JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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STATE OF RIO DE JANEIRO
THE FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON RECUPERATION OF THE GUANABARA BAY ECOSYSTEM

VOLUME 2 MAIN REPORT

MARCH 1994

KOKUSAI KOGYO CO., LTD. TOKYO

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ON
RECUPERATION
OF
THE GUANABARA BAY ECOSYSTEM

LIST OF REPORTS

VOLUME 1 SUMMARY
VOLUME 2 MAIN REPORT
VOLUME 3 SUPPORTING REPORT I
VOLUME 4 SUPPORTING REPORT II
VOLUME 5 DATA BOOK

The cost estimate was made based on US$ in January 1994

PREFACE

In response to a request from the Government of the Federative Republic of Brazil, the Government of Japan decided to conduct a Master Planning Study on Recuperation of the Guanabara Bay Ecosystem and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Brazil a study team headed by Dr. Akira Sugiyama, Kokusai Kogyo Co., Ltd., 6 times between March 1992 and January 1994.

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

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

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

March 1994

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

March 1994

Mr. Kensuke Yanagiya
President,
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit to you the final report on "THE STUDY ON RECUPERATION OF THE GUANABARA BAY ECOSYSTEM IN THE FEDERATIVE REPUBLIC OF BRAZIL". This report has been prepared by the Study Team in accordance with the contract signed on March 6 and October 2, 1992 and March 12 and November 1, 1993 between the Japan International Cooperation Agency and Kokusai Kogyo Co., Ltd..

The report contains the study results on the existing environmental conditions of Guanabara Bay and its basin and the Master Plan to improve the water quality and to restore the ecosystem of the bay.

The existing environmental conditions were graphically arranged on the "Environmental Information Map of Guanabara Bay and its Basin" attached to the report. The Master Plan presented in this report consists of the target year, the target water quality, the target reduction loads, effectiveness and cost of the applicable measures and the optimum combinations of measures to attain the target water quality by the target year.

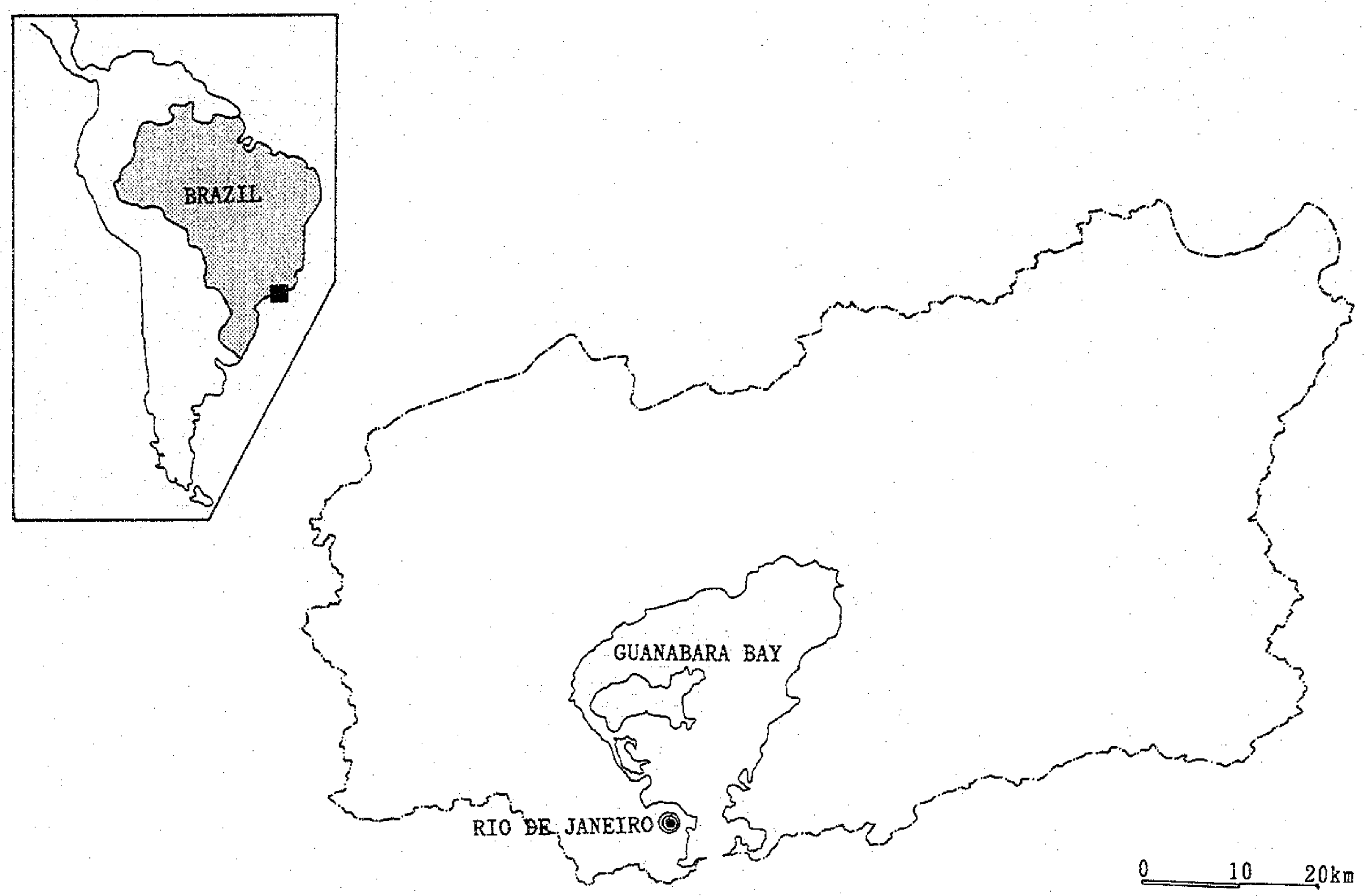
We hope that the implementation of the proposed Master Plan would greatly contribute to environmental improvement which is precious to the residents and the aquatic lives in the bay.

All members of the Study Team wish to express grateful acknowledgement to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Environmental Agency, Ministry of Construction, Ministry of Transport, Municipality of Kobe, Overseas Economic Cooperation Fund, Embassy of Japan in Brazil and also to officials and individuals of Rio de Janeiro State and Federal Government of Brazil for the assistance they have extended to the Study Team.

Very truly yours,

杉山 明

Akira Sugiyama
Team Leader,
The Study on Recuperation
of the Guanabara Bay Ecosystem



Landsat False Color Picture on Nov.26,1991

LANDSAT IMAGE OF THE STUDY AREA

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ABBREVIATIONS

(1) Organization and Agency

AFB	:	Agence Financeiro de Basin
BNDS	:	Banco Nacional de Desenvolvimento Social
CECA	:	Comissao Estadual de Controle Ambiental (State Commission for Environmental Control)
CEDAE	:	Companhia Estadual de Aguas e Esgotos (State Company of Water and Sewages)
CIDE-RJ	:	Cidade do Rio de Janeiro (Rio de Janeiro City)
CODIN	:	Companhia Distrito Industriais
CODEG	:	Comissao Coordenadora para Execucao do Programa de Despoluicao da Baia de Guanabara
COMLURB	:	Copanhia Municipal de Limpeza Urbana (Minicipal Company of Urban Cleaning)
CONAMA	:	Conselho Nacional de Meio Ambiente
DCON	:	Divisao de Controle de Industrias (FEEMA)
DHN	:	Diretoria de Hidrografia e Navegacao
DILAB	:	Divisao de Laboraterios (FEEMA)
DRM-RJ	:	Departamento de Recursons Minerais, Secretaria de Estado de Industria, Comercio e Turismo
DSGME	:	Diretoria de Servico Geografico Minisiterio do Exercito
FECAM	:	Special fund for Environmental Control
FEEMA	:	Fundacao Estadual de Engenharia do Meio Ambiente
GEDEG	:	Grupo Executivo de Depoluciao da Baia de Guanabara (Executive Group for Depollution of the Guanabara Bay)
GERSOL	:	Grupo Executivo de Residuos Solidos
IBARM	:	Instituto Brasileiro de Meio Ambiente e dos Recursos Renovaveis

IBGE : Instituto Brasileiro de Geografia e Statistica

IDB : Inter-American Development Bank

IEF : Fundacao Instituto Estasual de Florstas

IMO : International Maritime Organization

IMPE : Instituto de Pesquisas Espaciais

INPH : Instituto de Pesquisas Hidroviarias

IPLANRIO : Instituto de Planejamento Municipal

JICA : Japan International Cooperation Agency

NGO : Non-governmental Organization

OECF : Overseas Economic Cooperation Fund (Japan)

SEMAN : Secretaria de Meio Ambiental

SEMAMPE : Secretaria Estadual de Meio Ambiente e Projetos Especiais (State Secretariat of Environment and Special Project)

SERLA : Superientendencia Estadual de Rios e Lagoas

SSPU : Subsecretaria Superintendencia de Planejamento Urbano

UERJ : Univrsidade do Estado do Rio de Janeiro

UFRJ : Universidade Federal do Rio de Janeiro

(2) Oceanography

CDL : Chart Datum Level

HHW : Highest High Water

HW : High Water

LLW : Lowest Low Water

LW : Low Water

MHWN : Mean High Water Neaps

MHWS : Mean High Water Spring

MLWN : Mean Low Water Neaps

MLWS : Mean Low Water Springs

MSL : Mean Sea Level

(3) Water and Sediment Quality

As : Arsenic

BOD : Biochemical Oxygen Demand

C : Carbon

Cd : Cadmium

CHl-a : Chlorophyll-a

CN : Cyanide

COD (Cr) : Chemical Oxygen Demand by Potassium Dichromate Method

COD (Mn) : Chemical Oxygen Demand by Potassium Permanganate Method

Coliform : Coliform Group Bacteria

Cr (6+) : Sexivalent Chromium

DBOD : Dissolved Biochemical Oxygen Demand

DCOD : Dissolved Chemical Oxygen Demand

EC : Eletric Conductivity

Hg : Mercury

H_2S : Hydrogen Sulfide

IL : Ignition Loss

MBAS : Methylene Blue Active Substance

MPN : Most Probable Number

NH_4-N : Ammonium Nitrogen

NO_2-N : Nitrite Nitrogen

NO_3-N	:	Nitrate Nitrogen
Pb	:	Lead
PCB	:	Polychlorinated Biphenyls
pH	:	Potential of Hydrogen
PO_4-P	:	Phosphate Posphorus
SS	:	Suspended Solid
SS(IL)	:	Ignition Loss of Suspended Solid
TDP	:	Total Dissolved Phosphorus
TOP	:	Total Organic Phosporous
THg	:	Total Mercury
TIN	:	Total Inorganic Nitrogen
TIP	:	Total Inorganic Phosphorous
TKN	:	Total Kjeldahl Nitrogen
TN	:	Total Organic Nitrogen
TOC	:	Total Organic Carbon
TON	:	Total Organic Nitrogen
TP	:	Total Phosphorus
TR(IL)	:	Ignition Loss of Total Residue
Turbid	:	Turbidity
NTU	:	Nephelometric Turbidity Units

(4) River Load

(5) Regulation and System

APP	:	Area de Protecao Permanente
EIA	:	Environmental Impact Assessment
PPP	:	Pollutor-pays Principle

RIMA	:	Relatorio de impacto Ambiental
SISNAMA	:	Sistema Nacianal de Meio Ambiente
TCPHA	:	Cria a Taxa de Controle da Poluciao Hidrica e Atmosferica (Taxation for Control of Water and Air Pollution)

(6) Report

IC/R	:	Inception Report
P/R	:	Progress Report
I/R	:	Interim Report
DF/R	:	Draft Final Report
F/R	:	Final Report
S/R	:	Supporting Report

PART I

INTRODUCTION

CHAPTER 1

SCOPE OF THE STUDY

CHAPTER 1

SCOPE OF THE STUDY

The objectives and contents of the Study were summarized together with members list of each committee, the study team and counterparts in this chapter.

The list of principal cooperators, who extended their cooperation to the study team during the Study was also shown.

1.1 Objectives and Area of the Study

The objectives of the study are as follows:

(1) To formulate a master plan for the water pollution control and the recuperation of Guanabara Bay's ecosystem.

(2) To transfer technology to Brazilian counterparts during the study.

The study focused on Guanabara Bay which covers an area of 395km^2, including 48km^2 of islands and islets; a catchment area of about 4,000 km^2 and also a part of the Atlantic Ocean, around the mouth of the bay (see **Fig. 1.1-1**).

1.2 Organization for the Study

1.2.1 Implementation Planning Committee and Steering Committee

For the smooth and effective execution of the study, the Implementation Planning Committee and the Steering Committee were organized on the Brazilian side. Both committees were headed by Dr. Manuel Sanches (Until April, 1993) and Dr. Roberto D'Avila (May to August, 1993) and Mr. Geraldo Lessa (from September, 1993), and they consist of administrative and technical leaders belonging to several governmental institutions of the State of Rio de Janeiro, as shown in **Table 1.2-1** and **Table 1.2-2**.

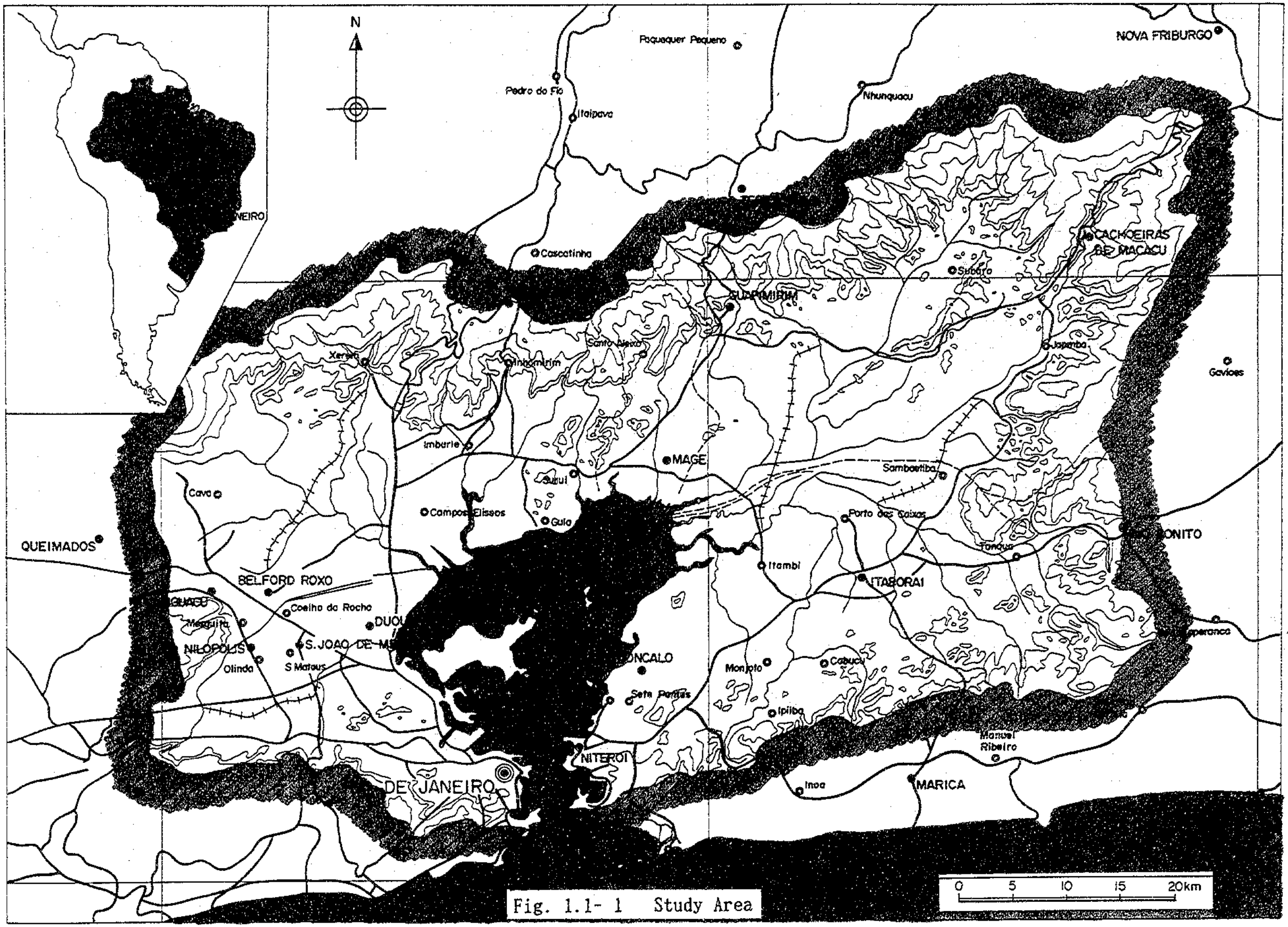

Fig. 1.1- 1 Study Area

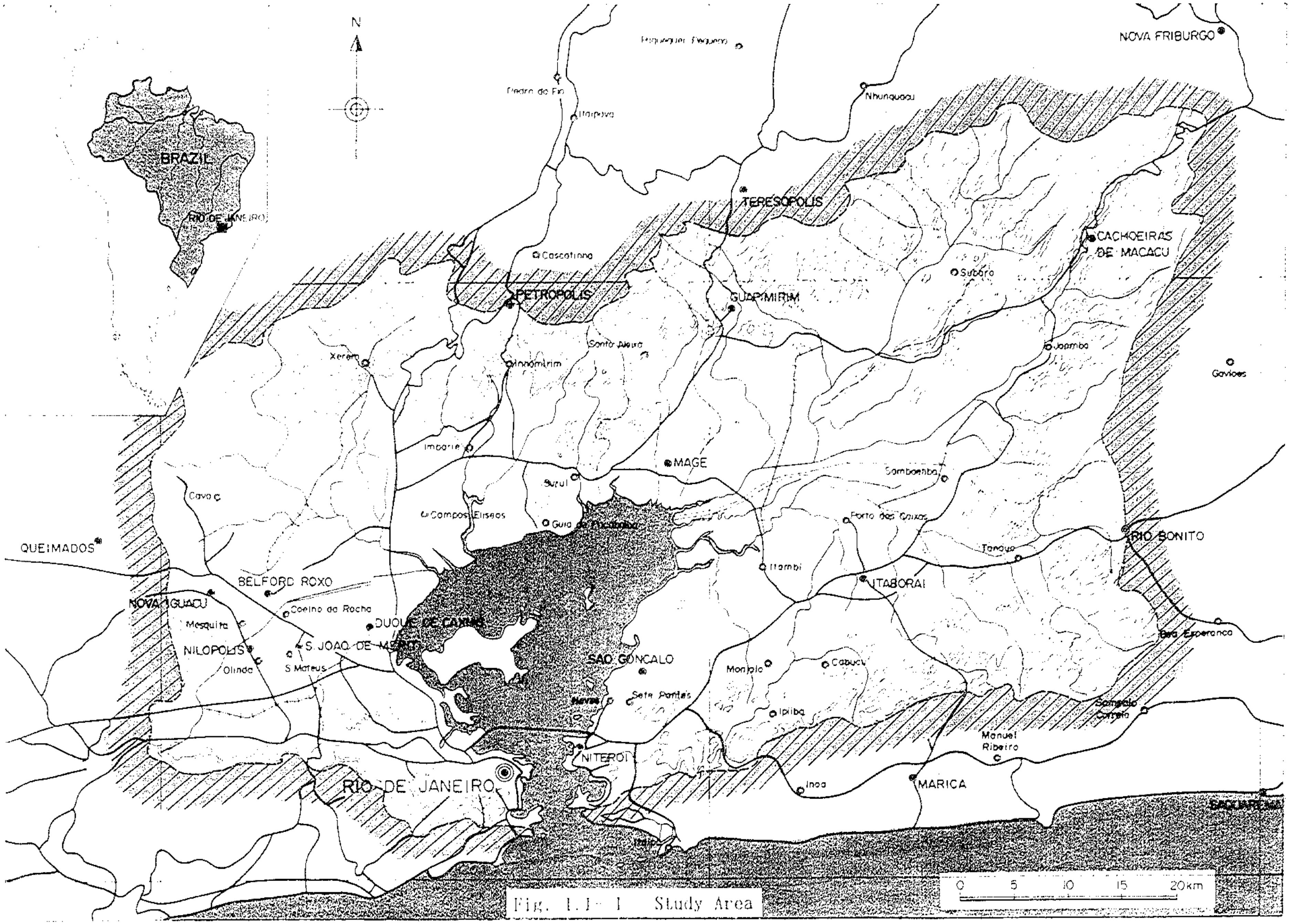

Fig. I.1-1 Study Area

Table 1.2-1 List of the Implemmentation Planning Committee Members

NAME	POST / INSTITUTION
Manuel Sanches (until Aptil, 1993)	President of GEDEG (Chairman),(SEMAMPE)
Roberto D'Avila (May to August, 1993)	President of GEDEG (Chairman),(SEMAMPE)
Geraldo Lessa (from September, 1993)	President of CODEG (Chairman),(SEMAMPE)
Rosangela Costa	Director of Administration (IEF)
Dora Negreiros	Special Assistant (FEEMA)
Amarilio P. de Souza	Sanitary Engineer (FEEMA)
Carolina Dubex	Sociologist (SECPLAN)
Helder G. Pinho da Costa	Engineer (FEEMA)
Leila Heizer Santos	Engineer (FEEMA)
Katia Leite Mansur	Geologist (DRM)
Marcia Marques Gomes	Biologist (UERJ)
Monica Cardoso Ferraz	Architect (SECPLAN)
Victor M. Barbosa Coelho	Engineer (FEEMA)
Mihai Constantin Cauli	Architect (SECPLAN)
Ronaldo F. de Oliveira	Biologist (FEEMA)

Table 1.2-2 List of the Steering Committee Members

NAME	POST
(SEMAMPE/GEDEG/CODEG))	
Manuel Sanches (until April, 1993)	President of GEDEG (Chairman)
Roberto D'Avila (May to August, 1993)	President of GEDEG (Chairman)
Geraldo Lessa (from September, 1993)	President of CODEG (Chairman)
Helder G. Pinho da Costa	Advisor
Victor M. Barbosa Coelho	Engineer
Amarilio Pereira de Souza	Consulting Engineer
(FEEMA)	
Adir Ben Kauss	President
Eduardo R. Ferreira Neto	Director
Victoria Braile	President's Assistant
(SERLA)	
Carlos Carbonel	
(DEFESA CIVIL)	
Paulo G. dos Santos Filho	
(IEF)	
Axel Schimidt Grael	President
(CEDAE)	
Mauricio Abramant Guerbatin	President's Assistant
(GERSOL)	
Altamirando de Morais	
(COMLURB)	
Sergio Augusto da C. Lobato	President's Assistant
(INPH)	
Alberto Homsi	
(DHN)	
Ana Claudia de Paula	
(CAPITANIA dos Portos)	
Luiz Gonzaga da Silva	

1.2.2 Supervising Committee

JICA organized a Supervising Committee headed by Dr. Senro Imai to supervise the study. The committee consists of six environmental experts belonging to national and local governmental agencies in Japan, as shown in **Table 1.2-3.**

Table 1.2-3 List of the Supervising Commitee Members

Name	Post / Institution
Senro Imai	Institute for International Cooperation, JICA
Kiyoshi Hasegawa	Public Works Research Institute Ministry of Construction
Toshio Okazumi	Kanto Regional Bureau Ministry of Construction
Yasushi Hosokawa	Port and Harbour Research Institute Ministry of Transportation
Michitaka Nakao	Environment Bureau Kobe Municipal Government
Tetsuo Hayakawa (until June,1993)	Water Quality Bureau, Environment Agency
Susumu Ohta (from July,1993)	Water Quality Bureau, Environment Agency

1.2.3 JICA Study Team

The JICA Study Team headed by Dr. Akira Sugiyama consists of twelve experts shown in **Table 1.2-4**; ten are from Kokusai Kogyo Co., Ltd. and two are Brazilian engineers.

Table 1.2-4 List of the JICA Study Team Members

Name	Charge
Akira Sugiyama	Team Leader
Takeyasu Kikuta	Water Quality Conservation Plan
Fumio Yanata	Hydrology, Hidraulics and Meteorology
Akiko Mukade	Water and Sediment Quality Analysis (1)
Takehiko Nakane	Water and Sediment Quality Analysis (2)
Eiichi Hayakawa	Land Use
Hideo Kawai	Ecosystem
Masaru Obara	Regional Development and Socio-Economy
Constantino A. Pessoa	Water Pollution and Source Analysis
Masahiro Tajima	Pollution Runoff Mechanism
Kyoji Ishita	Pollution Mechanism in the Bay
Masaharu Kina	Coordinator

1.2.4 Brazilian Counterpart Personnel (Technical Sub-Committee)

The Brazilian counterpart personnel, the Technical Sub-Committee, consists of the twenty-three experts shown in **Table 1.2-5**. Most of them are from FEEMA.

Table 1.2-5 List of the Brazilian Counterparts

Name	Charge
(FEEMA)	
Adir Ben Kauss	Chairman of Technical Sub-Committee
Rene Justen	Coordinator (until August, 1992)
Eduardo Rodrigues Ferreira Neto	Coordinator (from Sept., 1992)
Elizabeth Cristina da Rocha Lima	Water Quality Conservation Plan
Kikue Higashi	Water and Sediment Quality Analysis Ecosystem
Anselmo Frederico Neto	Hydrology and Hydraulics
Ilma Conde Perez	Pollution Source
Tania Muniz	Land Use and Socio-Economy
Maria Regina Fonseca	Pollution Mechanism
Marcio Henrique Krause de Almeida	Pollution Runoff Mechanism
Walter Yoshihiko Aibe	Hydrodynamic Model
Sergio Sahlit	Pollution Source
Elza Aparecida Baezzo Moreira	Laws and Regulations
(INPH)	
Berenice Mota Vargas	Hydrodynamic Model
Theo Agostinho Masson	Current Measurement
Paulo Cesar Maiorano	Current Measurement
Marcos Dourado	Current Measurement
Luis Carlos Pucci	Current Measurement
(COPPE/UFRJ)	
Renato Parkinson Martins	Hydrodynamic Model
Isabel Marcia Gonsalves do N. Gurguel	
Lucia Vercosa Carvalheira	
(IEF)	
Axel Schmidt Grael	Land Use
(SERLA)	
Weber Figueiredo da Silva	River Survey

1.3 Cooperators

The study area extends widely over land, rivers and sea covering various study items. Moreover, many samples were taken from the sea and the rivers for water quality analysis. Therefore, the study was performed with the cooperation of a great number of people not only from the counterpart organization FEEMA but also from various organizations within the State of Rio de Janeiro, Federal Government and the UFRJ and UERJ universities etc.. We greatly appreciate the cooperation extended to us, during the data collection stage, by these organizations. We also express our gratitude to the following people who cooperated with us mainly through field surveys, data collection, sample analyses and discussions.

Table 1.3-1 List of Cooperators

Institution	Name
FEEMA (DILAB)	Ailton Martins Noronha Antonio Miranda de Mendonca Antonio Jose Bianchi Nunes Aristides Pereira Gomes Ariston Pereira de Jesus Aurelio Simoes Pinto Celia Regina de Almeida Ramos Freitas Celio Rozendo Dorothy Lopes da Silva David Goncalves Rua Debora Nunes de Lima Dilson Correa Lima Edesio Antunes Cardoso Edson Cardoso Alves Elcio Cardoso Elcio Claudio Diniz Euclydes Severo Filho Fernando Batalha Alvares Gisela Lima Gisela Alves Gomara Glaucia Freitas Sampaio Pinto Helena Beatriz de Azevedo Maia Hugo Fortini Israel de Oliveira Pinto

(Continued)

Institution	Name
FEEMA (DILAB)	Joao Alberto Machado Jorge Losmino dos Santos Jorge Ney Carvalho de Almeida Jorge Rodrigues Penna Jorgina Celia Tiburcio dos Santos Jose Florentino Fernandes Jose Joao de Mendonca Jose Roberto Souza Araujo Josue de Mattos Julio Coelho de Almeida Leolpoldo Dias da Cruz Luiz Carlos Sant'anna Queiroz
FEEMA (DECON)	Neise Ribeiro Vieira Carvalho Carlito Veira Joao Branco
FEEMA (Assessoria de Computacao)	Luiz Carlos
FEEMA (DILAB)	Marcia de Souza Drolshagen Maria Celia Lima Maria da Gloria Lima Cabral Maria Dalva de Souza Oliveira Maria Helena Santos de Souza Leao Marilza Farias Maia Marly de Oliveira Milton Muniz Santos Nancy Gageiro Orlando do Nascimento Pedro Chianello Ricardo Celso Alves da Silva Rosalvo Moraes de Oliveira Ruben Tavares Bastos Sebastiana Bezerra Figueiredo Sergio Maghelli Solemar Terra Quintanilha Thea Maria Martins Urbano Francisco Dutra Filho Valmir Verissimo da Silva Vera Lucia da Silva Cardoso Zeneide Batista
FEEMA(Trainee)	Ana Paula Botelho Cristiana Guedes de Abreu Daniele Boun de Farias Gisele Soares Chagas Ingrid Lourenco Lima Neuza Maria Paula Muniz Odimar Artur Rodrigues Britto
FEEMA(DIVEA-2)	Norma Crud Maciel
FEEMA (DIAG)	

(Continued)

Institution	Name
FEEMA(Botafogo)	Joao Ferreira de Sousa Nelson Mayerie Villela
DHN	Alvarenga Carlos M. P. Hansen
INPH	Antonio Paulo dos Santos Pinto Luiz Antonio Braga Martins Luiz Geraldo Dias Ferreira Junior Wagner Santos Scisinio Dias
FEEMA (Nucleo de Residuos)	Jorge Luiz Vasconcelos Pinto
DEFESA CIVIL	Nilton de Barros Junior
CAPITANIA DOS PORTOS	Gileno Macedo Franca
UFRJ	Elmo da Silva Amador Leticia Paulo Cesar Rosman Segio Bonecker
UERJ	David Man Wai Zee Isabel Marcia Gonsales do N. Gurguel Lucia Vercosa Carvalheira
USP	Yara Schaefel Navelli Tomonaga Iwai
IEF	Luiz Carlos Servullo de Aquino
METEOROLOGIA E CLIMATOLOGIA	Armando de Sa Tavares Luiz Carlos Austin Adelia Tapiassu
PETROBRAS	Elzio Luz Leal Ronaldo Torres
CONSULTANT	Waldemar Londres Vergara Filho
CEDAE (Estacao Penha)	Luiz Carlos Esteves Carlos Henrique
CEDAE	Nilo Shinzato Eduardo Pachelo Jordao Luiz Edmundo Cascad Silus Samuel Fuks Joao Eduardo Osorio R.
STE	Pedro Piulo Ernani de Souza Costa
COMLURB	Jose Henrique Penido
National Museum	Iva Nilce da Silva Brum

1.4 Study Schedule

The study is divided broadly into three phases. Phase 1, started in March 1992 and was completed in September 1992. Phase 2, went from October 1992 until February 1993 and Phase 3 went from March 1993 until January 1994.

During the study period the Inception Report, the Progress Report (1), the Progress Report (2), the Interim Report (1), the Progress Report (3), the Interim Report (2) and the Draft Final Report were prepared and discussions were held on the plans and results of each report, between the study team and the Brazilian counterparts, in the middle of March, at the beginning of October, at the end of December 1992; in the middle of March, in the middle of September 1993; and in the middle of January 1994 respectively.

Through the study, technical transfer to Brazilian counterparts on data acquisition and analyses in various fields related to water conservation was accomplished.

1.5 Study Contents

The procedures of the Master Plan for the Recuperation of the Guanabara Bay Ecosystem and the studies performed are summarized as shown in **Fig. 1.5-1** and **Table 1.5-1** to **Table 1.5-3**, and are composed of three major parts:

A. Understanding of Pollution Mechanism
   (1) Generation and discharge mechanisms in the basin
   (2) Runoff mechanism of the rivers and the sewerage network
   (3) Circulation and sedimentation mechanism in the bay

B. Understanding of Socioeconomic Conditions Related to Pollution
   (1) Socioeconomic indicators for pollution source evaluation
   (2) Development plan
   (3) Legal system and administrative organization
   (4) Resident awareness and education
   (5) Socioeconomic indicators for environmental resource evaluation

C. Examination of Water Quality Improvement Measures

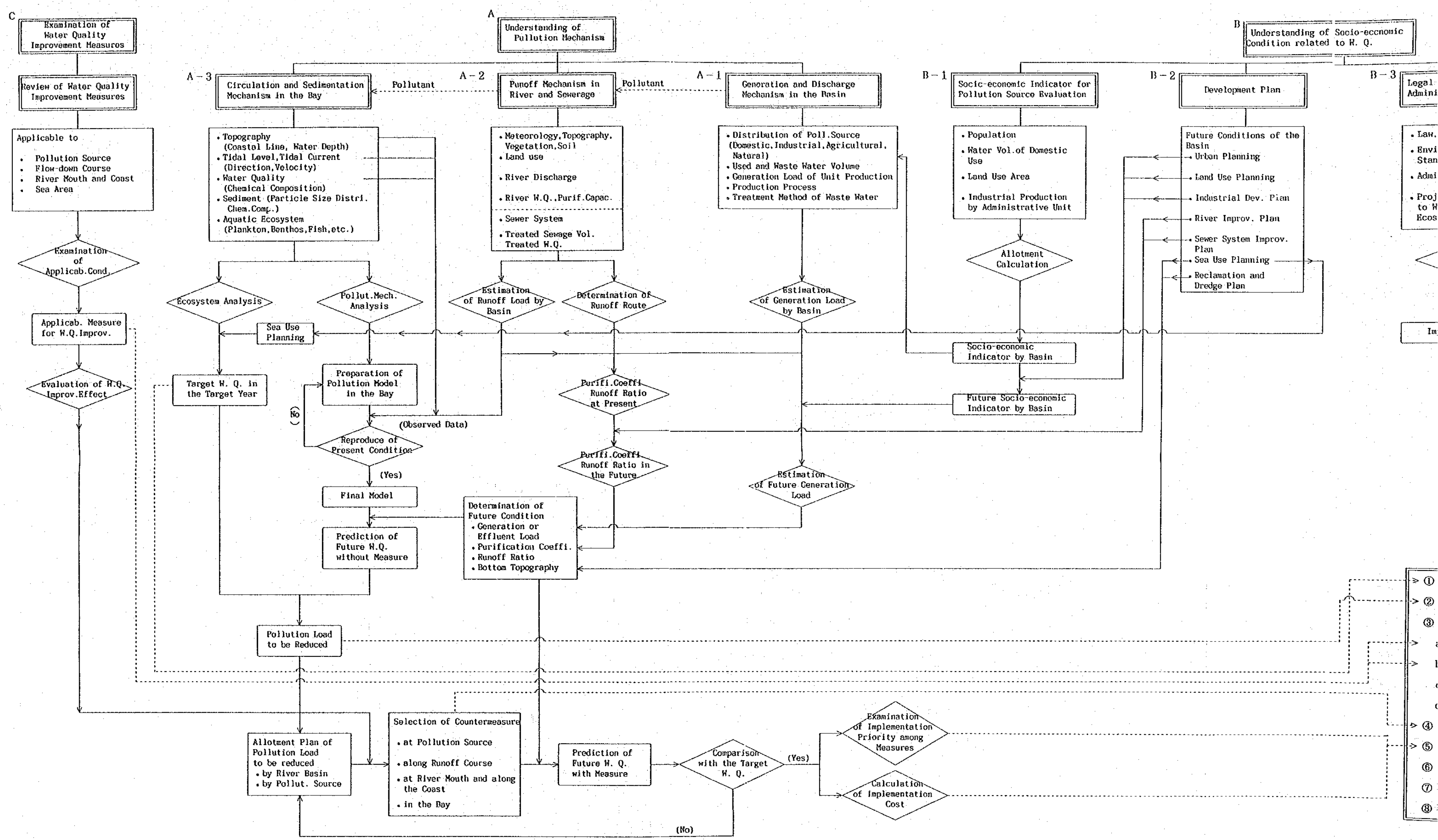

Fig. 1.5-1 Procedures of the Master Plan

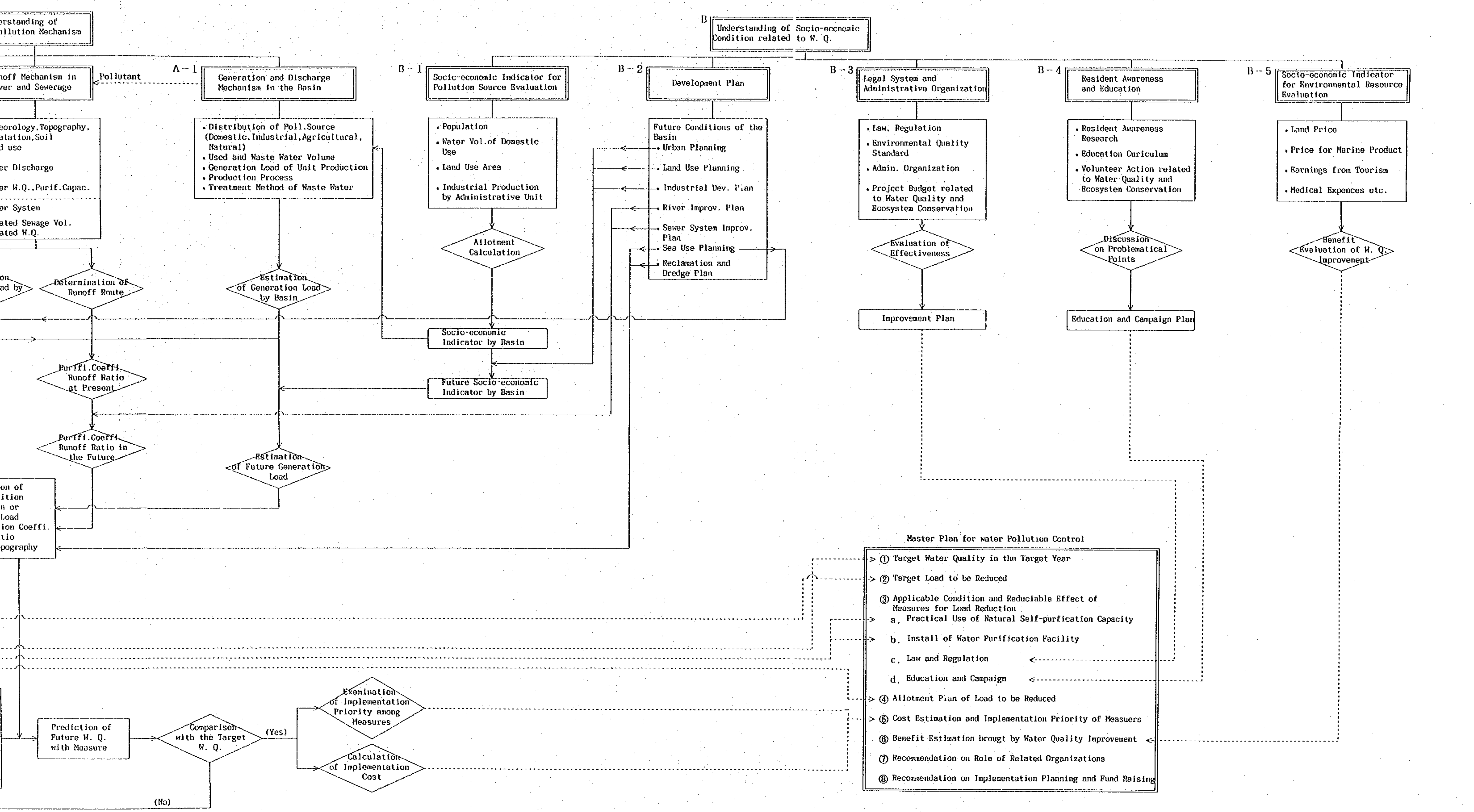

Fig. 1.5-1　Procedures of the Master Plan

Table 1.5-1 Study Contents (Phase I)

Item / Content	Content / Amount
1. Socioeconomic Conditions	Data collection and analysis for socioeconomic conditions.
2. Basin Division and Land use	Data collection, field reconnaisance and data analysis using LANDSAT images.
3. Estimation of Generation and Effluent Load	Data collection and analysis for pollution sources, sewer system and sewage treatment plant.
4. Runoff Mechanism and Runoff Load in Rivers and Sewerage	Data collection and analysis for river system, discharge, water quality and runoff load.
(River Survey)	Field survey for cross leveling, discharge and water quality of 25 rivers.
5. Load Circulation and Sedimentation Mechanisms in the Bay	Data collection and analysis for topography, tides, tidal currents, sea-bottom materials, water quality and aquatic ecosystem.
	Field survey for
(Sedimentation)	. bottom materials : 15 points . core sampling : 02 points
(Water Quality)	. preliminary survey : 47 points . simultaneous survey : 18 points
(Aquatic Ecosystem)	. plankton : 18 points . salt marsh/mangrove : 10 points . fouling lives : 08 points . benthos : 17 points
(Tidal Current observation)	. 25 hours observation : 05 points
6. Pollution Simulation of the Bay	Data Collection, analysis and preliminary modeling
7. Present System/Standard for Water Quality Conservation	Data collection and analysis

Table 1.5-2 Study Contents (Phase II)

Item / Content	Content / Amount
1. Socioeconomic Conditions	Data collection and analysis for socioeconomic conditions.
2. Basin Division and Land use of the Basin	Data collection and analysis for basin division, and land use analysis.
3. Estimation of Generation and Effluent Load	Data collection and analysis for pollution sources, raw sanitary sewage, solid waste and sewer/sewage treatment plant system.
4. Runoff Mechanism and Runoff Load in Rivers and Sewerage	Data collection and analysis for river system, discharge, water quality and runoff load.
(River Survey)	Field survey for . discharge and water quality on normal day. . hourly change of discharge and water quality. . discharge and water quality change along river course. . discharge and water quality on freshet time. . water quality of rainfall.
5. Load Circulation and Sedimentation Mechanism in the day	Data Collection and analysis for topography, tides, tidal currents, sea-bottom materials, water quality and aquatic ecosystem. Field survey for
(Sedimentation)	. core sampling : 04 points . elution oxygen consumption test : 03 samples
(Water Quality)	. preliminary survey : 34 points . simultaneous survey : 19 points . primary productivity : 06 points
(Aquatic Ecosystem)	. phytoplankton : 18 points . zooplankton : 12 points . salt marsh/mangrove : 12 points . fouling lives : 05 points . benthos : 17 points
(Tide Observation)	. Paqueta island : 01 month
(Tide Current Observation)	. 15 nights and days : 03 points . 25 hours observation : 06 points
6. Pollution Simulation of the Bay	Technical transfer to counterparts for simulation model. Modelling of hydrodynamic and diffusion model
7. Present System/Standard for Water Quality Conservation	Data collection and analysis for regulation, water quality standards, administrative organization and resident awareness
8. Water Quality Improvement Measures	Review of water quality improvement measures

Table 1.5-3 Study Contents (Phase III)

Item / Content	Content / Amount
1. Socioeconomic Conditions	Data collection and analysis for socioeconomic conditions.
2. Estimation of Generation and Effluent Load	Data collection and analysis for point pollution sources, including monitoring of industrial waste water.
3. Runoff Mechanism and Runoff Load in Rivers	Field survey for discharge and water quality of periodical survey, hourly change survey for 24 hours and detail survey in principal rivers (along river course).
4. Load Circulation and Sedimentation Mechanism in the day	Field Survey for water quality at 08 points, release test, settling test and primary productivity test on site, and tidal current observation at 2 points (3 days and nights).
5. Pollution Mechanisms in the Bay (Numerical simulation)	Technical transfer of hydrodynamic model and diffusion model.
6. Social System for Water Quality Conservation	Hearing present situations and issues of social systems for water quality conservation.
7. Counter-measures for Water Quality Improvement	Hearing effective counter-measures applicable to recuperation of the Guanabara bay ecosystem.
8. Master Plan for Water Quality Improvement	An overall study for the master plan on recuperation of the Guanabara bay ecosystem.

PART II

NATURAL AND SOCIOECONOMIC CONDITIONS IN THE GUANABARA BAY BASIN

CHAPTER 2

NATURAL CONDITIONS

CHAPTER 2

NATURAL CONDITIONS

Pollutants flows out from their sources to rivers accompanying with rain water and artificial sewage. Then after a certain time, they reach the bay.

The runoff ratio and runoff speed of the pollutants are controlled by the basin topography, rainfall pattern, geology, etc., and the volume and quality of pollutants from non-point sources are controlled by vegetation and land use conditions.

The natural conditions in the basin should also be taken into consideration upon the selection and design of the water quality improvement facilities.

From this viewpoint, the natural conditions in the basin deeply related to pollution mechanism and pollution prevention measures are compiled in this chapter.

2.1 Topography and Drainage System

The topographical features and the drainage system of the Guanabara Bay Basin are set out on topographical maps at a scale of 1:50,000. **Fig. 2.1-1** is a reference for these maps.

Fig. 2.1-2 shows the geomorphologic classification of the Basin. A high mountain range rising to a height of 1,000 to 2,000 m marks the northern limit of the study area and is called Serra do Mar. Along the southern boundary there is a low mountain range rising to a height of 500 to 1,000 m, running parallel to the coast. The rocky mountains that constrict the mouth of Guanabara Bay are a part of this low mountain range.

The major part of the Guanabara Bay Basin bounded by the above mentioned mountain ranges is covered with hills and plains. Consequently, the eastern and western edge of the Basin are not always obvious.

Major plains cover the areas adjacent to the northeast and northwest corners of Guanabara Bay. A large part of the estuary delta is covered by swamp. The swamp near the river mouth of the Rio Guapimirim is widely covered with a mangrove forest.

About forty-five (45) rivers flow into Guanabara Bay from the catchment area. The Rio Guapimirim, the Rio Cacerebu and the Rio Iguacu have relatively large catchment areas. The former two flow into the Bay from the east forming a complex mesh-like route as they meander toward the swampy area where it disperses its abundant flow into several river mouths. Where the Rio Iguacu flows in from the west. The rivers that pass through the municipality of Rio de Janeiro and the adjacent area have steep grades and often cause inundation because the urban area that occupies a large part of their catchment area increases the runoff ratio of rainfall (see **Fig. 2.1-3**).

The Guanabara Bay Basin was divided into twenty-four (24) sub-basins according to the observation network for river discharge and water quality prepared in this study (see Chapter 9). **Fig. 2.1-4** shows these sub-basins.

	MI-2715/3 MIGUEL PEREIRA	MI-2715/4 ITAIPAVA (1966)	MI-2716/3 TERESOPOLIS (1966)	MI-2716/4 NOVA FRIBURGO (1966)
MI-2744/2 PARACAMBI (1963)	MI-2745/1 CAVA (1963)	MI-2745/2 PETROPOLIS (1966)	MI-2746/1 ITABORAI (1969)	MI-2746/2 RIO BONITO (1964/66)
MI-2744/4 MI-2743/2 SANTA CRUZ (1982)	MI-2745/3 MI-2774/1 VILLA MILITAR (1982)	MI-2745/4 MI-2774/2 BAIA DE GUANABARA (1982)	MI-2746/3 MI-2774/A-1 MARICA (1962)	MI-2746/4 SAQUAREMA (1966)

Fig. 2.1-1 Topographical Maps Covering the Study Area

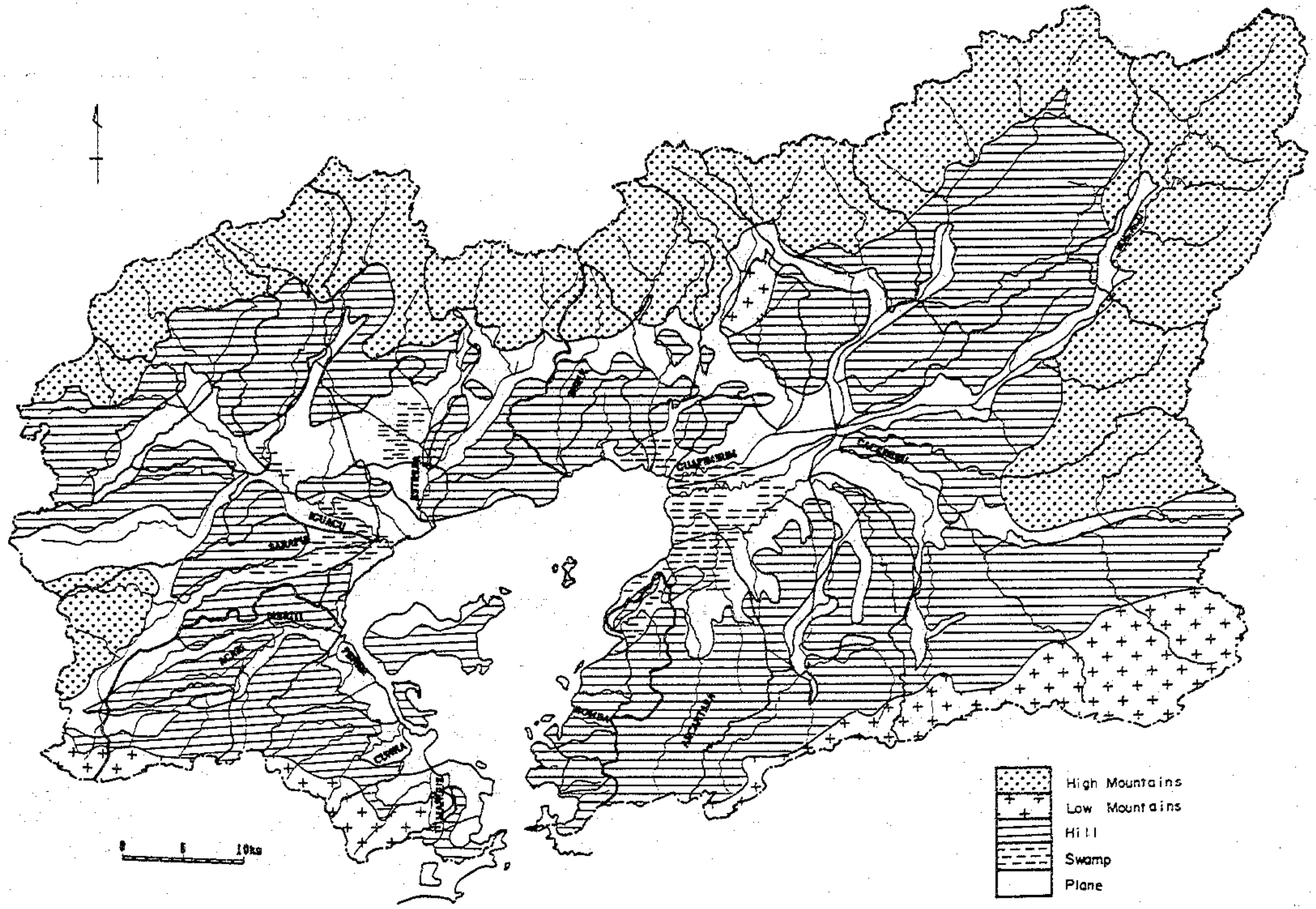

Fig. 2.1- 2 Geomorphlogical Classification of the Guanabara Bay Basin

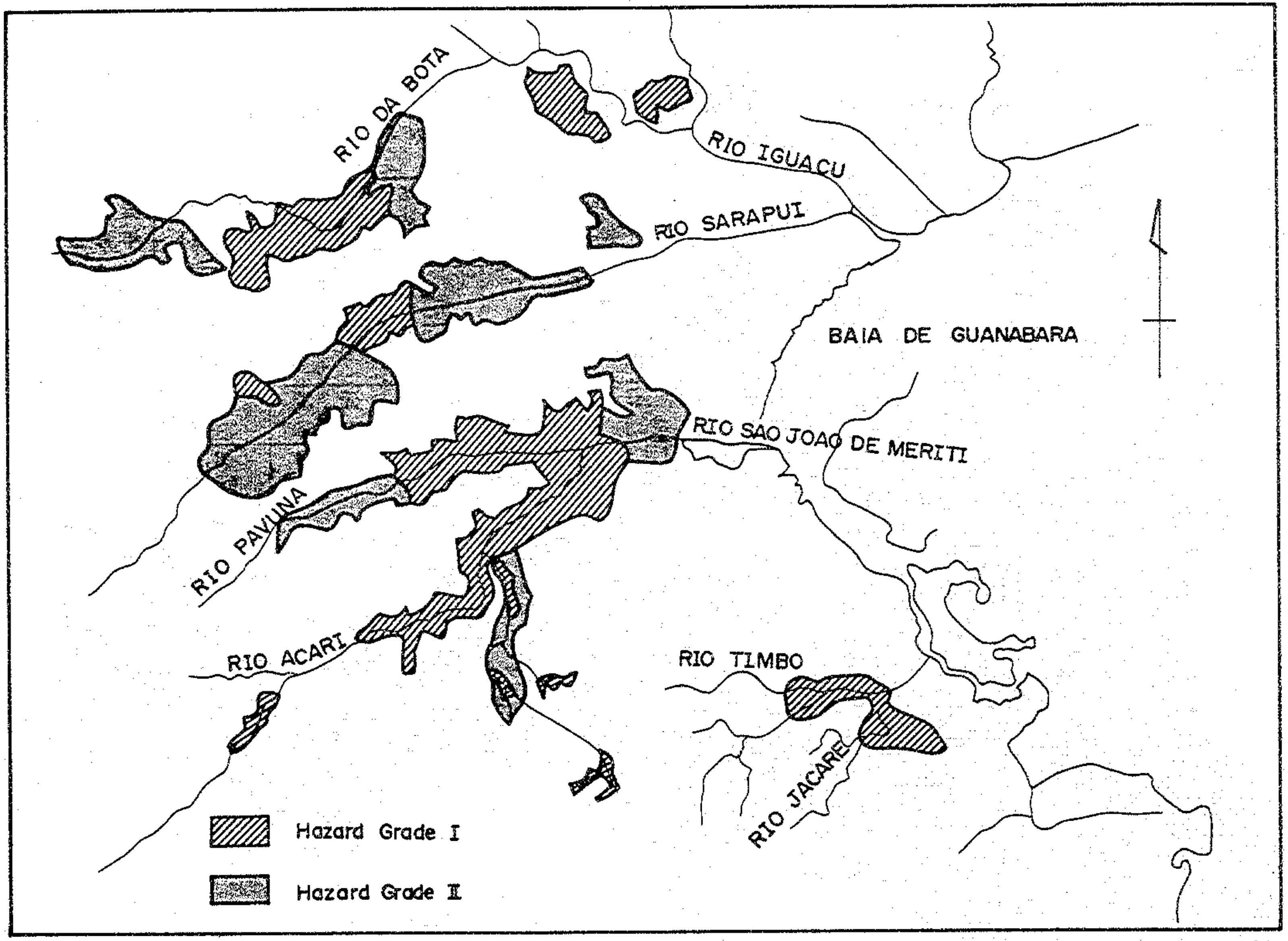

Fig. 2.1- 3 Inudation Areas in Rio de Janeiro Municipality and its Adjacencies

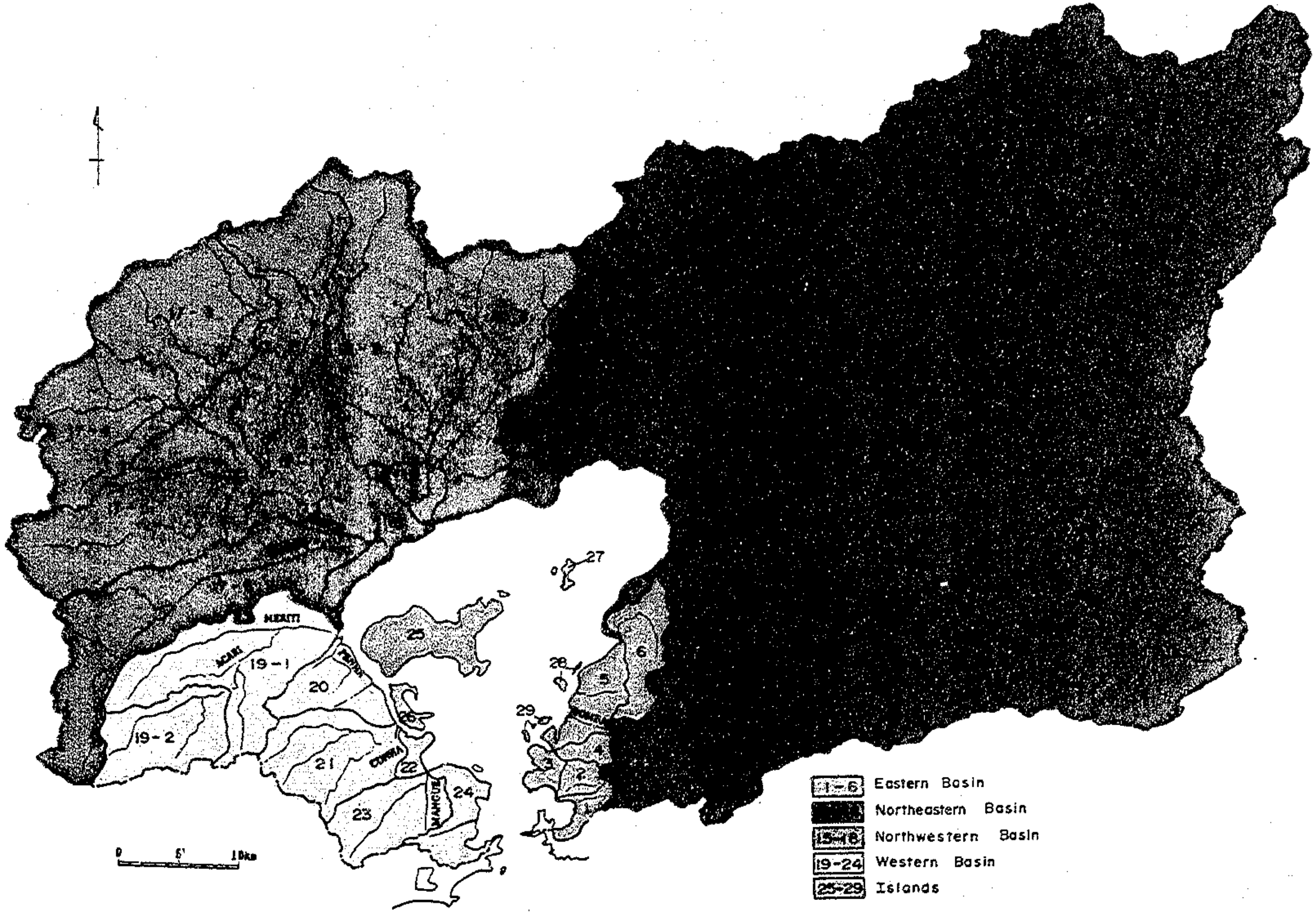

Fig. 2.1- 4 Sub-basins in the Guanabara Bay Basin

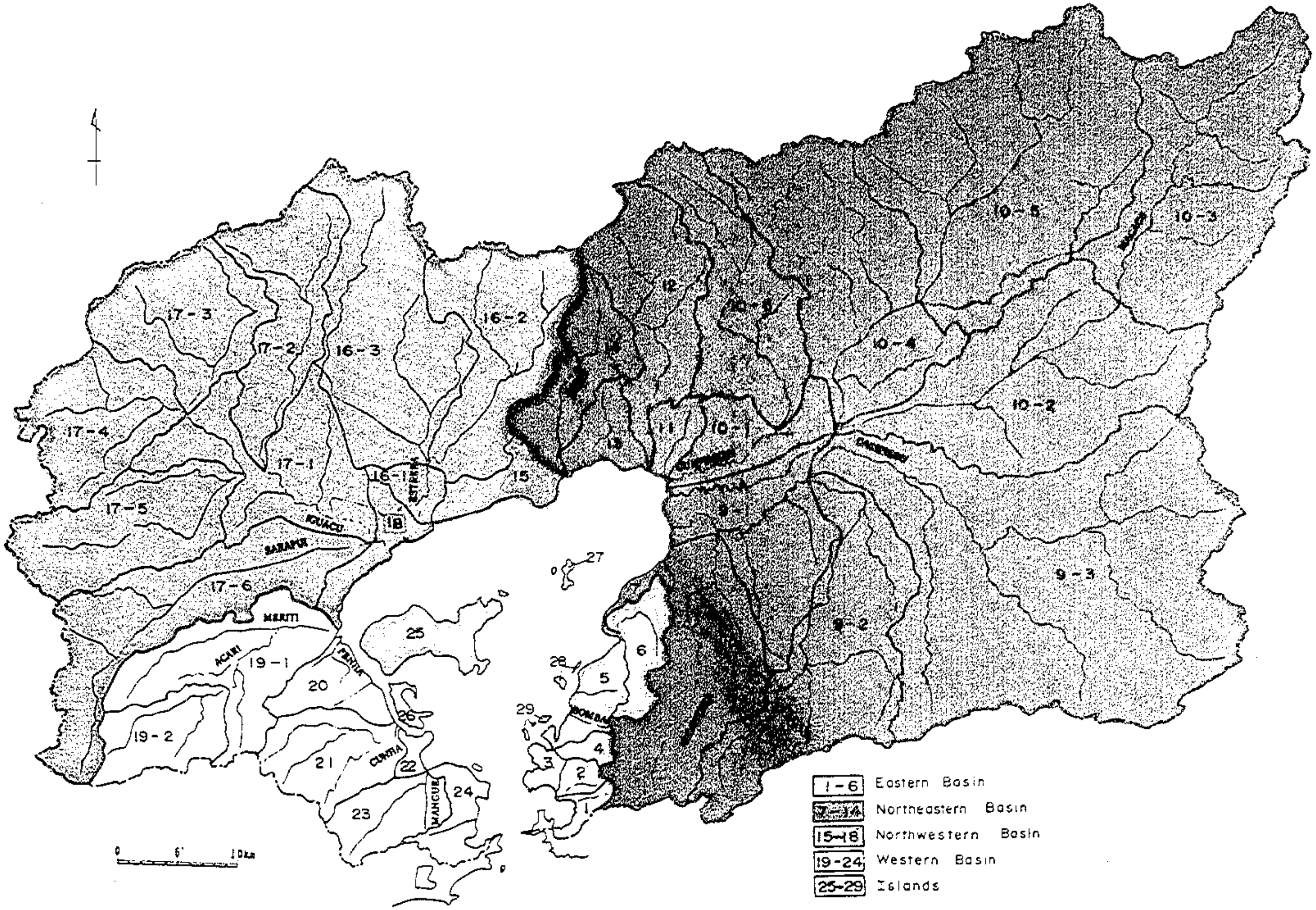

Fig. 2.1- 4 Sub-basins in the Guanabara Bay Basin

2.2 Geology and Soil

Fig. 2.2-1 is a geological map of the Guanabara Bay Basin.

The lower Precambrian basement rocks consisting of various gneisses are widely distributed in the Guanabara Bay Basin and form the mountains and hills.

Surui Granite, a late Precambrian granite, intrudes into early Precambrian gneisses in the northern area adjacent to Guanabara Bay and forms hills with the height of 200 to 300 m. Tertiary alkali rocks also intrude into the Precambrian gneisses around the eastern and western edges of the Basin.

Pleistocene sediments called Macacu Formation are found around the eastern and southern margin of the Guapimirim plain. This formation mainly consists of weak consolidated medium to coarse sand with lenses and thin layers of fine sand.

2.3 Climate

Fig. 2.3-1 shows the monthly average temperature and precipitation in Rio de Janeiro. Theoretically speaking; for sub-tropical areas, the dry and wet seasons are differentiated using a graph where on the vertical axis 30°C (temperature) corresponds with 60mm (precipitation). The period when the temperature curve is above the precipitation curve is regarded as the dry season because evaporation exceeds precipitation.

In case of Rio de Janeiro, only August is in a typical dry season, but precipitation is relatively little from the second half of June until the first half of September.

Fig. 2.3-2 shows the precipitation and temperature distribution in the Guanabara Bay basin. Precipitation in the highlands is about twice as much as that in the lowlands.

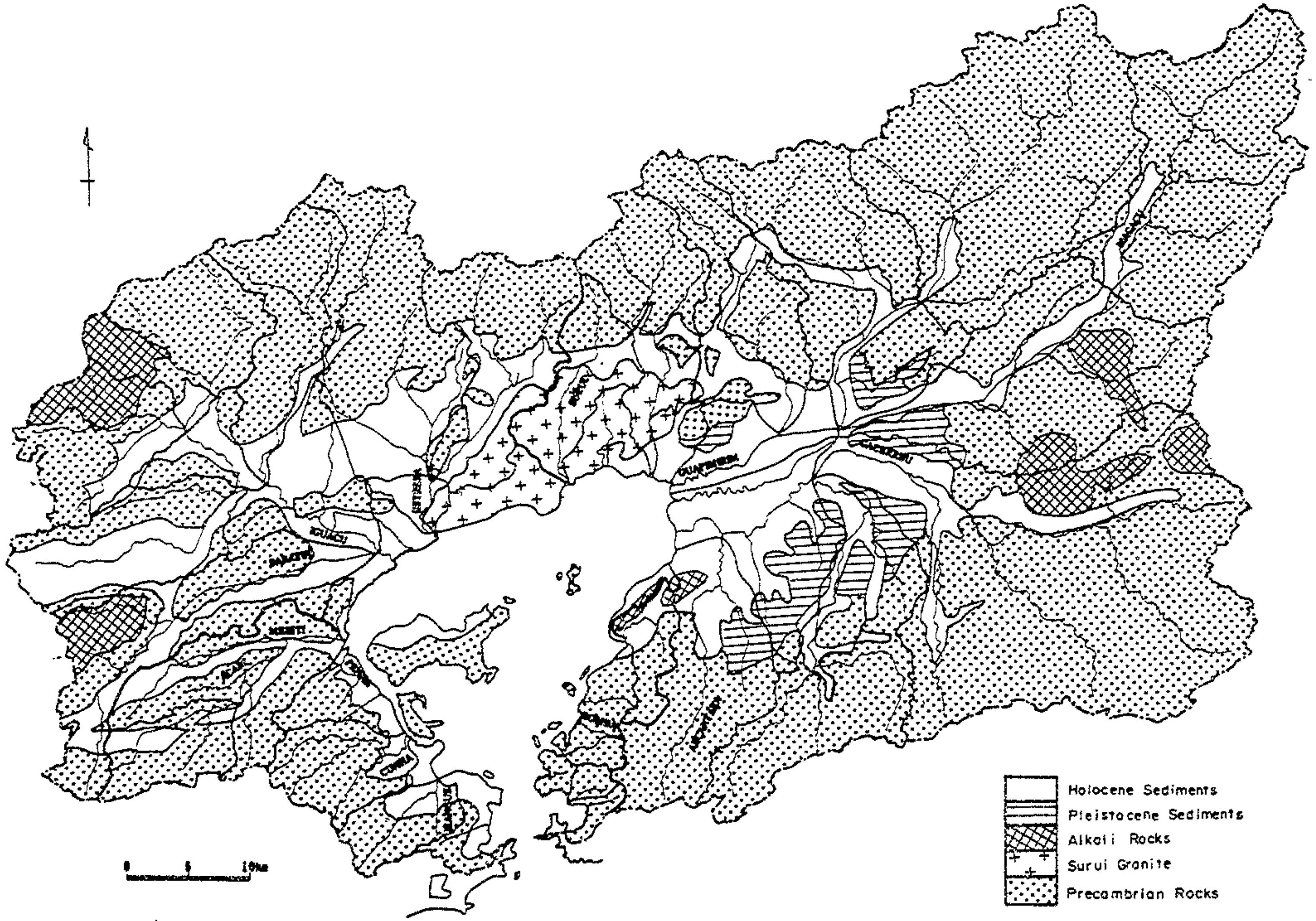

Fig. 2.2- 1 Geology of the Guanabara Bay Basin

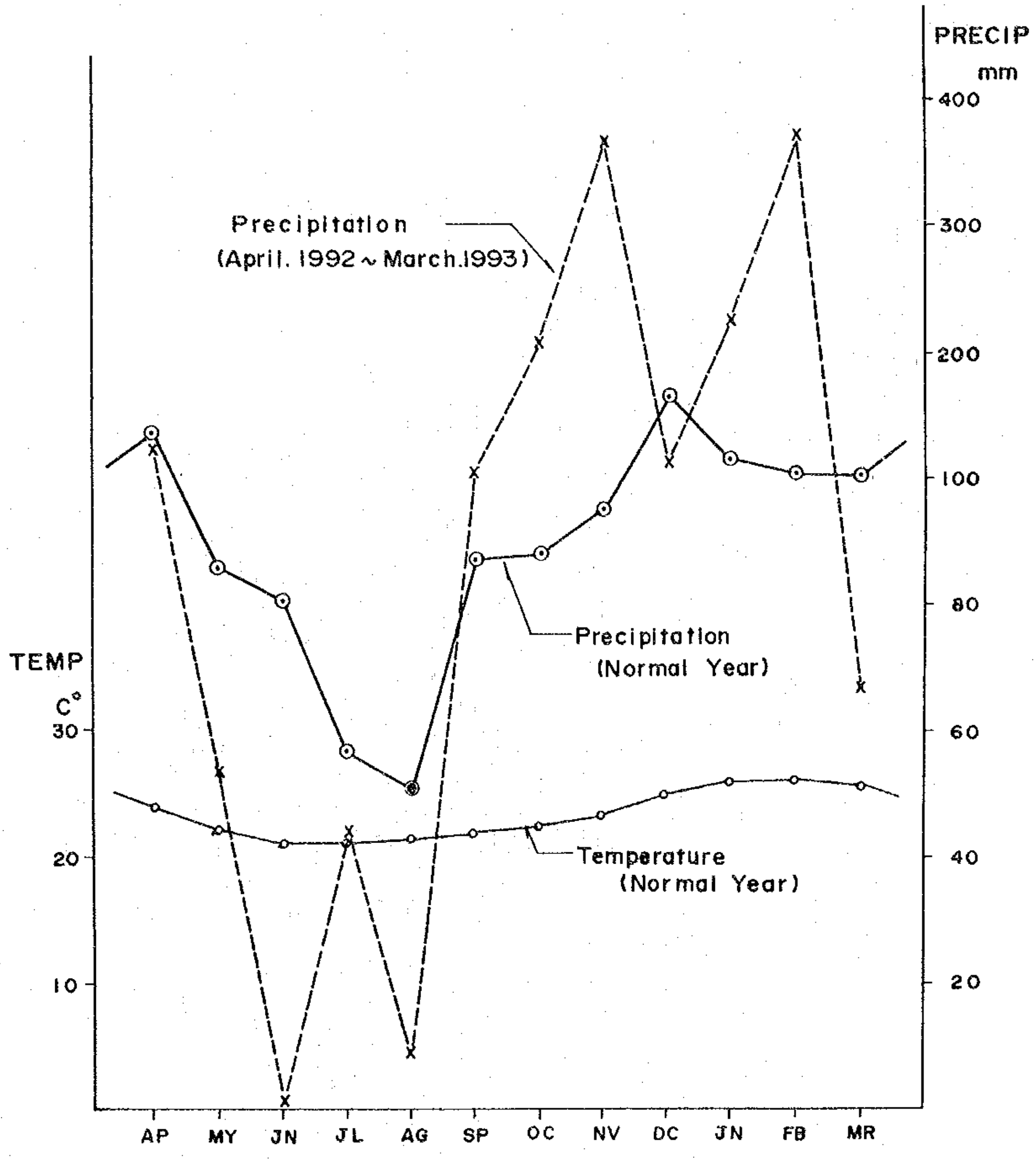

Fig. 2.3- 1 Monthly Average Temperature and Precipitation in Rio de Janeiro

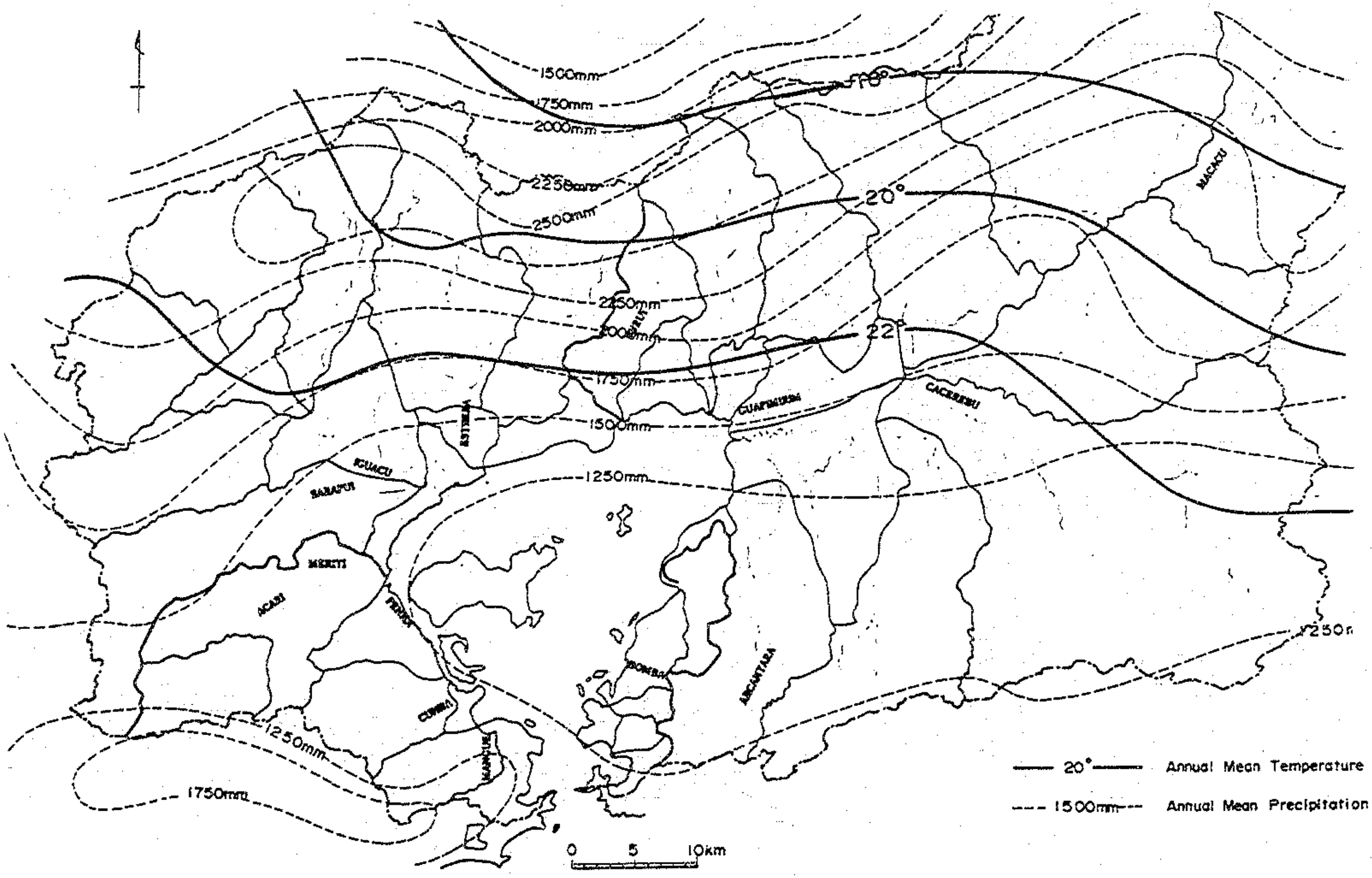

Fig. 2.3- 2 Climatic Condition in the Guanabara Bay Basin

2.4 Vegetation

Fig. 2.4-1 shows the forest area and the environmental protection area around Guanabara Bay. The largest protected area is in the Serra do Orgaos and also takes in part of the Serra do Mar on the northern edge of the basin. Another attractive forest is Tijuca, which is isolated in the megalopolis. These mountain forests are included in the tropical atlantic morphoclimatic zone and are largely designated as an environmental protection area. Though at first glance these look like the primary forests, in fact, they are secondary forests with developed vegetal succession.

Since the forest of Serra do Mar has an annual precipitation of 2,200 mm and a relative humidity of 80 to 90 % constantly through-out the year, the vegetation of the forest is extraordinarily flush and rich in species.

Tijuca's primary forest was destroyed by the cultivation of sugar cane and coffee from the 17th century. Until in 1961 ecological reforestation started, with the resultant natural regeneration of the forest.

Another environmental protection area is around the mouth of Rio Guapimirim where a mangrove forest is found. In recent years, however, the mangrove forest has reduced due to deforestation and land development in the adjacent areas. Though besides the above mentioned forests, very little other forests area is designated as an environmental protection area, generally speaking, the area of forests is rapidly diminishing.

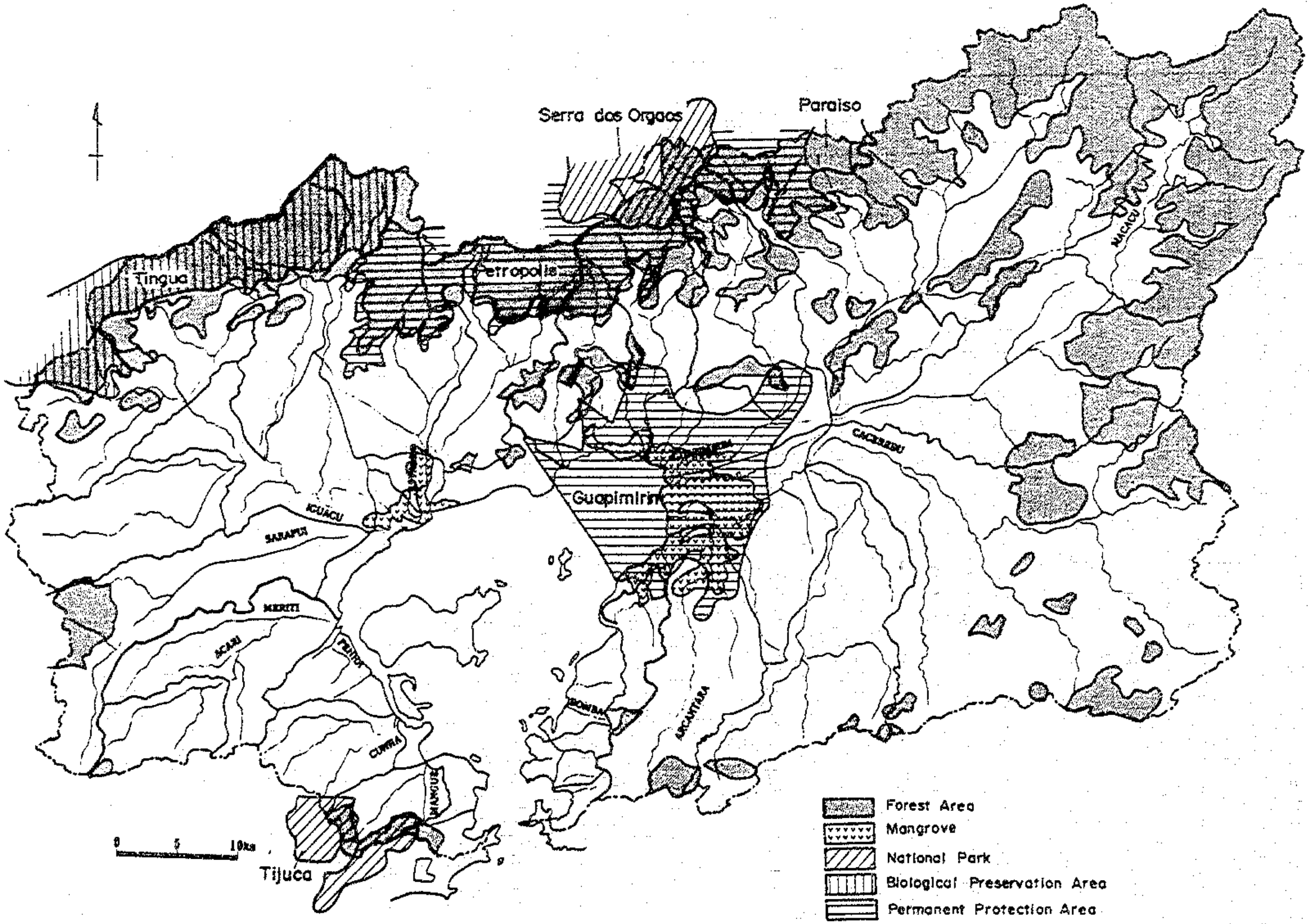

Fig. 2.4- 1 Forest Areas and Environmental Protection Area

2.5 Land Use

The present (Nov. 1991, **Fig. 2.5-1**) and past (May 1984) land use conditions were analyzed from a LANDSAT thematic image acquired from the Instituto Nacional de Pesquisas (INRE).

The land use was classified into the seven (7) categories as follows:

Urban area	:	densely built-up area, industrial area, residential area, new town with surrounding open space, roads, railways, airports, harbor facilities, artificial land
Grassland and farmland	:	grassland, pasture land, farmland, orchard, farmhouses, cattle sheds
Forest	:	tree crowns covering more than 80 % of the area
Mangrove forest	:	mangrove forest area
Bareland	:	rocky surface area, sand beach
Water body	:	rivers, ponds, sea
Swamp	:	

Fig. 2.5-2 shows the land use ratio for each sub-basin in 1991 and **Fig. 2.5-3** shows the change in urban and forest areas between 1984 and 1991.

Conspicuous changes did not occur in this period because most of the major changes in the Bay area were completed in the 1960's. But same minor changes are found such as a small decrease in mangrove forests and the widespread housing developments around Duque de Caxias, San Goncalo and Itaborai.

Vast farmlands were located in the eastern district of the Basin according the 1960 topographical map, however, the 1991 mop shows the distribution to be more sporadic. Cultivation of farmlands and fruit gardens around Itaborai and Rio Boito in 1984, for the most part, had been abandoned or the areas were changed to pasture.

Marshland around the rivers had already decreased in the 1960's due to river improvement works. The shore line still changes marginally due to reclamation and other causes.

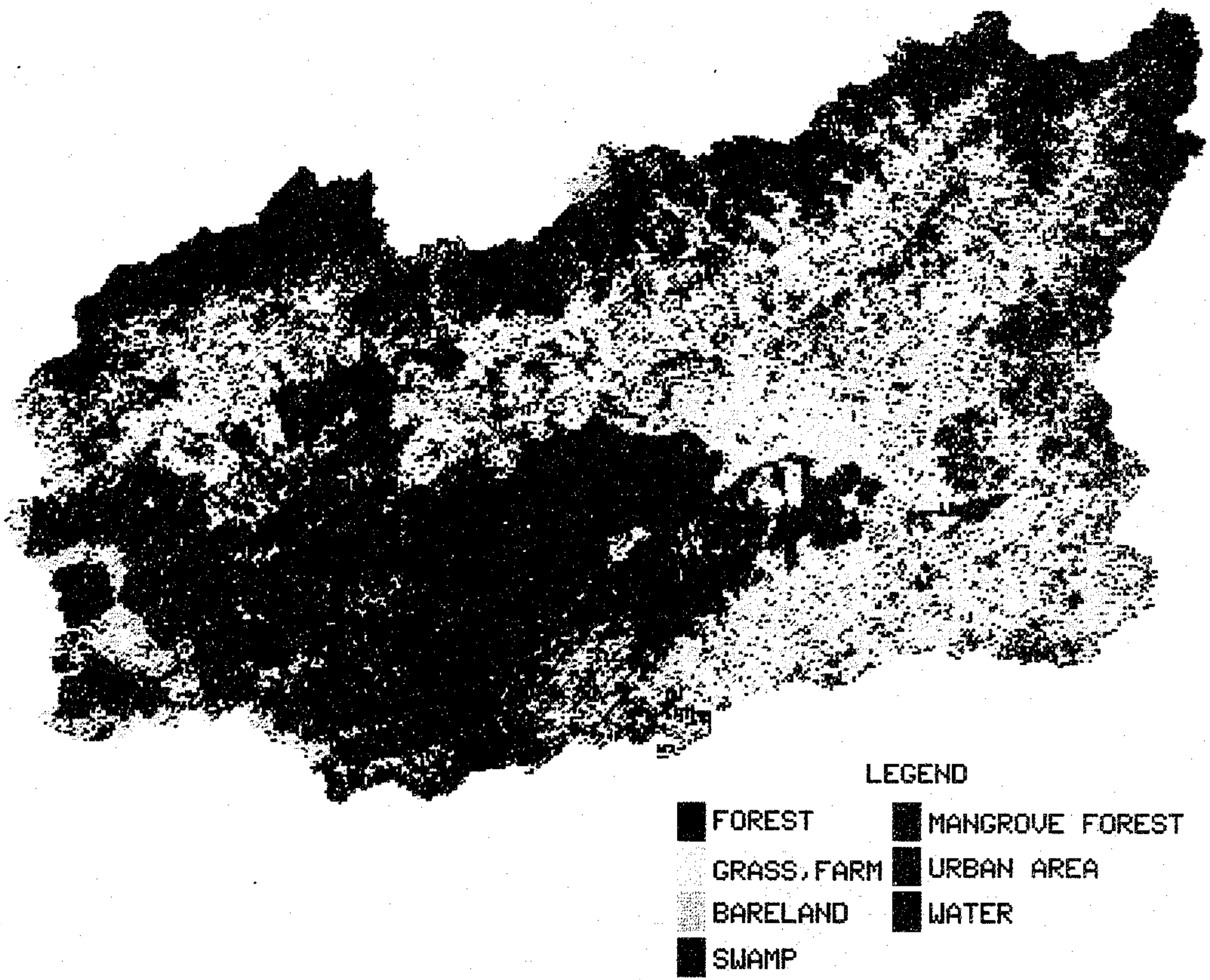

Fig. 2.5- 1　Land Use Condition in 1991 interpreted from the LANDSAT/TM data

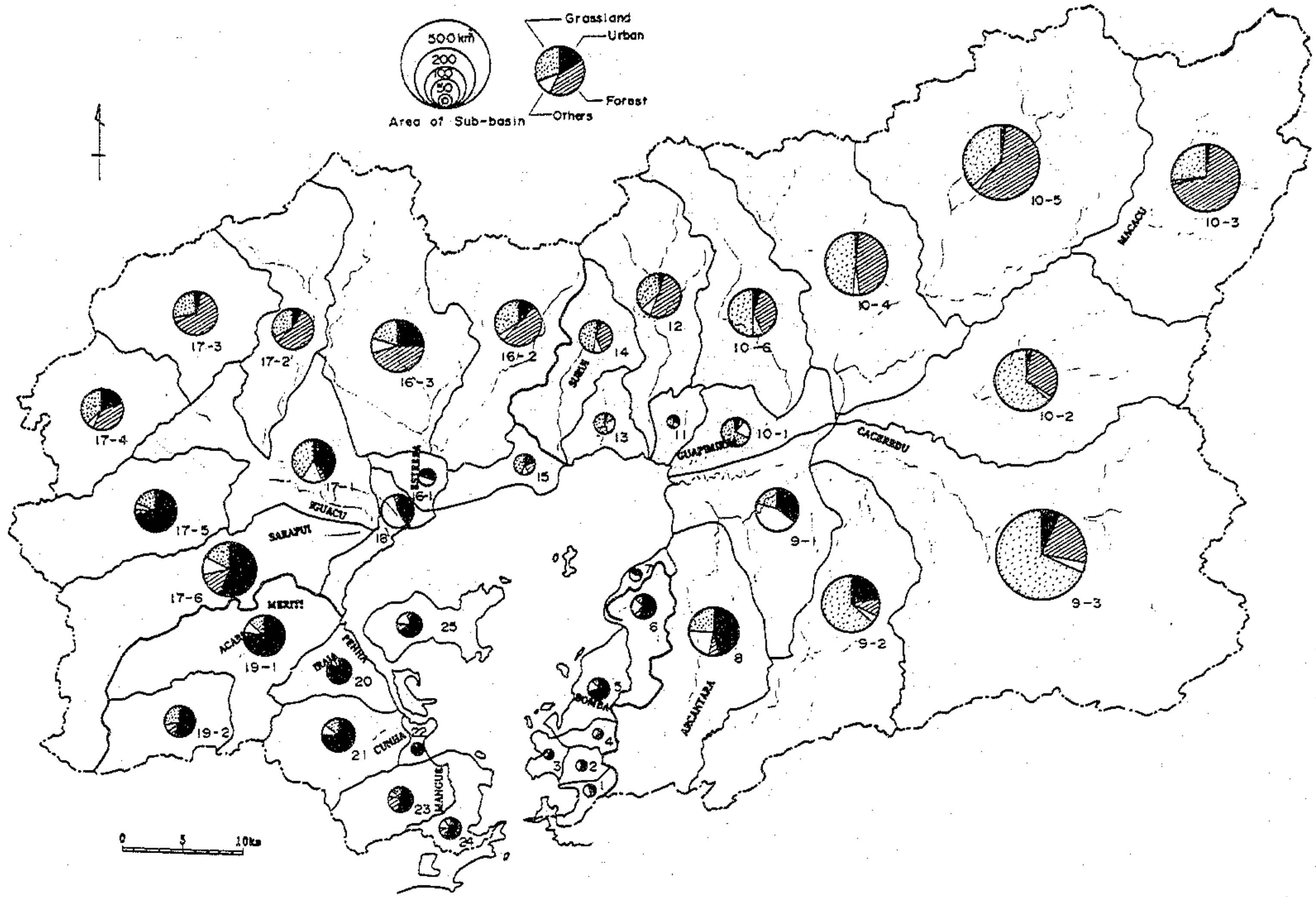

Fig. 2.5- 2   Area Ratio by Land Use Category in Each Sub-basin in 1991

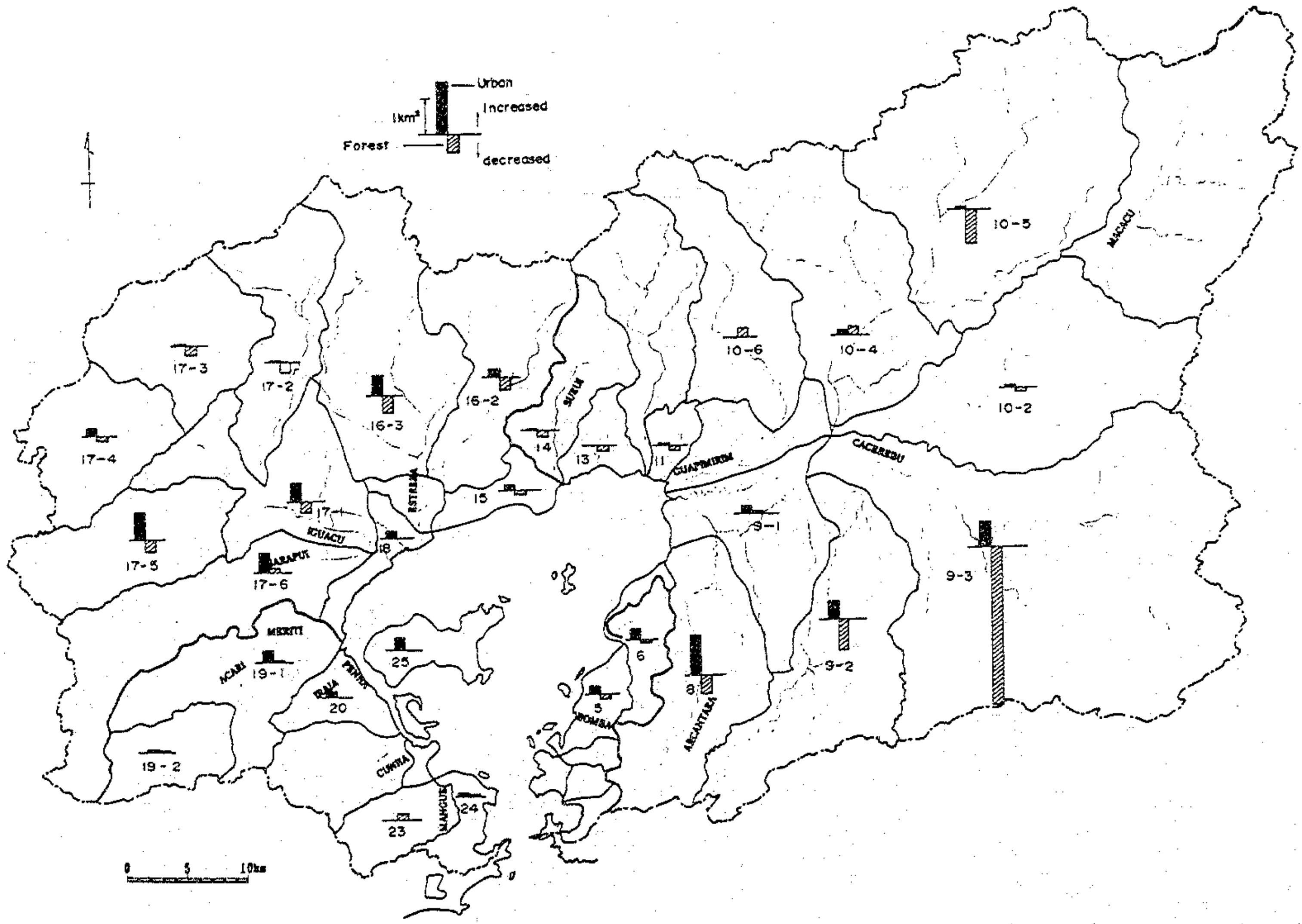

Fig. 2.5- 3 Area Change of Urban and Forest between 1984 and 1991

2.6 Soil Erosion

The field surveys and the interpretation of the LANDSAT image made it clear that no large scale erosion or outflow of soil occurred in recent years. At the ridge of mountains, however, outcrops of hard rock were observed. On the other hand at the foot of mountains and in hilly districts, clayey zones resulting from violent weathering were observed in many places. Therefore, small gully erosions are occurring on the cutting slope of roadways, soil pits for civil engineering and clay mines for pottery in the hilly districts. Also small outflow of earth and sand was observed. Gully erosion on a small scale occurred on some lower mountain slopes and on hillsides. Some outflow of earth and sand was observed on river cliffs consisting of unconsolidated sand and mud with a height of 2 to 3 m.

On account of the absence of data, the outflow volume of the earth and sand at the time of disasters such as landslides and floods is unknown. However, judging from the state of the natural environmental, it is not thought that a large volume of earth has continuously flowed out. For example, mangrove forests around the Rio Guapimirim show that the natural land condition has remained unchanged for a long time. Because, mangrove forests demand the following three conditions: an extremely flat landform with a large river, a shoaling beach where a large volume of mud sediments have deposited over a long time, and an area sheltered from wind and waves.

CHAPTER 3

SOCIOECONOMIC CONDITIONS

CHAPTER 3

SOCIOECONOMIC CONDITIONS

The basic causes of water pollution are daily human activities, and industrial production. The improvement of water quality, therefore, would either call for controlling daily activities and industrial production or the formulation of methods that would minimize the discharge of pollutants.

In this chapter, population distribution and statistics, and the type and scale of the main industries in the basin regulating industrial production and daily human activities will be arranged by Municipality based on the results of the national census.

Further, surveys on present works for the improvement of sanitary infrastructures and budget apportionment for environment related works were carried out to estimate the desire of the state and municipality to invest on environmental improvement projects.

3.1 Administrative Unit

In the Federative Republic of Brazil, the basic administrative unit within each state is the municipality.

The Guanabara bay Basin is located within the State of Rio de Janeiro, and straddles wholly or partly 12 municipalities of the State. As compared to the 43,305 km^2 of the state of Rio de Janeiro, these 12 municipalities add up to a total of 6,632 km^2, of which around 4,000 km^2 are included in the Guanabara Bay basin.

The municipalities entirely included in the Basin are Nilopolis, San Joan de Meriti, Duque de Caxias, Mage, Itaborai, San Goncalo and Cachoeiras de Macacu, while those partially included are Niteroi, Nova Iguacu, Rio Bonito, Petropolis and Rio de Janeiro.

As for Petropolis, only the southern tip of it is included in the Guanabara Bay basin, but no population center exists in the area, thereby justifying its exclusion from the basin for all practical purposes.

Fig. 3.1-1 shows the administrative units included in the Guanabara Bay basin.

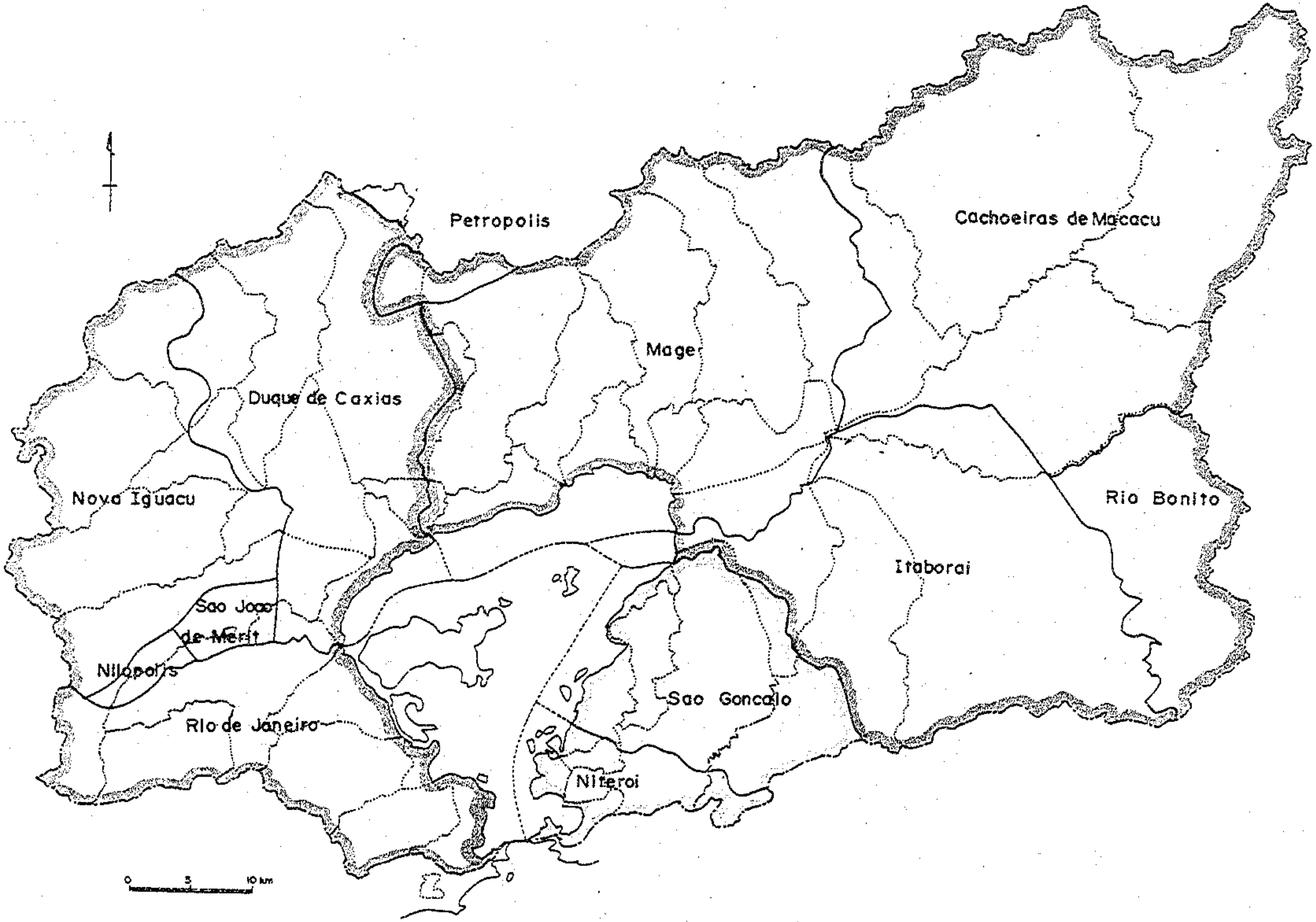

Fig. 3.1- 1 Administrative Units included in the Guanabara Bay Basin