5. STRATEGIC PLAN FOR SEWERAGE DEVELOPMENT

The strategic plan for the sewerage development is formulated based on the results of the review of CEDAE M/P and priority projects are identified.

5.1 SEWERAGE SYSTEM PLANNING

Almost all wastewater is collected by gravity flow with some pumping stations.

Conventional activated sludge process is applied to treat wastewater for its stable operation with high BOD/SS removal efficiencies. The process is rather easily upgraded to include nutrients removal.

5.2 PROJECT IMPLEMENTATION PRIORITY

(1) Sewer districts with existing facilities are highly cost-effective and ones with already acquired or secured WWTP sites will not need time for site acquisition.

(2) The investment and pollutant removal efficiencies are generally higher in the districts with large service population and high-population density.

(3) If no road exists nor is yet planned along the rivers, it might be difficult to install trunk sewers for such locations.

Taking these points and also CEDAE's priority concept into account, the implementation program was proposed as shown in *Figure 5.1*.

5.3 PROJECT COST ESTIMATES

The sewerage project costs consist of the following components:

- Direct construction costs
- Land acquisition
- Administrative expenses (5% of direct costs)
- Engineering services (10% of direct costs)
- Physical contingency (10% of direct costs)

The direct construction costs of WWTPs, pumping stations and main sewers are estimated by the cost-capacity formulae developed based on the actual contracted costs for the recent construction works. Land acquisition will be required for the construction of new WWTPs.

The total project cost for all the sewerage systems is estimated to be US$ 1,579 million, whereas that for the first stage project for the four sewer districts (i.e. Pavuna, Acari, Sarapuí, and Bangu) is estimated to be US$ 394 million.

The breakdown of the project costs by components is shown in *Table 5.1*.

Table 5.1 Project Costs (in US$ 1,000)

Components		Costs (in US$ 1,000)		
		2004-2010	2011-	Total
Direct costs	Pavuna	105,321	-	105,321
	Acari	101,211	-	101,211
	Sarapui	26,157	-	26,157
	Bangu	81,730	-	81,730
	Others	-	942,828	942,828
	Total	314,419	942,828	1,257,247
Indirect costs	Pavuna	26,330	-	26,330
	Acari	25,303	-	25,303
	Sarapui	6,540	-	6,540
	Bangu	21,085	-	21,085
	Others	-	242,935	242,939
	Total	79,258	242,935	322,197
Total Project Costs		393,677	1,185,763	1,579,440

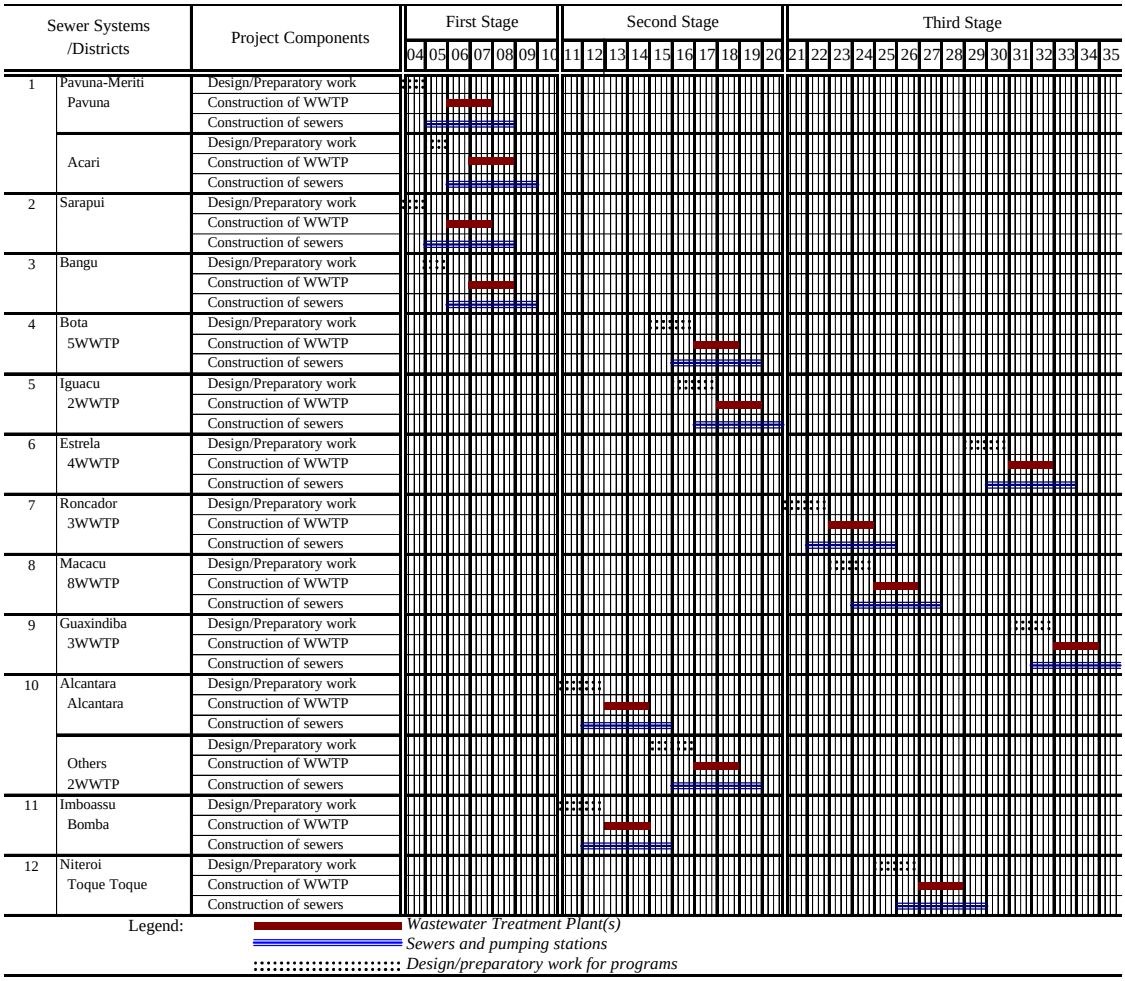

Figure 5.1 Project Implementation Schedule

Major portions of the sewerage system O/M costs are those for electricity, personnel, chemicals, repairs, cleaning, and other miscellaneous purposes. The average annual O/M expenses for the sewerage systems is assumed to be 5% of the direct costs, and the annual O/M cost for the Phase-I facilities is estimated to be US$ 63 million.

5.4 PROJECT EVALUATION

The proposed strategic plan targets the sewerage development of the entire Study Area and the improvement of the Guanabara Bay environment, achieving the middle term water quality target that eliminates the existing obnoxious conditions, also approaching the Environment Standard by CONAMA.

The improvement of sanitation conditions of the basin and of the environment conditions generates an economic benefit and the plan is judged to be economically viable with 10.0% EIRR. Although investment costs would be a burden to the State and operation costs would worsen the CEDAE's financial conditions, it is judged to be financially viable with 10.8% FIRR on condition of the State investment and low to medium interest rates loans for CEDAE.

From operational and management viewpoints, the plan can be managed and operated by CEDAE considering that CEDAE has performed similar projects, in principal. However, there are several issues to be addressed to improve the management and operation capabilities of the company.

The plan includes provision of sewerage from Favela areas.

The implementation of the plan may cause minor negative impacts such as land acquisition for the WWTP sites, large scale construction work and noise and others around the WWTP sites, which will be investigated in detail in the next phase of the study; so far major negative impacts are not expected.

In conclusion, the strategic plan is judged to be viable.

5.5 SELECTION OF PRIORITY PROJECT

It is judged that Pavuna, Acari, Sarapui and Bangu districts with the total area of 9,270 hectares show the highest implementation priority. The locations of the four sewer districts are shown in *Figure 5.2*.

It is assumed that the first construction stage will start in 2004 and be completed by 2010, and the following stages will be implemented after 2011.

Table 5.2 summarizes the major features of these four sewer districts.

Table 5.2 First Stage Program (2004 to 2010)

Sewer district	Area (ha)	WWTPs Capacity (L/d)	Required Site Area (ha)	Remarks
Pavuna	3,660	1,500	-	Existing capacity not included
Acari	3,100	1,100	-	
Sarapuí	640	1,000	-	Existing capacity not included
Bangu	1,870	1,000	6.5	
Total	9,270	4,600	6.5	

Source: The figures were obtained from CEDAE and updated by the M/P review results.

It is confirmed that the Short-term Water Quality Improvement Target can be achieved by implementation of the Priority Project.

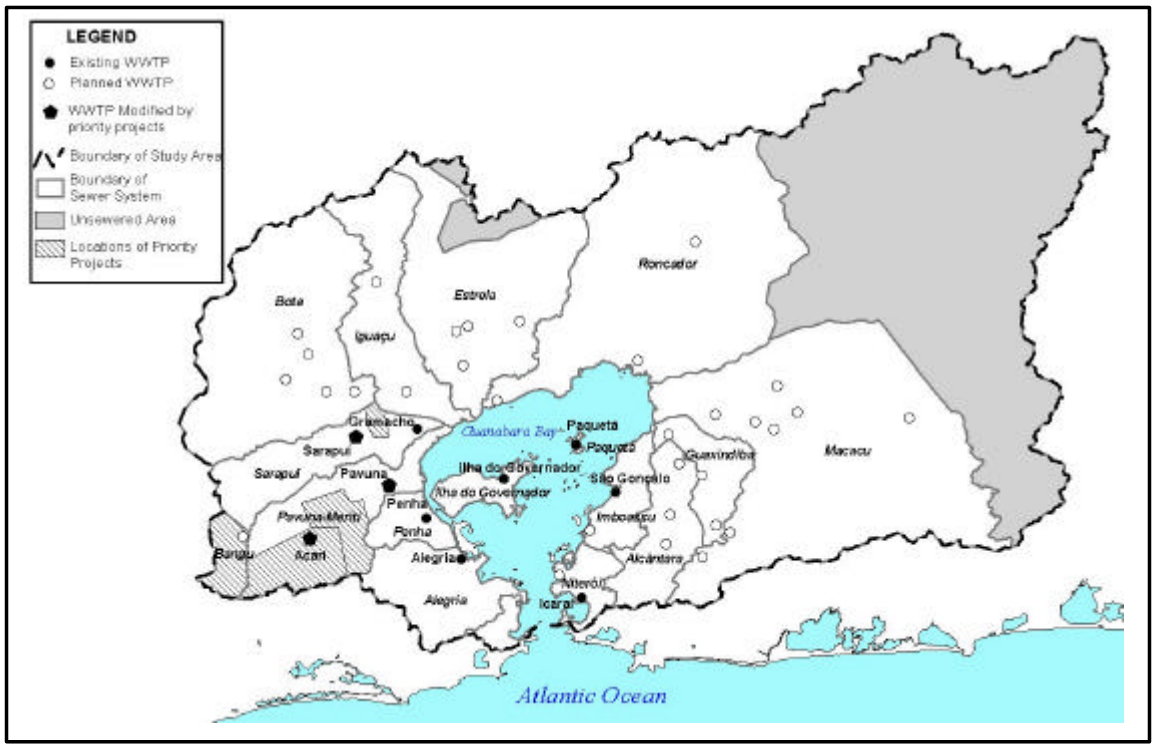

Figure 5.2 Location of Priority Project

6. FEASIBILITY STUDY ON THE PRIORITY PROJECT

6.1 STUDY AREA

The high priority area of 9,270 hectares is selected as the study area in consideration of the conditions of existing sewers, topography, needs for sewer extension, and urban development patterns. The area is shown in *Figure 6.1*. The existing and project sewer service areas in each sewer district are summarized in *Table 6.1*:

Table 6.1 Sewer Districts in Existing and F/S Areas

Sewer System	Sewer District	Existing Area	F/S Area	Green Belt and Others	Total
Pavuna -Meriti	Pavuna	4,900	3,660	0	8,560
	Acari	730	3,100	600	4,430
	Sub-total	5,600	6,760	600	12,990
Sarapuí	Sarapuí	7,300	640	0	7,940
Bangu	Bangu	0	1,870	0	1,870
Total		12,930	9,270	600	22,800

(Unit: ha)

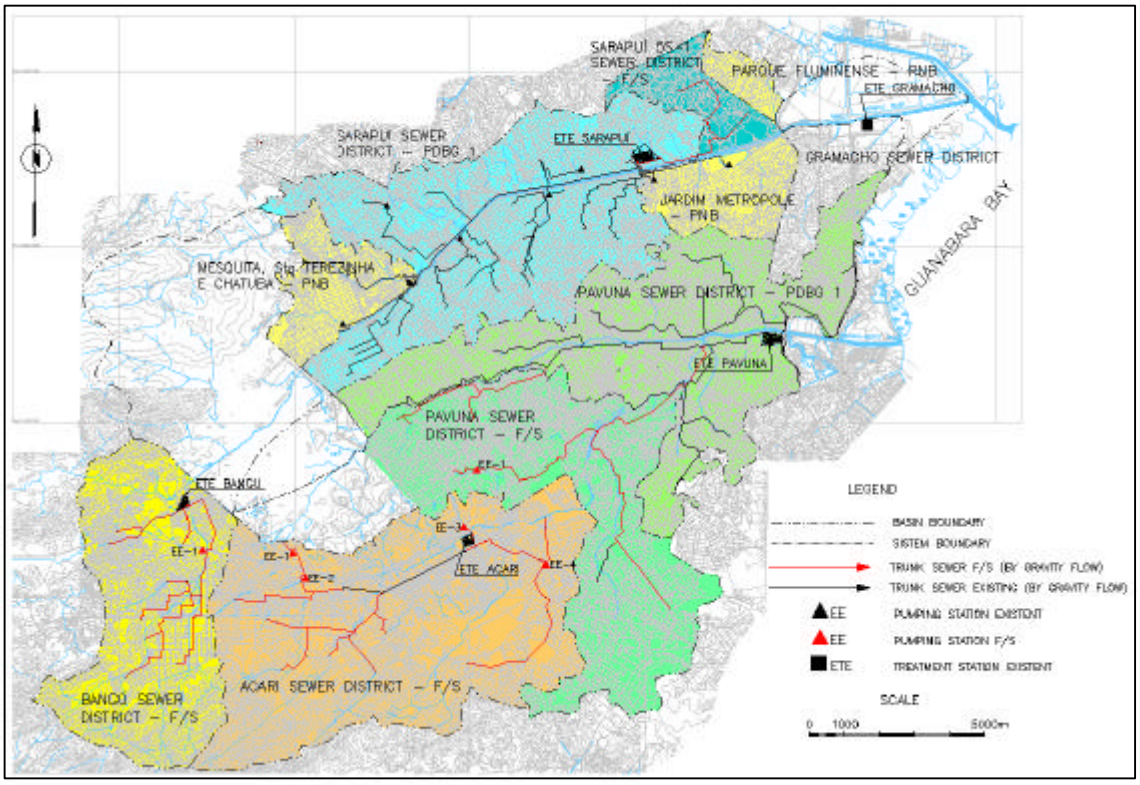

Figure 6.1 Location of Priority Project

6.2 DESIGN BASIS

6.2.1 DESIGN POPULATION

The future population calculated on the basis of the census data for each municipality is applied to the relevant sewer district(s). The rate of sewered population to the whole population in sewer districts is estimated to be 90% as shown in *Table 6.2*.

Table 6.2 Sewered Populations by Sewer District and Year

Sewer System	Sewer District	2000	2005	2010	2015	2020
Pavuna -Meriti	Pavuna	950,000	969,000	990,500	1,011,000	1,029,600
	Acari	360,000	367200	375,300	383,100	390,200
	Sub-total	1,310,000	1,336,200	1,365,800	1,394,100	1,419,800
Sarapuí	Sarapuí	709,800	740,500	772,600	800,200	825,900
Bangu	Bangu	340,700	346,000	352,200	358,100	363,200
Total		2,360,500	2,422,700	2,490,600	2,552,400	2,608,900

(Unit: person)

6.2.2 DESIGN WASTEWATER FLOWS AND THEIR CHARACTERISTICS

(1) Wastewater Flow Rates

In estimating wastewater flow rates, per capita wastewater flow rates are obtained based on the water consumption data as follows:

- Average daily per capita wastewater flow rate = 220Lpcd
- Maximum hourly wastewater flow rate = Average daily wastewater flow rate x 1.8

For the system hydraulic design, 20 Lpcd of inflow/infiltration is added to the per capita wastewater flow rates. Thus, the average daily wastewater flow rates of each sewer district are estimated as shown in *Table 6.3*:

Table 6.3 Average Daily Wastewater Flow Rates

Sewer System	Sewer District	2000	2005	2010	2015	2020	(in L/s) (2020)
Pavuna -Meriti	Pavuna	228,000	232,560	237,720	242,640	247,104	(2,860)
	Acari	86,400	88,128	90,072	91,944	93,648	(1,084)
	Sub-total	314,400	320,688	327,792	334,584	340,752	(3,944)
Sarapuí	Sarapuí	170,352	177,720	185,424	192,048	198,216	(2,294)
Bangu	Bangu	81,768	83,040	84,528	85,944	87,168	(1,009)
Total		566,520	581,448	597,744	612,576	626,136	(7,247)

(Unit: m^3/day)

(2) Wastewater Characteristics

Brazilian technical standards define that BOD and SS generations per capita per day are 54 grams and 60 grams, respectively. These values are divided by per capita wastewater flow rate of 240 L/capita/day and BOD and SS concentrations of wastewater are obtained as 230 and 250 mg/L, respectively.

6.3 PRELIMINARY DESIGN OF SEWERAGE FACILITIES

6.3.1 COLLECTION SYSTEM

The Project consists of a total of 1,833 km of sewers, ranging from 150 to 1,500 mm in diameter, together with six pumping stations. The sewer construction types, lengths, sizes and specifications are enumerated in *Table 6.4*.

Table 6.4 Collection System Components

Sewer District	Branch Sewer	Trunk Sewer Open Cut	Trunk Sewer Pipe Jacking	Trunk Sewer Pressure Pipe	Total
Pavuna	695,000	7,170	15,642		717,812
Acari	558,000	7,690	16,148	1,010	582,848
Sarapuí	96,000	2,090	4,660		102,750
Bangu	411,000	5,770	12,910		429,680
Total	1,760,000	22,720	49,360	1,010	1,833,090

(Unit: m)

6.3.2 WWTPS

The Project consists of the expansion of Pavuna and Sarapui WWTPs and the construction of new WWTPs in Acari and Bangu sewer districts. Activated sludge process, applied to the existing facilities of Pavuna and Sarapuí WWTPs, is also applied to Acari and Bangu WWTPs. The process is reliable with high BOD and SS removal efficiencies. It is easy to be upgraded for nutrients removal. The capacities and major features of the WWTPs are shown in *Table 6.5*

Table 6.5 WWTPs

WWTPs	Design Treatment Capacity (L/s)		Influent Qualities BOD/SS (mg/L)	Effluent Qualities BOD/SS (mg/L)
	Existing	F/S		
Pavuna	1,500	1,500	230/250	20/20
Acari	-	1,100	230/250	20/20
Sarapuí	1,500	1,000	230/250	20/20
Bangu	-	1,000	230/250	20/20

6.3.3 GENERAL LAYOUT PLAN

General layout plan of sewerage facilities of Pavuna, Acari, Sasrapuí and Bangu sewer districts are shown in *Figures 6.2 to 6.5*, respectively.

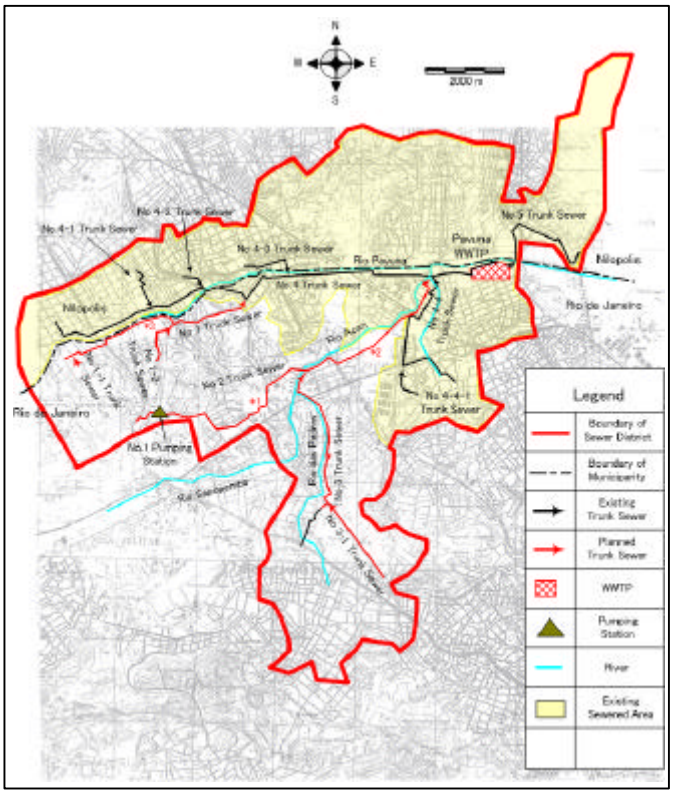

Figure 6.2
General Layout Plan of
Pavuna Sewer District

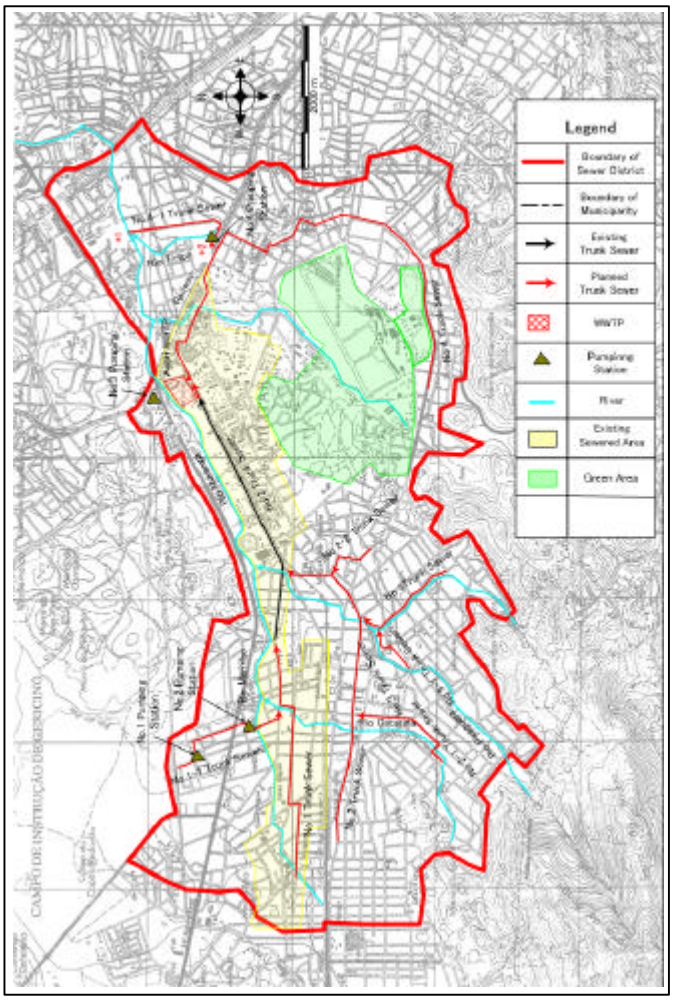

Figure 6.3
General Layout Plan of
Acari Sewer District

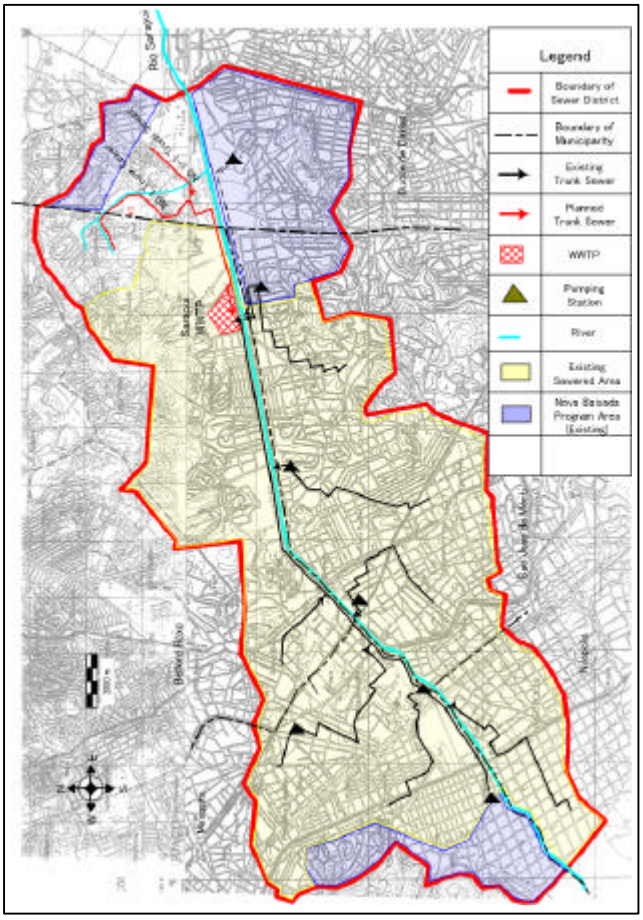

Figure 6.4
General Layout Plan of
Sarapuí Sewer District

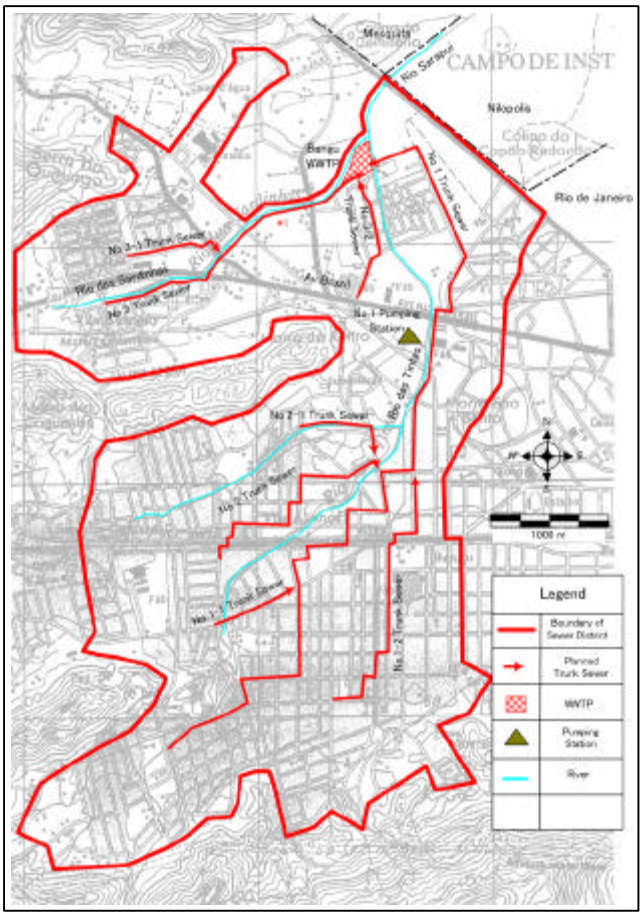

Figure 6.5
General Layout Plan of
Bangu Sewer District

6.4 COST ESTIMATES

The labor and equipment rates are estimated at the price level in mid-July 2003 and converted to US Dollars using the current exchange rate: One US Dollar (US$) = 2.9 Brazilian Real (R$) = 120 Japanese Yen (¥)

6.4.1 DIRECT COSTS

The Project, to be undertaken over the period from 2004 through 2010, will require a total direct cost of US$ 314 million (mid-July 2003 price level, without cost escalation). *Table 6.6* shows the direct costs according to component:

Table 6.6 Project Cost of Priority Project

Sewer District	WWTPs	Sewers	Pumping Station	Total
Pavuna	14,872	90,374	75	105,321
Acari	28,293	72,548	370	101,211
Sarapuí	11,741	14,416		26,157
Bangu	26,935	54,745	50	81,730
Total	81,841	232,083	495	314,419

(Unit: US$1,000)

6.4.2 O & M COSTS

The O&M costs consist of those for administrative and operational personnel, power for WWTPs and pumping stations; chemicals for sludge conditioning; sludge disposal and sewer inspection/cleaning as shown in *Table 6.7*. The total annual O&M cost is estimated at US$10,500,000.

Table 6.7 Project O&M Costs

Facility	Item	Pavuna	Acari	Sarapuí	Bangu	Total
Sewers	Personnel	724,500	621,000	103,500	414,000	1,863,000
WWTPs	Personnel	600,300	1,014,300	434,700	1,014,300	3,063,600
	Electricity	1,226,711	912,453	778,745	783,354	3,701,263
	Chemicals	659,764	223,636	439,852	203,294	1,526,546
	Sludge disposal	79,920	30,059	53,341	27,280	190,600
	Routine repairs	32,000	48,464	25,890	48,092	154,447
	WWTP subtotal	2,598,695	2,228,912	1,732,528	2,076,320	8,636,456
Total		3,323,196	2,849,912	1,836,028	2,490,320	10,499,457

(Unit: US$/year)

6.4.3 IMPLEMENTATION PLAN

Most of the materials for civil works are locally available with qualities complying with internationally acceptable standards, while certain types of electrical and mechanical equipment are to be imported. The estimated capital costs have the following components:

- Direct or construction costs
- Land acquisition and compensation
- Administration expenses (5% of direct costs)
- Engineering services (10% of direct costs)
- Physical contingencies (10% of direct costs)

The figure and table below present the cost disbursement schedule of the Project facilities components on annual basis in accordance with the seven-year construction schedule from 2004 through 2010.

Priority Project Costs are shown in *Table 6.8.*

Table 6.8 Priority Project Costs

Item	Foreign Costs	Local Costs	Total
Direct Cost	14,852	299,567	314,419
Land Acquisition (Bangu WWTP)	-	650	650
Administrative Expense (5%)	-	15,722	15,722
Engineering Services (10%)	-	31,443	31,443
Physical Contingencies (10%)	-	31,443	31,443
Total of Indirect Cost	**-**	**79,258**	**79,258**
Total of Capital Costs	**14,852**	**378,825**	**393,677**

Note: Estimated by the JICA Study Team in consultation with CEDAE.

Implementation schedule is shown in Figure 6.6.

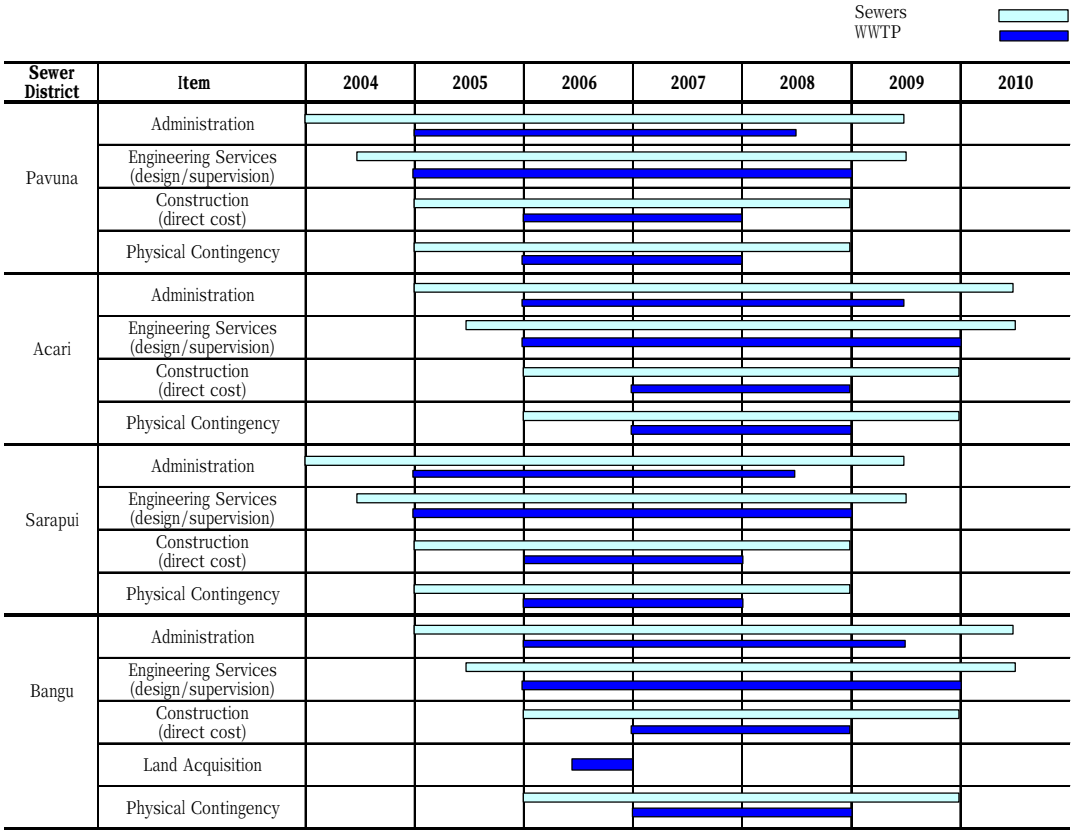

Figure 6.6 Implementation Schedule

6.5 PROJECT EVALUATION

6.5.1 ACHIEVEMENT OF WATER QUALITY TARGET

The Priority Project reduces the pollutant load from the western portion of the basin, resulting in the improvement of water quality in the western part of theBay. The water quality simulation confirmed that the water quality over the entire bay area will be less than 10 mg/l BOD, which is an index of the Short-term Improvement Target.

6.5.2 FINANCIAL EVALUATION

Financial evaluation was made based on the cash outflow derived from the disbursement schedule of the project implementation schedule and residual value and cash inflow that consists of operation revenue, subsidy from the state and bank loans. FIRR was calculated considering several alternatives for the State subsidy and bank loans conditions.

As a result of the comparison of FIRRs of each alternative, it is concluded that the project is financially viable with 9.7 % FIRR under the following conditions:

- The State provides investments of US$20 million in 2006 and US$4 million from 2007 to 2009.
- 30% of construction costs is financed by a bank loan with favorable conditions (interest rate of 2.5%; Grace period of 7 years; and loan period of 25 years)
- 30% of construction costs is financed by a bank loan with international conditions (interest rate of 5.5%; Grace period of 7 years; and loan period of 25 years)

In case the State fails to provide the above investments, FIRR declines to 8.2% and the project is still judged to be viable.

6.5.3 ECONOMIC EVALUATION

Even in the economic analysis, the economic cost was obtained by converting the cash outflow used in the financial analysis by excluding taxes and adjusting the unskilled labor costs. Economic benefits were assessed by employing the Contingent Valuable Method, in which "the value of Guanabara Bay with improved water quality" was determined by interviewing residents and tourists. The analysis resulted in 12.9% EIRR and it is concluded that the project is economically viable.

6.5.4 SOCIAL EVALUATION

Social impacts of the proposed project were evaluated by focusing on the possible impacts to Favelas from the viewpoints of fair distribution of the project benefits and' sewerage services affordability by residents.

The priority project was planned with the following assumptions for Favelas:

- Since sewer cannot be installed in disordered streets, intervention programs shall install sewers when they improve streets.
- New intervention programs shall collect sewage and discharge it into CEDAE's trunk sewers.

As for the affordability, it was concluded that sewerage charge is affordable to Favelas inhabitants by applying the *de facto* special tariff system.

6.5.5 ENVIRONMENTAL EVALUATION

The EIA study identified possible negative/positive impacts and proposed mitigation/optimization measures. These measures will be taken into consideration in the detailed design stage to prepare technical specifications of the proposed projects. This report's mitigation/optimization measures will be a guide for proposing concrete PBA (Plano Básico Ambiental: Basic Environmental Plan), which includes procedures, time schedule and estimated costs. It is concluded that the proposed project is environmentally feasible.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

Technically, the proposed system will handle the estimated quantity of wastewater from 2009 through 2020 in accordance with generally accepted engineering practices. The collected wastewater will be treated through the conventional activated sludge process.

Significant benefits to environment, public health, and economy can be derived from the proposed Project, including both direct and indirect ones. In particular, the proposed Project will achieve the short-term target of the strategic plan, eliminating unpleasant conditions of the western part of the Bay. This will greatly contribute to the improvement of the living conditions of nearby residents as well as to the mitigation of disagreeable conditions around the international airport that is an international gateway.

The Feasibility Study has verified the technical, economic, institutional and environmental feasibility of the proposed Priority Project; however, F/S has also revealed that the Project is financially difficult to implement without appropriate financial support. At the beginning of the Project, the investment costs for such a magnitude of construction works would be a financial burden to CEDAE considering its present financial conditions.

7.2 RECOMMENDATIONS

The Study revealed that the conditions of the environmental and sewerage administration of the Rio de Janeiro State does not necessarily assure the sound implementation and operation of the Project. Therefore, recommendations were made from the viewpoints of the reinforcement of the environmental administration. Some of the recommendations were attached to practical proposals to address the issues.

7.2.1 FOR THE BETTER ENVIRONMENTAL ADMINISTRATION

What is necessary for the reinforcement of the environmental administration are an effective managerial function and political or people's support for policies attaching importance to the environment.

(1) Integration of Functions

SEMADUR should setup a department or section within its own organization with the following functions:

- Information pool of activities and plans related to the Bay environmental improvement.
- Preparation of scenarios for the Bay environmental improvement through analysis of collected data and information.
- Selection of the optimal scenario.
- Revision of Strategic plan that is technically, economically and financially feasible.
- Implementation of Strategic plan.
- Coordination of budget allocation to activities for the Bay improvement.

Water quality simulation model (WQSM) and Decision Support System (DSS), both developed in this Study, can be used as tools for integration of policy by selecting the optimal scenario.

It is also recommended to enforce the current water quality monitoring program carried out by FEEMA to make it the information source for the proposed organization in SEMADUR. Required features of the proposed monitoring program have been attached to the recommendation.

(2) Encouragement of Environmental Awareness

Study provided two tools for the encouragement of the residents' awareness as shown below: namely, environmental education programs and Homepage for the Guanabara Bay Water quality. The study recommended the State should realize the proposed environmental education programs, and update and develop the Homepage.

1) Environmental Education

Implementation of two types of environmental education are recommended:

- Training of Trainers: This program is to train leaders of the environmental education and has been employed as one of program components of PDBGI. It is expected that the trained leaders launch various types of environmental education in different places in the basin, resulting in environmental education spreading over whole basin. It is required to introduce evaluation system of its effect in the subsequent implementation.
- Community-based environmental education: There are several community based environmental education programs operated by NGOs in the basin. These activities are of small scale and localized but result in immediate results. It is required to support a number of these activities to spread the effects over whole basin.

2) Homepage

The Homepage has been created to disseminate information to the users to increase their understanding and awareness about the water quality in Guanabara Bay (http://www.cibg.rj.gov.br/). Since the homepage has been setup as a trial, it is expected that the concerned organization should update and develop the homepage to make it a better information distributing tool in order to improve the people's awareness level.

7.2.2 FOR THE SOUND IMPLEMENTATION AND OPERATION OF THE PROJECT

(1) Implementation of Priority Project

CEDAE should take the first action to realize the Project, which is to make the decision of carrying out the implementation of the Project.

(2) Financial Improvement of CEDAE

CEDAE should continue to monitor the indicators in the SNIS report, analyzing the differences between its own indicators and the indicators of other water supply companies. It should set targets, and prepare an action plan. Major issues to be addressed by the action plan are as follows:

- Increase of Operation Revenue
- Decrease of O&M Expenditure
- Support for the connection fee

(3) Operation and Maintenance Improvement of CEDAE

So far, no comprehensive sewer rehabilitation program has been established to identify the actual situation. Under these circumstances, it is apparent that there is an urgent need for sewer rehabilitation and retrofitting. It is recommended that a sewer renovation program is

carried out, involving preparation of sewer network inventory, and establishment of a program of inspections, cleanings and rehabilitations of sewers. These should be responsibility of the newly established Sewerage Department in CEDAE.

(4) Implications of Future Actions and Studies

Because of the recommended plan for the positive control of water quality in the Bay and waterways in the Study Area, several special actions and investigations are necessary to provide a sound basis for detailed planning and system design. Specifically, urgent studies and actions should be undertaken for the continued protection and improvement of the environment of the Area.

(5) Monitoring of Wastewater Treatment Plant Operation

It is strongly required to monitor operation conditions of WWTPs to secure the design operational performance of wastewater treatment.