3.5.2 Construction Materials

(1) General

The construction materials investigation was carried out to clarify the quality and available quantity of the materials to be used for the Project and covered the following items.

(1) Concrete Aggregate
(2) Concrete Mixing Test
(3) Soil Material

Details of the construction materials investigation are given in Annex 2.

(2) Concrete Aggregate

(A) Location of the material sources and required quantities of aggregate

Sand quarry/borrow areas are located at:

- Río San Pablo, Quevedo:	170 km east of Portoviejo
- Cantera Basaltica Picoazá:	16 km west of Portoviejo
- San Jacinto:	54 km north west of Portoviejo

Gravel quarry/river deposits are located at:

- Río San Pablo, Quevedo:	170 km east of Portoviejo
- Quarry around Picoazá area:	
Cantera Basaltica Picoazá:	16 km west of Portoviejo
San Carlos/Río de Oro:	14 km west of Portoviejo
Carlos Poggi:	15 km west of Portoviejo

As the estimated total volume of concrete structures and shotcrete in accordance with the design is approximately 230,000 m^3, the assumed quantities of aggregate are considered to be as follows:

Fine aggregates: 230,000 m^3 x 0.4m^3/m^3 of concrete = 92,000 m^3

Coarse aggregates: 230,000 m^3 x 0.75m^3/m^3 of concrete = 172.500 m^3

(B) Fine aggregate

A site reconnaissance and availability survey were carried out in the vicinity of the Project area as well as in the environs of the city of Portoviejo in accordance with description of the materials survey report in the feasibility study.

Possible sources of sand (grain size under 5 mm) for fine aggregate were considered as follows:

(i) Quevedo, Río San Pablo

The sand material is available as a deposit in the Río San Pablo river near Quevedo town. The area of the deposit is approximately 100 ha, which is enough to provide the total quantity of fine aggregate required. The concession for it belongs to MOP (Ministerio de Obras Publicas). It is andesite sand. The location of the borrow area is 170 km from Portoviejo, as shown in Figure 3.5.1.

(ii) Picoazá, Cantera Basáltica Picoazá

Crushed sand is produced here using rod mill with a capacity of 30 ton/hr. Small size aggregates crushed by the secondary crusher are fed to the rod mill, crushed, screened and washed using a wet type spiral classifier to control fineness modulus of the sand. It is basalt sand. At the present time, almost all of the sand produced here is supplied to La Esperanza Dam Project as fine aggregate for concrete structure. As the concession area for this quarry is more than 200 ha., it can produce the total quantity of fine aggregate required. The location of this quarry is shown in Figure 3.5.2 and 16 km from Portoviejo city.

(iii) San Jacinto at Manta Beach

In consideration of concrete quality, beach sand is normally unsuitable because it contains salt. However, as quite a lot of sand taken from San Jacinto at Manta Beach is used in Portoviejo City and its vicinity for concrete aggregate, a test sample was taken from these areas because they are considered as one of the possible sources of the materials. As sand is available over more than 10 km along the beach, the quantity of fine aggregate there is considered to be sufficient. The locations are as shown in Figure 3.5.1. The distance is 54 km from Portoviejo.

(C) Coarse aggregate

The prospective aggregate sources in the Feasibility Study Report are as follows.

- Existing quarry at Picoazá: Good quality basalt aggregate in sufficient quantity at a distance of 16 km from Portoviejo.

- River deposit at Quevedo: Good quality andesite aggregate in sufficient quantity at a distance of 170 km from Portoviejo.

The site reconnaissance and availability investigation for coarse aggregate were carried out concurrently with the survey for fine aggregate. At San Pablo in Quevedo, river deposit of andesite cobbles is available, and a crushing/screening plant is being operated by MOP (Ministerio de Obras Públicas) there. However as only small size aggregate for asphalt pavement (maximum size: 13 mm) is produced here, sampling was considered unnecessary.

In the Picoazá area, there are four aggregate quarries operated by three firms. The rock in all of them is basalt. The production capacity (more than 150 ton/hr) and the quarry concession area (more than 100 ha.) are considered sufficient to supply concrete aggregate for the Project. The distance from the quarries to Portoviejo is 14 - 16 km. As a result of field investigation, sampling was carried out at "San Carlos/Río de Oro" quarry and the samples were sent to the laboratory in Quito for aggregate and concrete trial mixing tests.

(3) Concrete Mixing Test

(A) General

Concrete mixing test was carried out to estimate an adequate mix proportion of water, aggregate and admixture in accordance with specified conditions of maximum size of coarse aggregate, design compressive strength, slump, etc.

(B) Conditions of concrete mixing test

The design condition of the concrete mixing test was tentatively determined as follows.

Type of Concrete	Max.Size of Aggregate (mm)	Design Compressive Strength at 28 days (kg/cm2)	Slump (cm)	Cement Use (kg/m^3)
A - 1	25	300	10 - 14	283
A - 2	25	210	10 - 14	250
B - 1	40	300	8 - 12	283
B - 2	40	240	8 - 12	246
B - 3	40	210	8 - 12	229
B - 4	40	170	8 - 12	204

(C) Mixing materials

The following materials were used for the concrete mixing test.

i). Water : Clean water
ii). Cement : Portland cement, type 1 E
iii). Fine aggregate : - Quevedo quarry; river sand
- Picoaza quarry; crushed sand
- San Jacinto; beach sand
iv). Coarse aggregate : San Carlos; quarry gravel
v). Water reducing and AE agents : Airbeton, Resin Vinsol

(D) Concrete Mixing Test

The mix proportions for the concrete were as determined on the basis of the Basic Mix Proportions for Concrete Mixing Test Table in the Technical Specifications, in accordance with the procedure of ACI.

Test result for the concrete specimens at the age of 28 days are shown below.

(a) Test-1: Strength at the age of 28 days using Quevedo sand

Test-1 Conc. Type	No. 1 kg/cm2	No. 2 kg/cm2	No. 3 kg/cm2	Average strength kg/cm2	Expected strength kg/cm2
A1	245	168	163	192	300
A2	110	104	109	108	210
B1	201	204	148	184	300
B2	145	145	144	145	240
B3	136	126	134	132	210
B4	76	83	87	82	170

Note: * F.M. of the sand: 1.66

(b) Test-2: Strength at 28 days using Picoaza sand

Test-2 Conc. Type	No. 1 kg/cm2	No. 2 kg/cm2	No. 3 kg/cm2	Average strength kg/cm2	Expected strength kg/cm2
A1	168	154	167	163	300
A2	134	138	145	139	210
B1	226	196	214	212	300
B2	143	143	144	143	240
B3	124	123	128	125	210
B4	86	78	85	83	170

Note: * F.M. of the sand: 2.65

(c) Test-3: Strength at 28 days using San Jacinto sand

Test-3 Conc. Type	No. 1 kg/cm2	No. 2 kg/cm2	No. 3 kg/cm2	Average strength kg/cm2	Expected strength kg/cm2
A1	190	192	192	191	300
A2	109	107	107	108	210
B1	194	190	179	188	300
B2	124	136	129	130	240
B3	95	94	91	94	210
B4	61	94	94	62	170

Note: * F.M. of the sand: 1.00

(3) Soil Materials Tests

(A) General

The results of the several soil tests in the Feasibility Study Report show that the rock types in the area of the open channel are clay-silt and weathered rock. It concluded that the clay-silt along the open channel showed critical swelling which would affect the concrete lining, and the use of this material was not suitable for the embankment because of the shrinkage anticipated. The report recommended that further detailed soil investigation be performed in the detailed design stage.

Soil materials to be used for the embankment of Severino open channel were sampled at the test pits and these samples were sent to Quito for laboratory testing in the present detailed study stage.

(B) Location of test pits and sampling

Test pits were dug along the open channel to take samples of the materials to be used for embankment to investigate their characteristics. Test pits were also dug along the transmission line to take samples for the purpose of obtaining parameters for the design of tower foundations.

The locations of the test pits are shown in Figure 3.5.3 and 3.5.4. There were 10 test pits for the Severino open channel and 5 for the transmission line.

Along the Severino open channel, 20 disturbed samples were taken, 2 for each pit, one at a depth of between 0 to 2 m and the other taken at a depth of between 2 to 5 m.

(C) Laboratory test

The following laboratory tests were carried out on the samples taken from the pits to determine the characteristics of the soils.

-	Natural Moisture Content	:	20 Nos. ASTM D-2216
-	Specific Gravity	:	20 Nos. ASTM D-854
-	Unit Weight	:	10 Nos. ASTM C-29
-	Grain Size Analysis	:	20 Nos. ASTM D-422
-	Atterberg Limit	:	20 Nos. ASTM D-423 and D-424
-	Uniaxial Compression	:	10 Nos. ASTM D-2166
-	Triaxial Compression (uu)	:	10 Nos. ASTM D-2850
-	Consolidation	:	10 Nos. ASTM D-2435
-	Proctor Compaction	:	15 Nos. ASTM D-698
-	Swelling	:	20 Nos. ASTM D-4546
-	Shrinkage	:	20 Nos. ASTM D-427
-	Pin-hole test	:	20 Nos. ASTM D-4647

(D) Result of the test

The results of the tests are summarized and shown in Table 3.5.3.

(4) Conclusion and Recommendations

(A) Concrete aggregate investigations

The investigations were carried out with a view to finding potential sources of aggregate, available quality and quantity of the material, and transportation distance.

1) Fine aggregate

a) Quevedo, Rio San Pablo

This river deposit can supply a sufficient quantity of fine aggregate for the project, but the quality of the material was found to be unsatisfactory in the laboratory tests because it contained organic impurities. Further, the transport distance from the project site is as far as 170 km.

b) Picoaza, Cantera Basaltica Picoaza

Considering the quality of the sand, quantity available, supply capacity and transport distance, this quarry is one of the best sources of fine aggregate for the Project.

c) San Jacinto at Manta Beach

The quality is sub-standard due to the large fine material content and considerable contamination by salt water. If this material is used for the purpose of adjusting the fineness modulus by mixing it with the Picoaza sand mentioned above, thorough washing with clean water will be necessary.

2) Coarse aggregate

In the Picoaza area, there are four aggregate quarries operated by three mining companies. The quarried material is the same. The quality of the aggregate is acceptable for use in concrete, according to the test report. However, a test for materials finer than the 75 μm sieve (ASTM C-117) is recommended for further investigation.

There is sufficient quality and supply capacity to satisfy concrete demand for the project.

(B) Trial concrete mixing

In the tests, none of the specimens achieved the expected compressive strength of 28 days. The lower strengths obtained in Test-1 and Test-3 are considered to be caused by the low quality of sand used. However, in spite of using better quality fine aggregate, the target compressive strength at the age of 28 days was not achieved in Test-2, either.

The lower-than-expected strength is probably attributable to cement quality. Though cement was not included in the materials investigation in this study, test data obtained from the cement manufacturer shows that the compressive strength of hydraulic cement mortars made of it is approximately 30% lower than the required value. Another important factor affecting concrete strength is the fineness of the cement. According to the Concrete Manual, published by U.S. Department of Interior, Bureau of Reclamation, the average specific surface of the cement shall be not less than 2,800 square centimeter per gram. In consideration of this, detailed testing of the cement is recommended at a later date.

During the Phase 2 Study in Ecuador, some additional investigations are made mainly for concrete mix, which was not satisfactorily resulted in the Phase I Study. Concrete mix test results are collected from the report on the construction of the Conguillo inlet structure executed in 1989-1990 and from the La Esperanza dam construction under way. These exisiting concrete mix data indicate that more than 300 kg of cement should be used to produce 1.0 m^3 of concrete with a compressive strength of 250 kg/cm^2. In the La Esperanza dam construction, structural pumpable concrete with maximum size of aggregate of 25 mm contains 380 kg/m^3 of cement to obtain average 28-day strength of 290 kg/cm^2 with a guaranteed strength of 253 kg/cm^2.

(C) Soil materials

The results of the soil tests show that the soil materials are composed of fine particles (under 75 μm) from weathered mudstone, classified as MH or CH, containing ML and CL in parts. Generally, suitable materials for embankments requires to have good compactibility, low shrinkage, and only a small decrease in shear strength when the water content is increased.

The "Standard Design and Construction, Japan Road Association" and "Earth Manual, U.S. Bureau of Reclamation" recommends the materials for embankment to have the following characteristics:-

- Maximum particle size : 100 mm
- Percentage by weight passing 4.76 mm sieve : 25 - 50 %
- Percentage by weight passing 75 μm sieve : 0 - 25 %
- Plastic limit : under 10

The test results show that almost none of the samples fulfil the above requirements and the following conclusions are made.

i) The soil has bad compaction characteristics. The proctor compaction test indicated that the percentage of the optimum moisture content is very high (31 - 46 %) and γd max is very low (1.06 - 1.39 g/cm^3).

ii) The values of the swelling pressure are slightly high (2 - 25 t/m^2), which will have a possibility to affect the concrete lining.

iii) The volume change due to shrinkage is very high (25 - 57 %). There will thus be the possibility of slaking if the soil is dried and submerged repeatedly not only to the embankment fill but also the cutting surface of the waterway.

Considering the above, these soil materials are judged unsuitable for the embankment, but if proper and careful countermeasures are taken, it is not necessary to reject these materials totally.

3.6 ENVIRONMENTAL STUDY

3.6.1 Objectives and Approach

The objectives of this environmental study are:

i) to review the existing environmental information,

ii) to evaluate the existing and predictable water quality conditions in the study area based on new water quality analysis,

iii) to establish the guidelines for a prevention of the water quality deterioration in the reservoirs,

iv) to establish the guidelines for a conservation and management plan in the vicinity areas of the reservoirs,

v) to establish the guidelines for the protection of the mangrove and Chame habitat in the Chone and Portoviejo estuaries and in the permanent inundation wetland areas,

vi) to establish a program for the Simbocal tidal gate operation.

Based on the existing environmental information, the project actions reconnaissance, field trips, generation of new data and interviews with authorities and personnel related to this context, the above objectives are developed for the purpose of generating a document which will be the basis for the development and implementation of the management and monitoring plan by CRM.

(1) Summary of project actions reconnaissance

During the present study a general reconnaissance of project actions was undertaken, including the following:

- Daule Peripa-La Esperanza diversion tunnel

- Severino pumping station
- Severino open channel
- La Esperanza-Poza Honda diversion tunnel
- Daule Peripa-Severino transmission line
- Access roads

No major environmental impacts are expected in the tunnel constructions since they will be excavated underground. In the location of the pumping station and open channel no mayor impacts are expected. The area in general is highly deforested and with a low population density.

At the end of the transmission line, on the right bank of the Daule river, immediately downstream of the Daule-Peripa dam, there is an ecological reservation of CEDEGE with an area of about 200 ha. This area is actually under a sustained reforestation process and environmental management, thus it is recommended that the transmission line does not transect this area.

Access roads could incentivate new colonization to adjacent areas, and could enhance the value of the land. Although in general, opening or improving rural roads could incentivate deforestation in the areas adjacent to the access roads, deforestation is already accentuated, and the actual condition of the existing roads has not stopped the massive deforestation process, so a significant impact on the further deforestation of the area is not foreseen with the improvement of the access roads.

The implementation of the environmental management plans for the reservoirs should act as a control for new colonization of the areas adjacent to the reservoirs that could be incentivated with the improvement of the access roads, especially in Poza Honda.

The population of Membrillo, adjacent to the Membrillo outlet in La Esperanza could become more dependent on inland water transportation. Preventive measures to avoid point source pollution into the reservoir because of an inland port situation should be considered.

3.6.2 Sampling for Water Quality Analysis

Water analysis sampling was carried out in 17 predetermined stations throughout the project area as shown in Figure 3.3.4. Sampling was carried out during the dry season (November 18 - December 3, 1993, May 30 - June 13 and August 15 - 29, 1994), and

during the rainy season (January 10 - 28, 1994). Twenty six (26) physical-chemical parameters were evaluated in each station, and results in BOD, COD, T-N, and T-P are used as evaluation parameters for pollution load analysis. Although no mayor industries as point source pollution are present in the area, tests on heavy metals were also made.

3.6.3 Water Quality in Reservoirs

The water quality of the Daule Peripa reservoir will determine the water quality conditions at La Esperanza reservoir, together with the water quality of the inflow to the reservoir.

The water quality of La Esperanza reservoir (C2) will be estimated by the following equation:

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

where:

C2= water quality at La Esperanza reservoir
L0= load from Daule-Peripa reservoir
Q0= volume from Daule-Peripa reservoir
C0= quality of diverted water
L1= annual load to La Esperanza reservoir from its own basin
Q1= annual inflow to La Esperanza reservoir from its own basin
C1= quality of own basin flow to La Esperanza

The water quality at Poza Honda reservoir is calculated by the same method, in this case L0, Q0, and C0 must be the La Esperanza reservoir's. The suitability of Daule-Peripa, La Esperanza, and Poza Honda water for irrigation, source of raw water for treatment plant and domestic uses is further evaluated in (2) of this subsection.

By using the above mentioned equation and the existing water quality data in Daule Peripa, La Esperanza, and Poza Honda as shown in Table 3.6.1, the future water quality is predicted, and the results are shown in Table 3.6.2.

The future water quality at La Esperanza would be better than those of Daule-Peripa in BOD and COD, but worse in T-N, and T-P. In Poza Honda reservoir the water quality basically remain same except for COD. No significant impact is expected from the COD increment in 1.58 mg/l.

(1) Eutrophication

The past, present and future water quality condition at Poza Honda is evaluated using the information available (1981-1994), and the Program for Warm Tropical Lakes (LACAT) developed by the Panamerican Center for Sanitary Engineering and the Environment (CEPIS) and using the concept of multiple regression for total phosphorus:

$$[T\text{-}P] = 0.290\ L(p)^{0.891}\ T_w^{0.676} / Z^{0.934}$$

where,

[T-P]	=	total phosphorus (mg/l) for assessment of trophic condition
L(p)	=	annual phosphorus surface load (g/m^2/year)= L/A
T_w	=	retention time (years) = V/Q
Z	=	reservoir depth in (m) = V/A
L	=	annual inflow of phosphorus load (t/year) = Q•P
Q	=	annual inflow of water (MCM/year)
P	=	phosphorus concentration of inflow water (mg/l)
A	=	surface area of reservoir (km^2)
V	=	total storage volume of reservoir (MCM)

Additionally, the CEPIS formula for tropical lakes was used in this study (Salas & Limón, 1985)

$$P(f) = \left(\frac{L(p)}{Z}\right)\left(\frac{Tw^{3/4}}{3}\right)$$

where,

P(f) =Resulting phosphorous concentration, in g/m^3

Eutrophication ranges for both cases are:

Trophic level	[T-P] (mg/l)	or	P(f) (g/m^3)
Oligotrophic	≤0.01		
Mesotrophic	0.01 - 0.03		
Eutrophic	0.03 - 0.1		
Hipereutrophic	≥0.1		

The trophic condition of the Poza Honda reservoir is assessed by the abovementioned procedure as follows:

Trophic Condition of Poza Honda Reservoir

Year	[T-P] (mg/l)	P(f) (g/m^3)	Most probable trophic condition	Reference of input data
1981	0.218	0.41	Hipereutrophic	Vásconez
1982	0.278	0.39	Hipereutrophic	Vásconez
1987	0.078	0.066	Eutrophic	PHIMA-OEA
1992	0.048	0.052	Eutrophic	CRM-JICA
1994	0.06	0.065	Eutrophic	JICA
Future estimated	0.070	0.082	Eutrophic	JICA

The trophic study PHIMA/OEA detected that by 1983 the major factors affecting eutrophication were the agricultural and cattle raising practices accounting for 74% of the phosphorus load, and the watershed deforestation and pronounced slopes favoring erosion, sedimentation process, and the consequent nutrient leaching into the reservoir. The eutrophic condition will become serious in the future unless an efficient program for prevention of water quality deterioration is implemented together with the conservation of the areas adjacent to the reservoir.

Water quality at La Esperanza is also evaluated by the same procedure and its trophic condition is assessed as follows:

Trophic Condition of La Esperanza Reservoir

Year	[T-P] (mg/l)	P(f) (g/m^3)	Most probable trophic condition	Reference of input data
1992	0.061	0.069	Eutrophic	CRM/JICA
1994	0.063	0.068	Eutrophic	JICA
Future estimated	0.066	0.072	Eutrophic	JICA

No drastic changes in the trophic condition of La Esperanza reservoir are expected if the plant biomass existing in the impoundment area is removed before inundation, and if the environmental management plan is implemented as a long term control measure.

(2) Suitability of reservoir water for various uses

The following basic parameters established by the Official Register of Ecuador, June 5/1989 as suitable raw water for drinking purpose are taken into account.

Parameter	Unit	Type of Treatment	
		Conventional	Disinfection
		Maximum allowable values	
BOD-5	mg/l	2	2
Fecal Coliforms	MPN/100 ml	600	20
Total Coliforms	MPN/100 ml	3,000	100
DO	mg/l	more than 4	more than 6
PH	Unit	6-9 (Range)	6-9 (Range)
Color	Units	100	20
Chlorides	mg/l	250	250
Turbidity	Units	100	10

Except for BOD in all reservoirs and DO in Daule-Peripa reservoir, the parameters show a good suitability of water as source of raw water for treatment plants. Low values

of DO of Daule-Peripa are related to the massive infestation of aquatic plant (Eichornia crassipes).

Suitability of the water as source for irrigation use was evaluated based on the electrical conductivity and salinity ranges in the reservoirs.

RAS* (meq/l)	Electrical conductivity (Umohs/cm) Restriction Degree None	Low - Moderate	Severe
0-3	<200	200 - 700	>700
3-6	<300	300 - 1,200	>1,200
6-12	<500	500 - 1,900	>1,900
12-20	<1,300	1,300 - 2,900	>2,900
20-40	<2,900	2,900 - 5,000	>5,000

Salts present in the reservoir water

Indicator	Unit	Daule - Peripa	La Esperanza	Poza Honda
Conductivity	Umhos/cm	149.50	516.66	335.37
Sodium as Na	mg/l	11.30	32.83	23.50
	meq/l	0.49	1.43	1.01
Calcium as Ca	mg/l	14.38	46.17	28.67
	meq/l	0.72	2.30	1.43
Magnesium	mg/l	8.82	15.50	8.00
	meq/l	0.72	1.28	0.66
RAS*	meq/l	0.58	1.07	0.70

* Relative Absorption of Sodium = $\frac{Na}{\sqrt{(Ca + Mg)/2}}$ (meq/l)

In conclusion, the water from the Daule-Peripa reservoir are without restriction for irrigation purpose. La Esperanza and Poza Honda have a little restriction. They can be used for crops with moderate tolerance to salts or for soils with a moderate to high infiltration rate.

3.6.4 Water Quality in Rivers and Estuaries

(1) River flow regime

Table 3.6.3 and Table 3.6.4 show the existing and future river flow calculated by the mathematical hydrological model used in the water balance in this project, for the situations with and without added dilution flow. The condition "with" dilution flow is recommended to dilute pollutants in the river course.

The mentioned study estimates that in the rainy season, the river flow discharge in the Chone River would be increased about 9 % at the river mouth area and 34 % at the Carrizal river. In the Carrizal River, the mean discharge in the dry season could be increased from 140 MCM to 417 MCM, while in Portoviejo river, a remarkable (100%) improvement of river flow discharge would be expected, from 111 MCM to 221 MCM, as indicated in the following table.

Change of River Flow Regime (%)
"Without" Dilution Flow Condition

Period	(1) Chone River Mouth	(2) Chone Upst'm	(3) Carr'l River	(4) Porto. Downst.	(5) Porto. Upst'm	(6) Chico River
a) Rainy	+9	0	+29	+16	+34	+28
b) Dry	+88	0	+147	+16	+65	+151
c) Annual	+22	0	+47	+16	+42	+61

Change of River Flow Regime (%)
"With" Dilution Flow Condition

Period	(1) Chone River Mouth	(2) Chone Upst'm	(3) Carr'l River	(4) Porto. Downst.	(5) Porto. Upst'm	(6) Chico River
a) Rainy	+9	0	+34	+29	+43	+31
b) Dry	+132	0	+197	+49	+100	+165
c) Annual	+29	0	+59	+36	+58	+67

Remarks:

(1) Simbocal (ST-6)
(2) H. Saida (ST-5)
(3) Bachillero (ST-4)
(4) Dario Guevara (ST-16)
(5) Potoviejo (ST-14)
(6) Rio Chico (ST-11)

The condion "with" dilution flow assures an additional flow of 20% of the irrigation water demand, or equivalent to the estimated return flow from the agricultural area.

(2) Pollution load analysis

The water quality in rivers and estuaries is evaluated by using the concept of pollution load analysis, based on the existing information and water quality surveys. Four prediction points are assessed with and without dilution flow conditions:

P-1) Lower reach of Chone river (st-6), at Simbocal
P-2) Estuary area of the Chone river (st-8), at Punta Prieta
P-3) Middle reach of the Portoviejo river, at the downstream confluence point with the Chico river (st-15),Guayaba.
P-4) Estuary area of the Portoviejo river (st-17)

Results obtained are summarized as follows:

Result of Water Quality Prediction "Without" dilution flow

(unit: mg/l)

Prediction Point	BOD		COD		T-N		T-P	
	act.	fut.	act.	fut.	act.	fut.	act.	fut.
I. P-1								
a) Rainy season	10.7	11.4	19.0	19.0	2.4	2.6	0.25	0.27
b) Dry season	14.0	12.4	24.3	17.8	1.4	1.9	0.20	0.23
c) Average	12.3	11.7	21.7	18.7	1.9	2.4	0.23	0.26
II. P-2								
a) Rainy season	11.3	8.5	18.7	14.4	2.1	2.0	0.00	0.22
b)Dry season	18.0	14.7	32.7	26.5	1.3	2.1	0.30	0.19
c) Average	14.7	10.8	24.8	18.9	1.5	2.0	0.15	0.21
III. P-3								
a) Rainy season	13.3	16.7	20.0	20.9	1.9	2.6	0.24	0.37
b) Dry season	14.3	23.3	23.7	28.1	1.3	3.3	0.40	0.68
c) Average	13.8	18.9	21.9	23.2	1.6	2.9	0.32	0.47
IV. P-4								
a) Rainy season	12.0	17.4	17.3	21.6	2.2	2.8	0.43	0.39
b) Dry season	19.0	24.4	33.7	29.3	0.9	3.7	0.30	0.70
c) Average	15.5	19.6	25.5	24.1	1.5	3.1	0.37	0.49

Result of Water Quality Prediction "With" dilution flow

(unit: mg/l)

Prediction	BOD		COD		T-N		T-P	
Point	act.	fut.	act.	fut.	act.	fut.	act.	fut.
I. P-1								
a) Rainy season	10.7	11.4	19.0	19.0	2.4	2.6	0.25	0.27
b) Dry season	14.0	10.0	24.3	14.4	1.4	1.5	0.20	0.19
c) Average	12.3	11.0	21.7	17.6	1.9	2.3	0.23	0.25
II. P-2								
a) Rainy season	11.3	8.5	18.7	14.4	2.1	2.0	0.00	0.22
b) Dry season	18.0	13.6	32.7	24.4	1.3	1.9	0.30	0.18
c) Average	14.4	10.5	24.8	18.3	1.7	1.9	0.15	0.20
III. P-3								
a) Rainy season	13.3	15.0	20.0	18.7	1.9	2.4	0.24	0.33
b) Dry season	14.3	18.1	23.7	21.8	0.9	2.6	0.13	0.53
c) Average	13.8	16.1	21.9	19.8	1.4	2.4	0.19	0.40
IV. P-4								
a) Rainy season	12.0	15.6	17.3	19.4	2.2	2.6	0.43	0.35
b) Dry season	19.0	19.1	33.7	22.9	0.9	2.9	0.30	0.55
c) Average	15.5	16.8	25.5	20.7	1.5	2.7	0.37	0.42

The results in the situation with dilution show that at the lower reach of the Chone river at Simbocal (P-1) the future water quality during the dry season would be improved in BOD and COD.

At the estuary area of the Chone river, Punta Prieta (P-2), the future water quality would be improved for BOD and COD, while T-N and T-P will slightly increase.

At the middle reach of the Portoviejo river, downstream confluence point with the Chico river at Guayaba (P-3), and at the Portoviejo estuary area (P-4), the water quality deterioration could be serious mainly due to the increased waste water discharge from Portoviejo city.

When a self purification coefficient of 0.1 is assumed between P-1 and P-2, the future water quality of BOD at P-2 could be reduced as much as 50% of the predicted value by the following Streeter-Phelph's equation:

$$C3'' = C3' \times \exp(-Kt)$$

where:

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

(3) Pesticides and fecal pollution

Pesticide analysis was carried out by CRM during the dry season on December 12, 1993 and June 3 and 6 and August 16 and 30 of 1994, when agricultural runoff and agrochemical application in the field is minimal or non existent. Concentrations of Cis-Heptachlor was detected in a range below the maximum residue limit (MRL) established by the Codex Alimentarius FAO/WHO, 1990, as reported by MAG, Sanidad Vegetal, Ecuador, 1993-1994.

Concentrations of Heptachlor were detected in the second sampling campaign, August 30/94, in the areas of Simbocal (St-6); upstream and at the middle reach of Portoviejo river (St-14 and 15).

Pesticide analysis was also carried out by CRM during the rainy season on January 1994, that is after the application of pesticides in dry season and just when the first rain came, in this case the concentrations of Heptachlor were beyond the maximum residue limit (MRL) at the three stations mentioned above.

It is assumed that the reported values will increase in the future, when the irrigation area is increased with the project condition as shown in the following table.

Agricultural Area

Area	Existing Agricultural Area (ha)	Net Potential Irrigation Area (ha) JICA-CRM
	Reference→1988 Data (Except Amarillos-Guarango Systems)	
Carrizal-Chone System	1,516	15,000
Poza Honda System	4,518	10,050
Rio Chico System	1,383	1,700

It is evident from the above data that the Chico river irrigation area will be the least affected by an increment in the irrigation area, and with an added 4 m^3/sec flow with the project condition. Water quality condition in the Chico river will be a more suitable source for the Ceibal treatment plant rather than the Portoviejo river.

Microbiological analysis carried out by CRM during the months of December/93 and January, June and August/94, shows a generalized fecal contamination from the Daule-peripa reservoir at Conguillo inlet (st-1) to Simbocal(st-6), including la Esperanza (st-2), and Tosagua (st-3). Fecal contamination is also present from Poza Honda (st-9) to the Portoviejo river estuary (st-17), including Mancha Grande (st-10), and upstream (st-12 and 13) and downstream (st-14 and 15) Portoviejo river.

Higher concentrations of coliforms and total bacteria count at the Conguillo inlet are probably related to the reduced water exchange rate at the end of the dry season in this part of the reservoir. The high total coliform count for the Portoviejo river estuary reflects the raw sewage coming mainly from Portoviejo city, and recalls the need for a proper sewage treatment system at Portoviejo city to avoid future increases in coliform counts.

(4) Salinity measurements

Salinity measurements were conducted during the months of June and August of 1994, at the same sampling sites as for tidal measurements. Surface and bottom samplings, 20 cm and 50 cm below the water surface respectively, were made at every sampling site.

Salinity changes with the height of the tide, being greater at the highest tide. Average salinity concentration is greater in the estuary at stations 1 and 2, and it decreases upstream from the estuary as shown in Figure 3.6.1.

3.6.5 Environmental Management and Conservation Programs

(1) Program for prevention of water quality deterioration in reservoirs

The program for prevention of the deterioration of the water quality is basically oriented towards an adequate use of the adjacent areas of the reservoirs, and the establishment of protection zones.

Since it is estimated that the mayor contribution to the possible eutrophication is derived from the agricultural, cattle raising, and other human activities, these activities are to comply with sound management and planning practices.

(A) Area of influence

The following three basic zones have been defined in the area of influence, considering the actual use of the land, the potential use of the land, the risk of erosion and the reservoir as a public interest component.

Zone A: This zone is surrounding and limiting the impoundment. It is the area where variations in the level of the water directly affect the land, and where human activities are directly related to the use of the water resource.

Zone B: This zone is associated with agriculture practices, cattle raising and human settlement.

Zone C: This zone is associated with steep slopes, where the isolated patches of altered forest are capable of regeneration if left untouched.

Zoning around Poza Honda and La Esperanza reservoirs is defined in Figure 3.6.2 and Figure 3.6.3, respectively, and their areas are as follows.

	Area (km^2)		
Resorvior	Zone A	Zone B	Zone C
Poza Honda	8.23	11.06	12.17
La Esperanza	32.89	124.02	48.26

The actual land use of the defined areas around Poza Honda and La Esperanza is as follows :

Actual Use of the Land

Land Use	Poza Honda Zone			La Esperanza Zone		
	A (ha)	B (ha)	C (ha)	A (ha)	B (ha)	C (ha)
Dense Forest	295	560	658	386	3,619	2,008.4
Low Dens.Forest	123	94	190	130	577.2	300
Total Forest	(418)	(654)	(848)	(516)	(4,196)	(2,308.4)
Pasture land	291	250	354	2,769	8,132	2,477.6
Annual Crops	43	60	11	-	54.2	12.2
Permanent Crops	71	128	2	3.3	20	17.2
Ponds	-	6.00	-	-	-	-
Populated Centers	-	7.00	-	ND	ND	ND
Nude Soil	-	0.62	2.5	-	-	10.3

(B) Proposed use of the land

The following strategies have been considered adequate to enhance soil conservation, reduce soil erosion, and increase land productivity for local farmers. When improving the productivity of the land, the farmer will tend to follow the strategies proposed, which in turn will promote the conservation of the soil and eventually improve the conditions of water quality in the reservoirs.

(i) Zone A

- Establishment of this area as a protection buffer belt between water body and human activity.

- Reforestation with flowering and fruit bearing species to attract local fauna.

- Prohibition of animal husbandry, soaps, oil, liquid and solid waste disposal into the reservoir.

Proposed Use of the Land
Zone A-Reforestation Area

	Area Type	Poza Honda	La Esperanza
(1)	Total Area (ha)	823	3,289
(2)	Forested Area (ha)	418	516
(3)	Grassland Area (ha)	291	2,769
(4)	Area (ha) to be Reforested= 80% of (3) @ 300 trees/ha	233	2,215

(ii) Zone B

This zone is to be considered to be a protected area of multiple use with restrictions. Since this area is settled by people deriving a living as farmers and cattle raisers, the absolute preservation of the Zone is not recommendable (although desireable) to avoid excessive social impact to be caused by resettlement. None the less, the activities derived from the population must be regulated and restricted in several uses to gain control over the erosion, deforestation and non point pollution sources originated in this area.

The conservation strategies considered are the following:

- Improvement of pasture areas
- Agroforestry
- Forestry and pasture land
- Agroforestry and pasture land
- Forestry plantations
- Row plantations as sediment barriers
- Construction of erosion ditches

Proposed Use of the Land
Zone B-Agroforestry for Pasture Land

Item	Land Use	%	# of Plants per ha.	Poza Honda (ha)	La Esperanza (ha)
Total Area Zone B				1,106	12,402
(A)	Agroforestry in Slopes < 70%				
(1)	Pasture Area	100	-	250	8,132
(2)	Proposed Agroforestry Area = (3) + (4)	20	-	50	1,626
(3)	Agroforestry, & Annual Crops = (3.1) + (3.2)	10	-	25	813
(3.1)	Forestry Plantation	6	1,110	15	488
(3.2)	Annual Crops	4	200	10	325
(4)	Agroforestry & Permanent Crops = (4.1) + (4.2)	10	-	25	813
(4.1)	Permanent Crops	6	200	15	488
(4.2)	Forestry Plantation	4	1,110	10	325
(B)	Forestry Plantations and Grazing in Slopes < 70%				
(1)	Pasture Area	100	-	250	8,132
(2)	Proposed Area	80	100	200	6,506

(iii) Zone C

For Poza Honda and La Esperanza, this zone is considered for absolute protection, where no human activity should be allowed. The area is partially covered with isolated patches of altered forest between cleared areas with varying degrees of deforestation. The area has the possibility of regeneration if left untouched, and in the areas where the isolation between forested patches is large, reforestation by human intervention will accelerate the process.

(C) Impounded areas

(i) Plant biomass control

- Before inundation of La Esperanza reservoir, the vegetation such as trees, brush and crops should be removed from the reservoir area by extraction or by burning the brush and remaining plant cover. The purpose is to avoid future organic matter decomposition in the impoundment, and reducing the possibility of an eutrophied water quality condition.

- The existing water quality conditions in Daule Peripa reservoir have promoted the infestation of the aquatic plant, Eichoniae crassipes. This aquatic plant is considered the most problematic plant in the world for reservoirs and impoundments.

- The aquatic plant in the Daule Peripa reservoir, by April 1991, had covered an estimated 12,000 ha, with an estimated growth rate of 4,000 ha/year. It is assumed that by December 1993 the coverage area is around 22,000 ha, due to the reduced extraction and/or control implemented at the Daule Peripa reservoir.

- According to the water quality prediction discussed in 3.6.3, the future water quality at La Esperanza would be better in BOD and COD, but worse in T-N and T-P. In Poza Honda, the water quality could be the same except for COD which could slightly increase.

- The physical characters of the reservoirs are summarized as follows:

Item	Daule Peripa	La Esperanza	Poza Honda
Impoundment			
Area (km^2)	270	29	6.1
Reservoir			
Fetch (km)	100	22	14
Configuration	Branched	Branched	Non Branched

Colonization of La Esperanza is considered high since the water quality conditions are predicted to be worse in T-N and T-P, and the configuration of the reservoir is of a branched type, with channels that will favor the enclosure of the plant, as is the case in the Daule-Peripa.

In Poza Honda the possibility of colonization is considered low, since the T-P condition is to improve, and the reservoir fetch combined with the non-branched configuration allows an efficient discharge of the plant over the spillway during the rainy season, when river flows are maximized towards the dam site.

Recommended actions for control include the following:

1- Short term strategy: Physical isolation of an area adjacent to the Conguillo inlet by a trash boom, to avoid masses of plants to enter into the tunnel while operating.

2- Medium term strategy: Mechanical and hydraulic control actually being carried out by CEDEGE in the Daule-Peripa reservoir. The control may be necessary in Poza Honda and La Esperanza reservoir:

- To prevent the blockage of navigation channel
- To eliminate the substratum for vector of diseases
- To reduce the organic matter effluents that my cause euthrophication problems
- To avoid excessive evapotranspiration from the reservoirs
- To lessen the risks of physical deterioration of the dam works

(2) Basic program for conservation of mangrove habitat

(A) Chone Estuary

The Chone river estuary is so deteriorated that it is considered an estuary in great danger of suffering an ecological collapse by a massive degradation of the environmental quality and the loss of the ecosystem functions.

The proposed conservation program is prepared in support of the existing efforts, and intends to implement corrective measures in the different components of the system. The following components are included in the management and conservation program:

- Mangrove forest management

Reforestation of the areas adjacent to the estuary located below EL. 100 m and to prepare the integrated management plan for the Chone river which is the main producer of sediments directed towards the estuary. Reforestation of drainage and inflow channels at the shrimp farms is also suggested as a contribution from the shrimp farms to the community, when receiving a surplus fresh water flow during the dry season by the project operation.

Declare as protected areas, Isla Corazon and the existing mangrove patch in the upper reach of the estuary left margin as shown in Figure 3.6.4, in an estimated area of 40 ha for Isla Corazon and 123 ha in Calle Larga. Isla Corazon is already considered as a forestry research area by DIGMER, and a zone of tourist interest by CETUR.

Promote the culture and seeding of bivalves such as Anadara sp., in an effort to establish a sustainable use of the forest, and educate the local people in the proper use and importance of the mangrove ecosystem, while deriving an economic benefit out of it.

- Mariculture industry management

The only areas for the shrimp farming industry to expand are a few existing mangrove patches, especially in the upper reaches of the estuary, and the lands adjacent to the wetlands, also in the upper reaches of the estuary. CRM must take measures so that the existing legislation is applied and the infractors are sanctioned, CRM must cooperate with the PMRC efforts in this respect and coordinate actions for the implementation of the law.

- Water quality management

Implementation of the new design for Simbocal tidal gate is proposed. The existing tidal gate at Simbocal is deteriorated, and its operational capacity diminishes with the highest tides of the lunar cycle, because the wooden gate floats and allows the intrusion of salt water.

Regulation, control and implementation of management strategies for pesticide, herbicide and fertilizer use in the agricultural areas upstream from the estuary are discussed in this study, as well as the guidelines for an integrated pest management implementation program.

Implementation of sewerage disposal systems according to sound sanitary engineering practices for the population adjacent to the estuary channels is advised for the reduction of the raw sewage effluent discharge into the estuary.

- Erosion management

Erosion problems derived from the agricultural practices in the adjacent hills has already been reported. The adjacent area of influence generating erosion and sediment deposition in the estuary will be defined as an area which is characterized by steep slopes and deforestation with high risk of erosion. Joining efforts with PMRC in the following strategies to control erosion is recommended.

- Agricultural runoff control

The Chone river estuary will receive the drainage waters from 15,000 hectares of agricultural land to be abilitated for year round farming when the project is placed to service, and the impact on the estuary by the increase in agrichemical runoff could be significant, although the increase in fresh water flow during the dry season will have positive effects in the ecosystem and fisheries of the area, by reducing the salinity, especially in the upper areas of the estuary, where eutrophic conditions have been already detected by PMRC.

The implementation of 15,000 ha for year round farming will inevitably promote the use of pesticides, herbicides and inorganic fertilizers. The concentration of pesticides and agrochemicals leaching from the agricultural area into the estuary will have a detrimental effect in the ecosystem and fisheries. Shrimp post-larvae are one of the most sensitive organisms to be affected.

(B) Portoviejo river estuary

The mangrove area in Las Gilces in the Portoviejo river estuary is estimated to be 81.3 ha for 1984 and 1987, with no reduction in the covered area, while the shrimp farm expansion is reported in 103.1 ha for 1984 and 128.5 in 1987, with an increment of 25.3 ha.

The Portoviejo river is the recipient of point source pollution loads from the cities of Portoviejo, Roca Fuerte, Mejia, Sosote, El Higueron and Salinas. Only in Portoviejo, there is a sewerage treatment plant to cover 18% of the urban population.

No conservation efforts are reported for the Portoviejo river estuary. The proposed conservation area includes the area of mangrove forest and the intermediate sandy beach belt existing between the mangrove area and the ocean.

The basic concept is to declare this area as protected with controled use as a public recreational area for the population of Portoviejo city.

The proposed conservation program includes the following actions:

1-Declaration of a protected area according to the existing legislation for mangrove areas, stressing the reasons for the need of a public recreational area, mangrove conservation and bird sanctuary condition of the existing vegetation.

2-Stopping of further shrimp farm development in the area, through the existing legal entities in charge.

3-Declaration of the beach area as of public interest for recreational purposes, and not adequate for constructions such as hotels, resorts and the like.

4-Improvement of the sewerage system for Portoviejo city which is highly recommended to maintain adequate water quality conditions for recreation and ecosystem.

5-Promotion of nature oriented tourism for bird watching, mangrove ecology education and leisure. Tourism oriented towards shore fishing (casting) is already a popular activity in the area.

6-Implementation of an Integrated Pest Management Program for the agricultural area to be implemented with the project, including control of the types of pesticide used.

(3) Basic program for the conservation of Chame and wetland habitat

In the area where the Carrizal and Chone rivers converge, between Simbocal and La Margarita, there are 21 permanent lagoons, some of which are about 350 ha in extension, and 57 wetlands, with an average area of 60 ha/each, which dry out during the dry season. Traditionally, these areas have been used for the small scale culture of Chame (Dormitator latifrons), and fresh water prawns (Machrobrachium sp).

The culture of Chame is an extensive practice carried out by local farmers, which derive a significant income to the farmers. A total estimated of 1,380 ha of permanently inundated areas in Chone have been identified in previous studies.

A permanently inundated area is an area which retains water even during the dry season, and the main objective of the present program is to protect and maintain the areas permanently inundated, to ensure the continuation of this ecosystem and the local Chame production.

(A) Ecological importance

Wetlands as well as mangroves serve as biological filters for the improvement of water quality flowing through them. These are fragile ecosystems, and should be managed carefully. The wetlands also provide feeding grounds for migratory and endemic fauna, flood control areas, and are utilized by their landscape and aesthetic value for tourism and recreation.

(B) Socio-economic importance

The most important permanently inundated area within the estimated 1,380 ha (between Simbocal and San Antonio), is La Sabana with an estimated area of 400 ha, where 90-100 families derive an income through the culture of Chame.

The estimated Chame production for La Sabana, per family per year for an average area of 5 cuadras/family (1 cuadra= 0.75 ha) is 30 Chame boxes/year, which means a production of 30 boxes for 3.75 ha/family.

The annual income from Chame production (2'998,800 sucres/family/year) corresponds to an average monthly income of 249,900 sucres/family/month.

The above data shows how the Chame producing families can enjoy an income from the Chame production as a secondary activity, since the culture of Chame is done in an extensive and artisanal mode of production, where operational costs and maintenance are minimum, ie. no feeding or pumping costs involved.

This condition allows the Chame producer to dedicate most of his time to other activities such as farming, commerce or cattle raising, and thus derive a second income which will allocate this families in the 301,000-400,000 sucres/ month income, approaching the highest average income/family in the area.

From the nutritional viewpoint, Chame is an excellent protein supplement for the local population, and well accepted as a regular food by the population. Chame is a hardy animal, capable of withstanding more than 24 hours outside the water if maintained humid, facilitating the transportation and storage, in an area where refrigeration and electricity is scarce.

From the socio-cultural viewpoint , this is a traditional activity practiced in the area for more than 30 years, and 92% of the existing culture area is located in the Chone and Tosagua areas, with an estimated area of 914 ha.

(C) Significant Areas

The following areas have been reported as subject to inundation in the province of Manabi:

Type of Inundation	Area of Inundation (ha)	
	Chone	Portoviejo
Permanent	1,380	120
Seasonal	5,320	4,680
Occasional	8,010	590

The permanent inundation areas are areas which retain water even during the dry season. The seasonal inundation area is an area subject to inundation during the rainy season, and occasional inundation area is the area inundated in periods of extraordinary floods.

(D) Water dynamics

The water inflow to the permanently inundated areas has several sources:

1- Precipitation during the rainy season, the annual average precipitation for the area is 1,000-1,200 mm; and the annual average evapotranspiration is estimated in 1,000-1,100 mm.

2- Runoff from adjacent hills located north-east(NE) of la Sabana, and north, north-west (N-NW) of La Pampa de Vellis.

3- Floods caused by the Carrizal river for la Sabana, and floods caused by the Chone river for La Pampa de Vellis and adjacent areas between La Margarita and Simbocal.

The partial drainage of these areas occurs during the dry season, because of the difference in elevation existing between La Sabana and Simbocal, and eventually the Chone river estuary. The magnitude of the drained volume is dependent on the surface water elevation maintained at Simbocal during the dry season by means of the artificial handling of the Simbocal tidal gate.

In the situation with project, where the flood condition of the Carrizal river is to be regulated, the remaining sources of water inflow will be the runoff and the rainfall, and the water supply scheme to be proposed in the conservation program for the area of La Sabana. It is considered that the adequate management of the Simbocal tidal gate is of vital importance to maintain the water level in this area during the dry season, and a detailed program for the operation of the Simbocal tidal gate is discussed further in this report.

The condition for the areas located between Simbocal and La Margarita are similar, except for the fact that the Chone river is not subject to flood control with the project condition, so these areas will still have the possibility of inundation by floods of the Chone river because the maximum flow in La Segua for a 50 year return period is 720 m^3/sec and 580 m^3/sec for a 25 year return period, and the carrying capacity of the Chone river in this area is only 150 m^3/sec.

(E) Existing conflicts

1- The agricultural activities adjacent to the inundated area are carried out during the dry season, and are expected to be done year round with the project condition. Conflicts arising between the agricultural practices and the wetland ecology and its human use are the following:

i) Pesticide and agrochemical runoff from the agricultural area towards the inundated area could affect the trophic chain through bioaccumulation.

ii) Maintaining an adequate surface water elevation at Simbocal during the dry season for the conservation of the inundated area promotes excessive soil humidity and development of diseases such as fungus to agricultural crops in the adjacent areas.

2- Shrimp farm expansion is exerting a pressure to move upstream of Simbocal in view of the lack of space to expand in the estuary area, and the existing legislation forbidding the cutting of mangrove.

3- Technified Chame farms are colonizing adjacent areas of the wetlands with massive dirt movement, invading potentially floodable areas, and eventually generating effluent high in BOD and nutrients that could affect the wetland.

(F) Proposed conservation plan

The proposed conservation plan is mainly directed towards implementing strategies for the preservation of La Sabana, since this area is the one to be directly affected by the project through the regulation of flow in La Esperanza. As previously stated, the area of La Pampa de Vellis and adjacent areas between Simbocal and La Margarita will still be subject to inundation by floodflows of the Chone river.

The successful implementation of the conservation program is directly related to the declaration of the wetland area as a protected area of restricted use, based on its ecological and socio-economical importance. CRM should in cooperation with PMRC and the ZEM Bahia-San Vicente-Canoa approach the legal authorities related to this purpose.

(i) Hydrology

The proposed limit for the wetland conservation area is elevation EL. 6 m above sea level, which will allow for the adequate hectarage and water depth for the artisanal culture of Chame. The stored volume in the wetland area at this elevation is estimated to be 16 MCM.

The maximum storage water capacity at Simbocal is 3 MCM, covering 120 ha of wetlands during the dry season.,

(ii) Agrochemical runoff

The water quality management scheme is basically directed towards the reduction of the toxic pesticide runoff coming from the adjacent agricultural areas. The integrated pest management program could be a positive approach for the reduction of agrochemicals from the irrigation area adjacent to the wetlands.

(iii) Use of adjacent land

The existing conflict between farmers and Chame culturists due to the water saturation of the soil when the water level at Simbocal is adequate to prevent wetland drainage can be attenuated if the farmers in the adjacent areas will grow water resistant plants, such as rice, which under inundated conditions will generate better yields than in a non inundated condition.

(iv) Colonizing of aquaculture farms

The change in the use of the land adjacent to the wetlands to the establishment of shrimp and/or Chame technified farms must be stopped with the declaration of the wetland as protected area.

(4) Operational program for Simbocal tidal gate

In the case of the Chone River estuary, the shrimp farming activity has covered an area of 4,967 ha, accounting for 41 % of the shrimp farms of the Manabi province. It is estimated that the shrimp ponds in this area store approximately 33.5-55.2 MCM, which is equivalent to the storage capacity of the estuary at low tide. The daily water exchange of the shrimp farms is estimated in 3.3-5.5 MCM/day, or approximately 10% of the stored volume.

The water quality of the estuary is a result of the uncontrolled agricultural, maricultural and ecological mismanagement of the system. It is considered that the Chone River estuary is about to suffer an ecological collapse, due to the massive deforestation of mangrove forest, and the effluent discharge from the agriculture, mariculture and urban development.

The artisanal Chame production in the wetland area of La Sabana and La Segua is dependent on the fresh water level at Simbocal to maintain an adequate water level and avoid drainage of the wetland area to a level which makes the culture of Chame unfeasible during the dry season. At the same time, the agricultural farmers adjacent to the wetland areas require to lower the water level at Simbocal, to avoid excessive water saturation of the soil at the farming area, which tends to the development of fungus and diseases in the agricultural crops during the dry season. This situation has been discussed before in the Basic Program for the Conservation of Chame Habitat.

The abovementioned situation originates the existing conflicts centered in the operation of the Simbocal tidal gate, and provides the need for an operational program of the tidal gate.

The following requirements are expected from the proper management program for the tidal gate at Simbocal:

1- During the dry season (July-December), the tidal gate must allow for the inflow into the estuary of 99 MCM of fresh water allocated for the improvement of the shrimp farming production and the lowering of the salinity content in the estuary water.

2- Also, in this season, the gate must allow the inflow of fresh water into the estuary, during the low tide at Simbocal, for about one hour two times a day and working at 35 % of its full capacity. The remaining time the gate must be closed to maintain the wtaer level and to avoid teh salinity intrusion.

3- During this season, the operation of the gate must allow to keep enough quantity of water to avoid the drainage of the Chame farms, and also to preserve the wetlands. At the same time, the retained water level at Simbocal must allow the upstream farmers to draw water out from the Carrizal River for irrigation purposes.

4- During the rainy season, the operation of the tidal gate must allow for the discharge of flood flows of 25,50 and 100 years of return period,

Results of the hydrological analysis show that the volume generated by a 25 and 50 year return period floods a considerable agricultural area, mainly due to the fact that the existing Simbocal tidal gate is insufficient to discharge the mentioned volumes.

To achieve the above mentioned requirements, it is necessary to implement a new design for the Simbocal tidal gate structure taking into account the recommendations previously stated.

3.6.6 Recommendations

1) Future studies are recommended to evaluate the socio-economic impact of the project during construction and operation, such as employment, development of the economy, relocation and resettlement of households and structures, and land aquisition and compensation.

2) Development and implementation of the EMMP is recommended for the adjacent areas of the reservoirs, based on the present and existing environmental studies.

3) Total coliforms determination and bacteria count is recommended to be done in all reservoirs, and in a periodic schedule, as proposed in the program for establishing a water quality criteria. This analysis will provide criteria to evaluate suitability of the water for the different uses, from the microbiological point of view.

4) Pesticide analysis is recommended in all the reservoirs, and in a regular schedule, to evaluate the possible danger of pesticide polluted water entering the intake of the treatment plants for human consumption. Special attention should be paid to Cis-heptachlor, which already appears in concentrations of greather than the maximum allowed.

5) Eradication of the plant biomass in La Esperanza impoundment area before inundation is of critical importance to avoid future deterioration of the water quality.

6) Implementation of aquatic plant control mechanisms such as described in this report and the coordination with CEDEGE are recommendable to improve water quality conditions at Conguillo inlet, and avoid further colonization of the plant into the other reservoirs.

7) The implementation of the sewarage system for Portoviejo city should be considered as a priority to avoid the serious future deterioration expected for the Portoviejo river.

8) Design of the proposed new Simbiocal dike is recommendable to allow the stored water elevation to reach 6 m above sea level.

9) A new Simbocal tidal gate operation manual should be established based on the present study, to achieve efficiency and coordination of the operation for the existing users, and the conservation of the wetland area.

10) Periodic tidal measurements should be made in a monitoring program, during 2 consecutive days of each month, and for a one year period, to adjust the existing operational program. At the same time, salinity measurements of top and bottom samples are recommnendable to be taken during the same period and in the same tidal measurement stations, to evaluate tide mixing patterns and fresh water requirements of the estuary.

11) An Integrated Pest Management Program (IPM) should be implemented as outlined in this study, for the irrigation area in an effort to reduce the use of pesticides and inorganic fertilizers, and through this mechanism improve the water quality conditions in rivers, estuaries and wetlands.

3.6.7 Environmental Management and Monitoring Plan

The present study is conceived as a first step of a management and monitoring plan, and should be understood as such. Programs and basic studies are well detailed in the different sections of the study, and the present section acts as a summary, with the objective of clarifying the environmental aspects to be managed and monitored, and to delineate a framework through the technical and financial viewpoints.

The JICA study team proposed in 1992 a structural organization consisting of three units, namely Environmental Management Unit (MAU), Environmental Monitoring Unit (MOU), and Laboratory (LAB). MAU has the function of overall management of the EMMP, including inter and inner institutional implementation of each plan and program. MOU has the planning and execution functions of the various kinds of studies and monitoring plans or programs in accordance with the policies decided by MAU. LAB has the roles of the physical, chemical, bacteriological and pesticide analysis for water and soil, and the research and development study for the establishment of appropriate EMMP of the project. The organizational chart is shown in Figure 3.6.5.

(1) Cost for Imprementation of EMMP

Several programs are to be conducted in EMMP for the Project during a period of five to seven years from 1995. The cost for these program is estimated at US$ 2.7 million indicatively, as shown hereunder.

EMMP Indicative Cost for Implementation

Program	Item	Indicative Cost in (US$)	
		Foreign Currency	Local Currency
A- Water Quality:			
• Program for Establishment of Water Quality Standard	Local Personnel	–	73,000
	Equipment	101,500	
• Program to Reduce Effects of Agrochemical	Local Personnel	–	84,000
	International Consultant	50,000	
	Equipment	170,300	
• Program for Biomass Removal from La Esperanza Impoundment Area	Local Personnel	–	24,000
	Equipment	1,800	
• Program for Aquatic Weed Control in Reservoirs	Local Personnel	–	150,000
B- Protection and Conservation			
B-1 Reservoir area			
• Program for Reforestation and Land Use Control around Reservoirs area	Local Personnel	–	156,800
	International Consultant & Local Experts	206,000	
	Equipment	523,200	
	Civil Works	420,000	
B-2 Estuary and Alluvial Areas			
• Program for Reforestation and Conservation of the Chone River Estuary	Local Personnel		327,000
	International Consultant & Local Experts	140,000	
	Equipment	127,800	
• Program for Conservation of the Portoviejo river Estuary	Local Personnel	–	5,600
	Equipment	24,200	
• Program for Conservation of Wetlands and Chame Habitats	Local Personnel	–	43,200
	International Consultant	72,000	
	Equipment	29,200	
C- Operation of Simbocal Tidal Gate			
• Program for Redesign, Implementation and Operation of the New Simbocal Gate	Local Personnel	–	7,200
	Equipment	3,200	
Total Estimated EMMP Cost		1,869,200	870,800

(2) Cost for Administration of EMMP

The annual cost for administration by CRM for EMMP has been estimated in US$ 207,000 as shown below.

Administrative Cost for EMMP

Item	Unit Cost/Year (US$)	No.	Total Cost/Year (US$)
i) Personnel			
- Professional staff	5,000	5	25,000
- Assistants	4,000	10	40,000
- Others	3,000	6	18,000
ii) Office Cost			
- Vehicles	6,000	4	24,000
- LAB equipment	–	1	50,000
- Others	–	1	50,000
Total:			207,000

Note: Do not include overhead because they are government officers

3.7 Institutional Study

3.7.1 General

Institutional study has two-fold objectives; firstly, to conduct institutional analysis of the executing agency, the Manabi Rehabilitation Center (CRM): and, secondly, to propose recommended institutional arrangements and support programs necessary for the operation and management stage for the comprehensive transbasin and reservoir operation including the detailed design and construction supervision stage on the basis of the present institutional analysis.

Institutional analysis was made to evaluate resources allocation, their respective competence and strength as well as constraints of the executing agency. For this, present

CRM was analyzed from the viewpoints of legal settings, organization, human resources and technical competence, financial aspects, and relation with other authorities concerned.

On the basis of the institutional analysis, institutional arrangements and support programs are proposed. Herein three alternative organizational structures are tentatively proposed. Also proposed are the required training programs and the need of the establishment of the Transbasin and Reservoir Management System as a management tool for the entire system. Lastly, institutional programs with brief program description and its implementation schedule with time framework are presented.

3.7.2 Institutional Analysis of CRM

(1) Overview of Legal Settings

CRM was established on November 7, 1962, by an official decree which was published on November 23 of the same year as an official register No. 314. Its origin of establishment arose from a provincial citizen's strike which broke out for provoking a drastic countermeasures against the economic stagnation in Manabi Province caused by a prolonged drought in 1962. According to the original legal instrument, CRM was organized as juridical persons of private law with social and public purposes. Its functions involved supply of irrigation and potable water, and provision of some urban infrastructures such as housing and paved roads. When CRM prepared a development plan, it was subject to the approval of the National Coordination Board for Economic Plan (predecessor of CONADE).

On September 14, 1970, CRM was entirely modified. Due to this reform, CRM was subordinated to the Ministry of Agriculture and Livestock (MAG) for making best coordination between its own works and nationwide programs, provided that the same functions were maintained as was previously.

CRM was restructured again on January 19, 1978, according to the executive decree No. 2180, the official register No. 516. This decree dictated that CRM need to play an important role for the economic and social development of the Province. It mentioned that CRM had to change its structure in connection with regional organization, and should be coordinated with other public authorities so that the Provincial population was able to get the maximum benefits by the economic and

social development. Presently, CRM is an institution of public law with proper funds, subordinated to MAG as shown in Figure 3.7.1.

(2) Organizational Analysis

1) Purposes and Objectives

The article 2 of the in force law points out among others the following purposes and objectives.

(a) To prepare plans and programs, and to work out projects for Manabi Province in conformity with the national development plans in cooperation with public and private organizations in the Province for better use and allocation of the available resources;

(b) To execute the works according to the plans, programs and projects, placing priority to the best use of water resources for irrigation and potable water and sanitation;

(c) To advise municipalities for their urban development;

(d) To maintain and develop promotion programs so that the execution of the works in the region get the necessary support from the public and private sectors in the Province; and

(e) To assist the establishment of enterprises and take part in them for the management and maintenance of the regional works carried out and others oriented to the integrated development of the Province.

In conclusion, the main objective of CRM is to formulate plans, programs and projects, and to execute them for the realization of the socio-economic development of Manabi Province.

2) Organizational Structure and Functions

Organization

The new regulation improved several functions, compared with the previous organization. First, duty of the Vice Executive Director, which had covered both technical and administrative matters in the old organization, only specializes in

technical functions. This enables CRM to promote efficient operation and management.

Second, a new organization was created in the present structure: the Training Department. Although this new unit is still weak in every point due mainly to early creation and limited personnel. This is on the right path towards the achievement of the formation of the functional CRM. In case this unit becomes effective and functional, it will greatly contribute to strengthen CRM's technical competence and level.

Third, the Directorate of Human Resources and Administration in the old organization was separated into two Directorates in the new organization: (i) the Directorate of Human Resources, and (ii) the Directorate of Administration.

Fourth, the Department of Furniture belonging to the Directorate for Finance in the old organization is transferred to the Directorate for Administration in the present organization.

Figure 3.7.2 illustrates the present organization of CRM. As shown, CRM is organized with four hierarchical levels: Directive Level, Advisory Level, Auxiliary or Supporting Level, and Operative Level as explained below.

(a) The Directive Level is formed with the Directive Board, the Executive Director, and the Vice Executive Director. This has the supreme authority to formulate strategies and policies, to approve plans, programs and projects , and to authorize contracts, agreements and loans.

(b) The Advisory Level is composed of the Technical Council, the Internal Audit Unit, the Legal Advisor Unit, the Social Communication Unit, the Institutional Development Unit, and the Directorate for Regional Planning.

(d) The Auxiliary or Supporting Level comprises the Directorate for Human Resources, the Directorate for Finance, the Directorate for Administration, the Department of Computation and Information System, and the Secretariat.

(e) The Operative Level consists of the Directorate for Physical Infrastructure and the Directorate for Socio- Economic Development. The Directorate for Physical Infrastructure has seven Departments. Among these departments,

the departments involved in the specific projects are temporary: the Department of Poza Honda Project, the Department of Carrizal-Chone Project, the Department of Transbasin Project, and the Department of Potable Water Plant Project. When the projects concerned are completed, the said Departments will end their existence. The Directorate for Socio-Economic Department also has seven Departments. These Departments correspond to the Departments related to the specific projects in the Directorate for Physical Infrastructure.

In addition, CRM has three permanent Regional Water Supply Systems in the Study area : Poza Honda, Chone, and La Estancilla. However, these work units do not appear in the organizational structure presented in Figure 3.7.2, and they are likely to be organized as the semi-commissioned water supply enterprises. This is an crucial organizational drawback. Even though CRM is formally entitled to operate these water supply systems, in practice CRM operates and manages them in rather passive and elusive way due to organizational weakness. They should be directly controlled and supervised by the Directorate for Physical Infrastructure under the present organization, or under the proposed Directorate which will be responsible for the operation and maintenance presented in the following section.

CRM, moreover, has two temporary work units established for the specific purposes: PHIMA and PFI. PHIMA was established on March 13, 1987, in accordance with the technical cooperation agreement with the Organization of American States. The objectives of the establishment of PHIMA were to give technical support to CRM in the context of the national and regional economic development with special emphases on water resources development and environmental management. PFI, on the other hand, was created in January 1993 with the purposes to evaluate CRM's present institutional capabilities and thereby to work out necessary measures and actions for the purpose of reinforcement of CRM's organization and its functions.

Functions

CRM was recoganized to serve both for a regional planning agency like CONADE on a national level, and the implementing agency for the socio-economic development of the Province. CRM, however, has so many departments and units belonging to the Advisory and Auxiliary Levels in higher administrative hierarchy

relative to the Operative Level, posing the unbalanced and bureaucratic organizational structure. This possibly causes the delay of prompt decision making inside CRM and the slight disorder of command for the functions to the lower level.

Organization of the Operative Level is in particular too weak to implement its functions to meet the said objectives for the Province. The present functions of the Directorate for Physical Infrastructure are to formulate plans and studies, execute construction, supervise project implementation, and manage project facilities belonging to CRM. These functions have not been fully undertaken due to organizational weakness, weak cohesion and less coordination among Departments concerned. The Directorate should be reorganized and reinforced into two new Directorates to fully carry out the functions and duties, according to the functions. Among other things, present Department of Study and Design, which is weakest in its functions, should be strengthened and transformed to Directorate.

On the other hand, the functions of the Directorate for Socio-Economic Development are to guide to establish enterprises and/or associations for the better use of the water resources, in particular for irrigation, to execute river basin management including environmental monitoring, to study water and soil quality for irrigation, and to assist farmers to organize their communities. In reality, however, its main activities are limited only part of irrigation-related duties. The function for environmental monitoring and management, which is presently assigned to the Department of River Basin Management, has been rarely undertaken due mostly to organizational weakness, lack of technical backgrounds and know-how, and limited personnel.

As to water tariffs for irrigation and water supply, it is unclear which department or unit under which hierarchy level has the authorized responsibility to review, assess and evaluate water tariff rates. Water tariff rates remain unchanged almost in the last 20 years for the irrigation use, charged unrealistically low, compared with the production costs. There is no practical and functional mechanism to deal with this matter in CRM's present organization.

Workforce

As of February 1993, CRM has 1,239 personnel: 743 in CRM headquarters; 274, Poza Honda; 82, Chone; 91, La Estancilla; and 49 others.

Out of 743 personnel in CRM headquarters, 178 personnel belongs to the Executive, Advisory and Auxiliary Levels, while 565 personnel is engaged in the Operative Level (191 in the Directorate for Physical Infrastructure and 374 in the Directorate for Socio-Economic Development). Seen from the engagement of workforce by department/unit, the Department of Rural Development for Poza Honda has the largest (147 personnel), followed by the Department of Study of Water and Soil (92) and the Department of Construction (76). However, no personnel is presently assigned to those departments of the Institutional Development and the Department of Transbasin Project. Three Regional Water Supply Systems have the personnel: 274 Poza Honda, 82 Chone and 91 La Estancilla. Two temporary work units have the workforce of 20 (PHIMA) and 4 (PFI) personnel, respectively.

Analyzed by the type of employment in the whole CRM, 309 staff is categorized into permanent professional/administrative personnel, which is the core of CRM organization in decision making, management and operation: 230 CRM headquarters, 41 Poza Honda, 17 Chone, and 21 La Estancilla. As for worker/labor category, permanent personnel is 599 staff and temporary of 318. Even though the organizational functions and strength cannot be evaluated only from the number of personnel, the present allocation of workforce possibly inhibits CRM from executing full-fredged functional operation.

With the enactment of new budget law No. 18 (November 30, 1993), all the government agencies and institutions are required to curtail their expenditures including personnel expenses for self-financing. CRM is also subject to this law, and this directly affects the employment situation of the temporary workforce in particular. CRM is obliged to decrease the number of temporary workers possibly to half of the present level. Owing to this retrenchment in its workforce, CRM needs to allocate its manpower efficiently according to the needs and requirements by making full use of its own human resources.

Table 3.7.1 shows the allocation of CRM' workforce as of March 1993.

(3) Financial Aspects

CRM's receipt comes from six financial categories: (i) actual current tributary, (ii) actual current non-tributary, (iii) capital transfer, (iv) current transfer, (v) finance

accounts, and (vi) balance in banks ant petty cash. CRM's receipt amounting to S/. 2,939 million in 1987 rose by 73% to S/. 5,095 million 1990. Its receipt was then projected to increase sharply by around 190% to S/. 14,750 million in 1992. Table 3.7.2 shows CRM's receipt and expenditure for the period of 1985 - 1990.

Out of the six financial categories, the actual current tributary and capital transfer are the largest sources ; it accounts for more than half of CRM's total receipt. In 1992, the actual current tributary was projected at S/. 5,540 million, sharing 38% of the total CRM's receipt. The capital transfer and its amount reached S/. 6,940 million in 1992, peaking the largest share of 47% of the CRM's receipt in the same year.

On the expenditure side, it has nine categories: (i) remuneration, (ii) services, (iii) consumables and materials, (iv) office furniture, (v) acquisition of real estate and livestock property, (vi) construction and other investment, (vii) amortization and loans, (viii) current transfer, and (ix) global budget. Among them, construction and other investment is the largest expenditure item, sharing 45% in 1992. The second largest is the remuneration for CRM's personnel, whose share shows upward trend from 10% in 1987 to 20% in 1992.

One of the controversial expenditure item is the current transfer, which is channeled as a subsidy to finance the three Regional Water Supply Systems, which have long suffered huge financial losses. The new law No. 18, promulgated on November 30, 1992, prohibits any subsidy to governmental agencies without exceptions. Therefore, CRM requires to retrench the subsidy entirely and rationalize the operation and management of these Systems. According to the 1993 budget, the subsidy channeled from CRM to them amounted to S/. 1,420 million, distributed at S/. 800 million to Poza Honda, S/. 320 million to La Estancilla, and S/. 300 million to Chone.

Concerning the water tariff rates for irrigation and water supply, the average tariff rate of the water supply valid from October 1992 is around S/. 110/m3, classified as S/. 25/m3 for domestic use, S/. 150/m3 for commercial use and S/. 500/m3 for industrial use, for the minimum range between 0 - 10 m3 water use, respectively. This rate is far less than the water production cost of around S/. 600/m3. On irrigation water rate, it is currently S/.90/time/ha, which is equivalent to S/. 0.09/m3. Thus the water charge is only nominal and negligibly small. Although the Water

Law (Decree No. 369 in 1972) specifies that the operation and maintenance costs must be borne by water users or final consumers, the principle of the Law has not been fully abode by in practice. This aggravates the CRM's financial position, discharging the valuable water resources.

(4) Human Resources and Technical Competence

Out of 309 permanent professional/administrative personnel in CRM as seen in workforce, around 120 personnel is categorized into professional with educational background of university level. Approximately 60 staffs have technical backgrounds with educational level of technical school. The rest is grouped into administrative staff with education either university or high school. On the other hand, most of the workers/labors usually have the high school education or less, with no prior technical background.

Analyzed by field of profession, engineering shares the largest. Among other things, agronomists and civil engineers including assistant staffs number around 50 and 60 personnel, respectively. However, other fields of engineers such as electrical, mechanical, and geological engineers are a few numbers. The number of specialized profession such as financial analyst, and economist is also quite limited.

In view of the technical competence by the stage of project implementation, present technical base can be more or less applicable to study, design, construction and supervision for the small-scale projects. However, technical weakness can be demonstrated in the operation and maintenance. Evaluated by the scale of project, current level of technical competence can be only applicable to the small-scale projects which need average technical requirements and base as well as simple set of technical combination. Thus, this is a critical aspect for such a large-scale project as the Transbasin Project, which requires high level of technical requirement with integrated operation and management system.

Some of the technical shortcomings analyzed above are the products of such attributes as weak technical backgrounds of the manpower, less motivation and enthusiasm, lack of work discipline, lethargy to duties and so forth. Political intervention sometimes undermines the sound organizational strength and functions, and mismanages the human resource allocation. This is particularly serious for the professional personnel who are mostly in the supervisory and managerial positions.

Low salary for the governmental personnel compared with private sector is possibly one of the reasons for less motivation and enthusiasm, and lack of work discipline.

(5) Relation with Other Institutions Concerned

There are several institutions, which are directly or indirectly concerned with CRM such as the National Development Council (CONADE), the Ministry of Agriculture and Livestock (MAG), the Ecuadorian Institute of Water Resources (INERHI), the Committee of Guayas River Basin Development (CEDEGE), and the Jipijapa and Pajan Board of Water Resources (JRH). Besides there is the coordination with the Provincial Council, municipalities and other parties.

Concerning the water resources management and use in particular, CRM has the institutional relation with INERHI, JRH, IEOS and municipal governments. There seems no superimposition in their mutual functions (master plan study). On the contrary, the lack or deficiency of the functions and coordination can be frequently observed. The inter-institutional coordination is incipient. However, as far as the potable water is concerned, functions of CRM, JRH and IEOS are somewhat overlapped by the municipalities.

Hereunder the functions of the authorities concerned are briefed in view of the relation with CRM.

1) CONADE is the agency which is solely responsible for formulating national development plan, and controls and guides ministries in accordance with the national development plans. CRM has the special relation with CONADE in preparation of its own plans, programs and projects for Manabi Province so as to coordinate them with the national development plans.

2) INERHI is the agency for the water resources development in Ecuador. Concerning the water management and river basin development for the Chone river and the Portoviejo river, its authority belongs to INERHI. However, the competence of water management and use in Manabi Province has been transferred to CRM by means of concessions in accordance with the agreement between INERHI and CRM.

3) CEDEGE is the agency which is responsible for the water resources development of Guayas river basin, and controls Daula-Peripa dam. In line