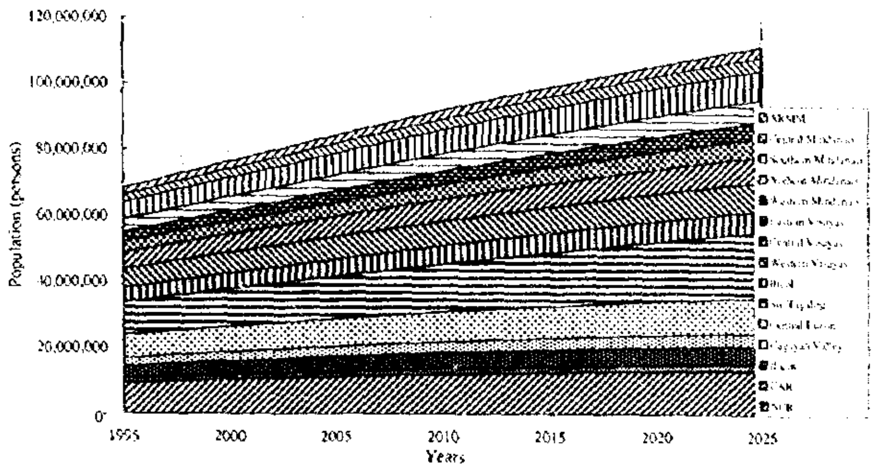


Figure 4-1 RESULT OF POPULATION PROJECTION BY REGION (MEDIUM LEVEL)

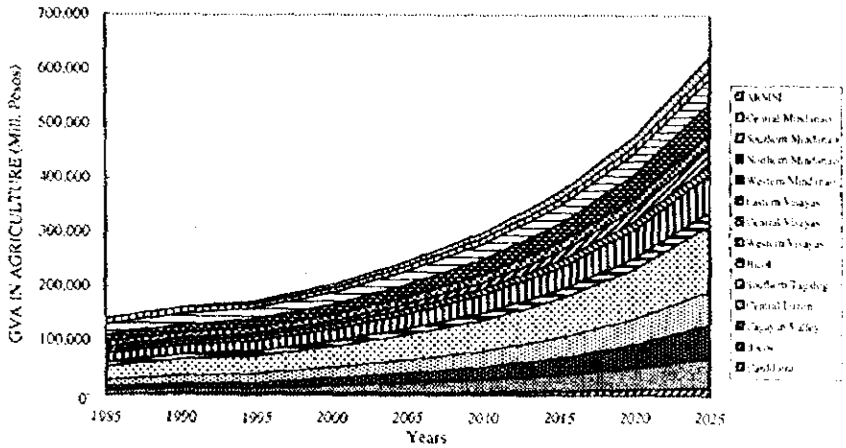


Figure 4-2 PAST AND FUTURE TENDENCY OF GVA IN AGRICULTURE BY REGION (AT CONSTANT 1985 PRICES)

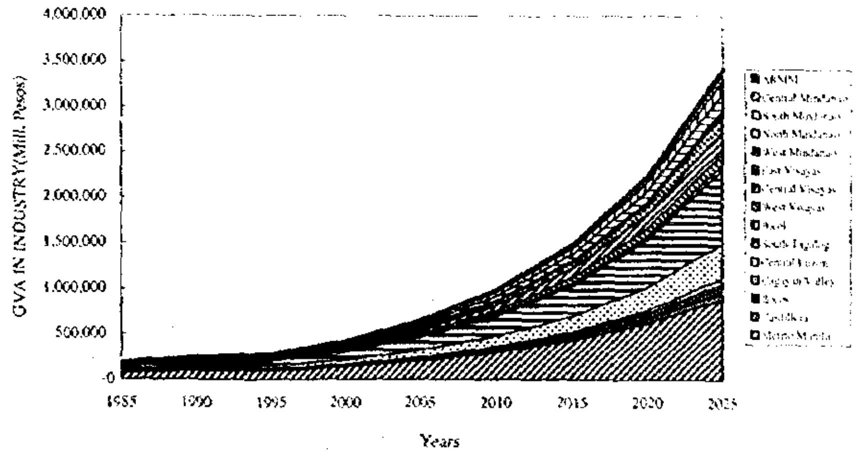


Figure 4-3 PAST AND FUTURE TENDENCY OF GVA IN INDUSTRY BY REGION (AT CONSTANT 1985 PRICES)

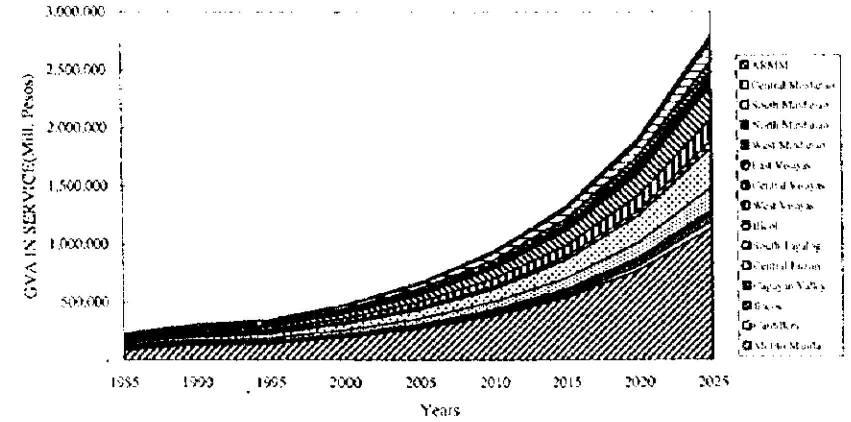


Figure 4-4 PAST AND FUTURE TENDENCY OF GVA IN SERVICE BY REGION (AT CONSTANT 1985 PRICES)

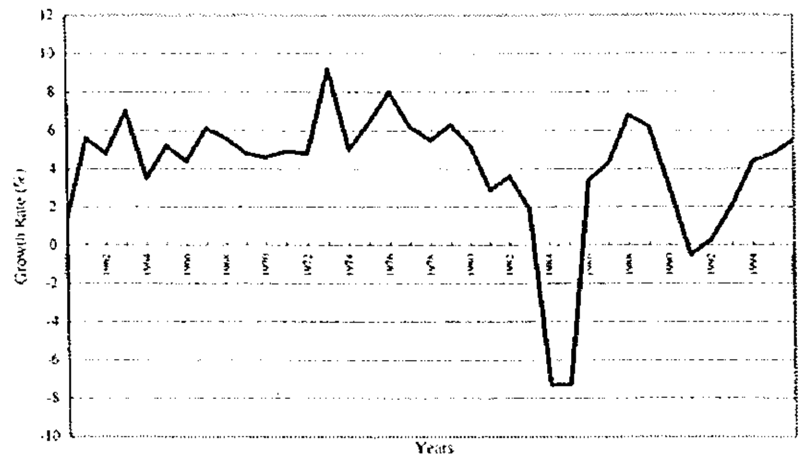


Figure 4-5 PERFORMANCE OF GROWTH RATE OF GDP FOR THE PHILIPPINES

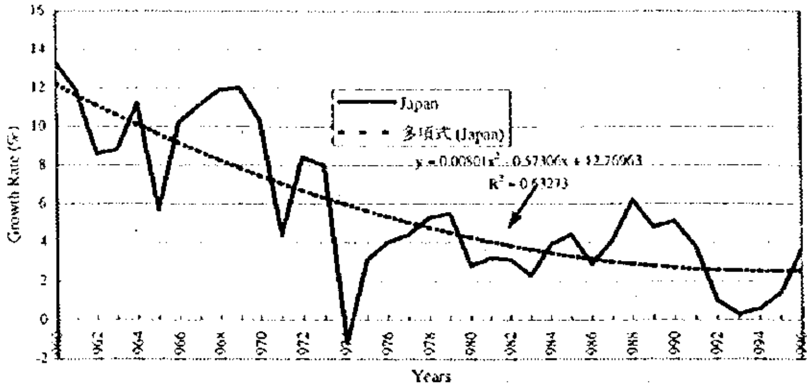


Figure 4-6 PERFORMANCE OF GROWTH RATE OF GDP FOR JAPAN

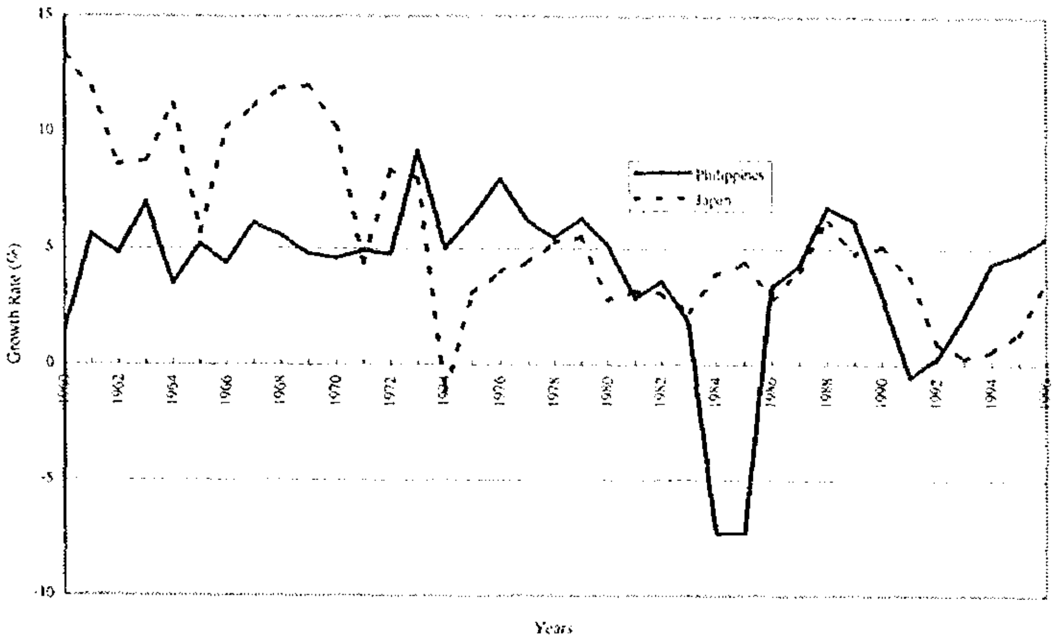


Figure 4-7 **COMPARISON OF GROWTH RATE OF GDP BETWEEN THE PHILIPPINES AND JAPAN**

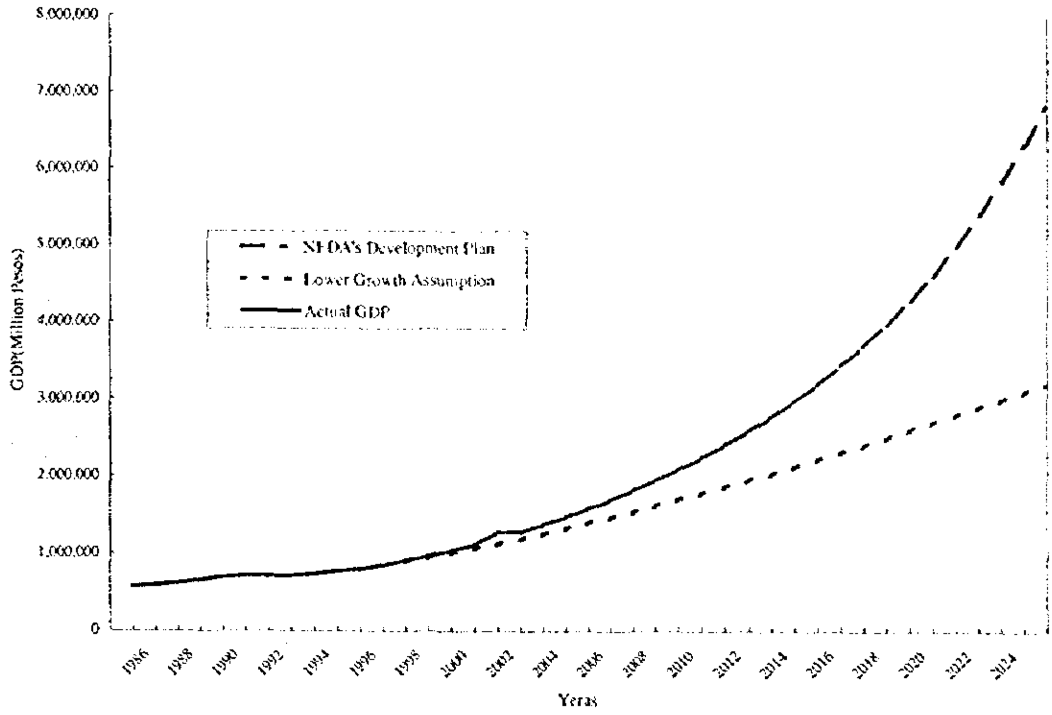


Figure 4-8 FUTURE GDP BASED ON NEDA'S DEVELOPMENT PLAN AND LOWER GROWTH

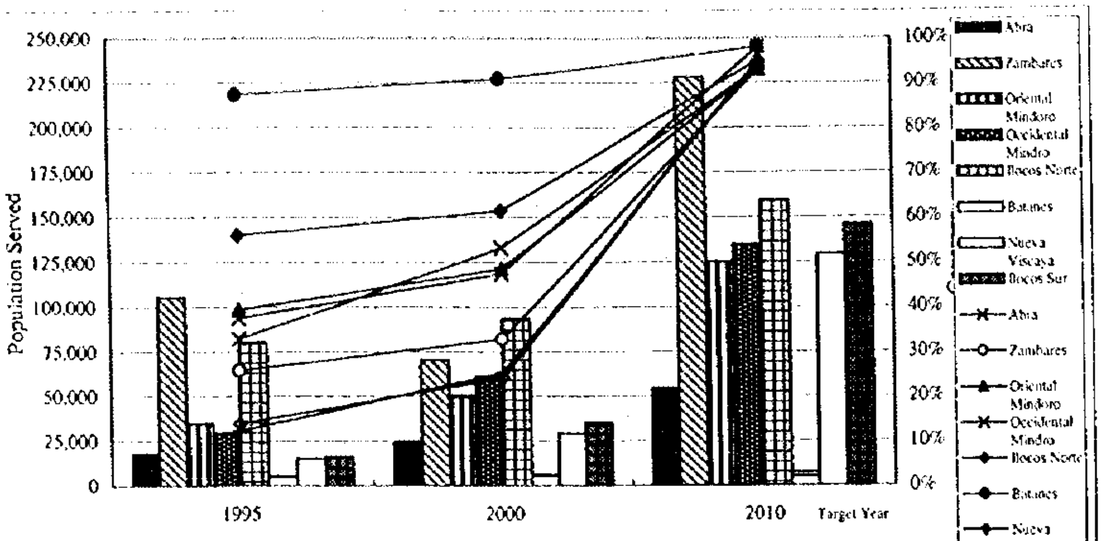


Figure 4-9 TREND FOR LEVEL-III, URBAN

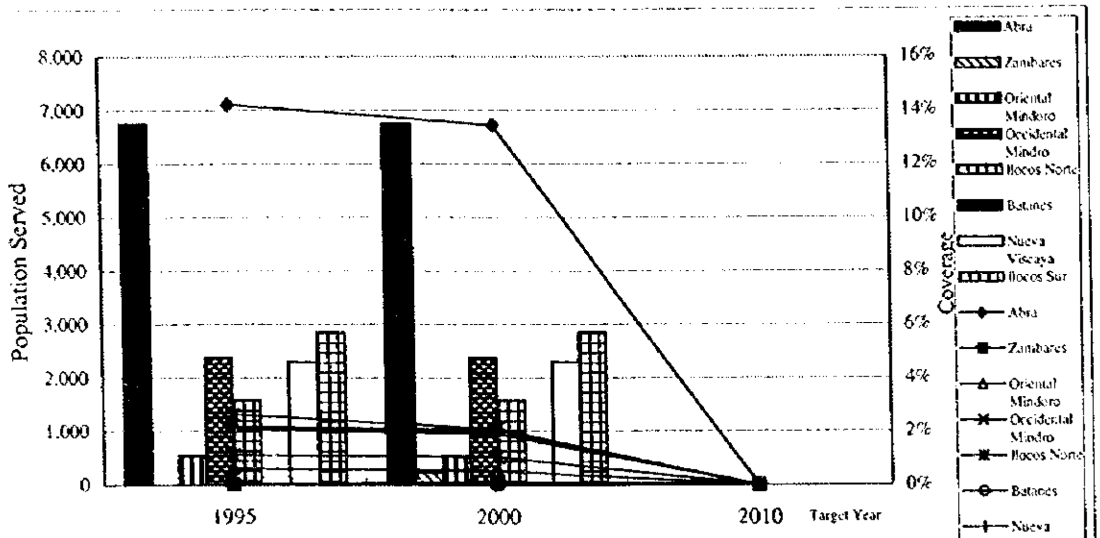


Figure 4-10 TREND FOR LEVEL-II, URBAN

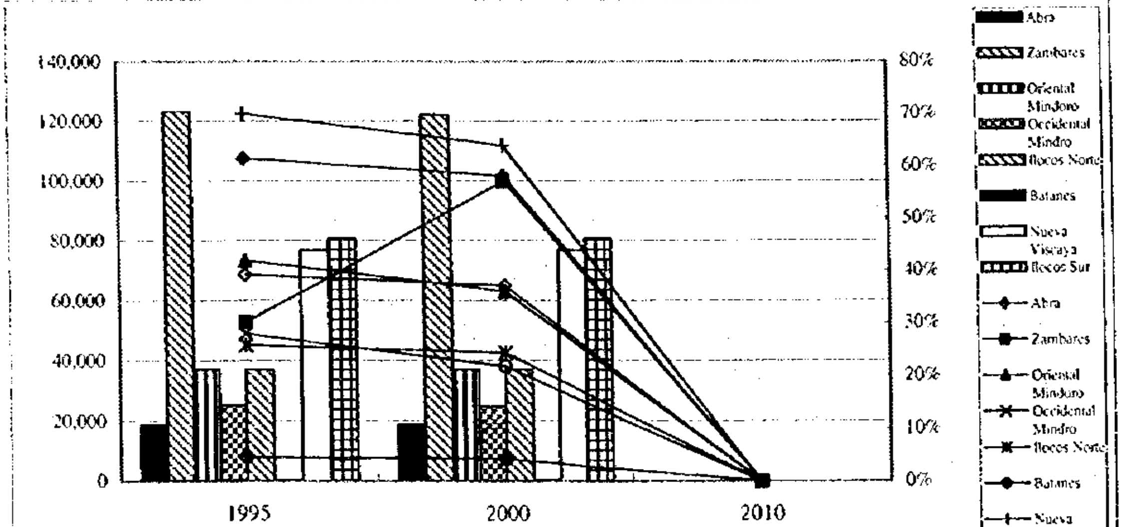


Figure 4-11 TREND FOR LEVEL-I, URBAN

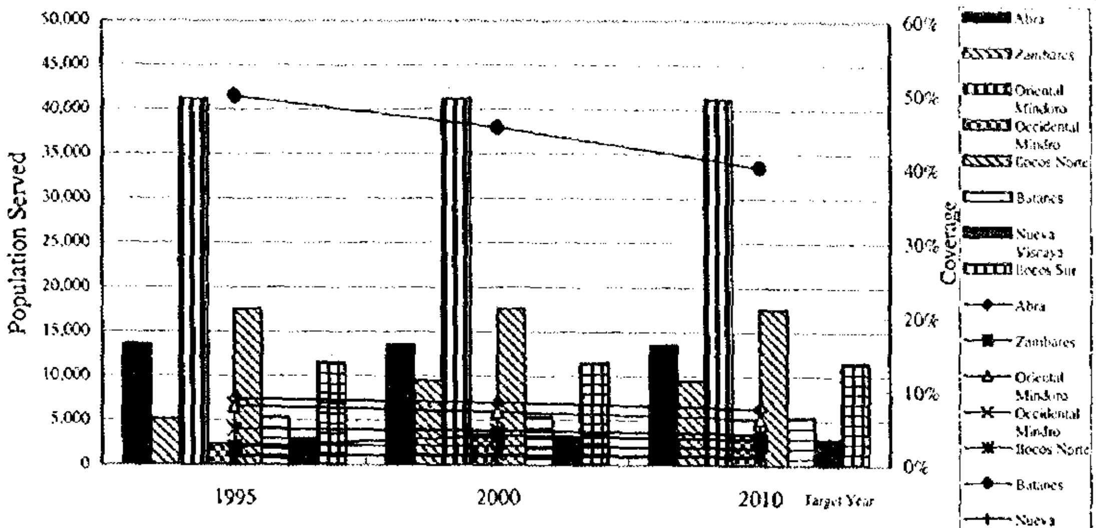


Figure 4-12 TREND FOR LEVEL-III, RURAL

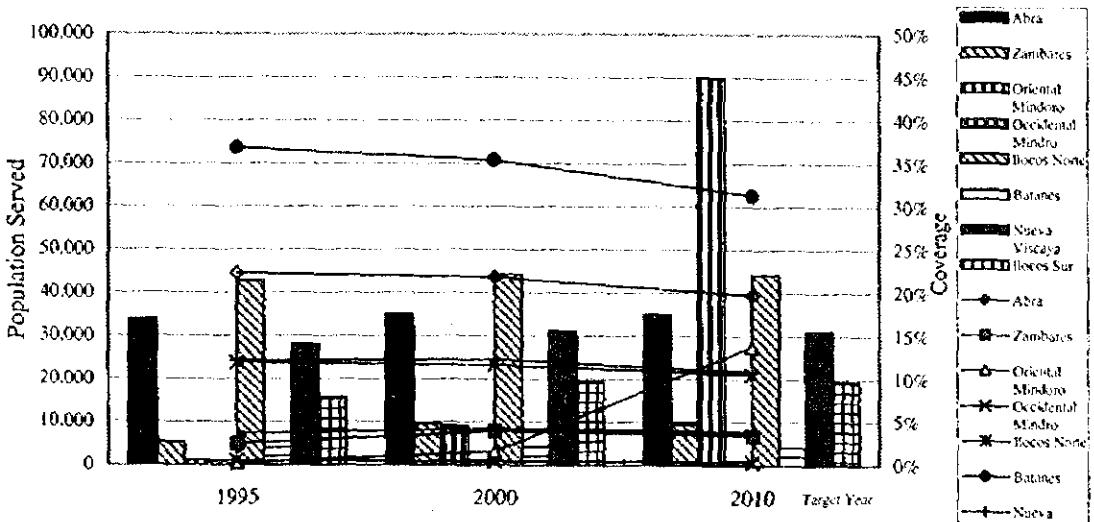


Figure 4-13 TREND FOR LEVEL-II, RURAL

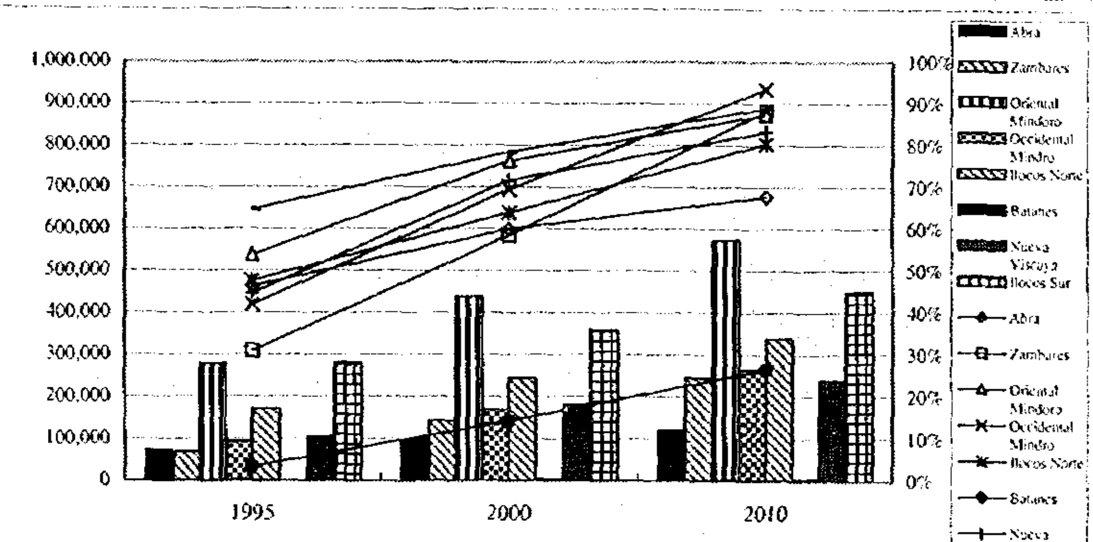


Figure 4-14 TREND FOR LEVEL-I, RURAL

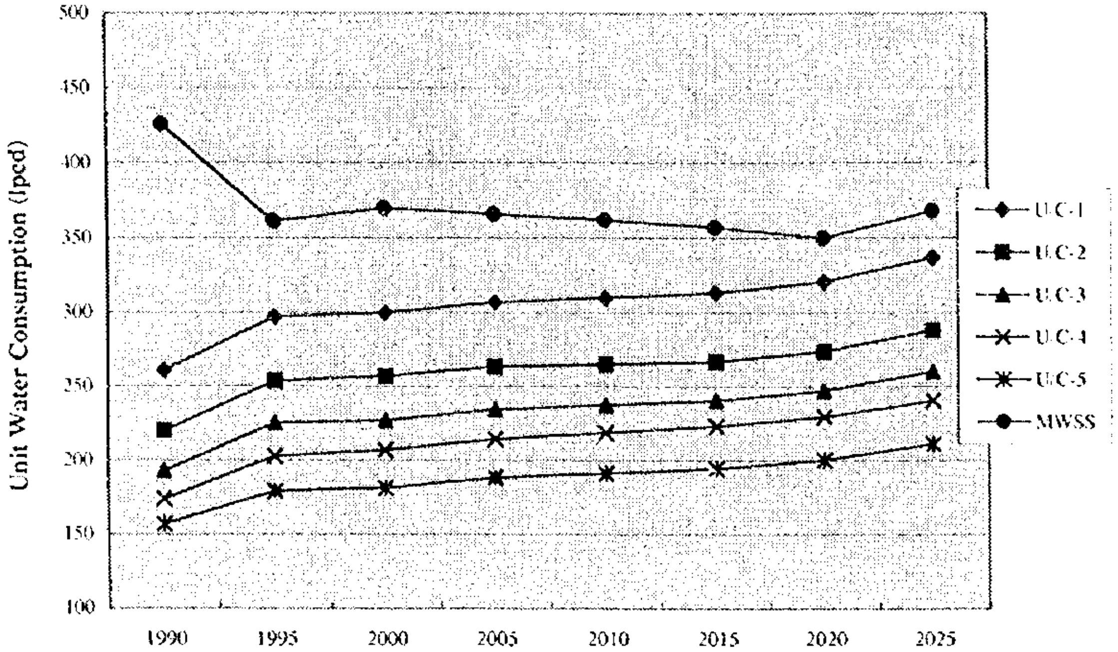


Figure 4-15 UNIT WATER CONSUMPTION FOR LEVEL-III SYSTEM

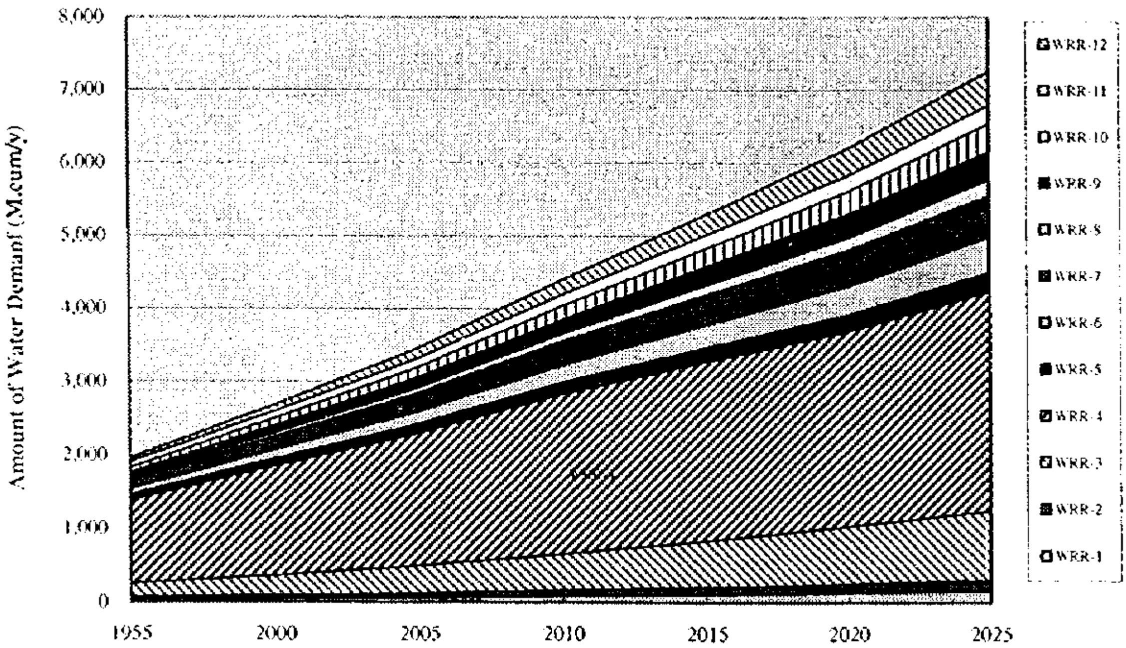


Figure 4-16 PUBLIC WATER DEMAND

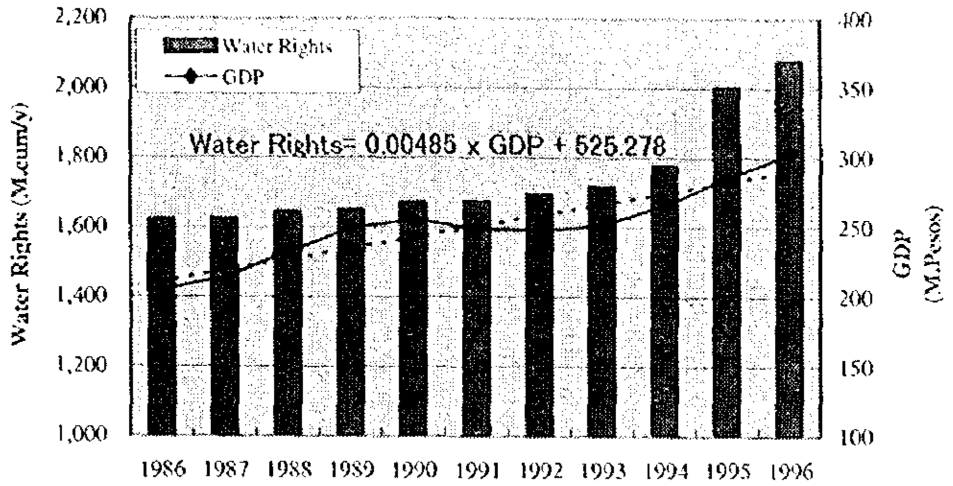


Figure 4-17 WATER RIGHTS AND INDUSTRIAL GDP

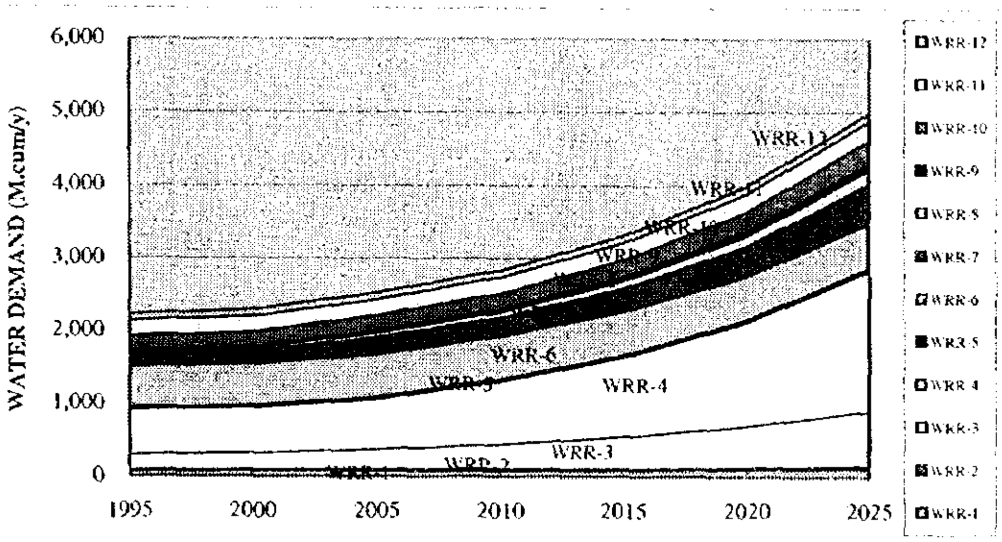


Figure 4-18 INDUSTRIAL WATER DEMAND (High Scenario)

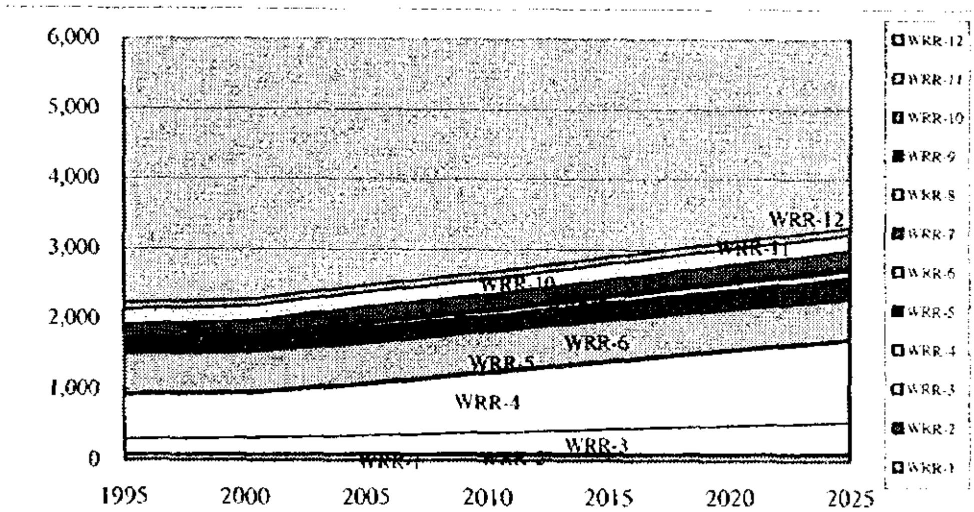


Figure 4-19 INDUSTRIAL WATER DEMAND (Low Scenario)

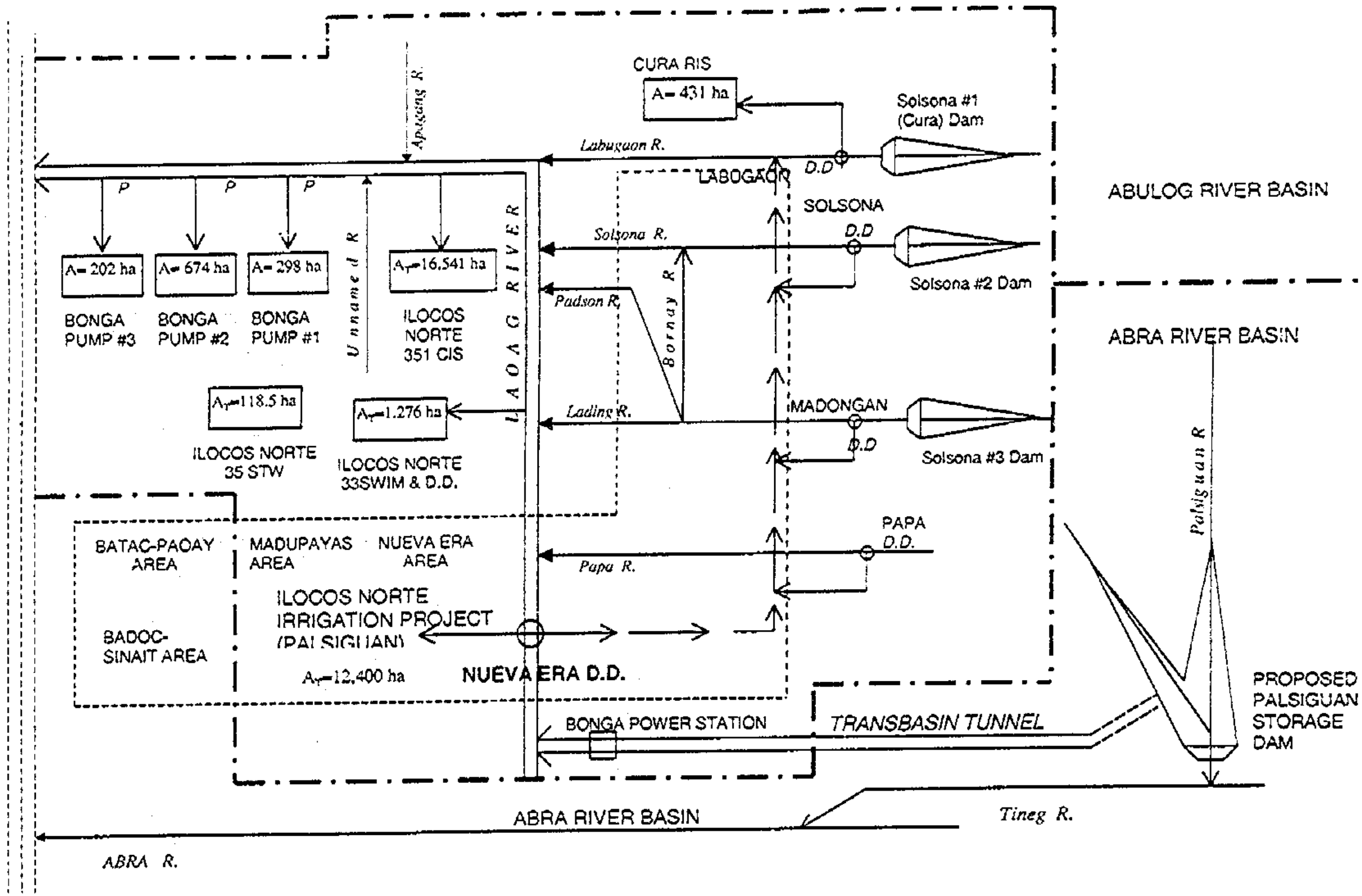


Figure 4 - 20 SCHEMATIC DIAGRAM OF IRRIGATION DEVELOPMENT SCHEMES: LAOAG RIVER BASIN (WRR 1)

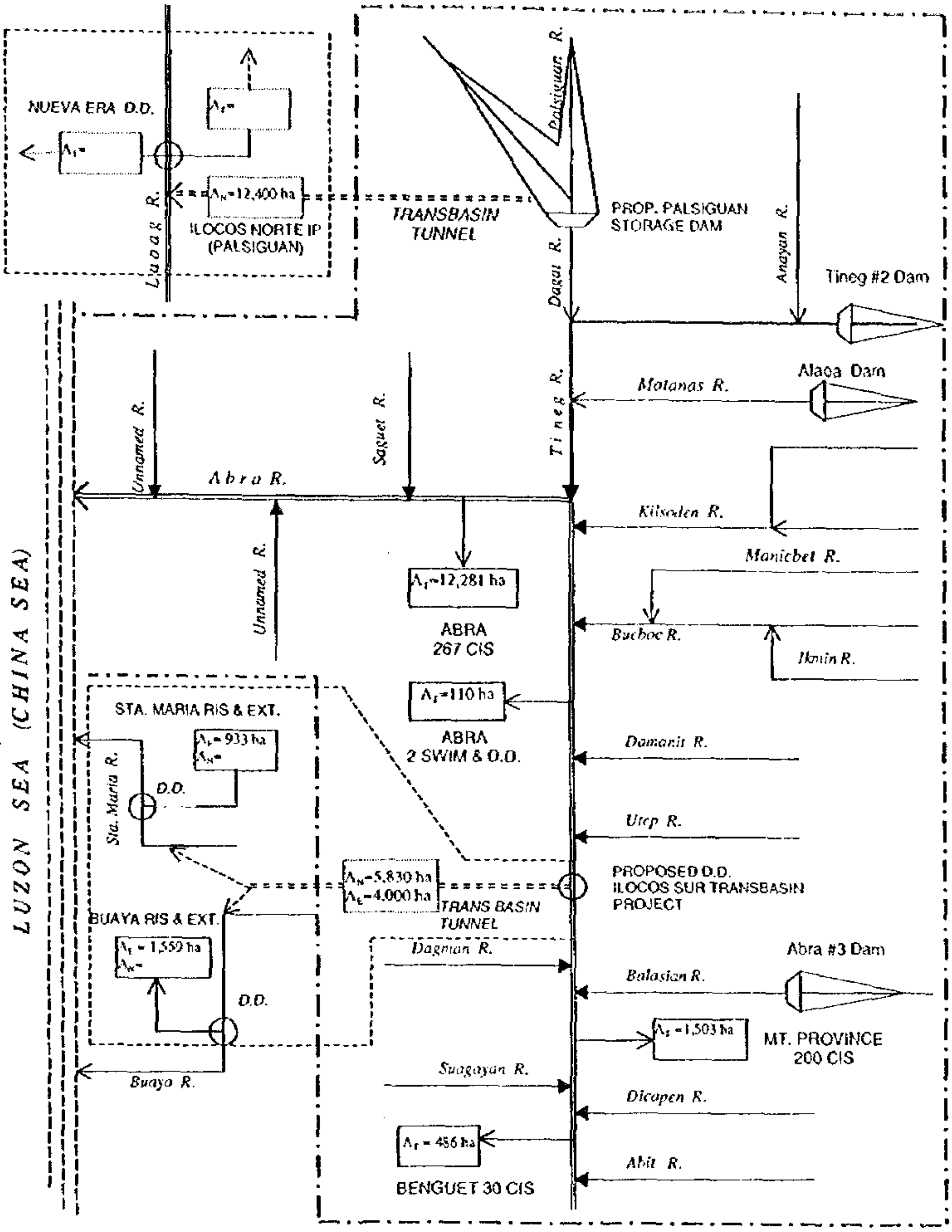


Figure 4 - 21 **SCHEMATIC DIAGRAM OF IRRIGATION DEVELOPMENT SCHEMES: ABRA RIVER BASIN (WRR 1)**

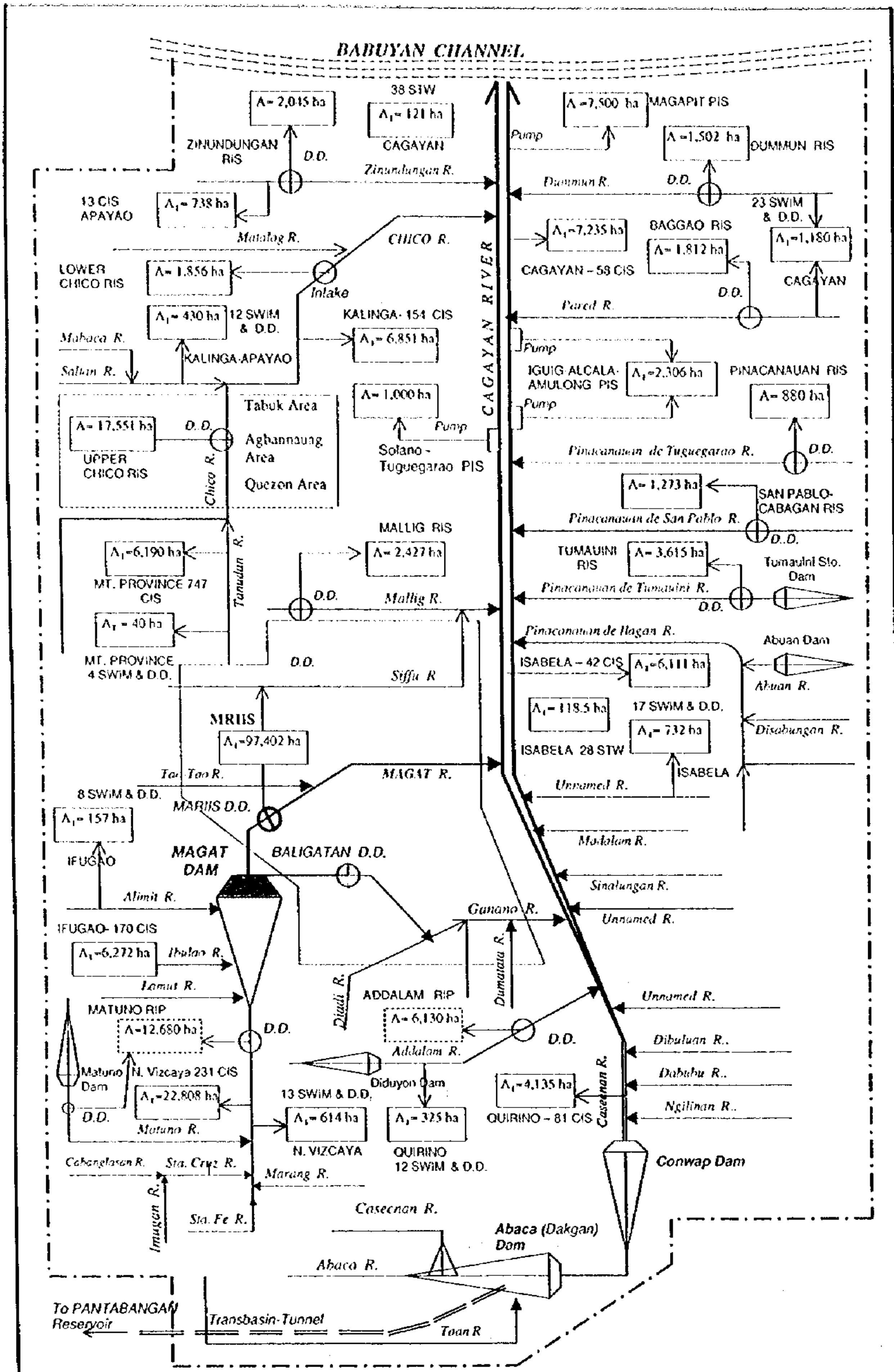


Figure 4 - 22 SCHEMATIC DIAGRAM OF IRRIGATION DEVELOPMENT SCHEMES: CAGAYAN RIVER BASIN (WRR 2)

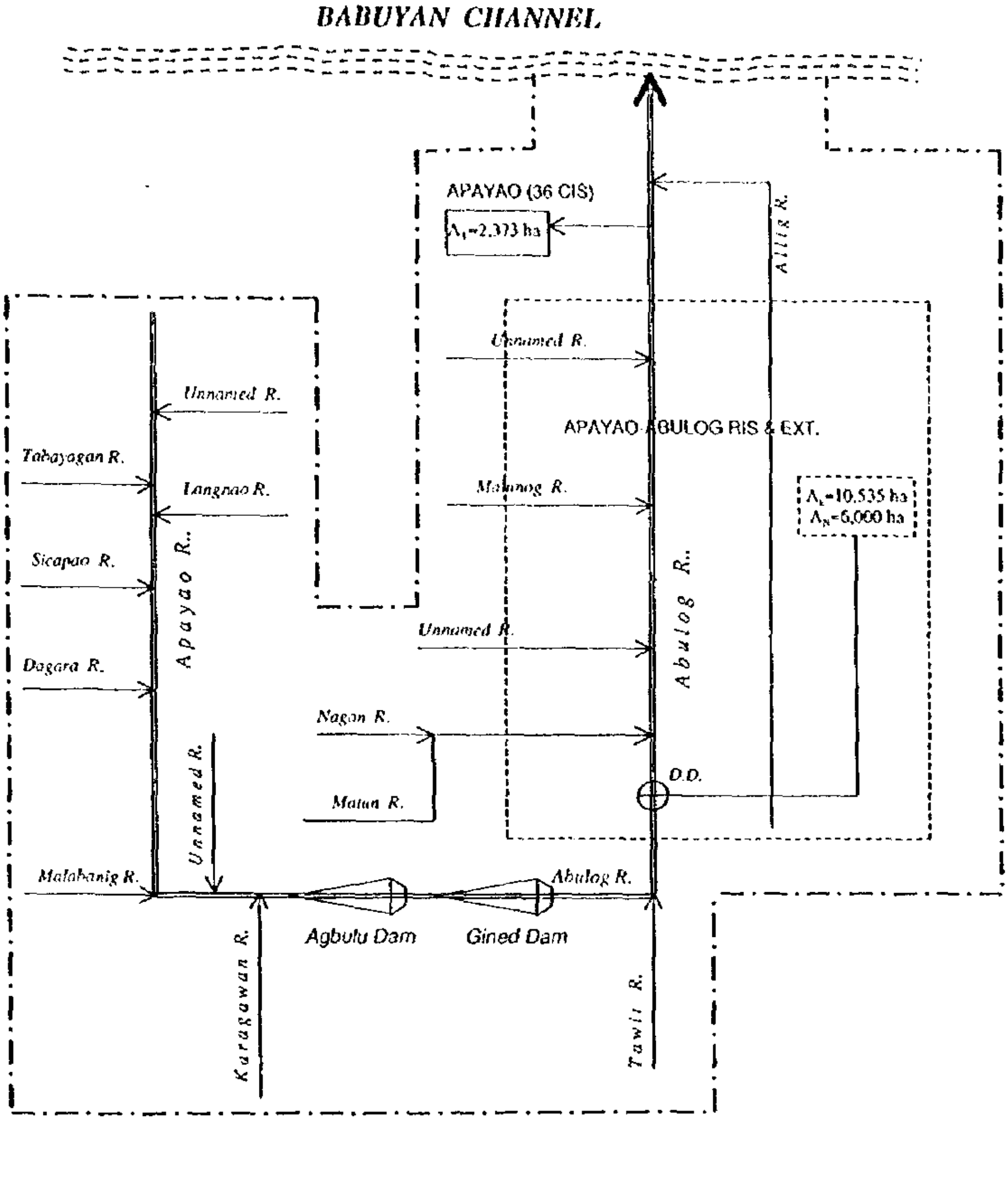


Figure 4 - 23 **SCHEMATIC DIAGRAM OF IRRIGATION DEVELOPMENT SCHEMES: ABULOG RIVER BASIN (WRR 2)**

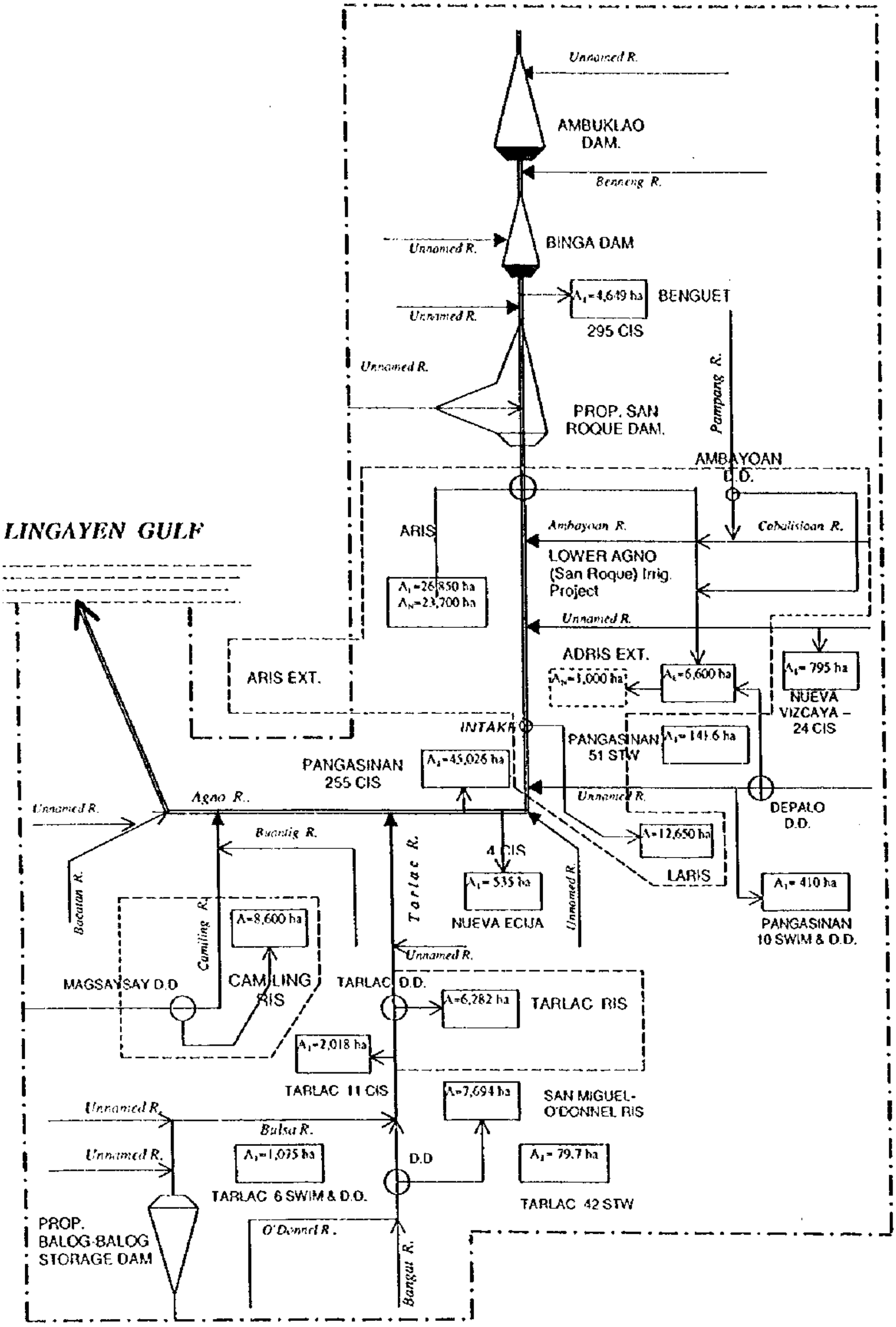


Figure 4 - 24 SCHEMATIC DIAGRAM OF IRRIGATION DEVELOPMENT SCHEMES: AGNO RIVER BASIN (WRR 3)

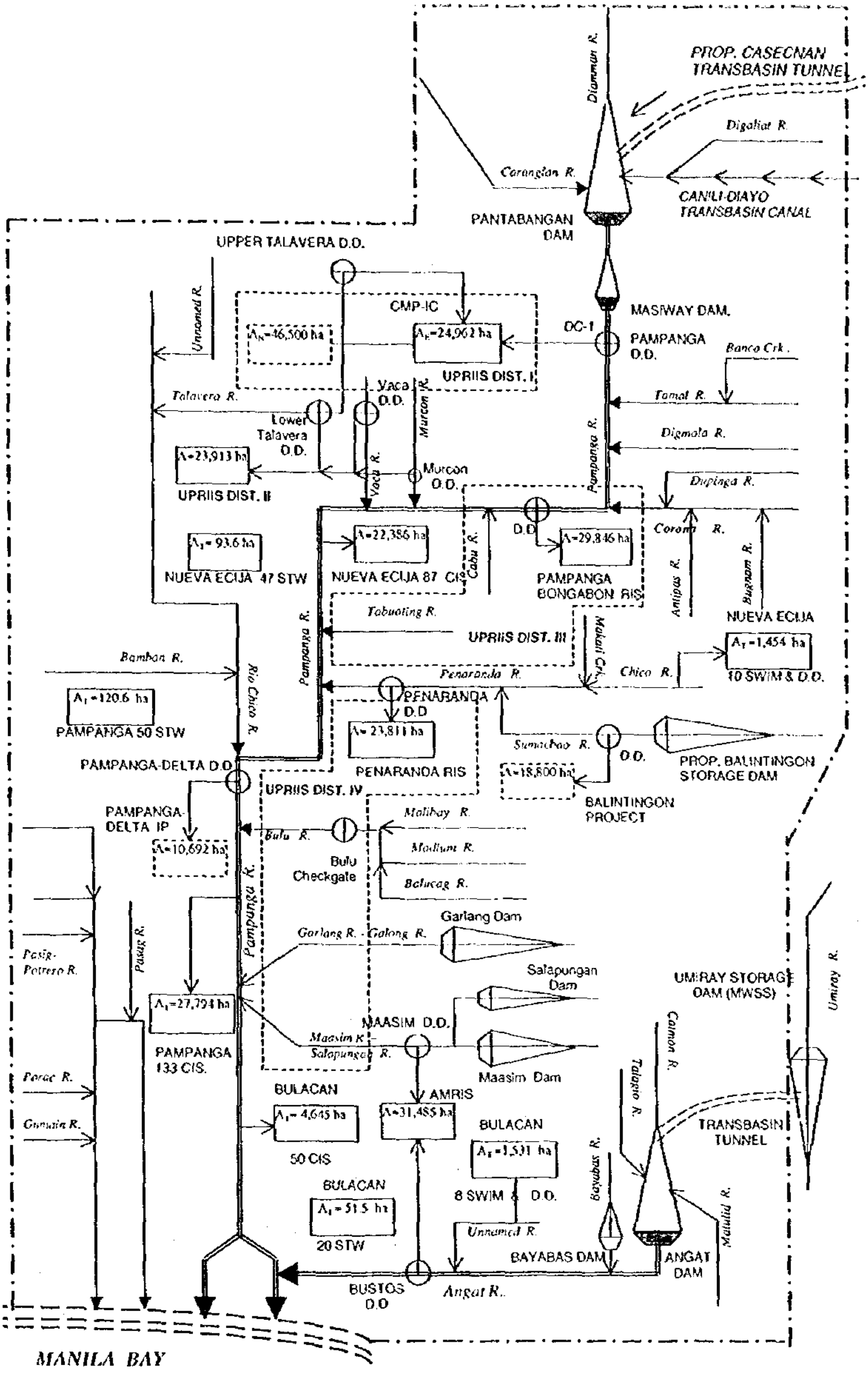


Figure 4 - 25 SCHEMATIC DIAGRAM OF IRRIGATION DEVELOPMENT SCHEMES: PAMPANGA RIVER BASIN (WRR 3)

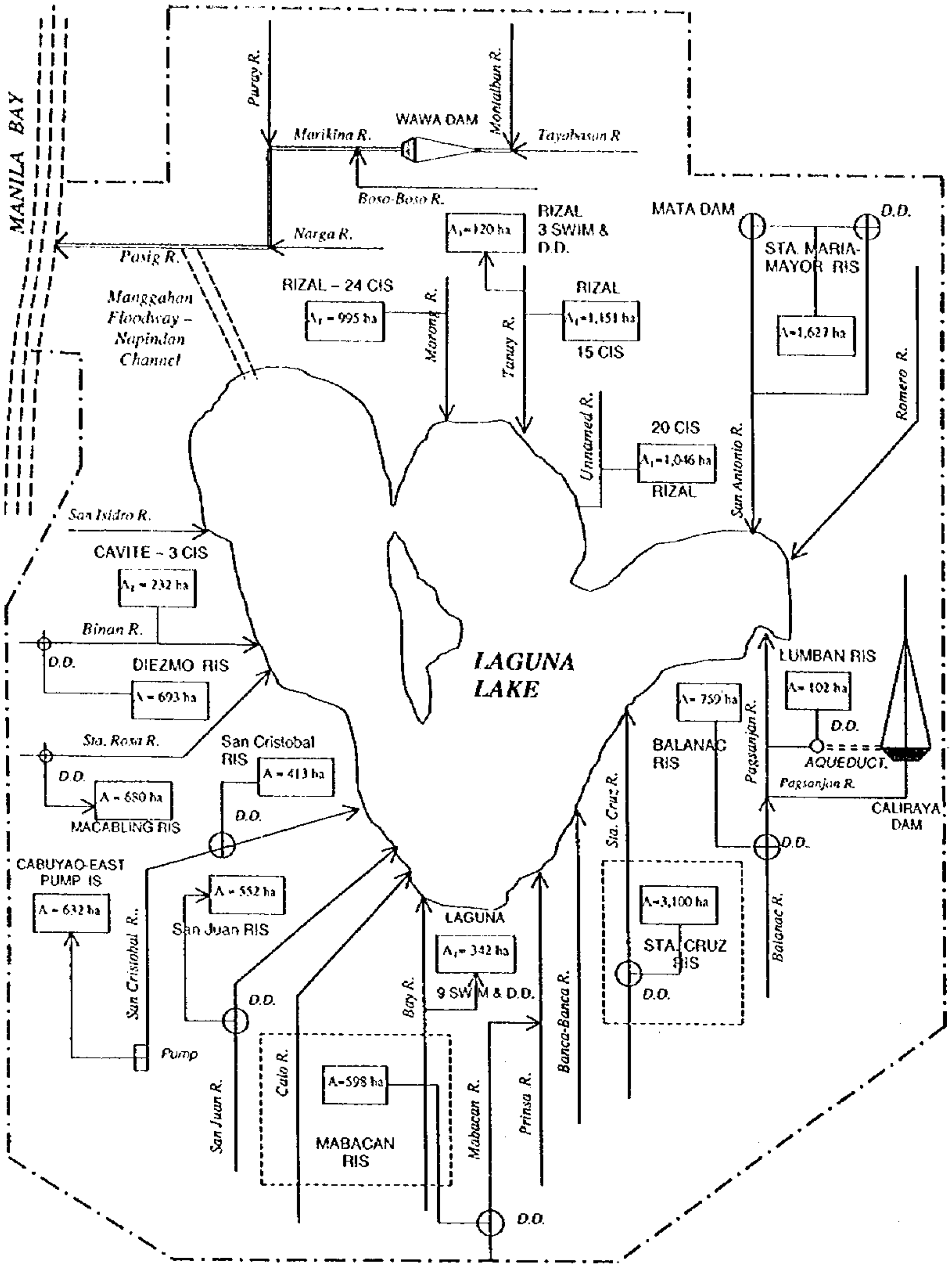


Figure 4 - 26 SCHEMATIC DIAGRAM OF IRRIGATION DEVELOPMENT SCHEMES: PASIG-LAGUNA LAKE RIVER BASIN (WRR 4)

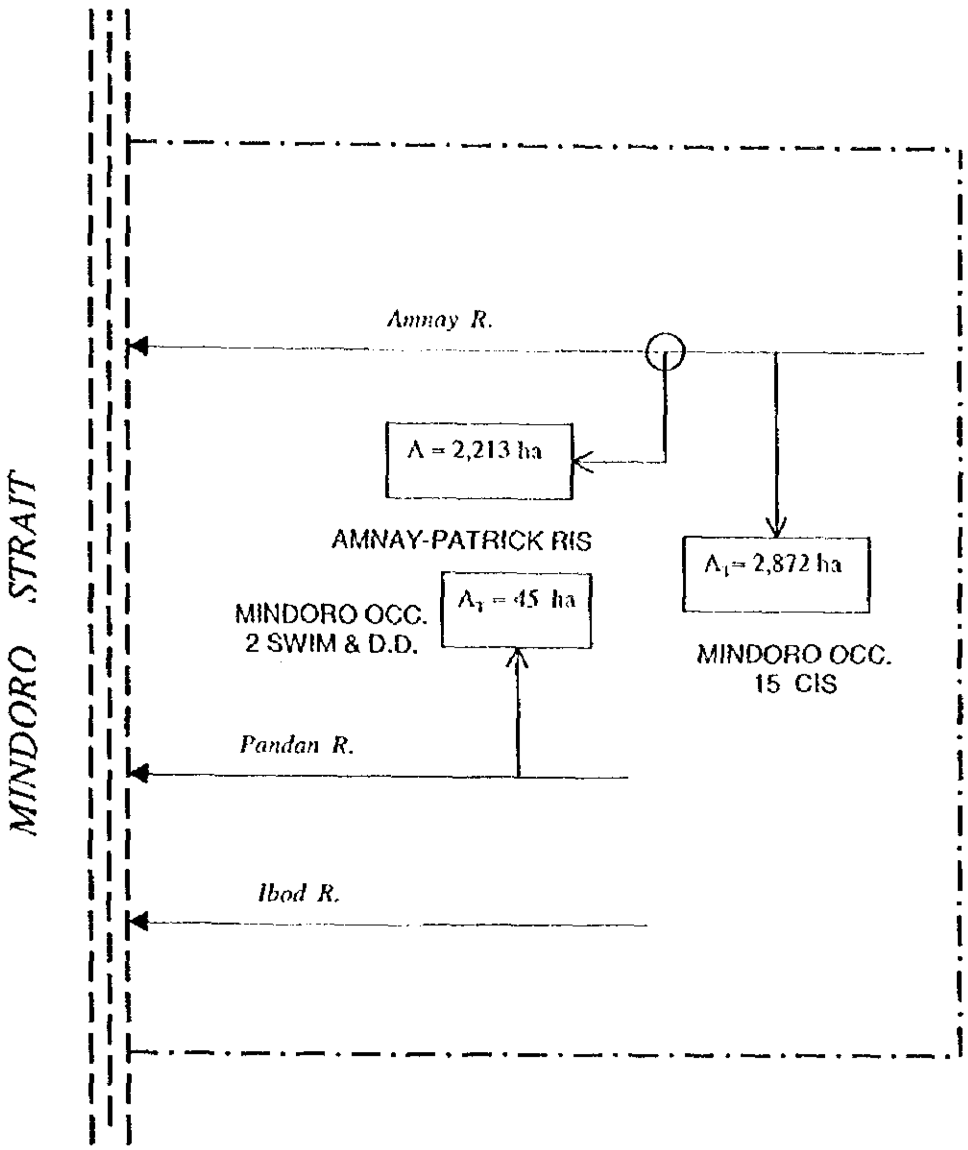


Figure 4 - 27 **SCHEMATIC DIAGRAM OF IRRIGATION DEVELOPMENT SCHEMES: AMNAY-PATRICK RIVER BASIN (WRR 4)**

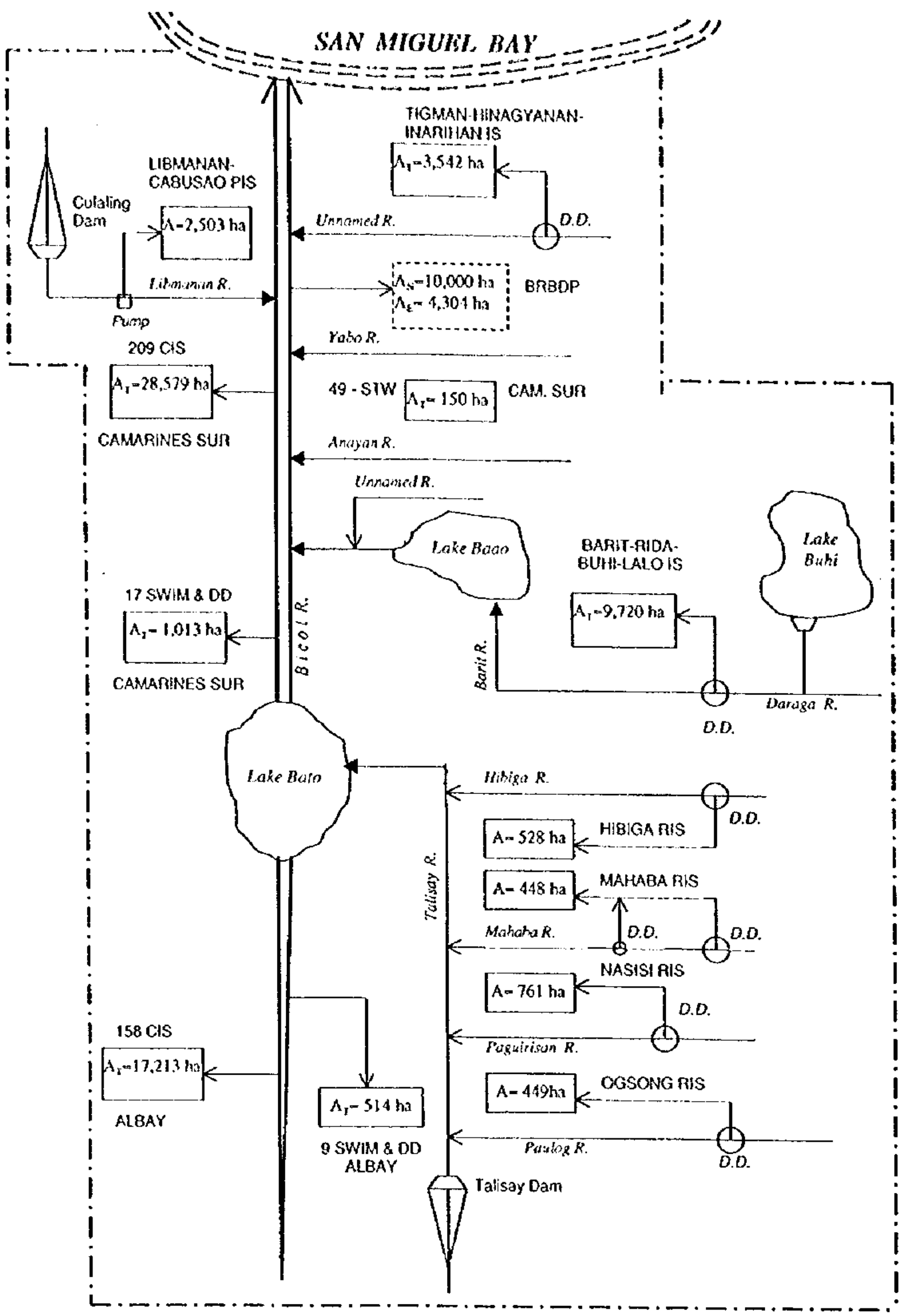


Figure 4 - 28 SCHEMATIC DIAGRAM OF IRRIGATION DEVELOPMENT SCHEMES: BICOL RIVER BASIN (WRR 5)

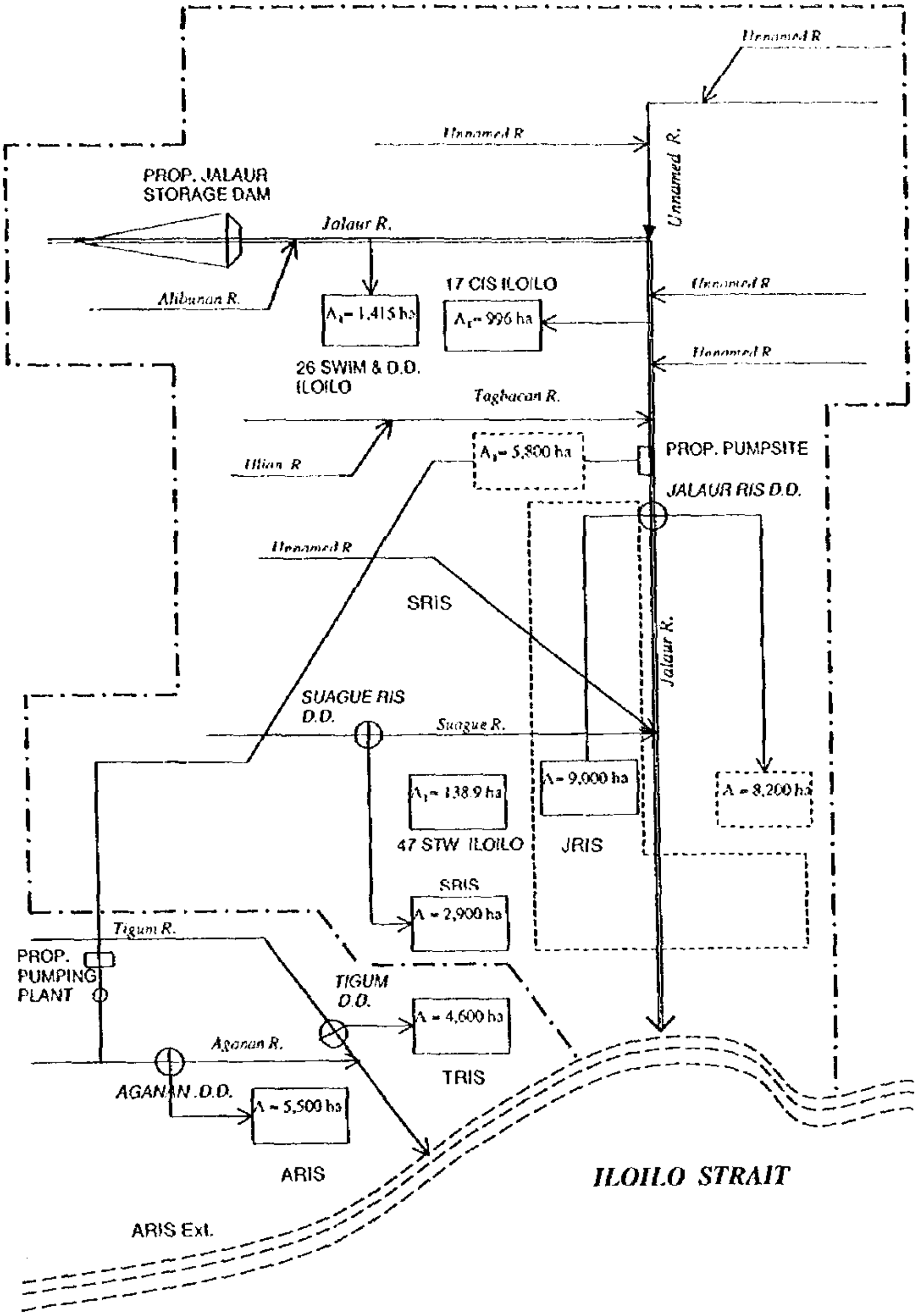


Figure 4 - 29 SCHEMATIC DIAGRAM OF IRRIGATION DEVELOPMENT SCHEMES: JALAUR RIVER BASIN (WRR 6)

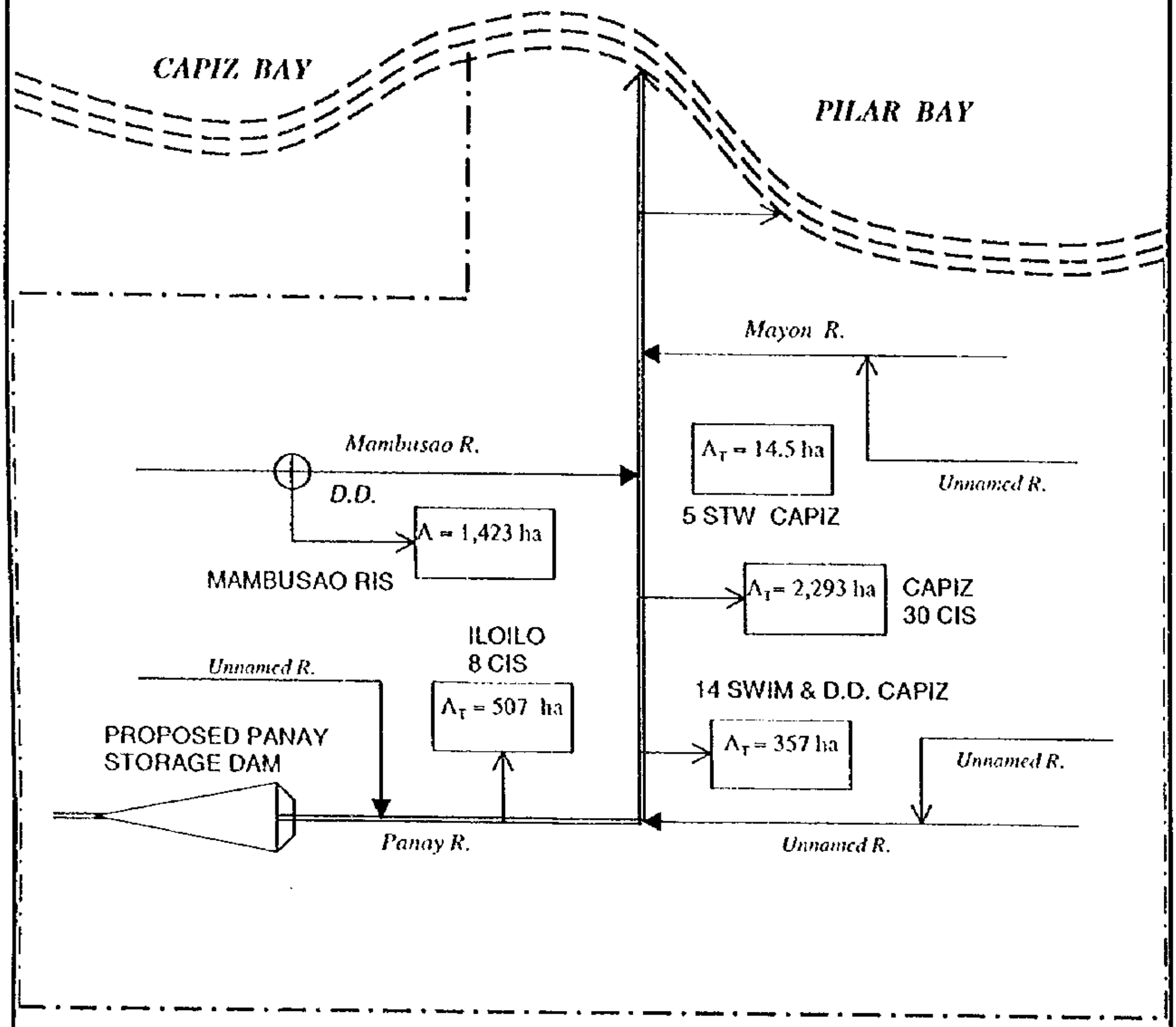


Figure 4 - 30 SCHEMATIC DIAGRAM OF IRRIGATION DEVELOPMENT SCHEMES: PANAY RIVER BASIN (WRR 6)

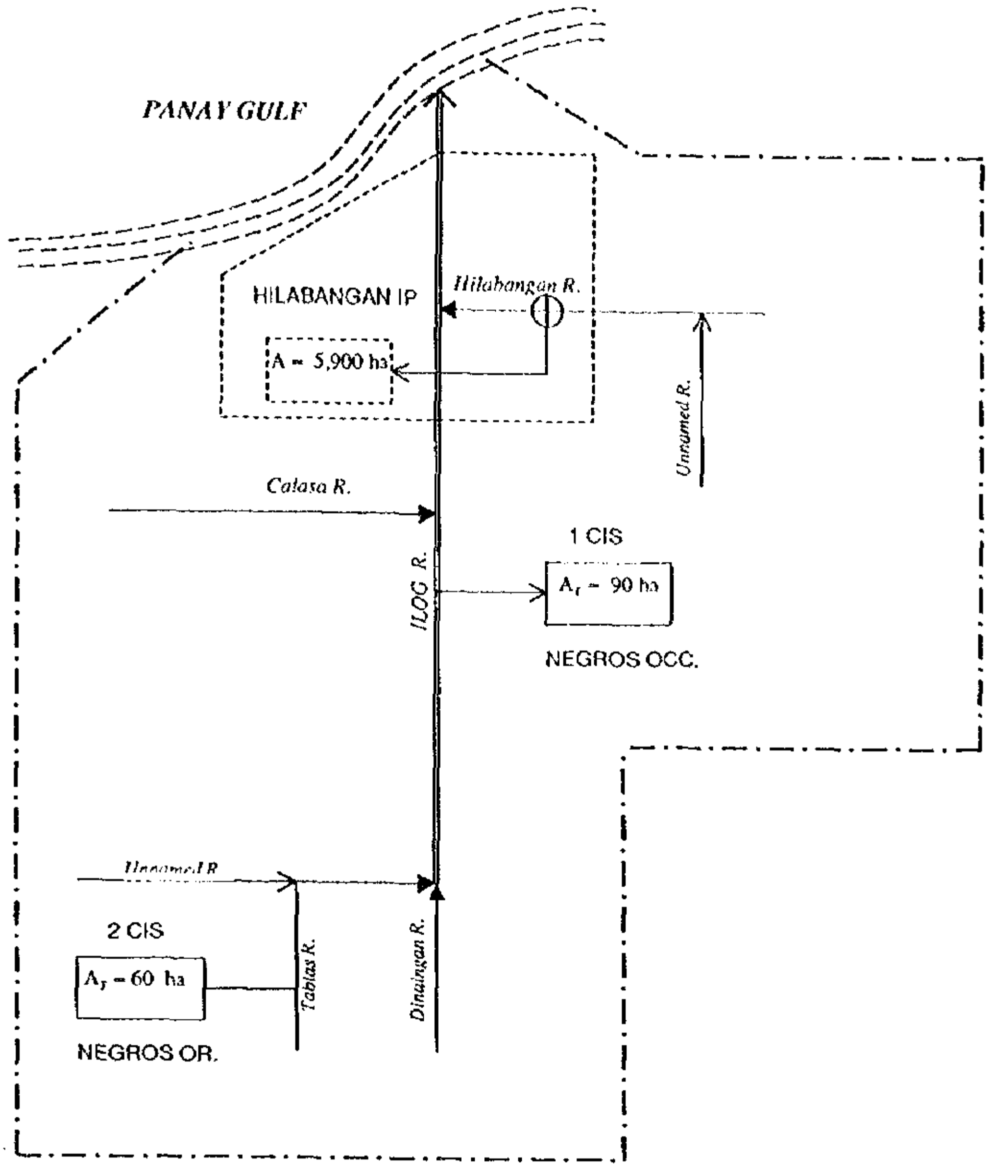


Figure 4 - 31 **SCHEMATIC DIAGRAM OF IRRIGATION DEVELOPMENT SCHEMES: ILOG-HILABANGAN RIVER BASIN (WRR 6)**

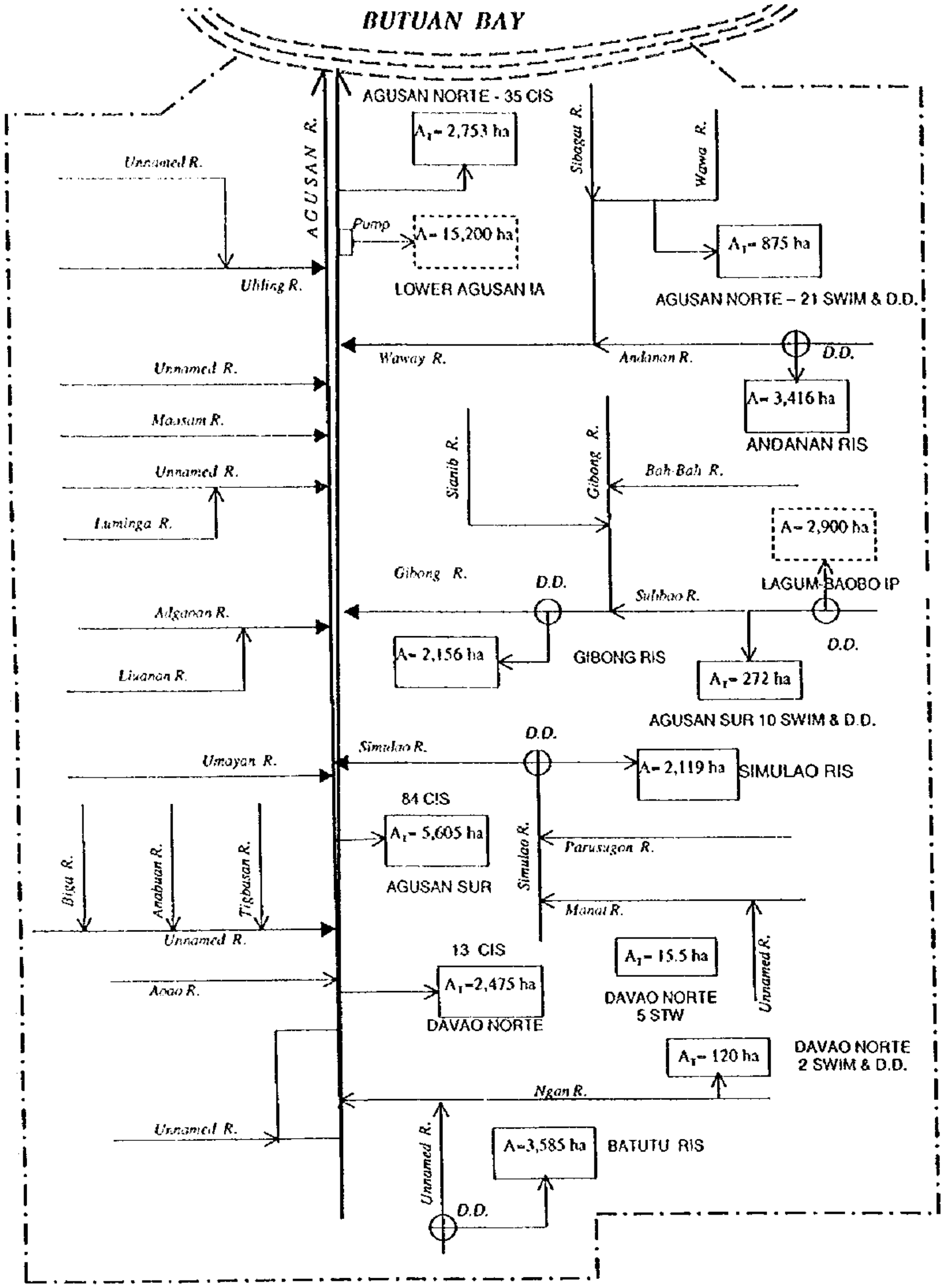


Figure 4 - 32 SCHEMATIC DIAGRAM OF IRRIGATION DEVELOPMENT SCHEMES: AGUSAN RIVER BASIN (WRR 10)

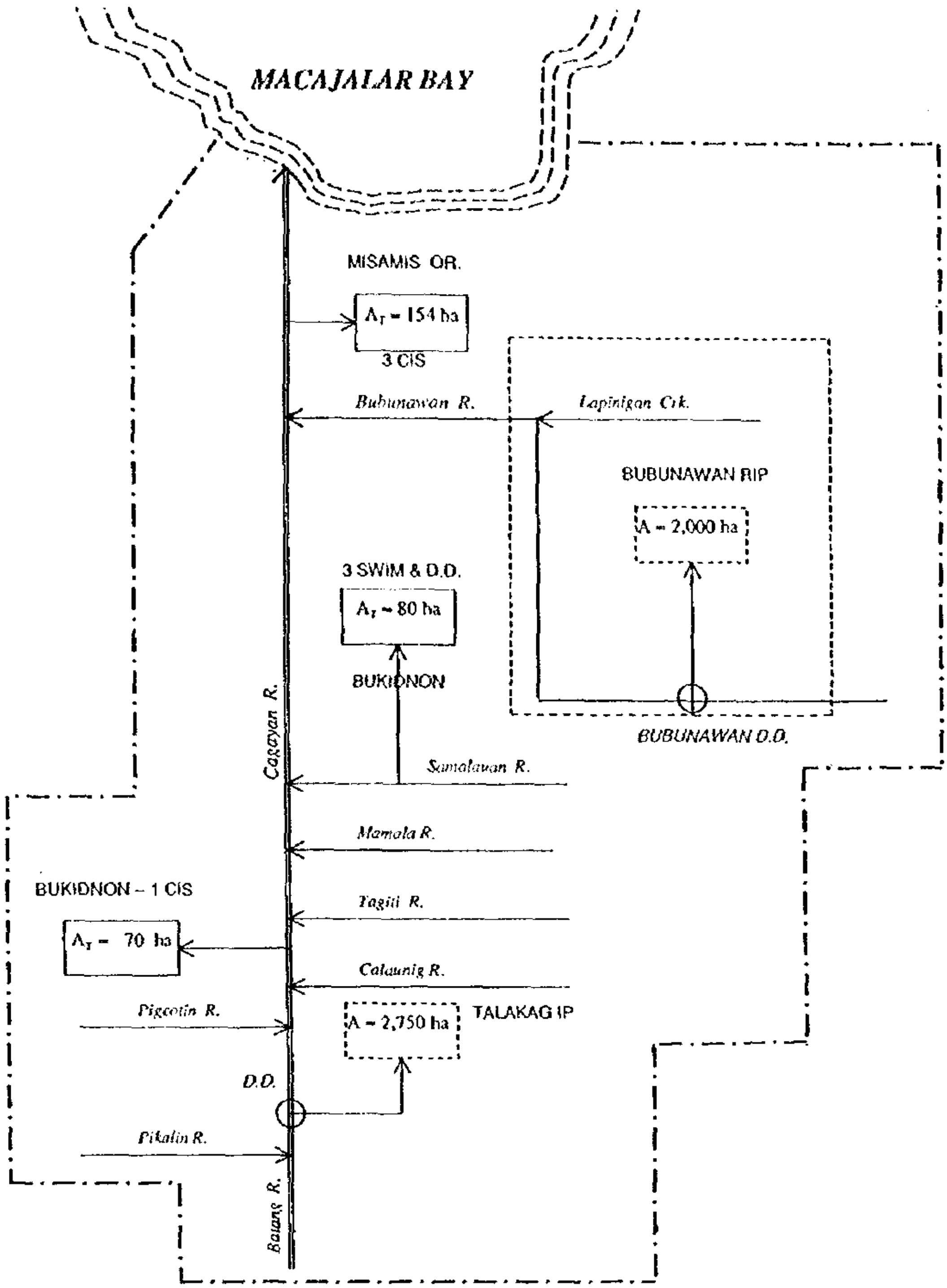


Figure 4 - 33 **SCHEMATIC DIAGRAM OF IRRIGATION DEVELOPMENT SCHEMES: CAGAYAN (MINDANAO) RIVER BASIN (WRR 10)**

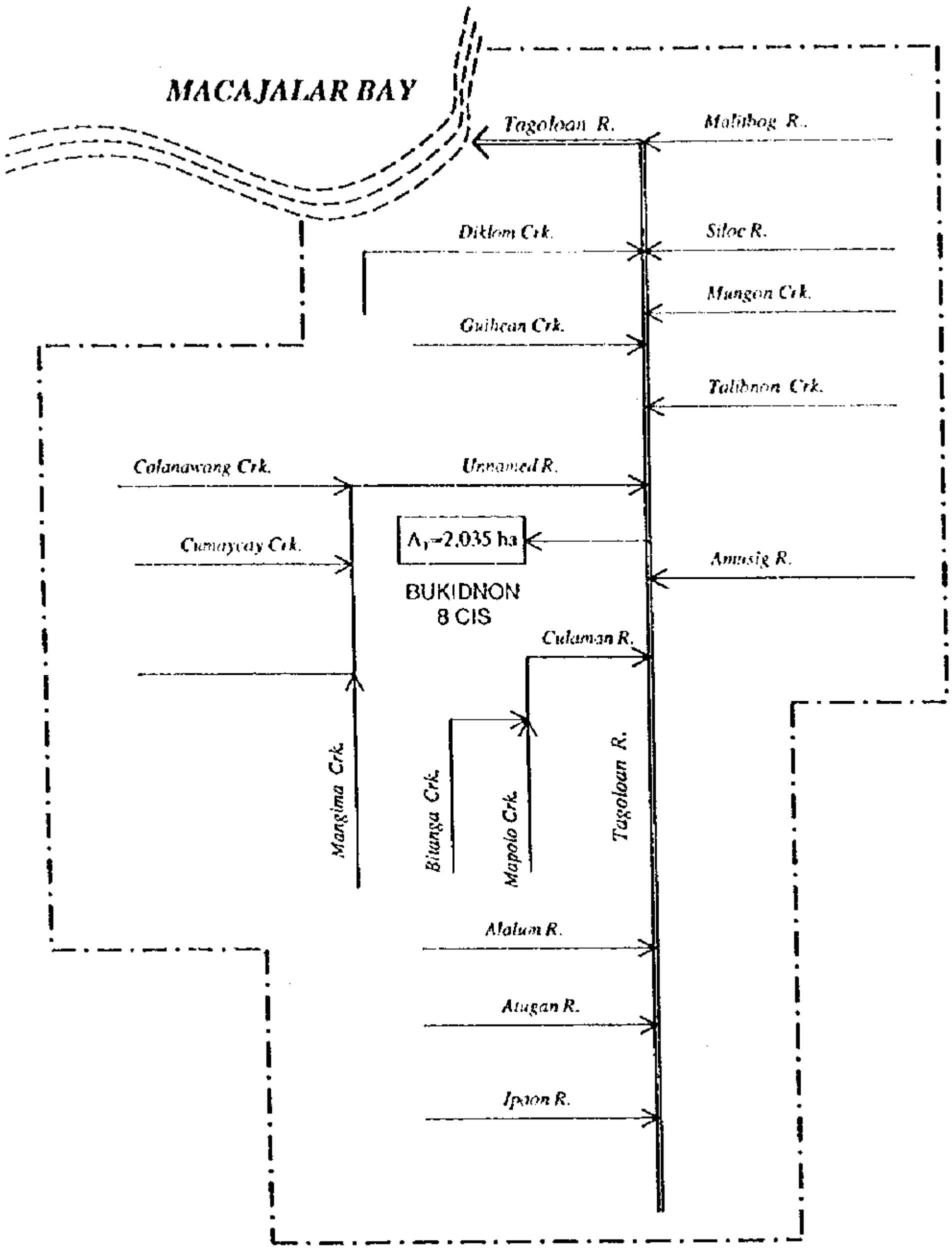


Figure 4 - 34 **SCHEMATIC DIAGRAM OF IRRIGATION DEVELOPMENT SCHEMES: TAGOLOAN RIVER BASIN (WRR 10)**

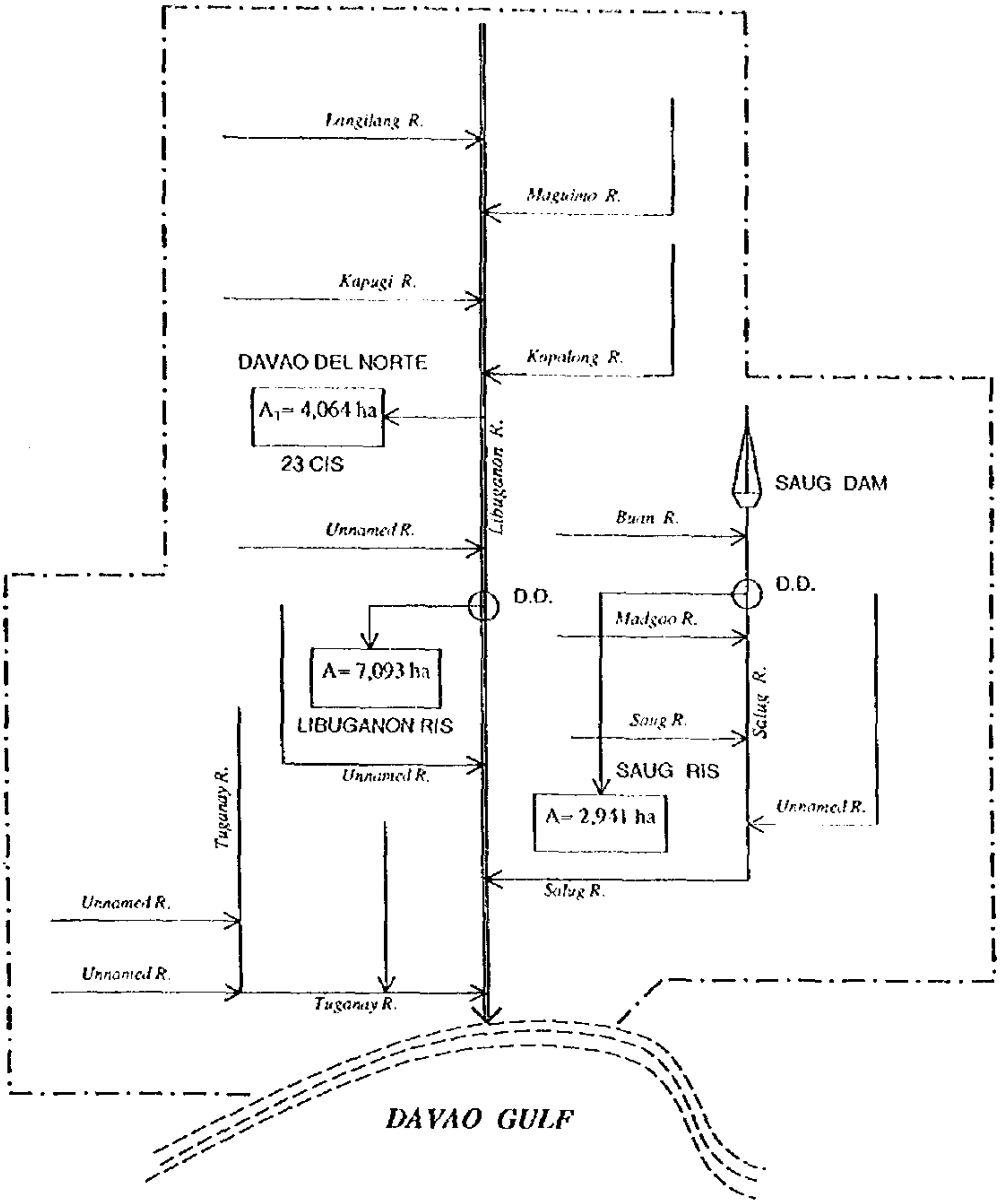


Figure 4 - 35 SCHEMATIC DIAGRAM OF IRRIGATION DEVELOPMENT SCHEMES: TAGUM-LIBUGANON RIVER BASIN (WRR 11)

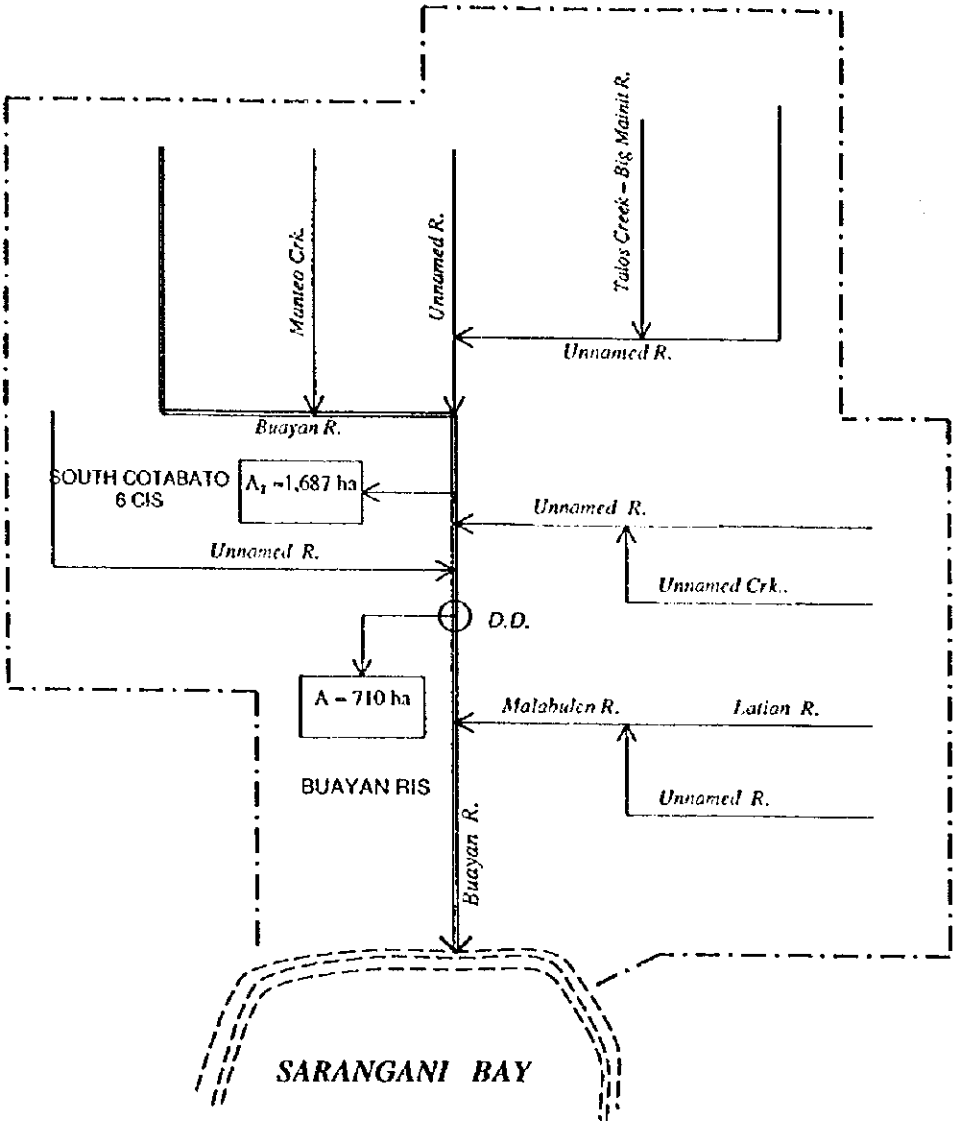


Figure 4 - 36 SCHEMATIC DIAGRAM OF IRRIGATION DEVELOPMENT SCHEMES: BUAYAN-MALUNGON RIVER BASIN (WRR 11)

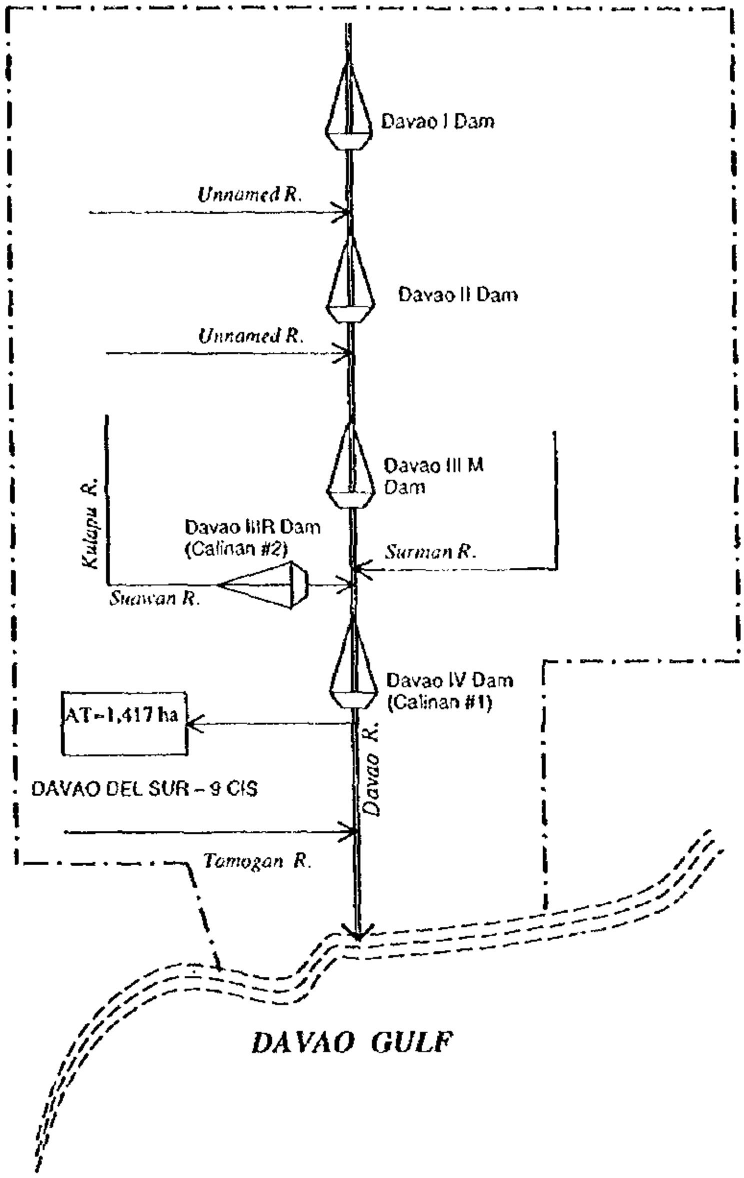


Figure 4 - 37 SCHEMATIC DIAGRAM OF IRRIGATION DEVELOPMENT SCHEMES: DAVAO RIVER BASIN (WRR 11)

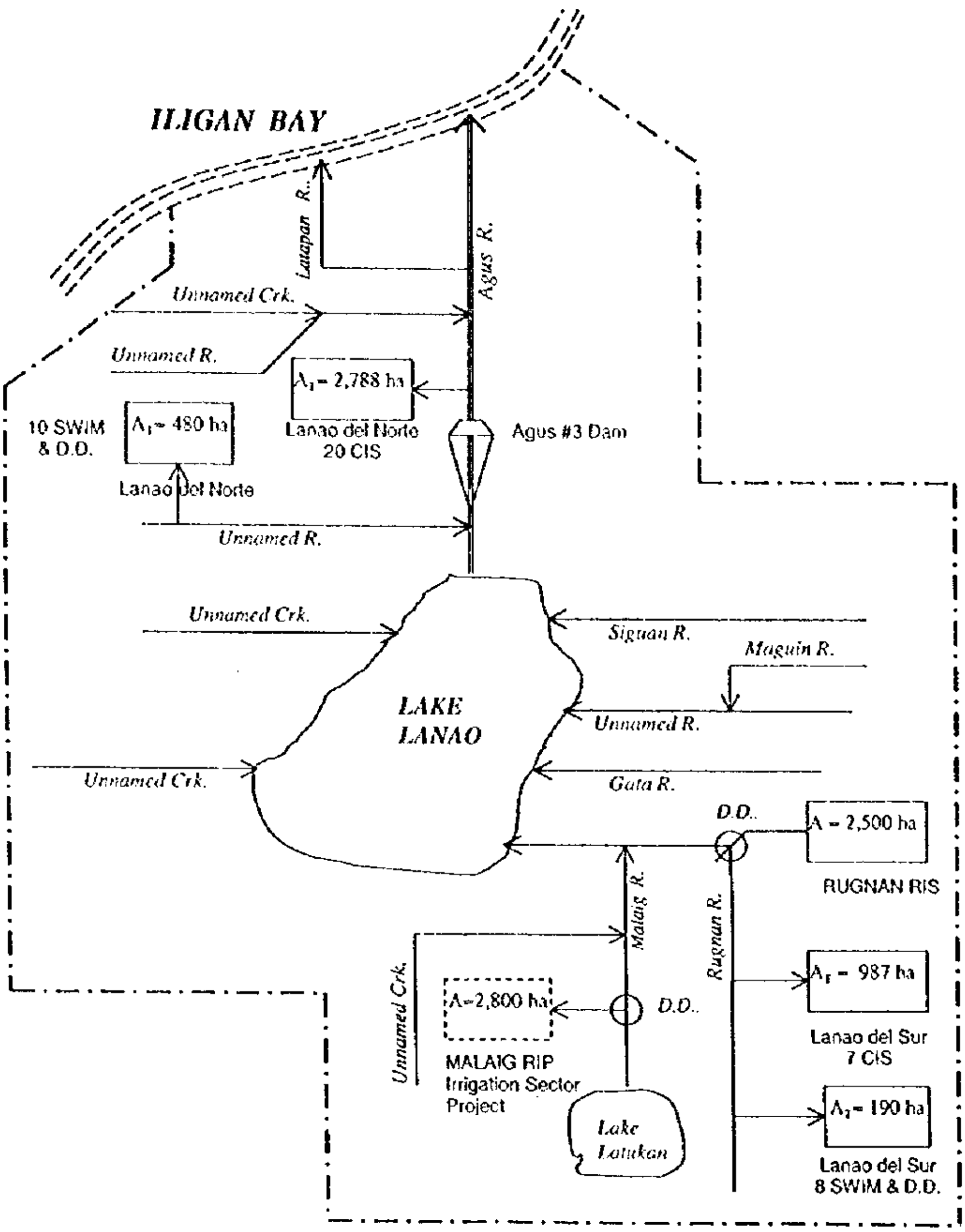


Figure 4 - 38 SCHEMATIC DIAGRAM OF IRRIGATION DEVELOPMENT SCHEMES: AGUS RIVER BASIN (WRR 12)

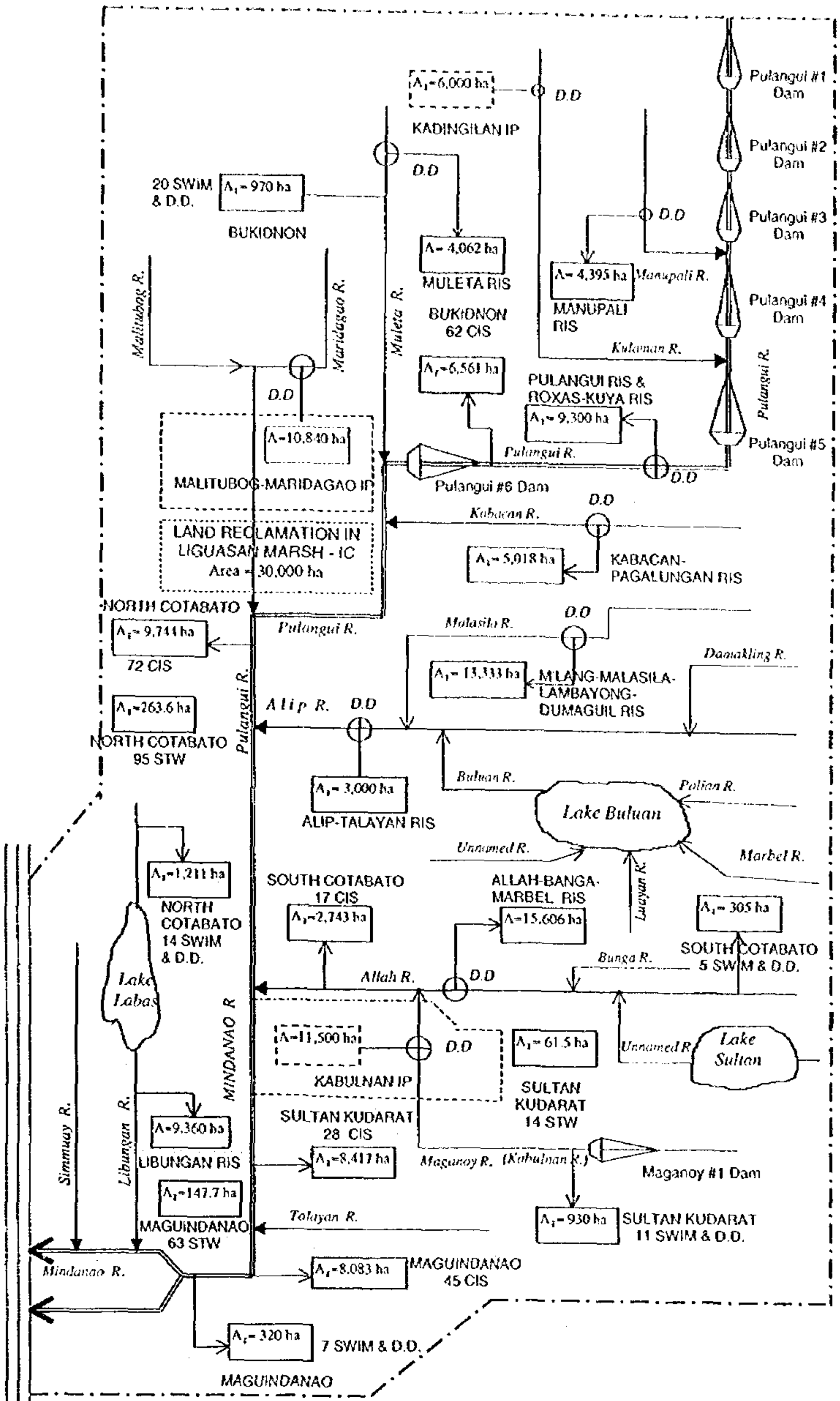
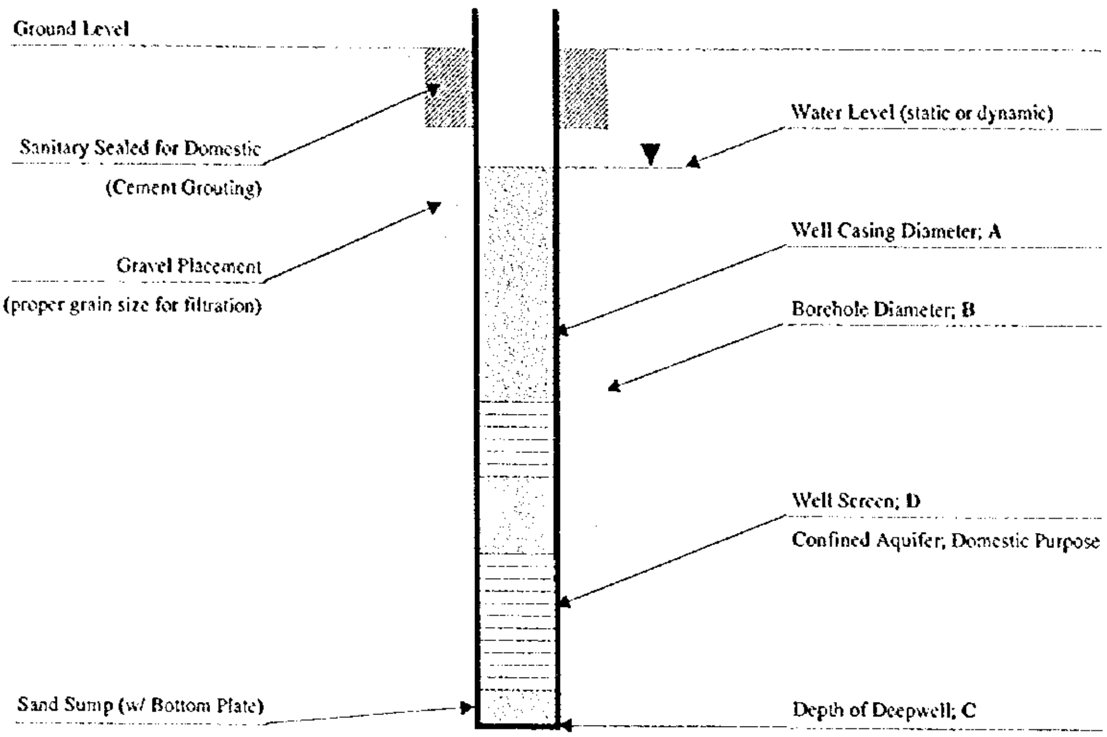


Figure 4 - 39 SCHEMATIC DIAGRAM OF IRRIGATION DEVELOPMENT SCHEMES: MINDANAO RIVER BASIN (WRR 12)



Water Supply Category		Diameter		Depth or Length	
		Well Casing mm (in.) - size A	Borehole mm (in.) - size B	Well String m - size C	Well Screen by Depth - size D
Municipal	Level-III	250 (10")	444.50 (17"-1/2)	103.3 to 218.6	30%
	Level-II	150 (6")	311.15 (12"-1/4)	53.8 to 101.1	25%
	Level-I	100 (4")	269.88 (10"-5/8)	35.9 to 67.4	20%
	Private L-I	100 (4")	200.03 (7"-7/8)	17.9 to 33.7	15%
	Commercial	150 (6")	269.88 (10"-5/8)	16.5 to 42.5	25%
Industrial		250 (10")	444.50 (17"-1/2)	99.1 to 255.2	35%
Irrigation		200 (8")	374.65 (14"-3/4)	16.5 to 42.5	40%

Remarks : Municipal deepwell should be equipped with sanitary material sealed & be designed to fix confined aquifer for domestic water use. Irrigation deepwell shall be utilized (pumped) by seasonal requirement.
Various pump will be required for each type of deepwell such as submersible, self-priming, handpump, etc.

Figure 4-40 TYPICAL DEEPWELL STRUCTURES

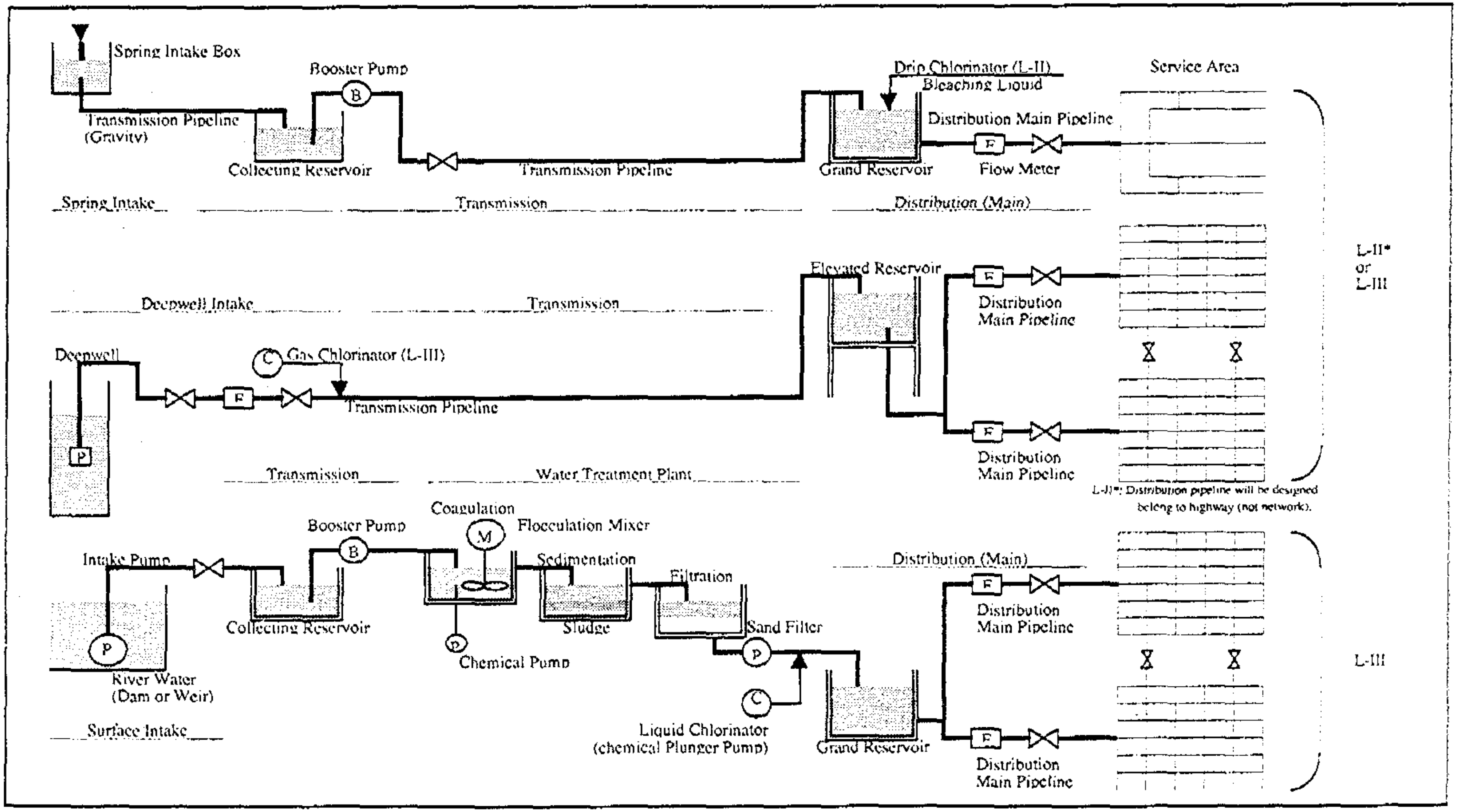
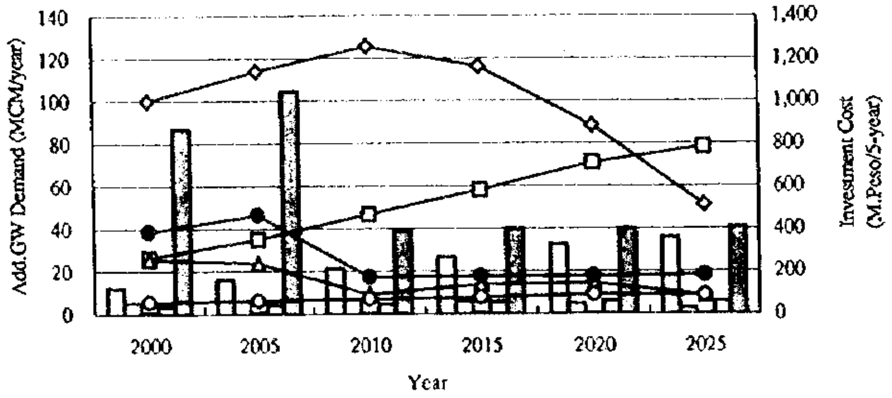
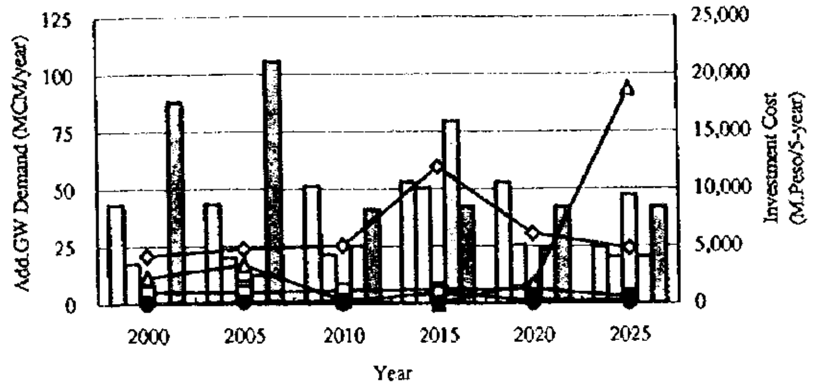


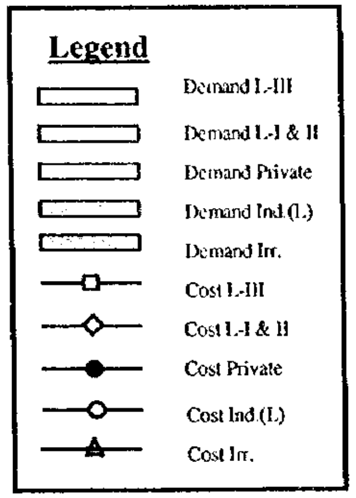
Figure 4-41 TYPICAL WATER SUPPLY SYSTEMS FOR COST ESTIMATION OF GROUNDWATER DEVELOPMENT

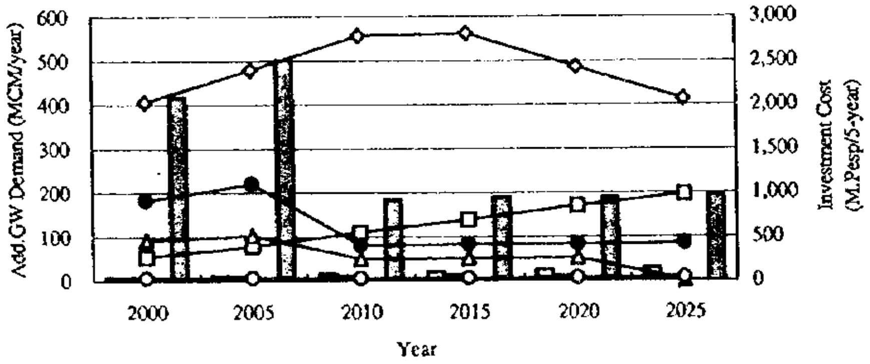


WATER RESOURCES REGION I (WRR-I)

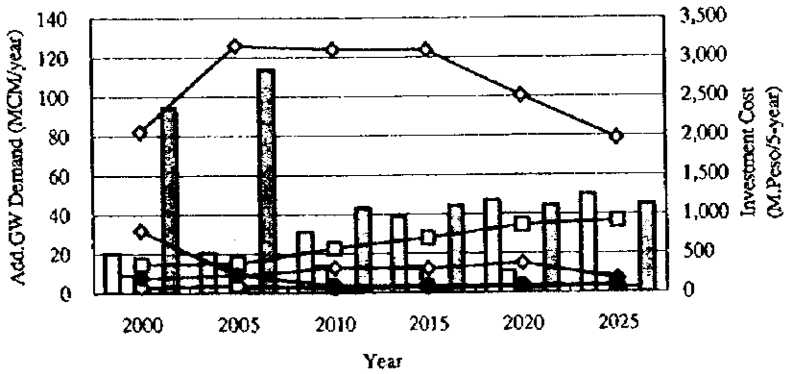


WATER RESOURCES REGION IV (WRR-IV)

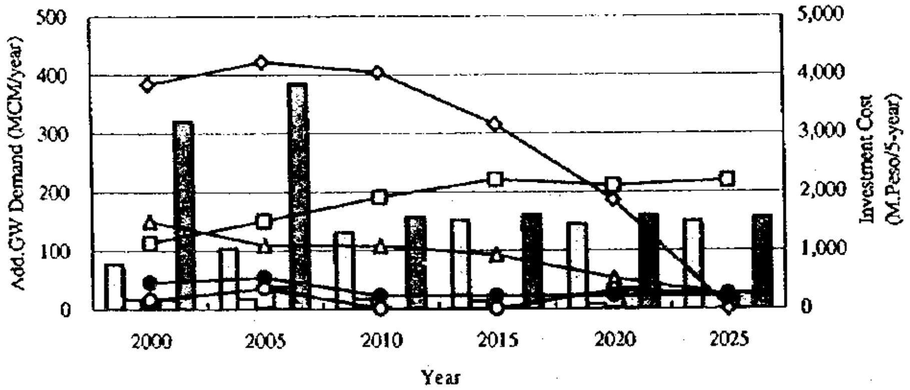




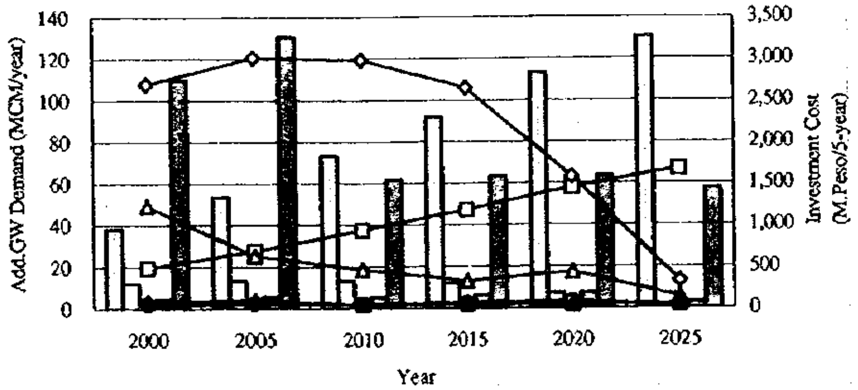
WATER RESOURCES REGION II (WRR-II)



WATER RESOURCES REGION V (WRR-V)

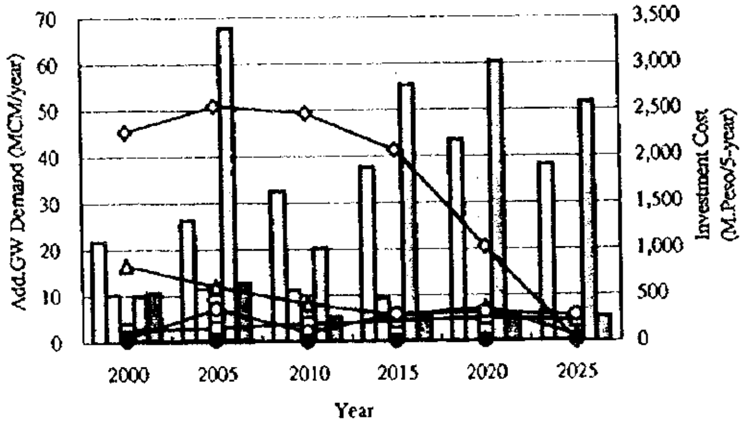


WATER RESOURCES REGION III (WRR-III)

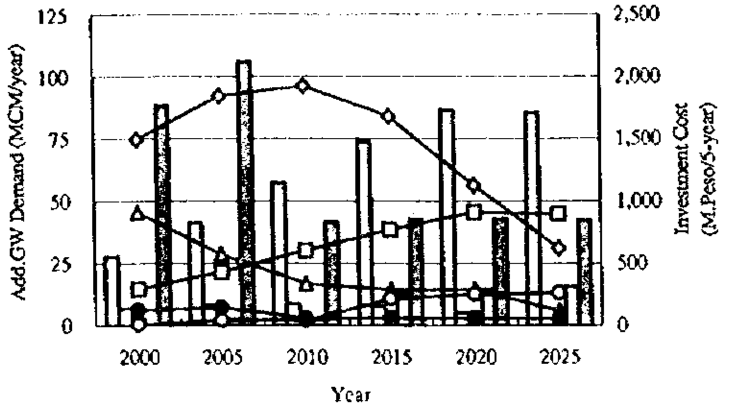


WATER RESOURCES REGION VI (WRR-VI)

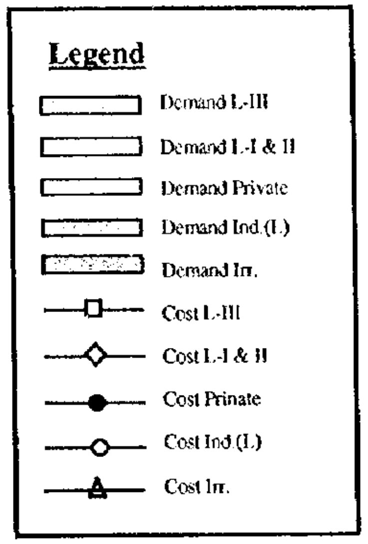
Figure 4-42 FUTURE REQUIRMENT OF GROUNDWATER DEVELOPMENT BY WATER RESOURCES REGION (1/2)

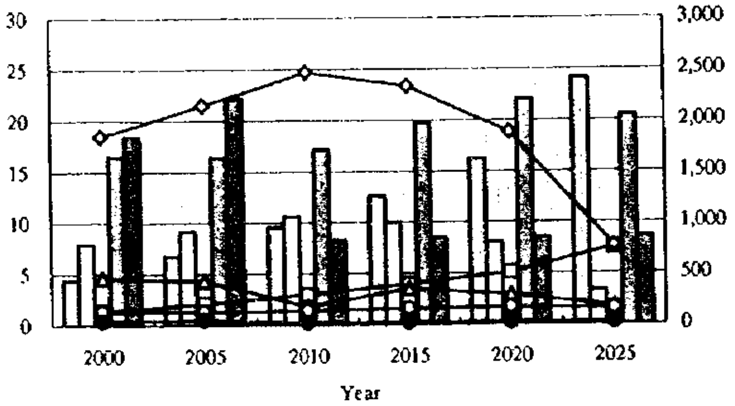


WATER RESOURCES REGION VII (WRR-VII)

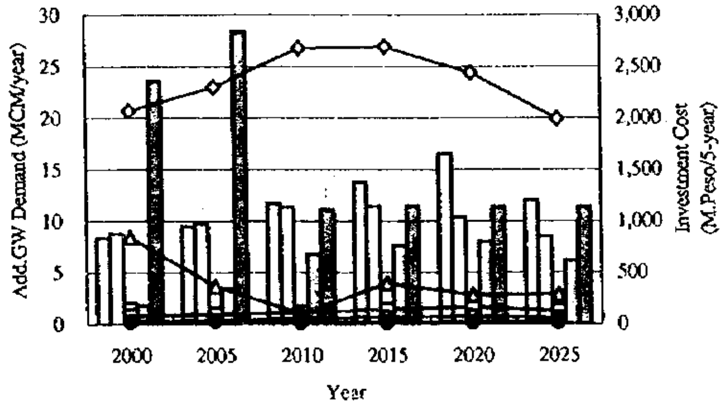


WATER RESOURCES REGION X (WRR-X)

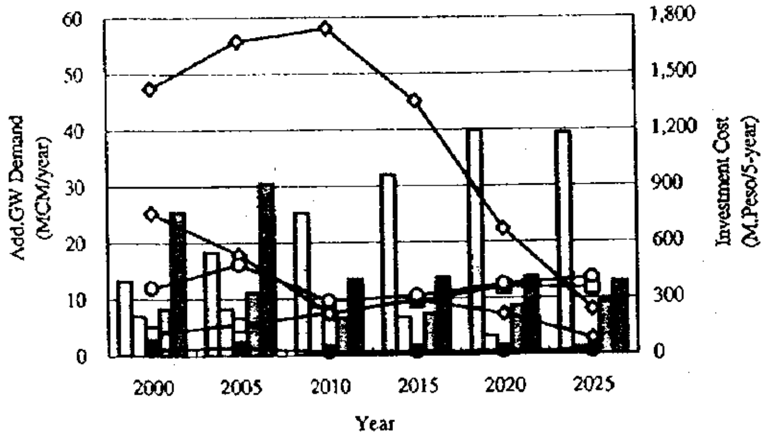




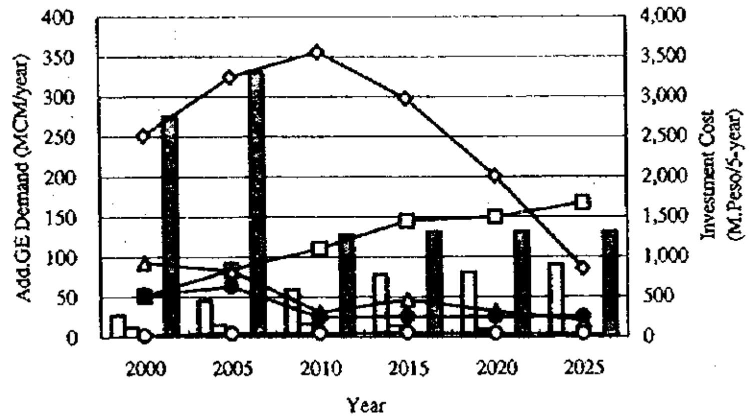
WATER RESOURCES REGION VIII (WRR-VIII)



WATER RESOURCES REGION XI (WRR-XI)



WATER RESOURCES REGION IX (WRR-IX)



WATER RESOURCES REGION XII (WRR-XII)

Figure 4-42 FUTURE REQUIRMENT OF GROUNDWATER DEVELOPMENT BY WATER RESOURCES REGION (2/2)

CHAPTER V

SURFACE WATER RESOURCES PLANNING

V SURFACE WATER RESOURCES PLANNING

5.1 Overview of Present Water Use and Water Resources Development Plans

5.1.1 Classification of Proposed and On-going Water Resources Development Plans

With regard to surface water, the water resources development schemes are broadly divided into two different types in terms of the mode of water intake. These are run-of-river type and storage type schemes. In case of the former type, river water is off-taken in harmony with the natural streamflow without any seasonal regulation, while the latter one is associated with the provision of the comparatively large-scale reservoirs to seasonally regulate the streamflow so as to ensure the stable water use throughout a year. The diversion schemes for irrigation water supply and run-of-river type schemes for hydropower generation which are not associated with construction of a large-scale of reservoir are categorized into the former type. In view of the sustainable water resources development for a certain basin, this type of scheme would be continued to be implemented as long as the long-term water demand can be met without seasonal regulation of streamflow. Since these run-of-river schemes do not enhance the dependable or firm flow in the basin, the storage type schemes will be required to be realized in case the water deficit is foreseen against the future water demand in the basin and/or adjacent basin as a result of the water balance study to examine if the projected water demand in the target year can be met by the proposed water resources schemes.

In the field investigation, the data and previous study reports related with the water resources development have been gathered as much as possible from the related governmental agencies such as NPC, NIA, MWSS, LWUA. As a result of the data and information collection, it is clarified that most of the large-scale reservoir type development plans have been proposed by NPC for the purpose of hydropower generation and/or multi-purpose development. Even though the development plan is originally proposed for the single purpose of hydropower generation only, the tail water should be unexceptionably utilized for the other purposes including irrigation and municipal water supply by means of the provision of afterbay weir on the downstream reach of the dam. Thus, most of the large-scale reservoir schemes are considered to be covered by the hydropower projects proposed by NPC in accordance with the previous studies with exception of a limited number of schemes, which include the storage schemes for the single purpose of augmenting irrigation water supply in irrigation areas of AMRIS under the WRDP as well as the storage type dams for the purpose of municipal water supply to Metro Cebu and other large cities. However, it is expected that those dams contemplated as a single purpose dam for the time being will also be furnished with other purpose(s) in the final design stage in line with the NWRB's policy. For instance, the schemes which are originally formulated for the purpose of irrigation water supply only may be provided with mini-hydropower station to harness a head created by the proposed dam as long as they could retain the economic viability exceeding the marginal value as a whole on the condition of inclusion of such additional development.

In addition to the storage type schemes proposed by NPC, a lot of small scale dams under the Small Water Impounding Management (SWIM) are planned to be constructed or under construction. Besides, It is proposed that many SWIM projects be constructed all over the country. These projects are planned to have small effective storage volumes in their reservoirs, aiming primarily at irrigation water supply. Therefore, it is anticipated that these schemes would also contribute to the seasonal regulation of streamflow in the basin where some of them are situated.

The storage type dams contemplated or under construction in the country which are described above are categorized into the following four groups:

i) Storage type dam schemes planned mainly for hydropower development by NPC
ii) Small-scale dam schemes under SWIM mainly for the purpose of irrigation water supply (SWIM projects)
iii) Storage type dam for the single-purpose of municipal water supply
iv) Storage type dam for the single-purpose of irrigation water supply

On the other hand, it is recommended that the single-purpose dam project be reformulated taking into account the water demands in other sectors in an around the river basin in accordance with the national policy.

5.1.2 Storage Type Dam Development Plans by NPC

Table 5-2 lists the existing large-scale dam schemes proposed by NPC and NIA as well as schemes identified and examined at a level of master plan study in this study. Out of them, the proposed hydropower schemes were studied at the different levels such as definite design, feasibility study, pre-feasibility study. The locations of reservoir type projects are shown in Figures 5-1 to 5-11. The hydropower projects are largely classified in accordance with the mode of utilization of streamflow for the purpose of power generation as follows:

- Run-of-river type with or without a pond for daily regulation of streamflow
- Reservoir type with a reservoir for seasonal regulation of streamflow
- Lake outlet type which utilizes a natural lake for reservoir
- Pumped storage type

Out of the above four development types, the reservoir and lake outlet types can seasonally regulate the streamflow. The proposed schemes categorized into these two types that were picked out by water resources region from the project list are shown in Table 5-2 together with the schemes identified in this study.

As discussed in the foregoing Section 3.3, the significant increase of sediment inflow is becoming one of the critical issues in some of existing major reservoirs in this country. Hence, it is needed to fully consider the necessity of the watershed management in formulating the development plan on the reservoir type schemes at a level of feasibility study.

5.1.3 Small Water Impounding Management (SWIM) Project

5.1.3.1 Master Plan on SWIM Project

It is generally accepted that the SWIM projects bring about the quick benefits and favorable effects to their beneficiaries with relatively low capital investment needed for construction of small dam and reservoirs, as compared with large-scale reservoir type projects. Accordingly, it is expected that the SWIM projects play an important role in promoting and/or accelerating the development of rural areas.

The master plan study on the small water impounding management (SWIM) was completed under JICA in March 1990. At that time, the SWIM projects had been studied by DPWH, NIA, NEA and BSWM. In the master plan, a total of 501 SWIM projects which were identified by those agencies all over the Philippines were further examined to select the qualified projects for the earlier implementation. These SWIM projects were planned to be developed for some of the following purposes:

- Irrigation
- Watershed management
- Inland fishery
- Flood control
- Mini-hydro power generation
- Domestic water supply

Out of the candidate 501 projects, 230 projects were selected as the qualified ones applying the following guidelines on development scale:

- The small-scale multi-purpose water resources development project which can also function as a first line of defense against flood in the basin is preferred. (In principle, the dam height should be less than 30 m, storage volume is less than 50 MCM.)

- The project should include both engineering and vegetative protection works in the watershed covered by the planned dam, with the protected area of less than 100 km^2.

- The project should have an irrigation service area of not more than 500 ha and should have installed capacity for hydropower generation of not more than 5,000 kW.

- The project construction cost for dam and its appurtenant structures should not exceed 50 million Pesos.

A total number of qualified SWIM projects selected in accordance with the above guidelines amount to 230 projects, whose locations are illustrated by water resources region in Figures 5-12 to 5-25. These candidate SWIM projects are geographically broken down by the water resources region as shown below:

Number of Qualified SWIM Projects by Region and Agency

Region No.	Nos. of Candidate Projects	Nos. of Qualified SWIM Projects			
		Total	Classification by Agency		
			DPWH	NIA	BSWM
I	63	41	6	10	24
II	62	35	4	0	31
III	63	27	1	9	17
IV	38	11	5	2	4
V	55	20	1	14	5
VI	15	9	1	0	8
VII	82	35	0	26	9
VIII	44	14	1	5	8
IX	14	8	0	1	7
X	25	10	0	0	10
XI	15	10	1	0	9
XII	25	11	3	0	8
Total	501	230	23	67	140

As seen above, 140 projects were grouped into the BSWM's ones, which are mostly low dams of less than 15 m in height. The main development purpose of the qualified SWIM projects are mostly irrigation development, while flood control, inland fishery development and watershed management and water supply are major incidental purposes. In general, the qualified SWIM projects are characterized with the relatively small catchment areas of not more than 30 km^2 and low dam height of not more than 30 m.

Besides, their embankment volumes and storage capacities are less than 0.35 million m^3 and 10 million m^3, respectively. On the other hand, the irrigation areas covered by the qualified SWIM projects ranged from 5 ha to 500 ha and their average irrigation area per one project was around 126 ha. The mini-hydro power station was planned to be provided for the eleven projects with an installed capacity of less than 700 kW.

5.1.3.2 Implementation of SWIM Projects

Until now, the SWIM projects have been implemented with the two different financing sources of funding, namely the OECF's fund and the Government's own fund, out of which the former case may be regarded as the continuation of the JICA's master plan.

(1) SWIM Projects Implemented with OECF's Fund

After the completion of the master plan study under JICA, a total of 25 SWIM projects were selected for implementation with the fund of OECF. At present, the construction works of those projects are underway under the control of DPWH. According to the original construction schedule, these projects are going to be completed in 1998, but it is informed that the construction works for some projects are delayed to some extent in comparison with the original schedule.

(2) SWIM Projects Implemented with Self-Fund of the Government

In addition to the SWIM projects financed by OECF, a lot of other SWIM projects have been implemented by the Government's own finance. According to the aforesaid JICA's master plan study report, 49 SWIM projects had been completed or were under construction with the Government's own budget at the time of carrying out the master plan study. Their engineering and construction works were wholly handled by the various agencies such as DPWH, NIA, FMB, NEA, BSWM, FSDC. According to the latest information, 256 SWIM projects are constructed by the Government's own budget and are now in operation in the whole Philippines. In addition thereto, a lot of SWIM projects are proposed to be constructed by NIA and BSWM.

During the field investigation, unfortunately, the detailed location maps and reservoir dimensions as of the respective SWIM projects including the effective storage volumes could not be obtained from the concerned agencies.

5.1.3.3 Necessity of Coordinated Management of SWIM Projects

As aforesaid, many small impounding projects have been constructed or are proposed to be constructed by the various agencies concerned. However, it could not be clarified whether or not dam and its appurtenant structures of other SWIM projects than those under DPWH were designed in accordance with the standard design criteria explained in Part-D of the Supporting Report. It was reported in the JICA's master plan that some of the SWIM projects provided earlier than the commencement of the master plan had been damaged and/or washed away due to the dam failure. In this respect, it is hoped that all the SWIM projects in the country are constructed and managed in a coordinated way. Besides, there is a possibility that the sedimentation rates in upstream basins of those small dams will become higher than originally designed, since the problem of degradation of watershed is common to most of the river basins in the Philippines. In case that the reservoir has been filled up with sediment, the dredging works will need to be conducted periodically. Therefore, it is considered that the watershed management plan should also be established and implemented for the basins where the SWIM projects are located or to be located.

5.2 Water Balance Study by Water Resources Region

5.2.1 Assessment of Water Resources Potential in Each Water Resources Region

To verify the situation of water deficit and necessity of water resources development in the future on a regional basis, as the first step, the water balance study was carried out for each of the 12 water resources regions applying the total water resources potential and water demand in 2025. In the region-wide water balance study, the total water resources potential was derived to be a sum of those of groundwater and surface water. The water resources potential was preliminarily estimated for each of the water resources regions applying the following procedures:

- The groundwater resources potential for each water resources region which is discussed in the foregoing Section 2.3 was applied for the assessment.

- The surface water potential for each water resources region was estimated for the exceedance probability of 50 % and 80 % based on flow duration curve at the selected representative stream gauging stations, which were constructed with mean daily discharges per 100 km^2. The mean daily discharges for the latest 5 years were used, since the streamflow data for the period are comparatively complete with short-term period of interruption of water level observation with respect to most of the representative stream gauging stations. The flow duration curves thus derived are shown in Figures 5-24 to 5-26.

Figures 5-24 to 5-26 show that the discharges of 80 % firmness in river basins of Luzon island become considerably small as compared with those in Mindanao island. This seems to imply that the low flow of dry period in Mindanao island is comparatively stable due to the relatively constant rainfall throughout a year, while in Luzon island the streamflow is severely affected by the relatively lesser rainfall amount during the dry season. Besides, the streamflow observed at existing stream gauging stations in Luzon island might be affected by upstream water diversion to irrigation areas, although it is too hard to accurately estimate the diversion discharges at certain intervals in this master plan study. Based on these flow duration curves, the water resources potential of each water resources region was derived as follows:

Water Resources Potential in Each Water Resources Region

No.	Groundwater	Surface Water Probability		Total Potential Probability of Surface Water	
		50 %	80 %	50 %	80 %
	(1)	(2)	(3)	=(1) + (2)	=(1) + (3)
I	1,248	10,100	3,250	11,348	4,498
II	2,825	16,800	8,510	19,625	11,335
III	1,721	10,800	7,890	12,521	9,611
IV	1,410	19,700	6,370	21,110	7,780
V	1,085	9,960	3,060	11,045	4,145
VI	1,144	19,500	14,200	20,644	15,344
VII	879	3,770	2,060	4,649	2,939
VIII	2,557	15,900	9,350	18,457	11,907
IX	1,082	16,200	12,100	17,282	13,182
X	2,116	42,100	29,000	44,216	31,116
XI	2,375	16,300	11,300	18,675	13,675
XII	1,758	25,100	18,700	26,858	20,458
Total	20,200	206,230	125,790	226,430	145,990

5.2.2 Water Balance in Each Water Resources Region

The future water demands were projected by water resources basin and water consuming sector for the period up to the target year 2025 at an interval of 5 year as explained in the corresponding Parts of this Supporting Report.

To look at the water balance of water resources potential and water demand, the total water demand in each water resources region was estimated by summing up those in the municipal, industrial and agricultural sectors. In the estimate, the total water demand in each water resources region in 2025 was counted to be a sum of those of the following sectors under each of the high and low economic growth scenarios, which are set up in Part-A of this Supporting Report:

(1) Municipal water
(2) Industrial water
(3) Agricultural water
- Irrigation
- Livestock and poultry
- Fishery

The water resources potentials corresponding to the surface water potentials for the exceedance probability of 50% and 80% were applied to compare with the total water demands in 2025 in the aforesaid two cases. Out of those two different water resources potentials, the former one corresponds to the probability of hydrologic condition, based on which the maximum irrigation area to be developed is usually determined. While, the latter is considered to be the maximum water resources to be exploited through provision of storage type dams in the region for the purpose of regulating streamflow.

The results of the region-wide water balance study are tabulated in Table 5-3 and those in case of the 80% probability are summarized below:

Water Balance by Water Resources Region

No.	Total Water Resource Potentials (Probability of Surface Water: 80%)	Water Demand in 2025		Difference	
		Case-1	Case-2	Case-1	Case-2
	(1)	(2)	(3)	=(1) - (2)	=(1) - (3)
I	4,498	3,041	2,874	1,457	1,624
II	11,335	12,466	7,618	-1,131	3,717
III	9,611	18,168	14,618	-8,557	-5,007
IV	7,780	10,052	7,368	-2,272	412
V	4,145	4,167	2,841	-22	1,304
VI	15,344	7,595	6,206	7,749	9,138
VII	2,939	2,729	2,226	210	713
VIII	11,907	1,956	1,644	9,951	10,263
IX	13,182	4,598	3,616	8,584	9,566
X	31,116	3,682	2,253	27,434	28,863
XI	13,675	4,141	2,390	9,534	11,285
XII	20,458	12,806	6,946	7,652	13,512

Note: Case-1; High economic growth scenario
Case-2; Low economic growth scenario

The following table shows rations of the water resources potential to water demand in 2025 in case that the surface water potential is estimated on the condition that the maximum available discharge is a daily discharge with 50 % dependability:

Water Balance by Water Resources Region (Surface Water : 50 % Dependable Discharge)

WRR No.	Total Water Resource Potentials	Water Demand in 2025		Ratio of Potential to Demand	
		Case-1	Case-2	Case-1	Case-2
	(1)	(2)	(3)	=(1) / (2)	=(1) / (3)
I	11,348	3,041	2,874	3.78	3.95
II	19,625	12,466	7,618	1.57	2.58
III	12,521	18,168	14,618	0.69	0.86
IV	21,110	10,052	7,368	2.10	2.87
V	11,045	4,167	2,841	2.65	3.89
VI	20,644	7,595	6,206	2.72	3.33
VII	4,649	2,729	2,226	1.70	2.09
VIII	18,457	1,956	1,644	9.44	11.22
IX	17,282	4,598	3,616	3.76	4.78
X	44,216	3,682	2,253	12.01	19.63
XI	18,675	4,141	2,390	4.51	7.81
XII	26,858	12,806	6,946	2.10	3.87

Notes : 1. Economic growth scenario Case-1; High economic growth scenario
Case-2; Low economic growth scenario

2. The potential of surface water was estimated on the condition that the maximum available discharge is a daily discharge of 50 % dependability.

As seen in Table 5-3, the agricultural water demand is still dominant out of the total water demand in 2025 for every water resources region, except for the WRR IV where the municipal and industrial (M&I) water demands in Metro Manila occupy the relatively large part of the total water demand in the WRR VI. As far as the municipal and industrial water demands are concerned, it appears that the M&I water demand can be met under the present condition without provision of new large scale storage type dams, except for specific cities such as Metro Manila and Metro Cebu where the water demand is projected largely expand in the future.

In case of the high economic growth scenario, it is projected that the water deficit would take place in the four water resources regions, WRR II, III, IV and V as shown in the above two tables. While, the water deficit is projected to take place only in the water resources region, WRR III, in case of the low economic growth scenario. Thus, it is foreseen that the severe water deficit in the target year 2025 would come out in the water resources regions II, III and IV, which are all situated in Luzon island. For the time being, on the other hand, two large-scale storage type projects for water resources region III are under construction or going to be implemented in the near feature. These are the Casecnan Transbasin project and San Rouqe multi-purpose dam project. It is expected that the future water deficit in the WRR III would be much mitigated through the completion of these storage type projects. Furthermore, it is considered that the Pampanga river whose streamflow is to be augmented by the Casecnan Transbasin project is expectable to be one of the sources to meet the future municipal and industrial water demands in Metro Manila located in the WRR IV.

5.3 Water Balance Study and Surface Water Development Planning for Major River Basins

5.3.1 Methodology

The region-wide water balance study reveals that the water deficit in the target year 2025 might take place in the WRR III and IV as discussed in the foregoing Section II5.2. On the other hand, it has to be noted that the water demand does not take place uniformly in the water resources region. Likewise, the water resources available and/or exploitable differ from place by place in the region. From such a viewpoint, more detailed water balance study for each of the 20 major river basins was carried out in order to verify the necessity of new storage type schemes to meet the water demand in the target year 2025. Prior to the water balance study, the water demand, which is in excess of the water quantity to be supplied by groundwater, is calculated for each of the sectoral water demands. After that, the water demand to be met by surface water was compared with the mean 10-day runoff from the major river basin taking into account regulated flow from the existing and proposed storage type dams(s).

Of the sectoral water demands in the target year 2025, the agricultural water demand is projected to be outstandingly large in comparison with those of other sectors with the exception of large cities such as Metro Manila and Metro Cebu. On the other hand, the exact locations of the existing major irrigation areas, especially locations of their irrigation off-take weirs, are not sufficiently made clear yet. Accordingly, the water balance study for each major river basin was carried out setting the reference point at river mouth and proposed dam sites in the basin.

Should the water deficit be found out in balance of water demand and supply in 2025, it was attempted to regulate the streamflow through incorporation of the effective storage volume(s) of the proposed storage type schemes listed in Table 5-2.

5.3.2 Basic Criteria for Water Balance Study

The basic criteria for the water balance study were set up for the following major factors which have a significant effect on the water balance:

- Dependability of water supply for respective sectors of water use
- River maintenance flow
- Return flow

(1) Dependability of water supply or use for each sector

It is generally accepted that the hydrological periods for which constant water supply or water use corresponding to the demand be guaranteed may be adopted to be different ones by the sectors, taking into consideration the significance of situation to be brought about by draught condition. Usually, the dependability of water supply or use in M&I, hydropower and irrigation sectors is taken to be 95 %, 90 % and 80 % of the whole hydrologic period, respectively. Taking the different guaranteed periods of those sector into consideration, the probable draught years in which water demands in some of the sectors are targeted to be met in water balance are determined as follows:

Return Period of Draught Year	Sectoral Water Demand to be Met
5-year	(M&I) + (Hydropower) + (Irrigation)
10-year	(M&I) + (Hydropower)
20-year	(M&I)

Concerning each major river basin, the runoff data at the representative stream gauging station were derived through the hydrological analysis for each of the above three different return period as described in Part–B of this Supporting Report. The runoff data were transposed to each of the proposed dam site in the major river basin and the remaining basin applying a factor which is estimated by multiplying their catchment area ratio by the ratio of their mean annual rainfall depths. The mean annual rainfalls were estimated based on the isohyetal maps illustrated in Figures B-2 to B-13 in "Part-B : Hydrology" of this Supporting Report. In fact, the hydrologic condition in draught year of a 5-year return period is an important determinant in estimating requirement of future water resources to meet the water demand over the projection period, since the agricultural water demand occupies the absolutely dominant part of the total demand except for the major river basins concerned with municipal water supply to Metro Manila located in WRR IV.

(2) River maintenance flow

In determining the river maintenance flow, such factors as navigation, fishing, picturesque scenery, salt water intrusion, clogging of river mouth, riparian structures, groundwater table, flora and fauna, and river water quality need to be considered to maintain the normal function of the river. In the Philippines, on the other hand, at least 10 % of the dependable flow of the river is assumed as the required minimum maintenance flow.

Although the required maintenance flow is considered variable for each river due to their spesific conditions on the aforesaid factors, it was simply assumed that the historical minimum daily flow is adopted as the required river maintenance flow. Consequently, a flow rate of 0.0025 $m^3/sec/km^2$ which is approximated to be an average of recorded minimum daily discharges at the whole of the selected representative stream gauging stations is adopted for the water balance study.

(3) Return flow

Some water diverted from a river for M&I and irrigation water supply returns to the river, while no water is consumed with respect to water used for hydropower. It is assumed that 30 % of water diverted for irrigation schemes comes to the return flow. Since the amount of M & I water is very little in comparison with the irrigation water, no return flow is taken into consideration.

5.3.3 Procedure for Water Balance Study

The water balance study was carried out on a 10-day basis in consideration of the regulation effect of the existing and proposed storage type projects for each of the major river basins. With regard to each of the major river basins, as the first step, the irrigation water demand was estimated by means of multiplying the total irrigation area projected for the year 2025 by the 10-day unit water requirement expressed in liter/ha. The other water demands than irrigation water demands are assumed to be constant throughout a year.

Concerning the future water demand to be supplied with surface water, as aforesaid, the agricultural water demand is projected to be dominantly large in most of the major river basins, while the municipal and industrial water demand is not significant in quantity of the water demand. Hence, the draught year of 5-year return period was adopted for the present water balance study. Furthermore, it was assumed that the water demand for fishery be supplied with groundwater and the river maintenance flow, since the fish ponds are situated in the alluvial plains close to river mouth where abundant groundwater is exploitable. Moreover, it is considered preferable to use it, taking into account the pollution of surface water in the downstream reach, which would be accelerated due to increase of use of fertilizer, industrial development, etc.

Concerning the major river basin, it is divided into two type of catchments, namely the catchment covered by the storage type dams (referred to as the "dam catchment") and the remaining catchment. The reservoir operation for the dam catchment was conducted using the following formula:

$$V_i = V_{i-1} + (Q_i - WT) \times N_i \times 0.0864 - A_i \times E \times N_i/1000$$
$$WT = WMI + IA \times W_i \times N_i \times 24 \times 3600/1000$$

Where,

Vi	:	Remaining storage volume of i-th 10-day period (MCM)
V_{i-1}	:	Remaining storage volume of the previous 10-day period (MCM)
Qi	:	Inflow discharge of i-th 10-day period (m^3/sec)
Ai	:	Reservoir area (km^2)
E	:	Evaporation (mm/day)
Ni	:	Number of days of the i-th 10-day period
WT	:	Total water demand of i-th 10-day period (m^3/sec)
WMI	:	Municipal and industrial water demand in the basin (m^3/sec)
IA	:	Irrigation area (ha)
Wi	:	Unit water requirement (liter/ha)

The M&I water demand as well as the irrigation area which can be covered by the regulated outflow from the reservoir were estimated through the trial and error method. In succession, the water balance for the remaining area was made applying the same procedure as that for the dam catchment taking into account the required maintenance flow as well as the return flow. Through those procedures, the water demand and supply balance in each major river basin was examined. The following Subsections 5.6.4 to 5.6.12 describe the results of the water balance study for each major river basin as well as the necessity of development of new storage type schemes. Figures 5-27 to 5-46 illustrate the water demands for the period from 1996 to 2025 in both higher and lower economic growth scenarios and the mean 10-day discharges in the 5-year probable draught year for the 20 major river basins, respectively.

5.3.4 Water Balance in the Laoag and Abra River Basins: WRR I

(1) Main Features of Water Resources Region I

In the Water Resources Region I, the Ilocos Region, there are two major river basins, the Laoag and Abra river basins. The water resources region I is situated in the northwestern part of Luzon island, covering an area of about 14,400 km^2. The main topographic feature in the WRR I is that, in the eastern part of the region, the highly complex mountains called the Cordillera Mountains run in the direction from north to south.

The Type I climate is prevailing in the Laoag basin, characterized by the two pronounced seasons, namely dry season from November to April and wet season during the rest of the year. The annual average rainfall amounts to about 2,800 mm and the mean temperature is 26 ℃.

The major economic activities in the WRR I are mining industries and agricultural. Especially, the Ilocos region had the second largest proportion of irrigated land to total cultivated area, which had reached about 40 % in 1980's.

(2) Water Balance in the Laoag River Basin

The Laoag river basin with a catchment area of 1,355 km^2 is located in the northern part of the WRR I, originating from the Cordillera Mountains. The catchment area is equivalent to about 9.4 % of the total area of the WRR I. In case of the high economic growth scenario, the total water demand for the Laoag river basin is projected to be 891.4 million m^3/year or 28.3 m^3/sec in the target year 2025. Out of the total water demand, that to be covered by surface water is estimated by deducting on the amount shared by groundwater from the total water demand as shown in Table 5-4 and below:

Water Demand in the Year 2025, to be Covered by Surface Water: the Laoag River Basin

(Unit : MCM)

	Water Demand to be supplied by Surface Water			
Year	Municipal	Industrial	Agriculture	Total
1996	0.0	3.4	403.4	406.8
2025	0.0	3.4	874.9	878.3

As shown in Table 5-4, the irrigation water demand accounts for 99.1 % of the total water demand in 2025. The water balance study was carried out based on the streamflow data at existing stream gauging station at Laoag City (C.A.=1,355 km^2) where mean discharge for a probable 5-year droughty year is derived to be 68.2 m^3/sec and considering the proposed storage type schemes listed below:

Proposed Storage Type Dam Projects in the Laoag River Basin

No.	Name of Scheme	Main Purpose	Status
1	Palsiguan/Nueva	Irrigation	F/S
2	Cura-Tina-Gasgas	Irrigation	F/S

As a result of the water balance study, it is clarified out that, in case of the high economic growth, the total water demand in the year 2025 would be able to be sufficed through the construction either of the above storage type dam projects. From the aspect of the financial overburden, it appears that the Cura-Tina-Gasgas dam project is more preferable.

In case of the lower economic growth, on the other hand, the total water demand in the year 2025 could be met without the provision of new storage type dam.

(3) Water Balance in the Abra River Basin

Out of the river basins situated in the WRR I, the Abra river basin has the largest catchment area of 5,125 km^2. It is located adjacent to the aforesaid Laoag river basin in the south. The Abra river also originates from the Cordillera Mountains. Its catchment area accounts for about 35.6 % of the total area of the WRR I. In case of the higher economic growth scenario, the total water demand in the Abra river basin is projected to be about 346 million m^3/year or 11.0 m^3/sec for the target year 2025. Out of the total water demand, that to be covered by surface water is estimated by deducting the amount shared by groundwater therein from the total water demand as shown in Table 5-5 and below:

Water Demand in the Year 2025, to be Covered by Surface Water: the Abra River Basin

(Unit : MCM)

	Water Demand to be supplied by Surface Water			
Year	Municipal	Industrial	Agriculture	Total
1996	0.0	19.4	215.7	235.1
2025	0.0	19.4	313.3	332.7

As shown in Table 5-5, the irrigation water demand accounts for 68.9 % of the total water demand in 2025. The water balance study was carried out based on the streamflow data at existing stream gauging station at Bumagcat (C.A.=2,575 km^2) where mean discharge for a probable 5-year droughty year is derived to be about 81.0 m^3/sec and considering the proposed storage type schemes listed below:

Proposed Storage Type Dam Projects in the Abra River Basin

No.	Name of Scheme	Main Purpose	Status
1	Binongan/Tineg	Multi-purpose	F/S
2	Supo	Multi-purpose	M/P

The water balance study clarified that the total water demand in the year 2025 would be sufficed under the present condition without the provision of new storage type dam.

5.3.5 Water Balance in the Cagayan and Abulog River Basins : WRR II

(1) Main Features of Water Resources Region II

The Water Resources Region II, the Cagayan Valley Region, has an area of about 34,500 km^2. It is located in the northern portion of Luzon island. It has two major river basins, the Cagayan and Abulog river basins.

The WRR II falls under the type III climate zone, generally characterized by no pronounced maximum rainfall period and a short dry period. It is relatively dry during the period from December to April and wet during the rest of the year. The rainfall pattern varies widely throughout the region. Mean annual air temperature ranges from 23.6 ℃ to 26 ℃. The relative humidity varies from 75 % to 85 % with a normal relative humidity of 80 %.

The agriculture is the primary source of livelihood for a large portion of the valley's population. The secondary economic activity involves the marketing, processing and transportation of agricultural products. However, a ratio of irrigated cropland area to the total cropland area is still as low as less than 10 % as a whole.

(2) Water Balance in the Cagayan River Basin

The Cagayan river basin with a catchment area of 25,619 km^2 occupies a larger part of the WRR II, accounting for about 74 % of the total area of the WRR II. In case of the high economic growth, the total water demand in the Cagayan river basin is projected to be about 14,401 million m^3/year or 456.7 m^3/sec for the target year 2025. Out of the total water demand, that to be covered by surface water is estimated by deducting the amount shared by groundwater therein from the total water demand as shown in Table 5-6 and below:

Water Demand in the Year 2025, to be Covered by Surface Water: the Cagayan River Basin

(Unit : MCM)

	Water Demand to be supplied by Surface Water			
Year	Municipal	Industrial	Agriculture	Total
1996	0.0	1.1	4,320.0	4,321.1
2025	0.0	18.0	14,169.5	14,187.5

As shown in Table 5-6, the irrigation water demand accounts for 99.7 % of the total water demand in 2025. The water balance study was carried out based on the streamflow data at existing stream gauging station at Tuguegarao (C.A.=646 km^2) where mean discharge for a probable 5-year droughty year is derived to be about 31.9 m^3/sec and considering the proposed storage type schemes in the basin.

The Magat multi-purpose dam exists in the Cagayan river basin, one of the major 5 large scale dams in the Philippines. In the previous master plan on water resources development in the

Cagayan river basin, a number of storage type schemes are proposed to be developed to meet the future water demands in various sectors such as irrigation, municipal water. However, none of them has been proceeded to the implementation so far. In addition to the existing Magat dam, the proposed storage type schemes are picked out as the promising schemes in accordance with the Project List of NPC as follows:

Existing and Proposed Storage Type Dam Projects in the Cagayan River Basin

No.	Name of Scheme	Main Purpose	Status
1	Magat	Multi-purpose	Existing
2	Bantay	Multi-purpose	M/P
3	Malig II	Multi-purpose	M/P
4	Abuan	Multi-purpose	F/S
5	Chiko IV	Multi-purpose	D/D
6	Matsuno	Multi-purpose	F/S
7	Diduyon	Hydropower	F/S
8	Siffu I	Multi-purpose	M/P
9	Casecnan* (Abaca dam/Conwap dam)	Multi-purpose	On-going
10	Addalam A	Hydropower	D/D
11	Ilaguen B	Hydropower	D/D

Note: *; The river water impounded by the dam is to be conveyed to the existing Pantabangan reservoir on the Pampanga river through the transbasin tunnel.

Out of the above storage type projects, the Casecnan transbasin project is planned to divert water of the Cagayan basin into existing Pantabangan reservoir on upstream reach of the Pampanga river. In the previous master plan study on water resources development in the Cagayan river basin, the Malig II and Matsuno dams are given a high priority on development. Besides, NPC is planning to develop the two small hydropower projects, namely Addalam A and Ilaguen B. As a result of the water balance study, it is found out that the total water demand in the year 2025 would be able to be met by the river flow to be regulated with the existing Magat dam and these new 4 storage type dams, even though some of the basin runoff is diverted to the Pampanga river basin through the transbasin tunnel.

(3) Water Balance in the Abulug River Basin

The Abulog river basin with a catchment area of 3,372 km^2 is located in the northern part of the Region II, adjacent to the Cagayan river basin in the south. The Abulog river basin is blessed with abundant annual rainfall of more than 3,000 mm. Its catchment area accounts for about 9.8% of the total area of the WRR II. In case of the higher economic growth scenario, the total water demand in the Abulug river basin is projected to be about 941 million m^3/year or 29.8 m^3/sec for the target year 2025. Out of the total water demand, that to be covered by surface water is estimated deducting the amount shared by groundwater from the total water demand as shown in Table 5-7 and below:

Water Demand in the Year 2025, to be Covered by Surface Water: the Abulog River Basin

(Unit : MCM)

Year	Water Demand to be supplied by Surface Water: Municipal	Industrial	Agriculture	Total
1996	0.0	5.1	193.7	198.8
2025	0.0	87.2	935.2	940.3

As shown in Table 5-7, the irrigation water demand accounts for 99.2 % of the total water demand in 2025. The water balance study was carried out based on the streamflow data at existing stream gauging station at Bulu (C.A.=1,609 km^2) where mean discharge for a probable 5-year droughty year is derived to be 142.4 m^3/sec and considering the proposed storage type schemes listed below:

Proposed Storage Type Dam Projects in the Abulog River Basin

No.	Name of Scheme	Main Purpose	Status
1	Gened	Hydropower	F/S
2	Agbulu	Hydropower	D/D

In the 1996 Power Development Program, NPC proposes to complete the Agbulu hydroelectric project until 2006. The water balance study clarified that the total water demand in the year 2025 would be sufficed with the river flow regulated by the proposed new storage type dam.

5.3.6 Water Balance in the Agno and Pampanga River Basins : WRR III

(1) Main Features of Water Resources Region III

The Water Resources Region III, the Central Luzon Region, consists principally of the Agno and Pampanga river basins, covering an area of 23,600 km^2. These two major rivers flow mainly on a valley commonly referred to as the Central Plain of Luzon. The valley floor is relatively flat, extensively cultivated, and has long been known as the rice bowl of the Philippines.

The Type I climate is prevailing in the WRR III, characterized by the two pronounced seasons, namely dry season from November to April and wet season during the rest of the year. The annual average rainfall varies from about 2,000 mm in the central part of the region to more than 3,000 mm in the northwestern part. The mean temperature is comparatively constant throughout a year, annual mean temperature being 27 ℃.

The economic activity in the region is essentially agricultural, but recently a trend towards industrialization takes place especially in the province of Bulcan and Pampanga.

(2) Water Balance in the Agno River Basin

The Agno river basin with a catchment area of 5,952 km^2 is located in the central part of the WRR III. Its catchment area is equivalent to about 25.2 % of the total area of the WRR III. In case of high economic growth scenario, the total water demand in the Agno river basin is projected to be about 8,024 million m^3/year or 254.4 m^3/sec for the target year 2025. Out of the total water demand, that to be covered by surface water is estimated extracting the amount shared by groundwater from the total water demand as shown in Table 5-8 and below:

Water Demand in the Year 2025, to be Covered by Surface Water: the Agno River Basin

(Unit : MCM)

Year	Water Demand to be supplied by Surface Water: Municipal	Industrial	Agriculture	Total
1996	1.0	0.7	1,285.3	1,287.0
2025	336.9	0.7	5,392.8	5,730.4

As shown in Table 5-8, the irrigation water demand accounts for 99.5 % of the total water demand in 2025. There exist two major reservoirs on a mainstream of the Agno, namely the Ambuklao and Binga dam/reservoirs. Besides, construction of the San Roque muli-purpose dam project that has an active storage volume of 575 million m^3 is going to start in the near future. The water balance study was carried out based on the streamflow data at existing Pangasinan stream gauging station (C.A.=281 km^2) where mean discharge for a probable 5-year droughty year is derived to be 14.9 m^3/sec and considering the existing and proposed storage type projects listed below:

Existing and Proposed Storage Type Dam Projects in the Agno River Basin

No.	Name of Scheme	Main Purpose	Status
1	Ambuklao	Hydropower	Existing
2	Binga	Hydropower	Existing
3	San Rouque	Multi-Purpose	On-going
4	Boloc II	Hydropower	M/P
5	Mount Caas	Hydropower	M/P
6	Mount Caas	Hydropower	M/P
7	Tebbo	Hydropower	M/P
8	Balog-Balog	Multi-purpose	F/S

There exist two large-scale storage type dams in the Agno river basin, namely the Ambuklao and Binga dams. In addition, the San Rouque dam is going to be implemented in a form of BOT. The other dams were identified in this study on the basis of 1 to 50,000 scaled topographic maps except for the Balog-Balog multi-purpose dam project on which a feasibility study was carried out. As a result of the water balance study, it is forecast that the total water demand in the year 2025 would be almost met after the completion of the Balog-Balog multi-purpose dam project.

(3) Water Balance in the Pampanga River Basin

The Pampanga river basin occupies a catchment area of 6,487 km^2, located adjacent to the Agno river basin in the east. Its catchment area accounts for about 27.5 % of the total area of the WRR III. In case of high economic growth scenario, the total water demand in the Pampanga river basin is projected to be about 9,829 million m^3/year or 311.7 m^3/sec for the target year 2025. Out of the total water demand, that to be covered by surface water is estimated deducting the amount shared by groundwater from the total water demand as shown in Table 5-9 and below:

Water Demand in the Year 2025, to be Covered by Surface Water: the Pampanga River Basin

(Unit : MCM)

	Water Demand to be supplied by Surface Water			
Year	Municipal	Industrial	Agriculture	Total
1996	0.0	14.1	2,215.0	2,229.1
2025	266.2	14.1	6,022.8	6,303.1

As shown in Table 5-9, the irrigation water demand accounts for 94.7 % of the total water demand in 2025. The Pantabangan reservoir is provided on a mainstream of the Pampanga river. It has an active storage volume of 1,757 million m^3. Besides, the inflow is going to be augmented by water diverted from the Cagayan river basin after the completion of the Casecnan Transbasin project. The water balance study was carried out based on the streamflow data at the same stream gauging station as that used for the water balance study of the Agno river basin, since the Arayat stream gauging station on the Pampanga river which is selected through the hydrological analysis is much affected by diversion of river water at upstream point for irrigation water supply. The following existing and proposed storage type projects are considered in carrying out the water balance study.

Existing and Proposed Storage Type Dam Projects in the Agno River Basin

No.	Name of Scheme	Main Purpose	Status
1	Pantabangan	Multi-Purpose	Existing
2	Angat	Multi-Purpose	Existing
3	Casecnan Transbasin	Multi-Purpose	On-going
4	Balintingon	Multi-purpose	F/S

The water balance study clarified that the total water demand in the year 2025 would be almost sufficed with the river flow regulated by the existing and proposed 3 storage type dams as well as that augmented by the Casecnan Transbasin Project in case of high economic growth scenario.

5.3.7 Water Balance in the Pasig-Laguna Bay and Amnay-Patrick River Basins: WRR IV

(1) Main Features of the Water Resources Region IV

The Water Resources Region IV, the Southern Tagalog Region, with a total area of 46,500 km^2, consists of the southern part of Luzon island and islands inclusive of Mindoro, Palawan and Rombilin. It also includes the Metropolitan Mnaila area. The Luzon portion is relatively flat with some isolated hills. It is further punctuated by the presence of two famous inland water bodies, namely Laguna lake and Taal lake. Mindoro island is mountainous with coastal plain on the east and southwest sides where its towns and settlement are located, but hinterlands have remained largely unexplored.

The Type I climate is predominant in the WRR IV, although all of the four climate types are observed there. The region is characterized by the two pronounced seasons, namely dry season from November to April and wet season during the rest of the year. The annual average rainfall varies from about 1,500 mm in the southwestern part to 2,000 mm in the northeastern part. Thus, the annual rainfall amount in the region is small to some extent as compared with those in the northern regions of Luzon island.

The industrial activity in the region concentrates in Metro Manila and its surrounding provinces, while the other areas are still agricultural. On the other hand, it is forecast that the agricultural lands in the region would decrease from now on due to the urbanization.

(2) Water Balance in the Pasig-Laguna Bay Basin

The Pasig-Laguna Bay basin with a catchment area of 4,678 km^2 is located in the northern part of the WRR IV. It covers the Metro Manila area. Numerous streams inflow into the Laguna lake, from which the Pasig river flows down to the Manila bay. The water use of the river is observed mainly in the upper basin of the Pasig river and catchment area of the Laguna lake. Since the municipal water for the Metro Manila is being supplied mainly from existing Angat dam, the water balance study for the basin is made for the area excluding the Metro Manila. In the present study, the total water demand in the Pasig-Laguna Bay basin is projected to be 3,596 million m^3/year or 114.0 m^3/sec for the target year 2025. Out of the total water demand, that to be covered by surface water is estimated by deducting the amount shared by groundwater from the total demand as shown in Table 5-10 and below:

Water Demand in the Year 2025, to be Covered by Surface Water: the Pasig-Laguna Bay River Basin

(Unit : MCM)

Year	Water Demand to be supplied by Surface Water			
	Municipal	Industrial	Agriculture	Total
1996	0.0	223.3	150.7	374.0
2025	0.0	0.0	399.6	399.6

Note : The water demands for Metro Manila are deducted.

As shown in Table 5-10, the irrigation water demand accounts for 100 % of the total water demand in 2025. The water balance study was carried out based on the streamflow data at existing Gen Trias stream gauging station where mean discharge for a probable 5-year droughty year is derived to be 0.57 m^3/sec and considering the following existing storage type scheme:

Existing Storage Type Dam Project in the Pasig-Laguna Bay Basin

No.	Name of Scheme	Main Purpose	Status
1	Caliraya	Hydropower	Existing

For the time being, no large scale storage type schemes are proposed to be provided in the basin. As a result of the water balance study, it is found out that the total water demand in the year 2025 would be almost sufficed in case of the high economic scenario. In case that the water shortage is likely to take place in the future, it is recommended to construct the small water impounding dams shown in Figure 5-15 (1/3).

(3) Water Balance in the Amnay-Patrick River Basin

Out of the river basins in the WRR IV, the Amnay-Patrick river basin has the largest catchment area of 993 km^2. It is located in the western part of Mindoro island. Its catchment area accounts for about 2.1 % of the total area of the WRR IV. In the present study, the total water demand in the Amnay-Patrick river basin is projected to be about 817 million m^3/year or 25.9 m^3/sec for the target year 2025. Out of the total water demand, that to be covered by surface water is estimated by extracting the amount shared by groundwater therein from the total water demand as shown in Table 5-11 and below:

Water Demand in the Year 2025, to be Covered by Surface Water: the Amnay-Patrick River Basin

(Unit : MCM)

Year	Water Demand to be supplied by Surface Water			
	Municipal	Industrial	Agriculture	Total
1996	0.0	0.1	53.8	53.9
2025	0.0	0.1	704.6	704.7

As seen above, the irrigation water demand accounts for almost all of the total water demand in 2025. For the time being, there is no candidate of the large scale storage type schemes in the Amnay-Patrick river basin. The water balance study was carried out based on the streamflow data at existing stream gauging station on the Caguray river (C.A.=136 km^2) where mean discharge for a probable 5-year drought year is derived to be 8.4 m^3/sec, taking into account the following storage type dam identified in this study:

Identified Storage Type Dam in the Amnay-Patrick River Basin

No.	Name of Scheme	Main Purpose	Status
1	Amnay	Multi-Purpose	M/P

The water balance study clarified that the total water demand in the year 2025 would be sufficed by means of providing the Amnay multi-purpose dam in the future.

5.3.8 Water Balance in the Bicol River Basins ; WRR V

(1) Main Features of Water Resources Region V

The Bicol river basin is the only one major river basin that exists in the WRR V, the Bicol Region, with a total land area of 17,600 km^2. It is located in the most southern part of of Luzon island and its surrounding islands. In the Luzon portion of the region, the major topographic features are the Eastern Bicol Cordillera in the northeast, the Ragay hills in the southwest, and the Bicol Plain in the central portion. Mt. Mayon is a part of the cordillera, having the highest portion in the area with an elevation of 2,421 m above sea level.

The climate in the region falls under three types in the different parts, while the eastern portion over the Bicol Peninsula is characterized by the Type II climate with no dry season with very pronounced maximum rainfall from November to May. As a whole, the region has an annual average rainfall of about 2,300 mm and a mean temperature of 27 ℃.

The economic activity in the WRR V is generally agricultural, such crops as rice, copra, corn and abaca being the principal crops.

(2) Water Balance in the Bicol River Basin

The Bicol river basin with a catchment area of 3,771 km^2 is located in the northern part of the WRR V, originating from the Cordillera Mountains. Its catchment area is equivalent to about 21.4 % of the total area of the WRR V. In case of the higher economic growth, the total water demand in the Bicol river basin is projected to be about 1,977 million m^3/year or 62.7 m^3/sec for the target year 2025. Out of the total water demand, that to be covered by surface water is estimated deducting the amount shared by groundwater therein from the total water demand as shown in Table 5-12 and below:

Water Demand in the Year 2025, to be Covered by Surface Water: the Bicol River Basin

(Unit : MCM)

Year	Water Demand to be supplied by Surface Water			
	Municipal	Industrial	Agriculture	Total
1996	0.0	2.1	619.5	621.6
2025	2.2	14.8	1,161.4	1,178.4

As seen above, the irrigation water demand accounts for 99.2 % of the total water demand in 2025. There are neither existing storage type dams nor proposed ones in the Bicol river basin. However, natural lakes scatter in the basin, which are considered to contribute to the seasonal regulation of the natural streamflow of the Bicol. These are Buhl, Bato and Baao lakes. The water balance study was carried out based on the streamflow data at existing Sto. Domingo stream gauging station where mean discharge for a probable 5-year droughty year is derived to be 25.1 m^3/sec and considering the following two storage type dam projects identified through this study:

Proppposed Storage Type Dam Projects in the Bicol River Basin

No.	Name of Scheme	Main Purpose	Status
1	Sipocot	Multi-purpose	M/P
2	Talisay	Multi-purpose	M/P

As a result of the water balance study, streamflow of the Bicol river needs to be regulated to irrigate the target area of paddy fields in 2025. This study proposes to implement the Talisay multi-purpose dam project in order to suffice the water demands until the target year of 2025 out of the above two storage type dams identified through this study.

5.3.9 Water Balance in the Panay, Jalaur and Ilog-Hilabangan River Basins : WRR VI

(1) Main Features of the Water Resources Region VI

The Water Resources Region VI, the Western Visayas Region, with a total area of some 20,200 km^2, covers Negros island and Panay island. Three major river basins lie in the WRR VI, namely the Panay and Jalaur river basins in Panay island and the Ilog-Hilabangan river basin in Negros island. In Panay island, the major topographic features are the Cordillera Mountains on the west, as well as the wide plains and rolling terrain on the central and eastern portions of the island. The eastern periphery of Negros island is bounded by high mountains with most of its flat lands located in the western and northwestern portions thereof.

The two types of climate are prevailing over the WRR VI. The western halves of Panay island and Negros island are under Type I, characterized by two pronounced seasons, the dry season from November to April and the wet season during the rest of the year. The rest of the region is under the Type III climate, having seasons not very pronounced, but relatively dry season from November to April and wet season during rest of the year. As a whole, the region has an average annual rainfall of about 2,500 mm. The mean annual temperature is 27.5℃ with little variation throughout a year.

The major economic activity in the WRR VI is agricultural and the sugar industry. The major crops are sugar cane, rice and corn. The other land uses comprise pastures, timberlands, farmsteads and open spaces. Negros island is the top sugar-producing area in the Philippines, producing about twice the total productions in the rest of the country in 1960's.

(2) Water Balance in the Panay River Basin

The Panay river basin with a catchment area of 1,843 km^2 drains the northeastern area of Panay island situated in the WRR VI. The Panay multi-purpose dam was proposed to be provided on the upper reach of the Panay. The study was carried out at a pre-feasibility study level in the past. In case of the higher economic growth scenario, the total water demand in the Panay river basin is projected to be about 655 million m^3/year or 20.8 m^3/sec for the target year 2025. Out of the total water demand, that to be covered by surface water is estimated extracting the amount shared by groundwater therein from the total water demand as shown in Table 5-13 and below:

Water Demand in the Year 2025, to be Covered by Surface Water: the Panay River Basin

(Unit : MCM)

Year	Water Demand to be supplied by Surface Water			
	Municipal	Industrial	Agriculture	Total
1996	2.3	1.9	52.9	57.1
2025	26.2	1.9	296.4	324.5

As shown in Table 5-13, the irrigation water demand accounts for 90.3 % of the total water demand. The water balance study was carried out based on the streamflow data at existing Tacas Cuartero stream gauging station (C.A.=880 km^2) where mean discharge for a probable 5-year drought year is derived to be 45.6 m^3/sec and considering the following proposed storage type scheme:

Proposed Storage Type Dam Project in the Panay River Basin

No.	Name of Scheme	Main Purpose	Status
1	Panay	Multi-Purpose	F/S

As a result of the water balance study, it is found out that the total projected water demand for the year 2025 would be almost met by means of implementing the Panai multi-purpose dam project.

(3) Water Balance in the Jalaur River Basin

The Jalaur river basin is located south of the Panay river basin in the island of Panay, adjacent thereto. It covers a catchment area of 1,503 km^2, generally flowing down southwards. The catchment area accounts for about 7.4 % of the total area of the WRR VI. In case of the higher economic growth scenario, the total water demand in the Jalaur river basin is projected to be about 1,463 million m^3/year or 46.4 m^3/sec for the target year 2025. Out of the total water demand, that to be covered by surface water is estimated deducting the amount shared by groundwater from the total water demand as shown in Table 5-14 and below:

Water Demand in the Year 2025, to be Covered by Surface Water: the Jalaur River Basin

(Unit : MCM)

Year	Water Demand to be supplied by Surface Water			
	Municipal	Industrial	Agriculture	Total
1996	0.0	0.2	219.3	219.5
2025	0.0	0.2	620.0	620.2

Table 5-14 reveals that in the year 2025 the irrigation water demand accounts for 98.6 % of the total water demand. In the previous study, the Jalaur multi-purpose dam was proposed to be provided in the upper reach, while the study on Jalaur Irrigation Systems and Rural Development Project which is now underway under JICA proposes to improve and rehabilitate the total irrigation service area of 21,720 ha on the condition without any of new water resources development projects therein. As shown in the above, in the Jalaur river basin, the irrigation water demand accounts for most part of the total demand. On the other hand, the water balance study clarifies that the storage type dam or small impounding dams would need to be provided in order to meet the water demand after 2020.

(4) Water Balance in the Ilog-Hilabangan River Basin

The Ilog-Hilabangan river basin is situated in the southern part of Negros island with a catchment area of 1,945 km^2. It is the largest river basin in Negros island, occupying about 9.6 % of the total area of the WRR VI. In case of the higher economic growth scenario, the total water demand in the Ilog-Hilabangan river basin is projected to be 1,167 million m^3/year or 37.0 m^3/sec for the target year 2025. Out of the total water demand, that to be covered by surface water is estimated by extracting the amount shared by groundwater therein from the total water demand as shown in Table 5-15 and below:

Water Demand in the Year 2025, to be Covered by Surface Water: the Ilog-Hilabangan River Basin

(Unit : MCM)

Year	Water Demand to be supplied by Surface Water			
	Municipal	Industrial	Agriculture	Total
1996	0.0	140.7	2.8	316.9
2025	0.0	140.7	500.1	640.8

As shown in Table 5-15, the irrigation water demand accounts for 77.6 % of the total water demand in 2025. For the time being, there is no candidate of the large scale storage type schemes in the the Ilog-Hilabangan river basin. The water balance study was carried out based on the streamflow data at existing stream gauging station at Pandang Orong with a catchment area of 1,453 km^2 where mean discharge for a probable 5-year drought year is derived to be 48.7 m^3/sec and considering the following storage type dam project:

Proposed Storage Type Dam Project in the Ilog-Hilabangan River Basin

No.	Name of Scheme	Main Purpose	Status
1	Ilog No. 1	Multi-Purpose	M/P

As a result of the water balance study, it is estimated that the projected water demand for the target year 2025 would be able to be sufficed by means of providing the above Ilog No. 1 multi-purpose dam.

5.3.10 Water Balance in the Agusan, Tagaloan and Cagayan De Oro River Basins : WRR X

(1) Main Features of Water Resources Region X

The Water Resources Region X, the Northern Mindanao Region, with an area of about 24,300 km², occupies the northern portion of Mindanao Island. There are three major river basins in the WRR X, namely the Agusan, Tagaloan and Cagayan De Oro river basins.

The climate of the region is characterized by no dry season, but with a very pronounced precipitation period generally during the months of December through March. Normal annual precipitation varies from less than 2,000 mm in the extremely southern portion of the region to over 3,000 mm in the northeastern portion. The air temperature is comparatively constant with the mean temperature of about 25 ℃.

The major physiographic features are the Pacific Cordillera on the east, the Central Cordillera on the west and the Davao-Agusan trough in the central part of the basin. The Davao-Agusan trough is a down-warped valley with its flood plain at the central part. The central flood plain sloped gently downstream to the north, and is generally less than 50 meters above sea level.

Forestry and logging is the major industry in the region. Agricultural development is, besides, fast progressed with the construction of several irrigation projects. Livestock farming is also developing as the major activity.

(2) Water Balance in the Agusan River Basin

The Agusan river basin has the third largest catchment area of 10,921 km² in the philippines. It is located in the northern part of the WRR X, originating from the Cordillera Mountains. It occupies a major part of the WRR X, accounting for about 45 % of the total area thereof. In case of the higher economic growth scenario, the total water demand for the Agusan river basin is projected to be about 2,172 million m³/year or 68.9 m³/sec for the target year 2025. Out of the total water demand, that to be covered by surface water is estimated extracting the amount shared by groundwater therein from the total water demand as shown in Table 5-16 and below:

Water Demand in the Year 2025, to be Covered by Surface Water: the Agusan River Basin

(Unit : MCM)

	Water Demand to be supplied by Surface Water			
Year	Municipal	Industrial	Agriculture	Total
1996	0.0	1.8	311.8	313.6
2025	0.0	1.8	2,047.3	2,049.1

As seen in the above, the irrigation water demand in year 2025 accounts for 99.6 % of the total water demand in 2025. For the time being, no storage type schemes are proposed to be provided in the basin. The water balance study was carried out based on the streamflow data at existing Kalaw Bridge stream gauging station with a catchment area of 1,355 km² where mean discharge for a probable 5-year drought year is derived to be 59.3 m³/sec.

The water balance study clarified that the total water demand in the year 2025 would be sufficed with the river flow under the present condition.

(3) Water Balance in the Tagaloan River Basin

Out of the river basins, the Tagaloan river basin covers a catchment area of 1,704 km², located adjacent to the aforesaid Agusan river basin in the east. The catchment area accounts for about 7 % of the total area of the WRR X. In case of the higher economic growth scenario, the total water demand in the Tagaloan river basin is projected to be about 283 million m³ or 9.0 m³/sec for the target year 2025. Out of the total water demand, that to be covered by surface water is estimated by deducting the amount shared by groundwater from the total water demand as follows:

Water Demand in the Year 2025, to be Covered by Surface Water: the Tagaloan River Basin
(Unit : MCM)

Year	Water Demand to be supplied by Surface Water: Municipal	Industrial	Agriculture	Total
1996	0.8	29.7	8.5	39.0
2025	33.9	29.7	111.0	174.6

Table 5-17 shows that in 2025 the irrigation water demand accounts for 60.1 % of the total water demand in 2025. The water balance study was carried out based on the streamflow data at existing stream gauging station at Pina-auan (C.A.=533 km^2) where mean discharge for a probable 5-year droughty year is derived to be 22.0 m^3/sec. Although the Tagaloan II hydroelectric project is originally planned to be of the storage type dam project, NPC proposes to develop it as the run-of-river type project in the latest 1996 Power Development Project. This study identified the following multi-purpose dam project on the Tagaloan river:

Identified Storage Type Dam Project in the Tagaloan River Basin

No.	Name of Scheme	Main Purpose	Status
1	Tagaloan	Multi-Purpose	M/P

The water balance study clarified that the total water demand in the year 2025 would be met with the streamflow to be regulated by the storage type dam above.

(4) Water Balance in the Cagayan De Oro River Basin

The Cagayan De Oro river basin is located in the eastern part of the WRR X with a catchment area of 1,521 km^2, adjacent to the aforesaid Tagoloan river basin in the east. The catchment area accounts for about 6.3 % of the total area of the WRR X. In case of the higher economic growth scenario, the total water demand in the Cagayan De Oro river basin is projected to be about 316 million m^3/year or 10.0 m^3/sec for the target year 2025. Out of the total water demand, that to be covered by surface water is estimated by extracting the amount shared by groundwater therein from the total water demand as shown in Table 5-18 and below:

Water Demand in the Year 2025, to be Covered by Surface Water: the Cagayan De Oro River Basin
(Unit : MCM)

Year	Water Demand to be supplied by Surface Water: Municipal	Industrial	Agriculture	Total
1996	1.8	39.4	4.1	45.3
2025	71.0	143.5	177.9	288.4

As shown in Table 5-18, the irrigation water demand accounts for 60.3 % of the total water demand in 2025. The Bulanog-Batang hydroelectric project is proposed to be constructed on the Cagayan De Oro river. It is planned to be developed as the reservoir type dam with an active reservoir storage volume of 102 MCM. The streamflow to be regulated by the storage type dam is going to be utilized for municipal water supply to Cagayan De Oro City. The water balance study was carried out based on the streamflow data at existing stream gauging station at Uguiaban (C.A.=532 km^2) where mean discharge for a probable 5-year drought year is derived to be 59.6 m^3/sec and the proposed storage type dam project:

Proposed Storage Type Dam Project in the Cagayan De Oro River Basin

No.	Name of Scheme	Main Purpose	Status
1	Bulanog-Batang	Hydropower	F/S

The water balance study clarified that the total water demand in the year 2025 would be sufficed with the streamflow to be regulated by the proposed storage type dam.

5.3.11 Water Balance in the Davao, Tagum-Libuganon and Buyan-Marungun River Basins : WRR XI

(1) Main Features of Water Resources Region XI

The Water Resources Region XI, the Eastern Mindanao Region, with a total area of about 24,900 km^2, occupies the southeastern portion of Mindanao Island. There are three major river basins in the WRR XI, namely the Davao, Tagun-Libuganon and Buyan-Marungun river basins.

The region falls under the zones of the two climatic types of the Philippines, namely Type II and Type IX. In the Davao river basin, the type IV climate prevails, having rainfall more or less evenly distributed throughout a year. The average annual precipitation varies from 1,000 mm at the south to over 2,000 mm in the northeastern portion.

The main topographic features of the region are the Diwata Mountains in Surigao del Sur and the Mayo and Kampali Mountains in Davao Oriental, both fronting the Pacific Ocean and rising to elevations of more than 900 meters above mean sea level. The mountain ranges dividing the Cotabato and Agusan River Basins, also with elevations rising to more than 900 meters above sea level, run down from Davao del Norte to the Sarangani Bay and forms the western periphery of the region. Low-lying areas with elevations ranging from 0.3 meters to 300 m, dominate the region.

(2) Water Balance in the Davao River Basin

The Davao river basin with a catchment area of 1,623 km^2 is located in the northern part of the WRR XI. As described in the Inception Report, it was conceived that the water shortage would take place in Davao city in the future, which is a central city of the region in view of the economic activity. Hence, several storage type dams were identified in the first stage field investigation of this study.

In case of the high economic growth scenario, the total water demand in the Davao river basin is projected to be about 426 million m^3/year or 13.5 m^3/sec for the target year 2025. Out of the total water demand, that to be covered by surface water is estimated by deducting the amount shared by groundwater therein from the total water demand as shown in Table 5-19 and below:

Water Demand in the Year 2025, to be Covered by Surface Water: the Davao River Basin

(Unit : MCM)

Year	Water Demand to be supplied by Surface Water			
	Municipal	Industrial	Agriculture	Total
1996	7.6	10.6	20.8	39.0
2025	90.6	10.6	257.9	359.1

As shown in Table 5-19, the basin has a characteristic that the future water demand to be supplied by surface water is considerably small because of the comparatively abundant groundwater. In 2025 the irrigation water demand accounts for 67.1 % of the total water demand. The water balance study was carried out based on the same streamflow data as those used for the water balance study of the Agusan river basin and considering the following storage type dam projects identified in this study:

Identified Storage Type Dam Projects in the Davao River Basin

No.	Name of Scheme	Main Purpose	Status
1	Davao I	Multi-purpose	M/P
2	Davao II	Multi-purpose	M/P
3	Davao III	Multi-purpose	M/P

Out of the above three storage type dams, the Davao II dam project is considered to be the most preferable from the financial aspect. The water balance study clarified that the total water demand in the year 2025 would be sufficed with the streamflow regulated by the Davao II dam.

(3) Water Balance in the Tagum-Libuganon River Basin

The Tagum-Libuganon river basin has a catchment area of 3,064 km^2. It is situated adjacent to the Agusan river basin of the WRR X in the south. The catchment area accounts for about 12.3 % of the total one of the WRR XI. In case of the high economic growth scenario, the total water demand in the Tagum-Libuganon river basin is projected to be about 1,131 million m^3/year or 35.9 m^3/sec for the target year of 2025. Out of the total water demand, that to be covered by surface water is estimated by deducting the amount shared by groundwater from the total water demand as shown in Table 5-20 and below:

Water Demand in the Year 2025, to be Covered by Surface Water: the Tagum-Libuganon River Basin

(Unit : MCM)

Year	Water Demand to be supplied by Surface Water			
	Municipal	Industrial	Agriculture	Total
1996	0.0	39.1	226.1	265.2
2025	0.0	39.1	245.4	915.1

As shown in Table 5-20, the irrigation water demand accounts for 94.9 % of the total water demand in 2025. The water balance study was carried out based on the same streamflow data as those used for the water balance study of the Agusan river basin. To meet the water demand until the year 2025, the following storage type was identified in this study:

Identified Storage Type Dam Project in the Tagum-Libuganon River Basin

No.	Name of Scheme	Main Purpose	Status
1	Bubonao	Multi-Purpose	M/P

The water balance study clarified that the total water demand would be sufficed through the provision of the identified storage type dam.

(4) Water Balance in the Buyan-Marungun River Basin

The Buyan-Marungun river basin is located in the southern part of the WRR XI with a catchment area of 1,434 km^2. The catchment area accounts for about 5.8 % of the total area of the WRR XI. In case of the high economic growth scenario, the total water demand in the Buyan-Marungun river basin is projected to be about 766 million m^3/year or 24.3 m^3/sec for the target year of 2025. Out of the total water demand, that to be covered by surface water is estimated by deducting the amount shared by groundwater from the total water demand as shown in Table 5-21 and below:

Water Demand in the Year 2025, to be Covered by Surface Water: the Buyan-Marungun River Basin

(Unit : MCM)

Year	Water Demand to be supplied by Surface Water			
	Municipal	Industrial	Agriculture	Total
1996	1.0	129.1	59.0	189.1
2025	11.9	129.1	559.6	700.6

As seen in the above, the irrigation water demand accounts for 78.8 % of the total water demand in 2025. The following storage dam is identified in this study:

Identified Storage Type Dam Project in the Buayan-Marungun River Basin

No.	Name of Scheme	Main Purpose	Status
1	Dimuloc	Multi-purpose	M/P

The water balance study was carried out based on the same streamflow data as those used for the water balance study of the Agusan river basin. The water balance study clarified that the total water demand in the year 2025 would be sufficed by means of providing the Dimuloc multi-purpose dam.

5.3.12 Water Balance in the Mindanao and Agus River Basins : WRR XII

(1) Main Features of Water Resources Region XII

The Water Resources Region XII, the Southern Mindanao Region, covering an area of about 31,900 km^2, occupies the southeastern part of Mindanao Island. The two major river basins, the Mindanao and Agus river basins, are situated in the WRR XII.

The major land forms in the basin are the Central Cordillera on the eastern side, the Tiruray highland in the southwest, and the Lanao Bukidnon highland to the north. The Central Cordillera extends in a northerly direction for about 400 kilometers. The average elevation of this mountain chain is about 1,200 meters with the peak elevation of 2,954 meters reached at Mt. Apo, the highest point in the Philippines.

The northern portion of the WRR XII falls under the Type III climate zone in which the seasons are not very pronounced, relatively dry from November to April and wet during the rest of the year. The rest of the region is subject to the Type IV climate. The mean annual rainfall ranges between 1,500 mm in the southern part and about 2,500 mm in the northern part of the region. The mean annual temperature is recorded at 27.5 ℃ in the south and at 23.6 ℃ in the north.

Agriculture is the major economic activity in the region with the intensification of irrigation development and extension services in the Cotabato river basin. Cattle raising in the Bukidnon areas is also a major activity. Concerning industries, logging, sawmills and grain-mills are important activities.

(2) Water Balance in the Agus River Basin

The Agus river basin is located in the western part of the Mindanao river basin with a catchment area of 1,890 km^2. The Agus river outflows from the Lanao lake. Thus, the Agus river is blessed with stable streamflow since it is regulated by the large natural lake. A series of hydropower stations are provided along the Agus river utilizing the abundant streamflow as well as steep slope. The catchment area accounts for about 5.9 % of the total area of the WRR XII.

In case of the higher economic growth scenario, the total water demand for the Agus river basin is projected to be about 1,900 million m^3/year or 60.3 m^3/sec for the target year 2025. Out of the total water demand, that to be covered by surface water is estimated by deducting the amount shared by groundwater therein from the total demand as shown in Table 5-22 and below:

Water Demand in the Year 2025, to be Covered by Surface Water: the Agus River Basin

(Unit : MCM)

	Water Demand to be supplied by Surface Water			
Year	Municipal	Industrial	Agriculture	Total
1996	0.0	72.2	72.6	144.8
2025	103.5	72.2	1,312.8	1,488.5

As seen in the above, the irrigation water demand accounts for 87.9 % of the total water demand in 2025. The water balance study was carried out based on the streamflow data at existing stream gauging station on the Pulangi river (C.A.=3,100 km^2) where mean discharge for a probable 5-year droughty year is derived to be 114.4 m^3/sec and considering the existing lake-outlet type scheme listed below:

Existing Storage Type Dam Project in the Agus River Basin

No.	Name of Scheme	Main Purpose	Status
1	Agus I	Hydropower	Existing

The water balance study clarified that the total water demand in the year 2025 would be sufficed with the river flow regulated by the existing lake-outlet type project.

(3) Water Balance in the Mindanao River Basin

The Mindanao river basin is the second largest one in the Philippines with a catchment area of 23,169 km^2. The catchment area accounts for about 72.6 % of the total area of the WRR XII. The river basin is largely divided into three major tributary basins, the Pulangi, Allar and Darika river basins out of which the Pulangi river basin is dominantly large. A total of six hydropower projects are provided or proposed to be provided on the Pulangi river in order to harness the potential head. Also on the Allah river, one hydropower project is proposed so far. Thus, the water resources development plans for the Mindanao river basin have been established more intensively through the previous studies as compared with other major river basins in Mindanao island.

In case of the higher economic growth scenario, the total water demand in the Mindanao river basin is projected to be 13,634 million m^3/year or 432.3 m^3/sec for the target year 2025. Out of the total water demand, that to be covered by surface water is estimated by deducting the amount shared by groundwater from the total water demand as shown in Table 5-23 and below:

Water Demand in the Year 2025, to be Covered by Surface Water: the Mindanao River Basin

(Unit: MCM)

	Water Demand to be supplied by Surface Water			
Year	Municipal	Industrial	Agriculture	Total
1996	0.0	9.6	2,393.1	2,402.7
2025	1.2	9.6	13,476.2	13,487.0

Table 5-23 shows that in 2025 the irrigation water demand accounts for 99.8 % of the total water demand. The water balance study was carried out based on the streamflow data at existing stream gauging station on the Pulangi river and considering the existing and proposed storage type schemes listed below:

Existing and Proposed Storage Type Dam Projects in the Mindanao River Basin

No.	Name of Scheme	Main Purpose	Status
1	Pulangi I	Hydropower	Pre-F/S
2	Pulangi II	Hydropower	Pre-F/S
3	Pulangi III	Hydropower	F/S
4	Pulangi V	Hydropower	Pre-F/S
5	Pulangi VI	Hydropower	Pre-F/S
6	Maganoy	Hydropower	F/S

NPC is planning to complete the Pulangi V hydropower project in 2000's. The water balance study clarified that the total water demand in the year 2025 would be sufficed with the river flow regulated by the proposed storage type dam project. Furthermore, there are still abundant water resources in the Mindanao river basin which would enable further exploitation of water use for various sectors in and around the basin in the future, provided that the proposed storage type dams are constructed in series.

5.4 Surface Water Resources Development Plan for Major River Basin

5.4.1 Proposed Storage Type Dams

The main features of the impounding dam schemes as a measure to augment the surface water were obtained through the data collection from NPC and NIA in the present stage. In addition, several reservoir type schemes are newly identified through studying 1 to 50,000 scaled topographic maps. As described in the foregoing Section 5.3, the water demand and supply balance studies are carried out applying those future water demands and main features of the reservoir type developments in order to clarify the necessity of the reservoir type dam development to meet the surface water demand up to the target year 2025.

The necessity of new dam projects to meet the water demand until the year 2025 was assessed under the following conditions:

i) The water demands under the higher economic growth scenario are realized throughout the study period.

ii) The reservoir type dam projects, which are proceeded to be implemented in a form of BOT, are to be completed as originally scheduled.

Consequently, it is foreseen that the following major river basins would be subject to the water shortage for the period until the year 2025 in case of the high economic growth, requiring the development of new storage type dams:

Major River Basins Likely to Cause Water-Constraint until Year 2025

No.	Major River Basin	Water Resources Region (WRR)	Location (Group of Islands)
1	Laoag	WRR I	Luzon
2	Abra	WRR I	Luzon
3	Cagayan	WRR II	Luzon
4	Abulug	WRR II	Luzon
5	Agno	WRR III	Luzon
6	Pampanga	WRR III	Luzon
7	Amnay-Patric	WRR IV	Luzon
8	Bicol	WRR V	Luzon
9	Panay	WRR VI	Visayas
10	Jalur	WRR VI	Visayas
11	Ilog-Hilabangan	WRR VI	Visayas
12	Tagoloan	WRR X	Visayas
13	Cagayan De Oro	WRR IX	Mindanao
14	Tagum Libugannon	WRR XI	Mindanao
15	Davao	WRR XI	Mindanao
16	Buayan-Malungon	WRR XII	Mindanao
17	Mindanao	WRR XII	Mindanao

As listed above, a total of seventeen (17) major river basins would require the new surface water development in addition to the existing large scale dams and on-going and committed BOT projects in order to meet the water demands until the year 2025. Out of these 17 major river basins, it is forecasted that the major river basins in Luzon Island would face to the more serious water shortage until the year 2025.

With regard to each of the 17 major river basins that are likely to encounter the water shortage until the year 2025, the priority schemes are selected from those listed in Table 5-2 in order to meet the future water demand. The priority schemes are selected in accordance with the principles:

- The first priority is given to the impounding scheme which NPC and/or NIA propose to implement at earlier time,

- The impounding schemes on which higher level of study were carried out are given higher priority on implementation, as long as it is technically and economically feasible in the previous study. This means that the impounding schemes are lined up in the development plan for the water-constraint major river basin in order of their study levels, namely definite design, feasibility study, pre-feasibility study and map study,

- The impounding schemes that are not likely to have the significant adverse effects on natural and social environment, are given higher priorities.

The priority projects for meeting the future water demands are selected for each of the water-constraint major river basin taking into full consideration of the above principles as follows:

List of Proposed Impounding Dam Projects for Major River Basins

No.	Major River Basin	Water Resources Region (WRR)	Candidate Reservoir Type Projects to be Implemented up to Year 2025	
			Nos. of Candidate Projects	Name of Candidate Projects
1	Laoag	WRR I	2	Palsiguan-Nueva Multi-Purpose Dam Project Tina-Gasgas-Cura Multi-Purpose Dam Project
2	Abra	WRR I	1	Binongan Multi-Purpose Dam Project
3	Cagayan	WRR II	4	Mallig II Multi-Purpose Dam Project Matuno Multi-Purpose Dam Project Addalam A Hydroelectric Project Ilaguen B Hydroelectric Project
4	Abulug	WRR II	1	Agulubu Hydroelectric Project
5	Agno	WRR III	1	Balog-Balog Multi-Purpose Dam Project
6	Pampanga	WRR III	2	Balintingon Multi-Purpose Dam Project Bayabas and Massin Dam Project
7	Amnay-Patric	WRR IV	1	Amnay Multi-Purpose Dam Project
8	Bicol	WRR V	1	Talisay Multi-Purpose Dam Project
9	Panay	WRR VI	1	Panay Multi-Purpose Dam Project
10	Jalaur	WRR VI	1	Jalaur Multi-Purpose Dam Project
11	Ilog-Hilabangan	WRR VI	1	Ilog No.1 Multi-Purpose Dam Project
12	Tagoloan	WRR X	1	Tagoloan Multi-Purpose Dam Project
13	Cagayan De Oro	WRR X	1	Bulang-Batang Hydroelectric Project
14	Tagum-Libuganon	WRR XI	1	Bubonao Multi-Purpose Dam Project
15	Davao	WRR XI	1	Davao II Multi-Purpose Dam Project
16	Buayan-Malungun	WRR XI	1	Dimloc Multi-Purpose Dam Project
17	Mindanao	WRR XII	1	Pulangi Multi-Purpose Dam Project
	Total		22	

The locations of the proposed impounding dam projects for each of the 17 water resources regions are shown in Figures 5-1 to 5-11. The implementation plans of the Proposed impounding dam projects are depicted in Figures 5-47 to 5-66.

5.4.2 Preliminary Financial Disbursement Plan

The preliminary financial disbursement plan for the proposed storage type dam projects was prepared based on the project costs estimated in the previous studies as well as the data collected from NPC and NIA. The project costs estimated in the previous studies were adjusted to those at a price level of July 1997 applying the price escalation rates. The price escalation rates applied to the estimate of the present-day costs are discussed in Part-A of the

Supporting Report.

The disbursement schedule of the present-day construction cost for the 22 storage type dam projects selected in the foregoing Subsection 5.4.1 is presented in Table 5-24. The present-day costs at 5-year intervals are tabulated below for the period until the year 2025:

Present-Day Cost for Development of Storage Type Dams

(Unit: Million US$ per 5 years)

Year	2000	2005	2010	2015	2020	2025
Present-Day Cost	383	3,077	714	445	1,602	389

It is foreseen that a lot of the proposed storage type dam projects would be implemented in a form of BOT like the San Roque multipurpose dam project in the Agno river basin, taking into consideration the comparatively limited government budget which can be allocated to the sector of water resources development.

5.5 Operation and Management on Water Resource

In connection with the operation and management of water resources, the following focal points need to be kept in mind in order to attain the sustainable water resources development:

(1) Management of Watershed

The land use of watershed area of an impounding dam should be controlled strictly to secure the quality of the runoff and to control sediment inflow to the reservoir. The promotion of reforestation is effective to maintain the runoff from the watershed area in terms of quality and quantity. To effectively perform the watershed management, the relevant local government should also be responsible for the management of the watershed area in cooperation with the central governments concerned.

(2) Measurement and Recording of Intake Discharge

All intake discharges should be properly measured and recorded. These measurement and recording are the obligations of the ones who intake and utilize the discharges. The records should be compiled in daily, monthly and annual reports. Those reports need to be submitted to NWRB at intervals of a certain period. NWRB should be responsible for monitoring the water usage on the basis of the data presented in the reports with reference to the water right granted. In addition, NWRB should take actions when any issues and problems on water usage arise. NWRB is responsible for the preparation of the form and procedure for the reporting.

(3) Water Allocation during Dry Period

NWRB should establish the rule to allocate river discharge and impounded water in a reservoir and groundwater to water users during the dry period. NWRB should monitor the actual water allocation on the basis of the reports submitted by various water users. In case of a critical drought, the Board Meeting needs to be called to discuss the water allocation. In this respect, the following standard dependability should be observed unless otherwise the national standards are set up in the future:

- Municipality water supply : 95%
- Hydropower generation : 90%
- Irrigation water supply : 80%

(4) Operation and Maintenance of Dam

The discharge from a dam should be released in such a manner as not to cause harmful effect on affected people and river structures. Warning should be disseminated to people in the river within 30 minutes before the release from dam if the discharge will cause a certain rise in the river water level. The reservoir bed should be surveyed periodically to confirm whether the reservoir is functional. If sediment materials intrude into the reservoir active storage, the removal of sediment should be conducted with an expense of the owner of the dam.