11.4 Feasibility Designs of Daule Peripa - Esperanza Transbasin Scheme

(1) Tunnel

This tunnel was planned from the Conguillo river in the Daule Peripa reservoir to the Membrillo river in the La Esperanza reservoir. The detailed design was prepared for this tunnel by a Brasilian team.

Rock type in the tunnel formation consists of fine sandstone and mudstone. In 1986 the Brasilian team investigated the geology of the tunnel route by borings. The investigation resulted in the following engineering properties.

Unit weight	2.1 g/cm^3
Unconfined compressive strength	60 - 100 kg/cm^2
Static elastic modules	10,000 - 12,000 kg/cm^2
Permeability coefficient	1x10^{-4} - 1x10^{-5} cm/sec

These properties are almost the same as those for other tunnels investigated this time. The Brasilian team designed the following five typical tunnel sections with a 4.4 m diameter of semi-standard horse-shoe type.

Type 1 Shotcrete (20 cm in thickness) with wire mesh and drain holes

Type 2 Shotcrete (20 cm in thickness) with wire mesh, rock bolts (1.5 m long, 1.2 m pitch, 4 Nos.) and drain holes

Type 3 Shotcrete (30 cm in thickness) with wire mesh and reinforcement bars, steel support (1.5 m pitch) and drain holes

Type 4 Shotcrete (30 cm in thickness) with wire mesh and reinforcement bars, rock bolts, steel support and drain holes

Type 5 shotcrete (5 cm in thickness) with wire mesh, concrete lining (25 cm in thickness) with double reinforcement bars and drain holes

Type 1 was applied for about 77% of the tunnel length and type 2 was applied for 19% of the tunnel length, totaling 96% of the total tunnel length.

Only shotcrete with a thickness of 20 cm for a major part of the tunnel seems inadequate in view of the poor geological conditions. Rock bolts will be needed for the whole stretches of the tunnel. Therefore, the tunnel designs is proposed to be the same as those of the other two tunnels with four typical sections with concrete lining as shown in Fig. 11.13. The tunnel will have a standard horse-shoe section of 3.7 m in diameter instead of 4.4 m in diameter proposed by the Brasilian team. This difference in tunnel diameter is due to different roughness coefficient; 0.015 for concrete lined tunnel and 0.019 for shotcrete lined tunnel.

Tunnel lengths for the four types are tentatively decided as follows.

	Type I	Type II	Type III	Type IV
Distance (m)	3,000	3,000	2,000	300

Three tunnel work adits are planned with the same section as for the Esperanza - Poza Honda tunnel. They are located at the tunnel inlet with a length of 400 m, at the outlet with a length of 500 m, and about 4.0 km point from the inlet with a length of 350 m.

(2) Tunnel Inlet and Outlet (Fig. 11.14)

At the tunnel inlet, an energy dissipator with sleeve valves is designed to ensure a free open flow in the tunnel regardless of the water level of the Daule Peripa reservoir which will fluctuate from El. 85.0 m (normal high water level) to El. 60.0 m (low water level).

At the tunnel outlet, stop logs will be provided for tunnel maintenance. The stop logs will be operated only for tunnel maintenance when water level of the Esperanza reservoir is higher than the tunnel outlet elevation.

12. CONSTRUCTION PLAN AND COST ESTIMATES

12.1 Construction Plan and Schedule

12.1.1 Introduction

The construction works will be divided into two packages shown below and executed by contractors selected by international competitive tenders including prequalification. As for the engineering service, a consultant will be required for the execution of the project during both detailed design stage and construction supervision stage.

(1) Lot 1: Esperanza - Poza Honda and Poza Honda - Mancha Grande Transbasin Schemes

The Esperanza - Poza Honda transbasin scheme includes the construction of pumping station, steel pipeline, open channel with syphons, tunnel, inlet and outlet of the tunnel, work adits, access roads, power transmission line and substation as well as preparatory works.

(2) Lot 2: Daule Peripa - Esperanza Transbasin Scheme

Lot 2 works include the construction of tunnel, inlet and outlet of the tunnel, work adits and access roads as well as preparatory works.

12.1.2 Construction plan

(1) Basic Conditions

The commencement of the construction works is scheduled in September 1995, allowing times for financial arrangement of 10 months from January 1993 to October 1993, for selection of a consultant of 3 months from November 1993 to January 1994, for detailed designs of 12 months from February 1994 to January 1995 and for tendering, tender evaluation and contract award of 7 months from February 1995 to August 1995. The construction of the project is planned to be completed in February 2000 giving a construction period of 4.5 years (54 months).

With regard to workable days, 275 days are assumed in a year for earthworks, 280 days for concrete works and 276 days for tunnel works. As for daily working hours, one 8-hour shift per day is applied for earthworks and concrete works and two 10-hour shift per day is applied for tunnel works.

(2) Preparatory Work and Construction Facilities

For Lot 1 construction, a permanent access road is needed from Piedra Azul on the existing road Monta-Quevedo to the proposed Severino pumping station site for a distance of about 7 km. Also, the existing small earth road between the outlet of the Esperanza - Poza Honda tunnel and the inlet of the Poza Honda - Mancha Grande tunnel should be upgraded to be a permanent access road.

For Lot 2 construction, a permanent access road will be constructed from Buenaventura on the existing road to the inlet of the Daule Peripa - Esperanza tunnel through the outlet of the same tunnel for a distance of about 25 km.

Temporary buildings such as contractor's office, quarters, repair shop, warehouse, etc. will be constructed at the Severino pumping station site, Honorato Vasquez (near Poza Honda dam), San Placido (near Mancha Grande) and Membrillo (near the outlet of the Daule Peripa - Esperanza tunnel).

Water required for the construction and base camps is planned to be taken from the rivers such as the Severino river for the Severino pumping station site, the Pata de Pajaro river for the outlet of the Esperanza - Poza Honda tunnel, the Poza Honda reservoir for the inlet of the Poza Honda - Mancha Grande tunnel, the Mancha Grande river for the outlet of the Poza Honda - Mancha Grande river, the Membrillo river for the outlet of the Daule Peripa - Esperanza tunnel, and the Conguillo river for the inlet of the Daule Peripa - Esperanza tunnel.

Electric power for the construction and base camps is planned to be supplied by diesel generator sets.

Wireless telecommunication system will be provided for construction use to connect one project site with another. Wired telephone facilities will also be required within each work site.

(3) Major Construction Work

The construction work of the Severino pumping station is affected by the impounding of the La Esperanza dam, which is scheduled to be completed in May 1996 with reservoir impounding in the subsequent two rainy seasons. The construction method and design in relation with the La Esperanza reservoir will further be studied during the detailed design stage.

The excavation works for the Severino pumping station will be carried out by 10 m^3/min crawler drills, 32 ton bulldozers with ripper, 2.3 m^3 tractor shovels and 11 ton dump trucks. Concrete works for the pumping station will be carried out by 3.2 m^3 agitator trucks, 45 m^3/hr concrete pump cars, 1.0 m^3 concrete buckets with 30 ton truck crane. Concrete will be produced by a 0.75 m^3 x 2 concrete plant located at the tunnel portal, which will also be used for concrete works of tunnel, open channel, syphon, etc..

Two lanes of steel pipeline with 2.1 m diameter are planned to deliver water to the open channel. Open cut excavation will be carried out by 10 m^3/min crawler drills, 21 ton bulldozers, 32 ton bulldozers with ripper, 2.3 m^3 tractor shovels and 11 ton dump trucks. Concrete placing to anchor blocks and saddles will be made by 1 m^3 buckets with 30 ton truck crane and 45 m^3/hr concrete pump cars. Steel pipe segment of 6 m long transported from the Guayaquil port to the stock yard near the construction site will be transported to the installation site by 20 ton trailers and will be set in position by incline machines with a carrier and 30 ton truck crane.

For open channel construction, excavation work above the top level of the channel will be carried out using the same equipment for the steel pipeline excavation. The excavation of the channel itself will be made by 11 ton bulldozers, 0.6 m^3 backhoes and 11 ton dump trucks. The excavation will be finished to the lines and grades by jack hammers, pick hammers and barring. Concrete will be transported by 3.2 m^3 agitator trucks and concrete will be placed by 1.0 m^3 buckets with 30 ton crawler crane and 45 m^3/hr concrete pump cars. Concrete for syphons will be placed in-situ by 45 m^3/hr concrete pump cars.

Inlet and outlet works of each tunnel will be more or less affected by the reservoir water levels and river water levels. Open excavation works will be carried out in a similar manner for the pumping station, and concrete works will be made in the same manner for the open channel.

The tunnel construction is on a critical path of both Lot 1 and Lot 2. To minimize the construction period, the following work adits are proposed to be provided.

Esperanza - Poza Honda tunnel	No. 1 adit (650 m) and No.2 adit (500 m)
Poza Honda - Mancha Grande tunnel	No. 1 adit (350 m)
Daule Peripa - Esperanza tunnel	No.1 adit (400 m), No. 2 adit (450 m) and No. 3 adit (500 m)

A full-face attack method is recommended for tunnel excavation and tunnel mucking is by a rail haulage method. A driving rate is planned to be 130 m/month for each tunnel face. The Esperanza - Poza Honda tunnel and the Daule Peripa - Esperanza tunnel will be excavated with three tunnel faces, while the Poza Honda - Mancha Grande tunnel will be excavated with two tunnel faces.

Tunnel will be excavated by an arm type mechanical tunnelling machine with a cutting head. Excavated rocks will be loaded into 3 m^3 muck cars with 8 ton battery locomotives for hauling. The broken rocks carried out of the tunnel will be loaded by 1.2 m^3 tractor shovels into 8 ton dump trucks and transported to either embankment site or the spoil bank.

Immediately after finishing one cycle excavation operation of 1.2 m progress, a primary shotcrete of 10 cm thick with wire mesh and rock bolts of 2.0 m long will be provided. For lower compressive strength sections and fractured zones, steel H beam ribs and additional shotcreting will be required.

A concrete lining with 30 cm thick will be provided in parallel with the tunnel excavation works for the Esperanza - Poza Honda tunnel and the Daule Peripa - Esperanza tunnel, but for the Poza Honda - Mancha Grande tunnel parallel works of tunnel excavation and concrete lining will be difficult because of small tunnel diameter.

Lining concrete will be placed in the arch portion first and then placed in the invert portion. Progress of concrete lining is planned to be 138 m/month with 12.0 m long concrete lining span. It is planned to be 276 m/month for the Poza Honda - Mancha Grande tunnel. Concrete will be transported to the placing spot in tunnel by 3 m^3 concrete placer with 6 ton battery locomotive. Sliding forms of 12.0 m long will be used and concrete will be placed behind the forms by means of compressed air from the concrete placer. The invert concrete will be placed by 3 m^3 agitator car with invert sliding forms.

12.1.3 Construction schedule

The following basic schedule has been elaborated for the implementation of the project.

(1)	Financial arrangement:	10 months from January 1993 to October 1993
(2)	Selection of a consultant:	3 months from November 1993 to January 1994
(3)	Detailed design and preparation of tender documents:	12 month from February 1994 to January 1995
(4)	Tendering and contract award:	7 months from February 1995 to August 1995
(5)	Main construction works:	54 months from September 1995 to February 2000
(6)	Commissioning of the project:	From March 2000

The project schedule is shown in Fig. 12.1. Land acquisition and compensation for the construction will be settled by CRM prior to the commencement of the construction.

12.2 Cost Estimates

12.2.1 Introduction

Construction costs of the project are estimated on the basis of the feasibility designs, construction plan and schedule. Unit prices for each work item are established based on local condition, costs of available construction equipment, materials and labor.

The costs are estimated in the foreign currency portion (US Dollar portion) and in the local currency portion (Ecuadorian Sucre portion) and the local currency portion is converted to US Dollars for assessing the total cost.

Assumptions and condition applied for the cost estimate are as follows.

Price level	:	Prices as of July 1992
Exchange rate	:	US Dollar 1.00 = Ecuadorian Sucre 1,550 = Japanese Yen 128
Work quantity	:	Quantities based on the feasibility designs for each work item
Contractors	:	To be selected through an international competitive bidding
Construction cost	:	Direct construction cost = Contract Prices for Lot 1 and Lot 2, and Indirect construction costs consisting of costs for land acquisition and compensation, administration expenses, engineering services and contingencies.

12.2.2. Direct construction cost

(1) Preparatory Work

Costs for preparatory works include costs for insurance, temporary buildings, water supply system, electric power supply system, telecommunication system, provision of medical facilities, testing laboratory and temporary access roads.

The cost for the preparatory works is estimated at 10% of the sum of direct construction cost except the cost for preparatory works. For the Esperanza - Poza Honda transbasin scheme which includes pumping equipment, transmission line and substation equipment, cost for the preparatory works is estimated at 10% of the sum of the direct construction cost except cost for such equipment in addition to the cost for preparatory works.

(2) Civil Works

The costs of civil works are estimated based on work quantities and unit rates which include labor cost, material cost, equipment cost and contractor's overhead expenses and profits.

The overhead expenses and profits of the contractor are estimated to be 25% of the direct cost comprising the costs of labor, materials and equipment.

(3) Pumping Equipment and Other Hydromechanical Works

Prices for pumping equipment and other hydromechanical works are based on the recent international contract prices of similar works. The costs of imported equipment and materials are estimated of CIF Guayaquil prices excluding import duties and taxes. For supply and delivery of imported items, ocean freight and insurance are included in the foreign currency portion, and unloading cost and other port charges as well as inland transportation cost and included in the local currency portion.

(4) Transmission Line and Substation Equipment

Prices for tower materials, conductors and substation equipment are estimated at CIF Guayaquil prices excluding import duties and taxes. civil work costs such as for site clearance, earthworks, foundation works, etc. are included in the transmission line cost. Other conditions to estimate the foreign and local currency portions are the same as those for the hydromechanical works.

12.2.3 Indirect cost

(1) Land Acquisition and Compensation

All required land acquisition and compensation will be carried out by CRM according to the project implementation schedule. These costs are estimated based on the information of the actual land values and values of houses.

(2) Administration Expenses

The administration expenses of CRM for project implementation are estimated to be 2% of the direct construction cost and included in the local currency portion.

(3) Engineering Services

The engineering service cost for the detailed design is estimated based on the assumed man-months input to be about 3.2% of the direct construction cost. The engineering service cost for the construction supervision is also estimated based on the assumed man-months input to be about 7.1% of the direct construction cost.

(4) Contingencies

Contingencies are provided to cope with unforeseen physical conditions (physical contingency) and inflation (price contingency). The physical contingency is taken to be 10% of a sum of the direct construction cost, land acquisition and compensation, administration expenses and engineering services. The price contingency is estimated applying annual inflation rate of 3% for foreign currency portion. For local currency portion, the actual annual inflation rate in recent years is more than 40% and it is almost impossible to predict future inflation rate of Ecuadorian Sucre. Therefore, the price contingency for the local currency portion is estimated by converting the local currency portion into US Dollars and applying the same inflation rate of 3% per annum in terms of US Dollars.

12.2.4 Construction cost

The construction cost of the project excluding price contingency is estimated to be US$166.4 million in total, consisting of US$121.4 million in the foreign currency portion (73%) and S/. 69,750 million, equivalent to US$45.0 million (27%).

The total construction cost of the project including price contingency is estimated to be US$ 193.7 million consisting of US$ 141.5 million in the foreign currency portion and US$ 52.2 million equivalent in the local currency portion.

The construction cost is summarized below and the detailed construction cost is given in Table 12.1.

Construction Cost

(1,000 US$)

	Description	Foreign Currency	Local Currency	Total
1.	Lot 1			
	Esperanza - Poza Honda	58,537	19,384	77,921
	Poza Honda - Mancha Grande	8,667	3,237	11,904
	Sub-total (1)	67,204	22,621	89,825
2.	Lot 2			
	Daule Peripa - Esperanza	31,780	13,031	44,811
	Total (1 and 2)	98,984	35,652	134,636
3.	Land acquisition	-	100	100
4.	Administration	-	2,693	2,693
5.	Engineering services	11,410	2,455	13,865
	Total (1 to 5)	110,394	40,900	151,294
6.	Physical contingency	11,039	4,090	15,129
	Total (1 to 6)	121,433	44,990	166,423
7.	Price contingency	20,022	7,230	27,252
	Grand total	141,455	52,220	193,675

12.2.5 Annual disbursement schedule

Annual disbursement of the construction cost is estimated for the foreign and local currency portions based on the construction schedule and is summarized below. The detailed disbursement schedule is tabulated in Table 12.2.

(1,000 US$)

Year	Foreign Currency	Local Currency	Total
1994	4,233	275	4,508
1995	20,050	7,463	27,513
1996	23,503	11,332	34,835
1997	26,420	12,137	38,557
1998	31,723	11,839	43,562
1999	34,279	8,739	43,018
2000	1,247	435	1,682
Total	141,455	52,220	193,675

13. ENVIRONMENT

13.1 Environmental Impact Assessment

13.1.1 General

EIA is conducted for the selected plan, Alternative-5a, consisting of three transbasin schemes, i.e. Daule Peripa - Esperanza, Esperanza - Poza Honda and Poza Honda - Mancha Grande. The Chirijos dam construction is not included and therefore the socio-economic impacts related to resettlement is excluded in this EIA. The following 4 issues are taken up for EIA based on the project features of Alt-5a and the results of the Initial Environmental Examination (IEE) discussed in Chapter 7.

(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

13.1.2 Impacts on water quality of La Esperanza and Poza Honda reservoirs

The future water quality conditions of La Esperanza and Poza Honda reservoirs are predicted based on the existing water quality data. The future water quality in La Esperanza would be better than that of Daule Peripa in BOD and COD, but worse in T-N and T-P. In Poza Honda, the water quality could be improved slightly except for T-N. No significant impacts are not considered from this result because no drastic quality change would be expected in both reservoirs.

Based on the predicted water quality of T-P, the possibility of eutrophication of the reservoirs are assessed by using a concept of Vollenweider model. The possibilities of eutrophication of La Esperanza and Poza Honda reservoirs would be rather high even though the transbasin project could improve retention time of the reservoirs. The result is shown in Fig. 13.1. Both Daule Peripa dam (constructed in 1987) and Poza Honda dam (constructed in 1971) are considered to be under eutrophicated conditions. Therefore, La Esperanza dam would also be in the eutrophicated conditions. At present, effective and efficient countermeasures can not be considered unfortunately to avoid eutrophication, so a long term management of the reservoir would be necessary under the appropriate EMMP for the project.

13.1.3 Impact on river flow regime

The degree of the river flow change is estimated by the mathematical hydrologic model used in the water balance study in this project. In the rainy season, the river flow discharge in the Chone river would be reduced about 20% at the river mouth area and 40% at the Carrizal river mainly due to the flood control by La Esperanza dam. Since the Chone river has abundant discharge in the rainy season, the degree of river flow change will not cause significant impacts on the environment. Even in case of the Carrizal river, the mean discharge in the rainy season could be reduced from 94 m^3/s to 53 m^3/s only. In the dry season, the remarkable improvement of river flow discharge would be expected in both Chone and Portoviejo rivers. Consequently, the impacts caused by the river flow change would not bring about serious effects on the environment in the rivers and estuaries.

Change of River Flow Regime

Period		Chone R. (1) River Mouth	(2) Chone Upst'm	(3) Carr'l River	Portoviejo R. (4) Porto. Downst'm	(5) Porto. Upst'm	(6) Chico River
a) Rainy	(%)	-23	+1	-44	+8	-4	+14
b) Dry	(%)	+143	+23	+312	+139	+83	+194
c) Annual	(%)	-12	+2	-20	+19	+4	+26

Source: JICA Study Team

13.1.4 Impacts on water quality in rivers and estuaries

To clarify the impacts on water quality in the rivers, a qualitative approach is applied to reveal a degree of water quality deterioration in the Chone and Portoviejo rivers by using a concept of pollution load analysis. Based on the estimated pollution load change, the future water quality at 4 prediction points is assessed, and the result is summarized hereunder.

Result of Water Quality Prediction (unit: mg/l)

Prediction Point	BOD		COD		T-N		T-P	
	Exi't	Fut'e	Exi't	Fut'e	Exi't	Fut'e	Exi't	Fut'e
I. P-1								
a) Rainy	2.50	6.29	6.60	12.19	0.80	1.34	0.08	0.23
b) Dry	8.00	13.32	16.00	13.90	2.00	2.98	0.21	0.42
c) Ave.	5.25	7.59	11.30	12.51	1.40	1.64	0.15	0.27
II. P-2								
a) Rainy	2.50	5.09	6.60	9.26	0.80	1.10	0.08	0.18
b) Dry	8.00	5.59	16.00	7.74	2.00	1.24	0.21	0.18
c) Ave.	5.25	5.28	11.30	8.68	1.40	1.16	0.15	0.18
III. P-3								
a) Rainy	3.00	7.43	6.50	9.43	0.50	1.77	0.09	0.20
b) Dry	6.40	22.42	12.00	15.12	1.00	4.65	0.18	0.65
c) Ave.	4.70	10.09	9.25	10.44	0.75	2.28	0.14	0.28
IV. P-4								
a) Rainy	3.00	8.02	6.50	9.94	0.50	1.89	0.09	0.22
b) Dry	6.40	23.67	12.00	16.86	1.00	4.89	0.18	0.69
c) Ave.	4.70	10.96	9.25	11.24	0.75	2.45	0.14	0.30

Source: JICA Study Team

At the lower reach of the Chone river (P-1), the future water quality would be slightly worse than that of the present conditions. While, at the estuary area of the Chone river (P-2), the future water quality would be almost similar with the present conditions even though no self-purification capacity is considered, mainly due to the river flow improvement in the dry season. Thus, no significant impacts could be caused on the environment by the water quality change in the Chone river.

At the downstream of the confluence point with the Chico river (P-3) and the lower reach (P-4) in the Portoviejo river, the water quality deterioration could be serious mainly due to the wastewater discharge from Portoviejo city. For example, BOD in the dry season in 2020 would be almost 4 times of the present conditions, with BOD value of more than 22 mg/l. In other words, the Portoviejo river could be a sewer channel in 2020 especially in the dry season, which will cause negative effects on the potable water treatment plant at El Ceibal. Improvement of the existing sewerage system is needed in Portoviejo city.

13.1.5 Impacts on ecosystem and fishery

At present, no national parks, nature conservation areas and game refuges exist in the Chone - Portoviejo river basins, and the existence of endangered species has not been reported because of broadly spreaded cultivation and pasture lands. Thus, the ecosystem to be protected in the basins are principally the estuary of the Chone river which provides high productive habitats for fauna and flora, and the indigenous species, namely "chame" a kind of goby, which contributes to the local economy. The ecological area to be protected is shown in Fig. 13.2.

Although the impacts caused by river flow change would not be significant, the impacts caused by the water quality deterioration could be significant especially in the Portoviejo river. Therefore, the improvement of sewerage system in Portoviejo city is considered essential to mitigate the magnitude of impacts caused by the water quality deterioration.

The estuary in the Chone river which once had rich and wide mangrove forests, has been destroyed mainly due to shrimp pond construction. At present, only about 170 ha of mangrove remains. There are no room to expand shrimp ponds in the estuary area of the Portoviejo river, but about 450 ha of potential area still remains in the Chone river. Since the potential shrimp pond area is located outside the existing mangrove areas, any direct impacts would not be considered to mangrove ecosystem. However, uncontrolled expansion of shrimp ponds especially inland areas of the Chone river could cause serious problems not only on the ecosystem but also on the existing and future irrigation areas because of the discharge of saline water from ponds. Thus, strict regulation and control related to land use in the downstream area in the Chone river is recommended to protect the lands and ecosystem against the encroachment of overexploitation pressure.

The downstream area of the Chone river being prone to flood in the rainy season is considered the most important habitat of chame. Although the flood control function of La Esperanza dam definitely reduces the river flow discharge in the rainy season, it would be about 20% of the total river flow discharge in the rainy season at the river mouth area of the Chone river. This means that the river would have 135 m^3/s of discharge in the rainy season even with Project conditions, because La Esperanza dam covers less than 20% of the total catchment area of the Chone river. Therefore, no serious impacts would be expected on the habitat of chame by the Project.

13.2 Environmental Management and Monitoring Plan (EMMP)

13.2.1 Institutional aspect

Basically, EMMP consists of three units, i.e., Environmental Management Unit (MAU), Environmental Monitoring Unit (MOU) and Laboratory (LAB). MAU has a function of overall management of EMMP including inter and inner institutional coordination and decision making or effective implementation of each plan and program. MOU has planning and executing functions of various kinds of study and monitoring plan and/or program in accordance with the policy decided by MAU. LAB has roles of the physical and chemical analysis or test of water and soil, and the research and development study for establishment of appropriate EMMP of the Project.

Taking the lessons from the case for Daule Peripa dam into account, the following input data and information should be obtained previously to attain the objectives of EMMP more effectively and successfully.

(1) Cost-benefit Analysis of EMMP

Needless to say, EMMP should cost. In order to justify the activities of EMMP, a cost-benefit analysis study should be conducted taking all environmental aspects into account. The study would also clarify the necessary power, cooperation and budget of EMMP.

(2) Executing System of Projects and Programs of EMMP

EMMP must be a headquarter related to environmental aspects of the Project, but it does not mean to keep all task forces in it. Considering tight and scarce resources in budgets and sophisticated personnel in Ecuador, a proper entrusting system would be essential for smooth and efficient execution of actual projects and programs.

(3) Authorization of Activities of EMMP

The activities of EMMP could include inter-institutional matters. So, necessary right or power authorized by laws and ordinaries of the nation must be given to EMMP to ensure not only effective execution of the activities but also appropriate collaboration system with the existing concerned agencies.

13.2.2 Technical aspect

Well managed EMMP is indispensable to the sustainability of the Project. In this connection, the following items are to be managed and monitored regarding to water quality, conservation of vicinity area of reservoirs and protection of ecosystem and fishery.

- Water Quality

a) Protection of quality deterioration of water to be used for municipal, agricultural and aquacultural water supply,
b) Solution of problems related to eutrophication of the reservoir water in La Esperanza and Poza Honda dams,
c) Conservation of water quality in the estuary area,
d) Setting up of water quality criteria and standards as the management goal and target.

- Conservation of Vicinity Area of Reservoirs

a) Protection of water quality contamination of the reservoirs and canals,
b) Protection of excessive sedimentation of reservoirs,
c) Promotion of reforestation and land use control around the reservoir area,
d) Management of reservoir area for such uses as navigation, fishery, recreation and tourism.

- Protection of Ecosystem and Fishery

a) Protection of mangrove areas,
b) Protection of habitats of indigenous species "chame",
c) Management and coordination of land use and exploitation of the downstream area of the Chone river,
d) Management of the tidal gate at Simbocal in the downstream of the Chone river.

Besides, the following projects and programs are to be conducted under EMMP for the Project in order to attain effective and efficient implementation of EMMP.

- Water quality

a) Program for Establishment of quality standards (EMMP-WQ1)
b) Basic Study for Integrated River Water Conservation Project (EMMP-WQ2),
c) Program for Prevention of Water Quality Deterioration in Reservoirs (EMMP-WQ3),
d) Program for Prevention of Detrimental Effects by Agrochemicals (EMMP-WQ4).

- Conservation of Vicinity Area of Reservoirs

a) Basic Study for Delineation of Conservation Area of the Reservoirs (EMMP-RC1),
b) Basic Study for Fishery, Tourism and Recreation Development in the Reservoirs (EMMP-RC2),
c) Program for Conservation of the Reservoirs (EMMP-RC3).

- Protection of Ecosystem and fishery

a) Basic Study for Delineation of the Area to be conserved (EMMP-EF1),
b) Program for Conservation of Mangrove and Habitat of Chame (EMMP-EF2), and
c) Basic Study for Establishment of an Operation Manual of the Simbocal Tidal Gate for Better Management of Ecosystem and Aquaculture (EMMP-EF3).

13.2.3 Indicative cost estimate

The annual cost for administration and operation for EMMP is estimated about US$207,000 based on the Report of "PLAN DE MANEJO AMBIENTAL DE LAS AREAS DE AFECTACION DEL PROYECTO DE PROPOSITO MULTIPLE, DAULE PERIPA, 1990". The cost for projects and programs to be conducted under EMMP for the Project is estimated about US$1.2 million indicatively.

13.3 Conclusion and Recommendation

13.3.1 Conclusion

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 viewpoints conclusively if the following countermeasures are taken in future.

13.3.2 Recommendation

The following actions are recommended for the environmentally sound and sustainable development.

(1) To change Intake site of El Ceibal Treatment Plant

CRM is currently constructing a new potable water treatment plant with production capacity of 90,000 m^3/day at El Ceibal site under the Poza Honda Water Supply System. It is planned to take raw water for this plant from the Portoviejo river near Rocafuerte town. However, problems related to potable water treatment could take place due to the expected future serious quality deterioration of raw water in the Portoviejo river. Thus, it is necessary to change the planned intake site from the Portoviejo river to other areas to take better quality raw water.

The Chico river will be the best option of raw water source. The future water quality at Rio Chico, just upstream of the confluence point with the Portoviejo river, will be much better than that of the Portoviejo because the Chico river has less possibility of water quality deterioration in its basin. Therefore, it is recommendable to use the Chico river as a new raw water source of the El Ceibal Treatment Plant.

(2) To Improve Sewerage System

The degree of water quality deterioration of the rivers depends on the progress of wastewater treatment system. The future water quality at P-3, the downstream of confluence point with the Chico river in the Portoviejo river, is predicted in 4 cases, namely no improvement of existing sewerage system, improvement in 30%, 50% and 70% of sewerage coverage ratio.

The results indicate that the sewerage system improvement is effective for conservation of the river water quality.

Result of Water Quality Prediction (unit: mg/l)

P-3	BOD	COD	T-N	T-P
I. No Improvement				
a) Rainy	7.43	9.43	1.77	0.20
b) Dry	22.42	15.12	4.65	0.65
c) Ave.	10.09	10.44	2.28	0.28
II. 30% Sewerage Improvement				
a) Rainy	6.38	9.00	1.72	0.19
b) Dry	17.52	13.12	4.38	0.60
c) Ave.	8.35	9.73	2.19	0.26
III. 50% Sewerage Improvement				
a) Rainy	5.58	8.67	1.67	0.18
b) Dry	13.83	11.61	4.19	0.57
c) Ave.	7.05	9.19	2.12	0.25
IV. 70% Sewerage Improvement				
a) Rainy	4.79	8.35	1.63	0.17
b) Dry	10.14	10.10	3.99	0.53
c) Ave.	5.74	8.66	2.05	0.24

Source: JICA Study Team

(3) To Control and Manage Land Use

The estuary area and the flood plain in the downstream area of the Chone river are considered important ecological zones. Uncontrolled expansion of shrimp ponds especially in flood plain of the Chone river could cause serious problems not only on the ecosystem but also on the existing and future irrigation areas because of the discharge of saline water from ponds. Thus, strict regulation and control related to land use in the estuary and flood plain in the Chone river is recommended to protect the ecosystem against the encroachment of overexploitation pressures.

(4) To Improve the Operation of Simbocal Tidal Gate

The Simbocal tidal gate located in the downstream reach of the Chone river, is considered the focal point among beneficiaries such as shrimp culture, fish pond of chame and irrigation. Although CRM operates the gate at present, the gate seems to be sometimes confronted difficulties mainly due to lack of sufficient technical and scientific information, and of management capability of coordination among beneficiaries.

Moreover, proper operation of the gate is essential to conserve the habitat of chame and postlarvae of shrimp. Thus, the proper gate operation is recommended including i) to operate the gate strategically, ii) to coordinate the management of the gate between CRM, shrimp pond owners and aquacultural farmers of chame.

(5) To Establish EMMP and Its Operation Unit

Even if the results of EIA conclude that the proposed project would be acceptable from the environmental viewpoints, 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 EMMP is essential to attain environmentally sound and sustainable development of the Project.

14. PROJECT EVALUATION

14.1 Economic Evaluation

14.1.1 Economic benefit of the project

(1) Definition of Project Benefit

In the water balance study, all the water to be supplied from the Daule-Peripa diversion, the La Esperanza dam, the Esperanza-Poza Honda transbasin scheme, the Poza Honda dam and the Poza Honda-Mancha Grande transbasin scheme is compared with all the water demands for water supply, irrigation water, shrimp farming and river maintenance flows in the Chone and Portoviejo river basins as an integrated water supply scheme.

In order to quantify the benefit of the project consisting of three transbasin schemes and not including the La Esperanza dam nor the Poza Honda dam, it is necessary to define the benefit of the La Esperanza dam only and that of the Poza Honda dam only, and to define the benefit of the project as a balance of the total benefit of the integrated scheme and the benefits of the two dams.

The Poza Honda dam is capable of supplying 45 MCM/year for the Poza Honda Water Supply System which can meet the demand up to 1994, irrigation water of 25 MCM/year in dry years and 20 MCM/year in average years for 1,100 ha of the Santa Ana irrigation system and the river maintenance flow of 8 MCM/year.

The La Esperanza dam, on the other hand, is capable of supplying 40 MCM/year for the Chone-La Estancilla Water Supply System which can meet the demand up to 2017, irrigation water of 253 MCM/year in dry years and 171 MCM/year in average years for 15,000 ha of the Carrizal-Chone irrigation system and the river maintenance flow of 16 MCM/year.

The benefit of the project, which is the water transbasin scheme, will be calculated by deducting the above stated benefits of the Poza Honda dam and the La Esperanza dam from the total water supply benefit to the Chone and Portaviejo river basins.

(2) Water Supply Benefit

Demand for water supply is shown in Table 14.1. The water supply benefit of the project increases from 14.6 MCM/year in 2000 to 106.8 MCM/year in 2020 and is kept constant, 106.8 MCM/year, from 2021 onward to the Poza Honda Water Supply System, and increases from 0.9 MCM/year in 2017 to 5.2 MCM/year in 2020 and is kept constant, 5.2 MCM/year, from 2021 onward to the Chone-La Estancilla Water Supply System, also shown in Table 14.1.

Unit economic value of raw water for water supply is difficult to be determined. A range of US$ 0.3/m^3 to US$ 0.5/m^3 is assumed as a unit economic value of raw water for water supply purpose as one of the sensitivity tests on economic evaluation of the project.

(3) Irrigation Benefit

The irrigation benefit of the project is calculated to be US$ 7.8 million/year in its maturity as shown in Table 14.2.

In the Portoriejo river basin where the irrigation benefit of the project is expected, farmers are more or less familiar with irrigated farming and the irrigation systems have already been provided in large areas though they have not been utilized in their full extent because of water shortage. Therefore, 64 % of the total benefit in the first year, 80 % of the total benefit in the second year and 100 % of the total benefit from the third year are assumed for the evaluation of the irrigation benefit.

(4) Shrimp Farming Benefit

The shrimp farming benefit of the project is calculated to be US$ 7.3 million/year in its maturity as shown in Table 14.3.

Shrimp farming in the project area is generally practised in a scientific manner by large and medium enterprises. As far as beneficial to the shrimp farmers, they are assumed to willingly use fresh water with charge though they are not accustomed to apply fresh water. In this case, 50 % of the benefit is assumed to be generated in the first year, 75 % in the second year and 100 % from the third year.

14.1.2 Economic cost of the project

The financial cost is as estimated in Chapter 12. Conversion from financial cost to economic cost has been made in the following manners.

- Price inflation effect is not considered in the economic cost.

- Financial cost in foreing currency portion is estimated based on international prices at the border and, therefore, coincides with the economic cost.

- Labor cost and fuel cost in the local currency portion should be converted to the economic cost using conversion factors. Exchange rate of the local currency is changing day by day in the open money market and no shadow exchange rate exists.

- Shadow wage rate in the project area is assumed to be 70 % based on the actual unemployment ratio of about 30 %. Fuel cost in Ecuador is almost a half of the international price. Tax portion in the local procurement will be about 10 %.

- Out of the local currency portion, labor cost is assumed to be 50 % and the fuels cost is assumed to be 20 %. Then the conversion factor of the local currency portion is calculated to be 0.95 as explained below.

$$0.5 \times 0.7 + 0.2 \times 2.0 + 0.3 \times 1.0 = 1.05$$
$$1.05 \times 0.9 = 0.95$$

14.1.3 Economic internal rate of return of the project

Based on the considerations as above mentioned, a benefit stream as well as a cost stream is prepared as shown in Table 14.4.

The economic internal rates of return (EIRR) are calculated as follows for various unit water values for water supply.

Unit Raw Water Value ($US\$/m^3$)	Economic Internal Rate of Return (%)
0.3	11.4
0.4	12.8
0.5	13.9

The water unit cost of the existing water supply system is estimated to be about US$ 0.4/m^3 without counting the raw water cost, which may be compared with the assumed unit raw water values.

14.2 Financial Evaluation

14.2.1 Financial benefit of the project

(1) Water Supply Benefit

The current water tariff of CRM is as follows and CRM has a plan to increase the tariff gradually in the future.

Water Tariff Table of CRM

Valid from October 1991

Water Use (m^3/month)	Water Tariff (S/. per m^3) Domestic	Commercial	Industrial
0 - 10 m^3	25	150	500
10 - 25 m^3	30	190	500
25 - 50 m^3	66	250	500
50 - 100 m^3	90	325	500
100 - 500 m^3	120	425	500
500 - 1000 m^3	150	500	500

(Note) Exchange rate in Nov. 1991 : US$ 1.00 = S/ 1,150

The average tariff is about US$ 0.07/m^3 which is far less than the water production cost of US$ 0.39/m^3.

For the financial evaluation of the project, unit raw water price is assumed ranging from US$ 0.15/m^3 to US$ 0.25/m^3 as one of the sensibility tests for financial feasibility.

(2) Irrigation Benefit

Irrigation water charge of CRM is currently S/. 90/time/ha, which is equivalent to S/. 0.09/m^3. This water charge is only nominal and negligibly small.

If all the irrigation water supply benefit is charged to farmers, no benefit remains for farmers and they will lose their incentive for irrigated farming. It is assumed here that the irrigation benefit will be equally shared by the farmers and CRM. Then the irrigation water charge will be S/. 22,940/time/ha, more than 200 times of the current water charge.

Average irrigation benefit	US$ 591/ha
US$ 7,772,000/13,150 ha:	Refer to Table 14.2
Assumed water charge	US$ 295/ha
Times of irrigation	20 times/two crops in average
Water charge	US$ 14.8/time/ha
	(S/. 22,940/time/ha)
	US$ 0.015/m^3

(3) Shrimp Farming Benefit

The same philosophy as for the irrigation water charge is applied to the fresh water charge for shrimp farming. The water charge will be US$ 0.035/m^3 as explained below.

Average shrimp benefit	US$ 0.071/m^3
US$ 7,271,000/102.6 MCM :	Refer to Table 14.3
Assumed water charge	US$ 0.035/m^3

14.2.2 Financial cost of the project

The cost estimated in Chapter 12 is the financial cost. The inflational effect, 3.0 % per annum for both foreign currency and local currency portions in terms of US Dollars, will be duly taken into account.

The project benefit is also subject to inflation.

14.2.3 Financial internal rate of return of the project

Based on the considerations as above mentioned, a benefit stream as well as a cost stream is prepared as shown in Table 14.5.

The financial internal rates of return (FIRR) are calculated as follows for various water tariffs for water supply.

Unit Raw Water Value (US\$/m^3)	Financial Internal Rate of Return (%)
0.15	9.3
0.20	10.6
0.25	11.6

These FIRR may be compared with the current worldwide interest rate of loan of about 5 %. It is, however, considered difficult to increase water tariff or water charges as discussed herein from the social point of view. It is absolutely necessary to introduce soft loans for the implementation of the project.

14.3 Institutional Framework and Organization

The executing agency of the project is the Manabi Rehabilitation Center (CRM) under the Ministry of Agriculture and Livestock (MAG) of the Government of Ecuador. The cooperating agencies of the project are the Ecuadorian Institute of Water Resources (INERHI), the Committee for Guayas River Basin Development (CEDEGE), the Jipijapa & Pajan Board of Water Resources (JRH) under MAG, and the Ecuadorian Institute of Sanitary Works (IEOS) under the Ministry of Public Health of the Government of Ecuador. The National Development Council (CONADE) will also play an important role in the project implementation in terms of project priority ranking, introduction of foreign loans, etc.

The organization chart of the Executive Branch of the Government of Ecuador including the above mentioned organizations or institutions is given in Fig. 14.1.

CRM is responsible for development of water resources in the province of Manabi as well as regional development of the Manabi province. CRM is the agency responsible for water supply and irrigation development in the Manabi province.

Most of the water resources development projects in the Manabi province have been planned, studied, constructed, operated and maintained by CRM. Major projects handled and managed by CRM are the Poza Honda Multipurpose Project including the Poza Honda dam, Poza Honda water supply system and Poza Honda irrigation system, small irrigation schemes such as the Estancilla irrigation system, the Chico river irrigation system, etc., the Chone water supply system, the Estancilla water supply system and the Carrizal-Chone irrigation project including the La Esperanza dam under construction, Carrizal-Chone irrigation system of 15,000 ha for which the study has been completed up to the feasibility level.

The present organization of CRM is shown in Fig. 14.2. The Directorate for Physical Infrastructure of the present organization is proposed to be divided into two directorates, Directorate for study and Design and Directorate for Construction and O&M, to reinforce the present organization for efficient management of each project under construction. Each project will be handled by the Directorate of Study and Design up to the detailed design stage and by each project office of the Directorate for Construction and O&M for construction and O&M stages. Also an independent Department of Environment is proposed to be established under the existing Directorate for Socio-economic Development in view of increasing importance of environmental monitoring and management associated with infrastructural and socio-economic development. The recommended organization of CRM in its operative level is shown in Fig. 14.3.

The transbasin project office is to be organized toward the construction stage of the project. The proposed organization of the transbasin project office is shown in Fig 14.4. Project Manager will be appointed for the construction supervision of the project, who is responsible for the project implementation and acts as a chief counterpart of an international consultant.

TABLES

Table 4.1 Summary of Collected Data for Meteorology

Name of Station	Item	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Portoviejo	Mean Temperature	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==
	Relative Humidity	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	
	Monthly Rainfall					==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	
	Class A Pan Evaporation						==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	
	Wind Velocity				==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	
	Sunshine Hours					==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	
	Cloudiness				==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	
Santa Ana	Mean Temperature				==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==							
	Relative Humidity				==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==							
	Monthly Rainfall					==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==							
	Class A Pan Evaporation																					==	==	==	==	==	==							
	Wind Velocity				==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==													
	Cloudiness				==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==							
Rocafuerte	Mean Temperature					==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==			
	Relative Humidity				==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==			
	Monthly Rainfall					==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	
	Wind Velocity				==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==			
	Cloudiness				==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==			
Calceta	Mean Temperature						==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==						
	Monthly Rainfall					==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==						
	Class A Pan Evaporation													==	==	==	==	==	==															
	Wind Velocity											==	==	==	==	==	==	==	==	==	==	==	==	==	==									
	Sunshine Hours					==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==									
	Cloudiness				==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==						
Estancilla	Mean Temperature																										==	==	==	==	==	==	==	
	Relative Humidity																		==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	
	Monthly Rainfall						==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	
	Class A Pan Evaporation																													==	==	==	==	
	Wind Velocity																		==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	
	Sunshine Hours																											==	==	==	==	==	==	
	Cloudiness																		==	==	==	==	==	==	==	==	==	==	==	==	==	==	==	

Source: CRM

Table 4.2 Summary of Collected Data for Hydrology

Name of River	Name of Station	Item	1960										1970										1980										1990	
			0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1
Carrizal	Dos Bocas	Daily Rainfall												=	=	=	=			=	=	=	=	=	=	=	=	=	=	=	=	=	=	=
	Zapote	-do-							=	=	=	=	=	=	=	=		=	=	=	=	=	=	=			=							
	Calceta	-do-					=	=	=	=	=	=	=	=	=		=	=	=	=	=	=	=	=	=	=	=							
River	Calceta	Daily Discharge				=	=	=	=	=	=	=	=	=	=	=	=	=	=	=					=	=	=	=	=	=	=			
Chico	J.M. Chamotete	Daily Rainfall										=	=	=	=		=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=
River	Alajuela	Daily Discharge											=	=	=	=	=	=	=	=														
Portoviejo	Poza Honda	Daily Rainfall				=	=	=	=	=		=								=	=	=	=	=	=	=	=	=	=	=	=	=	=	
	Bellaflor	-do-																			=	=	=	=	=	=	=	=	=	=	=	=	=	
River	Honorato Vasquez	Daily Discharge				=		=	=	=		=																						
Daule	El Carmen	Daily Rainfall												=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=					
	Pichincha	Daily Discharge																							=	=	=	=	=	=	=			
River	Balzar	-do-																							=	=	=	=	=	=	=			
Chone	Chone	Monthly Rainfall			=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=				=	=	=
River	Boyaca	-do-						=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=
Name of River	Name of Station	Item	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1
			1960										1970										1980										1990	

Source: CRM & INAMHI

Table 4.3 Estimated Long-term Runoff at Proposed La Esperanza Damsite

Catchment Area : 445 sq.km (Unit : cu.m/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1971	3.16	15.05	38.16	36.21	10.20	3.08	0.50	0.10	0.08	0.06	0.10	0.05	106.75
1972	4.37	20.89	40.65	32.44	14.43	20.85	17.41	5.82	2.23	0.66	0.10	3.83	163.68
1973	13.17	35.88	40.98	36.33	25.48	17.47	2.27	0.21	0.12	0.05	0.10	0.04	172.10
1974	2.44	14.52	20.16	11.54	3.51	1.80	1.33	0.09	0.08	0.04	0.10	0.04	55.66
1975	11.72	38.60	44.84	33.88	14.28	4.80	1.57	0.29	0.10	0.24	0.10	0.05	150.45
1976	11.26	35.03	43.75	41.92	28.56	22.79	8.49	1.16	0.20	0.05	0.10	0.04	193.34
1977	3.44	29.21	38.98	29.20	6.74	3.82	1.83	0.24	0.09	0.05	0.10	0.04	113.74
1978	4.17	16.24	25.59	20.79	13.00	10.19	0.34	0.10	0.08	0.04	0.10	0.04	90.69
1979	0.04	21.04	17.05	17.51	14.29	7.69	0.80	0.10	0.08	0.05	0.10	0.04	78.80
1980	0.04	14.73	20.58	22.83	14.67	2.06	0.18	0.09	0.08	0.04	0.10	0.04	75.43
1981	1.17	22.86	36.19	27.45	12.53	0.90	0.85	0.56	0.09	0.05	0.10	0.04	102.80
1982	3.60	11.55	17.53	16.40	8.08	1.78	0.41	0.09	0.08	10.36	10.20	13.77	93.83
1983	18.87	32.92	46.71	54.59	39.90	40.76	31.55	19.60	13.14	0.31	0.10	0.61	299.07
1984	1.44	8.39	49.62	40.20	17.75	4.06	0.23	0.10	0.08	0.05	0.10	0.04	122.06
1985	4.44	11.26	21.06	21.55	8.46	1.37	0.59	0.09	0.08	0.04	0.10	0.04	69.07
1986	10.80	23.04	18.57	24.48	16.50	1.95	0.43	0.10	0.08	0.63	0.88	0.05	97.50
1987	7.07	37.05	57.43	52.18	33.31	13.82	0.88	0.69	0.72	0.12	0.21	0.59	204.08
1988	6.50	29.48	31.34	15.69	18.09	13.88	1.68	0.27	0.10	0.19	0.31	0.50	118.02
1989	10.76	34.27	26.93	24.20	17.61	3.75	0.70	0.10	0.08	0.05	0.10	0.04	118.60
1990	2.64	10.82	15.32	11.13	4.30	1.12	0.67	0.08	0.08	0.04	0.10	0.04	46.35
Mean	6.06	23.14	32.57	28.53	16.08	8.90	3.64	1.49	0.88	0.66	0.66	1.00	123.60
	(16.22)	(56.45)	(87.24)	(73.94)	(43.08)	(23.06)	(9.74)	(4.00)	(2.29)	(1.76)	(1.71)	(2.67)	(322.16)
Max.	18.87	38.60	57.43	54.59	39.90	40.76	31.55	19.60	13.14	10.36	10.20	13.77	299.07
Min.	0.04	8.39	15.32	11.13	3.51	0.90	0.18	0.08	0.08	0.04	0.10	0.04	46.35
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual

Note: The figure in the parentheses means MCM.

Table 4.4 Estimated Long-term Runoff at Poza Honda Damsite

Catchment Area : 170 sq.km (Unit : cu.m/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1971	0.00	5.98	12.94	10.59	2.29	0.70	0.32	0.06	0.01	0.00	0.00	0.00	32.90
1972	0.50	4.92	10.75	10.27	4.80	8.71	5.59	0.80	0.82	0.72	0.17	1.39	49.44
1973	5.84	12.31	13.81	11.42	8.11	6.86	1.23	0.21	0.06	0.02	0.00	0.00	59.89
1974	0.39	7.52	10.97	5.11	1.71	0.56	0.24	0.04	0.00	0.00	0.00	0.00	26.54
1975	4.68	13.46	15.66	11.26	4.90	1.75	0.41	0.10	0.03	0.01	0.04	0.00	52.30
1976	4.70	12.01	14.84	14.52	9.86	7.96	3.07	0.49	0.09	0.04	0.00	0.00	67.58
1977	1.11	5.15	11.40	10.84	4.10	0.73	0.16	0.05	0.01	0.00	0.00	0.00	33.56
1978	1.54	3.33	5.45	5.21	2.83	1.57	0.12	0.03	0.00	0.00	0.00	0.00	20.08
1979	0.00	6.86	8.56	5.25	2.48	1.03	0.22	0.04	0.00	0.00	0.00	0.00	24.47
1980	0.00	2.78	4.65	7.36	5.18	1.98	0.16	0.05	0.00	0.00	0.00	0.00	22.17
1981	0.34	9.01	15.53	11.51	5.51	0.67	0.19	0.07	0.01	0.00	0.00	0.00	42.84
1982	0.74	4.55	4.75	3.95	1.56	0.42	0.13	0.03	0.00	0.00	3.97	4.83	24.94
1983	7.32	11.80	17.72	20.64	14.34	12.51	10.48	7.30	3.68	3.23	0.18	0.06	109.27
1984	0.32	2.61	15.42	11.19	4.81	0.79	0.23	0.07	0.01	0.00	0.00	0.00	35.45
1985	1.63	3.47	5.35	4.49	1.99	0.78	0.13	0.03	0.00	0.00	0.00	0.00	17.86
1986	4.24	7.73	5.77	5.78	3.63	1.22	0.13	0.04	0.00	0.00	0.00	0.00	28.55
1987	0.00	12.06	14.02	13.41	10.67	5.10	0.36	0.17	0.95	0.11	0.02	0.00	56.87
1988	0.65	7.73	9.70	6.86	5.17	2.48	0.19	0.07	0.01	0.00	0.00	0.19	33.05
1989	5.93	13.10	10.70	8.87	4.98	1.35	0.19	0.07	0.02	0.16	0.00	0.00	45.37
1990	0.00	5.24	5.25	8.68	6.44	1.06	0.25	0.07	0.01	0.00	0.00	0.00	27.00
Mean	2.00	7.58	10.66	9.36	5.27	2.91	1.19	0.49	0.29	0.22	0.22	0.32	40.51
	(5.35)	(18.47)	(28.56)	(24.26)	(14.11)	(7.55)	(3.19)	(1.31)	(0.70)	(0.58)	(0.57)	(.87)	(105.55)
Max.	7.32	13.46	17.72	20.64	14.34	12.51	10.48	7.30	3.68	3.23	3.97	4.83	109.27
Min.	0.00	2.61	4.65	3.95	1.56	0.42	0.12	0.03	0.00	0.00	0.00	0.00	17.86
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual

Note: The figure in the parentheses means MCM.

Table 4.5 Estimated Long-term Runoff at Proposed Chirijos Damsite

Catchment Area : 80 sq.km (Unit : cu.m/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1971	0.00	1.96	5.57	4.88	0.87	0.25	0.13	0.02	0.00	0.00	0.00	0.00	13.68
1972	0.00	1.62	4.48	4.48	1.98	3.59	2.30	0.39	0.35	0.27	0.05	0.59	20.10
1973	2.39	5.58	5.77	4.77	3.45	2.81	0.51	0.06	0.02	0.00	0.00	0.00	25.37
1974	0.04	2.53	3.98	1.62	0.50	0.17	0.09	0.01	0.00	0.00	0.00	0.00	8.94
1975	1.90	6.07	6.56	4.73	1.90	0.63	0.16	0.03	0.01	0.00	0.00	0.00	22.00
1976	1.92	5.44	6.31	6.13	4.11	3.24	1.25	0.16	0.03	0.01	0.00	0.00	28.60
1977	0.97	3.58	5.09	4.34	1.60	0.24	0.06	0.01	0.00	0.00	0.00	0.00	15.90
1978	0.68	2.37	3.26	2.28	1.14	0.61	0.04	0.01	0.00	0.00	0.00	0.00	10.38
1979	0.00	1.85	2.78	2.33	1.05	0.44	0.09	0.01	0.00	0.00	0.00	0.00	8.55
1980	0.00	0.67	2.09	3.41	2.52	0.94	0.07	0.02	0.00	0.00	0.00	0.00	9.73
1981	0.00	2.42	3.50	2.25	1.14	0.09	0.03	0.00	0.00	0.00	0.00	0.00	9.42
1982	0.00	1.41	2.04	1.17	0.36	0.12	0.02	0.00	0.00	0.00	1.56	1.92	8.60
1983	2.61	4.49	5.54	6.43	5.60	4.98	3.98	2.92	1.73	1.40	0.07	0.03	39.76
1984	0.10	1.19	7.66	5.68	2.45	0.82	0.09	0.03	0.00	0.00	0.00	0.00	18.02
1985	0.54	1.26	2.60	3.19	1.81	0.80	0.17	0.02	0.00	0.00	0.00	0.00	10.40
1986	1.77	3.72	1.44	1.64	1.19	0.13	0.03	0.01	0.00	0.00	0.00	0.00	9.93
1987	0.30	4.44	5.47	4.95	3.89	1.51	0.12	0.04	0.07	0.00	0.00	0.00	20.81
1988	0.44	2.47	3.01	2.49	2.36	0.93	0.07	0.02	0.00	0.00	0.00	0.00	11.79
1989	2.00	5.65	4.54	3.56	1.82	0.32	0.06	0.02	0.00	0.00	0.00	0.00	17.98
1990	0.00	0.79	1.96	3.05	1.48	0.20	0.07	0.01	0.00	0.00	0.00	0.00	7.57
Mean	0.78	2.98	4.18	3.67	2.06	1.14	0.47	0.19	0.11	0.08	0.08	0.13	15.88
	(2.10)	(7.25)	(11.20)	(9.51)	(5.52)	(2.96)	(1.25)	(0.51)	(0.29)	(0.23)	(0.22)	(0.34)	(41.37)
Max.	2.61	6.07	7.66	6.43	5.60	4.98	3.98	2.92	1.73	1.40	1.56	1.92	39.76
Min.	0.00	0.67	1.44	1.17	0.36	0.09	0.02	0.00	0.00	0.00	0.00	0.00	7.57
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual

Note: The figure in the parentheses means MCM.

Table 4.6 Estimated Long-term Runoff at Daule-Peripa Damsite

Catchment Area : 4,200 sq.km (Unit : cu.m/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1971	66.06	254.77	417.81	524.38	326.81	141.17	43.43	10.97	6.22	3.18	26.64	10.38	1831.82
1972	57.55	246.24	473.23	531.86	316.54	177.85	134.79	92.67	48.50	27.10	11.51	11.82	2129.65
1973	155.64	549.11	645.64	551.23	359.18	272.02	122.88	27.74	10.84	7.33	13.83	6.20	2721.64
1974	50.53	233.06	410.65	385.03	190.72	89.81	36.69	16.27	5.07	2.11	1.57	4.06	1425.58
1975	131.06	536.49	666.03	572.98	337.19	180.19	54.91	18.83	8.00	3.02	5.76	13.00	2527.48
1976	130.68	524.31	648.94	570.09	398.20	296.87	150.85	57.78	17.95	5.86	3.07	3.57	2808.17
1977	72.29	302.42	551.54	460.07	132.73	65.57	34.70	8.00	11.15	4.92	1.76	2.90	1648.05
1978	71.76	345.38	546.45	442.45	276.51	127.13	19.87	8.19	4.75	1.89	1.10	1.71	1847.18
1979	71.04	313.26	428.86	350.62	183.58	107.89	37.82	7.36	4.78	10.89	2.04	2.43	1520.56
1980	2.16	258.18	422.53	448.14	248.98	91.68	16.36	7.03	3.99	1.67	1.62	4.03	1506.38
1981	37.90	299.92	649.10	481.77	136.93	21.80	10.29	5.23	3.09	1.40	0.91	1.59	1649.93
1982	110.44	368.20	361.42	257.06	203.29	106.75	14.23	6.75	4.07	63.33	97.15	207.91	1800.58
1983	266.19	582.90	669.25	626.56	415.92	325.28	249.51	142.10	105.59	58.11	18.84	31.09	3491.36
1984	33.90	293.49	726.13	629.86	251.64	57.82	15.42	6.99	3.91	2.15	1.04	2.00	2024.34
1985	137.14	280.27	349.79	222.82	88.36	87.75	44.64	6.43	3.84	1.60	0.95	1.62	1225.22
1986	141.97	348.29	498.14	513.19	205.62	73.38	23.08	7.83	5.05	6.90	21.08	6.58	1851.11
1987	114.40	565.08	684.98	519.72	364.91	231.50	65.35	15.91	20.96	4.59	2.54	3.67	2593.61
1988	134.73	423.15	381.96	346.72	271.30	118.29	24.48	13.04	6.49	2.54	1.32	2.01	1726.04
1989	129.29	537.98	631.01	444.39	305.81	209.84	49.55	13.61	6.96	2.90	4.22	4.30	2339.86
1990	45.09	214.72	374.10	352.26	191.04	95.96	28.78	10.32	4.85	1.86	1.10	1.74	1321.82
Mean	97.99	373.86	526.88	461.56	260.26	143.93	58.88	24.15	14.30	10.67	10.90	16.13	1999.52
	(262.46)	(913.29)	(1411.19)	(1196.37)	(697.09)	(373.06)	(157.71)	(64.69)	(37.07)	(28.57)	(28.26)	(43.21)	(5212.96)
Max.	266.19	582.90	726.13	629.86	415.92	325.28	249.51	142.10	105.59	63.33	97.15	207.91	3491.36
Min.	2.16	214.72	349.79	222.82	88.36	21.80	10.29	5.23	3.09	1.40	0.91	1.59	1225.22
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual

Note: The figure in the parentheses means MCM.

Table 4.7 Estimated Long-term Runoff at Santa Ana Station (New Diversion Damsite)

Catchment Area : 481.86 sq.km (Unit : cu.m/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1971	0.00	14.66	33.20	26.75	5.14	1.53	0.67	0.13	0.02	0.01	0.00	0.00	82.12
1972	0.00	14.11	27.33	24.82	11.24	19.54	13.67	2.77	1.65	1.18	0.33	1.54	118.18
1973	13.30	27.79	32.97	29.37	20.38	15.89	3.49	0.42	0.14	0.04	0.01	0.00	143.80
1974	0.70	16.47	25.22	12.48	4.42	1.35	0.44	0.08	0.01	0.00	0.00	0.00	61.18
1975	11.82	34.35	41.06	30.33	12.41	3.78	0.99	0.24	0.06	0.02	0.03	0.00	135.08
1976	11.84	30.95	36.97	34.00	22.52	18.46	8.42	1.37	0.24	0.12	0.02	0.01	164.90
1977	3.58	14.04	28.67	26.13	9.71	2.55	0.65	0.15	0.02	0.01	0.00	0.00	85.50
1978	3.99	9.66	15.67	13.61	6.93	3.85	0.27	0.07	0.01	0.00	0.00	0.00	54.07
1979	0.00	15.56	20.14	13.30	7.05	2.83	0.46	0.10	0.01	0.01	0.00	0.00	59.46
1980	0.00	6.88	11.69	17.91	13.41	5.74	0.38	0.12	0.01	0.01	0.00	0.00	56.16
1981	0.00	19.96	36.01	28.09	12.84	1.33	0.39	0.12	0.02	0.01	0.00	0.00	98.78
1982	0.00	9.83	10.16	8.98	4.04	1.31	0.16	0.04	0.01	0.00	10.09	13.97	58.61
1983	19.42	31.85	45.05	50.03	39.37	37.13	26.12	17.63	9.07	8.61	0.42	0.17	284.87
1984	0.49	6.07	37.81	27.04	10.04	1.50	0.38	0.13	0.02	0.01	0.00	0.00	83.48
1985	5.02	9.09	14.40	12.78	5.79	1.87	0.28	0.07	0.01	0.00	0.00	0.00	49.32
1986	11.00	20.43	15.57	15.58	9.62	2.94	0.31	0.09	0.01	0.01	0.00	0.00	75.56
1987	0.00	29.55	33.66	32.16	25.97	12.06	0.79	0.38	2.77	0.29	0.04	0.01	137.70
1988	1.63	18.82	23.90	17.82	13.33	5.95	0.43	0.15	0.02	0.01	0.00	0.49	82.54
1989	15.39	33.60	26.62	22.41	12.38	3.02	0.43	0.15	0.02	0.24	0.00	0.00	114.26
1990	0.00	13.37	14.14	21.62	15.27	2.12	0.49	0.15	0.02	0.01	0.00	0.00	67.18
Mean	4.91	18.85	26.51	23.26	13.09	7.24	2.96	1.22	0.71	0.53	0.55	0.81	100.64
	(13.15)	(45.94)	(71.01)	(60.29)	(35.07)	(18.76)	(7.93)	(3.26)	(1.83)	(1.42)	(1.42)	(2.17)	(262.24)
Max.	19.42	34.35	45.05	50.03	39.37	37.13	26.12	17.63	9.07	8.61	10.09	13.97	284.87
Min.	0.00	6.07	10.16	8.98	4.04	1.31	0.16	0.04	0.01	0.00	0.00	0.00	49.32
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual

Note: The figure in the parentheses means MCM.

Table 4.8 Estimated Long-term Runoff for Chico River (Confluent with Portoviejo River)

Catchment Area : 585 sq.km (Unit : cu.m/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1971	0.00	11.45	35.46	31.81	4.92	1.35	0.46	0.09	0.02	0.01	0.00	0.00	85.57
1972	0.00	11.26	30.81	31.01	13.33	21.60	13.30	1.89	1.69	0.99	0.10	1.66	127.64
1973	17.36	33.77	34.27	28.46	20.86	15.71	2.09	0.32	0.10	0.03	0.01	0.00	152.97
1974	0.00	14.33	23.62	10.80	3.40	1.00	0.22	0.03	0.01	0.00	0.00	0.00	53.41
1975	14.12	38.99	43.14	30.95	11.98	3.07	0.75	0.17	0.02	0.02	0.00	0.00	143.22
1976	13.79	33.96	39.74	38.40	25.41	18.99	6.44	0.74	0.19	0.06	0.01	0.00	177.75
1977	2.80	23.46	32.99	29.34	10.90	1.51	0.36	0.09	0.02	0.01	0.00	0.00	101.47
1978	4.24	14.01	19.60	13.49	6.09	2.62	0.23	0.02	0.01	0.00	0.00	0.00	60.31
1979	0.00	11.64	17.35	13.21	5.86	1.76	0.30	0.05	0.01	0.00	0.00	0.00	50.18
1980	0.00	4.34	13.45	21.23	15.21	4.93	0.36	0.08	0.01	0.00	0.00	0.00	59.62
1981	0.00	15.46	21.51	13.41	6.24	0.54	0.13	0.01	0.00	0.00	0.00	0.00	57.30
1982	0.00	6.67	10.31	6.23	1.67	0.56	0.07	0.01	0.00	0.00	9.96	14.27	49.75
1983	20.81	31.17	37.57	45.11	44.53	45.46	31.59	19.97	11.83	9.91	0.46	0.19	298.61
1984	0.47	7.81	48.41	34.29	14.17	3.86	0.50	0.15	0.02	0.01	0.00	0.00	109.70
1985	5.37	8.16	15.67	18.54	11.11	5.00	0.70	0.12	0.02	0.01	0.00	0.00	64.68
1986	13.72	23.46	9.01	11.47	8.24	0.72	0.18	0.02	0.01	0.00	0.00	0.00	66.83
1987	0.00	28.71	37.12	31.77	24.22	8.83	0.66	0.25	0.29	0.05	0.01	0.00	131.92
1988	1.30	14.93	17.76	15.02	14.33	5.07	0.36	0.09	0.01	0.01	0.00	0.00	68.88
1989	5.94	39.81	31.64	24.18	11.23	1.63	0.37	0.08	0.02	0.01	0.00	0.00	114.92
1990	0.00	4.89	12.07	17.64	8.43	0.92	0.20	0.03	0.01	0.00	0.00	0.00	44.19
Mean	5.00	18.91	26.58	23.32	13.11	7.26	2.96	1.21	0.71	0.56	0.53	0.81	100.95
	(13.38)	(46.07)	(71.18)	(60.44)	(35.11)	(18.81)	(7.94)	(3.24)	(1.85)	(1.49)	(1.37)	(2.16)	(263.03)
Max.	20.81	39.81	48.41	45.11	44.53	45.46	31.59	19.97	11.83	9.91	9.96	14.27	298.61
Min.	0.00	4.34	9.01	6.23	1.67	0.54	0.07	0.01	0.00	0.00	0.00	0.00	44.19
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual

Note: The figure in the parentheses means MCM.

Table 4.9 Estimated Long-term Runoff for Portoviejo River (Confluent with Chico River)

Catchment Area : 1,190 sq.km (Unit : cu.m/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1971	0.00	26.12	64.42	52.00	7.67	2.20	0.59	0.14	0.03	0.01	0.00	0.00	153.19
1972	0.00	31.29	57.64	50.55	20.59	32.40	23.10	5.32	1.74	0.99	0.13	0.09	223.83
1973	21.17	49.50	57.17	53.30	37.10	25.43	5.12	0.64	0.21	0.06	0.02	0.00	249.73
1974	0.00	25.22	40.98	22.76	8.86	2.30	0.33	0.06	0.02	0.01	0.00	0.00	100.53
1975	22.57	69.66	81.96	61.52	23.27	4.80	1.39	0.35	0.06	0.04	0.01	0.00	265.63
1976	22.05	60.64	66.70	58.21	37.50	30.79	13.94	1.91	0.46	0.18	0.03	0.01	292.41
1977	6.73	28.45	53.78	49.45	18.65	3.89	1.41	0.25	0.04	0.03	0.01	0.00	162.69
1978	6.67	20.49	31.49	24.79	11.14	5.35	0.38	0.07	0.02	0.01	0.00	0.00	100.41
1979	0.00	25.95	34.44	22.73	13.27	4.16	0.40	0.09	0.02	0.01	0.00	0.00	101.08
1980	0.00	11.53	22.81	33.94	25.10	10.27	0.60	0.15	0.03	0.01	0.00	0.71	105.16
1981	1.27	30.95	56.25	46.04	19.64	1.54	0.45	0.06	0.03	0.01	0.00	0.00	156.24
1982	0.00	10.93	12.87	13.07	6.39	1.88	0.17	0.02	0.00	0.00	19.28	28.94	93.55
1983	40.00	67.96	86.47	97.30	93.93	100.45	58.17	35.00	18.67	18.16	0.91	0.32	617.34
1984	0.50	0.62	74.09	48.03	14.02	1.89	0.49	0.09	0.03	0.01	0.00	0.00	139.79
1985	12.41	18.25	29.17	27.30	13.04	3.64	0.40	0.09	0.02	0.01	0.00	0.00	104.33
1986	23.08	43.88	30.16	31.85	19.33	3.82	0.49	0.10	0.03	0.01	0.00	0.00	152.75
1987	0.00	57.22	66.29	58.81	46.39	19.60	1.19	0.57	4.83	0.45	0.03	0.01	255.39
1988	0.00	33.96	40.66	32.66	25.15	9.46	0.65	0.18	0.03	0.02	0.00	0.00	142.75
1989	28.80	67.18	53.60	45.57	22.65	3.62	0.66	0.19	0.03	0.03	0.00	0.00	222.34
1990	0.00	23.29	27.17	37.57	24.68	2.50	0.49	0.12	0.03	0.01	0.00	0.00	115.86
Mean	9.26	35.15	49.41	43.37	24.42	13.50	5.52	2.27	1.31	1.00	1.02	1.50	187.75
	(24.81)	(85.64)	(132.33)	(112.42)	(65.40)	(34.99)	(14.79)	(6.08)	(3.41)	(2.69)	(2.65)	(4.03)	(489.24)
Max.	40.00	69.66	86.47	97.30	93.93	100.45	58.17	35.00	18.67	18.16	19.28	28.94	617.34
Min.	0.00	0.62	12.87	13.07	6.39	1.54	0.17	0.02	0.00	0.00	0.00	0.00	93.55
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual

Note: The figure in the parentheses means MCM.

Table 4.10 Estimated Long-term Runoff for Estuary of Portoviejo River

Catchment Area : 2,060 sq.km (Unit : cu.m/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1971	0.00	39.09	99.91	80.57	10.79	2.50	0.81	0.21	0.05	0.01	0.01	0.00	233.95
1972	0.00	48.22	89.30	78.64	33.17	42.34	38.79	7.98	3.25	0.98	0.20	0.04	342.90
1973	65.94	98.23	88.03	72.71	53.02	30.80	6.56	1.06	0.29	0.06	0.02	0.01	416.73
1974	0.00	17.56	68.55	30.36	10.75	2.35	0.50	0.06	0.03	0.01	0.00	0.00	130.16
1975	63.38	131.03	126.10	85.56	32.13	5.17	2.07	0.57	0.09	0.04	0.01	0.01	446.17
1976	25.77	130.62	109.97	90.80	58.97	38.32	20.65	2.74	0.73	0.09	0.05	0.01	478.71
1977	26.39	67.30	89.72	74.33	27.99	4.07	1.40	0.36	0.06	0.03	0.01	0.00	291.66
1978	8.37	48.33	54.84	34.59	14.38	4.93	0.61	0.06	0.03	0.01	0.00	0.00	166.16
1979	0.00	38.78	47.58	31.81	16.76	3.62	0.60	0.10	0.03	0.01	0.00	0.00	139.31
1980	0.00	17.17	37.00	51.01	38.44	11.52	1.00	0.23	0.04	0.01	0.00	0.00	156.42
1981	0.00	48.24	63.28	41.88	17.38	1.25	0.38	0.06	0.02	0.01	0.00	0.00	172.49
1982	0.00	14.51	20.50	14.09	5.31	1.51	0.16	0.02	0.01	0.00	31.30	59.12	146.53
1983	103.57	117.46	116.52	124.41	138.46	126.25	104.15	71.61	39.36	19.73	1.70	0.72	963.94
1984	1.45	1.36	134.78	79.74	27.50	4.34	1.15	0.31	0.07	0.02	0.01	0.00	250.72
1985	31.87	29.77	43.89	44.56	26.85	8.80	1.19	0.28	0.05	0.01	0.00	0.00	187.27
1986	63.83	79.71	32.19	36.66	25.31	2.40	0.61	0.07	0.03	0.01	0.00	0.00	240.83
1987	0.00	95.49	103.18	80.30	62.71	20.12	1.85	0.85	2.33	0.19	0.04	0.01	367.08
1988	0.01	52.98	51.19	40.84	36.86	10.47	1.00	0.24	0.05	0.01	0.01	0.00	193.66
1989	28.51	134.93	89.33	64.44	29.77	3.55	1.03	0.24	0.06	0.02	0.01	0.00	351.89
1990	0.00	23.93	36.77	45.41	23.61	1.86	0.55	0.06	0.03	0.01	0.00	0.00	132.22
Mean	20.95	61.74	75.13	60.14	34.51	16.31	9.25	4.36	2.33	1.06	1.67	3.00	290.44
	(38.43)	(152.91)	(204.93)	(174.10)	(101.27)	(54.18)	(22.90)	(9.42)	(5.28)	(4.16)	(4.10)	(6.23)	(777.91)
Max.	103.57	134.93	134.78	124.41	138.46	126.25	104.15	71.61	39.36	19.73	31.30	59.12	963.94
Min.	0.00	1.36	20.50	14.09	5.31	1.25	0.16	0.02	0.01	0.00	0.00	0.00	130.16
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual

Note: The figure in the parentheses means MCM.

Table 4.11 Estimated Long-term Runoff for Carrizal River (Confluent with Chone River)

Catchment Area : 1,166 sq.km (Unit : cu.m/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1971	2.18	26.64	80.72	75.92	16.30	2.96	0.29	0.12	0.09	0.69	0.06	0.05	206.01
1972	6.99	35.11	68.06	60.01	30.47	43.21	30.72	7.67	2.15	0.80	0.09	7.36	292.63
1973	27.50	58.87	65.88	60.83	44.31	30.44	2.58	0.20	0.13	0.14	0.06	0.05	290.99
1974	1.80	31.08	46.30	24.79	9.11	3.10	0.95	0.09	0.08	0.12	0.06	0.05	117.53
1975	29.17	79.22	87.57	68.32	30.08	6.17	1.55	0.16	0.10	0.13	0.07	0.05	302.58
1976	23.16	62.41	77.24	72.20	50.46	45.32	16.50	2.12	0.20	0.18	0.07	0.05	349.89
1977	7.37	53.03	69.19	56.42	16.09	3.73	1.58	0.13	0.09	0.13	0.06	0.05	207.88
1978	4.14	37.51	59.14	41.71	19.11	13.96	0.30	0.11	0.09	0.12	0.06	0.05	176.31
1979	0.05	32.97	43.90	43.58	23.31	9.71	1.00	0.12	0.09	0.12	0.06	0.05	154.97
1980	0.05	23.46	40.59	46.67	28.92	6.18	0.28	0.10	0.08	0.12	0.06	0.05	146.58
1981	0.05	45.54	65.48	44.10	19.25	0.90	0.24	0.11	0.08	0.12	0.06	0.05	175.98
1982	2.40	17.54	26.44	32.46	21.25	3.58	0.34	0.10	0.08	0.12	23.09	29.26	156.67
1983	49.22	77.81	97.59	108.13	85.63	101.73	76.22	44.37	28.78	21.10	0.52	0.13	691.25
1984	2.78	16.38	94.60	69.90	26.42	3.95	0.33	0.12	0.09	0.12	0.06	0.05	214.81
1985	9.31	18.08	33.42	35.45	15.46	2.80	0.39	0.09	0.08	0.12	0.06	0.05	115.32
1986	23.93	46.30	32.36	44.22	33.13	6.98	0.49	0.12	0.09	0.12	0.28	0.05	188.07
1987	12.91	72.12	104.14	89.77	64.02	24.25	1.04	0.22	0.68	0.16	0.06	0.05	369.40
1988	11.62	45.24	51.49	28.51	30.73	20.74	1.31	0.15	0.09	0.13	0.06	0.05	190.11
1989	11.22	73.59	54.10	42.77	27.65	3.52	0.48	0.12	0.09	0.12	0.06	0.05	213.77
1990	2.34	19.91	29.25	29.08	14.58	1.99	0.47	0.09	0.08	0.12	0.06	0.05	98.02
Mean	11.41	43.64	61.37	53.74	30.31	16.76	6.85	2.82	1.66	1.24	1.25	1.88	232.94
	(30.56)	(106.36)	(164.38)	(139.30)	(81.19)	(43.45)	(18.36)	(7.54)	(4.31)	(3.32)	(3.23)	(5.03)	(607.04)
Max.	49.22	79.22	104.14	108.13	85.63	101.73	76.22	44.37	28.78	21.10	23.09	29.26	691.25
Min.	0.05	16.38	26.44	24.79	9.11	0.90	0.24	0.09	0.08	0.12	0.06	0.05	98.02
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual

Note: The figure in the parentheses means MCM.

Table 4.12 Estimated Long-term Runoff for Chone River (Confluent with Carrizal River)

Catchment Area : 755 sq.km (Unit : cu.m/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1971	0.05	22.17	79.98	77.03	11.71	2.25	0.34	0.12	0.10	0.19	0.05	0.06	194.04
1972	0.79	26.53	59.83	49.83	21.34	41.48	31.66	11.52	6.21	0.46	0.07	0.06	249.78
1973	23.91	35.51	46.68	59.73	39.50	21.02	2.62	0.93	0.15	0.21	0.05	0.06	230.38
1974	1.78	41.37	52.45	28.23	21.30	3.22	0.51	0.12	0.10	0.19	0.05	0.06	149.36
1975	23.29	70.23	99.54	89.35	29.96	5.17	2.46	0.51	0.14	0.21	0.05	0.06	320.96
1976	22.81	58.32	60.93	63.84	46.27	42.79	17.41	0.88	0.21	0.23	0.06	0.06	313.82
1977	18.82	66.44	83.48	60.92	18.64	3.06	1.60	0.15	0.10	0.20	0.05	0.06	253.53
1978	4.86	41.05	49.69	32.25	12.61	5.18	0.21	0.11	0.10	0.19	0.05	0.06	146.35
1979	0.05	34.17	38.05	22.66	8.97	4.13	2.07	0.13	0.10	0.19	0.05	0.06	110.63
1980	0.05	30.15	55.42	60.39	31.61	9.68	0.29	0.14	0.10	0.19	0.05	0.06	188.14
1981	3.75	57.69	81.09	55.91	24.57	1.06	0.24	0.12	0.10	0.19	0.05	0.06	224.86
1982	2.95	16.33	22.02	26.57	13.22	3.85	0.18	0.09	0.10	0.19	22.72	31.96	140.19
1983	43.28	87.58	114.07	108.28	118.56	139.04	68.46	38.77	23.04	19.96	0.45	0.14	761.62
1984	1.81	12.02	73.01	70.54	30.21	5.16	1.30	0.16	0.10	0.20	0.05	3.29	197.85
1985	11.09	26.83	36.21	26.95	13.30	2.68	0.18	0.10	0.10	0.18	0.05	0.06	117.73
1986	21.98	44.78	23.82	24.30	14.88	0.38	0.16	0.09	0.10	0.18	0.05	0.06	130.77
1987	4.52	57.25	78.26	64.40	49.79	20.17	0.76	0.21	1.49	0.26	0.06	0.06	277.23
1988	8.67	38.40	41.95	31.06	30.48	10.75	0.39	0.14	0.10	0.19	0.05	0.06	162.24
1989	23.56	65.29	58.21	45.28	18.51	0.93	0.21	0.10	0.10	0.19	0.05	0.06	212.49
1990	2.43	18.59	32.79	42.52	19.47	2.30	1.55	0.13	0.10	0.19	0.05	0.06	120.19
Mean	11.02	42.54	59.37	52.00	28.74	16.22	6.63	2.73	1.63	1.20	1.21	1.82	225.11
	(29.52)	(102.90)	(159.03)	(134.79)	(76.99)	(42.03)	(17.76)	(7.30)	(4.23)	(3.21)	(3.13)	(4.87)	(585.76)
Max.	43.28	87.58	114.07	108.28	118.56	139.04	68.46	38.77	23.04	19.96	22.72	31.96	761.62
Min.	0.05	12.02	22.02	22.66	8.97	0.38	0.16	0.09	0.10	0.18	0.05	0.06	110.63
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual

Note: The figure in the parentheses means MCM.

Table 4.13 Estimated Long-term Runoff for Estuary of Chone River

Catchment Area : 2,267 sq.km (Unit : cu.m/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1971	3.50	46.74	151.65	143.14	27.36	4.94	0.57	0.09	0.02	0.69	0.00	0.00	378.71
1972	5.17	61.01	123.44	107.12	51.99	81.14	59.78	17.04	6.57	0.99	0.06	7.13	521.44
1973	54.46	94.87	111.38	114.33	81.47	51.00	4.69	0.71	0.12	0.04	0.01	0.00	513.08
1974	3.63	65.92	92.11	49.32	25.48	5.74	1.26	0.05	0.02	0.01	0.00	0.00	243.54
1975	55.60	144.02	176.19	144.45	57.08	10.44	3.41	0.19	0.06	0.04	0.01	0.00	591.49
1976	47.30	112.61	132.96	129.70	93.03	83.72	31.56	2.88	0.24	0.12	0.01	0.00	634.12
1977	16.11	112.28	141.53	110.14	32.56	6.96	3.49	0.14	0.03	0.03	0.00	0.00	423.28
1978	9.13	73.21	104.36	71.61	31.29	19.00	0.32	0.07	0.02	0.01	0.00	0.00	309.03
1979	0.00	63.54	79.25	67.16	34.22	14.69	2.42	0.09	0.02	0.01	0.00	0.00	261.41
1980	0.00	47.79	87.57	97.31	56.50	14.41	0.37	0.09	0.02	0.01	0.00	0.00	304.07
1981	0.00	96.90	136.60	92.67	40.30	1.57	0.29	0.08	0.02	0.02	0.00	0.00	368.43
1982	5.36	31.82	47.43	58.13	34.69	6.55	0.27	0.04	0.01	0.01	45.42	58.59	288.31
1983	95.21	151.12	195.75	207.48	189.29	224.65	140.86	82.75	52.97	44.06	0.91	0.17	1385.23
1984	4.60	26.75	159.85	130.26	52.52	8.40	0.86	0.12	0.03	0.02	0.00	4.13	387.55
1985	19.98	40.54	65.34	60.61	27.61	5.10	0.21	0.04	0.02	0.00	0.00	0.00	219.45
1986	46.24	83.63	54.07	69.16	50.08	5.69	0.29	0.07	0.02	0.01	0.00	0.00	309.27
1987	11.00	126.57	178.99	152.35	111.08	42.09	1.52	0.27	1.79	0.10	0.01	0.00	625.78
1988	21.30	78.57	89.05	54.65	57.38	30.81	1.61	0.13	0.03	0.02	0.00	0.00	333.55
1989	22.27	133.99	103.79	81.16	45.43	4.34	0.32	0.07	0.02	0.01	0.00	0.00	391.41
1990	4.67	36.00	57.36	63.73	30.86	3.80	1.50	0.06	0.02	0.01	0.00	0.00	198.00
Mean	21.28	81.39	114.43	100.22	56.51	31.25	12.78	5.25	3.10	2.31	2.32	3.50	434.36
	(56.99)	(198.32)	(306.50)	(259.78)	(151.36)	(81.01)	(34.23)	(14.06)	(8.04)	(6.19)	(6.02)	(9.38)	(1131.87)
Max.	95.21	151.12	195.75	207.48	189.29	224.65	140.86	82.75	52.97	44.06	45.42	58.59	1385.23
Min.	0.00	26.75	47.43	49.32	25.48	1.57	0.21	0.04	0.01	0.00	0.00	0.00	198.00
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual

Note: The figure in the parentheses means MCM.

Table 4.14 Estimation of Sediment Loads at Damsites

Name of Damsite	Target Year (year)	Catchment Area (sq.km)	Erosion Potential (t/sq.km/yr)	Delivery Ratio	Sediment Production (t/sq.km/yr)	Total Sediment ($t*10^6$)	Sediment Volume (m^3*10^6)
La Esperanza	100	445	4,645	0.2787	1,295	68.53	52.72
Poza Honda	-do-	170	4,734	0.3596	1,702	34.72	26.71
Chirijos	-do-	80	3,722	0.4280	1,379	13.21	10.16
Daule-Peripa	50	4,200	-	-	-	115.17	88.60

Source: PHIMA, Sediment Transport Report

Table 5.1 Unit Water Demand

Target

(Daily Average Basis)

Population	Unit Water Demand (l/person/day) Domestic Use (Target)	Industrial Use	Total (Target)
Less than 1,000	150	-	150
1,000 -5,000	180	-	180
5,000 - 20,000	225	23	248
20,000 - 50,000	300	30	330
50,000 - 100,000	375	38	413
100,000 and more	450	90	540

Source : IEOS, 1991

(Note) :

- To be applied in the hotter zones, annual mean temperature in which exceeds 18 degree centigrade (C), such as the Manabi Province (25.9 C of annual mean temperature in Portoviejo).
- Including commercial use water.
- Including water loss and unaccounted-for water in the system.
- Daily maximum demand = 150% of the daily average demand.

Proposed

(Daily Average Basis)

Population	Unit Water Demand (l/person/day) Year 1990 (55%)	Year 2000 (70%)	Year 2010 (85%)	Year 2020 (100%)
Less than 1,000	83	105	128	150
1,000 - 5,000	99	126	153	180
5,000 - 20,000	136	173	210	248
20,000 - 50,000	182	231	281	330
50,000 - 100,000	227	289	351	413
100,000 and more (Portoviejo and Manta)	297	378	459	540

Source : PHIMA, 1991

(Note) :

- To be applied for projection in the service area.
- Including commercial use water.
- Including water loss and unaccounted-for water in the system.
- Daily maximum demand = 150% of the daily average demand.

Table 5.2 Irrigation Water Demand in Volume
(5-year return period)

(Unit: 1,000 m3)

Scheme	Area (ha)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Carrizal-Chon	15,000	8,316	2,388	10,204	18,692	27,048	19,220	23,694	28,529	36,603	34,133	26,874	17,526	253,227
Amarillos	1,000	627	449	1,475	1,260	1,830	1,261	1,582	2,089	2,616	2,334	1,983	1,276	18,782
Guarango	1,500	1,784	1,906	3,526	3,192	3,456	2,380	2,705	3,325	4,258	4,039	3,185	2,165	35,921
Rio Chico	1,700	1,032	596	1,661	2,226	3,406	1,991	2,885	3,542	4,542	4,197	3,292	1,970	31,340
Pechiche-Pasa	850	997	648	1,726	1,749	1,925	1,357	1,547	1,896	2,417	2,288	1,808	1,195	19,553
Santa Ana	3,300	3,810	3,589	6,364	7,230	7,172	4,582	5,468	7,018	9,001	8,289	6,522	4,492	73,537
Mejia	1,250	1,438	1,357	2,402	2,719	2,696	1,722	2,066	2,656	3,413	3,142	2,419	1,695	27,725
Ceibal-Guayal	4,650	5,550	5,921	10,938	9,893	10,727	7,396	8,415	9,773	13,209	12,520	9,878	6,725	110,945
Total	29,250	23,554	16,854	38,296	46,961	58,260	39,909	48,362	58,828	76,059	70,942	55,961	37,044	571,030

Table 5.3 Irrigation Water Demand in Volume
(Average year)

(Unit: 1,000 m3)

Scheme	Area (ha)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Carrizal-Chone	15,000	0	0	0	3,424	16,522	10,353	14,988	26,639	33,558	32,302	24,225	9,406	171,417
Amarillos	1,000	0	0	416	435	1,189	919	1,269	2,003	2,462	2,209	1,801	867	13,570
Guarango	1,500	785	658	2,268	2,458	2,855	2,084	2,432	3,313	4,201	4,027	3,155	1,850	30,086
Rio Chico	1,700	0	0	469	940	2,260	1,294	2,131	3,344	4,341	3,944	3,047	1,150	22,920
Pechiche-Pasaje	850	352	143	1,078	1,075	1,294	663	1,225	1,732	2,272	2,091	1,637	737	14,299
Santa Ana	3,300	1,314	1,321	3,749	5,449	5,833	3,611	4,684	6,914	8,800	8,173	6,185	3,782	59,815
Mejia	1,250	496	502	1,420	2,051	2,194	1,357	1,767	2,617	3,341	3,098	2,342	1,427	22,612
Ceibal-Guayaba	4,650	2,443	2,047	7,038	7,618	8,864	6,479	7,565	10,291	13,032	12,483	9,785	5,749	93,394
Total	29,250	5,390	4,671	16,438	23,450	41,011	26,760	36,061	56,853	72,007	68,327	52,177	24,968	428,113

Table 6.1 Cost Summary for Alternatives of Water Transbasin Scheme

Unit : Mil. US$

Water Transbasin Scheme	Alt-1	Alt-2	Alt-3	Alt-4	Alt-5	Alt-6
CONSTRUCTION COST	**257.6**	**288.9**	**231.8**	**245.4**	**209.8**	**247.9**
Direct Cost	**185.3**	**208.0**	**167.9**	**176.5**	**152.1**	**179.6**
Daule Peripa Dam - Esperanza Dam Water Transbasin Scheme (Q=18 m3/s)	41.0	0.0	41.0	41.0	41.0	0.0
Daule Peripa Dam - Esperanza Dam Water Transbasin Scheme (Q=9 m3/s)	0.0	27.6	0.0	0.0	0.0	27.6
Rio Daule - Poza Honda Dam Water Transbasin Scheme (Q=9 m3/s)	0.0	80.8	0.0	0.0	0.0	0.0
Rio Daule - Poza Honda Dam Water Transbasin Scheme (Q=10 m3/s)	0.0	0.0	0.0	0.0	0.0	89.4
Esperanza Dam(Severino) - Poza Honda Dam Water Transbasin Scheme (Q=9 m3/s)	44.7	0.0	0.0	0.0	0.0	0.0
Esperanza Dam(Severino) - Poza Honda Dam Water Transbasin Scheme (Q=10 m3/s)	0.0	0.0	0.0	0.0	48.5	0.0
Esperanza Dam(Altamira) - Rio Portoviejo Water Transbasin Scheme (Q=12m3/s)	0.0	0.0	72.4	0.0	0.0	0.0
Poza Honda Dam - Rio Chamotete Water Transbasin Scheme (Q=4 m3/s)	0.0	0.0	0.0	0.0	8.1	8.1
Esperanza Dam - Guarango Water Transbasin Scheme (Q=23-5 m3/s)	54.5	54.5	54.5	0.0	54.5	54.5
Esperanza Dam - Guarango - Portoviejo Water Transbasin Scheme (Q=33-3.3 m3/s)	0.0	0.0	0.0	90.3	0.0	0.0
Chirijos Dam	45.1	45.1	0.0	45.1	0.0	0.0
Indirect Cost	**72.3**	**80.9**	**63.8**	**68.9**	**57.8**	**68.3**
Land aquisition and compensation	1.5	1.5	0.0	1.5	0.0	0.0
Administration expenses (5 % of I.1 + I.2.1)	9.3	10.5	8.4	8.9	7.6	9.0
Enginering services (10 % of I.1)	18.5	20.8	16.8	17.6	15.2	18.0
Contingency (20 % of I.1+I.2.1+I.2.2+I.2.3)	42.9	48.2	38.6	40.9	35.0	41.3
ANNUAL O&M COST	**4.45**	**7.03**	**4.19**	**3.72**	**4.97**	**7.72**
Energy Cost	**3.82**	**6.29**	**3.54**	**3.18**	**4.31**	**6.93**
O&M Cost	**0.63**	**0.74**	**0.65**	**0.54**	**0.66**	**0.79**

Table 9.1 COST COMPARISON

	(US$ million)	
	Alt. 5a	Alt. 5b
CONSTRUCTION COST	154.8	193.4
Direct Cost	112.2	140.2
Daule Peripa - Esperanza	41.0	41.0
Esperanza - Poza Honda	63.1	56.6
Poza Honda - Rio Chico	8.1	8.1
Esperanza - Guarango 1/	–	34.5
Indirect Cost	42.6	53.2
Land acquisition	0.0	0.0
Administration expenses	5.6	7.0
Engineering services	11.2	14.0
Contingency	25.8	32.2
ANNUAL O & M COST	5.24	5.02
Energy Cost	4.76	4.31
O & M Cost	0.48	0.71

Remarks:

1/ Esperanza - Guarango transbasin scheme for a capacity of 5 m^3/s is calculated to be US$ 54.5 million including cost of a part of the main canal for the Carrizal-Chone irrigation scheme. The main canal cost is common to six alternatives as shown in Table 6.1. For cost comparison of alternatives 5-a and 5-b, the irrigation canal cost of US$20.0 million is excluded, and the cost of the Esperanza - Guarango transbasin scheme is estimated to be US$34.5 million excluding the main irrigation canal cost.

Table 12.1 Detailed Construction Cost (1/2)

	Description	Foreign Currency (1,000 US$)	Local Currency (1,000 US$ equivalent)	Total Equivalent (1,000 US$ equivalent)
1. Lot I	Esperanza – Poza Honda and Poza Honda – Rio Mancha Tunnel Construction			
1.1	Esperanza – Poza Honda Tunnel			
(1)	Preparatory works	3,230	1,497	4,727
(2)	Pumping Station	16,871	3,238	20,109
(3)	Steel pipeline	1,870	430	2,300
(4)	Open Channel and syphon	5,598	4,211	9,810
(5)	Inlet and outlet works	319	136	455
(6)	Tunnel	18,948	7,001	25,949
(7)	Work adits	1,881	678	2,559
(8)	Access road	1,720	932	2,652
(9)	Transmission line and substation	8,100	1,260	9,360
	Total (1.1)	58,537	19,384	77,921
1.2	Poza Honda – Rio Mancha Tunnel			
(1)	Preparatory works	788	294	1,082
(2)	Inlet and outlet works	1,770	578	2,348
(3)	Tunnel	5,529	2,153	7,682
(4)	Work adits	580	211	791
	Total (1.2)	8,667	3,237	11,904
	Total (1)	67,204	22,621	89,825
2. Lot II	Daule Peripa – Esperanza Tunnel Construction			
(1)	Preparatory works	2,889	1,185	4,074
(2)	Inlet and outlet works	1,954	529	2,483
(3)	Tunnel	16,453	6,140	22,593
(4)	Work adits	2,158	773	2,931
(5)	Access road	8,326	4,404	12,730
	Total (2)	31,780	13,031	44,811
	Total (1 to 2)	98,984	35,652	134,636

Table 12.1 Detailed Construction Cost (2/2)

Description	Foreign Currency (1,000 US$)	Local Currency (1,000 US$ equivalent)	Total Equivalent (1,000 US$ equivalent)
3. Land acquisition and compensation	0	100	100
4. Administration expenses	0	2,693	2,693
5. Engineering services			
5.1 Detailed design	4,030	261	4,291
5.1 Construction supervision	7,380	2,194	9,574
Total (5)	11,410	2,455	13,865
Total (1 to 5)	110,394	40,900	151,294
6. Physical contingency	11,039	4,090	15,129
Total (1 to 6)	121,433	44,990	166,423
7. Price contingency	20,022	7,230	27,252
Grand Total	141,455	52,220	193,675

Table 12.2 Disbursement Schedule

Unit : 1,000 US$

Description	Total F.C+L.C	Total F.C.	Total L.C.	1992 F.C.	1992 L.C.	1993 F.C.	1993 L.C.	1994 F.C.	1994 L.C.	1995 F.C.	1995 L.C.	1996 F.C.	1996 L.C.	1997 F.C.	1997 L.C.	1998 F.C.	1998 L.C.	1999 F.C.	1999 L.C.	2000 F.C.	2000 L.C.
1. Esperanza-Poza Honda and Poza Honda-Rio Mancha Tunnel Construction(Lot I)																					
1.1 Esperanza-Poza Honda Tunnel																					
1.1 Preparotory work	4,727	3,230	1,497	0	0	0	0	0	0	485	225	2,584	1,198	0	0	0	0	0	0	162	75
1.2 Pumping station	20,109	16,871	3,238	0	0	0	0	0	0	0	0	1,731	1,383	237	200	3,428	381	11,177	1,242	298	33
1.3 Steel pipeline	2,300	1,870	430	0	0	0	0	0	0	0	0	0	0	0	0	1,856	421	13	9	0	0
1.4 Open channel & syphon	9,810	5,598	4,211	0	0	0	0	0	0	0	0	0	0	1,802	1,309	2,756	2,051	1,041	851	0	0
1.5 Inlet & outlet works	455	319	136	0	0	0	0	0	0	0	0	195	92	0	0	41	35	84	9	0	0
1.6 Tunnel	25,949	18,948	7,001	0	0	0	0	0	0	0	0	3,790	1,400	5,684	2,100	5,684	2,100	3,790	1,400	0	0
1.7 Work adits	2,559	1,881	678	0	0	0	0	0	0	0	0	0	0	1,881	678	0	0	0	0	0	0
1.8 Access road	2,652	1,720	932	0	0	0	0	0	0	0	0	0	0	1,720	932	0	0	0	0	0	0
1.9 Transmission line & substation	9,360	8,100	1,260	0	0	0	0	0	0	0	0	0	0	0	0	1,863	290	6,075	945	162	25
Total(1.1)	77,921	58,537	19,384	0	0	0	0	0	0	485	225	8,300	4,072	11,323	5,219	15,628	5,279	22,180	4,456	622	133
1.2 Poza Honda-Rio Mancha Tunnel																					
1.1 Preparotory work	1,082	788	294	0	0	0	0	0	0	158	59	630	235	0	0	0	0	0	0	0	0
1.2 Inlet & outlet works	2,348	1,770	578	0	0	0	0	0	0	0	0	0	0	784	438	986	140	0	0	0	0
1.3 Tunnel	7,682	5,529	2,153	0	0	0	0	0	0	0	0	1,931	682	2,431	919	1,167	553	0	0	0	0
1.4 Work adit	791	580	211	0	0	0	0	0	0	0	0	0	0	580	211	0	0	0	0	0	0
Total(1.2)	11,904	8,667	3,237	0	0	0	0	0	0	158	59	2,561	917	3,795	1,569	2,153	692	0	0	0	0
Total(1)	89,825	67,204	22,621	0	0	0	0	0	0	642	283	10,861	4,989	15,119	6,787	17,781	5,971	22,180	4,456	622	133
2. Daule Peripa-Esperanza Tunnel Construction(Lot II)																					
2.1 Preparotory work	4,074	2,889	1,185	0	0	0	0	0	0	433	178	2,311	948	0	0	0	0	0	0	144	59
2.2 Inlet & outlet works	2,483	1,954	529	0	0	0	0	0	0	0	0	0	0	0	0	409	240	1,518	286	27	3
2.3 Tunnel	22,593	16,453	6,140	0	0	0	0	0	0	0	0	0	0	4,113	1,535	8,226	3,070	4,113	1,535	0	0
2.4 Work adit	2,931	2,158	773	0	0	0	0	0	0	0	0	1,511	541	647	232	0	0	0	0	0	0
2.5 Access road	12,730	8,326	4,404	0	0	0	0	0	0	0	0	5,828	3,083	2,498	1,321	0	0	0	0	0	0
Total(2)	44,811	31,780	13,031	0	0	0	0	0	0	433	178	9,650	4,572	7,258	3,088	8,636	3,310	5,631	1,821	171	62
Total(1 and 2)	134,636	98,984	35,652	0	0	0	0	0	0	1,075	461	20,511	9,561	22,377	9,876	26,417	9,281	27,811	6,277	793	195
Disburse/Advace 15%				0	0	0	0	0	0	15,762	5,740	17,434	8,127	19,020	8,394	22,454	7,889	23,639	5,336	674	166
3. Land Acquisition and Compensation	100	0	100	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0
4. Administration Expenses	2,693	0	2,693	0	0	0	0	0	0	0	189	0	566	0	619	0	619	0	619	0	81
5. Engineering Services																					
5.1 Detailed Design	4,291	4,030	261	0	0	0	0	3,627	235	403	26	0	0	0	0	0	0	0	0	0	0
5.1 Supervision	9,574	7,380	2,194	0	0	0	0	0	0	517	154	1,550	461	1,697	505	1,697	505	1,697	505	221	66
Total(5)	13,865	11,410	2,455	0	0	0	0	3,627	235	920	180	1,550	461	1,697	505	1,697	505	1,697	505	221	66
6. Phisical Contingency	15,129	11,039	4,090	0	0	0	0	363	24	1,668	621	1,898	915	2,072	952	2,415	901	2,534	646	90	31
Total(1 to 6)	166,423	121,433	44,990	0	0	0	0	3,990	259	18,349	6,830	20,883	10,069	22,790	10,470	26,567	9,914	27,870	7,106	985	344
7. Price Contingency	27,252	20,022	7,230	0	0	0	0	243	16	1,701	653	2,621	1,264	3,630	1,668	5,157	1,924	6,407	1,634	263	92
Grand Total	193,675	141,455	52,220	0	0	0	0	4,233	275	20,050	7,463	23,503	11,332	26,420	12,137	31,723	11,838	34,278	8,739	1,247	435

Table 14.1 Raw Water Requirement for Water Supply

(MCM/Year)

Year	Total Demand			Demand met by Transbasin Scheme		
	Poza Honda	Chone-Est.	Total	Poza Honda	Chone-Est.	Total
1990	34.5	8.2	42.7	-	-	-
91	37.0	9.2	46.2	-	-	-
92	39.5	10.3	49.8	-	-	-
93	42.0	11.3	53.3	-	-	-
94	44.5	12.3	56.8	-	-	-
95	47.1	13.3	60.4	-	-	-
96	49.6	14.3	63.9	-	-	-
97	52.1	15.3	67.4	-	-	-
98	54.6	16.3	70.9	-	-	-
99	57.1	17.4	74.5	-	-	-
2000	59.6	18.4	78.0	14.6	-	14.6
01	63.3	19.7	83.0	18.3	-	18.3
02	67.1	20.8	87.9	22.1	-	22.1
03	70.8	22.1	92.9	25.8	-	25.8
04	74.5	23.3	97.8	29.5	-	29.5
05	78.3	24.5	102.8	33.3	-	33.3
06	82.0	25.7	107.7	37.0	-	37.0
07	85.7	27.0	112.7	40.7	-	40.7
08	89.4	28.2	117.6	44.4	-	44.4
09	93.2	29.4	122.6	48.2	-	48.2
2010	96.9	30.6	127.5	51.9	-	51.9
11	102.4	32.1	134.5	57.4	-	57.4
12	107.9	33.5	141.4	62.9	-	62.9
13	113.4	35.0	148.4	68.4	-	68.4
14	118.9	36.4	155.3	73.9	-	73.9
15	124.4	37.9	162.3	79.4	-	79.4
16	129.8	39.4	169.2	84.8	-	84.8
17	135.3	40.9	176.2	90.3	0.9	91.2
18	140.8	42.3	183.1	95.8	2.3	98.1
19	146.3	43.8	190.1	101.3	3.8	105.1
2020	151.8	45.2	197.0	106.8	5.2	112.0

Table 14.2 Total Irrigation Benefit

Irrigation Scheme	Area (ha)	Const. Cost ($/ha)	Annual Benefit ($/ha)	Annual Net Benefit ($/ha)	Annual Net Benefit (US$1,000)
Carrizal - Chone	15,000	3,795	1,067	687.5	10,313
Amarillos	1,000	4,337	995	561.3	561
Guarango	1,500	4,817	1,012	530.3	795
Rio Chico	1,700	3,177	986	668.3	1,136
Santa Ana	3,300	1,327	853	720.3	2,377
Pechiche - Pasaje	850	4,946	739	244.4	208
Mejia	1,250	2,581	845	586.9	734
Ceibal - Guayaba	4,650	2,598	852	592.2	2,753

Construction cost x 0.10 = Annual cost

Capital cost : 8%, O & M cost : 2%

Irrigation Benefit by Transbasin Scheme

Irrigation Scheme	Area (ha)	Annual Irrigation Benefit (US$1,000)
Amarillos	1,000	561
Guarango	1,500	795
Rio Chico	1,700	1,136
Santa Ana	2,200	1,585
Pechiche - Pasaje	850	208
Mejia	1,250	734
Ceibal - Guayaba	4,650	2,753
Total	13,150	7,772

Table 14.3 **Shrimp Farming Benefit**

(Prices in US$ 1,000)

	Production (1) (tons)	Fresh Water (2) Demand (MCM/year)	Gross (3) income	Production (4) cost	Profit (5)
With Project	7,734	102.6	34,030	17,015	17,015
Without Project	4,420	-	19,448	9,744	9,744
Net increase	3,314	102.6	14,582	7,271	7,271 (6)

Remarks:

(1) Net production in metric tons for effective shrimp pond area of 2,663 ha

(2) Annual fresh water requirement in MCM

(3) Farmgate price of shrimp : US$ 4.4/kg

(4) Production cost is assumed to be 50 % of the gross income.

(5) Profit or benefit without counting fresh water charge.

(6) Net increase of profit of US$ 7.27 million is the annual shrimp farming benefit of the project.

Table 14.4 Economic Cost and Benefit Stream

	Economic Cost (US$ million)			Economic Benefit (US$ million)		
	Construction	Energy (US$0.06/kwh)	O & M	Water Supply (US$0.3/m^3)	Irrigation	Shrimp Farm
1993						
94	4.24					
95	24.84					
96	30.45					
97	32.74					
98	35.99					
99	34.62					
2000	1.31	2.38	0.78	4.38	4.97	3.64
01		2.50	0.78	5.49	6.22	5.46
02		2.62	0.78	6.63	7.77	7.27
03		2.74	0.78	7.74	7.77	7.27
04		2.86	0.78	8.85	7.77	7.27
05		2.98	0.78	9.99	7.77	7.27
•		•	•	•	•	•
•		•	•	•	•	•
•		•	•	•	•	•
2020		4.76	0.78	33.60	7.77	7.27
•		•	•	•	•	•
•		•	•	•	•	•
•		•	•	•	•	•
2030		4.76	0.78	33.60	7.77	7.27

Table 14.5 Financial Cost and Benefit Stream

	Financial Cost (US$ million)			Financial Benefit (US$ million)		
	Construction	Energy (US$0.03/kwh)	O & M	Water Supply (US$0.15/$m^3$)	Irrigation	Shrimp Farm
1993	-					
94	4.51					
95	27.51					
96	34.84					
97	38.56					
98	43.56					
99	43.02					
2000	1.68	1.51	0.99	2.77	3.15	2.31
01		1.63	1.02	3.58	4.06	3.56
02		1.76	1.05	4.46	5.22	4.89
03		1.90	1.08	5.36	5.38	5.03
04		2.04	1.11	6.31	5.54	5.19
05		2.19	1.15	7.34	5.71	5.34
06		2.34	1.18	8.39	5.88	5.50
07		2.50	1.22	9.51	6.06	5.67
08		2.67	1.25	9.78	6.24	5.84
09		2.85	1.29	11.95	6.42	6.01
2010		3.04	1.33	13.25	6.62	6.19
11		3.24	1.37	15.10	6.81	6.38
12		3.44	1.41	17.04	7.02	6.57
13		3.66	1.45	19.09	7.23	6.76
14		3.88	1.49	21.24	7.45	6.97
15		4.11	1.54	23.51	7.67	7.18
16		4.35	1.59	25.86	7.90	7.39
17		4.61	1.63	28.64	8.14	7.61
18		4.87	1.68	31.73	8.38	7.84
19		5.15	1.73	35.02	8.63	8.08
2020		5.45	1.78	38.44	8.89	8.32

FIGURES

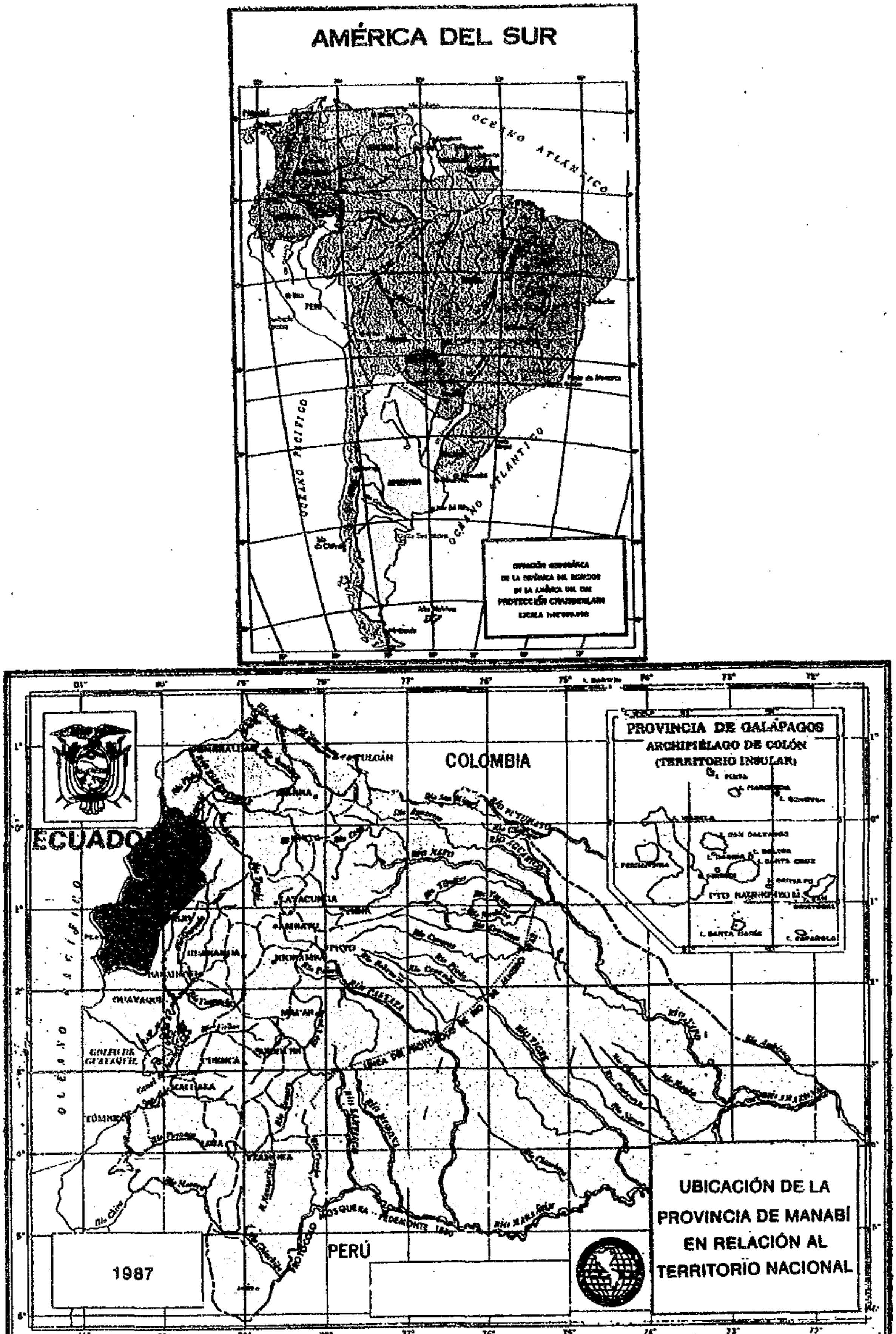
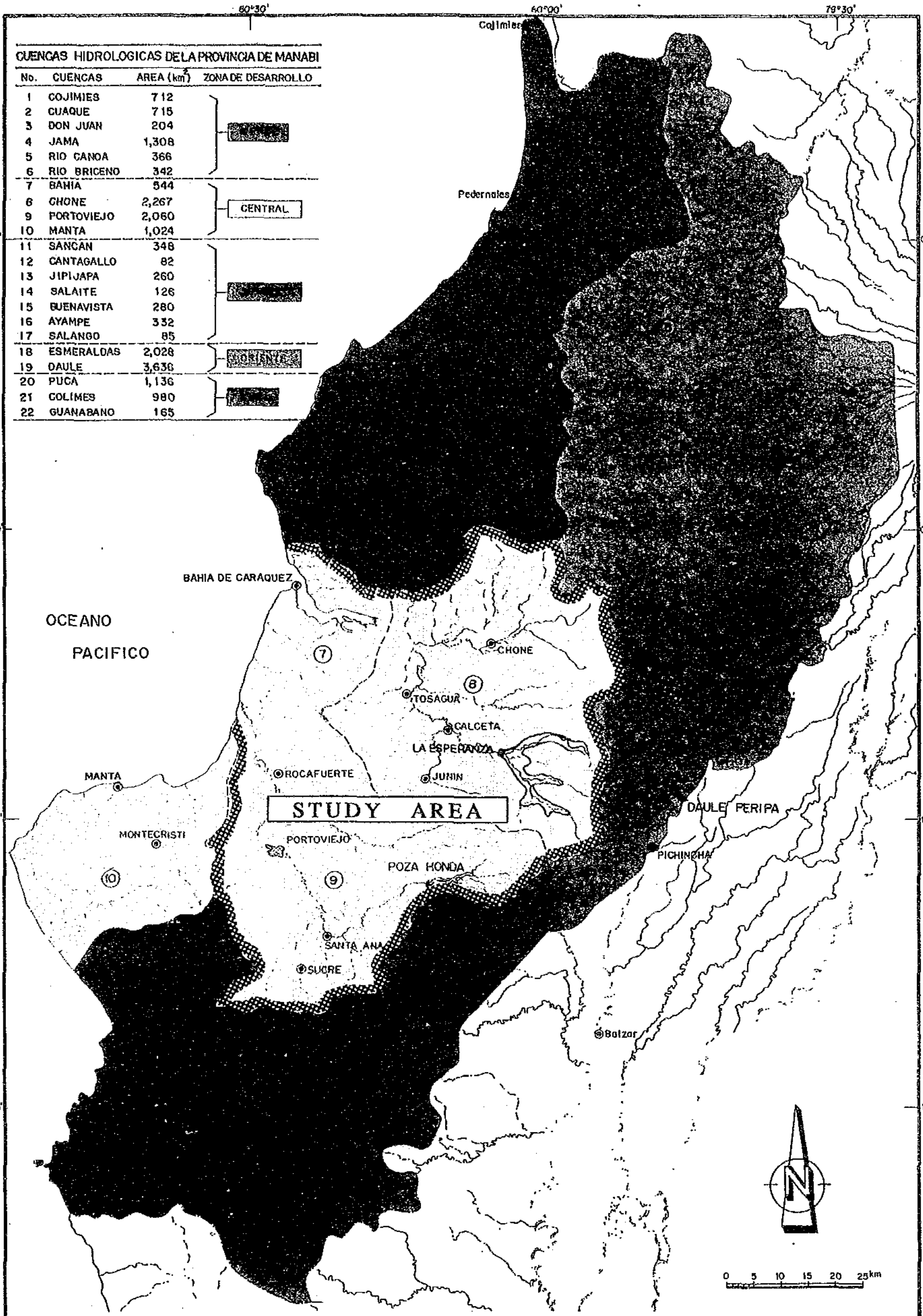


Fig. 1.1 LOCATION OF ECUADOR AND MANABI PROVINCE



CUENCAS HIDROLOGICAS DE LA PROVINCIA DE MANABI

No.	CUENCAS	AREA (km^2)	ZONA DE DESARROLLO
1	COJIMIES	712	[illegible]
2	CUAQUE	715	
3	DON JUAN	204	
4	JAMA	1,308	
5	RIO CANOA	366	
6	RIO BRICENO	342	
7	BAHIA	544	CENTRAL
8	CHONE	2,267	
9	PORTOVIEJO	2,060	
10	MANTA	1,024	
11	SANCAN	348	[illegible]
12	CANTAGALLO	82	
13	JIPIJAPA	260	
14	SALAITE	126	
15	BUENAVISTA	280	
16	AYAMPE	332	
17	SALANGO	85	
18	ESMERALDAS	2,028	ORIENTE
19	DAULE	3,636	
20	PUCA	1,136	[illegible]
21	COLIMES	980	
22	GUANABANO	165	

Fig. 1.2 LOCATION OF STUDY AREA

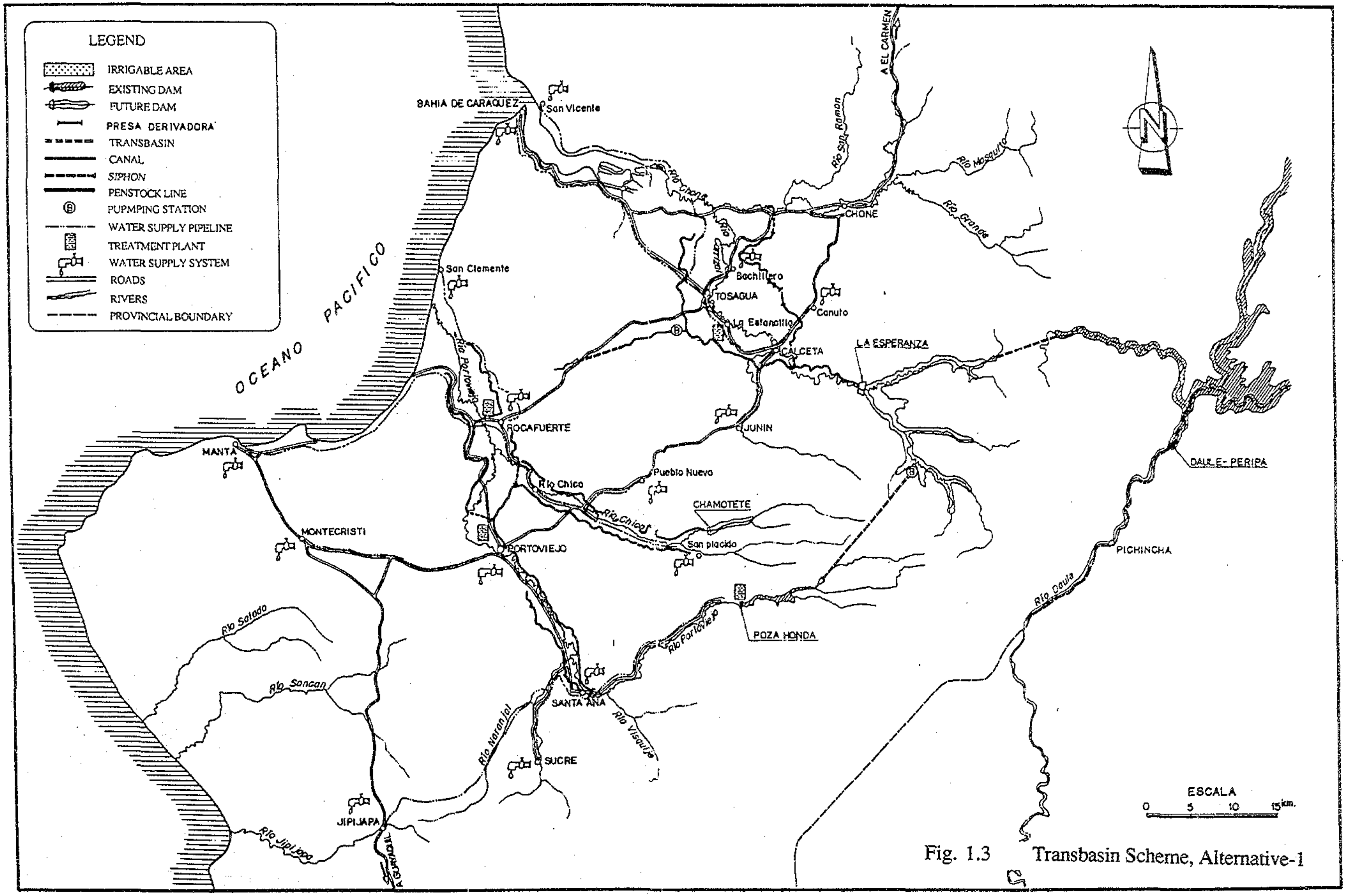


Fig. 1.3 Transbasin Scheme, Alternative-1

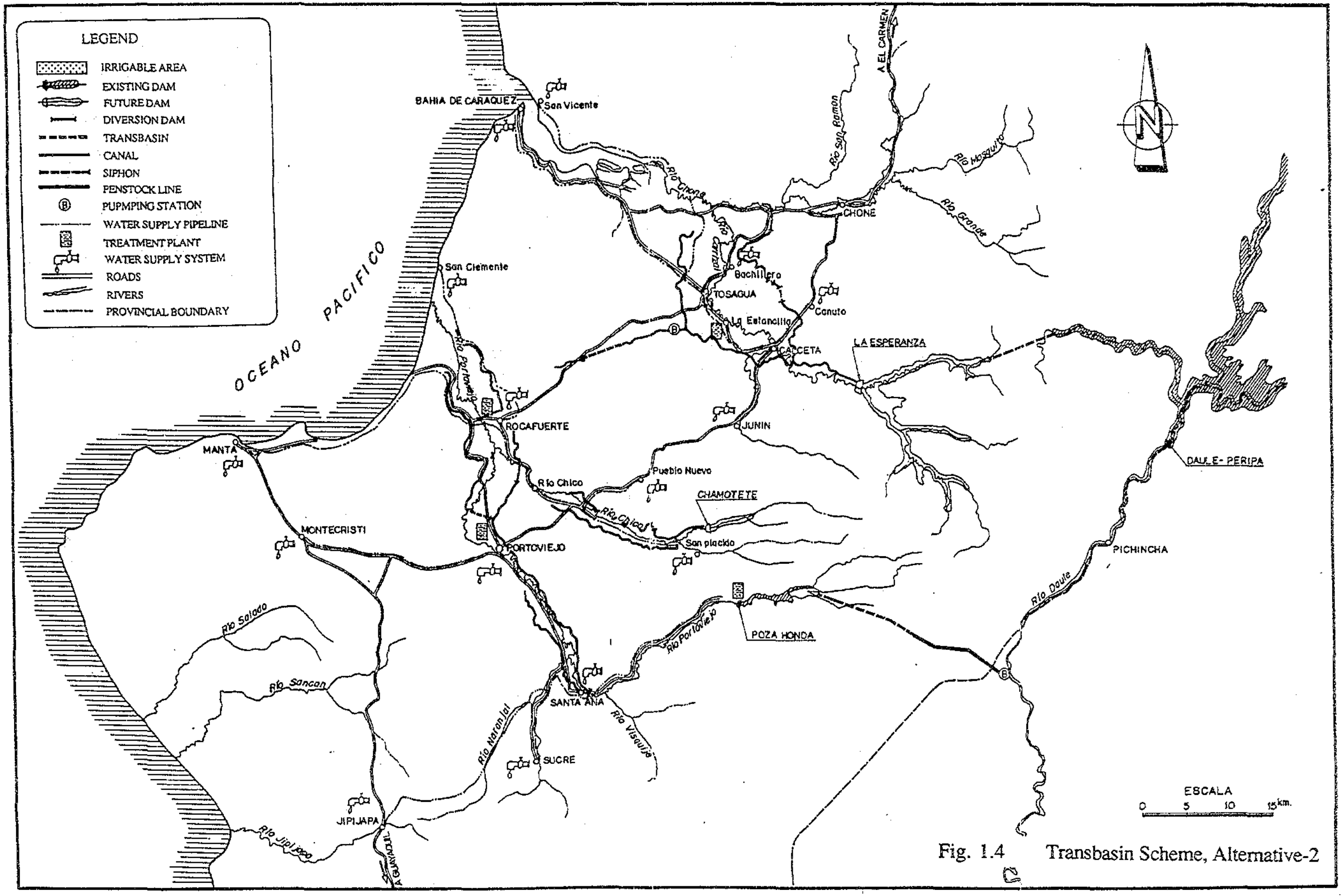


Fig. 1.4 Transbasin Scheme, Alternative-2

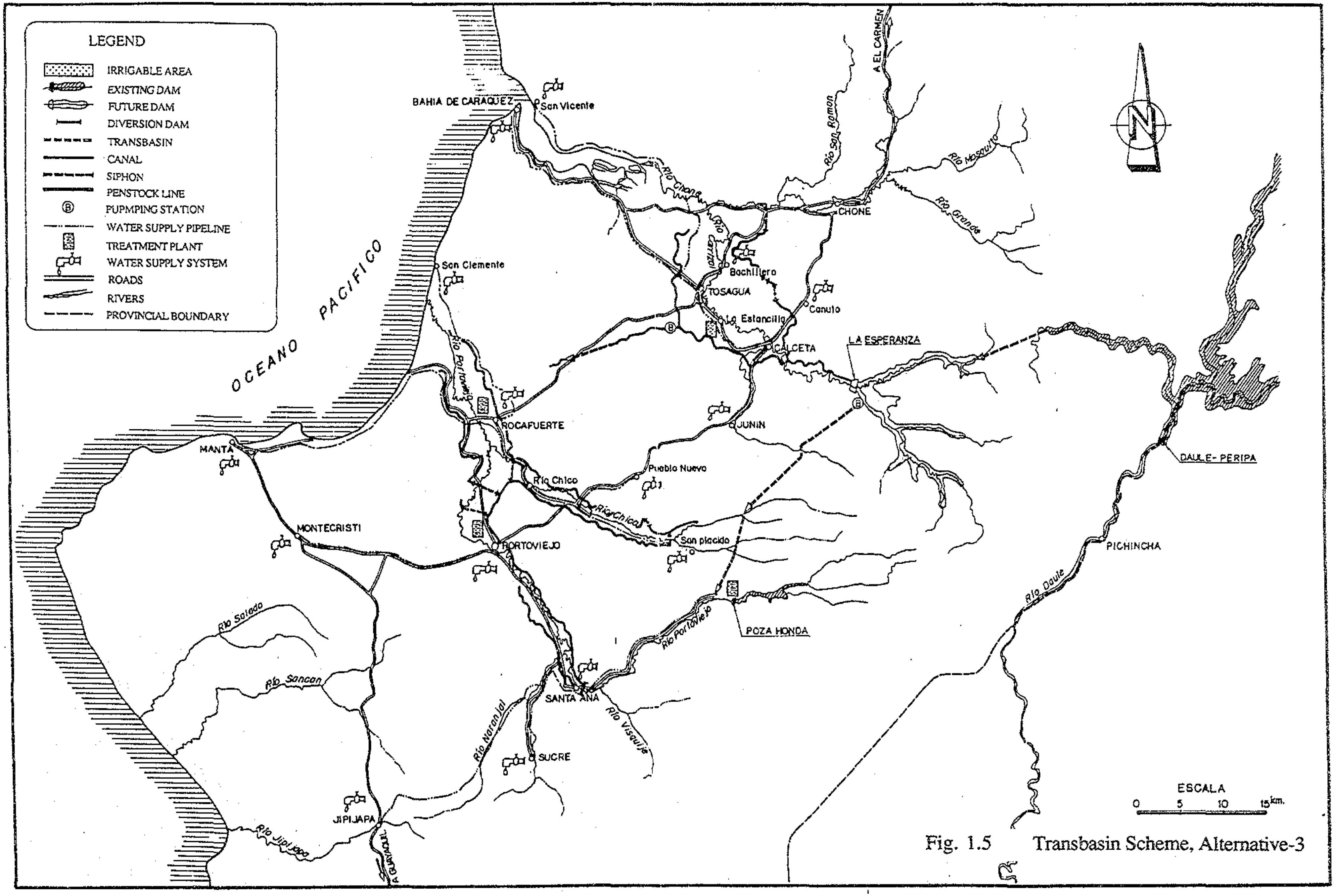


Fig. 1.5 Transbasin Scheme, Alternative-3

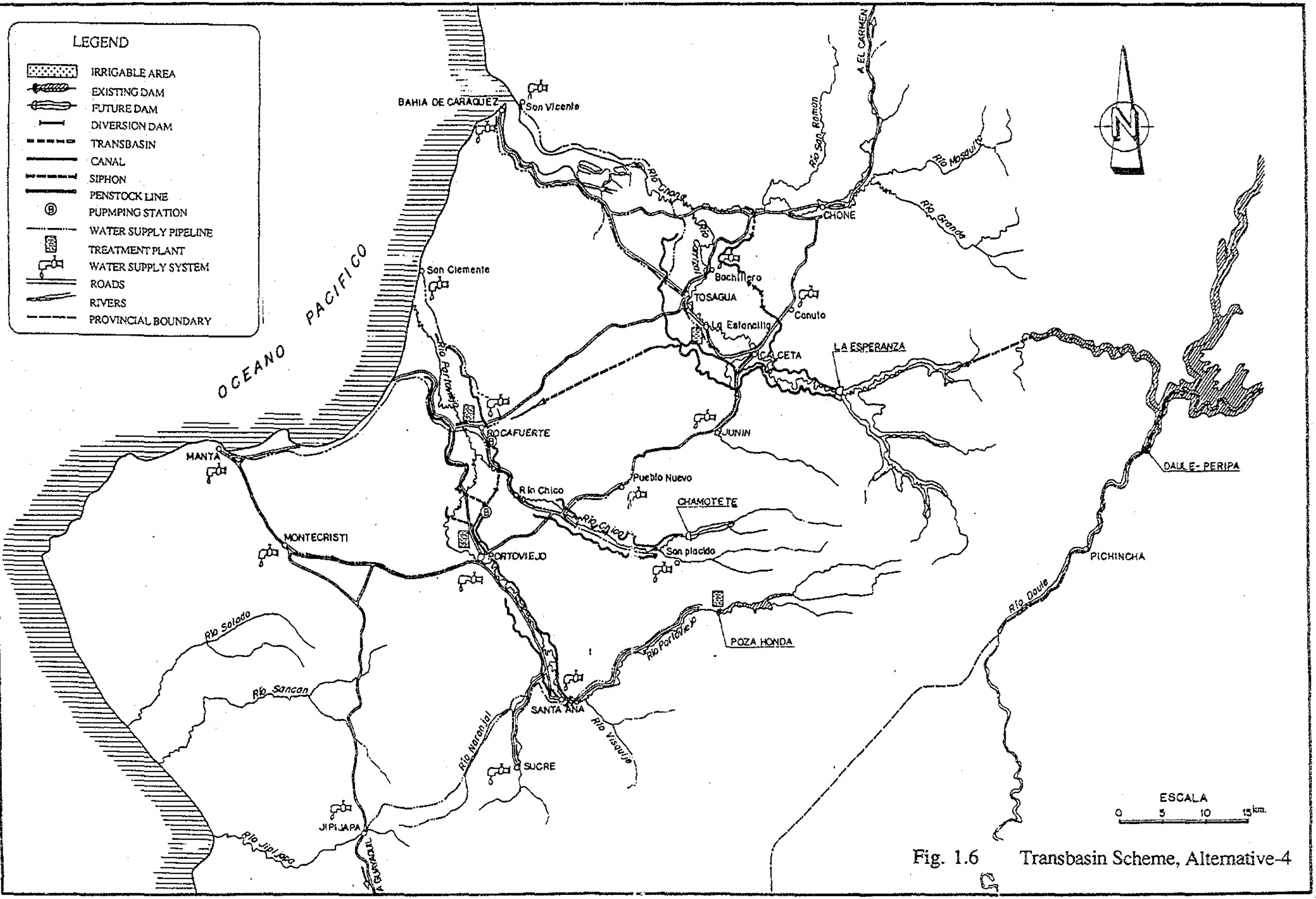


Fig. 1.6 Transbasin Scheme, Alternative-4

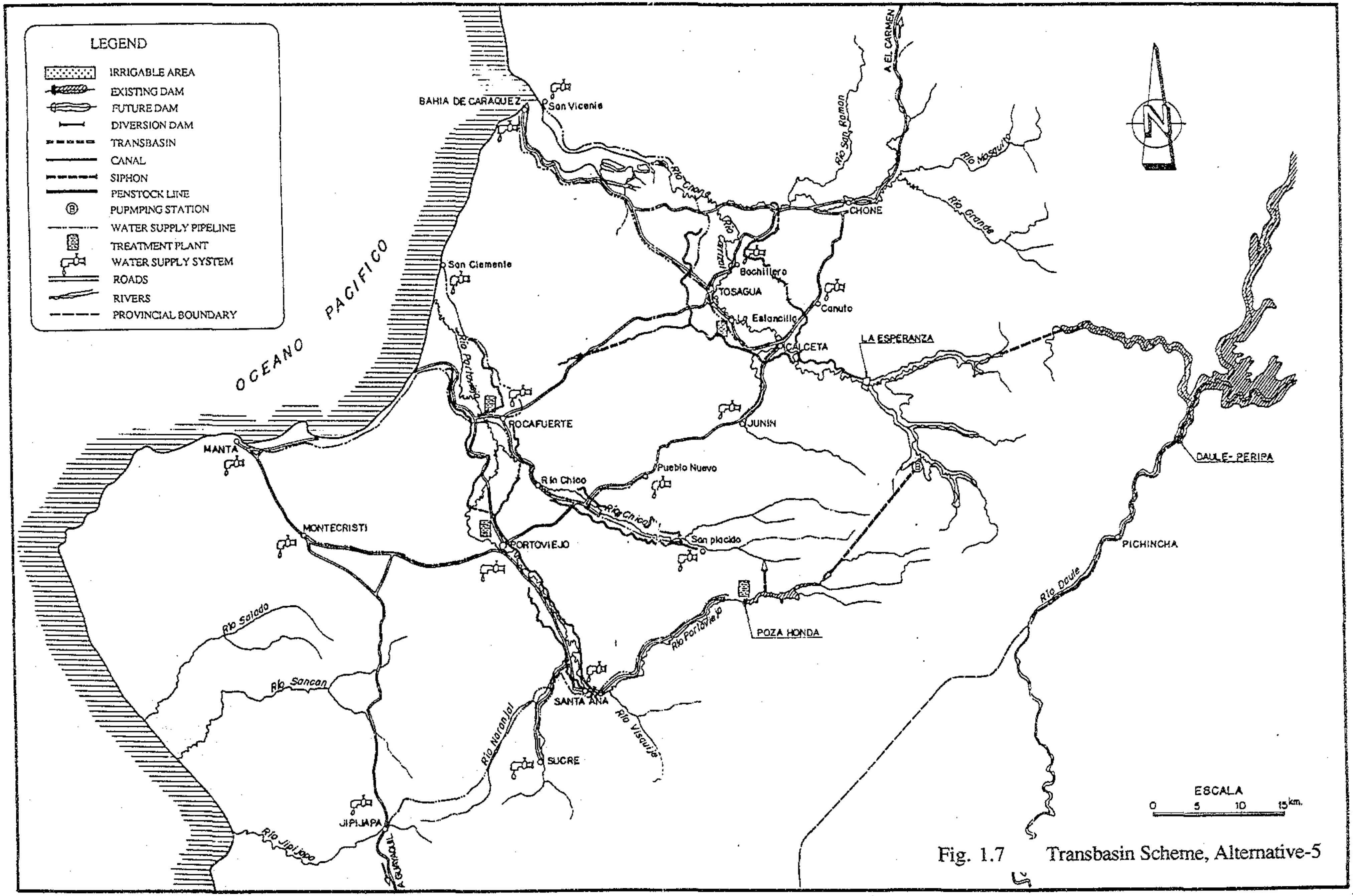


Fig. 1.7 Transbasin Scheme, Alternative-5

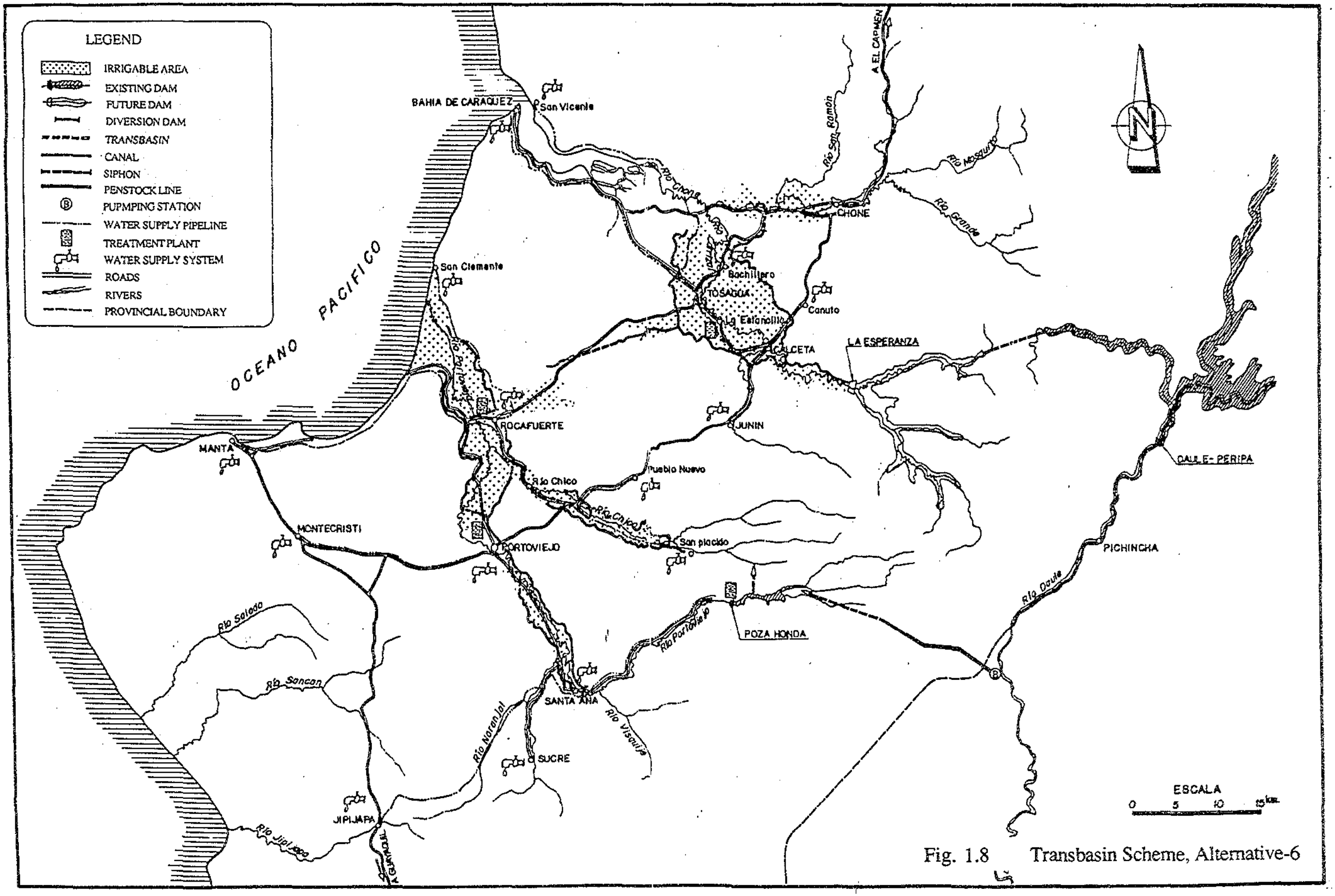


Fig. 1.8 Transbasin Scheme, Alternative-6

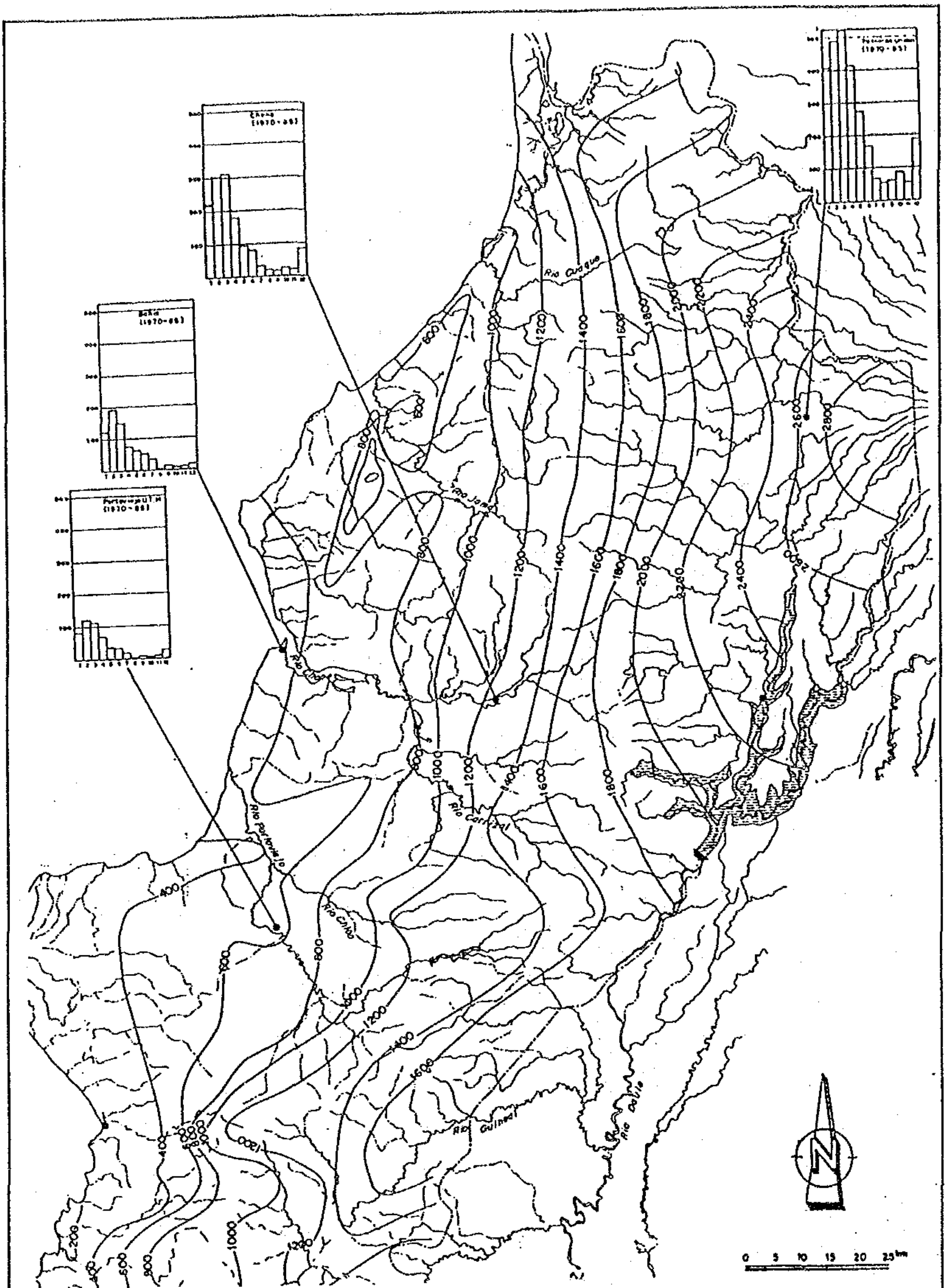


Fig. 4.1 Isohyetal Map for the Study Area

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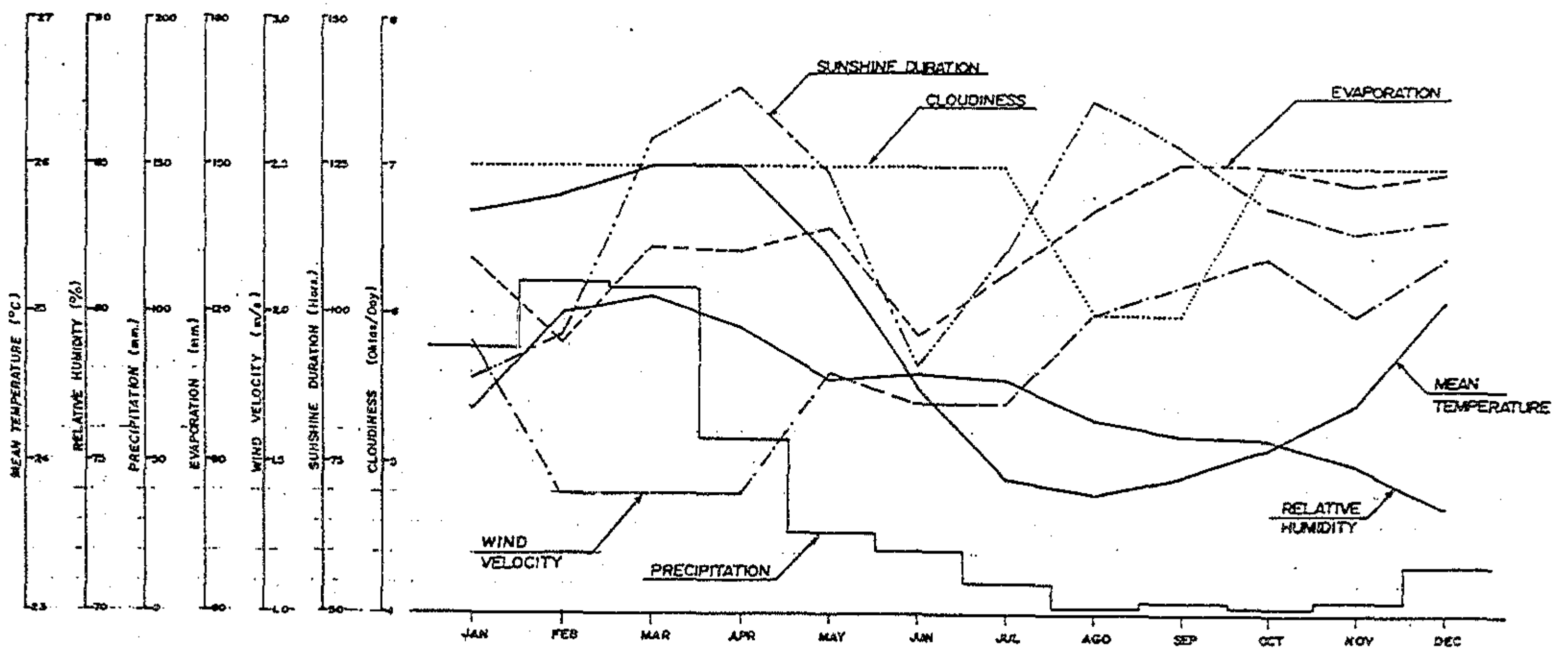

Item	Unit	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean/ Annual
Mean Temperature	(°C)	25.7	25.8	26.0	26.0	25.4	24.5	23.9	23.8	23.9	24.1	24.4	25.1	24.9
Relative Humidity	(%/day)	76.8	80.0	80.6	79.6	77.8	78.0	77.8	76.4	75.9	75.8	74.9	73.6	77.3
Precipitation	(mm/month)	88.4	111.0	109.3	58.1	27.8	21.6	11.1	2.3	4.5	2.7	4.8	17.0	458.6
Evaporation	(mm/month)	131.4	114.1	133.7	132.9	137.4	116.7	128.3	148.2	150.7	150.1	146.7	149.1	1639.3
Wind Velocity	(m/sec)	1.9	1.4	1.4	1.4	1.8	1.7	1.7	2.0	2.1	2.2	2.0	2.2	1.8
Sunshine Duration	(hrs/month)	89.1	93.5	129.3	138.3	123.9	91.7	110.8	136.1	128.6	118.6	114.1	116.2	1390.2
Mean Cloudiness	(oktas/day)	7	7	7	7	7	7	7	6	6	7	7	7	7

Fig. 4.2 Mean Meteorological and Hydrological Data of Portoviejo UTM

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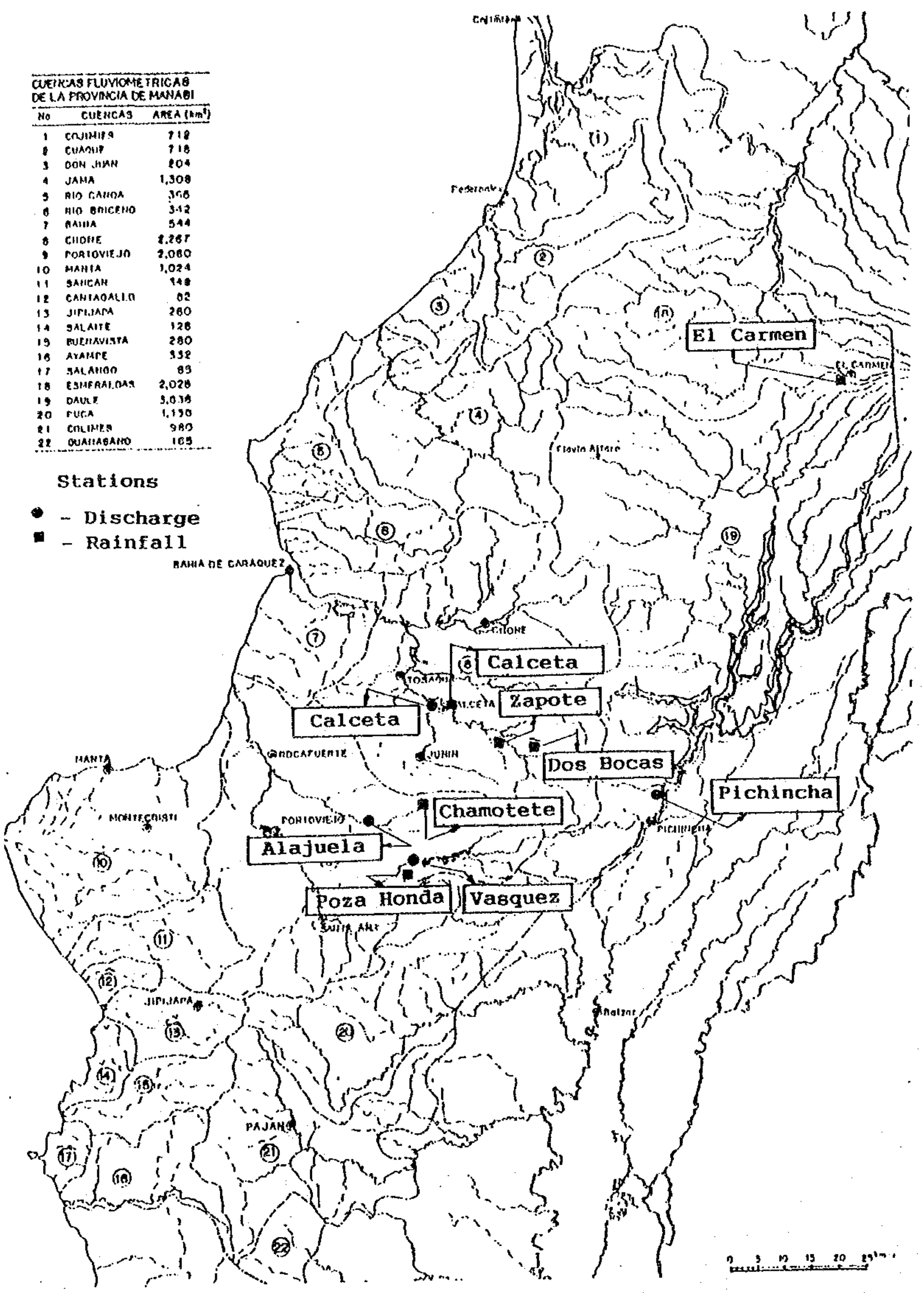

CUENCAS FLUVIOMETRICAS DE LA PROVINCIA DE MANABI

No	CUENCAS	AREA (km²)
1	COJIMIES	712
2	CUAQUE	718
3	DON JUAN	204
4	JAMA	1,308
5	RIO CANOA	368
6	RIO BRICENO	342
7	BAHIA	544
8	CHONE	2,267
9	PORTOVIEJO	2,080
10	MANTA	1,024
11	SANCAN	148
12	CANTAGALLO	62
13	JIPIJAPA	260
14	SALAITE	128
15	BUENAVISTA	280
16	AYAMPE	332
17	SALANGO	63
18	ESMERALDAS	2,028
19	DAULE	3,036
20	PUCA	1,130
21	COLIMES	980
22	GUANABANO	165

Fig. 4.3 Location of Meteorological Stations and Gauge Stations

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Crops	Days	Carrizal -Chone (ha.)	Amarillas (ha.)	Guarango (ha.)	Rb Chico (ha.)	Pechiche -Pasaje (ha.)	Santa Ana (ha.)	Mejia (ha.)	Ceibal -Guayaba (ha.)
Rice	135	5,970	400	595	680	340	1,310	500	1,850
Rice	135	5,970	400	595	680	340	1,310	500	1,850
Maize	120	740	50	75	90	40	165	60	230
Maize	120	740	50	75	90	40	165	60	230
Vegetables	120	740	50	80	80	40	165	60	230
Vegetables	120	1,780	110	180	200	90	385	150	550
Cotton	150	2,320	150	230	260	130	510	190	720
Peanut/Soybean	120	1,280	90	130	140	80	290	110	400
Citrus	365	2,220	150	220	250	130	490	180	690
Platano	365	3,010	200	300	340	170	660	250	930
Total		24,770	1,650	2,480	2,810	1,400	5,450	2,060	7,680

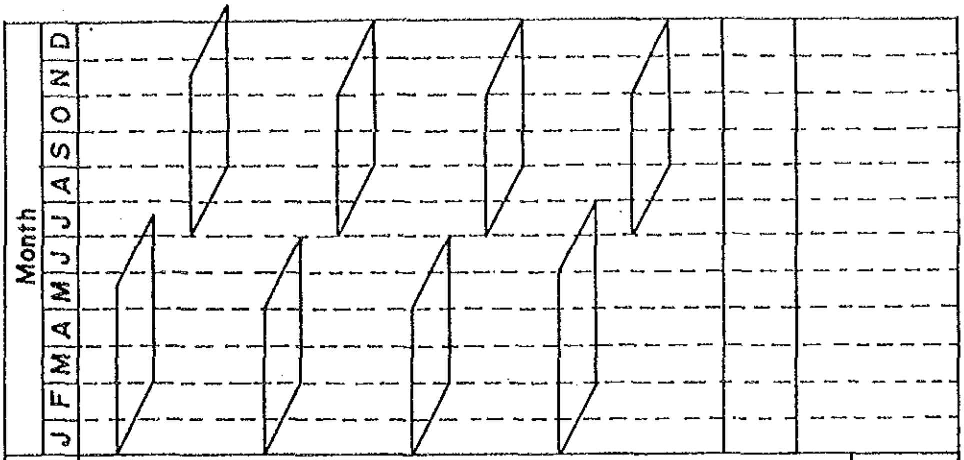


Fig. 5.1 Proposed Cropping Pattern

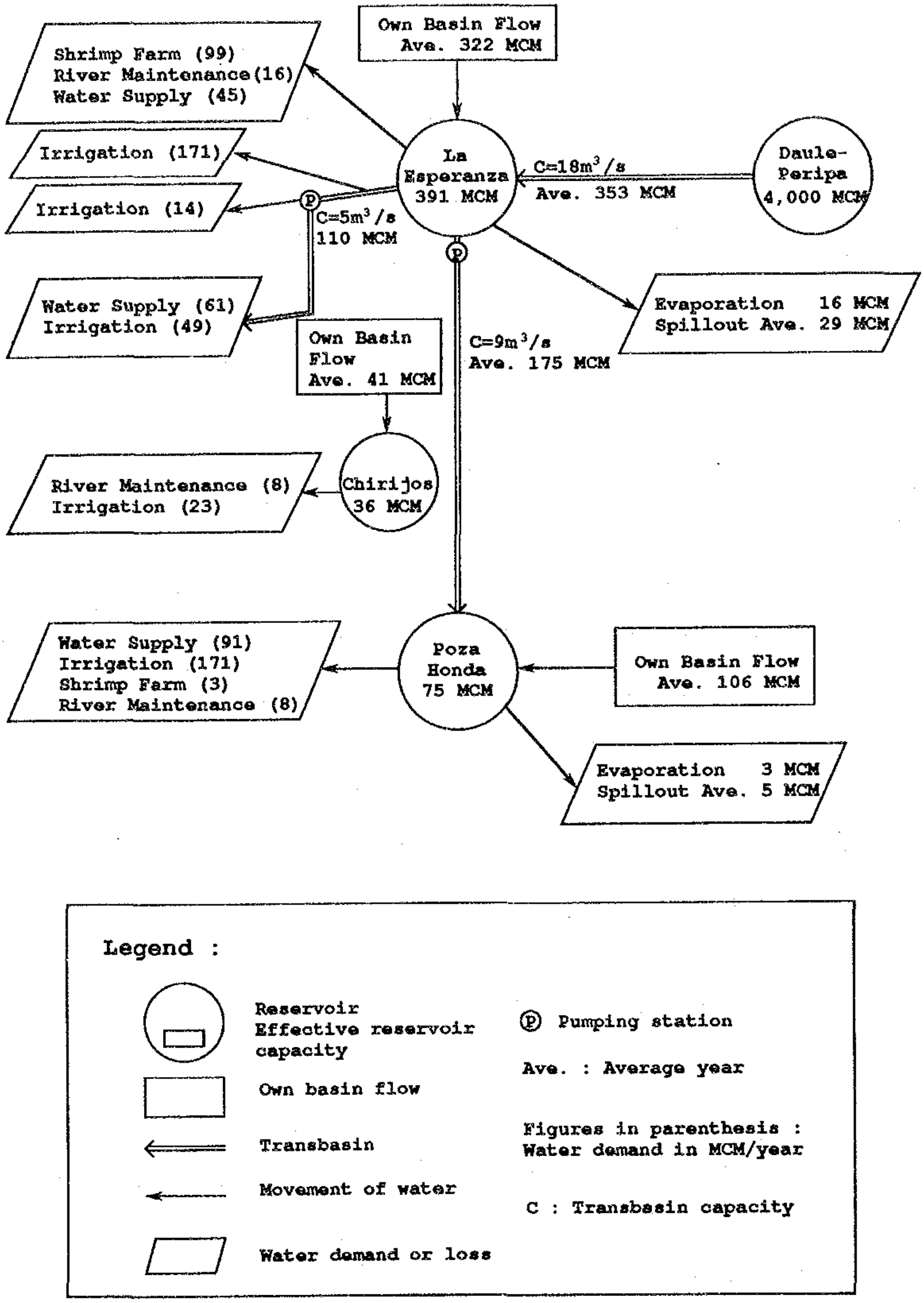


Fig. 6.1 SCHEMATIC WATER BALANCE FOR ALTERNATIVE - 1

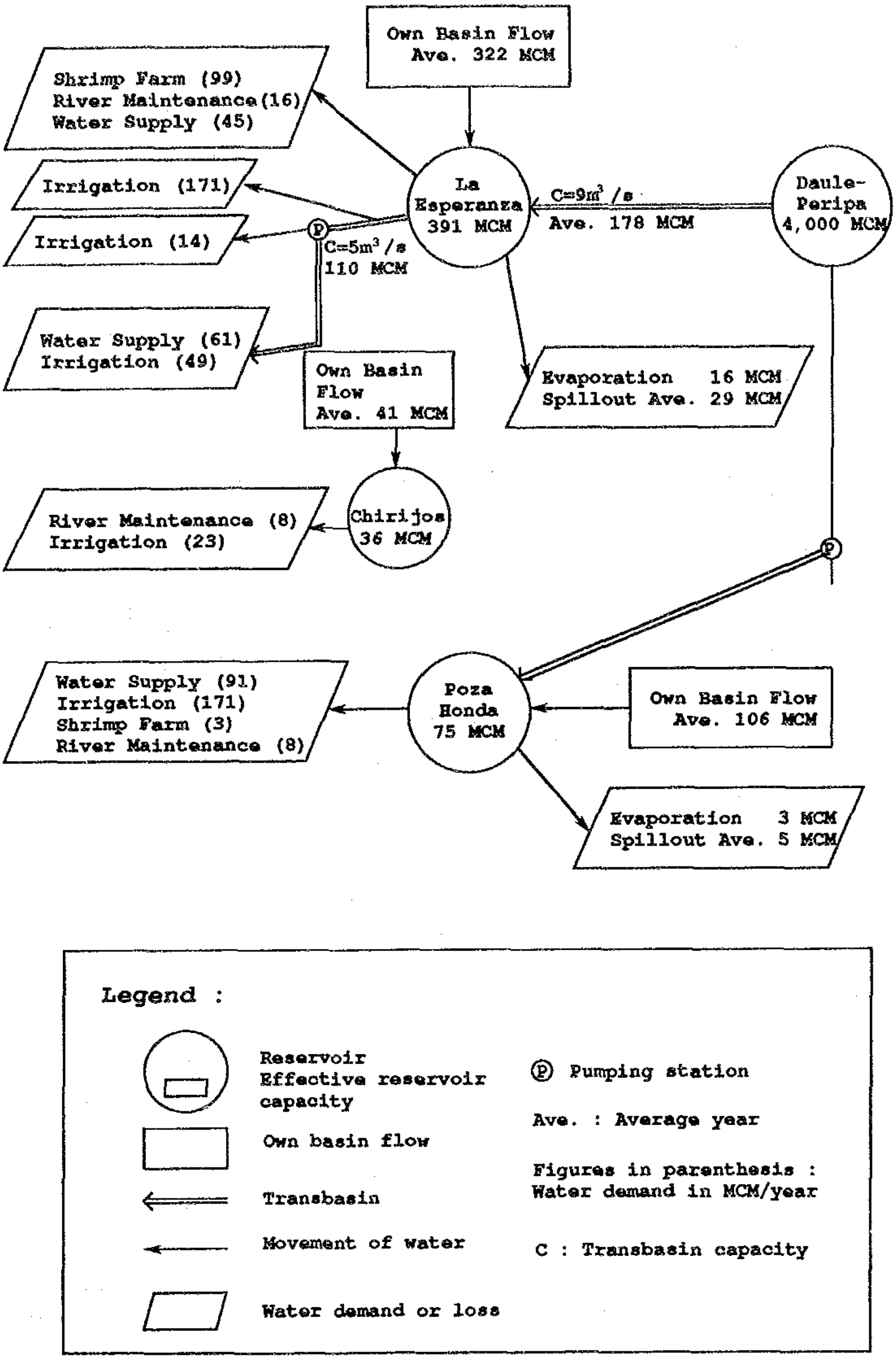


Fig. 6.2 SCHEMATIC WATER BALANCE
FOR ALTERNATIVE - 2

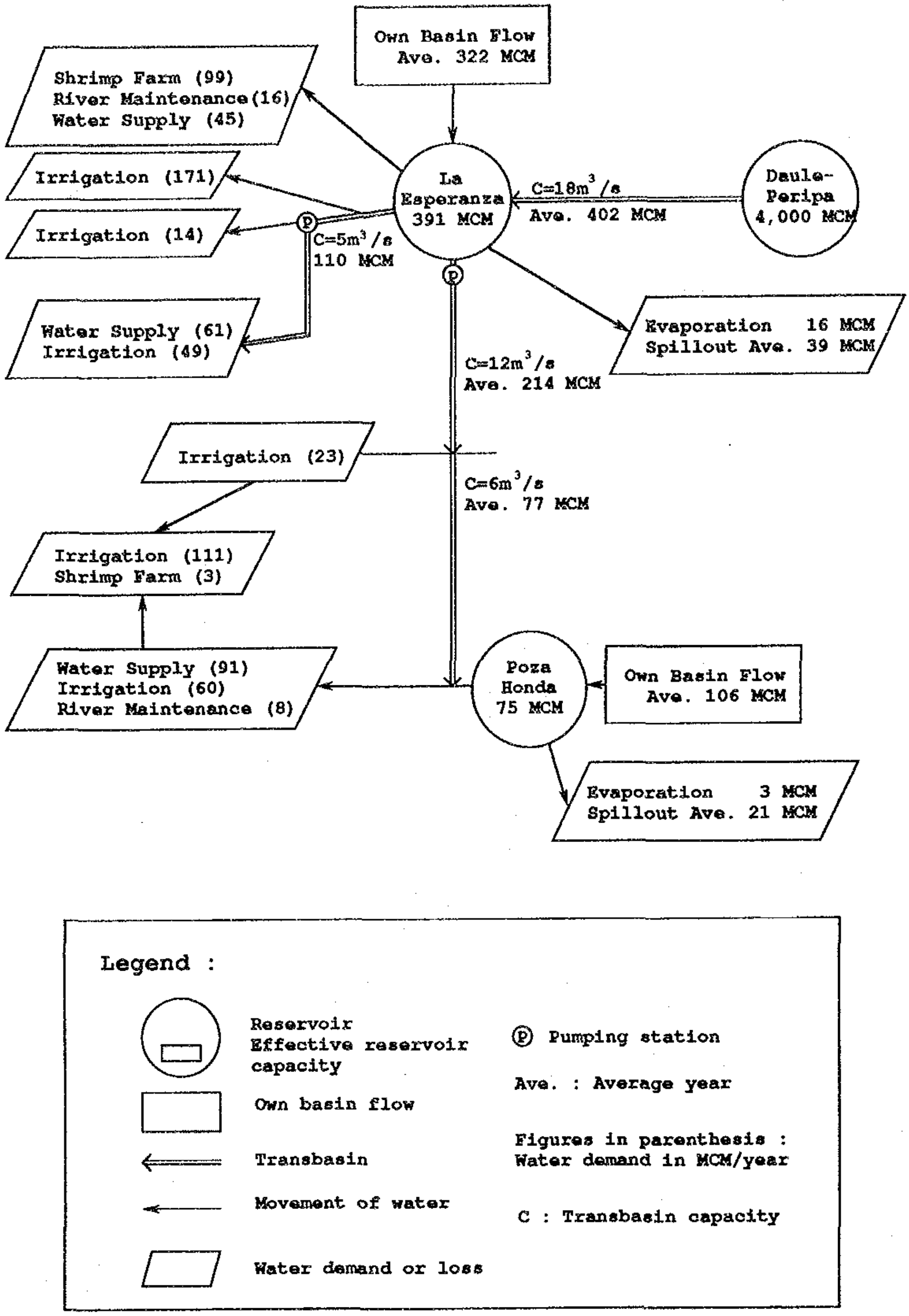


Fig. 6.3 SCHEMATIC WATER BALANCE FOR ALTERNATIVE - 3

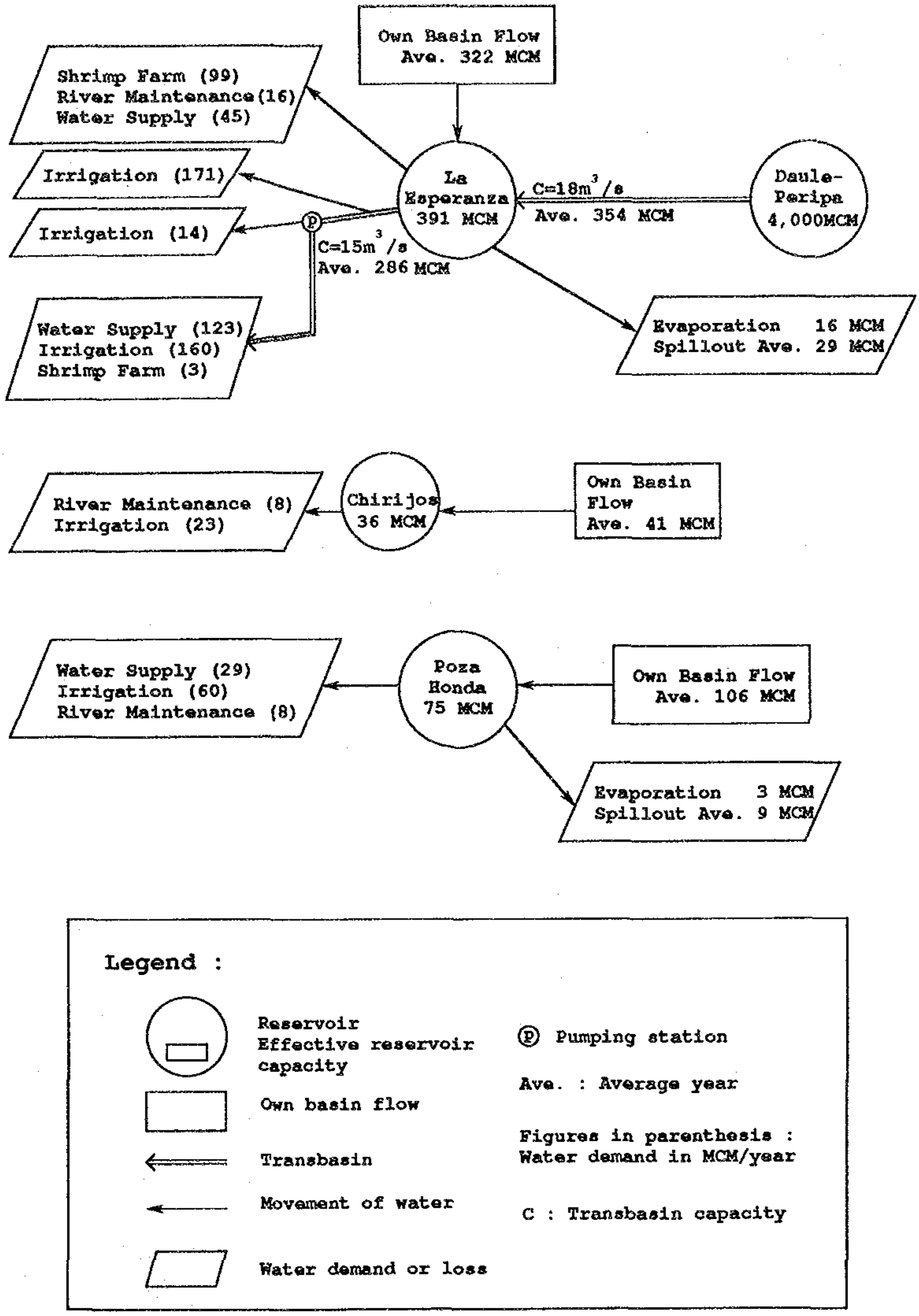


Fig. 6.4 SCHEMATIC WATER BALANCE FOR ALTERNATIVE - 4

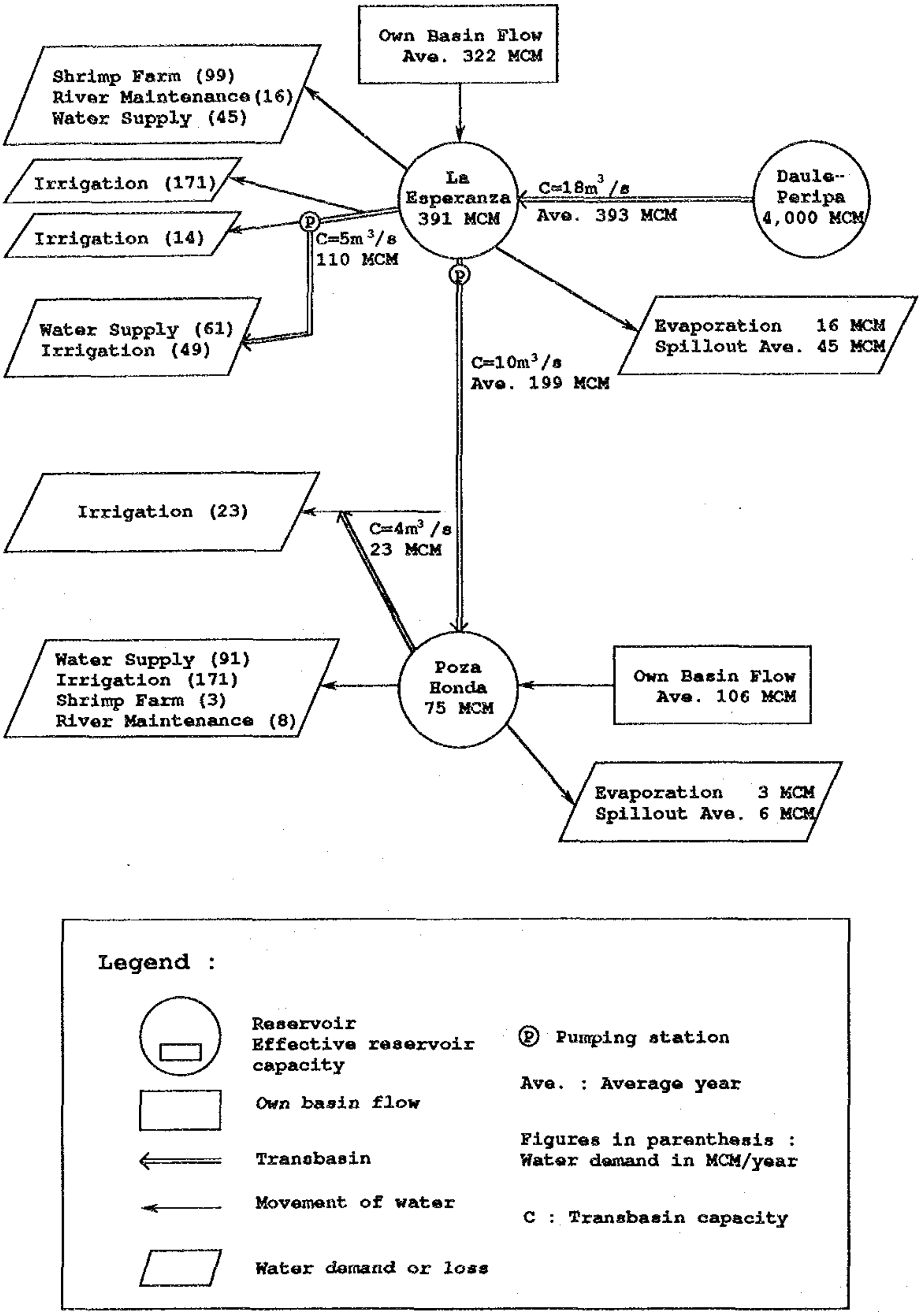


Fig. 6.5 SCHEMATIC WATER BALANCE FOR ALTERNATIVE - 5

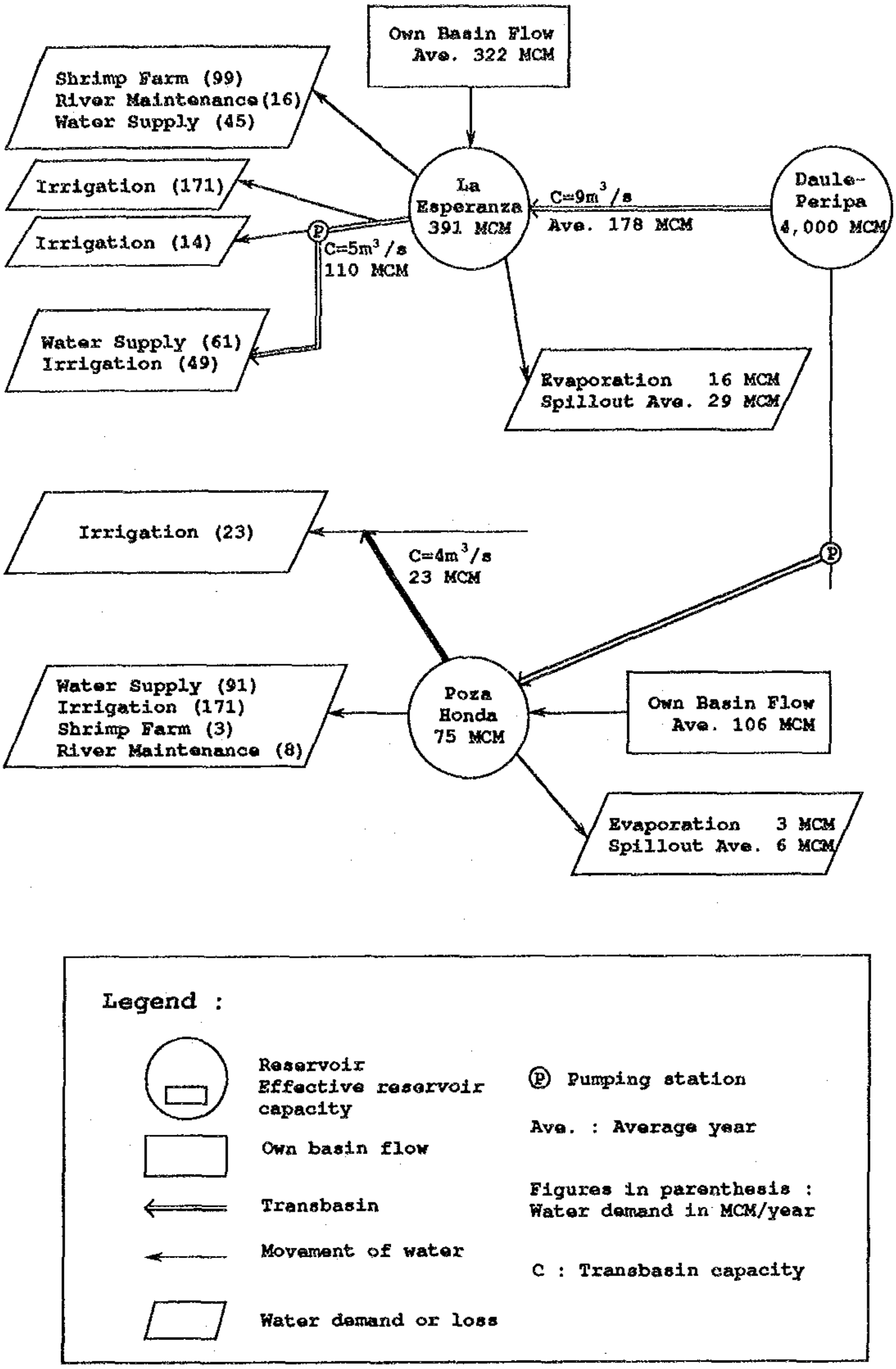


Fig. 6.6 SCHEMATIC WATER BALANCE
FOR ALTERNATIVE - 6

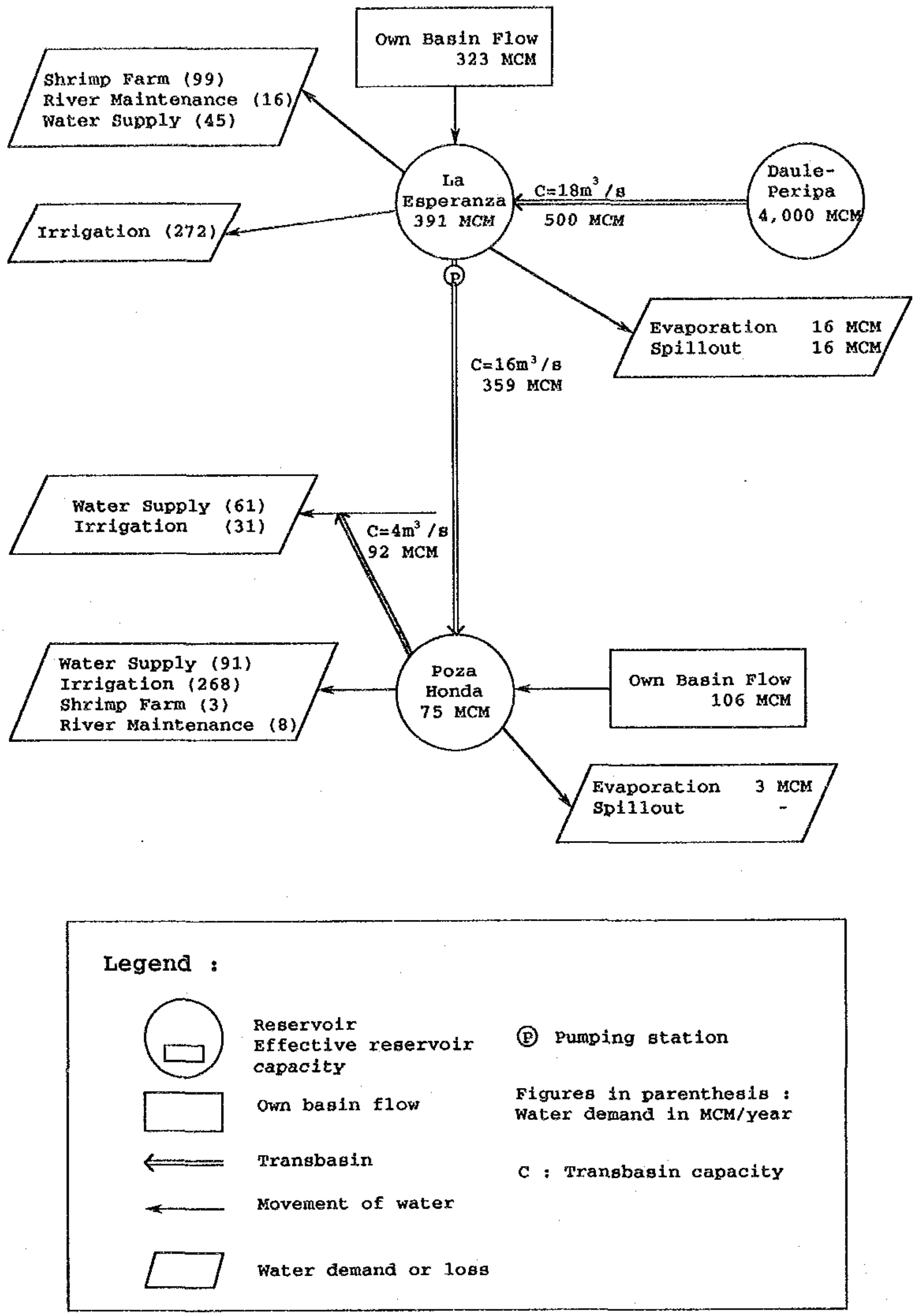


Fig. 9.1 SCHEMATIC WATER BALANCE FOR ALTERNATIVE - 5a

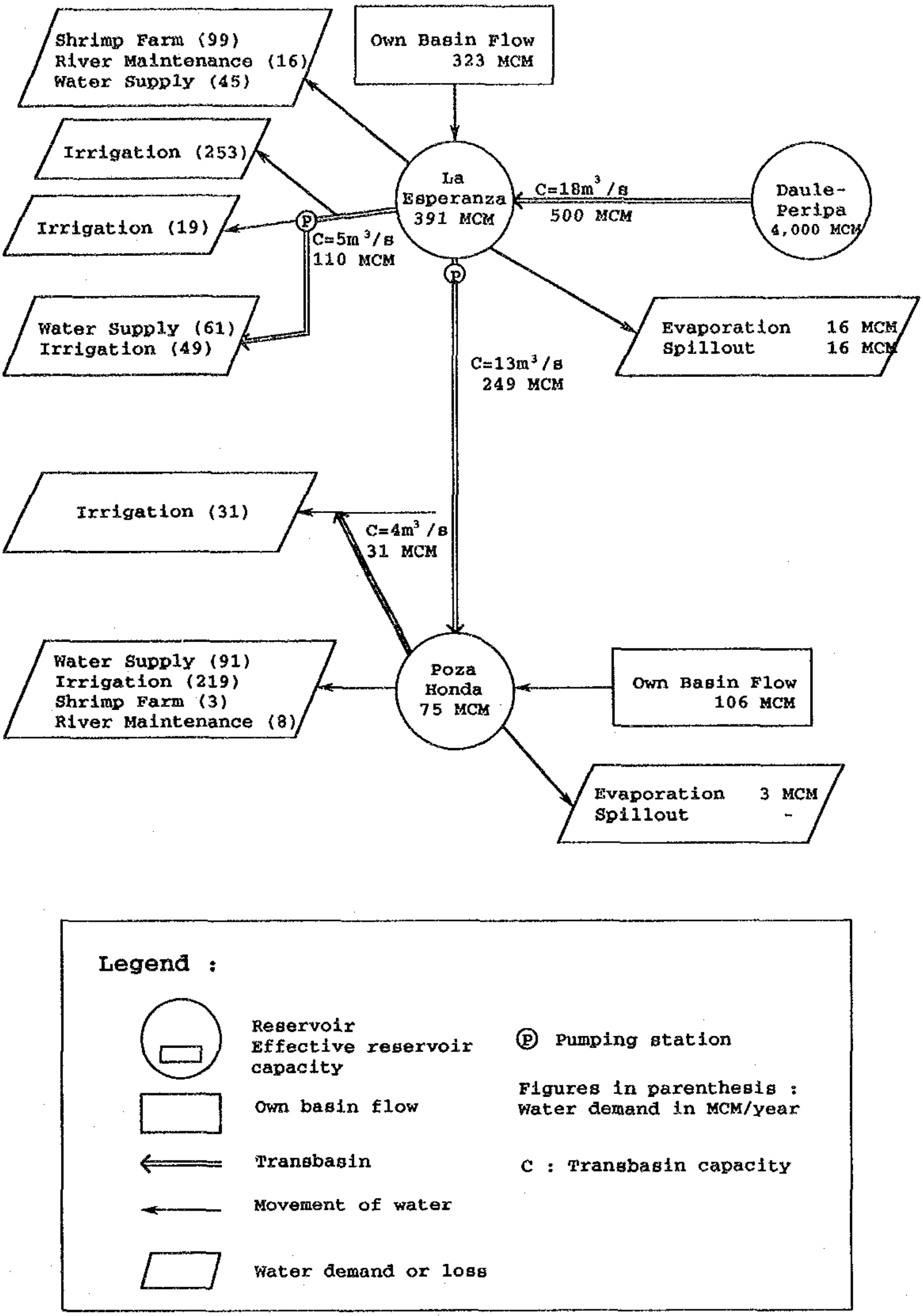
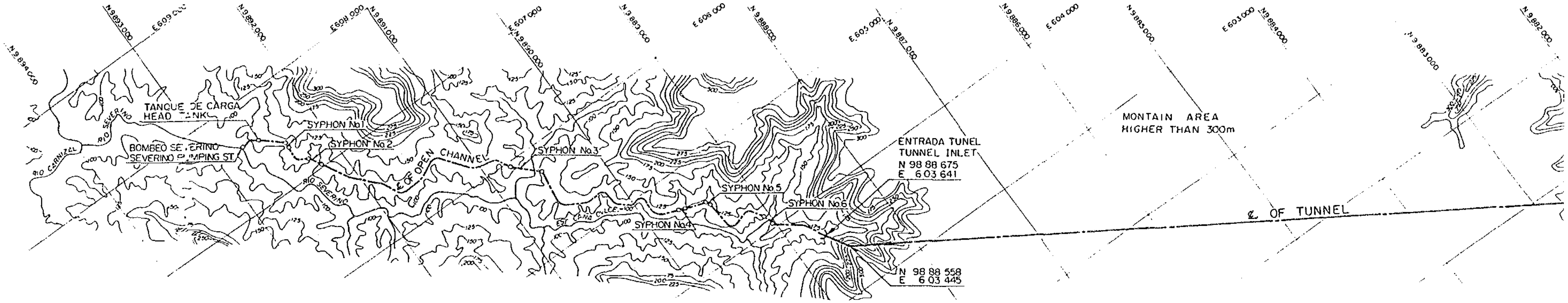
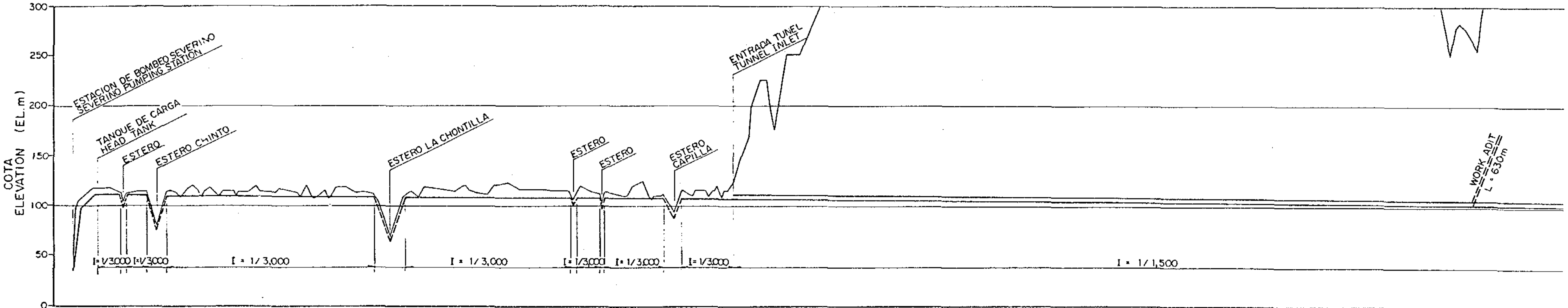


Fig.9.2 SCHEMATIC WATER BALANCE FOR ALTERNATIVE - 5b

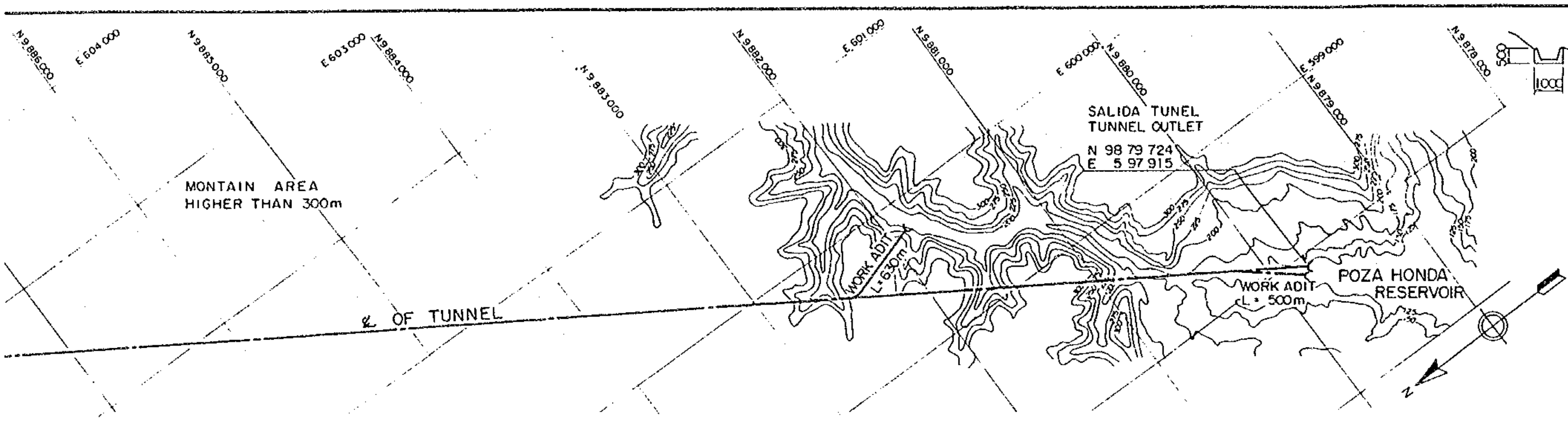


PLATA
PLAN SCALE A

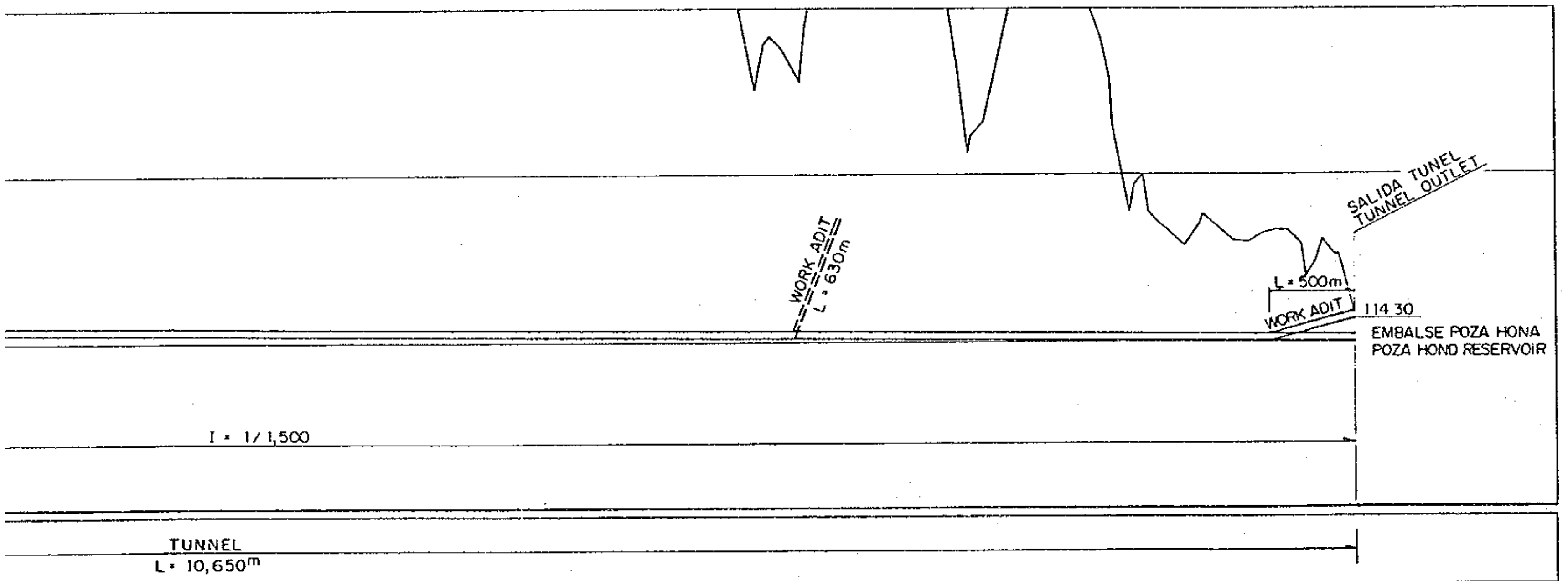


TIPOS DE ESTRUCTURAS / TYPE OF STRUCTURE	PIPELINE	OPEN CHANNEL	OPEN CHANNEL / SYPON SYPON		OPEN CHANNEL	SYPHON	OPEN CHANNEL	OPEN CHANNEL / SYPON	OPEN CHANNEL / SYPON	SYPHON	OPEN CHANNEL	TUNNEL L= 10,650m								
COTA DE ESTRUCTURAS / ELEVATION OF STRUCTURE (EL. m)	38 20	111.199	111.129 / 110.893	110 829	110.436	109760	109 282	108 734 / 108 502	108 422 / 108 195	107.998	107 673	107503 / 106 800	106 13	105 47	104 80	104 13	103 47	102.80	102.13	101.47
COTA DE TERRENO / ELEVATION OF GROUND (EL. m)	36	119	114 / 113	113	114	112	113	114 / 113	114 / 113	112	117	125								
DISTANCIA ACUMULADA / ACCUMULATE DISTANCE (m)	0	250 / 270	480 / 535	725	935	2965	3275	4920 / 4970	5210 / 5255	5845	6030	6540	7 540	8 540	9 540	10540	11.540	12 540	13.540	14 540
DISTANCIA / DISTANCE (m)	0	250 / 20	210 / 55	190	210	2030	310	1645 / 50	240 / 45	590	185	510	1,000	1.000	1.000	1.000	1.000	1,000	1 000	1 000
ESTACION / STATION	0+000	0+250 / 0+270	0+480 / 0+535	0+725	0+935	2+965	3+275	4+920 / 4+970	5+210 / 5+255	5+845	6+030	6+540	7+540	8+540	9+540	10+540	11+540	12+540	13+540	14+540

PERFIL
PROFILE H ; SCALE A
V ; SCALE B

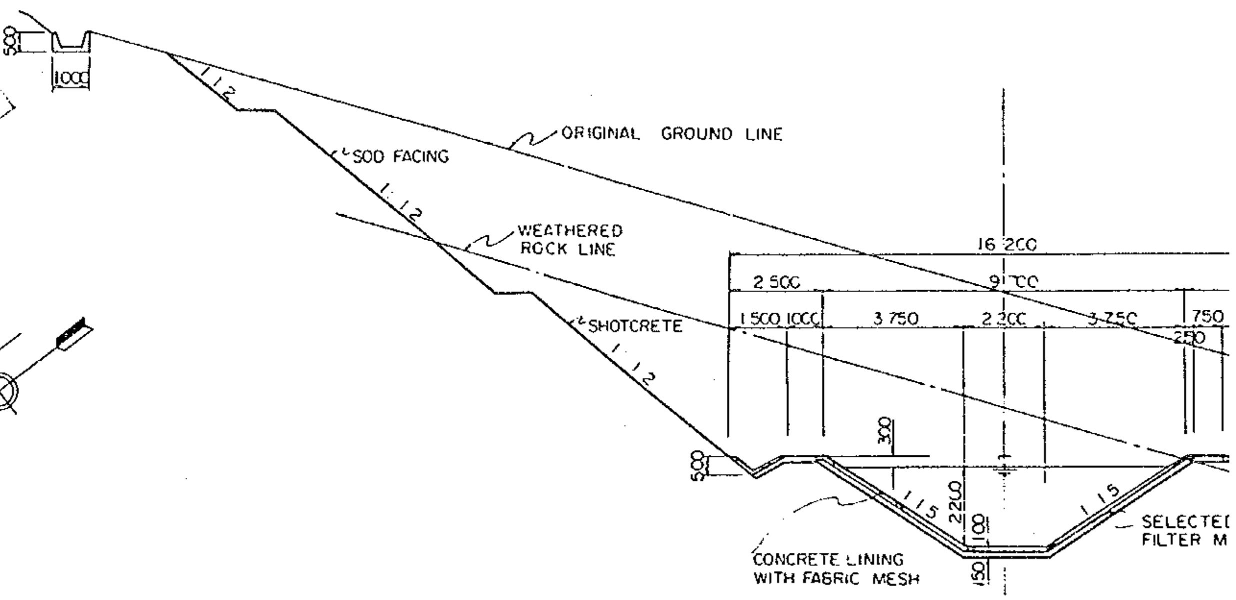


PLATA
PLAN SCALE A

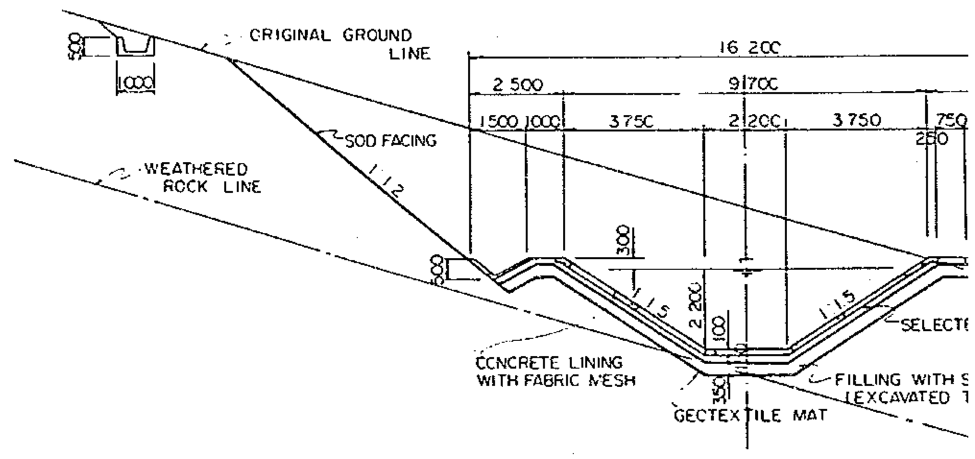


104.80	104.13	103.47	102.80	102.13	101.47	100.80	100.13	99.70
								120.00
9 540	10 540	11 540	12 540	13 540	14 540	15 540	16 540	17 190
1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	650
9+540	10+540	11+540	12+540	13+540	14+540	15+540	16+540	17+190

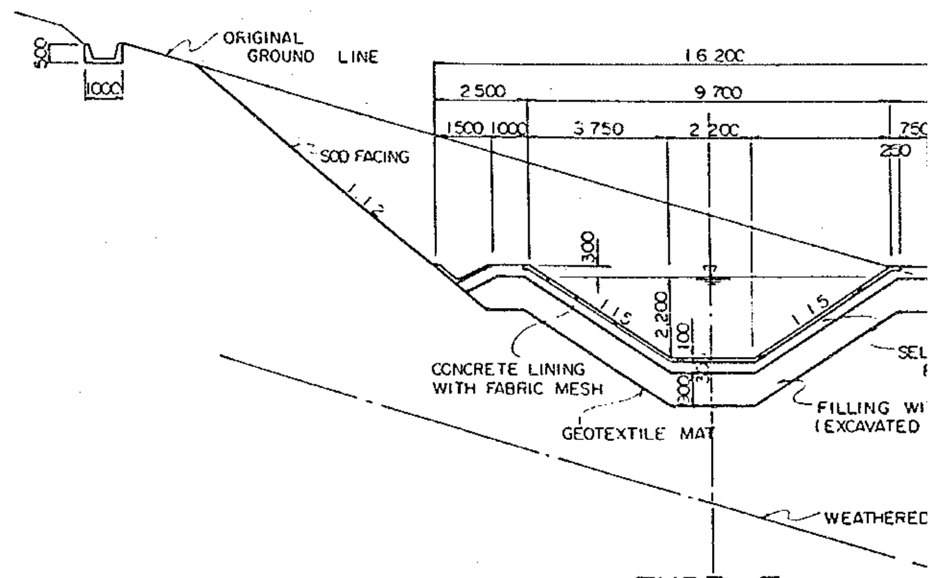
H ; SCALE A
V ; SCALE B



TYPE I

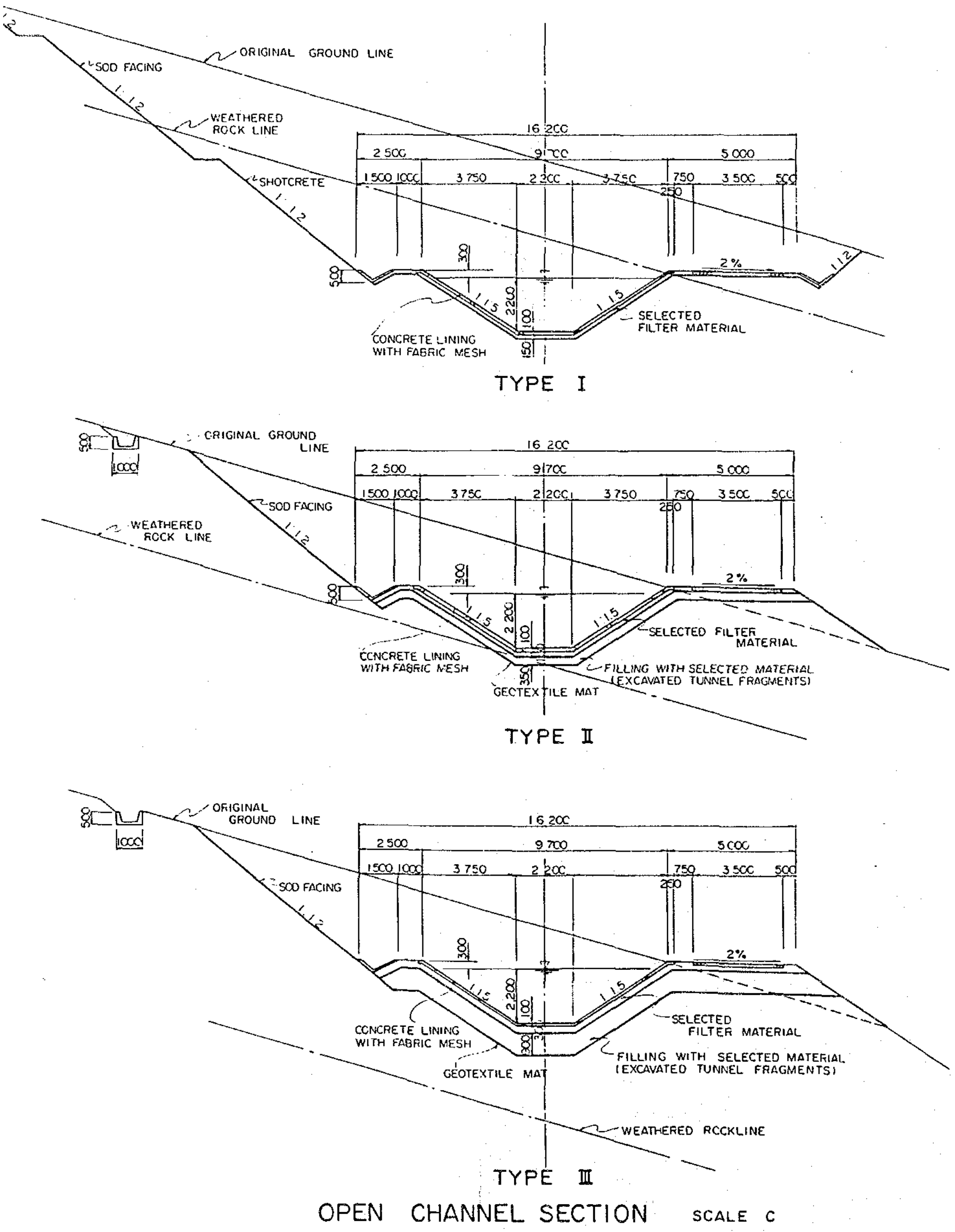


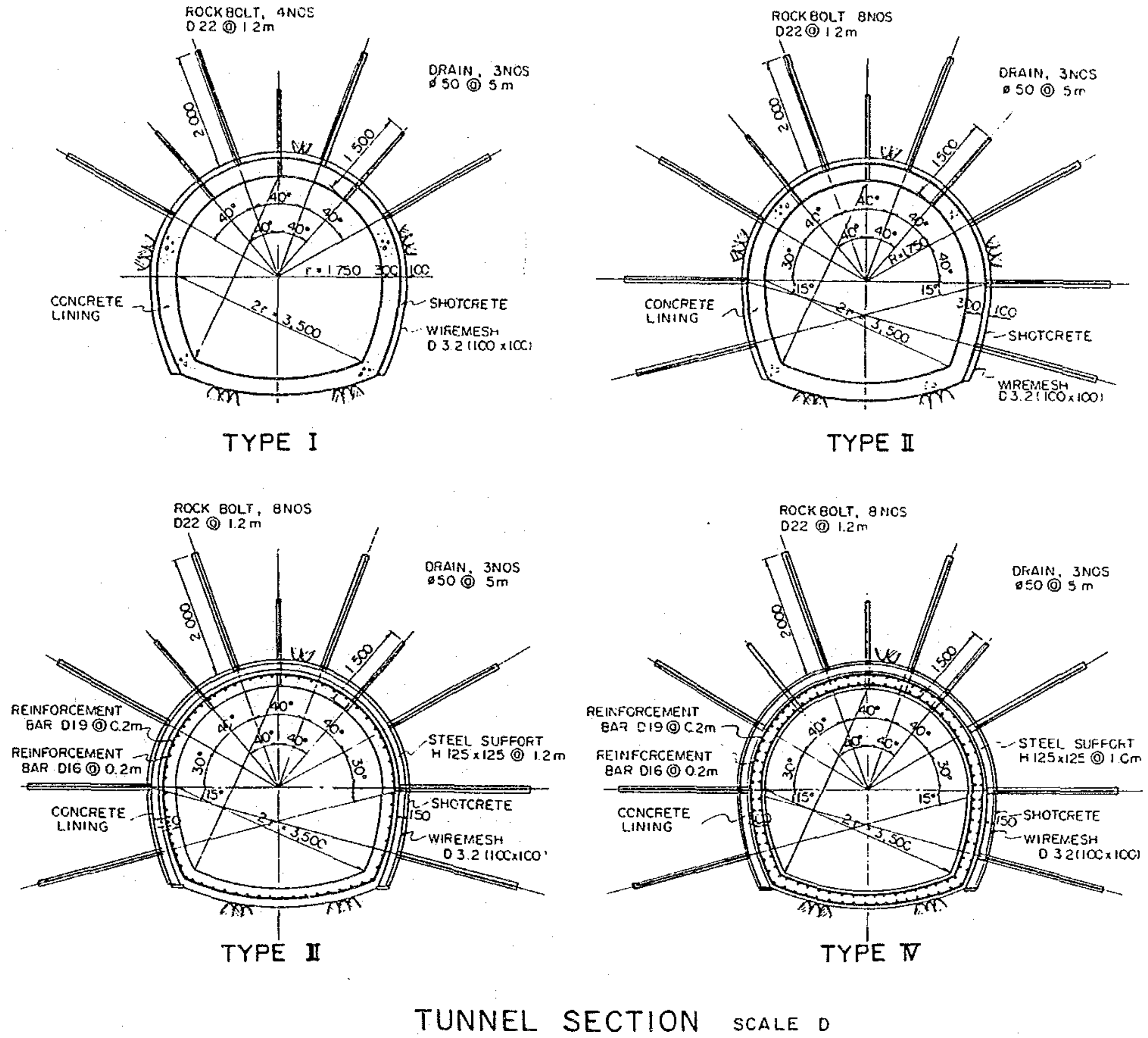
TYPE II



TYPE III

OPEN CHANNEL SECTION





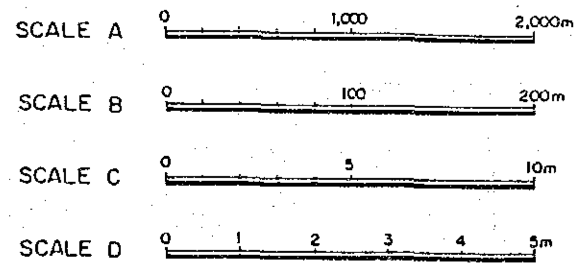


Fig. 11.1 Basic Design of Water Transbasin Scheme "Esperanza (Severino) - Poza Honda Dam"

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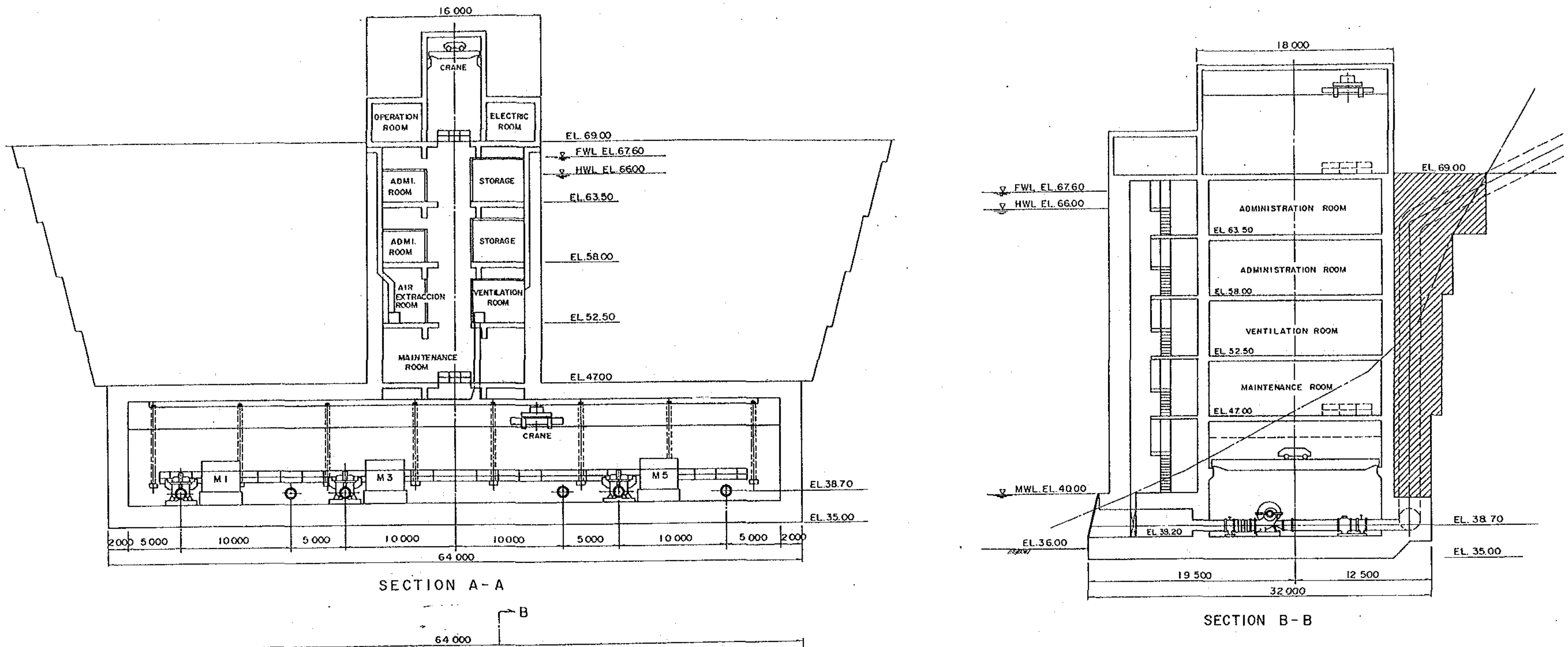

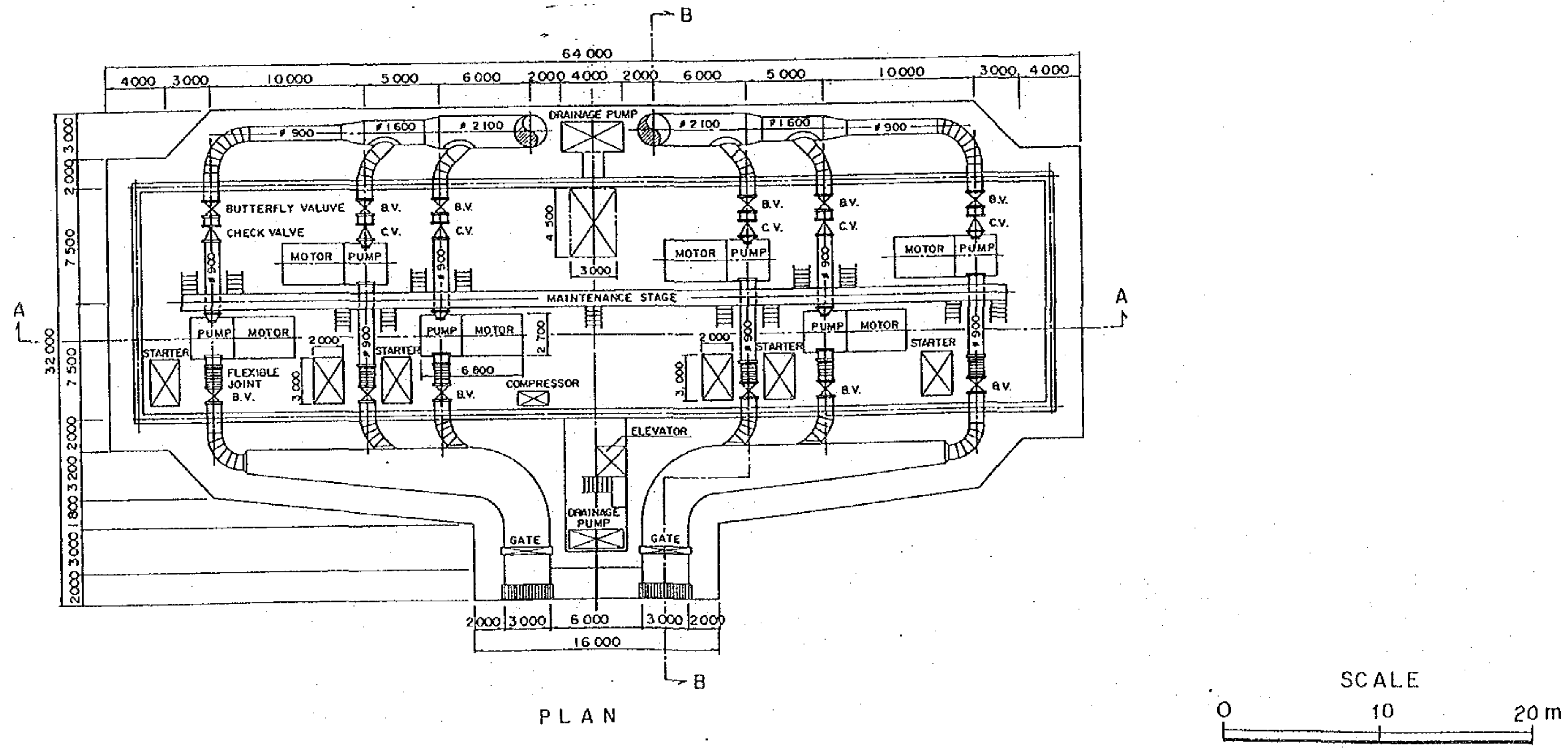

Fig. 11.2 Basic Design of Pumping Station at Severino

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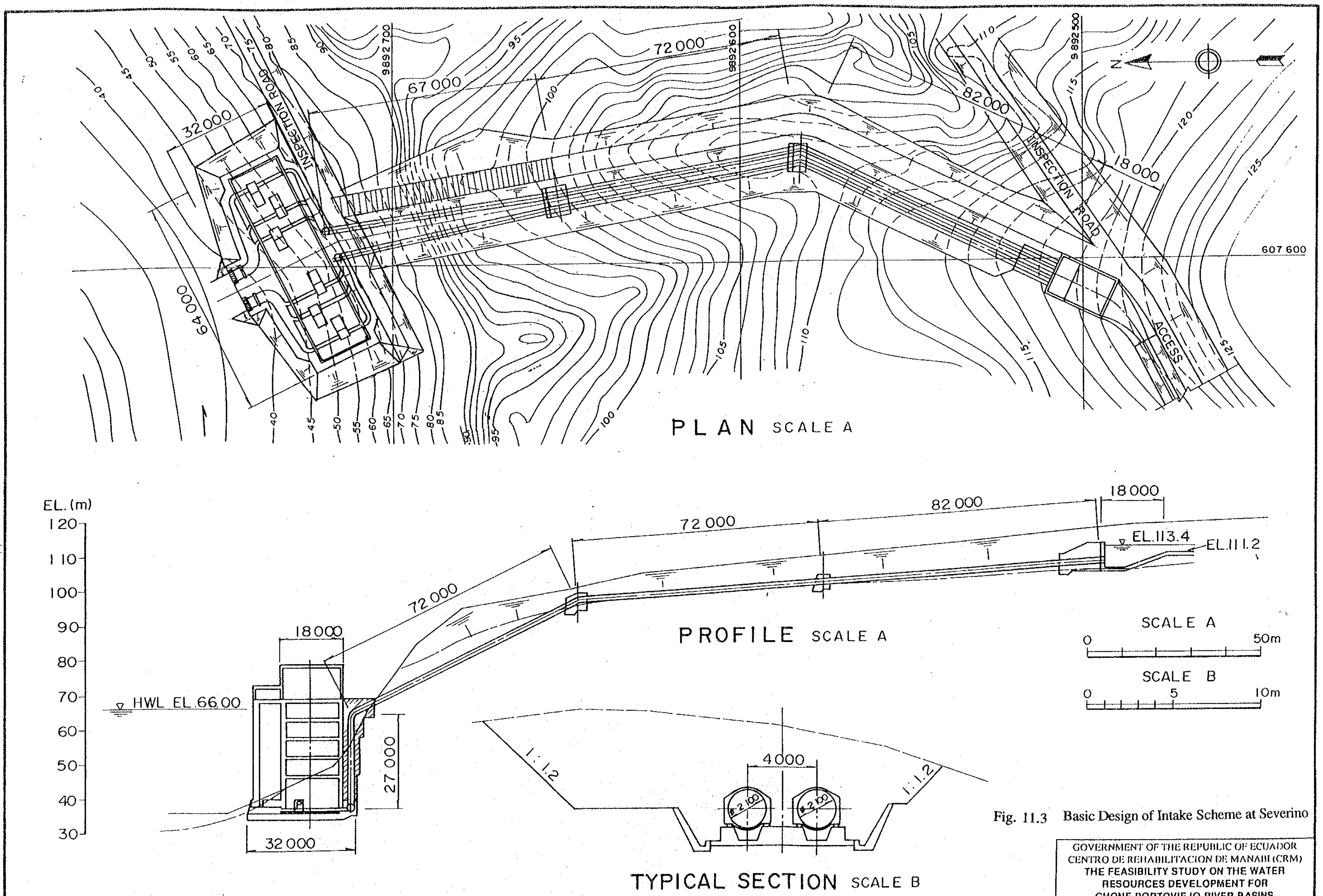

Fig. 11.3 Basic Design of Intake Scheme at Severino

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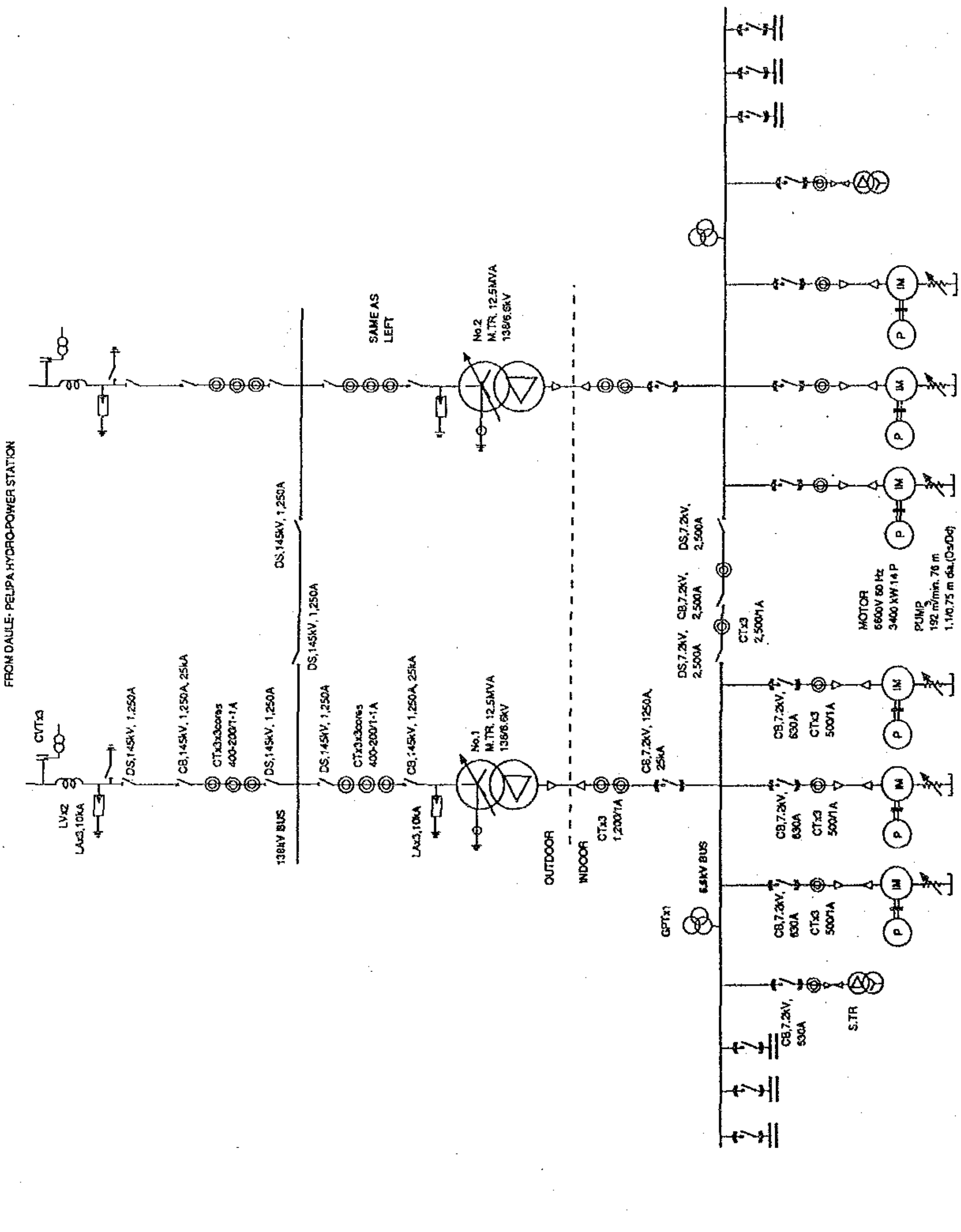

Fig. 11.4 Single Line Diagram
for Severino Pumping Station

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