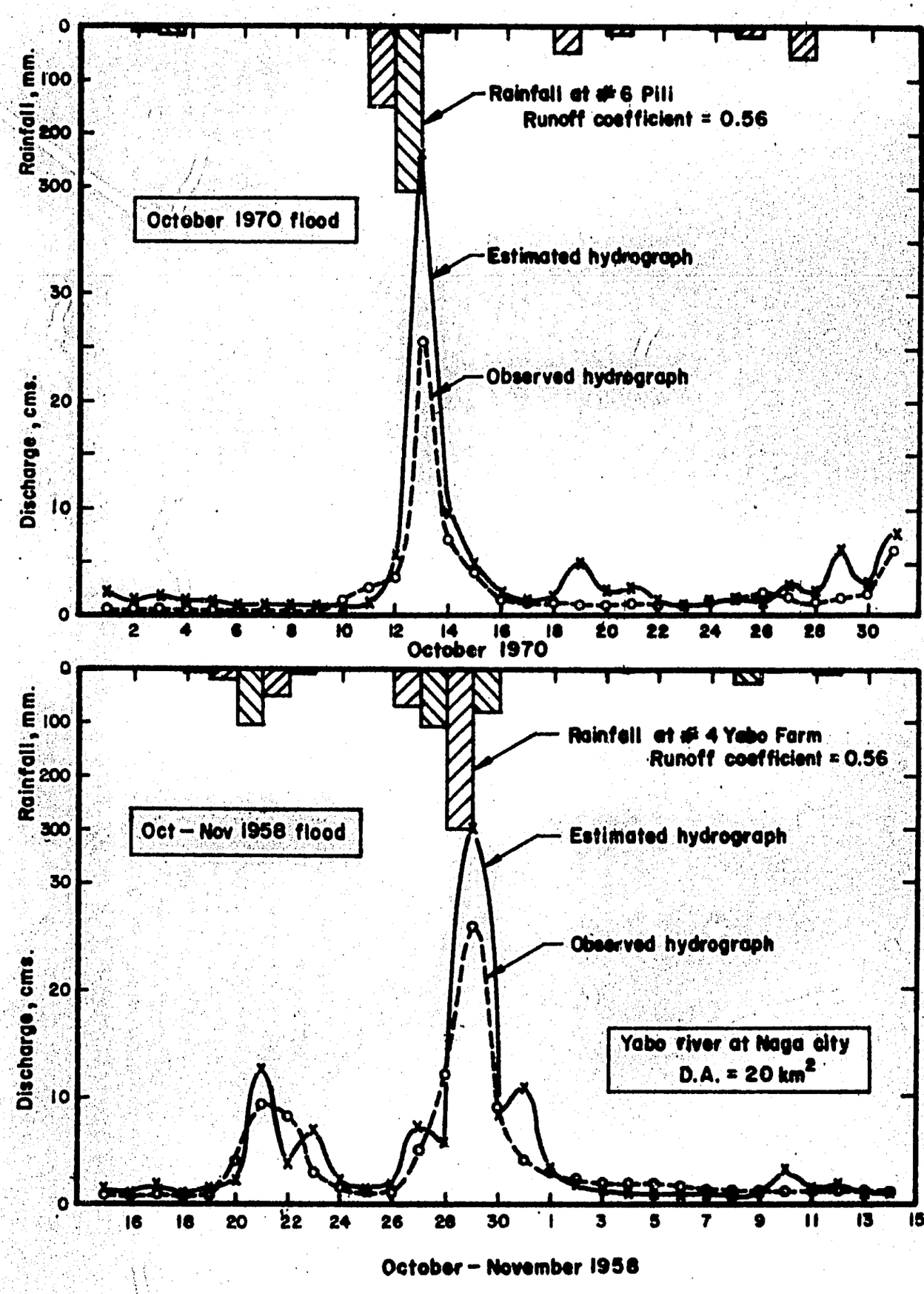



Fig.3.9 Comparison of observed and estimated hydrographs of Yabo river at Naga

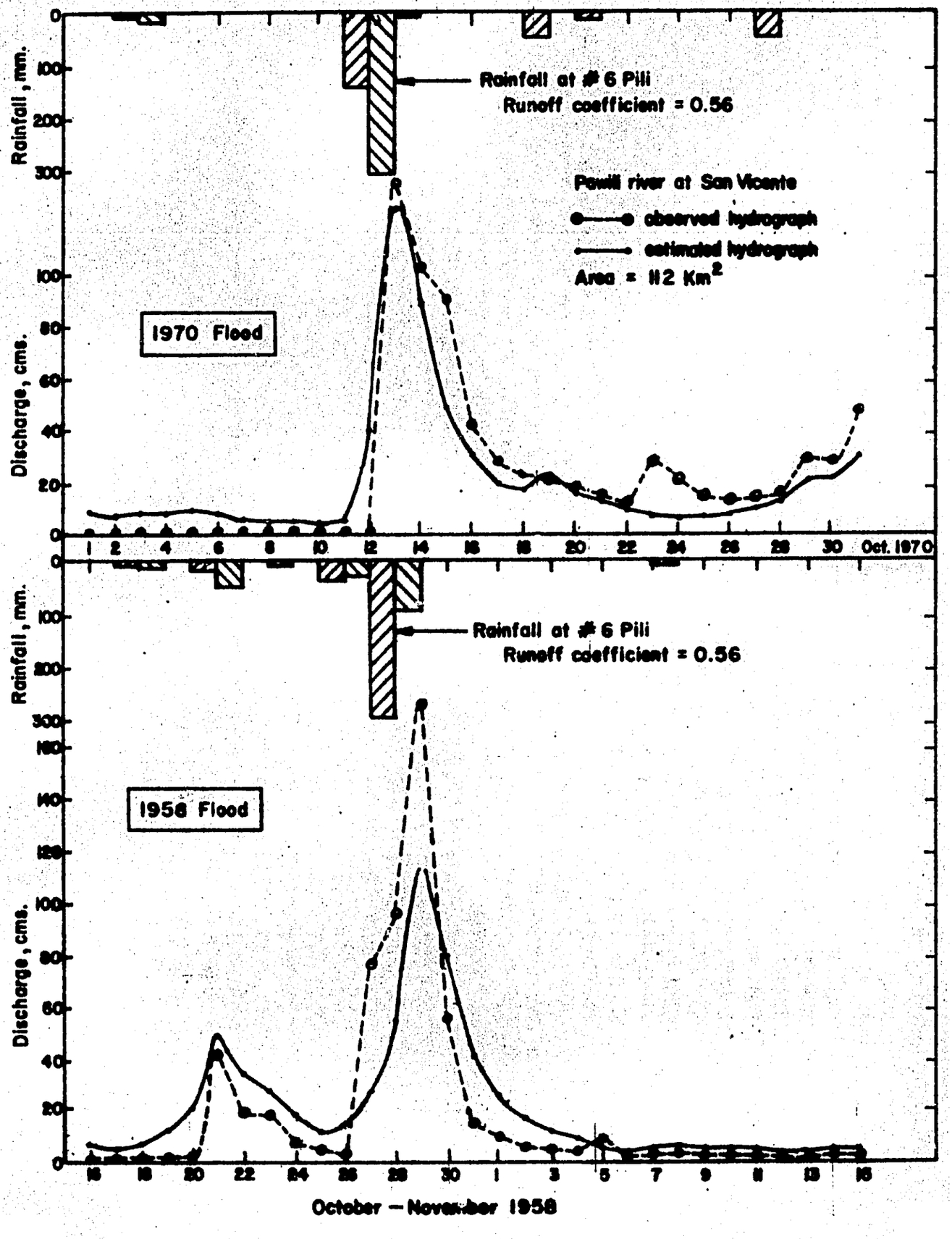



Fig. 3.10 Observed and estimated hydrographs of Pawili river at San Vicente

3.7.2 Frequency Analysis of the Two-Day Storms The annual two-day maximum rainfall for the raingage stations are tabulated in Table 3.6. Using the data shown in Table 3.6, a frequency analysis using Gumbel distribution (see Section A2, Appendix A) gave the design two-day storm at each station for return periods of 5, 10, 25, 50 and 100 years as shown in Table 3.7. For each return period, the average depth of rainfall over the entire basin was then computed using Thiessen method. The design weighted average rainfall for the basin was computed by multiplying each station design rainfall by its assigned percentage of area and totalling. The results are as shown in Table 3.8 and the plot of result is shown in Curve 4 of Fig.3.11.

3.7.3 Annual Maximum Average Two-Day Basin Rainfall As shown in Table 3.1, there are at least three and at most 11 rainfall stations in the basin which could be used to obtain the maximum average two-day basin rainfall for each year. The average basin rainfall for the two-day storm were obtained by the Thiessen method and by an arithmetic averaging of station measurements. The search for the maximum two-day basin rainfall was done by investigating all periods of storm at each station. The computed maximum average basin rainfall for each year is shown in Table 3.9. A frequency analysis using Gumbels distribution was done for the two sets of data series in Table 3.9 and the results are tabulated in Table 3.10 and plotted in Fig.3.11. A 90% confidence band to the plotted data is also shown in Fig.3.11. The recommended design basin average rainfall is shown by Curve 2 in Fig.3.11.

3.7.4 Average Basin Rainfall Preceding and Following the Two-Day Storm With the available 24 years of record, the northeast and northwest monsoon storms were averaged and plotted using the two-day maximum rainfall as reference point in time. The plots of the averages of these annual storms in terms of two-day rainfall are shown in Fig.3.12. The average two-day rainfall preceding and following the two-day storm are 22 mm and 19 mm respectively.

3.7.5 Design Basin Rainfall The 50-year design basin rainfall to be used as design input to the mathematical model is shown in Fig.3.13.

**Table 3.6 - Annual Maximum 2-Day Rainfall and Date of Occurrence for Some Selected Stations in the Basin**

| Year | 2-Day Maximum Rainfall (in mm) and Date When Storm Begins for Station No. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 7 | 9 | 10 | 14 | 21 |
| 1950 | - | - | - | - | - | 298.7 $\frac{29}{12}$ | - | 273.3 $\frac{29}{12}$ |
| 51 | - | - | - | - | - | 300.0 $\frac{20}{11}$ | - | 142.7 $\frac{25}{1}$ |
| 52 | - | - | - | - | - | 547.9 $\frac{20}{10}$ | - | 263.9 $\frac{23}{11}$ |
| 53 | - | - | - | - | - | 148.6 $\frac{15}{11}$ | - | 244.3 $\frac{26}{11}$ |
| 54 | - | - | - | - | - | 390.7 $\frac{7}{11}$ | - | 366.8 $\frac{7}{11}$ |
| 55 | - | - | - | - | - | - | - | 308.9 $\frac{5}{1}$ |
| 56 | - | 311.9 $\frac{9}{12}$ | - | 182.4 $\frac{8}{12}$ | - | 372.1 $\frac{8}{12}$ | 279.4 $\frac{8}{12}$ | 211.8 $\frac{5}{4}$ |
| 57 | - | 222.0 $\frac{12}{10}$ | - | 200.9 $\frac{29}{6}$ | - | 290.6 $\frac{10}{11}$ | 154.7 $\frac{8}{8}$ | 412.7 $\frac{10}{11}$ |
| 58 | - | 367.3 $\frac{28}{10}$ | - | 397.3 $\frac{28}{10}$ | - | 333.2 $\frac{28}{10}$ | 428.8 $\frac{28}{10}$ | 333.5 $\frac{28}{10}$ |
| 59 | - | 343.9 $\frac{17}{11}$ | - | 297.7 $\frac{29}{12}$ | - | 256.0 $\frac{30}{12}$ | 355.6 $\frac{15}{11}$ | 285.0 $\frac{15}{11}$ |
| 1960 | - | 302.0 $\frac{6}{10}$ | - | 380.0 $\frac{5}{10}$ | - | 359.4 $\frac{5}{10}$ | 376.4 $\frac{5}{10}$ | 197.4 $\frac{10}{2}$ |
| 61 | - | 365.8 $\frac{21}{9}$ | - | 268.2 $\frac{24}{7}$ | - | - | 122.9 $\frac{4}{7}$ | 213.6 $\frac{8}{12}$ |
| 62 | - | 197.1 $\frac{28}{5}$ | - | 189.7 $\frac{6}{7}$ | - | - | 182.1 $\frac{17}{5}$ | 243.8 $\frac{17}{5}$ |
| 63 | - | 241.6 $\frac{13}{8}$ | - | 223.5 $\frac{12}{8}$ | - | - | 254.0 $\frac{12}{8}$ | 252.0 $\frac{12}{8}$ |
| 64 | - | 279.4 $\frac{28}{9}$ | - | - | - | - | 182.9 $\frac{28}{9}$ | 577.7 $\frac{27}{11}$ |
| 65 | - | 127.0 $\frac{10}{12}$ | - | - | - | 137.7 $\frac{11}{7}$ | 247.9 $\frac{12}{7}$ | 219.2 $\frac{22}{5}$ |
| 66 | - | - | 354.3 $\frac{26}{12}$ | - | - | 304.1 $\frac{26}{12}$ | 286.0 $\frac{25}{12}$ | 282.2 $\frac{25}{9}$ |
| 67 | - | - | - | 439.0 $\frac{2}{11}$ | - | - | 209.1 $\frac{2}{9}$ | 244.5 $\frac{3}{11}$ |
| 68 | - | - | 227.1 $\frac{25}{9}$ | - | - | 335.0 $\frac{26}{9}$ | - | 118.4 $\frac{14}{10}$ |
| 69 | 133.0 $\frac{9}{12}$ | - | 218.4 $\frac{26}{3}$ | 349.9 $\frac{16}{11}$ | 100.3 $\frac{10}{12}$ | - | 151.2 $\frac{10}{12}$ | 263.5 $\frac{9}{10}$ |
| 1970 | 327.7 $\frac{12}{10}$ | - | 463.3 $\frac{12}{10}$ | - | 210.6 $\frac{17}{11}$ | - | 313.1 $\frac{12}{10}$ | 438.0 $\frac{17}{11}$ |
| 71 | 166.9 $\frac{28}{12}$ | - | 227.3 $\frac{14}{12}$ | 244.6 $\frac{14}{12}$ | 126.5 $\frac{25}{5}$ | 120.4 $\frac{28}{12}$ | 194.1 $\frac{28}{12}$ | 286.0 $\frac{9}{12}$ |
| 72 | 170.0 $\frac{13}{12}$ | - | 212.9 $\frac{24}{6}$ | 144.0 $\frac{5}{7}$ | 145.3 $\frac{4}{7}$ | 182.9 $\frac{7}{1}$ | 199.5 $\frac{24}{6}$ | 206.3 $\frac{1}{4}$ |
| 1973 | 200.2 $\frac{14}{10}$ | - | 225.6 $\frac{14}{10}$ | 118.9 $\frac{12}{5}$ | 281.7 $\frac{14}{10}$ | 252.5 $\frac{19}{11}$ | 264.2 $\frac{19}{11}$ | 381.8 $\frac{30}{10}$ |
| Mean | 199.6 | 275.8 | 275.6 | 264.3 | 172.9 | 289.4 | 247.2 | 288.0 |
| Std.Deviation | 75.5 | 78.5 | 96.4 | 101.6 | 73.2 | 109.1 | 85.4 | 102.0 |

Table 3.7 - Design 2-Day Rainfall for Some Selected Stations in the Basin (obtained by Gumbel method)

| Return Period (years) | Design 2-Day Rainfall (in mm) for Station No. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 7 | 9 | 10 | 14 | 21 |
| 2 | 192.2 | 266.3 | 265.5 | 250.7 | 165.4 | 274.6 | 235.2 | 273.2 |
| 5 | 282.3 | 350.1 | 368.2 | 360.5 | 257.6 | 386.8 | 325.1 | 375.3 |
| 10 | 341.9 | 405.6 | 436.2 | 433.2 | 318.7 | 461.0 | 384.7 | 442.9 |
| 25 | 418.9 | 477.2 | 523.9 | 527.0 | 397.6 | 556.9 | 461.6 | 530.1 |
| 50 | 474.0 | 528.4 | 586.7 | 594.8 | 454.0 | 625.5 | 516.6 | 592.6 |
| 100 | 529.1 | 579.7 | 649.5 | 661.2 | 510.4 | 694.0 | 571.7 | 655.0 |
| Length of Record (yrs.) | 5 | 10 | 7 | 13 | 5 | 16 | 17 | 25 |

Table 3.8 - Design 2-Day Average Basin Rainfall Depth Computed from Design Rainfall of Individual Stations

| Contribution of Station to Average Basin Rainfall (in mm) | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Station No. | | 2 | 4 | 6 | 7 | 9 | 10 | 14 | 21 | |
| Percentage Area | | 0.19 | 0.14 | 0.11 | 0.08 | 0.14 | 0.14 | 0.17 | 0.03 | 1.0 |
| Return Period | 2 | 36.5 | 37.3 | 29.2 | 20.1 | 23.2 | 38.4 | 40.0 | 8.2 | 232.8 |
| | 5 | 53.6 | 49.0 | 40.5 | 28.8 | 36.1 | 54.2 | 55.3 | 11.2 | 328.7 |
| | 10 | 65.0 | 56.8 | 48.0 | 34.6 | 44.6 | 64.5 | 65.4 | 13.2 | 392.2 |
| | 25 | 79.6 | 66.8 | 57.6 | 42.2 | 55.7 | 78.0 | 78.5 | 15.9 | 474.2 |
| | 50 | 90.1 | 74.0 | 64.5 | 47.6 | 63.6 | 87.6 | 87.8 | 17.8 | 532.9 |
| | 100 | 100.5 | 81.2 | 71.4 | 53.0 | 71.4 | 97.2 | 97.2 | 19.6 | 591.4 |

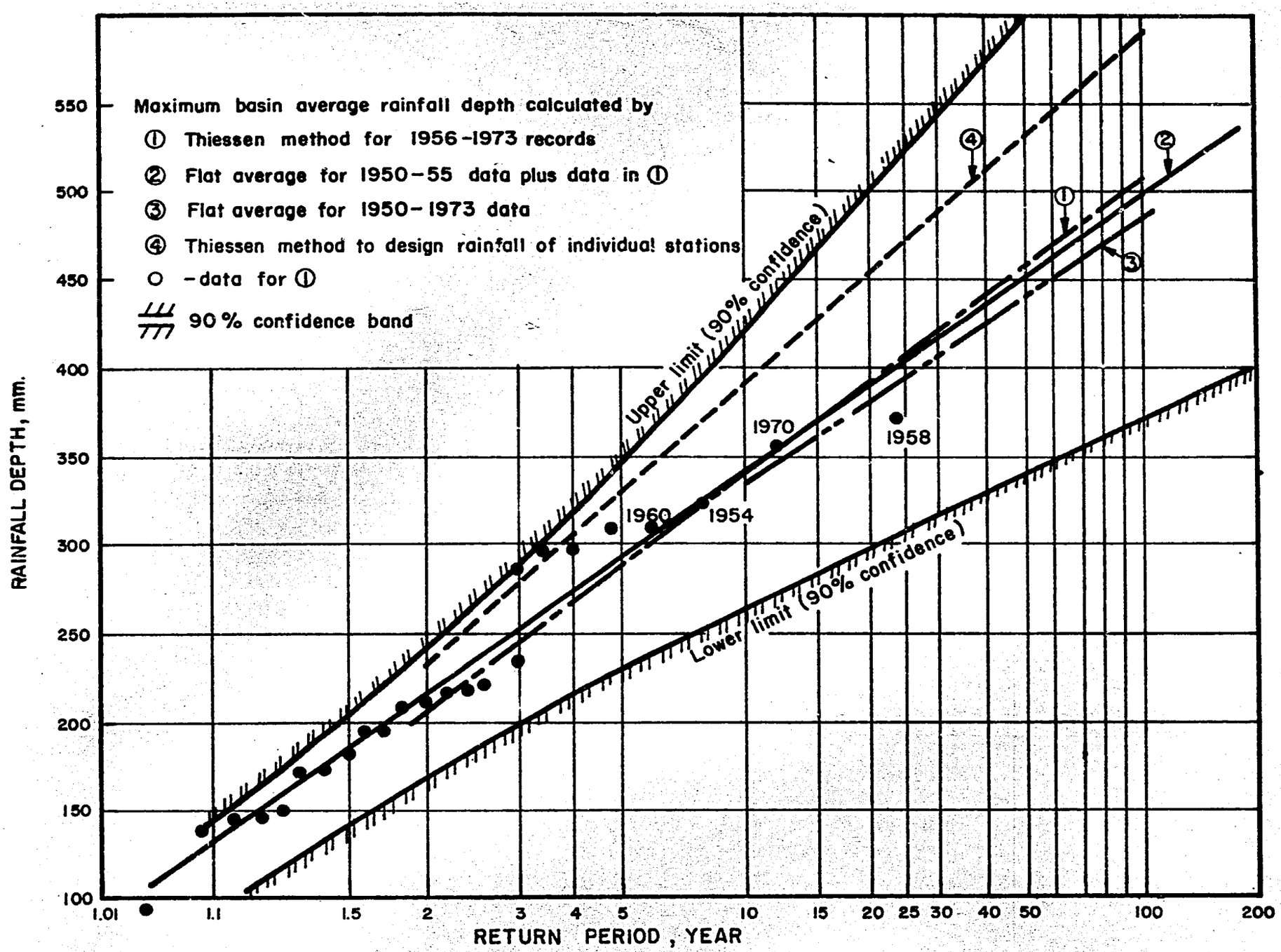



Fig. 3.11 Frequency analysis of the two-day basin rainfall

Table 3.9 - Annual Series of Maximum Average Basin Rainfall Caused by a Two-Day Storm

| Year | No.of Station Used | Date of Two-Day Storm | Two-Day Accumulated Rainfall Depth (in mm) at Station Number | | | | | | | | | | | | | | | Basin Rainfall (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 21* | 2 | 3 | 4 | 5 | 6 | 7 | 9 | 10 | 11 | 12 | 14 | 15 | 16* | 19* | Arithmetic Ave. | Thiessen Method |
| 1950 | 3 | 29-30/12 | 273.4 | - | - | - | - | - | - | - | 298.8 | - | - | - | - | - | 65.4 | 212.5 | 281.0 |
| 51 | 3 | 20-21/11 | 101.9 | - | - | - | - | - | - | - | 300.1 | - | - | - | - | - | 140.5 | 180.8 | 244.5 |
| 52 | 3 | 20-21/10 | 243.2 | - | - | - | - | - | - | - | 548.0 | - | - | - | - | - | 96.8 | 295.9 | 452.2 |
| 53 | 3 | 15-16/11 | 166.7 | - | - | - | - | - | - | - | 148.7 | - | - | - | - | - | 120.0 | 145.1 | 151.5 |
| 54 | 3 | 7-8/11 | 366.9 | - | - | - | - | - | - | - | 390.8 | - | - | - | - | - | 213.7 | 323.7 | 376.1 |
| 1955 | 3 | 27-28/11 | 229.7 | - | - | - | - | - | - | - | 290.0 | - | - | - | - | - | 405.6 | 308.3 | 281.4 |
| 56 | 5 | 9-10/12 | 133.9 | - | - | 312.0 | - | - | 110.1 | - | 280.7 | - | - | 196.2 | - | - | - | 206.6 | 221.6 |
| 57 | 5 | 10-11/11 | 413.9 | - | - | 183.8 | - | - | 119.8 | - | 290.6 | - | - | 152.5 | - | - | - | 213.9 | 216.0 |
| 58 | 5 | 28-29/10 | 333.6 | - | - | 367.4 | - | - | 397.4 | - | 333.3 | - | - | 428.9 | - | - | - | 372.1 | 372.5 |
| 59 | 5 | 15-16/11 | 285.1 | - | - | 344.0 | - | - | 279.8 | - | 216.5 | - | - | 355.7 | - | - | - | 296.2 | 297.3 |
| 1960 | 5 | 5-6/10 | 182.8 | - | - | 299.0 | - | - | 380.1 | - | 359.4 | - | - | 376.6 | - | - | - | 319.6 | 309.2 |
| 61 | 4 | 21-22/9 | 210.4 | - | - | 365.9 | - | - | 115.4 | - | - | - | - | 32.3 | - | - | - | 181.0 | 173.6 |
| 62 | 4 | 17-18/5 | 244.0 | - | - | 132.2 | - | - | 173.3 | - | - | - | - | 182.1 | - | - | - | 182.9 | 172.7 |
| 63 | 4 | 12-13/8 | 252.1 | - | - | 80.3 | - | - | 223.6 | - | - | - | - | 254.1 | - | - | - | 202.5 | 195.4 |
| 64 | 3 | 28-29/6 | 388.1 | - | - | 256.4 | - | - | - | - | - | - | - | 156.6 | - | - | - | 267.0 | 234.2 |
| 1965 | 4 | 12-13/7 | 63.3 | - | - | - | 154.3 | - | - | - | 123.3 | - | - | 248.0 | - | - | - | 147.2 | 149.0 |
| 66 | 5 | 26-27/12 | 189.6 | - | - | - | 52.1 | 354.4 | - | - | 304.1 | - | - | 174.7 | - | - | - | 215.0 | 218.4 |
| 67 | 5 | 2-3/11 | 182.8 | - | - | - | 0.0 | 790.6 | 439.0 | - | - | - | - | 17.3 | - | - | - | — Discard — | |
| 68 | 5 | 26-27/9 | 66.5 | - | - | - | 118.1 | 193.9 | - | - | 335.0 | - | - | 200.9 | - | - | - | 182.9 | 195.8 |
| 69 | 6 | 10-11/12 | 139.5 | 27.1 | 38.1 | - | - | 88.0 | - | 100.3 | - | - | - | 151.2 | - | - | - | 90.7 | 89.3 |
| 1970 | 5 | 12-13/10 | 193.1 | 327.7 | 257.2 | - | - | 463.4 | - | - | - | - | - | 313.1 | - | - | - | 310.9 | 356.6 |
| 71 | 10 | 28-29/12 | 239.1 | 166.9 | - | - | - | 151.0 | 164.1 | 98.0 | 120.4 | - | 131.8 | 194.1 | 109.5 | 76.2 | - | 145.0 | 146.5 |
| 72 | 11 | 24-25/6 | 75.9 | 118.4 | - | - | - | 213.0 | 77.3 | 126.8 | 173.2 | 204.5 | 19.3 | 199.5 | 78.3 | 12.5 | - | 118.1 | 138.5 |
| 1973 | 10 | 14-15/10 | 242.8 | 200.2 | 57.2 | - | - | 225.7 | - | 281.7 | 207.3 | 207.8 | 306.8 | 250.3 | 102.9 | - | - | 208.3 | 209.5 |

(-) Percentage contribution of station to average basin rainfall
* Stations outside the basin

Table 3.10 - Design Two-Day Basin Average Rainfall Depth (based on the annual series of Table 3.9)

| Basin Average Two-Day Rainfall Depth Computed from Annual Data by | Basin Average Rainfall Depth (in mm) for Return Period of | | | | | |
|---|---|---|---|---|---|---|
| | 2 yrs. | 5 yrs. | 10 yrs. | 25 yrs. | 50 yrs. | 100 yrs. |
| 1. Arithmatic average for 1950-1973 records | 211.3 | 285.0 | 333.9 | 396.9 | 441.9 | 487.0 |
| 2. Thiessen method for 1950-1973 records | 225.3 | 317.2 | 378.0 | 456.6 | 512.8 | 569.0 |
| 3. Same as (2) excluding 1950-1955 records (only 1 station in basin) | 206.7 | 287.1 | 340.4 | 409.2 | 458.4 | 507.6 |
| 4. Same as (2) except that 1950-1955 records computed as in (1) | 213.6 | 290.0 | 340.7 | 406.0 | 452.7 | 499.5 |
| 5. Recommended | 205 | 285 | 340 | 410 | 460 | 560 |

Table 3.11 - Comparison of Observed and Estimated Station Rainfalls

| Year | Two-Day Rainfall (in mm) at Station No. | | | Average Basin Rainfall mm |
|---|---|---|---|---|
| | 2 Sabang | 6 Pili | 14 Guinobatan | |
| 1966 | - (151.5) | 354.3 (265.5) | 174.7 (202.3) | 218.4 |
| 1968 | - (135.9) | 227.1 (239.8) | 98.4 (181.4) | 195.8 |
| 1970 | 327.7 (247.4) | 463.3 (436.7) | 313.1 (330.3) | 356.6 |
| 1971 | 166.9 (101.6) | 151.0 (179.4) | 194.1 (135.7) | 146.5 |
| 1972 | 118.4 ( 96.1) | 212.9 (169.6) | 199.5 (128.3) | 138.5 |
| 1973 | 141.0 (145.4) | 225.1 (256.5) | 250.3 (194.0) | 209.5 |

(-) estimated station rainfall using derived distribution

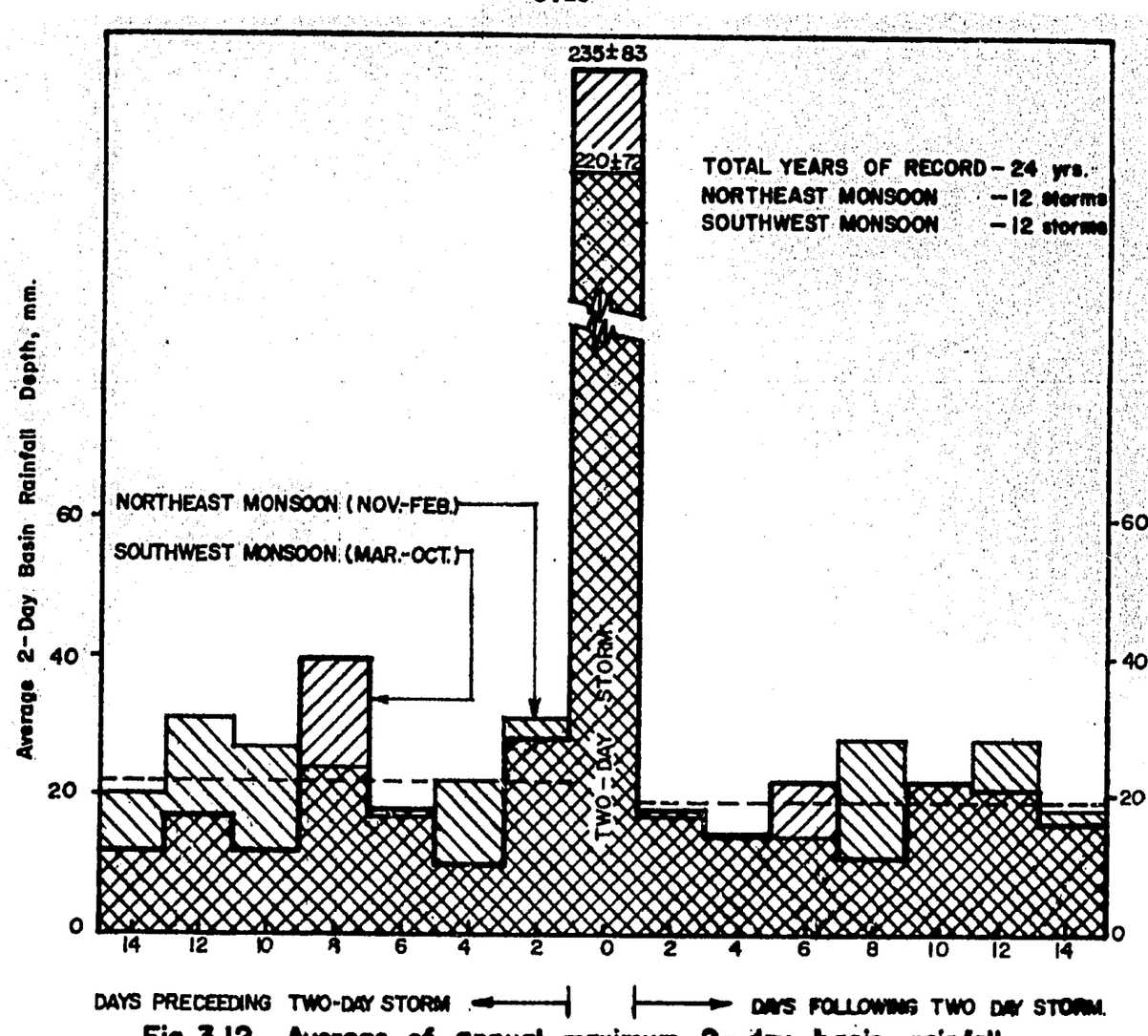



Fig. 3.12 Average of annual maximum 2-day basin rainfall

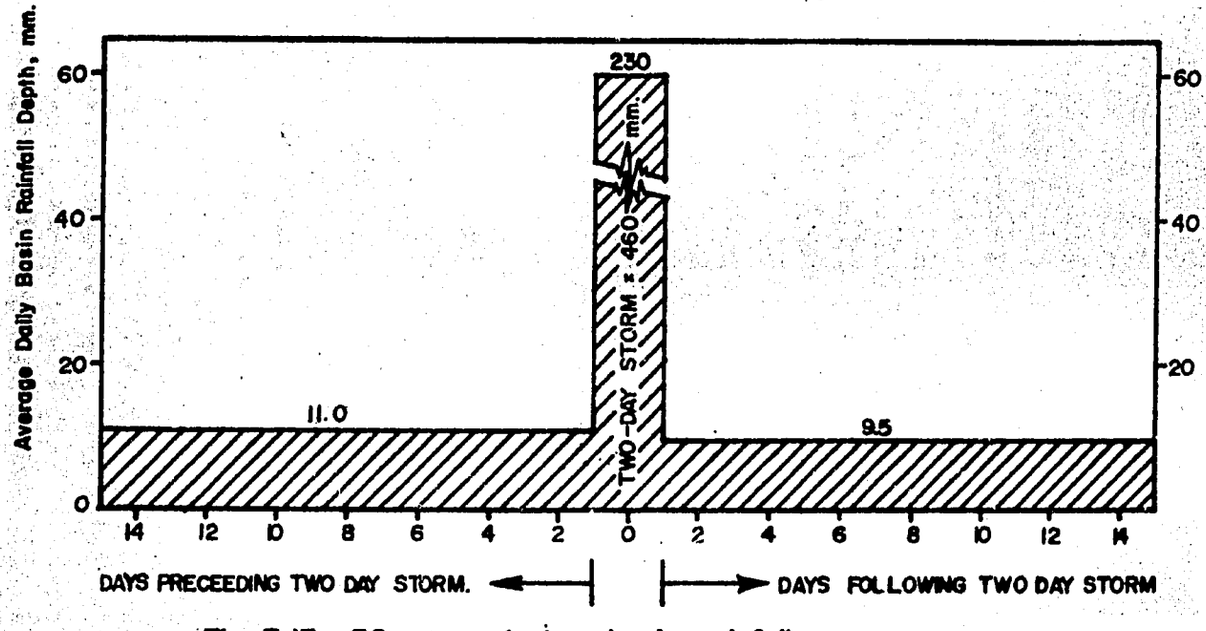



Fig. 3.13 50-year design basin rainfall

The design basin rainfall consists of a 460 mm of two-day storm and a rate of 11 mm per day and 9.5 mm per day rainfall preceding and following the two-day storm respectively. The rainfalls following and preceding the two-day storm rainfall were the average of 24 annual maximum storm events.

3.7.6 Conversion of the Two-Day Design Basin Rainfall into Station Rainfall The conversion of the two-day basin rainfall with a 50-year return period into station rainfall was done by applying to the basin rainfall a distribution obtained by a steepest ascent technique. The computational technique to obtain the distribution is discussed in Section A3 of Appendix A.

The distribution is 0.24, 0.43 and 0.33 respectively for rainfall station Nos.2, 6 and 14. With this distribution, the station rainfalls for the 460 mm basin rainfall are 314, 564 and 432 mm respectively for Station Nos.2, 6 and 14.

A comparison of the observed and estimated station rainfall using the derived distribution is shown in Table 3.11.

## 3.8 Hydrologic Input to Mathematical Model

The schematized model of the flood plain is a system of nodes and branches where the nodes carry the storage effect, inflow and outflow and the branches carry the inertial effects. The system consists of 31 nodes and 34 branches. Runoff from a catchment is assigned to the appropriate node.

The basin is divided into sub-catchments which are classified as: (1) gaged watershed, i.e. runoff or streamflow data is available at the desired point; (2) ungaged watershed; and (3) floodplain area where the direct rainfall less some losses is considered the equivalent runoff.

The division of the basin into sub-catchments is shown in Fig.3.14. The assignments of each of these sub-catchments: gaged, ungaged or floodplain area, into the nodes are summari ed in Table 3.12.

The areas considered as floodplain are marked in Fig.3.14 as $F_1$, $F_2$,..., etc. Also considered as floodplain areas are some small areas close to the boundary of the floodplain where the topography is flat and where there

Table 3.12 - Gaged Watersheds, Ungaged Watersheds and Floodplain Area that Contribute to the Node (for model calibration)

| Node Number | Gaged Stations | Ungaged Stations | Floodplain Area ($Km^2$) | Rainfall Station Applicable |
|---|---|---|---|---|
| 1 | G21 | V02 | - | 2 |
| 2 | - | V01 | 26.20 | 2 |
| 3 | G22,G23 | U24,V03 | 28.12 | 2 |
| 4 | - | U23,U25,V04 | 4.33 | 2 |
| 5 | - | V05 | 8.73 | 2 |
| 6 | - | U22 | 15.48 | 2 |
| 7 | - | V06,V07 | 10.00 | 2 |
| 8 | - | - | 17.00 | 2 |
| 9 | - | U21 | 27.88 | 2 |
| 10 | - | U20,V08,V09, V35 | 36.45 | 2 |
| 11 | G20 | U10,U11,U19, V34 | 40.10 | 6 |
| 12 | - | U8,U9,U18, V10 | 27.70 | 6 |
| 13 | - | U17,V11,V33 | 14.20 | 6 |
| 14 | - | U16 | 10.50 | 6 |
| 15 | G17 | - | 22.48 | 6 |
| 16 | - | V12 | 10.33 | 6 |
| 17 | G14 | U6,U7,V31, V32 | 11.25 | 6 |
| 18 | - | U15,V13 | 15.00 | 6 |
| 19 | - | V29,V30 | 17.38 | 6 |
| 20 | - | U14 | 29.08 | 6 |
| 21 | - | U04,U05,U13, V14 | 25.65 | 6 |
| 22 | G01,G03,G04, G06,G09 | U01,U02,U03, U12,V16,V17, V18,V19,V20, V21,V22,V23, V24,V25,V26, V27,V28,V15 | 194.95 | 14 |
| | | | 592.71 | |

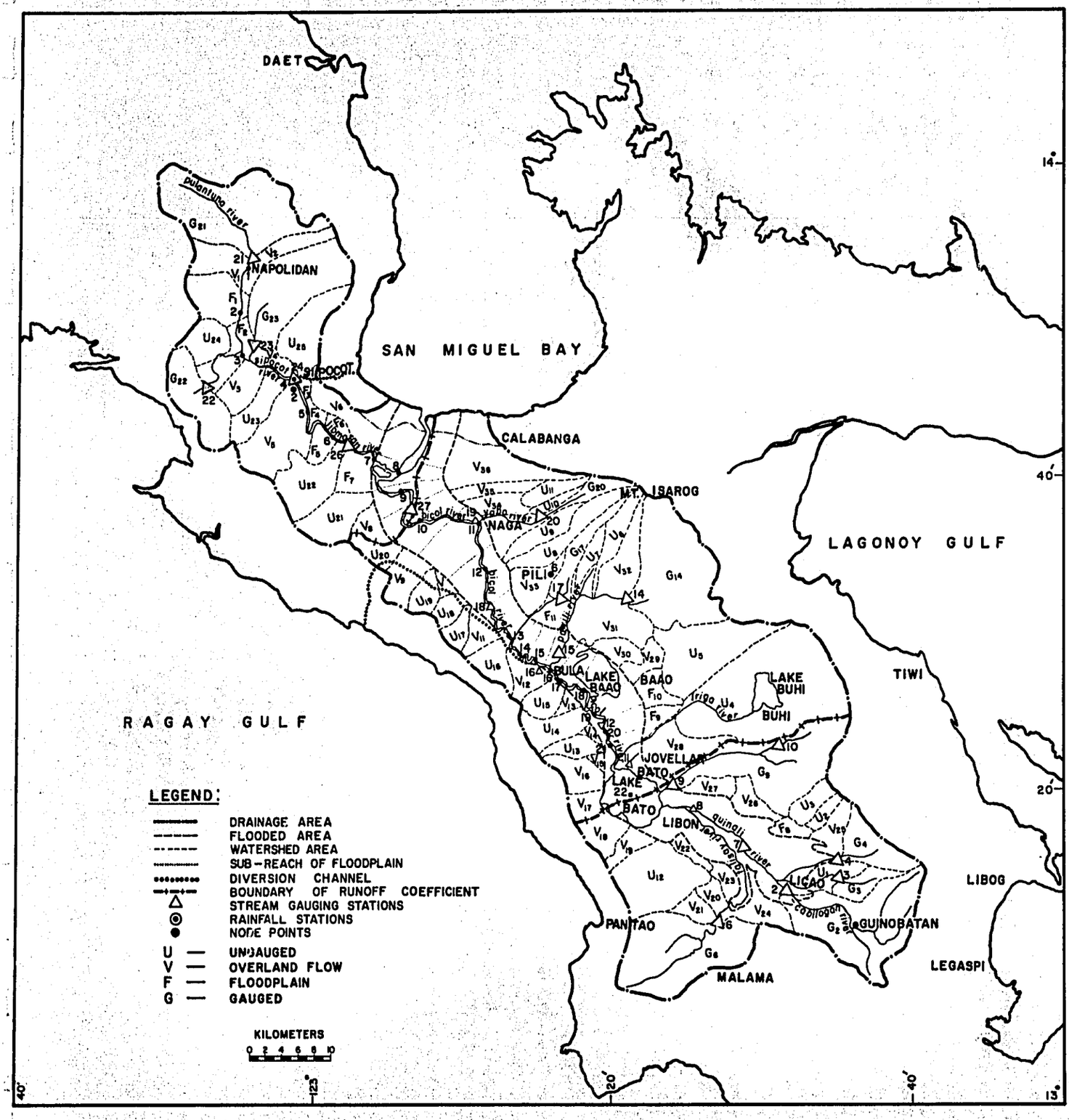



Fig. 3.14 - Division of the Basin into Subcatchments

is no single well-defined stream. Twenty-one percent of the total basin area are classified as flood plain area.

A catchment where there is a well-defined stream but for which no streamflow record is available, is classified as ungaged. They are marked in Fig.3.14 as $V_1$, $V_2$,..., $U_1$, $U_2$, ..., etc. Fifty-eight percent of the basin area are considered ungaged in the case of October 1970 storm.

A catchment with available streamflow record are marked in Fig.3.14 as $G_1$, $G_2$,..., etc.

The sub-catchments in the basin are code numbered as shown in Fig.3.14 and are classified in Table 3.12 according to which node number the catchment runoff is assigned.

## 3.9 Hydrologic Model

The rainfall-runoff process in the basin was modelled by dividing the basin in sub-catchments and schematizing the runoff to converge into predetermined node points. The basin rainfall was represented by three rainfall stations (Station Nos.2, 6 and 14) with each station covering separate regions in the basin. Thus a catchment in the region of Station No.2 would have the observed rainfall of Station No.2 as its rainfall input. The catchment runoff is estimated by using the derived distribution graph. The total streamflow at the catchment outlet would be the estimated runoff plus base flow. This total flow represents the catchment hydrologic input to the node.

Other inputs to the node are direct runoff (in case the node includes a floodplain area) and observed runoff in case a gaged watershed runoff enters the node.

A computer program was developed to calculate the total inflow to a node from a known rainfall input. The program details are discussed in Section 5.9 of Chapter V.

3.9.1 October 1970 Storm as Hydrologic Input The October 1970 storm produced a basin rainfall that had a return period of 13 years. Using rainfall records at Station Nos.2, 6 and 14 and runoff coefficients equal to 0.65, 0.69 and 0.51 (which were obtained from the calibrated model),

respectively for the areas represented by Station Nos.2, 6 and 14 and floodplain runoff coefficient equal to 0.85, the computed total runoff hydrographs to each node are shown in Fig.3.15.

From Fig.3.15, it is observed that the major runoffs from the basin is contributed by the areas near Lake Bato.

3.9.2 Design Storm as Hydrologic Input The 50-year basin rainfall was assumed to produce a design flood in the basin with the same return period. This design flood was used to estimate the effectiveness of the proposed flood control measures to floods larger than the highest recorded flood of 1970.

Using the hydrologic model to calculate the total runoff to the node points, all catchments were treated as ungaged watersheds. As in the 1970 storm input, the representative rainfall stations are Station Nos.2, 6 and 14.

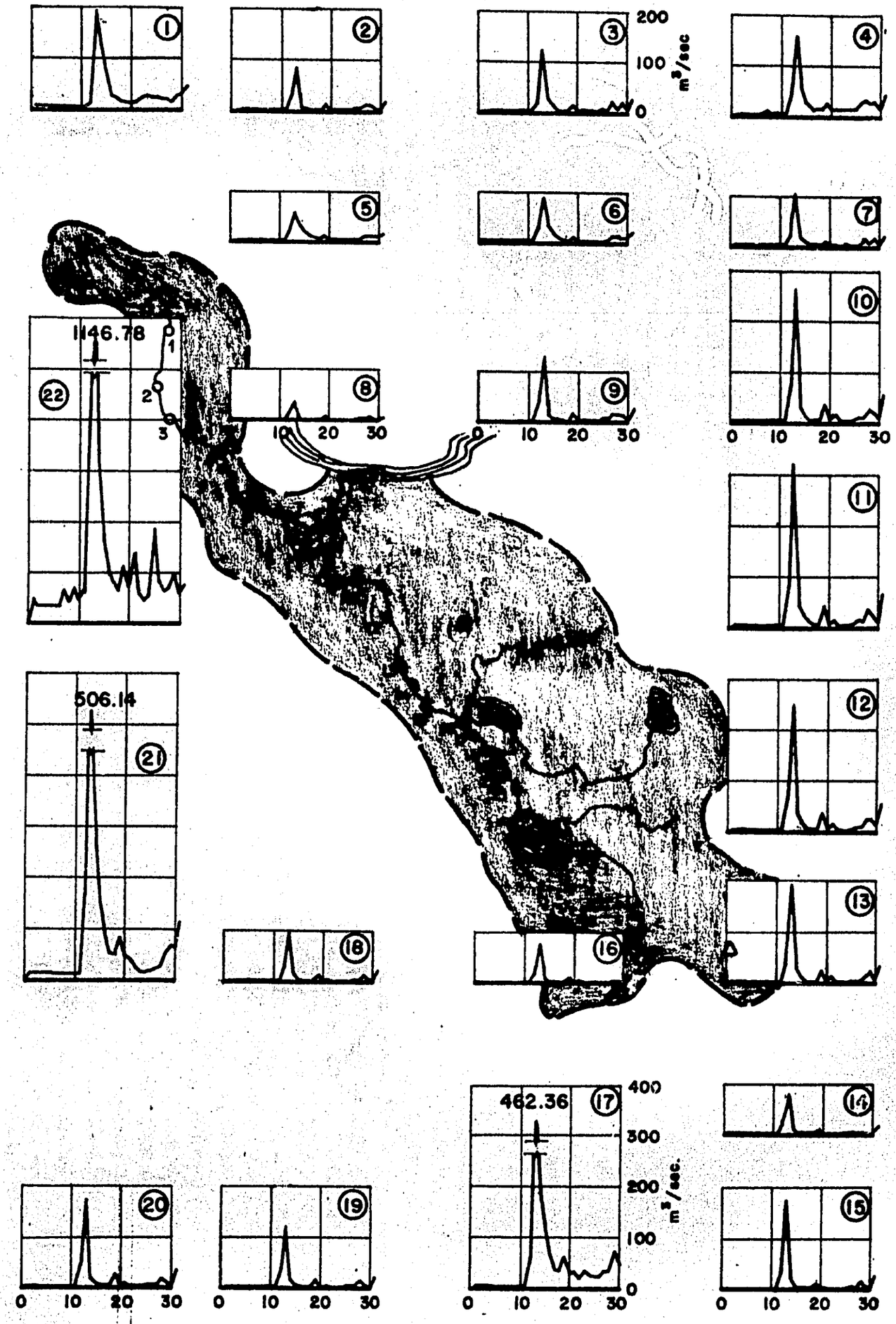



Fig. 3.15 Estimated hydrologic input to model calibration using the October 1970 storm

# IV WATER LEVELS IN SAN MIGUEL BAY AND RAGAY GULF

The water levels in San Miguel Bay is an important factor in controlling the discharge of water from the Bicol River Basin. Similarly, the levels in Ragay Gulf control the discharge from the Bicol-Ragay diversion channel which is being considered as one of the possible flood control measures for the Bicol River Basin. The water levels in both San Miguel Bay and the Ragay Gulf are variable with time and depend upon both astronomical and meteorological factors.

## 4.1 Astronomical Tides

The relative motion of the earth, moon and sun cause periodic tide-producing forces. The period of each constituent can be determined from astronomical studies. Table 4.1 shows some of the constituents with their respective periods.

The tidal variation, $\eta$, at a particular location and time t can be expressed as a sum of the effects of the various constituents

$$\eta = a_o + \sum_{i=1}^{N} a_i \sin\left(\frac{2\pi}{T_i} t + \delta_i\right) \qquad (4.1)$$

In Eq.(4.1), $a_o$ is the mean sea level, N is the total number of constituents while $a_i$, $\delta_i$ and $T_i$ are the amplitude, phase and period of the $i^{th}$ constituent.

4.1.1 Tidal Analysis In order to use Eq.(4.1) to determine the tidal variations in San Miguel Bay and Ragay Gulf, the appropriate values of $a_o$, $a_i$ and $\delta_i$ must be determined for the corresponding values of $T_i$. These values can be determined from information obtained from tidal records at these locations.

Each constituent listed in Table 4.1 affects the tidal elevations to varying degrees depending upon the physiography of the region where the tidal levels are to be determined. In view of the large extent of the land mass separating San Miguel Bay and Ragay Gulf, it is not surprising that the tidal behavior at these locations are dissimilar.

Given a sufficiently long length of tidal record at any location,

Table 4.1 - List of Important Tidal Constituents

| Name of Constituents | Period (hrs) | Description |
|---|---|---|
| Sa | 8759.124 | long period |
| Ssa | 4384.896 | |
| Mm | 661.278 | |
| MSf | 354.356 | |
| Mf | 327.869 | |
| $K_1$ | 23.934 | diurnal |
| $O_1$ | 25.819 | |
| $P_1$ | 24.066 | |
| $Q_1$ | 26.868 | |
| $M_1$ | 24.841 | |
| $J_1$ | 23.098 | |
| $M_2$ | 12.421 | semi-diurnal |
| $S_2$ | 12.00 | |
| $N_2$ | 12.658 | |
| $K_2$ | 11.967 | |
| $\nu_2$ | 12.626 | |
| $\mu_2$ | 12.872 | |
| $L_2$ | 12.192 | |
| $T_2$ | 12.016 | |
| $2N_2$ | 12.905 | |

the importance of each component can be identified and included in an appropriate manner when determining future tidal behavior. In view of the relatively short record of water levels (23 to 27 days) at San Miguel Bay and Ragay Gulf, the precise effect of each of the 20 constituents listed in Table 4.1 could not be properly identified. A criterion was therefore established which enabled those constituents to be identified in the order of the accuracy of their determination. The accuracy of the criterion and correspondingly the ability to predict future tidal levels depended upon the length of the available record of observed water levels at San Miguel Bay and Ragay Gulf.

The following analysis is hence divided into two sections. The first section describes the method of analysis which was used in determining how the 20 constituents and their corresponding values of $a_i$ and $\delta_i$ were obtained from field measurements. In the second section, an analysis was then made to select from these components listed those which were considered reliable for projecting or hindcasting astronomical tidal action at the towns of Balongay and Pasacao.

4.1.2 Method of Analysis for Determining $a_o$, $a_i$ and $\delta_i$ Eq.(4.1) can be written as

$$\eta = a_o + \sum_{i=1}^{N} \left[ a_i \cos\delta_i \sin\left(\frac{2\pi}{T_i} t\right) + a_i \sin\delta_i \cos\left(\frac{2\pi}{T_i} t\right) \right] \qquad (4.2)$$

To find the amplitude and phase of the $j^{th}$ component, i.e. $a_j$ and $\delta_j$, Eq.(4.2) is multiplied by $\sin(\frac{2\pi}{T_j} t)$ and integrated over a long time interval $\Delta t$ and divided by $\Delta t$ where $\Delta t$ is the length of the tidal record,

$$\frac{1}{\Delta t}\int_o^{\Delta t} \eta \sin\left(\frac{2\pi}{T_j} t\right)dt = \frac{1}{\Delta t}\left[\int_o^{\Delta t} a_o \sin\left(\frac{2\pi}{T_j} t\right)dt + \sum_{i=1}^{N} a_i \cos\delta_i \int_o^{\Delta t} \sin\left(\frac{2\pi}{T_i} t\right) \sin\left(\frac{2\pi}{T_j} t\right)dt \right.$$

$$\left. + \sum_{i=1}^{N} a_i \sin\delta_i \int_o^{\Delta t} \cos\left(\frac{2\pi}{T_i} t\right) \sin\left(\frac{2\pi}{T_j} t\right)dt \right] \qquad (4.3)$$

The right hand side of Eq.(4.3) can be integrated to yield,

$$\frac{1}{\Delta t}\int_{o}^{\Delta t} \eta \sin\left(\frac{2\pi}{T_j} t\right)dt = \frac{1}{\Delta t}\left[\frac{a_o}{2\pi} T_j\left(1-\cos\frac{2\pi\Delta t}{T_j}\right) + \sum_{i=1}^{N} a_i \cos\delta_i (A_{ij}-B_{ij}) + \sum_{i=1}^{N} a_i \sin\delta_i (C_{ij}+D_{ij})\right] \tag{4.4}$$

where

$$\left.\begin{aligned}
A_{ij} &= \frac{\sin\left[2\pi\Delta t\left(\frac{1}{T_i} - \frac{1}{T_j}\right)\right]}{4\pi\left(\frac{1}{T_i} - \frac{1}{T_j}\right)} \\
B_{ij} &= \frac{\sin\left[2\pi\Delta t\left(\frac{1}{T_i} + \frac{1}{T_j}\right)\right]}{4\pi\left(\frac{1}{T_i} + \frac{1}{T_j}\right)} \\
C_{ij} &= \frac{1-\cos\left[2\pi\Delta t\left(\frac{1}{T_i} - \frac{1}{T_j}\right)\right]}{4\pi\left(\frac{1}{T_i} - \frac{1}{T_j}\right)} \\
\text{and} \quad D_{ij} &= \frac{1-\cos\left[2\pi\Delta t\left(\frac{1}{T_i} + \frac{1}{T_j}\right)\right]}{4\pi\left(\frac{1}{T_i} + \frac{1}{T_j}\right)}
\end{aligned}\right\} \tag{4.5}$$

Taking the term $i = j$ out from the $\sum_{i=1}^{N}$ expressions and let the symbol $\sum_{i\neq j}^{N}$ mean the sum, $\sum_{i=1}^{N}$, excluding the term $i = j$, therefore

$$\frac{1}{\Delta t}\int_{o}^{\Delta t} \eta \sin\left(\frac{2\pi}{T_j} t\right)dt = \frac{1}{\Delta t}(M1+M2) + \left(\frac{a_j}{\Delta t} A_{jj}\cos\delta_j - \frac{a_j}{\Delta t} B_{jj}\cos\delta_j\right) + \left(\frac{a_j}{\Delta t} C_{jj}\sin\delta_j + \frac{a_j}{\Delta t} D_{jj}\sin\delta_j\right) \tag{4.6}$$

where

$$\left.\begin{aligned}
M1 &= \frac{a_o}{2\pi} T_j\left(1-\cos\frac{2\pi\Delta t}{T_j}\right) \\
\text{and} \quad M2 &= \sum_{i\neq j}^{N} a_i (A_{ij} - B_{ij})\cos\delta_i + \sum_{i\neq j}^{N} a_i (C_{ij} + D_{ij})\sin\delta_i
\end{aligned}\right\} \tag{4.7}$$

Let

$$k_j = \frac{1}{\Delta t}(M1+M2) + \frac{a_j}{\Delta t}(D_{jj}\sin\delta_j - B_{jj}\cos\delta_j),$$

Eq.(4.6) can be written as

$$\frac{1}{\Delta t}\int_{o}^{\Delta t} \eta \sin(\frac{2\pi}{T_j} t)dt = k_j + a_j\left[\frac{A_{jj}}{\Delta t}\cos\delta_j + \frac{C_{jj}}{\Delta t}\sin\delta_j\right] \tag{4.8}$$

For i=j, i.e. $T_i = T_j$, the terms containing $A_{jj}$ and $C_{jj}$ are indeterminate. As $\Delta t \to \infty$, $k_j \to$ zero and the last term on the right hand side of Eq.(4.8) is determined by L' Hospital rule. Eq.(4.8) then becomes

$$\lim_{\Delta t\to\infty} \frac{1}{\Delta t}\int_{o}^{\Delta t} \eta \sin(\frac{2\pi}{T_j} t)dt = \frac{a_j}{2}\cos\delta_j \tag{4.9}$$

Similarly, multiplying Eq.(4.2) by $\cos(\frac{2\pi}{T_j} t)$ and following the same procedure, one arrives at the result (corresponding to Eq.(4.8)) that,

$$\frac{1}{\Delta t}\int_{o}^{\Delta t} \eta \cos(\frac{2\pi}{T_j} t)dt = \ell_j + a_j\left[\frac{A_{jj}}{\Delta t}\sin\delta_j + \frac{C_{jj}}{\Delta t}\cos\delta_j\right] \tag{4.10}$$

$$\left.\begin{aligned} \text{where} \quad \ell_j &= \frac{1}{\Delta t}(N1 + N2) + \frac{a_j}{\Delta t}(D_{jj}\cos\delta_j + B_{jj}\sin\delta_j) \\ N1 &= \frac{a_o}{2\pi} T_j \sin\frac{2\pi\Delta t}{T_j} \\ \text{and} \quad N2 &= \sum_{i\neq j}^{N} a_i(C_{ij} + D_{ij})\cos\delta_i + \sum_{i\neq j}^{N} a_i(A_{ij} + B_{ij})\sin\delta_i \end{aligned}\right\} \tag{4.11}$$

As $\Delta t \to \infty$, Eq.(4.10) becomes

$$\lim_{\Delta t\to\infty} \frac{1}{\Delta t}\int_{o}^{\Delta t} \eta \cos(\frac{2\pi}{T_j} t)dt = \frac{a_j}{2}\sin\delta_j \tag{4.12}$$

The left hand sides of Eqs.(4.9) and (4.12) can be determined from the tidal record. The terms $a_j$ and $\delta_j$ can therefore be determined by solving simultaneously Eqs.(4.9) and (4.12). Performing this for j=1 to N, the amplitude and phase of each constituent can be found.

The mean sea level $a_o$ is given by

$$\lim_{\Delta t\to\infty} \frac{1}{\Delta t}\int_{o}^{\Delta t} \eta dt = a_o \tag{4.13}$$

The above tidal analysis is complete under the assumption that $\Delta t$ is large. In practice, $\Delta t$ is finite, therefore $k_j$ and $\ell_j$ may not be close enough to zero in order to make Eqs.(4.9) and (4.12) valid. One way to justify this is to study the absolute values of $k_j$ and $\ell_j$ for the available $\Delta t$ and compare them with $a_j$.

4.1.3 <u>Absolute Values of $k_j$ and $\ell_j$</u> The absolute value of $k_j$ can be written as

$$
\begin{aligned}
|k_j| &= \left|\frac{1}{\Delta t}(M1+M2) + \frac{a_j}{\Delta t}(D_{jj}\sin\delta_j - B_{jj}\cos\delta_j)\right| \\
&\leq \frac{1}{\Delta t}|M1+M2| + \frac{a_j}{\Delta t}|D_{jj}\sin\delta_j - B_{jj}\cos\delta_j| \\
&\leq \frac{1}{\Delta t}(|M1| + |M2|) + \frac{a_j}{\Delta t}(|D_{jj}| + |B_{jj}|) \qquad (4.14)
\end{aligned}
$$

Since

$$
\begin{aligned}
|A_{ij}| &\leq \frac{1}{4\pi\left|\frac{1}{T_i} - \frac{1}{T_j}\right|} \\
|B_{ij}| &\leq \frac{1}{4\pi\left(\frac{1}{T_i} + \frac{1}{T_j}\right)} \\
|C_{ij}| &\leq \frac{1}{2\pi\left|\frac{1}{T_i} - \frac{1}{T_j}\right|} \\
|D_{ij}| &\leq \frac{1}{2\pi\left(\frac{1}{T_i} + \frac{1}{T_j}\right)}
\end{aligned}
$$

therefore,

(i) $$|M1| = \frac{a_o T_j}{\pi}$$

(ii) $$
\begin{aligned}
|M2| &= \left|\sum_{i\neq j}^{N} \{a_i(A_{ij} - B_{ij})\cos\delta_i + a_i(C_{ij} + D_{ij})\sin\delta_i\}\right| \\
&\leq \sum_{i\neq j}^{N} a_i|(A_{ij} - B_{ij})\cos\delta_i + (C_{ij} + D_{ij})\sin\delta_i| \\
&\leq \sum_{i\neq j}^{N} a_i(|A_{ij} - B_{ij}| + |C_{ij} - D_{ij}|)
\end{aligned}
$$

$$\leq \sum_{i \neq j}^{N} a_i (|A_{ij}| + |B_{ij}| + |C_{ij}| + |D_{ij}|)$$

$$\leq \frac{3}{4\pi} \sum_{i \neq j}^{N} a_i \left[ \frac{1}{\left|\frac{1}{T_i} - \frac{1}{T_j}\right|} + \frac{1}{\left(\frac{1}{T_i} + \frac{1}{T_j}\right)} \right]$$

(iii) $|B_{jj}| \leq \frac{T_j}{6\pi}$

and (iv) $|D_{jj}| \leq \frac{T_j}{4\pi}$

Using (i) to (iv), the relation (Eq.(4.14)) can be written as

$$k_j \leq k_{jmax} \tag{4.15}$$

where $$k_{jmax} = \frac{1}{\Delta t} \left[ \frac{a_o T_j}{\pi} + \frac{3}{4\pi} \sum_{i \neq j}^{N} a_i \left( \frac{1}{\left|\frac{1}{T_i} - \frac{1}{T_j}\right|} + \frac{1}{\left(\frac{1}{T_i} + \frac{1}{T_j}\right)} \right) + \frac{3 a_j T_j}{8\pi} \right] \tag{4.16}$$

Therefore, Eq.(4.9) will be valid if

$$\frac{a_j}{2} \cos\delta_j \gg k_{jmax} \tag{4.17}$$

The absolute value of $\ell_j$ can be found in the similar manner. Eq.(4.12) will then be valid if

$$\frac{a_j}{2} \sin\delta_j \gg \ell_{jmax} \tag{4.18}$$

where $$\ell_{jmax} = \frac{1}{\Delta t} \left[ \frac{a_o T_j}{2\pi} + \frac{3}{4\pi} \sum_{i \neq j}^{N} \left( a_i \frac{1}{\left|\frac{1}{T_i} - \frac{1}{T_j}\right|} + \frac{1}{\left(\frac{1}{T_i} + \frac{1}{T_j}\right)} \right) + \frac{3 a_j T_j}{8\pi} \right] \tag{4.19}$$

Since $k_{jmax} > \ell_{jmax}$, the relations in Eqs.(4.17) and (4.18) can be combined as

$$\frac{a_j^2}{4} \gg 2k_{jmax}^2$$

or $$a_j \gg 2\sqrt{2}\, k_{jmax} \tag{4.20}$$

Eq.(4.20) is the required criterion.

Having found every $a_j$ and $\delta_j$, $k_{jmax}$ can be determined from Eq.(4.15). The ratio $2\sqrt{2}\ k_{jmax}/a_j$ can be used as a criterion for selecting the constituents for use in the tidal prediction.

The maximum value of $2\sqrt{2}\ k_{jmax}/a_j$ required to make the $j^{th}$ constituent acceptable is yet to be established.

4.1.4 Flow Chart for Computer Execution The computer program shown in Appendix B is written according to the flow chart shown in Fig.4.1.

4.1.5 Result of Tidal Analysis at Balongay. The result of the tidal analysis at Balongay using 27 days of recorded data is presented in Table 4.2. Column 6 indicates the order of each constituent. Order 1 corresponds to the constituent with the lowest value of $2\sqrt{2}\ k_{jmax}/a_j$.

The prediction using the first 6 constituents according to their rank order and the fourth constituent (j=4) seem to give good results when compared with the existing record. The inclusion of the fourth constituent, whose rank order is 15, is to include the effect of fortnightly variation which is apparent in the tidal record.

Therefore, the formula used for making tidal predictions at Balongay is

$$\eta = a_o + \sum_{i=1}^{7} a_i \sin\left(\frac{2\pi}{T_i} t + \delta_i\right) \qquad (4.21)$$

Eq.(4.21) expresses the relation between the tidal variation $\eta$ in meters and the time t in hours. The origin of the time axis is at 4:30 am., March 6, 1974. The values of $a_i$, $T_i$ and $\delta_i$ are presented in Table 4.3.

4.1.6 Result of Tidal Analysis at Pasaco The result of the tidal analysis at Pasacao using 23 days recorded data is presented in Table 4.4.

The formula used for making tidal predictions at Pasacao is

$$\eta = a_o + \sum_{i=1}^{4} a_i \sin\left(\frac{2\pi}{T_i} t + \delta_i\right) \qquad (4.22)$$

The origin of the time axis, t, is at 9 am., March 8, 1974. The values of $a_i$, $\delta_i$ and $T_i$ are presented in Table 4.5.

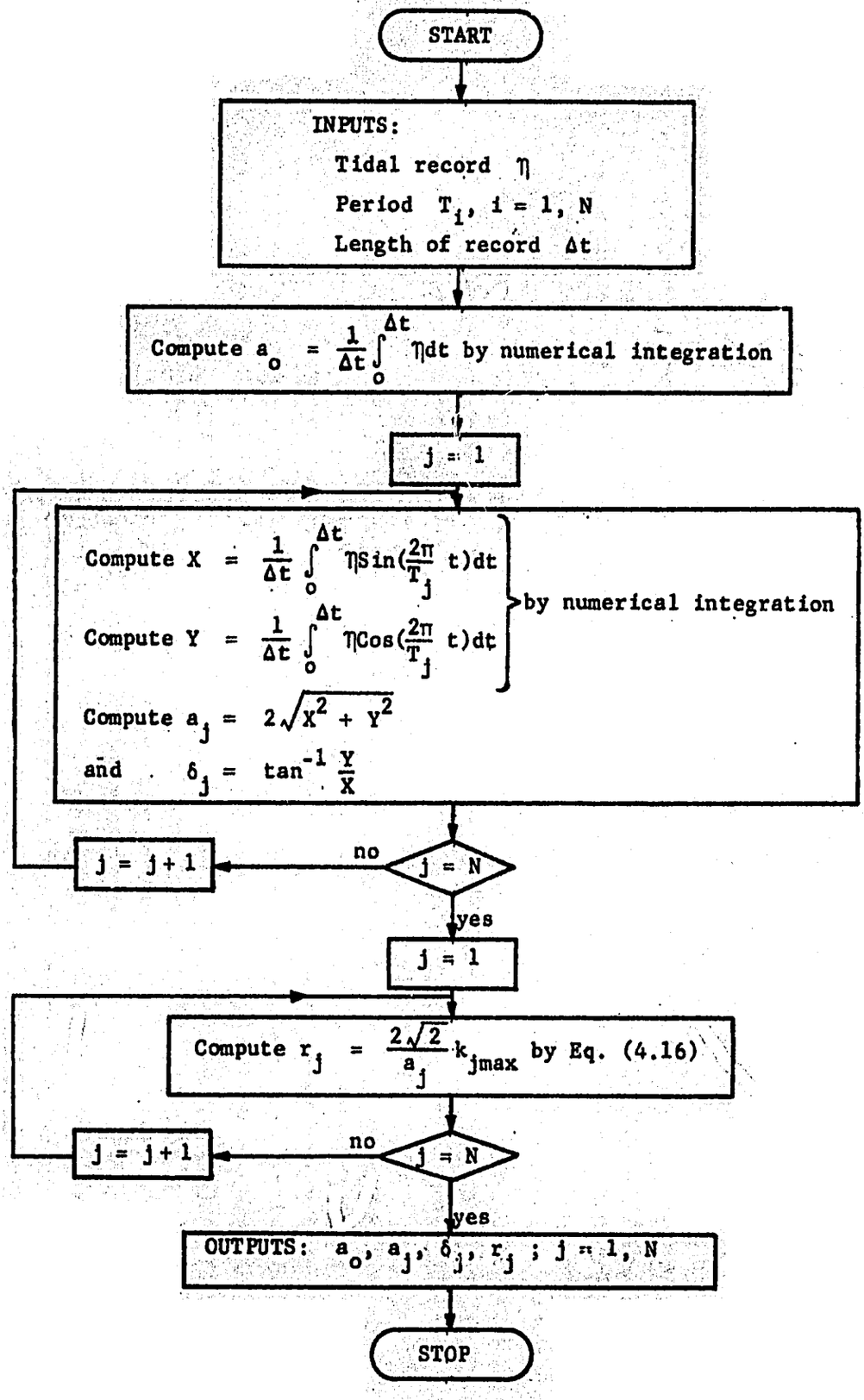



Fig. 4.1 - Computer Flow Chart for Tidal Analysis

Table 4.2 - Tidal Computations at Balongay, Using 27 Days of Record, $a_o = 1.221$ m

| j | Amplitude $a_j$ (m) | Phase $\delta_j$ (radian) | Period $T_j$ (hrs) | $2\sqrt{2}\,k_{jmax}$ | $\frac{2\sqrt{2}\,k_{jmax}}{a_j}$ | Order |
|---|---|---|---|---|---|---|
| 1 | 2.417 | 1.343 | 8759.124 | 54.18 | 22.42 | 16 |
| 2 | 2.350 | 1.116 | 4384.896 | 42.09 | 17.91 | 14 |
| 3 | 0.098 | 0.002 | 661.278 | 8.05 | 82.45 | 19 |
| 4 | 0.209 | -0.922 | 354.366 | 4.53 | 21.73 | 15 |
| 5 | 0.050 | -0.201 | 327.869 | 4.92 | 97.49 | 20 |
| 6 | 0.128 | 0.393 | 23.934 | 1.03 | 8.03 | 3 |
| 7 | 0.116 | -0.920 | 25.819 | 0.55 | 4.75 | 2 |
| 8 | 0.122 | 1.0 | 24.066 | 1.06 | 8.75 | 4 |
| 9 | 0.044 | 0.161 | 26.868 | 0.56 | 12.89 | 8 |
| 10 | 0.049 | -0.823 | 24.841 | 0.67 | 13.77 | 10 |
| 11 | 0.043 | 0.401 | 23.098 | 0.57 | 13.14 | 9 |
| 12 | 0.657 | 1.571 | 12.421 | 0.77 | 1.18 | 1 |
| 13 | 0.385 | 0.895 | 12.0 | 5.64 | 14.65 | 11 |
| 14 | 0.098 | 1.571 | 12.658 | 1.22 | 12.44 | 6 |
| 15 | 0.340 | 0.543 | 11.967 | 3.42 | 10.05 | 5 |
| 16 | 0.041 | 1.571 | 12.626 | 1.58 | 38.43 | 18 |
| 17 | 0.069 | 1.571 | 12.872 | 1.07 | 15.52 | 12 |
| 18 | 0.058 | -1.414 | 12.192 | 1.58 | 27.18 | 17 |
| 19 | 0.399 | 1.082 | 12.016 | 5.02 | 12.59 | 7 |
| 20 | 0.062 | 1.571 | 12.905 | 1.06 | 17.07 | 13 |

Table 4.3 - Value of Terms in Equation (4.21)

| i | $a_i$ (m) | $\delta_i$ (radian) | $T_i$ (hour) |
|---|---|---|---|
| 0 | 1.221 | - | - |
| 1 | 0.657 | 1.571 | 12.421 |
| 2 | 0.116 | -0.92 | 25.819 |
| 3 | 0.128 | 0.393 | 23.934 |
| 4 | 0.122 | 1.0 | 24.066 |
| 5 | 0.34 | 0.543 | 11.967 |
| 6 | 0.098 | 1.571 | 12.658 |
| 7 | 0.209 | -0.922 | 354.366 |

Table 4.4 - Tidal Computation at Pasacao Using 23 Days of Record, $a_o = 1.007$ m

| j | Amplitude $a_j$ (m) | Phase $\delta_j$ (radian) | Period $T_j$ (hrs) | $2\sqrt{2}\,k_{jmax}$ | $\frac{2\sqrt{2}\,k_{jmax}}{a_j}$ | Order |
|---|---|---|---|---|---|---|
| 1 | 2.000 | 1.370 | 8759.124 | 53.57 | 26.78 | 17 |
| 2 | 1.958 | 1.170 | 4384.896 | 41.70 | 21.29 | 14 |
| 3 | 0.292 | -0.988 | 661.278 | 8.54 | 29.19 | 18 |
| 4 | 0.421 | -0.374 | 354.366 | 6.23 | 14.80 | 8 |
| 5 | 0.311 | -0.800 | 327.869 | 6.47 | 20.82 | 13 |
| 6 | 0.309 | 0.198 | 23.934 | 2.18 | 7.05 | 3 |
| 7 | 0.241 | 1.571 | 25.819 | 0.76 | 3.16 | 2 |
| 8 | 0.299 | 0.674 | 24.066 | 2.23 | 7.46 | 4 |
| 9 | 0.052 | 0.988 | 26.868 | 0.83 | 16.02 | 10 |
| 10 | 0.013 | 1.571 | 24.841 | 1.19 | 91.83 | 20 |
| 11 | 0.075 | 1.571 | 23.099 | 0.94 | 12.58 | 6 |
| 12 | 0.463 | 0.876 | 12.421 | 0.94 | 2.03 | 1 |
| 13 | 0.392 | -0.497 | 12.000 | 6.63 | 16.91 | 11 |
| 14 | 0.065 | 1.571 | 12.658 | 1.65 | 25.38 | 16 |
| 15 | 0.364 | -0.874 | 11.967 | 3.97 | 10.90 | 5 |
| 16 | 0.104 | 1.571 | 12.626 | 1.48 | 14.19 | 7 |
| 17 | 0.062 | 1.571 | 12.872 | 1.13 | 18.18 | 12 |
| 18 | 0.044 | 1.571 | 12.192 | 1.73 | 39.40 | 19 |
| 19 | 0.396 | -0.305 | 12.016 | 5.96 | 15.07 | 9 |
| 20 | 0.050 | 1.571 | 12.905 | 1.16 | 23.38 | 15 |

Table 4.5 - Value of Terms in Equation (4.22)

| i | $a_i$ (m) | $\delta_i$ (radian) | $T_i$ (hrs) |
|---|---|---|---|
| 0 | 1.007 | - | - |
| 1 | 0.463 | 0.876 | 12.421 |
| 2 | 0.241 | 1.571 | 25.819 |
| 3 | 0.309 | 0.198 | 23.934 |
| 4 | 0.299 | 0.674 | 24.066 |

Using this method of tidal analysis, the formulas for tidal prediction at Balongay and Pasacao are those shown in Eqs.(4.21) and (4.22) with coefficients given in Table 4.3 and 4.5 respectively. As the length of the available tidal record increases, the accuracy of tidal predictions will be uniformly better. It should be noted that the recognition of the long period constituents by this method will be improved if a longer record is available. The short period of available records is the reason why the rank order of the long period constituents are usually high.

The value of $k_{jmax}$ for each constituent is only a global estimation of the error involved in estimating the amplitude and phase of that constituent. Therefore, the orders of the constituents (as shown in the last column of Tables 4.3 and 4.5) are only approximations.

The computing time for one month of data (hourly readings) is about one minute on a CDC 3600 digital computer.

Figs.4.2 and 4.3 show respectively the observed water surface levels at Balongay and Pasacao during a period of approximately one month. Also shown on these diagrams are the computed tidal levels using Eqs.(4.21) and (4.22).

Figs.4.4 and 4.5 show respectively the hindcasted tidal record for a typical one month period during the typhoon season at Balongay and Pasacao. The portion of this tidal data which was used for the boundary conditions of the mathematical model of the Bicol River Basin flood control study is shown on the figure.

The tidal fluctuations at San Miguel Bay and Ragay Gulf are generated by computer subroutines TIDAL1 and TIDAL2 respectively as shown in Appendix C.

## 4.2 Meteorological Tides

Meteorological conditions which are present during typhoon periods can have a considerable influence on the water levels in San Miguel Bay and Ragay Gulf. These conditions are: minimum central pressure, typhoon speed and path, typhoon size or radius, and local wind velocities. Eq.(4.23) describes the change in water level produced by typhoon effects

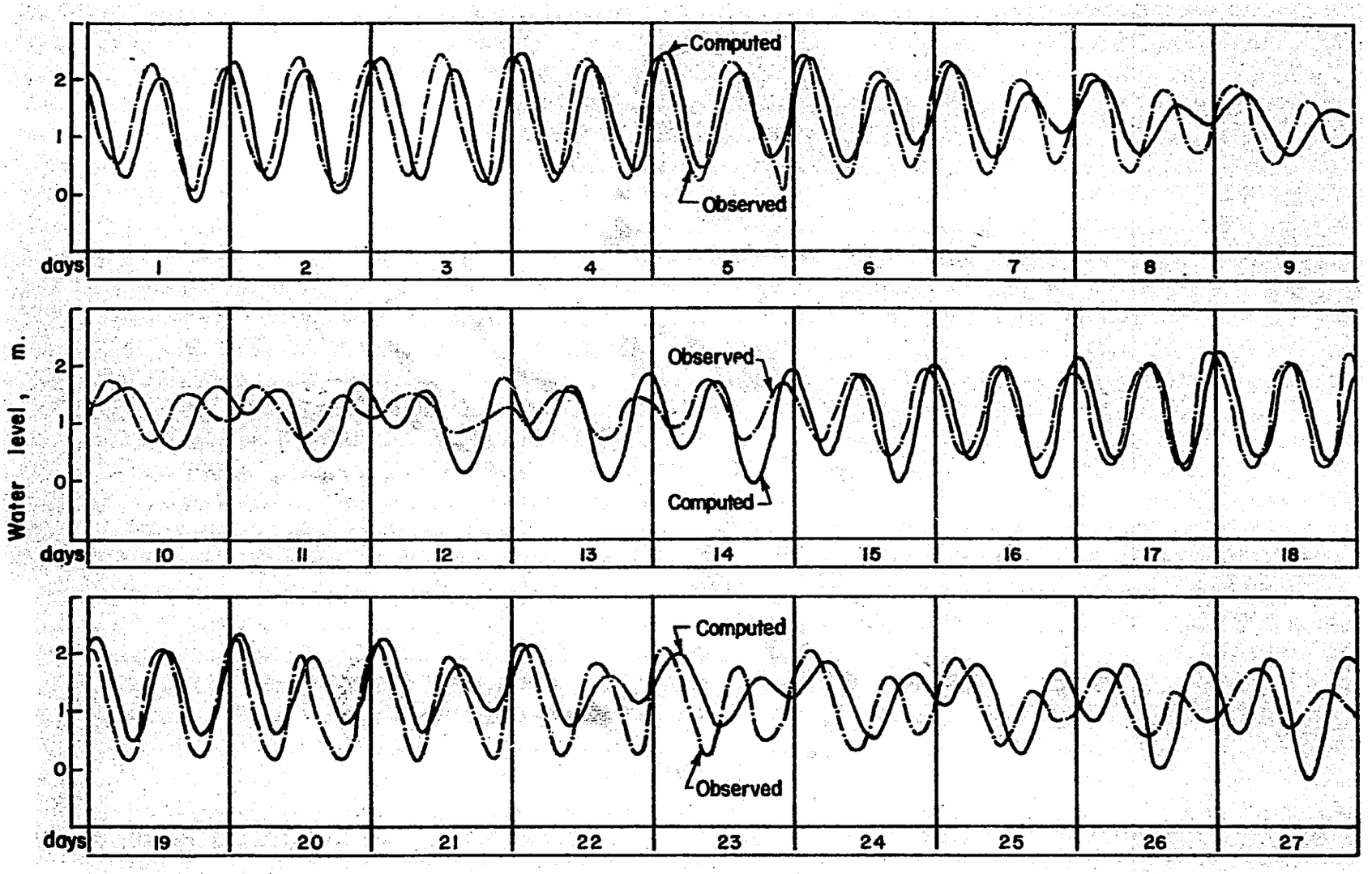



Fig. 4.2 Observed and computed tidal fluctuation at Balongay in San Miguel Bay

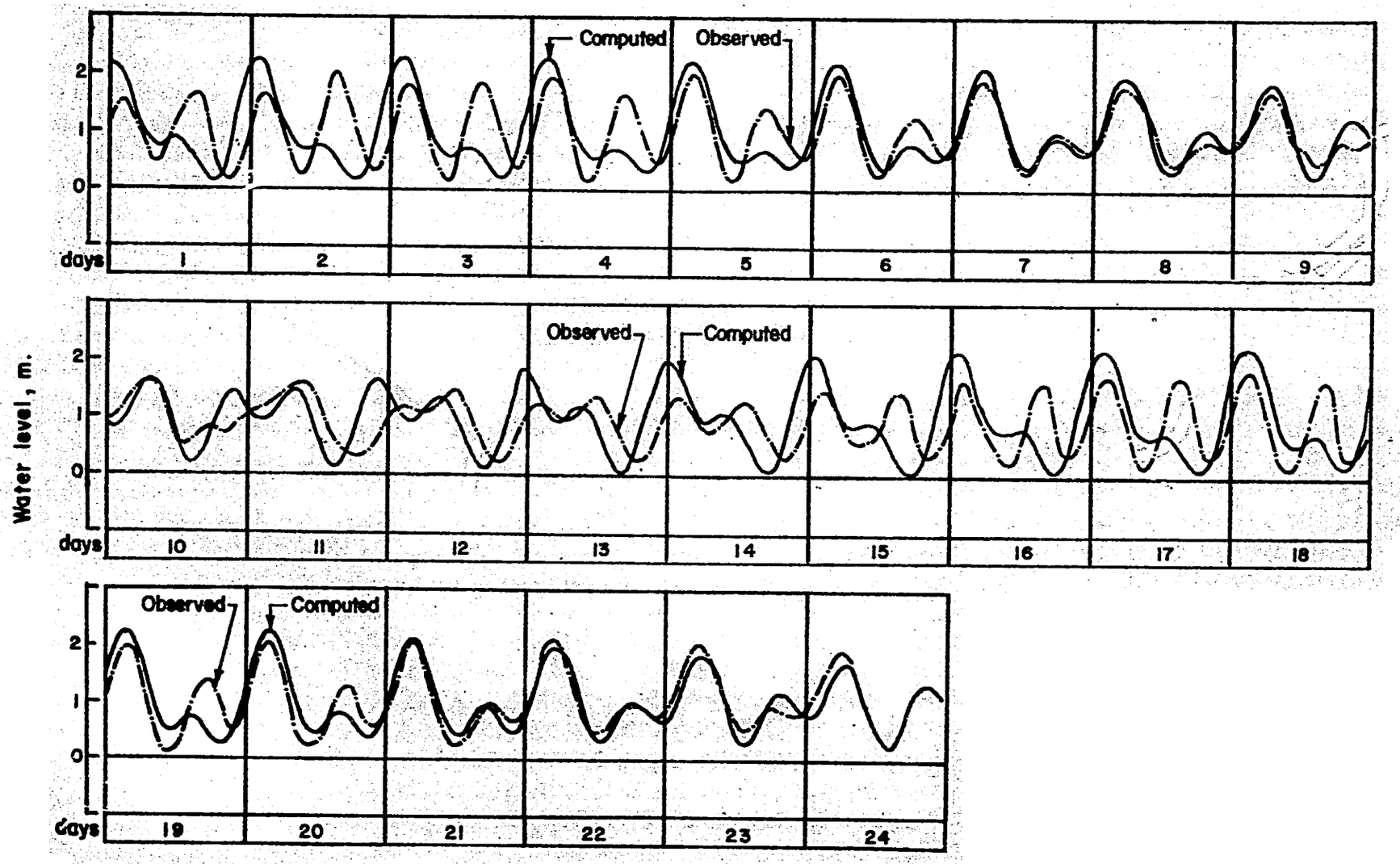



Fig. 4.3 Observed and computed tidal fluctuation at Pasacao in Ragay Gulf

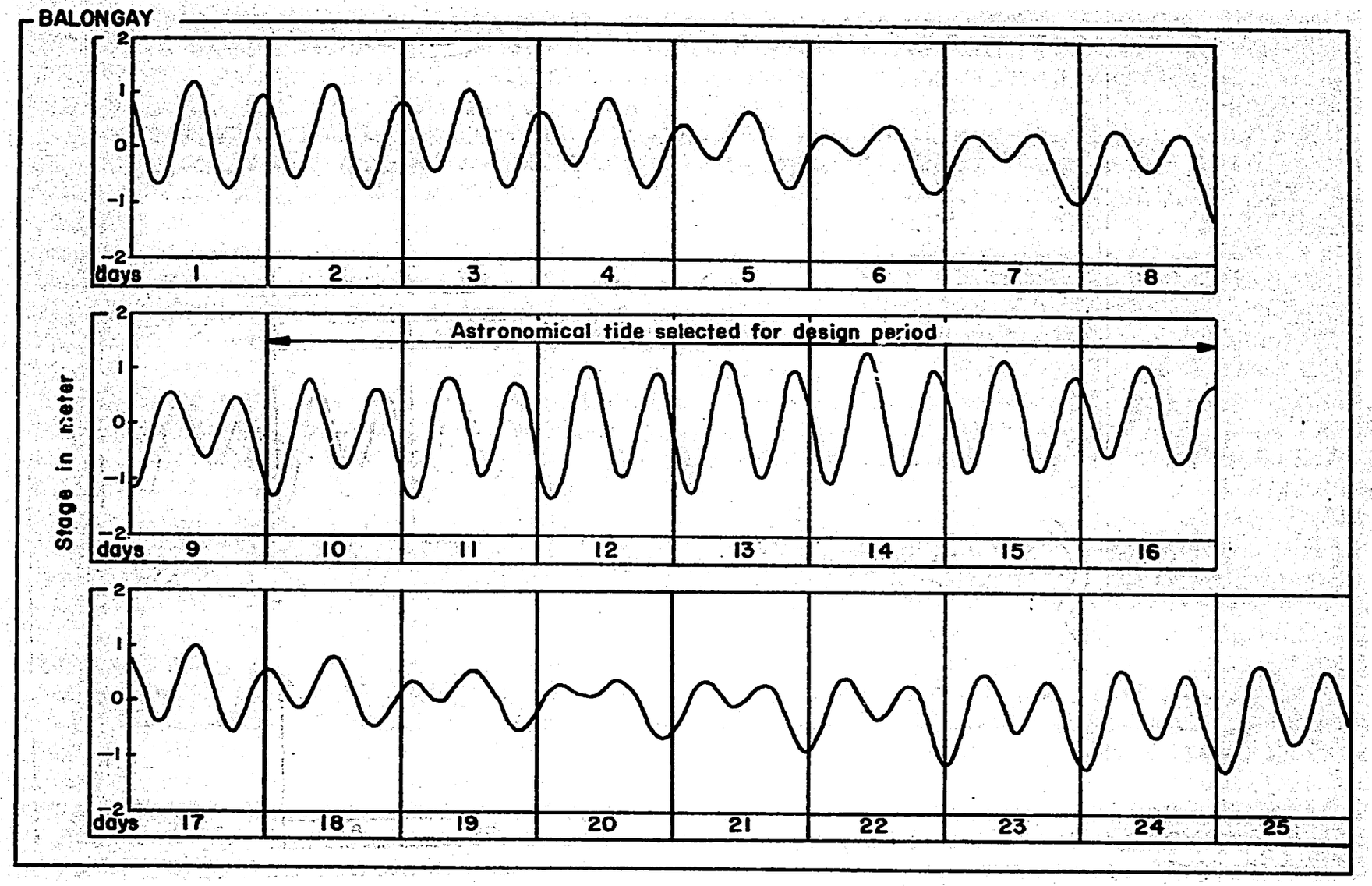



Fig. 4.4 Generated tidal fluctuation at Balongay in San Miguel Bay

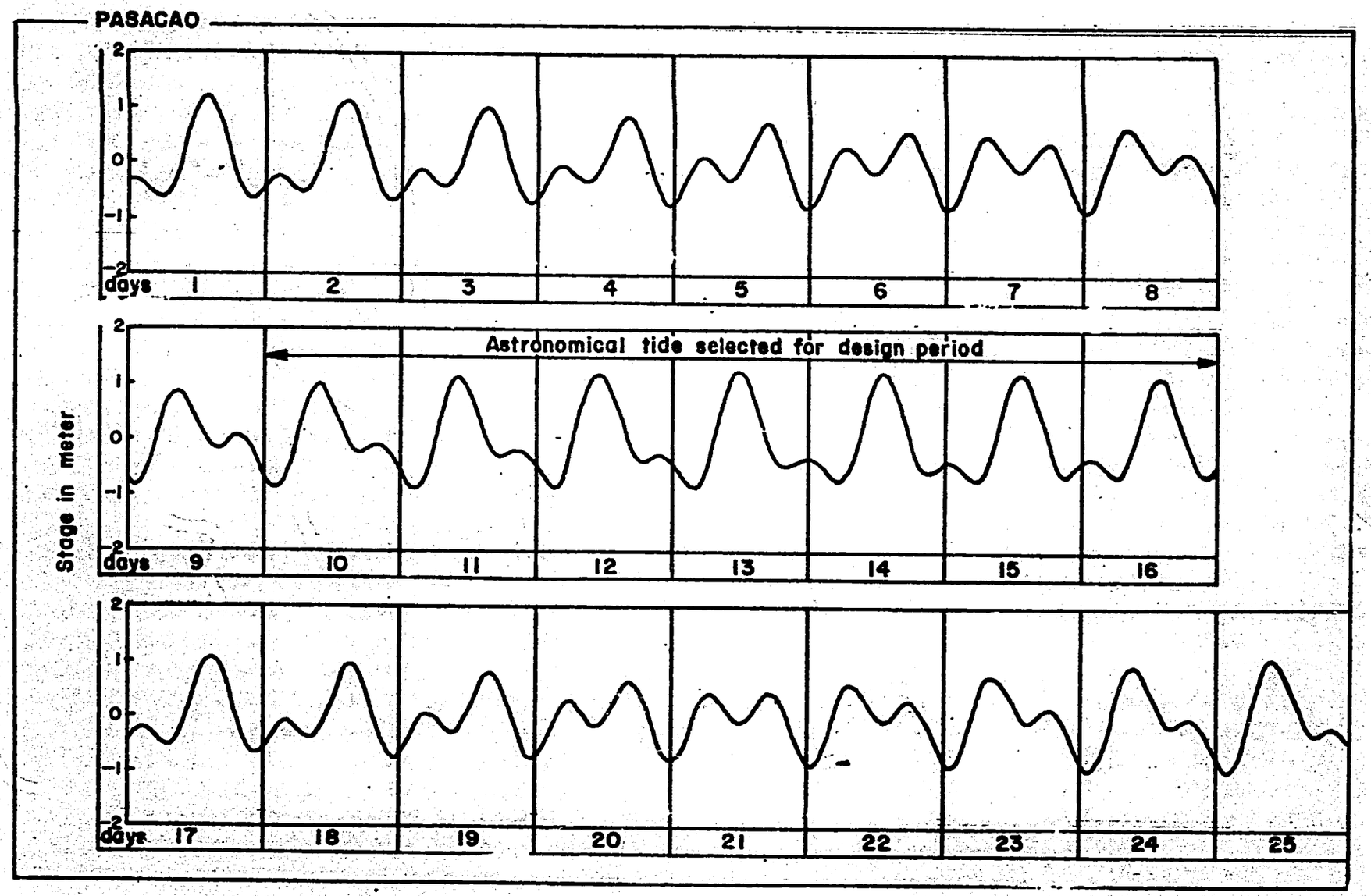



Fig. 4.5 Generated tidal fluctuation at Pasacao in Ragay Gulf

$$h = a\Delta p + b(W \cos\theta)^2 \tag{4.23}$$

In this equation, a and b are empirical constants which characterize the conditions where the wind set up is being determined. The first term on the right hand side represents the change in water level due to the reduction in the atmospheric pressure associated with typhoon storms while the second term shows the effect of surface friction caused by wind-water interaction.

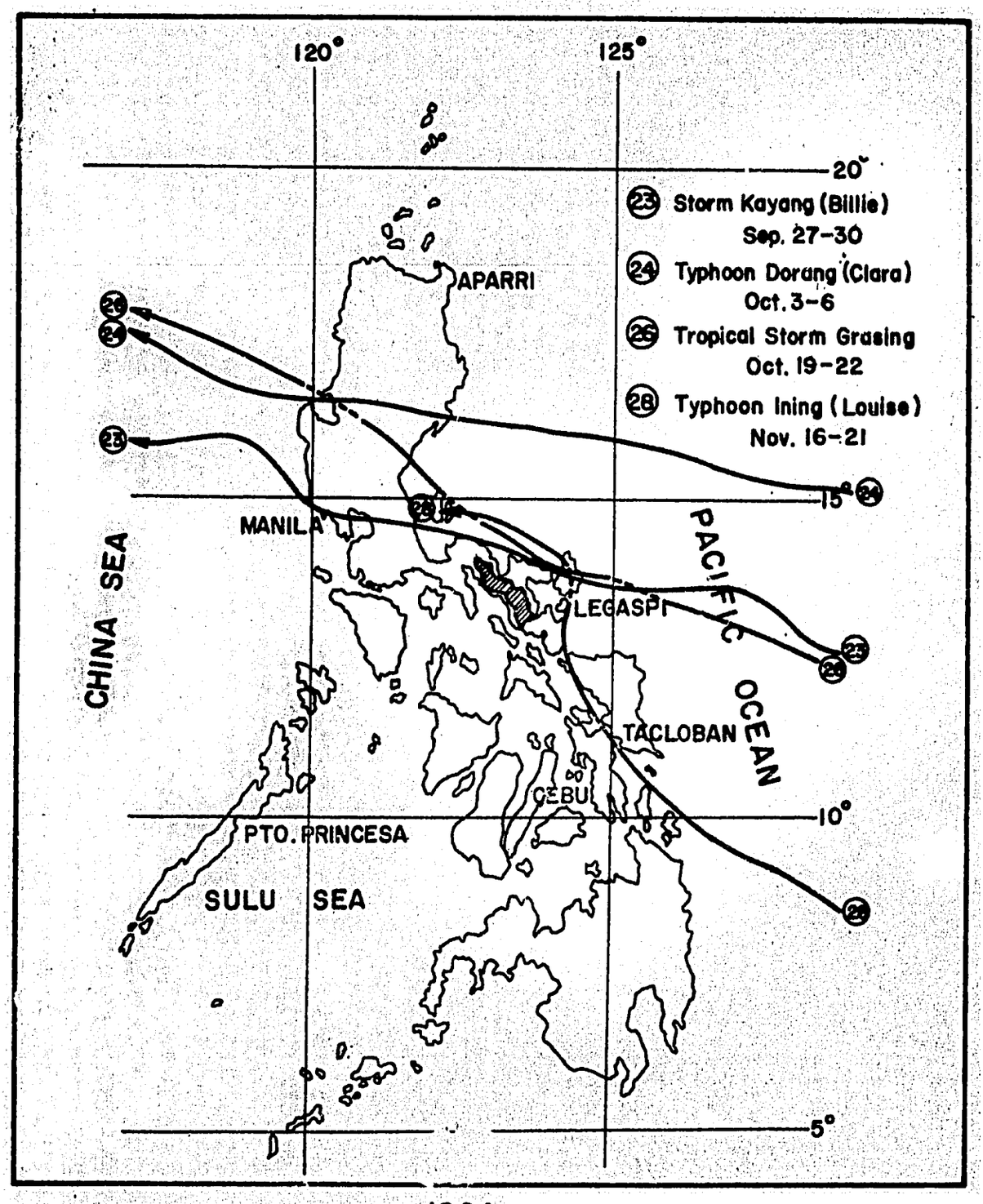
4.2.1 Pressure Distribution Tropical cyclones in the Philippines during the period 1964 thru 1972 were observed to have routes that exhibited a yearly tendency. Figs.4.6 to 4.9 show the typhoon routes affecting the Bicol Basin during the years 1964, 1970, 1971 and 1972. During these years, the typhoon paths were such as to influence to a considerable extent the meteorological conditions in the Bicol area. Fig.4.10 shows the relationship between the minimum pressure of the typhoon storms in the Philippines and the number of their occurrences during the 1964-1972 period.

In general, typhoons whose minimum central pressure is lower than 900 mb are considered as very large scale storms. Only three such storms affected the Bicol area between 1964 and 1972. The lowest central pressure ever recorded was 884 mb and was produced by Typhoon Ining in 1971. The radius of such large storms is difficult to define. An effective radius $r_o$ of 75 km is considered appropriate for very large scale typhoons. The equation used to describe the pressure variation in the typhoon area is

$$p = p_o + \Delta p \, e^{-r_o/r} \tag{4.24}$$

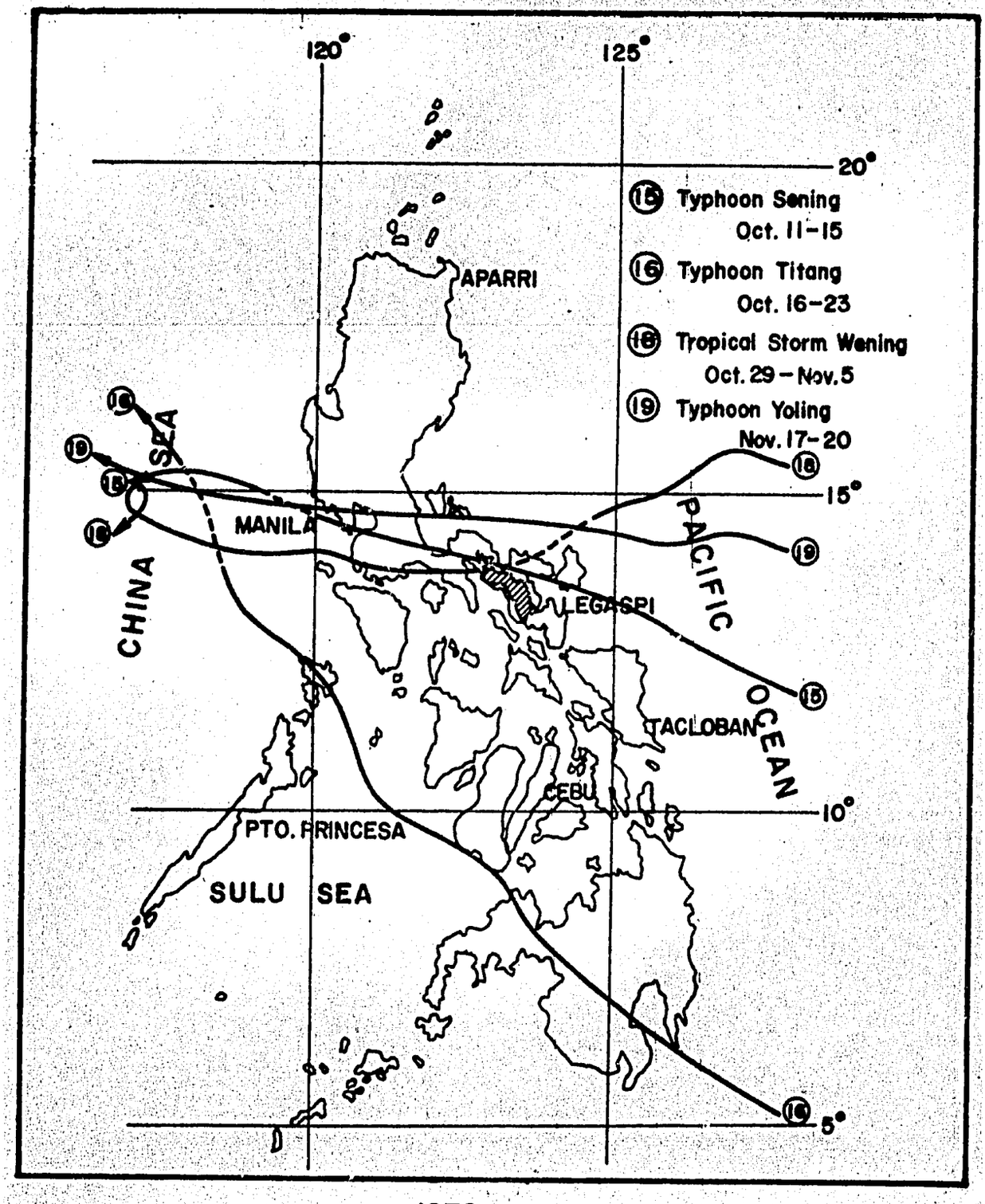
In Eq.(4.24), $p_o$ is the atmospheric pressure at the typhoon center, $r_o$ is the effective radius of influence of the typhoon, $\Delta p$ is the maximum pressure drop in the affected region and p is the pressure at a distance r from the typhoon center. For the storm selected as the design storm for the Bicol Region, the values of $\Delta p$ and $r_o$ are 133 mb and 75 km respectively. The pressure distribution in the typhoon affected area can therefore be expressed as

$$p = 880 + 133 \, e^{-75/r} \tag{4.25}$$



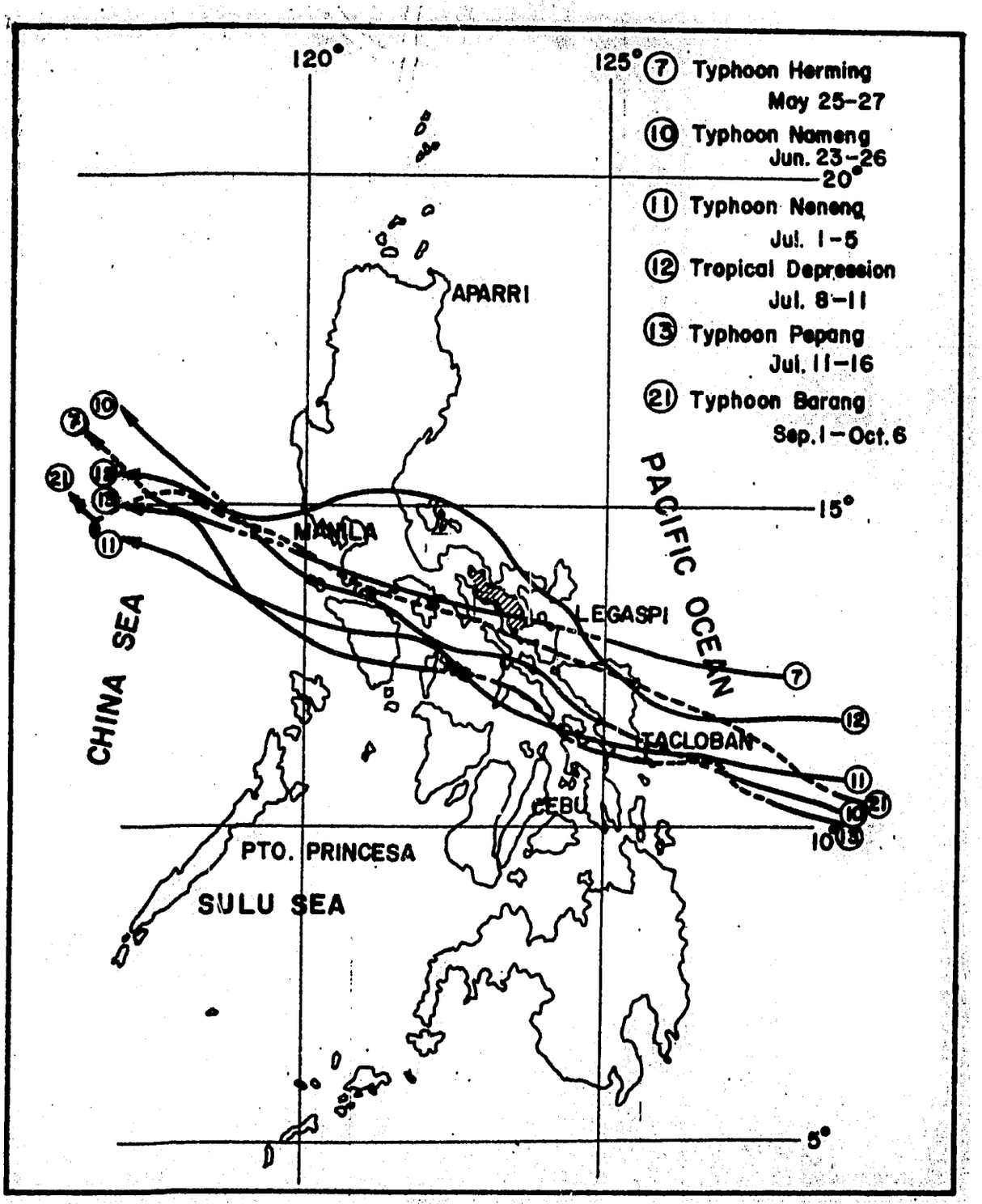

1964

Fig. 4.6 Tracks of Tropical Cyclones Affecting the Bicol Region in 1964



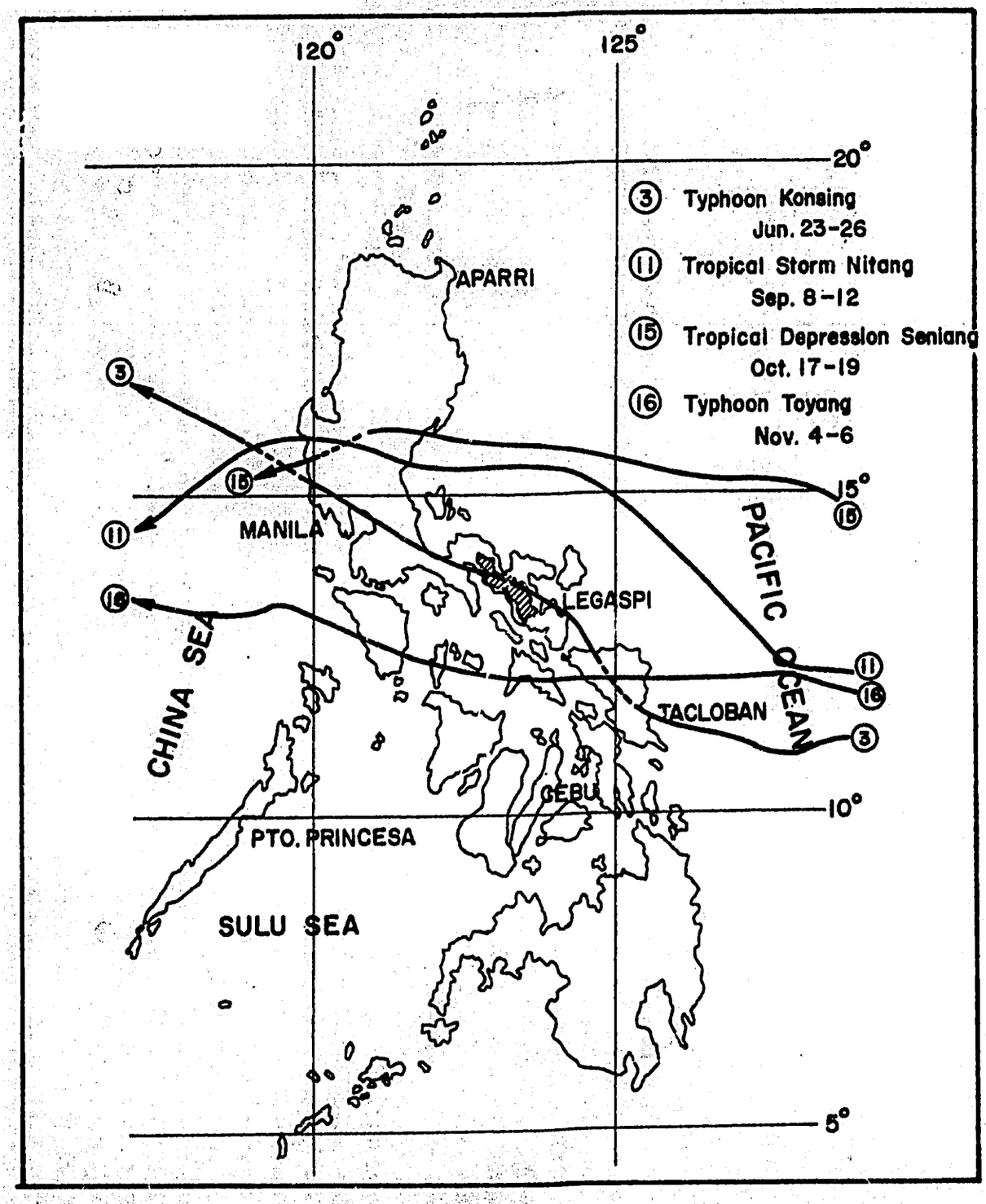

1970

Fig. 4.7 Tracks of Tropical Cyclones Affecting the Bicol Region in 1970




1971

Fig. 4.8 Tracks of Tropical Cyclones Affecting the Bicol Region in 1971




1972

Fig.4.9 Tracks of Tropical Cyclones Affecting the Bicol Region in 1972

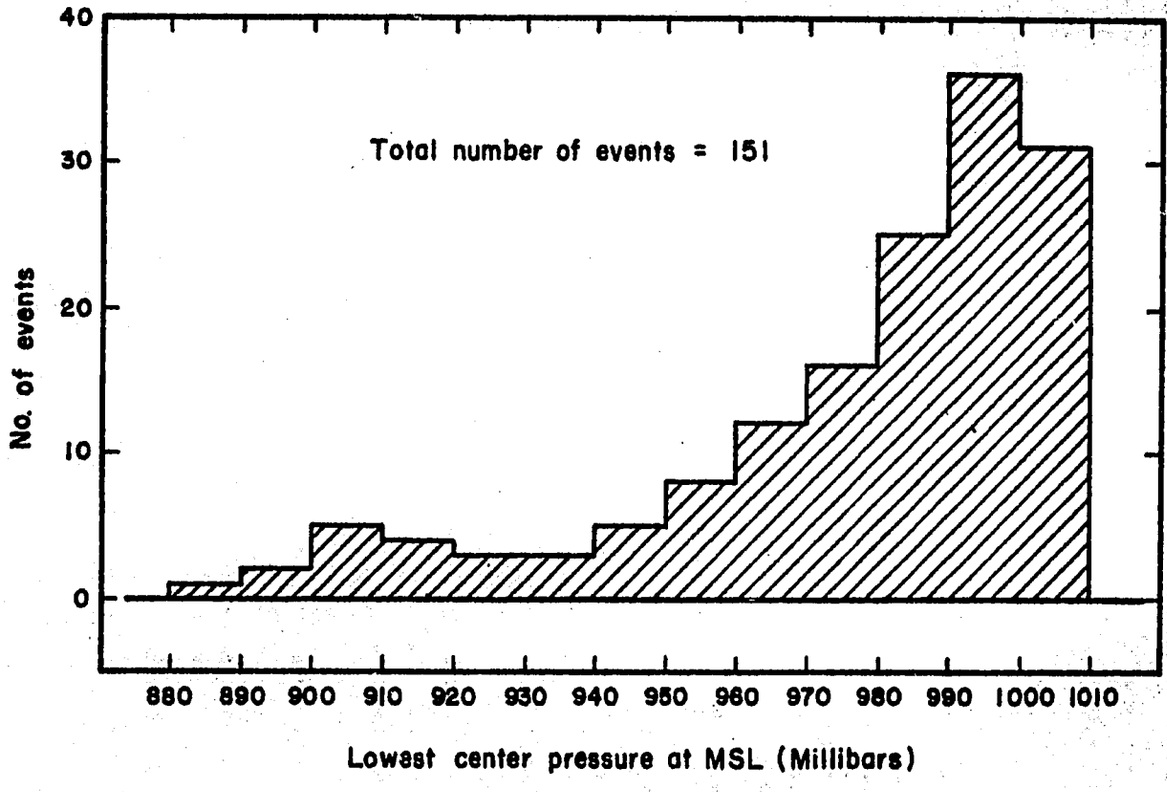



Fig. 4.10 Hindcast distribution of the typhoons from 1964 to 1972

where p is expressed in millibars and r in kilometers.

4.2.2 Velocity Distribution of Typhoon Winds The motion of the wind relative to the storm center can be approximated by assuming steady frictionless conditions and that there exists a three way balance between the Coriolis force, the centrifugal force and the pressure gradient force normal to the flow. The magnitude of this resultant velocity F(r) can be expressed as

$$F(r) = \left[\frac{\Delta\rho}{\rho_a}\frac{r_o}{r}e^{-r_o/r} + \left(\frac{fr}{2}\right)^2\right]^{1/2} - \frac{fr}{2} \qquad (4.26)$$

where $\rho_a = 0.0012$ gms/cc and the Coriolis parameter $f = 2\Omega\sin\phi$. For the Bicol River region, $f = 0.0000729$ radians/sec.

Empirical findings indicate that a better approximation to the actual wind speed $U_1$ relative to the typhoon center is

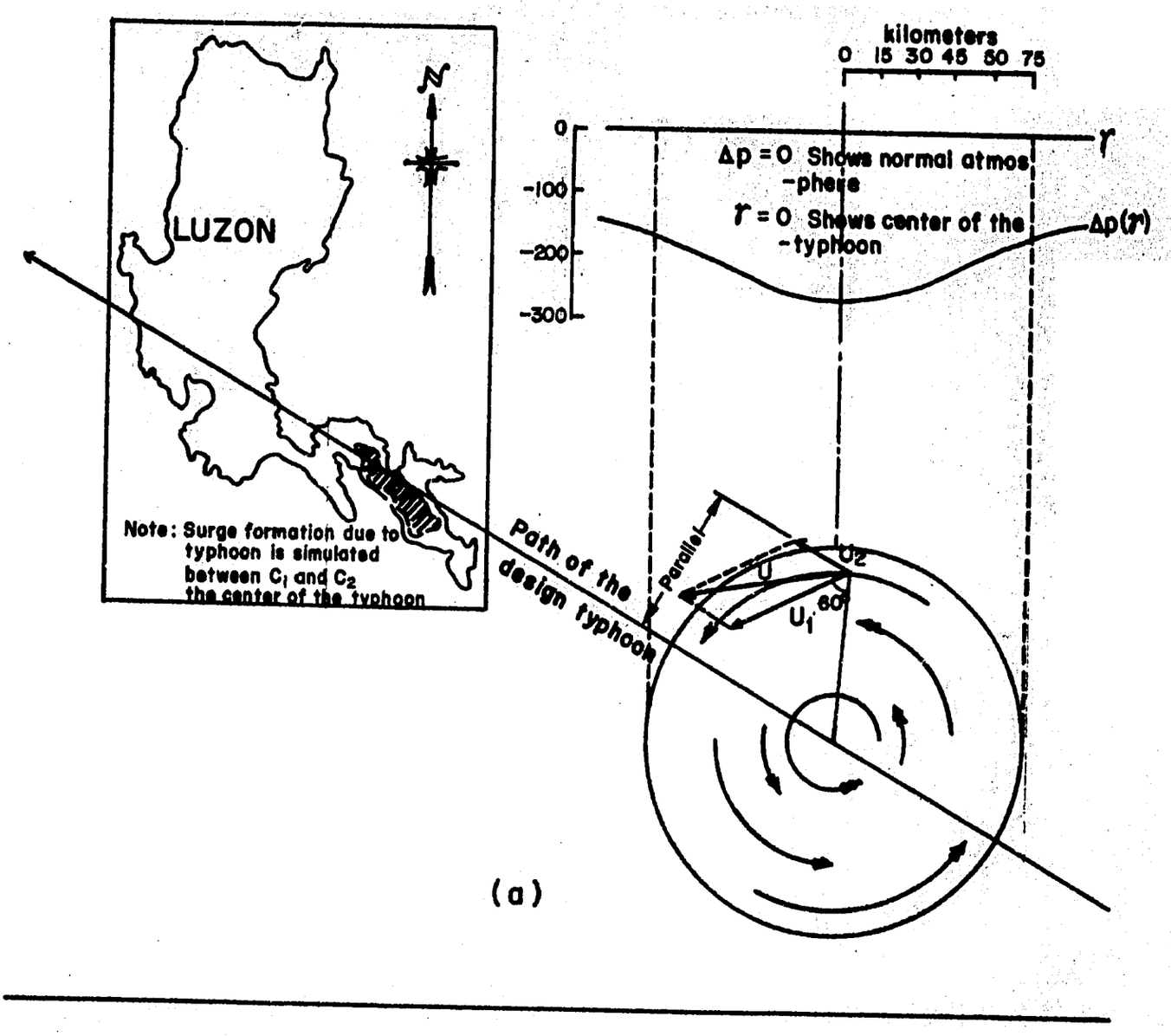
$$U_1 = 0.7\ F(r) \qquad (4.27)$$

This wind speed should be directed at an angle of approximately $60^o$ from the direction of the radius arm as shown in Fig.4.11. The wind velocity relative to the earth's surface must also include the effect of the motion of the center of the storm along the typhoon route. A design speed V of 50 km/hr and typhoon route passing directly through Balongay was selected as is shown in Fig.4.11. The contribution of this motion to the instantaneous wind speed at any distance r from the typhoon center is

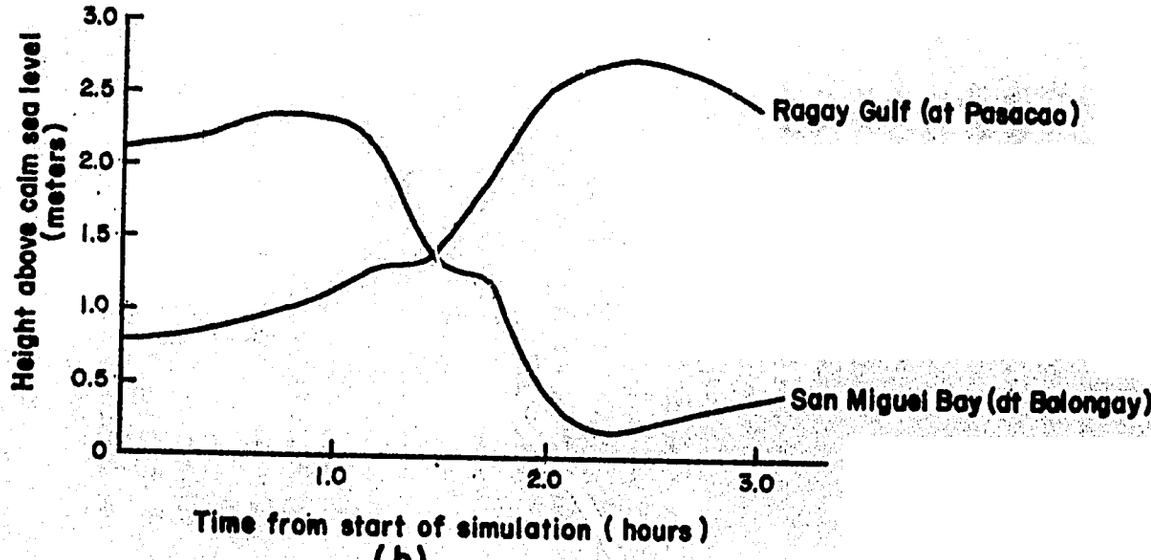
$$U_2 = 0.7\ \frac{F(r)}{F(r_o)}\ V \qquad (4.28)$$

The resultant of $U_1$ and $U_2$ can be determined at any position and time. Their vectorial sum is also shown in Fig.4.11.

Of particular interest is the continually changing component of the wind velocity normal to the mouth of the Bicol River estuary in San Miguel Bay and at the mouth of the Bicol Diversion where it is planned to enter Ragay Gulf. These wind components will produce a wind "set-up" of the ocean waters which in turn will affect the inland flow conditions.




(a)




(b)

Fig. 4.11 Design typhoon and typhoon surge

4.2.3 Storm Surge Of particular interest are the meteorological tides produced in the San Miguel Bay at Cuyapi and at the Ragay Gulf at Pasacao.

The static set up $S_1$ due to the low pressure center was determined as

$$S_1 = \frac{\Delta p}{\rho g} = 0.991\Delta p \tag{4.29}$$

In Eq.(4.29), the units of $S_1$ and $\Delta p$ are in centimeters and millibars respectively.

The change in water depth or set up $S_2$ due to the wind-water interaction is determined from Eq.(4.30)

$$S_2 = \frac{kF(U\cdot\cos\theta)^2}{h} \tag{4.30}$$

In Eq.(4.30), k is an empirical factor which depends upon the shape of the body of water, F is the fetch length, h is the average water depth and $(U\cdot\cos\theta)$ is the component of the wind velocity normal to the shoreline at San Miguel Bay at Balongay and at the Ragay Gulf at Pasacao. For these locations the following equations apply

$$S_2(\text{Balongay}) = \frac{0.048(30\text{ km})}{(20\text{ m})}(U\cdot\cos\theta)^2 \tag{4.31}$$

$$S_2(\text{Pasacao}) = \frac{0.032(250\text{ km})}{(100\text{ m})}(U\cdot\cos\theta)^2 \tag{4.32}$$

The total meteorological tide S is then the sum of $S_1$ and $S_2$.

By continually computing the wind field in the vicinity of Balongay and Pasacao as the design typhoon passes through the Bicol River Basin the instantaneous average wind velocity over the appropriate fetch length, can be determined and substituted into Eqs.(4.31) and (4.32) to determine the wind set up. The wind set up $S_2$ was computed in this manner and then added to the static set up. The combined effects $(S_1 + S_2)$ are shown in Fig.4.11. The maximum storm surge at Pasacao and Balonga was 2.78 and 2.36 meters respectively.

## 4.3 Combined Tides

The most severe tidal conditions would be produced if the maximum values of the astronomical and meteorological tides were exactly in phase. This was the condition which was considered to exist for the design conditions in this flood control study. The resultant water surface fluctuation is shown in Fig.4.12. The assumed relationship between the time variation of the water surface levels and the occurrence of the basin rainfall is also indicated.

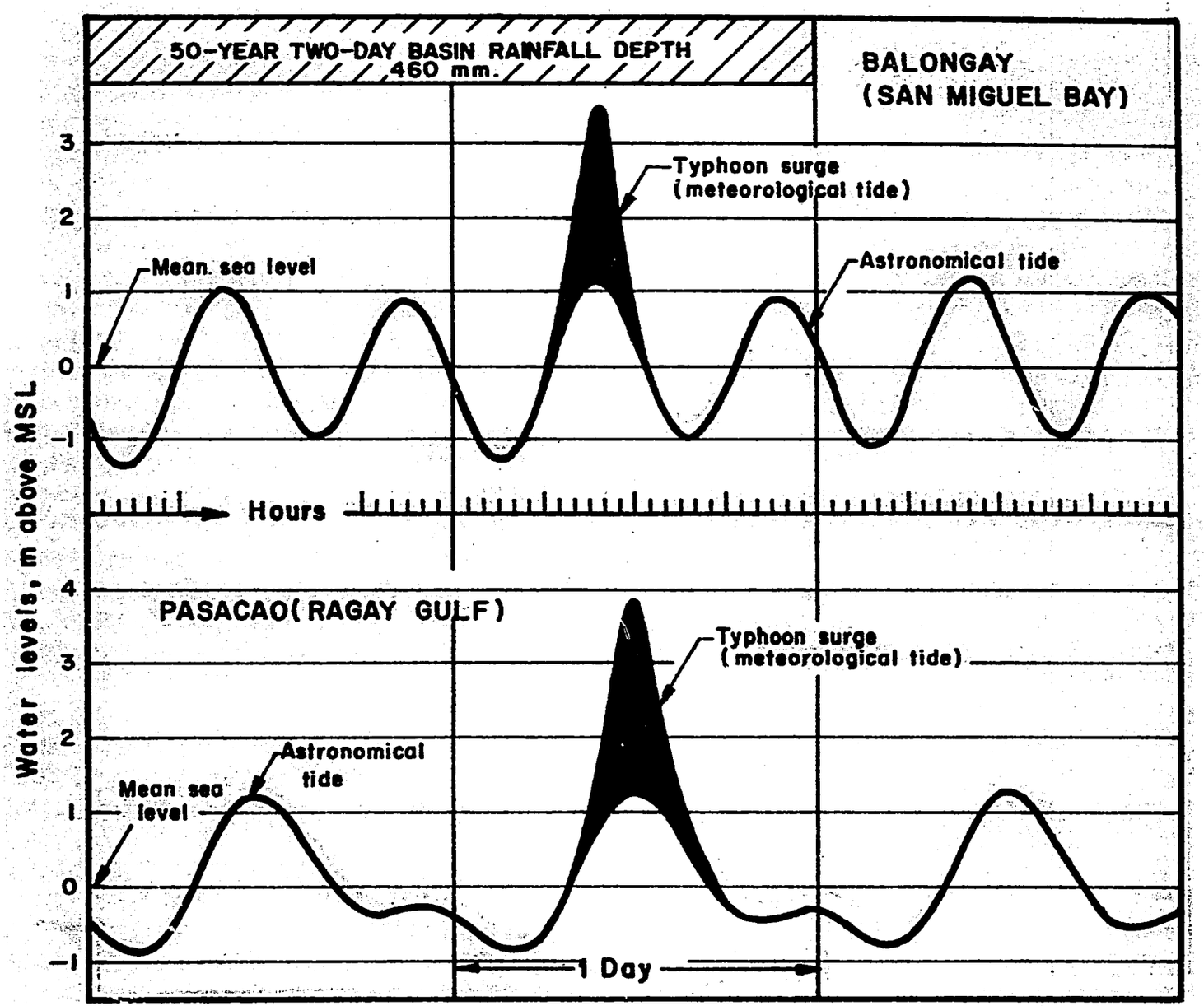



Fig.4.12 Typhoon surge superimposed on the astronomical tides

# V FLOOD CONTROL SIMULATION MODEL

## 5.1 Introduction

A flood control simulation mathematical model is constructed to describe the flooding condition in the river basin. The model extent covers the Bicol and Sipocot Rivers respectively from Lake Bato and Napolidan to the river mouth at San Miguel Bay. The mathematical model mainly consists of the unsteady free surface flow equations which are capable of handling storage and dynamic effects of flow condition in the rivers and flood plains. The complicated geometry of the rivers and their flood plains are schematized for the purpose of a convenient treatment in the mathematical model. The schematization called the node and branch technique is used to solve the unsteady free surface flow equations.

The model is calibrated to determine the empirical constants which govern the model outputs. The calibration is performed by assuming and adjusting the values of the empirical constants such that the 1970 previous flood flow records are reproduced. Once the model is calibrated, the effects of flood control schemes on flood flow condition in the Bicol River Basin can be investigated.

The mathematical model is translated into a FORTRAN IV computer program suited for the CDC 3600 Model which is capable of handling a maximum core storage capacity of 64K.

A detailed description is presented of the formulation of the flood control simulation model which was used to simulate and predict flood flow conditions in Bicol and Sipocot Rivers under various combinations of basic components of flood control schemes and different hydraulic and hydrologic inputs.

## 5.2 Basis of Mathematical Modelling of Unsteady Free Surface Flow

5.2.1 Governing Equations The unsteady free surface flow equations are the continuity and momentum equations. The equations are derived to describe flow conditions in the main channel and its berm portions. The application of these equations are complicated by the condition that the travel distance of fluid particles along the main channel and berm portions are not equal. This condition arises since in nature the degree of

meandering of the main channel and berm portions are unequal as shown in Fig.5.1. Schematization is required to adjust the berm geometry and its roughness coefficient such that the effective flow distances along the main channel and berm portions are equalized. The detail of this schematization for the berm portions will be discussed later. The unsteady free surface flow equations which consist of the continuity and momentum equations can be expressed as follows:

$$\frac{\partial Q}{\partial x} + T\frac{\partial H}{\partial t} - q = 0 \tag{5.1}$$

$$2M\frac{Q}{A}\frac{\partial Q}{\partial x} - M\frac{Q^2}{A^2}\frac{\partial A}{\partial x} + \frac{Q^2}{A}\frac{\partial M}{\partial x} + \frac{\partial Q}{\partial t} + gA\frac{\partial H}{\partial x} + \frac{gA\,Q|Q|}{\left(\sum_{i=1}^{3} K_i\right)^2} = 0 \tag{5.2}$$

In Eqs.(5.1) and (5.2), Q and H are the discharge and water level, q is the lateral discharge per unit distance which enters the flow channel perpendicularly, T and A are the total topwidth and cross sectional area of the flow section, K and M are the conveyance and momentum correction factors, g is the gravitational acceleration, x and t are the space and time coordinates. The parameters K and M are defined as

$$K_i = \frac{1}{n_i} A_i R_i^{2/3} \tag{5.3}$$

and

$$M = \frac{\sum_{i=1}^{3} \rho Q_i V_i}{\rho Q V} \tag{5.4}$$

In Eq.(5.4),

$$Q = \sum_{i=1}^{3} Q_i \quad \text{and} \quad V = \frac{Q}{\sum_{i=1}^{3} A_i} = \frac{Q}{A} \tag{5.5}$$

In Eqs.(5.3), (5.4) and (5.5), the subscript i refers to the number of the subsections referred to as the left berm, main channel and right berm. Subsection no.1 and no.3 are the left hand and right hand berms. Subsection no.2 is the main channel. The term $\rho$ is the water density.

The definition sketch of the variables used in Eqs.(5.1) and (5.2) are shown in Fig.5.2.

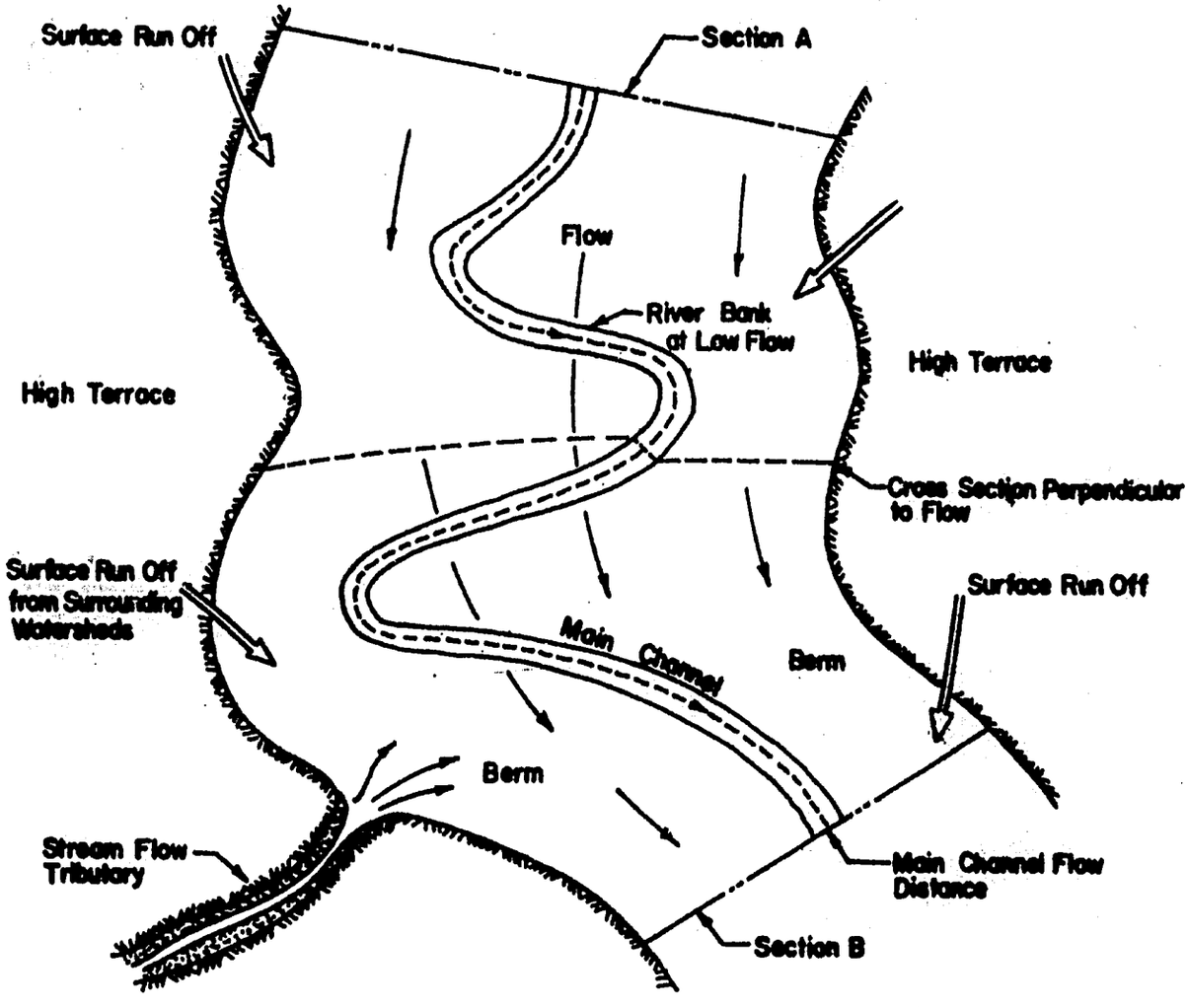



Fig. 5.1 Typical Reach of Bicol River During Flood

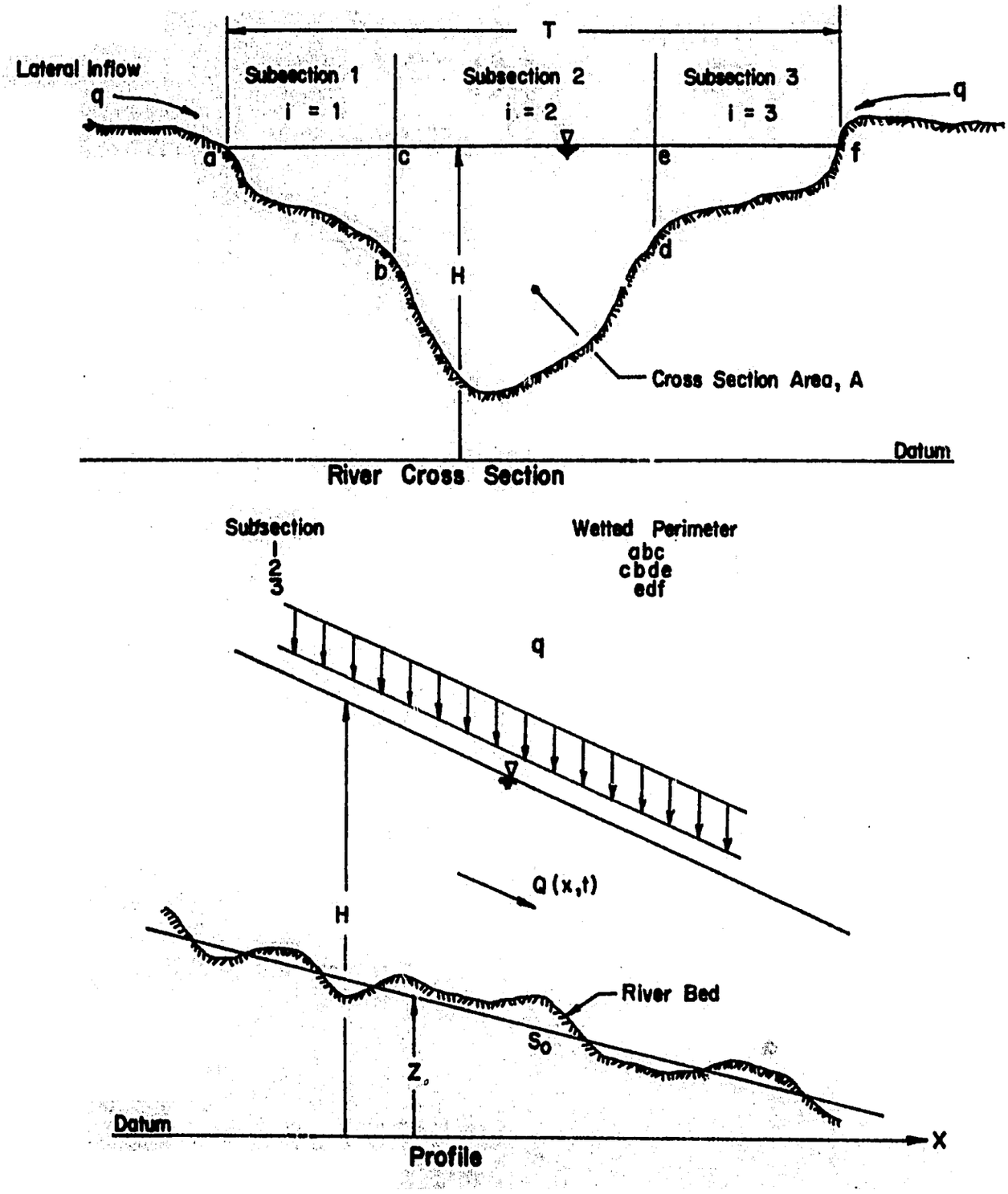



Fig. 5.2 Definition Sketch of an Element of a River with Berms

5.2.2 Node and Branch Schematization Technique The continuity and momentum equations as expressed in Eqs.(5.1) and (5.2) are solved numerically through the use of the node and branch computation technique. The method can conveniently handle a system of interconnected channels such as those created by the intersections of Bicol River, Sipocot River, cutoffs, diversion canals and boundary conditions imposed by San Miguel Bay and Ragay Gulf. The method requires a schematization procedure which considers the flow system consisting of a number of storage tanks connected by a number of channels. The channels joining the storage tanks are assumed to have geometric and hydraulic properties of the system that are both time dependent. The storage tank is called a node and the channel joining the storage tanks is called a branch. The function of the node can be visualized to accommodate all storage or mass transfer effects while the branches accommodate the hydraulic frictional effects and inertial effects which exist between the two nodes. This interpretation results from the development of the equations which describe the flow system.

In the node and branch computation technique, the following assumptions were made:

a) the water surface is horizontal in each node;

b) only one value of discharge exists along the entire length of a single branch at any instant; requires short branches

c) water levels vary linearly from one node to an adjacent node; - do -

d) the storage in each node is considered equal to the volume of the water in all branches from that node to a distance half way to each adjacent node.

Fig.5.3 shows the physical interpretation of the river geometry and flow condition assumed in the node and branch schematization. Fig.5.4 shows the time variations of the discharges of the branches and stages at the nodes in a typical river reach.

5.2.3 Reduced Forms of Continuity and Momentum Equations for the Node and Branch Computation Technique Eqs.(5.1) and (5.2) are the continuity and momentum equations which describe continuous variations of discharges and water levels with respect to time and space coordinates. Using the concept of the node and branch schematization, the river

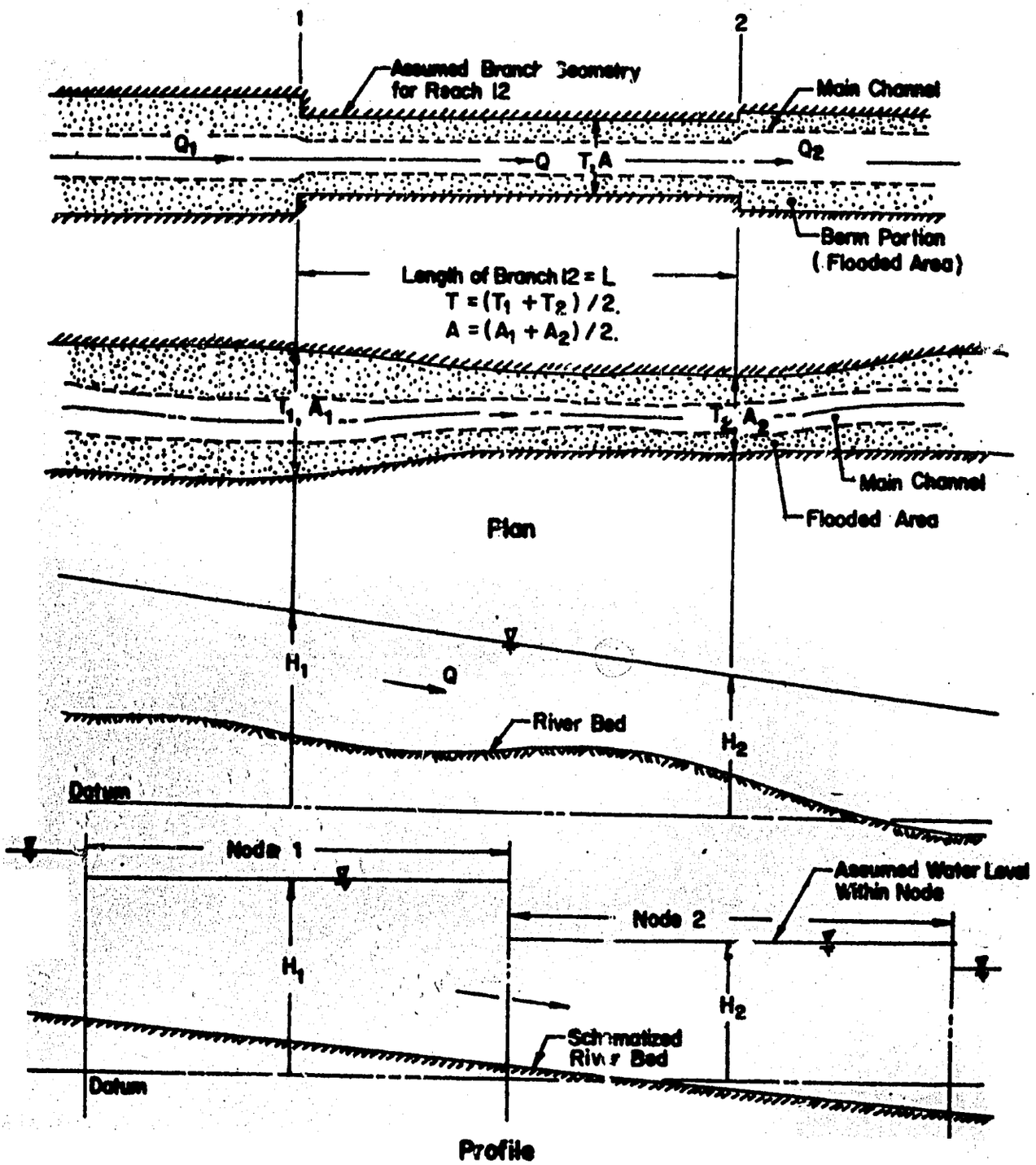



Fig. 5.3 Schematized Flow System for Node & Branch Computation

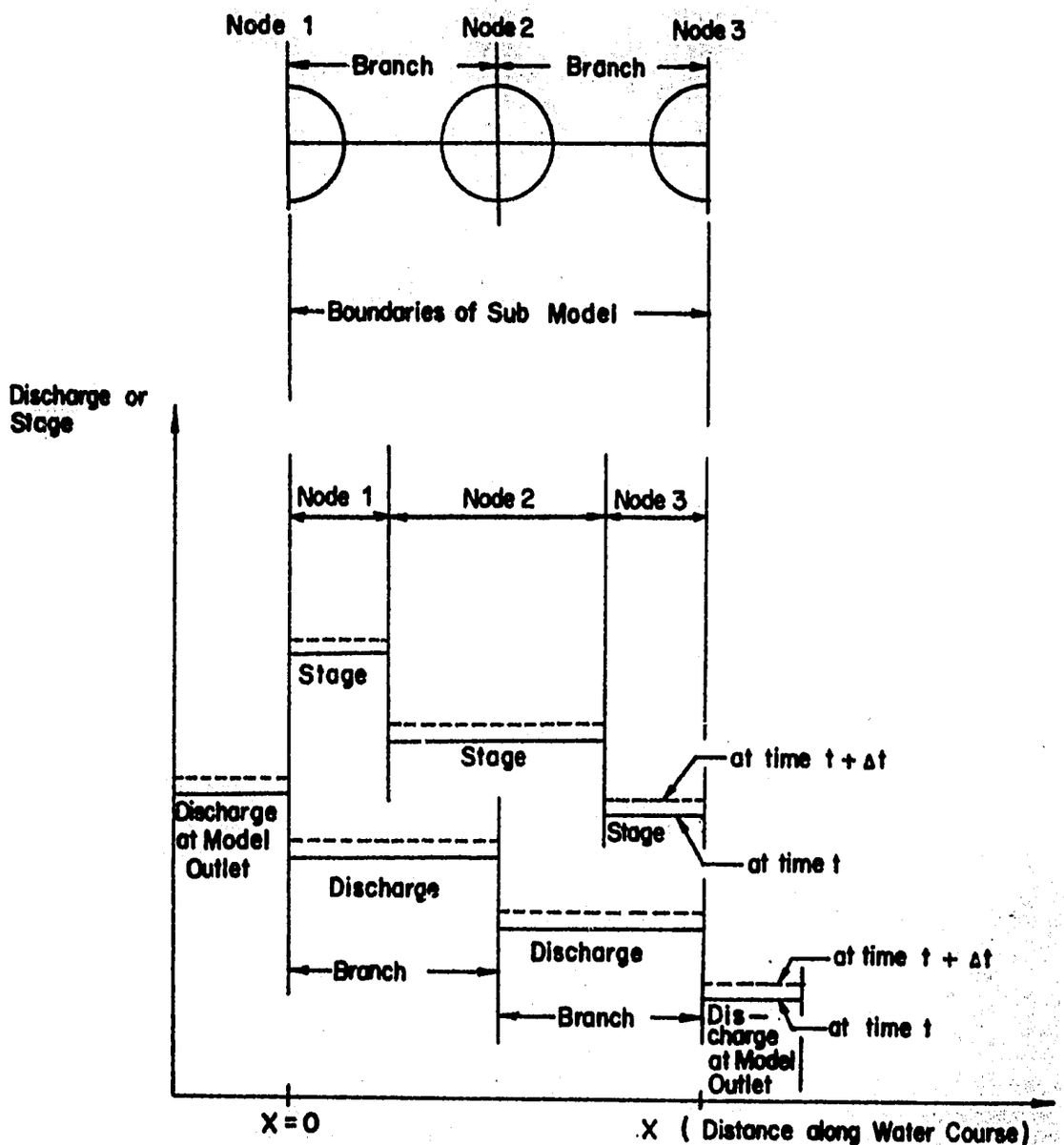



**Fig. 5.4 Graphical Representation of Assumptions Regarding Discharges in Branches and Stages in Nodes at Time t and t+Δt**

geometry and the flow condition are considered as time dependent functions which possess constant values within a specified space interval as shown in Figs.5.3 and 5.4. To make Eqs.(5.1) and (5.2) consistent with the node and branch schematization, the partial differentiation with respect to the space coordinate, x, is required to be replaced by the difference of a quantity, e.g. stage, discharge or cross sectional area, etc., per unit distance of the length of the branch. The substitution eliminates the partial differentiation with respect to x in Eqs.(5.1) and (5.2) and the equations are reduced to partial differential equations with respect to time alone. Since the equations satisfy the flow conditions for nodes and branches which are fixed in space, the partial differentiation with respect to time can be changed to a total differential equation with respect to time.

The conversion of the time and space partial differentiations in Eqs.(5.1) and (5.2) to the total differentiation with respect to time are described in detail below.

From Eq.(5.1), the differential form of the continuity equation for a node can be expressed as

$$\frac{dH}{dt} = \frac{\Sigma Q_{in} - \Sigma Q_{out}}{F} \tag{5.6}$$

In Eq.(5.6), F is the surface area of the node which is equal to the surface area of the water in the branches from the node half way to each adjacent node while $\Sigma Q_{in}$ and $\Sigma Q_{out}$ are the discharge summations into and out of the same node. The other parameters are previously defined.

From the momentum equation in Eq.(5.2), the following substitution for the partial differentiation with respect to x is made

$$\frac{\partial A}{\partial x} = \frac{A_2 - A_1}{L} \tag{5.7}$$

$$\frac{\partial M}{\partial x} = \frac{M_2 - M_1}{L} \tag{5.8}$$

$$\frac{\partial H}{\partial x} = \frac{H_2 - H_1}{L} \tag{5.9}$$

From the continuity equation in Eq.(5.1), the term $\frac{\partial Q}{\partial x}$ can be replaced by

$$\frac{\partial Q}{\partial x} = -\frac{(T_1 + T_2)}{2} \frac{\partial}{\partial t} \frac{(H_1 + H_2)}{2} \tag{5.10}$$

In Eq.(5.7) through (5.10), the subscripts 1 and 2 are assigned to the upstream and downstream nodes of the branch respectively, L is the length of the branch, the other parameters are previously defined.

Substituting Eqs.(5.6) through (5.10) into Eq.(5.2), the partial differential form of the momentum equation with respect to time which satisfies the flow in a branch can be written as

$$\frac{\partial Q}{\partial t} = \frac{MQT}{A} \frac{\partial}{\partial t} (H_1+H_2) + \frac{MQ^2}{A^2L} (A_2-A_1) - \frac{Q^2}{AL} (M_2-M_1) - \frac{gA}{L} (H_2-H_1) - \frac{gA\, Q|Q|}{\left[\sum_{i=1}^{3} K_i\right]^2}$$

As previously described, $\frac{\partial Q}{\partial t} = \frac{dQ}{dt}$ and $\frac{\partial}{\partial t} (H_1+H_2) = \frac{d}{dt} (H_1+H_2)$, the momentum equation can therefore be rewritten as

$$\frac{dQ}{dt} = \frac{MQT}{A} \left[ \frac{(\Sigma Q_{in} - \Sigma Q_{out})}{F_1} \text{ node } 1 + \frac{(\Sigma Q_{in} - \Sigma Q_{out})}{F_2} \text{ node } 2 \right] + \frac{MQ^2}{A^2L} (A_2-A_1)$$
$$- \frac{Q^2}{AL} (M_2-M_1) - \frac{gA}{L} (H_2-H_1) - \frac{gA\, Q|Q|}{\left[\sum_{i=1}^{3} K_i\right]^2} \tag{5.11}$$

In Eq.(5.11): $A = \frac{A_1 + A_2}{2}$, $T = \frac{T_1 + T_2}{2}$, $M = \frac{M_1 + M_2}{2}$, $K_i = \frac{(K_i)_1 + (K_i)_2}{2}$; $i = 1,2$ and 3.

Eqs.(5.6) and (5.11) are the reduced form of the continuity and momentum equations which described the time variations of water level and discharge in the node and branch respectively. In the flood control study, the two equations (5.6 and 5.11) are written for all nodes and branches in the Bicol and Sipocot Rivers.

## 5.3 Method of Averaging Main Channel and Berm Geometry

In the node and branch computation, the geometry of the main channel and berm cross sections is averaged for each river subreach defined for each branch. The cross section geometry is averaged by the following procedure:

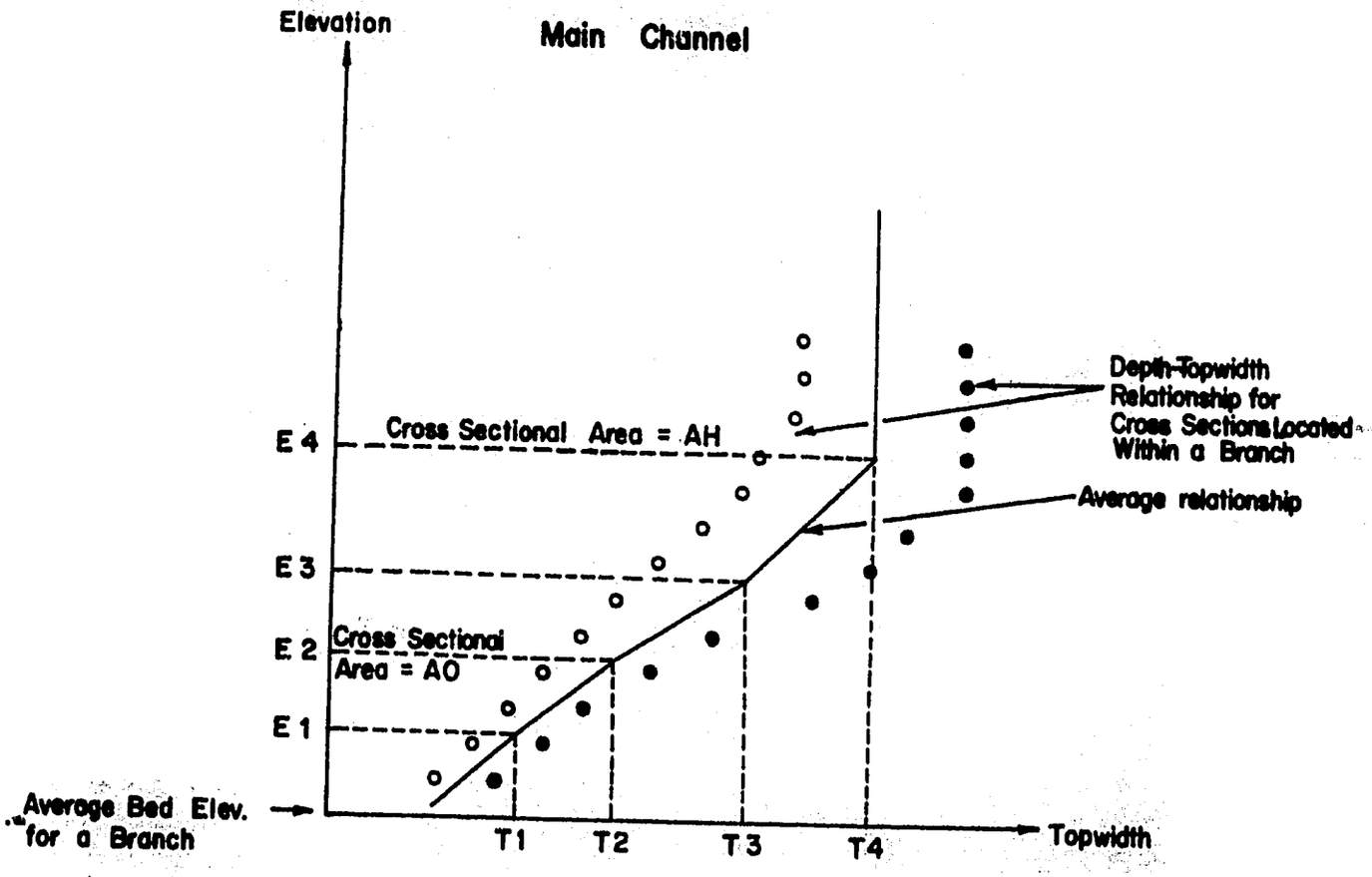
a) Plot the topwidth and depth relationships of the cross sections equally spaced within the subreach defined as a branch. Draw the average curve through these relationships.

b) The average elevation-depth relationship for the branch is then obtained.

c) Convert the average elevation-depth relationship to the average elevation-topwidth relationship of that branch. This can be done by setting the elevation of zero depth equal to the average bed elevation for the branch.

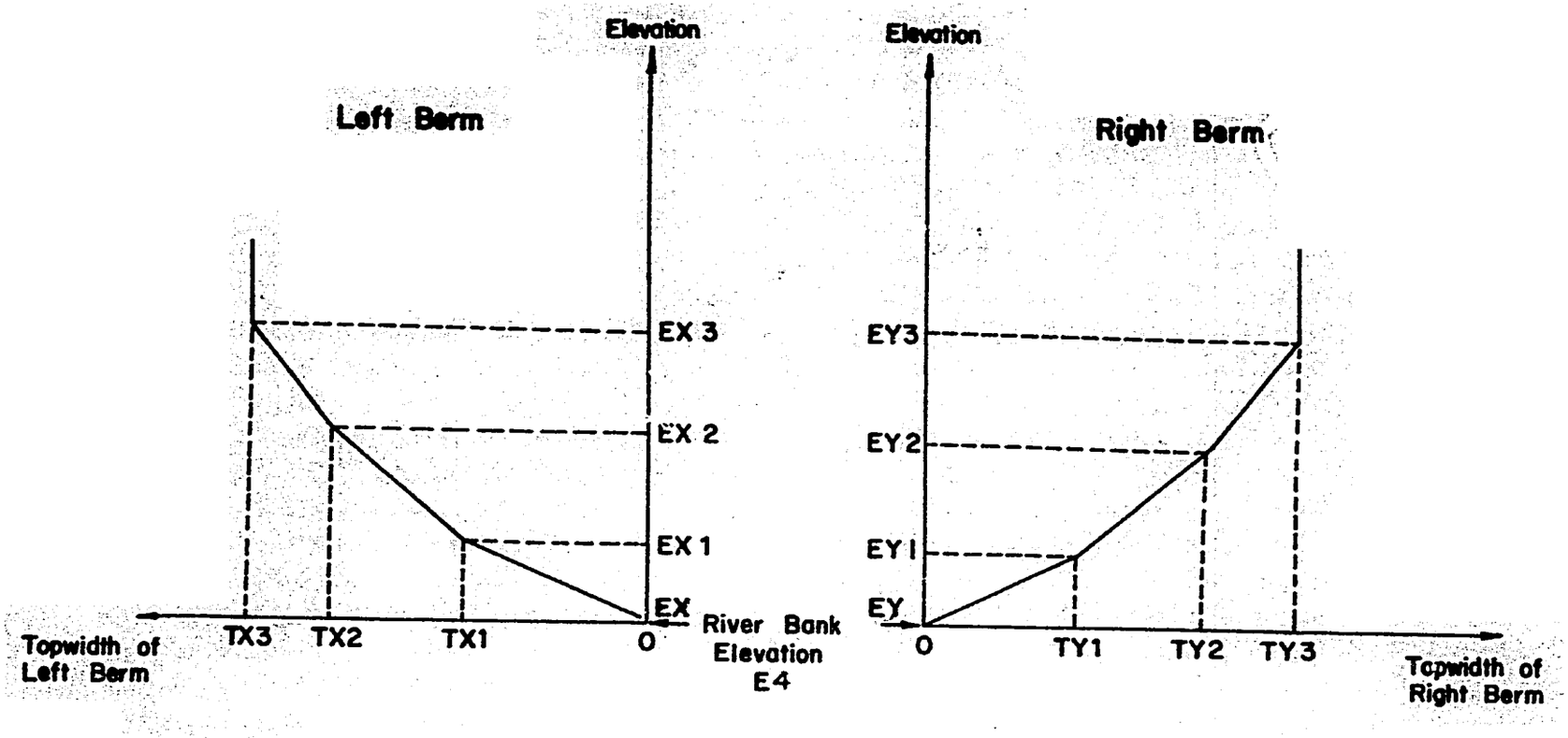
Further simplification is made by assuming the topwidth and elevation relationship to be linear but at different slopes for different elevation intervals. For the main channel, the topwidth is assumed constant when the elevation exceeds the river bank elevation. Figs.5.5 and 5.6 show the topwidth-elevation relationships for main channel and berms. From Figs.5.5 and 5.6 the essential information which is required in specifying the average topwidth and elevation relationship is the topwidths and elevations at some specific positions. The topwidths and their corresponding elevations at these positions are called specific topwidths and specific elevations. The topwidths and elevations designated as T1, T2, T3 and T4 and E1, E2, E3 and E4 are required for the main channel as shown in Fig.5.5. Furthermore, the knowledge of the main channel cross sectional area at the elevations E2 and E4 are required. For the berm sections as shown in Fig.5.6, the specific topwidths and corresponding elevations are designated as EX, EX1, EX2, EX3 and 0, TX1, TX2, TX3 for the left berm and EY, EY1, EY2, EY3 and 0, TY1, TY2, TY3 for the right berm.

The equations which are used in computing the cross sectional areas and topwidths of the average cross section of the branch are described below.




| Specific Elevation | Specific Topwidth | Specific Area |
|---|---|---|
| E 1 | T 1 | |
| E 2 | T 2 | A O |
| E 3 | T 3 | |
| E 4 ( Bank Elev. ) | T 4 | A H |

Fig. 5.5 Topwidth and Elevation Relationship of Main Channel Average Cross Section Specified for a Branch




| Specific Elevation | Specific Topwidth |
|---|---|
| E 4 or EX | 0 |
| EX1 | TX1 |
| EX2 | TX2 |
| EX3 | TX3 |

| Specific Elevation | Specific Topwidth |
|---|---|
| E 4 or EY | 0 |
| EY1 | TY1 |
| EY2 | TY2 |
| EY3 | TY3 |

Fig. 5.6 Topwidth and Elevation Relationship of Berm Average Cross Section Specified for a Branch

Main Channel  From the average topwidth and elevation relationship of the main channel as shown in Fig.5.5, the following relationship can be written:

Elevation Range: $E \leq E3$

$$A = A0 + (E-E2)\left(\frac{T1+T2}{2}\right) \quad ; \quad E < E3$$

$$T = T2 + \frac{(T3-T2)}{(E3-E2)}(E-E2) \quad ; \quad E2 \leq E \leq E3$$

$$T = T2 - \frac{(T2-T1)}{(E2-E1)}(E2-E) \quad ; \quad E < E2$$

Elevation Range: $E \geq E3$

$$A = A4 + (E-E4)\left(\frac{T1+T4}{2}\right) \quad ; \quad E > E3$$

$$T = T4 - \frac{(T4-T3)}{(E4-E3)}(E4-E) \quad ; \quad E3 \leq E \leq E4$$

$$T = T4 \quad ; \quad E > E4$$

In the above equations, A and T are the cross sectional area and the topwidth of the average cross section.

Berm Sections  The computation for the cross sectional area and topwidth of the left or right berms are the same. The following is the description in the computational method which is performed for the left berm. The same procedure is applicable to the right berm. From the average topwidth and elevation relationship of the left berm as shown in Fig.5.6, the following relationship can be written.

Elevation Range:

$EX \leq E \leq EX1$

$$T = (TX1-0)\frac{(E-EX)}{(EX1-EX)}$$

$$A = \frac{1}{2}T\,(E-EX)$$

$EX1 \leq E \leq EX2$

$$T = TX1 + (TX2-TX1)\frac{(E-EX1)}{(EX2-EX1)}$$

$$A = \frac{1}{2}TX1(EX1-EX) + \frac{1}{2}(T+TX1)(E-EX1)$$

$EX2 \leq E \leq EX3$

$$T = TX2 + (TX3-TX2)\frac{(E-EX2)}{(EX3-EX2)}$$

$$A = \frac{1}{2}TX1(EX1-EX) + \frac{1}{2}(TX2+TX1)(EX2-EX1) + \frac{1}{2}(T+TX3)(E-EX2)$$

$E > EX3$ $\qquad T = TX3$

$$A = \frac{1}{2} TX1(EX1-EX) + \frac{1}{2}(TX2+TX1)(EX2-EX1) + \frac{1}{2}\left(\frac{TX3+TX2}{2}\right)(EX3-EX2) + TX3(E-EX3)$$

In the above equations, A and T are the cross sectional area and topwidth of the average berm section. The same equations could be applied to the right berm when the area and topwidths are computed.

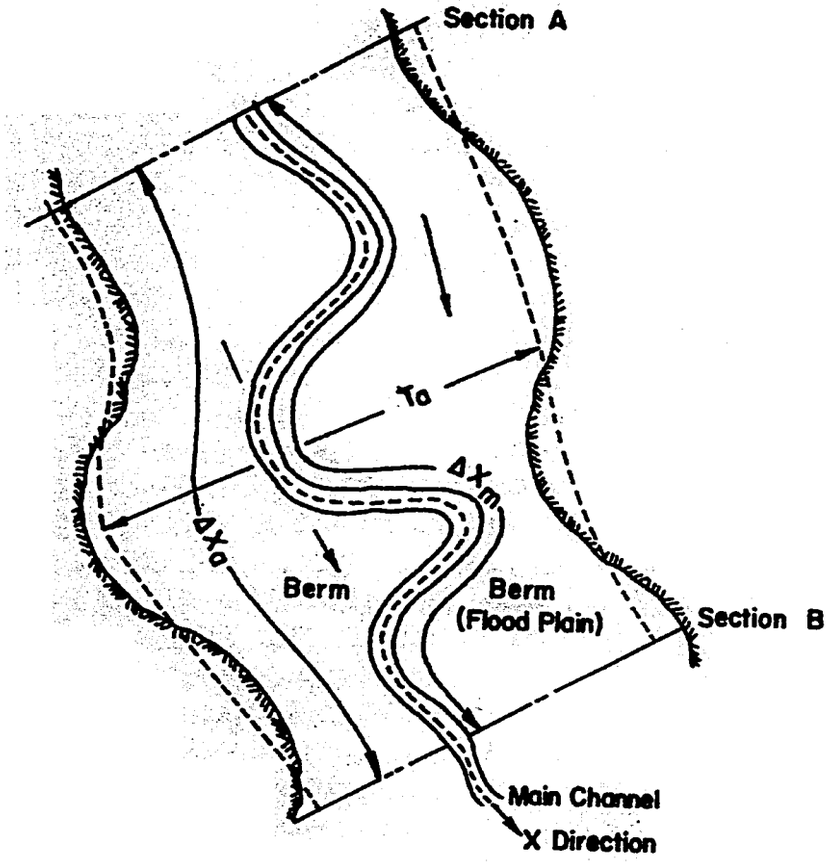
The hydraulic mean depth is defined as the ratio between the cross sectional area and the topwidth at the same elevation.

Knowing the water surface elevation, values can be found for the cross sectional area, the topwidth and the mean depth of the main channel and the berm of the averaged cross section. However, these computed values of the cross sectional area, topwidth and mean depth of the berm are not applicable to the continuity and momentum equations as expressed in Eqs.(5.6) and (5.11) since the berms are non-schematized, i.e. the flow distances along the main channel and the berms are unequal. Further schematization on the berm geometry is required. The procedure for the schematization of the berm geometry will be mentioned in the next section. No schematization on the main channel geometry is required.

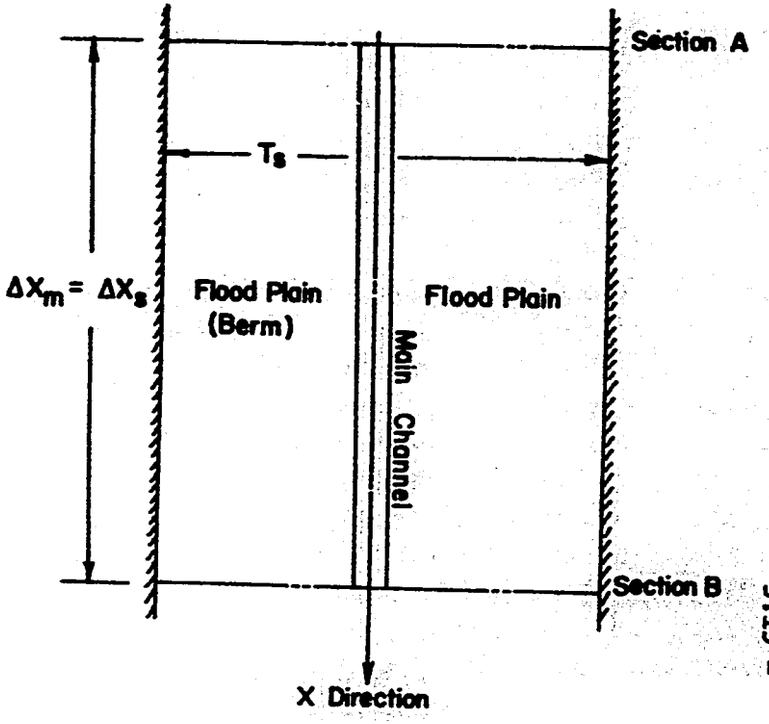
## 5.4 Schematization of Berm Geometry and Roughness Coefficients

Eqs.(5.6) and (5.11) are restricted to the condition that the flow distances along the main channel and berms are equal. Schematization of the berm geometry and its physical characteristic is required to equalize the different flow distances along main channel and berm as shown in Fig.5.7. The berm geometry which is required for schematization is the topwidth, cross sectional area, hydraulic mean depth and bed slope. The physical characteristic which requires the adjustment in the schematization is the berm roughness coefficient. The following is the mathematical description for the schematization in the geometry of the berm as shown in Fig.5.7.

5.4.1 Schematization of the Berm Topwidth The criterion for the schematization is that the water surface areas of the berm in the actual




Actual Bicol River and Flood Plain




Schematized Bicol River and Flood Plain

Fig. 5.7 Schematization of Bicol River Flood Plain (Berm Portion)

and schematized systems must be equal. Referring to Fig.5.7, the following relationship can be expressed:

$$T_s \Delta x_s = T_a \Delta x_a$$

$$T_s = T_a \frac{\Delta x_a}{\Delta x_s} \tag{5.12}$$

In Eq.(5.12), $T_a$ and $T_s$ are the actual and schematized topwidths of the berm, $T_a \Delta x_a$ is the actual water surface area of the berm, $\Delta x_a$ and $\Delta x_s$ are the actual and schematized flow distances of the berms, while $\Delta x_s$ is also equal to the flow distance measured along the meandering course of the main channel from section A to section B as shown in the same figure.

5.4.2 Schematization for Berm Cross Sectional Area The criterion for the schematization is that the volume of water stored in the berm portion in the actual and schematized flow system must be equal, i.e.

$$A_s \Delta x_s = A_a \Delta x_a$$

or

$$A_s = A_a \frac{\Delta x_a}{\Delta x_s} \tag{5.13}$$

In Eq.(5.13), $A_s$ and $A_a$ are the schematized and actual cross sectional areas of the berms, $\Delta x_a$ and $\Delta x_s$ are previously defined. The cross sectional areas of the berms in the actual and schematized systems are taken perpendicular to the flow direction in the berms.

5.4.3 Schematization for Mean Depth of Berm The mean depth which is schematized by maintaining the same quantity of surface area and water volume of the actual and schematized berm portion can be expressed as

$$D_s = \frac{A_s}{T_s} = \frac{A_a \cdot \frac{\Delta x_a}{\Delta x_s}}{T_a \cdot \frac{\Delta x_a}{\Delta x_s}} = \frac{A_a}{T_a} = D_a \tag{5.14}$$

In Eq.(5.14), $D_s$ and $D_a$ are the mean depths of the berm in the schematized and actual systems, $A_a$, $A_s$, $T_a$, $T_s$, $\Delta x_a$ and $\Delta x_s$ are previously defined.

5.4.4 Schematization for Bed Slope of Berm Portion Let y be the vertical space coordinate and x is the horizontal space coordinate measured along the flow direction in the flood plain. The schematization for the bed slope of the schematized berm portion, with regard to the same drop in the bed elevation in the actual and schematized berms, can be written as

$$S_s = \frac{\Delta y_s}{\Delta x_s} = \frac{\Delta y_a}{\Delta x_a} \cdot \frac{\Delta x_a}{\Delta x_s} = S_a \frac{\Delta x_a}{\Delta x_s} \qquad (5.15)$$

In Eq.(5.15), $S_a$ and $S_s$ are the bed slopes of the berm portion in the actual and schematized systems. The other parameters are previously defined. The value of $\Delta y_s$ is substituted with $\Delta y_a$ since the same drop in bed elevations in the actual and schematized berms is assumed.

5.4.5 Schematization for Berm Roughness Coefficient In the schematization, the discharge in the berm portion is maintained, i.e. the berm discharges in the actual and schematized berms $Q_a$ and $Q_s$ are the same. This implies the condition that

$$Q_s = Q_a$$

For the first explanation, it is assumed that

a) the steady state Manning Equation adequately describes the flow over the berm sections;

b) the hydraulic radius R could be approximated by the mean depth D.

It follows that

$$\frac{1}{n_s} A_s R_s^{2/3} S_s^{1/2} = \frac{1}{n_a} A_a R_a^{2/3} S_a^{1/2}$$

Substituting Eqs.(5.13), (5.14)and (5.15) into the above equation gives

$$n_s = n_a \left(\frac{A_s}{A_a}\right) \left(\frac{D_s}{D_a}\right) \left(\frac{S_s}{S_a}\right)^{1/2}$$

or

$$n_s = \left(\frac{\Delta x_a}{\Delta x_s}\right)^{3/2} n_a \qquad (5.16)$$

In Eq.(5.16), $n_s$ and $n_a$ are the berm roughness coefficients in the schematized and actual flow systems. The other parameters are pre-

viously defined.

Making use of the main channel and schematized berm geometry and roughness coefficients, the continuity and momentum equations as expressed in Eqs.(5.6) and (5.11) could be written.

## 5.5 Bicol River Basin Flood Control Simulation Model

### 5.5.1 Extent of Flood Control Simulation Model

Fig.5.8 shows the extent of the Bicol River Basin covered by the model. Thirty one nodes are assigned to the water course as shown in the figure. Thirty four branches are used to connect the nodes and to provide paths for the water movement between the nodes of the Bicol and Sipocot Rivers. Thirty one values of water levels at nodes, thirty four values of discharges along the branches and three additional values of discharges at system outlets are solved simultaneously through the use of the node and branch computation technique. Water discharges into nodes are estimated from streamflows of the Bicol and Sipocot tributaries and the surface runoffs produced by rainfall over gaged or ungaged watersheds assigned to the regions of the nodes. The water discharges to nodal points are considered as the boundary conditions of the flow system. The streamflow of the tributaries and surface runoffs from watersheds to the nodes are assigned to the nodal points from node no.1 to 24. It is assumed that there is no lateral discharges to node no.25 to node no.31. Fluctuation of sea water levels at the system outlets which are produced by combined effects of tide and typhoon are taken into account as the water level conditions that control water movement in the Bicol and Sipocot Rivers. Node no.31 at Balongay, node no.30 at Barcelona both on the eastern side of Luzon island and node no.27 at Pasacao on the western side of Luzon island are the nodal points in which their water levels are assigned equal to sea water levels. Topography of flood control schemes, e.g. Pulantuna Reservoir, diversions and cutoffs as well as the geometry of main channel and berm portions of Bicol and Sipocot Rivers are included in the model.

The flood control simulation model is used to simulate and determine the effectiveness of the flood control schemes on the water levels in the Bicol and Sipocot Rivers. The part of the model shown by the

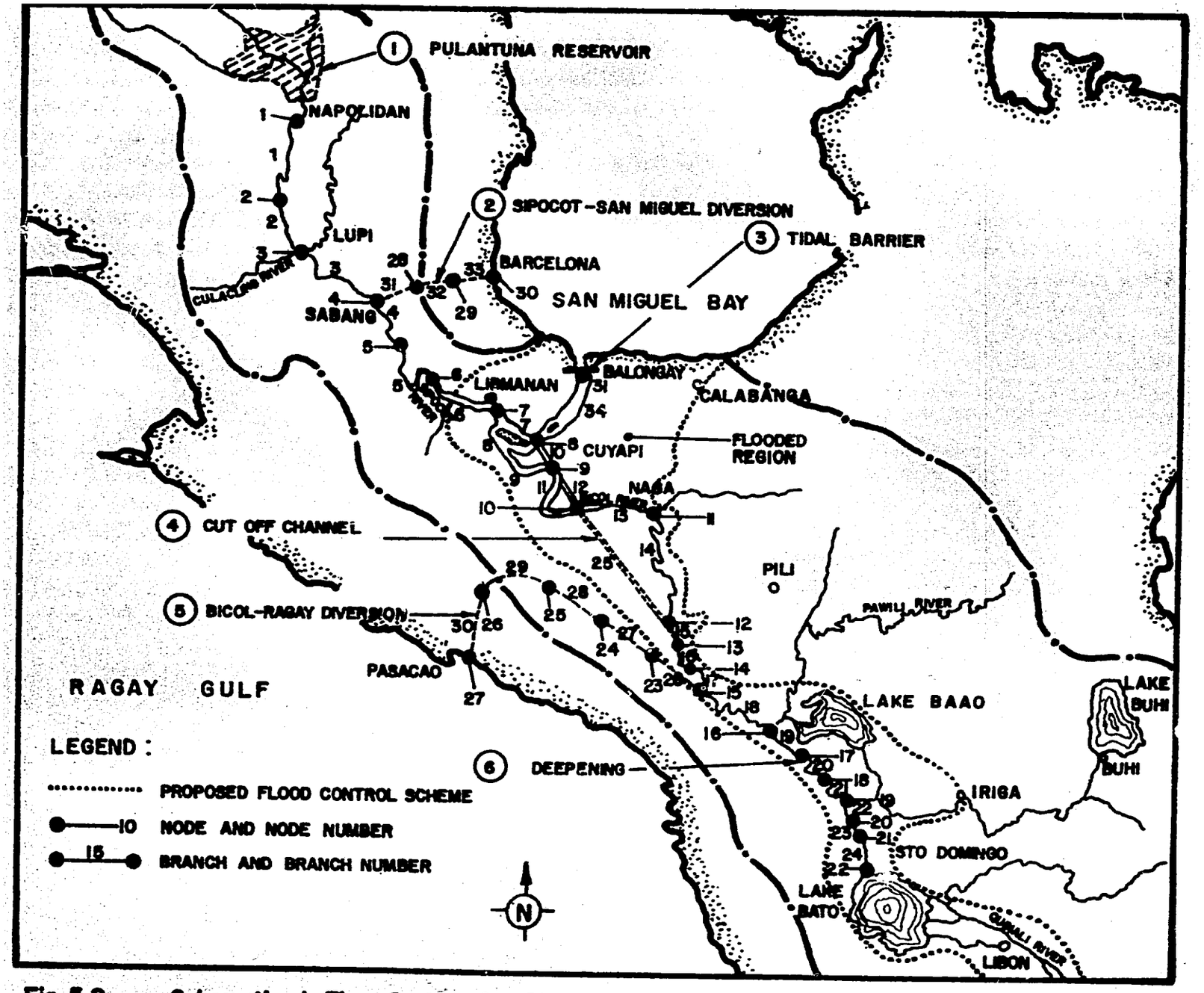



Fig. 5.8 Schematized Flow System for Bicol & Sipocot Rivers and Their Flood Control Schemes

dashed lines in Fig.5.8 represent the flood control schemes proposed in the present investigation.

5.5.2 Components of Flood Control Simulation Model The flood control simulation model is composed of three submodels as shown in Fig. 5.9. Those submodels consist of the hydrologic, tidal and river flow models.

The hydrologic model is used to convert rainfall over the basin's watersheds into time dependent discharges as inputs into the nodes.

The tidal model is used to simulate the fluctuations of the sea water levels on both sides of the Bicol Basin. The tidal model combines the effect of astronomical tidal generation with the storm surge produced by typhoon wind.

Water levels and discharges in the Bicol and Sipocot Rivers are computed through the use of the river flow model. The rainfall over the Bicol Basin and the fluctuation of sea water level as affected by tides and typhoons are considered as the major inputs to this model.

5.5.3 Unsteady Free Surface Flow Model

Finite difference equations - The unsteady free surface river flow model consists mainly of the continuity and momentum equations as expressed in Eqs.(5.6) and (5.11). The equations are solved numerically through the use of the following finite difference scheme

$$\vec{J}_{t+\Delta t} = \vec{J}_t + \{(1-\theta)\vec{f}_t + \theta\vec{f}_{t+\Delta t}\}\,\Delta t \;; \qquad 0 \leq \theta \leq 1 \qquad (5.17)$$

In Eq.(5.17), $\vec{f}(\vec{J},t) = \frac{d\vec{J}}{dt}$, $\vec{J}$ is the unknown vector representing either water level or discharge. The weighting factor was chosen, as suggested by Vreugdenhil (1969), as 0.55 to ensure numerical stability.

By substituting Eqs.(5.6) and (5.11) into Eq.(5.17), the finite difference form of the continuity and momentum equations written for nodes and branches can be obtained.

As an example, the finite difference form of the continuity equations for nodes 12 and 13 and the finite difference form of the momentum equation for branch no.15 which connects these two nodes are presented. Referring to Fig.5.10, the river discharge $Q_{16}$ enters node 13

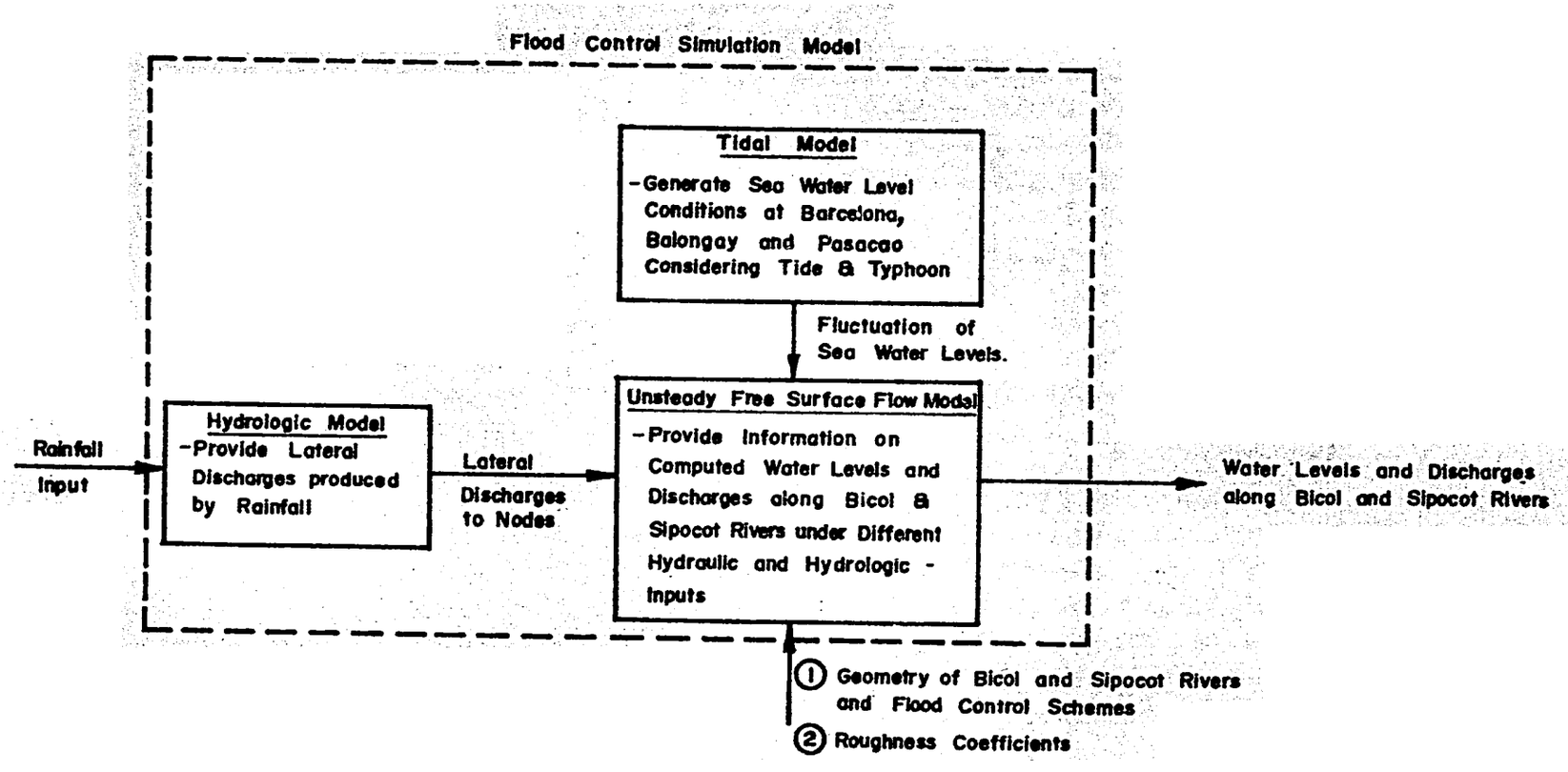
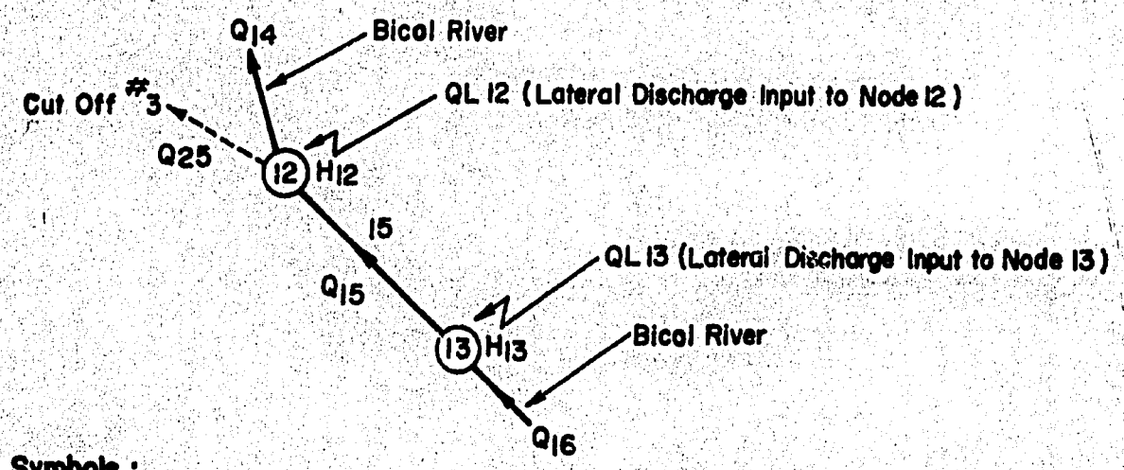



**Fig. 5.9 Flood Control Simulation Model and its Components.**




**Symbols :**

$Q_{15}$ : Discharge Along Bicol River through Branch no. 15

(13) $H_{13}$ : Water Level in Bicol River at Node no. 13

$Q_{25}$ : Discharge Along Cut Off #3 through Branch no. 25

$QL_{13}$ : Lateral Discharge to Node no. 13. The Discharge is produced Surface Run Off from Surrounding Watershed assigned to Node 13

**Fig. 5.10 Exaggerated View of Branch no.15, Node no.12 and no.13 and its Flow Domain**

through the upstream branch no.16, the surface runoffs from ungaged watersheds and the tributary streamflow in the vicinity of the node enter the node and is designated as QL13. The discharge from node 13 is referred to as $Q_{15}$. This flow enters the downstream node no.12 through branch no.15. The surface runoff and tributary streamflow designated as QL12 enters node 12 at the same instant. Water from node 12 then discharges in downstream direction through branch nos.14 and 25 with discharges whose magnitude are equal to $Q_{14}$ and $Q_{25}$ respectively.

The finite difference continuity equations for node no.12 and 13 can be expressed as follows:

Node 12

$$F_{12}\frac{\Delta H_{12}}{\Delta t} + \theta\Delta Q_{25} - \theta\Delta Q_{15} + \theta\Delta Q_{14} = -Q_{25} + Q_{15} - Q_{14} + QL12 + \theta\Delta QL12 \quad (5.18)$$

For Node 13

$$F_{13}\frac{\Delta H_{13}}{\Delta t} - \theta\Delta Q_{16} + \theta\Delta Q_{15} = Q_{16} - Q_{15} + QL13 + \theta\Delta QL13 \quad (5.19)$$

The finite difference form of the momentum equation written for the flow in branch no.15 can be expressed as

$$\Delta H_{13}\left[\theta g\frac{A_{15}}{L_{15}}\right] + \Delta H_{12}\left[-\theta g\frac{A_{15}}{L_{15}}\right] + \Delta Q_{15}\left[\left[-\frac{1}{\Delta t} + \frac{\theta M_{15}T_{15}}{A_{15}}\left[\frac{Q_{16}+QL13-2Q_{15}}{F_{13}} + \frac{2Q_{15}+QL12-Q_{25}-Q_{14}}{F_{12}}\right] + \theta 2Q_{15}\left[\frac{M_{15}}{A_{15}^2L_{15}}(A_{15}\text{ at D/S} - A_{15}\text{ at U/S}) - \left[\frac{M_{15}\text{ at D/S} - M_{15}\text{ at U/S}}{A_{15}L_{15}}\right] - g\frac{A_{15}}{\left[\sum_{i=1}^{3} K_{15,i}\right]^2}\frac{|Q_{15}|}{Q_{15}}\right]\right]\right.$$

$$+ \Delta Q_{16}\left[\frac{\theta M_{15}T_{15}Q_{15}}{A_{15}F_{15}}\right] + \Delta Q_{14}\left[-\frac{\theta M_{15}T_{15}Q_{15}}{A_{15}F_{12}}\right] + \Delta Q_{25}\left[-\frac{\theta M_{15}T_{15}Q_{15}}{A_{15}F_{12}}\right]$$

$$= -\left[\frac{M_{15}Q_{15}T_{15}}{A_{15}}\left(\frac{Q_{16}+QL13-Q_{15}}{F_{13}}+\frac{Q_{15}+QL12-Q_{25}-Q_{14}}{F_{12}}\right)+\frac{M_{15}Q_{15}^2}{A_{15}^2L_{15}}(A_{15}\text{ at D/S}-A_{15}\text{ at U/S})\right.$$

$$-\frac{Q_{15}^2}{A_{15}L_{15}}(M_{15}\text{ at D/S}-M_{15}\text{ at U/S})-g\frac{A_{15}}{L_{15}}(H_{12}-H_{13})-gA_{15}\frac{Q_{15}|Q_{15}|}{\left[\sum_{i=1}^{3}K_{15,i}\right]^2}$$

$$\left.+\Delta QL13\left(-\frac{\theta M_{15}T_{15}Q_{15}}{A_{15}F_{13}}\right)+\Delta QL12\left(-\frac{\theta M_{15}T_{15}Q_{15}}{A_{15}F_{12}}\right)\right] \qquad (5.20)$$

Eqs.(5.18), (5.19) and (5.20) are the continuity and momentum equations for node no.12, 13 and branch no.15. The equations have been linearized by dropping the nonlinear products, i.e. the products of all the increments, for example, $\Delta Q\Delta H$, $(\Delta H)^2$ and $(\Delta Q)^2$. The terms on the right hand side of the equations contain parameters which are previously known from the initially assigned values or from the previous step of computation and also from the given boundary conditions at nodes 12 and 13. Similar types of finite difference continuity and momentum equations can be written for all nodes and branches in the schematized flow system as shown in Fig.5.9.

Method of solving continuity and momentum equations -- The continuity and momentum equations for all nodes and branches form a set of linear algebraic equations which can be solved simultaneously. The unknowns are the incremental changes in the stages and discharges of all nodes and branches in the system within the time step of $\Delta t$ used in the computation. Fig.5.11 shows the isometric sketch of the procession of the step computation of water levels and discharges in a portion of a river network.

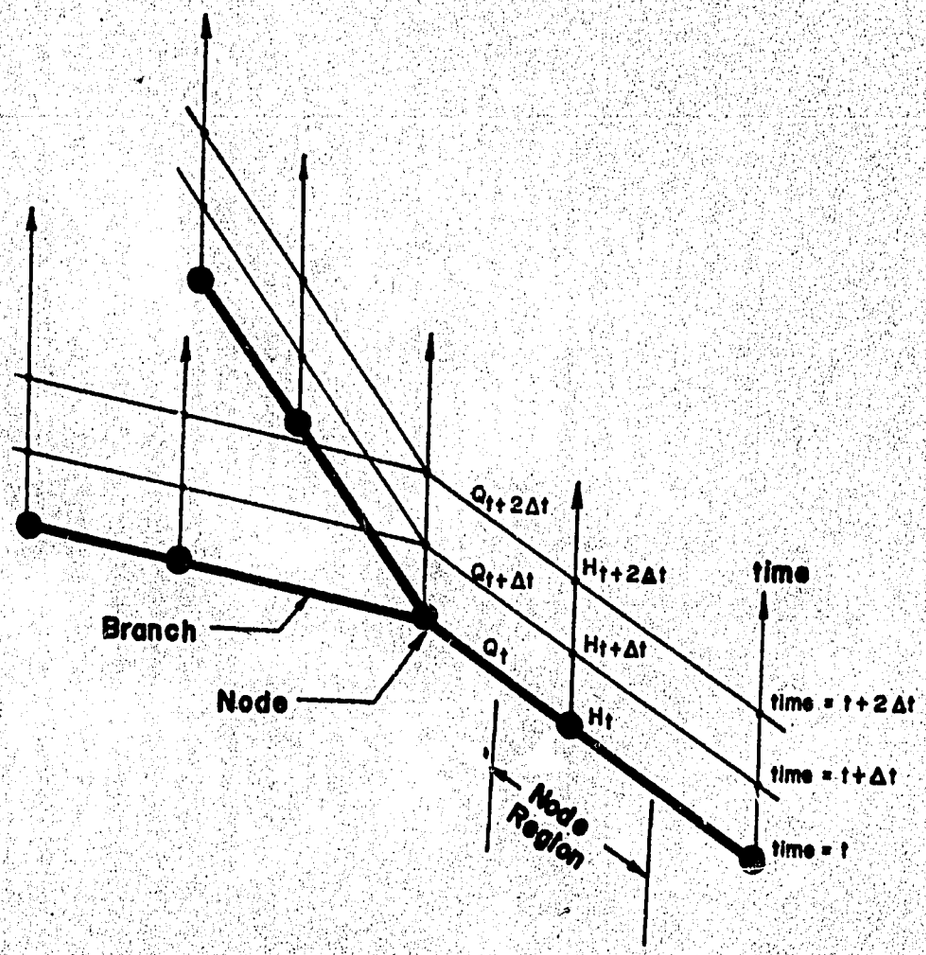
In matrix notation, the set of linear algebraic equations can be expressed as

$$[P][N] = [C]$$

or

$$[N] = [P]^{-1}[C] \qquad (5.21)$$

In Eq.(5.21), [N] is the unknown matrix which contains the incremental changes of stages and discharges within the time interval $\Delta t$, [P] is the known matrix which contains the coefficients of the elements of the matrix [N]. The matrix [P] is known from the previous




Note : $H_{t+\Delta t} = H_t + \Delta H_t$

$H_{t+2\Delta t} = H_{t+\Delta t} + \Delta H_{t+\Delta t}$

$Q_{t+\Delta t} = Q_t + \Delta Q_t$

$Q_{t+2\Delta t} = Q_{t+\Delta t} + \Delta Q_{t+\Delta t}$

Fig. 5.11 Procession of Step Computation for a River Network Using the Node and Branch Computational Procedure.

step of computation or from the initial conditions.

[C] is the known matrix which contains the known products of coefficients and boundary conditions and the isolated terms which are known from the previous step of computation or from the initial conditions.

Eq.(5.21) is solved on a CDC-3600 Digital Computer which is capable of handling a maximum core storage capacity of 64K. The computer language used is FORTRAN IV.

## 5.6 Model Calibration

The flood control simulation model is calibrated using the available previous flow records along the Bicol and Sipocot Rivers in the year of 1970. The hydraulic and hydrologic inputs to the model are available from field measurements. The hydraulic input to the model which serves as a downstream boundary condition is the observed mean daily sea water level at Cuyapi. The hydrologic input is the measured rainfall at three stations over the Bicol Watershed. The rainfall is converted to surface runoff which enters the nodes assigned to the Bicol and Sipocot Rivers. The surface runoff from ungaged watersheds were estimated from the basin rainfall using a distribution graph. The observed streamflows of the tributaries are used wherever possible as discharge inputs from the gaged watersheds. The model is calibrated by adjusting the empirical constants, contained in the governing equations which control the model outputs. The governing equations which contain the empirical constants are the unsteady free surface flow equations and the rainfall-runoff relationship. Adjustments are performed until the flow records during the storm of October 1970 are duplicated. These empirical constants are representative of the physical characteristics of the Bicol River Basin. These characteristics are the:

a) energy loss or roughness coefficients of the main channel and berms of the Bicol and Sipocot Rivers.

b) runoff coefficients which are defined as the ratio between the volume of surface runoff from the watershed to that of the rainfall on the same area.

Two sets of four runoff coefficients are used. The first set is used during the period prior to the storm in which the soil is partially saturated while the second set is used during the storm period in which the soil in the watershed is assumed to be fully saturated.

In the model calibration, all the flood control schemes were disregarded since they did not exist during the time of flooding in 1970.

The roughness coefficients which require adjustment are those for the main channel and berms of branch no.1 to no.24. The berm portions which were inundated during the flood period are those of branch nos.9, 11 and branch nos.13 and 24 along the Bicol River. In the calibration, the roughness coefficients are assumed for the main channel and berms for branches 1 to 24. Adjustments on the roughness coefficients of the main channel and berms are performed through a trial and error procedure. The locations of the gaging stations for which the flow records are available are shown in Fig.5.8. These stations are:

a) Sabang, Sipocot River (Node No.4)

b) Libmanan, Sipocot River (between Node Nos.6 and 7 on Branch No.6)

c) Naga City, Bicol River (Node No.11)

d) Ombao, Bicol River (between Node Nos.16 and 17)

e) Sto. Domingo, Bicol River (Node No.21)

f) Lake Bato, Bicol River (Node No.22)

The comparisons of the water levels computed from the flood control simulation model and from the 1970 field records for those gaging stations are shown in Fig.6 in Vol.I of this Report. Satisfactory results are obtained from the calibration. The following are the empirical constants which are obtained from the model calibration.

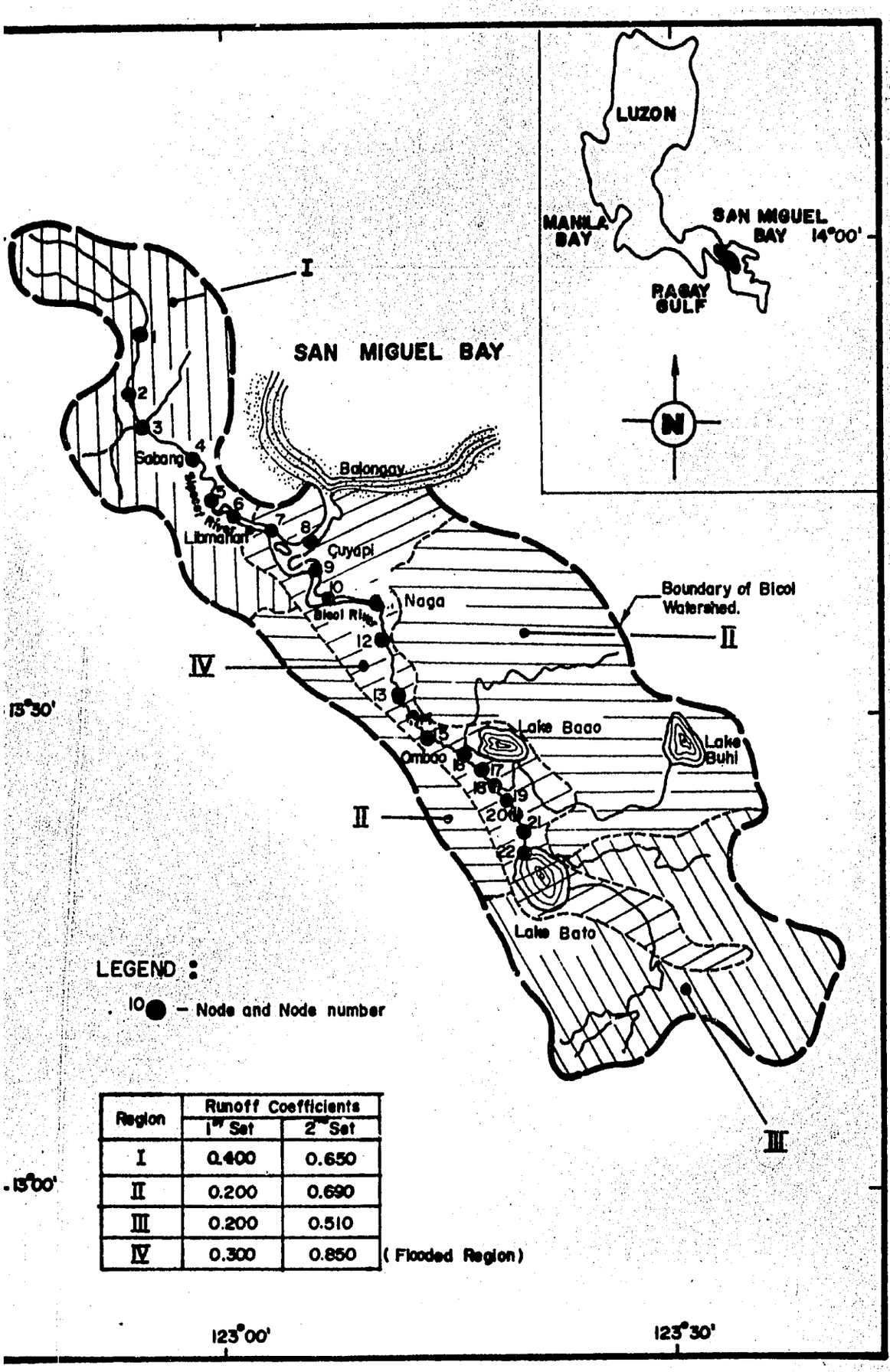
We have not seen

a) Runoff Coefficients There are two sets of runoff coefficients. The first set applies for rainfalls prior to the storm of October 12, 1970. The second set applies to rainfall during the typhoon. Each set contains four values:

1st set: R1 = 0.400 R2 = 0.200 R3 = 0.200 R4 = 0.300

2nd set: R1 = 0.650 R2 = 0.690 R3 = 0.510 R4 = 0.850

The symbols R1, R2, R3 and R4 are the values of the runoff coefficients which are assumed to apply to regions No.I, II, III and IV shown in Fig.5.12.




| Region | Runoff Coefficients | |
|---|---|---|
| | 1st Set | 2nd Set |
| I | 0.400 | 0.650 |
| II | 0.200 | 0.690 |
| III | 0.200 | 0.510 |
| IV | 0.300 | 0.850 |

(Flooded Region)

**Fig. 5.12** **Region of the Watersheds which Runoff Coefficients are Assigned, Bicol River Basin.**

b) Roughness Coefficients

| Branch No. | Left Berm | Main Channel | Right Berm |
|---|---|---|---|
| 1 | 5.0 | 0.1600 | 5.0 |
| 2 | 5.0 | 0.1500 | 5.0 |
| 3 | 5.0 | 0.1250 | 5.0 |
| 4 | 5.0 | 0.1050 | 5.0 |
| 5 | 5.0 | 0.0750 | 5.0 |
| 6 | 5.0 | 0.0700 | 5.0 |
| 7 | 5.0 | 0.0620 | 5.0 |
| 8 | 5.0 | 0.0620 | 5.0 |
| 9 | 0.0600 | 0.0195 | 0.0600 |
| 10 | 5.0 | 0.0195 | 5.0 |
| 11 | 5.0 | 0.0210 | 5.0 |
| 12 | 5.000 | 0.0210 | 5.000 |
| 13 | 0.0700 | 0.0220 | 0.0700 |
| 14 | 3.00 | 0.0290 | 3.000 |
| 15 | 6.000 | 0.0345 | 6.000 |
| 16 | 6.900 | 0.0352 | 6.900 |
| 17 | 6.900 | 0.0352 | 6.900 |
| 18 | 6.900 | 0.0352 | 6.900 |
| 19 | 6.750 | 0.0350 | 6.750 |
| 20 | 5.700 | 0.0310 | 5.700 |
| 21 | 4.900 | 0.0290 | 4.900 |
| 22 | 4.500 | 0.0270 | 4.500 |
| 23 | 4.900 | 0.030 | 4.900 |
| 24 | 4.850 | 0.0295 | 4.850 |
| 25 | 5.000 | 0.029 | 5.000 |
| 26 | 5.000 | 0.0350 | 5.000 |
| 27 | 5.000 | 0.0350 | 5.000 |
| 28 | 5.000 | 0.0350 | 5.000 |
| 29 | 5.000 | 0.0350 | 5.000 |
| 30 | 5.000 | 0.0350 | 5.000 |
| 31 | 5.000 | 0.100 | 5.000 |
| 32 | 5.000 | 0.080 | 5.000 |
| 33 | 5.000 | 0.060 | 5.000 |
| 34 | 5.000 | 0.0250 | 5.000 |

The runoff coefficients and the roughness coefficients are assumed invariant when the river basin is subjected to different flooding conditions.

Knowing the values of the empirical constants from the calibration, the model is then applied to predict the effectiveness of various combinations of flood control schemes. The procedure used in the model calibration and in the prediction of the effectiveness of the flood control schemes on the water levels in Bicol and Sipocot Rivers is shown in Fig.5.13.

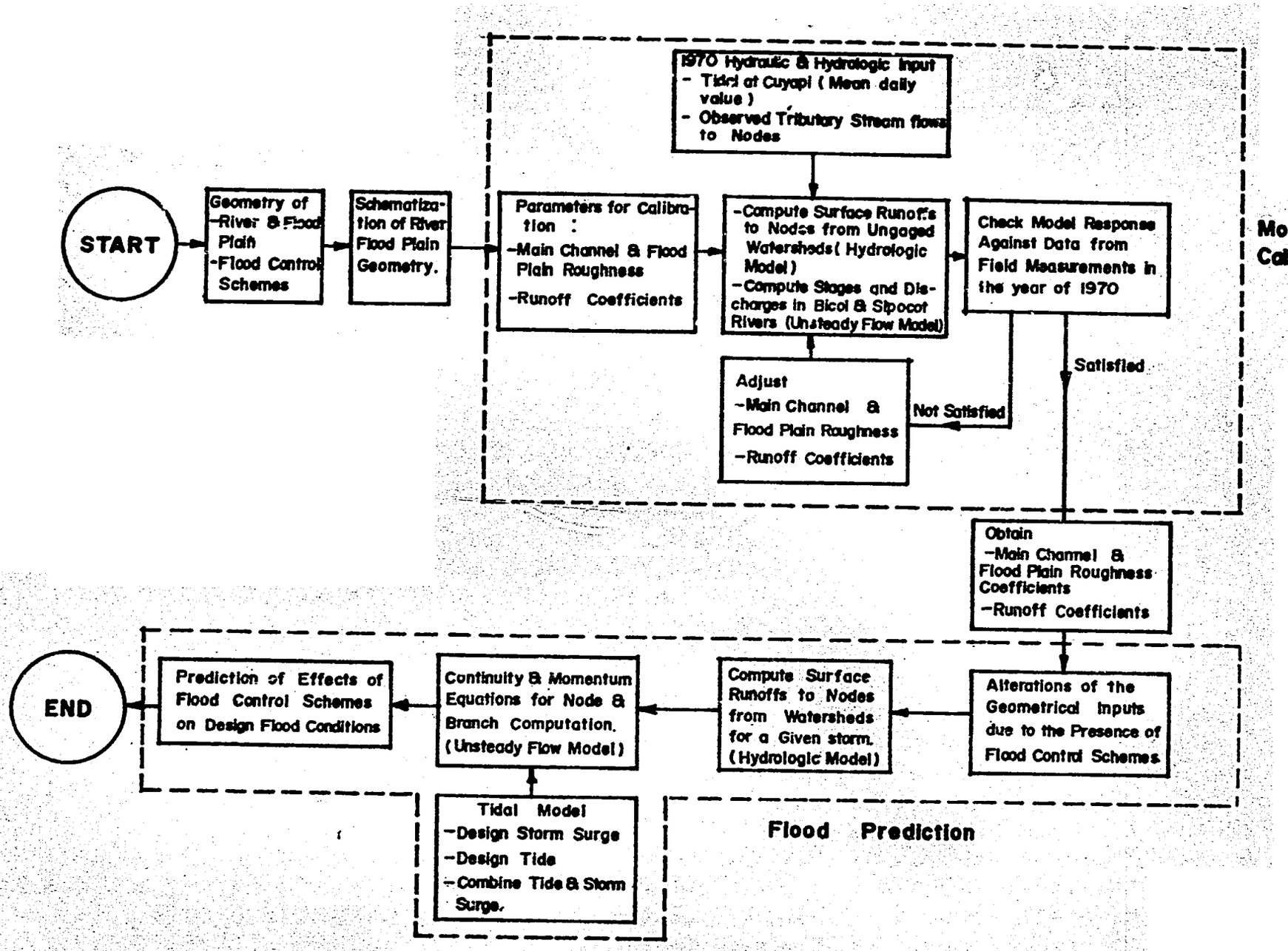



Fig. 5.13 Flow Chart for Model Calibration and Simulation of Flood Control Schemes.

## 5.7 Modelling of Flood Control Alternatives

The effectiveness of individual and combination of flood control schemes is calculated with hydrologic inputs that had return periods of 13 and 50 years. The return period of 13 years is selected since the input has the magnitude equivalent to that of the flood which occurred in October 1970.

The proposed flood control schemes and their combinations that were studied for their effectiveness are shown in Table 5.1. The portion of the basin included in the model could be altered by changing the geometrical dimension of the channels which are used as inputs to the model. For a specified combination of flood control measures, the geometry of the channels not to be included are reduced to a value close to zero. The adjustment on the geometry of the model to cope with the required conditions to be investigated can be described as follows:

a) With and Without Cutoff No.3 For a combination of measures in which channel Cutoff No.3 is not included, the topwidth, the cross sectional area and the mean depth of the cutoff are reduced to a very small amount close to zero. For the case that Cutoff No.3 is included, the topwidth, the cross sectional area and the mean depth are assigned their appropriate values. The roughness coefficient assigned to the branch representing Cutoff No.3 is equal to 0.029.

b) With and Without Diversion The following diversion canals are proposed to prevent flooding along the Bicol and Sipocot Rivers:

1) Sipocot - San Miguel Diversion
2) Bicol - Ragay Diversion

For a combination which does not include these diversion canals, the topwidth, the cross sectional area and the mean depth of the diversions are reduced to approximately zero. For the situation when these diversions are included, the appropriate geometry of the diversion is substituted. The roughness coefficients assigned for the branches along the diversions are as follows:

Table 5.1 - Proposed Flood Protection Schemes and Their Combinations which were evaluated in the present study.

| Combinations of Flood Protection Schemes | Basic Components of Flood Protection Schemes | | | | | |
|---|---|---|---|---|---|---|
| | Pulantuna Reservoir | Sipocot Diversion | Tidal Barrier | Cutoff No.3 | Ragay Diversion | Deepening River Bed |
| No.1 | X | | | | | |
| No.2 | | X | | | | |
| No.3 | | | X | | | |
| No.4 | | | | X | | |
| No.5 | | | | | X | |
| No.6 | | | | | | X |
| No.7 | X | | X | | | |
| No.8 | X | | | | X | |
| No.9 | X | | X | | X | |
| No.10 | X | X | X | | X | |
| No.11 | | | | | | |

| Sipocot-San Miguel Diversion | |
|---|---|
| Branch No. | Manning's n Main Channel |
| 28 | 0.10 |
| 29 | 0.08 |
| 30 | 0.06 |
| **Bicol-Ragay Diversion** | |
| 26 | 0.0350 |
| 27 | 0.0350 |
| 28 | 0.0350 |
| 29 | 0.0350 |

It should be noted that the roughness coefficients of the diversion canals are assumed in the same order of magnitude as those which existed in the nearby branches of Bicol and Sipocot Rivers.

c) With and Without Pulantuna Reservoir The surface area of the reservoir is considered as zero when it is not included in the combination of flood control measures to be investigated. For the case that the reservoir is included for consideration, the surface area of Pulantuna Reservoir is added to the surface area of Node 1 at Napolidan.

d) With and Without Channel Deepening The geometry of the actual cross sections of the Bicol River along the reach that is proposed for improvement is replaced by the proposed deepened and widened cross sections which would correspond to conditions when the channel improvement is completed. The roughness coefficients for the branches within the reach are assumed unchanged and equal to those obtained from the model calibration.

e) With and Without Tidal Barrier For a combination of flood control measures that do not include the tidal barrier, the sea water level at Balongay is used as the boundary condition for the river mouth. When the barrier is included, the boundary condition at the river mouth is the river discharge through the barrier towards the sea. The river discharge is computed through the use of equations describing the flow through the barrier for different upstream and downstream heads. The barrier is regulated in such a way that the gate is opened when the river stage is higher than the sea level. Since the river discharge through the barrier

has to be implicitly determined in connection with the water level on the river side of the barrier, the computation is therefore complicated and time consuming. To overcome such difficulties, an approximate computational procedure is performed in the present study. The procedure could be described in step by step as follows:

(1) The river discharge through the barrier, Q, is set equal to zero for the time that the computation is started. This can be explained since the water levels on the river and sea sides are initially equal. The discharge through the barrier is therefore zero.

(2) Use the discharge, Q, as the boundary condition at the mouth of the Bicol River at Balongay. Compute the water level of the next time step on the river side of the barrier through the use of the continuity and momentum equations, i.e. through the flood control simulation model.

(3) Check whether the computed river stage is higher or lower than the sea water level at the same time step.

(4) Set the discharge, Q, equal to zero if the sea water level is higher than the river stage. If the river stage is higher than sea level, compute the river discharge, Q, through the barrier using equations for the hydraulic characteristics of that control structure.

(5) Repeat the computation from step (2) through step (4) as desired.

## 5.8 Effectiveness of Flood Control Schemes

The magnitude of the effects of the flood control schemes on the water levels in the Bicol and Sipocot Rivers are determined by the application of the flood control simulation model. The absolute changes in the water levels are computed by comparing the water levels in Bicol and Sipocot Rivers under the conditions of with and without flood control schemes. The following are the stations along the Bicol and Sipocot Rivers for which the water level conditions under various combinations of flood control schemes and under the conditions of no flood control scheme are computed.

a) Libmanan, Sipocot River

b) Cuyapi, Bicol River

c) Naga City, Bicol River
d) Ombao, Bicol River
e) Sto. Domingo, Bicol River
f) Lake Bato, Bicol River

The comparison of the effectiveness of the various flood protection measures is determined by comparing, for the various flood control measures, peak water levels and the duration of inundation. The time dependent water levels as affected by different combinations of basic components of flood control schemes are presented. For detailed information, the complete analysis of the effectiveness of flood control schemes are shown in Volume I. Numerical values of the daily water levels along the Bicol and Sipocot Rivers for various combinations of flood control schemes are presented in this section. Peak stages at corresponding times at Libmanan, Cuyapi, Naga City, Ombao, Sto. Domingo and Lake Bato are also presented. Tables 5.2 through 5.12 show the computed daily water levels along Bicol and Sipocot Rivers when the flood has the return period of 13 years. Similarly, Tables 5.13 through 5.23 show the computed daily water levels along the rivers when the system is subjected to a flood whose return period is estimated as 50 years.

## 5.9 Computer Programming

5.9.1 List of Main Program and Subroutines The complete computer program of the flood control simulation model is given. The program is comprised of the main program and eighteen subroutines. The name of the main program and subroutines are as follows:

| Name | Program Type |
|---|---|
| BICOL2 | Main Program |
| INPUT2 | |
| RITIN2 | |
| SQ2 | |
| SURF2 | |
| STAGE2 | |
| DIFH2 | Subroutine |
| ATMK2 | |
| DIFAM2 | |
| GEO1 | |
| GEO2 | |
| GEO | |

## TABLE 5.2 DAILY WATER LEVELS ALONG BICOL - SIPOCOT RIVERS IN METERS ABOVE MSL.

### RETURN PERIOD OF DESIGN FLOOD 13 YEARS

### FLOOD PROTECTION SCHEME : ① POLUNTUNA RESERVOIR

| RIVER | SIPOCOT RIVER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOWN | SABANG | | | | LIBMANAN | | | CUYAPI | | | | NAGA | | | | OMBAO | | | | | | | | | | | | | | | | | |
| DATE \ NODE NO. | 1 | 2 | 3 | 4 | 5 | 6 | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 5 | 11.802 | 9.499 | 5.752 | 2.109 | 0.319 | 0.153 | 0.121 | 0.106 | 0.097 | 0.126 | 0.131 | 0.254 | 1.104 | 1.446 | 1.811 | 1.990 | 3.611 | 4.512 | 4.976 | 5.969 | 6.532 | 6.876 | 6.880 | 6.895 | 1.601 | 1.018 | 0.436 | -0.148 | -0.733 | 1.438 | 0.766 | 0.095 | 0.095 |
| 6 | 11.766 | 9.378 | 6.078 | 2.214 | 0.350 | -0.056 | -0.201 | -0.413 | -0.354 | -0.467 | -0.482 | -0.334 | 0.951 | 1.301 | 1.669 | 1.843 | 3.478 | 4.386 | 4.853 | 5.874 | 6.552 | 6.862 | 6.866 | 6.881 | 1.572 | 1.123 | 0.613 | 0.008 | -0.718 | 1.308 | 0.445 | -0.336 | -0.336 |
| 7 | 11.729 | 9.128 | 6.151 | 2.458 | 0.386 | -0.065 | -0.429 | -0.594 | -0.728 | -0.649 | -0.643 | -0.386 | 0.891 | 1.246 | 1.620 | 1.797 | 3.463 | 4.389 | 4.850 | 5.882 | 6.564 | 6.879 | 6.883 | 6.900 | 1.533 | 1.105 | 0.622 | 0.045 | -0.669 | 1.287 | 0.324 | -0.711 | -0.711 |
| 8 | 11.724 | 9.079 | 5.991 | 2.432 | 0.392 | -0.033 | -0.420 | -0.596 | -0.910 | -0.625 | -0.609 | -0.305 | 0.906 | 1.263 | 1.640 | 1.820 | 3.485 | 4.411 | 4.871 | 5.908 | 6.588 | 6.903 | 6.907 | 6.924 | 1.556 | 1.133 | 0.661 | 0.103 | -0.595 | 1.345 | 0.223 | -0.950 | -0.950 |
| 9 | 11.731 | 9.219 | 6.038 | 2.445 | 0.458 | 0.083 | -0.298 | -0.471 | -0.899 | -0.471 | -0.448 | -0.135 | 0.976 | 1.337 | 1.717 | 1.900 | 3.555 | 4.474 | 4.937 | 5.987 | 6.562 | 6.921 | 6.926 | 6.946 | 1.621 | 1.186 | 0.721 | 0.166 | -0.508 | 1.381 | 0.255 | -0.998 | -0.998 |
| 10 | 11.736 | 9.252 | 5.870 | 2.415 | 0.440 | 0.193 | -0.145 | -0.299 | -0.688 | -0.239 | 0.209 | 0.108 | 1.050 | 1.395 | 1.763 | 1.943 | 3.580 | 4.489 | 4.954 | 6.010 | 6.582 | 6.942 | 6.946 | 6.967 | 1.651 | 1.203 | 0.731 | 0.206 | -0.422 | 1.450 | 0.396 | -0.841 | -0.841 |
| 11 | 11.745 | 9.499 | 5.916 | 2.411 | 0.709 | 0.406 | 0.109 | -0.027 | -0.352 | 0.066 | 0.119 | 0.407 | 1.149 | 1.462 | 1.808 | 1.983 | 3.605 | 4.506 | 4.972 | 6.024 | 6.595 | 6.956 | 6.960 | 6.982 | 1.667 | 1.202 | 0.728 | 0.221 | -0.353 | 1.560 | 0.625 | -0.510 | -0.510 |
| 12 | 11.835 | 11.160 | 8.449 | 4.625 | 1.786 | 1.059 | 0.680 | 0.509 | 0.147 | 0.904 | 0.986 | 1.764 | 3.196 | 3.689 | 4.114 | 4.337 | 5.409 | 6.004 | 6.414 | 7.072 | 7.370 | 7.612 | 7.613 | 7.484 | 2.582 | 2.580 | 1.618 | 0.669 | -0.312 | 3.139 | 1.628 | -0.077 | -0.077 |
| 13 | 16.168 | 14.890 | 13.015 | 9.761 | 5.291 | 3.609 | 2.545 | 2.061 | 0.748 | 1.897 | 2.016 | 2.722 | 5.152 | 6.241 | 6.749 | 7.022 | 7.694 | 8.067 | 8.354 | 8.299 | 8.315 | 8.925 | 8.970 | 8.986 | 5.841 | 4.242 | 2.701 | 1.195 | -0.305 | 6.586 | 3.539 | 0.364 | 0.364 |
| 14 | 17.427 | 15.004 | 12.474 | 8.990 | 5.020 | 3.415 | 2.442 | 2.000 | 1.260 | 2.347 | 2.447 | 2.847 | 5.440 | 6.100 | 6.546 | 6.857 | 7.987 | 8.626 | 9.013 | 9.164 | 9.374 | 9.787 | 9.820 | 9.839 | 5.915 | 4.426 | 2.872 | 1.271 | -0.335 | 6.369 | 2.621 | 0.719 | 0.719 |
| 15 | 16.613 | 13.904 | 10.675 | 7.162 | 3.648 | 2.362 | 1.684 | 1.376 | 1.026 | 1.610 | 1.698 | 2.474 | 4.789 | 5.467 | 6.005 | 6.334 | 7.763 | 8.558 | 8.985 | 9.485 | 9.620 | 9.931 | 9.952 | 9.983 | 5.422 | 4.012 | 2.599 | 1.074 | -0.395 | 5.095 | 2.019 | 0.916 | 0.916 |
| 16 | 15.082 | 12.567 | 9.233 | 5.816 | 2.679 | 1.623 | 1.234 | 1.058 | 0.949 | 1.176 | 1.224 | 2.274 | 4.415 | 5.115 | 5.635 | 6.038 | 7.551 | 8.392 | 8.853 | 9.491 | 9.637 | 9.913 | 9.930 | 9.967 | 5.168 | 3.820 | 2.417 | 0.966 | -0.478 | 4.156 | 2.516 | 0.921 | 0.921 |
| 17 | 13.909 | 11.511 | 8.179 | 4.794 | 1.989 | 1.063 | 0.876 | 0.791 | 0.763 | 0.959 | 1.010 | 2.033 | 4.137 | 4.839 | 5.429 | 5.770 | 7.330 | 8.196 | 8.691 | 9.401 | 9.556 | 9.825 | 9.841 | 9.884 | 4.940 | 3.650 | 2.297 | 0.873 | -0.569 | 3.380 | 2.015 | 0.743 | 0.743 |
| 18 | 13.289 | 10.838 | 7.473 | 4.099 | 1.456 | 0.708 | 0.519 | 0.434 | 0.425 | 0.659 | 0.702 | 1.809 | 3.947 | 4.652 | 5.249 | 5.587 | 7.175 | 8.057 | 8.567 | 9.291 | 9.450 | 9.718 | 9.733 | 9.774 | 4.785 | 3.541 | 2.224 | 0.813 | -0.655 | 2.809 | 1.567 | 0.426 | 0.426 |
| 19 | 12.865 | 10.798 | 7.692 | 4.283 | 1.461 | 0.652 | 0.274 | 0.102 | 0.056 | 0.602 | 0.679 | 1.968 | 4.086 | 4.823 | 5.406 | 5.732 | 7.233 | 8.066 | 8.599 | 9.230 | 9.386 | 9.657 | 9.671 | 9.702 | 4.893 | 3.623 | 2.282 | 0.831 | -0.721 | 2.789 | 1.360 | 0.039 | 0.039 |
| 20 | 12.610 | 10.320 | 7.112 | 3.889 | 1.324 | 0.561 | 0.080 | -0.139 | -0.301 | 0.430 | 0.525 | 1.928 | 4.029 | 4.693 | 5.253 | 5.675 | 7.098 | 7.945 | 8.455 | 9.167 | 9.327 | 9.588 | 9.601 | 9.638 | 4.802 | 3.585 | 2.278 | 0.837 | -0.757 | 2.462 | 1.035 | -0.347 | -0.347 |
| 21 | 12.536 | 10.233 | 6.910 | 3.519 | 0.978 | 0.321 | -0.128 | -0.332 | -0.585 | 0.275 | 0.369 | 1.707 | 3.825 | 4.507 | 5.078 | 5.396 | 6.950 | 7.814 | 8.329 | 9.062 | 9.231 | 9.508 | 9.522 | 9.571 | 4.635 | 3.459 | 2.204 | 0.815 | -0.757 | 2.121 | 0.733 | -0.668 | -0.668 |
| 22 | 12.843 | 10.378 | 6.919 | 3.437 | 0.922 | 0.293 | -0.170 | -0.381 | -0.758 | 0.148 | 0.230 | 1.489 | 3.623 | 4.284 | 4.868 | 5.184 | 6.787 | 7.678 | 8.204 | 8.971 | 9.149 | 9.429 | 9.442 | 9.489 | 4.465 | 3.341 | 2.142 | 0.810 | -0.721 | 2.053 | 0.622 | -0.883 | -0.883 |
| 23 | 13.257 | 10.743 | 7.138 | 3.645 | 0.872 | 0.312 | -0.129 | -0.334 | -0.798 | 0.072 | 0.148 | 1.893 | 3.420 | 4.106 | 4.691 | 5.015 | 6.669 | 7.589 | 8.121 | 8.859 | 9.038 | 9.307 | 9.318 | 9.363 | 4.306 | 3.217 | 2.067 | 0.804 | -0.654 | 2.195 | 0.681 | -0.967 | -0.967 |
| 24 | 13.384 | 10.944 | 7.300 | 3.772 | 1.084 | 0.426 | -0.023 | -0.226 | -0.711 | 0.125 | 0.193 | 1.268 | 3.327 | 4.003 | 4.575 | 4.891 | 6.562 | 7.475 | 8.011 | 8.744 | 8.926 | 9.191 | 9.202 | 9.245 | 4.199 | 3.133 | 2.021 | 0.814 | -0.567 | 2.333 | 0.802 | -0.921 | -0.921 |
| 25 | 13.324 | 10.988 | 7.534 | 4.085 | 1.260 | 0.563 | 0.138 | -0.055 | -0.524 | 0.266 | 0.354 | 1.312 | 3.263 | 3.940 | 4.474 | 4.782 | 6.436 | 7.256 | 7.889 | 8.638 | 8.824 | 9.127 | 9.142 | 9.206 | 4.093 | 3.044 | 1.964 | 0.814 | -0.474 | 2.607 | 1.036 | -0.756 | -0.756 |

**REMARKS:**

| STATION | LIBMANAN | CUYAPI | NAGA | OMBAO | STO. DOMINGO | LAKE BATO |
|---|---|---|---|---|---|---|
| PEAK STAGE M.MSL | 3.590 | 2.920 | 3.287 | 8.111 | 9.987 | 9.987 |
| TIME | 13 - 12 - 0 | 13 - 11 - 0 | 13 - 14 - 0 | 13 - 15 - 0 | 15 - 12 - 0 | 15 - 12 - 0 |

## TABLE 5.3. DAILY WATER LEVELS ALONG BICOL - SIPOCOT RIVERS IN METERS ABOVE MSL.

### RETURN PERIOD OF DESIGN FLOOD 13 YEARS

### FLOOD PROTECTION SCHEME : ② SIPOCOT - SAN MIGUEL DIVERSION

| RIVER | SIPOCOT RIVER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOWN | SABANG | | | | LIBMANAN | | | CUYAPI | | | | NAGA | | | | OMBAO | | | | | STO DOMINGO | | | LAKE BATO | | | | PASACAO | | | BARCELONA | | BOLONGAY |
| DATE \ NODE NO. | 1 | 2 | 3 | 4 | 5 | 6 | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 5 | 11.893 | 9.252 | 6.243 | 1.323 | 0.185 | 0.120 | 0.107 | 0.101 | 0.097 | 0.124 | 0.129 | 0.246 | 1.071 | 1.404 | 1.759 | 1.933 | 3.555 | 4.456 | 4.921 | 5.902 | 6.567 | 6.872 | 6.876 | 6.888 | 1.555 | 0.985 | 0.414 | -0.159 | -0.733 | 0.667 | 0.272 | 0.095 | 0.095 |
| 6 | 11.849 | 9.102 | 6.517 | 1.435 | 0.147 | -0.149 | -0.340 | -0.426 | -0.354 | -0.468 | -0.482 | -0.336 | 0.947 | 1.297 | 1.664 | 1.838 | 3.473 | 4.382 | 4.848 | 5.868 | 6.546 | 6.857 | 6.860 | 6.875 | 1.567 | 1.119 | 0.610 | 0.006 | -0.718 | 0.722 | 0.168 | -0.336 | -0.336 |
| 7 | 11.822 | 8.873 | 6.616 | 1.557 | 0.164 | -0.155 | -0.471 | -0.615 | -0.728 | -0.650 | -0.644 | -0.388 | 0.888 | 1.241 | 1.615 | 1.792 | 3.459 | 4.385 | 4.846 | 5.877 | 6.559 | 6.874 | 6.878 | 6.894 | 1.529 | 1.102 | 0.620 | 0.043 | -0.669 | 0.840 | 0.260 | -0.711 | -0.711 |
| 8 | 11.862 | 8.834 | 6.491 | 1.529 | 0.182 | -0.115 | -0.467 | -0.627 | -0.910 | -0.627 | -0.610 | -0.307 | 0.902 | 1.259 | 1.636 | 1.815 | 3.481 | 4.407 | 4.867 | 5.903 | 6.584 | 6.898 | 6.902 | 6.919 | 1.552 | 1.129 | 0.659 | 0.101 | -0.595 | 0.822 | 0.252 | -0.950 | -0.950 |
| 9 | 11.862 | 8.974 | 6.539 | 1.564 | 0.267 | -0.001 | -0.347 | -0.505 | -0.898 | -0.473 | -0.454 | -0.143 | 0.962 | 1.323 | 1.706 | 1.889 | 3.553 | 4.477 | 4.937 | 5.984 | 6.560 | 6.918 | 6.923 | 6.943 | 1.610 | 1.175 | 0.704 | 0.161 | -0.508 | 0.839 | 0.214 | -0.998 | -0.998 |
| 10 | 11.869 | 9.011 | 6.372 | 1.523 | 0.318 | 0.173 | -0.156 | -0.306 | -0.683 | -0.242 | -0.212 | 0.103 | 1.048 | 1.392 | 1.760 | 1.940 | 3.578 | 4.487 | 4.952 | 6.007 | 6.579 | 6.939 | 6.943 | 6.964 | 1.648 | 1.201 | 0.730 | 0.205 | -0.422 | 0.833 | 0.218 | -0.841 | -0.841 |
| 11 | 11.867 | 9.238 | 6.411 | 1.555 | 0.450 | 0.386 | 0.107 | -0.020 | -0.354 | 0.063 | 0.116 | 0.406 | 1.147 | 1.460 | 1.806 | 1.981 | 3.603 | 4.504 | 4.970 | 6.021 | 6.592 | 6.953 | 6.958 | 6.979 | 1.665 | 1.200 | 0.727 | 0.222 | -0.353 | 0.863 | 0.267 | -0.510 | -0.510 |
| 12 | 11.941 | 11.078 | 8.940 | 3.313 | 1.339 | 0.922 | 0.629 | 0.496 | 0.142 | 0.898 | 0.980 | 1.750 | 3.162 | 3.652 | 4.090 | 4.319 | 5.401 | 6.002 | 6.413 | 7.072 | 7.369 | 7.610 | 7.611 | 7.481 | 3.574 | 2.576 | 1.616 | 0.669 | -0.312 | 2.284 | 1.294 | -0.077 | -0.077 |
| 13 | 18.960 | 16.965 | 14.460 | 7.761 | 4.231 | 2.890 | 2.056 | 1.676 | 0.701 | 1.860 | 1.979 | 2.685 | 4.954 | 5.988 | 6.573 | 6.872 | 7.604 | 8.011 | 8.310 | 8.252 | 8.277 | 8.922 | 8.968 | 8.983 | 5.716 | 4.150 | 2.641 | 1.166 | -0.305 | 6.701 | 5.145 | 0.364 | 0.364 |
| 14 | 17.187 | 15.081 | 12.673 | 6.488 | 3.644 | 2.552 | 1.896 | 1.598 | 1.166 | 2.319 | 2.415 | 2.835 | 5.377 | 6.048 | 6.487 | 6.772 | 7.923 | 8.563 | 8.956 | 9.203 | 9.313 | 9.772 | 9.807 | 9.829 | 5.848 | 4.384 | 2.852 | 1.266 | -0.335 | 5.677 | 4.330 | 0.719 | 0.719 |
| 15 | 15.678 | 13.092 | 10.377 | 4.801 | 2.290 | 1.514 | 1.246 | 1.124 | 1.013 | 1.623 | 1.713 | 2.486 | 4.826 | 5.487 | 6.004 | 6.324 | 7.735 | 8.519 | 8.961 | 9.450 | 9.577 | 9.910 | 9.983 | 9.966 | 5.412 | 4.003 | 2.552 | 1.071 | -0.395 | 3.736 | 2.644 | 0.916 | 0.916 |
| 16 | 12.716 | 11.373 | 8.778 | 3.571 | 1.427 | 1.023 | 0.997 | 0.984 | 0.944 | 1.183 | 1.231 | 2.299 | 4.464 | 5.149 | 5.711 | 6.046 | 7.542 | 8.373 | 8.837 | 9.473 | 9.607 | 9.891 | 9.909 | 9.947 | 5.175 | 3.824 | 2.419 | 0.968 | -0.478 | 2.684 | 1.841 | 0.921 | 0.921 |
| 17 | 13.335 | 10.706 | 8.069 | 2.864 | 0.917 | 0.660 | 0.732 | 0.765 | 0.765 | 0.965 | 1.015 | 2.075 | 4.187 | 4.874 | 5.450 | 5.786 | 7.330 | 8.188 | 8.684 | 9.392 | 9.533 | 9.805 | 9.820 | 9.864 | 4.953 | 3.661 | 2.304 | 0.877 | -0.569 | 2.034 | 1.321 | 0.743 | 0.743 |
| 18 | 12.996 | 10.299 | 7.720 | 2.593 | 0.734 | 0.366 | 0.411 | 0.431 | 0.429 | 0.673 | 0.717 | 1.846 | 3.985 | 4.679 | 5.266 | 5.601 | 7.178 | 8.055 | 8.565 | 9.286 | 9.432 | 9.700 | 9.714 | 9.754 | 4.797 | 3.551 | 2.230 | 0.817 | -0.655 | 1.798 | 1.102 | 0.426 | 0.426 |
| 19 | 12.621 | 10.410 | 8.052 | 2.872 | 0.822 | 0.324 | 0.128 | 0.038 | 0.050 | 0.599 | 0.676 | 1.963 | 4.065 | 4.792 | 5.385 | 5.714 | 7.224 | 8.062 | 8.555 | 9.225 | 9.368 | 9.640 | 9.654 | 9.684 | 4.880 | 3.614 | 2.276 | 0.829 | -0.721 | 1.994 | 1.223 | 0.035 | 0.039 |
| 20 | 12.544 | 10.021 | 7.548 | 2.581 | 0.692 | 0.216 | -0.109 | -0.257 | -0.309 | 0.424 | 0.519 | 1.925 | 4.042 | 4.708 | 5.262 | 5.581 | 7.100 | 7.943 | 8.454 | 9.164 | 9.310 | 9.572 | 9.585 | 9.621 | 4.805 | 3.586 | 2.278 | 0.837 | -0.757 | 1.804 | 1.115 | -0.347 | -0.347 |
| 21 | 12.703 | 10.032 | 7.455 | 2.360 | 0.503 | 0.087 | -0.254 | -0.409 | -0.589 | 0.287 | 0.383 | 1.732 | 3.851 | 4.525 | 5.091 | 5.408 | 6.955 | 7.815 | 8.330 | 9.061 | 9.217 | 9.493 | 9.507 | 9.556 | 4.646 | 3.467 | 2.210 | 0.818 | -0.767 | 1.559 | 0.872 | -0.668 | -0.668 |
| 22 | 12.129 | 10.365 | 7.570 | 2.348 | 0.483 | 0.086 | -0.284 | -0.452 | -0.762 | 0.164 | 0.248 | 1.530 | 3.667 | 4.331 | 4.893 | 5.206 | 6.797 | 7.680 | 8.207 | 8.972 | 9.136 | 9.415 | 9.428 | 9.474 | 4.483 | 3.354 | 2.150 | 0.815 | -0.721 | 1.554 | 0.865 | -0.883 | -0.883 |
| 23 | 13.562 | 10.768 | 7.875 | 2.614 | 0.538 | 0.118 | -0.245 | -0.410 | -0.805 | 0.080 | 0.157 | 1.313 | 3.448 | 4.129 | 4.709 | 5.030 | 6.677 | 7.592 | 8.124 | 8.862 | 9.027 | 9.294 | 9.306 | 9.350 | 4.320 | 3.228 | 2.075 | 0.808 | -0.654 | 1.770 | 1.019 | -0.967 | -0.967 |
| 24 | 13.418 | 10.747 | 7.884 | 2.650 | 0.589 | 0.160 | -0.177 | -0.330 | -0.712 | 0.130 | 0.199 | 1.281 | 3.348 | 4.020 | 4.588 | 4.904 | 6.560 | 7.480 | 8.015 | 8.748 | 8.916 | 9.179 | 9.190 | 9.233 | 4.209 | 3.141 | 2.016 | 0.817 | -0.567 | 1.819 | 1.039 | -0.921 | -0.921 |
| 25 | 13.326 | 10.760 | 8.028 | 2.815 | 0.708 | 0.297 | -0.006 | -0.144 | -0.529 | 0.268 | 0.355 | 1.320 | 3.276 | 3.932 | 4.485 | 4.792 | 6.444 | 7.361 | 7.895 | 8.643 | 8.824 | 9.117 | 9.131 | 9.195 | 4.102 | 3.051 | 1.968 | 0.816 | -0.474 | 1.935 | 1.085 | -0.754 | -0.754 |

**REMARKS:**

| STATION | LIBMANAN | CUYAPI | NAGA | OMBAO | STO. DOMINGO | LAKE BATO |
|---|---|---|---|---|---|---|
| PEAK STAGE M.MSL | 3.245 | 2.942 | 2.993 | 8.024 | 9.968 | 9.968 |
| TIME | 13-11-30 | 13-11-0 | 13-14-0 | 13-15-30 | 15-12-0 | 15-12-0 |

## TABLE 5.4. DAILY WATER LEVELS ALONG BICOL - SIPOCOT RIVERS IN METERS ABOVE MSL.

### RETURN PERIOD OF DESIGN FLOOD 13 YEARS

### FLOOD PROTECTION SCHEME : ③ TIDAL BARRIER

| RIVER | SIPOCOT RIVER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOWN | SABANG | | | | LIBMANAN | | | CUYAPI | | | NAGA | | | | OMBAO | | | | | STO. DOMINGO | | | | | | LAKE BATO | | | PASACAO | | BARCELONA | | BOLONGAY | |
| DATE \ NODE NO. | 1 | 2 | 3 | 4 | 5 | 6 | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 5 | 11.802 | 9.498 | 5.751 | 2.109 | 0.319 | 0.153 | 0.121 | 0.106 | 0.097 | 0.126 | 0.131 | 0.254 | 1.104 | 1.446 | 1.811 | 1.990 | 3.611 | 4.512 | 4.976 | 5.969 | 6.532 | 6.876 | 6.880 | 6.895 | 1.601 | 1.018 | 0.436 | -0.148 | -0.733 | 1.438 | 0.756 | 0.085 | 0.095 |
| 6 | 11.729 | 9.353 | 6.037 | 2.257 | 0.163 | -0.280 | -0.540 | -0.659 | -0.670 | -0.663 | -0.663 | -0.425 | 0.910 | 1.265 | 1.641 | 1.819 | 3.479 | 4.401 | 4.860 | 5.874 | 6.552 | 6.862 | 6.866 | 6.881 | 1.543 | 1.096 | 0.592 | -0.004 | -0.718 | 1.336 | 0.458 | -0.336 | -0.587 |
| 7 | 11.701 | 9.114 | 6.106 | 2.491 | 0.304 | -0.148 | -0.519 | -0.688 | -0.785 | -0.703 | -0.704 | -0.402 | 0.867 | 1.224 | 1.602 | 1.782 | 3.464 | 4.399 | 4.855 | 5.882 | 6.564 | 6.879 | 6.883 | 6.900 | 1.515 | 1.089 | 0.609 | 0.037 | -0.668 | 1.411 | 0.336 | -0.711 | -0.611 |
| 8 | 11.728 | 9.089 | 5.962 | 2.477 | 0.245 | -0.168 | -0.479 | -0.620 | -0.867 | -0.597 | -0.578 | -0.803 | 0.875 | 1.234 | 1.616 | 1.799 | 3.485 | 4.422 | 4.876 | 5.909 | 6.588 | 6.903 | 6.907 | 6.924 | 1.532 | 1.112 | 0.646 | 0.095 | -0.595 | 1.376 | 0.239 | -0.950 | -1.095 |
| 9 | 11.726 | 9.239 | 6.013 | 2.517 | 0.198 | -0.189 | -0.481 | -0.613 | -0.993 | -0.488 | -0.451 | -0.144 | 0.927 | 1.289 | 1.677 | 1.864 | 3.551 | 4.488 | 4.944 | 5.988 | 6.562 | 6.921 | 6.926 | 6.946 | 1.587 | 1.159 | 0.694 | 0.157 | -0.508 | 1.430 | 0.280 | -0.998 | -1.185 |
| 10 | 11.736 | 9.283 | 5.838 | 2.492 | 0.157 | -0.234 | -0.367 | -0.427 | -0.515 | -0.337 | -0.303 | -0.118 | 0.948 | 1.309 | 1.700 | 1.898 | 3.570 | 4.505 | 4.961 | 6.011 | 6.592 | 6.942 | 6.946 | 6.967 | 1.605 | 1.172 | 0.712 | 0.196 | -0.422 | 1.502 | 0.424 | -0.841 | -0.629 |
| 11 | 11.756 | 9.525 | 5.883 | 2.503 | 0.103 | -0.356 | -0.390 | -0.406 | -0.420 | -0.392 | -0.389 | -0.241 | 0.958 | 1.322 | 1.716 | 1.906 | 3.598 | 4.522 | 4.980 | 6.025 | 6.595 | 6.956 | 6.960 | 6.982 | 1.612 | 1.167 | 0.707 | 0.213 | -0.353 | 1.621 | 0.656 | -0.510 | -0.298 |
| 12 | 11.952 | 11.203 | 8.434 | 4.673 | 1.669 | 0.923 | 0.695 | 0.591 | 0.455 | 0.897 | 0.974 | 1.686 | 3.141 | 3.638 | 4.080 | 4.310 | 5.387 | 6.001 | 6.412 | 7.072 | 7.370 | 7.612 | 7.613 | 7.484 | 3.567 | 2.570 | 1.613 | 0.667 | -0.312 | 3.174 | 1.647 | -0.077 | 0.239 |
| 13 | 18.952 | 16.936 | 14.216 | 10.803 | 5.858 | 3.956 | 2.857 | 2.358 | 1.203 | 1.886 | 2.003 | 2.684 | 4.953 | 5.988 | 6.573 | 6.872 | 7.604 | 8.011 | 8.310 | 8.253 | 8.278 | 8.923 | 8.969 | 8.985 | 5.716 | 4.150 | 2.641 | 1.166 | -0.305 | 7.265 | 3.870 | 0.364 | 0.828 |
| 14 | 17.140 | 15.026 | 12.628 | 9.245 | 5.147 | 3.580 | 2.606 | 2.164 | 1.453 | 2.032 | 2.168 | 2.733 | 5.379 | 6.049 | 6.487 | 6.771 | 7.921 | 8.560 | 8.955 | 9.202 | 9.313 | 9.774 | 9.810 | 9.831 | 5.849 | 4.370 | 2.830 | 1.248 | -0.335 | 6.535 | 3.707 | 0.719 | 1.194 |
| 15 | 15.578 | 13.087 | 10.047 | 6.690 | 3.396 | 2.229 | 1.684 | 1.437 | 1.191 | 1.586 | 1.654 | 2.482 | 4.825 | 5.486 | 6.004 | 6.324 | 7.735 | 8.519 | 8.961 | 9.451 | 9.578 | 9.912 | 9.934 | 9.968 | 5.412 | 4.003 | 2.582 | 1.071 | -0.395 | 4.790 | 2.870 | 0.916 | 1.063 |
| 16 | 12.710 | 11.443 | 8.322 | 5.088 | 2.246 | 1.256 | 0.985 | 0.716 | 0.595 | 0.942 | 1.000 | 2.297 | 4.465 | 5.149 | 5.711 | 6.047 | 7.543 | 8.374 | 8.838 | 9.475 | 9.608 | 9.892 | 9.910 | 9.948 | 5.176 | 3.824 | 2.420 | 0.968 | -0.478 | 3.680 | 2.283 | 0.921 | 0.805 |
| 17 | 12.291 | 10.875 | 7.541 | 4.125 | 1.488 | 0.694 | 0.364 | 0.214 | 0.351 | 0.639 | 0.709 | 2.060 | 4.187 | 4.875 | 5.451 | 5.787 | 7.332 | 8.189 | 8.685 | 9.383 | 9.524 | 9.806 | 9.822 | 9.865 | 4.954 | 3.661 | 2.204 | 0.877 | -0.569 | 2.934 | 1.796 | 0.743 | 0.204 |
| 18 | 12.942 | 10.492 | 7.178 | 3.798 | 1.234 | 0.519 | 0.325 | 0.238 | 0.364 | 0.548 | 0.588 | 1.827 | 3.983 | 4.679 | 5.266 | 5.601 | 7.179 | 8.056 | 8.566 | 9.288 | 9.433 | 9.701 | 9.715 | 9.756 | 4.797 | 3.551 | 2.230 | 0.817 | -0.655 | 2.608 | 1.468 | 0.426 | 0.174 |
| 19 | 12.577 | 10.591 | 7.533 | 4.112 | 1.367 | 0.601 | 0.219 | 0.046 | -0.050 | 0.583 | 0.668 | 1.966 | 4.066 | 4.793 | 5.385 | 5.715 | 7.225 | 8.063 | 8.556 | 9.226 | 9.369 | 9.641 | 9.655 | 9.685 | 4.881 | 3.614 | 2.276 | 0.829 | -0.721 | 2.674 | 1.303 | 0.039 | -0.006 |
| 20 | 12.495 | 10.190 | 7.019 | 3.801 | 1.256 | 0.508 | 0.014 | -0.210 | -0.249 | 0.423 | 0.497 | 1.927 | 4.042 | 4.709 | 5.263 | 5.582 | 7.101 | 7.944 | 8.455 | 9.165 | 9.311 | 9.573 | 9.586 | 9.622 | 4.806 | 3.587 | 2.279 | 0.837 | -0.757 | 2.403 | 1.006 | -0.347 | 0.084 |
| 21 | 12.634 | 10.141 | 6.897 | 3.490 | 0.936 | 0.279 | -0.170 | -0.375 | -0.721 | 0.303 | 0.395 | 1.744 | 3.851 | 4.526 | 5.092 | 5.409 | 6.956 | 7.816 | 8.331 | 9.062 | 9.218 | 9.494 | 9.508 | 9.557 | 4.646 | 3.468 | 2.210 | 0.818 | -0.757 | 2.110 | 0.722 | -0.668 | -0.589 |
| 22 | 13.074 | 10.565 | 7.009 | 3.465 | 0.954 | 0.323 | -0.106 | -0.302 | -0.731 | 0.202 | 0.296 | 1.543 | 3.668 | 4.331 | 4.894 | 5.207 | 6.797 | 7.681 | 8.208 | 8.973 | 9.137 | 9.416 | 9.429 | 9.475 | 4.483 | 3.355 | 2.151 | 0.815 | -0.721 | 2.084 | 0.637 | -0.883 | -0.770 |
| 23 | 13.498 | 10.983 | 7.330 | 3.812 | 1.042 | 0.365 | -0.059 | -0.252 | -0.615 | 0.141 | 0.201 | 1.335 | 3.449 | 4.130 | 4.710 | 5.031 | 6.678 | 7.593 | 8.125 | 8.862 | 9.027 | 9.295 | 9.307 | 9.350 | 4.321 | 3.228 | 2.075 | 0.808 | -0.654 | 2.307 | 0.738 | -0.967 | -0.290 |
| 24 | 13.364 | 10.948 | 7.341 | 3.885 | 1.133 | 0.460 | 0.050 | -0.126 | -0.381 | 0.234 | 0.302 | 1.314 | 3.348 | 4.019 | 4.588 | 4.904 | 6.560 | 7.481 | 8.016 | 8.749 | 8.917 | 9.180 | 9.191 | 9.234 | 4.208 | 3.141 | 2.026 | 0.817 | -0.567 | 2.414 | 0.845 | -0.921 | -0.189 |
| 25 | 13.275 | 10.951 | 7.500 | 4.072 | 1.216 | 0.539 | 0.152 | -0.024 | -0.434 | 0.219 | 0.404 | 1.337 | 3.275 | 3.930 | 4.484 | 4.791 | 6.444 | 7.362 | 7.896 | 8.643 | 8.825 | 9.118 | 9.132 | 9.196 | 4.101 | 3.050 | 1.968 | 0.816 | -0.474 | 2.589 | 1.032 | -0.756 | -0.532 |

**REMARKS:**

| STATION | LIBMANAN | CUYAPI | NAGA | OMBAO | STO. DOMINGO | LAKE BATO |
|---|---|---|---|---|---|---|
| PEAK STAGE M.MSL | 3.629 | 2.570 | 2.805 | 8.023 | 9.969 | 9.969 |
| TIME | 13 - 13 - 0 | 13 - 13 - 0 | 13 - 16 - 0 | 13 - 15 - 0 | 15 - 12 - 0 | 15 - 12 - 0 |

TABLE 5.5. DAILY WATER LEVELS ALONG BICOL - SIPOCOT RIVERS IN METERS ABOVE MSL.

RETURN PERIOD OF DESIGN FLOOD 13 YEARS

FLOOD PROTECTION SCHEME : ④ CUTOFF NO. 3

| RIVER | SIPOCOT RIVER | | | | | | | BICOL RIVER | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOWN | SABANG | | | | LIBMANAN | | | CUYAPI | | | NAGA | | | | | OMBAO | |
| DATE \ NODE NO. | 1 | 2 | 3 | 4 | 5 | 6 | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | |
| 5 | 11.802 | 9.498 | 5.751 | 2.109 | 0.319 | 0.153 | 0.121 | 0.106 | 0.097 | 0.126 | 0.131 | 0.157 | 0.416 | 1.280 | 1.704 | 1.901 | 3.599 |
| 6 | 11.730 | 9.351 | 6.068 | 2.210 | 0.350 | -0.055 | -0.301 | -0.413 | -0.357 | -0.463 | -0.476 | -0.473 | 0.060 | 1.105 | 1.545 | 1.740 | 3.466 |
| 7 | 11.706 | 9.101 | 6.135 | 2.443 | 0.386 | -0.061 | -0.424 | -0.589 | -0.724 | -0.589 | -0.576 | -0.502 | 0.051 | 1.079 | 1.518 | 1.711 | 3.451 |
| 8 | 11.734 | 9.076 | 5.986 | 2.420 | 0.385 | -0.037 | -0.419 | -0.592 | -0.900 | -0.544 | -0.521 | -0.406 | 0.111 | 1.103 | 1.544 | 1.740 | 3.474 |
| 9 | 11.733 | 9.224 | 6.042 | 2.446 | 0.458 | 0.085 | -0.294 | -0.467 | -0.885 | -0.377 | -0.348 | -0.219 | 0.243 | 1.185 | 1.625 | 1.825 | 3.544 |
| 10 | 11.744 | 9.264 | 5.871 | 2.415 | 0.453 | 0.162 | -0.149 | -0.290 | -0.681 | -0.149 | -0.094 | 0.023 | 0.380 | 1.213 | 1.644 | 1.841 | 3.561 |
| 11 | 11.745 | 9.504 | 5.921 | 2.414 | 0.706 | 0.411 | 0.121 | -0.010 | -0.342 | 0.264 | 0.235 | 0.350 | 0.327 | 1.217 | 1.669 | 1.873 | 3.583 |
| 12 | 11.950 | 11.191 | 8.460 | 4.634 | 1.787 | 1.054 | 0.679 | 0.509 | 0.152 | 0.960 | 1.052 | 1.407 | 2.082 | 3.173 | 3.755 | 4.040 | 5.292 |
| 13 | 18.952 | 16.936 | 14.516 | 10.805 | 5.851 | 3.931 | 2.772 | 2.245 | 0.836 | 2.071 | 2.187 | 2.532 | 3.920 | 5.612 | 6.341 | 6.683 | 7.515 |
| 14 | 17.198 | 15.074 | 12.680 | 9.299 | 5.170 | 3.583 | 2.582 | 2.127 | 1.326 | 2.430 | 2.527 | 2.738 | 3.988 | 5.287 | 5.962 | 6.332 | 7.730 |
| 15 | 15.578 | 13.086 | 10.048 | 6.692 | 3.393 | 2.205 | 1.597 | 1.320 | 1.018 | 1.556 | 1.637 | 1.914 | 2.935 | 4.503 | 5.355 | 5.786 | 7.517 |
| 16 | 13.710 | 11.443 | 8.322 | 5.089 | 2.272 | 1.382 | 1.125 | 1.008 | 0.958 | 1.132 | 1.171 | 1.374 | 2.528 | 4.212 | 5.118 | 5.560 | 7.354 |
| 17 | 13.291 | 10.875 | 7.541 | 4.126 | 1.513 | 0.869 | 0.829 | 0.811 | 0.766 | 0.877 | 0.904 | 1.096 | 2.326 | 4.000 | 4.902 | 5.338 | 7.164 |
| 18 | 12.942 | 10.492 | 7.181 | 3.788 | 1.257 | 0.596 | 0.491 | 0.443 | 0.422 | 0.588 | 0.620 | 0.884 | 2.200 | 3.865 | 4.753 | 5.184 | 7.029 |
| 19 | 12.577 | 10.590 | 7.533 | 4.114 | 1.358 | 0.591 | 0.247 | 0.090 | 0.058 | 0.647 | 0.728 | 1.186 | 2.463 | 4.089 | 4.950 | 5.360 | 7.095 |
| 20 | 12.495 | 10.190 | 7.019 | 3.798 | 1.261 | 0.519 | 0.053 | -0.158 | -0.309 | 0.353 | 0.439 | 0.851 | 2.215 | 3.859 | 4.718 | 5.137 | 6.938 |
| 21 | 12.635 | 10.241 | 6.899 | 3.484 | 0.953 | 0.306 | -0.137 | -0.338 | -0.586 | 0.266 | 0.358 | 0.795 | 2.115 | 3.730 | 4.578 | 4.990 | 6.809 |
| 22 | 13.075 | 10.564 | 7.009 | 3.486 | 0.936 | 0.297 | -0.169 | -0.380 | -0.759 | 0.140 | 0.219 | 0.610 | 1.897 | 3.494 | 4.347 | 4.763 | 6.647 |
| 23 | 13.498 | 10.983 | 7.332 | 3.807 | 1.046 | 0.354 | -0.110 | -0.321 | -0.791 | 0.113 | 0.192 | 0.563 | 1.804 | 3.380 | 4.228 | 4.643 | 6.553 |
| 24 | 13.365 | 10.947 | 7.346 | 3.871 | 1.150 | 0.460 | -0.003 | -0.213 | -0.705 | 0.165 | 0.240 | 0.606 | 1.751 | 3.284 | 4.116 | 4.525 | 6.441 |
| 25 | 13.275 | 10.950 | 7.503 | 4.062 | 1.243 | 0.589 | +0.137 | -0.054 | -0.520 | 0.300 | 0.396 | 0.725 | 1.750 | 3.220 | 4.027 | 4.427 | 6.329 |

| RIVER | BICOL RIVER | | | | | | | BICOL-RAGAY DIVERSION | | | | | SIPOCOT-SAN MIGUEL DIVERSION | | | SAN MIGUEL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOWN | | | STO. DOMINGO | | | | LAKE BATO | | | | PASACAO | | BARCELONA | | | BOLONGAY |
| DATE \ NODE NO. | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 5 | 4.542 | 4.991 | 5.972 | 6.533 | 6.877 | 6.881 | 6.895 | 1.525 | 0.961 | 0.398 | -0.167 | -0.733 | 1.438 | 0.766 | 0.095 | 0.095 |
| 6 | 4.425 | 4.871 | 5.876 | 6.552 | 6.863 | 6.866 | 6.881 | 1.479 | 1.050 | 0.561 | -0.020 | -0.718 | 1.306 | 0.444 | -0.336 | -0.336 |
| 7 | 4.418 | 4.864 | 5.884 | 6.564 | 6.879 | 6.883 | 6.900 | 1.461 | 1.051 | 0.585 | 0.026 | -0.669 | 1.378 | 0.319 | -0.711 | -0.711 |
| 8 | 4.438 | 4.884 | 5.910 | 6.589 | 6.904 | 0.908 | 6.925 | 1.489 | 1.083 | 0.627 | 0.085 | -0.595 | 1.337 | 0.219 | -0.950 | -0.950 |
| 9 | 4.500 | 4.950 | 5.990 | 6.564 | 6.923 | 0.927 | 6.948 | 1.559 | 1.138 | 0.680 | 0.149 | -0.508 | 1.382 | 0.255 | -0.998 | -0.998 |
| 10 | 4.517 | 4.968 | 6.013 | 6.584 | 6.942 | 6.946 | 6.968 | 1.570 | 1.148 | 0.695 | 0.187 | -0.442 | 1.450 | 0.397 | -0.841 | -0.841 |
| 11 | 4.533 | 4.985 | 6.026 | 6.599 | 6.963 | 6.967 | 6.982 | 1.590 | 1.146 | 0.690 | 0.203 | -0.353 | 1.562 | 0.686 | -0.510 | -0.510 |
| 12 | 5.988 | 6.405 | 7.073 | 7.372 | 7.616 | 7.617 | 7.490 | 3.327 | 2.385 | 1.487 | 0.603 | -0.312 | 3.145 | 1.631 | -0.077 | -0.077 |
| 13 | 7.977 | 8.295 | 8.244 | 8.274 | 8.931 | 8.978 | 8.993 | 5.555 | 4.029 | 2.561 | 1.125 | -0.305 | 7.265 | 3.870 | 0.364 | 0.364 |
| 14 | 8.506 | 8.929 | 9.190 | 9.305 | 9.776 | 9.812 | 9.834 | 5.476 | 4.109 | 2.670 | 1.176 | -0.335 | 6.575 | 3.730 | 0.719 | 0.719 |
| 15 | 8.479 | 8.937 | 9.439 | 9.569 | 9.909 | 9.932 | 9.966 | 4.947 | 3.649 | 2.313 | 0.951 | -0.395 | 4.792 | 2.871 | 0.916 | 0.916 |
| 16 | 8.3-1 | 8.822 | 9.466 | 9.601 | 9.888 | 9.906 | 9.944 | 4.752 | 3.501 | 2.200 | 0.857 | -0.478 | 3.680 | 2.283 | 0.921 | 0.921 |
| 17 | 8.179 | 8.677 | 9.387 | 9.528 | 9.801 | 9.817 | 9.860 | 4.564 | 3.363 | 2.102 | 0.774 | -0.569 | 2.934 | 1.796 | 0.743 | 0.743 |
| 18 | 8.054 | 8.562 | 9.282 | 9.428 | 9.696 | 9.711 | 9.751 | 4.436 | 3.275 | 2.042 | 0.721 | -0.655 | 2.601 | 1.464 | 0.426 | 0.426 |
| 19 | 8.059 | 8.653 | 9.222 | 9.365 | 9.637 | 9.651 | 9.681 | 4.573 | 3.379 | 2.116 | 0.747 | -0.721 | 2.676 | 1.504 | 0.039 | 0.039 |
| 20 | 7.939 | 8.449 | 9.161 | 9.307 | 9.569 | 9.582 | 9.618 | 4.427 | 3.302 | 2.086 | 0.739 | -0.757 | 2.401 | 1.005 | -0.347 | -0.347 |
| 21 | 7.820 | 8.331 | 9.059 | 9.214 | 9.490 | 9.504 | 9.553 | 4.284 | 3.191 | 2.041 | 0.720 | -0.757 | 2.106 | 0.721 | -0.668 | -0.668 |
| 22 | 7.693 | 8.211 | 8.970 | 9.134 | 9.412 | 9.425 | 9.471 | 4.103 | 3.066 | 1.955 | 0.714 | -0.721 | 2.085 | 0.638 | -0.883 | -0.883 |
| 23 | 7.613 | 8.134 | 8.862 | 9.025 | 9.292 | 9.303 | 9.347 | 3.987 | 2.974 | 1.902 | 0.719 | -0.654 | 2.304 | 0.736 | -0.967 | -0.967 |
| 24 | 7.505 | 8.027 | 8.749 | 8.916 | 9.177 | 9.188 | 9.231 | 3.885 | 2.896 | 1.861 | 0.732 | -0.567 | 2.404 | 0.840 | -0.921 | -0.921 |
| 25 | 7.387 | 7.908 | 8.646 | 8.825 | 9.116 | 9.130 | 9.193 | 3.788 | 2.813 | 1.807 | 0.734 | -0.474 | 2.592 | 1.028 | -0.756 | -0.756 |

REMARKS:

| STATION | LIBMANAN | CUYAPI | NAGA | OMBAO | STO. DOMINGO | LAKE BATO |
|---|---|---|---|---|---|---|
| PEAK STAGE M.MSL | 3.781 | 2.912 | 3.161 | 7.874 | 9.966 | 9.966 |
| TIME | 13-11-0 | 13-10-0 | 13-14-0 | 13-13-30 | 15-0-0 | 15-0-0 |

## TABLE 5.6. DAILY WATER LEVELS ALONG BICOL - SIPOCOT RIVERS IN METERS ABOVE MSL.

### RETURN PERIOD OF DESIGN FLOOD 13 YEARS

### FLOOD PROTECTION SCHEME : ⑤ BICOL - RAGAY DIVERSION

| RIVER | SIPOCOT RIVER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOWN | SABANG | | | | LIBMANAN | | | CUYAPI | | | | NAGA | | | | | OMBAO | | | | | STO. DOMINGO | | | | | LAKE BATO | | | PASACAO | | | BARCELONA | | | BOLONGAY |
| DATE \ NODE NO | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 5 | 11.802 | 9.498 | 5.751 | 2.109 | 0.518 | 0.152 | 0.119 | 0.105 | 0.096 | 0.105 | 0.107 | 0.146 | 0.513 | 0.774 | 0.963 | 1.115 | 3.539 | 4.885 | 5.187 | 6.010 | 6.542 | 6.879 | 6.983 | 6.897 | 0.362 | -0.062 | -0.506 | -0.668 | -0.733 | 1.438 | 0.766 | 0.095 | 0.095 |
| 6 | 11.730 | 9.351 | 6.067 | 2.210 | 0.350 | -0.058 | -0.303 | -0.414 | -0.353 | -0.489 | -0.509 | -0.499 | 0.419 | 0.753 | 0.958 | 1.097 | 3.388 | 4.661 | 4.992 | 5.806 | 6.593 | 6.853 | 6.856 | 6.880 | 0.564 | 0.222 | -0.234 | -0.517 | -0.718 | 1.306 | 0.444 | -0.336 | -0.336 |
| 7 | 11.706 | 9.101 | 6.135 | 2.443 | 0.381 | -0.069 | -0.433 | -0.598 | -0.732 | -0.710 | -0.710 | -0.574 | 0.347 | 0.688 | 0.904 | 1.056 | 3.388 | 4.683 | 5.005 | 5.900 | 6.561 | 6.872 | 6.876 | 6.899 | 0.523 | 0.210 | -0.204 | -0.466 | -0.699 | 1.378 | 0.320 | -0.711 | -0.711 |
| 8 | 11.724 | 9.076 | 5.986 | 2.420 | 0.386 | -0.057 | -0.425 | -0.601 | -0.916 | -0.691 | -0.681 | -0.486 | 0.377 | 0.721 | 0.946 | 1.110 | 3.466 | 4.775 | 5.092 | 5.891 | 6.544 | 6.893 | 6.897 | 6.921 | 0.558 | 0.246 | -0.150 | -0.395 | -0.595 | 1.337 | 0.219 | -0.950 | -0.950 |
| 9 | 11.733 | 9.224 | 6.043 | 2.446 | 0.456 | 0.079 | -0.302 | -0.475 | -0.910 | -0.542 | -0.521 | -0.312 | 0.426 | 0.745 | 0.959 | 1.120 | 3.486 | 4.801 | 5.116 | 6.012 | 6.563 | 6.914 | 6.918 | 6.941 | 0.565 | 0.248 | -0.115 | -0.931 | -0.508 | 1.382 | 0.255 | -0.998 | -0.998 |
| 10 | 11.744 | 9.265 | 5.871 | 2.416 | 0.449 | 0.164 | -0.162 | -0.311 | -0.694 | -0.250 | -0.267 | -0.054 | 0.543 | 0.815 | 1.003 | 1.152 | 3.513 | 4.824 | 5.139 | 6.038 | 6.587 | 6.937 | 6.942 | 6.964 | 0.555 | 0.246 | -0.091 | -0.277 | -0.422 | 1.451 | 0.397 | -0.841 | -0.841 |
| 11 | 11.745 | 9.505 | 5.920 | 2.416 | 0.706 | 0.403 | 0.110 | -0.023 | -0.365 | 0.030 | 0.066 | 0.255 | 0.697 | 0.907 | 1.060 | 1.190 | 3.537 | 4.842 | 5.158 | 6.056 | 6.603 | 6.956 | 6.961 | 6.979 | 0.545 | 0.228 | -0.087 | -0.242 | -0.353 | 1.564 | 0.626 | -0.510 | -0.510 |
| 12 | 11.950 | 11.192 | 8.460 | 4.634 | 1.790 | 1.066 | 0.682 | 0.507 | 0.132 | 0.788 | 0.859 | 1.459 | 2.563 | 2.864 | 3.051 | 3.149 | 5.024 | 6.065 | 6.457 | 7.091 | 7.382 | 7.629 | 7.630 | 7.482 | 2.099 | 1.402 | 0.499 | -0.005 | -0.312 | 3.145 | 1.632 | -0.077 | -0.077 |
| 13 | 18.962 | 16.936 | 14.316 | 10.803 | 5.850 | 3.925 | 2.752 | 2.219 | 0.741 | 1.804 | 1.920 | 2.606 | 4.580 | 5.923 | 5.609 | 5.728 | 7.142 | 7.928 | 8.302 | 8.269 | 8.299 | 8.957 | 8.982 | 8.973 | 4.453 | 3.501 | 2.044 | 0.849 | -0.305 | 7.265 | 3.870 | 0.364 | 0.364 |
| 14 | 17.140 | 15.026 | 12.628 | 9.245 | 5.136 | 3.538 | 2.464 | 1.961 | 0.944 | 1.723 | 1.821 | 2.517 | 4.566 | 4.896 | 5.119 | 5.249 | 7.334 | 8.492 | 8.928 | 9.206 | 9.329 | 9.773 | 9.807 | 9.832 | 4.177 | 3.318 | 1.964 | 0.826 | -0.335 | 6.535 | 3.708 | 0.719 | 0.719 |
| 15 | 15.578 | 13.086 | 10.047 | 6.690 | 3.386 | 2.191 | 1.573 | 1.292 | 0.883 | 1.186 | 1.222 | 1.788 | 3.447 | 3.948 | 4.332 | 4.553 | 7.133 | 8.567 | 8.979 | 9.456 | 9.592 | 9.915 | 9.937 | 9.970 | 3.487 | 2.676 | 1.419 | 0.434 | -0.395 | 4.790 | 2.870 | 0.916 | 0.916 |
| 16 | 13.710 | 11.443 | 8.322 | 5.089 | 2.271 | 1.383 | 1.138 | 1.027 | 0.988 | 1.133 | 1.166 | 1.454 | 2.931 | 3.496 | 3.964 | 4.232 | 6.968 | 8.487 | 8.891 | 9.487 | 9.627 | 9.900 | 9.917 | 9.954 | 3.190 | 2.401 | 1.186 | 0.258 | -0.478 | 3.680 | 2.283 | 0.921 | 0.921 |
| 17 | 13.281 | 10.875 | 7.541 | 4.126 | 1.510 | 0.866 | 0.827 | 0.809 | 0.772 | 0.842 | 0.865 | 1.134 | 2.716 | 3.281 | 3.756 | 4.030 | 6.804 | 8.345 | 8.759 | 9.410 | 9.557 | 9.817 | 9.832 | 9.874 | 2.999 | 2.226 | 1.040 | 0.139 | -0.569 | 2.955 | 1.796 | 0.743 | 0.743 |
| 18 | 12.942 | 10.492 | 7.181 | 3.710 | 1.249 | 0.586 | 0.495 | 0.454 | 0.423 | 0.421 | 0.416 | 0.859 | 2.581 | 3.142 | 3.616 | 3.890 | 6.683 | 8.234 | 8.657 | 9.310 | 9.460 | 9.715 | 9.729 | 9.768 | 2.871 | 2.111 | 0.945 | 0.059 | -0.655 | 2.603 | 1.465 | 0.426 | 0.426 |
| 19 | 12.577 | 10.590 | 7.532 | 4.115 | 1.353 | 0.578 | 0.225 | -0.065 | 0.038 | 0.243 | 0.286 | 1.182 | 2.955 | 3.485 | 3.902 | 4.133 | 6.762 | 8.222 | 8.648 | 9.258 | 9.402 | 9.659 | 9.673 | 9.701 | 3.070 | 2.279 | 1.064 | 0.115 | -0.721 | 2.676 | 1.304 | 0.039 | 0.039 |
| 20 | 12.495 | 10.190 | 7.019 | 3.799 | 1.256 | 0.506 | 0.029 | -0.188 | -0.347 | -0.083 | -0.053 | 0.795 | 2.652 | 3.201 | 3.635 | 3.887 | 6.602 | 8.110 | 8.545 | 9.196 | 9.346 | 9.593 | 9.606 | 9.642 | 2.888 | 2.135 | 0.973 | 0.063 | -0.757 | 2.402 | 1.005 | -0.347 | -0.347 |
| 21 | 12.635 | 10.241 | 6.898 | 3.486 | 0.947 | 0.292 | -0.164 | -0.371 | -0.638 | -0.176 | -0.132 | 0.735 | 2.533 | 3.068 | 3.504 | 3.756 | 6.495 | 8.017 | 8.444 | 9.099 | 9.255 | 9.518 | 9.532 | 9.579 | 2.750 | 2.007 | 0.877 | 0.013 | -0.757 | 2.107 | 0.721 | -0.668 | -0.668 |
| 22 | 13.075 | 10.565 | 7.009 | 3.488 | 0.931 | 0.285 | -0.194 | -0.411 | -0.907 | -0.286 | -0.239 | 0.524 | 2.273 | 2.812 | 3.270 | 3.539 | 6.352 | 7.915 | 8.339 | 9.016 | 9.179 | 9.442 | 9.455 | 9.500 | 2.569 | 1.857 | 0.785 | -0.016 | -0.721 | 2.085 | 0.638 | -0.883 | -0.883 |
| 23 | 13.498 | 10.883 | 7.332 | 3.800 | 1.041 | 0.346 | -0.130 | -0.346 | -0.844 | -0.262 | -0.216 | 0.482 | 2.158 | 2.695 | 3.157 | 3.432 | 6.276 | 7.856 | 8.275 | 8.913 | 9.075 | 9.325 | 9.336 | 9.378 | 2.464 | 1.764 | 0.731 | -0.017 | -0.654 | 2.305 | 0.757 | -0.967 | -0.967 |
| 24 | 13.964 | 10.947 | 7.346 | 3.871 | 1.150 | 0.457 | -0.018 | -0.234 | -0.760 | -0.169 | -0.128 | 0.523 | 2.090 | 2.614 | 3.066 | 3.335 | 6.181 | 7.763 | 8.177 | 8.806 | 8.969 | 9.213 | 9.224 | 9.266 | 2.382 | 1.696 | 0.700 | 0.003 | -0.567 | 2.404 | 0.899 | -0.921 | -0.921 |
| 25 | 13.275 | 10.949 | 7.504 | 4.060 | 1.245 | 0.559 | +0.126 | -0.071 | -0.561 | 0.037 | 0.100 | 0.737 | 2.281 | 2.835 | 3.337 | 3.618 | 5.990 | 7.307 | 7.975 | 8.699 | 8.880 | 9.157 | 9.172 | 9.228 | 2.587 | 1.855 | 0.816 | 0.096 | -0.474 | 2.590 | 1.027 | -0.756 | -0.756 |

**REMARKS :**

| STATION | LIBMANAN | CUYAPI | NAGA | OMBAO | STO. DOMINGO | LAKE BATO |
|---|---|---|---|---|---|---|
| PEAK STAGE M.MSL | 4.103 | 3.664 | 2.693 | 7.517 | 9.973 | 9.973 |
| TIME | 13 - 12 - 0 | 13 - 11 - 0 | 13 - 8 - 0 | 13 - 14 - 0 | 15 - 12 - 0 | 15 - 12 - 0 |

## TABLE 5.7. DAILY WATER LEVELS ALONG BICOL - SIPOCOT RIVERS IN METERS ABOVE MSL.

### RETURN PERIOD OF DESIGN FLOOD 13 YEARS

### FLOOD PROTECTION SCHEME : ⑥ DEEPENING RIVERBED

| RIVER | SIPOCOT RIVER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOWN | SABANG | | | | LIBMANAN | | | CUYAPI | | | NAGA | | | | OMBAO | | | | STO. DOMINGO | | | | LAKE BATO | | | | | | | | |
| NODE NO / DATE | 1 | 2 | 3 | 4 | 5 | 6 | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 5 | 11.799 | 9.504 | 5.749 | 2.102 | 0.318 | 0.154 | 0.121 | 0.107 | 0.098 | 0.139 | 0.146 | 0.322 | 1.364 | 1.756 | 2.165 | 2.366 | 3.943 | 4.818 | 5.011 | 5.195 | 5.330 | 5.508 | 5.526 | 5.623 | 1.926 | 1.263 | 0.598 | -0.067 | -0.733 | 1.433 | 0.764 | 0.095 | 0.095 |
| 6 | 11.730 | 9.351 | 6.069 | 2.210 | 0.348 | -0.057 | -0.301 | -0.412 | -0.355 | -0.444 | -0.454 | -0.215 | 1.241 | 1.639 | 2.053 | 2.252 | 3.844 | 4.728 | 4.917 | 5.107 | 5.246 | 5.428 | 5.447 | 5.556 | 1.926 | 1.397 | 0.803 | 0.107 | -0.718 | 1.306 | 0.444 | -0.336 | -0.336 |
| 7 | 11.706 | 9.101 | 6.135 | 2.443 | 0.382 | -0.066 | -0.427 | -0.592 | -0.725 | -0.611 | -0.599 | -0.270 | 1.163 | 1.561 | 1.976 | 2.176 | 3.797 | 4.697 | 4.883 | 5.073 | 5.213 | 5.397 | 5.416 | 5.534 | 1.862 | 1.360 | 0.799 | 0.137 | -0.669 | 1.377 | 0.319 | -0.711 | -0.711 |
| 8 | 11.734 | 9.076 | 5.986 | 2.420 | 0.389 | -0.033 | -0.418 | -0.594 | -0.905 | -0.587 | -0.567 | -0.201 | 1.154 | 1.552 | 1.968 | 2.168 | 3.790 | 4.690 | 4.876 | 5.066 | 5.205 | 5.387 | 5.405 | 5.623 | 1.858 | 1.366 | 0.822 | 0.187 | -0.595 | 1.337 | 0.219 | -0.950 | -0.950 |
| 9 | 11.733 | 9.224 | 6.043 | 2.445 | 2.459 | 0.384 | -0.297 | -0.470 | -0.694 | -0.444 | -0.418 | -0.063 | 1.158 | 1.550 | 1.960 | 2.158 | 3.780 | 4.681 | 4.866 | 5.056 | 5.196 | 5.378 | 5.396 | 5.517 | 1.846 | 1.358 | 0.831 | 0.228 | -0.508 | 1.381 | 0.255 | -0.998 | -0.998 |
| 10 | 11.744 | 9.265 | 5.872 | 2.414 | 0.447 | 0.171 | -0.151 | -0.298 | -0.688 | -0.228 | -0.193 | 0.158 | 1.203 | 1.581 | 1.980 | 2.175 | 3.785 | 4.680 | 4.865 | 5.055 | 5.194 | 5.376 | 5.394 | 5.515 | 1.863 | 1.358 | 0.837 | 0.260 | -0.422 | 1.450 | 0.396 | -0.841 | -0.841 |
| 11 | 11.745 | 9.504 | 5.921 | 2.414 | 0.711 | 0.407 | 0.109 | -0.027 | -0.348 | 0.075 | 0.129 | 0.437 | 1.273 | 1.621 | 1.998 | 2.187 | 3.787 | 4.676 | 4.862 | 5.050 | 5.188 | 5.368 | 5.386 | 5.508 | 1.846 | 1.339 | 0.921 | 0.270 | -0.353 | 1.562 | 0.626 | -0.510 | -0.510 |
| 12 | 11.950 | 11.191 | 8.461 | 4.632 | 1.789 | 1.060 | 0.681 | 0.509 | 0.146 | 0.902 | 0.984 | 1.761 | 3.196 | 3.694 | 4.135 | 4.370 | 5.484 | 6.103 | 6.331 | 6.446 | 6.583 | 6.546 | 6.545 | 6.141 | 3.592 | 2.581 | 1.616 | 0.668 | -0.312 | 3.143 | 1.631 | -0.077 | -0.077 |
| 13 | 18.952 | 16.936 | 14.316 | 10.803 | 5.850 | 3.927 | 2.758 | 2.226 | 0.767 | 1.905 | 2.024 | 2.729 | 5.186 | 6.288 | 6.794 | 7.068 | 7.741 | 8.115 | 8.275 | 8.252 | 8.252 | 8.566 | 8.405 | 8.148 | 5.890 | 4.282 | 2.730 | 1.210 | -0.305 | 7.265 | 3.870 | 0.364 | 0.364 |
| 14 | 17.140 | 15.026 | 12.628 | 9.245 | 5.142 | 3.563 | 2.546 | 2.083 | 1.260 | 2.319 | 2.425 | 2.841 | 5.456 | 6.126 | 6.580 | 6.876 | 8.042 | 8.690 | 8.950 | 9.051 | 9.106 | 9.269 | 9.305 | 9.316 | 5.944 | 4.445 | 2.884 | 1.276 | -0.335 | 6.535 | 3.708 | 0.719 | 0.719 |
| 15 | 15.578 | 13.086 | 10.047 | 6.690 | 3.590 | 2.203 | 1.598 | 1.323 | 1.024 | 1.618 | 1.708 | 2.489 | 4.948 | 5.555 | 6.111 | 6.452 | 7.895 | 8.697 | 8.982 | 9.171 | 9.254 | 9.425 | 9.453 | 9.491 | 5.522 | 4.085 | 2.607 | 1.099 | -0.395 | 4.790 | 2.870 | 0.916 | 0.916 |
| 16 | 13.710 | 11.443 | 8.322 | 5.089 | 2.273 | 1.383 | 1.115 | 0.994 | 0.953 | 1.195 | 1.244 | 2.322 | 4.520 | 5.251 | 5.852 | 6.209 | 7.730 | 8.576 | 8.870 | 9.121 | 9.220 | 9.393 | 9.418 | 9.471 | 5.313 | 3.927 | 2.489 | 1.002 | -0.478 | 3.680 | 2.283 | 0.921 | 0.921 |
| 17 | 13.251 | 10.875 | 7.541 | 4.125 | 1.514 | 0.870 | 0.831 | 0.812 | 0.766 | 0.973 | 1.026 | 2.149 | 4.296 | 5.028 | 5.638 | 5.994 | 7.552 | 8.417 | 8.723 | 8.992 | 9.101 | 9.277 | 9.301 | 9.367 | 5.131 | 3.796 | 2.395 | 0.923 | -0.569 | 2.934 | 1.796 | 0.743 | 0.743 |
| 18 | 12.942 | 10.492 | 7.181 | 3.788 | 1.259 | 0.600 | 0.493 | 0.444 | 0.424 | 0.724 | 0.776 | 1.976 | 4.135 | 4.862 | 5.471 | 5.823 | 7.395 | 8.274 | 8.580 | 8.854 | 8.965 | 9.141 | 9.164 | 9.229 | 4.989 | 3.697 | 2.330 | 0.868 | -0.655 | 2.601 | 1.464 | 0.426 | 0.426 |
| 19 | 12.577 | 10.590 | 7.533 | 4.114 | 1.358 | 0.591 | 0.247 | 0.091 | 0.059 | 0.659 | 0.741 | 2.089 | 4.231 | 4.989 | 5.582 | 5.918 | 7.412 | 8.242 | 8.548 | 8.780 | 8.885 | 9.060 | 9.082 | 9.131 | 5.058 | 3.751 | 2.370 | 0.877 | -0.721 | 2.676 | 1.304 | 0.039 | 0.039 |
| 20 | 12.495 | 10.190 | 7.019 | 3.798 | 1.262 | 0.522 | 0.062 | -0.148 | -0.296 | 0.492 | 0.595 | 2.052 | 4.168 | 4.852 | 5.426 | 5.758 | 7.280 | 8.125 | 8.439 | 8.692 | 8.803 | 8.969 | 8.990 | 9.046 | 4.958 | 3.703 | 2.358 | 0.878 | -0.757 | 2.401 | 1.005 | -0.347 | -0.347 |
| 21 | 12.635 | 10.241 | 6.899 | 3.484 | 0.955 | 0.309 | -0.130 | -0.329 | -0.585 | 0.361 | 0.458 | 1.853 | 3.985 | 4.686 | 5.268 | 5.597 | 7.143 | 8.002 | 8.313 | 8.561 | 8.678 | 8.858 | 8.881 | 8.958 | 4.808 | 3.591 | 2.294 | 0.861 | -0.757 | 2.106 | 0.720 | -0.668 | -0.668 |
| 22 | 13.075 | 10.564 | 7.009 | 3.486 | 0.938 | 0.301 | -0.162 | -0.372 | -0.746 | 0.234 | 0.325 | 1.672 | 3.810 | 4.491 | 5.075 | 5.402 | 6.992 | 7.876 | 8.189 | 8.446 | 8.570 | 8.751 | 8.773 | 8.849 | 4.651 | 3.481 | 2.237 | 0.859 | -0.721 | 2.084 | 0.638 | -0.883 | -0.883 |
| 23 | 13.498 | 10.983 | 7.332 | 3.807 | 1.046 | 0.358 | -0.102 | -0.311 | -0.774 | 0.159 | 0.237 | 1.467 | 3.613 | 4.306 | 4.904 | 5.233 | 6.862 | 7.766 | 8.077 | 8.307 | 8.424 | 8.587 | 8.602 | 8.681 | 4.496 | 3.362 | 2.166 | 0.855 | -0.654 | 2.304 | 0.736 | -0.967 | -0.967 |
| 24 | 13.365 | 10.947 | 7.346 | 3.872 | 1.150 | 0.461 | -0.000 | -0.210 | -0.703 | 0.170 | 0.242 | 1.367 | 3.476 | 4.162 | 4.748 | 5.072 | 6.713 | 7.626 | 7.930 | 8.154 | 8.270 | 8.426 | 8.442 | 8.517 | 4.355 | 3.252 | 2.101 | 0.855 | -0.567 | 2.405 | 0.840 | -0.921 | -0.921 |
| 25 | 13.275 | 10.950 | 7.502 | 4.063 | 1.242 | 0.558 | 0.138 | -0.053 | -0.518 | 0.302 | 0.394 | 1.394 | 3.396 | 4.066 | 4.634 | 4.948 | 6.587 | 7.497 | 7.793 | 8.016 | 8.142 | 8.328 | 8.350 | 8.454 | 4.236 | 3.153 | 2.037 | 0.851 | -0.474 | 2.598 | 1.029 | -0.756 | -0.756 |

| REMARKS: | | | | | | |
|---|---|---|---|---|---|---|
| STATION | LIBMANAN | CUYAPI | NAGA | OMBAO | STO. DOMINGO | LAKE BATO |
| PEAK STAGE M.MSL | 3.893 | 3.295 | 3.163 | 8.127 | 9.495 | 9.495 |
| TIME | 13-11-0 | 13-11-0 | 13-15-0 | 13-16-0 | 15-12-0 | 15-12-0 |

TABLE 5.8. DAILY WATER LEVELS ALONG BICOL - SIPOCOT RIVERS IN METERS ABOVE MSL.

RETURN PERIOD OF DESIGN FLOOD 13 YEARS

FLOOD PROTECTION SCHEME : ⑦ POLUNTUNA RESERVOIR + TIDAL BARRIER

| RIVER | SIPOCOT RIVER | | | | | | | | BICOL RIVER | | | | | | | | | | | | | | | | BICOL-RAGAY DIVERSION | | | | | SIPOCOT-SAN MIGUEL DIVERSION | | | SAN MIGUEL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOWN | | SABANG | | | LIBMANAN | | | CUYAPI | | | NAGA | | | | OMBAO | | | | | STO. DOMINGO | | | | | LAKE BATO | | | PASACAO | | BARCELONA | | BOLONGAY | |
| DATE \ NODE NO. | 1 | 2 | 3 | 4 | 5 | 6 | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 5 | 11.802 | 9.499 | 5.752 | 2.109 | 0.319 | 0.153 | 0.121 | 0.106 | 0.097 | 0.126 | 0.131 | 0.254 | 1.104 | 1.446 | 1.811 | 1.990 | 3.611 | 4.512 | 4.976 | 5.969 | 6.532 | 6.876 | 6.880 | 6.895 | 1.601 | 1.018 | 0.436 | -0.148 | -0.733 | 1.438 | 0.766 | 0.095 | 0.095 |
| 6 | 11.766 | 9.380 | 6.067 | 2.261 | 0.163 | -0.280 | -0.540 | -0.555 | -0.670 | -0.663 | -0.663 | -0.425 | 0.910 | 1.265 | 1.641 | 1.819 | 3.479 | 4.401 | 4.860 | 5.874 | 6.552 | 6.862 | 6.866 | 6.881 | 1.543 | 1.096 | 0.592 | -0.004 | -0.718 | 1.338 | 0.459 | -0.336 | -0.587 |
| 7 | 11.727 | 9.143 | 6.122 | 2.506 | 0.308 | -0.146 | -0.518 | -0.687 | -0.785 | -0.703 | -0.705 | -0.403 | 0.867 | 1.224 | 1.602 | 1.782 | 3.464 | 4.399 | 4.855 | 5.882 | 6.564 | 6.879 | 6.883 | 6.900 | 1.515 | 1.089 | 0.609 | 0.037 | -0.669 | 1.421 | 0.341 | -0.711 | -0.612 |
| 8 | 11.719 | 9.094 | 5.969 | 2.489 | 0.251 | -0.165 | -0.477 | -0.618 | -0.867 | -0.597 | -0.577 | -0.303 | 0.875 | 1.234 | 1.616 | 1.799 | 3.485 | 4.422 | 4.876 | 5.909 | 6.588 | 6.903 | 6.907 | 6.924 | 1.532 | 1.112 | 0.646 | 0.095 | -0.595 | 1.384 | 0.243 | -0.950 | -1.095 |
| 9 | 11.725 | 9.234 | 6.010 | 2.518 | 0.199 | -0.189 | -0.480 | -0.613 | -0.993 | -0.488 | -0.451 | -0.144 | 0.927 | 1.289 | 1.677 | 1.864 | 3.551 | 4.498 | 4.944 | 5.988 | 6.562 | 6.921 | 6.926 | 6.946 | 1.587 | 1.159 | 0.694 | 0.157 | -0.508 | 1.431 | 0.280 | -0.998 | -1.185 |
| 10 | 11.729 | 9.280 | 5.837 | 2.490 | 0.156 | -0.234 | -0.367 | -0.427 | -0.515 | -0.336 | -0.303 | -0.118 | 0.948 | 1.309 | 1.700 | 1.888 | 3.570 | 4.505 | 4.961 | 6.011 | 6.582 | 6.942 | 6.946 | 6.967 | 1.605 | 1.172 | 0.712 | 0.196 | -0.422 | 1.501 | 0.423 | -0.841 | -0.629 |
| 11 | 11.737 | 9.520 | 5.879 | 2.500 | 0.102 | -0.356 | -0.390 | -0.406 | -0.421 | -0.393 | -0.389 | -0.241 | 0.958 | 1.322 | 1.716 | 1.906 | 3.588 | 4.522 | 4.980 | 6.025 | 6.595 | 6.956 | 6.960 | 6.982 | 1.612 | 1.167 | 0.707 | 0.213 | -0.353 | 1.619 | 0.655 | -0.610 | -0.398 |
| 12 | 11.832 | 11.170 | 8.421 | 4.666 | 1.666 | 0.922 | 0.694 | 0.591 | 0.455 | 0.897 | 0.973 | 1.686 | 3.141 | 3.638 | 4.080 | 4.310 | 5.397 | 6.001 | 6.412 | 7.072 | 7.370 | 7.612 | 7.613 | 7.434 | 3.567 | 2.570 | 1.613 | 0.667 | -0.312 | 3.169 | 1.645 | -0.077 | 0.339 |
| 13 | 16.168 | 14.890 | 13.015 | 9.761 | 5.300 | 3.641 | 2.650 | 2.200 | 1.166 | 1.885 | 2.001 | 2.684 | 4.953 | 5.988 | 6.573 | 6.872 | 7.604 | 8.011 | 8.310 | 8.253 | 8.278 | 8.923 | 8.969 | 8.985 | 5.716 | 4.150 | 2.641 | 1.166 | -0.305 | 6.586 | 3.539 | 0.864 | 0.800 |
| 14 | 17.427 | 15.004 | 12.474 | 8.991 | 5.023 | 3.429 | 2.494 | 2.069 | 1.425 | 2.028 | 2.165 | 2.732 | 5.379 | 6.049 | 6.487 | 6.771 | 7.921 | 8.560 | 8.955 | 9.202 | 9.313 | 9.774 | 9.810 | 9.831 | 5.849 | 4.370 | 2.830 | 1.248 | -0.335 | 6.369 | 3.621 | 0.719 | 1.205 |
| 15 | 16.513 | 13.904 | 10.675 | 7.161 | 3.651 | 2.378 | 1.778 | 1.505 | 1.218 | 1.591 | 1.645 | 2.482 | 4.825 | 5.486 | 6.004 | 6.324 | 7.735 | 8.519 | 8.961 | 9.451 | 9.578 | 9.912 | 9.934 | 9.968 | 5.412 | 4.003 | 2.552 | 1.071 | -0.395 | 5.095 | 3.019 | 0.916 | 1.044 |
| 16 | 15.092 | 12.597 | 9.233 | 5.815 | 2.666 | 1.562 | 1.141 | 0.950 | 0.802 | 1.074 | 1.122 | 2.297 | 4.465 | 5.149 | 5.712 | 6.047 | 7.543 | 8.374 | 8.938 | 9.475 | 9.608 | 9.892 | 9.910 | 9.948 | 5.176 | 3.824 | 2.420 | 0.968 | -0.478 | 4.155 | 2.516 | 0.921 | 1.027 |
| 17 | 13.909 | 11.511 | 8.179 | 4.796 | 1.924 | 0.984 | 0.712 | 0.589 | 0.670 | 0.832 | 0.858 | 2.058 | 4.186 | 4.875 | 5.451 | 5.787 | 7.331 | 8.189 | 8.685 | 9.393 | 9.534 | 9.806 | 9.822 | 9.865 | 4.954 | 3.661 | 2.304 | 0.877 | -0.569 | 3.381 | 2.016 | 0.743 | 0.466 |
| 18 | 13.289 | 10.838 | 7.472 | 4.103 | 1.435 | 0.632 | 0.208 | 0.016 | -0.177 | 0.429 | 0.524 | 1.824 | 3.983 | 4.679 | 5.266 | 5.601 | 7.179 | 8.056 | 8.566 | 9.288 | 9.433 | 9.701 | 9.715 | 9.756 | 4.797 | 3.551 | 2.230 | 0.817 | -0.655 | 2.812 | 1.568 | 0.426 | -0.013 |
| 19 | 12.865 | 10.799 | 7.691 | 4.287 | 1.459 | 0.646 | 0.246 | 0.064 | -0.086 | 0.572 | 0.667 | 1.962 | 4.065 | 4.793 | 5.385 | 5.715 | 7.225 | 8.063 | 8.556 | 9.226 | 9.369 | 9.641 | 9.655 | 9.685 | 4.881 | 3.614 | 2.276 | 0.829 | -0.721 | 2.792 | 1.362 | 0.039 | -0.443 |
| 20 | 12.610 | 10.320 | 7.112 | 3.888 | 1.330 | 0.569 | 0.024 | -0.223 | -0.686 | 0.387 | 0.504 | 1.934 | 4.042 | 4.709 | 5.263 | 5.582 | 7.101 | 7.944 | 8.455 | 9.165 | 9.311 | 9.573 | 9.586 | 9.622 | 4.806 | 3.586 | 2.279 | 0.837 | -0.757 | 2.462 | 1.036 | -0.347 | -0.471 |
| 21 | 12.596 | 10.233 | 6.909 | 3.521 | 0.983 | 0.340 | -0.064 | -0.247 | -0.501 | 0.329 | 0.426 | 1.744 | 3.852 | 4.526 | 5.092 | 5.409 | 6.956 | 7.816 | 8.331 | 9.062 | 9.218 | 9.494 | 9.508 | 9.557 | 4.646 | 3.468 | 2.210 | 0.818 | -0.757 | 2.132 | 0.734 | -0.668 | -0.964 |
| 22 | 12.843 | 10.379 | 6.918 | 3.437 | 0.933 | 0.216 | -0.132 | -0.235 | -0.769 | 0.190 | 0.279 | 1.544 | 3.669 | 4.332 | 4.894 | 5.207 | 6.798 | 7.681 | 8.208 | 8.973 | 9.137 | 9.416 | 9.429 | 9.475 | 4.483 | 3.355 | 2.151 | 0.815 | -0.721 | 2.054 | 0.623 | -0.883 | -0.509 |
| 23 | 13.257 | 10.744 | 7.134 | 3.653 | 0.975 | 0.346 | -0.072 | -0.261 | -0.850 | 0.146 | 0.234 | 1.347 | 3.449 | 4.129 | 4.710 | 5.031 | 6.678 | 7.593 | 8.125 | 8.662 | 9.027 | 9.295 | 9.307 | 9.350 | 4.320 | 3.228 | 2.075 | 0.808 | -0.654 | 2.201 | 0.685 | -0.967 | -1.225 |
| 24 | 13.384 | 10.945 | 7.297 | 3.783 | 1.057 | 0.395 | 0.004 | -0.174 | -0.450 | 0.218 | 0.291 | 1.310 | 3.348 | 4.019 | 4.588 | 4.904 | 6.561 | 7.481 | 8.016 | 8.749 | 8.917 | 9.180 | 9.191 | 9.234 | 4.209 | 3.141 | 2.026 | 0.817 | -0.567 | 2.341 | 0.806 | -0.921 | -0.398 |
| 25 | 13.323 | 10.990 | 7.530 | 4.097 | 1.207 | 0.489 | 0.030 | -0.178 | -0.615 | 0.373 | 0.450 | 1.353 | 3.276 | 3.930 | 4.483 | 4.791 | 6.444 | 7.362 | 7.896 | 8.643 | 8.825 | 9.118 | 9.132 | 9.196 | 4.100 | 3.050 | 1.968 | 0.816 | -0.474 | 2.616 | 1.040 | -0.756 | -0.897 |

| REMARKS: STATION | LIBMANAN | CUYAPI | NAGA | OMBAO | STO. DOMINGO | LAKE BATO |
|---|---|---|---|---|---|---|
| PEAK STAGE M.MSL | 3.403 | 2.553 | 2.804 | 8.023 | 9.969 | 9.969 |
| TIME | 13-13-0 | 13-13-0 | 13-16-0 | 13-15-0 | 15-12-0 | 15-12-0 |

## TABLE 5.9 DAILY WATER LEVELS ALONG BICOL - SIPOCOT RIVERS IN METERS ABOVE MSL.

RETURN PERIOD OF DESIGN FLOOD 13 YEARS

FLOOD PROTECTION SCHEME : ⑧ POLUNTUNA RESERVOIR + BICOL-RAGAY DIVERSION

| RIVER | SIPOCOT RIVER | | | | | | | BICOL RIVER | | | | | | | | | | | | | | | | | | BICOL-RAGAY DIVERSION | | | | | SIPOCOT-SAN MIGUEL DIVERSION | | | SAN MIGUEL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOWN | | | | SABANG | | | LIBMANAN | | CUYAPI | | | | NAGA | | | | OMBAO | | | | | | STO. DOMINGO | LAKE BATO | | | | | PASACAO | | | BARCELONA | BOLONGAY |
| DATE \ NODE NO | 1 | 2 | 3 | 4 | 5 | 6 | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 5 | 11.802 | 9.499 | 5.752 | 2.109 | 0.218 | 0.152 | 0.119 | 0.105 | 0.096 | 0.105 | 0.107 | 0.146 | 0.513 | 0.774 | 0.963 | 1.115 | 3.539 | 4.885 | 5.187 | 6.010 | 6.542 | 6.879 | 6.883 | 6.897 | 0.362 | -0.062 | -0.606 | -0.668 | -0.733 | 1.438 | 0.767 | 0.095 | 0.095 |
| 6 | 11.766 | 9.378 | 6.077 | 2.214 | 0.350 | -0.058 | -0.303 | -0.414 | -0.353 | -0.489 | -0.509 | -0.499 | 0.419 | 0.753 | 0.958 | 1.097 | 3.388 | 4.661 | 4.992 | 5.886 | 6.543 | 6.853 | 6.856 | 6.880 | 0.554 | 0.222 | -0.234 | -0.517 | -0.718 | 1.308 | 0.445 | -0.336 | -0.336 |
| 7 | 11.729 | 9.128 | 6.151 | 2.458 | 0.384 | -0.068 | -0.432 | -0.596 | -0.732 | -0.710 | -0.710 | -0.574 | 0.347 | 0.688 | 0.904 | 1.056 | 3.388 | 4.683 | 5.005 | 5.900 | 6.561 | 6.872 | 6.876 | 6.999 | 0.523 | 0.210 | -0.204 | -0.466 | -0.669 | 1.388 | 0.324 | -0.711 | -0.711 |
| 8 | 11.724 | 9.080 | 5.991 | 2.432 | 0.390 | -0.035 | -0.424 | -0.600 | -0.916 | -0.591 | -0.681 | -0.486 | 0.577 | 0.721 | 0.946 | 1.110 | 3.466 | 4.775 | 5.092 | 5.991 | 6.544 | 6.893 | 6.897 | 6.921 | 0.558 | 0.246 | -0.150 | -0.395 | -0.595 | 1.345 | 0.223 | -0.950 | -0.950 |
| 9 | 11.731 | 9.219 | 6.038 | 2.445 | 0.456 | 0.079 | -0.802 | -0.475 | -0.910 | -0.542 | -0.521 | -0.312 | 0.426 | 0.745 | 0.959 | 1.120 | 3.486 | 4.801 | 5.116 | 6.012 | 6.563 | 6.914 | 6.918 | 6.942 | 0.555 | 0.248 | -0.115 | -0.331 | -0.508 | 1.382 | 0.255 | -0.998 | -0.998 |
| 10 | 11.736 | 9.262 | 5.870 | 2.414 | 0.446 | 0.160 | -0.159 | -0.304 | -0.693 | -0.290 | -0.267 | -0.054 | 0.543 | 0.815 | 1.003 | 1.153 | 3.513 | 4.824 | 5.139 | 6.038 | 6.587 | 6.987 | 6.942 | 6.964 | 0.555 | 0.246 | -0.091 | -0.277 | -0.422 | 1.449 | 0.396 | -0.841 | -0.841 |
| 11 | 11.745 | 9.499 | 5.915 | 2.413 | 0.705 | 0.405 | 0.111 | -0.023 | -0.565 | 0.030 | 0.066 | 0.255 | 0.697 | 0.907 | 1.060 | 1.190 | 3.537 | 4.842 | 5.158 | 6.056 | 6.603 | 6.956 | 6.961 | 6.979 | 0.545 | 0.228 | -0.057 | -0.242 | -0.353 | 1.562 | 0.625 | -0.510 | -0.510 |
| 12 | 11.835 | 11.160 | 8.448 | 4.627 | 1.787 | 1.065 | 0.682 | 0.507 | 0.132 | 0.788 | 0.859 | 1.459 | 2.563 | 2.864 | 3.051 | 3.149 | 5.024 | 6.065 | 6.457 | 7.091 | 7.382 | 7.629 | 7.630 | 7.482 | 2.099 | 1.402 | 0.499 | -0.005 | -0.312 | 3.141 | 1.629 | -0.077 | -0.077 |
| 13 | 16.168 | 14.890 | 12.015 | 9.761 | 5.291 | 2.608 | 2.540 | 2.054 | 0.725 | 1.803 | 1.919 | 2.606 | 4.580 | 5.323 | 5.609 | 5.728 | 7.142 | 7.928 | 8.302 | 8.269 | 8.299 | 8.937 | 8.982 | 8.973 | 4.453 | 2.501 | 2.044 | 0.849 | -0.305 | 6.686 | 3.539 | 0.364 | 0.364 |
| 14 | 17.427 | 15.004 | 12.474 | 8.991 | 5.021 | 3.386 | 2.342 | 1.867 | 0.947 | 1.763 | 1.863 | 2.515 | 4.566 | 4.895 | 5.119 | 5.249 | 7.334 | 8.492 | 8.928 | 9.207 | 9.329 | 9.773 | 9.807 | 9.832 | 4.177 | 3.318 | 1.964 | 0.826 | -0.335 | 6.369 | 3.621 | 0.719 | 0.719 |
| 15 | 16.513 | 13.904 | 10.675 | 7.162 | 3.646 | 2.352 | 1.660 | 1.345 | 0.985 | 1.188 | 1.224 | 1.789 | 3.448 | 3.948 | 4.333 | 4.553 | 7.134 | 8.567 | 8.979 | 9.456 | 9.592 | 9.915 | 9.937 | 9.970 | 3.488 | 2.676 | 1.419 | 0.434 | -0.395 | 5.096 | 3.019 | 0.916 | 0.916 |
| 16 | 15.092 | 12.587 | 9.233 | 5.816 | 2.677 | 1.621 | 1.244 | 1.073 | 0.982 | 1.134 | 1.168 | 1.455 | 2.931 | 3.496 | 3.964 | 4.232 | 6.968 | 8.487 | 8.891 | 9.487 | 9.627 | 9.900 | 9.917 | 9.954 | 3.190 | 2.401 | 1.186 | 0.258 | -0.478 | 4.156 | 2.516 | 0.921 | 0.921 |
| 17 | 13.809 | 11.511 | 8.179 | 4.794 | 1.937 | 1.059 | 0.874 | 0.790 | 0.768 | 0.844 | 0.858 | 1.135 | 2.716 | 3.282 | 3.756 | 4.030 | 6.804 | 8.345 | 8.759 | 9.410 | 9.557 | 9.817 | 9.832 | 9.874 | 2.999 | 2.226 | 1.040 | 0.139 | -0.569 | 3.380 | 2.015 | 0.743 | 0.743 |
| 18 | 13.289 | 10.828 | 7.473 | 4.100 | 1.447 | 0.701 | 0.519 | 0.436 | 0.425 | 0.421 | 0.416 | 0.859 | 2.581 | 3.142 | 3.616 | 3.890 | 6.683 | 8.234 | 8.657 | 9.310 | 9.460 | 9.715 | 9.729 | 9.768 | 2.871 | 2.111 | 0.945 | 0.059 | -0.665 | 2.810 | 1.567 | 0.426 | 0.426 |
| 19 | 12.865 | 10.798 | 7.692 | 4.283 | 1.457 | 0.643 | 0.256 | 0.080 | 0.038 | 0.243 | 0.287 | 1.182 | 2.955 | 3.485 | 3.902 | 4.133 | 6.762 | 8.222 | 8.648 | 9.258 | 9.402 | 9.659 | 9.673 | 9.701 | 3.070 | 2.279 | 1.064 | 0.115 | -0.721 | 2.789 | 1.361 | 0.039 | 0.039 |
| 20 | 12.610 | 10.320 | 7.112 | 3.889 | 1.318 | 0.548 | 0.052 | -0.173 | -0.347 | -0.083 | -0.053 | 0.795 | 2.652 | 3.201 | 3.635 | 3.887 | 6.602 | 8.110 | 8.545 | 9.196 | 9.346 | 9.593 | 9.606 | 9.642 | 2.888 | 2.135 | 0.973 | 0.063 | -0.757 | 2.463 | 1.036 | -0.347 | -0.347 |
| 21 | 12.596 | 10.233 | 6.909 | 3.520 | 0.972 | 0.307 | -0.156 | -0.366 | -0.628 | -0.176 | -0.132 | 0.735 | 2.533 | 3.068 | 3.504 | 3.756 | 6.495 | 8.017 | 8.444 | 9.099 | 9.255 | 9.518 | 9.532 | 9.579 | 2.750 | 2.007 | 0.877 | 0.013 | -0.757 | 2.132 | 0.734 | -0.668 | -0.668 |
| 22 | 12.843 | 10.379 | 6.919 | 3.438 | 0.917 | 0.280 | -0.197 | -0.413 | -0.807 | -0.286 | -0.239 | 0.524 | 2.273 | 2.812 | 3.270 | 3.539 | 6.352 | 7.915 | 8.339 | 9.016 | 9.179 | 9.442 | 9.455 | 9.500 | 2.569 | 1.857 | 0.785 | -0.016 | -0.721 | 2.054 | 0.623 | -0.883 | -0.883 |
| 23 | 13.257 | 10.743 | 7.137 | 3.647 | 0.970 | 0.321 | -0.160 | -0.364 | -0.845 | -0.262 | -0.217 | 0.482 | 2.158 | 2.695 | 3.157 | 3.432 | 6.276 | 7.856 | 8.275 | 8.913 | 9.075 | 9.325 | 9.336 | 9.378 | 2.464 | 1.764 | 0.731 | -0.017 | -0.654 | 2.197 | 0.682 | -0.967 | -0.967 |
| 24 | 12.884 | 10.944 | 7.300 | 3.774 | 1.081 | 0.419 | -0.039 | -0.247 | -0.762 | -0.170 | -0.128 | 0.523 | 2.090 | 2.614 | 3.066 | 3.335 | 6.181 | 7.763 | 8.177 | 8.806 | 8.969 | 9.213 | 9.224 | 9.266 | 2.382 | 1.696 | 0.700 | 0.003 | -0.567 | 2.335 | 0.803 | -0.921 | -0.921 |
| 25 | 12.923 | 10.988 | 7.535 | 4.082 | 1.251 | 0.560 | 0.126 | -0.071 | -0.561 | 0.037 | 0.100 | 0.737 | 2.281 | 2.835 | 3.337 | 3.618 | 5.990 | 7.307 | 7.975 | 8.699 | 8.880 | 9.157 | 9.172 | 9.228 | 2.587 | 1.855 | 0.816 | 0.096 | -0.474 | 2.605 | 1.035 | -0.756 | -0.756 |

REMARKS :

| STATION | LIBMANAN | CUYAPI | NAGA | OMBAO | STO. DOMINGO | LAKE BATO |
|---|---|---|---|---|---|---|
| PEAK STAGE M. MSL | 3.841 | 3.683 | 2.693 | 7.517 | 9.973 | 9.973 |
| TIME | 13 - 12 - 0 | 13 - 11 - 0 | 13 - 8 - 0 | 13 - 14 - 0 | 15 - 12 - 0 | 15 - 12 - 0 |

## TABLE 5.10 DAILY WATER LEVELS ALONG BICOL - SIPOCOT RIVERS IN METERS ABOVE MSL

### RETURN PERIOD OF DESIGN FLOOD 13 YEARS

### FLOOD PROTECTION SCHEME : ⑨ POLUNTUNA RESERVOIR + TIDAL BARRIER + BICOL-RAGAY DIVERSION

| RIVER | SIPOCOT RIVER | | | | | | | | | | | | BICOL RIVER | | | | | | | | | | | | | | | | | | | | | | BICOL-RAGAY DIVERSION | | | | | SIPOCOT-SAN MIGUEL DIVERSION | | | SAN MIGUEL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOWN | SABANG | | | | LIBMANAN | | | CUYAPI | | | | NAGA | | | | OMBAO | | | | | STO DOMINGO | | | | | LAKE BATO | | | | PASACAO | | BARCELONA | | | BOLONGAY |
| DATE \ NODE NO. | 1 | 2 | 3 | 4 | 5 | 6 | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 5 | 11.802 | 9.499 | 5.752 | 2.109 | 0.919 | 0.152 | 0.119 | 0.105 | 0.096 | 0.105 | 0.107 | 0.146 | 0.515 | 0.774 | 0.963 | 1.115 | 3.539 | 4.885 | 5.187 | 6.010 | 6.542 | 6.879 | 6.883 | 6.897 | 0.362 | -0.062 | -0.506 | -0.668 | -0.753 | 1.438 | 0.767 | 0.095 | 0.095 |
| 6 | 11.766 | 9.381 | 6.064 | 2.275 | 0.119 | -0.514 | -0.591 | -0.717 | -0.756 | -0.768 | -0.772 | -0.642 | 0.347 | 0.701 | 0.922 | 1.075 | 3.400 | 4.692 | 5.014 | 5.989 | 6.546 | 6.853 | 6.856 | 6.880 | 0.527 | 0.197 | -0.249 | -0.524 | -0.718 | 1.348 | 0.464 | -0.396 | -0.836 |
| 7 | 11.726 | 9.147 | 6.112 | 2.557 | 0.215 | -0.247 | -0.570 | -0.717 | -0.968 | -0.781 | -0.766 | -0.621 | 0.280 | 0.633 | 0.863 | 1.029 | 3.394 | 4.709 | 5.022 | 5.904 | 6.563 | 6.873 | 6.877 | 6.899 | 0.493 | 0.186 | -0.218 | -0.471 | -0.669 | 1.441 | 0.852 | -0.711 | -0.711 |
| 8 | 11.717 | 9.101 | 5.963 | 2.496 | 0.217 | -0.213 | -0.532 | -0.707 | -0.948 | -0.709 | -0.706 | -0.499 | 0.314 | 0.666 | 0.904 | 1.080 | 3.469 | 4.796 | 5.106 | 5.994 | 6.545 | 6.894 | 6.898 | 6.921 | 0.529 | 0.224 | -0.161 | -0.400 | -0.895 | 1.889 | 0.245 | -0.950 | -0.830 |
| 9 | 11.723 | 9.236 | 6.006 | 2.529 | 0.165 | -0.240 | -0.484 | -0.595 | -0.947 | -0.567 | -0.535 | -0.354 | 0.292 | 0.635 | 0.879 | 1.066 | 3.485 | 4.829 | 5.134 | 6.016 | 6.564 | 6.916 | 6.920 | 6.942 | 0.512 | 0.219 | -0.128 | -0.357 | -0.508 | 1.438 | 0.284 | -0.998 | -1.115 |
| 10 | 11.728 | 9.282 | 5.834 | 2.494 | 0.152 | -0.247 | -0.376 | -0.435 | -0.520 | -0.394 | -0.369 | -0.280 | 0.289 | 0.629 | 0.877 | 1.068 | 3.504 | 4.857 | 5.159 | 6.041 | 6.586 | 6.938 | 6.943 | 6.964 | 0.501 | 0.213 | -0.105 | -0.282 | -0.422 | 1.504 | 0.424 | -0.841 | -0.606 |
| 11 | 11.736 | 9.520 | 5.878 | 2.502 | 0.091 | -0.411 | -0.488 | -0.515 | -0.525 | -0.521 | -0.524 | -0.489 | 0.152 | 0.548 | 0.827 | 1.038 | 3.515 | 4.891 | 5.198 | 6.058 | 6.600 | 6.954 | 6.959 | 6.980 | 0.460 | 0.179 | -0.106 | -0.248 | -0.353 | 1.620 | 0.655 | -0.510 | -0.523 |
| 12 | 11.832 | 11.170 | 8.419 | 4.671 | 1.637 | 0.837 | 0.678 | 0.599 | 0.562 | 0.732 | 0.757 | 1.297 | 2.509 | 2.821 | 3.016 | 3.119 | 5.016 | 6.070 | 6.460 | 7.092 | 7.382 | 7.629 | 7.629 | 7.482 | 2.075 | 1.385 | 0.490 | -0.009 | -0.312 | 3.173 | 1.647 | -0.077 | 0.539 |
| 13 | 16.168 | 14.890 | 13.015 | 9.761 | 5.298 | 3.631 | 2.612 | 2.148 | 1.009 | 1.624 | 1.931 | 2.593 | 4.441 | 5.139 | 5.474 | 5.610 | 7.080 | 7.898 | 8.269 | 8.236 | 8.275 | 8.939 | 8.984 | 8.977 | 4.346 | 3.405 | 1.967 | 0.799 | -0.305 | 6.586 | 2.539 | 0.364 | 0.765 |
| 14 | 17.427 | 15.004 | 12.474 | 8.991 | 5.019 | 3.413 | 2.538 | 1.996 | 1.286 | 1.893 | 1.998 | 2.531 | 4.574 | 4.932 | 5.134 | 5.274 | 7.306 | 8.445 | 8.887 | 9.160 | 9.231 | 9.766 | 9.802 | 9.829 | 4.173 | 3.312 | 1.956 | 0.818 | -0.335 | 6.369 | 3.621 | 0.719 | 1.212 |
| 15 | 16.513 | 13.904 | 10.675 | 7.161 | 3.837 | 2.330 | 1.651 | 1.342 | 1.095 | 1.190 | 1.223 | 1.860 | 3.591 | 4.052 | 4.396 | 4.597 | 7.124 | 8.528 | 8.948 | 9.428 | 9.557 | 9.902 | 9.925 | 9.961 | 3.526 | 2.710 | 1.446 | 0.451 | -0.395 | 5.095 | 3.019 | 0.916 | 1.231 |
| 16 | 16.082 | 12.597 | 9.233 | 6.817 | 2.659 | 1.530 | 0.963 | 0.706 | 0.570 | 0.600 | 0.604 | 1.157 | 2.916 | 3.493 | 3.956 | 4.222 | 6.953 | 8.471 | 8.877 | 9.474 | 9.603 | 9.884 | 9.902 | 9.940 | 3.182 | 2.394 | 1.181 | 0.255 | -0.478 | 4.157 | 2.516 | 0.921 | 0.551 |
| 17 | 13.909 | 11.511 | 8.178 | 4.799 | 1.909 | 0.929 | 0.498 | 0.303 | 0.263 | 0.286 | 0.304 | 0.894 | 2.691 | 3.267 | 3.745 | 4.020 | 6.799 | 8.342 | 8.757 | 9.406 | 9.540 | 9.802 | 9.917 | 9.860 | 2.990 | 2.218 | 1.032 | 0.135 | -0.569 | 3.884 | 2.017 | 0.743 | 0.237 |
| 18 | 13.289 | 10.938 | 7.471 | 4.107 | 1.419 | 0.579 | 0.001 | -0.262 | -0.388 | -0.224 | -0.207 | 0.670 | 2.564 | 3.135 | 3.613 | 3.888 | 6.683 | 8.236 | 8.659 | 9.310 | 9.446 | 9.701 | 9.715 | 9.754 | 2.869 | 2.109 | 0.943 | 0.058 | -0.655 | 2.815 | 1.570 | 0.426 | -0.297 |
| 19 | 12.865 | 10.800 | 7.688 | 4.295 | 1.439 | 0.602 | 0.162 | -0.038 | -0.139 | -0.168 | 0.210 | 1.155 | 2.944 | 3.477 | 3.997 | 4.129 | 6.761 | 8.223 | 8.649 | 9.257 | 9.389 | 9.647 | 9.660 | 9.688 | 3.067 | 2.277 | 1.062 | 0.113 | -0.721 | 2.797 | 1.365 | 0.039 | -0.434 |
| 20 | 12.610 | 10.320 | 7.111 | 3.894 | 1.310 | 0.529 | -0.054 | -0.319 | -0.902 | -0.198 | -0.127 | 0.788 | 2.658 | 3.207 | 3.640 | 3.892 | 6.604 | 8.112 | 8.547 | 9.197 | 9.333 | 9.581 | 9.594 | 9.629 | 2.892 | 2.139 | 0.975 | 0.065 | -0.757 | 2.466 | 1.037 | -0.347 | -0.875 |
| 21 | 12.956 | 10.223 | 6.907 | 3.525 | 0.970 | 0.312 | -0.146 | -0.355 | -0.747 | -0.158 | -0.102 | 0.753 | 2.536 | 3.072 | 3.509 | 3.761 | 6.499 | 8.021 | 8.448 | 9.102 | 9.245 | 9.507 | 9.521 | 9.568 | 2.754 | 2.010 | 0.879 | 0.014 | -0.757 | 2.125 | 0.735 | -0.668 | -0.996 |
| 22 | 12.843 | 10.579 | 6.916 | 3.446 | 0.900 | 0.268 | -0.177 | -0.379 | -0.711 | -0.245 | -0.200 | 0.545 | 2.277 | 2.817 | 3.275 | 3.544 | 6.358 | 7.921 | 8.344 | 9.020 | 9.169 | 9.432 | 9.445 | 9.490 | 2.573 | 1.860 | 0.787 | -0.016 | -0.721 | 2.059 | 0.626 | -0.883 | -0.690 |
| 23 | 12.257 | 10.746 | 7.131 | 3.663 | 0.935 | 0.286 | -0.144 | -.340 | 0.696 | -0.214 | -0.178 | 0.505 | 2.163 | 2.701 | 3.163 | 3.438 | 6.282 | 7.862 | 8.282 | 8.918 | 9.067 | 9.316 | 9.327 | 9.369 | 2.469 | 1.767 | 0.733 | -0.016 | -0.654 | 2.208 | 0.688 | -0.967 | -0.865 |
| 24 | 12.384 | 10.947 | 7.292 | 3.799 | 0.997 | 0.272 | -0.185 | -0.389 | -0.798 | -0.169 | -0.115 | 0.508 | 2.096 | 2.618 | 3.069 | 3.339 | 6.188 | 7.771 | 8.185 | 8.813 | 8.962 | 9.205 | 9.216 | 9.257 | 2.383 | 1.696 | 0.700 | 0.004 | -0.567 | 2.351 | 0.811 | -0.921 | -1.045 |
| 25 | 12.323 | 10.991 | 7.528 | 4.104 | 1.174 | 0.431 | 0.091 | -0.064 | -0.472 | 0.045 | 0.105 | 0.700 | 2.284 | 2.837 | 3.341 | 3.624 | 6.000 | 7.320 | 7.986 | 8.707 | 8.875 | 9.150 | 9.165 | 9.220 | 2.590 | 1.857 | 0.817 | 0.096 | -0.474 | 2.820 | 1.042 | -0.756 | -0.712 |

**REMARKS:**

| STATION | LIBMANAN | CUYAPI | NAGA | OMBAO | STO. DOMINGO | LAKE BATO |
|---|---|---|---|---|---|---|
| PEAK STAGE M.MSL | 3.300 | 2.384 | 2.673 | 7.466 | 9.961 | 9.961 |
| TIME | 13-13-0 | 13-12-0 | 13-9-0 | 13-14-0 | 15-0-0 | 15-0-0 |

TABLE 5.11 DAILY WATER LEVELS ALONG BICOL - SIPOCOT RIVERS IN METERS ABOVE MSL.

RETURN PERIOD OF DESIGN FLOOD 13 YEARS

FLOOD PROTECTION SCHEME : ⑩ POLUNTUNA RESERVOIR + SIPOCOT-SAN MIGUEL DIVERSION + TIDAL BARRIER + BICOL-RAGAY DIVERSION

| RIVER | SIPOCOT RIVER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOWN | SABANG | | | LIBMANAN | | | CUYAPI | | | NAGA | | | OMBAO | | | | | STO DOMINGO | | | | | LAKE BATO | | PASACAO | | | BARCELONA | | BOLONGAY | |
| NODE NO / DATE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 5 | 11.877 | 9.189 | 6.199 | 1.322 | 0.185 | 0.119 | 0.106 | 0.100 | 0.096 | 0.105 | 0.107 | 0.145 | 0.507 | 0.766 | 0.953 | 1.104 | 3.526 | 4.872 | 5.173 | 5.994 | 6.527 | 6.863 | 6.867 | 6.881 | 0.352 | -0.070 | -0.509 | -0.669 | -0.733 | 0.672 | 0.275 | 0.095 | 0.095 |
| 6 | 11.875 | 9.112 | 6.505 | 1.430 | -0.100 | -0.413 | -0.676 | -0.795 | -0.820 | -0.823 | -0.827 | -0.672 | 0.323 | 0.673 | 0.894 | 1.048 | 3.387 | 4.687 | 5.006 | 5.880 | 6.536 | 6.842 | 6.845 | 6.867 | 0.501 | 0.177 | -0.260 | -0.528 | -0.718 | 0.712 | 0.155 | -0.336 | -0.712 |
| 7 | 11.844 | 8.910 | 6.608 | 1.600 | -0.130 | -0.433 | -0.628 | -0.717 | -0.869 | -0.735 | -0.725 | -0.613 | 0.265 | 0.618 | 0.849 | 1.016 | 3.385 | 4.702 | 5.014 | 5.893 | 6.552 | 6.862 | 6.866 | 6.887 | 0.484 | 0.179 | -0.221 | -0.473 | -0.669 | 0.879 | 0.293 | -0.711 | -1.033 |
| 8 | 11.842 | 8.845 | 6.473 | 1.578 | -0.185 | -0.428 | -0.651 | -0.752 | -1.013 | -0.736 | -0.724 | -0.526 | 0.265 | 0.628 | 0.876 | 1.060 | 3.462 | 4.796 | 5.103 | 5.985 | 6.537 | 6.885 | 6.889 | 6.911 | 0.614 | 0.213 | -0.166 | -0.402 | -0.585 | 0.866 | 0.269 | -0.950 | -0.910 |
| 9 | 11.854 | 8.974 | 6.508 | 1.605 | -0.158 | -0.364 | -0.540 | -0.620 | -0.915 | -0.569 | -0.535 | -0.366 | 0.282 | 0.627 | 0.872 | 1.058 | 3.477 | 4.821 | 5.125 | 6.006 | 6.556 | 6.907 | 6.911 | 6.933 | 0.508 | 0.216 | -0.129 | -0.337 | -0.508 | 0.875 | 0.243 | -0.998 | -1.086 |
| 10 | 11.857 | 9.020 | 6.544 | 1.567 | -0.226 | -0.390 | -0.423 | -0.438 | -0.454 | -0.411 | -0.402 | -0.344 | 0.264 | 0.613 | 0.864 | 1.058 | 3.497 | 4.853 | 5.153 | 6.032 | 6.579 | 6.930 | 6.934 | 6.955 | 0.494 | 0.208 | -0.107 | -0.283 | -0.422 | 0.868 | 0.242 | -0.841 | -0.480 |
| 11 | 11.866 | 9.245 | 6.379 | 1.603 | -0.287 | -0.527 | -0.541 | -0.547 | -0.546 | -0.543 | -0.544 | -0.509 | 0.146 | 0.542 | 0.821 | 1.032 | 3.509 | 4.885 | 5.182 | 6.050 | 6.593 | 6.947 | 6.951 | 6.972 | 0.456 | 0.175 | -0.107 | -0.249 | -0.353 | 0.902 | 0.304 | -0.510 | -0.544 |
| 12 | 11.888 | 11.076 | 8.916 | 3.351 | 1.024 | 0.580 | 0.554 | 0.542 | 0.541 | 0.688 | 0.710 | 1.271 | 2.504 | 2.817 | 3.014 | 3.117 | 5.014 | 6.068 | 6.458 | 7.090 | 7.379 | 7.623 | 7.624 | 7.476 | 2.073 | 1.383 | 0.488 | -0.009 | -0.312 | 2.320 | 1.324 | -0.077 | 0.539 |
| 13 | 16.174 | 14.992 | 12.975 | 7.086 | 3.909 | 2.749 | 2.165 | 1.899 | 1.445 | 1.827 | 1.909 | 2.583 | 4.441 | 5.140 | 5.474 | 5.610 | 7.081 | 7.899 | 8.270 | 8.233 | 8.272 | 8.935 | 8.980 | 8.973 | 4.347 | 3.406 | 1.067 | 0.799 | -0.305 | 6.113 | 4.621 | 0.364 | 1.135 |
| 14 | 17.424 | 15.017 | 12.470 | 6.290 | 3.506 | 2.452 | 1.823 | 1.537 | 1.142 | 1.882 | 1.978 | 2.530 | 4.579 | 4.939 | 5.143 | 5.263 | 7.310 | 8.448 | 8.888 | 9.159 | 9.279 | 9.763 | 9.800 | 9.824 | 4.169 | 3.308 | 1.950 | 0.811 | -0.335 | 5.491 | 4.159 | 0.719 | 1.100 |
| 15 | 16.576 | 13.917 | 10.990 | 5.179 | 2.443 | 1.513 | 1.189 | 1.042 | 0.874 | 1.091 | 1.132 | 1.841 | 3.589 | 4.052 | 4.395 | 4.596 | 7.122 | 8.526 | 8.947 | 9.425 | 9.555 | 9.899 | 9.912 | 9.957 | 3.525 | 2.709 | 1.445 | 0.450 | -0.395 | 4.058 | 2.904 | 0.916 | 1.044 |
| 16 | 15.083 | 12.560 | 9.653 | 4.140 | 1.658 | 0.793 | 0.368 | 0.176 | 0.193 | 0.190 | 0.195 | 0.995 | 2.906 | 3.488 | 3.952 | 4.218 | 6.950 | 8.468 | 8.875 | 9.471 | 9.600 | 9.881 | 9.899 | 9.937 | 3.179 | 2.391 | 1.179 | 0.254 | -0.478 | 3.167 | 2.208 | 0.921 | 0.020 |
| 17 | 13.916 | 11.399 | 8.663 | 3.372 | 1.057 | 0.432 | 0.219 | 0.122 | 0.131 | 0.187 | 0.210 | 0.856 | 2.687 | 3.264 | 3.742 | 4.018 | 6.796 | 8.340 | 8.754 | 9.404 | 9.537 | 9.799 | 9.814 | 9.857 | 2.988 | 2.216 | 1.031 | 0.134 | -0.569 | 2.486 | 1.665 | 0.743 | 0.141 |
| 18 | 13.316 | 10.661 | 7.986 | 2.834 | 0.755 | 0.194 | -0.243 | -0.441 | -0.395 | -0.228 | -0.210 | 0.662 | 2.560 | 3.132 | 3.609 | 3.885 | 6.681 | 8.234 | 8.656 | 9.308 | 9.443 | 9.699 | 9.713 | 9.752 | 2.866 | 2.106 | 0.941 | 0.057 | -0.655 | 2.016 | 1.279 | 0.426 | -0.307 |
| 19 | 12.914 | 10.632 | 8.192 | 2.998 | 0.842 | 0.308 | 0.044 | -0.076 | -0.151 | 0.182 | 0.236 | 1.162 | 2.943 | 3.475 | 3.894 | 4.127 | 6.759 | 8.221 | 8.647 | 9.254 | 9.387 | 9.644 | 9.658 | 9.685 | 3.065 | 2.275 | 1.060 | 0.112 | -0.721 | 2.114 | 1.331 | 0.039 | -0.379 |
| 20 | 12.651 | 10.151 | 7.642 | 2.659 | 0.719 | 0.206 | -0.232 | -0.431 | -0.512 | -0.177 | -0.150 | 0.773 | 2.654 | 3.203 | 3.637 | 3.889 | 6.602 | 8.110 | 8.545 | 9.195 | 9.331 | 9.579 | 9.592 | 9.627 | 2.890 | 2.137 | 0.974 | 0.064 | -0.757 | 1.875 | 1.179 | -0.347 | -0.237 |
| 21 | 12.651 | 10.020 | 7.457 | 2.385 | 0.514 | 0.087 | -0.306 | -0.485 | -0.993 | -0.204 | -0.126 | 0.753 | 2.535 | 3.071 | 3.507 | 3.759 | 6.497 | 8.019 | 8.446 | 9.100 | 9.243 | 9.505 | 9.519 | 9.566 | 2.753 | 2.009 | 0.879 | 0.014 | -0.757 | 1.586 | 0.900 | -0.668 | -0.976 |
| 22 | 12.904 | 10.164 | 7.471 | 2.310 | 0.417 | 0.015 | -0.327 | -0.482 | -0.838 | -0.244 | -0.190 | 0.552 | 2.276 | 2.816 | 3.274 | 3.542 | 6.356 | 7.919 | 8.342 | 9.018 | 9.168 | 9.431 | 9.443 | 9.488 | 2.572 | 1.858 | 0.786 | -0.016 | -0.721 | 1.525 | 0.841 | -0.883 | -0.866 |
| 23 | 13.318 | 10.509 | 7.679 | 2.496 | 0.475 | 0.112 | -0.210 | -0.357 | -0.681 | -0.197 | -0.154 | 0.507 | 2.162 | 2.699 | 3.162 | 3.436 | 6.280 | 7.860 | 8.280 | 8.916 | 9.065 | 9.314 | 9.325 | 9.367 | 2.468 | 1.766 | 0.732 | -0.016 | -0.654 | 1.667 | 0.929 | -0.967 | -0.914 |
| 24 | 13.446 | 10.737 | 7.831 | 2.596 | 0.367 | -0.010 | -0.250 | -0.359 | -0.757 | -0.206 | -0.158 | 0.468 | 2.094 | 2.615 | 3.067 | 3.337 | 6.186 | 7.769 | 8.183 | 8.811 | 8.961 | 9.204 | 9.214 | 9.256 | 2.301 | 1.694 | 0.699 | 0.003 | -0.567 | 1.762 | 0.983 | -0.921 | -0.958 |
| 25 | 13.579 | 10.810 | 8.050 | 2.861 | 0.487 | 0.051 | -0.076 | -0.134 | -0.275 | 0.087 | 0.146 | 0.683 | 2.285 | 2.836 | 3.339 | 3.622 | 5.998 | 7.318 | 7.984 | 8.705 | 8.973 | 9.149 | 9.163 | 9.219 | 2.587 | 1.855 | 0.816 | 0.096 | -0.474 | 1.973 | 1.116 | -0.756 | -0.462 |

REMARKS:

| STATION | LIBMANAN | CUYAPI | NAGA | OMBAO | STO. DOMINGO | LAKE BATO |
|---|---|---|---|---|---|---|
| PEAK STAGE M.MSL | 3.218 | 3.072 | 2.671 | 7.474 | 9.958 | 9.958 |
| TIME | 13 - 13 - 0 | 13 - 13 - 0 | 13 - 8 - 30 | 13 - 14 - 0 | 15 - 12 - 0 | 15 - 12 - 0 |

TABLE 5.12 DAILY WATER LEVELS ALONG BICOL - SIPOCOT RIVERS IN METERS ABOVE MSL.

RETURN PERIOD OF DESIGN FLOOD 13 YEARS

FLOOD PROTECTION SCHEME : (II) NONE

| RIVER | SIPOCOT RIVER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOWN | SABANG | | | | LIBMANAN | | | CUYAPI | | | NAGA | | | | OMBAO | | | | STO. DOMINGO | | | | | LAKE BATO | | | PASACAO | | | BARCELONA | | BOLONGAY | |
| NODE NO / DATE | 1 | 2 | 3 | 4 | 5 | 6 | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 5 | 11.802 | 9.498 | 5.751 | 2.109 | 0.319 | 0.153 | 0.121 | 0.106 | 0.097 | 0.126 | 0.131 | 0.254 | 1.104 | 1.446 | 1.811 | 1.990 | 3.611 | 4.512 | 4.976 | 5.969 | 6.532 | 6.876 | 6.880 | 6.895 | 1.601 | 1.018 | 0.436 | -0.148 | -0.733 | 1.438 | 0.766 | 0.085 | 0.085 |
| 6 | 11.780 | 9.351 | 6.068 | 2.210 | 0.349 | -0.057 | -0.301 | -0.413 | -0.354 | -0.467 | -0.482 | -0.334 | 0.951 | 1.301 | 1.669 | 1.848 | 3.478 | 4.386 | 4.853 | 5.874 | 6.552 | 6.862 | 6.866 | 6.881 | 1.572 | 1.123 | 0.613 | 0.008 | -0.718 | 1.306 | 0.444 | -0.336 | -0.336 |
| 7 | 11.706 | 9.101 | 6.136 | 2.443 | 0.382 | -0.066 | -0.429 | -0.594 | -0.728 | -0.649 | -0.643 | -0.386 | 0.891 | 1.246 | 1.620 | 1.797 | 3.463 | 4.389 | 4.850 | 5.982 | 6.564 | 6.879 | 6.883 | 6.900 | 1.533 | 1.105 | 0.622 | 0.045 | -0.669 | 1.377 | 0.319 | -0.711 | -0.711 |
| 8 | 11.734 | 9.076 | 5.986 | 2.420 | 0.388 | -0.035 | -0.421 | -0.596 | -0.910 | -0.625 | -0.609 | -0.305 | 0.906 | 1.263 | 1.640 | 1.820 | 3.485 | 4.411 | 4.871 | 5.908 | 6.588 | 6.903 | 6.907 | 6.924 | 1.556 | 1.133 | 0.661 | 0.103 | -0.595 | 1.337 | 0.219 | -0.950 | -0.950 |
| 9 | 11.753 | 9.224 | 6.043 | 2.445 | 0.458 | 0.083 | -0.298 | -0.472 | -0.899 | -0.471 | -0.448 | -0.135 | 0.976 | 1.337 | 1.717 | 1.900 | 3.555 | 4.474 | 4.937 | 5.987 | 6.562 | 6.921 | 6.926 | 6.946 | 1.621 | 1.186 | 0.712 | 0.166 | -0.508 | 1.381 | 0.255 | -0.998 | -0.998 |
| 10 | 11.744 | 9.265 | 5.871 | 2.417 | 0.445 | 0.198 | -0.143 | -0.299 | -0.688 | -0.239 | -0.209 | 0.108 | 1.050 | 1.394 | 1.765 | 1.943 | 3.580 | 4.489 | 4.954 | 6.010 | 6.582 | 6.942 | 6.946 | 6.967 | 1.651 | 1.203 | 0.731 | 0.206 | -0.422 | 1.451 | 0.397 | -0.841 | -0.841 |
| 11 | 11.745 | 9.505 | 5.921 | 2.414 | 0.709 | 0.405 | 0.108 | -0.027 | -0.352 | 0.066 | 0.119 | 0.407 | 1.149 | 1.462 | 1.808 | 1.985 | 3.605 | 4.506 | 4.972 | 6.024 | 6.595 | 6.956 | 6.960 | 6.982 | 1.667 | 1.202 | 0.728 | 0.222 | -0.353 | 1.562 | 0.626 | -0.510 | -0.510 |
| 12 | 11.950 | 11.191 | 8.461 | 4.632 | 1.789 | 1.060 | 0.681 | 0.509 | 0.147 | 0.904 | 0.986 | 1.764 | 3.198 | 3.689 | 4.114 | 4.337 | 5.409 | 6.004 | 6.414 | 7.072 | 7.370 | 7.612 | 7.613 | 7.484 | 3.582 | 2.580 | 1.618 | 0.669 | -0.312 | 3.144 | 1.631 | -0.077 | -0.077 |
| 13 | 18.952 | 16.956 | 14.316 | 10.803 | 5.850 | 3.927 | 2.757 | 2.226 | 0.765 | 1.888 | 2.017 | 2.722 | 5.152 | 6.246 | 6.749 | 7.022 | 7.694 | 8.067 | 8.354 | 8.299 | 8.315 | 8.925 | 8.970 | 8.986 | 5.841 | 4.242 | 2.701 | 1.196 | -0.305 | 7.265 | 3.070 | 0.364 | 0.364 |
| 14 | 17.140 | 15.026 | 12.628 | 9.245 | 5.142 | 3.563 | 2.545 | 2.083 | 1.258 | 2.316 | 2.412 | 2.834 | 5.441 | 6.101 | 6.547 | 6.837 | 7.987 | 8.627 | 9.013 | 9.264 | 9.374 | 9.787 | 9.820 | 9.839 | 5.916 | 4.427 | 2.872 | 1.271 | -0.335 | 6.535 | 3.708 | 0.719 | 0.719 |
| 15 | 15.578 | 13.086 | 10.047 | 6.690 | 3.390 | 2.202 | 1.597 | 1.322 | 1.022 | 1.601 | 1.689 | 2.473 | 4.789 | 5.467 | 6.005 | 6.334 | 7.763 | 8.558 | 8.995 | 9.485 | 9.620 | 9.931 | 9.952 | 9.983 | 5.422 | 4.012 | 2.559 | 1.074 | -0.335 | 4.790 | 2.870 | 0.916 | 0.916 |
| 16 | 13.710 | 11.443 | 8.322 | 5.089 | 2.273 | 1.383 | 1.114 | 0.992 | 0.952 | 1.176 | 1.223 | 2.274 | 4.415 | 5.115 | 5.695 | 6.038 | 7.551 | 8.392 | 8.858 | 9.491 | 9.657 | 9.915 | 9.930 | 9.967 | 5.168 | 3.820 | 2.417 | 0.966 | -0.478 | 3.680 | 2.283 | 0.921 | 0.921 |
| 17 | 12.291 | 10.875 | 7.541 | 4.125 | 1.514 | 0.871 | 0.832 | 0.814 | 0.766 | 0.959 | 1.010 | 2.032 | 4.137 | 4.839 | 5.429 | 5.770 | 7.330 | 8.196 | 8.691 | 9.401 | 9.556 | 9.825 | 9.841 | 9.884 | 4.940 | 3.650 | 2.297 | 0.873 | -0.569 | 2.934 | 1.796 | 0.743 | 0.743 |
| 18 | 12.942 | 10.492 | 7.181 | 3.788 | 1.258 | 0.598 | 0.492 | 0.444 | 0.424 | 0.658 | 0.701 | 1.809 | 3.947 | 4.652 | 5.249 | 5.587 | 7.175 | 8.057 | 8.567 | 9.291 | 9.450 | 9.718 | 9.733 | 9.774 | 4.785 | 3.541 | 2.224 | 0.813 | -0.655 | 2.601 | 1.464 | 0.426 | 0.426 |
| 19 | 12.577 | 10.690 | 7.523 | 4.115 | 1.357 | 0.689 | 0.244 | 0.087 | 0.055 | 0.602 | 0.679 | 1.968 | 4.086 | 4.823 | 5.406 | 5.732 | 7.233 | 8.066 | 8.559 | 9.230 | 9.386 | 9.657 | 9.671 | 9.702 | 4.893 | 3.623 | 2.282 | 0.831 | -0.721 | 2.676 | 1.304 | 0.039 | 0.039 |
| 20 | 12.495 | 10.190 | 7.019 | 3.798 | 1.261 | 0.520 | 0.057 | -0.154 | -0.302 | 0.430 | 0.525 | 1.928 | 4.029 | 4.693 | 5.253 | 5.575 | 7.098 | 7.945 | 8.455 | 9.167 | 9.327 | 9.588 | 9.601 | 9.638 | 4.302 | 3.585 | 2.278 | 0.837 | -0.757 | 2.401 | 1.005 | -0.347 | -0.347 |
| 21 | 12.635 | 10.241 | 6.899 | 3.484 | 0.954 | 0.306 | -0.136 | -0.337 | -0.585 | 0.275 | 0.369 | 1.707 | 3.825 | 4.607 | 5.078 | 5.396 | 6.950 | 7.814 | 8.329 | 9.062 | 9.231 | 9.508 | 9.522 | 9.571 | 4.635 | 3.489 | 2.204 | 0.815 | -0.767 | 2.106 | 0.721 | -0.668 | -0.668 |
| 22 | 12.075 | 10.564 | 7.009 | 3.486 | 0.937 | 0.298 | -0.168 | -0.379 | -0.758 | 0.148 | 0.230 | 1.489 | 3.623 | 4.194 | 4.868 | 5.184 | 6.787 | 7.678 | 8.204 | 8.971 | 9.149 | 9.429 | 9.442 | 9.489 | 4.465 | 3.341 | 2.142 | 0.810 | -0.721 | 2.085 | 0.538 | -0.883 | -0.883 |
| 23 | 12.498 | 10.983 | 7.332 | 3.807 | 1.045 | 0.355 | -0.111 | -0.322 | -0.797 | 0.073 | 0.148 | 1.293 | 3.420 | 4.106 | 4.691 | 5.015 | 6.669 | 7.589 | 8.121 | 8.859 | 9.038 | 9.307 | 9.318 | 9.363 | 4.306 | 3.217 | 2.067 | 0.804 | -0.654 | 2.304 | 0.736 | -0.967 | -0.967 |
| 24 | 12.365 | 10.967 | 7.346 | 3.871 | 1.150 | 0.461 | -0.003 | -0.214 | -0.710 | 0.125 | 0.194 | 1.268 | 3.327 | 4.003 | 4.575 | 4.891 | 6.552 | 7.475 | 8.011 | 8.744 | 8.926 | 9.191 | 9.202 | 9.245 | 4.199 | 3.133 | 2.021 | 0.814 | -0.567 | 2.404 | 0.840 | -0.921 | -0.921 |
| 25 | 12.275 | 10.950 | 7.502 | 4.063 | 1.242 | 0.558 | 0.136 | -0.055 | -0.524 | 0.266 | 0.354 | 1.312 | 3.263 | 3.920 | 4.474 | 4.782 | 6.436 | 7.356 | 7.889 | 8.638 | 8.824 | 9.127 | 9.142 | 9.206 | 4.093 | 3.044 | 1.964 | 0.814 | -0.474 | 2.593 | 1.029 | -0.756 | -0.756 |

REMARKS:

| STATION | LIBMANAN | CUYAPI | NAGA | OMBAO | STO. DOMINGO | LAKE BATO |
|---|---|---|---|---|---|---|
| PEAK STAGE M.MSL | 3.880 | 3.256 | 3.081 | 8.111 | 9.987 | 9.987 |
| TIME | 13 - 11 - 0 | 13 - 11 - 0 | 13 - 15 - 0 | 13 - 15 - 0 | 15 - 12 - 0 | 15 - 12 - 0 |

## TABLE 5.13 DAILY WATER LEVELS ALONG BICOL - SIPOCOT RIVERS IN METERS ABOVE MSL.

### RETURN PERIOD OF DESIGN FLOOD 50 YEARS

### FLOOD PROTECTION SCHEME : (1) POLUNTUNA RESERVOIR

| RIVER | SIPOCOT RIVER | | | | | | | | | BICOL RIVER | | | | | | | | | | | | | | | BICOL-RAGAY DIVERSION | | | | | SIPOCOT-SAN MIGUEL DIVERSION | | | SAN MIGUEL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOWN | SABANG | | | | LIBMANAN | | | CUYAPI | | NAGA | | | OMBAO | | | | | STO. DOMINGO | | | | | | LAKE BATO | | | PASACAO | | | BARCELONA | | | BOLONGAY |
| DATE \ NODE NO. | 1 | 2 | 3 | 4 | 5 | 6 | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 5 | 12.483 | 9.951 | 6.825 | 3.407 | 0.845 | 0.845 | 0.206 | 0.143 | 0.101 | 0.153 | 0.162 | 0.389 | 1.441 | 1.828 | 2.214 | 2.419 | 3.941 | 4.787 | 5.265 | 6.159 | 6.677 | 7.013 | 7.017 | 7.029 | 1.967 | 1.291 | 0.616 | -0.059 | -0.733 | 2.802 | 1.198 | 0.095 | 0.095 |
| 6 | 12.437 | 9.921 | 6.752 | 3.252 | 0.817 | 0.194 | -0.185 | -0.358 | -0.356 | -0.415 | -0.428 | -0.144 | 1.325 | 1.723 | 2.130 | 2.326 | 4.723 | 5.203 | 5.203 | 6.155 | 6.689 | 7.037 | 7.042 | 7.056 | 1.990 | 1.446 | 0.837 | 0.125 | -0.718 | 2.062 | 0.788 | -0.336 | -0.336 |
| 7 | 12.459 | 9.916 | 6.830 | 3.338 | 0.794 | 0.159 | -0.297 | -0.604 | -0.717 | -0.640 | -0.521 | -0.101 | 1.407 | 1.820 | 2.234 | 2.456 | 3.975 | 4.830 | 5.309 | 6.211 | 6.726 | 7.066 | 7.070 | 7.082 | 2.078 | 1.522 | 0.908 | 0.194 | -0.669 | 1.973 | 0.616 | -0.711 | -0.711 |
| 8 | 12.452 | 9.918 | 6.751 | 3.288 | 0.793 | 0.180 | -0.296 | -0.512 | -0.896 | -0.531 | -0.506 | -0.076 | 1.350 | 1.759 | 2.173 | 2.372 | 3.911 | 4.766 | 5.247 | 6.204 | 6.735 | 7.087 | 7.092 | 7.107 | 2.040 | 1.508 | 0.921 | 0.239 | -0.595 | 1.925 | 0.518 | -0.950 | -0.950 |
| 9 | 12.474 | 9.932 | 6.837 | 3.363 | 0.807 | 0.224 | -0.214 | -0.413 | -0.885 | -0.377 | -0.338 | 0.118 | 1.452 | 1.869 | 2.284 | 2.488 | 4.017 | 4.867 | 5.347 | 6.258 | 6.768 | 7.112 | 7.116 | 7.129 | 2.123 | 1.566 | 0.971 | 0.300 | -0.508 | 2.003 | 0.574 | -0.998 | -0.998 |
| 10 | 12.461 | 9.928 | 6.760 | 3.294 | 0.886 | 0.380 | -0.017 | -0.197 | -0.681 | -0.193 | -0.152 | 0.283 | 1.429 | 1.828 | 2.234 | 2.433 | 3.954 | 4.799 | 5.280 | 6.246 | 6.774 | 7.129 | 7.134 | 7.150 | 2.081 | 1.534 | 0.958 | 0.324 | -0.422 | 2.052 | 0.709 | -0.841 | -0.841 |
| 11 | 12.477 | 9.935 | 6.847 | 3.353 | 0.948 | 0.506 | 0.216 | 0.084 | -0.330 | 0.039 | 0.156 | 0.524 | 1.555 | 1.948 | 2.348 | 2.549 | 4.058 | 4.896 | 5.376 | 6.295 | 6.804 | 7.151 | 7.155 | 7.169 | 2.152 | 1.567 | 0.974 | 0.348 | -0.353 | 2.203 | 0.958 | -0.510 | -0.510 |
| 12 | 13.745 | 12.325 | 10.443 | 6.379 | 2.783 | 1.606 | 0.998 | 0.722 | 0.187 | 1.171 | 1.283 | 2.120 | 3.713 | 4.417 | 4.944 | 5.199 | 6.269 | 6.864 | 7.168 | 7.594 | 7.659 | 8.062 | 8.067 | 7.965 | 4.326 | 3.142 | 1.986 | 0.860 | -0.312 | 4.297 | 2.214 | -0.077 | -0.077 |
| 13 | 16.640 | 15.603 | 14.434 | 10.981 | 6.055 | 4.108 | 2.897 | 2.347 | 0.830 | 2.034 | 2.153 | 2.819 | 5.230 | 6.265 | 6.798 | 7.079 | 7.977 | 8.476 | 8.798 | 8.718 | 8.733 | 9.482 | 9.554 | 9.573 | 5.810 | 4.306 | 2.751 | 1.222 | -0.305 | 7.452 | 3.987 | 0.364 | 0.364 |
| 14 | 17.418 | 15.321 | 13.282 | 9.699 | 5.363 | 3.687 | 2.639 | 2.163 | 1.320 | 2.406 | 2.508 | 2.936 | 5.645 | 6.419 | 6.921 | 7.256 | 8.509 | 9.204 | 9.546 | 9.842 | 9.948 | 10.413 | 10.458 | 10.458 | 6.251 | 4.679 | 3.046 | 1.363 | -0.335 | 6.822 | 3.847 | 0.719 | 0.719 |
| 15 | 16.317 | 13.836 | 11.416 | 7.840 | 4.081 | 2.659 | 1.867 | 1.501 | 1.063 | 1.824 | 1.923 | 2.623 | 5.233 | 6.017 | 6.609 | 6.986 | 8.412 | 9.204 | 9.571 | 10.127 | 10.248 | 10.583 | 10.612 | 10.660 | 5.974 | 4.444 | 2.833 | 1.211 | -0.396 | 5.551 | 3.247 | 0.916 | 0.916 |
| 16 | 15.112 | 12.558 | 9.908 | 6.381 | 3.031 | 1.863 | 1.366 | 1.140 | 0.980 | 1.437 | 1.518 | 2.513 | 4.984 | 5.784 | 6.414 | 6.803 | 8.292 | 9.120 | 9.500 | 10.160 | 10.184 | 10.573 | 10.596 | 10.648 | 5.823 | 4.314 | 2.749 | 1.183 | -0.478 | 4.586 | 2.698 | 0.921 | 0.921 |
| 17 | 14.287 | 11.723 | 8.996 | 5.545 | 2.386 | 1.339 | 0.992 | 0.835 | 0.775 | 1.240 | 1.317 | 2.465 | 4.839 | 5.680 | 6.292 | 6.681 | 8.187 | 9.024 | 9.415 | 10.102 | 10.226 | 10.500 | 10.521 | 10.675 | 5.718 | 4.239 | 2.693 | 1.074 | -0.569 | 3.872 | 2.256 | 0.743 | 0.743 |
| 18 | 13.741 | 11.163 | 8.291 | 4.834 | 1.319 | 0.966 | 0.624 | 0.468 | 0.450 | 1.064 | 1.149 | 2.412 | 4.728 | 5.511 | 6.143 | 6.524 | 8.038 | 8.880 | 9.285 | 10.009 | 10.137 | 10.402 | 10.420 | 10.474 | 5.598 | 4.163 | 2.648 | 1.030 | -0.655 | 3.294 | 1.804 | 0.426 | 0.426 |
| 19 | 13.408 | 10.842 | 7.948 | 4.493 | 1.622 | 0.726 | 0.509 | 0.120 | 0.071 | 0.934 | 1.027 | 2.357 | 4.612 | 5.386 | 6.012 | 6.385 | 7.901 | 8.744 | 9.165 | 9.897 | 10.026 | 10.290 | 10.307 | 10.361 | 5.480 | 4.083 | 2.601 | 0.936 | -0.721 | 2.943 | 1.441 | 0.039 | 0.039 |
| 20 | 13.123 | 10.599 | 7.544 | 4.104 | 1.359 | 0.559 | 0.089 | -0.125 | -0.290 | 0.670 | 0.775 | 2.285 | 4.498 | 5.239 | 5.852 | 6.214 | 7.736 | 8.581 | 9.020 | 9.779 | 9.912 | 10.172 | 10.188 | 10.240 | 5.345 | 3.995 | 2.555 | 0.979 | -0.757 | 2.597 | 1.100 | -0.347 | -0.347 |
| 21 | 12.895 | 10.447 | 7.372 | 3.966 | 1.197 | 0.435 | -0.040 | -0.256 | -0.550 | 0.581 | 0.691 | 2.208 | 4.379 | 5.119 | 5.726 | 6.080 | 7.603 | 8.449 | 8.905 | 9.653 | 9.788 | 10.049 | 10.064 | 10.117 | 5.226 | 3.909 | 2.510 | 0.972 | -0.757 | 2.431 | 0.884 | -0.668 | -0.668 |
| 22 | 12.725 | 10.286 | 7.153 | 3.728 | 1.090 | 0.386 | -0.089 | -0.306 | -0.686 | 0.505 | 0.606 | 2.112 | 4.264 | 4.977 | 5.570 | 5.914 | 7.444 | 8.294 | 8.771 | 9.532 | 9.670 | 9.931 | 9.946 | 9.996 | 5.090 | 3.814 | 2.462 | 0.978 | -0.721 | 2.253 | 0.725 | -0.883 | -0.883 |
| 23 | 12.705 | 10.234 | 7.207 | 3.772 | 1.063 | 0.384 | -0.070 | -0.277 | -0.722 | 0.455 | 0.558 | 2.005 | 4.150 | 4.864 | 4.455 | 5.794 | 7.329 | 8.181 | 8.675 | 9.414 | 9.556 | 9.821 | 9.836 | 9.885 | 4.975 | 3.712 | 2.410 | 0.980 | -0.654 | 2.283 | 0.727 | -0.967 | -0.967 |
| 24 | 12.676 | 10.205 | 7.094 | 3.660 | 1.061 | 0.430 | -0.005 | -0.203 | -0.647 | 0.453 | 0.574 | 1.904 | 4.042 | 4.736 | 5.316 | 5.648 | 7.193 | 8.051 | 8.556 | 9.308 | 9.454 | 9.719 | 9.733 | 9.780 | 4.851 | 3.628 | 2.356 | 0.986 | -0.567 | 2.262 | 0.767 | -0.921 | -0.921 |
| 25 | 12.694 | 10.213 | 7.193 | 3.751 | 1.070 | 0.452 | 0.089 | -0.076 | -0.488 | 0.497 | 0.613 | 1.849 | 3.947 | 4.644 | 5.225 | 5.553 | 7.101 | 7.961 | 8.470 | 9.204 | 9.353 | 9.624 | 9.638 | 9.684 | 4.753 | 3.541 | 2.298 | 0.984 | -0.474 | 2.383 | 0.921 | -0.756 | -0.756 |

**REMARKS:**

| STATION | LIBMANAN | CUYAPI | NAGA | OMBAO | STO. DOMINGO | LAKE BATO |
|---|---|---|---|---|---|---|
| PEAK STAGE M.MSL | 3.728 | 2.911 | 3.178 | 8.555 | 10.667 | 10.667 |
| TIME | 13 - 11 - 30 | 13 - 10 - 30 | 13 - 13 - 30 | 13 - 18 - 0 | 15 - 12 - 0 | 15 - 12 - 0 |

## TABLE 5.14 DAILY WATER LEVELS ALONG BICOL - SIPOCOT RIVERS IN METERS ABOVE MSL.

### RETURN PERIOD OF DESIGN FLOOD 50 YEARS

### FLOOD PROTECTION SCHEME : ② SIPOCOT - SAN MIGUEL DIVERSION

| RIVER | SIPOCOT RIVER | | | | | | | | BICOL RIVER | | | | | | | | | | | | | | | BICOL-RAGAY DIVERSION | | | | | SIPOCOT-SAN MIGUEL DIVERSION | | | SAN MIGUEL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOWN | | | | SABANG | | | LIBMANAN | | CUYAPI | | | NAGA | | | | OMBAO | | | | | | STO. DOMINGO | LAKE BATO | | | | | PASACAO | | | BARCELONA | BOLONGAY |
| DATE \ NODE NO | 1 | 2 | 3 | 4 | 5 | 6 | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 5 | 12.570 | 9.777 | 7.413 | 2.328 | 0.432 | 0.198 | 0.142 | 0.117 | 0.100 | 0.151 | 0.160 | 0.384 | 1.428 | 1.813 | 2.207 | 2.401 | 3.925 | 4.771 | 5.249 | 6.139 | 6.658 | 6.992 | 6.996 | 7.008 | 1.951 | 1.279 | 0.608 | -0.063 | -0.733 | 1.533 | 0.825 | 0.095 | 0.095 |
| 6 | 12.453 | 9.673 | 7.306 | 2.162 | 0.414 | -0.002 | -0.274 | -0.398 | -0.355 | -0.486 | -0.432 | -0.152 | 1.313 | 1.709 | 2.114 | 2.308 | 3.851 | 4.708 | 5.186 | 6.136 | 6.671 | 7.018 | 7.023 | 7.037 | 1.975 | 1.435 | 0.829 | 0.121 | -0.718 | 1.408 | 0.777 | -0.336 | -0.336 |
| 7 | 12.609 | 9.735 | 7.395 | 2.224 | 0.373 | -0.047 | -0.406 | -0.570 | -0.720 | -0.544 | -0.525 | -0.108 | 1.396 | 1.807 | 2.219 | 2.421 | 3.961 | 4.817 | 5.256 | 6.194 | 6.710 | 7.049 | 7.053 | 7.065 | 2.065 | 1.511 | 0.901 | 0.190 | -0.669 | 1.438 | 0.793 | -0.711 | -0.711 |
| 8 | 12.476 | 9.695 | 7.329 | 2.190 | 0.382 | -0.013 | -0.412 | -0.578 | -0.898 | -0.534 | -0.511 | -0.083 | 1.339 | 1.747 | 2.159 | 2.358 | 3.898 | 4.754 | 5.234 | 6.189 | 6.720 | 7.071 | 7.076 | 7.091 | 2.027 | 1.498 | 0.915 | 0.236 | -0.555 | 1.426 | 0.778 | -0.950 | -0.950 |
| 9 | 12.617 | 9.749 | 7.406 | 2.241 | 0.443 | 0.097 | -0.281 | -0.453 | -0.884 | -0.379 | -0.341 | 0.114 | 1.443 | 1.858 | 2.272 | 2.475 | 4.005 | 4.856 | 5.335 | 6.242 | 6.756 | 7.098 | 7.102 | 7.115 | 2.111 | 1.567 | 0.965 | 0.297 | -0.508 | 1.438 | 0.722 | -0.998 | -0.998 |
| 10 | 12.481 | 9.701 | 7.332 | 2.198 | 0.471 | 0.162 | -0.147 | -0.288 | -0.690 | -0.195 | -0.154 | 0.280 | 1.420 | 1.817 | 2.222 | 2.420 | 3.943 | 4.788 | 5.270 | 6.233 | 6.762 | 7.116 | 7.121 | 7.137 | 2.070 | 1.526 | 0.952 | 0.321 | -0.422 | 1.416 | 0.668 | -0.841 | -0.841 |
| 11 | 12.617 | 9.751 | 7.405 | 2.248 | 0.698 | 0.410 | 0.112 | -0.025 | -0.337 | 0.095 | 0.152 | 0.520 | 1.547 | 1.939 | 2.338 | 2.538 | 4.048 | 4.887 | 5.367 | 6.284 | 6.793 | 7.139 | 7.143 | 7.157 | 2.143 | 1.560 | 0.969 | 0.346 | -0.353 | 1.442 | 0.676 | -0.510 | -0.510 |
| 12 | 14.733 | 13.018 | 11.239 | 4.895 | 1.999 | 1.214 | 0.780 | 0.583 | 0.184 | 1.170 | 1.280 | 2.120 | 3.773 | 4.416 | 4.943 | 5.198 | 6.269 | 6.863 | 7.167 | 7.382 | 7.656 | 8.056 | 8.061 | 7.956 | 4.325 | 3.142 | 1.996 | 0.860 | -0.312 | 3.686 | 2.468 | -0.077 | -0.077 |
| 13 | 18.824 | 17.119 | 15.492 | 8.545 | 4.676 | 3.157 | 2.234 | 1.815 | 0.766 | 2.035 | 2.153 | 2.819 | 5.230 | 6.264 | 6.797 | 7.078 | 7.975 | 8.474 | 8.796 | 8.716 | 8.729 | 9.477 | 9.549 | 9.568 | 5.909 | 4.305 | 2.760 | 1.222 | -0.305 | 7.406 | 5.820 | 0.364 | 0.364 |
| 14 | 17.023 | 15.214 | 13.475 | 6.815 | 3.836 | 2.694 | 2.032 | 1.730 | 1.315 | 2.506 | 2.601 | 2.993 | 5.641 | 6.415 | 6.917 | 7.252 | 8.505 | 9.201 | 9.543 | 9.838 | 9.944 | 10.409 | 10.454 | 10.484 | 6.248 | 4.677 | 3.044 | 1.362 | -0.335 | 5.962 | 4.586 | 0.719 | 0.718 |
| 15 | 15.216 | 12.925 | 11.023 | 5.263 | 2.544 | 1.665 | 1.335 | 1.185 | 1.046 | 1.863 | 1.962 | 2.627 | 5.230 | 6.014 | 6.606 | 6.982 | 8.408 | 9.200 | 9.568 | 10.123 | 10.244 | 10.580 | 10.608 | 10.656 | 5.971 | 4.421 | 2.831 | 1.210 | -0.395 | 4.139 | 2.978 | 0.916 | 0.916 |
| 16 | 14.266 | 11.733 | 9.719 | 4.162 | 1.738 | 1.126 | 1.049 | 1.015 | 0.975 | 1.437 | 1.518 | 2.512 | 4.981 | 5.780 | 6.411 | 6.800 | 8.288 | 9.116 | 9.497 | 10.156 | 10.280 | 10.570 | 10.593 | 10.645 | 5.820 | 4.311 | 2.747 | 1.132 | -0.478 | 3.180 | 2.215 | 0.921 | 0.921 |
| 17 | 13.824 | 11.172 | 9.082 | 3.666 | 1.292 | 0.791 | 0.809 | 0.817 | 0.775 | 1.236 | 1.312 | 2.464 | 4.837 | 5.647 | 6.289 | 6.677 | 8.184 | 9.021 | 9.412 | 10.089 | 10.223 | 10.498 | 10.518 | 10.572 | 5.715 | 4.236 | 2.692 | 1.073 | -0.568 | 2.732 | 1.853 | 0.743 | 0.743 |
| 18 | 13.422 | 10.718 | 8.542 | 3.211 | 0.995 | 0.485 | 0.468 | 0.460 | 0.441 | 1.061 | 1.145 | 2.412 | 4.725 | 5.508 | 6.140 | 6.521 | 8.035 | 8.876 | 9.282 | 10.006 | 10.134 | 10.399 | 10.418 | 10.472 | 5.596 | 4.161 | 2.646 | 1.029 | -0.653 | 2.343 | 1.542 | 0.426 | 0.426 |
| 19 | 13.305 | 10.538 | 8.325 | 3.028 | 0.845 | 0.316 | 0.121 | 0.033 | 0.035 | 0.869 | 0.936 | 2.356 | 4.610 | 5.383 | 6.009 | 6.382 | 7.898 | 8.741 | 9.162 | 9.895 | 10.024 | 10.288 | 10.305 | 10.369 | 5.477 | 4.081 | 2.599 | 0.996 | -0.721 | 2.164 | 1.390 | 0.039 | 0.039 |
| 20 | 12.939 | 10.255 | 7.962 | 2.755 | 0.697 | 0.207 | -0.100 | -0.239 | -0.299 | 0.667 | 0.771 | 2.284 | 4.493 | 5.237 | 5.849 | 6.211 | 7.733 | 8.579 | 9.018 | 9.777 | 9.909 | 10.159 | 10.185 | 10.238 | 5.343 | 3.993 | 2.554 | 0.978 | -0.757 | 1.943 | 1.228 | -0.347 | -0.347 |
| 21 | 12.836 | 10.142 | 7.818 | 2.663 | 0.595 | 0.136 | -0.210 | -0.347 | -0.560 | 0.577 | 0.687 | 2.206 | 4.377 | 5.116 | 5.723 | 6.078 | 7.601 | 8.447 | 8.903 | 9.651 | 9.786 | 10.047 | 10.062 | 10.115 | 5.224 | 3.907 | 2.509 | 0.971 | -0.757 | 1.838 | 1.129 | -0.668 | -0.668 |
| 22 | 12.656 | 9.998 | 7.636 | 2.486 | 0.539 | 0.121 | -0.243 | -0.409 | -0.695 | 0.501 | 0.602 | 2.110 | 4.262 | 4.975 | 5.567 | 5.912 | 7.442 | 8.292 | 8.769 | 9.529 | 9.668 | 9.929 | 9.944 | 9.934 | 5.086 | 3.812 | 2.461 | 0.974 | -0.721 | 1.694 | 1.002 | -0.883 | -0.883 |
| 23 | 12.825 | 10.068 | 7.738 | 2.555 | 0.546 | 0.140 | -0.210 | -0.370 | -0.733 | 0.451 | 0.555 | 2.003 | 4.148 | 4.862 | 5.453 | 5.792 | 7.327 | 8.176 | 8.674 | 9.412 | 9.554 | 9.819 | 9.834 | 9.883 | 4.973 | 3.721 | 2.409 | 0.979 | -0.654 | 1.720 | 0.977 | -0.967 | -0.967 |
| 24 | 12.657 | 9.998 | 7.638 | 2.483 | 0.571 | 0.183 | -0.146 | -0.296 | -0.650 | 0.450 | 0.571 | 1.902 | 4.041 | 4.734 | 5.314 | 5.646 | 7.191 | 8.049 | 8.554 | 9.306 | 9.452 | 9.717 | 9.731 | 9.778 | 4.850 | 3.627 | 2.355 | 0.985 | -0.567 | 1.674 | 0.913 | -0.921 | -0.921 |
| 25 | 12.825 | 10.068 | 7.735 | 2.558 | 0.622 | 0.269 | -0.020 | -0.151 | -0.494 | 0.496 | 0.610 | 1.847 | 3.945 | 4.642 | 5.223 | 5.551 | 7.099 | 7.959 | 8.468 | 9.202 | 9.352 | 9.622 | 9.636 | 9.682 | 4.751 | 3.540 | 2.297 | 0.984 | -0.474 | 1.709 | 0.891 | -0.756 | -0.756 |

**REMARKS:**

| STATION | LIBMANAN | CUYAPI | NAGA | OMBAO | STO. DOMINGO | LAKE BATO |
|---|---|---|---|---|---|---|
| PEAK STAGE M. MSL | 3.147 | 2.785 | 3.499 | 8.552 | 10.664 | 10.664 |
| TIME | 13 - 11 - 0 | 13 - 10 - 30 | 13 - 13 - 30 | 13 - 18 - 30 | 15 - 12 - 0 | 15 - 12 - 0 |

## TABLE 5.15 DAILY WATER LEVELS ALONG BICOL - SIPOCOT RIVERS IN METERS ABOVE MSL.

### RETURN PERIOD OF DESIGN FLOOD 50 YEARS

### FLOOD PROTECTION SCHEME : ③ TIDAL BARRIER

| RIVER | SIPOCOT RIVER | | | | | | | | | BICOL RIVER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOWN | SABANG | | | | LIBMANAN | | | CUYAPI | | NAGA | | | OMBAO | | | | | | | STO. DOMINGO | | | | | LAKE BATO | | | | PASACAO | | | BARCELONA | | | BOLONGAY | | | | | | | |
| NODE NO / DATE | 1 | 2 | 3 | 4 | 5 | 6 | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | | | | | | | | | |
| 5 | 12.496 | 9.980 | 6.846 | 3.459 | 0.878 | 0.359 | 0.212 | 0.146 | 0.101 | 0.182 | 0.161 | 0.385 | 1.428 | 1.813 | 2.207 | 2.401 | 3.925 | 4.771 | 5.249 | 6.139 | 6.658 | 6.992 | 6.996 | 7.008 | 1.952 | 1.280 | 0.608 | -0.063 | -0.733 | 2.338 | 1.217 | 0.095 | 0.095 | | | | | | | | | |
| 6 | 12.274 | 9.883 | 6.731 | 3.282 | 0.752 | 0.098 | -0.521 | -0.511 | -0.471 | -0.548 | -0.578 | -0.234 | 1.292 | 1.692 | 2.101 | 2.298 | 3.850 | 4.713 | 5.191 | 6.136 | 6.671 | 7.018 | 7.023 | 7.037 | 1.962 | 1.422 | 0.819 | 0.115 | -0.718 | 2.023 | 0.799 | -0.336 | -0.657 | | | | | | | | | |
| 7 | 12.531 | 9.949 | 6.820 | 3.343 | 0.763 | 0.129 | -0.327 | -0.534 | -0.916 | -0.516 | -0.516 | -0.087 | 1.390 | 1.803 | 2.216 | 2.418 | 3.961 | 4.819 | 5.297 | 6.184 | 6.710 | 7.049 | 7.053 | 7.065 | 2.061 | 1.507 | 0.897 | 0.188 | -0.669 | 1.976 | 0.618 | -0.711 | -1.121 | | | | | | | | | |
| 8 | 12.398 | 9.905 | 6.749 | 3.321 | 0.766 | 0.150 | -0.299 | -0.503 | -0.591 | -0.498 | -0.487 | -0.043 | 1.334 | 1.741 | 2.154 | 2.353 | 3.898 | 4.757 | 5.235 | 6.189 | 6.720 | 7.071 | 7.076 | 7.091 | 2.021 | 1.492 | 0.910 | 0.233 | -0.595 | 1.948 | 0.530 | -0.950 | -1.408 | | | | | | | | | |
| 9 | 12.533 | 9.963 | 6.815 | 3.388 | 0.724 | 0.128 | -0.252 | -0.485 | -0.755 | -0.353 | -0.329 | 0.107 | 1.425 | 1.840 | 2.256 | 2.461 | 4.003 | 4.860 | 5.337 | 6.243 | 6.756 | 7.098 | 7.102 | 7.115 | 2.097 | 1.546 | 0.958 | 0.293 | -0.508 | 2.020 | 0.582 | -0.998 | -0.608 | | | | | | | | | |
| 10 | 12.402 | 9.913 | 6.749 | 3.349 | 0.707 | 0.111 | -0.143 | -0.759 | -0.445 | -0.161 | -0.106 | 0.176 | 1.377 | 1.777 | 2.190 | 2.391 | 3.936 | 4.795 | 5.273 | 6.234 | 6.762 | 7.116 | 7.121 | 7.137 | 2.044 | 1.508 | 0.942 | 0.315 | -0.442 | 2.089 | 0.728 | -0.841 | -0.642 | | | | | | | | | |
| 11 | 12.532 | 9.966 | 6.824 | 3.401 | 0.672 | 0.065 | -0.026 | -0.067 | -0.069 | -0.048 | -0.040 | 0.173 | 1.462 | 1.872 | 2.290 | 2.496 | 4.037 | 4.893 | 5.370 | 6.285 | 6.793 | 7.139 | 7.143 | 7.157 | 2.111 | 1.540 | 0.957 | 0.240 | -0.353 | 2.234 | 0.975 | -0.510 | -0.067 | | | | | | | | | |
| 12 | 14.716 | 12.974 | 10.810 | 6.684 | 2.902 | 1.629 | 1.083 | 0.835 | 0.377 | 1.190 | 1.308 | 2.107 | 3.770 | 4.413 | 4.941 | 5.196 | 6.268 | 6.863 | 7.167 | 7.392 | 7.656 | 8.057 | 8.061 | 7.956 | 4.322 | 3.139 | 1.998 | 0.858 | -0.518 | 4.434 | 2.311 | -0.077 | 0.166 | | | | | | | | | |
| 13 | 18.798 | 17.055 | 15.382 | 11.684 | 6.522 | 4.465 | 3.241 | 2.684 | 1.386 | 2.010 | 2.154 | 2.817 | 5.230 | 6.264 | 6.797 | 7.077 | 7.975 | 8.474 | 8.796 | 8.715 | 8.729 | 9.477 | 9.549 | 9.568 | 5.909 | 4.305 | 2.750 | 1.222 | -0.305 | 7.908 | 4.212 | 0.364 | 1.078 | | | | | | | | | |
| 14 | 17.004 | 15.131 | 13.300 | 9.775 | 6.464 | 3.790 | 2.755 | 2.285 | 1.529 | 2.146 | 2.275 | 2.835 | 5.649 | 6.420 | 6.921 | 7.255 | 8.506 | 9.201 | 9.543 | 9.838 | 9.944 | 10.409 | 10.454 | 10.494 | 6.250 | 4.678 | 3.045 | 1.362 | -0.335 | 6.895 | 3.891 | 0.719 | 1.232 | | | | | | | | | |
| 15 | 15.212 | 12.870 | 10.743 | 7.298 | 3.776 | 2.482 | 1.816 | 1.514 | 1.334 | 1.789 | 1.843 | 2.619 | 5.233 | 6.016 | 6.608 | 6.983 | 8.408 | 9.200 | 9.568 | 10.123 | 10.244 | 10.580 | 10.608 | 10.656 | 5.972 | 4.422 | 2.832 | 1.211 | -0.395 | 5.187 | 3.073 | 0.916 | 1.252 | | | | | | | | | |
| 16 | 14.269 | 11.718 | 9.297 | 6.842 | 2.693 | 1.617 | 1.137 | 0.919 | 0.735 | 1.399 | 1.508 | 2.512 | 4.983 | 5.781 | 6.411 | 6.800 | 8.289 | 9.116 | 9.497 | 10.157 | 10.280 | 10.570 | 10.583 | 10.645 | 5.820 | 4.312 | 2.748 | 1.133 | -0.478 | 4.169 | 2.521 | 0.921 | 0.903 | | | | | | | | | |
| 17 | 13.816 | 11.213 | 8.609 | 5.174 | 2.135 | 1.107 | 0.735 | 0.566 | 0.708 | 1.138 | 1.207 | 2.464 | 4.837 | 5.647 | 6.289 | 6.677 | 8.184 | 9.021 | 9.412 | 10.099 | 10.223 | 10.498 | 10.518 | 10.572 | 5.715 | 4.237 | 2.692 | 1.073 | -0.569 | 3.624 | 2.133 | 0.743 | 0.604 | | | | | | | | | |
| 18 | 13.399 | 10.909 | 8.036 | 4.595 | 1.763 | 0.817 | 0.413 | 0.230 | 0.360 | 0.981 | 1.088 | 2.413 | 4.726 | 5.508 | 6.140 | 6.521 | 8.035 | 8.876 | 9.282 | 10.007 | 10.134 | 10.399 | 10.418 | 10.472 | 5.596 | 4.161 | 2.646 | 1.029 | -0.655 | 3.135 | 1.726 | 0.426 | 0.004 | | | | | | | | | |
| 19 | 13.264 | 10.665 | 7.806 | 4.341 | 1.507 | 0.656 | 0.111 | -0.136 | -0.661 | 0.817 | 0.952 | 2.356 | 4.610 | 5.383 | 6.010 | 6.382 | 7.898 | 8.741 | 9.162 | 9.895 | 10.024 | 10.288 | 10.305 | 10.359 | 5.477 | 4.081 | 2.589 | 0.996 | -0.721 | 2.840 | 1.390 | 0.089 | -0.638 | | | | | | | | | |
| 20 | 12.896 | 10.413 | 7.427 | 4.002 | 1.303 | 0.582 | -0.050 | -0.301 | -0.181 | 0.723 | 0.794 | 2.284 | 4.493 | 5.237 | 5.849 | 6.211 | 7.733 | 8.579 | 9.018 | 9.777 | 9.908 | 10.169 | 10.185 | 10.238 | 5.343 | 3.993 | 2.554 | 0.978 | -0.757 | 2.529 | 1.066 | -0.347 | 0.184 | | | | | | | | | |
| 21 | 12.781 | 10.346 | 7.281 | 3.870 | 1.177 | 0.456 | -0.004 | -0.213 | -0.591 | 0.592 | 0.705 | 2.206 | 4.377 | 5.116 | 5.723 | 6.078 | 7.601 | 8.447 | 8.903 | 9.651 | 9.786 | 10.047 | 10.062 | 10.115 | 5.224 | 3.907 | 2.503 | 0.971 | -0.757 | 2.366 | 0.852 | -0.668 | -0.676 | | | | | | | | | |
| 22 | 12.601 | 10.169 | 7.089 | 3.670 | 1.059 | 0.387 | -0.046 | -0.241 | -0.546 | 0.512 | 0.617 | 2.108 | 4.262 | 4.975 | 5.567 | 5.912 | 7.442 | 8.292 | 8.769 | 9.530 | 9.668 | 9.929 | 9.944 | 9.994 | 5.088 | 3.812 | 2.461 | 0.974 | -0.721 | 2.214 | 0.706 | -0.883 | -0.350 | | | | | | | | | |
| 23 | 12.764 | 10.244 | 7.191 | 3.742 | 1.023 | 0.349 | -0.084 | -0.280 | -0.600 | 0.484 | 0.608 | 1.999 | 4.147 | 4.862 | 5.453 | 5.792 | 7.326 | 8.17[illegible] | 8.674 | 9.412 | 9.554 | 9.819 | 9.834 | 9.883 | 4.973 | 3.720 | 2.408 | 0.979 | -0.634 | 2.262 | 0.715 | -0.567 | -0.897 | | | | | | | | | |
| 24 | 12.601 | 10.170 | 7.089 | 3.668 | 1.052 | 0.407 | -0.020 | -0.215 | -0.529 | 0.492 | 0.619 | 1.902 | 4.040 | 4.733 | 5.314 | 5.646 | 7.191 | 8.049 | 8.554 | 9.306 | 9.452 | 9.717 | 9.731 | 9.778 | 4.849 | 3.626 | 2.355 | 0.985 | -0.567 | 2.268 | 0.770 | -0.921 | -0.741 | | | | | | | | | |
| 25 | 12.764 | 10.244 | 7.191 | 3.747 | 1.013 | 0.402 | 0.127 | 0.002 | -0.548 | 0.575 | 0.677 | 1.819 | 3.944 | 4.641 | 5.222 | 5.550 | 7.099 | 7.969 | 8.468 | 9.202 | 9.352 | 9.622 | 9.636 | 9.682 | 4.751 | 3.540 | 2.297 | 0.984 | -0.474 | 2.379 | 0.918 | -0.756 | -0.858 | | | | | | | | | |

**REMARKS:**

| STATION | LIBMANAN | CUYAPI | NAGA | OMBAO | STO. DOMINGO | LAKE BATO |
|---|---|---|---|---|---|---|
| PEAK STAGE M. MSL | 3.767 | 2.734 | 2.910 | 8.552 | 10.664 | 10.664 |
| TIME | 13 - 12 - 0 | 13 - 12 - 0 | 13 - 15 - 30 | 13 - 18 - 0 | 15 - 12 - 0 | 15 - 12 - 0 |

## TABLE 5.16 DAILY WATER LEVELS ALONG BICOL - SIPOCOT RIVERS IN METERS ABOVE MSL.

### RETURN PERIOD OF DESIGN FLOOD 50 YEARS

### FLOOD PROTECTION SCHEME : ④ CUT-OFF NO. 3

| RIVER | SIPOCOT RIVER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RIVER | BICOL RIVER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| RIVER | BICOL-RAGAY DIVERSION | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| RIVER | SIPOCOT-SAN MIGUEL DIVERSION | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| RIVER | SAN MIGUEL | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| TOWN | SABANG | | | | LIBMANAN | | | CUYAPI | | | NAGA | | | | OMBAO | | | | | STO. DOMINGO | | | | | | LAKE BATO | | | PASACAO | | | BARCELONA | | | BOLONGAY | |
| NODE NO. / DATE | 1 | 2 | 3 | 4 | 5 | 6 | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 5 | 12.492 | 9.985 | 6.851 | 3.453 | 0.875 | 0.359 | 0.212 | 0.145 | 0.101 | 0.155 | 0.164 | 0.214 | 0.600 | 1.411 | 1.992 | 2.240 | 3.943 | 4.888 | 5.339 | 6.222 | 6.732 | 7.070 | 7.075 | 7.087 | 1.814 | 1.177 | 0.540 | -0.057 | -0.733 | 2.334 | 1.214 | 0.095 | 0.095 |
| 6 | 12.375 | 9.881 | 6.738 | 3.252 | 0.820 | 0.197 | -0.183 | -0.356 | -0.358 | -0.407 | -0.412 | -0.366 | 0.283 | 1.477 | 1.979 | 2.209 | 3.887 | 4.819 | 5.278 | 6.212 | 6.739 | 7.090 | 7.094 | 7.109 | 1.868 | 1.344 | 0.763 | 0.086 | -0.718 | 2.003 | 0.789 | -0.336 | -0.356 |
| 7 | 12.525 | 9.944 | 6.850 | 3.325 | 0.788 | 0.158 | -0.295 | -0.601 | -0.712 | -0.476 | -0.455 | -0.329 | 0.339 | 1.553 | 2.069 | 2.295 | 3.985 | 4.924 | 5.376 | 6.266 | 6.772 | 7.114 | 7.119 | 7.131 | 1.935 | 1.410 | 0.831 | 0.154 | -0.669 | 1.963 | 0.611 | -0.711 | -0.711 |
| 8 | 12.399 | 9.902 | 6.757 | 3.303 | 0.800 | 0.184 | -0.291 | -0.507 | -0.887 | -0.455 | -0.429 | -0.281 | 0.331 | 1.496 | 2.000 | 2.232 | 3.921 | 4.859 | 5.312 | 6.255 | 6.776 | 7.131 | 7.136 | 7.152 | 1.897 | 1.395 | 0.844 | 0.198 | -0.695 | 1.935 | 0.524 | -0.950 | -0.950 |
| 9 | 12.534 | 9.959 | 6.837 | 3.355 | 0.804 | 0.226 | -0.208 | -0.406 | -0.876 | -0.286 | -0.249 | -0.077 | 0.539 | 1.446 | 2.051 | 2.307 | 4.004 | 4.947 | 5.403 | 6.303 | 6.807 | 7.153 | 7.157 | 7.171 | 1.975 | 1.458 | 0.900 | 0.264 | -0.508 | 1.998 | 0.571 | -0.998 | -0.998 |
| 10 | 12.403 | 9.907 | 6.764 | 3.306 | 0.892 | 0.384 | -0.010 | -0.189 | -0.670 | -0.088 | -0.035 | 0.152 | 0.633 | 1.439 | 2.019 | 2.264 | 3.941 | 4.872 | 5.333 | 6.288 | 6.809 | 7.167 | 7.172 | 7.188 | 1.946 | 1.437 | 0.894 | 0.291 | -0.422 | 2.060 | 0.713 | -0.841 | -0.841 |
| 11 | 12.535 | 9.958 | 6.845 | 3.343 | 0.941 | 0.499 | 0.221 | 0.095 | -0.326 | 0.164 | 0.297 | 0.490 | 0.856 | 1.578 | 2.136 | 2.381 | 4.041 | 4.963 | 5.423 | 6.333 | 6.838 | 7.185 | 7.190 | 7.205 | 2.017 | 1.469 | 0.910 | 0.316 | -0.353 | 2.195 | 0.955 | -0.510 | -0.510 |
| 12 | 14.726 | 12.974 | 10.816 | 6.669 | 2.921 | 1.674 | 1.043 | 0.756 | 0.214 | 1.343 | 1.473 | 1.895 | 2.704 | 3.919 | 4.610 | 4.909 | 6.160 | 6.854 | 7.161 | 7.401 | 7.671 | 8.084 | 8.089 | 7.397 | 4.091 | 2.970 | 1.885 | 0.806 | -0.312 | 4.482 | 2.304 | -0.077 | -0.077 |
| 13 | 18.798 | 17.055 | 15.382 | 11.683 | 6.516 | 4.441 | 3.156 | 2.571 | 0.971 | 2.196 | 2.321 | 2.663 | 4.125 | 5.839 | 6.525 | 6.852 | 7.877 | 8.446 | 8.788 | 8.717 | 8.733 | 9.493 | 9.566 | 9.586 | 5.717 | 4.161 | 2.654 | 1.173 | -0.305 | 7.908 | 4.212 | 0.364 | 0.364 |
| 14 | 17.004 | 15.131 | 13.300 | 9.775 | 5.464 | 3.786 | 2.725 | 2.242 | 1.380 | 2.482 | 2.582 | 2.903 | 4.240 | 5.603 | 6.441 | 6.862 | 8.339 | 9.159 | 9.522 | 9.833 | 9.943 | 10.419 | 10.465 | 10.506 | 5.922 | 4.436 | 2.885 | 1.283 | -0.335 | 6.856 | 3.891 | 0.719 | 0.719 |
| 15 | 15.212 | 12.870 | 10.743 | 7.298 | 3.774 | 2.471 | 1.760 | 1.437 | 1.058 | 1.824 | 1.920 | 2.195 | 3.471 | 5.142 | 6.056 | 6.536 | 8.224 | 9.162 | 9.546 | 10.119 | 10.243 | 10.585 | 10.614 | 10.663 | 5.584 | 4.128 | 2.633 | 1.111 | -0.395 | 5.197 | 3.073 | 0.916 | 0.916 |
| 16 | 14.269 | 11.718 | 9.297 | 5.843 | 2.694 | 1.640 | 1.255 | 1.081 | 0.973 | 1.375 | 1.449 | 1.789 | 3.126 | 4.921 | 5.880 | 6.372 | 8.116 | 9.085 | 9.478 | 10.153 | 10.279 | 10.572 | 10.595 | 10.648 | 5.450 | 4.029 | 2.557 | 1.036 | -0.478 | 4.170 | 2.522 | 0.921 | 0.921 |
| 17 | 13.816 | 11.213 | 8.609 | 5.175 | 2.149 | 1.181 | 0.929 | 0.814 | 0.773 | 1.222 | 1.299 | 1.680 | 3.033 | 4.832 | 5.788 | 6.274 | 8.023 | 8.994 | 9.396 | 10.095 | 10.221 | 10.498 | 10.519 | 10.574 | 5.365 | 3.969 | 2.510 | 0.981 | -0.569 | 3.625 | 2.134 | 0.743 | 0.743 |
| 18 | 13.399 | 10.809 | 8.036 | 4.594 | 1.772 | 0.870 | 0.582 | 0.450 | 0.458 | 0.973 | 1.060 | 1.460 | 2.875 | 4.678 | 5.630 | 6.109 | 7.872 | 8.851 | 9.267 | 10.002 | 10.131 | 10.399 | 10.417 | 10.472 | 5.241 | 3.892 | 2.463 | 0.936 | -0.655 | 3.134 | 1.726 | 0.426 | 0.426 |
| 19 | 13.264 | 10.665 | 7.807 | 4.341 | 1.498 | 0.666 | 0.278 | 0.101 | 0.072 | 0.730 | 0.835 | 1.315 | 2.775 | 4.566 | 5.506 | 5.974 | 7.739 | 8.719 | 9.149 | 9.890 | 10.021 | 10.286 | 10.304 | 10.358 | 5.126 | 3.812 | 2.416 | 0.902 | -0.721 | 2.840 | 1.389 | 0.039 | 0.039 |
| 20 | 12.896 | 10.413 | 7.426 | 4.007 | 1.299 | 0.519 | 0.061 | -0.147 | -0.302 | 0.574 | 0.674 | 1.154 | 2.624 | 4.402 | 5.334 | 5.794 | 7.571 | 8.559 | 9.006 | 9.772 | 9.906 | 10.167 | 10.183 | 10.236 | 4.984 | 3.720 | 2.369 | 0.883 | -0.757 | 2.533 | 1.068 | -0.347 | -0.347 |
| 21 | 12.781 | 10.316 | 7.282 | 3.872 | 1.141 | 0.401 | -0.063 | -0.274 | -0.560 | 0.526 | 0.633 | 1.136 | 2.563 | 4.310 | 5.226 | 5.673 | 7.446 | 8.431 | 8.894 | 9.647 | 9.782 | 10.044 | 10.060 | 10.113 | 4.874 | 3.641 | 2.328 | 0.878 | -0.757 | 2.367 | 0.852 | -0.668 | -0.668 |
| 22 | 12.601 | 10.169 | 7.089 | 3.669 | 1.056 | 0.365 | -0.105 | -0.319 | -0.698 | 0.439 | 0.538 | 1.031 | 2.426 | 4.144 | 5.087 | 5.496 | 7.285 | 8.279 | 8.761 | 9.525 | 9.665 | 9.926 | 9.941 | 9.991 | 4.731 | 3.542 | 2.277 | 0.880 | -0.721 | 2.213 | 0.705 | -0.883 | -0.883 |
| 23 | 12.764 | 10.243 | 7.193 | 3.737 | 1.039 | 0.370 | -0.078 | -0.282 | -0.725 | 0.447 | 0.551 | 1.048 | 2.383 | 4.067 | 4.961 | 5.391 | 7.179 | 8.172 | 8.668 | 9.409 | 9.551 | 9.816 | 9.831 | 9.880 | 4.627 | 3.458 | 2.230 | 0.887 | -0.654 | 2.259 | 0.714 | -0.947 | -0.947 |
| 24 | 12.601 | 10.170 | 7.091 | 3.665 | 1.064 | 0.430 | -0.006 | -0.205 | -0.651 | 0.437 | 0.558 | 0.994 | 2.266 | 3.921 | 4.804 | 5.230 | 7.040 | 8.[illegible]5 | 8.550 | 9.303 | 9.439 | 9.714 | 9.728 | 9.775 | 4.495 | 3.358 | 2.173 | 0.892 | -0.567 | 2.266 | 0.769 | -0.921 | -0.921 |
| 25 | 12.764 | 10.243 | 7.193 | 3.738 | 1.063 | 0.450 | 0.087 | -0.078 | -0.485 | 0.519 | 0.640 | 1.066 | 2.257 | 3.873 | 4.736 | 5.154 | 6.958 | 7.960 | 8.467 | 9.200 | 9.349 | 9.619 | 9.633 | 9.679 | 4.405 | 3.281 | 2.122 | 0.895 | -0.474 | 2.373 | 0.916 | -0.756 | -0.756 |

**REMARKS:**

| STATION | LIBMANAN | CUYAPI | NAGA | OMBAO | STO. DOMINGO | LAKE BATO |
|---|---|---|---|---|---|---|
| PEAK STAGE M.MSL | 3.843 | 2.852 | 3.418 | 8.407 | 10.669 | 10.669 |
| TIME | 13-10-30 | 13-10-30 | 13-13-30 | 13-17-0 | 15-12-0 | 15-12-0 |

## TABLE 5.17 DAILY WATER LEVELS ALONG BICOL - SIPOCOT RIVERS IN METERS ABOVE MSL.

### RETURN PERIOD OF DESIGN FLOOD 50 YEARS

### FLOOD PROTECTION SCHEME : ⑤ BICOL RAGAY DIVERSION

| RIVER | SIPOCOT RIVER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOWN | SABANG | | | | LIBMANAN | | | CUYAPI | | | NAGA | | | | OMBAO | | | | STO. DOMINGO | | | | | LAKE BATO | | | PASACAO | | | BARCELONA | | BOLONGAY |
| NODE NO. / DATE | 1 | 2 | 3 | 4 | 5 | 6 | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 5 | 12.436 | 9.980 | 6.846 | 3.460 | 0.877 | 0.357 | 0.210 | 0.143 | 0.098 | 0.118 | 0.122 | 0.196 | 0.741 | 1.069 | 1.290 | 1.399 | 3.799 | 5.133 | 5.456 | 6.193 | 6.673 | 6.996 | 7.000 | 7.011 | 0.600 | 0.123 | -0.421 | -0.640 | -0.733 | 2.339 | 1.217 | 0.095 | 0.095 |
| 6 | 12.374 | 9.882 | 6.738 | 3.252 | 0.819 | 0.195 | -0.186 | -0.359 | -0.355 | -0.478 | -0.495 | -0.413 | 0.639 | 1.030 | 1.271 | 1.380 | 3.726 | 5.029 | 5.366 | 6.173 | 6.678 | 7.016 | 7.020 | 7.041 | 0.744 | 0.354 | -0.169 | -0.490 | -0.718 | 2.002 | 0.789 | -0.336 | -0.336 |
| 7 | 12.525 | 9.944 | 6.830 | 3.325 | 0.785 | 0.152 | -0.304 | -0.511 | -0.725 | -0.641 | -0.635 | -0.403 | 0.709 | 1.113 | 1.362 | 1.477 | 3.832 | 5.140 | 5.478 | 6.240 | 6.722 | 7.051 | 7.055 | 7.070 | 0.814 | 0.416 | -0.103 | -0.424 | -0.669 | 1.964 | 0.612 | -0.711 | -0.711 |
| 8 | 12.399 | 9.902 | 6.757 | 3.303 | 0.799 | 0.181 | -0.300 | -0.518 | -0.909 | -0.637 | -0.622 | -0.364 | 0.657 | 1.054 | 1.305 | 1.422 | 3.779 | 5.089 | 5.423 | 6.232 | 6.732 | 7.073 | 7.077 | 7.097 | 0.785 | 0.408 | -0.070 | -0.363 | -0.595 | 1.935 | 0.524 | -0.950 | -0.950 |
| 9 | 12.534 | 9.958 | 6.837 | 3.354 | 0.807 | 0.230 | -0.212 | -0.413 | -0.898 | -0.471 | -0.448 | -0.166 | 0.755 | 1.143 | 1.387 | 1.504 | 3.878 | 5.197 | 5.532 | 6.296 | 6.773 | 7.107 | 7.111 | 7.122 | 0.824 | 0.439 | -0.024 | -0.295 | -0.508 | 1.997 | 0.570 | -0.998 | -0.998 |
| 10 | 12.404 | 9.907 | 6.764 | 3.306 | 0.888 | 0.381 | -0.020 | -0.202 | -0.690 | -0.349 | -0.220 | 0.044 | 0.719 | 1.117 | 1.338 | 1.450 | 3.821 | 5.138 | 5.471 | 6.284 | 6.777 | 7.122 | 7.127 | 7.144 | 0.785 | 0.411 | -0.014 | -0.247 | -0.422 | 2.060 | 0.714 | -0.841 | -0.841 |
| 11 | 12.535 | 9.958 | 6.845 | 3.344 | 0.941 | 0.503 | 0.213 | 0.079 | -0.342 | 0.064 | 0.114 | 0.378 | 0.977 | 1.207 | 1.434 | 1.547 | 3.915 | 5.230 | 5.567 | 6.341 | 6.815 | 7.149 | 7.153 | 7.165 | 0.824 | 0.424 | -0.000 | -0.210 | -0.353 | 2.197 | 0.955 | -0.510 | -0.510 |
| 12 | 14.726 | 12.974 | 10.816 | 6.670 | 2.919 | 1.664 | 1.024 | 0.733 | 0.178 | 1.106 | 1.211 | 1.992 | 3.269 | 3.641 | 3.913 | 4.033 | 5.718 | 6.654 | 7.075 | 7.391 | 7.667 | 8.074 | 8.079 | 7.959 | 2.919 | 2.129 | 0.994 | 0.230 | -0.312 | 4.483 | 2.305 | -0.077 | -0.077 |
| 13 | 18.798 | 17.055 | 15.382 | 11.683 | 6.514 | 4.434 | 3.129 | 2.536 | 0.811 | 1.931 | 2.049 | 2.707 | 4.668 | 5.368 | 5.657 | 5.772 | 7.462 | 8.384 | 8.764 | 8.701 | 8.720 | 9.485 | 9.558 | 9.568 | 4.510 | 3.561 | 2.100 | 0.893 | -0.305 | 7.908 | 4.212 | 0.364 | 0.364 |
| 14 | 17.004 | 15.131 | 13.300 | 9.775 | 5.459 | 3.771 | 2.674 | 2.176 | 1.215 | 2.243 | 2.343 | 2.746 | 4.853 | 5.290 | 5.555 | 5.716 | 7.893 | 9.103 | 9.480 | 9.803 | 9.917 | 10.404 | 10.450 | 10.494 | 4.576 | 3.671 | 2.243 | 1.014 | -0.335 | 6.895 | 3.891 | 0.719 | 0.719 |
| 15 | 15.212 | 12.870 | 10.743 | 7.298 | 3.771 | 2.461 | 1.732 | 1.400 | 1.001 | 1.355 | 1.423 | 2.259 | 4.139 | 4.652 | 5.052 | 5.286 | 7.782 | 9.168 | 9.539 | 10.101 | 10.226 | 10.571 | 10.600 | 10.651 | 4.152 | 3.272 | 1.896 | 0.749 | -0.395 | 5.197 | 3.073 | 0.916 | 0.916 |
| 16 | 14.269 | 11.718 | 9.297 | 5.843 | 2.692 | 1.632 | 1.242 | 1.065 | 0.956 | 1.105 | 1.137 | 1.794 | 3.690 | 4.283 | 4.770 | 5.044 | 7.674 | 9.135 | 9.501 | 10.148 | 10.271 | 10.562 | 10.585 | 10.637 | 3.925 | 3.064 | 1.716 | 0.603 | -0.478 | 4.170 | 2.822 | 0.921 | 0.921 |
| 17 | 13.816 | 11.213 | 8.609 | 5.175 | 2.142 | 1.173 | 0.917 | 0.801 | 0.762 | 0.858 | 0.882 | 1.610 | 3.507 | 4.130 | 4.641 | 4.924 | 7.591 | 9.072 | 9.439 | 10.100 | 10.221 | 10.492 | 10.512 | 10.566 | 3.865 | 2.949 | 1.612 | 0.508 | -0.569 | 3.625 | 2.134 | 0.743 | 0.743 |
| 18 | 13.359 | 10.809 | 8.036 | 4.595 | 1.768 | 0.860 | 0.569 | 0.436 | 0.426 | 0.492 | 0.519 | 1.372 | 3.341 | 3.967 | 4.477 | 4.762 | 7.463 | 8.949 | 9.322 | 10.013 | 10.137 | 10.397 | 10.415 | 10.468 | 3.663 | 2.824 | 1.508 | 0.421 | -0.655 | 3.135 | 1.726 | 0.426 | 0.426 |
| 19 | 13.264 | 10.665 | 7.807 | 4.342 | 1.493 | 0.652 | 0.252 | 0.070 | 0.037 | 0.234 | 0.278 | 1.266 | 3.240 | 3.860 | 4.363 | 4.642 | 7.339 | 8.837 | 9.217 | 9.907 | 10.031 | 10.288 | 10.305 | 10.358 | 3.546 | 2.715 | 1.415 | 0.345 | -0.721 | 2.840 | 1.390 | 0.039 | 0.039 |
| 20 | 12.896 | 10.413 | 7.426 | 4.009 | 1.293 | 0.502 | 0.027 | -0.189 | -0.340 | 0.025 | 0.069 | 1.085 | 3.075 | 3.688 | 4.183 | 4.462 | 7.183 | 8.694 | 9.082 | 9.795 | 9.922 | 10.173 | 10.189 | 10.240 | 3.401 | 2.589 | 1.320 | 0.279 | -0.757 | 2.534 | 1.068 | -0.347 | -0.347 |
| 21 | 12.781 | 10.316 | 7.282 | 3.873 | 1.134 | 0.391 | -0.103 | -0.328 | -0.618 | -0.032 | 0.032 | 1.076 | 3.013 | 3.611 | 4.094 | 4.366 | 7.074 | 8.579 | 8.977 | 9.675 | 9.803 | 10.054 | 10.069 | 10.120 | 3.305 | 2.501 | 1.252 | 0.241 | -0.757 | 2.368 | 0.852 | -0.668 | -0.668 |
| 22 | 12.601 | 10.170 | 7.089 | 3.670 | 1.050 | 0.357 | -0.146 | -0.325 | -0.783 | -0.107 | -0.044 | 0.941 | 2.858 | 3.447 | 3.925 | 4.197 | 6.926 | 8.443 | 8.851 | 9.557 | 9.689 | 9.939 | 9.953 | 10.003 | 3.162 | 2.378 | 1.171 | 0.209 | -0.721 | 2.214 | 0.706 | -0.883 | -0.883 |
| 23 | 12.764 | 10.243 | 7.192 | 3.739 | 1.033 | 0.355 | -0.113 | -0.326 | -0.814 | -0.041 | 0.024 | 0.983 | 2.821 | 3.394 | 3.858 | 4.121 | 6.839 | 8.349 | 8.765 | 9.446 | 9.579 | 9.833 | 9.847 | 9.894 | 3.083 | 2.307 | 1.125 | 0.204 | -0.654 | 2.260 | 0.714 | -0.967 | -0.967 |
| 24 | 12.601 | 10.170 | 7.091 | 3.664 | 1.062 | 0.421 | -0.030 | -0.236 | -0.731 | -0.012 | 0.045 | 0.908 | 2.678 | 3.243 | 3.704 | 3.969 | 6.708 | 8.230 | 8.656 | 9.344 | 9.481 | 9.734 | 9.747 | 9.793 | 2.955 | 2.200 | 1.061 | 0.199 | -0.567 | 2.266 | 0.769 | -0.921 | -0.921 |
| 25 | 12.764 | 10.243 | 7.193 | 3.737 | 1.058 | 0.435 | 0.064 | -0.104 | -0.546 | 0.156 | 0.232 | 1.019 | 2.672 | 3.219 | 3.662 | 3.917 | 6.642 | 8.155 | 8.585 | 9.247 | 9.385 | 9.642 | 9.656 | 9.700 | 2.897 | 2.145 | 1.027 | 0.210 | -0.474 | 2.372 | 0.915 | -0.756 | -0.756 |

**REMARKS:**

| STATION | LIBMANAN | CUYAPI | NAGA | OMBAO | STO. DOMINGO | LAKE BATO |
|---|---|---|---|---|---|---|
| PEAK STAGE M. MSL | 3.954 | 3.033 | 3.008 | 7.980 | 10.657 | 10.657 |
| TIME | 13 - 11 - 30 | 13 - 11 - 0 | 13 - 14 - 0 | 13 - 14 - 30 | 15 - 12 - 0 | 15 - 12 - 0 |

# TABLE 5.18 DAILY WATER LEVELS ALONG BICOL - SIPOCOT RIVERS IN METERS ABOVE MSL.

## RETURN PERIOD OF DESIGN FLOOD 50 YEARS

## FLOOD PROTECTION SCHEME : ⑥ DEEPENING RIVER BED

| RIVER | SIPOCOT RIVER | | | | | | | | BICOL RIVER | | | | | | | | | | | | | | | | | BICOL-RAGAY DIVERSION | | | | | SIPOCOT-SAN MIGUEL DIVERSION | | | SAN MIGUEL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOWN | SABANG | | | | LIBMANAN | | | CUYAPI | | | NAGA | | | | OMBAO | | | | | STO. DOMINGO | | | | | LAKE BATO | | | PASACAO | | BARCELONA | | | BOLONGAY |
| DATE \ NODE NO | 1 | 2 | 3 | 4 | 5 | 6 | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 5 | 12.496 | 9.980 | 6.946 | 3.459 | 0.980 | 0.363 | 0.217 | 0.150 | 0.106 | 0.223 | 0.244 | 0.715 | 2.228 | 2.744 | 3.184 | 3.446 | 4.920 | 5.738 | 5.983 | 6.191 | 6.345 | 6.580 | 6.603 | 6.716 | 2.833 | 1.958 | 1.062 | 0.165 | -0.783 | 2.336 | 1.217 | 0.098 | 0.089 |
| 6 | 12.374 | 9.882 | 6.738 | 3.251 | 0.822 | 0.201 | -0.179 | -0.351 | -0.355 | -0.307 | -0.292 | 0.271 | 2.074 | 2.586 | 3.026 | 3.289 | 4.788 | 5.620 | 5.862 | 6.074 | 6.233 | 6.473 | 6.497 | 6.618 | 2.826 | 2.091 | 1.282 | 0.387 | -0.718 | 2.602 | 0.798 | -0.336 | -0.336 |
| 7 | 12.515 | 9.944 | 6.830 | 3.325 | 0.787 | 0.158 | -0.292 | -0.497 | -0.706 | -0.400 | -0.367 | 0.276 | 2.069 | 2.579 | 3.012 | 3.271 | 4.767 | 5.599 | 5.839 | 6.036 | 6.183 | 6.405 | 6.427 | 6.631 | 2.806 | 2.083 | 1.296 | 0.397 | -0.669 | 1.963 | 0.611 | -0.711 | -0.711 |
| 8 | 12.399 | 9.902 | 6.757 | 3.302 | 0.800 | 0.185 | -0.288 | -0.504 | -0.880 | -0.402 | -0.368 | 0.246 | 1.360 | 2.462 | 2.892 | 3.148 | 4.650 | 5.497 | 5.732 | 5.937 | 6.089 | 6.317 | 6.340 | 6.453 | 2.711 | 2.022 | 1.176 | 0.423 | -0.585 | 1.935 | 0.523 | -0.980 | -0.980 |
| 9 | 12.534 | 9.958 | 6.837 | 3.364 | 0.809 | 0.236 | -0.201 | -0.339 | -0.870 | -0.279 | -0.278 | 0.304 | 1.980 | 2.478 | 2.859 | 3.151 | 4.654 | 5.469 | 5.723 | 5.913 | 6.035 | 6.266 | 6.286 | 6.383 | 2.700 | 2.008 | 1.274 | 0.458 | -0.508 | 1.937 | 0.571 | -0.930 | -0.930 |
| 10 | 12.404 | 9.907 | 6.764 | 3.307 | 0.830 | 0.265 | -0.012 | -0.192 | -0.669 | -0.115 | -0.070 | 0.498 | 1.305 | 2.386 | 2.800 | 3.098 | 4.558 | 5.357 | 5.627 | 5.826 | 5.974 | 6.192 | 6.213 | 6.320 | 2.613 | 1.988 | 1.232 | 0.465 | -0.422 | 2.061 | 0.714 | -0.841 | -0.841 |
| 11 | 12.535 | 9.958 | 6.846 | 3.342 | 0.947 | 0.503 | 0.225 | 0.088 | -0.313 | 0.177 | 0.227 | 0.712 | 1.961 | 2.427 | 2.828 | 3.070 | 4.568 | 5.400 | 5.630 | 5.814 | 5.962 | 6.153 | 6.173 | 6.364 | 2.668 | 1.984 | 1.289 | 0.468 | -0.363 | 2.195 | 0.953 | -0.510 | -0.510 |
| 12 | 14.726 | 12.974 | 10.816 | 6.669 | 2.920 | 1.668 | 1.030 | 0.740 | 0.189 | 1.179 | 1.292 | 2.136 | 3.842 | 4.528 | 5.085 | 5.355 | 6.463 | 7.078 | 7.276 | 7.312 | 7.365 | 7.428 | 7.489 | 7.194 | 4.467 | 3.249 | 2.067 | 0.896 | -0.312 | 4.482 | 2.804 | -0.077 | -0.077 |
| 13 | 18.798 | 17.055 | 15.382 | 11.683 | 6.515 | 4.436 | 3.137 | 2.547 | 0.963 | 2.045 | 2.166 | 2.830 | 5.282 | 6.324 | 6.858 | 7.142 | 8.042 | 8.542 | 8.742 | 8.723 | 8.727 | 9.024 | 9.123 | 9.139 | 5.972 | 4.357 | 2.787 | 1.241 | -0.305 | 7.908 | 4.212 | 0.864 | 0.864 |
| 14 | 17.004 | 15.131 | 13.300 | 9.773 | 5.461 | 3.779 | 2.705 | 2.217 | 1.324 | 2.398 | 2.501 | 2.939 | 5.692 | 6.497 | 7.022 | 7.375 | 8.698 | 9.371 | 9.611 | 9.754 | 9.818 | 10.042 | 10.092 | 10.133 | 6.347 | 4.738 | 3.090 | 1.384 | -0.355 | 6.835 | 3.891 | 0.719 | 0.719 |
| 15 | 15.212 | 12.870 | 10.743 | 7.298 | 3.774 | 2.472 | 1.762 | 1.439 | 1.063 | 1.852 | 1.952 | 2.650 | 5.333 | 6.162 | 6.783 | 7.181 | 8.627 | 9.430 | 9.681 | 9.928 | 10.012 | 10.212 | 10.848 | 10.307 | 6.140 | 4.548 | 2.916 | 1.253 | -0.395 | 5.197 | 3.073 | 0.916 | 0.916 |
| 16 | 14.269 | 11.718 | 9.297 | 5.243 | 2.695 | 1.644 | 1.263 | 1.090 | 0.983 | 1.503 | 1.592 | 2.555 | 5.120 | 5.960 | 6.613 | 7.022 | 8.521 | 9.354 | 9.611 | 9.904 | 9.996 | 10.185 | 10.215 | 10.285 | 6.011 | 4.456 | 2.846 | 1.182 | -0.478 | 4.170 | 2.522 | 0.921 | 0.921 |
| 17 | 13.816 | 11.213 | 8.609 | 5.175 | 2.146 | 1.185 | 0.934 | 0.820 | 0.779 | 1.319 | 1.405 | 2.519 | 4.990 | 5.836 | 6.498 | 6.904 | 8.415 | 9.254 | 9.515 | 9.813 | 9.906 | 10.091 | 10.119 | 10.194 | 5.911 | 4.366 | 2.794 | 1.124 | -0.569 | 3.634 | 2.134 | 0.743 | 0.743 |
| 18 | 13.359 | 10.809 | 8.036 | 4.594 | 1.774 | 0.876 | 0.591 | 0.462 | 0.453 | 1.151 | 1.245 | 2.477 | 4.881 | 5.698 | 6.351 | 6.746 | 8.266 | 9.110 | 9.377 | 9.691 | 9.787 | 9.968 | 9.994 | 10.071 | 3.792 | 4.310 | 2.747 | 1.080 | -0.653 | 3.134 | 1.726 | 0.426 | 0.426 |
| 19 | 13.264 | 10.665 | 7.807 | 4.339 | 1.506 | 0.672 | 0.288 | 0.113 | 0.077 | 1.024 | 1.125 | 2.435 | 4.770 | 5.577 | 6.223 | 6.611 | 8.130 | 8.973 | 9.247 | 9.552 | 9.650 | 9.850 | 9.855 | 9.933 | 5.676 | 4.232 | 2.702 | 1.048 | -0.721 | 2.839 | 1.389 | 0.039 | 0.039 |
| 20 | 12.896 | 10.413 | 7.426 | 4.007 | 1.302 | 0.526 | 0.082 | -0.120 | -0.263 | 0.799 | 0.909 | 2.378 | 4.659 | 5.434 | 6.067 | 6.445 | 7.968 | 8.814 | 9.096 | 9.406 | 9.507 | 9.684 | 9.708 | 9.786 | 5.544 | 4.145 | 2.668 | 1.031 | -0.757 | 2.553 | 1.068 | -0.347 | -0.347 |
| 21 | 12.781 | 10.346 | 7.283 | 3.871 | 1.143 | 0.408 | -0.045 | -0.251 | -0.517 | 0.717 | 0.830 | 2.323 | 4.532 | 5.319 | 5.942 | 6.311 | 7.830 | 8.674 | 8.962 | 9.256 | 9.357 | 9.533 | 9.557 | 9.635 | 5.425 | 4.061 | 2.613 | 1.025 | -0.797 | 2.366 | 0.852 | -0.668 | -0.668 |
| 22 | 12.601 | 10.169 | 7.089 | 3.668 | 1.059 | 0.372 | -0.091 | -0.301 | -0.665 | 0.626 | 0.737 | 2.249 | 4.439 | 5.176 | 5.785 | 6.144 | 7.669 | 8.516 | 8.814 | 9.108 | 9.213 | 9.388 | 9.410 | 9.487 | 5.287 | 3.963 | 2.563 | 1.027 | -0.721 | 2.213 | 0.705 | -0.883 | -0.883 |
| 23 | 12.764 | 10.243 | 7.193 | 3.737 | 1.041 | 0.373 | -0.074 | -0.278 | -0.685 | 0.611 | 0.753 | 2.169 | 4.328 | 5.063 | 5.667 | 6.018 | 7.543 | 8.391 | 8.695 | 8.969 | 9.074 | 9.250 | 9.273 | 9.348 | 5.169 | 3.869 | 2.510 | 1.031 | -0.654 | 2.258 | 0.714 | -0.967 | -0.967 |
| 24 | 12.601 | 10.169 | 7.091 | 3.665 | 1.067 | 0.436 | 0.004 | -0.193 | -0.638 | 0.556 | 0.691 | 2.069 | 4.217 | 4.927 | 5.518 | 5.861 | 7.396 | 8.249 | 8.564 | 8.836 | 8.947 | 9.122 | 9.143 | 9.217 | 5.035 | 3.767 | 2.449 | 1.034 | -0.567 | 2.266 | 0.769 | -0.921 | -0.921 |
| 25 | 12.764 | 10.243 | 7.193 | 3.737 | 1.065 | 0.454 | 0.088 | -0.078 | -0.505 | 0.654 | 0.747 | 1.986 | 4.114 | 4.827 | 5.417 | 5.755 | 7.292 | 8.146 | 8.459 | 8.715 | 8.823 | 9.000 | 9.022 | 9.094 | 4.928 | 3.674 | 2.388 | 1.030 | -0.474 | 2.373 | 0.915 | -0.756 | -0.756 |

**REMARKS:**

| STATION | LIBMANAN | CUYAPI | NAGA | OMBAO | STO. DOMINGO | LAKE BATO |
|---|---|---|---|---|---|---|
| PEAK STAGE M.MSL | 3.928 | 2.981 | 3.173 | 8.667 | 10.331 | 10.331 |
| TIME | 13 - 11 - 0 | 13 - 10 - 30 | 13 - 14 - 0 | 13 - 20 - 0 | 15 - 12 - 0 | 15 - 12 - 0 |

## TABLE 5.19 DAILY WATER LEVELS ALONG BICOL - SIPOCOT RIVERS IN METERS ABOVE MSL.

### RETURN PERIOD OF DESIGN FLOOD 50 YEARS

### FLOOD PROTECTION SCHEME : ⑦ POLUNTUNA RESERVOIR + TIDAL BARRIER

| RIVER | SIPOCOT RIVER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOWN | SABANG | | | | LIBMANAN | | | CUYAPI | | | | | | | | | | | | | | | | | | | | | | | | |
| NODE NO / DATE | 1 | 2 | 3 | 4 | 5 | 6 | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 5 | 12.483 | 9.951 | 6.825 | 3.407 | 0.845 | 0.346 | 0.106 | 0.143 | 0.101 | 0.153 | 0.162 | 0.389 | 1.441 | 1.828 | 2.224 | 2.419 | 3.941 | 4.787 | 5.265 | 6.159 | 6.677 | 7.013 | 7.017 | 7.029 | 1.967 | 1.291 | 0.616 | -0.059 | -0.733 | 2.302 | 1.198 | 0.095 | 0.095 |
| 6 | 12.437 | 9.922 | 6.744 | 3.284 | 0.749 | 0.095 | -0.322 | -0.512 | -0.469 | -0.546 | -0.574 | -0.227 | 1.305 | 1.767 | 2.118 | 2.315 | 3.866 | 4.727 | 5.206 | 6.156 | 6.689 | 7.037 | 7.042 | 7.056 | 1.977 | 1.434 | 0.827 | 0.119 | -0.718 | 2.023 | 0.799 | -0.336 | -0.655 |
| 7 | 12.458 | 9.922 | 6.820 | 3.356 | 0.771 | 0.134 | -0.324 | -0.532 | -0.915 | -0.544 | -0.514 | -0.081 | 1.402 | 1.816 | 2.231 | 2.433 | 3.975 | 4.832 | 5.310 | 6.211 | 6.726 | 7.066 | 7.070 | 7.082 | 2.074 | 1.518 | 0.905 | 0.192 | -0.669 | 1.985 | 0.623 | -0.711 | -1.121 |
| 8 | 12.451 | 9.921 | 6.743 | 3.308 | 0.754 | 0.137 | -0.316 | -0.521 | -0.996 | -0.504 | -0.463 | -0.043 | 1.344 | 1.752 | 2.167 | 2.367 | 3.911 | 4.769 | 5.248 | 6.205 | 6.735 | 7.087 | 7.092 | 7.107 | 2.033 | 1.501 | 0.916 | 0.237 | -0.595 | 1.939 | 0.526 | -0.850 | -0.986 |
| 9 | 12.472 | 9.937 | 6.825 | 3.397 | 0.724 | 0.121 | -0.260 | -0.433 | -0.763 | -0.353 | -0.328 | 0.110 | 1.434 | 1.851 | 2.268 | 2.474 | 4.015 | 4.872 | 5.349 | 6.258 | 6.768 | 7.112 | 7.116 | 7.129 | 2.108 | 1.554 | 0.963 | 0.296 | -0.508 | 2.027 | 0.586 | -0.998 | -0.612 |
| 10 | 12.459 | 9.934 | 6.746 | 3.338 | 0.700 | 0.109 | -0.144 | -0.259 | -0.443 | -0.158 | -0.104 | 0.181 | 1.387 | 1.788 | 2.203 | 2.404 | 3.948 | 4.806 | 5.284 | 6.246 | 6.774 | 7.129 | 7.134 | 7.150 | 2.056 | 1.517 | 0.947 | 0.318 | -0.422 | 2.081 | 0.724 | -0.841 | -0.641 |
| 11 | 12.475 | 9.944 | 6.826 | 3.411 | 0.678 | 0.067 | -0.024 | -0.066 | -0.068 | -0.047 | -0.039 | 0.177 | 1.470 | 1.981 | 2.300 | 2.507 | 4.047 | 4.902 | 5.379 | 6.296 | 6.804 | 7.151 | 7.155 | 7.169 | 2.121 | 1.598 | 0.962 | 0.343 | -0.353 | 2.242 | 0.978 | -0.510 | -0.065 |
| 12 | 13.744 | 12.325 | 10.437 | 6.394 | 2.763 | 1.566 | 1.053 | 0.820 | 0.378 | 1.189 | 1.307 | 2.107 | 3.771 | 4.414 | 4.941 | 5.197 | 6.268 | 6.864 | 7.168 | 7.394 | 7.659 | 8.063 | 8.067 | 7.965 | 4.323 | 3.139 | 1.983 | 0.859 | -0.312 | 4.309 | 2.220 | -0.077 | 0.168 |
| 13 | 16.648 | 15.603 | 14.434 | 10.981 | 6.063 | 4.189 | 3.009 | 2.495 | 1.345 | 2.015 | 2.155 | 2.817 | 5.230 | 6.265 | 6.798 | 7.079 | 7.977 | 8.476 | 8.798 | 8.719 | 8.733 | 9.482 | 9.584 | 9.573 | 5.910 | 4.306 | 2.750 | 1.222 | -0.305 | 7.452 | 3.987 | 0.364 | 1.052 |
| 14 | 17.418 | 15.321 | 13.282 | 9.659 | 5.366 | 3.698 | 2.690 | 2.232 | 1.524 | 2.154 | 2.283 | 2.838 | 5.650 | 6.422 | 6.923 | 7.258 | 8.509 | 9.204 | 9.547 | 9.842 | 9.948 | 10.415 | 10.458 | 10.458 | 6.252 | 4.690 | 3.047 | 1.363 | -0.335 | 6.822 | 3.847 | 0.719 | 1.229 |
| 15 | 16.317 | 13.836 | 11.416 | 7.840 | 4.083 | 2.670 | 1.924 | 1.584 | 1.350 | 1.762 | 1.845 | 2.619 | 5.235 | 6.019 | 6.611 | 6.987 | 8.412 | 9.204 | 9.572 | 10.127 | 10.288 | 10.583 | 10.612 | 10.660 | 5.975 | 4.425 | 2.834 | 1.212 | -0.395 | 5.551 | 3.247 | 0.916 | 1.268 |
| 16 | 15.112 | 12.558 | 9.908 | 6.380 | 3.031 | 1.848 | 1.286 | 0.987 | 0.688 | 1.402 | 1.517 | 2.512 | 4.985 | 5.784 | 6.411 | 6.804 | 9.292 | 9.120 | 9.500 | 10.160 | 10.284 | 10.573 | 10.596 | 10.648 | 5.823 | 4.314 | 2.749 | 1.133 | -0.478 | 4.526 | 2.698 | 0.921 | 0.862 |
| 17 | 14.287 | 11.723 | 8.996 | 5.545 | 2.374 | 1.263 | 0.747 | 0.513 | 0.757 | 1.140 | 1.199 | 2.464 | 4.839 | 5.650 | 6.292 | 6.681 | 8.187 | 9.024 | 9.415 | 10.102 | 10.226 | 10.500 | 10.521 | 10.575 | 5.718 | 4.239 | 2.694 | 1.074 | -0.569 | 3.872 | 2.256 | 0.743 | 0.417 |
| 18 | 13.741 | 11.163 | 8.290 | 4.835 | 1.914 | 0.925 | 0.473 | 0.267 | 0.331 | 0.980 | 1.060 | 2.415 | 4.728 | 5.511 | 6.143 | 6.524 | 8.088 | 8.880 | 9.285 | 10.009 | 10.137 | 10.402 | 10.420 | 10.474 | 5.598 | 4.163 | 2.648 | 1.030 | -0.655 | 3.294 | 1.804 | 0.426 | -0.037 |
| 19 | 13.400 | 10.842 | 7.947 | 4.494 | 1.641 | 0.713 | 0.159 | -0.093 | -0.627 | 0.825 | 0.968 | 2.357 | 4.612 | 5.386 | 6.012 | 6.385 | 7.901 | 8.744 | 9.165 | 9.897 | 10.026 | 10.290 | 10.308 | 10.361 | 5.480 | 4.088 | 2.601 | 0.996 | -0.721 | 2.944 | 1.441 | 0.080 | -0.577 |
| 20 | 13.123 | 10.539 | 7.545 | 4.103 | 1.343 | 0.477 | -0.419 | -0.827 | -0.123 | 0.738 | 0.806 | 2.286 | 4.495 | 5.239 | 5.852 | 6.214 | 7.736 | 8.581 | 9.020 | 9.779 | 9.912 | 10.172 | 10.188 | 10.240 | 5.345 | 3.995 | 2.555 | 0.979 | -0.757 | 2.536 | 1.033 | -0.347 | 0.246 |
| 21 | 12.896 | 10.447 | 7.371 | 3.968 | 1.197 | 0.419 | -0.186 | -0.461 | -0.641 | 0.641 | 0.748 | 2.209 | 4.379 | 5.119 | 5.726 | 6.080 | 7.603 | 8.449 | 8.906 | 9.653 | 9.788 | 10.049 | 10.094 | 10.117 | 5.226 | 3.909 | 2.510 | 0.972 | -0.787 | 2.432 | 0.888 | -0.488 | -0.615 |
| 22 | 12.715 | 10.286 | 7.152 | 3.730 | 1.071 | 0.334 | -0.286 | -0.569 | -0.538 | 0.585 | 0.700 | 2.117 | 4.264 | 4.977 | 5.570 | 5.914 | 7.444 | 8.294 | 8.771 | 9.532 | 9.670 | 9.931 | 9.946 | 9.996 | 5.090 | 3.814 | 2.462 | 0.975 | -0.721 | 2.255 | 0.726 | -0.883 | -0.535 |
| 23 | 12.385 | 10.235 | 7.205 | 3.773 | 1.092 | 0.393 | 0.044 | -0.114 | -0.349 | 0.548 | 0.645 | 2.006 | 4.150 | 4.864 | 5.456 | 5.794 | 7.329 | 8.181 | 8.675 | 9.414 | 9.556 | 9.821 | 9.836 | 9.885 | 4.975 | 3.722 | 2.410 | 0.980 | -0.654 | 2.285 | 0.728 | -0.967 | -0.771 |
| 24 | 12.676 | 10.205 | 7.094 | 3.665 | 1.035 | 0.415 | 0.028 | -0.148 | -0.502 | 0.487 | 0.606 | 1.894 | 4.042 | 4.735 | 5.316 | 5.648 | 7.193 | 8.051 | 8.556 | 9.308 | 9.454 | 9.719 | 9.733 | 9.780 | 4.851 | 3.628 | 2.356 | 0.986 | -0.567 | 2.265 | 0.768 | -0.921 | -0.721 |
| 25 | 12.694 | 10.214 | 7.192 | 3.757 | 1.028 | 0.419 | 0.133 | 0.003 | -0.553 | 0.577 | 0.679 | 1.822 | 3.945 | 4.643 | 5.224 | 5.552 | 7.100 | 7.961 | 8.470 | 9.204 | 9.353 | 9.634 | 9.638 | 9.684 | 4.752 | 3.541 | 2.298 | 0.984 | -0.474 | 2.386 | 0.922 | -0.756 | -0.876 |

**REMARKS :**

| STATION | LIBMANAN | CUYAPI | NAGA | OMBAO | STO. DOMINGO | LAKE BATO |
|---|---|---|---|---|---|---|
| PEAK STAGE M. MSL | 3.498 | 2.472 | 2.916 | 8.556 | 10.667 | 10 667 |
| TIME | 13 -12 - 0 | 13 - 11 - 30 | 13 - 15 - 0 | 13 - 18 - 30 | 15 - 12 - 0 | 15 - 12 - 0 |

## TABLE 5.20 DAILY WATER LEVELS ALONG BICOL - SIPOCOT RIVERS IN METERS ABOVE MSL.

RETURN PERIOD OF DESIGN FLOOD 50 YEARS

FLOOD PROTECTION SCHEME : ⑧ POLUNTUNA RESERVOIR + BICOL-RAGAY DIVERSION

| RIVER | SIPOCOT RIVER | | | | | | | | BICOL RIVER | | | | | | | | | | | | | | | BICOL-RAGAY DIVERSION | | | | | SIPOCOT-SAN MIGUEL DIVERSION | | | SAN MIGUEL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOWN | | | | SABANG | | | LIBMANAN | | CUYAPI | | | NAGA | | | | | OMBAO | | | | | | STO. DOMINGO | LAKE BATO | | | | | PASACAO | | BARCELONA | BOLONGAY |
| DATE \ NODE NO. | 1 | 2 | 3 | 4 | 5 | 6 | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 5 | 12.483 | 9.951 | 6.825 | 3.408 | 0.844 | 0.343 | 0.203 | 0.140 | 0.098 | 0.118 | 0.122 | 0.197 | 0.749 | 1.081 | 1.303 | 1.413 | 3.814 | 5.148 | 5.472 | 6.213 | 6.693 | 7.018 | 7.022 | 7.033 | 0.613 | 0.133 | -0.416 | -0.639 | -0.733 | 2.302 | 1.198 | 0.095 | 0.095 |
| 6 | 12.437 | 9.921 | 6.752 | 3.253 | 0.816 | 0.193 | -0.187 | -0.360 | -0.355 | -0.478 | -0.495 | -0.410 | 0.647 | 1.040 | 1.283 | 1.393 | 3.740 | 5.044 | 5.382 | 6.192 | 6.696 | 7.036 | 7.040 | 7.061 | 0.754 | 0.361 | -0.166 | -0.488 | -0.718 | 2.002 | 0.788 | -0.336 | -0.336 |
| 7 | 12.459 | 9.916 | 6.830 | 3.338 | 0.793 | 0.156 | -0.301 | -0.510 | -0.725 | -0.640 | -0.634 | -0.401 | 0.711 | 1.121 | 1.369 | 1.486 | 3.846 | 5.157 | 5.495 | 6.260 | 6.739 | 7.068 | 7.072 | 7.088 | 0.818 | 0.418 | -0.102 | -0.423 | -0.609 | 1.973 | 0.616 | -0.711 | -0.711 |
| 8 | 12.452 | 9.918 | 6.751 | 3.288 | 0.792 | 0.178 | -0.301 | -0.519 | -0.909 | -0.636 | -0.621 | -0.361 | 0.665 | 1.063 | 1.316 | 1.433 | 3.792 | 5.102 | 5.437 | 6.250 | 6.746 | 7.089 | 7.094 | 7.113 | 0.794 | 0.415 | -0.066 | -0.361 | -0.898 | 1.925 | 0.518 | -0.960 | -0.990 |
| 9 | 12.474 | 9.932 | 6.838 | 3.362 | 0.811 | 0.232 | -0.211 | -0.412 | -0.898 | -0.470 | -0.447 | -0.164 | 0.761 | 1.150 | 1.396 | 1.514 | 3.888 | 5.208 | 5.543 | 6.310 | 6.787 | 7.122 | 7.126 | 7.137 | 0.831 | 0.444 | -0.021 | -0.294 | -0.508 | 2.002 | 0.573 | -0.998 | -0.998 |
| 10 | 12.461 | 9.928 | 6.761 | 3.295 | 0.883 | 0.378 | -0.021 | -0.203 | -0.689 | -0.249 | -0.220 | 0.046 | 0.784 | 1.123 | 1.346 | 1.458 | 3.830 | 5.148 | 5.482 | 6.297 | 6.790 | 7.136 | 7.140 | 7.158 | 0.792 | 0.416 | -0.012 | -0.246 | -0.422 | 2.032 | 0.709 | -0.841 | -0.841 |
| 11 | 12.477 | 9.935 | 6.847 | 3.364 | 0.946 | 0.511 | 0.214 | 0.079 | [illegible] | 0.064 | 0.115 | 0.379 | 0.981 | 1.213 | 1.441 | 1.555 | 3.923 | 5.289 | 5.677 | 6.353 | 6.827 | 7.161 | 7.166 | 7.178 | 0.830 | 0.429 | 0.002 | -0.029 | -0.383 | 2.204 | 0.959 | -0.510 | -0.510 |
| 12 | 13.745 | 12.325 | 10.443 | 6.379 | 2.783 | 1.604 | 0.994 | 0.717 | 0.178 | 1.106 | 1.211 | 1.992 | 3.270 | 3.641 | 3.914 | 4.034 | 5.719 | 6.655 | 7.076 | 7.398 | 7.671 | 8.080 | 8.085 | 7.968 | 2.920 | 2.130 | 0.994 | 0.230 | -0.312 | 4.298 | 2.214 | -0.077 | -0.077 |
| 13 | 16.649 | 15.608 | 14.434 | 10.981 | 6.054 | 4.106 | 2.889 | 2.336 | 0.787 | 1.920 | 2.048 | 2.708 | 4.668 | 5.368 | 5.658 | 5.774 | 7.453 | 8.387 | 8.766 | 8.704 | 8.722 | 9.485 | 9.557 | 9.567 | 4.511 | 3.562 | 2.101 | 0.893 | -0.305 | 7.452 | 3.987 | 0.364 | 0.364 |
| 14 | 17.418 | 16.321 | 13.282 | 9.699 | 5.361 | 3.678 | 2.606 | 2.119 | 1.269 | 2.150 | 2.349 | 2.748 | 4.854 | 5.291 | 5.556 | 5.717 | 7.894 | 9.104 | 9.481 | 9.804 | 9.918 | 10.404 | 10.450 | 10.493 | 4.577 | 3.672 | 2.144 | 1.015 | -0.386 | 6.822 | 3.847 | 0.719 | 0.719 |
| 15 | 16.317 | 13.836 | 11.416 | 7.840 | 4.078 | 2.650 | 1.840 | 1.472 | 1.008 | 1.359 | 1.426 | 2.259 | 4.140 | 4.652 | 5.053 | 5.287 | 7.782 | 9.168 | 9.639 | 10.102 | 10.226 | 10.571 | 10.601 | 10.651 | 4.153 | 3.273 | 1.897 | 0.750 | -0.395 | 5.551 | 3.247 | 0.916 | 0.916 |
| 16 | 15.112 | 12.598 | 9.908 | 6.381 | 3.028 | 1.855 | 1.349 | 1.119 | 0.957 | 1.106 | 1.138 | 1.796 | 3.691 | 4.284 | 4.771 | 5.045 | 7.674 | 9.135 | 9.501 | 10.148 | 10.272 | 10.562 | 10.585 | 10.637 | 3.926 | 3.064 | 1.717 | 0.604 | -0.478 | 4.527 | 2.698 | 0.921 | 0.921 |
| 17 | 14.287 | 11.723 | 8.996 | 5.546 | 2.383 | 1.329 | 0.978 | 0.818 | 0.761 | 0.858 | 0.882 | 1.610 | 3.567 | 4.130 | 4.641 | 4.925 | 7.591 | 9.072 | 9.439 | 10.100 | 10.221 | 10.492 | 10.512 | 10.566 | 3.805 | 2.949 | 1.612 | 0.508 | -0.369 | 3.872 | 2.256 | 0.743 | 0.743 |
| 18 | 13.741 | 11.163 | 8.291 | 4.835 | 1.915 | 0.953 | 0.604 | 0.445 | 0.427 | 0.492 | 0.519 | 1.372 | 3.341 | 3.967 | 4.477 | 4.762 | 7.464 | 8.949 | 9.322 | 10.013 | 10.137 | 10.397 | 10.415 | 10.468 | 3.663 | 2.824 | 1.508 | 0.421 | -0.655 | 3.294 | 1.804 | 0.426 | 0.426 |
| 19 | 13.409 | 10.842 | 7.947 | 4.494 | 1.617 | 0.710 | 0.279 | 0.083 | 0.037 | 0.235 | 0.278 | 1.267 | 3.240 | 3.860 | 4.362 | 4.643 | 7.339 | 8.837 | 9.217 | 9.907 | 10.032 | 10.288 | 10.305 | 10.358 | 3.546 | 2.718 | 1.415 | 0.345 | -0.721 | 2.944 | 1.441 | 0.039 | 0.039 |
| 20 | 13.123 | 10.600 | 7.543 | 4.108 | 1.349 | 0.537 | 0.046 | -0.177 | -0.340 | 0.026 | 0.069 | 1.085 | 3.076 | 3.688 | 4.183 | 4.462 | 7.183 | 8.694 | 9.082 | 9.795 | 9.922 | 10.173 | 10.189 | 10.240 | 3.401 | 2.589 | 1.320 | 0.279 | -0.757 | 2.600 | 1.101 | -0.347 | -0.347 |
| 21 | 12.906 | 10.447 | 7.371 | 3.968 | 1.189 | 0.415 | -0.082 | -0.308 | -0.617 | -0.052 | 0.033 | 1.077 | 3.013 | 3.611 | 4.094 | 4.366 | 7.074 | 8.579 | 8.977 | 9.675 | 9.803 | 10.054 | 10.069 | 10.120 | 3.306 | 2.501 | 1.253 | 0.241 | -0.757 | 2.432 | 0.985 | -0.668 | -0.668 |
| 22 | 12.725 | 10.286 | 7.152 | 3.729 | 1.083 | 0.376 | -0.136 | -0.368 | -0.786 | -0.107 | -0.043 | 0.941 | 2.858 | 3.447 | 3.925 | 4.197 | 6.926 | 8.443 | 8.851 | 9.558 | 9.689 | 9.939 | 9.953 | 10.003 | 3.162 | 2.378 | 1.171 | 0.209 | -0.721 | 2.255 | 0.726 | -0.883 | -0.883 |
| 23 | 12.705 | 10.234 | 7.206 | 3.773 | 1.057 | 0.368 | -0.105 | -0.321 | -0.813 | -0.041 | 0.024 | 0.983 | 2.821 | 3.394 | 3.858 | 4.121 | 6.83[illegible] | 8.349 | 8.765 | 9.446 | 9.578 | 9.833 | 9.847 | 9.894 | 3.083 | 2.307 | 1.125 | 0.204 | -0.654 | 2.284 | 0.727 | -0.967 | -0.967 |
| 24 | 12.676 | 10.205 | 7.095 | 3.658 | 1.059 | 0.420 | -0.031 | -0.236 | -0.732 | -0.012 | 0.045 | 0.908 | 2.678 | 3.243 | 3.704 | 3.969 | 6.709 | 8.231 | 8.656 | 9.344 | 9.481 | 9.734 | 9.74 | 9.793 | 2.955 | 2.200 | 1.061 | 0.199 | -0.567 | 2.261 | 0.766 | -0.921 | -0.921 |
| 25 | 12.594 | 10.213 | 7.194 | 3.750 | 1.068 | 0.443 | -0.068 | -0.182 | -0.546 | 0.156 | 0.232 | 1.019 | 2.672 | 3.219 | 3.662 | 3.917 | 6.642 | 8.155 | 8.585 | 9.247 | 9.385 | 9.642 | 9.656 | 9.700 | 2.897 | 2.145 | 1.027 | 0.210 | -0.47[illegible] | 2.382 | 0.920 | -0.756 | -0.756 |

REMARKS:

| STATION | LIBMANAN | CUYAPI | NAGA | OMBAO | STO. DOMINGO | LAKE BATO |
|---|---|---|---|---|---|---|
| PEAK STAGE M. MSL | 3.780 | 3.001 | 3.009 | 7.981 | 10.657 | 10.657 |
| TIME | 13-11-30 | 13-11-0 | 13-14-0 | 13-14-30 | 15-12-0 | 15-12-0 |

## TABLE 5.21 DAILY WATER LEVELS ALONG BICOL - SIPOCOT RIVERS IN METERS ABOVE MSL.

### RETURN' PERIOD OF DESIGN FLOOD 50 YEARS

### FLOOD PROTECTION SCHEME : ⑨ POLUNTUNA RESERVOIR + TIDAL BARRIER + BICOL-RAGAY DIVERSION

| RIVER | SIPOCOT RIVER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOWN | SABANG | | | | LIBMANAN | | | CUYAPI | | | NAGA | | | OMBAO | | | | STO. DOMINGO | | | | | | LAKE BATO | | PASACAO | | | BARCELONA | | BOLONGAY | |
| DATE \ NODE NO | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 5 | 12.483 | 9.951 | 6.825 | 3.408 | 0.844 | 0.343 | 0.203 | 0.140 | 0.098 | 0.118 | 0.122 | 0.197 | 0.749 | 1.081 | 1.303 | 1.413 | 3.814 | 5.148 | 5.472 | 6.213 | 6.693 | 7.018 | 7.022 | 7.033 | 0.613 | 0.133 | -0.416 | -0.639 | -0.733 | 2.302 | 1.198 | 0.035 | 0.093 |
| 6 | 12.437 | 9.922 | 6.743 | 3.288 | 0.740 | 0.083 | -0.330 | -0.517 | -0.493 | -0.661 | -0.674 | -0.519 | 0.627 | 1.026 | 1.276 | 1.389 | 3.743 | 5.050 | 5.385 | 6.193 | 6.697 | 7.036 | 7.041 | 7.061 | 0.748 | 0.356 | -0.168 | -0.490 | -0.718 | 2.026 | 0.800 | -0.836 | -0.689 |
| 7 | 12.498 | 9.923 | 6.817 | 3.369 | 0.736 | 0.083 | -0.363 | -0.566 | -0.723 | -0.664 | -0.664 | -0.405 | 0.702 | 1.112 | 1.365 | 1.483 | 3.847 | 5.160 | 5.498 | 6.260 | 6.739 | 7.069 | 7.073 | 7.088 | 0.815 | 0.415 | -0.104 | -0.434 | -0.669 | 1.994 | 0.627 | -0.711 | -0.556 |
| 8 | 12.451 | 9.923 | 6.740 | 3.315 | 0.745 | 0.121 | -0.314 | -0.511 | -0.859 | -0.531 | -0.548 | -0.343 | 0.650 | 1.040 | 1.305 | 1.425 | 3.794 | 5.111 | 5.443 | 6.252 | 6.748 | 7.050 | 7.054 | 7.113 | 0.782 | 0.404 | -0.072 | -0.364 | -0.535 | 1.944 | 0.538 | -0.988 | -1.104 |
| 9 | 12.472 | 9.957 | 6.825 | 3.397 | 0.720 | 0.118 | -0.205 | -0.476 | -0.905 | -0.453 | -0.429 | -0.140 | 0.728 | 1.125 | 1.378 | 1.502 | 3.888 | 5.214 | 5.548 | 6.313 | 6.788 | 7.120 | 7.124 | 7.137 | 0.822 | 0.436 | -0.026 | -0.296 | -0.498 | 2.026 | 0.585 | -0.908 | -0.890 |
| 10 | 12.459 | 9.934 | 6.746 | 3.338 | 0.684 | 0.041 | -0.211 | -0.386 | -0.516 | -0.388 | -0.290 | -0.137 | 0.646 | 1.036 | 1.298 | 1.424 | 3.827 | 5.161 | 5.480 | 6.299 | 6.792 | 7.137 | 7.141 | 7.158 | 0.766 | 0.398 | -0.020 | -0.249 | -0.422 | 2.081 | 0.724 | -0.841 | -0.662 |
| 11 | 12.475 | 9.944 | 6.834 | 3.417 | 0.651 | -0.060 | -0.236 | -0.316 | -0.347 | -0.326 | -0.325 | -0.226 | 0.710 | 1.118 | 1.376 | 1.504 | 3.912 | 5.251 | 5.583 | 6.353 | 6.826 | 7.161 | 7.165 | 7.178 | 0.801 | 0.413 | -0.004 | -0.211 | -0.353 | 2.246 | 0.981 | -0.610 | -0.385 |
| 12 | 13.744 | 12.325 | 10.436 | 6.394 | 2.760 | 1.553 | 1.054 | 0.825 | 0.453 | 1.186 | 1.263 | 1.989 | 3.269 | 3.638 | 3.910 | 4.031 | 5.718 | 6.685 | 7.076 | 7.396 | 7.671 | 8.080 | 8.085 | 7.969 | 2.916 | 2.126 | 0.992 | 0.229 | -0.312 | 4.310 | 2.221 | -0.077 | 0.235 |
| 13 | 16.648 | 15.608 | 14.434 | 10.981 | 6.061 | 4.132 | 2.982 | 2.460 | 1.243 | 1.942 | 2.060 | 2.707 | 4.668 | 5.368 | 5.658 | 5.774 | 7.453 | 8.387 | 8.766 | 8.704 | 8.723 | 9.485 | 9.557 | 9.567 | 4.511 | 3.562 | 2.101 | 0.893 | -0.305 | 7.452 | 3.987 | 0.364 | 1.184 |
| 14 | 17.418 | 15.321 | 13.282 | 9.699 | 5.863 | 3.686 | 2.648 | 2.176 | 1.399 | 2.005 | 2.122 | 2.643 | 4.847 | 5.287 | 5.553 | 5.715 | 7.894 | 9.104 | 9.481 | 9.804 | 9.918 | 10.404 | 10.450 | 10.453 | 4.575 | 3.671 | 2.243 | 1.014 | -0.335 | 6.822 | 3.847 | 0.719 | 1.148 |
| 15 | 16.317 | 13.836 | 11.416 | 7.840 | 4.079 | 2.639 | 1.891 | 1.542 | 1.158 | 1.373 | 1.417 | 2.246 | 4.151 | 4.646 | 5.048 | 5.283 | 7.781 | 9.169 | 9.540 | 10.102 | 10.226 | 10.571 | 10.601 | 10.651 | 4.149 | 3.270 | 1.894 | 0.748 | -0.395 | 5.551 | 3.247 | 0.946 | 1.151 |
| 16 | 15.112 | 12.593 | 9.908 | 6.360 | 3.016 | 1.758 | 1.186 | 0.908 | 0.712 | 0.962 | 0.891 | 1.741 | 3.689 | 4.283 | 4.770 | 5.044 | 7.674 | 9.135 | 9.501 | 10.149 | 10.272 | 10.562 | 10.585 | 10.638 | 3.925 | 3.064 | 1.716 | 0.603 | -0.478 | 4.526 | 2.698 | 0.921 | 0.830 |
| 17 | 14.287 | 11.723 | 8.995 | 5.545 | 2.364 | 1.221 | 0.552 | 0.248 | 0.230 | 0.302 | 0.334 | 1.454 | 3.496 | 4.126 | 4.639 | 4.923 | 7.590 | 9.073 | 9.439 | 10.100 | 10.222 | 10.492 | 10.512 | 10.566 | 3.803 | 2.948 | 1.611 | 0.507 | -0.568 | 3.873 | 2.256 | 0.743 | -0.047 |
| 18 | 13.741 | 11.163 | 8.290 | 4.839 | 1.902 | 0.895 | 0.375 | 0.138 | 0.036 | 0.253 | 0.294 | 1.310 | 3.334 | 3.963 | 4.474 | 4.760 | 7.453 | 8.950 | 9.322 | 10.04 | 10.137 | 10.397 | 10.415 | 10.468 | 3.661 | 2.822 | 1.506 | 0.420 | -0.685 | 3.297 | 1.806 | 0.486 | 0.181 |
| 19 | 13.409 | 10.842 | 7.946 | 4.499 | 1.593 | 0.668 | 0.054 | -0.234 | -0.421 | 0.030 | 0.071 | 1.217 | 3.236 | 3.858 | 4.361 | 4.642 | 7.339 | 8.838 | 9.217 | 9.907 | 10.032 | 10.288 | 10.386 | 10.338 | 3.545 | 2.714 | 1.414 | 0.344 | -0.721 | 2.947 | 1.443 | 0.039 | -0.170 |
| 20 | 13.113 | 10.600 | 7.543 | 4.108 | 1.351 | 0.534 | -0.012 | -0.260 | -0.620 | -0.059 | 0.027 | 1.076 | 3.075 | 3.686 | 4.183 | 4.462 | 7.183 | 8.696 | 9.083 | 9.796 | 9.922 | 10.173 | 10.188 | 10.240 | 3.401 | 2.589 | 1.320 | 0.279 | -0.757 | 2.600 | 1.101 | -0.347 | -0.586 |
| 21 | 12.895 | 10.447 | 7.370 | 3.972 | 1.186 | 0.418 | -0.070 | -0.292 | -0.682 | -0.013 | 0.067 | 1.089 | 3.014 | 3.611 | 4.094 | 4.366 | 7.074 | 8.579 | 8.977 | 9.675 | 9.803 | 10.054 | 10.068 | 10.121 | 3.306 | 2.501 | 1.252 | 0.241 | -0.757 | 2.435 | 0.886 | -0.668 | -0.966 |
| 22 | 12.715 | 10.286 | 7.152 | 3.782 | 1.074 | 0.366 | -0.110 | -0.340 | -0.778 | -0.072 | -0.013 | 0.998 | 2.858 | 3.447 | 3.925 | 4.187 | 6.926 | 8.443 | 8.851 | 9.558 | 9.680 | 9.939 | 9.964 | 10.003 | 3.161 | 2.378 | 1.171 | 0.206 | -0.721 | 2.257 | 0.727 | -0.888 | -0.462 |
| 23 | 12.705 | 10.135 | 7.204 | 3.779 | 1.056 | 0.378 | -0.063 | -0.264 | -0.792 | 0.027 | 0.104 | 1.024 | 2.823 | 3.355 | 3.858 | 4.122 | 6.840 | 8.350 | 8.766 | 9.446 | 9.579 | 9.833 | 9.847 | 9.894 | 3.083 | 2.307 | 1.124 | 0.204 | -0.654 | 2.288 | 0.730 | -0.967 | -1.103 |
| 24 | 12.675 | 10.207 | 7.090 | 3.674 | 1.009 | 0.365 | -0.023 | -0.199 | -0.606 | 0.010 | 0.068 | 0.912 | 2.675 | 3.239 | 3.701 | 3.966 | 6.708 | 8.231 | 8.656 | 9.344 | 9.461 | 9.734 | 9.747 | 9.795 | 2.953 | 2.197 | 1.059 | 0.199 | -0.567 | 2.271 | 0.771 | -0.921 | -0.529 |
| 25 | 12.694 | 10.216 | 7.185 | 3.715 | 1.013 | 0.397 | 0.046 | -0.114 | -0.553 | 0.190 | 0.276 | 1.032 | 2.669 | 3.214 | 3.658 | 3.914 | 6.641 | 8.156 | 8.585 | 9.247 | 9.386 | 9.642 | 9.656 | 9.700 | 2.993 | 2.142 | 1.026 | 0.209 | -0.474 | 2.339 | 0.929 | -0.756 | -0.886 |

**REMARKS :**

| STATION | LIBMANAN | CUYAPI | NAGA | OMBAO | STO. DOMINGO | LAKE BATO |
|---|---|---|---|---|---|---|
| PEAK STAGE M.MSL | 3.532 | 2.593 | 2.775 | 7.981 | 10.657 | 10.657 |
| TIME | 13 -12-0 | 13-12-0 | 13-7-30 | 13-14-30 | 15 -12-0 | 15 -12-0 |

## TABLE 5.22 DAILY WATER LEVELS ALONG BICOL - SIPOCOT RIVERS IN METERS ABOVE MSL.

### RETURN PERIOD OF DESIGN FLOOD 50 YEARS

### FLOOD PROTECTION SCHEME : (10) POLUNTUNA RESERVOIR + SIPOCOT - SAN MIGUEL DIVERSION + TIDAL BARRIER + BICOL-RAGAY DIVERSION

| RIVER | SIPOCOT RIVER | | | | | | | | | | | BICOL RIVER | | | | | | | | | | | | BICOL-RAGAY DIVERSION | | | | | SIPOCOT-SAN MIGUEL DIVERSION | | | SAN MIGUEL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOWN | SABANG | | | | LIBMANAN | | CUYAPI | | | NAGA | | OMBAO | | | | | STO. DOMINGO | | | | | LAKE BATO | | | | PASACAO | | BARCELONA | | BOLONGAY | |
| DATE \ NODE NO | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 5 | 12.547 | 9.737 | 7.361 | 2.252 | 0.364 | 0.018 | -0.077 | -0.120 | -0.188 | -0.101 | -0.084 | -0.080 | 0.682 | 1.058 | 1.301 | 1.417 | 3.787 | 5.104 | 5.434 | 6.208 | 6.639 | 7.031 | 7.035 | 7.050 | 7.054 | 0.386 | 0.000 | -0.147 | -0.195 | 1.486 | 0.861 | 0.459 | -0.036 |
| 6 | 12.515 | 9.707 | 7.309 | 2.181 | 0.241 | -0.198 | -0.521 | -0.667 | -0.715 | -0.716 | -0.718 | -0.518 | 0.622 | 1.021 | 1.272 | 1.386 | 3.743 | 5.053 | 5.387 | 6.194 | 6.697 | 7.037 | 7.041 | 7.061 | 0.744 | 0.353 | -0.170 | -0.459 | -0.718 | 1.422 | 0.787 | -0.336 | -0.636 |
| 7 | 12.539 | 9.710 | 7.381 | 2.251 | 0.284 | -0.130 | -0.479 | -0.637 | -0.741 | -0.671 | -0.673 | -0.408 | 0.702 | 1.113 | 1.365 | 1.483 | 3.847 | 5.160 | 5.497 | 6.260 | 6.739 | 7.069 | 7.073 | 7.088 | 0.815 | 0.415 | -0.104 | -0.434 | -0.669 | 1.466 | 0.821 | -0.711 | -0.530 |
| 8 | 12.531 | 9.714 | 7.310 | 2.203 | 0.284 | -0.154 | -0.467 | -0.610 | -0.590 | -0.606 | -0.530 | -0.359 | 0.636 | 1.038 | 1.297 | 1.418 | 3.794 | 5.114 | 5.445 | 6.253 | 6.748 | 7.090 | 7.095 | 7.113 | 0.776 | 0.400 | -0.074 | -0.365 | -0.935 | 1.438 | 0.789 | -0.350 | -1.000 |
| 9 | 12.553 | 9.727 | 7.388 | 2.280 | 0.177 | -0.170 | -0.471 | -0.608 | -1.006 | -0.485 | -0.447 | -0.162 | 0.713 | 1.114 | 1.372 | 1.496 | 3.888 | 5.216 | 5.549 | 6.313 | 6.788 | 7.120 | 7.124 | 7.137 | 0.819 | 0.433 | -0.027 | -0.297 | -0.508 | 1.474 | 0.754 | -0.388 | -1.198 |
| 10 | 12.539 | 9.727 | 7.313 | 2.224 | 0.102 | -0.250 | -0.377 | -0.436 | -0.620 | -0.362 | -0.331 | -0.193 | 0.638 | 1.033 | 1.296 | 1.423 | 3.826 | 5.162 | 5.490 | 6.299 | 6.792 | 7.137 | 7.141 | 7.158 | 0.765 | 0.338 | -0.020 | -0.349 | -0.422 | 1.435 | 0.683 | -0.841 | -0.625 |
| 11 | 12.555 | 9.735 | 7.384 | 2.299 | 0.054 | -0.359 | -0.380 | -0.405 | -0.416 | -0.391 | -0.390 | -0.278 | 0.706 | 1.114 | 1.376 | 1.504 | 3.912 | 5.250 | 5.583 | 6.353 | 6.826 | 7.161 | 7.165 | 7.178 | 0.801 | 0.413 | -0.004 | -0.211 | -0.353 | 1.483 | 0.707 | -0.510 | -0.399 |
| 12 | 13.773 | 12.389 | 10.866 | 4.679 | 1.817 | 1.120 | 0.867 | 0.751 | 0.581 | 1.199 | 1.294 | 2.001 | 3.269 | 3.638 | 3.910 | 4.031 | 5.718 | 6.655 | 7.076 | 7.395 | 7.671 | 8.080 | 8.085 | 7.969 | 2.916 | 2.126 | 0.932 | 0.229 | -0.312 | 3.439 | 2.310 | -0.677 | 0.480 |
| 13 | 16.672 | 15.443 | 14.543 | 7.908 | 4.337 | 3.008 | 2.388 | 1.961 | 1.272 | 1.895 | 2.043 | 2.707 | 4.668 | 5.368 | 5.658 | 5.714 | 7.453 | 8.387 | 8.766 | 8.704 | 8.723 | 9.485 | 9.557 | 9.567 | 4.511 | 3.562 | 2.101 | 0.893 | -0.305 | 6.942 | 5.300 | 0.364 | 0.884 |
| 14 | 17.435 | 15.389 | 13.526 | 6.761 | 3.744 | 2.595 | 1.934 | 1.634 | 1.258 | 1.981 | 2.089 | 2.629 | 4.846 | 5.287 | 5.553 | 5.715 | 7.894 | 9.104 | 9.481 | 9.804 | 9.918 | 10.404 | 10.450 | 10.493 | 4.575 | 3.671 | 2.243 | 1.014 | -0.833 | 5.907 | 4.528 | 0.719 | 1.040 |
| 15 | 16.388 | 13.881 | 11.651 | 5.666 | 2.727 | 1.701 | 1.343 | 1.181 | 1.197 | 1.264 | 1.286 | 2.240 | 4.130 | 4.645 | 5.048 | 5.283 | 7.781 | 9.169 | 9.540 | 10.102 | 10.276 | 10.571 | 10.601 | 10.651 | 4.149 | 3.269 | 1.894 | 0.747 | -0.335 | 4.488 | 3.269 | 0.916 | 1.085 |
| 16 | 15.117 | 12.584 | 10.197 | 4.581 | 1.916 | 1.004 | 0.667 | 0.514 | 0.376 | 0.649 | 0.693 | 1.688 | 3.681 | 4.278 | 4.767 | 5.042 | 7.673 | 9.135 | 9.501 | 10.149 | 10.272 | 10.562 | 10.585 | 10.638 | 3.923 | 3.062 | 1.715 | 0.602 | -0.478 | 3.545 | 2.510 | 0.921 | 0.590 |
| 17 | 14.289 | 11.699 | 9.422 | 3.955 | 1.375 | 0.601 | 0.183 | -0.006 | 0.101 | 0.320 | 0.358 | 1.465 | 3.492 | 4.122 | 4.656 | 4.921 | 7.590 | 9.073 | 9.439 | 10.100 | 10.222 | 10.492 | 10.512 | 10.566 | 3.801 | 2.946 | 1.609 | 0.506 | -0.569 | 2.990 | 2.065 | 0.743 | 0.155 |
| 18 | 13.749 | 11.082 | 8.778 | 3.397 | 1.053 | 0.414 | 0.129 | -0.001 | 0.060 | 0.242 | 0.285 | 1.308 | 3.334 | 3.963 | 4.474 | 4.760 | 7.453 | 8.950 | 9.322 | 10.014 | 10.137 | 10.397 | 10.415 | 10.468 | 3.661 | 2.822 | 1.507 | 0.420 | -0.655 | 2.509 | 1.682 | 0.426 | 0.122 |
| 19 | 13.432 | 10.719 | 8.449 | 3.148 | 0.860 | 0.241 | -0.203 | -0.405 | -0.349 | 0.036 | 0.070 | 1.216 | 3.236 | 3.858 | 4.361 | 4.642 | 7.339 | 8.838 | 9.217 | 9.907 | 10.032 | 10.288 | 10.345 | 10.358 | 3.545 | 2.714 | 1.414 | 0.344 | -0.721 | 2.276 | 1.490 | 0.039 | -0.368 |
| 20 | 13.153 | 10.441 | 8.068 | 2.832 | 0.709 | 0.176 | -0.274 | -0.479 | -0.517 | -0.063 | -0.032 | 1.063 | 3.074 | 3.687 | 4.183 | 4.462 | 7.183 | 8.695 | 9.083 | 9.795 | 9.922 | 10.173 | 10.189 | 10.240 | 3.401 | 2.589 | 1.320 | 0.279 | -0.757 | 2.012 | 1.289 | -0.547 | -0.376 |
| 21 | 12.948 | 10.264 | 7.902 | 2.738 | 0.617 | 0.147 | -0.222 | -0.391 | -0.741 | -0.015 | 0.061 | 1.030 | 3.014 | 3.611 | 4.084 | 4.366 | 7.074 | 8.579 | 8.977 | 9.675 | 9.803 | 10.054 | 10.069 | 10.121 | 3.306 | 2.501 | 1.232 | 0.241 | -0.757 | 1.908 | 1.194 | -0.668 | -0.774 |
| 22 | 12.780 | 10.108 | 7.689 | 2.537 | 0.515 | 0.077 | -0.259 | -0.411 | -0.661 | -0.055 | 0.006 | 0.958 | 2.858 | 3.447 | 3.926 | 4.197 | 6.926 | 8.443 | 8.851 | 9.558 | 9.689 | 9.939 | 9.954 | 10.003 | 3.162 | 2.378 | 1.171 | 0.208 | -0.721 | 1.740 | 1.045 | -0.883 | -1.059 |
| 23 | 12.762 | 10.063 | 7.742 | 2.589 | 0.551 | 0.148 | -0.162 | -0.303 | -0.655 | 0.026 | 0.091 | 1.013 | 2.821 | 3.394 | 3.858 | 4.121 | 6.840 | 8.350 | 8.766 | 9.446 | 9.579 | 9.833 | 9.847 | 9.895 | 3.083 | 2.306 | 1.124 | 0.284 | -0.654 | 1.756 | 1.013 | -0.967 | -0.878 |
| 24 | 12.732 | 10.054 | 7.658 | 2.491 | 0.525 | 0.188 | -0.107 | -0.238 | -0.542 | 0.032 | 0.077 | 0.916 | 2.675 | 3.240 | 3.702 | 3.967 | 6.708 | 8.231 | 8.657 | 9.344 | 9.481 | 9.734 | 9.747 | 9.793 | 2.953 | 2.198 | 1.060 | 0.199 | -0.567 | 1.680 | 0.918 | -0.921 | -0.490 |
| 25 | 12.752 | 10.041 | 7.724 | 2.587 | 0.514 | 0.262 | 0.019 | -0.092 | -0.514 | 0.163 | 0.249 | 1.008 | 2.667 | 3.213 | 3.698 | 3.914 | 6.641 | 8.156 | 8.585 | 9.247 | 9.366 | 9.642 | 9.656 | 9.700 | 2.893 | 2.142 | 1.025 | 0.209 | -0.434 | 1.735 | 0.915 | -0.756 | -0.86 |

| REMARKS : STATION | LIBMANAN | CUYAPI | NAGA | OMBAO | STO. DOMINGO | LAKE BATO |
|---|---|---|---|---|---|---|
| PEAK STAGE M. MSL | 2.958 | 2.619 | 2.774 | 7.381 | 10.657 | 10.657 |
| TIME | 13 - 12 - 30 | 13 - 12 - 30 | 13 - 7 - 30 | 13 - 14 - 30 | 15 - 12 - 0 | 15 - 12 - 0 |

TABLE 5.23 DAILY WATER LEVELS ALONG BICOL - SIPOCOT RIVERS IN METERS ABOVE MSL.

RETURN PERIOD OF DESIGN FLOOD 50 YEARS

FLOOD PROTECTION SCHEME : (11) NONE

| RIVER | SIPOCOT RIVER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RIVER | BICOL RIVER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| RIVER | BICOL-RAGAY DIVERSION | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| RIVER | SIPOCOT-SAN MIGUEL DIVERSION | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| RIVER | SAN MIGUEL | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| TOWN | SABANG | | | | LIBMANAN | | | | CUYAPI | | | | NAGA | | | | OMBAO | | | | STO. DOMINGO | | | | LAKE BATO | | | PASACAO | | BARCELONA | | BOLONGAY | |
| NODE NO / DATE | 1 | 2 | 3 | 4 | 5 | 6 | | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 5 | 12.496 | 9.980 | 6.846 | 3.459 | 0.878 | 0.359 | 0.212 | 0.146 | 0.101 | 0.152 | 0.161 | 0.385 | 1.428 | 1.813 | 2.207 | 2.401 | 3.925 | 4.771 | 5.249 | 6.139 | 6.658 | 6.992 | 6.996 | 7.008 | 1.952 | 1.280 | 0.608 | -0.063 | -0.733 | 2.338 | 1.217 | 0.095 | 0.085 |
| 6 | 12.374 | 9.882 | 6.738 | 3.251 | 0.820 | 0.157 | -0.184 | -0.387 | -0.356 | -0.425 | -0.431 | -0.151 | 1.313 | 1.709 | 2.114 | 2.309 | 3.851 | 4.708 | 5.188 | 6.136 | 6.671 | 7.018 | 7.023 | 7.037 | 1.975 | 1.435 | 0.829 | 0.121 | -0.718 | 2.002 | 0.788 | -0.336 | -0.336 |
| 7 | 12.515 | 9.944 | 6.830 | 3.315 | 0.786 | 0.154 | 0.299 | -0.505 | 0.718 | -0.542 | 0.523 | -0.107 | 1.396 | 1.807 | 2.219 | 2.421 | 3.961 | 4.817 | 5.296 | 6.194 | 6.710 | 7.049 | 7.053 | 7.065 | 2.065 | 1.511 | 0.901 | 0.190 | -0.669 | 1.964 | 0.611 | -0.711 | -0.711 |
| 8 | 12.399 | 9.902 | 6.757 | 3.303 | 0.799 | 0.183 | -0.295 | -0.511 | -0.896 | -0.532 | -0.508 | -0.081 | 1.340 | 1.747 | 2.160 | 2.358 | 3.898 | 4.754 | 5.234 | 6.189 | 6.720 | 7.071 | 7.076 | 7.081 | 2.028 | 1.498 | 0.915 | 0.286 | -0.595 | 1.935 | 0.524 | -0.990 | -0.952 |
| 9 | 12.534 | 9.959 | 6.837 | 3.355 | 0.802 | 0.221 | -0.215 | -0.414 | -0.885 | -0.378 | -0.340 | 0.115 | 1.443 | 1.858 | 2.272 | 2.475 | 4.006 | 4.856 | 5.335 | 6.242 | 6.756 | 7.098 | 7.102 | 7.115 | 2.112 | 1.557 | 0.965 | 0.297 | -0.508 | 1.997 | 0.571 | -0.998 | -0.998 |
| 10 | 12.403 | 9.907 | 6.764 | 3.306 | 0.892 | 0.383 | -0.015 | -0.196 | -0.681 | -0.194 | -0.154 | 0.279 | 1.420 | 1.817 | 2.222 | 2.420 | 3.943 | 4.789 | 5.270 | 6.233 | 6.762 | 7.116 | 7.121 | 7.137 | 2.070 | 1.526 | 0.952 | 0.321 | -0.422 | 2.060 | 0.713 | -0.841 | -0.841 |
| 11 | 12.535 | 9.958 | 6.845 | 3.343 | 0.943 | 0.503 | 0.215 | 0.084 | -0.331 | 0.097 | 0.155 | 0.520 | 1.548 | 1.940 | 2.338 | 2.538 | 4.048 | 4.887 | 5.367 | 6.284 | 6.793 | 7.139 | 7.143 | 7.157 | 2.143 | 1.561 | 0.969 | 0.346 | -0.353 | 2.196 | 0.955 | -0.510 | -0.810 |
| 12 | 14.726 | 12.974 | 10.816 | 6.669 | 2.920 | 1.667 | 1.028 | 0.738 | 0.188 | 1.171 | 1.284 | 2.120 | 3.773 | 4.416 | 4.943 | 5.198 | 6.269 | 6.863 | 7.167 | 7.392 | 7.656 | 8.056 | 8.061 | 7.956 | 4.325 | 3.142 | 1.996 | 0.860 | -0.312 | 4.482 | 2.305 | -0.077 | -0.077 |
| 13 | 18.798 | 17.055 | 15.382 | 11.683 | 6.514 | 4.436 | 3.136 | 2.545 | 0.856 | 2.033 | 2.153 | 2.819 | 5.230 | 6.264 | 6.797 | 7.078 | 7.975 | 8.474 | 8.796 | 8.716 | 8.729 | 9.477 | 9.549 | 9.568 | 5.909 | 4.305 | 2.750 | 1.222 | -0.305 | 7.908 | 4.212 | 0.364 | 0.364 |
| 14 | 17.004 | 15.131 | 13.300 | 9.775 | 5.461 | 3.778 | 2.703 | 2.214 | 1.317 | 2.387 | 2.490 | 2.927 | 5.644 | 6.417 | 6.918 | 7.254 | 8.505 | 9.201 | 9.543 | 9.838 | 9.944 | 10.409 | 10.454 | 10.494 | 6.249 | 4.677 | 3.045 | 1.362 | -0.335 | 6.895 | 3.891 | 0.719 | 0.719 |
| 15 | 15.212 | 12.870 | 10.743 | 7.298 | 3.774 | 2.471 | 1.759 | 1.436 | 1.057 | 1.818 | 1.917 | 2.622 | 5.231 | 6.015 | 6.606 | 6.982 | 8.408 | 9.200 | 9.568 | 10.123 | 10.244 | 10.580 | 10.608 | 10.656 | 5.971 | 4.422 | 2.832 | 1.211 | -0.395 | 5.197 | 3.073 | 0.916 | 0.916 |
| 16 | 14.269 | 11.718 | 9.297 | 5.843 | 2.695 | 1.642 | 1.259 | 1.085 | 0.977 | 1.434 | 1.515 | 2.513 | 4.982 | 5.781 | 6.411 | 6.800 | 8.289 | 9.116 | 9.497 | 10.156 | 10.280 | 10.570 | 10.593 | 10.645 | 5.820 | 4.311 | 2.748 | 1.132 | -0.478 | 4.170 | 2.522 | 0.921 | 0.921 |
| 17 | 13.816 | 11.213 | 8.609 | 5.175 | 2.146 | 1.183 | 0.930 | 0.815 | 0.774 | 1.238 | 1.315 | 2.464 | 4.837 | 5.647 | 6.289 | 6.677 | 8.184 | 9.021 | 9.412 | 10.099 | 10.223 | 10.498 | 10.518 | 10.572 | 5.715 | 4.236 | 2.692 | 1.073 | -0.569 | 3.624 | 2.134 | 0.743 | 0.743 |
| 18 | 13.389 | 10.809 | 8.036 | 4.594 | 1.773 | 0.873 | 0.587 | 0.457 | 0.448 | 1.063 | 1.147 | 2.411 | 4.725 | 5.508 | 6.140 | 6.521 | 8.035 | 8.876 | 9.282 | 10.006 | 10.134 | 10.339 | 10.418 | 10.472 | 5.596 | 4.161 | 2.646 | 1.029 | -0.655 | 3.134 | 1.726 | 0.426 | 0.426 |
| 19 | 13.264 | 10.665 | 7.807 | 4.340 | 1.505 | 0.668 | 0.282 | 0.106 | 0.070 | 0.933 | 1.026 | 2.356 | 4.610 | 5.383 | 6.009 | 6.382 | 7.898 | 8.741 | 9.162 | 9.895 | 10.024 | 10.288 | 10.305 | 10.359 | 5.477 | 4.081 | 2.599 | 0.996 | -0.721 | 2.839 | 1.389 | 0.039 | 0.039 |
| 20 | 12.896 | 10.413 | 7.426 | 4.007 | 1.300 | 0.522 | 0.069 | -0.157 | -0.291 | 0.669 | 0.773 | 2.284 | 4.493 | 5.237 | 5.849 | 6.211 | 7.733 | 8.579 | 9.018 | 9.777 | 9.909 | 10.169 | 10.185 | 10.238 | 5.343 | 3.993 | 2.554 | 0.978 | -0.757 | 2.533 | 1.068 | -0.347 | -0.347 |
| 21 | 12.781 | 10.316 | 7.283 | 3.871 | 1.142 | 0.404 | -0.068 | -0.288 | -0.551 | 0.579 | 0.689 | 2.206 | 4.377 | 5.116 | 5.723 | 6.078 | 7.601 | 8.447 | 8.903 | 9.651 | 9.786 | 10.047 | 10.062 | 10.115 | 5.224 | 3.907 | 2.509 | 0.971 | -0.757 | 2.367 | 0.852 | -0.668 | -0.668 |
| 22 | 12.601 | 10.169 | 7.089 | 3.668 | 1.057 | 0.348 | -0.100 | -0.313 | -0.686 | 0.504 | 0.604 | 2.110 | 4.263 | 4.975 | 5.567 | 5.912 | 7.442 | 8.292 | 8.769 | 9.530 | 9.668 | 9.929 | 9.944 | 9.994 | 5.088 | 3.812 | 2.461 | 0.974 | -0.721 | 2.213 | 0.705 | -0.883 | -0.883 |
| 23 | 12.764 | 10.243 | 7.193 | 3.737 | 1.040 | 0.371 | -0.078 | -0.282 | -0.723 | 0.454 | 0.557 | 2.003 | 4.148 | 4.862 | 5.453 | 5.792 | 7.327 | 8.179 | 8.674 | 9.412 | 9.554 | 9.819 | 9.834 | 9.883 | 4.973 | 3.721 | 2.409 | 0.978 | -0.654 | 2.258 | 0.714 | -0.967 | -0.967 |
| 24 | 12.601 | 10.169 | 7.091 | 3.665 | 1.066 | 0.432 | -0.004 | -0.202 | -0.647 | 0.452 | 0.573 | 1.903 | 4.041 | 4.374 | 5.314 | 5.646 | 7.191 | 8.049 | 8.554 | 9.306 | 9.452 | 9.717 | 9.731 | 9.778 | 4.850 | 3.627 | 2.355 | 0.985 | -0.567 | 2.266 | 0.769 | -0.921 | -0.921 |
| 25 | 12.764 | 10.243 | 7.193 | 3.738 | 1.063 | 0.451 | 0.088 | -0.078 | -0.488 | 0.496 | 0.612 | 1.847 | 3.945 | 4.642 | 5.223 | 5.551 | 7.099 | 7.959 | 8.468 | 8.702 | 9.352 | 9.622 | 9.636 | 9.682 | 4.751 | 3.540 | 2.297 | 0.984 | -0.474 | 2.373 | 0.916 | -0.755 | -0.755 |

**REMARKS:**

| STATION | LIBMANAN | CUYAPI | NAGA | OMBAO | STO. DOMINGO | LAKE BATO |
|---|---|---|---|---|---|---|
| PEAK STAGE M.MSL | 3.934 | 2.986 | 3.155 | 8.552 | 10.664 | 10.664 |
| TIME | 13 -11 -30 | 13 -11-0 | 13 -14-0 | 13 -18-0 | 15 -12 -0 | 15 -12 -0 |

| Name | Program Type |
|---|---|
| BARIER | |
| SIMQ | |
| DESNIN | |
| TIDAL1 | Subroutine |
| BMET | |
| TIDAL2 | |
| PMET | |

The program handles 3 main parts namely: Hydrologic Model, Tidal Model and Unsteady Free Surface Flow Model. The program could handle all combinations of flood control schemes. Shown in Section C1 of Appendix C is the list of the computer programs of the main program and its subroutines.

5.9.2 Functions of Main Program and Subroutines

Main program BICOL2 - The water levels and discharges along Bicol and Sipocot Rivers, the cutoffs and diversion canals are computed from the program. The water level boundary conditions are the sea water levels at Balongay (Node No.31) and Barcelona (Node No.30) on the eastern side and at Pasacao (Node No.27) on the western side of the Luzon Island. The discharge boundary conditions are the surface runoffs which consist of overland flow and tributary streamflows. The discharge boundary conditions are assigned to the nodes. The program requires the knowledge of the roughness and runoff coefficients. The roughness coefficients are assigned for the branches in the flow system. The runoff coefficients are assigned to the Thiessen polygon subdivided for the watersheds in the river basin.

Main program BICOL2 also requires the following information:

a) The time interval used in the computation during the time of typhoon surge.

b) The return period of the flood under investigation.

c) The date which the computation starts.

d) The code assigned for the print out of input information.

e) Percentage of gate opening area of the tidal barrier.

f) Time difference between the peak times of the storm surge and the nearest high tide.

g) Heading of the data input.

h) Time interval that the lateral discharge inputs to the nodes are available.

i) Requested time interval for the printout of the computed results.

j) Maximum allowable error in water levels when steady condition is checked.

k) Codes assigned for the selections of the flood control schemes.

Subroutine INPUT2 - The following input information are read:

a) Numbers of nodes and branches in the flow system.

b) Numbers of days of the flood which are required under investigation.

c) Time interval for the numerical computation.

d) Initial water levels at the nodes when the computation starts.

e) Roughness coefficients for main channel and berms.

f) Distance intervals for main channel and berms.

g) The geometry of main channel and berms.

h) The surface area-elevation relationships of Lakes and Reservoir.

Subroutine RITIN2 - The input information which have been read in subroutine INPUT2 are written through this program.

Subroutine DESNIN - In this subroutine, the lateral discharge inputs to the nodes are computed. The lateral discharge inputs are determined either from the rainfall alone or from the distribution graph applied to the rainfall and the observed streamflows of the river tributaries. This depends on the condition of the design floods.

Subroutine TIDAL1 and TIDAL2 - In these subroutines, the fluctuations of the sea water levels on the eastern and western side of Luzon Island are generated respectively. The sea water levels generated on the eastern side are at Barcelona (the outlet of Sipocot-San Miguel Diversion) and Balongay (Site for Tidal Barrier). They are assumed equal. On the western side, the sea water level is generated at Pasacao (the

outlet of Bicol-Ragay Diversion). The subroutines combine the rise of the sea water levels produced by high tide and typhoon surge. Subroutines TIDAL1 and TIDAL2 further call respectively subroutines BMET and TMET which compute the height of the storm surge.

Subroutine BARIER - The river discharge through the barrier is computed. The gate of the barrier is set open if the sea water level is lower than the water level on the river side of the barrier.

Subroutine DIFH2 - The differences between the water levels at the downstream and upstream ends of the branches are computed.

Subroutine STAGE2 - The average water levels at the midway of the branches are computed.

Subroutine DIFAM2 - The differences between the downstream and upstream cross sectional areas and momentum correction factors of the branches are computed. Subroutine DIFAM2 calls subroutines GEO1 and GEO2 which compute respectively the cross sectional areas, the topwidths and the mean depths of the main channel and berms at the downstream and upstream ends of the branches.

Subroutine GEO - The cross sectional areas, topwidths and mean depths of cross sections at midway of the branches are computed. The momentum correction factor M and the conveyance K for the branch are also computed from this subroutine.

Subroutine ATMK2 - The main channel and berm geometry and the roughness coefficients are schematized to obtain the river system that the flow distances along main channel and berms are equal.

The condition is required in the continuity and momentum equations. The schematization also implies the condition that the friction slopes along the main channel and berms are equal.

Subroutine SURF2 - The surface areas of the nodes are computed. The surface areas of the nodes consist of the surface areas of the branches measured halfway of the distances to the adjacent nodes plus the additional surface areas of the lake or reservoir in its vicinity.

Subroutine SQ2 - The subroutine which computes the discharge summation per unit surface areas of the upstream and downstream nodes of each branch.

Subroutine SIMQ - The subroutine which solves the set of linearlized finite difference continuity and momentum equations which are expressed for the nodes and branches in the flow system. The method of solving the equations is performed through the application of the matrix inversion.

5.9.3 Computational Route of Main Program BICOL2 The computational route for the main program BICOL2 is described using the flow chart shown in Fig.5.14. The time step used in the computation is one hour but is reduced to thirty minutes or less to prevent mathematical instability during the period of rapid rise of sea water levels during the occurrence of storm surge. Main program BICOL2 consists of two main routes of computation. The first route is the computation to obtain an initial steady state condition which shall be used as the initial condition for the second route of computation. The first route of computation is the period of warming up the model. The second route of computation is the unsteady flow computation which the boundary conditions are allowed to vary with time. This route of computation involves the computation of flood flow in the model.

The detailed description for the first route of computation in the model can be expressed as follows:

(1) The boundary conditions are kept unchanged with time. These boundary conditions are the lateral discharge inputs to the nodes and the sea water levels at the nodes located at the system outlets. The boundary conditions are set equal to instantaneous values of the boundary condition at the date in which the computation of the second route starts.

(2) The initial water levels of all nodes are assumed.

(3) The initial discharge for each branch is computed by summing up the discharges which enter its upstream node.

(4) The water levels and the discharges are computed using the constant boundary conditions.

(5) The computation is repeated using the water levels and discharges of the subsequent previous step of computation as the initial conditions.

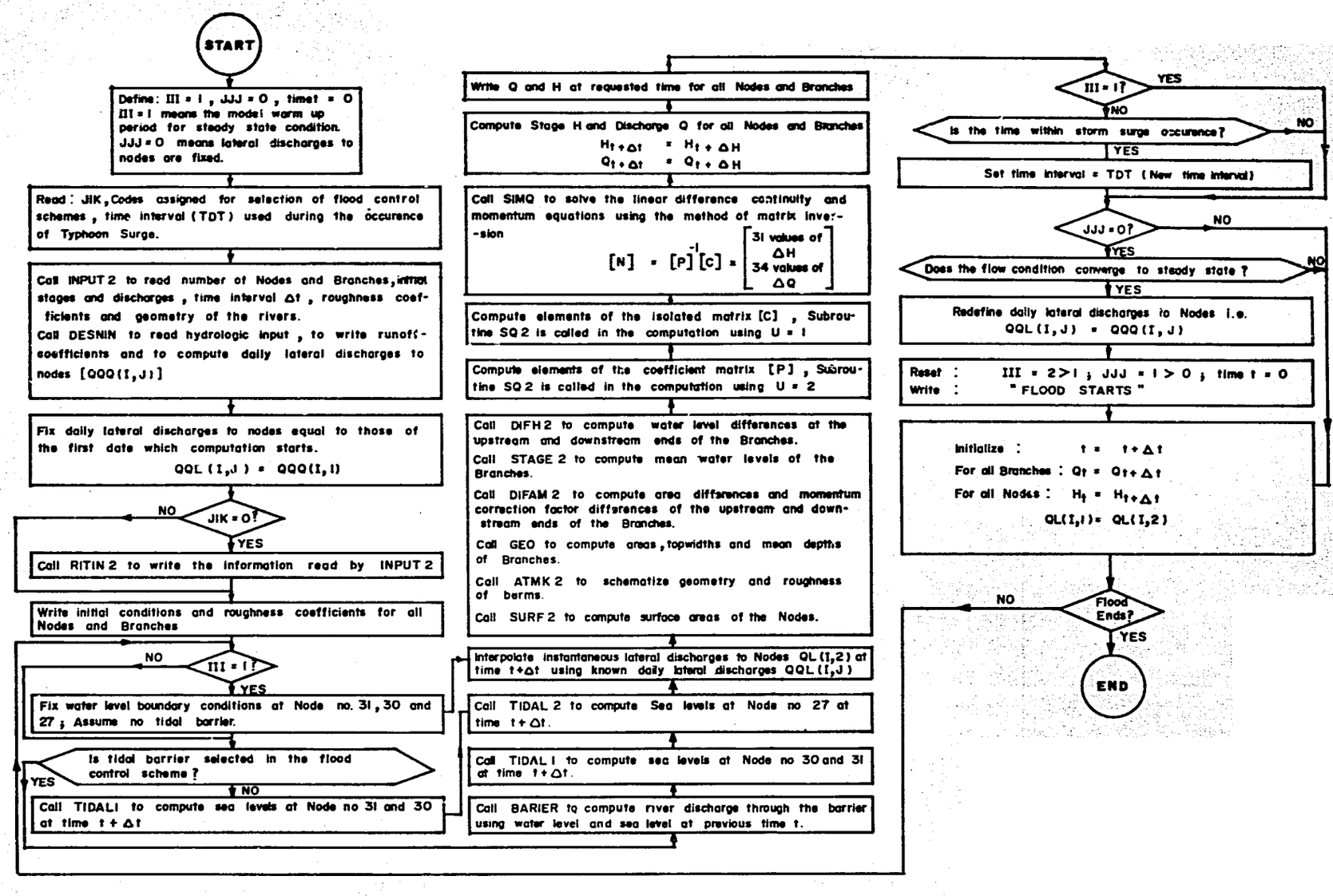



Fig.5.14 - Flow Chart Showing Computational Route of Flood Control Simulation Model

(6) The computation is performed until the water levels and the discharges in the system are unchanged with time.

(7) The water levels and discharges which are unchanged with time are used as the initial conditions for the second route of computation.

The detailed description for the second route of computation which involves the unsteady flood flow computation can be described as follows:

(1) The water levels and the discharges obtained from the first route of computation are used as the initial conditions for the start of the computation of the second route, i.e. at time t.

(2) The lateral discharge boundary condition and the sea water level condition are allowed to change with time. The time variation of the lateral discharge boundary condition is obtained from subroutine DESNIN. The sea level boundary condition is obtained from subroutines TIDAL1 and TIDAL2. Subroutine TIDAL1 is used to generate sea water level at the Node Nos.31 and 30. Subroutine TIDAL2 is used to generate sea water level at Node No.27.

(3) The water levels and the discharges in the nodes and branches are then computed for the time t+Δt using the time-varied boundary conditions at the corresponding time.

(4) The water levels and discharges in the system is initialized by substituting the water levels and the discharges at time t by the values at time t+Δt obtained from the previous step of computation.

(5) The computation is repeated from step (3) to step (4) until the flood period under the investigation is over.

In the computation of water levels and discharges in the nodes and branches, the computation procedure can be described in detail as follows:

(1) The elements of the coefficient matrix [P] are computed using the known water levels and discharges from the initial condition or from the previous step of computation, i.e. at time t.

(2) The elements of the isolated matrix [C] are computed using the known stages and discharges from the initial condition or from the previous step of computation at time t and the given boundary condition at time t+Δt.

(3) The unknown matrix [N] is solved through the method of matrix inversion. The matrix [N] contains the incremental changes in the water levels and discharges within the time step of $\Delta t$. The matrix [N] is related to the matrices [P] and [C] as

$$[N] = [P]^{-1}[C] = \begin{bmatrix} \text{Matrix} \\ \text{contains 31} \\ \text{values of } \Delta H \\ \text{and 34 values} \\ \text{of } \Delta Q \end{bmatrix}$$

(4) The water levels and the discharges of the nodes and of the branches at time $t+\Delta t$ are then computed through the following equations:

$$H_{t+\Delta t} = H_t + \Delta H$$

$$Q_{t+\Delta t} = Q_t + \Delta Q$$

In the above equations, Q and H are the discharge and the water level, $\Delta Q$ and $\Delta H$ are the incremental changes in the discharge and water level within the time increment $\Delta t$.

(5) The water levels and the discharges in the nodes and branches are initialized before the computation of the next time step is performed. The initialization is performed by substituting the water levels and the discharges at time t by the values at time $t+\Delta t$ obtained from the previous step of computation, i.e.

$$H_t = H_{t+\Delta t}$$

$$Q_t = Q_{t+\Delta t}$$

5.9.4 Preparation of Data Deck The computer program was organized such that the water levels and discharges along Bicol and Sipocot Rivers could be computed for different inputs and different flood control schemes. Various computational routes are provided in the same computer program and could be chosen by making a slight change on the input information. The input information are read through the main program BICOL2 via subroutine INPUT2 and DESNIN(QQQ). The sequence of the data deck prepared for a run, for example for the case when the tidal barrier is to be considered, is presented. The description for the symbols used in the computer program

is explained. The printouts of the input information read through the main program BICOL2, subroutine INPUT2 and subroutine DESNIN(QQQ) are released through subroutine RITIN2.

5.9.4.1 Sequence of data deck - Fig.5.15 shows the arrangement for the sequence of the data deck for the flood control simulation model. The following is the description for the symbols used in the input information.

| Card No. | Symbols | Description |
|---|---|---|
| 1 | TDT | Time interval used in the computation during the period of storm surge. |
| 2 | IRETURN | The return period of the flood. |
| 2 | ISTABLE | Code indicating the choice of time interval TDT during the time of typhoon surge. |
| 3 | NMKR | Date at which the computation is started. The computation can begin at any date within the period of flood under investigation. |
| 3 | JIK | Code to request the printout of the information input. |
| 4 | FACTOR | Percentage of opening area of the gate of the tidal barrier. |
| 4 | PHASE | Time difference in hours between the peak of storm surge and highest astronomical tide during the storm surge. |
| 5 | TYPE | Heading of data deck which indicates the selection of flood control schemes. |
| 6 | ALT | Time interval at which the lateral discharge inputs to nodes produced by surface runoffs from watersheds are available. |
| 6 | RHR | Time interval which the printout of stages and discharges along Bicol and Sipocot Rivers is required. |
| 6 | ACCU | The maximum allowable difference in the water levels at the nodes at different times before the steady flow condition is approached. |
| 7 | CODPOL | Code assigned for the selection of Pulantuna Reservoir. |
| 7 | CODSIP | Code assigned for the selection of Sipocot-San Miguel Diversion |
| 7 | CODPAS | Code assigned for the selection of Bicol-Ragay Diversion. |

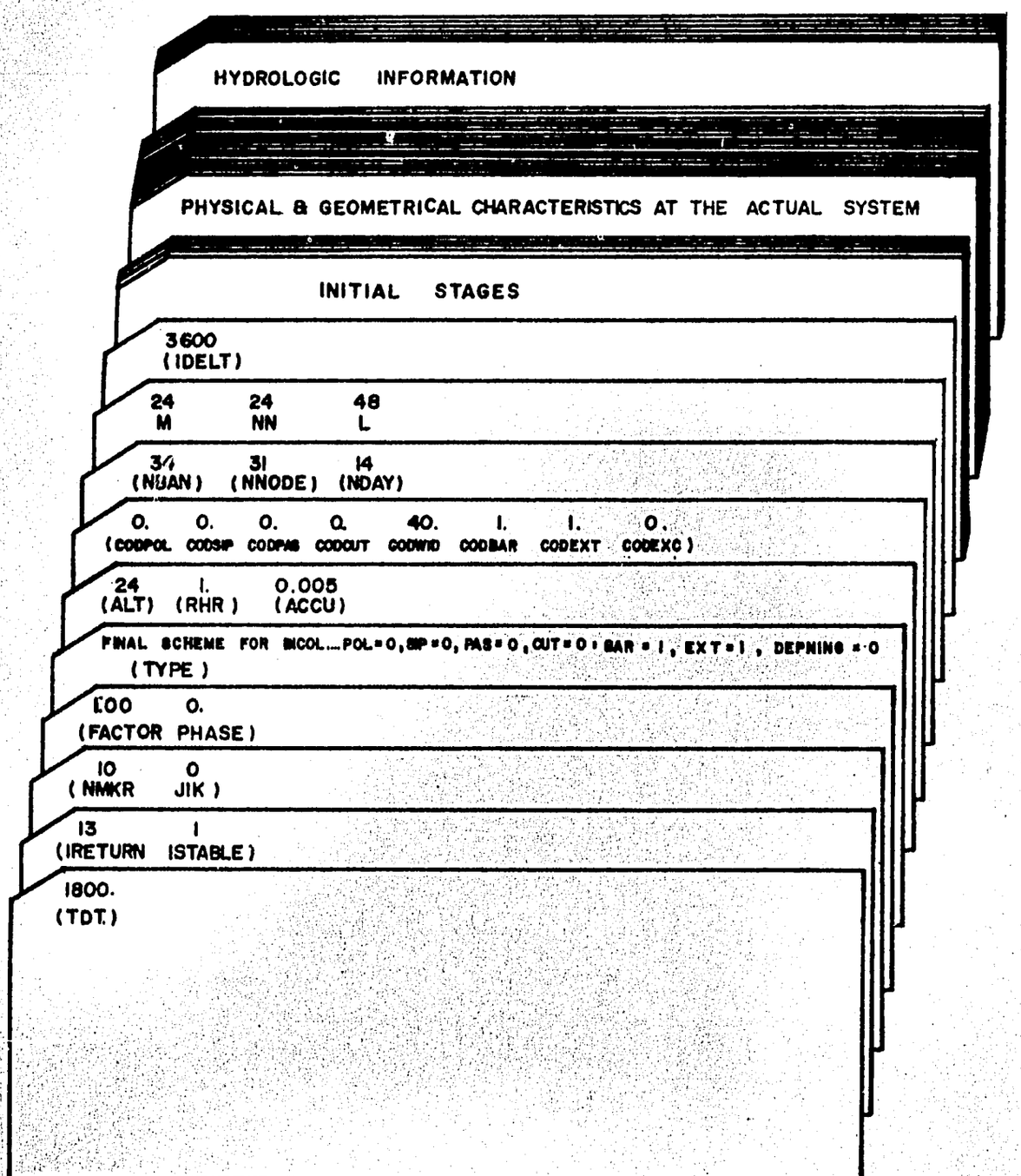



**Fig. 5.15 Sequence of Data Deck, Flood Control Simulation Model.**

| Card No. | Symbols | Description |
|---|---|---|
| 7 | CODCUT | Code assigned for the selection of Cutoff No.3. |
| 7 | CODWID | Code assigned for the selection of the width of Cutoff No.3. |
| 7 | CODBAR | Code assigned for the selection of the Tidal Barrier at Balongay. |
| 7 | CODEXT | Code assigned for the extension of the model from Cuyapi to Balongay. |
| 7 | CODEXC | Code assigned for the excavation and widening the river cross section from Km 69 to Km 83 + 900 in Bicol River. |
| 8 | NBAN | Numbers of branches in the flow system. |
| 8 | NNODE | Numbers of nodes in the flow system. |
| 8 | NDAY | Day period in which the flood flow is investigated. |
| 9 | M,NN,L | Number of available elevation-surface area relationships of Lake Bato, Lake Baao and Pulantuna Reservoir. |
| 10 | IDELT | Time interval used in the numerical computation of the continuity and momentum equations. IDELT is unchanged during the peak of storm surge unless it is specified. |
| 11-14 | H(I,1) | Initial water levels at nodes used in the numerical computation. |
| 15-26 | ENX(I),ENM(I), ENY(I) | Roughness coefficients for left berm, main channel and right berm of the branches. |
| 27-31 | DELX(I) | Distance interval along main channel in kilometers. |
| 32-36 | DELXX(I) | Distance interval along left berm in kilometers. |
| 37-41 | DELXY(I) | Distance interval along right berm in kilometers. |
| 42-50 | EX(I),EY(I) | Average river bank elevations on the left and right sides at midway of the branches. |
| 51-59 | EXUS(I), EYUS(I) | Average river bank elevations on the left and right sides at the upstream end of the branches. |
| 60-68 | EXDS(I), EYDS(I) | Average river bank elevations on the left and right sides at the downstream end of the branches. |
| 69-85 | E1(I),E2(I), E3(I),E4(I) | Specific elevations of the main channel cross sections of the branches. |
| 86-102 | T1(I),T2(I), T3(I),T4(I) | Specific topwidths of the main channel cross sections of the branches. |
| 103-111 | AO(I),AH(I) | Specific area of the main channel cross sections of the branches. |

| Card No. | Symbols | Description |
|---|---|---|
| 112-128 | EUS1(I),EUS2(I), EUS3(I),EUS4(I) | Specific elevations of the main channel cross sections at the upstream end of the branches. |
| 129-145 | TUS1(I),TUS2(I), TUS3(I),TUS4(I) | Specific topwidths of the main channel cross sections at the upstream end of the branches. |
| 146-154 | AOUS(I),AHUS(I) | Specific area of the main channel cross sections at the upstream end of the branches. |
| 155-171 | EDS1(I),EDS2(I), EDS3(I),EDS4(I) | Specific elevations of the main channel cross sections at the downstream end of the branches. |
| 172-188 | TDS1(I),TDS2(I), TDS3(I),TDS4(I) | Specific topwidths of the main channel cross sections at the downstream end of the branches. |
| 189-197 | AODS(I),AHDS(I) | Specific area of the main channel cross sections at the downstream end of the branches |
| 198-199 | EE1(I),EE2(I), EE3(I),EE4(I) | Specific elevations of the main channel cross sections at the excavated branches. |
| 200-201 | TT1(I),TT2(I), TT3(I),TT4(I) | Specific topwidths of the main channel cross sections of the excavated branches. |
| 202 | AAO(I),AAH(I) | Specific areas of the main channel cross sections of the excavated branches. |
| 203-204 | EEUS1(I),EEUS2(I), EEUS3(I),EEUS4(I) | Specific elevations of the main channel cross sections at the upstream end of the excavated branches. |
| 205-206 | TTUS1(I),TTUS2(I), TTUS3(I),TTUS4(I) | Specific topwidths of the main channel cross sections at the upstream end of the excavated branches. |
| 207 | AAOUS(I),AAHUS(I) | Specific areas of the main channel cross sections at the upstream end of the excavated branches. |
| 208-209 | EEDS1(I),EEDS2(I), EEDS3(I),EEDS4(I) | Specific elevations of the main channel cross sections at the downstream end of the excavated branches. |
| 210-211 | TTDS1(I),TTDS2(I), TTDS3(I),TTDS4(I) | Specific topwidths of the main channel cross sections at the downstream end of the excavated branches. |
| 212 | AAODS(I),AAHDS(I) | Specific areas of the main channel cross sections at the downstream end of the excavated branches. |
| 213-229 | EY1(I),EY2(I),EY3(I) | Specific elevations of the right berm cross sections of the branches. |

| Card No. | Symbols | Description |
|---|---|---|
| 230-246 | TY1(I),TY2(I),TY3(I) | Specific topwidths of the right berm cross sections of the branches. |
| 247-263 | EYUS1(I),EYUS2(I), EYUS3(I) | Specific elevations of the right berm cross sections at the upstream end of the branches. |
| 264-280 | TYUS1(I),TYUS2(I), TYUS3(I) | Specific topwidths of the right berm cross sections at the upstream end of the branches. |
| 281-297 | EYDS1(I),EYDS2(I), EYDS3(I) | Specific elevations of the right berm cross sections at the downstream end of the branches. |
| 298-314 | TYDS1(I),TYDS2(I), TYDS3(I) | Specific topwidths of the right berm cross sections at the downstream end of the branches. |
| 315-331 | EX1(I),EX2(I),EX3(I) | Specific elevations of the left berm cross sections of the branches. |
| 332-348 | TX1(I),TX2(I),TX3(I) | Specific topwidths of the left berm cross sections of the branches. |
| 349-365 | EXUS1(I),EXUS2(I), EXUS3(I) | Specific elevations of the left berm cross sections at the upstream end of the branches. |
| 366-382 | TXUS1(I),TXUS2(I), TXUS3(I) | Specific topwidths of the left berm cross sections at the upstream end of the branches. |
| 383-399 | EXDS1(I),EXDS2(I), EXDS3(I) | Specific elevations of the left berm cross sections at the downstream end of the branches. |
| 400-416 | TXDS1(I),TXDS2(I), TXDS3(I) | Specific topwidths of the left berm cross sections at the downstream end of the branches. |
| 417-422 | EBAT(I),SFBAT(I) | Specific elevations and surface areas of Lake Bato. |
| 423-428 | EBAO(I),SFBAO(I) | Specific elevations and surface areas of Lake Baao. |
| 429-440 | EPOL(I),SFPOL(I) | Specific elevations and surface areas of Pulantuna Reservoir. |
| 441 | KODE | Code assigned to the selection of the rainfall condition for 1970 or for 50-year design flood. |
| 442 | IST,IDT,IAX,IBL, IBA,IBB,IBC | Symbols for plotting if the subroutine for plotting is provided. |

| Card No. | Symbols | Description |
|---|---|---|
| 443 | RAIN2,RAIN6,RAIN14 RAINDE | 50 year design 2 day rainfall in millimeters at Station No.2, 6, 14 and basin respectively. |
| 444 | RC1(I) | Pre-storm runoff coefficients applicable to Thiessen polygon No.1, 2 and 3 and flood plain areas respectively ( oil is partially saturated). |
| 445 | RC2(I) | Runoff coefficients during and after storm applicable to Thiessen polygon No.1, 2 and 3 and flood plain areas (soil is saturated). |
| 446 | DIM1(I) | Ordinate of distribution graph at day I for watershed area less than 50 sq.km. |
| 447 | DIM2(I) | Ordinate of distribution graph at day I for watershed area greater than or equal to 50 sq.km. |
| 448 | EB,CB | Regression coefficients of base flow equation. |
| 449-466 | R1(K,I) | Daily rainfall in millimeters for stations 2, 6 and 14 in the year of 1970 (13 year return period) at day I. |
| 467-484 | R2(K,I) | Daily rainfall in millimeters for stations 2, 6 and 14 for design rainfall condition whose return period is of 50 years at day I. |
| 485-580 | G(K,I) | Runoff in CMS of gaged watershed K at day I. |
| 581-651 | INC,A,W,IS | Watershed computer code number for gaged and ungaged watersheds (series 100 and 200); watershed area in sq.km.; representative width of watershed in km; rainfall station number applicable to watershed. |
| Card numbers in this range are given on the next page | IN,IS,AA,NG,NU | Node number, raingage station number, flood plain area including berms, number of gaged watersheds, number of ungaged watersheds. |
| | IGC(I) | Code number of gaged watershed in 100 series. |
| | IUC(I) | Code number of ungaged watersheds in 200 series. |

| Node No. | CARD NUMBERS | | |
|---|---|---|---|
| | IN,IS,AA,NG,NU | IGC(I) | IUC(I) |
| 1 | 652 | 653 | 654 |
| 2 | 655 | - | 656 |
| 3 | 657 | 658 | 659 |
| 4 | 660 | - | 661 |
| 5 | 662 | - | 663 |
| 6 | 664 | - | 665 |
| 7 | 666 | - | 667 |
| 8 | 668 | - | - |
| 9 | 669 | - | 670 |
| 10 | 671 | - | 672 |
| 11 | 673 | 674 | 675 |
| 12 | 676 | - | 677 |
| 13 | 678 | - | 679 |
| 14 | 680 | - | 681 |
| 15 | 682 | 683 | - |
| 16 | 684 | - | 685 |
| 17 | 686 | 687 | 688 |
| 18 | 689 | - | 690 |
| 19 | 691 | - | 692 |
| 20 | 693 | - | 694 |
| 21 | 695 | - | 695 |
| 22 | 697 | 698 | 699,700 |

5.9.4.2 Physical and geometrical characteristics of Bicol River, Sipocot River and their flood protection schemes - The physical and geometrical input information for the flood control simulation model of the Bicol River Basin study mainly consist of:

a) Roughness coefficients for main channel and berms.

b) Relationships between elevation, topwidth and cross sectional area of main channel cross sections.

c) Relationships between elevation and topwidth of left berm and right berm cross sections.

d) Relationships between elevation and surface area of Lake Bato, Lake Baao and the proposed Pulantuna Reservoir.

Listed in Section C2 of Appendix C are the numerical values of the physical and geometrical inputs which are required in the flood control simulation model.

5.9.4.3 Hydrologic information - The lateral discharges to the nodes is composed of the surface runoffs from the watersheds in the Bicol River Basin.

In the model calibration, the rainfall data from September to November 1970 was used. The surface runoffs from the ungaged watersheds assigned to each node are estimated through the application of the distribution graph. The surface runoffs from the gaged watersheds are the observed streamflows. The total lateral discharge inputs to the nodes are the summation of the surface runoffs from the ungaged watersheds and the tributary streamflows.

In the prediction of the effectiveness of the flood control schemes on the water levels in the Bicol and Sipocot Rivers, the rainfall condition whose return periods are that of 13 years and 50 years were used. The period of 13 years is selected since the rainfall condition is the same as that occurred in 1970. The lateral discharge inputs to the nodes for the 13 year rainfall are estimated in the same way as previously performed in the model calibration. For the 50 year or other design rainfall condition, the surface runoff to the nodes are wholly estimated from the watersheds which are assumed ungaged.

5.9.5 Code Assignments and Instruction for Program Users

Card No.2 - Punch 13 for IRETURN when the effectiveness of the flood control schemes is measured for a design rainfall which has a return period of 13 years, equivalent to the 1970 flood event.

Punch 50 for IRETURN when the effectiveness is determined for the design rainfall with a return period of 50 years.

Card No.4 - Punch 1 for FACTOR if the gate opening is assumed fully open. The value of FACTOR can be set to any values between 0 to 1, e.g. if FACTOR is set equal to 0.5, the opening area of the gate is set at 50% of the total opening area.

Card No.5 - The heading of the data deck is punched consistent with the code of the symbols assigned for a combination of the flood

control schemes. The purpose of using the data heading is to help the program user to recognize easily which of the flood control schemes are selected in the combination. The data heading is not involved in the computation. The symbol for the data heading is TYPE.

Card No.7 - Flood control schemes could be selected by assigning code numbers to the following symbols.

| Symbols | Description | Instructions |
|---|---|---|
| CODPOL | Pulantuna Reservoir | Punch 1. for the selection;<br>0. for none |
| CODSIP | Sipocot-San Miguel Diversion | Punch 1. for the selection;<br>0. for none |
| CODPAS | Bicol-Ragay Diversion | Punch 1. for the selection;<br>0. for none |
| CODCUT | Cutoff No.3 | Punch 1. for the selection;<br>0. for none |
| CODWID | Width of Cutoff No.3 | Punch 40. for 40 meters wide or<br>20. for 20 meters wide, etc. |
| CODBAR | Tidal Barrier | Punch 1. for the selection;<br>0. for none |
| CODEXT | Extension Bicol River Mouth in the model from Cuyapi to Balongay | Punch 1. for the extension and<br>0. for no extension (model calibration) |
| CODEXC | Deepening and widening river bed | Punch 1. for the selection;<br>0. for none |

Card No.441 - The rainfall condition could be selected by assigning the number of the symbol KODE. Number 1 is used when the 1970 rainfall condition whose return period is 13 years is required. Any other number is assigned to KODE when the design rainfall condition whose return period is 50 years is used. The symbol KODE controls the computational route in subroutine DESNIN(QQQ).

Example: It is required to determine the effectiveness of a flood control scheme when the rainfall condition is similar to that which occurred in 1970. The flood control scheme composes of the following basic components:

(1) Pulantuna Reservoir

(2) Sipocot-San Miguel Diversion

(3) Tidal Barrier at Balongay

(4) Bicol-Ragay Diversion

The gate opening area of the tidal barrier is full.

Data Preparation:

| CARD No. | | |
|---|---|---|
| 2 | Punch: | 13 for IRETURN |
| 4 | Punch: | 1.00 for FACTOR |
| 5 | Punch: | POL = 1, SIP = 1, PAS = 1, CUT = 0, BAR = 1, EXT = 1, DEPNING = 0 |
| 7 | Punch: | 1. for CODPOL<br>1. for CODSIP<br>1. for CODPAS<br>0. for CODCUT<br>0. for CODWID<br>1. for CODBAR<br>1. for CODEXT<br>0. for CODEXC |
| 11 to 14 | The following initial stages at the nodes are assumed. | |
| | Punch: | 11.90 for H(1,1) ; 9.20 for H(2,1)<br>6.20 for H(3,1) ; 1.30 for H(4,1)<br>0.20 for H(5,1) ; 0.15 for H(6,1)<br>0.10 for H(7,1) ; 0.05 for H(8,1)<br>0.10 for H(9,1) ; 0.12 for H(10,1)<br>0.15 for H(11,1) ; 0.50 for H(12,1)<br>0.80 for H(13,1) ; 0.90 for H(14,1)<br>1.00 for H(15,1) ; 4.50 for H(16,1)<br>5.10 for H(17,1) ; 6.00 for H(18,1)<br>6.50 for H(19,1) ; 6.80 for H(20,1)<br>6.90 for H(21,1) ; 6.90 for H(22,1)<br>0.40 for H(23,1) ; -0.10 for H(24,1)<br>-0.50 for H(25,1) ; -0.70 for H(26,1)<br>-0.80 for H(27,1) ; 0.50 for H(28,1)<br>0.30 for H(29,1) ; 0.095 for H(30,1)<br>0.095 for H(31,1) |
| 441 | Punch: | 1 for KODE |

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# APPENDIX A

A1 CALCULATIONS FOR THE DISTRIBUTION GRAPH

A2 FREQUENCY ANALYSIS USING GUMBEL DISTRIBUTION

A3 DISTRIBUTION OF BASIN AVERAGE RAINFALL INTO STATION RAINFALL

# APPENDIX A

## A1 Calculations for the Distribution Graph

Table A-1 to A-8 summarize the data and calculations used in developing the distribution graph of each of the 8 watersheds in the Bicol River Basin that had available streamflow data.

Under Column 2 of each watershed are listed the observed daily mean discharges.

Column 3 is the modified streamflow, i.e. runoff caused mainly by the October 12-13, 1970 storm. These storm were obtained by examining the rainfall records nearest the watershed, and if rainfall (other than the 2-day storm) occurs, the observed runoff hydrograph is smoothened (assuming that the hydrograph irregularity was mainly caused by the random rainfall). The effect on the hydrographs of rainfall that occurred after the October 12-13 storm was neglected as the amount was negligible compared to the two-day storm. However, on October 19, 1970, 5 days after the storm, significant rainfall occurred in the basin. Hence, the streamflow records were abandoned from the day the hydrograph rises and further recession was estimated from the shape of the hydrograph.

Column 4 lists the values of base flow. A uniform method was adopted to separate the base flow from the observed hydrographs. A constant base flow was assumed from the first day to the day the peak flow occurred. Then a straight line was drawn from this point to a point on the lower portion of the recession segment of the hydrograph.

Column 5 shows the values of the direct runoff which is the modified streamflow (Col.3) less base flow (Col.4).

Each value of the direct runoff was divided by the total runoff, to obtain the coefficient of the distribution graph which are listed in Column 6. The cumulative of the coefficients of the distribution graph are listed in Column 7.

## A2 Frequency Analysis Using Gumbel Distribution

The Gumbel distribution is based on the assumption that the distribution of the extreme values of an event (e.g. annual maximum rainfall or flood) is unbounded. Gumbel proposed that the probability P of the occurrence of an event with value X is equal to or greater than any value

Table A1 - Arrangement of Data for Development of Distribution Graph (Units in CMS)

| 3 - Ugsong River, Ligao, Albay (Area = 11 km$^2$) | | | | | | |
|---|---|---|---|---|---|---|
| Date | Observed Stream Flow | Modified Stream Flow | Base Flow | Segregated Flow | Dist. Percentage | Cumulative Percentage |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Oct. 1970 | | | | | | |
| 9 | | | | | | |
| 10 | 0.037 | | | | | |
| 11 | 1.81 | 0.00 | 0.00 | 0.00 | 0.0 | 0 |
| 12 | 2.02 | 2.02 | 0.00 | 2.02 | 14.4 | 14.4 |
| 13 | 8.64 | 8.64 | 0.00 | 8.64 | 61.5 | 75.9 |
| 14 | 1.38 | 1.38 | 0.00 | 1.38 | 9.8 | 85.7 |
| 15 | 1.49* | 0.80 | 0.00 | 0.80 | 5.7 | 91.4 |
| 16 | 0.90 | 0.60 | 0.00 | 0.60 | 4.3 | 95.7 |
| 17 | 0.76 | 0.40 | 0.00 | 0.40 | 2.8 | 98.5 |
| 18 | 0.30 | 0.20 | 0.00 | 0.20 | 1.5 | 100.0 |
| 19 | 0.15 | 0.00 | 0.00 | 0.00 | 0.0 | 0 |
| 20 | 0.35 | | | | | |
| 21 | 0.54 | | | | | |
| 22 | | | | | | |
| Total | | | | 14.04 | 100.0 | |

Table A2 - Arrangement of Data for Development of Distribution Graph (Units in CMS)

| 17 - Anayan River, San Roque (Area = 17 km$^2$) | | | | | | |
|---|---|---|---|---|---|---|
| Date | Observed Stream Flow | Modified Stream Flow | Base Flow | Segregated Flow | Dist. Percentage | Cumulative Percentage |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Oct. 1970 | | | | | | |
| 9 | | | | | | |
| 10 | 0.39 | | | | | |
| 11 | 0.39 | 0.39 | 0.39 | 0.00 | 0.0 | 0 |
| 12 | 1.42 | 1.42 | 0.39 | 1.03 | 0.7 | 0.7 |
| 13 | 106.88 | 106.88 | 0.39 | 106.49 | 82.5 | 83.2 |
| 14 | 19.55 | 19.55 | 0.44 | 19.11 | 14.8 | 98.0 |
| 15 | 1.58 | 1.58 | 0.49 | 1.09 | 0.8 | 98.8 |
| 16 | 1.42 | 1.42 | 0.54 | 0.88 | 0.6 | 99.4 |
| 17 | 1.00 | 1.00 | 0.59 | 0.41 | 0.4 | 99.8 |
| 18 | 0.80 | 0.80 | 0.64 | 0.16 | 0.2 | 100.0 |
| 19 | 0.68 | 0.68 | 0.68 | 0.00 | 0.0 | |
| 20 | 4.54* | | | | | |
| 21 | | | | | | |
| 22 | | | | | | |
| Total | | | | 129.17 | 100.0 | |

* Day record abandoned

Table A3 - Arrangement of Data for Development of Distribution Graph
(Units in CMS)

| 20 - Yabo River, San Isidro (Area = 20 km$^2$) | | | | | | |
|---|---|---|---|---|---|---|
| Date | Observed Stream Flow | Modified Stream Flow | Base Flow | Segregated Flow | Dist. Percentage | Cumulative Percentage |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Oct. 1970 | | | | | | |
| 9 | 0.56 | | | | | |
| 10 | 1.57+ | | | | | |
| 11 | 2.60+ | 1.00 | 1.00 | 0.00 | 0.0 | 0 |
| 12 | 3.63 | 3.63 | 1.00 | 2.63 | 7.3 | 7.3 |
| 13 | 25.50 | 25.50 | 1.00 | 24.50 | 67.7 | 75.0 |
| 14 | 7.18 | 7.18 | 1.00 | 6.18 | 17.1 | 92.1 |
| 15 | 3.20+ | 3.20 | 1.00 | 2.20 | 6.1 | 98.2 |
| 16 | 1.38 | 1.38 | 1.00 | 0.40 | 1.1 | 99.3 |
| 17 | 1.20+ | 1.20 | 1.00 | 0.20 | 0.5 | 99.8 |
| 18 | 1.10+ | 1.10 | 1.00 | 0.10 | 0.3 | 100.0 |
| 19 | 1.03 | 1.00 | 1.00 | 0.00 | 0.0 | |
| 20 | 1.15+* | | | | | |
| 21 | 1.20 | | | | | |
| 22 | | | | | | |
| Total | | | | 26.21 | 100.0 | |

Table A4 - Arrangement of Data for Development of Distribution Graph
(Units in CMS)

| 1 - San Francisco River, Albay (Area = 131 km$^2$) | | | | | | |
|---|---|---|---|---|---|---|
| Date | Observed Stream Flow | Modified Stream Flow | Base Flow | Segregated Flow | Dist. Percentage | Cumulative Percentage |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Oct. 1970 | | | | | | |
| 9 | 2.80 | | | | | |
| 10 | 2.50 | | | | | |
| 11 | 9.00 | 2.50 | 2.5 | 0.00 | 0.0 | 0 |
| 12 | 12.60 | 12.60 | 2.5 | 10.10 | 6.9 | 6.9 |
| 13 | 48.93 | 48.93 | 2.5 | 46.43 | 31.7 | 38.6 |
| 14 | 42.00 | 42.00 | 2.6 | 39.40 | 26.9 | 65.5 |
| 15 | 21.60 | 21.60 | 2.7 | 18.90 | 12.9 | 78.4 |
| 16 | 18.72 | 18.72 | 2.8 | 15.90 | 10.8 | 89.2 |
| 17 | 9.60 | 9.60 | 2.8 | 6.80 | 4.6 | 93.8 |
| 18 | 7.92 | 7.92 | 2.9 | 5.00 | 3.4 | 97.2 |
| 19 | 7.44* | 5.8 | 2.9 | 2.90 | 2.0 | 99.2 |
| 20 | 6.96 | 4.2 | 3.0 | 1.20 | 0.8 | 100.0 |
| 21 | 6.96 | 3.0 | 3.0 | 0.00 | 0.0 | |
| 22 | 6.48 | | | | | |
| 23 | 5.52 | | | | | |
| 24 | | | | | | |
| Total | | | | 146.63 | 100.0 | |

+ Interpolated value
* Day record abandoned

Table A5 - Arrangement of Data for Development of Distribution Graph
(Units in CMS)

| 7 - Quinali River, Oas, Albay (Area = 232 km$^2$) | | | | | | |
|---|---|---|---|---|---|---|
| Date | Observed Stream Flow | Modified Stream Flow | Base Flow | Segregated Flow | Dist. Percentage | Cumulative Percentage |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Oct. 1970 | | | | | | |
| 9 | 4.57 | | | | | |
| 10 | 5.58 | | | | | |
| 11 | 9.07 | 5.00 | 5.00 | 0.00 | 0.0 | 0 |
| 12 | 10.00 | 10.00 | 5.00 | 5.00 | 6.8 | 6.8 |
| 13 | 35.40 | 35.40 | 5.00 | 30.40 | 41.5 | 48.3 |
| 14 | 26.00 | 26.00 | 5.00 | 21.00 | 28.7 | 77.0 |
| 15 | 14.00 | 14.00 | 5.00 | 9.00 | 12.3 | 89.3 |
| 16 | 8.45 | 8.45 | 5.00 | 3.45 | 4.7 | 94.0 |
| 17 | 7.52 | 7.52 | 5.00 | 2.52 | 3.4 | 97.4 |
| 18 | 6.02 | 6.02 | 5.00 | 1.02 | 1.4 | 98.8 |
| 19 | 7.21* | 5.60 | 5.00 | 0.60 | 0.8 | 99.6 |
| 20 | 7.21 | 5.25 | 5.00 | 0.25 | 0.4 | 100.0 |
| 21 | 6.68 | 5.00 | 5.00 | 0.00 | 0.0 | |
| 22 | 6.24 | | | | | |
| 23 | 5.80 | | | | | |
| 24 | | | | | | |
| Total | | | | 73.24 | 100.0 | |

Table A6 - Arrangement of Data for Development of Distribution Graph
(Units in CMS)

| 14 - Pawili River, San Vicente (Area = 112 km$^2$) | | | | | | |
|---|---|---|---|---|---|---|
| Date | Observed Stream Flow | Modified Stream Flow | Base Flow | Segregated Flow | Dist. Percentage | Cumulative Percentage |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Oct. 1970 | | | | | | |
| 9 | | | | | | |
| 10 | 0.30 | 0.30 | | | | |
| 11 | 0.68 | 0.30 | 0.30 | 0.00 | 0.0 | 0 |
| 12 | 0.96 | 0.96 | 0.30 | 0.66 | 0.2 | 0.2 |
| 13 | 134.61 | 134.61 | 0.30 | 134.31 | 31.1 | 31.3 |
| 14 | 119.62 | 119.62 | 1.00 | 118.62 | 27.4 | 58.7 |
| 15 | 90.16 | 90.16 | 3.00 | 87.16 | 20.2 | 78.9 |
| 16 | 41.96 | 41.96 | 5.00 | 36.96 | 8.6 | 87.5 |
| 17 | 28.86 | 28.86 | 7.00 | 21.86 | 5.1 | 92.6 |
| 18 | 26.46 | 26.46 | 9.00 | 17.46 | 4.0 | 96.6 |
| 19 | 21.00 | 21.00 | 11.00 | 10.00 | 2.3 | 98.9 |
| 20 | 18.06 | 18.06 | 13.00 | 5.06 | 1.1 | 100.0 |
| 21 | 15.00 | 15.00 | 15.00 | 0.00 | 0.0 | |
| 22 | 12.62* | | | | | |
| 23 | 28.86 | | | | | |
| 24 | | | | | | |
| Total | | | | 432.09 | 99.98 | |

* Day record abandoned

Table A7 - Arrangement of Data for Development of Distribution Graph (Units in CMS)

| 21 - Pulantuna River, Napulindan (Area = 172 km$^2$) | | | | | | |
|---|---|---|---|---|---|---|
| Date | Observed Stream Flow | Modified Stream Flow | Base Flow | Segregated Flow | Dist. Percentage | Cumulative Percentage |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Oct. 1970 | | | | | | |
| 9 | 5.52 | | | | | |
| 10 | 5.87+ | | | | | |
| 11 | 5.90+ | | | | | |
| 12 | 6.58 | 6.58 | 6.60 | 0.00 | 0.0 | 0 |
| 13 | 65.00+ | 65.00 | 6.60 | 58.40 | 20.0 | 20.0 |
| 14 | 118.00 | 118.00 | 6.60 | 111.40 | 38.2 | 58.2 |
| 15 | 75.00 | 75.00 | 6.65 | 68.40 | 23.4 | 81.6 |
| 16 | 27.70 | 27.70 | 6.70 | 21.00 | 7.2 | 88.8 |
| 17 | 20.00+ | 20.00 | 6.75 | 13.30 | 4.6 | 93.4 |
| 18 | 15.00+ | 15.00 | 6.80 | 8.20 | 2.8 | 96.2 |
| 19 | 12.02 | 12.02 | 6.85 | 5.20 | 1.8 | 98.0 |
| 20 | 12.86+* | 10.00 | 6.90 | 4.10 | 1.4 | 99.4 |
| 21 | 13.70 | 8.70 | 6.95 | 1.80 | 0.6 | 100.0 |
| 22 | 20.39+ | 7.00 | 7.00 | 0.00 | 0.0 | |
| 23 | 27.08 | | | | | |
| 24 | | | | | | |
| Total | | | | 292.00 | 100.0 | |

Table A8 - Arrangement of Data for Development of Distribution Graph (Units in CMS)

| 22 - Culacling River, Lupi (Area = 64 km$^2$) | | | | | | |
|---|---|---|---|---|---|---|
| Date | Observed Stream Flow | Modified Stream Flow | Base Flow | Segregated Flow | Dist. Percentage | Cumulative Percentage |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Oct. 1970 | | | | | | |
| 9 | 5.00 | | | | | |
| 10 | 2.70 | | | | | |
| 11 | 1.50 | | | | | |
| 12 | 1.15 | 1.15 | 1.15 | 0.00 | 0.0 | 0 |
| 13 | 20.10 | 20.10 | 1.15 | 18.95 | 19.9 | 19.9 |
| 14 | 37.90 | 37.90 | 1.15 | 36.75 | 38.5 | 58.4 |
| 15 | 17.02 | 17.02 | 1.50 | 15.52 | 16.3 | 74.7 |
| 16 | 9.64 | 9.64 | 2.00 | 7.64 | 8.0 | 82.7 |
| 17 | 8.69 | 8.69 | 2.50 | 6.19 | 6.5 | 89.2 |
| 18 | 7.40 | 7.40 | 2.80 | 4.60 | 4.8 | 94.0 |
| 19 | 6.07 | 6.07 | 3.20 | 2.87 | 3.0 | 97.0 |
| 20 | 5.40 | 5.40 | 3.50 | 1.90 | 2.0 | 99.0 |
| 21 | 5.00 | 5.00 | 4.00 | 1.00 | 1.0 | 100.0 |
| 22 | 4.84* | 4.60 | 4.60 | 0.00 | 0.0 | |
| 23 | 4.60 | | | | | |
| 24 | | | | | | |
| Total | | | | 95.42 | 100.0 | |

+ Interpolated value
* Day record abandoned

x and can be expressed as

$$P(X \geq x) = 1 - e^{-e^{-y}} \tag{A1}$$

where e is the base of natural logarithms and y is given by

$$y = \frac{1.0}{0.7797\ s}(X - \bar{x} + 0.45\ s) \tag{A2}$$

In Eq.(A2), X is the extreme event magnitude with probability P; $\bar{x}$ is the mean value of the annual series of extreme events of N number of years; and s is the standard deviation. The values of $\bar{x}$ and s are computed from the following equation:

$$\bar{x} = \frac{\Sigma x}{N} \tag{A3}$$

$$s = \sqrt{\frac{\Sigma(x-\bar{x})^2}{N-1}}$$

Plotting positions are determined by the formula

$$T = \frac{N+1}{M} \tag{A4}$$

where M is the rank of the item on the series, M being 1 for the largest.

For evaluation of the accuracy of the computed values of X, the confidence interval is computed as:

$$X - t(\alpha)s_e \qquad X + t(\alpha)s_e \tag{A5}$$

for which at confidence level, $\alpha = 90\%$, $t(\alpha) = 1.645$.

$s_e$ is computed by the formula:

$$s_e = \beta \frac{s}{\sqrt{N}} \tag{A6}$$

where

$$\beta = \sqrt{1 + 1.3K + 1.1K^2}$$

$$K = \frac{X - \bar{x}}{s}$$

A3 Distribution of Basin Average Rainfall into Station Rainfall

In this section, the distribution of basin rainfall into station rainfall is discussed. The basin has been divided into three regions, each region rainfall being represented by one raingage station. With three

representative stations and six years of record, let the rainfall records per station per year be as shown in the following table.

| year \ station | 1 | 2 | 3 |
|---|---|---|---|
| 1 | - | $r_{12}$ | $r_{13}$ |
| 2 | - | $r_{22}$ | $r_{23}$ |
| 3 | $r_{31}$ | $r_{32}$ | $r_{33}$ |
| 4 | $r_{41}$ | $r_{42}$ | $r_{43}$ |
| 5 | $r_{51}$ | $r_{52}$ | $r_{53}$ |
| 6 | $r_{61}$ | $r_{62}$ | $r_{63}$ |
| Distribution | D1 | D2 | D3 |

We would like to know the best distribution, D1 for station No.1, D2 for station No.2 and D3 for station No.3.

For any two stations in a given year referred to as the $i^{th}$ year

$$\frac{D1}{D2} = C^i_{12} \frac{r_{i1}}{r_{i2}} \tag{A7}$$

and

$$\frac{D1}{D3} = C^i_{13} \frac{r_{i1}}{r_{i3}} \tag{A8}$$

In the case, where there is no rainfall record for station No.1

$$\frac{D2}{D3} = C^i_{23} \frac{r_{i2}}{r_{i3}} \tag{A9}$$

where $C^i$ is a constant and would be equal to unity if the rainfall was always distributed in the same manner throughout the basin. The best set of D values are those which minimize the function

$$Z = \sum_{i=1}^{N} \{(1-C^i_{12})^2 + (1 - C^i_{13})^2\} \tag{A10}$$

or

$$Z = f(D1,D2,D3) \tag{A11}$$

To compute D1, D2 and D3 the "Steepest Ascent Method" is used. In this method the procedure is started by selecting an arbitrary distribution. The first selection is $D1^o$, $D2^o$ and $D3^o$ so Eq.(A11) becomes:

$$Z_o = f(D1^o, D2^o, D3^o) \tag{A12}$$

Moving from the collection of starting values to the first revised base values (D1',D2',D3') we have:

$$Z1 = Z_o + \Delta Z \tag{A13}$$

and

$$\begin{aligned} D1' &= D1^o + \Delta D1 \\ D2' &= D2^o + \Delta D2 \\ D3' &= D3^o + \Delta D3 \end{aligned} \tag{A14}$$

where

$$\Delta Z = \frac{\partial Z_o}{\partial D1} \cdot \Delta D1 + \frac{\partial Z_o}{\partial D2} \cdot \Delta D2 + \frac{\partial Z_o}{\partial D3} \cdot \Delta D3 \tag{A15}$$

Ideally Z1 is set equal to zero, and Eq.(A13) becomes:

$$\Delta Z = -Z_o \tag{A16}$$

Since the system is non linear a much smaller value of $\Delta Z$ is used. Arbitrarily the following step is attempted

$$\Delta Z = -0.01\ Z_o \tag{A17}$$

To compute $\Delta D1$, $\Delta D2$ and $\Delta D3$, consider that the increment for any parameter of the distribution D1, D2, D3 is proportional to the partial derivative of $Z_o$ with respect that parameter

$$\frac{\Delta D1}{\Delta D2} = \frac{\partial Z_o/\partial D1}{\partial Z_o/\partial D2} \tag{A18}$$

$$\Delta D2 = K \cdot \Delta D1 \tag{A19}$$

where

$$K = \frac{\partial Z_o/\partial D2}{\partial Z_o/\partial D1} \tag{A20}$$

and

$$\begin{aligned} \Delta D3 &= -(\Delta D1 + \Delta D2) \\ \Delta D3 &= -(1 + K)\Delta D1 \end{aligned} \tag{A21}$$

Substituting Eqs.(A18), (A19) and (A21) to Eq.(A15)

$$\Delta D1 = \frac{-0.01\ Z_o}{\frac{\partial Z_o}{\partial D1} + K\frac{\partial Z_o}{\partial D2} - (1+K)\frac{\partial Z_o}{\partial D3}} \tag{A22}$$

Solving Eq.(A22), the magnitude of $\Delta D1$ is determined. From Eqs.(A19) and (A21) we compute $\Delta D2$, and $\Delta D3$. From Eq.(A14) we get the first revised values of D1', D2' and D3'. And Eq.(A12) becomes:

$$Z1 = f(D1', D2', D3') \tag{A23}$$

The calcualtion is repeated with this new value of the distribution until the minimum value of Z1 is obtained.

A3.1 <u>Application of the Derived Rainfall Distribution</u> Using the 6 years data for Station Nos.2, 6 and 14 (shown in Table 3.11), for a minimum value of Z1, the computed values of $D_1$, $D_2$ and $D_3$ are 0.24, 0.43 and 0.33 respectively. From Fig.3.7, the areas of region corresponding to the rainfall stations are: $A_1 = 0.26\ A_T$, $A_2 = 0.45\ A_T$ and $A_3 = 0.29\ A_T$, where $A_T$ is the total basin area.

To obtain the station rainfall, the following equations are used:

$$R_1A_1 + R_2A_2 + R_3A_3 = R_B \sum_1^3 A_i \tag{A24}$$

$$\frac{R_1}{R_2} = \frac{D_1}{D_2} = C_1 = \frac{0.244}{0.430} = 0.568 \tag{A25}$$

$$\frac{R_1}{R_3} = \frac{D_1}{D_3} = C_2 = \frac{0.244}{0.326} = 0.748 \tag{A26}$$

where $R_B$ is the basin average rainfall depth.

Substituting Eqs.(A25) and (A26) into Eq.(A24), we have

$$R_1 = \frac{R_B\ \Sigma A_i}{A_1 + \frac{A_2}{C_1} + \frac{A_3}{C_2}} \tag{A27}$$

As an example, the basin average rainfall in 1970 is 356.6 mm (from Table 3.11). To solve for $R_1$ in Eq.(A27), we have

$$R_1 = \frac{356.6\ A_T}{0.26A_T + \frac{0.45A_T}{0.568} + \frac{0.29A_T}{0.748}}$$

$$= \frac{356.6}{1.440} = 247 \text{ mm}$$

$$R_2 = R_1/0.568 = 436 \text{ mm}$$

$$R_3 = R_1/0.748 = 330 \text{ mm}$$

Station rainfalls for other years were computed in the same manner as above and the results are shown in Table 3.11.

# APPENDIX B

## COMPUTER PROGRAMS FOR TIDAL ANALYSIS BY THE HARMONIC METHOD WITH ABSOLUTE VALUE

The computer programs are written in FORTRAN IV language and designed for runs in a CDC 3600 computer model.

```
      PROGRAM TIDE
C  PROGRAM FOR TIDAL ANALYSIS BY THE HARMONIC METHOD WITH ABSOLUTE VALUE
C  ETA = HOURLY TIDAL RECORD IN METERS
C  T = PERIODS IN HOURS
C  A = AMPLITUDES IN METERS
C  DELTA = PHASES ANGLE IN RADIAN
C  NCON = TOTAL NUMBER OF CONSTITUENTS
C  NDIM = TOTAL NUMBER OF DATA POINTS ≥ODD NUMBER+
C  STEP = TIME INTERVAL OF TIDAL RECORD
      DIMENSION ETA(8760),ETAS(8760),A(30),T(30),DELTA(30),CO(2)
      READ(60,1) STEP,NDIM,NCON
      READ(60,2) (T(I),I=1,NCON)
      J= NDIM/2
      IF(2*J.NE.NDIM) GO TO 40
      NDIM= NDIM-1
 40   READ(60,3) (ETA(I),I=1,NDIM)
 1    FORMAT(F10.4,2I10)
 2    FORMAT(8F10.4)
 3    FORMAT(16F5.2)
      WRITE(61,16)
 16   FORMAT(/*     TIDAL OBSERVATION USED IN THE ANALYSIS*/)
      WRITE(61,17) (ETA(I),I=1,NDIM)
 17   FORMAT(10X,24F5.2)
      DET= STEP*(NDIM-1)
      WRITE(61,50) DET
 50   FORMAT(/*     LENGTH OF RECORD = *,F15.2,*  HOURS*)
      CALL QSF(STEP,ETA,Z,NDIM)
      AZERO= Z/DET
      WRITE(61,20) AZERO
 20   FORMAT(/*     VALUE OF AZERO = *,F10.4,*  METERS*)


      WRITE(61,41)
 41   FORMAT(//*     VALUES OF I,A(I),DELTA(I),T(I),KJMAX,RATIO*//)
C  TO COMPUTE A(I) AND DELTA(I)
      DO 4 I=1,NCON
      DO 5 K=1,2
      DO 6 J=1,NDIM
      ARG= (2.*3.141593*(J-1)*STEP)/T(I)
      IF(K-1) 9,10,9
 9    ETAS(J)= ETA(J)*COS(ARG)
      GO TO 6
 10   ETAS(J)= ETA(J)*SIN(ARG)
 6    CONTINUE
      CALL QSF(STEP,ETAS,Z,NDIM)
      CO(K)= Z/DET
 5    CONTINUE
      A(I)= 2.*SQRT(CO(1)**2+CO(2)**2)
      IF(CO(1))37,12,37
 37   YDX= CO(2)/CO(1)
      S= ABS(YDX)
      IF(S-1000.) 11,12,12
 11   IF(YDX)30,31,32
 30   IF(CO(2))33,34,34
 33   DELTA(I)= ATAN(YDX)
      GO TO 4
 34   DELTA(I)= 3.141593+ATAN(YDX)
      GO TO 4
```

```
 31   IF(CO(1))35,36,36
 35   DELTA(I)= 3.141593
      GO TO 4
 36   DELTA(I)= 0.
      GO TO 4
 32   IF(CO(2)) 34,33,33
 12   IF(CO(2))80,90,90
 80   DELTA(I)= -3.141593/2.
      GO TO 4
 90   DELTA(I)= 3.141593/2.
 4    CONTINUE
C  TO COMPUTE KJMAX AND RATIO

      DO 7 J=1,NCON
      SUM= 0.
      DO 8 I=1,NCON
      IF(I-J)14,8,14
 14   SUM= SUM+A(I)*(1./ABS((1./T(I))-(1./T(J)))+1./((1./T(I))+(1./T(J))
     $))
 8    CONTINUE
      RJMAX= (2.*SQRT(2.)*((AZERO*T(J))/3.141593
     $+(3.*A(J)*T(J))/(8.*3.141593)
     $+(3.*SUM)/(4.*3.141593)))/DET
      RATIO= RJMAX/A(J)
      WRITE(61,42) J,A(J),DELTA(J),T(J),RJMAX,RATIO
 42   FORMAT(I5,5F15.4)
 7    CONTINUE
      STOP
      END
```

```
.4DS      TIDE                                                    02/19/75          ED

                                        IDENT      TIDE
     PROGRAM LENGTH                43045

     ENTRY POINTS
          TIDE      42413

     EXTERNAL SYMBOLS
          Q8QENTRY          THEND.            Q8QSTOPS          Q8QDICT.          QSF
          SINF              COSF              ATANF             TSH.              STH.

        00143 SYMBOLS
```

FTN5.5A 02/19/75

```
      SUBROUTINE QSF(H,Y,Z,N)
C  SUBROUTINE FOR INTEGRATION BY SIMPSON METHOD
C  NOTE THAT N MUST BE ODD
      DIMENSION Y(1)
      SUM= Y(1)+Y(N)
      N1= N-1
      DO 1 I=2,N1,2
      SUM= SUM+4.*Y(I)
 1    CONTINUE
      N2= N-2
      DO 2 I=3,N2,2
      SUM= SUM+2.*Y(I)
 2    CONTINUE
      Z= (H/3.)*SUM
      RETURN
      END
```

5,4DS QSF 02/19/75

```
                                        IDENT     QSF
      PROGRAM LENGTH              00144

      ENTRY POINTS
              QSF       00003

      EXTERNAL SYMBOLS
              QBQDICT,
         00045 SYMBOLS
LOAD
RUN,5,500,,NM

EXECUTION STARTED AT   1134 =36
```

# APPENDIX C

## C1. MAIN PROGRAM AND SUBROUTINES FOR THE BICOL RIVER BASIN FLOOD CONTROL SIMULATION MODEL

The computer programs are written in FORTRAN IV language and designed for runs in a CDC 3600 computer model of 64K capacity.

```
      PROGRAM BICOL2
      DIMENSION QOP(100)
      DIMENSION TYPE(10)
      COMMON N,G,U,C(90),P(8100),MX,MY,NNODE,NBAN,M,NN,NTIME,NDAY,CODPOL
      COMMON DELX(50),DELXX(50),DELXY(50),ALFAX(50),ALFAY(50),L,IB
      COMMON Q(50,2),H(50,2),QL(50,2),DQL(50),SUMQ(50),NMK
      COMMON ZI(50),NLIM,IDATE,IHOUR,IMIN,IDELT,DELT,ZET(50)
      COMMON A(50),AM(50),AH(50),AO(50),AX(50),AY(50),AXY,AOC,AHC,AOUS(5
     10),AHUS(50),AMC,AMUS(50),AXUS(50),AYUS(50),AUS(50),AODS(50),AHDS(5
     20),AMDS(50),AXDS(50),AYDS(50),ADS(50),F(50),SFBAO(50),SFBAT(50),SF
     3POL(50)
      COMMON HUD(50),HUS(50),HDS(50),HC
      COMMON ENX(50),ENM(50),ENY(50),EKX(50),EKM(50),EKY(50),EM(50),EKXU
     1S(50),EKMUS(50),EKYUS(50),EKXDS(50),EKMDS(50),EKYDS(50),ENXY,EKXY,
     2SUMK(50),ENMC,EKMC,EMUS(50),EMDS(50)
      COMMON EX(50),EY(50),E1(50),E2(50),E3(50),E4(50),EY1(50),EY2(50),E
     1Y3(50),EX1(50),EX2(50),EX3(50),EBAT(50),EBAO(50),EXUS1(50),EXUS2(5
     20),EXUS3(50),EYUS1(50),EYUS2(50),EYUS3(50),EUS1(50),EUS2(50),EUS3
     3(50),EUS4(50),EXDS1(50),EXDS2(50),EXDS3(50),EYDS1(50),EYDS2(50),EY
     4DS3(50),EDS1(50),EDS2(50),EDS3(50),EDS4(50),EC1,EC2,EC3,EC4,EXY,EX
     5Y1,EXY2,EXY3,EXUS(50),EYUS(50),EXDS(50),EYDS(50),EPOL(50)
      COMMON T(50),T1(50),T2(50),T3(50),T4(50),TX1(50),TX2(50),TX3(50),T
     1Y1(50),TY2(50),TY3(50),TX(50),TY(50),TM(50),TUS1(50),TUS2(50),TUS3
     2(50),TUS4(50),TC1,TC2,TC3,TC4,TXY1,TXY2,TXY3,TXUS1(50),TXUS2(50),T
     3XUS3(50),TYUS1(50),TYUS2(50),TYUS3(50),TXDS1(50),TXDS2(50),TXDS3(5
     40),TYDS1(50),TYDS2(50),TYDS3(50),TXY,TUS(50),TDS(50),TDS1(50),TDS2
     5(50),TDS3(50),TDS4(50),TMUS(50),TXUS(50),TYUS(50),TMDS(50)
      COMMON TXDS(50),TYDS(50),TMC
      COMMON RX(50),RY(50),RM(50),RMUS(50),RMDS(50),RMC,RXUS(50),RYUS(50
     1),RXDS(50),RYDS(50),RXY
      COMMON DIFFH(50),DIFFA(50),DIFFM(50)
      COMMON QX(50),QM(50),QY(50),CODSIP,CODPAS,CODCUT,CODWID,CODEXT
      COMMON QBCN(2),QROL(2),QPAS(2),QQL(31,61),CQC(31,61),CODEXC
      COMMON    EE1(4),EE2(4),EE3(4),EE4(4),AAO(4),AAH(4),TT1(4),TT2(4),
     1TT3(4),TT4(4),TTUS1(4),TTUS2(4),TTUS3(4),TTUS4(4),TTDS1(4),TTDS2(4
     2),TTDS3(4),TTDS4(4),EEUS1(4),EEUS2(4),EEUS3(4),EEUS4(4),EEDS1(4),E
     3EDS2(4),EEDS3(4),EEDS4(4),AAOUS(4),AAHUS(4),AAODS(4),AAHDS(4)
C BICOL2-PROGRAM TO COMPUTE STAGES AND DISCHARGES IN LIBMANAN AND BICOL RIV
C USING NODE AND BRANCH COMPUTATION
C MAIN PROGRAM BICOL2 CALLS SUBROUTINES--INPUT2,RITIN2,DIFH2,STAGE2,DIFAM2,
C GEO1,GEO2,ATMK2,SURE2,SQ2,SIMQ,TIDAL1,TIDAL2,BARIER,DESVIN
      KKK=KKJ=0
      MX=60
      MY=61
      ZETA=0,55
      G=9,81
      READ(MX,290)TDT
  290 FORMAT(1X,F7,0)
      ITDT=TDT
      READ(MX,600)IRETURN,ISTABLE
      READ(MX,600)NMKR,JIK
  324 JJJ=0
      III=1
      RITE=0,
      NME=0
      NTIME=0
```

```
C JIK=0,NOT PRINT DATA
C JIK=1,PRINT DATA
      NMK=NMKR
      READ(MX,234)FACTOR,PHASE
  234 FORMAT(1X,2F5.3)
      READ(MX,2001)TYPE
      WRITE(MY,2001)TYPE
 2001 FORMAT(10A8)
C CODE LIST.......  1=YES,0=NO
  679 FORMAT(5X,*1=YES*,5X,*0=NO*,/)
      WRITE(MY,679)
      READ(MX,601)ALT,RHR,ACCU
      READ(MX,601)CODPOL,CODSIP,CODPAS,CODCUT,CODWID,CODBAR,CODEXT,CODEX
     1C
    1 FORMAT(1X,I6,12I9/1X,I6,12I9/1X,I6,4I9,4X,*LIBMANAN*,5X,*AMBAU*)
      WRITE(MY,829)IRETURN
      WRITE(MY,830)CODPOL
      WRITE(MY,831)CODSIP
      WRITE(MY,832)CODPAS
      WRITE(MY,833)CODCUT
      WRITE(MY,834)CODWID
      WRITE(MY,835)CODBAR
      WRITE(MY,836)CODEXT
      WRITE(MY,837)CODEXC
  829 FORMAT(15X,*RETURN PERIOD OF FLOOD=*,I4,2X,*YEARS*)
  830 FORMAT(15X,*POLUNTUNA RESERVOIR=*,F7.1)
  831 FORMAT(15X,*SIPOCOT DIVERSION=*F7.1)
  832 FORMAT(15X,*PASACAO DIVERSION=*,F7.1)
  833 FORMAT(15X,*CUT OFF NO.3=*F7.1)
  834 FORMAT(15X,*CUT OFF WIDTH=*,F7.1)
  835 FORMAT(15X,*TIDAL BARRIER=*,F7.1)
  836 FORMAT(15X,*EXTENSION AT CUYAPI=*,F7.1)
  837 FORMAT(15X,*DEEPENING RIVER BED=*,F7.1)
C READ GEOMETRY AND INITIAL CONDITIONS
      CALL INPUT2
      WRITE(MY,235)PHASE,IDELT,FACTOR
  235 FORMAT(5X,*PHASE=*,2X,F5.3,*TIME INTERVAL=*,2X,I5,*GATE FACTOR=*,
     12X,F5.3)
      NTME=(NMKR-1)*24*3600/IDELT
      NTME1=NTME
      DELL=DELT/3600.
      IF(JIK)2003,2003,2002
C PRINT OUT GEOMETRY AND INITIAL CONDITIONS
 2002 CALL RITIN2
C PRINT OUT INITIAL CONDITIONS
 2003 WRITE(MY,600)IDATE,IHOUR,IMIN
      WRITE(MY,604)(H(I,1),I=1,NNODE)
      WRITE(MY,604)(Q(I,1),I=1,NBAN),QBCN(1),QBOL(1),QPAS(1)
      WRITE(MY,601)(QL(I,1),I=1,NNODE)
  602 FORMAT(1X,9F7.4)
   90 FORMAT(20X,* N FOR BRANCH 1------24* ,/)
      WRITE(MY,90)
      WRITE(MY,602)(ENX(I),ENM(I),ENY(I),I=1,24)
   91 FORMAT(20X,*N FOR CUT OFF 3*,/)
      WRITE(MY,91)
      WRITE(MY,602)ENX(25),ENM(25),ENY(25)
```

```
   92 FORMAT(20X,*N FOR  BRANCH 26---30,PASACAO DIVERSION*,/)
      WRITE(MY,92)
      WRITE(MY,602)(ENX(I),ENM(I),ENY(I),I=26,30)
   93 FORMAT(20X,*N FOR BRANCH 31--33,SIPOCOT DIVERSION*,/)
      WRITE(MY,93)
      WRITE(MY,602)(ENX(I),ENM(I),ENY(I),I=31,33)
   94 FORMAT(20X,*N FOR BRANCH 34, EXTENSION AT CUYAPI*,/)
      WRITE(MY,94)
      WRITE(MY,602)ENX(34),ENM(34),ENY(34)
      DO 457I=1,NNODE
      DO 457J=1,NDAY
  457 QQL(I,J)=QL(I,1)
      ADAY=NDAY-NMK
      NLIM=ADAY*24.*3600./DELT
      NLIM=NLIM+NTME
      AIK=DELT/3600.
      IK=AIK
      IF(IK)225,225,226
  225 IK=1
  226 DO 521I=1,NBAN
      ENX(I)=ENX(I)*ALFAX(I)**1.5
  521 ENY(I)=ENY(I)*ALFAY(I)**1.5
  600 FORMAT(1X,3I5)
  601 FORMAT(1X,8F9.3)
  604 FORMAT(1X,13F9.3)
C READ BOUNDARY CONDITIONS
  502 NTIME=NTIME+1
      GO TO (200,201),III
  200 BRR=0.
      KBRR=BRR
      H302=H(30,2)=H(30,1)
      H312=H(31,2)=HSEA2=H(31,1)
      H272=H(27,2)=H(27,1)
       GO TO 202
  201 IF(KBRR)210,210,211
C GENERATE TIDAL INPUT AT BARCELONA AND BOLONGAY
  210 CALL TIDAL1(NTME,DELL,HSEA2,PHASE)
      H302=H312=H(30,2)=H(31,2)=HSEA2
      GO TO 212
C READ DISCHARGE THROUGH BARRIER AT BOLONGAY
  211 CALL BARIER(H(31,1),HSEA2,QQBOL)
      QBOL(2)=QQBOL*FACTOR
C GENERATE TIDAL INPUT AT BARCELONA
  251 CALL TIDAL1(NTME,DELL,HSEA2,PHASE)
      H302=H(30,2)=HSEA2
C GENERATE TIDAL INPUT AT PASACAO
  212 CALL TIDAL2(NTME,DELL,HSEA3,PHASE)
      H272=H(27,2)=HSEA3
C INTERPOLATION FOR NODE INPUTS
  202 DO 555I=1,NNODE
  555 QL(I,2)=QQL(I,NMK)+(QQL(I,NMK+1)-QQL(I,NMK))*NTIME*DELT/3600./ALT
      DT=NTIME*DELT/3600./ALT
      IF(DT-1.)679,680,680
  680 NMK=NMK+1
      NTIME=0
  679 DO 59I=1,NNODE
```

```
   59 DQL(I)=QL(I,2)-QL(I,1)
      CALL DIFH2
      CALL STAGE2
      CALL DIFAM2
      CALL GEO
      CALL ATMK2
      CALL SURF2
C STORE MATRICES
C CONTINUITY EQS,
      DO 311I=1,4225
  311 P(I)=0.
      K1=-65
      DO 100I=1,NNODE
      K1=K1+66
  100 P(K1)=F(I)/DELT
      P(1717)=P(1915)=ZETA
      P(1981)=ZETA*(1.-BRR)+F(31)/DELT*BRR
      P(2016)=P(2082)=P(2148)=P(2214)=P(3969)=P(2280)=P(2346)=P(2412)=P(
     12477)=P(4168)=P(2544)=P(2609)=P(2675)=P(2740)=P(2806)=P(2872)=P(35
     287)=P(2938)=P(3004)=P(3070)=P(3655)=P(3136)=P(3202)=P(3268)=P(3334
     3)=P(3400)=P(3466)=P(3532)=P(3728)=P(3794)=P(3860)=P(3926)=P(4058)=
     4P(4124)=ZETA
      P(2017)=P(2083)=P(2149)=P(2215)=P(2281)=P(2347)=P(2413)=P(2478)=P(
     12543)=P(2608)=P(2674)=P(2739)=P(2805)=P(3585)=P(2871)=P(2937)=P(30
     103)=P(3069)=P(3135)=P(3201)=P(3267)=P(3333)=P(3399)=P(3465)=P(3531
     2)=P(3597)=P(3663)=P(3729)=P(3795)=P(3861)=P(3927)=P(3993)=P(4059)=
     3P(4125)=P(4191)=-ZETA
C MOMENTUM EQS,
      ZTG=ZETA*G
      K1=32
      K2=97
      DO 101I=1,7
      P(K1)=ZTG*A(I)/DELX(I)
      P(K2)=-ZTG*A(I)/DELX(I)
      K1=K1+66
  101 K2=K2+66
      P(429)=ZTG*A(8)/DELX(8)
      P(494)=-P(429)
      P(495)=-ZTG*A(9)/DELX(9)
      P(560)=-P(495)
      P(496)=-ZTG*A(10)/DELX(10)
      P(561)=-P(496)
      P(562)=-ZTG*A(11)/DELX(11)
      P(627)=-P(562)
      K1=563
      K2=628
      DO 102I=12,24
      P(K1)=-ZTG*A(I)/DELX(I)
      P(K2)=ZTG*A(I)/DELX(I)
      K1=K1+66
  102 K2=K2+66
      P(641)=-ZTG*A(25)/DELX(25)
      P(671)=-P(641)
      P(965)=ZTG*A(26)/DELX(26)
      P(1487)=-P(965)
      P(1488)=ZTG*A(27)/DELX(27)
```

```
      P(1553)=-P(1488)
      P(1554)=ZTG*A(28)/DELX(28)
      P(1619)=-P(1554)
      P(1620)=ZTG*A(29)/DELX(29)
      P(1685)=-P(1620)
      P(1686)=ZTG*A(30)/DELX(30)
      P(1751)=-ZETA*EM(30)*T(30)*Q(30,1)/A(30)/F(27)
      P(257)=ZTG*A(31)/DELX(31)
      P(1817)=-P(257)
       P(1818)=ZTG*A(32)/DELX(32)
      P(1883)=-P(1818)
      P(1884)=ZTG*A(33)/DELX(33)
      P(1949)=-ZETA*EM(33)*T(33)*Q(33,1)/A(33)/F(30)
      P(520)=ZTG*A(34)/DELX(34)
      P(2015)=-ZETA*EM(34)*T(34)*Q(34,1)/A(34)/F(31)*(1.-BKR)-P(520)*BRK
      U=2.0
      CALL SQ2
      K1=2047
      DO 103I=1,NBAN
      SUMK(I)=EKX(I)+EKM(I)+EKY(I)
      TERM1=-1./DELT
      TERM2=ZETA*EM(I)*T(I)/A(I)*SUMQ(I)
      TERM3=ZETA*2.*Q(I,1)*(EM(I)*DIFFA(I)/A(I)**2/DELX(I)-DIFFM(I)/A(I)
     1/DELX(I)-G*A(I)*ABS(Q(I,1))/SUMK(I)**2/Q(I,1))
      P(K1)=TERM1+TERM2+TERM3
  103 K1=K1+66
      DO 104I=1,NBAN
  104 ZET(I)=ZETA*EM(I)*T(I)*Q(I,1)/A(I)
      K1=2048
      K2=2112
      DO 105I=1,6
      J=I+1
      P(K1)=ZET(J)/F(J)
      P(K2)=-ZET(I)/F(I)
      K1=K1+66
  105 K2=K2+66
      P(3999)=-ZET(3)/F(4)
      P(4000)=-ZET(4)/F(4)
      P(2507)=-ZET(6)/F(7)
      P(2508)=ZET(7)*(-1./F(7)+1./F(8))
      P(2573)=ZET(7)/F(8)
      P(2638)=ZET(7)/F(8)
      P(4198)=-ZET(7)/F(8)
      P(2379)=ZET(8)/F(7)
      P(2444)=ZET(8)*(-1./F(7)+1./F(8))
      P(2574)=ZET(8)/F(8)
      P(2639)=ZET(8)/F(8)
      P(4199)=-ZET(8)/F(8)
      P(2445)=ZET(9)/F(8)
      P(2510)=ZET(9)/F(8)
      P(2640)=ZET(9)*(1./F(8)-1./F(9))
      P(2705)=ZET(9)/F(9)
      P(2770)=ZET(9)/F(9)
      P(4200)=-ZET(9)/F(8)
      P(2446)=ZET(10)/F(8)
      P(2511)=ZET(10)/F(8)
```

```
      P(2576)=ZET(10)*(1./F(8)-1./F(9))
      P(2706)=ZET(10)/F(9)
      P(2771)=ZET(10)/F(9)
      P(4201)=-ZET(10)/F(8)
      P(2577)=-ZET(11)/F(9)
      P(2642)=-ZET(11)/F(9)
      P(2772)=ZET(11)*(1./F(9)-1./F(10))
      P(2837)=ZET(11)/F(10)
      P(3617)=ZET(11)/F(10)
      P(2578)=-ZET(12)/F(9)
      P(2643)=-ZET(12)/F(9)
      P(2708)=ZET(12)*(1./F(9)-1./F(10))
      P(2838)=ZET(12)/F(10)
      P(3618)=ZET(12)/F(10)
      K1=2774
      K2=2904
      DO 106I=13,23
      P(K1)=-ZET(I)/F(I-3)
      P(K2)=ZET(I)/F(I-2)
      K1=K1+66
  106 K2=K2+66
      P(2709)=-ZET(13)/F(10)
      P(3619)=ZET(13)/F(10)
      P(3620)=-ZET(14)/F(12)
      P(3621)=-ZET(15)/F(12)
      P(3688)=-ZET(17)/F(15)
      P(3689)=-ZET(18)/F(15)
      P(3500)=-ZET(24)/F(21)
      P(2721)=-ZET(25)/F(10)
      P(2786)=-ZET(25)/F(10)
      P(2851)=ZET(25)/F(10)
      P(2916)=-ZET(25)/F(12)
      P(2981)=ZET(25)/F(12)
      P(3112)=-ZET(26)/F(15)
      P(3177)=ZET(26)/F(15)
      P(3762)=-ZET(26)/F(23)
      P(3698)=ZET(27)/F(23)
      P(3828)=-ZET(27)/F(24)
      P(3764)=ZET(28)/F(24)
      P(3894)=-ZET(28)/F(25)
      P(3830)=ZET(29)/F(25)
      P(3960)=-ZET(29)/F(26)
      P(3896)=ZET(30)/F(26)
      P(2207)=ZET(31)/F(4)
      P(2272)=-ZET(31)/F(4)
      P(4092)=-ZET(31)/F(28)
      P(4028)=ZET(32)/F(28)
      P(4158)=-ZET(32)/F(29)
      P(4094)=ZET(33)/F(29)
      P(2470)=ZET(34)/F(8)
      P(2535)=ZET(34)/F(8)
      P(2600)=ZET(34)/F(8)
      P(2665)=ZET(34)/F(8)
C STORE MATRICES
C CONTINUITY EQS,
      C(1)=-Q(1,1)+QL(1,1)+ZETA*DQL(1)
```

```
      C(2)=Q(1,1)-Q(2,1)+QL(2,1)+ZETA*DQL(2)
      C(3)=Q(2,1)-Q(3,1)+QL(3,1)+ZETA*DQL(3)
      C(4)=Q(3,1)-Q(4,1)-Q(31,1)+QL(4,1)+ZETA*DQL(4)
      C(5)=Q(4,1)-Q(5,1)+QL(5,1)+ZETA*DQL(5)
      C(6)=Q(5,1)-Q(6,1)+QL(6,1)+ZETA*DQL(6)
      C(7)=Q(6,1)-Q(7,1)-Q(8,1)+QL(7,1)+ZETA*DQL(7)
      C(8)=Q(7,1)+Q(8,1)+Q(9,1)+Q(10,1)-Q(34,1)+QL(8,1)+ZETA*DQL(8)
      C(9)=Q(11,1)+Q(12,1)-Q(9,1)-Q(10,1)+QL(9,1)+ZETA*DQL(9)
      C(10)=Q(13,1)-Q(11,1)-Q(12,1)+QL(10,1)+ZETA*DQL(10)+Q(25,1)
      C(11)=Q(14,1)-Q(13,1)+QL(11,1)+ZETA*DQL(11)
      C(12)=Q(15,1)-Q(14,1)+QL(12,1)+ZETA*DQL(12)-Q(25,1)
      C(13)=Q(16,1)-Q(15,1)+QL(13,1)+ZETA*DQL(13)
      C(14)=Q(17,1)-Q(16,1)+QL(14,1)+ZETA*DQL(14)
      C(15)=Q(18,1)-Q(17,1)-Q(26,1)+QL(15,1)+ZETA*DQL(15)
      C(16)=Q(19,1)-Q(18,1)+QL(16,1)+ZETA*DQL(16)
      C(17)=Q(20,1)-Q(19,1)+QL(17,1)+ZETA*DQL(17)
      C(18)=Q(21,1)-Q(20,1)+QL(18,1)+ZETA*DQL(18)
      C(19)=Q(22,1)-Q(21,1)+QL(19,1)+ZETA*DQL(19)
      C(20)=Q(23,1)-Q(22,1)+QL(20,1)+ZETA*DQL(20)
      C(21)=Q(24,1)-Q(23,1)+QL(21,1)+ZETA*DQL(21)
      C(22)=-Q(24,1)+QL(22,1)+ZETA*DQL(22)
      C(23)=Q(26,1)-Q(27,1)+QL(23,1)+ZETA*DQL(23)
      C(24)=Q(27,1)-Q(28,1)+QL(24,1)+ZETA*DQL(24)
      C(25)=Q(28,1)-Q(29,1)+QL(25,1)+ZETA*DQL(25)
      C(26)=Q(29,1)-Q(30,1)+QL(26,1)+ZETA*DQL(26)
      C(27)=Q(30,1)-QPAS(1)+QL(27,1)+ZETA*DQL(27)-F(27)*(H(27,2)-H(27,1)
     1)/DELT
      C(28)=Q(31,1)+QL(28,1)+ZETA*DQL(28)-Q(32,1)
      C(29)=Q(32,1)+QL(29,1)+ZETA*DQL(29)-Q(33,1)
      C(30)=Q(33,1)-QBCN(1)+QL(30,1)+ZETA*DQL(30)-F(30)*(H(30,2)-H(30,1)
     1)/DELT
      C(31)=Q(34,1)+QL(31,1)-QBOL(1)+ZETA* DQL(31)-F(31)*(H(31,2)-H(31,1
     1))/DELT*(1,-BRR)-ZETA*(QBOL(2)-QBOL(1))*BRR
       U=1,
      CALL SQ2
      DO 107I=1,NBAN
      TERM1=EM(I)*Q(I,1)*T(I)*SUMQ(I)/A(I)
      TERM2=EM(I)*Q(I,1)**2*DIFFA(I)/A(I)**2/DELX(I)
      TERM3=Q(I,1)**2*DIFFM(I)/A(I)/DELX(I)
      TERM4=G*A(I)*DIFFH(I)/DELX(I)
      TERM5=G*A(I)*Q(I,1)*ABS(Q(I,1))/SUMK(I)**2
  107 ZI(I)=TERM1+TERM2-TERM3-TERM4-TERM5
C MOMENTUM EQS,
      C(32)=-ZI( 1)-ZET( 1)/F( 1)*DQL( 1)-ZET( 1)/F( 2)*DQL( 2)
      C(33)=-ZI( 2)-ZET( 2)/F( 2)*DQL( 2)-ZET( 2)/F( 3)*DQL( 3)
      C(34)=-ZI(3)-ZET(3)/F(3)*DQL(3)-ZET(3)/F(4)*DQL(4)
      C(35)=-ZI( 4)-ZET( 4)/F( 4)*DQL( 4)-ZET( 4)/F( 5)*DQL( 5)
      C(36)=-ZI(5)-ZET(5)/F(5)*DQL(5)-ZET(5)/F(6)*DQL(6)
      C(37)=-ZI( 6)-ZET( 6)/F( 6)*DQL( 6)-ZET( 6)/F( 7)*DQL( 7)
      C(38)=-ZI( 7)-ZET( 7)/F( 7)*DQL( 7)-ZET( 7)/F( 8)*DQL( 8)
      C(39)=-ZI( 8)-ZET( 8)/F( 7)*DQL( 7)-ZET( 8)/F( 8)*DQL( 8)
      C(40)=-ZI( 9)-ZET( 9)/F( 9)*DQL( 9)-ZET( 9)/F( 8)*DQL( 8)
      C(41)=-ZI(10)-ZET(10)/F( 8)*DQL( 8)-ZET(10)/F( 9)*DQL( 9)
      C(42)=-ZI(11)-ZET(11)/F( 9)*DQL( 9)-ZET(11)/F(10)*DQL(10)
      C(43)=-ZI(12)-ZET(12)/F( 9)*DQL( 9)-ZET(12)/F(10)*DQL(10)
      C(44)=-ZI(13)-ZET(13)/F(10)*DQL(10)-ZET(13)/F(11)*DQL(11)
```

```
      C(45)=-ZI(14)-ZET(14)/F(11)*DQL(11)-ZET(14)/F(12)*DQL(12)
      C(46)=-ZI(15)-ZET(15)/F(12)*DQL(12)-ZET(15)/F(13)*DQL(13)
      C(47)=-ZI(16)-ZET(16)/F(13)*DQL(13)-ZET(16)/F(14)*DQL(14)
      C(48)=-ZI(17)-ZET(17)/F(14)*DQL(14)-ZET(17)/F(15)*DQL(15)
      C(49)=-ZI(18)-ZET(18)/F(15)*DQL(15)-ZET(18)/F(16)*DQL(16)
      C(50)=-ZI(19)-ZET(19)/F(16)*DQL(16)-ZET(19)/F(17)*DQL(17)
      C(51)=-ZI(20)-ZET(20)/F(17)*DQL(17)-ZET(20)/F(18)*DQL(18)
      C(52)=-ZI(21)-ZET(21)/F(18)*DQL(18)-ZET(21)/F(19)*DQL(19)
      C(53)=-ZI(22)-ZET(22)/F(19)*DQL(19)-ZET(22)/F(20)*DQL(20)
      C(54)=-ZI(23)-ZET(23)/F(20)*DQL(20)-ZET(23)/F(21)*DQL(21)
      C(55)=-ZI(24)-ZET(24)/F(21)*DQL(21)-ZET(24)/F(22)*DQL(22)
      C(56)=-ZI(25)-ZET(25)/F(12)*DQL(12)-ZET(25)/F(10)*DQL(10)
      C(57)=-ZI(26)-ZET(26)/F(15)*DQL(15)-ZET(26)/F(23)*DQL(23)
      C(58)=-ZI(27)-ZET(27)/F(23)*DQL(23)-ZET(27)/F(24)*DQL(24)
      C(59)=-ZI(28)-ZET(28)/F(24)*DQL(24)-ZET(28)/F(25)*DQL(25)
      C(60)=-ZI(29)-ZET(29)/F(25)*DQL(25)-ZET(29)/F(26)*DQL(26)
      C(61)=-ZI(30)-ZET(30)/F(26)*DQL(26)-ZET(30)/F(27)*DQL(27)
     1+ZTG*A(30)/DELX(30)*(H(27,2)-H(27,1))
      C(62)=-ZI(31)-ZET(31)/F( 4)*DQL( 4)-ZET(31)/F(28)*DQL(28)
      C(63)=-ZI(32)-ZET(32)/F(28)*DQL(28)-ZET(32)/F(29)*DQL(29)
      C(64)=-ZI(33)-ZET(33)/F(29)*DQL(29)-ZET(33)/F(30)*DQL(30)
     1+ZTG*A(33)/DELX(33)*(H(30,2)-H(30,1))
      C(65)=-ZI(34)-ZET(34)/F( 8)*DQL( 8)-ZET(34)/F(31)*DQL(31)
     1+ZTG*A(34)/DELX(34)*(H(31,2)-H(31,1))*(1.-BRR)+ZET(34)/F(31)*(QBOL
     2(2)-QBOL(1))*BRR
C MATRIX INVERSION
      N=65
      CALL SIMQ(P,C,N,KS)
      DO 108I=1,NNODE
  108 H(I,2)=H(I,1)+C(I)
      HLIBM =(H(6,2)+2.2*H(7,2))/3.2
      HAMBAO=(H(15,2)+1.8*H(16,2))/2.8
      QPAS(2)=QPAS(1)+C(27)
      QBCN(2)=QBCN(1)+C(30)
      H(27,2)=H272
      H(30,2)=H302
      IBRR=KBRR+1
      GO TO (420,421),IBRR
  420 H(31,2)=H312
      QBOL(2)=QBOL(1)+C(31)
  421 DO 109I=1,NBAN
      J=NNODE+I
  109 Q(I,2)=Q(I,1)+C(J)
      NTME=NTME+1
      NME=NME+1
      QOP(NME)=QBOL(2)
      RITE=RITE+1.
      IMIN=IMIN+IDELT/60
      IF(IMIN-60)40,41,41
   41 IMIN=IMIN-60*IK
      IHOUR=IHOUR+1*IK
      IF(IHOUR-24)40,42,42
   42 IHOUR=IHOUR-24
      IDATE=IDATE+1
   40 ANTM=DELT*RITE/3600.
      IF(ANTM-RHR)404,45,45
```

```
   45 WRITE(MY,619)IDATE,IHOUR,IMIN,NTME,NTIME
  619 FORMAT(1X,3I5,2X,3I10)
      WRITE(MY,1)(ID,ID=1,31)
      WRITE(MY,604)(H(I,2),I=1,NNODE),HLIBM,HAMBAD
      WRITE(MY,604)(Q(I,2),I=1,NBAN)
      DO 77I=1,NBAN
      QX(I)=Q(I,2)*EKX(I)/SUMK(I)
      QM(I)=Q(I,2)*EKM(I)/SUMK(I)
   77 QY(I)=Q(I,2)*EKY(I)/SUMK(I)
      WRITE(MY,604)(QX(I),I=1,NBAN)
      WRITE(MY,604)(QM(I),I=1,NBAN)
      WRITE(MY,604)(QY(I),I=1,NBAN)
      WRITE(MY,604)(QL(I,2),I=1,NNODE) ,QBCN(2),QBDL(2),QPAS(2)
      WRITE(MY,604)(QOP(I),I=1,NME)
      IF(III-1)570,570,569
  569 IF(ISTABLE)570,570,571
  571 IF(IDATE-13)570,572,572
  572 IF(IDATE-14)573,574,570
  573 DELT=TDT
      IDELT=DELT
      DELL=DELT/3600.
      IF(KKK)568,568,570
  568 NTME=(NTME-1)*3600/ITDT+1
      NLIM=NLIM+10000
      KKK=1
      GO TO 570
  574 DELT=3600.
      IDELT=DELT
      DELL=DELT/3600.
      IF(KKJ)567,567,570
  567 NLIM=NLIM-10000
      NTME=(NTME-1)/(3600/ITDT)+1
      KKJ=1
  570 RITE=0.
      NME=0
C  FLOOD STARTS
      IF(JJJ)650,650,3002
C CHECKING OF CONVERGENCY
  650 DO 700I=1,NNODE
      DELH=ABS(H(I,2)-H(I,1))
      IF(DELH-ACCU)700,700,3002
  700 CONTINUE
C TRANSFER HYDROLOGIC NODE INPUTS
      DO 170I=1,NNODE
      DO 170J=1,NDAY
  170 QQL(I,J)=QQQ(I,J)
C READ CONDITION OF TIDAL BARRIER
C CODBAR=0---NO TIDAL BARRIER
C CODBAR=1,---WITH TIDAL BARRIER
      BRR=CODBAR
      KBRR=BRR
      NTME=NTME1
      NTIME=0
      NMK=NMKR
      NME=0
      JJJ=1
```

```
      III=2
      IDATE=NMK
      IHOUR=IMIN=0
      WRITE(MY,4000)
 4000 FORMAT(20X,*FLOOD STARTS*)
 3002 CONTINUE
      GO TO 44
  404 IF(JJJ.EQ.1)GO TO 405
      GO TO 44
  405 IF(IDATE.GE.12.AND.IDATE.LE.13)406,44
  406 CONTINUE
      WRITE(MY,600)IDATE,IHOUR,IMIN
      WRITE(MY,1)(IO,IO=1,31)
      WRITE(MY,604)(Q(I,2),I=1,NBAN),QBCN(2),QBOL(2),QPAS(2)
      WRITE(MY,604)(H(I,2),I=1,NNODE),HLIBM,HAMBAD
C INITIALIZE
   44 DO 110I=1,NNODE
      QL(I,1)=QL(I,2)
  110 H(I,1)=H(I,2)
      DO 111I=1,NBAN
  111 Q(I,1)=Q(I,2)
      QPAS(1)=QPAS(2)
      QBCN(1)=QBCN(2)
      QBOL(1)=QBOL(2)
      IF(NTME-NLIM)502,500,500
  500 STOP
      END
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4US   BICOL2                                                    01/02/75        ED

                                    IDENT     BICOL2
PROGRAM LENGTH                 04464

ENTRY POINTS
        BICOL2   00472

BLOCK NAMES
                 46451

EXTERNAL SYMBOLS
        QBQENTRY.        THEND.          Q1Q10100        Q2Q0/111        Q10041
        QBQDICT.         INPUT2          RITIN2          TIDAL1          BARIER
        DIFH2            STAGE2          DIFAM2          GEO             ATMK2
        SQ2              SIMQ            TSH.            STH.            SLO.
        QNSINGL.
   01031 SYMBOLS
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```
      SUBROUTINE INPUT2
      COMMON N,G,U,C(90),P(8100),MX,MY,NNODE,NBAN,M,NN,NTIME,NDAY,CODPOL
      COMMON DELX(50),DELXX(50),DELXY(50),ALFAX(50),ALFAY(50),L,IB
      COMMON Q(50,2),H(50,2),QL(50,2),DQL(50),SUMQ(50),NMK
      COMMON ZI(50),NLIM,IDATE,IHOUR,IMIN,IDELT,DELT,ZET(50)
      COMMON A(50),AM(50),AH(50),AO(50),AX(50),AY(50),AXY,AOC,AHC,AOUS(5
     10),AHUS(50),AMC,AMUS(50),AXUS(50),AYUS(50),AUS(50),AODS(50),AHDS(5
     20),AMDS(50),AXDS(50),AYDS(50),ADS(50),F(50),SFBAO(50),SFBAT(50),SF
     3POL(50)
      COMMON HUD(50),HUS(50),HDS(50),HC
      COMMON ENX(50),ENM(50),ENY(50),EKX(50),EKM(50),EKY(50),EM(50),EKXU
     1S(50),EKMUS(50),EKYUS(50),EKXDS(50),EKMDS(50),EKYDS(50),ENXY,EKXY,
     2SUMK(50),ENMC,EKMC,EMUS(50),EMDS(50)
      COMMON EX(50),EY(50),E1(50),E2(50),E3(50),E4(50),EY1(50),EY2(50),E
     1Y3(50),EX1(50),EX2(50),EX3(50),EBAT(50),EBAO(50),EXUS1(50),EXUS2(5
     20),EXUS3(50),EYUS1(50),EYUS2(50),EYUS3(50),EUS1(50),EUS2(50),EUS3
     3(50),EUS4(50),EXDS1(50),EXDS2(50),EXDS3(50),EYDS1(50),EYDS2(50),EY
     4DS3(50),EDS1(50),EDS2(50),EDS3(50),EDS4(50),EC1,EC2,EC3,EC4,EXY,EX
     5Y1,EXY2,EXY3,EXUS(50),EYUS(50),EXDS(50),EYDS(50),EPOL(50)
      COMMON T(50),T1(50),T2(50),T3(50),T4(50),TX1(50),TX2(50),TX3(50),T
     1Y1(50),TY2(50),TY3(50),TX(50),TY(50),TM(50),TUS1(50),TUS2(50),TUS3
     2(50),TUS4(50),TC1,TC2,TC3,TC4,TXY1,TXY2,TXY3,TXUS1(50),TXUS2(50),T
     3XUS3(50),TYUS1(50),TYUS2(50),TYUS3(50),TXDS1(50),TXDS2(50),TXDS3(5
     40),TYDS1(50),TYDS2(50),TYDS3(50),TXY,TUS(50),TDS(50),TDS1(50),TDS2
     5(50),TDS3(50),TDS4(50),TMUS(50),TXUS(50),TYUS(50),TMDS(50)
      COMMON TXDS(50),TYDS(50),TMC
      COMMON RX(50),RY(50),RM(50),RMUS(50),RMDS(50),RMC,RXUS(50),RYUS(50
     1),RXDS(50),RYDS(50),RXY
      COMMON DIFFH(50),DIFFA(50),DIFFM(50)
      COMMON QX(50),QM(50),QY(50),CODSIP,CODPAS,CODCUT,CODWID,CODEXT
      COMMON QBCN(2),QBOL(2),QPAS(2),QOL(31,61),QQO(31,61),CODEXC
      COMMON    EE1(4),EE2(4),EE3(4),EE4(4),AAO(4),AAH(4),TT1(4),TT2(4),
     1TT3(4),TT4(4),TTUS1(4),TTUS2(4),TTUS3(4),TTUS4(4),TTDS1(4),TTDS2(4
     2),TTDS3(4),TTDS4(4),EEUS1(4),EEUS2(4),EEUS3(4),EEUS4(4),EEDS1(4),E
     3EDS2(4),EEDS3(4),EEDS4(4),AAOUS(4),AAHUS(4),AAODS(4),AAHDS(4)
C INPUT2--PROGRAM TO READ  NUMBER OF NODES AND BRANCH IN LIBMANAN AND BICOL
C RIVERS,DISTANCE INTERVALS,ROUGHNESS COEFFICIENTS,GEOMETRY OF MAIN CHANNELS AN
CTHEIR FLOOD PLAINS,GEOMETRY OF PROPOSED EXCAVATED SECTIONS,GEOMETRY OF CUT OFF
CAND DIVERSIONS,GEOMETRY OF LAKEBATO,LAKE BAAO AND POLUNTUNA RESERVOIR,
  600 FORMAT(1X,3I5)
  601 FORMAT(1X,8F9.3)
  602 FORMAT(1X, 9F7.4)
  603 FORMAT(4(F6.2,E14.7))
  604 FORMAT(1X, 6F9.3)
  679 FORMAT(10F8.3)
      READ(MX,600)NBAN,NNODE,NDAY
      READ(MX,600)M,NN,L
      IDATE=NMK
      IHOUR=IMIN=0
      READ(MX,600)IDELT
      DELT=IDELT
C READ INITIAL CONDITION
      READ(MX,601)(H(I,1),I=1,NNODE)
C READ ROUGHNESS COEFFICIENT
      READ(MX,602)(ENX(I),ENM(I),ENY(I),I=1,NBAN)
C READ MAIN CHANNEL GEOMETRY
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```
      READ(MX,601)(DELX(I),I=1,NBAN)
      READ(MX,601)(DELXX(I),I=1,NBAN)
      READ(MX,601)(DELXY(I),I=1,NBAN)
      DELXX(34)=DELXX(34)*CODEXT+0.01/1000.
      DELXY(34)=DELXY(34)*CODEXT+0.01/1000.
      DELX(34)=DELX(34)*CODEXT+0.01/1000
      DO 666I=1,NBAN
      DELX(I)=DELX(I)*1000.
      DELXX(I)=DELXX(I)*1000.
      DELXY(I)=DELXY(I)*1000.
      ALFAX(I)=DELXX(I)/DELX(I)
  666 ALFAY(I)=DELXY(I)/DELX(I)
      READ(MX,601)( EX(I),EY(I),I=1,NBAN)
      READ(MX,601)(EXUS(I),EYUS(I),I=1,NBAN)
      READ(MX,601)(EXDS(I),EYDS(I),I=1,NBAN)
       READ(MX,601) (E1(I),E2(I),E3(I),E4(I), E1(I+1),E2 (I+1),E3(I+1),
     $ E4(I+1),I= 1, NBAN, 2)
       READ(MX,601)(T1(I),T2(I),T3(I),T4(I), T1(I+1),T2(I+1),T3(I+1),T4(
     $I+1), I= 1, NBAN, 2)
      READ(MX,601)(AO(I),AH(I),I=1,NBAN)
       READ(MX,601)(EUS1(I),EUS2(I),EUS3(I),EUS4(I), EUS1(I+1),EUS2(I+1)
     $, EUS3(I+1), EUS4(I+1), I=1, NBAN, 2)
       READ(MX,601)(TUS1(I),TUS2(I),TUS3(I),TUS4(I), TUS1(I+1),TUS2(I+1)
     $, TUS3(I+1), TUS4(I+1), I= 1, NBAN, 2)
      READ(MX,601)(AOUS(I),AHUS(I),I=1,NBAN)
       READ(MX,601)(EDS1(I),EDS2(I),EDS3(I),EDS4(I), EDS1(I+1),EDS2(I+1)
     $, EDS3(I+1), EDS4(I+1), I=1, NBAN, 2)
       READ(MX,601)(TDS1(I),TDS2(I),TDS3(I),TDS4(I), TDS1(I+1),TDS2(I+1)
     $, TDS3(I+1), TDS4(I+1), I= 1, NBAN, 2)
      READ(MX,601)(AODS(I),AHDS(I),I=1,NBAN)
C READ GEOMETRY OF BICOL DEEPENING SECTIONS
       READ(MX,601)(EE1(I),EE2(I),EE3(I),EE4(I),EE1(I+1),EE2(I+1),EE3(I+
     11),EE4(I+1),I=1,4,2)
       READ(MX,601)(TT1(I),TT2(I),TT3(I),TT4(I),TT1(I+1),TT2(I+1),TT3(I+
     11),TT4(I+1),I=1,4,2)
       READ(MX,601)(AAO(I),AAH(I),I=1,4)
       READ(MX,601)(EEUS1(I),EEUS2(I),EEUS3(I),EEUS4(I),EEUS1(I+1),EEUS2
     1(I+1),EEUS3(I+1),EEUS4(I+1),I=1,4,2)
       READ(MX,601)(TTUS1(I),TTUS2(I),TTUS3(I),TTUS4(I),TTUS1(I+1),TTUS2
     1(I+1),TTUS3(I+1),TTUS4(I+1),I=1,4,2)
        READ(MX,601)(AAOUS(I),AAHUS(I),I=1,4)
       READ(MX,601)(EEDS1(I),EEDS2(I),EEDS3(I),EEDS4(I),EEDS1(I+1),EEDS2
     1(I+1),EEDS3(I+1),EEDS4(I+1),I=1,4,2)
       READ(MX,601)(TTDS1(I),TTDS2(I),TTDS3(I),TTDS4(I),TTDS1(I+1),TTDS2
     1(I+1),TTDS3(I+1),TTDS4(I+1),I=1,4,2)
       READ(MX,601)(AAODS(I),AAHDS(I),I=1,4)
      IF(CODEXC)333,333,334
C  EQUIVALENT DEEPENING PROCESS
  334 DO 335I=1,4
      J=I+18
      E1(J)=EE1(I)
      E2(J)=EE2(I)
      E3(J)=EE3(I)
      E4(J)=EE4(I)
      AO(J)=AAO(I)
      AH(J)=AAH(I)
```

```
      T1(J)=TT1(I)
      T2(J)=TT2(I)
      T3(J)=TT3(I)
      T4(J)=TT4(I)
      TUS1(J)=TTUS1(I)
      TUS2(J)=TTUS2(I)
      TUS3(J)=TTUS3(I)
      TUS4(J)=TTUS4(I)
      TDS1(J)=TTDS1(I)
      TDS2(J)=TTDS2(I)
      TDS3(J)=TTDS3(I)
      TDS4(J)=TTDS4(I)
      EUS1(J)=EEUS1(I)
      EUS2(J)=EEUS2(I)
      EUS3(J)=EEUS3(I)
      EUS4(J)=EEUS4(I)
      EDS1(J)=EEDS1(I)
      EDS2(J)=EEDS2(I)
      EDS3(J)=EEDS3(I)
      EDS4(J)=EEDS4(I)
      AOUS(J)=AAOUS(I)
      AHUS(J)=AAHUS(I)
      AODS(J)=AAODS(I)
      AHDS(J)=AAHDS(I)
  335 CONTINUE
  333  READ(MX,604)(EY1(I),EY2(I),EY3(I), EY1(I+1),EY2(I+1),EY3(I+1), I=
     $ 1, NBAN, 2)
       READ(MX,604)(TY1(I),TY2(I),TY3(I), TY1(I+1),TY2(I+1),TY3(I+1), I=
     $ 1, NBAN, 2)
       READ(MX,604)(EYUS1(I),EYUS2(I),EYUS3(I), EYUS1(I+1),EYUS2(I+1),EY
     $ US3(I+1), I=1, NBAN, 2)
       READ(MX,604)(TYUS1(I),TYUS2(I),TYUS3(I), TYUS1(I+1),TYUS2(I+1),TY
     $ US3(I+1), I=1, NBAN, 2)
       READ(MX,604)(EYDS1(I),EYDS2(I),EYDS3(I), EYDS1(I+1),EYDS2(I+1),EY
     $ DS3(I+1), I=1, NBAN, 2)
       READ(MX,604)(TYDS1(I),TYDS2(I),TYDS3(I), TYDS1(I+1),TYDS2(I+1),TY
     $ DS3(I+1), I=1, NBAN, 2)
       READ(MX,604)(EX1(I),EX2(I),EX3(I), EX1(I+1),EX2(I+1),EX3(I+1), I=
     $ 1, NBAN, 2)
       READ(MX,604)(TX1(I),TX2(I),TX3(I), TX1(I+1),TX2(I+1),TX3(I+1), I=
     $ 1, NBAN, 2)
       READ(MX,604)(EXUS1(I),EXUS2(I),EXUS3(I), EXUS1(I+1),EXUS2(I+1),EX
     $ US3(I+1), I=1, NBAN, 2)
       READ(MX,604)(TXUS1(I),TXUS2(I),TXUS3(I), TXUS1(I+1),TXUS2(I+1),TX
     $ US3(I+1), I=1, NBAN, 2)
       READ(MX,604)(EXDS1(I),EXDS2(I),EXDS3(I), EXDS1(I+1),EXDS2(I+1),EX
     $ DS3(I+1), I=1, NBAN, 2)
       READ(MX,604)(TXDS1(I),TXDS2(I),TXDS3(I), TXDS1(I+1),TXDS2(I+1),TX
     $ DS3(I+1), I=1, NBAN, 2)
C READ LAKE SURFACE AREA
      READ(MX,603)(EBAT(I),SFBAT(I),I=1,M)
      READ(MX,603)(EBAO(I),SFBAO(I),I=1,NN)
      READ(MX,603)(EPOL(I),SFPOL(I),I=1,L)
C GENERATE HYDROLOGIC NODE INPUTS
      CALL DESNIN(QQQ)
      DO 571I=1,NNODE
```

```
  571 QL(I,1)=QWQ(I,NMK)
  572 Q(1,1)=QL(1,1)
      Q(2,1)=Q(1,1)+QL(2,1)
      Q(3,1)=Q(2,1)+QL(3,1)
      Q(4,1)=(Q(3,1)+QL(4,1))-(Q(3,1)+QL(4,1))*CODSIP*0,20 -1,*(1,-CODSI
     1P)
      Q(5,1)=Q(4,1)+QL(5,1)
      Q(6,1)=Q(5,1)+QL(6,1)
      Q(7,1)=(Q(6,1)+QL(7,1))/2,
      Q(8,1)=Q(7,1)
      Q(24,1)=QL(22,1)
      Q(23,1)=Q(24,1)+QL(21,1)
      Q(22,1)=Q(23,1)+QL(20,1)
       Q(21,1)=Q(22,1)+QL(19,1)
      Q(20,1)=Q(21,1)+QL(18,1)
      Q(19,1)=Q(20,1)+QL(17,1)
      Q(18,1)=Q(19,1)+QL(16,1)
      Q(17,1)=(Q(18,1)+QL(15,1))-(Q(18,1)+QL(15,1))*CODPAS*0,20-1,*(1,-
     1CODPAS)
      Q(16,1)=Q(17,1)+QL(14,1)
      Q(15,1)=Q(16,1)+QL(13,1)
      Q(14,1)=(Q (15,1)+QL(12,1))-(Q(15,1)+QL(12,1))*CODCUT*0,5-1,*(1,-
     1CODCUT)
      Q(25,1)=(Q(15,1)+QL(12,1))*CODCUT*0,5 +1,0
      Q(13,1)=Q(14,1)+QL(11,1)
      Q(12,1)=(Q(13,1)+Q(25,1)+QL(10,1))/2,
      Q(11,1)=Q(12,1)
      Q(10,1)=(Q(11,1)+QL(12,1)+QL(9,1))/2,
      Q(9,1)=Q(10,1)
      Q(26,1)=(Q(18,1)+QL(15,1))*CODPAS*0,20+1,0
      Q(27,1)=Q(26,1)+QL(23,1)
      Q(28,1)=Q(27,1)+QL(24,1)
      Q(29,1)=Q(28,1)+QL(25,1)
      Q(30,1)=Q(29,1)+QL(26,1)
      Q(31,1)=(Q(3,1)+QL(4,1))*CODSIP*0,20 +1,0
      Q(32,1)=Q(31,1)+QL(28,1)
      Q(33,1)=Q(32,1)+QL(29,1)
      Q(34,1)=Q(7,1)+Q(8,1)+Q(9,1)+Q(10,1)+QL(8,1)
      QBOL(1)=Q(34,1)+QL(31,1)
      QBCN(1)=Q(33,1)+QL(30,1)
      QPAS(1)=Q(30,1)+QL(27,1)
  573 RETURN
      END
```

```
  INPUT2                                          12/30/74        ED

                                  IDENT     INPUT2
PROGRAM LENGTH                 02305

ENTRY POINTS
        INPUT2    00034

BLOCK NAMES
                  46451

EXTERNAL SYMBOLS
        THEND,          DBODICT,        DESNIN          TSH,            QNSINGL,
   00623 SYMBOLS
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```
      SUBROUTINE RITIN2
      COMMON N,G,U,C(90),P(8100),MX,MY,NNODE,NBAN,M,NN,NTIME,NDAY,CODPOL
      COMMON DELX(50),DELXX(50),DELXY(50),ALFAX(50),ALFAY(50),L,IS
      COMMON Q(50,2),H(50,2),QL(50,2),DQL(50),SUMQ(50),NMK
      COMMON ZI(50),NLIM,IDATE,IHOUR,IMIN,IDELT,DELT,ZET(50)
      COMMON A(50),AM(50),AH(50),AO(50),AX(50),AY(50),AXY,AOC,AHC,AOUS(5
     10),AHUS(50),AMC,AMUS(50),AXUS(50),AYUS(50),AUS(50),AODS(50),AHDS(5
     20),AMDS(50),AXDS(50),AYDS(50),ADS(50),F(50),SFBAO(50),SFBAT(50),SF
     3BOL(50)
      COMMON HUD(50),HUS(50),HDS(50),HC
      COMMON ENX(50),ENM(50),ENY(50),EKX(50),EKM(50),EKY(50),EM(50),EKXU
     1S(50),EKMUS(50),EKYUS(50),EKXDS(50),EKMDS(50),EKYDS(50),ENXY,EKXY,
     2SUMK(50),ENMC,EKMC,EMUS(50),EMDS(50)
      COMMON EX(50),EY(50),E1(50),E2(50),E3(50),E4(50),EY1(50),EY2(50),E
     1Y3(50),EX1(50),EX2(50),EX3(50),EBAT(50),EBAO(50),EXUS1(50),EXUS2(5
     20),EXUS3(50),EYUS1(50),EYUS2(50),EYUS3(50),EUS1(50),EUS2(50),EUS3
     3(50),EUS4(50),EXDS1(50),EXDS2(50),EXDS3(50),EYDS1(50),EYDS2(50),EY
     4DS3(50),EDS1(50),EDS2(50),EDS3(50),EDS4(50),EC1,EC2,EC3,EC4,EXY,EX
     5Y1,EXY2,EXY3,EXUS(50),EYUS(50),EXDS(50),EYDS(50),EPOL(50)
      COMMON T(50),T1(50),T2(50),T3(50),T4(50),TX1(50),TX2(50),TX3(50),T
     1Y1(50),TY2(50),TY3(50),TX(50),TY(50),TM(50),TUS1(50),TUS2(50),TUS3
     2(50),TUS4(50),TC1,TC2,TC3,TC4,TXY1,TXY2,TXY3,TXUS1(50),TXUS2(50),T
     3XUS3(50),TYUS1(50),TYUS2(50),TYUS3(50),TXDS1(50),TXDS2(50),TXDS3(5
     40),TYDS1(50),TYDS2(50),TYDS3(50),TXY,TUS(50),TDS(50),TDS1(50),TDS2
     5(50),TDS3(50),TDS4(50),TMUS(50),TXUS(50),TYUS(50),TMDS(50)
      COMMON TXDS(50),TYDS(50),TMC
      COMMON RX(50),RY(50),RM(50),RMUS(50),RMDS(50),RMC,RXUS(50),RYUS(50
     1),RXDS(50),RYDS(50),RXY
      COMMON DIFFH(50),DIFFA(50),DIFFM(50)
      COMMON QX(50),QM(50),QY(50),CODSIP,CODPAS,CODCUT,CODWID,CODEXT
      COMMON QBCN(2),QBOL(2),QPAS(2),QOL(31,61),QUQ(31,61),CODEXC
      COMMON    EE1(4),EE2(4),EE3(4),EE4(4),AAO(4),AAH(4),TT1(4),TT2(4),
     1TT3(4),TT4(4),TTUS1(4),TTUS2(4),TTUS3(4),TTUS4(4),TTDS1(4),TTDS2(4
     2),TTDS3(4),TTDS4(4),EEUS1(4),EEUS2(4),EEUS3(4),EEUS4(4),EEDS1(4),E
     3EDS2(4),EEDS3(4),EEDS4(4),AAOUS(4),AAHUS(4),AAODS(4),AAHDS(4)
C RITIN2--PROGRAM TO WRITE NUMBER OF NODES AND BRANCH IN LIBMANAN AND BICOL
C RIVERS,DISTANCE INTERVALS,ROUGHNESS COEFFICIENTS,GEOMETRY OF MAIN CHANNELS AND
CTHEIR FLOOD PLAINS,GEOMETRY OF PROPOSED EXCAVATED SECTIONS,GEOMETRY OF CUT OFFS
CAND DIVERSIONS,GEOMETRY OF LAKEBATO,LAKE BAAO AND POLUNTUNA RESERVOIR,
  600 FORMAT(1X,3I5)
  601 FORMAT(1X,8F9.3)
  602 FORMAT(1X,9F7.4)
  603 FORMAT(4(F6.2,E14.7))
  604 FORMAT(1X, 6F9.3)
  609 FORMAT(1H1)
  679 FORMAT(10F8.3)
  800 FORMAT(20X,*INITIAL CONDITIONS*)
  801 FORMAT(20X,*BOUNDARY CONDITIONS*)
  802 FORMAT(20X,*LATERAL BOUNDARY CONDITIONS*)
  803 FORMAT(20X,*MANNING COEFFICIENT*)
  804 FORMAT(20X,*LIBMANAN--BICOL RIVERS GEOMETRY*)
  805 FORMAT(20X,*CONTROL VALUES*)
      WRITE(MY,805)
      WRITE(MY,600)NBAN,NNODE,NDAY
      WRITE(MY,600)M,NN,L
      WRITE(MY,600)IDATE,IHOUR,IMIN
```

```
      WRITE(MY,600)IDELT
      WRITE(MY,800)
      WRITE(MY,601)(Q(I,1),I=1,NBAN)
      WRITE(MY,601)(H(I,1),I=1,NNODE)
      WRITE(MY,679) QBCN(1), QBOL(1), QPAS(1)
      WRITE(MY,601)(QL(I,1),I=1,NNODE)
      WRITE(MY,803)
      WRITE(MY,602)(ENX(I),ENM(I),ENY(I),I=1,NBAN)
      WRITE(MY,804)
      WRITE(MY,601)(DELX(I),I=1,NBAN)
      WRITE(MY,601)(DELXX(I),I=1,NBAN)
      WRITE(MY,601)(DELXY(I),I=1,NBAN)
      WRITE(MY,601)(EX(I),EY(I),I=1,NBAN)
      WRITE(MY,601)(EXUS(I),EYUS(I),I=1,NBAN)
      WRITE(MY,601)(EXDS(I),EYDS(I),I=1,NBAN)
      WRITE(MY,601) (E1(I),E2(I),E3(I),E4(I), E1(I+1),E2 (I+1),E3(I+1),
     $ E4(I+1),I= 1, NBAN, 2)
      WRITE(MY,601)(T1(I),T2(I),T3(I),T4(I), T1(I+1),T2(I+1),T3(I+1),T4(
     $I+1), I= 1, NBAN, 2)
      WRITE(MY,601)(AO(I),AH(I),I=1,NBAN)
      WRITE(MY,601)(EUS1(I),EUS2(I),EUS3(I),EUS4(I), EUS1(I+1),EUS2(I+1)
     $, EUS3(I+1), EUS4(I+1), I=1, NBAN, 2)
      WRITE(MY,601)(TUS1(I),TUS2(I),TUS3(I),TUS4(I), TUS1(I+1),TUS2(I+1)
     $, TUS3(I+1), TUS4(I+1), I= 1, NBAN, 2)
      WRITE(MY,601)(AOUS(I),AHUS(I),I=1,NBAN)
      WRITE(MY,601)(EDS1(I),EDS2(I),EDS3(I),EDS4(I), EDS1(I+1),EDS2(I+1)
     $, EDS3(I+1), EDS4(I+1), I=1, NBAN, 2)
      WRITE(MY,601)(TDS1(I),TDS2(I),TDS3(I),TDS4(I), TDS1(I+1),TDS2(I+1)
     $, TDS3(I+1), TDS4(I+1), I= 1, NBAN, 2)
      WRITE(MY,601)(AODS(I),AHDS(I),I=1,NBAN)
      WRITE(MY,601)(EE1(I),EE2(I),EE3(I),EE4(I),EE1(I+1),EE2(I+1),EE3(I+
     11),EE4(I+1),I=1,4,2)
      WRITE(MY,601)(TT1(I),TT2(I),TT3(I),TT4(I),TT1(I+1),TT2(I+1),TT3(I+
     11),TT4(I+1),I=1,4,2)
      WRITE(MY,601)(AAO(I),AAH(I),I=1,4)
      WRITE(MY,601)(EEUS1(I),EEUS2(I),EEUS3(I),EEUS4(I),EEUS1(I+1),EEUS2
     1(I+1),EEUS3(I+1),EEUS4(I+1),I=1,4,2)
      WRITE(MY,601)(TTUS1(I),TTUS2(I),TTUS3(I),TTUS4(I),TTUS1(I+1),TTUS2
     1(I+1),TTUS3(I+1),TTUS4(I+1),I=1,4,2)
      WRITE (MY,601)(AAOUS(I),AAHUS(I),I=1,4)
      WRITE(MY,601)(EEDS1(I),EEDS2(I),EEDS3(I),EEDS4(I),EEDS1(I+1),EEDS2
     1(I+1),EEDS3(I+1),EEDS4(I+1),I=1,4,2)
      WRITE(MY,601)(TTDS1(I),TTDS2(I),TTDS3(I),TTDS4(I),TTDS1(I+1),TTDS2
     1(I+1),TTDS3(I+1),TTDS4(I+1),I=1,4,2)
      WRITE(MY,601)(AAODS(I),AAHDS(I),I=1,4)
      WRITE(MY,604)(EY1(I),EY2(I),EY3(I), EY1(I+1),EY2(I+1),EY3(I+1), I=
     $ 1, NBAN, 2)
      WRITE(MY,604)(TY1(I),TY2(I),TY3(I), TY1(I+1),TY2(I+1),TY3(I+1), I=
     $ 1, NBAN, 2)
      WRITE(MY,604)(EYUS1(I),EYUS2(I),EYUS3(I), EYUS1(I+1),EYUS2(I+1),EY
     $ US3(I+1), I=1, NBAN, 2)
      WRITE(MY,604)(TYUS1(I),TYUS2(I),TYUS3(I), TYUS1(I+1),TYUS2(I+1),TY
     $ US3(I+1), I=1, NBAN, 2)
      WRITE(MY,604)(EYDS1(I),EYDS2(I),EYDS3(I), EYDS1(I+1),EYDS2(I+1),EY
     $ DS3(I+1), I=1, NBAN, 2)
      WRITE(MY,604)(TYDS1(I),TYDS2(I),TYDS3(I), TYDS1(I+1),TYDS2(I+1),TY
```

```
$ DS3(I+1), I=1, NBAN, 2)
 WRITE(MY,604)(EX1(I),EX2(I),EX3(I), EX1(I+1),EX2(I+1),EX3(I+1), I=
$ 1, NBAN, 2)
 WRITE(MY,604)(TX1(I),TX2(I),TX3(I), TX1(I+1),TX2(I+1),TX3(I+1), I=
$ 1, NBAN, 2)
 WRITE(MY,604)(EXUS1(I),EXUS2(I),EXUS3(I), EXUS1(I+1),EXUS2(I+1),EX
$ US3(I+1), I=1, NBAN, 2)
 WRITE(MY,604)(TXUS1(I),TXUS2(I),TXUS3(I), TXUS1(I+1),TXUS2(I+1),TX
$ US3(I+1), I=1, NBAN, 2)
 WRITE(MY,604)(EXDS1(I),EXDS2(I),EXDS3(I), EXDS1(I+1),EXDS2(I+1),EX
$ DS3(I+1), I=1, NBAN, 2)
 WRITE(MY,604)(TXDS1(I),TXDS2(I),TXDS3(I), TXDS1(I+1),TXDS2(I+1),TX
$ DS3(I+1), I=1, NBAN, 2)
 WRITE(MY,603)(EBAT(I),SFBAT(I),I=1,M)
 WRITE(MY,603)(EBAD(I),SFBAD(I),I=1,NN)
 WRITE(MY,603)(EPOL(I),SFPOL(I),I=1,L)
 RETURN
 END
```

```
4; S    RITIN2                                                    12/30/74        ED

                                    IDENT     RITIN2
   PROGRAM LENGTH                 01723

   ENTRY POINTS
          RITIN2    00113

   BLOCK NAMES
                     46451

   EXTERNAL SYMBOLS
          THEND,            08QDICT,          STH,              QNSINGL,
      00615 SYMBOLS
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```
      SUBROUTINE SQ2
      COMMON N,G,U,C(90),P(8100),MX,MY,NNODE,NBAN,M,NN,NTIME,NDAY,CODPOL
      COMMON DELX(50),DELXX(50),DELXY(50),ALFAX(50),ALFAY(50),L,IB
      COMMON Q(50,2),H(50,2),QL(50,2),DQL(50),SUMQ(50),NMK
      COMMON ZI(50),NLIM,IDATE,IHOUR,IMIN,IDELT,DELT,ZET(50)
      COMMON A(50),AM(50),AH(50),AO(50),AX(50),AY(50),AXY,AOC,AHC,AOUS(5
     10),AHUS(50),AMC,AMUS(50),AXUS(50),AYUS(50),AUS(50),AODS(50),AHDS(5
     20),AMDS(50),AXDS(50),AYDS(50),ADS(50),F(50),SFBAO(50),SFBAT(50),SF
     3POL(50)
      COMMON HUD(50),HUS(50),HDS(50),HC
      COMMON ENX(50),ENM(50),ENY(50),EKX(50),EKM(50),EKY(50),EM(50),EKXU
     1S(50),EKMUS(50),EKYUS(50),EKXDS(50),EKMDS(50),EKYDS(50),ENXY,EKXY,
     2SUMK(50),ENMC,EKMC,EMUS(50),EMDS(50)
      COMMON EX(50),EY(50),E1(50),E2(50),E3(50),E4(50),EY1(50),EY2(50),E
     1Y3(50),EX1(50),EX2(50),EX3(50),EBAT(50),EBAO(50),EXUS1(50),EXUS2(5
     20),EXUS3(50),EYUS1(50),EYUS2(50),EYUS3(50),EUS1(50),EUS2(50),EUS3
     3(50),EUS4(50),EXDS1(50),EXDS2(50),EXDS3(50),EYDS1(50),EYDS2(50),EY
     4DS3(50),EDS1(50),EDS2(50),EDS3(50),EDS4(50),EC1,EC2,EC3,EC4,EXY,EX
     5Y1,EXY2,EXY3,EXUS(50),EYUS(50),EXDS(50),EYDS(50),EPOL(50)
      COMMON T(50),T1(50),T2(50),T3(50),T4(50),TX1(50),TX2(50),TX3(50),T
     1Y1(50),TY2(50),TY3(50),TX(50),TY(50),TM(50),TUS1(50),TUS2(50),TUS3
     2(50),TUS4(50),TC1,TC2,TC3,TC4,TXY1,TXY2,TXY3,TXUS1(50),TXUS2(50),T
     3XUS3(50),TYUS1(50),TYUS2(50),TYUS3(50),TXDS1(50),TXDS2(50),TXDS3(5
     40),TYDS1(50),TYDS2(50),TYDS3(50),TXY,TUS(50),TDS(50),TDS1(50),TDS2
     5(50),TDS3(50),TDS4(50),TMUS(50),TXUS(50),TYUS(50),TMDS(50)
      COMMON TXDS(50),TYDS(50),TMC
      COMMON RX(50),RY(50),RM(50),RMUS(50),RMDS(50),RMC,RXUS(50),RYUS(50
     1),RXDS(50),RYDS(50),RXY
      COMMON DIFFH(50),DIFFA(50),DIFFM(50)
      COMMON QX(50),QM(50),QY(50),CODSIP,CODPAS,CODCUT,CODWIU,CODEXT
      COMMON QBCN(2),QBOL(2),QPAS(2),QQL(31,61),QQR(31,61),CODEXC
      COMMON    EE1(4),EE2(4),EE3(4),EE4(4),AAO(4),AAH(4),TT1(4),TT2(4),
     1TT3(4),TT4(4),TTUS1(4),TTUS2(4),TTUS3(4),TTUS4(4),TTDS1(4),TTDS2(4
     2),TTDS3(4),TTDS4(4),EEUS1(4),EEUS2(4),EEUS3(4),EEUS4(4),EEDS1(4),E
     3EDS2(4),EEDS3(4),EEDS4(4),AAOUS(4),AAHUS(4),AAODS(4),AAHDS(4)
C SQ2 PROGRAM TO COMPUTE SUMMATIONS OF DISCHARGES AT THE UPSTREAM AND DOWNSTRE
C ENDS OF THE BRANCHES
    1 SUMQ(1)=(-U*Q(1,1)+QL(1,1))/F(1)+(U*Q(1,1)+QL(2,1)-Q(2,1))/F(2)
      SUMQ(2)=(Q(1,1)+QL(2,1)- U*Q(2,1))/F(2)+(U*Q(2,1)-Q(3,1)          +Q
     1L(3,1)          )/F(3)
      SUMQ(3)=(Q(2,1) +QL(3,1)                  -U*Q(3,1))/F(3)+(U*Q(3,1)-Q
     1(4,1)+QL(4,1)-Q(31,1))/F(4)
      SUMQ(4)=(Q(3,1)+QL(4,1)-Q(31,1)-U*Q(4,1))/F(4)+(U*Q(4,1)+QL(5,1)-Q
     1(5,1))/F(5)
      SUMQ(5)=(Q(4,1)+QL(5,1)-U*Q(5,1))/F(5)+(U*Q(5,1)+QL(6,1)-Q(6,1)
     1     )/F(6)
      SUMQ(6)=(Q(5,1)+QL(6,1)-U*Q(6,1)          )/F(6)+(U*Q(6,1)-Q(7,1)-Q(8
     1,1)+QL(7,1))/F(7)
      SUMQ(7)=(Q(6,1)-Q(8,1)+QL(7,1)-U*Q(7,1))/F(7)+(U*Q(7,1)+Q(8,1)+QL(
     18,1)+Q(10,1)+Q(9,1)-Q(34,1))/F(8)
      SUMQ(8)=(Q(6,1)-Q(7,1)+QL(7,1)-U*Q(8,1))/F(7)+(U*Q(8,1)+Q(7,1)+QL(
     18,1)+Q(10,1)+Q(9,1)-Q(34,1))/F(8)
      SUMQ(9)=(Q(11,1)+Q(12,1)-Q(10,1)-U*Q(9,1)+QL(9,1))/F(9)+(U*Q(9,1)+
     1Q(10,1)+Q(8,1)+QL(8,1)+Q(7,1)-Q(34,1))/F(8)
      SUMQ(10)=(Q(11,1)+Q(12,1)-Q(9,1)+QL(9,1)-U*Q(10,1))/F(9)+(U*Q(10,1
     1)+Q(9,1)+Q(8,1)+Q(7,1)+QL(8,1)-Q(34,1))/F(8)
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```
 SUMQ(11)=(Q(25,1)+Q(13,1)-Q(12,1)+QL(10,1)-U*Q(11,1))/F(10)+(U*Q(
1    11,1)+Q(12,1)+QL(9,1)-Q(9,1)-Q(10,1))/F(9)
 SUMQ(12)=(Q(25,1)+Q(13,1)-Q(11,1)+QL(10,1)-U*Q(12,1))/F(10)+(U*Q(
1    12,1)-Q(10,1)+QL(9,1)-Q(9,1)+Q(11,1))/F(9)
 SUMQ(13)=(Q(14,1)          +QL(11,1)-U*Q(13,1))/F(11)+(U*Q(13,1)+Q(2
15,1)-Q(11,1)-Q(12,1)+QL(10,1))/F(10)
 SUMQ(14)=(-Q(25,1)+Q(15,1)+QL(12,1)-U*Q(14,1))/F(12)+(U*Q(14,1)+QL
1    (11,1)          -Q(13,1))/F(11)
 SUMQ(15)=(Q(16,1)+QL(13,1)-U*Q(15,1))/F(13)+(U*Q(15,1)-Q(25,1)+QL(
112,1)-Q(14,1))/F(12)
 SUMQ(16)=(Q(17,1)+QL(14,1)-U*Q(16,1))/F(14)+(U*Q(16,1)+QL(13,1)-Q(
115,1))/F(13)
 SUMQ(17)=(Q(18,1)+QL(15,1)-Q(26,1)-U*Q(17,1))/F(15)+(U*Q(17,1)+QL(
114,1)-Q(16,1))/F(14)
 SUMQ(18)=(Q(19,1)+QL(16,1)-U*Q(18,1))/F(16)+(U*Q(18,1)+QL(15,1)-Q(
126,1)-Q(17,1))/F(15)
 SUMQ(19)=(Q(20,1)                          +QL(17,1)-U*Q(19,1))/F(17)+(U*Q(
119,1)+QL(16,1)-Q(18,1))/F(16)
 SUMQ(20)=(Q(21,1)+QL(18,1)-U*Q(20,1))/F(18)+(U*Q(20,1)
1       +QL(17,1)-Q(19,1))/F(17)
 SUMQ(21)=(Q(22,1)          +QL(19,1)-U*Q(21,1))/F(19)+(U*Q(21,1)+QL
1(18,1)-Q(20,1))/F(18)
 SUMQ(22)=(Q(23,1)+QL(20,1)-U*Q(22,1))/F(20)+(U*Q(22,1)          +QL
1(19,1)-Q(21,1))/F(19)
 SUMQ(23)=(Q(24,1)+QL(21,1)-U*Q(23,1))/F(21)+(U*Q(23,1)-Q(22,1)+QL(
120,1))/F(20)
 SUMQ(24)=(         +QL(22,1)-U*Q(24,1))/F(22)+(U*Q(24,1)+QL(21,1)-Q(
123,1))/F(21)
 SUMQ(25)=(Q(15,1)+QL(12,1)-Q(14,1)-U*Q(25,1))/F(12)+(U*Q(25,1)+Q(
1    13,1)+QL(10,1)-Q(11,1)-Q(12,1))/F(10)
 SUMQ(26)=(Q(18,1)+QL(15,1)-Q(17,1)-U*Q(26,1))/F(15)+(U*Q(26,1)+QL(
123,1)-Q(27,1))/F(23)
 SUMQ(27)=(Q(26,1)+QL(23,1)-U*Q(27,1))/F(23)+(U*Q(27,1)+QL(24,1)-Q(
128,1))/F(24)
 SUMQ(28)=(Q(27,1)+QL(24,1)-U*Q(28,1))/F(24)+(U*Q(28,1)+QL(25,1)-Q(
129,1))/F(25)
 SUMQ(29)=(Q(28,1)+QL(25,1)-U*Q(29,1))/F(25)+(U*Q(29,1)+QL(26,1)-Q(
130,1))/F(26)
 SUMQ(30)=(Q(29,1)+QL(26,1)-U*Q(30,1))/F(26)+(U*Q(30,1)+QL(27,1)-QP
1AS(1))/F(27)
 SUMQ(31)=(Q(3,1)+QL(4,1)-Q(4,1)-U*Q(31,1))/F(4)+(U*Q(31,1)+QL(28,1
1)-Q(32,1))/F(28)
 SUMQ(32)=(Q(31,1)+QL(28,1)-U*Q(32,1))/F(28)+(U*Q(32,1)+QL(29,1)-Q(
133,1))/F(29)
 SUMQ(33)=(Q(32,1)+QL(29,1)-U*Q(33,1))/F(29)+(U*Q(33,1)+QL(30,1)-QB
1CN(1))/F(30)
 SUMQ(34)=(Q(7,1)+Q(8,1)+Q(10,1)+Q(9,1)+QL(8,1)-U*Q(34,1))/F(8)+(U*
1Q(34,1)+QL(31,1)-QBOL(1))/F(31)
 RETURN
 END
```

```
                                    IDENT     SQ2
PROGRAM LENGTH                 00501

ENTRY POINTS
        SQ2        00003

BLOCK NAMES
                   46451

EXTERNAL SYMBOLS
        QBQDICT,
    00372 SYMBOLS
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```
      SUBROUTINE SURF2
      COMMON N,G,U,C(90),P(8100),MX,MY,NNODE,NBAN,M,NN,NTIME,NDAY,CODPOL
      COMMON DELX(50),DELXX(50),DELXY(50),ALFAX(50),ALFAY(50),L,IB
      COMMON Q(50,2),H(50,2),QL(50,2),DQL(50),SUMQ(50),NMK
      COMMON ZI(50),QLIM,IDATE,IHOUR,IMIN,IDELT,DELT,ZET(50)
      COMMON A(50),AM(50),AH(50),AO(50),AX(50),AY(50),AXY,AOC,AHC,AOUS(5
     10),AHUS(50),AMC,AMUS(50),AXUS(50),AYUS(50),AUS(50),AODS(50),AHDS(5
     20),AMDS(50),AXDS(50),AYDS(50),ADS(50),F(50),SFBAO(50),SFBAT(50),SF
     3POL(50)
      COMMON HOO(50),HUS(50),HDS(50),HC
      COMMON ENX(50),ENM(50),ENY(50),EKX(50),EKM(50),EKY(50),EM(50),EKXU
     1S(50),EKMUS(50),EKYUS(50),EKXDS(50),EKMDS(50),EKYDS(50),ENXY,EKXY,
     2SUMK(50),ENMC,EKMC,EMUS(50),ENDS(50)
      COMMON EX(50),EY(50),E1(50),E2(50),E3(50),E4(50),EY1(50),EY2(50),E
     1Y3(50),EX1(50),EX2(50),EX3(50),EBAT(50),EBAO(50),EXUS1(50),EXUS2(5
     20),EXUS3(50),EYUS1(50),EYUS2(50),EYUS3(50),EUS1(50),EUS2(50),EUS3
     3(50),EUS4(50),EXDS1(50),EXDS2(50),EXDS3(50),EYDS1(50),EYDS2(50),EY
     4DS3(50),EDS1(50),EDS2(50),EDS3(50),EDS4(50),EC1,EC2,EC3,EC4,EXY,EX
     5Y1,EXY2,EXY3,EXUS(50),EYUS(50),EXDS(50),EYDS(50),EPOL(50)
      COMMON T(50),T1(50),T2(50),T3(50),T4(50),TX1(50),TX2(50),TX3(50),T
     1Y1(50),TY2(50),TY3(50),TX(50),TY(50),TM(50),TUS1(50),TUS2(50),TUS3
     2(50),TUS4(50),TC1,TC2,TC3,TC4,TXY1,TXY2,TXY3,TXUS1(50),TXUS2(50),T
     3XUS3(50),TYUS1(50),TYUS2(50),TYUS3(50),TXDS1(50),TXDS2(50),TXDS3(5
     40),TYDS1(50),TYDS2(50),TYDS3(50),TXY,TUS(50),TDS(50),TDS1(50),TDS2
     5(50),TDS3(50),TDS4(50),TMUS(50),TXUS(50),TYUS(50),TMDS(50)
      COMMON TXDS(50),TYDS(50),TMC
      COMMON RX(50),RY(50),RM(50),RMUS(50),RMDS(50),RMC,RXUS(50),RYUS(50
     1),RXDS(50),RYDS(50),RXY
      COMMON DIFFH(50),DIFFA(50),DIFFM(50)
      COMMON QX(50),QM(50),QY(50),CODSIP,CODPAS,CODCUT,CODWID,CODEXT
      COMMON QBCN(2),QBOL(2),QPAS(2),QCL(31,61),QQQ(31,61),CODEXC
      COMMON    EE1(4),EE2(4),EE3(4),EE4(4),AAO(4),AAH(4),TT1(4),TT2(4),
     1TT3(4),TT4(4),TTUS1(4),TTUS2(4),TTUS3(4),TTUS4(4),TTDS1(4),TTDS2(4
     2),TTDS3(4),TTDS4(4),EEUS1(4),EEUS2(4),EEUS3(4),EEUS4(4),EEDS1(4),E
     3EDS2(4),EEDS3(4),EEDS4(4),AACUS(4),AAHUS(4),AAODS(4),AAHDS(4)
C SURF2 PROGRAM TO COMPUTE SURFACE AREA OF EACH NODE INCLUDING LAKE OR RESERVO
C SURFACE AREAS
      DO 85I=1,L
      IF(H(1,1)-EPOL(I))86,86,85
   86 ADPOL=SFPOL(I-1)+(SFPOL(I)-SFPOL(I-1))*(H(1,1)-EPOL(I-1))/(EPOL(I)
     1-EPOL(I-1))
      GO TO 87
   85 CONTINUE
   87 F(1)=T(1)*DELX(1)/2.+ADPOL*CODPOL
      DO 77I=2,6
   77 F(I)=T(I-1)*DELX(I-1)/2.+T(I)*DELX(I)/2.
      F(7)=T(6)*DELX(6)/2.+T(7)*DELX(7)/2.+T(8)*DELX(8)/2.
      F(8)=T(7)*DELX(7)/2.+T(8)*DELX(8)/2.+T(9)*DELX(9)/2.+T(10)*DELX(10
     1)/2.+T(34)*DELX(34)/2.
      F(9)=T(9)*DELX(9)/2.+T(10)*DELX(10)/2.+T(11)*DELX(11)/2.+T(12)*DEL
     1X(12)/2.
      F(10)=T(11)*DELX(11)/2.+T(12)*DELX(12)/2.+T(13)*DELX(13)/2.+
     1 T(25)*DELX(25)/2.*CODCUT
      DO 78I=11,21
   78 F(I)=T(I+2)*DELX(I+2)/2.+T(I+3)*DELX(I+3)/2.
      F(12)=F(12)+DELX(25)*T(25)/2.*CODCUT
```

```
      DO 75I=1,MM
      IF(H(17,1)-EBAD(I))70,70,73
   70 ADBAD=SFBAD(I-1)+(SFBAD(I)-SFBAD(I-1))*(H(17,1)-EBAD(I-1))/(EBAD(I
     1)-EBAD(I-1))
      GO TO 74
   73 CONTINUE
   74 DO 83I=1,M
      IF(H(22,1)-EBAT(I))80,80,83
   80 ADBAT=SFBAT(I-1)+(SFBAT(I)-SFBAT(I-1))*(H(22,1)-EBAT(I-1))/(EBAT(I
     1)-EBAT(I-1))
      GO TO 84
   83 CONTINUE
   84 F(17)=F(17)
      F(22)=T(24)*DELX(24)/2,+ADBAT
      F(4)=T(3)*DELX(3)/2,+T(4)*DELX(4)/2,+T(31)*DELX(31)/2,*CODSIP
      F(15)=T(16)*DELX(16)/2,+T(17)*DELX(17)/2,+T(26)*DELX(26)/2,*CODPAS
      F(23)=(T(26)*DELX(26)/2,+T(27)*DELX(27)/2,)*CODPAS+0,01
      F(24)=(T(27)*DELX(27)/2,+T(28)*DELX(28)/2,)*CODPAS+0,01
      F(25)=(T(28)*DELX(28)/2,+T(29)*DELX(29)/2,)*CODPAS+0,01
      F(26)=(T(29)*DELX(29)/2,+T(30)*DELX(30)/2,)*CODPAS+0,01
      F(27)=(T(30)*DELX(30)/2,)*CODPAS+0,01
      F(28)=(T(31)*DELX(31)/2,+T(32)*DELX(32)/2,)*CODSIP+0,01
      F(29)=(T(32)*DELX(32)/2,+T(33)*DELX(33)/2,)*CODSIP+0,01
      F(30)=T(33)*DELX(33)/2,*CODSIP+0,01
      F(31)=T(34)*DELX(34)/2,
      RETURN
      END
```



```
                                        IDENT     SURF2
PROGRAM LENGTH                 00413

ENTRY POINTS
        SURF2     00000

BLOCK NAMES
                  46451

EXTERNAL SYMBOLS
        PRODICT,
   00420 SYMBOLS
```

```
      SUBROUTINE STAGE2
      COMMON N,G,U,C(90),P(8100),MX,MY,NNODE,NBAN,M,NN,NTIME,NDAY,CODPOL
      COMMON DELX(50),DELXX(50),DELXY(50),ALFAX(50),ALFAY(50),L,IB
      COMMON Q(50,2),H(50,2),QL(50,2),DQL(50),SUMQ(50),NMK
      COMMON ZI(50),NLIM,IDATE,IHOUR,IMIN,IDELT,DELT,ZET(50)
      COMMON A(50),AM(50),AH(50),AO(50),AX(50),AY(50),AXY,AOC,AHC,AOUS(5
     10),AHUS(50),AMC,AMUS(50),AXUS(50),AYUS(50),AUS(50),AODS(50),AHDS(5
     20),AMDS(50),AXDS(50),AYDS(50),ADS(50),F(50),SFBAO(50),SFBAT(50),SE
     3POL(50)
      COMMON HOD(50),HUS(50),HDS(50),HC
      COMMON ENX(50),ENM(50),ENY(50),EKX(50),EKM(50),EKY(50),EM(50),EKXU
     1S(50),EKMUS(50),EKYUS(50),EKXDS(50),EKMDS(50),EKYDS(50),ENXY,EKXY,
     2SUMK(50),ENMC,EKMC,EMUS(50),EMDS(50)
      COMMON EX(50),EY(50),E1(50),E2(50),E3(50),E4(50),EY1(50),EY2(50),E
     1Y3(50),EX1(50),EX2(50),EX3(50),EBAT(50),EBAO(50),EXUS1(50),EXUS2(5
     20),EXUS3(50),EYUS1(50),EYUS2(50),EYUS3(50),EUS1(50),EUS2(50),EUS3
     3(50),EUS4(50),EXDS1(50),EXDS2(50),EXDS3(50),EYDS1(50),EYDS2(50),EY
     4DS3(50),EDS1(50),EDS2(50),EDS3(50),EDS4(50),EC1,EC2,EC3,EC4,EXY,EX
     5Y1,EXY2,EXY3,EXUS(50),EYUS(50),EXDS(50),EYDS(50),EPOL(50)
      COMMON T(50),T1(50),T2(50),T3(50),T4(50),TX1(50),TX2(50),TX3(50),T
     1Y1(50),TY2(50),TY3(50),TX(50),TY(50),TM(50),TUS1(50),TUS2(50),TUS3
     2(50),TUS4(50),TC1,TC2,TC3,TC4,TXY1,TXY2,TXY3,TXUS1(50),TXUS2(50),T
     3XUS3(50),TYUS1(50),TYUS2(50),TYUS3(50),TXDS1(50),TXDS2(50),TXDS3(5
     40),TYDS1(50),TYDS2(50),TYDS3(50),TXY,TUS(50),TDS(50),TDS1(50),TDS2
     5(50),TDS3(50),TDS4(50),TMUS(50),TXUS(50),TYUS(50),TMDS(50)
      COMMON TXDS(50),TYDS(50),TMC
      COMMON RX(50),RY(50),RM(50),RMUS(50),RMDS(50),RMC,RXUS(50),RYUS(50
     1),RXDS(50),RYDS(50),RXY
      COMMON DIFFH(50),DIFFA(50),DIFFM(50)
      COMMON QX(50),QM(50),QY(50),CODSIP,CODPAS,CODCUT,CODWID,CODEXT
      COMMON QBON(2),QBOL(2),QPAS(2),QOL(31,61),QQQ(31,61),CODEXC
      COMMON    EE1(4),EE2(4),EE3(4),EE4(4),AAO(4),AAH(4),TT1(4),TT2(4),
     1TT3(4),TT4(4),TTUS1(4),TTUS2(4),TTUS3(4),TTUS4(4),TTDS1(4),TTDS2(4
     2),TTDS3(4),TTDS4(4),EEUS1(4),EEUS2(4),EEUS3(4),EEUS4(4),EEDS1(4),E
     3EDS2(4),EEDS3(4),EEDS4(4),AAOUS(4),AAHUS(4),AAODS(4),AAHDS(4)
C-STAGE2 PROGRAM TO COMPUTE MEAN STAGE OF EACH BRANCH
      DO 1I=1,7
      HUS(I)=H(I,1)
    1 HDS(I)=H(I+1,1)
      HUS(8)=H(7,1)
      HDS(8)=H(8,1)
      HUS(9)=H(9,1)
      HDS(9)=H(8,1)
      HUS(10)=H(9,1)
      HDS(10)=H(8,1)
      HUS(11)=H(10,1)
      HDS(11)=H(9,1)
      HUS(12)=H(10,1)
      HDS(12)=H(9,1)
      DO2I=13,24
      HUS(I)=H(I-2,1)
    2 HDS(I)=H(I-3,1)
      HUS(25)=H(12,1)
      HDS(25)=H(10,1)
      HUS(26)=H(15,1)
      HDS(26)=H(23,1)
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```
      HUS(27)=H(23,1)
      HDS(27)=H(24,1)
      HUS(28)=H(24,1)
      HDS(28)=H(25,1)
      HUS(29)=H(25,1)
      HDS(29)=H(26,1)
      HUS(30)=H(26,1)
      HDS(30)=H(27,1)
      HUS(31)=H(4,1)
      HDS(31)=H(28,1)
      HUS(32)=H(28,1)
      HDS(32)=H(29,1)
      HUS(33)=H(29,1)
      HDS(33)=H(30,1)
      HUS(34)=H(8,1)
      HDS(34)=H(31,1)
      DO 3I=1,NBAN
    3 HUD(I)=(HUS(I)+HDS(I))/2.
      RETURN
      END
```



```
                                    IDENT     STAGE2
PROGRAM LENGTH                 00106

ENTRY POINTS
        STAGE2    00000

BLOCK NAMES
                  46451

EXTERNAL SYMBOLS
        08DDICT,
   00401 SYMBOLS
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```
      SUBROUTINE DIFH2
      COMMON N,G,U,C(90),P(8100),MX,MY,NNODE,NBAN,M,NN,NTIME,NDAY,CODPOL
      COMMON DELX(50),DELXX(50),DELXY(50),ALFAX(50),ALFAY(50),L,IB
      COMMON Q(50,2),H(50,2),QL(50,2),DQL(50),SUMQ(50),NMK
      COMMON ZI(50),NLIM,IDATE,IHOUR,IMIN,IDELT,DELT,ZER(50)
      COMMON A(50),AM(50),AH(50),AO(50),AX(50),AY(50),AXY,AOC,AHC,AOUS(5
     10),AHUS(50),AMC,AMUS(50),AXUS(50),AYUS(50),AUS(50),AODS(50),AHDS(5
     20),AMDS(50),AXDS(50),AYDS(50),ADS(50),F(50),SFBAO(50),SFBAT(50),SF
     3POL(50)
      COMMON HUD(50),HUS(50),HDS(50),HC
      COMMON ENX(50),ENM(50),ENY(50),EKX(50),EKM(50),EKY(50),EM(50),EKXU
     1S(50),EKMUS(50),EKYUS(50),EKXDS(50),EKMDS(50),EKYDS(50),ENXY,EKXY,
     2SUMK(50),ENMC,EKMC,EMUS(50),EMDS(50)
      COMMON EX(50),EY(50),E1(50),E2(50),E3(50),E4(50),EY1(50),EY2(50),E
     1Y3(50),EX1(50),EX2(50),EX3(50),EBAT(50),EBAO(50),EXUS1(50),EXUS2(5
     20),EXUS3(50),EYUS1(50),EYUS2(50),EYUS3(50),EUS1(50),EUS2(50),EUS3
     3(50),EUS4(50),EXDS1(50),EXDS2(50),EXDS3(50),EYDS1(50),EYDS2(50),EY
     4DS3(50),EDS1(50),EDS2(50),EDS3(50),EDS4(50),EC1,EC2,EC3,EC4,EXY,EX
     5Y1,EXY2,EXY3,EXUS(50),EYUS(50),EXDS(50),EYDS(50),EPOL(50)
      COMMON T(50),T1(50),T2(50),T3(50),T4(50),TX1(50),TX2(50),TX3(50),T
     1Y1(50),TY2(50),TY3(50),TX(50),TY(50),TM(50),TUS1(50),TUS2(50),TUS3
     2(50),TUS4(50),TC1,TC2,TC3,TC4,TXY1,TXY2,TXY3,TXUS1(50),TXUS2(50),T
     3XUS3(50),TYUS1(50),TYUS2(50),TYUS3(50),TXDS1(50),TXDS2(50),TXDS3(5
     40),TYDS1(50),TYDS2(50),TYDS3(50),TXY,TUS(50),TDS(50),TDS1(50),TDS2
     5(50),TDS3(50),TDS4(50),TMUS(50),TXUS(50),TYUS(50),TMDS(50)
      COMMON TXDS(50),TYDS(50),TMC
      COMMON RX(50),RY(50),RM(50),RMUS(50),RMDS(50),RMC,RXUS(50),RYUS(50
     1),RXDS(50),RYDS(50),RXY
      COMMON DIFFH(50),DIFFA(50),DIFFM(50)
      COMMON QX(50),QM(50),QY(50),CODSIP,CODPAS,CODCUT,CODWID,CODEXT
      COMMON QBCN(2),QROL(2),QPAS(2),QOL(31,61),QQQ(31,61),CODEXC
      COMMON    EE1(4),EE2(4),EE3(4),EE4(4),AAO(4),AAH(4),TT1(4),TT2(4),
     1TT3(4),TT4(4),TTUS1(4),TTUS2(4),TTUS3(4),TTUS4(4),TTDS1(4),TTDS2(4
     2),TTDS3(4),TTDS4(4),EEUS1(4),EEUS2(4),EEUS3(4),EEUS4(4),EEDS1(4),E
     3EDS2(4),EEDS3(4),EEDS4(4),AAOUS(4),AAHUS(4),AAODS(4),AAHDS(4)
C DIFH2 PROGRAM TO COMPUTE WATER LEVEL DIFFERENCES BETWEEN THE TWO NODES OF THE
C BRANCHES
      DO 100I=1,7
  100 DIFFH(I)=H(I+1,1)-H(I,1)
      DIFFH(8)=H(8,1)-H(7,1)
      DIFFH(9)=H(8,1)-H(9,1)
      DIFFH(10)=H(8,1)-H(9,1)
      DIFFH(11)=H(9,1)-H(10,1)
      DIFFH(12)=H(9,1)-H(10,1)
      DO 101I=13,24
  101 DIFFH(I)=H(I-3,1)-H(I-2,1)
      DIFFH(25)=H(10,1)-H(12,1)
      DIFFH(26)=H(23,1)-H(15,1)
      DIFFH(27)=H(24,1)-H(23,1)
      DIFFH(28)=H(25,1)-H(24,1)
      DIFFH(29)=H(26,1)-H(25,1)
      DIFFH(30)=H(27,1)-H(26,1)
      DIFFH(31)=H(28,1)-H(4,1)
      DIFFH(32)=H(29,1)-H(28,1)
      DIFFH(33)=H(30,1)-H(29,1)
      DIFFH(34)=H(31,1)-H(8,1)
      RETURN
      END
```

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PROGRAM LENGTH

ENTRY POINTS
        DIFH2     00003

BLOCK NAMES
                  46451

EXTERNAL SYMBOLS
        OBJDICT.
   00375 SYMBOLS
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```
      SUBROUTINE ATMK2
      COMMON N,G,U,C(90),P(8100),MX,MY,NNODE,NBAN,M,NN,NTIME,NDAY,CODPOL
      COMMON DELX(50),DELXX(50),DELXY(50),ALFAX(50),ALFAY(50),L,IB
      COMMON Q(50,2),H(50,2),QL(50,2),DQL(50),SUMQ(50),NMK
      COMMON ZI(50),NLIM,IDATE,IHOUR,IMIN,IDELT,DELT,ZET(50)
      COMMON A(50),AM(50),AH(50),AO(50),AX(50),AY(50),AXY,AOC,AHC,AOUS(5
     10),AHUS(50),AMC,AMUS(50),AXUS(50),AYUS(50),AUS(50),AODS(50),AHDS(5
     20),AMDS(50),AXDS(50),AYDS(50),ADS(50),F(50),SFBAO(50),SFBAT(50),SF
     3POL(50)
      COMMON HUD(50),HUS(50),HDS(50),HC
      COMMON ENX(50),ENM(50),ENY(50),EKX(50),EKM(50),EKY(50),EM(50),EKXU
     1S(50),EKMUS(50),EKYUS(50),EKXDS(50),EKMDS(50),EKYDS(50),ENXY,EKXY,
     2SUMK(50),ENMC,EKMC,EMUS(50),EMDS(50)
      COMMON EX(50),EY(50),E1(50),E2(50),E3(50),E4(50),EY1(50),EY2(50),E
     1Y3(50),EX1(50),EX2(50),EX3(50),EBAT(50),EBAO(50),EXUS1(50),EXUS2(5
     20),EXUS3(50),EYUS1(50),EYUS2(50),EYUS3(50),EUS1(50),EUS2(50),EUS3
     3(50),EUS4(50),EXDS1(50),EXDS2(50),EXDS3(50),EYDS1(50),EYDS2(50),EY
     4DS3(50),EDS1(50),EDS2(50),EDS3(50),EDS4(50),EC1,EC2,EC3,EC4,EXY,EX
     5Y1,EXY2,EXY3,EXUS(50),EYUS(50),EXDS(50),EYDS(50),EPOL(50)
      COMMON T(50),T1(50),T2(50),T3(50),T4(50),TX1(50),TX2(50),TX3(50),T
     1Y1(50),TY2(50),TY3(50),TX(50),TY(50),TM(50),TUS1(50),TUS2(50),TUS3
     2(50),TUS4(50),TC1,TC2,TC3,TC4,TXY1,TXY2,TXY3,TXUS1(50),TXUS2(50),T
     3XUS3(50),TYUS1(50),TYUS2(50),TYUS3(50),TXDS1(50),TXDS2(50),TXDS3(5
     40),TYDS1(50),TYDS2(50),TYDS3(50),TXY,TUS(50),TDS(50),TDS1(50),TDS2
     5(50),TDS3(50),TDS4(50),TMUS(50),TXUS(50),TYUS(50),TMDS(50)
      COMMON TXDS(50),TYDS(50),TMC
      COMMON RX(50),RY(50),RM(50),RMUS(50),RMDS(50),RMC,RXUS(50),RYUS(50
     1),RXDS(50),RYDS(50),RXY
      COMMON DIFFH(50),DIFFA(50),DIFFM(50)
      COMMON QX(50),QM(50),QY(50),CODSIP,CODPAS,CODCUT,CODWID,CODEXT
      COMMON QBCN(2),QBOL(2),QPAS(2),QQL(31,61),QQQ(31,61),CODEXC
      COMMON    EE1(4),EE2(4),EE3(4),EE4(4),AAO(4),AAH(4),TT1(4),TT2(4),
     1TT3(4),TT4(4),TTUS1(4),TTUS2(4),TTUS3(4),TTUS4(4),TTDS1(4),TTDS2(4
     2),TTDS3(4),TTDS4(4),EEUS1(4),EEUS2(4),EEUS3(4),EEUS4(4),EEDS1(4),E
     3EDS2(4),EEDS3(4),EEDS4(4),AAOUS(4),AAHUS(4),AAODS(4),AAHDS(4)
C ATMK2 PROGRAM TO SCHEMATIZE THE CHANNEL AND FLOOD PLAIN GOMETRY OF BICOL-
C LIBMANAN RIVERS
    1 DO 100I=1,NBAN
      AX(I)=AX(I)*ALFAX(I)
      AY(I)=AY(I)*ALFAY(I)
      TX(I)=TX(I)*ALFAX(I)
      TY(I)=TY(I)*ALFAY(I)
      RX(I)=RX(I)
      RY(I)=RY(I)
      EKX(I)=EKX(I)/ALFAX(I)**0.5
      EKY(I)=EKY(I)/ALFAY(I)**0.5
      A(I)=AX(I)+AM(I)+AY(I)
      T(I)=TX(I)+TM(I)+TY(I)
      TERM1=EKX(I)**2/AX(I)
      TERM2=EKM(I)**2/AM(I)
      TERM3=EKY(I)**2/AY(I)
      IF(AX(I))700,700,701
  700 TERM1=0.
  701 IF(AY(I))702,702,100
  702 TERM3=0.
  100 EM(I)=A(I)*(TERM1+TERM2+TERM3)/(EKX(I)+EKM(I)+EKY(I))**2

      RETURN
      END
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                                        IDENT     ATMK2
PROGRAM LENGTH                  00122

ENTRY POINTS
        ATMK2     00003

BLOCK NAMES
                  46451

EXTERNAL SYMBOLS
        02307111          QBQDICT.
   00406 SYMBOLS
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```
      SUBROUTINE DIFAM2
      COMMON N,G,U,C(90),P(8100),MX,MY,NNODE,NBAN,M,NN,NTIME,NDAY,CODPOL
      COMMON DELX(50),DELXX(50),DELXY(50),ALFAX(50),ALFAY(50),L,IB
      COMMON Q(50,2),H(50,2),QL(50,2),DQL(50),SUMQ(50),NMK
      COMMON ZI(50),NLIM,IDATE,IHOUR,IMIN,IDELT,DELT,ZET(50)
      COMMON A(50),AM(50),AH(50),AO(50),AX(50),AY(50),AXY,AOC,AHC,AOUS(5
     10),AHUS(50),AMC,AMUS(50),AXUS(50),AYUS(50),AUS(50),AODS(50),AHDS(5
     20),AMDS(50),AXDS(50),AYDS(50),ADS(50),F(50),SFBAO(50),SFBAT(50),SE
     3POL(50)
      COMMON HUD(50),HUS(50),HDS(50),HC
      COMMON ENX(50),ENM(50),ENY(50),EKX(50),EKM(50),EKY(50),EM(50),EKXU
     1S(50),EKMUS(50),EKYUS(50),EKXDS(50),EKMDS(50),EKYDS(50),ENXY,EKXY,
     2SUMK(50),ENMC,EKMC,EMUS(50),EMDS(50)
      COMMON EX(50),EY(50),E1(50),E2(50),E3(50),E4(50),EY1(50),EY2(50),E
     1Y3(50),EX1(50),EX2(50),EX3(50),EBAT(50),EBAO(50),EXUS1(50),EXUS2(5
     20),EXUS3(50),EYUS1(50),EYUS2(50),EYUS3(50),EUS1(50),EUS2(50),EUS3
     3(50),EUS4(50),EXDS1(50),EXDS2(50),EXDS3(50),EYDS1(50),EYDS2(50),EY
     4DS3(50),EDS1(50),EDS2(50),EDS3(50),EDS4(50),EC1,EC2,EC3,EC4,EXY,EX
     5Y1,EXY2,EXY3,EXUS(50),EYUS(50),EXDS(50),EYDS(50),EPOL(50)
      COMMON T(50),T1(50),T2(50),T3(50),T4(50),TX1(50),TX2(50),TX3(50),T
     1Y1(50),TY2(50),TY3(50),TX(50),TY(50),TM(50),TUS1(50),TUS2(50),TUS3
     2(50),TUS4(50),TC1,TC2,TC3,TC4,TXY1,TXY2,TXY3,TXUS1(50),TXUS2(50),T
     3XUS3(50),TYUS1(50),TYUS2(50),TYUS3(50),TXDS1(50),TXDS2(50),TXDS3(5
     40),TYDS1(50),TYDS2(50),TYDS3(50),TXY,TUS(50),TDS(50),TDS1(50),TDS2
     5(50),TDS3(50),TDS4(50),TMUS(50),TXUS(50),TYUS(50),TMDS(50)
      COMMON TXDS(50),TYDS(50),TMC
      COMMON RX(50),RY(50),RM(50),RMUS(50),RMDS(50),RMC,RXUS(50),RYUS(50
     1),RXDS(50),RYDS(50),RXY
      COMMON DIFFH(50),DIFFA(50),DIFFM(50)
      COMMON QX(50),QM(50),QY(50),CODSIP,CODPAS,CODCUT,CODWID,CODEXT
      COMMON QBCN(2),QBOL(2),QPAS(2),QQL(31,61),QQQ(31,61),CODEXC
      COMMON    EE1(4),EE2(4),EE3(4),EE4(4),AAO(4),AAH(4),TT1(4),TT2(4),
     1TT3(4),TT4(4),TTUS1(4),TTUS2(4),TTUS3(4),TTUS4(4),TTDS1(4),TTDS2(4
     2),TTDS3(4),TTDS4(4),EEUS1(4),EEUS2(4),EEUS3(4),EEUS4(4),EEDS1(4),E
     3EDS2(4),EEDS3(4),EEDS4(4),AAOUS(4),AAHUS(4),AAODS(4),AAHDS(4)
C DIFAM2 PROGRAM TO COMPUTE THE DIFFERENCES BETWEEN THE AREAS AND THE DIFFERENC
C BETWEEN MOMENTUM CORRECTION FACTORS FOR EACH BRANCH
    1 DO 102I=1,NBAN
      IB=I
      ENMC=ENM(I)
      HC=HUS(I)
      TC1=TUS1(I)
      TC2=TUS2(I)
      TC3=TUS3(I)
      TC4=TUS4(I)
      EC1=EUS1(I)
      EC2=EUS2(I)
      EC3=EUS3(I)
      EC4=EUS4(I)
      AOC=AOUS(I)
      AHC=AHUS(I)
      ID=1
      CALL GEO1
      TMUS(I)=TMC
      AMUS(I)=AMC
      RMUS(I)=RMC
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      EKMUS(I)=EKMC
      EXY=EXJS(I)
      EXY1=EXUS1(I)
      EXY2=EXUS2(I)
      EXY3=EXUS3(I)
      ENXY=ENX(I)
      TXY1=TXUS1(I)
      TXY2=TXUS2(I)
      TXY3=TXUS3(I)
      CALL GEO2
      AXUS(I)=AXY*ALFAX(I)
      TXUS(I)=TXY*ALFAX(I)
      RXUS(I)=RXY
      EKXUS(I)=EKXY/ALFAX(I)**0.5
      EXY=EYJS(I)
      EXY1=EYUS1(I)
      EXY2=EYUS2(I)
      EXY3=EYUS3(I)
      ENXY=ENY(I)
      TXY1=TYUS1(I)
      TXY2=TYUS2(I)
      TXY3=TYUS3(I)
      CALL GEO2
      AYUS(I)=AXY*ALFAY(I)
      TYUS(I)=TXY*ALFAY(I)
      RYUS(I)=RXY
      EKYUS(I)=EKXY/ALFAY(I)**0.5
      TUS(I)=TMUS(I)+TXUS(I)+TYUS(I
      AUS(I)=AMUS(I)+AXUS(I)+AYUS(I
      TERM1=EKXUS(I)**2/AXUS(I)
      TERM2=EKMUS(I)**2/AMUS(I)
      TERM3=EKYUS(I)**2/AYUS(I)
      IF(AXUS(I))700,700,701
  700 TERM1=0.
  701 IF(AYUS(I))702,702,100
  702 TERM3=0.
  100 EMUS(I)=AUS(I)*(TERM1+TERM2+TERM3)/(EKXUS(I)+EKMUS(I)+EKYUS(I))**2
      IF(AJS(I))903,903,904
  903 EMUS(I)=0.
  904 ENMC=ENM(I)
      HC=HDS(I)
      TC1=TDS1(I)
      TC2=TDS2(I)
      TC3=TDS3(I)
      TC4=TDS4(I)
      EC1=EDS1(I)
      EC2=EDS2(I)
      EC3=EDS3(I)
      EC4=EDS4(I)
      AOC=AODS(I)
      AHC=AHDS(I)
      ID=2
      CALL GEO1
      TMDS(I)=TMC
      AMDS(I)=AMC
      RMDS(I)=RMC
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```
      EKMDS(I)=EKMC
      EXY=EXDS(I)
      EXY1=EXDS1(I)
      EXY2=EXDS2(I)
      EXY3=EXDS3(I)
      ENXY=ENX(I)
      TXY1=TXDS1(I)
      TXY2=TXDS2(I)
      TXY3=TXDS3(I)
      CALL GE02
      AXDS(I)=AXY*ALFAX(I)
      TXDS(I)=TXY*ALFAX(I)
      RXDS(I)=RXY
      EKXDS(I)=EKXY/ALFAX(I)**0.5
      EXY=EYDS(I)
      EXY1=EYDS1(I)
      EXY2=EYDS2(I)
      EXY3=EYDS3(I)
      ENXY=ENY(I)
      TXY1=TYDS1(I)
      TXY2=TYDS2(I)
      TXY3=TYDS3(I)
      CALL GE02
      AYDS(I)=AXY*ALFAY(I)
      TYDS(I)=TXY*ALFAY(I)
      RYDS(I)=RXY
      EKYDS(I)=EKXY/ALFAY(I)**0.5
      TDS(I)=TMDS(I)+TXDS(I)+TYDS(I)
      ADS(I)=AMDS(I)+AXDS(I)+AYDS(I)
      TERM1=EKXDS(I)**2/AXDS(I)
      TERM2=EKMDS(I)**2/AMDS(I)
      TERM3=EKYDS(I)**2/AYDS(I)
      IF(AXDS(I))800,800,801
  800 TERM1=0.
  801 IF(AYDS(I))802,802,900
  802 TERM3=0.
  900 EMDS(I)=ADS(I)*(TERM1+TERM2+TERM3)/(EKXDS(I)+EKMDS(I)+EKYDS(I))**2
      IF(ADS(I))902,902,901
  902 EMDS(I)=0.
  901 DIFFA(I)=ADS(I)-AUS(I)
      DIFFM(I)=EMDS(I)-EMUS(I)
  102 CONTINUE
      RETURN
      END
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1DS    DIFAM2                                                    12/30/74

                                        IDENT    DIFAM2
    PROGRAM LENGTH              00361

    ENTRY POINTS
          DIFAM2    00000

    BLOCK NAMES
                    46451

    EXTERNAL SYMBOLS
          02307111        QBQDICT.        GE01        GE02
       00421
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```
      SUBROUTINE GE01
      COMMON N,G,U,C(90),P(8100),MX,MY,NNODE,NBAN,M,NN,NTIME,NDAY,CODPOL
      COMMON DELX(50),DELXX(50),DELXY(50),ALFAX(50),ALFAY(50),L,IB
      COMMON Q(50,2),H(50,2),QL(50,2),DQL(50),SUMQ(50),NMK
      COMMON ZI(50),NLIM,IDATE,IHOUR,IMIN,IDELT,DELT,ZET(50)
      COMMON A(50),AM(50),AH(50),AO(50),AX(50),AY(50),AXY,AOC,AHC,AOUS(5
     10),AHUS(50),AMC,AMUS(50),AXUS(50),AYUS(50),AUS(50),AODS(50),AHDS(5
     20),AMDS(50),AXDS(50),AYDS(50),ADS(50),F(50),SFBAO(50),SFBAT(50),SF
     3POL(50)
      COMMON HOD(50),HUS(50),HDS(50),HC
      COMMON ENX(50),ENM(50),ENY(50),EKX(50),EKM(50),EKY(50),EM(50),EKXU
     1S(50),EKMUS(50),EKYUS(50),EKXDS(50),EKMDS(50),EKYDS(50),ENXY,EKXY,
     2SUMK(50),ENMC,EKMC,EMUS(50),EMDS(50)
      COMMON EX(50),EY(50),E1(50),E2(50),E3(50),E4(50),EY1(50),EY2(50),E
     1Y3(50),EX1(50),EX2(50),EX3(50),EBAT(50),EBAO(50),EXUS1(50),EXUS2(5
     20),EXUS3(50),EYUS1(50),EYUS2(50),EYUS3(50),EUS1(50),EUS2(50),EUS3
     3(50),EUS4(50),EXDS1(50),EXDS2(50),EXDS3(50),EYDS1(50),EYDS2(50),EY
     4DS3(50),EDS1(50),EDS2(50),EDS3(50),EDS4(50),EC1,EC2,EC3,EC4,EXY,EX
     5Y1,EXY2,EXY3,EXUS(50),EYUS(50),EXDS(50),EYDS(50),EPOL(50)
      COMMON T(50),T1(50),T2(50),T3(50),T4(50),TX1(50),TX2(50),TX3(50),T
     1Y1(50),TY2(50),TY3(50),TX(50),TY(50),TM(50),TUS1(50),TUS2(50),TUS3
     2(50),TUS4(50),TC1,TC2,TC3,TC4,TXY1,TXY2,TXY3,TXUS1(50),TXUS2(50),T
     3XUS3(50),TYUS1(50),TYUS2(50),TYUS3(50),TXDS1(50),TXDS2(50),TXDS3(5
     40),TYDS1(50),TYDS2(50),TYDS3(50),TXY,TUS(50),TDS(50),TDS1(50),TDS2
     5(50),TDS3(50),TDS4(50),TMUS(50),TXUS(50),TYUS(50),TMDS(50)
      COMMON TXDS(50),TYDS(50),TMC
      COMMON RX(50),RY(50),RM(50),RMUS(50),RMDS(50),RMC,RXUS(50),RYUS(50
     1),RXDS(50),RYDS(50),RXY
      COMMON DIFFH(50),DIFFA(50),DIFFM(50)
      COMMON QX(50),QM(50),QY(50),CODSIP,CODPAS,CODCUT,CODWID,CODEXT
      COMMON QBCN(2),QBOL(2),QPAS(2),QQL(31,61),QQQ(31,61),CODEXC
      COMMON    EE1(4),EE2(4),EE3(4),EE4(4),AAO(4),AAH(4),TT1(4),TT2(4),
     1TT3(4),TT4(4),TTUS1(4),TTUS2(4),TTUS3(4),TTUS4(4),TTDS1(4),TTDS2(4
     2),TTDS3(4),TTDS4(4),EEUS1(4),EEUS2(4),EEUS3(4),EEUS4(4),EEDS1(4),E
     3EDS2(4),EEDS3(4),EEDS4(4),AAOUS(4),AAHUS(4),AAODS(4),AAHDS(4)
C GE01 PROGRAM TO COMPUTE CROSS SECTIONAL AREA,TOP WIDTH AND HYDRAULIC MEAN
C DEPTH OF MAIN CHANNELS AT THE UPATREAM AND DOWNSTREAM ENDS OF THE BRANCH
      IF(HC-EC1)60,60,61
   60 TMC=TC1
      AMC=AOC+(TC1+TC2)/2.*(EC2-EC1)+(TC1+TMC)/2.*(EC1-HC)
      GO TO 68
   61 IF(HC-EC2)62,62,63
   62 TMC=TC1+(TC2-TC1)*(HC-EC1)/(EC2-EC1)
      AMC=AOC+(TMC+TC2)/2.*(EC2-HC)
      GO TO 68
   63 IF(HC-EC3)64,64,65
   64 TMC=TC2+(TC3-TC2)*(HC-EC2)/(EC3-EC2)
      AMC=AOC+(TMC+TC2)/2.*(HC-EC2)
      GO TO 68
   65 IF(HC-EC4)66,66,67
   66 TMC=TC3+(TC4-TC3)*(HC-EC3)/(EC4-EC3)
      AMC=AHC+(TC4+TMC)/2.*(EC4-HC)
      GO TO 68
   67 TMC=TC4
      AMC=AHC+TC4*(HC-EC4)
  902 FORMAT(1X,3I5)
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```
   68 IF(AMC-0.01)900,900,901
  900 AMC=0.01
  901 RMC=AMC/TMC
      IF(IB-25)600,904,903
  904 AMC=AMC*CODCUT*CODWID/40.+0.01
      TMC=TMC*CODCUT*CODWID/40.+0.10
      RMC=AMC/TMC*CODCUT+0.01
      GO TO 600
  903 IF(IB-30)602,602,603
  603 IF(IB-33)604,604,600
  602 AMC=AMC*CODPAS+0.01
      TMC=TMC*CODPAS+0.10
      RMC=AMC/TMC*CODPAS+0.01
      GO TO 600
  604 AMC=AMC*CODSIP+0.01
      TMC=TMC*CODSIP+0.10
      RMC=AMC/TMC*CODSIP+0.01
  600 EKMC=1./ENMC+AMC*RMC**0.667
      RETURN
      END
```



```
                                    IDENT     GE01
PROGRAM LENGTH                 00246

ENTRY POINTS
        GE01      00007

BLOCK NAMES
                  46451

EXTERNAL SYMBOLS
        02307111          QBQDICT,
   00416 SYMBOLS
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```
      SUBROUTINE GEO2
      COMMON N,G,U,C(90),P(8100),MX,MY,NNODE,NBAN,M,NN,NTIME,NDAY,CODPOL
      COMMON DELX(50),DELXX(50),DELXY(50),ALFAX(50),ALFAY(50),L,IB
      COMMON Q(50,2),H(50,2),QL(50,2),DQL(50),SUMQ(50),NMK
      COMMON ZI(50),NLIM,IDATE,IHOUR,IMIN,IDELT,DELT,ZET(50)
      COMMON A(50),AM(50),AH(50),AO(50),AX(50),AY(50),AXY,AOC,AMC,AOUS(5
     10),AHUS(50),AMC,AMUS(50),AXUS(50),AYUS(50),AUS(50),AODS(50),AHDS(5
     20),AMDS(50),AXDS(50),AYDS(50),ADS(50),F(50),SFBAO(50),SFBAT(50),SF
     3POL(50)
      COMMON HUD(50),HUS(50),HDS(50),HC
      COMMON ENX(50),ENM(50),ENY(50),EKX(50),EKM(50),EKY(50),EM(50),EKXU
     1S(50),EKMUS(50),EKYUS(50),EKXDS(50),EKMDS(50),EKYDS(50),ENXY,EKXY,
     2SUMK(50),ENMC,EKMC,EMUS(50),EMDS(50)
      COMMON EX(50),EY(50),E1(50),E2(50),E3(50),E4(50),EY1(50),EY2(50),E
     1Y3(50),EX1(50),EX2(50),EX3(50),EBAT(50),EBAO(50),EXUS1(50),EXUS2(5
     20),EXUS3(50),EYUS1(50),EYUS2(50),EYUS3(50),EUS1(50),EUS2(50),EUS3
     3(50),EUS4(50),EXDS1(50),EXDS2(50),EXDS3(50),EYDS1(50),EYDS2(50),EY
     4DS3(50),EDS1(50),EDS2(50),EDS3(50),EDS4(50),EC1,EC2,EC3,EC4,EXY,EX
     5Y1,EXY2,EXY3,EXUS(50),EYUS(50),EXDS(50),EYDS(50),EPOL(50)
      COMMON T(50),T1(50),T2(50),T3(50),T4(50),TX1(50),TX2(50),TX3(50),T
     1Y1(50),TY2(50),TY3(50),TX(50),TY(50),TM(50),TUS1(50),TUS2(50),TUS3
     2(50),TUS4(50),TC1,TC2,TC3,TC4,TXY1,TXY2,TXY3,TXUS1(50),TXUS2(50),T
     3XUS3(50),TYUS1(50),TYUS2(50),TYUS3(50),TXDS1(50),TXDS2(50),TXDS3(5
     40),TYDS1(50),TYDS2(50),TYDS3(50),TXY,TUS(50),TDS(50),TDS1(50),TDS2
     5(50),TDS3(50),TDS4(50),TMUS(50),TXUS(50),TYUS(50),TMDS(50)
      COMMON TXDS(50),TYDS(50),TMC
      COMMON RX(50),RY(50),RM(50),RMUS(50),RMDS(50),RMC,RXUS(50),RYUS(50
     1),RXDS(50),RYDS(50),RXY
      COMMON DIFFH(50),DIFFA(50),DIFFM(50)
      COMMON QX(50),QM(50),QY(50),CODSIP,CODPAS,CODCUT,CODWID,CODEXT
      COMMON QBON(2),QBOL(2),QPAS(2),QQL(31,61),QQQ(31,61),CODEXC
      COMMON    EE1(4),EE2(4),EE3(4),EE4(4),AAO(4),AAH(4),TT1(4),TT2(4),
     1TT3(4),TT4(4),TTUS1(4),TTUS2(4),TTUS3(4),TTUS4(4),TTDS1(4),TTDS2(4
     2),TTDS3(4),TTDS4(4),EEUS1(4),EEUS2(4),EEUS3(4),EEUS4(4),EEDS1(4),E
     3EDS2(4),EEDS3(4),EEDS4(4),AAOUS(4),AAHUS(4),AAODS(4),AAHDS(4)
C GEO2 PROGRAM TO COMPUTE CROSS SECTIONAL AREAS,TOP WIDTH AND HYDRAULIC MEAN
C DEPTH OF FLOOD PLAIN OR BERM SECTIONS AT THE UPSTREAM AND DOWNSTREAM ENDS OF
C THE BRANCH
      IF(HC-EXY)40,40,41
   40 AXY=0.
      TXY=0.
      RXY=0.
      GO TO 448
   41 IF(HC-EXY1)42,42,43
   42 TXY=TXY1/(EXY1-EXY)*(HC-EXY)
      AXY=1./2.*TXY*(HC-EXY)
      GO TO 48
   43 IF(HC-EXY2)44,44,45
   44 TXY=TXY1+(TXY2-TXY1)/(EXY2-EXY1)*(HC-EXY1)
      AXY=1./2.*TXY1*(EXY1-EXY)+1./2.*(TXY1+TXY)*(HC-EXY1)
      GO TO 48
   45 IF(HC-EXY3)46,46,47
   46 TXY=TXY2+(TXY3-TXY2)/(EXY3-EXY2)*(HC-EXY2)
      AXY=1./2.*TXY1*(EXY1-EXY)+1./2.*(TXY1+TXY2)*(EXY2-EXY1)+1./2.*(TXY
     12+TXY)*(HC-EXY2)
      GO TO 48
```

```
   47 TXY=TXY3
      AXY=1./2.*TXY1*(EXY1-EXY)+1./2.*(TXY1+TXY2)*(EXY2-EXY1)+1./2.*(TXY
     12+TXY3)*(EXY3-EXY2)+(HC-EXY3)*TXY3
   48 RXY=AXY/TXY
  448 EKXY=1./ENXY*AXY*RXY**0.667
      RETURN
      END
```



```
                                    IDENT     GEO2
PROGRAM LENGTH                    00176

ENTRY POINTS
        GEO2      00003

BLOCK NAMES
                  46451

EXTERNAL SYMBOLS
        Q2007111          Q8QDICT,
   00404 SYMBOLS
```

```
      SUBROUTINE GEO
      COMMON N,G,U,C(90),P(8100),MX,MY,NNODE,NBAN,M,NN,NTIME,NDAY,CODPOL
      COMMON DELX(50),DELXX(50),DELXY(50),ALFAX(50),ALFAY(50),L,IB
      COMMON Q(50,2),H(50,2),QL(50,2),DQL(50),SUMQ(50),NMK
      COMMON ZI(50),NLIM,IDATE,IHOUR,IMIN,IDELT,DELT,ZET(50)
      COMMON A(50),AM(50),AH(50),AO(50),AX(50),AY(50),AXY,AOC,AMC,AOUS(5
     10),AHUS(50),AMC,AMUS(50),AXUS(50),AYUS(50),AUS(50),AODS(50),AHDS(5
     20),AMDS(50),AXDS(50),AYDS(50),ADS(50),F(50),SFBAO(50),SFBAT(50),SE
     3POL(50)
      COMMON HUD(50),HUS(50),HDS(50),HC
      COMMON ENX(50),ENM(50),ENY(50),EKX(50),EKM(50),EKY(50),EM(50),EKXU
     1S(50),EKMUS(50),EKYUS(50),EKXDS(50),EKMDS(50),EKYDS(50),ENXY,EKXY,
     2SUMK(50),ENMC,EKMC,EMUS(50),EMDS(50)
      COMMON EX(50),EY(50),E1(50),E2(50),E3(50),E4(50),EY1(50),EY2(50),E
     1Y3(50),EX1(50),EX2(50),EX3(50),EBAT(50),EBAO(50),EXUS1(50),EXUS2(5
     20),EXUS3(50),EYUS1(50),EYUS2(50),EYUS3(50),EUS1(50),EUS2(50),EUS3
     3(50),EUS4(50),EXDS1(50),EXDS2(50),EXDS3(50),EYDS1(50),EYDS2(50),EY
     4DS3(50),EDS1(50),EDS2(50),EDS3(50),EDS4(50),EC1,EC2,EC3,EC4,EXY,EX
     5Y1,EXY2,EXY3,EXUS(50),EYUS(50),EXDS(50),EYDS(50),EPOL(50)
      COMMON T(50),T1(50),T2(50),T3(50),T4(50),TX1(50),TX2(50),TX3(50),T
     1Y1(50),TY2(50),TY3(50),TX(50),TY(50),TM(50),TUS1(50),TUS2(50),TUS3
     2(50),TUS4(50),TC1,TC2,TC3,TC4,TXY1,TXY2,TXY3,TXUS1(50),TXUS2(50),T
     3XUS3(50),TYUS1(50),TYUS2(50),TYUS3(50),TXDS1(50),TXDS2(50),TXDS3(5
     40),TYDS1(50),TYDS2(50),TYDS3(50),TXY,TUS(50),TDS(50),TDS1(50),TDS2
     5(50),TDS3(50),TDS4(50),TMUS(50),TXUS(50),TYUS(50),TMDS(50)
      COMMON TXDS(50),TYDS(50),TMC
      COMMON RX(50),RY(50),RM(50),RMUS(50),RMDS(50),RMC,RXUS(50),RYUS(50
     1),RXDS(50),RYDS(50),RXY
      COMMON DIFFH(50),DIFFA(50),DIFFM(50)
      COMMON QX(50),QM(50),QY(50),CODSIP,CODPAS,CODCUT,CODWID,CODEXT
      COMMON QBCN(2),QBOL(2),QPAS(2),QOL(31,61),QQQ(31,61),CODEXC
      COMMON    EE1(4),EE2(4),EE3(4),EE4(4),AAO(4),AAH(4),TT1(4),TT2(4),
     1TT3(4),TT4(4),TTUS1(4),TTUS2(4),TTUS3(4),TTUS4(4),TTDS1(4),TTDS2(4
     2),TTDS3(4),TTDS4(4),EEUS1(4),EEUS2(4),EEUS3(4),EEUS4(4),EEDS1(4),E
     3EDS2(4),EEDS3(4),EEDS4(4),AAOUS(4),AAHUS(4),AAODS(4),AAHDS(4)
GEO PROGRAM TO COMPUTE CROSS SECTIONAL AREA,TOP WIDTH AND HYDRAULIC MEAN DEPTH
OF MAIN CHANNELS AND BERM SECTIONS OF THE FLOOD PLAINS AT THE MID OF BRANCH
      DO 900I=1,NBAN
      IF(HUD(I)-E1(I))60,60,61
   60 TM(I)=T1(I)
      AM(I)=AO(I)-(T1(I)+T2(I))/2.*(E2(I)-E1(I))-(T1(I)+TM(I))/2.*(E1(I)
     1-HUD(I))
      GO TO 68
   61 IF(HUD(I)-E2(I))62,62,63
   62 TM(I)=T1(I)+(T2(I)-T1(I))*(HUD(I)-E1(I))/(E2(I)-E1(I))
      AM(I)=AO(I)-(TM(I)+T2(I))/2.*(E2(I)-HUD(I))
      GO TO 68
   63 IF(HUD(I)-E3(I))64,64,65
   64 TM(I)=T2(I)+(T3(I)-T2(I))*(HUD(I)-E2(I))/(E3(I)-E2(I))
      AM(I)=AO(I)+(TM(I)+T2(I))/2.*(HUD(I)-E2(I))
      GO TO 68
   65 IF(HUD(I)-E4(I))66,66,67
   66 TM(I)=T3(I)+(T4(I)-T3(I))*(HUD(I)-E3(I))/(E4(I)-E3(I))
      AM(I)=AH(I)-(T4(I)+TM(I))/2.*(E4(I)-HUD(I))
      GO TO 68
   67 TM(I)=T4(I)
```

```
      AM(I)=AM(I)+T4(I)*(HUD(I)-E4(I))
   68 IF(AM(I)-0.01)20,20,69
   20 AM(I)=0.01
   69 RM(I)=AM(I)/TM(I)
      IF(I-25)600,606,605
  606 AM(I)=AM(I)*CODCUT*CODWID/40.+0.01
      TM(I)=TM(I)*CODCUT*CODWID/40.+0.10
      RM(I)=AM(I)/TM(I)*CODCUT+0.01
      GO TO 600
  605 IF(I-30)602,602,603
  603 IF(I-33)604,604,600
  602 AM(I)=AM(I)*CODPAS+0.01
      TM(I)=TM(I)*CODPAS+0.10
      RM(I)=AM(I)/TM(I)*CODPAS+0.01
      GO TO 600
  604 AM(I)=AM(I)*CODSIP+0.01
      TM(I)=TM(I)*CODSIP+0.10
      RM(I)=AM(I)/TM(I)*CODSIP+0.01
  600 EKM(I)=1./ENM(I)*AM(I)*RM(I)**0.667
      EXY=EX(I)
      EXY1=EX1(I)
      EXY2=EX2(I)
      ENXY=ENX(I)
      EXY3=EX3(I)
      TXY1=TX1(I)
      TXY2=TX2(I)
      TXY3=TX3(I)
      ICODE=1
  704 IF(HJD(I)-EXY)40,40,41
   40 AXY=0.
      TXY=0.
      RXY=0.
      GO TO 448
   41 IF(HJD(I)-EXY1)42,42,43
   42 TXY=TXY1/(EXY1-EXY)*(HUD(I)-EXY)
      AXY=1./2.*TXY*(HUD(I)-EXY)
      GO TO 48
   43 IF(HJD(I)-EXY2)44,44,45
   44 TXY=TXY1+(TXY2-TXY1)/(EXY2-EXY1)*(HUD(I)-EXY1)
      AXY=1./2.*TXY1*(EXY1-EXY)+1./2.*(TXY1+TXY)*(HUD(I)-EXY1)
      GO TO 48
   45 IF(HJD(I)-EXY3)46,46,47
   46 TXY=TXY2+(TXY3-TXY2)/(EXY3-EXY2)*(HUD(I)-EXY2)
      AXY=1./2.*TXY1*(EXY1-EXY)+1./2.*(TXY1+TXY2)*(EXY2-EXY1)+1./2.*(TXY
     12+TXY)*(HUD(I)-EXY2)
      GO TO 48
   47 TXY=TXY3
      AXY=1./2.*TXY1*(EXY1-EXY)+1./2.*(TXY1+TXY2)*(EXY2-EXY1)+1./2.*(TXY
     12+TXY3)*(EXY3-EXY2)+(HUD(I)-EXY3)*TXY3
   48 RXY=AXY/TXY
  448 EKXY=1./ENXY*AXY*RXY**0.667
      GO TO (700,701),ICODE
  700 AX(I)=AXY
      TX(I)=TXY
      RX(I)=RXY
      EKX(I)=EKXY
```

```
      EXY=EY(I)
      EXY1=EY1(I)
      EXY2=EY2(I)
      EXY3=EY3(I)
      TXY1=TY1(I)
      TXY2=TY2(I)
      TXY3=TY3(I)
      ENXY=ENY(I)
      ICODE=2
      GO TO 704
  701 AY(I)=AXY
      TY(I)=TXY
      RY(I)=RXY
      EKY(I)=EKXY
  900 CONTINUE
      RETURN
      END
```



```
                    IDENT    GEO

PROGRAM LENGTH              00500

ENTRY POINTS
        GEO       00003

BLOCK NAMES
                  46451

EXTERNAL SYMBOLS
        02007111          080DICT,
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```
      SUBROUTINE BARIER(HR,HS,Q)
C  SUBROUTINE FOR THE BARRIER CONCEPT NUMBER 1
C  Y1 = DEPTH OF WATER UPSTREAM(METRE)
C  Y2 = DEPTH OF WATER DOWNSTREAM, OCEAN SIDE( METRE)
C  HR = WATER SURFACE ELEVATION ABOVE MSL IN THE RIVER SIDE
C  HS = WATER SURFACE ELEVATION ABOVE MSL IN THE SEA SIDE
C  Q = DISCHARGE THROUGH BARRIER( METRE3/SEC)
C  USE FRANCIS SUBMERGED WEIR FORMULAR, P1224 DAVIS
C  SEE DEFINITION SKETCH ON BACK OF THIS CARD
C
      SLM= 5.
      Y1= SLM+HR
      Y2= SLM+HS
C  TO CONVERT CONSTANTS TO FEET
      PG= 1.78/0.3048
      PW= 6.1/0.3048
      RLG= 21./0.3048
      RLW= 25./0.3048
      GATE= 15.
      WEIR= 4.
      Y1N= Y1/0.3048
      Y2N= Y2/0.3048
      IF(Y1N.LT.0.) GO TO 1
      IF(Y1N.LE.PG) GO TO 2
      IF(Y1N.LE.Y2N) GO TO 2
      IF(Y2N.LT.PG) GO TO 5
 9    QGCFS= GATE*3.33*RLG*SQRT(Y1N-Y2N)*(Y1N-PG+0.381*(Y2N-PG))
      QG= 0.0283*QGCFS
      GO TO 6
 5    Y2N= PG
      GO TO 9
 6    IF(Y1N.LE.PW) GO TO 3
      IF(Y2N.LT.PW) GO TO 7
 10   QWCFS= WEIR*3.33*RLW*SQRT(Y1N-Y2N)*(Y1N-PW+0.381*(Y2N-PW))
      QW= 0.0283*QWCFS
      GO TO 8
 7    Y2N= PW
      GO TO 10
 8    Q= QG+QW
      GO TO 4
 1    WRITE(61,100)
 100  FORMAT(/*  Y1 IS LESS THAN ZERO, IMPOSSIBLE, SET Q=0*/)
 2    Q= 0.
      GO TO 4
 3    Q= QG
 4    RETURN
```

```
,4DS    BARIER                                                    12/30/74    ED

                                   IDENT     BARIER
PROGRAM LENGTH                 00246

ENTRY POINTS
        BARIER    00016

EXTERNAL SYMBOLS
        THEND,          QBQDICT,        SQRTF           STH,
   00101 SYMBOLS
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```
      SUBROUTINE SIMQ(A,B,N,KS)
      DIMENSION A(1),B(1)
C SIMQ-PROGRAM TO INVERSE THE MATRIX
C FORWARD SOLUTION
      TOL=0.0
      KS=0
      JJ=-N
      DO 65J=1,N
      JY=J+1
      JJ=JJ+N+1
      BIGA=0
      IT=JJ-J
      DO 30I=J,N
C SEARCH FOR MAXIMUM COEFFICIENT IN COLUMN
      IJ=IT+I
      IF(ABS(BIGA)-ABS(A(IJ)))20,30,30
   20 BIGA=A(IJ)
      IMAX=I
   30 CONTINUE
C TEST FOR PIVOT LESS THAN TOLERANCE (SINGULAR MATRIX)
      IF(ABS(BIGA)-TOL)35,35,40
   35 KS=1
      RETURN
C INTERCHANGE ROWS IF NECESSARY
   40 I1=J+N*(J-2)
      IT=IMAX-J
      DO 50K=J,N
      I1=I1+N
      I2=I1+IT
      SAVE=A(I1)
      A(I1)=A(I2)
      A(I2)=SAVE
C DIVIDE EQUATION BY LEADING COEFFICIENT
   50 A(I1)=A(I1)/BIGA
      SAVE=B(IMAX)
      B(IMAX)=B(J)
      B(J)=SAVE/BIGA
C ELIMINATE NEXT VARIABLE
      IF(J-N)55,70,55
   55 IQS=N*(J-1)
      DO 65IX=JY,N
      IXJ=IQS+IX
      IT=J-IX
      DO 60JX=JY,N
      IXJX=N*(JX-1)+IX
      JJX=IXJX+IT
   60 A(IXJX)=A(IXJX)-(A(IXJ)*A(JJX))
   65 B(IX)=B(IX)-(B(J)*A(IXJ))
C BACK SOLUTION
   70 NY=N-1
      IT=N*N
      DO80J=1,NY
      IA=IT-J
      IB=N-J
      IC=N
      DO 80K=1,J
```

```
      B(IB)=B(IB)-A(IA)*B(IC)
      IA=IA-N
   80 IC=IC-1
      RETURN
      END
```



```
                                  IDENT     SIMQ
PROGRAM LENGTH                 00465

ENTRY POINTS
        SIMQ      00003

EXTERNAL SYMBOLS
        QBQDICT,
   00156 SYMBOLS
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```
      SUBROUTINE DESNIN(QQQ)
C     **********   BICOL RIVER BASIN FLOOD CONTROL STUDY      ***********
C     ***** PROGRAM TO ESTIMATE (1) 1970 FLOOD HYDROGRAPH FOR INPUT ****
C     ***** TO MODEL CALIBRATION AND,  (2) DESIGN FLOOD HYDROGRAPHS  ***
C     ***** FOR STUDY OF DESIGN ALTERNATIVES,                        *****
C     R(K,I) - RAINFALL(IN MM) FOR STATION K AT DAY I
C     RA(K,I) - ACCUMULATED 2-DAY RAINFALL FOR STATION K AT DAY I
C     IGC(I) - CODE NUMBER OF GAGED WATERSHED IN 100 SERIES
C     IUC(I) - CODE NUMBER OF UNGAGED WATERSHED IN 200 SERIES
C     F(I) - FLOODPLAIN RUNOFF FOR DAY I IN CMS
C     U(J,I) - RUNOFF(IN CMS) OF UNGAGED WATERSHED J AT DAY I
C     G(J,I) - RUNOFF(IN CMS) OF GAGED WATERSHED J AT DAY I
C     RC(K) - RUNOFF COEFFICIENT FOR AREA K
C     DG(I),DIM1(I),DIM2(I) - ORDINATES OF DISTRIBUTION GRAPH AT DAY I
C     VA(I) - 2-DAY RAINFALL IN UNITS OF CMS
C     QG(I) - SUMMATION OF HYDROGRAPHS(IN CMS) FROM GAGED WATERSHEDS
C     FOR THE NODE
C     QU(I) - SUMMATION OF HYDROGRAPHS (IN CMS) FORM UNGAGED WATERSHEDS
C     FOR THE NODE
C     Q(I) - SOME DUMMY HYDROGRAPH
C     IC(I) - SOME DUMMY DATE
      DIMENSION R(4,95),RA(4,95),DG(10),VA(95),Q(95),QQQ(31,61),
     +RC(5),G(9,95),U(70,95),IGC(21),IUC(21),F(95),DIM1(10),DIM2(10),
     +QG(95),QU(95),RC1(4),RC2(4),R1(4,95),R2(4,95)
      DATA(NOG=8),(NOUG=63),(NNODE=22)
      READ(60,109) KODE
      READ(60,100) IST,IDT,IAX,IBL,IBA,IBB,IBC
  100 FORMAT(4A1,3A2)
C     RAIN2,RAIN6,RAIN14,RAINDES - RESPECTIVELY THE DESIGN RAINFALL
C     FOR STATIONS 2, 6, 14 AND BASIN
      READ(60,102) RAIN2,RAIN6,RAIN14,RAINDE
C     RUNOFF COEFFICIENTS, RC(I), I=1,2, AND 3 RESPECTIVELY FOR ZONE 1,2,
C     AND 3,  I=4 FOR FLOODPLAIN AREA
      READ(60,102) (RC1(I),I=1,4)
      READ(60,102) (RC2(I),I=1,4)
      READ(60,102) (DIM1(I),I=1,10)
      READ(60,102) (DIM2(I),I=1,10)
C     EB,CB - REGRESSION COEFFICENTS OF BASE FLOW EQUATION,
C           QB = EXP(CB)*A**EB
      READ(60,102) EB,CB
C     DAILY RAINFALL DATA, R(K,I), K=1,2, AND 3 RESPECTIVELY
C     FOR RAINGAGE STATION 2,6, AND 14
      DO 10 K=1,3
      READ(60,101) (R1(K,I), I=1,30)
      READ(60,101) (R1(K,I), I=31,61)
      READ(60,101) (R1(K,I), I=62,91)
   10 CONTINUE
      DO 1110 K=1,3
      READ(60,101) (R2(K,I), I=1,30)
      READ(60,101) (R2(K,I), I=31,61)
      READ(60,101) (R2(K,I), I=62,91)
 1110 CONTINUE
      IF(KODE .EQ. 1) 1111,1115
 1111 DO 1112 K=1,3
      DO 1112 I=1,91
 1112 R(K,I) =R1(K,I)
```

```
      GO TO 1020
 1115 DO 1116 K=1,3
      DO 1116 I=1,91
 1116 R(K,I) = R2(K,I)
      DO 11 K=1,3
      GO TO (5,6,7),K
    5 FACT = RAIN2/RAINDE
      GO TO 8
    6 FACT = RAIN6/RAINDE
      GO TO 8
    7 FACT = RAIN14/RAINDE
    8 DO 9 I=1,91
    9 R(K,I) = R(K,I)*FACT
   11 CONTINUE
  101 FORMAT(16F5.0)
  102 FORMAT(10F8.0)
  103 FORMAT(/,15F7.2)
 1020 DO 1022 K=1,8
      READ(60,107) (G(K,I),I=1,30)
      READ(60,107) (G(K,I),I=31,61
      READ(60,107) (G(K,I),I=62,91
 1022 CONTINUE
  107 FORMAT(8F10.0)
 1021 FORMAT(5X,10F8.3)
 5555 FORMAT(20X,*RUN OFF COEFFICIENT AT THE BEGINING OF FLOOD*)
 5556 FORMAT(20X,*RUN OFF COEFFICIENT DURING AND AFTER FLOOD*)
      WRITE(61,5555)
      PRINT 1021,(RC1(I),I=1,4)
      WRITE(61,5556)
      PR  T 1021,(RC2(I),I=1,4)
      HEREON TO 20 , CONVERT DAILY RAINFALL TO 2-DAY ACCUMULATED RAINFALL
      DO 20 K=1,3
      RA(K,1) = R(K,1)
      DO 15 I=2,91
      L1 = I/2
      L2 = L1*2
      IF(L2-I) 13,14,13
   13 RA(K,I) = 0.
      GO TO 15
   14 I1 = I+1
      RA(K,I) = R(K,I) + R(K,I1)
   15 CONTINUE
   20 CONTINUE
C     KODE = 1 INCASE THIS PROGRAM IS USED TO COMPUTE THE HYDROLOGIC
C     INPUTS TO MODEL CALIBRATION, OTHERWISE TO FINAL MODEL (WHERE ALL
C     WATERSHEDS ARE CONSIDERED UNGAGED
C     HEREON TO 11, THE INPUTED RAINFALL DATA ARE CONVERTED INTO
C     NON-UNIFORM DISTRIBUTION OVER THE BASIN BY A VALUE FACT
      DO 200 KL=1,2
      GO TO (21,35),KL
   21 IF(KODE.EQ.1) 22,34
   22 DO 30 K=1,8
      READ(60,105) INC,A,W,IS
   30 CONTINUE
      GO TO 200
C     NOG - TOTAL NUMBER OF GAGED WATERSHEDS
```

```
C       NOUG - TOTAL NUMBER OF UNGAGED WATERSHEDS (INCLUDING FLOODPLAIN
C       AREAS) USED
   34   N1 = NOG
        GO TO 38
   35   N1 = NOUG
   38   DO 190 JJJ=1,N1
        READ(60,105) INC,A,W,IS
  105   FORMAT(4X,I4,2F8.0,I2)
C       COMPUTE BASE FLOW, QB = F(AREA)
        QB = EXP(CB)*A**EB
C       USE DISTRIBUTION GRAPH DIM1(I) FOR A LESS THAN 50 SQ KM
C       USE DISTRIBUTION GRAPH DIM2(I) FOR A GREATER THAN 50 SQ KM
        IF(A.LE.50.) 45,47
   45   DO 46 I=1,10
   46   DG(I) = DIM1(I)
        GO TO 49
   47   DO 48 I=1,10
   48   DG(I) = DIM2(I)
   49   IF(IS-2) 51,50,51
   50   K=1
        GO TO 55
   51   IF(IS-6) 53,52,53
   52   K=2
        GO TO 55
   53   K=3
C       CONVERT 2-DAY RAINFALL TO RUNOFF IN CMS
   55   DO 60 I=1,91
        IF(I.LE.41) 58,59
   58   RC(K) = RC1(K)
        GO TO 60
   59   RC(K) = RC2(K)
   60   VA(I) = RA(K,I)*RC(K)*A/86.4
C       HEREON TO 69 COMPUTE TOTAL HYDROGRAPH
        DO 69 I=1,91
        IF(I-10) 65,65,67
   65   SUM = 0.
        DO 66 J=1,I
        J1 = I-J+1
   66   SUM = SUM + DG(J)*VA(J1)
        Q(I) = SUM + QB
        GO TO 69
   67   SUM = 0.
        DO 68 J=1,10
        J1 = I-J+1
   68   SUM = SUM +DG(J)*VA(J1)
        Q(I) = SUM + QB
   69   CONTINUE
        GO TO (70,71), KL
   70   DO 701 I=1,91
  701   Q(JJJ,I) = Q(I)
        GO TO 190
   71   DO 711 I=1,91
  711   U(JJJ,I) = Q(I)
  190   CONTINUE
  200   CONTINUE
C       HEREON TO 300, DISTRIBUTE HYDROGRAPH FROM WATERSHEDS AND FLOOD-
```

```
C     PLAIN TO CORRESPONDING NODE SYSTEM OF MATHEMATICAL MODEL
      DO 300 JJJ = 1,NNODE
C     IN - NODE NUMBER,  IS - RAINGAGE STATION NUMBER,  AA- FLOODPLAIN
C     AREA NEAR RIVER(INCLUDING BERMS),  NG - NO. OF GAGED WATERSHEDS
C     NU - NO. OF UNGAGED WATERSHEDS
      READ(60,109) IN,IS,AA,NG,NU
  109 FORMAT(2I3,F6.0,2I4)
      IF(NG.EQ.0) GO TO 72
      READ(60,106)(IGC(I),I=1,NG)
   72 CONTINUE
      IF(NU.EQ.0) GO TO 75
      READ(60,106)(IUC(I),I=1,NU)
  106 FORMAT(20I4)
      GO TO 75
   75 CONTINUE
      IF(IS-2) 77,76,77
   76 K=1
      GO TO 80
   77 IF(IS-6) 79,78,79
   78 K=2
      GO TO 80
   79 K=3
C     COMPUTE FLOODPLAIN RUNOFF
   80 DO 81 I=1,91
      IF(I.LE.41) 88,89
   88 RC(4) = RC1(4)
      GO TO 81
   89 RC(4) = RC2(4)
   81 F(I) = R(K,I)*AA*RC(4)/86.
C     HEREON TO 85 COMPUTE TOTAL DISCHARGE FOR A NODE
      DO 85 I=1,91
      SU1 = 0.
      SU2 = 0.
      DO 82 J=1,NG
      KK = IGC(J) - 100
   82 SU1 = SU1 + G(KK,I)
      QG(I) = SU1
      DO 83 J=1,NU
      KK = IUC(J)-200
   83 SU2 = SU2 + U(KK,I)
      QU(I) = SU2
   85 Q(I) = SU1+SU2+F(I)
      DO 509I=31,91
      II=I-30
  509 QQQ(JJJ,II)=Q(I)
  300 CONTINUE
      DO 310K=23,31
      DO 310J=1,61
  310 QQQ(K,J)=0.
      RETURN
      END
```

```
                    IDENT     DESNIN
PROGRAM LENGTH          24420

ENTRY POINTS
        DESNIN    22656

EXTERNAL SYMBOLS
        THEND,          02007111        QBQDICT,        EXPF            TSH
        QNSINGL,
   00411 SYMBOLS
```

```
      SUBROUTINE TIDAL1(I,DELT,OUT,PHASE)
C  SUBROUTINE TO GIVE THE WATER SURFACE ELEVATION ON THE SEA SIDE OF
C    THE BARRIER AT BALONGAY, WIND SET UP DUE TO TYPHOON IS INCLUDED,
C THIS SUBROUTINE IS ALSO USE TO GIVE SEA LEVEL AT BARCELONA
C  THIS SUBROUTINE MUST USE SUBROUTINE BMET
C  OUT IS THE WATER SURFACE ELEVATION ABOVE MSL, IN METER
C  I IS THE INDEX = 0,1,2,....,
C  DELT IS THE TIME INTERVAL IN HOUR
C  PHASE(INPUT) IS THE SHIFTING OF THE TIME OF OCCURANCE OF TYPHOON,
C    UNIT OF PHASE IS IN HOUR, EXAMPLE=  PHASE= 0, MEANS THE PEAK OF
C    TYPHOON TIDE COINCIDES WITH THE PEAK OF ASTRO TIDE, PHASE= 2,5
C    MEANS THE PEAK OF TYPHOON TIDE IS 2,5 HOURS AFTER THE PEAK OF
C    ASTRO TIDE( AT BALONGAY),
C  PHASE SHOULD BE BETWEEN 0, AND +24, HOURS,
C  NOTE- THE VALUE OF PHASE MUST BE THE SAME BOTH FOR TIDAL1 AND TIDAL2
      ETA(X)= 0.658*SIN((2,*3,1416*X)/12,421+1,571)
     $+0.116*SIN((2.*3,1416*X)/25,819-0,92)
     $+0.128*SIN((2,*3,1416*X)/23,934+0,393)
     $+0.122*SIN((2,*3,1416*X)/24,066+1,0)
     $+0.341*SIN((2,*3,1416*X)/11,967+0,543)
     $+0.098*SIN((2,*3,1416*X)/12,658+1,571)
     $+0.209*SIN((2,*3,1416*X)/354,366-0,922)
C  DAY= TIME IN DAY FROM THE ORIGIN OF TIME AXIS TO THE BEGINING OF
C    RAINFALL
      DAY=11,75
      TT= I*DELT
      T= TT+34,5-24,*DAY
      TASTRO= ETA(T)
      CALL BMET(DAY,TT,TMET,PHASE)
      OUT= TASTRO+TMET
      RETURN
      END
```



```
                                    IDENT    TIDAL1

PROGRAM LENGTH                 00222

ENTRY POINTS
        TIDAL1   00003

EXTERNAL SYMBOLS
        QBQDICT,        BMET            SINF
   00036 SYMBOLS
```

```
      SUBROUTINE BMET(DAY,TIN,ELE,PHASE)
C  SUBROUTINE TO GIVE THE VALUE OF TYPHOON TIDE AT BALONGAY FROM
C  MR. YAR ANALYSIS ROUTE NO. 2.
C  TIN IS IN HOUR, ELE IS IN METER ABOVE MSL
C  LINEAR INTERPOLATION IS USED
      DIMENSION Y(20),T(20)
      T(1)= 0.
      Y(1)= 0.
      T(2)= 24.*DAY+12.+PHASE
      Y(2)= 0.
      T(3)= T(2)+1.
      Y(3)= 0.1
      T(4)= T(3)+1.
      Y(4)= 0.68
      T(5)= T(4)+1.
      Y(5)= 1.75
      T(6)= T(5)+1.
      Y(6)= 2.36
      T(7)= T(6)+0.3
      Y(7)= 2.25
      T(8)= T(7)+0.2
      Y(8)= 1.8
      T(9)= T(8)+0.5
      Y(9)= 1.
      T(10)= T(9)+0.2
      Y(10)= 0.35
      T(11)= T(10)+0.3
      Y(11)= 0.2
      T(12)= T(11)+1.5
      Y(12)= 0.04
      T(13)= T(12)+2.
      Y(13)= 0.
      T(14)= T(13)+1000.
      Y(14)= 0.
      K= 14
      DO 1 I=1,K
      J= I
      IF(TIN.LT.T(I)) GO TO 2
    1 CONTINUE
    2 ELE= Y(J-1)+((Y(J)-Y(J-1))*(TIN-T(J-1)))/(T(J)-T(J-1))
      RETURN
```



```
                                    IDENT     BMET
PROGRAM LENGTH                 00252

ENTRY POINTS
        BMET      00053

EXTERNAL SYMBOLS
        OBJDICT,
   00042 SYMBOLS
```

```
      SUBROUTINE TIDAL2(I,DELT,OUT,PHASE)
C  SUBROUTINE TO GIVE THE WATER SURFACE ELEVATION AT PASACAO
C  WIND SET UP IS INCLUDED
C  THIS SUBROUTINE MUST USE SUBROUTINE PMET
C  OUT IS THE WATER SURFACE ELEVATION ABOVE MSL, IN METER
C  I IS THE INDEX - 0,1,2,...
C  DELT IS THE TIME INTERVAL IN HOUR
C  SEE FULL COMMENTS IN SUBROUTINE TIDAL1
      ETA(X)= 0.463*SIN((2.*3.1416*X)/12.421+0.867)
     $+0.241*SIN((2.*3.1416*X)/25.819+1.571)
     $+0.309*SIN((2.*3.1416*X)/23.934+0.198)
     $+0.299*SIN((2.*3.1416*X)/24.066+0.674)
C  DAY = TIME IN DAY FROM THE ORIGIN OF TIME AXIS TO THE BEGINING
C    OF RAINFALL
      DAY=11.75
      TT= I*DELT
      T= TT+33.5-24.*DAY
      TASTRO= ETA(T)
      CALL PMET(DAY,TT,TMET,PHASE)
      OUT= TASTRO+TMET
      RETURN
      END
```

```
5,4DS    TIDAL2

                                        IDENT     TIDAL2
PROGRAM LENGTH                 00165

ENTRY POINTS
        TIDAL2   00003

EXTERNAL SYMBOLS
        QBQDICT.        PMET            SINF
   00036 SYMBOLS
```

```
      SUBROUTINE PMET(DAY,TIN,ELE,PHASE)
C  SUBROUTINE TO GIVE THE VALUE OF TYPHOON TIME AT PASACAO FROM
C  MR, YAR ANALYSIS ROUTE NO, 2,
C  TIN IS IN HOUR, ELE IS IN METER ABOVE MT-
C  LINEAR INTERPOLATION IS USED
      DIMENSION Y(20),T(20)
      T(1)= 0,
      Y(1)= 0,
      T(2)= 24,*DAY+10,+PHASE
      Y(2)= 0,
      T(3)= T(2)+1,
      Y(3)= 0,08
      T(4)= T(3)+1,
      Y(4)= 0,47
      T(5)= T(4)+1,
      Y(5)= 1,03
      T(6)= T(5)+0,5
      Y(6)= 1,35
      T(7)= T(6)+0,5
      Y(7)= 2,2
      T(8)= T(7)+0,5
      Y(8)= 2,78
      T(9)= T(8)+0,5
      Y(9)= 2,58
      T(10)= T(9)+1,
      Y(10)= 1,72
      T(11)= T(10)+1,
      Y(11)= 1,
      T(12)= T(11)+1,
      Y(12)= 0,5
      T(13)= T(12)+1,
      Y(13)= 0,2
      T(14)= T(13)+1,
      Y(14)= 0,02
      T(15)= T(14)+1,
      Y(15)= 0,
      T(16)= T(15)+100
      Y(16)= 0,
      K= 16
      DO 1 I=1,K
      J= I
      IF(TIN.LT.T(I)) GO TO 2
1     CONTINUE
2     ELE= Y(J-1)+((Y(J)-Y(J-1))*(TIN-T(J-1)))/(T(J)-T(J-1))
      RETURN
      END
```

5,4DS PMET 12/30/74

```
                                    IDENT     PMET
PROGRAM LENGTH                 00255

ENTRY POINTS
        PMET      00053

EXTERNAL SYMBOLS
        QBQDICT,
   00042 SYMBOLS
```

## C2 HYDRAULIC AND GEOMETRIC CHARACTERISTICS OF THE SIPOCOT RIVER, BICOL RIVER AND THE PROPOSED FLOOD CONTROL SCHEMES

In the following pages are outlined: (1) the hydraulic characteristics of the diversion canals and the rivers and their berms; (2) geometry of the channels, reservoir and lakes; (3) hydrology data input; and (4) other relevant data input. The computer variable names are also given and correspondingly defined.

HYDRAULIC AND GEOMETRIC CHARACTERISTICS

'OR BICOL-SIPOCOT RIVERS AND FLOOD CONTROL SCHEMES

BICOL FLOOD CONTROL SIMULATION MODEL

ROUGHNESS COEFFICIENTS: LEFT BERM - MAIN CHANNEL - RIGHT BERM

ENX(I). ENM(I). ENY(I)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 5,0000 | 0,1600 | 5,0000 | 5,0000 | 0,1500 | 5,0000 | 5,0000 | 0,1250 | 5,0000 |
| 5,0000 | 0,1050 | 5,0000 | 5,0000 | 0,0750 | 5,0000 | 5,0000 | 0,0700 | 5,0000 |
| 5,0000 | 0,0620 | 5,0000 | 5,0000 | 0,0620 | 5,0000 | 0,0600 | 0,0195 | 0,0600 |
| 5,0000 | 0,0195 | 5,0000 | 0,0600 | 0,0210 | 0,0600 | 5,0000 | 0,0210 | 5,0000 |
| 0,0700 | 0,0220 | 0,0700 | 3,0000 | 0,0290 | 3,0000 | 6,0000 | 0,0345 | 6,0000 |
| 6,9000 | 0,0352 | 6,9000 | 6,9000 | 0,0352 | 6,9000 | 6,9000 | 0,0352 | 6,9000 |
| 6,7500 | 0,0350 | 6,7500 | 5,7000 | 0,0310 | 5,7000 | 4,9000 | 0,0290 | 4,9000 |
| 4,5000 | 0,0270 | 4,5000 | 4,9000 | 0,0300 | 4,9000 | 4,8500 | 0,0295 | 4,8500 |
| 5,0000 | 0,0290 | 5,0000 | 5,0000 | 1,0000 | 5,0000 | 5,0000 | 1,0000 | 5,0000 |
| 5,0000 | 1,0000 | 5,0000 | 5,0000 | 1,0000 | 5,0000 | 5,0000 | 1,0000 | 5,0000 |
| 5,0000 | 1,0000 | 5,0000 | 5,0000 | 1,0000 | 5,0000 | 5,0000 | 1,0000 | 5,0000 |
| 5,0000 | 0,0250 | 5,0000 | | | | | | |

DISTANCE INTERVALS FOR MAIN CHANNEL IN KILOMETERS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6000,000 | 7000,000 | 10000,000 | 8000,000 | 8000,000 | 8000,000 | 4000,000 | 2500,000 |
| 8000,000 | 3200,000 | 8500,000 | 1750,000 | 7500,000 | 10000,000 | 6000,000 | 4500,000 |
| 4500,000 | 7000,000 | 2000,000 | 3500,000 | 3500,000 | 7000,000 | 1000,000 | 7250,000 |
| 10500,000 | 4000,000 | 6000,000 | 6000,000 | 6000,000 | 6000,000 | 2800,000 | 2800,000 |
| 2800,000 | 5700,010 | | | | | | |

DISTANCE INTERVALS FOR LEFT BERM IN KILOMETERS

DELXX(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6000,000 | 7000,000 | 10000,000 | 8000,000 | 8000,000 | 8000,000 | 4000,000 | 2500,000 |
| 1650,000 | 3200,000 | 4250,000 | 1750,000 | 4650,000 | 5500,000 | 3750,000 | 2400,000 |
| 2750,000 | 3600,000 | 950,000 | 3500,000 | 1700,000 | 4450,000 | 1000,000 | 5500,000 |
| 10500,000 | 4000,000 | 6000,000 | 6000,000 | 6000,000 | 6000,000 | 2800,000 | 2800,000 |
| 2800,000 | 5700,010 | | | | | | |

DISTANCE INTERVALS FOR RIGHT BERM IN KILOMETERS

DELXY(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6000,000 | 7000,000 | 10000,000 | 8000,000 | 8000,000 | 8000,000 | 4000,000 | 2500,000 |
| 1650,000 | 3200,000 | 4250,000 | 1750,000 | 4650,000 | 5500,000 | 3750,000 | 2400,000 |
| 2750,000 | 3600,000 | 950,000 | 3500,000 | 1700,000 | 4450,000 | 1000,000 | 5500,000 |
| 10500,000 | 4000,000 | 6000,000 | 6000,000 | 6000,000 | 6000,000 | 2800.000 | 2800.000 |
| 2800,000 | 5700,010 | | | | | | |

LEFT AND RIGHT BANK ELEVATIONS AT MIDDLE OF BRANCHES IN METERS
MAIN CHANNEL

EX(I), EY(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 1,400 | 1,400 | 100,000 | 100,000 | 1,350 | 1,350 | 100,000 | 100,000 |
| 1,400 | 1,400 | 2,500 | 2,500 | 2,800 | 2,800 | 3,850 | 3,850 |
| 5,000 | 5,000 | 6,300 | 6,300 | 6,900 | 6,900 | 7,000 | 7,000 |
| 7,050 | 7,050 | 7,600 | 7,600 | 8,700 | 8,700 | 8,700 | 8,700 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 1,100 | 1,100 | | | | |

LEFT AND RIGHT BANK ELEVATIONS AT UPSTREAM [illegible]
MAIN CHANNEL

EXUS(I), EYUS(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 1,600 | 1,600 | 100,000 | 100,000 | 1,100 | 1,100 | 100,000 | 100,000 |
| 1,700 | 1,700 | 3,300 | 3,300 | 3,500 | 3,500 | 4,200 | 4,200 |
| 5,800 | 5,800 | 6,800 | 6,800 | 7,000 | 7,000 | 7,000 | 7,000 |
| 7,100 | 7,100 | 8,700 | 8,700 | 8,700 | 8,700 | 8,700 | 8,700 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 1,200 | 1,200 | | | | |

LEFT AND RIGHT BANK ELEVATIONS AT DOWNSTREAM OF BRANCHES IN METERS
MAIN CHANNEL

EXDS(I), EYDS(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 100,000 | 100,000 | 100,000 | 100,000 | 100.000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100.000 | 100,000 | 100,000 | 100,000 |
| 1,200 | 1,200 | 100,000 | 100,000 | 1.600 | 1,600 | 100,000 | 100,000 |
| 1,100 | 1,100 | 1,700 | 1,700 | 3.300 | 3,300 | 3,500 | 3,500 |
| 4,200 | 4,200 | 5,800 | 5,800 | 6.800 | 6,800 | 7,000 | 7,000 |
| 7,000 | 7,000 | 7,100 | 7,100 | 8.700 | 8,700 | 8,700 | 8,700 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100.000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100.000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 1,200 | 1.200 | | | | |

SPECIFIC ELEVATIONS OF MIDDLE CROSS SECTIONS OF BRANCHES IN METERS
MAIN CHANNEL

E1(I), E2(I), E3(I), E4(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 10,000 | 11,800 | 17,200 | 21,400 | 7,100 | 8,900 | 14,300 | 18,500 |
| 2,950 | 4,750 | 10,150 | 14,350 | -0,200 | 1,700 | 7,200 | 11,300 |
| -1,350 | -0,700 | 1,200 | 4,000 | -2,250 | -1,450 | 0,100 | 2,000 |
| -3,000 | -2,400 | -1,000 | 1,100 | -2,500 | -2,000 | -1,000 | 1,500 |
| -2,000 | -1,000 | 0,300 | 2,000 | -2,500 | -1,100 | 0,150 | 1,700 |
| -4,500 | -3,250 | -0,850 | 1,250 | -2,250 | -1,150 | 0,100 | 1,100 |
| -3,100 | -1,000 | 0,250 | 1,500 | -2,300 | -1,850 | -0,250 | 3,500 |
| -1,550 | -0,200 | 1,000 | 3,500 | -0,450 | 0,950 | 2,250 | 4,600 |
| -0,900 | -0,250 | 1,250 | 3,250 | 1,500 | 3,000 | 5,500 | 8,500 |
| 2,600 | 6,000 | 7,250 | 8,400 | 4,100 | 6,350 | 7,250 | 9,500 |
| 3,900 | 4,700 | 6,250 | 8,600 | 2,000 | 3,200 | 4,550 | 7,500 |
| 1,500 | 3,000 | 5,000 | 8,300 | 2,400 | 3,500 | 4,500 | 7,000 |
| -2,700 | -1,233 | -0,233 | 0,767 | -2,060 | 1,000 | 4,000 | 8,000 |
| -2,520 | 0,400 | 3,400 | 7,400 | -3,080 | 0,000 | 3,000 | 7,000 |
| -3,620 | -0,620 | 2,400 | 6,400 | -4,150 | -1,200 | 1,800 | 5,800 |
| -0,440 | 2,640 | 5,640 | 8,640 | -0,900 | 2,100 | 5,100 | 9,100 |
| -1,320 | 1,720 | 4,720 | 8,720 | -4,000 | -2,350 | -0,750 | 1,000 |

SPECIFIC TOPWIDTHS OF MIDDLE CROSS SECTIONS OF BRANCHES IN METERS
MAIN CHANNEL

T1(I), T2(I), T3(I), T4(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 30,000 | 52,000 | 78,000 | 90,000 | 30.000 | 52,000 | 78,000 | 90,000 |
| 30,000 | 52,000 | 78,000 | 90,000 | 30.000 | 52,000 | 78,000 | 90,000 |
| 63,000 | 93,000 | 104,000 | 115,000 | 70.000 | 111,000 | 156,000 | 180,000 |
| 27,000 | 42,000 | 64,000 | 84,000 | 59.000 | 78,000 | 88,000 | 102,000 |
| 50,000 | 77,500 | 118,000 | 140,000 | 42,500 | 45,000 | 47,500 | 50,000 |
| 52,000 | 96,000 | 130,000 | 161,000 | 42,500 | 45,000 | 47,500 | 50,000 |
| 41,000 | 62,000 | 85,000 | 108,000 | 25.000 | 41,000 | 57,500 | 70,000 |
| 35,500 | 47,500 | 57,500 | 64,500 | 42.000 | 48,000 | 55,000 | 66,500 |
| 37,000 | 44,500 | 56,000 | 65,000 | 26,000 | 41,000 | 57,000 | 71,000 |
| 33,000 | 58,000 | 83,000 | 106,000 | 25,000 | 37,500 | 50,000 | 64,500 |
| 15,000 | 27,000 | 47,500 | 55,000 | 26,000 | 36,000 | 47,000 | 62,000 |
| 27,500 | 36,500 | 52,500 | 67,500 | 33.000 | 50,000 | 67,000 | 75,000 |
| 40,000 | 45,600 | 50,000 | 53,870 | 17,600 | 23,600 | 29,600 | 37,600 |
| 28,800 | 34,800 | 40,800 | 48,800 | 28,800 | 34,800 | 40,800 | 48,800 |
| 39,800 | 45,800 | 51,800 | 59,800 | 49,600 | 55,600 | 61,600 | 69,600 |
| 28,800 | 34,800 | 40,800 | 48,800 | 28,800 | 34,800 | 40,800 | 48,800 |
| 28,800 | 34,800 | 40,800 | 48,800 | 220.000 | 360.000 | 525.000 | 700.000 |

SPECIFIC AREAS OF MIDDLE CROSS SECTIONS OF BRANCHES IN METERS
MAIN CHANNEL

AO(I), AH(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 102,500 | 789,200 | 102,500 | 789,200 | 102,500 | 789,200 | 102,500 | 789,200 |
| 102,100 | 588,050 | 123,800 | 658,800 | 46,600 | 261,040 | 73,370 | 392,020 |
| 88,500 | 381,100 | 119,000 | 252,000 | 176,600 | 827,300 | 95,600 | 202,000 |
| 141,970 | 345,770 | 27,700 | 328,000 | 73,250 | 306,700 | 108,950 | 328,400 |
| 50,900 | 267,000 | 72,960 | 367,700 | 164,000 | 341,500 | 99,200 | 273,100 |
| 25,570 | 209,900 | 27,890 | 180,140 | 85,030 | 375,700 | 84,800 | 315,000 |
| 62,800 | 162,100 | 61,500 | 275,000 | 95,400 | 388,000 | 95,400 | 388,000 |
| 128,400 | 498,000 | 157,500 | 595,000 | 95,400 | 388,000 | 95,400 | 388,000 |
| 95,400 | 388,000 | 662,500 | 2505,000 | | | | |

SPECIFIC ELEVATIONS OF UPSTREAM CROSS SECTIONS OF BRANCHES IN METERS
MAIN CHANNEL

EUS1(I), EUS2(I), EUS3(I), EUS4(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 11,450 | 13,250 | 18,650 | 22,850 | 8,650 | 10,450 | 15,850 | 20,050 |
| 5,400 | 7,200 | 12,600 | 16,800 | 0,350 | 2,250 | 7,750 | 11,850 |
| -1,150 | -0,500 | 1,400 | 4,200 | -1,650 | -0,850 | 0,700 | 2,600 |
| -3,000 | -2,400 | -1,000 | 1,100 | -3,000 | -2,500 | -1,500 | 1,000 |
| -1,400 | -0,400 | 0,900 | 2,600 | -2,340 | -0,940 | 0,310 | 1,860 |
| -4,200 | -2,950 | -0,550 | 1,550 | -2,160 | -1,060 | 0,190 | 1,190 |
| -1,900 | 0,200 | 1,450 | 2,700 | -2,300 | -1,850 | -0,250 | 3,500 |
| -1,350 | 0,000 | 1,200 | 3,700 | -0,250 | 1,150 | 2,450 | 4,800 |
| -0,400 | 0,250 | 1,750 | 3,750 | 2,550 | 4,050 | 6,550 | 9,550 |
| 3,400 | 6,800 | 8,050 | 9,200 | 4,400 | 6,650 | 7,550 | 9,800 |
| 3,900 | 4,700 | 6,250 | 8,600 | 0,200 | 1,400 | 2,750 | 5,700 |
| 1,700 | 3,200 | 5,200 | 8,500 | 3,400 | 4,500 | 5,500 | 8,000 |
| -2,000 | -0,533 | 0,467 | 1,467 | -1,860 | 1,200 | 4,200 | 8,200 |
| -2,260 | 0,660 | 3,660 | 7,660 | -2,800 | 0,280 | 3,280 | 7,280 |
| -3,360 | -0,340 | 2,660 | 6,660 | -3,880 | -0,930 | 2,070 | 6,070 |
| -0,210 | 2,870 | 5,870 | 8,870 | -0,680 | 2,320 | 5,320 | 9,320 |
| -1,120 | 1,920 | 4,920 | 8,920 | -2,500 | -0,850 | 0,750 | 2,500 |

SPECIFIC TOPWIDTHS OF UPSTREAM CROSS SECTIONS OF BRANCHES IN METERS
MAIN CHANNEL

TUS1(I), TUS2(I), TUS3(I), TUS4(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 30,000 | 52,000 | 78,000 | 90,000 | 30,000 | 52,000 | 78,000 | 90,000 |
| 30,000 | 52,000 | 78,000 | 90,000 | 30,000 | 52,000 | 78,000 | 90,000 |
| 63,000 | 93,000 | 104,000 | 115,000 | 70,000 | 111,000 | 156,000 | 180,000 |
| 27,000 | 42,000 | 64,000 | 84,000 | 59,000 | 78,000 | 88,000 | 102,000 |
| 50,000 | 77,500 | 118,000 | 140,000 | 42,500 | 45,000 | 47,500 | 50,000 |
| 52,000 | 96,000 | 130,000 | 161,000 | 42,500 | 45,000 | 47,500 | 50,000 |
| 41,000 | 62,000 | 85,000 | 108,000 | 25,000 | 41,000 | 57,500 | 70,000 |
| 35,500 | 47,500 | 57,500 | 64,500 | 42,000 | 48,000 | 55,000 | 66,500 |
| 37,000 | 44,500 | 56,000 | 65,000 | 26,000 | 41,000 | 57,000 | 71,000 |
| 33,000 | 58,000 | 83,000 | 106,000 | 25,000 | 37,500 | 50,000 | 64,500 |
| 15,000 | 27,000 | 47,500 | 55,000 | 26,000 | 36,000 | 47,000 | 62,000 |
| 27,500 | 36,500 | 52,500 | 67,500 | 33,000 | 50,000 | 67,000 | 75,000 |
| 40,000 | 45,600 | 50,000 | 53,870 | 17,600 | 23,600 | 29,600 | 37,600 |
| 28,800 | 34,800 | 40,800 | 48,800 | 28,800 | 34,800 | 40,800 | 48,800 |
| 39,800 | 45,800 | 51,800 | 59,800 | 49,600 | 55,600 | 61,600 | 69,600 |
| 28,800 | 34,800 | 40,800 | 48,800 | 28,800 | 34,800 | 40,800 | 48,800 |
| 28,800 | 34,800 | 40,800 | 48,800 | 220,000 | 360,000 | 525,000 | 700,000 |

SPECIFIC AREAS OF UPSTREAM CROSS SECTIONS OF BRANCHES IN METERS
MAIN CHANNEL

AOUS(I), AHUS(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 102,500 | 789,200 | 102,500 | 789,200 | 102,500 | 789,200 | 102,500 | 789,200 |
| 102,100 | 588,050 | 123,800 | 658,800 | 46,600 | 261,040 | 73,370 | 392,020 |
| 88,500 | 381,100 | 119,000 | 252,000 | 176,600 | 827,300 | 95,600 | 202,000 |
| 141,970 | 345,770 | 27,700 | 328,000 | 73,250 | 306,700 | 103,950 | 328,400 |
| 50,900 | 267,000 | 72,960 | 367,700 | 164,000 | 341,500 | 99,200 | 273,100 |
| 25,570 | 209,900 | 27,890 | 180,140 | 85,030 | 375,700 | 84,800 | 315,000 |
| 62,800 | 162,100 | 61,500 | 275,000 | 95,400 | 388,000 | 95,400 | 388,000 |
| 128,400 | 498,000 | 157,500 | 595,000 | 95,400 | 388,000 | 95,400 | 388,000 |
| 95,400 | 388,000 | 662,500 | 2505,000 | | | | |

SPECIFIC ELEVATIONS OF DOWNSTREAM CROSS SECTIONS OF BRANCHES IN METERS
MAIN CHANNEL

EDS1(I), EDS2(I), EDS3(I), EDS4(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 8,550 | 10,350 | 15,750 | 19,950 | 5,550 | 7,350 | 12,750 | 16,950 |
| 0,500 | 2,300 | 7,700 | 11,900 | -0,850 | 1,050 | 6,550 | 10,650 |
| -1,650 | -1,000 | 0,900 | 3,700 | -2,950 | -2,150 | -0,600 | 1,300 |
| -3,000 | -2,400 | -1,000 | 1,100 | -1,900 | -1,400 | -0,400 | 2,100 |
| -2,600 | -1,600 | -0,300 | 1,400 | -2,660 | -1,260 | -0,010 | 1,540 |
| -1,600 | -0,350 | 2,050 | 4,150 | -2,340 | -1,240 | 0,010 | 1,010 |
| -4,300 | -2,200 | -0,950 | 0,300 | -2,300 | -1,850 | -0,250 | 3,500 |
| -1,750 | -0,400 | 0,800 | 3,300 | -0,650 | 0,750 | 2,050 | 4,400 |
| -1,400 | -0,750 | 0,750 | 2,750 | 0,450 | 1,950 | 4,450 | 7,450 |
| 1,800 | 5,200 | 6,450 | 7,600 | 3,900 | 6,150 | 7,050 | 9,300 |
| 3,900 | 4,700 | 6,250 | 8,600 | 3,800 | 5,000 | 6,350 | 9,300 |
| 1,300 | 2,800 | 4,800 | 8,100 | 1,400 | 2,500 | 3,500 | 6,000 |
| -3,400 | -1,933 | -0,933 | 0,067 | -2,260 | 0,800 | 3,800 | 7,800 |
| -2,800 | 0,120 | 3,120 | 7,120 | -3,360 | -0,280 | 2,720 | 6,720 |
| -3,880 | -0,860 | 2,140 | 6,140 | -4,420 | -1,470 | 1,530 | 5,530 |
| -0,680 | 2,400 | 5,400 | 8,400 | -1,130 | 1,870 | 4,870 | 8,870 |
| -1,540 | 1,500 | 4,500 | 8,500 | -5,500 | -3,850 | -2,250 | -0,500 |

SPECIFIC TOPWIDTHS OF DOWNSTREAM CROSS SECTIONS OF BRANCHES IN METERS
MAIN CHANNEL

TDS1(I), TDS2(I), TDS3(I), TDS4(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 30,000 | 52,000 | 78,000 | 90,000 | 30,000 | 52,000 | 78,000 | 90,000 |
| 30,000 | 52,000 | 78,000 | 90,000 | 30,000 | 52,000 | 78,000 | 90,000 |
| 63,000 | 93,000 | 104,000 | 115,000 | 70,000 | 111,000 | 156,000 | 180,000 |
| 27,000 | 42,000 | 64,000 | 84,000 | 59,000 | 78,000 | 88,000 | 102,000 |
| 50,000 | 77,500 | 118,000 | 140,000 | 42,500 | 45,000 | 47,500 | 50,000 |
| 52,000 | 96,000 | 130,000 | 161,000 | 42,500 | 45,000 | 47,500 | 50,000 |
| 41,000 | 62,000 | 85,000 | 108,000 | 25,000 | 41,000 | 57,500 | 70,000 |
| 35,500 | 47,500 | 57,500 | 64,500 | 42,000 | 48,000 | 55,000 | 66,500 |
| 37,000 | 44,500 | 56,000 | 65,000 | 26,000 | 41,000 | 57,000 | 71,000 |
| 33,000 | 58,000 | 83,000 | 106,000 | 25,000 | 37,500 | 50,000 | 64,500 |
| 15,000 | 27,000 | 47,500 | 55,000 | 26,000 | 36,000 | 47,000 | 62,000 |
| 27,700 | 36,500 | 52,500 | 67,500 | 33,800 | 50,000 | 67,000 | 75,000 |
| 40,000 | 45,600 | 50,000 | 53,870 | 17,600 | 23,600 | 29,600 | 37,600 |
| 28,800 | 34,800 | 40,800 | 48,800 | 28,800 | 34,800 | 40,800 | 48,800 |
| 39,800 | 45,800 | 51,800 | 59,800 | 49,600 | 55,600 | 61,600 | 69,600 |
| 28,800 | 34,800 | 40,800 | 48,800 | 28,800 | 34,800 | 40,800 | 48,800 |
| 28,800 | 34,800 | 40,800 | 48,800 | 220,000 | 560,000 | 525,000 | 700,000 |

SPECIFIC AREAS OF DOWNSTREAM CROSS SECTIONS OF BRANCHES IN METERS
MAIN CHANNEL

AODS(I), AHDS(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 102,500 | 789,200 | 102,500 | 789,200 | 102,500 | 789,200 | 102,500 | 789,200 |
| 102,100 | 588,050 | 123,800 | 658,600 | 46,600 | 261,040 | 73,370 | 392,020 |
| 88,500 | 381,100 | 119,000 | 252,000 | 176,600 | 827,300 | 95,600 | 202,000 |
| 141,970 | 345,770 | 27,700 | 328,000 | 73,250 | 306,700 | 108,950 | 328,400 |
| 50,900 | 267,000 | 72,960 | 367,700 | 164,000 | 341,500 | 99,200 | 273,100 |
| 25,570 | 209,900 | 27,890 | 180,140 | 85,030 | 375,700 | 84,800 | 315,000 |
| 62,800 | 162,100 | 61,500 | 275,000 | 95,400 | 388,000 | 95,400 | 388,000 |
| 128,400 | 498,000 | 157,500 | 595,000 | 95,400 | 388,000 | 95,400 | 388,000 |
| 95,400 | 388,000 | 662,500 | 2505,000 | | | | |

SPECIFIC ELEVATIONS OF MIDDLE CROSS SECTIONS OF BRANCHES IN METERS
DEEPENING SECTIONS, MAIN CHANNEL

EE1(I), EE2(I), EE3(I), EE4(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4,000 | 4,850 | 6,000 | 8,400 | 5,000 | 7,350 | 8,500 | 9,500 |
| 5,000 | 7,000 | 7,700 | 8,550 | 4,000 | 5,250 | 6,500 | 7,500 |

SPECIFIC TOPWIDTHS OF MIDDLE CROSS SECTIONS OF BRANCHES IN METERS
DEEPENING SECTIONS, MAIN CHANNEL

TT1(I), TT2(I), TT3(I), TT4(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 50,000 | 50,000 | 58,000 | 107,000 | 50,000 | 50,000 | 57,500 | 64,500 |
| 50,000 | 50,000 | 52,500 | 55,000 | 50,000 | 50,000 | 57,000 | 62,000 |

SPECIFIC AREAS OF UPSTREAM CROSS SECTIONS OF BRANCHES IN METERS
DEEPENING SECTIONS, MAIN CHANNEL

AAO(I), AAH(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 142,500 | 402,600 | 268,000 | 391,000 | 250,000 | 331,500 | 172,300 | 298,300 |

SPECIFIC ELEVATIONS OF UPSTREAM CROSS SECTIONS OF BRANCHES IN METERS
DEEPENING SECTIONS, MAIN CHANNEL

EEUS1(I), EEUS2(I), EEUS3(I), EEUS4(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4,800 | 5,650 | 6,800 | 9,200 | 5,300 | 7,650 | 8,800 | 9,800 |
| 5,000 | 7,000 | 7,700 | 8,550 | 2,200 | 3.450 | 4,700 | 5,700 |

SPECIFIC TOPWIDTHS OF UPSTREAM CROSS SECTIONS OF BRANCHES IN METERS
DEEPENING SECTIONS, MAIN CHANNEL

TTUS1(I), TTUS2(I), TTUS3(I), TTUS4(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 50,000 | 50,000 | 58,000 | 107,000 | 50,000 | 50,000 | 57,500 | 64,500 |
| 50,000 | 50,000 | 52,500 | 55,000 | 50,000 | 50,000 | 57,000 | 62,000 |

SPECIFIC AREAS OF UPSTREAM CROSS SECTIONS OF BRANCHES IN METERS
DEEPENING SECTIONS, MAIN CHANNEL

AAOUS(I), AAHUS(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 142,500 | 402,600 | 268,000 | 391,000 | 250,000 | 331,500 | 172,300 | 298,300 |

SPECIFIC ELEVATIONS OF DOWNSTREAM CROSS SECTIONS OF BRANCHES IN METERS
DEEPENING SECTIONS, MAIN CHANNEL

EEDS1(I), EEDS2(I), EEDS3(I), EEDS4(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3,200 | 4,050 | 5,200 | 7,600 | 4,800 | 7,150 | 8,300 | 9,300 |
| 5,000 | 7,000 | 7,700 | 8,550 | 5,800 | 7,050 | 8,300 | 9,300 |

SPECIFIC TOPWIDTHS OF DOWNSTREAM CROSS SECTIONS OF BRANCHES IN METERS
DEEPENING SECTIONS, MAIN CHANNEL

TTDS1(I), TTDS2(I), TTDS3(I), TTDS4(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 50,000 | 50,000 | 58,000 | 107,000 | 50,000 | 50,000 | 57,500 | 64,500 |
| 50,000 | 50,000 | 52,500 | 55,000 | 50,000 | 50,000 | 57,000 | 62,000 |

SPECIFIC AREAS OF DOWNSTREAM CROSS SECTIONS OF BRANCHES IN METERS
DEEPENING SECTIONS, MAIN CHANNEL

AAODS(I), AAHDS(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 142,500 | 402,600 | 268,000 | 391,000 | 250,000 | 331,500 | 172,300 | 298,300 |

SPECIFIC ELEVATIONS OF MIDDLE CROSS SECTIONS OF BRANCHES IN METERS
RIGHT BERM

EY1(I), EY2(I), EY3(I)

| | | | | | |
|---|---|---|---|---|---|
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 1,900 | 3,100 | 5,000 | 100,000 | 100,000 | 100,000 |
| 2,000 | 3,500 | 5,000 | 100,000 | 100,000 | 100,000 |
| 2,500 | 3,700 | 5,000 | 5,000 | 7,100 | 10,000 |
| 5,000 | 10,000 | 15,000 | 10,000 | 10,000 | 15,000 |
| 10,000 | 10,000 | 15,000 | 10,000 | 13,800 | 15,000 |
| 10,000 | 12,100 | 15,000 | 7,350 | 7,350 | 10,000 |
| 7,200 | 7,200 | 10,000 | 8,100 | 8,100 | 10,000 |
| 8,700 | 8,700 | 10,000 | 8,700 | 9,600 | 10,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 2,600 | 3,500 | 5,000 |

SPECIFIC TOPWIDTHS OF MIDDLE CROSS SECTIONS OF BRANCHES IN METERS
RIGHT BERM

TY1(I), TY2(I), TY3(I)

| | | | | | |
|---|---|---|---|---|---|
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 3300,000 | 7800,000 | 14500,000 | 0,000 | 0,000 | 0,000 |
| 3300,000 | 8200,000 | 13400,000 | 0,000 | 0,000 | 0,000 |
| 1400,000 | 3300,000 | 5200,000 | 1050,000 | 1650,000 | 2450,000 |
| 50,000 | 1500,000 | 2400,000 | 50,000 | 2700,000 | 3700,000 |
| 100,000 | 1000,000 | 3550,000 | 100,000 | 3400,000 | 4400,000 |
| 3300,000 | 4350,000 | 5750,000 | 2000,000 | 3100,000 | 3250,000 |
| 2000,000 | 4700,000 | 5000,000 | 3000,000 | 5700,000 | 6600,000 |
| 3000,000 | 6000,000 | 7200,000 | 1250,000 | 2550,000 | 2900,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 3700,000 | 6250,000 | 10100,000 |

SPECIFIC ELEVATIONS OF UPSTREAM CROSS SECTIONS OF BRANCHES IN METERS
RIGHT BERM

EYUS1(I), EYUS2(I), EYUS3(I)

| | | | | | |
|---|---|---|---|---|---|
| 100,000 | 100,000 | 100,000 | 100,000 | 100.000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100.000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100.000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100.000 | 100,000 |
| 2,000 | 3,100 | 5,000 | 100,000 | 100.000 | 100,000 |
| 2,300 | 3,500 | 5,000 | 100,000 | 100,000 | 100,000 |
| 2,500 | 3,800 | 5,000 | 5,000 | 10.000 | 15,000 |
| 5,000 | 5,000 | 12,500 | 10,000 | 10,000 | 22,900 |
| 10,000 | 15,000 | 15,000 | 10,000 | 13.900 | 15,000 |
| 10,000 | 10,000 | 12,000 | 7,100 | 8,300 | 10,000 |
| 7,600 | 7,600 | 7,600 | 8,800 | 10,000 | 10,000 |
| 9,150 | 10,000 | 10,000 | 8,700 | 9,600 | 10,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100.000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 2.700 | 3.600 | 5.100 |

SPECIFIC TOPWIDTHS OF UPSTREAM CROSS SECTIONS OF BRANCHES IN METERS
RIGHT BERM

TYUS1(I), TYUS2(I), TYUS3(I)

| | | | | | |
|---|---|---|---|---|---|
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 3500,000 | 7500,000 | 12000,000 | 0,000 | 0,000 | 0,000 |
| 4000,000 | 7000,000 | 10900,000 | 0,000 | 0,000 | 0,000 |
| 270,000 | 780,000 | 1250,000 | 100,000 | 1050,000 | 1840,000 |
| 350,000 | 1500,000 | 2450,000 | 400,000 | 1100,000 | 2300,000 |
| 3000,000 | 3300,000 | 3400,000 | 100,000 | 3650,000 | 4700,000 |
| 2900,000 | 3400,000 | 4000,000 | 4500,000 | 4800,000 | 5200,000 |
| 1000,000 | 3000,000 | 3900,000 | 3000,000 | 6300,000 | 7000,000 |
| 3000,000 | 6400,000 | 7100,000 | 1250,000 | 2550,000 | 2900,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0.000 | 0.000 | 0,000 | 3700,000 | 6250,000 | 10100,000 |

SPECIFIC ELEVATIONS OF DOWNSTREAM CROSS SECTIONS OF BRANCHES IN METERS
RIGHT BERM

EYDS1(I), EYDS2(I), EYDS3(I)

| | | | | | |
|---|---|---|---|---|---|
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 2,500 | 3,700 | 5,000 | 100,000 | 100,000 | 100,000 |
| 2,000 | 3,100 | 5,000 | 100,000 | 100,000 | 100,000 |
| 2,300 | 3,500 | 5,000 | 3,300 | 3,800 | 5,000 |
| 5,000 | 10,000 | 15,000 | 5,000 | 5,000 | 12,500 |
| 10,000 | 10,000 | 22,900 | 10,000 | 15,000 | 15,000 |
| 10,000 | 13,900 | 15,000 | 10,000 | 10,000 | 12,000 |
| 7,100 | 8,300 | 10,000 | 8,700 | 8,700 | 8,700 |
| 8,800 | 10,000 | 10,000 | 9,150 | 10,000 | 10,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 2,700 | 3,600 | 5,100 |

SPECIFIC TOPWIDTHS OF DOWNSTREAM CROSS SECTIONS OF BRANCHES IN METERS
RIGHT BERM

TYDS1(I), TYDS2(I), TYDS3(I)

| | | | | | |
|---|---|---|---|---|---|
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 3900,000 | 8100,000 | 12900,000 | 0,000 | 0,000 | 0,000 |
| 3500,000 | 7500,000 | 12000,000 | 0,000 | 0,000 | 0,000 |
| 4000,000 | 7000,000 | 10900,000 | 270,000 | 780,000 | 1250,000 |
| 100,000 | 1050,000 | 1840,000 | 350,000 | 1500,000 | 2450,000 |
| 400,000 | 1100,000 | 2300,000 | 3000,000 | 3300,000 | 3400,000 |
| 100,000 | 3650,000 | 4700,000 | 2900,000 | 3400,000 | 4000,000 |
| 4500,000 | 4800,000 | 5200,000 | 1000,000 | 3000,000 | 3900,000 |
| 3000,000 | 6300,000 | 7000,000 | 3000,000 | 6400,000 | 7100,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 3700,000 | 6250,000 | 10100,000 |

SPECIFIC ELEVATIONS OF MIDDLE CROSS SECTIONS OF BRANCHES IN METERS
LEFT BERM

EX1(I), EX2(I), EX3(I)

| | | | | | |
|---|---|---|---|---|---|
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 3,000 | 3,900 | 5,000 | 100,000 | 100,000 | 100,000 |
| 2,200 | 3,500 | 5,000 | 100,000 | 100,000 | 100,000 |
| 2,200 | 3,500 | 5,000 | 4,500 | 5,000 | 10,000 |
| 3,000 | 5,000 | 10,000 | 12,500 | 30,000 | 30,000 |
| 10,000 | 15,000 | 15,000 | 10,000 | 20,000 | 30,000 |
| 8,500 | 10,000 | 10,500 | 7,000 | 8,700 | 10,000 |
| 7,300 | 7,300 | 10,000 | 10,000 | 10,000 | 20,000 |
| 10,000 | 20,000 | 25,000 | 10,000 | 16,200 | 20,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 2,000 | 3,000 | 5,000 |

SPECIFIC TOPWIDTHS OF MIDDLE CROSS SECTIONS OF BRANCHES IN METERS
LEFT BERM

TX1(I), TX2(I), TX3(I)

| | | | | | |
|---|---|---|---|---|---|
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 1050,000 | 1600,000 | 2350,000 | 0,000 | 0,000 | 0,000 |
| 1000,000 | 2000,000 | 3150,000 | 0,000 | 0,000 | 0,000 |
| 1300,000 | 3800,000 | 5400,000 | 5350,000 | 6400,000 | 6800,000 |
| 400,000 | 1400,000 | 2350,000 | 270,000 | 450,000 | 750,000 |
| 50,000 | 100,000 | 1000,000 | 700,000 | 850,000 | 1350,000 |
| 150,000 | 300,000 | 350,000 | 350,000 | 500,000 | 600,000 |
| 550,000 | 1140,000 | 1850,000 | 150,000 | 500,000 | 600,000 |
| 50,000 | 350,000 | 650,000 | 650,000 | 1450,000 | 1900,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 1360,000 | 3100,000 | 6550,000 |

SPECIFIC ELEVATIONS OF UPSTREAM CROSS SECTIONS OF BRANCHES IN METERS
LEFT BERM

EXUS1(I), EXUS2(I), EXUS3(I)

| | | | | | |
|---|---|---|---|---|---|
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 2,800 | 4,000 | 5,000 | 100,000 | 100,000 | 100,000 |
| 2,500 | 3,500 | 5,000 | 100,000 | 100,000 | 100,000 |
| 3,000 | 4,000 | 5,000 | 5,000 | 5,000 | 10,000 |
| 10,000 | 15,000 | 15,000 | 10,000 | 12,500 | 23,000 |
| 10,000 | 20,000 | 22,500 | 12,000 | 20,000 | 28,000 |
| 7,900 | 8,900 | 10,000 | 8,000 | 9,000 | 10,000 |
| 7,500 | 10,000 | 20,000 | 10,000 | 20,000 | 25,000 |
| 13,000 | 20,000 | 25,000 | 10,000 | 16,200 | 20,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 2,100 | 3,100 | 5,100 |

SPECIFIC TOPWIDTHS OF UNSTREAM CROSS SECTIONS OF BRANCHES IN METERS
LEFT BERM

TXUS1(I), TXUS2(I), TXUS3(I)

| | | | | | |
|---|---|---|---|---|---|
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 1020,000 | 2140,000 | 3100,000 | 0,000 | 0,000 | 0,000 |
| 1100,000 | 2360,000 | 4440,000 | 0,000 | 0,000 | 0,000 |
| 3000,000 | 5500,000 | 8200,000 | 100,000 | 3800,000 | 4350,000 |
| 1200,000 | 1550,000 | 1850,000 | 40,000 | 1000,000 | 1100,000 |
| 500,000 | 650,000 | 800,000 | 650,000 | 950,000 | 1050,000 |
| 200,000 | 450,000 | 700,000 | 380,000 | 720,000 | 1100,000 |
| 1000,000 | 1850,000 | 2250,000 | 50,000 | 600,000 | 1000,000 |
| 210,000 | 600,000 | 750,000 | 650,000 | 1450,000 | 1900,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 1360,000 | 3100,000 | 6550,000 |

SPECIFIC ELEVATIONS OF DOWNSTREAM CROSS SECTIONS OF BRANCHES IN METERS
LEFT BERM

EXDS1(I), EXDS2(I), EXDS3(I)

| | | | | | |
|---|---|---|---|---|---|
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 2,000 | 3,300 | 5,000 | 100,000 | 100,000 | 100,000 |
| 2,800 | 4,000 | 5,000 | 100,000 | 100,000 | 100,000 |
| 2,500 | 3,500 | 5,000 | 3,300 | 4,000 | 5,000 |
| 5,000 | 5,000 | 10,000 | 10,000 | 15,000 | 15,000 |
| 12,500 | 12,500 | 25,000 | 10,000 | 20,000 | 22,500 |
| 12,000 | 20,000 | 28,000 | 7,900 | 8,900 | 10,000 |
| 8,000 | 9,000 | 10,000 | 8,700 | 10,000 | 20,000 |
| 10,000 | 20,000 | 25,000 | 13,000 | 20,000 | 25,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| 100,000 | 100,000 | 100,000 | 2,100 | 3,100 | 5,100 |

SPECIFIC TOPWIDTHS OF DOWNSTREAM CROSS SECTIONS OF BRANCHES IN METERS
LEFT BERM

TXDS1(I), TXDS2(I), TXDS3(I)

| | | | | | |
|---|---|---|---|---|---|
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 1100,000 | 3200,000 | 5300,000 | 0,000 | 0,000 | 0,000 |
| 1020,000 | 2140,000 | 3100,000 | 0,000 | 0,000 | 0,000 |
| 1100,000 | 2360,000 | 4440,000 | 3000,000 | 5500,000 | 8200,000 |
| 100,000 | 3800,000 | 4350,000 | 1200,000 | 1550,000 | 1050,000 |
| 40,000 | 1000,000 | 1100,000 | 500,000 | 650,000 | 800,000 |
| 650,000 | 950,000 | 1050,000 | 200,000 | 450,000 | 700,000 |
| 380,000 | 720,000 | 1100,000 | 1000,000 | 1850,000 | 2250,000 |
| 50,000 | 600,000 | 1000,000 | 210,000 | 600,000 | 750,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 0,000 | 0,000 | 0,000 | 1360,000 | 3100,000 | 6550,000 |

## ELEVATIONS-SURFACE AREAS OF LAKE BATO

EBAT(I), SFBAT(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0,00 | 6,0000000+006 | 1,00 | 6.0000000+006 | 2,00 | 6.0000000+006 | 3,00 | 1.0500000+007 |
| 4,00 | 1,5000000+007 | 5,00 | 2.8000000+007 | 6,00 | 3.6000000+007 | 7,00 | 4.2500000+007 |
| 8,00 | 5,0000000+007 | 9,00 | 5.6000000+007 | 10,00 | 6.2000000+007 | 11,00 | 7.0000000+007 |
| 12,00 | 7,7500000+007 | 13,00 | 8,5000000+007 | 14,00 | 9.3500000+007 | 15,00 | 1.0200000+008 |
| 16,00 | 1,0700000+008 | 17,00 | 1,1200000+008 | 18,00 | 1.1650000+008 | 19,00 | 1.2100000+008 |
| 20,00 | 1,2500000+008 | 21,00 | 1.2900000+008 | 22,00 | 1.2900000+008 | 23,00 | 1.2900000+008 |

## ELEVATIONS-SURFACE AREAS OF LAKE BAAO

EBAO(I), SFBAO(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0,00 | 2,0000000+006 | 1,00 | 2.0000000+006 | 2,00 | 2.0000000+006 | 3,00 | 2,0000000+006 |
| 4,00 | 2,0000000+006 | 5,00 | 2,7000000+007 | 5,50 | 3.5000000+007 | 6,00 | 4.1000000+007 |
| 6,50 | 4,7000000+007 | 7,00 | 5,2500000+007 | 7,50 | 5.7500000+007 | 8,00 | 6.2500000+007 |
| 8,50 | 6,7000000+007 | 9,00 | 7.1500000+007 | 9,50 | 7.6000000+007 | 10,00 | 8.1000000+007 |
| 10,50 | 8,5000000+007 | 11,00 | 8,9500000+007 | 11,50 | 9.4000000+007 | 12,00 | 9.8500000+007 |
| 13,00 | 1,0700000+008 | 14,00 | 1,1600000+008 | 15,00 | 1.2400000+008 | 16,00 | 1.2400000+008 |

## ELEVATIONS-SURFACE AREAS OF POLUNTUNA RESERVOIR

EPOL(I), SFPOL(I)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0,00 | 0,0000000+000 | 1,00 | 0,0000000+000 | 2,00 | 0,0000000+000 | 3,00 | 0.0000000+000 |
| 4,00 | 0,0000000+000 | 5,00 | 0,0000000+000 | 6,00 | 0.0000000+000 | 7,00 | 0.0000000+000 |
| 8,00 | 0,0000000+000 | 9,00 | 0,0000000+000 | 10,00 | 0.0000000+000 | 11,00 | 2.5000000+005 |
| 12,00 | 5,0000000+005 | 13,00 | 8,0000000+005 | 14,00 | 1.2500000+006 | 15,00 | 1.6000000+006 |
| 16,00 | 2,0000000+006 | 17,00 | 2,5000000+006 | 18,00 | 3.0000000+006 | 19,00 | 3.5000000+006 |
| 20,00 | 3,8000000+006 | 21,00 | 4,2500000+006 | 22,00 | 4.6000000+006 | 23,00 | 5.2000000+006 |
| 24,00 | 5,5000000+006 | 25,00 | 6,1000000+006 | 26,00 | 6.5000000+006 | 27,00 | 7.0000000+006 |
| 28,00 | 7,5000000+006 | 29,00 | 8,0000000+006 | 30,00 | 8.5000000+006 | 31,00 | 9.0000000+006 |
| 32,00 | 9,5000000+006 | 33,00 | 1,0000000+007 | 34,00 | 1.0500000+007 | 35,00 | 1.1000000+007 |
| 36,00 | 1,1500000+007 | 37,00 | 1,2000000+007 | 38,00 | 1.2600000+007 | 39,00 | 1.3200000+007 |
| 40,00 | 1,3700000+007 | 50,00 | 1,9500000+007 | 60,00 | 2.6000000+007 | 70,00 | 3.3500000+007 |
| 80,00 | 4,2000000+007 | 90,00 | 5.2000000+007 | 100,00 | 6.5000000+007 | 110,00 | 8.2500000+007 |

## HYDROLOGIC AND PHYSICAL INPUT INFORMATION

## FOR SUBROUTINE DESNIN, BICOL FLOOD CONTROL SIMULATION MODEL

```
*,1
314,000 564,000 432,000 460,000
  0,400   0,200   0,200   0,300
  0,650   0,690   0,510   0,850
  0,075   0,706   0,139   0,042   0,020   0,013   0,006   0,000   0,000   0,000
  0,108   0,362   0,245   0,121   0,070   0,042   0,027   0,017   0,008   0,000
  0,871  -2,707
```

Line

1 KODE = 1 for model calibration, other than 1 for design study

2 Symbols for plotting

3 RAIN2, RAIN6, RAIN14, RAINDE - 50 year design 2 day rainfall in mm at station Nos. 2, 6, 14 and basin respectively

4 RC1(I = 1,4) - Pre-storm runoff coefficients for Thiesen polygon Nos. 1, 2, 3 and floodplain areas respectively

5 RC2(I = 1,4) - Runoff coefficients during and after the storm for Thiesen polygon Nos. 1, 2, 3 and floodplain area respectively

6 DIM1(I = 1,10) - Distribution graph for catchments with area less than or equal to 50 Sq.Km.

7 DIM2(I = 1,10) - Distribution graph for catchment with areas greater than 50 Sq.Km.

8 EB,CB - Regression coefficients of the base flow-catchment area relationship

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6,9 | 10,5 | 0,2 | -0,0 | -0,0 | -0,0 | -0,0 | -0,0 | 12,2 | 43,0 | -0,0 | -0,0 | -0,0 | 3,0 | -0,0 |
| -0,0 | -0,0 | -0,0 | -0,0 | -0,0 | 3,3 | 16,5 | -0,0 | 5,8 | 4,8 | -0,0 | -0,0 | -0,0 | 20,5 | -0,0 |
| -0,0 | -0,0 | -0,0 | -0,0 | -0,0 | -0,0 | -0,0 | -0,0 | 5,1 | -0,0 | 10,2 | 115,3 | 212,4 | 7,4 | 3,0 |
| -0,0 | 7,1 | -0,0 | 26,2 | 5,6 | 6,1 | 7,6 | 3,6 | 4,6 | 11,4 | 21,1 | 24,1 | 43,9 | 4,8 | 4,8 |
| 52,6 | 21,0 | -0,0 | -0,0 | 1,8 | -0,0 | -0,0 | 2,8 | 2,0 | 10,9 | 13,7 | 12,7 | 11,4 | 19,6 | -0,0 |
| -0,0 | 21,1 | 101,3 | 104,7 | 13,2 | -0,0 | 2,0 | 37,2 | 26,7 | 31,7 | 41,9 | 10,9 | 28,7 | 34,8 | 25,9 |
| 6,6 | | | | | | | | | | | | | | |

R1(1,I = 1,91) - Daily rainfall in mm at Station No. 2 (Sabang, Sipocot), Sept. 1 to Nov. 30, 1970

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 36,4 | 49,5 | 13,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 9,9 | 24,9 | 0,2 | 0,0 | 0,5 | 1,3 | 38,4 |
| 0,5 | 2,5 | 5,5 | 15,0 | 9,6 | 0,5 | 42,2 | 4,6 | 30,7 | 6,1 | 22,9 | 1,5 | 0,0 | 7,6 | 10,2 |
| 1,3 | 1,0 | 10,2 | 15,5 | 0,5 | 0,5 | 0,0 | 0,8 | 0,3 | 0,2 | 0,5 | 153,4 | 309,9 | 11,4 | 3,6 |
| 0,0 | 0,0 | 0,0 | 47,8 | 0,0 | 16,5 | 0,0 | 0,0 | 0,0 | 5,8 | 20,1 | 0,0 | 58,2 | 0,5 | 5,6 |
| 71,1 | 24,6 | 0,5 | 0,0 | 0,5 | 0,0 | 0,0 | 0,0 | 0,0 | 10,2 | 2,5 | 3,3 | 8,6 | 6,4 | 0,0 |
| 0,2 | 10,4 | 197,1 | 121,4 | 1,5 | 0,5 | 0,0 | 37,1 | 2,5 | 9,6 | 3,8 | 0,5 | 24,1 | 1,5 | 15,2 |
| 13,9 | | | | | | | | | | | | | | |

R1(2,I = 1,91) - Daily rainfall in mm at Station No. 6 (Pili), Sept. 1 to Nov. 30, 1970

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3,0 | 26,4 | 3,5 | -0,0 | -0,0 | -0,0 | -0,0 | -0,0 | 13,0 | 56,9 | -0,0 | -0,0 | 0,8 | 9,6 | 12,7 |
| 11,2 | -0,0 | 7,1 | 47,2 | 0,2 | 1,5 | 0,2 | -0,0 | 12,2 | 31,5 | 6,9 | 7,6 | 0,2 | 10,2 | 7,6 |
| 8,9 | 3,3 | -0,0 | -0,0 | -0,0 | -0,0 | 31,0 | 7,1 | 27,9 | 12,2 | 14,5 | 101,8 | 211,3 | 16,2 | 1,0 |
| -0,0 | 3,8 | -0,0 | 16,3 | -0,0 | 27,7 | 1,5 | 2,6 | 4,8 | 41,9 | 10,4 | 1,3 | 10,7 | 7,6 | 4,6 |
| -0,0 | 41,9 | 1,3 | -0,0 | 2,3 | -0,0 | 0,5 | 6,6 | -0,0 | 22,1 | 2,5 | 18,6 | 8,9 | 21,3 | -0,0 |
| 1,3 | 3,3 | 51,1 | 67,8 | 52,3 | -0,0 | 1,8 | 48,8 | 13,7 | 58,4 | 7,6 | 8,1 | 45,5 | 14,2 | 28,7 |
| -0,0 | | | | | | | | | | | | | | |

R1(3,I = 1,91) - Daily rainfall in mm at Station No. 14 (Guinobatan), Sept. 1 to Nov. 30, 1970

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 |
| -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 |
| 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 230.0 | 230.0 | 9.5 | 9.5 |
| 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 |
| 9.5 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 |
| -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 |
| -0.0 | | | | | | | | | | | | | | |

R2(1,I = 1,91) - Estimated 50 year design daily rainfall in mm at Station No. 2 (Sabang, Sipocot)

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 |
| -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 |
| 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 230.0 | 230.0 | 9.5 | 9.5 |
| 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 |
| 9.5 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 |
| -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 |
| -0.0 | | | | | | | | | | | | | | |

R2(2,I = 1,91) - Estimated 50 year design daily rainfall in mm at Station No. 6 (Pili)

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 |
| -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 |
| 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 11.0 | 230.0 | 230.0 | 9.5 | 9.5 |
| 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 |
| 9.5 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 |
| -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 | -0.0 |
| -0.0 | | | | | | | | | | | | | | |

R2(3,I = 1,91) - Estimated 50 year design daily rainfall in mm at Station No. 14 (Guinobatan

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5,600 | 7,100 | 11,300 | 8,000 | 6,700 | 6,400 | 6,100 | 6,600 |
| 8,100 | 7,900 | 10,900 | 8,800 | 9,900 | 9,800 | 14,500 | 11,200 |
| 13,600 | 10,500 | 11,800 | 10,200 | 12,800 | 10,200 | 11,800 | 11,400 |
| 17,700 | 11,100 | 8,300 | 9,500 | 14,600 | 9,700 | 6,940 | 5,520 |
| 4,560 | 5,040 | 3,600 | 3,600 | 3,200 | 3,200 | 2,800 | 2,500 |
| 9,000 | 12,600 | 48,930 | 42,000 | 21,600 | 18,120 | 9,600 | 7,960 |
| 1,440 | 6,960 | 6,960 | 6,480 | 5,520 | 5,040 | 3,600 | 2,800 |
| 2,500 | 3,600 | 3,200 | 3,600 | 5,040 | 7,440 | 6,000 | 3,600 |
| 2,000 | 2,000 | 1,800 | 3,200 | 2,500 | 2,000 | 2,000 | 2,200 |
| 3,600 | 3,200 | 2,500 | 1,800 | 2,000 | 1,800 | 6,960 | 18,720 |
| 13,800 | 4,080 | 3,600 | 7,440 | 6,480 | 18,000 | 6,960 | 9,000 |
| 9,600 | 7,440 | 8,400 | | | | | |

G(1,I = 1,91) - Observed daily discharge in CMS at Station No. 1, San Francisco River at Bonbongsuran, Sept. 1 to Nov. 30, 1970

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0,370 | 0,850 | 3,590 | 2,430 | 0,810 | 0,600 | 0,410 | 0,244 |
| 0,204 | 0,510 | 3,510 | 1,420 | 0,600 | 0,450 | 0,540 | 2,110 |
| 1,740 | 0,570 | 0,430 | 0,480 | 0,480 | 0,570 | 0,620 | 0,540 |
| 0,780 | 0,880 | 0,710 | 0,810 | 0,710 | 0,780 | 0,650 | 0,620 |
| 0,570 | 0,570 | 0,620 | 0,570 | 0,280 | 0,212 | 0,212 | 0,300 |
| 0,680 | 0,960 | 134,610 | 119,620 | 90,160 | 41,960 | 28,860 | 26,460 |
| 21,000 | 18,060 | 15,000 | 12,620 | 28,860 | 21,450 | 15,720 | 13,560 |
| 14,280 | 16,440 | 29,820 | 27,900 | 47,900 | 40,490 | 40,000 | 0,368 |
| 0,416 | 0,440 | 0,326 | 0,312 | 0,218 | 0,286 | 0,280 | 0,282 |
| 0,284 | 0,312 | 1,510 | 2,050 | 2,170 | 2,170 | 2,760 | 42,450 |
| 36,570 | 31,140 | 21,900 | 6,910 | 7,160 | 5,760 | 3,930 | 3,360 |
| 2,980 | 3,060 | 3,440 | | | | | |

G(2,I = 1,91) - Observed daily discharge in CMS at Station No. 14, Pawili River at San Vincente, Sept. 1 to Nov. 30. 1970

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0,770 | 0,920 | 0,930 | 0,940 | 0,823 | 0,706 | 0,590 | 0,565 |
| 0,540 | 1,010 | 1,480 | 1,360 | 1,240 | 0,880 | 0,900 | 0,920 |
| 2,140 | 1,380 | 1,193 | 1,007 | 0,820 | 2,860 | 1,070 | 0,905 |
| 0,740 | 0,743 | 0,746 | 0,750 | 0,720 | 0,690 | 0,655 | 0,620 |
| 0,593 | 0,566 | 0,560 | 0,520 | 0,500 | 0,520 | 0,560 | 1,570 |
| 2,600 | 3,630 | 25,500 | 7,180 | 4,280 | 1,380 | 1,262 | 1,146 |
| 1,030 | 1,115 | 1,200 | 1,040 | 0,880 | 1,300 | 1,720 | 2,140 |
| 1,690 | 1,240 | 1,510 | 1,780 | 6,090 | 10,400 | 2,500 | 2,200 |
| 1,900 | 1,525 | 1,150 | 1,110 | 1,070 | 1,030 | 1,050 | 1,070 |
| 1,325 | 1,580 | 1,360 | 1,140 | 0,920 | 3,180 | 5,460 | 5,540 |
| 5,640 | 4,920 | 4,300 | 3,630 | 2,945 | 2,260 | .820 | 1,380 |
| 1,320 | 1,260 | 1,200 | | | | | |

G(3,I = 1,91) - Observed daily discharge in CMS at Station No. 20, Yabo River at Yabo Farm, Sept. 1 to Nov. 30, 1970

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6,260 | 7,070 | 6,950 | 6,800 | 6,130 | 5,470 | 4,800 | 4,640 |
| 4,480 | 14,540 | 24,600 | 18,240 | 11,880 | 5,520 | 6,700 | 7,880 |
| 6,790 | 5,700 | 6,250 | 6,790 | 7,340 | 6,850 | 6,360 | 6,360 |
| 6,360 | 6,290 | 6,210 | 6,140 | 8,320 | 10,490 | 8,920 | 7,340 |
| 7,160 | 6,980 | 6,800 | 6,070 | 5,340 | 5,430 | 5,520 | 5,870 |
| 5,910 | 6,580 | 170,000 | 118,000 | 72,850 | 27,700 | 22,470 | 17,250 |
| 12,020 | 12,860 | 13,700 | 20,390 | 27,080 | 24,840 | 22,600 | 20,360 |
| 16,820 | 13,280 | 21,510 | 29,740 | 39,930 | 50,110 | 60,300 | 40,620 |
| 20,900 | 18,020 | 15,110 | 14,796 | 14,483 | 14,170 | 28,925 | 43,680 |
| 36,370 | 29,060 | 23,800 | 18,540 | 13,280 | 56,635 | 99,190 | 80,545 |
| 61,900 | 81,600 | 101,300 | 121,000 | 88,300 | 55,600 | 65,305 | 75,010 |
| 64,240 | 53,470 | 42,700 | | | | | |

G(4,I = 1,91) - Observed daily discharge in CMS at Station No. 21, Poluntuna River at Napolidan, Sept. 1 to Nov. 30, 1970

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0,510 | 0,510 | 0,510 | 0,500 | 0,470 | 0,440 | 0,390 | 0,350 |
| 0,350 | 0,350 | 0,720 | 1,250 | 1,200 | 1,050 | 0,950 | 1,400 |
| 1,680 | 1,100 | 0,750 | 0,820 | 0,950 | 1,400 | 1,900 | 2,800 |
| 1,200 | 0,800 | 0,920 | 1,150 | 1,400 | 1,980 | 1,850 | 1,680 |
| 1,500 | 1,300 | 1,200 | 4,500 | 5,640 | 5,300 | 5,000 | 2,700 |
| 1,500 | 1,150 | 20,100 | 37,900 | 17,020 | 9,640 | 8,690 | 7,400 |
| 6,070 | 5,400 | 5,000 | 4,840 | 4,600 | 4,600 | 6,800 | 13,150 |
| 7,760 | 5,240 | 12,500 | 4,840 | 10,360 | 40,950 | 15,200 | 7,200 |
| 4,060 | 2,800 | 2,800 | 2,800 | 2,800 | 2,800 | 3,710 | 4,440 |
| 6,070 | 3,360 | 2,100 | 1,400 | 5,240 | 12,000 | 29,100 | 46,350 |
| 10,360 | 4,200 | 3,150 | 29,100 | 22,600 | 7,500 | 22,280 | 8,580 |
| 7,700 | 37.900 | 10,000 | | | | | |

G(5,I = 1,91) - Observed daily discharge in CMS at Station No. 22, Culacling River, Sept. 1 to Nov. 30, 1970

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1,390 | 1,250 | 1,250 | 1,250 | 1,320 | 1,600 | 1,390 | 1,390 |
| 1,320 | 1,390 | 1,320 | 1,760 | 1,390 | 1,320 | 1,530 | 1,680 |
| 1,920 | 1,460 | 1,320 | 1,130 | 1,190 | 1,320 | 1,320 | 1,460 |
| 1,460 | 1,530 | 1,680 | 2,100 | 2,000 | 1,920 | 1,840 | 1,680 |
| 1,530 | 1,390 | 1,390 | 2,500 | 2,500 | 1,530 | 1,460 | 1,530 |
| 1,680 | 1,680 | 1,760 | 1,760 | 1,920 | 2,200 | 2,500 | 3,220 |
| 3,840 | 3,340 | 3,340 | 3,340 | 3,460 | 3,460 | 1,840 | 2,980 |
| 4,200 | 4,260 | 3,100 | 3,100 | 3,100 | 4,400 | 3,100 | 2,620 |
| 2,620 | 2,740 | 2,400 | 2,860 | 2,860 | 2,980 | 3,220 | 3,460 |
| 3,840 | 4,400 | 5,560 | 5,560 | 5,740 | 5,920 | 5,740 | 6,100 |
| 9,980 | 9,320 | 9,100 | 8,800 | 9,100 | 8,660 | 8,000 | 6,640 |
| 5,560 | 6,280 | 5,560 | | | | | |

G(6,I = 1,91) - Observed daily discharge in CMS at Station No. 23, Yabo River at Sipocot, Sept. 1 to Nov. 30, 1970

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0,075 | 0,076 | 0,076 | 0,130 | 0,015 | 0,016 | 0,017 | 0,017 |
| 0,018 | 0,150 | 0,900 | 0,130 | 0,044 | 0,014 | 0,150 | 0,630 |
| 0,258 | 0,054 | 2,830 | 0,400 | 0,490 | 0,250 | 0,032 | 0,028 |
| 1,030 | 0,350 | 0,076 | 0,054 | 0,130 | 0,054 | 0,200 | 0,150 |
| 0,044 | 0,044 | 0,076 | 0,054 | 0,300 | 0,054 | 0,044 | 0,037 |
| 1,810 | 2,020 | 8,640 | 1,380 | 1,490 | 0,900 | 0,760 | 0,300 |
| 0,150 | 0,350 | 0,054 | 0,490 | 0,400 | 0,450 | 0,150 | 1,030 |
| 0,490 | 0,450 | 0,490 | 0,490 | 0,630 | 1,380 | 0,760 | 0,560 |
| 0,560 | 0,560 | 0,200 | 0,200 | 0,200 | 0,490 | 0,630 | 0,250 |
| 0,350 | 0,400 | 0,250 | 0,200 | 0,032 | 0,630 | 1,810 | 2,380 |
| 0,490 | 0,350 | 0,250 | 0,300 | 0,760 | 1,700 | 1,810 | 0,690 |
| 0,630 | 1,100 | 2,120 | | | | | |

G(7,I = 1,91) - Observed daily discharge in CMS at Station No. 3, Ugsong River at Benanam, Sept. 1 to Nov. 30, 1970

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0,648 | 0,680 | 0,920 | 0,760 | 0,552 | 0,456 | 0,424 | 0,392 |
| 0,392 | 0,840 | 1,374 | 0,614 | 0,553 | 0,488 | 5,376 | 0,920 |
| 0,584 | 0,520 | 0,648 | 0,760 | 0,648 | 1,328 | 0,760 | 0,680 |
| 0,800 | 1,200 | 0,760 | 0,760 | 0,800 | 0,760 | 0,680 | 0,584 |
| 0,552 | 0,488 | 0,456 | 0,424 | 0,424 | 0,424 | 0,392 | 0,392 |
| 0,392 | 1,424 | 106,880 | 19,546 | 1,576 | 1,424 | 1,000 | 0,800 |
| 0,680 | 4,536 | 1,376 | 0,920 | 0,840 | 0,720 | 0,680 | 0,840 |
| 1,520 | 0,760 | 5,056 | 1,472 | 4,744 | 0,720 | 0,720 | 0,680 |
| 0,720 | 0,680 | 1,040 | 1,200 | 0,720 | 4,120 | 3,040 | 1,376 |
| 1,080 | 0,840 | 0,800 | 0,760 | 0,760 | 0,720 | 59,140 | 10,301 |
| 3,997 | 2,840 | 7,256 | 2,556 | 2,995 | 1,424 | 1,691 | 1,471 |
| 4,744 | 2,041 | 4,988 | | | | | |

(8,I = 1,91) - Observed daily discharge in CMS at Station No. 17, Arayan River, Sept. 1 to

| | | |
|---|---|---|
| 101 | 131 | 14 |
| 102 | 112 | 6 |
| 103 | 20 | 6 |
| 104 | 172 | 2 |
| 105 | 64 | 2 |
| 106 | 85 | 2 |
| 107 | 11 | 14 |
| 108 | 17 | 6 |

INC,A,IS - Characteristics of the eight gage watersheds (INC - watershed code number, series 100; A - watershed area in Sq.Km; IS - rainfall station number applicable to watershed)

| | | |
|---|---|---|
| 201 | 10 | 614 |
| 202 | 9 | 614 |
| 203 | 16 | 714 |
| 204 | 196 | 37 6 |
| 205 | 80 | 25 6 |
| 206 | 24 | 16 6 |
| 207 | 14 | 10 6 |
| 208 | 29 | 29 6 |
| 209 | 19 | 14 6 |
| 210 | 5 | 9 6 |
| 211 | 20 | 13 6 |
| 212 | 64 | 2014 |
| 213 | 14 | 8 6 |
| 214 | 31 | 17 6 |
| 215 | 14 | 6 6 |
| 216 | 15 | 8 6 |
| 217 | 10 | 7 6 |
| 218 | 8 | 6 6 |
| 219 | 10 | 7 6 |
| 220 | 15 | 7 6 |
| 221 | 40 | 17 2 |
| 222 | 51 | 12 2 |
| 223 | 22 | 14 2 |
| 224 | 21 | 11 2 |
| 225 | 35 | 20 2 |
| 226 | 17 | 7 2 |
| 227 | 16 | 14 2 |
| 228 | 23 | 8 2 |
| 229 | 9 | 3 2 |
| 230 | 54 | 10 2 |
| 231 | 40 | 14 2 |
| 232 | 9 | 4 2 |
| 233 | 8 | 4 2 |
| 234 | 23 | 8 6 |
| 235 | 6 | 4 6 |
| 236 | 11 | 6 6 |
| 237 | 18 | 5 6 |
| 238 | 5 | 4 6 |
| 239 | 4 | 2 6 |
| 240 | 2 | 2 6 |
| 241 | 21 | 8 6 |
| 242 | 9 | 6 6 |
| 243 | 22 | 1214 |
| 244 | 14 | 814 |
| 245 | 7 | 314 |
| 246 | 11 | 714 |
| 247 | 9 | 314 |
| 248 | 13 | 614 |
| 249 | 30 | 914 |
| 250 | 14 | 614 |
| 251 | 19 | 814 |
| 252 | 14 | 314 |
| 253 | 39 | 13 6 |
| 254 | 14 | 9 6 |
| 255 | 12 | 4 6 |
| 256 | 34 | 12 6 |
| 257 | 29 | 6 6 |
| 258 | 16 | 11 6 |
| 259 | 39 | 1314 |
| 260 | 90 | 2414 |
| 261 | 11 | 5414 |
| 262 | 42 | 0 6 |
| 263 | 31 | 0 6 |

INC,A,W,IS - Characteristics of the sixty three ungaged watersheds. (INC - watershed code number, series 200; A - watershed area in Sq.Km; W - representative width of watershed in Km; IS - rainfall station number applicable to watershed)

```
 1  2  0,00    1   1
104
227
 2  2 26,20    0   1
226
 3  2 28,12    2   2
105 106
224 228
 4  2  4,33    0   3
223 225 229
 5  2  8,73    0   1
230
 6  2 13,48    0   1
222
 7  2 10,00    0   2
231 232
 8  2 17,00    0   0
 9  2 27,88    0   1
221
10  6 36,45    0   4
220 233 234 258
11  6 40,00    1   4
103
219 210 211 257
12  6 27,70    0   4
208 209 218 235
13  6 14,20    0   3
217 236 256
14  6 10,50    0   1
216
15  6 22,48    1   0
108
16  6 10,33    0   1
237
17  6 11,25    1   4
102
206 207 262 263
18  6 15,00    0   2
215 238
19  6 17,38    0   2
254 255
20  6 29,08    0   1
214
21  6 25,65    0   4
204 205 213 239
22 14194,95    2  21
101 107
201 202 203 212 240
241 242 243 244 245
246 247 248 249 250
251 252 253 259 260
261
```

IN,IS,AA,NG,NU - Input information to nodes. (IN - node number;
IS - rainfall station number applicable to area of node;
AA - total flood plain area in Sq.Km in the node region;
NG - total number of gaged watershed for the nodes;
NU - total number of ungaged watersheds for the nodes)