The alluvium consisting of corse sand has high water permeability. The river water around the fan head runs underground, so that the river flow is rarely observed in the channel. In the Porac river, there are several underground flows coming from the Pasig-potrero river.

It is reported that there was scouring of about 2 m in depth at the fan head during the flood of 1972. The sand scoured was washed-out and deposited at around Mancatian Bridge is the estimated depth of 1.5 m. The gradient the riverbed at the fan head is from 1/65 to 1/90.

The channel of about 12 km long from about 2 km downstream of Mancatian Bridge to Bacolor has a riverbed of 300 - 200 m wide and gradient of 1/100 - 1/1,000. The riverbed is composed of the sand washed away from the fan but no severe sedimentation of sand is observed in this section. BPW has started embankment works during this section together with construction of a bridge at Bacolor.

Pampanga Delta area is located downstream from STA 4./1 The riverbed in this section is composed of fine sand which is not deposited in the upstream and midstream reaches. In this section, the gradient is gentle ranging from 1/1000 to 1/1500 and the tidal effects decrease the flow velocity and the tractive force of river water. The aforesaid fine sand is easily deposited. There are fishponds near the junction of the Gua-Gua river at the river-mouth. In the neighbourhood, a dredger is being operated to excavate the riverbed.

3.5.2 Riverbed Material

Cross-section survey was made at the place of every 1 km along the present river and soil material samples were taken at each spot of high-water channel and low-water channel along the cross-section line. For the samples taken soil tests were carried on grading, specific gravity, moisture content and apparent specific gravity.

There is some difference of grain size between high-water channel and low-water channel. In the high-water channel, upstream from the junction of the Guagua river, there are clay silt between STA. 0 - STA 4, medium grain sand between STA 5 - STA 18, medium to coarse grain size sand between STA 19 - STA 27 and gravel between STA 28 - STA 32. On the other hand, in the low-water channel, there is clay silt between STA 0 - STA 4, medium grain sand between STA 5 - STA 13, medium to coarse grain sand between STA 14 - STA 26 and gravel between STA 27 - STA 32. Judging from this result, sandy materials flowing down from the fan are deposited in the channel upstream of STA 5 and

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/1: In this plan, a station is placed for every 1 km upstream from the junction of the Pasig-potrero river and Gua-Gua rivers as a starting point (STA.0).

the river channel downstream of STA 5 to the junction is covered with silty sediment.

Specific gravities of sandy materials range from 2.15 to 2.83 and the average value is 2.57. The value is rather low compared with sand in general due to their content of porous fine gravel. A trend that grains of larger size have smaller specific gravity was found but not generalized. The minimum value of specific gravity is 1.46 in case of gravel with grain diameter 1 cm.

Moisture content range from 2 to 40.5%.

3.5.3 Use of Rivers and River Water

i) There are only four bridges across the Pasig-potrero including one under construction. Although other local roads are divided by rivers in rainy season, riverbed is used for the transportation between villages in dry season, by crossing it. There is also boat traffic of 2 - 3 tons at the rivermouth area.

ii) A substantial quantity of the riverbed sand is excavated around Mancation Bridge (estimated at about 846,000 m^3 in 1977) and is used mainly as construction material and partly as glass material.

iii) The use of the high water channel is very few, but on the limitted area paddy field farming is carried out.

iv) The embankment is partly used for track roads to transport river sand.

v) The use of river water is very limited. Especially, in dry seasons as it turns to underground flows, there is no supply of service water. Where there is spring water, it is used as drinking water for domestic animals.

vi) Fishery is being carried out in the downstream of the Pasig-potrero river where it joins the Guagua river.

3.5.4 Existing Riparian Structures

(1) Embankment

Before 1966, the embankment of 3.7 km long was constructed on the western bank up stream of Mancatian Bridge crossing the old channel in order to protect villages near Porao. It was however destroyed by a flood in May, 1966 and the damage occurred in the adjacent areas.

The improvement program of the Pasig-potrero river was designed by BPW based on the recommendation of ECAFE. Since the floods which took place in July-August, 1974, the embankment work has been commenced on the upper stream of Santa Barbara. The embankment work has been completed for 12 km between Bacolor and Mitla and the project is expected to be completed in 1982. The work is being carried out at the rate of 2.0 - 3.7 km annually and the riverbed sand is used for the embankment material. The height of the embankment is 3.5 m on the average and 6.0 m at the maximum.

However, the embankment broke in 1976 and 1977 at the bending place where the course of the river changes artificially. In October 1977, because of the lack of sufficient facilities to deal with inland water flow, the embankment was scoured and broken from the land side. Erosion caused by rain took place at several places on the embankment and the compaction of the embankment is generally insufficient.

(2) Revetment

The revetment work is carried out on both banks from the upstream of the bridge site of the by-pass road at STA 4 to the existing bank of Mitla. The surface of the bank lower than the planned water level (H.W.L.) is reveted by boulders to the thickness of 30 cm.

The foot of the embankment is protected by dry masonry of same material to the depth of 1.0 m. The groyne of 1 m high and 5 m long is built for about 150 m at intervals of 5 - 10 m along the bends of the river course; one along the left bank near STA 9 and others along the right bank near STA 12. The similar protection is applied to the bank on the right side upstream of Macatian Bridge.

(3) Sluice

In the existing embankment of 7 km long from Mitla to San Juan, 10 drain pipes are installed; four places in the left bank and six in the right bank. They are made of Hume pipes connected by concrete collars. The inside diameters vary from 900 mm to 1,200 mm by place and the drain capacity is about 2-3 m^3/S. Crossing the national highway near Bacolor, 14 drainpipes with the inside diameter varying from 900 mm to 1,200 mm by place are placed. At the crossing the by-pass highway, 8 drainpipes with the inside diameter varying from 600 mm to 1,500 mm and two box culverts with two span of 2 m high and 2 m wide are placed. On the Porac - Angeles road near Mancatian, cross drainpipes with an inside diameter of 300 mm are placed at several places. Eight drainpipes with an inside diameter of 1,000 mm are placed to drain stream water in the east side of No.1 Mancatian Bridge.

These drainpipes generally insufficient in their drainage capacities, and during flood time water overflowed from the pipes flows on the road.

(4) Bridges

From the upper stream, there are two Mancatian bridges (No.1 and No.2) and one bridge each across Cabanbangan and Bacolor. The bridge over Bacolor is now under construction. These bridges are all made of concrete.

The cross sections under these bridges have flow areas sufficient to discharge the design flood volume of 900 m^3/s.

The existing riparian structures on the Pasig-potrero river are presented in FIGURE III-7.

3.6 Agriculture Setting

3.6.1 Physical Background

The agricultural land in the project area lies on the recent alluvial fan formed by the Pasig-potrero river. The land is very gently sloping downwards from northwest to southeast at an altitude ranging from a few meters to 220 meters. The average slope is about 2% in the upstream area and about 0.07% in the middle to downstream area.

The soils are derived from the recent alluvium deposited by the Pasig-potrero river and its tributaties. Based upon the morphological features of the soil profile and chemical and physical properties, the soils are classified into three soil groups in terms of soil series in order, namely, the Angeles series, the La Poz series and a soil series associated with the Hydrosols. Among three soil series, the soils of Angeles and the La Poz series are widely extended in the most part of the project area and have long been cultivated to their maximum extent, principally with paddy and sugar cane. While, the soils associated with the Hydrosols are mainly lie in the swampy southeast part of the project area. Due to the frequent occurrence of flooding in this area, the land is utilized only for small-scale paddy fields and fish culture.

All the soils consists of sandy particles ranging from coarse to very fine, which are easy to till with good drainage. However, water holding capacity and fertilizer holding capacity are poor. The low water holding capacity, in particular, causes drought damage against crops even during rainy season.

In recent years, some 4,440 ha of the low-lying paddy fields has been deeply covered by the fresh sand deposited by the flooding of the Pasig-potrero river, out of which some 1,750 ha lost its arability. The arability and productivity of the remaining paddy fields were also considerably lowered.

3.6.2 Socio-economic Background

(1) Land use

According to the statistics provided by the Bureau of Forestry and the Agricultural Economics, Pampanga, total project area is around 23,540 ha, out of which 13,140 ha is used for agricultural production including fishpond and the residual 10,400 ha for village yard, public land and forestry. The major land use as of the end of 1977 is summarized in TABLE III-7.

(2) Land tenure system and farm size

The Agricultural Land Reform Code was legislated in 1963, aiming at creating a truly viable social economic structure in agriculture. The objective was further strengthened by the Presidential Decree in 1972 and 1973 which intended to facilitate and enhance programme implementation of the agrarian reform.

According to the information provided by the Proviacial Office of the Bureau of Agrarian Reform, the land reform programme has covered about 77% or about 600 families of rice producer with 1,500 ha of paddy field at the end of 1977. The remaining 2,050 ha of paddy field and about 5,710 ha of upland field are mainly cultivated with tenant system.

The tenant system in the project area are classified into: (1) land rent by cash payment of P 2,500/ha on an average; (2) land rent by crop sharing arrangement with such ratios as 50-50, 30-70, 35-65, etc. The most common ratio is 50-50; (3) land rent by fixed amount of proceeds; and (4) land rent without charge. Among four tenant systems, (2) and (3) systems are prevailing in the project area.

Average holding size in the project area including tenant system lies between 1-3 ha.

(3) Agricultural supporting services

The agricultural supporting services such as agricultural research, extension programme, agricultural credit and seed multiplication have been relatively well organized into the MASAGANA 99 and extensively operated in the project area. Besides, village community as the rural organization for agricultural development has also been formed under the guidance of the Central Government in recent years. These services are, although not enough, contribute to the achievement of the agricultural exploitation particularly for paddy rice production in the area.

(4) Irrigation facilities

Since long irrigation system have been introduced. At present, 10 irrigation systems are working in the project area using the surface water, commanding a total area of about 1,670 ha, all of which are managed by the water user's association organized under the village community.

However, as the irrigation facilities are mainly fed by small tributaries of the Pasig-potrero river or small springs, complete irrigation can not be attained even in the wet season due to the shortage of water. Furthermore, an actual irrigability by those facilities are, more or less, deteriorated due to the serious flooding and sand-sedimentation by the Pasig-potrero river. In recent years, to cope with meager irrigation water availability, about 440 wells have been installed for the irrigation of 1,150 ha.

(5) Marketing and prices

a) Marketing system of rice and sugar

There exist three alternative marketing channels for rice distribution. In every case, consumers get rice from the last distributor, or "licensed retailers".

For the first case, middlemen or rice mill owners buy rice from farmers and sell it to wholesalers. Wholesalers in turn sell it to the licensed retailers. In the second case, National Grain Authority (NGA) buys rice from farmers in the first place and sell it to the retailers. In the last case, rice is purchased by farmers' cooperatives. The cooperatives sell it to the rice mill owners and NGA. About sixty percent of the marketed rice is through the first channel, thirty percent through second and ten percent through the third in recent years.

Sugarcane produced by farmers or estate farms of sugar mill is milled in Integrated Sugar Central Company Incorporated (ISCOO) and Pampanga Sugar Development Company Incorporated (PASDECO). ISCOO is a semi-governmental corporation owned by National Sugar Development Corporation. ISCOO collected sugarcane from its estate farm (around 1,400 ha) and also from private farmers. PASDECO is a private company operating sugar mill wholly under the contract base with farmers. After milling in ISCOO or PASDECO, sugar is sold to the Philippine National Bank (PNB) from which all the cash payment is made to planters. The sugar, then, delivered to the Philippine Sugar Commission (PSC), which is the governmental organization for controlling the price of sugar and the amount to be sold. From PSC, a part of the sugar is exported overseas and a part to domestic consumption through the licensed trader.

b) Price of food crops

Price of rice increased considerably during the past five years. Retail price of rice (fancy variety) was P631 per ton in 1973, which went up to P1,299 per ton in 1977. Annual average price increase was about 20% during the period. Farmgate price of rice also increased during 1971-1976. The price was P1,116 per ton in 1976 which is around 1.7 times of that in 1971. The farmgate price and retail price are summarized in TABLE III-8 and TABLE III-9.

As mentioned earlier, PNB purchased sugar from ISCOO and PASDECO. The price/1 is P90 per picul or US$192.3 per ton during 1977-1978. The purchasing price has also fluctuated reflecting the world market price. During 1974-1975 the price was P134.4 per picul or US$287.2 per ton, which is about 50% higher than that of the current price. The purchase price by PNB is presented in TABLE III-10.

3.6.3 Present Agricultural Production

(1) Agricultural land classification

In due consideration of the degree of the flood and sand sedimentation damage, the agricultural land in the project area is classified into six blocks.

The area defined as the Agricultural Block I extends over the upper-reach of the Pasig-potrero river. The area occupies about 8,670 ha. The land, having an elevation at more than 10 m above sea level, is quite free from the flooding. The land have long been cultivated with sugarcane under rain-fed condition. No irrigation facilities are provided in this area due to lack of the water source.

The Agricultural Block II is an area which occupies about 930 ha. The land of this area is also free from the flooding similar to the Block I. The land mainly extends over the vicinity of the Block I. In this Block, the irrigation facilities using both surface and groundwater have been developed and paddy cultivation two to three times a year has been started under the national campaign of the MASAGANA 99.

The area of the Agricultural Block III is mainly composed of paddy field with the land area of about 2,420 ha. Because of the low-lying topography, the land in this Block is occasionally affected by the flooding of the Pasig-potrero river and its tributaries. Though irrigation facilities have long been developed in this Block, more than half of them were severely damaged by the flood in 1972.

The Agricultural Block IV extends over the southeast part of the project area with the area of 1,250 ha. The seasonal flooding of the Pasig-potrero river and the Guagua river inundates the area with deep water and sand sedimentation. Only the limited area has been developed for paddy field in this Block, while some 1,190 ha for fishpond along the Guagua river.

The area defined as the Agricultural Block V extends along the middle reach of the Pasig-potrero river. The total area is about 1,570 ha. Though paddy field with irrigation facilities has been developed in this area they have been seasonally affected by flooding and accompanied sand sedimentation of the Pasig-potrero river. In particular, the flood in 1972 inundated the paddy field with more than 50 cm coarse sand sedimentation. In consequence, 1,300 ha of the land has been left fallow and the productivity of the remaining portion has been considerably lowered.

The area defined as the Agricultural Block VI occupies a part of fan-head area of the plain and have a total area of approximately 900 ha. This area was affected by sheet erosion and gullying severely. Particularly damaged by the floods in 1966 and in 1972, it has been turned into waste land.

/1: Price of brown sugar

(2) Cropping pattern

Dominant agricultural production in the project area is paddy and sugarcane. Recently, under crop diversification and intensification programme, vegetables, peanut and other legumes have been introduced as the second crops in the low-lying area. The production pattern being practiced by the farmers in the project area is affected by the availability of irrigation water and probable occurrence of flooding of the river. The typical cropping patterns are summarized in FIGURE III-8.

Owing to the MASAGANA 99 programme, high yielding varieties of paddy (IR series) have been extensively distributed over the project area. Major works of the farming operations are done by manual labor, partially supplemented by animal power and tractors. Fertilizer application and plant protection are extensively practiced under the guidance of the agricultural extension office.

Sugar cane is planted immediately after the rainy seasons and is harvested after 10 to 12 months from the planting. The ratooning cultivation system is popular in the project area. The most prevailing varieties of sugarcane are P.O.J. series and Hawaii 1933.

(3) Crop production

According to the past production record in the related Municipalities, the unit yield of paddy and sugarcane fluctuated yearly and locally. This might be attributed to flooding of the rivers and uneven distribution of rainfall.

In 1977/78, total production of paddy was 20,060 tons and that of sugarcane was 189,800 tons. Details of the production together with the planting area are as shown in TABLE III-11.

(4) Fish production

The fishpond culture is the second important field next to the crop production in the primary economic sector in the project area. At present, about 1,190 ha of fish-pond has been developed in the reparian land extending mainly over the southern part of the project area. Milk-fish is a predominant variety, representing more than 90% of the total production.

Generally, fish is harvested twice a year and at about 1.4 ton/ha on an average per year. This unit yield is rather low compared with other areas in the Philippines. This is mainly due to the fact that the area is beset with problems of muddy flood water intrusion into the pond during the rainy season, which adversely affect the growth and production of fish-food. The gross fish production is estimated at about 1,680 tons per annum and its gross value is at P 8.18 million or P 6,870 per ha.

3.6.4 Agricultural Production Value

Based upon the current farmgate price in 1978 and agricultural production, the gross and net annual values of the agricultural crops in the project area are estimated at P74.87 million and P44.81 million respectively. The production value of sugarcane shares greater part, than the production value of the paddy, although potential cultivatable land for paddy is nearly half of the total project area. This is mainly due to the seasonal occurrence of destructive flooding and accompanied sand-sedimentation. Details of the products value is presented in TABLE III-12.

3.6.5 Farm Economy

The following two typical farms are selected taking into account the agricultural conditions affected by the flood and sand sedimentation. One of the typical farm is taken from the area of Agricultural Block III where the land is frequently affected by seasonal flooding and the other farm from the area of Agricultural Block V where the farm land is being left to the devastation due to flooding and sand-sedimentation.

As shown in TABLE III-13, the net annual agricultural income is only P10,850 for the typical farmer in Agricultural Block III and as low as P1,930 in Agricultural Block V. The net reserves are P6,240 and -P470 in Agricultural Block III and Agricultural Block V, respectively.

The farmer in the Agricultural Block V is still at subsistence level. The deficit of net reserve and shortage of living allowance is supplemented by wages obtained from such outside working as sugarcane harvesting, fish-pond fishing and construction works in the project area.

3.7 Road Network and Related Structures

3.7.1 Road Network

The project area is well served by five national roads, Manila North Road (San Fernando-Angeles), Manila North Expressway (San Fernando-Angeles), San Fernando-Bataan Baundary Road (San Fernande-Guagua), Olongapo-Gapan Road (San Fernando-Guagua, under construction) and Angeles-Bataan Road (Angeles-Porac). These are the key roads in the project area and are all paved roads under good maintenance.

There are also provincial road networks in the project area. Main routes are Guagua-Sta. Rita-Porac Road, Bacolor-Porac Road, Bacolor-Sta. Rita Road and Bacolor-Angeles Road. In and around the towns, many short provincial roads exist. Out of them, about 60% is paved road and the rest is graveled or earth road. These locally maintained roads suffered from damages in every rainy season. The routes of national and provincial roads together with the approximate location of km posts are as shown in PPFS 312.

Besides the above, there are three crossing sites on the Pasig-potrero river, Mitla-Balas, Balas-Potrero and San Juan-Santa Barbara. The present traffic volume at each point will not justify construction of the bridges and their connecting roads, but it may be necessary to provide an appropriate facility in future such as submergible road to enable transport during the period of low flow taking into consideration of level embankment and river channel design.

According to the traffic volume data on the roads in the project area obtained from a provincial-wide origin-destination survey conducted by the Provincial Government of Pampanga on July 23-24, 1976, average daily transportations are estimated as shown in TABLE III-14 and PPFS 403.

From TABLE III-14, it can be judged that the traffic on the Manila North Road (San Fernando-Angeles), the San Fernando-Bataan Baundary Road (San Fernando-Guagua) and the Angeles-Porac Road is considerably heavy. But the former two roads have large capacity enough to meet such heavy traffic at present and will have no serious transportation problem in future because the Manila North Expressway and the Olongapo-Gapan Road will cover their future traffic increase, while the Angeles-Porac Road will be required to widen the road to meet future increase of transportation.

On the other hand, as traffic on the provincial roads is light at present and no heavy increase is anticipated in future, widening of the roads will not be required, however improvement of the road surface condition is necessary.

3.7.2 Related Structures

There are four bridges on the Pasig-potrero river. They are, from the upstream, Mancatian bridge No.1 (15.70 m x 2 + 18.70 m x 2) and No.2 (18.70 m x 6) constructed in 1968 on the Angeles-Porac Road, Sta. Barbara bridge (15.00 m x 10) completed and waiting for open to serve on the Olongapo-Gapan road and San Miguel bridge (18.50 m x 6 + 19.50 m x 2) under construction on the San Fernando-Bataan Baundary road.

Flow capacity under the girders of Mancatian bridge No.2 is calculated at 900 m^3/s at the river bed elevation of 94.75 m. Since the elevation is 94.14 m, in February 1978, reconstruction of Mancatian bridge No.2 is not necessary as far as the river bed elevation under the bridge is below EL. 94.75 m to keep more than 1.50 m of clearance for flood flow. Sta. Barbara bridge and San Miguel bridge have flow capacity of 1,160 m^3/s and m^3/s respectively, and there will be no problem in future gainst flood flow including downstream increment of flow. The short span bridges on the main provincial roads are shown in TABLE III-15.

On the Olongapo-Gapan Road constructed recently, larger size pipes and boxes are provided. On other old roads small size structures are replaced with large one whenever they are reconstructed on the old roads taking into consideration of over flow due to past flood. Drainage facilities provided for the national roads in the project area are shown in TABLE III-16.

3.8 Flood and Sand Sedimentation Damage

3.8.1 General

Flood and sedimentation damage consists of direct damage, indirect damage and intangible damage which is not quantifiable. Direct damage includes such damages as damage on agricultural product, damage on buildings and properties and damage on public goods such as roads, bridges, schools, etc. Indirect damage is the net economic losses of goods and services to the nation due to the interruption of business, industry, commerce, traffic, communications and other activities, both within and outside the area subject to flooding, and the cost of activities made necessary by the flood such as emergency flood fighting measures and relief, care and rehabilitation of flood victims.

Beside above, loss of life, impairment of public health due to outbreak of contegious disease, insects and unfavourable effect on social and political stability are another important damages. These damages are difficult to be quantified and called intangible damage.

In this study, mainly the direct damage is taken into account for the flood damage estimation of the past main floods due to the difficulty in assessment of the indirect and intangible ones. The direct damages consist of the damage on agricultural production, damage on houses, damage on transportation facilities and damage on river structures. The flood damages are valued at 1978 prices.

Since there are no systematic assessment records of the past flood damages, the damages of the past five floods, namely, 1966 flood, 1972 flood and 1974, 1976 and 1977 floods are assessed in this report on the basis of the collected data and information through interviews concerning the flooded areas, depths and durations.

3.8.2 Flooded Area

The flooded area delineated for the floods in 1966, 1972, 1974 1976 and 1977 are illustrated in FIGURE III-9 to III-13 together with the depth and duration of flooded water and sand sediment depth. The submerged areas in these floods reached 5,090 ha, 5,500 ha, 4,490 ha, 3,020 ha and 3,080 ha for the floods in 1966, 1972, 1974, 1976 and 1977, respectively. Details of the flooded area by each flood are presented in TABLE III-17.

Land use of the flooded area by each flood is shown in TABLE III-18, which shows that a greater portion of the affected area consists of paddy field.

3.8.3 Damages on Agricultural Production

The agricultural damages caused by flood and sand sediment are classified into (1) crop damage, (2) damage on agricultural facilities such as irrigation facilities, farm roads and their related structures, (3) expenditures on such additional works as re-transplanting and cleaning of the product, (4) losing or lowering of land arability and productivity and, (5) damage on fishpond culture.

(1) Damage on crop

As stated in the previous section, the farm land affected by flood and sand sediment is mainly lowlying paddy field. Almost all of the sugar cane and other upland crops are free from flooding. The crop damages in the floods in 1966, 1972, 1974, 1976 and 1977 estimated at P3.65 million, P8.68 million P3.59 million, P2.78 million and P2.46 million respectively taking into account the depth of the flood, duration and sand sedimentation. The details are as shown in TABLE III-19.

(2) Damage on agricultural facilities

According to the informations obtained from the agricultural extension offices in the project area, large extent of the ridges of paddy field and the embankments of irrigation canals and creaks were eroded out seriously by the past distructive flooding of the Pasig-potrero river. The damages on these facilities are estimated at P460 thousand in 1966, P920 thousand in 1972, P490 thousand in 1974, P430 thousand in 1976 and P360 thousand in 1977. The breakdown is given in TABLE III-20.

(3) Additional expenditure

Additional expendire was required for such works as re-transplanting and cleaning of the product submerged in flood water and sand sedimentation, which are estimated on the basis of the data obtained through the agricultural extension offices. They totaled P1.44 million in 1966, P440 thousand in 1977. The details are as shown in TABLE III-21.

(4) Damage on land arability and productivity

Losing or lowering of the land arability and land productivity caused by deep sand sedimentation is one of the serious damage in the project area. The effect of this damage lasts for long period, but only the actual damages for the year are estimated in this chapter. Based upon the informations obtained by the field interviews with the villagers and data provided by the agricultural extension offices, the damages under this category are estimated at P2.12 million in 1966, P5.08 million in 1972, P1.29 million in 1974, P0.68 million in 1976 and P0.24 million in 1977, respectively. The details are as shown in TABLE III-22.

(5) Flood damage on fish culture

Lowlying swampy area in the southern part of the project area is frequently affected by the flooding of the Pasig-potrero river and the Guagua river. In consequense, the fishpond facilities and fish production in this area has suffered considerable damages. According to the data provided by the Bureau of Fishery Regional Office, the damages are estimated at P79 thousand in 1966, P991 thousand in 1972, P67 thousand in 1974, P80 thousand in 1976 and P30 thousand in 1977, respectively. The details are as shown in TABLE III-23.

3.8.4 Damages on Houses, Transportation Facilities and River Structures

(1) Damage on houses

In this study, only the damage on private houses in taken into consideration, excluding the damage on public buildings such as schools, churches and on factories. For the estimation of the flood damage, effect of the wind and rainfall is not included and the damages on household effects are not taken into account. As shown in FUGURE III-9 to III-13, no flood water had not exceeded the floor level of the houses except the flood except in 1972.

The damage value is estimated by multiplying the number of houses by house values assuming flood damage rate based on the inundation depth above floor level as detailed in TABLE III-24. The damage value is estimated at P3.51 million in 1972 flood.

(2) Damage on transportation

Due to flood water and sand sedimentation brought by the flood, transportation facilities have been damaged. In particular, Angeles-Porac road, San Fernando-Guagua road, Bacolor-Porac road and Angeles-Porac bridge has suffered frequent damages by floods.

Damages on bridges and roads can be approximately measured by the actual rehabilitation costs which are shown in TABLE III-25. In due consideration for the flood scales, the damages are estimated at P1.2 million for the 1966 flood, P2.3 million for the 1972 flood and P0.57 million for the 1974 flood.

Besides the direct damage described above, indirect and intangible damages such as i) increased cost for detouring and ii) decreased regional product resulting from temporary closure of major transportation arteries exist. These damages are hard to quantity and not estimated in this study.

(3) Damage on river structures

For mitigating the flood and sand sedimentation damages caused by the flooding of the Pasig-potrero river, protection works including levees have been implemented partially. No fundamental countermeasures, however, has not yet been taken in the Psig-potrero river basin.

Due to inadequate structural condition, the right bank levee of about 3.7km just upstream of the Mancatian bridge No.2, was broken by the floods in 1966, 1972 and 1976. In 1976, the right bank levee of about 300m just upstream of the Mancatian bridge No.2 was totally destroyed by the flooding of the river. Further, in 1977, a flood flow broke through the right levee at about 5.5km downstream of the Mancatian No.2 bridge and rushed to the levee in the rear to destroy it. At this time, the left levee was also partially damaged at upstream site of the destroyed portion.

3.8.5 Total Damage

Total damages are calculated for the main floods in 1966, 1972, 1974, 1976 and 1977 by aggregating the damages estimated in this section excluding these on river structures. They are P8.95 million, P21.48 million, P6.01 million, P4.41 million and P3.19 million for the floods in 1966, 1972 1974, 1976 and 1977 at 1978 prices respectively. The breakdown of the total damages are presented in TABLE III-26.

IV. THE PROJECT

4.1 Project Conception

The object of this project is to establish the most effective plan to mitigate the damages in the project area caused by the flood and sediment flow. As stated in the preceding Chapter, the Pasig-potrero river, having sediment production resources of a large scale in the mountain region, discharges huge volume of sediment every year. Annual sediment flow at the control point is estimated at 475,000m^3 on an average and 2,295,000m^3 at the maximum flood. Even though the treatment of the sand sediment may be theoretically possible only by the river course excavation plan without any kinds of measure to arrest and control the sediment in the mountain region, continous dredging of huge amount of deposit would be required, and moreover, risk of the flood damages due to levee break and overflow and destruction of the river structures will still remain. This treatment method is, therefore, cannot be the fundamental one. Accordingly, the Sabo plan to prevent deposit production and control sediment discharge in the mountain region, and the river improvement plan to protect the river basin from the flood shall be planned as a combined and inseparable project.

For the Sabo planning, the past maximum flood sediment discharge during the flood in 1972 was applied as an objective design volume to be treated. It was planned to arrest and control sediment discharge in the mountain region as much as possible, and to treat the remaining sediment at the sand arresting basin located in the area of alluvial fan and the channel in the lower reaches. This idea will also be justified from a viewpoint of enlargeing a development potential in the plain of lower reaches. Under this principle, altogether 10 Sabo dams were planned to be constructed in the mountain region to arrest and control about 1,014,000 m^3 at the maximum flood and to reserve and control the remaining 835,000 m3 in the sand arresting basin located at the alluvial fan and in the channel of lower reaches. In the river course from the confluence of the Timbu creek and the Pasig-potrero river to the sand arresting basin, river bed consolidation works and groynes will be provided to prevent lowering of the riverbed and the irregular talweg, and to protect both river banks from errosion and collapse. Furthermore, afforestation works were planned on the high-water channel between each groyne.

For the river improvement plan, only the Pasig-potrero river is taken up as the objective river for this project after study of the conditions of the adjacent Abacan river and Porac river. The counter-measures for flood control and sand sediment at the lower reaches were planned in accordance with the Sabo plan at the upper reaches. After reviewing the BPW plan partly under construction, flood discharge of 900 m3/s at the Mancatian bridge was applied as the design flood of this river course plan, and the river course was planned to have enough cross section to flow the design flood discharge with the levees and other structures. As for the discharged sediment, it was schemed to discharge about 30,000 m3 of sediment per year to the channel of lower reaches on an average. Distribution of sand and flood water with and without the Sabo and river improvement facilities are as shown on Figure IV-I.

Besides the above, a prospect of agricultural production in future and possibility of constructing the storage dam and hydropower plan proposed in the ECAFE's report were also studied in this report.

4.2 Sabo and Afforestation Plan

4.2.1 General

For the Sabo plan, the direct control of sediment at the production site shall be the fundamental policy. However, in the case of this catchment area, the construction of direct control devices is very difficult with considerable loose erosion area. The Sabo plan in this project area is, therefore, to treat the sediment through the sediment control function of the Sabo dams. The maximum flood in the past is adopted as the objective flood for the Sabo plan, which corresponds to 1972 flood.

In determining the sediment volume for the Sabo plan, sub-control point is set up at the converging point of the Timbu creek and Papatak creek and the section between the sediment producing source in the mountain and the sub-control point is determined as the planning section. (FIGURE IV-2)

The plan is formulated to follow the basic concept of the Sabo works that the sediment run-off, shall be controlled and retained as much as possible at the mountain area. Limitation in the construction of Sabo dams from the topography and geology of the area, and the efficiency is taken into consideration together with the possibility of storing the residual sediment at the downstream. Overall plan is, thus, formulated, which will provide a basis for the future provision of the direct works.

4.2.2 Sediment Volume in Sabo Plan

The volume of sediment considered in the establishment of the Sabo plan is classified into the designed volume of sediment production, designed volume of sediment run-off, designed volume of controlled sediment and the designed volume of surplus sediment run-off, and these items are defined as follows: (FIGURE IV-3 & 4)

(1) Designed volume of sediment production

The designed volume of sediment production is the total of the primary sediment volume produced through the erosion of the mountain during the period of maximum flood and the secondary sediment volume which is the unstable sediment volume accumulated at the river bed.

The primary sediment volume produced during maximum flood totals 2,622,000m3, as described in Chapter 3. By adding the sediment volume of 1,810,000m3 discharged downstream due to the secondary erosion of the sediment accumulated at the river bed, the total designed sediment volume production during maximum flood becomes 4,432,000 m3.

(2) Designed volume of sediment run-off

The designed volume of sediment run-off is the total volume of sediment production less the volume that is temporarily deposited on the river bed (2,580,000 m3), before the run-off reaches the sub-control point. In this Sabo plan, the designed volume of sediment run-off is 1,849,000 m3. The average annual sediment run-off is estimated at 328,000 m3 assuming no river bed control is made.

(3) Designed volume of controlled sediment

The designed volume of controlled sediment is the volume that can be controlled or retained through the construction of Sabo dam at the mountain. As described subsequently, the total volume of sediment controlled through construction of 10 sabo dams is estimated at 1,014,000 m3.

(4) Designed volume of surplus sediment run-off

The designed volume of surplus sediment run-off is the volume of sediment that is in excess of the volume controlled or retained through the provision of the Sabo dams, and the volume is estimated at 835,000 m3 which is the difference between the designed volume of sediment run-off (1,849,000 m3) and the designed volume of controlled sediment (1,014,000 m3). This designed volume of surplus sediment is the volume which requires control at the downstream during the period of maximum flood.

4.2.3 Sabo Plan

As described in Section 4.2.1 the basic policy in this plan is to control the sediment run-off as much as possible at the mountain area and to retain any surplus run-off at the downstream. The control of the sediment production is to be made by provision of Sabo dams at the mountain, to the maximum extent through their controlling and retaining function.

The control of the sediment is effected by the fortifying function of the foot of the mountain through sedimentation of sand in the Sabo dam. In other words, it is through the function of restraining the sediment production from the erosion slope at the mountain side. From the present condition of the mountain, it is considered that this is possible only at the Bucbuc creek and the Yangca creek. The control of sediment run-off may be divided into control by Sabo dam and control by the river itself. The effect of the control by the Sabo dam is the difference in the volume of sediment between the sedimentation gradient at abnormal flood period and the sedimentation gradient at the normal season. (The details are as shown in Appendix II)

Basing on the above basic principle, a plan for the construction of 10 Sabo dams is formulated through comparative studies of various alternatives. In the planning of the Sabo dams, ample consideration is given to the fact that it is not possible to construct high dams on thick gravel layer. In the locationing of the Sabo dams, emphasis is placed on the Bucbuc Creek where the volume of sediment production is large and six Sabo dams are planned. However, due to the limitation of available suitable site for Sabo dam construction along the Bucbuc creek catchment area, the surplus sediment run-off is planned to be treated at Papatao Creek downstream where 3 Sabo dams are planned. A Sabo dam is also planned at the Timbu River. Then, the total designed controlled volume comes to 1,014,000m3 and the volume of surplus sediment run-off which is beyond control is 835,000m3 at the sub-control point. The volume of sediment production and the volume of sediment run-off for each catchment area after the construction of the Sabo dams as well as the controlled and retained volumes by the dams and the volume retained at the river bed are as shown in TABLE IV-1.

Furthermore, in order to maintain the safety of the dams and to maintain the existing river bed as well as to prevent erosion and falling of the river banks, 4 groundsels and 9 groyne works are provided in the 1.5 km section downstream of the sub-control point.

The trend of change of run-off at the maximum flood through provision of Sabo facility at the planned control point is shown in FIGURE IV-5.

4.2.4 Sabo facilities

(1) Foundation of Sabo dam and related facilities

The foundation condition of the typical locations for Sabo dams and groundsels are as described below. In the detailed design stage, further investigation through test boring will be necessary.

Sites for Sabo dams No. 2-A, No. 3 and No. 4-A

The river banks on both sides of each dam site are nearly perpendicular or very steep in slope and are composed of Agglomerates (I). The shearing strength of the rocks is estimated at about 40-50 t/m^2 and the permeability coefficient is estimated at 10^{-5}cm/sec. The existence of some Tuff is identified at some locations, but this will not be a problem for the dam foundation. The widths of the river are 45m, 20m and 25m at the three locations respectively and the river bed sedimentation is mainly medium size to coarse sand, deposited to a depth of 10-20m.

Site for dam No. 5

Test borings at five points were carried out along the axis of the main and auxiliary dams for the purpose of detailed design. The left bank is an almost perpendicular cliff whereas the right bank is mainly a hillside and a peninsular extrusion of the mountain ridge with a small valley formed through erosion. The whole of the left bank and the lower part of the right bank are composed of Agglomerate (I) with an estimated shearing strength of 60t/m2. The talus deposited to a depth of about 5m at the col of the extrusion on the right bank, has to be completely removed. As a whole, there is no problem anticipated at this site as a Sabo dam site. The river width is about 22m, and the sedimentation deposited to a maximum depth of about 34m, is of the same composition as other dam sites.

Site of groundsel No. 1-A

The left bank is composed of welded Tuff with a shearing strength of about $40t/m^2$ whereas the fan talus (II-a) at the right bank is composed of medium to coarse sand and gravels of a maximum grain size of 0.2m. There is no problem for the left bank as the foundation of a groundsel of small dead weight but some protective measures have to be provided at the foot and the slope at the right bank. The river bed sedimentation is the same as other dam sites, deposited to a depth of over 10m.

(2) Sabo facilities

From the result of studies on the foundation, the basic structural plan for the facilities are made as follows:

i) Sabo dam

This is composed of the main dam, the auxiliary dam and the apron, and where necessary foot protection and retaining wall may be provided. The dam height is to be below 15m and the width is to be adequate to span with both banks. The width of the crest is to be 2.0m, the downstream slope to be 1:0.2 and the thickness of the apron to be 2.0m.

ii) Groundsel

This is composed of the main groundsel, the auxiliary groundsel, the vertical wall and the apron. The total height is about 6.0 to 7.0m and the effective height is about 3m. The width is to be adequate to span with both banks, the downstream slope to be 1:0.2, the width of the crest to be 2.0m and the thickness of the apron to be 1.5m.

iii) Groyne work

This is to be the water-permeable cushion gabion made of iron wire, with a height of 2.4m and a length adequate to extend from both banks to the water channel.

The cross sectional structures of all the facilities are so determined as to satisfy the design conditions and the details are as shown in TABLE IV-2.

(3) Materials

All the Sabo dams and groundsels, will be made of concrete, and cement-rich cocrete will be adopted for the spillway of the Sabo dams and portions of 0.5m or less in thickness in order to prevent abrasion by rolling stones or gravels.

Portland cement will be used and the fine aggregates used in concrete mixing will be obtained in the vicinity of the structures. As for coarse aggregates, it is in principle desirable that coarse aggregates be taken from quarry, but where it is not possible or insufficient in quantity, selected river bed gravel may be used. The cobblestone for cushion gabion will in principle be taken from quarry, but materials selected from the river bed nearby may be used in the construction of groundsel and groyne works. The sheet piles to be used will conform to the JIS specification or its equivalent.

The floor slab of apron and others will be provided with joint at 20m intervals and water stop will be provided at the expansion joints of Sabo dams. For the groyne works, cushion gabion of iron wire net will be laid to the stipulated depth at the locations where the groundsel upstream and downstream are completed. Cobblestone used for the gabion shall be larger than the size of the mesh, the cobblestone shall be carefully packed in, and any gaps inside will be filled up with gravel.

4.2.5 Afforestation Plan

The planting works are for the purpose of preventing the collapse or erosion of the mountain slopes and controlling sediment production through early covering of the erosion area with vegetation. From the results of survey, the following types of plant may be considered for the afforestration plan.

(1) Kamachile (Camachile)
(2) Kakawati Kakauti
(3) Ipil-ipil
(4) Alibangbang
(5) Pine tree
(6) Grama grass
(7) Cogon grass

Any successful result cannot be expected in the planting of the above plant unless the planting site are stable. Since the erosion areas in the catchment consists of pyroclastic flow deposits, the slope is liable to collapse easily and it is necessary to stabilize the hillside slopes with civil engineering structures. In this regard, it is anticipated that the stabilization of the foot of the hill and the river bed with the Sabo dams may serve as a basis for future implementation of direct control works such as civil engineering structures and afforestration. Since the construction of civil works in such a large erosion area to facilitate planting of vegetations is difficult, the locations suitable for planting at the first step shall be in the water channel between the downstream groyne work sections. The timing of planting shall be at such time when sediment is deposited to a certain extent and the side erosion of both banks have come to a pause. Planting is also necessary within the river flow section at the fan region.

4.3 River Improvement Plan and Sand Arresting Basin Plan

4.3.1 General

Prior to preparing the captioned plans for the Pasig-potrero river, the following two flood prevention plans were studied preliminarily.

(1) Plan to divert a part of floodwater of the Abacan river from a point upstream of Angeles City to the Pasig-potrero river.

(2) Plan to divert a part of floodwater of the Pasig-potrero river to the Porac river.

The two plans, (1) and (2), were, however, discarded because Plan (1) would increase floods downstream of the Pasig-potrero river and thus merely pass flood damage from the area downstream of the Abacan river over to the Pasig-potrero river basin, and at present, floodwater from the Abacan river would be less likely to cause damage to Angeles City, whereas Plan (2) would increase the danger of flooding Porac Town, which is now relatively safe from floods, and thus raise the potential of flood damage.

The river improvement plan and sand arresting basin plan formulated in the project is, therefore, to treat only the Pasig-potrero river for the improvement. The plan covers flood prevention and the countermeasure of the discharged sand for a stretch of about 27 km from the fan-head to its confluence with the Guagua river. The river improvement plan covers the downstream area of the Pasig-potrero river from the river mouth to STA15+950, and aims to install a river channel to safely discharge the design flood.

Based on the review of the plan prepared by the BPW, which is now partially under way and the results of hydrological study, the design flood discharge for river improvement plan was set to be 900 m^3/s.

As mentioned before, the basic aim of the erosion control plan is to control and regulate discharged sand by a group of Sabo dams to be constructed in the mountain region upstream of the river. Because of topographical and geological conditions, however, it is impossible to control all the discharged sand with the Sabo dams. Accordingly, a sand arresting basin and the related facilities were planned for the stretch from STA 15+950 to STA 27 for preventing the sand spilled out from the upstream and flows into the river channel.

In preparing the basic plan for the sand arresting basin, the distribution of sediment volume after constructing of Sabo dams is taken into consideration. Even after the control by the group of Sabo dams to be constructed in the upstream area, sand of 835,000 m^3 will still flow down into the fan area during the maximum flood. Of this volume, 144,000 m^3 of sand will further flow out from the fan into the downstream river course. (Annual mean sediment discharges corresponding thereto will be 304,000 m^3 and 30,000 m^3 respectively.) Therefore, the sand arresting basin plan is prepared to control the balance between the quantity of sand coming into the fan and the quantity of sand which runs further downstream. That is, 691,000 m^3 at maximum flood, or 274,000 m^3 on the yearly average.

According to the construction plan for the project, it will take 10 years more to construct all of the group of Sabo dams upstream of the river after the completion of the river improvement and sand arresting basin works. Therefore, there will not be enough sand control capacity by the Sabo dams during 10 years. Thus a temporary plan providing the sand arresting basin with an extra capacity for a total capacity of 941,000 m^3 will be made.

4.3.2 Review of the BPW Plan

As aforementioned, the river improvement and traning works of the Pasig-potrero river has been carried out since 1974 based on the plan prepared by BPW in 1964. According to the BPW plan, the river channel is designed to pass the design flood of 900 m^3/sec at the Mancation Bridge (drainage area: 44 km^2). This design was examined by using six formulas including the formula used by BPW and the rational formula. The results of the examination show that the design flood of 900 m^3/s corresponds to flood having a probability of once in 80 years and the design flood has safficient safety from the view point of river engineering.

Comments on the BPW plan are made on the basis of the available drawings and site reconnaissance as follows.

(1) The alignment of the levees was determined for the stretch from the rivermouth to STA 23. In this stretch, levees are already constructed for the stretch of 12 km from Bacolor to Mitora. This alignment seems reasonable as a whole from the viewpoint of the topography and traces of old river channel, the following, however, are pointed out:

a) There are hydraulic sharp bends having small curvature compared with the channel width; e.g. curvature less than 4 times of the channel width, and no widenning is provided there.

b) The Psig-potrero river joins with the Gua-gua river at the right angle.

c) The widths of the river are set to be 150 m for the downstream stretch of 7 km and 300 m for the upstream stretch. These fairly wide and flat channel in the upstream causes meandering of water course during the low flow seasons.

d) The alignment of levees for the stretch of 500 m long between STA 8 and STA 7 where the channel width decreases from 300 m at the upstream to 150 m at the downstream seems to be effective to increase the tractive force against sand.

(2) The profile of the riverbed becomes flatter gradually from the upstream to the downstream and seems stable.

(3) The existing river channel is of single cross section and the elevation of the riverbed is almost same as that of the inland. The BPW plan contemplates to excavate a low water channel having 30-meter bottom width in the center, which seems to be effective for stabilization of the water course during the low flow season and for lowering the high water elevation. The excavation of low water channel at the Badolor Bridge and the By-Pass Bridge will be limited to the depth of 2 m below the present riverbed to protect the bridge foundations.

(4) The existing embankment has a single cross section having side slopes of 3 to 1 and is built using the riverbed materials collected from the nearby area. The side slopes are judged to be safe against slip. The river-side slope is protected by rip lap. The completed cross section has a sufficient hight including free board against the planned high water level. The fact that some parts of the slope surface are eroded by rainfall incidcates that the compaction of embankment is insufficient.

(5) There is a plan to construct continuous levees for the stretch from STA 16 to the head of the fan, the details of this plan except their alignment are not available yet.

The outline of the BPW plan is illusted in FIGURE IV-6 and IV-7 together with the plan contemplated in this study.

4.3.3 Alignment, Longitudinal Profile and Cross-section

The river improvement covers the stretch from STA 0 to STA 15+950 and is formulated as follows:

(1) Alignment Plan

The alignment of the river course for this river improvement plan is basically the same as that of the BPW plan now partially underconstruction. For the no-levee section of the river from the downstream point of STA 2+350 m to the confluence with the Guagua river new levees will be built in conformity with the alignment line of the BPW plan.

As for the no-levee stretch from upstream Mitora (STA 13+50) to the higher upstream end of the river channel (STA 15+950), the BPW plan gives the alignment slightly inward of the embankment from the foots of the fan on both sides of the river. However, there will be no problems concerning the dischange capacity even if the distance between the levees is slightly narrowed. This river improvement plan, therefore, brings the alignments to a point near the foots of the fan to narrow the distance between the levees. The BPW plan conceives this section to have a continuous embankment, whereas this river improvement plan will provide open levees on both sides of the river at points where the small tributaries flow into the Pasig-potrero river so that the river channel may be able to drain inland water and retard abnormal floods, through the openings.

Since present river channel has no low water channel, the low flow take meandering and unsteady courses in the wide river bed. The BPW plans to build a low water channel of 30 meters wide in river bed in the center during the low flow seasons in order to fix water-course. The river improvement plan also provides a low water channel along the centerline of the channel as in the BPW plan. The low water channel will be 30 meters wide in the upstream of the STA 4+500 point as in the BPW plan, but 60 meters wide in the downstream because flow velocity decreases due to the gentle gradient of the river bed, and because the river bed cannot be dug deep enough due to existance of the piers of the Bacolor Bridge, and thus a sufficient low water channel cross section cannot be secured by the bed wide of 30 m.

(2) Profile Plan

The longitudinal profile of the low water channel is so planned that the sediment discharge in the channel will be balanced and that the river bed will remain steady. In other words, sediment from the sand arresting basin will be transported downstream as much as possible without allowing it to settle down in the river channel.

To attain the above purpose, the gradient of river bed is planned to decrease gradually from upstream without sudden change based on the present river bed gradient. The BPW plan is also considered to aim at a similar objective, and shows a reasonable shape as a whole. However, the digging depth specified therein seems relatively deep for a low water channel as described hereunder.

This river improvement plan formulates the longitudinal profile plan after a careful study of the depth of the piers of the existing bridges. The riverbed gradient thus determined is 1/100 at the head of the upstream of the river channel, and 1/1,800 at the end of the downstream. The gradient linking the limited level of excavation at the Bacolor Bridge with the river bed level at the mouth of the river becomes steeper than that of the adjacent upstream stretch. To prevent such an unnatural continuance of the riverbed gradients, two drop stretchures of 70 cm high each will be constructed downstream of the Bacolor Bridge.

The crest of the embankment will have a free board of 1.5 m above the planned flood level taking into account connection to bridge abutments. The longitudinal profile plan is outlined in FIGURE IV-8 and IV-9.

(3) Cross Section Plan

The river should have a cross section which allows safe discharge of planned flood water of 900 m^3/s. This will be secured by building levees. Since it is difficult to secure stable channel for the low flows by single cross section, BPW planned composite cross sections having low water channel along the centerline of the channel. The plan specifies a digging depth of 3 to 5 m for this low water channel. This river improvement plan will also propose a river channel with composite cross sections, having a low water channel as in the BPW plan. The low water channel will have a flow area large enough to discharge 120 m^3/s which have return period of 1.1 years. Under these conditions, the depth of the low water channel will be 2.0 to 2.5 m. These section are considerably smaller than that of the BPW plan, but the above-mentioned design discharge is considered reasonable for the low water channel from the engineering point of view.

The levees will have a free board of 1.5 m above the planned flood level. The lowest part of the downstream area needs no early construction of complete levees along the Pasig-potrero river because no levees have been constructed for the Guagua river as yet. Accordingly, the right levee of 1.5 km long from STA 0+50 to STA 1+580 and the left levee of 1.9 km long from STA 0+50 to STA 1+950 will have no free board above the planned flood level, for the time being. The standard cross section is shown in FIGURE IV-10.

4.3.4 Plan of Sand Arresting Basin

As mentioned in 4.3.1, sand arresting basin are planned to supplement sand control capacity against the following sediment discharge.

Sand Volume to be Arrested

(m^3)

	After Facility Completed	Provisional/1 Period
Maximum Flood Time	691,000	941,000
Annual Average	274,000	0

/1: During the period after completion of river improvement works until the completion of all the Sabo dams.

The sand arresting basin aims at controlling the planned sediment discharge in the stretch from STA 27 to STA 15+950 (from the fan to the river channel), and thus minimizing settlement of sand on the river channel. The sand arresting basin will have four parts of different functions as follows.(FIGURE IV-11)

(1) Valley part
(2) Guide part
(3) Sand arresting basin part
(4) Branching and confluent part

(1) Valley Part (STA 27 to STA 24+300)

The valley part extends about 2.7 km long downstream of a point near the No. 1-A consolidation area. The valley is formed by erosion by the Pasig-potrero river. The eroded cliffs are brittle, sandy ones, and side erosion is still active. This plan aims to transport the sand flowing out from the Sabo dams through this part and preventing side erosion.

(2) Guide Part (STA 24+300 to STA 20+850)

This part extends over about 3.45 km downstream of the valley part. There is an S-shaped curve near STA 23+400, where Agglomerates lie on both banks of the river, causing the so-called oscillating phenomenon of water and sand flow during the flood time.

Important function of this part is to prevent this phenomenon at the curve. For this purpose, a channel will be dug as straight as possible to guide the water to the fan. The channel will be 70 m wide, taking into account the maximum width which can be obtained at the narrow point near STA 23+400, and 2.5 to 3 m deep.

(3) Sand Arresting Basin Part (STA 20+850 to STA 19+550)

This part extends over 1.3 km downstream of the guide part. This part will have a excavated basin for sand arresting of about 560,000 m^2 in area with the maximum width of about 650 m and maximum depth of about 5 m. The sand arresting basin intends to deposit and control sediment discharge to the downstream river channel within the planned volume. It also serves to separate earth and sand from the river water.

The sand arresting basin will have a bottle shape as viewed from the top, considering the conditions of topography and the smooth connection of this part with the adjacent upstream and downstream parts.

(4) Branching and Conflvent Part (STA 19+550 to STA 15+950)

This part covers the stretch of 3.6 km long downstream of the sand arresting basin and includes the Mancatian Bridge. The water course is separated into two branches by a sand bar located between No. 1 and No. 2, Mancatian Bridges and the branches joins again downstream of the bridge.

Comparing the two branched water courses, under the Mancatian Bridges, the following can be pointed out:

- The eastern branch running on the side of the Angeles City is considered as the main course of river flow at present.
- The right bank of the western branch on the side of the Porac City needs more safety against floods because this portion was often attacked by floods into collapse resulting serious flood damages in the past.

In view of the above observations, it is planned that a channel will be excavated from the downstream end of the sand arresting basin part to the confluence of the branches downstream of the bridges in the eastern branch to ensure steady water flow and hydraulically smooth branching and confluence of the river water. The eastern channel will be able to discharge the amount of water anticipated for the low water channel downstream (120 m^3/sec). Then, the western branch will work only at the time of big floods.

The village located on the sand bar between the branches will be protected from flood by a polder embankment.

The lowest end of this part is connected to the river channel, and open levees will be built for the purposes of discharging inland water and retarding floodwater as in the case of the uppermost part of the river channel.

4.3.5 Study on the River Channel Stability

This paragraph deals with the study of securing the sediment transport capacity of the planned river channel and the stability of the riverbed on the basis of nonuniform flow and sediment calculations.

(1) Study of Transport Capacity

Non-uniform flow calculation was made for the five different discharge, namely 120 m^3/s, 400 m^3/s, 520 m^3/s, 900 m^3/s and 1,100 m^3/s at the Mancatian Bridge. The results of the above-mentioned 5 cases show that the levees planned will have an free board of more than 1.5 meters above the planned flood discharge of 900 m^3/s over the entire stretch.

Even at locations of the bridges, where the bottlenecks of discharge capacity may happen, the planned channel sections have discharge capacities leaving sufficient clearance under the girders as shown below.

	Name of Bridge	Clearance
Sta. 2	Bacolor Bridge	2.3 m
Sta. 4+200	Highway Bridge	3.2 m
Sta. 18+400	Mancatian Bridge	1.9 m

(2) Study of River Bed Stability

The safety of the riverbed of the planned channel was studied from the view point of continuity of sediment discharge in the longitudinal direction. Sediment can be roughly classified into bed load, suspended load, and wash load. The riverbed stability is reviewed in due consideration of these aspects.

i) River channel portion

The calculation results of bed load in the river channel from STA 0 to STA 16 shows that the volume of bed load transported varies longitudinally in the same trend as longitudinal changes in fluid number and flow velocity. The stretch may be roughly divided into two sub-stretches. One is from STA 0 to STA 5, where bed load is affected by the back water downstream; and the other from STA 5 to 16.

In the sub-stretch of STA 5 to STA 16, bed load discharge is approximately continuous, and is considered nearly steady except for local variations near the STA 9, STA 11 and STA 15 points where bed load tends to settle near the STA 9 and STA 11 points and its deposition tends to decrease near STA 15 downstream of fuse portion. The discharge of bed load in the sub-stretch from STA 0 to STA 5 where the back-water exists is considerably smaller that of the upstream subsection from STA 5 to STA 16 points ($QB=10^{-2}$ for the STA 0 to STA 5 sub-stretch and $QB=10^{-1}$ for the STA 5 to STA 16 sub-stretch). Most of the bed load carried down from upstream by floodwater seems to deposit in this subsection.

The calculation results of suspended load shows that discharge volume is extremely great in the downstream of STA 5, but has similar trend in the case of bed load upstream of STA 5. The calculation results for suspended load downstream of STA 5 is against the actual condition. If the calculation results are true, the sub-stretch downstream of STA 5 would show an extreme degradation phenomenon. Since wash load sample taken in this sub-stretch are very fine, wash load will not affect riverbed variations.

Calculations of sediment inflow from the upstream into section of STA 16+200 at flood time give approximately the following results: 144 x 10^3 m^3 at the 1972 flood, and 30 x 10^3 m^3 at a flood having a probability of about once a year. If these amounts of sediment settle in the low water channel having bottom width of about 50 m, downstream of STA 5, the sediment depths will be 0.6 m at the 1972 flood (144 x 10^3/50 ÷ 5,000)) and 0.15 m at the annual flood (30 x 10^3/(50 ÷ 5,000).

ii) Sand arresting basin portion

There remain problems for these parts regarding the simple one-dimensional treatment of the subject by the non-uniform and sediment formulas, but the calculation results are fairly reasonable trend, indicating that sediment discharge capacity is large enough to carry sediment to the sand arresting basin in the valley and guide part and become small enough to deposit sediment in the sand arresting basin part, and become nearly steady in the branching and confluent part with some sediment there. Thus the design of the sand arresting basin will satisfy its function. The degradiation in the valley and guide part will be dealt with by the groynes and the riverbed compaction.

As for sediment deposited in the sand arresting basin, its slope is about 1 to 60 to 1 to 100 at a point where slope becomes stable near the fan. If it is about 1 to 80, the quantity of sediment to be stored in this basin will be about 725,000 m^3 and the sand arresting basin has enough sand storage capacity. The branching and confluence part from the sand reservoir to the river channel will be steady so far as tractive force is concerned. Variations of the riverbed depend on the supply of sand from the sand arresting basin upstream and the width of river channel. In the most dangerous case where no sand is supplied from the basin. The degradiation of the riverbed may occur by 0.4 m at the same scale of 1972 flood (144,000/(100 x 3500)) and by 0.1 m at the flood having a probability of about once a year. Therefore, it is necessary to take sufficient care about the management and maintenance not only of the sand arresting basin but also of the branching and confluence part.

4.3.6 Prospective Riparian Structures

The following facilities were planned on the basis of the river improvement plan and the sand arresting plan described in the preceding sections.

(1) Levees

The construction work of levee will consist of the following:

- New levee including open levee where no levees exist at present - 19,700 m in total.

- Supplemental embankment where the embankment section is insufficient - 14,300 m in total.

- Polder embankment for the village in the sand bar at Mancatian - 12,700 m in total.

The levees covering from STA 0 to STA 23 will have a crest with of 6 m and side slope of 3 to 1 following the BPW plan. For the above work, earth embankment of 699,000 m^3 in volume will be required.

In principle, the earth excavated fromlthe riverbed will be used for building the levees. The riverbed material taken in the upstream area is sand containing no fine particles (SW or SP by the soil classification of the US Bureau of Reclamation) and the material taken from the riverbed from the mouth of the river to a point near STA 4 in the Pampanga delta, where the ground is soft, can be classified into fine slit, and clay soils of SM, CL and ML. It will be necessary to mix the coarse sand of the upstream area with the soil of SW or SL to keep the permeability of the levee low enough.

(2) Revetment

High water channel

The entire section of the existing levees upstream of STA 4+200 is protected by dry mansonry, and this will be used as it is. The newly built levees will be protected by wet mansonry over the entire section below the planned high water level. The left bank will be reveted 9,000 m long, and the right bank, 8,020 m long.

Low water channel

Revetment in low water channel is desirable for the entire section for securing the stability of channel. Considering the construction cost and the present condition of earth excavation from the riverbed, however, low-water channel revetment will be applied only to protection sections at the Bacolor Bridge and highway bridge and the drops. Groyne works will be used for this purpose.

In points, such as curves in the waterway, which are subject to water hammering action, groynes will be built to cope with the side erosion of the water as mentioned later.

Revetment of inland side

The records on the past levee breaks indicates that the inland water often eroded the foot of the embankment from the land side and broke the levee finally. At the places attacked by inland water the toe of the inner slope of the embankment will be protected first. The levee from STA 7 to STA 9+250 on the left bank; and from STA 8 to STA 9+280 and STA 13+330 to STA 14 on the right bank will be reveted by groyne. In the embankment of the river mouth which has no free board above the planned flood level, the inner face of the slope will be attacked by inland water from the Guagua river, and washed by water overtopping from the Pasig-potrero river. The levee from STA 0+50 to STA 1+600 on the left bank, and from STA 0+50 to STA 1 on the right bank will be protected by wet masonry.

(3) Groynes

Groynes will be built in two places; one is in the waterway from the valley part upstream to the fan to control the meandering of water flow and prevent side erosion, and the other in the water channel downstream to protect the parts which are subject to water hammering action. Skelton and cribwork groynes with high permeability of water will be used because of their great stability against washing action. In the valley section, where cobble stones possibly run in, rugged skelton gryones will be built, whereas cribwork groynes will be constructed in the river channel. The total length of the skelton gryones will be 18,490 m, and that of cribwork groynes will be 14,590 m.

(4) Groundsel

The riverbed will be consolidated where necessary in the stretch from the valley to the sand arresting basin to ensure a steady riverbed height. Ten groundsel will be constructed as follows:

Concrete groundsel : 1 each at the upstream and downstream ends of the sand arresting basin

Wet masory groundsel: 3 in valley parts
1 downstream of the sand arresting basin
2 downstream of the Mancatian bridge
2 at the downstream end of the sand arresting basin

(5) Retaining Walls

Concrete retaining walls will be built just downstream of the No. 1 and No. 2 Mancatian Bridges in order to prevent the channel wall from side erosion and collaspe at the narrow part of the waterway. The retaining walls will have a total length of about 350 m.

(6) Culverts

Calverts will be laid at the following 3 points to discharge the inland water.

No. 1 Culvert: (STA 1+900, left bank) Box culvert 2 m x 2 m x 3 span

No. 2 Culvert: (STA 1+856, right bank) Box culvert 2 m x 2 m x 2 span

No. 3 Culvert: (STA 7+470, right bank) Hume pipe 1.65 m in inside diameter

The construction and spacing of the above-mentioned facilities are outlined in FIGURE IV-12.

4.3.7 Management and Maintenance

The management and maintenance required for the river improvement plan are as mentioned below.

(1) The river will be surveyed each year for its profile and cross sections at 1-km intervals to obtain data on variations of the river bed. Also, water level will be observed at fixed times, preferably, weekly, in the dry season, daily in the wet season, and hourly during flood time.

(2) Until the all Sabo dams are filled up with sand, no sand will flow down into the sand arresting basin. After the filling up, sand of 274,000 m^3 will be discharged from the upstream into the basin on the yearly average basis. This volume of sand will be excavated from the basin yearly.

(3) The low water channel in the stretch of 3 km long from Bacolor to the confluence with the Guagua river will be excavated by depth of 0.5 m in every dry season to keep the river with designed flow. Earth of 30,000 m^3 will have to be dug out for this purpose.

(4) The spoil bank of the excavated sand and earth mentioned in (2) and (3) above will be located at places near the river course; sand from the sand arresting basin on the left bank of the fan upstream of Mankatian and earth from the downstream channel in fish ponds near Bacolor.

(5) In future when demand of sand materials increases, the high water channel of 9 km long from STA 7 to STA 16 can be excavated to some extent leaving control area of 50 m wide from the toes of both levees. The quantity of sand thus excavated is estimated at approximately 1,500,000 m^3.

4.4 Prospective Agricultural Development

4.4.1 General

As stated in section 3.6.1, all the soils in the project area are, in general, considered suitable for the cultivation of both paddy, sugarcane and upland crops except the existence of sandy texture with low water holding capacity and lack of organic matters. The climatic conditions of the area are also favorable for crop growing except uneven availability of rainfall. Besides, the agricultural supporting services are extensively propagated among the farmers through institutional programs being promoted by the Government.

The most important constraint to the agricultural development in the area is the seasonal flooding of the Pasig-potrero river and accompanied sand sediments. Proper river improvement and Sabo works would, therefore, induce further agricultural development of the project area.

In due consideration of the above background, the prospective agricultural land use and cropping pattern in the project area after the implementation of the Sabo and river improvement project is envisaged as follows.

4.4.2 Prospective Agricultural Land Use

After the Pasig-potrero Flood Control and Sabo Project is implemented the areas classified into Agricultural Block III with 2,430 ha and V with 1,570 ha will be improved to the field condition similar to the Agricultural Block II where the land is free from the floods and sand sedimentation. The productivity of these areas is expected to increase to the level of Agricultural Block II and the crop production pattern will be drastically changed. Though the area of Agricultural Block IV will be released from flooding of the Pasig-potrero river, flood from the Guagua river will still remain and the field condition will not be improved much. The area of Agricultural Block VI is totally devastated and the land use will not be changed even after the project is implemented. A part of the area will be used as forest land for the protection of the embankment against flooding.

In due consideration of the prospective field condition in the project area, the land use is planned as shown in TABLE IV-5.

Compared with the present land use, the area of irrigated paddy field will be augmented by 1,040 ha (46.8% increase) and the area of upland field by 250 ha (4.1% increase). The area of fallow or waste land will be reduced to 100 ha from 1,750 ha.

4.4.3 Prospective Cropping Pattern

Taking into account present agricultural condition and the prospective productivity of the farm land which would be realized with the implementation of the project, the prospective cropping pattern is forecasted as illustrated in TABLE IV-6. The major crop in the lowland area will be paddy. As secondary crop, legume and vegetables will be introduced and intensive crop production is expected to be practiced. The cropping pattern in the upland field will remain almost the same. Sugar cane will be a main crop supplemented by minor cereals such as maize and cassava.

4.4.4 Prospective Crop Yield and Production

The prospective yield is estimated on the basis of the recent achievements both in rain-fed field and well-irrigated field in the project area. In the area with adequate irrigation water throughout the crop season, paddy yield of about 3.8 t/ha on an average is obtained while about 2.5 t/ha in the rain-fed area. Based upon these data, prospective paddy yield is also assumed for 3.8 t/ha for irrigated paddy and 2.5 t/ha for rain-fed paddy. The productivity of the paddy in Agricultural Block III and Agricultural Block V are expected to be restored to the level in Agricultural Block II. The period required for full restoration is assumed at 5 years after implementing flood control works.

Present production conditions for upland crops and secondary crops are likely to remain unchanged and the prospective yields of 34 t/ha, 0.6 t/ha and 1.0 t/ha are estimated for sugar cane, secondary crops (mongo bean) and upland crops (maize). The details of crop yields are shown in TABLE IV-7.

From the agricultural land use and the prospective crop yields estimated, the gross production of each crop after the full development is obtained. The annual gross production of paddy and sugar cane are 30,350 t and 189,800 t respectively. The incremental paddy production to be attributable to the project is about 10,290 t/yr or 51.3% of the present production.

4.4.5 Agricultural Production Value

Based upon the current farm gate prices in 1978, the gross value of each product is estimated at P34,900,000 for paddy rice, P430,000 for secondary crops, P51,250,000 for sugar cane and P310,000 for upland crops, respectively which totals P86,890,000/yr. Deducting the annual total production cost from the total gross value, the total net production value is estimated at P51,640,000. The net annual incremental value of the production is estimated at P6,830 thousand or about 15% increase compared with that under present condition without the project. The details are as shown in TABLE IV-8.

4.4.6 Farm Economy

The area in Agricultural Block III and in Agricultural Block V will be restored to the field condition as good as in Block II through the project execution. To forecast the effect of the project implementation, typical farms are selected from these two blocks for budget analysis.

As shown in TABLE IV-9, the net annual income will be augmented from P10,850 to P19,920 in Block III and from P1,930 to P15,830 in Block V. The increments are P9,070 in Block III and P13,900 in Block V. The net annual reserves will also be increased from P6,240 to P12,200 in Block III and from -P470 to P10,870 in Block V. The increments are P5,960 in Block III and P12,670 in Block V. These data clearly show that the substantial improvement is expected in the financial status of the farmers in the project area.

4.5 Dam and Hydro-power Generation

Reviewing the ECAPE Advisory Group's suggestion made in the report on flood and sediment problems of the Pasig-potrero river prepared in December 1964, the possibility of constructing a dam at just downstream site of the confluence of the Timbu creak and the Pasig-potrero main river was investigated and studied. The results of the study are as follows.

4.5.1 Topographic Condition, Geologic Condition and Flood Control Effect

After investigation in the upstream area of the Pasig-potrero river and its tributaries, and examination on the topographic maps of 1 to 5,000 in scale, it is concluded that the site selected at little upstream of the groundsel No. 1-B is the only site worthy of further examination as the storage dam site from a viewpoint of storage capacity and catchment area. River width at the dam site is about 200m and elevation of the riverbed is about 220m (ECAPE reports mentioned that the reverbed is about 236m). The cross section of the proposed dam axis is as shown on DRAWING PPFS 313. The crest length, reservoir capacity and dam volume vary according to dam height as shown Figure IV-13.

As stated in the preceding section 3.3.2, the rock exposed on the right abutment is Aggromerates (II) and that on the left is Welded Tuff (I). Between these exposed rock, fan deposit and river deposit exist with unknown depth up to the firm foundation.

From the results of the test drilling carried out on the dam axis which crosses the right side flat terrace as shown DRAWING PPFS 313, it is considered that the fan deposit in the right side is a loose composition of boulder and sandy soil having a depth of several tens of meters and is highly permeable. Therefore, in case of the water storage dam, such fan deposit together with river deposit shall be removed to considerable extent, and construction of an appropriate cutoff or an impermeable curtain wall is indispensable up to the foundation of low permeability which would necessitate huge construction cost.

The river channel of the Pasig-potrero river is to be improved to allow discharge up to 900 m^3/s at Mancatian bridge No. 2 site. Therefore, the flood control benefit attributable to the storage dam will come out only in the case of larger runoffs than 900 m^3/s which are very rare. It is, therefore, rather doubtfull that the provision of the flood control space against runoffs larger than 900 m^3/s is justified by the expected benefit from flood damage reduction.

4.5.2 Conclusive Remarks

It is considered that the water storage dam on the Pasig-petrero river is not justifiable due to unfavourable geological condition, small flood control effect and large dead space for flowing sand sedimentation. Consequently, a hydropower generation plan is also not acceptable.

However, in the future when the sand flow is controlled successfully as scheduled by the Sabo works, a storage reservoir on the Pasig-potrero river may be taken into consideration in accordance with the results of benefit cost re-examination.

V CONSTRUCTION PLAN AND IMPLEMENTATION SCHEDULE

5.1 General

The construction plans for Sabo facilities and river improvement works were prepared taking into account the present condition of the project area, characterestics of the facilities and the construction methods applied for the similar projects in the country. Special attention was paid to the interrelation between the Sabo works and the river improvement works.

The construction periods required for the Sabo works will be 15 years and 5 years for river improvement works. The construction works will be executed on a contract basis and carried out mainly during the dry seasons. The implementation schedule for the Sabo works and the river improvement works is as shown in FIGURE V-1.

5.2 Sabo Facilities

No.5 dam on the Timber creek is to be constructed first where flowing sand is relatively plenty compared with its catchment area. Subsequently, No.4 dam on the Bucbuc creek where the largest amount of flowing sand is in existence will be implemented. The construction of No.3 dam on the Papatac creek and the river bed consolidation works in the lower reaches will follow.

The consturction of the Sabo dams and the river consolidation works were so scheduled that the overall works will be advanced expeditiously paying due attention to the interrelation of these works. Access roads for transportation of construction machinery and materials and other preparatory works will be implemented firstly. In parallel with this, a coffer dam will be constructed to close the half of the river and the river flow will be diverted.

The river bed will be excavated up to the required depth for the foundation base of each structure and concrete placing will be made at least to the river bed level subsequently. The excavation works and concrete placing will be made in due accordance with the progress of each works and shall be completed during one dry season. After the completion of the excavation works and concrete placing for the half river, the other half river will be closed and the construction works will be made in the same manner. The joint portions of the main dam, sub-dam, side wall and apron will be completed in this order.

The construction works, particularly for the foundation portions under the river bed will be executed mainly during the dry seasons. The upper portions of the structures above the river bed level may also be carried out during the rainy seasons as well as dry seasons provided that access roads are movable and the access to the structures is secured.

The concrete placing will amount to 4,000 m^3 in the mountain region and 7,000 m3 in the plain region. The work efficiency of concrete placing is assumed to be 55 m3/day or 1,000 m3/month. The construction period for the Sabo facilities was estimated at 15 years taking account of the construction method, annual construction quantity, topographic condition and the characterestics of the Sabo works.

5.3 River Improvement Works and Sand Arresting Basin

The construction plan of the river improvement works was drawn up with the objective of the expeditious implementation of the project, paying due attention to the river works being constructed in accordance with the BPW Plan. The embankment works will be carried out during the dry seasons. The construction materials will partly be transported to the construction site during the rainy seasons as well as the dry seasons. The construction period was estimated at 5 years taking into account the construction method, annual construction quantity, topographic condition and that the works will mainly be carried out in the plain area and will be executed in the following manner.

First, construction of access roads and preparatory works will be executed. In the meantime, sand arresting basin will be excavated and excavation of the river channel will be carried out to stabilize the talweg at fanhead portion.

Next, the construction of a polder and the retaining wall will be conducted for protecting the Mancatian village from flooding. For the improvement works for the lower river channel, the portions where flow capacity is inadequate and damaged by the past flood will be commenced first. The sluice to be installed in the channel is to be constructed in parallel with the embankment construction.

VI. PROJECT ORGANIZATION

6.1 Existing Organizations

Overall planning and execution of flood control projects in the Philippines have been conducted by Bureau of Public Works (BPW) of Department of Public Works, Transportation and Communication (DPWTC). Under BPW, Pampanga River Control System (PRCS) is now in charge of the construction of flood control works for the whole Pampanga river system. General organizations of the BPW, DPWTC and PRCS are illustrated in FIGURE VI-1 to FIGURE VI-3.

For facilitating flood control projects, Task Force for Flood Control and Related Activities (Task Force) was established under the direct control of DPWTC in 1976. Main function of the Task Force is to review and study flood control schemes and to conduct necessary coordination between different authorities concerned. Planning on the Pasig-potrero river flood control and sabo project is now being carried out by the Task Force as a pioneer project for controlling sand sedimentation in the country. The organization of the Task Force is presented in FIGURE VI-4. As mentioned in the preceding chapters, construction of levees and necessary works for flood control of the Pasig-potrero river started in 1974. Apalit Office of PRCS is now in charge of the construction works.

6.2 Project Implementing Organization

Task Force will be responsible for detailed design for the river improvement and sabo works. From the stage of the construction, PRCS will be responsible for all the project implementation. For the construction of sabo dams, Sabo Dam Implementation Office is to be established near the damsite under the control of PRCS. Task Force will give necessary assistance and technical advice to PRCS and the Implementation Office during the construction stage.

Proposed organization for the project implementation is presented in FIGURE VI-5.

6.2.1 Task Force

Subsequent to the planning, Task Force will be continuously in charge of the detailed design works. Although actual construction will be carried out by PRCS and the Implementing Office to be established under the control of PRCS. Task Force will give assistance both in technical and operational matters to PRCS and the Implementation Office and make necessary coordination between different authorities concerned.

6.2.2 Sabo Dam Implementation Office

Under PRCS, Sabo Dam Implementation Office will be established. Main function of the Office is to conduct construction and maintenance of the sabo dams and the related facilities. The construction and maintenance of the river improvement works will remain under the direct responsibility of PRCS.

For executing the works for sabo dam, the Office, headed by Project Manager, will maintain three sections, namely, Administrative Section, Survey and Design Section and Construction and Maintenance Section. The Administrative Section will be in charge of accounting, personnel and other general services. The Survey and Design Section will be involved in the survey works and design works for the dams. Construction and its maintenance including material and equipment control will be under the Construction and Maintenance Section.

Total number of staff will be around 46 personnel including 7 senior engineers and 39 assistant staffs and others.

VII. COST ESTIMATE

7.1 Project Costs

Project costs for the sabo works and the river improvement works and the related facilities are estimated on the following conditions.

(1) Only machinery cost, the cost of steel products and engineering cost are included in the foreign currency portion, while most of the materials and laborer are assumed to be procured locally.

(2) Both sabo works and river improvement works are assumed to be constructed under contract base.

(3) Engineering cost is included in the cost estimate which is around 12 % of the total cost excluding contingency.

(4) All the costs which were invested for the river improvement works until the end of dry season of 1977/1978 are considered to be sunk cost, which are excluded from the cost estimate.

(5) Physical contingency is included in the cost estimate which is about 15 % of the total cost excluding engineering cost, while price contingency is not included in the cost estimate.

(6) The project costs are estimated at early 1978 price level.

(7) All the conversion from Peso to US Dollar is made at the exchange rate of P 7.4 = US$1.00

The estimated project costs are P 235 million which comprises P 138 million for the Sabo works and P 98 million for the river improvement works and the related facilities.

($Px10^3$)

Cost Item	Local Currency Portion	Foreign Currency Portion	Total
Sabo Works	107,381	30,400 (4,108)	137,781
River Improvement Works and Related Facilities	75,970	21,730 (2,937)	97,700 /1
Total	183,351	52,130 (7,045)	235,481

Note: Figures in the parentheses indicate the equivalent value of US$

/1 : From 1974 to 1977, around P 24 million was spent for the river improvement works, which is excluded from the cost estimated here.

Details of the cost estimate are presented in TABLE VII-1 and TABLE VII-2 and the annual disbursement schedule is shown in TABLE VII-3.

7.2 Operation and Maintenance Costs

Operation and maintenance costs of the Sabo dams includes the cost for protection of the dam crest and their downstream beds while that of the river improvement works and the related facilties includes the cost for excavation of sand deposit at the sand arresting basin, dredging cost at the confluence with the Guagua river and maintenance costs of the river structures.

The estimated annual operation and maintenance costs are P420 thousand and P195 thousand for the Sabo dams and the river improvement works and the related facilities respectively after completion of all the project works.

Cost Item	Amount ($P \times 10^3$)
Sabo Dams	420
River Improvement and Related Facilities	195
Total	615

VIII. PROJECT EVALUATION

8.1 General

Economic evaluation was made on the basis of "with and without-project principle." The net incremental benefit attributable to the project is defined as the change of the economic and socio-economic conditions with and without the project. "Without project" condition in this study is assumed as the condition that no improvement works were undertaken for the Pasig-potrero river.

The direct benefits of the project was estimated as the sum of the expected annual damage reduction value and the net annual incremental value of the agricultural production in the project area using economic prices of agricultural products. Economic cost of the project was obtained by adjusting the project given in Chapter VII. COST ESTIMATE considering taxes and duties on machineries and materials required for the project implementation. Internal rate of return of the project was estimated from these costs and benefits assuming that the economic life of the project is fifty years after all the Sabo works are completed. Project evaluation was made taking into account the expected indirect and intangible benefits of the project and the special characteristics of the project as well as the direct benefits of the project.

All the benefits and costs were valued as of early 1978. Exchange rate of US$1 = P7.4 or P1 = US$0.135 is used in this study.

8.2 Benefit Estimation

8.2.1 Direct Benefit

The expected annual flood damage reduction value attributable to the project was estimated based on the flood damage data for the 1966 flood, 1972 flood and 1974 flood. The data for the 1976 flood and 1977 flood were excluded since parts of river improvement works had been already implemented before these floods. In this chapter, flood damage calculated in Chapter III was reestimated using the economic price of paddy/1 for applying the economic analysis.

The flood damage for these floods were valued at P9.1 million for the 1966 flood, P21.9 million for the 1972 flood and P6.2 million for the 1974 flood, respectively as shown in TABLE VIII-1. The corresponding exceeding probabilities for these floods were estimated at 1/7, 1/25 and 1/4 from the available rainfall data. The relation between flood scale and the damage was estimated from the flood scale-damage relation prepared on the basis of these three points. (FIGURE VIII-1)

/1 For the economic evaluation, economic price of paddy was estimated at P1,200/t

Upon the completion of the river improvement works, the project area will be protected from the flood until the design flood of 900 m^3/s (return period of 80 years). The total expected annual damage reduction due to the project execution is, thus, estimated by flood scale-damage relation and the occurrence probability of each flood. As detailed in TABLE VIII-2, the total expected annual damage reduction is estimated at P4.56 million.

Besides the damage reduction, the project execution will bring about increase in cropping area as well as increase in unit yield of crops, resulting in expansion of the agricultural output in the project area. The incremental value of the agricultural products estimated in Section 4.4.4, was revaluated at P7.34 million using economic prices of the products/1. The production increase is expected to be attained after five year development period. The breakdown of the incremental value is shown in TABLE III-3.

Total annual direct benefit of the project is obtained by summing up the total expected annual damage reduction and the increment in the agricultural production. Both the damage reduction benefit and incremental benefit are expected to accure after the completion of the river improvement works, and will attain full development in the 5th year, 1988. The total annual direct benefit expected during the economic life of the project is shown in TABLE VIII-4.

8.2.2 Indirect and Intangible Benefits

Besides the direct benefits estimated in the previous section, various indirect and intangible benefits would be brought about by the implementation of the project. These benefits are as follows.

(1) Increase in the production of goods and services from preventing the interruption of economic activigy during the flood in the region and to avoid the cost of activities made necessary by the flood such as emergency flood fighting measures.

(2) Raising agricultural potential by stabilizing the agricultural land through elimination of the flood and sediment damage. The rice production increase which is expected to be around 11,700 tons will contribute greatly to the food production of the project area, and also to the foreign exchange saving by reducing the food import.

(3) Raising the farm income level in the project area which is relatively low and also to improve the income disparity between the regions.

(4) To avoid loss of life and improve the sanitary condition, through which contributing to social stability in the region.

/1 Economic farm gate price of paddy, P1,200/t, was used.