# 5. ALTERNATIVE RETARDING BASIN PLANS

## 5.1 Alternative Cases

### 5.1.1 Poponto Retarding Basin

Poponto Swamp is habitually inundated mainly due to flood coming from the Agno River and Tarlac River. In addition to these condition, this swamp has four (4) tributaries including Baka River (409 $km^2$) with a total catchment area of about 580 $km^2$. Flood water from these tributaries discharges into this swamp as illustrated in Fig. 5.1. Estimated 100-yr probable flood peak discharges from these tributaries are 200 $m^3/s$, 390$m^3/s$ 1,490 $m^3/s$ and 210 $m^3/s$ respectively.

Considering these conditions, several conceivable alternative retarding basin plans have been studied. As the basic alternative plans, a retarding basin with a confining dike and a retarding basin without a confining dike are considered. Both ideas are shown in Fig. 5.1.

Comparing these two basic alternative plans, the retarding basin plan with confining dikes is disqualified due to the following constraints;

(1) Poponto retarding basin is planned for flood peak reduction of the Agno River and Tarlac River. When this basin start to function as a retarding basin, flood water coming from the tributaries can not be drained out toward the downstream of the Agno River due to topographical point of view. As a result, areas to be protected by confining dikes suffer from inland inundation.

(2) Pump facilities are the most effective countermeasure to solve this inland water problem. However, huge construction cost is required to install the facilities because the objective catchment area, of 580 $km^2$ is too large to drain by pumping.

Retarding basin plan without confining dike is further divided into four (4) alternative cases. Flood control method by these alternatives are illustrated in Fig. 5.2 and described below;

- Case 1 : Natural retarding basin
  Flood water coming from the Agno River, Tarlac River and tributaries flows into the swamp, then flows out to the lower Agno River after natural flood retardation of swamp.

- Case 2 : Gated control retarding basin without side overflow dike
  A gated control weir is provided at the outlet of swamp. Flood water from each river enter into the swamp and its outflow is to be controlled by gates.

- Case 3 : Gated control retarding basin with a side overflow dike
  A by-pass floodway channel to convey flood water from the Agno River directly to the lower Agno River is provided passing through the swamp area. Flood water from the Tarlac River is lead to the swamp for retardation. A gated control weir is provided at the outlet of the Poponto Swamp to control its outflow. Two alternative cases are considered in this Case. One is to provide side overflow dike at by-pass channel and the other is no side overflow dike.

- Case 4 : Retarding Basin with dike, two overflow dike and a drainage gate
  River channels of both the Agno River and Tarlac River are provided with side overflow dikes. Flood is partly retained in the retarding basin and partly flowed down to the lower Agno River passing through the drainage gate after flood water level in the Agno River subsided.

### 5.1.2 Camiling Retarding Basin

Camiling swamp area is habitually inundated due to flood coming from Agno River and Camiling River. A retarding basin with a side overflow type, which has a higher flood control effect than a natural type, is introduced in this retarding basin plan taking into account the topographic and land use constraints.

Natural retarding basin plan is also conceivable for the Camiling swamp. However, flood retarding effect to the downstream area by this plan is not so high, since this is located in the lower reaches of the Agno River.

Furthermore, retarding capacity of this swamp is very small compared to the Poponto swamp.

## 5.2 Selection of Retarding Basin Plan

### 5.2.1 Poponto Retarding Basin

The selection of prospective flood retarding basin plan has been done in four (4) alternative cases by adopting the criteria described in Section 3.2.

Flood control effects were compared and evaluated by changing the flood peak cut rate and the dimensions of flood control structures for Cases 2, 3 and 4.

The study results including principal features, required construction costs and decreased river improvement costs due to flood retarding effect by each alternative case are shown in Table 5.1 and summarized below;

| Item | Unit | Case-1 | Case-2 | Case-3 | Case-4 |
|---|---|---|---|---|---|
| Peak inflow | $m^3/s$ | 13,110 | 13,110 | 10,860 | 8,330 |
| Peak reduction | $m^3/s$ | 3,180 | 7,500 | 7,500 | 8,330 |
| Retarding volume | $Mill.m^3$ | 757 | 1,445 | 1,356 | 1,515 |
| Flood water level | EL.m | 16.6 | 18.4 | 18.2 | 18.5 |
| Retarding area | $km^2$ | 347 | 445 | 433 | 455 |
| Control gate | m | none | 150 | 150 | none |
| Side overflow dike | m | none | none | 2,100 | 5,000 |
| Facility cost | Mill.P | 0 | 1,128 | 1,653 | 1,681 |
| Reduction in river improvement cost | Mill.P | 4,126 | 4,869 | 3,266 | 2,085 |
| Difference | Mill.P | -4,126 | -3,741 | -1,613 | -404 |

The study concludes that all these retarding basin plans are prospective in terms of flood control. Among the four (4) cases, the natural retarding basin plan (case-1) is the most advisable one to consider. Accordingly, this natural retarding basin plan is being considered in the integrated flood control plans.

5.2.2 Camiling Retarding Basin

Flood control effects are compared and evaluated by changing the peak overflow amount and the dimensions of flood control structures.

The study results are described in Table 5.2 and summarized below;

| Item | Unit | Case-1 | Case-2 | Case-3 |
|---|---|---|---|---|
| Peak overflow | $m^3/s$ | 2,000 | 2,500 | 3,000 |
| Retarding volume | Mill.$m^3$ | 120 | 173 | 230 |
| Flood water level | EL.m | 12.3 | 13.4 | 14.3 |
| Retarding area | $km^2$ | 43 | 52 | 60 |
| Side overflow dike | m | 2,400 | 2,370 | 2,350 |
| Facility cost | Mill.₱ | 712 | 740 | 779 |
| Reduction in river improvement cost | Mill.₱ | 371 | 451 | 521 |
| Difference | Mill.₱ | 341 | 289 | 258 |

The study concludes that the facility cost for this retarding basin with side overflow dike exceeds the reduction in river improvement cost, therefore, it is assessed that the Camiling retarding basin plan is not a predominant to river improvement plan. Accordingly, Camiling retarding basin plan is not proceeded in the integrated flood control plans.

It would be possible to reclaim swamp area for land use with the progress of river basin conservation and river improvement works. However, it is recommended to secure retarding effect until such time that the Agno River become stable.

# 6. SELECTED DAMS

## 6.1 Principal Features

Moriones and Lower O'Donnell combined dam plan with the flood peak cut ratio at 50% is selected as the optimum scale for flood control dam. Accordingly, the following dams are taken into consideration for the integrated flood control plan;

| Categories | Name of Dam | Criteria |
|---|---|---|
| Existing dams | Ambuklao<br>Binga | Flood control effect under the current reservoir operation rule be adopted. |
| On-going dam | Balog-Balog | Flood control effect under the designed reservoir operation rule be adopted. |
| Designed dam | San Roque | Flood control effect under the designed reservoir operation rule be adopted. |
| Identified dams | Moriones and<br>Lower O'Donnell | Single purpose flood control dam be considered. |

Principal features of existing, on-going and designed dams are described in Chapter 2, and Moriones and Lower O'Donnell combined dam plan are described as follows;

| | Moriones | Lower O'Donnell |
|---|---|---|
| - Catchment area ($km^2$) | 537 | 278 |
| - River name | Moriones | O'Donnell |
| - Flood control | | |
| Peak cut ratio (%) | 50 | |
| 100-yr peak inflow ($m^3/s$) | 3,310 | |
| 100-yr controlled peak outflow ($m^3/s$) | 1,690 | |
| - Reservoir | | |
| Flood water level (El.m) | 101.0 | |

| | | |
|---|---|---|
| Surcharge water level (El.m) | 98.7 | |
| Sediment level (El. m) | 89.5 | |
| Gross storage (Mill. $m^3$) | 563.8 | |
| Flood control storage (Mill. $m^3$) | 325.3 | |
| Dead storage (Mill. $m^3$) | 238.5 | |
| Reservoir area at SWL ($km^2$) | 48 | |
| - Dam | | |
| Type | Concrete gravity | Concrete gravity |
| Crest elevation (El.m) | 103 | 103 |
| Crest length (m) | 375 | 260 |
| Crest width (m) | 8 | 8 |
| Height (m) | 53 | 38 |
| Dam volume ($m^3$) | 277,000 | 92,000 |
| Saddle dam volume, earthfill ($m^3$) | 650,000 | |
| - Spillway | | |
| Type | Free overflow crest with gated conduit | |
| Design flood, 200-yr ($m^3/s$) | 3,860 | |
| Overflow crest elevation (El.m) | 98.7 | |
| Overflow crest width (m) | 180 | |
| Gate (No. x width x height) | 15 x 4 m x 4 m | |
| Energy dissipater | Stilling basin | |
| - Diversion | | |
| Type | Tunnel | Tunnel |
| Design flood, 2-yr ($m^3/s$) | 640 | 340 |
| Tunnel diameter (m) | 6 | 5 |
| Tunnel length (m) | 200 | 240 |
| Number of tunnel (lanes) | 1 | 1 |

Layout plan of Moriones and Lower O'Donnell combined dam plan is shown in Figs. 6.1 and 6.2.

## 6.2 Site Conditions and Compensation

Lower O'Donnell damsite is located on the O'Donnell River about 12 km southwest of Tarlac town. Access to the damsite from Tarlac town is by 2 km of paved road, 3 km of unpaved road, 7 km of dirt road on top of dike and 3 km of foot trail.

Moriones damsite is located on the Moriones River about 9 km west of Tarlac. Access to the damsite from Tarlac is by 8.5 km of paved road, 15 km of dirt road and 1.5 km of foot trail.

Both damsites are mainly underlain by sedimentary rocks. These rocks consist mainly of sandstone, siltstone and conglomerate. The damsites are considered to be in good and acceptable geological condition. Major problem is water leakage from low saddles, therefore, construction of saddle dams are necessary in portion where it is required to prevent water leakage.

In the reservoir area, especially Moriones damsite, some villages such as Moriones, Villa Aglipay, Lubigan and Iba are located along the Moriones River where about 1,600 families (90% in Moriones and 10% in Lower O'Donnell) are living. Majority of the inhabitants living in these villages are farmers. About 75% of the reservoir area are used mainly for rainfed paddy field.

There are two existing irrigation system in this reservoir area. One is Sula and Iba Irrigation System servicing an area of 250 ha on the left bank of the Moriones River, and the other is Lubigan Irrigation System which irrigates an area of about 200 ha on the right bank. In addition to these existing irrigation systems, Western Barrios Impounding Irrigation Project (1,030 ha) is on-going. This project is a grant-in-aid by the Government of Japan. Location of this SWIM project is shown in Fig. 6.3 and its project features are as follows:

| Name of dam | Mangillog | Bulelatin | Pangasan | Balnges |
|---|---|---|---|---|
| Catchment area ($km^2$) | 8.1 | 2.0 | 12.9 | 27.9 |
| Dam height (m) | 19.3 | 10.0 | 17.3 | 24.2 |
| Dam Volume ($m^3$) | 363,000 | 37,000 | 81,800 | 158,200 |
| Total storage capacity (Mill.$m^3$) | 3.21 | 0.73 | 1.14 | 1.82 |
| Effective storage cap.(Mill.$m^3$) | 3.11 | 0.70 | 0.98 | 1.47 |
| Irrigation canal (km) | 10.32 | 1.58 | 3.13 | 8.80 |
| Irrigation area (ha) | | | | |
| Wet season (Rice) | 360 | 120 | 200 | 350 |
| Dry season (Corn) | 232.5 | 60 | 200 | 350 |

Data Source : BASIC DESIGN REPORT ON THE PROJECT FOR WESTERN BARRIOS IMPOUNDING IRRIGATION by JICA.

After implementing the Moriones and Lower O'Donnell combined dam plan, agricultural land of about 40 $km^2$ including 820 ha of the Western Barrios irrigation area will be inundated by the reservoir. Its annual agricultural production foregone including the on-going irrigation system is about 34.3 x $10^6$ Pesos per year. This production foregone is considered as the negative benefit in the economic evaluation.

Western Barrios Impounding Irrigation Project is on-going now as described above. According to the said basic design report, sediment yield of 125.2 $m^3/km^2/yr$ is applied for dam design. This value is far apart from 8,200 $m^3/km^2/yr$ which is macroscopically estimated for this region by the STUDY, therefore it is recommended to review this sediment yield at damsites.

# 7. SELECTED RETARDING BASIN PLAN

## 7.1 Principal Features

Poponto natural retarding basin plan is selected for the integrated flood control plan. Its principal features are as follows:

| Item | Probable flood <1 | | | |
|---|---|---|---|---|
| | 100-yr | 50-yr | 25-yr | 10-yr |
| Peak inflow to basin ($m^3/s$) | 14,100 | 11,600 | 9,190 | 6,420 |
| Peak outflow from basin ($m^3/s$) | 10,200 | 8,670 | 7,210 | 5,360 |
| Peak cut amount ($m^3/s$) | 3,900 | 2,930 | 1,980 | 1,060 |
| Flood control storage (Mill.$m^3$) | 757 | 594 | 431 | 226 |
| Flood water level (El.m) | 16.6 | 16.1 | 15.6 | 14.8 |
| Inundated area ($km^2$) | 347 | 318 | 288 | 238 |

Note: <1; Rainfall for hydrological base point at Wawa is applied.

General plan of Poponto retarding basin is shown in Fig.7.1

## 7.2 Site Condition

Poponto retarding basin is located north of Tarlac and south of Alcala. This is a flat and low-lying area which spreads from the confluence of the Agno River and Tarlac River with a lowest ground elevation of about 10 m. Poponto retarding basin extends up to the upstream reaches of the Tarlac River and its tributaries. Rivers in this area are exceedingly meandering because of its topographical condition.

Alluvial plain which is spread in this area is composed mainly of organic clay and silt with little sand.

Most of low-lying areas south of the Manila-San Fernando railway and west of Moncada town is habitually inundated due to flood. Around this low-lying areas residential villages are scattered. Major towns such as Moncada and Paniqui are developed because of their favorable elevated location avoiding excessive flood damage.

## 8. WORK QUANTITIES AND COST ESTIMATE

Two kinds of construction costs are estimated, i.e. financial cost and economic cost. The economic cost is used for evaluation of the integrated flood control plan for economic view point.

The construction costs are estimated from the work quantities which are estimated based on the facilities designed and unit prices. In addition to this, the following provisions are taken into account:

| | | |
|---|---|---|
| - Preparatory works | : | 10% of the sum of the estimated main work cost |
| - Miscellaneous works | : | 15% of the sum of the estimated main work cost and preparatory cost |
| - Government administration | : | 5% of the sum of main construction cost and compensation cost |
| - Engineering services | : | 16% of the main construction cost |
| - Physical contingency | : | 15% of the sum of the main construction cost, compensation cost and administration cost |

Compensation cost is disregarded in the economic construction cost estimate because this cost is evaluated based on the agricultural production forgone as described in Section 6.2.

Financial and economic construction costs with work quantities are shown in Tables 8.1 and 8.2.

# *TABLES*

## Table 2.1 FEATURES OF QUALIFIED AND ON-GOING SMALL IMPOUNDING DAM SCHEMES IN THE STUDY AREA

| No. | Name of Project | River Name | Dam Type | Catch. Area (km2) | Dam Height (m) | Crest Elev. (m) | NWL (m) | Reserv. Area (ha) | Effect. Storage (mill.m3) | Total Storage (mill.m3) | Project Cost <1 (mill.P) | Purpose <2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Qualified Dam** | | | | | | | | | | | | |
| DPWH- 1 | Saytan Dam & Reservoir SWIP | Saytan | Zoned Earthfill | 4 | 24 | 235 | 232.5 | 3 | 0.284 | 0.296 | 40.3 | IR,FC,IF,MH |
| DPWH-17 | Acop Dam & Reservoir SWIP | Acop | Zoned Earthfill | 9 | 12 | 112 | 110 | 6 | 0.414 | 0.460 | 14.2 | IR,FC,IF |
| DPWH-18 | Calitlitan Dam & Reservoir | Calitlitan | Zoned Earthfill | 12 | 21 | 122 | 120 | 8 | 0.765 | 0.850 | 32.3 | IR,FC,IF |
| DPWH-19 | Kita-Kita Dam & Reservoir | Kita-Kita | Zoned Earthfill | 9 | 12 | 112 | 110 | 10 | 0.351 | 0.390 | 10.6 | IR,FC,IF |
| DPWH-20 | Salvacion Dam & Reservoir | Salvacion | Zoned Earthfill | 5 | 13 | 49 | 47 | 5 | 0.459 | 0.510 | 13.7 | IR,FC,IF |
| DPWH-21 | San Angel Dam & Reservoir | San Angel | Zoned Earthfill | 9 | 13 | 56 | 54 | 10 | 0.261 | 0.290 | 12.0 | IR,FC,IF |
| NIA-29 | Alibeng SWIP | Alibeng | Zoned Earthfill | 11 | 30 | 130 | 127 | 26 | 1.730 | 1.903 | 31.0 | IR,FC,IF |
| NIA-31 | Digap SWIP | Digap | Zoned Earthfill | 1 | 10 | 100 | 97.5 | 4 | 0.071 | 0.078 | 6.2 | IR,FC,IF |
| NIA-32 | Diket SWIP | Diket | Zoned Earthfill | 1 | 23 | 200 | 197.5 | 8 | 0.368 | 0.405 | 17.3 | IR,FC,IF |
| NIA-57 | Bigbiga CIS | Bigbiga | Zoned Earthfill | 4 | 22 | 140 | 137.5 | 77 | 0.439 | 0.483 | 21.1 | IR,FC,IF |
| NIA-58 | Tangcarang CIP | Tangcarang | Zoned Earthfill | 2 | 21 | 140 | 137.5 | 5 | 0.278 | 0.306 | 9.0 | IR,FC,IF |
| NIA-59 | Lawacamulag CIP | Bulelatin | Zoned Earthfill | 2 | 8.8 | 97.2 | 96 | 34 | 0.719 | 0.725 | 8.9 | IR,FC,IF |
| BSWM- 9 | Pugaro SWIP | - | Homogeneous E. | 0.9 | 6.5 | 93 | 91 | 12 | 0.194 | 0.214 | 5.3 | IR,WD,IF,FC |
| BSWM-10 | Pamaranum SWIP | Pamaranum | Homogeneous E. | 1.2 | 8.2 | 93.7 | 91 | 2 | 0.067 | 0.090 | 4.9 | IR,WD,IF,FC |
| BSWM-14 | Mabini SWIP | - | Homogeneous E. | 1 | 10 | 122.6 | 120 | 2 | 0.160 | 0.181 | 5.8 | IR,WD,IF,FC |
| BSWM-15 | San Gonzalo SWIP | - | Homogeneous E. | 0.7 | 14.5 | - | - | 2 | 0.170 | 0.185 | 7.5 | IR,WD,IF,FC |
| BSWM-63 | Villa Boado SWIP | - | Homogeneous E. | 0.8 | 11 | 94 | 92 | 6 | 0.213 | 0.230 | 5.7 | IR,WD,IF,FC |
| BSWM-65 | Maniniog Swip | Maniniog | Homogeneous E. | 2 | 13.5 | 112.5 | 109 | 1 | 0.042 | 0.050 | 5.4 | IR,WD,IF,FC |
| **On-Going Dam** | | | | | | | | | | | | |
| WBII- 1 | Mangillog Dam & Reservoir | - | Zoned Earthfill | 8.1 | 19.3 | 111.3 | 108 | 71 | 3.110 | 3.210 | - | IR |
| *WBII- 2* | *Bulelatin Dam & Reservoir* | - | *Homogeneous E.* | *2* | *10* | *98* | *96* | *34* | *0.700* | *0.730* | - | *IR* |
| WBII- 3 | Pangasan Dam & Reservoir | - | Zoned Rockfill | 12.9 | 17.3 | 130.8 | 126.5 | 22 | 0.980 | 1.140 | - | IR |
| WBII- 4 | Balnges Dam & Reservoir | - | Zoned Earthfill | 27.9 | 24.2 | 98.2 | 94 | 25 | 1.470 | 1.820 | - | IR |

Note; <1: 1989 price level including compensation and administration costs estimated by JICA SWIM Study Team.
<2: IR=Irrigation, FC=Flood Control, WD=Watershed Management, MH=Mini Hydropower, IF=Inland Fishery

## Table 4.1 PRESENT STATUS OF DAM PROJECT

| No. | Name of Dam | River Basin | Catchment Area($km^2$) | Present Status | Latest Study | Agency | Remarks |
|---|---|---|---|---|---|---|---|
| 1. | Ambuklao | Agno | 617 | Existing | | NAPOCOR | |
| 2. | Binga | Agno | 860 | Existing | | NAPOCOR | |
| 3. | Tabu | Agno | 1,051 | Master Plan | LHPPS<1 | NAPOCOR | Selected thru 2nd screening in LHPPS |
| 4. | San Roque | Agno | 1,250 | D/D completed | | NAPOCOR & NIA | |
| 5. | Upper Ambayoan | Ambayoan | 151 | Master Plan | IDP<2 | NIA | Recommended site for development in IDP |
| 6. | Upper Sapinit | Ambayoan | 270 | Master Plan | IDP | NIA | Excluded due to studies of economic & alternatives in IDP |
| 7. | Lower Ambayoan | Ambayoan | 310 | Inventory | IDP | NIA | Only site inventory in IDP |
| 8. | Kalipkip | Tuboy | 75 | Master Plan | IDP | NIA | Excluded due to studies of economic & alternatives in IDP |
| 9. | Lubas | Tuboy | 90 | Master Plan | IDP | NIA | Recommended site for development in IDP |
| 10. | Bangat | Tarlac | 39 | Master Plan | Balog-Balog F/S<3 | NIA | Evaluated as alternative site in F/S |
| 11. | O'Donnell | Tarlac | 119 | Master Plan | Balog-Balog F/S | NIA | Evaluated as alternative site in F/S |
| 12. | Lower O'Donnell | Tarlac | 278 | Inventory | IDP | NIA | Only site inventory in IDP |
| 13. | Balog-Balog | Tarlac | 283 | On-going | | NIA | |
| 14. | Moriones | Tarlac | 537 | Master Plan | Balog-Balog F/S | NIA | Evaluated as alternative site in F/S |
| 15. | Camiling | Camiling | 221 | Master Plan | IDP | NIA | Recommended site for development in IDP |
| 16. | Pila | Olo | 130 | Master Plan | IDP | NIA | Recommended site for development in IDP |
| 17. | Bayaoas | Bayaoas | 64 | Master Plan | IDP | NIA | Excluded due to studies of economic & alternatives in IDP |

NOTE: <1 Study on Hydropower Potentials in Luzon Island
JICA, August 1987

<2 Irrigation Development Plan for Central Luzon
NIA, January 1978

<3 Feasibility Study on Balog-Balog Multi-Purpose Project
ELC and Philtech, July 1980

DM

## Table 4.2 FLOOD AT DAMSITES

100yr Probable Rainfall 1,075 mm
50yr Probable Rainfall 950 mm
Runoff Coefficient 0.7

| Damsite | C.A. (km2) | 100yr Flood Peak (m3/s) | 100yr Flood Amount (x Mill.m3) | 100yr Flood Period (hr) | 50yr Flood Peak (m3/s) | 50yr Flood Amount (x Mill.m3) | 50yr Flood Period (hr) |
|---|---|---|---|---|---|---|---|
| Tabu | 1,051 | 5,518 | 790.9 | 79.6 | 4,887 | 698.9 | 79.5 |
| San Roque | 1,250 | 6,438 | 940.6 | 81.2 | 5,625 | 831.3 | 82.1 |
| Upper Ambayoan | 151 | 1,276 | 113.6 | 49.5 | 1,125 | 100.4 | 49.6 |
| Upper Sapinit | 270 | 1,998 | 203.2 | 56.5 | 1,755 | 179.6 | 56.2 |
| Lower Ambayoan | 310 | 2,217 | 233.3 | 58.5 | 1,938 | 206.2 | 59.1 |
| Kaiipkip | 75 | 750 | 56.4 | 41.8 | 660 | 49.9 | 42.0 |
| Lubas | 90 | 864 | 67.7 | 43.5 | 761 | 59.9 | 43.7 |
| Bangat | 39 | 460 | 29.3 | 35.4 | 402 | 25.9 | 35.8 |
| O'Donnell | 119 | 1,071 | 89.5 | 46.4 | 940 | 79.1 | 46.7 |
| Lower O'Donnell | 278 | 2,043 | 209.2 | 56.9 | 1,793 | 184.9 | 57.3 |
| Moriones | 537 | 3,356 | 404.1 | 66.9 | 2,954 | 357.1 | 67.2 |
| Camiling | 221 | 1,713 | 166.3 | 53.9 | 1,503 | 147.0 | 54.3 |
| Pila | 130 | 1,144 | 97.8 | 47.5 | 1,008 | 86.5 | 47.7 |
| Bayaoas | 64 | 666 | 48.2 | 40.2 | 589 | 42.6 | 40.2 |

Table 4.3 SCREENING OF PROSPECTIVE DAMSITE FOR FLOOD CONTROL (100-YR FLOOD)

| Name of Damsite | River | (A) Catchment area (km2) | Riverbed elevation (EL.m) | Topo.max. elevation (EL.m) | Sediment Volume (mill.m3) | Peak Discharge (m3/s) | Hydro. Required Volume (mill.m3) | Dam height from riverbed (m) | Adopted dam height criteria |
|---|---|---|---|---|---|---|---|---|---|
| Tabu | Agno | 1,051 | 310 | <1 420 | 52.5 | 5,518 | 790.9 | 110 | TWL of Binga dam |
| San Roque | Agno | 1,250 | 100 | 320 | 107.3 | 6,438 | 940.6 | 198 | Hydro. required |
| Upper Ambayoan | Ambayoan | 151 | 465 | >800 | 41.5 | 1,276 | 113.6 | 173 | Hydro. required |
| Upper Sapinit | Ambayoan | 270 | 175 | >500 | 74.3 | 1,998 | 203.2 | 143 | Hydro. required |
| Lower Ambayoan | Ambayoan | 310 | 125 | 400 | 85.3 | 2,217 | 233.3 | 124 | Hydro. required |
| Kalipkip | Tuboy | 75 | 150 | 380 | 20.6 | 750 | 56.4 | 71 | Hydro. required |
| Lubas | Tuboy | 90 | 90 | 180 | 24.8 | 864 | 67.7 | 62 | Hydro. required |
| Bangat | Tarlac | 39 | 150 | 260 | 7.8 | 460 | 29.3 | 49 | Hydro. required |
| O'Donnell | Tarlac | 119 | 140 | 300 | 23.8 | 1,071 | 89.5 | 39 | Hydro. required |
| Lower O'Donnell | Tarlac | 278 | 75 | 110 | 55.6 | 2,043 | 209.2 | 35 | Topo. maximum |
| Moriones | Tarlac | 537 | 60 | 100 | 107.4 | 3,356 | 404.1 | 40 | Topo. maximum |
| Camiling | Camiling | 221 | 155 | 460 | 44.2 | 1,713 | 166.3 | 103 | Hydro. required |
| Pila | Olo | 130 | 55 | 180 | 26.0 | 1,144 | 97.8 | 90 | Hydro. required |
| Bayaoas | Bayaoas | 64 | 55 | 260 | 12.8 | 666 | 48.2 | 70 | Hydro. required |

Note: <1; Tail water level of Binga power station.

| Name of Damsite | Crest elevation (EL.m) | Flood water level (EL.m) | Sediment level (EL.m) | Gross storage (mill.m3) | (B) Flood Storage (mill.m3) | (C) Peak cut Ratio of flood (%) | (D) Dam Volume (mill.m3) | Storage efficiency SE=(B)/(D) | Flood control efficieny FCE=SE*(A)*(C)/1,000 |
|---|---|---|---|---|---|---|---|---|---|
| Tabu | 420 | 415 | 370.5 | 201.8 | 149.3 | 43 | 0.841 | 178 | 80 |
| San Roque | 298 | 293 | 180.0 | 1,047.9 | 940.6 | 100 | 8.545 | 110 | 138 |
| Upper Ambayoan | 638 | 633 | 574.0 | 155.1 | 113.6 | 100 | 2.508 | 45 | 7 |
| Upper Sapinit | 318 | 313 | 255.0 | 277.5 | 203.2 | 100 | 2.444 | 83 | 22 |
| Lower Ambayoan | 249 | 244 | 189.5 | 318.6 | 233.3 | 100 | 2.864 | 81 | 25 |
| Kalipkip | 221 | 216 | 191.0 | 77.0 | 56.4 | 100 | 0.749 | 75 | 6 |
| Lubas | 152 | 147 | 121.0 | 92.5 | 67.7 | 100 | 0.836 | 81 | 7 |
| Bangat | 199 | 194 | 171.5 | 37.1 | 29.3 | 100 | 0.239 | 123 | 5 |
| O'Donnell | 179 | 174 | 155.5 | 113.3 | 89.5 | 100 | 1.110 | 81 | 10 |
| Lower O'Donnell | 110 | 105 | 98.2 | 147.5 | 91.9 | 66 | 0.409 | 225 | 41 |
| Moriones | 100 | 95 | 82.7 | 381.5 | 274.1 | 82 | 0.217 | 1,263 | 556 |
| Camiling | 258 | 253 | 206.0 | 210.5 | 166.3 | 100 | 1.251 | 133 | 29 |
| Pila | 145 | 140 | 102.0 | 123.8 | 97.8 | 100 | 1.112 | 88 | 11 |
| Bayaoas | 125 | 120 | 89.0 | 61.0 | 48.2 | 100 | 0.419 | 115 | 7 |

## Table 4.4 SCREENING OF PROSPECTIVE DAMSITE FOR FLOOD CONTROL (50-YR FLOOD)

| Name of Damsite | River | (A) Catchment area (km2) | Riverbed elevation (EL.m) | Topo.max. elevation (EL.m) | Sediment Volume (mill.m3) | Peak Discharge (m3/s) | Hydro. Required Volume (mill.m3) | Dam height from river-bed (m) | Adopted dam height criteria |
|---|---|---|---|---|---|---|---|---|---|
| Tabu | Agno | 1,051 | 310 | <1 420 | 52.5 | 4,887 | 698.9 | 110 | TWL of Binga dam |
| San Roque | Agno | 1,250 | 100 | 320 | 107.3 | 5,625 | 831.3 | 191 | Hydro. required |
| Upper Ambayoan | Ambayoan | 151 | 465 | >800 | 41.5 | 1,125 | 100.4 | 168 | Hydro. required |
| Upper Sapinit | Ambayoan | 270 | 175 | >500 | 74.3 | 1,755 | 179.6 | 138 | Hydro. required |
| Lower Ambayoan | Ambayoan | 310 | 125 | 400 | 85.3 | 1,938 | 206.2 | 119 | Hydro. required |
| Kalipkip | Tuboy | 75 | 150 | 380 | 20.6 | 660 | 49.9 | 69 | Hydro. required |
| Lubas | Tuboy | 90 | 90 | 180 | 24.8 | 761 | 59.9 | 60 | Hydro. required |
| Bangat | Tarlac | 39 | 150 | 260 | 7.8 | 402 | 25.9 | 47 | Hydro. required |
| O'Donnell | Tarlac | 119 | 140 | 300 | 23.8 | 940 | 79.1 | 37 | Hydro. required |
| Lower O'Donnell | Tarlac | 278 | 75 | 110 | 55.6 | 1,793 | 184.9 | 35 | Topo. maximum |
| Moriones | Tarlac | 537 | 60 | 100 | 107.4 | 2,954 | 357.1 | 40 | Topo. maximum |
| Camiling | Camiling | 221 | 155 | 460 | 44.2 | 1,503 | 147.0 | 99 | Hydro. required |
| Pila | Olo | 130 | 55 | 180 | 26.0 | 1,008 | 86.5 | 87 | Hydro. required |
| Bayaoas | Bayaoas | 64 | 55 | 260 | 12.8 | 589 | 42.6 | 68 | Hydro. required |

Note: <1; Tail water level of Binga power station.

| Name of Damsite | Crest elevation (EL.m) | Flood water level (EL.m) | Sediment level (EL.m) | Gross storage (mill.m3) | (B) Flood Storage (mill.m3) | (C) Peak cut Ratio of flood (%) | (D) Dam Volume (mill.m3) | Storage efficiency SE=(B)/(D) | Flood control efficieny FCE=SE*(A)*(C)/1,000 |
|---|---|---|---|---|---|---|---|---|---|
| Tabu | 420 | 415 | 370.5 | 201.8 | 149.3 | 46 | 0.841 | 178 | 86 |
| San Roque | 291 | 286 | 180.0 | 938.6 | 831.3 | 100 | 7.815 | 106 | 133 |
| Upper Ambayoan | 633 | 628 | 574.0 | 141.9 | 100.4 | 100 | 2.310 | 43 | 6 |
| Upper Sapinit | 313 | 308 | 255.0 | 253.9 | 179.6 | 100 | 2.242 | 80 | 22 |
| Lower Ambayoan | 244 | 239 | 189.5 | 291.5 | 206.2 | 100 | 2.607 | 79 | 24 |
| Kalipkip | 219 | 214 | 191.0 | 70.5 | 49.9 | 100 | 0.708 | 70 | 5 |
| Lubas | 150 | 145 | 121.0 | 84.7 | 59.9 | 100 | 0.785 | 76 | 7 |
| Bangat | 197 | 192 | 171.5 | 33.7 | 25.9 | 100 | 0.221 | 117 | 5 |
| O'Donnell | 177 | 172 | 155.5 | 102.9 | 79.1 | 100 | 0.995 | 79 | 9 |
| Lower O'Donnell | 110 | 105 | 98.2 | 147.5 | 91.9 | 71 | 0.409 | 225 | 44 |
| Moriones | 100 | 95 | 82.7 | 381.5 | 274.1 | 88 | 0.217 | 1,263 | 597 |
| Camiling | 254 | 249 | 206.0 | 191.2 | 147.0 | 100 | 1.132 | 130 | 28 |
| Pila | 142 | 137 | 102.0 | 112.5 | 86.5 | 100 | 1.027 | 84 | 11 |
| Bayaoas | 123 | 118 | 89.0 | 55.4 | 42.6 | 100 | 0.394 | 108 | 7 |

Table 4.5 RESULTS OF INITIAL SCREENING

| Name of Damsite | River Basin | Catchment Area (km2) | Storage Efficiency 100-yr Flood | Storage Efficiency 50-yr Flood | Flood Control Ef. 100-yr Flood | Flood Control Ef. 50-yr Flood | Selected damsite | Remarks |
|---|---|---|---|---|---|---|---|---|
| Tabu | Agno | 1,051 | 178 | 178 | 80 | 86 | | High efficiency for flood control, however, Tabu is discarded in favor of San Roque due to lower flood control efficiency. |
| San Roque | Agno | 1,250 | 110 | 106 | 138 | 133 | * | High efficiency for flood control. |
| Upper Ambayoan | Ambayoan | 151 | 45 | 43 | 7 | 6 | | Low efficiency for flood control. |
| Upper Sapinit | Ambayoan | 270 | 83 | 80 | 22 | 22 | | Upper Sapinit is discarded in favor of Lower Ambayoan due to lower flood control efficiency. |
| Lower Ambayoan | Ambayoan | 310 | 81 | 79 | 25 | 24 | * | Lower Ambayoan has highest flood control efficiency in the Ambayoan River basin. |
| Kalipkip | Tuboy | 75 | 75 | 70 | 6 | 5 | | Low efficiency for flood control. |
| Lubas | Tuboy | 90 | 81 | 76 | 7 | 7 | | Low efficiency for flood control. |
| Bangat | Tarlac | 39 | 123 | 117 | 5 | 5 | | Low efficiency for flood control. |
| O'Donnell | Tarlac | 119 | 81 | 79 | 10 | 9 | | Low efficiency for flood control. |
| Lower O'Donnell | Tarlac | 278 | 225 | 225 | 41 | 44 | * | High efficiencies. |
| Moriones | Tarlac | 537 | 1,263 | 1,263 | 556 | 597 | * | High efficiencies. Compensation problem can probably be settled. |
| Camiling | Camiling | 221 | 133 | 130 | 29 | 28 | * | High efficiency for flood control. |
| Pila | Olo | 130 | 88 | 84 | 11 | 11 | | Low efficiency for flood control. |
| Bayaoas | Bayaoas | 64 | 115 | 108 | 7 | 7 | | Low efficiency for flood control. |

Table 4.6 SUMMARY OF FLOOD CONTROL DAMSITE ALTERNATIVE STUDY

| Item | Damsite | | | | | | Without |
|---|---|---|---|---|---|---|---|
| | San Roque | Lower Ambayoan | Lower O'Donnell | Moriones | Moriones & Lower O'Donnell | Camiling | Dam |
| I. River Basin | Agno | Ambayoan | Tarlac | Tarlac | Tarlac | Camiling | |
| II. Catchment Area (km2) | 1,250 | 310 | 278 | 537 | 815 | 221 | |
| III. Peak Cut Ratio (%) | 30 | 30 | 30 | 50 | 50 | 30 | |
| IV. Discharge at Damsite (m3/s) | | | | | | | |
| 1. 100-yr peak inflow | 6,380 | 1,800 | 1,700 | 2,250 | 3,310 | 1,240 | |
| 2. 100-yr controlled outflow | 4,500 | 1,270 | 1,200 | 1,160 | 1,690 | 880 | |
| V. Flood Control Storage (mill.m3) | 173 | 42 | 53 | 245 | 325 | 49 | |
| VI. Elevation (EL.m) | | | | | | | |
| 1. Surcharge water level | 240.0 | 230.0 | 107.2 | 94.0 | 98.7 | 231.5 | |
| 2. Dam crest elevation | 244.1 | 233.2 | 109.9 | 97.9 | 103.0 | 235.4 | |
| VII. Dam Height (m) | 149.1 | 118.2 | 44.9 | 47.9 | 53.0 | 85.4 | |
| VIII. Dam Volume (mill.m3) | | | | | | | |
| 1. Main dam (concrete) | 3.87 | 2.24 | 0.13 | 0.22 | 0.37 | 0.55 | |
| 2. Saddle dam (earthfill) | 0 | 0 | 1.50 | 0.21 | 0.65 | 0 | |
| IX. Construction Cost (mill.P) | | | | | | | |
| 1. Main construction | 8,036 | 4,551 | 897 | 802 | 1,547 | 1,355 | |
| 2. Compensation | 10 | 11 | 26 | 71 | 107 | 4 | |
| 3. G/A, E/S & Contingency | 2,955 | 1,674 | 334 | 309 | 590 | 499 | |
| Total | 11,001 | 6,236 | 1,257 | 1,182 | 2,244 | 1,858 | |
| X. Peak Discharge at Base Point (m3/s) | | | | | | | |
| 1. BP.1 | 16,970 | 17,070 | 17,130 | 16,590 | 16,170 | 17,210 | 17,310 |
| 2. BP.2 | 14,100 | 14,520 | 14,580 | 13,980 | 13,490 | 14,820 | 14,820 |
| 3. BP.3 | 8,170 | 8,940 | 9,190 | 9,190 | 9,190 | 9,190 | 9,190 |
| 4. BP.4 | 4,840 | 6,370 | 6,370 | 6,370 | 6,370 | 6,370 | 6,370 |
| 5. BP.5 | 2,180 | 2,180 | 2,180 | 2,180 | 2,180 | 1,840 | 2,180 |
| 6. BP.6 | 6,720 | 6,720 | 6,410 | 5,830 | 5,260 | 6,720 | 6,720 |
| 7. BP.7 | 1,730 | 1,240 | 1,730 | 1,730 | 1,730 | 1,730 | 1,730 |
| XI. Reduction in River Improvement Costs by Dam Plan (mill.P) | | | | | | | |
| 1. River improvement works | 185 | 113 | 160 | 460 | 745 | 133 | |
| 2. O & M cost (dredging) | 2,529 | 2,010 | 1,332 | 1,030 | 2,362 | 698 | |
| Total | 2,714 | 2,123 | 1,492 | 1,490 | 3,107 | 831 | |
| XII. Dam Cost less Reduction in River Improvement Cost (mill.P) | 8,287 | 4,113 | -235 | -308 | -863 | 1,027 | |

DM

## Table 4.7 SAN ROQUE DAM ALTERNATIVE CASES

| Item | Peak Cut Ratio (%) 90 | 70 | 50 | 30 | 0 |
|---|---|---|---|---|---|
| I. Discharge | | | | | |
| 1. 200-yr peak inflow (m3/s) | 7,750 | 7,750 | 7,750 | 7,750 | 7,750 |
| 2. 100-yr peak inflow (m3/s) | 6,380 | 6,380 | 6,380 | 6,380 | 6,380 |
| 3. 100-yr controlled peak outflow (m3/s) | 750 | 2,000 | 3,250 | 4,500 | 6,380 |
| II. Storage | | | | | |
| 1. Sediment (mill. m3) | 256.0 | 256.0 | 256.0 | 256.0 | - |
| 2. Calculated flood control (mill. m3) | 786.2 | 505.6 | 295.6 | 143.9 | - |
| 3. Design flood control (mill. m3) | 943.4 | 606.7 | 354.7 | 172.7 | - |
| III. Elevation | | | | | |
| 1. Dam bottom (El. m) | 95.0 | 95.0 | 95.0 | 95.0 | - |
| 2. Sediment (El. m) | 213.0 | 213.0 | 213.0 | 213.0 | - |
| 3. Calculated SWL (El. m) | 293.0 | 272.0 | 255.0 | 237.0 | - |
| 4. Design SWL (El. m) | 304.0 | 280.0 | 259.0 | 240.0 | - |
| 5. FWL (El. m) | 309.5 | 284.4 | 262.3 | 242.1 | - |
| 6. Dam crest (El. m) | 311.5 | 286.4 | 264.3 | 244.1 | - |
| IV. Dam Volume | | | | | |
| 1. Main dam, concrete (mill. m3) | 9.90 | 7.25 | 5.34 | 3.87 | - |
| 2. Saddle dam, earthfill (mill. m3) | 0 | 0 | 0 | 0 | - |
| V. Construction Cost (Financial) | | | | | |
| 1. Preparatory works (mill. P) | 1,495 | 1,111 | 833 | 617 | - |
| 2. Civil works (mill. P) | 14,956 | 11,115 | 8,329 | 6,172 | - |
| 3. Metal works (mill. P) | 80 | 138 | 159 | 199 | - |
| 4. Miscellaneous works (mill. P) | 2,480 | 1,855 | 1,398 | 1,048 | - |
| Total of 1 to 4 (mill. P) | 19,011 | 14,219 | 10,719 | 8,036 | - |
| 5. Compensation (mill. P) | 20 | 16 | 13 | 10 | - |
| 6. Government administration (mill. P) | 951 | 712 | 537 | 402 | - |
| 7. Engineering services (mill. P) | 3,042 | 2,275 | 1,715 | 1,286 | - |
| 8. Physical contingency (mill. P) | 2,997 | 2,242 | 1,690 | 1,267 | - |
| Grand Total (mill. P) | 26,021 | 19,464 | 14,674 | 11,001 | - |
| VI. Peak Discharge at Base Point | | | | | |
| 1. BP.1 (m3/s) | 14,870 | 15,540 | 16,240 | 16,970 | 17,310 |
| 2. BP.2 (m3/s) | 11,660 | 12,400 | 13,180 | 14,100 | 14,820 |
| 3. BP.3 (m3/s) | 5,510 | 6,280 | 7,160 | 8,170 | 9,190 |
| 4. BP.4 (m3/s) | 1,130 | 2,360 | 3,610 | 4,840 | 6,370 |
| 5. BP.5 (m3/s) | 2,180 | 2,180 | 2,180 | 2,180 | 2,180 |
| 6. BP.6 (m3/s) | 6,720 | 6,720 | 6,720 | 6,720 | 6,720 |
| 7. BP.7 (m3/s) | 1,730 | 1,730 | 1,730 | 1,730 | 1,730 |
| VII. Reduction in River Improvement Cost by Dam Plan (mill.P) | | | | | |
| 1. River improvement works | 1,020 | 770 | 470 | 185 | 0 |
| 2. O & M cost (dredging) | 2,529 | 2,529 | 2,529 | 2,529 | 0 |
| Total | 3,549 | 3,299 | 2,999 | 2,714 | 0 |
| VIII. Dam Cost less Reduction in River Improvement Cost (mill.P) | 22,472 | 16,165 | 11,675 | 8,287 | 0 |

DM

## Table 4.8 LOWER AMBAYOAN DAM ALTERNATIVE CASES

| Item | Peak Cut Ratio (%) 90 | 70 | 50 | 30 | 0 |
|---|---|---|---|---|---|
| I. Discharge | | | | | |
| 1. 200-yr peak inflow (m3/s) | 2,200 | 2,200 | 2,200 | 2,200 | 2,200 |
| 2. 100-yr peak inflow (m3/s) | 1,800 | 1,800 | 1,800 | 1,800 | 1,800 |
| 3. 100-yr controlled peak outflow (m3/s) | 210 | 560 | 920 | 1,270 | 1,800 |
| II. Storage | | | | | |
| 1. Sediment (mill. m3) | 203.0 | 203.0 | 203.0 | 203.0 | - |
| 2. Calculated flood control (mill. m3) | 201.2 | 127.3 | 71.7 | 34.6 | - |
| 3. Design flood control (mill. m3) | 241.4 | 152.8 | 86.0 | 41.5 | - |
| III. Elevation | | | | | |
| 1. Dam bottom (El. m) | 115.0 | 115.0 | 115.0 | 115.0 | - |
| 2. Sediment (El. m) | 221.0 | 221.0 | 221.0 | 221.0 | - |
| 3. Calculated SWL (El. m) | 257.5 | 246.0 | 236.0 | 228.5 | - |
| 4. Design SWL (El. m) | 262.0 | 250.0 | 238.5 | 230.0 | - |
| 5. FWL (El. m) | 264.5 | 252.0 | 240.0 | 231.2 | - |
| 6. Dam crest (El. m) | 266.5 | 254.0 | 242.0 | 233.2 | - |
| IV. Dam Volume | | | | | |
| 1. Main dam, concrete (mill. m3) | 3.98 | 3.22 | 2.62 | 2.24 | - |
| 2. Saddle dam, earthfill (mill. m3) | 0 | 0 | 0 | 0 | - |
| V. Construction Cost (Financial) | | | | | |
| 1. Preparatory works (mill. P) | 610 | 500 | 412 | 357 | - |
| 2. Civil works (mill. P) | 6,106 | 5,001 | 4,126 | 3,568 | - |
| 3. Metal works (mill. P) | 18 | 30 | 33 | 32 | - |
| 4. Miscellaneous works (mill. P) | 1,010 | 830 | 686 | 594 | - |
| Total of 1 to 4 (mill. P) | 7,744 | 6,361 | 5,257 | 4,551 | - |
| 5. Compensation (mill. P) | 14 | 13 | 12 | 11 | - |
| 6. Government administration (mill. P) | 388 | 318 | 263 | 228 | - |
| 7. Engineering services (mill. P) | 1,239 | 1,018 | 841 | 728 | - |
| 8. Physical contingency (mill. P) | 1,222 | 1,004 | 830 | 718 | - |
| Grand Total (mill. P) | 10,607 | 8,714 | 7,203 | 6,236 | - |
| VI. Peak Discharge at Base Point | | | | | |
| 1. BP.1 (m3/s) | 16,420 | 16,650 | 16,870 | 17,070 | 17,310 |
| 2. BP.2 (m3/s) | 13,720 | 13,980 | 14,250 | 14,520 | 14,820 |
| 3. BP.3 (m3/s) | 8,080 | 8,370 | 8,660 | 8,940 | 9,190 |
| 4. BP.4 (m3/s) | 6,370 | 6,370 | 6,370 | 6,370 | 6,370 |
| 5. BP.5 (m3/s) | 2,180 | 2,180 | 2,180 | 2,180 | 2,180 |
| 6. BP.6 (m3/s) | 6,720 | 6,720 | 6,720 | 6,720 | 6,720 |
| 7. BP.7 (m3/s) | 430 | 690 | 960 | 1,240 | 1,730 |
| VII. Reduction in River Improvement Cost by Dam Plan (mill.P) | | | | | |
| 1. River improvement works | 371 | 281 | 192 | 113 | 0 |
| 2. O & M cost (dredging) | 2,010 | 2,010 | 2,010 | 2,010 | 0 |
| Total | 2,381 | 2,291 | 2,202 | 2,123 | 0 |
| VIII. Dam Cost less Reduction in River Improvement Cost (mill.P) | 8,226 | 6,423 | 5,001 | 4,113 | 0 |

DM

Table 4.9 LOWER O'DONNELL DAM ALTERNATIVE CASES

| Item | Peak Cut Ratio (%) 90 | 70 | 50 | 30 | 0 |
|---|---|---|---|---|---|
| I. Discharge | | | | | |
| 1. 200-yr peak inflow (m3/s) | - | - | 2,010 | 2,010 | 2,010 |
| 2. 100-yr peak inflow (m3/s) | - | - | 1,700 | 1,700 | 1,700 |
| 3. 100-yr controlled peak outflow (m3/s) | - | - | 870 | 1,200 | 1,700 |
| II. Storage | | | | | |
| 1. Sediment (mill. m3) | - | - | 135.0 | 135.0 | - |
| 2. Calculated flood control (mill. m3) | - | - | 86.1 | 44.3 | - |
| 3. Design flood control (mill. m3) | - | - | 103.3 | 53.2 | - |
| III. Elevation | | | | | |
| 1. Dam bottom (El. m) | - | - | 65.0 | 65.0 | - |
| 2. Sediment (El. m) | - | - | 104.2 | 104.2 | - |
| 3. Calculated SWL (El. m) | - | - | 108.8 | 106.8 | - |
| 4. Design SWL (El. m) | - | - | 109.5 | 107.2 | - |
| 5. FWL (El. m) | - | - | 109.9 | 107.9 | - |
| 6. Dam crest (El. m) | - | - | 111.9 | 109.9 | - |
| IV. Dam Volume | | | | | |
| 1. Main dam, concrete (mill. m3) | - | - | 0.14 | 0.13 | - |
| 2. Saddle dam, earthfill (mill. m3) | - | - | 1.90 | 1.50 | - |
| V. Construction Cost (Financial) | | | | | |
| 1. Preparatory works (mill. P) | - | - | 74 | 65 | - |
| 2. Civil works (mill. P) | - | - | 740 | 647 | - |
| 3. Metal works (mill. P) | - | - | 68 | 68 | - |
| 4. Miscellaneous works (mill. P) | - | - | 132 | 117 | - |
| Total of 1 to 4 (mill. P) | - | - | 1,014 | 897 | - |
| 5. Compensation (mill. P) | - | - | 28 | 26 | - |
| 6. Government administration (mill. P) | - | - | 52 | 46 | - |
| 7. Engineering services (mill. P) | - | - | 162 | 143 | - |
| 8. Physical contingency (mill. P) | - | - | 164 | 145 | - |
| Grand Total (mill. P) | - | - | 1,420 | 1,257 | - |
| VI. Peak Discharge at Base Point | | | | | |
| 1. BP.1 (m3/s) | - | - | 16,940 | 17,130 | 17,310 |
| 2. BP.2 (m3/s) | - | - | 14,360 | 14,580 | 14,820 |
| 3. BP.3 (m3/s) | - | - | 9,190 | 9,190 | 9,190 |
| 4. BP.4 (m3/s) | - | - | 6,370 | 6,370 | 6,370 |
| 5. BP.5 (m3/s) | - | - | 2,180 | 2,180 | 2,180 |
| 6. BP.6 (m3/s) | - | - | 6,190 | 6,410 | 6,720 |
| 7. BP.7 (m3/s) | - | - | 1,730 | 1,730 | 1,730 |
| VII. Reduction in River Improvement Cost by Dam Plan (mill.P) | | | | | |
| 1. River improvement works | - | - | 265 | 160 | 0 |
| 2. O & M cost (dredging) | - | - | 1,332 | 1,332 | 0 |
| Total | - | - | 1,597 | 1,492 | 0 |
| VIII. Dam Cost less Reduction in River Improvement Cost (mill.P) | - | - | -177 | -235 | 0 |

DM

Table 4.10 MORIONES DAM ALTERNATIVE CASES

| Item | Peak Cut Ratio (%) 90 | 70 | 50 | 30 | 0 |
|---|---|---|---|---|---|
| I. Discharge | | | | | |
| 1. 200-yr peak inflow (m3/s) | 2,540 | 2,540 | 2,540 | 2,540 | 2,540 |
| 2. 100-yr peak inflow (m3/s) | 2,250 | 2,250 | 2,250 | 2,250 | 2,250 |
| 3. 100-yr controlled peak outflow (m3/s) | 280 | 720 | 1,160 | 1,600 | 2,250 |
| II. Storage | | | | | |
| 1. Sediment (mill. m3) | 104.0 | 104.0 | 104.0 | 104.0 | - |
| 2. Calculated flood control (mill. m3) | 472.5 | 319.2 | 204.1 | 107.4 | - |
| 3. Design flood control (mill. m3) | 567.0 | 383.2 | 244.9 | 128.9 | - |
| III. Elevation | | | | | |
| 1. Dam bottom (El. m) | 50.0 | 50.0 | 50.0 | 50.0 | - |
| 2. Sediment (El. m) | 82.5 | 82.5 | 82.5 | 82.5 | - |
| 3. Calculated SWL (El. m) | 100.4 | 96.3 | 92.5 | 88.7 | - |
| 4. Design SWL (El. m) | 102.6 | 98.2 | 94.0 | 89.7 | - |
| 5. FWL (El. m) | 105.8 | 100.7 | 95.9 | 91.0 | - |
| 6. Dam crest (El. m) | 107.8 | 102.7 | 97.9 | 93.0 | - |
| IV. Dam Volume | | | | | |
| 1. Main dam, concrete (mill. m3) | 0.33 | 0.26 | 0.22 | 0.19 | - |
| 2. Saddle dam, earthfill (mill. m3) | 3.00 | 0.44 | 0.21 | 0.07 | - |
| V. Construction Cost (Financial) | | | | | |
| 1. Preparatory works (mill. P) | 134 | 72 | 61 | 51 | - |
| 2. Civil works (mill. P) | 1,342 | 724 | 606 | 510 | - |
| 3. Metal works (mill. P) | 15 | 25 | 31 | 35 | - |
| 4. Miscellaneous works (mill. P) | 224 | 123 | 104 | 89 | - |
| Total of 1 to 4 (mill. P) | 1,715 | 944 | 802 | 685 | - |
| 5. Compensation (mill. P) | 115 | 92 | 71 | 52 | - |
| 6. Government administration (mill. P) | 92 | 52 | 44 | 37 | - |
| 7. Engineering services (mill. P) | 274 | 151 | 128 | 110 | - |
| 8. Physical contingency (mill. P) | 288 | 163 | 137 | 116 | - |
| Grand Total (mill. P) | 2,484 | 1,402 | 1,182 | 1,000 | - |
| VI. Peak Discharge at Base Point | | | | | |
| 1. BP.1 (m3/s) | 15,960 | 16,270 | 16,590 | 16,910 | 17,310 |
| 2. BP.2 (m3/s) | 13,270 | 13,620 | 13,980 | 14,340 | 14,820 |
| 3. BP.3 (m3/s) | 9,190 | 9,190 | 9,190 | 9,190 | 9,190 |
| 4. BP.4 (m3/s) | 6,370 | 6,370 | 6,370 | 6,370 | 6,370 |
| 5. BP.5 (m3/s) | 2,180 | 2,180 | 2,180 | 2,180 | 2,180 |
| 6. BP.6 (m3/s) | 5,090 | 5,450 | 5,830 | 6,190 | 6,720 |
| 7. BP.7 (m3/s) | 1,730 | 1,730 | 1,730 | 1,730 | 1,730 |
| VII. Reduction in River Improvement Cost by Dam Plan (mill.P) | | | | | |
| 1. River improvement works | 800 | 660 | 460 | 265 | 0 |
| 2. O & M cost (dredging) | 1,030 | 1,030 | 1,030 | 1,030 | 0 |
| Total | 1,830 | 1,690 | 1,490 | 1,295 | 0 |
| VIII. Dam Cost less Reduction in River Improvement Cost (mill.P) | 654 | -288 | -308 | -295 | 0 |

DM

## Table 4.11 MORIONES AND LOWER O'DONNELL COMBINED DAM ALTERNATIVE CASES

| Item | Peak Cut Ratio (%) | | | | |
|---|---|---|---|---|---|
| | 90 | 70 | 50 | 30 | 0 |
| **I. Discharge** | | | | | |
| 1. 200-yr peak inflow (m3/s) | - | 3,860 | 3,860 | 3,860 | 3,860 |
| 2. 100-yr peak inflow (m3/s) | - | 3,310 | 3,310 | 3,310 | 3,310 |
| 3. 100-yr controlled peak outflow (m3/s) | - | 1,050 | 1,690 | 2,340 | 3,310 |
| **II. Storage** | | | | | |
| 1. Sediment (mill. m3) | - | 238.5 | 238.5 | 238.5 | - |
| 2. Calculated flood control (mill. m3) | - | 425.4 | 271.1 | 141.2 | - |
| 3. Design flood control (mill. m3) | - | 510.5 | 325.3 | 169.4 | - |
| **III. Elevation** | | | | | |
| 1. Dam bottom at Moriones (El. m) | - | 50.0 | 50.0 | 50.0 | - |
| 2. Sediment (El. m) | - | 89.5 | 89.5 | 89.5 | - |
| 3. Calculated SWL (El. m) | - | 100.7 | 97.6 | 94.3 | - |
| 4. Design SWL (El. m) | - | 102.1 | 98.7 | 95.1 | - |
| 5. FWL (El. m) | - | 105.2 | 101.0 | 96.9 | - |
| 6. Dam crest (El. m) | - | 107.2 | 103.0 | 98.9 | - |
| **IV. Dam Volume** | | | | | |
| 1. Main dam, concrete (mill. m3) | - | 0.42 | 0.37 | 0.33 | - |
| 2. Saddle dam, earthfill (mill. m3) | - | 1.75 | 0.65 | 0.15 | - |
| **V. Construction Cost (Financial)** | | | | | |
| 1. Preparatory works (mill. P) | - | 146 | 117 | 100 | - |
| 2. Civil works (mill. P) | - | 1,467 | 1,174 | 997 | - |
| 3. Metal works (mill. P) | - | 37 | 54 | 70 | - |
| 4. Miscellaneous works (mill. P) | - | 247 | 202 | 175 | - |
| Total of 1 to 4 (mill. P) | - | 1,897 | 1,547 | 1,342 | - |
| 5. Compensation (mill. P) | - | 136 | 107 | 85 | - |
| 6. Government administration (mill. P) | - | 102 | 83 | 71 | - |
| 7. Engineering services (mill. P) | - | 303 | 247 | 215 | - |
| 8. Physical contingency (mill. P) | - | 320 | 260 | 224 | - |
| Grand Total (mill. P) | - | 2,758 | 2,244 | 1,937 | - |
| **VI. Peak Discharge at Base Point** | | | | | |
| 1. BP.1 (m3/s) | - | 15,680 | 16,170 | 16,690 | 17,310 |
| 2. BP.2 (m3/s) | - | 12,930 | 13,490 | 14,080 | 14,820 |
| 3. BP.3 (m3/s) | - | 9,190 | 9,190 | 9,190 | 9,190 |
| 4. BP.4 (m3/s) | - | 6,370 | 6,370 | 6,370 | 6,370 |
| 5. BP.5 (m3/s) | - | 2,180 | 2,180 | 2,180 | 2,180 |
| 6. BP.6 (m3/s) | - | 4,780 | 5,260 | 5,880 | 6,720 |
| 7. BP.7 (m3/s) | - | 1,730 | 1,730 | 1,730 | 1,730 |
| **VII. Reduction in River Improvement Cost by Dam Plan (mill.P)** | | | | | |
| 1. River improvement works | - | 1,020 | 745 | 345 | 0 |
| 2. O & M cost (dredging) | - | 2,362 | 2,362 | 2,362 | 0 |
| Total | - | 3,382 | 3,107 | 2,707 | 0 |
| **VIII. Dam Cost less Reduction in River Improvement Cost (mill.P)** | - | -624 | -863 | -770 | 0 |

DM

## Table 4.12 CAMILING DAM ALTERNATIVE CASES

| Item | Peak Cut Ratio (%) 90 | 70 | 50 | 30 | 0 |
|---|---|---|---|---|---|
| I. Discharge | | | | | |
| 1. 200-yr peak inflow (m3/s) | 1,510 | 1,510 | 1,510 | 1,510 | 1,510 |
| 2. 100-yr peak inflow (m3/s) | 1,240 | 1,240 | 1,240 | 1,240 | 1,240 |
| 3. 100-yr controlled peak outflow (m3/s) | 150 | 390 | 630 | 880 | 1,240 |
| II. Storage | | | | | |
| 1. Sediment (mill. m3) | 71.0 | 71.0 | 71.0 | 71.0 | - |
| 2. Calculated flood control (mill. m3) | 204.0 | 139.4 | 87.4 | 41.0 | - |
| 3. Design flood control (mill. m3) | 244.8 | 167.3 | 104.9 | 49.2 | - |
| III. Elevation | | | | | |
| 1. Dam bottom (El. m) | 150.0 | 150.0 | 150.0 | 150.0 | - |
| 2. Sediment (El. m) | 216.5 | 216.5 | 216.5 | 216.5 | - |
| 3. Calculated SWL (El. m) | 264.5 | 253.0 | 241.5 | 229.0 | - |
| 4. Design SWL (El. m) | 271.0 | 258.0 | 245.5 | 231.5 | - |
| 5. FWL (El. m) | 275.3 | 261.5 | 247.9 | 233.4 | - |
| 6. Dam crest (El. m) | 277.3 | 263.5 | 249.9 | 235.4 | - |
| IV. Dam Volume | | | | | |
| 1. Main dam, concrete (mill. m3) | 1.55 | 1.14 | 0.82 | 0.55 | - |
| 2. Saddle dam, earthfill (mill. m3) | 0 | 0 | 0 | 0 | - |
| V. Construction Cost (Financial) | | | | | |
| 1. Preparatory works (mill. P) | 250 | 192 | 144 | 104 | - |
| 2. Civil works (mill. P) | 2,506 | 1,919 | 1,445 | 1,044 | - |
| 3. Metal works (mill. P) | 15 | 21 | 27 | 30 | - |
| 4. Miscellaneous works (mill. P) | 416 | 319 | 242 | 177 | - |
| Total of 1 to 4 (mill. P) | 3,187 | 2,451 | 1,858 | 1,355 | - |
| 5. Compensation (mill. P) | 6 | 5 | 4 | 4 | - |
| 6. Government administration (mill. P) | 159 | 123 | 93 | 68 | - |
| 7. Engineering services (mill. P) | 510 | 392 | 297 | 217 | - |
| 8. Physical contingency (mill. P) | 503 | 387 | 294 | 214 | - |
| Grand Total (mill. P) | 4,365 | 3,358 | 2,546 | 1,858 | - |
| VI. Peak Discharge at Base Point | | | | | |
| 1. BP.1 (m3/s) | 16,780 | 16,920 | 17,060 | 17,210 | 17,310 |
| 2. BP.2 (m3/s) | 14,820 | 14,820 | 14,820 | 14,820 | 14,820 |
| 3. BP.3 (m3/s) | 9,190 | 9,190 | 9,190 | 9,190 | 9,190 |
| 4. BP.4 (m3/s) | 6,370 | 6,370 | 6,370 | 6,370 | 6,370 |
| 5. BP.5 (m3/s) | 1,380 | 1,530 | 1,680 | 1,840 | 2,180 |
| 6. BP.6 (m3/s) | 6,720 | 6,720 | 6,720 | 6,720 | 6,720 |
| 7. BP.7 (m3/s) | 1,730 | 1,730 | 1,730 | 1,730 | 1,730 |
| VII. Reduction in River Improvement Cost by Dam Plan (mill.P) | | | | | |
| 1. River improvement works | 345 | 276 | 210 | 133 | 0 |
| 2. O & M cost (dredging) | 698 | 698 | 698 | 698 | 0 |
| Total | 1,043 | 974 | 908 | 831 | 0 |
| VIII. Dam Cost less Reduction in River Improvement Cost (mill.P) | 3,322 | 2,384 | 1,638 | 1,027 | 0 |

DM

## Table 5.1 POPONTO RETARDING BASIN ALTERNATIVE STUDY

| Item | Case No. 1 | 2-1-1 | 2-1-2 | 2-2-1 | 2-2-2 | 2-2-3 | 2-3-1 | 2-3-2 | 2-3-3 |
|---|---|---|---|---|---|---|---|---|---|
| I. Discharge (m3/s) | | | | | | | | | |
| 1.Peak inflow to basin | 13,110 | 13,110 | 13,110 | 13,110 | 13,110 | 13,110 | 13,110 | 13,110 | 13,110 |
| 2.Peak outflow from basin | 9,930 | 6,610 | 5,610 | 7,610 | 6,610 | 5,610 | 7,610 | 6,610 | 5,610 |
| 3.Peak cut | 3,180 | 6,500 | 7,500 | 5,500 | 6,500 | 7,500 | 5,500 | 6,500 | 7,500 |
| II. Flood Control Storage (mill.m3) | 757 | 1,319 | 1,445 | 1,153 | 1,248 | 1,394 | 1,068 | 1,186 | 1,353 |
| III. Flood Water Level (El.m) | 16.59 | 18.06 | 18.37 | 17.64 | 17.88 | 18.24 | 17.43 | 17.72 | 18.14 |
| IV. Inundated Area (km2) | 347 | 428 | 445 | 406 | 419 | 438 | 394 | 410 | 433 |
| V. Dimension of structure (m) | | | | | | | | | |
| 1.Width of control gate | 0 | 150 | 150 | 200 | 200 | 200 | 300 | 300 | 300 |
| VI. Construction Cost (mill.P) | | | | | | | | | |
| 1.Control gate | 0 | 1,102 | 1,128 | 1,419 | 1,447 | 1,487 | 2,096 | 2,145 | 2,213 |
| VII. Peak Discharge at BP1 (m3/s) | 13,260 | 10,320 | 10,030 | 11,010 | 10,780 | 10,240 | 11,610 | 11,090 | 10,380 |
| VIII. Reduction in River Improvement Costs by Retarding Basin Plan (mill.P) | | | | | | | | | |
| 1.River improvement works | 1,542 | 2,226 | 2,285 | 2,035 | 2,093 | 2,234 | 1,863 | 2,008 | 2,204 |
| 2.O & M cost(dredging) | 2,584 | 2,584 | 2,584 | 2,584 | 2,584 | 2,584 | 2,584 | 2,584 | 2,584 |
| Total | 4,126 | 4,810 | 4,869 | 4,619 | 4,677 | 4,818 | 4,447 | 4,592 | 4,788 |
| IX. Retarding Basin Cost less Reduction in River Improvement Cost (mill.P) | -4126 | -3708 | -3741 | -3200 | -3230 | -3331 | -2351 | -2447 | -2575 |

| Item | Case No. 3-1 | 3-2 | 3-3 | 3A | 4-1 | 4-2 | 4-3 |
|---|---|---|---|---|---|---|---|
| I. Discharge (m3/s) | | | | | | | |
| 1.Peak overflow to basin | 3,000 | 4,000 | 5,000 | 0 | 3,000 | 4,500 | 6,000 |
| 2.Peak inflow to basin | 8,860 | 9,860 | 10,860 | 5,960 | 5,330 | 6,830 | 8,330 |
| 3.Peak outflow from basin | 1,360 | 2,360 | 3,360 | 460 | - | - | - |
| 4.Peak cut | 7,500 | 7,500 | 7,500 | 5,500 | 5,330 | 6,830 | 8,330 |
| II. Flood Control Storage (mill.m3) | 1,346 | 1,337 | 1,356 | 1,370 | 922 | 1,189 | 1,515 |
| III. Flood Water Level (El.m) | 18.12 | 18.10 | 18.15 | 18.18 | 17.06 | 17.73 | 18.55 |
| IV. Inundated Area (km2) | 432 | 430 | 433 | 435 | 374 | 410 | 455 |
| V. Dimension of structure (m) | | | | | | | |
| 1.Width of control gate | 150 | 150 | 150 | 150 | 0 | 0 | 0 |
| 2.Length of side overflow | 3,600 | 2,850 | 2,100 | 0 | 7,800 | 6,350 | 5,000 |
| VI. Construction Cost (mill.P) | | | | | | | |
| 1.Control gate | 1,107 | 1,102 | 1,107 | 1,111 | 0 | 0 | 0 |
| 2.Side overflow | 936 | 741 | 546 | 0 | 2,028 | 1,651 | 1,300 |
| 3.Drainage gate | 0 | 0 | 0 | 0 | 340 | 357 | 381 |
| Total | 2,043 | 1,843 | 1,653 | 1,111 | 2,368 | 2,008 | 1,681 |
| VII. Peak Discharge at BP1 (m3/s) | 10,520 | 10,440 | 10,340 | 12,150 | 12,590 | 11,170 | 9,740 |
| VIII. Reduction in River Improvement Costs by Retarding Basin Plan (mill.P) | | | | | | | |
| 1.River improvement works | 2,075 | 2,108 | 2,137 | 1,535 | 1,362 | 1,732 | 2,085 |
| 2.O & M cost(dredging) | 1,129 | 1,129 | 1,129 | 1,129 | 0 | 0 | 0 |
| Total | 3,204 | 3,237 | 3,266 | 2,664 | 1,362 | 1,732 | 2,085 |
| IX. Retarding Basin Cost less Reduction in River Improvement Cost (mill.P) | -1161 | -1394 | -1613 | -1553 | 1006 | 276 | -404 |

Table 5.2 CAMILING RETARDING BASIN ALTERNATIVE STUDY

| Item | Case No. 1 | Case No. 2 | Case No. 3 |
|---|---|---|---|
| I. Discharge (m3/s) | | | |
| 1.Peak overflow to basin | 2,000 | 2,500 | 3,000 |
| 2.Peak cut | 2,000 | 2,500 | 3,000 |
| II. Flood Control Storage (mill.m3) | 120 | 173 | 230 |
| III. Flood Water Level (El.m) | 12.25 | 13.37 | 14.30 |
| IV. Inundated Area (km2) | 43 | 52 | 60 |
| V. Dimension of structure (m) | | | |
| 1.Length of side overflow | 2,400 | 2,370 | 2,350 |
| VI. Construction Cost (mill.P) | | | |
| 1.Side overflow | 624 | 616 | 611 |
| 2.Drainage gate | 88 | 124 | 168 |
| Total | 712 | 740 | 779 |
| VII. Peak Discharge at BP1 (m3/s) | 15,700 | 15,250 | 14,800 |
| VIII. Reduction in River Improvement Costs by Retarding Basin Plan (mill.P) | 371 | 451 | 521 |
| IX. Retarding Basin Cost less Reduction in River Improvement Cost (mill.P) | 341 | 289 | 258 |

## Table 8.1 FINANCIAL CONSTRUCTION COST OF MORIONES AND LOWER O'DONNELL COMBINED DAM PLAN

PEAK CUT = 50%, DAM CREST EL = 105.0 M

| WORK ITEM | UNIT | UNIT PRICE (Pesos) | WORK QUANTITY MORIONES | LOWER O'DONNELL | TOTAL | AMOUNT (Mill. P) |
|---|---|---|---|---|---|---|
| I PREPARATORY WORKS | | | | | | 117.36 |
| II CIVIL WORKS | | | | | | |
| 2.1 River Diversion Works | | | | | | |
| Tunnel excavation | m3 | 1,170 | 8,810 | 7,710 | 16,520 | 19.33 |
| Lining concrete | m3 | 2,770 | 3,160 | 3,000 | 6,160 | 17.06 |
| Plug concrete | m3 | 2,230 | 790 | 390 | 1,180 | 2.63 |
| Steel bar | ton | 29,000 | 158 | 150 | 308 | 8.93 |
| Consideration grout | m | 1,830 | 1,510 | 1,510 | 3,020 | 5.53 |
| Cofferdam | m3 | 160 | 108,900 | 75,300 | 184,200 | 29.47 |
| Sub-Total of 2.1 | | | | | | 82.95 |
| 2.2 Dam | | | | | | |
| Excavation (common) | m3 | 73 | 40,000 | 22,000 | 62,000 | 4.53 |
| Excavation (rock) | m3 | 260 | 120,000 | 64,000 | 184,000 | 47.84 |
| Concrete | m3 | Variable | 277,000 | 92,000 | 369,000 | 599.15 |
| Curtain grout | m | 2,620 | 15,450 | 10,000 | 25,450 | 66.68 |
| Consolidation grout | m | 1,830 | 7,300 | 3,600 | 10,900 | 19.95 |
| Saddle dam | m3 | 160 | | | 650,000 | 104.00 |
| Excava. for saddle dam | m3 | 73 | | | 300,000 | 21.90 |
| Sub-Total of 2.2 | | | | | | 864.04 |
| 2.3 Spillway | | | | | | |
| Excavation (common) | m3 | 73 | 104,400 | 0 | 104,400 | 7.62 |
| Excavation (rock) | m3 | 260 | 44,700 | 0 | 44,700 | 11.62 |
| Concrete | m3 | 2,280 | 30,420 | 0 | 30,420 | 69.36 |
| Steel bar | ton | 29,000 | 456 | 0 | 456 | 13.22 |
| Sub-Total of 2.3 | | | | | | 101.82 |
| 2.4 Connection Channel | | | | | | |
| Excavation | m3 | 60 | | | 2,080,000 | 124.80 |
| Sub-Total of 2.4 | | | | | | 124.80 |
| Total of II | | | | | | 1,173.62 |
| III METAL WORKS | | | | | | |
| Diversion closure gate | ton | 158,000 | 41 | 20 | 61 | 9.64 |
| Spillway gate | ton | 227,000 | 188 | 0 | 188 | 42.68 |
| Outlet gate | ton | 227,000 | 0 | 7 | 7 | 1.59 |
| Total of III | | | | | | 53.90 |
| IV MISCELLANEOUS WORKS | | | | | | 201.73 |
| Total of I to IV | | | | | | 1,546.62 |
| V COMPENSATION | | | | | | 107.00 |
| VI GOVERNMENT ADMINISTRATION | | | | | | 82.68 |
| VII ENGINEERING SERVICES | | | | | | 247.46 |
| VIII PHYSICAL CONTINGENCY | | | | | | 260.44 |
| GRAND TOTAL | | | | | | 2,244.20 |

## Table 8.2 ECONOMIC CONSTRUCTION COST OF MORIONES AND LOWER O'DONNELL COMBINED DAM PLAN

PEAK CUT = 50%, DAM CREST EL = 103.0 M

| WORK ITEM | UNIT | UNIT PRICE (Pesos) | WORK QUANTITY MORIONES | LOWER O'DONNELL | TOTAL | AMOUNT (Mill. P) |
|---|---|---|---|---|---|---|
| I PREPARATORY WORKS | | | | | | 100.54 |
| II CIVIL WORKS | | | | | | |
| 2.1 River Diversion Works | | | | | | |
| Tunnel excavation | m3 | 1,008 | 8,810 | 7,710 | 16,520 | 16.65 |
| Lining concrete | m3 | 2,369 | 3,160 | 3,000 | 6,160 | 14.59 |
| Plug concrete | m3 | 1,908 | 790 | 390 | 1,180 | 2.25 |
| Steel bar | ton | 24,000 | 158 | 150 | 308 | 7.39 |
| Consideration grout | m | 1,556 | 1,510 | 1,510 | 3,020 | 4.70 |
| Cofferdam | m3 | 132 | 108,900 | 75,300 | 184,200 | 24.31 |
| Sub-Total of 2.1 | | | | | | 69.90 |
| 2.2 Dam | | | | | | |
| Excavation (common) | m3 | 63 | 40,000 | 22,000 | 62,000 | 3.91 |
| Excavation (rock) | m3 | 223 | 120,000 | 64,000 | 184,000 | 41.03 |
| Concrete | m3 | Variable | 277,000 | 92,000 | 369,000 | 521.20 |
| Curtain grout | m | 2,075 | 15,450 | 10,000 | 25,450 | 52.81 |
| Consolidation grout | m | 1,556 | 7,300 | 3,600 | 10,900 | 16.96 |
| Saddle dam | m3 | 132 | | | 650,000 | 85.80 |
| Excava. for saddle dam | m3 | 63 | | | 300,000 | 18.90 |
| Sub-Total of 2.2 | | | | | | 740.61 |
| 2.3 Spillway | | | | | | |
| Excavation (common) | m3 | 63 | 104,400 | 0 | 104,400 | 6.58 |
| Excavation (rock) | m3 | 223 | 44,700 | 0 | 44,700 | 9.97 |
| Concrete | m3 | 1,948 | 30,420 | 0 | 30,420 | 59.26 |
| Steel bar | ton | 24,000 | 456 | 0 | 456 | 10.94 |
| Sub-Total of 2.3 | | | | | | 86.75 |
| 2.4 Connection Channel | | | | | | |
| Excavation | m3 | 52 | | | 2,080,000 | 108.16 |
| Sub-Total of 2.4 | | | | | | 108.16 |
| Total of II | | | | | | 1,005.42 |
| III METAL WORKS | | | | | | |
| Diversion closure gate | ton | 135,000 | 41 | 20 | 61 | 8.24 |
| Spillway gate | ton | 192,000 | 188 | 0 | 188 | 36.10 |
| Outlet gate | ton | 192,000 | 0 | 7 | 7 | 1.34 |
| Total of III | | | | | | 45.68 |
| IV MISCELLANEOUS WORKS | | | | | | 172.75 |
| Total of I to IV | | | | | | 1,324.38 |
| V COMPENSATION | | | | | | 0.00 |
| VI GOVERNMENT ADMINISTRATION | | | | | | 66.22 |
| VII ENGINEERING SERVICES | | | | | | 211.90 |
| VIII PHYSICAL CONTINGENCY | | | | | | 208.59 |
| GRAND TOTAL | | | | | | 1,811.09 |

# *FIGURES*

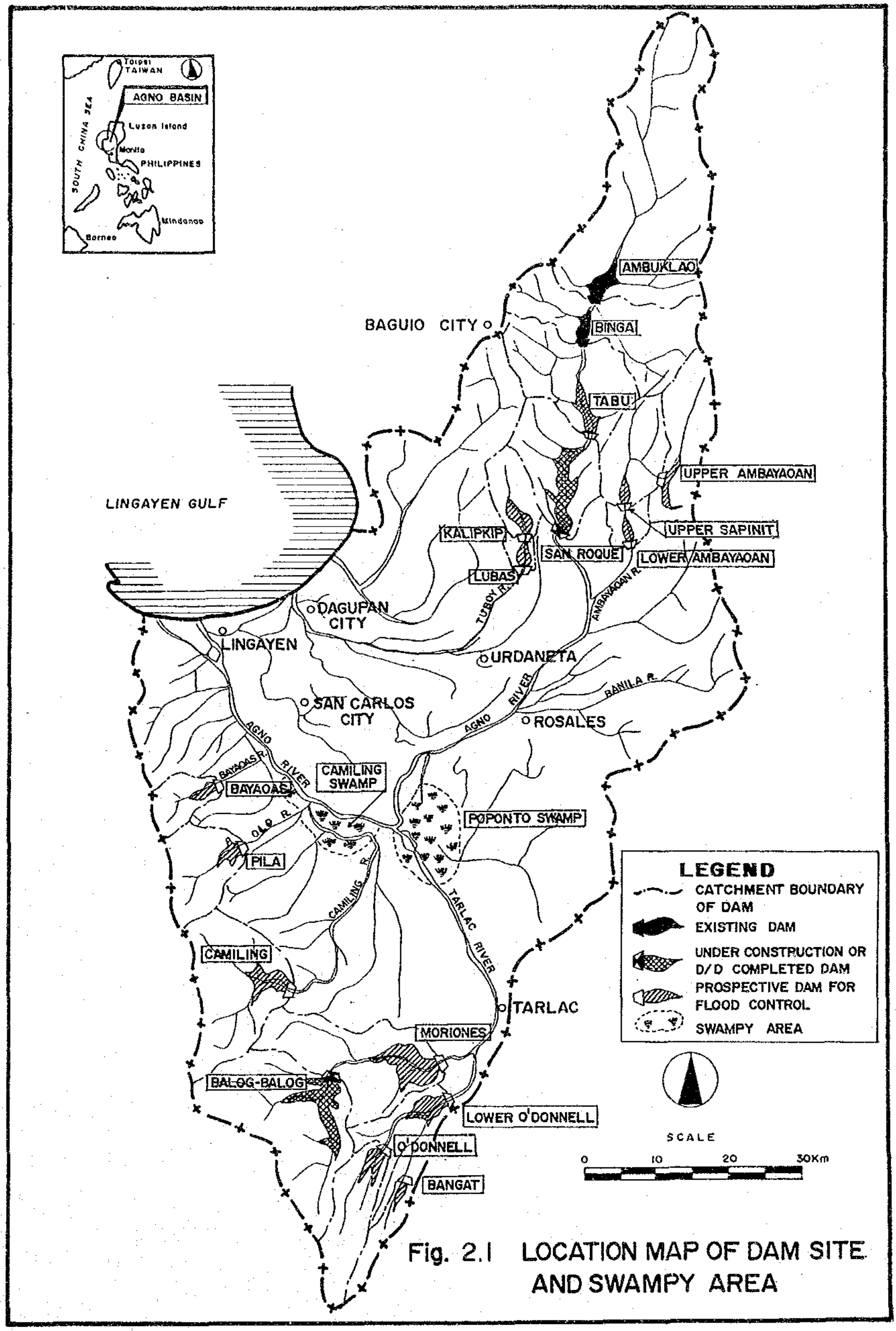



Fig. 2.1 LOCATION MAP OF DAM SITE AND SWAMPY AREA

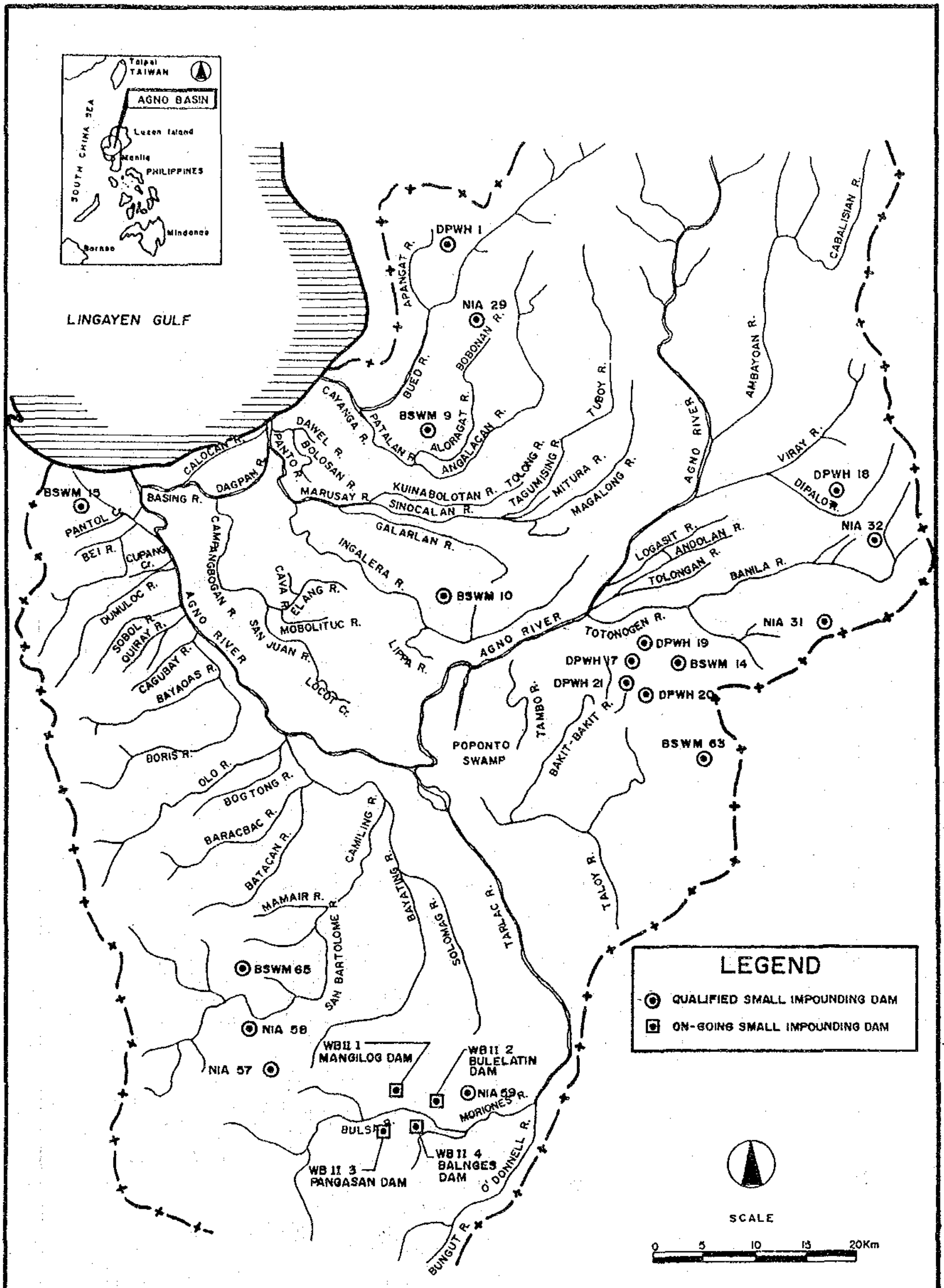



**Fig. 2.2 QUALIFIED AND ON-GOING SMALL IMPOUNDING DAM SCHEMES IN THE STUDY AREA**

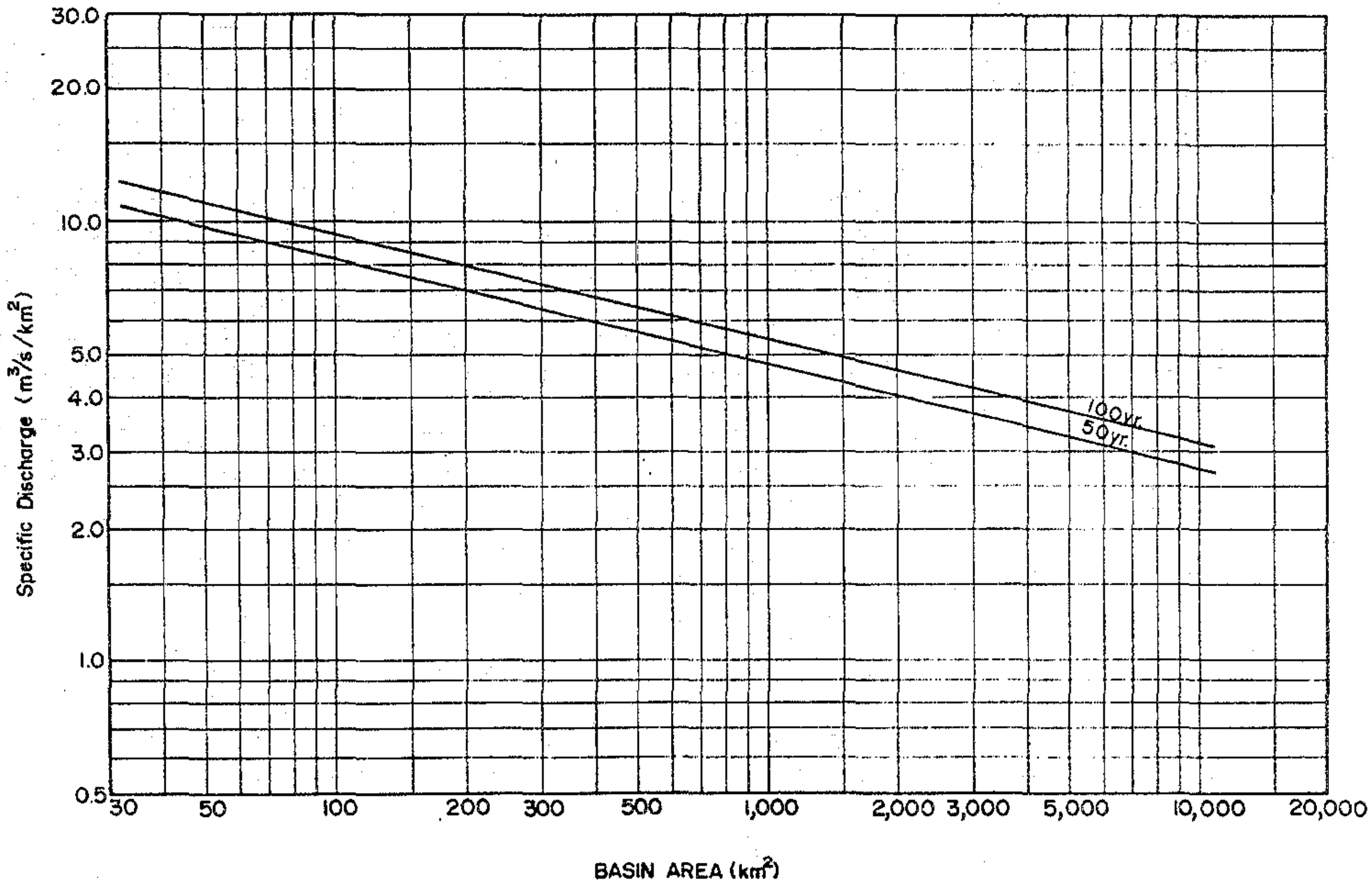
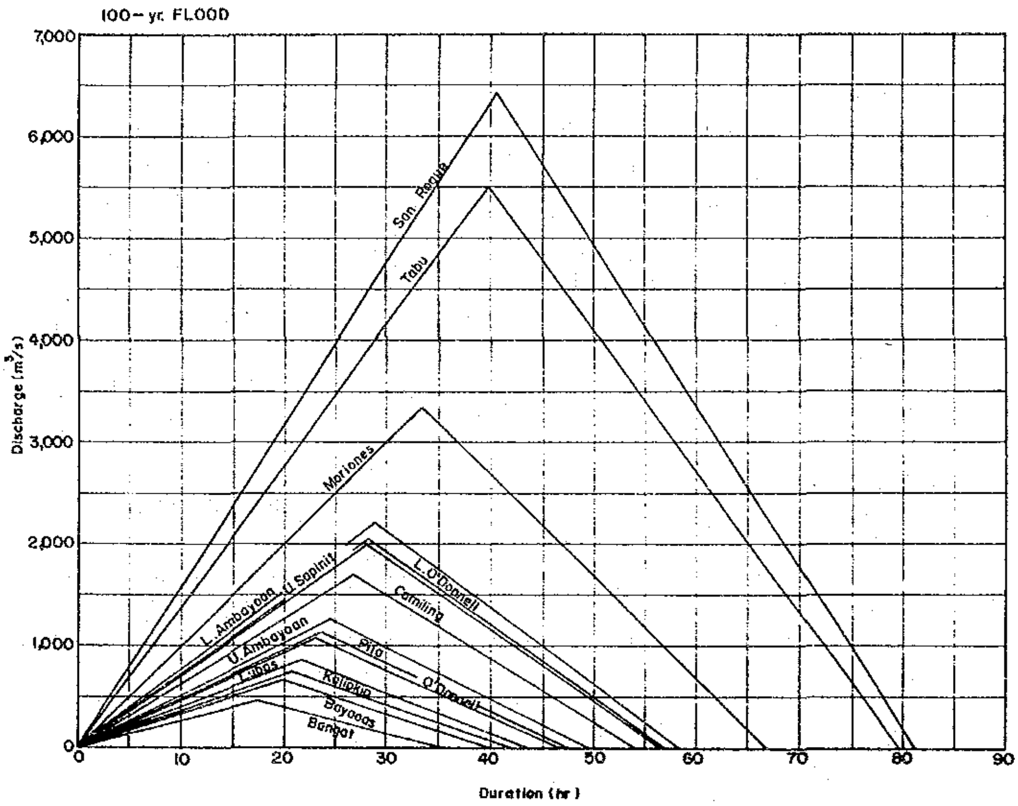



Fig. 4.1 RELATION BETWEEN BASIN AREA AND SPECIFIC DISCHARGE



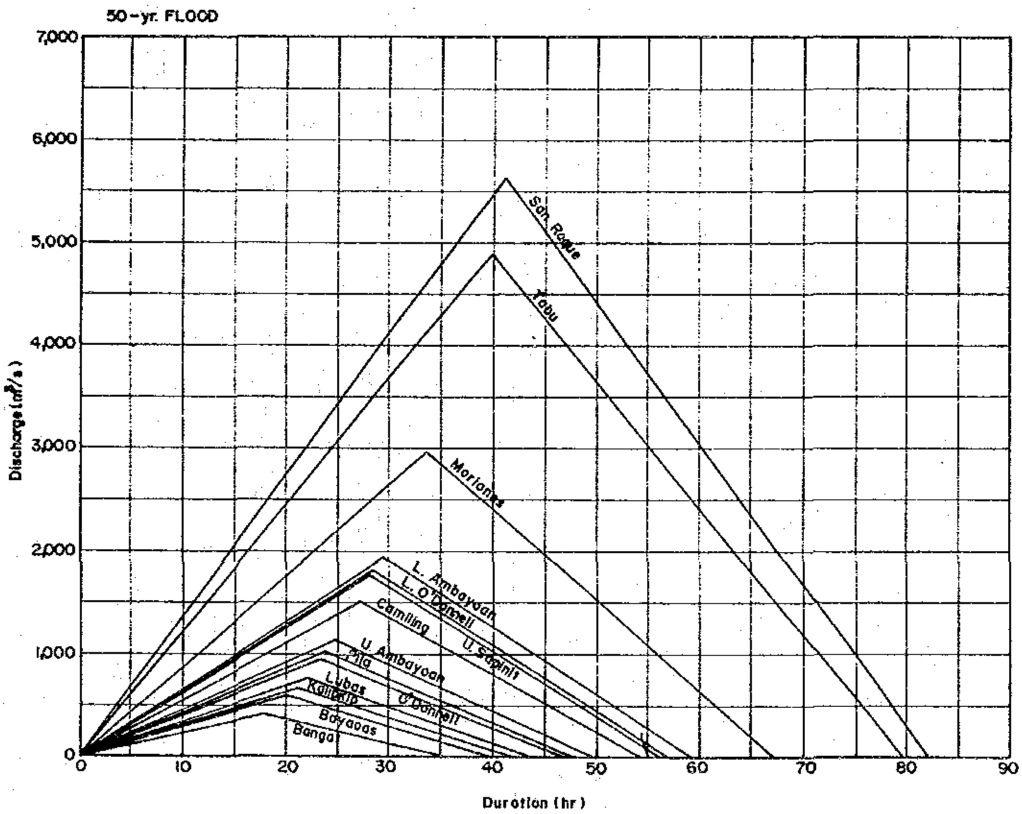




Fig. 4.2 ASSUMED HYDROGRAPH AT DAMSITE

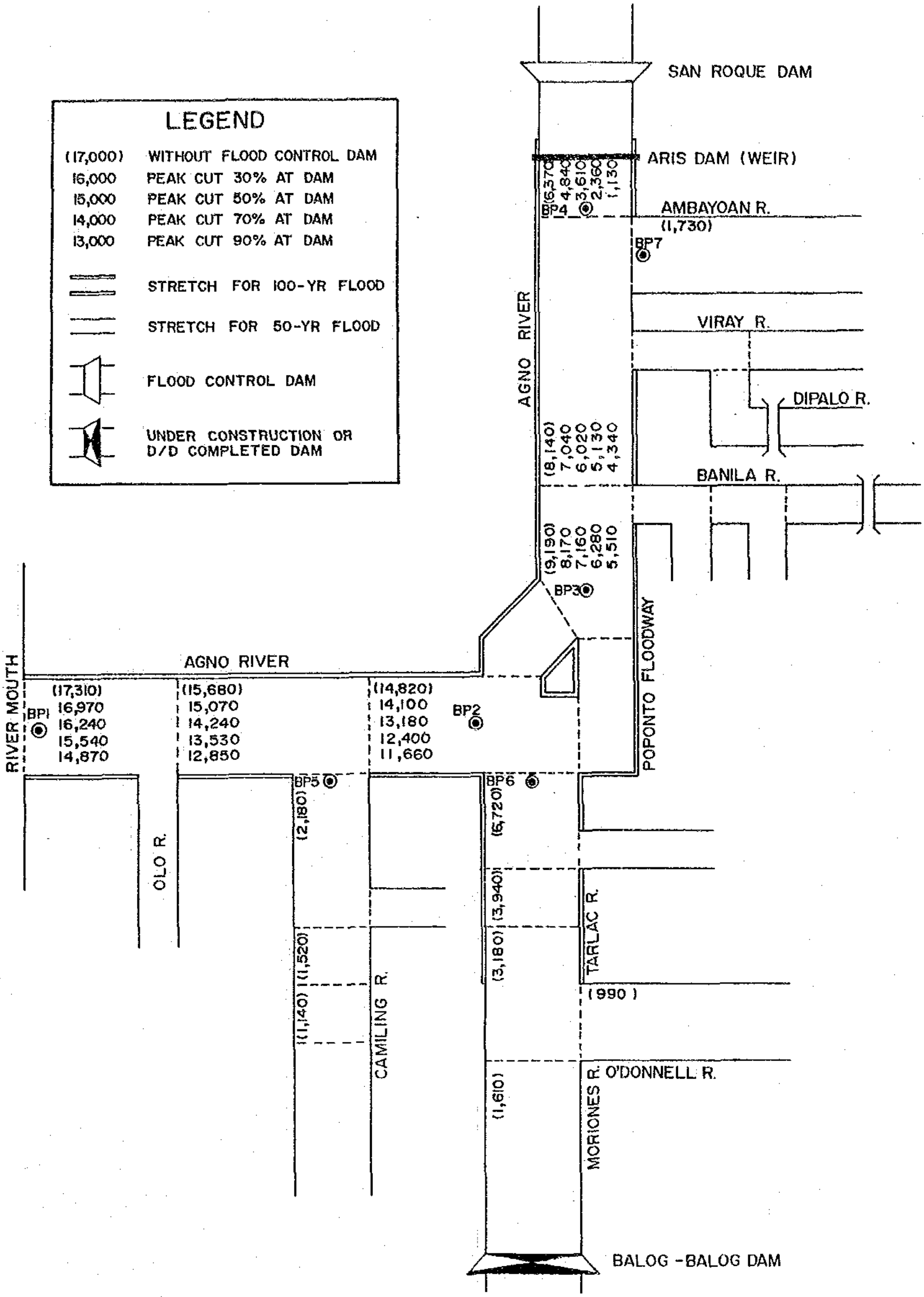



Fig. 4.3 PROBABLE FLOOD DISCHARGE CONTROLLED BY SAN ROQUE DAM

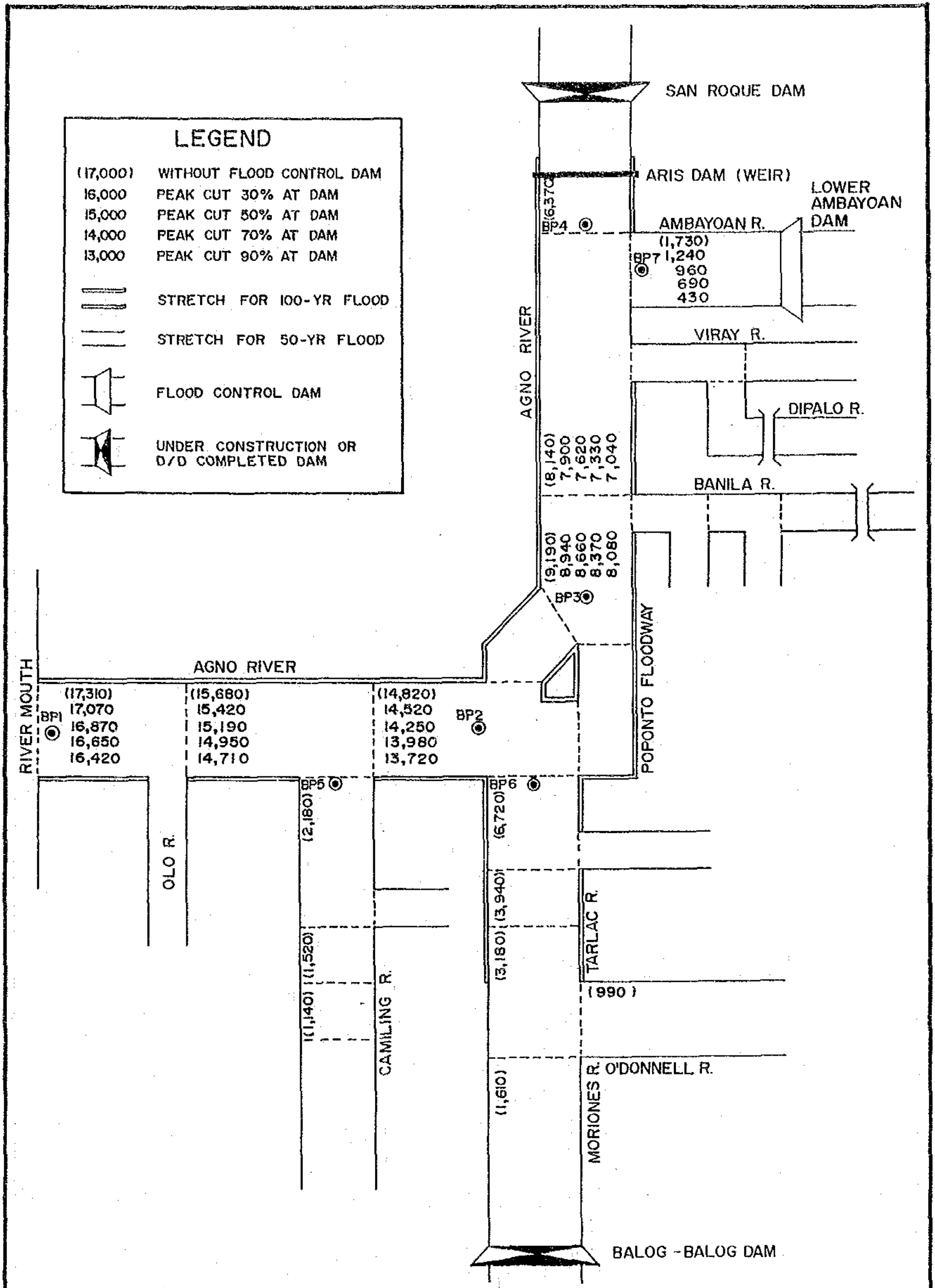



Fig. 4.4 PROBABLE FLOOD DISCHARGE CONTROLLED BY LOWER AMBAYOAN DAM

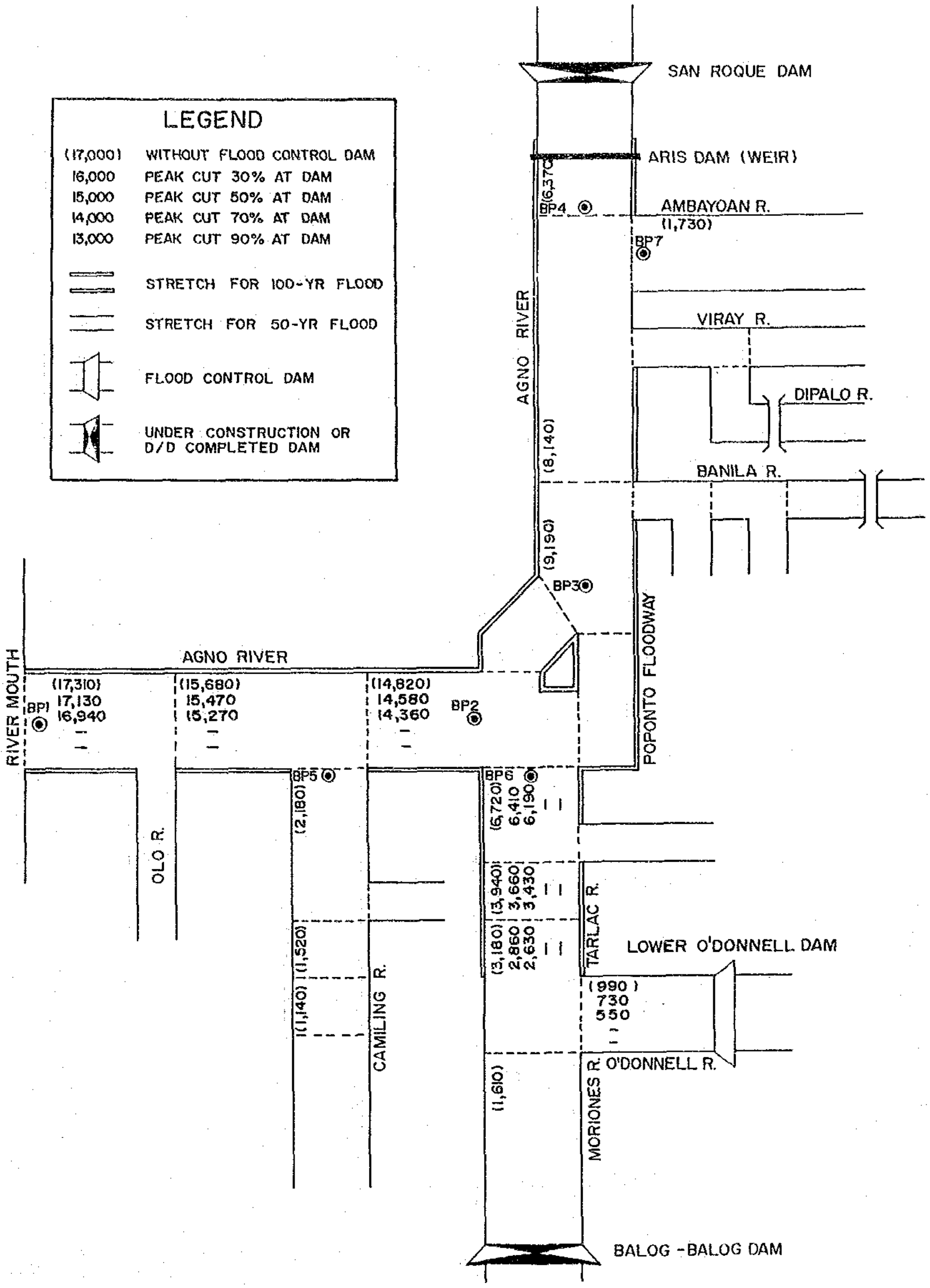



Fig. 4.5 PROBABLE FLOOD DISCHARGE CONTROLLED BY LOWER O'DONNELL DAM

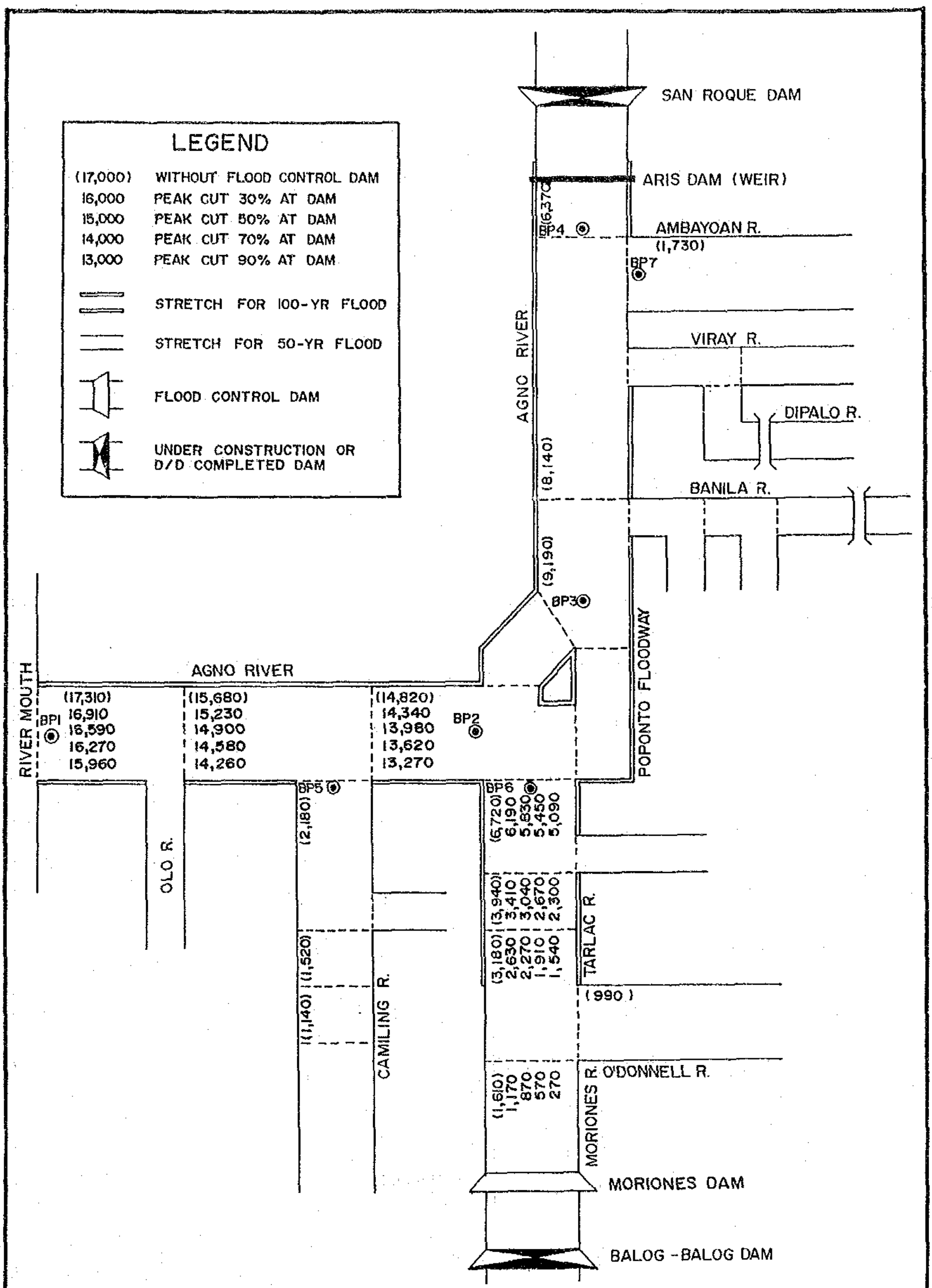



Fig. 4.6 PROBABLE FLOOD DISCHARGE CONTROLLED BY MORIONES DAM

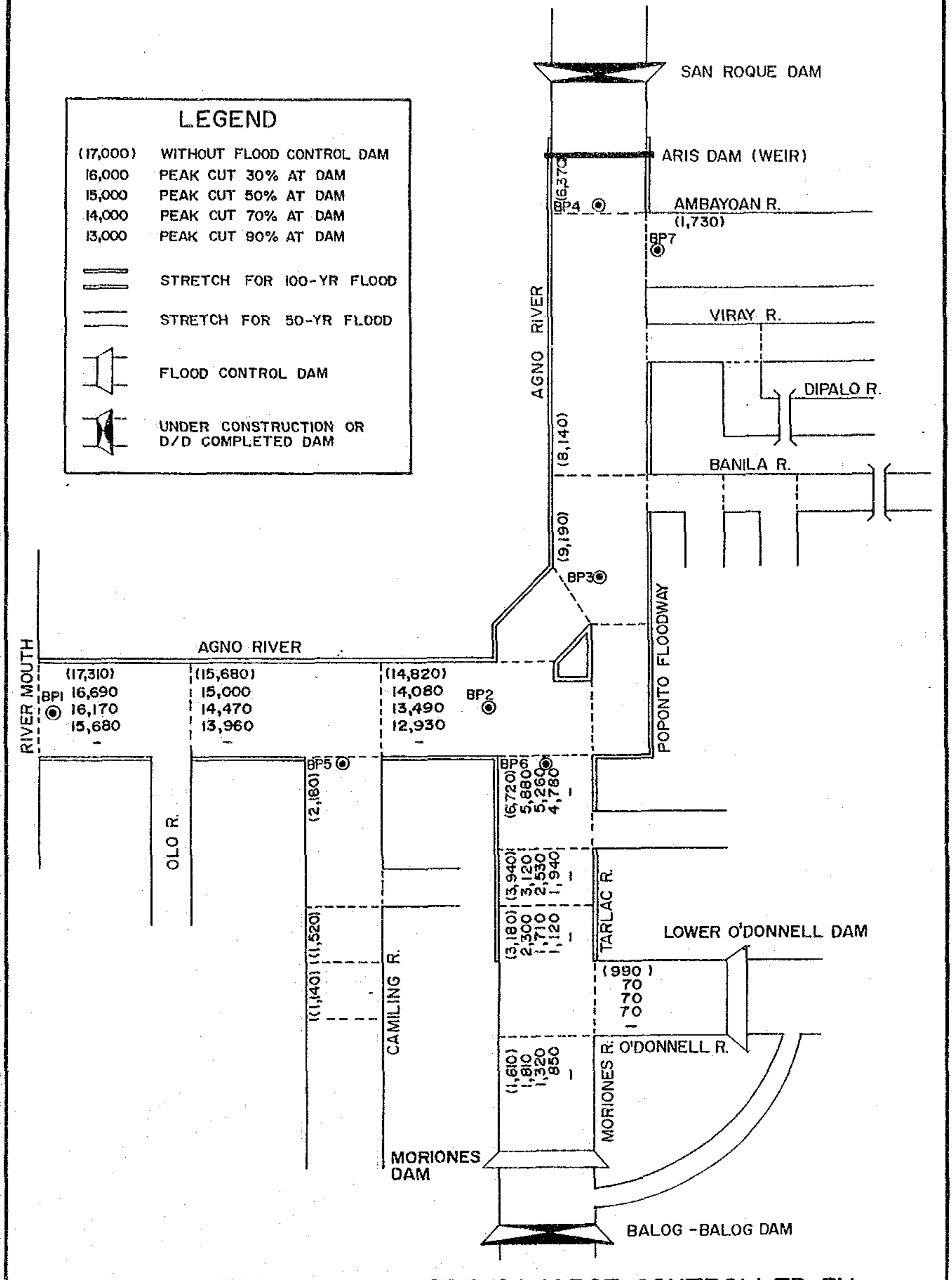



Fig. 4.7 PROBABLE FLOOD DISCHARGE CONTROLLED BY MORIONES AND LOWER O'DONNELL DAMS

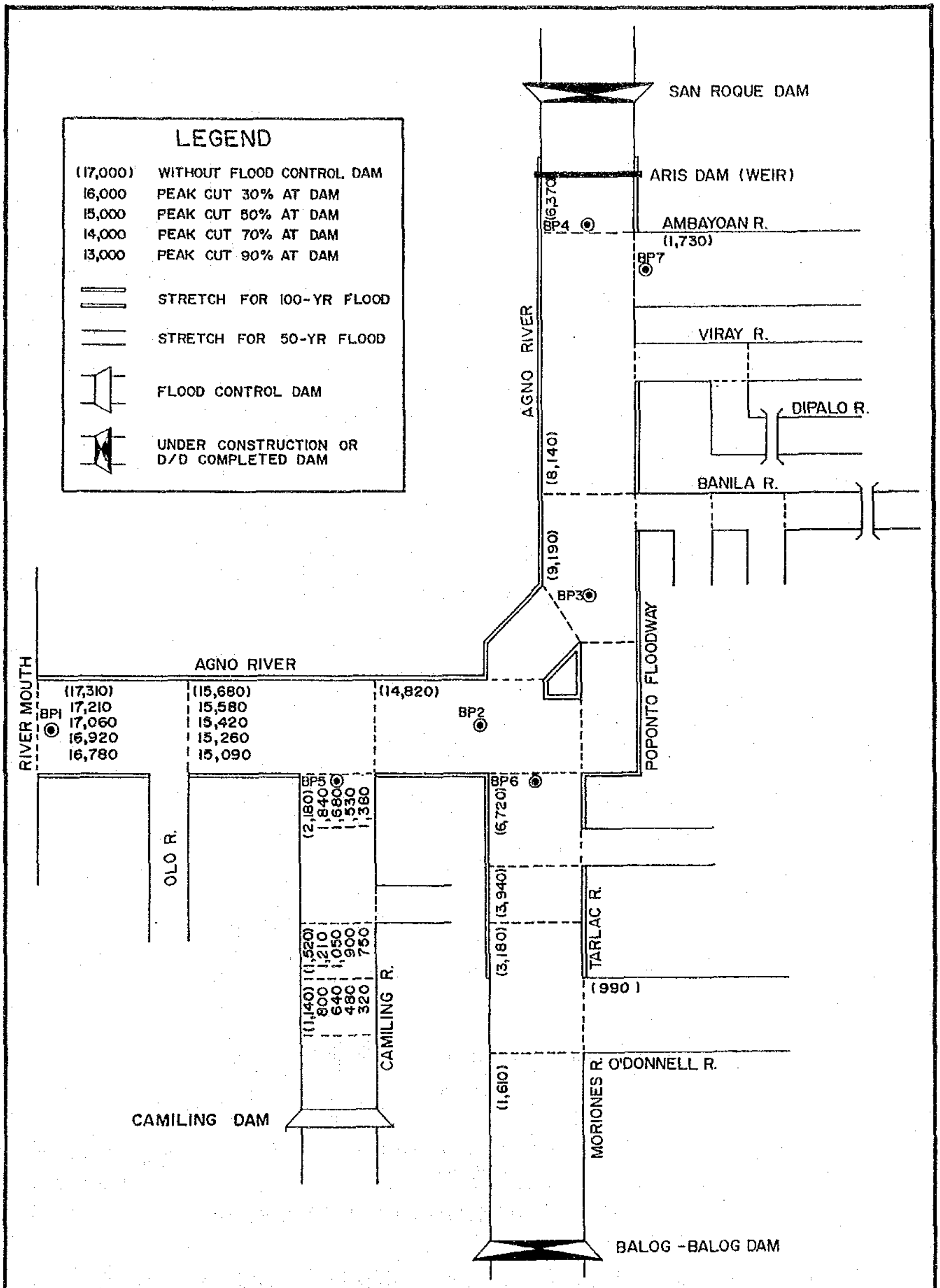



Fig. 4.8 PROBABLE FLOOD DISCHARGE CONTROLLED BY CAMILING DAM

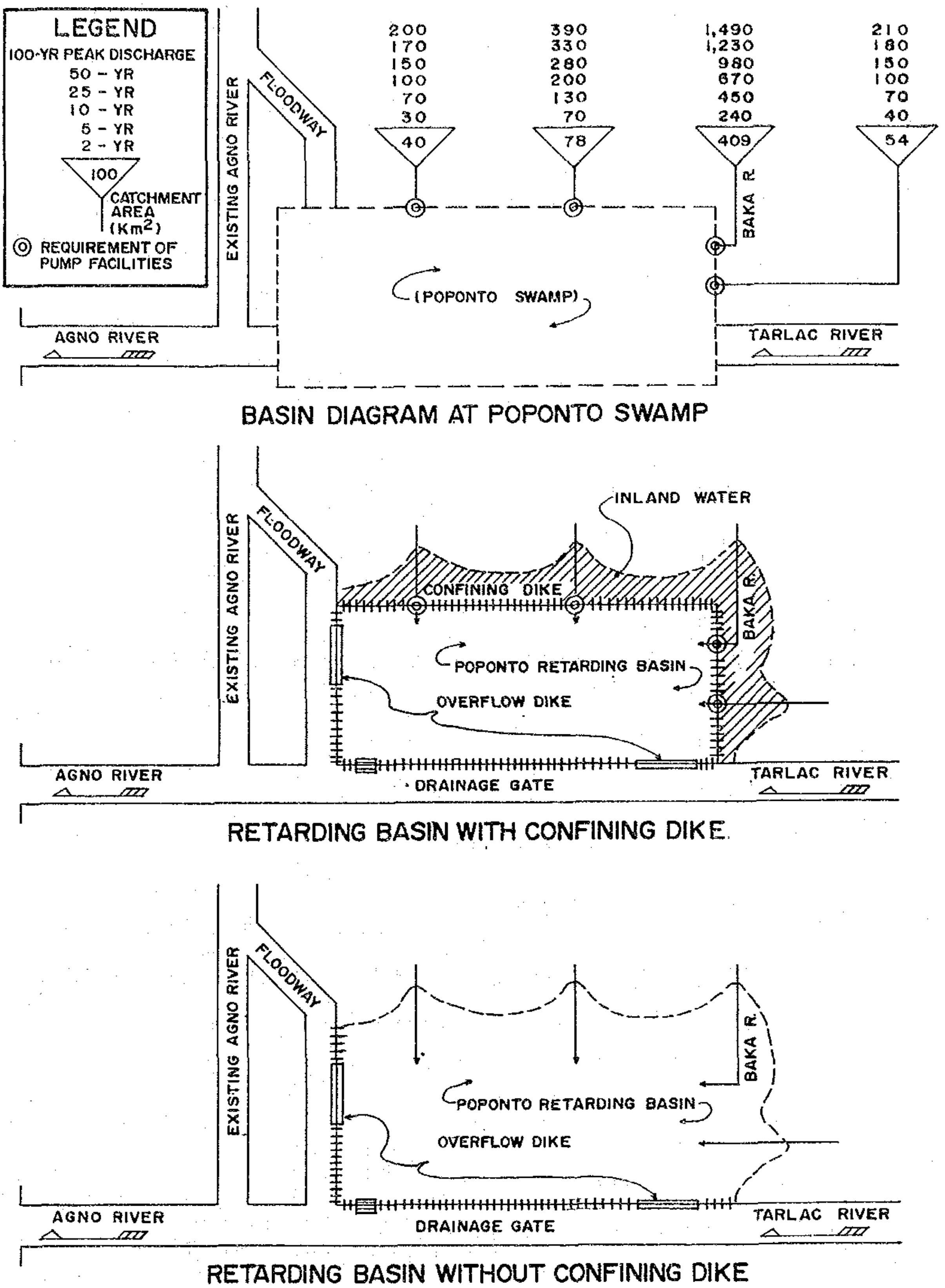



Fig. 5.1 BASIN DIAGRAM AND BASIC ALTERNATIVE PLAN OF POPONTO FLOOD RETARDING BASIN SCHEME

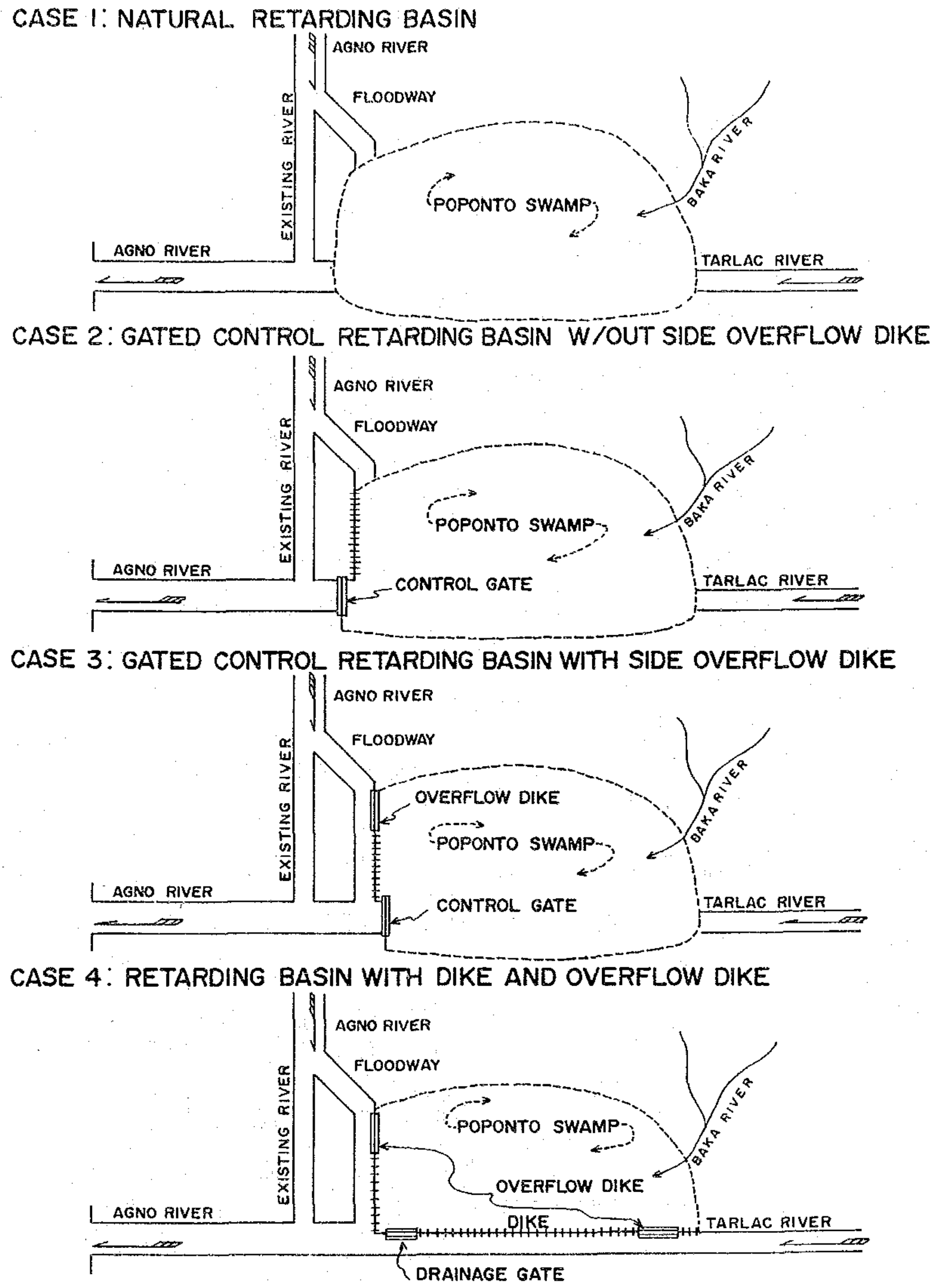



**Fig. 5,2 ALTERNATIVE PLAN OF POPONTO FLOOD RETARDING BASIN SCHEME**

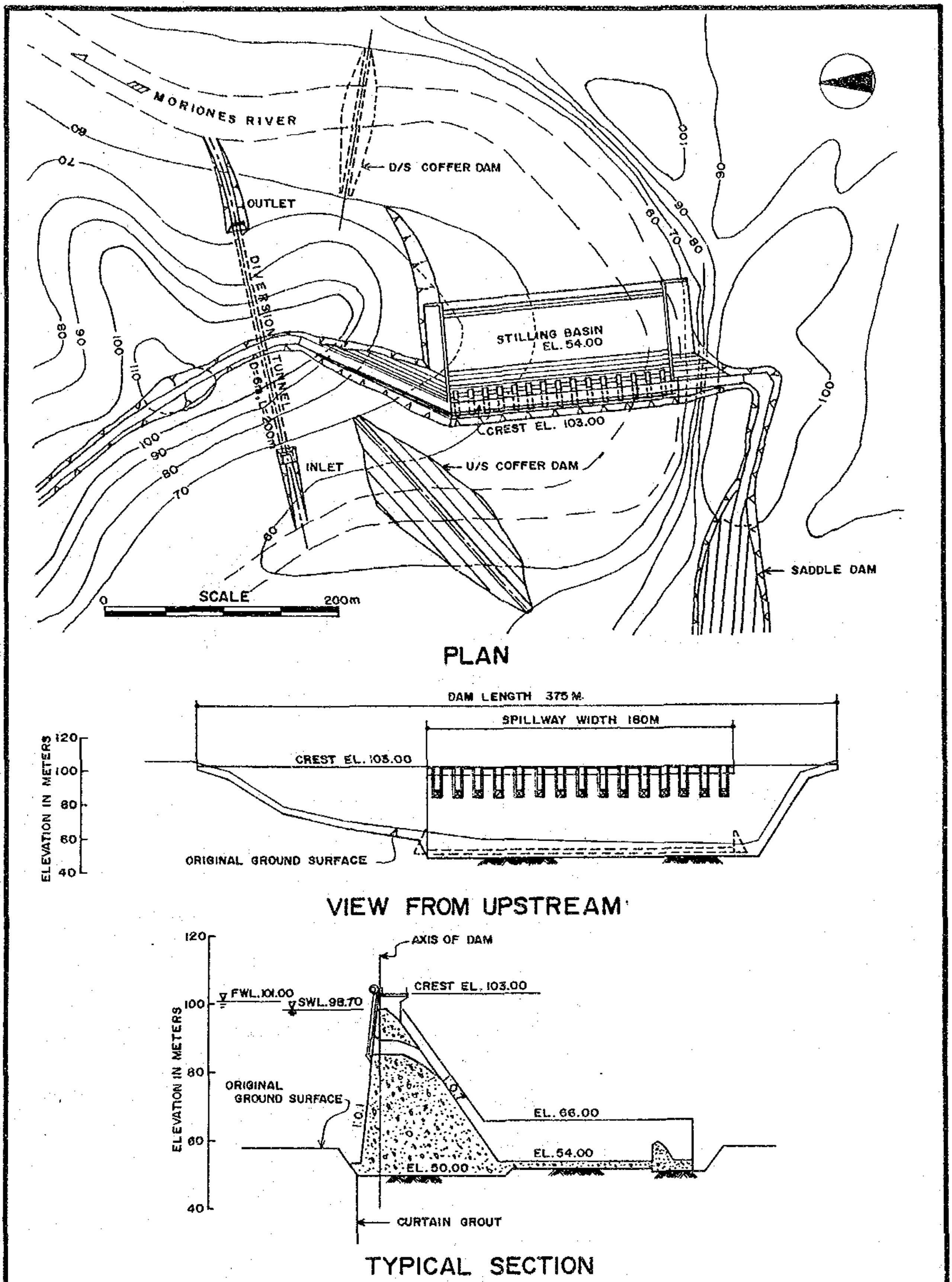



Fig. 6.1 LAYOUT PLAN OF MORIONES AND LOWER O'DONNELL COMBINE DAM PLAN (MORIONES SITE)

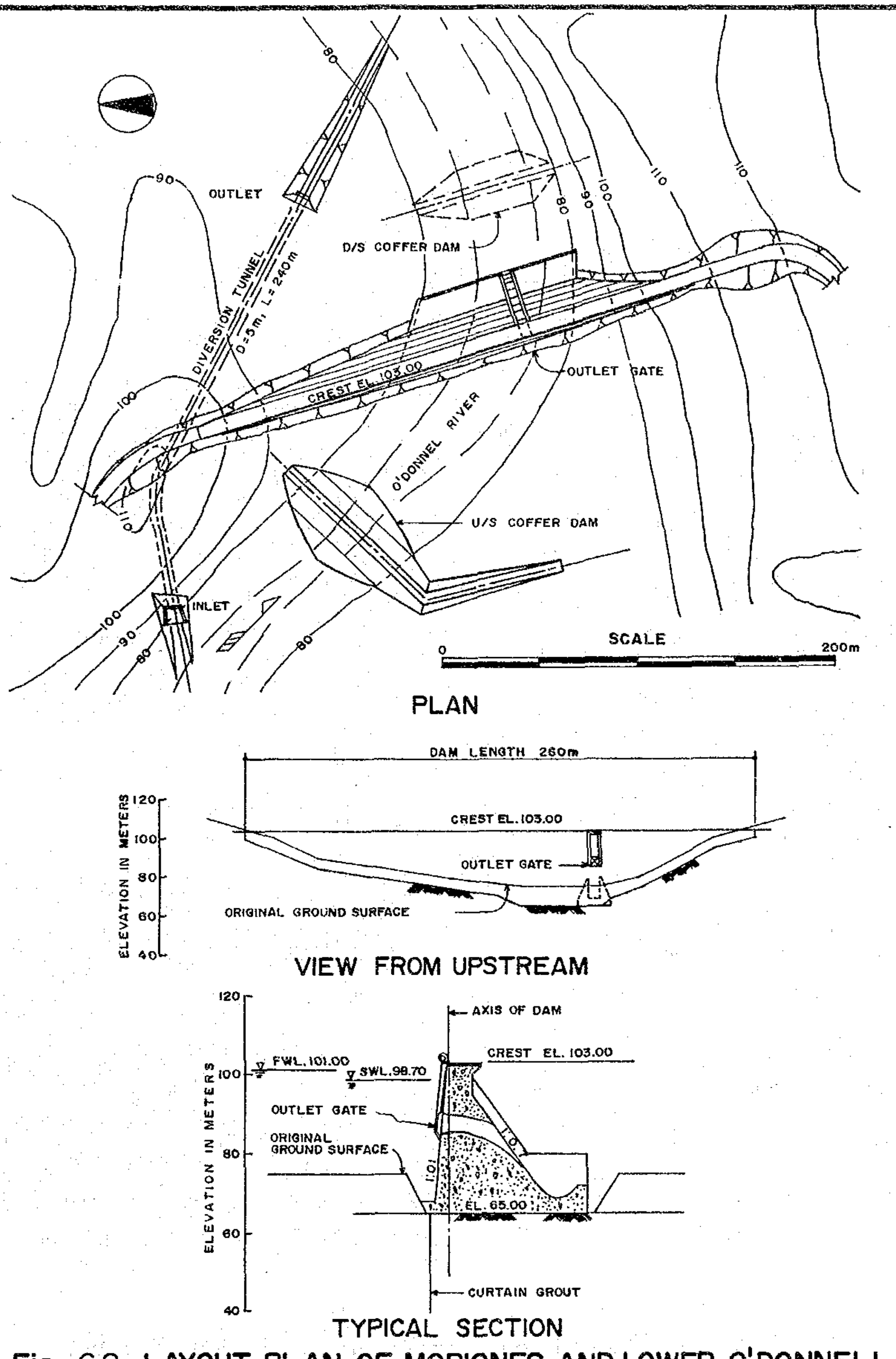



Fig. 6.2 LAYOUT PLAN OF MORIONES AND LOWER O'DONNELL COMBINE DAM PLAN (LOWER O'DONNELL SITE)

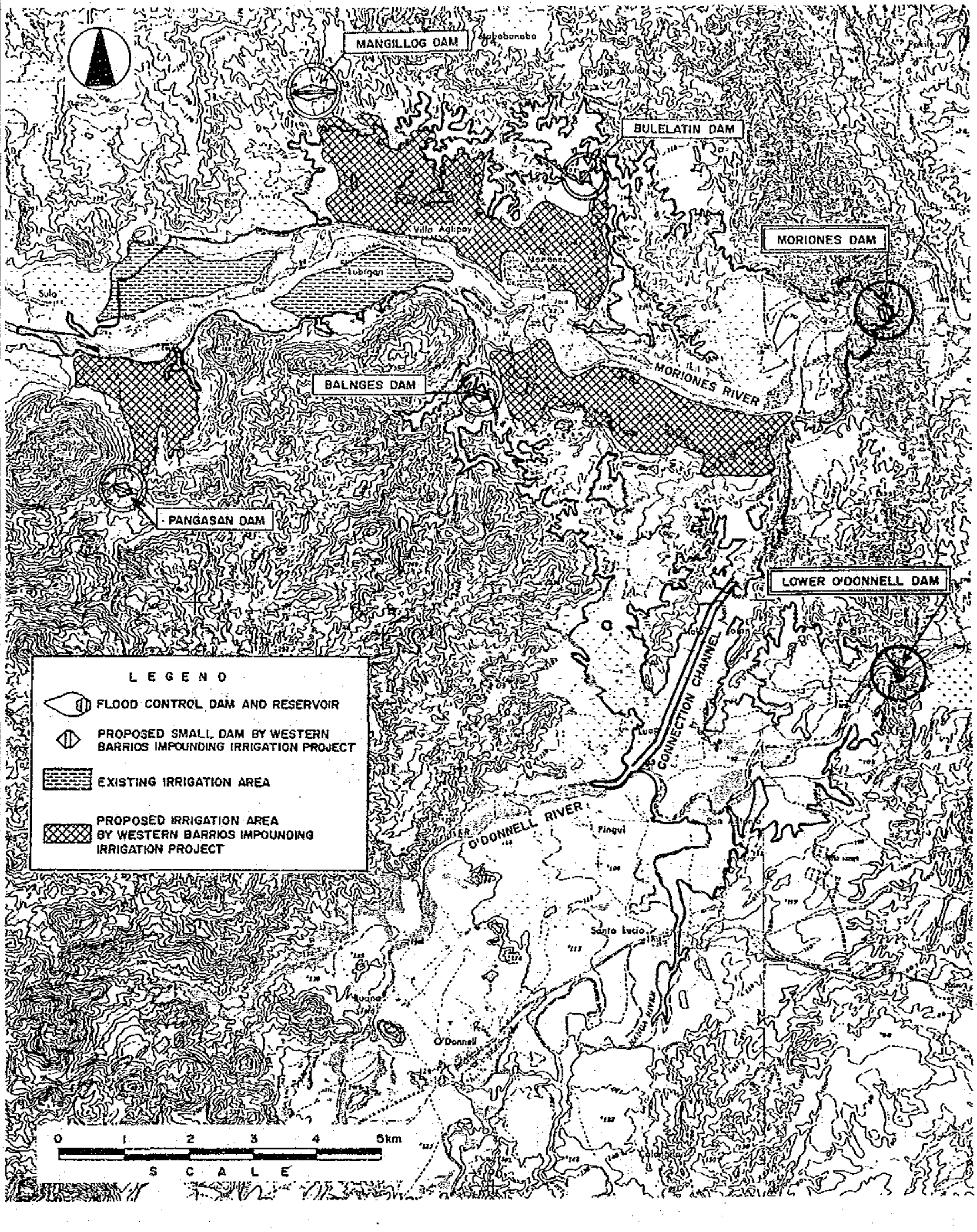



Fig. 6.3 EXISTING AND ON-GOING IRRIGATION SYSTEM IN RESERVOIR

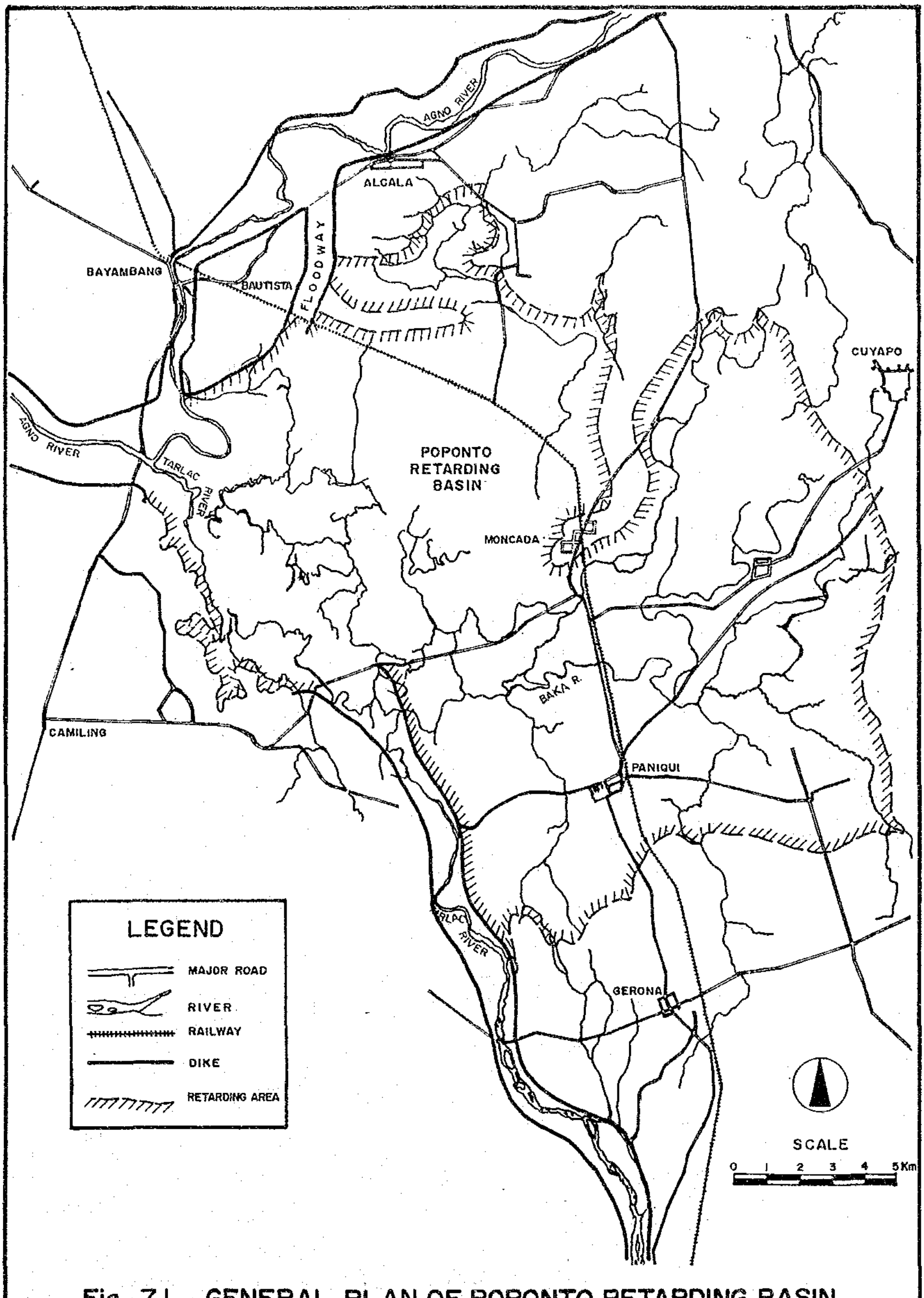



Fig. 7.1 GENERAL PLAN OF POPONTO RETARDING BASIN

9. FF

# *9. FF*

# *FLOOD FORECASTING AND WARNING SYSTEM*

## FLOOD FORECASTING AND WARNING SYSTEM

## SUMMARY


(1) This study deals with the Flood Forecasting and Warning System (herein after called FFWS) as one of the non-structural component of the flood control measures in the Master Plan stage of Agno River Flood Control Study.

(2) FFWS exists in the Agno River basin, which has been installed in 1982 as ABC (Agno, Bicol and Cagayan Rivers) System. FFWS for dam operation is also on-going in the Binga-Ambuklao dam basin, where is located in upstream of Agno River.

(3) The following three problems were found in the existing FFWS in Agno River basin. The FFWS plan in the master plan study formulated to solve the existing problems.

- Insufficient budget and staff for maintenance.
- Low reliability of forecasting due to limited number of raingauge stations.
- Less warning effectiveness due to unreliable communication system between concerned agencies.

(4) The Integrated FFWS plan was formulated as one of the components of frame work plan of The Agno River Flood Control. The system defines the final status of the Agno River basinwide FFWS in the far future.

(5) The following three objectives are defined in the Integrated FFWS plan formulation.

- for resident's protection from flood incident
- for flood operation of the flood control facilities
- for basinwide flood management

(6) The basic condition of the Integrated FFWS plan formulation is shown below:

(a) The integrated FFWS is defined to be composed of the following systems.

- Hydrological observation network system
- Telemetry system
- Flood forecasting system
- Flood warning system
- Monitoring system

(b) The target area of the integrated FFWS is all the flood prone area in the Study area, where is delineated in the supporting report of the Flood damage analysis.

(c) The control center of the system is to be located at Rosales, the same place where the existing ARFFO for the following reasons.
- The local level of the disaster coordination is expected to be the responsibility of the local agency in consideration with the further decentralization.
- Sufficient and timely maintenance and repair works will be undertaken promptly, if the control office is situated in the basin.

(d) Communication between headquarter and the FFWS control office should be maintained in order that flood forecasting and warning activity of the basin is monitored at the headquarter.

(e) Communication between the integrated FFWS control office and FFWSDO Binga dam office should be intensified for effective basinwide flood management. The other flood control structures to be constructed are to be obliged to install their own FFWS and to be connected to the FFWS control office.

(f) Flood warning network system between local agencies such as municipality and FFWS control office, which aims to intensify the local level of flood warning, flood preparedness and flood fighting activity, is considered in the integrated FFWS plan component.

(g) The warning stations along the river course, which aim to prevent the residents from approaching the river during flood, are taken into account in the integrated FFWS plan formulation.

(7) The integrated FFWS in the Agno River basin is consisted of the following systems.

(a) Hydrological Observation System
- Water level stations : 17 stations
- Raingauge stations : 32 stations

(b) Telemetering Network System
- System Control Center : Rosales, DPWH
- Repeater Station : 2 stations

(c) Monitoring of Flood Operation System
- For Binga-Ambuklao FFWSDO sub-system (Existing)
- For Balog-Balog Flood Operation System (New)
- For San Roque Flood Operation System (New)
- For Moriones Flood Operation System (New)

(d) Monitoring at DPWH central office

(e) Flood Forecasting System
- One computer system in Rosales control center

(f) Flood Warning System
- Duplex link between Rosales control center and the related 29 local agencies
- 31 Warning stations along the river

(8) The total cost of the Integrated FFWS in Agno River basin is estimated to 740 million pesos. The economic internal rate of return is expected to 19.26%.

(9) The following institutional arrangement is assumed to be recommendable for the smooth operation of the integrated FFWS:

(a) Local level of FFWS activity shall be transferred to the local agency.

(b) The suitable agency to be responsible for the local flood forecasting is assumed to be DPWH, considering its responsibility for the river administration and the regular maintenance work of the hydrological stations.

(c) The role of PAGASA is assumed to be advisory for the transfer of flood forecasting technology, and further research of applicable new technology for the improvement of flood forecasting.

(d) Flood warning activity is responsibility of OCD. It is tasked to prepare the program for improvement of Disaster Coordination Council's activities.

(e) Telecommunication training center is recommended to be established in collaboration with PAGASA, NAPOCOR, NIA, DPWH and NTC in Manila. The purposes of the center are to train the staff, stock and supply the spare parts of the telemetering facilities. The prompt repair work will be expected once the center is established.

(f) Flood Operation system for the dams to be constructed is responsibility of the owner agency.

(g) Multiplex communication system with DPWH central office should be provided for the monitoring if FFWS activity.

(10) The priority FFWS plan is formulated as one of the components of Long Term Plan of Agno River Flood Control. The target year of the completion of the priority FFWS plan is 2010.

(11) The following objectives are assessed to formulate the priority FFWS development plan in the Study Area.

- To improve the flood forecasting accuracy of the forecasting points in the existing Agno River FFWS.
- To carry out the effective flood warning activity in the Study Area.

(12) The priority FFWS in the Agno River basin is consisted of the following systems.

(a) Hydrological Observation System
- Water level stations : 7 stations
- Raingauge stations : 14 stations

(b) Telemetering Network System
- System Control Center : Rosales, DPWH
- Repeater Station : 2 stations

(c) Monitoring of Flood Operation System
- For Binga-Ambuklao FFWSDO sub-system (Existing)

(d) Monitoring at DPWH central office by the existing communication link.

(e) Flood Forecasting System
- One computer system in Rosales control center

(f) Flood Warning System
- Duplex link between Rosales control center and the related 5 local agencies

(13) The total cost of the Integrated FFWS in Agno River basin is estimated to 260 million pesos. The economic internal rate of return is expected to 28.91%.

## FF: FLOOD FORECASTING AND WARNING SYSTEM

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## ABBREVIATIONS

| | |
|---|---|
| FFWS | Flood Forecasting and Warning System |
| ABC | Agno, Bicol and Cagayan River Basins |
| FFWSDO | Flood Forecasting and Warning System for Dam Operation |
| ARFFC | Agno River Flood Forecasting Center |
| RF/WL st. | Rainfall / Water Level Station |
| RP st. | Repeater Station |
| NFFO | National Flood Forecasting Office |
| PAGASA | Philippine Atomospheric Geophysical and Astronomical Services Administration |
| OCD | Office of Civil Defense |
| NIA | National Irrigation Agency |
| NAPOCOR | National Power Cooperation |
| DPWH | Department of Public Works and Highways |
| NWRB | National Water Resouerces Board |
| O/M | Operation and Maintenance |
| HEP | Hydro Electric Power |
| NDCC | National Disaster Coordination Council |
| RDCC | Rigional Disaster Coordination Council |
| PDCC | Provincial Disaster Coordination Council |
| MCDD | Municipality Disaster Coordination Council |
| BCDD | Barangay Disaster Coordination Council |
| DLG | Deparrtment of Local Government |
| DSWD | Department of Social Welfare and Development |
| FOS | Flood Operation System |
| NTC | National Telecommunication Commision |

# FLOOD FORECASTING AND WARNING SYSTEM

## 1. INTRODUCTION

This study deals with the Flood Forecasting and Warning System (herein after called FFWS) as one of the non-structural component of the flood control measures in the Master Plan stage of Agno River Flood Control Study.

Chapter 2 reviews the present condition of the existing FFWS in the Agno River basin which has been operated by the Agno - Bicol - Cagayan Rivers Flood Forecasting and Warning System Project (ABC system) under PAGASA since 1982.

The integrated FFWS Framework Plan is formulated in Chapter 3. The system defines the final status of the Agno River basinwide FFWS in the far future.

Chapter 4 presents the priority FFWS development plan in Agno River basin. The target year defined 2010, same as the long term river improvement plan in the Agno River Basin Flood Control Master Plan Study.

## 2 PRESENT CONDITION OF THE EXISTING FFWS

### 2.1 Existing and On-going FFWS in The Agno River Basin

The Government of the Republic of the Philippines have fully recognized the importance of the flood forecasting and warning system, and establishes the first FFWS in Pampanga River basin in 1973. Due to the effectiveness of the first system to mitigate the damage of the 1976 flood, the Government decided to provide the FFWS to the Agno, Bicol and Cagayan River basins (ABC system), and commenced its operation in 1982.

The importance of FFWS for dam operation was also recognized by the Government when the flood disaster occurred in downstream plain of the Angat dam due to typhoon "KADING" in 1978. The disaster caused the loss of 100 lives. It was reported that shortcoming in the operation procedures of the Angat dam, inadequate hydrological networks and lack of reliable communication systems were seemingly attributable to this unfortunate incident. Consequently, FFWS for dam operation for the Binga-Ambuklao damns, located upstream of the Agno River, was designed in 1987 and presently under bidding for construction.

The existing Agno River FFWS, out of ABC system, and FFWSDO of the Binga-Ambuklao sub-system in Fig.2.1 and the features of each hydrological station is shown in Table 2.1 and summarized below.

(1) The Agno River FFWS (the part of ABC system)

(a) Flood Forecasting Points
- . San Roque, Carmen, Wawa, Banaga (Agno River)
- . Tibag (Tarlac River)
- . Santa Barbara ( Sinocalan River)

(b) Hydrological observation network
- . 6 raingauge stations
- . 7 water level gauging stations

(c) Telemetering system

<u>Simplex link</u>
- . Binga RF/WL st. - Sto.Tomas RP st. - Rosales, ARFFO
- . San Roque RF/WL st. - Rosales, ARFFO

. Carmen RF/WL st. - Rosales, ARFFO

. Wawa RF/WL st. - Rosales, ARFFO

. Tibag RF/WL st. - Rosales, ARFFO

. Banaga WL st. - Rosales, ARFFO

. Sta.barbara RF/WL st. - Rosales, ARFFO

Multiplex Link

. Rosales, ARFFO - Quezon city, NFFO

(d) Flood forecasting system

- Input data
  . 3 hourly rainfall and water level record
- Output data
  . Forecasted water level and discharge
  . Recorded rainfall and water level
- Forecasting time
  . 12 hours in advance
- Data processing time
  . 1 hour

(e) Flood warning system

- Warning processing time
  . 2 hours after forecasting activity
- Local agency to be disseminated
  . OCD, Local radio broadcast, National police

(f) Operation condition

- Data collection rate
  . 85.5% for 6 rainfall stations
  . 54.3% for 7 water level stations
- Operating stations as of Oct.1989
  . 6 rainfall stations are operated under the good condition.
  . 2 water level stations are operated under the good condition.
  ( Santa Barbara and Wawa )

(g) Existing Problems

- Insufficient budget and staff for maintenance.
- Low reliability of forecasting due to limited number of raingauge stations.
- Less warning effectiveness due to unreliable communication system between concerned agencies.

(2) FFWS for dam operation (Binga-Ambuklao sub system)

(a) Target Area

. The downstream of the Binga dam to avoid man-made disaster due to improper operation.

(b) Hydrological Observation system

Simplex Link

. Badayan RF st. - Mt.Toyangan RP st. - Binga FFWSDO office

. Apunan RF st. - Mt.Toyangan RP st. - Binga FFWSDO office

. Bobok RF st. - Mt.Toyangan RP st. - Binga FFWSDO office

. Ambuklao dam RF/WL st. - Mt.Toyangan RP st. - Binga FFWSDO office

. Binga dam RF/WL st. - Binga FFWSDO office

Multiplex Link

. Binga FFWSDO office - Mt.Ampucao RP st. - NAPOCOR headquarter

(c) Flood Forecasting system

- Input data
  . hourly rainfall, water level and dam release record
- Output data
  . forecasted inflow and water revel of reservoir
  . optimum reservoir and gate operation procedures
- Flood forecasting measure
  . flood run-off model simulation analysis
- Flood warning system
  . flood warning through 18 warning station in downstream
  . warning dissemination by means of 6 patrol cars
- Others
  . The rehabilitation of the existing FFWS in the Agno River basin is included.

2.2 Forecasting Model Assessment

Storage function method, which is commonly used for flood run-off analysis, is applied as the flood forecasting model of the existing FFWS. The model is composed of six sub-basins and six channels, as sown in Fig.2.2.

The reliability of the model mainly depends on the accuracy of basin rainfall estimation. The Tiessen method is applied to estimate the basin rainfall for the forecasting model. The network of the rainfall stations is presently composed of six raingauge stations, and will be extended to eleven stations after installation of the FFWSDO Binga-Ambuklao sub system.

The factors applied to determine the reliability of the model are :

1) the number of raingauge stations,
2) respective tiessen area,
3) the difference elevation between basin mean and station mean,

The reliability of the basin rainfall estimation is shown in Table 2.2, which considered the FFWS for the Binga-Ambuklao dams operation.

It was found that the Ambuklao-Binga, San Roque-Carmen, Upper Tibag, and Wawa-Banaga sub-basins are less reliable to estimate the basin rainfall, and may not be applicable for flood forecasting model if adequate accuracy is designed.

| Sub-basin | Catchment Area ($Km^2$) | Basin Mean Elevation (El.m) | Distribution of RF stations | | |
|---|---|---|---|---|---|
| | | | Available Station (Nos.) | Max. Tiessen ($Km^2$) | Average Elevation (El.m) |
| 1. Upper Ambuklao | 620 | 1,530 | 4(4) | 256 | 1,350 |
| 2. Ambuklao-Binga | 240 | 1,300 | 3(2) | 100 | 990 |
| 3. Binga-San Roque | 390 | 950 | 3(3) | 192 | 1,010 |
| 4. San Roque-Carmen | 1,210 | 560 | 4(2) | 686 | 195 |
| 5. Carmen-Wawa | 430 | 15 | 2(2) | 221 | 20 |
| 6. Upper Tibag | 920 | 370 | 1(1) | 920 | 30 |
| 7. Tibag-Wawa | 650 | 35 | 3(2) | 261 | 20 |
| 8. Wawa-Banaga | 1,520 | 420 | 3(1) | 1,038 | 140 |

Note: ( ) : Those available stations which are located in the sub-basin.

A few raingauge stations are required to be installed at the north east part of the mountain area in San Roque-Carmen sub-basin. Upper Tibag sub-basin has only one station. It is strongly required to install a few raingauge stations in the upper basin. Since there is no raingauge station in the south west mountainous of Wawa-Banaga sub-basin at present, it is less reliable in basin rainfall estimation.

Another approach to forecast flood is based on the flood discharge observation at upstream water level gauging station and computation the downstream flood level considering the lag time of flood from upstream site and the run-off from the residual basin. This procedure can be applied at Binga, San-Roque, Carmen, Wawa and Banaga. The features of each channel condition is shown in Table 2.3 and summarized below.

| Forecasting Point | Catchment Area ($km^2$) | Upstream basin | | | Residual basin | | C.A ratio of upstream (%) |
|---|---|---|---|---|---|---|---|
| | | Check point | Catchment Area ($km^2$) | Channel Lag time (hr) | Catchment Area ($km^2$) | Basin Lag time (hr) | |
| 1. Binga Dam | 860 | Ambuklao dam | 620 | 1.0 | 240 | 3.0 | 73 |
| 2. San Roque | 1,250 | Binga dam | 860 | 4.0 | 390 | 3.0 | 69 |
| 3. Carmen | 2,460 | San Roque | 1,250 | 5.0 | 1,210 | 8.0 | 51 |
| 4. Wawa | 4,460 | Carmen | 2,450 | 4.0 | | | |
| | | Tibag | 920 | 4.0 | 1,080 | 6.0 | 76 |
| 5. Banaga | 5,980 | Wawa | 4,460 | 8.0 | 1,520 | 7.0 | 75 |

Due to the foregoing facts it is assessed that flood forecasting without flood run-off model is difficult because of the following reasons.

- Channel lag time is insufficient for most of the channels.
- The residual basin cannot neglect for all forecasting points.

Accordingly, installation of additional raingauge stations is required in order to estimate the basin rainfall with high degree of accuracy and to execute a reliable flood forecasting activity.

## 2.3 Flood Forecasting and Warning

### 2.3.1 The Procedures of Flood Forecasting and Warning

Since the installation of the FFWS in the Agno River basin in 1982, several typhoons have swept the basin, and the FFWS was effective in mitigating the damages due to flood. The standard procedure of forecasting and warning activity for the Agno River basin is described in the flow chart shown in

Fig.2.3.

Flood bulletin is furnished by PAGASA to the concerned agencies which contains various flood information, such as the real meteorological and hydrological conditions of the basin, the predicted rainfall, forecasted water level at the forecasting points and the indication of the warning area to be flooded. There are three categories of flood bulletins; flood outlook, flood advisory and flood warning; depending on the severity of the actual and forecast hydrological situations.

The flood situation is classified based on the predetermined flood assessment levels, alert level, alarm level and critical level for respective forecast point. Each flood assessment level is defined depending on the capacity of a river to confine the discharge within its banks as shown below and the assessment levels for respective forecasting point is shown in Table 2.4.

i) ALERT LEVEL

River stage equivalent to 60% of maximum flow capacity.

ii) ALARM LEVEL

Water level at gauging station which is the equivalent to 80% of the maximum flow capacity.

iii) CRITICAL LEVEL

Water level equivalent to maximum flow capacity.

The category of flood bulletin depends on the hydrological conditions which is related to the flood assessment levels as shown below.

i) FLOOD OUTLOOK

Promptly the water level have exceeded the alert level at any station, or after the peak stage and water level have receded below the alarm level when the preceding bulletin is an Advisory.

ii) FLOOD ADVISORY

When the water level is forecasted to reach or exceed Alert level within 24 hours, or, when water level have receded below the Critical level and is forecasted to recede to or below the Alarm level within 24 hours.

iii) FLOOD WARNING

When the water level is forecasted to reach or exceed the Critical level within 24 hours, or, the water level remains above the critical level.

Issuance of flood bulletin is one of the main flood warning activities executed by PAGASA. The information contained in the bulletin is disseminated to the residents living in the flood prone areas, mainly through broadcasting. Flood preparedness activities such as self-guarding, evacuation and sand-bagging, which are to follow the forecasting and warning activity mentioned above, are expected to be executed under the supervision of Office of Civil Defense (OCD), however, no activity for flood preparedness has been reported until now, because of insufficient institutional arrangement between PAGASA and OCD.

2.3.2 Previous Forecasting and Warning Activities

To examine previous forecast and warning activities, typhoon "GADING" which attacked the basin in July 1986, was selected because of its data availability.

Series of flood bulletins issued during the period of the typhoon is summarized in Table 2.5. At that time, the flood damage was concentrated in the areas located along Sinocalan and Bued rivers and their surrounding. The first bulletin, in the form of Flood outlook, was issued on 17:00, July 8, 1986 because it was predicted to exceed the Alert level at Sta.barbara forecast point within the next 24 hours. However the water level actually had exceeded the Alarm level after 12 hours, and exceeded the critical level 24 hours after the issuance of the first bulletin. It can be said that the reliability of the forecasting model is inadequate because of the inaccurate basin rainfall estimation.

The first warning issued at 11:00a.m., July 9, 18 hours after the issuance of the first bulletin, warned the residents at the downstream of Sinocalan and Bued rivers to evacuate due to overflowing of said rivers. However, at that time, the water level at Sta.barbara had already reached the Critical level.

This indicates that the issuance of flood warning wasn't timely so as to allow residents to prepare for the flood.

Accordingly, improvement of the flood forecasting model and the proper arrangement for timely warning are required for more effective activity of FFWS in the Agno River basin.

## 2.4 Operation and Maintenance Conditions

Operation and maintenance work for the existing Agno River FFWS is the responsibility of National Flood Forecasting Office in PAGASA headquarters. There are forty-seven staff in charge for the FFWS in the Philippines. Incidentally, seven stuff stay in Rosales, Agno River Flood Forecasting Office (ARFFO) who are in charge in the operation and maintenance works of Agno River FFWS. The staff functional composition in shown in Table 2.6.

In spite of the great deal of endeavor by the staff, the operation and maintenance condition is relatively poor. Data collection rate, which is the rate of data to be sent to ARFFO from respective station through telemeter system, was examined to be clear the actual operation and maintenance condition.

Table 2.7 shows the annual data collection rate for each telemetering station. As for the rainfall gauging station, most of the stations are in good condition except Binga station. Hydrological data at Binga damsite is sent to Rosales, ARFFO through the repeater station at Santo Tomas. It was found that the telemetry condition between Santo Tomas and Rosales ARFFO is poor. Accordingly, the on-going Binga-Ambuklao Dam operation system project was designed to replace the repeater station at Mt.Ampucao. The replacement work is also expected to improve the telemetry condition between San Roque and Rosales, ARFFO.

Comparing the data collection rate between raingauge stations and water level gauging stations, the latter is much less reliable except Santa Barbara and Wawa. The problem of the stations isn't mainly the telecommunication system but hydrological observation. Because, the water level gauging stations which has less data collection rate are the sensing pole type stations except for Banaga. Once the sensing pole is damaged, it cannot be repaired because of the lack of spare parts. Procurement of the spare parts depends on import, and it takes long time and costly to secure the spare parts. On the other hand, the well type gauging stations are still in good condition and secures high data collection rate. The clogging problem is considerable to the well type gauging station, however, it can resolve by man power maintenance without any spare parts to be imported. Therefore, it is supposed that the well type gauging station is suitable for the continuous water level observation in Agno River.

The data collection rate for respective station is summarized below.

| Station Name | Data Collection Rate | |
|---|---|---|
| | Rainfall | Water level |
| Binga Damsite | 23.94% | 2.27% |
| San Roque | 91.80% | 74.39% |
| Santa Barbara | 99.54% | 99.72% |
| Carmen | 99.56% | 19.27% |
| Wawa | 98.86% | 98.21% |
| Banaga | - | 83.46% |
| Tibag | 99.47% | 2.70% |

Note : Data period ; July 1982 - May 1989

Discharge measurement work, that is the most important maintenance work for water level station, is also insufficient. It is generally required to carry out the discharge measurement work once a month to improve the rating curve between water level and discharge. However, the actual frequency of discharge measurement is twice a year because of the insufficient number of staff to take charge of the measurement work.

## 2.5 Present Institutional Organization

The six agencies, PAGASA, NIA, NAPOCOR, DPWH, NWRB and OCD relate to FFWS operation and maintenance in the Philippines. Out of those agencies, PAGASA, NIA and NAPOCOR are the executive agencies and the others are working as the monitoring agencies.

"The Institutional and Management Study", was executed by PAGASA under the FFWSDO project in August 1989. The study aims to establish an institutional arrangement among the agencies related to FFWSDO, in order to achieve an effective O/M of the system and for a sound operation of inter-agency coordination system with a clear demarcation of jurisdictions of the agencies involved.

The study concluded that there was no need to modify/alter the existing framework surrounding FFWSDO project, and the obligations of each agencies were well defined and no discrepancy was observed among them. The tasks of the respective agencies to FFWS and FFWSDO is shown in Table 2.8, and summarized below.

(1) PAGASA

- Responsible for flood forecasting and warning of Pampanga and ABC FFWS.
- Responsible for O/M of Pampanga and ABC FFWS.
- Supervision of FFWSDO flood forecasting activity.

(2) NIA/(3) NAPOCOR

- Responsible for flood forecasting related to FFWSDO.
- Responsible for dam operation and discharge warning.
- Responsible for O/M of FFWSDO equipment.

(4) DPWH

- Monitoring of FFWS activity in Pampanga, Agno, Bicol and Cagayan river basins.
- Supporting to O/M of Pampanga and ABC system.

(5) NWRB

- Institutional coordination between agencies related to FFWS/FFWSDO O/M.

(6) OCD

- Responsible for local level warning activity.
- Coordination of Disaster Coordination Council.

However, reconsideration of the task distribution among agencies is required in respect to the basin-wide FFWS in Pampanga, Agno, Bicol and Cagayan

River basins. Because, the basin-wide FFWS is the one of components of flood control plan in the basin. And the river administration including flood control in the basin is responsible to DPWH.

Therefore, the basin-wide FFWS should be operated in the basin under the supervision of DPWH. On the other hand, the responsibility of PAGASA is assumed not to forecast the local level of flood but to forecast the nation-wide of the weather, typhoon truck and rainfall distribution. Accordingly, the institutional feasibility study is required for the operation of the basin-wide FFWS.

# 3. THE INTEGRATED FFWS

## 3.1 Basic Concept

Until recently, the standard flood control measure was to build massive levee to prevent residual area from flooding. The magnitude of flood control work generally depends on the flood damage potential in the basin. However, enlargement of river capacity leads to encourage the economical development and to increase the latent damage of flood in the protected area. The role of FFWS is to disseminate the flood situation to the residents in the area, where has high population density and large amount of property, under such flood control policy. Because, the social requirement to flood dissemination enlarges together with the latent damage of flood.

Another approach to flood protection receiving widespread acceptance is to provide minimum levee protection, and to rely on zoning regulations to restrict development in flood prone areas, where is less susceptible to flood damage. The new approach can be expected less investment of flood control work, however, the overflow is frequent. Under the flood control policy, FFWS is expected one of the alternative of structural measures of flood control.

The master plan of Agno River flood control applied the latter policy. However, FFWS isn't treated as the alternative of structural measures. Because, the selected retarding basins, poponto swamp and the confluence of Agno and Camiling Rivers, has no residential area. In the master plan of Agno River flood control, FFWS is expected to satisfy social requirement, providing information of flood status, and FFWS aims to minimize the flood damage, when flood attacks to the Pangasinan Plain.

The integrated FFWS in the Agno River basin is defined as one of the components of the framework plan of the Agno River basin flood control.

## 3.2 Objectives

The following three objectives are established to formulate the Master Plan for the integrated FFWS in the Study Area.

(1) <u>FFWS for Resident's Protection from Flood Incident</u>

It aims to secure the life of people and to minimize flood damage in the flood prone area by enhancing prompt flood protection activities which necessitate sufficient and accurate information, through agencies and organizations concerned, with respect to advanced forecast of extreme floods which exceed the capacity of existing river facilities.

(2) <u>FFWS for Flood Operation</u>

It aims to execute promptly effective operation of the flood control facilities such as dams, floodways and retarding basins by forecasting the magnitude of flood inflow into the said facilities in advance. It also aims to avoid artificial flood disasters by reporting warning information in advance, that will be affected concerning flood release from the said facilities.

(3) <u>FFWS for Basinwide Flood Management</u>

It aims to execute effective basinwide flood management and administration by integrated real time operation for all the flood control facilities in the basins concerned with real time access to the information concerning river and basin conditions.

## 3.3 Basic Condition and Criteria

### 3.3.1 Basic Condition

The following basic conditions are applied to the integrated FFWS.

(1) The integrated FFWS is defined to be composed of the following systems.

- Hydrological observation network system
- Telemetry system
- Flood forecasting system
- Flood warning system
- Monitoring system

(2) The target area of the integrated FFWS is all the flood prone area in the Study area, where is delineated in the supporting report of the Flood damage analysis.

(3) The control center of the system is to be located at Rosales, the same place where the existing ARFFO for the following reasons.

- The local level of the disaster coordination is expected to be the responsibility of the local agency in consideration with the further decentralization.
- Sufficient and timely maintenance and repair works will be undertaken promptly, if the control office is situated in the basin.

(4) Communication between headquarter and the FFWS control office should be maintained in order that flood forecasting and warning activity of the basin is monitored at the headquarter.

(5) Communication between the integrated FFWS control office and FFWSDO Binga dam office should be intensified for effective basinwide flood management. The other flood control structures to be constructed are to be obliged to install their own FFWS and to be connected to the FFWS control office.

(6) Flood warning network system between local agencies such as municipality and FFWS control office, which aims to intensify the local level of flood warning, flood preparedness and flood fighting activity, is considered in the integrated FFWS plan component.

(7) The warning stations along the river course, which aim to prevent the residents from approaching the river during flood, are taken into account in the integrated FFWS plan formulation.

### 3.3.2 Design Criteria

To satisfy the three objectives as mentioned in Section 3.2, the following design criteria is adopted.

(1) <u>Selection of the forecasting points</u>
The forecasting points were selected considering the following criteria.

- The area of high population density along the rivers in the target area.
- The river section seems to overflow easily in respect to the present

condition of the river improvement work.

- Existing and proposed damsite, diversion of floodway and retarding basin.
- The essential points to be required in respect to the basinwide flood management.

(2) The number of the raingauge stations

The accuracy of the basin rainfall estimation is the key requirement to construct reliable flood forecasting activity. The number of rainfall stations, which is related to the accuracy of the basin rainfall estimation, defines at least three stations in respective sub-basin, which is the same accuracy with the FFWSDO plan.

(3) Selection of the connected relative agency for flood warning activity

The local agencies to be connected to the FFWS control center for warning dissemination are selected according to the following criteria.

- The municipality which are located along the main tributary and far from the FFWS control office.
- The local agency which is the member of the RDCC.

(4) Selection of the flood warning station along the river

The location of the warning stations are desired according to the following criteria.

- The population distribution along the river, whose density is higher than 2000 persons/$km^2$.
- In the retarding basin, to be defined in the master plan.
- The downstream of dam, between the damsite and the lower confluence of the main tributary.

## 3.4 Flood Forecasting and Warning Plan

### 3.4.1 Hydrological Observation and Telemetering Network System

The following 17 water level gauging stations are selected as the forecasting points, according to the design criteria as mentioned in Section

3.3.2. The location of the forecasting points are described in Fig.3.1 and 3.2.

| Agno River Basin | Sinocalan River Basin | Bued River Basin |
|---|---|---|
| 1.San Roque (Agno) | 12.Santa Barbara (Sinocalan) | 15.Camp I (Bued) |
| 2.Carmen (Agno) | 13.Binalonan (Tagumising) | 16.Manaoag (Aloragat) |
| 3.Bayambang (Agno) | 14.Malasiqui (Ingalera) | 17.Mapandan(Angalacan) |
| 4.Wawa (Agno) | | |
| 5.Urbiztondo (Agno) | | |
| 6.Banaga (Agno) | | |
| 7.San Nicolas (Ambayoan) | | |
| 8.Tayug (Viray-Dipalo) | | |
| 9.Rosales (Banila) | | |
| 10.Tibag (Tarlac) | | |
| 11.Camiling (Camiling) | | |

For a reliable flood forecasting activity, 32 raingauge telemetry stations, including 6 existing rainfall stations, are proposed to be installed to satisfy the defined criteria as mentioned in Section 3.3.2.

The telemetry network is designed considering the distance between the FFWS control office and respective hydrological station. The hydrological stations that are to be located in the north and south mountains are assumed to be difficult to be telemetered directly. Therefore, two repeater stations shall be constructed, one on Mt.Ampucao, for the data transmission of the hydrological stations in north mountain area, and another on Mt.Bamban, for the ones in south mountain area.

The proposed hydrological observation and telemetry network system is shown in Fig.3.1.

### 3.4.2 Flood Forecasting System

The flood forecasting model is constructed by means of the telemeterized real time hydrological records. The proposed flood forecasting model is shown in Fig.3.2.

The computer system shall be installed at the integrated FFWS control office for the prompt flood forecasting activity. The following functions are expected to the computer system.

- Data bank system
- Flood forecasting system
- Flood routing analysis
- Dam operation optimization during the flood in respect of basinwide flood management

Rainfall prediction isn't taken into account in the integrated FFWS because the technology is still premature and so far unreliable.

### 3.4.3 Flood Warning System

Effective and prompt warning activity is usually dependent on the reliability of forecasting activity and communication systems. However, the public communication system such as telephone and broadcast are still less developed and not completely reliable. Especially during typhoon, the public telephone network is crowded and takes some time to connect or the line may be broken by accident. So far it is unreliable to use the public communication system for flood warning activity, then, an exclusive communication line is required for effective and prompt warning activity.

According to the task distribution related to flood control works, to evacuation of residents is not DPWH matter but OCD matter as shown in Section 2.5. Therefore, the warning system of the integrated FFWS is taking into account the communication system between FFWS control office and the affected municipalities. The actual warning activity is tasked to the Disaster Coordination Council under the OCD's supervision. The DPWH's obligation is to furnish information with regards to the status of the river and the forecast water level to the affected municipality, where the municipal Disaster Coordination Council is located, as soon as possible. Therefore, the arrangement for evacuation isn't taken into account in the integrated FFWS in the Agno River basin.

The local agencies which were selected to be connected to the flood warning system are identified below and shown in Fig.3.3.

- 21 municipalities.
- 2 OCD local office. (San Fernando, Lingayen)
- 3 local radio broadcast companies. (Dagupan, Urdaneta, Tarlac)
- 2 national police local office. (Dagupan, Urdaneta)
- 1 DPWH local office. (Tarlac)

The co-relation of the forecasting point and affected municipality was examined based on the flood routing analysis as described in Fig.3.4.

Another warning system is necessary to be installed by DPWH. Its main purpose is to discourage residents from approaching the river. During the typhoon "OPENG", that battered central and northern Luzon islands in Sep.1989, 19 out of the 24 lost lives were caused by drowning as shown below. this indicates that warning activities such as evacuating residents away from river side is assumed to strongly contribute to the relief of human lives. Therefore, warning stations should be also considered for installation along the river.

| Cause | Number of lost lives |
|---|---|
| Drowned | 19 |
| Landslide | 4 |
| Electrocuted | 1 |

3.5 System Management Plan

Before applying the FFWS for flood control works, the financial and technical capability for operation and maintenance should be considered first. Flood forecasting and warning technology is still remote in the world but is improving day by day. It needs high technology to construct the system. Most FFWS facilities are costly and have to be imported from the developed countries. The integrated system to be proposed must be justified in respect to the financial ability of the government for sufficient maintenance work.

Well skilled staff for operation and maintenance are also required especially in hydrology and telecommunication. The hydrologists, are mainly required at the control center to supervise the regular discharge measurement work at all of water level stations. The flood forecasting computation including adjusting flood forecasting model is also tasked to the hydrologist. To improve the flood forecasting technology and the hydrological observation, it is recommended to provide sufficient training period to the hydrologist before the system operation.

On the other hand, telecommunication specialists are absolutely lacking in the Philippines. The discrepancy of the salary between the government and the private company for the telecommunication experts is assumed to be the main reason. In the new institutional arrangement is strongly required to acquire the telecommunication expert for the FFWS.

Considering the above, the following institutional arrangement is assumed to be recommendable for the smooth operation of the integrated FFWS.

(1) Local level of FFWS activity shall be transferred to the local agency.

(2) The suitable agency to be responsible for the local flood forecasting is assumed to be DPWH, considering its responsibility for the river administration and the regular maintenance work of the hydrological stations.

(3) The role of PAGASA is assumed to be advisory for the transfer of flood forecasting technology, and further research of applicable new technology for the improvement of flood forecasting.

(4) Flood warning activity is responsibility of OCD. It is tasked to prepare the program for improvement of Disaster Coordination Council's activities.

(5) Telecommunication training center is recommended to be established in collaboration with PAGASA, NAPOCOR, NIA, DPWH and NTC in Manila. The purposes of the center are to train the staff, stock and supply the spare parts of the telemetering facilities. The prompt repair work will be expected once the center is established.

(6) Flood Operation system for the dams to be constructed is responsibility of

the owner agency.

(7) Multiplex communication system with DPWH central office should be provided for the monitoring if FFWS activity.

## 3.6 The Integrated FFWS and Cost Estimate

The integrated FFWS in the Agno River basin, as shown in Fig.3.6, consists of the following systems.

- Hydrological Observation System
  . Water level stations : 17 stations (Existing 7 stations included)
  . Raingauge stations : 32 stations (Existing 6 stations included)

- Telemetering Network System
  . System Control Center : Rosales, DPWH (Extension of the Existing ARFFO, PAGASA)
  . Repeater Station : 2 stations
    - Mt.ampucao (Extension of the existing station)
    - Mt.Bamban (Newly constructed)

- Monitoring of FOS
  . Flood control monitoring system : 4 monitors in Rosales control center
    - For Binga-Ambuklao FFWSDO sub-system (Existing)
    - For Balog-Balog Flood Operation System (New)
    - For San Roque Flood Operation System (New)
    - For Moriones Flood Operation System (New)

- Monitoring at DPWH central office
  . Multiplex communication system is concerned for the monitoring of basin-wide FFWS activity.

- Flood Forecasting System
  . One computer system in Rosales control center

- Flood Warning System
  . Duplex link between Rosales control center and the related 29 local

agencies

. 31 Warning stations along the river

The estimated direct cost is described in Table 3.1 and summarized below.

| Item | Direct Cost (x1000 Yen) |
|---|---|
| Agno River flood forecasting system | 1,035,564 |
| Flood warning system | 349,958 |
| Monitoring system at DPWH central office | 131,361 |
| Monitoring for Binga-Ambuklao dam system | 15,818 |
| Balog-Balog FOS | 505,318 |
| San Roque FOS | 478,506 |
| Moriones FOS | 506,818 |
| TOTAL | 3,023,343 |

3.7 Socio-Economic Context

The expected benefit of the integrated Agno River FFWS is complicated to figure out as monetary value. There is no authorized measures to justify economically in the world until now. Because, the major expected benefit to FFWS is to relief the human life against the flood and the improvement of the environment aspects. Besides, the social welfare such as the information service about the real time condition of the river is also expected to the benefit of the system. The following items are considered to be the benefit of the FFWS.

i) To eliminate lost of human lives

ii) To mitigate environmental damage such as spread of an epidemics due to flood inundation

iii) To mitigate the housing property damage

iv) To mitigate the livestock damage

v) To mitigate the commercial stock damage

vi) To mitigate the economic activity damage

vii) To mitigate the relief and urgent supply expense viii)To improve social welfare such as public awareness to flood information

Out of the above expected benefits to FFWS, item (iii) through (vii) is the countable as the monetary value. On the other hand, the value of human life and of environmental assets should not be express in monetary terms. However, it is noted that those intangible benefit is mainly expected to FFWS. *Therefore the economic evaluation of the FFWS isn't absolute to justify the* project of FFWS but the reference to the economic feasibility. THe project justification of FFWS should be depended on the maturity of the structural river improvement condition and the Government policy to the flood control and public welfare.

According to the Meteorological Telemetering System Project, which is completed detail design stage under PAGASA as of Nov.1989, 5% of direct damage is expected to be mitigated by the telemetering system, and the assumption has applied by the Government of Philippines.

In the case of the Agno River FFWS the economic internal rate of return (EIRR) is expected to 19.26%, if the assumption is applied.

# 4. LONG TERM DEVELOPMENT PLAN

## 4.1 Concept of Long Term Development Plan

It was found that there are three major problems of the existing Agno River FFWS as mentioned in Section 2.1, and repeated below.

- Insufficient budget and staff for maintenance
- Low reliability of forecasting due to insufficient raingauge stations
- Less warning effectiveness due to unreliable communication system between relative agencies

The said problems should be taken into account in the integrated FFWS in Agno River Basin. The Long Term Plan is formulated as the priority development plan, which is a part of the FFWS integrated system, as mentioned in Chapter 3.

The following objectives are assessed to formulate the priority FFWS development plan in the Study Area.

i) To resolve the problems of the existing FFWS in the basin, as mentioned above.

ii) To select the appropriate technology of the flood forecasting in respect to the present technology level in the Philippines.

iii) To select the economically feasible system in respect to the flood damage value of the target area.

iv) To select the priority area in respect of the number of the affected people and density of the flood damage potential.

v) To select the priority area in respect to the magnitude of the river improvement work of the river section.

## 4.2 Priority FFWS Development Plan

Priority development plan is considered according to the above concept and the present status of FFWS institutional aspects. The selected scheme will be treated in the coming Feasibility Study in Agno River Flood Control. The system configuration is described in Fig.4.1.

(1) Objectives

The priority scheme of the Agno River FFWS aims to attain the following two objectives.

- To improve the flood forecasting accuracy of the forecasting points in the existing Agno River FFWS.
- To carry out the effective flood warning activity in the Study Area.

(2) Objective rivers

The following three rivers are selected to the priority FFWS development in the Study Area.

- Main Agno River
- Tarlac River
- Sinocalan-Tagumising River

(3) Flood Forecasting Points

Seven flood forecasting points are selected as shown below. Out of them, 6 forecasting points have already existed. Considering the population distribution and river characteristic, these forecasting points are reasonable to be selected. The population distribution is shown in Fig.3.5.

In addition to these six forecasting points, Binalonan forecasting point is selected in this study. Because, the station is located upstream of Santa Barbara forecasting point, where is so far less accuracy than the other forecasting point. To improve the forecasting accuracy of the station, installation of Binalonan forecasting point is required.

- San Roque (Agno River, Existing)
- Carmen (Agno River, Existing)
- Wawa (Agno River, Existing)
- Banaga (Agno River, Existing)
- Tibag (Tarlac River, Existing)
- Santa Barbara (Sinocalan River, Existing)
- Binalonan (Tagumising River, New)

(4) Flood Forecasting Measure

The simple and accurate flood forecasting method is proposed in consideration with the present availability of the forecasting technology. Combination of water level co-relation method with rainfall run-off analysis method is applied. The available data for flood forecasting is the following.

San Roque Forecasting Point

- Binga Dam Power discharge and Spillout Record.
- Basin Rainfall estimation in Binga-San Roque sub-basin by means of the following raingauge stations.
  - . Binga Damsite (Existing)
  - . Teb-bo (New)
  - . San Roque (Existing)
  - . Mt.Ampucao (On-going)

Carmen Forecasting Point

- Water level record of San Roque forecasting Point.
- Basin rainfall estimation in San Roque-Carmen sub-basin by means of the following raingauge stations.
  - . San Roque (Existing)
  - . Carmen (Existing)
  - . Malilit (New)
  - . Siminbaan (New)
  - . Umingan (New)

Wawa Forecasting Point

- Water level co-relation to Carmen forecasting point.
- Water level co-relation to Tibag forecasting point.

Banaga Forecasting point

- Water level co-relation to Wawa forecasting point.

Tibag Forecasting Point

- Basin rainfall estimation in upper tibag sub-basin by means of the following raingauge stations.
  - . Tibag (Existing)

. Negrito (New)
. Iba (New)
. Balog-balog (New)

<u>Santa Barbara Forecasting Point</u>

- Water level co-relation to Binalonan forecasting point.

<u>Binalonan Forecasting Point</u>

- Basin rainfall estimation in upper binalonan sub-basin by means of the following raingauge stations.
    . San Roque (Existing)
    . Mt.Ampucao (Existing)
    . Binalonan (New)

(5) *Flood Warning System*

As mentioned in Section 3.4.3., two kinds of warning system are assessed. One is to provide communication lines between FFWS control office and the relative local agencies, such as municipality, national police and local broadcast stations. The system aims to execute the municipal level of flood preparedness and flood fighting activity. However, inter-municipal institutional coordination is required to satisfy the object, and it is concluded that the conduction of the system is postponed because the detail analysis of the local level of institutional coordination is insufficient.

On the other hand, it also aims to disseminate flood information to the residents through the local radio broadcast. It seems to be effective to provide the self-guarding against flood by the residents. Accordingly, the following five relative agencies are selected to be linked by the communication line with Agno River FFWS control office.

- Local Radio Broadcast. (Dagupan, Urdaneta, Tarlac)
- OCD regional/provincial office (San Fernando, Lingayen)

The installation if the warning stations along the river is postponed. The system is expected to be strongly effective from the past experience. However, in consideration with the present condition of the river improvement work, it is difficult to point out the priority area for the warning system.

The priority warning area is generally determined based on the population distribution along the river. In respect to the criteria, the following area are selected as the priority area of the installation of the warning station.

- Lingayen (Lower Agno River)
- Wawa-Bayambang-Carmen (Upper Agno River)
- Dagupan-Calasiao-Santa Barbara (Panto-Sinocalan River)
- Urdaneta (Sinocalan River)
- Binalonan (Tagumising River)

However, all of the above areas are listed up the priority area of the river improvement works in the master plan. Based in the flood control plan in the master plan study, the role of the FFWS doesn't aim to the point warning, but aim to provide the general information to the whole residents in the flood prone area.

(6) Monitoring System of Dam Operation

In the framework plan, four flood operation system are concerned as mentioned in Section 3.6. Out of the flood operation system, the on-going Binga-Ambuklao FFWSDO is monitored at the Agno River FFWS control center.

(7) System Operation and Management

The control center is replaced from NFFO at Manila to Rosales. Because, the basin-wide FFWS should be managed by inter-basin agency in consideration with the further de-centralization. Therefore, the Agno River priority FFWS is operated by the Agno River FFWS control center in Rosales.

Regarding the institutional arrangement for O/M of the Agno River FFWS, The following four alternatives will be assessed at the coming feasibility study on Agno River Flood Control.

- Alternative 1
    . Operation and maintenance : DPWH
- Alternative 2
    . Operation : PAGASA

. Maintenance : DPWH

- Alternative 3

    . Operation and Maintenance : PAGASA

- Alternative 4

    . Operation and Maintenance : PAGASA and DPWH

(8) Cost and Benefit

The project cost is estimated to 1,825 million yen, and the detail is described in Table 4.1. The benefit is estimated based on the number of the affected residents. The 56% of the residents in the flood prone area may be affected. Therefore, 56% of the direct benefit is taken into account for the economic evaluation.

Subsequently, the economic internal rate of return for the Agno River Priority FFWS is estimated to 28.91%.

# *TABLES*

## TABLE 2.1 PRINCIPAL FEATURES OF THE EXISTING / ONGOING TELEMETERING GAUGING STATIONS

The Existing Telemetering Stations.

| Station Name | Binga dam | San roque | Carmen | Tibag | Wawa | Banaga | Santa Barbara |
|---|---|---|---|---|---|---|---|
| 1.Location | Binga damsite | Irrigation intake site | Immediately downstream of Plaridel Br. | Agana Br. | 300 m downstream of Wawa Br. | Padilla Br. | Maramba Br. |
| -Latitude | 16°23'21" | 16°07'37" | 15°03'24" | 15°29'14" | 15°46'28" | 16°01'50" | 16°00'24" |
| -Longitude | 120°41'07" | 120°41'07" | 120°35'34" | 120°34'09" | 120°26'50" | 120°12'44" | 124°24'04" |
| 2.Kind of station | RF(*1) & WL(*2) | RF & WL | RF & WL | RF & WL | RF & WL | WL | RF & WL |
| 3.River Name | Agno river | Agno river | Agno river | Tarlac river | Agno river | Agno river | Sinocolan river |
| 4.Catchment Area | 936 $km^2$ | 1,225 $km^2$ | 2,209 $km^2$ | 872 $km^2$ | 4,196 $km^2$ | 5,560 $km^2$ | 180 $km^2$ |
| 5.Water level gauge type | Sensing pole | Sensing pole | Sensing pole | Sensing pole | Well | Well | Well |
| 6.High water level (m AMSL(*3)) | 479.3 | 100.9 | 29.0 | 50.2 | 15.5 | 3.8 | 7.2 |
| 7.Low water level (m AMSL) | 478.8 | 94.4 | 21.5 | 5.5 | 5.5 | -1.2 | 1.7 |

The Telemetering Stations to be constructed on FFWSDO Project-II.

| Station Name | Apunan | Bobok | Badayan | Ambuklao dam | Binga dam |
|---|---|---|---|---|---|
| 1.Location | Mt. Apunan | Mt. Bobok | Hilltop at Badayan town. | Ambuklao damsite | Binga damsite |
| -Latitude | 16°34'22" | 16°27'00" | 16°45'18" | 16°27'40" | 16°23'52" |
| -Longitude | 120°49'29" | 120°49'03" | 120°49'53" | 120°44'38" | 120°43'38" |
| 2.Kind of station | RF | RF | RF | RF & WL | RF & WL |
| 3.Altitude (m AMSL) | 1,240 | 1,497 | 1,700 | 758 | 586 |
| 4.Catchment Area | - | - | - | 686 | 936 |
| 5.Water level gauge type | - | - | - | Pressure | Pressure |
| 6.High water level (m AMSL(*3)) | - | - | - | 752.0 | 575.0 |
| 7.Low water level (m AMSL) | - | - | - | 694.0 | 555.0 |

Source : Data List FF.301

Note : (*1) RF : Rainfall station.

(*2) WL : Water level gauging station.

(*3) AMSL : Above mean sea level.

TABLE 2.2 BASIN CHARACTERISTIC OF THE EXISTING MODEL

| Sub-Basin | Catchment Area (km2) | Elevation Max (El.m) | Elevation Min (El.m) | Elevation Ave. (El.m) | Lag-Time (hr.) | Distribution of Rainfall Station: Available ST. Nos. | Theesen Area (Km2/Nos.) | Average Elevation (El.m) | Reliability |
|---|---|---|---|---|---|---|---|---|---|
| 1. Ambuklao Dam Sub-Basin | 620 | 2500 | 735 | 1530 | 3.0 | 4(4) | 74 - 256 | 1345 | Good |
| 2. Ambuklao - Binga Sub-basin | 240 | 2500 | 500 | 1300 | 3.0 | 3(2) | 79 - 100 | 994 | Poor |
| 3. Binga - San Roque Sub-basin | 390 | 2290 | 300 | 950 | 3.0 | 3(3) | 80 - 192 | 1005 | Good |
| 4. San Roque - Carmen Sub-basin | 1210 | 1000 | 40 | 560 | 8.0 | 4(2) | 62 - 686 | 195 | Poor |
| 5. Carmen - Wawa Sub-basin | 430 | 40 | 10 | 15 | 6.0 | 2(2) | 115 - 221 | 20 | Good |
| 6. Upper Tibag Sub-basin | 920 | 1400 | 60 | 370 | 6.0 | 1(1) | 920 | 27 | Poor |
| 7. Tibag - Wawa Sub-basin | 650 | 170 | 10 | 35 | 6.0 | 3(2) | 168 - 261 | 21 | Good |
| 8. Wawa - Banaga Sub-basin | 1520 | 1500 | 5 | 420 | 7.0 | 3(1) | 247 - 1038 | 12 | Poor |
| 9. Upper Sta. Barbara Sub-basin | 460 | 1200 | 8 | 200 | 4.0 | 4(1) | 72 - 225 | 140 | Good |

## TABLE 2.3 CHANNEL CHARACTERISTIC OF THE EXISTING MODEL

| Channel Section | River | River Length (Km) | Elevation Max (El.m) | Elevation Min (El.m) | River Gradient | Lag-Time (hr.) | C.A of Upstream (Km2) | C.A of Residual (Km2) | C.A ratio of Upstream (%) |
|---|---|---|---|---|---|---|---|---|---|
| 1. Ambuklao - Binga | Agno R. | 13 | 690 | 565 | 0.00926 | 1.0 | 617 | 243 | 72 |
| 2. Binga - San Roque | Agno R. | 44 | 479 | 98 | 0.00858 | 4.0 | 860 | 390 | 69 |
| 3. San Roque - Carmen | Agno R. | 32 | 98 | 25 | 0.00225 | 5.0 | 1250 | 1213 | 51 |
| 4. Carmen - Wawa | Agno R. | 31 | 25 | 10.5 | 0.00046 | 4.0 | 2463 | 1079 | 70 |
| 5. Tibag - Wawa | Tarlac R. | 38 | 48 | 10.5 | 0.00097 | 4.0 | 861 | 1079 | 44 |
| 6. Wawa - Banaga | Agno R. | 47 | 10.5 | 1.3 | 0.00020 | 8.0 | 4403 | 1523 | 74 |
| 7. Upper Sta. Barbara | Sinocalan R. | 56 | 150 | 4.5 | 0.00256 | 8.0 | 396 | 0 | 100 |

# TABLE 2.4 FLOOD ASSESSMENT LEVELS OF THE FORECASTING POINTS

(as of May 1987)

| St.No. | St. Name | Assessment Water Level(m) Lower Limit | Upper Limit | Alert Level | Alarm Level | Critical Level | Rating Curve A | B | C |
|---|---|---|---|---|---|---|---|---|---|
| 200501 | Binga Damsite | - | - | 6.30<br>(6.30) | 12.50<br>(12.50) | 19.50<br>(19.50) | - | - | - |
| 200502 | San Roque | 0.00 | 10.00 | 5.30<br>(2.20) | 6.20<br>(4.30) | 7.50<br>(7.50) | 11.92372 | 0.00000 | 2.69489 |
| 200503 | Santa Barbara | 0.00 | 8.00 | 2.90<br>(2.50) | 3.70<br>(5.00) | 5.00<br>(6.50) | 1.81216 | 0.50000 | 2.63672 |
| 200504 | Carmen | 0.00 | 7.00 | 4.70<br>(2.50) | 5.60<br>(5.00) | 7.00<br>(7.00) | 2.51579 | 2.00000 | 3.48725 |
| 200505 | Wawa | 0.00 | 10.00 | 6.30<br>(3.40) | 8.20<br>(6.70) | 10.00<br>(10.00) | 39.32286 | 0.50000 | 2.08889 |
| 200506 | Banaga | - | - | -<br>( - ) | -<br>( - ) | -<br>( - ) | - | - | - |
| 200507 | Tibag | 0.00 | 12.00 | 4.10<br>(1.70) | 5.60<br>(3.40) | 8.00<br>(8.00) | 21.82252 | 2.00000 | 2.17500 |

Note :

- The alert, alarm and critical levels are the equivalent water levels when 40%, 60% and 100%, respectively of the pre-determined discharge conveyed through the cross-section of a river at gauging station are reached.

- The critical level at a gauging station which served as a reference level is the level at which the confined water of some portion of the channel within the jurisdiction of the atation starts to overflow the unprotected river banks at the earliest time.

- Rating curve is defined the following formula;

$$Q = A \times (H + B)^{C}$$

- ( ) : Assessment water levels as of 1983.

TABLE 2.5 (1/2) SERIES OF FLOOD BULLETIN DURING TYPHOON "GADING"

Typhoon : GADING (July 8 -15 '1986)

| DATE | TIME | WATER LEVEL (cm) BINGA DAM | SAN ROQUE | STA. BARBARA | BANAGA | CARMEN | WAWA | TIBAG | ACCUMULATED HOURLY RAINFALL FROM 8:00 (mm) BINGA DAM | SAN ROQUE | STA. BARBARA | CARMEN | WAWA | TIBAG | ISSUED FLOOD BULLETIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Assessment level : | | | | | | | | | | | | | | | |
| Alert level | | 630 | 530 | 290 | - | 470 | 630 | 410 | | | | | | | |
| Alarm level | | 1250 | 620 | 370 | - | 560 | 820 | 560 | | | | | | | |
| Critical level | | 1950 | 750 | 500 | - | 700 | 1000 | 800 | | | | | | | |
| 08-Jul | 2.00 | NA | 0 | 180 | 91 | NA | 67 | NA | NA | 0 | 1 | 4 | 0 | 14 | |
| 08-Jul | 5.00 | NA | 0 | 180 | 114 | NA | 68 | NA | NA | 0 | 2 | 6 | 0 | 14 | |
| 08-Jul | 8.00 | NA | 0 | 180 | 143 | NA | 67 | NA | NA | 0 | 10 | 6 | 0 | 14 | |
| 08-Jul | 11.00 | NA | 26 | 184 | 152 | NA | 64 | NA | NA | 0 | 21 | 21 | 1 | 0 | |
| 08-Jul | 14.00 | NA | 16 | 201 | 133 | NA | 62 | NA | NA | 0 | 57 | 38 | 11 | 6 | |
| 08-Jul | 17.00 | NA | 0 | 213 | 117 | NA | 61 | NA | NA | 0 | 75 | 56 | 13 | 9 | Outlook(1) |
| 08-Jul | 20.00 | NA | 0 | 225 | 137 | NA | 65 | NA | NA | 0 | 135 | 94 | 42 | 21 | |
| 08-Jul | 23.00 | NA | 7 | 240 | 130 | NA | 78 | NA | NA | 0 | 190 | 111 | 118 | 37 | |
| 09-Jul | 2.00 | NA | 8 | 317(*1) | 137 | NA | 88 | NA | NA | 1 | 228 | 143 | 142 | 52 | |
| 09-Jul | 5.00 | NA | 34 | 441(*2) | 154 | NA | 96 | NA | NA | 8 | 247 | 161 | 167 | 65 | Advisory(2) |
| 09-Jul | 8.00 | NA | 153 | 489(*2) | 179 | NA | 117 | NA | NA | 8 | 247 | 161 | 167 | 65 | |
| 09-Jul | 11.00 | NA | 199 | 542(*3) | 181 | NA | 143 | NA | NA | 0 | 51 | 18 | 9 | 6 | Warning(3) |
| 09-Jul | 14.00 | NA | 188 | 558(*3) | 164 | NA | 239 | NA | NA | 0 | 95 | 56 | 32 | 20 | |
| 09-Jul | 17.00 | NA | 193 | 565(*3) | 163 | NA | 364 | NA | NA | 0 | 131 | 90 | 44 | 25 | Warning(4) |
| 09-Jul | 20.00 | NA | 199 | 567(*3) | 163 | NA | 421 | NA | NA | 0 | 163 | 112 | 50 | 27 | |
| 09-Jul | 23.00 | NA | 199 | 568(*3) | 163 | NA | 459 | NA | NA | 0 | 168 | 115 | 54 | 33 | |
| 10-Jul | 2.00 | NA | 199 | 569(*3) | 168 | NA | 506 | NA | NA | 0 | 190 | 132 | 78 | 52 | |
| 10-Jul | 5.00 | NA | 199 | 569(*3) | 182 | NA | 109 | NA | NA | 0 | 198 | 140 | 90 | 62 | Warning(5) |
| 10-Jul | 8.00 | NA | 199 | 570(*3) | 204 | NA | 508 | NA | NA | 0 | 0 | 0 | 1 | 0 | |
| 10-Jul | 11.00 | NA | 199 | 569(*3) | 215 | NA | 519 | NA | NA | 0 | 13 | 18 | 13 | 15 | |
| 10-Jul | 14.00 | NA | 199 | 568(*3) | 210 | NA | 524 | NA | NA | 0 | 14 | 23 | 16 | 16 | |
| 10-Jul | 17.00 | NA | 196 | 568(*3) | 198 | NA | 538 | NA | NA | 0 | 31 | 35 | 24 | 45 | Warning(6) |
| 10-Jul | 20.00 | NA | 199 | 569(*3) | 197 | NA | 556 | NA | NA | 0 | 63 | 61 | 48 | 55 | |
| 10-Jul | 23.00 | NA | 199 | 569(*3) | 193 | NA | 571 | NA | NA | 0 | 67 | 66 | 54 | 62 | |
| 11-Jul | 2.00 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | |
| 11-Jul | 5.00 | NA | 181 | 569(*3) | 202 | NA | 614 | NA | NA | 0 | 81 | 77 | 72 | 71 | Warning(7) |
| 11-Jul | 8.00 | NA | 199 | 569(*3) | 215 | NA | 633(*1) | NA | NA | 0 | 0 | 0 | 0 | 0 | |
| 11-Jul | 11.00 | NA | 199 | 570(*3) | 223 | NA | 631(*1) | NA | NA | 0 | 0 | 0 | 0 | 2 | |
| 11-Jul | 14.00 | NA | 199 | 570(*3) | 221 | NA | 628 | NA | NA | 0 | 0 | 1 | 3 | 6 | |
| 11-Jul | 17.00 | NA | 199 | 570(*3) | 212 | NA | 623 | NA | NA | 0 | 0 | 1 | 3 | 6 | Warning(8) |
| 11-Jul | 20.00 | NA | 199 | 570(*3) | 205 | NA | 623 | NA | NA | 0 | 0 | 1 | 3 | 6 | |
| 11-Jul | 23.00 | NA | 186 | 569(*3) | 198 | NA | 612 | NA | NA | 0 | 0 | 1 | 3 | 6 | |
| 12-Jul | 2.00 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | |
| 12-Jul | 5.00 | NA | 146 | 562(*3) | 199 | NA | 582 | NA | NA | 0 | 0 | 1 | 3 | 6 | Warning(9) |
| 12-Jul | 8.00 | NA | 137 | 560(*3) | 202 | NA | 575 | NA | NA | 0 | 0 | 1 | 3 | 6 | |
| 12-Jul | 11.00 | NA | 154 | 551(*3) | 212 | NA | 562 | NA | NA | 0 | 0 | 0 | 0 | 0 | |
| 12-Jul | 14.00 | NA | 143 | 541(*3) | 206 | NA | 549 | NA | NA | 0 | 0 | 0 | 0 | 0 | |
| 12-Jul | 17.00 | NA | 133 | 529(*3) | 189 | NA | 535 | NA | NA | 0 | 0 | 0 | 0 | 0 | Warning(10) |
| 12-Jul | 20.00 | NA | 127 | 517(*3) | 176 | NA | 524 | NA | NA | 0 | 0 | 0 | 0 | 0 | |
| 12-Jul | 23.00 | NA | 140 | 505(*3) | 172 | NA | 511 | NA | NA | 0 | 8 | 0 | 0 | 0 | |

Note :

(*1) : Higher than Alert level.

(*2) : Higher than Alarm level.

(*3) : Higher than Critical level.

# TABLE 2.5 (2/2) SERIES OF FLOOD BULLETIN DURING TYPHOON "GADING"

Typhoon : GADING (July 8 -15 '1986)

| DATE | TIME | WATER LEVEL (cm) BINGA DAM | SAN ROQUE | STA. BARBARA | BANAGA | CARMEN | WAWA | TIBAG | ACCUMULATED HOURLY RAINFALL FROM 8:00 (mm) BINGA DAM | SAN ROQUE | STA. BARBARA | CARMEN | WAWA | TIBAG | ISSUED FLOOD BULLETIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Assessment level : | | | | | | | | | | | | | | | |
| Alert level | | 630 | 530 | 290 | - | 470 | 630 | 410 | | | | | | | |
| Alarm level | | 1250 | 620 | 370 | - | 560 | 820 | 560 | | | | | | | |
| Critical level | | 1950 | 750 | 500 | - | 700 | 1000 | 800 | | | | | | | |
| 13-Jul | 2.00 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | |
| 13-Jul | 5.00 | NA | 134 | 477(*2) | 166 | NA | 482 | NA | NA | 0 | 8 | 0 | 0 | 0 | Warning(11) |
| 13-Jul | 8.00 | NA | 142 | 472(*2) | 166 | NA | 480 | NA | NA | 0 | 8 | 0 | 0 | 0 | |
| 13-Jul | 11.00 | NA | 140 | 463(*2) | 172 | NA | 472 | NA | NA | 0 | 0 | 0 | 0 | 0 | |
| 13-Jul | 14.00 | NA | 93 | 453(*2) | 172 | NA | 464 | NA | NA | 0 | 0 | 0 | 0 | 0 | |
| 13-Jul | 17.00 | NA | 84 | 443(*2) | 165 | NA | 456 | NA | NA | 0 | 0 | 0 | 0 | 0 | Warning(12) |
| 13-Jul | 20.00 | NA | 85 | 432(*2) | 160 | NA | 448 | NA | NA | 0 | 1 | 0 | 0 | 0 | |
| 13-Jul | 23.00 | NA | 90 | 419(*2) | 151 | NA | 433 | NA | NA | 0 | 1 | 0 | 0 | 0 | |
| 14-Jul | 2.00 | NA | 131 | 398(*2) | 149 | NA | 415 | NA | NA | 0 | 1 | 0 | 0 | 2 | |
| 14-Jul | 5.00 | NA | 144 | 398(*2) | 149 | NA | 415 | NA | NA | 0 | 1 | 0 | 0 | 2 | Warning(13) |
| 14-Jul | 8.00 | NA | 118 | 392(*2) | 149 | NA | 412 | NA | NA | 0 | 1 | 0 | 0 | 4 | |
| 14-Jul | 11.00 | NA | 140 | 384(*2) | 153 | NA | 407 | NA | NA | 0 | 0 | 1 | 0 | 2 | |
| 14-Jul | 14.00 | NA | 100 | 376(*2) | 155 | NA | 404 | NA | NA | 0 | 0 | 1 | 1 | 3 | |
| 14-Jul | 17.00 | NA | 102 | 368(*1) | 150 | NA | 401 | NA | NA | 0 | 0 | 4 | 6 | 13 | Advisary(14) |
| 14-Jul | 20.00 | NA | 112 | 361(*1) | 152 | NA | 399 | NA | NA | 0 | 16 | 17 | 13 | 38 | |
| 14-Jul | 23.00 | NA | 109 | 357(*1) | 147 | NA | 396 | NA | NA | 0 | 18 | 18 | 14 | 38 | |
| 15-Jul | 2.00 | NA | 106 | 355(*1) | 146 | NA | 391 | NA | NA | 0 | 18 | 18 | 14 | 38 | |
| 15-Jul | 5.00 | NA | 101 | 354(*1) | 147 | NA | 387 | NA | NA | 0 | 18 | 18 | 14 | 38 | Advisary(15) |
| 15-Jul | 8.00 | NA | 117 | 353(*1) | 147 | NA | 384 | NA | NA | 0 | 18 | 18 | 14 | 38 | |
| 15-Jul | 11.00 | NA | 111 | 349(*1) | 145 | NA | 380 | NA | NA | 0 | 0 | 0 | 0 | 0 | |
| 15-Jul | 14.00 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | |
| 15-Jul | 17.00 | NA | 79 | 337(*1) | 150 | NA | 374 | NA | NA | 0 | 0 | 0 | 0 | 2 | Advisary(16) |
| 15-Jul | 20.00 | NA | 76 | 333(*1) | 144 | NA | 371 | NA | NA | 0 | 0 | 0 | 0 | 2 | |
| 15-Jul | 23.00 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | |

Note :

(*1) : Higher than Alert level.

(*2) : Higher than Alarm level.

(*3) : Higher than Critical level.

## TABLE 2.6 STAFF COORDINATION OF THE EXISTING AGNO RIVER FFWS

(as of June 1989)

| Organizational Division Inside PAGASA NFFO | Major Engaged Field | Number of Allowed Staff by States | | | |
|---|---|---|---|---|---|
| | | Specialist | Engineer | Technician | Total |
| **Headquarters, Quezon City** | | | | | |
| 1. Office of the Director | | | | | |
| | Meteo. / Hydro. | 3 | 3 | 5 | 11 |
| | | (7) | (5) | (8) | (20) |
| | Clerical | - | - | 2 | 2 |
| | | (-) | (-) | (2) | (2) |
| | Sub-total | 3 | 3 | 7 | 13 |
| | | (7) | (5) | (10) | (22) |
| 2. Hydrology and Flood Forecasting Center | | | | | |
| | Meteo. / Hydro. | 1 | 9 | 7 | 17 |
| | | (2) | (11) | (11) | (24) |
| 3. Telemetery Systems Service Center | | | | | |
| | Meteo. / Hydro. | - | - | - | - |
| | | (1) | (-) | (2) | (3) |
| | Telecom / Electronic. | - | 7 | 10 | 17 |
| | | (-) | (4) | (12) | (16) |
| | Sub-total | - | 7 | 10 | 17 |
| | | (1) | (4) | (14) | (19) |
| | Total | 4 | 19 | 24 | 47 |
| | | (10) | (20) | (35) | (65) |
| **Agno River Flood Forecasting Center** | | | | | |
| | Meteo. / Hydro. | - | 2 | 3 | 5 |
| | | (1) | (6) | (4) | (11) |
| | Telecom / Electronic. | - | - | 2 | 2 |
| | | (-) | (1) | (-) | (1) |
| | Clerical | - | - | - | - |
| | | (-) | (-) | (1) | (1) |
| | Total | - | 2 | 5 | 7 |
| | | (1) | (7) | (5) | (13) |

Source : PAGASA NFFO.
Note : ( ) as of 1983.