THE REPUBLIC OF THE PHILIPPINES

REPORT

FOR

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

AUGUST 1977

JAPAN INTERNATIONAL COOPERATION AGENCY

THE REPUBLIC OF THE PHILIPPINES

REPORT

FOR

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

AUGUST 1977

JAPAN INTERNATIONAL COOPERATION AGENCY

Preface

The floods which regularly assault the monsoon regions in Southeast Asia not only inflict incalculable damage to both human lives and properties but also constitute a major factor in hampering the development of these regions.

The Luzon Island is no exception to this rule. It is still fresh in our memory that the floods in 1967 and 1975 submerged the granary belt of the Island.

It is gratifying, in the 1975 flood, the flood forecasting and warning system at work in the Pampanga River Basin however that played a significant role in facilitating the evacuation and rescue of the inhabitants, demonstrating the effectiveness of Japan's technical and economic cooperation.

The Government of the Philippines, recognizing the importance of the flood forecasting and warning system, has decided to extend the system to the Agno, Bical, and Cagayan River Basins.

At the request of the Government of the Republic of the Philippines, the Government of Japan decided to conduct a feasibility survey of the forecasting and warning system of the said three rivers through the Japan International Cooperation Agency.

The Agency organized a survey team of 15 experts headed by Mr. Tunetaka KAWAI, Water Management Officer River Planning Division, River Bureau, Ministry of Construction, and had it carry out three rounds of field survey since November 1976. The findings of the survey were compiled into Progress Report I and II, and were submitted to the Government of the Republic of the Philippines in April 1977.

The present Report we are now submitting herewith has been compiled taking fully into account also of the questions and answers voiced at the meetings held in the Philippines.

I sincerely hope that, on the basis of of this report, the flood forecasting and warning system of the said three rivers will be completed as soon as possible so that it may further contribute to the stability of the livelihood and the welfare of the inhabitants in the basins.

Finally, I would like to express my deep appreciation to all the team members who participated in the survey for their hard work and my heartfelt gratitude to the authorities concerned in the Republic of the Philippines for their cooperations.

August 1977

Shinsaku Hogen
President

Japan International Cooperation Agency

Letter of Transmittal

To: Mr. Shinsaku Hogen, President
Japan International Cooperation Agency

In accordance with your request we are pleased to submit herewith the survery report on the flood forecasting and warning system project in the Agno, Bicol and Cagayan River Basins, which has been prepared for the field survey carried out since November 1976.

The report is a collection of the findings of a feasibility study on the proposed extension of the flood forecasting and warning system, as now at work in the Pampanga River Basin, to cover three other rivers in the Luzon Island: Agno, Bicol, and Cagayan Rivers.

These three river basins, situated under the direct influence of monsoons and typhoons, are hit by the utterly severe floods and high tides almost from year to year, which result in the inestimable loss of human lives and properties and the disability of social activities.

In the circumstances, the proposed flood forecasting and warning system serves not only the direct purpose of reducing the damages from floods but also the indirect purpose of improving the public livelihood and welfare of the inhabitants along the rivers, which will be of significant importance to the further growth of the Philippines.

It is, therefore, my sincere hope that the project will be put into action as soon as practically possible, with the cooperation and understanding of the Authorities concerned of the Government of the Philippines.

We wish to express our sincere appreciation and gratitude to the personnel of the Authorities concerned of the Government of the Philippines, the Typhoon Committee Secretariat, ESCAP, the officers of the Japanese Embassy, and the staff of the Japan International Cooperation Agency for their courtesies and cooperation afforded us during our field survey.

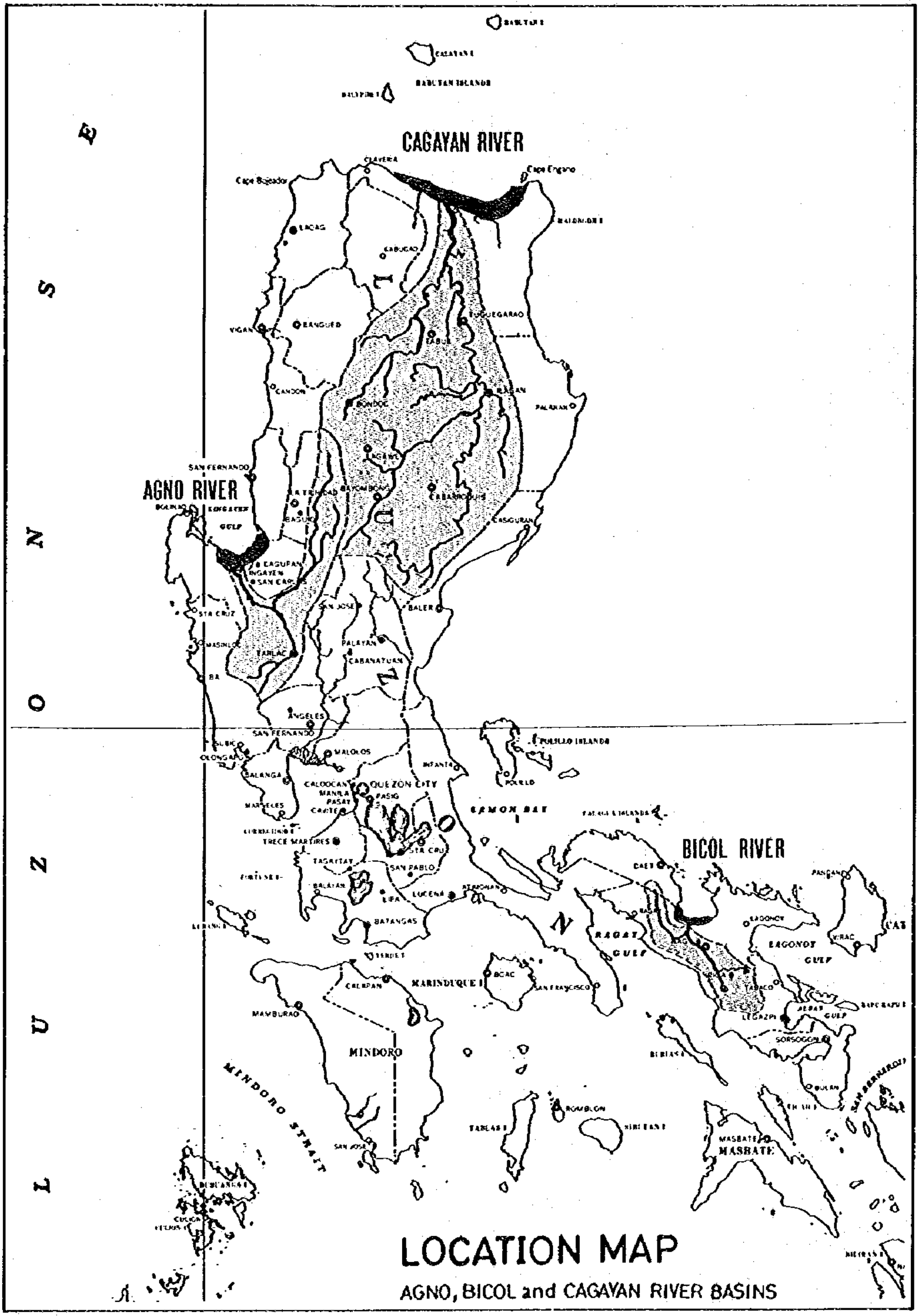
August 1977

T. Kawai

Tsunetaka Kawai
Leader
Japanese Survey Team for the
Flood Forecasting and Warning
System in the Republic of the
Philippines

TABLE OF CONTENTS

CONTENTS



LOCATION MAP

AGNO, BICOL and CAGAYAN RIVER BASINS

I. Introduction

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 floods caused by heavy rains and storm surges caused by strong winds that accompany monsoons and typhoons. Since among the islands, Luzon is densely populated and highly developed, if this island is assaulted by floods or storm surges, inestimable damage to human life and property and social paralysis would result. It is one of the important national policies to prevent or mitigate disasters due to floods and storm surges in order to improve public securities, public welfare, the land conservations, and the development of the country.

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

Forecasting and warning about floods are therefore significant. Their role and functions are important before the flood control work is completed, and after completion they will serve to assist the flood control work as well as to prepare for emergencies. When the forecasting and warning are performed successfully, many lives and properties are to be saved from floods and storm surges.

The Government of the Philippines, 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 Government of Japan. 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 Government of the Philippines requested the cooperation of the Government of Japan 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 Government of Japan sent the Survey Team for Flood Forecasting and Warning Systems to the Philippines and assigned it the feasibility study.

2. Survey Objective

The purpose of this survey is to perform a feasibility study for the plan to extend the flood forecasting and warning system, which is currently effective on the Pampanga River, to three rivers the Agno, Bicol and Cagayan. The survey includes the following items.

1) Discussions with the officials concerned

2) Collection and examination of data

3) Reconnaissance of the basins and sites of proposed stations and subcenters

4) Survey of meteorological and hydrological characteristics

5) Socio-economic characteristics survey and study of the target area

6) Analysis of forecasting model and observatory network

7) Radio propagation test and survey of the necessary conditions for the establishment of the proposed telecommunication system

8) Preliminary design of civil works, telemetering and telecommunication facilities

9) Proposal of the operation and maintenance plan

10) Rough estimate of expenditures

11) Proposal of program for system construction and personnel training

3. Organization of Survey Team

The survey team comprises the following three teams:

First Survey Team

Second Survey Team

Third Survey Team

The survey teams are organized as follows.

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

River Engineering Expert:

Yoshiaki Tsukamoto***, Staff, International Co-operation Section, Planning Bureau, Ministry of Construction.

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.

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

Takeshi Hashimoto**, Researcher, Hydrology Section, Public Works Research Institute/AKABANE, 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 Export:

Seiji Miyazawa*, Chief Forecaster, Meteorological Agency.

Telecommunication Expert:

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 District Construction Bureau, Ministry of Construction.

Shuji Suga**, Association of Electrical Engineering.

Yoshiharu Nakagawa**, - ditto -

Socio-economic specialist:

Joji Ishii**, Deputy Manager of Research and Development Section, C.T.I. Eng. Co., Ltd.

Coodinator: 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.

*** denotes member of Third survey Team.

4. Process of Survey

The first survey was made from November 18th to December 17th, 1976, to obtain an understanding of overall project.

The purpose of the second survey was mainly the selection of the location of telemetering stations and the radio propagation tests during the period from January 31st to March 5th, 1977.

The third survey team submitted the Progress Report II to the Government of the Philippines in April, 1977.

The Final Report is a consolidation of surveys completed up to this time.

In addition, the Interim Report in December, 1976, the Progress Report I in February, 1977 and the Progress Report II in April, 1977, were submitted to the Government of the Philippines.

5. Acknowledgement

The team herewith expresses its heartily gratitude to Dr. R.L. Kintanar, Administrator, Phillipine Atomospheric, Geophysical and Astronomical Services Administration (PAGASA), Mr. D. Anolin, Director of Bureau of Public Works (BPW), Mr. J.E. Sunga, Director, Infrastructure Staff of National Economic Development Authority, (NEDA), Dr. S.N. Sen, Chief Adviser, Typhoon Committee Secretariat (TCS), and the staff member of the above-mentioned agencies for their active cooperation.

II. Conclusion and Recommendations

Based on the surveys of hydrometeorology, socio-economics, radio wave propagation tests in the Philippines, and discussion with the officials concerned and studies in Japan, the survey team presents suggestions and recommendation as follows.

1. Target Area

Taking into consideration the socio-economic features such as distribution of population and houses, situation of land utilization, and damage of probable floods, as well as hydrometeorological features such as topographic features of the basin, run-off of rainfall, and frequency of flood attack, the survey team proposes the following districts as the target of flood forecasting system.

1) Agno river basin

Entire Pangasinan Plain including the major municipalities of Dagupan, Lingayen, Bugallon, Sta. Barbara, Bayambang and Rosales. Central part of Tarlac Province including the major municipalities of Tarlac, Gerona, Paniqui and Moncada

2) Bicol river basin

Central part of the basin, from Lake Bato to Lake Baao and the flood plain surrounding Naga city

3) Cagayan river basin

Flood plain along the middle reaches from Ilagan to Tumauini
Flood plain along the lower reaches from Tuguegarao to Apari

2. Facilities and Networks

To achieve the purpose of this project, the following facilities and networks are to be established:

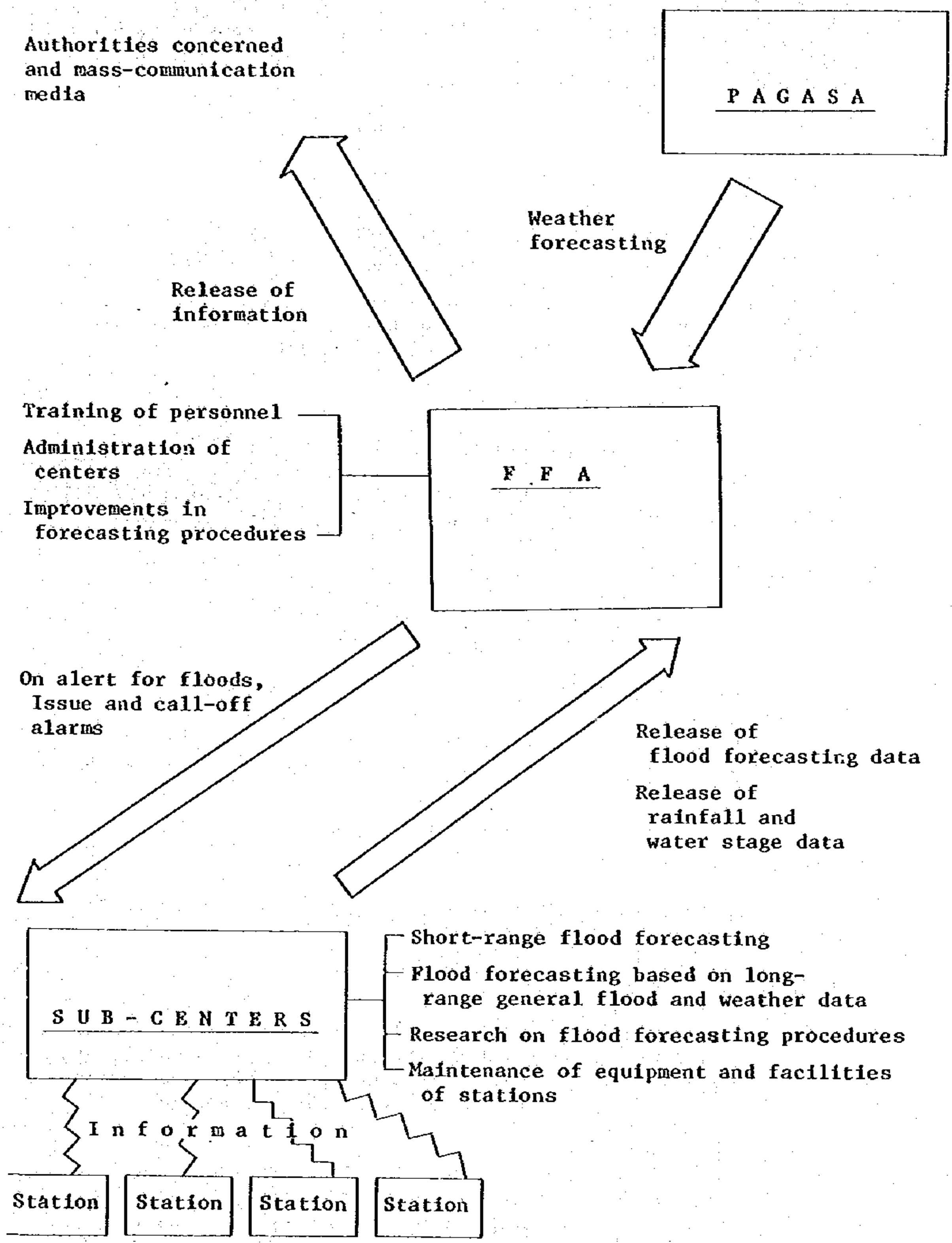
1) Agno River Basin

Seven telemetering stations (one more rainfall station is to be added in the near future) (Binga Dam, Sta. Barbara, San Roque, Carmen, Wawa, Tibag & Bañaga), one repeater station (Mt. Sto.Tomas) and one sub-center (Carmen, Rosales)

2) Bicol River Basin

Nine telemetering stations (Napolidan, Sipocot, Barongay, Camaligan, Ocampo, Ombao, Buhi, Bato & Ligao), two repeater stations (Sipocot Hill & Iriga) and one sub-center (Camaligan Naga)

FUNCTIONS OF FFA AND SUB-CENTERS



3) Cagayan River Basin

Four telemetering stations (Tuguegarao, Tumauini, Maris Dam & Dalibubun), one repeater station (Ilagan) and one sub-center (Tuguegarao)

Various development projects are to be achieved in this basin. When the basin is further developed in the future, more accurate forecast will be necessary. Telemetering stations, therefore, are needed additionally in the lower basin and Chico River Basin after the further survey.

4) A set of two relay stations at Deliman and Tanay, to connect the sub-center with the Flood Forecasting Center (FFC). Communication between the FFC and sub-centers will be achieved by multiplex telecommunication system and SSB radio telephone.

3. Functions and Organization of the Sub-centers

The function of sub-center is as below.

1) To collect the meteorological and hydrological data from the telemetering station and transmit them to the FFC.

2) To predict a short-term feature of flood according to the collected hydrological data and transmit them to the FFC.

3) To receive the information of the long-term forecast about flood, and utilize it for flood forecast.

4) To study to improve the method of forecasting.

5) To maintain the equipments and facilities in the stations.

One supervising engineer and one technician as hydrologists, and one supervising engineer, two qualified engineers and two technicians as telecommunication engineers, are to be assigned in each sub-center. In other words, there are seven persons - two hydrologists and five telecommunication engineers.

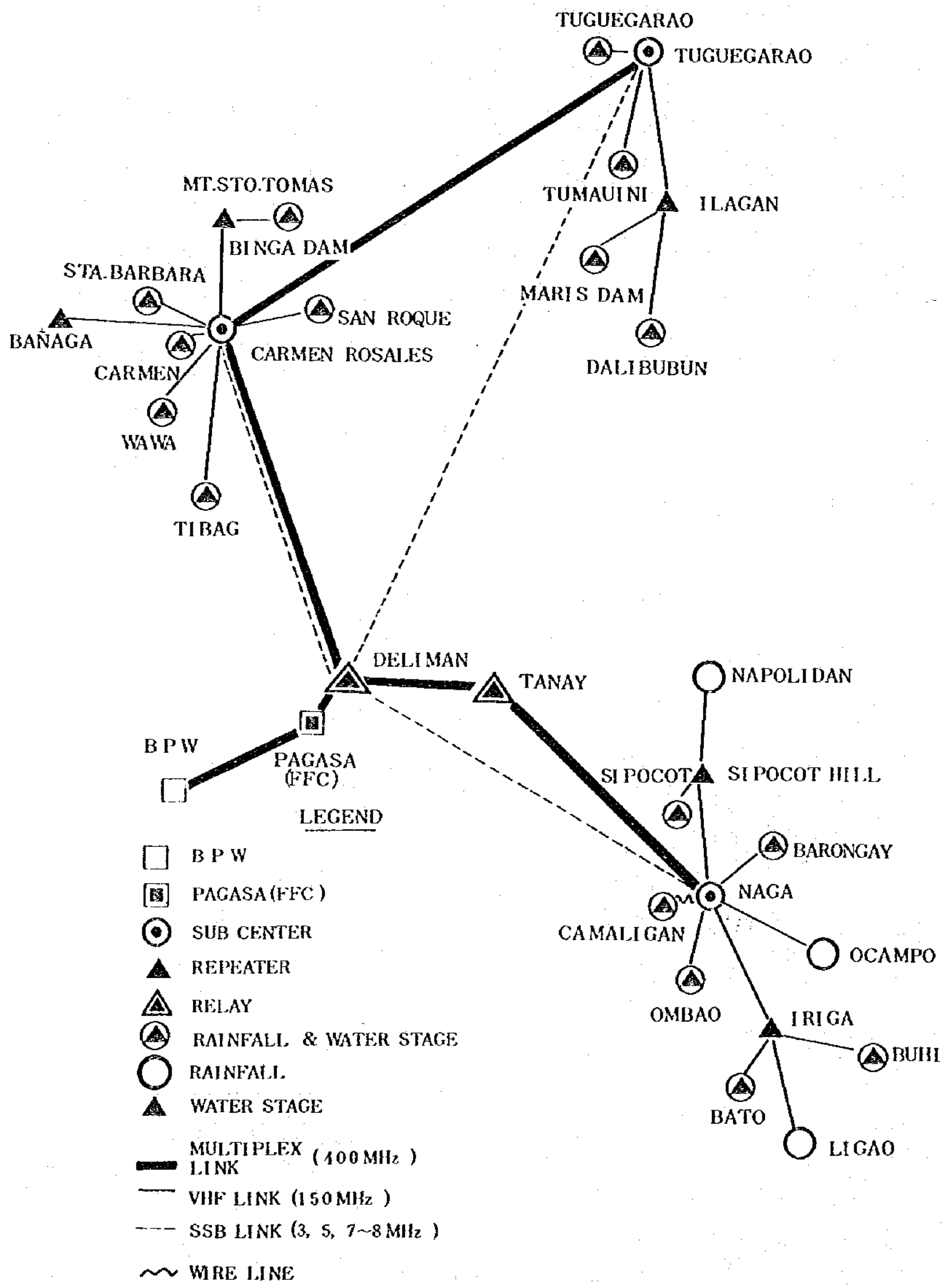
4. Functions and Organization of the FFC

The functions of the Flood Forecasting Center (FFC) are:

1) To review the short-term flood forecasting from the sub-center.

2) To forecast the outlook of the long-term flood, based on information of the sub-center and weather forecast of Philippine

TELECOMMUNICATION NETWORK



Atmospheric Geophysical and Astronomical Service Administration (PAGASA), and to submit the outlook to each sub-center.

3) To issue the flood warning to each sub-center and direct sub-center to call it off.

4) To inform the agencies concerned of the existing and predicted flood situations.

5) To study to improve the method of forecast.

6) To supervise the daily activities of the sub-centers, such as administration of the station and study of the method of forecast.

7) To train the personnel.

One chief engineer and four supervising engineers as hydrologists, one chief engineer and one supervising engineer and two qualified engineers and two technicians as telecommunication engineers are posted in FFC. In other words, there are eleven persons; five hydrologists and six telecommunication engineers.

5. Provision of Personnel

To ensure the effective operation of the system, staff members as mentioned below are to be required,and the following schemes concerning the staff members are to be executed.

1) To assign eight hydrologists (two in each sub-center and two in FFC), and eleven telecommunication engineers (two in each sub-center and five in FFC including ones for Pampanga River system). As the matter of course, it is recommended to assign only disciplined personnel.

2) To increase three hydrologists in FFC and fifteen telecommunication engineers, three in each sub-center and six in FFC during on-the-job training in addition to the above-mentioned number. Therefore, at the start of the operation of this system, the staff members are eleven hydrologists and twenty-six telecommunication engineers (total thirty-seven). Five of telecommunication engineers assigned for the Pampanga River station are included in the above.

3) For training in hydrology and telecommunication, trainees are selected and despatched to suitable organizations with techniques and experiences in flood forecasting procedures.

4) Shortly before completion of the construction, consultants will commence training of staff members.

6. Schedule of Implementation

The following two alternative schedules are studied.

Case I: The construction of whole system which includes the telemetry network in each basin, communication between sub-center and FFC through multiplex telecommunication and SSB telephone network will be started at the same time. On-the-job training will be undertaken by consultants for two years. Therefore, the complete start of the system will be approximately two and a half years later.

Case II: The construction of sub-systems of three rivers (Agno, Bicol and Cagayan) will be started step-by-step in three years. On-the-job training will be undertaken by consultants for two years. Therefore, the complete start of the whole system will be in about five years.

The "Case I" is to meet with the urgent demand for the system by the Government of the Philippines.

In the "Case I", at a glance, construction period is shorter and it looks more effective, but in the light of the experience in the Pampanga River, greater difficulties are predicated in formation of organization and assignment of experienced personnel. The reason because it would require an excessively large number of thirty-seven-eleven hydrologists and twenty-six telecommuncation engineers - and, moreover, all of them may have to be trained in a short time before assignment. And under the circumstance mentioned above, the extended system may also have to be operated by a large number of less experienced. Therefore, the introduction of the schedule would require a special assistance and co-operation of the Government to overcome predicated difficulties.

On the contrary, the "Case II" will require a longer construction period but this is a steady schedule in which a smoother formation of organization, and training and assignment of the personnel may be easier.

Schedule of Implementation

Case I

Item \ Year	1	2	3	4	5
Manufacture of Telecommunication Equipments	6M				
Settlement of Equipments	2M				
Civil Work	8M				
Training		24M			

Case II

Item \ Year	1	2	3	4	5
Agno System					
Manufacture of Telecommunication Equipments		30M			
	6M				
Settlement of Equipments	2M				
Civil Work	6M				
Training		24M			
Bicol System			30M		
Construction		8M			
Training			24M		
Cagayan System				30M	
Construction			8M		
Training				24M	

7. Cost Estimation

Expenditure will pay for civil work, telecommunication facilities and its installation, technical services, and operation and maintenance in the period of test run.

		Construction Cost	(Economic Cost)
Case I	Foreign Currency	US$6,094,000	(US$6,068,000)
	Local Currency	₱3,255,000	(₱3,255,000)
	Total	US$6,535,000	(US$6,509,000)
Case II	Foreign Currency	US$7,194,000	(US$6,556,000)
	Local Currency	₱3,464,000	(₱3,255,000)
	Total	US$7,663,000	(US$6,995,000)

(Exchange Rate US$ 1=₱7.39)

Note:

1) The space for FFC and the monitor stations needs to be provided immediately by the Government of the Philippines.

2) Proposed 10% annual increase in the commodity price is included in the construction cost but is excluded in the economic cost.

Case 1 COST (Three sub-system by Simultaneous Construction Method)

	Foreign Currency	Local Currency
Civil Works	1,019 x 10^3 US$	2,527 x 10^3 ₱
Telecommunication	3,131	-
Technical Services	989	-
Operation and Maintenance	125	76
Contingency	830	509
Total	6,094	3,255

6,535 x 10^3 US$

Case 2 COST (Three Sub-system by Step-by-step Construction Method)
(priority: 1. Agno system 2. Bicol system 3. Cagayan system)

	Foreign Currency	Local Currency
Civil Works	1,102 $\times 10^3$ US$	2,688 $\times 10^3$ ₱
Telecommunication	3,384	-
Technical services	1,674	156
Operation and Maintenance	136	81
Contingency	898	539
Total	7,194	3,464

7,663 $\times 10^3$ US$

8. Benefit

The usual technique of economic analysis is hardly applicable to the flood forecasting and warning system, because the benefit is intangible like the case of education projects or public health project.

In fact human lives and properties of the inhabitants are heavily damaged by flood every year as listed in the following table. The system is very sure to play an important role for disaster prevention and promotion of public welfare, by timely and effective information for the operation of evacuation, flood defense and rescue.

Especially, it should be noted that through this operation number of human lives are brought out of vital danger caused by flood.

Besides, indirect benefits such as acceleration of development projects, increase of private and public properties, and promotion of the will to work of inhabitants are expected.

The flood forecasting and warning system requires much shorter time and smaller expenditure than flood control works and the system carries out the benefit of disaster prevention to an extent even though it is not so big as the benefit by flood control works.

Estimated Maximum Damage by Probable Flood

River Basin	Target Area	Popullation	Property	Damage
	km^2	$x\ 10^3$	$x\ 10^6$ ₱	$x\ 10^6$ ₱
Agno	1,540	500	1,888	531
Bicol	570	200	553	143
Cagayan	1,420	180	581	139
Total	3,530	880	3,022	813
			$x\ 10^6$US$	$x\ 10^6$US$
			411	111

9. Proposal for the New Organization

In order to make the newly extended flood forecasting system function effectively, number of skilled engineers and large budget for operation and maintenance of the system are required.

However, the existing Flood Forecasting Center (F F C) which may be mentioned as the operational center of the new system, has following problems unsolved. The effective management of the new system by FFC may become difficult without solving these problems.

1) Under the present system, FFC has no proper staff and budget, therefore, the necessary personnel and expenses cannot be smoothly secured.

2) New employment and/or transfer of number of personnel in a limited period may be difficult.

3) The existing FFC can hardly manage the extended system in an integrated and systematic manner.

4) Because the improvement of salary of the personnel is difficult, the skilled engineers are apt to transfer to other organizations.

5) Because of the lack of the research and planning section, improvement in the accuracy of forecasting and extention of the system to other rivers are difficult.

In order to solve these problems, and to operate the new system effectively, the Survey Team proposes establishment of the new organization, the Flood Forecasting Authority (F F A).

The new FFA should have an appropriate position in the organization of the Government, proper staff and budget.

The new organization is a ' proposal ' by the Survey team, therefore, its implementation will be reviewed as an issue of improvement of administrative organization by the Government of the Philippines.

Flood Forecasting Authority (F.F A)

- FFA
  - New FFC
    - Management Division
    - Hydrology Division
    - Telecommunication Division
    - Planning Division
    - Research Division
    - Training Division (Training of engineers)
  - Sub-Center
    - Management Section
    - Hydrology Section
    - Telecommunication Section

10. Additional Recommendation

1) The staffs and equipment of FFC will be transferred to FFA, when the new organization starts.

2) Installation and restoration of hydrological station which will come under the new-system should be completed as early as possible.

3) Under present level of forecasting, a quantitative rainfall forecasting technique is not yet fully developed, therefore, forecasting may be performed by means of the existing technique. To assist this, an effective use of the PAGASA meteorological rader may be taken into consideration.

4) To up-grade accuracy of forecasting, use of computers is recommended.

III. Hydro-Meterological Characteristics

§-1. The Agno River

1. Geography

The Agno River has a drainage area of 5,646 km^2 (Estuary: Baay West), and is the third largest river in Luzon next to the Cagayan and Pampanga Rivers. A half of its drainage area, particularly the watershed in Banguet Province is mountainous having an average elevation of some 2,000 m above MSL.

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 alluvial fan and a delta, and then flows into Lingayen Gulf. This fan and delta is called the Pangasinan Plain, and has long been developed economically, together with Pampanga Plain, being the granary of Central Luzon.

The Agno River has a course of about 200 km, 90 km of which 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 plain.

Poponto 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 temporarily retains flood water from the Tarlac River.

Dagupan and Sta. Barbara form the center of the Pangasinan Plain, which was formed as a reault of floods from the Agno River. Changes in river course as well as river improvement works led to the separation of the Agno River from the Plain. The plain is at present protected from the flood by the dykes along the right bank of the river.

2. Climate

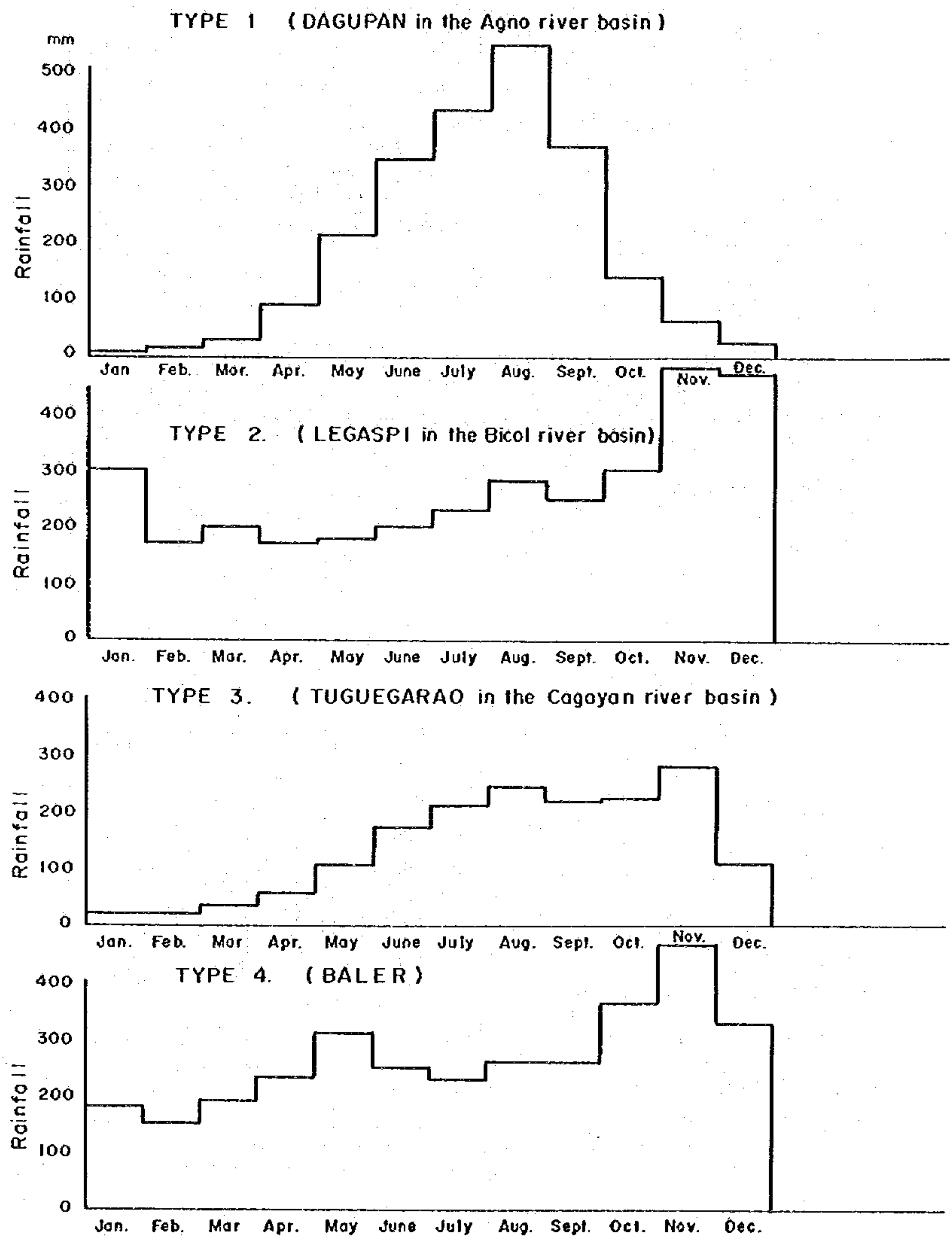
Since temperature differences in the Philippine Archipelago are relatively small, climatic classification of the islands has been based upon the presence or absence of a dry season and rainy season. The four types of conditions selected for climatic classification are:**

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

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

** Report on the Cagayan River Basin, Luzon Island, Philippines

Fig. The Four Types of Conditions for Climate



Third type - This type has no pronounced rainy season and only a short dry period lasting for 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. Determinant 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 to April and the wet season from May to October. Annual precipitation varies from 2,000 mm in the neighborhood of Tarlac to 4,000 mm in the upper stream of the Agno River. 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 within a month in August, 1911, and 1,168 mm in 24 hours in July, 1911, in Baguio City located in the watershed area 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 mountaineous topography, the flood runoff reaches the plain in several hours and the river mouth in a day. For this reason, the flood hydrograph of the river shows very sharp rise and falls. The largest recent flood was experienced in May, 1976, when some gaging stations were washed away resulting discontinuity of stream flow measurement thereafter. BPW has estimated the design flood with a 100-year return period as 10,000 m^3/sec at Wawa, Bayambang, (drainage area is 4,196 km^2), whereas 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.

The Pangasinan Plain suffers from floods very often; the largest was in May, 1976, flooding the entire Plain including the flood plain along the Tarlac River, causing an inestimable damage.

5. Flood Control Works

BPW has been in charge of Agno River flood control, and its primary plan including construction of dyke systems and flood ways. The Agno tends to expand to the Pangasinan Plain beyond the right bank of the river. The dyke on this side is the most important structure. Also, the dyke on the right bank of Tarlac River between Tarlac 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, and retards the runoff from the Tarlac River at the confluence. The Alcara flood way has recently been completed with the view to divert the 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 reaches of Bayambang.

Flood control in the basin of the Dagupan River has not progressed, probably because this river does not drain landside waters. In order to facilitate better drainage of the Dagupan River basin, it seems that some sluices or pumping stations may be required in the future.

Concerning other hydraulic structures, the National Power Corporation (NPC) has Ambuklao Dam, and Binga Dam both having a height of nearly 100 m in the upstream of the Agno, the National Irrigation Administration (NIA) has an intake dam of the Agno irrigation system at San Roque, San Manuel, and an intake dam at Tarlac on the Tarlac River.

6. Gaging Stations

There are 10 stream gaging stations along the Agno River, one station along the Tarlac River and 3 stations along the Dagupan River. Discharge measurement is also performed at these stations, except those located in the tidal reaches. 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 installed in many of these stations were broken down during the floods in 1972 and/or 1976. Observation at the most of these stations is currently done with the staff gages. The station at San Roque, San Mannuel, was half destroyed and a staff gage has been temporarily installed. The station at Tibag, Tarlac has been abandoned. All the data from the gaging stations are compiled at the BPW headquarters.

As regards meteorological observatories, there is the Dagupan Synoptic Station, PAGASA, which monitors all essential meteorological factors. The rain gaging stations, with PAGASA as the center, number as many as 22 including those in the Agno and Dagupan basins. In addition, both NIA and NPC have independent rain gaging networks.

Daily observation is performed at all gaging stations. As compared with the water level gaging stations, the rain gaging stations have less interruption of recording. These data are gathered by the PAGASA headquarters via the Synoptic Station.

§-2. The Bicol River

1. Geography

The Bicol River is a medium sized river in the Philippines with a drainage area of 2,717 km^2 at Barongay Station covering the Provinces of Camarines Sur and Albay, the southernmost part of Luzon. The major part of the drainage area is flat alluvial land and tableland with volcanic deposits. The basin has higher mountains including volcanos over 2,000 m high to the east, and relatively lower mountains to the west. The runoff starts from Mayon volcano, the most famous mountain in Luzon, with an elevation of 2,421 m and after being regulated through the lakes of Bato, Baao and Buhi, comes into the main stream 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 Sipocot 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 the main river course, which meanders considerably across the plain. Then it joins the Sipocot River and pours into San Miguel Bay.

The Bicol River has a very gentle slope. Lake Bato, in spite of its location about 70 km from the river mouth, has a minimum water level of only 5.0 m above MSL. This is 1/14,000 in terms of water 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 becomes more than 1,000 m wide at its estuary.

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

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 river mouth.

2. Climate

The climate of this basin is of the second type described previously, having no dry season but has a pronounced rainy season from November to January. 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.

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

3. Precipitation

There is no dry season in this district. There are possibilities of heavy rains 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.

Frequent and heavy floods are caused by storm surges generated in San Miguel Bay. The bay is subject to high tides, and in addition many violent typhoons pass over the area. Maximum storm surge is estimated to be as high as 2.5-3 m, and the flood tide in San Miguel Bay is about 1.5 m above MSL. Therefore, the water level in the bay may reach 4 m above MSL, when the storm surge occurs simultaneously with the astronomical flood tide.

5. Flood Control Works

Concerning the flood control works of the Bicol River, the 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 straighten the meandering channel in the vicinity of Naga City. Future programs, however, include drastic projects such as the dyke system in the lower reaches, direct diversion channel from Lake Bato to Ragay Gulf, dams in the upper Sipocot River.

As for the water resources development, the integration of irrigation networks including the Lalo River irrigation system by NIA is another construction project.

6. Gaging Stations

Gaging stations located at 27 places in all are generally under BPW control, and discharge measurements are performed at the most of 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 are installed with automatic level recorder, which are out of order except one at Mabulo, Naga. Therefore, reading is done with staff gages.

A synoptic Station of PAGASA is located in Pili, Camarines Sur and monitors all essential meteorological factors. There are 14 rain gaging stations of PAGASA, where daily observation is performed.

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

§-3. The Cagayan River

1. Geography

The Cagayan River is the largest river in Luzon, having a drainage area of 27,580 km^2 at the river mouse, Aparri .

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

The river has a total length of 400 km, 120 km of which in 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 extensively through the flood plain of the Cagayan valley.

Marshes and swamps are found in some parts of the lower reaches.

2. Climate

The climate is controlled by high mountains in three directions, trade winds, monsoons, and cyclones which attack the basin four times a year in an average.

Mean annual temperature at Tuguegarao, located at central reaches, is 26.6°C, with small temperature differentials between months. Average humidity is 80% and does not change noticeably.

3. Precipitation

The dry season lasts from December to April, whereas rainy season from May to November. The average annual rainfall is 1,000 mm in Alcara or in the northern part, and 3,000 mm in the south-eastern mountains. The heaviest rain which brought floods was recorded in Tuguegarao in November, 1906, when a monthly rainfall of 1,316 mm with the maximum 24-hour rainfall of 318 mm was recorded.

4. Flood and Storm Surge

Floods caused by this river tend to flow down very slowly because of its detension over the extensive flood plain, extremely gentle slope, retardation of natural flood by several gorges, and meandering of the river.

Water stage gaging is performed at gaging stations located along the river course, but no discharge measurement is performed. Therefore, the discharge flow, up to this time, is unknown.

The water stage in case of floods may rise higher than 10 m above the normal stage. Valleys are very often damaged by the floods, and the maximum area damaged is estimated to be 2,080 km^2.

No serious damage due to high tide has been recorded. Considering the features of Babuyan Gulf into which the river pours, no significant storm surge would be expected to occur.

5. Flood Control Works

BPW has been principally in charge of flood control on the Cagayan River, although no plan has actually been completed. This may indicate that the river course remains natural. Development of water resources has been progressing. The Maris 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 take place 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 insufficient 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 taken during the period of floods. All the data are compiled at the BPW headquarters.

With regard to meteorological observation, there is Tuguegarao Synoptic Station, PAGASA, which monitors all essential meteorological factors, and there are 26 rain gaging stations belonging to PAGASA, however, many of them have already been abandoned. The number of this kind of stations seems to be too small considering the large drainage area. The rainfall data are gathered by the PAGASA headquaters through the synoptic station.

IV. Socio-Economic Characteristics

§-1. The Agno River

The drainage area of the river covers four provinces --- Mountain, Benguet, Pangasinan, Tarlac. The area administrated is 13,118 km^2.

1. Population

The basin has a population of about 2,302 thousand. Population density is as high as 146.3 persons/km^2, which is fairly high compared with the national average.

The each following eight cities or municipalities has a population of more than 50 thousand. Baguio, Benguest: 84.5 thousand, Dagupan, Pangasinan: 84.3 thousand, Bayambang, Pangasinan: 56.4 thousand, 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	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: 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

1970 Population Census

2. Industry

In the mountainous area, mainly centered in the Provinces of Mountain and Benguet, medium latitude agricultural products (such as cabbages, tomatoes, carrots, cauliflowers, etc.) are cultivated on the alluvial soil of the Trinidad Valley up to the skirt of the surrounding mountains, being the principal source of vegetable supply in the Philippines. Production in logging and forestry is the highest in Luzon and the second highest in the Philippines. Mining and quarrying are active, and Benguet Province has mining as the most important industry, including the refining of gold.

In the plain area around Pangasinan, agriculture is well developed producing mainly palay (unhulled rice), sugar cane, tobacco, livestock, and poultry. In the lower drainage area around Lingayen and Dagupan, fish culture is 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	Cabbages Tomatoes Carrots Cauliflowers Strawberries etc.	Cabbages Tomatoes Carrots Cauliflowers Strawberries etc.	Palay (rough rice) Tobacco Coconut Sugarcane Livestock Poultry	Palay (rough rice) Sugar Poultry Goats

Source: NEDA Statistical Year Book of The Philippines

Number of Establishments in Agna 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
Pangasinan	20,561	2,307	12,397	3,934	1,610	313
Tarlac	9,980	941	6,068	2,087	704	180

Source: NEDA Statistical Year Book of The Philippines

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 between 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 crossing highway No. 3 serve effectively as inter-regional semi-trunk roads.

The results of the 1975 survey of traffic volume at places of heavy traffic are as follows (number of cars):

Places of comparatively easy access: 1,000 - 1,500/day.

Cities in Benguet Province (Bagivere, Taba, Campie): 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.

The first railway was constructed between Manila and Dagupan in the Philippines, and the northern line now starts at Manila and terminates at San Fernand Union and plays an important role as a means of transportation in the area.

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

Existing Highway Kilometerages
(As of June 30, 1972)

Name of Province	Mountain			Benguet		
Item / Rank	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

Source: Department of Public Highways

Name of Province	Pangasinan			Tarlac		
Item / Rank	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

Source: Department of Public Highways

4. Damage

In the Agno River basin, the average annual damage due to floods during the past 10 years is ₱60 million, and the areas suffered extends as much as 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 of	Date	Damages	Rainfall
1966	Klaring	May 11-22	₱ 430,000	Baguio 286.8 mm
1967	Trimg	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

Source: Bureau of Public Works
Philippine Atomospheric Geophisical and Astronomical Service Administration

5. Basin Development Project

The government of the Philippines is making efforts to develop the Agno River basin, with priority of road systematization and river improvement. The regional projects are listed below.

A. Manila North Road

B. Second Luzon Highway Package Project

C. Tarlac - Sta Rosa Road

D. Rosario - Baguio Road
Bauang - Baguio Road

E. Paniqui - 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 into 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 possibility of forecasting and warning about floods in the future. This possibility is based upon meteorology, hydrographical features, frequency of floods and data from past observations.

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

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

Next, in the estimation of the major indistries in the target area according to the statistic data, the general and public properties are as follows:

(1) General property

1 Private building construction

Number of private building construction	Floor area ($x10^3$ m^2)	Value ($x10^3$ ₱)
900	470	70,000

Source of basic data: National Census and Statistics Office

2 Household

Number of families ($x10^3$)	Annual family income (₱)	Value of household ($x10^3$ ₱)
100	5,190	519,000

Source of basic data: National Census and Statistics Office
Note: For house fixtures, a household is assumed to have properties equal to its annual income.

3 Mineral production

Value of metallics ($x10^3$ ₱)	Value of non-metallics ($x10^3$ ₱)	Total value ($x10^3$ ₱)
3,000	12,000	15,000

Source of basic data: Bureau of Mines

4 Manufacturing production

Firms	Employment	Value of fixed asset ($x10^3$ ₱)	Value of production ($x10^3$ ₱)
50	2,600	10,000	140,000

Source of basic data: National Census and Statistics Office

5 Commercial trade total gross receipts

	Number of establishments	Employment	Total gross receipts ($x10^3$ ₱)
Wholesale gross receipts	170	1,700	77,000
Retail gross receipts	7,400	23,000	119,000
Total	7,570	24,700	196,000

Source of basic data: National census and Statistics Office

6 Fish pond production

Area (ha)	Production (ton)	Value (x10^3 ₱)
9,200	8,000	61,000

Source of basic data: Fisheries Statistics of the Philippines

7 Crops production

	Area (ha)	Production (x10^3 ton)	Value (x10^3 ₱)
Palay	57,000	41,000	92,000
Corn	3,000	2,000	5,000
Sugarcane	4,000	23,000	13,000
Tobbaco	1,000	1,000	3,000
Coconut	2,000	2,000	3,000
Abaca	-	-	-
Others	7,000	70,000	62,000
Total	74,000	139,000	178,000

Source of basic data: National Food and Agriculture Council

8 Livestock and poultry on farms

	Number	Value (x10^3 ₱)
Carabao	84,000	35,000
Cattle	32,000	12,000
Swine	115,000	10,000
Horses	4,000	1,000
Goats	42,000	1,000
Chicken	606,000	2,000
Ducks	-	-
Total	883,000	61,000

Source of basic data: Bureau of Agricultural Economics

Total General Property Value: 1,240,000 x 10^3 ₱ (169,000 x 10^3 US$).

(2) Public property

9 National road & railway reconstruction cost

National road kilometerages	Railway kilometerages	Reconstruction value (x10^3 ₱)
370	60	572,000

Source of basic data: Department of Public Highways, Philippine National Railways

10 School reconstruction cost

Number of private schools	Number of public schools	Reconstruction value (x10^3 ₱)
100	900	71,000

Source of basic data: Department of Education and Culture,
Educational Statistics,
Bureau of Public Works.

11 Transportation

Traffic volume	Average of fare (₱)	Value (x10^3 ₱)
50,000 cars	100	5,000

Source of basic data: Department of Public Highways
National Census and Statistics Office

Note: For transportation, an average income obtained from a car used for business purposes is assumed as a property value.

Total Public Property Value: 648,000 x 10^3 ₱ (88,000 US$)

(3) Target area property value

	(x10^3 ₱)
(1) General Property	1,240,000
(2) Public Property	648,000
(3) Total (x10^3 ₱)	1,888,000
Total (x10^3 US$)	257,000

Note: (1) The properties in the target area were calculated according to the ratio of population or an area based on the statistical value of provinces and regions.

(2) The values of productions and properties (production value) in 1976 were calculated with reference to the growth ratios of consumers' prices and productions.

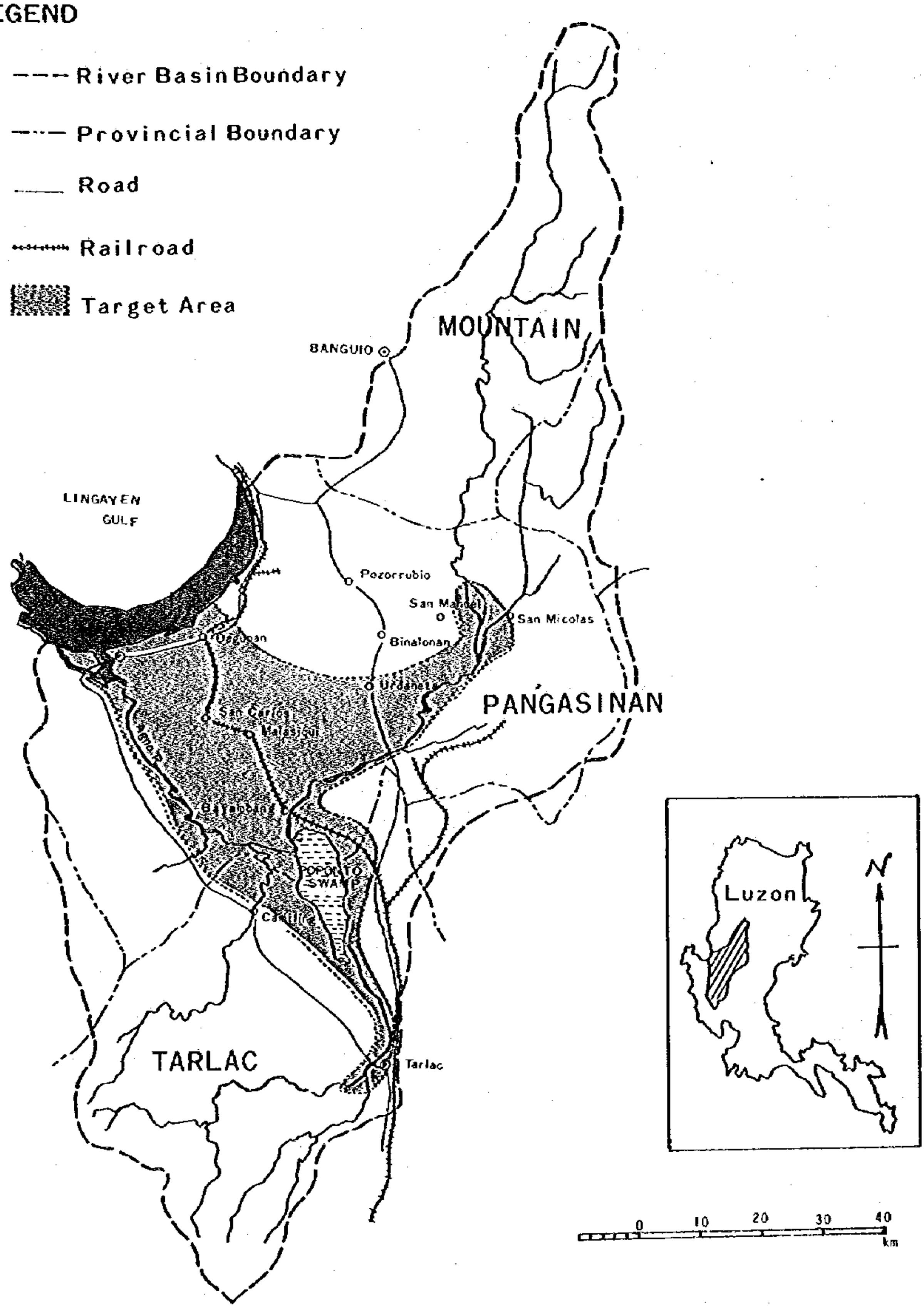
The basic data is filed in Appendix.

(3) In the conversion of Pesos into US Dollars, US$1 was calculated in terms of ₱7.39.

Fig. 4-1 TARGET AREA
— AGNO RIVER BASIN —

LEGEND

- - - River Basin Boundary
-·- Provincial Boundary
—— Road
+++ Railroad
Target Area



§-2. The Bicol River

The 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 next to Metro Manila.

The each following seven cities has a 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: 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		

1970 Population Census

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 entered 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, etc.	Palay, Coconut, Abaca, Banana, Livestock, Poultry, etc.	Palay, Corn, Vegetable, Root-crops, Coconuts, Abaca, etc.

Source: NEDA Statistical Year Book of The Philippines

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

Source: NEDA Statistical Year Book of The Philippines

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 between 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, 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 (Legaspi, Ligao, Qas, Polangui): 200-1,100/day.

Cities in Camarines Sur Province (Iriga, Pili, Naga, Nabua): 800-2,400/day.

In addition to highways, the southern railway laid from Manila to Legaspi plays an important role as a means of transportation in the area. Railroad and national roads functioning as life lines generally run along the Bicol Valley, and cross the main flood plains at several points.

Existing Highway Kilometerages
(As of June 30, 1972)

Name of Province / Rand / Item	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

Source: Department of Public Highways

Name of Province / Rank / Item	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 damages reaches 580 km^2. The amount of the damages in the past 10 years (1966-1975), caused by typhoon, and tropical cyclone are listed below:

Flood Information of Cyclone

Year	Name	Date	Damages	Rainfall
1967	Welming	Nov.1 - 5	₱18,000,000	Daet Com. Norte 175.5 mm
1973	Luming	Oct.2 - 9	₱ 3,200,000	Daet Com. Norte 200.1 mm

Source: Bureau of Public Works, Philippine Atomospheric, Geophysical and Astronomical Services Administration

Note: Damages in December 1975 and December 1976 are not recorded.

5. Basin Development Project

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

The regional projects are listed below.

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 and social characteristics 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 extending from Naga city to the river mouth.

Next, in the estimation of the major industries in the target area according to the statistic data, the general and public properties are as follows:

(1) General property

1 Private building construction

Number of private building construction	Floor area (x10^{3}m^2)	Value (x10^3 ₱)
900	470	70,000

Source of basic data: National Census and Statistics Office

2 Household

Number of families (x10^3)	Annual family income (₱)	Value of household (x10^3 ₱)
50	3,180	159,000

Source of basic data: National Census and Statistics Office

Note: For household fixtures, a household is assumed to have properties equal to its annual income.

3 Manufacturing production

Firms	Employment	Value of fixed asset (x10^3 ₱)	Value of production (x10^3 ₱)
25	1,100	3,000	21,000

Source of basic data: National Census and Statistics Office

4 Commercial trade total gross receipts

	Number of establishments	Employment	Total gross receipts (x10^3 ₱)
Wholesale gross receipts	50	400	18,000
Retail gross receipts	1,300	4,000	17,000
Total	1,350	4,400	35,000

Source of basic data: National Census and Statistics Office

5 Fish pond production

Area (ha)	Production (ton)	Value (x10^3 ₱)
3,800	800	4,000

Source of basic data: Fisheries Statistics of the Philippines

6 Crops production

	Area (ha)	Production ($x10^3$ ton)	Value ($x10^3$ ₱)
Palay	30,000	46,000	27,000
Corn	6,000	5,000	2,000
Sugarcane	–	–	–
Tabbaco	–	–	–
Coconut	8,000	4,000	5,000
Abaca	4,000	4,000	9,000
Others	9,000	19,000	9,000
Total	57,000	78,000	52,000

Source of basic data: National Food and Agriculture Council

7 Livestock and poultry on farms

	Number	Value ($x10^3$ ₱)
Carabao	19,000	8,000
Cattle	3,000	1,000
Swine	34,000	3,000
Horses	–	–
Goats	–	–
Chicken	303,000	1,000
Ducks	–	–
Total	359,000	13,000

Source of basic data: Bureau of Agricultural Economics

Total General Property Value: 301,000 x 10^3 p (41,000 x 10^3 US$).

(2) Public property

8 National road & railway reconstruction cost

National road kilometerages	Railway kilometerage	Reconstruction value ($x10^3$ ₱)
90	50	231,000

Source of basic data: Department of Public Highways
Philippine National Railways

9 School reconstruction cost

Number of private schools	Number of public schools	Reconstruction value (x10³ ₱)
20	250	19,000

Source of basic data: Department of Education and Culture
Educational Statistics
Bureau of Public Works

10 Transportation

Traffic volume	Average of fare (₱)	Value (x10³ ₱)
20,000 Cars	100	20,000

Source of basic data: Department of Public Highway
National Census and Statistics Office

Note: For transportation, an average income obtained from a car used for business purposes is assumed as a property value.

Total Public Property Value: $252,000 \times 10^3$ ₱ ($34,000 \times 10^3$ US$)

(3) Target area property value

(x10³ ₱)

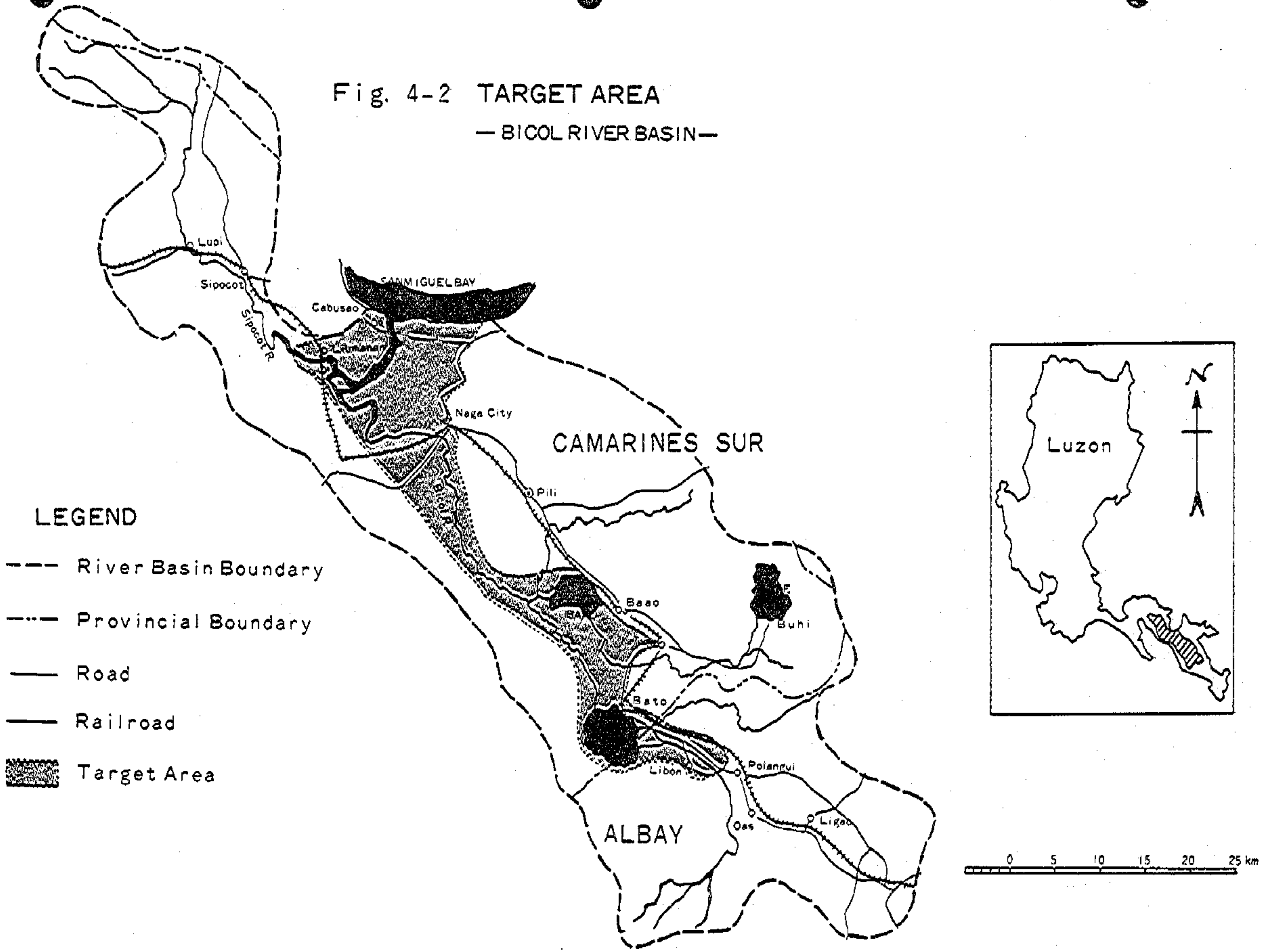
(1) General property	301,000
(2) Public property	252,000
(3) Total (x10³ ₱)	553,000
Total (x10³ US$)	75,000

Note: (1) The properties in the target area were calculated according to the ratio of population or an area based on the statistical values of provinces and regions.

(2) The values of productions and properties (production value) in 1976 were calculated with reference to the growth ratios of consumers' prices and productions. The basic data is filed in Appendix.

(3) In the conversion of Pesos into US Dollars, US$1 was calculated in terms of ₱7.39.

Fig. 4-2 TARGET AREA
—BICOL RIVER BASIN—



§-3. The Cagayan River

The basin of this river covers seven provinces --- Cagayan, Isabela, Nueva Vizcaya, Benguet, Ifugao, Mountain, Kalinga Apayao --- and its area administrated is about 30,000 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 that in other regions.

There are only two cities of more than 50 thousand population each. Ilagan, Isabela: 62.1 thousand, Tuguegarao, 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: 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

Per 1970 Population Census

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
Crope	Palay, Corn, Legumes, Rootcrops, Vegetables, Fruits, Tobacco, Sugarcane, Caraboos, Hogs, etc.	Rootcrops, Corn, Vegetables, Fruits, Coconuts, Sugarcane, etc.	Palay, Corn, Tabacco, Fruits, Mango, Peanuts, Tomatoes, Vegetables, Coconuts, Sugarcane, etc.	Palay, Mango, Pomelo, Jackfruit, Vegetables, Potatoes, Maguey, etc.

Source: NEDA Statistical Year Book of The Philippines

Number of Establishments in Cagayan River Basin by Major Industry Division

Province	Total Number of Establish-ments	Manufac-turing	Wholesale and Retail Trade Res-taurants and Hotels	Transport Storage and Com-munication	Community Social and Personal Services	Other Economic Activi-ties
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

Source: NEDA Statistical Year Book of The Philippines

3. Traffic

The traffic network in the Cagayan River basin is composed mainly of the roads. The road system includes trunk roads connecting between 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, 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		
Rank / Item	National	Provincial Municipal and City	Toal	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

Source: Department of Public Highways

Name of Province	Isabela			Nueva Vizcaya		
Rank / Item	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 reaches 570 km^2. The amount of damage in the past 10 years (1966-1975), caused by the violent typhoons and tropical cyclones, is listed below.

Flood Information

Year	Name of Cyclone	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

Source: Bureau of Public Works, Philippine Atomospheric, Geophysical and Astronomical Services Administration.

5. Basin Development Project

This region has large potential for development, and the government of the Philippines is making efforts to progress 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 the light 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 reaches, from Tuguegarao city to Aparri.

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

Next, in the estimation of the major industries in the target area according to the statistic data, the general and public properties are as follows:

(1) General property

1 Private building construction

Number of private building construction	Floor area ($x10^3 m^2$)	Value ($x10^3$ ₱)
100	40	4,000

Source of basic data: National Census and Statistics Office

2 Household

Number of families ($x10^3$)	Annual family income (₱)	Value of household ($x10^3$ ₱)
40	2,230	89,000

Source of basic data: National Census and Statistics Office

Note: For household fixtures, a household is assumed to have properties equal to its annual income.

3 Manufacturing production

Firms	Employment	Value of fixed asset ($x10^3$ ₱)	Value of production ($x10^3$ ₱)
20	800	1,000	13,000

Source of basic data: National Census and Statistics Office

4 Commercial trade total gross receipts

	Number of establishments	Employment	Total gross receipts ($x10^3$ ₱)
Wholesale gross receipts	30	300	17,000
Retail gross receipts	1,700	5,000	24,000
Total	1,730	5,300	41,000

Source of basic data: National Census and Statistics Office

5 Fish pond production

Area (ha)	Production (ton)	Value ($x10^3$ ₱)
500	100	1,000

Source of basic data: Fisheries Statistics of the Philippines.

6 Crops production

	Area (ha)	Production (x10³ ₱)	Value (x10³ ₱)
Palay	71,000	101,000	58,000
Corn	63,000	43,000	19,000
Sugarcane	-	-	-
Tabbaco	6,000	5,000	9,000
Coconut	-	-	-
Abaca	-	-	-
Others	2,000	19,000	26,000
Total	142,000	168,000	112,000

Source of basic data: National Food and Agriculture Council

7 Livestock and poultry on farms

	Number	Value (x10³ ₱)
Carabao	41,000	17,000
Cattle	5,000	2,000
Swine	46,000	4,000
Horses	4,000	1,000
Goats	-	-
Chicken	303,000	1,000
Ducks	-	-
Total	399,000	25,000

Source of basic data: Bureau of Agricultural Economics

Total General Property Value: 285,000 x 10^3 ₱ (39,000 x 10^3 US$)

(2) Public property

8 National road & railway reconstruction cost

National road kilometerages	Railway Kilometerages	Reconstruction value (x10³ ₱)
220	-	275,000

Source of basic data: Department of Public Highways
Philippines National Railways

9 School reconstruction cost

Number of private schools	Number of public schools	Reconstruction value (x10³ ₱)
30	250	20,000

Source of basic data: Department of Education and Culture
Educational Statistics
Bureau of Public Works

10 Transportation

Traffic volume	Average of fare	Value (x10^3 ₱)
10,000 cars	100	1,000

Source of basic data: Department of Public Highway
National Census and Statistics Office

Note: For transportation, an average income obtained from a car kept for business purposes is assumed as a property value.

Total Public Property Value: 285,000 x 10^3 ₱ (39,000 x 10^3 US$)

(3) Target area property value

(x 10^3 ₱)

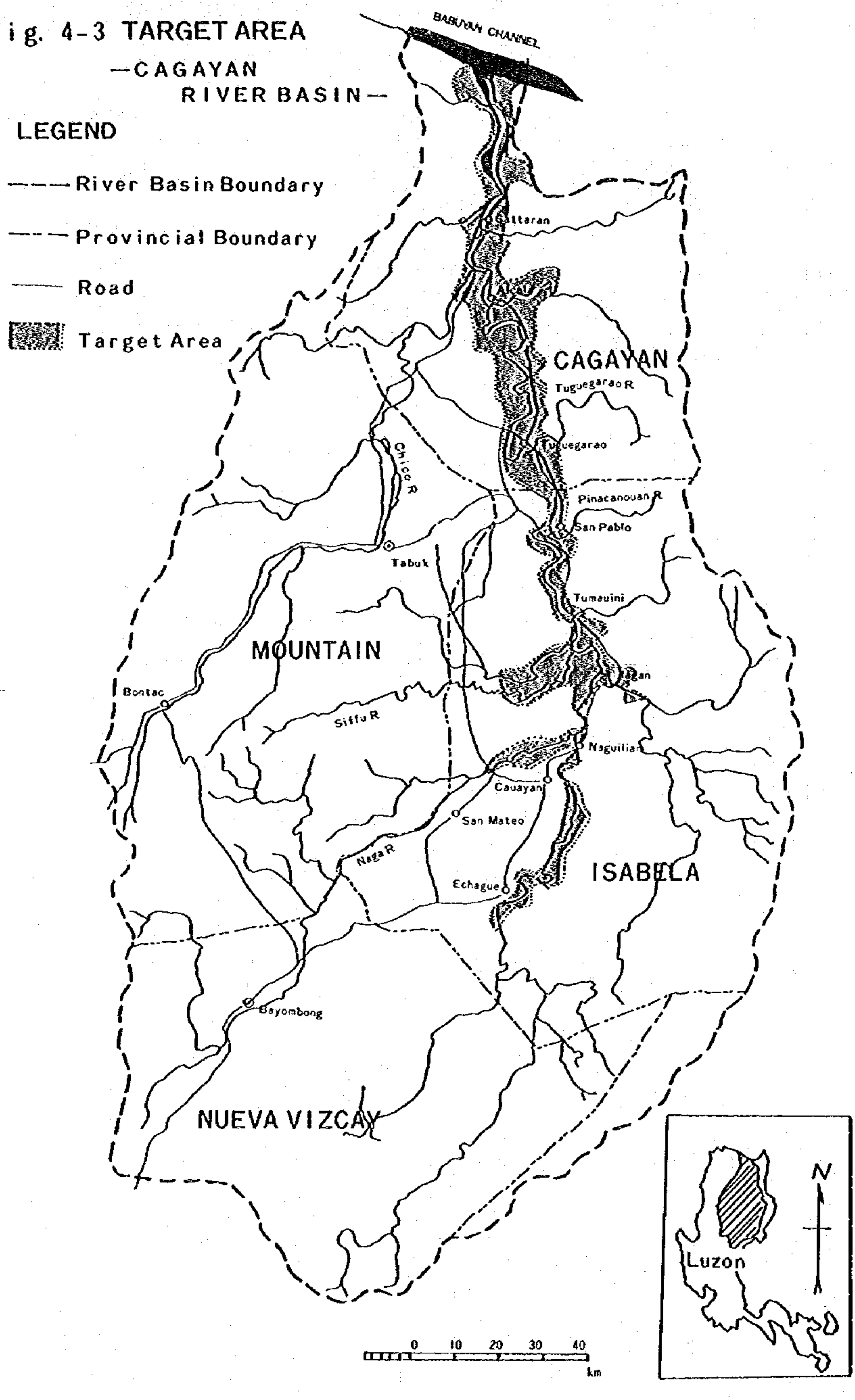
(1) General property	285,000
(2) Public property	296,000
(3) Total (x10^3 ₱)	581,000
Total (x10^3 US$)	79,000

Note: (1) The properties in the target area were calculated according to the ratio of population or an area based on the statistical values of provinces and regions.

(2) The values of productions and properties (production value) in 1976 were calculated with reference to the growth ratios of consumers' prices and productions. The basic data is filed in Appendix.

(3) In the conversion of Pesos into US Dollars, US$1 was calculated in terms of ₱7.39.

Fig. 4-3 TARGET AREA
—CAGAYAN RIVER BASIN—



V. Flood Forecasting Procedures

It is essential to determine the location of the hydrological stations and the Forecasting and Warning stations necessary during times of floods in the regions in question. Methods of Flood Forecast can be examined from the released hydrological data and further, with reference to present flood records, the accuracy and reliability of Flood Forecasting Methods can be checked.

Since the existing flood records are in a daily basis, flood forecasting and its accuracy should be judged on daily basis. However, with the establishment of Flood Forecasting and Warning System, flood information can be obtained on hourly basis. It would then be necessary to check Flood Forecasting Methods through hourly flood information of the rivers.

§-1. The Agno River

1. Hydrograph and Hyetograph

1-1 Existing hydrological stations.

Water stage and rainfall gaging stations of the Agno River basin are located throughout the entire basin as shown in Fig 5-1. Most of the rainfall gaging station began operation in the period from 1974 to 1975. Tibac station, one of the hydrological stations was washed away by the floods in 1969 and since then observations was discontinued.

1-2 Rainfall Data

Data concerning rainfall which seems to have caused floods in the past 10 years (1967-1976) in the Agno River basin are recorded. These Hyetograph are included in Appendix.

1-3 Water Stage Data

From the rainfall data, major floods in the Agno river were selected. The following points were selected for water stage telemetering stations in the Agno River system.

Binga Dam

San Roque

Carmen Rosales

Tibag

Wawa

Bañaga (Because of lack of observation data for Bañaga. data for Baay-West were substituted for them.)

Due to river improvement of the Agno River, the right bank area is separated from the floods, and in order to prevent the major cities from inundation, Sta Barbara was also selected.

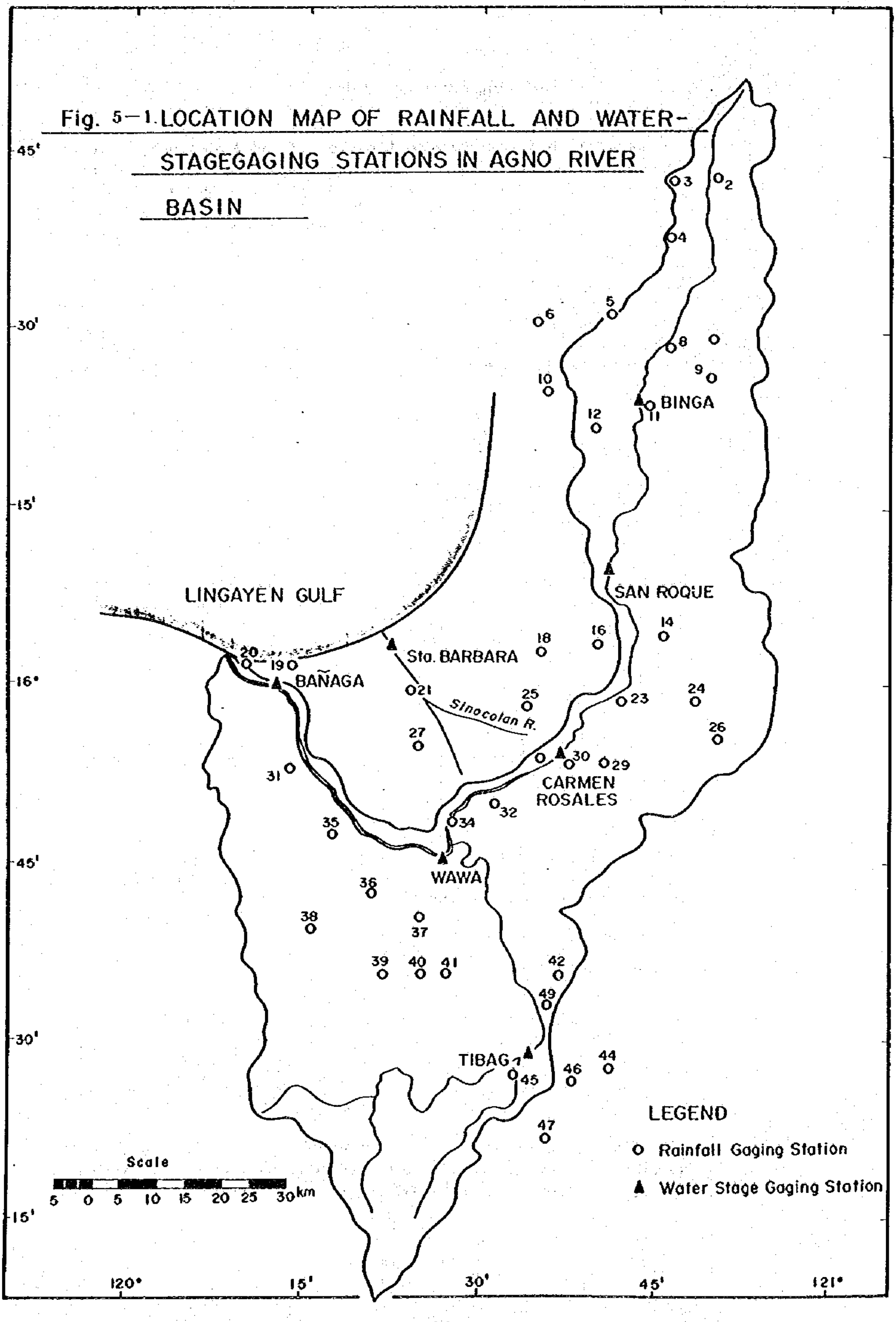


Fig. 5-1 LOCATION MAP OF RAINFALL AND WATER-STAGEGAGING STATIONS IN AGNO RIVER BASIN
LINGAYEN GULF
BINGA
SAN ROQUE
Sta. BARBARA
BAÑAGA
Sinocolan R.
CARMEN
ROSALES
WAWA
TIBAG
LEGEND
Rainfall Gaging Station
Water Stage Gaging Station
Scale
5 0 5 10 15 20 25 30km
45'
30'
15'
16°
45'
30'
15'
120°
15'
30'
45'
121°
2
3
4
5
6
8
9
10
11
12
14
16
18
19
20
21
23
24
25
26
27
29
30
31
32
34
35
36
37
38
39
40
41
42
44
45
46
47
49

Table Locasion of Rainfall Gaging Station

Agno River Basin

No	Name of Stations	Location: Latitude	Location: Longitude	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	16°52'00"	120°47'00"	2134	OG	Jan. 1966	CM								Δ	○			
2	Buguias,Agno river,Benguet	16°43'20"	120°49'40"	1400	OG	1950	CM	○		○	○		○	○					
3	Km.50, Benguet	16°43'00"	120°46'00"	2287	OG	Jan. 1968	CM			X	○	○							
4	Adaoay, Kabayan, Benguet	16°38'10"	120°45'40"	860	OG	1950	CM		X	○	○	○	○	Δ	○	○	○	Δ	
5	Tubeyo, Atok, Benguet	16°31'30"	120°41'00"	1540	OG	1950	CM	○	X	○	○	○	○	○	○	○	X	○	
6	Sayangan,Atok,Benguet	16°31'20"	120°34'20"	580	OG	1971	CM												
7	Karao, Bokod, Benguet	16°29'40"	120°49'40"	900	OG	1971	CM			○	○	○	○	○	○	○	X	X	
8	Ambuklao,Bukud,Benguet	16°28'50"	120°45'40"	740	OG	1949	CM												
9	Bobok gauge #5, Benguet	16°26'30"	120°49'30"	360	OG	1950	CM										○		
10	Baguio City, Benguet	16°26'30"	120°49'30"	1501	RG/OG	1902-39;1947	MGSD												
11	Binga HE.plant,Itogan,Benguet	16°24'00"	120°44'00"	583	OG	1957	CM	○	○	○	○	Δ	Δ	○	Δ	○	Δ	X	
12	Balatoc Mines,Itogan,Benguet	16°22'00"	120°39'00"	720	OG	1947	CM		○	○	○	○	○	○	○	○	○	Δ	
13	Agno, Pangasinan	16°07'00"	119°48'50"	20	OG	1972	CM												
14	San Nicolas, Pangasian	16°04'00"	120°45'45"		RG/OG	Spet.1974	HM									○	○	○	
15	Mabini, Pangasian	16°04'10"	119°56'30"	20	OG	1947	CM												
16	San Manuel,Pangasian	16°04'00"	120°40'00"		RG/OG	July, 1974	CM												
17	Dagupan City, Pangasian	16°03'00"	120°20'00"	2	RG/OG	1902-39;1947	MGSD												
18	Binalonan, Pangasian	16°03'00"	120°35'20"	37	OG	1972	CM												
19	Matalava, Pangasian	16°02'00"	120°14'00"	2	RG/OG	Feb. 1971	HM												
20	Labrador,Pangasian	16°01'42"	120°08'30"		RG/OG	July, 1974	HM									○	○	○	
21	Sta.Barbara, Pangasian	15°59'47"	120°24'14"	17	RG/OG	July, 1974	HM												
22	Dasol, Pangasian	15°59'30"	119°52'48"		RG/OG	Dec. 1974	HM												
23	Sta. Maria, Pangasian	15°59'11"	120°42'13"		RG/OG	July, 1974	HM									○	Δ	○	
24	San Quintin, Pangasian	15°59'00"	120°48'38"	95	RG/OG	July, 1974	HM									○	X	X	
25	Urdaneta, Pangasian	15°58'30"	120°34'10"	24	RG/OG	July, 1974	HM												
26	Umingan, Pangasian	15°55'37"	120°50'13"	128	RG/OG	July, 1974	HM									Δ	○	○	
27	Malasigue, Pangasian	15°55'17"	120°24'43"	45	RG/OG	July, 1974	HM												
28	Villasis, Pangasian	15°54'15"	120°35'05"	21	RG/OG	July, 1974	HM									○	○	○	
29	Balungao, Pangasian	15°54'00"	120°40'20"	50	OG	1971	CM						○	○	○	○	○	○	
30	Rosales, Pangasian	15°53'36"	120°37'42"	27	RG/OG	Apr. 1969	HM				Δ	○	○	Δ	○	○	○	○	
31	Aguilar, Pangasian	15°53'22"	120°14'15"		RG/OG	July, 1974	HM									○	○	○	
32	Alcala, Pangasian	15°50'40"	120°31'22"	19	RG/OG	July, 1974	HM									○	○	○	
33	Intanta, Pangasian	15°49'36"	119°54'18"		RG/OG	Dec. 1974	HM									Δ	Δ	X	
34	Bayambang, Pangasian	15°48'42"	120°27'08"	13	RG/OG	July, 1974	HM									○	○	○	
35	Magatarem, Pangasian	15°47'30"	120°17'30"		RG/OG	July, 1974	HM										○	Δ	
36	Catagudingan,San Clemente Tarlac	15°43'00"	120°21'00"		RG/OG	Jan. 1975	HM-NIA										○	○	
37	Surgui 1st Camiling, Tarlae	15°41'00"	120°25'00"		RG/OG	May, 1970	HM					○	○	○	○	○	○	○	
38	Anoling,Camiling, Tarlae	15°40'00"	120°15'30"		RG/OG	Jan. 1975	HM-NIA										○	○	
39	Mayantoc, Tarlae	15°36'20"	120°21'50"	50	OG	1974	CM									○	○	○	
40	Canamongan,Sta.Ignasia,Tarlae	15°36'00"	120°25'00"		RG/OG	Jan. 1975	HM-NIA										○	○	
41	Nambalan,Mayantoc,Tarlae	15°36'00"	120°27'00"		RG/OG	Jan. 1975	HM-NIA										○	○	
42	Matapitap,Gerona,Tarlae	15°36'00"	120°37'00"		RG/OG	Jan. 1975	HM-NIA										○	○	
43	San Jaunto,Victoria,Tarlae	15°33'00"	120°36'00"		RG/OG	Jan. 1975	HM-NIA										○	○	
44	Amucao, Tarlae	15°28'00"	120°41'00"		RG/OG	Jan. 1975	HM-NIA										○	○	
45	Carangian Damsite, Tarlae	15°27'30"	120°33'00"		RG/OG	Jan. 1975	HM-NIA										○	○	

Legend

○ : Collected data

X : No data

Table 5-2 Maximum Water Gage Height

The Agno River Basin

Unit: (m)
( ) Discharge(m^3/s)

Station / Year	BINGA DAM		SAN ROQUE		CARMEN ROSALES		WAWA		BAÑAGA (BAAY-WEST)		TIBAG		STA.BARBARA		BAYAMBANG	
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	)

Hydrographs from each hydrological station are included in Appendix.

Table 5-2 shows the annual highest water stage at hydrological stations.

2. Travelling Time

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

Flood Water Travelling Time

Section of River	Distance	Slope	Rate of Flood Water Movement	Flood Water Travelling 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~Bañaga	70	1/20,000	1.0	19

3. Tributaries on which the Forecast is to apply

3-1 Division of Drainage

Delineation of sub-basins must be worked out with regards to distribution of population and houses, land use and productivity. The sub-basins were selected with regards to the topographical, meteorological and hydrological features of the area, frequency of floods, and the accuracy of flood forecast in the future depends on results of hydrological observations to date. As a result, 4 areas were selected as follows:

(1) Left bank of the Agno River, downstream of San Roque.

(2) Area along the Tarlac River, downstream of Tibag.

(3) Lingayen Area, downstream of Wawa.

(4) Dagupan Area.

3-2 Flood Forecasting Points

The forecasting points for the above areas are as follows:

San Roque

Carmen Rosales

Tibag

Wawa

Sta. Barbara

4. Telemetering Stations

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

Discharging telemetering means the observation of discharge in ordinary times and in times of floods, drawing out stage-discharge rating curves, and converting the observed water stage into discharge.

Agno River Basin: List of Gaging Station

No.	Station	Location of Station	River Basin	Remarks
1.	Binga Dam	Downstream of Binga Dam: around the office	Agno R.	Newly constructed Rainfall, water level
2.	San Roque	Right Abutment of Agno Irrigation System Intake	Agno R.	Newly constructed Rainfall, water level, discharge
3.	Carmen	On the right bank of the Plaridal Bridge	Agno R.	Newly constructed Rainfall, water level, discharge
4.	Wawa	On the right bank of the Bridge under construction	Agno R.	Newly constructed Rainfall, water level, discharge
5.	Tibag	On the left bank of Bridge	Tarlac R.	Newly constructed Rainfall, water level, discharge
6.	Sta. Barbara	On the left bank of Maramba Bridge	Sinocolan R.	Newly constructed Rainfall, water level, discharge
7.	Bañaga	On the left bank of Padilla Bridge	Agno R.	Newly constructed Rainfall, water level,
8.	Bamban	On the hill near Bamban overhead Bridge	Tarlac R.	in future Rainfall

5. Flood Forecasting Model

The following figure shows the Flood Forecasting model of the Agno River, which has been worked out from the results of sub basins and forecasting point.

Fig. 5-2 LOCATION MAP OF TELEMETERING STATION IN AGNO RIVER BASIN

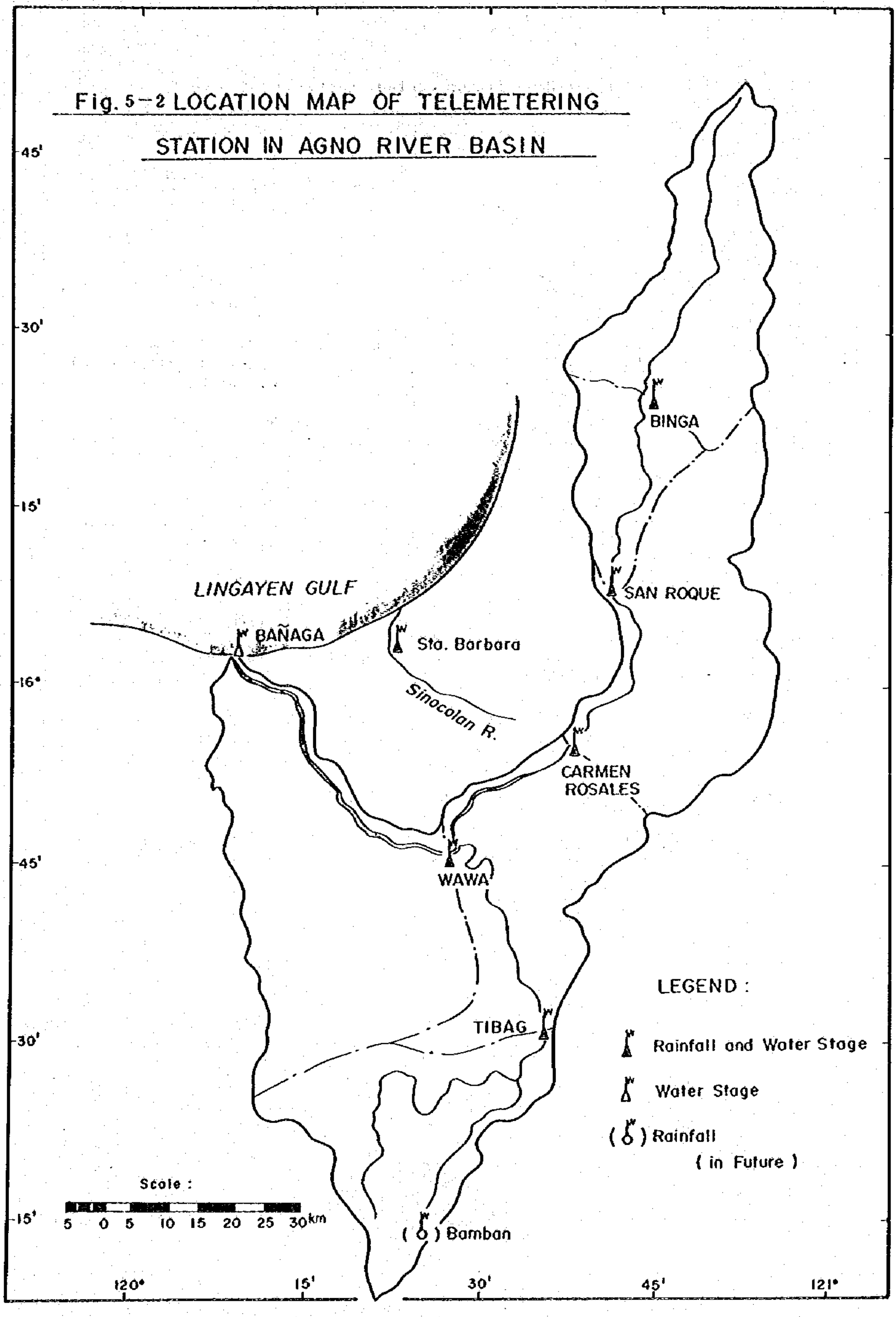
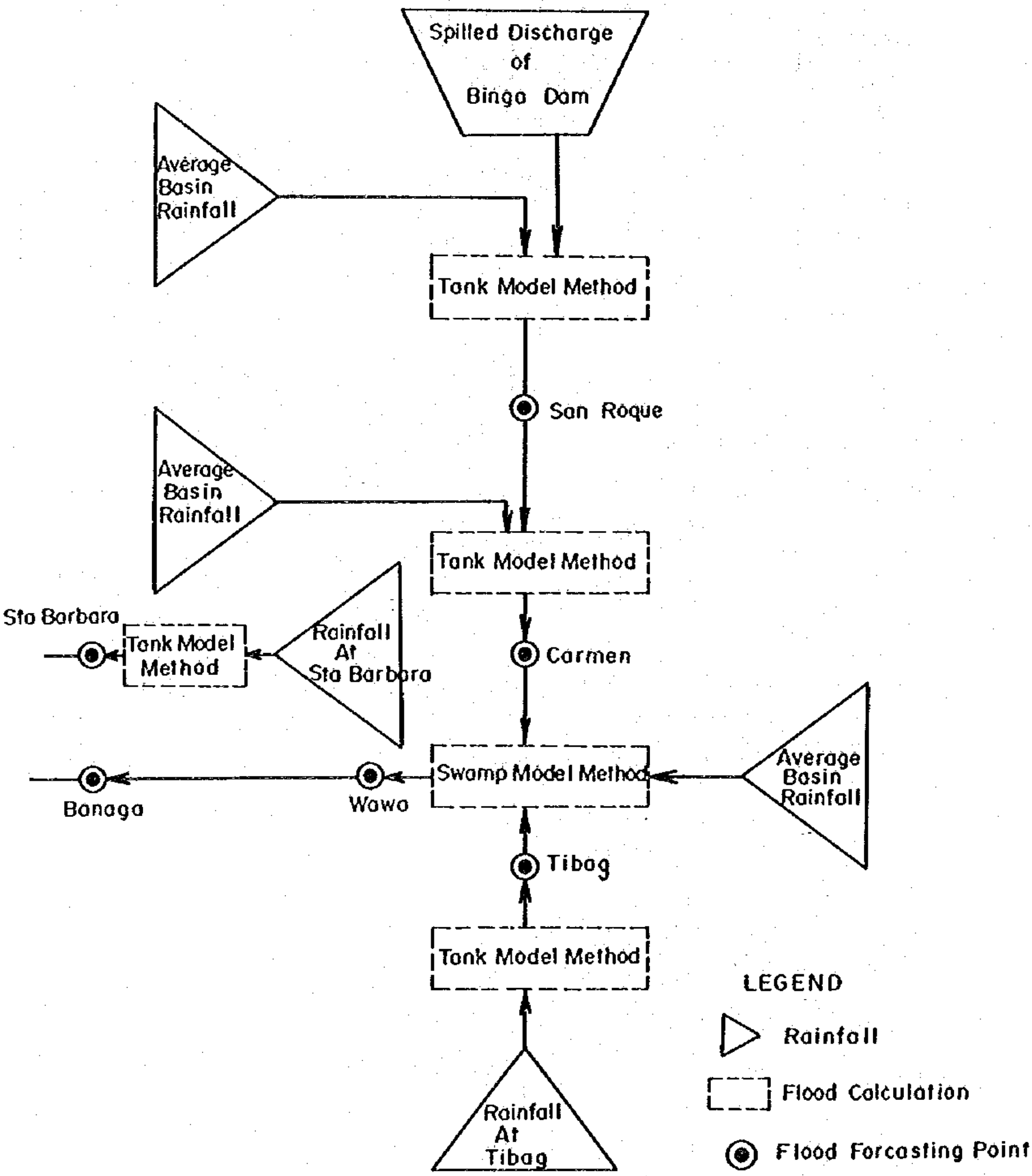


Fig.5—3 FLOOD FORECASTING MODEL

THE AGNO RIVER BASIN

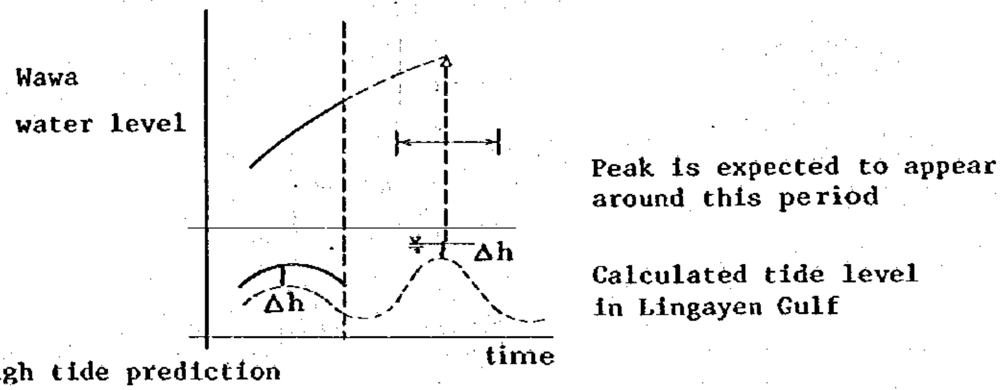


6. Storm Surge Model

Forecasting at Bañaga can be estimated through two methods --- flood time prediction and high tide prediction.

(1) Flood time prediction

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



(2) High tide prediction

Formula for calculations of high tide in Lingayen Gulf:

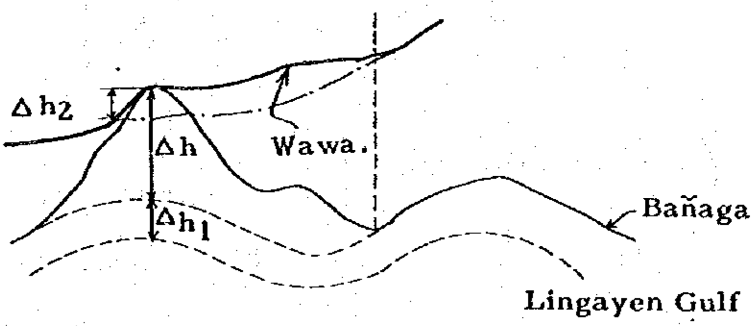
$$h = a\ (1{,}013 - P) + b\ V^2$$

where,

P: atmospheric pressure (mb)
V: wind velocity (m/s)

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

b) Forecasting of the maximum deviation



Where, Δh_1 amount of increased water level during floods

Δh deviation

Δh_2 the difference in water level between Bañaga and Wawa

Δh_2 = (Wawa W.L.) - (Banaga W.L.)

However, when h_2 becomes below zero, reverse current occurs. Therefore, in forecasting the water level of Wawa, a review must be made in connection with h_2.

Data available at Dagupan Synoptic Station or those supplied by FFC through nearby observatory must be made use of in the computation of the maximum wind velocity and the lowest atmospheric pressure.

7. Flood Forecasting Method

7-1 San Roque point

(1) Estimation of basin rainfall (daily rainfall)

The arithmetic mean of Binga Dam rainfall (R_1) and San Roque rainfall (R_2) is taken.

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

(2) Spilled discharge of Binga Dam

The amount of Binga Dam discharge is converted into rainfall depth (R_{Bd}).

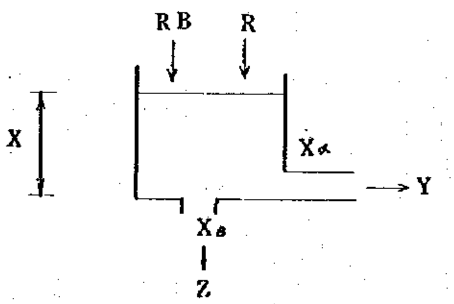
$$R_{Bd} = Q_{Bd} \times 86.4 \times / As \quad (mm)$$

Where, Q_{Bd}: spilled discharge of Binga Dam (m^3/s)

As : the drainage area between Binga Dam and San Roque

1225 - 936 = 289 km^2

(3) Tank model method



The model as shown in the sketch is an explanation of the tank model method. If, rainfall: $(R+R_{Bd})n$,

storage: X_n, outflow: Y_n, infiltration: Z_n.

Outflow rate $Y_n = \alpha.Xn$

Infiltration $Z_n = \beta.X_n$

Discharge rate $Q_n = Y_n \times As/86.4$

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

$X'_n = X_n - Y_n - Z_n$

Adding the rainfall $(R+R_{Bd})_{n+1}$ at the time point (n+1) to this residual X'_n, storage X_{n+1} is obtained at the time point (n+1).

$X_{n+1} = X'_n + (R+R_{Bd})_{n+1}$

In the tank model method, the travelling time of the flow in the river channel is not considered. So the calculated outflow must be shifted forward from the culculated time. Travelling time is inferred from actual measured results.

(4) Determination of model parameter and adjustment of actual measured values:
Model parameter α and β are determined from observed data. The ratio of the calculated discharge and observed discharge is the correction coefficient F. The adjustment of the predicted values is the product of F and the average rainfall in the region.

7-2 Carmen point

(1) Average basin rainfall (daily rainfall)

The average basin rainfall (R) is calculated by taking the arithmetic mean of the San Roque, (R_1) and Carmen, (R_2) rainfalls.

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

(2) Discharge at San Roque

The discharge at San Roque (Qsd) is converted into rianfall depth (R_{sd}).

$$R_{sd} = \frac{Qsd \times 86.4}{Ac}$$

Where Ac is drainage area between San Roque and Carmen, 2209 km^2.

(3) Tank model method

The calculation method is the same as for San Roque.

$Qn = Y_n \times Ac/86.4$

Where Y_n: Out flow rate at San Roque point.

(4) Determination of model parameter and adjustment of the actual observed values

This is also the same as in the case of San Roque.

7-3 Tibag Point

(1) Average basin rainfall (daily rainfall)

Rainfall at Tibag (R_1), 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 in the case of San Roque.

$Q_n = Y_n \times A_4/86.4$

A_4: Drainage area at Tibag, 872 km^2

(3) Determination of model parameter and adjustment of the actual observed values

This is also the same as in the case of San Roque.

7-4 Wawa Point

(1) Average basin rainfall (daily rainfall)

The arithmetic mean values of Tibag rainfall (R_1), Carmen rainfall, (R_2) and Wawa rainfall (R_3).

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

(2) Residual downstream outflow amount (Q_z)

$Q_z = R \times A_4/86.4$ (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 outflow (m^3/s)

Q_C: Carmen outflow (m^3/s)

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

(4) Flood adjustment calculation (flood retarding)

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)×Δt = (average outflow)× Δt + (storage difference before and after Δt), if Δt is shortened enough so that there is no large error in assuming that the variations I and O is in a linear state, during Δt,

$$\left(\frac{I_n + I_{n+1}}{2}\right) \times \Delta t = \left(\frac{O_n + O_{n+1}}{2}\right) \times \Delta t + (V_{n+1} - V_n)$$

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

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

$$I_{(n,\ n+1)}\Delta t - O_n \cdot \Delta t + V_n + \frac{O_n}{2} \cdot \Delta t) = (V_{n+1} + \frac{O_{n+1}}{2} \cdot \Delta t)$$

and,

$\phi = V + \frac{O}{2} \cdot \Delta t, \varphi = O \times \Delta t$, is calculated.

Where, the value of O_n is calculated from $O = C \times \sqrt{2g. \Delta h} \times B$

Δh: water level difference (m)

B: river width (m)

C: discharge coefficient

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 observed water level.

7-5 Sta. Barbara point

(1) Average basin rainfall

Sta. Barbara rainfall (R) represents the basin rainfall.

(2) Inflow amount

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

A_5: Sinoçolan river drainage area, 180 km^2

(3) Flood retarding

The method is the same as in the case of Wawa. However, the discharge (O) is determined from the following formula.

$$0 = C \cdot \sqrt{2g\,(H_1 - H_2)}$$

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

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

Where, H_1: Inundated area W.L.

A: Sinocolan River inundated area (km^2)

H_2: Calculated tide level in Bañaga

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

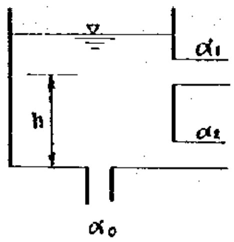
8. Verification of the Flood Forecasting Model

8-1 Verification of the Storm Surge Model at Bañaga Point

Comparison of the maximum wind velocity and lowest atmospheric pressure of Dagupan during recent big typhoons and the daily average water stage at the Bañaga point show no occurence of high tides. Analysis of high accuracy rate due to hourly report of hydrological information will become necessary after the establishment of Bañaga Telemetering Station.

8-2 Tank Model Analysis

The constants for the tank model obtained from existing flood data are as follows. The results of calculation for verification using these constants are shown in the following diagram.



Forecasting Point	αo	$\alpha 1$	$\alpha 2$	h	Notes
San Roque	0.0	0.5	0.1	50	
Carmen	0.05	0.30	0.10	70	
Tibag	-	-	-	-	No analysis, lack of discharge data
Sta. Barbara	-	-	-	-	Ditto

8-3 Analysis of water level correlation

Since no sufficient rainfall and sischarge data were available to verify the tank model, flood forecast calculations were made by the water level correlation formula.
Fig. 5-6-8 show a graphic representation of the water level correlation among the water level telemetering stations.
Fig.5-9-10 illustrates water level profiles estimated from the diagrams.

Fig5-4-1 WIND VELOCITY, ATMOSPHERIC PRESSURE AND WATER STAGE

Bañaga (1)

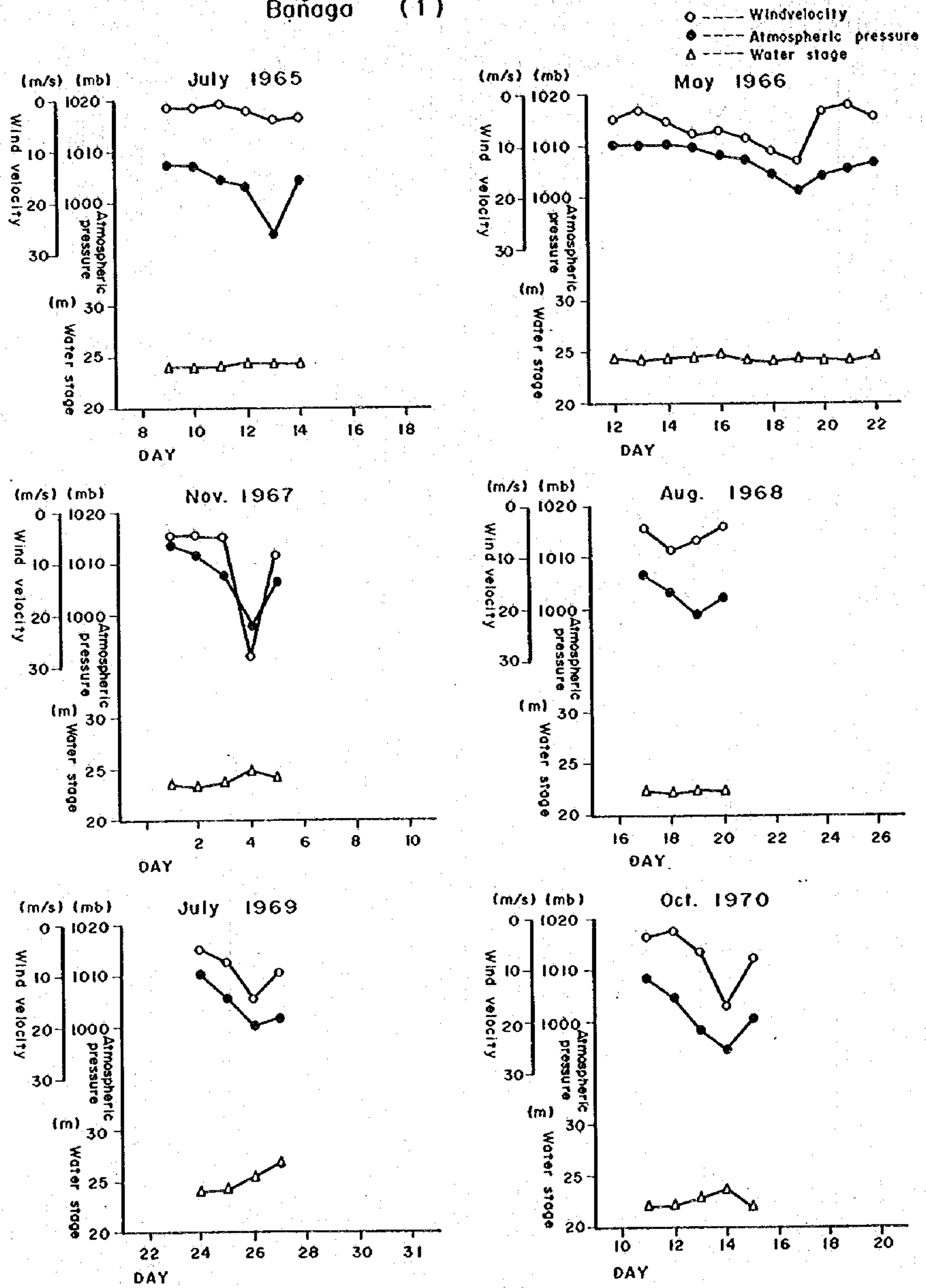


Fig.5-4-2 WIND VELOCITY, ATMOSPHERIC PRESSURE AND WATER STAGE

Bañaga (2)

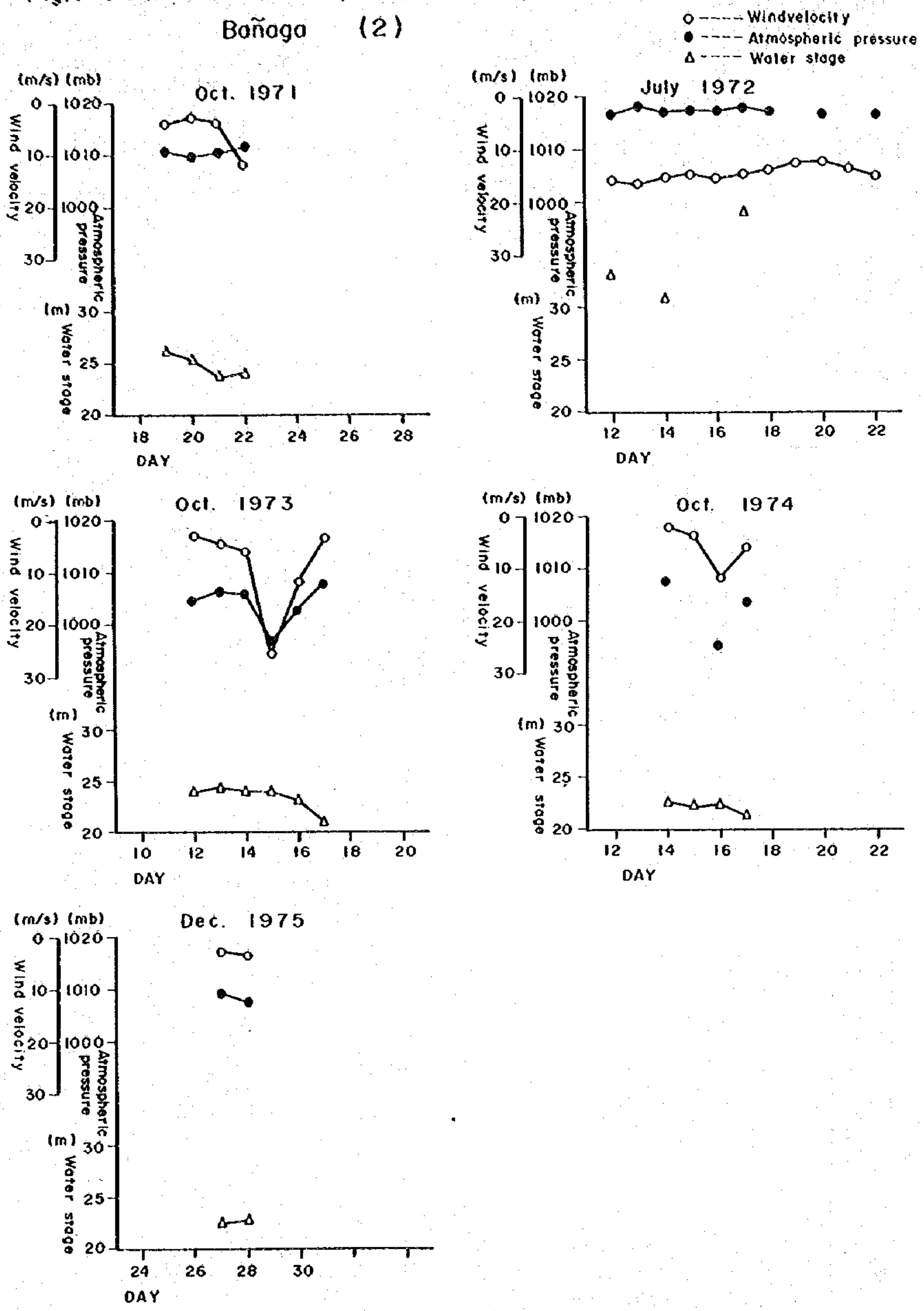
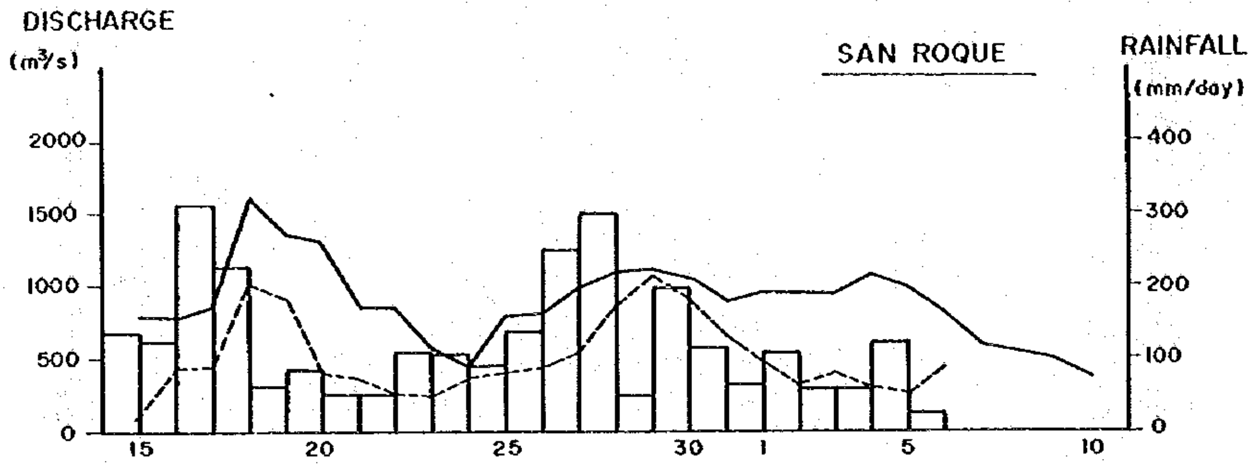


Fig. 5−5 OBSERVED AND CALCULATED RUNOFF AT AGNORIVER (TANK MODEL METHOD)

July Aug 1972



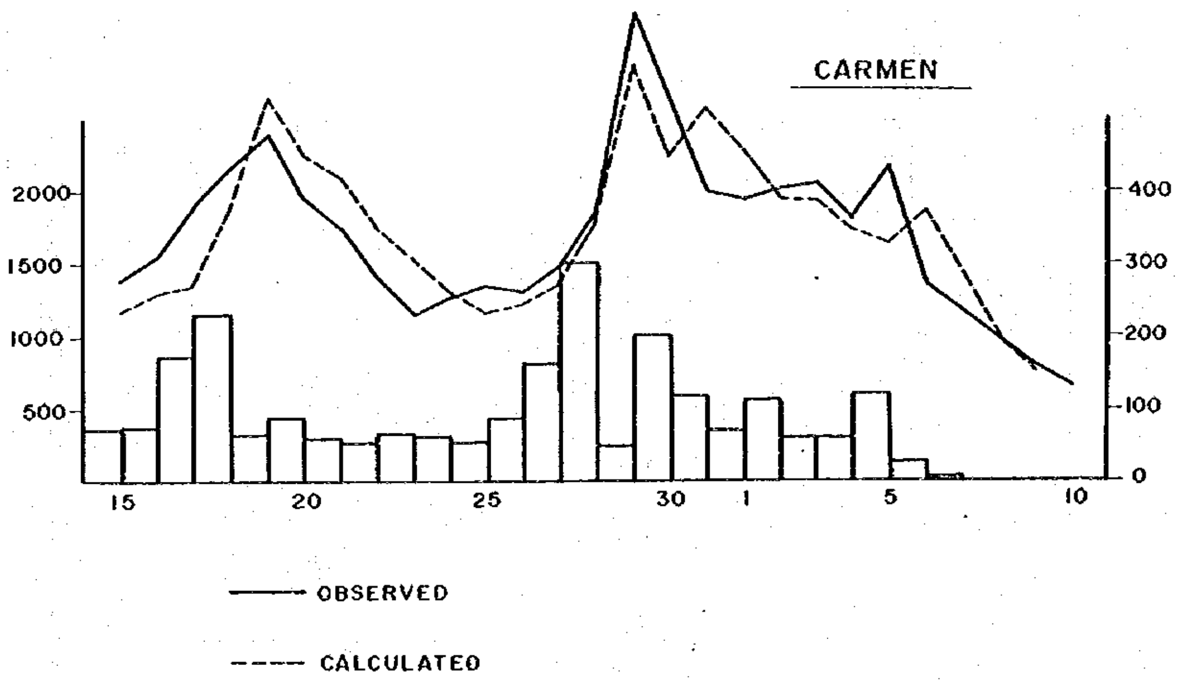


Fig. 5—6 CORRELATION BETWEEN SPILLED DISCHARGE OF BINGA DAM AND SAN ROQUE GAGE HEIGHTS

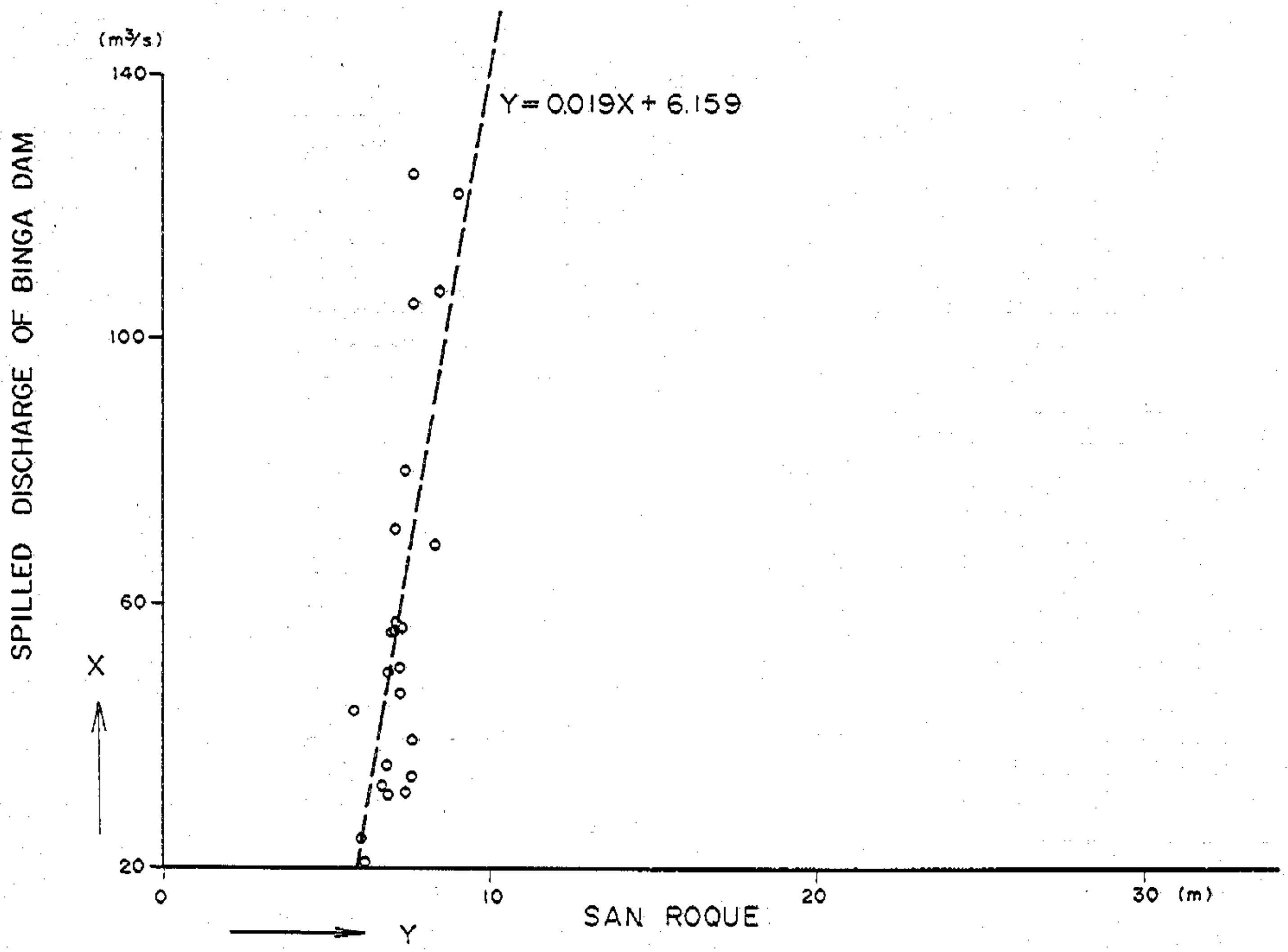


Fig. 5—7 CORRELATION BETWEEN GAGE HEIGHTS AT SAN ROQUE AND CARMEN

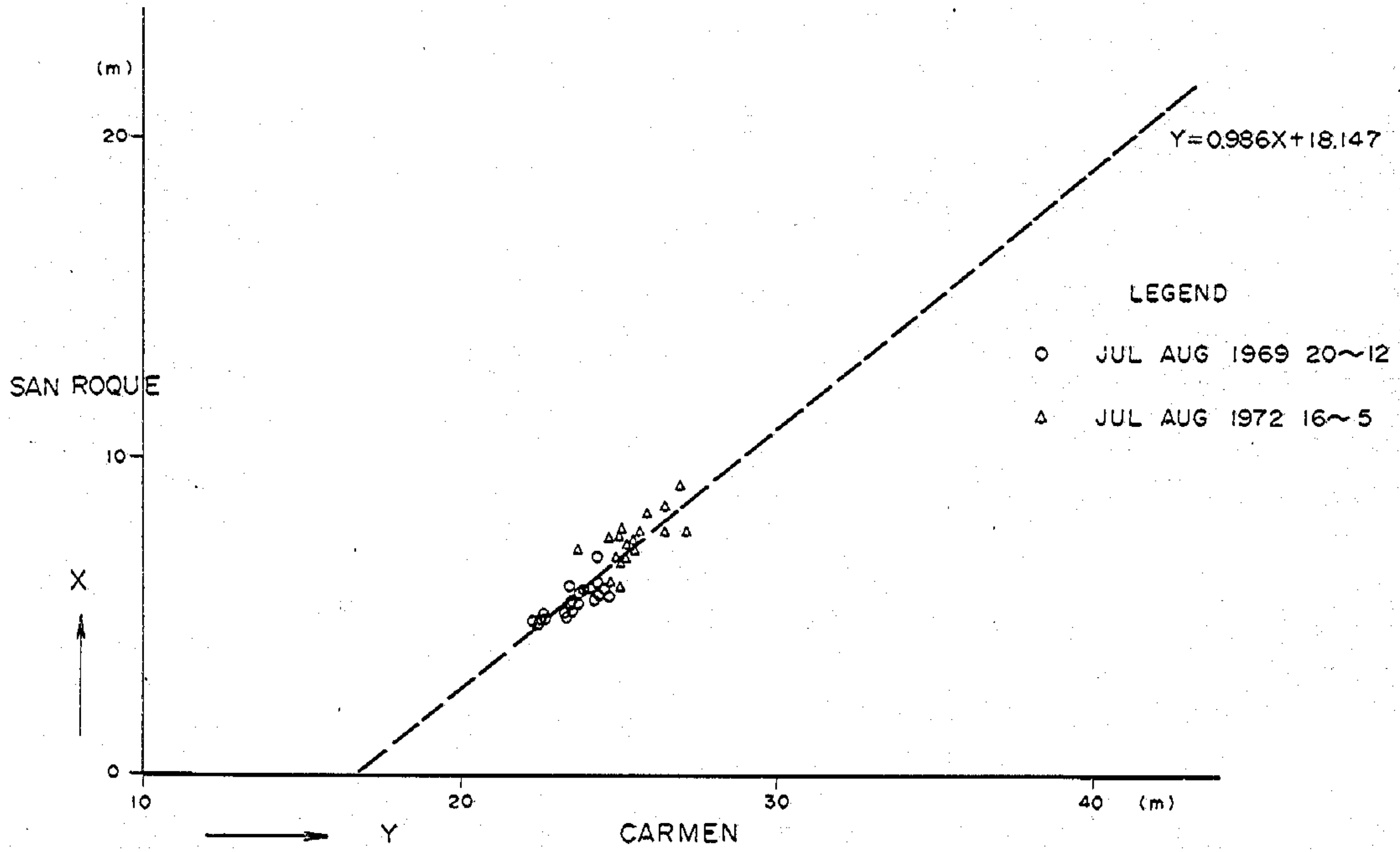


Fig. 5-8 CORRELATION BETWEEN GAGE HEIGHTS AT CARMEN AND WAWA

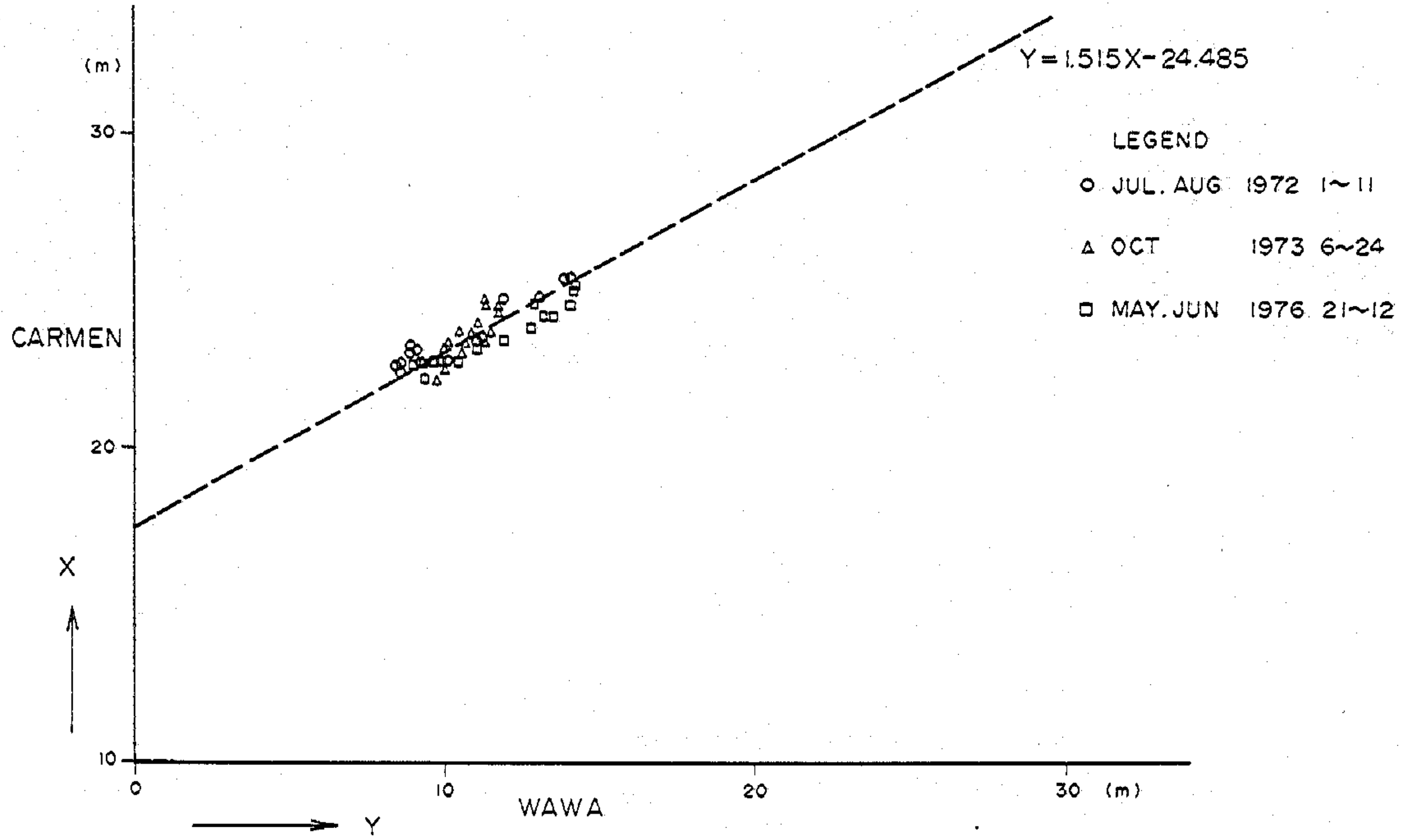


Fig 5-9 OBSERVED AND CALCULATED WATER GAGE HEIGHT
(CORRELATION METHOD)

Oct. 1974

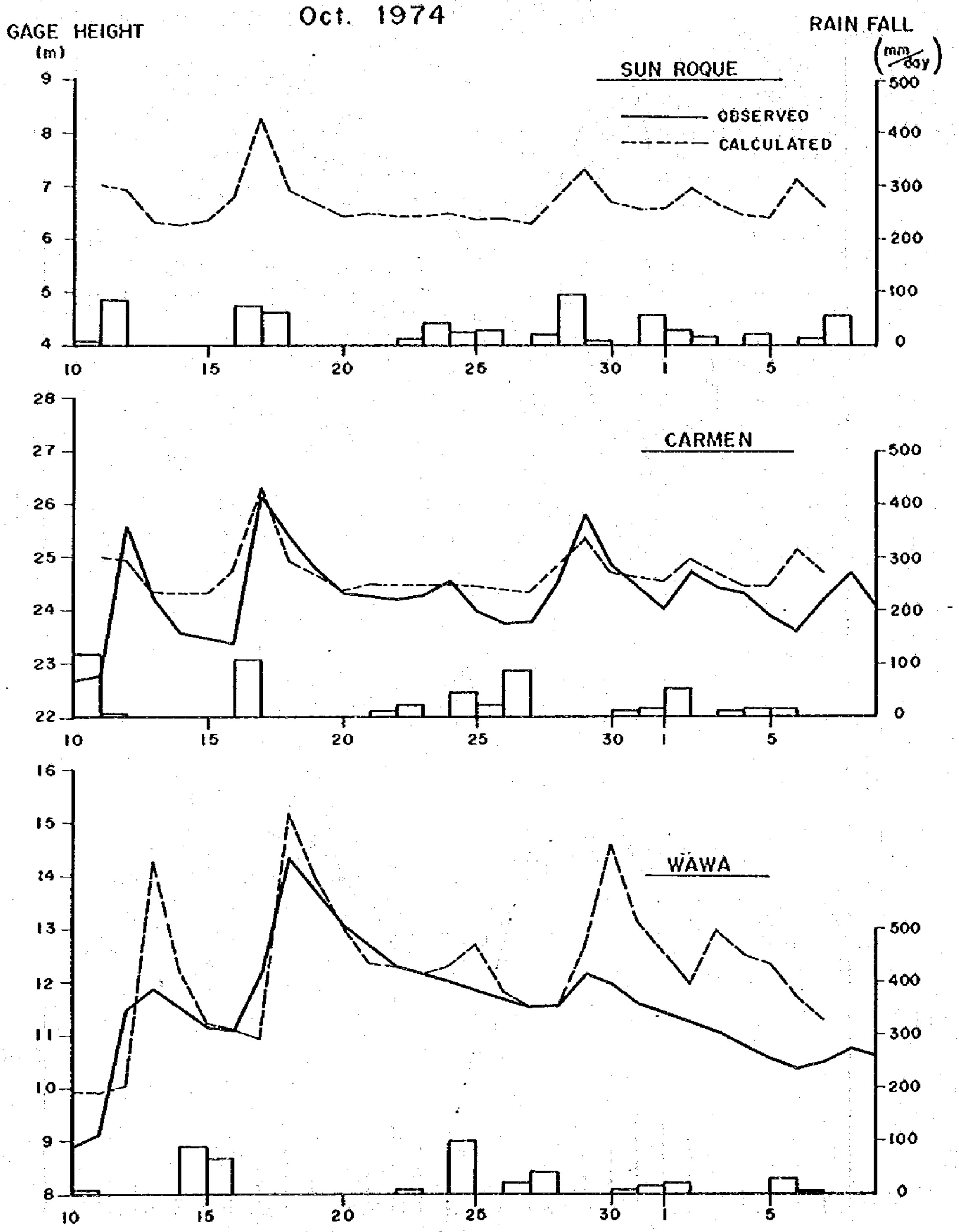
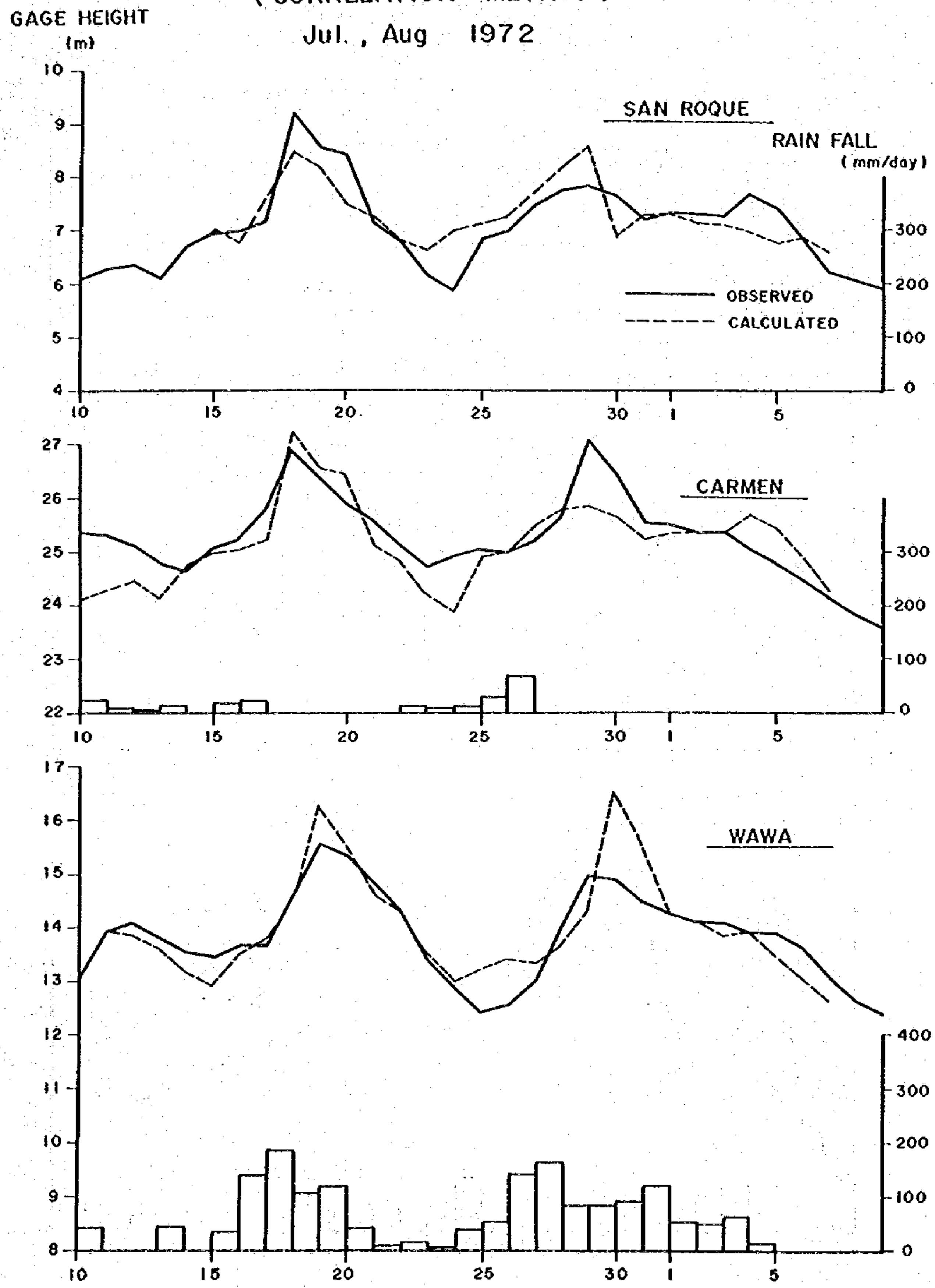


Fig. 5-10 OBSERVED AND CALCULATED WATER GAGE HEIGHT (CORRELATION METHOD)



§-2. The Bicol River

1. Hydrograph and Hyetograph

1-1 Existing hydrological stations

The major water stage and rainfall telemetering stations in the Bicol River basin as shown in Fig.5-11 are distributed in the entire region and most of the rainfall gaging stations began operation after 1975.

1-2 Data of rainfall

Data of rainfall considered to have caused floods in the Bicol Region in the ten-year period from 1967 to 1976 are recorded. The hydrographs are shown in Appendix.

1-3 Data of water stage

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

Bato

Ombao

Camaligan

Sipocot

Barongay

Hydrolographs of the various hydrological station are shown in Appendix.

Table 5-4 shows the highest water stage of the various hydrological station every year.

2. Travelling Time

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

Fig. 5-11 LOCATION MAP OF RAINFALL AND WATERSTAGE GAGING STATION IN BICOL RIVER BASIN

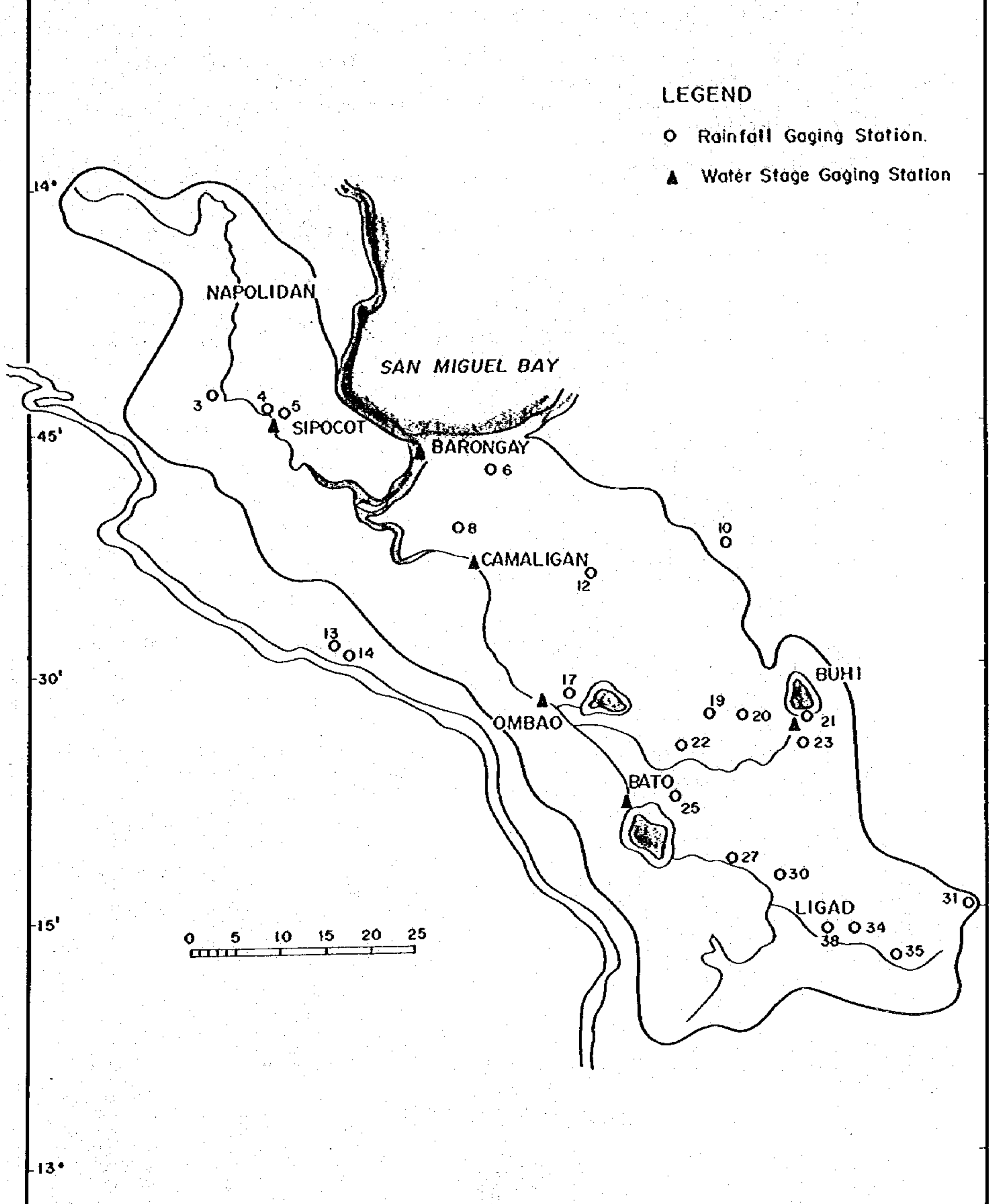


Table 5-3 Location of Rainfall Gaging Station

Bicol River Basin

No.	Name of Stations	Location: Latitude	Location: Longitude	Location: Elevation	Type of Ins	Date Established	Managed by	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	
1	Daet, Camarines, Norte	14°08'00"	122°59'00"	4	RG/OG	1948	MGSD												
2	Caramoan, Camarines, Sur	13°47'20"	123°52'00"	10	OG	1972	CM												
3	Napolidan, Lupi, Cam. Sur	13°47'12"	122°55'00"		RG/OG	May, 1976	HM-NIA											○	
4	Sipocot, Cam. Sur	13°46'10"	122°58'30"	18	OG	1969	CM				○	○	○	○	○	○	○		
5	Impig, Sipocot, Cam. Sur	13°46'00"	122°59'00"		RG/OG	May, 1976	HM-NIA												
6	Inarihan, Calabanga, Cam. Sur	13°42'30"	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											○	
8	Baras, Canaman, Cam. Sur	13°38'48"	123°10'00"		RG/OG	May, 1976	HM-NIA												
9	Tigaon, Camarines, Sur	13°38'00"	123°30'06"		RG/OG	May, 1976	HM-NIA												
10	Consocep. Ocampo. Cam. Sur	13°37'42"	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											○	
12	(CSAC) Pili, Camarineras, Sur	13°36'00"	123°18'00"		RG/OG	Aug. 1976	AM												
13	Pasacao, Camarines, Sur	13°31'30"	123°02'20"	15	OG	1969	CM												
14	Caraman, Pasacao	13°31'00"	123°03'00"		RG/OG	May, 1976	HM-NIA												
15	Joroan, Tiwi, Albay	13°29'30"	123°37'00"	14	OG	1947	CM												
16	Naglabong, Tiwi, Albay	13°28'30"	123°39'20"	52	OG	1971	CM												
17	San Ramon, Bula, Cam. Sur	13°28'12"	123°16'18"		RG/OG	May, 1976	HM-NIA											○	
18	Pob. Tiwi, Albay	13°27'30"	123°40'30"	5	OG	1971	CM												
19	Mt. Iriga, Iriga City	13°27'00"	123°25'00"		RG/OG	Sept. 1976	HM-NIA												
20	Sta. Cruz, Baao, Cam. Sur	13°27'00"	123°27'00"	11	OG	1969	CM												
21	San Francisco, Buhi, Cam. Sur	13°26'42"	123°31'00"		RG/OG	May, 1976	HM-NIA											○	
22	Barit, Iriga City	13°25'00"	123°23'00"	100	RG/OG	May, 1976	HM-NIA												
23	Buhi Camarines Sur	13°25'00"	123°30'50"	10	OG	1950	CM			○	X	X	Δ	○	Δ	X	X		
24	Parapoto, Malinao, Albay	13°24'00"	123°42'00"		RG/OG	Dec. 1971	AM												
25	Bato, Camarines, Sur	13°22'20"	123°22'40"	15	OG	1972	CM												
26	Tabaco, Albay	13°21'30"	123°43'40"	8	OG	1971	CM												
27	Central Libon, Albay	13°18'00"	123°26'20"	13	OG	1972	CM						Δ	○	○	○	○		
28	Pob. Bacacay, Albay	13°17'40"	123°47'20"	4	OG	1971	CM												
29	Cabasan, Bacacay, Albay	13°17'40"	123°47'20"	4	OG	1971	CM												
30	Agus, Polangui, Albay	13°17'24"	123°29'00"		RG/OG	May, 1976	HM-NIA												
31	Mayon Rest House, Albay	13°15'00"	123°41'00"		OG	1971	CM						○	Δ	○	○	X		
32	Sto. Domingo (Libog) Albay	13°14'10"	123°46'30"	15	OG	1947	CM												
33	Pio, Duran, Albay	13°14'00"	123°32'00"		OG	1960	CM			○	X	○	○	○	○				
34	Alliang, Ligao, Albay	13°14'00"	123°33'00"		RG/OG	May, 1976	HM-NIA							○	○	Δ	○		
35	Guinobatan, Albay	13°12'00"	123°36'00"	80	OG	1947	CM			○	○	○	○	○	○	○	○		
36	Pantao, 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	Villa Hermosa, Albay	13°11'10"	124°07'40"	5	OG	1971	CM												
39	Malama, Ligao, Albay	13°09'00"	123°27'40"	90	OG	1971	CM						Δ	○	○	○	Δ	X	
40	Legaspi City, Albay	13°08'00"	123°44'00"	19	RG/OG	1949	MGSD												
41	Gogon Pawa, Marito, Albay	13°07'20"	123°52'00"	60	OG	1947	CM												
42	BLLm, Jovellar, Albay	13°04'20"	123°36'00"	10	OG	1972	CM												

Legend

○ : Collected data

X : No data

Table 5-4 Maximum Water Gage Height
The Bicol River Basin

Unit: (m)
( ) Discharge(m^3/s)

Station / Year	OMBAO		NAGA		SIPOCOT		CUYAPI		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										

Flood Water Travelling Time

Section of River	Distance	Slope	Rate of Flood Water Movement	Flood Water Travelling 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 - Cuyapi	30	$\frac{1}{38,000}$	0.3	28
Sipocot - Cuyapi	28	$\frac{1}{8,000}$	0.6	13

3. Tributaries on which the Forecast is to apply

3-1 Division of sub-basins

Division of sub-basins is worked out as illustrated in Fig. 4-7 with considerations to the target areas of Bicol River.

3-2 Flood Forecasting Points

The forecasting points are as follows:

Bato

Ombao

Camaligan

Sipocot

Also, for forecasting high tides in San Miguel bay, actual tide measurements are carried out at Barongay.

4. Telemetering Stations

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

5. Flood Forecasting Model

The following figure represents the flood forecasting model for the Bicol River with regards to the results of the study of the tributaries to be forecasted.

Bicol River Basin: List of Gaging Station

No.	Station	Location of Station	River Basin	Remarks
1.	Ligao	In the center of Ligao town	Bicol R.	Newly constructed Rainfall
2.	Bato	At the side of Lake Bato Pobulacion Bato	Bicol R.	Newly constructed Rainfall, water level
3.	Buhi	At the side of Lake Buhi Pobulacion Buhi	Bicol R.	Newly constructed Rainfall, water level,
4.	Ombao	On the right of bank of Bicol River	Bicol R.	Newly constructed Rainfall, water level, discharge
5.	Ocampo	In the Town Hall of Ocampo	Bicol R.	Newly constructed Rainfall
6.	Camaligan	In the office of Bicol Flood Control	Bicol R.	Newly constructed Rainfall, water level, discharge
7.	Barongay	On the right bank of Bicol River Barongang Dario	Bicol R.	Newly constructed water level
8.	Sipocot	On the left bank of Sipocot River	Sipocot R.	Newly constructed Rainfall, water level, discharge
9.	Napolidan	Next to highway Napolidan Village	Sipocot R.	Newly constructed Rainfall

Fig. 5-12 LOCATION MAP OF TELEMETERING STATION
BICOL RIVER BASIN

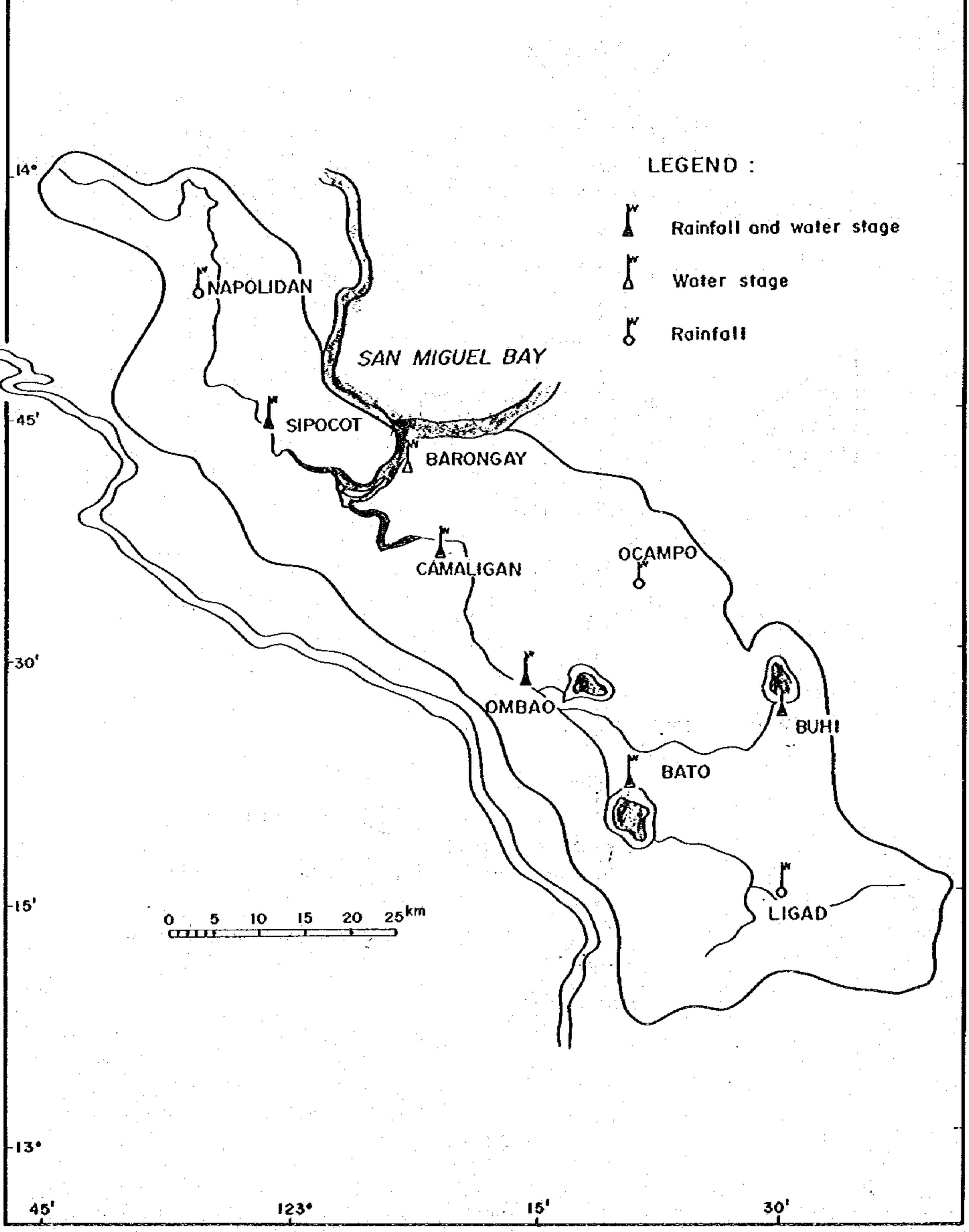
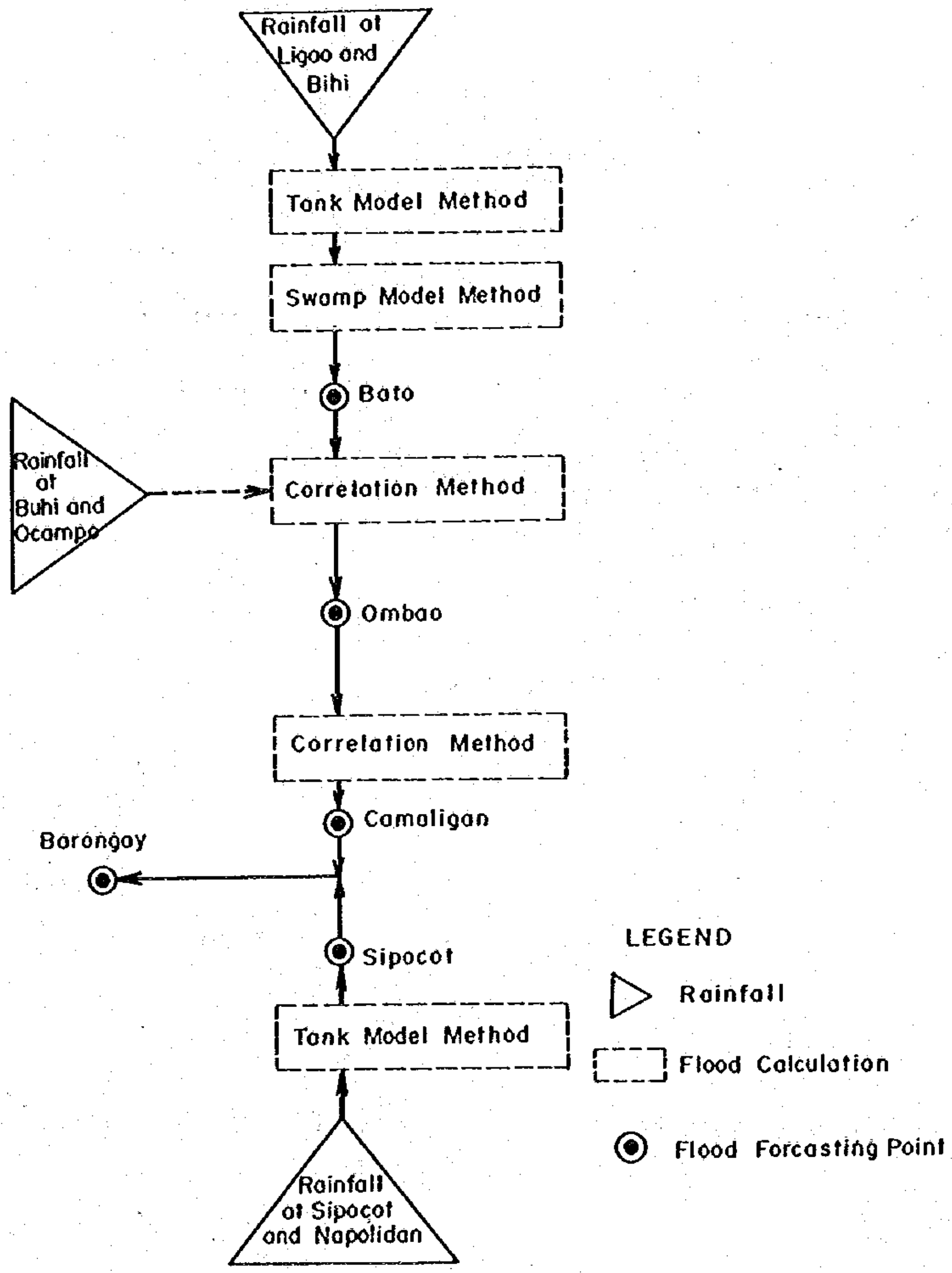


Fig. 5-13 FLOOD FORECASTING MODEL
BICOL RIVER BASIN



6. Storm Surge Model

6-1 Barongay Point

Forecast of high tide at Barongay Point is done in the same way as in the Bañaga.

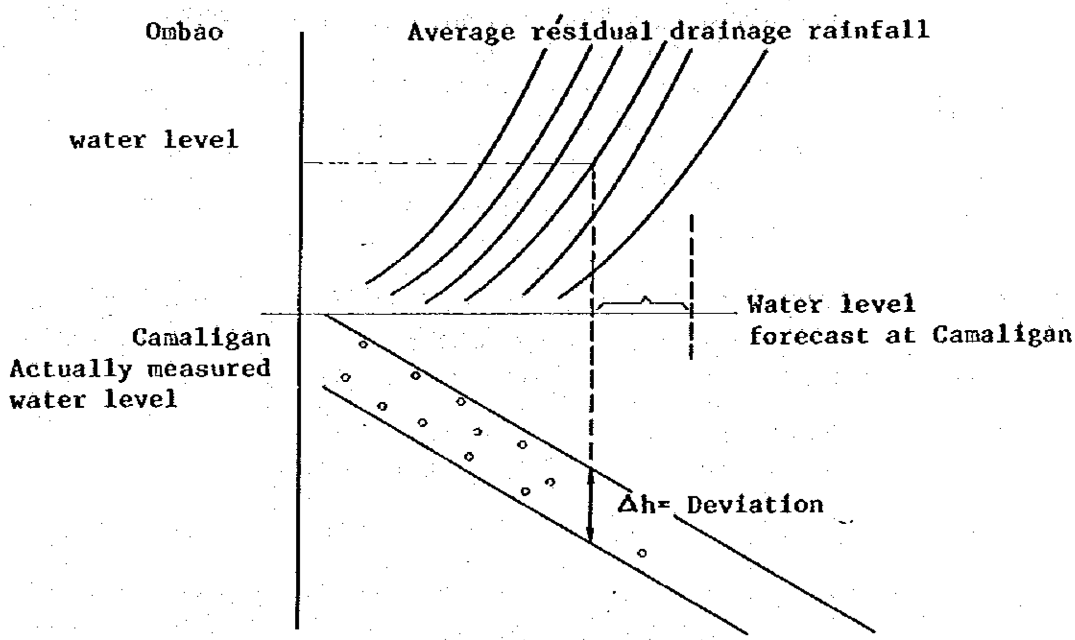
6-2 Camaligan point

(1) Average residual basin rainfall

The arithmetic mean between Ombao rainfall (R_1) and Camaligan rainfall (R_2) is taken.

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

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



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

7. Flood Forecasting Method

7-1 Bato point

(1) Average basin rainfall

The arithmetic mean between Ligao rainfall (R_1) and Bato rainfall (R_2) is taken.

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

(2) Lake Bato Inflow

Inflow at Lake Bato is calculated by the Tank Model Method.

$$QB = \frac{Y \times A_B}{86.4}$$

Where A_B is Drainage Surface of Lake Bato (km^2)

(3) Water Stage at Lake Bato

Using the following formula, the rise in the water stage (H) due to an increased inflow is calculated and added to the previous water stage (H_{n1-}).

$$H = \frac{Q_B \times 86.4}{A_L}$$

$$H_n = H_{n-1} + H$$

where A_L: Area of water surface of Lake Bato (km^2)

H_{n-1}, H_n: Water stage of the lake in the previous day and the observation day. (m)

The water stage of the lake when there is no inflow is calculated by the following formula:

$$MH = 0.035H - 0.151$$

Where MH: Fall in water stage of Lake Bato (m)

H: Water stage of Lake Bato (m)

7-2 Ombao point

Taking into considerations the travelling time from Bato point to Ombao point, the water stage is calculated by the following correlation formula:

$$H_O = H_B + a$$

Where H_O: Ombao Point Water Stage (m)

H_B: Bato Point Water Stage in respect to Tavelling time

a: Constant