- Required sectional area to be computed by uniform flow calculation method (roughness coefficient: 0.035)

6) Structural Planning

- Dike shall be constructed using excavated material and covered by clayey soil and sodding.
- Slope protection shall be provided at severe bending portions.
- Maintenance road shall be metaled by gravel to ensure activities in rainy season.
- One bridge shall be reconstructed in accordance with the design width and elevation of channel.

(6) River Improvement Works of Sapang Cauayan River

A dammed lake can be seen from the ridge between the Marimla and Sapang Cauayan rivers. This lake will be preserved as it is. Water from the lake flows down through the channel of 50 m wide and 5 m deep draining into the Marimla River.

River channel is formed by downcutting lahar deposits so that both banks are easily eroded by flood water and even heavy rain drops. Accordingly, bank protection works are required from the outlet of dammed lake to the confluence of the Marimla River, a total length of 4 km, to ensure Highway Route 3 restoration.

Figure H.22 shows the typical section of proposed bank protection which is designed to be flexible to changes of riverbed elevations. Gabion mattress revetment with a slope of 1V:2.0H is recommended.

2.5 *SHORT-TERM PLAN (1994-1996)*

(1) Basic Concept

The short-term plan is based on the understanding that the amount of sediment delivered from the Sacobia River is still uncertain although it is rapidly decreasing and sediment should be trapped as much as possible in the sand pocket area. Since the lower half of the affected area in the right bank of the Bamban River upstream of Highway Route 329 has so far a gentle ground slope and a thin cover of sediment, it is the most effective to store sediment in the area.

Flood waters are drained through the Sapang Balen River for a few years. The drainage system is to be constructed in 1995 so as to make the area along the river safe against a 5- to 10-year flood by widening and dredging of the river channel and diking with slope protection.

(2) Short-Term Plan (Phase I in 1994)

The Sacobia River flowed in the affected overbank area in the right bank of the Bamban River after filling up the river channel of pre-eruption topography. It changed its direction easily in accordance with changes in micro-topography of the alluvial fan. The river channel branched away a few sub-channels. A part of the Sacobia River flowed down the affected area and drained into the Sapang Balen River, while the remaining flows joined with the Bamban River.

DPWH constructed lateral dikes at just upstream of Highway Route 329, left side closing dikes and right side open dikes to create a sand pocket in the affected area. A small creek was expanded as a collector channel draining excess water in the sand pocket to the Sapang Balen River. A separation dike was built along the Bamban River to separate the Sacobia River from the Bamban River so as to prevent heavy siltation of the Bamban River near the San Francisco Bridge.

The lateral dikes were not completed in 1994 due to the delay in construction works. Due to the incomplete end structures, the Sapang Balen River was silted up and floods with eroded sediment breached the Sapang Balen river dike near Navaling village. About 100 ha of cultivated areas were affected.

(3) Short-Term Plan (Phase II in 1995-1996)

In this period, sand pocket structures shall be constructed to trap sediment, to prevent secondary erosion of the deposited materials and to release excess water safely into the drainage system. The drainage system shall have a flood flow capacity against 5 to 10-year flood and the capacity shall be maintained during the rainy season by excavation, if needed. The Sapang Balen River is planned to be drained into the Bamban River at 7 km downstream of the San Francisco Bridge. A 5-meter high road dike is planned parallel to the existing Highway Route 329 and it will have the function as end structure of the sand pocket as well as a new elevated road for Highway Route 329 to be partially serviceable before the 1996 rainy season.

The major structures to be implemented in this period will be:

1995

1) Construction of a sump with 0.3 million m^3 of storage capacity upstream of Highway Route 329
2) Construction of right side closing dike
3) Construction of lateral dikes to trap and consolidate sediment in the sand pocket (first and second rows of gabion groundsill)
4) Widening and dredging of collection canal and the Sapang Balen River
5) Protection and rehabilitation of dikes (left side ring dike, separation dike, dikes along the Bamban River)
6) Reconstruction of San Francisco Bridge
7) Excavation of the riverbed of the Bamban River

The existing structures of the sand pocket area and the structures to be constructed in 1995 are illustrated in Figure H.25, and the proposed lateral dikes composed of two rows of gabion groundsills are shown in Figure H.26. This two rows of gabion groundsills can arrest sediment inflow and stabilize the settled deposits from anticipated re-erosion.

Regarding improvement works of the Sapang Balen River channel, two alternative alignment of the new Sapang Balen River channel are proposed. One is straight alignment from the outlet of the sand pocket to the planned confluence point of the Bamban River near Balutu, and the other is curvature alignment encompassing the silted area to the same confluence point. The former alignment is recommendable from the engineering viewpoint, however, the latter may have the advantages of some retention function of siltation and ease of land acquisition. Figure H.23 shows the alignments and typical cross-section to accommodate 5-10 year flood.

1996

1) Construction of a 5-m high road dike along the existing Highway Route 329
2) Maintenance of sump and collection channel
3) Maintenance of the Sapang Balen River
4) Protection and rehabilitation of existing dikes

5) Channeling works of the Sacobia River near Dolores to control the watercourse towards the sand pocket
6) Construction of lateral dikes for stabilization of the sand pocket (third and fourth rows of gabion groundsill)
7) Excavation of the riverbed of the Bamban River and Sapang Balen River

In line with the newly constructed San Francisco Bridge, a 5-m elevated road dike of Highway Route 329, as shown in Figure H.11, shall be constructed not only to protect the transportation route between the central and northern parts of Luzon Island but to retain excess sediment outflow from the sand pocket as an end structure of the area.

The volume of excavation from the riverbed is estimated to be 1.1 million m^3 and 0.4 million m^3 in the Bamban River and the Sapang Balen River, respectively.

2.6 *MEDIUM TERM PLAN (1997-2000)*

(1) Basic Concept of Alternatives

After the completion of the structural measures proposed in the short-term plan in 1997, the sediment supply from the Sacobia River will be maintained within the allowable amount to the Bamban River because of natural reduction of sediment yield in the pyroclastic flow field. Then, the situation of sediment balance will create some choices for the future improvement/development. The following are expected as issues to be solved in this period.

- Stabilization of riverbed covered with accumulated sediment and braiding river course
- Restoration of Highway Route 3 with bridges
- Restoration of lahar-affected area confined by existing dike system

These issues are crucial because they have to be linked tightly with the future development program, namely the long-term plan. However, there will still be a considerable amount of transported sediment to the lower reaches of the Bamban River due to re-erosion of deposited sediment, in particular, in the spindle-shaped valley between Maskup and Mactan, and in the upstream channel of the Bamban River. Installation of sediment control facilities targeting these sediment accumulated areas is indispensable for realizing the restoration works mentioned above.

The alternatives to be considered are composed of the places to plan the expected control structures and restoration work. The following are possible alternatives under the conditions created through execution of the short-term plan, and Figure H.27 illustrates the structural measures taken in each alternative.

1) Alternative-1 : Permanent use of sand pocket without restoration works

2) Alternative-2 : Provisional use of sand pocket and construction of Maskup and Dolores consolidation dams

3) Alternative-3 : Provisional use of sand pocket, construction of Dolores consolidation dam and series of consolidation dams between Mactan and Maskup

4) Alternative-4 : Provisional use of sand pocket, construction of Maskup and Dolores consolidation dams and Upper Bamban bed girdles

(2) Alternative 1

Construction work on lateral dikes in the sand pocket and channel excavation of some 1.5 million m^3 per year has to continue until the sediment discharge will reduce to the pre-eruption condition over the Sacobia-Bamban River basin. The sand pocket will be stabilized towards upstream by constructing a series of lateral dikes with gabion groundsills and collection canals in accordance with the accumulation of sediment. In addition, the Sapang Balen River shall be upgraded to ensure the flow capacity for a 20-year flood.

The major structures to be implemented in this alternative will be:

1997

1) Construction of lateral dikes for stabilization of the sand pocket (fifth and sixth rows of gabion groundsill)
2) Maintenance of sump and collection channel
3) Improvement of the Bamban River
4) Excavation/dredging of the Bamban River and the Sapang Balen River

1998

1) Construction of lateral dikes for stabilization of the sand pocket (seventh row of gabion groundsill)
2) Maintenance of sump and collection channel
3) Improvement of the Bamban River
4) Excavation/dredging of the Bamban River and the Sapang Balen River

1999

1) Maintenance of sump and collection channel
2) Improvement of the Bamban River
3) Improvement of the Sapang Balen River
4) Excavation/dredging of the Bamban River and the Sapang Balen River

2000

1) Construction of lateral dikes for stabilization of the sand pocket (eighth row of gabion groundsill)
2) Maintenance of sump and collection channel
3) Improvement of the Bamban River
4) Improvement of the Sapang Balen River
5) Excavation/dredging of the Bamban River and the Sapang Balen River

Figure H.28 illustrates the alternative components by year.

(3) Alternative 2

For the purpose of reducing re-erosion of sediment in the Mactan-Maskup reaches and consolidating the riverbed, consolidation dams at Maskup and Dolores are planned. Training works between these two dams are also required to maintain the river channel. Restoration of Highway Route 3 and bridge construction will become possible after the training works are completed.

Reclamation of the affected area in the left bank of the Bamban River will commence in this period. A step of pilot firming will be necessary before implementing reclamation works.

When the consolidation works of the Sacobia River are completed, the Sacobia River is ready to join with the Bamban River. The channeling and diking works will be carried out within a single dry season. The point of the confluence shall be determined somewhere near San Pedro Hill, since that point can reduce the excavation volume to the minimum. It is noted that the timing of diversion of the Sacobia River back to the Bamban River shall be determined on the basis of monitoring of sediment movement in the basin because of uncertainty in lahar activities and errors in estimate of sediment erosion rate.

Restoration of Highway Route 3 will be implemented in this period, including bridge and road construction.

Maintenance excavation/dredging of 1.5 million m^3 per year has to be continued until the sediment discharge will reduce to the pre-eruption condition over the Sacobia-Bamban River basin.

The major structures to be implemented in this period will be:

<u>1997</u>

1) Construction of lateral dikes for stabilization of the sand pocket (fifth row of gabion groundsill)
2) Maintenance of sump and collection channel
3) Construction of Maskup and Dolores consolidation dams
4) Improvement of the Bamban River
5) Excavation/dredging of the Bamban River and the Sapang Balen River

<u>1998</u>

1) Training works for the Sacobia River to shift its direction to the Bamban River
2) Improvement of the Bamban River
3) Improvement of the Sapang Cauayan River
4) Excavation/dredging of the Bamban River
5) Reclamation of the sand pocket area

<u>1999</u>

1) Construction of the Bamban bridge
2) Restoration of Highway Route 3
3) Improvement of the Bamban River
4) Excavation/dredging of the Bamban River
5) Agricultural restoration work in the reclaimed area

<u>2000</u>

1) Improvement of the Bamban River
2) Excavation/dredging of the Bamban River
3) Agricultural restoration work in the reclaimed area

Figure H.28 illustrates the alternative components by year.

(4) Alternative 3

After completion of construction of Maskup and Dolores consolidation dams, a remarkable volume of unstable sediment will remain in the valley between Mactan and Maskup, and in the Upper Bamban River channel between Bamban and Malonzo. Alternative 3 will target the area between Mactan and Maskup to stabilize erodible sediment by construction of a series of consolidation dams.

Maintenance excavation/dredging of 1.5 million m^3 per year has to be continued until the sediment discharge will reduce to the pre-eruption condition over the Sacobia-Bamban River basin.

The major structures to be implemented in this period will be:

1997

1) Construction of lateral dikes for stabilization of the sand pocket (fifth row of gabion groundsill)
2) Maintenance of sump and collection channel
3) Construction of Maskup and Dolores consolidation dams
4) Improvement of the Bamban River
5) Excavation/dredging of the Bamban River and the Sapang Balen River

1998

1) Training works for the Sacobia River to shift its direction to the Bamban River
2) Construction of a series of consolidation dams between Mactan and Maskup
2) Improvement of the Bamban River
3) Improvement of the Sapang Cauayan River
4) Excavation/dredging of the Bamban River
5) Reclamation of the sand pocket area

1999

1) Construction of a series of consolidation dams between Mactan and Maskup
2) Construction of the Bamban Bridge
3) Restoration of Highway Route 3
4) Improvement of the Bamban River
5) Excavation/dredging of the Bamban River
6) Agricultural restoration work in the reclaimed area

2000

1) Construction of a series of consolidation dams between Mactan and Maskup
2) Improvement of the Bamban River
3) Excavation/dredging of the Bamban River
4) Agricultural restoration work in the reclaimed area

Figure H.30 illustrates the alternative components by year.

(5) Alternative 4

While Alternative 3 targets unstable sediment remaining in the valley between Mactan and Maskup after completion of construction of Maskup and Dolores consolidation dams, Alternative 4 will stabilize the Upper Bamban River channel between Bamban and Malonzo. The erodible sediment in this segment will cause riverbed aggradation in the lower reaches of the Bamban River. Thus, a series of bed girdles are to be installed so as to stabilize the river channel of the upper reaches in the Bamban River.

Maintenance excavation/dredging of 1.5 million m^3 per year shall be executed until 1998, then the volume of 1.0 million m^3 per year has to be excavated until the sediment discharge will reduce to the pre-eruption condition over the Sacobia-Bamban River basin.

The major structures to be implemented in this period will be:

1997

1) Construction of lateral dikes for stabilization of the sand pocket (fifth row of gabion groundsill)
2) Maintenance of sump and collection channel
3) Construction of Maskup and Dolores consolidation dams
4) Improvement of the Bamban River
5) Excavation/dredging of the Bamban River and the Sapang Balen River

1998

1) Training works for the Sacobia River to shift its direction to the Bamban River
2) Construction of a series of consolidation dams between Mactan and Maskup
2) Improvement of the Bamban River
3) Improvement of the Sapang Cauayan River
4) Excavation/dredging of the Bamban River
5) Reclamation of the sand pocket area

1999

1) Construction of a series of bed girdles between Bamban and Malonzo
2) Construction of the Bamban bridge
3) Restoration of Highway Route 3
4) Improvement of the Bamban River
5) Excavation/dredging of the Bamban River
6) Agricultural restoration work in the reclaimed area

2000

1) Improvement of the Bamban River
2) Excavation/dredging of the Bamban River
3) Agricultural restoration work in the reclaimed area

Figure H.31 illustrates the alternative components by year.

(6) Sediment Balance Forecast for Alternatives

1) Sediment Concentration

Sediment transportation rate has been estimated using Brown formula because of high adaptability for transportation mechanism from bed load transport (individual particle transportation) to immature debris flow (Ref.H.2). Table H.4 shows the estimated average sediment concentration at several reference points. These values of concentration rate can be regarded as relatively small amounts compared with the observed data for the period 1991 to 1993. Based on the 1994 observation, however, the frequency of mudflow and hyper-concentrated flow events has drastically diminished. Furthermore, the annual sediment transportation volume could simulate the 1994 situation of sediment deposition well.

2) Annual Sediment Transportation Volume

The annual rainfall amount at the Middle-Sacobia gauge in 1993 is almost equivalent to the annual average rainfall value for the period from 1991 to 1994, as shown in Figure H.32. Through regression analysis on the daily basis between the point rainfall of Middle-Sacobia and area rainfall over the Sacobia basin estimated in Chapter 6, basin mean rainfall on daily basis is computed as shown in Figure H.33.

According to the observation data by PHIVOLCS for the occurrence of small and moderate-scale lahars in 1994, daily rainfall of 20 mm is likely to be the threshold of those events as shown in Figure H.34. The flood volume is estimated by multiplying the runoff coefficient of 0.85 to the total volume of daily rainfall over 20 mm as shown in Figure H.33.

The annual rainfall amount of 1,570 mm is likely to contribute the sediment transport volume in the Sacobia River. The volume of annual sediment transport is regarded as a deposition volume considering porosity of 40%. Those volumes are tabulated for the reference points by each condition in Table H.4.

3) Sediment Balance Forecast

Figure H.35 shows the future sediment balance from 1995 to 2000 in the case of no-action in the future. The balance shows that secondary erosion will be the major sediment source in the future.

- Sediment delivery from the sediment source zone is still considerable in a few years, and deposits will flow down the sand pocket area with incremental sediment yield due to secondary erosion in the reach from Mactan to Maskup.

- The downstream area from Route 329 will receive sediment outflow from the sand pocket area. Siltation and flooding with much sediment will continue every year.

- Since a remarkable volume of sediment is still deposited in the upstream channel of the Bamban River, the lower reach riverbed will gradually aggrade and San Francisco Bridge will face the serious problem of insufficient freeboard.

In order to provide information on sediment balance for the comparative study in the flood and mudflow control plan, sediment balance is computed for the following alternatives.

a) Preliminary screening among the alternatives proposed in the USACE study (Ref.H.3)

  - Immediate diversion of the Sacobia to the Bamban upstream from Malonzo (Figure H.36), or downstream from Malonzo (Figure H.37)

  - Permanent sand pocket with control structure (Figure H.38)

  The immediate diversion alternative needs continuous excavation work ranging from 3 to 8 million m^3 of annual rate. Regarding the confluence point of both rivers, the upstream point from Malonzo is preferable judging from sediment balance. The permanent sand pocket alternative also requires maintenance excavation work of 0.9 million m^3 annually, as well as the prudent investigation for structural design of the control structure.

b) Comparative study among stepwise alternatives

  - No. 1: Permanent use of sand pocket (Figure H.39)

  - No. 2: Provisional use of sand pocket and Maskup and Route 3 consolidation dams (Figure H.40)

  - No. 3: Provisional use of sand pocket and series of consolidation dams from Maskup to Mactan (Figure H.41)

  - No. 4: Provisional use of sand pocket, Maskup and Route 3 consolidation dams, and Upper-Bamban groundsills (Figure H.42)

  Alternatives No.1 to No.3 require maintenance excavation work of almost 1.5 million m^3 per year, while No.4 requires that of 1.0 million m^3 per year, since thick erodible sand has accumulated in the river channels of the Bamban River and the Sacobia River. Even if sediment control structures are planned in the upper reaches of the Sacobia River to firmly consolidate the riverbed, the diluted floodwater could cause much erosion in the lower reaches of both rivers in proportion to the sediment transportation rate.

According to the simulation results of sediment transportation forecast in Chapter 7, the erodible river bed of the upper-Bamban River will become stable 10 years later as the result of moderating slope of river bed due to down-cutting. Thus, channel excavation of 1.0 to 1.5 million m^3 could be assumed to be continued until the year of 2004.

Those forecasted sediment volumes still have some uncertainty and error because of insufficient basic information of sediment transportation mechanism, therefore the continuous monitoring to elaborate the sediment movement is crucial for appropriately constructing proposed structural measures.

(7) Evaluation of Alternatives

Each alternative is usually evaluated on the basis of effectiveness of technical performance, social effects and economic efficiency. In this section, the evaluation of alternatives is executed focusing on effectiveness of technical performance. The following evaluation is summarized in Table H.5.

1) Alternative 1

The expected functions of Alternative 1 are to retain sediment outflow from the Sacobia River and to stabilize the accumulated deposits to avoid dispersion of re-eroded sediment to the low-lying areas. The main source of sediment to be trapped by the sand pocket will be the valley between Mactan and Maskup where the volume of some 80 million m^3 has accumulated during serious lahar events in 1991 to 1993. Re-eroded sediment of some 3 to 4 million m^3 per year in this valley will continue to be transported into the sand pocket for a long period. Thus, the sand pocket has to be maintained continuously until the river course in the valley forms a stable channel.

The Sapang Balen River will encounter flooding and siltation problems because of muddy flood water from the Sacobia River in every rainy season, therefore, upgrading its flow capacity to 20-year flood is crucial for the protection of low-lying areas. The river channel has to be maintained through excavation/dredging of deposited sediment as well as construction of dikes and slope protection works.

Although Alternative 1 is composed of relatively simple and economical structural measures, continuous maintenance works such as excavation/dredging and repair/extension of the sand pocket structures is inevitable to sustain the sediment retention and flood control functions for a long time. Furthermore, there is no chance for restoration of Highway Route 3 and the sand pocket area until the riverbed in the valley between Mactan and Maskup becomes naturally stable.

b) Alternative 2

Alternative 2 will solve the problem indicated by Alternative 1 through construction of Maskup and Dolores consolidation dams to partially stabilize the riverbed at the end of the valley between Mactan and Maskup. As the results of separation of the Sacobia River from the sand pocket area and stabilization of its channel by river training works, restoration work of Highway Route 3 and the affected area confined in the dike system can be started in 1999 at the earliest.

Excavation/dredging of 1.5 million m^3 per year still has to continue until the riverbeds of the Upper Bamban River and the valley become stable. Thus, continuous monitoring of sediment movement over the Sacobia-Bamban River basin is indispensable for judgment of appropriate direction to be taken by year.

c) Alternative 3

The main target area of Alternative 3 is the valley between Mactan and Maskup, where lahar flow accumulated sediment of 10 to 15 m in depth for the period of 1991 to 1993. Although a series of consolidation dams will firmly stabilize sediment deposits, the foundation of those dams will be placed on the erodible loose lahar materials, so that subsidence of dam body is expected due to heavy scouring of the front side, seepage, and piping beneath the dam body. Therefore, careful monitoring during heavy rains shall be executed to avoid a man-made disaster caused by collapse of the consolidation dam, since there are still uncertainties of the structural reliability between loose foundation and dam body.

Regarding excavation/dredging, the volume of 1.5 million m^3 also has to be excavated annually even though a series of consolidation dams are completed and firmly stabilize the riverbed of the valley because a remarkable volume of deposited sediment will be eroded from the Upper Bamban River channel. Thus, Alternative 3 can be placed at a lower priority compared with Alternative 2.

d) Alternative 4

The main target area of Alternative 4 is the in-channel area of the Upper Bamban River, where the volume of some 23 million m^3 has accumulated during lahar events of 1991 to 1993. A series of bed girdles is effective to accelerate the formation of low-water channel and simultaneously stabilize the erodible sediment deposits. Furthermore, bed girdle is a low-height structure so that the side effects of scouring, piping and seepage can be held at the minimum.

Annual excavation/dredging volume will be reduced to 1.0 million m^3 due to stabilization of the riverbed. Compared with Alternative 2, both alternatives are preferable as optimum plan. The selection of the optimum plan shall be based on social and economic evaluation.

2.7 *CONSTRUCTION PLAN*

(1) Basic Condition

The following basic conditions are commonly applied to the construction plans of Sacobia-Bamban river system.

1) Projected annual working days are estimated on the assumption that work will be suspended on 53 Sundays, 19 national and non-working holidays, and 100 rainy days. Consequently, the average workable days is assumed to be 210 days per year.

2) Most construction works will be undertaken on a 6-day week with 8 hours of work per day.

3) Skilled and unskilled labor can be recruited from areas around the sites and from Metro Manila.

4) Major construction materials to be required are gravel, boulder, mountain clayey soils, cement, reinforcing bars and structural steel. Since construction sites are located in and around Angeles City or near Metro Manila, these materials are easily obtainable commercially. Mountain soils are available in or around construction sites and boulders are transported from some borrow pits in Tarlac Province (one of them is located at Mayantoc along Camiling River, about 2 hours from Bamban River). However, some special structural steel materials may have to be imported because they are not locally produced.

5) Major construction equipment to be needed such as bulldozers, loaders, backhoes, truck cranes, dump trucks, etc., are available in Metro Manila or the vicinity of construction sites on rental basis.

6) Excavated earth material from the Bamban River channel will be disposed at a spoil bank area. The swampy left bank area, mostly downstream of the Bamban River, is proposed.

7) Water for construction works can be obtained from shallow wells at sites and river water may also be used. Commercial electric power is available at sites.

8) As access road to the sites, a national expressway (North Superhighway), national highways (Route Nos. 3, 10 and 329), and many provincial and municipal roads are available. River channels could also play the role of access road in dry season.

9) Construction works will be executed by contract system and administered by the MPR-PMO with assistance from engineering consultants.

(2) Project Components

The optimum plan which shows the highest economic viability among the four alternatives for mudflow and flood control for the Sacobia-Bamban River basin includes the following construction work components:

1) Maskup Consolidation Dam (8 m high by 460 m long).

2) Training works of the Sacobia River between Maskup Consolidation Dam and the confluence with Bamban River including Dolores Consolidation Dam (7 m high by 800 m long), channel excavation, diking slope protection (5 km long).

3) A series of gabion groundsills in the sand pocket (8.9 km).

4) Highway Route 329 road dike including 3 bridges (4.4 km long).

5) Bamban River improvement works including slope protection for dikes (14 km long) and spur dikes (0.5 km long).

6) Bank protection of the Sapang Cauayan River (4 km long).

7) Restoration of Highway Route 3 including Bamban bridge (2.8 km long).

8) Maintenance work : Channel desilting works of the Sapang Balen and Bamban Rivers (13.5 million cubic meters for 9 years).

Figure H.43 shows the project plan including the components mentioned above, and Figure H.44 shows the implementation schedule.

(3) Standard Construction Method of Major Works

1) Steel-wall type sabo dam and groundsill

Sabo/consolidation dams are designed to be made of double-walled steel-filled with lahar material and provided with concrete top cover, steel sheet piling, concrete apron and gabion mattress. They shall be constructed by using construction equipment such as cranes, backhoes and bulldozers.

2) Earthworks of dike/road embankment, and channel desilting

Embankments for dike/road made of excavated lahar material are to be done mainly by heavy equipment such as bulldozers, backhoes/tractor shovels and dump trucks.

Channel excavation is to be executed by using equipment such as tractor shovels for loading, dump trucks for hauling to specific spoil bank and bulldozers for collecting /spreading at channel and spoil banks.

3) Groundsill and slope protection works

Groundsills and bank/slope protection works which consist of gabion mattress, and wet stone masonry are to be carried out by manpower supported by equipment such as cranes or backhoes.

4) Spur dike

Spur dikes made of concrete piles and concrete beams can be constructed by using cranes with drop hammer attachment for driving piles and manpower for concrete beams.

2.8 *COST ESTIMATE*

(1) Conditions for Cost Estimate

Cost estimates in the Medium-Term Plan Stage are based on the following criteria:

a) Construction works are to be executed on the contract basis.

b) Prices are based on the 1994 end price level.

c) Exchange rates used to convert foreign currencies into local currency are US$1.00 = Peso 25.00 = Yen 100 (Peso 1.00 = Yen 4).

d) Estimated cost is divided into two portions, namely foreign currency (FC) and local currency (LC), because foreign financial assistance is expected for implementation of the Project.

e) Cost of main civil works is estimated by multiplying work quantities by the respective unit costs.

(2) Components of Project Cost

Project cost consists of costs for main construction works, compensation (land acquisition and house evacuation), physical contingencies and others. Main construction cost consists of costs for preparatory works, main works and miscellaneous works. Others include administration cost and engineering services cost.

The following components are estimated on the percentage basis.

- Cost of Preparatory Works : 5% of cost of main works
- Cost of Miscellaneous Works : 10% of cost of main works
- Physical Contingencies and Others : 25% of main construction works

1) Unit Cost

Unit costs include contractor's expenses for labor, materials, equipment, as well as overhead, profit, insurance, bond, field supervision and administration, security and safety control, value added tax (10% of labor and equipment), etc.

Unit costs employed for estimation are mainly based on the unit costs used for on-going protection/rehabilitation works implemented by MPR-PMO. Similar projects such as the Pampanga Delta Improvement Project are made as reference.

2) Main Construction Cost

Main construction cost consists of costs for preparatory works, main works and miscellaneous works.

Cost of preparatory works covers the establishment of contractor's site offices, water, power supply and communication systems, topographic survey and soil investigation, transportation of construction equipment, preparation of drawings, and so on.

Cost of main works covers costs to be required for major civil work items in the Project such as excavation, consolidation dams, channeling, slope protection works, groundsills, bridges, road embankment and pavement, and so on.

Cost of miscellaneous works covers minor civil work items compared with the major items mentioned above, including irrigation inlets, drainage outlets, drainage ditch, demolition of existing structures, temporary roads and bridges, maintenance of roads, and so on.

3) Compensation Cost

Compensation cost covers land acquisitions and house evacuations to be required for construction of proposed facilities. In this study, estimate of quantities of land to be purchased and houses to be relocated is limited to the area where the structures are newly proposed such as Highway Route 329 road dike (land of existing sand pocket, area between dikes and river channels are not included in the compensation items).

Areas to be affected by project construction are almost paddy or sugarcane farmlands, and houses of farmers.

4) Physical Contingencies and Others

Cost for physical contingencies is prepared for unknown construction works. Administration cost, among others, is defined as the necessary cost for salary of government staff, office equipment, and so on. Cost for engineering services covers the detail design and construction supervision of the project by engineering consultants employed by the government.

5) Foreign and Local Currency Portions

Foreign currency portion covers mainly the cost of all construction equipment, a part of materials, and most of engineering services.

Local currency portion covers mainly the cost of all labor, a part of materials, value added tax, compensation for land and houses, administration, and a small part of engineering services.

(3) Estimated Project Cost

1) Cost of Alternatives

To select the optimum mudflow/flood control plan for the Sacobia-Bamban River basin, four alternatives as described briefly below were also compared from the viewpoint of cost.

Alternative 1:
- a series of gabion groundsills in the sand pocket
- Highway Route 329 road dike
- The Sapang Balen River improvement based on a 20-year flood
- Slope protection works of the Bamban River
- Desilting works in the Sapang Balen and Bamban channels

Alternative 2:
- One row of groundsill in the sand pocket
- Highway Route 329 road dike
- Maskup and Dolores consolidation dams
- Training works composed of diking and slope protection between Maskup and the confluence of the Bamban River
- Slope protection works of the Bamban and Sapang Cauayan Rivers
- Restoration of Highway Route 3
- Desilting works in the Sapang Balen and Bamban channels

Alternative 3:
- Same components of Alternative 2
- A series of consolidation dams between Mactan and Maskup

Alternative 4:
- Same components of Alternative 2
- A series of bed girdles in the upper reach of Bamban River

Total financial costs of alternatives are summarized below. Estimated costs are shown in Table H.6, and detailed breakdowns for each alternative are given in Tables H.7 to H.10.

(Unit: million Pesos)

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
FC Portion	660	1,151	2,377	1,261
LC Portion	452	778	1,597	852
Total	1,112	1,929	3,974	2,113

2) Cost of Proposed Plan

Alternative 2 could be selected as proposed plan because of the highest economic viability. The following table gives a summary of financial cost:

Components			Cost (million Pesos)
1.	Main Construction Cost		1,534
1.1	Preparatory Works		67
1.2	Main Works		1,334
	(1)	Sand Pocket	332
	(2)	Sacobia River	625
	(3)	Bamban River	205
	(4)	Sapang Cauayan River	41
	(5)	Restoration of Highway Route 3	131
1.3	Miscellaneous Works		133
2.	Compensation Cost		9
3.	Physical Contingencies & Others		386
	Total		1,929
Maintenance Work (Desilting)			810

After completion of construction works, it is important for the related-government agencies to maintain and operate the constructed project structures in good condition. Annual cost of maintenance and operation is assumed to be 0.5% of main construction cost, namely 16.0 million pesos. The cost excludes the above-mentioned desilting cost.

3) Disbursement Schedule

Shown in Table H.11 is the annual disbursement schedule of project cost based on the implementation schedule in Figure H.44.

H.3 SHORT AND MEDIUM TERM PLAN FOR ABACAN RIVER SYSTEM

3.1 PRESENT CONDITION OF ABACAN RIVER BASIN

(1) Upper Reaches

Although no lahar from the pyroclastic flow field has observed in the Sapang Bato River since April 1992, a remarkable volume of lahar deposits still remain in the river channel. Total volume of unstable sediment is estimated at 3.7 million m^3 in the upper reaches of the Abacan River in 1994, of which 1.5 million m^3 of the unstable sediment is stored by sabo dams mainly made of gabions constructed from November 1991 to June 1993.

One of the issues in the headwaters of the Abacan River system is to stabilize sediment stored in sabo dams. In fact, some sabo dams were partially or completely collapsed due to deterioration of the materials and local scouring at the front side of the subdams in 1994, and the others are likely to be damaged in 1995.

Mudflow organized into lahar from pyroclastic flow deposits and ashfall frequently flowed down through the Sapang Bato River in 1991 and early 1992, while mudflow in the Taug River was mainly organized into ashfall deposit in the basin. The mudflow in both rivers caused various problems while it flowed down the river channel such as serious bank erosion destroying residential areas, heavy channel scouring and a remarkable volume of sediment deposition. Before the eruption, the Abacan River and its tributaries formed a low-water channel. The residents had utilized the low river bank for farmlands and fishponds beside the stream. At that time the river banks of the Abacan River and its tributaries were relatively safe from lateral erosion during floods. After the lahar events, however, the former low-water channel was completely buried with sediment or scoured out by mudflow. Even in the 1994 rainy season, bank collapses triggered by lateral erosion occurred frequently, in particular, at the bend. That is another issue of the Abacan river system.

Regarding remaining sediment in the upper reaches of the Abacan River, 2.2 million m^3 of sediment still remains in the river channel of tributaries under unstable condition. Taking into consideration sediment discharge of about 0.5 million m^3 per year at No. 9 sabo dam which is regarded as a downstream end structure of the sediment retention system, the remaining unstable sediment deposits will be gradually transported to the lower reaches of the Abacan River for the next several years. Then, if the unstable sediment stored at sabo dams can be firmly stabilized, sediment discharge from the headwaters of the Abacan River will rapidly reduce to a certain level of some 40,000 m^3 per year.

Mitigating the after-effects of lahar events is the main target of sediment retention measures in the Abacan river system.

(2) Middle and Lower Reaches

1) River Conditions before Eruption

Flooding occasionally occurred downstream of the Capaya Bridge before the Mt. Pinatubo eruption due to overflowing from the river channel of 20 to 30 m wide, while the upstream reaches of the Capaya Bridge hardly experienced flooding.

After the 1972 flood which was the biggest flood recorded in the Central Luzon area, river improvement works commenced. Until the eruption of Mt. Pinatubo, some shortcut channels, high parallel dikes of 3 m high and 7 km long in a stretch of Brgy. San Patrician, Sta. 4+000, to Brgy. Malino, Sta. 11+000, and dry stone masonry at severe bending portions were completed.

On the other hand, the upper reaches from the Capaya Bridge formed a 200 to 300 m wide valley where the river stream of 30 m wide flowed down and was utilized for paddy and sugarcane fields and fishponds.

Regarding reparian structures, there were many pipe culverts installed for irrigation water, and seven bridges including spillway such a box culvert type bridge, namely, Ninoy Aquino Bridge at Brgy. San Juan, Capaya Bridge of the North Super Highway, Pandan Bridge of Angeles - Magalang Road, Abacan Bridge of National Road Route 3, Abacan Railway Bridge, Friendship Bridge at the uppermost stretch of the Lower Abacan River, and San Francisco Spillway between Abacan Road and the railway bridges.

2) Present River Conditions

River width in a stretch of the downstream end to Capaya Bridge (Sta. 0+600 to Sta. 17+700) ranges from 100 to 150 m, where the river channel is confined in a dike system, while the reaches from Capaya Bridge to Friendship Bridge (Sta. 17+700 to Sta. 25+300) range from 150 to 300 m without a diking system.

At the downstream end of the Abacan River, the river width has gradually reduced from 150 m to 30 m, which corresponds to the width of the San Lorenzo Bridge at the end of the Bungang Guinto River.

Longitudinal riverbed profiles as shown in Figure H.45 are between 1/900 and 1/130. Riverbed material consists of sandy lahar including pumice stones in the whole reaches. Remarkable aggradation of riverbed due to reduced sediment transportability is observed at the most downstream reach in the vicinity of Mexico. Severe lateral erosion of 5 to 10 m high bank frequently occurs in the urban area of Angeles City, which accompanies loss of valuable houses and lands.

3) Existing Structures

The protection/rehabilitation works are being continuously undertaken at present. Dikes, slope protection, spur dikes, bridges, intake pipes have been constructed in the Lower Abacan River (refer to Figure H.46).

a) Diking System

The protection/rehabilitation works by means of diking in the Abacan River started in November 1991. The river channel was confined in a dike system with 3 to 5 m in height and 7 m top width which were built of lahar materials within the reaches from Sabo Dam No. 9 at the Friendship Bridge in Angeles City to the confluence of the San Fernando/Bungang Guinto rivers.

There is a structural problem in that the constructed dikes are weak from lateral erosion and local scouring of flood waters because they are made of sandy lahar materials. In early 1994, the breached dikes at several meandering portions in the downstream reaches were rehabilitated and reinforced with wet stone masonry-type slope protection.

b) Channel Excavation

At present, the sediment accumulated in the upper reaches are transported gradually to the downstream end of the river and there is a severe problem of siltation in the vicinity of Mexico in the alluvial plain of the Pampanga Delta. Dredging work for the Bungang Guinto River, downstream of the Abacan River, was executed and is also scheduled in 1995.

c) Spur Dikes

To protect the Capaya bridge of the North Super Highway from vertical and lateral erosions of river channel, 18 spur dikes of 14 m long, 2 m wide, 3 m high, were built with gabion mattress in an interval of about 50 m in the vicinity of the bridge.

d) Reconstruction of Bridges

The reconstruction of Abacan Bridge in Angeles City which was washed away by lahar in June 1991 was completed with a span of 300 m long in the following year of 1992, and one bailey bridge of National Road Route 10 in Mexico was constructed in 1994.

4) Flow Capacity

Present flow capacity of the Lower Abacan River was examined by means of non-unifom flow calculation using the cross sections of channel at intervals of 600 m newly surveyed in early 1994. Figure H.47 shows the present flow capacity calculated considering the freeboard of 0.8 m to 1.0 m. The lower reaches from Sta. 6+000 have the flow capacity of 500 to 1,000 m^3/s, while the upper reaches from Sta. 6+000 have the flow capacity of 2,000 to 4,000 m^3/s.

3.2 *SEDIMENT RETENTION MEASURES*

(1) Possible Structural Measures

The possible structural measures for sediment retention are nominated and preliminary evaluation is done taking into account the site conditions as follows:

1) Sabo Dam

Before the onset of the 1994 rainy season, there were nine sabo dams in the Abacan headwaters, of which four sabo dams partially or completely collapsed during the rainy season of 1994. The damaged portions of the remaining and partially collapsed sabo dams are required to be restored within the dry season before the 1995 rainy season, because they have a relatively large storage of sediment due to the gentle riverbed slope. Above all, the key sabo dams, which preserve the important facilities and areas or have relatively large storage among existing sabo dams, are inevitable to be reconstructed as permanent structures.

2) Spur Dike

A spur dike/groin, either permeable or impermeable, is placed at approximately right angle to the riverbank for controlling flow direction towards the center of the channel so as to prevent bank erosion. Taking into account the site condition of escarpment of 10 m high with sandy materials in the Sapang Bato River, neither a permeable spur dike nor impermeable one avoid local scouring around the foot of escarpment. Therefore, a spur dike is not recommendable for protection measures against bank erosion along the Sapang Bato River.

3) Retaining Wall

Retaining wall along the bank would be appropriate against bank erosion. It has a function of protecting bank and training flood water along the wall. Local scouring used to occur along such a structure in case of improper foundations, so that the low-water channel has to be aligned apart from these structures.

(2) Structural Plan

1) Basic Consideration

Some sabo dams have been repaired almost every year due to deterioration of materials and local scouring at the front side. In the 1994 rainy season, No. 2 and TL-1 sabo dams were damaged during the flood on July 24 to 26. The spillways of No. 2 sabo dam were washed out for over 5 m, and also the same portion of TL-1 sabo dam collapsed for over 20 m. Before this flood, the front portion of No. 2 sabo dam was already partially damaged forming an overhanging shape with the sandbags. On the other hand, the subdam of TL-1 sabo dam completely collapsed before the flood, so that the spillway easily subsided by local scouring around its front side during the flood. Then the gabion wire was broken by tensile stress and finally, the spillway collapsed completely.

Since the retained volume of sediment in TL-1 sabo dam was relatively large and TM-1 sabo dam which could solely control eroded sediment from TL-1 sabo dam in the downstream reach had already been filled up with sediment the collapse of TL-1 sabo dam caused the deposition of eroded sediment and tremendous river bank erosion in the downstream channels happened, in particular, at the Taug River. While, the Taug dike in the right bank of the Taug

River was under construction at that time and some parts of the concrete facing fell due to heavy local scouring.

No. 9 sabo dam plays the most important role among the sediment retention structures in the Abacan River, such as diminishing the exceeding sediment discharge to the lower reaches and sustaining the foundation of the Friendship Bridge. Once No. 9 sabo dam collapses in a heavy rain, enormous retained sediment will be eroded immediately and debris flow forming a high surge will run through the lower reaches with tremendous bank erosion and destroying the riparian structures. On September 10, the left sidewall of 10 m wide in No. 9 sabo dam was partially breached by moderate-scale thunderstorm. Figure H.48 shows riverbed scouring around the foundation of the Friendship Bridge during this event. The damaged left sidewall was protected by temporary sandbag dike as of December 1994.

In due consideration of the above-mentioned condition, rehabilitation works for existing sabo dams are inevitable as the Short-Term Plan to be executed in 1995-1996. Then, the selected dams with high priority for sediment retention shall be reconstructed as permanent structures in the Medium-Term Plan to be executed in 1997-1999. Considering the protected facilities, retained capacity and site availability to be reconstructed, the following sabo dams are nominated to be reconstructed as permanent structures;

- No. 9 sabo dam
- No. 6 sabo dam
- TM-1 sabo dam

Regarding bank erosion along the Sapang Bato River, the retaining wall shall also be constructed in the Medium-Term Plan, since small-scale spur dikes are now being constructed in the area to be protected with financing by the local government.

As for bank erosion of the Pasig River toward the Taug River just upstream of the watching point Delta 5, possibility of lahar intrusion into the Taug River may still be low. Close monitoring at the site will be necessary in the 1995 rainy season.

The components of proposed sediment retention measures are shown in Figure H.49.

2) Short-Term Plan (1994-1996)

<u>1994</u>

DPWH executed rehabilitation work for damaged portion of sabo dams such as restoration of concrete facing, subdams and so on. The dike protection work in the right bank of the Taug River was also carried out to protect Angeles City.

On August 6, a lahar of the Pasig River spilled from the river channel immediately downstream of the watching point Delta 5 toward the left bank and flowed down some hundreds meters. Since there is a risk of lahars flowing into the Taug River, DPWH extended the left side dike to connect the ridge of the Delta 5 as shown in Figure H.50.

<u>1995</u>

Taking into consideration the current situation of the existing sabo dams, urgent rehabilitation works are required to avoid the occurrence of further dam collapse and succeeding bank erosion and sediment dispersion. Based on the site inspection, the following works shall be carried out at each dam site in 1995:

a) No. 9 Sabo Dam

The left abutment dike of the main dam was washed out for 60 m long due to the moderate-scale flood in September 1994. The sandbag dike was installed on the damaged portion as a temporary measure. The following repair works will be required as shown in Figure H.51;

i) Reconstruction/improvement of the left and right dikes such as raising, widening and slope protection work;

ii) Setting up the apron at immediately downstream portion of the main dam;

iii) Installation of additional new step dam between the main dam and the subdam so as to secure the depth of embedment for the main dam and reduce energy of dropping flow; and

iv) Concrete facing on the top of gabion works as protection.

b) TM-1 Sabo Dam

The subdam of TM-1 sabo dam has insufficient height, so that the middle portion of the subdam was washed out by scouring and the base ground of the main dam was exposed. The following rehabilitation works are urgently required as shown in Figure H.52:

i) Raising of wings in the main dam;
ii) Installation of the apron immediately downstream of the main dam;
iii) Rebuilding low spillway at the breached portion of the subdam;
iv) Reinforcement of the downstream side of the subdam; and
v) Concrete facing on the top of gabion works.

c) No. 6 Sabo Dam

The base ground of the main dam is exposed 1 m deep due to scouring. The following rehabilitation works are required as shown in Figure H.53:

i) Raising of both wings in the main dam;
ii) Installation of the apron immediately downstream of the main dam;
iii) Construction of new subdam replacing the existing broken subdam; and
iv) Concrete facing on the top of gabion works.

d) No. 4 Sabo Dam

The downstream surface of the spillway, the subdam and the tertiary dam are partially damaged, so that the following rehabilitation works are necessary as shown in Figure H.54:

i) Raising of wings in the main dam and the subdam;
ii) Installation of additional two-step dams in order to reduce energy of dropping flow at the main and subdams;
iii) Construction of the tertiary step dam, replacing the existing broken tertiary dam; and
iv) Concrete facing on the top of gabion works

1996

Rehabilitation work for the existing sabo dams shall be continued, based on the monitoring activities at each site in the 1995 rainy season.

3) Medium-Term Plan (1997-1999)

For the purpose of stabilization of sediment retained in the storage areas of the existing sabo dams so as to avoid the occurrence of mudflow caused by collapse of the deteriorated sabo dams and protect important facility foundations such as Friendship Bridge, the following sabo dams shall be reconstructed as permanent structures in the Medium Term Plan:

a) No. 9 sabo dam
b) No. 6 sabo dam
c) TM-1 sabo dam

Steel double-walled type sabo dam is also recommendable as described for the structural measures of the Sacobia River. Principal features of those sabo dams are shown in Table H.12 and Figures H.55 to H.57.

The embedment depth of the dam base is set at 3 m in consideration of the soft base ground condition at each site. Height of the spillway crest is determined to keep continuous longitudinal profile to the existing sabo dam.

The design discharge of 100-year flood is adopted for flow capacity of the proposed spillway. Sediment concentration of floods is assumed to be 15% which is half of that in the Sacobia River, since mudflow and hyper-concentrated flow has not occurred in the Abacan River after piracy at Abacan Gap in April 1992.

A set of counter dams, apron, cut-off and riverbed protection works are adopted to prevent heavy scouring around the front side. In addition, the spillway and apron will be covered with concrete to prevent abrasion by sediment collision.

Regarding bank protection works to protect the residential areas against heavy lateral erosion in the upper reaches, the target areas around Sapang Bato, Margot and Anonas Villages are nominated as protective areas. A total length of 3,700 m made of gabion is proposed for retaining works as shown in Figure H.58.

3.3 FLOOD CONTROL MEASURES

(1) Planning Conditions

1) Design Scale

The Abacan River basin can be categorized into a river flowing down the urbanized area of Angeles City, while it is regarded as a relatively small-scale river. The design scale shall be placed on a relatively high level for the Abacan River, so that a 20-year flood is adopted for designing the Medium-Term Plan.

2) Design Discharge

Referring to the estimated probable peak discharge in Chapter 6, the following figures are employed as design discharge (refer to Figure H.59):

River Reach (Sta.)	Design Discharge
No. 3 (25+300 to 18+000)	430 m^3/s
No. 4 (18+000 to 11+000)	510 m^3/s
No. 5 (11+000 to 0+000)	620 m^3/s

3) Applicable Flood Control Measure

Taking the progress of existing river improvement works and topographic conditions into account, river improvement works are regarded as the most optimum measures.

4) Design Freeboard

The freeboard of 0.8 m and 1.0 m shall be applied according to the design discharge of 200 m^3/s to 500 m^3/s, and 500 m^3/s to 2,000 m^3/s, respectively.

(2) River Improvement Plan

1) Channel Alignment

Alignment planning shall follow the present channel alignment.

2) Channel Longitudinal Profile

Although the existing bed elevations and slopes are still remarkably fluctuating, design longitudinal profiles will follow the existing riverbed elevations and longitudinal profiles in consideration of the following:

a) According to the longitudinal riverbed survey carried out in early 1994 (refer to Figure H.45), the present riverbed elevations are slightly lower than the landside ground levels in the whole reaches.

b) As a result of examination of the present flow capacity, the existing dikes have sufficient capacity to drain the design flood in most parts of whole reaches.

c) Existing slope protections were constructed on the basis of existing riverbed elevations.

To determine the design high water level, the following conditions are applied:

a) High water levels are computed by non-uniform flow calculation.

b) High water level at the most downstream point is obtained by uniform flow calculation.

c) Roughness coefficient of 0.035 is used.

Figure H.60 shows the proposed longitudinal profiles including design high water levels and bed elevations.

3) Channel Cross Section

Although stabilization of low water channel is desirable from the viewpoints of dike protection and irrigation water supply, it is difficult and costly to install and maintain the low water channel because of erodible sandy materials of the riverbed. Thus, a single cross section is designed for river improvement works.

In addition, slope protection works are planned at the meandering portions. Figure H.61 shows the proposed typical cross sections of river channel.

4) Channeling in the Urban Area of Angeles City

To protect banks from heavy lateral erosion in the valley reach of about 7 km long from the Capaya Bridge to No. 9 sabo dam (Friendship Bridge) in Angeles City, channeling work to stabilize the channel alignment is proposed. Channel is designed as trapezoid-shaped with slope protection of wet stone masonry type as shown in Figure H.62.

Planning features of proposed channel are as follows:

a)	Design channel width	: 46.3 m
b)	Design channel bed width	: 33.1 m
c)	Design water depth	: 2.5 m
d)	Design freeboard	: 0.8 m
e)	Design longitudinal channel bed slope	: 1/150
f)	Design side slope	: 1V : 2.0H
g)	Roughness coefficient	: 0.035

5) Downstream from the Abacan River (Bungang Guinto River)

It is necessary to continuously dredge the riverbed of the Bungang Guinto River to ensure the sufficient drainage capacity of the downmost Abacan River.

6) Structure Arrangement

Figure H.63 shows the arrangement of proposed structures in the Abacan River Improvement Plan.

a) Slope protection for dikes

Slope protection has been constructed in a total of about 4 km long until 1994 and will be continued in 1995. Additional slope protection work is proposed around the severe meandering portions of 13 km long.

b) Slope protection for channeling in Angeles urban area

Channeling work of 7 km long in the urban area of Angeles City is planned with bank protection.

c) Bridges

The following two bridges are to be constructed as permanent structures.

- Bailey bridge of National Road Route 10 at Mexico
- Spillway washed out by lahars between the Friendship Bridge and the Abacan Railway Bridge.
  (The Pandan bridge in Angeles City is excluded in this Project since it is proposed by another scheme.)

d) Channel excavation

To maintain the design riverbed channel excavation work will be necessary. The deposition volume is estimated at some 2 million m^3 for the period of 1996 to 1999.

(3) Preliminary Design of Structures

1) Slope Protection for Dikes

Slope protection of wet stone masonry type with a slope of 1V : 2H as shown in Figure H.22 which has already been constructed in the Abacan and Bamban rivers are proposed to be constructed for diking reaches.

2) Slope Protection for Channeling in Angeles City

Slope protection of wet stone masonry type with a slope of 1V : 2H as shown in Figure H.62 are proposed in the urban area of Angeles City, so that houses of inhabitants along the river will be free from the danger of falling into the flood waters due to lateral erosion.

3) Bridge

Proposed bridge structures consist of concrete permanent bridge supported by concrete piers and abutments.

3.4 CONSTRUCTION PLAN

(1) Basic Conditions

The basic conditions are the same as those applied to the construction plans of Sacobia-Bamban river system.

(2) Project Components

The plan for mudflow and flood control of the Abacan River system includes the following major construction work components.

1) Reconstruction of 3 sabo dams (No. 6 of 8 m high by 76 m long, No.9 of 8.5 m high by 101 m long, and TM-1 of 7 m high by 126 m long).

2) Retaining wall type bank protection for the Sapang Bato River (3.4 km long).

3) Slope protection for the Lower Abacan River dikes (13 km long).

4) Channeling with revetment in Angeles City urban area (7.3 km long).

5) Bridge construction (2 bridges).

6) Maintenance work : Channel desilting (2 million cubic meters for 4 years).

Figure H.63 shows the project plan of the components mentioned above, and Figure H.64 shows the implementation schedule.

Construction methods of the Abacan River basin project are the same as those of the Sacobia-Bamban River basin project.

3.5 COST ESTIMATE

As for Abacan River basin, no alternatives are considered for comparative study, so that only project cost is estimated. The following is a tabulation of estimated project cost, excluding price contingencies.

(Unit: million Pesos)

	Financial Cost	Economic Cost
FC Portion	460	400
LC Portion	306	266
Total	766	666

Table H.13 show the itemized breakdown of estimated financial cost. Financial cost is summarized as follows.

	Components		Cost (million Pesos)
1.	Main Construction Cost		613
1.1	Preparatory Works		27
1.2	Main Works		533
	(1)	Sabo Dam Reconstruction	131
	(2)	Sapang Bato River	60
	(3)	Abacan River	342
1.3	Miscellaneous Works		53
2.	Physical Contingencies & Others		153
	Total		766
Maintenance Work (Desilting)			120

Table H.14 is the annual disbursement schedule of project cost based on the implementation schedule as shown in Figure H.64.

After completion of construction works, it is important for the related government agencies to maintain and operate the constructed project structures in good condition. Annual cost of maintenance and operation is assumed to be 0.5% of main construction cost, namely 3.8 million pesos. The cost is excludes the above-mentioned desilting cost.

H.4 LONG-TERM PLAN

The long-term development plan are introduced on the basis of the future development plan in the regional development program, of which the one of the plans is the West Central Luzon Regional Development Program which is being carried out by JICA and the another is the Integrated Plan by the MPC. A few development plans are introduced in this Progress Report (2).

4.1 ROAD NETWORK

The future extension plan of road network is shown in Figure H.65. Of the plans, the North Expressway improvement and its extension to Clark Field and to Rosales is included in the Integrated Plan for the Mt. Pinatubo affected area (Final Draft) by MPC. The project aims to improve the capacity of the existing North Luzon Expressway and to provide a direct access route to Clark Field and the Provinces of Tarlac and Pangasinan. The project is composed of four (4) segments as follows:

1)	Balintawak to Tabang Segment	25 km
2)	Burol to Sta. Ines Segment	55 km
3)	Dau to Bamban Segment	10 km
4)	Bamban to Rosales Segment	82 km
	Total length	172 km

Of the segment, the alignment of Dau to Bamban Segment of 10 km with 4-lane stretch is aligned to run into and along the eastern border of the Clark Field and west of the existing MacArthur Highway (Route 3). The project involves the construction of a bridge of 800 m long acrossing the Sacobia River and a bridge of 100 m long acrossing the Bamban River. Total construction cost is estimated at 5,758 million Pesos, of which those for Dau to Bamban Segment is estimated at 1,183 million Pesos.

4.2 AGRICULTURAL DEVELOPMENT

(1) Present Condition

Discussion with the NIA Central and Provincial officials in Tarlac and Pampanga indicate the absence of a long-term and even short-term rehabilitation program of lahar damaged irrigation systems. This may be attributed to the following:

1) the NIA is still waiting on the recommendation of a Master Plan on how to control lahar, including the effectiveness of the infrastructure measures that the DPWH is presently undertaking,

2) uncertainty of funding support from the National Government due to the effect of Local Government Code on devolution and stream-lining program, and

3) hesitation of farmers in the heavily-covered lahar areas to venture in the planting of traditional crops due lack of proper land reclamation technology

It is necessary that a development program be formulated for its rehabilitation and restoration. Meanwhile a rehabilitation program be formulated to restore the agricultural potential of the Study Area starting with the irrigation systems which were damaged by the lahar flow. The location map of the priority schemes are shown in Figure H.66.

(2) Urgent Rehabilitation /Restoration Works

This may be considered as an interim program to restore and improve the agricultural production in the Study Area by rehabilitating all CIS which are still rehabitable and where protective measures to stave-off further damages due to lahar flow have already been in-place and/or can be easily installed. This may include the following:

1) Sacobia-Bamban River Basin

There are about 9 existing irrigation systems/projects within the Sacobia-Bamban river basin which are not directly affected by lahar flow. This systems/projects were damaged mainly due to increase in siltation brought about by ashfall and flash flood within their watersheds. Urgent restoration in this 9 systems is necessary in order to attain crop production prior to their pre-eruption condition. They are covered mostly within the political jurisdiction of Tarlac Province with the following Municipal distribution:

Town/City	No. of CIS/CIP	Area(ha)
a) Bamban	1	400
b) Capas	2	702
c) Concepcion	6	4,033
Total	9	5,135

2) Abacan River Basin

There are about 22 existing irrigation systems/projects within the Abacan River basin which are not directly affected by lahar flow. This systems/projects were damaged mainly due to increase in siltation brought about by ashfall and flood within their watersheds. Urgent restoration in this 22 systems is necessary in order to attain crop production prior to their pre-eruption condition. They are covered mostly within the political jurisdiction of Pampanga Province with the following Municipal distribution:

Town/City	No. of CIS/CIP	Area(ha)
a) Angeles	1	120
b) Mabalacat	3	303
c) Magalang	3	136
d) Arayat	7	782
e) Mexico	1	180
f) San Fernando	2	84
g) Santa Ana	1	28
h) Candaba	3	754
i) San Luis	1	206
Total	22	2,539

The Selection Criteria in identifying the priority CIS/CIP for Urgent Restoration Works which are affected by Mt. Pinatubo eruption and under this Study are as follows:

a) Systems that were programmed and/or on-going for rehabilitation prior to eruption but suspended/stopped due to the eruption,

b) Projects that were programmed and/or on-going but were stopped indefinitely due to the eruption, and

c) Systems/projects that had already availed of rehabilitation funds but still need further rehabilitation/ restoration due to continuous flow of lahar or sediments caused by ashfall.

List of Priority CIS/CIP for Urgent Restoration Works in the Sacobia-Bamban River basin (Tarlac Province) and Abacan River basin (Pampanga Province) is tentatively given in Table H.15.

(3) Land Reclamation

1) Present Condition

The Northern portion of the Bamban River, which is about 3,000 ha is composed of eight (8) existing CIS with some non-registered areas. A total of 1,350 ha was directly damaged of which 465 ha was severely covered with lahar in 1991.

At present, the northern portion of the Bamban River would be safe from lahar with the completion of concrete-lined left bank dike of the Bamban River and because of the diversion of the Sacobia River to sand pocket area.

Agricultural activities in areas where damaged was minimal and/or spared from lahar cover has also been resumed. Farmers harnessed available rainfall and plain run-off including shallow well pumps for irrigation water supplement specially during scarce rainfall.

Considering that the Marimla and Sapang Cauayan Rivers which would be the source of irrigation water are free from lahar, the area is presently attractive for irrigation development. However, due to insufficient hydrological data, it is recommended that further study be undertaken to ascertain water availability to meet irrigation requirement for the proposed development scheme.

2) Bamban-Concepcion Area Irrigation Development and Land Reclamation

The proposed project considered for medium-term irrigation development plan has a total potential irrigable area of about 3,000 ha and therefore falls on the category of National Irrigation Project (NIP). The proposed diversion structure of the ogee-type is about 800 meter upstream of the former bridge site at the national highway in Bamban town and the water source would be the Marimla and Sapang Cauayan rivers.

3) Bamban Crop Experimental Station

A 20 ha pilot demonstration farm and/or crop experimental station is being envisioned to conduct experiments to determine the best crops on lahar medium covered areas 1.0 to 1.5 m deep. Crop propagation experiments may include rice, sugarcane, mongo, corn, peanut among others. It is also aimed to encourage lahar-affected farmers to plant suitable crops based on the result of the Crop Experimental Station.

4) Concepcion Crop Experimental Station

A 20 ha pilot demonstration farm is being envisioned to conduct experiments to determine the best crops on heavy covered lahar areas 1.5 to 2.5 m deep. It is also aimed to encourage lahar affected farmers to plant suitable crops based on the result of the Crop Experimental Station. The Selection Criteria in identifying areas for Medium Term Irrigation Development are as follows:

a) Systems or areas which are of run-off-river type either partially or wholly-covered with lahar but have strong potential for irrigation development,

b) Areas that are already safe from lahar flow where protective infrastructure has already been in-place, and

c) Areas were agricultural activities has resumed despite of deficient irrigation infrastructures.

5) Sand Pocket Area

Long term irrigation development program are envisaged in the areas located in the downstream reach from sand pocket structures when the medium term plan of DPWH to re-channel Sacobia River back to its upstream confluence at the Bamban River.

6) Irrigation Development and Land Reclamation in Concepcion

The long-term irrigation development has a potential irrigable area of about 3,095 ha and therefore falls on the category of National Irrigation Project (NIP). The proposed diversion structure of the ogee-type shall be constructed along Bamban River on the western tip of ring levee protecting barangay Telabanca in the Municipality of Concepcion. The areas which were not damaged and/or covered with lahar of about 2,630 ha are being planted with rice through available rainfall and by shallow well pumps supplement.

Another alternative which is categorized into medium-term irrigation development is through extensive groundwater irrigation due to the following reasons:

a) the area is already safe from lahar flow due to the construction of lahar/mudflow control infrastructure facilities,

b) the area is extensively planted with crops even with deficient irrigation facilities, and

c) in order to alleviate the living condition of the farmers and bring Government closer to the lahar-affected families.

7) Sand Pocket Area Irrigation Development and Land Reclamation

Sand pocket area is being utilized by DPWH as lahar catchment basin for the Sacobia River. It has a potential irrigable area for long-term irrigation development program of about 715 ha. The proposed cropping pattern and farming technology including the type of crops will be based on the result and recommendation of the proposed Concepcion Crop Experimental Station.

(4) Proposed Phased Development

In the long term plan, the formulation of an irrigation development plan in the Study Area is inevitable to ensure the agricultural productivity before the eruption. The phased development is formulated preliminarily as follows:

1) Phase I - Urgent Restoration Works
   - Phase I.A
     - a) 9 CIS/CIP in the Sacobia-Bamban River basin, all in the Province of Tarlac
     - b) 22 CIS/CIP in the Abacan River basin, all in the Province of Pampanga
   - Phase I.B
     - a) Bamban Crop Experimental Station
     - b) Concepcion Crop Experimental Station

2) Phase II
   - a) Bamban-Concepcion Area Irrigation Development and Land Reclamation Project located at the Northern portion of the Bamban River
   - b) Irrigable Service Area = 3000 ha
   - c) Land Reclamation Area = 1350 ha

3) Phase III - Irrigation Development and Land Reclamation Project located at the Southern portion of the Bamban River
   - a) Concepcion Area Irrigation Development and Land Reclamation
     - Irrigable Service Area = 3095 ha
     - Land Reclamation Area = 465 ha
   - b) Sand Pocket Area Irrigation Development and Land Reclamation
     - Irrigable Service Area = 715 ha
     - Land Reclamation Area = 715 ha

The Implementation Schedule is formulated preliminarily as shown in Figure H.67.

4.3 TOURISM

Damming of Marimla and Sapang Cauayan rivers by the aggradation of the Sacobia River has led to the intermittent formation of lakes. Although the damming of Marimla River was breached in 1991, the dammed lake at Sapang Cauayan River still remains with a storage of 7 million m^3 at El. 90 m.

A peaceful, beautiful scenery can be seen from the hilltop between Marimla and Sapang Cauayan rivers and blue lake surface stretched to the foot of the hill. The water quality satisfies the criteria adopted by the Government of the Philippines.

H.5 PROJECT EVALUATION

5.1 ALTERNATIVE SCHEMES

Four(4) alternative schemes are formulated in the Sacobia/Bamban Rivers and one (1) scheme in the Abacan River according to the various component of the flood/mudflow control structures. These are already introduced in Sections H.2 and H.3, respectively. In this section, the economic analysis of these alternative schemes was made to confirm their economic viability and to select the best alternative for the Sacobia/Bamban scheme.

5.2 COST ESTIMATE

The construction cost was estimated on the basis of the following preconditions:

1) the base period of cost estimate was set at the end of 1994
2) the exchange rates were assumed at US$ 1=Peso 25=Y 100
3) the estimate excludes tax and duties
4) the estimate does not include the price contingency for the future
5) the administration cost was estimated at 5% of the main construction cost
6) the physical contingency cost, administration cost and engineering services cost were estimated at 25% of the main construction cost.

The reclamation cost of the sand pocket is not included in any alternative schemes because the cultivation of the lahar affected farm land is not deemed feasible at the present stage of the Study yet. The cost for desilting works were treated as the maintenance cost and scheduled to be disbursed in four(4) years for Abacan and for nine(9) years for Sacobia/Bamban starting from the initial stage of the construction.

The operation and maintenance costs of each alternative were estimated at 0.5% of the total of the main construction cost.

The cost (financial) of all alternatives are summarized in Table H.16 for each alternative scheme.

5.3 BENEFIT OF THE PROJECT

(1) Criteria of Benefit

The benefit to be accrued from the implementation of the Project was defined in this Study as the reduction of the direct and indirect damages caused by the flood/mudflow. The probable direct and indirect damages were estimated under the without-project conditions at the end of 1994. The damage under the with-project conditions were assumed to be zero under the design flood of 20 year-return period. Thus, the project benefit constitutes the probable damage to occur by the flood of the designed scale.

(2) Estimate of Direct Damage

In estimating the damageable value of all the properties in the probable inundation area, a "Barangay Data Base" was established in the GIS. All the data required for the estimate of damage including the population, the number of household, properties and areas of each barangay were input and arranged in this Data Base.

The method of estimating the damageable value is stated by each item hereunder:

1) Building

A regression formula showing the relationship between the number of houses, establishments and households were generated through a multi-variable regression analysis for each barangay. The number of the affected building was obtained by the formula through inputting the affected area of each barangay.

2) Agricultural Crops

The land use map of each crop of each barangay was stored in GIS Barangay Data Base. The damage of agricultural crops were computed according to the area affected by the flood of each return period. The damage of the livestock was estimated by a ratio of the agricultural crops.

3) Infrastructures

The length of roads and bridges were stored in the Barangay Data Base for each barangay. The damage to these infrastructures were computed according to the area affected in each barangay.

The probable damage value was computed based on the percentage of the affected area to the total barangay area. The unit value of each property applied is as shown in Table H.17. The damage rate of each property was measured and applied by the depth of the flood and lahar as shown in the damage curve of Figure H.68. The inundation area of floods for each return period is depicted in Figure H.69.

The average annual direct damage was obtained for each river after aggregating each property damage and is tabulated in Tables H.18 and H.19. Judging from the gradient of the curves shown under the above-mentioned tables, the design period of 20 years can be said reasonable.

(3) Estimate of Indirect Damage

In this Study, the indirect damage were estimated as stated hereunder.

1) Additional Transportation Cost

The probable extra cost of transportation due to the unserviceability of roads and bridges caused by the flood was computed based on the detour distance, duration and the vehicle operation cost. The total traffic demand for crossing the Bamban River was assumed at 13,000 per day based on the recent traffic survey of JICA and DPWH. The detour alternative routes were assumed for each origin-destination route under the normal condition i.e. under the pre-eruption conditions as shown in Figure H.70. The computation formula and other data for the computation is shown in Table H.20. The time value of drivers were not included in this Study.

2) Loss of Production by Interruption of Economic Activities

The loss of the production by the interruption of economic activities caused by floods were estimated based on the per capita GRDP of non-agricultural sector (estimated at P36,900 in 1996 at 1994 price) multiplied by the duration and the number of affected people in urban areas.

3) Evacuation and Building Clean-up Costs

The evacuation cost and the building clean-up cost to occur at the time of disasters were estimated based on the duration and the historical statistics as shown in Table H.17.

5.4 COMPARISON OF COST AND BENEFIT

The financial cost shown in Tables H.18 and H.19 was converted into the economic cost to adjust the distorted market price value. Considering the current unemployment situation, the market wage was adjusted by shadow wage rate which was assumed at 60% of the market wage rate. In order to adjust the distortion of the official exchange rate, the standard conversion factor of 0.86 was applied. The compensation of the land acquisition was adjusted through evaluating the land value by the production foregone value assuming the cultivation of the irrigated paddy. The cost-benefit comparison is presented in Tables H.20 to H.24.

The disbursement of capital investment was assumed evenly during four years of construction period. The desilting works were assumed to start from the beginning of the construction.

Benefits were assumed to accrue immediately after the completion of the Project. When the expected rapid economic growth in the Central Luzon Region is considered, the value of properties in the Study Area is also expected to increase rapidly. In this Study, the flood control benefit (saving of direct damages) was assumed to increase at the same rate as that of GRDP of the Region i.e. 8.23 % p.a.

The benefit accrued from the saving of detour costs of vehicles is also expected to increase as the traffic volume increases. In this Study, the growth rate estimated for the new North Luzon Expressway studied by JICA in the LISR Study was adopted and 1.9% p.a. growth of traffics were applied. While, assuming the completion of the said new highway after 15 years, the transportation benefit was treated to be excluded from the project benefit. Among the four alternatives for the Sacobia/Bamban Rivers, the Alternative-1 does not include the construction of the road dike of the Route 329. This is the reason for the Alternative-1 to have less benefit than the other alternatives.

The result of the EIRR computation shows that only the Sacobia/Bamban Alternative-3 was unjustified. Among four alternatives for the Sacobia/Bamban Rivers, the Alternative-2 showed the highest EIRR of 14.6% followed by the Alternative-4 with a slight difference. The Abacan scheme showed a high EIRR of 28.2%.

5.5 IMPLICATION OF ECONOMIC EVALUATION

(1) "Present Status"

It is to be noted that the project benefit to be accrued from the saving of the probable direct damage was computed on the basis of the present (as of end 1994) conditions of the Study Area which is being covered partially by lahar deposit. Therefore, in such an area as Bamban municipality where a wide lahar deposit exists, the probable damage counted in the economic analysis is far less than that to be occurred under the pre-eruption conditions. In other words, there are less probable damage remaining in such a heavily-damaged area, which worked to reduce the EIRR of the Project.

(2) Evaluation of Abacan Scheme

The high EIRR (28.2%) of the Abacan Scheme was derived mainly from the saving of probable building damages to occur in the probable inundation area which includes some densely-populated areas near around Mexico, Santa Ana and Arayat municipalities. The comparatively small amount of the construction cost is another reason of the high EIRR.

(3) Evaluation of Sacobia/Bamban Alternatives

The Alternative-2 (14.6%) has a slight advantage comparing with the Alternative-4 (14.4%) in terms of EIRR value. A major difference in structural components between these two alternatives is that the Alternative-4 has the component of the construction of a series of bed girdles in the Bamban River while the Alternative-2 does not have the component. The resulted EIRR shows that the construction of a series of bed girdles in the Bamban River would work to reduce the EIRR, though the Alternative-4 itself can be justified as a whole.

The benefit to be accrued from the saving of probable direct damages constitutes more than half of the total project benefit (c.f. Table H.21). Like the case of the Abacan, the component of building damage constitutes the major portion of the total benefit (c.f. Table H.19). This is resulted from the fact that some densely-populated areas in Concepcion municipality are included in the probable inundation area.

The transportation benefit - savings of the detour cost of vehicles caused by the flooding of roads - occupies more than 40% of the total benefit. This shows the fact that the Study Area constitutes an important location in terms of the transportation connecting the National Capital Region and the Northern Luzon Regions. The transportation of raw materials and final products transported into and out of San Fernando and/or Angeles constitutes the major flow of the traffic.

(4) Reclamation of Sand-Pocket

The pre-eruption conditions of the current sand-pocket area is shown below:

Name Brgy	Telabanca	Malonzo	Sto. Rosario	Sapang Balen	Tabun
Area(sq.km)	7.7	2.4	1.7	7.9	1.7
H/H(1990)	350	128	379	60	528
Pop(1990)	2,249	811	2,268	347	3,001

The total area of about 22 square km land is now abandoned and utilized as the sand trap. As shown above, there existed in this area five (5) barangays before the eruption and the population was about 8,700 (1,450 households) in total of the whole barangays.

In this Study, the reclamation of the sand-pocket area was not included as a component. Because, the feasibility of the lahar cultivation was obscure. Assuming the sugarcane cultivation which is most profitable among various crops and assuming the normal yield of 45 ton/ha,

Net Income = P 20,930 * 2,200 ha = P 46 million/year
Reclamation Cost(Annualized) =P 68.7 million (for 2,200 ha)

The simple comparison of annual cost and benefit suggests that the exclusion of the component is better for the Project. It seems better for the Project to implement the reclamation when an appropriate technology of the lahar cultivation is established and the lahar farming becomes feasible for farmers. Meanwhile, the present Project can prepare the conditions for a possible use of the sand-pocket area for farming. The area will be ready for farmers to cultivate with their own will and investment for the cultivation.

(5) Tourism Development

Apart from the structural measures to cope with possible natural disasters, the present Project will pave the way for the region to promote a possible tourism development in this area. Actually, a small natural lake has been created after the eruption in the upper stream of the Sapang Cauayan River in a walking distance from the Route No.3. When the safety of the climbing Mt. Pinatubo is assured, then a volcano tourism with a sight-seeing network linking the mountains and lakes will become popular in this area. In the CLDP Study of JICA, the development of a sort of eco-tourism is being envisaged in the Region. An amusement Park in Clark Field is also proposed in the same Study. A golf course is under construction near Dolores in Mabalacat municipality. All these tourism development plans can be realized only after the security against possible natural disasters is assured by such a structural measures proposed by the present Project.

(6) Physical Benefits

The Project benefit was estimated by the saving of probable direct and indirect damages caused by the probable flood and/or lahar with a scale of 20-year return period. The consequent physical benefit will extend to the following :

1) Population to be relieved from inundation	:	53,000 (8% of Study Area)
2) Number of household to be relieved	:	10,000 (7%)
3) Land area to be saved from inundation	:	87 square km (8%)
4) Farm land to be saved	:	4,300 ha

In summing up, the Project , as a whole of Abacan and Sacobia/Bamban Schemes, will relieve 53,000 persons of 10,000 households from suffering the inundation and will also save 87 square km of land in which 4,300 ha is a farm land.

The road traffic will be possibly to be maintained to its normal order , which is absolutely necessary for economic activities and also for the daily life of an ordinary people. With a security of the safety from the natural disasters, a company can make an investment with a longer time span. The most valuable benefit of the Project seems to be that many people can be free from the risk of losing their lives though it is not included in the benefit computation.

REFERENCES

Ref No.	*TITLE*
H.1	US Army Corps of Engineers "Mount Pinatubo Recovery Action Plan, Long Term Report - Eight River Basins, Volume I: Main Report", March 1994
H.2	Vanoni, Vito A., "Sedimentation Engineering", Copyright 1975
H.3	US Army Corps of Engineers "Mount Pinatubo Recovery Action Plan, Abbreviated Version - Eight River Basins, Main Text", July 1994

TABLES

Table H.1 Possible Structural Measures in Sacobia-Bamban River System

Structural Measures	Applicable Area	Purpose	Dimension/Components	Adaptability/Evaluation
Revegetation	Sediment Source Zone	- To prevent sheet and gully/rill erosion - To contribute to environmental conservation	-	Revegetation will be effective when the pyroclastic deposit field become cool.
Simple Sabo Dam	Sediment Source Zone	- To control sediment inflow from tributaries	-	Sediment control effect might be small compared with measures in the middle reaches.
Sabo Dam	Sediment Deposition/Secondary Erosion Zone	- To retain sediment inflow	Mactan Dam: 10 m in height, 78 m in length, 100,000 m3 in volume	Retention capacity is relatively small compared with anticipated sediment inflow, and construction cost is not economically viable.
Consolidation Dam	Sediment Deposition/Secondary Erosion Zone	- To consolidate accumulated sediment and reduce sediment discharge - To control watercourse	Maskup Dam: 8 m in height, 460 m in length; Dolores Dam: 7 m in height, 800 m in length; A series of dams: 8 m each in height, 8,360 m in total length (9 dams).	Consolidation dam at Maskup is preferable to stabilize accumulated sediment and control sediment discharge. Although a series of consolidation dams will firmly stabilize sediment, it is costly.
Sand Pocket	Sediment Deposition/Secondary Erosion Zone	- To retain sediment inflow	- Slope protection work of closing dike - A series of lateral groundsills - A sump to trap fine particles - Channeling and excavation of Sapang Balem River	If the components of sand pocket structure are completed, sediment control effect may be enormous.
Bed Girdle	Sediment Deposition/Secondary Erosion Zone	- To stabilize riverbed and reduce sediment discharge	6 rows of groundsill between Bamban and Malonzo, 400 m in length.	Bed girdles in the upper reaches of Bamban River will be effective in regulating riverbed aggradation of the lower reaches.
Channel Works	Sediment Deposition/Secondary Erosion Zone	- To fix watercourse and avoid lateral erosion and scouring	5 km in length between Maskup and Bamban	In the case of joining the Sacobia River with the Bamban River, channel works will be needed to avoid forming distributary channel.
Channel Excavation	Sediment Deposition/Secondary Erosion Zone	- To maintain riverbed elevation or increase flow capacity		Channel excavation is necessary in the aggrading portion of the riverbed.
Dike	Sediment Conveyance Zone	- To protect land from flooding	50 km in length, 4-8 m in height	New dike system will be needed with mountain soil cover and slope protection instead of lahar dike.
Spur Dike/Groin	Sediment Conveyance Zone	- To protect dike from scouring	4 meandering parts	A spur dike/groin will be placed at the meandering part to reduce the flow velocity along the dike.

Table H.2 Comparison of Alternatives for Flood and Mudflow Control on USACE Study

Alternative	Case 1 No Action	Case 2 Diversion and Dredging	Case 3 USACE s Levee Plan
Plan		Immediate Diversion of Sacobia to Bamban	Permanent Sand Pocket with Control Structure
Major Component		Diversion of Sacobia River Diking along Sacobia River Dredging Bamban/Parua River (4 mcm every year)	6 - 13 m high levees Control structure
Cost * (million pesos)		Initial cost (million pesos) Diking and channeling of Sacobia River 100 Levee restoration and protection 200 Total 300 Annual Cost, dredging for 10 years 240 Total Capital Cost (10% discount rate) 2,000	Initial cost (million pesos) Levee and control structures 1,370 Total 1,370 Annual Cost, dredging for 10 years 60 Total Capital Cost (10% discount rate) 1,840
Advantage		• easy construction of Sacobia channel • free from Sacobia floods in the right bank of Bamban River downstream of Highway 329	• easy maintenance • sand trap in sand pocket • free from Sacobia floods in the right bank of Bamban River downstream of Highway 329
Disadvantage	• high risk of San Francisco Bridge due to siltation in 1995 • high risk of flooding in right bank of Bamban downstream of Highway 329 due to Sacobia floods and mudflows. Some 4,000 ha will be affected. • high risk of flooding due to siltation of Bamban River	• moderate risk of San Francisco Bridge due to uncertainty of implementation of dredging work in rainy season in 1995 • continuous dredging for more than 10 years • continuous maintenance of the Sacobia diversion channel • no delay is allowed for heightening San Francisco Bridge	• high risk in San Francisco Bridge and right bank area downstream of Highway 329 in 1995 • no prospect for recovery of sand pocket area and transportation system • no delay is allowed for heightening San Francisco Bridge
Remarks	The areas along Bamban River have a high risk of floods and mudflows for several years.	Intensive dredging works are required for removing 4.0 mcm of sediment a year.	Dredging in Bamban River or channeling of Sapang Balem River is required in rainy season of 1995.

* Preliminary cost estimates for Case 2 and Case 3 include some errors and cost common to the three cases such as restoration of Highway No. 3, maintenance of levees and training of Bamban river channel is not included in the comparison.

Table H.3 Comparison of Dam Types

Item to be compared	Dam Type			
	Gabions	Concrete Gravity	Masonry	Double Wall
Main Materials	Gabions, Boulders	Concrete	Boulders Cover Concrete	Steel Bar, Filling Sand
Durability of Dam Body	low	high	moderate	moderate
Adaptability on Soft Base	moderate	low	low	moderate
Flexibility against Deformation	moderate	low	low	moderate
Construction Period	moderate	long	long	short
Construction Cost	low	high	high	low
Preferable Dam Type				○

Note: Preferable dam type means the most suitable dam type for the unstable sandy base as a permanent structure.

Table H.4 Evaluation of Alternatives

	Alternative-1	Alternative-2	Alternative-3	Alternative-4
Plan	- Permanent use of sand pocket	- Provisional use of sand pocket - Shift of Sacobia R. to Bamban R. with sediment retention structures	- Provisional use of sand pocket - Shift of Sacobia R. to Bamban R. with sediment retention structures	- Provisional use of sand pocket - Shift of Sacobia R. to Bamban R. with sediment retention structures
Major Components	- Sand pocket structure - Sapang Balen R. improvement - Bamban R. Improvement	- Sand pocket structure (temporary) - Maskup & Dolores consolidation dam - Sacobia R. training works - Bamban R. Improvement	- Sand pocket structure (temporary) - Maskup & Dolores consolidation dam - Series of consolidation dams between Mactan & Maskup - Sacobia R. training works - Bamban R. Improvement	- Sand pocket structure (temporary) - Maskup & Dolores consolidation dam - Bed girdles in upper Bamban R. - Sacobia R. training works - Bamban R. Improvement
Advantage	- Simple measures	- Possibility to restore Highway Route 3 & sand pocket area - Solution of siltation problem in low-lying area	- Possibility to restore Highway Route 3 & sand pocket area - Solution of siltation problem in low-lying area	- Possibility to restore Highway Route 3 & sand pocket area - Solution of siltation problem in low-lying area - Possibility to utilize river water of upper Bamban River
Disadvantage	- Continuous construction & maintenance work of sand pocket structure - No chance of restoration for Highway Route 3 & affected area - Continuous siltation problem in low-lying area	- Apprehension of scouring at front side of dams	- Apprehension of scouring at front side of dams - Close monitoring to scouring downstream of consolidation dams - Uncertainty of safety for long lateral structures on loose sandy base - Prolonging construction period and inevitability of structural flexibility for topographic change - Low cost benefit ratio	- Apprehension of scouring at front side of dams - Close monitoring to scouring downstream of bed girdles
Remarks	- Maintenance excavation of 1.5 million m^3/year	- Maintenance excavation of 1.5 million m^3/year - Inevitability of monitoring activity to topographic change and constructed structures	- Maintenance excavation of 1.5 million m^3/year - Inevitability of monitoring activity to topographic change and constructed structures	- Maintenance excavation of 1.0 million m^3/year - Inevitability of monitoring activity to topographic change and constructed structures

Table II.5 Project Cost of Alternatives for Sacobia-Bamban River System

Cost Unit : Pesos

Work Items	Unit	Unit Cost	Alternative-1		Alternative-2		Alternative-3		Alternative-4	
			Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount
1.MAIN CONSTRUCTION COST				880,440,000		1,534,387,500		3,170,147,500		1,681,012,500
1.1 Preparatoty Works	L.S			38,280,000		66,712,500		137,832,500		73,087,500
1.2 Main Works				765,600,000		1,334,250,000		2,756,650,000		1,461,750,000
1.2.1 Sand Pocket				283,780,000		140,900,000		140,900,000		140,900,000
(1) Lateral Dike of Groundsills	m	13,000	17,500	227,500,000	8,900	115,700,000	8,900	115,700,000	8,900	115,700,000
(2) Revetments	m	8,400	6,700	56,280,000	3,000	25,200,000	3,000	25,200,000	3,000	25,200,000
1.2.2 Highway Route 329 Road Dike				192,100,000		191,100,000		191,100,000		191,100,000
(1) Embankment and Pavement	m	37,500	4,300	161,250,000	4,300	161,250,000	4,300	161,250,000	4,300	161,250,000
(2) Bridges (3 bridges)	m2	25,000	1,234	30,850,000	1,194	29,850,000	1,194	29,850,000	1,194	29,850,000
1.2.3 Consolidation Dams (Maskup & Others)						157,000,000		1,579,400,000		157,000,000
1) Steel wall & tie rod	ton	32,000			1,080	34,560,000	14,850	475,200,000	1,080	34,560,000
2) Steel sheet piling	ton	56,000			360	20,160,000	4,050	226,800,000	360	20,160,000
3) Plain concrete	m3	2,200			5,980	13,156,000	77,670	170,874,000	5,980	13,156,000
4) Reinforced concrete	m3	3,000			6,400	19,200,000	57,600	172,800,000	6,400	19,200,000
5) Gabion mattress	m3	1,600			14,120	22,592,000	83,000	132,800,000	14,120	22,592,000
6) Rubble concrete	m2	1,500			5,600	8,400,000	5,600	8,400,000	5,600	8,400,000
7) Others	L.S					38,932,000		392,526,000		38,932,000
1.2.4 Sacobia River Training Works						468,300,000		468,300,000		468,300,000
(1) Dolores Cosolidation Dam						278,300,000		278,300,000		278,300,000
1) Steel wall & tie rod	ton	32,000			1,760	56,320,000	1,760	56,320,000	1,760	56,320,000
2) Steel sheet piling	ton	56,000			560	31,360,000	560	31,360,000	560	31,360,000
3) Plain concrete	m3	2,200			9,300	20,460,000	9,300	20,460,000	9,300	20,460,000
4) Reinforced concrete	m3	3,000			9,600	28,800,000	9,600	28,800,000	9,600	28,800,000
5) Gabion mattress	m3	1,600			19,420	31,072,000	19,420	31,072,000	19,420	31,072,000
6) Rubble concrete	m2	1,500			11,000	16,500,000	11,000	16,500,000	11,000	16,500,000
7) Others	L.S					93,788,000		93,788,000		93,788,000
(2) Training Work	m	38,000			5,000	190,000,000	5,000	190,000,000	5,000	190,000,000
1.2.5 Bamban River Improvement				204,500,000		204,500,000		204,500,000		204,500,000
(1) Revetments	m	14,000	14,000	196,000,000	14,000	196,000,000	14,000	196,000,000	14,000	196,000,000
(2) Spur Dikes	m	17,000	500	8,500,000	500	8,500,000	500	8,500,000	500	8,500,000
1.2.6 Bank Protection for Sapang Cauayan River	m	10,300			4,000	41,200,000	4,000	41,200,000	4,000	41,200,000
1.2.7 Sapang Balen River Improvement				85,220,000						
(1) Excavation, Dike, Road, etc	m	4,700	9,200	43,240,000						
(2) Revetments	m	7,000	3,240	22,680,000						
(3) Bridge	m2	25,000	772	19,300,000						
1.2.8 Restoration of Highway Route 3						131,250,000		131,250,000		131,250,000
(1) Embankment and Pavement	m	16,500			2,500	41,250,000	2,500	41,250,000	2,500	41,250,000
(2) Bamban Bridge	m2	25,000			3,600	90,000,000	3,600	90,000,000	3,600	90,000,000
1.2.9 Bed Girdles in Bamban River	m	51,000							2,500	127,500,000
1.3 Miscellaneous Works	L.S			76,560,000		133,425,000		275,665,000		146,175,000
2. COMPENSATION COST				9,000,000		9,000,000		9,000,000		9,000,000
(1) Land Acquisition	ha	200,000	35	7,000,000	35	7,000,000	35	7,000,000	35	7,000,000
(2) House Evacuation	each	100,000	20	2,000,000	20	2,000,000	20	2,000,000	20	2,000,000
3. PHYSICAL CONTINGENCY AND OTHERS				222,360,000		385,846,875		794,786,875		422,503,125
Grand Total				1,111,800,000		1,929,234,375		3,973,934,375		2,112,515,625
MAINTENANCE WORK										
Desilting Works	m3	60	13,500,000	810,000,000	13,500,000	810,000,000	13,500,000	810,000,000	10,500,000	630,000,000

Notes:
(1) Preparatory works = 5 % of main works.
(2) Miscellaneous works = 10 % of main works.
(3) Physical contingency and others = 25 % of main construction cost and compensation cost.

Table H.6 Project Cost of Alternative-1 for Sacobia-Bamban River System (Financial)

Cost Unit : Pesos

Work Items	Unit	Quantity	F.C Portion		L.C Portion		Total
			Unit Cost	Amount	Unit Cost	Amount	
1.MAIN CONSTRUCTION COST				527,744,200		352,695,800	880,440,000
1.1 Preparatoty Works	L.S			22,945,400		15,334,600	38,280,000
1.2 Main Works				458,908,000		306,692,000	765,600,000
1.2.1 Sand Pocket				170,000,000		113,780,000	283,780,000
(1) 3rd to 8th Groundsills	m	17,500	7,800	136,500,000	5,200	91,000,000	227,500,000
(2) Revetments	m	6,700	5,000	33,500,000	3,400	22,780,000	56,280,000
1.2.2 Highway Route 329 Road Dike				115,260,000		76,840,000	192,100,000
(1) Embankment and Pavement	m	4,300	22,500	96,750,000	15,000	64,500,000	161,250,000
(2) Bridges	m2	1,234	15,000	18,510,000	10,000	12,340,000	30,850,000
1.2.3 Sapang Balen River Improvement				50,948,000		34,272,000	85,220,000
(1) Excavation, Dike, Road, etc	m	9,200	2,800	25,760,000	1,900	17,480,000	43,240,000
(2) Revetments	m	3,240	4,200	13,608,000	2,800	9,072,000	22,680,000
(3) Bridge	m2	772	15,000	11,580,000	10,000	7,720,000	19,300,000
1.2.4 Bamban River Improvement				122,700,000		81,800,000	204,500,000
(1) Revetments	m	14,000	8,400	117,600,000	5,600	78,400,000	196,000,000
(2) Spur Dikes	m	500	10,200	5,100,000	6,800	3,400,000	8,500,000
1.3 Miscellaneous Works	L.S			45,890,800		30,669,200	76,560,000
2. COMPENSATION COST						9,000,000	9,000,000
(1) Land Acquisition	ha	35			200,000	7,000,000	7,000,000
(2) House Evacuation	each	20			100,000	2,000,000	2,000,000
3. PHYSICAL CONTINGENCY AND OTHERS				131,936,050		90,423,950	222,360,000
Grand Total				659,680,250		452,119,750	1,111,800,000
MAINTENANCE WORK							
Desilting Works (1.5 million m3 x 9 years)	m3	13,500,000	36	486,000,000	24	324,000,000	810,000,000

Notes:
(1) Preparatory works = 5% of main works.
(2) Miscellaneous works = 10% of main works.
(3) Physical contingency = 25 % of main construction cost and compensation cost.

Table II.7 Project Cost of Alternative-2 for Sacobia-Bamban River System (Financial)

Cost Unit : Pesos

Work Items	Unit	Quantity	F.C Portion		L.C Portion		Total
			Unit Cost	Amount	Unit Cost	Amount	
1.MAIN CONSTRUCTION COST				920,918,620		613,468,880	1,534,387,500
1.1 Preparatoty Works	L.S			40,039,940		26,672,560	66,712,500
1.2 Main Works				800,798,800		533,451,200	1,334,250,000
1.2.1 Sand Pocket				84,420,000		56,480,000	140,900,000
(1) 3rd to 5th Groundsills	m	8,900	7,800	69,420,000	5,200	46,280,000	115,700,000
(2) Revetments	m	3,000	5,000	15,000,000	3,400	10,200,000	25,200,000
1.2.2 Highway Route 329 Road Dike				114,660,000		76,440,000	191,100,000
(1) Embankment and Pavement	m	4,300	22,500	96,750,000	15,000	64,500,000	161,250,000
(2) Bridges (3 bridges)	m2	1,194	15,000	17,910,000	10,000	11,940,000	29,850,000
1.2.3 Maskup Consolidation Dam				94,000,000		63,000,000	157,000,000
1) Steel wall & tie rod	ton	1,080	19,000	20,520,000	13,000	14,040,000	34,560,000
2) Steel sheet piling	ton	360	33,600	12,096,000	22,400	8,064,000	20,160,000
3) Plain concrete	m3	5,980	1,300	7,774,000	900	5,382,000	13,156,000
4) Reinforced concrete	m3	6,400	1,800	11,520,000	1,200	7,680,000	19,200,000
5) Gabion mattress	m3	14,120	1,000	14,120,000	600	8,472,000	22,592,000
6) Rubble concrete	m2	5,600	900	5,040,000	600	3,360,000	8,400,000
7) Others	L.S			23,359,200		15,572,800	38,932,000
1.2.4 Sacobia River Training Works				281,218,800		187,081,200	468,300,000
(1) Dolores Cosolidation Dam				167,218,800		111,081,200	278,300,000
1) Steel wall & tie rod	ton	1,760	19,000	33,440,000	13,000	22,880,000	56,320,000
2) Steel sheet piling	ton	560	33,600	18,816,000	22,400	12,544,000	31,360,000
3) Plain concrete	m3	9,300	1,300	12,090,000	900	8,370,000	20,460,000
4) Reinforced concrete	m3	9,600	1,800	17,280,000	1,200	11,520,000	28,800,000
5) Gabion mattress	m3	19,420	1,000	19,420,000	600	11,652,000	31,072,000
6) Rubble concrete	m2	11,000	900	9,900,000	600	6,600,000	16,500,000
7) Others	L.S			56,272,800		37,515,200	93,788,000
(2) Channeling Work	m	5,000	22,800	114,000,000	15,200	76,000,000	190,000,000
1.2.5 Bamban River Improvement				122,700,000		81,800,000	204,500,000
(1) Revetments	m	14,000	8,400	117,600,000	5,600	78,400,000	196,000,000
(2) Spur Dikes	m	500	10,200	5,100,000	6,800	3,400,000	8,500,000
1.2.6 Bank Protection for Sapang Cauayan River	m	4,000	6,200	24,800,000	4,100	16,400,000	41,200,000
1.2.7 Restoration of Highway Route 3				79,000,000		52,250,000	131,250,000
(1) Embankment and Pavement	m	2,500	10,000	25,000,000	6,500	16,250,000	41,250,000
(2) Bamban Bridge	m2	3,600	15,000	54,000,000	10,000	36,000,000	90,000,000
1.3 Miscellaneous Works	L.S			80,079,880		53,345,120	133,425,000
2. COMPENSATION COST						9,000,000	9,000,000
(1) Land Acquisition	ha	35			200,000	7,000,000	7,000,000
(2) House Evacuation	each	20			100,000	2,000,000	2,000,000
4. PHYSICAL CONTINGENCY AND OTHERS				230,229,655		155,617,220	385,846,875
Grand Total				1,151,148,275		778,086,100	1,929,234,375
MAINTENANCE WORK							
Desilting Works (1.5 million m3 x 9 years)	m3	13,500,000	35	486,000,000	24	324,000,000	810,000,000

Notes:
(1) Preparatory works = 5 % of main works.
(2) Miscellaneous works = 10 % of main works.
(3) Physical contingency and others = 25 % of main construction cost and compensation cost.

Table II.8 Project Cost of Alternative-3 for Sacobia-Bamban River System (Financial)

Cost Unit : Pesos

Work Items	Unit	Quantity	F.C Portion		L.C Portion		Total
			Unit Cost	Amount	Unit Cost	Amount	
1.MAIN CONSTRUCTION COST				1,901,220,710		1,268,926,790	3,170,147,500
1.1 Preparatoty Works	L.S			82,661,770		55,170,730	137,832,500
1.2 Main Works				1,653,235,400		1,103,414,600	2,756,650,000
1.2.1 Sand Pocket				84,420,000		56,480,000	140,900,000
(1) 3rd to 5th Groundsills	m	8,900	7,800	69,420,000	5,200	46,280,000	115,700,000
(2) Revetments	m	3,000	5,000	15,000,000	3,400	10,200,000	25,200,000
1.2.2 Highway Route 329 Road Dike				114,660,000		76,440,000	191,100,000
(1) Embankment and Pavement	m	4,300	22,500	96,750,000	15,000	64,500,000	161,250,000
(2) Bridges (3 bridges)	m2	1,194	15,000	17,910,000	10,000	11,940,000	29,850,000
1.2.3 A group of Consolidation Dams				946,436,600		632,963,400	1,579,400,000
1) Steel wall & tie rod	ton	14,850	19,000	282,150,000	13,000	193,050,000	475,200,000
2) Steel sheet piling	ton	4,050	33,600	136,080,000	22,400	90,720,000	226,800,000
3) Plain concrete	m3	77,670	1,300	100,971,000	900	69,903,000	170,874,000
4) Reinforced concrete	m3	57,600	1,800	103,680,000	1,200	69,120,000	172,800,000
5) Gabion mattress	m3	83,000	1,000	83,000,000	600	49,800,000	132,800,000
6) Rubble concrete	m2	5,600	900	5,040,000	600	3,360,000	8,400,000
7) Others	L.S			235,515,600		157,010,400	392,526,000
1.2.4 Sacobia River Training Works				281,218,800		187,081,200	468,300,000
(1) Dolores Cosolidation Dam				167,218,800		111,081,200	278,300,000
1) Steel wall & tie rod	ton	1,760	19,000	33,440,000	13,000	22,880,000	56,320,000
2) Steel sheet piling	ton	560	33,600	18,816,000	22,400	12,544,000	31,360,000
3) Plain concrete	m3	9,300	1,300	12,090,000	900	8,370,000	20,460,000
4) Reinforced concrete	m3	9,600	1,800	17,280,000	1,200	11,520,000	28,800,000
5) Gabion mattress	m3	19,420	1,000	19,420,000	600	11,652,000	31,072,000
6) Rubble concrete	m2	11,000	900	9,900,000	600	6,600,000	16,500,000
7) Others	L.S			56,272,800		37,515,200	93,788,000
(2) Channeling Work	m	5,000	22,800	114,000,000	15,200	76,000,000	190,000,000
1.2.5 Bamban River Improvement				122,700,000		81,800,000	204,500,000
(1) Revetments	m	14,000	8,400	117,600,000	5,600	78,400,000	196,000,000
(2) Spur Dikes	m	500	10,200	5,100,000	6,800	3,400,000	8,500,000
1.2.6 Bank Protection for Sapang Cauayan River	m	4,000	6,200	24,800,000	4,100	16,400,000	41,200,000
1.2.7 Restoration of Highway Route 3				79,000,000		52,250,000	131,250,000
(1) Embankment and Pavement	m	2,500	10,000	25,000,000	6,500	16,250,000	41,250,000
(2) Bamban Bridge	m2	3,600	15,000	54,000,000	10,000	36,000,000	90,000,000
1.3 Miscellaneous Works	L.S			165,323,540		110,341,460	275,665,000
2. COMPENSATION COST						9,000,000	9,000,000
(1) Land Acquisition	ha	35			200,000	7,000,000	7,000,000
(2) House Evacuation	each	20			100,000	2,000,000	2,000,000
3. PHYSICAL CONTINGENCY AND OTHERS				475,305,178		319,481,698	794,786,875
Grand Total				2,376,525,858		1,597,408,488	3,973,934,375
MAINTENANCE WORK							
Desilting Works (1.5 million m3 x 9 years)	m3	13,500,000	36	486,000,000	24	324,000,000	810,000,000

Notes:
(1) Preparatory works = 5 % of main works.
(2) Miscellaneous works = 10 % of main works.
(3) Physical contingency and others= 25 % of main construction cost and compensation cost.

Table II.9 Project Cost of Alternative-4 for Sacobia-Bamban River System (Financial)

Cost Unit : Pesos

Work Items	Unit	Quantity	F.C Portion		L.C Portion		Total
			Unit Cost	Amount	Unit Cost	Amount	
1.MAIN CONSTRUCTION COST				1,008,893,620		672,118,880	1,681,012,500
1.1 Preparatoty Works	L.S			43,864,940		29,222,560	73,087,500
1.2 Main Works				877,298,800		584,451,200	1,461,750,000
1.2.1 Sand Pocket				84,420,000		56,480,000	140,900,000
(1) 3rd to 5th Groundsills	m	8,900	7,800	69,420,000	5,200	46,280,000	115,700,000
(2) Revetments	m	3,000	5,000	15,000,000	3,400	10,200,000	25,200,000
1.2.2 Highway Route 329 Road Dike				114,660,000		76,440,000	191,100,000
(1) Embankment and Pavement	m	4,300	22,500	96,750,000	15,000	64,500,000	161,250,000
(2) Bridges (3 bridges)	m2	1,194	15,000	17,910,000	10,000	11,940,000	29,850,000
1.2.3 Maskup Consolidation Dam				94,000,000		63,000,000	157,000,000
1) Steel wall & tie rod	ton	1,080	19,000	20,520,000	13,000	14,040,000	34,560,000
2) Steel sheet piling	ton	360	33,600	12,096,000	22,400	8,064,000	20,160,000
3) Plain concrete	m3	5,980	1,300	7,774,000	900	5,382,000	13,156,000
4) Reinforced concrete	m3	6,400	1,800	11,520,000	1,200	7,680,000	19,200,000
5) Gabion mattress	m3	14,120	1,000	14,120,000	600	8,472,000	22,592,000
6) Rubble concrete	m2	5,600	900	5,040,000	600	3,360,000	8,400,000
7) Others	L.S			23,359,200		15,572,800	38,932,000
1.2.4 Sacobia River Training Works				281,218,800		187,081,200	468,300,000
(1) Dolores Cosolidation Dam				167,218,800		111,081,200	278,300,000
1) Steel wall & tie rod	ton	1,760	19,000	33,440,000	13,000	22,880,000	56,320,000
2) Steel sheet piling	ton	560	33,600	18,816,000	22,400	12,544,000	31,360,000
3) Plain concrete	m3	9,300	1,300	12,090,000	900	8,370,000	20,460,000
4) Reinforced concrete	m3	9,600	1,800	17,280,000	1,200	11,520,000	28,800,000
5) Gabion mattress	m3	19,420	1,000	19,420,000	600	11,652,000	31,072,000
6) Rubble concrete	m2	11,000	900	9,900,000	600	6,600,000	16,500,000
7) Others	L.S			56,272,800		37,515,200	93,788,000
(2) Channeling Work	m	5,000	22,800	114,000,000	15,200	76,000,000	190,000,000
1.2.5 Bamban River Improvement				122,700,000		81,800,000	204,500,000
(1) Revetments	m	14,000	8,400	117,600,000	5,600	78,400,000	196,000,000
(2) Spur Dikes	m	500	10,200	5,100,000	6,800	3,400,000	8,500,000
1.2.6 Bank Protection for Sapang Cauayan River	m	4,000	6,200	24,800,000	4,100	16,400,000	41,200,000
1.2.7 Restoration of Highway Route 3				79,000,000		52,250,000	131,250,000
(1) Embankment and Pavement	m	2,500	10,000	25,000,000	6,500	16,250,000	41,250,000
(2) Bamban Bridge	m2	3,600	15,000	54,000,000	10,000	36,000,000	90,000,000
1.2.8 Bed Girdles in Bamban River	m	2,500	30,600	76,500,000	20,400	51,000,000	127,500,000
1.3 Miscellaneous Works	L.S			87,729,880		58,445,120	146,175,000
2. COMPENSATION COST						9,000,000	9,000,000
(1) Land Acquisition	ha	35			200,000	7,000,000	7,000,000
(2) House Evacuation	each	20			100,000	2,000,000	2,000,000
3. PHYSICAL CONTINGENCY AND OTHERS				252,223,405		170,279,720	422,503,125
Grand Total				1,261,117,025		851,398,600	2,112,515,625
MAINTENANCE WORK							
Desilting Works (1.5 million m3 x 3years & 1.0 million m3 x 6years)	m3	10,500,000	36	378,000,000	24	252,000,000	630,000,000

Notes:
(1) Preparatory works = 5 % of main works.
(2) Miscellaneous works = 10 % of main works.
(3) Physical contingency and others = 25 % of main construction cost and compensation cost.

Table H.10 Annual Disbursement Schedule of Project Cost for Sacobia-Bamban River System

(Unit : Peso)

Work Items	Total				1996		1997		1998		1999		2000	
	Unit	Quantity	Unit Cost	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount
1. MAIN CONSTRUCTION COST				1,534,387,500		369,265,000		609,730,000		465,117,500		48,300,000		41,975,000
1.1 Preparatory Works	L.S	1		66,712,500		16,055,000		26,510,000		20,222,500		2,100,000		1,825,000
1.2 Main Works				1,334,250,000		321,100,000		530,200,000		404,450,000		42,000,000		36,500,000
1.2.1 Sand Pocket				140,900,000		88,000,000		52,900,000						
(1) 3rd to 5th Groundsills	m	8,900	13,000	115,700,000	5,800	75,400,000	3,100	40,300,000						
(2) Slope Protection	m	3,000	8,400	25,200,000	1,500	12,600,000	1,500	12,600,000						
1.2.2 Highway Route 329 Road Dike				191,100,000		191,100,000								
(1) Embankment & Pavement	m	4,300	37,500	161,250,000	4,300	161,250,000								
(2) Bridges	each	3		29,850,000	3	29,850,000								
1.2.3 Maskup Consolidation Dam	L.S	1		157,000,000			1	157,000,000						
1.2.4 Sacobia River Channeling Works				468,300,000				278,300,000		190,000,000				
(1) Dolores Consolidation Dam	L.S	1		278,300,000			1	278,300,000						
(2) Channeling Works	m	5,000	38,000	190,000,000					5,000	190,000,000				
1.2.5 Bamban River Improvement				204,500,000		42,000,000		42,000,000		42,000,000		42,000,000		36,500,000
(1) Slope Protection	m	14,000	14,000	196,000,000	3,000	42,000,000	3,000	42,000,000	3,000	42,000,000	3,000	42,000,000	2,000	28,000,000
(2) Spur Dikes	m	500	17,000	8,500,000									500	8,500,000
1.2.6 Bank Protection (S. Cauayan R.)	m	4,000	10,300	41,200,000					4,000	41,200,000				
1.2.8 Restoration of Highway Route 3				131,250,000					2,501	131,250,000				
(1) Embankment & Pavement	m	2,500	16,500	41,250,000					2,500	41,250,000				
(2) Bamban Bridge	each	1		90,000,000					1	90,000,000				
1.3 Miscellaneous Works	L.S	1		133,425,000		32,110,000		53,020,000		40,445,000		4,200,000		3,650,000
2. COPENSATION COST				9,000,000		9,000,000								
(1) Land Acquisition	ha	35	200,000	7,000,000	35	7,000,000								
(2) House Evacuation	each	20	100,000	2,000,000	20	2,000,000								
3. PHYSICAL CONTINGENCY & OTHERS	L.S	1		385,846,875		94,566,250		152,432,500		115,279,375		12,075,000		10,493,750
TOTAL				1,929,234,375		472,831,250		762,162,500		581,396,875		60,375,000		52,468,750
MAINTENANCE WORK														
Desilting Works	cu m	13,500,000	60	810,000,000	(For 9 years from 1996 to 2004,1,500,000 cu.m/yr x 60 Peso = 90,000,000 Peso/yr)									

Notes:
(1) Preparatory works = 5% of main works.
(2) Miscellaneous works = 10% of main works.
(3) Physical contingency and others = 25% of main construction cost.

Table H.11 Design Condition and Principal Features of Proposed Sabo Dam in Abacan River Basin

	No. 9 Sabo Dam	No. 6 Sabo Dam	TM-1 Sabo Dam
Design Conditions			
Catchment Area	33.3 km^2	3.5 km^2	8.3 km^2
Design Discharge	400 m^3/s	130 m^3/s	200 m^3/s
Overflow Depth	2.4 m	2.1 m	1.5 m
Freeboard	0.8 m	0.6 m	0.8 m
Dimension of Structure			
Effective Height	5.5 m	5.0 m	4.0 m
Height of Main Dam	8.5 m	8.0 m	7.0 m
Length of Main Dam	101 m	76 m	126 m
Width of Main Dam	11 m	10 m	9 m
Spillway Width	60 m	25 m	60 m
Wing Height	3.5 m	3.0 m	3.0 m
Apron Length	21 m	18 m	14 m

Table H.12 Project Cost for Abacan River System (Financial)

Cost Unit : Pesos

Work Items	Unit	Quantity	F.C Portion Unit Cost	F.C Portion Amount	L.C Portion Unit Cost	L.C Portion Amount	Total
1.MAIN CONSTRUCTION COST				368,389,850		244,450,900	612,840,750
1.1 Preparatoty Works	L.S			16,016,950		10,628,300	26,645,250
1.2 Main Works				320,339,000		212,566,000	532,905,000
1.2.1 Reconstruction of Sabo Dams				78,624,000		51,876,000	130,500,000
(1) Sabo Dam No.9				45,235,000		29,765,000	75,000,000
1) Steel wall & tie rod	ton	210	19,000	3,990,000	13,000	2,730,000	6,720,000
2) Steel sheet piling	ton	130	33,600	4,368,000	22,400	2,912,000	7,280,000
3) Plain concrete	m3	1,370	1,300	1,781,000	900	1,233,000	3,014,000
4) Reinforced concrete	m3	2,470	1,800	4,446,000	1,200	2,964,000	7,410,000
5) Gabion mattress	m3	8,390	1,000	8,390,000	600	5,034,000	13,424,000
6) Rubble concrete	m3	5,400	900	4,860,000	600	3,240,000	8,100,000
7) Others	L.S			17,400,000		11,652,000	29,052,000
(2) Sabo Dam TM-1				20,938,000		13,862,000	34,800,000
1) Steel wall & tie rod	ton	200	19,000	3,800,000	13,000	2,600,000	6,400,000
2) Steel sheet piling	ton	100	33,600	3,360,000	22,400	2,240,000	5,600,000
3) Plain concrete	m3	1,400	1,300	1,820,000	900	1,260,000	3,080,000
4) Reinforced concrete	m3	2,090	1,800	3,762,000	1,200	2,508,000	6,270,000
5) Gabion mattress	m3	3,160	1,000	3,160,000	600	1,896,000	5,056,000
6) Rubble concrete	m3	-	900	0	600	0	0
7) Others	L.S			5,036,000		3,358,000	8,394,000
(3) Sabo Dam No.6				12,451,000		8,249,000	20,700,000
1) Steel wall & tie rod	ton	130	19,000	2,470,000	13,000	1,690,000	4,160,000
2) Steel sheet piling	ton	50	33,600	1,680,000	22,400	1,120,000	2,800,000
3) Plain concrete	m3	830	1,300	1,079,000	900	747,000	1,826,000
4) Reinforced concrete	m3	1,090	1,800	1,962,000	1,200	1,308,000	3,270,000
5) Gabion mattress	m3	2,260	1,000	2,260,000	600	1,356,000	3,616,000
6) Rubble concrete	m3	-	900	0	600	0	0
7) Others	L.S			3,000,000		2,028,000	5,028,000
1.2.2 Bank Erosion Protection Works for Sapang Balen River	m	3,400	10,700	36,380,000	7,000	23,800,000	60,180,000
1.2.3 Channeling in Angeles Urban Area	m	7,300	10,800	78,840,000	7,200	52,560,000	131,400,000
1.2.4 Slope Protection in Lower Reach	m	13,000	8,400	109,200,000	5,600	72,800,000	182,000,000
1.2.5 Bridge Works (2 bridges)	m2	1,153	15,000	17,295,000	10,000	11,530,000	28,825,000
1.3 Miscellaneous Works	L.S			32,033,900		21,256,600	53,290,500
2. PHYSICAL CONTINGENCY AND OTHERS				92,097,463		61,112,725	153,210,188
Grand Total				460,487,313		305,563,625	766,050,938
MAINTENANCE WORK							
Desilting Works	m3	2,000,000	36	72,000,000	24	48,000,000	120,000,000

Notes:

(1) Preparatory works = 5% of main works.
(2) Miscellaneous works = 10% of main works.
(3) Physical contingency and others = 25% of main construction cost.

Table H.13 Annual Disbursement Schedule of Project Cost for Abacan River System

(Unit : Peso)

Work Items	Total				1996		1997		1998		1999		2000	
	Unit	Quantity	Unit Cost	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount
1. MAIN CONSTRUCTION COST				612,840,750		41,860,000		217,134,375		160,899,375		81,880,000		111,067,000
1.1 Preparatory Works	LS	1		26,645,250		1,820,000		9,440,625		6,995,625		3,560,000		4,829,000
1.2 Main Works				532,905,000		36,400,000		188,812,500		139,912,500		71,200,000		96,500,000
1.2.1 Reconstruction of Sabo Dams				130,500,000				75,000,000		20,700,000		34,800,000		
(1) Sabo Dam No.6	LS	1		20,700,000					1	20,700,000				
(2) Sabo Dam No.9	LS	1		75,000,000			1	75,000,000						
(2) Sabo Dam TK-1	LS	1		34,800,000							1	34,800,000		
1.2.2 Bank Protection (S. Bato R.)	m	3,400	17,700	60,180,000									3,400	60,180,000
1.2.3 Channeling in Angeles City	m	7,300	18,000	131,400,000			3,500	63,000,000	3,800	68,400,000				
1.2.4 Slope Protection in Lower Reach	m	13,000	14,000	182,000,000	2,600	36,400,000	2,600	36,400,000	2,600	36,400,000	2,600	36,400,000	2,600	36,400,000
1.2.5 Bridge Works	each	2		28,825,000			1	14,412,500	1	14,412,500				
1.3 Miscellaneous Works	LS	1		53,290,500		3,640,000		18,881,250		13,991,250		7,120,000		9,658,000
2. PHYSICAL CONTINGENCY & OTHERS	LS	1		153,210,188		10,465,000		54,283,594		40,224,844		20,470,000		27,766,750
TOTAL				766,050,938		52,325,000		271,417,969		201,124,219		102,350,000		138,833,750
MAINTENANCE WORK														
Desilting Works	cu.m	2,000,000	60	120,000,000	400,000	24,000,000	400,000	24,000,000	400,000	24,000,000	400,000	24,000,000	400,000	24,000,000

Notes:
(1) Preparatory works = 5% of main works.
(2) Miscellaneous works = 10% of main works.
(3) Physical contingency and others = 25% of main construction cost.

Table H.14 List of Priority CIS/CIP for Urgent Restoration (1/2)

Province of Tarlac

NAME	LOCATION	PARTS DAMAGED BY LAHAR	ESTIMATED REHAB. COST (Million Pesos)	SERVICE AREA (ha)	IRRIGABLE AREA (ha)				CROP YIELD in CAVANS/HA.				NUMBER OF FARMER BENEFICIARIES
					WET		DRY		WET		DRY		
					a/	b/	a/	b/	a/	b/	a/	b/	
1 Panaisan CIS *	Bamban	A. B. C.	2.522	400.00	300.00	112.00	200	50	80	80	85	85	60
2 Lab CIS *	Capas	A. B. C. D. E.	2.975	362.00	242.00	242.00	120	120	80	80	85	85	140
3 Kawili-wili CIP	Capas	A. B. C.	29.500	340.00	0.00	0.00	0	0	0	0	0	0	300
4 Balucuk CIS *	Concepcion	B. C. E.	0.820	119.00	100.00	100.00	100	100	85	85	85	85	45
5 Lucong CIS *	Concepcion	A. B. C. D. F.	30.677	2,250.00	1600.00	1,300.00	1000	900	85	85	90	90	700
6 Sta. Monica CIS *	Concepcion	A. F.	3.017	740.00	300.00	300.00	300	150	85	85	85	85	193
7 Sto. Rosario CIS *	Concepcion	A. F.	2.580	210.00	200.00	200.00	100	100	85	85	90	90	102
8 Tinang CIS	Concepcion	A. B. C.	2.980	600.00	190.00	190.00	40	40	80	80	85	85	170
9 Caluluan PIS	Concepcion	B. C.	0.300	114.00	114.00	114.00	70	50	75	75	85	85	42
SUB-TOTAL			**75.371**	**5135.00**	**3046.00**	**2558.00**	**1930**	**1510**					**1752**

NOTE:

* CIS/CIP already availed of Rehabilitation of Areas Affected by Mt. Pinatubo Eruption (RAAMPE) Funds

A. Repair and desilting of dam and reservoir

B. Desilting of Irrigation Canals

C. Installation of Control Slidegates

D. Upgrading of Service Roads

E. Installation of Pumps and/or Desilting at the Intake Works

F. Canal Lining

a/ - Before Eruption

b/ - After eruption and/or after partial rehabilitation using RAAMPE Funds in 1993;
Note that after rehabilitation, some systems were again affected by lahar flow.

Table H.15 List of Priority CIS/CIP for Urgent Restoration (2/2)

Province of Pampanga

NAME	LOCATION	PARTS DAMAGED BY LAHAR	ESTIMATED REHAB. COST (Million Pesos)	SERVICE AREA (ha)	IRRIGABLE AREA (ha)				CROP YIELD in CAVANS/HA.				NUMBER OF FARMER BENEFICIARIES
					WET		DRY		WET		DRY		
					a/	b/	a/	b/	a/	b/	a/	b/	
10 Cutud CIS *	Angeles City	A. B. C.	0.821	120.00	26.66	20.51	13.66	10.93	50	40	40	35	16
11 Mawaque CIS *	Mabalacat	A. B. F.	0.116	80.00	80.00	80.00	31.25	25.00	70	55	80	70	46
12 Sapang Biabas CIS *	Mabalacat	B. C. F.	0.070	110.00	70.20	50.00	25.00	20.00	70	55	65	52	96
13 Sta. Maria CIS	Mabalacat	A. B. F.	6.500	112.91	97.50	75.00	93.75	75.00	70	50	65	51	95
14 San Agustin CIS *	Magalang	A. B. C. F.	0.120	65.21	65.21	65.21	62.55	50.04	70	70	65	65	22
15 Camias CIS *	Magalang	A. B. C.	0.520	58.00	58.00	48.00	58.00	48.00	85	85	65	65	28
16 Banquili CIS	Magalang	A. B. C. F.	0.570	13.00	13.00	13.00	0.00	0.00	65	65	0	0	14
17 Bitas Libutad CIS *	Arayat	A. B. F.	0.550	265.00	140.40	108.00	12.50	10.00	65	65	50	50	69
18 Gatiawin CIS *	Arayat	A. B. F.	0.500	62.00	62.56	62.56	0.00	0.00	70	70	0	0	30
19 Inumang Baca CIS *	Arayat	A. B. F.	0.950	132.00	110.49	84.99	0.00	0.00	60	60	0	0	55
20 San Roque Bitas CIS*	Arayat	A. B.	0.070	126.00	126.00	103.00	4.00	3.00	70	70	50	50	80
21 Lacmit CIS *	Arayat	A. B.	0.100	138.00	138.00	138.00	0.00	0.00	60	60	0	0	72
22 Panlinlang CIS *	Arayat	A. B. F.	0.250	29.00	29.00	29.00	13.00	10.00	30	30	50	50	15
23 Buenavista CIS *	Arayat	A. B. F.	0.405	30.00	30.00	30.00	0.00	0.00	60	60	0	0	15
24 Pandacaqui CIS *	Mexico	A. B. C. D. F.	1.330	180.00	100.00	77.00	15.60	12.00	80	80	55	55	54
25 Calulut I CIS *	San Fernando	A. B.	0.180	59.97	59.97	59.97	65.65	50.50	85	85	75	75	40
26 Telabastagan CIS *	San Fernando	A. B.	0.100	24.00	24.00	24.00	9.10	7.00	75	75	60	60	15
27 San Agustin CIS	Sta. Ana	A. B. C. F.	0.410	28.00	26.00	26.00	0.00	0.00	70	70	0	0	16
28 Pansinao PIS	Candaba	E.	0.200	163.00	120.00	120.00	120.00	120.00	85	85	95	95	93
29 Sto. Rosario PIS	Candaba	E.	0.200	280.00	220.00	220.00	50.00	50.00	35	35	95	95	115
30 Gulap PIS	Candaba	E.	0.200	311.00	40.00	40.00	320.00	320.00	70	70	110	110	136
31 San Sebastian PIS	San Luis	E.	0.200	206.20	206.20	206.20	120.00	120.00	45	45	100	100	176
SUB-TOTAL			**14.362**	**2593.29**	**1843.19**	**1680.44**	**1014.06**	**931.47**					**1298**
GRAND TOTAL			**89.733**	**7728**	**4889.19**	**4238.44**	**2944.06**	**2441.47**					**3050**

Table H.16 Project Cost of Flood/Mudflow Control Works

Sacobia-Bamban River

(1) Alternative 1

Unit : Pesos million

Work Items	Financial Cost F.C. Portion	Financial Cost L.C. Portion	Financial Cost Total	Economic Cost F.C. Portion	Economic Cost L.C. Portion	Economic Cost Total
1) Main Construction Cost	600.64	401.30	1001.94	600.64	276.09	876.74
2) Compensation Cost	0.00	9.00	9.00	0.00	3.69	3.69
3) Physical Contingency and Other Costs	150.16	100.32	250.49	150.16	69.02	219.18
4) Total	750.81	510.62	1261.43	750.81	348.80	1099.61

(2) Alternative 2

Unit : Pesos million

Work Items	Financial Cost F.C. Portion	Financial Cost L.C. Portion	Financial Cost Total	Economic Cost F.C. Portion	Economic Cost L.C. Portion	Economic Cost Total
1) Main Construction Cost	1090.00	668.94	1758.94	1090.00	460.23	1550.23
2) Compensation Cost	0.00	9.00	9.00	0.00	3.69	3.69
3) Physical Contingency and Other Costs	272.50	167.23	439.73	272.50	115.06	387.56
4) Total	1362.50	845.17	2207.67	1362.50	578.98	1941.48

(3) Alternative 3

Unit : Pesos million

Work Items	Financial Cost F.C. Portion	Financial Cost L.C. Portion	Financial Cost Total	Economic Cost F.C. Portion	Economic Cost L.C. Portion	Economic Cost Total
1) Main Construction Cost	2069.55	1323.89	3393.44	2069.55	910.84	2980.38
2) Compensation Cost	0.00	9.00	9.00	0.00	3.69	3.69
3) Physical Contingency and Other Costs	517.39	330.97	848.36	517.39	227.71	745.10
4) Total	2586.93	1663.87	4250.80	2586.93	1142.24	3729.17

(4) Alternative 4

Unit : Pesos million

Work Items	Financial Cost F.C. Portion	Financial Cost L.C. Portion	Financial Cost Total	Economic Cost F.C. Portion	Economic Cost L.C. Portion	Economic Cost Total
1) Main Construction Cost	1161.77	716.79	1878.56	1161.77	493.15	1654.92
2) Compensation Cost	0.00	9.00	9.00	0.00	3.69	3.69
3) Physical Contingency and Other Costs	290.44	179.20	469.64	290.44	123.29	413.73
4) Total	1452.22	904.99	2357.20	1452.22	620.13	2072.35

Abacan River

Unit : Pesos million

Work Items	Financial Cost F.C. Portion	Financial Cost L.C. Portion	Financial Cost Total	Economic Cost F.C. Portion	Economic Cost L.C. Portion	Economic Cost Total
1) Main Construction Cost	379.19	251.65	630.84	379.19	173.14	552.33
3) Physical Contengency and Other Costs	94.80	62.91	157.71	94.80	54.10	148.90
3) Total	473.99	314.56	788.55	473.99	227.24	701.23

Note for Financial Cost :
1) At 1994 end price level.
2) Physical contingency and other costs = (1)* 25% which covers the physical contingency, administration and engineering services costs.

Note for Economic Cost :
1) Share of unskilled labour was assumed at 50% of Main Construction Cost.
2) Shadow Wage Rate of 60% was assumed.
3) Standard Coversion Factor of 0.86 was assumed.
4) Land acquisition cost was shadow-priced based on production foregone value.

Table H.17 Unit Values of Damageable Properties applied for Damage Estimate

Items	Unit Value
I. Direct Damage	
1. Buildings*	
1) Residential Buildings	51,000 Pesos/building
2) Non-Residential	265,000 Pesos/building
3) Household effects	14,000 Pesos/building
4) Inventory stock/equipment	143,000 Pesos/building
2. Agricultural Crops	
Irrigated Paddy	12,650 Pesos/ha
Rainfed Paddy	9,440 Pesos/ha
Sugar Cane	20,930 Pesos/ha
Corn	9,810 Pesos/ha
5) Livestock	(estimated by 7% of crop damage)
3. Infrastructure	
6) Road	
National Road	1,750 Pesos/m
Other Roads	1,400 Pesos/m
7) Bridge	
National Bridge	60,000 Pesos/m
Local Bridge	50,000 Pesos/m
8) Irrigation System	640 Pesos/m
II. Indirect Damage	
9) Additional Transportation Cost	
10) Disruption of Economic Activity	
11) Evacuation Cost	216 Pesos/family/week
12) Emergency Clean-up Cost	150 Pesos/day/building

Source :
- Table 2-3 of Interim Report (2)
- Table 6.7 of Interim Report (1) for unit values of agricultural crops

Note :
* Values assumed as those after depreciated by 50%.

Table H.18 Estimated Average Annual Damage for Abacan River

(A) Return Period	(B) Probability of Exceedance for Return Period	(C) Events within Intervals	(D) Flood Damage up to Indicated Return Period: Buildings (Pesos 10^6)	Agr'l Crops (Pesos 10^6)	Infrastructure (Pesos 10^6)	(E) Average Flood Damage (Pesos 10^6)	(F) Flood Damage within Intervals (Pesos 10^6)	(G) Average Annual Flood Damage up to Indicated Return Period (Pesos 10^6)
2	0.5		123.41	16.48	17.78			0.00
		0.3				240.47	72.14	
5	0.2		253.32	33.36	36.58			72.14
		0.1				411.23	41.12	
10	0.1		390.06	51.14	58.00			113.26
		0.05				597.16	29.86	
20	0.05		541.49	70.40	83.24			143.12
		0.03				816.65	24.50	
50	0.02		729.58	91.69	116.91			167.62
		0.01				1064.38	10.64	
100	0.01		925.35	115.96	149.27			178.26

Table H.19 Estimated Average Annual Damage for Sacobia-Bamban River

(A) Return Period	(B) Average Annual Probability of Exceedance for Return Period	(C) Events within Intervals	(D) Flood Damage up to Indicated Return Period: Buildings (Pesos 10^6)	Agr'l Crops (Pesos 10^6)	Infrastructure (Pesos 10^6)	(E) Average Flood Damage (Pesos 10^6)	(F) Flood Damage within Intervals (Pesos 10^6)	(G) Average Annual Flood Damage up to Indicated Return Period (Pesos 10^6)
2	0.5		49.25	21.73	19.33			0.00
		0.3				137.07	41.12	
5	0.2		101.01	43.73	39.09			41.12
		0.1				232.37	23.24	
10	0.1		156.12	66.41	58.38			64.36
		0.05				331.58	16.58	
20	0.05		214.11	89.88	78.27			80.94
		0.03				436.15	13.08	
50	0.02		273.17	117.56	99.32			94.02
		0.01				553.72	5.54	
100	0.01		342.07	154.22	121.12			99.56

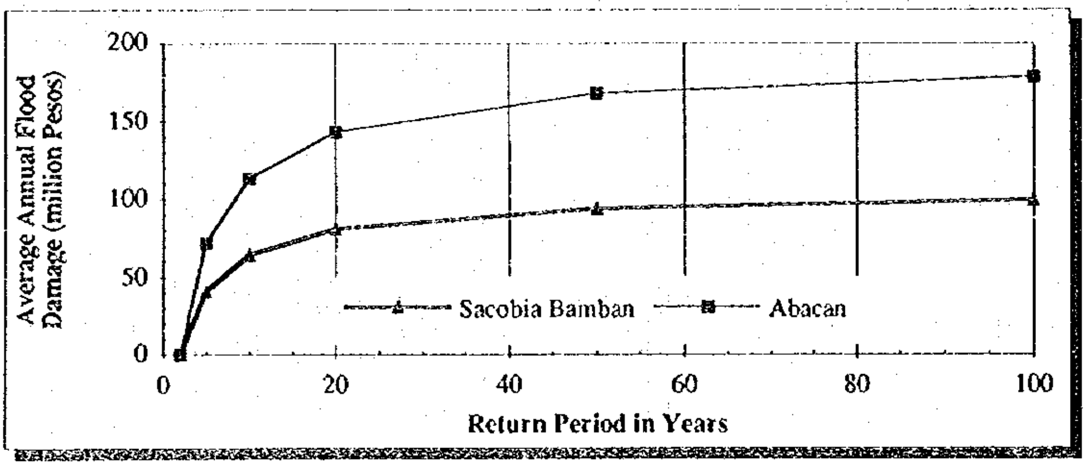

Table II.20 Data for Additional Transportation Cost

(1) Computation Formula :

SCF = CFw/o - CFw/
CF = TDC * DF

$$TDC = (\sum_{i=1}^{4} VOCi * ADTi) * DL$$

where , SCF = Cost saving by reduction of risk for road unserviceability caused by flood(P)
CF = Cost by flood(P)
TDC = Total traffic diversion cost(P)
DF = Duration of unserviceability(days)
VOCi = Vehicle operation cost of vehicle type i(P / vehicle·km)
ADTi = Average daily traffic volume of vehicle type i (vehicle / day)
DL = Detouring length (km)

(2) Vehicle Operating Cost(VOC)

	Car/Van	Jeepney	Bus	Truck
Running Cost(P/km)	2.29	1.61	3.65	4.93
Fixed Cost(P/min.)	0.123	0.593	0.835	0.937

(3) Average : Average speed assumed : 40km / hr

(4) Detour Distance(km) and Duration of Unserviceability(month)

Duration	Route Code	(w/o) Total Detour	(w/) Normal Distance	Detour Distance	Route Alternatives
For Dry Season (6 months)	D.1 :	111.6	86.5	25.1	MNL-Mololos-Gapan-St.Rosa-Tarlac
	D.2 :	62.3	57.5	4.8	S.Fernando-Mabalacat-S.Francisco Brg.-Capas-Tarlac
	D.3:	57.5	57.5	0	S.Fernando-Mabalacat-(Bamban River)-Bamban
	D.4:	44.3	44.3	0	S.Fernando-Mabalacat-S.Francisco Brg.-Concepcion
For Rainy Season (5 months)	R.1.1:	111.6	86.5	25.1	MNL-Mololos-Gapan-St.Rosa-Tarlac
	R.1.2 :	62.3	57.5	4.8	S.Fernando-Mabalacat-S.Francisco Brg.-Capas-Tarlac
	R.1.3:	50.5	27.9	22.6	S.Fernando-Mabalacat-S.Francisco Brg.-Bamban
	R.1.4:	44.3	44.3	0	S.Fernando-Mabalacat-S.Francisco Brg.-Concepcion
30 days in Rainy Season (1 month)	R.2.1 :	111.6	86.5	25.1	MNL-Mololos-Gapan-St.Rosa-Tarlac
	R.2.2:	154.4	39.7	114.7	Angeles-Sta.Rita-Gapan-St.Rosa-Tarlac
	R.2.3:	166.8	11.6	155.2	Angeles-Sta.Rita-Gapan-St.Rosa-Lapaz-Concepcion
	R.2.4:	151.3	29	122.3	Angeles-Sta.Rita-Gapan-St.Rosa-Lapaz-Concepcion-Bamban
Normal Condition(w/) (through the year)	N.1 :	-	86.5	-	MNL-S.Fernando-Mabalacat-Bamban Brg.-Capas-Tarlac
	N.2 :	-	57.5	-	S.Fernando-Mabalacat-Bamban Brg.-Capas-Tarlac
	N.3:	-	27.9	-	S.Fernando-Mabalacat-Bamban Brg.-Bamban
	N.4:	-	44.3	-	S.Fernando-Mabalacat-S.Francisco Brg.-Concepcion
	N.5 :	-	39.7	-	Angeles-Mabalacat-Bamban Brg.-Capas-Tarlac
	N.6:	-	11.6	-	Angeles-Mabalacat-Bamban Brg.-Bamban
	N.7:	-	29	-	Angeles-Mabalacat-S.Francisco Brg.-Concepcion

Table II.21 Cost-Benefit Analysis of Sacobia-Bamban (Alternative-1)

Unit : Peso million

No	Year	Economic Cost Capital	Economic Cost O & M	Cost Total	Benefit Flood Cntrl	Benefit Transport	Benefit Others	Benefit Total	B - C
1	1996	274.90	84.96	359.86					-359.86
2	1997	274.90	84.96	359.86					-359.86
3	1998	274.90	84.96	359.86					-359.86
4	1999	274.90	84.96	359.86					-359.86
5	2000		84.96	84.96	130.09	12.42	17.49	160.00	75.04
6	2001		84.96	84.96	140.80	12.65	18.22	171.68	86.72
7	2002		84.96	84.96	152.39	12.89	18.99	184.27	99.31
8	2003		84.96	84.96	164.93	13.14	19.80	197.87	112.91
9	2004		84.96	84.96	178.50	13.39	20.65	212.54	127.58
10	2005		4.38	4.38	193.19	13.64	21.53	228.37	223.99
11	2006		4.38	4.38	209.09	13.90	22.47	245.46	241.08
12	2007		4.38	4.38	226.30	14.17	23.44	263.91	259.52
13	2008		4.38	4.38	244.92	14.44	24.46	283.82	279.44
14	2009		4.38	4.38	265.08	14.71	25.54	305.33	300.94
15	2010		4.38	4.38	286.90	14.99	26.66	328.55	324.17
16	2011		4.38	4.38	310.51	0.00	27.84	338.35	333.97
17	2012		4.38	4.38	336.06	0.00	29.08	365.14	360.76
18	2013		4.38	4.38	363.72	0.00	30.38	394.10	389.72
19	2014		4.38	4.38	393.66	0.00	31.74	425.40	421.01
20	2015		4.38	4.38	426.05	0.00	33.17	459.22	454.84
21	2016		4.38	4.38	461.12	0.00	34.66	495.78	491.40
22	2017		4.38	4.38	499.07	0.00	36.24	535.30	530.92
23	2018		4.38	4.38	540.14	0.00	37.88	578.02	573.64
24	2019		4.38	4.38	584.59	0.00	39.61	624.20	619.82
25	2020		4.38	4.38	632.71	0.00	41.42	674.13	669.74
26	2021		4.38	4.38	684.78	0.00	43.32	728.10	723.71
27	2022		4.38	4.38	741.14	0.00	45.31	786.45	782.06
28	2023		4.38	4.38	802.13	0.00	47.40	849.53	845.15
29	2024		4.38	4.38	868.15	0.00	49.59	917.74	913.35
30	2025		4.38	4.38	939.59	0.00	51.89	991.48	987.10
								EIRR=	13.14%
								NPV(12%)=	166

Note :

- -O & M Cost was computed at 0.5 % of the Main Construction Cost.
- - Flood control benefit was assumed to grow at the same rate as that of GRDP (8.23% p.a.) of the Region.
- -Transportation benefit was assumed to increase at the same growth as that of North Luzon Express Way(1.9% p.a.).
- -Other benefit includes evacuation costs and building clean-up costs, and loss of production caused by the interruption of economic activities.

Table II.21 Cost-Benefit Analysis of Sacobia-Bamban (Alternative-2)

Unit : Peso million

No	Year	Economic Cost Capital	Economic Cost O & M	Cost Total	Benefit Flood Cntrl	Benefit Transport	Benefit Others	Benefit Total	B - C
1	1996	485.37	84.96	570.33	0.00	0.00	0.00	0.00	-570.33
2	1997	485.37	84.96	570.33	0.00	0.00	0.00	0.00	-570.33
3	1998	485.37	84.96	570.33	0.00	0.00	0.00	0.00	-570.33
4	1999	485.37	84.96	570.33	0.00	0.00	0.00	0.00	-570.33
5	2000		84.96	84.96	130.09	244.31	17.49	391.89	306.93
6	2001		84.96	84.96	140.80	248.95	18.22	407.97	323.01
7	2002		84.96	84.96	152.39	253.68	18.99	425.06	340.10
8	2003		84.96	84.96	164.93	258.50	19.80	443.23	358.27
9	2004		84.96	84.96	178.50	263.41	20.65	462.56	377.60
10	2005		7.75	7.75	193.19	268.41	21.53	483.14	475.39
11	2006		7.75	7.75	209.09	273.51	22.47	505.07	497.32
12	2007		7.75	7.75	226.30	278.71	23.44	528.45	520.70
13	2008		7.75	7.75	244.92	284.01	24.46	553.39	545.64
14	2009		7.75	7.75	265.08	289.40	25.54	580.02	572.27
15	2010		7.75	7.75	286.90	294.90	26.66	608.46	600.71
16	2011		7.75	7.75	310.51	0.00	27.84	338.35	330.60
17	2012		7.75	7.75	336.06	0.00	29.08	365.14	357.39
18	2013		7.75	7.75	363.72	0.00	30.38	394.10	386.35
19	2014		7.75	7.75	393.66	0.00	31.74	425.40	417.64
20	2015		7.75	7.75	426.05	0.00	33.17	459.22	451.47
21	2016		7.75	7.75	461.12	0.00	34.66	495.78	488.03
22	2017		7.75	7.75	499.07	0.00	36.24	535.30	527.55
23	2018		7.75	7.75	540.14	0.00	37.88	578.02	570.27
24	2019		7.75	7.75	584.59	0.00	39.61	624.20	616.45
25	2020		7.75	7.75	632.71	0.00	41.42	674.13	666.38
26	2021		7.75	7.75	684.78	0.00	43.32	728.10	720.35
27	2022		7.75	7.75	741.14	0.00	45.31	786.45	778.70
28	2023		7.75	7.75	802.13	0.00	47.40	849.53	841.78
29	2024		7.75	7.75	868.15	0.00	49.59	917.74	909.99
30	2025		7.75	7.75	939.59	0.00	51.89	991.48	983.73
	NPV=	1474	474	1948	1293	994	122	2408	460
					54%	41%	5%	(100)	
								EIRR=	14.55%
								NPV(12%)=	460

Note :
- O & M Cost was computed at 0.5 % of the Main Construction Cost.
- Flood control benefit was assumed to grow at the same rate as that of GRDP (8.23% p.a.) of the Region.
- Transportation benefit was assumed to increase at the same growth as that of North Luzon Express Way(1.9% p.a.).
- Other benefit includes evacuation costs and building clean-up costs, and loss of production caused by the interruption of economic activities.

Table II.21 Cost-Benefit Analysis of Sacobia-Bamban (Alternative-3)

Unit : Peso million

No	Year	Economic Cost Capital	O & M	Cost Total	Flood Cntrl	Benefit Transport	Others	Benefit Total	B - C
1	1996	930.00	84.96	1014.96					-1014.96
2	1997	930.00	84.96	1014.96					-1014.96
3	1998	930.00	84.96	1014.96					-1014.96
4	1999	930.00	84.96	1014.96					-1014.96
5	2000		84.96	84.96	130.09	244.31	17.49	391.89	306.93
6	2001		84.96	84.96	140.80	248.95	18.22	407.97	323.01
7	2002		84.96	84.96	152.39	253.68	18.99	425.06	340.10
8	2003		84.96	84.96	164.93	258.50	19.80	443.23	358.27
9	2004		84.96	84.96	178.50	263.41	20.65	462.56	377.60
10	2005		14.87	14.87	193.19	268.41	21.53	483.14	468.28
11	2006		14.87	14.87	209.09	273.51	22.47	505.07	490.21
12	2007		14.87	14.87	226.30	278.71	23.44	528.45	513.59
13	2008		14.87	14.87	244.92	284.01	24.46	553.39	538.53
14	2009		14.87	14.87	265.08	289.40	25.54	580.02	565.16
15	2010		14.87	14.87	286.90	294.90	26.66	608.46	593.60
16	2011		14.87	14.87	310.51	0.00	27.84	338.35	323.49
17	2012		14.87	14.87	336.06	0.00	29.08	365.14	350.28
18	2013		14.87	14.87	363.72	0.00	30.38	394.10	379.24
19	2014		14.87	14.87	393.66	0.00	31.74	425.40	410.53
20	2015		14.87	14.87	426.05	0.00	33.17	459.22	444.36
21	2016		14.87	14.87	461.12	0.00	34.66	495.78	480.92
22	2017		14.87	14.87	499.07	0.00	36.24	535.30	520.44
23	2018		14.87	14.87	540.14	0.00	37.88	578.02	563.16
24	2019		14.87	14.87	584.59	0.00	39.61	624.20	609.34
25	2020		14.87	14.87	632.71	0.00	41.42	674.13	659.26
26	2021		14.87	14.87	684.78	0.00	43.32	728.10	713.23
27	2022		14.87	14.87	741.14	0.00	45.31	786.45	771.58
28	2023		14.87	14.87	802.13	0.00	47.40	849.53	834.67
29	2024		14.87	14.87	868.15	0.00	49.59	917.74	902.87
30	2025		14.87	14.87	939.59	0.00	51.89	991.48	976.62
								EIRR=	8.69%
								NPV(12%)=	-909

Note :

-O & M Cost was computed at 0.5 % of the Main Construction Cost.

- Flood control benefit was assumed to grow at the same rate as that of GRDP (8.23% p.a.) of the Region.

-Transportation benefit was assumed to increase at the same growth as that of North Luzon Express Way(1.9% p.a.).

-Other benefit includes evacuation costs and building clean-up costs, and loss of production caused by the interruption of economic activities.

Table H.21 Cost-Benefit Analysis of Sacobia-Bamban (Alternative-4)

Unit : Peso million

No	Year	Economic Cost Capital	Economic Cost O & M	Cost Total	Benefit Flood Cntrl	Benefit Transport	Benefit Others	Benefit Total	B - C
1	1996	518.09	85.04	603.13					-603.13
2	1997	518.09	85.04	603.13					-603.13
3	1998	518.09	85.04	603.13					-603.13
4	1999	518.09	56.50	574.59					-574.59
5	2000		56.50	56.50	130.09	244.31	17.49	391.89	335.39
6	2001		56.50	56.50	140.80	248.95	18.22	407.97	351.47
7	2002		56.50	56.50	152.39	253.68	18.99	425.06	368.56
8	2003		56.50	56.50	164.93	258.50	19.80	443.23	386.73
9	2004		56.50	56.50	178.50	263.41	20.65	462.56	406.06
10	2005		8.27	8.27	193.19	268.41	21.53	483.14	474.87
11	2006		8.27	8.27	209.09	273.51	22.47	505.07	496.80
12	2007		8.27	8.27	226.30	278.71	23.44	528.45	520.18
13	2008		8.27	8.27	244.92	284.01	24.46	553.39	545.12
14	2009		8.27	8.27	265.08	289.40	25.54	580.02	571.75
15	2010		8.27	8.27	286.90	294.90	26.66	608.46	600.19
16	2011		8.27	8.27	310.51	0.00	27.84	338.35	330.08
17	2012		8.27	8.27	336.06	0.00	29.08	365.14	356.87
18	2013		8.27	8.27	363.72	0.00	30.38	394.10	385.83
19	2014		8.27	8.27	393.66	0.00	31.74	425.40	417.12
20	2015		8.27	8.27	426.05	0.00	33.17	459.22	450.95
21	2016		8.27	8.27	461.12	0.00	34.66	495.78	487.51
22	2017		8.27	8.27	499.07	0.00	36.24	535.30	527.03
23	2018		8.27	8.27	540.14	0.00	37.88	578.02	569.75
24	2019		8.27	8.27	584.59	0.00	39.61	624.20	615.93
25	2020		8.27	8.27	632.71	0.00	41.42	674.13	665.85
26	2021		8.27	8.27	684.78	0.00	43.32	728.10	719.82
27	2022		8.27	8.27	741.14	0.00	45.31	786.45	778.17
28	2023		8.27	8.27	802.13	0.00	47.40	849.53	841.26
29	2024		8.27	8.27	868.15	0.00	49.59	917.74	909.46
30	2025		8.27	8.27	939.59	0.00	51.89	991.48	983.21
								EIRR=	14.39%
								NPV(12%)=	443

Note :
- O & M Cost was computed at 0.5 % of the Main Construction Cost.
- Flood control benefit was assumed to grow at the same rate as that of GRDP (8.23% p.a.) of the Region.
- Transportation benefit was assumed to increase at the same growth as that of North Luzon Express Way(1.9% p.a.).
- Other benefit includes evacuation costs and building clean-up costs, and loss of production caused by the interruption of economic activities.

Table II.21 Cost-Benefit Analysis of Abacan Scheme

Unit : Peso million

No	Year	Economic Cost		Cost	Benefit			Benefit	B - C
		Capital	O & M	Total	Flood Cntrl	Transport	Others	Total	
1	1996	175.31	28.32	203.63					-203.63
2	1997	175.31	28.32	203.63					-203.63
3	1998	175.31	28.32	203.63					-203.63
4	1999	175.31	28.32	203.63					-203.63
5	2000		2.76	2.76	230.03	0.00	24.00	254.03	251.27
6	2001		2.76	2.76	248.96	0.00	24.87	273.83	271.07
7	2002		2.76	2.76	269.45	0.00	25.78	295.23	292.47
8	2003		2.76	2.76	291.63	0.00	26.74	318.37	315.60
9	2004		2.76	2.76	315.63	0.00	27.74	343.37	340.61
10	2005		2.76	2.76	341.61	0.00	28.79	370.40	367.63
11	2006		2.76	2.76	369.72	0.00	29.89	399.61	396.85
12	2007		2.76	2.76	400.15	0.00	31.05	431.19	428.43
13	2008		2.76	2.76	433.08	0.00	32.26	465.34	462.57
14	2009		2.76	2.76	468.72	0.00	33.53	502.25	499.49
15	2010		2.76	2.76	507.30	0.00	34.86	542.15	539.39
16	2011		2.76	2.76	549.05	0.00	36.25	585.30	582.54
17	2012		2.76	2.76	594.23	0.00	37.71	631.95	629.19
18	2013		2.76	2.76	643.14	0.00	39.25	682.39	679.63
19	2014		2.76	2.76	696.07	0.00	40.86	736.93	734.17
20	2015		2.76	2.76	753.36	0.00	42.54	795.90	793.14
21	2016		2.76	2.76	815.36	0.00	44.31	859.67	856.91
22	2017		2.76	2.76	882.46	0.00	46.16	928.63	925.87
23	2018		2.76	2.76	955.09	0.00	48.11	1003.20	1000.44
24	2019		2.76	2.76	1033.69	0.00	50.15	1083.84	1081.08
25	2020		2.76	2.76	1118.77	0.00	52.28	1171.05	1168.29
26	2021		2.76	2.76	1210.84	0.00	54.52	1265.37	1262.60
27	2022		2.76	2.76	1310.49	0.00	56.87	1367.37	1364.61
28	2023		2.76	2.76	1418.35	0.00	59.34	1477.69	1474.92
29	2024		2.76	2.76	1535.08	0.00	61.92	1597.00	1594.24
30	2025		2.76	2.76	1661.41	0.00	64.63	1726.05	1723.29
								EIRR=	28.17%
								NPV(12%)=	1814

Note :

- -O & M Cost was computed at 0.5 % of the Main Construction Cost.
- - Flood control benefit was assumed to grow at the same rate as that of GRDP (8.23% p.a.) of the Region.
- -Transportation benefit was assumed to increase at the same growth as that of North Luzon Express Way(1.9% p.a.).
- -Other benefit includes evacuation costs and building clean-up costs, and loss of production caused by the interruption of economic activities .