社会開発調査部報告書

JAPAN INTERNATIONAL COOPERATION AGENCY

CENTRO DE REHABILITACION DE MANABI (CRM)
THE REPUBLIC OF ECUADOR

THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE - PORTOVIEJO RIVER BASINS

FINAL REPORT
VOLUME II

MAIN REPORT

MARCH 1995

NIPPON KOEI CO., LTD.
Tokyo, Japan

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ESTIMATE OF PROJECT COST

Price Level	:	August 1994
Currency Exchange Rate	:	US$1 = S/. 2,250 = Yen 100

PREFACE

In response to a request from the Government of the Republic of Ecuador, the Government of Japan decided to conduct a detailed design study on the Water Transbasin Schemes for Chone-Portoviejo River Basins and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Ecuador a study team headed by Mr. Osamu Takahashi, Nippon Koei Co. Ltd., three times between October 1993 and February 1995.

The team held discussions with the officials concerned of the Government of Ecuador, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Ecuador for their close cooperation extended to the team.

March 1995

Kimio Fujita
President
Japan International
Cooperation Agency

March 1995

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Sir,

Letter of Transmittal

We are pleased to submit herewith the final report for the Detailed Design Study on the Water Transbasin Schemes for Chone-Portoviejo River Basins in Ecuador.

The Study was completed through the discussions with the officials of the Ecuadorian Government, field investigations and studies during three visits from October 1993 to February 1995, and the home work thereafter.

The Final Report consists of the following reports and documents:

1. Main Report, Summary
2. Main Report
3. Main Report, Annex 1
   - Design Criteria
   - Hydrological Study
   - Water Transbasin Plan
4. Main Report, Annex 2
   - Geology and Construction Materials
5. Main Report, Annex 3
   - Environmental Study
6. Design Calculation Report
7. Quantity Calculation Report
8. Construction Plan and Schedule
9. Cost Estimate
10. Implementation Program
11. Design Drawings

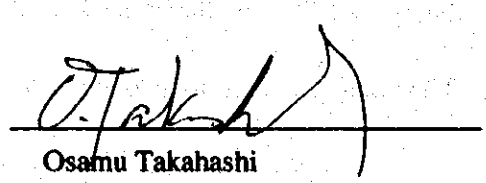
12. Prequalification and Tender Documents for Contract Package 1: Civilworks for Daule-Peripa ~ La Esperanza Transbasin

13. Prequalification and Tender Documents for Contract Package 2: Civilworks for La Esperanza ~ Poza Honda and Poza Honda ~ Mancha Grande Transbasins

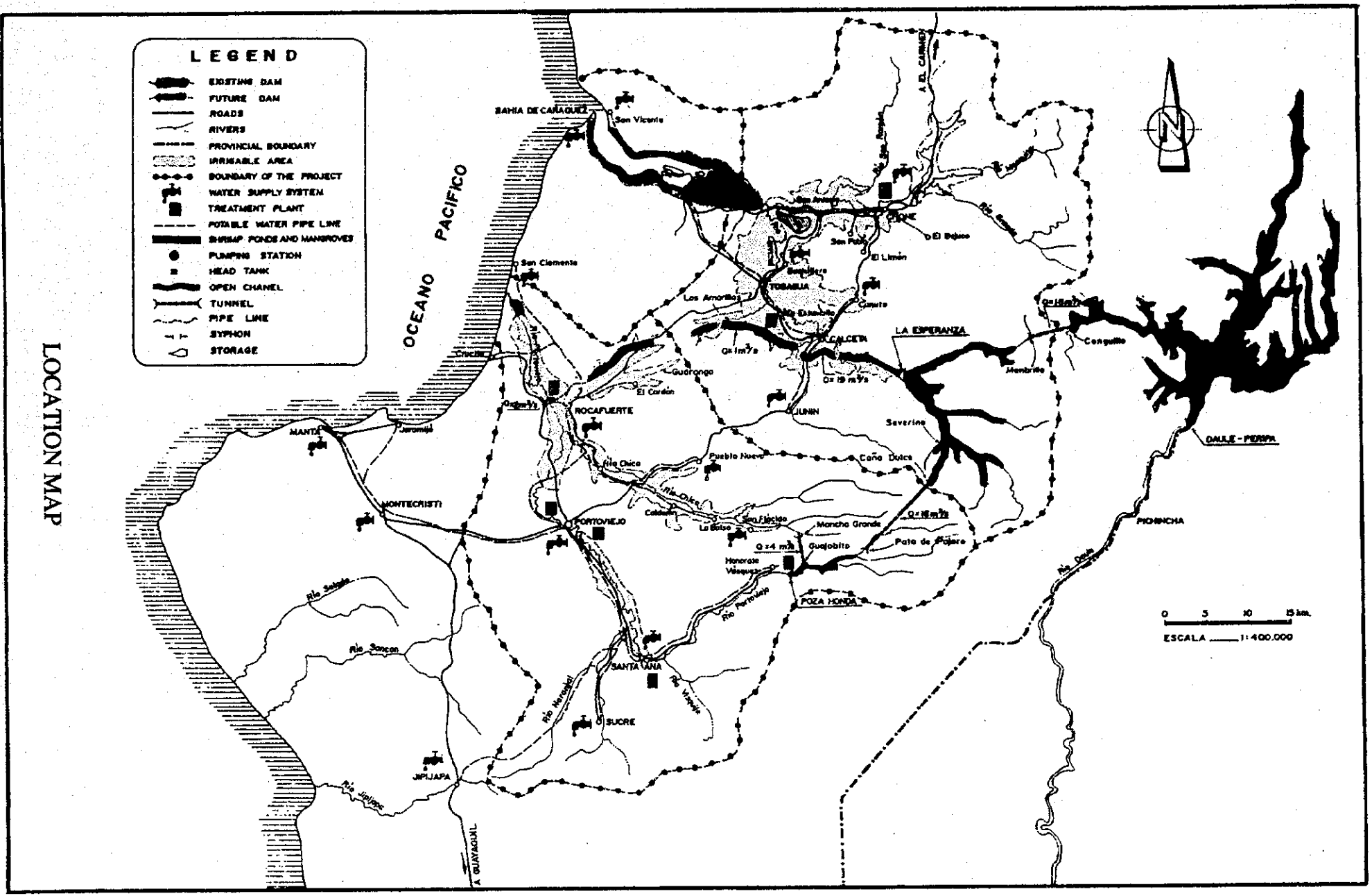
14. Tender Documents for Contract Package 3: Electrical and Mechanical Works

Taking this opportunity, we would like to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs and the Ministry of Construction, and also to convey our appreciation to the officials of the Manabi Rehabilitation Center (CRM) and the Embassy of Japan in Ecuador for their kind cooperation and assistance throughout our field study.

Very truly yours,



Osamu Takahashi
Team Leader
The Detailed Design Study on
the Water Transbasin Schemes
for Chone-Portoviejo River Basins


LEGEND
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Pata de Pájaro
Honorato Vásquez
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Río Portoviejo
Río Sabana
Río Suncon
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SANTA ANA
SUCRE
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DAULE - PERIPA
0 5 10 15 km.
ESCALA 1:400.000

THE DETAILED DESIGN STUDY ON
THE WATER TRANSBASIN SCHEMES
FOR CHONE-PORTOVIEJO RIVER BASINS

Period of Study : October 1993 – March 1995
Counterpart Agency : Manabi Rehabilitation Center (CRM)

EXECUTIVE SUMMARY

1. BACKGROUND

The Province of Manabi has long been suffering a habitual water shortage problem. The Chone and Portoviejo river basins are located in the central part of the Manabi Province and have a great potential for socio-economic development if only a sufficient quality and quantity of water supply is assured. The Centro de Rehabilitación de Manabí (CRM), to solve this severe water shortage problem, has been making greatest efforts, which, however, cannot meet ever growing water demands.

2. OBJECTIVES

The objective of the Study is to elaborate a detailed design of the Project. The Project is proposed to satisfy water demands in the Project area for municipal water supply, irrigation and shrimp farming, projected for 2020, by means of water transbasin from the Daule-Peripa reservoir to the Project area.

3. THE PROJECT AREA

The Project area is the Chone-Portoviejo river basins with an area of 4,870 km^2, which is dominated by a complicated tropical climate affected by the Humboldt cold current and El Niño phenomenon. Mean annual rainfall varies from 400 mm in the coastal southwestern part to 1,800 mm in the mountainous eastern part, with about 90 % of the annual rainfall concentrated in the rainy season from December to May. The population of the Project beneficiary area including Manta and Jipijapa cities was 685,600 in 1990, and is forecasted to increase to 1,240,300 in 2020.

4. THE PROJECT

The Project comprises the following three transbasin schemes.

(1) Daule-Peripa ~ La Esperanza Transbasin Scheme by gravity with a capacity of 18 m^3/s

(2) La Esperanza-Poza Honda Transbasin Scheme by pumping with a capacity of 16 m^3/s

(3) Poza Honda ~ Mancha Grande Transbasin Scheme by gravity with a capacity of 4 m^3/s

5. PROJECT COST

The Project is proposed to be implemented by the following three contract packages:

Package 1 : Civilworks for Daule-Peripa ~ La Esperanza Transbasin Scheme

Package 2 : Civilworks for La Esperanza ~ Poza Honda and Poza Honda ~ Mancha Grande Transbasin Schemes

Package 3 : Electrical and Mechanical Works including Power Transmission Line

The construction work will take 54 months (4.5 years) starting in June 1997 and the Project will be put into service from December 2001.

Project costs are estimated under the following conditions.

Price level : August 1994
Exchange rate : US$ 1.0 = S/. 2,250 = Japanese ¥100

The summary of the cost estimates is given below.

(US$ million)

	Foreign Currency	Local Currency	Total
Package 1	29.04	14.20	43.24
Package 2	52.30	27.47	79.77
Package 3	25.05	2.64	27.69
Sub-total	106.39	44.31	150.70
Administration	–	0.25	0.25
Land Acquisition	–	3.01	3.01
Engineering Service	10.01	1.52	11.53
Physical Contingency	9.38	4.50	13.88
Price Contingency	17.76	7.67	25.44
Total Cost	143.54	61.27	204.81

6. PROJECT EVALUATION

6.1 Economic and Financial Evaluation

The economic internal rates of return (EIRR) of the project are calculated as follows.

Unit Raw Water Value for Water Supply (US$/m^3)	EIRR (%)
0.3	11.9
0.4	13.4
0.5	14.8

The financial benefit of water supply for irrigation and shrimp farming is assumed to be a half of the total benefit, leaving another half of the total benefit for farmers. The financial internal rates of return (FIRR) of the project are calculated as follows.

Unit Raw Water Price for Water Supply (US$/m^3)	FIRR (%)
0.15	8.6
0.20	10.0
0.25	11.2

6.2 Socio-economic Impacts

Socio-economic impacts of the Project will include improvement of sanitary conditions, development in commercial and industrial activities, impact on local socio-economy during construction of the Project and impact on rural area development.

6.3 Environmental Impact Assessment

Environmental Impact Assessment (EIA) is conducted for the Project for the following four issues:

- Impacts on water quality of La Esperanza and Poza Honda reservoirs
- Impacts on river flow regime
- Impacts on water quality in rivers and estuaries
- Impacts on eco-system and fishery

Although several environmental impacts having certain effects on the environment are pointed out through EIA, these are not considered substantial because most of them could be

mitigated by proper countermeasures. Therefore, the Project is judged acceptable from the environmental viewpoint.

7. RECOMMENDATIONS

1) To start financial arrangement for project implementation with special emphasis on obtaining a soft loan

2) To execute the proposed countermeasures to mitigate the environmental impacts and, at the same time, to implement the proposed Environmental Management and Monitoring Plan

3) To complete the following associated projects to ensure the Project benefit

   - La Esperanza dam construction
   - El Ceibal water treatment plant with pertinent water transmission lines
   - Cuatro Esquinas water treatment plant with pertinent water transmission lines
   - Carrizal-Chone irrigation project
   - Rehabilitation of the Poza Honda irrigation system
   - Re-construction of the Simbocal tidal gate

4) To reinforce the organization of CRM as the Executing Agency of the Project

FINAL REPORT

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I.	MAIN REPORT (SUMMARY)
II.	MAIN REPORT
III.	MAIN REPORT (ANNEX 1)
	1. DESIGN CRITERIA
	2. HYDROLOGICAL STUDY
	3. WATER TRANSBASIN PLAN
IV.	MAIN REPORT (ANNEX 2)
	4. GEOLOGY AND CONSTRUCTION MATERIALS
V.	MAIN REPORT (ANNEX 3)
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FINAL REPORT

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ABBREVIATION

Ecuadorian Institutions

CEDEGE	:	Committee for Guayas River Basin Development
CETUR	:	Ecuadorian Corporation for Tourism
CLIRSEN	:	Integrated Center for Remote Sensing Survey
CONADE	:	National Development Council
CPC	:	Chamber of Shrimp Producer
CRM	:	Manabi Rehabilitation Center
DIGMER	:	Directorate General of Merchant Marine
DINAC	:	National Directorate of Valuation and Cadastre
DINAF	:	National Directorate of Forestry
DITURIS	:	Directorate of Tourism
EMAPAM	:	Municipal Enterprise of Potable Water and Sewerage of Manta
ESPOL	:	Polytechnic Littoral College
GOE	:	Government of Ecuador
IEOS	:	Ecuadorian Institute of Sanitary Works
IERAC	:	Ecuadorian Institute for Agrarian Reform
IGM	:	Geographic Military Institute
INAMHI	:	National Institute of Meteorology and Hydrology
INEC	:	National Institute of Statistics and Census
INECEL	:	Ecuadorian Institute for Electrification
INEFAN	:	Ecuadorian Institute of Forestry and Natural Areas
INEN	:	Ecuadorian Institute of Standards
INERHI	:	Ecuadorian Institute of Water Resources
INIAP	:	Institute of Agricultural Investigations
INOCAR	:	Military Oceanographic Institute
JRH	:	Jipijapa and Pajan Board of Water Resources
MAG	:	Ministry of Agriculture and Livestock
MICIP	:	Ministry of Industry, Commerce, Integration and Fishery
MOP	:	Ministry of Public Works and Communications
PFI	:	Institutional Reinforcement Planning Unit of CRM

PHIMA	:	Integrated Water Resources Development Plan of Manabi
PMRC	:	Management Program of Coastal Resources

International or Foreign Institutions

ACI	:	American Concrete Institute
ASCE	:	American Society of Civil Engineers
ASTM	:	American Society for Testing and Materials
CAF	:	Corporación Andina de Fomento
CEPIS	:	Panamerican Center for Sanitary Engineering and the Environment
CIDIAT	:	Interamerican Center for Integrated Development of Water and Land
FAO	:	Food and Agriculture Organization of the United Nations
IDB/BID	:	Interamerican Development Bank
IEC	:	International Electrotechnical Commission
JEC	:	Japanese Electrotechnical Committee
JICA	:	Japan International Cooperation Agency
JIS	:	Japanese Industrial Standards
OAS/OEA	:	Organization of American States
OECF	:	Overseas Economic Cooperation Fund of Japan
SCS	:	Soil Conservation Service of USDA
UNDP	:	United Nations Development Program
USA	:	United States of America
USAID	:	United States Agency for International Development
USDA	:	United States Department of Agriculture
WHO	:	World Health Organization of the United Nations

Technical Terms

A.C.	:	Alternating Current
ACSR	:	Aluminum Cable Steel Reinforced
BOD	:	Biochemical Oxygen Demand
COD	:	Chemical Oxygen Demand

D.C.	:	Direct Current
DO	:	Dissolved Oxygen
EC/CE	:	Electrical Conductivity
EIA	:	Environmental Impact Assessment
EMMP	:	Environmental Management and Monitoring Plan
FEM	:	Finite Element Method
F.M.	:	Finess Modulus
F/S	:	Feasibility Study
FWL	:	Flood Water Level
GPS	:	Global Positioning System
H	:	Horizontal
HWL	:	High Water Level
IEE	:	Initial Environmental Examination
IPM	:	Integrated Pest Management
LACAT	:	Program for Warm Tropical Lakes
LWL	:	Low Water Level
MOL	:	Minimum Operating Level
NATM	:	New Austrian Tunneling Method
PLC	:	Power Line Carrier
RWL	:	Reservoir Water Level
SPT	:	Standard Penetration Test
ST	:	Station
T-N	:	Total Nitrogen
T-P	:	Total Phosphorus
TRMS	:	Transbasin and Reservoir Management System
TSS	:	Total Suspended Solid
V	:	Vertical
ZEM	:	Special Zone for Management

Economic Terms and Others

CIF	:	Cost Insurance and Freight

EIRR	:	Economic Internal Rate of Return
FC	:	Foreign Currency
FIRR	:	Financial Internal Rate of Return
FOB	:	Free on Board
GDP	:	Gross Domestic Product
GRP	:	Gross Regional Product
IVA	:	Sales Tax or Value Added Tax
LC	:	Local Currency
NGO/ONG	:	Non Governmental Organization

ABBREVIATION OF MEASURES

Length

mm	=	millimetre
cm	=	centimetre
m	=	metre
km	=	kilometre
masl	=	metre above sea level
EL.	=	elevation

Area

ha	=	hectare
m^2	=	square metre
km^2	=	square kilometre

Volume

l, lit	=	litre
Kl, Klit	=	kilolitre
l/s	=	litre per second
m^3	=	cubic metre
m^3/s, cms	=	cubic metre per second
m^3/min	=	cubic metre per minute
m^3/hr	=	cubic metre per hour
MCM, mcm	=	million cubic metre
m^3/d, cmd	=	cubic metre per day

Weight

mg	=	milligram
mg/l	=	milligram per litre
meq/l	=	milli-equivalent per litre
g	=	gram
kg	=	kilogram
t, ton	=	ton
t/y	=	ton per year
MT	=	metric ton

Time

sec	=	second
min	=	minute
hr, HR	=	hour
d	=	day
yr	=	year

Money

S/.	=	Ecuadorian Sucres
¥	=	Japanese Yen
US$	=	U. S. Dollars

Energy

Kcal	=	Kilocalorie
KW, Kw	=	kilowatt
MW, Mw	=	megawatt
KWh, Kwh	=	kilowatt-hour
GWh, Gwh	=	gigawatt-hour
V	=	volt
KV	=	kilovolt
KVA	=	kilovolt ampere
MVA	=	megavolt ampere
Hz	=	Hertz

Others

%	=	percent
°	=	degree
'	=	minute
"	=	second
°C	=	degree Celsius
MD, md	=	man-day
mil.	=	million
NO. Nos	=	number
pers.	=	person
Umho	=	micromho
ppt	=	parts per thousand
ppm	=	parts per million
ppb	=	parts per billion
l/h/d	=	litre per person per day
g/c/d	=	gram per capita per day
LS	=	lump sum
MPN	=	most probable numbers
O&M	=	Operation and Maintenance
p.a.	=	per annum
rpm	=	revolutions per minutes

THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS

SUMMARY

1. Introduction

The Province of Manabi has long been suffering a habitual water shortage problem. The Chone and Portoviejo river basins are located in the central part of the Manabi Province and have a great potential for socio-economic development if only a sufficient quality and quantity of water supply is assured. The Centro de Rehabilitación de Manabí (CRM) has been making greatest efforts to solve this severe water shortage problem since its establishment in 1962, and has implemented and has been implementing several water resources development projects in the Project area, which, however, cannot meet ever growing water demands without the implementation of the Water Transbasin Schemes for the Chone-Portoviejo river basins (the Project) diverting water of the existing Daule-Peripa reservoir to the Project area.

CRM started a comprehensive master plan study on the integrated water resources development of the Manabi Province (PHIMA) in 1986 in cooperation with other relevant Governmental institutions. The Organization of American States (OAS) joined the PHIMA study in late 1987 and the Government of Japan also joined the PHIMA study in early 1989 through the Japan International Cooperation Agency (JICA). The PHIMA final report issued in January 1990 by JICA recommended to conduct a feasibility study on the water transbasin schemes from the Daule-Peripa reservoir to the Chone-Portoviejo river basins.

A feasibility study on the Project was conducted by JICA in collaboration with CRM and other relevant institutions of the Government of Ecuador from March 1991 to December 1992. The feasibility study justified the Project to be socio-economically feasible and environmentally sound.

At the request of the Government of Ecuador, the Government of Japan agreed to proceed with the Project into the Detailed Design Stage. JICA, in collaboration with CRM, executed the detailed design study on the Project from October 1993 to March 1995.

The objective of the Project is to contribute the socio-economic development of the Project area by stable water supply to meet the following water demands:

(1) Water supply for domestic, tourism and industrial use to cover the population of 650,000 in the Portoviejo river basin including the Manta and Jipijapa area (70%

of the total population) and the population of 40,000 in the Chone river basin (12% of the total population) in the year 2020.

(2) Water supply for irrigation in a net area of 12,150 ha in the Portoviejo river basin and 1,000 ha in the Chone river basin.

(3) Fresh water supply to shrimp farms in a gross area of 5,500 ha in the estuaries of the Chone and Portoviejo rivers.

(4) Increase of river maintenance flow to improve water quality and to conserve eco-systems of the Chone and Portoviejo rivers including their estuaries.

2. The Project Area

The Manabi Province has an area of about 19,000 km^2, while the Project area, the Chone-Portoviejo river basins has an area of 4,871 km^2. Topographically, the Project area forms higher elevations towards the east from the flat coastal area in the west. Major geological layers in the Project area are Borbón, Onzole and Tosagua formations in Tertiary. The Onzole formation consisting of soft sandstone and mudstone is profoundly related to engineering works of the Project.

The Project area is dominated by a complicated tropical climate affected by the Humboldt cold current and El Niño phenomenon. Mean annual rainfall in the Project area varies from 400 mm in the south-western part to 1,800 mm in the eastern part, with about 90% of the annual rainfall concentrated in the rainy season from December to May. The seasonal fluctuation of mean monthly temperature, on the other hand, is small, the lowest of 23.8°C in August and the highest of 26.0°C in March in Portoviejo City.

The Project area is basically formed by two river systems, the Chone river system with a catchment area of 2,267 km^2 and the Portoviejo river system with a catchment area of 2,060 km^2. The Carrizal river is a major tributary of the Chone river with a catchment area of 1,166 km^2, and the Chico river is a major tributary of the Portoviejo river with a catchment area of 585 km^2.

Population of Ecuador was 9.7 million in 1990. Population of the Manabi Province was 1,032,000 in 1990, while the population of the Project area was 480,300 in the same year. The population of the Project beneficiary area including Manta and Jipijapa area was 685,600 in 1990, and is forecasted to increase to 1,240,300 in 2020. Gross Domestic Product (GDP) of Ecuador was S/.8,130 billion in 1990, with GDP per capita of S/.840,000, equivalent to US$ 1,030. Gross Regional Product (GRP) of the Manabi

Province was S/.599 billion in 1990, with GRP per capita of S/.580,000, equivalent to US$ 710.

3. Water Resources Development in and around the Project Area

In the Project area, a number of water resources development projects have been planned, studied and implemented. The following projects and studies are, among others, closely related to the Project, as referred to Figure S-1.

(1) Poza Honda Multipurpose Project in the Portoviejo river basin

(2) Daule-Peripa Dam Project on the Daule river, located immediate east of the Project area.

(3) La Esperanza Dam Project on the Carrizal river, a major tributary of the Chone river.

(4) Water Transbasin Project from the Daule-Peripa to the Poza Honda and the La Esperanza reservoirs.

(5) Carrizal-Chone Multipurpose Project in the Chone river basin.

The Poza Honda project was implemented by CRM in the following stages:

- Construction of the Poza Honda dam in 1971
- Construction of Guarumo water treatment plant with a capacity of 43,000 m^3/day with water transmission system to Portoviejo and Manta in 1976
- Construction of Santa Ana intake weir and an irrigation system for 3,300 ha in 1984
- Construction of Caza Lagartos treatment plant with a capacity of 20,000 m^3/day with a pertinent water transmission system to Manta in 1987
- Cuatro Esquinas treatment plant at Portoviejo with a capacity of 90,000 m^3/day with the water transmission pipeline system to Portoviejo, to be completed in late 1995
- El Ceibal treatment plant at Rocafuerte with a capacity of 90,000 m^3/day with the water transmission pipeline system to Manta and Rocafuerte, to be completed in late 1995.

The PHIMA Study evaluated a water supply capacity of the Poza Honda dam at Santa Ana intake weir site with a catchment area of 481 km^2 including the Poza Honda catchment of 175 km^2, to be 107 MCM/year. On the other hand, water demand in 1990 was estimated by PHIMA to be 25 MCM/year for water supply and 75 MCM/year for irrigation, totaling 100 MCM/year. Although it is technically possible for the Poza Honda dam to meet the 1990 water demand, CRM actually limited the irrigation supply to assure domestic water supply even during consecutive dry years. The Poza Honda dam cannot afford to feed the new treatment plants with additional 66 MCM/year of water demand without suspending the irrigation water supply. This is one of the major reasons for urgent necessity of water to be diverted from the Daule-Peripa to the Portoviejo river basin. The Poza Honda reservoir will function as a water receiving pond to be diverted from the La Esperanza reservoir to supply the Portoviejo river basin under the Project.

The Daule-Peripa dam was constructed by CEDEGE in 1987, with the main objectives of (i) flood control, (ii) domestic water supply, (iii) irrigation water supply and (iv) hydroelectric power generation. It is noted that a reservoir capacity of 500 MCM is allocated for use in the Manabi province. According to the inter-institutional agreement signed in late 1986 between CEDEGE and CRM, CRM is entitled to divert up to 500 MCM/year with the maximum diversion of 18 m^3/s.

The construction of the La Esperanza dam was commenced in 1992 by CRM in the upper reach of the Carrizal river and is scheduled to be completed in 1996. The objectives of La Esperanza are (i) flood control and (ii) irrigation water supply to the Carrizal-Chone area. Once La Esperanza is constructed, the inundation problem in the rainy season and the water shortage problem in the dry season will mostly be solved in the Chone river basin. The Portoviejo river basin will, however, still remain without water until the Project is realized. La Esperanza will function as an intermediate pond to divert water from Daule-Peripa to Poza Honda.

The water transbasin project was formulated in 1987 in the following plan by CRM.

(1) Water of the Daule-Peripa reservoir will be diverted to La Esperanza with a transbasin capacity of 12 m^3/s.

(2) Water released by Daule-Peripa will be pumped up at the Daule river at about 30 km downstream of Daule-Peripa, by about 150 m to be diverted into Poza Honda with a final capacity of 12 m^3/s.

The PHIMA study in 1989 recommended to give a capacity of 18 m^3/s instead of 12 m^3/s to the Daule-Peripa-La Esperanza transbasin. CRM requested CEDEGE to

construct the tunnel entrance with a capacity of 18 m^3/s, and CEDEGE constructed it in 1990 accordingly. CRM also revised the tunnel design from Daule-Peripa to La Esperanza to have a capacity of 18 m^3/s in 1989. The water transbasin scheme from Daule-Peripa to La Esperanza is one of the important components of the Project.

CRM conducted a feasibility study on the Carrizal-Chone irrigation project, to which water is supplied by the La Esperanza dam. Since the La Esperanza dam is scheduled to be completed in 1996, CRM has a strong desire to proceed with the project. In late 1994,CAF, Corporación Andina de Fomento, accepted to finance US$ 4.0 million for the detailed design of the project.

4. Water Demands

Three regional water supply systems currently serve the expanded Project area including Manta and Jipijapa area. They are Poza Honda System, La Estancilla System and Chone System, all of which are operated and maintained by CRM, except Caza Lagartos treatment plant which is managed by the Manta Municipal Water Supply Company.

Water demands in the service area are projected as follows:

Regional Water Supply System	Average Water Demand (m^3/day)			
	1990	2000	2010	2020
Poza Honda	89,950	155,470	252,730	395,800
Chone	8,780	17,260	27,510	39,570
La Estancilla	12,500	30,760	52,180	76,940
Total	111,230	203,480	332,420	512,290
in MCM/year	41	74	121	187
Unit demand (l/p/d)	207	285	355	428

There are three irrigation systems in the Project area. They are (i) Poza Honda, (ii) Chico and (iii) La Estancilla. The service areas and actually irrigated areas in 1988 are as follows:

Irrigation System	Commanding area (ha)	Irrigated area in 1988 (ha)
Poza Honda	8,750	4,850
Chico	2,050	1,380
La Estancilla	2,730	1,520
Total	13,530	7,750

Although the Project area is provided with irrigation facilities covering an area of 13,530 ha, an area of 7,750 ha was insufficiently irrigated in 1988 due to shortage of water resources.

The following eight irrigation schemes with a total net area of 29,250 ha are formulated in the Project area and the irrigation water requirements were calculated for a once in 5 year dry year.

Scheme	River Basin	Net Irrigation Area (ha)	Water Requirement (MCM/year)
Carrizal-Chone	Carrizal and Chone	15,000	253
Amarillos	Carrizal	1,000	19
Guarango	Portoviejo	1,500	36
Río Chico	Chico	1,700	31
Pechiche-Pasaje	Chico and Portoviejo	850	20
Santa Ana	Portoviejo	3,300	74
Mejía	Portoviejo	1,250	28
Ceibal-Guayaba	Portoviejo	4,650	111
Total		29,250	572

Shrimp farming is practiced in the estuary of the Chone river where 4,967 ha was operated in 1990 and 5,417 ha will be operated in 2000. Salinities are influenced by seasonal fluctuation of rainfall and runoff. Water around shrimp ponds have salinities as low as 0 parts per thousand (ppt) in the rainy season due to heavy rainfall and abundant runoff of the river, while it rises more than 40 ppt equal to or even higher than that of seawater in the dry season. The optimum range of salinity for good growth of shrimp is from 15 to 25 ppt. If proper fresh water supply controls the salinity of water in the shrimp ponds within the optimum range, shrimp production will be notably increased.

Annual fresh water requirement in 2000 onward is estimated to be 100 MCM in the Chone estuary and 3 MCM in the Portoviejo estuary as explained below.

	Gross Area (ha)	Net Area (ha)	Area receiving fresh water (ha)	Unit water requirement (m^3/ha)	Total water requirement (MCM/year)
Chone river					
Zone A (Sea side)	990	594	475	49,500	23.5
Zone B (River Side)	4,427	2,656	2,125	35,700	76.0
Portoviejo river	130	78	63	44,300	2.8
Total	5,547	3,328	2,663	-	102.3

(Note) Net area is assumed to be 60% of the gross area. Also, the area actually receiving fresh water from the Project is assumed to be 80% of the net area.

5. Integrated Reservoir Operation and Water Balance Study

An integrated reservoir operation and water balance study is conducted under the following conditions:

(1) The interbasin flows, the natural flows from the catchment area downstream of a dam, can be used to meet water demands especially during the rainy season. Use of up to 60% of the interbasin flow is assumed to be allowed.

(2) A dam should release a constant flow as a river maintenance flow. The river maintenance flows are 8 MCM/year from Poza Honda and 16 MCM/year from La Esperanza.

(3) Dilution water equivalent to 20% of the irrigation water requirement is applied to dilute irrigation return flows.

The study confirmed that all the water demands can be met with a guarantee level of more than 80% (water shortage is allowed in only one year out of five years) under the following conditions.

(1) Full capacity pumping up from La Esperanza is only possible for reservoir water levels higher than EL. 47 m.

(2) Water diversion from Poza Honda to Mancha Grande is only possible for reservoir water levels higher than EL. 94 m.

(3) Target water levels are EL. 63.5 m for La Esperanza and EL. 102.5 m for Poza Honda. This means that water transbasin from Daule-Peripa to La Esperanza is suspended when La Esperanza water levels are higher than EL. 63.5 m and that water transbasin from La Esperanza to Poza Honda is suspended when Poza Honda levels are higher than EL. 102.5 m.

(4) Water transbasin capacities are as follows

Daule-Peripa ~ La Esperanza	:	18 m^3/s
La Esperanza ~ Poza Honda	:	16 m^3/s
Poza Honda ~ Mancha Grande	:	4 m^3/s

The result of the water balance study is given in Figure S-2.

6. Studies and Investigations for the Project

Studies and investigations conducted in the feasibility study stage are reviewed, updated and supplemented in this detailed study stage.

In the hydrological studies, the river flow simulation study is revised and updated, the reservoir sedimentation study is supplemented, and the water quality study is reviewed with some additional water quality tests.

The detailed topographic mapping is made at the structure sites and additional topographic survey is carried out along the access roads and the route of the power transmission line.

Geological investigations as well as the construction material investigations are conducted to supplement the previous geotechnical and material investigations and to further confirm geotechnical conditions and availability of construction materials.

The environmental studies are reviewed and detailed with additional water quality tests in the study area and tidal measurements in the Chone estuary. The institutional studies are also reviewed and detailed.

7. Design of Project Facilities

The Project comprises the following three water transbasin schemes as shown in Figure S-1.

(1) Daule-Peripa ~ La Esperanza Transbasin Scheme

Diversion tunnel		
	Capacity	18 m^3/s, Free flow
	Length	8.3 km
	Section	3.7 m in diameter
		Standard horseshoe section
	Gradient	1/1,500
Access roads		
	Conguillo access road	22.6 km
	Membrillo access road	0.4 km
	El Guasmo access road	1.6 km

(2) La Esperanza ~ Poza Honda Transbasin Scheme

Severino pumping station

Pumping capacity	16 m^3/s
Maximum head	70.0 m
Design head	60.0 m
Nos.of pump unit	6 units (one for reserve)
Discharge of one unit	192 m^3/min. (3.2 m^3/s)
Type	Vertical shaft, single suction volute type

Penstock

Length	173 m (No.1 penstock)
	170 m (No.2 penstock)
Nos. of lanes	2 lanes
Diameter	1,000 - 2,400 mm

Head tank

Width	16.8 m - 8.8 m
Length	56.7 m

Open channel

Capacity	16 m^3/s
Length	5.5 km
Gradient	1/3,000
Section	Trapezoidal, concrete lined

Syphons

Syphon No.	Length	Max.head
1	72 m	8.7 m
2	233 m	36.6 m
3	326 m	47.6 m
4	76 m	5.5 m
5	174 m	17.5 m

Diversion tunnel

Capacity	16 m^3/s, Free flow
Length	11.4 km
Section	3.5 m in diameter
	Standard horseshoe section
Gradient	1/1,500

Severino substation

Capacity	2 x 12.5 MVA
Voltage ratio	138/13.8 kV

Daule-Peripa ~ Severino Transmission Line

Length	32.6 km
Voltage	138 kV

Access roads

Severino access road	9.3 km
Caña Dulce inlet access road	2.7 km
Los Cuyuyes access road	14.8 km
La Seca access road	3.8 km

(3) Poza Honda-Mancha Grande Transbasin Scheme

Diversion tunnel

Capacity	4 m^3/s
Length	4.1 km
Section	2.5 m in diameter
	Standard horseshoe section
Gradient	1/3,900

Access road

Poza Honda Inlet access road	0.7 km

Rocks through the proposed tunnel formation are mudstone with an unconfined compressive strength ranging from 60 kg/cm^2 to 100 kg/cm^2, which is classified into soft rocks. Permeability is generally low, in the order of 10^{-5} cm/sec.

Judging from the geological conditions, New Austrian Tunnelling Method (NATM) is considered most suitable for tunnel construction. Load header is applied for tunnel excavation. Immediately after excavation, shotcrete will be provided on the excavated rock surface. Several rock bolts are to be driven depending on actual rock conditions. The tunnel construction will be completed by concrete lining for the whole stretches of the tunnel. Steel support is to be used for tunnelling in the colluvial and weathered rock zone near tunnel portals. Drain holes are also provided to relieve water pressure around the tunnel.

8. Construction Schedule and Cost Estimate

The Project is proposed to be implemented by the following three contract packages:

Package 1: Civilworks for Daule-Peripa~La Esperanza Transbasin Scheme

Package 2: Civilworks for La Esperanza~Poza Honda and Poza Honda~Mancha Grande Transbasin Schemes

Package 3: Electrical and Mechanical Works including Power Transmission Line

The following basic schedule for Project implementation is established as shown in Figure S-3.

(1) Financial arrangement for construction : 10 months from April 1995 to January 1996

(2) Selection of a consultant : 3 months from February 1996 to April 1996

(3) Tendering and contracts including prequalification for Packages 1 and 2

- Package 1 : 13 months from May 1996 to May 1997
- Package 2 : 13 months from May 1996 to May 1997
- Package 3 : 11 months from July 1997 to May 1998

(4) Construction works

- Package 1 : 54 months from June 1997 to November 2001
- Package 2 : 54 months from June 1997 to November 2001
- Package 3 : 42 months from June 1998 to November 2001

(5) Commissioning of the Project : December 2001

Project costs are estimated at the price level of August 1994 as follows.

(US$ million)

	Foreign Currency	Local Currency	Total
Package 1	29.04	14.20	43.24
Package 2	52.30	27.47	79.77
Package 3	25.05	2.64	27.69
Sub-total	106.39	44.31	150.70
Administration	-	0.25	0.25
Land Acquisition	-	3.01	3.01
Engineering Service	10.01	1.52	11.53
Physical Contingency	9.38	4.50	13.88
Price Contingency	17.76	7.67	25.44
Total Cost	143.54	61.27	204.81

The annual disbursement is estimated according to the construction schedule and summarized as follows.

(US$ million)

Year	Foreign Currency	Local Currency	Total
1996	-	0.14	0.14
1997	27.43	14.48	41.91
1998	35.59	15.30	50.89
1999	30.27	14.13	44.40
2000	39.66	12.47	52.13
2001	10.59	4.75	15.34
Total	143.54	61.27	204.81

The operation and maintenance cost of the Project is estimated also at the price level of August 1994 as follows.

(US$ million/year)

Year	O&M Cost except Energy	Energy Cost	Total O&M Cost
2002	0.82	1.55	2.37
2010	0.82	1.93	2.75
2015	0.82	2.28	3.10
2020	0.82	2.69	3.51

9. Environmental Impact of the Project

Environment Impact Assessment (EIA) is conducted for the Project for the following four issues based on the Project features and the results of the Initial Environmental Examination (IEE).

(1) Impacts on water quality of La Esperanza and Poza Honda reservoirs

(2) Impacts on river flow regime

(3) Impacts on water quality in rivers and estuaries

(4) Impacts on eco-system and fishery

Although several environmental impacts having certain effects on the environment are pointed out through EIA, these are not considered substantial for the Project because most of them could be mitigated by proper countermeasures. Therefore, the Project is judged acceptable from the environmental viewpoint.

Even if the results of EIA conclude that the Project is acceptable from the environmental viewpoint, it is not possible to eliminate all uncertainties related to environmental impacts caused by the Project. Unexpected environmental problems might arise after implementation of the Project. It is important to monitor the effectiveness and efficiency of the proposed mitigation measures, and, therefore, CRM has decided to conduct an Environmental Management and Monitoring Plan (EMMP) as an associated project to the Transbasin Project. In late 1994, CAF agreed to finance for the implementation of EMMP.

10. Institutional Framework and Organization

The executing agency of the Project is the Manabi Rehabilitation Center (CRM), who is responsible for development of water resources including potable water supply and irrigation in the province of Manabi as well as urban and regional development of the Manabi Province. Major projects handled and managed by CRM are the Poza Honda Multipurpose Project, small irrigation schemes such as the La Estancilla irrigation system, the Chico river irrigation system, etc., the Chone and La Estancilla water supply systems, and the Carrizal-Chone Multipurpose Project including the La Esperanza dam.

A transbasin project office will be organized towards the construction of the Project. The main project office will be located at the Severino pumping station site and branch offices are located at the Conguillo tunnel inlet site and at the Poza Honda tunnel inlet site. An international consultant as well as an Ecuadorian consultant will be employed by CRM to assist CRM in construction supervision of the Project.

Upon completion of the Project construction, CRM will hand over the transmission line between Daule-Peripa and Severino to INECEL for operation and maintenance. Also, the access roads will be handed over to the Ministry of Public Works (MOP) for maintenance. CRM will be responsible for operation and maintenance of the remaining Project facilities. The Severino project office will become a Severino operation and maintenance center (O&M Center) responsible for operation and maintenance of Project facilities. The Conguillo tunnel inlet and the Poza Honda tunnel inlet will be operated and maintained by the Conguillo O&M

branch office and the Poza Honda O&M branch office, respectively, under the direction of the Severino O&M Center.

11. Project Evaluation

The economic benefit for municipal and industrial water supply depends on the valuation of a unit raw water value as shown below.

Water Supply Benefit (US$ million/year)

Year	Unit raw water value (US$/m^3)			Water Demand (MCM/year)
	0.3	0.4	0.5	
2002	6.6	8.8	11.1	22.1
2005	10.0	13.3	16.7	33.3
2010	15.6	20.8	26.0	51.9
2015	23.8	31.8	39.7	79.4
2020	33.6	44.8	56.0	112.0

The other economic benefits are estimated to be U$7.8 million/year for irrigation water supply and US$7.3 million/year for shrimp farming.

The economic internal rates of return (EIRR) of the project are calculated as follows.

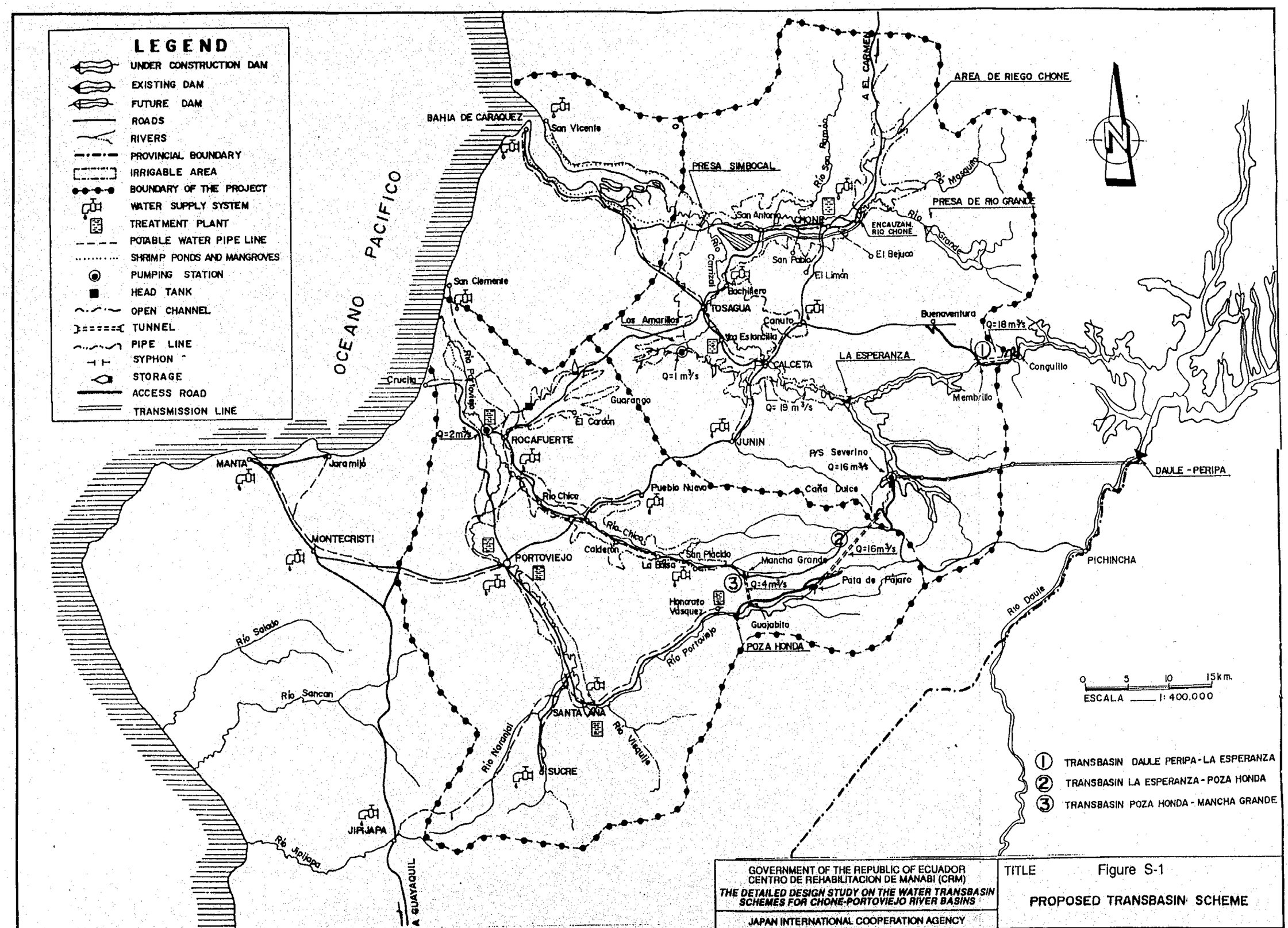
Unit Raw Water Value for Water Supply (US$/m^3)	EIRR (%)
0.3	11.9
0.4	13.4
0.5	14.8

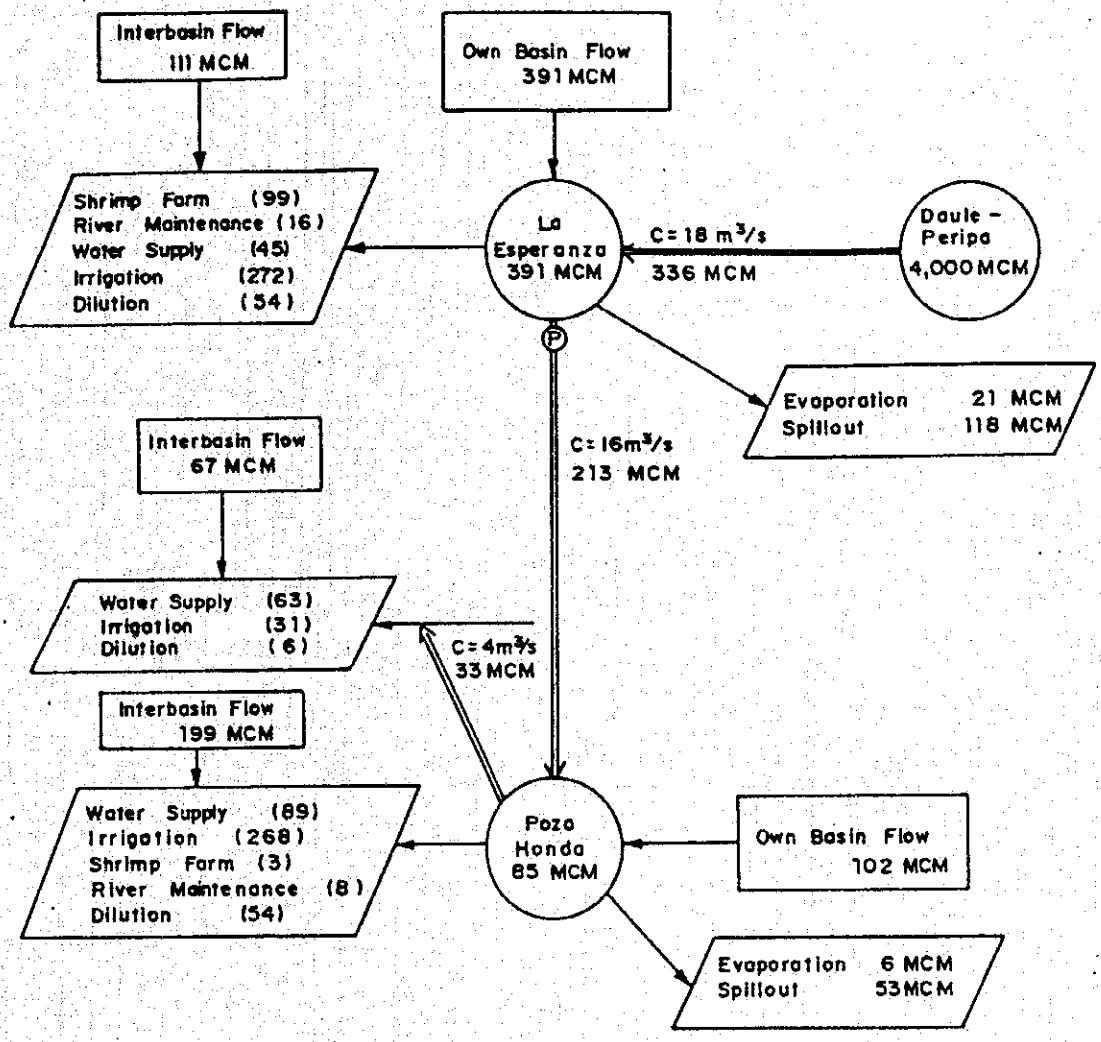
The financial benefit of water supply for irrigation and shrimp farming is assumed to be a half of the total benefit, leaving another half of the total benefit for farmers. The financial internal rates of return (FIRR) of the project are calculated as follows depending on pricing of unit raw water for water supply.

Unit Raw Water Price for Water Supply (US$/m^3)	FIRR (%)
0.15	8.6
0.20	10.0
0.25	11.2

Besides the tangible benefits as analyzed above, the Project will surely bring about an enormous socio-economic impact in the Project area. They are, among others, as follows.

- Socio-economic impact during construction of the Project
- Impact on local commercial activities
- Impact on industrial development
- Improvement of sanitary condition
- Impact on rural area development including eco-tourism development


LEGEND
UNDER CONSTRUCTION DAM
EXISTING DAM
FUTURE DAM
ROADS
RIVERS
PROVINCIAL BOUNDARY
IRRIGABLE AREA
BOUNDARY OF THE PROJECT
WATER SUPPLY SYSTEM
TREATMENT PLANT
POTABLE WATER PIPE LINE
SHRIMP PONDS AND MANGROVES
PUMPING STATION
HEAD TANK
OPEN CHANNEL
TUNNEL
PIPE LINE
SYPHON
STORAGE
ACCESS ROAD
TRANSMISSION LINE
OCEANO PACIFICO
BAHIA DE CARAQUEZ
San Vicente
PRESA SIMBOCAL
Río San Ramón
A EL CARMEN
AREA DE RIEGO CHONE
Río Mosquito
PRESA DE RIO GRANDE
Río Grande
ENCAUZAM. RIO CHONE
CHONE
San Antonio
Río Carrizal
San Pablo
El Limón
El Bejuco
San Clemente
Bachillero
TOSAGUA
Los Amarillos
Canuto
Buenaventura
Q=18 m³/s
Río Portoviejo
Crucita
Guarango
El Cardón
Q=1 m³/s
CALCETA
LA ESPERANZA
Q=19 m³/s
Congullo
Membrillo
Q=2m³/s
ROCAFUERTE
JUNIN
P/S Severino
Q=16 m³/s
MANTA
Jaramijó
DAULE - PERIPA
Pueblo Nuevo
Caña Dulce
Río Chico
MONTECRISTI
Calderón
La Edisa
San Plácido
Mancha Grande
Q=16m³/s
PORTOVIEJO
Pata de Pájaro
Q=4m³/s
PICHINCHA
Honorato Vásquez
Guajabito
POZA HONDA
Río Daule
Río Salado
Río Sancan
Río Portoviejo
SANTA ANA
Río Naranjal
Río Viaquilla
SUCRE
JIPIJAPA
Río Jipijapa
A GUAYAQUIL
0 5 10 15km.
ESCALA 1: 400.000
① TRANSBASIN DAULE PERIPA - LA ESPERANZA
② TRANSBASIN LA ESPERANZA - POZA HONDA
③ TRANSBASIN POZA HONDA - MANCHA GRANDE
GOVERNMENT OF THE REPUBLIC OF ECUADOR
CENTRO DE REHABILITACION DE MANABI (CRM)
THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY
TITLE Figure S-1
PROPOSED TRANSBASIN SCHEME



Legend :

- Reservoir / Effective reservoir capacity
- Own basin flow and Interbasin flow
- Transbasin
- Movement of water
- Water demand or loss
- (P) Pumping station
- Figures in parenthesis : Water demand in MCM/year
- Q
- C : Transbasin capacity

GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) *THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS* JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Figure S-2 SCHEMATIC WATER BALANCE

Figure S-3 *IMPREMENTATION SCHEDULE*