(2) Material cost

Most of construction materials are supplied from local markets, and therefore the local material prices were canvassed in Portoviejo, Guayaquil and Quito as shown in Table J.3. The local material prices include local net price, inland transportation and sales tax (I.V.A.), and the purchase price at the project site. The imported materials which are not available in local markets are estimated on the exemption of import duties and taxes.

(3) Equipment cost

Equipment and plant for the construction will be provided by the contractor. The prices of equipment are prevailing prices in Japan as of July 1992. The prices of equipment itself are estimated based on the CIF price in Guayaquil. The duties and taxes charged for the import of equipment is excluded in this cost estimate.

The equipment cost is divided into foreign and local portions. The foreign currency portion mainly includes the costs of depreciation, spare parts and consumable, while the local currency portion includes the cost of mechanic labor, the cost for the repair and maintenance and administration expenses. The costs of equipment required for the project are listed in Table J.4.

(4) Contractor's indirect cost

The overhead expenses and profits are contributed to the unit rates of each work item. These expenses are estimated at 25 percent of the direct cost including labor cost, material cost and equipment cost.

(5) Unit price

The unit prices for each work item are estimated in accordance with the above conditions in Table J.9.

2.2.3 Hydromechanical works

The prices for hydromechanical works in each Lot are based on the recent international contract prices of similar works. The cost of imported equipment and materials is estimated at the CIF price in Guayaquil excluding the import duties and taxes. Cost for supply and delivery of imported items, ocean freight and insurance are included in the foreign currency portion. Costs for unloading and other charges at the port and for inland transportation are estimated in the local currency portion. Installation costs are portionally shared by the foreign and local portions.

2.2.4 Transmission line and substation equipment

The prices for tower materials, conductors and substation equipment are estimated at the CIF price in Guayaquil excluding import duties and taxes. The civil works such as site clearance, earthwork and foundation treatment are included in the transmission line cost. Other conditions to estimate the foreign and local portions are the same as those of hydromechanical works.

2.2.5 Constitution of construction cost

- Lot I construction work (Esperanza – Poza Honda and Poza Honda – Rio Mancha Grande Tunnel)

  a) Esperanza – Poza Honda Tunnel
  - Preparatory works
  - Pumping station (including hydromechanical work)
  - Steel pipeline
  - Open channel and syphon
  - Inlet and outlet
  - Tunnel
  - Work adits
  - Access road
  - Transmission line and substation

  b) Poza Honda – Rio Mancha Grande Tunnel
  - Preparatory works
  - Inlet and outlet
  - Tunnel
  - Work adits

– Lot II construction work (Daule Peripa – Esperanza Tunnel)

- Preparatory works
- Inlet and outlet
- Tunnel
- Work adits
- Access road

2.3 Indirect Cost

2.3.1 Land acquisition and compensation

All required land acquisition and compensation shall be carried out by CRM along with the project implementation schedule. Those cost are estimated based on the information of land value and housing value as shown in Table J.5.

2.3.2 Administration expenses

All allowance of 2 percent of the direct construction cost is provided for the executing agency of CRM, which is a part of the local currency portion.

2.3.3 Engineering services

The cost of engineering services for the detailed design including the preparation of tender documents is estimated based on the assumed man-months (Expatriate 127 M/M, Local 70 M/M). As for construction supervision, the engineering services cost is also estimated at about 7.1 percent of the direct construction cost, based on the assumed man-months.

2.3.4 Contingencies

Contingencies are provided to cope with unforeseen physical conditions (physical contingency) and inflation (price escalation). The rate of physical contingency is assumed at 10 percent of an amount required for direct construction cost, land acquisition and compensation, administration expenses and engineering services.

The cost of price escalation is estimated over a period of 7 years from 1994 to 2000 applying the inflation rate of 3 percent per annum for foreign currency portion. As for local currency portion, the price escalation is converted to the foreign currency portion applying the same annual rate, since the escalation rate is assumed to be more than 40 percent per annum and related with the devaluation rate of US$. The cost of price escalation is estimated at a part of the foreign currency.

2.4 Construction Cost

The construction cost of the project excluding price escalation is estimated at S/. 257,956 million (US$ 166.42 million) equivalent in total, consisting of S/. 188,221 million in the foreign currency portion (US$ 121.43 million, 73.0%) and S/. 69,735 million in the local currency portion (27.0%).

The total construction cost of the project including price escalation is estimated at S/. 300,195 million (US$ 193.67 million) equivalent in total, consisting of S/. 230,460 million in the foreign currency portion (US$ 148.68 million, 76.8%) and S/. 69,735 million in the local currency portion (23.2%). The following shows the summary of the total construction cost, and further details are referred to in Tables J.6 and J.7:

	Foreign Currency (1,000 US$)	Local Currency (1,000 S/.)	Total Equivalent (1,000 S/.)
Direct cost	98,983.67	55,260,949	208,685,638
Land acquisition	0	155,000	155,000
Administration expenses	0	4,174,000	4,174,000
Engineering services	11,410.00	3,805,000	21,490,500
Physical contingency	11,039.37	6,339,495	23,450,519
Sub total	121,433.04	69,734,444	257,955,656
Price escalation	27,251.78	0	42,240,259
Total	148,684.82	69,734,444	300,195,915

2.5 Annual Disbursement Schedule

Annual disbursement of the construction cost for the foreign and local currencies is estimated on the basis of the construction schedule and is summarized below, and a further detailed disbursement schedule is tabulated in Table J.8.

	Foreign Currency (1,000 US$)	Local Currency (1,000 S/.)	Total Equivalent (1,000 S/.)
1994	4,248.43	400,950	6,986,017
1995	20,683.46	10,584,583	42,643,946
1996	24,766.97	15,606,500	53,995,303
1997	28,087.95	16,228,644	59,764,967
1998	33,647.56	15,367,239	67,520,957
1999	35,911.41	11,013,341	66,676,026
2000	1,339.04	533,187	2,608,699
Total	148,684.82	69,734,444	300,195,915

TABLES

Table J.1 Major Construction Equipment (1/2)

Description	Spec.	Required Number			
		Esperanza-Poza Honda	Poza Honda-Rio Mancha	Daule Peripa-Esperanza	Total
Bulldozer with ripper	32 ton	1	-	1	2
Bulldozer	21 ton	2	1	4	7
Bulldozer	11 ton	3	2	3	8
Tractor shovel	2.3 m^3	3	1	8	12
Tractor shovel	1.2 m^3	3	2	3	8
Backhoe	0.6 m^3	2	-	2	4
Backhoe	0.3 m^3	2	-	2	4
Dump truck	11 ton	10	4	34	48
Dump truck	8 ton	6	4	6	16
Crawler drill	7 m^3/min	1	1	1	3
Crawler drill	10 m^3/min	3	-	1	4
Air compressor	10 m^3/min	1	1	1	3
Air compressor	13.5 m^3/min	3	-	1	4
Vibrating roller	10 ton	2	-	2	4
Vibrating roller	4 ton	2	1	2	5
Vibrating roller	1 ton	2	2	2	6
Concrete plant	0.75 m^3 x 2	1	-	1	2
Concrete plant	1.0 m^3	2	1	1	4
Agitator truck	3.2 m^3	10	6	8	24
Concrete bucket	1.0 m^3	4	1	1	6
Concrete pump car	45 m^3/hr	1	1	1	3
Truck crane	30 ton	1	1	1	3
Truck crane	20 ton	2	1	1	4
Crawler crane	30 ton	2	-	-	2
Trailer	20 ton	2	1	1	4
Rammer	80 kg	10	5	10	25
Compactor	100 kg	10	5	10	25
Concrete vibrator	55 mm	20	10	10	40
Arm type tunneling machine	65 kw	3	2	3	8
Muck loader, inclined	0.3 m^3	1	-	1	2
Muck car	3 m^3	15	10	15	40

Table J.1 Major Construction Equipment (2/2)

Description	Spec.	Required Number			
		Esperanza-Poza Honda	Poza Honda-Rio Mancha	Daule Peripa-Esperanza	Total
Battery locomotive	8 ton	3	2	3	8
Air compressor	16 m^3/min	3	2	3	8
Vent fan	300 m^3/min	40	15	32	87
Vent fan	100 m^3/min	12	4	12	28
Winch	150 kw	1	1	2	4
Leg hammer	2.7 m^3/min	9	6	9	24
Pick hammer	7 kg	15	10	15	40
Jack hammer	2.4 m^3/min	5	3	5	13
Stopper drill	2.7 m^3/min	5	5	5	15
Shotcrete spray gun	10 m^3/hr	3	2	3	8
Concrete presscrete	3 m^3	12	8	12	32
Battery locomotive	6 ton	6	4	6	16
Agitator car	3 m^3	8	4	6	18
Concrete vibrator	55 mm	15	10	15	40
Form vibrator	0.2 kw	15	10	15	40
Sliding form, 3.7 m dia., 12 m long		-	-	3	3
Sliding form, 3.5 m dia., 12 m long		3	-	-	3
Sliding form, 2.5 m dia., 12 m long		-	2	-	2
Diesel generator	300 kw	6	2	6	14
Diesel generator	200 kw	6	2	6	14
Motor grader	3.7 m	1	-	2	3
Macadam roller	10 ton	1	-	1	2
Tire roller	20 ton	1	-	1	2
Asphalt distributor	4 kl	1	-	1	2
Emulsion sprayer	200 lit	1	-	1	2
Water sprinkler	5.5 klit	2	-	2	4

Table J.2 Labor Cost (Labor Wage)

Description	Unit	Foreign Currency (US$)	Local Currency (S/.)
Foreman, foreign	M.D.	234	-
Technician, foreign	M.D.	156	-
Foreman, tunnel	M.D.		12,000
Foreman	M.D.	-	7,800
Mechanic	M.D.	-	10,200
Electrician	M.D.	-	10,200
Operator, heavy	M.D.	-	10,800
Operator, light	M.D.	-	9,000
Assistant operator	M.D.	-	7,800
Plant operator	M.D.	-	9,200
Driver, dump truck	M.D.	-	7,200
Driver, ordinary	M.D.	-	6,900
Rigger	M.D.	-	6,900
Carpenter	M.D.	-	6,900
Formworker	M.D.	-	6,900
Concrete worker	M.D.	-	6,900
Driller	M.D.	-	8,000
Tunnel worker	M.D.	-	8,000
Pipe fitter	M.D.	-	6,900
Brick worker	M.D.	-	6,900
Mason	M.D.	-	6,900
Plumber	M.D.	-	6,900
Painter	M.D.	-	6,900
Welder	M.D.	-	10,200
Plasterer	M.D.	-	6,900
Powderman	M.D.	-	10,200
Reinforcing worker	M.D.	-	6,900
Boring worker	M.D.	-	9,000
Grout worker	M.D.	-	9,000
Pavement worker	M.D.	-	6,900
Skilled worker	M.D.	-	8,000
Semi skilled worker	M.D.	-	6,900
Common labor	M.D.	-	6,600

Table J.3 Construction Material Cost (1/2)

Description	Unit	Foreign Currency (US$)	Local Currency (S/.)
Gasoline	litre	0.02	149
Light oil	litre	0.02	144
Lubricant	litre	0.30	2,168
Grease	kg	0.41	2,962
Heavy oil	litre	0.02	144
Electric	kwh	0.00	54
Portland cement	ton	41.17	49,091
Bitumen 80/100	kg	0.01	85
Bitumen MC30	litre	0.01	85
Emulsion, K170	litre	0.01	85
Reinforcement, round	ton	259.23	309,091
Reinforcement, deformed	ton	263.04	313,637
Annealed iron wire	kg	0.55	653
Channel steel	ton	312.59	372,728
Steel plate	ton	423.52	505,000
Angle steel	ton	358.34	427,273
Nail	kg	0.42	501
Dynamite	kg	0.00	5,520
ANFO	kg	0.00	1,035
Detonator, delay, open	No	0.00	2,990
Detonator, relay, tunnel	No	0.00	2,990
Lead wire	m	0.00	489
Timber, square	m^3	26.39	194,318
Timber, plank	m^3	23.46	172,727
Timber, log	m^3	23.46	172,727
Plywood	m^3	175.95	354,546
Birbed wire	kg	0.46	551
Concrete aggregate	m^3	14.45	12,800
Sand	m^3	19.88	17,600
Base	m^3	12.83	11,360
Subbase	m^3	12.73	11,280
Chipping	m^3	14.45	12,800
Rubble, cobble	m^3	13.01	11,520
Gabion rock	m^3	12.96	11,480
Stone pitching	m^3	13.55	12,000
Lead wire	m	0.05	6
H-shape steel	ton	562.50	61,034
Fablic mesh	m^2	3.61	392
Bit, 65 mm	No	221.29	24,011
Rod, 3 m	No	309.80	33,616
Sleeve	No	79.66	8,644
Shank rod	No	230.14	24,972
Bit, 36 mm	No	53.11	5,763
Taper rod, 2 m	No	79.66	8,644

Table J.3 Construction Material Cost (2/2)

Description	Unit	Foreign Currency (US$)	Local Currency (S/.)
Bit 75 mm	No	283.25	30,734
Taper rod, 1.5 m	No	65.50	7,107
Insert bit, 36 mm, 1.7 m	No	115.95	12,582
Air entrain agent	kg	2.06	224
Water reduced agent	kg	3.01	326
Metal form, 300 x 1500	No	22.34	2,424
Bolt and nut	No	0.27	29
Clamp	No	2.66	288
Crip	No	0.31	34
Anchor bolt, 22 mm, 0.4 m	No	1.34	145
Metal form, 200 x 1500	No	22.34	2,424
Cone	No	0.17	19
Separator, 8-10 mm	m	0.70	76
Form oil	litre	2.15	233
Metal form 150 x 1500	No	16.76	1,818
Metal form 100 x 1500	No	15.47	1,678
Hunch form, 200 x 1500	No	31.37	3,404
Pipe support	m	24.06	2,611
Portal frame	No	33.60	3,646
Scaffolding pipe	m	2.57	280
Air bubble agent	kg	6.19	671
Gas pipe, 50 mm	m	4.21	457
PVC pipe, 40 mm	m	2.06	224
Lozenge shape net	m^2	5.24	569
Gabion, 0.4 x 1.2 m, 3.2 mm	m	16.07	1,744
Waterstop, 200 mm	m	10.74	1,166
PVC pipe, 50 mm	m	2.84	308
Ventilation pipe, 600 mm	m	12.38	1,343
Water pipe, 100 mm	m	9.45	1,026
Water pipe, 150 mm	m	15.75	1,709
Rock bolt, 22 mm	m	5.24	569
Wire mesh, 3.2 mm, 100	m^2	1.80	196

Table J.4 Equipment Cost (1/2)

Description	Unit	Foreign Currency (US$)	Local Currency (S/.)
Bulldozer, 21 ton	Hr	37.71	15,888
Bulldozer, 15 ton	Hr	23.41	9,864
Bulldozer, 11 ton	Hr	18.85	7,944
Bulldozer w/ripper 32 ton	Hr	59.60	25,917
Backhoe, 0.6 m^3	Hr	22.16	9,334
Backhoe, 0.2 m^3	Hr	11.36	4,621
Tractor shovel, 2.2 m^3	Hr	28.13	11,850
Tractor shovel, 1.2 m^3	Hr	15.09	6,140
Dump truck, 11 ton	Hr	12.88	5,237
Dump truck, 8 ton	Hr	9.05	3,684
Truck crane, 30 ton	Hr	46.32	16,893
Crawler drill, 10 m^3/min	Hr	20.78	7,770
Jack hammer, 20 kg	Day	7.02	1,592
Leg hammer, 30 kg	Day	9.36	2,122
Pick hammer, 7 kg	Day	1.27	289
Motor grader, 3.7 m	Hr	20.23	8,227
Macadam roller 10-12 ton	Hr	11.85	4,322
Tire roller, 8-20 ton	Hr	13.10	4,779
Vibrating roller, 1 ton	Hr	4.81	1,661
Vibrating roller, 10 ton	Hr	29.56	11,800
Rammer, 60-100 kg	Day	7.05	2,200
Compactor, 90 kg	Day	5.58	1,742
Concrete plant, 0.75 x 2	Hr	84.48	31,587
Agitator truck, 3.2 m^3	Hr	14.41	5,866
Concrete pump car, 45 m^3/Hr	Hr	36.22	14,736
Air compressor, 10.5 m^3/min	Day	94.43	34,441
Air compressor, 13.5 m^3/min	Day	105.52	38,486
Diesel generator, 200 kVA	Day	56.94	19,046
Diesel generator, 300 kVA	Day	84.97	28,420
Concrete bucket, 1 m^3	Day	16.85	5,814
Concrete vibrator, 60 mm	Day	5.32	1,451
Form vibrator	Day	1.41	385
Concrete spray gun	Hr	9.17	3,258
Sprinkler, 5.5 kl	Hr	8.54	3,475
Tunnel machine, arm type	Hr	238.20	73,631
Vent fan, 450 m^3/min	Day	31.33	10,132
Vent fan, 100 m^3/min	Day	2.73	884
Air compressor, 27 m^3/min	Hr	12.38	4,274
Muck loader, rail, 0.4 m^3	Hr	40.97	15,677
Muck car, 3 m^3	Day	20.84	8,152
Battery locomotive, 6 ton	Hr	37.77	18,642
Battery locomotive, 8 ton	Hr	46.30	22,851
Rail, 22 kg/m	Day	1.02	278
Guide shell	Day	18.72	4,244
Winch, 200 kw	Day	567.35	263,397

Table J.4 Equipment Cost (2/2)

Description	Unit	Foreign Currency (US$)	Local Currency (S/.)
Air compressor, 16 m^3/min	Hr	9.70	3,344
Vent fan, 300 m^3/min	Day	34.18	11,053
Batcher plant, 25 m^3/Hr	Hr	83.00	29,478
Spray machine, shotcrete	Hr	31.59	11,809
Concrete placer, 3 m^3	Hr	29.48	10,173
Air compressor, 22 m^3/min	Hr	12.38	4,274
Muck car, 4.5 m^3	Day	23.93	9,358
Winch, 100 kw	Day	292.27	135,689
Agitator car, 3 m^3	Hr	24.35	8,403
Muck loader, incline, 0.2 m^3	Hr	37.33	14,288

Table J.5 Land Acquisition and Compensation

Description	Amount (1,000 S/.)
Lot I Construction work (150 ha)	90,000
Lot II Construction work (50 ha)	30,000
Housing (50 Nos.)	35,000
Total	155,000

Table J.6 Construction Cost

Description	Foreign Currency (1,000 US$)	Local Currency (1,000 S/.)	Total Equivalent (1,000 S/.)
1. Lot I Construction work			
1.1 Esperanza – Poza Honda Tunnel	58,536.81	30,045,218	120,777,274
1.2 Poza Honda – Rio Mancha Tunnel	8,667.07	5,017,749	18,451,708
Sub total (1)	67,203.88	35,062,967	139,228,981
2. Lot II Construction work (Daule Peripa – Esperanza Tunnel)	31,779.79	20,197,982	69,456,657
Total (1 and 2)	98,983.67	55,260,949	208,685,638
3. Land acquisition and compensation	0	155,000	155,000
4. Administration expenses	0	4,174,000	4,174,000
5. Engineering services	11,410.00	3,805,000	21,490,500
Total (1 to 5)	110,393.67	63,394,949	234,505,138
6. Physical contingency	11,039.37	6,339,495	23,450,519
Total (1 to 6)	121,433.04	69,734,444	257,955,656
7. Price escalation	27,251.78	0	42,240,259
Grand total	148,684.82	69,734,444	300,195,915

Table J.7 Detailed Construction Cost (1/2)

	Description	Foreign Currency (1,000 US$)	Local Currency (1,000 S/.)	Total Equivalent (1,000 S/.)
1. Lot I	Esperanza – Poza Honda and Poza Honda – Rio Mancha Tunnel Construction			
1.1	Esperanza – Poza Honda Tunnel			
(1)	Preparatory works	3,230.37	2,320,512	7,327,586
(2)	Pumping Station	16,870.62	5,019,234	31,168,695
(3)	Steel pipeline	1,869.79	666,958	3,565,133
(4)	Open Channel and syphon	5,598.21	6,527,548	15,204,774
(5)	Inlet and outlet works	319.18	210,933	705,662
(6)	Tunnel	18,947.76	10,851,370	40,220,398
(7)	Work adits	1,880.88	1,051,663	3,967,027
(8)	Access road	1,720.00	1,444,000	4,110,000
(9)	Transmission line and substation	8,100.00	1,953,000	14,508,000
	Total (1.1)	58,536.81	30,045,218	120,777,274
1.2	Poza Honda – Rio Mancha Tunnel			
(1)	Preparatory works	787.92	456,159	1,677,435
(2)	Inlet and outlet works	1,769.92	896,360	3,639,736
(3)	Tunnel	5,529.25	3,337,441	11,907,779
(4)	Work adits	579.98	327,789	1,226,758
	Total (1.2)	8,667.07	5,017,749	18,451,708
	Total (1)	67,203.88	35,062,967	139,228,981
2. Lot II	Daule Peripa – Esperanza Tunnel Construction			
(1)	Preparatory works	2,889.07	1,836,180	6,314,239
(2)	Inlet and outlet works	1,953.86	819,691	3,848,174
(3)	Tunnel	16,452.67	9,516,766	35,018,405
(4)	Work adits	2,158.00	1,198,908	4,543,808
(5)	Access road	8,326.19	6,826,437	19,732,032
	Total (2)	31,779.79	20,197,982	69,456,657
	Total (1 to 2)	98,983.67	55,260,949	208,685,638

Table J.7 Detailed Construction Cost (2/2)

Description	Foreign Currency (1,000 US$)	Local Currency (1,000 S/.)	Total Equivalent (1,000 S/.)
3. Land acquisition and compensation	0.00	155,000	155,000
4. Administration expenses	0.00	4,174,000	4,174,000
5. Engineering services			
5.1 Detailed design	4,030.00	405,000	6,651,500
5.1 Construction supervision	7,380.00	3,400,000	14,839,000
Total (5)	11,410.00	3,805,000	21,490,500
Total (1 to 5)	110,393.67	63,394,949	234,505,138
6. Physical contingency	11,039.37	6,339,495	23,450,519
Total (1 to 6)	121,433.04	69,734,444	257,955,656
7. Price escalation	27,251.78	0	42,240,259
Grand Total	148,684.82	69,734,444	300,195,915

Remarks: Escalation amount of LC portion is converted to FC(US$), since the rate of LC is estimated at more than 40% per annum and related with devaluation rate of US$.

Table J.8 Disbursement Schedule

Unit : 1,000 US$, 1,000 S/.

Description	Total		1992		1993		1994		1995		1996		1997		1998		1999		2000	
	F.C.(US$)	L.C.(S/.)	F.C.(US$)	L.C.(S/.)	F.C.(US$)	L.C.(S/.)	F.C.(US$)	L.C.(S/.)	F.C.(US$)	L.C.(S/.)	F.C.(US$)	L.C.(S/.)	F.C.(US$)	L.C.(S/.)	F.C.(US$)	L.C.(S/.)	F.C.(US$)	L.C.(S/.)	F.C.(US$)	L.C.(S/.)
1. Esperanza-Poza Honda and Poza Honda-Rio Mancha Tunnel Construction(Lot I)																				
1.1 Esperanza-Poza Honda Tunnel																				
1.1 Preparotory work	3,230.37	2,320,512	0.00	0	0.00	0	0.00	0	484.55	348,077	2,584.30	1,856,410	0.00	0	0.00	0	0.00	0	161.52	116,025
1.2 Pumping station	16,870.62	5,019,234	0.00	0	0.00	0	0.00	0	0.00	0	1,731.22	2,143,165	236.62	309,478	3,427.64	590,316	11,177.09	1,924,943	298.05	51,332
1.3 Steel pipeline	1,869.79	666,958	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	1,856.46	653,256	13.33	13,702	0.00	0
1.4 Open channel & syphon	5,598.21	6,527,548	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	1,801.56	2,028,677	2,755.99	3,179,733	1,040.66	1,319,138	0.00	0
1.5 Inlet & outlet works	319.18	210,933	0.00	0	0.00	0	0.00	0	0.00	0	194.50	141,833	0.00	0	40.52	54,606	84.16	14,494	0.00	0
1.6 Tunnel	18,947.76	10,851,370	0.00	0	0.00	0	0.00	0	0.00	0	3,789.55	2,170,274	5,684.33	3,255,411	5,684.33	3,255,411	3,789.55	2,170,274	0.00	0
1.7 Work adits	1,880.88	1,051,663	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	1,880.88	1,051,663	0.00	0	0.00	0	0.00	0
1.8 Access road	1,720.00	1,444,000	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	1,720.00	1,444,000	0.00	0	0.00	0	0.00	0
1.9 Transmission line & substation	8,100.00	1,953,000	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	1,863.00	449,190	6,075.00	1,464,750	162.00	39,060
Total(1.1)	58,536.81	30,045,218	0.00	0	0.00	0	0.00	0	484.55	348,077	8,299.57	6,311,682	11,323.39	8,089,229	15,627.94	8,182,512	22,179.79	6,907,301	621.57	206,417
1.2 Poza Honda-Rio Mancha Tunnel																				
1.1 Preparotory work	787.92	456,159	0.00	0	0.00	0	0.00	0	157.58	91,232	630.34	364,927	0.00	0	0.00	0	0.00	0	0.00	0
1.2 Inlet & outlet works	1,769.92	896,360	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	784.10	679,590	985.82	216,770	0.00	0	0.00	0
1.3 Tunnel	5,529.25	3,337,441	0.00	0	0.00	0	0.00	0	0.00	0	1,930.91	1,056,925	2,431.13	1,424,002	1,167.21	856,514	0.00	0	0.00	0
1.4 Work adit	579.98	327,789	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	579.98	327,789	0.00	0	0.00	0	0.00	0
Total(1.2)	8,667.07	5,017,749	0.00	0	0.00	0	0.00	0	157.58	91,232	2,561.25	1,421,852	3,795.21	2,431,381	2,153.03	1,073,284	0.00	0	0.00	0
Total(1)	67,203.88	35,062,967	0.00	0	0.00	0	0.00	0	642.13	439,309	10,860.82	7,733,534	15,118.60	10,520,610	17,780.97	9,255,796	22,179.79	6,907,301	621.57	206,417
2. Daule Peripa-Esperanza Tunnel Construction(Lot II)																				
2.1 Preparotory work	2,889.07	1,836,180	0.00	0	0.00	0	0.00	0	433.36	275,427	2,311.26	1,468,944	0.00	0	0.00	0	0.00	0	144.45	91,809
2.2 Inlet & outlet works	1,953.86	819,691	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	409.24	371,935	1,518.07	443,046	26.55	4,710
2.3 Tunnel	16,452.67	9,516,766	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	4,113.17	2,379,191	8,226.33	4,758,383	4,113.17	2,379,192	0.00	0
2.4 Work adit	2,158.00	1,198,908	0.00	0	0.00	0	0.00	0	0.00	0	1,510.60	839,236	647.40	359,672	0.00	0	0.00	0	0.00	0
2.5 Access road	8,326.19	6,826,437	0.00	0	0.00	0	0.00	0	0.00	0	5,828.33	4,778,506	2,497.86	2,047,931	0.00	0	0.00	0	0.00	0
Total(2)	31,779.79	20,197,982	0.00	0	0.00	0	0.00	0	433.36	275,427	9,650.19	7,086,686	7,258.43	4,786,794	8,635.57	5,130,318	5,631.24	2,822,238	171.00	96,519
Total(1 and 2)	98,983.67	55,260,949	0.00	0	0.00	0	0.00	0	1,075.49	714,736	20,511.01	14,820,220	22,377.03	15,307,404	26,416.54	14,386,114	27,811.03	9,729,539	792.57	302,936
Disburse/Advace 15%			0.00	0	0.00	0	0.00	0	15,761.71	8,896,668	17,434.36	12,597,187	19,020.48	13,011,293	22,454.06	12,228,197	23,639.38	8,270,108	673.68	257,496
3. Land Acquisition and Compensation	0.00	155,000	0.00	0	0.00	0	0.00	0	0.00	155,000	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
4. Administration Expenses	0.00	4,174,000	0.00	0	0.00	0	0.00	0	0.00	292,180	0.00	876,540	0.00	960,020	0.00	960,020	0.00	960,020	0.00	125,220
5. Engineering Services																				
5.1 Detailed Design	4,030.00	405,000	0.00	0	0.00	0	3,627.00	364,500	403.00	40,500	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
5.1 Supervision	7,380.00	3,400,000	0.00	0	0.00	0	0.00	0	516.60	238,000	1,549.80	714,000	1,697.40	782,000	1,697.40	782,000	1,697.40	782,000	221.40	102,000
Total(5)	11,410.00	3,805,000	0.00	0	0.00	0	3,627.00	364,500	919.60	278,500	1,549.80	714,000	1,697.40	782,000	1,697.40	782,000	1,697.40	782,000	221.40	102,000
6. Phisical Contingency	11,039.37	6,339,495	0.00	0	0.00	0	362.70	36,450	1,668.13	962,235	1,898.42	1,418,773	2,071.79	1,475,331	2,415.15	1,397,022	2,533.68	1,001,213	89.50	48,471
Total(1 to 6)	121,433.04	69,734,444	0.00	0	0.00	0	3,989.70	400,950	18,349.44	10,584,583	20,882.58	15,606,500	22,789.67	16,228,644	26,566.61	15,367,239	27,870.46	11,013,341	984.58	533,187
7. Price Escalation	27,251.78	0	0.00	0	0.00	0	258.73	0	2,334.02	0	3,884.39	0	5,298.28	0	7,080.95	0	8,040.95	0	354.46	0
Grand Total	148,684.82	69,734,444	0.00	0	0.00	0	4,248.43	400,950	20,683.46	10,584,583	24,766.97	15,606,500	28,087.95	16,228,644	33,647.56	15,367,239	35,911.41	11,013,341	1,339.04	533,187

Table J. 9 Breakdown of Construction Cost (1/11)

Item No.	Work	Unit	Quantity	Foreign Currency (US$) Unit Price	Amount	Local Currency (s/.) Unit Price	Amount
Lot-I	Esperanza-Poza Honda Tunnel and Poza Honda-Rio Mancha Tunnel *Construction*						
	A. Esperanza-Poza Honda Tunnel						
1.	General (Preparatory works)	L.S.			3,230,366.34		2,320,511,572
2.	Pumping station						
2.1	Earthworks						
	Site clerance	ha	1.4	391.40	547.96	265900	372,260
	Excavation,common	m3	8,400	2.39	20,076.00	1765	14,826,000
	Excavation,rock	m3	32,000	6.44	206,080.00	4781	152,992,000
	Shotcrete,slope protection	m2	6,000	12.53	75,180.00	10387	62,322,000
	Anchor bar,slope protection	m	1,500	10.02	15,030.00	4539	6,808,500
	Drain hole	m	800	9.77	7,816.00	4776	3,820,800
	Wet rubble masonry	m2	500	22.22	11,110.00	25596	12,798,000
	Gravel bedding	m3	600	17.66	10,596.00	24095	14,457,000
	Others(5%)	L.S.			*17,321.80*		*13,419,828*
	Subtotal of item 2.1				363,757.76		281,816,388
2.2	Concrete work						
	Concrete,substructure	m3	11,300	53.38	603,194.00	49062	554,400,600
	Concrete,structure	m3	1,300	58.37	75,881.00	51749	67,273,700
	Concrete,around steel pipe	m3	2,000	52.37	104,740.00	47314	94,628,000
	Form,substructure	m2	13,000	2.86	37,180.00	12226	158,938,000
	Form,structure	m2	800	2.95	2,360.00	16015	12,812,000
	Reinforcement	ton	1,835.0	337.27	618,890.45	585878	1,075,086,130
	Others(5%)	L.S.			72,112.27		98,156,922
	Subtotal of item 2.2				1,514,357.72		2,061,295,352
2.3	Miscellaneous work						
	Base	m3	430	23.13	9,945.90	20662	8,884,660
	Bituminous surfacing	m2	2,900	0.87	2,523.00	1365	3,958,500
	Fence	m	380	20.00	7,600.00	7750	2,945,000
	Gate	No	2	240.00	480.00	93000	186,000
	Others(5%)	L.S.			1,027.45		798,708
	Subtotal of item 2.3				21,576.35		16,772,868
2.4	Building work	L.S.			45,430.73		61,838,861
2.5	Electrical work	L.S.			22,715.37		30,919,431

Table J. 9 Breakdown of Construction Cost (2/11)

Item No.	Work	Unit	Quantity	Foreign Currency (US$) Unit Price	Foreign Currency (US$) Amount	Local Currency (s/.) Unit Price	Local Currency (s/.) Amount
2.6	Mechanical work						
	Pumps and motors	L.S.			6,929,307.00		1,193,380,650
	Valves and pipes	L.S.			2,379,375.00		409,781,250
	Overhead travelling crane	L.S.			436,671.00		75,204,450
	Operation,control and instrumentation panels	L.S.			5,157,432.00		888,224,400
	Subtotal of item 2.6				14,902,785.00		2,566,590,750
	Subtotal of item 2				16,870,622.93		5,019,233,650
3.	Steel pipeline						
3.1	Earthworks						
	Site clerance	ha	0.6	391.40	234.84	265900	159,540
	Excavation,common	m3	23,100	2.39	55,209.00	1765	40,771,500
	Excavation,weathered rock	m3	8,300	3.38	28,054.00	2433	20,193,900
	Excavation,rock	m3	1,600	6.44	10,304.00	4781	7,649,600
	Shotcrete,slope protection	m2	800	12.53	10,024.00	10387	8,309,600
	Anchor bar,slope protection	m	400	10.02	4,008.00	4539	1,815,600
	Sod facing,slope protection	m2	2,600	0.20	520.00	745	1,937,000
	Gravel bedding	m3	400	17.66	7,064.00	24095	9,638,000
	Others(5%)	L.S.			5,770.89		4,523,737
	Subtotal of item 3.1				121,188.73		94,998,477
3.2	Concrete work						
	Concrete,base,anchor block	m3	500	52.37	26,185.00	47314	23,657,000
	Concrete,structure	m3	2,900	58.37	169,273.00	51749	150,072,100
	Form,structure	m2	3,700	2.95	10,915.00	16015	59,255,500
	Reinforcement	ton	140.0	337.27	47,217.80	585878	82,022,920
	Others(5%)	L.S.			12,679.54		15,750,376
	Subtotal of item 3.2				266,270.34		330,757,896
3.3	Steel pipe installation	m	500	2938.00	1,469,000.00	455000	227,500,000
	Subtotal of item 3.3				1,469,000.00		227,500,000
3.4	Inspction road						
	Base	m3	440	23.13	10,177.20	20662	9,091,280
	Bituminous surfacing	m2	2,900	0.87	2,523.00	1365	3,958,500
	Others(5%)	L.S.			635.01		652,489
	Subtotal of item 3.4				13,335.21		13,702,269
	Subtotal of item 3				1,869,794.28		666,958,642

Table J. 9 Breakdown of Construction Cost (3/11)

Item No.	Work	Unit	Quantity	Foreign Currency (US$) Unit Price	Foreign Currency (US$) Amount	Local Currency (s/.) Unit Price	Local Currency (s/.) Amount
4.	Open channel and syphon						
4.1	Earthworks						
	Site clerance	ha	20.1	391.40	7,867.14	265900	5,344,590
	Excavation,common	m3	571,500	2.20	1,257,300.00	1596	912,114,000
	Excavation,weathered rock	m3	100,000	3.19	319,000.00	2242	224,200,000
	Excavation,rock	m3	37,400	6.23	233,002.00	4578	171,217,200
	Fill and backfill,tunnel rock	m3	11,800	3.08	36,344.00	2360	27,848,000
	Selected sand & gravel fill	m3	18,400	17.66	324,944.00	24095	443,348,000
	Random backfill	m3	65,300	2.95	192,635.00	2111	137,848,300
	Excavation,structure,drain	m3	3,200	3.33	10,656.00	2551	8,163,200
	Shotcrete,slope protection	m2	15,000	12.53	187,950.00	10387	155,805,000
	Anchor bar,slope protection	m	3,800	10.02	38,076.00	4539	17,248,200
	Drain hole	m	1,900	9.77	18,563.00	4776	9,074,400
	Sod facing,slope protection	m2	60,000	0.20	12,000.00	745	44,700,000
	Gravel bedding	m3	4,300	17.66	75,938.00	24095	103,608,500
	Gabion	m3	540	58.16	31,406.40	24066	12,995,640
	Geotextile	m2	20,200	3.61	72,922.00	1394	28,158,800
	Others(5%)	L.S.			140,930.18		115,083,692
	Subtotal of item 4.1				2,959,533.72		2,416,757,522
4.2	Concrete work						
	Concrete,channel lining	m3	6,500	59.38	385,970.00	53065	344,922,500
	Concrete,syphon culvert	m3	6,600	55.48	366,168.00	49350	325,710,000
	Concrete,structure	m3	1,200	56.55	67,860.00	50538	60,645,600
	Concrete,bridge	m3	350	63.19	22,116.50	56776	19,871,600
	Concrete,drainage structure	m3	3,200	55.48	177,536.00	49350	157,920,000
	Backfill concrete	m3	3,800	50.55	192,090.00	46103	175,191,400
	Form,channel lining	m2	56,400	4.12	232,368.00	21322	1,202,560,800
	Form,syphon culvert	m2	20,000	3.43	68,600.00	17768	355,360,000
	Form,structure	m2	23,600	2.95	69,620.00	16015	377,954,000
	Reinforcement	ton	1,035.0	337.27	349,074.45	585878	606,383,730
	Fabric mesh	m2	65,000	5.11	332,150.00	1328	86,320,000
	Waterstop	m	12,100	13.83	167,343.00	3481	42,120,100
	Others(5%)	L.S.			121,544.80		187,747,987
	Subtotal of item 4.2				2,552,440.75		3,942,707,717
4.3	Inspction road						
	Base	m3	2,840	23.13	65,689.20	20662	58,680,080
	Bituminous surfacing	m2	18,900	0.87	16,443.00	1365	25,798,500
	Fence	m	10,800	0.00	0.00	7000	75,600,000
	Others(5%)	L.S.			4,106.61		8,003,929
	Subtotal of item 4.3				86,238.81		168,082,509
	Subtotal of item 4				5,598,213.27		6,527,547,747

Table J. 9 Breakdown of Construction Cost (4/11)

Item No.	Work	Unit	Quantity	Foreign Currency (US$) Unit Price	Foreign Currency (US$) Amount	Local Currency (s/.) Unit Price	Local Currency (s/.) Amount
5.	Inlet and outlet works						
5.1	Earthworks						
	Site clerance	ha	0.6	391.40	234.84	265900	159,540
	Excavation,common	m3	18,600	2.39	44,454.00	1765	32,829,000
	Excavation,weathered rock	m3	12,000	3.38	40,560.00	2433	29,196,000
	Excavation,rock	m3	900	6.44	5,796.00	4781	4,302,900
	Fill and backfill	m3	200	2.74	548.00	3599	719,800
	Drain hole	m	680	9.77	6,643.60	4776	3,247,680
	Shotcrete,slope protection	m2	5,400	12.53	67,662.00	10387	56,089,800
	Anchor bar,slope protection	m	1,350	10.02	13,527.00	4539	6,127,650
	Gabion	m3	100	58.16	5,816.00	24066	2,406,600
	Others(5%)	L.S.			9,262.07		6,753,949
	Subtotal of item 5.1				194,503.51		141,832,919
5.2	Concrete work						
	Concrete,structure	m3	500	58.37	29,185.00	51749	25,874,500
	Form,structure	m2	900	2.95	2,655.00	16015	14,413,500
	Reinforcement	ton	20.0	337.27	6,745.40	585878	11,717,560
	Others(5%)	L.S.			1,929.27		2,600,278
	Subtotal of item 5.2				40,514.67		54,605,838
5.3	Mechanical work and electrical equipment						
	Inlet mechanical facilities	L.S.			0.00		0
	Outlet mechanical facilities						
	Outlet cscreen	L.S.			13,284.00		2,287,800
	Maintenance gate	L.S.			53,136.00		9,151,200
	Chain block/geared trolley	L.S.			9,477.00		1,632,150
	Accessories	L.S.			8,262.00		1,422,900
	Sub total(Outlet)				84,159.00		14,494,050
	Electrical equipment	L.S.			0.00		0
	Subtotal of item 5.3				84,159.00		14,494,050
	Subtotal of item 5				319,177.18		210,932,807

Table J. 9 Breakdown of Construction Cost (5/11)

Item No.	Work	Unit	Quantity	Foreign Currency (US$) Unit Price	Foreign Currency (US$) Amount	Local Currency (s/.) Unit Price	Local Currency (s/.) Amount
6.	Tunnel						
	Excavation,tunnel	m3	180,100	38.86	6,998,686.00	21946	3,952,474,600
	Shotcrete for tunnel	m3	15,300	157.09	2,403,477.00	91553	1,400,760,900
	Steel wire mesh	m2	115,600	4.68	541,008.00	1547	178,833,200
	Rock bolt	m	112,000	19.06	2,134,720.00	9054	1,014,048,000
	Steel support	ton	345.0	1348.30	465,163.50	183036	63,147,420
	Concrete,tunnel	m3	48,200	70.69	3,407,258.00	61199	2,949,791,800
	Form,tunnel	m2	121,800	17.78	2,165,604.00	4626	563,446,800
	Form,structure	m2	4,000	2.95	11,800.00	16015	64,060,000
	Reinforcement	ton	470	371.00	174,370.00	644465	302,898,550
	Drain hole	m	9,600	9.77	93,792.00	4776	45,849,600
	Others(3%)	L.S.			551,876.36		316,059,326
	Subtotal of item 6				18,947,754.86		10,851,370,196
7.	Work adits						
	Site clearance	ha	0.3	391.40	117.42	265900	79,770
	Excavation,common	m3	9,800	2.39	23,422.00	1765	17,297,000
	Excavation,weathered rock	m3	9,000	3.38	30,420.00	2433	21,897,000
	Shotcrete,slope protection	m2	1,800	12.53	22,554.00	10387	18,696,600
	Anchor bar,slope protection	m	900	10.02	9,018.00	4539	4,085,100
	Excavation,tunnel	m3	10,400	35.06	364,624.00	19557	203,392,800
	Excavation,inclined tunnel	m3	13,500	39.38	531,630.00	23505	317,317,500
	Shotcrete,tunnel	m3	1,740	157.09	273,336.60	91553	159,302,220
	Steel wire mesh	m2	22,350	4.68	104,598.00	1547	34,575,450
	Rock bolt	m	15,300	19.06	291,618.00	9054	138,526,200
	Steel support	ton	26.0	1348.30	35,055.80	183036	4,758,936
	Concrete,tunnel	m3	1,260	60.31	75,990.60	52158	65,719,080
	Form,tunnel	m2	3,280	15.53	50,938.40	7273	23,855,440
	Form,structure	m2	140	2.95	413.00	16015	2,242,100
	Reinforcement	ton	7.0	371.00	2,597.00	644465	4,511,255
	Drain hole	m	1,000	9.77	9,770.00	4776	4,776,000
	Others(3%)	L.S.			54,783.08		30,630,974
	Subtotal of item 7				1,880,885.90		1,051,663,425
8.	Access road						
8.1	Access road to pumping station	m	7,000	160.00	1,120,000.00	136000	952,000,000
8.2	Improvement of existing road to outlet	m	12,000	50.00	600,000.00	41000	492,000,000
	Subtotal of item 8				1,720,000.00		1,444,000,000

Table J. 9 Breakdown of Construction Cost (6/11)

Item No.	Work	Unit	Quantity	Foreign Currency (US$) Unit Price	Foreign Currency (US$) Amount	Local Currency (s/.) Unit Price	Local Currency (s/.) Amount
9.	Transmission line and substation equipment						
	Transmission line,138kV,30km	L.S.			2,592,000.00		1,004,400,000
	Expansion of switchgear	L.S.			972,000.00		167,400,000
	Substation equipment	L.S.			4,536,000.00		781,200,000
	Subtotal of item 9				8,100,000.00		1,953,000,000
	Total (A)				58,536,814.76		30,045,218,038
	B. Poza Honda-Rio Mancha Tunnel						
1.	General (Preparatory works)	L.S.			787,915.22		456,158,958
2.	Inlet and outlet works						
2.1	Earthworks						
	Site clearance	ha	1.1	391.40	430.54	265900	292,490
	Excavation,common	m3	43,500	2.39	103,965.00	1765	76,777,500
	Excavation,weathered rock	m3	27,000	3.38	91,260.00	2433	65,691,000
	Excavation,rock	m3	2,900	6.44	18,676.00	4781	13,864,900
	Fill and backfill	m3	200	2.74	548.00	3599	719,800
	Excavation,shaft	m3	4,200	37.87	159,054.00	41163	172,884,600
	Shotcrete,tunnel and shaft	m3	130	157.09	20,421.70	91553	11,901,890
	Wire mesh	m2	1,200	4.68	5,616.00	1547	1,856,400
	Rock bolt	m	300	19.06	5,718.00	9054	2,716,200
	Drain hole	m	1,300	9.77	12,701.00	4776	6,208,800
	Shotcrete,slope protection	m2	11,000	12.53	137,830.00	10387	114,257,000
	Anchor bar,slope protection	m	2,500	10.02	25,050.00	4539	11,347,500
	Sod facing,slope protection	m2	2,700	0.20	540.00	745	2,011,500
	Gabion	m3	50	58.16	2,908.00	24066	1,203,300
	Geotextile	m2	1,100	3.61	3,971.00	1394	1,533,400
	Others(5%)	L.S.			29,434.46		24,163,314
	Subtotal of item 2.1				618,123.70		507,429,594
2.2	Concrete work						
	Concrete,structure	m3	500	56.55	28,275.00	50538	25,269,000
	Concrete,shaft	m3	1,500	60.31	90,465.00	52158	78,237,000
	Form,structure	m2	900	2.95	2,655.00	16015	14,413,500
	Form,shaft	m2	2,300	15.53	35,719.00	7273	16,727,900
	Reinforcement	ton	120.0	337.27	40,472.40	585878	70,305,360
	Others(5%)	L.S.			9,879.32		10,247,638
	Subtotal of item 2.2				207,465.72		215,200,398

Table J. 9 Breakdown of Construction Cost (7/11)

Item No.	Work	Unit	Quantity	Foreign Currency (US$) Unit Price	Foreign Currency (US$) Amount	Local Currency (s/.) Unit Price	Local Currency (s/.) Amount
2.3	Miscellaneous work						
	Base	m3	160	23.13	3,700.80	20662	3,305,920
	Bituminous surfacing	m2	1,100	0.87	957.00	1365	1,501,500
	Others(5%)	L.S.			232.89		240,371
	Subtotal of item 2.3				4,890.69		5,047,791
2.4	Mechanical work and electrical equipment						
	Inlet mechanical facilities						
	Trashrack	L.S.			26,568.00		4,575,600
	Sleeve valve	L.S.			253,206.00		43,607,700
	Butterfly valve,0.8m	L.S.			215,136.00		37,051,200
	Butterfly valve,0.9m	L.S.			69,579.00		11,983,050
	Steel pipe	L.S.			126,522.00		21,789,900
	Ventilation/duct,generator/ compressor,drain pump/ pipe	L.S.			146,205.00		25,179,750
	Control equipment/panel	L.S.			63,261.00		10,894,950
	Accessories	L.S.			6,966.00		1,199,700
	Subtotal (Inlet)				907,443.00		156,281,850
	Outlet mechanical facilities	L.S.			0.00		0
	Electrical equipment	L.S.			32,000.00		12,400,000
	Subtotal of item 2.4				939,443.00		168,681,850
	Subtotal of item 2				1,769,923.11		896,359,633
3.	Tunnel						
	Excavation,tunnel	m3	39,600	50.73	2,008,908.00	31641	1,252,983,600
	Shotcrete for tunnel	m3	4,600	157.09	722,614.00	91553	421,143,800
	Steel wire mesh	m2	33,000	4.68	154,440.00	1547	51,051,000
	Rock bolt	m	26,100	19.06	497,466.00	9054	236,309,400
	Steel support	ton	210.0	1348.30	283,143.00	183036	38,437,560
	Concrete,tunnel	m3	13,300	73.70	980,210.00	62349	829,241,700
	Form,tunnel	m2	31,900	17.72	565,268.00	5345	170,505,500
	Form,structure	m2	1,100	2.95	3,245.00	16015	17,616,500
	Reinforcement	ton	320.0	371.00	118,720.00	644465	206,228,800
	Drain hole	m	3,500	9.77	34,195.00	4776	16,716,000
	Others(3%)	L.S.			161,046.27		97,207,016
	Subtotal of item 3				5,529,255.27		3,337,440,876

Table J. 9 Breakdown of Construction Cost (8/11)

Item No.	Work	Unit	Quantity	Foreign Currency (US$) Unit Price	Foreign Currency (US$) Amount	Local Currency (s/.) Unit Price	Local Currency (s/.) Amount
4.	Work adits						
	Site clearance	ha	0.1	391.40	39.14	265900	26,590
	Excavation,common	m3	2,300	2.39	5,497.00	1765	4,059,500
	Excavation,weathered rock	m3	1,300	3.38	4,394.00	2433	3,162,900
	Shotcrete,slope protection	m2	500	12.53	6,265.00	10387	5,193,500
	Anchor bar,slope protection	m	250	10.02	2,505.00	4539	1,134,750
	Excavation,inclined tunnel	m3	7,280	39.38	286,686.40	23505	171,116,400
	Shotcrete,tunnel	m3	530	157.09	83,257.70	91553	48,523,090
	Steel wire mesh	m2	6,800	4.68	31,824.00	1547	10,519,600
	Rock bolt	m	4,700	19.06	89,582.00	9054	42,553,800
	Steel support	ton	8.0	1348.30	10,786.40	183036	1,464,288
	Concrete,tunnel	m3	380	60.31	22,917.80	52158	19,820,040
	Form,tunnel	m2	1,000	15.53	15,530.00	7273	7,273,000
	Form,structure	m2	42	2.95	123.90	16015	672,630
	Reinforcement	ton	2.0	371.00	742.00	644465	1,288,930
	Drain hole	m	300	9.77	2,931.00	4776	1,432,800
	Others(3%)	L.S.			16,892.44		9,547,255
	Subtotal of item 4				579,973.78		327,789,073
	Total (B)				8,667,067.38		5,017,748,539
	Total (Lot I)				67,203,882.15		35,062,966,577

Table J. 9 Breakdown of Construction Cost (9/11)

Item No.	Work	Unit	Quantity	Foreign Currency (US$) Unit Price	Amount	Local Currency (s/.) Unit Price	Amount
Lot-II	Daule.Peripa-Esperanza Tunnel Construction						
1.	General (Preparatory works)	L.S.			2,889,071.27		1,836,180,194
2.	Inlet and outlet works						
2.1	Earthworks						
	Site clerance	ha	0.6	391.40	234.84	265900	159,540
	Excavation,common	m3	27,000	2.39	64,530.00	1765	47,655,000
	Excavation,shaft	m3	4,200	37.87	159,054.00	41163	172,884,600
	Shotcrete,tunnel and shaft	m3	140	157.09	21,992.60	91553	12,817,420
	Wire mesh	m2	1,330	4.68	6,224.40	1547	2,057,510
	Rock bolt	m	330	19.06	6,289.80	9054	2,987,820
	Drain hole	m	1,000	9.77	9,770.00	4776	4,776,000
	Shotcrete,slope protection	m2	2,000	12.53	25,060.00	10387	20,774,000
	Anchor bar,slope protection	m	500	10.02	5,010.00	4539	2,269,500
	Gabion	m3	50	58.16	2,908.00	24066	1,203,300
	Others(5%)	L.S.			15,053.68		13,379,235
	Subtotal of item 2.1				316,127.32		280,963,925
2.2	Concrete work						
	Concrete,structure	m3	800	56.55	45,240.00	50538	40,430,400
	Concrete,shaft	m3	2,300	60.31	138,713.00	52158	119,963,400
	Form,structure	m2	1,400	2.95	4,130.00	16015	22,421,000
	Form,shaft	m2	4,100	15.53	63,673.00	7273	29,819,300
	Reinforcement	ton	130.0	337.27	43,845.10	585878	76,164,140
	Others(5%)	L.S.			14,780.06		14,439,912
	Subtotal of item 2.2				310,381.16		303,238,152
2.3	Mechanical work and electrical equipment						
	Inlet mechanical facilities						
	Trashrack	L.S.			26,568.00		4,575,600
	Sleeve valve	L.S.			354,375.00		61,031,250
	Butterfly valve,1.0m	L.S.			341,739.00		58,855,050
	Butterfly valve,1.2m	L.S.			69,579.00		11,983,050
	Steel pipe	L.S.			142,317.00		24,510,150
	Ventilation/duct,generator/ compressor,drain pump/ pipe	L.S.			146,205.00		25,179,750
	Control equipment/panel	L.S.			82,296.00		14,173,200
	Accessories	L.S.			7,614.00		1,311,300
	Sub total (Inlet)				1,170,693.00		201,619,350

Table J. 9 Breakdown of Construction Cost (10/11)

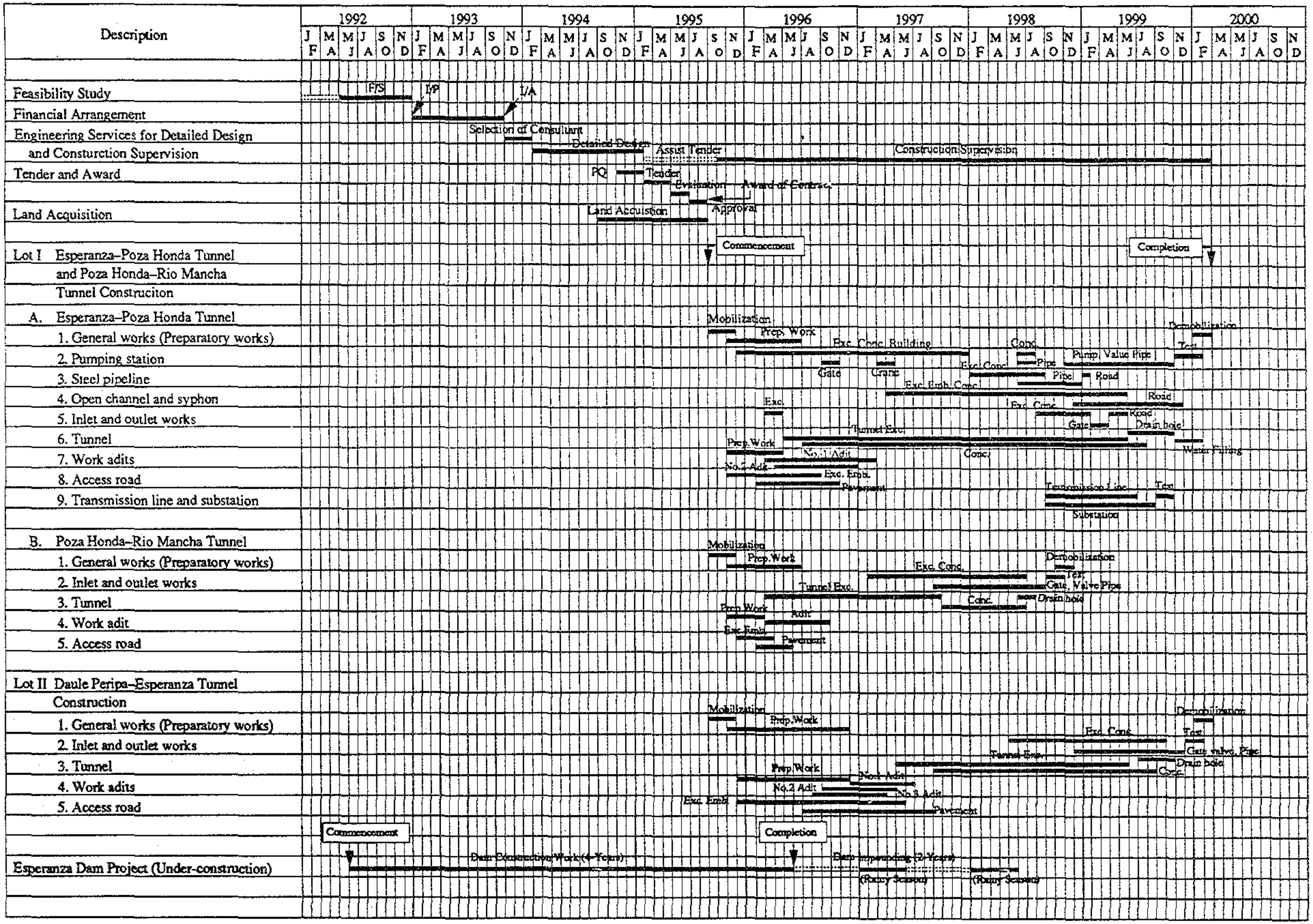
Item No.	Work	Unit	Quantity	Foreign Currency (US$) Unit Price	Foreign Currency (US$) Amount	Local Currency (s/.) Unit Price	Local Currency (s/.) Amount
	Outlet mechanical facilities						
	Outlet cscreen	L.S.			23,409.00		4,031,550
	Maintenance gate	L.S.			83,511.00		14,382,450
	Chain block/geared trolley	L.S.			9,477.00		1,632,150
	Accessories	L.S.			8,262.00		1,422,900
	Subtotal (Outlet)				124,659.00		21,469,050
	Electrical equipment	L.S.			32,000.00		12,400,000
	Subtotal of item 2.3				1,327,352.00		235,488,400
	Subtotal of item 2				1,953,860.48		819,690,477
3.	Tunnel						
	Excavation,tunnel	m3	151,500	40.59	6,149,385.00	23524	3,563,886,000
	Shotcrete for tunnel	m3	13,000	157.09	2,042,170.00	91553	1,190,189,000
	Steel wire mesh	m2	94,400	4.68	441,792.00	1547	146,036,800
	Rock bolt	m	90,700	19.06	1,728,742.00	9054	821,197,800
	Steel support	ton	500.0	1348.30	674,150.00	183036	91,518,000
	Concrete,tunnel	m3	39,900	70.69	2,820,531.00	61199	2,441,840,100
	Form,tunnel	m2	100,400	17.78	1,785,112.00	4626	464,450,400
	Form,structure	m2	3,300	2.95	9,735.00	16015	52,849,500
	Reinforcement	ton	670.0	371.00	248,570.00	644465	431,791,550
	Drain hole	m	7,500	9.77	73,275.00	4776	35,820,000
	Others(3%)	L.S.			479,203.86		277,187,375
	Subtotal of item 3				16,452,665.86		9,516,766,525
4.	Work adits						
	Site clearance	ha	0.2	391.40	78.28	265900	53,180
	Excavation,common	m3	7,000	2.39	16,730.00	1765	12,355,000
	Excavation,weathered rock	m3	3,000	3.38	10,140.00	2433	7,299,000
	Shotcrete,slope protection	m2	800	12.53	10,024.00	10387	8,309,600
	Anchor bar,slope protection	m	400	10.02	4,008.00	4539	1,815,600
	Excavation,tunnel	m3	10,400	35.06	364,624.00	19557	203,392,800
	Excavation,inclined tunnel	m3	17,700	39.38	697,026.00	23505	416,038,500
	Shotcrete,tunnel	m3	2,040	157.09	320,463.60	91553	186,768,120
	Steel wire mesh	m2	26,240	4.68	122,803.20	1547	40,593,280
	Rock bolt	m	18,000	19.06	343,080.00	9054	162,972,000
	Steel support	ton	31.0	1348.30	41,797.30	183036	5,674,116
	Concrete,tunnel	m3	1,480	60.31	89,258.80	52158	77,193,840
	Form,tunnel	m2	3,860	15.53	59,945.80	7273	28,073,780
	Form,structure	m2	160	2.95	472.00	16015	2,562,400
	Reinforcement	ton	8.0	371.00	2,968.00	644465	5,155,720
	Drain hole	m	1,200	9.77	11,724.00	4776	5,731,200
	Others(3%)	L.S.			62,854.29		34,919,644
	Subtotal of item 4				2,157,997.27		1,198,907,780

Table J. 9 Breakdown of Construction Cost (11/11)

Item No.	Work	Unit	Quantity	Foreign Currency (US$) Unit Price	Foreign Currency (US$) Amount	Local Currency (s/.) Unit Price	Local Currency (s/.) Amount
5.	Acsess road						
5.1	Earthworks						
	Site clearance	ha	26.0	391.40	10,176.40	265900	6,913,400
	Excavation,common	m3	1,768,000	1.82	3,217,760.00	1304	2,305,472,000
	Excavation,rock	m3	100	5.70	570.00	4187	418,700
	Removal of sliding material	m3	37,000	1.72	63,640.00	1094	40,478,000
	Excavation,structure & drain	m3	21,000	2.52	52,920.00	1810	38,010,000
	Excavation,drain channel	m3	20,000	1.26	25,200.00	905	18,100,000
	Embankment	m3	855,000	2.05	1,752,750.00	1463	1,250,865,000
	Backfill of structure	m3	3,500	2.05	7,175.00	1463	5,120,500
	Subgrade finishing	m3	1,617,000	0.44	711,480.00	295	477,015,000
	Improved subbase	m3	23,500	8.66	203,510.00	6537	153,619,500
	Improved subgrade material	m3	63,500	3.73	236,855.00	2776	176,276,000
	Selected subbase	m3,km	9,000,000	0.13	1,170,000.00	114	1,026,000,000
	Slope,grassing	m2	10,000	0.20	2,000.00	745	7,450,000
	Stone stairway	m3	200	0.00	0.00	34000	6,800,000
	Gabion	m3	2,500	58.16	145,400.00	24066	60,165,000
	Others(0%)	L.S.			0.00		0
	Subtotal of item 5.1				7,599,436.40		5,572,703,100
5.2	Pavement work						
	Bituminous surfacing	m2	150,000	0.87	130,500.00	1365	204,750,000
	Others(0%)				0.00		0
	Subtotal of item 5.2				130,500.00		204,750,000
5.3	Drainage work						
	Concrete,side drain	m3	2,000	57.30	114,600.00	50561	101,122,000
	Subdrain,perforated conc.pipe	m	15,000	0.00	0.00	11920	178,800,000
	Filter,subdrain	m3	17,700	17.66	312,582.00	24095	426,481,500
	Concrete pipe,dia.1.0m	m	600	4.63	2,778.00	162097	97,258,200
	Concrete pipe,dia.1.2m	m	280	5.91	1,654.80	197981	55,434,680
	Concrete,structure,culvert	m3	2,700	56.55	152,685.00	50538	136,452,600
	Form,structure	m2	3,000	2.95	8,850.00	16015	48,045,000
	Reinforcement	ton	9.2	337.27	3,102.88	585878	5,390,078
	Others(0%)	L.S.			0.00		0
	Subtotal of item 5.3				596,252.68		1,048,984,058
	Subtotal of item 5				8,326,189.08		6,826,437,158
	Total (Lot II)				31,779,783.96		20,197,982,133

FIGURES

Fig. J.1 Construction Schedule



Annex K

ENVIRONMENT

ANNEX K. ENVIRONMENT

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1 Objectives

The Feasibility Study on Water Resources Development for Chone-Portoviejo River Basins (the Project) is the further study derived from the recommendation of the final report on PHIMA in 1990 specifically focusing on the water transbasin scheme from the existing Daule-Peripa dam to the Chone-Portoviejo river basins. This sectoral report is prepared to depict the result of Environmntal Impact Assessment (EIA) of the Project.

In the Chone-Portoviejo river basins, a number of water resources development projects have been studied, and some of them were constructed, another is under construction, and the others are waiting for further studies for implementation. Since the EIA for each project has been conducted specifically, this Environmental Study (the Study) is conducted by focusing on the transbasin scheme in principle. Therefore, the objectives of the Study are as follows;

1) To identify impacts which are expected to cause impacts on the environment by the transbasin project,
2) To describe and quantify the impacts, and to evaluate the magnitude or significance of them,
3) To provide necessary inputs related to the environment for the formulation of an environmentally sound alternative plan of the water transbasin project,
4) To propose countermeasures for mitigation of the significance of the impacts,
5) To prepare a framework of environmental management and monitoring plan for the Project, and
6) To evaluate the acceptability of the Project through the viewpoint of the environment.

1.2 Approach of the Study

A screening and scoping approach is taken for the Study because it ensures time and cost saving for implementation of Environmental Impact Assessment (EIA), and also it is common approach of EIA in the developing countries. Based on this approach, the Study is divided into two stages; i) Stage-1: Initial Environmental

Examination (IEE) for evaluation of the proposed 6 alternatives of the Project, ii) Stage-2: Detailed EIA for evaluation of the acceptability of the selected alternative plan by considering the magnitude of impacts and by proposing the possible countermeasures specifically.

In this context, the study area covers all areas which are expected to be caused environmental impacts by the Project during Stage-1 in principle. In Stage-2, it covers the area being expected to have significant impacts caused by the selected alternative plan.

2. INITIAL ENVIRONMENTAL EXAMINATION (IEE)

2.1 General

2.1.1 Methodology

IEE is considered an appropriate method to attain the objectives during Stage-1. The IEE is essentially an initial examination of the environmental effect potentials of the proposed alternatives based mostly on the preliminary information which can be readily obtained. The result of IEE thus would be one of the useful tools for selection of the most recommendable alternative through the environmental viewpoint. Besides, the IEE is a first approach of EIA by scoping, which needs to be carried out at the study level to determine whether a detailed EIA is required in Stage-2.

A checklist method is applied as a basic tool of IEE in this Study, because it is the useful initial method for identification of impacts and evaluation of significance of them. The checklist is prepared by using major items of environmental effect as rows and major project components as columns. And the expected effects are evaluated from A to C for each alternative with classifying positive or negative. The checklist items are selected by the discussion with the Ecuadorian counterparts taking into account of the features of the Project and the guidelines of JICA.

2.1.2 Selection of Environmental Items

Considering the major components of the Project, the environmental items for IEE were selected from the common items for dam, water supply, irrigation and fishery development projects. The selected items should also reflect the following characteristics of the environment in the study area being pointed out by conducting a review of the existing data and a field reconnaissance:

a) Socio-economic impacts caused by the Chirijos dam could bring about negative effects with relatively high magnitude.
b) The Project would improve the existing river flow discharge, but might cause water quality deterioration mainly due to increase sewage.
c) The Project would improve the water quality of Poza Honda dam by diverting water from Daule-Peripa dam.
d) Vegetation in the basins is considered rather poor, and there are no designated areas such as national parks, wild reserves and game refuges.

Thus, the impacts on precious terrestrial ecosystem would have relatively low magnitude.

e) Mangrove forests located in the Chone river mouth area have been encroached so many years and scarcely remain at present.

f) Inland navigation is not common in the rivers, so a change of river flow regime would not cause impacts on navigation.

According to the most recent EIA report for the Project, namely "PLAN INTEGRAL DE DESARROLLO DE LOS RECURSOS HIDRICOS DE LA PROVINCIA DE MANABI, ANNEXOS II AMBIENTAL (1990) JICA, the following items were selected for the evaluation of impacts caused by the Project. Although this report concluded that the Project would cause higher positive effects than negative ones, it recommended further in depth and quantitative studies related to water quality deterioration in the downstream areas and socio-economic impacts caused by the proposed dam projects.

- Regulation of river flow discharge,
- Modification of land use pattern,
- Impacts due to flood control,
- Eutrophication of reservoirs,
- Water quality deterioration,
- Erosion and silt runoff,
- Loss of cultural and natural assets,
- Socio-economic impacts, and
- Water-borne parasitic diseases.

Based on the information mentioned above, 19 environmental items are selected for comparative evaluation of the alternatives. The selected items are shown in Table K.2.1.

2.2 Result of IEE

2.2.1 Summary of IEE

Since the previous environmental study explicitly concluded the justification of the Project, this environmental study is conducted focusing on the evaluation of the proposed 6 alternatives from environmental viewpoints and on the scoping of environmental impacts caused by the Project. The detailed consideration of IEE is described in the Interim Report of the Project submitted by the JICA Study Team in March 1992. In this connection, it should be noted that there might be some discrepancies in the predicted values such as river flow discharge and water quality between IEE and EIA. But this is not unusual because it comes from the differencies of the study depth. The result of IEE is shown in Table K.2.1 and its summary is described below:

(1) Items related to Project Location

The major negative effects on the environment are considered the impacts related to the dam construction, especially in terms of resettlement of the displaced people and loss of agricultural lands in the proposed reservoir area. The preliminary field survey reveals that about 1,870 people living below EL 130 m need to be displaced and 861 ha of the cultivation area including grassland would be submerged by the construction of the Chirijos dam. While, to provide municipal water to the Chone-Portoviejo river basins is one of the purposes of the Project, so it is unavoidable to increase sewage volume in all alternatives. Thus, the alternatives which include a dam scheme would provoke rather high magnitude of impacts on the environment.

(2) Items during Construction Stage

During the construction stage, serious environmental impacts are not expected, because no precious ecosystems and aesthetic places are in and around the project area. Although some soil erosion and silt runoff would be considered, the magnitude of this impact could be reduced by taking proper construction methods such as a silt sedimentation pond, regreening of quarry sites and road-side slopes. Thus, no differences could be found among the alternatives.

(3) Items resulting to Project Operation

During the operation stage, various kind of positive and negative effects could be caused by the alternatives. The three major environmenal aspects are considered to have relatively high magnitude of impacts, namely a change of river flow discharge, a change of water quality and an impact on eutrophication of the existing and proposed reservoirs.

Since the Project definitely increases a pollution load due to municipal, agricultural and aquacultural water supply, the water deterioration is considered unavoidable in the Chone and Portoviejo rivers. The result of water quality assessment shows that the level of deterioration would be serious in the most alternatives if the pervation ratio of sewerage system would not be improved during 1990 to 2020, and that the alternatives which could cause relatively high magnitude of impacts are the Alternative-1, 2 and 4.

While, the Alternative-1, 2, 5 and 6 have a plan to divert water to Poza Honda dam from Daule-Peripa dam through the La Esperanza dam or from the Daule river in the downstream of Daule-Peripa dam. This plan would improve the water quality in Poza Honda dam, and contribute to prevent eutrophication of the reservoir due to *dilluting the concentration of nutrients and shortening the retention time of the* reservoir.

Although the possibility of eutrophication in the Chirijos dam can not be assessed precisely due to the inavailability of water quality data, it could be rather high by considering its long retention time (less than one times per year) and existing conditions of the Poza Honda dam.

One of the economically valuable fish species, Dormitator latifrons, which has the local name "Chame", exists in the downstream area of the Chone river. Although some impacts would be caused by the Project on the habitats of this fish and to the local people who are catching them, the magnitude of the impacts is not considered serious, because chame has rather high tolerance against water quality deterioration, and the Project ensures the river runoff volume to satisfy the ecologically necessary maintenance flow and the water demand for the aquaculture, namely shrimp ponds, in the river mouth area.

2.2.2 Conclusion of IEE

1) Among the alternatives, the most recommendable one are the Alternative-3, 5 and 6, and the least one is the Alternative-4 on the other hand.

2) The water quality deterioration would be rather serious in the Chone-Portoviejo river basins mainly due to the increase of pollution loads from domestic and irrigation water use. This means that the development of the sewerage system must be inevitable to prevent water quality deterioration in the rivers.

3) The increase of an average river runoff could be mostly found in the Portoviejo river, but the average runoff would be decreased in the Carrizal river and the Chone river mouth area. However, the projected runoff could be improved in the dry season, it must be reevaluated based on the monthly runoff data in the next EIA study stage.

4) The major environmental aspects to be conducted more detailed EIA in the next study stage are as follows:

   i) Socio-economic impacts in terms of resettlement,
   ii) River runoff changes, and
   iii) Water quality deterioration in the rivers.

3. ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

3.1 Environmental Items to be Assessed

(1) Selection of Alternative Plan

Based on the results of the broad study in Stage-1, the Alternative-5 (Alt-5) being put top priority from the environmental viewpoints is ultimately selected as the optimum plan of transbasin scheme in the Interim Report submitted to the Government of Ecuador (GOE) in March 1992. Alt-5 is a plan to divert water from Daule Peripa dam to La Esperanza dam, La Esperanza dam to Poza Honda dam, and then Poza Honda dam to the Chico river instead of Chirijos dam construction. Thus, the socio-economic impacts related to resettlement are omitted in this EIA.

(2) Environmental Items to be Assessed

Taking into account of the project feature of Alt-5 and the results of IEE in Stage-1, the following aspects are selected as the major environmental items to be conducted EIA carefully:

a) Impacts on water quality in La Esperanza and Poza Honda dams caused by water diversion from Daule Peripa dam,
b) Impacts on the existing flow regime of the Chone-Portoviejo rivers,
c) Impacts on water quality in the Chone-Portoviejo rivers and estuaries,
d) Impacts on fishery and ecosystem in the rivers and estuaries caused by the change of water quality and river flow regime.

3.2 Impacts on Water Quality in La Esperanza and Poza Honda Dams

3.2.1 Water Quality Change by Water Diversion

In case of Alt-5, La Esperanza dam receives water diverted from Daule Peripa dam, and provides water to the downstream area of the Chone and Carrizal rivers for municipal, agricultural and aquacultural purposes. Moreover, the water of La Esperanza dam is diverted to Paza Honda dam to provide sufficient water to the Portoviejo and Chico rivers for the same purposes. Thus, the water quality prediction in La Esperanza and Poza Honda dams are very important to clarify the impacts not only in the reservoirs themselves but also in the downstream areas.

(1) Concept of Water Quality Prediction

The water quality of La Esperanza dam is principally determined by quality and quantity of the diverted water from Daule Peripa dam, and those of the inflow water to the dam. Thus, the water quality of La Esperanza dam (C2) could be estimated by the following equation:

$$C2 = (L0 + L1)/(Q0 + Q1) = (Q0 \times C0 + Q1 \times C1)/(Q0 + Q1)$$

where

L0,Q0 : load and volume from Daule Peripa dam,
C0 : quality of diverted water,
L1,Q1 : annual load and inflow to La Esperanza dam, and
C1 : quality of inflow water.

Also the water quality of Poza Honda dam is calculated by the same method. In this case, L0, Q0 and C0 must be the La Esperanza dam's.

(2) Water Quality Prediction

The existing water quality conditions in Daure Pelipa, La Esperanza and Poza Honda dams are shown in Table K.3.1. Based on these data, the future water quality is predicted by using the equation mentioned above, and the result is shown in Table K.3.2.

The future water quality in La Esperanza dam would be better than that of Daule Peripa dam in BOD and COD, but worse in T-N and T-P. In Poza Honda dam , the water quality could be improved only except for T-N. No significant impacts are not expected from this result though some eutrophication might be occured in the reservoir of La Esperanza dam.

3.2.2 Possibility of Eutrophication of the Reservoir

The potential of eutrophication normally depends on a nutrient inflow and characteristics of a reservoir. Based on the predicted water quality of T-P, the possibility of eutrophication of the reservoir is assessed by using a concept of Vollenweider model described below. The result is shown in Table K.3.3 and Fig. K.3.1.

$Lp=[P] \times (Z \times r + Z \times Vp)$

where:

Lp(g/m2/y)	:	Annual phosphorus surface load, given by L/A,
L(t/y)	:	Annual inflow load of phosphorus, given by Q x C,
Q(MCM/y),P(mg/l)	:	Annual inflow volume and phosphorus concentration of inflow water,
A(km2)	:	Surface area of reservoir,
Z(m)	:	Average depth of reservoir, given by V/A,
V(MCM)	:	Total storage volume of reservoir,
r(times/y)	:	Retention time, given by Q/V, and
Vp(m)	:	Sediment velocity coefficient.

The possibilities of eutrophication of La Esperanza dam and Poza Honda dam would be rather high even though the transbasin project could improve retention time of the reservoirs. Both Daule Peripa dam (constructed in 1987) and Poza Honda dam(constructed in 1971) are considered to be under eutrophicated conditions taking the water quality data and high production potentials of phytoplankton into account especially in the dry season. Therefore, La Esperanza dam would be similar eutrophicated conditions of these dams.

Mainly due to the difficulties from practical viewpoints, effective and efficient countermeasures can not be considered unfortunately to avoid eutrophication, so a long term management of the reservoir to solve the problems caused by eutrophication would be necessary under the appropriate EMMP for the Project.

3.3 Impacts on River Flow Regime

The Project definitely brings about a change of flow regime in the Chone-Portoviejo rivers mainly due to the diversion of water from Daule Peripa dam and usage of water for various kinds of purposes. Thus, it is necessary to calculate the river flow changes qualitatively with and without project conditions for evaluation of impacts caused by the Project. In case of Alt-5, 500 MCM of water is planned to be diverted to La Esperanza dam from Daule Peripa dam, and 400 MCM of water in it to be diverted to Poza Honda dam from La Esperanza dam. This means that the Portoviejo river will receive much amount of water than that of La Esperanza dam, and the river flow conditions of the Portoviejo river would be improved considerably.

3.3.1 Prediction Points

Since a change of river flow regime has close relation with future water quality conditions in the Chone-Portoviejo rivers, the following 6 stations are selected as the prediction points of a river flow change in case of Alt-5. The location of them is shown in Fig. K.3.2.

a) River mouth of the Chone rive (St.12, Simbocal),
b) Upstream of the Chone river (St.13, H. Saida),
c) Carrizal river (St.14, Bachillero),
d) Downstream of the Portoviejo river (St.1, Dario Guevara),
e) Upstream of the Portoviejo river (St.3, Portoviejo),
f) Chico river (St.6, Rio Chico).

3.3.2 Result of River Flow Change

Table K.3.4 shows the existing and future river flow calculated 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 is not expected to 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 m3/s to 53 m3/s only. While 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.			Portoviejo R.	
	(1) River Mouth	(2) Chone Upst'm	(3) Carr'l River	(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

3.4 Impacts on Water Quality in Rivers and Estuaries

3.4.1 Concept of Water Quality Prediction

The Project envisages to supply water for municipal, agricultural and aquacultural purposes by diverting water from Daule Peripa dam. Thus, the impacts on water quality are expected to be caused mainly due to an additional pollution load discharge. 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.

The Chone river can be divided into 2 regions through the viewpoint of water quality change, namely 1) middle reach of the Chone river (by the confluence point of the Chone and Carrizal rivers), and 2) estuary area of the Chone river. While, the Portoviejo river is also divided into 2 regions, namely 3) middle reach of the Portoviejo river (by the confluence point of the Portoviejo and Chico rivers), and 4) lower reach of the Portoviejo river. Taking the location of the water bodies mentioned above, the following 4 points are selected as the water quality prediction points. Fig.K.3.3 shows the location of 4 prediction points and the schematic diagram of water quality analysis.

- P-1: Simbocal (downstream of the confluence point of the Chone and Carrizal rivers),
- P-2: Punta Prieta (middle reach of estuary area of the Chone river),
- P-3: Guayaba (downstream of the confluence point of the Portoviejo and Chico rivers), and
- P-4: Dario Guevara (lower reach of the Portoviejo river).

3.4.2 Estimation of Pollution Load

(1) Pollution Load Unit

Four water quality items, namely BOD, COD, T-N and T-P are selected as the indexes for assessment of water quality change caused by the Project, because these are very common items which have ralatively high availability of basic data for EIA and there are no major industries which might cause water pollution by hazardous substances in the study area.

a) Municipal water supply

Per capita pollution load unit and quality of sewage of BOD, COD, T-N and T-P is shown in Table K.3.5 based on the data obtained from IEOS and "A GUIDELINE FOR INTEGRATED BASIN-WIDE SEWERAGE SYSTEM DEVELOPMENT, 1983, MINISTRY OF CONSTRUCTION IN JAPAN". Since this unit depends on a living standard of the local people, it is adjusted by the JICA Study Team considering the existing water supply ratio and unit water consumption rate.

The water quality of sewage is calculated by dividing a per capita load unit by a per capita sewage volume. The per capita sewage volume is assumed 40 % and 65 % of the per capita municipal water demand in 1990 and 2020 in this study.

Only in Portoviejo, there is a sewage treatment plant which has 6,500 m3/d of treatment capacity. It covers about 18 % of the population in the Portoviejo urban area. Thus, the load from sewage treatment plant is to be calculated by multiplying quality and volume of treated sewage. The collected domestic sewage is treated by lagoon and then discharged to the public water bodies. Thus, a pollution load reduction rate is estimated at 50 % in BOD, 40 % in COD, and 30 % in T-N and T-P based on the data and information obtained from IEOS.

b) Agricultural water supply

Since a pollution load change by agricultural development is usually brought about by land use change in the project area. Thus, the set-up of unit pollution load by land use is needed to calculate pollution load change caused by the Project. Because no data related to pollution load unit are available in Ecuador, the following load units commonly used in Japan are applied in this study.

Load Unit (kg/ha/y)

Land use	BOD	COD	T-N	T-P
1) Paddy	82	102	32	3.2
2) Pasture	59	106	14	1.6
3) Perennial crop	14	18	73	0.7
4) Upland	20	26	28	0.9
5) Others (forest etc.)	12	15	2	0.4

Source: INTEGRATED WATER QUALITY CONTROL IN LAKES, MINISTRY OF CONSTRUCTION JAPAN, 1987

At present, a cattle grazing is a common farm type and a lot of cattles are being raised in wide range of the proposed irrigation area. The existing pastures in the project area are planned to convert to the irrigation land so that the pollution load of cattles will be decreased by the Project. Thus, the load derived from cattles is estimated by using the following load unit commonly used in Japan.

Pollution Load Unit (kg/head/y)

Item	BOD	COD	T-N	T-P
- Cattle	234	193	138	20

Source: GUIDELINES FOR INTEGRATED BASIN-WIDE SEWERAGE SYSTEM, MINISTRY OF CONSTRUCTION JAPAN, 1986

c) Aquacultural water supply

Semi-extensive and semi-intensive shrimp farming are being conducted in the estuaries of the Chone and Portoviejo rivers. According to the Interim Report of the Project, there is about 450 ha of area expanding potential in the Chone river though no potential in the Portoviejo river. Thus, a load unit of shrimp pond is necessary to estimate the existing and future pollution loads from shrimp ponds. Since the data related to an unit load of shrimp pond are not available in Ecuador at present, the actual data obtained by water quality survey shown in Table K.3.1 are applied for calculation of pollution loads in this Study.

3.4.3 Volume of Waste Water

a) Domestic Waste Water

Based on the data related to the municipal water demand and the projection of population described in the Interim Report, the volume of domestic waste water is calculated by multiplying the unit sewage discharge and the population in the water served area both in 1990 and 2020. The results are shown in Table K.3.6.

b) Drained Water from Irrigation Area

By considering the evapotranspiration and soil permeability in the study area, the volume of drained water from irrigation area (return flow) is assumed 20 % of the water requirement of each irrigation area.

c) Drained Water from Shrimp Pond

Based on the data related to a common shape of shrimp pond and its water exchange rate (10 %), the drained water volume is estimated and shown in Table K.3.14.

3.4.4 Estimation of Pollution Load Change

a) Load Change by Municipal Water Supply

Two main sources are to be considered for estimation of pollution load from municipal water supply, namely a load from untreated sewage and a load from treated sewage. Since there are no concrete sewerage improvement plans in the project area, the load is estimated in the same conditions of the existing sewerage system. The results are shown in Table K.3.7 and K.3.8. Moreover, the most cities do not have sufficient canals and drains for sewage collection. Thus, only 70 % of the load from untreated sewage is assumed to be discharged to the public water bodies. The result of the incremental pollution load from municipal water supply from 1990 to 2020 is shown in Table K.3.9.

b) Load Change by Agricultural Water Supply

As for the load from agricultural water supply, 3 pollution sources, namely load from irrigation water, load from land use change and load from cattles are to be considered for calculation of the incremental pollution load. The load from irrigation water depends of the water quality of water sources such as La Esperanza and Poza Honda dams. So the predicted water quality data in this study are used as the quality of irrigation water for load estimation. The results are shown in Table K.3.10 to K.3.12. The incremental load from irrigation area is shown in Table K.3.13.

c) Load Change by Aquacultural Water Supply

Although a lot of fresh water developed by the Project will be used in the existing shrimp ponds, the total load from existing shrimp ponds is expected to be same because the total amount of nutrients applied now would not be changed even after receiving fresh water from the Project. Therfore, only the load derived from the potential shrimp pond areas is considered the source causing an additional pollution load by the Project. Thus, the load from 450 ha of the potential shrimp pond areas in the Chone estuary zone is calculated in this Study. The result is shown in Table K.3.14.

d) Total Incremental Load caused by the Project

The total incremental pollution load caused by the Project is estimated by summing up the results mentioned above, and summarized in Table K.3.15.

3.4.5 Prediction of Water Quality Change

(1) Simbocal (P-1)

The future water quality at Simbocal (P-1) in the middle reach of the Chone river (C3') in 2020 can be estimated by the following equation, and the result is shown in Table K.3.16.

$C3' = (L3 + L3')/Q3' = (L3 + L1 + L2)/Q3'$

where

L1,L2	:	incremental load from irrigation and municipal water supply,
L3	:	existing load of river flow,
L3'	:	additional future load of river flow (L1+L2),
Q3'	:	volume of future river flow,

(2) Punta Prieta (P-2)

The future water quality at P-2 (C5') can be predicted by the following equation, and the result is shown in Table K.3.17.

$C5' = (L3' + L4 + Ls)/(Q3' + Q4 + Qs)$

where

L3'	:	future load of river flow,
L4	:	load from potential shrimp ponds,
Ls,Qs	:	load and volume by tidal action,

(3) Guayaba (P-3)

The water quality at Guayaba (P-3) in the middle reach of the Portoviejo river (C8') in 2020 can be estimated by the following equation, and the result is shown in Table K.3.18.

$C8' = (L8 + L8')/Q8' = (L8 + L6 + L7)/Q8'$

where

L6,L7	:	incremental load from irrigation and municipal water supply,
L8	:	existing load of river flow,
L8'	:	additional future load of river flow (L6+L7),
Q8'	:	volume of future river flow.

(4) Dario Guevara (P-4)

The future water quality at Dario Guevara (P-4) in the lower reach of the Portoviejo river (C11') can be predicted by the following equation, and the result is shown in Table K.3.19.

C11'=(L8+L8'+L9+L10)/(Q8'+Q9+Q10)

where

L9,L10	:	incremental load from irrigation and municipal water supply,
Q9,Q10	:	incremental discharge from irrigation and municipal water supply,
L8,	:	existing load of river flow,
L8'	:	additional future load of river flow (L9+L10),
Q8'	:	volume of future river flow.

3.4.6 Evaluation

The results of water quality prediction are summarized hereunder.

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

Prediction Point	BOD		COD		T-N		T-P	
	Exi'g	Fut'e	Exi'g	Fut'e	Exi'g	Fut'e	Exi'g	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 P-1, the lower reach of the Chone river, the future water quality would be slightly worse than that of the present conditions even though the remarkable increase of river flow in the dry season. But the impact on environment would not be serious because the values of future water quality are considered to be acceptable level for aquaculture.

While, the estuary area of the Chone river, at P-2, the future water quality would be almost similar with the present conditions mainly due to the river flow improvement in the dry season. Moreover, the water quality of BOD should be better than that of the estimated one because any self-purification capacity did not considered in this prediction. When a self-purification coefficient is assumed 0.1, the future water quality of BOD at P-2 could be only 50 % of the predicted value by using the following Streeter-Phelph's equation. Thus, no significant impacts could be caused on the environment by the water quality change in the Chone river.

C3"=C3' x exp(-Kt)

where

C3"	:	future quality with self-purification capacity,
C3'	:	predicted future water quality,
K	:	self-purification coefficient (K *is applied* 0.1 *in this study*),
t	:	time (hour) to reach P-2 from P-1 (t=5km / 0.2(m/s) /3,600=7 hours)

In the Portoviejo river, the water quality deterioration could be serious mainly due to the waste water discharge from Portoviejo city. For example, BOD in the dry season would be almost 4 times than that of the present conditions, and also the predicted value could be considerably high, more than 22 mg/l. In other words, the Portoviejo river could be a sewerage channel in 2020 especially in the dry season. Thus, the impacts on the environment could be significant, and it could cause negative effects to the potable water treatment plant construction plan at El Ceibal. Consequently, it is strongly recommended to improve the existing sewerage system in Portoviejo city.

At the river mouth area of the Portoviejo river, P-4 Dario Guevara, the future water quality conditions would be almost same those of at P-3. However, BOD value could be about 60 % of the predicted one when a self-purification capacity is condidered in the prediction. But anyhow, the impact caused by water quality deterioration would be significant in the Portoviejo river even though the remarkable improvement of the river flow discharge by the Project.

3.4.7 Necessary Actions to be Taken

As mentioned in the previous section, the water quality deterioration in the downstream of the Portoviejo river could be serious. The following actions are strongly recommended to mitigate the magnitude of impact and to avoid future problems with regard to the river water utilization.

(1) To Change Intake Site of El Ceibal Treatment Plant

CRM currently proceeds to construct a new potable water treatment plant which has the production capacity 90,000 m3/day, namely El Ceibal Treatment Plant, in the Poza Honda System. It is planned to take the raw water for this plant from the Portoviejo river near Rocafuerte town. However, problems related to potable water treament could be expected due to the serious quality deterioration of raw water in the Portoviejo river. Thus, it could be necessary to change the planned intake site from the Portoviejo river to other areas being able to take raw water with better quality.

The Chico river could be one of options of raw water source. The future water quality at Rio Chico, just upstream of the confluence point with the Portoviejo river, is estimated by the same method applied to the other prediction points, and it is shown hereunder. The future water quality could be fairly better than that of the Portoviejo. Moreover, the Chico river has less possibility of water quality deterioration in its basin. Therefore, it is recommendable to use the Chico river for the better raw water source of the El Ceibal Treatment Plant.

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

Chico R.	BOD		COD		T-N		T-P	
(Rio Chico)	Exi'g	Fut'e	Exi'g	Fut'e	Exi'g	Fut'e	Exi'g	Fut'e
a) Rainy	4.00	5.07	8.50	8.46	0.60	0.83	0.08	0.10
b) Dry	9.00	11.02	12.00	8.99	1.00	1.88	0.14	0.21
c) Ave.	6.55	6.03	10.25	8.55	0.80	1.00	0.11	0.12

Source: JICA Study Team

(2) To Improve Sewerage System

The degree of water quality deterioration of the rivers depends on the progress of waste water treatment system, namely sewerage system in the cities being planned to provide municipal water by the Project. Therefore, it is necessary to clarify the relationship between the future water quality of the rivers and sewerage system coverage ratio in order to evaluate the effectiveness of sewerage system as a countermeasure for conservation of water quality in the rivers.

The future water quality at P-3 is predicted in 4 cases, namely no improvement of existing sewerage system, 30 %, 50 %, and 70 % of sewerage coverage ratio. The result is shown hereunder. The concentration of BOD and COD would become better considerably by the improvement of sewerage coverage ratio. As for T-N and T-P would be improved gradually because the waste water from irrigation water is not able to be treated. This result, however, revealed the effectiveness of the sewerage system for conservation of the river water quality. Thus, the improvement of sewerage system should be promoted in future.

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				
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				
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				
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

3.5 Impacts on Ecosystem and Fishery

3.5.1 Possible Impacts on Ecosystem and Fishery

The possible impacts on ecosystem and fishery caused by the Project are i) to change existing flow regime of the Chone-Portoviejo rivers which may cause the loss of habitats of fauna and flora, ii) to deteriorate water quality in the rivers which may cause same effects, iii) to expand shrimp ponds which may cause the destruction of ecosystem such as mangrove, and the detrimental effects on existing and future agricultural areas.

At present, there are not any national parks, nature conservation areas and game refuges in the Chone-Portoviejo river basins, and the existence of endangerd 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 which contributes to the local economy, namely "Chame" a kind of goby. The ecological area to be protected is shown in Fig. K.3.4.

3.5.2 Impacts caused by Change of River Flow Regime

As described in Chapter 3.3, the impacts on the existing river flow regime caused by the Project would not be significant because of less reduction rate of discharge in the rainy season and much increase of discharge in the dry season. Consequently, the impacts caused by the river flow change would not bring about serious effects on the ecosystem in the rivers and estuaries.

3.5.3 Impacts caused by Change of Water Quality

In the downstream and estuarine area of the Chone river, the deterioration of water quality is not so serious mainly due to relatively small amount of pollution load discharge and increase of river flow in the dry season. However, the water quality in the Portoviejo river could be deteriorated drastically mainly due to the dicharge of municipal waste water from Protoviejo city despite of the improvement of river flow discharge by the Project. So, the negative effects on the ecosystem could be caused by the Project in the downstream area of the Portoviejo river although no precious species are not reported so far. Therefore, the improvement of sewerage system in Portoviejo city is considered essential to mitigate the magnitude of impacts caused by the water quality deterioration.

3.5.4 Impacts caused by Shrimp Pond Expansion

(1) Mangrove Area

The estuary in the Chone river once had rich and wide mangrove forests, has been destroyed mainly due to shrimp pond construction. In 1988, CLIRSEN documented the conservation of mangroves using 1987 data. The avarage annual loss of mangrove area between 1969-1984 and 1984-1987 are 153 and 211 ha/y, respectively in the estuary of the Chone river. At present, only about 170 ha of mangrove remains according to PMRC report. A change of mangrove areas is shown below.

Change of Areas in Estuary of the Chone River
(Chone estuary area)

Item	1696	1984	1987
a.Mangrove (ha)	3,973	1,674	1,040
b.Salt Farm (ha)	584	0	0
c.Shrimp Pond (ha)	na	4,189	4,826

Source: "ESTUDIO MULTITEMPORAL DE LOS MANGLARES, CAMARONERAS Y AREAS SALINAS DE LA COSTA ECUATORIANA, MEDIANTE INFORMACION DE SENSORES REMOTOS, 1990, CLIRSEN.

It is widely known that estuarine mangrove areas support rich ecosystems and major fisheries such as juveniles of many commercially important fish migration and congregation in shallow zones for feeding and refuge from predators. Shrimp, in particular takes advantage of favorable shallow water habitats during critical life cycle stages. Various studies have revealed that shrimp postlarvae are present virtually all year in mangrove waters although numbers fluctuate seasonally.

(2) Impacts caused by Shrimp Pond Expansion

According to the ANNEX E. AQUACULTURE in the Interim Report, there are no room to expand shrimp ponds in the estuary area of the Portoviejo river, but about 450 ha of potential area still remain in the Chone river. Since the potential shrimp pond area does not include the existing mangrove areas, any direct impacts would not be considered to mangrove ecosystem.

However, uncontrolled expansion of shrimp ponds especially in the floodplain 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 strongly recommended to protect the lands and ecosystems against the encroachment by overexploitation pressure.

3.5.5 Impacts on Indigenous Species

(1) Indigenous Species

In the Project area, a goby, Dormitator latifrons, locally known as "Chame" can be listed up as an indigenous fish species especially in the Chone river. This fish is considered as resident within the estuary zone and it is known to enter river to spawn on the flooded fringes in upstream. The peak spawning season is during the rainy season rising floods in the Chone river, but it also shows a continuous breeding into the dry season. Pond culture of chame is common in the Chone river. The wild young chame (5-15 cm) stocked into these ponds are grown on through the dry season. Chame is the most common fish caught in the rivers and in adjacent floodplains. According to the survey conducted by CRM in 1986, there are 773 ha and 33 cultivators in Manabi province. The production yield is 329 kg/ha and total amount to about 254 t in 1986.

CRM had initiated a chame program in its Rural Development in 1980 with objective to produce chief source of protein in rural area. In 1985 it also successfully carried reproduction through hormone. However, one of a problem in chame fishery is the availability of juveniles for culture. Currently culture is practiced by stcoking small fish caught from the wild. In the future, it is necessary to produce post-larvae or juveniles in hatchery.

(2) Impacts on the Habitat of Chame

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 reduce the river flow discharge in the rainy season, it would be only 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 m3/s of discharge in the rainy season even with Project conditions. Moreover, La Esperanza dam covers less tahn 20 % of the total catchemnt area of the Chone river. Therefore, no serious impacts would be expected on the habitat of chame by the Project.

Besides, uncontroled expansion of shrimp pond and agricultural area could threat the habitat of chame because of construction of additional artificial barriers in the river channels, increase of salinity and drainage of water from floodplains. Thus, it is strongly recommended to conserve the floodplain shown in Fig. K.3.4 against the encraochment by shrimp cultural and agricultural activities.

(3) 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, well management of the gate is essential to conserve the habitat of chame and postlarvae of shrimp. Thus, the following points are to be recommended:

a) To operate the gate strategically, for example to close the gate at the end of the rainy season,
b) To coordinate the management of the gate between CRM, shrimp pond owners and aquacultural farmers of chame.

4. ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN (EMMP)

4.1 Objectives

Normally, prediction of impacts and evaluation of these magnitude are conducted by EIA. Even if results of EIA conclude that the proposed projects would be acceptable through the environmental viewpoints, it is not possible to eliminate all uncertainties related to environmental impacts caused by the projects. Besides, unexpected environmental problems might be occured after implementation of the projects. Moreover, it is very important to monitor the effectiveness and efficiency of the proposed mitigation measures. Thus, Environmental Management and Monitoring Plan (EMMP) is needed to cope with these matters by integrated ways. In other words, EMMP is to be one of tools to ensure the sustainability of projects being reflected environmentally sound conditions.

Consequently, the principal objectives of EMMP in this study are to clarify the environmental aspects to be managed and monitored, and to delineate a framework of EMMP through the technical, institutional and financial viewpoints.

4.2 Institutional Aspect

4.2.1 Structural Organization

Basically, EMMP Unit consists of 3 units, namely Environmental Management Unit (MAU), Environmental Monitoring Unit (MOU) and Laboratory (LAB). MAU has the functions of overall management of EMMP including inter and inner institutional coordination and fundamental decision for effective implementation of each plan and program. While, MOU has the 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. The principal functions of each unit are described hereunder. The proposed structural organization is shown in Fig. K.3.5.

(1) MAU

- To manage all environmental aspects related to the Project,
- To organize implementation of management and monitoring plan,

- To preparé a concrete management and monitoring plan both in short-term and long-term ranges,
- To coordinate inter and inner institutional matters related to EMMP,
- To cope with expected/unexpected environemntal issues,
- To conduct and supervise actual management programs,
- To establish environmental standard and criteria as a goal and target of EMMP.

(2) MOU

- To prepare a concrete monitoring plan,
- To conduct and supervise actual monitoring programs,
- To analyse data obtained by monitoring plan,
- To evaluate effectiveness and efficiency of mitigation measures,
- To propose concrete mitigation measures.

(3) Laboratory

- To analyze sampled water and soil,
- To develop effective analysis methods for specific study, such as eutrophication, occurence of H2S, aquatic weeds control, agrochemical control, bio-assey etc.,
- To conduct basic study for establishment of environmental standard and criteria,
- To research and develop appropriate technology for management and monitoring methods related to environemntal issues.

4.2.2 Necessary Input

Taking the lessons in case of Daule Peripa dam into account, to attain the objectives of EMMP Unit more effectivelly and successfully, the following input data and information should be obtained previously:

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

4.3 Technical Aspect

Based on the results of EIA of the Project, the following environmental aspects are selected as the environmental aspects to be managed and monitored:

a) Water Quality,
b) Conservation of Vicinity Areas of the Reservoir,
c) Protection of Ecosystem and Fishery.

4.3.1 Water Quality

Well managed water resources development projects must guarantee not only quantity but also quality of the developed water resources. Thus, the management of water quality is essential to attain the sustainability of the Project. In this connection, several key elements to be managed and monitored regarding to water quality are described hereunder.

(1) Items to be Managed

a) Protection of quality deterioration of the water to be used for municipal, agricultural and aquacultural water supply,
b) Solution of problems caused by eutrophication of the reservoir water in La Esperanza and Poza Honda dams,
c) Conservation of water quality in the estuary area,

d) Setting up water quality criterion and standards as the management goal and target.

(2) Indexes to be Monitored

a) Phisico-chemical substances (PH, SS, EC),
b) Organo-chemical substances (DO, BOD, COD, NH4-N, NO2-N, NO3-N, T-N, T-P),
c) Sediment load (Cross section survey),
d) Harmful substances (agrochemicals, heavy metals)
(This must be conducted ad hoc base.).

(3) Monitoring Stations

a) Regular points
- Chone river: 6 stations at least
(Estuary area, Simbocal, H. Saida, Bachillero, La Esperanza dam, and Upstream of the dam).
- Portoviejo river: 6 stations at least
(Dario Guevara, Guayaba, Portoviejo, Rio Chico, Poza Honda dam, and Upstream of the dam).
b) Irregular points
- These points should be determined in accordance with the objectives of the specific programs.

(4) Monitoring Period and Frequency

a) First 5 years after completion
- Regular monitoring should be conducted at least one time per month,
b) After the first 5 years
- Regular monitoring should be conducted at least six times per year, (however, it depends on future water quality conditions.)

(5) Projects/Programs to be Conducted

The following projects/programs are to be conducted under the EMMP for the Project.

a) Program for Establishment of Quality Standard (EMMP-WQ1),
b) Basic Study for Integrated River Water Conservation Project (EMMP-WQ2),
c) Program for Prevention of Water Quality Deterioration in Reservoir (EMMP-WQ3),
d) Program for Prevention of Detrimental Effects by Agrochemicals (EMMP-WQ-4).

4.3.2 Conservation of Vicinity Area of Reservoir

(1) Items to be Managed

a) Protection of water quality contamination of the reservoirs and canals,
b) Protection of exceeding sedimentation of reservoirs,
c) Promotion of reforestation and land use control around the reservoir area,
d) Management of reservoir area for appropriate and tourism.

(2) Indexes to be Monitored

a) Land use conditions around the reservoir area,
b) Vegetation and forest coverage,
b) Navigation and fishery in the reservoir,
c) Sediment loads (Refer to Section 4.3.1).

(3) Management and Monitoring Area

In principle, the management and monitoring area is to be the vicinity area of the reservoir. As for the data and information related to the catchement area of the reservoir are to be obtained by the relevant agencies.

(4) Monitoring period and frequency

a) First 5 years after completion: twice a year,
b) After the first 5 years: once a year.

(5) Projects/Programs to be Conducted

The following projects/programs are to be conducted under the EMMP for the Project.

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

4.3.3 Protection of Ecosystem and Fishery

(1) Items to be Managed

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

(2) Indexes to be Monitored

a) Land use conditions such as shrimp pond and irrigation area,
b) Distribution of mangrove area and habitat of chame.

(3) Monitoring Area

The management and monitoring areas are to be the Estuary area and the downstream area of the Chone river.

(4) Monitoring Period and Frequency

a) First 5 years after completion: twice a year,
b) After the first 5 years: once a year.

(5) Projects/Programs to be Conducted

The following projects/programs are to be conducted under the EMMP for the Project.

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 Establishemnt of an operation manual of the Simbocal Tidal Gate for better Management of Ecosystem and Aquaculture (EMMP-EF3).

4.4 Indicative Cost Estimation

4.4.1 Cost for Administration and Operation

The annual cost for administration and operation for EMMP Unit is estimated about US$ 207,000 indicatively based on the Report of "PLAN DE MANEJO AMBIENTAL DE LAS AREAS DE AFECTACION DEL PROYECTO DE PROPOSITO MULTIPLE, DAULE PERIPA, 1990.

Administrative and Operational Cost for EMMP

Item	Unit/y (US$)	No.	Total/y (US$)
i) Personnel			
- Prof'al Staff	5,000	5	25,000
- Ass'nt Staff	4,000	10	40,000
- Others	3,000	6	18,000
ii) Office cost			
- Vehicle	6,000	4	24,000
- Labo. equip.	-	1	50,000
- Others	-	1	50,000
Grand Total			207,000

note : *not including overhead because of the governmental officers*
Source : JICA Study Team

4.4.2 Cost for Projects and Programs

As mentioned in Chapter 4.3, several projects and programs are to be conducted in EMMP for the Project. The cost for these projects and programs is estimated about US$ 1.2 million indicatively. Details are shown hereunder.

Indicative Cost for Project/Program in EMMP

Project/Program	Item	Unit (US$)	No. (M/M)	Total (US$)
I. Water Quality		-	-	678,000
a) EMMP-WQ1				84,000
	- Spec'st (Foreign)	10,000/M	5	50,000
	- Spec'st (Local)	2,000/M	10	20,000
	- Others (20 % of personnel cost)			14,000
b) EMMP-WQ2				336,000
	- Spec'st (Foreign)	10,000/M	20	200,000
	- Spec'st (Local)	2,000/M	40	80,000
	- Others (20 % of personnel cost)			56,000
c) EMMP-WQ3				108,000
	- Spec'st (Foreign)	10,000/M	5	50,000
	- Spec'st (Local)	2,000/M	20	40,000
	- Others (20 % of personnel cost)			18,000
d) EMMP-WQ4				150,000
	- Spec'st (Foreign)	10,000/M	6	60,000
	- Spec'st (Local)	2,000/M	20	40,000
	- Others (50 % of personnel cost)			50,000
II. Reservoir Conservation		-	-	267,000
a) EMMP-RC1				60,000
	- Spec'st (Foreign)	10,000/M	2	20,000
	- Spec'st (Local)	2,000/M	5	20,000
	- Others (50 % of personnel cost)			20,000
b) EMMP-RC2				72,000
	- Spec'st (Foreign)	10,000/M	4	40,000
	- Spec'st (Local)	2,000/M	10	20,000
	- Others (20 % of personnel cost)			12,000
c) EMMP-RC3				135,000
	- Spec'st (Foreign)	10,000/M	5	50,000
	- Spec'st (Local)	2,000/M	20	40,000
	- Others (50 % of personnel cost)			45,000
III. Ecology and Fishery		-	-	264,000
a) EMMP-EF1				84,000
	- Spec'st (Foreign)	10,000/M	5	50,000
	- Spec'st (Local)	2,000/M	10	20,000
	- Others (20 % of personnel cost)			14,000
b) EMMP-EF2				72,000
	- Spec'st (Foreign)	10,000/M	4	40,000
	- Spec'st (Local)	2,000/M	10	20,000
	- Others (20 % of personnel cost)			12,000
c) EMMP-EF3				108,000
	- Spec'st (Foreign)	10,000/M	4	50,000
	- Spec'st (Local)	2,000/M	10	40,000
	- Others (20 % of personnel cost)			18,000
Grand Total				1,209,000

Source: JICA Study Team

5. CONCLUSION AND RECOMMENDATION

5.1 Summary and Conclusion

(1) Detailed EIA is conducted for the selected alternative plan, namely Alternative-5 (Alt-5), which plans to divert water from Daule Peripa dam to La Esperanza dam, La Esperanza dam to Poza Honda dam, and then Poza Honda dam to the Chico river instead of Chirijos dam construction. The environmental items of EIA are determined the following 4 issues based on the project feature of Alt-5 and the results of IEE.

a) Impacts on water quality in La Esperanza and Poza Honda dams caused by water diversion from Daule Peripa dam,
b) Impacts on the existing flow regime of the Chone-Portoviejo rivers,
c) Impacts on water quality in the Chone-Portoviejo rivers and estuaries caused by consumption of the diverted water from Daule Peripa dam,
d) Impacts on fishery and ecosystem in the rivers and estuaries caused by the change of water quality and river flow regime.

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

(3) 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 dams would be rather high even though the transbasin project could improve retention time of the reservoirs. 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 be similar eutrophicated conditions with these dams. 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.

(4) 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 is not expected to 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 m3/s to 53 m3/s only. While 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.

(5) By using the pollution load analysis, the impacts on water quality are expected qualitatively at the strategically selected 4 prediction points. 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.

(6) 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 waste water discharge from Portoviejo city. For example, BOD in the dry season would be almost 4 times than that of the present conditions, and also the predicted value could be considerably high, more than 22 mg/l. In other words, the Portoviejo river could be a sewerage channel in 2020 especially in the dry season. Thus, the impacts on the environment could be significant, and it could cause negative effects to the potable water treatment plant construction plan at El Ceibal. Consequently, it is strongly recommended to improve the existing sewerage system in Portoviejo city.

(7) The impacts on precise ecosystem would be not considered so significant because there are not any national parks, nature conservation areas and game refuges in the Chone-Portoviejo river basins, and the existence of endangered species has not been reported.

(8) 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 mainly due to the discharge of municipal waste water from Protoviejo

city. So, the negative effects on the ecosystem could be caused by the Project although no precious species are not reported so far. Therefore, the improvement of sewerage system in Portoviejo city is considered essential to mitigate the magnitude of impacts caused by the water quality deterioration.

(9) The estuary in the Chone river once had rich and wide mangrove has been destroyed mainly due to shrimp pond construction. At present, only about 170 ha of mangrove remains according to PMRC report. According to the ANNEX E. AQUACULTURE in the Interim Report, there are no room to expand shrimp ponds in the estuary area of the Portoviejo river, but about 450 ha of potential shrimp pond area still remain in the Chone river. Since the potential shrimp pond area does not include the existing mangrove areas, any direct impacts would not be considered to mangrove ecosystem.

(10) 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 down stream area in the Chone river is strongly recommended to protect the encroachment of lands and ecosystems by overexploitation of shrimp ponds.

(11) 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 reduce the river flow discharge in the rainy season, it would be only 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 m3/s of discharge in the rainy season even with Project conditions. Moreover, La Esperanza dam covers less than 20 % of the total catchemnt area of the Chone river. Therefore, no serious impacts would be expected on the habitat of chame by the Project.

(12) Although several environmental impacts having significant effects on the environment are pointed out through EIA, these are not considered substantial for the Project because most of them would be able to mitigate the magnitude by taking proper countermeasures described in the next Chapter. Therefore, the Project is considered acceptable from the environmental viewpoints conclusively if the recommended countermeasures would be taken in future.

5.2 Recommendation

The following actions are strongly recommended to mitigate the magnitude of impacts and to avoid future problems with regard to the environmentally sound and sustainable development.

(1) To Change Intake Site of El Ceibal Treatment Plant

CRM currently proceeds to construct a new potable water treatment plant which has the production capacity 90,000 m3/day, namely El Ceibal Treatment Plant, in the Poza Honda System. It is planned to take the raw water for this plant from the Portoviejo river near Rocafuerte town. However, problems related to potable water treament could be expected due to the serious quality deterioration of raw water in the Portoviejo river. Thus, it could be necessary to change the planned intake site from the Portoviejo river to other areas being able to take raw water with better quality.

The Chico river could be one of options of raw water source. The future water quality at Rio Chico, just upstream of the confluence point with the Portoviejo river, could be fairly better than that of the Portoviejo. Moreover, the Chico river has less possibility of water quality deterioration in its basin. Therefore, it is recommendable to use the Chico river for the better 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 waste water treatment system, namely sewerage system in the cities being planned to provide municipal water by the Project. The future water quality at P-3 is predicted in 4 cases, namely no improvement of existing sewerage system, 30 %, 50 %, and 70 % of sewerage coverage ratio. This result, revealed the effectiveness of the sewerage system for conservation of the river water quality. Thus, the improvement of sewerage system should be promoted in future especially in Portoviejo city.

(3) To Control and Manage Land Use

The estuary area and the floodplain in the downstream area of the Chone river are considered very important ecological zones. Uncontrolled expansion of shrimp ponds especially in floodplain 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 floodplain in the Chone river is strongly recommended to protect the ecosystem against the encroachment by 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, well management of the gate is essential to conserve the habitat of chame and postlarvae of shrimp. Thus, the following points are to be recommended:

a) To operate the gate strategically, for example to close the gate at the end of the rainy season,
b) 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 projects would be acceptable through the environmental viewpoints, it is not possible to eliminate all uncertainties related to environmental impacts caused by the projects. Besides, unexpected environmental problems might be occured after implementation of the projects. Moreover, it is very important to monitor the effectiveness and efficiency of the proposed mitigation measures. Thus, EMMP is essential to attain environmentally sound and sustainable development of the Project.

TABLES

Table K.3.1 Water Quality Conditions in the Study Area (1/4)

(St.1) Dario Guevara, Portoviejo R.(prediction point:P-4)

Item	Date / Unit	1988 Mar. 15	1988 Apr. 26	1988 Jun. 18	1991 Nov. 21	1992 July. 13	Ave.
1) W. Temp	C	-	-	-	26.0	25.4	25.7
2) pH	-	-	-	-	8.6	7.0	7.8
3) EC	um	-	-	-	-	1,130	1,130
4) DO	mg/l	-	-	-	1.2	8.8	5.0
5) DSS	mg/l	-	-	-	-	-	-
6) TSS	mg/l	-	-	-	1,480	-	1,480
7) BOD	mg/l	-	-	-	6.4	3.0	4.7
8) COD	mg/l	-	-	-	12.0	6.5	9.3
9) NH4-N	mg/l	-	-	-	0.10	0.05	0.08
10) NO2-N	mg/l	-	-	-	0.00	0.00	0.00
11) NO3-N	mg/l	-	-	-	0.60	0.30	0.45
12) T-N	mg/l	-	-	-	1.00	0.50	0.75
13) T-P	mg/l	-	-	-	0.18	0.09	0.14

(St.2) Guayaba, Portoviejo R. (prediction point P-3)

Item	Date / Unit	1988 Mar. 15	1988 Apr. 26	1988 Jun. 18	1991 Nov. 21	1992 July. 13	Ave.
1) W. Temp	C	28.0	28.0	-	26.0	26.0	27.0
2) pH	-	7.8	7.9	-	7.7	6.8	7.6
3) EC	um	1,499	737	-	-	1,140	1,125
4) DO	mg/l	7.4	7.6	-	1.2	7.2	5.9
5) DSS	mg/l	1,349	663	-	-	-	1,006
6) TSS	mg/l	1,394	678	-	800	-	957
7) BOD	mg/l	1.0	1.7	-	5.6	2.0	2.6
8) COD	mg/l	-	-	-	10.0	5.0	7.5
9) NH4-N	mg/l	0.42	0.26	-	0.11	0.04	0.21
10) NO2-N	mg/l	0.01	0.01	-	0.01	0.00	0.01
11) NO3-N	mg/l	0.20	0.20	-	0.80	0.32	0.38
12) T-N	mg/l	-	-	-	1.00	0.40	0.70
13) T-P	mg/l	0.38	0.38	-	0.18	0.07	0.25

(St.3) Portoviejo, Portoviejo R.

Item	Date / Unit	1988 Mar. 15	1988 Apr. 26	1988 Jun. 18	1991 Nov. 22	1992 July. 13	Ave.
1) W. Temp	C	29.0	28.5	30.0	27.0	25.3	28.0
2) pH	-	7.9	8.0	7.9	7.7	6.9	7.7
3) EC	um	1,745	898	1,978	-	1,200	1,455
4) DO	mg/l	4.8	5.4	5.8	6.0	8.0	6.0
5) DSS	mg/l	1,570	808	1,780	-	-	1,386
6) TSS	mg/l	1,615	838	1,800	500	500	1,051
7) BOD	mg/l	2.4	1.5	6.9	7.5	3.2	4.3
8) COD	mg/l	-	-	-	10.0	7.0	8.5
9) NH4-N	mg/l	0.62	0.55	0.90	0.28	0.17	0.50
10) NO2-N	mg/l	0.05	0.03	0.02	0.01	0.01	0.02
11) NO3-N	mg/l	0.50	1.20	-	1.20	0.72	0.91
12) T-N	mg/l	-	-	-	2.00	1.20	1.60
13) T-P	mg/l	0.37	0.35	0.33	0.12	0.07	0.25

(St.4) Santa Ana, Portoviejo R.

Item	Date / Unit	1988 Mar. 15	1988 Apr. 26	1988 Jun. 18	1991 Nov. 22	1992 July. 13	Ave.
1) W. Temp	C	27.0	26.5	28.0	27.2	24.2	26.6
2) pH	-	7.9	7.9	7.9	7.8	7.3	7.8
3) EC	um	735	439	873	-	800	712
4) DO	mg/l	7.4	7.6	8.1	7.6	8.8	7.9
5) DSS	mg/l	662	395	786	-	-	614
6) TSS	mg/l	667	400	801	350	-	555
7) BOD	mg/l	1.5	1.0	0.7	7.3	5.0	3.1
8) COD	mg/l	-	-	-	14.0	9.0	11.5
9) NH4-N	mg/l	0.22	0.28	0.25	0.24	0.17	0.23
10) NO2-N	mg/l	0.01	0.08	0.01	0.01	0.01	0.02
11) NO3-N	mg/l	0.20	1.20	-	1.40	0.98	0.95
12) T-N	mg/l	-	-	-	2.00	1.40	1.70
13) T-P	mg/l	0.24	0.26	0.25	0.16	0.11	0.20

Table K.3.1 Water Quality Conditions in the Study Area (2/4)

(St.5) Poza Honda, Portoviejo R.

Item	Date / Unit	1988 Mar. 15	1988 Apr. 26	1988 Jun. 18	1991 Nov. 22	1992 July. 13	Ave.
1) W. Temp	C	25.0	26.0	27.0	28.0	27.1	26.6
2) pH	-	7.3	7.7	6.8	9.3	7.7	7.8
3) EC	um	295	194	184	-	700	343
4) DO	mg/l	0.9	5.3	1.4	7.4	9.2	4.8
5) DSS	mg/l	266	174	166	-	-	202
6) TSS	mg/l	271	194	176	500	-	285
7) BOD	mg/l	16.6	2.1	13.8	8.0	4.5	9.0
8) COD	mg/l	-	-	-	17.0	9.2	13.1
9) NH4-N	mg/l	1.80	2.00	0.95	0.30	0.15	1.04
10) NO2-N	mg/l	0.07	0.01	0.01	0.01	0.00	0.02
11) NO3-N	mg/l	0.50	1.00	-	0.90	0.45	0.71
12) T-N	mg/l	-	-	-	1.50	0.75	1.13
13) T-P	mg/l	0.17	0.22	0.18	0.16	0.08	0.16

(St.6) Rio Chico, Chico R., Portoviejo R.

Item	Date / Unit	1988 Mar. 15	1988 Apr. 26	1988 Jun. 15	1991 Nov. 22	1992 July. 14	Ave.
1) W. Temp	C	29.0	29.0	28.0	31.2	25.6	28.6
2) pH	-	8.0	8.1	8.1	8.1	7.2	7.9
3) EC	um	1,346	602	1,419	-	1,050	1,122
4) DO	mg/l	7.3	2.9	7.7	5.4	9.6	6.6
5) DSS	mg/l	1,211	541	1,277	-	-	1,010
6) TSS	mg/l	1,221	611	1,327	1,520	-	1,170
7) BOD	mg/l	3.1	1.2	1.3	9.1	4.0	3.7
8) COD	mg/l	-	-	-	12.0	8.5	10.3
9) NH4-N	mg/l	0.42	0.25	0.45	0.17	0.10	0.28
10) NO2-N	mg/l	0.00	0.01	0.01	0.01	0.01	0.01
11) NO3-N	mg/l	0.10	0.20	-	0.60	0.36	0.32
12) T-N	mg/l	-	-	-	1.00	0.60	0.80
13) T-P	mg/l	0.25	0.32	0.28	0.14	0.08	0.21

(St.7) El Pasaje, Chico R.

Item	Date / Unit	1988 Mar. 15	1988 Apr. 26	1988 Jun. 18	1991 Nov. 21	1992 July. 14	Ave.
1) W. Temp	C	-	-	-	31.9	25.4	28.7
2) pH	-	-	-	-	8.7	7.0	7.9
3) EC	um	-	-	-	-	1,130	1,130
4) DO	mg/l	-	-	-	7.6	8.8	8.2
5) DSS	mg/l	-	-	-	-	-	-
6) TSS	mg/l	-	-	-	600	-	600
7) BOD	mg/l	-	-	-	5.9	3.0	4.5
8) COD	mg/l	-	-	-	10.0	7.0	8.5
9) NH4-N	mg/l	-	-	-	0.22	0.13	0.18
10) NO2-N	mg/l	-	-	-	0.01	0.01	0.01
11) NO3-N	mg/l	-	-	-	0.60	0.36	0.48
12) T-N	mg/l	-	-	-	1.00	0.60	0.80
13) T-P	mg/l	-	-	-	0.14	0.08	0.11

(St.8) Punta Blanca, Estuary, Chone R.

Item	Date / Unit	1988 Mar. 15	1988 Apr. 7	1988 Jun. 18	1991 Nov. 21	1992 July. 14	Ave.
1) W. Temp	C	-	30.0	-	-	-	30.0
2) pH	-	-	8.0	-	-	-	8.0
3) EC	um	-	64,486	-	-	-	64,486
4) DO	mg/l	-	10.8	-	-	-	10.8
5) DSS	mg/l	-	58,037	-	-	-	58,037
6) TSS	mg/l	-	58,047	-	-	-	58,047
7) BOD	mg/l	-	3.7	-	-	-	3.7
8) COD	mg/l	-	6.30	-	-	-	6.30
9) NH4-N	mg/l	-	1.40	-	-	-	1.40
10) NO2-N	mg/l	-	0.00	-	-	-	0.00
11) NO3-N	mg/l	-	0.20	-	-	-	0.20
12) T-N	mg/l	-	0.84	-	-	-	0.84
13) T-P	mg/l	-	0.13	-	-	-	0.13

Table K.3.1 Water Quality Conditions in the Study Area (3/4)

(St.9) Punta Prieta, Estuary, Chone R. (prediction point:P-2)

Item	Date / Unit	1988 Mar. 15	1988 Apr. 7	1988 Jun. 18	1991 Nov. 21	1992 July. 14	Ave.
1) W. Temp	C	-	30.5	-	-	-	30.5
2) pH	-	-	8.0	-	-	-	8.0
3) EC	um	-	51,515	-	-	-	51,515
4) DO	mg/l	-	8.3	-	-	-	8.3
5) DSS	mg/l	-	46,363	-	-	-	46,363
6) TSS	mg/l	-	46,378	-	-	-	46,378
7) BOD	mg/l	-	5.3	-	-	-	5.3
8) COD	mg/l	-	9.0	-	-	-	9.0
9) NH4-N	mg/l	-	1.60	-	-	-	1.60
10) NO2-N	mg/l	-	0.00	-	-	-	0.00
11) NO3-N	mg/l	-	0.10	-	-	-	0.10
12) T-N	mg/l	-	4.20	-	-	-	4.20
13) T-P	mg/l	-	0.18	-	-	-	0.18

(St.10) Isla El Morro, Estuary, Chone R.

Item	Date / Unit	1988 Mar. 15	1988 Apr. 6	1988 Jun. 18	1991 Nov. 21	1992 July. 14	Ave.
1) W. Temp	C	-	30.0	-	-	-	30.0
2) pH	-	-	7.9	-	-	-	7.9
3) EC	um	-	33,063	-	-	-	33,063
4) DO	mg/l	-	9.4	-	-	-	9.4
5) DSS	mg/l	-	29,756	-	-	-	29,756
6) TSS	mg/l	-	29,776	-	-	-	29,776
7) BOD	mg/l	-	6.0	-	-	-	6.0
8) COD	mg/l	-	10.20	-	-	-	10.20
9) NH4-N	mg/l	-	1.35	-	-	-	1.35
10) NO2-N	mg/l	-	0.00	-	-	-	0.00
11) NO3-N	mg/l	-	0.10	-	-	-	0.10
12) T-N	mg/l	-	1.40	-	-	-	1.40
13) T-P	mg/l	-	0.23	-	-	-	0.23

(St.11) Drained Water from Shrimp Pond

Item	Date / Unit	1988 Mar. 15	1988 Apr. 26	1988 Jun. 18	1991 Nov. 21	1992 July. 14	Ave.
1) W. Temp	C	-	-	-	-	27.5	27.5
2) pH	-	-	-	-	-	7.7	7.7
3) EC	um	-	-	-	-	2,000	2,000
4) DO	mg/l	-	-	-	-	6.4	6.4
5) DSS	mg/l	-	-	-	-	-	-
6) TSS	mg/l	-	-	-	-	-	-
7) BOD	mg/l	-	-	-	-	13.00	13.00
8) COD	mg/l	-	-	-	-	17.50	17.50
9) NH4-N	mg/l	-	-	-	-	0.36	0.36
10) NO2-N	mg/l	-	-	-	-	0.01	0.01
11) NO3-N	mg/l	-	-	-	-	1.19	1.19
12) T-N	mg/l	-	-	-	-	2.64	2.64
13) T-P	mg/l	-	-	-	-	0.26	0.26

(St.12) Simbocal, Chone R. (prediction point: P-1)

Item	Date / Unit	1988 Mar. 15	1988 Apr. 7	1988 Jun. 18	1991 Nov. 21	1992 July. 15	Ave.
1) W. Temp	C	-	30.5	-	28.0	26.8	28.4
2) pH	-	-	8.1	-	8.5	7.4	8.0
3) EC	um	-	16,234	-	-	660	5,631
4) DO	mg/l	-	7.2	-	6.4	5.6	6.4
5) DSS	mg/l	-	14,610	-	-	-	14,610
6) TSS	mg/l	-	14,640	-	4,000	-	9,320
7) BOD	mg/l	-	9.0	-	8.0	2.5	6.5
8) COD	mg/l	-	-	-	16.0	6.6	11.3
9) NH4-N	mg/l	-	1.65	-	0.28	0.11	0.68
10) NO2-N	mg/l	-	0.01	-	0.00	0.00	0.00
11) NO3-N	mg/l	-	0.20	-	0.90	0.36	0.49
12) T-N	mg/l	-	1.40	-	2.00	0.80	1.40
13) T-P	mg/l	-	0.35	-	0.21	0.08	0.21

Table K.3.1 Water Quality Conditions in the Study Area (4/4)

(St.13) H. Saida, Chone R.

Item	Date / Unit	1988 Mar. 16	1988 Apr. 26	1988 Jun. 17	1991 Nov. 21	1992 July. 15	Ave.
1) W. Temp	C	30.0	-	30.0	26.0	26.8	28.2
2) pH	-	7.9	-	8.0	7.2	7.4	7.6
3) EC	um	405	-	532	-	660	532
4) DO	mg/l	7.5	-	8.1	2.0	5.6	5.8
5) DSS	mg/l	364	-	479	-	-	422
6) TSS	mg/l	369	-	494	1,100	-	654
7) BOD	mg/l	7.0	-	4.0	8.0	3.0	5.5
8) COD	mg/l	-	-	-	17.0	7.5	12.3
9) NH4-N	mg/l	0.18	-	0.25	0.31	0.12	0.22
10) NO2-N	mg/l	0.01	-	0.01	0.00	0.00	0.01
11) NO3-N	mg/l	0.70	-	-	0.70	0.28	0.56
12) T-N	mg/l	-	-	-	2.00	0.80	1.40
13) T-P	mg/l	0.35	-	0.14	0.31	0.12	0.23

(St.14) Bachillero, Carrizal R., Chone R.

Item	Date / Unit	1988 Mar. 16	1988 Apr. 27	1988 Jun. 15	1991 Nov. 21	1992 July. 15	Ave.
1) W. Temp	C	30.0	30.5	27.0	29.0	30.4	29.4
2) pH	-	7.9	7.5	7.8	8.8	7.4	7.9
3) EC	um	471	465	750	-	750	609
4) DO	mg/l	6.8	6.9	7.4	7.4	6.8	7.1
5) DSS	mg/l	424	418	675	-	-	506
6) TSS	mg/l	434	433	715	1,800	-	846
7) BOD	mg/l	6.0	7.0	2.3	8.8	3.0	5.4
8) COD	mg/l	-	-	-	15.0	8.0	11.5
9) NH4-N	mg/l	0.26	0.20	0.45	0.22	0.09	0.24
10) NO2-N	mg/l	0.00	0.00	0.01	0.00	0.00	0.00
11) NO3-N	mg/l	0.00	1.00	-	0.70	0.28	0.50
12) T-N	mg/l	-	-	-	1.00	0.40	0.70
13) T-P	mg/l	0.42	0.43	0.43	0.29	0.12	0.34

(St.15) La Esperanza, Carrizal R., Chone R.

Item	Date / Unit	1988 Mar. 16	1988 Apr. 27	1988 Jun. 16	1991 Nov. 21	1992 July. 15	Ave.
1) W. Temp	C	-	-	-	27.0	27.3	27.2
2) pH	-	-	-	-	7.6	7.2	7.4
3) EC	um	-	-	-	-	400	400
4) DO	mg/l	-	-	-	6.8	9.2	8.0
5) DSS	mg/l	-	-	-	-	-	-
6) TSS	mg/l	-	-	-	430	-	430
7) BOD	mg/l	-	-	-	2.4	3.5	3.0
8) COD	mg/l	-	-	-	6.0	6.5	6.3
9) NH4-N	mg/l	-	-	-	0.18	0.22	0.20
10) NO2-N	mg/l	-	-	-	0.00	0.00	0.00
11) NO3-N	mg/l	-	-	-	1.00	1.20	1.10
12) T-N	mg/l	-	-	-	2.00	2.40	2.20
13) T-P	mg/l	-	-	-	0.18	0.22	0.20

(St.16) Daule-Peripa Dam, Daule R.

Item	Date / Unit	1989 Average	1990 Average	1991 Average	1991 Nov. 23	1992 July. 16	Ave.
1) W. Temp	C	-	-	26.6	28.5	28.2	27.8
2) pH	-	-	-	6.8	8.5	7.5	7.6
3) EC	um	-	-	125	-	87	106
4) DO	mg/l	-	-	2.8	4.6	5.6	4.3
5) DSS	mg/l	-	-	-	-	-	-
6) TSS	mg/l	-	-	-	160	-	160
7) BOD	mg/l	-	-	-	8.8	5.5	7.2
8) COD	mg/l	-	-	-	15.0	11.5	13.3
9) NH4-N	mg/l	-	-	0.19	0.10	0.07	0.12
10) NO2-N	mg/l	-	-	-	0.01	0.01	0.01
11) NO3-N	mg/l	-	-	-	0.40	0.28	0.34
12) T-N	mg/l	0.49	0.41	-	1.00	0.70	0.65
13) T-P	mg/l	0.11	0.11	0.05	0.13	0.09	0.10

note: Water quality data on Nov. 1991 and July 1992 are obtained by the water quality survey in this study.

Source: 1) CALIDAD DE LAS AGUAS SUPERFICIALES, PHIMA, 1988
2) MANEJO ANBIENTAL DEL EMBALSE DAULE-PERIPA (INFORME TECNICO),

Table K. 3.2 Estimation of Water Quality of La Esperanza and Poza Honda Dams

Item		Discharge (MCM/y)	Water Quality and Load			
			BOD	COD	T-N	T-P
A. La Esperanza Dam						
1) QO (v. from Daule Peripa)		500.00				
2) CO (q. of w. from Daule Peripa)	(mg/l)		7.20	13.30	0.65	0.10
3) LO = QO x CO	(t/y)		3,600.00	6,650.00	325.00	50.00
4) Q1 (inflow to La Esperanza)		376.00				
5) C1 (w.q. of inflow w.)	(mg/l)		3.00	6.30	2.20	0.20
6) L1 = Q1 x C1	(t/y)		1,128.00	2,368.80	827.20	75.20
7) C2 (LO + L1)/(QO + Q1) (w.q. of La Esperanza)	(mg/l)		5.40	10.30	1.32	0.14
B.						
1) Q3 (v. from La Esperanza)		400.00				
2) C2 (q. of w. from La Esperanza)	(mg/l)		5.40	10.30	1.32	0.14
3) L3 = Q3 x C2	(t/y)		2,158.90	4,118.17	526.12	57.17
4) Q4 (inflow to Poza Honda)		95.00				
5) C4 (w.q. of inflow w.)	(mg/l)		9.00	13.10	1.13	0.16
6) L4 = Q4 x C4	(t/y)		855.00	1,244.50	107.35	15.20
7) C5 (L3 + L4)/(Q3 + Q4) (w.q. of Poza Honda)	(mg/l)		6.09	10.83	1.28	0.15

Source: JICA Study Team

Table K. 3.3 Possibility of Eutrophication in the Reservoirs of La Esperanza Dam and Poza Honda Dam

Item	unit	Daule Peripa Dam	La Esperanza Dam with Project		Poza Honda Dam with Project	
		(Existing)	(Existing)	(Future)	(Existing)	(Future)
1) Annual inflow (Q)	MCM	5,000	376	876	95	495
2) Dam volume (V)	MCM	5,300	455	455	98	98
3) surface area (A)	km2	200	32	32	5	5
4) Ave. depth (Z = V/A)	m	27	14	14	20	20
5) Conc'n pf T-P (C)	mg/l	0.10	0.20	0.14	0.16	0.15
6) Retention time (r = Q/V)	times/y	0.9	0.8	1.9	1.0	5.1
7) Annual load of T-P (L = Q x C)	t/y	500	75	125	15	72
8) T-P surface load (Ls = L/A)	g/m2/y	2.5	2.4	3.9	3.0	14.4
9) Z x r	m. times/y	25	12	27	19	99

Source: JICA Study Team

Table K.3.4 Existing and Future River Flow Conditions in the Study Area

	Chone R.						Portoviejo R.					
	(1) River Mouth		(2) Chone Upst'm		(3) Carrizal River		(4) Porto'jo Downst'm		(5) Porto'jo Upst'm		(6) Chico River	
	Exist'g	Future	Exist'g	Future	Exist'g	Future	Exist'g	Future	Exist'g	Future	Exist'g	Future
I. C.A. (km2)	2,267	2,267	755	755	1,166	1,166	2,060	2,060	1,190	1,190	585	585
II. Dis'ge (MCM)												
a) Rainy sea'n												
Jan	55.16	44.97	28.56	29.08	29.57	18.87	50.10	62.39	19.80	25.61	12.96	17.34
Feb	210.96	155.31	110.26	110.47	113.11	57.26	154.82	154.28	85.90	78.12	49.01	53.68
Mar	296.60	220.81	153.91	154.54	159.07	82.66	181.60	187.12	114.93	107.85	68.90	75.38
Apr	259.77	198.34	134.78	135.74	139.29	76.90	146.06	153.60	102.85	96.32	60.45	66.43
May	146.47	114.96	74.49	75.82	78.56	45.72	90.23	93.00	64.07	57.54	33.98	39.11
Jun	81.00	72.81	42.04	43.03	43.44	34.27	35.64	57.65	28.36	34.53	18.82	24.99
sub total	1,049.96	807.20	544.04	548.68	563.04	315.68	658.45	708.04	415.91	399.97	244.12	276.93
monthly m.	174.99	134.53	90.67	91.45	93.84	52.61	109.74	118.01	69.32	66.66	40.69	46.16
b) Dry sea'n												
Jul	33.13	35.87	17.18	18.35	17.76	20.49	23.38	37.69	13.71	19.08	7.67	13.22
Aug	13.61	22.34	7.08	8.45	7.31	15.84	12.52	26.54	7.10	12.96	3.14	8.16
Sep	8.04	20.09	4.22	5.94	4.30	15.79	7.80	25.06	5.16	11.66	1.84	8.58
Oct	5.99	35.69	3.11	4.72	3.21	40.05	4.69	21.90	4.54	10.81	1.45	8.55
Nov	6.01	34.27	3.14	4.46	3.24	38.93	6.27	20.22	4.59	10.26	1.37	6.51
Dec	9.07	34.27	4.72	5.62	4.87	37.87	9.49	21.21	5.60	10.58	2.10	8.35
sub total	75.85	182.53	39.45	47.54	40.69	168.97	64.15	152.62	40.70	75.35	17.57	53.37
monthly m.	12.64	30.42	6.58	7.92	6.78	28.16	10.69	25.44	6.78	12.56	2.93	8.90
Total	1,125.81	989.73	583.49	596.22	603.73	484.65	722.60	860.66	456.61	475.32	261.69	330.30
monthly m.	93.82	82.48	48.62	49.69	50.31	40.39	60.22	71.72	38.05	39.61	21.81	27.53

Source: JICA Study Team

Table K.3.5 Per Capita Pollution Load Unit and Sewage Water Quality

Item	unit	1990	2020
I. 1) Water consumption	l/c./d	159	407
2) Sewage Volume	l/c./d	64	265
II. Unit load			
BOD			
1) Excretion	g/c./d	10	20
2) Others	g/c./d	6	48
3) Total	g/c./d	16	68
4) Concentration	mg/l	252	257
COD			
1) Excretion	g/c./d	5	10
2) Others	g/c./d	3	24
3) Total	g/c./d	8	34
4) Concentration	mg/l	126	128
T-N			
1) Excretion	g/c./d	2	7
2) Others	g/c./d	1	6
3) Total	g/c./d	3	13
4) Concentration	mg/l	47	49
T-P			
1) Excretion	g/c./d	0.3	1.2
2) Others	g/c./d	0.2	1.0
3) Total	g/c./d	0.5	2.2
4) Concentration	mg/l	7.9	8.3

note: 1) Sewage volume is assumed at 40 % and 65 % of water consumption in 1990 and 2020.
2) Unit load is assumed by considering the existing sewage water quality data.

Source: 1) JICA Study Team
2) "A GUIDELINE FOR BASIN-WIDE SEWERAGE SYSTEM, 1979 M. OF CONSTRUCTION, JAPAN"

Table K.3.6 Estimation of Sewage Volume by Municipal Water Supply

Item / Sub-basin		Unit	Chone R. (1) River Mouth	Chone R. (2) Chone upstream	Chone R. (3) Carrizal River	Portoviejo R. (4) Porto'jo downst'm	Portoviejo R. (5) Porto'jo upstream	Portoviejo R. (6) Chico River
I.	Total Population							
	a. 1990		0	70,657	89,525	40,391	204,747	40,379
	b. 2020		0	108,247	129,245	55,410	383,310	62,528
II.	% of sewerage system							
	a. 1990		0	0	0	0	18	0
	b. 2020		0	0	0	0	4	0
III.	Unit sewage vol.							
	a. 1990	l/day	64	64	64	64	64	64
	b. 2020	l/day	265	265	265	265	265	265
IV.	Sewage vol. to be treated							
	a. 1990	m3/day	0	0	0	0	2,351	0
	b. 2020	m3/day	0	0	0	0	4,060	0
V.	% of non-sewerage system							
	a. 1990		100	100	100	100	82	100
	b. 2020		100	100	100	100	96	100
VI.	Population without sewerage system							
	a. 1990		0	70,657	89,525	40,391	167,893	40,379
	b. 2020		0	108,247	129,245	55,410	367,978	62,528

note: 1) Unit sewege volume is estimated at 40 % and 65 % of the unit water demand in 1990 and 2020.
2) Population in coastal areas is excluded because the sewage would be discharged to sea directly.

Source: JICA Study Team

Table K.3.7 Pollution Load by Municipal Water Supply (without sewage treatment)

River	Water Supply Population		Poll'n Load Unit		Sewer Volume		Pollution Load		
Year	1990	2020	1990 (g/c./d)	2020 (g/c./d)	1990 (MCM/y)	2020 (MCM/y)	1990 (t/y)	2020 (t/y)	Balance (t/y)
I. Chone R.	70,657	108,247			1.6	10.5			
a) BOD			6	68			413	2,687	2,274
b) COD			8	34			206	1,343	1,137
c) T-N			3	13			77	514	437
d) T-P			0.5	2.2			13	87	74
II. Carrizal R.	89,525	129,245			2.1	12.5			
a) BOD			6	68			523	3,208	2,685
b) COD			8	34			261	1,604	1,343
c) T-N			3	13			98	613	515
d) T-P			0.5	2.2			16	104	87
III. Portoviejo R. (upstream)	167,893	367,978			3.9	35.6			
a) BOD			6	68			980	9,133	8,153
b) COD			8	34			490	4,567	4,076
c) T-N			3	13			184	1,746	1,562
d) T-P			0.5	2.2			31	295	265
IV. Portoviejo R. (downstream)	40,391	55,410			0.9	5.4			
a) BOD			6	68			236	1,375	1,139
b) COD			8	34			118	688	570
c) T-N			3	13			44	263	219
d) T-P			0.5	2.2			7	44	37
V. Chico R.	40,379	62,528			0.9	6.0			
a) BOD			6	68			236	1,552	1,316
b) COD			8	34			118	776	658
c) T-N			3	13			44	297	252
d) T-P			0.5	2.2			7	50	43

note:
1) Population of III.Portoviejo(upstream) is excluded the number of persons who live in sewerage service areas.
2) Population in coastal areas is excluded because the sewage would be discharged to sea directly.
3) Pollution load unit is quated from "A GUIDELINE FOR BASIN-WIDE SEWERAGE SYSTEM, M. OF CONSTRUCTION, JAPAN, 1979".
4) Sewer volume is estimated at 40 % and 65 % of the total water demand in 1990 and 2020.

Source: JICA Study Team

Table K.3.8 Pollution Load from Sewage Treatment Plant (with treatment)
(Case-I: No improvement of sewerage pervation ratio)

	Sewage Vol. to be Treated		Sewage Quality		Reduc'n Rate		Pollution Load		
Year	1990	2020	1990	2020	1990	2020	1990	2020	Balance
River	(m3/d)	(m3/d)	(mg/l)	(mg/l)	(%)	(%)	(t/y)	(t/y)	(t/y)
I. Chone R.	0	0							
a) BOD	-	-	251	257	50	90	0	0	0
b) COD	-	-	125	128	40	80	0	0	0
c) T-N	-	-	47	49	30	50	0	0	0
d) T-P	-	-	7.8	8.3	30	50	0	0	0
II. Carrizal R.	0	0							
a) BOD	-	-	251	257	50	90	0	0	0
b) COD	-	-	125	128	40	80	0	0	0
c) T-N	-	-	47	49	30	50	0	0	0
d) T-P	-	-	7.8	8.3	30	50	0	0	0
III. Portoviejo R. (upstream)	2,351	4,060							
a) BOD	-	-	251	257	50	90	108	38	-70
b) COD	-	-	125	128	40	80	64	38	-26
c) T-N	-	-	47	49	30	50	28	36	8
d) T-P	-	-	7.8	8.3	30	50	5	6	1
IV. Portoviejo R. (downstream)	0	0							
a) BOD	-	-	251	257	50	90	0	0	0
b) COD	-	-	125	128	40	80	0	0	0
c) T-N	-	-	47	49	30	50	0	0	0
d) T-P	-	-	7.8	8.3	30	50	0	0	0
V. Chico R.	0	0							
a) BOD	-	-	251	257	50	90	0	0	0
b) COD	-	-	125	128	40	80	0	0	0
c) T-N	-	-	47	49	30	50	0	0	0
d) T-P	-	-	7.8	8.3	30	50	0	0	0

note: 1) Existing reduction rate is set based on the data obtained from CRM.
2) Future reduction rate (2020) is assumed by the Study Team.

Source: 1) PLAN INTEGRAL DE DESARROLLO DE LOS RECURSOS HIDRICOS DE LA PROVINCIA DE MANABI, 1990, JICA
2) JICA Study Team

Table K.3.9 Incremental Load from Municipal Water Supply (1990-2020)
(Case-I: No improvement of sewerage pervation ratio)

Pollution Load	Sub-basin	Chone R.			Portoviejo R.		
		(1) River Mouth (t/y)	(2) Chone upstream (t/y)	(3) Carrizal River (t/y)	(4) Porto'jo downst'm (t/y)	(5) Porto'jo upstream (t/y)	(6) Chico River (t/y)
BOD							
a) Without treatment		0	1364	1611	684	4892	790
b) With treatment		0	0	0	0	-63	0
c) Net increase		0	1364	1611	684	4829	790
COD							
a) Without treatment		0	682	806	342	2446	395
b) With treatment		0	0	0	0	-24	0
c) Net increase		0	682	806	342	2422	395
T-N							
a) Without treatment		0	262	309	131	937	151
b) With treatment		0	0	0	0	7	0
c) Net increase		0	262	309	131	944	151
T-P							
a) Without treatment		0	44	52	22	159	26
b) With treatment		0	0	0	0	1	0
c) Net increase		0	44	52	22	160	26

note: 1) Load discharge ratio of untreated waste water is assumed 60% of the total pollution load.
2) Load discharge ratio of treated waste water is assumed 90% of the total pollution load.

Source: JICA Study Team

Table K. 3.10 Pollution Load from Irrigation Water

	Sub-basin	Chone R. (1) River Mouth	(2) Chone upstream	(3) Carrizal River	Poroviejo R. (4) Porto'jo downst'm	(5) Porto'jo upstream	(6) Chico River
Water req'nt	(MCM/y)	0	68.6	116.4	123.5	82.4	37.2
Water quality							
a) BOD	(mg/l)	-	5.4	5.4	6.1	6.1	6.1
b) COD	(mg/l)	-	10.3	10.3	10.8	10.8	10.8
c) T-N	(mg/l)	-	1.32	1.32	1.28	1.28	1.28
d) T-P	(mg/l)	-	0.14	0.14	0.15	0.15	0.15
Pollution load							
a) BOD	(t/y)	0	370	629	753	503	227
b) COD	(t/y)	0	706	1,199	1,334	890	402
c) T-N	(t/y)	0	91	154	158	106	48
d) T-P	(t/y)	0	10	16	19	12	6

note: 1) Irrigation water of Chone and Carrizal comes from La Esperanza Dam.

2) Quality of La Esperanza (C2) is predicted by the following method:

C2 = (Q0 x C0 + Q1 x C1)/(Q0 + Q1)

where

Q0, C0: Volume and quality of diverted water from Daule Peripa dam,

Q1, C1: Volume and quality of inflow water to La Esperanza dam,

3) Irrigation water of Portoviejo and Chico comes from Poza Honda Dam.

4) Quality of Poza Honda (C5) is predicted by the following method:

C5 = (Q3 x C2 + Q4 x C4)/(Q3 + Q4)

where

Q3, C2: Volume and quality of diverted water from La Esperanza dam,

Q4, C4: Volume and quality of inflow water to Poza Honda dam,

5) Existing water quality data of Daule Peripa, La Esperanza and Poza Honda were obtained by water quality survey.

Source: JICA Study Team

Table K.3.11 Incremental Pollution Load by Land Use Change (1/3)

Year / River	Irrigation Area 1990 (ha)	Irrigation Area 2020 (ha)	Load Unit (kg/ha/y)	Pollution Load 1990 (t/y)	Pollution Load 2020 (t/y)	Balance (t/y)
I. Chone R.						
1) Paddy	30	2,390				
a) BOD			82	2	196	194
b) COD			102	3	244	241
c) T-N			32	1	76	76
d) T-P			3.2	0.1	7.6	7.6
2) Pasture	860	0				
a) BOD			59	51	0	-51
b) COD			106	91	0	-91
c) T-N			14	12	0	-12
d) T-P			1.6	1.4	0.0	-1.4
3) Perennial	770	2,090				
a) BOD			14	11	29	18
b) COD			18	14	38	24
c) T-N			73	56	153	96
d) T-P			0.7	0.5	1.5	0.9
4) Upland	630	1,520				
a) BOD			20	13	30	18
b) COD			26	16	40	23
c) T-N			28	18	43	25
d) T-P			0.9	0.6	1.4	0.8
5) Others	3,710	0				
a) BOD			12	45	0	-45
b) COD			15	56	0	-56
c) T-N			2	7	0	-7
d) T-P			0.4	1.5	0.0	-1.5
Total	6,000	6,000				
a) BOD			-	121	256	135
b) COD			-	180	321	141
c) T-N			-	94	272	177
d) T-P			-	4.1	10.5	6.4
II. Carrizal R.						
1) Paddy	40	3,980				
a) BOD			82	3	326	323
b) COD			102	4	406	402
c) T-N			32	1	127	126
d) T-P			3.2	0.1	12.7	12.6
2) Pasture	1,440	0				
a) BOD			59	85	0	-85
b) COD			106	153	0	-153
c) T-N			14	20	0	-20
d) T-P			1.6	2.3	0.0	-2.3
3) Perennial	1,280	3,490				
a) BOD			14	18	49	31
b) COD			18	23	63	40
c) T-N			73	93	255	161
d) T-P			0.7	0.9	2.4	1.5
4) Upland	1,050	2,530				
a) BOD			20	21	51	30
b) COD			26	27	66	38
c) T-N			28	29	71	41
d) T-P			0.9	0.9	2.3	1.3
5) Others	6,190	0				
a) BOD			12	74	0	-74
b) COD			15	93	0	-93
c) T-N			2	12	0	-12
d) T-P			0.4	2.5	0.0	-2.5
Total	10,000	10,000				
a) BOD			-	201	426	224
b) COD			-	300	535	235
c) T-N			-	157	453	296
d) T-P			-	6.7	17.5	10.7

Table K.3.11 Incremental Pollution Load by Land Use Change (2/3)

Year / River	Irrigation Area 1990 (ha)	Irrigation Area 2020 (ha)	Load Unit (kg/ha/y)	Pollution Load 1990 (t/y)	Pollution Load 2020 (t/y)	Balance (t/y)
III. Portoviejo R. (upstream)						
1) Paddy	380	2,320				
a) BOD			82	31	190	159
b) COD			102	39	237	198
c) T-N			32	12	74	62
d) T-P			3.2	1.2	7.4	6.2
2) Pasture	760	0				
a) BOD			59	45	0	-45
b) COD			106	81	0	-81
c) T-N			14	11	0	-11
d) T-P			1.6	1.2	0.0	-1.2
3) Perennial	200	1,180				
a) BOD			14	3	17	14
b) COD			18	4	21	18
c) T-N			73	15	86	72
d) T-P			0.7	0.1	0.8	0.7
4) Upland	3,210	1,050				
a) BOD			20	64	21	-43
b) COD			26	83	27	-56
c) T-N			28	90	29	-60
d) T-P			0.9	2.9	0.9	-1.9
5) Others	0	0				
a) BOD			12	0	0	0
b) COD			15	0	0	0
c) T-N			2	0	0	0
d) T-P			0.4	0.0	0.0	0.0
Total	4,550	4,550				
a) BOD			-	143	228	85
b) COD			-	206	285	79
c) T-N			-	127	190	63
d) T-P			-	5.5	9.2	3.7
IV. Portoviejo R. (downstream)						
1) Paddy	750	1,950				
a) BOD			82	62	160	98
b) COD			102	77	199	122
c) T-N			32	24	62	38
d) T-P			3.2	2.4	6.2	3.8
2) Pasture	790	0				
a) BOD			59	47	0	-47
b) COD			106	84	0	-84
c) T-N			14	11	0	-11
d) T-P			1.6	1.3	0.0	-1.3
3) Perennial	200	2,540				
a) BOD			14	3	36	33
b) COD			18	4	46	42
c) T-N			73	15	185	171
d) T-P			0.7	0.1	1.8	1.6
4) Upland	4,410	1,660				
a) BOD			20	88	33	-55
b) COD			26	115	43	-72
c) T-N			28	123	46	-77
d) T-P			0.9	4.0	1.5	-2.5
5) Others	0	0				
a) BOD			12	0	0	0
b) COD			15	0	0	0
c) T-N			2	0	0	0
d) T-P			0.4	0.0	0.0	0.0
Total	6,150	6,150				
a) BOD			-	199	229	30
b) COD			-	279	288	9
c) T-N			-	173	294	121
d) T-P			-	7.8	9.5	1.7

Table K.3.11 Incremental Pollution Load by Land Use Change (3/3)

Year / River	Irrigation Area 1990 (ha)	Irrigation Area 2020 (ha)	Load Unit (kg/ha/y)	Pollution Load 1990 (t/y)	Pollution Load 2020 (t/y)	Pollution Load Balance (t/y)
V. Chico R.						
1) Paddy	50	1,020				
a) BOD			82	4	84	80
b) COD			102	5	104	99
c) T-N			32	2	33	31
d) T-P			3.2	0.2	3.3	3.1
2) Pasture	1,050	0				
a) BOD			59	62	0	-62
b) COD			106	111	0	-111
c) T-N			14	15	0	-15
d) T-P			1.6	1.7	0.0	-1.7
3) Perennial	900	890				
a) BOD			14	13	12	0
b) COD			18	16	16	0
c) T-N			73	66	65	-1
d) T-P			0.7	0.6	0.6	0.0
4) Upland	550	640				
a) BOD			20	11	13	2
b) COD			26	14	17	2
c) T-N			28	15	18	3
d) T-P			0.9	0.5	0.6	0.1
5) Others	0	0				
a) BOD			12	0	0	0
b) COD			15	0	0	0
c) T-N			2	0	0	0
d) T-P			0.4	0.0	0.0	0.0
Total	2,550	2,550				
a) BOD			-	90	109	19
b) COD			-	147	137	-10
c) T-N			-	97	116	18
d) T-P			-	3.0	4.5	1.5

note:
1) I. Chone R. includes a part of Carrizal-Chone area.
2) II. Carrizal R. includes a rest of Carrizal-Chone irrigation area and Amarillos irrigation areas.
3) III. Portoviejo R.(upstream) includes Santa Ana and Mejia irrigation areas.
4) IV. Portoviejo R.(downstream) includes Guarango and Ceibal-Guayaba irrigation areas.
5) V. Chico R. includes Rio Chico and Pechiche-Pasaje irrigation area.
6) Irrigation area is calculated based on the PHIMA report 1990, JICA.
7) Pollution load unit is quoted from "A GUIDELINE FOR BASIN-WIDE SEWERAGE SYSTEM, M. OF CONSTRUCTION, JAPAN, 1979.

Source: JICA Study Team

Table K.3.12 Decrease of Pollution Load by Change of Cattle Heads

Year / River	Pasture Area 1990 (ha)	Pasture Area 2020 (ha)	Load Unit (kg/h./y)	Pollution Load 1990 (t/y)	Pollution Load 2020 (t/y)	Balance (t/y)
I. Chone R.	860	0				
a) Cattle heads	1118	0				
b) BOD			234	262	0	-262
c) COD			193	216	0	-216
d) T-N			138	154	0	-154
e) T-P			20	22	0	-22
II. Carrizal R.	1440	0				
a) Cattle heads	1872	0				
b) BOD			234	438	0	-438
c) COD			193	361	0	-361
d) T-N			138	258	0	-258
e) T-P			20	37	0	-37
III. Portoviejo R. (upstream)	760	0				
a) Cattle heads	988	0				
b) BOD			234	231	0	-231
c) COD			193	191	0	-191
d) T-N			138	136	0	-136
e) T-P			20	20	0	-20
IV. Portoviejo (downstream)	790	0				
a) Cattle heads	1027	0	234			
b) BOD			193	198	0	-198
c) COD			138	142	0	-142
d) T-N			20	21	0	-21
e) T-P			9	9	0	-9
V. Chico R.	1050	0				
a) Cattle heads	1365	0				
b) BOD			207	283	0	-283
c) COD			193	263	0	-263
d) T-N			66	90	0	-90
e) T-P			9	12	0	-12
Total	4900	0				
a) Cattle heads	6370	0				
b) BOD			207	1319	0	-1319
c) COD			193	1229	0	-1229
d) T-N			66	420	0	-420
e) T-P			9	57	0	-57

note: 1) Pasture area is quoted from Table K.3.12.
2) Average heads of cattle is 1.3 heads/ha quoted from "PROYECTO MULTIPLE CARRIZAL-CHONE, SISTEMA DE RIEGO Y DRENAJE, 1988".
3) Pollution load unit is quoted from "A GUIDELINE FOR BASIN-WIDE SEWERAGE SYSTEM, M. OF CONSTRUCTION, JAPAN, 1979.

Source: JICA Study Team

Table K. 3.13 Incremental Load from Irrigation Area by the Project

Sub-basin	Chone R.			Portoviejo R.		
Pollution Load	(1) River Mouth (t/y)	(2) Chone upstream (t/y)	(3) Carrizal River (t/y)	(4) Porto'jo downst'm (t/y)	(5) Porto'jo upstream (t/y)	(6) Chico River (t/y)
BOD						
a) Irrigation water	0	185	314	377	251	114
b) Land use change	0	67	112	42	15	10
c) Cattle	0	-52	-88	-46	-40	-57
d) Net increase	0	200	338	373	226	67
COD						
a) Irrigation water	0	353	600	667	445	201
b) Land use change	0	70	117	39	5	-5
c) Cattle	0	-43	-72	-38	-28	-53
d) Net increase	0	380	645	668	422	143
T-N						
a) Irrigation water	0	45	77	79	53	24
b) Land use change	0	89	148	31	61	9
c) Cattle	0	-31	-52	-27	-4	-18
d) Net increase	0	103	173	83	110	15
T-P						
a) Irrigation water	0	5	8	9	6	3
b) Land use change	0	3	5	2	1	1
c) Cattle	0	-4	-7	-2	-2	-11
d) Net increase	0	4	6	9	5	-7

note: 1) Load discharge ratio of irrigation water and land use change is assumed 50% of each pollution load.
2) Load discharge ratio of cattles is assumed 20% of the total load.

Source: JICA Study Team

Table K.3.14 Change of Load from Water Supply for Aquaculture (Shrimp Pond)

Item	unit	Water Quality		Pollution Load		
		Pumped Water (mg/l)	Drained Water (mg/l)	1990 (t/y)	2020 (t/y)	Increase (t/y)
a) Shrimp farm area	ha	5097	5547	-	-	-
b) Growout pond ratio	%	80	80	-	-	-
c) Net water area	ha	4078	4438	-	-	-
d) Average depth	m	0.7	0.7	-	-	-
e) Water exchange rate	%/d	10	10	-	-	-
f) Discharge volume	MCM/y	1042	1134	-	-	-
g) Water quality item						
- BOD		6.0	13.0	7,293	7,937	644
- COD		10.2	17.5	7,605	8,277	671
- T-N		1.40	2.64	1,292	1,406	114
- T-P		0.23	0.26	31	34	3

note: 1) Water quality data are obtained by water quality survey.
2) Data related to shrimp pond are quoted from Interim Report of this Project.

Source: JICA Study Team

Table K.3.15 Estimation of Incremental Pollution Load by the Project

Sub-basin / Pollution Load	Chone R. (1) River Mouth (t/y)	Chone R. (2) Chone upstream (t/y)	Chone R. (3) Carrizal River (t/y)	Portoviejo R. (4) Porto'jo downst'm (t/y)	Portoviejo R. (5) Porto'jo upstream (t/y)	Portoviejo R. (6) Chico River (t/y)
BOD						
a) Municipal water	0	1,364	1,611	684	4,829	790
b) Irrigation	0	200	339	373	227	67
c) Aquaculture	644	0	0	0	0	0
Total	644	1,564	1,950	1,057	5,056	857
COD						
a) Municipal water	0	682	806	342	2,422	395
b) Irrigation	0	380	645	668	421	143
c) Aquaculture	671	0	0	0	0	0
Total	671	1,062	1,451	1,010	2,843	538
T-N						
a) Municipal water	0	262	309	131	945	151
b) Irrigation	0	103	173	83	109	15
c) Aquaculture	114	0	0	0	0	0
Total	114	365	482	214	1,054	166
T-P						
a) Municipal water	0	44	52	22	160	26
b) Irrigation	0	4	6	9	5	-8
c) Aquaculture	3	0	0	0	0	0
Total	3	48	58	31	165	18

Source: JICA Study Team

Table K.3.16 Prediction of River Flow Discharge and Water Quality in 2020 (P-1, Simbocal, Chone River)

Prediction point / Item		P-1 Rainy Season	P-1 Dry Season	P-1 Annual
River Flow Discharge				
I. Existing (Q3)	(MCM/y)	1049.96	75.85	1125.81
II. Future (Q3')	(MCM/y)	807.20	182.53	989.73
Pollution Load				
I. Existing (L3)				
a) BOD	(t/y)	3,321	674	3,995
b) COD	(t/y)	8,585	1,281	9,866
c) T-N	(t/y)	660	120	780
d) T-P	(t/y)	133	24	157
II. Additional Load (L1+L2)				
a) BOD	(t/y)	1,758	1,758	3,515
b) COD	(t/y)	1,257	1,257	2,513
c) T-N	(t/y)	424	424	847
d) T-P	(t/y)	53	53	106
III. Future Load (L3')				
a) BOD	(t/y)	5,079	2,431	7,510
b) COD	(t/y)	9,841	2,538	12,379
c) T-N	(t/y)	1,084	543	1,627
d) T-P	(t/y)	186	77	263
Water Quality				
I. Existing (C3)				
a) BOD	(mg/l)	2.50	8.00	5.25
b) COD	(mg/l)	6.60	16.00	11.30
c) T-N	(mg/l)	0.80	2.00	1.40
d) T-P	(mg/l)	0.08	0.21	0.15
II. Future (C3')				
a) BOD	(mg/l)	6.29	13.32	7.59
b) COD	(mg/l)	12.19	13.90	12.51
c) T-N	(mg/l)	1.34	2.98	1.64
d) T-P	(mg/l)	0.23	0.42	0.27

Source: JICA Study Team

Table K.3.17 Prediction of River Flow Discharge and Water Quality in 2020 (P-2, Chone Estuary)

Item / Prediction point		P-2 Rainy Season	P-2 Dry Season	P-2 Annual
Inflow Volume				
I. Existing Inflow				
a) River inflow (Q3)	(MCM/y)	1,049.96	75.85	1,125.81
b) Tidal inflow (Qs)	(MCM/y)	781.92	794.88	1,576.80
c) Total inflow	(MCM/y)	1,831.88	870.73	2,702.61
II. Future Inflow				
a) River inflow (Q3')	(MCM/y)	807.20	182.53	989.73
b) Tidal inflow (Qs)	(MCM/y)	781.92	794.88	1,576.80
c) Addit'l inflow (Q4)	(MCM/y)	41.04	41.04	82.08
d) Total inflow	(MCM/y)	1,630.16	1,018.45	2,648.61
Pollution Load				
I. Existing Load				
A. Load from river (L3)				
a) BOD	(t/y)	2,625	607	3,232
b) COD	(t/y)	6,930	1,214	8,143
c) T-N	(t/y)	840	152	992
d) T-P	(t/y)	84	16	100
B. Load from tidal action (Ls)				
a) BOD	(t/y)	2,893	2,941	5,834
b) COD	(t/y)	4,926	5,008	9,934
c) T-N	(t/y)	657	668	1,325
d) T-P	(t/y)	102	103	205
C. Total load				
a) BOD	(t/y)	5,518	3,548	9,066
b) COD	(t/y)	11,856	6,221	18,077
c) T-N	(t/y)	1,497	819	2,316
d) T-P	(t/y)	186	119	305
II. Future Load				
A. Load from river (L3')				
a) BOD	(t/y)	5,079	2,431	7,510
b) COD	(t/y)	9,841	2,538	12,379
c) T-N	(t/y)	1,084	543	1,627
d) T-P	(t/y)	186	77	263
B. Load from tidal action (Ls)				
a) BOD	(t/y)	2,893	2,941	5,834
b) COD	(t/y)	4,926	5,008	9,934
c) T-N	(t/y)	657	668	1,325
d) T-P	(t/y)	102	103	205
C. Additional load (L4)				
a) BOD	(t/y)	322	322	644
b) COD	(t/y)	336	336	671
c) T-N	(t/y)	57	57	114
d) T-P	(t/y)	2	2	3
D. Total load				
a) BOD	(t/y)	8,294	5,694	13,988
b) COD	(t/y)	15,103	7,881	22,983
c) T-N	(t/y)	1,798	1,268	3,066
d) T-P	(t/y)	289	182	471
Water Quality				
I. Existing (C5)				
a) BOD	(mg/l)	2.50	8.00	5.25
b) COD	(mg/l)	6.60	16.00	11.30
c) T-N	(mg/l)	0.80	2.00	1.40
d) T-P	(mg/l)	0.08	0.21	0.15
II. Future (C5')				
a) BOD	(mg/l)	5.09	5.59	5.28
b) COD	(mg/l)	9.26	7.74	8.68
c) T-N	(mg/l)	1.10	1.24	1.16
d) T-P	(mg/l)	0.18	0.18	0.18

Source: JICA Study Team

Table K.3.18 Prediction of River Flow Discharge and Water Quality in 2020 (P-3, Guayaba, Portoviejo River)

Prediction point / Item		P-3 Rainy Season	Dry Season	Annual
River Flow Discharge				
I. Existing (Q8)	(MCM/y)	658.45	64.15	722.60
II. Future (Q8')	(MCM/y)	708.04	152.62	860.66
Pollution Load				
I. Existing (L8)				
a) BOD	(t/y)	2,307	465	2,773
b) COD	(t/y)	4,986	618	5,604
c) T-N	(t/y)	646	99	745
d) T-P	(t/y)	49	7	56
II. Additional Load (L6+L7)				
a) BOD	(t/y)	2,956	2,956	5,912
b) COD	(t/y)	1,691	1,691	3,381
c) T-N	(t/y)	610	610	1,220
d) T-P	(t/y)	92	92	183
III. Future Load				
a) BOD	(t/y)	5,263	3,421	8,685
b) COD	(t/y)	6,677	2,308	8,985
c) T-N	(t/y)	1,256	709	1,965
d) T-P	(t/y)	140	99	239
Water Quality				
I. Existing (C8)				
a) BOD	(mg/l)	3.00	6.40	4.70
b) COD	(mg/l)	6.50	12.00	9.25
c) T-N	(mg/l)	0.50	1.00	0.75
d) T-P	(mg/l)	0.09	0.18	0.14
II. Future (C8')				
a) BOD	(mg/l)	7.43	22.42	10.09
b) COD	(mg/l)	9.43	15.12	10.44
c) T-N	(mg/l)	1.77	4.65	2.28
d) T-P	(mg/l)	0.20	0.65	0.28

Source: JICA Study Team

Table K.3.19 Prediction of River Flow Discharge and Water Quality in 2020 (P-4, Portoviejo River)

Item / Prediction point		P-4 Rainy Season	P-4 Dry Season	Annual
River Flow Discharge				
I. Existing (Q8)	(MCM/y)	658.45	64.15	722.60
II. Future				
a) River discharge (Q8')	(MCM/y)	708.04	152.62	860.66
b) Additional flow (Q9+Q10)	(MCM/y)	14.23	14.23	28.46
c) Total flow	(MCM/y)	722.27	166.85	889.12
Pollution Load				
I. Existing (L11)				
a) BOD	(t/y)	1,975	411	2,386
b) COD	(t/y)	4,280	770	5,050
c) T-N	(t/y)	329	64	393
d) T-P	(t/y)	59	12	71
II. Future				
A. Load from river (L8')				
a) BOD	(t/y)	5,263	3,421	8,685
b) COD	(t/y)	6,677	2,308	8,985
c) T-N	(t/y)	1,256	709	1,965
d) T-P	(t/y)	140	99	239
B. Additional Load (L9+L10)				
a) BOD	(t/y)	528	528	1,056
b) COD	(t/y)	505	505	1,010
c) T-N	(t/y)	107	107	214
d) T-P	(t/y)	16	16	32
C. Total Load (L11')				
a) BOD	(t/y)	5,791	3,949	9,741
b) COD	(t/y)	7,182	2,813	9,995
c) T-N	(t/y)	1,363	816	2,179
d) T-P	(t/y)	156	115	271
Water Quality				
I. Existing (C11)				
a) BOD	(mg/l)	3.00	6.40	4.70
b) COD	(mg/l)	6.50	12.00	9.25
c) T-N	(mg/l)	0.50	1.00	0.75
d) T-P	(mg/l)	0.09	0.18	0.14
II. Future (C11')				
a) BOD	(mg/l)	8.02	23.67	10.96
b) COD	(mg/l)	9.94	16.86	11.24
c) T-N	(mg/l)	1.89	4.89	2.45
d) T-P	(mg/l)	0.22	0.69	0.30

Source: JICA Study Team

Table K.3.20 Additional River Flow Discharge and its Quality and Pollution Load

Item	Sub-basin	Chone R. (1) River Mouth	Chone R. (2) Chone upstream	Chone R. (3) Carrizal River	Portoviejo R. (4) Porto'jo downst'm	Portoviejo R. (5) Porto'jo upstream	Portoviejo R. (6) Chico River
Additional River Flow Discharge							
a) Sewege volume	(MCM/y)	0.00	7.58	8.90	3.76	28.16	4.39
b) Irr'n return flow	(MCM/y)	0.00	13.72	23.28	24.70	16.48	7.44
c) Aqu're return flow	(MCM/y)	82.08	0.00	0.00	0.00	0.00	0.00
d) Total	(MCM/y)	82.08	21.30	32.18	28.46	44.64	11.83
Water Quality							
I. Mean							
a) BOD	(mg/l)	7.8	73.5	60.6	37.1	113.3	72.4
b) COD	(mg/l)	8.2	49.9	45.1	35.5	63.7	45.5
c) T-N	(mg/l)	1.4	17.1	15.0	7.5	23.6	14.0
d) T-P	(mg/l)	0.0	2.3	1.8	1.1	3.7	1.5
Pollution Load							
I. Total							
a) BOD	(t/y)	644	1,565	1,950	1,056	5,056	856
b) COD	(t/y)	671	1,063	1,450	1,010	2,843	538
c) T-N	(t/y)	114	365	482	214	1,054	166
d) T-P	(t/y)	3	48	58	32	165	18

Source: JICA Study Team

FIGURES

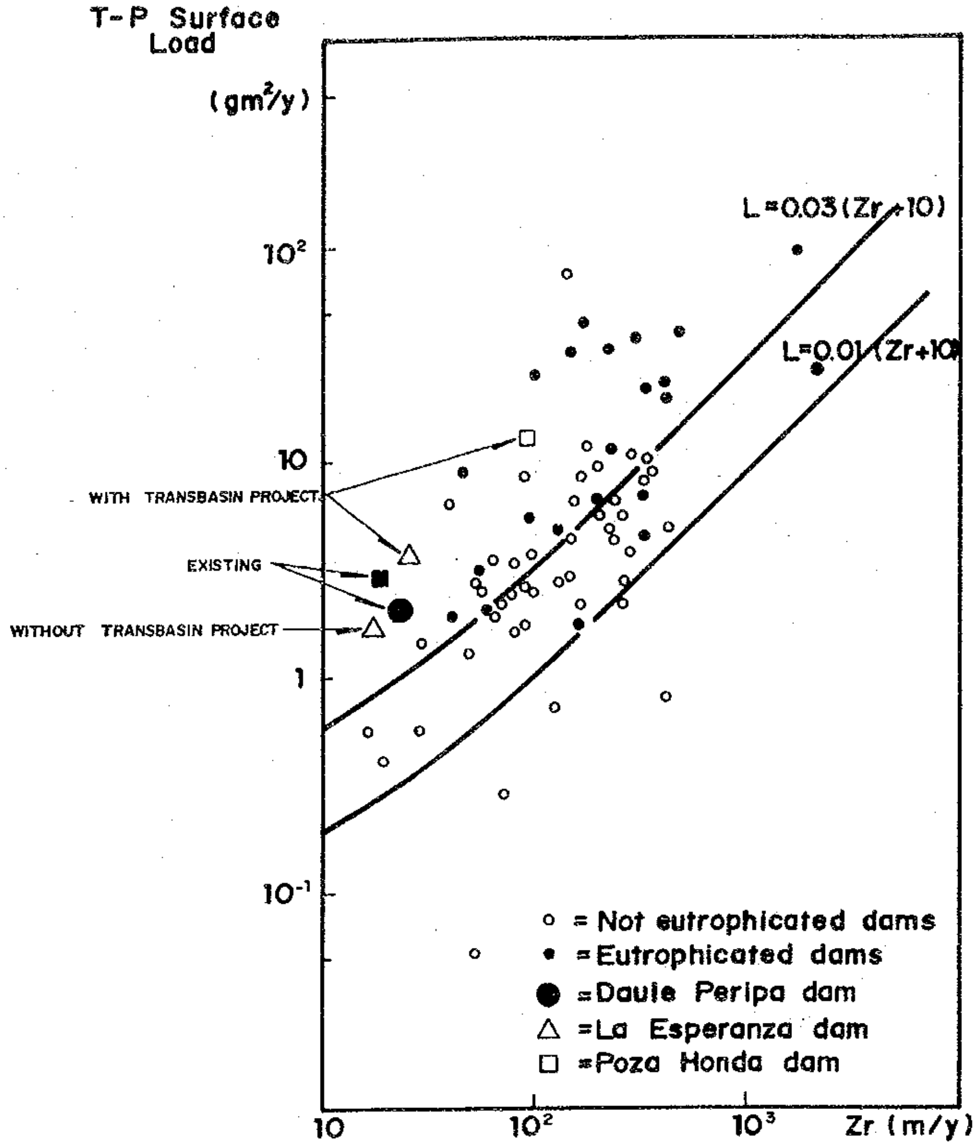


Fig.K.3.1 Possibility of Eutrophication (Vollenweider Model)

GOVERNMENT OF THE REPUBLIC OF ECUADOR
CENTRO DE REHABILITACION DE MANABI (CRM)
THE FEASIBILITY STUDY ON THE WATER RESOURCES DEVELOPMENT FOR CHONE-PORTOVIEJO RIVER BASINS

JAPAN INTERNATIONAL COOPERATION AGENCY

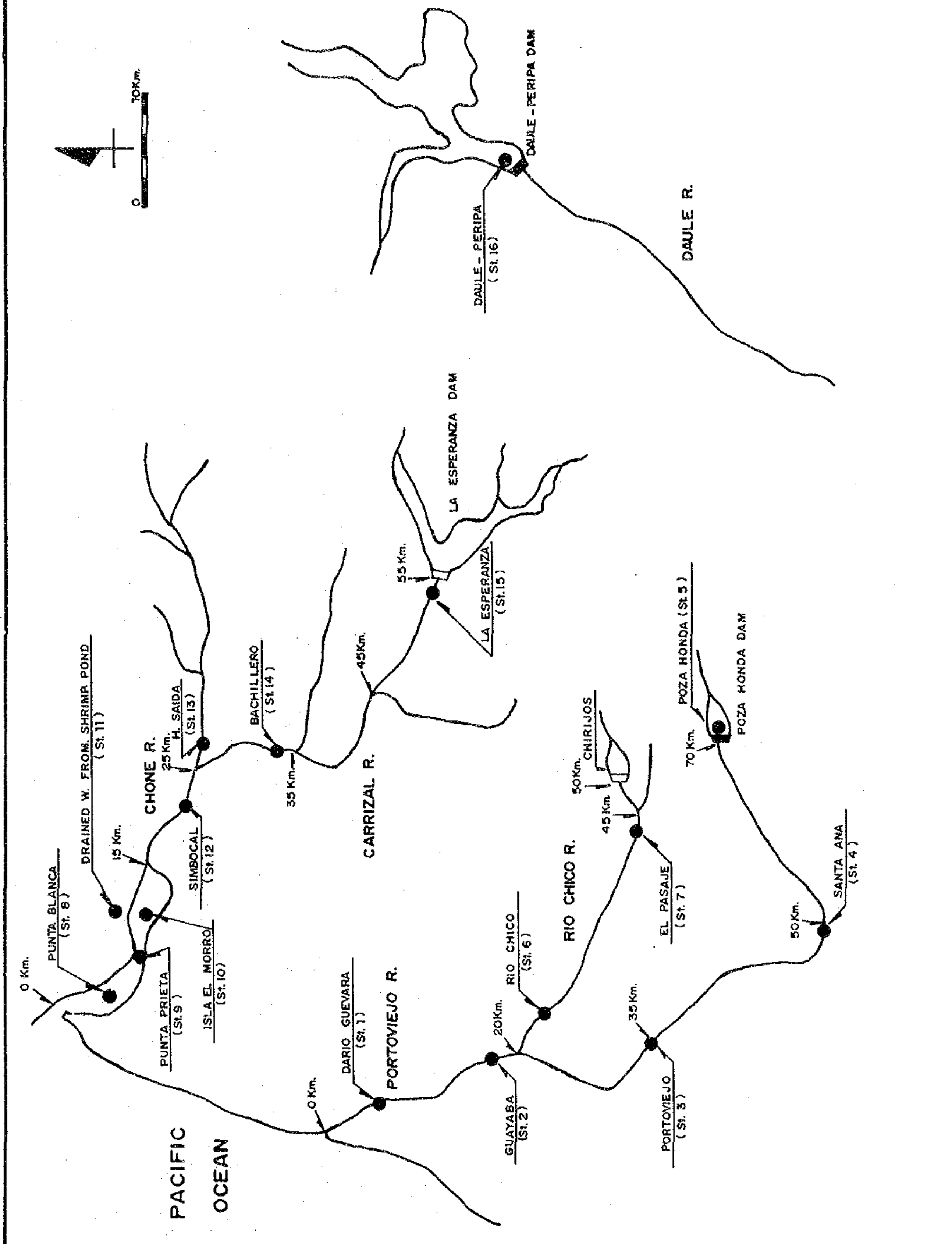


Fig. K.3.2 Location of water Quality Survey Stations

GOVERNMENT OF THE REPUBLIC OF ECUADOR
CENTRO DE REHABILITACION DE MANABI (CRM)
THE FEASIBILITY STUDY ON THE WATER RESOURCES DEVELOPMENT FOR CHONE - PORTOVIEJO RIVER BASINS

JAPAN INTERNATIONAL COOPERATION AGENCY

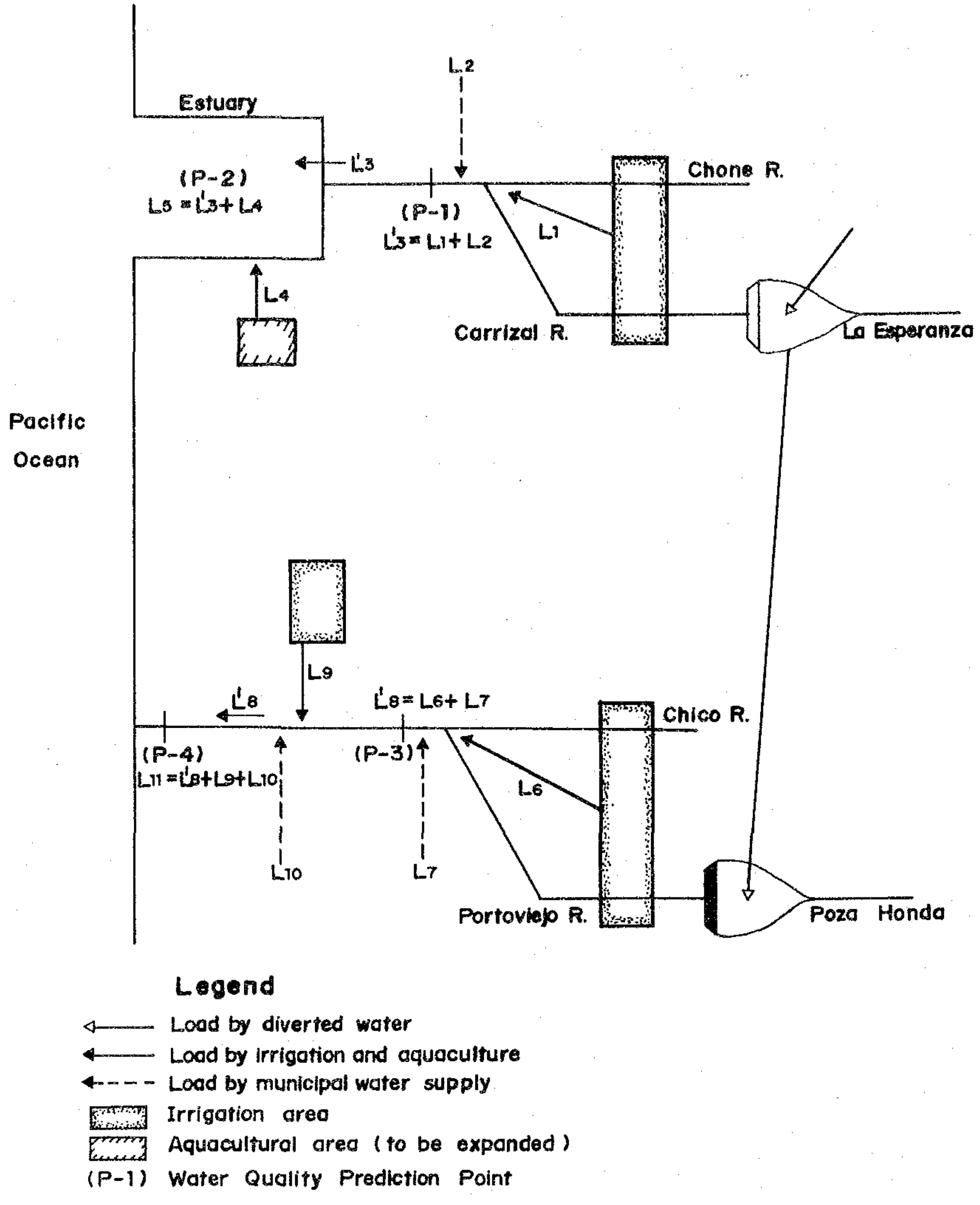


Fig. K 3.3 Schematic Diagram of Pollution Load Analysis

GOVERNMENT OF THE REPUBLIC OF ECUADOR
CENTRO DE REHABILITACION DE MANABI (CRM)
THE FEASIBILITY STUDY ON THE WATER RESOURCES DEVELOPMENT FOR CHONE - PORTOVIEJO RIVER BASINS

JAPAN INTERNATIONAL COOPERATION AGENCY

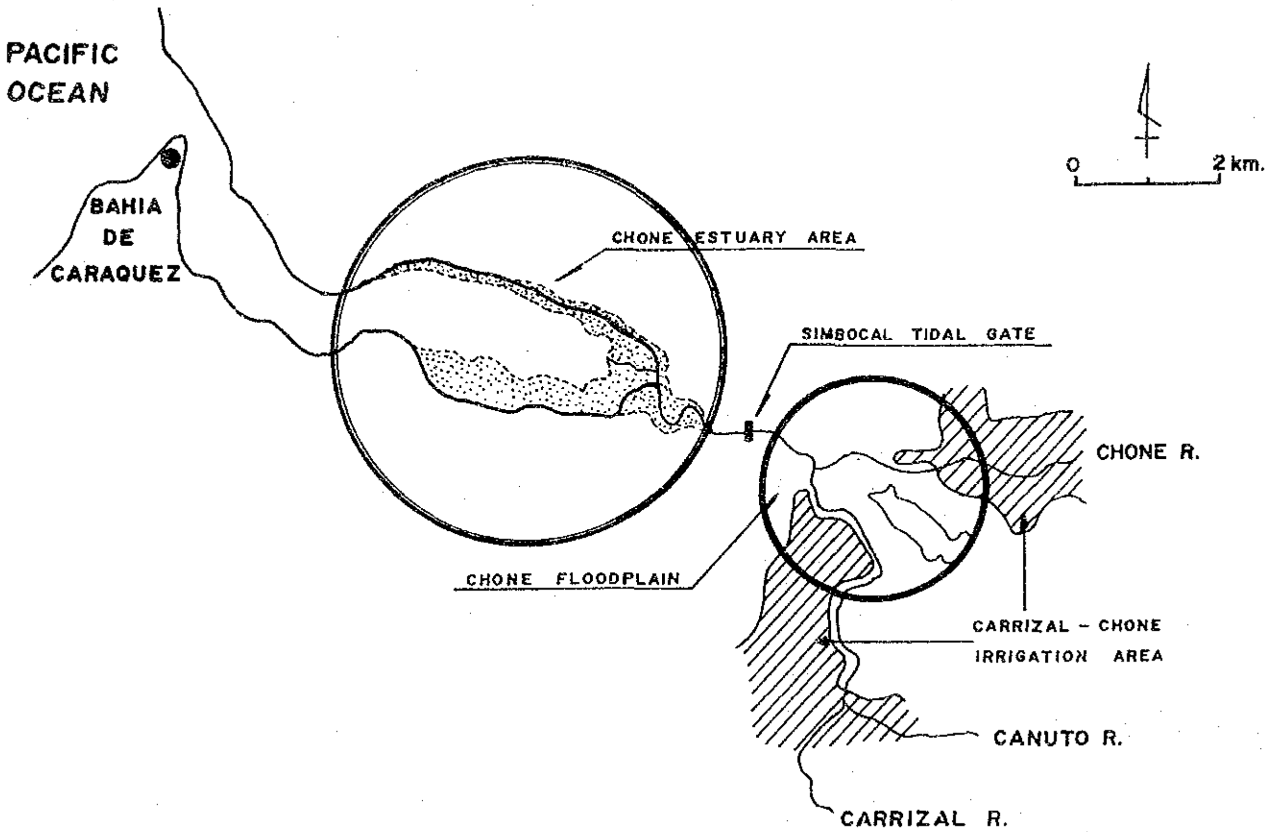


Fig. K.3.4 *Ecological Area to be Protected.*

GOVERNMENT OF THE REPUBLIC OF ECUADOR
CENTRO DE REHABILITACION DE MANABI (CRM)
THE FEASIBILITY STUDY ON THE WATER
RESOURCES DEVELOPMENT FOR
CHONE - PORTOVIEJO RIVER BASINS

JAPAN INTERNATIONAL COOPERATION AGENCY

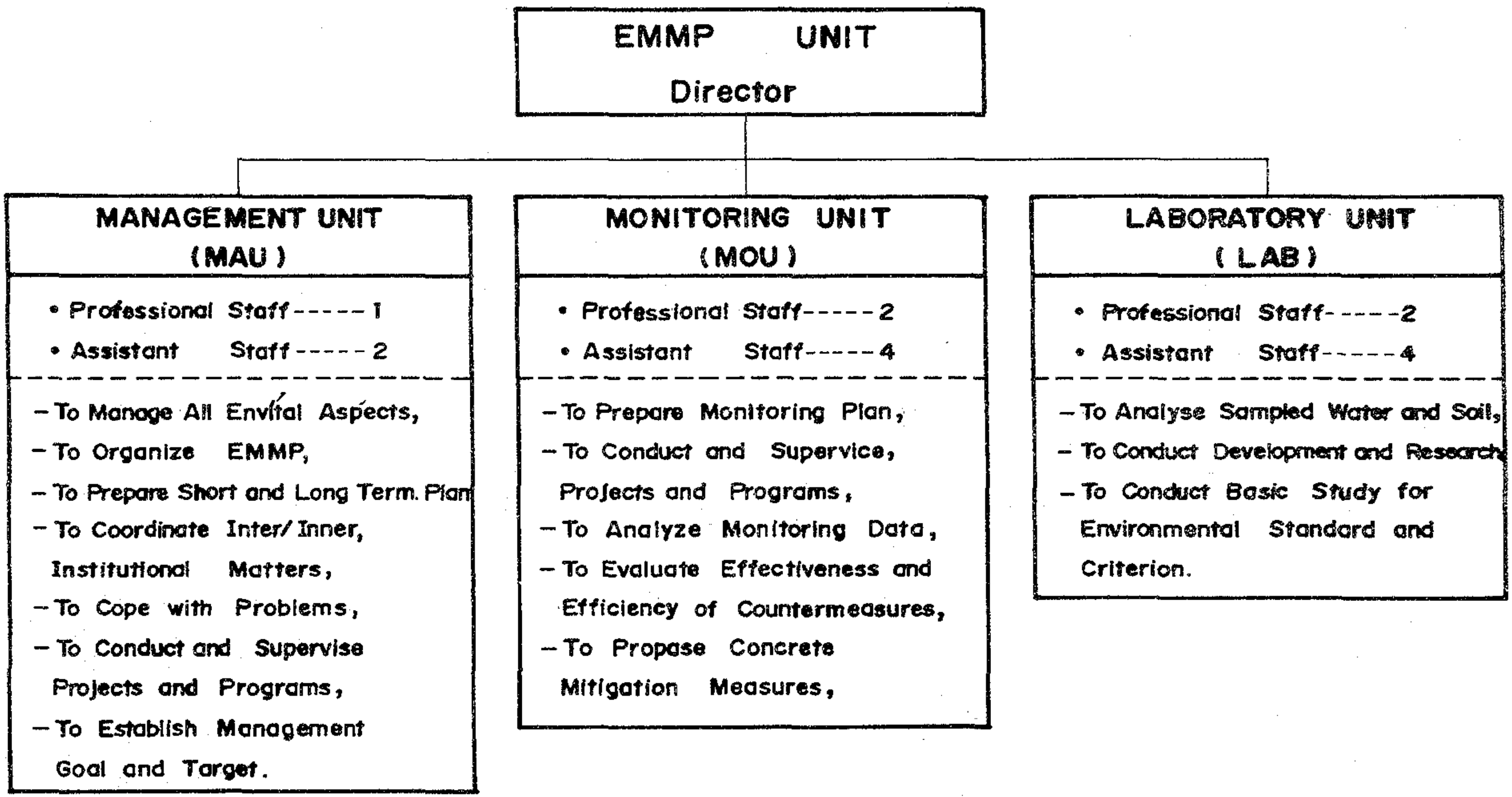


Fig. K.3.5 Structural Organization of EMMP UNIT

GOVERNMENT OF THE REPUBLIC OF ECUADOR
CENTRO DE REHABILITACION DE MANABI (CRM)
THE FEASIBILITY STUDY ON THE WATER RESOURCES DEVELOPMENT FOR CHONE – PORTOVIEJO RIVER BASINS

JAPAN INTERNATIONAL COOPERATION AGENCY

JICA