JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE SOCIALIST REPUBLIC OF VIETNAM
MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT

THE MASTER PLAN STUDY
ON
DONG NAI RIVER AND SURROUNDING BASINS
WATER RESOURCES DEVELOPMENT

FINAL REPORT

VOLUME X

APPENDIX X FORMULATION OF MASTER PLAN

AUGUST 1996

NIPPON KOEI CO., LTD., TOKYO JAPAN

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Volume I	Executive Summary	
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The cost estimate was based on the December 1995 price level and expressed in US$ according to the exchange rate of US$ 1.00 = Vietnamese Dong 11,014 = Japanese Yen 101.53 as of December 15, 1995.

LIST OF ABBREVIATIONS

AFS	Agriculture and Forestry Service (PC)
CEMMA	Committee for Ethnic Minorities and Mountainous Areas
DCWSSS	Design Company for Water Supply and Sanitation System (HCMC-PC)
EA	Environment Assessment (Multi-lateral Lending Agencies)
ECSP	Evaluation Commission for State Projects
EIA	Environmental Impact Assessment
ENCO	Ho Chi Minh City Environmental Committee
EVN	*General Company of Electricity of Viet Nam (Abolished and renamed in November 1995 as Vietnamese Power Corporation)*
FIPI	Forest Inventory and Planning Institute (MOARD)
GCOP	Governmental Committee on Organization and Personnel
GDLA	General Department of Land Administration
GDMH	General Department of Meteorology & Hydrology
GOV	Government of Viet Nam
GSO	General Statistical Office
HCMC	Ho Chi Minh City
HEC	Ho Chi Minh Environment Committee (HCMC)
HIDC	Hydraulic Investigation and Design Company (MOARD)
HPC	Ho Chi Minh People's Committee (HCMC)
HSDC (or SDC)	Ho Chi Minh Sewerage and Drainage Company (HCMC)
HWSC (or WSC)	Ho Chi Minh Water Sypply Company (HCMC)
IDD	Irrigation and Drainage Department (MOARD)
IEE	Initial Environmental Examination
IER	Institute for Economic Research (HCMC-PC)
IHPH	Institute of Hygiene and Public Health (MOPH)
IM	Institute of Mines (MOID)
INVESCo	Investment Company for the Development of Water Sector (HCMC-PC/TUPWS)
IOE	Institute of Energy (MOID)
IURP	Institute of Urban and Rural Planning (HCMC-PC/Construction Service)
IWRE	Institute of Water Resources Economics (MOARD)
IWRP	Institute of Water Resources Planning (MOARD)
IWRR	Institute of Water Resources Research (MOARD)
JICA	Japan International Cooperation Agency (Japan)

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IWRP	Institute of Water Resources Planning (MOARD)
IWRR	Institute of Water Resources Research (MOARD)
JICA	Japan International Cooperation Agency (Japan)

MOAFI	*Ministry of Agriculture and Food Industry (Abolished and integrated into the new MOARD)*
MOAP	Ministry of Aquatic Products
MOARD (New)	Ministry of Agriculture and Rural Development (Created in October 1995 by the merger of the former Ministry of Water Resources, Ministry of Agriculture and Food Industry and Ministry of Forestry)
MOC	Ministry of Construction
MOCI	Ministry of Culture and Information
MOD	Ministry of Defence
MOE	*Ministry of Energy (Abolished and integrated into the new MOID)*
MOET	Ministry of Education and Training
MOFI	Ministry of Finance
MOFO	*Ministry of Forestry (Abolished and integrated into the new MOARD)*
MOFA	Ministry of Foreign Affairs
MOHI	*Ministry of Heavy Industry (Abolished and integrated into the new MOID)*
MOID(New)	Ministry of Industry (Created in November 1995 by the merger of the former Ministries of Heavy Industry, Light Industry and Energy)
MOJ	Ministry of Justice
MOIT	Ministry of Interior
MOLI	*Ministry of Light Industry (Abolished and integrated into the new MOID)*
MOLWISA	Ministry of Labour, War Invalids and Social Affairs
MOPH	Ministry of Public Health
MOPI (New)	Ministy of Planning and Investment (Formed from a merger of the former SPC amd SCCI)
MOSTE	Ministry of Science, Technology and Environment
MOTC	Ministry of Transport and Communications
MOT	Ministry of Trade
MOWR	*Ministry of Water Resources (Abolished and integrated into the new MOARD)*
MPAC	Ministrial Project Appraisal Committee
NEA	National Environment Agency
NGO	Non-Governmental Organization
NIAPP	National Institute for Agricultural Planning and Projection
NPAC	National Project Appraisal Committee
OECC	Overseas Environmental Cooperation Centre
OECF	Overseas Economic Cooperation Fund (Japan)
PC	People's Committee (executive arm of the People's Council)

PCC	Power Construction Company (VPC)
PIDC	Power Investigation and Design Company (VPC)
PPC	Provincial People's Committee (City People's Committee = CPC)
SBV	State Bank of Viet Nam
SCCI	*State Committee for Cooperation and Investment (Abolished and integrated into the new MOPI)*
SFEZ (or SFEA)	Southern Focal Economic Zone (or Southern Focal Economic Area)
SIWRP	Sub-Institute of Water Resources Planning (MOARD-IWRP)
SIWRR	Southern Institute of Water Resources Research (MOARD)
SPC	*State Planning Committee (Abolished and integrated into the new MOPI)*
SRV	Socialist Republic of Viet Nam
UNDP	United Nations Development Programme
UNICEF	United Nations International Children's Education Fund
UNIDO	United Nations Industrial Development Agency
VPC (New)	Vietnam Power Corporation (the former General Company of Electricity of Viet Nam = EVN)
WASECO	Water and Sewerage Construction Company (MOC)
WB	World Bank
WHO	World Health Organization
WPMI (IWRPM)	Water Planning and Management Institute (MOARD)
WRD(or WRS)	Water Resources Department or Water Resouce Service (PC)
WSC	Water Supply Company (under Construction Services of the PC)

Note : Abbreviations in *Italics* are no more existent (already abolished and integrated in November 1995).

Measurements

Length

mm	=	millimeter
cm	=	centimeter
m	=	meter
km	=	kilometer
ft	=	foot
yd	=	yard

Area

cm^2	=	square centimeter
m^2	=	square meter
ha	=	hectare
km^2	=	square kilometer

Volume

cm^3	=	cubic centimeter
l	=	litre
kl	=	kilolitre
m^3	=	cubic meter

Weight

g	=	gram
kg	=	kilogram
ton	=	metric ton

Time

s	=	second
min	=	minute
h	=	hour
d	=	day
y	=	year

Electric Measurements

V	=	Volt
A	=	Ampere
Hz	=	Hertz (cycle)
W	=	Watt
kW	=	kilowatt
MW	=	Megawatt
GW	=	Gigawatt

Other Measures

%	=	percent
PS	=	horsepower
°	=	degree
10^3	=	thousand
10^6	=	million
10^9	=	billion

Derived Measures

m^3/s	=	cubic meter per second
kWh	=	Kilowatt hour
MWh	=	Megawatt hour
GWh	=	Gigawatt hour
kVA	=	kilovolt ampere

Currencies

US$	=	US Dollar
VND	=	Vietnamese Dong

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FORMULATION OF MASTER PLAN

APPENDIX X
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1. NEEDS FOR WATER RESOURCES DEVELOPMENT IN THE STUDY AREA

Vietnamese economy enjoyed its high performance of more than 8 % in terms of the annual GDP growth rate in last a few years. The Government launched a medium-term economic development programme toward the year 2000, so-called "Socio-economic Stabilization and Development Strategy to the year 2000", in which economic development is targeted to sustain 7.5 % in the annual GDP growth rate. The World Bank predicts 6.0 % of GDP growth over a period of the year 1990 to 2010 as the most probable scenario.

The Southern Focal Economic Area (SFEA), which covers the main part of the Study Area, acts as a locomotive of economic development in the nation along with the Hanoi-Hai Phong area and the Da Nang area. This area covers the whole of Ho Chi Minh City, Dong Nai province and Ba Ria-Vung Tau province and a part of Song Be, Tay Ninh, Long An and Binh Thuan provinces with a land area of 12,400 km^2 and a population of 7.8 million. It includes the so-called "Economic Triangle Zone" that is formed by the three places of Ho Chi Minh City, Bien Hoa and Vung Tau and is emerging as a focal place of economic development in Viet Nam. In the area, there are large potential demands for domestic and industrial water supply as well as for electricity supply. Some industrial estates are already put in service and nearly 20 estates are now under planning. According to the study made by the Ministry of Science, Technology and Environment, the expected GDP growth rate in the area up to the year 2010 is 12 to 13 % and the estimated demands for water and electricity in the year 2010 are 3.9 million m^3/day and 22.5 billion kWh/year respectively. Such being the case, the amount of water to be supplied to this area by the target year 2015 is estimated at about 50 m^3/s, which is nearly the same as that estimated in Appendix VII.

The Study Area has been suffering from the shortfall of electricity especially in the dry season. The estimate made in Appendix V indicates that the demand of electricity supply in the Southern Region (PC2) in the year 2015 will be about 10,400 MW (Peak load) and 12.01 GWh/year in the base case scenario, which are almost ten times larger than the present demands. Water resources development for hydropower generation, as far as economically viable, is virtually needed to meet these demand by taking share of the system supply capacity, although the thermal power is expected to take major share in the year 2015. It is also to be noted that hydropower development is being reevaluated recently not only for economic viewpoint, but also from the consideration of environmental protection and natural resources conservation; that is, hydropower is clean and renewable energy inherently bestowed to the land.

The east coast area, covering Ninh Thuan and Binh Thuan provinces, is economically lagging behind from the other regions in the Study Area along with the central highland area. The area is fairly dry with less rainfall, and the coastal rivers are generally small in the catchment area,

resulting in the limitedly available water resources. These conditions are impeding the expansion of irrigation schemes, and the extreme shortage of water in the dry season is causing the low cropping intensity in paddy cultivation.

Nevertheless, this area has the largest potential for the expansion of irrigation schemes in the Study Area. The total area of the potential irrigation schemes concentrated in this area is estimated at more than 40,000 ha. Available water in the area falls short of developing these potential schemes, and the possible measure to solve this problem is to divert water from the Dong Nai River basin to the coastal area. Full exploitation of the local water resources such as the Cai and Luy rivers is also required for this purpose.

There is an area called "HCMC-Long An Delta", which extends in the low-lying downstream reaches of the East Vam Co River and administratively belongs to Long An province and Ho Chi Minh City. Most of the HCMC-Long An Delta is short of irrigation water and suffers from acidic soil and salinity intrusion that takes place in the dry season, causing adverse effects to agriculture and people's daily life. A possible measure to improve this situation in the HCMC-Long An Delta is to introduce fresh water by water transfer from the Dong Nai River basin to this area.

Needs for water resources development in the Study Area including the discussions above are specified as follows:

a) Development of hydropower to cope with chronic shortfall of electric power in the southern Viet Nam, especially acute in the dry season,

b) Development of domestic and industrial water supply to secure healthy manpower and to sustain the economic development in the SFEA,

c) Agricultural development in the east coast area, where shortage of water is one of shackles in the expansion of the irrigation schemes,

d) Agricultural development in the low-lying HCMC-Long An Delta area, where fresh water is seriously lacking in the dry season for irrigation, acid flushing and salinity repulsion,

e) Development of the promising irrigation schemes in the areas other than the east coast and the HCMC-Long An Delta which are in the planning or potential status,

f) Exploitation of groundwater for water supply and agricultural development in the Study Area, and

g) Promotion of afforestation in the areas where deforestation to cause excessive soil erosion and sedimentation is progressing.

It takes much time to realize water resources development projects for all the needs mentioned above. Furthermore, those needs are mainly listed from the viewpoint to sustain the economic development in the Study Area. There is an argument that economic disparity between urban and rural areas is great in the Study Area. To enhance the living standard in the rural area and to narrow down the economic disparity between two areas, implementation of small scale projects with quick effect of development is in particular desired in the rural area. In the following Section, strategies for the enhancement of living standard in the rural area are dealt with first.

2. STRATEGIES FOR THE ENHANCEMENT OF LIVING STANDARD IN THE STUDY AREA

Migration of people seeking job opportunities from rural areas to large towns such as Ho Chi Minh City, called mechanical increase, not only has merits to supply labour force necessary for sustaining economic development of the SFEA, which is a locomotive of national economic development, but also brings side-effects to deteriorate urban amenity as represented by squatter's houses built along the rivers and canals. Excessive migration of people to urban areas mainly results from the living of rural area staying at a subsistence level. This severe lives in the rural area may be inferred from the performance of rural water supply projects in the Study Area as dealt with in Appendix VII, Domestic and Industrial Water Supply; that is, the work to collect drinking water still shares a large part of daily life of women and children in the rural area.

Taking into account the living condition in the rural area, matters to be carried out for the socio-economic development in the Study Area most urgently are to improve social amenity and to create job opportunities in the rural area.

In terms of water resources development, enhancement of social amenity can be made by improving water supply in the rural area besides district and major towns in the respective regions. As discussed in Appendix VII, a total of 1,207 rural water supply projects are proposed to be implemented within the coming 20 years as parts of the work to enhance social amenity.

On the other hand, creation of job opportunities will be made by improving and rehabilitating small scale irrigation projects scattered throughout the Study Area. As discussed in Appendix VI, Agricultural Development and Irrigation, a total of 229 small scale irrigation schemes are identified in the Study Area, consisting of 164 improvement and rehabilitation schemes and 65 new schemes. As part of creating job opportunities in the rural area, actions to realize the improvement and rehabilitation of those 164 existing schemes as well as the implementation of 65 new schemes are urgently required to be taken with a project title of Rural Agricultural Development Project (RADP).

Following is the summary of small scale projects to be implemented for the rural development in the Study Area:

Province	Small Scale Irrigation Projects				Rural Water Supply Projects	
	Existing Rehabilitation Projects		New Proposed Projects		Number of Communes	Number of Projects
	Number of Projects	Total Area (ha)	Number of Projects	Total Area (ha)		
Lam Dong	25	10,809	3	3,050	29	93
Dac Lac	1	120	0	0	19	46
Ninh Thuan	15	3,932	3	6,400	9	47
Binh Thuan	56	20,033	2	608	25	193
Ba Ria-Vung Tau	15	8,080	18	8,450	20	239
Dong Nai	33	16,930	7	9,770	18	190
Song Be	16	4,581	20	11,094	11	78
Tay Ninh	3	3,260	12	21,870	9	119
Long An	0	0	0	0	30	202
Total	164	67,745	65	61,242	170	1,207

Further details of rural water supply projects and small scale irrigation projects are summarized in Tables 2.1 and 2.2, respectively.

It is furthermore noted that promotion of small scale irrigation schemes has effects not only to create job opportunities through direct employment or participation, but also to enhance the induction of agro-based industry and to improve chronic malnutrition common in the rural area.

It is true that it takes much time to complete the rural water supply programme and the rural agricultural development programme due to their numerous number. However, implementation of one rural water supply project or rural agricultural development project generates quick effect to the beneficial area. Thus, it is considered urgent to make an implementation programme of rural water supply and rural agricultural development projects to carry out step by step. Even if the implementation of those rural water supply projects and rural agricultural development projects is undertaken step by step, financial burden to the government is so heavy that assistance from foreign countries is strongly desired.

Taking into account the urgent needs and quick effects to improve living standard in the rural area, implementation of rural water supply projects and rural agricultural development projects is proposed to list as candidates of the master plan projects, the selection of which is dealt with in the subsequent Section 4.1.

3. OPTIMAL ALLOCATION OF WATER AVAILABLE IN THE DONG NAI RIVER BASIN

3.1 Principal Approaches

Needs for water resources development in the Study Area were discussed in the preceding Chapter 1. To meet the requirement of each need, water available in the Dong Nai River basin is desired to be allocated in an optimal way. The principal approaches formulating the optimal water allocation in the Dong Nai River basin are represented as follows:

a) Water development in the major potential area with creation of reservoirs - Dong Nai and Be River basins,

b) Agricultural development in the east coast area with water diverted from the Dong Nai River basin, and

c) Agricultural development in the HCMC-Long An Delta area with water transfer from the Be River basin

A schematic diagram for the above approaches is depicted in Figure 3.1 as a basin model.

As discussed in Appendix VII, Domestic and Industrial Water Supply, water demands of district and major towns in the Study Area are expected to grow rapidly in future, and groundwater will be a main source to meet the demands. Cities and towns developed and to be developed in the downstream reaches of the Dong Nai and Saigon rivers, i.e. HCMC and the corridor towns between Bien Hoa and Vung Tau, will seek to those two rivers as main water sources to meet domestic and industrial water demand, since water demands of those areas are too large to rely on the water sources such as groundwater.

Taking into account the fact that drinking water is one of basic human needs for daily life, water requirements of HCMC and the corridor towns between Bien Hoa and Vung Tau to the Dong Nai and Saigon rivers are to be treated as the constraint to be met in the mathematical model of the water allocation study to be discussed in the subsequent Section 3.5. It is noted here that there might be high chances that domestic and industrial water to supply for the development in the downstream reaches of the Dong Nai River will not meet their demands, unless close coordination and cooperation is made with the reservoirs to be built and especially the existing Tri An reservoir in the upstream reaches in terms of water release plan. In this context, a strong recommendation is to establish an institutional coordination body among the ministries and authorities concerned for managing the reservoirs to be built.

Another issue to be focused when the water allocation study is discussed is the protection of natural environment as presented by a fact that low-lying areas extending in the lower reaches

of the Dong Nai River, the Saigon River and the Vam Co River suffer from such problems as the degradation of natural environment due to deforestation of estuarine mangrove forests (refer to Appendix IV, Natural Environment) and the decrease of agricultural production due to salinity intrusion. Thus, the water allocation study will be carried out by paying attention on the protection of natural environment. In fact, this issue to protect natural environment will be incorporated in the mathematical model to be discussed in the subsequent Section 3.5 as constraints for salinity intrusion and maintenance flow.

3.2 Water Development in the Major Potential Area

As for the alignment of the reservoirs to be created in the Dong Nai River main stream, the combined development of Dong Nai No. 3 and No. 4 projects with the reservoirs would be most promising in view of electricity generation as well as domestic and industrial water supply in the downstream area, particularly the SFEA. Others, such as No. 1, No. 2, No. 6 and No. 8 are omitted from the list of schemes to be implemented by the target year 2015 because of low economic indices and social and environmental reasons. While further details are referred to Appendix IV, Natural Environment, and Appendix V, Hydropower Generation, Table 3.1 summarizes the screening process of reservoirs to be added to the mathematical model of water allocation.

Dong Nai No. 3 project has a large active storage capacity of 899 million m^3, the creation of which makes it possible to increase not only the installed capacity of Dong Nai No. 4 (up to double of the independent No. 4) but also its firm energy generation. It also contributes to increasing the firm energy generation of Tri An project and the river flow in the dry season at the downstream reaches of Tri An project. Thus, simultaneous combined development of the Dong Nai No. 3 and No. 4 is desirable, but in case where Dong Nai No. 4 is developed before Dong Nai No. 3, the design of the project should be made in consideration of future expansion.

In the Be River, Fu Mieng multipurpose project with the reservoir is promising in view of electricity generation and diversion of water to the HCMC-Long An Delta through the existing Dau Tieng reservoir. Besides the reservoirs mentioned above, i.e. one existing reservoir of Tri An and three proposed reservoirs of Dong Nai No. 3, Dong Nai No. 4 and Fu Mieng, following reservoirs are to be incorporated in the mathematical model of water allocation study; Dau Tieng, Thac Mo, Ham Thuan-Da Mi, Da Nhim, Dai Ninh and Song Luy. Dau Tieng is the existing reservoir built for the irrigation development in the Saigon and Vam Co river basins. Since Thac Mo, Da Nhim and Ham Thuan-Da Mi, which is under construction but is treated as existing project in the model, are the existing reservoirs constructed in the upper reaches of the Be, Dong Nai and La Nga rivers respectively, simulated outflows from those three reservoirs

are treated as inflow to the mathematical model of the water allocation study. Dai Ninh and Song Luy are the reservoirs proposed as part of diversion to the east coast area as discussed below.

3.3 Agricultural Development in the East Coast Area

Creation of the Dai Ninh reservoir in the upper Dong Nai River will be the core component to divert water from the Dong Nai River to the east coast area. Water diversion will make it possible to generate an electric power of 300 MW and then to expand the irrigation schemes in the Phan Ri and Phan Thiet plains. While further details are referred to Appendix VI, Agricultural Development and Irrigation, Table 3.2 summarizes the screening process of potential irrigation projects to be added to the mathematical model of water allocation besides the existing irrigation projects.

Diverted water would be capable of irrigating a cultivated land of about 40,000 ha which covers the Phan Ri plain (29,700 ha out of a total potential area of 32,000 ha) and an east part of the Phan Thiet plain (10,000 ha) in conjunction with the water resources available in the east coast area even if actual irrigation area is changed with diversion amount. La Nga No. 3 diversion project to irrigate additional potential irrigation area in Phan Thiet plain was initially considered, however, since economic viability of the scheme is low, this diversion concept is cancelled. The maximum irrigable area in Phan Thiet plain which is to be supplied with water from the Dai Ninh reservoir through the Phan Ri plain is limited to be 10,000 ha because of the topographical constraint. To regulate local flow and to re-regulate the outflow from the Dai Ninh powerplant, the Luy reservoir is also proposed to be built.

3.4 Agricultural Development in the HCMC-Long An Delta Area

The beneficiary area of the HCMC-Long An Delta to receive diverted water from the Be River through the existing Dau Tieng reservoir is delineated as an area spreading between the West Vam Co River and the Saigon River. Potential irrigation projects as well as the existing one are Dau Tieng existing (45,000 ha), Dau Tieng extension (48,390 ha), Tay Ninh lower (14,300 ha), Long An Delta-Rach Tram (54,000 ha), and HCMC (46,000 ha) as referred to Table 3.2.

As diversion measures, both the Fu Mieng reservoir and the Phuoc Hoa reservoir are possible spots from where water can be diverted to the Dau Tieng reservoir through an open channel. Although the Fu Mieng reservoir has a physical advantage for diversion rather than the Phuoc Hoa, the diversion of water before power generation brings the loss of energy output. Taking

into account the above condition, following two development scenarios are considered as the alternatives to select the optimal diversion scheme from the Be River to the Dau Tieng reservoir as schematically depicted in Figure 3.2:

Scenario-A : Fu Mieng multipurpose project with a diversion channel of 7 km long, and Phuoc Hoa irrigation project with a low intake weir for the pump intake; and

Scenario-B : Fu Mieng hydropower project, and Phuoc Hoa irrigation project with the Phuoc Hoa dam with a diversion channel of 16 km long.

Besides the irrigation development by inter-basin water transfer discussed above, following are to be incorporated in the mathematical model of water allocation as referred to Table 3.2; Phuoc Hoa (45,680 ha), Ta Pao (23,000 ha), Vo Dat (15,000 ha), Tay Ninh Upper (15,100 ha) and Dong Nai riparian existing (23,400 ha). It is noted here that Tay Ninh Upper and Tay Ninh Lower schemes are not one large scale irrigation project, but an integration of small scale irrigation schemes.

Based on the approaches mentioned above, a mathematical model for the optimal water allocation in the Dong Nai River basin will be composed as discussed below.

3.5 Model Formulation

3.5.1 Problem Statement for the Study Area

As noted in the previous Sections, many development projects in hydropower, agriculture, water supply and other sectors have been proposed for the project target year 2015. These proposed projects, as noted below, including the recently developed and committed ones are presented schematically in Figure 3.3:

- Site 1: Dai Ninh reservoir and hydropower (committed);
- Site 2: Dong Nai No. 3 reservoir and hydropower (planned);
- Site 3: Dong Nai No. 4 reservoir and hydropower (planned);
- Site 4: Tri An reservoir and hydropower (existing);
- Site 5: Fu Mieng reservoir, hydropower and diversion (planned);
- Site 6: Phuoc Hoa irrigation and diversion (planned);

- Site 7: Dau Tieng reservoir (existing), irrigation and diversion (planned);
- Site 8: Phan Ri reservoir, irrigation and diversion (planned);
- Site 9: Phan Thiet irrigation (planned);
- Site 10: Ta Pao irrigation (planned);
- Site 11: Vo Dat irrigation (planned);
- Site 12: Dau Tieng irrigation (existing) and diversion;
- Site 13: Tay Ninh upper irrigation (planned);
- Site 14: Tay Ninh lower irrigation (planned);
- Site 15: Dong Nai riparian irrigation (on-going);
- Site 16: Long An Delta-Rach Tram irrigation (planned);
- Site 17: HCMC irrigation (planned);
- Site 18: Hoa An water supply intake (existing and planned); and
- Site 19: Phu Cuong water supply intake (on-going and planned).

As shown in Figure 3.3, the structured problem presented is to find out the optimal allocation of the available water resources within the Study Area. Selecting the projects for water resources development and determining the scale of water allocation for various sectors on a project-to-project base are the answer to this structured problem.

3.5.2 Formulation of Mathematical Model

In order to formulate a mathematical model to seek the optimal allocation of water resources available in the Study Area, one of the operations research methods, Mixed Integer Programming Method, has been applied in Phase II study. Based on the screened projects presented in Figure 3.3, a set of mathematical model has been prepared as presented in Attachment-1.

As noted in Attachment-1, constraints for each site consist of storage continuity equation, water balance and other specific criteria. In determining reservoir size, optimal diversion capacity, intake weir construction and irrigation pump facility, integer variables have been introduced at these sites. It should be noted that all the integer variables attached to these sites become one (1) if the optimization process finds it economically feasible to build the facility, or zero if it is not optimal or infeasible. For instance, if the reservoir at site 2 (Dong Nai No. 3 damsite) is not feasible, the integer variable at site 2 becomes zero. Therefore, the corresponding decision variables of the reservoir at Dong Nai 3 damsite would also become zero in the constraints specified for this site. These integer variables representing reservoir, diversion canal, intake weir and irrigation pump facility are included in the Sites 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16 and 17. In particular, since the selection between sites 5 and 6 is sought as a diversion

measure from the Be River to the HCMC-Long An Delta area, the sum of integer variables at the site 5 and 6 becomes one at most; that is, integer one is given to either site or zero is given for both. For Sites 1, 4, 15, 18 and 19, the integer value is not given, since these are existing or committed projects or since right-of-way is given in water allocation, i.e. Sites 18 and 19.

3.5.3 Objective Function

The objective function utilized in the Dong Nai Mixed Integer Programming Model is to maximize the net benefit, which is the difference between the annual economic benefit and cost given for each site as expressed below:

Net Benefit = Total Benefit - Total Cost

where total benefit includes benefit which will be obtained by hydropower generation, irrigation development and water supply. Total cost in the objective function includes construction costs for the proposed dam, irrigation development, diversion channel and water supply facilities as well as the operation and maintenance cost for them.

3.6 Parameter Inputs for Model Application

3.6.1 Estimate of Natural Inflow

In order to determine the optimal solution for the Dong Nai Mixed Integer Programming Model, monthly discharge at the Hoa An intake with assumption that the Tri An power station is operating as the existing condition, for a duration of 29 water-years is prepared as noted in Table 3.3. This Table is required because the mathematical model presented in Attachment-1 requires monthly inflow data for all the project sites considered.

The representative year for this analysis, which represents the 4-year drought flow, is defined based on the data given in Table 3.3, since the 4-year drought is utilized in order to coincide with the planning scheme of the irrigation development. From this Table, the year 1974 is defined to be the 4-year drought flow for the study. Natural inflow data for each site have been prepared using Tank Model and by multiplying the ratio of catchment area and mean annual rainfall for respective site. It should be mentioned here that the model utilizes a water-year in order to well represent the seasonal flow patterns and seasonal water demand patterns; that is, the first month of the 4-year drought starts in November 1973 and the last month of the standard year be October 1974. The representative 4-year drought flow utilized in the model is presented in Table 3.4.

3.6.2 Reservoir and Power Plant Parameters

Storage-water level relationships required for the Dong Nai Mixed Integer Programming Model are obtained with reference Appendix V, Hydropower Generation and Appendix VI, Agricultural Development and Irrigation. The following presents the tail water level and storage-water level function utilized in the model:

(Unit: m)

Site	TWL	Storage-Water Level Function
Dai Ninh	209.5	H=0.0794*S+860
Dong Nai 3	487.0	H=0.0250*S+543
Dong Nai 4	287.0	H=0.290*S+442
Tri An	3.8	H=0.0047*S+ 50
Fu Mieng	40.0	H=0.0173*S+ 69

For each reservoir alternative, the maximum active storage and the maximum plant discharge incorporated in the Model are assumed as follows:

Case	Maximum Active Storage (million m^3)	Maximum Plant Discharge (m^3/s)
Dai Ninh		
Case 1	252.00	57.0
Dong Nai No. 3		
Case 1	622.29	197.2
Case 2	1,244.58	224.4
Case 3	2,240.50	232.0
Dong Nai No. 4		
Case 1	134.05	92.8
Case 2	294.91	136.8
Fu Mieng		
Case 1 (without Div.)	460.0	460.0
Case 2 (with Div.)	460.0	220.0
Phan Ri (Song Luy)		
Case 1	25.0	-
Case 2	50.0	-
Case 3	75.0	-
Case 4	100.0	-
Case 5	125.0	-
Case 6	150.0	-
Case 7	175.0	-
Case 8	200.0	-
Tri An		
Case 1 (Existing)	2,542.0	880.0
Dau Tieng		
Case 1 (Existing)	1,100.0	-

Since Tri An and Dau Tieng reservoirs are existing, one reservoir alternative is given in the model. Similarly, for Dai Ninh reservoir, one alternative obtained from the feasibility study report prepared by PIDC2 is incorporated in the Model as specified above.

Minimum monthly firm discharge for Dai Ninh power plant (19 m^3/s) and Tri An power plant (230 m^3/s) under 4-year drought flow has also been incorporated in the model in order to obtain realistic results for the release from these dams.

3.6.3 Irrigation and Water Supply Parameters

In Dong Nai Mixed Integer Programming Model, monthly water requirements and maximum irrigable area are obtained for sites 6, 7, 8, 9, 10, 11, 13, 14, 16, and 17. These water requirements are presented in Table 3.5. For the existing irrigation at Dau Tieng (45,000 ha) and Dong Nai riparian area (23,400 ha), water requirements have been incorporated in the Model as mandatory demand in order to secure the current irrigation condition in the area. Furthermore, it should be noted here that for Site 9, Phan Thiet, maximum irrigable area is defined to be 10,000 ha. This value is obtained based on the assumption that water required for irrigation is obtained from the natural inflow to Phan Thiet and diversion from Song Luy dam at Phan Ri. Therefore, the right bank of the Ca Ty River in the Phan Thiet plain is not included in the maximum irrigable area (refer to Appendix VI, Agricultural Development and Irrigation). Return flow for the maximum irrigable area of each site is summarized as follows:

Site	Project	Return Flow (%)	Max. Irrigable Area (ha)
Site 6	Phuoc Hoa	0.10	45,680
Site 7	Dau Tieng (Extension)	0.10	48,390
Site 8	Phan Ri	0.15	29,700
Site 9	Phan Thiet	0.15	10,000
Site 10	Ta Pao	0.15	23,000
Site 11	Vo Dat	0.15	15,000
Site 12	Dau Tieng (Existing)	0.10	45,000
Site 13	Tay Ninh Upper	0.10	15,100
Site 14	Tay Ninh Lower	0.10	14,300
Site 15	Dong Nai Riparian (Existing)	0.10	23,400
Site 16	Long An Delta	0.10	54,000
Site 17	HCMC	0.10	46,000
	Total		369,570

Water supply requirements at the Hoa An intake for HCMC and the economic triangle zone and at the Saigon intake (Phu Cuong) for HCMC are also obtained based on demand projection of the municipality and industrial sites as well as the implementation programme of water supply projects as follows:

Site	Requirements, m^3/sec	
Hoa An	36.8	(3,187,000 m^3/day)
Saigon	10.9	(940,000 m^3/day)

A requirement of 36.8 m^3/sec at Hoa An is estimated under the condition that all the towns along National Highway No. 51 along with HCMC seek to the Dong Nai River as a primary water source to meet their water demands. These requirements are treated as mandatory release in the model as mentioned in preceding Section 3.1. It is noted here that water demands in the year 2015 are estimated at 2.1 million m^3/day for HCMC and 1.7 million m^3/day for the towns along National Highway No. 51. Details of the demand calculation are presented in Appendix VII.

3.6.4 Parameters for Water Diversion

Diversion schemes within the Study Area are considered at sites 1, 5, 6, 7, 8 and 12. For sites 5 and 6, alternative schemes, as specified in preceding Section 3.4 above, are incorporated in the model together with five maximum diversion capacity alternatives for each site. Similarly, a total of five alternatives for the maximum diversion capacity at the sites 7 and 12 are incorporated. For Site 8 (Phan Ri to Phan Thiet diversion), the maximum diversion capacity of the channel is defined at 40 m^3/s. For Site 1 (Dai Ninh), the maximum diversion capacity has to follow the maximum plant discharge of 57.0 m^3/s which is the maximum turbinable flow.

3.6.5 Salinity Intrusion, Maintenance Flow and other Parameters

Salinity intrusion is one of major adverse factors for the agricultural development and water supply in the areas lying in the downstream reaches of the Dong Nai, Saigon and Vam Co rivers. An intensive study to assess the amount of maintenance flow not to cause any adverse effects to agricultural development and water supply by salinity intrusion is undertaken in Appendix IX.

According to the Vietnamese standard, salinity concentration of drinking water is stipulated to be 0.25 g/l or less. Simulation of salinity intrusion discussed in Appendix IX reveals that an amount of 100 m^3/s be secured at Site 18, Hoa An intake for water supply, as maintenance flow of the Dong Nai River to keep the salinity concentration to the stipulated level, whilst 25 m^3/s at Site 19, Phu Cuong intake for water supply, as maintenance flow of the Saigon River.

Similarly, the minimum flow required for the Vam Co River is defined from the result of the salinity intrusion simulation study at Xuan Khanh where the intake of irrigation canal for Long An Delta-Rach Tram exists. At this point, since water is utilized for the agricultural development only, a salinity concentration of 4.0 g/l is utilized as the standard to maintain, and 20 m^3/s has been determined to be the discharge to release for preventing the East Vam Co River from salinity intrusion.

Minimum flow required at the Cai River in the east coast area has been defined so as to maintain 10 percent of the natural inflow (4-year drought flow) to the site for each month which is defined in Table 3.4 at a point just downstream of the Phan Thiet irrigation water intake. Similarly, the minimum stream flow just downstream of Phan Ri damsite in the Luy River is set at 10 percent of the natural inflow (4-year drought flow to the site for each month). Furthermore, maintenance flow released from the Dau Tieng reservoir to the Saigon River is set at 20 m^3/s, while requirement downstream of Phuoc Hoa pump station has been set at 18.6 m^3/s, which is the historical minimum flow obtained from 30-year Tank Model simulation at the Phuoc Hoa gauging station.

3.6.6 Costs and Benefits for Objective Function

The objective function presented in Attachment-1 includes cost and benefit functions of all the water resources development projects included in the model. The projects are reservoir, hydropower, water diversion, irrigation and water supply. Construction costs related to existing facilities, such as Tri An, Ham Thuan-Da Mi, Thac Mo and Dau Tieng, are treated as sunk cost and are not included in the model. Construction costs which would be utilized in the objective function depend on the integer variables chosen as the optimal set of solution. Herebelow present costs and benefits for each alternative scheme incorporated in the model. It should be noted here that all the costs and benefits given for each alternative scheme are based on the study result of Phase II; that is, a further detailed study to estimate the benefits and costs for the selected master plan projects is carried out through Phase III based on this optimal water allocation study (refer to subsequent Section 3.8).

(1) Reservoir and Hydropower Stations:

Construction costs related to reservoir and hydropower stations are presented below:

Case	Total cost (million US$)
Dai Ninh	
Case 1	526.0
Dong Nai No. 3	
Case 1	256.0
Case 2	326.0
Case 3	375.0
Dong Nai No. 4	
Case 1	302.0
Case 2	397.0
Fu Mieng	
Case 1 (without Div.)	248.0
Case 2 (with Div.)	254.0

(2) Irrigation Projects:

Costs related to the irrigation works at each station are presented below:

Annual Cost for Dam and Weir

Unit: US$ mil.

	Investment Cost	Annual Cost for Dam and Weir			
		Investment	O&M	Total	Remarks
Site 6 (Phuoc Hoa)					
Headworks:					
Alt.-1	80.75	8.08	0.6	8.69	
Alt.-2	28.73	2.87	2.6	5.52	
Site 8 (Phan Ri) and Site 9 (Phan Tiet)					
Song Luy Reservoir:					
Alt. - 1	29.50	3.0	0.2	3.2	
Alt. - 2	31.50	3.2	0.2	3.4	
Alt. - 3	33.50	3.4	0.3	3.7	
Alt. - 4	36.00	3.6	0.3	3.9	
Alt. - 5	38.50	3.9	0.3	4.2	
Alt. - 6	40.50	4.1	0.3	4.4	
Alt. - 7	43.50	4.4	0.3	4.7	
Alt. - 8	50.50	5.4	0.4	5.8	Maximum
Site 10 (Ta Pao) and Site 11 (Vo Dat)					
Weir Construction Cost:					
Ta Pao	12.60	1.26	0.1	1.35	
Vo Dat	16.30	1.63	0.1	1.75	

Note: Alternative-1 for Phuoc Hoa dam and Alternative-2 for Phuoc Hoa pump station

Annual Cost for Irrigation Development

	Irrigation Scheme	Irrigation System Investment Cost	Annual Cost for Irrigation System			Annual Cost per 1,000 ha
			Investment (US$/ha)	O & M (US$/ha)	Total (US$/ha)	(US$/1,000 ha)
Site 6	Phuoc Hoa	3,470	347	34	381	381,000
Site 7	Dau Tieng (Extension)	1,300	130	49	179	179,000
Site 8	Phan Ri	2,470	247	23	270	270,000
Site 9	Phan Thiet	1,550	155	23	178	178,000*
Site 10	Ta Pao	2,210	221	26	247	247,000
Site 11	Vo Dat	2,850	285	43	328	328,000
Site 12	Dau Tieng (Existing)	1,300	130	49	179	179,000
Site 13	Tay Ninh Upper	2,340	234	58	292	292,000
Site 14	Tay Ninh Lower	2,320	232	58	290	290,000
Site 16	Long An Delta	2,040	204	29	233	233,000
Site 17	HCMC	2,237	224	29	253	253,000

* Including the construction cost for diversion channel.

(3) Diversion Channels

Costs related to alternative diversion channels are presented below:

Case	Max. Div. Capacity (m^3/s)	Total Cost (mil. US$)
Fu Mieng Diversion (Site 5)		
Case 1	60	20
Case 2	70	22.6
Case 3	80	25.2
Case 4	90	27.8
Case 5	100	30.3
Phuoc Hoa Diversion (Site 6)		
Case 1	40	33
Case 2	55	48
Case 3	60	56
Case 4	70	66
Case 5	80	72
Dau Tieng Diversion (Site 7)		
Case 1	60	2.1
Case 2	70	2.4
Case 3	80	2.8
Case 4	90	3.3
Case 5	100	3.8
Dau Tieng Existing (Site 12)		
Case 1	60	5.5
Case 2	70	6.4
Case 3	80	7.5
Case 4	90	8.7
Case 5	100	10.2

It is noted for Phan Ri (Site 8) that construction cost of the diversion channel with the maximum capacity of 40 m^3/s is included in the irrigation development cost at Phan Thiet.

(4) Water Supply Projects:

Construction costs to develop drinking and industrial water are as follows:

Sites 18 and 19

	Investment Cost US$ mil.	Annual Cost US$ mil.
Hoa An	800	80.0
Saigon	75	7.50

Benefits incorporated in the Model are assumed to be US$ 0.07/kWh, which is the long run marginal cost for electric power generation, for all hydropower generation and US$ 0.15/m^3 for water supply, which is the average water tariff derived from revenue for the HCMC water supply system. Incremental benefits for each irrigation project are defined as follows:

Site	Project	Benefit $/ha
Site 6	Phuoc Hoa [1]	1,174
Site 7	Dau Tieng (Extension)	1,128
Site 8	Phan Ri	990
Site 9	Phan Thiet	962
Site 10	Ta Pao	828
Site 11	Vo Dat	975
Site 12	Dau Tieng (Existing)	1,128
Site 13	Tay Ninh Upper	1,128
Site 14	Tay Ninh Lower	1,128
Site 15	Dong Nai Riparian	1,000
Site 16	Long An Delta	457
Site 17	HCMC	474

[1] Including water supply benefit of $424/ha

3.7 Model Solution

Given the structured problem and the constraints as stated above, the model is solved using the General Algebraic Model (GAMS) incorporating Optimization Subroutine Library (OSL) solver. The optimal solution obtained from the model is presented in Table 3.6 and Figure 3.4, from which the following can be said:

(1) Water Diversion and Irrigation Development

It can be said that the water resources in the Study Area are relatively abundant and that diversion of water from the Be River to the Saigon and Vam Co rivers would enable additional irrigation development in the latter area. In order to compare the potential irrational development scenario of diverted-case and non-diverted case, the model is applied by enforcing integer variables at both Fu Mieng and Phuoc Hoa diversion alternatives to be zero; that is, no diversion scheme is considered from the Be River to Saigon River. Constraints incorporated in the model, such as boundary conditions at the Dong Nai River at Hoa An, the Saigon River at Phu Cuong and the Vam Co River, have been kept the same. The result of this analysis is as follows:

Unit: ha

Site	Project	Max. Irrig. Area	Diversion	No Diversion
Site 6	Phuoc Hoa	45,680	45,680	45,680
Site 7	Dau Tieng (Extension)*	48,390	48,390	37,264
Site 8	Phan Ri	29,700	29,700	29,700
Site 9	Phan Thiet	10,000	10,000	10,000
Site 10	Ta Pao	23,000	19,000	23,000
Site 11	Vo Dat	15,000	12,617	15,000
Site 12	Dau Tieng (Existing)	45,000	45,000	45,000
Site 13	Tay Ninh Upper	15,100	10,825	10,825
Site 14	Tay Ninh Lower	14,300	14,300	14,300
Site 15	Dong Nai Riparian	23,400	23,400	23,400
Site 16	Long An Delta*	54,000	31,170	0
Site 17	HCMC*	46,000	46,000	0
	Total	369,570	336,082	274,169

Note: * Beneficiary areas by diversion from the Be River.

The above result presents the fact that it is not possible to irrigate a total of 88,300 ha (entire irrigation area of Long An Delta and HCMC irrigation area and part of Dau Tieng Extension) without the water diversion from the Be River, although the case without diversion shows a favour for Ta Pao and Vo Dat. Water resources in the Study Area are abundant, as noted above, however, utilization of water in the Study Area would not be optimally allocated unless water is diverted from the Be River to the Saigon River.

Furthermore, considering the paddy production in the Study Area to compare with the demand growth at the target term of the year 2015, the following Table is presented to analyze the incremental paddy production in the Study Area:

Incremental Paddy Production

Site	Project	Development Area (ha)	Present Production (ton)	Future Production (ton)	Production Increment (ton)
Site 6	Phuoc Hoa	45,680	39,630	139,360	99,730
Site 7	Dau Tieng (Extension)	48,390	181,460	235,660	54,200
Site 8	Phan Ri	29,700	41,440	182,660	141,220
Site 9	Phan Thiet	10,000	22,230	61,500	39,270
Site 10	Ta Pao	19,000	51,950	150,510	98,560
Site 11	Vo Dat	12,620	1,750	107,100	105,350
Site 12	Dau Tieng (Extension)	45,000	168,750	168,750	0
Site 13	Tay Ninh Upper	10,830	40,590	124,490	83,900
Site 14	Tay Ninh Lower	14,300	53,630	164,450	110,820
Site 15	Dong Nai Riparian	23,400	70,200	70,200	0
Site 16	Long An Delta	31,170	53,200	192,070	138,870
Site 17	HCMC	46,000	55,800	221,630	165,830
	Total	336,090	780,630	1,818,380	1,037,750

With an increased irrigation area of 267,690 ha (i.e. 336,090 ha minus 68,400 ha of existing Dau Tieng and Dong Nai Riparian) by irrigated agricultural development, the incremental paddy production is estimated to be 1.04 million tons per annum in the year 2015. While, the requirement of paddy to meet the population increased by 7.3 million in the Study Area from the year 1995 to 2015 would be about 2.1 million tons by assuming a per capita consumption of 285 kg/year. The irrigation development to the full extent under the optimum utilization of water resources in the Dong Nai and surrounding river basins would contribute to the stable food supply in the Study Area. This irrigation development matches to the agricultural development policy in the Study Area to intensify food crops such as rice by taking into consideration the present situation that food production can only satisfy 50 % of demands in food stuffs. By doing such endeavour in agricultural development, there would still fall short of food supply, which would have to be supplemented by the increased paddy production through the rehabilitation and extension of the existing irrigation schemes and import of paddy mainly from the Mekong Delta.

Monthly diversion amount of respective diversion schemes is summarized in Table 3.7.

(2) Comparision of Diversion Schemes at Phuoc Hoa and at Fu Mieng

It is worth mentioned that the diversion scheme of Fu Mieng is selected as the optimal diversion scheme when compared with the Phuoc Hoa scheme. As a comparision, the model is set so as to enforcing the selection of Phuoc Hoa diversion scheme. The result of the analysis reveals that the net benefit of the model when Phuoc Hoa diversion scheme is selected would become US$ 491 million while that of Fu Mieng diversion scheme is US$ 492 million. While the difference of net benefit between two schemes is marginal, the model tentatively concludes that Fu Mieng diversion scheme is more beneficial and therefore it is included in the optimal set of solutions. However, further studies to select the optimal one between two alternatives shall continue in the feasibility study to be carried out in future.

(3) Development of East Coast Area by Dai Ninh Diversion

From the optimal set of solutions presented, it is found that diverted water from Dai Ninh to the east coast area would fully be utilized by constructing the Song Luy reservoir and by re-diverting water to the Cai River for the full development of Phan Thiet and Phan Ri plains, and that Phan Ri would be developed by constructing the Song Luy reservoir with the active storage capacity of 110 million m^3.

(4) Development of Hydropower Damsites

The results also indicate that the reservoir development at Dong Nai No. 3 and Dong Nai No. 4 is not required from the optimal water allocation standpoints. It should be noted that, however, this result is based on the constraints incorporated in the Model, as presented previously (underestimated energy output due to draught year), and that electricity demand by the target year 2015 is not included in the Model (no consideration for capacity value). Hydropower development in the Study Area is studied separately in Appendix V. Reservoir development recommended in Appendix V, such as Dong Nai No. 3 and Dong Nai No. 4, would create further positive impacts to the downstream flow, especially in the dry season. Therefore, the optimal set of solutions obtained by the water allocation study should concurrently be considered.

(5) Water Requirement at the Hoa An Intake and Future Development of the Dong Nai River Basin beyond the Target Year 2015

As discussed in preceding Section 3.6.5, the minimum flow requirement at the Hoa An intake for the salinity intrusion is set at 100 m^3/s, whilst water supply requirements for HCMC and the towns along National Highway No. 51 are 36.8 m^3/s. Since the minimum monthly firm discharge at Tri An is set at 230 m^3/s, the balance between water actually released from the Tri An power plant and water requirements for water supply and salinity intrusion is counted as the

future potential for development. Following is the discharge secured at Hoa An before the abstraction of requirements for water supply:

(Unit in m^3/s)

Jan.	Feb.	Mar	Apr.	May	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.
414	234	241	243	468	294	472	1,015	500	1,237	674	295

The above Table suggests the fact that a further development of some 100 m^3/s (i.e. = 234 - 36.8 - 100 m^3/s) be possible beyond the target year 2015 at the downstream reaches of the Dong Nai River, provided that the minimum flow of 100 m^3/s is kept at the Hoa An intake for salinity intrusion and that the minimum monthly firm discharge at Tri An is kept at 230 m^3/s. Direct diversion from Bien Hoa of the Dong Nai River to the Saigon River and further through the Rach Tra canal to the East Vam Co River would be considered as one of development alternatives beyond the year 2015 for further development of low-lying areas extended in HCMC and Long An province. Such a proposed diversion route is shown in Figure 3.5. Figure 3.6 shows the comparison of flow of the Dong Nai River at Hoa An between that in the Model Solution after abstraction of water requirement for irrigation and diversion for the Master Plan Projects, and the natural flow under the condition with the Tri An reservoir. To make sure the development plans at the lower reaches of the Dong Nai River, intensive measurements to clarify the amount of mandatory release for salinity intrusion are required to be continued.

Similarly, discharge secured at Phu Cuong of the Saigon River, where the minimum flow is set at 25 m^3/s for salinity intrusion, after the abstraction of requirements for water supply is as follows:

(Unit in m^3/s)

Jan.	Feb.	Mar	Apr.	May	Jun.	July	Aug.	Sep	Oct.	Nov.	Dec.
25	25	25	25	37	83	42	25	52	75	60	25

For the East Vam Co River, discharge secured just downstream of Xuan Khanh, where the minimum flow is set at 20 m^3/s for salinity intrusion, after the abstraction of water requirements for irrigation for Long An Delta-Rach Tram is also presented as follows for reference:

(Unit in m^3/s)

Jan.	Feb.	Mar	Apr.	May	Jun.	July	Aug.	Sep	Oct.	Nov.	Dec.
20	20	20	20	22	59	32	62	59	183	54	26

3.8 Sensitivity Test

A 4-year drought flow estimated at Hoa An is used to gain the optimal water allocation of the Dong Nai River basin as discussed in preceding Section 3.6.1, since the Hoa An site is

considered to be the most appropriate place to measure hydrological regime of the whole of the Dong Nai River basin. However, there is an argument that hydrological regime does not necessarily coincide between the Dong Nai main stream and the Be River, which is the crucial water source for the diversion scheme to the Saigon and East Vam Co river areas. Indeed, a careful assessment of discharge data at the Phuoc Hoa station, which is the representative discharge gauge in the Be River basin, shows the 4-year drought in the 1969 water year, i.e. November 1968 to October 1969, against the 1974 water year at Hoa An.

A sensitivity test is carried out to see the change of irrigable area, in particular in the Saigon and East Vam Co river basin, by applying flow data of the 1969 water year to each interesting site. Following shows the result of sensitivity test and compares the irrigable areas gained by applying 1969 and 1974 water year data for each scheme:

Irrigation Scheme		Irrigable Area, ha		
		Maximum	1974 Water Year	1969 Water Year
Site 6	Phuoc Hoa	45,680	45,680	45,680
Site 7	Dau Tieng (Extension)	48,390	48,390	48,390
Site 8	Phan Ri	29,700	29,700	29,700
Site 9	Phan Tiet	10,000	10,000	10,000
Site 10	Ta Pao	23,000	19,000	19,000
Site 11	Vo Dat	15,000	12,617	8,915
Site 12	Dau Tieng (Existing)	45,000	45,000	45,000
Site 13	Tay Ninh Upper	15,100	10,825	8,926
Site 14	Tay Ninh Lower	14,300	14,300	1,4300
Site 15	Dong Nai Riparian (Existing)	23,400	23,400	23,400
Site 16	Long An Delta	54,000	31,170	23,773
Site 17	HCMC	46,000	46,000	40,752
	Total	369,570	336,082	317,836

The above sensitivity test tells the tendency that the irrigable area, in particular Long An Delta and HCMC, reduces as the flow of the Be River decreases. Taking into consideration the uncertainties involved in return flow, cropping pattern and maintenance flow of the Saigon and East Vam Co rivers, the result obtained by using hydrological data of the 1974 water year is treated as a prime result, whilst reference for the result gained by the 1969 data.

4 FORMULATION OF MASTER PLAN

4.1 Selection of Master Plan Projects

The optimal allocation study of water resources available in the Study Area as discussed above has presented various significant points of consideration for the integrated development of the Study Area. Based on the result of the optimization study as well as discussions to enhance the living standard in the rural area given in Chapter 2, master plan projects to be implemented within coming 20 years, i.e. by the year 2015, in the Study Area are proposed as given below:

(1) Improvement and rehabilitation of 164 small scale irrigation projects as well as the implementation of 65 new ones as the rural agricultural development project,
(2) A total of 1,207 rural water supply projects,
(3) Two hydropower projects with reservoir (420 MW in total);
    Dong Nai No. 3: 180 MW
    Dong Nai No. 4: 240 MW,
(4) The Be-Saigon diversion project (a diversion amount of 66 m^3/sec to the existing Dau Tieng in the Saigon River basin),
(5) Eight (8) irrigation projects (242,560 ha in total) including Song Luy irrigation reservoir project (110 million m^3 in active storage); Phuoc Hoa (45,680 ha), Dau Tieng Extension (48,390 ha), Phan Ri (29,700 ha), Phan Thiet (10,000 ha), Ta Pao (19,000 ha), Vo Dat (12,620 ha), Long An Delta (31,170 ha) and HCMC (46,000 ha),
(6) Water supply project along National Highway No. 51 (1.7 million m^3/day in demand), and
(7) Strengthening of the organization on water-related institutions.

The master plan projects proposed in the Study Area are summarized in Table 4.1 and shown in Figure 4.1 except for Item 7, which is the institutional proposal to smoothly implement the projects mentioned in Items 1 to 6 and is discussed in subsequent Section 4.3.

As discussed in Chapter 2 above, attention is also called for the socio-economic development of the Study Area, especially taking into account the living condition in the rural area. In order to raise the living condition in the rural area, it is proposed that the rural water supply projects, as discussed in Appendix VII and the rural agricultural development projects discussed in Appendix VI be incorporated as a set of master plan project. Noting the urgent demand which must be responded by the Government, these rural agricultural development projects and rural water supply projects are critical for the overall increase of the living standard in the rural area. This set of master plan projects would not only create job opportunities but also focus on the improvement of social amenity and reduction of poverty in the rural area. In other words and most importantly, it would contribute to the sustainable development of the rural area. While

the scale of each project within this set of master plan projects is small, the significance of the impacts of these projects which will contribute to the rural area cannot be neglected.

In the water allocation study in Phase II, the power output of Dong Nai No. 3 , No. 4 and Fu Mieng, which is tentatively selected as the diversion alternative of the Be-Saigon diversion project in this study, was assumed to be 130 MW, 318 MW and 60 MW. However, based on the topographic survey and the further optimization study carried out in Phase III, the capacities of these projects are modified to 180 MW, 240 MW and 55 MW respectively.

In view of the integrated regional development, a total of eight irrigation projects out of ten projects which are optimally defined in the above Section 3.7 are incorporated as the master plan projects due to the fact that Tay Ninh Upper (10,825 ha) and Tay Ninh Lower (14,300 ha) are included in a list of master plan projects to deal with the rural agricultural development projects since those two areas are a cluster of small scale irrigation projects. As noted above, the irrigation development to the full extent under the optimal utilization of water resources in the Dong Nai and surrounding river basins would contribute to the stable food supply in the Study Area.

Furthermore, the optimal allocation study has also revealed the facts that, in order to support the full development of potential irrigation area, three key projects: 1) Dai Ninh hydropower/diversion for the inter-basin transfer of water resources of the upper Dong Nai River basin for the development of east coast area; 2) Fu Mieng hydropower/diversion for the inter-basin transfer of water resources of the upper Be River basin for the development of the Saigon and East Vam Co river basins; and 3) Song Luy irrigation reservoir for the full utilization of water resources to be made available by the construction of Dai Ninh for the east coast area are indispensable. Taking into consideration that the Dai Ninh project is already given the priority to be developed in early 2000s by the Vietnamese Government, the project is treated as a committed project, the development of which is determined; that is, the Dai Ninh project is excluded in the list of this master plan projects to be developed by the year 2015. Meanwhile, Fu Mieng and Song Luy reservoir projects are included in the list of this master plan projects.

Moreover, in view of the electric supply situation that electric power demand is expected to grow some 10 times greater than the present level within coming 20 years as discussed in Appendix V as well as in view that indigenous and renewable energy, i.e. hydropower, shall be developed as much as possible to save fossil fuel for foreign exchange earnings, the combined scheme of Dong Nai No. 3 and Dong Nai No. 4 is included as a master plan project. As noted in the above Section, this master plan project would create further positive impacts to the downstream flow, especially in the dry season. Considering the full development of SFEA and further demand which will be created by future expansion of Economic Triangle Zone, HCMC and its vicinities beyond the target year of 2015 to the mid-21 century, the positive

impacts of the combined scheme of Dong Nai No. 3 and Dong Nai No. 4 cannot be neglected and this scheme is thus incorporated as the master plan project.

Development of domestic and industrial water, as discussed in Appendix VII and the Section above, is important not only for meeting the basic human needs in the Study Area, but also for economic development in the southern Viet Nam including SFEA promised as a locomotive of national economic development. While many districts and major towns scattered in the Study Area still have such a scale that their water demands can be met with the development of groundwater, HCMC and the corridor area along National Highway No. 51 between Bien Hoa and Vung Tau are needed to seek a water source of domestic and industrial water supply to surface water such as the Dong Nai River due to a large future demand of 2.1 million m^3/day for the former and 1.7 million m^3/day for the latter in the year 2015, thus incorporated in the optimal water allocation study.

Water supply projects for HCMC and the corridor area along National Highway No. 51 are considered to be highly possible candidates for master plan projects by taking into account the development scale as well as the influence to the economic development in the nation.

Currently, a master plan study is now undertaken with funds from the Asian Development Bank to make a concrete development plan for the water supply of HCMC. On the other hand, the corridor area along the National Highway No. 51 consisting of five demand zones (refer to Appendix VII) does not so far have a clear plan for water supply in an integrated manner, even if studies for a few specific projects are independently carried out by the Vietnamese Government. Taking into consideration the situation mentioned above, the water supply project along National Highway No. 51 is selected as the master plan project of water supply.

Flood mitigation study discussed in Appendix VIII identifies the flood prone-areas in the Study Area such as Cat Tien and Ta Lai area in the upper Dong Nai, Ta Pao and Phu Dien area in the La Nga River and the lower Dong Nai and Saigon river areas. Since flood simulation study reveals that flood damages in the said areas are substantially solved with flood retardation effects of the existing and proposed reservoirs, flood mitigation projects are not included in the list of master plan projects. However, in case where the proposed irrigation master plan projects are still susceptible to flooding, in particular, local flooding, a flood mitigation plan shall be discussed as part of irrigation development for those projects.

Finally, the result of the optimal allocation study of water resources available in the Study Area has emphasized the importance of integrated approach to the water resources development. Most of the development projects reviewed in this master plan study, although some are newly identified during the study period, have been studied previously by line ministries and agencies or by provincial governments. However, while some of these projects have been found feasible as an individual project, feasibility in terms of the Dong Nai River and surrounding

river basins as a whole has never been analyzed. The master plan projects above, also presented in Figure 4.1, gives a skeleton Figure of how the Study Area's development should take place by the target year of 2015, however, overall planning, coordination and management of the water resources development in the Study Area must also be integrated in order to reach this skeleton Figure by the year 2015.

Considering the Study Area's feasibility as a whole and integrated planning and management of water resources development as noted above, a regional level institutional framework or a management unit for continuing the project-related activities of the Dong Nai Master Plan is recommended to be created as discussed in following Section 4.2 as well as for maintaining the proposed implementation schedule of the master plan projects.

4.2 Implementation Schedule and Fund Management of the Master Plan Projects

4.2.1 Implementation Schedule

As discussed in the preceding Section 4.1, six master plan projects (except for Item 7), which are to be developed within coming 20 years by the target year 2015, are selected from five sectors, i.e. (1) Rural agricultural development projects, (2) Rural water supply projects, (3) Two hydropower projects (4) Fu Mieng multipurpose reservoir project, (5) Eight large scale irrigation projects and (6) Water supply project along National Highway No. 51. An implementation schedule for those projects is prepared by incorporating necessary lead time such as feasibility study and detailed design as given in Figures 4.2, 4.3 and 4.4, which include the implementation schedule for the Dai Ninh project and HCMC water supply project as well for reference.

The implementation schedule of three hydropower master plan projects including Fu Mieng (refer to Figure 4.2) is basically prepared based on the study result of generation expansion planning, which suggests to commission Dong Nai No. 3 and No. 4 in the year 2008 and Fu Mieng in the year 2010 taking into consideration the development scenario of irrigation schemes at HCMC and Long An Delta as well. As for eight irrigation master plan projects, the plan to build the reservoir projects in the Dong Nai River basin as well as project viability and socio-economic needs in the region is given the high priority in preparing the implementation schedule of those projects (refer to Figure 4.3), i.e. commissioning of Dai Ninh for the Phan Ri and Phan Thiet projects in the year 2003, whilst the year 2004 to 2008 for Fu Mieng. Further detailed discussions for preparing the implementation schedule of the irrigation master plans are referred to Appendix VI.

Alternative 1, which mainly seeks water sources to the Dong Nai and Ray rivers, is selected as the development plan for the water supply project along National Highway No. 51, i.e. water supply master plan project. As discussed in Appendix VII, the selection of Alternative 1 is based on the economic comparison among alternatives, which have the implementation schedule of respective water supply projects added to the demand centres so as to meet their water demand. Figure 4.4 is prepared to graphically depict the implementation schedule of the water supply projects to be developed for the water supply project along National Highway No. 51 with lead time.

Rural agricultural development projects need a study including feasibility study to determine the implementation order of numerous projects prior to actual construction works (refer to Figure 4.3). The implementation of new projects will be undertaken with a slight time delay of two years for that of improvement and rehabilitation projects in consideration of the required preparation period towards the implementation. While the determination of implementation order among the projects is awaited by the coming feasibility study, the priority in implementation should be placed on the projects which are not involved in the eight large scale irrigation projects. Among those not included in the eight large projects, following are main factors to be taken into a consideration the implementation order:

Technical aspect:

- Condition of scheme facilities (extent of damages and deterioration);
- Availability of water resources; and
- Preparation for rehabilitation, improvement and construction,

Socio-economic aspect:

- Number of direct and indirect beneficiaries;
- Regional economic situation (poverty);
- Effect to enhancement of employment opportunity; and
- Effect to enhancement of rural industry,

Institutional aspect:

- Capacity and capability of O & M organizations at a local level;
- Availability of agricultural supporting services; and
- Formation and activities of farmers' organization, and

Economic and financial aspect:

- Economic and financial feasibility; and
- Cost recovery at least for operation and maintenance.

Rural water supply projects also need a study and investigation to select the priority communes and their drilling sites of wells prior to the actual construction works. This sort of study and investigation will iterate every five years by splitting the implementation of all the projects into five packages (refer to Figure 4.4).

Although priority communes are selected through the study carried out prior to the actual implementation of rural water supply projects, basic approaches to select the priority communes would be as follows:

Poverty and remoteness

Most of poor and remote communes, in particular communes in the highland area where minority groups live, suffer from drinking water.

Less availability of aquifer

In the area where poor or deep aquifer is only available, local funds are far short of implementation.

Afflicted area by less rainfall, salinity intrusion and acid water

The areas afflicted by less rainfall, salinity intrusion and acid water have hardship in collecting drinking water.

Large water demand

The communes with a large number of population have large water demand, requiring urgent implementation of the rural water supply project.

Administration support

Taking into account the fact that rural water supply projects cannot be implemented without full support of local authorities, their implementation capability is one of essential elements to select the communes where the project is implemented.

According to the information given in Appendix I, Ninh Thuan and Binh Thuan provinces lie in the lowest category (Per capita GDP less than VND 300,000 a year) among three in the nation in terms of income, followed by Tay Ninh, Song Be and Lam Dong provinces lying in the middle income provinces (Per capita GDP ranging between VND 300,000 and 450,000). Taking into account less availability of aquifer and small rainfall as well, Ninh Thuan and Binh Thuan provinces would be the first provinces to implement rural water supply projects.

A further detailed study to estimate construction costs for the selected master plan projects is carried out through the work of Phase III as discussed in Appendixes V, VI and VII. With the

construction costs so estimated and the implementation schedule discussed above, a disbursement schedule of all the master plan projects invested over a time horizon of coming 20 years from the year 1996 to 2015 is prepared as given in Table 4.2. Impacts of investment costs necessary for the implementation of the master plan projects to the national budget are discussed in following Section.

4.2.2 Fund Management

A disbursement schedule of the investment costs necessary for the implementation of the proposed master plan projects is prepared as discussed in preceding Section 4.2.1 (refer to Table 4.2). The availability of public fund, which is defined as public investment consisting of government investment through ministries and departments, to be allocated to the master plan projects is assessed by comparing the public fund invested in the Study Area, i.e. one city and nine provinces.

The estimate of public fund invested in the Study Area is commenced with the prediction of all the public investment in the nation from GDP projected up to the year 2015, followed by the projection of ratio of public fund invested in the Study Area to the public investment in the nation.

GDP up to the year 2015 is estimated based on a GDP value of VND 170,258 billion in the year 1994 and the average GDP growth rates, 9.0 % per annum in the period of the year 1993 to 2005, in real terms, whilst 8.0 % for a period of the year 2006 to 2010 and 7.0 % for a period of the year 2011 to 2015 as shown in Table 4.3. Further discussions to predict the GDP growth rates are referred to Appendix I.

Rates of public fund expenditure to GDP vary in a range 2.8 % to 8.9 % with an average value of 6.5 % for a time period of the year 1988 to 1994. Applying the value of 6.5 % to the projected GDP, public investment is estimated up to the year 2015. Public fund expenditure used in the Study Area was 27.3 % for the national expenditure in the year 1992. Applying this rate to the public investment in the nation, public fund to be invested in the Study Area is estimated.

The master plan projects selected in this study belong to hydropower, irrigation and water supply sectors, the share of which is estimated at 20 %, 10 % and 5 % respectively in the public investment of the Study Area based on the past performance. Applying a rate of 35 %, which is the sum of shares for the three public sectors, to the public fund in the Study Area, funds available for hydropower, irrigation and water supply are estimated by dividing a time period of 20 years into four phases; Phase I for a time period of the year 1996 to 2000, Phase

II for a time period of the year 2001 to 2005, Phase III for a time period of the year 2006 to 2010 and Phase IV for a time period of the year 2011 to 2015.

Total investment requirements necessary for the implementation of the master plan projects are nearly VND 1,870 billion during Phase I, VND 12,010 billion during Phase II, VND 13,330 billion during Phase III and VND 3,080 billion during Phase IV (refer to Table 4.2), corresponding to 8.7, 36.3, 27.0 and 4.4 % of the projected total public investment allocation to the Study Area in the respective phases, whilst 24.9, 103.8, 77.1 and 12.5 % of the public funds allocated to the hydropower, irrigation and water supply sectors in the Study Area. The study on fund management tells that the total investment costs for the master plan projects during Phase II will require a marginally larger share of the projected public fund availability.

However, taking into consideration the future promised development in the region as well as the importance of three sectors to boost its economic development, a total investment of some VND 30,300 billion for the master plan projects is judged to fall within the reasonable share of the total public investment to be allocated to the Study Area.

The Dong Nai water resources development projects are characterized by two aspects; one is regional development and the other is long-term development. In order to implement the planned schedule of all the projects in the Study Area, these two aspects will have to be fully taken into account to strengthen the linkage between planning and budgeting in the existing budgetary preparation system.

Investment programmes of various line agencies do not seem to be always well coordinated. Each programme is assessed on its own merit without being examined under any macro perspective. It also happens that a budget which does not support the development plan is proposed on the regional basis. At the time of budget preparation, an emphasis shall be given to the linkage between planning and budgeting.

Investment planning could be efficiently carried out through coordination of public development projects and within the inter-regional and/or inter-provincial framework. In this connection, problems in planning and monitoring of public fund flow might deserve the most urgent attention since they have a great bearing on resources allocation and their efficient use.

As pointed out in numerous study reports, the sole key to improvement for efficient use of allocated resources lies in human resource development. To enhance the efforts toward the efficiency improvement and to promote properly the proposed projects in the Study Area, it is essential to establish a systematic and coordinated personnel training system. Lack of such a system or weak back supporting will be clearly a major hindrance to future development of project management in the Study Area.

The decentralization being promoted by the central government would empower the local governments to command local development projects. The proper implementation of those projects would be hampered by insufficient capabilities of local governments for project planning, implementation and management. The transfer of government funds (subsidies) from central and provincial agencies or administrations to the local governments should be carefully undertaken as their abilities are upgraded.

As proposed in subsequent Section 4.3, the Project Management Office (PMO) under the Dong Nai Water Resources Development Committee (DWRDC) inter-positioned between the national and provincial levels would be instrumental for general coordination and technical guidance related to project planning, implementation and management, and for coherent and mutually consistent actions by the local government's.

4.3 Management Systems for the Master Plan Projects

In October 1995, Viet Nam's National Assembly has approved a major government reorganization (or ministry reshuffle), and eight ministries and agencies were revamped to create the following three new ministries :

- Ministry of Agriculture and Rural Development (MOARD) :
  created from the merger of the former Ministry of Water Resources, Ministry Agriculture and Food Industry and Ministry of Forestry
- Ministry of Industry (MOID) :
  created from the merger of the former Ministries of Energy, Heavy Industry and Light Industry
- Ministry of Planning and Investment (MOPI) :
  formed from the merger of the former State Planning Committee (SPC) and State Committee for Cooperation and Investment (SCCI).

The resolution to revamp certain government agencies was approved in October 1995 by the deputies at the 8th session of the National Assembly, and a number of cabinet members have been appointed.

With Viet Nam's shift from a centralized to a market economy, this restructuring aims to separate the state management from production and business for the following two reasons :

a) to enhance the role of state management and the macro management by ministries, and

b) to allow businesses to have independent finance, investment and marketing.

As a result of restructuring, ministries are now "state management bodies" and "General Corporations" newly established engage in business but not management activities. In total, 21 corporations were established for promotion in business. They can only acquire capital and are solely responsible for making a profit. To avoid evils of the monopoly status of a corporation, the Vietnamese government intends to prepare laws to encourage competition and to establish at least two corporations in one industry.

Priorities are given to important industries like power that need to move ahead with their industrialization. The Viet Nam Power Corporation, one of 21 general corporations, takes charge of power industry development.

At present, the change appears only at the top level and it is supposed that the substantial/real restructuring (merger) will be carried out gradually. In fact, the decrees of the Prime Minister issued thereafter to the ministries and institutions concerned state that such establishments are not allowed to dismiss, nominate and replace staff or to transfer capital and property until instructions are received from the National Assembly.

The government agencies and institutions related to water resources development and management are shown in Figure 4.5.

(1) Present Institution for Regional Water Resources Development

The development of the Dong Nai River and surrounding basins area may be viewed both from the perspective of water resources development and regional development.

Although the integrated planning for provincial development exists, the scope for regional (inter-provincial) planning, at least up to very recently, was limited to only the special economic zones (in South : Southern Focal Economic Zone = SFEZ).

Besides, certain areas covering many provinces are planned as a unit by an agency specifically assigned for the task in a specific sector. As noted, the so-called river basin development projects like the Mekong, Red River, Dong Nai River, etc. may be units for monitoring spatial development.

Many public agencies are involved in the area development, coming under the jurisdiction of several types of provincial administration or local governments. At the national level, there are eight (8) principal national agencies involved in the water resources development as follows:

National Agencies

a) Ministry of Agriculture and Rural Development (MOARD)

b) Ministry of Planning and Investment (MOPI)

c) Ministry of Industry (MOID)

d) Vietnamese Power Corporation (VPC) (Ex-Ministry of Energy and the former General Company of Electricity of Viet Nam)

e) Ministry of Science, Technology and Environment (MOSTE)

f) Ministry of Construction (MOC)

g) Ministry of Labour, War Invalids and Social Affairs (MOLWISA)

h) Ministry of Public Health (MOPH).

At the provincial level, the Provincial or City's People's Committee is the most important institution insofar as area development is concerned. Its direct mission is to oversee the living improvement of the local people. The policy and strategy are channelled through the counterpart committees set up at the district level and the precinct level (refer to Figure 4.5).

The policy on the types of activities to be promoted for national financing is passed down to the lowest level which will in turn pass up the proposed development projects to be screened at the provincial level.

(2) Institutional Constraints

The focus of all these agencies has been directed to provincial organization, be it a part of provincial administration or local government. Assuming that each agency is successful in directing its development effort through the provincial organization, the effort is within the confinement of a single province.

Provincial needs help determine the agency's effort. Priority is inevitably determined within the light of these needs, which can be different from one province to the next. If failure of implementation takes place in a province, it would not be linked to the possibility of that in another province. The negative effect resulting from the failure on development effort of another province will tend to be overlooked as well.

Thus, the institutional framework for local development in Viet Nam has been as effective as could be expected, more specifically in the organized migration projects and migration to new economic zones. Although rural development has been actively pursued with formalized administrative apparatus, development of any given region (or area) has not been so handled (except for the Master Plan Study on Integrated Regional Development Program in Central Viet Nam which has started in the year 1995).

That is, Viet Nam, has no formal regional (or inter-provincial) planning as an ongoing task with regular planning machinery. This anomaly inhibits the formulation and integration of development projects that must be launched together in separate provinces within the same

region and/or basin. Even when the formulation of development projects for several provinces within a region (or basin) can be effected, the strategic implementation of these development projects is highly unlikely since there is no mechanism by which the relevance of implementation can be pushed and monitored. The absence of a regional context in which to politicize and articulate the development of the region may be said to account for its ineffectiveness.

Taking into account the present conditions and implications just noted, the following are some problems which the central and local governments have to tackle from now on:

a) Although there have been, for a long time, the policy and strategies promulgated to accelerate the decentralization, the local governments are, in practice, not really autonomous from the administrative and financial viewpoints.

b) In planning and implementing the regional water resources development projects, relationships at various levels among the central ministries/agencies, among the local authorities and between the central and local governments are not well coordinated.

c) Particularly in the local authorities, the number of staff in charge of planning, implementing and managing water resources development projects are very limited.

d) In general, capabilities of the staff in planning, implementing and managing water resources development projects have not sufficiently been developed in provincial and local authorities.

e) In spite of the existence of an information system for water resources development, the basic and/or accurate data are neither yet properly stored nor distributed to the authorities interested.

(3) Strengthening Provincial (Local) Institution

The Vietnamese government intends to promote the policy to decentralize the present administration system to provincial and local authorities to establish a bottom-up managing system. Decentralization of the administration system aims to allow greater participation of provincial administration and local governments in the annual planning and budgeting process and to link regional development needs to national decision-making processes.

Judging from the analyses described in the previous Section, this policy does not seem to be thoroughly put into practice. To realize the above decentralization, it is essential to expand and increase the institutional, financial and technical capabilities of both provincial administration and local governments. Water resources development will only be successful, when the local governments take the leading role in planning, implementation and coordination of the

development programmes/projects in other sectors. The role of central government will mainly be to provide technical guidance for their smooth implementation.

(4) Institutional Arrangements for Implementing the Dong Nai Projects

In terms of development of the Study Area, it will be better to treat it as a spatial unit. Administratively, each of ten (10) provinces concerned may be treated as a unit, which is a part of the so-called provincial administration under the Provincial/City People's Committee (PPC or CPC).

For the implementation of this "Master Plan Study on Dong Nai River and Surrounding Basins Water Resources Development", the Vietnamese government has already established a preliminary management system (Steering Committee) for supervising the Study. Thus, it is proposed to consolidate it as a foundation for further development. The following are some general ideas on how to strengthen the management system and to enable the smooth implementation of the master plan projects as scheduled in Figures 4.2 to 4.4:

a) First of all, the central government should promote human resource development in cooperation with the local authorities. To develop the capabilities of local authorities in planning, implementing and managing the water resources development project as well as rural development ones, it is required to increase the number of staff in charge and to provide them proper trainings.

b) In accordance with the decentralization of administration system, it is necessary to reassess the role of each local authority, to provide it with functional responsibilities and to improve the capabilities, especially to plan, coordinate and finance the projects.

c) The information system for water resources and rural development management should be established/consolidated to ensure the smooth and prompt implementation of the projects so that useful data can be timely distributed to those who need them, even at any levels.

d) Since it is difficult to promote the water resources and rural development effectively unless local authorities are really autonomous, financial decentralization should be strongly performed together with institutional reform.

Basically, it seems to be practical to make most of the existing system or to develop the existing "Steering Committee for the Master Plan Study". Therefore, institutional arrangements proposed here are to establish a "Committee" in charge of development of the Dong Nai River and Surrounding Basins (tentatively called as "Dong Nai Water Resources Development Committee: DWRDC"), based on the existing management system.

The DWRDC may consist of chairmen of ten (10) Provincial/City People's Committees concerned and representatives from the Ministries/Agencies relevant to the water resources development. This Committee may be chaired by the Project Management Office (PMO) director. Figure 4.6 shows the proposed structure for implementing the master plan projects.

Project management system

To enable the institutions concerned to assume specific water resources development roles in a region (area), a new institution called a "Project Management Office (PMO)" may be established under the "DWRDC" to facilitate the coordination at every national, ministry/department and regional/provincial levels.

The development administration with the DWRDC/PMO is described below for national, regional/provincial and local levels.

Supervision and coordination at the national level

As a national governing body on the water resources development management, the Dong Nai Water Resources Development Committee (DWRDC) will assume policy formulation, final decision and approval on the water resources development management matters.

The functions of this Committee are to provide overall policy and guidance, to review annual and multi-year projects/programmes, to supervise their implementation at the regional level and to promote institutional and financial capabilities in its management system.

As a working office, the Project Management Office (PMO) is responsible for the coordination of the overall regional development management activities and for the review, recommendation and advisory matters for the DWRDC. Major tasks of the PMO are to formulate the development projects, their screening, coordination, monitoring and evaluation and to submit them for final approval by the DWRDC.

The inter-regional and inter-provincial projects/programmes will be coordinated at the Ministry of Planning and Investment (MOPI), and Evaluation Commission for State Projects, Office of the Government levels.

Management and coordination at the provincial level

At the provincial level, the existing Department (Services) of Construction Management in each Provincial/City People's Committee will be strengthened with the support of PMO (refer to Figure 4.7).

Main functions of PMO to be effected through DWRDC are the following :

- to review and update the Master Plan occasionally,

- to review the projects/programmes of line agencies, and to coordinate and integrate them for submission to MOPI, Office of the Government and Evaluation Commission for State Projects,
- to identify fund sources for implementation of the projects,
- to prepare/initiate the regional water resources development, multi-sector projects/ programmes and/or integrated area development, and
- to promote investment opportunities to the Dong Nai River basin area.

Monitoring and evaluation at the provincial level

At the local government level, the Department of Construction Management and Department of Science Technology and Environment in each People's Committee concerned will undertake the monitoring and evaluation of the projects and will submit revised proposals for the annual and multi-year projects/programmes to DWRDC.

To improve and strengthen the capabilities of the existing development management system, it is recommended to start an "institutional supporting programme", which comprises the following major components:

a) To assist the DWRDC/PMO activities and ensure the smooth implementation of the development projects, this programme will dispatch from the central office an experienced development expert to the PMO for a time period of five years.

b) Principal ministries/agencies, i.e. MOPI, MOARD, MOID, VPC, MOC, MOSTE, and agencies concerned will assign/dispatch the experts in planning, implementing and managing the water resources and regional development projects to the PMO. They will undertake the counterpart training.

c) This programme will assist this decentralized management system for 10 years mainly by means of providing the salary of experts and certain local staff and necessary equipment like personal computers.

d) To deal with a large volume of data and information, it is necessary to standardize the document formats as simple as possible, while the equipment and instruments for filing/keeping the system will be provided with appropriate instructions and procedures.

e) While the regional water resources development management is a joint responsibility of the central and local governments, especially at the initial stage, its effectiveness and success will depend largely on their skills and resources. To realize the expected satisfactory results, it is vital to provide training seminars and workshops with a view of disseminating all development related information to the interested people.

PMO may play important roles in implementing this programme. The following functions seem particularly relevant :

a) to provide technical assistance to local governments comprising districts and communes/precincts for the preparation of provincial (or local) development plans,

b) to prepare simple standardized document formats and system for various data necessary for water resources development management, including monitoring and evaluation of project/programme implementation, and

c) to organize training seminars and workshops as mentioned above.

For the purposes of operation and maintenance, the completed irrigation and water supply projects (systems) will be transferred under the supervision of the Provincial/City People's Committee(s) concerned (People's Committees Enterprises). As for the power generating structures and facilities, their operation and maintenance will be carried out by the Electrical Power Company under the supervision of the Vietnamese Power Corporation (VPC).

Considering the optimal utilization of water resources available in the Dong Nai River basin area, it is essential to keep close contacts among all agencies concerned, because their problems are inter-related and complementary. The Dong Nai Water Resources Development Committee (DWRDC) proposed above will play a pivotal role in their coordination, collaboration and settlement of problems.

4.4 Selection of Priority Projects

As discussed in preceding Section 4.1, Selection of Master Plan Projects, this Study aims to develop water resources available in the Dong Nai River and its surrounding basins for two major objectives; (i) rural development in the Study Area and (ii) economic development mainly for SFEA. The former objective is tried to gain through the implementation of rural agricultural development projects and the rural water supply projects.

The latter intends to contribute to economic development through the enhancement of the production level of hydropower, staple foods through the large scale irrigation projects and domestic and industrial water supply. In short, the master plan projects are composed of five independent sectors with different development objectives. That is to say that the development objectives of this study, i.e. rural development and economic development, cannot be accomplished even if any of the above five development objectives is lacked. Thus, priority projects to proceed to the feasibility study stage or the next advanced stage are proposed to be selected from each of the following five sectors:

- Rural agricultural development project,
- Rural water supply project,
- Hydropower project,
- Large scale irrigation project, and
- Large scale water supply project.

Following is the discussion to select the priority project from each sector.

(1) Rural Agricultural Development Project

As the rural agricultural development project, identified are a total of 229 projects, of which 164 projects are improvement and rehabilitation of existing ones, whilst 65 projects are new implementation. Of 229 projects, a total of 53 projects are included in the command area of eight large scale irrigation master plan projects, and thus are screened out from the priority list to advance to the next study stage as small scale irrigation projects.

Remaining 176 projects are classified into two; 118 exiting projects requiring rehabilitation and 58 new projects. Taking into consideration the fact that improvement and rehabilitation of existing projects can be expected to gain the quick and high returns with low costs, implementation priority should be given to the improvement and rehabilitation of existing projects. Among the 118 existing projects, implementation order can hardly be determined at this moment due to the fact that thorough investigation for them has not be undertaken through this study. Thus, a study to determine the implementation order among them as well as a feasibility study for the projects selected as top priority for implementation shall be carried out toward their implementation.

Even so, a general idea to select priority projects for the implementation has been discussed in preceding Sub-section 4.2.1, Implementation Schedule. According to it, main points to focus on the selection of priority projects are placed on five aspects of (i) technical aspect, (ii) socio-economic aspect, (iii) institutional aspect, (iv) economic and financial aspect and (v) environmental aspect. A Terms of Reference (TOR) for the feasibility study of the small scale irrigation project is prepared as attached in Attachment-2.

(2) Rural Water Supply Project

A total of 1,207 projects are proposed to be implemented as rural water supply projects for the 170 communes in the Study Area (refer to Table 2.1). As done for the small scale irrigation project, in-depth study has not been carried out for the rural water supply project, but only the communes, which require the project, are identified through this Study.

The in-coming study for the rural water supply projects will thus commence with the work of selecting priority communes to implement the project, followed by the feasibility studies for the

projects to be implemented in the priority communes. As discussed in preceding Sub-section 4.2.1, main points to be considered in determining the priority order of communes to implement rural water supply projects are (i) poverty and remoteness, (ii) less availability of aquifer, (iii) afflicted area by less rainfall, salinity intrusion and acid water, (iv) large water demand and (v) administration support. A TOR for the feasibility study of the rural water supply project is prepared as attached in Attachment-3.

(3) Hydropower Project

A total of three projects, i.e. Dong Nai No. 3 and No. 4 and Fu Mieng, are proposed as the hydropower master plan projects in this study. Dong Nai No. 3 and No. 4 are recommended to be developed as a combined project with a total installed capacity of 420 MW in aiming at harnessing available hydropower potential at the site efficiently. Their commissioning year is expected at the beginning of the year 2008.

On the other hand, Fu Mieng is a multipurpose project with development objectives of hydropower and irrigation. The proposed installed capacity as a hydropower project is 55 MW, whilst the net incremental area by implementing Fu Mieng diversion is 88,300 ha in the Dau Tieng Extension and HCMC-Long An delta irrigation areas. The expect commissioning year of the Fu Mieng multipurpose project is proposed at the beginning of the year 2010. It is to be noted that further detailed studies are needed for comparing two projects, i.e. Fu Mieng and Phuoc Hoa, as alternatives of the Be-Saigon diversion project.

Since the combined development of Dong Nai No. 3 and No. 4 is expected to be installed earlier as well as to give greater contribution to the rapidly growing power demand than Fu Mieng, the former is selected as the priority project of hydropower sector. Attached in Attachment-4 is the TOR for the feasibility study of Dong Nai No. 3 and No. 4.

(4) Large Scale Irrigation Project

A total of eight projects, which are Phuoc Hoa, Dau Tieng Extension, Phan Ri, Phan Tiet, Ta Pao, Vo Dat, HCMC and Long An delta, are proposed as the large scale irrigation master plans. Those are categorized into five development packages in view of similarity of individual projects, trans-basin diversion of water and regional developments as shown below:

Development Package	Area (ha)	Master Plan Project	
1. Phan Ri-Phan Thiet Irrigation Project	39,700	1.1	Pha Ri Irrigation Scheme (29,700 ha)
		1.2	Phan Thiet Irrigation Scheme (10,000 ha)
2. Lower La Nga Plain Irrigation Project	31,620	2.1	Ta Pao Irrigation Scheme (19,000 ha)
		2.2	Vo Dat Irrigation Scheme (12,620 ha)
3. Phuoc Hoa Irrigation Project	45,680		Phuoc Hoa Irrigation Project (45,680 ha)
4. Dau Tieng Extension and HCMC-Long An Delta Project	125,560	4.1	Dau Tieng Extension Irrigation Scheme (48,390 ha)
		4.2	HCMC Irrigation Scheme (46,000 ha)(*1)
		4.3	Long An Irrigation Scheme (31,170 ha)
Total	242,560 ha		

(1*): including on-going Hoc Mon-Bac Binh Chanh Irrigation Scheme with a command area of 12,197 ha

To select a priority project from among the above four development packages, an evaluation is carried out by applying three elements on the projects, i.e. (i) social impacts translated as degree of contribution to the regional development, (ii) maturity of projects translated as whether or not the project has proceeded to a higher study stage toward implementation and (iii) economic viability. Following shows the evaluation result to select the priority project from among the above five packages based on the above three evaluation criteria:

Development Package	Master Plan Project	Area (ha)	Social Impact	Maturity	Economic Viability	Priority Ranking
1. Phan Ri-Phan Thiet Irrigation Project	Phan Ri	29,700	A	B	A	1
	Phan Thiet	10,000	A	C	A	
2. Lower La Nga Plain Irrigation Project	Ta Pao	19,000	A	C	A	3
	Vo Dat	12,620	B	C	C	
3. Phuoc Hoa Irrigation Project	Phuoc Hoa	45,680	B	B	B	2
4. Dau Tieng Extension and HCMC-Long An Delta Project	Dau Tieng Extension	48,390	B	B	B	4
	HCMC Delta	46,000	C	C	C	
	Long An Delta	31,170	C	C	C	

Phan Ri-Phan Thiet project shows the highest attractiveness to proceed to the feasibility study stage based on the above three criteria, and therefor is selected as the priority project of the large scale irrigation project (refer to Appendix VI for further discussion). Attached in Attachment-5 is the TOR for the feasibility study of Phan Ri-Phan Thiet irrigation project.

(5) Large Scale Water Supply Project

Water supply project along National Highway No. 51 is selected as one of master plan projects in this study. According to the preliminary study carried out for the project (refer to Appendix VII), it is recommend to supply domestic and industrial water from the Dong Nai River to three demand centres of Bien Hoa, Tam Phuoc and Nhon Trach in Dong Nai province by burying pipelines as a major component. On the other hand, Da Den and Song Ray reservoir projects are proposed to be built as a major component for supplying domestic and industrial water to the Phu My and Vung Tau demand centres in Ba Ria-Vung Tau province.

A development alternative to include these three projects, i.e. pipeline, Da Den and Song Ray, shows the highest economic viability among three alternatives, and furthermore those three are required to be developed urgently for meeting the rapidly growing water demand. Taking into account these facts, a package project to include these three projects is recommend to be selected as a priority project to proceed to the feasibility study stage. Attached in Attachment-6 is the TOR for the feasibility study of the water supply project along National Highway No. 51.

For implementing the proposed master plan projects on the scheduled track, the reinforcement of the system to manage the master plan projects is included as one of the most essential elements. In this context, a programme to strengthen the management body is proposed. Attached in Attachment-7 is TOR for such a programme.

TABLES

Table 2.1 List of Rural Water Supply (RWS) Projects Proposed in the Study Area

Province	District	Number	
		Communes	RWS projects
Tay Ninh	Duong Minh Chau	1	6
	Chau Thanh	1	16
	Trang Bang	6	93
	Tan Chau	1	4
		9	119
Song Be	Bu Dang	3	16
	Loc Ninh	4	26
	Phuoc Long	4	36
		11	78
Dac Lac	Dac Nong	10	23
	Dak R'Lap	9	23
		19	46
Lam Dong	Da Huoai	8	22
	Da Te	10	38
	Cat Tien	11	33
		29	93
Ninh Thuan	Ninh Phuoc	4	26
	Ninh Hai	5	21
		9	47
Binh Thuan	Tuy Phong	3	20
	Bac Binh	5	37
	Ham Thuan Bac	6	42
	Ham Thuan Nam	5	39
	Ham Tan	6	55
		25	193
Ba Ria-Vung Tau	Tan Thanh	4	24
	Chau Duc	7	90
	Long Dat	4	68
	Xuyen Moc	5	57
		20	239
Dong Nai	Tan Phu	10	85
	Dinh Cuan	8	105
		18	190
Long An	Tan Tru	5	28
	Can Duoc	5	41
	Can Giuoc	5	45
	Thu Thuan	5	26
	Ben Luc	5	36
	Duc Hue	5	26
		30	202
	Grand Total	170	1,207

Table 2.2 List of Existing and New Small Irrigation Schemes for RADP

Unit : ha

Code	Name of Scheme	Designed Area
Lam Dong Province		
L1	Tuyen Lam	2,832
L2	Cam Ly Thuong	400
L3	Dai Don	2,700
L4	Dinh An	150
L5	Tan Rai	140
L6	La Ou	100
L7	Da Ham	400
L8	Ka Lai	150
L9	P'Roh	415
L10	Phu Hoi	150
L11	DaMi	120
L12	Ta Nung	200
L13	ChoMo DaQuyen	200
L14	DaTien tang	100
L15	Da Sa	150
L16	Fiveran	230
L17	So 2	152
L18	So 5	200
L19	Loc An	240
L20	East Di Linh	100
L21	Dasaoi 1	150
L22	Chieng Thang	500
L23	West Di Linh	250
L24	Lien Khuong	620
L25	Ro Men	160
	Existing Total	10,809
L26	Da Te	2,000
L27	Da Klo	800
L28	Caden	250
	Proposed Total	3,850
	Total	13,859
Dac Lac Province		
DL1	Cau Tu	120
	Existing Total	120
Ninh Thuan Province		
N1	Song Pha	4,719
N2	Nha Trinh-Lien Cam	12,600
N3	CK7	100
N4	O Cam-Nha Hui	300
N5	Binh Phu	100
N6	Dong Nhiep	392
N7	Ba Ho	110
N8	Ta Noi	120
N9	Ca Tien	420
N10	Cha Vinh	250
N11	Ma Ren	500
N12	Binh Tu	150
N13	Tuan Tu	100
N14	Ban Que	250
N15	Phuoc An	560
N16	Phuoc Thien	400
N17	Du	180
	Existing Total	21,441
N18	Song Inia	2,500
N19	Song Sat	1,500
N20	Tan Giang	2,300
	Proposed Total	6,400
	Total	27,842
Binh Thuan Province		
B1	Tuy Tinh	1,200
B2	Ba Ra	150
B3	Ba Nao	220
B4	Vinh Hao	100
B5	Dong Moi	1,200
B6	Song Khieng	150
B7	Ta Son	135
B8	812	150
B9	Xuan Quang	150
B10	Uy Thuy	1,000
B11	Cha Vau	350
B12	E Chim	500
B13	Ma Tang	179
B14	Ma O	250
B15	Tam Ru	324
B16	Can Rang	225
B17	Te Mu	300
B18	Dong Mang	130
B19	Ma Ni	250
B20	Dong Gon	120
B21	Nha Mung	150
B22	Phong Nam	130
B23	Tien Loi	130
B24	Dong De	600
B25	Song Linh	250
B26	Thu Sung	100
B27	Cam Hang	120
B28	Cay Khe	1,800
B29	O Xuyen	1,500
B30	Kim Long	1,500
B31	Bau Tiet	150
B32	Sieng Giang	500
B33	Dan Sanh	1,000
B34	Thay Nghe	120
B35	Giang Ech	120
B36	Ba Nao	100
B37	Suoi Da	650
B38	Nui Dat	270
B39	Tan Ha	120
B40	Co Kieu	230
B41	Suoi Do	120
B42	Lang Da	200
B43	Suoi Le	150
B44	Chu Lu	150
B45	Suoi Lach	120
B46	Ut Sang	200
B47	K'Ho	100
B48	Cau Chay	120
B49	Tra Tan	610
B50	Vo Xu	5,000
B51	Ta Bua	500
B52	H.74	250
B53	Suoi Cat	110
B54	Tra Cap	150
B55	Suoi Chua	300
B56	Cay Xoai Ui	180
B57	Cau Chay	150
	Existing Total	25,033
B57	Da Bac	500
B58	Ta Mon	108
	Proposed Total	608
	Total	25,641
Ba Ria-Vung Tau Province		
V1	Kim Long	200
V2	Song Dinh I	600
V3	Song Xoai	1,000
V4	Chau Pha	150
V5	Suoi Do Ii	300
V6	Gia Hoet	650
V7	Suoi Giau	1,200
V8	Xuyen Moc	450
V9	Lo O	400
V10	Song Ray	800
V11	Cau Moi	250
V12	Da Bang	1,300
V13	Suoi nuoc	150
V14	Bat Thien	250
V15	Suoi Cat	380
	Existing Total	8,080
V16	Bau Ngua	800
V17	Sam Duc	900
V18	Suoi Lao	800
V19	Suoi Sac	800
V20	Ben Ke	900
V21	Lo O 3	200
V22	Lo O 2	500
V23	Tam Bo	1,000
V24	Chau Pha	700
V25	Giao Keo	500
V26	Ap Ba	100
V27	Suoi Chich	200
V28	Bao Nap	300
V29	Binh Chau	200
V30	Da Bang 2	200
V31	Suoi Sao	150
V32	Rach Chanh	100
V33	Nuoc Ngot	100
	Proposed Total	8,450
	Total	16,530
Dong Nai Province		
D1	Cu Nhi	250
D2	Gia Ieu I	250
D3	Gia Ieu II	200
D4	Suoi Ran	600
D5	Gia Ui	560
D6	Nui Le	400
D7	Suoi Vong	1,100
D8	Phuoc Thai	100
D9	Ong Keo	5,400
D10	Phuoc Tan	100
D11	Long Thanh	450
D12	Tan Hanh	250
D13	Hoa An	110
D14	Hiep Hoa	350
D15	Tan An	100
D16	Thien Tan	350
D17	Long Chien	100
D18	Mieu Van	150
D19	Loi Hoa	300
D20	Binh Phuoc	100
D21	Binh Hoa	350
D22	Bau Ham	150
D23	Suoi Ca	600
D24	Long An	250
D25	Song May	1,300
D26	Thanh Nien	100
D27	Ba Long	110
D28	Suoi Dam	250
D29	Nam Sao	350
D30	Dong Hiep	600
D31	Ong Tho	150
D32	Ong Bich	100
D33	Da Ton	1,400
	Existing Total	16,930
D34	Da Vang	180
D35	Cau Moi	3,000
D36	Suoi Nhan	1,540
D37	Da Ka-Ya	350
D38	Song Thao	700
D39	La Buong	400
D40	Xom Mai	200
	Proposed Total	6,370
	Total	23,300
Song Be Province		
S1	Cau Nom	350
S2	Ta Te	120
S3	Tong Le Chan	120
S4	Tan An	411
S5	Suoi Giai	1,670
S6	Bu Mon	180
S7	Duk Tol	100
S8	An Khuong	110
S9	Loc Khanh	150
S10	Suoi Sau	300
S11	Da Bang	400
S12	Ong Huu	150
S13	Bach Dang	140
S14	Tan An	150
S15	Tan My I	130
S16	Thuong Tan II	100
	Existing Total	4,581
S17	Loc Quang	378
S18	Suoi Ong	100
S19	Thanh Hoa	172
S20	Suoi Kal	324
S21	Sock Trao	800
S22	Can Le	180
S23	Dong Xoai	4,600
S24	Nuoc Trong	1,200
S25	Duc Lieu	450
S26	Thuong Tan	123
S27	Tan Loi	383
S28	Tong Nhiem	200
S29	Cho Chet	110
S30	Chanh My	330
S31	Phu Hoi	250
S32	Rung Cam	350
S33	M'Rea	265
S34	Da Yeu	25
S35	An Tay-Phu An	500
S36	Bu Nau	128
	Proposed Total	10,869
	Total	15,450
Tay Ninh Province		
T1	Phuoc Chi	2,360
T2	Long Thuan	700
T3	Long Khanh	300
	Existing Total	3,260
T4	Phuoc Luu	2,600
T5	Long Khanh B	700
T6	Long Hung	1,000
T7	Dia Xu B	2,500
T8	Dia Xu A	700
T9	Long Thuan B	1,900
T10	Tra Cu	2,700
T11	Hoa Hoi	3,100
T12	Cu Ba Chan	2,700
T13	Ben Suoi	3,700
T14	Cay Oi	2,900
T15	Ben Dinh	2,500
	Proposed Total	19,300
	Total	22,560

Legend

Scheme excluded from candidate schemes for RADP

Table 3.1 Screening of Candidates for Hydropower Master Plan Projects

	FIRST SCREENING			SECOND SCREENING				GENERATION EXPANSION PLAN (Year)	CANDIDATES FOR MASTER PLAN PROJECT
	Estimated Capacity (MW)	Economic Index *	Economic Assessment	Assumed Capacity (MW)	Ann. Net Benef. (M.$/Year) **	Degree of Impact on Environment	Overview Assessment		
Dong Nai No.1	80 - 130	SCC=3900/4400 SGC=13/18	Low Economic Viability	-	-	-	Less Attractive	-	
Dong Nai No.2	100 - 160	SCC=3300/3800 SGC=11/15	Low Economic Viability	-	-	-	Less Attractive	-	
Dong Nai No.3	110 - 170	SCC=2400/2600 SGC=9/10	Viable	130	4.6	Moderate	Viable		
Dong Nai No.4	120 - 190	SCC=2200/2700 SGC=6/7	Viable	147	9.4	Low	Viable	-	
Combined No.3-No.4				448	48.3	Low	Viable	2006 - 2008	Selected
Dong Nai No.5	60	SCC=5400 SGC=10	Low Economic Viability	-	-	-	Less Attractive	-	
Dong Nai No.6	200 - 350	SCC=2200/2900 SGC=8/9	Viable	322	-9	Moderate National Park	Less Attractive	-	
Dong Nai No.8	155	SCC=3700 SGC=8	Viable	134	-32.5	High National Park	Less Attractive	-	
Combined No.3-No.8				340	-18.5	Moderate/High National Park	Less Attractive	-	
Can Don	*70*	*SCC=2800* *SGC=8*	Viable	*80*	*5.4*	Moderate	Viable	- ***	
Fu Mieng			Diversion involved	60 (Multi) 126 (Single)	5.8 12.9	Moderate/High	Viable	2005 - 2009 as Multipurpose	Selected
Bao Loc	80 - 140	SCC=3200/4000 SGC=11/12	Low Economic Viability	-	-	-	Less Attractive	-	
La Nga No.3			Diversion involved	62 (Multi) 73 (Single)	-3.6 -0.4	Moderate	Less Attractive	-	
Da M'Bri	Further study recommended as Pumped Storage (Length of Waterway / Head = 14.3)								
Da R'Keh / Anh Kong	Further study recommended as Pumped Storage (Length of Waterway / Head = 9.2)								
Da R'Tih	Further study recommended as Pumped Storage (Length of Waterway / Head = 15)								
Da Siat	Further study recommended as Pumped Storage (Length of Waterway / Head = 7.8)								

Notes : * Specific Capacity Cost (SCC) = Inst. Capacity / Project Cost ($/kW)
Specific Generation Cost (SGC) = Annual Economic Cost / Annual Energy (Cent / kWh)

** Annual Net Economic Benefit assuming Coal Thermal Plant as the least cost alternative at Discount Rate of 10 %

*** In case the cost of Combined Cycle Plant increased 20 %, then it will be required in 2013

Table 3.2 Screening of Candidate Schemes for Irrigation Master Plant Projects

Code	Schemes Classification: Main	Schemes Classification: Sub	Identified Irrigation Schemes: Name of Scheme	Area (ha)	Factors for Screening: Source of Irrigation Water	Availability of Water Resource	Maturity of Planning	Social Impact	Natural Environ. Impact	Economic Viability	Formulation and Area of Candidate M/P Projects: Formulation	Area (ha)
A	Existing Irrigation Schemes (excluding Minor Existing Irrigation Schemes (smaller than 100 ha), 339 schemes with 34,033 ha in total)	A.1 Large and Medium Irrigation Schemes (Area larger than 2,000 ha)	- Vo Xu	5,000	D	F	C (for rehabili.)	P	S+, G+, H+ & C+	-	Included in Ta Pao Irri. Scheme	
			- Phan Rang	12,800	S + DV	F	A (for rehabili.)	P	S+, G+, H+ & C+	H	Rehabilitated independently	
			- Song Pha	4,710	S + DV	F	C (for rehabili.)	P	S+, G+, H+ & C+	M	Rehabilitated independently with Phan Rang	
			- Dai Don	2,700	D	F	C (for rehabili.)	P			Formulated as Rural Agricultural	
			- Tuyen Lam/Quan Hiep	2,832	D	F	C (for rehabili.)	P	S+, G+, H+ & C+		Development Project (RADP) including Tay	
			- Phuoc Chi	2,260	S	F	C (for rehabili.)	P			Ninh Riparian Schemes, comprising of:	
		A.2 Small Irrigation Schemes (Area larger than 100 ha and less than 2,000 ha)	161 schemes including 2 - Tay Ninh Riparian Schemes (1,000 ha in total)	59,953	D + S + DV	A & P	C (for rehabili.)	P & J	S+, G+, H+ & C+	M	(1) Small Existing Irri. Schemes including Dai Dong, Tuyen Lam/Quan Hiep and Phuoc Chi schemes (164 schemes)	67,745
		A.3 New Small Irrigation Schemes	65 schemes including 12 - Tay Ninh Riparian Schemes (21,870 ha in total)	61,242	D + S + DV	A & P	C (for rehabili.)	P & J	S+, G+, H+ & C+		(2) New Small Irri. Scheme (65 schemes)	61,242
											(Total : Initially screened 231 schemes)	(128,987)
B	On-going and Planned Irrigation Schemes		- Dau Tieng (Exisitng)	45,000	D	F	In operation	P & J	G+	-	In operation	
			- Dau Tieng (Extension)	48,390	D	A	B	P & J	G+	H	Selected as candidate M/P project	48,390
			- Phuoc Hoa	45,680	D	F	B	P & J	S+ & H+	M	Selected as candidate M/P project	45,680
			- Hoc Mon - Bac Binh Chan	12,197	D	F	In implement.	P & J	H+ & C-	H	In implementation	
			- Song Quao	8,000	S + DV	F	In implement.	P & J	H+	-	In implementation	
C	Potential Irrigation Schemes	C.1 Potential Irrigation Schemes in HCMC - Long An Delta (including on-going Hoc Mon - Bac Binh Chanh Irrigation Scheme of 12,197 ha)	- HCMC	46,000	D	A	C	P & J	H+ & C-	M	Selected as candidate M/P project	46,000
			- Long An	54,000	D	A	B	P & J	H+ & C-	M	Selected as candidate M/P project	54,000
											(Total)	(100,000)
		C.2 Potential Schemes in East Coast expecting water resources diverted from Dong Nai river basin (including existing irrigation schemes with 18,928 ha in total)	- Phan Ri	29,700	S + DV	A	B	P, J & T	S+, H+ & C+	H	Formulated as Phan Ri - Phan Thiet Irrigation Project, comprising	
											(1) Phan Ri Irrigation Scheme	29,700
			- Phan Thiet	24,400	S + DV	A	B	P & J	S+, H+ & C+	H (18,000 ha in Quao river basin)	(2) Phan Thiet Irrigation Scheme (excluding on-going Song Quao Irri. Scheme 8,000 ha)	10,000
										L (6,400 ha in Ca Ty river basin)		
											(Total)	(39,700)
			- Ham Tan	8,000	S + DV	P	B	P & J	S+, H+ & C+	L	Omitted 6,400 ha in Ca Ty river basin from candidate M/P Project	
		C.3 Potential Schemes in La Nga River and other basins (including existing irrigation schemes with 24,660 ha in total)	- Lower La Nga	38,000	D	F	B	P & J	H+	H (Ta Pao Scheme) M (Vo Dat Scheme)	Omitted from candidate M/P project	
			(1) Ta Pao Irrigation Scheme	(23,000)							Selected as M/P project, comprising	
			(2) Vo Dat Irrigation Scheme	(15,000)							(1) Ta Pao Irrigation Scheme	23,000
											(2) Vo Dat Irrigation Scheme	15,000
											(Total)	(38,000)
			- Phan Rang Extension	15,400	S	P	C	P & J	S+, H+ & C+	L	Omitted from candidate M/P project	
			- Tuy Phong	4,200	S	A	C	P & J	S+, H+ & C+	L	Omitted from candidate M/P project	
			- Song Phang	5,030	S	P	C	P & J	S+, H+ & C+	L	Omitted from candidate M/P project	
			- Song Ray	13,710	S	P	B	P & J	S+, H+ & C+	M	Omitted from candidate M/P project	
			- Song Dinh	4,740	S	P	B	P & J	S+, H+ & C+	M	Omitted from candidate M/P project	

Abbreviation of Screening Factors

D : Dong Nai River Basin
DV : Diversion from Dong Nai River Basin (including Possibility)
S : Surrounding Basin

F : Fully available
A : Available subject to water resources development
P : Poor or insufficient

A : F/S by Ministry
B : Pre-F/S by Ministry
C : Preliminary Study by Province

P : Poverty alleviation
J : Job opportunity
T : Transmigration

+ : Positive
- : Negative
T : Topography
S : Soil erosion
G : Groundwater
H : Hydro. situation
C : Coastal zone
F : Flora & fauna

H : High
M : Marginal
L : Low

Table 3.3 Simulated Monthly Discharge at Hoa An Water Intake

(Unit: m^3/sec)

Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Mean
1964	1302.45	517.67	373.47	313.92	296.37	296.78	716.86	700.14	790.80	984.59	1668.08	1769.24	810.86
1965	1322.80	569.29	372.86	312.46	297.92	315.48	971.89	742.06	554.77	491.35	1097.65	1389.84	703.20
1966	958.07	495.07	354.87	309.52	300.54	306.93	345.62	602.64	855.99	986.64	1139.78	1508.08	680.31
1967	1325.82	799.05	397.38	326.59	302.50	315.81	613.89	487.25	1300.97	1885.76	2117.95	2647.64	1043.38
1968	1748.25	634.11	351.06	307.91	301.01	301.79	313.00	448.93	760.99	1376.89	1595.90	2020.05	846.66
1969	1267.16	578.45	357.72	311.52	301.63	300.46	306.88	349.83	603.92	820.35	1733.60	2041.43	747.75
1970	1160.91	427.72	342.94	306.54	300.74	300.11	257.49	755.21	1005.97	845.37	994.69	2123.02	735.06
1971	1687.10	722.92	434.65	346.67	308.03	303.72	460.13	671.32	1006.37	958.24	1405.84	2044.98	862.50
1972	1151.88	564.50	380.38	321.80	302.94	302.16	271.97	476.03	562.24	482.16	1872.08	2340.61	752.40
1973	1322.04	688.04	414.75	333.01	304.53	301.66	307.28	363.20	445.94	668.23	1598.01	1603.77	695.87
1974	842.51	466.55	368.99	315.89	301.60	300.75	526.38	581.02	616.51	809.62	1289.43	2239.83	721.59
1975	1437.92	523.64	380.26	317.39	302.36	307.31	303.82	344.88	979.94	980.29	2328.01	1419.70	802.13
1976	857.80	456.24	339.78	306.07	300.64	300.05	301.86	461.61	633.13	1555.29	2161.65	1732.75	783.91
1977	995.69	418.12	333.86	303.01	299.16	298.64	207.25	157.01	686.72	1409.96	1251.70	1070.62	619.31
1978	658.76	380.83	321.62	298.85	296.27	298.20	186.73	441.12	713.61	1295.92	2845.06	2446.08	848.59
1979	1326.49	534.88	344.84	303.27	296.30	299.00	404.33	622.33	1126.09	1910.51	1235.52	1797.47	850.09
1980	1086.89	491.94	339.85	302.28	296.00	295.34	308.16	648.12	779.29	683.90	1649.20	1847.62	727.38
1981	987.11	483.31	357.29	309.60	296.10	296.54	348.64	762.89	1025.87	1703.52	1515.88	1696.60	815.28
1982	876.80	370.76	306.30	296.33	295.71	302.13	301.27	327.91	593.39	1229.59	2035.24	1848.45	731.99
1983	1142.97	492.07	335.21	299.24	294.32	301.31	293.76	311.69	582.10	905.94	2129.14	2310.80	783.21
1984	1289.40	509.15	360.78	305.30	293.18	295.20	407.56	579.70	549.11	1891.28	1812.54	1796.66	840.82
1985	699.70	390.39	320.98	295.38	292.48	294.12	289.04	418.07	551.68	784.30	1440.93	1834.73	634.32
1986	778.52	467.08	363.19	308.50	293.58	292.53	300.94	329.35	601.76	2284.05	2495.53	2188.99	892.00
1987	1134.76	577.56	372.50	313.28	294.84	293.49	302.53	581.77	1694.67	1981.11	1477.39	1798.89	901.90
1988	1297.20	569.02	367.99	309.79	294.69	293.54	295.11	441.08	498.55	747.65	1237.29	1935.67	690.63
1989	1199.14	499.84	354.40	304.68	294.30	293.96	309.60	476.94	1018.18	1776.31	1835.61	1731.97	841.24
1990	1029.84	506.99	365.87	309.60	295.45	295.15	315.46	960.28	861.36	1913.89	2242.45	1710.17	900.54
1991	1316.38	542.02	358.85	306.68	296.25	295.90	296.56	313.77	762.87	1192.41	1751.66	2117.18	795.88
1992	1031.23	479.81	324.44	298.65	295.54	295.26	362.77	853.53	960.07	2579.97	2275.78	1874.17	969.27
mean	1146.06	522.66	358.52	310.13	298.10	299.77	366.44	524.47	797.34	1280.52	1732.19	1892.66	794.07
minimum	658.76	370.76	306.30	295.38	292.48	292.53	186.73	157.01	445.94	482.16	994.69	1070.62	462.78

Note: Tri An Hydropower Plant is assumed to be in operation.

Table 3.4 4-year Drought Inflow Utilized in the Model

(Unit: m^3/sec)

Site	Name	Nov-73	Dec	Jan - 74	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1	Dai Ninh	23.12	17.78	12.72	10.62	9.59	8.92	7.26	11.32	18.96	32.65	58.68	73.27
2	Dong Nai 3	64.88	29.70	9.95	1.73	0.75	0.86	2.86	4.46	32.67	80.05	71.72	100.90
3	Dong Nai 4	6.74	3.08	1.03	0.18	0.08	0.09	0.30	0.46	3.39	8.31	7.45	10.48
4	Tri An	269.44	117.72	45.09	15.24	11.08	10.82	23.46	61.83	231.00	393.23	427.64	506.20
5	Fu Mieng	164.83	131.44	103.62	87.54	86.17	88.25	237.59	221.52	149.98	220.52	187.71	395.13
6	Phuoc Hoa	49.09	29.76	13.65	4.35	3.55	4.76	91.21	81.90	40.49	81.32	62.33	182.40
7	Dau Tieng	132.67	74.56	41.94	21.26	11.25	10.01	60.20	121.62	73.97	51.82	82.13	119.65
8	Phan Ri	2.43	1.10	0.60	0.52	0.46	0.42	0.38	0.46	7.50	7.46	5.11	30.31
9	Phan Thiet	1.52	0.69	0.37	0.33	0.29	0.27	0.24	0.29	4.70	4.67	3.20	18.99
10	Ta Pao	66.15	52.25	50.95	50.61	50.30	50.00	34.62	69.43	104.61	101.54	268.97	243.81
11	Vo Dat	33.38	9.81	7.60	7.02	6.50	5.99	10.97	38.93	98.59	93.37	146.31	124.14
13	Tay Ninh Upper	85.00	50.50	24.25	10.50	8.40	8.40	39.83	63.91	46.98	85.79	66.94	193.52
14	Tay Ninh Lower	97.09	57.68	27.70	11.99	9.59	9.59	45.49	73.00	53.66	98.00	76.47	221.06
15	Riparian	117.77	63.03	31.77	14.64	10.84	11.17	144.90	132.21	106.66	172.65	136.61	372.06
17	HCMC	79.73	44.81	25.20	12.77	6.76	6.01	36.17	73.09	44.45	31.14	49.36	71.90

Table 3.5 Irrigation Water Requirement

(Unit: m^3/sec/1,000 ha)

Site	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Site 6	Phuoc Hoa	0.62	0.87	0.37	0.57	0.92	0.19	0.19	0.29	0.24	0.16	0.37	0.47
Site 7	Dau Tieng (Extension)	0.79	0.97	0.73	0.24	0.68	0.36	0.21	0.29	0.45	0.48	0.19	0.45
Site 8	Phan Ri	0.78	1.18	0.78	0.48	0.62	0.66	0.62	0.1	0.3	0.69	1.09	0.79
Site 9	Phan Thiet	0.78	1.18	0.78	0.48	0.62	0.66	0.62	0.1	0.3	0.69	1.09	0.79
Site 10	Ta Pao	1.28	1.07	1.14	1.12	0.31	0	0.03	0.04	0.04	0.06	0.57	0.97
Site 11	Vo Dat	1.21	1.02	1.06	1.03	0.29	0	0.03	0.04	0.04	0.05	0.46	0.79
Site 12	Dau Tieng (Existing)	0.79	0.97	0.73	0.24	0.68	0.36	0.21	0.29	0.45	0.48	0.19	0.45
Site 13	Tay Ninh Upper	0.79	0.97	0.73	0.24	0.68	0.36	0.36	0.21	0.29	0.45	0.48	0.19
Site 14	Tay Ninh Lower	0.79	0.97	0.73	0.24	0.68	0.36	0.36	0.21	0.29	0.45	0.48	0.19
Site 15	Dong Nai Riparian*	0.61	0.72	0.38	0.25	1.19	0.43	0.49	0.11	0.06	0.12	0.23	0.92
Site 16	Long An Delta	0.89	1.09	1.16	0.96	0.29	0.02	0.28	0.69	0.19	0.17	0.69	0.79
Site 17	HCMC	0.89	1.09	1.16	0.96	0.29	0.02	0.28	0.69	0.19	0.17	0.69	0.79

* existing irrigation scheme

Table 3.6 Optimal Solution Obtained from the Model

Item	Optimum Output	Max Irrigable Area	Unit
Net Benefit	492		Million US Dollars
Generated Energy			
Dai Ninh	1,128		GWh/year
Tri An	1,245		GWh/year
Fu Mieng	329		GWh/year
Irrigation Development			
Phuoc Hoa	45,680	(45,680)	ha
Dau Tieng (Extension)	48,390	(48,390)	ha
Phan Ri	29,700	(29,700)	ha
Phan Thiet	10,000	(10,000)	ha
Ta Pao	19,000	(23,000)	ha
Vo Dat	12,617	(15,000)	ha
Dau Tieng (Existing)	45,000	(45,000)	ha
Tay Ninh Upper	10,825	(15,100)	ha
Tay Ninh Lower	14,300	(14,300)	ha
Dong Nai Riparian	23,400	(23,400)	ha
Long An Delta	31,170	(54,000)	ha
HCMC	46,000	(46,000)	ha
Reservoirs			
Dai Ninh	Alternative (Alt) 1 (Storage capacity: 252 million m^3)		
Dong Nai 3	*		
Dong Nai 4	*		
Fu Mieng	Alt 1 (Storage capacity:460 million m^3)		
Song Luy	Alt 7 (Storage capacity:150 million m^3)		

Note: Irrigation areas in the parentheses show the maximum potential area.

*: In this model, the 4-year drought flow is applied and consequently the power out of the project is underestimated. The project is eventually selected as one of the master plan projects based on the generation expansion planning study (refer to Appendix V: Hydropower Generation).

Table 3.7 Diversion Amount in the Optimal Solution Obtained from the Model

(Unit: m^3/s)

Diversion		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Dai Ninh		21	19	19	19	19	19	19	19	19	29	53	30
Fu Mieng	alt 1	25	60	60	60	38	-	-	60	16	-	60	3
Phuoc Hoa		no diversion (Pump Irrigation)											
Dau Tieng (Extension)	alt 7	70	100	90	56	31	16	9	13	20	22	9	20
Phan Ri-Phan Thiet	alt 1	7	11	8	5	6	6	2	-	-	40	9	7
Tay Ninh Lower	alt 1	34	56	57	45	-	-	-	-	-	-	-	-

Note: The figures are calculated under the 4-year drought condition.

Table 4.1 Master Plan Projects in the Study Area

Project	Scale	Remarks
Rural Development		
Small irrigation schemes	229 schemes	- 164 for rehabilitation and 65 for new construction
Rural water supply	1,207 schemes	
Hydropower Projects	475 MW	
Dong Nai No. 3	180 MW*	
Dong Nai No. 4	240 MW*	- Combinated develop with Dong Nai No. 3
Reservoir Project		
Be-Saigon Doversion Project (in case of Fu Mieng Multipurpose Reservoir)	55 MW*	- With a diversion channel on Dau Tieng
Irrigation Projects	242,560 ha	
	150 Mill. m^3	
Phuoc Hoa	45,680 ha	- Pump-up scheme
Dau Tieng Extension	48,390 ha	- Supplemented to Dau Tieng Existing
Phan Ri	29,700 ha	- Song Luy reservoir
Phan Thiet	10,000 ha	- Song Luy reservoir
Ta Pao	19,000 ha	
Vo Dat	12,620 ha	
HCMC-Long An Delta	77,170 ha	- LA Delta and Hoc Mon-North Binh Chanh
Water Supply Projects		
Area along National Highway No. 51	1.7 Mill. m^3/day in demand	Domestic and industrial uses

Note*: In the optimal water allocation study in Phase II, the power output of Dong Nai No. 3, No. 4 and Fu Mieng were assumed to be 130 MW, 318 MW and 60 MW. However, the figures are eventually modified based on the results of the topographic survey and the optimization study carried out in Phase III.

Table 4.2 Disbursement Schedule of the Master Plan Projects

Unit : Million US$

Master Plan Projects	Project Cost	Phase I					Phase II					Phase III					Phase IV				
		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
(1) Rural agricultural development projects																					
	231				3.9	3.9	15.9	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	14.9	11.5	11.5
(2) Rural water supply projects																					
	72		4.5	4.5	4.5	4.5		4.5	4.5	4.5	4.5		4.5	4.5	4.5	4.5		4.5	4.5	4.5	4.5
(3) Hydropower projects																					
- Dong Nai No.3	490								49.0	98.0	98.0	147.0	98.0								
- Dong Nai No.4	398								39.8	79.6	79.6	119.4	79.6								
Sub-total (3)	888								88.8	177.6	177.6	266.4	177.6								
(4) Be-Saigon Diversion Project (in case of Fu Mieng Multipurpose project)																					
	285										28.5	57.0	57.0	85.5	57.0						
(5) Large scale irrigation packages																					
- Phan Ri - Phan Thiet	180						12.8	12.8	12.8	17.8	41.5	32.5	21.5	19.6	4.2	4.2					
- Lower La Nga	160										11.5	19.3	19.3	15.4	11.5		12.4	20.8	20.8	16.6	12.4
- Phuoc Hoa	220					11.0	33.0	46.2	35.2	55.0	39.6										
- Dau Tieng and HCMC - Long An Delta	243									7.4	7.4	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	16.9	16.9
Sub-total (5)	803	0.0	0.0	0.0	0.0	11.0	45.8	59.0	48.0	80.2	100.0	76.1	65.1	59.3	40.0	28.5	36.7	45.1	45.1	33.5	29.3
(6) Water supply project along National Highway No.51																					
- Bien Hoa demand centre	65					6.9	17.4	10.4						6.0	15.0	9.0					
- Tam Phuoc demand centre	68		2.5	2.5		7.3	12.1	7.2					7.2	18.1	10.9						
- Nhon Trach demand centre	103		5.0	5.0	2.5	10.4	25.9	15.5					7.8	19.4	11.7						
- Phu My demand centre	101		3.8	8.0	22.4	11.9				11.1	27.7	16.6									
- Vung Tau demand centre	127			12.0	20.7	12.4				16.4	40.9	24.5									
Sub-total (6)	464	0.0	11.3	27.5	45.6	49.0	55.4	33.2	0.0	27.4	68.6	41.2	15.0	43.5	37.5	9.0	0.0	0.0	0.0	0.0	0.0
Ground Toal	2,750	0	16	32	54	68	117	112	157	305	395	456	335	208	154	57	52	65	65	50	45
Total by Phase		170	(= VND 1,870 billion)				1,090	(= VND 12,010 billion)				1,210	(= VND 13,330 billion)				280	(= VND 3,080 billion)			

Note: The costs in VND are estimated by using an exchange rate of US$ 1.00 = VND 11,014.

Table 4.3 Fund Availability for the Master Plan Projects

Unit: billion VND

Phase	Year	Projected GDP	Public Investment	Public Fund in the Study Area (1)	Funds for Three Sectors 1) in the Study Area (2)	Funds Necessary for MPP 2) (3)	(3)/(1) %	(3)/(2) %
	1994	170,258	11,067	3,021				
	1995	185,581	12,063	3,293	-	-	-	-
	1996	202,284	13,148	3,590				
I	1997	220,489	14,332	3,913				
	1998	240,333	15,622	4,265				
	1999	261,963	17,028	4,649				
	2000	285,540	18,560	5,067	21,484	7,519	1,870	8.7	24.9
	2001	311,238	20,230	5,523				
	2002	339,250	22,051	6,020				
II	2003	369,782	24,036	6,562				
	2004	403,063	26,199	7,152				
	2005	439,338	28,557	7,796	33,053	11,569	12,010	36.3	103.8
	2006	474,485	30,842	8,420				
	2007	512,444	33,309	9,093				
III	2008	553,440	35,974	9,821				
	2009	597,715	38,851	10,606				
	2010	645,532	41,960	11,455	49,395	17,288	13,330	27.0	77.1
	2011	690,719	44,897	12,257				
	2012	739,070	48,040	13,115				
	2013	790,804	51,402	14,033				
IV	2014	846,161	55,000	15,015				
	2015	905,392	58,850	16,066	70,486	24,670	3,080	4.4	12.5
				Total	174,418	61,046	30,290	17.4	49.6

Note: 1) Three sectors include hydropower, irrigation and water supply.
2) MPP means the master plan projects, and the costs in VND are estimated by using an exchange rate of US$ 1.00 = VND 11,014
3) GDP in 1994 price

FIGURES

SOCIALIST REPUBLIC OF VIET NAM
MASTER PLAN STUDY ON DONG NAI RIVER AND SURROUNDING BASINS WATER RESOURCES DEVELOPMENT
JAPAN INTERNATIONAL COOPERATION AGENCY

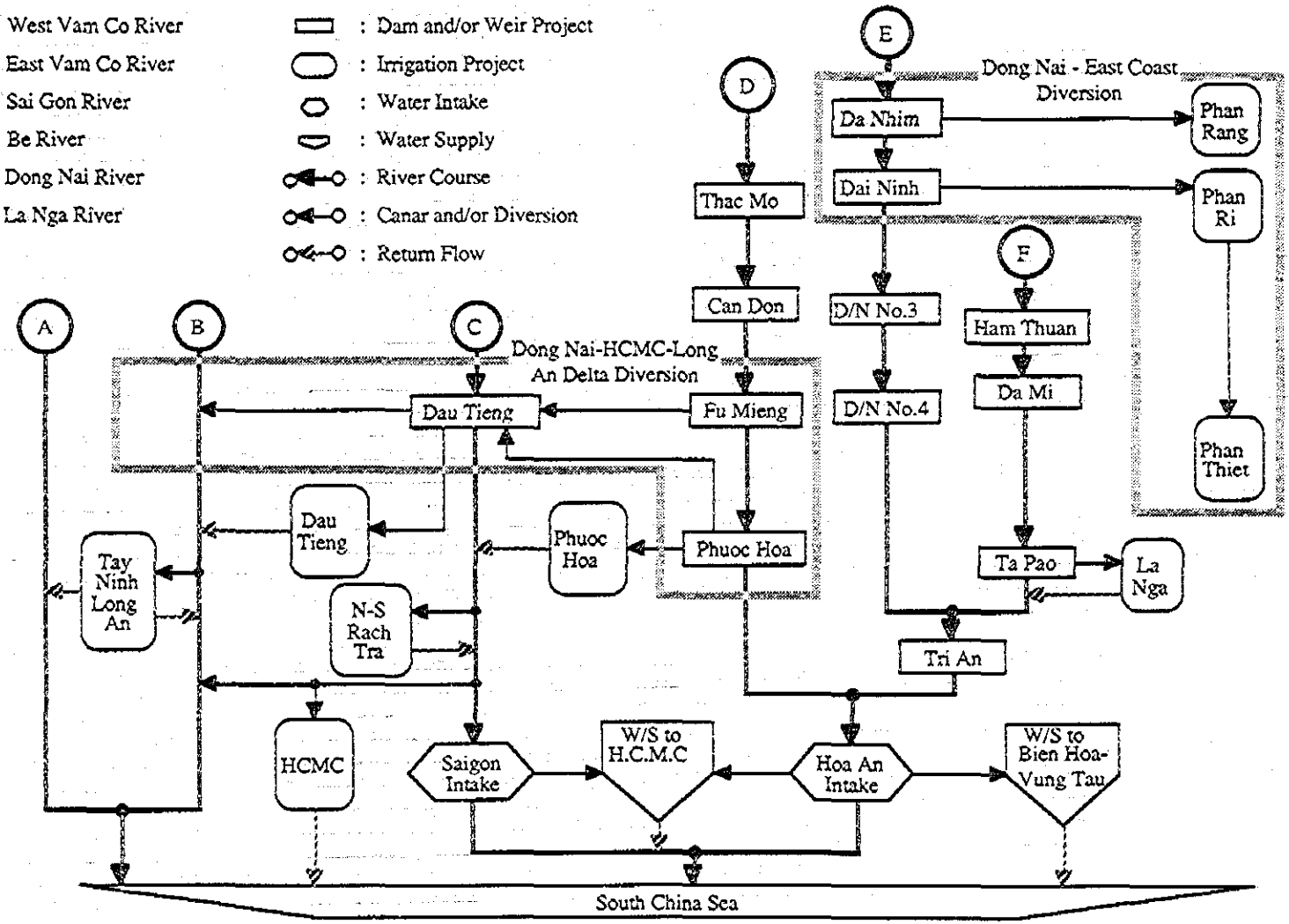
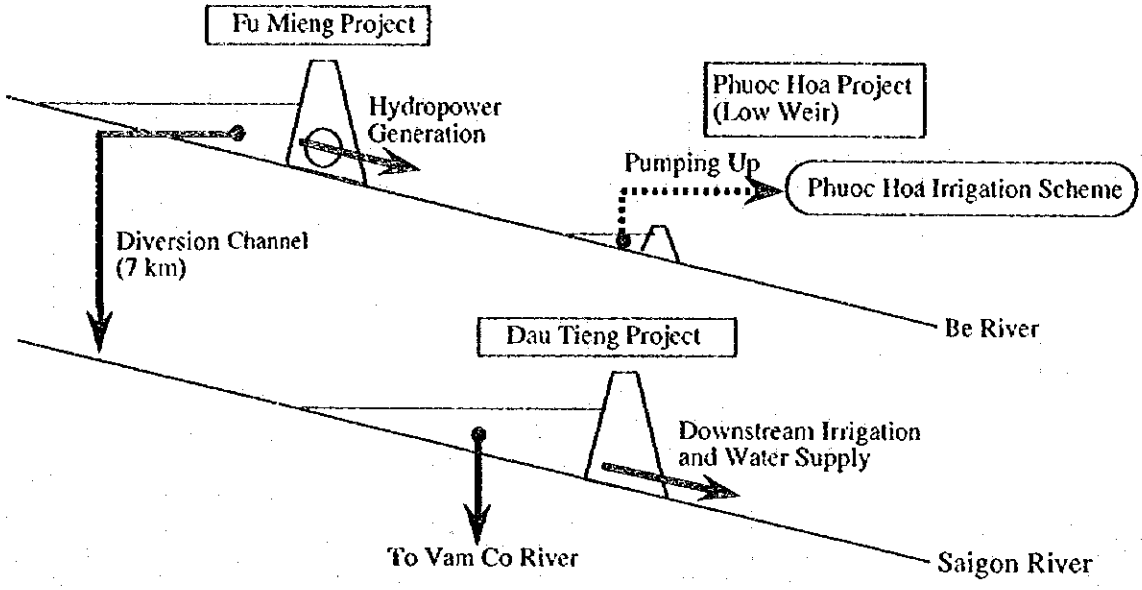
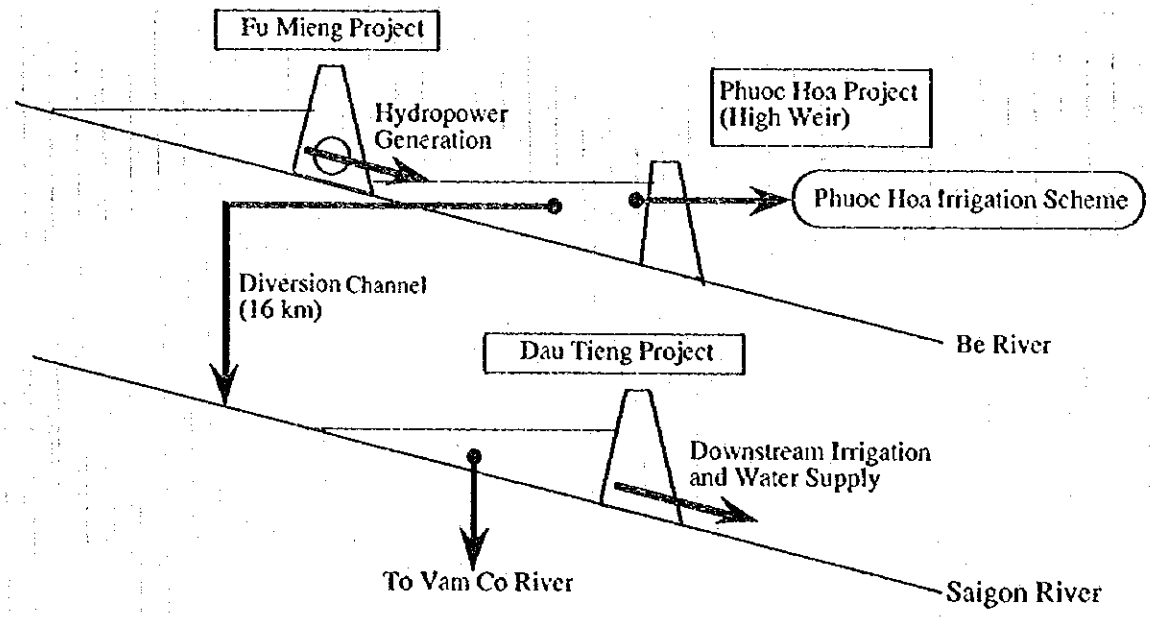


Figure 3.1
Schematic Diagram of Basin Model

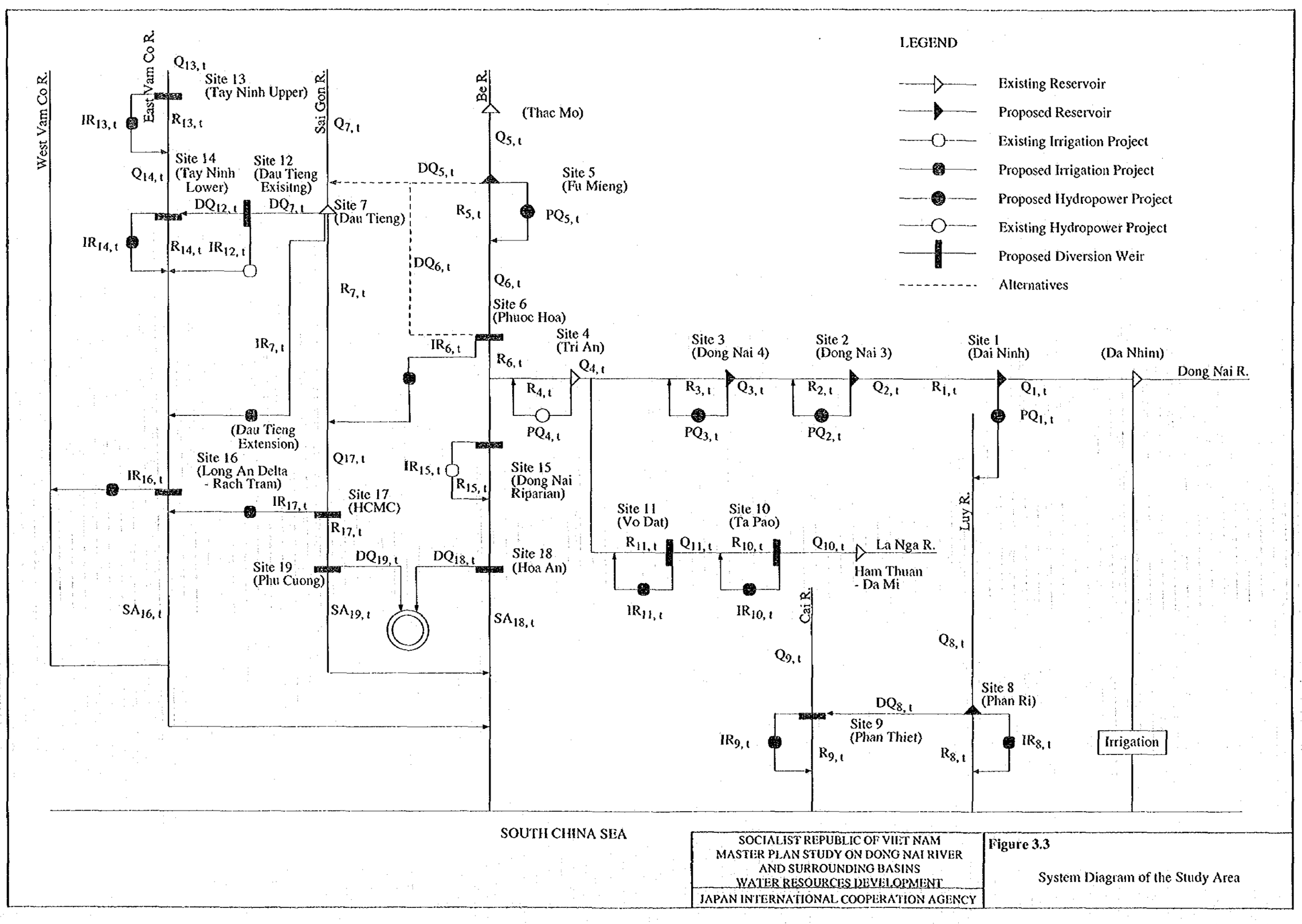
A. Fu Mieng Project with Diversion Channel, and Phuoc Hoa Project with Low Intake Weir and Pumping Facility



B. Fu Mieng Project and Phuoc Hoa Project with High Intake Weir with Diversion Channel



SOCIALIST REPUBLIC OF VIET NAM MASTER PLAN STUDY ON DONG NAI RIVER AND SURROUNDING BASINS WATER RESOURCES DEVELOPMENT JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 3.2** **Diversion Alternatives from the Be River to the HCMC - Long An Delta**



SOCIALIST REPUBLIC OF VIET NAM
MASTER PLAN STUDY ON DONG NAI RIVER AND SURROUNDING BASINS
WATER RESOURCES DEVELOPMENT
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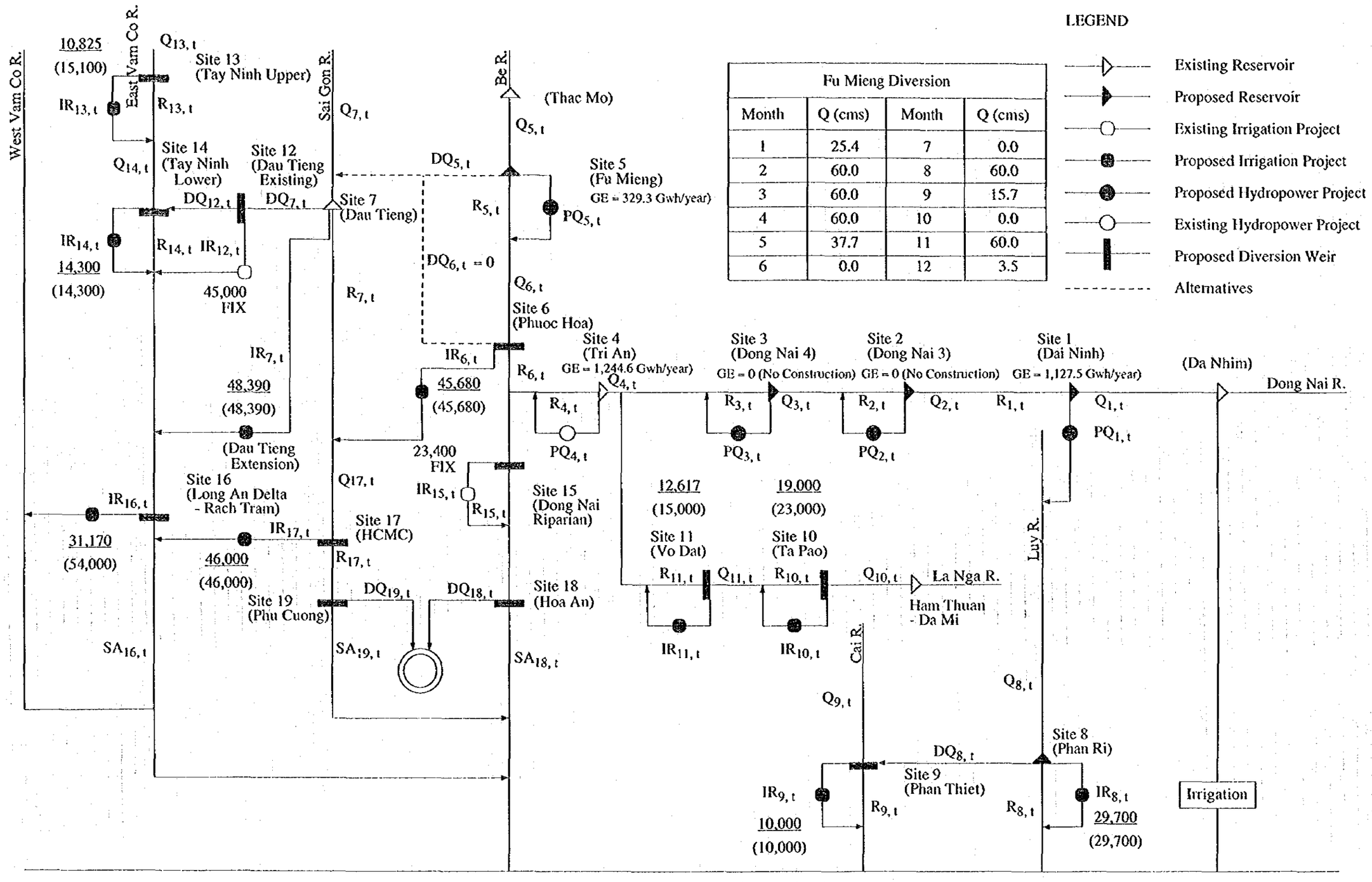
Figure 3.3

System Diagram of the Study Area



Fu Mieng Diversion			
Month	Q (cms)	Month	Q (cms)
1	25.4	7	0.0
2	60.0	8	60.0
3	60.0	9	15.7
4	60.0	10	0.0
5	37.7	11	60.0
6	0.0	12	3.5

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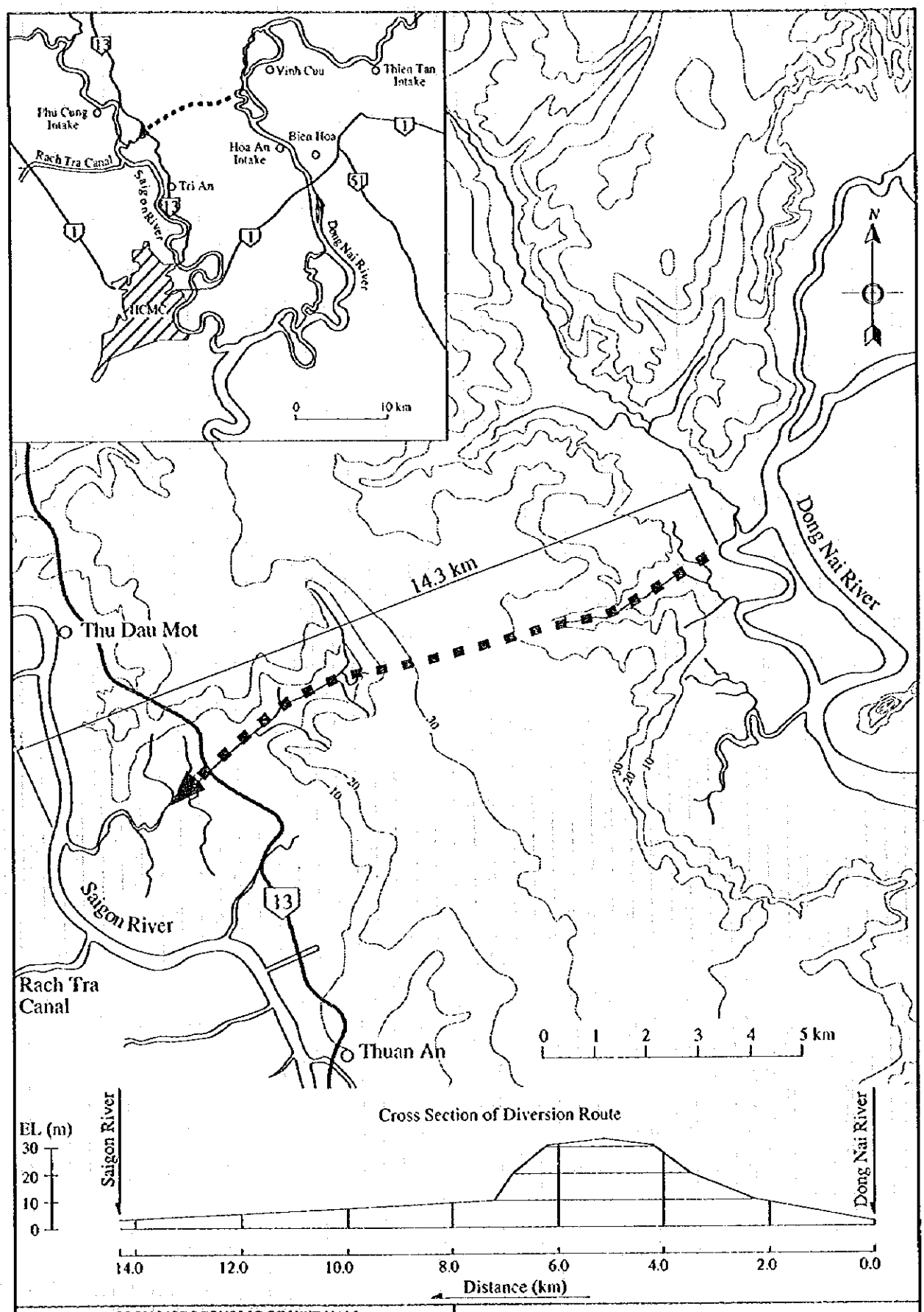
Figure 3.4

Optimal Solution Obtained from the Model



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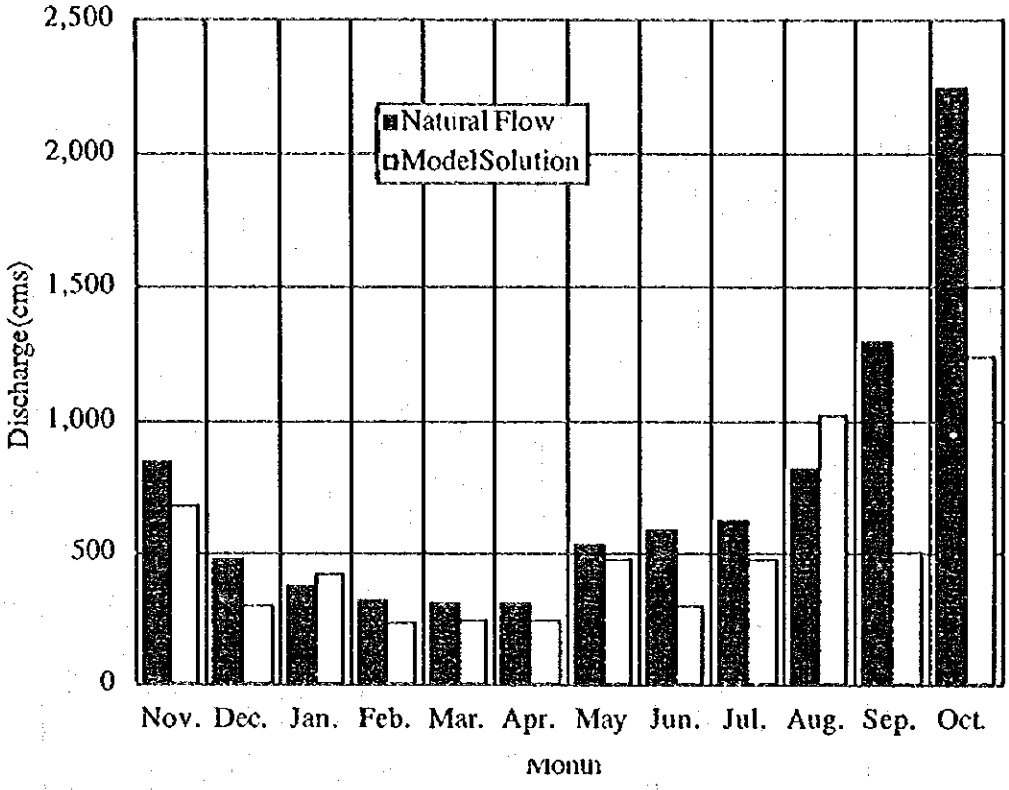
MASTER PLAN STUDY ON DONG NAI RIVER AND SURROUNDING BASINS WATER RESOURCES DEVELOPMENT

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 3.5
Diversion Route from the Dong Nai River to the Saigon River



Unit: m^3/s

	Natural	GAMS
Nov.	842.5	673.5
Dec.	466.6	295.1
Jan.	369.0	414.3
Feb.	315.9	233.5
Mar.	301.6	240.6
Apr.	300.8	243.4
May	526.4	468.1
Jun.	581.0	294.2
Jul.	616.5	471.5
Aug.	809.6	1,014.8
Sep.	1,289.4	500.1
Oct.	2,239.8	1,236.6

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Figure 3.6
Discharge at Hoa An Pumping Station

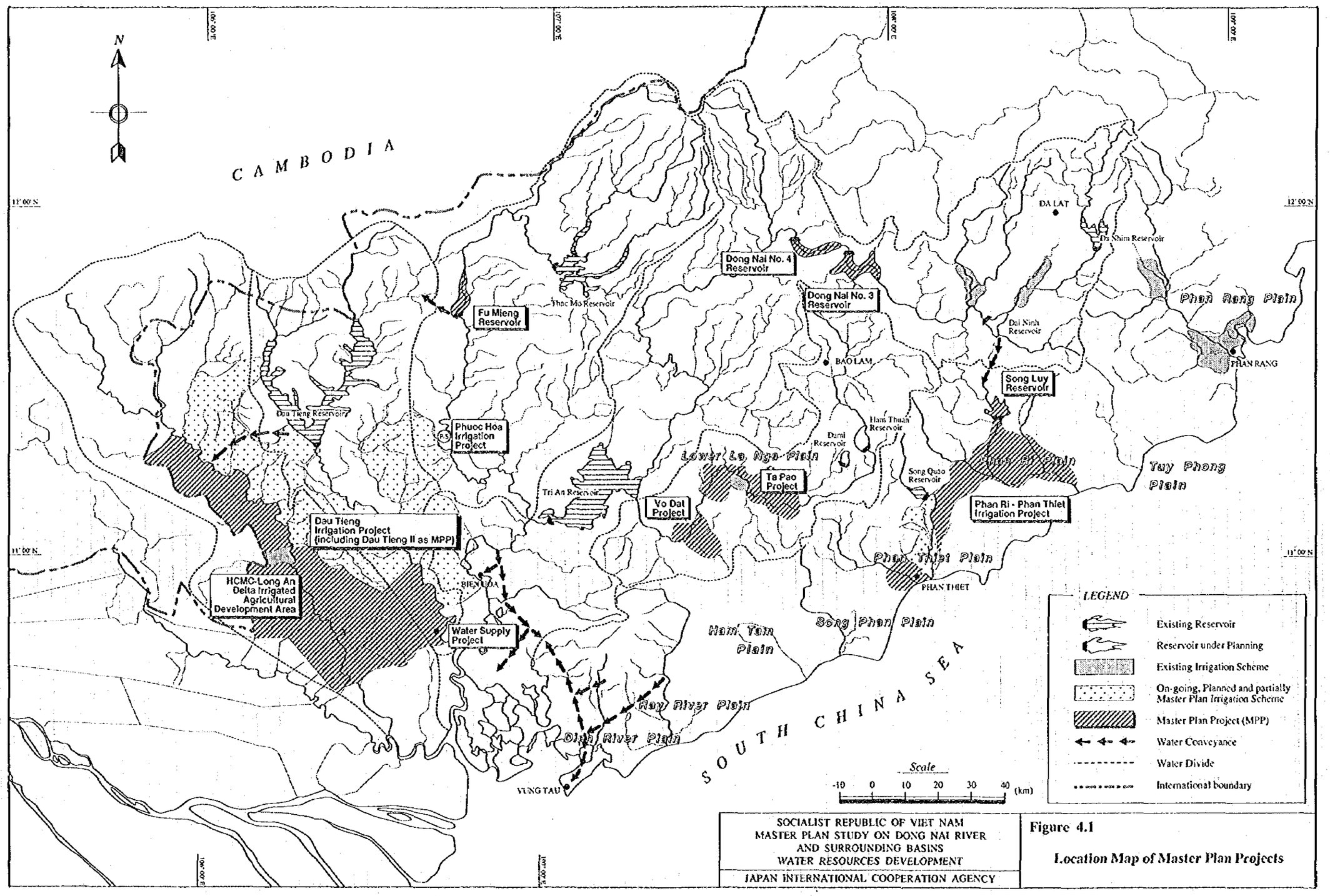

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Figure 4.1

Location Map of Master Plan Projects