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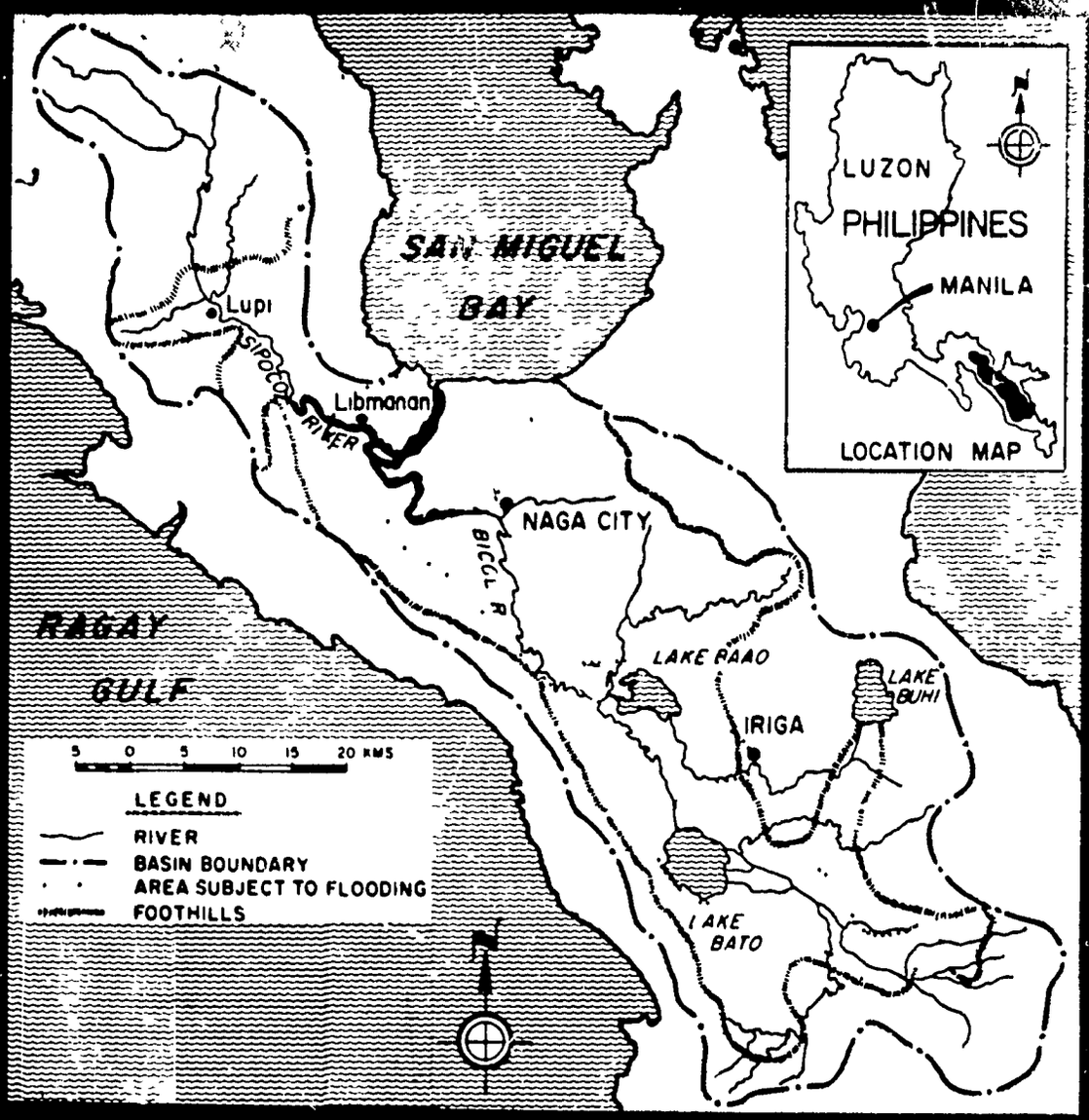
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SIPOCOT RIVER
Libmanan
NAGA CITY
BICOL R
RAGAY GULF
LAKE RAAO
LAKE BUHI
IRIGA
LAKE BATO
LUZON
PHILIPPINES
MANILA
LOCATION MAP
5 0 5 10 15 20 KMS
LEGEND
RIVER
BASIN BOUNDARY
AREA SUBJECT TO FLOODING
FOOTHILLS

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Architects and Engineers
Manila

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8751 Paseo de Roxas
Makati, Rizal, Philippines

1 September 1976

The Honorable Cabinet Coordinator
Bicol River Basin Development Program
NIA Building, Quezon City

Dear Sir·

I have the nonor to transmit the Final Report in five (5) volumes covering the pre-feasibility water resource development study of the Bicol River Basin. It incorporates the suggestions of the CWRS Steering Committee as discussed at their August 26, 1976 meeting.

The study recommends an immediate implementation of the Naga-Calabanga IAD and the Baliwag-San Vicente IAD and a feasibility study for the Rinconada IAD. The latter involves a complex system of regulation for the three natural reservoirs of the Bicol Basin, - Lakes Bato, Buhi, and Baao. The merit of the Lake Bato-Pantao Diversion Channel should also be determined in the feasibility study. The Terms of Reference for all three IAD's are included for use in preparing design memorandum or feasibility studies. In order to insure the effectiveness of the water-oriented construction program, it is essential that efforts should include the following measures:

- Agricultural & fishery practices and infrastructure,
- Flood proofing, flood plain zoning & interior drainage;
- Public water supplies & water pollution control; and
- Financial, educational and health programs, etc.

In addition, the following programs of on-going investigations should be continued· (a) collection of rainfall, river stages and discharge data, (b) groundwater exploration, (c) watershed management, and (d) cloud seeding.

It was a pleasure to cooperate with you and the BRBDP in the conduct of the studies, and I hope that the results lead the way toward improving life in the Bicol Basin and the Philippines.

Very truly yours,

TIPPETTS-ABBETT-McCARTHY-STRATTON
and TRANS-ASIA ENGINEERING ASSOCIATES,INC.-
A JOINT VENTURE

LAWRENCE SHERMAN
Principal

COMPREHENSIVE WATER RESOURCES DEVELOPMENT STUDY

CONTENTS

SUMMARY REPORT

PREFACE

The Final Report of the Comprehensive Water Resources Development Study (CWRS) for the Bicol River Basin in Luzon, Philippines, presents a detailed plan for the development of water resources in the Basin with recommendations for its implementation. This report contains five (5) volumes:

- o Volume One, Summary, briefly outlines the Comprehensive Water Resource Plan for the Basin and summarizes the main recommendations of the Study;
- o Volume Two, Main Report, gives the detailed explanation on the methods used and analyses developed for the Comprehensive Water Resources Plan;
- o Volume Three, Appendices A through E, summarizes the methodologies and results of the hydrological and hydraulic model studies made during the study;
- o Volume Four, Appendices F and G, provides back-up data and analyses for the engineering and economic studies prepared for the Plan; and
- o Volume Five, Appendix R, provides the terms of reference and budgetary cost estimates of the feasibility studies for those projects that have the highest priority.

This study was made pursuant to a contract between the Government of the Republic of the Philippines and the Joint Venture of Tippetts-Abbett-McCarthy-Stratton Engineers and Architects (TAMS) and Trans-Asia Engineering Associates Inc. (TAE). The United States Agency for International Development (USAID)

assisted in the funding of this study. The purpose of this reconnaissance or pre-feasibility study is to identify major water resource projects in the Basin for further study and for immediate implementation.

INTRODUCTION

The Bicol River Basin is located in Southern Luzon, about 400 kilometers southeast of Manila. The basin is about 130 km long, bounded on the northeast by a chain of volcanoes and on the southwest by the Ragay Hills. It has a drainage area of 312,000 hectares. The Bicol River occupies the flat central plain and flows in a generally northwesterly direction from the Lake Bato to the Bicol Estuary which drains into San Miguel Bay. The Sipocot River drains the northwestern portion of the basin, joining the Bicol River at the head of the estuary. The lower portions of the Bicol and Sipocot Rivers and the Bicol Estuary are tidal. The fertile lands of the flood plain are mainly utilized for the cultivation of rice, the most important agricultural crop of the basin. Most of the higher lands are covered by second-growth timber with patches of coconut, banana, and other agricultural crops including some rice cultivated on terraces.

The climate is tropical with average annual rainfalls of 1,100 mm to 3,600 mm, depending on location. The higher rainfalls are due to orographic factors. Precipitation records also indicate a somewhat higher rainfall expectancy over the Sipocot Basin in the northwestern portion of the basin. Excessive rainfalls are almost always associated with the passage of typhoons which affect the basin 3 or 4 times per year.

In 1975, the population of the Bicol Basin was 1,090,124 or about 2.6

percent of the population of the Philippines. The average density of population in the basin is 248.2 persons per square kilometer. Population projections show it increasing at about 1.7 percent or slightly more than the rate of increase during the period 1960-1975 (1.4 percent). This is significantly less than the projected average annual increase in population for the Philippines which is estimated at 2.8 percent. The lower rate of increase in population within the Basin reflects the apparent belief of its residents that the quality of life is better elsewhere.

Information on the labor force and on unemployment rates confirm the belief that living standards in the area lag behind the national average. About 33 out of every 100 people in the Bicol area are working or seeking work compared with a national figure of 40. Regional trends in average family income are below that of the Philippines and the difference shows a tendency to increase. For example, in 1957 the average family income in Bicol was 387 pesos below the national average. By 1971, the difference had increased to 952 pesos.

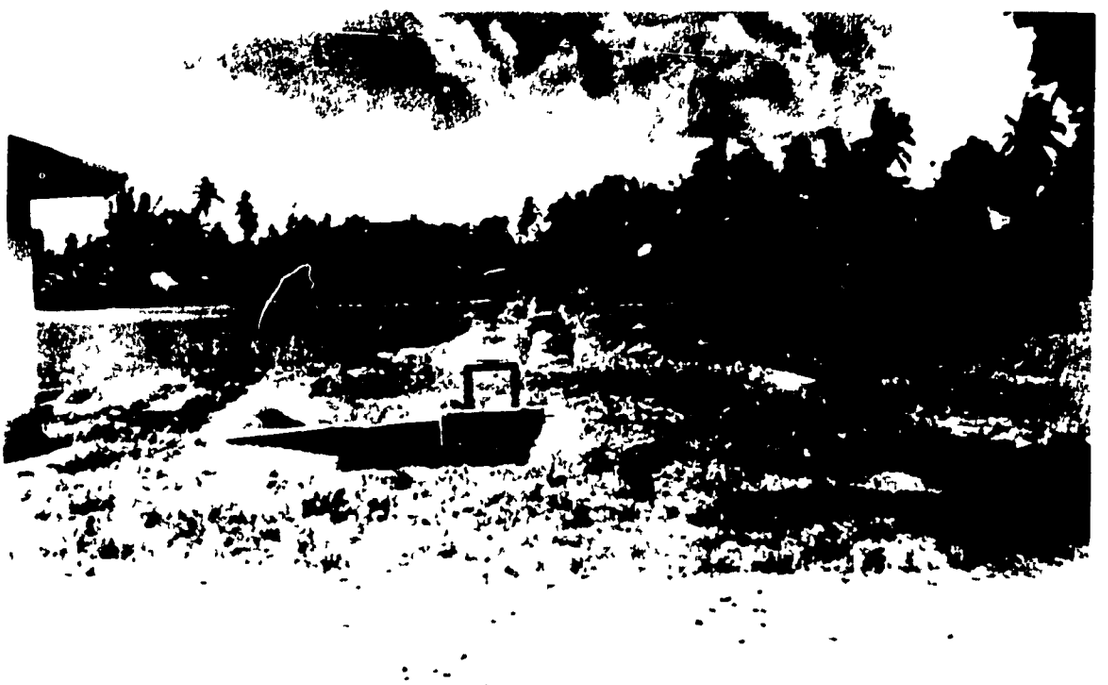
The economy of the Bicol Basin is agricultural with about 80 percent of its population living in rural areas whereas the national average is about 70 percent. Only the urban aspect of the Naga-Calabanga area keeps the percentage of the population living in rural areas from exceeding 90 percent.

Rice is the most important agricultural crop in the Basin with over fifty (50) percent of the agricultural lands devoted to it. Historically, about 60 percent of the value of agricultural production is derived from the cultivation of rice. Coconut is the second most important crop in the Basin. Commercial sugar cane, recently introduced into the Basin, is the only major crop which is likely to change the historical agricultural patterns in the

TYPICAL BARANGAY SCENE

Basin. The importance of the control of water is greatest on rice since it is cultivated in the flood plain - and is therefore subjected to flooding and drainage problems. In the dry season, supplemental water is required. The other crops are generally grown outside the flood plain and require little or no supplemental water during the dry season. Presently, the average rice farmer cultivates a 2-hectare farm. He plants about 1.5 crops of rice a year with an average yield between 1 and 2 tons per hectare. Based on 1970-71 Agricultural Census with adjustments for inflation and increases in productivity, the 1975-1976 annual value of crops produced on the average farm would be approximately ₱3,897 in the Basin, whereas the national average would be ₱4,533.

Economically, the Bicol Basin's greatest potential lies in the continued development of its agriculture. The improved utilization of water resources offers the easiest and most effective way of increasing its agricultural productivity.



IRRIGATION FACILITIES, BARIT IRRIGATION DISTRICT

WATER RESOURCE PROBLEMS

The principal water resource problems in the Bicol River Basin which can be ameliorated by physical works are those related to flood, drainage and salinity control and to the improvement of water supply for irrigation, domestic use and other purposes.

Flood Control

Of the 312,000 hectare basin drainage area, some 40,000 hectares are subject to annual flooding. During the major flood in 1956, an estimated 56,000 hectares were inundated. A flood damage survey undertaken during the pre-feasibility studies found that in excess of 40,000 hectares were flooded in December 1975. Estimates based on the damage survey which followed this flood indicated that it caused between 31 and 45 million pesos damage. The major portion of these damages were to the agricultural sector and, in particular, to the rice crop. These damages were due to the inundation caused by the flood waters and poor interior drainage. Erosion with subsequent deposition of sediment was also a source of damages in some areas. To a major degree, the extent of the damage to agriculture is minimized because the farmers generally wait to the end of the rainy season (November and December) to plant their rice. In the 1975 floods, only a portion of the value of the rice crops was lost. Farmers apparently utilize their experience very effectively to minimize the exposure of their crops to the hazard of flooding. This is a major factor in the prevention of flood losses throughout the basin.

Flooding in the Bicol Basin is the result of frequent typhoons with accompanying high intensity and long duration rainfall and monsoon rainfalls. About 65,000 hectares lie in the flood plain, at elevations ranging from near zero to several meters above sea level. Much of the most productive agricultural land is within this area. Severe floods and poor drainage cause extensive damage to crops. Additional damages are caused to buildings, commercial enterprises, the transportation and communications systems. Flood

impacts on human health and on the basin ecology have not been measured, but they are said to be extensive.

A plan for flood protection and river control was formulated in 1957 consisting of 16 cutoff channels, levees and dredging. Since then, Cutoffs No. 1 and No. 2 and part of No. 3 have been completed and some dredging of the estuary has been carried out. Other proposals in recent years have been made including dikes, reservoir storage, diversion channels, and tidal barriers.

The water-oriented problems of the basin can be summarized as follows:

Drainage

About 16,800 hectares are poorly drained and/or waterlogged due to their location at low elevation, and a significant portion can be considered for potential development.

Salinity

Sea water intrusion has extended no further inland than Naga City during the low flow periods of record. However, the periods of salinity intrusion are short and are eliminated in the next tidal cycle. Under those conditions, the intrusion will not be a serious deterrent to agricultural use of water from the Bicol River except when water is taken from the Bicol Estuary proper.

Water Supply

The major need for water supply is for irrigation. A more certain supply of water to lands currently irrigated and the provision of water for land

without supplemental water would be very effective in increasing crop yields and reducing the risks associated with agriculture. Such improvements would also have impacts on the crop processing and marketing functions and upon many other activities. Of the 312,000 hectares in the basin, arable lands in flood plain and upland areas which could be irrigated have been estimated at 86,000 hectares provided water supplies were available and drainage and other works were undertaken. At present, only about 44,000 hectares are irrigated in the wet season but only 37,000 can be irrigated in the dry season due to inadequate water supplies.

IRRIGATION CANAL-BARIT DISTRICT

In addition to the large consumptive requirements for irrigation water, many of the population centers of the basin are known to have inadequate supplies of water for domestic use and for municipal and industrial needs. Surface waters are badly contaminated with organic wastes, fecal organisms, and pesticides. Although most domestic supplies are from upland springs and groundwater, it is suspected that these supplies are often also contaminated. The ingestion of polluted water has led to excessive incidence of enteric disease in the basin. Thus, the problems of water supply encompass both the quantity of water and the quality of water at its sources, at its points of distribution and at its points of discharge after use.

For the near future, irrigation water supplies will be dependent mainly on surface water facilities. Additional groundwater supplies are also being investigated which can serve municipal and irrigation needs.

Agricultural Practices

Increases in crop yields and more efficient use of water and production materials are possible with improved agricultural practices. The Bicol River Basin is similar to other regions undergoing agricultural development. Not only are new or additional physical facilities needed but such supporting services as land reform, research and extension services, agricultural credit, marketing, supply of farm production requisites, cooperatives and other farmers' organizations are an essential part of the overall development effort.

Other problems

Some upland areas of the basin are steep and have erodible soils and inadequate vegetation. These conditions, together with high intensity

rainfalls, lead to problems of soil erosion. These problems are evident particularly in the Mount Mayon area where the coarse volcanic deposits are particularly susceptible to erosion; and in the Pulantuna River watershed. As a result, sediments are deposited in Lake Bato, in the Bicol River, and in San Miguel Bay affecting flood channels, water storage, irrigation diversion channels, and navigation.

Commercial fishing is an important activity in the basin, in the lakes, rivers and estuary. Inadequate low flows and flooding in rivers and inadequate depths for fish trapping equipment in lakes impede the maintenance and growth of this industry.

At present, there are severe shortages in electric power and inadequate distribution facilities in the basin. National programs of improvements are underway. Opportunities for hydropower have been considered in this study.

Waterways in the basin are used for navigation by two types of vessels-inter-island vessels traversing the river between Naga City and San Miguel Bay and beyond, and smaller vessels operating only on the inland waters.

NAGA CITY WATERFRONT

APPROACH TO COMPREHENSIVE PLANNING

The investigation of the Bicol River Basin was not solely a study of the needs, justification and desirability of building a system of facilities for the control and regulation of the water resources of the basin. Primarily, it was to improve the quality of life in the Basin and to permit the area to make its maximum contribution to national economic progress. In order to accomplish these broad objectives, a system or "package" approach was used. which included not only physical facilities but supporting services needed to implement the Comprehensive Water Resources Plan.

Among the elements considered were:

- o Land reform
- o Compact farm development
- o Agricultural credit and rural bank expansion
- o Water resource development including flood control
- o Drainage, salinity control and irrigation
- o Road development
- o Rural electrification
- o Livestock development
- o Fisheries development
- o Other support services.

The impact of the recommended comprehensive plan on export and import substituting industries was given special consideration. The emphasis was to determine the extent those projects can enhance the nation's foreign exchange position.

The national, regional, and basin viewpoint have been carefully considered in the selection of component parts of the comprehensive plan and in the determination of their desirability. The Bicol River Basin has been selected by the nation in Presidential Decree No. 926 dated April 28, 1976 as a model for planning of water and land development and to meet the aspirations of the population for improvement of its well-being.

REVIEW OF FLOOD CONTROL PROJECTS

Initial consideration was given to flood control projects identified in previous investigations. The mathematical model LATIS was adopted to test

the effectiveness of these flood control schemes. This computerized model has been shown through a long history of previous studies and initial review to be a reliable means of estimating the changes of water surface elevations resulting from flood control measures. It was calibrated with available field data for the October 1970 flood due to Typhoon Sening. This flood has been estimated to have a recurrence interval of about 13 years. The result of this evaluation can be summarized as follows:

Bicol Cutoffs and Dikes

The estimated cost of Cutoff No. 3 (40 meters bottom width channel) with replacement of PNR and Manila South Highway Bridges is ₱32,610,000. Flood control benefits will not justify, and the cutoff channel was reduced in bottom width to 10 meters to serve as an interior drainage and irrigation canal. The dikes were also retained as local protection works.

Bicol-Ragay Diversion Channel

Estimated cost of a canal capable of discharging 200 cms is about 110 million pesos, without right-of-way, relocation and irrigation costs. However, flood control effects are localized and are not sufficient to economically justify the project costs.

Sipocot-San Miguel Bay Diversion Channel

Estimated investment cost for canal (capacity 1150 cms) is about ₱100 million. An alternate alignment through Manga River would cost about ₱60 million. Flood control effects are limited to Sipocot River near the point of diversion with maximum effect at Sipocot. Flood damages prevented would

not economically justify construction.

Reservoirs

The Bicol watershed was examined for potential reservoirs. Upstream of Ombao, the Bicol Basin has considerable surface storage in Lakes Bato, Buhi and Baao. For example, during the 1970 flood the peak inflow to Lake Bato was estimated at 1060 cms while maximum outflow was about 340 cms. Lakes Buhi and Baao have similar flood moderating effects. The studies indicated that other flood control reservoirs including one on the Talisay River would not significantly reduce the flood peaks in lower valley. Within the Sipocot-Libmanan River portion of the Bicol Basin, flood storage would not be effective as Pulantuna and/or Culacling Reservoirs control only small portions of watershed. However, it appears that flood benefits could arise if the natural storage of Lake Bato, Lake Buhi and Lake Baao was enhanced by regulation of outflow.

The feasibility studies should consider the most desirable utilization of the available storage capacity in the natural reservoirs, - Lake Bato, Lake Buhi, and Lake Baao. The alternatives investigated should include the raising of the lake levels to increase flood storage capacity. If major reduction in flood damage within the basin appears likely, or if the increased water storage produces benefits to agriculture through irrigation or to fisheries, the possibilities of the construction of levees to protect the urban and developed portions of the municipalities of Bato and Buhi and the adjacent agricultural areas should be explored. In addition, the costs involved in the relocation of the urban areas should be determined.

Tide Barrier at Balongay, San Nicolas, Tributary Outlets and other Locations

Tide barriers at Balongay would cost about ₱220 million and have little effect on flood elevations with serious adverse effects through elimination of tidal flushing and modification of existing marine environment. The San Nicolas damsite would create similar problems. Flap-gate structures on the interior drainage canals would control the intrusion of salt water at less cost.

Lake Bato-Pantao Bay Diversion

In addition to the projects developed in previous studies, a diversion channel from Lake Bato to Pantao Bay was considered. The investment cost of a channel capable of discharging 450 cms would be about ₱105 million.

ALTERNATIVES CONSIDERED

Flood Control

The above analysis indicated that the following principal alternative systems of flood control works for the Bicol Basin be considered:

Alternative 1 - One or more diversion channels.

Alternative 2 - One or more diversion channels and local protection works.

Alternative 3 - Local protection works.

Alternative 4 - Local protection works with a control structure on the Bicol River downstream of its confluence with the Pawili River.

Alternative 1 is not considered a reasonable alternative as it would not provide protection for the substantial area of agricultural lands that lie in the downstream portion of the basin. Alternatives 2, 3, and 4 would include levees for local protection in the lower estuary to above Naga City. These levees would generally not exceed two meters in height above ground level and would where possible incorporate natural levees and existing roads. The most reasonable arrangement for Alternative 2 would consist of the Lake Bato-Pantao Bay Diversion to provide to provide flood protection for upstream areas below Lake Bato and sedimentation control for Lake Bato with levees to protect the downstream lands.

Alternative 4 would increase the regulation of flood water by a control structure at or near Ombao. This would supplement the protection afforded by the downstream levee system and could reduce flood damage in unprotected areas such as Naga City.

Economic studies indicate that Alternative 3 local protection levees for the downstream areas can be economically justified by the flood damages prevented. Alternatives 2 and 4 would reduce the flood hazard below Lake Bato and within areas unprotected by the local protection levees provided under Alternative 3. The economic feasibility of the alternatives will depend upon more detailed studies.

Irrigation, Drainage and Salinity Control

The alternatives available in meeting the irrigation, drainage, and salinity requirements of the agricultural lands within the basin are somewhat limited. Hydrologic studies indicate that there is an ample supply of water

to meet the estimated agricultural requirements for irrigation provided additional storage within the basin is provided to increase the available supply during the dry season - February through May. In addition, a number of irrigation systems must be enlarged and extended to distribute water to the irrigable areas. The feasibility study should consider alternative methods of supplying the required water in order to determine the most economical and desirable sources of irrigation water and canal network to the remote areas.

The improvement of drainage in general would be accomplished by the enlargement and extension of the existing drainage system with a range of capacities investigated to insure that the most efficient and economic system is provided. The reduction and/or elimination of the intrusion of salt water would be accomplished by flap gate controls on each of the canal and stream draining the leveed area. Stop-logs would be provided for interior water control.

Power

The possibilities of the development of hydro-electric power in the basin was investigated. Pulantuna High Dam was found to be the most desirable and economical site, but even at this site the costs of construction indicate that it is not cost-effective at this time. However, the site should be reserved so that development within the reservoir area would not prevent its future utilization.

COMPREHENSIVE WATER RESOURCE DEVELOPMENT PLAN

The Comprehensive Water Resource Development Plan was formulated from consideration of the water-oriented requirements for flood and salinity control,

drainage, water supply for agricultural and urban populations, and other water uses such as fishing. In general, the plan consists of:

- levees to protect the alluvial plain from overflow along San Miguel Bay and the Bicol and Libmanan Rivers;
- flap-gate control structures at all drainage outlets in the leveed areas, to prevent the inflow of water during floods and salt water at other times. Stop logs would be provided for control of interior water levels;
- extension and improvement of the drainage systems within the projected areas to provide a minimum 5-year capacity;
- extension and improvement of irrigation system and/or systems with sufficient storage to furnish an adequate water supply to practically all lands which would benefit from irrigation; and
- provision of the additional measures, programs and infrastructure required to ensure that the water-oriented construction program would be effectively utilized. Those programs include:

    - o Agricultural and fishery practices,
    - o Infrastructure,
    - o Flood Proofing,
    - o Flood plain Zoning,
    - o Interior Drainage,
    - o Public Water supplies,
    - o Water Pollution Control, and
    - o Financial, educational and health.

The Bicol River Basin Development Program (BRBDP) has sub-divided the area under its administration into ten (10) project areas, seven of which include areas within the Bicol Basin. For efficient construction management, project administration and operation, the Comprehensive Water Resource Development Plan has been sub-divided into separate areal projects which relate to the BRBDP project areas follows:

Naga-Calabanga IAD

Naga-Calabanga IAD would comprise integrated development for irrigation, drainage, salinity and flood control. The irrigated area in the project would be approximately 11,200 hectares. Flood levees would be constructed along San Miguel Bay from Calabanga to the Estuary, and parallel to the Bicol River upstream to Camaligan. The existing major waterways would be dredged as required, to serve as the main drains. A supplemental network of lateral and farm drains would also be constructed. An outlet structure would be placed at the outlet of each of the main drains. Irrigation water supplies, depending on the areas served, would be from groundwater, local streams originating on the western slope of Mt. Isarog, out-of-basin diversion from the Tigman and Hinagyanan Rivers on the northern slope of Mt. Isarog, and Bicol River and tidal tributaries as augmented by controlled releases from Lake Bato. Irrigated areas would be provided with distribution systems up to the compact farm level.

RICE PADDIES - NAGA-CALABANGA AREA

The estimated costs of the overall system is:

Item	Total Cost
Flood Levees (about 25.5 kilometers)	₱ 1,326,000
Drainage system with outlet structures	9,644,000
Irrigation facilities including the allocation of the upstream costs for the control structure	21,762,000
On-Farm Development	5,016,000
Right-of-way Relocations	1,500,000
Engineering	6,125,000
T O T A L	₱45,373,000

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Right-of-way Relocations	1,500,000
Engineering	6,125,000
T O T A L	₱45,373,000

It is estimated that the annual benefits of the program at full development would be ₱43,135,000.

Computation indicates that the merit of the program is as follows:

Internal Rate of Return (IRR)	22.1%
Net Present Value (PV)	₱29.916 million
Benefit/Cost Ratio	1.65 to 1

The sensitivity analysis indicates that the project is viable over a wide range of assumptions; only the reduction of the benefits to 50 percent would reduce the Benefit-Cost ratio below unity.

It is estimated that the foreign exchange requirement in dollars would be about $2,405,000 or about 40 percent of the estimated costs.

A feasibility study of the Naga-Calabanga IAD project is estimated to take about 14 months and cost about $422,600.00. Local costs are estimated at about ₱1,000,000. The study would identify the characteristics of the flood control, irrigation and drainage, land development, inland fishery, and public water supply facilities that will meet the need of the area at least cost. Available alternatives will be examined. The determination of the most economic and desirable irrigation water supply should consider the use of the Bicol River, the runoff from Mt. Isarog directly into the area and from the Tigman River, and groundwater development. Several of these sources would require pumping.

Design criteria will be determined and preliminary plans and outline specifications developed for the facilities which are found to have technical,

economical and social merit. Based upon these designs, cost estimates will be made and preliminary construction schedules developed.

Baliwag-San Vicente IAD

Baliwag-San Vicente IAD would provide for drainage, salinity control, flood control and irrigation. Some 16,250 hectares have been classified as irrigable, of which only about 5,660 hectares are currently irrigated. Cutoff No. 3 would serve as the main drainage outlet through the low-lying portion of the area which would have first priority for development. In this area, the use of dredged natural channels, outlet works, interior drainage works, and irrigation facilities would serve for the irrigation of about 12,000 hectares, including 1,400 hectares which are currently waterlogged. Irrigable areas at higher elevation would be served by local streams from the Ragay hills groundwater or by extending the irrigation facilities of the lower developed areas. An alternative water supply would be a canal at higher elevation at the base of the Ragay Hills. Flood protection would be provided by levees. Water supply would be from the Bicol River, augmented by upstream storage releases from Lake Bato which would also assist in salinity control.

WATERLOGGED AREAS - BALIWAG-SAN VICENTE AREA

The estimated costs would be:

Item	Total Cost
Flood levees (about 27 kilometers)	₱ 1,940,000
Drainage including outlet structures	11,085,000
Irrigation facilities including the allocation of the upstream costs of the control structure	21,733,000
On-Farm development	5,056,000
Right-of-way and relocation	2,500,000
Engineering	6,900,000
TOTAL	₱51,154,000

It is estimated that the annual benefit of the overall project at full development would be about ₱45,080,000.

Economic analysis shows the following:

Internal Rate of Return (%)	21.3
Net Present Value (Thousand ₱)	27,761.
Benefit/Cost Ratio	1.56 to 1

The sensitivity analysis indicates that the project is economically viable over a wide range of assumptions; only with a reduction of benefits by about 50 percent would the Benefit-Cost Ratio be reduced below unity.

It is estimated that the foreign exchange requirement in dollars would be about $2,712,000 or about 40 percent of the estimated costs.

A feasibility study of the Baliwag-San Vicente IAD would take about 14 months and require about $495,000. The local costs of the study are estimated at about ₱1,400.000.00. The studies would identify the magnitude of the flood control, drainage, irrigation, public water supply, land development and institutional components of the project that will produce the needed improvements at least cost.

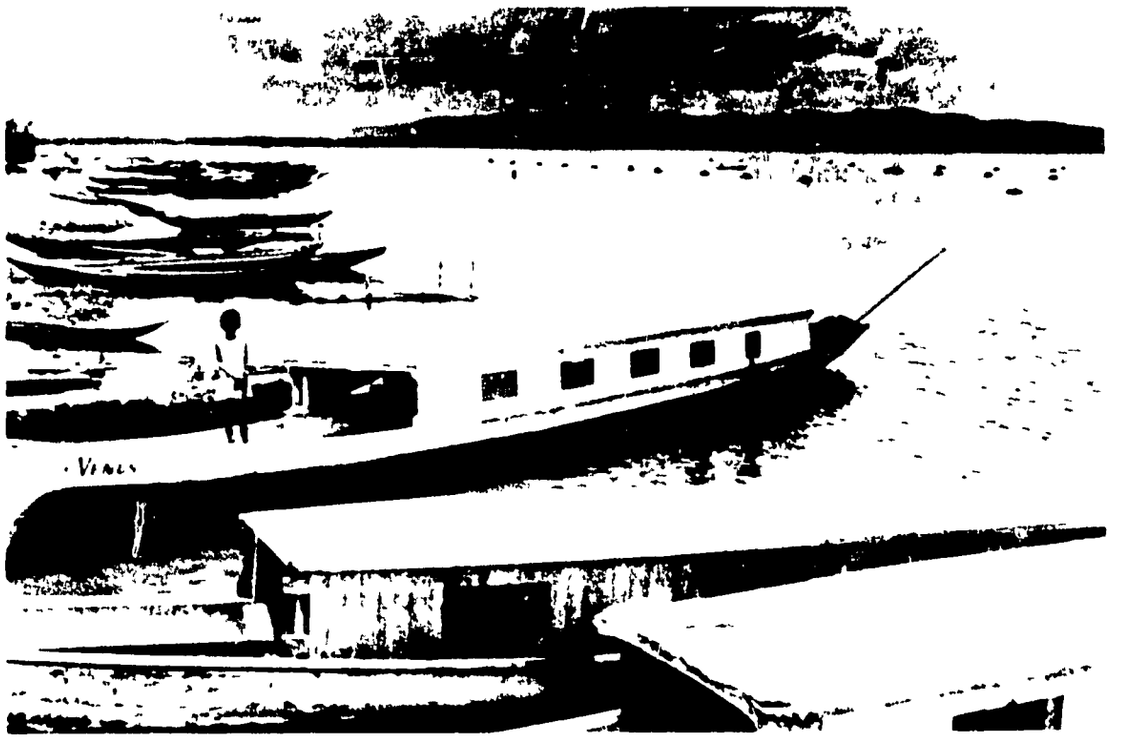
Preliminary designs would be developed and costs estimated for the facilities found economical.

During this study, alternative sources of water should be considered for irrigation water supply. Among these sources are groundwater, streams in the Ragay Hills, and the Bicol River. This water can be transmitted by gravity and pumping, utilizing lateral canals along the foothills and by the Libmanan

River. The evaluation of the groundwater potential will require a major geologic effort. However, due to the costs of furnishing irrigation water supply to remote portions of the area it may be economical.

Rinconada IAD

The Rinconada IAD would focus on the development of Lakes Bato, Baao and Buhi. Regulatory structures at the mouths of the lakes would maintain water levels for fishery development, store water to augment irrigation water requirements, and minimize flood risk within the area. Discharges during the low flow season would benefit lands within other IAD's by providing irrigation water and controlling salinity. Other works in addition to the



LAKE BATO

regulatory structure would include dredging of the river channels below Lake Bato and Lake Buhi, a major drainage channel between Lakes Baao and Bato, levees to define the Lake Baao boundaries, and irrigation facilities. The merit of constructing the Lake Bato-Pantao Bay Diversion would be explored further in the feasibility study. The Rinconada IAD contains several separated irrigable areas totalling approximately 14,000 hectares, which would be benefited by facilities ranging from better water supplies to complete development. In addition, the merit of reclaiming about 4,000 hectares of poorly drained and/or waterlogged lands would be determined.

BICOL RIVER BELOW LAKE BATO

The estimated costs of the project works are as follows:

Item	Total Cost
Lake Baao	
Levee	₱ 1,673,000
Drainage and Irrigation Facilities	9,840,000
On-Farm	2,400,000
Sub-total	13,913,000
Lake Buhi	
Control Structure and Low Flows Channel	6,746,000
Lake Bato	
Control Structure and Low Flows Channel	7,083,000
Right-of-way, Relocation	2,500,000
Engineering	8,125,000
Sub-total with control structure	38,367,000
or	
Sub-total without control structure	31,284,000
Lake Bato-Pantao Diversion Channel	
Construction	98,000,000
Right-of-way, Relocation	5,000,000
Engineering and Design	2,625,000
Sub-total	105,625,000
TOTAL Construction cost with control structure	₱143,992,000
TOTAL Construction cost without control structure	₱136,909,000

It is estimated that the annual benefits of the Lakes Baao and Buhi at full project development would be ₱22,879,000. All the benefits of the Lake Bato-Pantao Bay Diversion Channel have not been quantified at this time due to lack of data on sedimentation in this lake. The flood benefits for this project are estimated to be in the order of magnitude of 7.5 million pesos per year in 1976.

The economic merits of the Lake Baao and Lake Buhi portion of the Rinconada (The cost of the control structure and low water channel at Lake Bato has been allocated for purposes of economic analysis to Naga-Calabanga IAD and Balivag-San Vicente IAD) and the Lake Bato-Pantao Diversion Channel are shown separately:

	Lake Buhi and Lake Baao Diversion	Lake Bato Diversion
Internal Rate of Return %	20.9	5.4
Net Present Value (thousand pesos)	₱17,625	-₱35,907
Benefit/Cost Ratio	1.50 to 1	0.43 to 1

These indices indicate that Lake Baao and Lake Buhi portions of the project are feasible. The Lake Bato-Pantao Bay Diversion Channel clearly is not feasible at this time. However, all the benefits of the diversion project were not quantified and a more detailed economic analysis should be made in the feasibility studies.

A sensitivity analysis was made of these projects, increasing investment costs 50 percent, reducing benefits 25 percent and 50 percent, placing a constraint on yields and reducing project life to 1990. Under all conditions except when the estimated benefits were reduced by 50 percent, the Lake Buhi and Lake Baao projects were viable. Similar sensitivity checks were made for the Lake Bato-Pantao Diversion channel. They indicate that it would be viable when benefits were increased by 300 percent. The foreign exchange requirement in dollars for the Rinconada Project (Lake Baao, Lake Buhi and Lake Bato) is estimated to be about $6,850,000 or about 40 percent of its total cost. If the Lake Bato-Pantao Bay Diversion channel is included, the foreign exchange requirement in dollars increases to about $17, 632,000.

A feasibility study of the Rinconada IAD Project including the Lake Bato-Pantao Bay Diversion Channel would take about 10 months and cost about 481,400 dollars and about 1,500,000 pesos. The study would identify the flood control, irrigation and drainage, land development, inland fishery development, and water supply projects which would maximize benefits at least economic costs. Preliminary designs would be prepared, and the construction, and operation and maintenance costs estimated. Ecological studies would be made to determine impact of the projects on the environment. In addition, the study would determine the institutional mechanisms that will insure the transfer of technology to project beneficiaries, and the support services, i.e. land reform, credit, agricultural development, and post-production and intensive education program, required to develop the full potential of the project.

The Rinconada IAD area includes three lakes - Lake Bato, Lake Buhi and Lake Baao. The investigations should determine the optimum utilization of their sites. If an increase in their flood levels appears to the economic and to the social advantage to the overall basin, the costs of protection by levees, and/or relocation of the developed urban portions of the municipalities of Bato and Buhi should be investigated. The local costs are estimated at about ₱3,000,000.

Libmanan-Cabusao IAD

Libmanan-Cabusao IAD is currently under construction. The feasibility studies for this project were completed and construction of the main canal was initiated in May 1976. Levees, irrigation and drainage works are included in the project.

Pili-Bula IAD

Pili-Bula IAD has about 19,000 gross irrigable hectares. Only about half of this area has adequate water supplies for dry season irrigation although over 13,800 hectares are potentially served by existing irrigation systems. The principal sources of water are currently streams originating on the slopes of Mt. Isarog whose supplies are insufficient in the dry season. Some areas are served by groundwater. It is believed that the irrigated areas can be substantially increased if groundwater development, whose exploration appears promising is confirmed, or by pumping from the Bicol River. Until overall estimates of groundwater are determined, feasibility studies of extending the irrigation area can not be made.

Quinale IAD

Quinale IAD has problems that are somewhat different from the other developed portions of the Basin. In this area, due to the proximity to Mt. Mayon, material from recent eruptions is transported into the natural streams and canals resulting in a partial choking. Cultivated areas, with the exception of ricefields, have a drainage problem and are subject, during periods of heavy rainfall, to severe flooding due to the inadequate capacity of drainage channels. The floods also cover significant areas with sand and silt which permanently reduce their productivity and under severe conditions must be removed for continued agricultural use. The problems of the IAD can be ameliorated only by a program of watershed management. This may include control of vegetation, protection of slopes by structural means, sedimentation basins to intercept larger and heavier portions of suspended and bed load, and

improvement of the hydraulic performance of streams and canals. Adequate water is generally available for irrigation but drainage and irrigation supply works can not be justified until volume of sediment is reduced.

Sipocot-Del Gallego IAD

Sipocot-Del Gallego IAD would provide for watershed treatment of the steeply sloping lands to reduce erosion, increase infiltration of the existing rainfall, and reduce the silt load carried by flood waters. As previously discussed, while Pulantuna Dam can not be justified by current needs, the plan would provide for protection of the damsite and potential reservoir area by restricting development, particularly urban settlements, as it appears possible that construction of the Pulantuna Dam may be found feasible when the lower basin is more intensely developed. In addition, the plan provides for the construction of low dams for supplemental water supply when required to augment the supply of water available for irrigation or salinity control. There are a number of potential sites for such dams in the watershed. The actual selection of the number and location of the supplemental storage dams would be made after a water balance study of the basin based on results of feasibility studies of other portions of the basin.

Combination of Projects

The combined total cost of the Naga-Calabanga IAD, Baliwag-San Vicente IAD, and Rinconada IAD projects would be about ₱128 million without Lake Bato Diversion Channel. If the diversion channel is included, the total cost would be ₱233 million.

The economic feasibility of the three IAD's were determined using three indices as shown below:

	IAD's Without Lake Bato Diversion	IAD's With Lake Bato Diversion
Internal Rate of Return (%)	21.1	17.3
Net Present Value (thousand ₱)	71,992	36,131
Benefit/Cost Ratio	1.55 to 1	1.19 to 1

The indices show clearly that the three IAD's are economically with or without the Lake Bato Diversion Channel. The latter project can only be considered feasible if it is included as a portion of the overall project.

The sensitivity analysis indicates that the entire group of projects are feasible under most circumstances except when costs are increased by 50 percent or benefits are reduced by 50 percent. The positive flood control provided by the Bato Diversion Channel gives greater certainty that the benefits developed for the other projects will be achieved.

General Conclusions

Recent studies involving mathematical modeling have indicated that the damages from salinity intrusion are not as serious as believed earlier. With the expected increased use of the Bicol River and tributaries, however, the problems may worsen unless low-flow augmentation is accomplished from supplemental surface water reservoirs. The feasibility studies of Lakes Bato, Baao and Buhi will indicate what can be expected by regulation of these lakes. If other storage is required, additional low head reservoirs can be developed in the basin.

Watershed management has been discussed above for the Quinale IAD and the Sipocot-Del Gallego IAD. Watershed protection could also have valuable benefits for other portions of the Bicol Basin. Some 185,000 hectares or 59 percent of the basin area consist of steeply sloping lands which under adverse conditions of susceptible soils and heavy rainfall, are subject to excessive erosion. The management program would include both structural and vegetative methods and may be different for each project area.

The pre-feasibility field studies of the geologic characteristics of the Bicol Basin indicated the possibility of good groundwater potentials in a number of areas. The existing exploration program should be continued, in order to determine potential groundwater and costs. This would permit a balanced utilization of both groundwater and surface water supplies in various IAD's.

There is also the necessity to continue the existing hydromet program which consists of the periodic observations of rainfall, stream stages and discharges.

Finally, cloud seeding has been a controversial issue in many locations but its effectiveness and economic value in increasing water supplies when needed has been demonstrated in a number of areas. An exploratory program to determine its appropriateness for the Bicol Basin should be undertaken, including additional rainfall gages, and tests of ground-based burners and aircraft seeding over at least three dry seasons.

The above described physical works and programs do not include a number of additional measures that should be provided in each of the areas designated

for integrated area development. These are not detailed nor are cost estimates presented in the pre-feasibility report but some are outlined below.

Farming practices, and infrastructure to supply agricultural materials and process and market crops should be improved. As applicable, commercial fisheries should be subject to similar programs. Organization of farm management and farm ownership is being addressed by existing programs which should be extended.

Flood proofing to protect existing buildings and zoning to control types and methods of construction of buildings and other physical works should be undertaken for the floodplain. This would reduce the flood damage and inconvenience from heavy rains due to improper building and road construction or inadequate interior drainage works.

Public water supplies should be installed, expanded, or modified to serve a greater portion of the population and business enterprises with water of adequate quantity and quality. In this connection, water pollution control programs are also needed. Roads, telephone service, and public transportation services to serve urban and rural population and agricultural activities should be expanded.

Financial, educational, and health and other economic and social services should be instituted or supported to a greater extent than at current levels.

The physical works, related programs and the other activities described above to improve the economic and social climate of the Bicol region are a necessary pre-requisite to the infusion of capital for agro-business. Plans

to support off-farm employment, and the supporting commercial and personal service industries are also needed to increase employment opportunities and raise the overall economic health of the region.

THE SOCIO-ECONOMIC IMPACT OF THE PLAN

The construction and implementation of the recommended package program in the Comprehensive Water Resources Plan will improve the utilization of the human and natural resources in the Bicol River Basin. The overall impact of this program will be the improvement in the quality of life for the inhabitants of the Basin.

The plan when implemented will reduce the flood damages on agricultural and urban lands, provide sufficient water to irrigate a total of about 16 thousand additional hectares, reclaim and irrigate about 2,500 hectares of poorly drained and waterlogged lands and reduce or eliminate the intrusion of saltwater on about 9 hundred hectares of land. Agricultural Economic Studies indicate that with the project completed, the rice farmer on poor quality lands will be able to increase his yields in a normal wet season from 1.1 to 1.8 tons per hectare, and his cropping intensity from 1.8 to 2.5. Similarly on the most productive lands, wet season yields are expected to increase from 1.4 to 4.8 tons per hectare and the cropping intensity from 2.1 to 2.75. With the provision of ample water, dry season yields and cropping intensity will be similarly improved. It is estimated that net farm income which is presently negative on the more marginal lands will increase to about ₱1,650 per year, the more productive land will also see net farm income increase from near subsistance to over ₱11,000. In addition, the fishery projects at Lakes Baao and

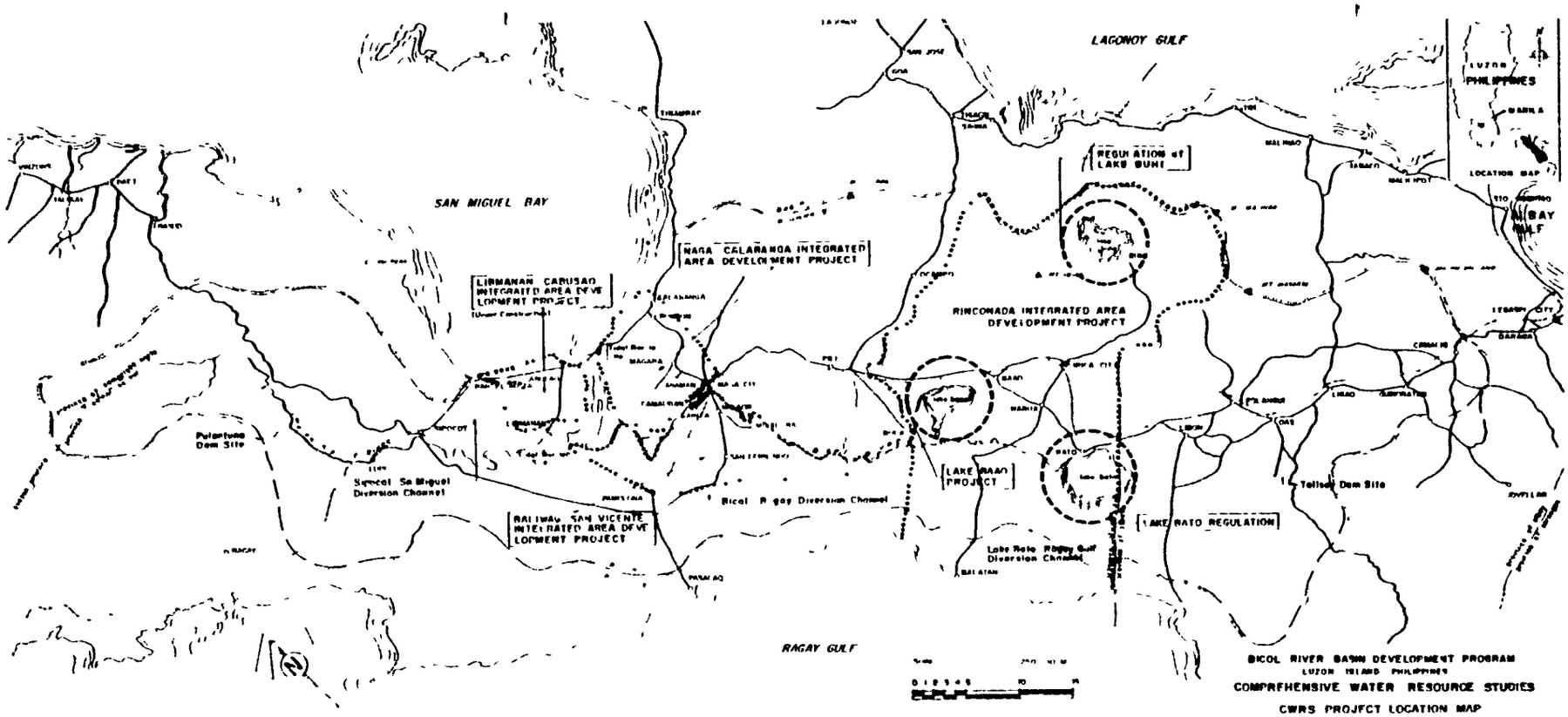
Bato are expected to increase employment opportunities by well over a thousand persons where they are completed. The reduction of flooding is expected to reduce the incidence of disease in the wet season and improve the capital formation of the poorer subsistence farmer which now farm the marginal lands susceptible to flooding and drainage problems.

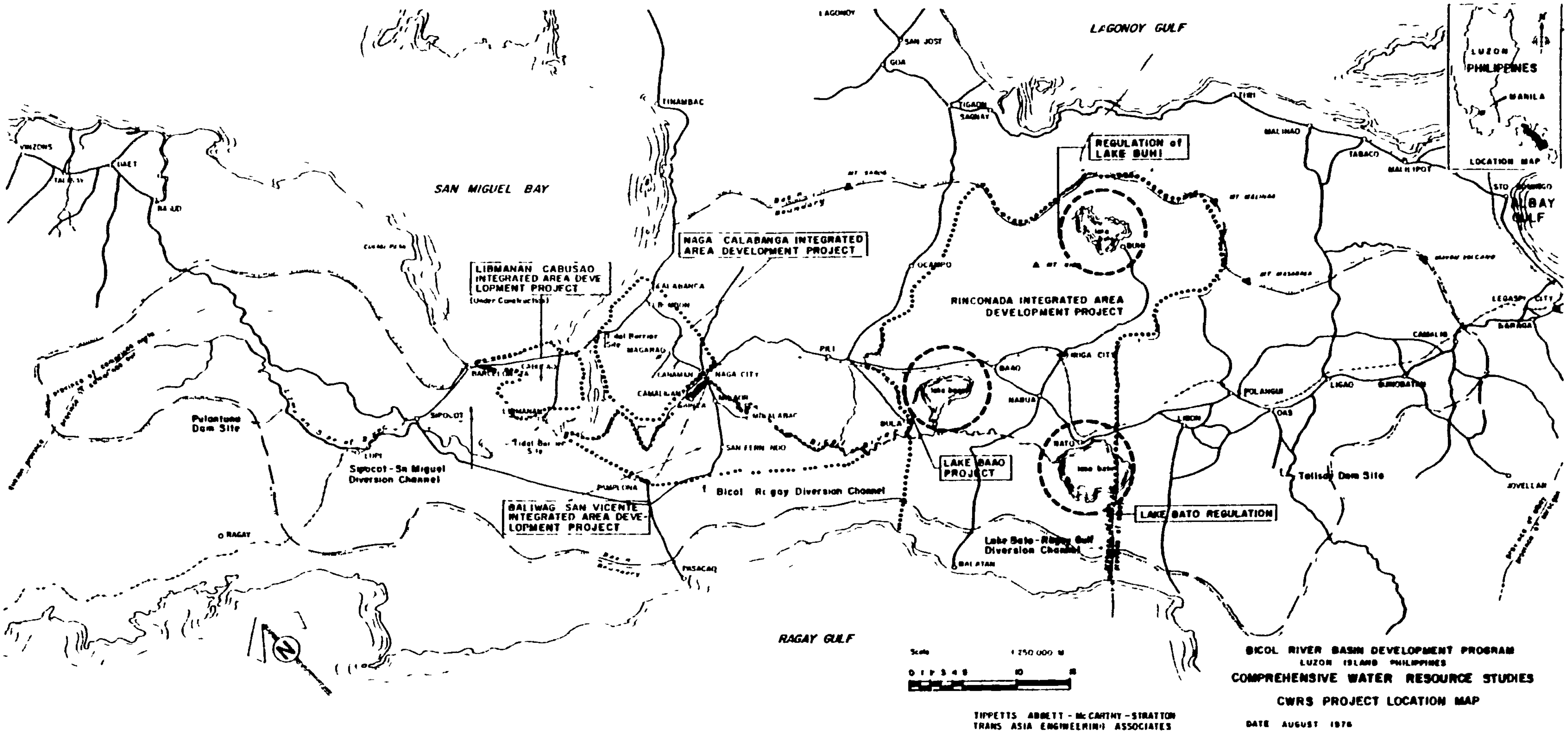
RECOMMENDATIONS

On the basis of the Comprehensive Water Resources Development Study, it is recommended that:

1. Prepare a design memorandum outlining the project performance requirements, basic designs, and cost estimates. This should be initiated immediately because the facilities required in the Naga-Calabanga IAD and Baliwag-San Vicente IAD are justified beyond a reasonable doubt.
2. Prepare a feasibility study of the facilities required for the Rinconada IAD. Although the Lake Bato-Pantao Bay Diversion Channel seems to be economically marginal, it should be included as part of feasibility studies for the Rinconada IAD since not all the benefits have been quantified in this pre-feasibility study.
3. Continue the program for supplemental surface water resources, watershed management, groundwater exploration and cloud seeding for the Pili-Bula IAD, Quinale IAD, and Sipocot-Del Gallego IAD. The hydromet program for collection of rainfall and streamflow and salinity data should be continued.

4. Develop supporting programs which will complement the construction program and improve its effectiveness. These programs should insure adequate farm credit, extension services, feeder roads, and improved educational and health facilities be made available to the farmer. The combined effects of the improved physical and social infrastructure should insure an improvement in the quality of life for all the basin's inhabitants.


SAN MIGUEL BAY
LAGONOY GULF
RAGAY GULF
LIRMANAN CABUSAO INTEGRATED AREA DEVELOPMENT PROJECT
NAGA CALARANGA INTEGRATED AREA DEVELOPMENT PROJECT
RINCONADA INTEGRATED AREA DEVELOPMENT PROJECT
REGULATION of LAKE BUHI
LAKE BACO PROJECT
LAKE BATO REGULATION
RAILWAY SAN VICENTE INTEGRATED AREA DEVELOPMENT PROJECT
Polantuna Dam Site
Sipocot Sa Miguel Diversion Channel
Bicol River Diversion Channel
Lake Bato Ragay Gulf Diversion Channel
Tollosa Dam Site
LUZON PHILIPPINES
LOCATION MAP
BICOL RIVER BASIN DEVELOPMENT PROGRAM
LUZON ISLAND PHILIPPINES
COMPREHENSIVE WATER RESOURCE STUDIES
CWRS PROJECT LOCATION MAP
DATE AUGUST 1976



LAGONOY GULF
SAN MIGUEL BAY
RAGAY GULF
ALBAY GULF
LUZON
PHILIPPINES
MANILA
LOCATION MAP
REGULATION of LAKE BUHI
NAGA CALABANGA INTEGRATED AREA DEVELOPMENT PROJECT
LIBMANAN CABUSAO INTEGRATED AREA DEVELOPMENT PROJECT
(Under Construction)
RINCONADA INTEGRATED AREA DEVELOPMENT PROJECT
LAKE BAAO PROJECT
LAKE BATO REGULATION
BALIWAG SAN VICENTE INTEGRATED AREA DEVELOPMENT PROJECT
Sipocot - San Miguel Diversion Channel
Bicol Ragay Diversion Channel
Lake Bato - Ragay Gulf Diversion Channel
Pulantuna Dam Site
Tidal Barrier Site
Tellsay Dam Site
NAGA CITY
IRIGA CITY
LEGASPI CITY
TINAMBAC
TIGAON
SAGÑAY
LAGONOY
SAN JOSE
GOA
TIWI
MALINAO
TABACO
MALILIPOT
STO DOMINGO
VINZONS
DAET
BASUD
OCAMPO
CALABANGA
PILI
BAAO
NABUA
BUHI
BATO
LIBON
POLANGUI
OAS
LIGAO
GUINOBATAN
CAMALIG
DARAGA
JOVELLAR
BULA
MINALABAC
SAN FERNANDO
PAMPLONA
PASACAO
BALATAN
RAGAY
SIPOCOT
LUPI
LIBMANAN
MAGARAO
CANAMAN
CAMALIGAN
GAINZA
MILAOR
CABUSAO
Scale 1:250 000 M
BICOL RIVER BASIN DEVELOPMENT PROGRAM
LUZON ISLAND PHILIPPINES
COMPREHENSIVE WATER RESOURCE STUDIES
CWRS PROJECT LOCATION MAP
TIPPETTS ABBETT - McCARTHY - STRATTON
TRANS ASIA ENGINEERING ASSOCIATES
DATE AUGUST 1976