PHILIPPINES

PROGRESS REPORT I

FOR

THE FLOOD FORECASTING SYSTEMS IN THE AGNO, BICOL, AND CAGAYAN RIVER BASINS

FEBRUARY 1977

JAPAN INTERNATIONAL COOPERATION AGENCY

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CONTENTS

I. Summary

1. Background and Objective of Project

The Philippine Islands are located near the eastern edge of the Eurasian Continent, between 10° and 20° N latitude. Naturally, the Islands are directly influenced by both monsoons and typhoons. Every year the islands are assaulted by high tides caused by strong winds and floods caused by heavy rains that accompany monsoons and typhoons. Because, among the islands, Luzon is densely populated and highly developed, if this island is assaulted by floods or high tides, inestimable damage to human life and property and social paralysis would result.

The Philippine Government has been painstakingly engaged in flood control work and river improvement, however, they are far from completed. Yet, it may be said that "completion" is not possible in work of this kind. This is because natural forces may bring larger floods than that which a completed dyke is estimated to be able to handle safely.

Forecasts and warning about floods are therefore significant. Their role and functions are supplementary before the work is completed, and after completion they will serve to ensure that the objective is accomplished as well as to provide for emergencies.

The Philippine Government, having fully recognized the importance of the forecasting and warning system, completed a flood forecasting and warning system in 1973 for the Pampanga River, one of the most important rivers in central Luzon, in cooperation with the Typhoon Committee, ESCAP and the Japanese Government. The fact that

the Pampanga system demonstrated its effectiveness satisfactorily in the huge flood of May, 1976, and protected many lives and much property from disaster is well remembered. Based upon the lessons learned on that occasion, the Philippine Government requested the cooperation of the Japanese Government with a plan to extend the system to three rivers - the Agno River in central Luzon, the Bicol River in southern Luzon and the Cagayan River in northern Luzon. In response to this request, through the Japan International Cooperation Agency (J.I.C.A.), the Japanese Government dispatched The Survey Team for Flood Forecasting and Warning Systems in the Philippines and assigned it to the feasibility study.

2. Survey Objective

The objective of this survey is to produce a feasibility study for the plan to extend the flood forecasting and warning system, currently effective on the Pampanga River, to three rivers, the Agno, Bicol and Cagayan. The survey includes the items as listed below.

1) Discussions with officials concerned.
2) Collection and organization of data.
3) Inspection of the sites.
4) Survey of meteorological and hydrological characteristics.
5) Socio-economic characteristics survey and study of target area.
6) Preparation of forecasting model and observatory network.
7) Telecommunication system proposal.
8) Preparation of the operation and maintenance plan.

9) Rough estimate of expenditures.

10) Proposal for system construction and personnel training program.

3. Organization of Survey Team

The survey team comprises the following three teams:

First Survey Team

Second Survey Team

Japan Project Team

The first and second survey teams are organized as listed below.

Team leader: Tsunetaka Kawai*, Water Management Officer, River Planning Division, River Bureau, Ministry of Construction.

River Specialists: Kazuhiro Yamaguchi*, Deputy Head, River Improvement Division, River Bureau, Ministry of Construction.

Fumio Kodama*, Head, Operational Control Center for Tone River Dams, Kanto Regional Construction Bureau, Ministry of Construction.

Yumio Ishii*, Manager of Water Resources Department, C.T.I. Eng. Co., Ltd.

Joji Ishii, Deputy Chief of Research & Development Section, C.T.I. Eng. Co., Ltd.

Toyohara Hiruma**, Deputy Manager of Water Resources Department, C.T.I. Eng. Co., Ltd.

Takeshi Hashimoto, Researcher, Hydrology Section, Public Works Research Institute, Ministry of Construction.

Koichiro Katsuragi, Chief, Area Water Management

Section, Operational Control Center for Yodo River Dams, Kinki Regional Construction Bureau, Ministry of Construction.

Meteorological Specialists:

Seiji Miyazawa*, Chief Forecaster, Meteorological Agency.

Telecommunication Specialist:

Osamu Tsumura*, Head, Electricity and Telecommunication Section, Minister's Secretariat, Ministry of Construction.

Kazuhiko Takayama**, Senior Engineer, Electricity and Telecommunication Section, Minister's Secretariat, Ministry of Construction.

Mitsuru Shimizu**, Staff, Electricity and Telecommunication Section, Minister's Secretariat, Ministry of Construction.

Masamichi Komura, Chief-clerk, Electricity and Telecommunication Section, Kanto Regional Construction Bureau, Ministry of Construction.

Shuji Suga, Construction & Electricity Techniques Corp.

Yoshiharu Nakagawa, " " " "

Coordinator: Yuji Okazaki, Research & Development Section, Social Development & Cooperation Department, Japan International Cooperation Agency.

NOTE: * denotes member of First Survey Team.

** denotes member of Second Survey Team.

The Japan Project Team consists of the personnel listed below and several other engineers from C.T.I. Eng. Co., Ltd.

River Specialist: Hisataka Suganuma, Acting Section Chief, Water Resources Department.

Socio-economic Specialist: Zen'o Ohno, Deputy Chief of Research & Development Section.

4. Process of Survey

The first survey was conducted at the sites in the Philippines to obtain an understanding of the overall project. The survey was conducted from November 18th to December 17th, 1976. The second survey took place during the period from January 31st to March 5th, 1977, and was mainly the selection of the locations of telemetering stations and the radio propagation tests. The work of the Japan Project Team commenced in December, 1976, after the first survey team returned to Japan, and is scheduled to be completed in March, 1977.

Progress Report I is a consolidation of surveys conducted and completed up to this time. In addition, an Interim Report was submitted in December, 1976. Progress Report II is scheduled to be submitted at the end of March, 1977.

5. Conclusions and Recommendations

1. According to the surveys conducted so far, extension of the flood forecasting and warning system to the Agno, Bicol and Cagayan Rivers is feasible.

2. The system consists of the following facilities and networks.

1) Seven telemetering stations (one more station will be added in the near future), one repeater station and one sub-center (Carmen, Rosales) on the Agno River.

2) Nine telemetering stations, two repeater stations and one sub-center (Camaligan, Naga) on the Bicol River.

3) Four telemetering stations, one or two repeater stations and one sub-center (Tuguegarao) on the Cagayan River.

4) A set of transmitting/receiving facilities near Manila City, to contact sub-centers and the Flood Forecasting Center (FFC). Communication between the FFC and sub-centers will be by multiplex transmission/receiving or SSB radio telephone.

5) FFC forecasts flood characteristics (time and duration of highest water level) on the basis of information from sub-centers and meteorological information produced by the Philippine Atmospheric Geophysical and Astronomical Service Administration (PAGASA). FFC then sends this information to each sub-center and also contacts the related organizations.

6) Upon completion of the entire system, 15 hydrologists and 26 telecommunication engineers will be required for operation and maintenance of the system. These personnel will be assigned to the FFC as well as each sub-center.

7) It is desirable to computerize the whole system in the future to improve both the accuracy and efficiency of forecasting.

3. It was observed that the number of trained personnel would not be sufficient to meet the requirements of extension of flood forecasting beyond the Panpanga system. Therefore, it is preferable

that the implementation of the system be performed step-by-step depending upon the availability of trained personnel and accumulation of experience.

The following steps are tentatively proposed:

1st step: Completion of the Agno system telemetering network, which will be connected to FFC by the multiplex telecommunication system.

2nd step: Completion of the telemetering network in the Bicol or Cagayan system . Communication with the FFC will be by radio telephone.

3rd step: Completion of the telemetering network in the remaining river system. Communication with the FFC will be by radio telephone.

4th step: Completion of the multiplex telecommunication system between the sub-center established in the 2nd step and the FFC.

5th step: Completion of the multiplex telecommunication system between the sub-center established in the 3rd step and the FFC.

4. It is preferable that the construction of the system be completed within three years. Transfer of technology should be carried out on an on-the-job basis. Also, this tranining is required for about two years after the completion of each system. Accordingly, it may take about 5 years before the entire system functions smoothly.

In this connection, it is advisable to assign three hydrologists and three telecommunication engineers to FFC. Furthermore, Japan must be responsible for the training of the Philippine hydrologists and telecommunication engineers.

Proposed Schedule of Implementation

	1	2	3	4	5
Agno System					
Telemeter installation	—				
Communication with FFC	—				
Personnel training	—	—	—	—	
Bicol System*					
Telemeter installation	—	—			
Communication with FFC			—		
Personnel training	—	—	—	—	—
Cagayan System					
Telemeter installation		—			
Communication with FFC			—		
Personnel training		—	—	—	—

NOTE: In this schedule the Bicol System is second, but the Cagayan System may precede it.

5. The expenditures for this system are now under consideration taking into account the following items.

Construction cost

Gaging stations

Telecommunication facilities

Operation and maintenance costs (for 5 years)

Equipment

Personnel

Vehicles

Consultant services

Design of the system

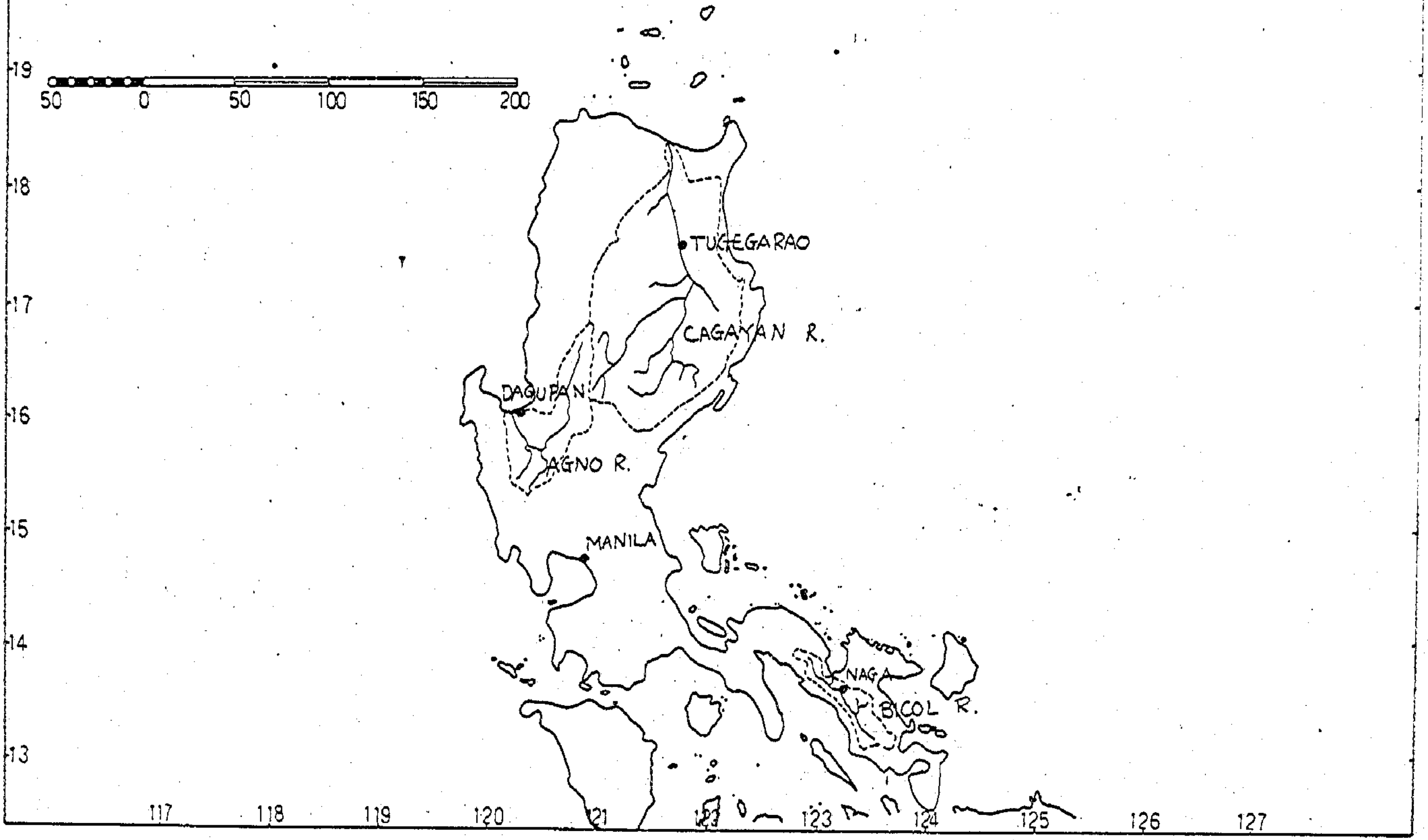
Management of construction work

Technical guidance

6. Installation and restoration of hydrological stations to be included in this system should be completed as early as possible in order to facilitate availability of reliable data.

7. It is desirable to make use of rainfall forecasting, although rainfall forecasting techniques are not sufficiently developed. In this connection, it will be of great help if information from PAGASA meteorological radar is effectively utilized.

Fig LOCATION MAP OF AGNO R., BICOL R. & CAGAYAN R.



II. Hydrological Characteristics

§-1 The Agno River

1. Geomorphology

The Agno River has a drainage area of 5,646 km^2 (Estuary: Baay West, Lingnayen Stn), and is the third largest river in Luzon next to the Cagayan and Panpanga Rivers. Half of the drainage areas of the rivers are mountainous, and in particular the water source of the Agno River is a mountainous area of 2,000m in elevation in Banguet Province.

The main branch is Tarlac River (the drainage area is about 1,900 km^2 including Poponto Swamp), which joins the Agno River in midstream from the left at Banyambang. The Tarlac River has its source on Mt. Pinatubo (elevation is 1,745 m) located in Tarlac Province.

The Agno River, after passing through the mountainous area, forms a vast fan and a delta, and then flows into Lingayan Gulf. This fan and delta is called the Pangasinan Plain, and has long been developed económically, together with Panpanga Plain. These plains are the granary of Central Luzon.

The Agno River has a course of about 200 km, of which 90 km runs in mountainous zones, forming deep canyons. The average slope of the river bed is, about 1/50 in canyons, and about 1/1,000 on the plains.

Ponpoto Swamp is located in the vicinity of Bayambang, where the Tarlac River joins the Agno River. The swamp has an area of about 25 km^2 and naturally accommodates flood waters from the Tarlac River at the junction.

Dagupan and St. Barbara form the center of the Pangasinan Plain. The plain was originally formed as a result of floods on the Agno River. Changes in river course as well as river improvement works led to the separation of the Agno River from the Plain. Now floods are prevented by the dikes on the right bank.

Run-off from the plain is discharged into the Lingayan Gulf through the Dagupan river which was once a branch of the Agno river.

2. Climate

Since temperature differences in the Philippine Archipelago are relatively small, climatic classification of the islands has been based upon the presence or absence of a dry season and rainy season. The four types of conditions selected for climatic classification are:

First type - This type is characterized by two pronounced reasons --- dry from November to April and wet the remaining months of the year.

Second type - This type has no dry season but has a pronounced rainy season from November to January.

Third type - This type has no pronounced rainy season and only a slight dry period lasting from one to three months.

Fourth type - This type has no dry season and a pronounced rainy season.

The climate in the Agno River basin is of the first type. Determining factors are the 2,000 m mountains surrounding the basin, and monsoons and typhoons.

Floods are brought by heavy rains caused by monsoons and also by an average of 4 typhoons a year. Maximum and minimum mean monthly temperatures at Dagupan are 29°C in August and 26°C in January, a comparatively small temperature differential. Mean annual humidity is 75% in lowlands and 85% in the mountains.

3. Precipitation

In this drainage area, the dry season is from November through April and the wet season May through October. Annual precipitation varies from 4,000 mm in the upper stream of the Agno River to 2,000 mm in the neighborhood of Tarlac. Such great variation is caused by the influence of mountains upon precipitation produced by monsoons. The records of heavy rains which caused floods were 3,462 mm in a month in August, 1911 and 1,168 mm in 24 hours in July, 1911, in Baguio city located in the upper part of the Agno River. Recently, in 1972 and 1976 disasters due to heavy rain were experienced.

4. Flood and Storm Surge

Since the Agno River basin is characterized by mountainous topography, the flood runoff reaches the plain in several hours and the estuary in a day. For this reason, the hydrograph of a flood is a very sharp curve. The largest recent flood was experienced in May, 1976, when some gaging stations were washed away and no complete measurement could actually be made. In the BPW scheme, this river has a flood of 10,000 m^3/sec in a 100-year period, at Wawa, Bayambang, in mid-course (drainage area is 4,196km^2) and in the NPC scheme, Binga Dam has a spillway with a designed discharge of 5,770 m^3/sec (drainage area is 936 km^2).

Considering the features of Lingayen gulf, storm surges are expected to a certain extent, although smaller than those expected at the estuary of the Bicol River in San Miguel Bay.

As mentioned above, the Pangasinan Plain was formed by floods often. The largest was in May, 1976, producing inestimable damage, flooding the entire Pangasin Plain including the Tarlac River.

5. River Training Works

BPW has been in charge mainly of Agno River flood control, and the primary plan included dyke systems and flood ways. The Pangasinan Plain tends to expand to the right bank of the river, and the dyke on this side is the most important structure. Also, the dyke on the right bank of Tarlac iver between Tarlac City and Poponto Swamp is no less important. At present, these dykes have been 70-80% completed. The left bank of these rivers has no dykes in many places, and construction work is now under way.

Poponto Swamp is located at the junction of the Tarlac River and Agno River at mid-course, and adjust the amount of outflow of the Tarlac River at the confluence. The Alcara flood way has recently been completed with the intent to introduce peak flow of 3,000 m^3/sec of the Agno River into the swamp. This flood way is expected to contribute much to minimizing possible floods in the lower course of Bayambang.

Development of flood control in the drainage of the Dagupan River has not progressed, probably because this river runs inland. It seems that some sluices or pumping stations may be required in the future.

Concerning other hydrographic structures, the upper stream of this river has Ambuklao Dam and Binga Dam belonging to National Power Corporation (NPC), both having a height of nearly 100m;

in San roque, San Mannuel, there is an intake dam of the Agne irrigation system belonging to the National Irrigation Administration (NIA); and an intake dam in Tarlac City on the Tarlac River, which also belongs to NIA.

6. Gaging Station

Gaging stations are generally under BPW control. There are 10 stations along the Agno River, one station along the Tarlac River and 3 stations along the Dagupan River. These stations, except those located in the tidal areas, perform discharge measurements. Observation of water level is performed three times a day --- morning, noon and evening --- and also is performed hourly as an extra precaution in case of a flood. The automatic water gages previously available in many of these stations were broken during floods in 1972 or 1976. Reading at most stations is done with the staff gages. The San Roque, San Mannuel, station was half destroyed, and the station at Tibag, Tarlac has been abandoned. All the data from the gaging stations are collected at the BPW headquaters.

As regard meteorological observatories, there is the Dagupan Synoptic Station, PAGASA, which monitors all major meteorological factors. The rain gage stations, with PAGASA as the center, number as many as 22 including those in the Agno Basin and Dagupan Basins.

In addition, both NIA and NPC have independent gaging station networks.

Daily observation is performed at all gaging stations other than the Synoptic Station. As compared with the water level gaging stations, the rain gage stations have fewer recording omissions. These data are gathered by the PAGASA headquarters via the Synoptic Station.

§-2 The Bicol River

1. Geomorphology

The Bicol River is a medium size river with a drinage area of 2,717 km^2 (Estuary: Cuyapi, Libmanan Station) covering the Provinces of Camarino Sur and Albay, the southernmost part of Luzon. The majority of the drainage area is flat alluvial land or tableland with volcanic deposits. The basin has mountains including volcanos 2,000 m in elevation to the east, and rather lower mountains to the west. The source of the river is Mayon volcano, the most famous mountain in Luzon, with an elevation of 2,421 m. The runoff, after being regulated through the lakes of Bato, Baao and Buhi, comes into the course of the Bicol River.

The main tributary is the Sipocot River, which enters from the left at a point 8 km from the estuary. Unlike the main stream, the basin of the tributary is almost all mountainous terrain.

Rainfall in the mountains that are the source of the river immediately flows down the steep mountain slopes and rapids, and enters into the main river course, which meanders considerably while flowing across the plain. Then it joins the Sipocot River and pours into San Miguel Bay.

The Bicol River has a very gradual slope. Lake Bate, in spite of its location about 70km from the estuary, has

a minimum water level of only 5.0 m above the MSL. This is 1/14,000 in terms of surface slope.

In the case of the Sipocot River, the slope is 1/250 and the fall is 100 m in about 25 km between Napolidan and the junction with the main stream. The course of the Bicol River, after joining the Sipocot River, widens and finally becoming more than 1,000 m wide at its estuary.

Since the Bicol River flows so slowly, the tide can reach areas upstream from Naga City (about 35 km upstream from estuary).

The topographic features of the basin can be classified as follows: Sipocot basin and the surrounding mountains; plain of volcanic deposits upstream from Bato Lake; and low wetlands extending between Naga City and the estuary.

2) Climate

The climate of this basin is of the second type described previously. The climate is determined by topographical features open toward the northeast, and monsoons and cyclones.

Northeastern monsoons between November and February have a great influence on this basin, while the trade winds are obstructed by mountain ranges. There are low mountains only to the southwest, therefore the basin is only slightly affected by southwestern monsoons. Cyclones average two a year.

Mean annual temperature is 27°C and temperature differentials between localities are small. Mean humidity is 85% at Naga City.

3. Precipitation

There is no dry season in this region. Heavy rains are possible in October, November and December, mainly due to the influences of wind direction and topography. The average annual rainfall varies from 2,000 mm in the southwestern area to 3,600 mm in the northwestern area.

The highest monthly rainfall was 2,900 mm at Naga. Recent heavy rains were recorded in December, 1975, and December, 1976.

4. Flood and Storm Surge

Rainfall on mountains reaches the plain soon, from where it flows very slowly to the estuary due to low, flat terrain including large lakes. The river flooded in December, 1975, and in December, 1976, when the entire Bicol Plain was heavily damaged.

The cause of more often and heavier floods is storm surge which is generated in San Miguel Bay. The sectoral form of the bay is subject to high tides, and in addition many violent typhoons pass over the drainage area. Storm surge is estimated to be as high as 2.5~3m. Since the floodtide in San Miguel Bay is about 1.5 m above MSL, when storm surge is added to the astronomical tide, high tide is 4 m above MSL.

5. River Training Works

Concerning the training works of the Bicol River, Bicol River Basin Development Program (BRBDP) works out the basic plan and BPW is in charge of execution. The only project under construction is 'Cut-off No. 3' which is intended to alter meandering in the vicinity of Naga City. Future programs, however, include drastic projects such as the dyke system in the lower course, direct drainage from Lake Bate to Ragay Gulf through diversion channels dams in the upper Sipocot river, etc.

The integration of irrigation networks including the Lalo River irrigation system by NIA is an other construction project.

6. Gaging Stations

Gaging stations are generally under BPW control, number 27, and discharge measurements are made at most stations. Daily observations of water level are performed twice --- morning and evening --- or three times --- morning, noon and evening --- and also performed hourly as an extra precaution in case of a flood. Many stations have automatic water gages, which are out of order except at Mabulo, Naga. Therefore, reading is done with staff gages.

The meteorological observatory is Pili Synoptic Station, PAGASA, which monitors all major meteorological factors. The rain gage stations, with PAGASA as the center, total 14, where daily observations are performed.

Considering the size of the drainage area, the number of gaging stations is greater than in many other areas.
This indicates that the development of the overall drainage area is advanced.

§-3 The Cagayan River

1. Geomorphology

The Cagayan River is the largest river in Luzon, having a drainage area of 27,580 km^2 (Estuary: Appari Station).

The river is located in the northernmost part of Luzon, and flows northward pouring into Babuyan Channel. Mountains with elevations at the 2,000 m level surround the east, south and west parts of the drainage area, and the river flows north, east of the center. The Cagayan valley is comparatively flat and is divided into Ilagan, Tugegarao and Appari areas by bottlenecks. Main branches are, the Chico River which joins from the left at a point 55 km from the estuary, the Ilagan River which joins from the right at Ilagan, 200 km from the estuary, and the Magat River which joins from the left at Naguilian, 230 km from the estuary. Both the Chice River and Magat River have extensive drainage areas, which together cover 1/3 of the overall drainage area.

The river has a total length of 400 km, of which 120 km is mountains and about 300 km on plains. The average slope of the river bed on the plains is as gentle as 1/8,000 in the 230 km between the estuary and Naguilian. The river meanders considerably while running through the flood plain of the Cagayan Valley.

Marshes and swamps are found in some parts of the lower stream and also near the estuary.

2. Climate

This basin has no noticeable rainy season but does have a short dry season, and is of the third type described previously.

The climate is controlled by high mountains in three directions, trade winds, monsoons, and an average of four cyclones a year.

Mean annual temperature at Tuguegarao, situated at mid-stream, is 26.6°C, with small temperature differentials between months. Mean humidity is 80% and does not change noticeably.

3. Precipitation

In terms of rainfall, December through April is the dry season and May through November is the rainy season. The average annual rainfall is 1,000 mm in Alcara, in the northern part, and 3,000 mm in the southeastern mountains. The heaviest rain which brought floods was experienced in Tugegarao in November, 1906, when a monthly rainfall of 1,316 mm was recorded. In this case, the rainfall in 24 hours was 318 mm at the maximum.

4. Flood and Storm Surge

Floods caused by this river tend to flow down very slowly because of extensive area, extremely gentle slope in valleys, regulation of natural flood by several bottlenecks, and meandering of the river.

No discharge measurement is performed by the gaging stations located along the river course, and the discharge flow up to this time is unknown. However, the water stage in case of floods may rise higher than 10 m above the normal stage. Valleys are damaged by the floods very often, and the maximum area damaged is estimated to be 2,080 km^2.

No serious damage due to high tide has been recorded. Also, considering the features of Babuyan Gulf into which the river pours, no extremely high tide is expected to occur.

5. River Training Works

BPW has been the main promoter of flood control on the Cagayan River, although no plan has actually been completed. This may indicate that the river course remains natural. Utilization of water resources has been progressing. The Oscariz Dam on the Magat River, completed by NIA, can provide irrigation for vast farmland. Many other irrigation systems are now being planned.

Increasing demand for the flood control or river improvement will be made when these development projects are completed.

6. Gaging Stations

Gaging stations are generally under BPW control. There are 9 stations along the Cagayan River, 2 stations along the Chico River, 2 stations along the Magat River and one station along the Ilagan River. However, the number of stations seems to be too few for the extensive area of the river basin. These stations perform the water stage gaging only, 2 or 3 times a day with staff gages. Hourly reading is performed as an extra precaution in case of floods. All the data are collected at the BPW headquarters.

The meteorological observatory is Tugegarao Synoptic Station, PAGASA, which monitors all major meteorological factors. There are 26 rain gage stations, with PAGASA as the center, although many of them have been abandoned. The number of stations of this kind seems to be too small considering the large drainage area. The rainfall data are gathered by the PAGASA headquaters via the synoptic station.

III. Socio-Economic Characteristics

§-1. The Agno River

The drainage area of the river covers four provinces --- Mountain, Benquet, Pangasinan, Tarlac.

The area administrated is km^2.

1. Population

The basin has a population of about 2,302 thousand.

Population density is about 146.3 persons/km^2, which is fairly high.

The following eight cities have populations of more than 50 thousand.

Baquio, Benquet: 84.5 thousand, Daqupan, Pangasinan: 84.3 thousand, Bayambang, Pangasinan: 56.4 thousand, Tarlac, Tarlac: 135.1 thousand.

Agno River Basin: Summary of Population Statistics

Population / Province	Population 1970 Census	Pop. Increase (1960 - 70) %	Pop. Density (per sq.km)	Pop. Projection 1975	Pop. Distribution (%) Urban	Pop. Distribution (%) Rural	Literacy Rate (%) 1970
Province Total/Ave	2,302,513	26.6	146.3	2,609,203	18.01	81.99	78.73
Mountain	93,112	8.4	44.4	105,259	3.59	96.41	61.55
Benguet	263,550	43.5	99.3	309,656	31.84	68.16	79.87
Pangasinan	1,386,143	23.3	258.2	1,547,604	19.90	80.10	86.03
Tarlac	559,708	31.2	183.3	646,684	16.70	83.30	87.45

Source of basic data: Bureau of the Census and Statistics

Cities and Towns With 50,000 or More Inhabitants

Cities and Towns	Population 1970	Cities and Towns	Population 1970
Baguio, Benguet	84,538	Urdaneta, Pangasinan	58,690
San Carlos, Pangasinan	84,333	Bayambang, Pangasinan	56,415
Dagupan, Pangasinan	83,582	Lingayen, Pangasinan	56,096
Malasiqui, Pangasinan	61,423	Tarlac, Tarlac	135,128

2. Industry

In the mountainous area, mainly centered in the Provinces of Mountain and Benquet, medium latitude agricultural products (such as cabbage, tomatos, carrots, cauliflower, etc.) are the primary products of the Philippines, which are cultivated on the alluvial soil of the Trinidad Valley up to the base of the surrounding mountains. Production in logging and forestry is the highest in Luzon and socond highest in the philippines. Mining and quarrying are active, and Benquet Province has mining as its most important industry, including the refining of gold. [illegible], [illegible] of [illegible].

In the plain area, mainly centered around Pangasinan, agricultural activities are developing to produce palay (rough rice), sugar cane, tobacco, livestock, and poultry. In the lower drainage of Lingayen and Dagupan, fishpond and fish culture are active. Besides these, copper refining, cement manufacture and salt making are found.

Economic Information

Name of Province	Mountain	Benguet	Pangasinan	Tarlac
Area (ha)	209,733	259,938	536,817	305,345
Income (FY1972-73)	₱1,063,812	₱2,978,411	₱6,027,620	₱4,735,300
Industry	Agriculture Logging & Forestry Mining & Quarrying Manufacturing	Agriculture Logging & Forestry Mining & Quarrying	Agriculture Logging & Forestry Fishing Mining	Agriculture Logging & Forestry
Crop	Cabbage Tomatoes Carrots Cauliflower Strawberries etc.	Cabbage Tomatoes Carrots Cauliflower Strawberries etc.	Palay (rough rice) Tobacco Coconut Sugarcane Livestock Poultry	Palay (rough rice) Sugar Poultry Goats

Number of Establishments in Agno River Basin
by Major Industry Division

Province	Total Number of Establishments	Manufacturing	Wholesale and Retail Trade Restaurants and Hotels	Transport Storage and Communication	Community Social and Personal Services	Other Economic Activities
Mountain	773	118	583	29	31	12
Benguet	5,722	448	4,507	96	490	181
Pangasina	20,561	2,307	12,397	3,934	1,610	313
Tarlac	9,980	941	6,068	2,087	704	180

3. Traffic

The traffic network in the Agno River basin is composed mainly of road systems and railroads. The road system includes the trunk roads connecting this region and other regions, inter-regional semi-trunk roads and roads used for daily life. Among the trunk roads, national highways No. 3, No. 13 and No. 11 are most important. They are the key routes that connect this region to Manila. Highway No. 3 runs through the central part of Pangasinan Plain from north to south and connects the main cities; highways No. 13 and No. 11 cross No. 3 and serve effectively as inter-regional semi-trunk roads.

The results of the 1975 survey of traffic volume at places of heavy traffic are; (No. of cars)

Places of comparatively easy access: 1,000 - 1,500/day. Cities in Benquet Province (Bagivere, Taba, Cample): more than 5,000/day. Cities in Pangasinan and Tarlac Province (Asingan, Sto. Tomas, Tarlac): 6,000/day. Other cities (Sta Barbara, Dagupan, Lingayen): 3,000 - 4,000/day.

As mentioned above, this region forms an important traffic center both with railroads and highways. These routes pass through several flood plains.

Existing Highway Kilometerages
(As of June 30, 1972)

Name of Province	Mountain			Benguet		
	National	Provincial Municipal and City	Total	National	Provincial Municipal and City	Total
Earth	44.03	114.19	158.22	13.71	422.89	435.60
Macadam	131.98	169.34	301.32	72.81	385.19	458.00
Low type bit	34.37	6.88	41.25	155.76	209.22	364.98
High type bit	—	—	—	45.19	40.68	86.87
Concrete	—	—	—	18.43	1.05	19.48
Misc. & Comb.	—	—	—	—	—	—
Total	210.38	290.41	500.79	305.90	1,059.03	1,364.93

Name of Province	Pangasinan			Tarlac		
	National	Provincial Municipal and City	Total	National	Provincial Municipal and City	Total
Earth	28.28	297.80	326.08	8.59	110.43	119.02
Macadam	159.44	784.64	944.08	7.82	344.20	352.02
Low type bit	63.74	147.63	211.37	37.70	183.31	221.01
High type bit	129.55	92.10	221.65	36.48	—	36.48
Concrete	93.59	2.61	96.20	76.39	6.69	83.08
Misc. & Comb.	—	425.82	425.82	—	—	—
Total	474.60	1,750.60	2,225.70	166.98	644.63	811.61

4. Damage

In the Agno River basin, the average annual damage due to floods in the past is ₱60 million, and the areas damaged reached 1,720 km^2. The amount of damage in the past 10 years (1966-1975), caused by typhoons, tropical cyclones, etc., are listed below.

Flood Information

Year	Name	Date	Damages	Rainfall
1966	Klaring	May 11 ~ 22	₱ 430,000	Baguio 286.8 mm
1967	Trining	Oct 14 ~ 18	₱1,773,800	Baguio 1,215.7 mm
1967	Welming	Nov 1 ~ 5	₱ 170,000	Baguio 96.1 mm
1968	Huaning	Aug 17 ~ 20	₱ 400,000	Dagupan 114.4 mm
1969	Elang	Jul 24 ~ 27	₱2,000,000	Baguio 545.7 mm
1973	Luming	Oct 2 ~ 9	₱6,300,000	Dagupan 34.6 mm

5. Basin Development Projects

The government of the Philippines is making an effort to develop the Agno River basin, with priority placed on road systematization and river improvement.

Regional Projects

A. Manila North Road,

B. Second Luzon Highway Package Project

C. Tarlac - Sta Rosa Road

D. Rosario - Baguio Road

Bauang - Baguio Road

E. Paneque - Camiling - Wawa - Bayambang Road

F. Agno and Tarlac River Control Projects

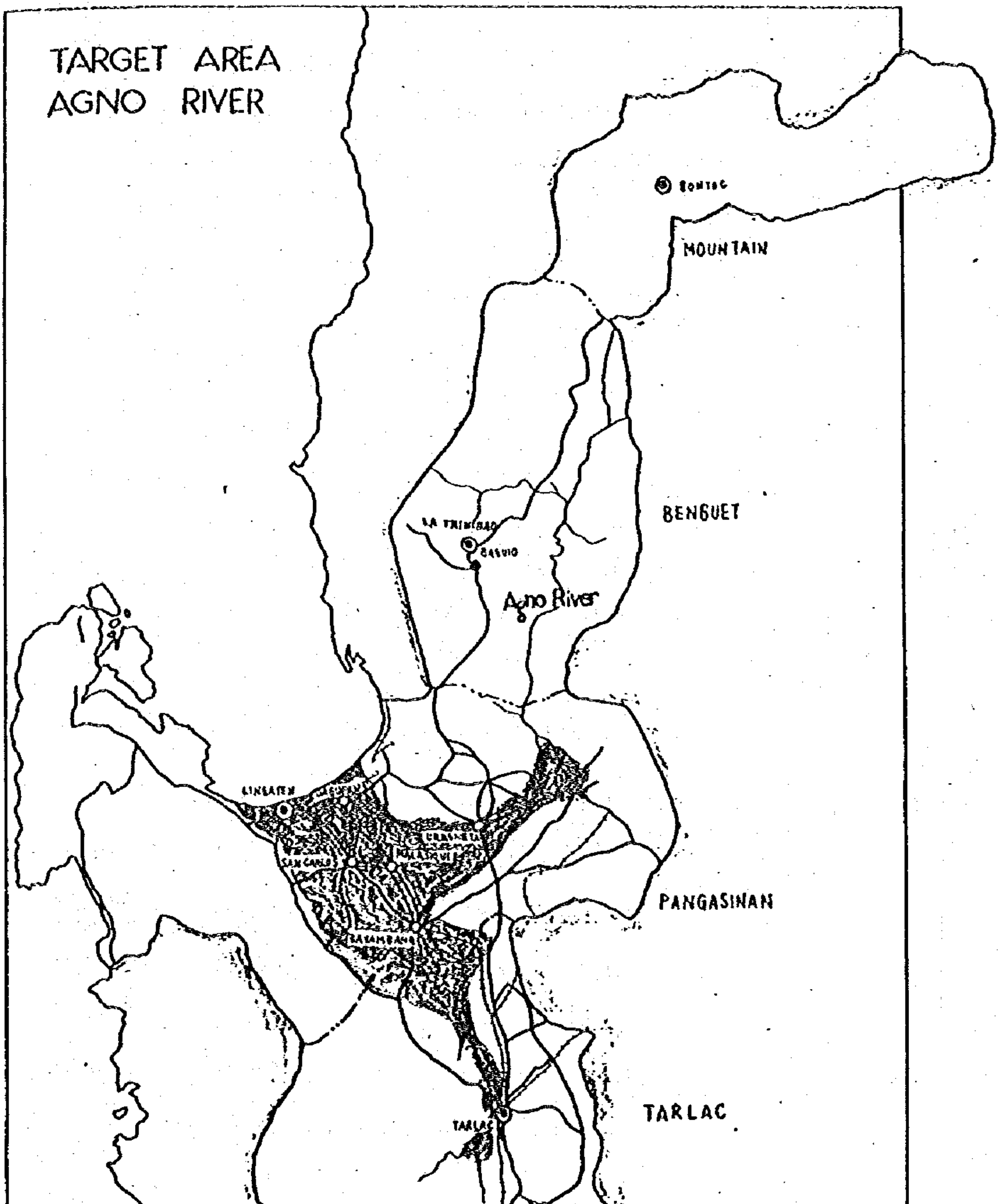
G. Rehabilitation of National and Commercial Irrigation Systems and Installation of Irrigation Pumps within Disaster Areas

6. Target Area

At this time, the selection of target area for flood forecasting and warning is made as follows: taking consideration the distribution of population and houses, use and productivity of land, economic effects upon investment and their regional concentration, and topographic features in the Agno River basin, as well as the probability of forecasting and warning about floods in the future. This probability is based upon meteorology, hydrographical features, frequency of floods and data from past observations.

(1) The entire Pangasinan Plain including the major cities of Dagupan, Lingayen, Bagallon, Sta Barbaba, Bayambang, and Rosales.

(2) The central part of Tarlac Province including the major cities of Tarlac, Garona, Paniqui, and Moncada.


TARGET AREA
AGNO RIVER
MOUNTAIN
BENGUET
Agno River
PANGASINAN
TARLAC

§-2 The Bicol River

This basin of this river covers three provinces --- Camarines Norte, Camarines Sur and Albay --- and the area administrated is 9,930 km^2.

1. Population

The basin has a population of about 1,884 thousand. Density of population is about 189 persons/km^2, which is the second to Metropolitan Manila.

The following seven cities have populations of more than 50 thousand.

Legaspi, Albay: 84.1 thousand, Naga, Camarines Sur: 79.8 thousand, Iriga, Camarines Sur: 77.4 thousand, Libmanan, Camarines Sur: 62.8 thousand, Ligao, Albay: 56.8 thousand.

Bicol River Basin: Summary of Population Statistics

Population / Province	Population 1970 Census	Pop. Increase (1960 - 70) (%)	Pop. Density (per sq.km)	Pop. Projection 1975	Pop. Distribution (%) Urban	Rural	Literacy Rate (%) 1970
Province Total/Ave	1,884,624	28.7	189.3	2,057,153	20.30	79.70	88.97
Camarines Norte	262,207	39.4	124.1	303,337	25.98	74.02	92.22
Camarines Sur	948,436	15.7	180.0	994,626	21.08	78.92	87.68
Albay	673,981	30.9	264.0	759,190	13.86	86.14	87.02

Source of basic data: Bureau of the Census and Statistics

Cities and Towns with 50,000 or More Inhabitants

Cities and Towns	Population 1970	Cities and Towns	Population 1970
Legaspi, Albay	84,090	Tabaco, Albay	60,572
Naga, Camarines Sur	79,846	Daraga-Locsin, Albay	58,335
Iriga, Camarines Sur	77,382	Ligao, Albay	56,765
Libmanan, Camarines Sur	62,762		

2. Industry

Agricultural industry is active in the basin. Cultivation of palay, corn, vegetables, root crops, etc. is dominant mainly in the Bicol Plain. The plain is the granary of the regions. Other active industries are, livestock, poultry, etc., logging and forestry mainly for lumber and logs, coastal fishing and production of marine products centered around the fishing ports of Naga and Colobong, fishponds and fish culture, mining, coconut oil production and the chemical industry.

Economic Information

Name of Province	Camarines Norte	Camarines Sur	Albay
Area (ha)	211,249	526,682	255,257
Income (FY1972-73)	₱1,644,805	₱4,411,522	₱5,140,204
Industry	Agriculture Logging & Forestry Fishing Mining	Agriculture Logging & Forestry Fishing Mining & Quarrying	Agriculture Logging & Forestry Fishing
Crop	Palay, Corn Abaca, Banana Coconut	Palay, Coconut Abaca, Banana Livestock, Poultry	Palay, Corn, Vegetable, Rootcrops, Coconuts, Abaca

Number of Establishments in Bicol River Basin
by Major Industry Division

Province	Total Number of Establishments	Manufacturing	Wholesale and Retail Trade Restaurants and Hotels	Transport Storage and Communication	Community Social and Personal Services	Other Economic Activities
Camarines Norte	3,807	431	2,820	106	372	78
Camarines Sur	13,425	1,494	9,727	1,150	802	252
Albay	10,533	1,623	6,992	1,028	706	184

3. Traffic

The traffic network in the Bicol river basin is composed mainly of the road systems and railroads. The road system includes trank roads connecting this region and other regions, inter-regional semi-trunk roads and the roads used in daily life. The most important road is national highway No. 1, which is the key route to the north (mainly to Manila), and also serves effectively as an inter-regional semi-trunk road, connecting the main cities while passing through the central part along the Bicol Valley. According to the 1975 traffic survey, traffic volume at main points is as follows: (No. of cars)

Places of comparatively easy access: 200-400/day.

Cities in Albay Province (Legazpi, Ligao, Oas, Polangui):200-1,100/day. Cities in Camarines Sur Province (Iriga, Pili, Naga, Nabua): 800-2,400/day.

The railroad plays an important role in addition to the highways. Railroads and national roads functioning as lifelines generally run along the Bicol Valley, and cross the main flood plains at several points.

Existing Highway Kilometerages
(As of June 10, 1972)

Name of Province	Camarines Norte			Camarines Sur		
	National	Provincial Municipal and City	Total	National	Provincial Municipal and City	Total
Earth	—	14.58	14.58	10.00	622.27	632.27
Macadam	57.03	489.63	546.66	75.70	723.50	799.20
Low type bit	51.20	64.07	115.27	135.62	191.74	327.36
High type bit	20.27	79.78	100.05	71.63	21.91	93.54
Concrete	59.05	5.60	64.65	32.35	14.06	46.41
Misc. & Comb.	—	—	—	—	—	—
Total	187.55	653.66	841.21	325.30	1,573.48	1,898.78

Name of Province	Albay		
	National	Provincial Municipal and City	Total
Earth	63.4	319.23	383.57
Macadam	111.69	395.06	506.75
Low type bit	102.60	140.79	243.39
High type bit	97.53	78.38	175.91
Concrete	20.31	1.98	22.29
Misc. & Comb.	13.37		13.37
Total	409.84	935.44	1,345.28

4. Damage

In the Bicol River basin, the average annual damage due to flood in the past is ₱30 million, and the area damaged reached 580km^2. The amount of the damages in the past 10 years (1966-1975), caused by typhoon, and tropical cyclone are listed below: :

Flood Information

Year	Name	Date	Damages	Rainfall
1967	Welming	Nov 1 - 5	₱18,000,000	Daet Cam. Norte 173.5 mm
1973	Luming	Oct 2 - 9	₱ 3,200,000	Daet Cam. Norte 200.1 mm

5. Basin Development Projects

The government of the Philippines set up the 'Bicol River Basin Development Program' with the intention to develop the Bicol region. The region's potential for development is rather high in view of the advanced agriculture and also the various transportation, water resources and flood control projects.

Regional Projects

A. Quirino Highway

B. Legaspi Airport (Package of 5 Airport Projects)

C. Port of Tabaco , (Package of 4 Port Projects)

D. Southern Luzon Electrification Project, Stages IV & V

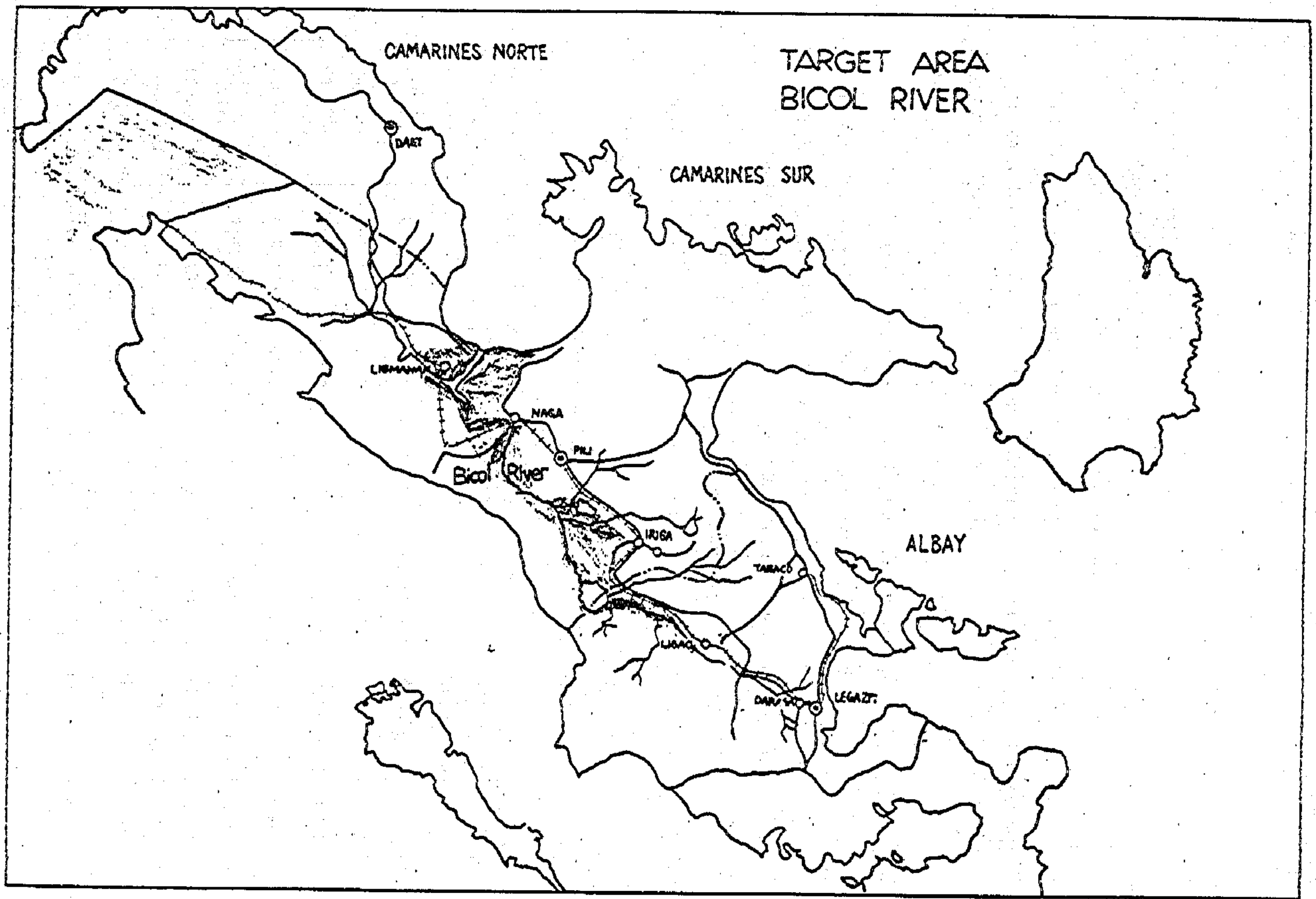
E. Tiwi Geothermal Pilot Plant (2-10 MW)

6. Target Area

The selection of target areas for flood forecasting and warning at this time is made as follows: taking into consideration the distribution of population and of houses, utility and productivity of land, economical effects upon investment with regional concentration and topographic features in the Bicol river basin, as well as the certainty of forecasting and warning about floods in the future. This certainty is based upon meteorology, hydrographical features, frequency of floods and the data of observation so far.

(1) Central part of the basin, from Lake Baao to Lake Bato.

(2) Alluvial plain surrounding Naga city.


TARGET AREA
BICOL RIVER
CAMARINES NORTE
CAMARINES SUR
ALBAY
DAET
NAGA
PILI
IRIGA
Bicol River

§-3. The Cagayan River

The basins of this river covers seven Provinces --- Cagayan, Isabela, Nueva. Vizcaya, Benquet, Ifugao, Mountain, Kalinga Apayao --- and its area administrated is km^2.

1. Population

The basin has a population of about 2,037 thousand. Density of population is about 50 persons/km^2, which is lower than in other regions.

There are only two cities of more than 50 thousand population:

Ilegan, Isabela: 62.1 thousand, Tuquegarao, Cagayan: 52.9 thousand.

Cagayan River Basin: Summary Population Statistics

Population / Province	Population 1970 Census	Pop. Increase (1960 - 69) (%)	Pop. Density (per sq.km)	Pop. Projection 1975	Pop. Distribution (%) Urban	Rural	Literacy Rate (%) 1970
Province Total/Ave	2,036,723	37.4	51.0	2,377,808	14.35	85.65	72.18
Cagayan	581,237	30.5	64.6	659,316	14.58	85.42	80.75
Kalinga Apayao	136,249	52.2	19.3	156,584	8.08	91.92	70.47
Isabela	648,123	46.6	60.8	768,727	13.39	86.61	81.91
Nueva Vizcaya	221,965	60.7	31.9	274,868	23.19	76.81	80.14
Ifugao	92,487	20.4	36.7	103,398	5.79	94.21	50.62
Mountain	93,112	8.4	44.4	105,259	3.59	96.41	61.55
Benguet	263,550	43.5	99.3	309,656	31.84	68.16	79.87

Source of basic data: Bureau of the Census and Statistics.

Cities and Towns With 50,000 or More

Cities and Towns	Population 1970
Ilagan, Isabela	62,118
Tuguegarao, Cagayan	52,956

2. Industry

Although agriculture is the leading industry, the great majority of land is uncultivated. Palay, corn, native tobacco, and fruits are the main products from the limited farmland. In addition, logging and forestry are active, and the production of lumber is the second highest in Luzon. Coastal fishing as well as fishing ponds and fish culture industries are found.

Economic Information

Name of Province	Cagayan	Ifugao	Isabela	Nueva Vizcaya
Area (ha)	900,267	251,673	1,066,456	696,107
Income (FY1972-73)	₱8,058,248	₱ 971,600	₱9,122,962	₱1,395,627
Industry	Agriculture Logging & Forestry	Agriculture Fishing Mining	Agriculture Logging & Forestry Fishing	Agriculture Logging & Forestry
Crop	Palay, Corn Legumes, Rootcrops, Vegetables Fruits, Tobacco, etc. Sugarcane, Carabaos, Hogs.	Rootcrops Corn, Vegetable, Fruits, Coconuts, Sugarcane.	Palay, Corn Tobacco, Fruits, Mango Peanuts, Tomatoes, Vegetables, Coconuts, Sugarcane.	Palay, Mango, Pomelo, Jackfruit, Vegetable, Potatoes, Maguey

Number of Establishments in Cagayan River Basin by Major Industry Division

Province	Total Number of Establishments	Manufacturing	Wholesale and Retail Trade Restaurants and Hotels	Transport Storage and Communication	Community Social and Personal Services	Other Economic Activities
Cagayan	9,133	1,549	4,519	2,457	460	148
Ifugao	—	—	—	—	—	—
Isabela	5,578	748	3,583	583	556	108
Nueva Vizcaya	3,110	307	1,820	607	259	117

3. Traffic

The traffic network in the Cagayan River basin is composed mainly of the roads. The road system includes trunk roads connecting this region and other regions, inter-regional semi-trunk roads and roads used for daily life. The Philippines-Japanese Friendship Road is the most important trunk road, which is the key route that links this region to the south (mainly to Manila), and also serves effectively as an inter-regional semi-trunk road, connecting the main cities while passing through the central part of the region from north to south. The Philippines-Japanese Friendship Road, functioning as life line, runs along the Cagayan Valley and crosses the main flood plains at several points.

Existing Highway Kilometerages
(As of June 30, 1972)

Name of Province	Cagayan			Ifugao		
	National	Provincial Municipal and City	Total	National	Provincial Municipal and City	Total
Earth	6.00	240.46	246.46	99.82	138.01	237.83
Macadam	355.18	658.23	1,013.41	163.42	84.78	248.20
Low type bit	11.31	51.36	62.67	18.72	1.80	20.52
High type bit	49.16	45.75	44.91		—	—
Concrete	63.40	0.08	63.48	0.97	—	0.97
Misc. & Comb.	—	—	—	—	—	—
Total	485.05	995.88	1,480.93	282.93	224.59	507.52

Name of Province	Isabela			Nueva Vizcaya		
	National	Provincial Municipal and City	Total	National	Provincial Municipal and City	Total
Earth		546.30	546.30	141.20	95.96	237.16
Macadam	189.92	1,191.22	1,381.14	176.71	208.54	385.25
Low type bit	26.88	17.56	44.44	20.63	7.75	28.38
High type bit	31.66	21.37	53.03	7.78	0.60	8.38
Concrete	44.63	—	44.63	46.53	0.20	46.73
Misc. & Comb.	—	—	—	70.36	—	70.36
Total	293.09	1,776.45	2,069.54	463.21	313.05	776.26

4. Damage

In the Cagayan river basin, the average annual damages due to the floods in the past is ₱2.7 million, and the area damaged reached 570km^2. The amounts of damage in the past 10 years (1966-1975), caused by the the violent typhoons and tropical cyclones, is listed below:

Flood Information

Year	Name	Date	Damages	Rainfall
1966	Klaring	May 11 ~ 22	₱ 1,400,000	Raxas City 310.7 mm
1967	Trining	Oct 14 ~ 18	₱10,000,000	Aparri 273.1 mm
1968	Huaning	Aug 17 ~ 20	₱ 200,000	Tuguegarao 178.7 mm
1968	Nitang	Sep 24 ~ 29	₱ 150,000	Aparri 241.3 mm
1969	Elang	Jul 24 ~ 27	₱ 350,000	Cagayan 222.5 mm
1970	Pitang	Sep 8 ~ 12	₱ 8,700,000	Tuguegarao 22.2 mm
1973	Luming	Oct 2 ~ 9	₱ 1,200,000	Tuguegarao 199.3 mm

5. Basin Development Projects

This region has large potential for development, and the government of the Philippines is making an effort toward progress in the program, a part of which is now under way.

Regional Projects

A. Magat River Multi-purpose Project (Irrigation Phase)

B. Cagayan Valley Electrification Project

C. Matuno River Project

D. Magat River Project (Power Phase)

6. Target Area

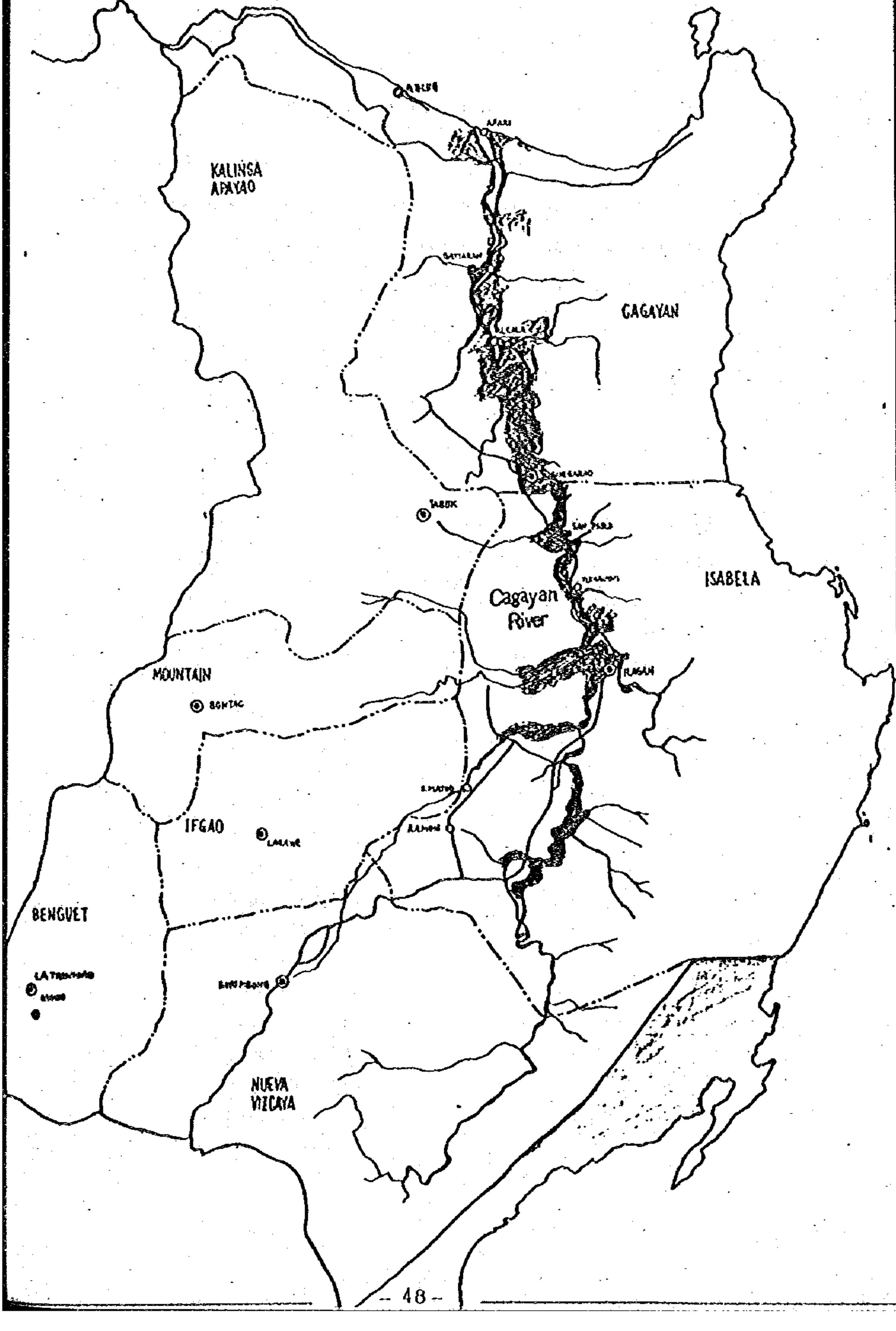
At this time, the selection of the target area for flood forecasting and warning is made as follows, in view of the distribution of population and houses, and the use and productivity of land in the Cagayan River basin, as well as meteorology, hydrographic features and flood frequency.

(1) Areas along the lower course, from Tuquegarao city to Appari.

(2) Alluvial plains along the river course, from Gattaran to Apparri.

(3) Alluvial plains along the river course, from Ilagan to Tumauini.

TARGET AREA
CAGAYAN RIVER



IV. Flood Forecasting Procedure

§-1 The Agno River

1. Hydrographic and Hyetographic Characteristics

(1) Existing water stage, runoff and rainfall gaging stations. Water stage and rainfall gaging stations of the Agno River basin are located throughout the entire basin as shown in Fig. 5.1. Location and collected data of each station are indicated in Table 5.1.

(2) Rainfall Data

Table 5.2 indicates the data concerning rainfall which seems to have caused floods in the past 10 years (1967-1976) at principal points in the Agno river basin.

Selected rainfalls are as follows:

October, 1967
August, 1968
September, 1968
October, 1968
July, 1969
August, 1969
September, 1970
July, 1972
August, 1972
October, 1973
October, 1974
November, 1974
September, 1975
May, 1976
June, 1976

Fig LOCATION MAP OF RAINFALL OBSERVATION STN.

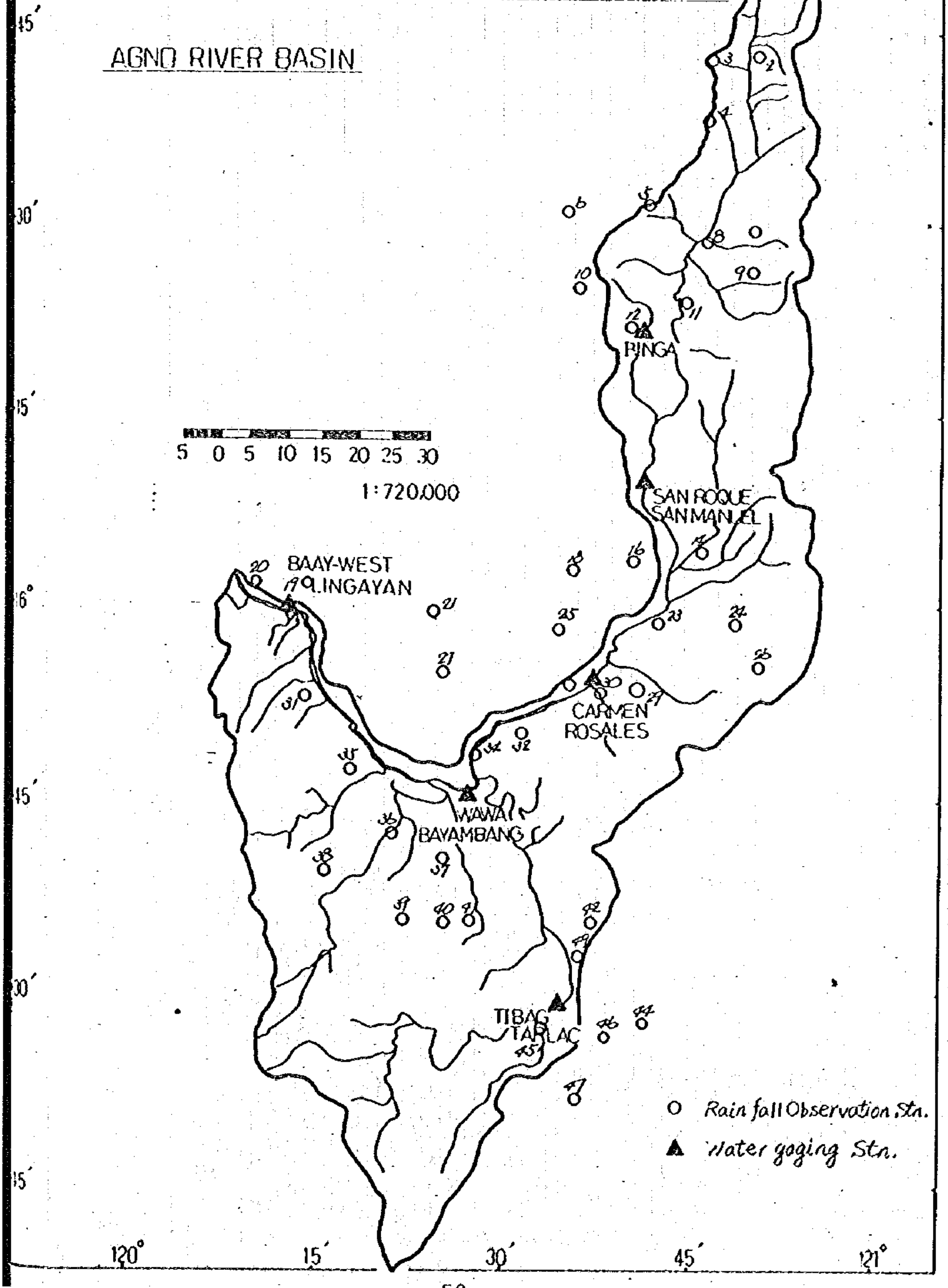


Table Location of Rainfall Observation Stn.

TABLE - 5.1 AGNO River Basin (1)

No	Name of Stations	Location: Latitude	Location: Longitude	Location: Elevation in meters	Type of Ins.	Date Established	Managed by	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1	Mt. Data Mankayan Benguet	[illegible]°[illegible]'30"	120°4[illegible]'[illegible]0"	2134	OG	Jan 1956	CM								Δ	○		
2	[illegible] Agno river Benguet	16°43'[illegible]"	120°49'40"	1400	OG	1950	CM	○		○	○		○	○				
3	Km 50 Benguet	16°43'00"	120°[illegible]'20"	2287	OG	Jan 1963	CM			×	○	○						
4	Adaoay Kabayan Benguet	16°38'10"	120°45'20"	860	OG	1950	CM	○	×	○	○	○	○	Δ	○	○	○	Δ
5	Tabeo Atok Benguet	[illegible]°31'30"	120°41'00"	1540	OG	1950	CM	○	×	○	○	○	○	○	○	○	×	○
6	[illegible] Atok Benguet	[illegible]°31'20"	120°34'20"	550	OG	1971	CM											
7	Karao Bokod Benguet	16°2[illegible]'[illegible]0"	[illegible]'40"	900	OG	1971	CM			○	○	○	○	○	○	○	×	×
8	Ambuklao Bokod Benguet	[illegible]°28'50"	120°45'4[illegible]"	740	OG	1949	CM											
9	School house #5 Benguet	15°26'30"	120°39'30"	450	OG	1950	CM										○	
10	Baguio City Benguet	16°25'00"	120°36'30"	1501	RG/OG	1902-III-1947	MGSD											
11	Binga dam Itogon Benguet	15°24'00"	120°44'00"	583	OG	1957	CM	○	○	○	○	Δ	Δ	○	Δ	○	Δ	×
12	Balatoc Mines Itogon Benguet	16°22'00"	120°39'00"	[illegible]20	OG	1947	CM		○	○	○	○	○	○	○	○	○	Δ
13	Agno, Pangasinan	[illegible]°37'30"	119°49'50"	25	OG	1972	CM											
14	San Nicolas Pangasinan	15°04'30"	120°45'45"		RG/OG	Sept. 1974	HM									○	○	○
15	Mabini, Pangasinan	16°04'10"	119°56'30"	20	OG	1947	CM											
16	San Manuel Pangasinan	16°04'30"	120°40'00"		RG/OG	July 1974	CM											
17	Dagupan City Pangasinan	[illegible]°03'30"	120°20'00"	2	RG/OG	1902-II-1947	MGSD											
18	Binalonan Pangasinan	16°03'00"	120°35'30"	37	OG	1972	CM											
19	[illegible] Pangasinan	16°02'30"	120°14'00"	2	RG/OG	Feb 1971	HM											
20	Labrador Pangasinan	16°01'42"	120°35'30"		RG/OG	July 1974	HM									○	○	○
21	Sta Barbara Pangasinan	15°54'47"	120°24'[illegible]	17	RG/OG	July 1974	HM											
22	Dasol Pangasinan	15°59'30"	[illegible]°[illegible]'45"		RG/OG	Dec 1974	HM											
23	Sta. Maria Pangasinan	15°59'[illegible]	120°22'13"		RG/OG	July 1974	HM									○	Δ	○
24	San Quintin Pangasinan	15°59'00"	120°43'35"	65	RG/OG	July 1974	HM									○	×	×
25	Urdaneta Pangasinan	15°58'[illegible]"	120°34'10"	24	RG/OG	July 1974	HM											
26	Umingan Pangasinan	15°55'37"	120°50'13"	128	RG/OG	July 1974	HM									Δ	○	○
27	Malasiqui Pangasinan	15°55'17"	120°2[illegible]'43"	45	RG/OG	July 1974	HM											
28	Villasis Pangasinan	15°54'15"	120°35'05"	21	RG/OG	July 1974	HM									○	○	○
29	Balungao Pangasinan	15°54'30"	120°40'20"	50	OG	1971	CM							○	○	○	○	○
30	Rosales Pangasinan	[illegible]°53'36"	120°37'42"	27	RG/OG	Apr. 1969	HM				Δ	○	○	Δ	○	○	○	○
31	Aguilar Pangasinan	15°53'22"	[illegible]°[illegible]'15"		RG/OG	July 1974	HM									○	○	○
32	Alcala Pangasinan	15°50'40"	120°31'32"	19	RG/OG	July 1974	HM									○	○	○
33	Infanta Pangasinan	15°[illegible]	[illegible]		RG/OG	Dec 1974	HM									Δ	Δ	×
34	[illegible] Pangasinan	[illegible]°42'42"	120°27'06"	13	RG/OG	July 1974	HM									○	○	○
35	Mangatarem Pangasinan	15°47'30"	120°17'30"		RG/OG	July 1974	HM										○	Δ
36	[illegible] Camiling Tarlac	15°43'[illegible]	[illegible]°21'00"		RG/OG	Jan 1975	HM-NIA										○	○
37	[illegible] Camiling Tarlac	15°41'30"	120°25'00"		RG/OG	May [illegible]	HM					○	○	○	○	○	○	○
38	Anoling Camiling Tarlac	[illegible]°40'30"	[illegible]°[illegible]'30"		RG/OG	Jan 1975	HM-NIA										○	○
39	Mayantoc Tarlac	[illegible]°36'20"	12[illegible]°21'50"	50	OG	1974	CM									○	○	○
40	[illegible] Tarlac	[illegible]°36'30"	[illegible]		RG/OG	Jan 1975	HM-NIA										○	○

Table ... Location of Rainfall Observation Stn.

TABLE-5.1(2). AGNO River Basin (2)

No	Name of Stations	Location			Type of Ins	Date Established	Managed by	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
		Latitude	Longitude	Elevation in meters														
41	Namoasin Mayantoc Tarlac	15°36'00	120°27'00		RG/OG	Jan 1975	HM NIA										○	○
42	Nitampiop Gerona Tarlac	15°36'00"	120°37'00"		RG/OG	Jan 1975	HM NIA										○	○
43	San Jacinto Victoria Tarlac	15°33'00"	120°36'00"		RG/OG	Jan 1975	HM-NIA										○	○
44	Amucao, Tarlac	15°28'00"	120°41'00"		RG/DG	Jan 1975	HM-NIA										○	○
45	Carangian [illegible] Tarlac	15°21'30"	120°33'00		RG/OG	Jan 1975	HM-NIA										○	○

(3) Water Stage Data

From the rainfall data, principal floods in the Agno river are to be selected.

In this connection, the following points were selected as water stage telemetering stations on the Agno River through hydrological and socio-economic study.

- Binga Dam
- San Roque, San Manuel
- Carmen, Rosales
- Tibag, Tarlac
- Wawa, Bayanbang
- Baay-West, Lingayan

Due to river improvement, the right bank of the Agno River has become an inner water area, and Poblacion Norte, Sta. Barbara, is also selected for the flood prevention of Dagupan, one of the main cities.

The record of water stage is shown in Table 5.3.

(4) Water Stage - Rainfall Diagram

Fig. 5.2 in the attached sheets indicates rainfall and water stage.

A G N O

	BINGA DAM		SAN ROQUE		CARMEN ROSALES		WAWA BAYAMBANG		BAAY-WEST, LINGAYEN		TARLAC		STA.BARBARA		DOBLACION BAYANAANG	
1966			May 20	(3694) 7.99	May 20	(2404) 26.60	—		Sept.13	3.24	Sept.27	(481) 2.88	May 21	(153) 5.33	May 21	(840) 16.25
67			Oct.18	(1182)	Oct.17	(3855) 27.60	Oct.19	13.00	Aug.19	3.20	July 30	(499) 2.76	Oct.18	(154) 5.34	Oct.18	(1229) 16.85
68			Sep.29	(4350) 8.40	Sep.28	(2764) 26.48	Aug.31	15.38	Aug.31	3.36	June 6	(29) 1.46	Aug.	(156) 5.40	Aug.29	(1251) 16.88
69			July29	(2158) 7.30	July28	(1658) 25.33	Aug.7	13.51	Aug.8	2.93	—		Aug.6	(148) 5.20	Aug.7	(521) 15.50
70			Oct.15	(550) 5.90	Sep.12	(1545) 25.18	Sep.2	12.95	Sep.11	2.84	—		Sep.12	(133) 5.36	Sep.12	(649) 75.85
71			Aug.14	(863) 6.99	Oct.11	(2307) 26.17	—		July	3.20	—		July21	(131) 5.30	Oct.11	(772) 16.12
72			July18	(1611) 9.19	July29	(3413) 27.25	July19	15.78	July17	3.98	—		July19	(135) 5.44	July19	(2425) 18.29
73			Oct.8	(455) 5.79	Oct.8	(1270) 24.80	Oct.17	11.77	Aug.27	2.98	—		Oct.9	(137) 5.48	Oct.9	(460) 18.29
74			July23	(390) 5.60	Oct.17	(2436) 26.33	Oct.18	15.59	Aug.17	3.80	—		Oct.20	(125) 5.14	Oct.29	(1929) 12.50
75					Sep.18	695 23.90	Oct.24	16.77	Aug.17	2.96					Jan.17	(31) 12.86
76			(June)		(May25	26.99)	(May26	14.22)							(May	)

2. Travelling Time

The rate of movement of flood waters was calculated from the average rate of flow of water, and the estimated travel time of flood waters through sections of the river is shown in the table below.

Flood Water Travel Time

Section of River	Distance	Slope	Rate of Flood Water Movement	Flood Water Travel Time
Binga Dam ~ San Roque	50 km	1/100	5.0 m/s	3 hr
San Roque ~ Carmen	50	1/600	3.0	5
Carmen ~ Wawa	45	1/3,500	1.5	8
Tibac ~ Wawa	50	1/1,500	1.3	11
Wawa ~ Baay-West Lingayen	70	1/20,000	1.0	19

3. Tributaries to be Forecast

3-1. Division of Drainage

Division of sub-basins must be worked out on the basis of the distribution of population and houses, use and productivity of land, and their regional concentration.

The selection was made, taking into consideration the probability of forecasting floods in the future. This probability is based upon topographical features, meteorology, hydrological features, frequency of floods and past data observations.

The following 4 areas were selected.

(1) Left bank of Agno river, below San Roque.

(2) Area along the Tarlac river, below Tibag.

(3) Lingayen Area, below Wawa.

(4) Dugupan Area.

The forecasting points for the above areas are as follows:

San Roque, San Manuel

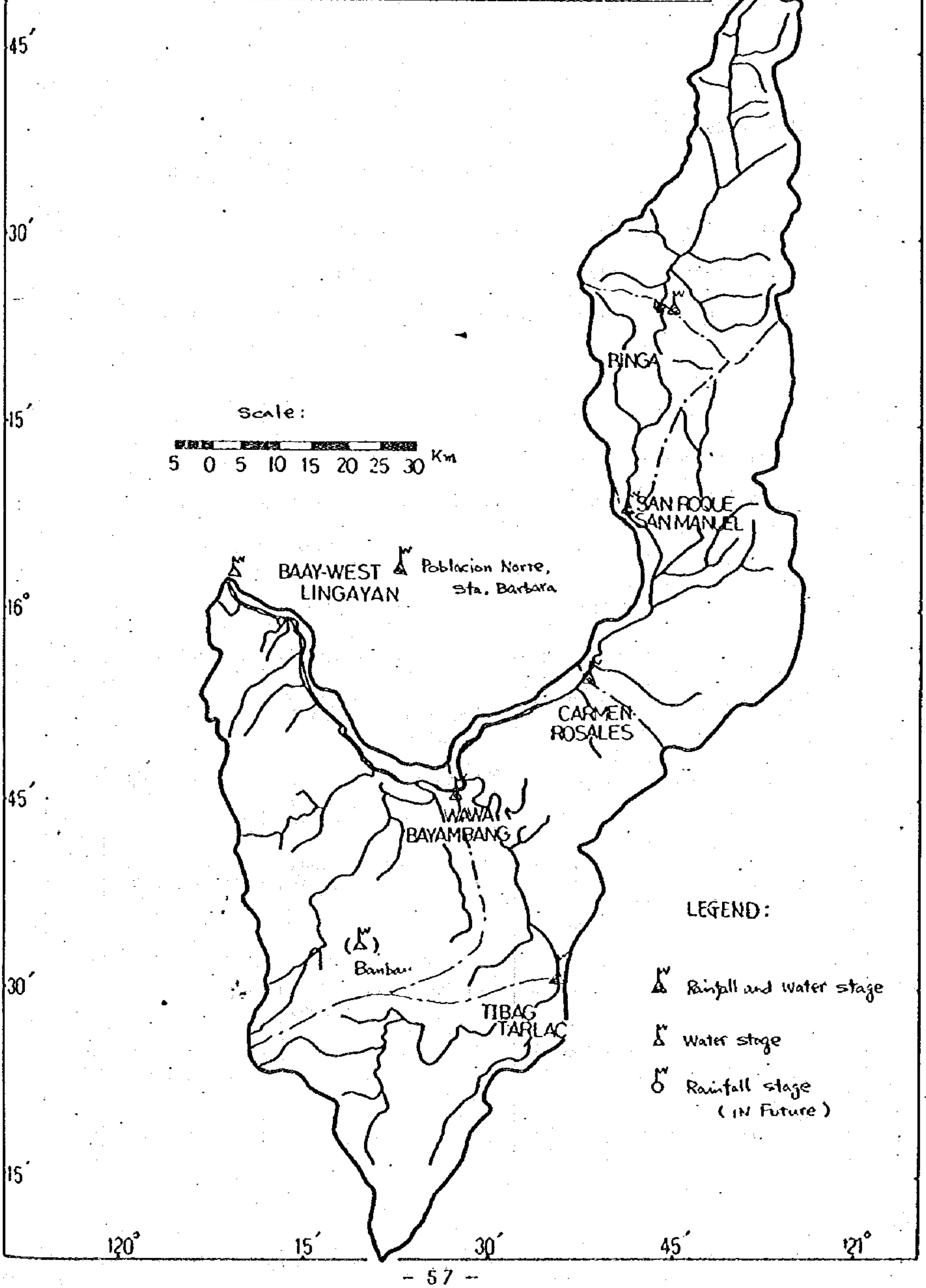
Carmen, Rosales

Tibag, Tarlac

Wawa, Bayambang

Poblaction Norte, Sta. Barbara

Fig TELEMETERING STATION THE AGNO RIVER BASIN



4. Telemetering Station

The points indicated in the following table are the telemetering stations for flood forecasting.

Telemetering for discharge means the usual observation of discharge or floods, preparation of stage-discharge rating curves, and in so doing the conversion of the observed water stage into discharge.

Bamban rainfall telemetring station in the upper reaches of the Tarlac River will be established in the future and will serve to forecast not only for the Tarlac River but also for the Panpanga River.

Agno River Basin: List of Rain Gaging Station

No.	Station	Location of Station	River Basin	Remarks
1.	Binga Dam	Downstream of the Dam: around the office	Agno R.	Newly constructed
2.	San Rogue, San Manuel	Right Abutment of Agno Irrigation System Intake	Agno R.	Newly constructed
3.	Carmen, Rosales	Flood Control System Office	Agno R.	
4.	Wawa, Bayambang		Agno R.	"
5.	Tibag, Tarlac	On the right bank of Agno Br.	Tarlac R.	"
6.	Pobulacion Norte, Sta. Barbara		Sinocolan R. (Dagupan R.)	"
(7)	Bamban		Tarlac R.	in future

Table - Agno River Basin: List of the Water Stage Gaging Stations

No.	Station	Location of Station	River Basin	Remarks
1.	Binga Dam		Agno R.	Newly constructed
2.	San Rogue, San Manuel		Agno R.	Newly constructed
3.	Carmen, Rosales		Agno R.	
4.	Wawa, Bayambang		Agno R.	The older one was swept away
8.	Baay-West, Lingayan		Agno R.	Tide
5.	Tibag, Tarlac		Tarlac R.	
6.	Pobulacion Norte, Sta. Barbara		Dagupan R.	

Table - Agno River Basin: List of the Discharge Gaging Station

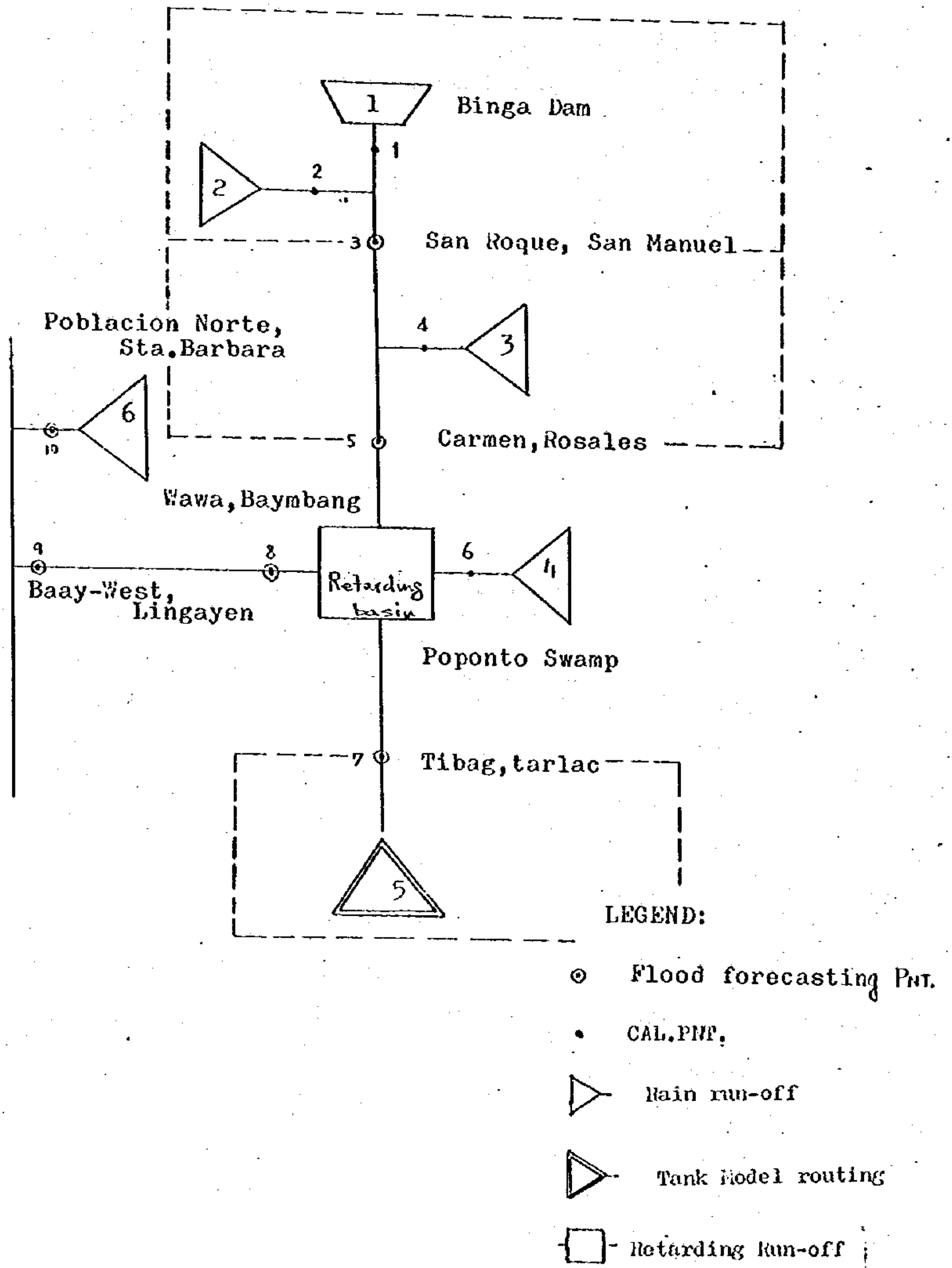
No.	Station	Location of Station	River Basin	Remarks
2.	San Rogue, San Manuel		Agno R.	
3.	Carmen, Rosales		Agno R.	
4.	Wawa, Bayambang		Agno R.	
5.	Tibag, Tarlac		Tarlac R.	

5. Runoff and Flood Routing Model

Fig. 5-3 shows the runoff and flood routing model of the Agno River, which has been worked out on the basis of the results of tributaries to be forecast.

Fig-5-3 FLOOD FORECASTING MODEL

The Agno River Basin



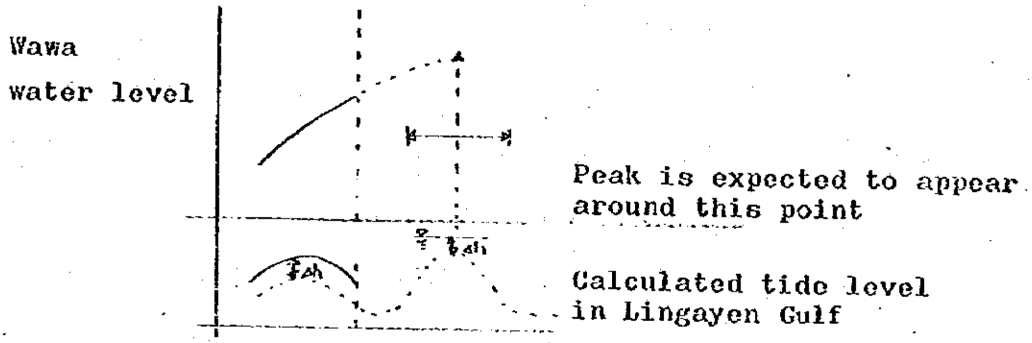
6. Storm Surge Model

6-1. Baay-west, Lingayen station

Forecasting at Baay-west, Lingayen, can be viewed through two methods --- flood time prediction and high tide prediction.

(1) Flood time

Since water stage of Baay-west, Lingayen, is affected by flood water, a considerable difference is inevitable between the measured water level and the calculated astronomical tide level of Lingayen Gulf. Consequently, correction must be made according to the difference between the actually measured water level and the calculated water level.



(2) High tide

Storm surge formula for tide in Lingayen Gulf:

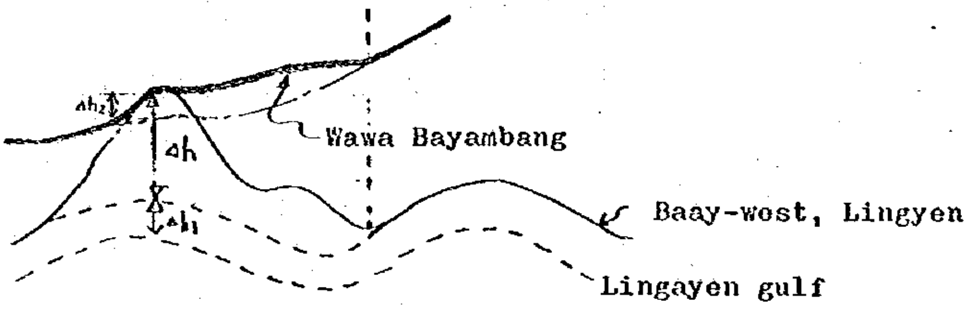
$$\Delta h = a\,(1{,}013 - P) + b.V^2$$

Where, P is atmospheric pressure (mb)

V is wind velocity (m/s)

a) The course of typhoons, wind velocity and minimum atmospheric pressure can be forecast from existing data.

b) Forecast of the maximum deviation



Where, Δh_1 is amount of increased water level during a flood

Δh is deviation

Δh_2 is the difference in water level between Baay-west and Wawa

Δh_2 = (Wawa W.L.) - (Baay-west W.L.)

However, when Δh_2 becomes minus, a back current occurs.

Therefore, in forecasting the water level of Wawa - Bayambang a review must be made in connection with Δh_2.

The maximum wind velocity and the lowest atmospheric pressure data are available at Dagupan Synoptic Station, or any nearby observatory.

7. Flood forecasting method

7-1. San Roque, San Manuel point

(1) Average basin rainfall (daily rainfall)

The arithmetic mean method is applied to Binga dam rainfall (R_1) and San Roque, San Manuel, rainfall (R_2).

$$R = \frac{R_1 + R_2}{2} \quad \text{(mm)}$$

(2) Spill of Binga dam (average daily discharge)

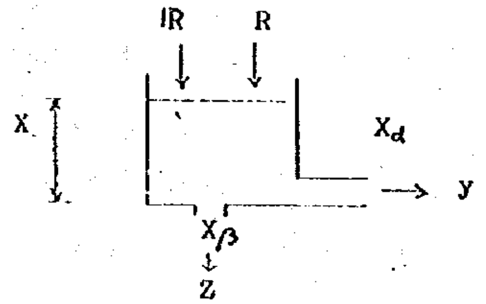
The amount of Binga dam discharge is converted into rainfall depth.

$\mathbb{R} = Q \times 86.4 \times / A_1$ (mm)

Where, Q is the spill (m3/s)

A is the Binga dam drainage area 936 km^2

(3) Tank model method



The model as shown in the sketch is an explanation of the tank model method. If, rainfall: $(R + \mathbb{R})_n$, storage : X_n, outflow: Y_n, : infiltration: Z_n,

α times of X_n is Y_n and β times is Z_n.

Outflow amount $Y_n = \alpha X_n$

Infiltration $Z_n = \beta X_n$

Discharge amount $Q_n = Y_n \times A_2 / 86.4$

A_2: San Roque, San Manuel, drainage area 1,225km^2

Storage X_n minus discharge Y_n and infiltration Z_n becomes resiual X'_n.

$X'_n = X_r - Y_r - Z_n$

When rainfall $(R + \mathbb{R})_{n+1}$ at the time point (n+1) is added to this residual X'_n, storage is X_{n+1} at the time point (n+1).

$$X_{n+1} = X'_n + (R + \mathbb{R})_{n+1}$$

In the tank model method, the traveling time of flow in the channel is excluded. So forecasting is performed by shifting the calculated outflow amount at the calculated time point forward. Traveling time is inferred from actual measured results.

(4) Analysis of constants and adjustment of the actual measured values

Analysis constants α and β are determined from observed data through trial results. However, adjustment of predicted values during forecasting is done by determining the correction coefficient F for residual downstream rainfall R, and inserting the product F from the following formula.

$$F = \frac{\text{Calculated discharge } (Q_1) - \text{Actual observed discharge } (Q_2)}{\text{Actual observed discharge } (Q_2)}$$

7-2. Carmon, Rosales point

(1) Average basin rainfall (daily rainfall)

The arithmetic mean method is applied to San Roque, San Manuel, (R_1) and Carmon, Rosales, (R_2) rainfalls.

$$R = \frac{R_1 + R_2}{2} \quad (mm)$$

(2) Discharge at San Roque, San Manuel

The discharge is converted into rainfall depth.Y.

(3) Tank model method

The calculation method is the same as for San Roque, San Manuel.

$Q_n = Y_n \times A_3/86.4$

A_3 : Carmen, Rosales, drainage area 2,209km^2

(4) Analysis of constants and adjustment of the actual observed values

This is also the same as for San Roque, San Manuel.

7-3. Tibag, Tarlac Point

(1) Average basin rainfall (daily rainfall)

Rainfall at Tibag, Tarlac, represents the basin rainfall. However, when Bamban telemetering station is established in the future, the arithmetic mean method will be applied.

(2) Tank model method

The calculation method is the same as for San Roque, San Manuel.

$Q_n = Y_n \times A_4/86.4$

A_4: Tibag, Tarlac, Point drainage area 872km^2

(3) Analysis of constants and adjustment of the actual observed values

This is also the same as for San Roque, San Manuel.

7-4. Wawa, Bayambang, point

(1) Average basin rainfall (daily rainfall)

The arithmetic mean method is applied to Tibag, Tarlac, rainfall (R_1), Carmon, Rosales, rainfall (R_2) and Wawa, Bayambang, rainfall (R_3).

$$R = \frac{R_1 + R_2 + R_3}{3} \quad \text{(mm/day)}$$

(2) Residual downstream outflow amount (Q_z)

Q_z = R X A_4/86.4 (m^3/s)

A_4: Residual drainage area (km^2)

4,196 - 872 - 2,209 = 1,115 km^2

(3) Inflow amount (Q)

Q_T: Tibag, Tarlac, outflow (m^3/s)

Q_C: Carmen, Rosales, outflow (m^3/s)

Q_Z: Residual drainage area outflow (m^3/s)

(4) Flood adjustment calculation (retarding runoff)

Generally,

I_n: Inflow amount at time n (m^3/s)

O_n: Outflow amount at time n (m^3/s)

V_n: Total storage amount at time n (m^3/s)

Δt: Time difference between time n and time n+1 (sec)

Since (average inflow)XΔt = (average outflow)X Δt + (storage difference before and after Δt), if Δt is shortened enough so that there is no large error in the assumed variations of I and O during Δt,

$$\left(\frac{I_n + I_{n+1}}{2}\right).\ \Delta t = \left(\frac{Q_n + Q_{n+1}}{2}\right).\ \Delta t + (V_{n+1} - V_n)$$

Where, I_n and I_{n+1} are already known,

$$\frac{I_n + I_{n+1}}{2} = I_{(n,\ n+1)}$$

$$I_{(n,\ n+1)}\Delta t - Q_n\ \Delta t + (V_n + \frac{Q_n}{2}\ t) = (V_{n+1} + \frac{Q_{n+1}}{2}\ t)$$

and is calculated as,

$$\phi = V + \frac{Q}{2}\Delta t,\quad \varphi = Q\Delta t,$$

Where, the value of Q_n is calculated with $Q = C \times \sqrt{2g\Delta h} \times B$

Δh: water level difference (m)

C: discharge coefficient

B: iver width (m)

When conversion is made into water level, calculation is performed by the least square method using formula, $Q = AH^2 + BH + C$, where Q is the calculated discharge and H is the actual measured value.

7-5. Poblacion Norte, Sta Barbara point

(1) Average basin rainfall

Poblacion Norte, Sta Barbara rainfall (R) represents the basin rainfall.

(2) Inflow amount

$Q = R \times A_5/86.4$ (m^3/s)

A_5: Dagupan river drainage area 180km^2

(3) Retarding runoff

The method is the same as that for Wawa-Bayanbang, provided the discharge amount (O) is determined from the following formula.

$$O = C\sqrt{2g\,(H_1 - H_2)}$$

$$H_1 = H_{1\ n-1} + \Delta h$$

$$\Delta h = Q/\ A' \times 10^6$$

Where, H_1: Inundated area W.L.

A: Dagupan river inundated area (km^2)

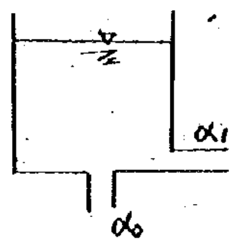
H_2: Calculated tide level in Lingayen Gulf

However, the application of the tank model method may be required when the effects of downstream tide level can be disregarded and discharge can be observed.

7-6 Verification of the Flood Forecasting Method

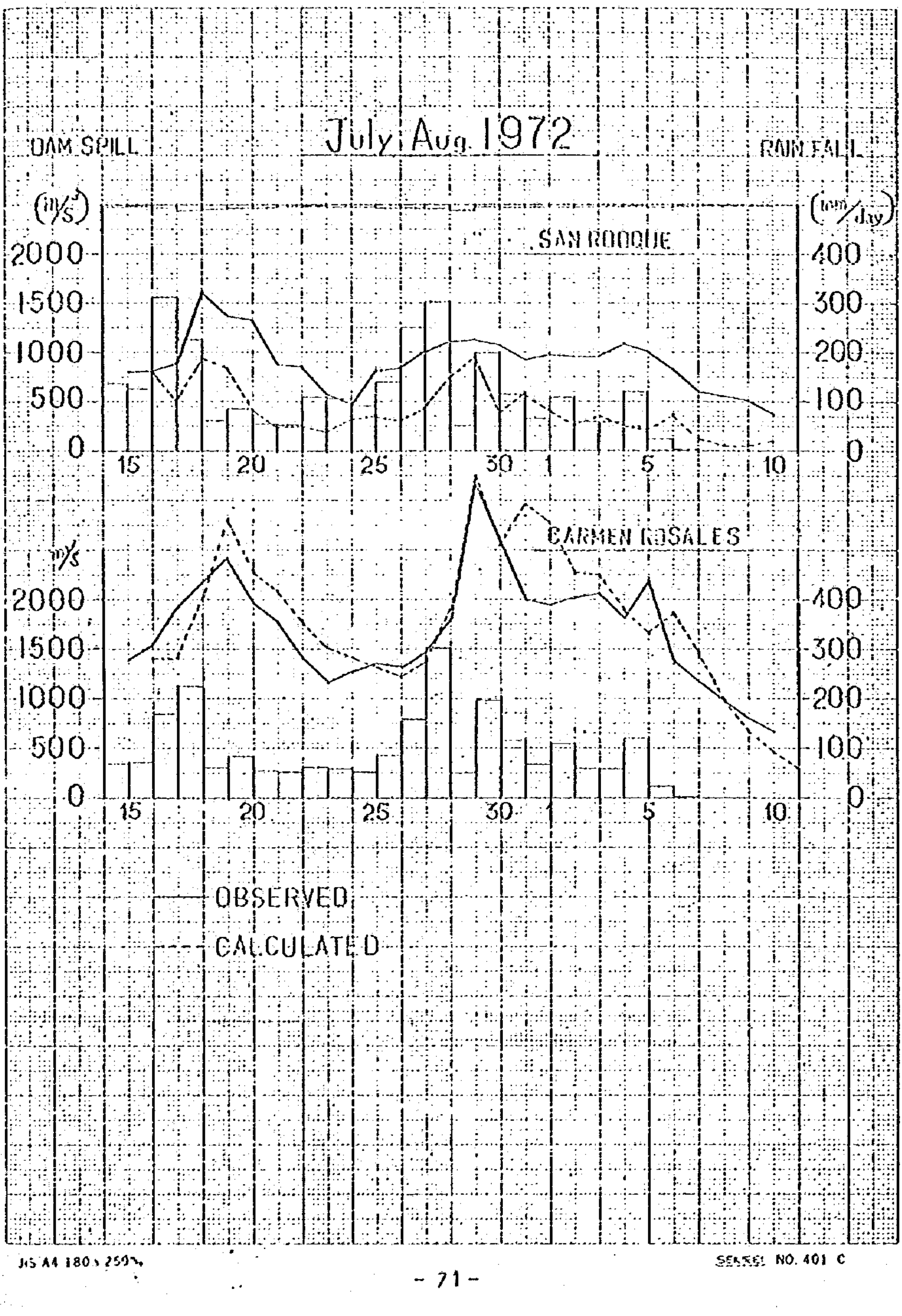
1) Tank Model Analysis

The constants for the tank model being studied at present are as follows. The results of calculation for verification using these constants are shown in the following diagram.

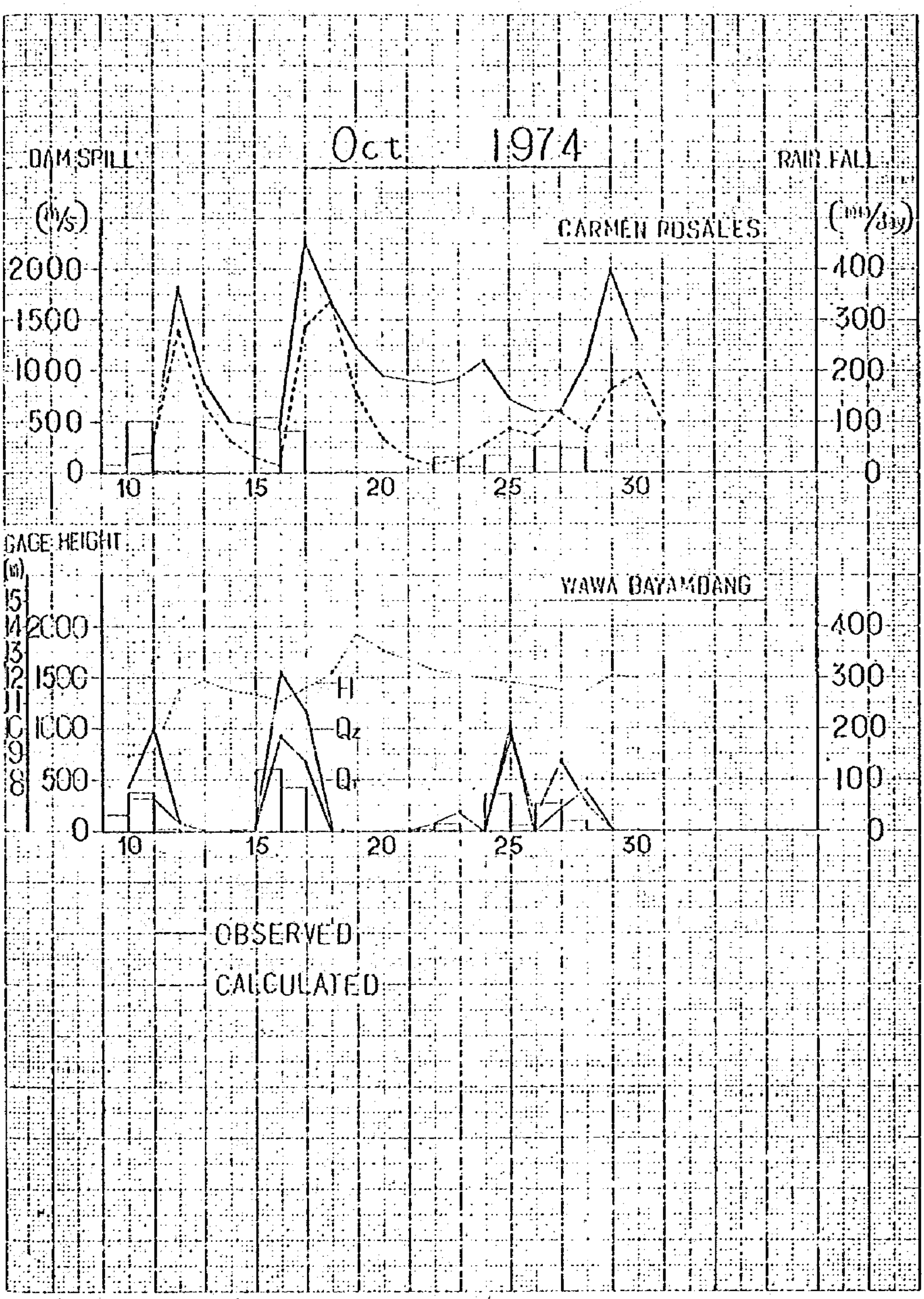


Tank Model Constants at Forecasting Points

Forecasting Point	α_0	α_1	Notes
San Roque San Manuel	0.0	0.75	
Carmen, Rosales	0.075	0.25	
Tibag, Tarlac			
Poblacion Norte Sta. Barbara			



JIS A4 180 x 250%   SEKISUI NO. 401 C


Oct 1974
DAM SPILL
(m³/s)
RAIN FALL
(mm/day)
CARMEN ROSALES
2000
1500
1000
500
0
400
300
200
100
0
10
15
20
25
30
GAGE HEIGHT
(m)
WAWA BAYAMBANG
15
14
13
12
11
10
9
8
2000
1500
1000
500
0
400
300
200
100
0
H
Q2
Q1
10
15
20
25
30
OBSERVED
CALCULATED
JIS A4 180×250%
SEKISUI NO. 401 C

§-2. The Bicol River

1. Hydrographic and Hyetographic Characteristics

(1) Existing water stage, discharge and rainfall telemetering stations.

Existing water stage, discharge and rainfall telemetering stations in the Bicol River basin are shown in the following diagram and tables.

(2) Data of rainfall

Data of rainfall available at the main rain gage stations are shown in Fig. .

(3) Data of water stage

The following table shows the water level recorded at main stations including forecasting points on the Bicol River.

(4) Hydrographic and Hyetographic Characteristics

The next figures on the attached sheets indicate the water stage and rainfall curves during major floods based on the records.

Fig LOCATION MAP OF RAINFALL OBSERVATION STN.

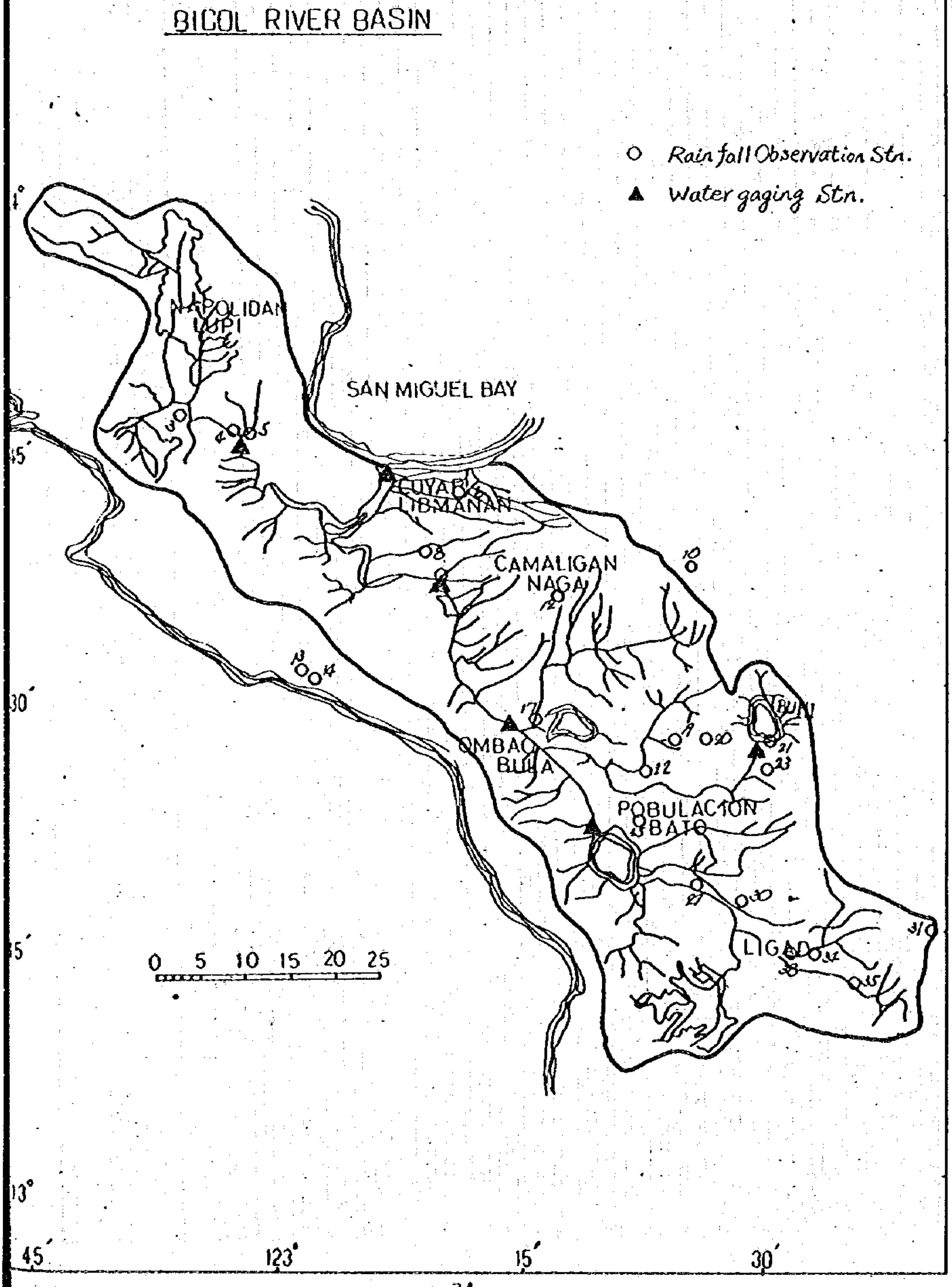


Table Location of Rainfall Observation Stn.

BICOL River Basin

No	Name of Stations	Latitude	Longitude	Elevation	Type of Ins	Date of Established	Managed by	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1	Daet, Camarines Norte	14°06'00"	122°57'00"	4	RG/OG	1949	M(GD)											
2	[illegible] Camarines Sur	13°47'20"	123°52'00"	10	OG	1972	CM											
3	[illegible] Lupi Cam. Sur	13°47'12"	122°55'[illegible]		RG/OG	May 1976	HM NIA											O
4	Sipocot Cam. Sur	13°46'10"	122°58'30"	18	OG	1969	CM				O	O	O	O	O	O	O	
5	Impig Sipocot Cam. Sur	13°46'00"	122°59'00"		RG/OG	May 1976	HM-NIA											
6	[illegible] Cam. Sur	13°42'37"	123°12'00"		RG/OG	June 1976	HM-NIA											
7	San Juan Libmanan Cam. Sur	13°41'42"	123°03'00"		RG/OG	Sept 1976	HM-NIA											O
8	[illegible] Libmanan Cam. Sur	13°38'45"	123°10'00"		RG/OG	May 1976	HM NIA											
9	[illegible] Camarines Sur	13°38'00"	123°33'00"		RG/OG	May 1976	HM-NIA											
10	[illegible] Cam. Sur	13°37'45"	123°25'30"	200	RG/OG	May 1976	HM-NIA											
11	NIA Compound Naga City	13°37'30"	123°11'00"		RG/OG	May 1976	HM-NIA											O
12	[illegible] Camarines Sur	13°36'00"	123°18'00"		RG/OG	Jun 1976	AM											
13	[illegible] Camarines Sur	13°31'30"	123°[illegible]20"	15	OG	1969	CM											
14	[illegible] Pasacao	13°31'00"	123°03'00"		RG/OG	May 1976	HM-NIA											
15	Joroan Tiwi Albay	13°29'35"	123°37'00"	14	OG	1947	CM											
16	[illegible] Tiwi Albay	13°28'30"	123°39'30"	52	OG	1971	CM											
17	[illegible] Cam. Sur	13°28'12"	123°16'18"		RG/OG	May 1976	HM NIA											O
18	[illegible] Tiwi Albay	13°27'30"	123°40'35"	5	OG	1971	CM											
19	[illegible] Iriga City	13°27'00"	123°25'00"		RG/OG	Sept 1976	HM-NIA											
20	Sta. Cruz [illegible] Cam. Sur	13°27'00"	123°27'[illegible]	11	OG	1967	CM											
21	San Francisco Buhi Cam. Sur	13°26'43"	123°31'10"		RG/OG	May 1976	HM-NIA											O
22	Barit Iriga City	13°25'00"	123°23'00"	100	RG/OG	May 1976	HM-NIA											
23	[illegible] Camarines Sur	13°25'00"	123°30'00"	10	OG	1950	CM			O	X	X	Δ	O	Δ	X	X	
24	[illegible] Malinao Albay	13°24'30"	123°42'[illegible]		RG/OG	Dec. [illegible]	AM											
25	Bato Camarines Sur	13°22'20"	123°22'40"	15	OG	1972	CM											
26	Tabaco Albay	13°21'30"	123°43'40"	3	OG	[illegible]	CM											
27	[illegible] Libon Albay	13°18'00"	123°26'00"	13	OG	1972	CM						Δ	O	O	O	O	
28	Pob. Bacacay Albay	13°17'40"	123°47'20"	4	OG	[illegible]	CM											
29	[illegible] Bacacay Albay	13°17'43"	123°47'20"	4	OG	1971	CM											
30	[illegible] Albay	13°17'24"	123°2[illegible]'00"		RG/OG	May 1976	HM-NIA											
31	[illegible] Albay	13°15'00"	123°41'00"		OG	1971	CM						O	Δ	O	O	X	
32	Sto. Domingo ([illegible]) Albay	13°14'10"	123°46'[illegible]	15	OG	1947	CM											
33	[illegible] Albay	13°14'00"	123°32'00"		OG	1963	CM			O	X	O	O	O	O			
34	[illegible] Ligao Albay	13°14'00"	123°33'00"		RG/OG	May 1976	HM-NIA							O	O	Δ	O	
35	[illegible] Albay	13°12'00"	123°36'00"	10	OG	1947	CM			O	O	O	O	O	O	O	O	
36	[illegible] Libon Albay	13°11'40"	123°26'00"	5	OG	1972	CM											
37	Rapu-Rapu Albay	13°11'10"	124°07'20"	5	OG	1972	CM											
38	[illegible] Albay	13°11'10"	124°07'20"	5	OG	1971	CM											
39	[illegible] Albay	13°09'00"	123°27'40"	40	OG	1971	CM						Δ	O	O	O	Δ	X
40	Legaspi City Albay	13°08'00"	123°44'00"	19	RG/OG	1949	(GS)											

Table Location of Rainfall Observation Stn.

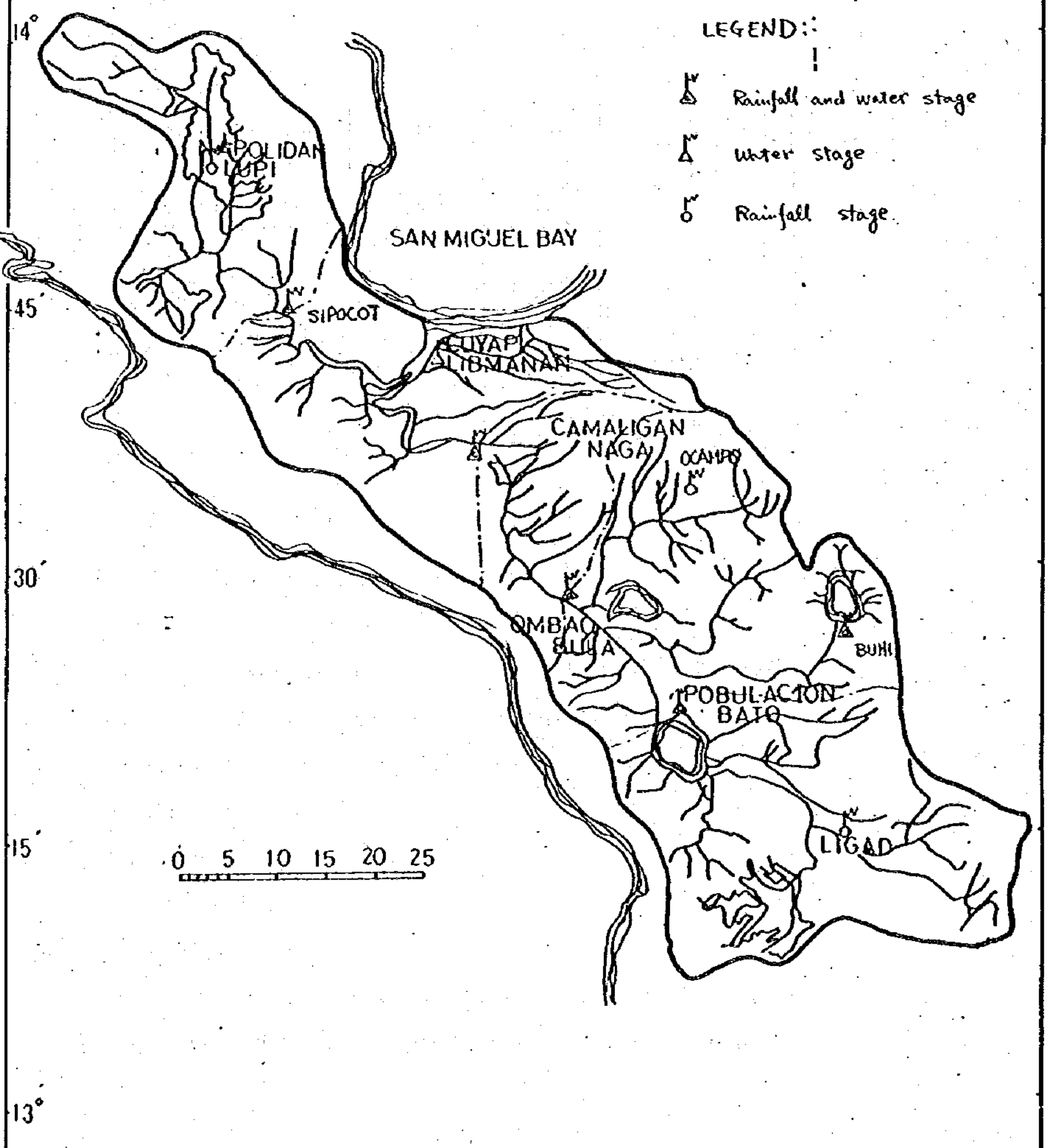
BICOL River Basin

No.	Name of Stations	Location			Type of Ins	Date of Established	Managed by
		Latitude	Longitude	Elevation			
[illegible]	[illegible]	[illegible]	[illegible]	60	CG	[illegible]	[illegible]
[illegible]	[illegible] Albay	[illegible]	[illegible]	10	CG	[illegible]	[illegible]

B I C O L

	OMBAO,Bula		MABULO,NAGA		SABANG SABANG SIPOCCT		CUYAPI LIBMANAN		POBLACION BATO	
1966			—		—		—		—	
67			—		—		—		—	
68	Sep.27	(287) 6.02	—		Jan.2	(418) 4.51	Nov.21	3.16	Sep.30	7.50
69	Dec.15	(142) 4.67	Jan.1	4.53	Nov.19	(280) 4.04	Nov.9	3.05	Dec.14	7.55
70	Oct.14	(701) 8.92	Oct.14	6.39	Jan.4	(51) 2.26	Dec.29	3.10	Oct.14	16.14
71	Dec.29	(549) 7.88	May 27	5.20	Jan.10	(59) 2.14	Feb.25	3.16	July16	7.99
72	Jan.12	(412) 6.94	—		—		Mar.17	3.09	Jan.11	8.88
73	Oct.17	(442) 7.15	—		—		—		Oct.17	9.21
74	Jan.10	(581) 8.10	—		July20	(114) 2.93	—		Jan.12	8.37
75	Oct.29	(283) 5.99	Aug.20	2.60	Dec.29	(137) 9.54	—		Dec.28	
76										

Fig TELEMETERING STATION THE BICOL RIVER BASIN



2. Travelling Time

The rate of movement of flood waters was calculated from the average rate of flow of water, and the estimated travel time of flood waters through sections of the river is shown in the table below.

Flood Water Travel Time

Section of River	Distance	Slope	Rate of Flood Water Movement	Flood Water Travel Time
Poblacion Bato ~ Ombao Bula	17 km	$\frac{1}{18,000}$	0.4 m/s	12 hr
Ombao Bula ~ Mabulo	20	$\frac{1}{7,000}$	0.6	9
Mabulo ~ Cuyari	30	$\frac{1}{38,000}$	0.3	28
Sipocot ~ Cuyari	28	$\frac{1}{8,000}$	0.6	13

3. Tributaries to be Forecast

3-1. Division of sub-basins

Division of sub-basins is worked out as illustrated in Fig. , taking the target areas into consideration.

The forecasting points are as follows:

Pobulacion, Bato

Ombao, Bula

Canaligan, Naga

Sipocot

Also, for forecasting high tides in San Miguel bay, actual tide measurements are performed at Cuyapi, Libmanan.

4. Telemetering station

The following tables indicate the telemetering stations for forecasting floods on the Bicol River.

Bicol River Basin: List of Rain Gaging Station

No.	Station	Location of Station	River Basin	Remarks
1.	Ligao		Bicol R.	Newly constructed
2.	Pobulacion, Bato		Bicol R.	"
3.	Buhi		Bicol R.	"
4.	Ombao, Bula		Bicol R.	"
5.	Ocampo		Bicol R.	"
6.	Camaligan, Naga		Bicol R.	"
7.	Cuyapi, Libmanan		Bicol R.	"
8.	Sipocot		Sipocot R.	
9.	Napolidan, Lupi		Sipocot R.	

Bicol River Basin: List of the Water Stage Gaging Station

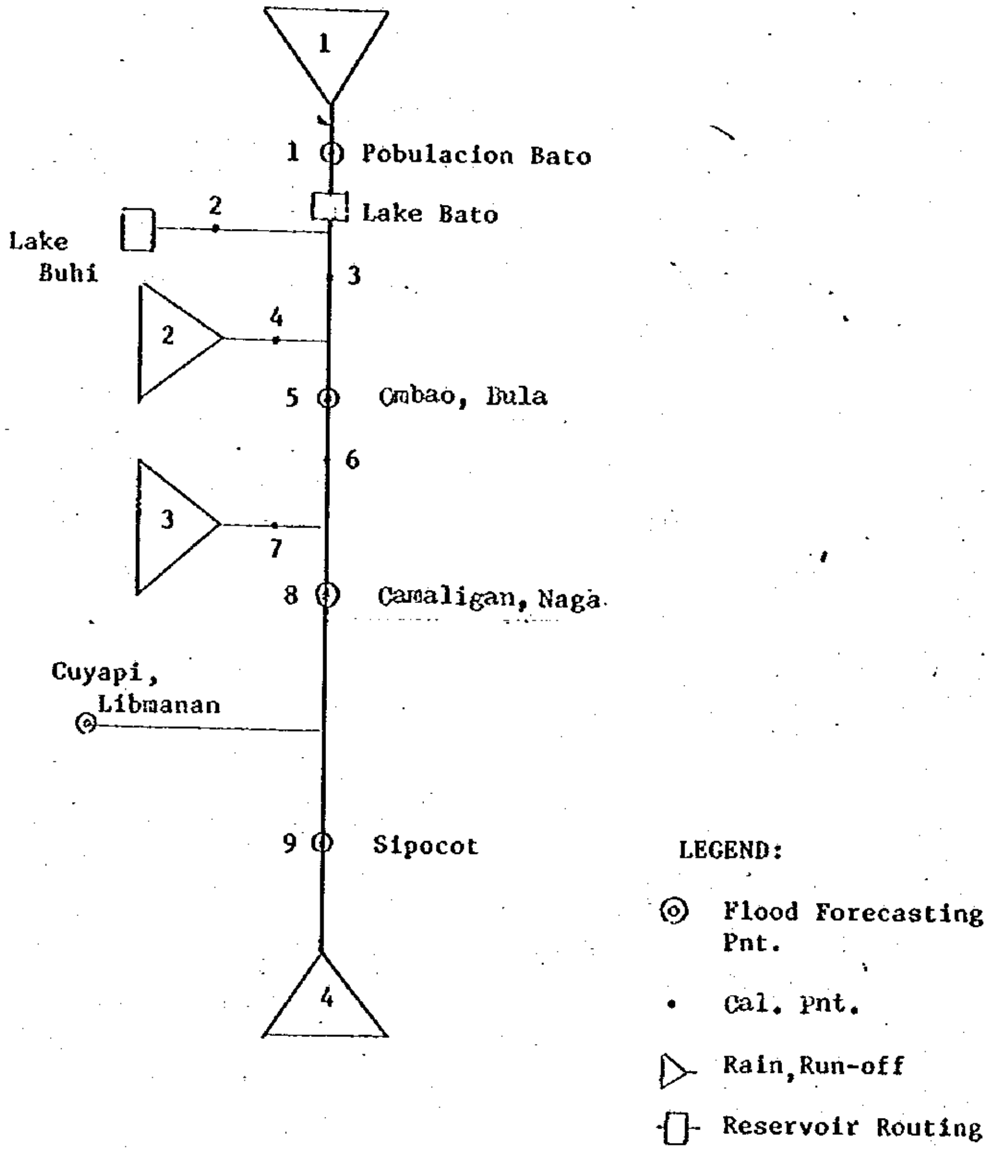
No.	Station	Location of Station	River Basin	Remarks
2.	Pobulacion, Bato		Bicol R.	
3.	Buhi		Bicol R.	
4.	Ombao, Bula		Bicol R.	
6.	Camaligan, Naga		Bicol R.	Transferred from PNR Br. of Mabulo
7.	Cuyapi, Libmanan		Bicol R.	Tide
8.	Sipocot		Sipocot R.	
9.	Napolidan, Lupi		Sipocot R.	

Bicol River Basin: List of the Discharge Gaging Station

No.	Station	Location of Station	River Basin	Remarks
9.	Napolidan, Lupi		Sipocot R.	

5. Runoff and Flood Routing Model

The following figure represents the runoff and flood routing model for the Bicol River, which has been worked out on the basis of the results of the study of the tributaries to be forecast.



FLOOD FORECASTING MODEL

6. Storm surge model

6-1. Cuyapi Libmanan point

This is the same as in the case of Baay-west, Lingayen of the Agno river.

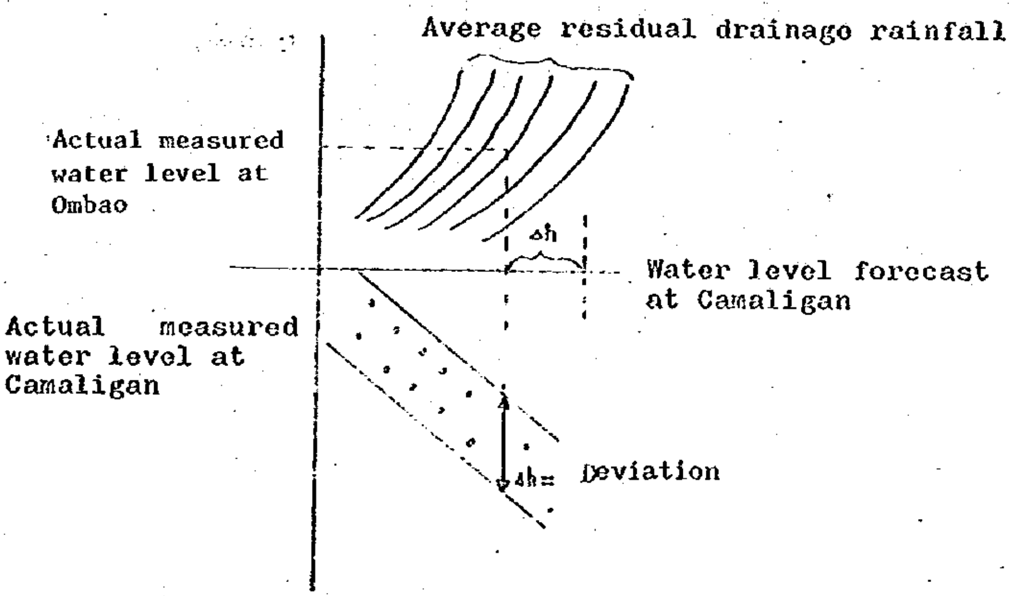
6-2. Camaligan, Naga point

(1) Average residual basin rainfall

The arithmetic mean method is applied to Ombao, Bula, rainfall (R_1) and Camaligan, Naga, rainfall (R_2).

$$R = \frac{R_1 + R_2}{2}$$

(2) Correlation of the Camaligan water level from residual drainage rainfall, and the Ombao, Bula, water level.



In case of high tide, the water level forecast is determined taking the deviation into consideration.

7. Flood forecasting method

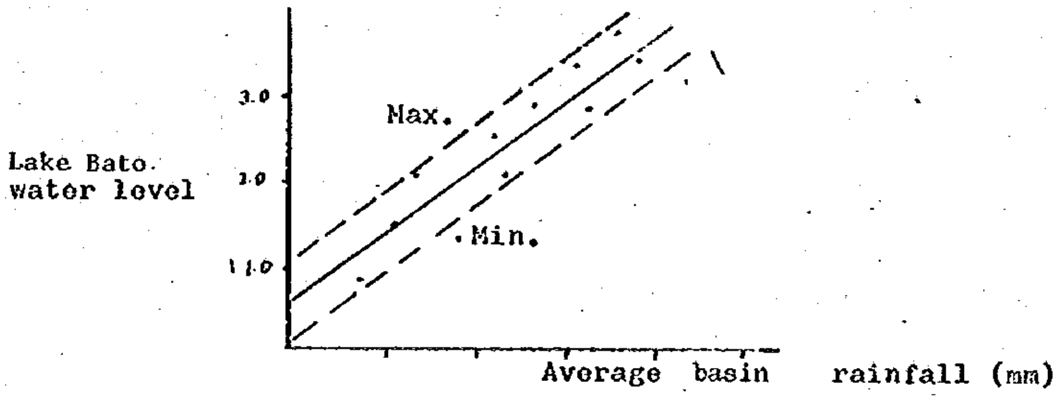
7-1. Pobulacion, Bato, point

(1) Average basin rainfall

The arithmetic mean method is applied to Ligao rainfall (R_1) and Pobulacion, Bato, rainfall (R_2).

$$R = \frac{R_1 + R_2}{2}$$

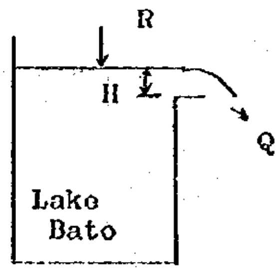
(2) Correlation between the average basin rainfall and lake Bato water level.

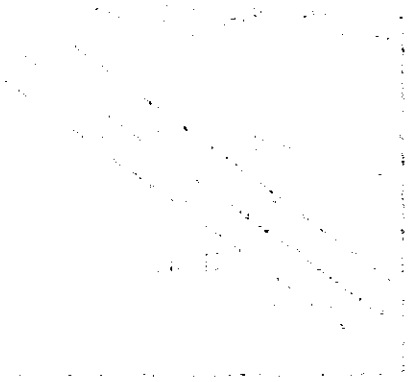


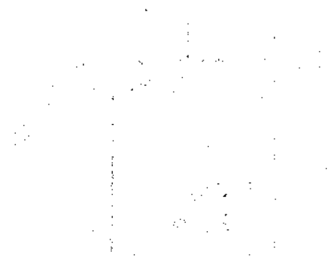
(3) Estimation of Lake Bato discharge

The tank model method is applied. Analysis of constants is inferred from the actual measured water level.

$Q = 1.8 \times B \times H^{3/2}$. That is, $Q = 1.8 \times f(BH^{3/2})$.







7-2. Ombao, Bula point

(1) Estimation of Buhi discharge

The same method as Lake Bato is applied.

(2) Estimation of traveling time

A traveling time of constant value is estimated in the discharge amount at Lake Bato and Lake Buhi.

(3) Average basin rainfall

Ombao, Bula, rainfall (R_1)

Pobulacion, Bato, rainfall (R_2)

Buhi rainfall (R_3)

Ocampo rainfall (R_4)

$$R = \frac{R_1 + R_2 + R_3 + R_4}{4}$$

(4) Estimation of residual basin discharge

$Q = R \times A/86.4 \quad (m^3/s)$

A: Inundated area (km^2)

(5) Ombao inflow amount

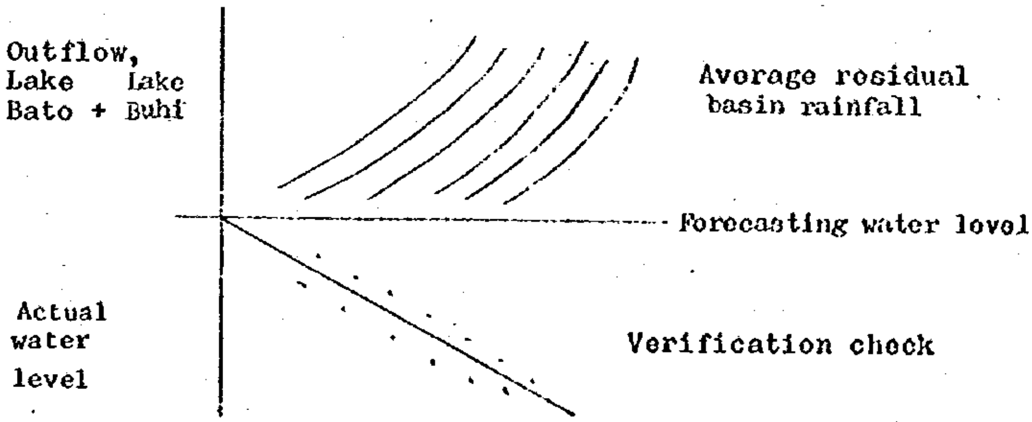
Q_T: Lake Bato discharge amount (m^3/s)

Q_H: Lake Buhi discharge amount (m^3/s)

Q: Residual basin outflow amount (m^3/s)

$Q_o = Q_T (T_1) + Q_H (T_1) + Q$

(6) Forecasting of Ombao water level



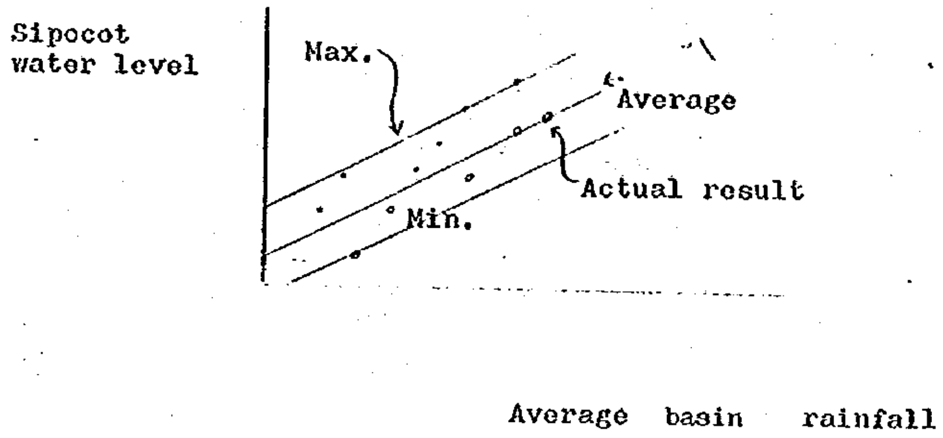
7-3. Flood forecasting at Sipocot point

(1) Average basin rainfall

The arithmetic mean method is applied to Napolidan , Lupi rainfall (R_1) and Sipocot rainfall (R_2).

$$R = \frac{R_1 + R_2}{2} \quad (mm)$$

(2) Correlation between rainfall and water level



7-4. Flood Forecasting Method

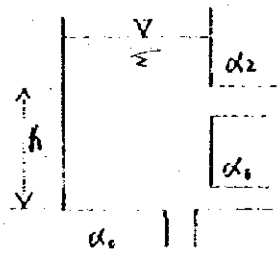
The method used at each flood forecasting point is shown in the following table.

Flood Forecasting Point	Flood Forecasting Method
Poblacion Bato	Combination of tank model and model of water reduction in a lake.
Ombao Bula	Formula indicating relationship with the Poblacion Bato water level.
Camaligan Nago	Formula indicating relationship with the Ombao Bula water level.
Sipocot	Tank model.

The flood forecasting method at each point is shown below.

(1) Poblacion Bato

Outflow model



$\alpha_0 = 0.1$

$\alpha_1 = 0.1$

$\alpha_2 = 0.6$

$h = 60$ mm

Model of water reduction in a lake

$H = 0.035H - 0.151$

$\dot{H}$: Amount of reduction in lake water level (m)

H: Lake (water) level

(2) Ombao Bula

$H_2 = 1.22\ H_1 - 3.8$ Coefficient of correlation = 0.990

H_2: Water level at Ombao Bula (m)

H_1: Water level at Poblacion Bato on the previous day (m)

(3) Camaligan Nago

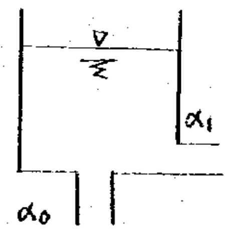
$H_2 = 0.596\ H_1 + 0.1$ Coefficient of correlation = 0.828

H_2: Water level at Camaligan Nago

H_1: Water level at Ombao Bula on the previous day

(4) Sipocot

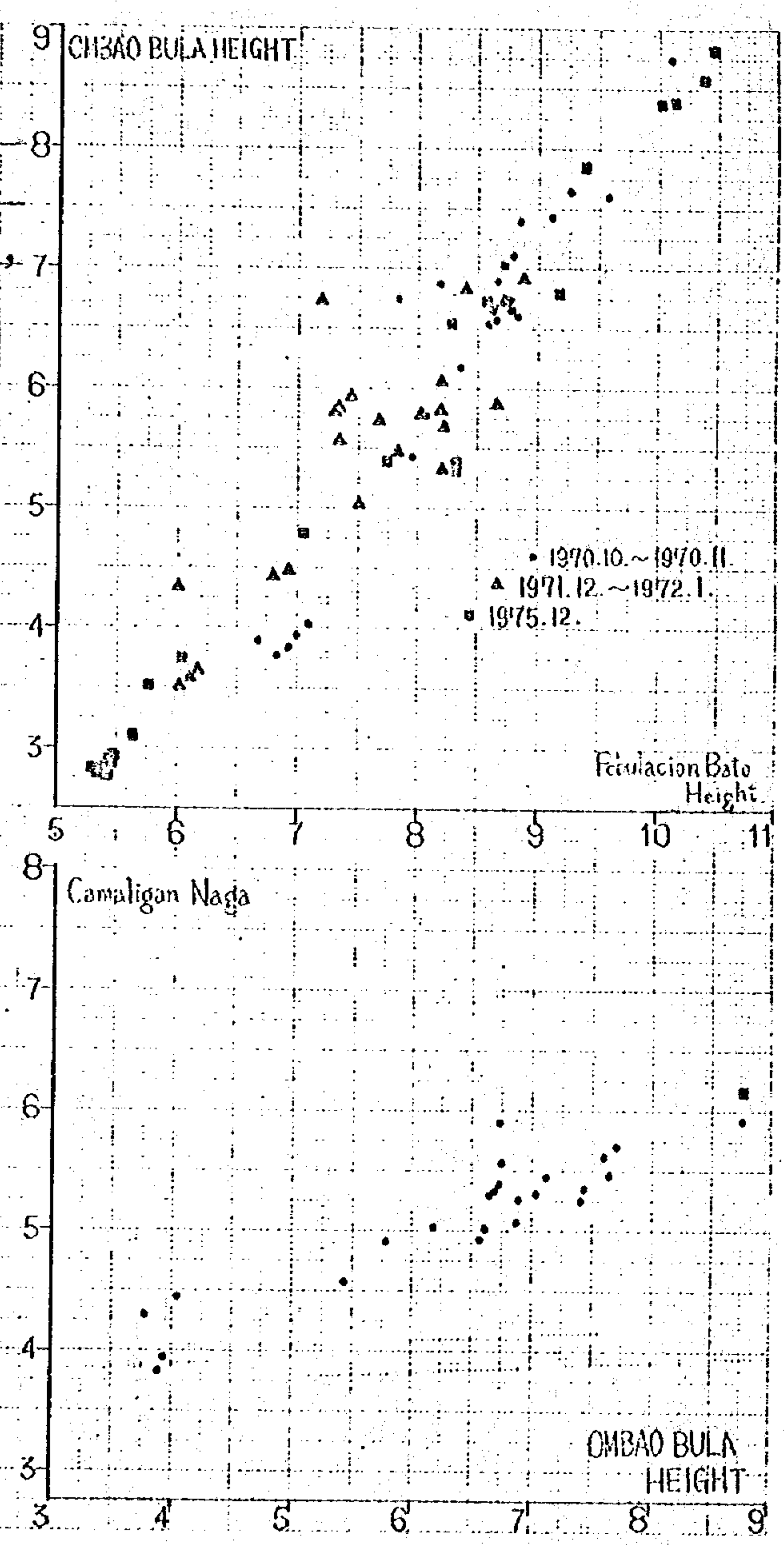
Outflow model

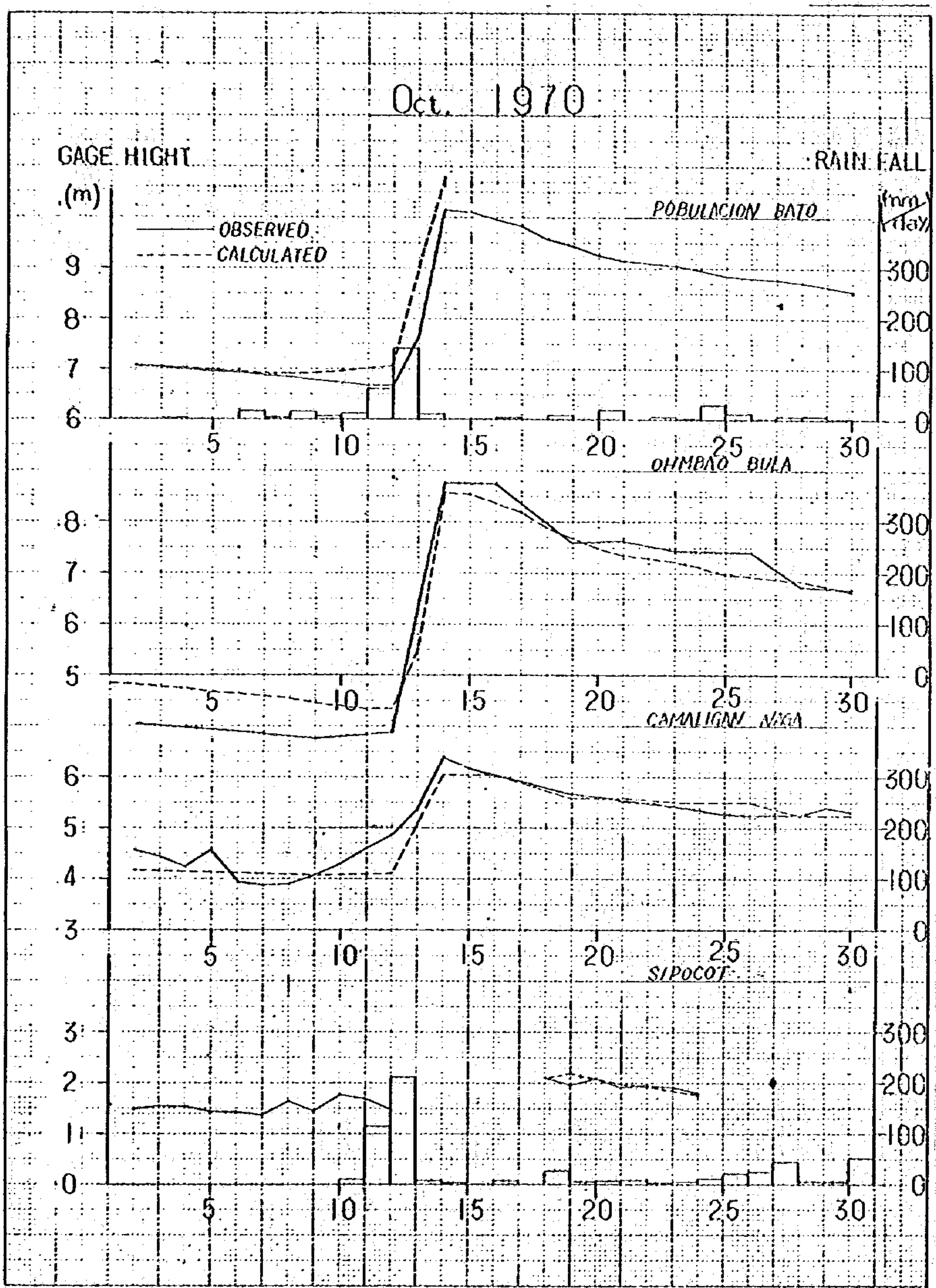


$\alpha_0 = 0.1$

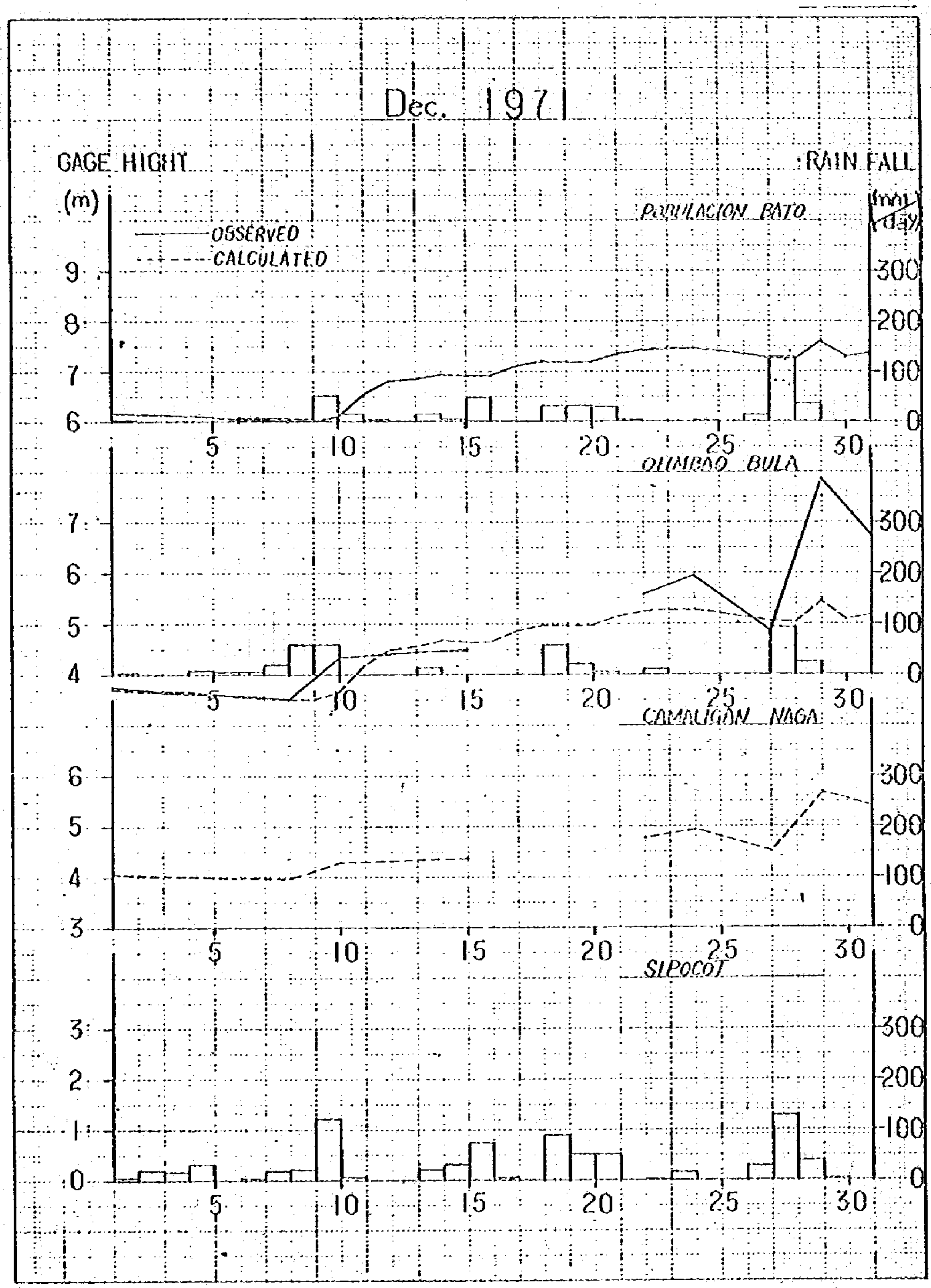
$\alpha_1 = 0.1$

FIG. CO-RELATION AMONG WATER LEVELS AT POBULACION BATO, OMBAOBULA AND CAMALIGAN NAGA

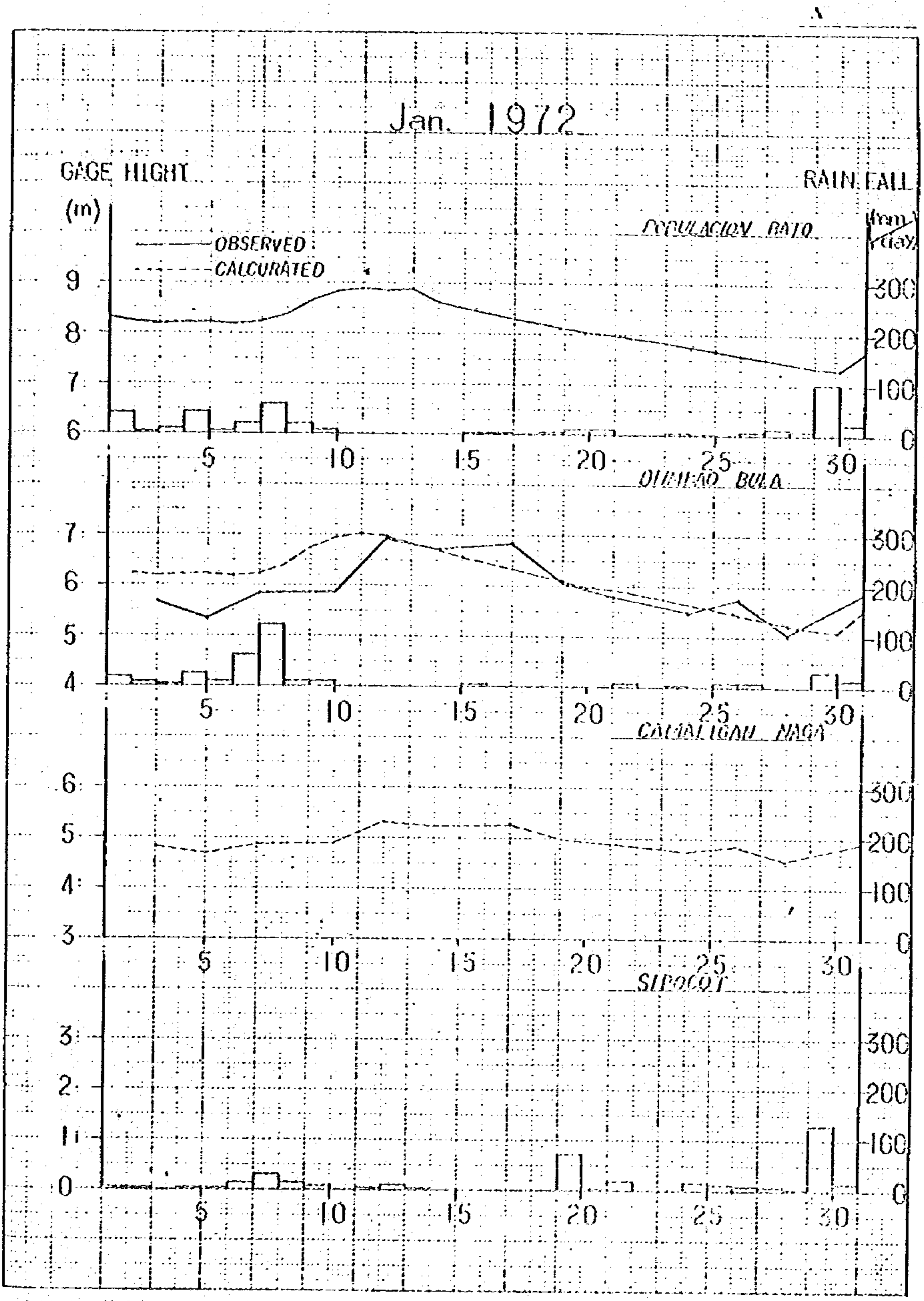


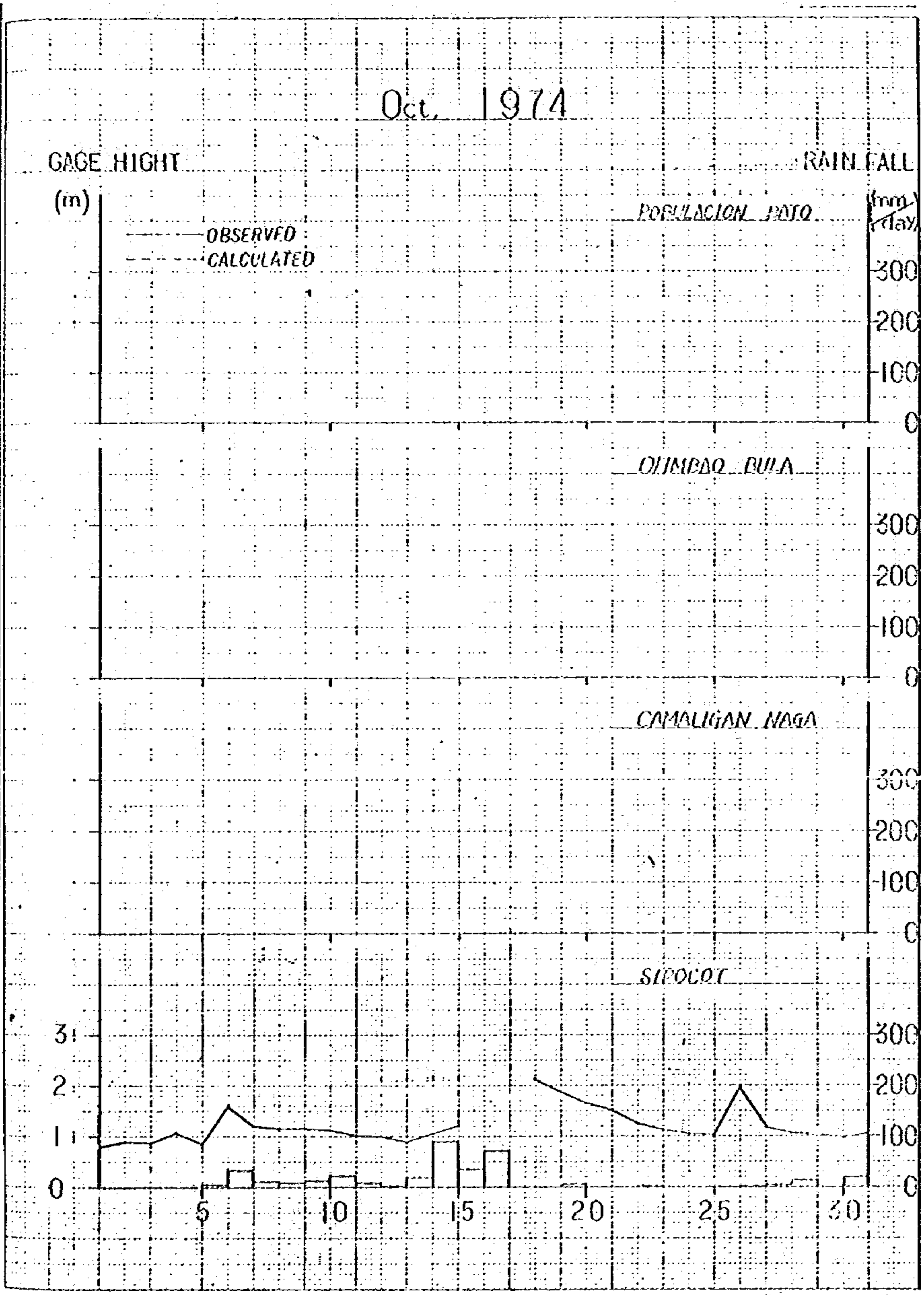


Oct. 1970
GAGE HIGHT
(m)
RAIN FALL
(mm/day)
OBSERVED
CALCULATED
POBULACION BATO
OHMBAO BULA
CAMALIGAN NAGA
SIPOCOT



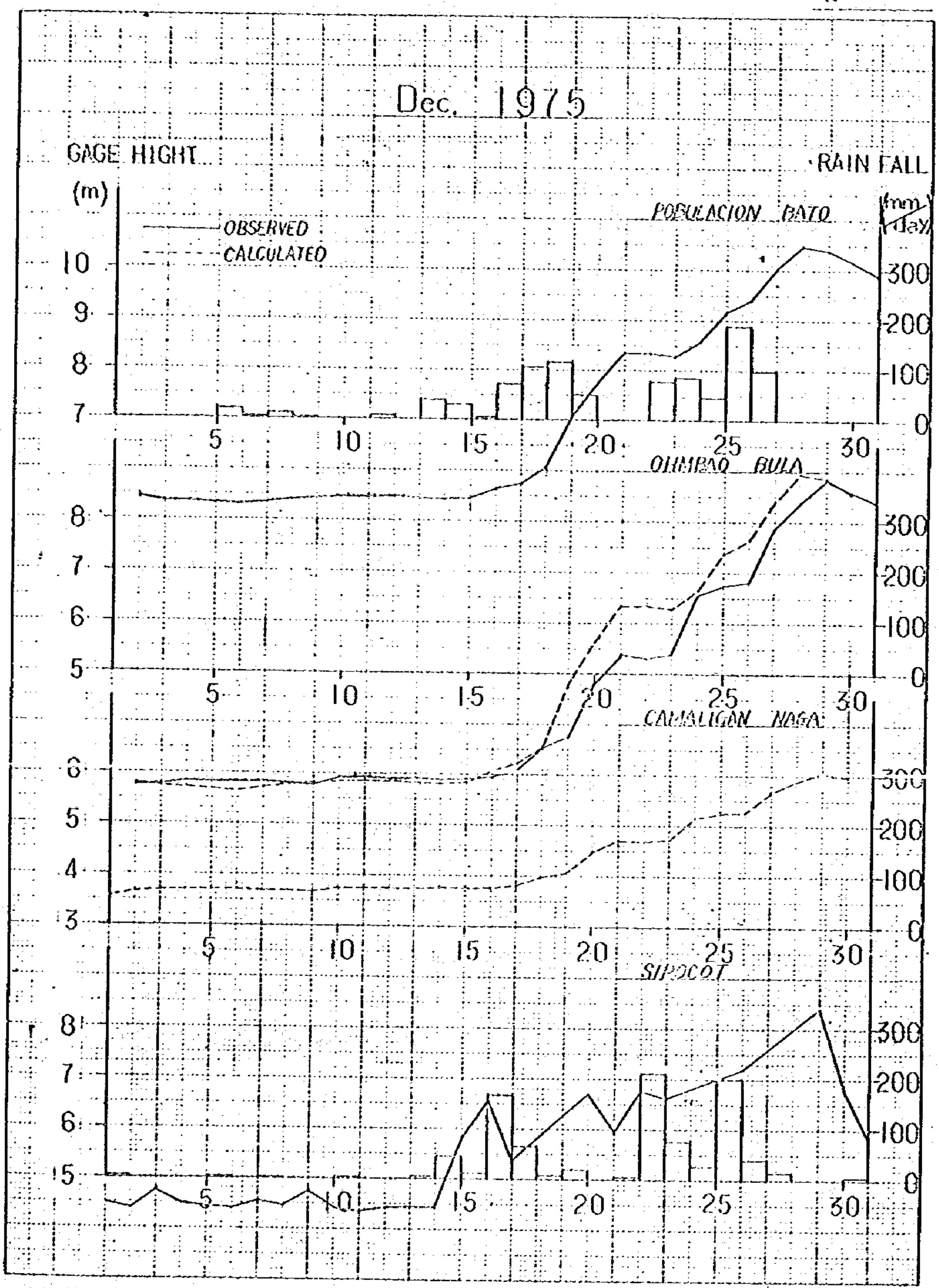
Dec. 1971
GAGE HIGHT (m)
RAIN FALL (mm/day)
OBSERVED
CALCULATED
POBULACION BATO
OLIMBAO BULA
CAMALIGAN NAGA
SIPOCOT


Jan. 1972
GAGE HIGHT
(m)
RAIN FALL
OBSERVED
CALCURATED
9
8
7
6
5
10
15
20
25
30
300
200
100
0
4
3
2
1
SIPOCOT



Oct. 1974
GAGE HIGHT
(m)
RAIN FALL
(mm/day)
OBSERVED
CALCULATED
POBLACION PATO
OJINBAO BULA
CAMALIGAN NAGA
SIPOCOT
300
200
100
0
3
2
1
0
5
10
15
20
25
30

Dec. 1975



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SERIES NO 401 C

§-3. The Cagayan River

1. Hydrographic and Hyetographic Characteristics

(1) Existing water stage and rainfall telemetering stations.

Existing water stage and rainfall telemetoring stations in the Cagayan river basin are shown in the diagram and table below.

(2) Rainfall Data

The following table indicates the rainfall data available at the main stations in the Cagayan basin.

(3) Water Stage Data

The following table shows the records of flood water levels at the main stations in the Cagayan basin.

(4) Hydrographic and Hyetographic Characteristics

The water level and rainfall curves during major floods are shown on the following sheets.

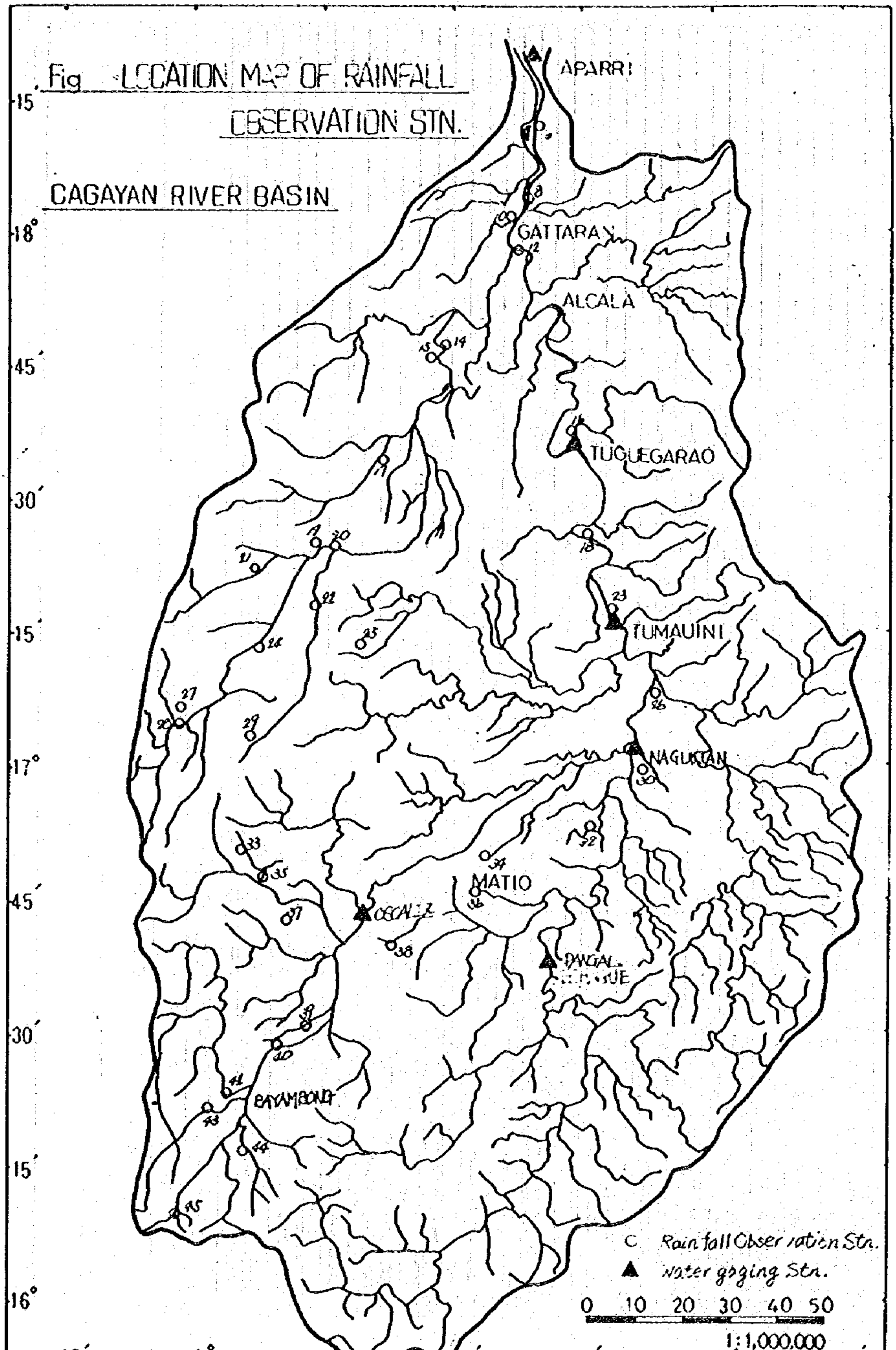


Fig LOCATION MAP OF RAINFALL OBSERVATION STN.
CAGAYAN RIVER BASIN
APARRI
GATTARAN
ALCALA
TUGUEGARAO
TUMAUINI
NAGUILIAN
MATIO
ORSCALES
BAYAMBONG
Rainfall Observation Stn.
Water gazing Stn.
0 10 20 30 40 50
1:1,000,000
45′
121°
15′
30′
45′
122°
15′
18°
17°
16°

Table Location of Rainfall Observation Stn.

CAGAYAN River Basin (1)

No.	Name of Stations	Location: Latitude	Location: Longitude	Location: Elevation	Type of Ins	Date of Established	Managed by	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1	[illegible] Cagayan	18°34'00"	121°12'00"		RG/OG	May 1976	HM											
2	[illegible] Cagayan	18°27'40"	121°21'00"	5	OG	1973	CM											
3	[illegible] Cagayan	18°24'30"	121°35'42"		RG/OG	May 1976	HM											
4	Aparri Cagayan	18°22'00"	121°38'00"	4	RG/OG	1903-39, 1947	MGSD								O	X	O	O
5	[illegible] Kalinga-Apayao	18°13'00"	121°23'00"		OG	1971	CM											
6	Lal-lo Cagayan	18°12'00"	121°39'40"	7	OG	1973	CM								O	O	O	O
7	[illegible] Kalinga-Apayao	18°08'10"	121°08'00"	320	OG	1969	CM											
8	Gattaran Cagayan	18°03'42"	121°36'24"	10	RG/OG	May 1976	NIA				O	O	O	O	O	O	O	O
9	[illegible] Kalinga-Apayao	18°01'30"	121°11'00"	120	OG	1948	CM											
10	[illegible] Lasam Cagayan	18°01'30"	121°37'10"	10	OG	1947	CM											
11	Mt. Polis Pass Banaue Ifugao	17°58'00"	121°01'30"	1900	OG	1963	CM											
12	[illegible] Alcala Cagayan	17°56'00"	121°37'40"	10	OG	1948-71	CM	Δ	O	O	Δ	Δ	Δ			X	X	X
13	[illegible] Kalinga-Apayao	17°45'30"	121°12'40"	231	OG	1969	CM											
14	Piat Cagayan	17°47'36"	121°28'36"	40	RG/OG	May 1976	HM											O
15	[illegible] Tuao Cagayan	17°45'50"	121°27'30"	35	OG	1947	CM	O	O	O	O	O	O	O	O	O	O	X
16	Tuguegarao Cagayan	17°37'00"	121°44'00"	24	RG/OG	1903-39, 1947	MGSD	O	O	O	O	O	O	O	O	O	O	O
17	Pinukpuk Kalinga-Apayao	17°34'40"	121°22'00"	120	OG	1971	CM					O	O	O	O	O	O	O
18	[illegible] Isabela	17°35'42"	121°45'48"	20	RG/OG	May 1976	HM										O	
19	[illegible] Kalinga-Apayao	17°25'00"	121°14'00"		OG	1974	CM								O	O	O	
20	[illegible] Kalinga-Apayao	17°24'40"	121°16'00"	360	OG	1947	CM	O		O	O	O	O	O		O	O	O
21	[illegible] Kalinga-Apayao	17°22'00"	121°07'00"	740	OG	1963	CM			O	X	O	O	O	X	X	X	X
22	[illegible] Kalinga-Apayao	17°18'00"	121°14'10"	500	OG	1963	CM	O	X	O	O	O	O	O	O	O	O	X
23	Tumauini Isabela	17°16'42"	121°48'12"		RG/OG	May 1976	HM											O
24	[illegible] Kalinga-Apayao	17°13'30"	121°07'20"	800	OG	1963	CM											
25	[illegible] Kalinga-Apayao	17°13'30"	121°19'00"		OG	1966-70	CM											
26	Ilagan Isabela	17°08'00"	121°53'10"	40	OG	1925-39, 1949-1960	CM	O	O	O	O	O	O	O	O	O	O	O
27	[illegible] Mt. Province	17°07'00"	120°58'00"		OG	1963	CM	O	X	O	O	O	X	X	O	O	X	O
28	Bontoc Mt. Province	17°05'00"	120°58'00"		OG	1950	CM	X	O	O	O	O	O	O	O	O	X	X
29	[illegible] Mt. Province	17°03'30"	121°06'20"		OG	1963	CM	X	X	O	O	O	X	O	O	O	X	O
30	Reina Mercedes Isabela	16°59'30"	121°51'00"		RG/OG	May 1976	HM											O
31	[illegible] Mt. Province	16°57'00"	120°52'00"		OG	1963	CM			O	O	O	O	O	O	O	O	O
32	[illegible] Cauayan Isabela	16°53'00"	121°45'00"		RG/OG	Dec 1974	HM-NIA											
33	[illegible] Lagawe Ifugao	16°51'10"	121°05'10"	900	OG	1969	CM			O	X	O	X	O	O	O	X	
34	[illegible] San Mateo Isabela	16°50'00"	121°33'00"		RG/OG	Dec 1974	HM-NIA										O	
35	[illegible] Lagawe Ifugao	16°48'00"	121°07'20"	470	OG	1970	CM			O		O		O	O	O	O	O
36	[illegible] Ramon Isabela	16°46'00"	121°32'00"		RG/OG	Dec 1974	HM-NIA										O	
37	[illegible] Lamut Ifugao	16°43'20"	121°10'20"	320	OG	1971	CM						O	O	O	O	X	O
38	[illegible] N.V.	16°40'00"	121°20'00"	243	OG	Jan 1966	CM		O	O	O	O	O	X				
39	[illegible]	16°31'10"	121°11'50"	225	OG	1967	CM		O	O	O	O	O	O	O	O	O	
40	[illegible] Kalinga-Apayao	16°31'00"	121°57'00"		OG	1948	CM											

Table Location of Rainfall Observation Stn.

CAGAYAN River Basin (2)

No	Name of Stations	Location: Latitude	Location: Longitude	Location: Elevation	Type of Ins	Date of Established	Managed by	[illegible]	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
41	[illegible]	16 29 00	121°09 00'	970	RG/OG	March 1976	HM											O
[illegible]	[illegible]	[illegible]	121°07 20'	310	OG	[illegible]	CM			O	O	O	O	O	O	O	O	O
[illegible]	[illegible]	[illegible] 22 30'	121°01 00'	610	OG	Jan [illegible]	CM											
44	[illegible]	[illegible] 17 10	121°05 20	864	OG	[illegible]	CM			O	O	O	O	O	O	O	O	O
45	[illegible]	[illegible] 10 00	[illegible] 57 00	550	OG	[illegible]	CM	O	O	O	O	O	O	O	O	O	O	O

CAGAYAN

	PANGAL ECHAGUE		OSCARIZ		(NAGULUAN)		TUGUEGARAO		APARRI							
1966	Nov.22	(7735) 15.55							Nov.14	0.92						
67	Nov.4	(7848) 17.50							June28	0.94						
68	Nov.30	(4258) 9.75			Nov.30	(2838) 7.7	Dec.1	17.50	July26	1.08						
69	Nov.24	(1302) 6.00			Nov.26	(2182) 6.78	Nov.27	18.03	Nov.28	1.15						
70	Sep.12	(7503) 12.50			Oct.14	(7899) 13.83	Oct.16	21.95	Aug.10	1.99						
71	Nov.16	(4511) 10.00			Oct.12	(9692) 15.90	Dec.2	20.97	Mar.22	1.77						
72	Nov.7	(2233) 7.25			Nov.7	(1879) 6.84	July19	18.37	Jan.14	7.21						
73	Oct.15	(5032) 10.75					Nov.22	15.20	(June	)						
74	June11	(4511) 16.00														
75																
76																

2. Travelling Time

The rate of movement of flood waters was calculated from the average rate of flow of water, and the estimated travel time of flood waters through sections of the river is shown in the table below.

Flood Water Travel Time

Section of River	Distance	Slope	Rate of Flood Water Movement	Flood Water Travel Time
Pangal ~ Tumauini	90 km	1/1,000	5.4 m/S	5 hr
Tumauini~Tuguegarao	50	1/3,500	3.4	4
Tuguegarao ~ Aparri	110	1/6,500	2.0	15

3. Tributaries to be forecast

Division of sub-basin is made in 4 blocks, taking into consideration the target area which extends from Pangal to the estuary. The blocks are shown in the following figure.

The forecasting points are as follows.

Pangal

Oscariz dam

Tumauini

Tuguegarao

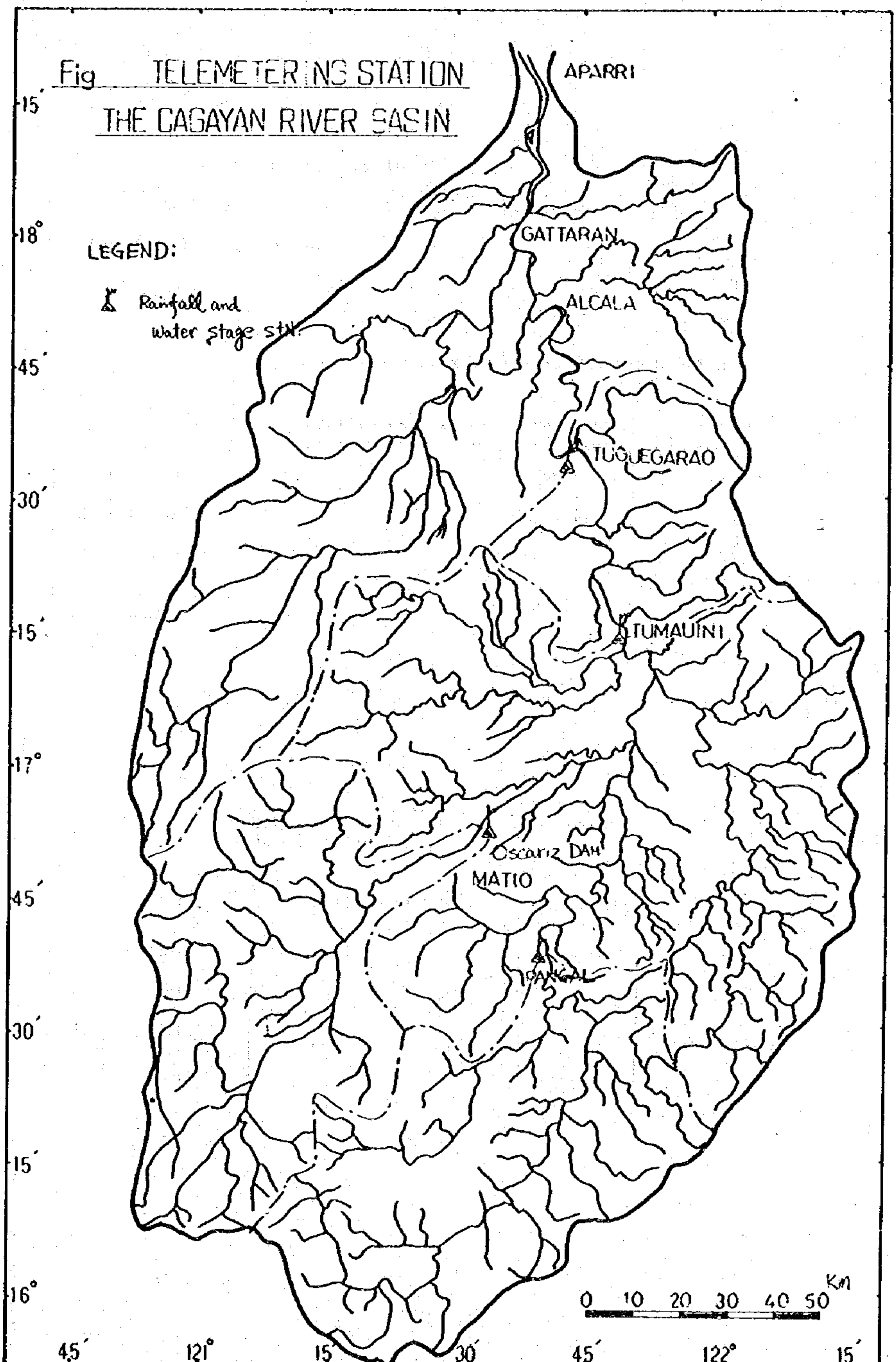


Fig TELEMETERING STATION
THE CAGAYAN RIVER BASIN
APARRI
GATTARAN
ALCALA
TUGUEGARAO
TUMAUINI
Oscariz DAM
MATIO
CANGAL
LEGEND:
Rainfall and water stage stN.
0 10 20 30 40 50 KM
15'
18°
45'
30'
15'
17°
45'
30'
15'
16°
45'
121°
15
30'
45'
122°
15'

4. Telemetering stations

The following telemetering stations are selected for flood forecasting.

Cagayan River Basin: List of Rain Gauging Station

No.	Station	Location of Station	River Basin	Remarks
1.	Fangal		Cagayan R.	Newly constructed
2.	Oscariz Dam		Matio R.	"
3.	Tumauini		Cagayan R.	"
4.	Tuguegarao		Cagayan R.	"

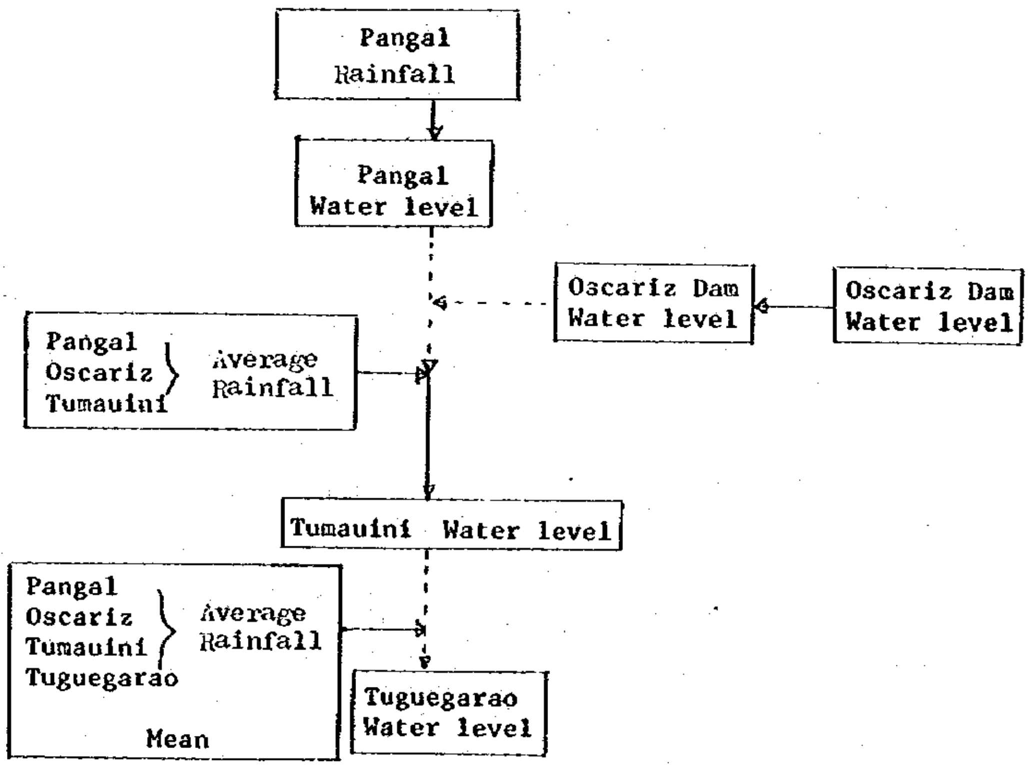
Cagayan River Basin List of the Water Level Gauging Station

No.	Station	Location of Station	River Basin	Remarks
1.	Fangal		Cagayan R.	
2.	Oscariz Dam		Matio R.	
3.	Tumauini		Cagayan R.	Newly constructed
4.	Tuguegarao		Cagayan R.	

5. Runoff and flood routing model

This model was worked out on the basis of correlation between rainfall and water level at the respective points.

The Cagayan River Basin



FLOOD FORECASTING MODEL

6. Storm surge model

In the Cagayan river basin, storm surge probably can be disregarded, therefore no study is made.