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THE REPUBLIC OF THE PHILIPPINES

PLANNING REPORT ON THE PASIG-POTRERO RIVER FLOOD CONTROL AND SABO PROJECT

MAIN REPORT

SEPTEMBER 1978

JAPAN INTERNATIONAL COOPERATION AGENCY

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SUMMARY

1. The Pasig-potrero river with the catchment area of 125 Km^2 and the total length of 35 Km, rising in Mt. Pinatubo of the Cabusilan mountains at west side of Central Luzon flows south eastward and joins the Guagua river. A huge volume of collapsed debris transported by flood water from unconsolidated mountain region has formed an alluvial fan in the middle reaches of the river. The basin area has been suffered from the heavy damages in every flood due to the sediment flow.

2. The damages in the Pasig-potrero river basin caused by flooding, standing water and earth and sand deposit are such direct ones as damages on the agricultural products, land and facilities, roads, levees and related structures, and suspension of transportation and communication and indirect and intangible ones. In the 1972 flood which is the largest among all recorded in the past, direct damages alone was estimated at P 21.5 million. Under such circumstances, inhabitants in the basin have waited for a long time to arrest and control the sediment flow and to improve the river conditions.

3. As the objective area of this project, a plan including the adjacent Abacan river and the Porac river was studied, but as a result of the field investigation and the study, it was decided to treat only the Pasig-potrero river for this project from a view-point of preventing damage dispersion and maintenance of the present stable river conditions of the two rivers.

4. For the Sabo plan, the sediment volume discharged at the past maximum flood which occurred in 1972 was applied as sediment volume to be treated. Through the study of the aerial photographs taken in 1966 and 1976 and the field investigation, it was estimated that about 2,622,000 m^3 of sediment was produced during the 1972 flood. The design maximum sediment production of about 4,432,000 m^3 at the flood time was derived from totalling 2,622,000 m^3 and 1,810,000 m^3 which was produced secondarily from river bed deposit. The design sediment discharge during flood time at the sub-control point, the confluence of the Pasig-potrero river and Timbu creek, was estimated at 1,849,000 m^3 taking into account the control volume of about 2,583,000 m^3 by the river bed.

5. Under the principle that the Sabo plan shall be made to arrest and control the sdeiment production at the mountain region as much as possible, a desolation preventive measures against the mountain side desolation were studied at first as the basic direct measures. But these measures were abandoned as their execution is difficult due to the topographical condition

and their effect is considered rather small compared with the construction cost. To draw up the sediment treatment plan by arresting and control function of the Sabo dam, storage and control possibility on the lower reaches was investigated at the same time anticipating that not all of the design sediment discharge may be arrested or controlled by the proposed Sabo dams and some of which flows down to the downstream due to limitation of the dam site in the mountain region. After investigation of the dam site, 10 dam sites including 6 in the Bucbuc creek, 3 in the Papatac creek and, 1 in the Timbu creek were selected and planned to arrest and control 1,014,000 m3 of sediment and let flow down the uncontrolled balance of 835,000 m3 to be treated at the lower reaches.

6. The river bed consolidation works and groynes were planned to be provide at the fan head portion of lower reaches of the sub-control point to prevent lowering of the river bed and unstable change of the talweg, and to protect the both river banks from erosion and collapse. The Sabo dams and riverbed consolidation works were planned as a concrete structure. As a typical example, detailed design of the No.5 Sabo dam in the Timbu creek had been carried out and the design drawing including the related documents had been prepared.

7. A sand arresting basin will be provided in the area of alluvial fan at above the Mancatian bridge to arrest and treat the uncontrolled sediment discharge of 835,000 m3. Furthermore, allowance capacity of 260,000 m3 will be provided to the sand arresting basin anticipating possibility of excess over the design sediment storage capacity of 691,000 m3 during the tentative period between completion of the river improvement works and Sabo works. (Yearly average sediment discharge after completion of the Sabo dams was estimated at 304,000 m3)

8. In the planning of the river improvement works, design flood discharge of 900 m3/s at Mancatian bridge was applied after reviewing the BPW plan under construction partially. With respect to sediment, it was planned to discharge 30,000 m3 of the sand in average year and 144,000 m3 in flood time from the sand arresting basin to the lower channel. The sediment in the sand arresting basin was planned to be dredged annually to limit sediment flow to the lower reaches as small as possible.

9. In the planning of river improvement works, all the river courses were planned to have enough capacity to discharge design flood of 900 m^3/s, and the plane shape of the river course was planned to correspond with the BPW plan as much as possible on the portion already completed. The cross sectional shape of the river channel has the composite type.

10. The levee will be constructed all along the river course including the open levee, and the slope surface of the levee is protected with the dry masonry work, and with the wet masonry work and gabion where required. Groyne works were planned to protect the banks and to control the talweg. Appropriate protective works were planned for a part of the slope of low water channel and the back side slope of levee where damaged during past flood. Three drainage facilities will be installed for drainage of water outside of the levee at the lower reaches.

11. To study suitability of the river bed materials for construction of the levee and other structures, the soil test of the samples collected from each point of river bed was performed. In accordance with the results, careful embankment and compaction for the levee construction were planned from a viewpoint of the specific gravity and strength.

12. For the project implementation, it is recommended that the construction of the river improvement works will remain under the direct responsibility of PRCS, while the construction of the Sabo dams will be under Sabo Dam Implementation Office to be established near the damsite under the control of PRCS. Task Force will be responsible for the detailed design of the Sabo dams and will give necessary assistance and technical advice to PRCS and to the Implementation Office during the construction stage.

13. Construction period required for the Sabo works and river improvement works were estimated at 15 years and 5 years respectively. The project costs for Sabo works and river improvement works were estimated at P 138 million, P 98 million respectively, totalling P 236 million. Yearly operation and maintenance cost after completion of the project was estimated at P 0.6 million.

14. The direct economic benefit per annum derived from this project will be P 4.6 million for the effects of mitigation of flood damage and P 7.3 million for the agricultural production increase, totalling P 11.9 million. The benefit is expected to accrue after completion of the river improvement works.

15. Internal economic rate of return was estimated at 4.5 % on the basis of the direct benefit and economic construction cost of the project. Though the internal economic rate of return is not so high, implementation of the project will be satisfactorily justified if special characteristics of this project is taken into consideration that the beneficial influence are considerably larger than the tangible direct benefit, and has such indirect effects as promotion of regional economy through flood prevention and increase in the employment opportunity in the project works, and such intangible effects as stabilization of regional public peace

and order and contribution to better income distribution in the region.

Technically the Sabo plan and river improvement plan are inseparable in this project, since the damages caused by the flood and sediment will hardly be prevented without stabilizing sediment produced at the mountain region. Therefore, it is necessary to implement the project as the combination of the Sabo works and river improvement works.

16. This project shall be executed under long-term and overall plan with the appropriate design prepared under due consideration of the local conditions. It is also recommended that the most effective stagewise development will be planned through the observation and study on the effects and influence of facilities and structures already implemented.

Principal Features of the Project

The Pasig-potrero river flood control and Sabo project is divided roughly into two structure groups ; the Sabo facilities and river improvement facilities. The principal features of the project are as follows:

(1) Hydrology and Geology

River length	35 km
Catchment area	125 km^2
Annual precipitation	2,000 mm
Design flood discharge	900 m^3/s
Design maximum sediment production	5,941,000 m^3
Proposed sediment control volume by Sabo dams	1,014,000 m^3
Proposed arresting volume of sediment in the sand arresting basin	691,000 m^3

(2) Sabo Dam

All the Sabo dams are straight concrete gravity type.

Dam	River	Height (m)	Crest Length (m)	Crest Elevation (m)	Sediment Reserving pacity (10^3m^3)	Sediment Control Volume (10^3m^3)	Sediment Arresting Volume (10^3m^3)
No. 2-A	Papatac	15	63	257	380	120	0
No. 2-B	Papatac	14	60	276	220	100	0
No. 3	Papatac	14	40	298	490	120	30
No. 4-A	Bucbuc	15	38	326	370	110	30
No. 4-B	Bucbuc	15	43	364	270	80	30
No. 4-C	Bucbuc	15	48	399	200	80	20
No. 4-D	Bucbuc	15	68	425	200	70	20
No. 4-E	Bucbuc	15	65	461	150	50	20
No. 4-F	Bucbuo	15	43	503	150	50	20
No. 5	Timbu	15	31	276	900	267	0
Total					3,330	1,047	170

(3) Sand Arresting Basin

Site	: Alluvial fan area at above Mancatian
Area	: Length 900 m Maximum width 650 m About 560,000 m^2
Sediment reserving capacity	: 691,000 m^3
Basin bottom elevation	: EL.127^m - 109^m
Excavation volume	: 3,234,000 m^3

(4) Levee (including open levee)

Length	
New Levee	: 17,220 m
Tentative levee	: 2,530 m
Height	: 5 - 6 m
Crest width	: 6 - 15 m
Slope	: 1 : 3 front and rear
Channel excavation volume	: 973,000 m^3

(5) River Bed Consolidation Work

Work No.	Structure	Crest Length (m)	Height (m)	Site
No. 1-A	Concrete	194	7	Sta. 26 + 498
No. 1-B	- do -	190	6	Sta. 27 + 000
No. 1-C	- do -	176	6	Sta. 27 + 500
No. 1-D	- do -	290	7	Sta. 28 + 000
	- do -	400	4.5	Sta. 19 + 550
	- do -	400	4.5	Sta. 20 + 850
	Wood pile with wet masonry	180	2	Sta. 15 + 900
	- do -	180	2	Sta. 16 + 150
	- do -	180x2	2	Sta. 18 + 300
	- do -	180	2	Sta. 19 + 300
	- do -	180	2	Sta. 24 + 300
	- do -	180	2	Sta. 25 + 700
	- do -	180	2	Sta. 26 + 400

(6) Groyne Work

Structure	Number of Site	Length	Site
Iron wire gabion mat filled with cobbles	18	From river bank to the channel	Fan head portion
Wood piling with iron wire gabion filled with cobbles	146	- do -	Sand arresting basin & curved portion of the river channel
Skelton work with iron wire gabion filled with cobbles	185	- do -	Fan head portion

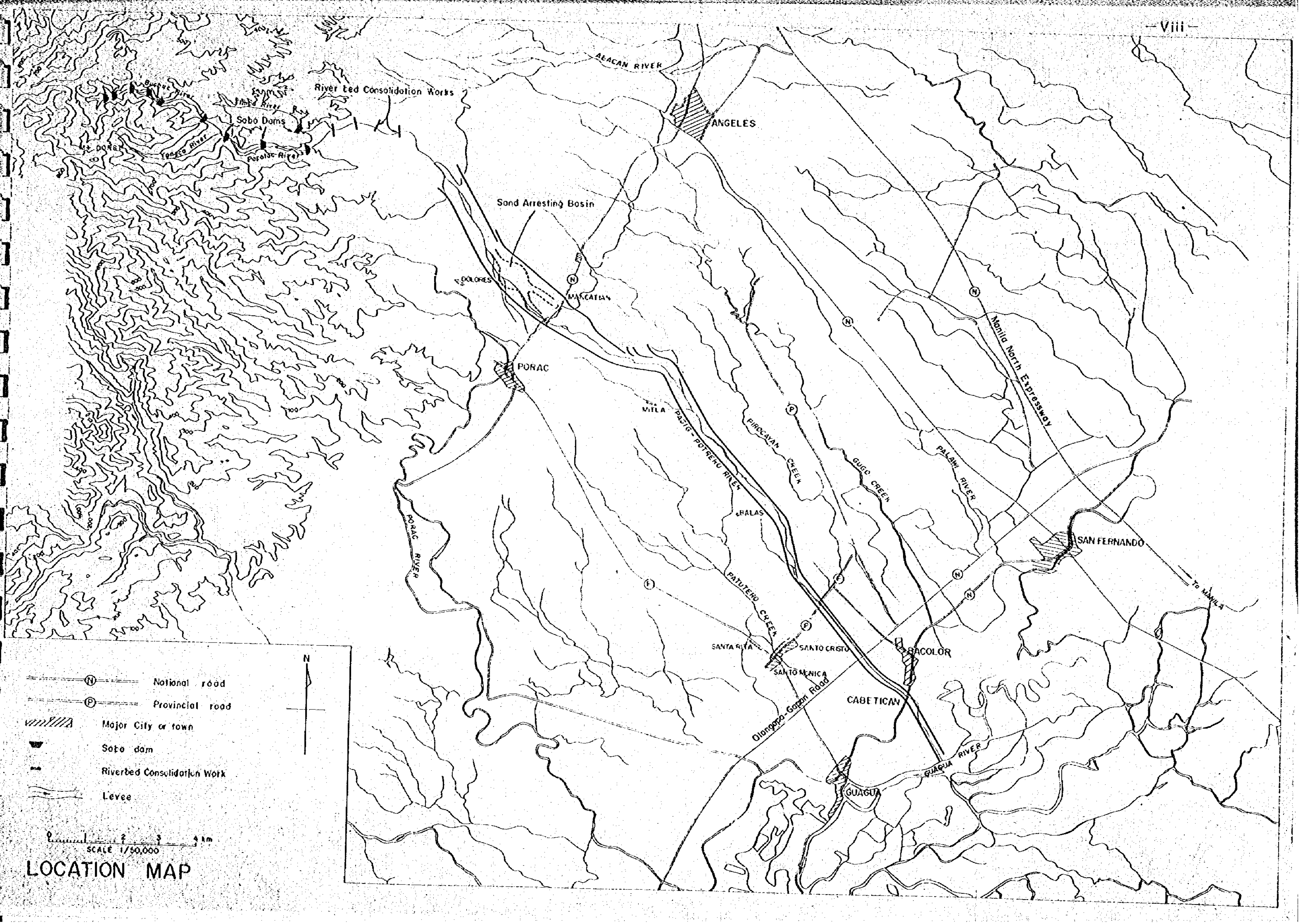
(7) Drainage Structure

Work No.	Structure	Gate	Length (m)	Site
No. 1	Box calvert 2 m x 2 m x 3 sets	with	32	Sta. 0 + 900
No. 2	Box calvert 2 m x 2 m x 2 sets	with	32	Sta. 0 + 856
No. 3	Hume pipe ∅1.65 m x 1 set	without	10	Sta. 7 + 470

(8) Construction Cost (Financial Cost)

($Px10^3$)

	Local Currency	Foreign Currency	Total
Sabo work	107,381	30,400	137,781
River improvement work	75,970	21,730	97,700
Total	183,351	52,130	235,481


ABACAN RIVER
ANGELES
River bed Consolidation Works
Sabo Dams
Sand Arresting Basin
DOLORES
MANCATIAN
PORAC
VILLA
PASIG-POTRERO RIVER
PIROCAYAN CREEK
GUGO CREEK
PALAWI RIVER
Manila North Expressway
SAN FERNANDO
To MANILA
PORAC RIVER
BALAS
PATUTERO CREEK
SANTA RITA
SANTO CRISTO
SANTO MONICA
BACOLOR
CABETICAN
Olongapo-Gapan Road
GUAGUA RIVER
GUAGUA
N
National road
Provincial road
Major City or town
Sabo dam
Riverbed Consolidation Work
Levee
0 1 2 3 4 km
SCALE 1/50,000
LOCATION MAP

PLANNING REPORT

ON

THE PASIG-POTRERO RIVER FLOOD CONTROL AND SABO PROJECT

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ABBREVIATIONS

JICA	Japan International Cooperation Agency
ECAFE /1	Economic Commission for Asia and Far East
ADB	Asian Development Bank
UNDP	United Nations Development Programme
MPWTC	Ministry of Public Works, Transportations and Communications
BPW	Bureau of Public Works
PRCS	Pampanga River Control System
TFFCRA	Task Force for Flood Control and Related Activities
NEDA	National Economic and Development Authority
NIA	National Irrigation Administration
mm	millimeter
cm	centimeter
m	meter
km	kilometer
km^2	square kilometer
m^2, cm^2	square meter, square centimeter
m^3, cm^3	cubic meter, cubic centimeter
g	gram
kg	kilogram
t	metric ton
sec.	second
min.	minute

/1: Reorganized to ESCAP

hr	hour
yr	year
ha	hectare
C	centigrade
kW	kilowatt
EL	elevation above mean sea level
FWL	flood water surface level
HWL	high water surface level
LWL	low water surface level
WL	water surface level
ASTM	American Society for Testing and Materials
JIS	Japanese Industrial Standard
O.M.C.	optimum moisture content
M.D.D.	maximum dry density
#	ASTM sieve number
No.	number
ϕ, dia.	diameter
%	percentage
Ref.	reference
$	United States dollar
P	Philippine peso
¥	Japanese yen
ℓ	liter

<u>Currency Equivalent</u>

P1 = $0.135 $1 = P7.4

I. INTRODUCTION

1.1 Historical Background

The Pasig-potrero river originates in Mt. Pinatubo of the Cabusilan mountains, runs through unconsolidated mountain regions and joins the Guagua river. It has been carrying considerable amounts of collapsed debris to the middle reach of the river which formed an alluvial fan. Due to lack of the flood protection works and sand protection structures, the basin area has been annually inundated during wet season and suffered from the heavy damages caused by both flood water and sand which was flushed down to the lower reach by the flood water. Particularly, the floods in 1966, 1972, 1974 and 1976 affected seriously the basin area with considerable damages.

Under this situation, the first investigation for controlling the river was made in 1964 by ECAFE. The investigation, although it was not a detailed survey but only a preliminary one, identified the problem in the basin and formulated a plan to construct a storage dam with some power scheme. But the detailed study had not proceeded since then and any implementation of the improvement plan had not been made until 1974.

In 1974, river improvement works on the Pasig-potrero river was started as a flood control scheme of the Pampanga River Flood Control System which is one of the three flood control projects included in the Central Luzon Flood Control Project. The improvement works are now being underway and a part of the levee is already constructed.

Through the implementation of the flood control scheme and the experience of floods thereafter, the Government of the Philippines recognized necessities of formulating a combined plan of sabo dams together with river improvement works for controlling flood and sand sedimentation damages. With this background, the Government of the Philippines asked technical assistance to the Japanese Government for planning the flood control and Sabo project in 1976.

In compliance with this request, the Japanese Government decided to send a preliminary survey team to the Philippines and entrusted the survey to Japan International Cooperation (JICA). In the survey conducted during February 17, 1977 to March 8, 1977, necessity of the flood control and Sabo plan was confirmed and scope of work for the planning was discussed.

1.2 Objectives and Scope of Work

Following the preliminary survey, detailed field investigation, which consisted of wet season and dry season investigation, was carried out by the associated team consisting Nippon Koei Co., Ltd., CTI Engineering and Sabo Technical Center under the contract with JICA. Wet season investigation was made from August 22, 1977 to September 20, 1977, while dry season investigation was conducted from November 1, 1977 to March 31, 1978.

This study aims to formulate a flood control and Sabo plan for the Pasig-potrero river and to prepare its implementation plan together with the economic evaluation.

The scope of work which was undertaken by the survey team consists of two stages, namely, field investigation in the Philippines and home work in Japan. The field investigation includes the following work items:

1) General reconnaissance;
2) Collection of relevant data and information;
3) Topographic and geological survey;
4) Hydrological and hydraulic survey;
5) Survey on river condition;
6) Survey on sand production and its discharge;
7) Flood damage survey;
8) Agricultural and socio-economic survey; and
9) Preparation of detailed design of No. 5 Sabo Dam

Through the field investigation, present condition of the project area and the problems to be solved were identified.

The home work was conducted in Japan after finishing the field investigation for about four months from April 1978 through the end of July 1978. In the study optimum plan for flood control and Sabo was formulated through the comparative studies. Basic designs for the optimum plan were prepared together with its implementation plan. The construction costs and benefits were estimated, on the basis of which economic evaluation was made for ascertaining the economic viability of the project.

II. NATIONAL AND REGIONAL SOCIO-ECONOMIC CONDITION

2.1 National Economic Background

2.1.1 Economic Indices

The Republic of the Philippines consists of more than 7,000 islands with the total land of 298,000 km^2. Total population was estimated at 41.8 million in 1975 and the population density was 140 persons per km^2. Annual population increase was around 3.1% during 1960-1970 period and around 2.7% during 1970-1975 period on the average.

The economy of the Philippines has grown very steadily during the last decade and the Gross National Product (GNP) attained around P 77,628 million (US$10,480 million equivalent). The GNP grew at an annual rate of 5.1% during 1966-1971, 6.6% during 1971-1976 and 6.1% for the last 1976-1977. Per-capita GNP is estimated at US$240 in 1977.

Agricultural sector is still the largest sector in the economy dominating 30.4% of GNP. Industrial sector including mining and quarrying, manufacturing and construction shares 28.4%, in which manufacturing is the largest, while service sector shares 41.2% of GNP. In terms of the employment structure, about 54% of the labor force is absorbed in agriculture sector, while 15% of the labor force in industrial sector. About 31% of the labor force is working in service sector. Unemployment rate is estimated at 4-5% of the working population. But the ratio would become higher if taking into account the existence of the under-employment in agricultural sector.

In the agricultural sector, agricultural crops including rice, corn, coconut, sugarcane, banana and other crops produced P 24.3 billion with its share of 63% in the total value added of the sector in 1976. Rice is the most important crop in the agricultural crops produced in the country. Total production of rice (in milled rice) was 3,800 thousand tons in 1976. The production has been increasing steadily during the past 10 years except the stagnation pepiod around 1972-1973. Annual increase ratio of rice production was around 2% for the period of 1966-1977. Despite of the steady increase of the rice production, it is not yet sufficient for domestic consumption. Imports of rice were ranging from 60 thousand tons to 620 thousand tons during the past 5 years.

Production of copra were fluctuating affected partly by world market price and partly by natural conditions. Most of the products were for foreign consumption. In 1976, out of the total production of about 2.7 million tons, about 85% was exported, while residual 15% was consumed locally. Sugarcane is another important crop for export. Its total production increased from about 1.9 million tons in 1970 to 2.9 million tons in 1976, experiencing fluctuation during the period.

The total exports of the country in 1976 was US$2,574 million. It grew at an annual growth rate of 23.5% during 1972-1976 period. They consist of agricultural products, mineral products, manufactures and others. Agricultural commodities have been dominating among all the export goods. In 1976, US$1,532 million or nearly 60% of the total export value came from agricultural products. Manufactures accounted for 22.7% and mineral products 17.6%.

Total imports of the commodity in 1976 were US$3,633 million. It increased at an average growth rate of 31% during 1972-1976 period. Main components of the imports were raw materials and capital goods. In 1976, raw materials including mineral and fuels account for about 60% of the total imports in value. Capital goods share 30%, while consumer goods share the residual 10%.

Exports and imports were roughly in balance in value during 1970-1972 period. In 1973, trade balance recorded a surplus. Since 1974, however, it was deteriorated and the deficit attained US$1,059 million in 1976. The balance of payments recorded surplus from 1970 to 1974. It turned to a deficit from 1975 despite the huge non-monetary capital surplus. In 1975, deficits of the balance of payment attained US$521 million.

All the indexes indicate steady price increase during 1965 to 1977 except the extraordinary period of 1971-1974. Wholesale price increased at 6.2% annually on the average. Retail price increased at 8.4% and consumer price at 7.4% during 1974-1977 period.

Revenue of the national government increased at an annual rate of 12.3% and attained P 21.7 billion in 1977. Current expenditure grew up at an annual rate of 7.3% and reached P 17.4 billion in 1977. Current surplus which is the balance of the revenue and the current expenditure shows surplus for the past three years ranging from about two to four billion pesos. The surplus were spent on the infrastructure investment which strengthened the economic base of the country.

2.1.2 <u>Five-Year Development Plan</u>

Five-Year Development Plan (1978-1982) was formulated for solving the problems and difficulties of the economy of the Philippines in succession of the preceding Four-Year Development Plan within the framework of the national Ten-Year Development Plan. The Plan envisages to raise GNP to P 112.2 billion in 1982 with an annual growth rate of about 8% during the period. Per capita GNP will increase at an average annual rate of 5.0%, assuming annual population growth rate of 2.9%, and attain P 2,157 in 1982.

During the plan period, some dramatic production shift will occur within the economy as evidenced by the changes in relative contribution of each sector to total net domestic product. After 1979, the share of the industry sector will exceed that of agriculture. The share of manufacturing to total net domestic product will match the share of agricultural output and industry as a whole will be the dominant sector in the economy. The share of the agriculture will drop to 24.3% in 1987 from 30.9% in 1976.

For attaining the economic and social objectives of the Plan, investment program for providing the physical plan is formulated. Public investment for the infrastructure program will increase from about P 14,954 million in 1978 to approximately P 25,494 in 1983 and attain P 55,608 million in 1987. Investment requirement for water resources development during 1978-1982 is estimated at P 22.4 billion. Out of the total amount about P 2.6 billion or 12% is allocated to flood control and drainage program. After implementing the flood control and drainage program, an incremental area of about 1.07 million ha is expected to benefit from flood and potential damages to the floodable areas will be reduced to 1.1 million ha by 1987 from the present 2.5 million ha.

2.2 Regional Socio-Economic Background

2.2.1 General

Central Luzon is located in the central part of Luzon Island, consisting of six provinces (Bataan, Bulacan, Nueva Ecija, Pampanga, Tarlac and Zambles) and five cities (Angeles, Cabanatuan, Olongapo, Palayan and San Jose), and has total area of about 18,300 km^2. It has the total population of 4,400 thousand (in 1975) and is the country's second most populous region sharing a consistent one-tenth of the total national population. The population density was 240 persons per square kilometer, which is almost twice that of the national level.

2.2.2 Gross Regional Domestic Product and Regional Economic Structure

Gross regional domestic product (GRDP) of Central Luzon was P 6,222 million (US$841 million) in 1976 (at 1972 prices). The share of the region in the gross national product was about 9% in 1976. Per-capita GRDP was P 1,368 (US$185), which is lower than the national level. During the past five years of 1972 to 1976, GRDP increased by 5.4% per annum on the average, while per-capita GRDP only by 2.0% per annum.

Agriculture sector including fishery and forestry is the region's largest economic sector, producing about 40% of the total regional product. Industrial sector including the mining and quarrying, manufacturing and electricity, gas and water continues to be the second largest sector in the region producing 33% of GRDP. Commerce and service sector is another important sector in the regional economy producing about one-fourth of total regional output. Characteristics of the economic structure is also represented by the labor force absorption by the various sectors of the economy. Agriculture sector is the single, largest employer with 519.6 thousand or roughly equivalent to 41% of all employed workers. Services sector as a whole absorbs about 42% and industrial sector draws 17%. About 4% of the labor force is classified as unemployment.

As mentioned above, agricultural sector including fishery and forestry is the largest component of the economy. Out of the total agricultural production in the nation, the region shares about 14% for agricultural crops. 10% for livestock, 15% for poultry, 9% for fishery and 1% for forestry, in terms of the gross value added. As a single crop, about one-fourth of the national rice production, or about one mill on tons of milled rice is harvested in the region, for which the Central Luzon is called granary of the Philippines.

2.2.3 <u>Five-Year Regional Development Plan</u>

To contend with the problems of the region, the development plan for 1978-1982 is formulated. For the years from 1978 to 1982, an average growth rate of 8.5% is aimed to lift the GRDP from P 7,847.6 million in 1978 to P 10,860.9 million in 1982. During the period, high annual growth rates are set both for industrial sector and service sector while relatively low growth rate is applied for agriculture sector. The share of the agricultural sector to the total GRDP would be reduced from 34.8% in 1978 to 30.8% in 1982. Manufacturing, on the other hand, which would share 29% of the GRDP by 1978 would get 30.2% by 1982 and become a leading sector in the economy.

2.2.4 <u>Flood Condition and Its Protection Works</u>

As mentioned in the preceding section, Central Luzon Region is called the rice granary of the Philippines. However, this area is a annually inundated during rainy season by the flood of the Pampanga river as well as the smaller waterways and tributaries. Particularly, the low-lying areas have been affected severely. The damages are not only caused by flood water but also by sand sedimentation brought by the flood water.

Facing the flood and sedimentation problem, the Bureau of Public Works (BPW) made a comprehensive overall scheme of the Pampanga River Flood Control System in order to eliminate or minimize flood damages. Included in the scheme is the Pasig Potrero river flood and erosion control plan. The Pasig Potreto river, located in South-western part of the Central Luzon Plain, affects the five municipalities by flooding annually with considerable sedimentation. Particularly, damage caused by sand sedimentation has been serious in the area, which not only deteriorated agricultural production but also damaged infrastructures such as roads, irrigation facilities and housing facilities. For eliminating the flood, construction of parallel earth-dikes, dry-boulder and rip-rapping, dredging and improvement of the channel are underway together with installation of gates and construction of revetment and bridges.

Total amount of P 160.7 million was spent for the whole Pampanga River Control System during 1973 to 1977 and additional P 148.2 million is planned to be invested from the period of 1978-1982. For the Pasig-potrero river along, about P 24.2 million was used during past five years of 1973-1977 and about P 23.9 million is expected to be allocated for 1978-1982 period.

III GENERAL CONDITION OF THE PROJECT AREA

3.1 Location and Population

The project area is located in the central part of the Pampanga province in the Central Luzon, about 60 km north west from Manila, the capital of the Republic of the Philippines, extending with 6 km width and 35 km length along the Pasig-Potrero river, a tributary of the Guagua river. Total project area is some 235 Km^2 (23,500 ha) out of which some 11,950 ha (50.1%) is alluvial plain and has been cultivated as farm land.

Administratively, the project area includes four municipalities and forty three barrangays. According to the census, the population of the Pampanga province was 93,170 with 15,290 households as of February, 1978 excluding mountainous area. The population density was high of 704 persons/km^2 and average family size was 6.1 persons.

3.2 Topography and Geology

3.2.1 Topography

The Pasig-potrero River, a branch of the Guagna River, is originated in the eastern slope of the Mt. Pinatubo and flows eastwards or southeastwards until it reaches to the confluence to the main Guagua River between Guagua and Bacolor.

Mt. Pinatubo is an extinct volcano formed in early Quartanary, and the geomorphologic features of the volcano are still preserved in the conical mountain slope located on the western side of the project area.

Geomorphologically, the project area is divided into the following two regions:

(1) a mountainous region
(2) an alluvial fan region

Topographic condition of the mountainous region is quite different between the southern and nothern sides of the Pasig River. The south-southern mountain region appears to be a part of an old volcanic slope, which is higher in the west and lower in the east. The mountain side is so intensively eroded and rugged that original surface is rarely preserved. The hill, which is the source of the Pasig-potrero river and the Porac river, forms a kind of topographic wall trending north to south on the slope of Mt. Pinatubo. This topographic feature suggests for the hill to be a somma of Mt. Pinatubo. The Sacobia river flows down to the east through a cleft of the somma, which was presumably formed by a partial destruction of the somma.

On the other hand, the northern mountain slope to the north from the Pasig river shows many flat planes of the initial form, which tend to be higher in the west and lower in the east in general with slight undulation. The fact that the slope converges to the said cleft at the top of the Abacan river (Fig. III-1) suggests that the slope was supplied with mud flow from or pyroclastic flow through the cleft. This mild slope of deposit consists of two different depositional surfaces, one in the upstream part and the other in the middle to downstream part. (Fig. III-2) Another depositional surface which is lower than the above two is seen on the left bank of the middle reach of the Pasig river very sporadically.

A mild slope along the Pasig river, the area between the Abacan River and the Porac River, is the youngest alluvial fan which the Pasig river has formed. From the above situations of the topographic units, geomorphologic history is restored as the following three stages.

(1) Formation of Pinatubo volcano (volcanic activity)

(2) Formation of the old fan surfaces along the Abacan river with material supplied from a partial destruction of the somma at the location of the present cleft or with pumice flow after the cleft was cut.

(3) Erosion of the ground surface formed by (1) and (2), and formation of the youngest alluvial fan between the Sacobia river and the Porac river.

3.2.2 Geology

The mountain area of the project is located on the eastern slope of the Pinatubo Volcano. Basement rocks widely distributed on the southern side of the Pasig river, consist of the Agglomerates and Agglomeratic lava flows which form the main body of the Pinatubo Volcano. On the northernside of the Porac river, gentle slopes dipping toward the east, which is the original surface of the volcanic deposits develops. The Abacan river basin is located in these deposits. Thus, the diffences in lithologic nature of the rocks composing the basins make the marked differences in the characteristics of the basin.

Geological history in the mountain area is composed of the following stages. (Fig. III-2)

(1) Formation of the main body of the Pinatubo Volcano.

(2) Formation of the caldera and central cone (Mt. Pinatubo)

(3) Partial destruction of the somma.

(4) Outflow of the pyroclastic material through the destroyed part and the formation of the old fans (at the end of the volcanic body)

(5) Formation of the alluvial fans (erosion of the volcanic body)

The main body of the Pinatubo Volcano consists of the volcanic conglomerates, volcanic breccia, agglomerates (in a narrow sense), tuff breccia and tuff. It is divided into two parts, namely, lower bed deposited under the water activity and hard upper bed consisting of agglomeratic or pure lava flows and welded tuff.

The gentle slopes occupying the northernside of the Pasig river are comprised of four kinds of pyroclastic flow deposits outflowed through the cleft. A fan-shaped slope comprised of the newest pyroclastic flow deposits converges at the cleft mentioned above. Newer pyroclastic flow deposits show more distinct fan-shape and preserves the original surface of deposition. An old fan was built-up after the pyroclastic flow deposits outflowed. Distribution of it, however, is limited in the northeastern part of the project area around Parsapis.

An alluvial fan developed down stream of the Pasig river, which will be tentatively called the "Pasig alluvial fan", is a temporary accumulation area of debris supplied mainly through the Pasig river partly though the Abacan river. These fan deposits are rich in fine grained material, indicating that they are supplied from erosion of the mountainside composed of pyroclastic flow deposits.

The most important factors in regard to Sabo planning among these lithologic units are (1) the pyroclastic flow deposits that are the major source of debris deposition and (2) the Pasig alluvial fan deposits derived from (1).

3.3 Meteorology and Hydrology

3.3.1 Meteorology

The climatic condition in the project area belongs to Type III[/1] of the Philippines climate zoning. the rainy and dry seasons are relatively distinct with an average annual rainfall of about 2,000 mm; the rainy season lasts from May to November with peaks of 400 to 500 mm per month in July and August and the dry season from December to April with the least rainfall of 10 to 20 mm in January.

The average annual temperature is about 27°C over the project area. The monthly fluctuation in temperature is within the range of 3°C from the highest of 28.3°C around May when the rainy season starts, to the lowest of 25.9°C in December when the rainy season ends.

Relative humidity is considerably high at 73% on the annual average with the variation of monthly average of approximately 20% from 62% in

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/1: The climate in the Philippines is largely divided into four types: The Type 3 consists of the rainy season ranging from May to November and the dry season from December to April.

April and 81% in July. Daily and yearly evaporation is approximately 3.5 mm and 1,250 mm, respectively.

As for the wind direction, southeast trade wind prevails in the dry season, and southwest monsoon in the rainy season. The annual average wind velocity is 5.4 knots with the monthly change from 4 to 8 knots. The daily average ranges for 1 knot at the minimum to 22 knots at the maximum.

The average daily sun-shine duration is 365 minutes in the rainy season and 458 minutes in the dry season. On the contrary to the sun-shine duration, the average daily cloud cover reaches at 7.7 in the rainy season, and remains at 5.0 in the dry season.

3.3.2 Hydrology

The Pasig-Potorero River basin is situated at the area between latitudes 15°00' to 15°08' North and longitudes 120°25' to 120°38' East. The basin area amounts to 125 km^2 in total, including an area of 44 km^2 upstream of the Mancatian Bridge.

Although the basin area is rather small, the hydrological observation network has been established in a good spatial distribution. As shown on FIGURE II-3 in the APPENDIX I, there are twenty two rainfall gauging stations including seven automatic recording stations, and seven water level gauging stations equipped with staves; 3 along the Pasig-potorero river, 2 along the Guagua river, in and around the basin.

The ratios between annual runoff and annual rainfall are estimated to be 0.69 at Der Carmen and 0.32 at Valdez along the Porac river, and 0.34 at H.D.A Dolores and 0.10 at Cabetican Bacolor along the Pasig-potorero river. These figures show that the runoff coefficents of both river decrease considerably in the downstream, and that the runoff coefficiants of the Pasig -potorero river is fairly smaller than that of the Porac river. These facts indicate that the runoffs from the headreaches percorate under the ground and from underground flows during low flow season and that the underground flow from the Pasig-potorero river discharges into the Porac river.

The distribution patterns of monthly rainfall recorded at those stations which are very alike and mostly similar to that of Manila, show distinct rainy and dry seasons. The maximum monthly rainfall is 2,274.5 mm which was recorded at Porac in July, 1972.

In terms of the daily rainfall amounts and the total rainfall amounts during the past big floods, the seven major stations of C. Apalit C. Apalit, S. Arayat, Bacolor, Masantol, S. Porac, S. Fernando and Clerk Field have good corelation with each other. The coefficients of daily rainfall corelation between stations range from 0.69 to 0.94 and those of total rainfall corelation from 0.63 to 0.99. In view of the above results, it is concluded that the basin rainfall in the Pasign-potorero river basin can be represented by the point rainfall at the Porac station which is situated nearly at the center of the basin.

The durations of the past heavy and continuous rainfalls which caused floods in and around the basin were exaimed on the basis of the hourly rainfall records at Porac. In many floods, except those in 1972 and in 1976, rainfalls did not continue to more than three days (72 hours). From the rainfall record at Porac and from that at Clark Field which covers the longest period of observation, probabilities of one-day and three-day rainfall were estimated as shown in TABLE III-1. The rainfalls at Porac and Clark Field during the major flood since 1965 are as shown on TABLE III-2. The July 1972 Flood was caused by excess rainfall inundating the lowland area in the downstream of the Pasig-potorero, which was resulted by continuous heavy rainfall in more than one months accompanied by three typhoons in series from June to August. The flood discharge is estimated at 400-500 m^3/s at the Mancation Bridge.

Based on the rainfall records at Porac and Clark Field observed at the time of the major floods, the exceeding probabilities of one-day and three-day and continuous rainfalls are estimated as shown in TABLE-4.

For the design flood discharge, 900 m^3/sec at the Mancation Bridge was applied by BPW. The adequacy of this design flood are exaimed by six different methods and the results are as shown in TABLE III-5. From these estimates it is shown that the estimated figures are similar except those in Case C which is not appropriate for estimation of flood from short-time rainfall and those in Case E which generally gives larger figures for a small basin. From this figures obtained in Case D where the estimates were made based on the rainfall records at Porac are adopted as the design flood discharge. The discharge of 900 m^3/sec at the Mancation Bridge corresponds to the discharge estimated from the daily rainfall at Porac having a probability of 1 to 80, and its specific discharge equivalents to 20 $m^3/sec/km^2$ ($q = Q/A = 900\ m^3/sec/44\ km^2$,). Considering that figures in Case D are larger than those in Case E and F which are estimated on the base of the envelope curve formulas developed from the peak discharges observed in the Philippines, the design flood discharge adopted is considered to be adequate and in the safe side.

3.4 Debris Production and Sedimentation

3.4.1 Present Condition

(1) General

The desolation of the mountain area has been influenced by the geological conditions and is limited to the area of (1) the pyroclastic flow deposits, and (2) the fan deposits (FIGURE III-4).

Since the pyroclastic deposits are distributed mostly on the eastern side of the Pasig river, the desolation of the mountainous region is also limited to the eastern side of the river, i.e. the left side of the Bucbuc creek and Papatac creek or the Timbu creek basin. There are various types of desolation as mentioned below.

1) collapse on the hillsides caused by coast-erosion,

2) surface erosion on the collapsed slope,

3) gully erosion,

4) landslide or landslide liked collapse (massive collapse),

5) small scale collapse occurring singly

As for the collapse on the hillside, 1) and 2) have had the greatest effect.

(2) Desolation in the tributaries

Bucbuc creek basin

Bucbuc creek is seriously wasted in the Pasig river, particulary, the left bank side is much wasted against relatively stable right bank side. This is due to the fact that the left bank side is composed of pyroclastic flow deposits which are not resistant to vertical erosion and collapse, while the right bank side consists of hard volcanic rocks such as agglanerates.

The plane which is about 30 m high from the river-bed near the confluence of the Yangca and the Bucbuc creeks is a terrace comprised of the ancient river-bed deposits at least 40 m in level distance for ten years during 1966-1976. The produced debris volume amounts to about 150,000 m^3 and is equivalent to 1.5 m in depth, in terms of annual denudation rate per present collapsed area (vertically projected area). Although it seems stable now, this part is erosive in a flood season because of the under-cut slope.

In the upstream area of No.4 damsite, collapses are remarkable on the left bank. Most dominant types of collape are as follows.

1) collapses on the hillside caused by river-bank erosion

2) surface erosion on the collapsed slope

The upper stream of the Bucbuc creek is divided into two branches. Collapses near the upper area of the left branch are so remarked that it is almost to connect with the adjacent Sacobia River. A part of the pyroclastic flow deposits are distributed also in the right branch basin and make collapsed areas, though not so large scale as in the left branch basin.

The river-bed shows a little ruggedness but has been gradually flattened due to the progressive deposition in the lower part. River-bed deposits are mainly composed of sand and pebble with very few boulders.

Papatac Creek basin

The basin, with about 3 km length, is a narrow valley and is considered to be transportation section for the debris. The debris that have been produced in the basin are only from the re-erosion of the old river-bed deposits and of the terrace deposits in the upstream side of No.3 damsite and the downstream side of No.2-A damsite. Old massive collapses exist, on the left bank about 700 m upstream of No.2-A damsite and on the right bank about 800 m downstream of No.3 damsite. However, these supply little debris at bank present.

A V-shaped valley about 300 m long, located on the upper left bank of No.3 damsite, was just a small valley only 60 m long in 1966, but has grown into a larger valley. Through the progressive erosion of the terrace for the past 10 years, especially in 1972. The debris volume produced by this erosion amounts to about 125,000 m^3, equivalent to about 1.25 m per year in eroded depth. Debris production is now active in the basin.

The Timbu Creek basin

The Timbu creek basin consists of the pyroclastic flow deposite (I), (II) and welded tuff (II) excepting the narrow agglomerates (I). The basin is markedly wasted due to the destruction of the pyroclastic deposits following the Bucbuc creek basin. Large scale collapses have frequently occurred along the river bank in the pyroclastic flow deposits occupying about 60% of this basin.

The eroded debris volume of terrace deposite existing on the right bank of the Timbu creek near the confluence with the Pasig river amounted to about 200,000 m^3 during 1966-1976 with erosion depth of about 1.00 m/year per present collapsed area. The collapse on the left coast of the Timbu creek occurred on the original pyroclastic flow deposits and is now active. There is a waterfall in the downstream of the Timbu creek. The area is composed of volcanic conglomerates belonging to agglomerates (I). On the upstream of the waterfall, debris is arrested with 100 m width and 1 km length.

A narrow valley of 20 m width exists at No.2 damsite. In the upper riverbed a very wide piling area of 250 m in maximum width is formed. The right bank side of the piling area forms at terrace with 5 m height, a part of which is utilized as upland crop production. On the upstream of that piling area, the pyroclastic flow deposits and terrace deposits are distributed, which are the most wasted land in the Timbu creek basin.

(3) Debris produced in the mountain region

On the basis of the results of the field investigation and the aerial-photo interpretation, the debris volume produced in the mountain region is estimated at 328,000 m^3 per annum on an average. About 80% of the total volume, or 261,000 m^3, is produced in the Bucbuc creek, while about 50,000 m^3 in the Timbu creek. Debris production in the

Yangca and the Papatac creek basins is limitted, less than 10,000 m^3 for each basin. (TABLE III-6 and FIGURE III-5)

For estimating the debris production in the mountain region during 1972 flood, it is assumed that 80% of the debris volume produced during 1966-1976 was produced in 1972 in due consideration of the rainfall data. The estimated debris production in 1972 is about 2,622,000 m^3. Besides this, debris was derived from riverbed itself, which amounted to around 1,810,000 m^3. (unstable debris volume produced in the riverbed). Total debris production is estimated at 4,432,000 m^3 by summing them up. However, all of the debris produced was not discharged by the flood. The debris control capacity on the river channel of the mountain region is estimated at 2,583,000 m^3.

Actual debris volume discharged in 1972 flood is, therefore, estimated at 1,848,000 m^3 by deducting the control capacity on the river channel from the total production.

The debris volume produced during 1966-1976 in the river channel along the alluvial fan is estimated at 1,465,000 m^3 (146,500 m^3 per year on an average), which is an another large supply source of the debris.

3.4.2 Debris Discharge Mechanism

As mentioned earlier, the waste type in the mountainous area is classified into five types. Each type has following debris discharge mechanism.

Waste Type	Debris Discharge Mechanism			
Collapse of mountain slope based on coast erosion	occurrence of collapses →	formation of the talus cone →	out flow by running water (or flow into the main river)	
Surface erosion on a collapsed slope	occurence of collapses →	surface erosion (sheet erosion) →	forming the debris cone at the mouth of the stream →	flowing into the main river or a tributary
Gulley erosion	occurence of collapses →	gully erosion →	forming the small alluvial cones →	flowing into the main river or a tributary
Landslide or collapse similar to landslide (massive collapse)	occurence of collapses (or landslides) →	lateral erosion of collapsed masses →	flowing into the main river or tributary	
Small scale collapses occurring singly	occurence of collapses →	formation of river-or stream-bed deposits →	flowing into the main river or tributary	

3.4.3 Present Condition of the Fan Area

The Pasig alluvial fan is divided into three parts from the morphology.

(1) stable river course portion between the confluence of Timbu creek with Papatac creek and Sta. 23 point.

(2) the portion where the flood have occured often, though it seems relatively stable at present.

(3) stable river course portion with little chance of flooding on the fan area.

Judging from the morphological features of the alluvial fan, the debris volume discharged to the downstream is larger than that supplied from the upstream after depositing the sediment (I) on the fan and the elevation of the river bed has been lowered. This tendency is reflected by the recent riverbed fluctuation. Most important portion is (2) flooded portion for flood control in the downstream. Direction of the discharged debris and flood water has been affected by the meander condition of the river channel on the upstream side of the fan head, and determined at fan area of the portion (2). The water flooded at the portion (2) had run to the downstream taking the following courses (FIGURE III-4).

(1) along the stream passing through Manibaug

(2) along the Pasig river

(3) crossing the lowland area, 500 m south of Mancation Bridge

3.5 Present River Condition

3.5.1 River Course and Sedimentation

The Pasig-potrero river originates from near the eastern slope of the Cabusilan Mountains located at the western border of Pampanga Province, forming an alluvial fan downstream in mountain areas. It flows down the Pampanga Plain and joins the Guagua river. The river is 35 km long and has a basin of 125 km^2 in area. The river flows east merging tributaries of the Yangca, Bucbuc and Timbu. It changes its course to the south-east at the top of the fan and flows down to the Guagua river through Mancatian, Mitla, Santa Barbara and Bacolor.

The river is characterized by the abundant outflow of sand. A large amount of sand have been washed out in the river because of the considerable debris production in the mountain area and the produced sand is relatively small in the diameter. The sand washed out forms an alluvial fan at the outlet of mountain areas.