FLOOD DAMAGE ANALYSIS

1. INTRODUCTION

The flood damage analysis in this stage was conducted focussing on the maximum inundation areas of priority projects for the Feasibility Study which were identified in the Master Plan Study, namely, the Upper Agno Project and the Pantal-Sinocalan Project.

The objectives of the flood damage analysis were the additional study on the actual flooding condition in the Pantal-Sinocalan River Basin as well as the estimation of the annual average flood damage under the condition without project as the basis for the planning and the evaluation of flood control measures for two (2) projects mentioned above.

In the previous stage, the flood damage analysis was conducted with the same purposes but it covered all the study area, namely all the Agno River Basin and the Allied River Basin. The main activities in the previous study are as follows:

(1) Preparation of flood maps for the 1972 and 1984 floods, both of which brought about serious flood damage to the entire study area;

(2) Estimation of the maximum inundation area which has 2,465 km^2 and covers fifty-two (52) cities/municipalities in Regions I and III;

(3) Division of the maximum inundation area into 2,465 meshes of 1.0 km square for the estimation of flood damage;

(4) Estimation of assets such as the number of houses/buildings, area of agricultural land use which is classified into eight (8) commodi ties and fishpond, and length of railway, roads and irrigation canals in all the meshes;

(5) Determination of the damage value and estimation of damage rate of each asset, which are functions of inundation depth and duration;

(6) Estimation of the indirect damage which consists of suspension of economic activities, additional transportation cost and costs for rescue/relief activities in addition to the direct damage mentioned above;

(7) Estimation of the flood damage corresponding to seven (7) probable floods with return periods of 1.05, 2, 5, 10, 25, 50 and 100-year; and

(8) Computation of annual average flood damage based on the probable flood damage.

Based on the result of the previous study, additional study with the following contents was conducted in the stage of the Feasibility Study to attain the objectives mentioned above.

(1) Preparation of the flood map in the Pantal-Sinocalan River Basin for the 1989 September flood based on the interview survey along the Pantal-Sinocalan River and the flood map prepared by the AFCS;

(2) Estimation of the maximum inundation area for the Upper Agno Project and the Pantal-Sinocalan Project;

(3) Count/measure of number, acreage and length of assets consisting of houses/buildings, agricultural commodities, and infrastructures in 1.0 km meshes made on the maps of 1:25,000 scale which were newly prepared for the Feasibility Study;

(4) Adjustment of city/municipal total assets distributed in the related meshes with the statistical data published by the related agencies;

(5) Review of floor space of houses/buildings by the new maps with a scale of 1:5,000 as the basis for estimation of the damage value in Dagupan City and Calasiao in which the floor space are judged wider than the average in the study area estimated in the previous study;

(6) Computation of the flood damage from the revised mesh data, as well as of the unit value and damage rate for each asset on seven (7) probable floods; and

(7) Estimation of the annual average flood damage based on the probable flood damage consisting of the direct damage and the indirect damage.

2. FLOODING CONDITION OF THE PANTAL-SINOCALAN RIVER BASIN

In the Master Plan Study, flood maps delineating the inundation areas of the 1972 and 1984 floods were prepared by the Study Team in cooperation with the AFCS. In both floods, water of the Agno River overflowed particularly in the upper reaches and ran into the Allied Rivers; thus, bringing about tremendous damage in most of the low-lying Allied River Basins and in areas along the Agno River and its tributaries.

In the 1989 September flood, heavy rainfall of some 5-year return period occurred only in the Allied River Basins. Consequently, the flood map is judged to be very helpful to formulate the flood control measures for the Pantal-Sinocalan River under the condition that the flooding of the Upper Agno River is prevented by the measures which will also be formulated in this Study.

Fig. 2.1 presents the inundation area due to the flooding from the Pantal-Sinocalan River in the 1989 September flood, which was determined by the Study Team through site visits and interview-surveys as well as the information from the AFCS Office. The inundation area totaled 55.19 km^2 and the flood covered about 6.03 km^2 in the municipality of Urdaneta and 49.16 km^2 in the municipalities of Sta. Barbara, Calasiao and Dagupan City. Water depths varied from 0.50 m in residential and urban centers and 2.0 m in low-lying areas.

3. IDENTIFICATION OF TARGET ASSETS

3.1 Maximum Inundation Area

The maximum inundation areas of the two (2) Priority Projects selected for the Feasibility Study are located in the following river basins.

Project	Maximum Inundation Area
Upper Agno	Upper Agno (180 Km^2) (upstream from Bayambang) Pantal-Sinocalan (879 Km^2) Cayanga-Patalan (205 Km^2)
Pantal-Sinocalan	Pantal-Sinocalan (879 Km^2)

The maximum inundation area related to the Upper Agno Project has 1,264 Km^2 and extends in thirty (30) municipalities and two (2) cities, while that of the Pantal-Sinocalan Project has 879 km^2 and includes fifteen (15) municipalities and two (2) cities, as tabulated in Table 3.1 and shown in Fig. 3.1.

The same mesh partition employed in the previous study was applied in this study, but grouping of the meshes into blocks, which are units to evaluate the flood control effects, was made more precisely so that the effects of the planed flood control facilities can be evaluated in more detail. The following table tabulates the number of blocks of three (3) maximum inundation areas.

Maximum Inundation Area	Number of Blocks
Upper Agno River Basin	6
Pantal-Sinocalan River Basin	24
Cayanga-Patalan River Basin	3

3.2 Houses and Buildings

Maps with a scale of 1:25,000 were prepared newly for the Feasibility Study along the Upper Agno River and the Pantal-Sinocalan River. Based on the new maps, the dots which show the location of houses/buildings were counted to revise the number of houses/building in meshes covered by the new maps. In this revision, the adjustment was made in such a way that the total number in related twenty-three (25) cities/municipalities is equal to that in Table 3.2 which are estimated based on the census of the population. Based on the revised number of houses, schools and commercial buildings were distributed to each mesh assuming that the number of school and commercial buildings is proportional to the population.

Fig. 3.3 indicates the population distribution per meshes and Table 3.3 lists the population and number of houses, schools and commercial buildings per blocks in the maximum inundation areas for the Priority Projects.

As shown, the total population in the maximum inundation area for the Upper Agno Project is 1,064.9 thousand, while that for the Pantal-Sinocalan Project is 756.0 thousand. Among them, the municipality with the highest population is Dagupan City with 111.2 thousand persons, followed by San Carlos City with 101.0 thousand persons included in the maximum inundation areas of both the projects.

3.3 Agricultural Commodities and Fish Culture

The agricultural land use was revised from the acreage measured on the new maps with a scale of 1:25,000. Adjustments were made so that the acreage of each commodity and fishpond in twenty-five (25) cities/municipalities are almost equal to the land use tabulated in Table 3.4, which was obtained from the City/Municipality Profile of 1989/1990 furnished by the provincial offices of the Department of Agriculture. Agricultural commodities are classified into irrigated paddy, rainfed paddy, sugarcane, corn, tobacco, root crop, legume and other crops to estimate flood damage. Root crop, legume and other crops include the following crops:

Root Crop: Camote, Casava, Gabi, Garlic, Onion, Peanut, Togue, Turnip

Legume: Beans, Mungo

Other Crops: Ampalaya, Black pepper, Cotton, Eggplant, Guaple, Jute, Okra, Pechay, Squash, Sweet Melon, Sweet Potato, Tomato, Upo, Watermelon, Yam

Fig. 3.4 indicates the distribution of the agricultural land use per meshes and Table 3.5 shows the agricultural land use summarized according to blocks in the maximum inundation areas for the Priority Projects. Out of the 1264 km^2 of total maximum inundation area, agricultural land accounts for 62.3 % or 788.0 km^2, and paddy fields total 586.0 km^2, occupying 74.4 % of the total agricultural land.

3.4 Infrastructures

The infrastructures for which length was measured on the new maps were roads, railways and irrigation canals. The roads indicated in the new maps of 1:25,000 were classified into the four (4) classifications; namely, national, provincial, city/municipal and barangay roads, based on the road map of Pangasinan area prepared by the DPWH. The lengths of these roads in each mesh were obtained as summarized in Table 3.6. The lengths of railways and irrigation canals were similarly measured on the new maps, as shown also in Table 3.6. Fig. 3.5 indicates the total length of those infrastructures of all meshes in the maximum inundation area.

4. PROBABLE DAMAGE AND ANNUAL AVERAGE FLOOD DAMAGE

4.1 Estimation Method of Flood Damage

4.1.1 Damage to Houses/Buildings

Flood damage to houses/buildings was estimated according to the following formulae:

Residential House Damage = (Number of Houses) x (Unit Value of House Structure) x (Damage Rate)

Household Effects Damage = (Number of Houses) x (Household Effect Value/House) x (Damage Rate)

Non-Residential Building Damage = (Number of Building) x (Unit Value of Building Structure) x (Damage Rate)

Inventory Stock/Equipment Damage = (Number of building) x (Unit Value of stock/equipment) x (Damage Rate)

As the unit values of residential house and non-residential buildings, 48,700 pesos and 269,000 pesos were used respectively in Dagupan City and Calasiao, while 29,600 pesos and 154,000 pesos were applied in other area as tabulated below. The cost per square meter of each class/quality, depreciation, distribution and average floor space in other area were obtained from related agencies in previous study. However, in Dagupan City and Calasiao where the floor space of houses/buildings are wider than that in other area, the floor space was measured on the maps with a scale of 5,000 which were made newly for the Feasibility Study and the unit value mentioned above was determined newly in this study as tabulated below.

Class/ Quality	Unit Cost (P/m2)	Depreci- ation (%)	Distri- bution (%)	Urban Area Floor Space (m2)	Urban Area Damage Value (P/Unit)	Other Area Floor Space (m2)	Other Area Damage Value (P/Unit)
Residential House							
- High Quality	3,900	50	4.3	80	6,708	55	4,612
- Mid. Quality	2,400	50	50.3	60	36,216	35	21,126
- Low Quality	850	50	45.4	30	5,789	20	3,859
Total			100.0		48,713		29,597
Non-residential Building							
- High Quality	3,900	50	11.0	210	45,045	120	25,740
- Mid. Quality	2,400	50	89.0	210	224,280	120	128,160
Total			100.0		269,325		153,900

The unit value of household effects was set at 8,000 pesos and calculated as shown in the following table.

Class	Cost (₱/Unit)	Depreci- ation (%)	Distri- bution (%)	Damage Value (₱/Unit)
- High	43,000	50	4.3	925
- Middle	22,000	50	50.3	5,533
- Low	6,500	50	45.4	1,476
Total			100.0	7,933

The inventory stock/equipment value was estimated at 83,000 pesos based on the information furnished by the DPWH and an insurance company, as well as the questionnaire carried out at the sites. The damage rate of each item mentioned above are tabulated in Table 4.1.

4.1.2 Agricultural Damage

Agricultural damage consists of damage to crops, fishponds and livestock as discussed hereinafter.

(1) Crop Damage

The degree of damage on crops varies from month to month, depending on the cropping pattern and the time when flooding occurs. Therefore, the annual damage value should be taken and this is estimated as an aggregate of the expected net income and accumulated expenditure for the production spent until the time when flood takes place, where flood frequency and cultivated area in each month have to be taken into account, as expressed by the following formula.

$$\text{Crop Damage} = \sum_{i=\text{Jan.}}^{\text{Dec.}} (\text{Area}) \times (\text{Damageable Value/ha}) \times (\text{Damage Rate})$$

where;

Damageable Value = (RP x FF x (RA x DC + NI))

RP = Ratio of area planted on the month to total area for the crop

FF = Flood frequency on the month

RA = Ratio of damageable cost accumulated from the planting till the month to the total damageable cost

DC = Damageable cost which is obtained from the production cost by deducting cost for harvesting and processing

NI = Net income obtained from multiplying yield with price and deducting production cost

Crop	Damageable Value (₱/ha)
Irrigated Paddy	9,452
Rainfed Paddy	4,726
Sugarcane	7,093
Corn	115
Tobacco	61
Root Crop	2,675
Legume	484
Other Crops	193

The damageable value of each crop mentioned above are shown in Table 4.2, together with cropping pattern and other figures, while damage rates are shown in Table 4.3 classifying the crops into paddy, upland crop and tobacco.

(2) Fishpond

Damage to fishpond consists of the damage to the fish stock and the facilities, and is calculated as follows:

Fish Stock Damage = (Area) x (Fish Value/ha) x (Damage Rate)

Facility Damage = (Area) x (Damageable Value) x (Damage Rate)

The fish value was set at 16,600 pesos/ha as shown in the following table, while the damageable value of facility (dike) was assumed at 80,000 pesos/ha, based on interview survey with BFAR, DA and fishpond operators.

Stage	Pieces of Fish (Pc./ha)	Prices of Fish (Peso/Pc.)	Value of Fish (Peso/ha)
Fry	3,000	0.6	1,800
Middle	2.700	5.7	15,429
Last	2,400	13.5	32,420
Average			16,543

Regarding the damage rate for the fish stock, it is assumed that when the inundation depth exceeds 10.0 cm above pond banks, 90% of the fish stock is lost, while the damage rate for the facilities is assumed to vary from 0.5% to 40% corresponding to the return period of floods as shown in Table 4.4.

(3) Livestock

Damage to livestock was estimated at 7% of the crop damage based on the actual damage records of the five (5) floods that occurred between 1974 and 1986.

4.1.3 Damage to Infrastructures

Flood damage to roads, railways and irrigation canals was estimated as follows:

Damage = (Length) x (Unit Value) x (Damage Rate)

Regarding the water supply facility and telecommunication facility, the following equation was applied:

Damage = (Number of Population) x (Unit Value/Person) x (Damage Rate)

The unit values of road, railway, irrigation canal, water supply facility and telecommunication facility were obtained from the interview-survey with DPWH, PNR and NIA, as follows:

Item	Unit Value (Peso)
National Road	1,490/m
Provincial Road	1,172/m
City/Municipal Road	1,172/m
Barangay Road	352/m
Railway	2,800/m
Irrigation Canal	638/m
Water Supply Facility	350/Person
Telecom. Facility	10/Person

The damage rate for infrastructures was determined based on the flood damage record of each infrastructure. Table 4.4 presents the damage rates which vary with the extent of flooding.

4.1.4 Indirect Damage

The indirect damage consists of loss on economic activity, additional transportation cost due to the change of traffic route and rescue/relief activity cost.

The loss on economic activity was obtained by the following equation.

Loss on Economic Activity = (Suspension Days of Economic Activity) x (Number of Affected Persons) x (GRDP per Capita) / (Economic Activity Days)

Suspension days of economic activity was assumed as shown in the following table, corresponding to the magnitude of floods based on the interviews with officials of the AFCS and the DPWH, as well as the inhabitants. GRDP per capita in 1989 was 9,480 pesos, and as the economic activity days of a year, 300 was assumed.

The additional transportation cost was assumed constant at 590,000 pesos in spite of the magnitude of the flood based on the information obtained from the AFCS and the DPWH, while the rescue/relief activity cost was estimated at 5% of the total direct damage according to the actual percentage for the seven (7) floods that occurred during 1972 to 1988.

The following table shows three (3) kinds of indirect damages, total indirect damage, total direct damage and percentage of total indirect damage to the total direct damage, all of which were estimated for the maximum inundation area of the Master Plan.

Return Period (Year)	Economic Susp. of Days	Affected Persons (1000 ₱)	Indirect Damage 1 (Mil. ₱)	Indirect Damage 2 (Mil. ₱)	Indirect Damage 3 (Mil. ₱)	Indirect Damage (Mil. ₱)	Direct Damage (Mil. ₱)	Indirect D./ Direct D. (%)
1.05	1	937	29.6	0.6	32.3	62.5	646.4	9.7
2	2	1,055	66.7	0.6	49.0	116.3	979.6	11.9
5	6	1,175	222.8	0.6	75.6	299.0	1,512.0	19.8
10	9	1,369	389.3	0.6	98.6	488.5	1,969.8	24.8
25	14	1,406	622.0	0.6	127.5	750.1	2,549.8	29.4
50	18	1,435	816.2	0.6	150.1	966.9	3,001.4	32.2
100	21	1,557	1,033.2	0.6	174.6	1,208.4	3,492.4	34.6

Note : Indirect Damage 1 : Loss on economic damage
Indirect Damage 2 : Additional transportation cost
Indirect Damage 3 : Rescue/relief activity cost

Based on the above results, the indirect damage in the maximum inundation area for the Priority Projects is assumed to be proportional to the total direct damage.

4.2 Probable Flood Damage and Annual Average Flood Damage

The probable flood damage corresponding to the floods in seven (7) probabilities was calculated separately for the maximum inundation areas of the Upper Agno Project and the Pantal-Sinocalan Project by the method mentioned before. The annual average flood damage was estimated by the following formula based on the flood damage for each probable discharge.

$$\text{Annual Average Flood Damage} = \sum_{i=1}^{n} 1/2 \times [D(Qi-1) + D(Qi)] \times [P(Qi-1) - P(Qi)]$$

where:

D(Qi-1), D(Qi) : flood damage caused by floods with Qi-1 and Qi discharge, respectively.

P(Qi-1), P(Qi) : Probabilities of occurrence of Qi-1 and Qi discharges, respectively.

n : number of floods applied

4.2.1 Maximum Inundation Area for the Upper Agno Project

The probable flood damage to the maximum inundation area for the Upper Agno Project, including the indirect damage, is tabulated in Table 4.5 and the annual flood damage per blocks is indicated in Table 4.6. A flood of 10-year return period affects 793 thousand persons in the flooded area of 919 Km^2 and causes the damage of 1,196 million Pesos at the 1989 price level. The annual average flood damage is estimated at 457.7 million Pesos at the same price level.

4.2.2 Maximum Inundation Area for the Pantal-Sinocalan Project

The probable flood damage and annual average flood damage in the maximum inundation area for the Pantal-Sinocalan Project are indicated in Tables 4.7 and 4.8, respectively. Because of a flood of 10-year return period, 745 thousand persons are affected and flood damage is estimated at 985 million pesos in the flooded area of 868 Km^2 at the 1989 price level. The annual average flood damage is estimated at 504.4 million Pesos at the same price level.

TABLES

Table 3.1 CITIES/MUNICIPALITIES IN MAXIMUM INUNDATION AREA

Name of City/ Municipality	Administrative Area (Km2)	Maximum Inundation Area (Km2)			
		Upper Agno & Allied	Upper Agno	Pantal-Sinocalan	Cayanga-Patalan
Alcala	36.5	13	13	0	0
Asingan	66.6	67	30	37	0
Basista	15.6	16	0	16	0
Bautista	126.3	6	6	0	0
Bayambang	75.2	57	17	40	0
Binalonan	77.6	61	0	41	20
Binmaley	61.2	62	0	62	0
Calasiao	53.4	54	0	54	0
Laoac	40.5	41	0	0	41
Lingayen	67.7	29	0	29	0
Malasiqui	127.	92	4	88	0
Manaoag	27.2	19	0	0	19
Mangaldan	44.8	45	0	30	15
Mapandan	30.	30	0	19	11
Pozorrubio	136.6	32	0	0	32
Rosales	68.4	8	8	0	0
San Fabian	92.4	11	0	0	11
San Jacinto	39.1	28	0	0	28
San Manuel	133.7	52	36	16	0
San Nicolas	210.2	1	1	0	0
Sta. Barbara	77.4	69	0	69	0
Sta. Maria	69.5	28	28	0	0
Sto. Tomas	8.3	5	5	0	0
Sison	97.7	12	0	0	12
Tayug	51.3	15	15	0	0
Urbiztondo	81.8	58	0	58	0
Urdaneta	121.	111	0	105	6
Villasis	75.8	60	16	44	0
Dagupan City	37.2	38	0	38	0
San Carlos City	166.4	133	0	133	0
Camiling	140.5	1	1	0	0
Rosario	72.8	10	0	0	10
Total		1264	180	879	205

Table 3.2 POPULATION AND NUMBER OF HOUSES IN CITIES/MUNICIPALITIES OF MAXIMUM INUNDATION AREA OF UPPER AGNO AND PANTAL-SINOCALAN RIVER BASINS

City/ Municipality	Area (Km2)	Popu- lation	House (No.)	School (No.)	Commer- cial (No.)
Alcala	13	17788	2965	55	36
Asingan	67	41103	6851	77	79
Basista	16	19984	3331	39	38
Bautista	6	5512	919	8	11
Bayambang	57	60140	10023	133	117
Binalonan	41	20856	3478	44	43
Binmaley	62	54312	9052	120	103
Calasiao	54	58175	9696	102	114
Lingayen	29	40944	6825	79	79
Malasiqui	92	57714	9619	117	108
Mangaldan	30	35435	5905	65	70
Mapandan	19	13273	2212	37	26
Rosales	8	6434	1072	14	13
San Manuel	52	22082	3680	46	42
San Nicolas	1	438	73	1	1
Sta. Barbara	69	39151	6525	78	76
Sta. Maria	28	12154	2026	36	23
Sto. Tomas	5	9540	1590	23	19
Tayug	15	6980	1163	18	14
Urbiztondo	58	26409	4401	39	52
Urdaneta	105	76489	12748	106	154
Villasis	60	38111	6352	66	74
Dagupan City	38	111196	18533	161	223
San Carlos City	133	101029	16839	338	195
Camiling	1	1308	218	2	3
Total	1059	876557	146096	1804	1713

Table 3.3 POPULATION AND NUMBER OF HOUSES IN BLOCKS OF MAXIMUM INUNDATION AREA

Block No.	Area (Km2)	Population	House (No.)	School (No.)	Commercial (No.)
Upper Agno River Basin					
90	7	444	74	0	0
95	37	16322	2720	34	33
120	73	29826	4971	74	58
130	5	3152	525	6	6
140	55	66481	11081	163	132
170	3	3737	623	7	8
Sub-total	180	119962	19994	284	237
Pantal-Sinocalan River Basin					
30	37	19279	3214	40	37
50	12	9433	1572	19	19
51	25	12459	2077	23	25
52	23	13085	2180	26	25
53	13	9604	1602	17	18
54	7	41796	6966	63	84
55	3	6870	1145	10	13
56	80	96330	16055	166	192
57	37	58401	9733	119	116
60	15	9814	1636	18	21
61	15	10812	1802	22	22
62	35	25631	4274	41	53
63	31	22460	3742	34	42
64	20	11151	1858	25	20
65	41	36140	6022	53	73
70	80	71102	11848	196	137
71	108	63867	10644	140	124
72	20	15013	2503	51	29
73	49	30871	5146	90	59
74	53	36469	6079	74	67
75	20	36483	6080	66	71
80	35	18330	3056	30	35
81	65	47522	7923	93	90
82	55	53673	8945	104	104
Sub-total	879	756595	126102	1520	1476
Total	1059	876557	146096	1804	1713
Cayanga-Patalan River Basin					
10	34	39568	6594	80	33
40	15	16249	2708	29	31
20	156	132553	22092	233	259
Sub-total	205	188370	31394	342	323
Grand Total	1264	1064927	177490	2146	2036

Table 3.4 AGRICULTURAL LAND USE IN CITIES/MUNICIPALITIES IN MAXIMUM INUNDATION AREA OF UPPER AGNO AND PANTAL-SINOCALAN RIVER BASINS

City/ Municipality	Area (Km2)	Paddy: Irri. Paddy (ha)	Paddy: Rainfed Paddy (ha)	Paddy: Sub-total (ha)	Others: Sugar-cane (ha)	Others: Corn (ha)	Others: Tobacco (ha)	Others: Root Crop (ha)	Others: Legume (ha)	Others: Other Crops (ha)	Others: Sub-total (ha)	Fish Pond (ha)	Total (ha)
Alcala	13	334	966	1300	0	0	0	0	0	0	0	0	1300
Asingan	67	4038	150	4188	0	121	0	45	130	260	556	7	4751
Basista	16	0	1176	1176	0	69	0	0	75	8	152	11	1339
Bautista	6	13	134	147	0	219	0	6	0	8	233	0	380
Bayambang	57	190	3828	4018	0	1279	10	180	63	103	1635	47	5700
Binalonan	41	620	1179	1799	164	86	0	41	91	29	411	1	2211
Binmaley	62	0	800	800	0	15	0	42	0	70	127	2515	3442
Calasiao	54	598	2616	3214	0	67	0	3	27	29	126	28	3368
Lingayen	29	0	468	468	0	117	0	47	13	12	189	778	1435
Malasiqui	92	288	3851	4139	0	694	113	79	4	207	1097	13	5249
Mangaldan	30	301	1569	1870	81	202	0	161	123	205	772	153	2795
Mapandan	19	94	489	583	113	54	0	36	20	31	254	16	853
Rosales	8	432	137	569	0	9	5	14	2	2	32	0	601
San Manuel	52	2048	28	2076	0	74	60	163	84	30	411	0	2487
San Nicolas	1	6	0	6	0	0	0	0	1	0	1	0	7
Sta. Barbara	69	553	3563	4116	0	135	0	4	115	202	456	0	4572
Sta. Maria	28	525	846	1371	0	223	234	48	477	242	1224	0	2595
Sto. Tomas	5	370	98	468	7	0	17	0	0	5	29	0	497
Tayug	15	583	187	770	0	21	0	9	60	16	106	3	879
Urbiztondo	58	0	2246	2246	0	732	0	87	29	76	924	13	3183
Urdaneta	105	4969	1438	6407	0	74	37	0	1087	828	2026	0	8433
Villasis	60	1130	3073	4203	0	500	580	55	160	245	1540	0	5743
Dagupan City	38	0	305	305	0	0	0	66	10	0	76	1342	1723
San Carlos City	133	3	4598	4601	0	74	0	82	73	227	456	151	5208
Camiling	1	6	2	8	0	2	0	0	0	0	2	0	10
Total	1059	17101	33747	50848	365	4767	1056	1168	2644	2835	12835	5078	68761

Table 3.5 AGRICULTURAL LAND USE IN BLOCKS IN MAXIMUM INUNDATION AREA

Block No.	Area (Km2)	Paddy: Irri. Paddy (ha)	Paddy: Rainfed Paddy (ha)	Paddy: Sub-total (ha)	Others: Sugar-cane (ha)	Others: Corn (ha)	Others: Tobacco (ha)	Others: Root Crop (ha)	Others: Legume (ha)	Others: Other Crops (ha)	Others: Sub-total (ha)	Fish Pond (ha)	Total (ha)
Upper Agno River Basin													
90	7	87	2	89	0	6	7	17	10	2	42	0	131
95	37	1654	47	1701	0	56	31	88	65	62	302	0	2003
120	73	2107	1432	3539	0	315	303	72	592	337	1619	6	5164
130	5	281	86	367	0	6	2	10	1	1	20	0	387
140	55	1065	2568	3633	7	938	104	74	32	168	1323	21	4977
170	3	8	53	61	0	141	2	5	0	0	148	1	210
Sub-tatal	180	5202	4188	9390	7	1462	449	266	700	570	3454	28	12872
Pantal-Sinocalan River Basin													
30	37	935	808	1743	112	69	11	59	73	33	357	1	2101
50	12	79	344	423	5	23	0	3	17	29	77	1	501
51	25	505	1141	1646	0	51	6	2	107	120	286	0	1932
52	23	179	1246	1425	0	65	3	4	33	75	180	1	1606
53	13	128	578	706	0	18	0	1	10	12	41	0	747
54	7	20	107	127	0	2	0	7	4	1	14	76	217
55	3	0	0	0	0	0	0	0	0	0	0	135	135
56	80	527	3258	3785	131	265	0	227	168	263	1054	1096	5935
57	37	0	294	294	0	43	0	27	5	24	99	1118	1511
60	15	429	321	750	32	22	4	8	91	52	209	0	959
61	15	996	22	1018	0	29	11	38	30	33	141	0	1159
62	35	1616	486	2102	20	36	13	9	279	217	574	0	2676
63	31	1716	287	2003	0	52	3	12	218	196	481	0	2484
64	20	297	578	875	52	28	2	17	78	68	245	7	1127
65	41	1511	948	2459	6	111	109	12	324	237	799	1	3259
70	80	77	3375	3452	0	280	28	47	66	114	535	18	4005
71	108	110	5440	5550	0	1109	0	185	128	189	1611	27	7188
72	20	2	727	729	0	4	0	8	3	40	55	102	886
73	49	0	1621	1621	0	78	0	28	21	73	200	170	1991
74	53	143	1451	1594	0	93	0	50	14	50	207	1603	3404
75	20	0	233	233	0	1	0	23	3	18	45	674	952
80	35	1708	838	2546	0	141	128	20	183	157	629	4	3179
81	65	567	3298	3865	0	566	266	87	71	188	1178	16	5059
82	55	354	2158	2512	0	219	23	28	18	76	364	0	2876
Sub-total	879	11899	29599	41458	358	3305	607	902	1944	2265	9381	5050	55889
Total	1059	17101	33747	50848	365	4767	1056	1168	2644	2835	12835	5078	68761
Cayanga-Patalan River Basin													
10	34	1062	470	1532	0	32	158	36	61	58	345	0	1877
20	156	2512	3350	5862	219	548	143	108	289	258	1565	11	7438
40	15	138	216	354	9	22	14	33	62	94	234	131	719
Sub-total	205	3712	4036	7748	228	602	315	177	412	410	2144	142	10034
Grand Total	1264	20813	37783	58596	593	5369	1371	1345	3056	3245	14979	5220	78795

Tabel 3.6 INFRASTRUCTURES IN BLOCKS
IN MAXIMUM INUNDATION AREA

Block No.	Area (Km2)	Road (Km) Nat.	Pro.	Mun.	Bar.	Rail-way (Km)	Irri. Canal (Km)
Upper Agno River Basin							
90	7	0.0	0.1	0.0	0.1	0.0	0.0
95	37	0.0	9.6	1.7	6.8	0.0	17.4
120	73	12.1	11.3	9.7	29.3	0.0	34.4
130	5	3.5	0.0	0.0	1.2	0.0	3.2
140	55	20.7	10.0	19.5	40.1	2.2	2.8
170	3	1.1	0.0	0.0	0.0	1.0	0.0
Sub-total	180	37.4	31.0	30.9	77.5	3.2	57.8
Pantal-Sinocalan River Basin							
30	37	4.1	9.4	3.3	29.7	0.0	26.1
50	12	9.1	0.2	3.4	7.8	0.0	9.6
51	25	0.5	5.1	2.6	19.2	0.0	8.9
52	23	0.0	7.3	3.8	25.7	0.0	6.9
53	13	4.5	0.9	0.8	11.2	0.4	1.7
54	7	2.9	0.7	9.4	13.4	0.9	0.0
55	3	1.1	0.0	0.0	4.4	0.0	0.0
56	80	27.2	15.5	11.9	104.3	7.6	29.7
57	37	9.8	18.7	4.8	40.2	0.0	0.0
60	15	2.8	7.1	2.3	18.1	0.0	7.4
61	15	0.0	6.5	3.0	16.1	0.0	8.7
62	35	5.4	14.4	7.5	47.8	0.0	14.1
63	31	1.0	18.6	10.6	49.4	0.0	9.0
64	20	1.5	3.9	0.8	25.0	0.0	16.2
65	41	8.1	10.4	4.1	30.7	0.0	4.8
70	80	11.2	27.4	13.3	93.0	2.5	0.0
71	108	4.3	22.8	9.2	63.5	5.9	0.0
72	20	1.3	2.9	1.0	8.4	2.4	0.0
73	49	0.0	9.5	4.9	33.6	3.4	0.0
74	53	8.7	7.0	2.8	22.4	0.0	0.0
75	20	8.6	5.3	2.7	23.7	0.0	0.0
80	35	1.2	11.8	1.0	13.5	0.0	26.9
81	65	2.2	14.1	11.2	51.3	0.0	0.5
82	55	6.6	21.2	9.8	77.8	3.8	5.4
Sub-total	879	122.1	240.7	124.2	830.2	26.9	175.9
Total	1059	159.5	271.7	155.1	907.7	30.1	233.7
Cayanga-Patalan River Basin							
10	34	2.0	6.5	3.4	22.9	0.0	12.5
20	156	46.8	53.2	26.4	177.9	1.0	27.8
40	15	4.0	2.4	1.3	9.7	2.0	0.3
Sub-total	205	52.8	62.1	31.1	210.5	3.0	40.6
Grand Total	1264	212.1	333.8	186.2	1186.2	33.1	274.3

Table 4.1 DAMAGE RATES OF HOUSE/BUILDING

Properties	Flood Damage Rate (%)			
	Flood Level Below Floor Level	Flood Level Above Floor Level (m)		
		Less than 0.5	0.5 - 1.0	More than 1.0
House/Building Structure				
Ground Slope				
Less than 0.1 %	3.0	5.3	7.2	11.7
0.1 - 0.2 %	3.0	8.3	12.6	19.2
More than 0.2 %	3.0	12.4	21.0	33.0
Indoor Movables				
Residential				
Household Effects	-	8.6	19.1	36.6
Non-residential				
Depreciable assets	-	18.0	31.4	44.3
Inventory Stock	-	12.7	27.6	39.8

Source: Master Plan Study on the Cagayan River Basin Water Resources Development, 1987, JICA
Panay River Basin-wide Flood Control Study, 1985, JICA
Nationwide Flood Control Plan and River Dredging Program, 1982, JICA
Technical Standard for River and Sabo Works, Ministry of Construction, Japan

Table 4.2 DAMAGEABLE VALUE OF CROPS (1/2)

Name of Crops : Irrigated Paddy

Month		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
A. Cropping Calender			2nd							1st			
B. Planted Area (%)	1st Crop						25	75	100	100	75	25	
	2nd Crop	100	100	75	25							25	75
C. Accumulated Cost (%)	1st Crop						16	38	54	74	85	98	
	2nd Crop	54	74	85	98							16	38
D. Flood Frequency (%)		0	0	0	0	0.04	0.08	0.25	0.29	0.13	0.13	0.08	0

E. Yield	(ton/ha)	4.5	H. Net Income	(P/ha)	8,795
F. Price	(P/ton)	3,780	I. Damageable Cost	(P/ha)	6,115
G. Production Cost	(P/ha)	8,215			
J. Damageable Value	(P/ha)	9,452			

Name of Crops : Rainfeded Paddy

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
A. Cropping Calender												
B. Planted Area (%)						25	75	100	100	75	25	
C. Accumulated Cost (%)						16	38	54	74	85	98	
D. Flood Frequency (%)	0	0	0	0	0.04	0.08	0.25	0.29	0.13	0.13	0.08	0

E. Yield	(ton/ha)	2.8	H. Net Income	(P/ha)	2,934
F. Price	(P/ton)	3,780	I. Damageable	(P/ha)	5,910
G. Production Cost	(P/ha)	7,650			
J. Damageable Value	(P/ha)	4,726			

Name of Crops : Corn

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
A. Cropping Calender												
B. Planted Area (%)	100	95	55	7							25	75
C. Accumulated Cost (%)	64	89	96	100							18	39
D. Flood Frequency (%)	0	0	0	0	0.04	0.08	0.25	0.29	0.13	0.13	0.08	0

E. Yield	(ton/ha)	3.0	H. Net Income	(P/ha)	4,509
F. Price	(P/ton)	4,080	I. Damageable Cost	(P/ha)	6,921
G. Production Cost	(P/ha)	7,731			
J. Damageable Value	(P/ha)	115	Negligibly small		

Name of Crops : Sugarcane

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
A. Cropping Calender												
B. Planted Area (%)	40	55	65	75	95	100	100	100	100	93	75	60
C. Accumulated Cost (%)	8	16	20	29	38	47	62	70	77	92	95	100
D. Flood Frequency (%)	0	0	0	0	0.04	0.08	0.25	0.29	0.13	0.13	0.08	0

E. Yield	(ton/ha)	60	H. Net Income	(P/ha)	2,700
F. Price	(P/ton)	235	I. Damageable Cost	(P/ha)	6,600
G. Production Cost	(P/ha)	11,400			
J. Damageable Value	(P/ha)	7,093			

Table 4.2 DAMEGEABLE VALUE OF CROPS (2/2)

Name of Crops : Tobacco

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
A. Cropping Calender												
B. Planted Area (%)	100	100	100	95	8						8	95
C. Accumulated Cost (%)	45	60	75	90	100						15	30
D. Flood Frequency (%)	0	0	0	0	0.04	0.08	0.25	0.29	0.13	0.13	0.08	0

E. Yield	(ton/ha)	1.2	H. Net Income	(P/ha)	5,340
F. Price	(P/ton)	20,000	I. Damageable Cost	(P/ha)	2,400
G. Production Cost	(P/ha)	18,660			
J. Damageable Value	(P/ha)	61	Negligibly small		

Name of Crops : Root Crop (peanut)

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
A. Cropping Calender						No Seasonable						
B. Planted Area (%)	100	100	100	100	100					100	100	100
C. Accumulated Cost (%)	50	50	50	50	50					50	50	50
D. Flood Frequency (%)	0	0	0	0	0.04	0.08	0.25	0.29	0.13	0.13	0.08	0

E. Yield	(ton/ha)	1.5	H. Net Income	(P/ha)	7,600
F. Price	(P/ton)	9,600	I. Damageable Cost	(P/ha)	6,200
G. Production Cost	(P/ha)	6,800			
J. Damageable Value	(P/ha)	2,675			

Name of Crops : Legume

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
A. Cropping Calender												
B. Planted Area (%)	100	100	50								50	100
C. Accumulated Cost (%)	60	80	100								20	40
D. Flood Frequency (%)	0	0	0	0	0.04	0.08	0.25	0.29	0.13	0.13	0.08	0

E. Yield	(ton/ha)	1.5	H. Net Income	(P/ha)	9,925
F. Price	(P/ton)	14,650	I. Damageable Cost	(P/ha)	10890
G. Production Cost	(P/ha)	12,050			
J. Damageable Value	(P/ha)	484			

Name of Crops : Vegetables (Eggplant)

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
A. Cropping Calender												
B. Planted Area (%)	100	100	50								8	95
C. Accumulated Cost (%)	60	80	100								20	40
D. Flood Frequency (%)	0	0	0	0	0.04	0.08	0.25	0.29	0.13	0.13	0.08	0

E. Yield	(ton/ha)	8.0	H. Net Income	(P/ha)	28,150
F. Price	(P/ton)	4,900	I. Damageable Cost	(P/ha)	10,210
G. Production Cost	(P/ha)	11,050			
J. Damageable Value	(P/ha)	193			

Table 4.3 DAMAGE RATES OF CROPS

Crops	Flood Duration (days)	Flood Damage Rate (%) Inundation Depth Above Ground Level (m) Less than 0.5	0.5 - 1.0	More than 1.0
Paddy				
	1 to 2	21	24	37
	3 to 4	30	44	54
	5 to 6	36	50	64
	Longer than 7	50	71	74
Upland Crops				
	1 to 2	27	35	51
	3 to 4	42	48	67
	5 to 6	54	67	81
	Longer than 7	67	74	91
Tobacco				
	1	50		
	2	75		
	Longer than 3	100		

Source : Master Plan Study on the Cagayan River Basin Water Resources Development, 1987, JICA
Panay River Basin-wide Flood Control Study, 1985, JICA
Nationwide Flood Control Plan and River Dredging Program, 1982, JICA
Technical Standard for River and Sabo Works, Ministry of Construction, Japan

Note : Damage rate for tobacco is based on the the study results of The Kelantan River Basin Flood Control Project, Malaysia, JICA, 1988

Table 4.4 DAMAGE RATES OF FISH POND FACILITY AND INFRASTRUCTURES

(Unit %)

Item	Return Period						
	1.05-Yr.	2-Yr.	5-Yr.	10-Yr.	25-Yr.	50-Yr.	100-Yr.
Fish Pond Facility	0.1	4.5	13.0	18.0	26.0	34.0	40.0
Road	0.5	4.0	6.0	9.0	12.0	16.0	18.0
Railway	2.0	11.0	20.0	26.0	36.0	43.0	50.0
Irrigation Facility	3.0	5.0	9.0	12.0	15.0	20.0	23.0
Water Supply Facility	1.0	5.0	15.0	20.0	30.0	35.0	40.0
Telecommunication Facility	2.0	12.0	24.0	27.0	36.0	43.0	50.0

Note: The damage rates shown above are assumed mainly based on the available damage records.

Table 4.5 PROBABLE FLOOD DAMAGE IN MAXIMUN INUNDATION AREA FOR UPPER AGNO PROJECT

Unit : Million Pesos

Item	Return Period (Year)						
	1.05	2	5	10	25	50	100
1. Affected People(1000 person)	61	150	474	793	803	817	840
2. Affected Area (km2)	109	223	684	919	939	953	986
3. Direct Damage							
(1) Agricultural Damage							
- Crops	30	58	108	138	156	164	174
- Livestocks	2	4	8	10	11	11	12
- Fishpond	0	21	77	147	151	218	243
Sub-total	32	83	192	294	317	393	428
(2) Non-agricultural Damage							
- Residential Bldg.	46	102	250	394	510	601	675
- Non-residential Bldg.	12	27	62	91	139	176	205
Sub-total	58	129	313	485	649	777	880
(3) Infrastructures							
- Road/Bridge	0	7	39	88	119	161	189
- Railways	0	1	10	18	28	35	40
- Irrigation Facility	0	1	9	16	19	26	31
- Water Supply Facility	0	3	25	55	84	100	118
- Telecommunication	1	0	1	2	3	4	4
Sub-total	2	12	84	179	254	325	383
Total	92	224	589	958	1,220	1,495	1,691
4. Indirect Damage	9	27	117	238	359	481	585
Grand Total	101	250	705	1,196	1,579	1,976	2,277

Table 4.6 ANNUAL AVERAGE FLOOD DAMAGE IN MAXIMUM INUNDATION AREA FOR UPPER AGNO PROJECT

Unit:Million Pesos

Block No.	Return Period (Year) 1.05	2	5	10	25	50	100
Upper Agno River Basin							
90	0.0	0.7	1.2	1.3	1.5	1.5	1.5
95	0.0	6.3	11.8	14.1	15.6	16.3	16.7
120	0.0	15.0	28.1	33.8	38.3	40.1	41.1
130	0.0	1.0	2.1	2.7	3.2	3.3	3.4
140	0.0	30.9	61.0	73.7	82.5	85.7	87.5
170	0.0	0.1	0.7	1.1	1.5	1.6	1.7
Sub-total	0.0	54.0	104.9	126.7	142.6	148.5	151.9
Pantal-Sinocalan River Basin							
30	0.0	0.5	2.3	3.4	4.2	4.5	4.7
50	0.0	0.0	0.4	1.0	1.7	2.0	2.2
51	0.0	0.0	0.1	0.8	1.6	2.0	2.2
52	0.0	0.0	0.0	0.1	0.2	0.2	0.2
53	0.0	0.0	0.2	0.7	1.3	1.5	1.7
54	0.0	0.1	0.3	1.7	3.8	4.8	5.5
55	0.0	0.1	0.4	1.0	1.6	1.9	2.1
56	0.0	1.0	7.1	15.5	24.5	28.3	30.7
57	0.0	1.0	3.8	8.0	13.3	16.0	17.7
60	0.0	0.0	1.6	2.8	3.7	4.0	4.2
61	0.0	0.0	0.7	1.3	1.8	2.0	2.1
62	0.0	0.0	2.6	5.6	8.5	9.7	10.4
63	0.0	0.5	3.5	5.4	6.8	7.3	7.7
64	0.0	0.0	1.2	2.5	3.8	4.4	4.7
65	0.0	0.0	2.5	5.1	8.2	9.7	10.6
70	0.0	2.3	10.5	15.6	19.8	21.8	22.8
71	0.0	3.0	13.7	20.0	24.7	26.6	27.6
72	0.0	0.1	2.1	3.4	4.5	5.0	5.4
73	0.0	0.6	8.0	13.7	18.1	20.0	21.1
74	0.0	1.5	10.1	16.8	22.3	24.8	26.3
75	0.0	0.6	3.1	6.0	9.4	11.0	12.1
80	0.0	5.6	15.4	19.6	22.4	23.4	23.9
81	0.0	3.1	8.7	11.4	14.4	15.8	16.7
82	0.0	0.7	2.1	3.2	4.3	4.9	5.4
Sub-total	0.0	20.5	100.2	164.4	224.7	251.4	267.8
Cayanga-Patalan River Basin							
10	0.0	0.1	0.2	0.3	0.4	0.5	0.5
20	0.0	1.6	10.3	17.1	22.4	24.4	25.6
40	0.0	2.8	7.0	9.0	10.7	11.4	11.8
Sub-total	0.0	4.5	17.5	26.4	33.5	36.3	37.9
Total	0.0	79.1	222.7	317.6	400.9	436.3	457.7

Table 4.7 PROBABLE FLOOD DAMAGE IN MAXIMUN INUNDATION AREA FOR PANTAL-SINOCALAN PROJECT

Unit : Million Pesos

Item	Return Period (Year)						
	1.05	2	5	10	25	50	100
1. Affected People (1000 person)	0	719	741	745	746	749	749
2. Affected Area (km2)	0	831	861	868	869	873	873
3. Direct Damage							
(1) Agricultural Damage							
- Crops	0	127	127	127	130	134	138
- Livestocks	0	9	9	9	9	9	9
- Fishpond	0	25	107	143	145	210	215
Sub-total	0	161	243	279	284	354	362
(2) House/Building Damage							
- Residential Bldg.	0	199	253	285	338	393	446
- Non-residential Bldg.	0	27	46	57	82	102	127
Sub-total	0	226	299	343	420	495	573
(3) Infrastructures							
- Road/Bridge	0	34	53	80	107	143	161
- Railways	0	8	15	20	27	32	38
- Irrigation Facility	0	5	10	13	17	22	26
- Water Supply Facility	0	13	39	52	78	92	105
- Telecommunication	0	1	2	2	3	3	4
Sub-total	0	61	118	167	232	293	333
Total	0	448	660	789	936	1,141	1,267
4. Indirect Damage	0	53	131	196	271	368	439
Grand Total	0	501	791	985	1,206	1,509	1,706

Table 4.8 ANNUAL AVERAGE FLOOD DAMAGE IN MAXIMUM INUNDATION AREA
FOR PANTAL-SINOCALAN PROJECT

Unit:Million Pesos

Block No.	Return Period (Year)						
	1.05	2	5	10	25	50	100
30	0.0	2.6	7.4	9.6	11.2	11.9	12.3
50	0.0	1.4	3.8	4.8	5.7	6.1	6.3
51	0.0	2.6	6.5	8.1	9.2	9.7	10.0
52	0.0	2.0	5.1	6.3	7.2	7.6	7.8
53	0.0	1.7	4.4	5.5	6.3	6.6	6.7
54	0.0	3.5	9.3	11.7	13.5	14.2	14.7
55	0.0	0.8	2.6	3.5	4.1	4.4	4.6
56	0.0	15.8	42.4	54.8	63.8	67.5	69.8
57	0.0	5.5	18.4	25.2	30.7	33.2	34.6
60	0.0	2.3	5.6	7.0	7.9	8.3	8.5
61	0.0	1.7	4.9	6.5	7.7	8.2	8.5
62	0.0	4.4	11.7	15.1	17.6	18.5	19.0
63	0.0	3.7	9.4	11.9	13.7	14.5	14.9
64	0.0	2.2	6.0	7.6	8.8	9.2	9.5
65	0.0	4.2	10.9	14.0	16.4	17.4	18.0
70	0.0	8.8	23.0	29.0	33.5	35.4	36.5
71	0.0	11.4	29.4	37.0	42.2	44.3	45.5
72	0.0	2.0	5.3	6.9	8.1	8.6	8.9
73	0.0	5.5	14.8	19.1	22.6	24.1	25.0
74	0.0	6.1	19.4	27.0	32.8	35.3	36.8
75	0.0	3.5	11.5	15.6	18.7	20.1	21.0
80	0.0	8.0	19.9	24.4	27.4	28.5	29.1
81	0.0	6.8	17.8	22.4	25.4	26.6	27.3
82	0.0	6.7	18.0	23.1	26.8	28.3	29.1
Total	0.0	113.2	307.5	396.1	461.3	488.5	504.4

FIGURES

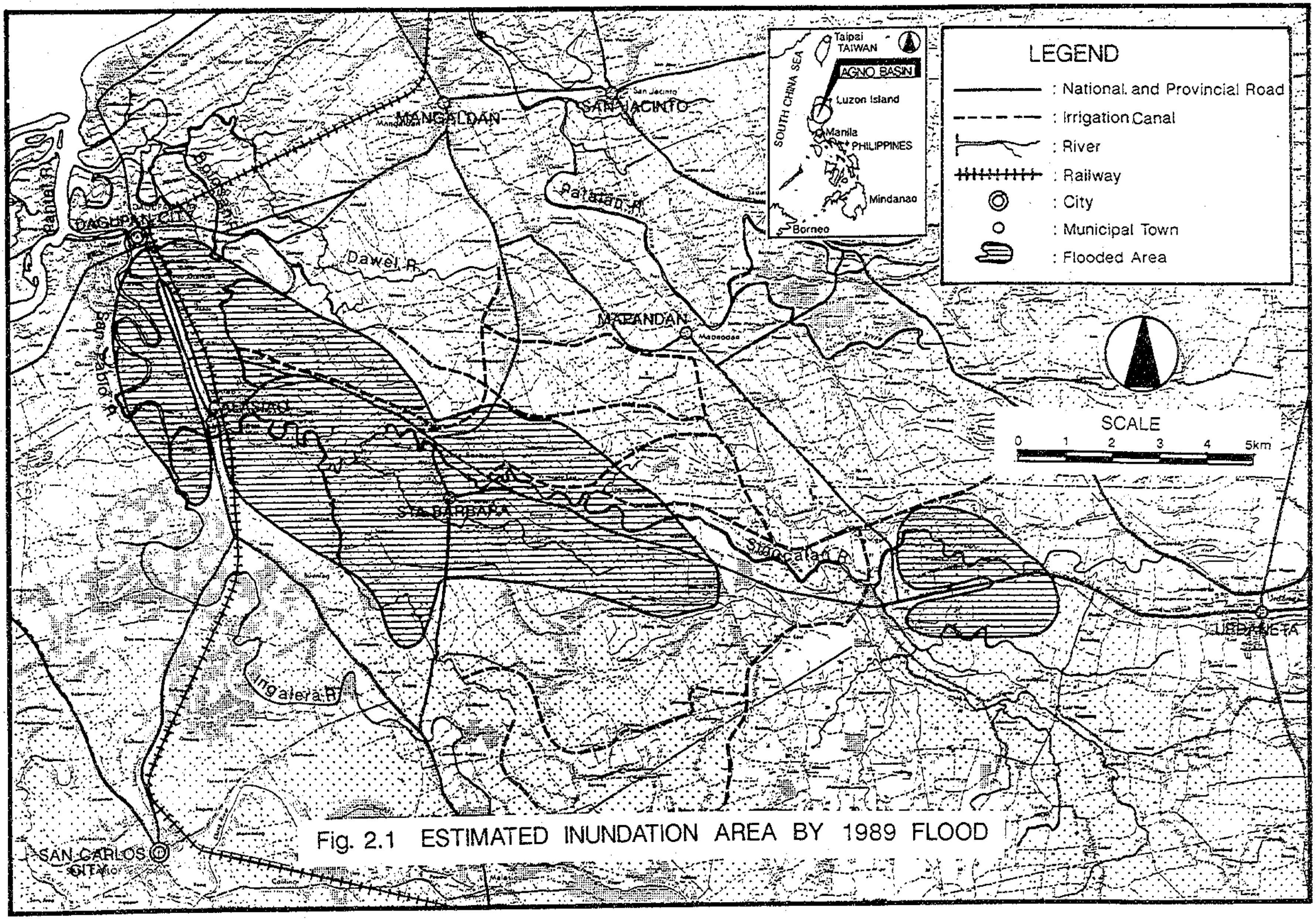


Fig. 2.1 ESTIMATED INUNDATION AREA BY 1989 FLOOD

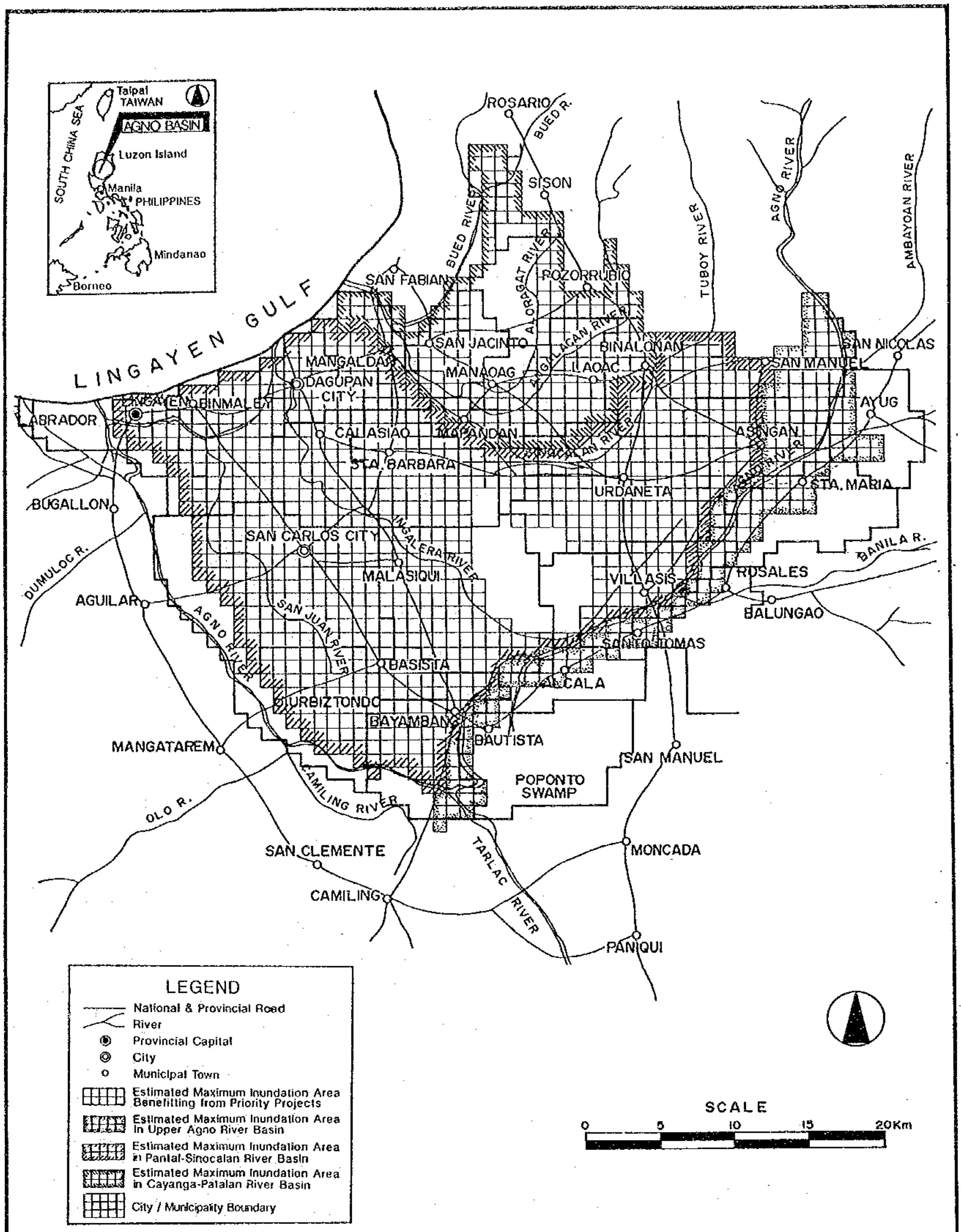


Fig. 3.1 CITIES AND MUNICIPALITIES IN MAXIMUM INUNDATION AREA FOR PRIORITY PROJECTS

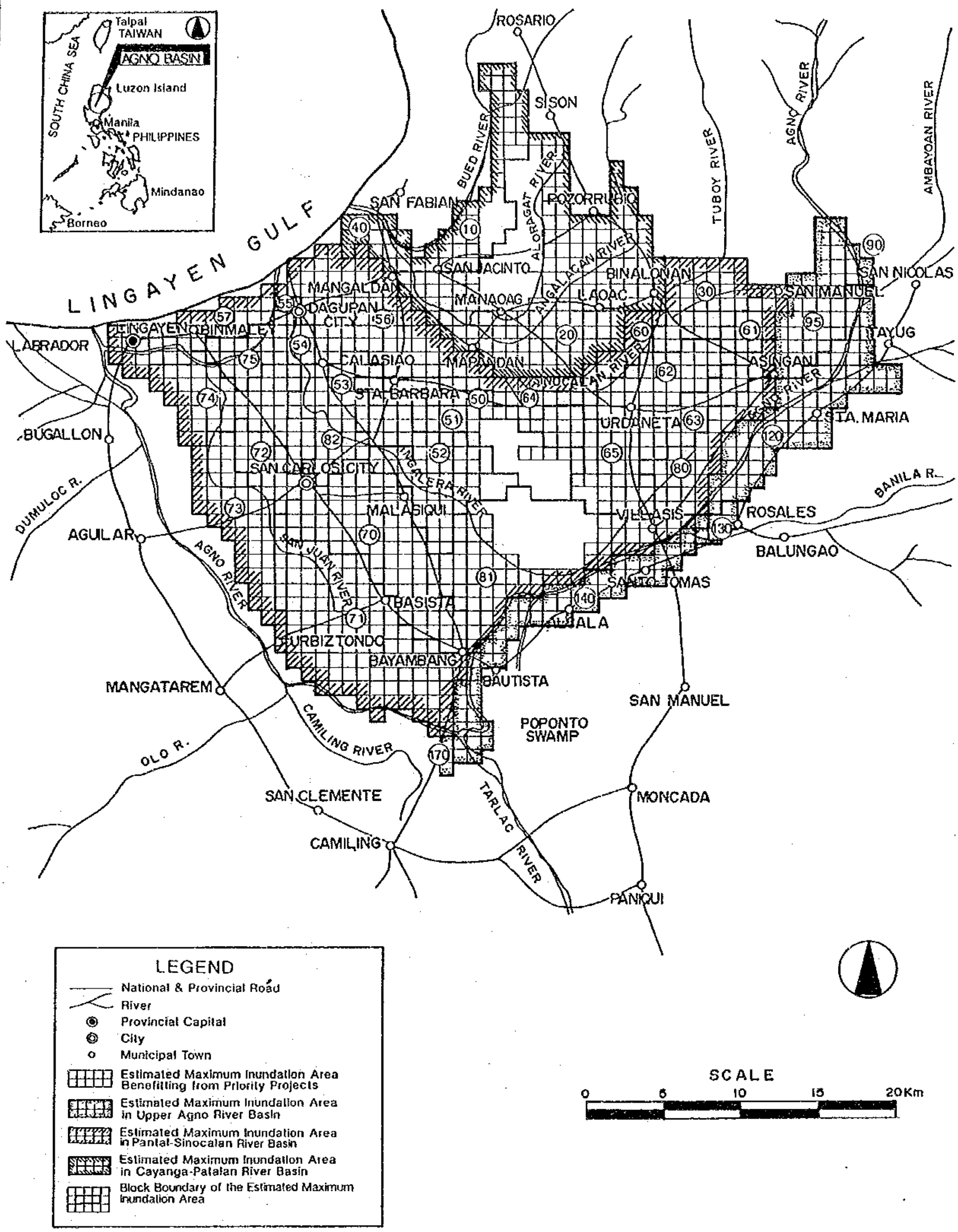


Fig. 3.2 BLOCKS IN MAXIMUM INUNDATION AREA FOR PRIORITY PROJECTS

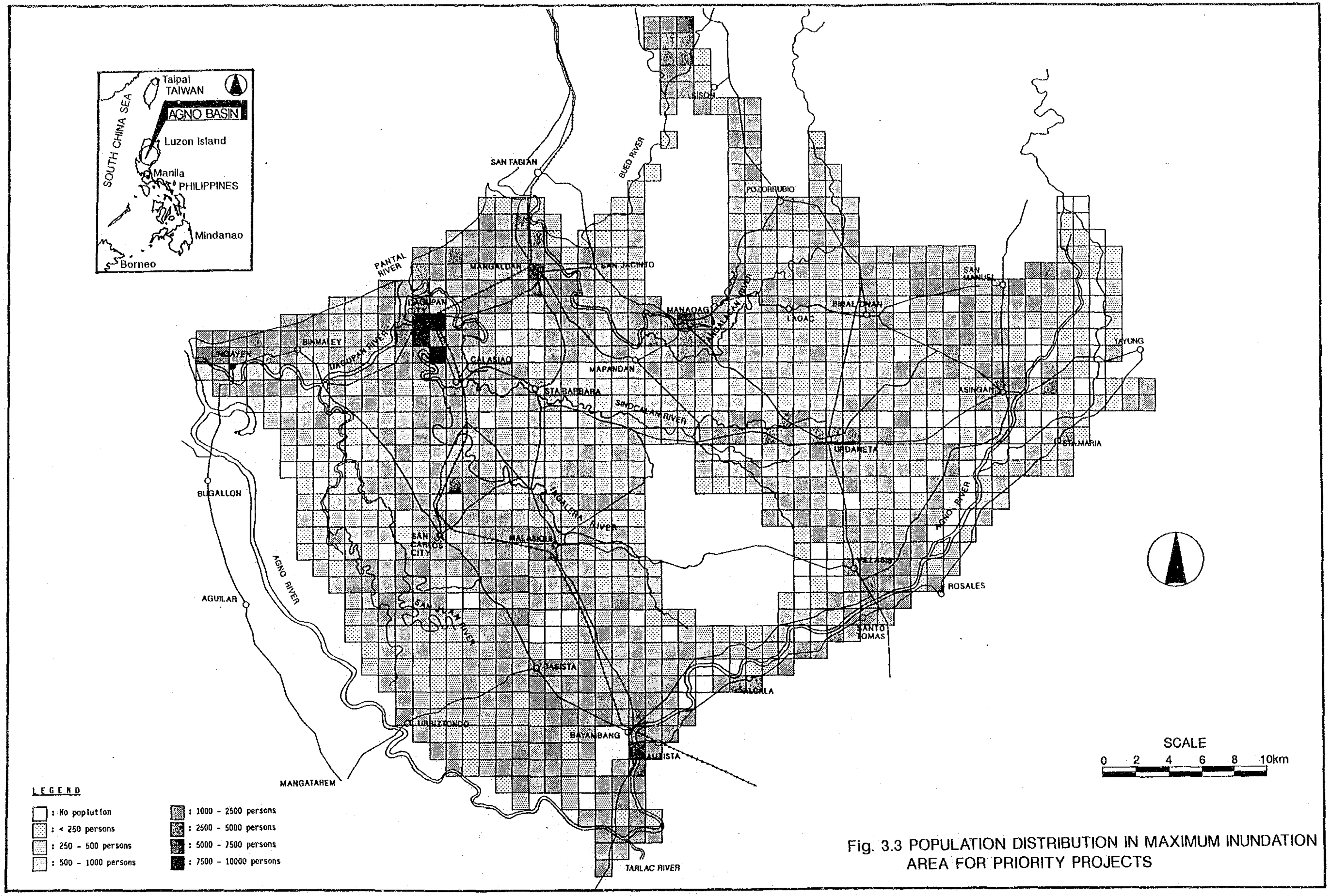


Fig. 3.3 POPULATION DISTRIBUTION IN MAXIMUM INUNDATION AREA FOR PRIORITY PROJECTS

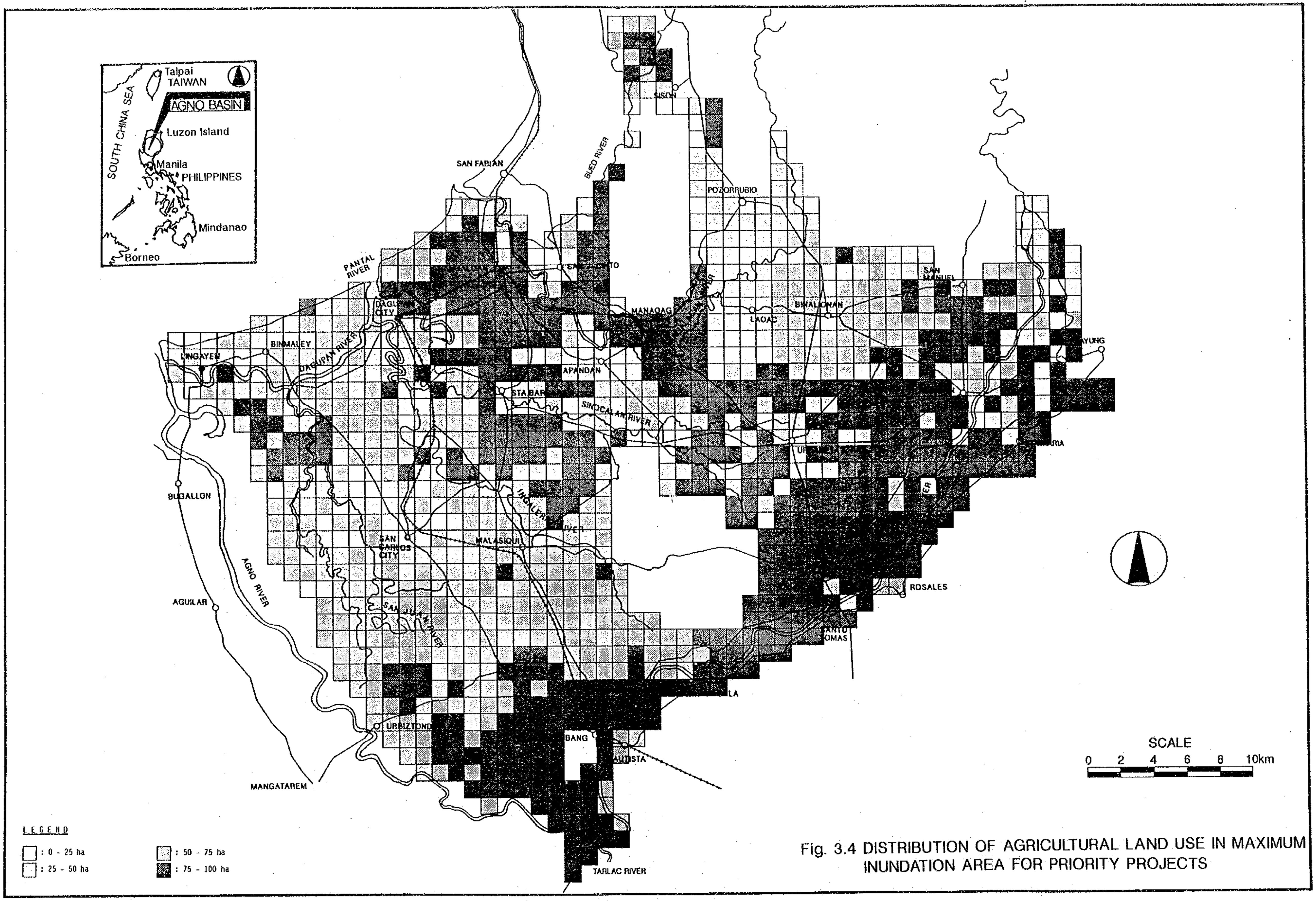


Fig. 3.4 DISTRIBUTION OF AGRICULTURAL LAND USE IN MAXIMUM INUNDATION AREA FOR PRIORITY PROJECTS

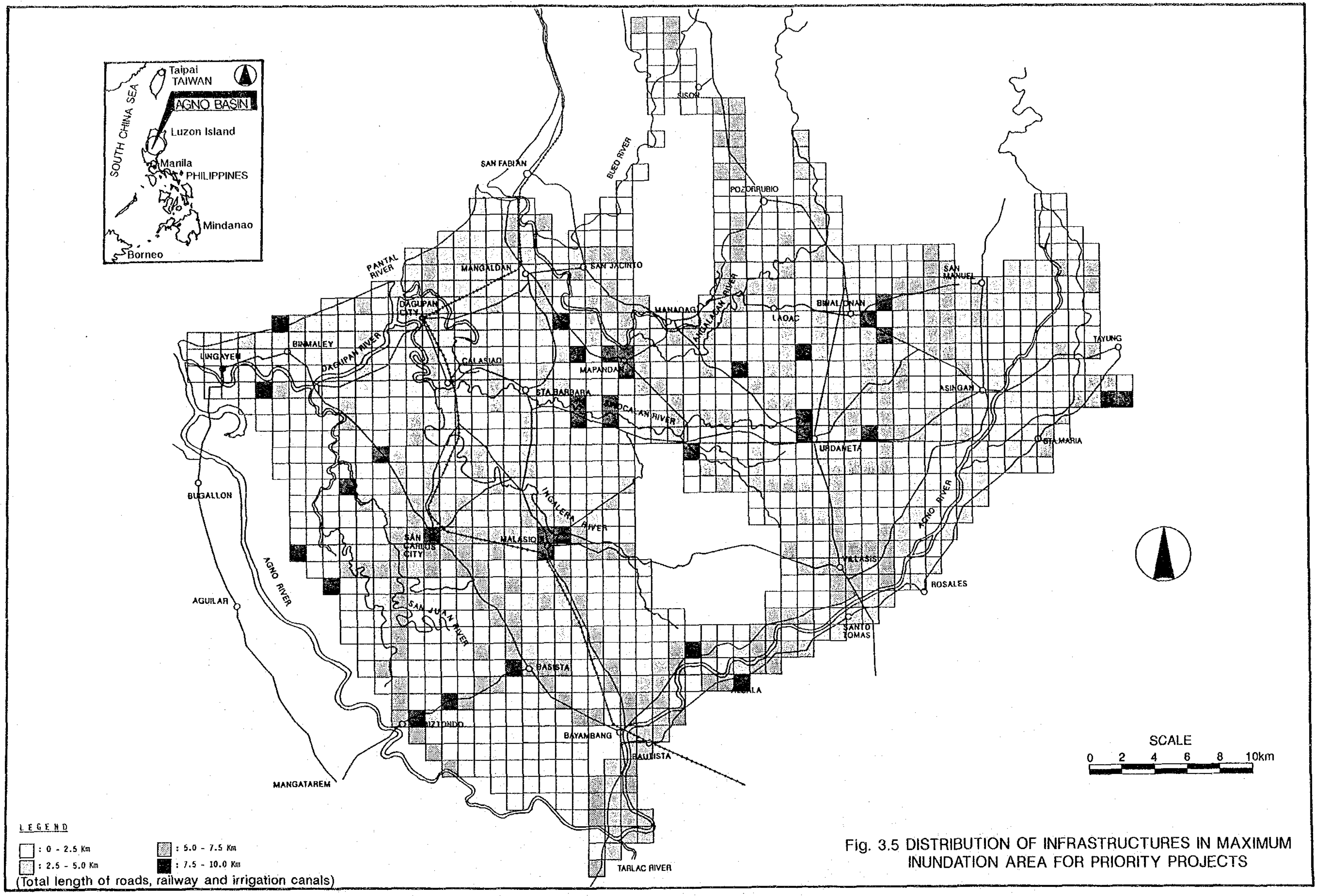
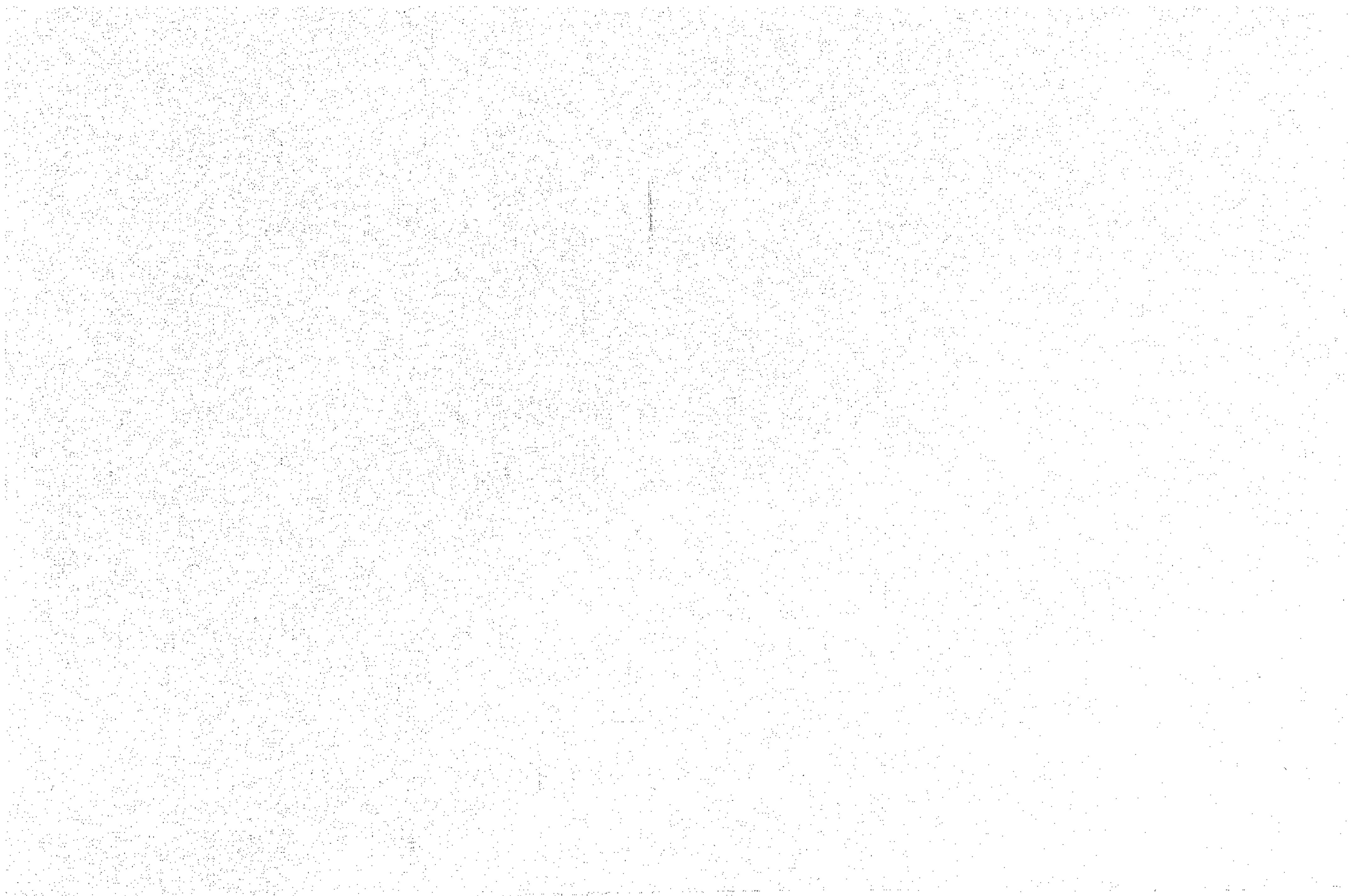


Fig. 3.5 DISTRIBUTION OF INFRASTRUCTURES IN MAXIMUM INUNDATION AREA FOR PRIORITY PROJECTS



8. SD

8. SD

SEDIMENT CONTROL PLAN

SD: SEDIMENT ANALYSIS

SUMMARY

(1) The increase of sediment yield caused by the earthquake is assumed to be negligible from the results of field investigations, although devastation of watershed caused by the 1990 earthquake was observed in the Viray and Dipalo river basins.

(2) As for sedimentation in the Poponto Swamp, heavy sedimentation with a depth of 1 to 2 m has been taking place since 1972 in areas such as the lowest portion below EL. 10 m and the areas near the sources of sediment which are the Agno and Tarlac rivers.

(3) The design sedimentation volume for 50 years of the Poponto Swamp was estimated at 260 million m^3. However, in order to prepare for an excessive sedimentation, the monitoring of sedimentation in the swamp was also recommended in this Study. A total of 35 sites were selected as measuring sites.

(4) The river mouth of the Pantal-Sinocalan River has been naturally maintained with a width of 200-300 m.

(5) It is assessed that the proposed priority project will not aggravate the existing condition of the river mouth. Overtopping of floodwater will not take place during a flood less than the design flood insofar as the river mouth is maintained under the existing condition.

(6) According to the results of the sediment balance and riverbed fluctuation analyses, the proposed river channel for the Upper Agno River is more stable than the existing one. In particular, scouring at the Carmen stretch will be considerably mitigated by widening the stretch.

(7) As for the Pantal-Sinocalan River, the existing river channel is comparatively stable except the upper stretches upstream of Binalonan. The proposed river channel is also expected to be as stable as the existing one in spite of the major improvement works such as the construction of the bypass channel and the widening of the channel.

SD: SEDIMENT ANALYSIS

TABLE OF CONTENTS

Page

SUMMARY SD.S1
TABLE OF CONTENTS .... SD.i
LIST OF TABLES .... SD.iii
LIST OF FIGURES .... SD.iv
ABBREVIATIONS .... SD.v

1. INTRODUCTION SD.1

2. REVIEW OF PRESENT CONDITION OF SEDIMENTATION IN STUDY AREA SD.2

2.1 Sediment Yield after Earthquake SD.2
2.2 Sedimentation in Poponto Swamp SD.2
2.3 River Mouth Clogging of Pantal River SD.3

3. SEDIMENT BALANCE ANALYSIS SD.5

3.1 Methodology SD.5
3.1.1 Simulation Case SD.5
3.1.2 Simulation Model SD.5

3.2 Upper Agno River System SD.8
3.2.1 System Model SD.8
3.2.2 Stability of Proposed River Channel SD.8
3.2.3 Sedimentation of Poponto Swamp SD.8

3.3 Pantal-Sinocalan River System SD.9
3.3.1 System Model SD.9
3.3.2 Stability of Proposed River Channel SD.9

Page

4. RIVERBED FLUCTUATION ANALYSIS SD.10

4.1 Purpose of Riverbed Fluctuation Analysis SD.10

4.2 Methodology SD.10

4.2.1 Simulation Model SD.10

4.2.2 Condition SD.11

4.3 Results of Simulation SD.12

5. SEDIMENT CONTROL PLAN SD.13

5.1 Stability of Proposed Channel SD.13

5.1.1 Upper Agno River SD.13

5.1.2 Pantal-Sinocalan River SD.13

5.2 Sedimentation in Poponto Swamp SD.13

5.3 River Mouth Clogging of Pantal River SD.14

LIST OF TABLES

No.		Page
2.1	SUMMARY OF FIELD INVESTIGATION ON SEDIMENT YIELD	SD.16
3.1	ASSUMED CONDITION OF SEDIMENT BEHAVIOR BY MODEL	SD.17
3.2	CONSTANTS OF RATING CURVE FOR EXISTING UPPER AGNO RIVER CHANNEL	SD.18
3.3	CONSTANTS OF RATING CURVE FOR PROPOSED AGNO RIVER CHANNEL (PRIORITY PROJECT)	SD.18
3.4	RIVER BED FLUCTUATION OF UPPER AGNO RIVER	SD.19
3.5	SIMULATED ANNUAL SEDIMENT BALANCE FOR EXISTING UPPER AGNO RIVER CHANNEL (1982-1986)	SD.20
3.6	SIMULATED ANNUAL SEDIMENT BALANCE FOR EXISTING BALANCE FOR EXISTING UPPER AGNO RIVER CHANNEL	SD.21
3.7	SIMULATED ANNUAL SEDIMENT BALANCE FOR PROPOSED UPPER AGNO RIVER CHANNEL (PRIORITY PROJECT, WITHOUT SAN ROQUE DAM) .	SD.21
3.8	SIMULATED ANNUAL SEDIMENT BALANCE FOR PROPOSED UPPER AGNO RIVER CHANNEL (PRIORITY PROJECT, WITH SAN ROQUE DAM) ...	SD.21
3.9	CONSTANTS FOR RATING CURVE FOR EXISTING PANTAL-SINOCALAN RIVER CHANNEL	SD.22
3.10	CONSTANTS FOR RATING CURVE FOR PROPOSED PANTAL-SINOCALAN RIVER CHANNEL (PRIORITY PROJECT)	SD.22
3.11	SEDIMENT BALANCE FOR EXISTING PANTAL-SINOCALAN RIVER CHANNEL	SD.23
3.12	SEDIMENT BALANCE FOR PROPOSED PANTAL-SINOCALAN RIVER CHANNEL (PRIORITY PROJECT)	SD.23

LIST OF FIGURES

No.		Page
2.1	AGNO RIVER BASIN MAP	SD.24
2.2	RESULT OF INTERVIEW ON SEDIMENTATION IN POPONTO SWAMP AREA	SD.25
2.3	LOCATION OF DREDGING AREA	SD.26
2.4	CROSS SECTION PROFILE AT RIVER MOUTH OF PANTAL RIVER	SD.27
3.1	RELATIONSHIP BETWEEN PARTICLE SIZE AND RIVER BED GRADIENT	SD.28
3.2	UPPER AGNO RIVER SYSTEM SEDIMENT BALANCE MODEL	SD.29
3.3	RESULT OF SEDIMENT BALANCE SIMULATION (EXISTING CONDITION)	SD.30
3.4	UPPER AGNO RIVER SYSTEM SEDIMENT BALANCE	SD.31
3.5	SEDIMENT BALANCE DIAGRAM	SD.32
3.6	PANTAL-SINOCALAN RIVER SYSTEM SEDIMENT BALANCE MODEL	SD.33
3.7	PANTAL-SINOCALAN RIVER SYSTEM SEDIMENT BALANCE	SD.34
4.1	DESIGN HYDROLOGRAPH	SD.35
4.2	RESULT OF RIVER BED FLUCTUATION ANALYSIS (FRAMEWORK PLAN)	SD.36
4.3	RESULT OF RIVER BED FLUCTUATION ANALYSIS (PRIORITY PROJECT)	SD.37
5.1	PROPOSED MEASUREMENT SITE FOR SEDIMENTATION IN POPONTO SWAMP AREA	SD.38

ABBREVIATIONS

1. NAME OF PHILIPPINE GOVERNMENT AGENCIES

AFCS	Agno River Flood Control System
ARIS	Agno River Irrigation System
DENR	Department of Environment and Natural Resources
DOTC	Department of Transportation and Communication
DPWH	Department of Public Works and Highways
GOP	Government of the Philippines
LATRIS	Lower Agno and Totonogen River Irrigation System
NAPOCOR	National Power Corporation
NAMRIA	National Mapping and Resource Information Authority
NIA	National Irrigation Administration
OCD	Office of Civil Defense
PENRO	Provincial Environment and Natural Resources Office
PM	Project Manager
PMO	Project Management Office
PNR	Philippine National Railways
TASMORIS	Tarlac River and San Miguel - O'Donnel River Irrigation System

2. NAME OF JAPANESE GOVERNMENT AND OTHER OFFICIAL AGENCIES AND ORGANIZATION

GOJ	Government of Japan
JICA	Japan International Cooperation Agency
MOC	Ministry of Construction, Japan
OECF	Overseas Economic Cooperation Fund, Japan
UN	United Nations

3. MEASUREMENT UNITS

(Length)		(Weight)	
mm	millimeter(s)	gr(grs)	gramme(s)
cm	centimeter(s)	kg(kgs)	kilogramme(s)
m	meter(s)	ton(s)	ton(s), eq'vt to 1,000kg
km	kilometer(s)		

(Area)

mm^2	square millimeter(s)
cm^2	square centimeter(s)
m^2	square meter(s)
km^2	square kilometer(s)
ha(has)	hectare(s)

(Time)

sec	second(s)
min	minute(s)
hr(hrs)	hour(s)
dy(dys)	day(s)
mth(mths)	month(s)
yr(yrs)	year(s)

(Volume)

cm^3	cubic centimeter(s)
m^3	cubic meter(s)
ltr	liter(s)

SD: SEDIMENT ANALYSIS

1. INTRODUCTION

The sediment analysis was performed to formulate a sediment control plan related to the selected priority projects. The main study items are as follows:

a) To review the present condition of sedimentation.

b) To conduct sediment balance analysis in order to estimate sedimentation in Poponto Swamp and to study stability of proposed river channels of the Upper Agno River and the Pantal-Sinocalan River.

c) To conduct detailed riverbed fluctuation analysis for the Upper Agno River stretches of which dikes have been proposed to be moved backward.

d) To formulate a sediment control plan on the basis of the studies mentioned above.

2. REVIEW OF PRESENT CONDITION OF SEDIMENTATION IN STUDY AREA

2.1 Sediment Yield After Earthquake

In July 1990 a huge earthquake of magnitude 7.8 on the Richter scale took place in Central Luzon. This earthquake did not only damage structures such as bridges and buildings but also devastated mountain slopes. According to the disaster survey report on the Kennon Road prepared by DPWH, slope failure, rock and debris fall and landslide significantly increased after the earthquake along the road in the Bued River Basin. The riverbed rose significantly due to the sediment flow from these new sources.

The mountain areas upstream of the priority project areas such as the Agno, Ambayoan, Viray-Dipalo, Banila, Tarlac and Tuboy river basins may have been affected also by the earthquake (Fig. 2.1), and sediment yield of the basins may have increased. Field investigations were, therefore, conducted to verify the sediment yield rate. In the field investigations, the riverbeds were inspected at the outlets of valleys up to their alluvial fans. The results of the field investigations are summarized in Table 2-1.

No remarkable effect of the earthquake was observed in the Agno, Ambayoan, Banila, Tarlac and Tuboy rivers insofar as the riverbed conditions are concerned. The riverbed elevation of these rivers has been almost unchanged by the earthquake. As for the Viray and Dipalo rivers, their riverbeds rose due to debris flow from the devastated mountain slopes so high that the irrigation dams have been completely buried in some 5 m of sediment.

The sediment yield rates of the two devastated river basins of Viray and Dipalo are estimated to have increased to a considerable extent by the effect of the earthquake. The mountainous area of the two river basins (111 km^2) is, however, less than 4% of that of the whole Upper Agno River Basin upstream of Wawa (2,863 km^2) of which sediment yield is related to the priority project area. As far as the project area of the Upper Agno River stretch and the Poponto Swamp is concerned, it is evaluated that the devastation of the two river basins does not lead to a significant change of sedimentation condition. Therefore, the design sediment yield rate estimated in the Master Plan Study may be applied again without any revision for the Feasibility Study.

2.2 Sedimentation in Poponto Swamp

The Poponto swamp has been evaluated as a natural retarding basin in the Master Plan Study. A major part of floodwaters from the Upper Agno River is proposed to be led to the swamp by the proposed diversion facility, and it may result in an increase of sedimentation in the swamp.

Field investigations and interviews were conducted in this Feasibility Study to know the present condition of sedimentation in the Poponto swamp. The accumulative depth of sedimentation in the period from 1972 to 1991 for each interview site is shown in Fig. 2.2.

The heaviest sedimentation for the last 20 years was experienced during the flood of July 1972, when the maximum water level in the swamp reached to about EL. 16 m. The flood deposited a 1 m layer of sand and silt on some lower areas near the Agno and Tarlac rivers.

Heavy sedimentation has been taking place in areas such as the lowest portion below EL. 10 m and the areas near the sources of sediment which are the Agno and Tarlac rivers. In such areas, the accumulative depth since 1972 has reached up to 1 to 2 m.

2.3 River Mouth Clogging of Pantal River

Excessive sedimentation at a river mouth may block river flow and be a cause of overbanking. Moreover, it may hinder navigation of fishing boats. As for the Pantal River, a sand bar is developing from the left side and the water depth at the river mouth is as shallow as only 1 m although a 60 m wide portion with the maximum depth of from 7 to 8 m exist (Fig. 2.1) along the left shore. In this Feasibility Study field investigations and interviews were additionally conducted to assess the river mouth condition.

The results of the investigations are summarized as follows:

a) The width of the river mouth has been naturally maintained at about 200 to 300 m in spite of seasonal fluctuations that it is wider in the rainy season and narrower in the dry season.

b) In the dry season the water depth sometimes becomes shallow due to sedimentation, however, the river mouth has never been closed completely. Motorized fishing boats navigate along the deeper portion of the channel.

c) AFCS introduced the Dredge Visayas I to the Dagupan stretch of the Pantal-Sinocalan River in 1986. Since then, the Visayas I has been dredging the channel as shown in Fig. 2.3. In the stretch with a length of 2 km which is suffering from sedimentation, some 90,000 m^3 of sediment have been removed yearly. The purpose of the dredging is to maintain the required carrying capacity of the channel to prevent overtopping of floodwater from the banks.

3. SEDIMENT BALANCE ANALYSIS

Sediment balance simulation was carried out for both the Upper Agno River System and the Pantal-Sinocalan River System. The purposes of the simulation are as follows:

a) To estimate the design sedimentation volume of the Poponto natural retarding basin.

b) To study the stability of the proposed river channels for the priority projects.

3.1 Methodology

3.1.1 Simulation Case

Sediment balance analysis was carried out in two cases for each river system, the existing condition and the condition with the proposed priority project. The case of the priority project of the Upper Agno River System was, moreover, divided into the two cases of with and without the proposed San Roque Dam.

Case No.	River System	Condition	Remarks
1-1	Upper Agno	Existing Condition	
1-2-1	-ditto-	Priority Project	Without San Roque Dam
1-2-2	-ditto-	-ditto-	With San Roque Dam
2-1	Pantal-Sinocalan	Existing Condition	
2-2	-ditto-	Priority Project	

3.1.2 Simulation Model

The applied simulation model, which is the same as the one applied in the Master Plan Study, consists of subbasin, dam reservoir, confluence, river channel, irrigation system, diversion and natural retarding basin models. In order to construct the sediment discharge rating curves, the following empirical formulae were adopted according to the components of sediment:

Component	Applied Formula
Bed Load	Sato-Kikkawa-Ashida's Formula
Suspended Load	Lane-Kalinske's Formula
Wash Load	100% passage but some % are trapped in lower stretch*

* 5% of wash load is assumed to be trapped and deposited in the lowest stretches of the Pantal and Dagupan rivers.

The behavior of sediment assumed by the models is summarized in Table 3.1 and the river system diagrams for the Upper Agno and Pantal-Sinocalan are shown in Figs. 3.2 and 3.6. In addition, some important conditions for the simulation are discussed hereinafter.

(1) Sediment Yield

In accordance with the discussion in 2.1, it is assumed that the increase of the sediment yield caused by the earthquake is negligible. Therefore, the design sediment yield rates estimated in the Master Plan Study were again adopted. The annual sediment yield for the basins related to the priority project areas are as follows:

Basin	Annual Sediment Yield (mil. m^3/yr.)	Remarks
Upper Agno River	16.57	Tributaries included
Tarlac River	7.66	
Tuboy River	0.83	Sediment source to Pantal-Sinocalan

(2) Trap Efficiency of Poponto Swamp

The design sedimentation volume in the Poponto Swamp was estimated by applying a trap efficiency of 90% for the following reasons:

a) According to the Brune's curve which was based on the sedimentation records of dam reservoirs, the trap efficiency of the swamp changes in a range of 0 to 90% in accordance with its water level as shown in the following table. The value of 90% is the safest value.

Water Level (EL.m)	Storage Capacity C (mil. m^3)	Annual Inflow I (mil. m^3)	C/I	Trap Efficiency (%)
10.0	0	6,500	0.000	0
12.0	50	6,500	0.009	30 - 60
14.0	200	6,500	0.037	60 - 85
16.0	470	6,500	0.086	75 - 90

b) The result of hydraulic analysis shows that the rise of the high water level due to the design sedimentation obtained by using a trap efficiency of 90% is as small as 40 cm. The high water level is not influenced so much by the sedimentation volume.

c) Periodical measurement of ground level is proposed to monitor sedimentation in the swamp in order to prepare for excessive sedimentation of more than the design sedimentation.

(3) Riverbed Material

The regression lines based on the observed data in the Agno River were applied to determine the particle size of riverbed materials because the observed data are insufficient in number. Fig. 3.1 shows the regression lines between particle size and riverbed gradient of the Agno River.

(4) Flow Discharge and Period of Simulation

Flow discharge at each reference point was determined on the basis of the estimated daily discharge at San Roque for 27 years from 1960 to 1986. The sediment balance simulation was also carried out for the period of 27 years.

3.2 Upper Agno River System

3.2.1 System Model

The river channel upstream of the Poponto swamp was divided into 10 stretches as shown Fig. 3.2. The main features and constants of sediment discharge rating curves for these stretches are presented in Tables 3.2 and 3.3.

3.2.2 Stability of Proposed River Channel

The results of simulation are presented in Tables 3.5 and 3.6 and Figs. 3.3 and 3.4. The sediment balance was also obtained by comparing the two records of cross section profiles which were surveyed in 1981 and 1989 as tabulated in Table 3.4. The results are summarized as follows:

a) The simulation results show that the applied model well simulates appropriately the movement of sediment under the existing condition (Fig. 3.3).

b) Widening of the Poponto Floodway and the Carmen stretch of the Upper Agno River is proposed under the priority project. The low water channel is proposed to be widened to 150 m. The stability of the river channel is expected to be improved by the proposed river channel improvement. In particular, scouring of the Carmen stretch and sedimentation of the lower stretch will be considerably mitigated by widening the channel.

c) The effect of the San Roque Dam appears at the uppermost stretch. The supply of sediment from the mountainous area is trapped by the dam reservoir, but it results in degradation of the riverbed in the lower stretches.

3.2.3 Sedimentation of Poponto Swamp

The Poponto Swamp is proposed to be utilized as a natural retarding basin, and most of the floodwaters from the Upper Agno River will be led to the swamp. The design sedimentation volume in the swamp was estimated by the sedimentation balance simulation, taking into consideration the proposed San Roque and Balog-Balog dams.

Fig. 3.5 shows the results of simulation, and the annual sediment volume estimated at 5,143,000 m^3/year. If the design life of 50 years is considered, the design sedimentation volume of 260 million m^3 is obtained.

3.3 Pantal-Sinocalan River System

3.3.1 System Model

The Pantal-Sinocalan River channel was divided into thirteen (13) stretches for the existing condition and fourteen (14) stretches for the priority project. The system model diagram is shown in Fig. 3.6 and the main features and constants for sediment discharge rating curves for these divided stretches are presented in Tables 3.10.

3.3.2 Stability of Proposed River Channel

The results of simulation are presented in Tables 3.11 and 3.12 and Fig. 3.7, and are summarized as follows:

a) The river channel is comparatively stable even under the existing condition except the sedimentation stretches upstream of Binalonan.

b) The major improvement work for the Pantan-Sinocalan River is the construction of a bypass channel from Calasiao to the Dagupan River. The existing narrow and meandering channel is also to be widened to 100-200 m and cut short. As for the proposed channel, the tendency of the riverbed fluctuation is almost the same as the existing condition.

c) Sedimentation in the Dagupan River stretch of which riverbed is very deep at present is expected under the proposed project. It may result in smoothing of the riverbed.

4. RIVERBED FLUCTUATION ANALYSIS

4.1 Purpose of Riverbed Fluctuation Analysis

The right dike of the Poponto Floodway is proposed to be set back by 350 m to widen the channel from the original 850 m to 1,200 m. Also in the Carmen stretch, which has been a so-called bottleneck of the Agno River, the right dike is proposed to be set back to widen the channel from 650-900 m to 900 m.

The riverbed fluctuation simulation was carried out to assess the effect of widening the river channel at the above stretches in the aspect of stability of the channel.

4.2 Methodology

4.2.1 Simulation Model

The simulation model consists of non-uniform flow calculation and sediment discharge calculation. The following equation was used for calculating the riverbed fluctuation based on the longitudinal imbalance of sediment discharge.

$$DZ = Z_{t+1} - Z_t = (Q_{B1} - Q_{B2}) \times Dt \,/\, B \,/\, DX \,/\, (1 - \lambda)$$

Where,

DZ	:	Riverbed fluctuation in duration t
Z	:	Riverbed height
Q_{B1}, Q_{B2}	:	Sediment volume flowed through upstream and downstream sections
B	:	River width which caused riverbed fluctuation
λ	:	Porosity of riverbed sand
DX	:	Distance between sections

The calculating procedure is as follows:

a) At first, non-uniform flow calculation for the initial riverbed is done by using the flow discharge at time t to obtain the friction velocity U_* at each section.

b) The sediment discharge volume at each section is calculated by the sediment discharge formula.

c) Then, the riverbed height Z_{t+1} after time D_t by using the above-mentioned equation.

d) The above procedure is repeated sequentially up to n times in order to obtain the riverbed height at time tn.

4.2.2 Condition

(1) Simulation Case

The riverbed fluctuation simulation was conducted in 4 cases to clarify the widening effect of river channels; namely, two conditions for the Framework Plan and two for the priority project, as follows:

Case No.	River Channel	Width of H.W.C (m)	Width L.W.C (m)	Flood Scale
1-1	Framework Plan	Proposed	180	100-year Flood
1-2	-ditto-	Existing	180	-ditto-
2-1	Priority Project	Proposal	150	10-year Flood
2-2	-ditto-	Existing	150	-ditto-

(2) Calculation Stretch

The calculation stretch with a length of 27 km was set from the Poponto Swamp to Asingan (FW 310 - AG361).

(3) Sediment Discharge Formula

Bed and suspended loads were considered as components of sediment which cause riverbed fluctuation, while wash load was excluded. As in the sediment balance analysis, Sato-Kikkawa-Ashida's Formula and Lane-Kalinske's Formula were applied to calculate sediment discharge for bed and suspended loads, respectively.

(4) Water Discharge

For the Framework Plan and the priority project, 100-year flood and 10-year flood hydrographs were applied, respectively (Fig. 4.1).

4.3 Results of Simulation

The results of simulation are presented in Figs. 4.2 and 4.3, and are summarized as follows:

a) The widened channel bed is more stable than the existing channel in most stretches.

b) The most significant effect appears in the Carmen stretch. The riverbed subsidence of 160 cm at the section AG-343 is improved by as much as 80 cm under the Framework Plan, although the effect is not so clear in the cases of the priority project.

c) Riverbed subsidence is expected in the narrow stretches of AG328-AG330 and AG347-AG352. In order to mitigate the subsidence completely in the stretches, the river channels are required to be widened as wide as the upper stretches; namely, widening by some 300 m and 1,500 m are required for the two narrow stretches, respectively.

5. SEDIMENT CONTROL PLAN

5.1 Stability of Proposed Channel

5.1.1 Upper Agno River

Widening of the Poponto Floodway and the Carmen stretch of the Upper Agno River is proposed under the priority project. The low water channel is proposed to be widened to 150 m.

According to the results of the sediment balance and the riverbed fluctuation analyses, the proposed river channel is more stable than the existing one. In particular, scouring at the Carmen stretch will be considerably mitigated by widening the stretch.

5.1.2 Pantal-Sinocalan River

The major improvement work for the Pantal-Sinocalan River is the construction of a bypass channel from Calasiao to the Dagupan River. The existing narrow and meandering channel is also to be widened to 100-200 m and cut short.

According to the results of the sediment balance analysis, the existing river channel is originally stable except the upper stretches upstream of Binalonan. The proposed river channel is also expected to be as stable as the existing one in spite of the major improvement works.

5.2 Sedimentation in Poponto Swamp

The Poponto Swamp is proposed to be utilized as a natural retarding basin, and most of the floodwaters from the Upper Agno River will be led to it together with sediment. The design sedimentation volume in the Poponto Swamp was estimated at 260 million m^3 for 50 years in this Study.

The value of 260 million m^3 was obtained on the basis of some assumptions such as sediment yield rates and trap efficiency, although the value is considered to be the safest value at present. Therefore, in order to prepare for excessive sedimentation of more than the design value, monitoring of sedimentation in the swamp is required.

The monitoring is recommended in the following manner:

a) Concrete posts with a scale will be erected at selected sites as shown in Fig. 5.1.

b) The ground levels will be measured with the posts, periodically at the end of the rainy season every year.

c) In addition to the periodical measurement, the ground levels shall be measured immediately after a big flood.

d) A phased installation schedule of the concrete posts is recommended to ease financial difficulties. A total of 35 posts will be installed in two phases; 9 of them will be installed under the first phase at the selected sites where heavy sedimentation is expected. The installation and measurement shall be carried out as soon as possible even prior to the commencement of the improvement works of the floodway and the natural retarding basin.

e) The remaining 26 posts shall be installed under the second phase, which may be during the improvement works. The measurements at the total of 35 sites, which were selected as a site per 4 km^2, will make it possible to estimate the sedimentation volume in the Poponto Swamp.

5.3 River Mouth Clogging of Pantal River

As discussed in 2.3, the river mouth of the Pantal-Sinocalan River has been naturally maintained with a width of 200-300 m. Under the existing condition a problem of river mouth clogging has never taken place.

It is assessed that the proposed river improvement plan of the priority project will not aggravate the existing condition of the river mouth from the following reasons:

a) The river improvement plan of the proposed pripity project follows the existing condition of the river mouth, although a bypass channel is proposed to be excavated from Calaciao to the Dagupan River. The flow regime will never be changed even after the completion of the project because neither dam nor floodway will be provided. The project, therefore, will not aggravate the existing condition of the river mouth which has been naturally maintained.

b) In addition, the design high water level for the stretch of the river mouth was decided on the basis of the non-uniform flow calculation applied for the existing cross section. If it is considered that the cross section survey was conducted in the dry season when the river channel became narrow and shallow, overtopping of floodwaters will not take place during a flood less than the design flood insofar as the river mouth is maintained under the existing condition.

However, in order to monitor the transition of the river mouth, periodical topographical survey shall be carried out. A cross section survey at the river mouth is recommended to be done once a year, at least, at the end of the dry season.

TABLES

Table 2.1 SUMMARY OF FIELD INVESTIGATION ON SEDIMENT YIELD

River Basin	Mountainous Area (km2)	Sediment Yield Rate <1 (m3/yr/km2)	Change of River Bed After Earthquake	Remarks
Upper Agno	1,310	8,100	No significant change is found along the stretch from San Roque Dam site to the ARIS dam.	
Ambayoan	413	12,200	The river bed near the intake dam of the Ambayoan River Irrigation System is partially covered with mud but the river bed elevation is almost same as what it used to be before the earthquake.	
Viray	66	3,500	The intake dam of the Viray River Irrigation System is completely buried in gravel. The depth of the accumulative sedimentation after the earthquake is estimated at more than 5 meters.	Numerous landslides took place on the mountain slopes and resulted in debris flow along the valley with heavy rainfall. The intake dam was reportedly buried in gravel carried by two floods in August 1991.
Dipalo	45	6,100	As same as the Viray River, the intake dam of the Dipalo River Irrigation System is completely buried in gravel. The depth of the accumulative sedimentation after the earthquake is estimated at some 5 meters.	The situation is same as that of the Viray River. The intake dam was reportedly buried in gravel by two floods in August 1991.
Banila	58	5,300	Mud and logs are scattered on the river bed along the stretch in the alluvial fan but the river bed has not been raised significantly.	
Tarlac	971	7,900	No change is found along the stretch near the intake dam of the Tarlac River Irrigation System.	According to NIA, the watershed of the Balog-Balog Dam has not been affected by the earthquake. A significant increase of sediment inflow to the TASMORIS has not been reported since the event of the earthquake.
Tuboy	115	7,200	No change is found along the stretch in the alluival fan.	

Note:<1 : Estimated in the Master Plan Study

Table 3.1 ASSUMED CONDITION OF SEDIMENT BEHAVIOR BY MODEL

Model	Bed Load	Suspended Load	Wash Load
Sub-basin	Daily sediment yield is estimated by the following equation: Qy = C x Qw x Qw Qy : Sediment yield Qw : Water discharge C : Constant estimated from sediment yield rate Sediment yield is assumed to be composed of 50% of bed material load (bed + suspended load) and 50 % of wash load.		
Dam Reservior	100 % trapped	100 % trapped	Trapped according to trap efficiency by Brune's curve
Confluence	100 % passage	100 % passage	100 % passage
River Channel	Sato-Kikkawa & Ashida's formula	Lane-Kalinke's formula	100 % pass in upper stretches but some % are trapped in lower stretches. <1
Diversion to Irrigation System	No inflow	Qsi = Qsu x Qwi/Qwu Qsi : Sediment inflow Qsu : Sediment discharge at upper ref. point Qwi : Water inflow Qwu : Water discharge at upper ref. point	Same as suspended load
Diversion to Floodway	Qsi = Qsu x Qwi/Qwu Qsu : Sediment inflow Qsu : Sediment discharge of upper ref. point. Qwi : Water inflow Qwu : Water discharge at upper ref. point	Same as bed load	Same as bed load
Retarding Basin (Popont Swamp)	Same as dam reservior model. Trap efficiency of 90 % is applied.		

Note : <1 : 5 % of wash load is assumed to trapped and deposited in the lowest stretch of the Pantal River.

Table 3.2 CONSTANTS OF RATING CURVE FOR EXISTING UPPER AGNO RIVER CHANNEL

No.	Stretch	Section Nos	Length (km)	Gradient of River Bed	Width of H.W.C. (m)	Width of L.W.C. (m)	Bed Load (Ton/day) ALPHA	Bed Load (Ton/day) BETA	Suspended Load (Ton/day) ALPHA	Suspended Load (Ton/day) BETA	Remark
C- 1	Agno R. (1)	AG281 - AG298	10.1	1/ 2000	210	80	0.953	0.91	0.130	1.67	
C- 2	Agno R. (2)	AG299 - AG309	6.3	1/ 1800	1630	100	0.518	1.08	0.171	1.53	
C- 3	Agno R. (3)	AG321 - AG340	9.6	1/ 1700	1450	118	0.659	1.05	0.176	1.47	
C- 4	Agno R. (4)	AG341 - AG346	2.6	1/ 1500	750	140	1.667	0.99	0.504	1.55	
C- 5	Agno R. (5)	AG347 - AG351	2.7	1/ 1400	970	98	1.219	1.01	0.683	1.38	
C- 6	Agno R. (6)	AG352 - AG367	8.4	1/ 1300	2470	81	0.936	1.08	0.395	1.35	
C- 7	Agno R. (7)	AG368 - AG414	7.9	1/ 600	2640	140	2.780	1.17	0.003	1.71	
C- 8	Agno R. (8)	AG415 - AG423	5.0	1/ 400	1960	107	2.360	1.25	0.010	1.64	
C- 9	Agno R. (9)	AG453 - AG460	3.7	1/ 300	1550	43	0.970	1.35	1.326	1.32	
C-10	Agno R. (10)	AG461 - AG475	7.5	1/ 200	1340	49	2.248	1.36	0.714	1.51	
CF	FLOOD WAY	FW314 - FW320	3.8	1/ 1600	850	45	1.738	0.94	2.662	1.15	
CT	Tarlac R.	TA212		1/ 1600	1000	120	1.318	1.03	1.174	1.45	
CB	Banila R.	BN375		1/ 1000	650	30	0.752	1.15	0.058	1.46	
CV	Viray-Dipalo R.	VP424		1/ 400	390	70	0.111	1.46	0.127	1.79	
CA	Ambayoan R.	AM444		1/ 200	540	110	0.007	2.14	0.414	1.57	

Note : Width of L.W.C. means width of low water channel bed.

Table 3.3 CONSTANTS OF RATING CURVE FOR PROPOSED UPPER AGNO RIVER CHANNEL (PRIORITY PROJECT)

No.	Stretch	Section Nos	Length (km)	Gradient of River Bed	Width of H.W.C. (m)	Width of L.W.C. (m)	Bed Load (Ton/day) ALPHA	Bed Load (Ton/day) BETA	Suspended Load (Ton/day) ALPHA	Suspended Load (Ton/day) BETA	Remark
C- 1	Agno R. (1)	AG281 - AG298	7.0	1/ 1850	250	100	1.007	0.93	0.099	1.68	
C- 2	Agno R. (2)	AG299 - AG309	6.3	1/ 1850	1630	100	0.592	1.04	0.203	1.50	
C- 3	Agno R. (3)	AG321 - AG340	9.6	1/ 1600	1450	150	0.738	1.04	0.389	1.50	
C- 4	Agno R. (4)	AG341 - AG346	2.6	1/ 1600	900	150	1.338	1.01	0.476	1.53	
C- 5	Agno R. (5)	AG347 - AG351	2.7	1/ 1600	970	150	0.655	1.01	0.291	1.52	
C- 6	Agno R. (6)	AG352 - AG367	8.4	1/ 1300	2470	150	1.051	1.03	0.203	1.47	
C- 7	Agno R. (7)	AG368 - AG414	7.9	1/ 600	2640	150	2.666	1.13	0.004	1.77	
C- 8	Agno R. (8)	AG415 - AG423	5.0	1/ 400	1960	107	2.360	1.25	0.010	1.64	Same as existing
C- 9	Agno R. (9)	AG453 - AG460	3.7	1/ 300	1550	43	0.970	1.35	1.326	1.32	Same as existing
C-10	Agno R. (10)	AG461 - AG475	7.5	1/ 200	1340	49	2.248	1.36	0.714	1.51	Same as existing
CF	FLOOD WAY	FW314 - FW320	3.8	1/ 1600	1200	150	0.790	1.03	0.477	1.48	
CT	Tarlac R.	TA212		1/ 1600	1000	120	1.318	1.03	1.174	1.45	Same as existing
CB	Banila R.	BN375		1/ 1000	650	30	0.752	1.15	0.058	1.46	Same as existing
CV	Viray-Dipalo R.	VP424		1/ 400	390	70	0.111	1.46	0.127	1.79	Same as existing
CA	Ambayoan R.	AM444		1/ 200	540	110	0.007	2.14	0.414	1.57	Same as existing

Note : Width of L.W.C. means width of low water channel bed.

Table 3.4 RIVER BED FLACTUATION OF UPPER AGNO RIVER

Stretch		Length	Deepest River Bed Level (m)		Water Channel (cu. m)		Deformation of the Deepest River Bed Level		Deformation of Volume of Low Water Channel	Quantity of Extracted River Bed Materials	Quantity of Dredging /Excavation	Total Sediment Volume		
		(m)	as of 1981	as of 1989	as of 1981	as of 1989	(m)	(m/year)	(cu. m)	(cu. m)	(cu. m)	(cu. m)	(cu. m/yr)	(cu. m/yr/m)
	AG- 180	1,000	4.90	5.09	923,200	957,600	0.19	0.03	(34,400)			(34,400)	(4,914)	(4.9)
	AG- 282	1,500	6.40	6.32	1,039,950	1,099,125	-0.08	-0.01	(59,175)			(59,175)	(8,454)	(5.6)
	AG- 285	1,000	6.20	8.02	706,600	753,625	1.82	0.26	(47,025)			(47,025)	(6,718)	(6.7)
	AG- 287	1,000	7.80	8.32	687,900	603,625	0.52	0.07	84,275			84,275	12,039	12.0
C- 1	AG- 289	1,000	8.10	7.94	658,100	660,270	-0.16	-0.02	(2,170)			(2,170)	(310)	(0.3)
	AG- 291	800	7.80	8.94	457,424	551,616	1.14	0.16	(94,192)			(94,192)	(13,456)	(16.8)
	AG- 293	1,000	8.15	9.63	607,780	657,000	1.48	0.21	(49,220)			(49,220)	(7,031)	(7.0)
	AG- 295	1,100	9.90	9.82	725,450	685,740	-0.08	-0.01	39,710			39,710	5,673	5.2
	AG- 297	1,400	10.10	7.62	962,920	1,510,110	-2.48	-0.35	(547,190)			(547,190)	(78,170)	(55.8)
	C- 1 TOTAL	9,800			6,769,324	7,478,711			(709,387)			(709,387)	(101,341)	(10.3)
	AG- 299	1,000	10.10	10.95	793,120	1,074,450	0.85	0.12	(281,330)			(281,330)	(40,190)	(40.2)
	AG- 301	1,000	11.09	11.52	668,340	638,680	0.43	0.06	29,660			29,660	4,237	4.2
C- 2	AG- 303	1,000	12.20	10.68	401,300	594,280	-1.52	-0.22	(192,980)			(192,980)	(27,569)	(27.6)
	AG- 305	1,050	13.37	13.50	409,248	385,980	0.13	0.02	23,268			23,268	3,324	3.2
	AG- 307	750	13.50	13.83	215,040	197,850	0.33	0.05	17,190			17,190	2,456	3.3
	AG- 309	900	15.40	13.81	284,688	403,560	-1.59	-0.23	(118,872)			(118,872)	(16,982)	(18.9)
	C- 2 TOTAL	5,700			2,771,736	3,294,800			(523,064)			(523,054)	(74,723)	(13.1)
	AG- 322	1,100	15.30	14.70	331,760	483,340	-0.60	-0.09	(151,580)			(151,580)	(21,654)	(19.7)
	AG- 324	1,100	15.65	15.33	193,600	379,500	-0.32	-0.05	(185,900)			(185,900)	(26,557)	(24.1)
	AG- 326	900	15.90	14.41	336,240	421,200	-1.49	-0.21	(84,960)			(84,960)	(12,137)	(13.5)
	AG- 328	900	16.80	16.20	574,371	490,500	-0.60	-0.09	83,871			83,871	11,982	13.3
C- 3	AG- 330	1,300	16.85	17.30	550,407	443,950	0.45	0.06	106,457			106,457	15,208	11.7
	AG- 333	1,300	18.25	18.30	482,170	346,125	0.05	0.01	136,045			136,045	19,435	15.0
	AG- 336	1,000	18.84	18.27	441,100	257,850	-0.57	-0.08	183,250			183,250	26,179	26.2
	AG- 338	1,200	18.27	19.48	637,200	396,360	1.21	0.17	240,840			240,840	34,406	28.7
	C- 3 TOTAL	8,800			3,546,848	3,218,825			328,023			328,023	46,860	5.3
	AG- 340	1,000	19.15	18.49	696,000	737,400	-0.66	-0.09	(41,400)			(41,400)	(5,914)	(5.9)
	AG- 342	1,000	20.06	20.10	869,000	874,400	0.04	0.01	(5,400)			(5,400)	(771)	(0.8)
C- 4	AG- 344	1,000	21.40	20.41	526,600	579,270	-0.99	-0.14	(52,670)			(52,670)	(7,524)	(7.5)
	C- 4 TOTAL	3,000			2,091,600	2,191,070			(99,470)			(99,470)	(14,210)	(4.7)
	AG- 347	1,000	21.79	20.90	541,800	589,250	-0.89	-0.13	(47,450)			(47,450)	(6,779)	(6.8)
C- 5	AG- 349	1,000	22.50	21.40	576,000	527,100	-1.10	-0.16	48,900			48,900	6,986	7.0
	AG- 351	950	21.90	22.60	226,252	344,470	0.70	0.10	(118,218)			(118,218)	(16,888)	(17.8)
	C- 5 TOTAL	2,950			1,344,052	1,460,820			(116,768)			(116,768)	(16,681)	(5.7)
	AG- 353	900	24.54	23.07	325,206	280,800	-1.47	-0.21	44,406			44,406	6,344	7.0
	AG- 355	1,000	24.92	24.13	691,680	483,500	-0.79	-0.11	208,180			208,180	29,740	29.7
C- 6	AG- 357	1,000	25.63	25.11	500,700	375,000	-0.52	-0.07	125,700			125,700	17,957	18.0
	AG- 359	1,400	25.34	26.80	403,480	166,250	1.46	0.21	237,230			237,230	33,890	24.2
	AG- 362	1,000	25.90	28.10	355,000	222,500	2.20	0.31	132,500			132,500	18,929	18.9
	AG- 364	1,300	26.80	28.70	405,080	298,675	1.90	0.27	106,405			106,405	15,201	11.7
	AG- 367	900	29.85	29.90	511,065	113,400	0.05	0.01	397,665			397,665	56,809	63.1
	C- 6 TOTAL	7,500			3,192,211	1,940,125			1,252,086			1,252,086	178,869	23.8
	AG- 369	1,100	31.40	32.80	627,319	225,060	1.40	0.20	402,259			402,259	57,466	52.2
	AG- 403	900	32.50	33.60	363,455	537,300	1.10	0.16	(173,844)			(173,844)	(24,835)	(27.6)
	AG- 405	1,450	35.75	35.20	638,073	792,280	-0.55	-0.08	(154,207)			(154,207)	(22,030)	(15.2)
C- 7	AG- 408	900	36.25	38.30	333,045	228,690	2.05	0.29	104,355			104,355	14,908	16.6
	AG- 410	1,100	36.60	38.40	361,350	110,110	1.80	0.26	251,240		54,279	196,951	28,137	25.6
	AG- 412	1,500	38.00	42.08	583,350	114,000	4.08	0.58	469,350			469,350	67,050	44.7
	C- 7 TOTAL	6,950			2,906,592	2,007,440			899,153			899,153	128,450	18.5
	AG- 416	1,600	44.20	45.00	471,520	229,312	0.80	0.11	242,208			242,208	34,601	21.6
	AG- 418	1,000	47.40	46.98	59,500	177,120	-0.42	-0.06	(117,620)			(117,620)	(16,803)	(16.8)
C- 8	AG- 422	1,200	54.60	51.52	159,300	213,480	-3.08	-0.44	(54,180)			(54,180)	(7,740)	(6.5)
	C- 8 TOTAL	3,800			690,320	619,912			70,408			70,408	10,058	2.6
	AG- 453	1,100	56.70	57.30	901,862	308,990	0.60	0.09	592,873			592,873	84,696	77.0
	AG- 455	1,000	57.80	58.90	1,307,875	376,600	1.10	0.16	931,275			931,275	133,039	133.0
C- 9	AG- 457	1,000	61.15	61.22	1,176,650	271,600	0.07	0.01	905,050			905,050	129,293	129.3
	AG- 459	900	63.10	64.18	1,001,160	97,020	1.08	0.15	904,140			904,140	129,163	143.5
	C- 9 TOTAL	4,000			4,387,548	1,054,210			3,333,338			3,333,338	476,191	119.0
	AG- 461	1,000	65.20	67.49	1,641,500	0	2.29	0.33	1,641,500			1,641,500	234,500	234.5
	AG- 463	1,000	68.55	71.30	2,061,500	0	2.75	0.39	2,061,500			2,061,500	294,500	294.5
C-10	AG- 465	900	72.50	78.80	573,800	0	6.30	0.90	573,800			573,800	81,971	91.1
	AG- 467	1,900	78.22	81.10	495,000	196,380	2.88	0.41	298,620			298,620	42,660	22.5
	AG- 471	900	91.90	90.33	280,390	0	-1.57	-0.22	280,390			280,390	40,056	44.5
	AG- 473	550	94.20	95.91			2.71	0.39				0	0	0.0
	C-10 TOTAL	6,250			5,052,190	196,380			4,855,810			4,855,810	693,687	111.0

Table 3.5 SIMULATED ANNUAL SEDIMENT BALANCE FOR EXISTING UPPER AGNO RIVER CHANNEL (1982 - 1986)

No.	Stretch	Section Nos	Length (km)	Gradient of River Bed	Width of H.W.C. (m)	Width of L.W.C. (m)	Sediment Transport Capacity (1000 m^3/yr) B.M.L.	W.L.	TOTAL	Sediment Balance (1000 m3/yr)	(m3/yr/m)	Remark
C- 1	Agno R. (1)	AG281 - AG298	10.1	1/ 2000	210	80	177	3149	3326	-67	-6.6	
C- 2	Agno R. (2)	AG299 - AG309	6.3	1/ 1800	1630	100	111	3149	3260	-23	-3.7	
C- 3	Agno R. (3)	AG321 - AG340	9.6	1/ 1700	1450	118	88	3174	3262	208	21.7	
C- 4	Agno R. (4)	AG341 - AG346	2.6	1/ 1500	750	140	296	3174	3470	-114	-43.8	
C- 5	Agno R. (5)	AG347 - AG351	2.7	1/ 1400	970	98	182	3174	3356	-82	-30.4	
C- 6	Agno R. (6)	AG352 - AG367	8.4	1/ 1300	2470	81	96	3086	3182	62	7.4	
C- 7	Agno R. (7)	AG368 - AG414	7.9	1/ 600	2640	140	158	3156	3314	34	4.4	
C- 8	Agno R. (8)	AG415 - AG423	5.0	1/ 400	1960	107	191	2991	3182	63	12.6	
C- 9	Agno R. (9)	AG453 - AG460	3.7	1/ 300	1550	43	192	1557	1749	288	77.8	
C-10	Agno R. (10)	AG461 - AG475	7.5	1/ 200	1340	49	422	1627	2049	1032	137.6	
CF	FLOOD WAY	FW314 - FW320	3.8	1/ 1600	850	45	1	25	26	-1	-0.3	

Note : Width of L.W.C. means width of low water channel bed.

Table 3.6 SIMULATED ANNUAL SEDIMENT BALANCE FOR EXISTING UPPER AGNO RIVER CHANNEL

No.	Stretch	Section Nos	Length (km)	Gradient of River Bed	Width of H.W.C. (m)	Width of L.W.C. (m)	Sediment Transport Capacity (1000 m^3/yr) B.M.L.	W.L.	TOTAL	Sediment Balance (1000 m^3/yr)	(m3/yr/m)	Remark
C- 1	Agno R. (1)	AG281 - AG298	10.1	1/ 2000	210	80	253	5380	5633	-100	-9.9	
C- 2	Agno R. (2)	AG299 - AG309	6.3	1/ 1800	1630	100	152	5380	5532	-29	-4.6	
C- 3	Agno R. (3)	AG321 - AG340	9.6	1/ 1700	1450	118	127	5681	5808	384	40.0	
C- 4	Agno R. (4)	AG341 - AG346	2.6	1/ 1500	750	140	511	5681	6192	-254	-97.7	
C- 5	Agno R. (5)	AG347 - AG351	2.7	1/ 1400	970	98	257	5681	5938	-117	-43.3	
C- 6	Agno R. (6)	AG352 - AG367	8.4	1/ 1300	2470	81	134	5527	5661	122	14.5	
C- 7	Agno R. (7)	AG368 - AG414	7.9	1/ 600	2640	140	214	5611	5825	54	6.8	
C- 8	Agno R. (8)	AG415 - AG423	5.0	1/ 400	1960	107	264	5322	5586	115	23.0	
C- 9	Agno R. (9)	AG453 - AG460	3.7	1/ 300	1550	43	274	2806	3080	437	118.1	
C-10	Agno R. (10)	AG461 - AG475	7.5	1/ 200	1340	49	593	2853	3446	1957	260.9	
CF	FLOOD WAY	FW314 - FW320	3.8	1/ 1600	850	45	8	302	310	-11	-2.9	

Note : Width of L.W.C. means width of low water channel bed.

Table 3.7 SIMULATED ANNUAL SEDIMENT BALANCE FOR PROPOSED UPPER AGNO RIVER CHANNEL (PRIORITY PROJECT, WITHOUT SAN-ROQUE DAM

No.	Stretch	Section Nos	Length (km)	Gradient of River Bed	Width of H.W.C. (m)	Width of L.W.C. (m)	Sediment Transport Capacity (1000 m^3/yr) B.M.L.	W.L.	TOTAL	Sediment Balance (1000 m^3/yr)	(m3/yr/m)	Remark
C- 1	Agno R. (1)	AG281 - AG298	7.0	1/ 1850	250	100	11	710	721	-2	-0.3	
C- 2	Agno R. (2)	AG299 - AG309	6.3	1/ 1850	1630	100	9	710	719	28	4.4	
C- 3	Agno R. (3)	AG321 - AG340	9.6	1/ 1600	1450	150	295	5681	5976	133	13.9	
C- 4	Agno R. (4)	AG341 - AG346	2.6	1/ 1600	900	150	428	5681	6109	-185	-71.2	
C- 5	Agno R. (5)	AG347 - AG351	2.7	1/ 1600	970	150	243	5681	5924	-105	-38.9	
C- 6	Agno R. (6)	AG352 - AG367	8.4	1/ 1300	2470	150	132	5527	5659	42	5.0	
C- 7	Agno R. (7)	AG368 - AG414	7.9	1/ 665	2640	150	174	5611	5785	93	11.8	
C- 8	Agno R. (8)	AG415 - AG423	5.0	1/ 400	1960	107	264	5322	5586	115	23.0	Same as existing
C- 9	Agno R. (9)	AG453 - AG460	3.7	1/ 300	1550	43	274	2806	3080	437	118.1	- Ditto -
C-10	Agno R. (10)	AG461 - AG475	7.5	1/ 200	1340	49	593	2853	3446	1957	260.9	- Ditto -
CF	FLOOD WAY	FW314 - FW320	3.8	1/ 1600	1200	150	258	4971	5229	0	0.0	

Note : Width of L.W.C. means width of low water channel bed.

Table 3.8 SIMULATED ANNUAL SEDIMENT BALANCE FOR PROPOSED UPPER AGNO RIVER CHANNEL (PRIORITY PROJECT, WITH SAN-ROQUE DAM

No.	Stretch	Section Nos	Length (km)	Gradient of River Bed	Width of H.W.C. (m)	Width of L.W.C. (m)	Sediment Transport Capacity (1000 m^3/yr) B.M.L.	W.L.	TOTAL	Sediment Balance (1000 m^3/yr)	(m3/yr/m)	Remark
C- 1	Agno R. (1)	AG281 - AG298	7.0	1/ 1850	250	100	11	395	406	-2	-0.3	
C- 2	Agno R. (2)	AG299 - AG309	6.3	1/ 1850	1630	100	9	395	404	28	4.4	
C- 3	Agno R. (3)	AG321 - AG340	9.6	1/ 1600	1450	150	295	3157	3452	133	13.9	
C- 4	Agno R. (4)	AG341 - AG346	2.6	1/ 1600	900	150	428	3157	3585	-185	-71.2	
C- 5	Agno R. (5)	AG347 - AG351	2.7	1/ 1600	970	150	243	3157	3400	-105	-38.9	
C- 6	Agno R. (6)	AG352 - AG367	8.4	1/ 1300	2470	150	132	3002	3134	42	5.0	
C- 7	Agno R. (7)	AG368 - AG414	7.9	1/ 665	2640	150	174	3052	3226	93	11.8	
C- 8	Agno R. (8)	AG415 - AG423	5.0	1/ 400	1960	107	264	2764	3028	115	23.0	Same as existing
C- 9	Agno R. (9)	AG453 - AG460	3.7	1/ 300	1550	43	274	247	521	437	118.1	- Ditto -
C-10	Agno R. (10)	AG461 - AG475	7.5	1/ 200	1340	49	593	110	703	-593	-79.1	
CF	FLOOD WAY	FW314 - FW320	3.8	1/ 1600	1200	150	258	2762	3020	0	0.0	

Note : Width of L.W.C. means width of low water channel bed.

Table 3.9 CONSTANTS OF RATING CURVE FOR EXISTING PANTAL-SINOCALAN RIVER CHANNEL

No.	Stretch	Section Nos	Length (km)	Gradient of River Bed	Width of H.W.C. (m)	Width of L.W.C. (m)	Bed Load (Ton/day) ALPHA	Bed Load (Ton/day) BETA	Suspended Load (Ton/day) ALPHA	Suspended Load (Ton/day) BETA	Remark
C- 1	Pantal R.	S 1 - S 6	2.6	1/ 3000	348	58	0.290	0.98	0.062	1.77	5 % of wash load is trapped
C- 2	Marusay R.	S 7 - S14	2.2	1/ 2800	92	52	0.349	0.95	0.066	1.83	
C- 3	Sinocalan R. (1)	S15 - S21	7.5	1/ 2700	71	33	0.418	0.94	0.147	1.77	
C- 4	Sinocalan R. (2)	S22 - S34	6.4	1/ 2500	43	16	0.524	0.93	0.410	1.71	
C- 5	Sinocalan R. (3)	S35 - S43	4.5	1/ 2300	45	25	0.627	0.93	0.260	1.75	
C- 6	Sinocalan R. (4)	S44 - S49	3.0	1/ 2000	51	23	0.737	0.94	0.267	1.72	
C- 7	Sinocalan R. (5)	S50 - S59	8.7	1/ 1800	62	26	1.629	0.96	0.318	1.75	
C- 8	Sinocalan R. (6)	S60 - S65	6.3	1/ 1300	61	25	2.112	1.01	0.270	1.78	
C- 9	Tagamusing R. (1)	S66 - S73	8.4	1/ 1100	59	17	3.152	1.09	0.218	1.80	
C-10	Tagamusing R. (2)	S74 - S78	5.5	1/ 600	49	17	2.223	1.35	0.007	2.09	
C-11	Tagamusing R. (3)	S78 - S80	2.2	1/ 400	70	28	0.078	2.24	0.007	2.03	
C-12	Tuboy R. (1)		7.0	1/ 200	500	10	0.186	2.17	0.452	1.49	
C-13	Tuboy R. (2)		3.5	1/ 100	500	5	33.584	1.37	2.724	1.26	
C-14	DAGUPAN R.			1/ 2500	300	50	0.482	0.97	0.154	1.77	
C-15	INGALERA R.			1/ 2200	20	15	0.645	0.91	0.245	1.82	
C-16	BINGCO R.			1/ 2000	20	10	0.730	0.92	0.449	1.73	
C-17	MACALONG R.			1/ 1800	10	7	0.837	0.83	0.475	1.71	
C-18	MITURA R.			1/ 1200	15	10	1.397	0.93	0.242	1.78	

Note : Width of L.W.C. means width of low water channel bed.

Table 3.10 CONSTANTS OF RATING CURVE FOR PROPOSED PANTAL-SINOCALAN RIVER CHANNEL (PRIORITY PROJECT)

No.	Stretch	Section Nos	Length (km)	Gradient of River Bed	Width of H.W.C. (m)	Width of L.W.C. (m)	Bed Load (Ton/day) ALPHA	Bed Load (Ton/day) BETA	Suspended Load (Ton/day) ALPHA	Suspended Load (Ton/day) BETA	Remark
C- 1	Pantal R.	S 1 - S 6	2.8	1/ 2350	550	60	0.364	1.07	0.104	1.72	5 % of wash load is trapped
BP-1	BYPASS (1)	D 0 - D 3	1.9	1/ 2350	400	60	0.440	1.04	0.117	1.74	- Ditto -
BP-2	BYPASS (2)	P 1 - P 7	3.3	1/ 2350	220	40	0.550	0.99	0.180	1.76	
C- 3	Sinocalan R. (1)	P 7 - S21	0.6	1/ 2350	220	40	0.554	0.99	0.183	1.75	
C- 4	Sinocalan R. (2)	S22 - S34	5.3	1/ 1850	200	30	1.155	0.98	0.263	1.71	
C- 5	Sinocalan R. (3)	S35 - S43	3.8	1/ 1850	200	30	0.898	0.99	0.204	1.72	
C- 6	Sinocalan R. (4)	S44 - S49	1.9	1/ 1850	200	30	1.132	1.00	0.254	1.72	
C- 7	Sinocalan R. (5)	S50 - S59	7.9	1/ 1600	150	30	1.064	1.02	0.377	1.72	
C- 8	Sinocalan R. (6)	S60 - S65	5.1	1/ 1150	100	25	1.987	1.05	0.208	1.75	
C- 9	Tagamusing R. (1)	S66 - S73	7.8	1/ 900	100	17	2.201	1.24	0.011	2.05	
C-10	Tagamusing R. (2)	S74 - S78	5.5	1/ 600	49	17	2.223	1.35	0.007	2.09	Same as existing
C-11	Tagamusing R. (3)	S78 - S80	2.2	1/ 400	70	28	0.078	2.24	0.007	2.03	- Ditto -
C-12	Tuboy R. (1)		7.0	1/ 200	500	10	0.186	2.17	0.452	1.49	- Ditto -
C-13	Tuboy R. (2)		3.5	1/ 100	500	5	33.584	1.37	2.724	1.26	- Ditto -
C-14	DAGUPAN R.			1/ 2500	300	50	0.482	0.97	0.154	1.77	- Ditto -
C-15	INGALERA R.			1/ 2200	20	15	0.645	0.91	0.245	1.82	- Ditto -
C-16	BINGCO R.			1/ 2000	20	10	0.730	0.92	0.449	1.73	- Ditto -
C-17	MACALONG R.			1/ 1800	10	7	0.837	0.83	0.475	1.71	- Ditto -
C-18	MITURA R.			1/ 1200	15	10	1.397	0.93	0.242	1.78	- Ditto -

Note : Width of L.W.C. means width of low water channel bed.

Table 3.11 SEDIMENT BALANCE FOR EXISTING PANTAL-SINOCALAN RIVER CHANNEL

No.	Stretch	Section Nos	Length (km)	Gradient of River Bed	Width of H.W.C. (m)	Width of L.W.C. (m)	Sediment Transport Capacity (1000 m^3/yr) B.M.L.	W.L.	TOTAL	Sediment Balance (1000 m^3/yr)	(m3/yr/m)	Remark
C- 1	Pantal R.	S 1 - S 6	2.6	1/ 3000	348	58	58	423	481	17	6.5	
C- 2	Marusay R.	S 7 - S14	2.2	1/ 2800	92	52	33	445	478	20	9.1	
C- 3	Sinocalan R. (1)	S15 - S21	7.5	1/ 2700	71	33	53	445	498	20	2.7	
C- 4	Sinocalan R. (2)	S22 - S34	6.4	1/ 2500	43	16	61	445	506	-18	-2.8	
C- 5	Sinocalan R. (3)	S35 - S43	4.5	1/ 2300	45	25	42	445	487	-13	-2.9	
C- 6	Sinocalan R. (4)	S44 - S49	3.0	1/ 2000	51	23	30	453	483	11	3.7	
C- 7	Sinocalan R. (5)	S50 - S59	8.7	1/ 1800	62	26	41	453	494	-5	-0.6	
C- 8	Sinocalan R. (6)	S60 - S65	6.3	1/ 1300	61	25	36	453	489	-11	-1.7	
C- 9	Tagamusing R. (1)	S66 - S73	8.4	1/ 1100	59	17	19	409	428	-2	-0.2	
C-10	Tagamusing R. (2)	S74 - S78	5.5	1/ 600	49	17	17	409	426	-8	-1.5	
C-11	Tagamusing R. (3)	S78 - S80	2.2	1/ 400	70	28	9	409	418	40	18.2	
C-12	Tuboy R. (1)		7.0	1/ 200	500	10	15	375	390	126	18.0	
C-13	Tuboy R. (2)		3.5	1/ 100	500	5	125	359	484	234	66.9	

Note : Width of L.W.C. means width of low water channel bed.

Table 3.12 SEDIMENT BALANCE FOR PROPOSED PANTAL-SINOCALAN RIVER CHANNEL (PRIORITY PROJECT)

No.	Stretch	Section Nos	Length (km)	Gradient of River Bed	Width of H.W.C. (m)	Width of L.W.C. (m)	Sediment Transport Capacity (1000 m^3/yr) B.M.L.	W.L.	TOTAL	Sediment Balance (1000 m^3/yr)	(m3/yr/m)	Remark
C- 1	Pantal R.	S 1 - S 6	2.8	1/ 2350	550	60	79	402	481	19	6.8	
BP-1	BYPASS (1)	D 0 - D 3	1.9	1/ 2350	400	60	77	423	500	28	14.7	
BP-2	BYPASS (2)	P 1 - P 7	3.3	1/ 2350	220	40	64	445	509	-1	-0.3	
C- 3	Sinocalan R. (1)	P 7 - S 21	0.6	1/ 2350	220	40	63	445	508	-6	-10.0	
C- 4	Sinocalan R. (2)	S22 - S34	5.3	1/ 1850	200	30	45	445	490	-14	-2.6	
C- 5	Sinocalan R. (3)	S35 - S43	3.8	1/ 1850	200	30	32	455	487	0	0.0	
C- 6	Sinocalan R. (4)	S44 - S49	1.9	1/ 1850	200	30	32	453	485	8	4.2	
C- 7	Sinocalan R. (5)	S50 - S59	7.9	1/ 1600	150	30	40	453	493	-12	-1.5	
C- 8	Sinocalan R. (6)	S60 - S65	5.1	1/ 1150	100	25	28	453	481	-9	-1.8	
C- 9	Tagamusing R. (1)	S66 - S73	7.8	1/ 900	100	17	13	409	422	3	0.4	
C-10	Tagamusing R. (2)	S74 - S78	5.5	1/ 600	49	17	17	409	426	-8	-1.5	Same as existing
C-11	Tagamusing R. (3)	S78 - S80	2.2	1/ 400	70	28	9	409	418	40	18.2	- Ditto -
C-12	Tuboy R. (1)		7.0	1/ 200	500	10	15	375	390	126	18.0	- Ditto -
C-13	Tuboy R. (2)		3.5	1/ 100	500	5	125	359	484	234	66.9	- Ditto -

Note : Width of L.W.C. means width of low water channel bed.

FIGURES

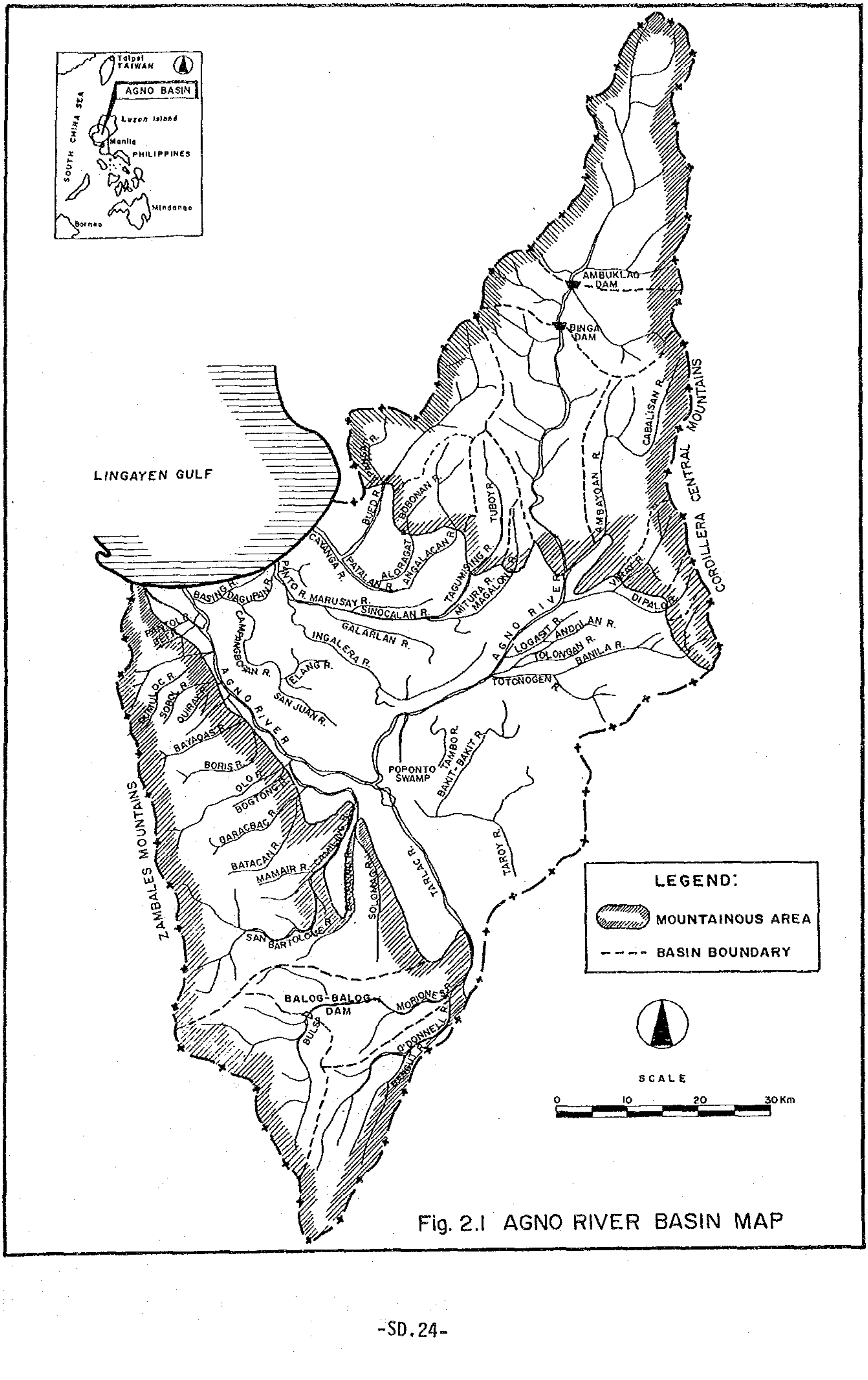


Fig. 2.1 AGNO RIVER BASIN MAP

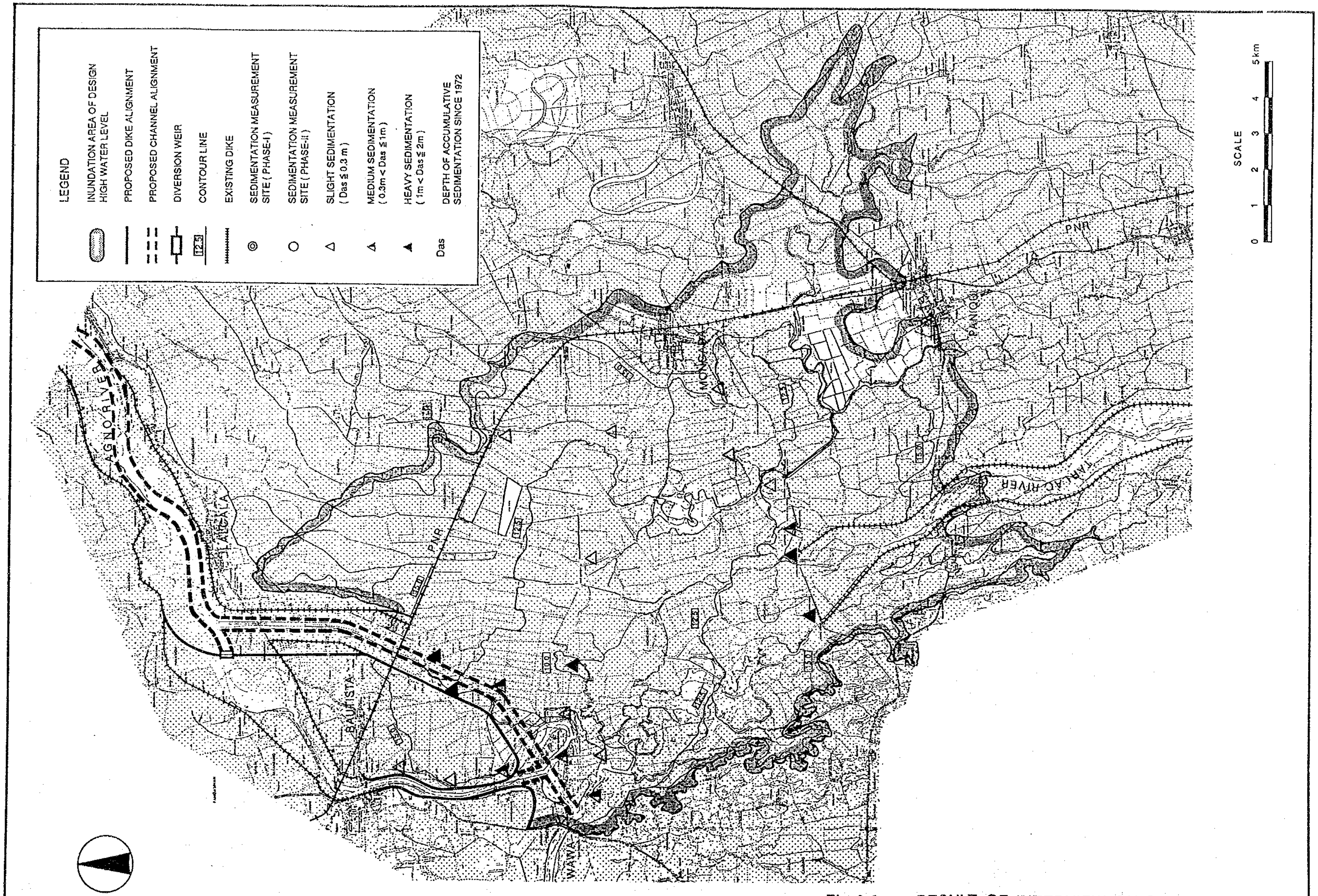
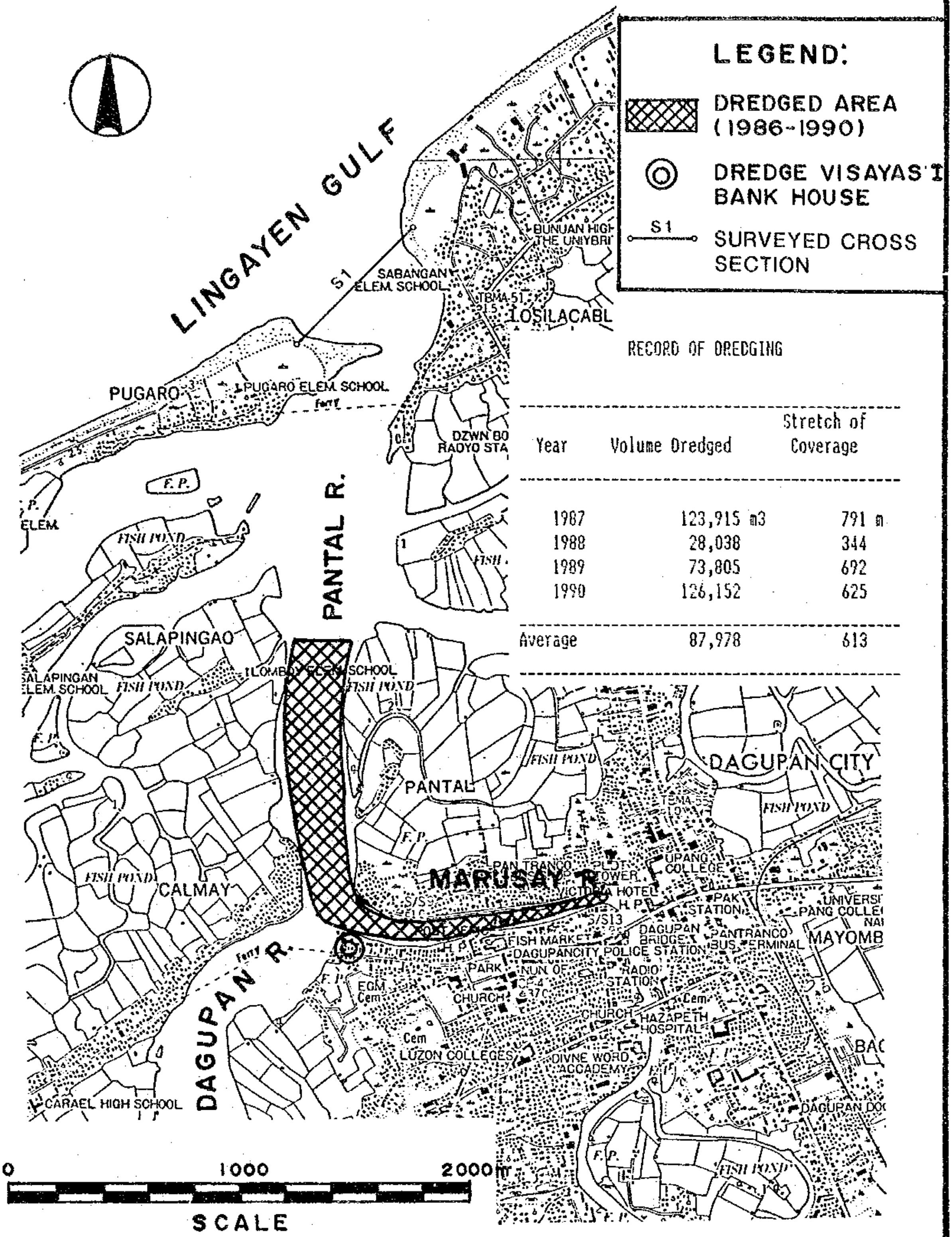


Fig.2.2 RESULT OF INTERVIEW ON SEDIMENTATION IN POPONT SWAMP AREA



RECORD OF DREDGING

Year	Volume Dredged	Stretch of Coverage
1987	123,915 m3	791 m
1988	28,038	344
1989	73,805	692
1990	126,152	625
Average	87,978	613

Fig. 2.3 LOCATION OF DREDGING AREA

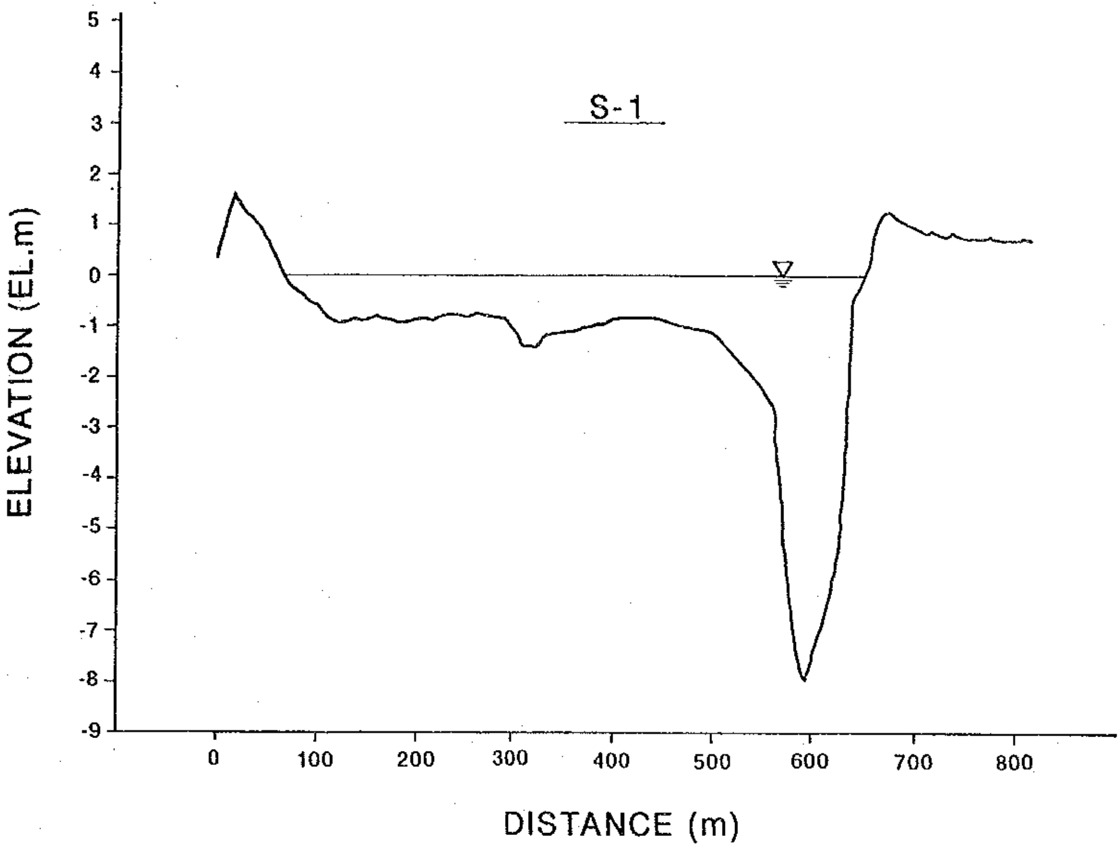


Fig.2.4 CROSS SECTION PROFILE AT RIVER MOUTH OF PANTAL RIVER

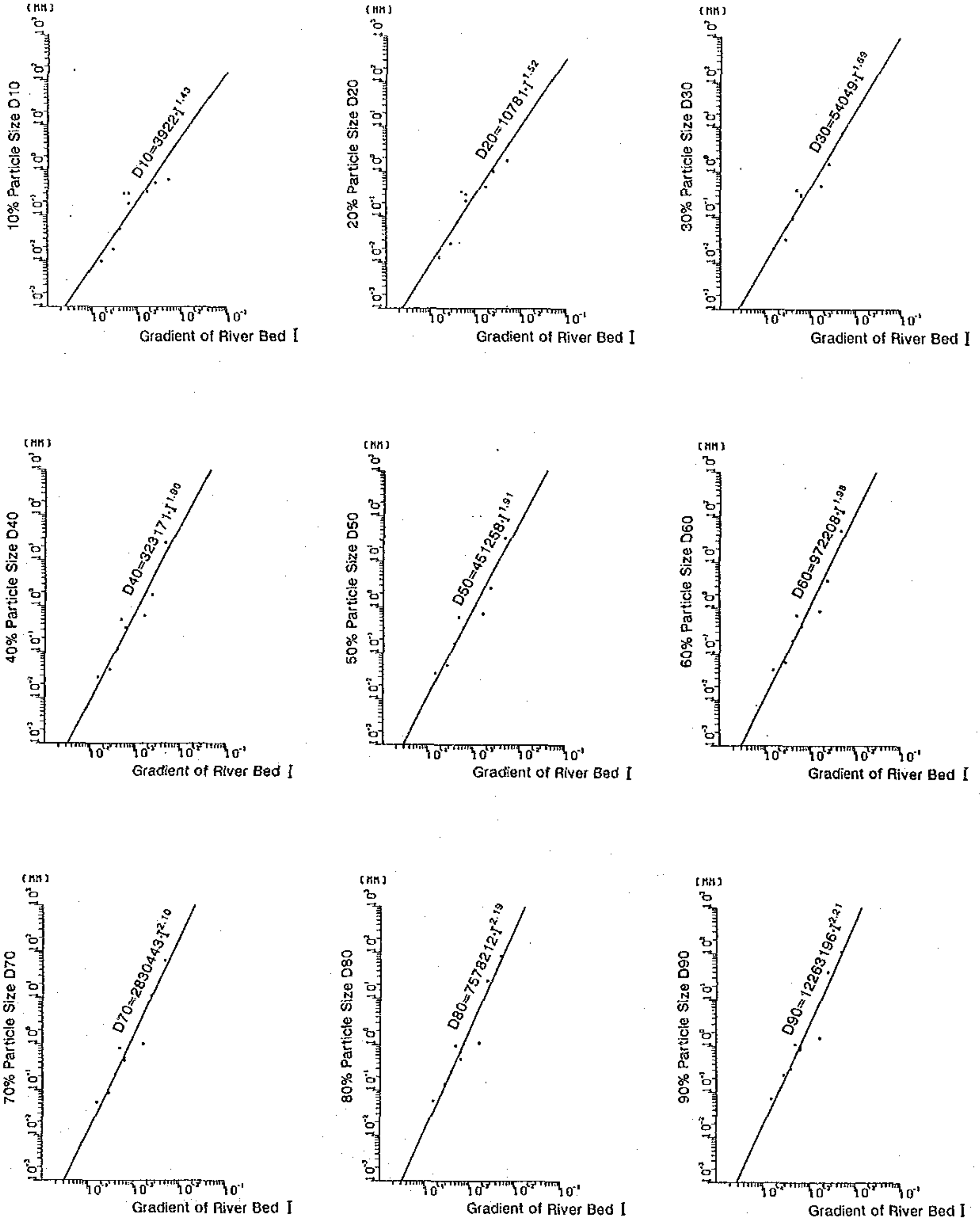


Fig.3.1 RELATIONSHIP BETWEEN PARTICLE SIZE AND RIVER BED GRADIENT

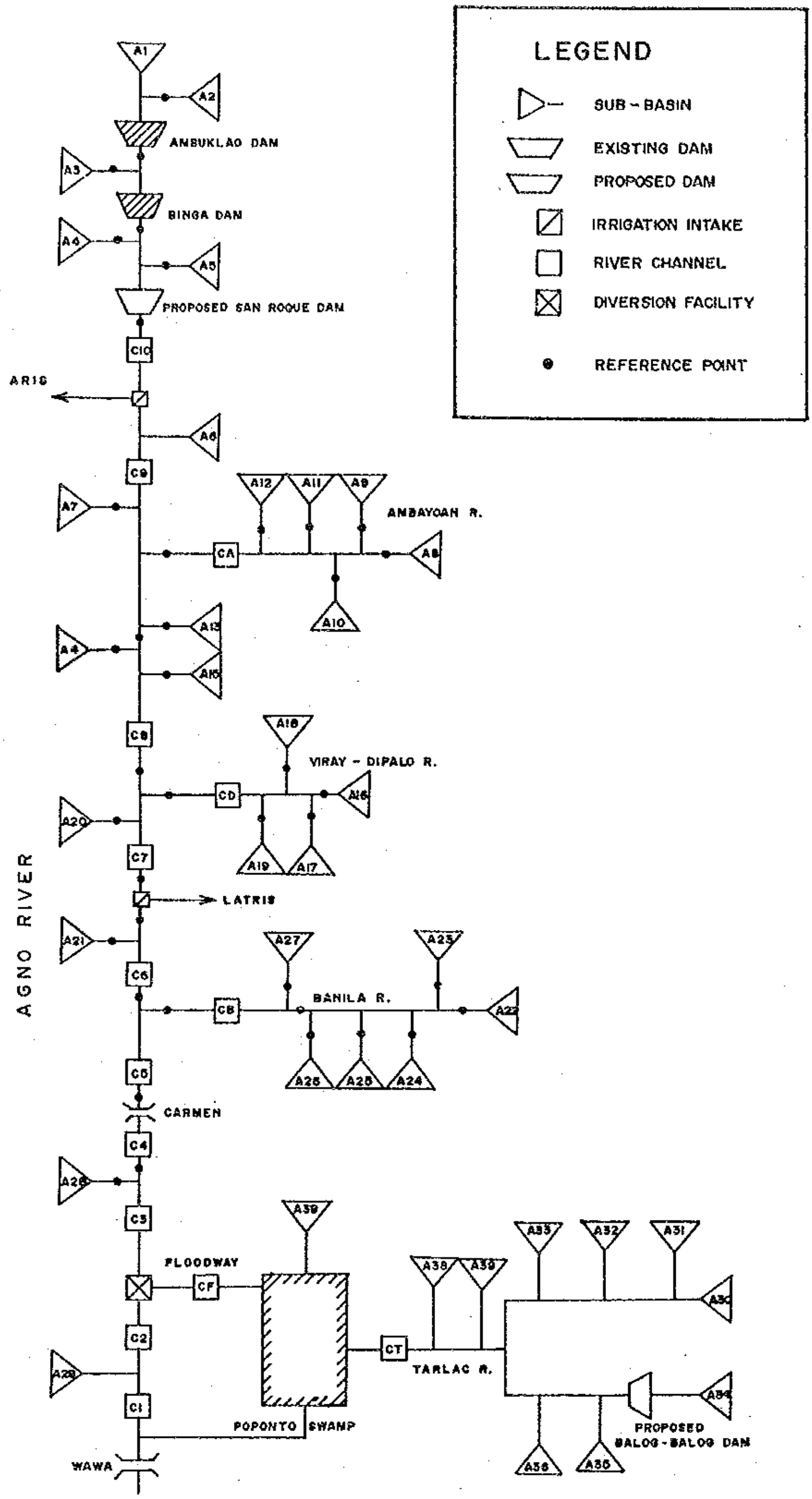


Fig. 3.2 UPPER AGNO RIVER SYSTEM SEDIMENT BALANCE MODEL

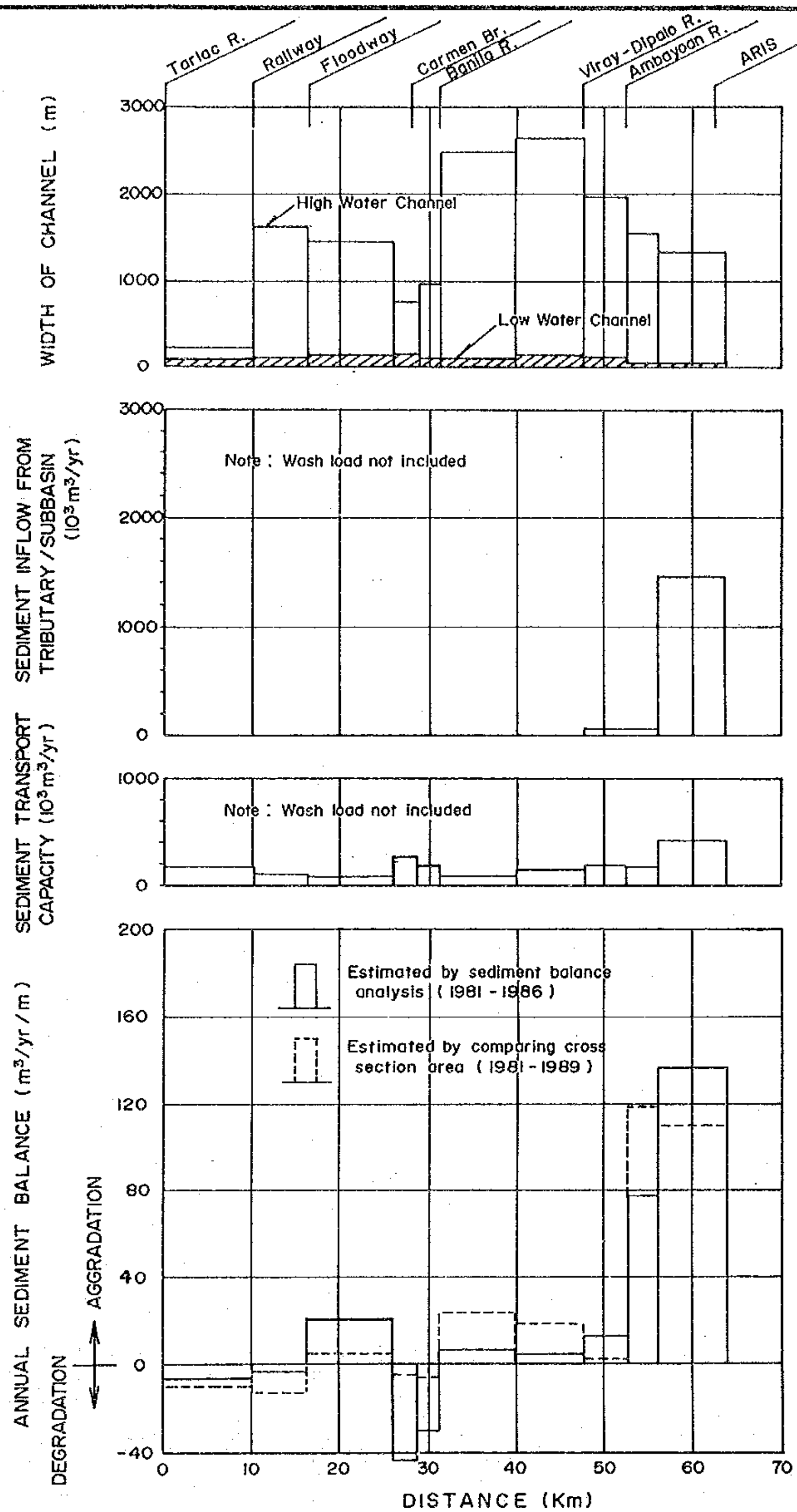
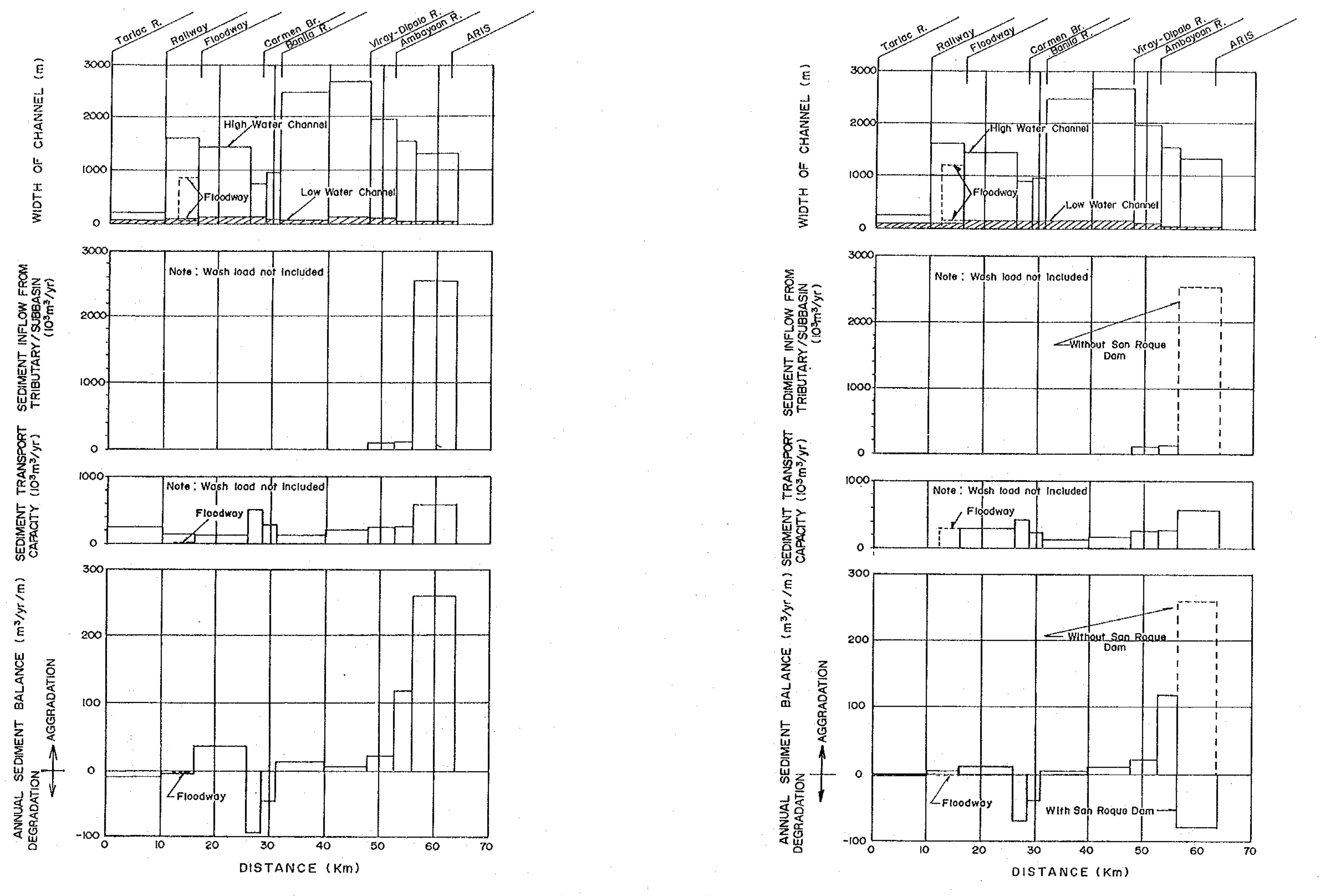


Fig. 3.3 RESULT OF SEDIMENT BALANCE SIMULATION (EXISTING CONDITION)



a)Existing Condition

b)Priority Pproject

Fig.3.4 UPPER AGNO RIVER SYSTEM SEDIMENT BALANCE

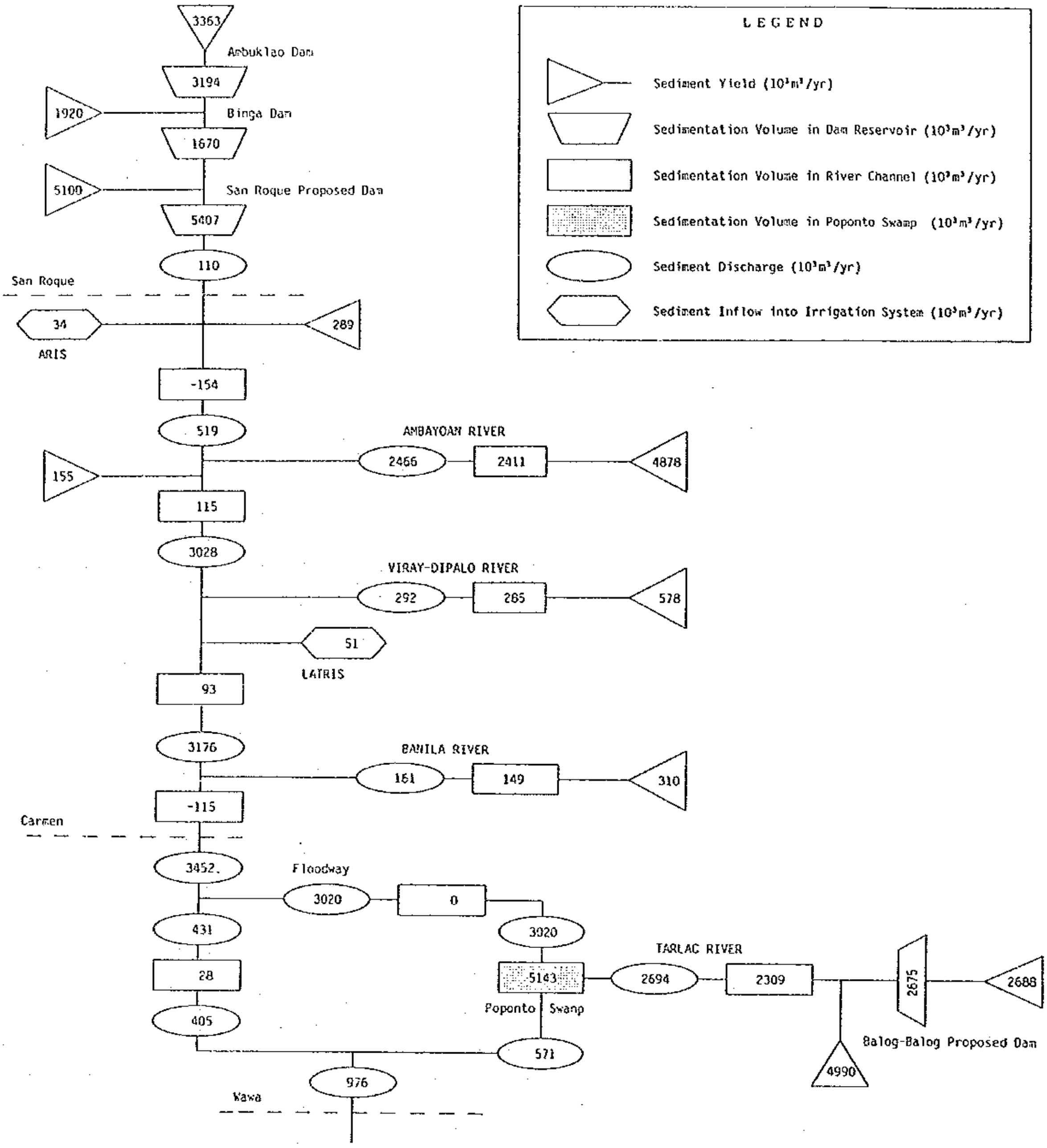


Fig. 3.5 SEDIMENT BALANCE DIAGRAM

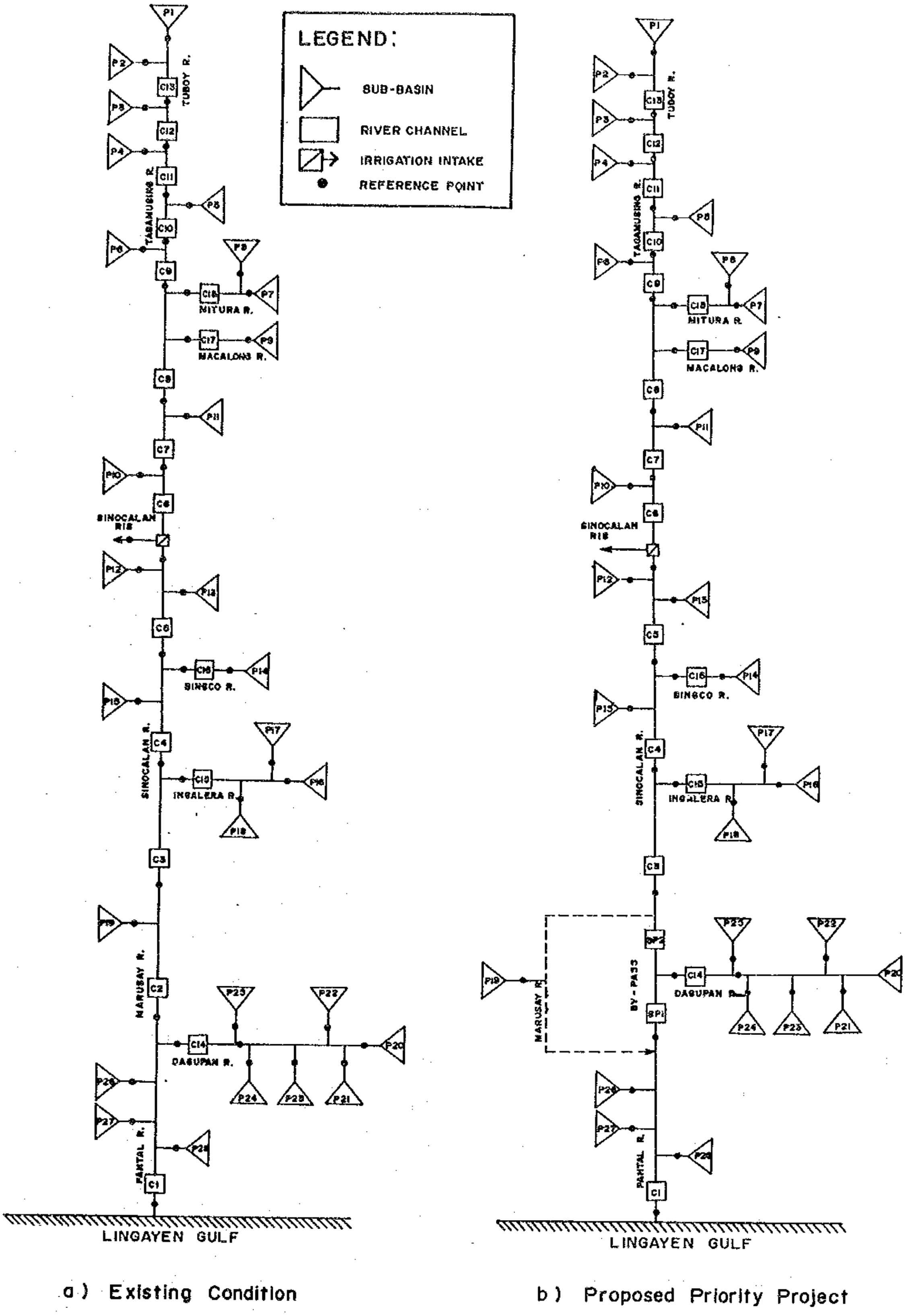


Fig.3.6 PANTAL-SINOCALAN RIVER SYSTEM SEDIMENT BALANCE MODEL

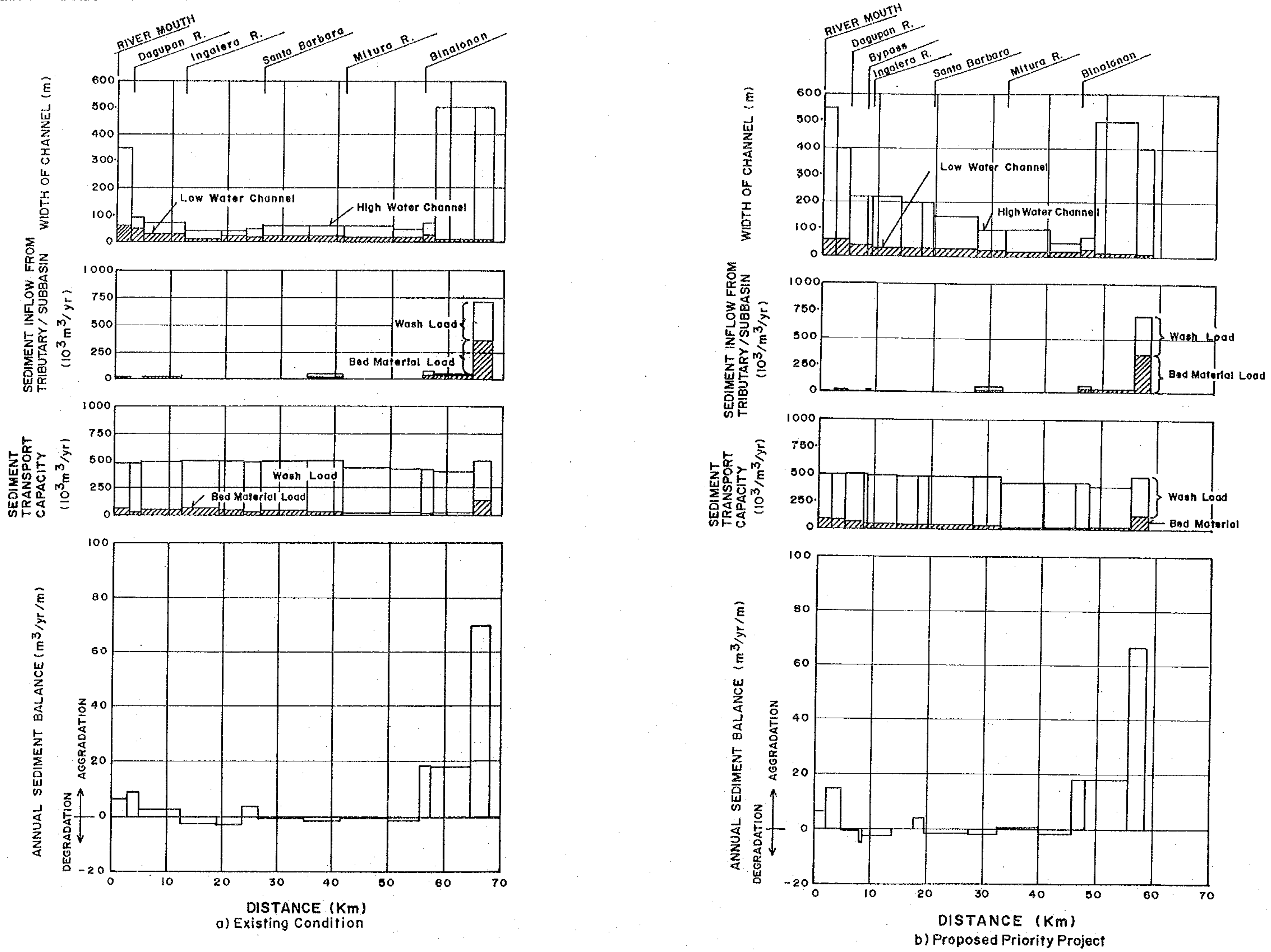


Fig. 3.7 PANTAL-SINOCALAN RIVER SYSTEM SEDIMENT BALANCE

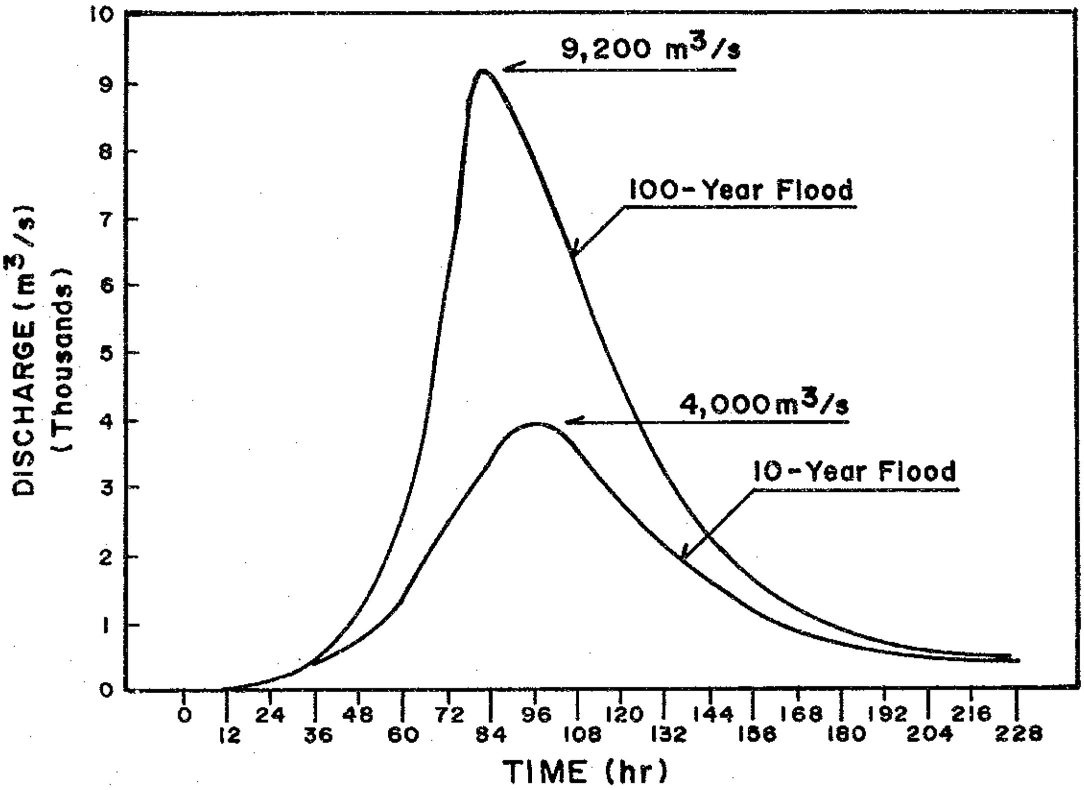


Fig. 4.1 DESIGN HYDROGRAPH

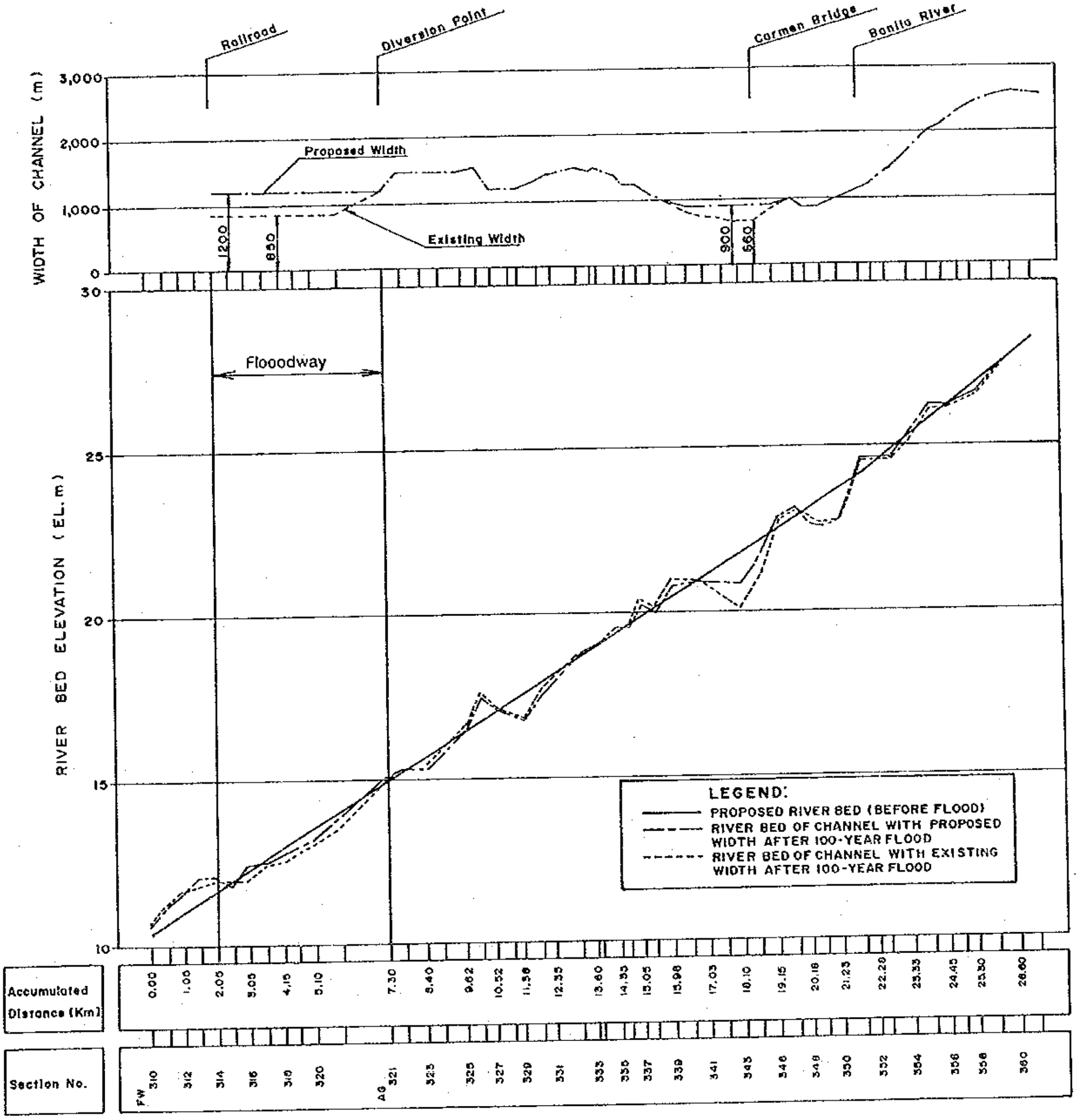


Fig.4.2 RESULT OF RIVER BED FLUCTUATION ANALYSIS (FRAMEWORK PLAN)