6. SEDIMENT ANALYSIS

6. SEDIMENT ANALYSIS

Sediment analysis deals with:

i) Amount of natural sediment yield from the watershed
ii) Discharge of mine tailings
iii) Sediment balance in the river channels

6.1 Estimation of Sediment Yield

6.1.1 Natural Sediment Yield

(1) Sources of Sediment Yield

The sediment yield sources are categorized as below:

A. Natural Sediment Yield
  - a1. erosion of ground surface
  - a2. landfall, landslide
  - a3. erosion of river bed and channel

B. Artificial Sediment Yield
  - b1. agriculture development, deforestation
  - b2. road construction
  - b3. mine tailings

In the watershed of the Study Area, the major artificial sediment yield sources are considered to be mine tailings and road construction.

For estimating the natural sediment yield, the sediment yield due to agricultural development and deforestation is treated as the existing condition in the mountain area.

(2) Classification of Watershed

The watershed of the Study Area is divided into three, Southern Cordillera mountains, Central Luzon Plain and Zambales mountains. It is assumed that the sediment yield from the Luzon Plain is negligible. Most of the sediment is yielded from the Southern Cordillera mountains and the

Zambales mountains. The watershed of these mountain areas is divided into four classes for assessing the potential sediment yield as defined below:

Classification	Condition of land	Tone in aerial photograph
LANDFALL (La)	landfall/landslide area without vegetation (high yield)	white
BARE LAND (Ba)	bare land with almost no trees and grass (medium yield)	white or light gray
PARTIAL FOREST LAND (Va)	mixed with bare land and forest/grass land (low yield)	light gray or gray
FOREST LAND (Fa)	fully covered with forest and grass (little yield)	dark

(3) Natural Sediment Yield

The watersheds of the Southern Cordillera mountains and the Zambales mountains are divided into 37 (N1-N37) and 22 (S1-S22) sub-basins respectively. The sediment yield potential of these sub-basins is assessed in terms of the foregoing four classes by use of 1:60,000 scale aerial photographs taken in 1980-1981.

Areas of these four classes are measured for each sub-basin and the natural sediment yield is estimated for each sub-basin by use of the formula below.

$$Ns = La \times Ld + Ba \times Bd + Va \times Vd + Fa \times Fd$$
$$= (500\ La + 50\ Ba + 5\ Va + Fa) \times Fd$$

Where,

NS	:	Natural sediment yield (m^3/year)
La,Ld	:	Area and yield depth of landfall; assumed Ld = 500 Fd
Ba,Bd	:	Area and yield depth of bare land; assumed Bd = 50 Fd
Va,Vd	:	Area and yield depth of partial forest land assumed Vd = 5 Fd
Fa,Fd	:	Area and yield depth of forest land

There is no regiment records of sediment yield except those of the Ambuklao and Binga dams.

The sediment yield depth of forest land (Fd) at Ambuklao and Binga dam sites is, therefore, counted backward to be 1.3 mm (Fd) from the recorded annual sediment yield at both reservoirs; 3.71 x $10^6 m^3$/year for the Ambuklao and 5.01 x $10^6 m^3$ for the Binga. The record of sediment yield at the Ambuklao and Binga dams is shown in Table 6.1.1.

The estimated natural sediment yield is shown in Table 6.1.2 for the Southern Cordillera mountains and Table 6.1.3 for the Zambales mountains. The aerial distribution is shown in Figure 6.1.1 and Figure 6.1.2 respectively.

The estimated annual average natural sediment yields are summarized below:

Site	Catchment* Area (km^2)	Annual Natural Average Yield Rate ($m^3/km^2/yr$)	Sediment Average Yield ($10^6 m^3/yr$)
Ambuklao Dam	617	5,400	3.3
Binga Dam	860	6,100	5.3
San Roque Dam	1,250	8,300	10.4
Agno River Basin (N17)	1,310	8,100	10.7
Allied River Basins (N18-N37)	975	8,000	7.8
Southern Cordillera (N1-N37)	2,285	8,100	18.5
Zambales (S1-S22)	1,949	7,400	14.4
Study Area (N1-37 & S1-S22)		7,800	16.6

* : Mountain area only

6.1.2 Discharge of Mine Tailings

(1) Production of Ore

The southern area of the Cordillera Central Mountain Range is the most important mining district in the Philippines and is dotted with many copper and gold mines as shown in Figure 6.1.3. There are three major mine companies in the Agno River basin. The annual average production of ore by the three companies is reported to be 10,837,000 tons, and their main disposal systems are provided to convey and deposit milled tailings in the tailings dams. The present state of these mining activities and disposal systems is summarized in Table 6.1.4.

(2) Monitoring Sediment Yield

The report "Restudy of San Roque Multi-purpose Dam Project" (JICA, 1985) dealt with the flow amount of mine tailings and monitored the suspended load downstream of major tailings dams. The annual suspended load at three stations (B, C, D) located downstream of the three major mining areas (see Figure 6.1.3) is estimated from monitored records as shown in Table 6.1.5. The total annual suspended load at these sites, which is composed of natural sediment and partly of sediment from mine tailings, is estimated at 640,000 m^3/yr (or 1,020,000 tons/yr).

(3) Sediments Deposited in ARIS

The results of grain size distribution analysis of sampled sediments in the main and lateral canals of Agno River Irrigation System (ARIS) show that the major component (about 90%) of the sediment is sand (larger than 0.42 mm). On the other hand, over 60% of the samples taken from the mine tailing dams are composed of silt and/or clay (smaller than 0.074 mm).

(4) Tailings Dam and Related Facilities

A series of site reconnaissances over the mining areas and tailings dams of the three mine companies were conducted from June to September, 1989. The inspection results suggest that the treatment of mine tailings was done fairly well and no particular defects in the tailings dam structures were observed, at least during the inspection period.

(5) Preliminary Assessment of the Amount of Mine Tailings

It is rather difficult to assess the sediment discharge amount from the existing mines quantitatively since there is no definitive records.

However, the findings described in the foregoing paragraphs suggest that it is rather difficult to assume that the major source of the sediment deposited downstream of San Roque in the Agno River, especially in the ARIS irrigation facilities, is mine tailings

It can be inferred that the discharge of mine tailings will not affect the lower reaches of the Agno River so seriously if the following conditions are held:

1) The amount of ore is not over the present level, in the order of 10 million m^3/year.
2) The present condition of the disposal system is continued or improved.
3) The amount of ore milled from illegal mines is not increased.

In case the production of ore is increased in the future, it will be necessary to improve the disposal system and to impose legal controls on the illegal mines.

6.2 Sediment Balance Analysis

6.2.1 River Bed Fluctuations in the Existing Channels

A Study on river bed fluctuations in the existing channels of the Agno River main course, the Tarlac River, and the Banila River was conducted by using river bed cross sections surveyed in 1981 and 1989. The results are summarized as follows:

River	Stretch	Condition of River Bed Fluctuation
Agno	River mouth - Wawa	Aggradation; especially large sedimentation from river mouth to Urbiztondo
	Wawa - Santa Maria	Degradation; scouring the narrow pass around Carmen Bridge.
	Santa Maria - San Roque	Aggradation; the alluvial fan formulated with river bed materials composed of large sized grains
Tarlac	Confluence - Tagumbao	Aggradation; at Poponto Swamp and the stretch from Paniqui to Tagumbao
Banila	Confluence - Lapaz Lapaz - Umingan	Degradation Sediment deposition

The deepest river bed fluctuation and annual sediment volume of the existing channels of the Agno River, the Tarlac River and the Banila River are illustrated in Figure 6.2.1. No records are available for the other rivers.

6.3.2 Sediment Transport Capacity

(1) River Bed Materials

Sampling of the river bed materials was conducted by the Study Team and gradation tests were done by DPWH during the study period.

The sampling sites for river bed materials were selected along the courses of the Agno River, its major tributaries and the Allied Rivers. Their locations and particle sizes are shown in Figure 6.2.2. River bed materials in the upper reaches of the Agno River down to San Manuel are composed mainly of gravel and coarse sand (2.0-76.2 mm). The main bed materials gradually change into sand from the beginning of the alluvial fan in San Manuel to the confluence with the Tarlac River at Wawa (0.074-0.42 mm). At Wawa and the rivermouth, the content of sand and silt increases up to 50%. In the lower reaches of the Agno River, the bulk of the sediment is composed of silt (smaller than 0.074 mm).

(2) Sediment Discharge Rating Curves

The following formulas are employed for estimating the sediment discharge rating curves:

Bed load	:	Sato-Kikkawa-Ashida's formula
Suspended load	:	Lane-Kalinske's formula
Wash load	:	$Qws = A\ Qw^2$

Where,

Qws	:	Volume of wash load (tons/day)
Qw	:	Flow discharge (m^3/sec)
A	:	Constant

The grain size distribution obtained from test results of sampled river bed materials is used for the calculation. The reference points of the sediment discharge rating curves are selected along the Agno River and its major tributaries taking into account the stretches of design river channel, the base points of sediment control and the sampling sites of bed load discharge. The location of the reference points is shown in Figure 6.2.3.

(3) Annual Sediment Transport Capacity

The annual sediment transport capacity of the Agno River and its tributaries is estimated by using the factors of the sediment discharge rating curves presented in Table 6.2.1. The estimate is based on the daily discharge for twenty-seven years from 1960 to 1986 at San Roque.

The transport capacity of the Agno River decreases in the transition portion between the mountain area and the alluvial fan,and tends to increase in the narrow stretch from Santa Maria to Wawa. The capacity of the design channel in the Framework Plan is mostly much larger than that of the existing channel, the difference is about 570,000 m^3/yr at the maximum point as shown in Figure 6.2.4. The tendency of capacity fluctuation between the existing and the design conditions is approximately the same.

Table 6.1.1 SEDIMENT YIELD AT AMBUKLAO AND BINGA DAMSITES

No.	Item	Unit	Ambuklao	Binga	Remarks
1.	Drainage Area	km2	617	860	
2.	Sedimentation Record	mil.m3/yr.	3.6	1.2	(2)=(4)/(3)
3.	Period	yrs.	30(1956-1986)	26(1960-1986)	
4.	Sediment Volume	mil.m3	108	31.32	
5.	Annual Inflow	mil.m3	1287 <1	1807 <1	
6.	Annual Runoff Depth	mm	2,086	2,101	(6)=(5)/(1)
7.	Reservoir Capacity	mil.m3	329	87.4	
8.	Capacity/Inflow	-	0.26	0.048	(8)=(7)/(5)
9.	Trap Efficiency	%	97	85	by Brune's Diagram
10.	Sediment Trapped by Upper Dam	mil.m3/yr.	-	3.6	
11.	Sediment Yield	mil.m3/yr.	3.71	5.01	(11)=(2)/(9)+(10)
12.	Sediment Yield Rate	m3/km2/yr.	6,143	5,917	(12)=(11)/(1)

Data Source : Sedimentation Studies of Ambuklao & Binga Reservoir, NAPOCOR, 1988
Note : <1 : Re-Study of the San Roque Multi-Purpose Project Final Report, JICA, 1985

Table 6.1.2 NATURAL SEDIMENT YIELD IN SOUTHERN CORDILLERA MOUNTAINS (1/2)

Sub-Basin Unit No.	Area of Sub-Basin (km2)	(1) Mountain Area of Sub-Basin (km2)	Area of each Land (km2) Land Fall (La)	Bare Land (Ba)	Partial Forest Land (Va)	Forest (Fa)	(2) Annual Sediment Yield (10^6m3/yr) (MS)	(3) Sediment Yield Rate (m3/km2/yr)	Remarks Mountain Area in Sub-Basin (MA:%)
M1	48	48	0.023	0.24	21.03	26.71	0.20	4,208	
M2	56	56			13.03	42.97	0.14	2,510	
M3	60	60	0.018	1.54	41.77	16.67	0.40	6,750	
M4	33	33	0.015	0.27	8.62	24.10	0.11	3,474	
M5	55	55	0.048	1.78	16.17	37.00	0.30	5,457	
M6	68	68	0.110	2.29	19.62	45.98	0.41	5,995	
M7	41	41	0.030	1.52	10.14	29.31	0.22	5,422	
M8	72	72	0.009	4.37	16.92	50.70	0.47	6,469	
M9	103	103	0.086	2.98	19.33	80.60	0.48	4,660	
M10	81	81	0.187	4.10	21.92	54.79	0.60	7,429	
Sub-Total (M1-M10)	617	617	0.526	19.09	188.55	408.83	3.33	5,413	Ambuklao Dam Basin Sediment Yield Data 3.71 x 10^6m3/yr
M11	143	143	0.122	7.48	24.48	110.92	0.87	6,076	
M12	100	100	0.117	10.67	32.72	56.49	1.06	10,557	
Sub-Total (M1-M12)	860	860	0.765	37.24	245.75	576.24	5.26	6,121	Binga Dam Basin Sediment Yield Data 5.01 x 10^6m3/yr
M13	80	80	0.125	2.07	41.00	36.81	0.53	6,627	
M14	111	111	0.043	44.90	20.53	45.53	3.14	28,280	(Tanu Planning Dam)
M15	94	94	0.036	2.63	18.63	72.70	0.41	4,361	
M16	105	105	0.043	11.97	19.22	73.77	1.03	9,779	
Sub-Total (M1-M16)	1,250	1,250	1.012	98.81	345.13	805.05	10.37	8,296	San Roque proposed Dam Basin
M17	85	60		1.17	25.88	32.95	0.29	4,785	(MA:70%)
Sub-Total (M1-M17)	1,335	1,310	1.012	99.98	371.01	838.00	10.66	8,135	Agno River Basin

Table 6.1.2 NATURAL SEDIMENT YIELD IN SOUTHERN CORDILLERA MOUNTAINS (2/2)

Sub-Basin Unit No.	Area of Sub-Basin (km2)	(1) Mountain Area of Sub-Basin (km2)	Area of each Land (km2): Land Fall (La)	Bare Land (Ba)	Partial Forest Land (Va)	Forest (Fa)	(2) Annual Sediment Yield (10^6m3/yr) (MS)	(3) Sediment Yield Rate (m3/km2/yr)	Remarks Mountain Area in Sub-Basin (MA:%)
M18	151	151	0.020	13.50	50.00	87.48	1.33	8,803	
M19	119	119		28.94	30.11	59.95	2.15	18,107	Lower Ambayoan
M20	40	40		8.20	1.76	30.04	0.58	14,587	Proposed Dam
M21	53	53		11.34	4.00	37.66	0.81	15,322	
M22	50	50		1.30	1.25	47.45	0.15	3,086	(MA:20%)
M23	39	39	0.047	0.54	4.10	34.31	0.14	3,510	
M24	29	6	0.018	0.27	0.81	4.90	0.04	6,815	(MA:20%)
M25	69	66	0.077	3.38	9.68	52.86	0.40	6,082	(MA:95%)
M26	73	44	0.112	1.17	10.58	32.14	0.26	5,895	(MA:60%)
M27	93	14	0.016		3.24	10.74	0.05	3,245	(MA:15%)
M28	75	75		7.04	9.88	58.08	0.60	7,964	
M29	15	15		1.27	4.01	9.72	0.12	8,083	
M30	16	8		0.09	1.62	6.29	0.02	3,070	(MA:50%)
M31	21	17		0.23	12.58	4.42	0.09	5,148	(MA:80%)
M32	66	10			2.93	6.84	0.04	4,289	(MA:15%)
M33	66	56		0.32	5.49	50.19	0.12	2,174	(MA:85%)
M34	44	13		0.18	2.30	10.52	0.04	3,102	(MA:30%)
M35	80	80	0.034	1.94	21.24	56.79	0.36	4,501	
M36	102	92	0.016	3.65	12.05	76.28	0.43	4,621	M 35.36 Bued River Basin (MA:90%)
M37	67	27		0.45	6.71	19.84	0.10	3,654	(MA:40%)
Sub-Total (M18-M37)	1,268	975	0.340	83.81	194.34	696.50	7.83	8,038	Allied River Basin
Total (M1-M37)	2,603	2,285	1.352	183.79	565.35	1,534.50	18.49	8,094	North Area

Table 6.1.3 NATURAL SEDIMENT YIELD IN ZAMBALES MOUNTAINS

Sub-Basin Unit No.	Area of Sub-Basin (km2)	(1) Mountain Area of Sub-Basin (km2)	Area of each Land (km2): Land Fall (La)	Bare Land (Ba)	Partial Forest Land (Va)	Forest (Fa)	(2) Annual Sediment Yield (10^6m3/yr) (MS)	(3) Sediment Yield Rate (m3/km2/yr)	Remarks Mountain Area in Sub-Basin (MA:%)
S1	119	119	0.054	18.43	15.63	84.89	1.44	12,143	
S2	39	39	0.025	7.67	6.85	24.46	0.59	15,157	
S3	121	121		7.02	11.12	102.86	0.66	5,474	Lower O'Donnell proposed Dam Site
S4	29	17				17.00	0.02	1,300	(MA:75%)
S5	283	283	0.304	32.21	12.08	238.41	2.68	9,469	Balog-Balog Dam Site
S6	254	254	0.104	24.37	25.89	203.64	2.08	8,207	Moriones proposed Dam
S7	34	34			0.86	33.14	0.05	1,432	
S8	138	104			0.32	103.68	0.14	1,316	(MA:75%)
S9	221	221	0.284	13.73	13.13	193.86	1.41	6,400	Camiling proposed Dam
S10	20	20		1.08	1.80	17.12	0.10	5,208	
S11	42	21		0.32	2.57	18.11	0.06	2,907	(MA:50%)
S12	190	114		2.03	13.85	98.12	0.35	3,066	(MA:60%)
S13	105	63	0.050	2.87	5.21	54.87	0.32	5,147	(MA:60%)
S14	146	124	0.190	10.06	10.41	103.34	0.98	7,898	(MA:85%)
S15	130	130	0.074	16.26	27.54	86.13	1.40	10,738	
S16	21	13	0.036	2.00	0.51	10.45	0.17	13,100	(MA:60%)
S17	78	31		5.27	7.38	18.35	0.41	13,367	(MA:40%)
S18	64	64	0.034	8.57	21.54	33.86	0.76	11,925	
S19	8	8		0.15	0.25	7.60	0.02	2,657	
S20	54	43		1.13	12.19	29.68	0.19	4,448	(MA:80%)
S21	72	61		0.50	22.99	37.51	0.23	3,782	(MA:85%)
S22	129	65	0.022	1.31	19.35	44.32	0.28	4,351	(MA:50%)
Total (S1-S22)	2,297	1,949	1.177	154.98	231.47	1,561.40	14.34	7,375	

Table 6.1.4 SUMMARY OF OPERATING MINES ALONG AGNO AND BUED RIVERS

Mine	Production of Ore <1 (1000DMT)	Daily Milling Capacity (MT)	Tailing Dam Capacity (MT)	Start of Use	Present Dam Status	Cost	Remarks
A. AGNO RIVER							
1. Philex Mines	9,521	27,500 Copper ore	Dam #1 85,375,342	1969	Completely filled-up (Dec. 1988)	P10 M	in 1976, the dam was washed out due to typhoon "Dading". It was re-built the same year.
			Dam #2 57,417,615	1981	51% full (good until Feb. 1991)	P38 M	
			Dam #3 142,596,768	Jan. 1990	under construction	P84.8 M (initial construction cost)	
2. Benguet Corp.	1,199	3,500	Dam #1 6,121,000	Mar. 1969	Completely filled-up June, 1986	P6.33 M	of the total mill tailings producted, 16% is recovered as sandfill for underground openings and the remaining volume is impounded in the dams.
			Dam #2 7,075,000	June 1977	Completely filled-up Nov. 1986	P56.03 M	underground openings and the remaining volume is impounded in the dams.
			Dam #3 3,930,000	Nov. 1986	10% filled-up as of May, 1988	P35.36 M	this dam will be constructed in two stages.
3. Itogon-Suyoc Mines	117	350	1,091,724	1981	76% filled	P1326 M	dam construction is atill going on
Sub-total	10,837						
B. BUED RIVER							
1. Benguet Explo. Inc.	62	150					Tailings are being dumped into their underground opening. Surface ponds are used as contingency meas.

Data source : Memorandum Report on Technical Data needed by DPWH and JICA
Note : <1 : Average from 1985 to 1988

Table 6.1.5 ANNUAL SUSPENDED LOAD DISCHARGE OF FIXED POINTS B-E

Fixed Point	Location	Annual Suspended Load Discharge (1,000 ton/yr)	(1,000 cu.m/yr) <1
B	Ambalanga River, Downstream of Benguet Corp. and I.S.M.I. mines	198	124
C	Albian Creek, Downstream of Tailing's Dam No. 1 of Philex	661	413
D	Manaa Creek, Downstream of Tailing's Dam No. 2 of Philex	159 <2	99 <2
	Sub-Total	1,018	636
E	Agno River, Downstream of San Roque Dam Site	5,163	3,227

Note :
<1 : Unit weight of 1.6 ton/cu.m was assumed.
<2 : Since the correlation between discharge and suspended load was not observed, the average load of 455 ton/day was used for the estimate.

Table 6.2.1 CONSTANTS FOR SEDIMENT DISCHARGE RATING CURVE

Reference Point		EXISTING CHANNEL				DESIGN CHANNEL			
		Bed Load (ton/day)		Suspended Load (ton/day)		Bed Load (ton/day)		Suspended Load (ton/day)	
		ALPHA	BETA	ALPHA	BETA	ALPHA	BETA	ALPHA	BETA
AGNO									
P-1		1.124	1.358	0.357	1.510	0.058	1.851	0.127	1.715
P-2		0.485	1.346	0.633	1.322	0.120	1.607	0.064	1.714
P-3		0.137	1.386	0.025	1.676	0.260	1.387	0.028	1.749
P-4		0.401	1.224	0.006	1.871	0.909	1.145	0.016	1.773
P-5		0.122	1.377	0.086	1.707	0.376	1.254	0.176	1.637
P-6		1.458	0.961	0.516	1.403	0.575	1.145	0.250	1.547
P-7		0.554	1.156	0.237	1.559	0.311	1.266	0.159	1.638
P-8		1.113	1.042	0.401	1.471	0.512	1.131	0.184	1.678
P-9		0.150	1.128	0.035	1.714	0.230	1.131	0.060	1.701
P-10		0.452	0.868	0.031	1.451	0.056	1.208	0.002	1.857
AMBAYOAN									
P-11		0.009	2.215	0.128	1.809	3.963	1.295	0.382	1.649
P-12		0.007	2.143	0.414	1.571	0.303	1.567	0.252	1.668
VIRAY-DIPALO									
P-13		1.634	1.685	1.063	1.596	16.256	1.477	2.483	1.562
P-14		1.184	1.718	0.631	1.687	4.250	1.662	2.009	1.555
P-15		0.111	1.461	0.127	1.785	0.053	1.913	0.113	1.866
BANILA									
P-16		5.320	1.364	0.240	1.561	70.949	1.070	0.871	1.717
P-17		0.037	1.907	0.121	1.449	1.177	1.500	0.064	1.806
P-18		0.752	1.146	0.058	1.463	0.082	1.789	0.020	1.576
TARLAC									
P-19		0.369	1.250	0.281	1.654	1.293	1.178	0.884	1.576
P-20		1.318	1.029	1.174	1.452	0.866	1.123	0.779	1.537
O'DONNELL									
P-21	<2	0.688	1.374	0.280	1.727	0.688	1.374	0.280	1.727
MORIONES									
P-22	<2	0.000	3.200	0.414	1.418	0.000	3.200	0.414	1.481
CAMILING									
P-23		0.472	1.330	0.100	1.753	0.007	2.325	0.135	1.815
P-24		0.458	1.418	0.013	1.780	0.059	1.858	0.006	2.017
OLO									
P-25	<2	0.311	1.862	0.030	1.930	0.311	1.862	0.030	1.930
BAYAOAS									
P-26	<2	1.215	1.535	0.026	1.937	1.215	1.535	0.026	1.937
TUBOY									
P-27	<2	4.507	1.349	3.725	1.626	4.507	1.349	3.725	1.626
ANGALACAN									
P-28	<2	6.532	1.448	0.920	1.530	6.532	1.448	0.920	1.530
BUED									
P-29	<2	0.479	1.747	2.388	1.425	0.479	1.747	2.388	1.425

Note: <1 : Qs = ALPHA * Q^BETA
Where, Q : Flow Discharge (m3/s)
Qs : Sediment Discharge (m3/s)

<2 : River improvement is not carried out.

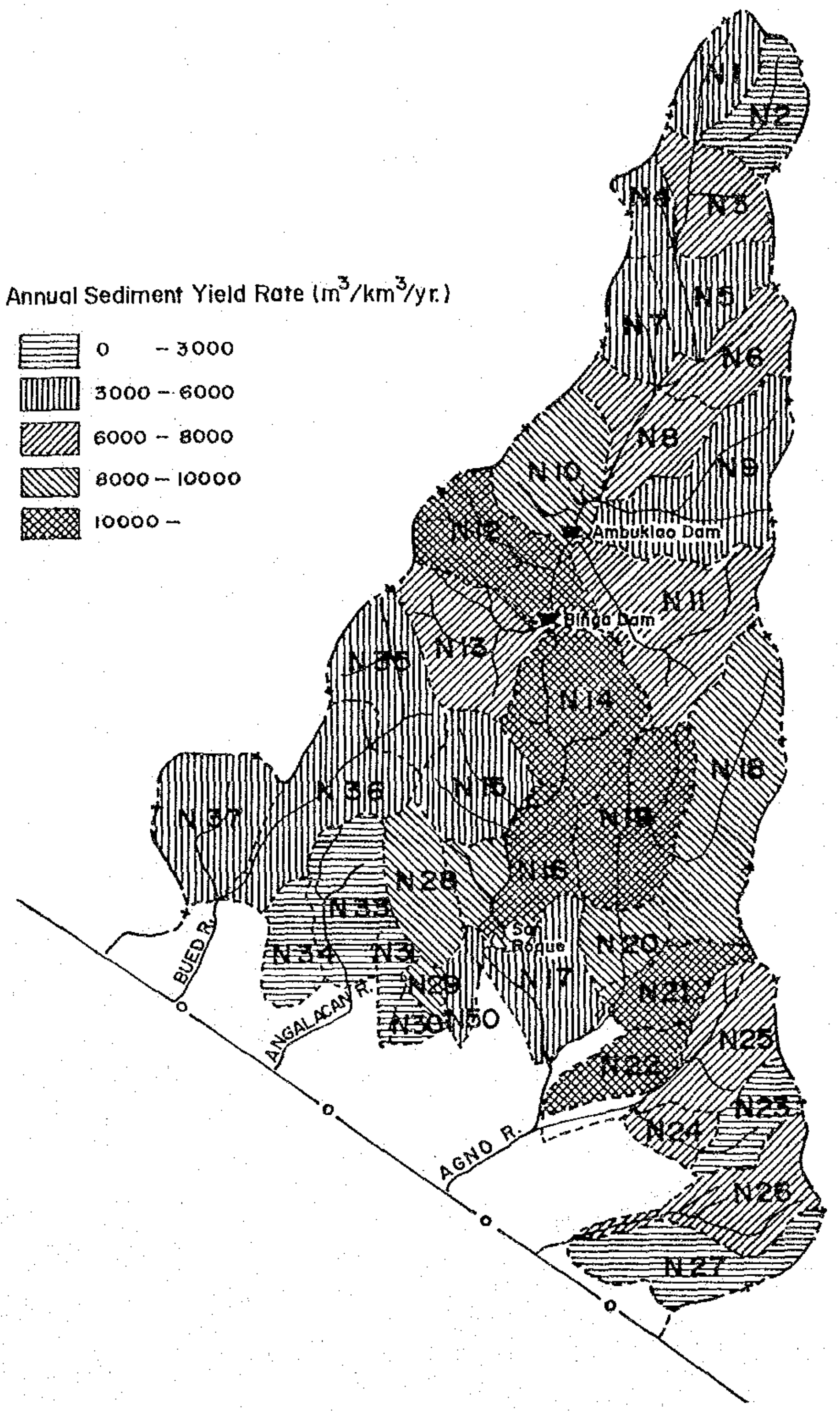

Fig. 6.1.1 THE AREA DISTRIBUTION OF SEDIMENT YIELD IN SOUTHERN CORDILLERA MOUNTAINS

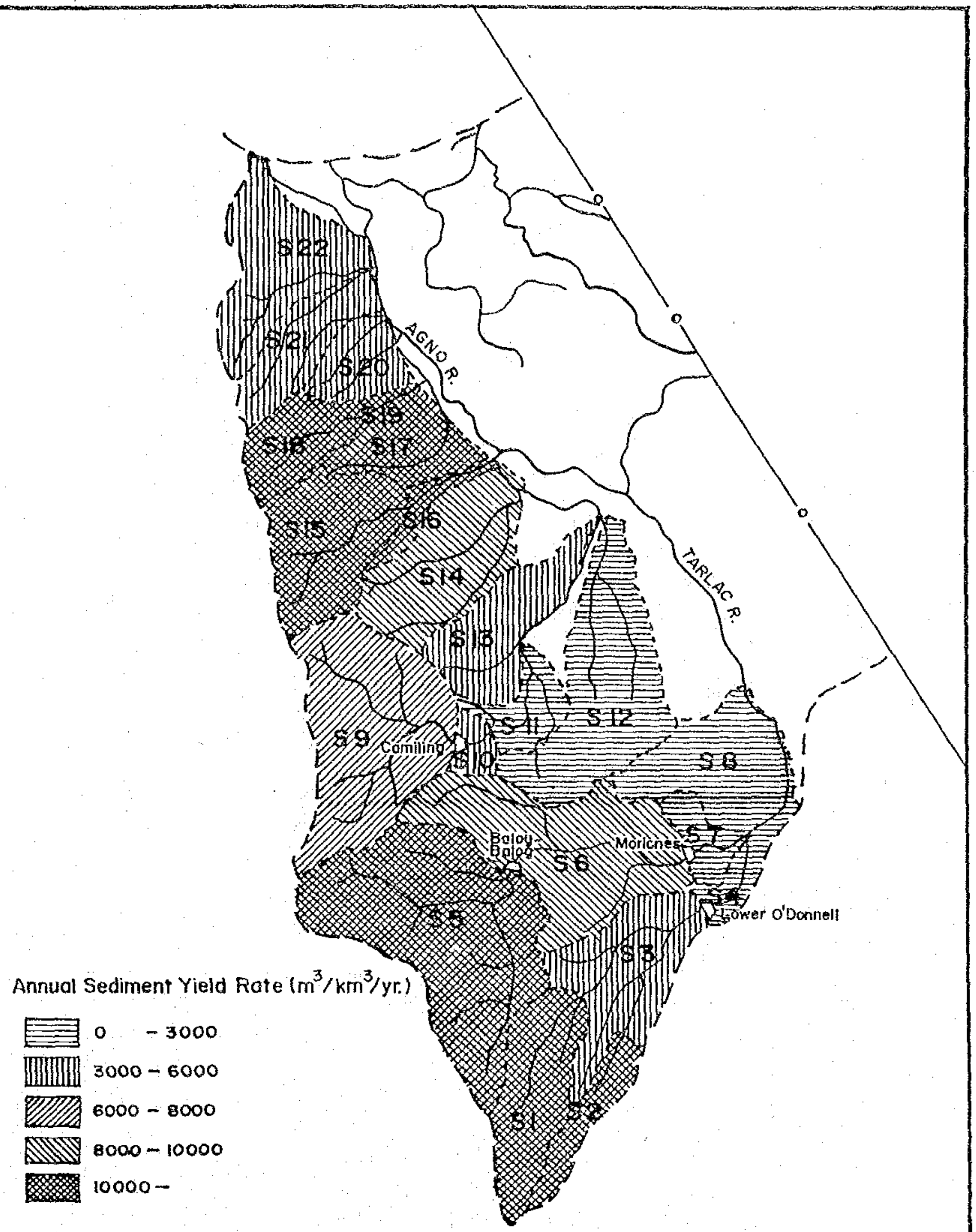

Fig. 6.1.2 THE AREA DISTRIBUTION OF SEDIMENT YIELD IN ZAMBALES MOUNTAINS

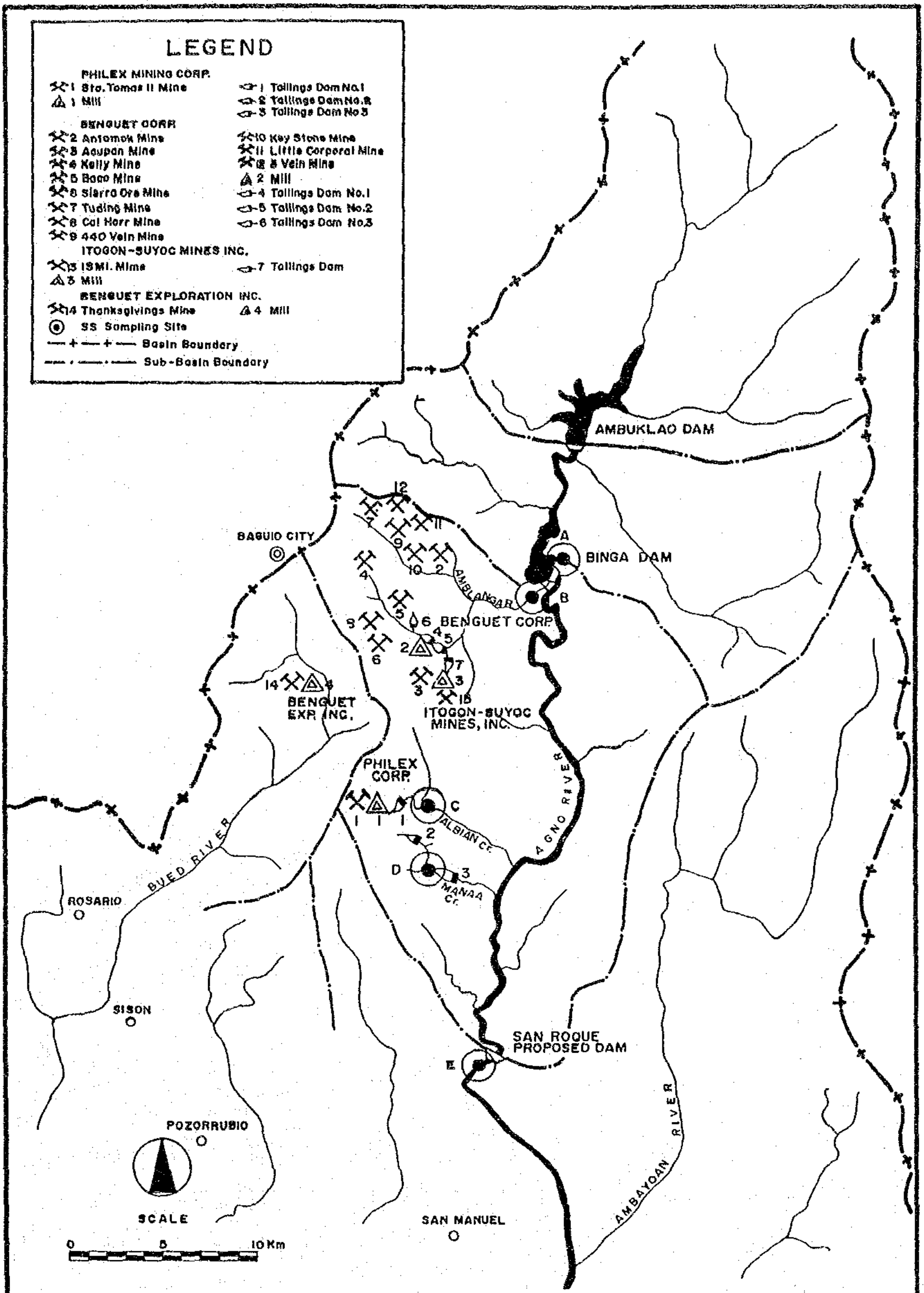

Fig. 6.1.3 LOCATION MAP OF MINES INDUSTRY AREA

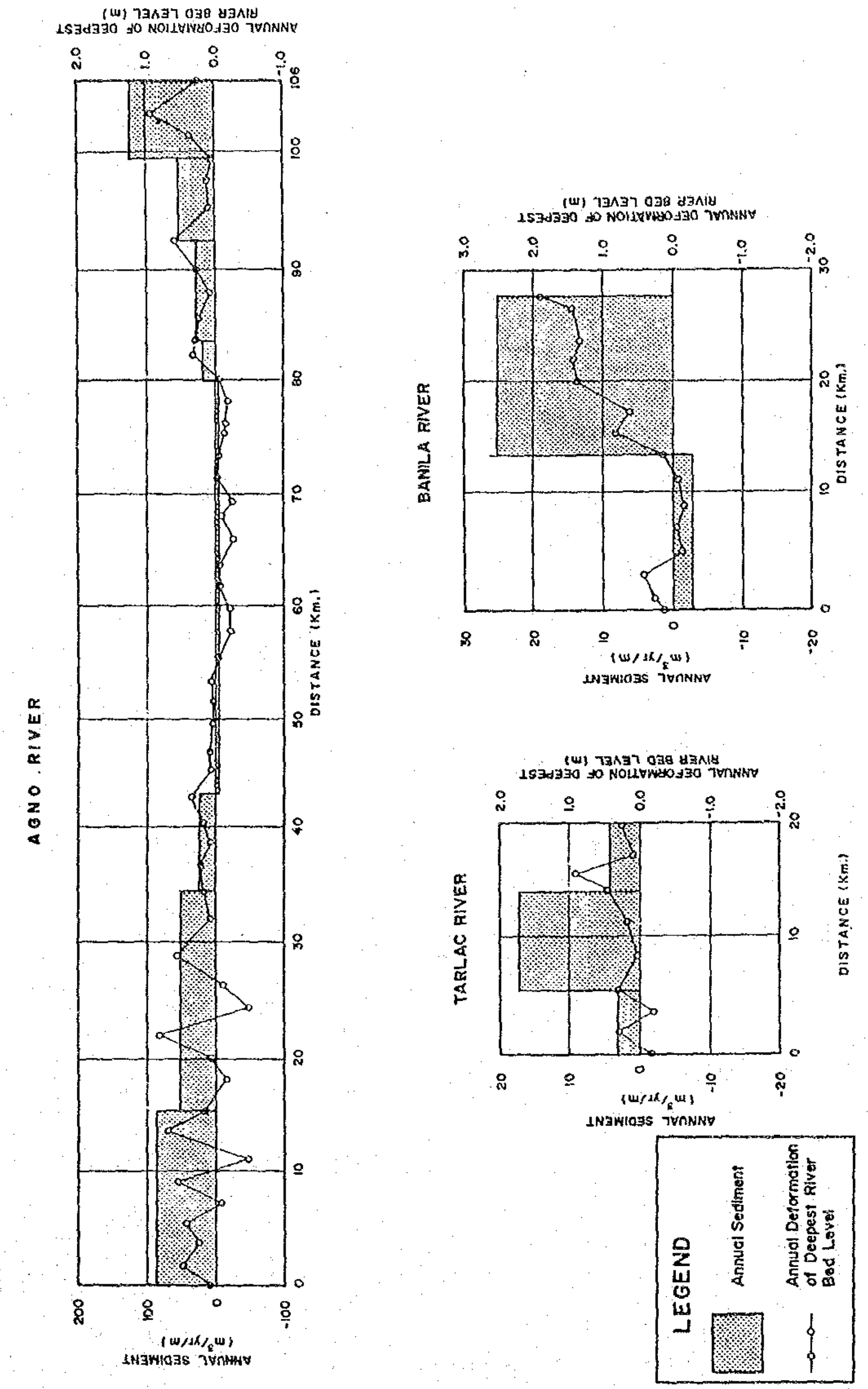

Fig. 6.2.1 ANNUAL SEDIMENT AND DEFORMATION OF DEEPEST RIVER BED LEVEL OF EXISTING CHANNEL

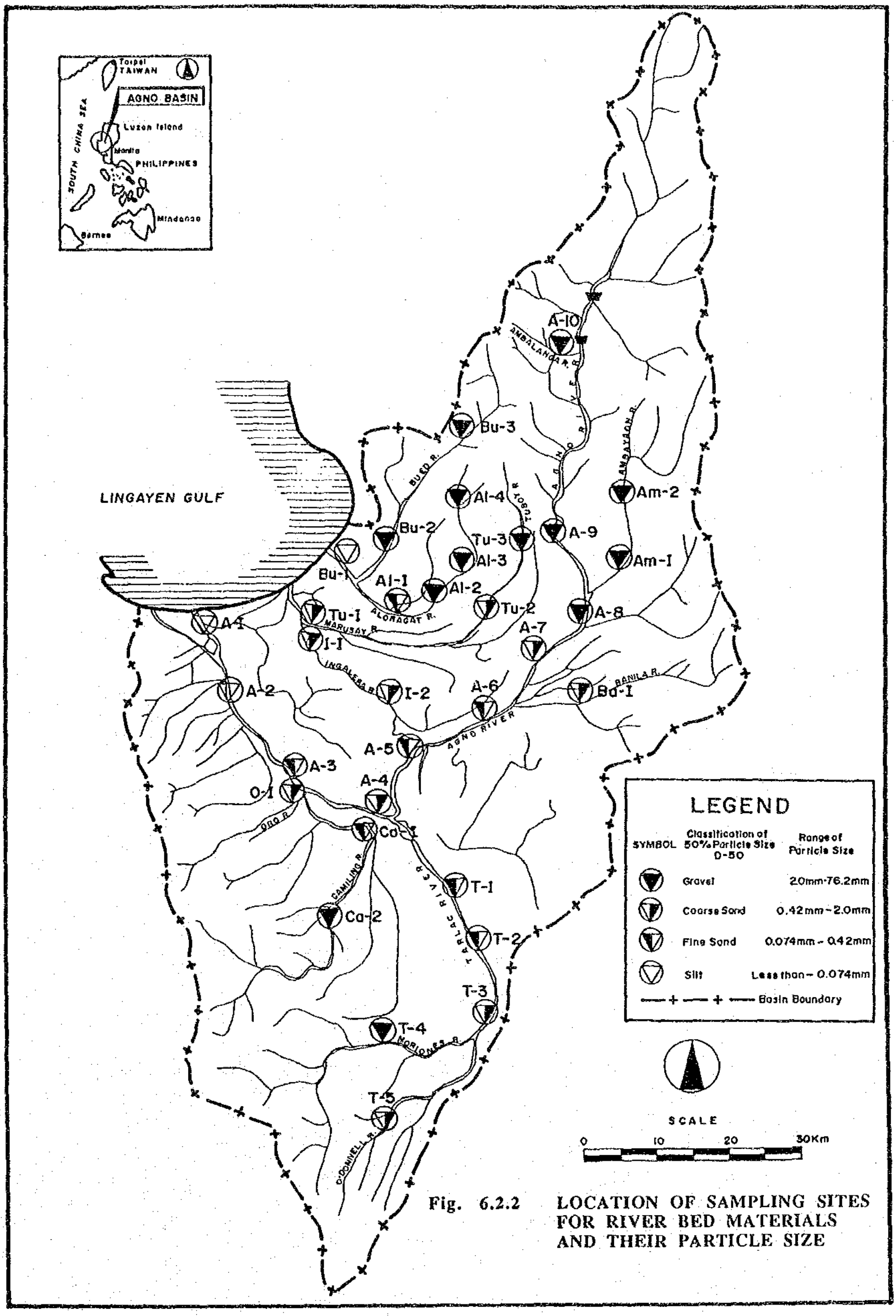

Fig. 6.2.2 LOCATION OF SAMPLING SITES FOR RIVER BED MATERIALS AND THEIR PARTICLE SIZE

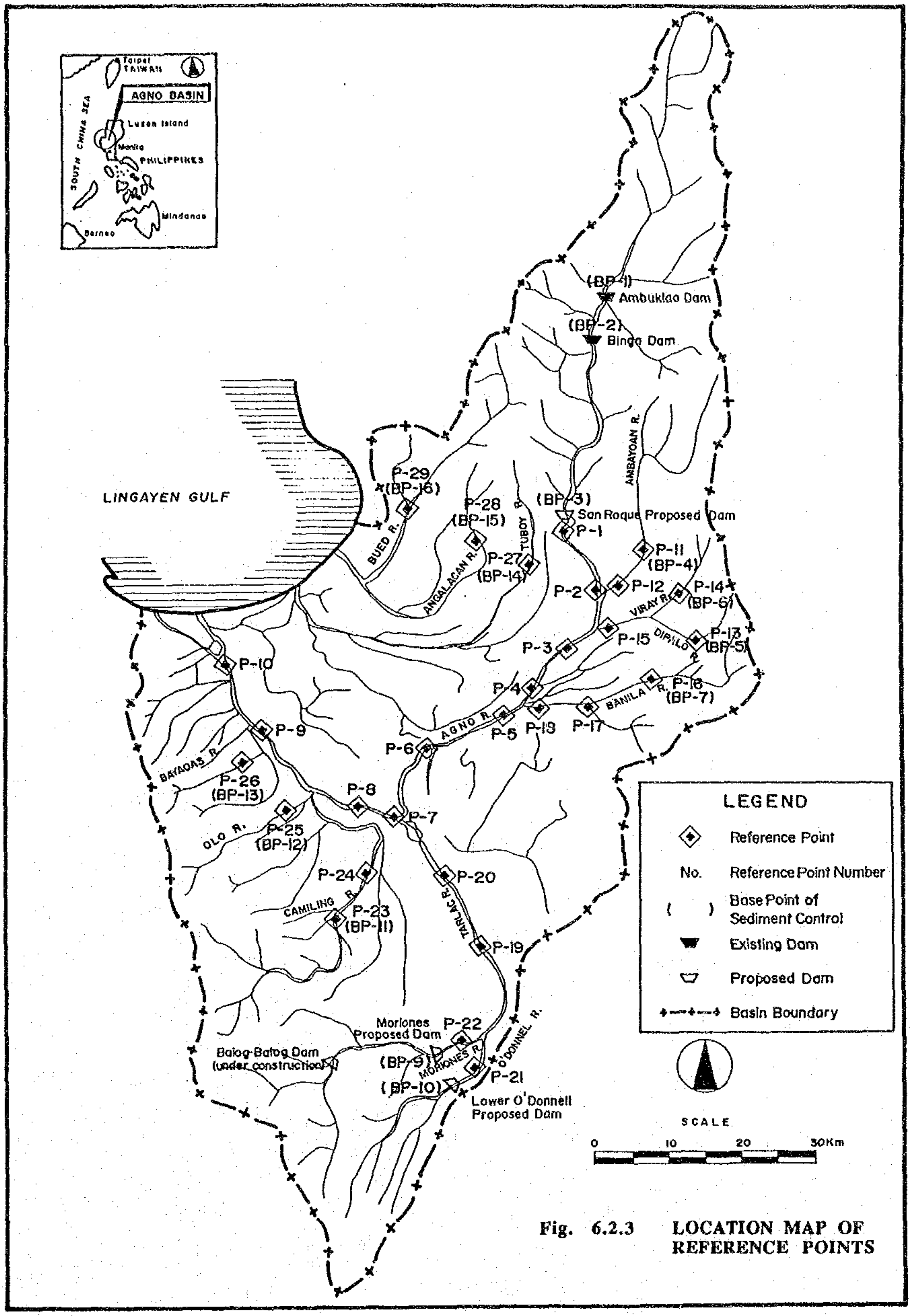

Fig. 6.2.3 LOCATION MAP OF REFERENCE POINTS

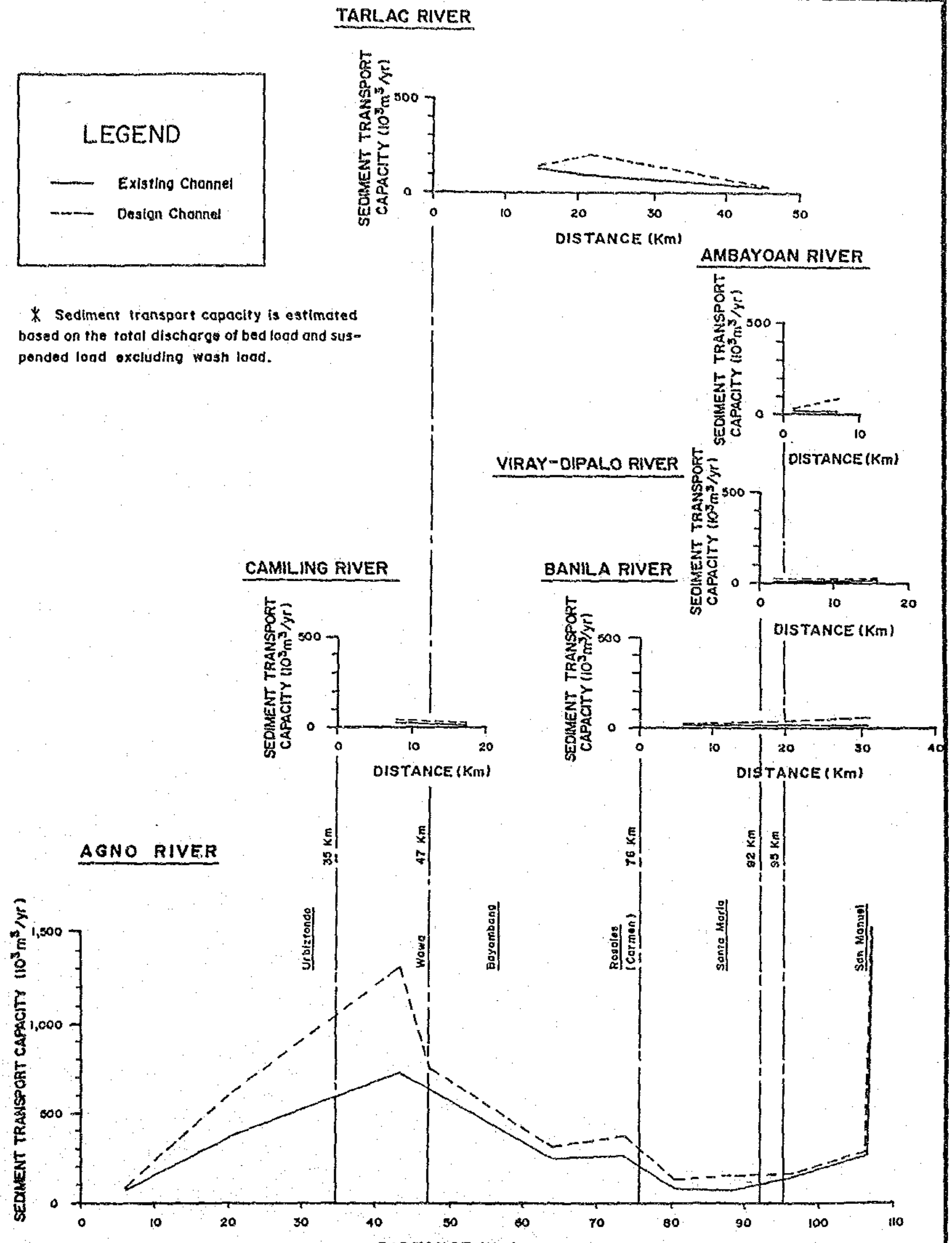

Fig. 6.2.4 ANNUAL SEDIMENT TRANSPORT CAPACITY

7. GEOLOGY

7. GEOLOGY

7.1 Physiography of the Study Area

Physiography of the Agno River basin is divided into three provinces. One is the South Cordillera Mountains. This province is the northern mountainous area ranging in altitude from about 70 to 2,900 meters, and includes the Agno, Ambayoan, Tuboy and Bued Rivers. The second is the Central Luzon Plain. This province is the central widespread plain area ranging in altitude from 0 to 380 meters, and includes the Agno and Tarlac Rivers and the Poponto swamp. The third is the Zambales Mountains. This province is the southwestern mountainous area ranging in altitude from about 20 to 1,700 meters, and includes the O'Donnell, Moriones (Bulsa) and Camiling Rivers.

7.2 Geology of the Agno River Basin

The Agno River basin is underlain by sedimentary rocks, igneous rocks and metamorphic rocks of Jurassic to Quarternary age as shown in Figure 7.2.1. Sedimentary rocks consist of sandstone, conglomerate and siltstone of Tertiary age. These sedimentary rocks are distributed in the Bued and Tuboy River basins, upper and downstream basin of the Agno River and eastern area of the Zambales Mountains.

The igneous rocks are divided into volcanic and intrusive rocks. The volcanic rocks consist of andesetic to dacitic plugs and basaltic to dacitic lavas and pyroclastics of Quaternary age. These plugs are exposed in Mt. Pulag, Pinatubo and isolated mountains in the Central Luzon Plain and eastern foot of the Zambales Mountains. The intrusive rocks consist of diorite of Neogene age and ultramafic rocks of Cretaceous to Paleogene age. The former called the Agno batholith is widespread in the South Cordillera Mountains. The latter consists of predominantly peridotite, gabbro, and diabase dykes, composing majority of the Zambales Mountains.

Metamorphic rocks are the oldest rock in the basin and consist of metasediments and metavolcanics of probably Jurassic, Neogene age. These rocks are widespread in the South Cordillera Mountains and exposed in a limited area of the Zambales Mountains.

7.3 Geology of the Planned Dam Sites

The geological line of the five damsites selected through the Dam and Retarding Basin studyis are described hereinafter.

San Roque damsite

The feasibility study was prepared by Electroconsult (ELC) in 1981. The damsite is underlain by diorite complex and is considered to be in comparatively good condition from a geological viewpoint. ELC assessed that the fault zones are filled with clay and silt that constitute impervious screens. However, further investigation of the characteristics of these faults will be required. The geological map is shown in Figure 7.3.1.

Lower Ambayoan damsite

The damsite is underlain by metavolcanics, and is considered to be in good geological condition. An investigation of the damsite and reservoir, especially concerning the inferred fault along the Ambayoan River and the inferred landslide, is required. The geological map is shown in Figure 7.3.2.

Lower O'Donnell damsite

The damsite is underlain by sedimentary rocks that are sandstone, siltstone and conglomerate, and is considered to be in good or acceptable geological condition. A problem in the reservoir area is water leakage from low saddles. At least two saddle-dams are necessary. The geological map is shown in Figure 7.3.3.

Moriones damsite

The damsite that lies next to Lower O'Donnell damsite is underlain by sedimentary rocks. These rocks are sandstone, siltstone and conglomerate. The damsite is considered to be in good or acceptable geological condition. A problem in the reservoir area is water leakage from low saddles. At least five saddle dams are necessary. The geological map is shown in Figure 7.3.4.

Camiling damsite

The damsite is underlain by ultramafic rocks that are gabbro, peridotite and diabase dyke. In the reservoir area there are several landslides that might be induced to slide by impounding. These landslides occurred in a mainly peridotite area. The damsite is considered to be in acceptable geological condition. The geological map is shown in Figure 7.3.5.

7.4 Geotechnical Assessment of Dike Foundation and Materials

The foundations of the planned dikes along the Agno River have little problem with consolidation settlement.

Rehabilitation of the broken dikes near San Roque has continued for about thirty years, and the existing dike location has moved about 300 meters west of the old dike. The old dike, which is made of silty clay and sand, was eroded and broken by the swift velocity of the Agno River in the narrow river channel during flooding because of its poorly graded sand and gravel materials.

The hilly areas are composed of weathered sedimentary rocks and terrace deposits and may be a suitable source for dike material. Materials in plain areas may be also suitable for dike materials if coarse material and fine material are blended well together.

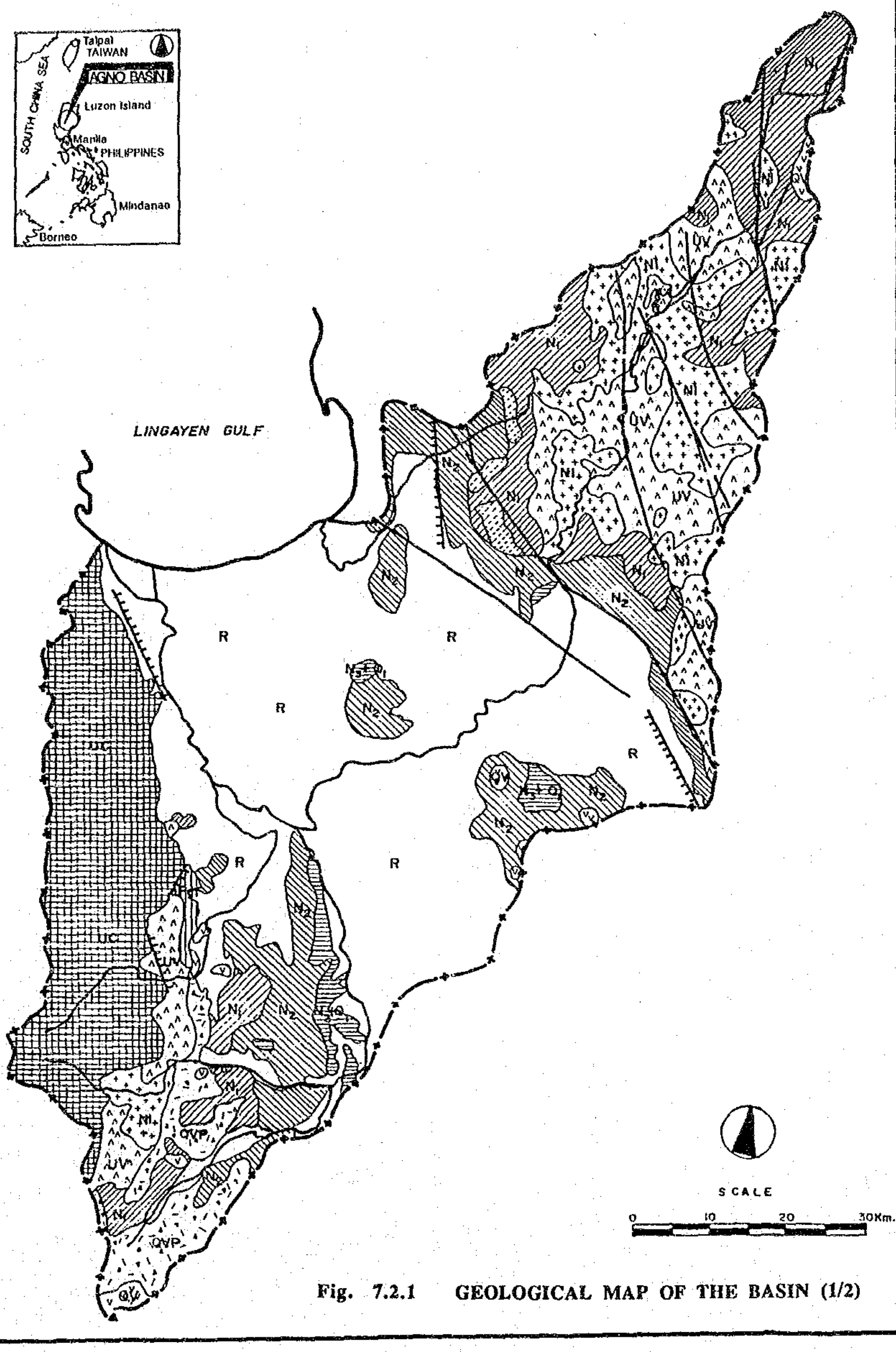

Fig. 7.2.1 GEOLOGICAL MAP OF THE BASIN (1/2)

SEDIMENTARY ROCKS

Symbol	Age	Description
R	Recent	Alluvium, fluvial and beach deposits.
N_3+Q_1	Pliocene-Pleistocene	Marine and terrestrial sediments, associated with reef limestone.
N_2	Upper Miocene-Pliocene	Largely marine clastics overlain by pyroclastics and tuffaceous sedimentary rocks.
N_1	Oligocene-Miocene	Thick, extensive marine deposits, largely wackes, shales and reef limestone, underlain by conglomerate.
Pg_1	Paleocene-Eocene	Thick, extensive marine deposits largely wackes and shales associated with minor conglomerate and reef limestone.

VOLCANIC ROCKS

Symbol	Age	Description
QVP	Pliocene-Quarternary	Volcanic plain or volcanic piedmont deposits, chiefly pyroclastics and volcanic debris at foot of volcanoes.
QV	Pliocene-Quarternary	Non-active cones (generally andesite), also dacitic and andesitic plugs.
N_1	Oligocene-Miocene	Mostly submarine andesite and basalt flows, intercalated with pyroclastics and clastic sedimentary rocks.
UV	Undifferentiated	Metamorphosed submarine flows, largely spilites and basalts. Often designated as "Metavolcanics". Most units probably Cretaceous and Paleogene.

INTRUSIVE ROCKS

Symbol	Age	Description
NI	Neogene	Largely Miocene quartz diorite. Mostly batholiths and stocks, include granodiorite and diorite porphyry facies.
UC	Cretaceous-Paleogene	Undifferentiated ultramafic and plutonic rocks. Predominantly peridotite associated with gabbro and diabase dikes.

GEOLOGICAL SYMBOLS

Formational boundary

High angle fault

Normal fault

Fig. 7.2.1 GEOLOGICAL MAP OF THE BASIN (2/2)

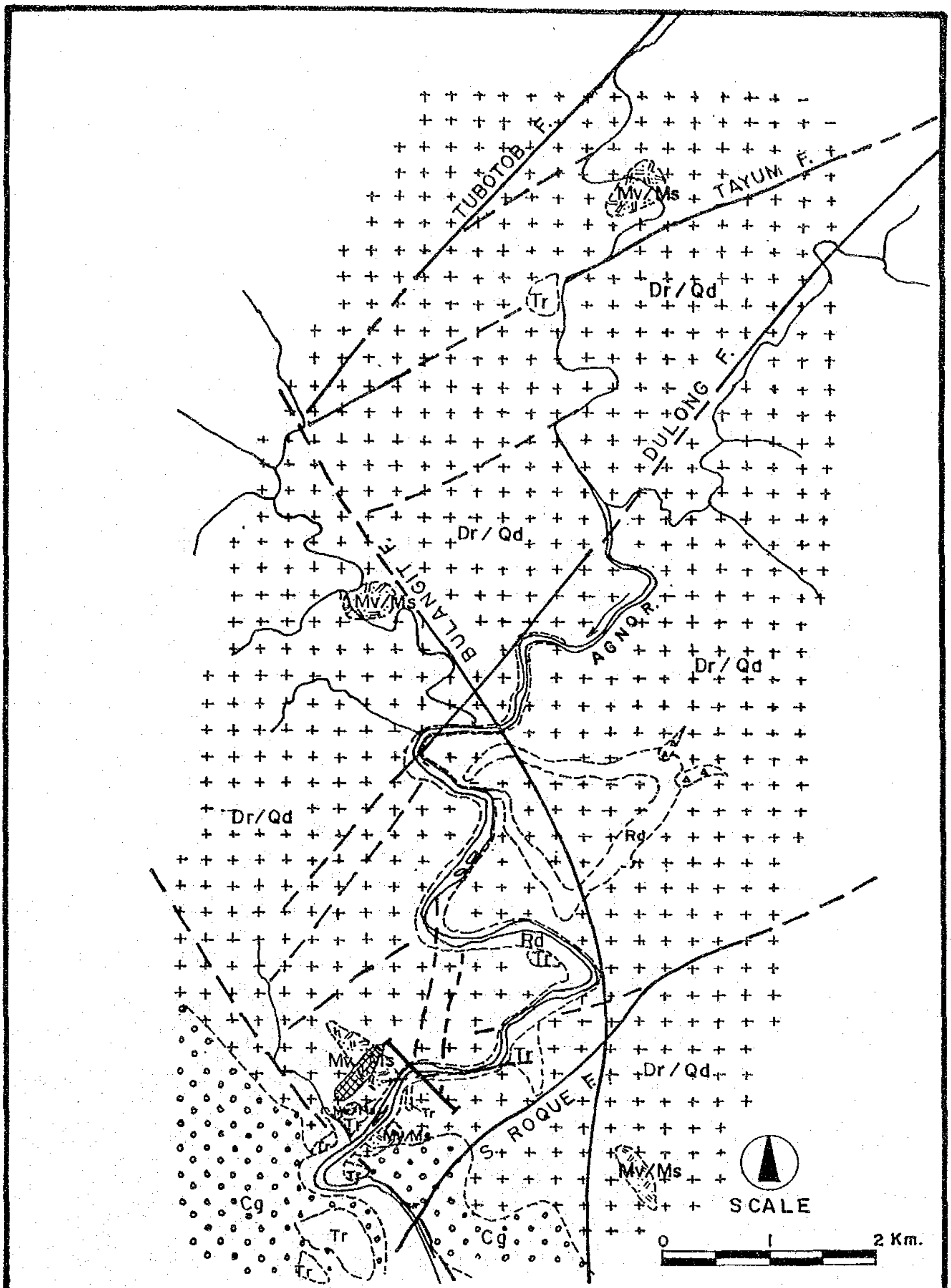

Fig. 7.3.1 GEOLOGICAL MAP OF SAN ROQUE DAMSITE
(See Legend in Fig. 7.3.6)

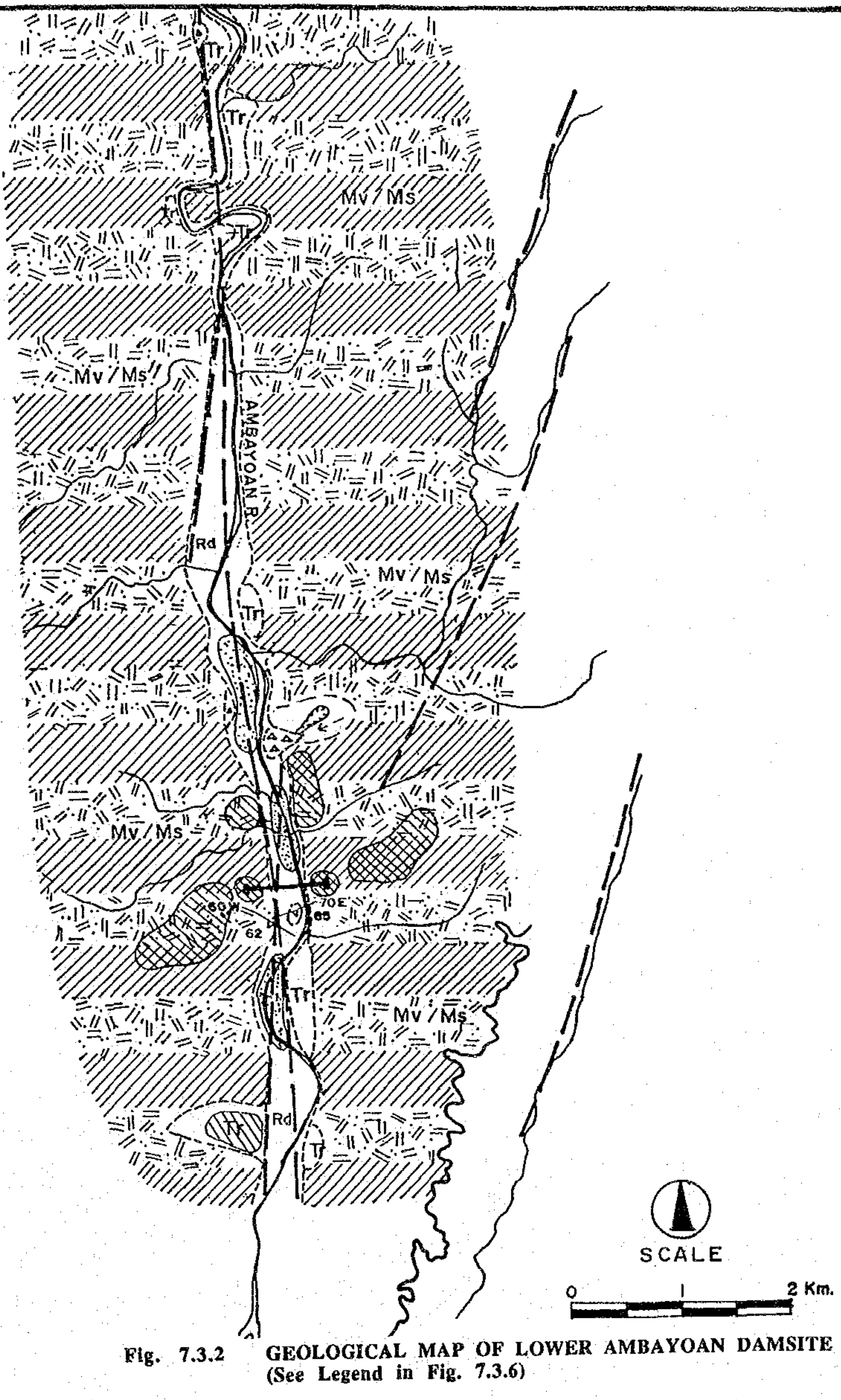

Fig. 7.3.2 GEOLOGICAL MAP OF LOWER AMBAYOAN DAMSITE (See Legend in Fig. 7.3.6)

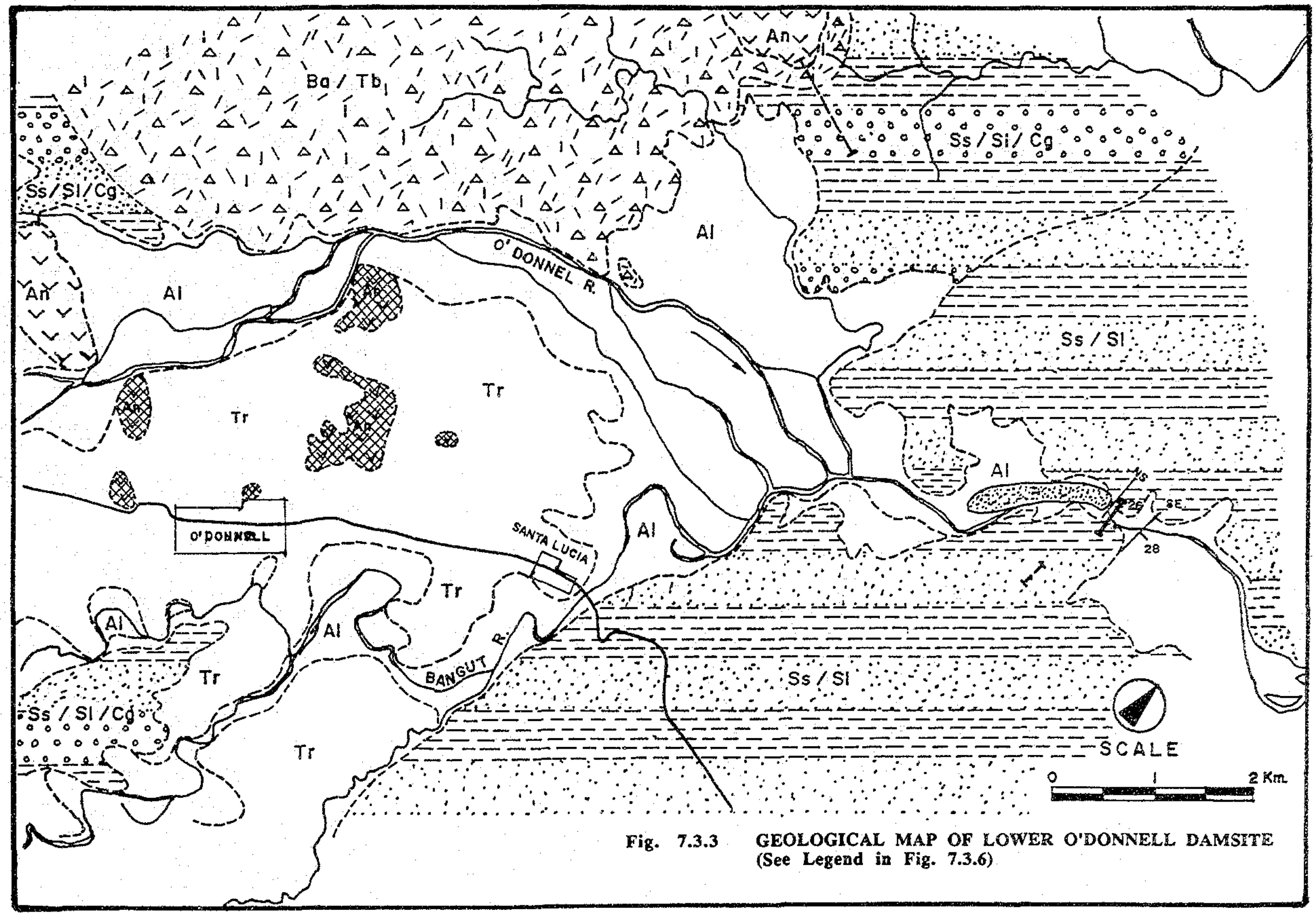

Fig. 7.3.3 GEOLOGICAL MAP OF LOWER O'DONNELL DAMSITE
(See Legend in Fig. 7.3.6)

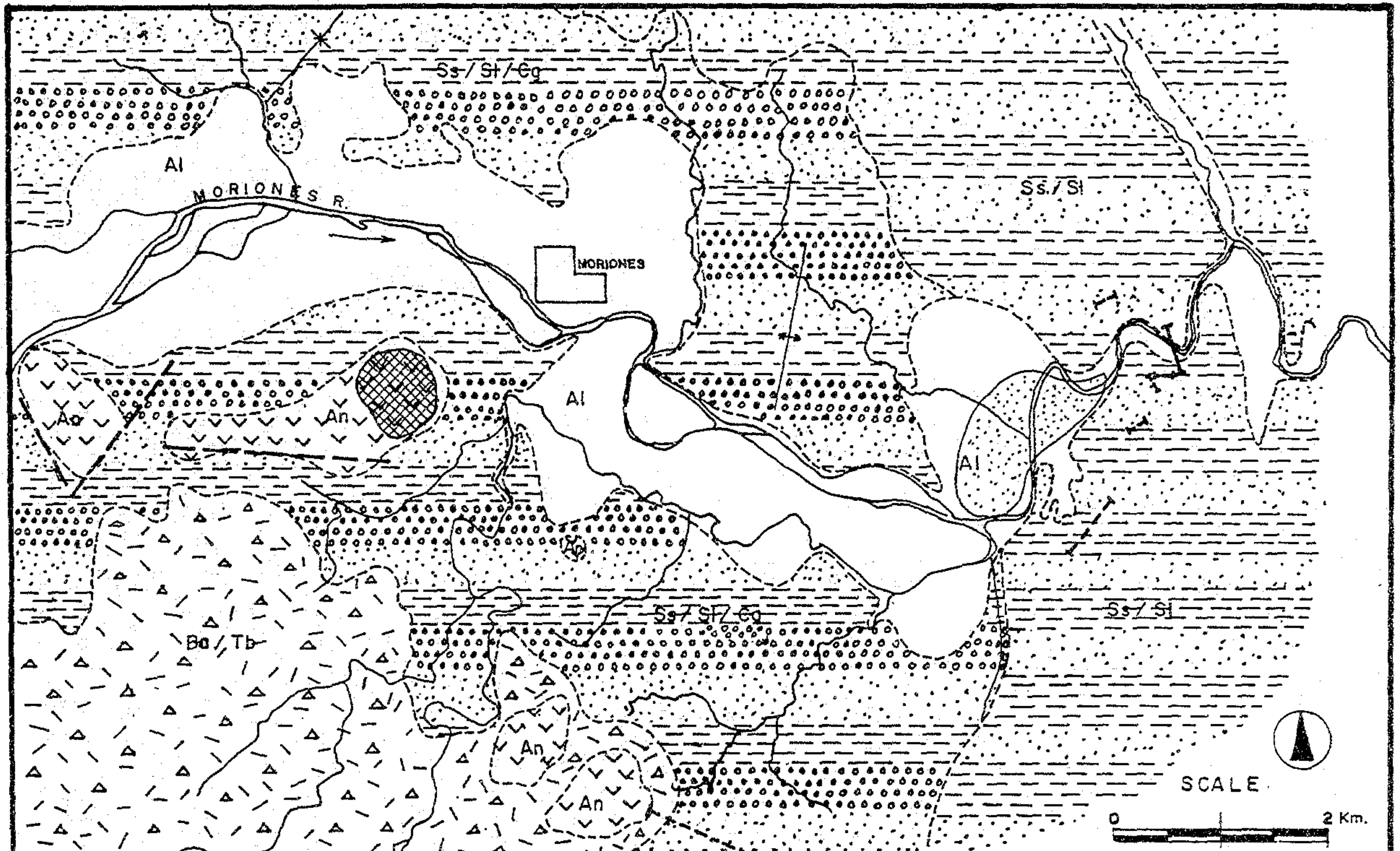

Fig. 7.3.4 GEOLOGICAL MAP OF MORIONES DAMSITE
(See Legend in Fig. 7.3.6)

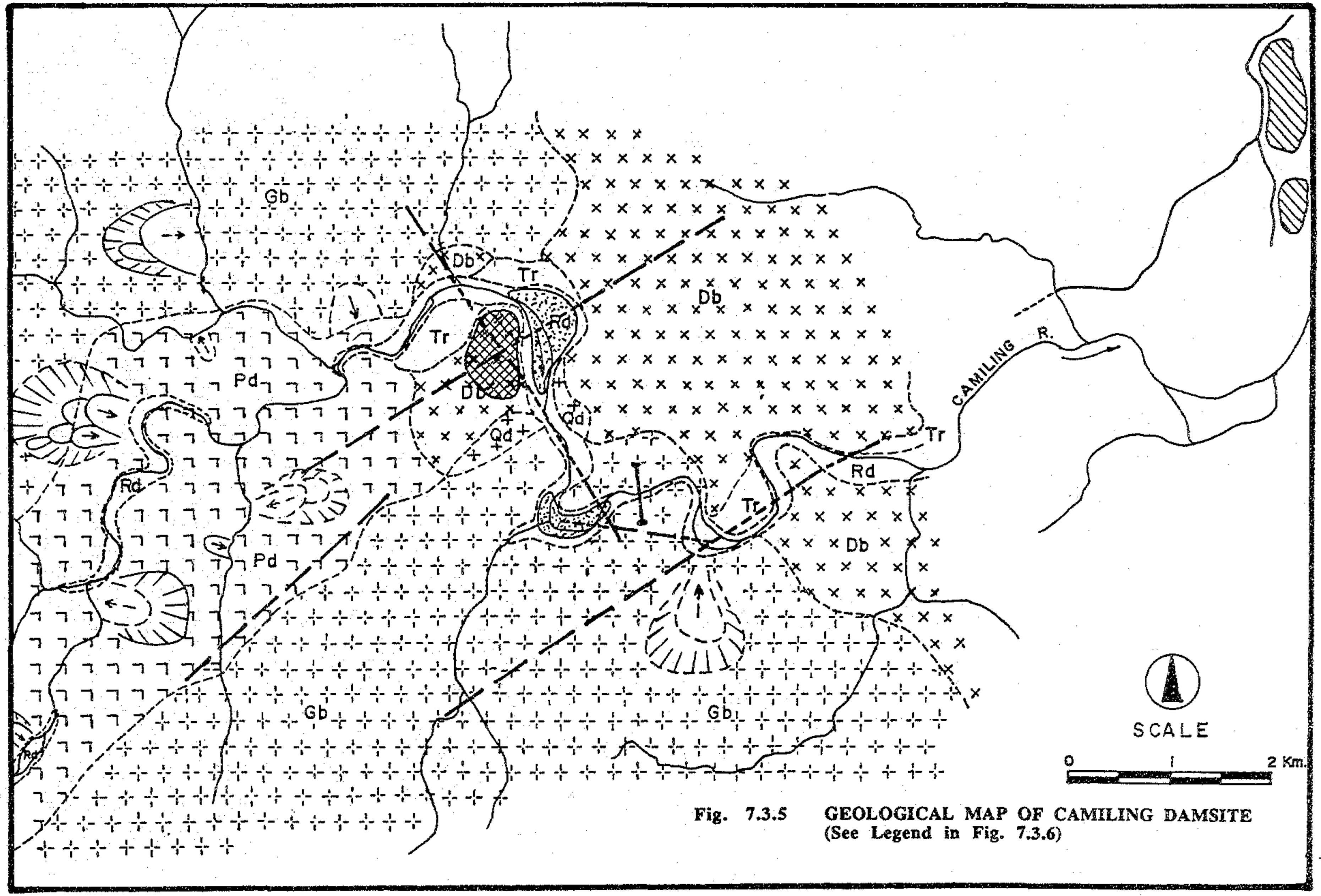

Fig. 7.3.5 GEOLOGICAL MAP OF CAMILING DAMSITE
(See Legend in Fig. 7.3.6)

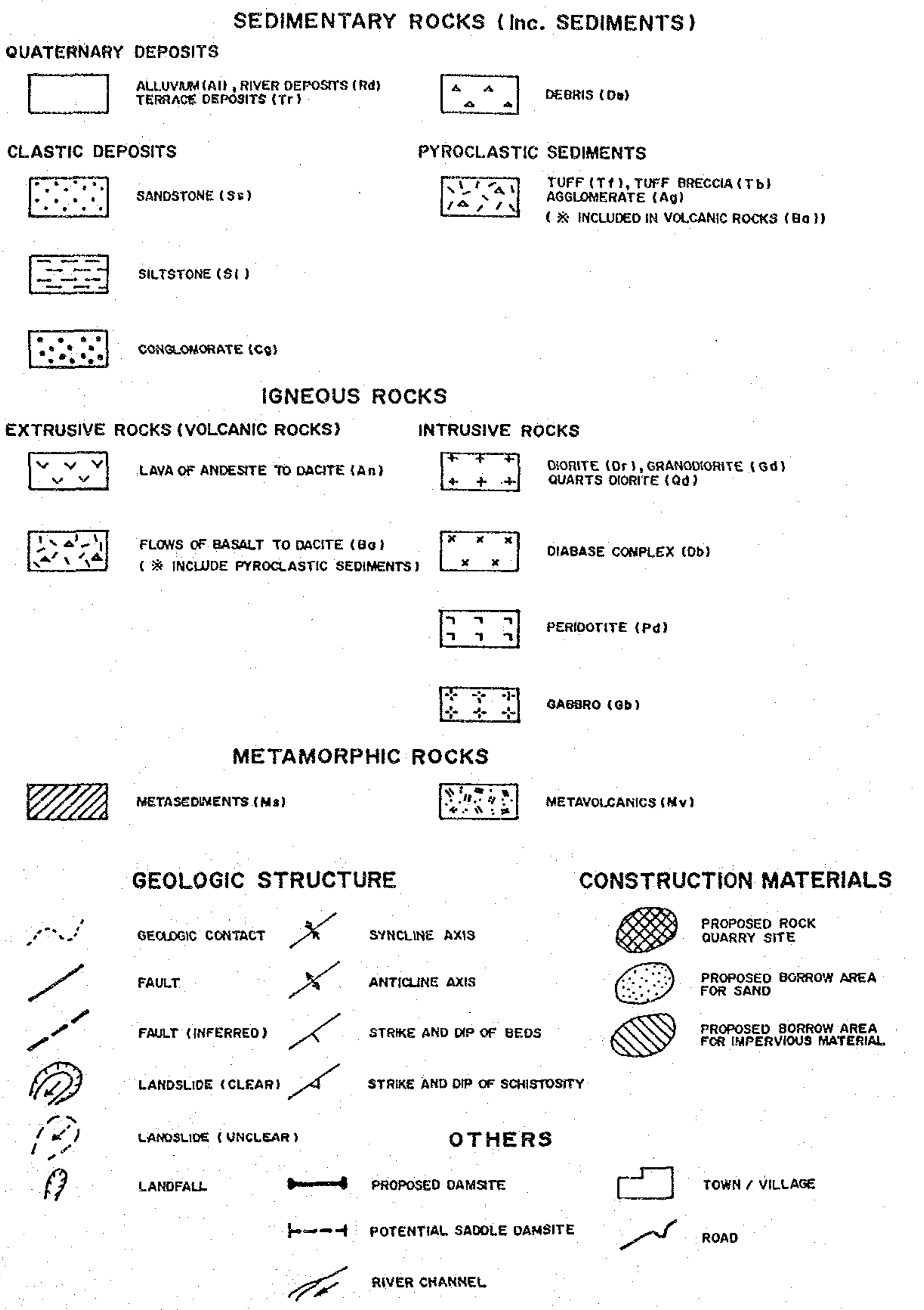

Fig. 7.3.6 LEGEND OF GEOLOGICAL MAP (DAMSITE)

8. MASTER PLAN FORMULATION CRITERIA

8. MASTER PLAN FORMULATION CRITERIA

8.1 Basic Concept

8.1.1 Definition of Flood Control and Sediment Control Plans

The comprehensive flood control master plan is composed of flood control and sediment control plans. The Study focuses on the flood control plan but also studies the sediment control at a conceptual level only. The flood forecasting and warning system is studied as a part of nonstructural measures.

8.1.2 Flood Control Measures Subject to Master Plan

The flood control structural and non-structural measures which are to be studied in the Master Plan are listed below.

(1) Flood Control Plans

a. Flood Control Dams
b. Flood Retarding Basins
c. River Improvements
   - Improvement of channel alignment including short-cut
   - Construction of diking systems
   - Deepening and widening of river channels
   - River bank protection (Revetment and Groin)
   - Other appropriate facilities
d. Floodway

(2) Sediment Control

a. Sediment Control in Watershed
   - Sabo dams and other facilities
   - Afforestation
   - Legal and structural measures for preventing mine tailings discharge
   - Legal and structural measures for preventing landslide and soil erosion due to road construction

Afforestation and legal measures for tailings discharge and road construction are not covered by the Master Plan and are limited to recommendation for further study only.

b. River Improvement

- Channel improvement for flushing sediment
- Riverbed excavation and/or dredging

(3) Non-structural Measure

a. Flood Forecasting and Warning System

8.2 Definition of Framework Plan and Long Term Plan

The Master Plan is composed of two staged plans, the Framework Plan and the Long Term Plan. The Framework Plan is defined as an ideal portrait of a flood control plan which is to be achieved in the unspecified future. The Long Term Plan is defined as a stage development plan of the Framework Plan which is to be achieved at the target year of 2020 (30 year-long term plan).

The flood control target and planning period of these plans are specified below.

a. River Improvement and Floodway

	Flood Control Target	Planning Period
(1) Framework Plan		
- Main Agno River and Tarlac River	100 year flood	Non-specific future plan
- Other Major Tributaries of Agno River	50 year flood	ditto
- Allied Rivers	50 year flood	ditto
(2) Long Term Plan		
- Agno River	Feasible scale	20 years (up to 2010)
- Allied Rivers	Feasible scale	20 years (up to 2010)

b. Flood Control Dams and Retarding Basins

	Flood Control Target	
(1) Framework Plan		
- Flood Control Dam	100 year flood	Non-specific future plan
- Retarding basin	100 year flood	ditto
(2) Long Term Plan		
- Flood Control Dam	100 year flood	20 years (up to 2010)
- Retarding basin	Feasible scale	20 years (up to 2010)

8.3 Alternative Study Criteria

8.3.1 River Improvement and Floodway

Rivers subject to the Framework Plan are listed below:

River basin	River system
(1) Agno River	Main stream, Ambayoan, Viray-Dipalo, Banila, Tarlac, Camiling
(2) Allied Rivers	Main stream of Cayanga-Patalan, Bued, Aloragat, Angalacan,
	Main stream of Panto-Sinocalan, Tagumising, Macalang, Ingalera, Dagupan

The first priority of river improvement is given to construction and strengthening of the diking system.

Along this line, the following countermeasures are to be incorporated in formulation of the river improvement plan.

(i) Improving channel alignment including short-cuts
(ii) Deepening and widening river channel
(iii) Protecting river bank from erosion

In connection with the above formulation of the river improvement plan, alternatives including floodway are taken into consideration from the viewpoint of least costly river improvement measures.

8.3.2 Flood Control Dams and Retarding Basins

(1) Flood Control Dams

<u>Basic Study Criteria and Assumptions for Initial Screening</u>

(i) The existing Ambuklao and Binga dams are studied in terms of flood control effect under existing condition, modification and/or reconstruction of these dams are not considered.

(ii) On-going Balog-Balog dam is also studied in terms of flood control effect without modification of its design.

(iii) The scheme of San Roque dam (detailed design completed) is studied in terms of flood control effect of the present design. A single purpose scheme for flood control in the same damsite is also reviewed.

(iv) All the other dam schemes are studied as single purpose schemes for flood control.

(v) Concrete gravity type is applied for flood control dam.

(vi) 50-year sediment is adopted for dead storage.

(vii) Storage efficiency and flood control efficiency are used for the selection index in the initial screening.

- Storage Efficiency (SE) = Flood control storage/Dam volume
- Flood Control Efficiency (FCE)
  = SE x Catchment area x Flood peak cut ratio/1,000

(viii) The horizontal flood peak cut method is applied for the initial screening.

<u>Second Screening Criteria for Least Costly Comparison</u>

(i) River improvement works are selected as the alternative facilities to the flood control dams. Reduction in river improvement construction costs gained by flood control effect of the dam and the dam construction cost are compared.

(ii) Design flood is 100-year flood.

(iii) The constant-rate and constant-volume outflow method is assumed as the reservoir operation method.

(iv) The design dead storage is assumed to be equivalent at least to the sediment volume of 50-year period by use of the sediment yield estimated in the Supporting Report (SD : Sediment Control Plan).

(2) Retarding Basins

Basic Study Criteria and Assumptions

(i) Design flood is 100-year flood.

(ii) The horizontal flood peak cut method is applied to flood control at a retarding basin for the cases having artificial flood control structures.

(iii) Existing 1:50,000 topographical maps are used for estimating the retarding basin capacity.

(iv) The maximum flood water level of the Poponto retarding basin is set at El. 18.5m while that of the Camiling retarding basin is set at El. 15.0m to avoid inundation of Camiling town.

(v) River improvement works are selected as the alternative facilities to a retarding basin. Reduction in river improvement construction cost gained by flood control effect of a retarding basin and the retarding basin facility cost are compared.

8.3.3 Sabo Works

<u>Basic Study Criteria and Assumption</u>

1)	Design sediment discharge for sediment control	:	50% of the present natural sediment yield
2)	Design allowable sediment	:	Sediment transport capacity at the reference point
3)	Design excess sediment volume to be controlled	:	Balance between 1) and 2)

8.4 Design Criteria

8.4.1 Structural Design

Structural design of alternative flood control facilities and related structures is made by a standard design method. The standard design is prepared for each of the following structures under the basic design conditions prepared by the Study:

- Related structures for River Improvement Plan;
  River dike, Revetment, Groin, Groundsill, Water gate, Sluice way, Bridge
- Related structures for Floodway Plan;
  Floodway dike, Revetment, Diversion facilities
- Closing dike in Allied Rivers;
  Closing dike, Revetment, Groin
- Related structures for Flood Control Dam Plan;
  Dam, Spillway, River diversion facilities
- Related structures for Retarding Basin Plan;
  Retarding basin dike, Overflow facilities, Drainage gate, Pumping stations
- Related structures for Sediment Control Plan ;
  Sabo Dam

8.4.2 Basic Design Criteria Applied

The basic design is made based on the two standards shown below. The design of the river improvement works executed recently in the Study Area is also taken into consideration.

(i) Technical Standard for River and Sabo facilities prepared by the Ministry of Construction of Japan.

(ii) Design Guidelines, Criteria and Standards (Vol. I & II) prepared by DPWH.

9. SCREENING OF FLOOD CONTROL ALTERNATIVES

9. SCREENING OF FLOOD CONTROL ALTERNATIVES

9.1 River Improvement and Floodway

9.1.1 Definition of Alternatives

The subject river systems are divided into three groups; the Agno River main stream, the Agno River tributaries and the Allied Rivers. River improvement alternative plans are formulated for each group. Floodway and closing dike plans are also independently formulated for the Agno River main stream and the Allied Rivers as an alternative to the respective river improvement plans. These alternatives are summarized below.

A. Sole River Improvement

Agno Main stream

Alternatives with respect to type of bypass channel at Alcala

A.2.1 : Natural diversion through Poponto bypass channel with existing Agno main channel unchanged

A.2.2 : Controlled diversion through Poponto bypass by a weir provided in Agno main channel

A.2.3 : Full diversion of Agno main stream from existing Agno channel to Poponto bypass and river maintenance flow only released to existing Agno main channel

Agno Tributaries

. Sole River Improvement

Allied Rivers

. Sole River Improvement

B. River Improvement with Floodway

Agno Main stream

B1 : River Improvement with Agno Floodway

Allied Rivers

A floodway to divert Aloragat River flood flow of the Cayanga-Patalan River

B2 : Aloragat floodway; a bypass floodway toward Angalacan River

Alternatives with respect to diversion of Tuboy River flood flow of the Pantal-Sinocalan River

B3 : San Manuel floodway toward Agno River main stream

B4 : Binalonan floodway; a bypass floodway toward Angalacan-Patalan River

C. River Improvement with Closing Dike

C1 : River Improvement and Bued Closing Dike for the Cayanga-Patalan River

(1) Alternative with Respect to Type of Bypass Channel at Alcala

The technical highlight of river improvement for the main stream of the Agno River is to dissolve a hydraulic bottle-neck at Bayambang and to increase its flow capacity in connection with improvement of the existing by-pass channel through Poponto swamp area. Three alternatives (A.2.1, A.2.2 and A.2.3) are formulated for this purpose, and the case of full diversion, A.2.3 is adopted.

(2) Agno Tributaries and Allied Rivers

For the Allied Rivers and the tributaries of the Agno River, only river improvement plans are formulated based on the initial screening study.

(3) River Improvement with Agno Floodway

An alternative which combines river improvement works of the existing river system and a new bypass floodway is formulated for comparison with a sole river improvement plan. The Agno floodway in Alternative B1 for the main stream of the Agno River aims to divert the major flood runoff (about 6,400 m^3/s) from the drainage area upstream of the San Roque dam site toward the Lingayen Gulf, while the said runoff is discharged downstream through the existing Agno river channel in the case "without" Agno floodway (river improvement only). (Refer to the alignment in Figure 9.1.1.)

The advantages of the case "with" Agno floodway are:

i) Reduction of flood discharge in the Agno River main stream especially in the stretch between San Roque and WaWa.

ii) Incidental use as a main drainage channel for the Allied Rivers (Bued, Aloragat, and Angalacan).

(4) Flooding Alternatives for Allied Rivers

For the Allied Rivers two floodway alternatives are formulated. The Aloragat floodway in Alternative B2 aims to divert the flood runoff from the Aloragat River into the Angalacan River. The alternatives B3 and B4 aim to treat the flood runoff from the Tuboy River by constructing the San Manuel floodway (B3) or the Binalonan floodway (B4) respectively. A closing dike is planned on the left bank of the Bued River in Alternative C1 to prevent overflow into the Aloragat River.

The layouts of the alternatives of river improvement and floodway plans are illustrated in Figure 9.1.1.

9.1.2 Screening of Floodway Alternatives

These independent plans (sole river improvement, river improvement with floodway, river improvement with closing dike) are compared by the least cost criteria.

The construction cost of the Agno floodway is very high and, therefore, the scheme "with" Agno floodway is inferior to the scheme of sole river improvement, though the flood diversion and drainage effectiveness in the latter case are extremely high.

For the Allied Rivers the case with the Binalonan floodway, B4 is the only case which is superior to the cases of sole river improvement.

The Bued closing dike is compared with the case of sole river improvement for the Angalacan river, and is adopted as a part of the river improvement works of the Bued river.

9.2 Flood Control Dams and Retarding Basins

9.2.1 Flood Control Dams

(1) Existing and On-going Dams

The existing dams in the Agno River basin are Ambuklao and Binga dams. Both are located in the east of Baguio City in the upper reaches of the main Agno. These dams were constructed in 1956 and 1960 respectively for hydropower generation by NAPOCOR.

The Balog-Balog dam in the upper reaches of the Bulsa river, a tributary of Tarlac river is the only dam project under construction in the Study Area. The primary purpose of this dam is irrigation water supply by NIA.

The San Roque dam is planned upstream of ARIS intake weir and its detailed design was completed, but implementation has not been started yet. The primary purpose of this dam is hydropower generation by NAPOCOR and irrigation water supply by NIA.

Principal features of these dams are summarized below and their locations are shown in Figure 9.2.1.

	Ambuklao	Binga	Balog-Balog	San Roque
Catchment area (km^2)	617	860	283	1,250
Storage volume ($x10^6m^3$)				
- Gross	327 (1956) 217 (1986)	87 (1960) 61 (1986)	683	1,150
- Effective	258 (1956) 209 (1986)	48 (1960) 39 (1986)	575	670
- Flood control			60	160
Dam type	Rockfill	Rockfill	Gravelfill	Gravelfill
Dam height (m)	129	107	113.5	210
Dam volume ($x10^6m^3$)	5.8	1.9	11.9	43.2
Installed capacity (MW)	75	100	33	390

(2) Screening of Prospective Flood Control Dams

In addition to the identified NAPOCOR and NIA damsites, the Study examined the possible damsites on 1/50,000 topographical maps. The seventeen prospective damsites selected by the Study are all the same as those already identified in the previous studies. Those existing, on-going and identified dams are listed in Table 9.2.1 and shown in Figure 9.2.1.

Among the seventeen damsites, three dams are existing or under construction. The remaining fourteen damsites, therefore, are studied by applying the initial screening criteria defined in Section 8.3.

Storage efficiency and flood control efficiency are estimated for each damsite and the results are shown in Table 9.2.2. Five damsites having high storage and flood control efficiencies are selected for a further alternative study. These chosen are the San Roque, Lower Ambayoan, Lower O'Donnell, Moriones and Camiling damsites.

(3) Selection of Flood Control Dams

River improvement works are selected as the alternative facilities to a flood control dam. The dam cost is compared with the reduction in river improvement cost gained by the flood control effect of a flood control dam.

The alternative costs of the river improvement works are assumed to consist of dike embankment, high water channel revetment and maintenance dredging costs.

The study results including dam features, dam construction costs, peak discharge at base points, and decreased river improvement costs due to flood control effects of each dam are summarized in Table 9.2.3. The construction cost of each dam exceeds the cost reduction in river improvement except the Lower O'Donnel and Moriones dams. It is assessed that the dam plans with a single purpose of flood control are not economically superior to the river improvement plans except in the case of Moriones and the Lower O'Donnel.

The Moriones and Lower O'Donnel reservoirs are connected with an open channel constructed across their two watersheds at the part of the low and thin ridge. The flood control efficiency of the combined Moriones-O'Donnell dam (herein after defined as Moriones-O'Donnell dam) is assessed to be higher than that of two single dams. The Moriones-O'Donell dam is, therefore, selected for the integrated flood control plan.

9.2.2 Retarding Basins

Potential retarding basin areas are Poponto swamp and Camiling swamp from the viewpoints of topographical conditions and land use.

(1) Poponto Retarding Basin

The Poponto swamp is located south of the confluence of the main Agno and Tarlac Rivers as shown in Figure 9.2.1. This swamp area functions as a natural retarding basin partly for the Tarlac River and partly for the Agno River. The flood flow of the Agno River is diverted into the Poponto swamp through the existing floodway.

In the initial screening study three types of retarding basins are formulated as below:

i) Natural retarding basin,
ii) Retarding basin with confining dikes, and
iii) Retarding basin without confining dikes.

The type with confining dikes, however, is disqualified because of the constraints summarized hereunder.

The flood runoff of the Baka River and its tributaries, which is drained into the downstream of the Tarlac River near the junction with the Agno River, is trapped behind the confining dike. In short, the areas surrounding the swamp to be protected from flood disaster by confining dikes suffer from inland inundation in the Baka river drainage area. The total drainage area is about 580 km^2, and its probable 100-year flood peak discharge is estimated to be 2,300 m^3/s as illustrated in Figure 9.2.2. The drainage pumping facilities required to treat this condition are not feasible due to their huge construction cost.

A natural retarding basin and three types of retarding basins without confining dikes are studied further as illustrated in Figure 9.2.3.

- Case 1 : Natural retarding basin with an improved floodway. Natural retarding effect without artificial structures except upgrading of a floodway.
- Case 2 : Gate controlled retarding basin without a side overflow dike. A part of the flood runoff of the Agno River is diverted through the floodway and flood runoff from the Tarlac River is controlled by a gate controlled weir provided at the outlet of the Poponto Swamp with horizontal peak cut.
- Case 3 : Gate controlled retarding basin with a side overflow dike. A floodway which conveys the flood water from the Agno River directly to the downstream is provided through the northern part of the swamp while the flood water from the Tarlac River is retained in the swamp for retardation by a gate controlled weir provided at the outlet of the swamp. Two alternatives are considered: i.e., with a side overflow dike at the floodway and without a side overflow dike. A part of the Agno flood water is retained in the swamp through the side overflow dike.
- Case 4 : Retarding basin with a dike, two overflow dikes and a drainage gate. River channels of both the Agno and Tarlac Rivers are provided. A part of the Tarlac flood runoff and the Agno flood runoff overflow into the retarding basin through respective overflow dikes provided on the floodway channels and the stored water is drained through the drainage gate after the flood in the Agno River has subsided.

The results of alternative cost comparison with river improvement works are summarized in Table 9.2.4. The facility costs for retarding basins are all less than the reduction in river improvement costs. The natural retarding basin type, of which additional cost is negligible, is the most efficient of the four alternatives, though the amount of peak flood reduction is least among them. The general plan of this natural retarding basin is shown in Figure 9.2.4.

(2) Camiling Retarding Basin

The Camiling swamp is located in the downstream reaches of Camiling river as shown in Figure 9.2.1. A natural retarding type and an overflow type which has a higher flood control effect than the natural one are introduced as alternative retarding basins taking into account topographic and land use constraints.

The natural retarding type is assessed to be inferior to the river improvement alternative due to the following constraints:

i) retarding capacity of this swamp is limited because of the small swamp area.

ii) reduction in river improvement cost gained by flood peak-cut by the basin is small because of its location in the downstream reaches of the Agno River.

The overflow type is studied further by changing the amount of flood peak cut from 2,000 m^3/s (case-1) to 3,000 m^3/s (case-3).

As shown in Table 9.2.5, the facility cost for this type of retarding basin also exceeds the reduction in river improvement cost, therefore, it is assessed that the Camiling retarding basin plan is not economically superior to the river improvement plan.

Table 9.2.1 PRESENT STATUS OF DAM PROJECTS

No.	Name of Dam	River Basin	Catchment Area (km2)	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 Potencials 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

Table 9.2.2 RESULTS OF DAMSITES SCREENING

Name of Damsite	River Basin	Catchment Area (km2)	Storage Efficiency 100-yr Flood	Storage Efficiency 50-yr Flood	Flood Control Efficiency 100-yr Flood	Flood Control Efficiency 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.
Bangai	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 9.2.3 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)	0.00	0.00	1.50	0.21	0.65	0.00	
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	

Table 9.2.4 POPONTO RETARDING BASIN ALTERNATIVE STUDY

Item	Alternatives			
	Case 1	Case 2	Case 3	Case 4
I. Dischage (m3/s)				
1. Peak inflow into basin	13,110	13,110	10,860	8,330
2. Peak outflow from basin	9,930	5,610	3,360	-
3. Peak cut	3,180	7,500	7,500	8,330
4. Peak side overflow into basin	-	-	5,000	6,000
II. Flood Control Storage (mill.m3)	757	1,445	1,356	1,515
III. Flood Water Level (El.m)	16.59	18.37	18.15	18.55
IV. Inundated Area (km2)	347	445	433	455
V. Dimension of Structure (m)				
1. Width of control gate	-	150	150	-
2. Length of side overflow	-	-	2,100	5,000
VI. Construction Cost (mill.Pesos)				
1. Control gate	-	1,128	1,107	-
2. Side overflow weir	-	-	546	1,300
3. Drainage gate	-	-	-	381
Total	0	1,128	1,653	1,681
VII. Peak Discharge at River Mouth(BP1),(m3/s)	13,260	10,030	10,340	9,740
VIII. Reduction in River Improvement Costs by Retarding Basin Plan (mill.Pesos)				
1. River Improvement works	1,542	2,285	2,137	2,085
2. O & M cost (dredging)	2,584	2,584	1,129	0
Total	4,126	4,869	3,266	2,085
IX. Retarding Basin Cost less Reduction in River Improvement Cost(mill.Pesos)	-4,126	-3,741	-1,613	-404

Table 9.2.5 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

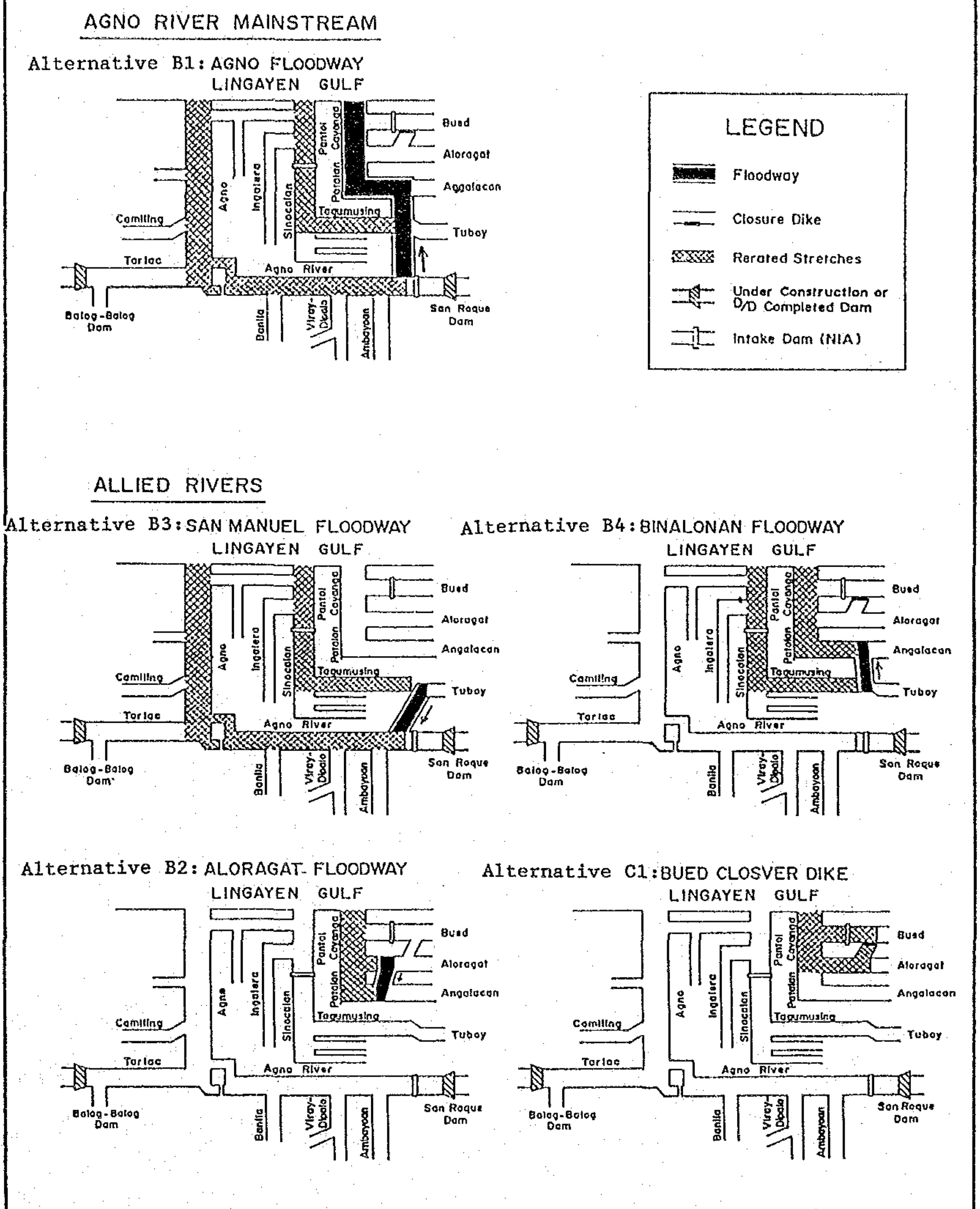

Fig. 9.1.1 FLOODWAY ALTERNATIVES

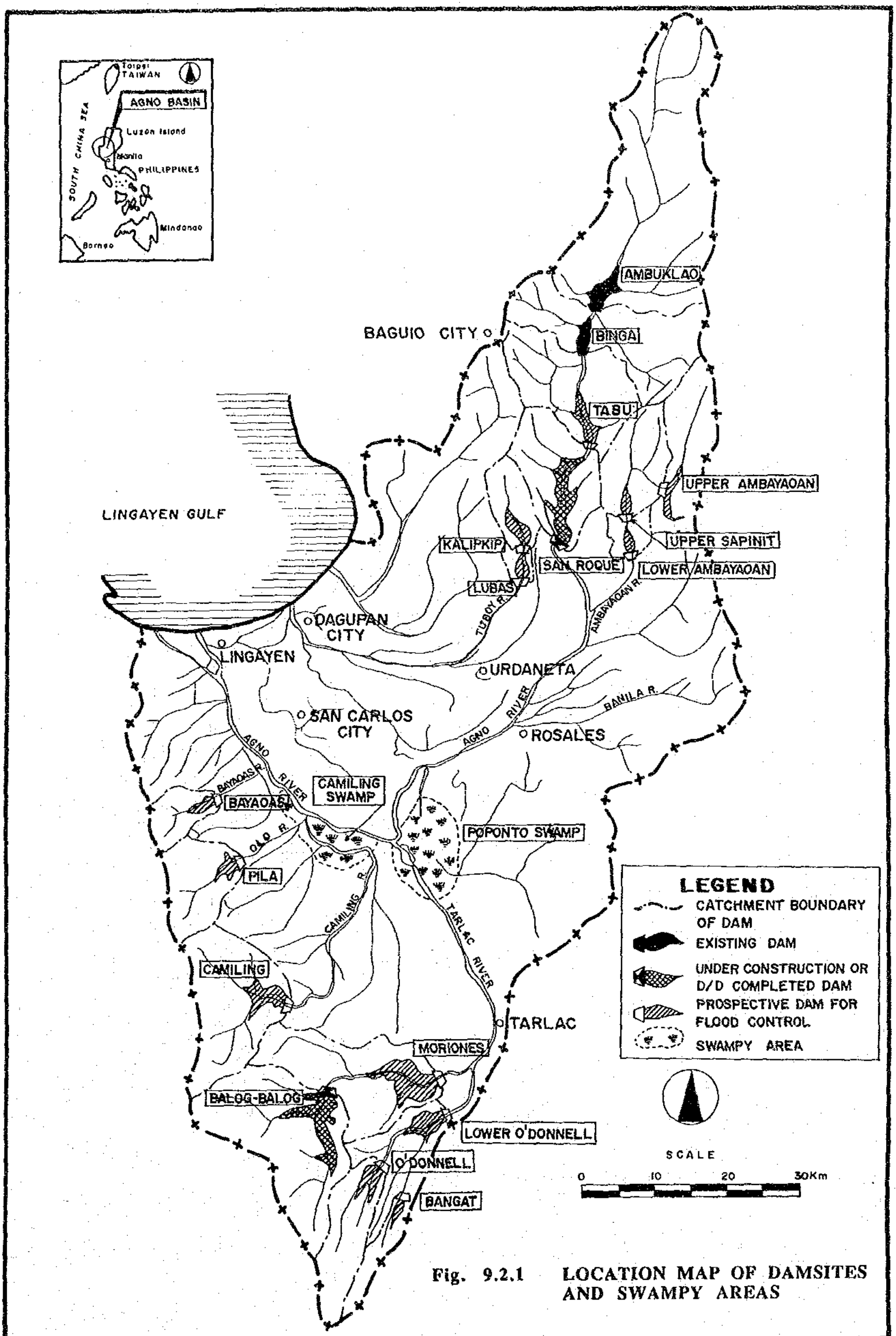

Fig. 9.2.1 LOCATION MAP OF DAMSITES AND SWAMPY AREAS

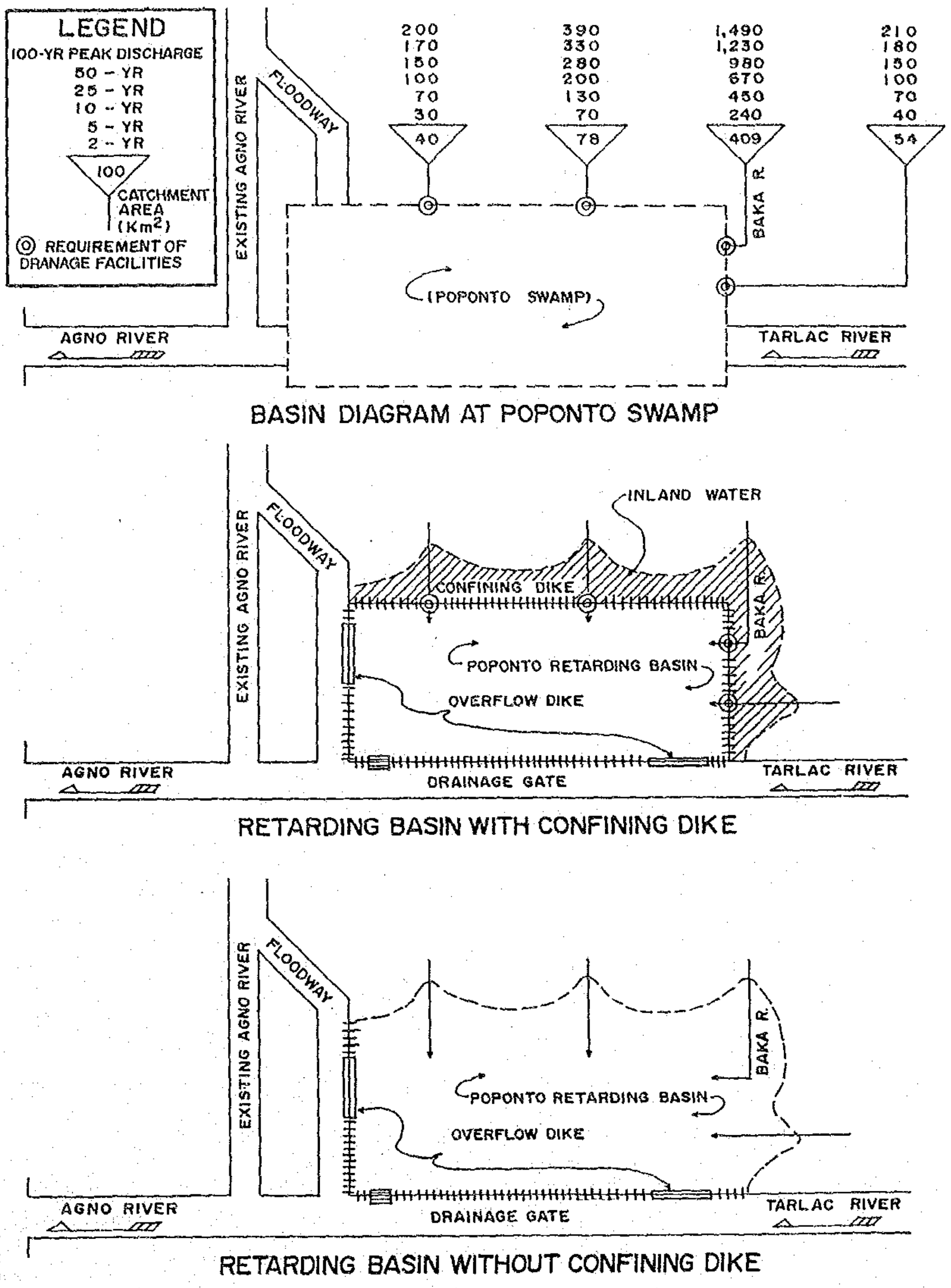

Fig. 9.2.2 BASIN DIAGRAM AND BASIC ALTERNATIVE PLAN OF POPONTO FLOOD RETARDING BASIN SCHEME

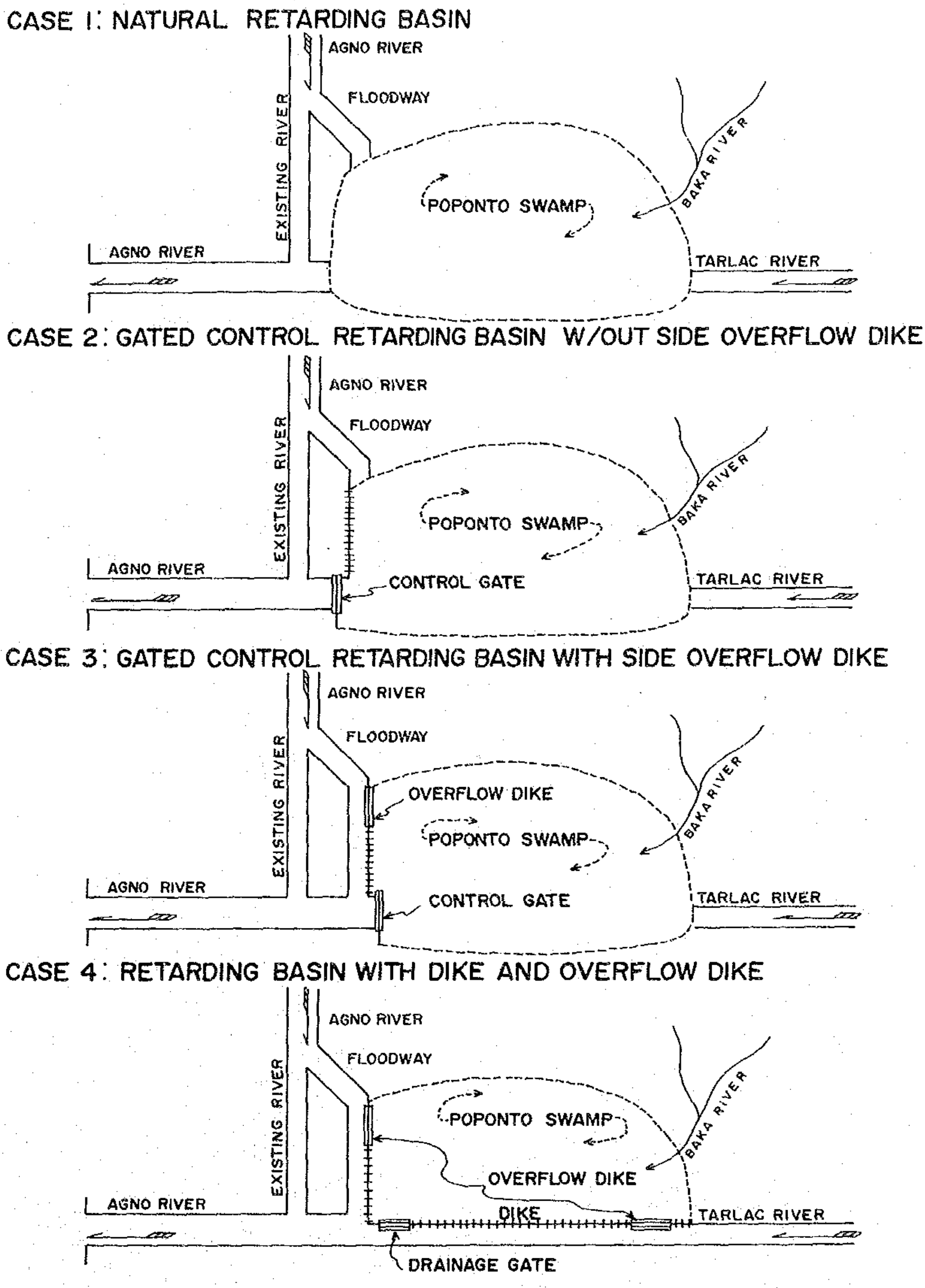

Fig. 9.2.3 ALTERNATIVE PLAN OF POPONTO FLOOD RETARDING BASIN SCHEME

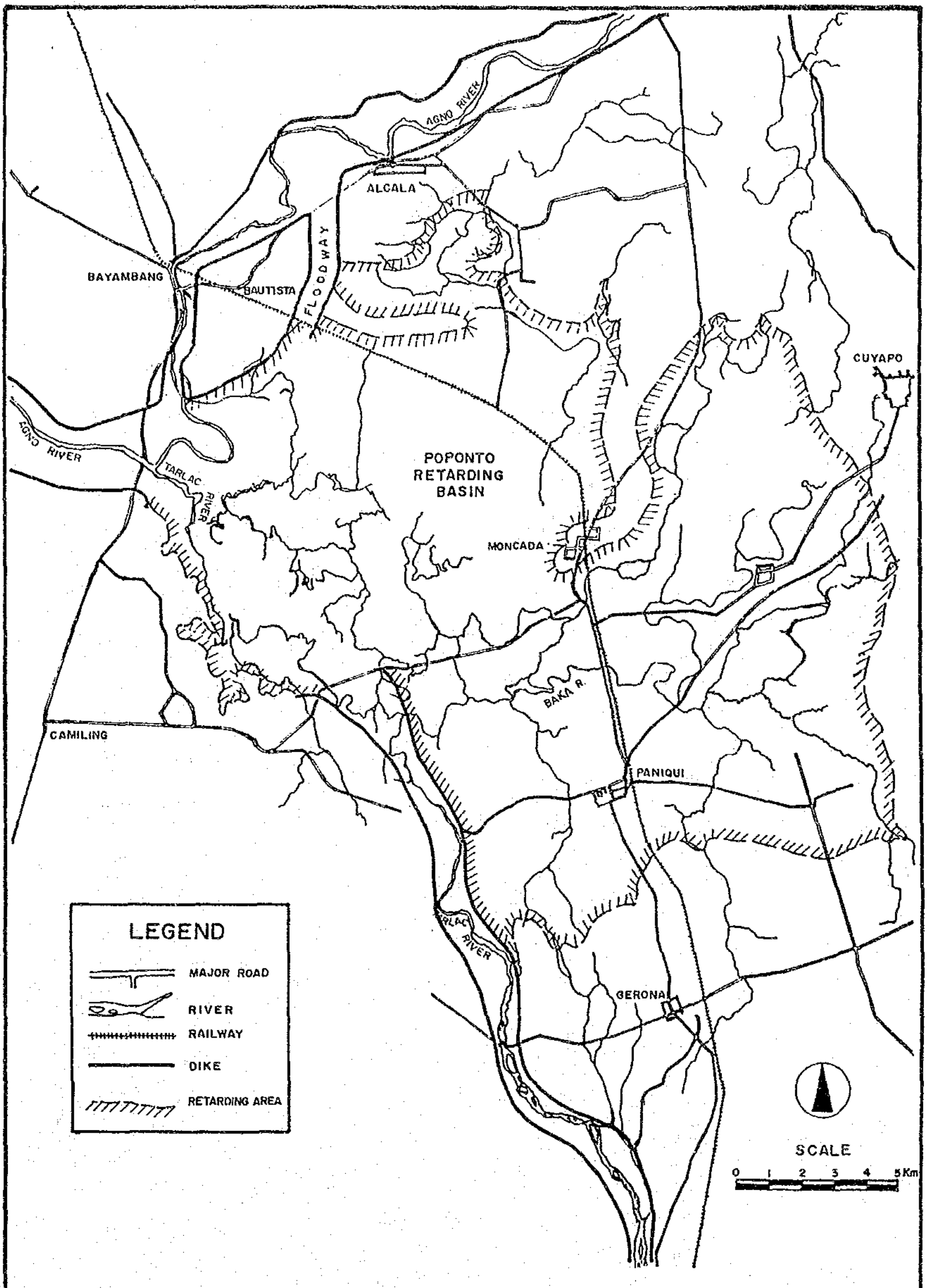

Fig. 9.2.4 GENERAL PLAN OF POPONTO RETARDING BASIN

10. MASTER PLAN

10. MASTER PLAN

10.1 Plan Formulation Process

Plan formulation and optimization of the Master Plan (Framework Plan and Long Term Plan) were made in the following process.

Step-1 Alternative Flood Control Structural Measures

(1) River improvement, floodway, flood control dam, and flood retarding basin plans were independently formulated to fulfill the flood control target (100-year flood for the Agno main stream and the Tarlac River and 50-year flood for the others).

(2) The least costly measures were selected from each of the foregoing independent plans.

Step-2 Framework Plan

(1) Alternative framework plans were formulated by integrating the least costly measures selected in Step-1.

(2) Optimization of the framework plan was made among these alternatives for each river by the least cost criteria assuming that the reduction in flood damage gained by the structural measures is the same among all the alternatives.

Step-3 Long Term Plan

(1) A feasible combination of the structural measures was reorganized as a stage development plan on the way to the Framework Plan based on the Framework Plan in Step-2 for each river, taking into account the socio-economic conditions in the target year, 2010.

(2) Optimization was made for each river using an economic benefit cost analysis to find out the economically feasible scale and the most efficient flood control scale.

Step-4 Implementation Program for Long Term Plan

(1) An implementation program was formulated for the optimum scale of the Long Term Plan. An alternative implementation program was also formulated under constraint of the available amount of investment fund up to the target year, 2010.

10.2 Framework Plan

10.2.1 Alternative Framework Plans

The least costly schemes selected from each of the four independent alternative structural measures in Chapter 9 are summarized below.

i) River improvement only : All the river improvement works including Bued closing dike for the Cayanga-Patalan River
ii) Floodway : Binalonan floodway for the Pantal-Sinocalan River
iii) Flood control dam : Moriones-O'Donnel dam for the Tarlac River
iv) Flood retarding basin : Poponto natural retarding basin for the Agno River and the Tarlac River

These least costly structural measures were integrated and several alternative framework plans were formulated for the respective river stretches in the Study Area as set out below.

Agno River Main Stream and Tarlac River

Case 1 : Sole River improvement
Case 2 : Combination of river improvement and Poponto natural retarding basin
Case 3 : Combination of river improvement, Poponto natural retarding basin and Moriones-O'Donnel dam
Case 4 : Combination of river improvement and Moriones-O'Donnel dam

Agno River Tributaries

- . Ambayoan River : Sole river improvement
- . Viray-Dipalo River : Sole river improvement
- . Banila River : Sole river improvement
- . Camiling River : Sole river improvement

Allied Rivers

. Pantal-Sinocalan

Case 1 : Sole river improvement

Case 2 : River improvement and Binalonan floodway

. Cayanga-Patalan :

Sole river improvement with Bued closing dike

The design flood distributions of alternative framework plans for the Agno River and its main tributaries are illustrated in Figure 10.2.1 and for the Allied Rivers in Figure 10.2.2. The economic cost of these alternatives is summarized in Table 10.2.1. Corresponding work quantities are shown in Table 10.2.2 for the Agno River and the Tarlac River, Table 10.2.3 for the Agno River Tributaries, and Table 10.2.4 for the Allied Rivers.

10.2.2 Proposed Framework Plan

Among the four alternatives for the Agno River and the Tarlac River, Case 2, which is a combination of river improvement and Poponto natural retarding basin, has the least construction cost. Case 3, which is a combination of river improvement, Poponto natural retarding basin and the Moriones - O'Donnel dam, has the least project cost if the annual sediment dredging cost of river channels is taken into account. The project economic cost of the two cases is summarized below:

Project Economic Cost (million pesos)

	Case 2; River improvement & Retarding Basin	Case 3; River improvement, Retarding Basin & Dam
Construction Cost Only	11,988	13,357
Construction Cost with reduction in annual cost of dredging sediment	11,988	11,718

The combined case of river improvement, Poponto retarding basin and Moriones-O'Donnel dam is proposed as the Framework Plan for the Agno River and the Tarlac River. The Moriones-O'Donnel dam is included in the Framework Plan in spite of the land acquisition and resettlement difficulties identified in Section 10.3.1 because the project life of small irrigation schemes and small impounding dams is expected to be short and the need for this dam is expected to be very high in the future.

For the Agno River tributaries, the case of sole river improvement is the least costly and is proposed as the Framework Plan. The economic project cost is summarized below.

Project Economic Cost (million pesos)

Camiling river	451
Banila River	1,023
Viray-Dipalo River	278
Ambayoan River	173
Total	1,925

For the Allied Rivers, Case 1 which is a combination of river improvement and Binalonan floodway is the least costly and is proposed as the Framework Plan. The Bued closure dike is provided upstream of the Bued River as a part of river improvement works. The location of the Binalonam floodway and the Bued closure dike is illustrated in Figure 10.2.4. The economic project cost of Case 2 and Case 3 is summarized below.

Project Economic Cost (million pesos)

	Case 1; River improvement with Binalonan Floodway	Case 2; Sole River Improvement
Pantal-Sinocalan River	2,553	2,824
Cayanga-Patalan River	1,246	1,158
Total	3,799	3,982

10.2.3 Features of Framework Plan

The general layout of the proposed Framework Plan is illustrated in Figure 10.2.3 for the Agno River and Figure 10.2.4 for the Allied Rivers.

The alignment plans, longitudinal profiles and typical cross-sections of the proposed Framework Plan are shown in the following figures:

	Agno River Main Stream	Tarlac River	Agno River Tributaries	Allied Rivers
Plan (new 1/25,000)	Figs.10.2.5	Figs.10.2.6	-	-
(1/50,000)	-	-	Figs.10.2.7 - 10.2.9	Figs.10.2.10
Longitudinal Profile	Fig. 10.2.11	Fig. 10.2.12	Figs.10.2.13 - 10.2.16	Figs.10.2.17 - 10.2.24
Typical Cross-section	Figs.10.2.25	Fig. 10.2.26	Figs.10.2.27 - 10.2.30	Figs.10.2.31 - 10.2.38

The major design features including design discharge, river bed gradient, low water channel width, high water channel width, dike height and low water channel height are tabulated in Table 10.2.5 for the Agno River main stream, Table 10.2.6 for the Tarlac River and the Agno River Tributaries and Table 10.2.7 for the Allied Rivers.

In the Framework Plan of the Agno River, new dikes with high water channel width of about 1.5 km are planned on the left and right banks from the river mouth to the middle reaches at Bayamban. At present only the right bank levee exists from AG-45. These new dikes are provided to protect Lingayan town area (refer to Figures 10.2.5 and 10.2.25). Since the existing high water channel in the section between AG-45 and AG-83 varies from 2.5 km to 3.5 km, the new dike on the right bank is to be constructed inside the existing dike. If this new dike is provided the land use between the new dike and the existing dike will be enhanced. However, the existing dike which is planned to be raised in the Long Term Plan, should be kept in the same place as the secondary dike system even after the construction of the new dike. The purpose of the secondary dike is to secure the safety of the primary dike although the newly planned high water channel is wide enough.

10.3 Long Term Plan

10.3.1 Optimization of Development Scale

The Long Term Plan is formulated as a stage development plan of the Framework Plan up to the target year 2020. For optimization of the development scale of the Long Term Plan, the following combinations of flood control structural measures are adopted:

i) Agno River and Tarlac River; combination of river improvement and Poponto natural retarding basin without Moriones-O'Donnel dam

ii) Agno River Tributaries; river improvement only

iii) Allied Rivers; river improvement with Binalonan floodway

Although the Moriones-O'Donnell dam is included in the proposed Framework Plan for the Agno River and the Tarlac River, it is excluded from the Long Term Plan because of the expected implementation difficulties involved in the land acquisition and resettlement in the said reservoir areas. The reservoir areas are occupied by about 1,600 families (90% in Moriones area and 10% in O'Donnell area), agricultural land of about 40 km^2 including irrigation systems of the Sula-Iba (250 ha) and the Lubigan (200 ha), and the on-going Western Barrios Impounding Irrigation Project (1,030 ha). The Western Barrios Project is under construction by a grant from the Government of Japan.

The minimum development scale of the river improvement is set for the 10-year flood and the project economic costs for different development scales of the Long Term Plan are estimated as presented in Table 10.3.1 for the Agno River and the Tarlac River, Table 10.3.2 for the Agno Tributaries and Table 10.3.3 for the Allied Rivers.

The optimization was made in the range from 10-year flood to 50-year flood in terms of economic internal rate of return (EIRR) assuming a 15 year construction period from 1995. Table 12.2.1 presents the economic project cost, economic benefit and EIRR for each development scale. The optimum points are illustrated in Figure 12.2.1. The corresponding optimum development scale is summarized below.

River/Region	Optimum Development Scale	EIRR (%) Future Development Level	Current Development Level
a. Agno River and Tarlac River	25-year flood	16.6	(3.9)
b. Agno River Tributaries	25-year flood	15.5	(3.1)
c. Allied Rivers	10-year flood	33.8	(15.2)
Regional Assessment			
d. Study Area	25-year flood	20.5	(6.5)

The highest EIRR is found at the minimum development scale (10-year flood) for the Allied Rivers.

10.3.2. Proposed Long Term Plan

The development scale of the Long Term Plan is proposed as set out below assuming that all the investment fund is available by the target year 2020 (refer to Section 13.2).

	Proposed Development Scale	Financial Project Cost (million pesos)
Agno river and Tarlac River	25-year flood	11,048
Agno River Tributaries	25-year flood	1,640
Allied Rivers	10-year	3,286
Total		15,974

The design capacity of the stretch in TA-246 of the Tarlac River (near San Isidoro) is planned at 1,750 m^3/s which is slightly smaller than the 10-year flood (2,100 m^3/s) without provision of the prospective Moriones-O'Donnel dam. The reason is that the design capacity of the Framework plan with the Moriones-O'Donnel dam becomes higher than the 100-year flood if the capacity of this stretch is set at 2,100 m^3/s.

The proposed Long Term Plan (10-year flood) for the Allied Rivers is worked out without the Binalonan floodway but takes into account the design flood distribution of the Framework Plan with the Binalonan floodway (50-year flood). The reason is that simultaneous implementation of the Pantal-Sinocalan River and the Cayanga-Patalan River is expected to be difficult (refer to Section 13.2). The design capacity of the Tagamusing River is smaller (160 m^3/s) than the 10-year flood (360 m^3/s) at the downstream stretch for the time being before implementation of the Framework Plan. The design flood distribution of the proposed Long Term Plan is illustrated in Figure 10.3.1.

10.3.3 Features of Long Term Plan

The composition of the foreign currency and local currency portions of the financial cost of the proposed Long Term Plan is shown in Tables 10.3.4. The corresponding cost breakdown and the work quantities are presented in the Supporting Reports, CP : Construction Plan. The alignment plans, longitudinal profiles and typical cross-sections of the proposed Long Term Plan are presented in the same Figures for the Framework Plan (Figures 10.2.5-10.2.38). The major features including design discharge, river bed gradient, low water channel width, high water channel width, dike height and low water channel height are tabulated in Table 10.3.5 for the Agno River main stream, Table 10.3.6 for the Tarlac River and the Agno River Tributaries, and Table 10.3.7 for the Allied Rivers. The work quantities are summarized below:

Work Items	Unit	Agno River	Tarlac River	Agno River Tributary	Pantal River	Cayanga River	Total
Improvement Length	km	109.4	37.0	79.7	129.6	77.0	432.7
Excavation	1,000 m^3	24,670	4,300	1,200	4,220	1,840	36,230
Dredging	1,000 m^3	13,030	0	0	40	260	13,330
Embankment	1,000 m^3	15,270	1,360	2,580	4,010	720	23,940
Revetment	1,000 m^2	514	96	190	373	193	1,366
Groin	no.	958	244	1,070	952	1,095	4,319
Sluiceway	no.	16	2	26	39	22	105
Water Gate	no.	2	0	0	0	0	2
Bridge	no.	5	3	14	22	9	53
Fixed Weir	no.	1	0	0	0	0	1

10.4 Flood Forecasting and Warning System

10.4.1 Definition and Objective of Flood Forecasting and Warning System

The flood forecasting and warning system (FFWS) is defined as one of the non-structural component of the flood control Master Plan Framework Plan and Long Term Plan).

The FFWS Framework Plan aims to up-grade the existing system and to achieve an integrated nation-wide flood forecasting and warning system which fulfills the following objectives:

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

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

ii) <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 these facilities in advance. It also aims to avoid artificial flood disasters by disseminating in advance to the people to be affected information concerning flood release from those facilities.

iii) FFWS for Basinwide Flood Management

It aims to execute effective basinwide flood management and administration by integrated real time operation of all the flood control facilities in the basin. It necessitates real time access to the information on river and basin conditions.

The target area of the integrated FFWS is the whole flood prone area in the Study Area (refer to Section 5.2).

10.4.2 Existing FFWS

In the Agno River basin there are the ABC (Agno, Bicol and Cagayan Rivers) System installed in 1982 and an on-going system for the Binga-Ambuklao dam basin (refer to Figure 10.4.1 and Table 10.4.1). These systems, however, have the following operational problems:

i) insufficient budget and staff for maintenance,
ii) insufficient reliability of forecasting due to limited number of raingauge stations, and
iii) insufficient warning activities due to unreliable communication system among agencies concerned.

10.4.3 FFWS Framework Plan

(1) Basic Conditions of the FFWS Framework Plan

The FFWS Framework Plan is formulated to fulfill the following basic conditions:

i) The control center of the system is established at Rosales, the same place of the existing ARFFO.
ii) The existing ARFFO is unified with the newly established Control Center to execute operation and maintenance of the observation facilities in the basin effectively and consistently.
iii) The authorized limited rights of PAGASA with respect to warning

actions in the basin are reinforced in order to execute warning activities promptly.

iv) A communication system is installed in the headquarters in order to monitor the flood forecasting and warning activities in the subject river basin.

v) FFWSDO Ambuklao and Binga control offices are connected with the integrated FFWS center by intensified communication systems in order to monitor all the observation records and operation and maintenance records obtained from the offices at the center. The flood discharge information recorded in the downstream areas is sent to the offices through the systems as a supplemental information for flood releasing operations.

vi) Intensified communication systems are provided among the newly constructed flood control facilities and the integrated FFWS Center for the same purpose stated above.

vii) Flood warning network system among local agencies such as municipality and FFWS control offices are provided to intensify the local level of flood warning, flood preparedness and flood fighting activity.

viii) Warning stations are provided along the river course to prevent the residents from approaching the river during flood.

(2) FFWS Framework plan

The proposed FFWS Framework Plan is composed of the system components listed below.

(a) Hydrological Observation Network System

- Water level stations : 17 stations (existing 7 stations included)
- Raingauge stations : 32 stations (existing 6 stations included)

(b) Telemetering Network System

- System Control Center : Rosales, DPWH
- Repeater Station : 2 stations
    - Mt. Ampucao (extension of the existing station)
    - Mt. Bamban (newly constructed)

(c) Flood Forecasting System

- One computer system in Rosales control center

(d) Flood Warning Network System

- Duplex link between Rosales control center and the related 29 local agencies
- 31 Warning stations along the river

(e) Monitoring System: 4 monitors in Rosales Control Center

a. Flood Operation System

- For Balog-Balog Flood Operation System (New)
- For San Roque Flood Operation System (New after dam construction)
- For Moriones Flood Operation System (New after dam construction)

b. Monitoring at DPWH central office

The locations of the proposed hydrological observation network system, the telemetering network system and the control center are illustrated in Figure 10.4.2. The location of the flood warning network system is illustrated in Figure 10.4.3.

The total project cost of the integrated FFWS in the Agno River basin is estimated at 796 million pesos as shown in Table 10.4.2. The economic internal rate of return is expected to be 19.3%.

The flood forecasting points of the integrated FFWS are illustrated in Figure 10.4.4. The effectiveness of these forecasting points is assessed in terms of affected population in the related municipalities and is summarized in Figure 10.4.5.

(3) Institutional Arrangement

The following institutional arrangement is recommended for further study to achieve smooth operation of the proposed integrated FFWS:

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

(b) The DPWH is responsible for the local flood forecasting in connection with its responsibility for the river administration and the regular maintenance work of the hydrological stations.

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

(d) A telecommunication training center is to be established in collaboration with PAGASA, NAPOCOR, NIA, DPWH and NTC in Manila. The purpose of the center is to train the staff and to stock and supply the spare parts of the telemetering facilities. Prompt repair work will be expected once the center is established.

(e) The provision of flood operation systems for new dams is the responsibility of the owner agency.

10.4.4 FFWS Long Term Plan

(1) Basic Conditions of the FFWS Long Term Plan

The Long Term Plan is formulated as a stage-wise development plan up to the target year 2010 which finally aims to set up the FFWS integrated system planned as the Framework plan. The basic conditions to be taken into account for formulating the Long Term Plan are set out below:

i) To resolve the problems experienced in operation and maintenance of the existing FFWS in the basin.

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

iii) To establish an appropriate scale which is economically feasible with respect to the value of social assets in the flood prone area.

iv) To select the priority area with respect to distribution of affected population (population density) and degree of the flood damage potential.

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

i) To improve the flood forecasting accuracy of the forecasting points in the existing Agno River FFWS.

ii) To carry out the effective flood warning activity in the Study Area.

(2) FFWS Long Term Plan

The proposed FFWS Long Term Plan is composed of the system components listed below.

(a) Hydrological Observation Network System
- Water level stations : 7 stations (existing)
- Raingauge stations : 14 stations (existing 6 stations included)

(b) Telemetering Network System
- System Control Center : Rosales, DPWH
- Repeater Station : 2 stations
  - Mt. Ampucao (extension of the existing station)
  - Mt. Bamban (newly constructed)

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

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

(e) Monitoring System
- Flood operation system for Binga-Ambuklao FFWSDO sub-system (existing).
- Monitoring at DPWH central office with the existing communication link.

The location of the proposed system is illustrated in Figure 10.4.6. The total project cost of the FFWS Long Term Plan is estimated at 281 million pesos as shown in Table 10.4.3. The economic internal rate of return is expected to be 28.9%.

10.5 Sabo Works

10.5.1 Definition and Objective of Sabo

It is assessed that active yield of sediment in the Study Area is mainly due to poor vegetation in the mountainous area of about 4,200 km^2 which occupies 55% of the study area of 7,460 km^2. Slope erosions caused by road construction and some portion of mine tailings constitute a part of the sediment yield in the watershed.

The average natural sediment yield of the mountanous area is estimated to be about 7,800 m^3/km^2/year (refer to Section 6.1). Neither sabo works, afforestation nor legal sediment control only can control this large amount of sediment yield.

The Sabo Framework Plan is formulated as a part of sediment control defined in Sections 8.1.1 and 8.1.2, assuming that the sediment control plan will be implemented in the future as described below.

a. Afforestation
   Fifty percent of the sediment yield in the mountain area will be mitigated by afforestation/reforestation. In order to achieve this target all of the partial forest land (800 km^2) and about 60% of the bare land (200 km^2) must be totally afforested; total afforestation of about 1,000 km^2.

b. Mine
   Sediment due to mine tailings will be totally controlled.

c. Road
   Landslide and solid erosion due to road construction will be totally controlled.

d. Sabo Works
   The remaining part of the sediment yield which will not be controlled by the foregoing three measures (a, b and c) will be dealt with by sabo works such as sabo dams.

The excess sedimentation in the river channels caused by imbalanced sediment transport capacity is treated by maintenance operation of dredging or excavation.

10.5.2 Sabo Framework Plan

(1) Sabo dam

The Sabo Dam Framework Plan is formulated for the project life of 20 years assuming that the excess sediment yield will be all stored inside the sabo dam reservoir. The required number of sabo dams, 32, are in addition to the San Roque dam and the Moriones - O'Donnell dam as summarized below.

Required Number of Sabo Dams

Location	Volume ($10^3 m^3/yr$)	for 20 years	for 50 years
Ambuklao Dam	1,681	Ambuklao Dam	Ambuklao Dam
Binga Dam	960	Binga Dam	Binga Dam
San Roque Dam	2,550	San Roque Dam	San Roque Dam
Ambayoan	1,126	6	33
Dipalo	13	1	1
Viray	74	4	6
Balog-Balog Dam	1,344	Under const.	Under const.
Moriones Dam	1,042	Moriones and Lower O'donnell dam	
Lower O'Donnel Dam	1,349	Moriones and Lower O'donnell dam	
Camiling	373	3	5
Olo	376	4	11
Bayaoas	191	1	3
Tuboy	267	3	9
Angalacan	39	2	3
Bued	346	8	33
Total	11,731	32 plus San Roque, Moriones and Lower O'donnell	104

The locations of the dam sites for the 20-year plan are shown in Figure 10.5.1 and their major dimensions and construction cost are summarized in Table 10.5.1. The total construction cost is estimated at about 2.6 billion pesos.

If the project life is set at 50 years an additional 72 dams will be required with an approximate dam height of 25 m. It is recommended, therefore, to proceed with afforestation/reforestation simultaneously with sabo dam construction instead of proceeding sabo dam construction only.

(2) Other facilities

Groundsill

Degradation occurs due to the imbalance of sediment discharge mainly caused by the decrease of sediment supply from the upper basin due to the construction of large scale dams such as San Roque. Groundsill should be provided at the scouring portion of the low water channel. The stretches to be provided with groundsill are proposed as follows:

River	Stretch
Agno River	San Roque - San Manuel
Tarlac River	Lower O'Donnell Dam - Confluence of the Tarlac River
- Ditto -	Moriones Dam - Confluence of the Tarlac River

Settling Basin

A settling basin shall be provided to trap inflowing sediments in front of the intake of each irrigation system and maintenance dredging in the basin shall also be conducted. The annual sediment inflow to the irrigation systems is estimated based on the results of the sediment balance analysis for the Proposed Framework Plan (River improvement, Moriones - O'Donnell dam and sabo dams):

Irrigation System	Sediment Inflow Volume (m^3/yr)
ARIS	208,000
LATRIS	22,000
Ambayoan RIS	71,000
Dipalo RIS	11,000
SMORIS	4,000
Tarlac RIS	3,000
Camiling RIS	64,000
Total	383,000

10.5.3 River Maintenance

The total sediment volume in the river channels of the Agno River and the tributaries is estimated at about 1,400,000 m^3/year by the sediment balance simulation analysis under the condition with the proposed Framework Plan as summarized below (refer to Figure 10.5.2):

Item	Sediment Volume ($10^3 m^3$/yr)
(1) Sediment Yield	15,481
(2) Sedimentation in Dam Reservoirs	8,823
(3) Sedimentation in Sabo Dams	2,334
(4) Sedimentation in Poponto Swamp	244
(5) Sediment Inflow to Irrigation Systems	383
(6) Sediment Discharge to Lingayen Gulf	2,291
(7) Sedimentation in River Channels	1,406
	(15,481 - 14,075)

The amount of excess sedimentation shall be disposed of annual maintenance dredging operation.

10.5.4 Dam Maintenance

The remaining dead storage of the existing dams, Ambuklao dam and Binga dam is not enough because of the unexpected huge sediment yield. Maintenance dredging of the dam reservoir should be conducted for the conservation of the design dead storage. The remaining life of the dead storage is estimated at 18 years for the Binga dam while the dead storage of the Ambuklao dam is almost full.

Table 10.2.1 PROJECT ECONOMIC COST OF ALTERNATIVE FRAMEWORK PLANS

A. AGNO MAIN AND TARLAC RIVER — Unit : Million Pesos

	Case 1 Sole River Improvement	Case 2 River Improvement & Natural Retarding Basin	Case 3 River Improvement, Natural Retarding Basin & Dam	Case 4 River Improvement & Dam
Agno Main Stream	11,472	10,700	10,485	11,202
Tarlac River	1,587	1,288	1,061	1,265
Moriones-O. Dam	-	-	1,811	1,811
Sub-total	13,059	* 11,988	13,357	14,278
Production Foregone	-	-	340	340
Increase in Dredging	2,166	-	-	2,166
Reduction in Dredging	-		-1,979	-1,979
Sub-total	2,166	-	-1,639	527
Grand total	15,225	11,988	* 11,718	14,805

B. AGNO TRIBUTARIES — Unit : Million Pesos

Camiling River	451
Banila River	1,023
Viray-Dipalo River	278
Ambayoan River	173
Total	1,925

C. ALLIED RIVERS

	Case 1 with Binalonan Floodway	Case 2 without Binalonan Floodway
Panto-Sinocalan	2,553	2,824
Cayanga-Patalan	1,246	1,158
Total	* 3,799	3,982

Remark:
* : The case of least cost

Table 10.2.2 WORK QUANTITIES OF ALTERNATIVE FRAMEWORK PLANS OF AGNO MAIN STREAM AND TARLAC RIVER

Work Item	Unit	Case 1 River Improvement Only	Case 2 River Improvement and Natural Retarding Basin	Case 3 River Improvement, Natural Retarding Basin and Dam	Case 4 River Improvement and Dam
(1) Excavation	(m3)	33,275,000	33,925,000	33,175,000	32,525,000
(2) Dredging	(m3)	17,075,000	17,075,000	17,075,000	17,075,000
(3) Embankment	(m3)	29,953,000	23,361,000	21,725,000	27,066,000
(4) Sodding	(m2)	8,215,000	7,454,000	7,029,000	7,903,000
(5) Revetment	(m2)	614,400	687,700	683,500	608,500
(6) Groin	(Nr)	1,202	1,202	1,202	1,202
(7) Sluice Way	(Nr)	20	18	18	20
(8) Water Gate	(Nr)	3	3	2	3
(9) Bridge					
New	(m2)	65,250	65,250	62,250	65,250
Rehab.	(m2)	0	0	0	0
(10) Concrete Weir	(Nr)	0	1	1	0
(11) Dam	(Nr)	0	0	1	1

Table 10.2.3 WORK QUANTITIES OF ALTERNATIVE FRAMEWORK PLANS OF AGNO TRIBUTARIES (RIVER IMPROVEMENT ONLY)

Work Item	Unit	Camiling River	Banila River	Viray-Dipalo River	Ambayoan River
(1) Excavation	(m3)	845,000	968,000	185,000	85,000
(2) Dredging	(m3)	0	0	0	0
(3) Embankment	(m3)	1,228,800	1,664,800	144,200	332,500
(4) Sodding	(m2)	537,100	827,200	134,400	171,500
(5) Revetment	(m2)	59,900	67,000	39,900	23,400
(6) Groin	(Nr)	276	420	286	88
(7) Sluice Way	(Nr)	4	14	4	4
(8) Water Gate	(Nr)	0	0	0	0
(9) Bridge					
New	(m2)	2,300	8,600	6,200	3,000
Rehab.	(m2)	0	0	0	0
(10) Concrete Weir	(Nr)	0	0	0	0

Table 10.2.4 WORK QUANTITIES OF ALTERNATIVE FRAMEWORK PLANS OF ALLIED RIVERS

Work Item	Unit	Pantal-Sinocalan River Case 1 W/ Binalonan Floodway	Pantal-Sinocalan River Case 2 W/O Binalonan Floodway	Cayanga-Patalan River Case 1	Cayanga-Patalan River Case 2
(1) Excavation	(m3)	5,711,800	6,376,000	2,361,300	2,220,800
(2) Dredging	(m3)	38,000	133,000	440,000	390,000
(3) Embankment	(m3)	6,514,600	8,058,000	1,772,600	1,330,600
(4) Sodding	(m2)	3,525,500	4,154,100	883,100	690,200
(5) Revetment	(m2)	470,400	399,500	193,800	193,500
(6) Groin	(Nr)	754	962	1,095	1,095
(7) Sluice Way	(Nr)	33	39	16	16
(8) Water Gate	(Nr)	0	0	0	0
(9) Bridge					
New	(m2)	15,000	16,000	4,400	4,500
Rehab.	(m2)	400	750	3,000	2,700
(10) Concrete Weir	(Nr)	0	0	0	0

Table 10.2.5 FEATURES OF DESIGN CHANNEL OF AGNO RIVER FOR FRAMEWORK PLAN

River: AGNO RIVER
Design Flood: 100-yr

Item	Unit	Agno R. RM - AG45	AG45 - AG65	AG65 - AG109	AG109 - AG177	AG177 - AG180+0.8k
Design Discharge	m3/s	12300	12300	12300	11100	9900
Distance	m	6850	9050	15150	10500	2200
Gradient of River Bed	-	1/6500	1/6500	1/3500	1/2000	1/2000
River Width	m	1500	1500	1500	1500	1500
Width of Channel Bed	m	400-300	300	240	200	200
Dike Height (Ave.)	m	4.7	5.3	6.2	5.6	4.8
Water Depth	m	8.73-9.57	9.57-10.7	10.7	10.7-9.41	9.41-9.14
Low Channel Height(Ave.)	m	6.5	6.5	6.5	6.5	6.0

Item	Unit	Retarding 1> AG180+0.8k -AG314	Floodway AG314 - AG320(b)	Bayanbang 2> AG282(a)- AG307	AG320(b) -AG351	Agno R. AG351 - AG367
Design Discharge	m3/s	-	8200	1000	9200	8200
Distance	m	6100	3600	10450	15300	7650
Gradient of River Bed	-	1/1550	1/1550	Existing	1/1550	1/1000
River Width	m	-	1000-830	Existing	900-2500	1000-3200
Width of Channel Bed	m	180	180	Existing	180	180
Dike Height (Ave.)	m	5.4	4.8	4.5-0.0	5.5	5.2
Water Depth	m	9.14-7.66	7.66-8.00	8.0-4.0	8.0	8.0-5.5
Low Channel Height(Ave.)	m	4.5	4.5	5.0	4.0	3.0

1>:Retarding Basin Stretch 2>:Bayanbang Stretch of Agno R.

Item	Unit	Agno R. AG367 AG414	AG414 - - AG453	AG453 - AG495	AG459 - AG473
Design Discharge	m3/s	8200	8200	6400	6400
Distance	m	7700	5300	3000	6450
Gradient of River Bed	-	1/700	1/370	1/370	1/210
River Width	m	1050-2500	1250-2400	1000-1900	300-1300
Width of Channel Bed	m	180	150	150	150
Dike Height	m	4.0	3.3	2.8	2.8-4.0
Water Depth	m	5.5	4.8	4.3	4.3-5.5
Low Channel Height	m	3.0	3.0	3.0	3.0

Table 10.2.6 FEATURES OF DESIGN CHANNEL OF TARLAC RIVER AND TRIBUTARIES OF AGNO RIVER FOR FRAMEWORK PLAN (1/2)

River: TALRAC RIVER
Design Flood: 100-yr

Item	Unit	Retarding Basin	Tarlac R.		
		AG180+0.8k TA200	TA200 - TA227	TA227 - TA251	TA251 - TARIS DAM
Design Discharge	m3/s	-	2600	2600	1750
Distance	m	8100	13000	11800	4150
Gradient of River Bed	-	1/1850	1/1300	1/760	1/692
River Width	m	-	1700-640	1600-600	600-270
Width of Channel Bed	m	160	160	160	140
Dike Height (Ave.)	m	8.2	3.9	3.5	1.5
Water Depth	m	8.9-4.82	4.82-4.0	4.0	4.0-3.5
Low Channel Height(Ave.)	m	5.0-2.0	2.0	2.0	3.5

River: CAMILING RIVER
Design Flood: 50-yr

Item	Unit	Camiling R.					
		AG143+1.0k CA156+0.3k	CA156+0.3k - CA162	CA162 - CA167	CA167 - CA172	CA172 - CA173	CA173 - CA175
Design Discharge	m3/s	2200	1550	1550	1550	1150	1150
Distance	m	3550	4650	4300	4950	1300	2050
Gradient of River Bed	-	1/2000	1/2000	1/1000	1/550	1/300	Existing
River Width	m	250	180	180	180	130	130
Width of Channel Bed	m	60	50	50	50	35	Existing
Dike Height (Ave.)	m	5.3	4.2	3.6	2.8	1.8	1.8-0.0
Water Depth	m	8.86-7.71	7.71-7.5	7.5-7.1	7.1-5.42	5.42-5.22	5.22-4.8
Low Channel Height(Ave.)	m	4.7	4.7	4.7	4.5	4.5	4.0

River: BANILA RIVER
Design Flood: 50-yr

Item	Unit	Banila R.					
		AG349- AG349+3.7k	AG349+3.7k - BN381	BN381 - BN386	BN386 - BN394	BN394 - BN397	BN397 - BN401
Design Discharge	m3/s	1400	1400	950	440	440	340
Distance	m	3700	8050	4550	7600	2900	4100
Gradient of River Bed	-	1/1295	1/835	1/520	1/265	Existing	Existing
River Width	m	180	180	120	120	120	120
Width of Channel Bed	m	30	30	20	10	Existing	Existing
Dike Height (Ave.)	m	3.5	3.2	2.9	2.4	2.1	1.3
Water Depth	m	7.5	7.0	7.0-6.42	6.42-3.14	3.14-1.5	1.5
Low Channel Height (Ave.)	m	5.0	4.8	4.8	4.8-2.5	1.0	1.0

Table 10.2.6 FEATURES OF DESIGN CHANNEL OF TARLAC RIVER AND TRIBUTARIES OF AGNO RIVER FOR FRAMEWORK PLAN (2/2)

River: VIRAY-DIPALO RIVEIVER
Design Flood: 50-yr

Item	Unit	Viray-Dipalo R. AG414-VD425	VD425-VD428	VD428-VD430	VD430-VD430+0.6K	Viray R. VD430+0.6k-VD433	VD433-VD434+0.5k
Design Discharge	m3/s	750	750	750	750	370	370
Distance	m	2800	3100	2000	600	2400	1450
Gradient of River Bed	-	1/375	1/300	1/250	1//127	1/127	1/75
River Width	m	380-290	320-270	320-260	300	150	150
Width of Channel Bed	m	30	30	30	30	15	15
Dike Height (Ave.)	m	1.7	1.7	1.7	1.7	0.9	0.9
Water Depth	m	4.0	4.0	4.0	4.0	2.9	2.9
Low Channel Height (Ave.)	m	3.3	3.3	3.3	3.3	2.8	2.8

Item	Unit	Dipalo R. VD430+0.6k-VD436	VD436-VD437	VD437-VD439	VD439-VD441	VD441-VD442
Design Discharge	m3/s	350	350	210	210	210
Distance	m	1500	700	1950	1950	1000
Gradient of River Bed	-	1/170	1/125	1/125	1/80	1/68
River Width	m	100	100	100	100	100
Width of Channel Bed	m	15	15	10	10	10
Dike Height (Ave.)	m	2.6	2.6	2.3	2.1	1.9
Water Depth	m	3.8	3.0	2.5	2.3	2.1
Low Channel Height (Ave.)	m	2.0	1.2	1.0	1.0	1.0

River: AMBAYOAN RIVER
Design Flood: 50-yr

Item	Unit	Ambayoan R. AG461-AM444+0.5k	AM444+0.5k-AM448	AM448-AM451+0.4k
Design Discharge	m3/s	1750	1750	1750
Distance	m	1800	3550	3350
Gradient of River Bed	-	1/390	1/205	1/150
River Width	m	400	400	400
Width of Channel Bed	m	50	50	50
Dike Heightn (Ave.)	m	4.2	2.2	2.0
Water Depth	m	5.5	3.7	3.5
Low Channel Height (Ave.)	m	2.8	2.5	2.5

Table 10.2.7 FEATURES OF DESIGN CHANNEL OF ALLIED RIVERS FOR FRAMEWORK PLAN (1/4)

River: CAYANGA-PATALAN-ANGALACAN RIVER
Design Flood: 50-yr (with Closure Dike)

Item	Unit	Cayanga R. R.M - Bued R.	Patalan R. Bued R.- Aloragat R.	Angalacan River Aloragat R. - 21.0 k	21.0 k- Maraboc	Maraboc - 27.o k	27.0 k - Bugayong
Design Discharge	m3/s	3100	1850	1250	1250	500	500
Distance	m	6500	8300	6200	2800	3200	3300
Gradient of River Bed	-	1/1300	1/1100	1/650	1/460	1/460	1/230
River Width	m	500	200	150	120	100	80
Width of Channel Bed	m	65	45	40	35	25	20
Dike Height	m	2.9	3.3	2.2	2.1	0.7	0.3
Water Depth	m	8.2	7.3	6.2	6.1	4.7	4.3
Low Channel Height	m	6.5	5.0	5.0	5.0	5.0	4.0

Item	Unit	Angalacan R. Bugayong -Killo Br.	Killo Br. -37.5k
Design Discharge	m3/s	370	370
Distance	m	2700	4500
Gradient of River Bed	-	1/190	1/140
River Width	m	60	50
Width of Channel Bed	m	15	15
Dike Height (Ave.)	m	0.4	1.1
Water Depth	m	3.6	3.3
Low Channel Height (Ave.)	m	4.0	3.0

River: BUED RIVER
Design Flood: 50-yr (with Closure Dike)

Item	Unit	Bued River Junction -2.0k	2.0k- 4.0k	4.0k- NIA Dam	NIA Dam -11.9k	11.9k- 16.5k	16.5k- 19.7k
Design Discharge	m3/s	1300	1300	1300	1300	1000	1000
Distance	m	2000	2000	3300	4600	4600	3200
Gradient of River Bed	-	1/400	1/280	1/170	1/143	1/140	1/70
River Width	m	400	400	400	400	400	400
Width of Channel Bed	m	30	20	20	20	20	20
Dike Height (Ave.)	m	4.4-2.0	2.1	2.1	1.9	1.6	1.4
Water Depth	m	8.2-5.8	5.6	3.3	2.4	2.1	1.9
Low Channel Height (Ave.)	m	5.0	3.5	2.0	1.5	1.5	1.5

Table 10.2.7 FEATURES OF DESIGN CHANNEL OF ALLIED RIVERS FOR FRAMEWORK PLAN (2/4)

River: ALORAGAT RIVER
Design Flood: 50-yr (with Closure Dike)

Item	Unit	ALORAGAT RIVER Junction -7.0k	7.0k- 11.5k	11.5k- 17.0k	17.0k- 19.7k
Design Discharge	m3/s	470	470	250	170
Distance	m	7000	4500	5500	2700
Gradient of River Bed	-	1/680	1/355	1/355	1/185
River Width	m	90	80	50	45
Width of Channel Bed	m	30	20	10	10
Dike Height (Ave.)	m	2.8-0.0	0	1.3	1.4
Water Depth	m	7.3-4.2	4.0	4.0	2.8
Low Channel Height (Ave.)	m	5.5	5.0	3.5	2.0

River: PANTO-MARUSAY-SINSINOCALAN-TUBOY RIVER
Design Flood: 50-yr (with Floodway)

Item	Unit	PANTO R.	MARUSAY R.		SINOCALAN R.		
		R.M- Dagupan R.	Dagupan R. -4.0k	4.0k - Ingalera R.	Ingalera R. -18.0k	18.0k- 25.5k	25.5k- Mitura R.
Design Discharge	m3/s	2700	1650	1650	1000	650	650
Distance	m	2500	1500	4300	9700	7500	5500
Gradient of River Bed	-	1/1750	1/1750	1/1750	1/1750	1/1450	1/1100
River Width	m	400	120	220	220	150	100
Width of Channel Bed	m	70	60	50	30	30	25
Dike Height (Ave.)	m	3.7-3.4	3.0	3.0	2.6	2.4	2.0
Water Depth	m	8.0-7.7	7.5	7.5	7.1	6.9	6.0
Low Channel Height (Ave.)	m	5.5	5.5	5.5	5.5	5.5	5.0

Item	Unit	TAGUMISING R. Mitura R. -36.7k	36.7k- Sta. Maria	Sta. Maria -43.5k
Design Discharge	m3/s	160	160	120
Distance	m	5700	4700	2100
Gradient of River Bed	-	1/700	1/430	1/350
River Width	m	100	80	80
Width of Channel Bed	m	10	10	10
Dike Height	m	0	0	0
Water Depth	m	4.0	3.3	3.0
Low Channel Height	m	5.0	4.5	4.5

Table 10.2.7 FEATURES OF DESIGN CHANNEL OF ALLIED RIVERS FOR FRAMEWORK PLAN (3/4)

River: DAGUPAN RIVER
Design Flood: 50-yr

Item	Unit	DAGUPAN R. Junction -7.5k	SAN JUAN R. 7.5k-12.7k	12.7k-Elang R.	ELANG R. San Juan - 27.6k
Design Discharge	m3/s	1100	900	650	310
Distance	m	7500	5200	9000	5900
Gradient of River Bed	-	1/5000	1/5000	1/5000	1/5000
River Width	m	250	100	100	50
Width of Channel Bed	m	60	30	30	20
Dike Height (Ave.)	m	3.2	3.6	4.1	3.3
Water Depth	m	7.7	7.6	7.6	7.0
Low Channel Height (Ave.)	m	5.5	5.0	4.5	4.5

River: INGALERA RIVER
Design Flood: 50-yr

Item	Unit	INGALERA RIVER Junction -Malasigui	Malasigui - 26.0k	26.0k - 32.0k	32.0k- San Nicolas	San Nicolas -37.5k
Design Discharge	m3/s	600	460	260	260	150
Distance	m	13300	12700	6000	4000	1500
Gradient of River Bed	-	1/3600	1/1800	1/1000	1/700	1/700
River Width	m	100	60	50	50	40
Width of Channel Bed	m	25	15	15	10	10
Dike Height (Ave.)	m	3.0	2.2	1.3	1.7	1.3
Water Depth	m	7.5	6.9	5.5	4.9	4.2
Low Channel Height (Ave.)	m	5.5	5.5	5.0	4.0	3.5

River: MITURA-MAGALONG RIVER ER
Design Flood: 50-yr

Item	Unit	MITURA R. Junction -5.3k	5.3k- Taboy	MAGALONG RIVER Taboy - 19.0k	19.0k - 21.0k
Design Discharge	m3/s	250	250	180	140
Distance	m	5300	8900	4800	2000
Gradient of River Bed	-	1/800	1/460	1/460	1/250
River Width	m	50	40	35	30
Width of Channel Bed	m	10	8	6	4
Dike Height (Ave.)	m	2.0-1.0	1.5	1.4	1.3
Water Depth	m	6.0-5.2	4.7	4.3	3.7
Low Channel Height (Ave.)	m	5.0	4.0	3.5	3.0

Table 10.2.7 FEATURES OF DESIGN CHANNEL OF ALLIED RIVERS FOR FRAMEWORK PLAN (4/4)

River: BINALONAN FLOODWAY/TUBOY RIVER
Design Flood: 50-yr

Item	Unit	Binalonan Floodway		Tuboy R.	
		Junction -1.8k	1.8k- 6.7k	6.7k- 10.6k	10.6k- 12.2k
Design Discharge	m3/s	650	650	550	550
Distance	m	1800	4900	3900	2000
Gradient of River Bed	-	1/400	1/355.5	1/190	1/143-1/67
River Width	m	60	60	60	60
Width of Channel Bed	m	15	15	15	15-10
Dike Height (Ave.)	m	2.5	2.4	1.7	1.7-0.3
Water Depth	m	6.1-6.0	6.0-5.7	4.7	4.7-3.3
Low Channel Height (Ave.)	m	4.5	4.5	4.0	4.0

Table 10.3.1 PROJECT ECONOMIC COST OF ALTERNATIVE LONG TERM PLAN FOR MAIN AGNO AND TARLAC RIVERS

(Unit : Million Pesos)

Return Period	Work Item	Main Agno River					Tarlac River			Grand Total
		Lower Agno River	Poponto Stretch		Upper Agno River	Total of Agno River	Confluence		Total of Tarlac River	
		RM-AG282	Bayambang Stretch	Poponto Floodway	AG309-AG473		AG180-TA200	TA200-TA265		
1/100	I. Main Construction Cost	4,509	121	774	1,548	6,952	281	598	879	7,831
	II. Compensation	533	1	19	137	690	48	23	71	761
	III. Administration	252	6	40	84	382	16	31	47	429
	IV. Engineering Services	721	19	124	248	1,112	45	96	141	1,253
	V. Physical Contingency	795	19	125	265	1,204	52	98	150	1,354
	Grand Total	6,810	166	1,082	2,282	10,340	442	846	1,288	11,628
1/50	I. Main Construction Cost	3,979	98	730	1,457	6,264	263	529	792	7,056
	II. Compensation	533	1	19	137	690	48	23	71	761
	III. Administration	226	5	37	80	348	16	28	44	392
	IV. Engineering Services	637	16	117	233	1,003	42	85	127	1,130
	V. Physical Contingency	710	16	118	251	1,095	49	87	136	1,231
	Grand Total	6,085	136	1,021	2,158	9,400	418	752	1,170	10,570
1/25	I. Main Construction Cost	3,526	66	619	1,317	5,528	245	468	713	6,241
	II. Compensation	533	1	19	137	690	48	23	71	761
	III. Administration	203	3	32	73	311	15	25	40	351
	IV. Engineering Services	564	11	99	211	885	39	75	114	999
	V. Physical Contingency	639	11	101	229	980	46	77	123	1,103
	Grand Total	5,465	92	870	1,967	8,394	393	668	1,061	9,455
1/10	I. Main Construction Cost	2,955	58	572	1,226	4,811	230	382	612	5,423
	II. Compensation	533	1	19	137	690	48	23	71	761
	III. Administration	174	3	30	68	275	14	20	34	309
	IV. Engineering Services	473	9	92	196	770	37	61	98	868
	V. Physical Contingency	550	9	93	215	867	44	64	108	975
	Grand Total	4,685	80	806	1,842	7,413	373	550	923	8,336

Table 10.3.2 PROJECT ECONOMIC COST OF ALTERNATIVE LONG TERM PLAN FOR AGNO RIVER TRIBUTARIES

(Unit : Million Pesos)

Return Period	Work Item	Camiling River	Banila River	Viray-Dipalo River	Ambayoan River	Total
1/50	I. Main Construction Cost					
	1. Preparatory Works	24	54	15	9	102
	2. Main Works	239	543	148	92	1,022
	3. Miscellaneous Works	40	90	24	15	169
	Total of I.	303	687	187	116	1,293
	II. Compensation	30	69	19	12	130
	III. Administration	17	38	10	6	71
	IV. Engineering Services	48	110	30	19	207
	V. Physical Contingency	53	119	32	20	224
	Grand Total	451	1,023	278	173	1,925
1/25	I. Main Construction Cost					
	1. Preparatory Works	19	38	14	9	80
	2. Main Works	190	379	144	87	800
	3. Miscellaneous Works	31	63	24	14	132
	Total of I.	240	480	182	110	1,012
	II. Compensation	24	48	18	11	101
	III. Administration	13	26	10	6	55
	IV. Engineering Services	38	77	29	18	162
	V. Physical Contingency	42	83	32	19	176
	Grand Total	357	714	271	164	1,506
1/10	I. Main Construction Cost					
	1. Preparatory Works	15	34	14	8	71
	2. Main Works	148	337	140	81	706
	3. Miscellaneous Works	24	56	23	13	116
	Total of I.	187	427	177	102	893
	II. Compensation	19	43	18	10	90
	III. Administration	10	24	10	6	50
	IV. Engineering Services	30	68	28	16	142
	V. Physical Contingency	32	74	31	18	155
	Grand Total	278	636	264	152	1,330

Table 10.3.3 PROJECT ECONOMIC COST OF ALTERNATIVE LONG TERM PLAN FOR ALLIED RIVERS (1/2)

1. Pantal-Sinocalan River with Binalonan Floodway (Unit : Million Pesos)

Return Period	Work Item	Pantal-Sinocalan River	Dagupan River	Ingalera River	Macalong River	Binalonan Floodway	Total
1/50	I. Main Construction Cost						
	1. Preparatory Works	39	39	38	7	13	136
	2. Main Works	389	389	375	71	131	1,355
	3. Miscellaneous Works	64	64	62	12	22	224
	Total of I.	492	492	475	90	166	1,715
	II. Compensation	49	49	48	9	17	172
	III. Administration	27	27	26	5	9	94
	IV. Engineering Services	79	79	76	14	27	275
	V. Physical Contingency	85	85	82	16	29	297
	Grand Total	732	732	707	134	248	2,553
1/25	I. Main Construction Cost						
	1. Preparatory Works	36	34	34	7	12	123
	2. Main Works	360	342	339	65	116	1,222
	3. Miscellaneous Works	59	56	56	11	19	201
	Total of I.	455	432	429	83	147	1,546
	II. Compensation	46	43	43	8	15	155
	III. Administration	25	24	24	5	8	86
	IV. Engineering Services	73	69	69	13	24	248
	V. Physical Contingency	79	75	74	14	26	268
	Grand Total	678	643	639	123	220	2,303
1/10	I. Main Construction Cost						
	1. Preparatory Works	33	29	27	5	11	105
	2. Main Works	326	287	273	48	108	1,042
	3. Miscellaneous Works	54	47	45	8	18	172
	Total of I.	413	363	345	61	137	1,319
	II. Compensation	41	36	35	6	14	132
	III. Administration	23	20	19	3	8	73
	IV. Engineering Services	66	58	55	10	22	211
	V. Physical Contingency	72	63	60	11	24	230
	Grand Total	615	540	514	91	205	1,965

Table 10.3.3 PROJECT ECONOMIC COST OF ALTERNATIVE LONG TERM PLAN FOR ALLIED RIVERS (2/2)

2. Cayanga-Patalan River with Binalonan Floodway (Unit : Million Pesos)

Return Period	Work Item	Cayanga-Patalan River	Bued River	Aloragat River	Total
1/50	I. Main Construction Cost				
	1. Preparatory Works	40	19	7	66
	2. Main Works	401	190	71	662
	3. Miscellaneous Works	66	31	12	109
	Total of I.	507	240	90	837
	II. Compensation	51	24	9	84
	III. Administration	28	13	5	46
	IV. Engineering Services	81	38	14	133
	V. Physical Contingency	88	42	16	146
	Grand Total	755	357	134	1,246
1/25	I. Main Construction Cost				
	1. Preparatory Works	36	19	7	62
	2. Main Works	360	186	68	614
	3. Miscellaneous Works	59	31	11	101
	Total of I.	455	236	86	777
	II. Compensation	46	24	9	79
	III. Administration	25	13	5	43
	IV. Engineering Services	73	38	14	125
	V. Physical Contingency	79	41	15	135
	Grand Total	678	352	129	1,159
1/10	I. Main Construction Cost				
	1. Preparatory Works	32	18	7	57
	2. Main Works	317	181	67	565
	3. Miscellaneous Works	52	30	11	93
	Total of I.	401	229	85	715
	II. Compensation	40	23	9	72
	III. Administration	22	13	5	40
	IV. Engineering Services	64	37	14	115
	V. Physical Contingency	69	40	15	124
	Grand Total	596	342	128	1,066

Table 10.3.4 PROJECT FINANCIAL COST OF LONG TERM PLAN (1/2)

(Unit: 1,000 Pesos)

River	F.C.	L.C.	Total
I. Agno River			
1. Lower Agno River			
(1) RM-AG045	955,609	679,183	1,634,792
(2) AG045-AG122	1,958,053	963,113	2,921,166
(3) AG122-AG282	979,063	519,039	1,498,102
Sub-total of 1	3,892,725	2,161,335	6,054,060
2. Poponto Stretch			
(1) Bayambang Stretch	76,139	53,450	129,589
(2) Poponto Floodway	685,298	312,500	997,798
Sub-total of 2	761,437	365,950	1,127,387
3. Upper Agno River			
(1) AG309-AG351	299,418	225,551	524,969
(2) AG351-AG405	222,559	155,322	377,881
(3) AG405-AG473	871,344	429,655	1,300,999
Sub-total of 3	1,393,321	810,528	2,203,849
Total of I	6,047,483	3,337,813	9,385,296
II. Tarlac River			
(1) AG180-TA200	456,111	184,589	640,700
(2) TA200-TA265	446,532	333,839	780,371
Total of II	902,643	518,428	1,421,071
III. Agno River Tributary			
(1) Camiling River	225,737	161,015	386,752
(2) Banila River	459,202	314,534	773,736
(3) Viray-Dipalo River	150,801	149,433	300,234
(4) Ambayoan River	101,274	78,013	179,287
Total of III	937,014	702,995	1,640,009
GRAND TOTAL (I+II+III)	7,887,140	4,559,236	12,446,376

(CF-LG25A)

Table 10.3.4 PROJECT FINANCIAL COST OF LONG TERM PLAN (2/2)

(Unit: 1,000 Pesos)

River	F.C.	L.C.	Total
I. Panto-Sinocalan River			
(1) Panto-Sinocalan River	539,589	376,417	916,006
(2) Dagupan River	379,441	207,483	586,924
(3) Ingalera River	334,582	219,499	554,081
(4) Macalong River	57,757	45,235	102,992
(5) Binalonan Floodway	0	0	0
Sub-Total I.	1,311,369	848,634	2,160,003
II. Cayanga-Patalan River			
(1) Cayanga-Patalan River	338,684	262,748	601,432
(2) Bued River	214,179	161,985	376,164
(3) Aloragat River	61,882	86,802	148,684
Sub-Total I.	614,745	511,535	1,126,280
Total of I. and II.	1,926,114	1,360,169	3,286,283

(CF-LG250)

Table 10.3.5 FEATURES OF DESIGN CHANNEL OF AGNO RIVER FOR LONG TERM PLAN

River: AGNO RIVER
Design Flood: 25-yr

		Agno R.				
Item	Unit	Rivermouth -AG45	AG45 - AG65	AG65 - AG109	AG109 - AG177	AG177 - AG180+0.8k
Design Discharge	m3/s	9000	9000	9000	8100	7500
Distance	m	6850	9050	15150	10500	2800
Gradient of River Bed	-	1/6500	1/6500	1/3500	1/2000	1/2000
River Width	m	1500	(1500)	(1500)	(1500)	(1500)
Width of Channel Bed	m	360-250	240	200	200	200
Dike Height (Ave.)	m	3.6	4.2	5.1	4.5	4.1
Water Depth	m	8.1-9.0	9.0-10.1	10.1	10.1-8.8	8.8-8.4
Low Channel Height(Ave.)	m	6.5	6.5	6.5	6.5	6.0

		Retarding 1>	Floodway	Bayambang 2>	Agno R.	
Item	Unit	AG180+0.8k -AG314	AG314 - AG320(b)	AG282(a) - AG307	AG320(b) - AG351	AG351 - AG367
Design Discharge	m3/s	-	5200	600	5800	5100
Distance	m	6100	3600	10450	15300	7650
Gradient of River Bed	-	1/1550	1/1550	Existing	1/1550	1/1000
River Width	m	-	1000-830	160-2000	600-2500	100-3200
Width of Channel Bed	m	180	180	Existing	180	180
Dike Height (Ave.)	m	4.7	4.0	4.1-0.0	4.4	4.4
Water Depth	m	8.4-7.0	7.0	7.6-3.4	6.9	6.9-4.8
Low Channel Height(Ave.)	m	4.5	4.5	5.0	4.0	3.0

1>:Retarding Basin Stretch   2>:Bayambang Stretch of Agno R.

		Agno R.			
Item	Unit	AG367 - AG414	AG414 - AG453	AG453 - AG459	AG459 - AG473
Design Discharge	m3/s	5100	5100	3800	3800
Distance	m	7700	5300	3000	6450
Gradient of River Bed	-	1/700	1/370	1/370	1/210
River Width	m	1050-2500	1250-2400	1000-1900	300-1300
Width of Channel Bed	m	180	150	150	150
Dike Height (Ave.)	m	3.3	2.8	2.0	2.0-3.0
Water Depth	m	4.8	4.3	3.8	3.8-4.8
Low Channel Height (Ave.)	m	3.0	3.0	3.0	3.0

Table 10.3.6 FEATURES OF DESIGN CHANNEL OF TARLAC RIVER AND TRIBUTARIES OF AGNO RIVER FOR LONG TERM PLAN (1/2)

River: TALRAC RIVER
Design Flood: 25-yr

		Returding Basin	Tarlac R.		
Item	Unit	AG180+0.8k - TA200	TA200 - TA227	TA227 - TA251	TA251 - TARIS Dam
Design Discharge	m3/s	-	2600	2600	1750
Distance	m	8100	13000	11800	4150
Gradient of River Bed	-	1/1850	1/1300	1/760	1/692
River Width	m	-	1700-640	1600-600	600-270
Width of Channel Bed	m	160	160	160	140
Dike Height (Ave.)	m	7.2	3.9	3.5	1.5
Water Depth	m	7.9-4.82	4.82-4.0	4.0	4.0-3.5
Low Channel Height(Ave.)	m	5.0-2.0	2.0	2.0	3.5

River: CAMILING RIVER
Design Flood: 25-yr

		Camiling R.					
Item	Unit	AG143+1.0k CA156+0.3k	CA156+0.3k - CA162	CA162 - CA167	CA167 - CA172	CA172 - CA173	CA173 - CA175
Design Discharge	m3/s	1650	1150	1150	1150	850	850
Distance	m	3550	4650	4300	4950	1300	2050
Gradient of River Bed	-	1/2000	1/2000	1/1000	1/550	1/300	Existing
River Width	m	250	180	180	180	130	130
Width of Channel Bed	m	50	40	40	40	30	Existing
Dike Height (Ave.)	m	5.0-3.2	3.1	2.8	2.0	1.0	1.0-0.0
Water Depth	m	8.2-6.9	6.9-6.7	6.7-6.3	6.3-4.8	4.8-4.4	4.4-4.2
Low Channel Height(Ave.)	m	4.7	4.7	4.7	4.5	4.5	4.0

River: BANILA RIVER
Design Flood: 25-yr

		Banila R.					
Item	Unit	AG349- AG349+3.7k	AG349+3.7k - BN381	BN381 - BN386	BN386 - BN394	BN394 - BN397	BN397 - BN401
Design Discharge	m3/s	1000	1000	650	300	300	230
Distance	m	3700	8050	4550	7600	2900	4100
Gradient of River Bed	-	1/1295	1/835	1/520	1/265	Existing	Existing
River Width	m	180	180	120	120	120	120
Width of Channel Bed	m	20	20	15	8	Existing	Existing
Dike Height (Ave.)	m	3.1	2.8	2.5	2.1	1.9	1.1
Water Depth	m	7.1	6.6	6.6-6.0	6.6-2.8	2.8-1.3	1.3
Low Channel Height (Ave.)	m	5.0	4.8	4.8	4.8-2.5	1.0	1.0

Table 10.3.6 FEATURES OF DESIGN CHANNEL OF TARLAC RIVER AND TRIBUTARIES OF AGNO RIVER FOR LONG TERM PLAN (2/2)

River: VIRAY-DIPALO RIVER
Design Flood: 25-yr

Item	Unit	Viray-Dipalo R. AG414 -VD425	VD425 -VD428	VD428 -VD430	VD430- VD430+0.6K	Viray R. VD430+0.6K -VD433	VD433 -VD434+0.5K
Design Discharge	m3/s	550	550	550	550	270	270
Distance	m	2800	3100	2000	600	2400	1450
Gradient of River Bed	-	1/375	1/300	1/250	1/127	1/127	1/75
River Width	m	380-290	320-270	320-260	300	150	150
Width of Channel Bed	m	30	30	30	30	15	15
Dike Height (Ave.)	m	1.4	1.4	1.4	1.4	0.75	0.75
Water Depth	m	3.7	3.7	3.7	3.7	2.75	2.75
Low Channel Height (Ave.)	m	3.3	3.3	3.3	3.3	2.8	2.8

River: VIRAY-DIPALO RIVER
Design Flood: 25-yr

Item	Unit	Dipalo R. VD430+0.6K -VD436	VD436 -VD437	VD437 -VD439	VD439 -VD441	VD441 -VD442
Design Discharge	m3/s	250	250	150	150	150
Distance	m	1500	700	1950	1950	1000
Gradient of River Bed	-	1/170	1/125	1/125	1/80	1/68
River Width	m	100	100	100	100	100
Width of Channel Bed	m	15	15	10	10	10
Dike Height (Ave.)	m	2.4	2.4	1.95	1.75	1.55
Water Depth	m	3.6	2.8	2.35	2.15	1.95
Low Channel Height(Ave.)	m	2.0	1.2	1.0	1.0	1.0

River: AMBAYOAN RIVER
Design Flood: 25-yr

Item	Unit	Ambayoan R. AG461- AM444+0.5K	AM444+0.5K - AM448K	AM448- AM451+0.4k
Design Discharge	m3/s	1350	1350	1350
Distance	m	1800	3550	3350
Gradient of River Bed	-	1/390	1/205	1/150
River Width	m	400	400	400
Width of Channel Bed	m	50	50	50
Dike Height(Ave.)	m	3.9	1.9	1.7
Water Depth	m	5.2	3.4	3.2
Low Channel Height(Ave.)	m	2.8	2.5	2.5

Table 10.3.7 FEATURES OF DESIGN CHANNEL OF ALLIED RIVERS FOR LONG TERM PLAN (1/3)

River: CAYANGA-PATALAN-ANGALACAN RIVER
Design Flood: 10-yr (with Closure Dike)

Item	Unit	Cayanga R.	Patalan R.	Angalacan River			
		R.M - Bued R.	Bued R.- Aloragat R.	Aloragat R. - 21.0k	21.0k- Maraboc	Maraboc - 27.0k	27.0k - Bugayong
Design Discharge	m3/s	1500	800	400	400	280	280
Distance	m	6500	8300	6200	2800	3200	3300
Gradient of River Bed	-	1/1300	1/1100	1/650	1/460	1/460	1/230
River Width	m	500	200	150	120	100	80
Width of Channel Bed	m	40	30	25	25	20	20
Dike Height	m	1.9	2.1	0.3	0	0	0
Water Depth	m	7.4	6.1	4.5	4.1	3.8	3.2
Low Channel Height	m	6.5	5.0	5.0	5.0	5.0	4.0

Item	Unit	Angalacan River	
		Bugayong -KILLO Br.	Killo Br. -37.5k
Design Discharge	m3/s	190	190
Distance	m	2700	4500
Gradient of River Bed	-	1/190	1/140
River Width	m	60	50
Width of Channel Bed	m	15	15
Dike Height	m	0	0
Water Depth	m	3	2.4
Low Channel Height	m	4.0	3.0

River: BUED RIVER
Design Flood: 10-yr (with Closure Dike)

Item	Unit	Bued River					
		Junction -2.0 K	2.0 K - 4.0 K	4.0 K - NIA Dam	NIA Dam 11.9 K	11.9 K - 16.5 K	16.5 K 19.7
Design Discharge	m3/s	750	750	750	750	500	500
Distance	m	2000	2000	3300	4600	4600	3200
Gradient of River Bed	-	1/400	1/280	1/170	1/143	1/140	1/70
River Width	m	400	400	400	400	400	400
Width of Channel Bed	m	30	20	20	20	20	20
Dike Height	m	1.9-1.1	2.1	1.9	1.4	1.2	1.1
Water Depth	m	7.4-5.1	4.6	2.9	1.9	1.7	1.6
Low Channel Height	m	5.0	3.5	2.0	1.5	1.5	1.5

Table 10.3.7 FEATURES OF DESIGN CHANNEL OF ALLIED RIVERS FOR LONG TERM PLAN (2/3)

River: ALORAGAT RIVER
Design Flood: 10-yr (with Closure Dike)

Item	Unit	ALORAGAT RIVER Junction -7.0k	7.0k- 11.5k	11.5k- 17.0k	17.0k- 19.7k
Design Discharge	m3/s	300	300	150	100
Distance	m	7000	4500	5500	2700
Gradient of River Bed	-	1/680	1/355	1/335	1/185
River Width	m	90	80	50	45
Width of Channel Bed	m	30	20	10	10
Dike Height	m	1.6-0.0	0.0	0.3	0.8
Water Depth	m	6.1-3.2	3.2	3.2	2.2
Low Channel Height	m	5.5	5.0	3.5	2.0

River: PANTO-MARUSAY-SINOCALAN-TAGUMISING RIVER
Design Flood: 10-yr (w/o Floodway)

Item	Unit	PANTO R.	MARUSAY R.		SINOCALAN R.		
		R.M - Dagupan R.	Dagupan R. -4.0K	4.0k - Ingalera R.	Ingalera R. -18.0k	18.0k- 25.5k	25.5k - Mitura R.
Design Discharge	m3/s	1900	1250	1250	900	650	650
Distance	m	2500	1500	4300	9700	7500	5500
Gradient of River Bed	-	1/1750	1/1750	1/1750	1/1750	1/1450	1/1100
River Width	m	400	120	220	220	150	100
Width of Channel Bed	m	60	60	40	30	30	25
Dike Height	m	2.7	2.6	2.6	2.4	2.4	2.0
Water Depth	m	7.2	7.1	7.1	6.9	6.9	6.0
Low Channel Height	m	5.5	5.5	5.5	5.5	5.5	5.0

Item	Unit	TAGUMISING R. Mitura R. -36.7k	36.7k- Sta. Maria	Sta. Maria -43.5k
Design Discharge	m3/s	160	160	120
Distance	m	5700	4700	2100
Gradient of River Bed	-	1/700	1/430	1/350
River Width	m	100	80	80
Width of Channel Bed	m	10	10	10
Dike Height	m	0	0	0
Water Depth	m	4.0	3.3	3.0
Low Channel Height	m	5.0	4.5	4.5

Table 10.3.7 FEATURES OF DESIGN CHANNEL OF ALLIED RIVERS FOR LONG TERM PLAN (3/3)

River: DAGUPAN RIVER
Design Flood: 10-yr

Item	Unit	DAGUPAN R. Junction -7.5k	SAN JUAN R. 7.5k-12.7k	12.7k-Erang R.	ELANG R. San Juan - 27.6k
Design Discharge	m3/s	700	550	390	190
Distance	m	7500	5200	9000	5900
Gradient of River Bed	-	1/5000	1/5000	1/5000	1/5000
River Width	m	250	100	100	50
Width of Channel Bed	m	60	30	20	15
Dike Height	m	2.7	3.2	3.3	2.3
Water Depth	m	7.2	7.2	7.0	6.0
Low Channel Height	m	5.5	5.0	4.5	4.5

River: INGALERA RIVER
Design Flood: 10-yr

Item	Unit	INGALERA RIVER Junction -Malasigui	Malasigui -26.0k	26.0k-32.0k	32.0k - San Nicolas	San Nicolas -37.5k
Design Discharge	m3/s	360	260	150	150	80
Distance	m	13300	12700	6000	4000	1500
Gradient of River Bed	-	1/3600	1/1800	1/1000	1/700	1/700
River Width	m	100	60	50	50	40
Width of Channel Bed	m	15	12	8	8	6
Dike Height	m	2.4	0.5	0.0	0.6	0.3
Water Depth	m	7.1	5.8	4.3	4.0	3.2
Low Channel Height	m	5.5	5.5	5.0	4.0	3.5

River: MITURA-MAGALONG RIVER
Design Flood: 10-yr

Item	Unit	MITURA R. Junction -5.3k	MAGALONG RIVER 5.3k-Taboy	Taboy - 19.0k	19.0k - 21.0k
Design Discharge	m3/s	130	130	90	70
Distance	m	5300	8900	4800	2000
Gradient of River Bed	-	1/800	1/460	1/460	1/250
River Width	m	50	40	35	30
Width of Channel Bed	m	10	8	6	4
Dike Height	m	2.0-0.0	0.3	0.4	0.5
Water Depth	m	6.0-3.8	3.7	3.3	2.9
Low Channel Height	m	5.0	4.0	3.5	3.0

Table 10.4.1 PRINCIPAL FEATURES OF THE EXISTING/ON-GOING TELEMETERING GAUGING STATIONS

The Existing Telemetering Stations.

Station Name	Binga dam	San Roque	Carmen	Tibag	Wawa	Banaga	Sta. 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°07'21"	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	Sinocalan River
4. Catchment Area	936 km2	1,225 km2	2,209 km2	872 km2	4,196 km2	5,560 km2	180 km2
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	Ambklao 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)	-	-	-	752.0	575.0
7. Low Water Level (m AMSL)	-	-	-	694.0	555.0

Note : (*1) RF : Rainfall station
(*2) WL : Water level gauging station
(*3) AMSL : Above mean sea level

Table 10.4.2 COST ESTIMATE OF AGNO RIVER INTEGRATED FFWS

(Unit : Million Pesos)

Item No.	Description	Equipment Cost	Civil Works	Total
1. Construction Cost				
1.1 Direct Cost				
(1)	Agno River FFWS	107.45	14.06	121.51
(2)	San Roque FOS	67.83	5.78	73.61
(3)	Moriones FOS	71.73	6.25	77.98
(4)	Balog-Balog FOS	71.73	6.25	77.98
(5)	Mt. Ampucao Repeater Station	14.00	0.08	14.08
(6)	Mt. Malabobo Repeater Station	11.74	1.57	13.31
(7)	St. Ignacia Repeater Station	9.79	0.63	10.42
(8)	Binga Dam Office	2.40	0.03	2.43
(9)	Cabanatuan Repeater Station	0.30	0.02	0.32
(10)	NIA FFWS Center	0.77	0.03	0.80
(11)	PAGASA FFWS Center (DIC)	3.74	0.08	3.82
(12)	OCD Monitor Station	0.97	0.03	1.00
(13)	DPWH FFWS Center	3.58	0.08	3.66
(14)	Municipal Warning System	14.54	0.60	15.14
(15)	Measuring Equipment	5.34	0.77	6.11
(16)	Spare Parts	31.51	0.77	32.28
	Total of Direct Cost	417.42	37.03	454.45
1.2 Indirect Cost		97.97	24.75	122.72
	Total of Construction Cost	515.39	61.78	577.17
2. Engineering Services				115.38
3. Contingency				103.85
	Grand Total			796.40

Table 10.4.3 COST ESTIMATE OF AGNO RIVER LONG TERM FFWS

(Unit : Million Pesos)

Item No.	Description	Equipment Cost	Civil Works	Total
1. Construction Cost				
1.1 Direct Cost				
	(1) Agno River FFWS	81.67	8.32	89.99
	(2) Mt. Ampucao Repeater Station	14.00	0.08	14.08
	(3) Mt. Malabobo Repeater Station	11.74	1.57	13.31
	(4) Binga Dam Office	2.40	0.03	2.43
	(5) PAGASA FFWS Center (DIC)	3.74	0.08	3.82
	(6) DPWH FFWS Center	3.58	0.08	3.66
	(7) Municipal Warning System	14.54	0.60	15.14
	(8) Measuring Equipment	5.34	0.77	6.11
	(9) Spare Parts	13.17	1.07	14.24
	Total of Direct Cost	150.18	12.60	162.78
1.2 Indirect Cost		37.55	3.15	40.70
	Total of Construction Cost	187.73	15.75	203.48
2. Engineering Services				40.70
3. Contingency				36.63
	Grand Total			280.81

Table 10.5.1 MAJOR DIMENSIONS OF PROPOSED SABO DAMS (1/2)

Dam No.	Name of River	Height (m)	Width (m)	River Bed Gradient	Construction Cost (mil. peso)	Total Dam Volume (m3)	Remarks
D-1	Ambayoan	20	100	1/35	70	1,190,000	Upper Ambayoan Dam Site
D-2	- ditto -	20	100	1/35	70	1,190,000	
D-3	- ditto -	20	200	1/65	140	4,810,000	Upper Sapinit Dam Site
D-4	- ditto -	20	100	1/70	70	2,380,000	
D-5	- ditto -	20	300	1/100	210	11,400,000	
D-6	- ditto -	20	150	1/30	105	1,620,000	
Sub - Total (Ambayoan)					665	22,590,000	
D-7	Dipalo	20	100	1/20	70	680,000	
D-8	Viray	20	100	1/5	70	170,000	
D-9	- ditto -	20	100	1/12	70	425,000	
D-10	- ditto -	20	100	1/20	70	680,000	
D-11	- ditto -	10	100	1/15	40	205,000	
Sub - Total (Viray)					320	1,480,000	
D-12	Camiling	20	180	1/75	125	4,950,000	Camiling Dam Site
D-13	- ditto -	15	140	1/25	77	935,000	
D-14	- ditto -	10	140	1/75	56	1,875,000	
Sub - Total (Camiling)					258	7,760,000	
D-15	Olo	25	150	1/60	126	4,050,000	Pila Dam Site
D-16	- ditto -	20	100	1/35	70	1,190,000	
D-17	- ditto -	20	100	1/35	70	1,190,000	
D-18	- ditto -	20	100	1/35	70	1,190,000	
Sub - Total (Olo)					336	7,620,000	

Table 10.5.1 MAJOR DIMENSIONS OF PROPOSED SABO DAMS (2/2)

Dam No.	Name of River	Height (m)	Width (m)	River Bed Gradient	Construction Cost (mil. peso)	Total Dam Volume (m3)	Remarks
D-19	Bayaoas	20	180	1/75	125	4,950,000	Bayaoas Dam Site
D-20	- ditto -	20	150	1/65	105	3,510,000	Kalipkip Dam Site
D-21	- ditto -	15	100	1/40	55	1,020,000	
D-22	- ditto -	15	140	1/25	77	935,000	
Sub - Total (Tuboy)					362	5,465,000	
D-23	Angalacan	15	80	1/25	44	485,000	
D-24	- ditto -	15	100	1/15	55	380,000	
Sub - Total (Angalacan)					99	865,000	
D-25	Bued	20	100	1/45	70	1,530,000	
D-26	- ditto -	20	100	1/45	70	1,530,000	
D-27	- ditto -	20	100	1/45	70	1,530,000	
D-28	- ditto -	20	100	1/15	70	510,000	
D-29	- ditto -	20	100	1/25	70	850,000	
D-30	- ditto -	20	100	1/15	70	510,000	
D-31	- ditto -	20	100	1/10	70	340,000	
D-32	- ditto -	20	100	1/10	70	340,000	
Sub - Total (Bued)					560	7,140,000	
Total					2,600		

Note: The construction cost of each dam was estimated in proportion to the volume of dam, based on the estimation that the cost of dam of 20 m in height and 100 m in width was 70,000,000 pesos.