JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

STATE SECRETARIAT OF PLANNING AND GENERAL COORDINATION,
PARANÁ STATE, THE FEDERATIVE REPUBLIC OF BRAZIL

THE MASTER PLAN STUDY ON THE UTILIZATION OF WATER RESOURCES IN PARANÁ STATE IN THE FEDERATIVE REPUBLIC OF BRAZIL

FINAL REPORT

SECTORAL REPORT VOLUME L
WATER ENVIRONMENT MANAGEMENT

December, 1995

Yachiyo Engineering Co., Ltd.
Tokyo, Japan

and

Nippon Koei Co., Ltd.
Tokyo, Japan

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COMPOSITION OF FINAL REPORT

1. EXECUTIVE SUMMARY

2. MAIN REPORT
   - I. Strategy for Paraná State
   - II. Master Plan for Iguaçu River Basin
   - III. Master Plan for Tibagi River Basin

3. SECTORAL REPORT
   - A. Socio-economy
   - B. Meteorology, Hydrology and Surface Water Resources
   - C. Hydrogeology and Groundwater Resources
   - D. Domestic and Industrial Water
   - E. Agriculture
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   - I. Water Quality and Sewerage
   - J. Soil Erosion and Forest
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   - L. Water Environment Management
   - M. Institution
   - N. Cost Estimate, and Economic and Financial Assessment

4. DATA BOOK

THE MASTER PLAN STUDY
ON
THE UTILIZATION OF WATER RESOURCES IN PARANA STATE
IN
THE FEDERATIVE REPUBLIC OF BRAZIL

Sectoral Report Vol. L

Water Environment Management

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CHAPTER 1 INTRODUCTION

1.1 General

The study was carried out to formulate the strategy for the water environment management in Paraná state, which provide the framework composed of policy and implementation strategy, and to prepare the operation and monitoring system plan giving the basis for the water environment management. Also, the master plan for the operation and monitoring system was formulated for the selected pilot river basins; the Iguaçu and Tibagi river basins.

In order to achieve the mentioned objectives, the study established the methodology for formulation of a master plan for the water environment management through identification of the problems and needs in the management of water environment at present as shown in the work flow chart for the study in Figure 1.1.

1.2 Methodology

1.2.1 Present Situation in Water Sectors

The urban areas with population of 72 % to the total population of Paraná state are mainly developed in the hilly area. Therefore, some of the urban areas are facing or predicted to face severe water shortage due to the less availability of surface water resources. The water shortage, specially, in the major cities including Curitiba Metropolitan Area (CMA), Londrina and Cascavel becomes serious due to concentration of population. In order to supplement the water deficit in these urban areas, the groundwater source has been developed by the local government, the state water supply company and/or water users. There, however, are many unauthorized water users and the total numbers of the boreholds are supposed to be about 10,000 in the whole Paraná state while the registered ones are about 3,000.

The sewage and industrial waste water in the urban areas are discharged with treatment into the adjacent rivers and however, insufficient capacity of the existing sewerage system induces the river water pollution in these rivers. Also, in the rural areas, the use of pesticide and fertilizer in the agricultural activities has an adverse effect on the river water quality and aquatic ecology.

The forest area in Paraná state has been significantly decreased from 85 % in 1890 to 10 % in 1980 mainly for agricultural use. This change of land use has induced severe soil erosion in the whole Paraná state. As a secondary adverse effect, the eroded soils bring the pesticide and fertilizer provided for the agricultural land to the rivers.

Flood prone areas are mainly distributed along the Iguaçu river and were significantly damaged by the floods with a large magnitude in 1983, 1992 and 1995. The damaged major cities along the Iguaçu river were; Foz do Iguaçu, Capanema, União da Vitoria, Rio Negro and Mafra, Porto Amazonas and São Mateus do Sul, and Curitiba Metropolitan Area.

Aquatic ecology along the rivers in Paraná state has been deteriorated under the mentioned water uses situation.

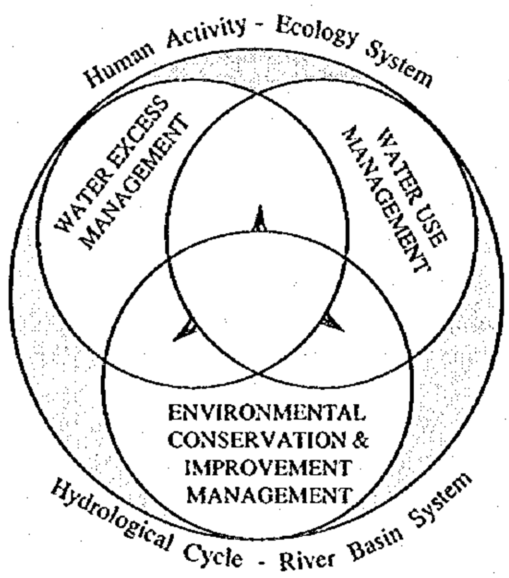
1.2.2 Definition of Water Environment Management

Water is a renewable resource that naturally follows the hydrologic cycle illustrated in Figure-1.2. In order to draw an ideal portrait of managing the future water environment, the Study defines the framework of the water environment formed by two (2) folds of systems:

(1) Hydrologic cycle - river basin system, formed by the basic three (3) systems; atmospheric water, surface water and sub-surface water with basic four (4) dimensions of quantity, quality, time and space, and

(2) Human activity - ecosystem, which is an interactive biosphere between human activity and ecosystem relating to water.

The Study, also, defines a "Water Environment Management" as managing available water resources (surface water and groundwater) and excess water (flood control), and environmental conservation and improvement such as the ecosystem, soil erosion, water quality, etc. as illustrated as follows:



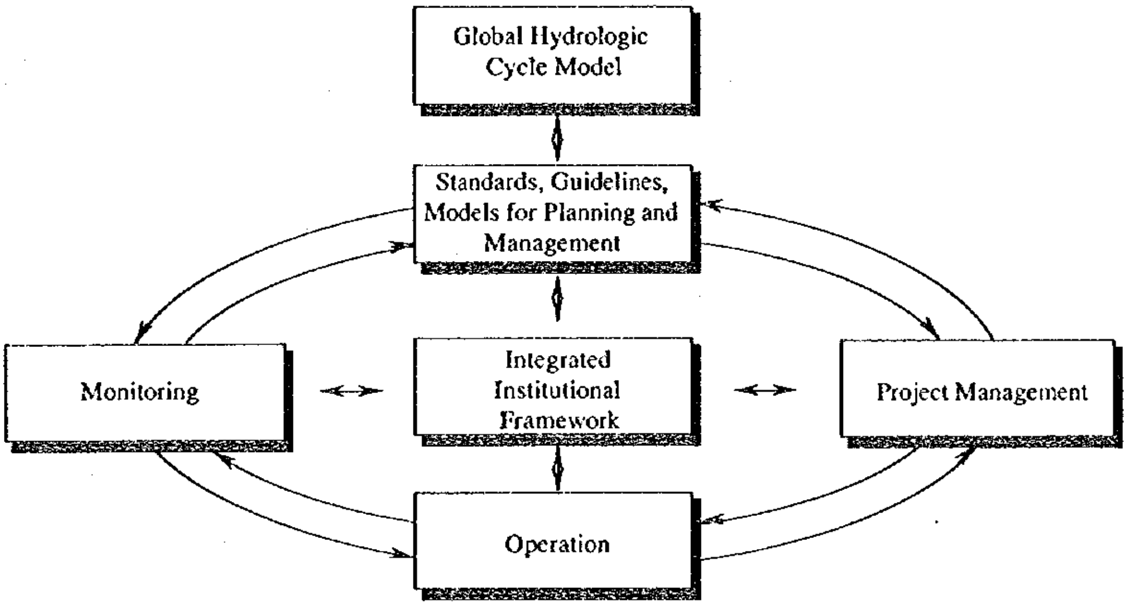
Water use management (water resources development) and water excess management (flood control) are two (2) major components aiming to achieve people's social well being in the sphere of water environment. Surface and sub-surface water supply and use, hydropower generation, inland navigation, fish culture and groundwater use are included in the water use management (WU).

While environmental conservation and improvement management are provided to achieve symbiosis of human being and natural environment. Waste treatment, ecosystem conservation and soil erosion improvement occupy a part of the environmental conservation management (EC).

Water excess management (WE) consisting of flood plain control and urban storm water control is treated separately from the WU and EC because it has both nature of the WE and EC. These three (3) components are interactive and their fringes have a tendency to expand responding to the expansion of region's economic size.

1.2.3 Concept of Integrated Management of Water Environment

In order to establish a master plan covering the aforesaid management fields interactive between them, the Study applied an integrated management framework which forms a hierarchy of basic models and systems as shown below:



The institutional framework is at the center of integrated management of these frames. The human activity - ecology system is interactive with the hydrologic cycle - river basin system. Figure-1.3 also indicates significant role of monitoring in water environment management, which provides quantitative basis for environmental standards, laws and actions at present and for future improvement, and necessity of environmental impact analysis including initial environmental examination in the project management

1.2.4 Study Policy

In order to attain comprehensive approach to management of the water environment including development and use of water resources, the Study deploys the following study policies:

1) Water basin and hydrologic cycle approach,

2) Integrated approach,

3) Interactive approach, and

4) Uniform planning, monitoring and management criteria.

Both the Strategy and Master Plan address the framework of model formulation and management of water environment using the water basins (river basin, groundwater basin or sub-basin) as a study and management unit rather than a political or administrative unit. Sector study and management models intend to clarify linkage among three basic sub-systems in the hydrologic cycle. Integrated and interactive approaches with uniform criteria are pre-requisite for the consistent, effective and comprehensive management.

CHAPTER 2 PRESENT CONDITION OF RIVER BASIN MANAGEMENT

2.1 River System Classification for River Administration

The river waters in Brazil are classified into federal, state and municipality in terms of administrative and legislative power. The new constitution promulgated on October 1988 stipulates jurisdiction of the lakes, rivers, any water course in land and hydraulic energy potentials, and delineates the power limit of the Union (the Federal Republic), the states, the federal district and the municipalities. The water code, decree 24643, July 10, 1934 stipulates general rules on the ownership of rivers, lakes and those of underground as well as river beds and their border areas, and general stipulation on the concession, authorization or permission of water use and the obligations of the title holders. However, those provisions on ownership have been replaced by the new constitution.

These laws define the public water use rights not only by river situations but also by water use purposes. According to the location in land within its domain, the main rivers in Paraná State are classified into the federal and state rivers (refer to Figure-2.1):

Federal River	State River
Paraná river (main stream)	Piquiri river (main & tributaries)
Paranapanema river (main stream)	Ivai river (main & tributaries)
Iguaçu river (main stream)	Pirapó river (main & tributaries)
Itararé river (main stream)	Tibagi river (main & tributaries)
Ribeira river (main stream)	Cinzas river (main & tributaries)
Negro river (a tributary of the Iguaçu river)	Coastal zone (main & tributaries)

Although the main stream of these rivers can be classified into either federal or state, their tributaries are not able to be classified all in one state or municipality. The administrative territory of the tributary is not necessarily same as that of the main stream into which water of the tributary flows. Therefore, the river basins can not be necessarily classified definitely into federal, state and municipality in terms of location. Table-2.1 presents the location belonging of nations, states and municipalities to the river basins in Paraná State in 1991. The municipal boundaries vary year by year and thus they may be different in 1995.

Further details of the legal framework with respect to administrative and legislative power are presented in the Sectoral Report M for Institution. The classification with regard to environmental quality standards prepared by the CONAMA (the National Environmental Council) is presented in the Sectoral Report I for Water Quality and Sewerage.

2.2 Institution Related to Water Environment Management

The river water in Paraná state is currently administrated by three (3) levels of authorities: federal level, state level and municipal level.

The major organizations of the federal level are the National Department of Water and Electric

Energy (DNAEE), ELETROBRAS, ELETROSUL, ITAIPU, the Ministry of Mines and Energy (MME), National Council of Environment (CONAMA), Brazilian Institute of Environment (IBAMA), Ministry of Environment and Legal of Amazon Region, Secretariat of National Irrigation (SIR) and Ministry of Regional Integration (MIR).

The DNAEE, ELETROBRAS, ELETROSUL and ITAIPU are placed under the MME. The CONAMA and IBAMA are placed under the Ministry of Environment and Legal of Amazon Region. The SIR is placed under MIR.

The major organizations of Paraná State are State Council of the Environment, Environmental Institute of Paraná (IAP), Superintendency of Erosion Control and Environmental Sanitation (SUCEAM), State Secretariat of the Environment (SEMA), Council of Regional Development of the Coastal Area of Paraná, Institute for Municipal Assistance of Paraná State (FAMEPAR), State Secretariat of Urban Development (SEDU), State Council of Fishing (COESPE), State Council of Irrigation and Drainage (CEID), Department of Supervision (DEFIS), Operational Department of Agriculture and the Supply (DAGRI), Agronomic Institute of Paraná (IAPAR), Company of Agriculture and Livestock Breeding Development of Paraná (CODAPAR), State Secretariat of Agriculture and Supply (SEAB), Minerals of Paraná Corporation (MINEROPAR), Energy Company of Paraná (COPEL), Sanitation Company of Paraná (SANEPAR), State Secretariat of Higher Education, Science and Technology (SETI), Managing Unit of the Program of Environmental Sanitation of Curitiba Metropolitan Region (PROSAM), Coordination of the Metropolitan Region of Curitiba (COMEC), Economic and Social Development Institute of the State of Paraná (IPARDES), State Secretariat of Planning and General Coordination (SEPL) and State Secretariat of Transport (SETR).

The COPEL and SANEPAR are independent companies. The COESPE, CEID, DEFIS, DAGRI, IAPAR and CODAPAR are placed under SEAB. The FAMEPAR is placed under SEDU. The PROSAM, COMEC and IPARDES are placed under SEPL, while IAP and SUCEAM are subordinated to SEMA after the reorganization in February, 1995.

In Paraná State, there are 371 cities and municipalities which are divided into several regions based on the micro-zoning established by the state government as of 1993.

In addition, there are also autonomous public institutions like Inter Municipal Concessionaire for the Environmental Protection of Tibagi River Basin (COPATI) and non-governmental organizations (NGO) like Permanent Regional Commission Against Floods in the Iguaçu River (CORPRERI and COPRENE).

Administration of river waters is involved in purposes of water use, stages of implementation and location situations. For example, a hydroelectric company must apply concession for construction of a hydroelectric power plant to the DNAEE, a federal organization even located in the state river because all hydroelectric potentials belong to the federation. Monitoring authority of water quality of the federal river in Paraná state is granted to the DNAEE. On the other hand, a water consuming company must apply concession for water use in the tributaries of the Iguaçu river to the IAP, a state institution, because the IAP is in charge of grants of the water use (concession, authorization and permission) in the state river.

The Study has conducted an interview survey regarding decision tree of administrative power in charge of each water environment sector in order to visualize the management framework of river waters and environment in Paraná State. The water environment sectors subjected to the survey include groundwater use management, fish culture management, inland navigation management, hydropower generation management, surface water supply management, ecosystem conservation management, waste treatment management, soil erosion improvement management, and water excess (flood control) management including flood plain and urban storm water.

Water administration of each sector is involved in water use licensing, study, planning, design, implementation, operation and maintenance, monitoring, and warning and rescue activities. The result of interview survey is summarized in Table-2.2 which is based on information available from several organizations.

An interview survey has also been conducted for the institutions which have legal responsibility of administration of operation and monitoring systems. The items subject to survey cover:

(1) Operation system; groundwater supply, surface water supply, river-reservoir operation for multifarious water use, river-reservoir operation for flood control, power load operation,

(2) Monitoring system; collection and bank systems for meteorological and hydrologic data, flood forecasting and warning systems, groundwater basin (quality and quantity), aqua ecology monitoring, fish resources monitoring, waste discharge monitoring, soil erosion monitoring, surface water supply monitoring.

The COPEL and SANEPAR conduct monitoring for their operational purpose to fulfill public demand and their quantity and quality standards, though they have not direct legal responsibility on monitoring for superintendency. The interview result is summarized in Table-2.3.

Further information concerning the administrative and legislative power of the federal and state organizations are presented in the Sectoral Report M for Institution.

2.3 Monitoring and Operation Systems

2.3.1 Existing Monitoring System and On-going SIMEPAR's System

(1) Existing monitoring system

There are various kinds of monitoring stations in Paraná State, but the reported number of stations is different each other in different institutions. A list of recorded stations in DNAEE is adopted in this report.

Meteorological stations, rainfall gauging stations, flow measurement stations, and water quality stations are distributed in space fairly well in Paraná State. The location map of the rainfall gauging stations equipped with automatic recording and telemetric systems is shown in Figure-2.2. The location map of the automatic and telemetric flow measurement stations is shown in Figure-2.3. Further information of these stations are described in the Sectoral Report B for Meteorology, Hydrology and Surface Water Resources.

There are 844 rain fall, 217 stream flow, 193 river-reservoir water quality, 104 river-reservoir water ecology and 132 sediment measurement stations in Paraná state. The breakdown of these monitoring stations and corresponding observation frequency are summarized in Table-2.4.

The ways of measurement are classified into three (3) types; by manual observation, by automatic recording and by telemetric system. Forty-two (42) of 171 automatic rainfall gauging stations are equipped with telemetric equipment. Twenty-one (21) of 69 automatic flow measurement stations and another one station are equipped with telemetric equipment. These telemetric systems are also used for flood warning and reservoir operation.

There are 193 water quality monitoring stations in Paraná State. The water quality has been monitored by the SUREHMA since 1970, and its monitoring was succeeded by the IAP from 1989 to present after abolishment of the SUREHMA. The aerial distribution of these stations is shown in Figure-2.4. The monitoring items are water temperature, dissolved oxygen (DO), coliform fecal, pH, biochemical oxygen demand (BOD), total nitrogen (T-N), total phosphate (T-P), turbidity and total solid.

Most of these telemetric systems have been installed by the DNAEE and the rest are by ELETROSUL, COPEL, and CESP (Electrical Central of São Paulo). The Iguaçu river basin is most concentrated with regard to telemetric measurement stations in Paraná state. There are 13 stations installed by the DNAEE in this basin including the ones in Santa Catarina State. These telemetric systems are operated by the DNAEE as a part of the flood warning national system and by COPEL for reservoir operation. Figures-2.5 shows the telemetric system in the Iguaçu river basin.

There is no periodical measurement of groundwater level in Paraná state. However, the records of about 2,800 wells are available out of 3,100 registered ones though these are limited to pumping test results for development wells. There is little observation wells in Paraná State. According to the right of groundwater use regulation established by the IAP, groundwater quality tests of each well are supposed to be conducted every five years including physical, chemical and bacteriological analysis. However, this regulation seems not to be conducted in deed.

(2) SIMEPAR

The SIMEPAR was established by the Government of Paraná State in 1993 under the agreement of two (2) related agencies of the IAPAR and COPEL for provision of meteorological and hydrological data with high reliability. As of 1995, preparation works including construction of operation center and procurement of equipment are going on in Curitiba.

Figure-2.6 shows the system plan of the SIMEPAR mainly composed of data collection system and computer system in an operation center being constructed in Paraná Federal University in Curitiba. The data collection system is planned to consist of; 1) weather radars at Irati, Catanduva and Apucarana, 2) satellites image reception of METEOSAT, GOES and TIROS, 3) lightning sensors, 4) telemetering weather stations of 116 nos. in Paraná and Santa Catarina States in the Iguaçu river basin, 5) telemetering water level gauging stations of 44 nos., 6) atmospheric environmental stations, 7) radio sondes and vertical profiler, and 8) global telecommunication system. The computer system is designed to be composed of data processing system, data storage system and product generation system.

The IAP, COPEL and IAPAR will be connected with exclusive line or telephone cable and easily approach to the data storage system. Also, public users are able to connect their computer with the data storage system and to obtain data and information. Data and information to be available in this system are given in Table-2.5.

Total project cost is estimated at US$ 35 million which is scheduled to be financed by the Government of Paraná and to be disbursed during 5 years as shown in Figure-2.7.

2.3.2 Existing Operation System

The flood forecasting and warning system for the Iguaçu river has been operated by the DNAEE, and its information is distributed to the COPEL and civil defense and municipalities for rescue activities. The flow of warning information is illustrated in Figure-2.8.

Reservoir operations of the COPEL and ELETROSUL (Electrical Central of South of Brazil) are conducted considering interaction between the existing reservoirs along the Iguaçu river for maximizing hydroelectric power generation and control of excess water. The operation direction of each dam is dispatched daily during normal condition and it can be shortened up to every 10 minutes in case of emergency. Collected data through telemetric networks are analysed for each reservoir and operation directions of next day are decided according to the monthly operation program. All of these dispatches are transferred through telephone or computer networks. There is no remote control in operation.

There are three (3) reservoirs in the Iguaçu river basin which were constructed by the SANEPAR and PETROBRAS for domestic and industrial water supply for Curitiba metropolitan area. Besides, many intake structures are provided for water supply to the municipalities by the SANEPAR and autonomous bodies in the whole Paraná state. These structures has been operated by the aforesaid organizations in consideration to maintain downstream flow rate in accordance with the regulation.

2.4 Problems and Needs in Existing River Basin Management

2.4.1 Institution and Organization

The problems and needs with respect to the institution and organization in Paraná State are dealt with in the Sectoral Report M for Institution.

2.4.2 Monitoring and Operation Systems

(1) Monitoring system

Rainfall Stations

The number of rainfall stations is fairly well distributed for the purpose of macro-scale water resources development planning and operation. It is difficult to specify density requirement of precipitation stations on a unit-area basis in general. An investigation of the problem (Langbein 1960) indicates that population density may be one of the major factors affecting the density of precipitation stations. According to the report of this investigation, the "reasonable minimum objective" lines in Figure-2.9 represent a compromise between uniform adequacy in regard to population and that desirable on a purely geographic basis. This figure shows the data on density-of-precipitation gauges in various countries before 1960 and the situation of Paraná State in 1993 was plotted on it. The situation of Paraná State is close to Spain and better than reasonable minimum objective line.

Although it is fairly good in view of macro-planning, it is necessary to examine appropriate numbers and distribution of rainfall stations when discussing about convective rainfall in spotty areas. Because the concentrated and spotty aerial distribution of many heavy rainfall centers is difficult to monitor, increasing the density of gauges is one of effective ways to improve accuracy of the apparent average aerial rainfall.

River-Reservoir Measurement Stations

The number of river-reservoir water flow measurement stations in Paraná State is fairly good for water resources development in view of large scale basin development according to Langbein (1960). Figure-2.10 shows the data on density of stream flow gauges in various countries before 1960 and the situation of Paraná State in 1993 was plotted on it. The situation of Paraná State in 1993 is better than Italy and Japan before 1960 in terms of relative density.

Water Quality Monitoring Stations

Aerial distribution of the water quality monitoring cannot be assessed in number only because the water quality deterioration was mainly conducted by human activity and it tend to cluster around the spots. It is necessary to examine the locations of the observation stations concerning effluent points.

Ground Water Measurement Stations

It is serious problem that there is no periodical observation station of ground water level in Paraná State. Observation of groundwater level is basic requirement for groundwater development and monitoring. It is needed to install observation wells which measure groundwater level daily and quality twice a year.

Data Transfer and Bank Systems

Since water environment information can be effectively used for various purposes, it is necessary to collect these data and transfer to the institutions concerned and open to the public. To realize these services, multifarious use of existing systems and supplement of new systems are necessary to be studied.

On the other hand each institution in Paraná State maintains its data system for its own purpose with own standard, and it results in significant discrepancy among respective data at present. For example, there are three data bank systems in different institutions in Paraná State: i.e., MSDHD (DNAEE), CADASTRO-PLU-FLU (IAP) and SISTEMA DAD (COPEL). There are also two Geographical Information Systems: i.e., in IAP and SANEPAR. These data bank systems are needed to be integrated and administrated with a uniform regulation and standards.

(2) Operation system

The DNAEE has a flood forecasting system in the Iguaçu river and reported good accuracy in prediction results. It forecasts water levels 12 hours ahead. It seems to be enough for rescue activities against the floods, but the lead time may be necessary to be examined concerning necessary period for flood fighting activities.

The number and distribution of telemetric precipitation stations for flood forecasting used in the upper Iguaçu river may not to be sufficient to capture concentrated heavy rainfalls, like convective rainfalls. An aptitude study on the existing operation systems may be required taking the influence of convective rainfalls into consideration in the future.

CHAPTER 3 STRATEGY FOR WATER ENVIRONMENT MANAGEMENT

3.1 Framework of Strategy for Water Environment Management

Strategy of the water environment management provides a set of medium-term to long-term principles and broad action programs in order to support the achievement goals and to implement the key policies for protection, improvement, development and management of the water environment as a guideline. This definition of Strategy does not include independent project identification, ranking, or financing, while a Master Plan includes investment - or project oriented. A Master Plan is a specific set of projects that are placed within the context of the achievement goals and policies of the Strategy.

The Strategy proposed in this study is composed of policy and implementation strategy as shown in Figure-3.1. The policy is composed of core objectives and three (3) policy kits; principles, improvement of implementation measures and improvement of institutional arrangement. Objectives of water environment management are to establish an ideal portrait of healthy water environment. Identification of problems and needs at present and in future and image of future direction of creating healthy water environment will provide a basis of objective formulation.

Principles define broad framework and basis for detailed guidelines, standards and practices. Designation of specific model areas will be required for actual implementation of improvement measures for problem areas.

Implementation strategy is composed of three (3) sets of programs and one implementation schedule. These are project programs for model areas, improvement programs for organization and law, improvement programs for financing and cost recovery arrangement, and implementation schedule for these programs. Project programs are composed of water use (or called water resources development) programs and environmental conservation and improvement programs. Respective sector programs are to be formulated for specific model areas.

3.2 Water Environmental Policy

3.2.1 Necessity of Water Environment Management

The water environmental issues in Paraná State are classified into the urban based and rural based ones. The problems predicted in Paraná State are; shortage of domestic and industrial water supply, deterioration of surface water and groundwater resources due to increase of domestic and industrial sewage loads and waste disposal, their impact on aqua-ecology due to pollution loads and reduction of green coverage, variation of heat and evapotranspiration mechanism, increase of flood runoff, variation of base flow and groundwater recharge, deterioration of riverain landscape, and occupancy of illegal residents in the flood prone areas as indicated in Figure-3.2.

These urban issues are predicted to be induced due to concentration of population and growing economic activities as given in Table 3.1. Expansion of urban areas and increase of population density are consequence of migration from the rural area to the urban area rather than raise of birth rate in case of Paraná State. Enhancement of land use, increase of factories and modernization of life style are product of concentration and growth of economy in the urban areas.

Impact on the aquatic ecology due to increase of sediment, pesticide and fertilizer loads from agricultural land development, and change of food cycle in ecosystem due to deforestation and construction of hydropower dams are major environmental issues in the rural areas. Problems and needs relating to rural domestic water supply, industrial and agricultural water demand, and inland navigation are rather minor. Variation of temperature and weather due to change of evapotranspiration mechanism, and variation of runoff mechanism due to deforestation is not clear. These rural issues are impacts due to mainly development of agricultural land and water resources. Deforestation is consequence of mainly agricultural land development.

Relationship between the mentioned environmental issues and each management unit of the multifarious water use and improvement project is illustrated in Figure-3.2.

These progressive problems are predicted to cause significant deterioration of living environment and quality of life in both the urban and rural areas in Paraná State in the future while public interests in Paraná State demand both creation of high quality of living environment and preservation of ecology.

In this circumstances, an integrated water environment management will be urgently necessary for preservation and/or restoration of natural and living environment, i.e., symbiosis with natural environment.

Figures-3.3 and 3.4 illustrate causal relationship of prospective urban issues of water environment in Paraná State in relation to management framework.

3.2.2 Direction of Healthy Water Environment

The progressive development issues are predicted to cause significant deterioration of living environment and to increase risk of encroachment of human life both in the urban and rural areas in Paraná State. Under this situation, all the people in Paraná State are entitled to a healthy and productive life in harmony with nature and therefore, the desirable water environment management in Paraná State is required to satisfy the followings:

1) Water use management for sustainable development

   a) to maintain and supply reliable fresh water resources in quantity,

   b) to maintain and supply safe fresh water resources in quantity,

   c) to control adequate use of fresh water resources, and

d) to avoid conflict among competing water uses.

2) Water excess management

a) to minimize risk of death and injury of human life and property damages or loss (private and social) from flood,

b) to control excessive runoff properly,

c) to control discharges of waste and toxic material into fresh water sources during flood.

3) Environmental conservation and improvement management

a) to reproduce and/or maintain the original genetic library of the aquatic ecosystem at the time when the original forest coverage was still well maintained,

b) to minimize risk of encroachment of aquatic ecosystem due to human influences,

c) to reproduce and/or maintain the riverain natural landscape,

d) to minimize impact of human influences to aquatic ecosystem such as discharges of waste and toxic materials.

3.2.3 Objectives of Management of Water Environment

The objectives of water environment management are established for Paraná as follows:

1) to maintain sustainable development of reliable and safe water resources to achieve people's social well being, and symbiosis of human beings and natural environment,

2) to minimize risk of encroachment of human life and ecosystem library due to human influences,

3) to improve and/or reproduce the damaged water environment, and

4) to coordinate smooth implementation and operation of multifarious water use and improvement projects among the institutions.

These objectives coincide with the title of chapter 18 of "Agenda 21: Program of Action for Sustainable Development" declared in June, 1992 in Rio de Janeiro, "Protection of the quality and supply of freshwater resources: Application of integrated approaches to the development, management and use of water resources".

The first objective is established on the basis of the Principle-1 of the "Rio Declaration of Environment and Development," which described that human beings are at the center of concerns for sustainable development and they are entitled to healthy and prospective life in harmony with nature. The sustainable development of reliable and safe freshwater resources is to be contained in the hydrologic cycle, and symbiosis of human beings and natural environment is to be contained in the human activity - ecology system.

The second objective is to be attained by the operation and monitoring systems and the quality control management system. The third objective is to be attained by the multifarious water use and improvement project management. The fourth objective is to be attained by the integrated institutional framework (refer to the conceptual diagram in Figure-1.2).

3.2.4 Composition of Policy

For preservation, improvement and restoration of the water environment of Paraná State, the following policies are proposed to be arranged comprehensively and effectively (refer to Figure-3.1):

(1) Policy and principles

It is desirable to launch a clear definition of a long-term economic development policy of Paraná State which is sound to water environment rather than the conventional growth pole development policy and is to be linked with the state policy of water environment.

Principles are to be clearly established as a part of the state policy for water environment in order to materialize the objectives of water environment. The principles provide broad policy framework which define desirable water environment and basis of setting guidelines, standard, and practices for managing, planning and other necessary activities.

Guidelines, standards, and practices define all necessary limits and targets for management and countermeasures, and methodology and procedure for uniformity and consistency.

(2) Model areas as implementation measures

Model areas are the areas or regions where water environment issues are presently significant or predicted to be significant in the future, and specific monitoring, administration, management, or provision of countermeasures are assessed to be necessary regardless of urban or rural areas. The state government is expected to appoint the areas appropriately and timely as a part of policy. The selected pilot river basins are independent on the model areas in principle, but those will become a model case study.

(3) Institutional arrangement

Improvement of institutional arrangement will be necessary for the integrated management including allocation and coordination of water use right, monitoring, project implementation and operation. The institutional arrangement includes legal framework, administrative framework and organization.

3.2.5 Principles

The following principles are formulated assuming the future conditions of Paraná State:

(1) Principle of symbiosis of human beings and natural environment

Standards and criteria related to water are to be newly established or improved being linked with the principle of symbiosis of human beings and natural environment.

This principle defines the essential power to establish the water quality and quantity standards not only for protecting human life but also for preserving aquatic ecology. For example, the standard for sewage treatment will require both the quality for domestic water supply and the quantity and quality (toxic control) for aquatic ecology. This concept suggests that preservation of ecosystem will eventually result in protection of human life in the hydrologic and ecological cycle.

Particular attention may needs to be paid to the fact that original capacity of genetic library and biological diversity in Brazil is extremely larger than that in the industrialized countries and their preservation is essential not only for Brazilians but also for present and future generation of human being as a whole.

In order to achieve this principle, a continuous and long-term effort to monitor the existing genetic library, in particular aqua species including microorganism, will be essential requirement at a starting point in addition to the existing meteorological, hydrological, and water quality monitoring stations.

Also, It will be necessary to introduce biological assay or indices as a part of water quality standards in addition to the existing physical and chemical standards.

(2) Principle of hydrologic cycle

The principle of hydrologic cycle defines quantitative assessment and sustainable development of surface and groundwater resources, and linkage between waste water treatment and contamination level in the hydrologic cycle.

The hydrologic cycle management is a fundamental principle to materialize sustainable development of freshwater resources and protection of the quality and supply of freshwater resources. Hydrologic cycle management is a tandem of the integrated management of quality and quantity. Hydrologic cycle, also, covers recycle use of water resources (such as industrial water use in urban areas) with respect to effective use and principle of risk and benefit.

(3) Principle of multifarious water use

Multifarious or multipurpose water use is essential to meet the following needs:

- diversified and competing water use

- effective use of limited quantity of water resources

- fair and efficient allocation of water resources

- preservation of water environment

(4) Principle of cleaner production

The principle of cleaner production aims to enhance and achieve production technologies which enable to minimize waste yield and use of toxic materials in factory's production process (the guideline by United Nations Environment Program - UNEP).

The cleaner production covers the following basic three (3) process:

1) Reduction technology to reduce the content of toxic chemical materials contained in sewage and solid waste in the production process, and to reduce the use of the toxic chemical materials in quantity.

2) Recycle technology to prevent occurrence and discharge of toxic chemical materials by new technologies and confine in a closed cycle system.

3) Reuse technology to change toxic and non-toxic materials into non-toxic resources for reuse.

For minimizing or reducing waste effluents from industrial factories, it is essential to introduce and enhance the in - process technology which is successful in some of the industrialized countries rather than relying on the end-of-pipe technology only.

(5) Principle of risk management

Risk management, which is composed of risk assessment and risk control management, will be a fundamental tool to minimize risk of encroachment of human life and genetic library due to human influences. The risk assessment will require comprehensive monitoring and operation systems and the risk management will need water quality and quantity standards under the principle of symbiosis. Flood control level is also to be considered as a part of the comprehensive risk management.

(6) Principle of risk and benefit

The principle of risk and benefit will be an appropriate and practical way of risk management among the risk control principles; 1) risk free or zero risk principle, 2) risk-based principle (uniform risk), and 3) risk benefit principle. The risk and benefit principle is a yardstick to establish standards for controlling water quality (organic effluents and chemical substances relating to occurrence of cancer, etc.) for both domestic water supply and conservation of ecosystem, to establish an allowable limit of risk, and to assess provision of monetary measures including structural measures. The principle of risk and benefit is to be employed as a concept of trade-off between risk and benefit or a concept of the multiple objective policy.

In view of the risk and benefit the in-processing technology might be highly justifiable for the industrial waste treatment, while the septic tank method might be efficient as the household domestic sewage treatment. A proper combination of public sewerage (basin sewerage system), village sewerage and household sewerage may be effective to increase service ratio and to control increasing future pollution loads. That is, economically efficient treatment methods are necessary to sought out in reference to population density in the service area rather than relying on the basin sewerage system only.

(7) Principle of integrated and comprehensive management

Integrated and comprehensive management is essential to meet the following needs:

- to achieve balanced development for multifarious water demand and sustainable development,
- to control linkage of water and land use management,
- to control linkage of surface and groundwater management for sustainable (or rechargeable) development,
- to control linkage of water quality and quantity for the comprehensive risk management and the principle of symbiosis, and
- to control smooth implementation and operation management.

(8) Principle of proper cost recovery

Establishment of an appropriate cost recovery system including pricing mechanism and charging system will be essential to approach to the goal of water environment management effectively. The principle of "users - to - pay" and "pollutant - to - pay" will be necessary to be materialized.

3.2.6 Identification of Model Areas

Model areas for the respective project management sector are identified on the basis of river systems, administrative division and the major problems on water environment thereat and proposed as shown in Table-3.2.

3.3 Implementation Strategy

3.3.1 Composition of Implementation Strategy

Implementation strategy is composed of the following programs:

(1) Project programs

Concrete project programs for respective water environment issues are to be formulated for each model areas designated after coordination among federal and state agencies, organizations and municipalities concerned. The project programs are two (2) folds; water resources development (water use) and environmental conservation and improvement.

The project programs will be classified into the following hierarchy:

a) Programs for achieving objectives of water environment management, composed of existing or on-going programs and new programs

b) Programs for the state of urgency when the objectives can not be attained, composed of measures for abnormal drought, flood and water quality

(2) Organization and law

Institutional development and human resources development are strategic elements of the capacity building for implementation. Institutional development includes strengthening of organization and legal framework and development of community participation. Development of human resources includes strengthening of education and training capacity, sharing of knowledge and data and improvement of career structure (refer to Sectoral Report (M): Institutions).

(3) Financing and cost recovery arrangement

The implementation strategy for financing and cost recovery arrangement is presented in the Sectoral Report (N): Economic and Financial Assessment.

(4) Implementation schedule of project programs

Selection and formulation of comprehensive implementation programs and schedule are to be conducted through screening procedures of the project programs for the model areas after coordination among agencies, organizations and municipalities concerned since all the prospective programs may not be implemented because of financial and time constraints. The SEPL or other relevant institution will be required to support implementation and to appoint an appropriate implementing organization in case of multi-disciplinary approach.

The implementation programs are composed of water resources development programs and environmental conservation and improvement programs.

3.3.2 Implementation Strategy and Schedule for Project Programs

Project programs for respective management sector are to be formulated with the proposed principles. An example of the goal and implementation strategy for sector project programs for water use management and environmental conservation and improvement management are shown in Table-3.3 and Table-3.4 respectively.

It will be proposed to arrange two (2) stages in implementation schedule:

- First stage : present to the year 2005
- Second stage : the year 2006 to 2015.

The project programs to be conducted urgently and/or to be conducted as extension of the present and on-going programs are to be attributed to the first stage. The project programs which are required to achieve the desirable or ideal conditions of water environment in the first quarter of the 21st century are to be attributed to the second stage if conduct of these can be waited to the necessary extent of time.

3.4 Framework of River System Administration

3.4.1 River System Classification

At present the rivers in Paraná State is classified into two, the federal river and the state river in terms of jurisdiction of river and water by the constitution and the water code as described in Section 2.1.

Classification	Jurisdiction	Institution in Charge
1) Federal river	international and inter-state rivers	DNAEE
2) State river	other than federal rivers	IAP
3) Rivers in specially designated areas	(appoint coordination and management unit occasionally)	(examples; COMEC, PROSAM)

The river classification relating to the ownership of river and water resources will be subject to review in the future because the federal government has been reviewing the laws relating to the jurisdiction.

3.4.2 River System Administration

The future river system administration is desired to manage the following matters effectively.

1) integrated management of ownership of river and water resources
   - public water use right
   - priority in conflicting water uses
   - concession, authorization and permission procedures,
2) designation of model areas for water environment management and related

administration,

3) integrated management of project identification, planning and implementation,

4) integrated management of operation rules of dams, reservoirs and facilities related water,

5) integrated monitoring and management of quantity and quality of the water environment,

6) consignment or trust of the administration to municipal institutions.

The integrated institutional framework imaged in Figure-1.2 will be required to fulfill the foregoing administrative requirement. It aims to manage interactive process among planning (including modeling and standards), project implementation, operation and monitoring.

3.5 Institution and Legal Arrangement

At present, the government of Paraná State has been managing fairly well the administration of multiple disciplinary projects for rivers in specially designated areas such as Curitiba Metropolitan area where coordination, cooperation, and collaboration is required among institutions concerned. Management Unit of the Program of Environmental Sanitation of Curitiba Metropolitan Region (PROSAM) and Coordination of the Metropolitan Region of Curitiba (COMEC) are good examples of integrated management. These units are jointly operated by the state (SEMA, IAP and SUCEAM), municipalities, SANEPAR, etc. with collaboration by other organizations.

Therefore, the Study Team has assessed that the existing institutional framework of Paraná State has a high potential to manage the envisaged water environment provided with some improvement and flexible operational arrangement.

3.6 Monitoring and Operation Systems

3.6.1 Framework of Monitoring and Operation Systems

(1) Task of operation and monitoring systems

Task of the operation and monitoring systems is to provide necessary information and data for achieving the objectives of water environment management. The necessary information is to be classified into three:

1) Data base for project planning and implementation, including forecasting models, multifarious water use and improvement projects, and guidelines and standards,

2) Data base for administration and superintendence, including law systems, institutional framework and bulletin to the citizens, and

3) Data base for operation and monitoring, including operation of water and river facilities such as dams, intakes, and pumping stations, and maintenance.

These data bases provide the basis of interactive management procedure among the management systems and models illustrated in Figure-1.2:

1) Global hydrologic cycle model

2) Water use and waste forecasting models in socioeconomy - hydrology - ecology system

3) Multifarious water use and improvement project management

4) Integrated institutional framework

5) Operation and monitoring of surface - subsurface water system

(2) Target

As a part of the policy, the targets of A, B and C is proposed to establish desirable operation and monitoring system, of which linkage among these targets and management items of water environment is illustrated in Figure-3.5:

Target - A : High Density and Multi - dimensional monitoring

The high density and multi - dimensional monitoring aims to establish:

1) Multifarious indicator monitoring of human activity and aquatic ecology

   a) water quality items for environmental protection laws

   b) water quality and quantity items for Domestic and Industrial water supply

   c) water quality and quantity items for ecosystem preservation

   d) water quantity items for riverain landscape

   e) water quality items for recreation

   f) items for acid river and saline river

   g) items for bulletin to the citizens

2) Multitude point monitoring --- enhancement of regional density

   a) point to area and basin monitoring (regional monitoring)

   b) surface to hydrologic cycle monitoring

3) Time series monitoring --- enhancement of time axis

   c) monitoring responding to flow duration

   d) time series monitoring responding to seasonal variation (annual, monthly, 10 days, 5 days, daily, hourly, drought period, irrigation period, etc.)

Target - B : Unified Monitoring

1) Enhancement of real time and telemetric systems

2) Simultaneous monitoring of water quality and quantity

3) Regular operation systems with flexible operation to emergency

4) Linkage with surface water and groundwater

Target - C : Integrated Operation and Monitoring

In order to superintend various monitoring items and standards effectively with consistent and uniform procedure integrated operation of water and river facilities is to be attained.

1) Effective management of water and river facilities including dams, intakes, diversion facilities, outlet facilities and regulation facilities

2) Effective management of waste water treatment and water quality control facilities including treatment plants, ponds, channel, etc.

(3) System Component

A proposed operation and maintenance system is to be composed of four basic component: i.e., hydrologic cycle and simultaneous monitoring, ecosystem library monitoring, flood forecasting and warning systems, and bulletin to the citizens.

1) a system for hydrologic cycle monitoring and simultaneous monitoring of water quality and quantity

   a) a system for linking atmospheric water, surface water and groundwater observation

   b) data analysis system

   c) data bank system

   d) unified method of observation

   e) telemetering network system for real time observation

2) a system for monitoring ecosystem library

a) observation system of the population status of listed, endemic, and threatened species of aquatic, terrestrial, and avian fauna

b) observation system of terrestrial flora

c) observation system of aquatic flora

d) data bank system

3) flood forecasting and warning systems

a) hydrological observation network system

b) telemetering network system

c) flood forecasting system

d) flood warning network system

e) monitoring system

4) a bulletin system to the citizens

a) information network system for risk management

b) information network system for daily, weekly and annual reports

3.6.2 Proposed Operation and Monitoring Systems for Water Environment Management

(1) Institutional arrangement

The architecture of the monitoring and operation system for desirable water environmental management is proposed as given in Figure-3.6. The proposed State Center will administratively manage water environment all over the state, using the observed data through data and information network connecting the state center and regional centers. The regional center will monitor water environment and manage the projects at the regional level in the respective river basins and also bulletin data and information on water environment to the public and communities and discuss with communities in order to maintain and/or improve it.

Under the current organization, the SEMA is required to function as the state center and the regional centers, the branch office of the state center, are desired to be newly established for the river basins of; 1) the Iguaçu and Paraná III including Curitiba Metropolitan Area, 2) the Piquiri and Paraná II, 3) the Ivai and Paraná I, 4) the Tibagi, Pirapo and Paranapanemas II to IV, 5) the Cinzas, Paranapanema I and Itarare, and 6) the Ribeira and coastal area, under the

SEMA.

Figure-3.7 gives the institutional relationship between the state and regional centers and the related agencies, and other public communities. Also, Figure 3.7 proposes the provision of the integrated data base system and a committee for data base management. The integrated data base system is proposed to be provided at the state center and the data related to water environment observed or collected by the institutions will be registered in the data base in accordance with permission of a committee. When a committee is judged to check accuracy and reliability of data to be stored, a committee is able to provide a working group consisting of engineers belonging to the related institutions.

The COPATI, CORPRERI and COPRENE are acting as a part of water environmental management at the community level. Similar organizations will be established in accordance with the degree of severity of problems and needs. In the project management, it is considered that public and community participation for water environmental management will be expected to be one of indispensable and effective manners in order to smoothly implement the management work and to create healthy water environment by sufficiently reflecting their public intention and opinions. The regional centers will contact closely to these communities therefor.

(2) Monitoring system and information network

The integrated monitoring system is planned to be composed of sub-systems as indicated in Table-3.5; SYSTEM-1 for hydrological cycle (refer to Figure 3.8); SYSTEM-2 for ecosystem library; SYSTEM-3 for flood forecasting and warning; and SYSTEM-4 for a bulletin system to the citizens, taking into account the aforesaid targets of A to C. The monitored data by the system will be conveyed or transmitted to the state center and then, stored into the aforesaid integrated data base system.

The collected data and information will be analyzed by the state center for well managing the water environment in Paraná State and the results are proposed to be compiled into an annual report to be published.

(3) Implementation schedule

It is recommend to activate the desirable operation and monitoring systems step by step by the target year 2015. The policy target is composed of the following three:

Target - A : High density and multi-dimensional monitoring

Target - B : Unified monitoring

Target - C : Integrated operation and monitoring

The implementation schedule are presented in Table-3.7. Target - B and C are composed of institutional arrangement and networks including equipment. The institutional arrangement covers provision of management centers (a state center and several regional centers) for actual operation and maintenance and organizational and legal arrangement. An ideal image of the system architecture is illustrated in Figure-3.6.

The implementation schedule of the monitoring system (system-1 to 4) to be managed by the management centers is presented in Table-3.8. The implementation schedule of the network systems to be managed by the respective management centers is presented in Table-3.9

CHAPTER 4 MASTER PLAN STUDY

4.1 Problems and Needs on Water Environmental Management

The problems identified for the Iguaçu and Tibagi river basins are shown in Figures-4.1 to 4.3 and described as follows:

(1) Surface and sub-surface water resources management

Major large urban areas are; Curitiba and Foz do Iguaçu in the Iguaçu river basin, and Londrina and Ponta Grossa in the Tibagi river basin. Out of them, the urban area at Ponta Grossa in the Tibagi river basin and Foz do Iguaçu at the confluence of the Iguaçu and Parana rivers have a sufficient surface water sources for domestic and industrial (D&I) and agricultural water supply, which is predicted to meet D&I water demands during 20 years till 2015.

In Curitiba Metropolitan Area (CMA), the SANEPAR and PETROBRAS constructed three (3) dams and reservoirs for D&I water supply in the Passauna, Verde and Piraquara rivers. Also, the SANEPAR has initiated groundwater resources development by providing the bore holes in the aquifers of the Karst and Guabirotuba Formation. Also, private industrial companies has intensively obtained ground water from the aquifers of the Guabirotuba Formation in CMA. However, since CMA is located in the most upstream of the Iguaçu river basin and its surface water availability is rather small comparing its future water demands under the present condition, surface and subsurface water resources are required to be developed under consistent management and control in order to meet the future D&I water demands during 20 years till 2015. While, there are no inspection bore holes which are usually provided to measure groundwater table and water quality and to evaluate the potential ground water resources of an aquifer.

Londrina urban area is located downstream of the Tibagi river basin and its water source for D/I water supply is currently depending on the Tibagi river, lifting the water taken at the Tibagi river to the SANEPAR's water treatment plant by pump and pipeline with a significant hydraulic head of about 200 m. The COPEL has a plan to develop Jataizinho and Cebolao dams and reservoirs for hydropower generation, both which are located near Londrina urban area. To reduce the lifting hydraulic head from the intake site to the treatment plant and construction and operation and maintenance cost of the planned water supply facilities, it is expected to provide an intake in the planned reservoir area and to convey water to Londrina under planning and operational management of the SANEPAR and COPEL.

In other urban areas mainly developed along the existing road on the hilly area, the surface and/or subsurface water resources development are necessary to be selected or combined according to the availability of the aforesaid water resources. Although the groundwater monitoring has not been made in these areas, there is low possibility that the groundwater extraction at the current level induces the significant problems on surface and ground water uses.

(2) Water excess management

There are no significant flooding problems in the Tibagi river basin, while the several areas have suffered from the inundation due to floods with large magnitude in the Iguaçu river basin. The flood prone areas in the Iguaçu river basin are spread at eight (8) locations; 1) the southern part of CMA along the Irai-Iguaçu river, 2) Sao Mateus do Sul, 3) Port Amazonas, 4) Rebouças and Guarapuava, 5) Uniao da Vitoria, 6) Rio Negro and Mafra along the Negro river, a tributary of the Iguaçu river, 7) Foz do Iguaçu, and 8) Capanema.

The water excess management needs combination of structural and non-structural measures in order to mitigate flood damages, taking into account degree of flood damages there, cost for improving flooding situation, socio-economic needs and so on. Structural measures such as provisions of dyking system and/or river channel improvement are planned to be applied for the aforesaid areas of 1), 2) and 5). While, non-structural measures such as land use control in flood prone areas, appropriate resettlement, evacuation based on information from FFWS of DNAEE, and/or flood proofing are recommended for all the areas.

In executing the proposed structural and non-structural flood control works, monitoring on such socio-economic condition as properties, land use and population in the flood prone areas are necessary to be made in order to grasp change of flood damage potential for planning and selecting appropriate countermeasures.

(3) Water quality management

The SANEPAR provides about 90 sewerage facilities with a capacity to meet sewage of population of about 700,000 corresponding to about 50 % of total population in 1993 in CMA. The other 50 % of sewage is discharged with or without preliminary treatment into the tributaries joining to the Iguaçu river. While, the SANEPAR takes river water in at these tributaries for domestic and industrial water supply and therefore, the drought discharge downstream from the intake sites is decreased. As a result, this decrease of drought discharge and influx of sewage in the tributaries have worsened the river water quality in CMA and the Iguaçu river.

While, since other urban areas in the Tibagi and Iguaçu river basins are mainly developed in the hilly areas, their sewage is discharged into the adjacent tributaries of the areas and the river water quality is predicted to be worsened due to increase of sewage load during 20 years till 2015. Also, it is considered that pesticide and fertilizer are one of water pollution sources but there are no sufficient data for identification of magnitude of impact and effect for human beings and ecological system.

According to an investigation on heavy metals contained in the riverbed material in the Iguaçu and Tibagi rivers, which was undertaken by the JICA Study Team, heavy metals such as lead and chrome were detected at high concentration. It is considered that the pollution source may be natural mineral and/or industrial waste water from the urban area. However, the availability of data on riverbed material is rather limited for evaluation of polluted situation and therefore, it is required to carry out water quality analysis on riverbed material in order to provide sufficient data for evaluation of pollution situation and source.

Monitoring work for water quality of the river water have been carried out at 54 locations in the Iguaçu river basin and 38 locations in the Tibagi river basin by the DNAEE and IAP with a frequency of three (3) to four (4) times a year. However, the observation at a large part of the stations was not undertaken in these years even in CMA though the water quality in CMA has been worsened as described above.

Furthermore, a reporting system of the industrial waste water quality to be measured by the owner of industrial factory is not established by the Government. In consideration of increase of industrial waste water loads due to industrialization, a reporting system is necessary to be urgently introduced with institutional support.

(4) Aquatic ecological system conservation management

There is no sufficient data for evaluating the present aquatic ecological system along the Iguaçu and Tibagi rivers. Therefore, it is strongly required to investigate the present situation of aquatic ecological system in the river basins and monitor future change of its system.

(5) Soil erosion management

The Iguaçu and Tibagi river basins are ranked at the tolerant or moderate soil erosion area in general. However, the most upstream areas in the tributaries and origin of the river basins have been developed mainly for agricultural activities and soil erosion rate has been increased by diversification of vegetation condition from natural forest or vegetation to agricultural crops.

It is considered that increase of soil erosion will induce deterioration of the groundwater recharge system and reduction of base flow discharge thereby, increase of flood peak discharge due to reduction of infiltration rate of rainfall and retention function of the basin. Furthermore, the high sediment concentration will worsen river water quality and require high operation and maintenance costs for such water use facilities as water treatment plant and irrigation canal system.

In order to formulate an soil erosion control plan and provide countermeasures, it is necessary to measure the actual sediment discharge from the severe erodible areas. However, a frequency of the sediment survey carried out by the DNAEE, IAP and COPEL is less than ten (10) times a year in average and is insufficient for estimate of sediment discharge with high accuracy.

(6) Inland navigation management

Currently, the Paraná river is used as a navigation route to Paraguay and States of Sao Paulo and Mato Grosso do Sul. There is a plan to develop inland navigation routes which enable to navigate to Doutor Camargo in the Ivai river and Jataizinho in the Tibagi river through the Parana and Paranapanema rivers. Provision of navigation locks at the existing and planned dam/reservoirs for hydropower generation along the Parana and Paranapanema rivers are also planned to be undertaken by the project.

It is recommended to include the environmental impact assessment in updating the feasibility studies for the mentioned navigation development projects in order to clarify affected items and their magnitude of the impacts to be induced by implementation of the projects, though the project may have no significant impacts on water environment.

4.2 Existing Monitoring and Operation System in the Iguaçu and Tibagi River Basins

4.2.1 Operation System

Table-4.1 indicates the existing operation and monitoring system for water environmental management.

The existing domestic water supply systems using surface and subsurface water sources has been operated by the SANEPAR and autonomous bodies, and its system management has been done well on measuring intake discharge, counting distributed water amount, and so on. While, industrial water users are mainly taking water in from the both water sources individually. These industrial water users are divided into two (2) parts; authorized and unauthorized water users. The former users apply for their water uses with their intake discharges and industrial waste water amount to the IAP, and the IAP permits/registers them taking into account the water availability. But, operational records are not submitted to the IAP. As for the later users, there is no management work done by the IAP and SANEPAR. Especially, there is a report that a number of the bore holes managed with permission by the IAP are 3,400 while unmanaged ones are more than 10,000 in the whole Parana State.

There are six (6) dams operated by the ELETROSUL and COPEL for hydropower generation and three (3) dams operated by the SANEPAR and PETROBRAS for D&I water supply in the Iguaçu river basin. There are two (2) dams and reservoirs in the Tibagi river basin, though there is a plan for cascade hydropower development by construction of dams. The existing dams have been constructed for a single purpose not for multifarious uses. However, there are needs for such multifarious use of the existing and planned reservoirs as hydropower generation, water supply, flood control, navigation and fish culture in order to effectively use the available water resources. There are such plans and possibility as the inland navigation development connecting the Parana river and the Paranapanema with the Ivai and Tibagi rivers through the existing and planned dams/reservoirs, the Irai dam development for water supply and flood control, possibility of hydropower generation and fish culture development in the reservoirs in the Iguaçu and Tibagi rivers, and so on.

Six (6) hydropower stations in the Iguaçu river basin and two (2) in the Tibagi river basin is operated and managed by the ELETROSUL and COPEL.

4.2.2 Monitoring System

Monitoring of meteorological and hydrological data in the Iguaçu and Tibagi river basins has been made by the DNAEE, IAP, COPEL and IAPAR. A number of the observation stations in the aforesaid river basins are summarized as follows:

Observation Items		Iguaçu River	Tibagi River
Catchment area (km^2)		68,700	24,635
Meteorological stations		16 (4,294)	7 (3,519)
Rainfall observation stations		301 (228)	126 (196)
Rate of automatic and telemetering gauges (%)		17	13
Flow observation stations	a) Main stream	39	21
	b) Tributaries	58	25
Water quality observation		58	38
Sediment observation stations	a) Main stream	9	10
	b) Tributaries	31	21

Note: Figures in parenthesis indicate density of observation station (1 no. / km^2).

The DNAEE has developed flood forecasting and warning system (FFWS) composed of telemetering rainfall and water level gauges and forecasting model in the Iguaçu river basin in order to distribute information and data on flood to the COPEL and ELETROSUL for their reservoir operation and to Civil Defense for the activities against flood. Also, the COPEL and ELETROSUL have own operation system including meteorological and hydrological observation and data transmission system.

The DNAEE will start the project named as National Strategic Network in 1995, which will consists of installation of 513 rainfall and water level telemetering stations covering whole Brazil, data transmission system using the satellites of TIROS, NOAA and SCD 1 and data storage and analyzing system to raise reliability of data transmission network. The existing telemetering system in the FFWS in the Iguaçu river is scheduled to be incorporated into this nationwide system.

River water quality monitoring has been carried out at the main stream and tributaries of the aforesaid rivers with a frequency of four (4) times or more a year by the IAP and DNAEE. However, it is identified that there are interrupted periods in the large part of observation records at many stations and that it is impossible to evaluate its change on river water quality there. Test items are 1) water temperature, 2) pH, 3) dissolved oxygen, 4) coliform fecal, 5) BOD, 6) total nitrogen, 7) total phosphate, 8) turbidity, and 9) total solid in general. Water quality analysis for heavy metal have been undertaken in accordance with the requirement.

As for monitoring on aquatic ecological system, there have been no integrated and/or periodical investigation but it is initiated by the IAP, COPEL and the public organization of COPATI in these years.

Sediment sampling and its analysis have been made at 40 sites in the Iguaçu river and 31 sites in the Tibagi river by the IAPAR, COPEL, DNAEE and IAP. However, the frequency of observation is quite insufficient for evaluating soil erosion rate with high accuracy. While, the gross soil erosion rate has been examined by the pilot projects by the IAPAR under the EMATER.

4.3 Master Plan for Water Environment Management

4.3.1 General Conditions

The master plan was studied by applying the methodology for planning and the strategy for the water environment management by the Study described in the previous Chapters. Figure-4.4 indicates issues to be monitored in the Iguaçu and Tibagi river basin.

The Study employed an integrated management framework composed of; 1) integrated institutional framework; 2) water uses and waste water forecasting for planning in socio-economy-hydrology-aquaecology system; 3) project management for multifarious water use and water environmental improvement; 4) monitoring and operation of surface and subsurface water system; and 5) global hydrological cycle model. The master plan for the Iguaçu and Tibagi river basins were studied by applying the mentioned concept.

The current study has established the following implementation targets for monitoring and operation system as illustrated in Figure 3.5:

Target-A : High density and multi-dimensional monitoring for observation points, items and frequency

Target-B : Unified monitoring for observation methods and observation linkage of surface and subsurface water levels

Target-C : Integrated operation and monitoring for effective operation for water use facilities, river structures, water treatment facilities and water quality facilities

The Master Plan aims to enhance the existing monitoring and operation systems to the target levels during 20 years till 2015.

4.3.2 Monitoring System in the Iguaçu and Tibagi River Basins

The current level of the existing monitoring and operation system was evaluated by comparing the targets of A to C and the required activities for reaching these target levels and were studied together with their urgencies and implementation schedule. The result is described as follows:

(1) Monitoring for meteorological data

The required number of additional meteorological gauging stations are estimated by assuming 1,200 km^2 per a station indicated in the required density in Table-3.6 as follows:

Observation Items	Iguaçu River	Tibagi River
Catchment area (km^2)	68,700	24,635
1) Existing Meteorological Stations		
a) Number of stations	16	7
b) Density (no./km^2)	4,294	3,519
2) Required Meteorological Stations		
a) Number of stations	58	21
b) Density (no./km^2)	1,200	1,200
3) Additionally required stations	42	14
4) SIMEPAR's System	38	14
5) Further Provision of Stations	4	0

As indicated in the above table, the on-going SIMEPAR's project are scheduled to provide the meteorological gauging stations with telemetering equipment in the Iguaçu and Tibagi river basins. The SIMEPAR's system will give more detailed and sufficient data and information related to weather condition in the respective river basins. Four (4) meteorological gauges are evaluated to be provided to the Iguaçu river basin.

While, the required number of additional rainfall gauging stations are estimated as follows:

Observation Items	Iguaçu River	Tibagi River
Catchment area (km^2)	68,700	24,635
1) Existing Meteorological Stations		
a) Number of stations	301	126
b) density (no./km^2)	228	196
2) Required Meteorological Stations		
a) Number of stations	404	145
b) density (no./km^2)	170	170
3) Additionally required stations	103	19
4) SIMEPAR's System Improving the Existing Stations by provision of telemetering equipment	38	14
5) Further Provision of Stations	103	19

As shown in the mentioned table, the existing stations will be improved by the SIMEPAR's project and provide the real time data on rainfall in the Paraná State, though no installation of new rainfall gauges are included in the project. Therefore, the new installation of 122 stations in total is required.

The spatial distribution of the mentioned meteorological gauges are recommended to be decided taking into account the meteorological characteristics based on the data to be provided by the SIMEPAR's system and the existing observation network after its completion of the project.

(2) Stream flow observation

The water resources development by providing dam/reservoir or weir structures will require the stream flow data with high accuracy at the structure sites for managing the project from planning to operation and maintenance. Since the currently proposed development schemes are generally located in the upstream river basin and there are no stream flow gauges at the site, stream gauges are required to be installed in accordance with the project implementation:

Municipalities	Potential Surface Water Resources
Iguaçu River Basin	
1) Curitiba Metropolitan Area	Tributaries of the upper Iguaçu river
2) Cascavel	Tributary of the Iguaçu river, the Piquiri river or a river flowing into the Paraná river
3) Foz do Iguaçu	Parana river
4) Guarapuava	Tributaries of the Iguaçu or Piquiri rivers
5) Other large urban areas (6 municipalities)	Rivers adjacent to the respective urban area
Tibagi River Basin	
1) Ponta Grossa	Tibagi river
2) Londrina	Tibagi river and neighboring tributaries
3) Apucarana	Tibagi river and neighboring tributaries
4) Other large urban areas (7 municipalities)	Tributaries adjacent to the respective urban area

The water demands in most of the above urban areas is considered to occupy the large part of flow discharge at the intake sites where the drainage area is comparatively small, and therefore, the strict management will be necessary in order to minimize the impact on water environment.

Among the rivers in the mentioned municipalities, there are no gauges at the proposed intake sites in the urban areas of Cascavel, Guarapuava and 5 municipalities in the Iguaçu river basin, and Londrina, Apucarana and 4 municipalities in the Tibagi river basin. Therefore, the total of 18 gauges are proposed to be installed in the mentioned tributaries.

(3) River water quality observation

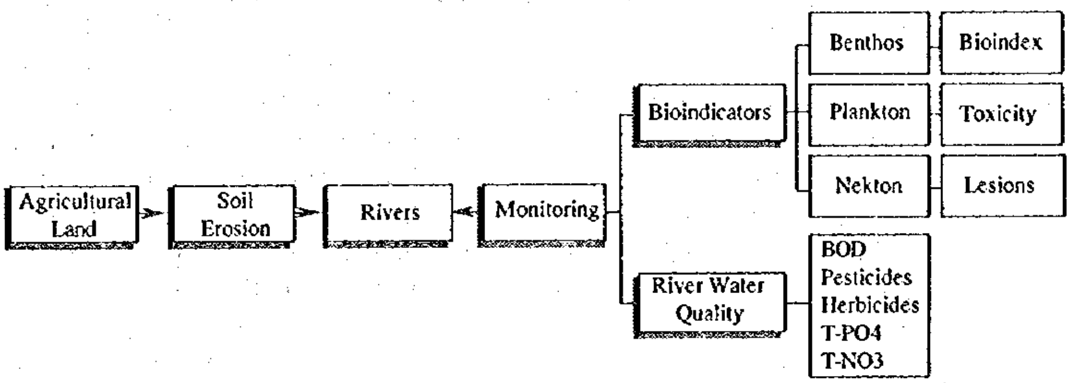
Water quality stations have been installed at the major points along the main stream, at the main tributaries and at locations where quality problems are identified or predicted. But, its observation work after 1990 has been interrupted at several stations. In addition, heavy metals were identified with high concentration in both the Tibagi and Iguaçu rivers by the water quality analysis undertaken by JICA.

From these aspects, the current observation network is required to be strengthened by restarting the observation work at the mentioned stations and carrying out water quality test for heavy metal in the streams flowing in the industrial areas. Furthermore, a reporting system for industrial waste water and treated water from the sewerage treatment plant of the SANEPAR is strongly required to control the river water quality.

The mentioned activities have priorities considering the deterioration of river water qualities in CMA and other urban areas and is proposed to be implemented in the 1st stage. In the 2nd stage, provision of additional water quality stations is recommended to be installed at locations where water quality is predicted to be worsened by inflow of the sewage and industrial waste water from the urbanized areas to the tributaries. The proposed new stream flow gauge sites for water use management are also prospective as water quality monitoring sites.

While, the pesticide and fertilizer utilized in agricultural sector are one of the significant water pollution source. It is necessary to investigate and identify the kind of pesticide and fertilizer currently utilized in agricultural sector and its chemical composition, and degree of influence of those to aquatic ecology and human beings firstly, since there are no sufficient data to specify test items for detecting pesticide and fertilizer in the Study. The standards and guidelines for water quality monitoring for pesticide and fertilizer are required to be established on the basis of the investigation result.

As one of monitoring method for pesticide and fertilizer, bioindicators such as benthos, plankton and nekton will give the basis for evaluating polluted situation in aquatic ecology due to pesticide and fertilizer as well as water quality tests as proposed in the Sectoral Report K for Ecology):



(3) Sediment observation

Research and investigation work have been made by the IAPAR under the EMATER, and sediment observation has made mainly by the DNAEE, COPEL, IAP and IAPAR. In order to identify problems and monitor effects due to reforestation and terracing works proposed in the current study, it is necessary to undertake more frequent observation of sediment loads at the existing stations or station to be newly established in the severe erosion areas. In observation, sediment flow samples at flood time, which occupies the major part of the annual sediment discharge, is necessary to be taken intensively. Identified severe erosion areas are as follows:

Pilot River Basin	Rivers with Severe Erosion Areas
Iguaçu River Basin	1) Santo Antonio
	2) Capanema
	3) Chopin
	4) Cavernoso
	5) Potinga
	6) Gonçalves Dias and Andrade
Tibagi River Basin	1) Congonhas
	2) A small river flowing in Assai
	3) S. Jeronimo
	4) A small river flowing near Sapopema

In these river basins, the intensive measurement is required to be carried out at the existing stream gauge sites in the Iguaçu and Tibagi river basin. With respect to sediment monitoring in the river in Assai, S. Jeronimo river and the river near Sapopema in the Tibagi river basin, there are no gauges and therefore, provision of new stream gauges in these rivers and monitoring of sediment loads are recommended.

(4) Aquatic ecology monitoring

There has been no integrated aquatic ecology monitoring. It, therefore, is required to initiate the monitoring work so as to provide basic data for establishing the conservation plan of aquatic ecosystem along the rivers.

Aquatic ecology monitoring is required to include bioindicator sampling such as benthos, plankton and nekton and chemical analysis for aquatic biota and water quality as proposed in the ecological improvement study. Also, investigation on vegetation along the river side area using the available Geographic Information System (GIS) and fish inventory survey are recommended to be carried out.

Aquatic ecological data and information obtained through monitoring is necessary to be analyzed and evaluated by the IAP. However, aquatic ecology in the river is judged to be affected by the surrounding ecological system and therefore, data and information for such ecological system is necessary for achieving the objective of aquatic ecology monitoring. There is an idea of establishment of a biodiversity institute which deals with the ecological monitoring and research in the Parana river basin, Parana State or nationwide level.

(5) Establishment of integrated monitoring system for surface and subsurface water resources in Curitiba Metropolitan Area and Expansion to Other Urban Areas

There are many bore holes provided by the SANEPAR and private industrial factories. The surface water resources development is going on in CMA where both water resources is mutually affected in quality and quantity. In order to undertake well balanced development for these water resources, the following monitoring work is required:

a) prediction of domestic and industrial water demands based on population, land use, economic data, and so on,

b) provision of monitoring bore holes for observation of water table and water quality, and additional river water level gauge in the Karst area,

c) installation of flow meter to the authorized and unauthorized bore holes as well as identification of location of the unauthorized bore holes, and

d) establishment of global hydrological cycle model which enables to estimate potential water resources and to evaluate water demand/supply balance incorporating both water resources and other hydrological components.

The establishment of monitoring system including the model mentioned above is recommended to be made for CMA in the 1st stage, where the intensive ground water development has been carried and it is predicted to induce such problems as lowering of ground water table and reduction of intake discharge at the existing bore holes thereby. The 2nd stage will apply the established monitoring method and model to other basins, where occurrence of similar problems are predicted. The required inspection bore holes for the urban areas are as follows:

Municipalities	Required Number of Boreholds	Total Length of Boreholds (m)
Iguaçu River Basin		
1) Curitiba Metropolitan Area (Karst)	17	1,020
Curitiba Metropolitan Area (Guabirotuba Formation)	20	1,600
2) Cascavel	6	480
3) Foz do Iguaçu	10	800
4) Guarapuava	1	80
5) Other large urban areas (6 municipalities)	11	880
Tibagi River Basin		
1) Londrina	4	320
2) Apucarana	2	160
3) Other large urban areas (7 municipalities)	10	800

(6) Establishment of integrated data base system under SEMA

There are no integrated data base system for water environmental management in the SEMA. While, the SUCEAM and IAP will require the data base system for planning water resources development and conservation of water environment. The proposed data base system will contain; a) socio-economic data such as economic indices, land use and population, b) meteorological and hydrological data, c) data on ground water, d) water quality records, e) sediment observation data, and f) aquatic ecological data. The data accumulated in the data base system will be used for prediction of water demand, water demand/supply balance analysis incorporating surface and subsurface water resources, simulation of river water quality, and so on.

(7) Data and information network

The proposed State Center is able to collect data and information from the computer systems of the SIMEPAR and DNAEE through the existing telephone cable line. This data transmission system is applied for communication system between the state and regional centers and other related institutions in the 1st stage. In order to raise reliability of transmission method between these institutions, the satellite system will be introduced in the 2nd stage.

4.3.3 Required Cost

The required incremental cost for providing the proposed monitoring system was estimated on the basis of the cost data and information provided by the counterpart personnel. But, other incremental cost for operation and maintenance, and replacement of observation equipment for the proposed additional meteorological and hydrological observation stations and integrated computer system was not worked out. The result is described as follows:

(1) Provision of additional meteorological and hydrological observation stations

On-going SIMEPAR's project

The SIMEPAR's project is going on as described in Chapter 2 and the total cost of US$ 35 million is scheduled to be disbursed during coming 5 years from 1996. Therefore, the mentioned cost is excluded from the master plan.

Meteorological observation stations

Four (4) observatories are proposed to be newly provided in the Iguaçu river basin. The observation items are 1) temperature, 2) wind velocity and direction, 3) sunshine hours, 4) humidity, 5) pan evaporation, 6) rainfall and 7) radiation. A required cost for provision of an observatory is estimated at US$ 7,500 per one station including equipment and civil works. The total cost is US$ 30,000 for the Iguaçu river basin.

Rainfall gauging stations

New rainfall gauging stations of 122 is necessary to meet the target density of observation network. Assuming an unit price of US$ 1,500 for provision of a rainfall gauge with an automatic recorder, the total cost is estimated at US$ 183,000.

Stream flow gauging stations

New stream flow gauges are proposed to be provided at eighteen (18) sites for water use management for water supply and water quality monitoring, three (3) sites for management of soil erosion improvement, and five (5) sites for monitoring base flow in the Karst area. The required cost is estimated at US$ 260,000.

Inspection boreholes

The total number and length of the proposed inspection boreholds are 81 holes and 6,140 m and the required cost is estimated as follows:

Municipalities	Number of Boreholds	Length of Boreholds (m)	Boring Unit Price (US$)	Boring Amount (US$)	Monitoring Equipment (US$)	Total Cost (US$)
Iguaçu River Basin						
1) Curitiba						
• Karst	17	1,020	270	275,400	136,000	411,400
• Guabirotuba Formation	20	1,600	110	176,000	160,000	336,000
2) Cascavel	6	480	80	38,400	48,000	86,400
3) Foz do Iguaçu	10	800	80	64,000	80,000	144,000
4) Guarapuava	1	80	80	6,400	8,000	14,400
5) Other large urban areas (6 municipalities)	11	880	80	70,400	88,000	158,400
Tibagi River Basin						
1) Londrina	4	320	80	25,600	32,000	57,600
2) Apucarana	2	160	80	12,800	16,000	28,800
3) Other large urban areas (7 municipalities)	10	800	80	64,000	80,000	144,000
Total	81	6,140		733,000	648,000	1,381,000

Telemetering system

It is recommended that telemetering system is provided in 2nd stage after 2005 based on hydrological analysis to decide the required numbers and exact location using observation records to be obtained by the existing and on-going SIMEPAR's systems, since the SIMEPAR is planned to provide the weather radar which enables to monitor rainfall amount and its movement in real time and to decrease the requirement of provision of the telemetering system. Therefore, the cost for provision of telemetering system is not included in the master plan.

(2) Integrated data base system and transmission system

A computer system with a printer and other accessories are proposed for the integrated data base system for water environment management. The telephone line transmission system connecting between the state and regional centers is applied for cost estimate. The cost for one set of computer system and telephone network system is estimated at US$ 10,000. This computer system is proposed to be provided at the state center and six (6) regional centers and therefore, seven (7) sets and the cost of US$ 10,000 are required.

(3) Annual investigation cost for water quality and sediment loads

The incremental annual cost for water quality analysis is estimated by assuming test items of water and air temperature, dissolved oxygen, coliform fecal, pH, BOD, COD, total nitrogen, total phosphate, turbidity, total solid, heavy metals such as lead and chrome, and pesticide and fertilizer for identifying the basic condition of river water quality. Also, it is assumed that observation frequency is four (4) times a year, and two (2) samples are taken at one location and analyzed. Sampling cost is mainly estimated by mobilization cost and personnel expenses.

In estimating the required cost, the sampling and analysis are assumed to be carried out at the existing and newly provided 64 stations in the Iguaçu river basin and 48 stations in the Tibagi river basin.

Based on the unit prices available in the IAP and sampling cost, the cost of one sampling and water quality analysis for them are estimated at US$ 1,500 and the annual cost for water quality analysis is derived at US$ 384 thousands for the Iguaçu river basin and US$ 288 thousands for the Tibagi river basin.

Sediment sampling and analysis for identification of sediment loads require the annual cost of US$ 3,000 per station assuming the frequency of 10 times a year and three (3) samples/location per sampling. Applying this unit cost per year to all the stations, US$ 120 thousand for the Iguaçu river basin and US$ 102 thousand for the Tibagi river basin are necessary to carry out monitoring works.

4.3.4 Implementation Schedule of the Required Activities

The implementation schedule for the required activities is given as shown in Figure-4.5. The required activities to cope with the problems and needs related to urbanization and industrialization, and the on-going projects and strengthening of the existing monitoring systems are scheduled to be undertaken in the 1st stage during 10 years to 2005. The activities in the 2nd stage are mainly for the expansion or upgrading of monitoring system established in the 1st stage.

CHAPTER 5 FURTHER STUDY REQUIRED

The following studies are required to establish desirable water environment management system based on a concept of river basin management in Paraná state:

(1) Study on state and regional centers

The mentioned management centers are recommended to realize a concept of river basin management in the wide area of Paraná state. The study on detailed organization, function, activities and necessary arrangement for staffing, budget, and equipment is urgently required to be carried out by the Government of Paraná state as well as the studies on an integrated data base system and information network.

(2) Meteorological and hydrological monitoring

Presently, the system of SIMEPAR is being implemented by the Government of Paraná State. This system will improve the existing meteorological and hydrological observation network by providing telemetering observation system and rainfall radar system, both which cover the river basins in Paraná state. It is recommended to carry out the following studies and analysis based on the data to be obtained by the mentioned system and to establish a program of provision of additional observation equipment:

1) Meteorological analysis to clarify its characteristics in the respective river basins in Paraná state,

2) Analysis on relationship between rainfall depth, area and duration, which will give the important information to decide location and number of additional rainfall stations proposed by the Study, and

3) Base flow analysis to work out the natural flow to investigate base flow characteristics, and water demand and supply balance analysis under the present water use condition for planning of future water supply plan and river water quality improvement plan and necessary actions.

4) Flood runoff analysis using rainfall data to be obtained by the SIMEPAR's system and the existing rainfall stations, flood hydrograph data at the necessary stations for effective operation of flood forecasting and warning system and the existing planned dams. Specially, rainfall-runoff model for urban storm water is required to be established for managing drainage system in the large urban areas.

5) Sediment analysis in river basins to be identified as severe erosion area by using the available data as well as topographic survey in the existing reservoirs for measuring the actual sedimentation, and establishment of sediment balance model incorporating the effect of measures for soil erosion control

6) Water quality studies to calibrate applied model for estimation of BOD load and other indices presenting the river water quality condition for management of water quality

(3) Establishment of global hydrological cycle model for Curitiba metropolitan area

The Study introduced the mentioned concept for managing water quantity and quality and aquatic ecology in Curitiba metropolitan area. The further study is required to be carried out to provide the proposed hydrological observation stations for surface water and inspection boreholds for groundwater, and to investigate and monitor aquatic ecology in the area. The study will work out the global hydrological cycle model incorporating the surface and sub-surface water and aquatic ecology, using observation data to be obtained through the study.

TABLES

Table - 2.1 Nation, State and Municipality Located in the River Basin in Parana State (1991)

River Basin	International	State	Municipality (Municipalities of Parana)
(1) Parana (main stream and tributaries	Brazil, Paraguay	Parana, Mato Grosso Do Sul, Sao Paulo	Loanda, Marilena, Porto Rico, Querencia Do Norte, Santa Cruz de Monte Castelo, Sao Pedro Do Parana, Altonia, Icaraima, Perola, Sao Jorge do Patrocinio, Umuarama, Xambre, Cascavel, Ceu Azul, Foz do Iguacu, Guaira, Marechal Candido Rondon, Matelandia, Medianeira, Missal, Nova Santa Rosa, Palotina, Santa Helena, Santa Terezinha do Itaipu, Sao Jose das Palmeras, Sao Miguel do Iguaçu, Terra Roxa, Teledo, Vera, Cruz do Oeste, Pinhas, Fazenda Rio Grande
(2) Paranapanema (main stream and tributaries	Brazil	Parana, Sao Paulo	Andira, Cambara, Itambaraca, Jacarezinho, Ribeirao Claro, Cornelio Procopio, Leopolis, Santa Mariana, Sertaneja, Alvorada Do Sul, Bela Vista do Paraiso, Cafeara, Cambe, Centenario do Sul, Colorado, Florestopolis, Guaraci, Itaguaje, Jaguapita, Lupionopolis, Miraselva, Nossa Senhoras das Gracas, Porecatu, Primeiro de Maio, Rolandia, Santa Ines, Santo Inacio, Alto Parana, Cruzeiro dos Sul, Diamante do Norte, Guairaca, Inaja, Itauna do Sul, Jardim Olinda, Nova Esperanca, Nova Londrina, Paranacity, Paranapoema, Paranavai, Santo Antonio do Caiua, Sao Joao do Caiua, Terra Rica, Uniflor
(3) Iguacu (main stream and tributaries	Brazil, Argentina	Parana, Santa Catarina	Agudos do Sul, Almirante Tamandare, Ampere, Antonio Olinto, Araucaria, Balsa Nova, Barracao, Bituruna, Boa Vista Da Aparecida, Campina Grande Do Sul, Campo do Tenente, Campo Largo, Cantagalo, Capanema, Capitao Leonidas Marques, Cascavel, Catanduvas, Ceu Azul, Chopinzinho, Clevelandia, Colombo, Contenda, Coronel Vivida, Cruz Machado, Curitiba, Dois Vizinhos, Eneas Marques, Foz do Iguaçu, Francisco Beltrao, general Carneiro, Guaraniacu, Guarapuava, Inacio Martins, Irati, Itapejara do Oeste, Lapa, Laranjeiras do Sul, Mallet, Mandirituba, Mangueirinha, Mariopolis, Marmeleiro, Matelandia, Medianeira, Nova Prata do Iguaçu, Palmas, Palmeira, Pato Branco, Paula Freitas, Paulo, Frontin, Perola do Oeste, Pien Pinhao, PiraquaraPlanarto, Porto Amazonas, Porto Vitoria, Pranchita, Quatro Barras, Quedas do Iguaçu, Quintandinha, Realeza, Rebouças, Renascenca, Rio Azul, Rio Negro, Salgado Filho, Salto do Lontra, Santa Izabel do Oeste, Santa Terezinha de Itaipu, Santo Antonio do Sudoeste, Sao Joao do Triunfo, Sao Jorge do Oeste, Sao Pinhais, Fazenda Rio Grande
(4) Piquiri	Brazil	Parana	Altamira Do Parana, Altonia, Alto Piquiri, Aranna, Assis Chateaubriand, Boa Esperanca, Braganey, Cafelandia, Campina da Lagoa, Campo Mourao, Cantagalo, Cascavel, Catanduvas, Cianorte, Corbelia, Cruzeiro Do Oeste, Formosa do Oeste, Francisco Alves, Goio Ere, Guaraniacu, Guarapuava, Ipora, Janiopolis, Jesuitas, Juranda, Laranjeiras do Sul, Mambore, Marilus, Moreira Sales, nova Aurora, Nova Cantu, Nova Santa Rosa, Palmital, Palotina, Perola, Pitanga, Roncador, Tapejara, Terra Roxa, Toledo, Tuneiras do Oeste, Tupassi, Turvo, Ubirata, Umuarama, Xambre
(5) Ivai	Brazil	Parana	Alto Parana, Amapora, Apucarana, Araruna, Barbosa Ferraz, Bom Sucesso, Borrazopolis, California, Cambira, Campo Mourao, Candido de Abreu, Cianorte, Cidade Gaucha, Cruzeiro do Oeste, Douradina, Doutor Camargo, Engenheiro Beltrao, Faxinal, Fenix, Floral, Floresta, Guairaca, Guaporema, Guarapuava, Grandes Rios, Icaraima, Imbituba, Indianopolis, Irati, Iretama, Itambe, Ivai, Ivaipora, Ivatuba, Jandaia do Sul, Japura, Jardim Alegre, Jussara, Kalore, Loanda, Lunardelli, Mambore, Mandaguacu, Mandaguari, Manoel Ribas, Maria Helena, Marialva, Marilandia do Sul, Marinaga, Marumbi, Mirador, Nova Alianca do Ivai, Nova Esperanca, Nova Olimpia, Ortigueira, Ourizona, Paicandu, Paraiso do Norte, Paranavai, Peabiru, Pitanga, Palanaltina do Parana, Presidente Castelo Branco, Prudentopolis, Querencia do Joao do Ivai, Sao Jorge do Ivai, Sao Pedro do Ivai, Sao Tome, Tamboara, Tapejara, Tapira, Terra Boa, Tuneiras do Oeste, Turvo, Umuarama
(6) Pirapo	Brazil	Parana	Apucarana, Arapongas, Astorga, Atalaia, Cambira, Colorado, Cruzeiro do Sul, Florida, Guaraci, Iguaracu, Itaguaje, Jaguapita, Jandaia do Sul, Jardim Olinda, Lobato, Mandaguacu, Mandaguari, Marialva, Maringa, Munhoz de Mello, Nossa Senhora das Gracas, Nova Esperanca, Paranacity, Paranapoema, Presidente Castelo Branco, Rolandia, Sabaudia, Santafe, Santa Ines, Sarandi, Unifor
(7) Tibagi	Brazil	Parana	Apucarana, Arapongas, Assai, Bela Vista Do Paraiso, California, Cambe, Castro, Congonhinhas, Cornelio Procopio, Curiuva, Ibipora, Imbituva, Ipiranga, Irati, Ivai, Jataizinho, Leopolis, Londrina, Marilandia do Sul, Nova America Da Colina, Nova Fatima, Ortigueira, Palmeira, Pirai do Sul, Ponta Grossa, Porto Amazonas, Primeiro de Maio, Rancho Alegre, Reserva, Rolandia, Santa Cecilia do Pavao, Santo Antonio do Paraiso, Sao Jeronimo da Serra, Sao Sebastiano da Amoreira, Saponema, Sertaneja, Sertanopolis, Teixerira Soares, Telemaco Borba, Tibagi, Urai
(8) Cinzas	Brazil	Parana	Abatia, Andira, Arapoti, Bandeirantes, Barra do Jacare, Carlopolis, Congonhinhas, Conselheiro Mairinck, Cornelio Procopio, Curiuva, Figueira, Guapirama, Ibaiti, Itambaraca, Jaboti, Jacarezinho, Jaguariaiva, Japira, Joaquim Tavora, Jundiai do Sul, Nova Fatima, Pinhalao, Pirai do Sul, Quatigua, Riberao Claro, Ribeirao do Pinhal, Santa Ameria, Santa Mariana, Santo Antonio da Platina, Saponema, Siqueira Campos, Tibagi, Tomazina, Wenceslau Braz
(9) Itarare (main stream and tributaries	Brazil	Parana, Sao Paulo	Arapoti, Carlopolis, Jaguariaiva, Joaquim Tavora, Pirai do Sul, Ribeirao Claro, Salto do Itarare, Santana do Itarare, Sao Jose da Boa Vista, Senges, Siqueira Campos, Wenceslau Braz
(10) Ribeira (main stream and tributaries	Brazil	Parana, Sao Paulo	Adrianopolis, Almirante Tamandare, Bocaiuva do Sul, Campina Grande do Sul, Campo Largo, Castro, Cerro Azul, Colombo, Guaraquecaba, Palmeira, Ponta Grossa, Quatro Barras, Rio Branco do Sul, Itaperuce, Tunas Do Parana
(11) Coastal basins	Brazil	Parana	Antonina, Guaraquecaba, Guaratuba, Matinhos, Morretes, Paranagua, Sao Jose dos Pinhais, Tijucas do Sul

Source : IAP

Table - 2.2 Institution in Charge of Water Administration by Sector

INSTITUTION	Federal					State								Municipality	NGO		
	MME				MIR	SEMA		SANE-PAR						Municipal Office			
SECTOR	DNPM	DNAEE	E-BRAS	IBAMA	SIR	SUCEAM	IAP		COMEC	SEAB	SEPL	SETR	COPEL*		COPATI	CORP-RERI	COP-RENE
(1) Ground water Use	P *6		*10			ST	ST, MO, P		*4		*5			ST, PL, DS, IP, OM, MO, WR			
(2) Fish Culture			*10	ST			ST, MO, P		*4		*5		ST *9		ST,MO *8		
(3) Inland-Navigation			*10						*4		*5	ST, PL	ST *9				
(4) Hydropower Generation		P	*10				MO, P		*4		*5		ST,PL,DS,IP,OM,MO				
(5) Surface Water Supply																	
a. Domestic and Industory		P *3	*10				ST, MO, P		*4		*5			ST, PL, DS, IP, OM, MO, WR			
b. Irrigation			*10		P *3		MO, P		*4		*5						
(6) Ecosystem Conservation																	
a. River-Lake			*10	ST			ST, MO, P		*4		*5			*7	MO *8		
b. Reservoir			*10	ST			ST, MO, P		*4		*5		ST,MO *9		MO *8		
(7) Waste Treatent																	
a. Waste disposal			*10				MO, P		*4		*5				ST *8		
b. Sewage treatment			*10				MO, P		*4		*5			ST, PL, DS, IP, OM, MO, WR	nd		
(8) Watershed Management																	
a. Soil erosion			*10			ST, DS, IP *1	ST, MO		*4	ST, DS, IP *2	*5						
b. Forest			*10	ST,DS			ST, MO, P		*4		*5				DS,IP *8		
(9) Water Excess Management																	
a. Flood Plain		MO, WR	*10			ST,IP	MO		*4		*5					MO, WR	MO, WR
b. Urban storm water			*10			ST, DS, IP *1	MO		*4		*5						
c. Rain drainage			*10			ST, DS, IP *1	MO		*4		*5						

Notes: (1) ST:study; PL:planning; DS:Design; IP:implementation; OM:Operation and Maintenance; MO:monitoring; WR:warning; P:Permission/Licencing

(2) Abbreviation of Institution: MME:Ministrio de Minas e Energia; E-BRAS:ELETRO BRAS; MIR:Ministry of Regional Integration, SIR:Secretariat of National Irrigation, * : Third Sector

(3) Notations

*1: ST, DS, IM and OM by request from municipality
*2: ST, DS, IM in rural area
*3: only in federal river
*4: COMEC is in charge of planning and coordination of public function of common interest in Curitiba Metropolitan Reagion.
*5: SEPL is in charge of budjet control of all public function of common interest in the state.
*6: only for mineral waters
*7: Answer from the organization is not available
*8: only in TIBAGI river basin
*9: only in COPEL's reservoirs
*10: in progress

Table - 2.3 Institution in Charge of Administration of Monitoring and Operation Systems

INSTITUTION / SECTOR	Federal					State									Municipal	NGO		
	MME				MIR		SEMA		SEPLAN						Municipal			
	DNPM	DNAEE	E-BRAS	IBAMA	SIN	SANE-PAR	IAP	SUCEAM	COMEC	SEAB	SEPL	IAPAR	SETR	COPEL	Office	COPATI	COR-PRERI	COP-RENE
I. OPERATION SYSTEM																		
(1) Ground water supply						*	*1								*			
(2) Surface water supply						*	*1								*			
(3) River-reservoir Operation for Multifarious Water Use		*	*			*	*1							*3	*			
(4) River-reservoir Operation for Flood Control		*	nd											*			nd	nd
(5) Power Load Operation		*	*											*4				
II. MONITORING SYSTEM																		
(1) Meteo-hydro Data Collection and Bank		*					*					*		*				
(2) Flood Forecasting and Warning Systems		*	nd									*5		*5			*	*
(3) Ground Water Basin (Quality and Quantity)	*						*											
(4) Aqua Ecology Monitoring				*			*									*		
(5) Fish Resources Monitoring							*							*6		*		
(6) Waste Discharge Monitoring				*		*	*											
(7) Watershed and Sediment Monitoring		*					*			*2				*				
(8) Surface Water Supply Monitoring		*					*											

Notes:
*1 : for ground water, surface water and multifarious water use system, IAP establishes requirements direction about water supply
*2 : moniroring specific projects
*3 : No COPEL's dam in Parana state is operated aiming for multifariouse water use.
*4 : Operation is done with CESP, ITAIPU and ELETROSUL.
*5 : Except warning systems.
*6 : Only in SEGREDO reservoir
nd : no data

Table - 2.4 Water Environment Measurement in Operation in Parana State

item	Number of Stations	Automatic Recorder	Telemeter
Rainfall (frequency)	844 (2 times/day)	171	42 (4 times/day)
Streamflow (frequency)	217 (*1)	69	22 (*1)
River-reservoir water quality (frequency)	193 (*2)	-	-
River-reservoir water ecology (frequency)	104 (*3)	-	-
Ground water level (frequency)	*4	-	-
Ground water quality (frequency)	Not Available *5	-	-
Sediment transportation (frequency)	132 (*6)	-	-

Notes
(1) Description within parentheses is frequency of observation
(2) Notations
*1 : Reporting two or four times per day for water level and monthly or bimonthly for flow rate measurement (manual)
*2 : Monthly or bimonthly
*3 : Monthly or trimonthly in rivers and two or four times per year in reservoirs
*4 : Pumping test data of about 2,400 wells are stored in the data bank system.
Ground water level of these wells are available only at installation date.
*5 : However there are 3,000 wells in data bank system in IAP and sampling procedure is done every 5 years according to the regulation established by IAP.
*6 : Monthly or bimonthly in rivers

Source : DNAEE and IAP

Table-2.5 Meteo-hydrological Data Planned to be Observed by SIMEPAR

Equipment	Products
Weather radars : 3 sites, Catanduvas, Irati and Apucarana	Echo top maps Rainfal accumulation maps Wind intensity maps with direction, speed and vertical profile
Satellites : METEOSAT, GOES and TIROS	Images from the geostationary satellites
Lightning sensors	Location of cloud-to-ground atmospheric electric discharges Location of cloud atmospheric electric discharges
Weather stations : 116 locations	Air temperature Atmospheric pressure Relative humidity Wind speed and direction Global radiation Ultra-violet radiation Rainfall amount Evaporation
Hydrological stations : 44 locations	Water level at a river and/or reservoir
Environmental stations detecting atmospheric pollution in Critiba Metropolitan Area : 2 static and 1 mobile	Soil temperature Soil humidity Sulphur dioxide (SO2) Nitrogen compounds (NO, NO2, and NOx) Carbon monoxide (CO) Sulphur gas (H2S) Ozone (O3) Hydrocarbons (methane and non-methane) Total particulates (TSP) Total inhalable particulates (PM 10)
Radio sondes and vertical profiler : 2 sets	Temperature Atmospheric pressure Humidity Wind direction and intensity
Global Telecommunication System (GTS) : 1 set	Global data observed in weather stations of the world synoptic network Global numeric forecast up to 10 days generated by NMC (USA) and ECMWF (U.K.)

Table-3.1 Present and Projected Socioeconomic Conditions and Water Use in Parana State

Socio-economic Parameters	1993	2015 (Projected)	Rate of 2015 to 1993
Population (base case)			
- State total	8,610,000	11,130,000	129%
- Urban population	6,460,000	9,970,000	154%
- Rural population	2,150,000	1,160,000	54%
- Ratio of Urban to Rural	75:25	90:10	120%
Urban Population Density (person/km2)			
- MRH 268 - Curitiba	231(1,960,500)	362(3,074,000)	157%
- MRH 281 - Londrina	73(741,200)	107(1,090,000)	147%
- MRH 282 - Maringa	112(406,800)	181(656,000)	162%
GDP-Parana	\$27,811,000,000	\$81,354,000,000	293%
- GDP-Parana per Capita	\$3,230	\$7,310	226%
Total Net Water Demand	1,660,000m3/day	3,290,000m3/day	198%
- Domestic	1,030,000m3/day	2,090,000m3/day	203%
- Industrial	480,000m3/day	980,000m3/day	204%
- Agricultural	150,000m3/day	220,000m3/day	147%
- Per Capita, Total Water Demand	277 l/day	371 l/day	134%
Service Ratio of Domestic Water Supply	about 70%	100% (planned)	143%
Water Resources Potential			
- Surface water	54,930,000m3/day	54,930,000m3/day	
- Ground water	15,030,000m3/day	15,030,000m3/day	
Water Utilization Ratio (Service/Potential)	estimated	planned	
- Surface water	3.9%	7.2%	183%
- Ground water	-3.2%	-	-
Hydro Power Generation			
- Installed Capacity	5,773MW	3,095MW	54%
- Firm Energy	23,156Gwh	13,627Gwh	59%
- Number of Hydropower Plants	18	31 (13 planned)	333%
Sewage Treatment Quantity (state)	113,800m3/day	348,900m3/day	307%
Estimated Effluent without Treatment Improvement			
- Curitiba	30mg/l	51mg/l	170%
- Londrina	20mg/l	32mg/l	160%
- Maringa	20mg/l	32mg/l	160%
Sewage Treatment Plan	present	planned	
- Diffusion Rate	17%	67%	394%
Agricultural Land			
- Total Cropping Area	6,300,000ha	-	-
- Total Pasture Area	6,540,000ha	-	-
Forest			
- Remaining Natural Forest	10,200km2 (5.1%)	-	-
Gross Soil Erosion		planned	
- Cinzas River	36ton/ha/year	7ton/ha/year	-
- Iguacu River	28ton/ha/year	8ton/ha/year	-
- Ivai River	33ton/ha/year	8ton/ha/year	-
- Itarare River	5ton/ha/year	1ton/ha/year	-
- Average	28ton/ha/year	8ton/ha/year	-

Table - 3.2 Model Areas for Respective Project Management Sector

Unit of Management	River Basin	Proposed Model Areas	Issues
Surface water supply a) Domestic water b) Industrial water c) Agriculture	Iguacu	10 municipalities with a population of more than 50,000 including Curitiba and Cascavel, identified in M/P 10 municipalities with a	Shortage of water supply
	Tibagi	10 municipalities with a population of more than 50,000, including Londrina, Ponta Grossa and Apucarana, identified in M/P	Shortage of water supply
	Others	Maringa, Umuarama and other municipalities with a population of more than 50,000, facing to water shortage	Shortage of water supply
Groundwater use	Iguacu	8 municipalities with a population of more than 50,000 including Curitiba and Cascavel, identified in M/P	Shortage of water supply
	Tibagi	6 municipalities with a population of with a population of more than 50,000, including Londrina and Apucarana, identified in M/P	Shortage of water supply
	Others	Maringa, Umuarama and other municipalities with a population of more than 50,000, facing to water shortage	Shortage of water supply
Water excess (flood control)	Iguacu	Curitiba Metropolitan Area in Region - 1	Flood damage
		Sao Mateus do Sul in Region - 2	Flood damage
		Uniao da Vitoria and Port Uniao in Region-4	Flood damage
		Rio Negro and Mafra in Region-5	Flood damage
		Foz do Iguacu in Region-6	Flood damage
	Coastal Area	Morretes in Region 7	Flood damage
Hydropower generation (planned up to 2015)	Iguacu	Planned installed capacity : 1400.0 MW	Power demand in Brazil
	Tibagi	1096.0 MW	Power demand in Brazil
Inland navigation	Ivai	Parana-Ivai route	Waterway (Cargo transport)
	Tibagi	Paranapanema-Tibagi route	Waterway (Cargo transport)
Waste treatment a) Sewage b) Water quality	Iguacu	Curitiba, Campo Largo, Guarapuva Pinhao and Cascavel	D/I sewage
	Tibagi	Ponta Grossa, Londrina, Castro, Cornelio Procopio, Arapongas and Apucarana	D/I sewage
	Ivai	Maringa and Ivai	D/I sewage
	Pirapo	Maringa	D/I sewage
Soil erosion improvement	Iguacu	41 municipalities specified as a severe erosion area by M/P	Soil erosion / Afforestation
	Tibagi	10 municipalities specified as a severe erosion area by M/P	Soil erosion / Afforestation
	Piquiri, Ivai and others	Municipalities facing severe erosion to be identified by the methodology applied by the Study	Soil erosion / Afforestation Soil erosion / Afforestation Soil erosion / Afforestation
Ecosystem conservation	Iguacu	Programs proposed by M/P	Preservation
	Tibagi	Programs proposed by M/P	Preservation
	Others	Programs proposed by Strategy	
Fish culture	Iguacu	Programs proposed by M/P	Preservation & demand
	Tibagi	Programs proposed by M/P	Preservation & demand
	Others	Programs proposed by Strategy	Preservation & demand

Table 3.3 An Example of Goal and Implementation Strategy for Water Use Management

Management Sector and Unit	Goal	Implementation Strategy	Related Principle
1. Surface Water Use (domestic and industrial water and agricultural use)	- To maintain and supply reliable and safe surface water resources with regard to quantity and quality. - To supply treated piped domestic and industrial water to all the water demand in urban and rural areas.	- To maintain quality of the existing and planned surface water source by land use control, waste disposal control, etc. - To develop newly reliable and safe surface water resources taking into consideration future land use plans. - To develop newly alternative fresh water sources such as groundwater and recycle use. - To develop treatment and distribution facilities to meet the water demand.	- Hydrologic cycle - Multifarious water use - Risk and benefit - Integrated and comprehensive management - Proper cost recovery
2. Groundwater Use	- To maintain and supply reliable and safe groundwater resources with regard to quality and quantity. - To develop effective and multifarious use of ground-water resources as clean water and energy resources depending on quality and temperature level.	- To control sustainable use of groundwater with regard to amount of recharge and quality without adverse effect. - To enhance use hydrothermal resources in Botucatu formation for industrial water and energy to reduce use of timber resources.	- Hydrologic cycle - Multifarious water use - Cleaner production - Integrated and comprehensive management - Proper cost recovery
3. Hydropower Generation	- To supply reliable electric power to the federal and state demand in consideration of effective use of water resources.	- To develop hydropower generation plants in consideration of multifarious water use and preservation of ecosystem	- Multifarious water use - Cleaner production - Risk and benefit - Integrated and comprehensive management
4. Inland Navigation	- To establish effective commercial waterway networks in the Ivai and Tibagi rivers linked with the existing railway and highway systems as clean transportation way.	- To develop the Parana - Ivai waterway and Paranapanema - Tibagi waterway in consideration of dam construction and preservation of ecosystem.	- Multifarious water use - Cleaner production - Integrated and comprehensive management - Proper cost recovery
5. Fish Culture	- To enhance fish culture to protect enadangered endemic fish species.	- To enhance commercial and public fish culture of endemic fishes in the dam reservoirs and swampy areas to protect endangered endemic fish species against fishing.	- Multifarious water use - Integrated and comprehensive management - Proper cost recovery

Table 3.4 An Example of Goal and Implementation Strategy for Environmental Conservation and Improvement Management

Management Sector	Goal	Implementation Strategy	Related Principle
1. Water Excess (Flood Control)	- To protect the peoples in the flood prone areas from the risk of death, injuries and property damages including infrastructures.	- Nonstructural measures are to be principal and structral measures are to be supplemented to the areas where the existing land use is highly enhanced. - Application of the integrated view of urban sewage, flood protection, storm drainage and environmental protection.	- Multifarious water use - Risk management - Risk and benefit - Integrated and comprehensive management - Proper cost recovery
2. Ecosystem Conservation	- To reproduce and/or maintain the original genetic library of the aquatic ecosystem in Parana State	- Protection and reproduction of presently surviving endemic species. - Preservation and reproduction of the original forest coverage relating to the aquatic ecosystem. - Preservation of marshlands, low lands along water courses, dunes, and so on. - To minimize impact of human influences to the aquatic ecosystem including discharges of waste and toxic material.	- Symbiosis of human beings and natural environment - Cleaner production - Risk management - Risk and benefit - Multifarious water use - Integrated and comprehensive management - Proper cost recovery
3. Soil Erosion Improvement	- To reduce the excessive soil loss from agricultural land to the acceptable level. - To enhance afforestation of the original forest coverage to preserve native flora and fauna, erosion control and stabilization of the hydrologic cycle.	- To apply terracing and tillage to control soil erosion from agricultural land. - To enhance afforestation without significant change in the existing agricultural land use. - To provide forest belts along the riverain for reproducing the aquatic ecosystem.	- Symbiosis of human beings and natural environment - Hydrologic cycle - Risk and benefit - Integrated and comprehensive management - Proper cost recovery
4. Waste Treatment	- To minimize discharges of waste and toxic materials into the fresh water resources to attain the symbiosis of human beings and natural environment.	- To introduce and enhance cleaner production technologies to control industrial effluent. - To apply proper combination of public sewerage, village sewerage and household sewerage in order to establish efficient treatment. - To control excessive use of pesticide and other toxic material. - To establish comprehensive water quality standard with regard to physical, chemical and biological attributes.	- Symbiosis of human beings and natural environment - Hydrologic cycle - Multifarious water use - Cleaner production - Risk management - Risk and benefit - Integrated and comprehensive management - Proper cost recovery
5. Operation and Monitoring Systems	- To maintain necessary information and data timely for achieving the objectives of water environment management	- To establish high density and multidimensional monitoring (human activity-ecology monitoring), unified and centralized monitoring, and integrated operation and monitoring systems. - To establish state and regional centers for water environment management provided with data bank systems, including genetic library and information network systems accessible to the public.	- Symbiosis of human beings and natural environment - Hydrologic cycle - Multifarious water use - Cleaner production - Risk management - Integrated and comprehensive management
6. Economic & Financial Arrangement	- To establish financially feasible and independent management systems for achieving the objectives of water environment management	- To apply the principle of risk and benefit. - To establish a proper cost recovery system with the principle of " users (beneficiaries) - to pay " and/or " pollutant - to pay ". - To establish proper cost allocation criteria.	- Hydrologic cycle - Multifarious water use - Cleaner production - Risk management - Risk and benefit - Proper cost recovery
7. Institutional Framework	- To establish and/or improve practicable legal systems and organizations for achieving the objectives of water environment management	- To improve regulatory and financing power of the SEMA, consisting of IAP and SUCEAM in order to achieve an integrated management of water environment. - To reinforce penalty and charge systems based on the principle of pollutant-to-pay and users-to-pay.	- Hydrologic cycle - Multifarious water use - Cleaner production - Risk management - Integrated and comprehensive management - Proper cost recovery

Table-3.5 Integrated Monitoring System

System Components	
I. Insitutional Arrangement 1) Establishment of the state center for water environment management a) a set of newly established data bank systems covering all of the state and all of the items listed in Table-3.6 and Figure-3.7. b) control of newly installed information network systems which connect the state center to other organisations and several regional water environment centers c) administration of water environment all over the state using the observed data through information systems and satellite remote sensing data d) in charge of SYSTEM-1, 2, 3, and 4 for inter-regional matters. 2) Establishment of the regional centers for water environment management (divisions of the state center) a) administration of regional water environment b) terminals of newly installed information network systems c) bulletin to municipality office, press, and public d) in charge of SYSTEM - 1, 2, 3, and 4 for regional matters. 3) Provision of a committee for data base management	2) SYSTEM - 2: a system for monitoring ecosystem library a) observation of the population status of listed, endemic, and threatened species of aquatic, terrestrial, and avian fauna by a field survey b) observation system of terrestrial flora using satellite remote sensing data c) observation system of aquatic flora by a field survey d) integrated data bank system 3) SYSTEM - 3: flood forecasting and warning systems a) improvement of federal telemetric system b) improvement of flood forecasting system c) sophisticated flood warning information with graphic display terminals through network systems 4) SYSTEM - 4: a bulletin system to the citizens a) information network system for risk management b) information network system for daily, weekly, and annual report
II. Integrated Monitoring System 1) SYSTEM - 1: a system for hydrologic cycle monitoring and simultaneous monitoring of water quality and quantity a) frequency and density and observation items which fulfill the requirement of the target-A as summarised in Table-3.6. b) integrated data analysis system c) integrated data bank system d) improvement of federal telemetric system e) installation of new telemetric system by state institutions f) information networks which connect federal and state information systems	***III. Information Network*** Installation of water environment information networks among the state center, regional centers, and related institutions (1) two-way information transfer among the state center, regional centers, federal offices, electric power companies, and water supply and sewer companies (2) water environment information retrieval through this network (3) warning information transfer through this network (4) bulletin through this network (5) as a transferring system of SYSTEM- 1, 2, 3, and 4.

Table- 3.6 Required Frequency and Density of Monitoring Items of Water Environment Management System by Implementation Stage

Category	Item		Density		Frequency	
	1st stage Present - 2005	2nd stage 2006 - 2015 onward	1st stage Present - 2005	2nd stage 2006 - 2015 onward	1st stage Present - 2005	2nd stage 2006 - 2015 onward
Meteorological Data	Temperature	Temperature	Present condition	one per 1,200 sq. km	hourly	hourly
	Wind Speed & Direction	Wind Speed & Direction	Present condition	one per 1,200 sq. km	hourly	hourly
	Sunshine Hour	Sunshine Hour	Present condition	one per 1,200 sq. km	daily	daily
	Solar Radiation	Solar Radiation	Present condition	one per 1,200 sq. km	hourly	hourly
	Humidity	Humidity	Present condition	one per 1,200 sq. km	hourly	hourly
	Pan Evaporation	Pan Evaporation	No information	undecided	daily	daily
	Precipitation	Precipitation	Present condition	one per 170 sq. km	hourly or less	hourly or less
Surface Water	Streamflow Quantity	Streamflow Quantity		*5	hourly or less	hourly or less
	Streamflow Quality	Streamflow Quality	*5	*5		
	Water Intake	Water Intake	*5	*5	daily	daily
	Waste Discharge	Waste Discharge	*5	*5	daily	daily
Subsurface Water	Ground water level	Ground water level	*6	*6	daily	daily
	Ground water Quality	Ground water Quality	*6	*6	*2	*2
	Pumping from the Wells	Pumping from the Wells	*6	*6		
Geographical Data	Topography	Topography	*3	*3	*1	*1
	Land use	Land use	a datum per 1 ha	a datum per 1 ha	once in 5 years (minimum)	once in 5 years (minimum)
	Vegetation	Vegetation	a datum per 1 ha	a datum per 1 ha	once in 5 years (minimum)	once in 5 years (minimum)
	Surface soil property	Surface soil property	a datum per 1 ha	a datum per 1 ha	*1	*1
	Aquifer Soil property	Aquifer Soil property	*3	*3	*1	*1
	Aquifer system	Aquifer system	*3	*3	*1	*1
Inventory	Water Supply	Water Supply			*1	*1
	Sewer System	Sewer System			*1	*1
	Population	Population	*4	*4	once in 5 years (minimum)	once in 5 years (minimum)
	River Structure	River Structure			*1	*1
	Well	Well			*1	*1
Ecology	Water Quality	Water Quality	*5	*5	4 times/years	4 times/years
	Fish Population	Fish Population	*5	*5	4 times/years	4 times/years
	Macroinvertebrates "Benthos"	Macroinvertebrates "Benthos"	*5	*5	4 times/years	4 times/years
	Forest Area	Forest Area	a datum per 1 ha	a datum per 1 ha	once in 5 years (minimum)	once in 5 years (minimum)
	Aquatic Bird Population	Aquatic Bird Population	*5	*5	4 times/years	4 times/years

Note: *1 : The data should be renewed with significant changes
*2 : Depend on the land use of the area
*3 : As a drawing
*4 : Distribution of Densely Inhabited Districts (DID) - the area where the population is over 4000 per 1 sq. km, and population by municipality
*5 : Representative points of the area
*6 : Depend on Influence area of each well

Table - 3.7 Proposed Implementation Target and Schedule

Target	Implementation Schedule	
	1st stage Present - 2005	2nd stage 2006 - 2015 onward
Target-A : High Density and Multi-dimensional Monitoring		
a) Multifarious Indicator Monitoring (quantity, quality, species)	△	○ to ◎
b) Multitude Point Monitoring (enhancement of regional density)	△	○ to ◎
c) Time Series Monitoring (enhancement of time axis)	△	○ to ◎
Target-B : Unified and Centralized Monitoring		
a) Institutional Arrangement	△	○ to ◎
b) Equipment and Network	△	○ to ◎
Target-C : Integrated Operation and Monitoring		
a) Institutional Arrangement	△	○ to ◎
b) Equipment and Network	△	○ to ◎

Note:

×: No Provision
△: Partial Operation
○: Full scale operation with introductory level and moderate density
◎: Full scale operation with advanced level and high density

Table - 3.8 Proposed Implementation Schedule of the Management Centers

Center	System - 1		System - 2		System - 3		System - 4	
	Hydrologic cycle monitoring and simultaneous monitoring of water quality and quantity		Monitoring ecosystem library		Flood forecasting and warning systems		A bulletin system to citizens	
	1st stage Present - 2005	2nd stage 2006 - 2015	1st stage Present - 2005	2nd stage 2006 - 2015	1st stage Present - 2005	2nd stage 2006 - 2015	1st stage Present - 2005	2nd stage 2006 - 2015
1) A State Center for Water Environment Management	△	◎	○	◎	○	◎	○	◎
2) Regional Centers for Water Environment Management (Branch offices of the State Center)	△	◎	△	◎	△	◎	△	◎

Note:

× : No Provision

△ : Partial Operation

○ : Full scale operation with introductory level and moderate density

◎ : Full scale operation with advance level and high density

Table - 3.9 Proposed Implementation Schedule of Networks

Information Through Network	State Center		Regional Center		Federal Offices		State Companies (COPEL, SANEPAR, etc.)		Municipalities	
	1st stage Present - 2005	2nd stage 2006 - 2015	1st stage Present - 2005	2nd stage 2006 - 2015	1st stage Present - 2005	2nd stage 2006 - 2015	1st stage Present - 2005	2nd stage 2006 - 2015	1st stage Present - 2005	2nd stage 2006 - 2015
Water Environment Information	○	◎	△	○ ~ ◎	○	◎	○	◎	△	○ ~ ◎
Warning Information	○	◎	△	○ ~ ◎	○	◎	○	◎	△	○ ~ ◎
Bulletin	○	◎	△	○ ~ ◎	○	◎	○	◎	△	○ ~ ◎

Note:

× : No Provision

△ : Partial Operation

○ : Full scale operation with introductory level and moderate density

◎ : Full scale operation with advance level and high density

Table-4.1 Existing Monitoring and Operation Systems in the Iguacu and Tibagi River Basins

Monitoring and Operation Systems	Iguacu River Basin	Tibagi River Basin	Related Institutions
I. OPERATION SYSTEM			
(1) Ground water supply	Insufficient data	Insufficient data	SUCEAM,IAP, SANEPAR
(2) Surface water supply			
a) Water amount taken from the river based on data base system established by JICA Study Team	12.6	7.2	SANEPAR, Autonomous bodies
(3) River-reservoir Operation for Multifarious Water Use	None	None	COPEL, SUCEAM, ELETROSUL
(4) River-reservoir Operation for Flood Control	None	None	COPEL, SUCEAM, ELETROSUL
(5) Power Load Operation			COPEL,
a) Nos. of hydropower stations	6	2	ELETROSUL
b) Total installed capacity (MW)	5,375	32	
II. MONITORING SYSTEM			
(1) Meteorological data observation (nos. of stations)	16 with an automatic gauge	7 with an automatic gauge	DNAEE, IAP, COPEL, IAPAR
(2) Precipitation observation			
a) Nos. of stations with manual reading gauge	248	111	DNAEE, IAP,
b) Nos. of stations with automatic recording gauge	36	10	COPEL, IAPAR,
c) Nos. of stations with telemetering system	17	5	ELETROSUL, ITAIP
(3) Flow observation system			
a) Nos. of stations with manual reading gauge			
• Main stream	21	15	
• Tributary	40	22	DNAEE, IAP,
b) Nos. of stations with automatic reading gauge			COPEL, IAPAR,
• Main stream	9	4	CESP, ELETROSUL,
• Tributary	13	3	ITAIP
c) Nos. of stations with telemetering system			
• Main stream	9	2	
• Tributary	5	-	
(4) Flood forecasting and warning system	A telemetered data collection system provided by DNAEE	none	DNAEE, COPEL, SUCEAM, IAPAR
(5) River water quality			
a) Nos. of observation stations			
• Main stream	21	13	DNAEE, IAP
• Tributary	33	15	
(6) Aqua ecology monitoring	Macro-invertebrate monitoring by IAP	Reseach of fauna and flora by COPATI in specific area	IAP
(7) Fish resources monitoring	Pilot investigation in Segredo reservoir by COPEL	An inventory survey at the downstream of Tibagi river by Londrina University	EMATER, COPEL, COPATI
(8) Waste discharge monitoring	not available	not available	IAP, SANEPAR
(9) Watershed and sediment monitoring			
a) Nos. of sediment flow observation stations			EMATER, COPEL,
• Main stream	9	10	DNAEE, IAP
• Tributary	31	21	
(10) Surface and sub-surface water supply monitoring	done by individual users	done by individual users	SUCEAM, SANEPAR

FIGURES

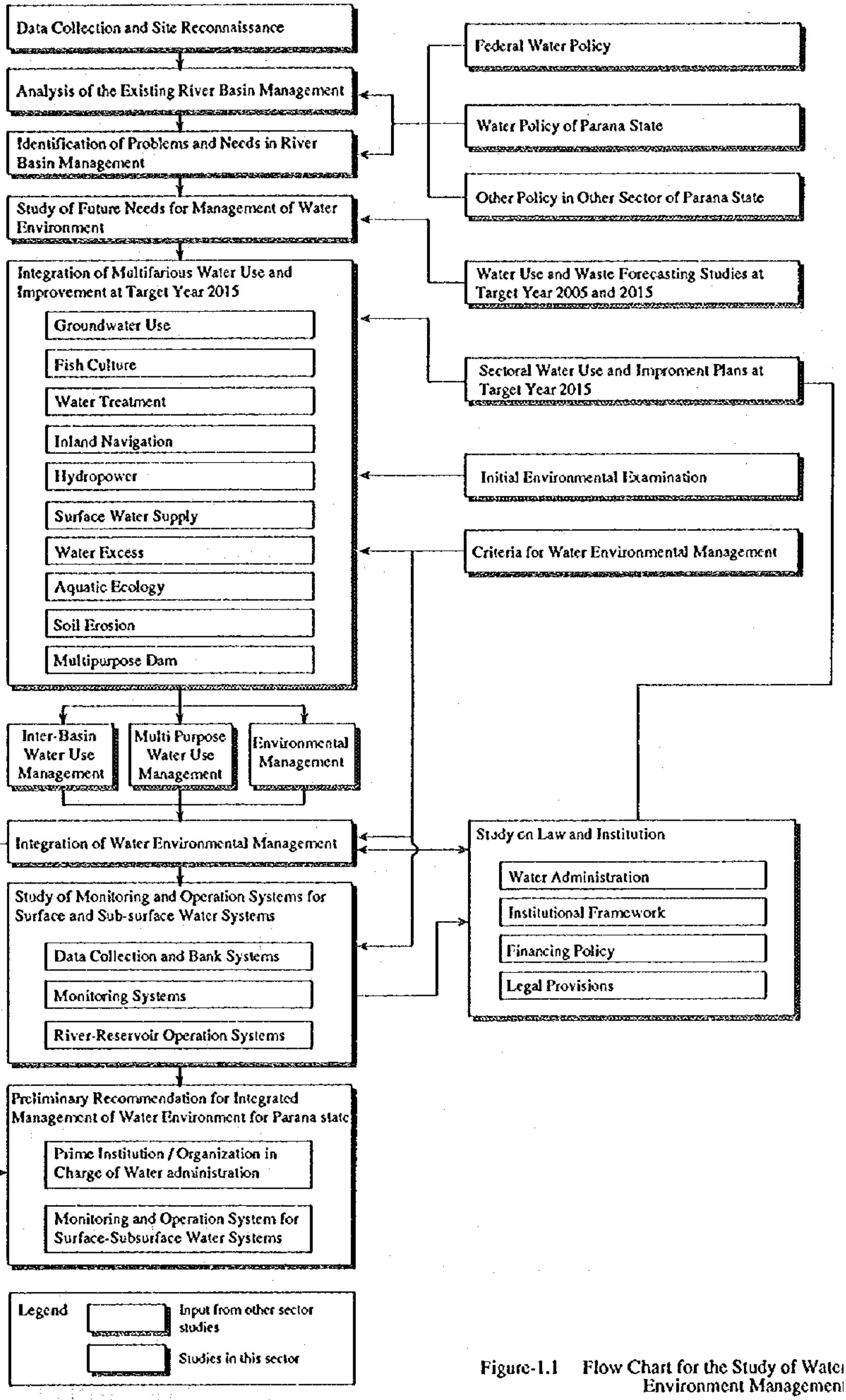
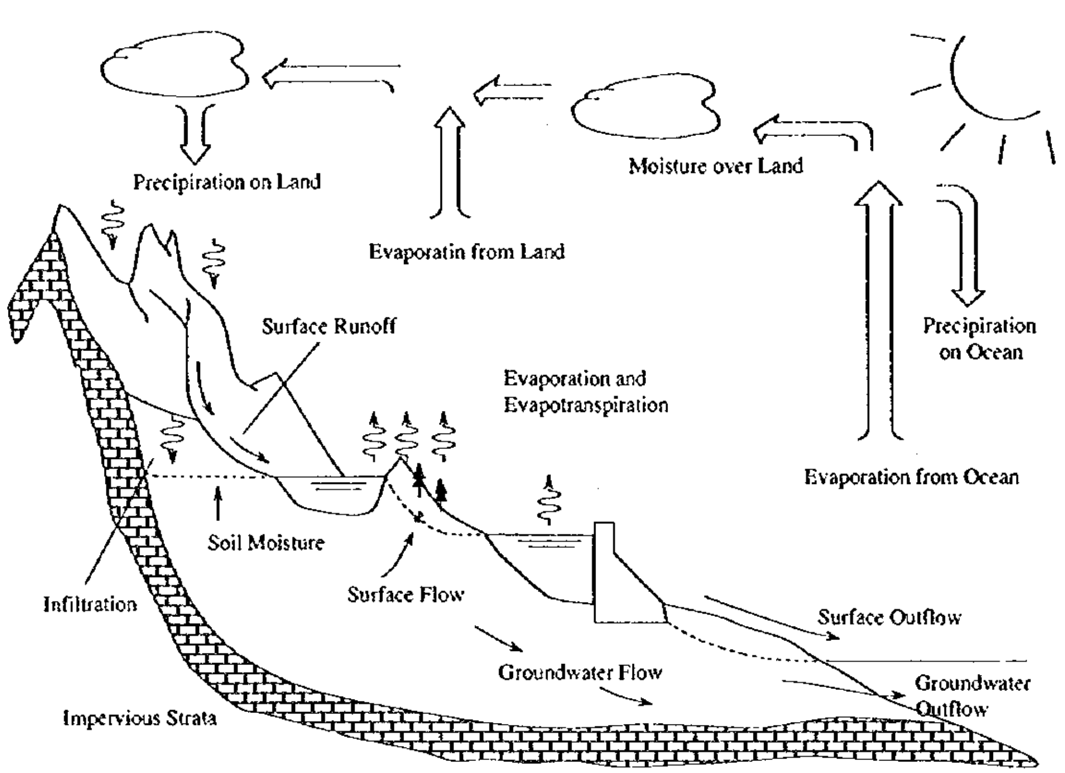
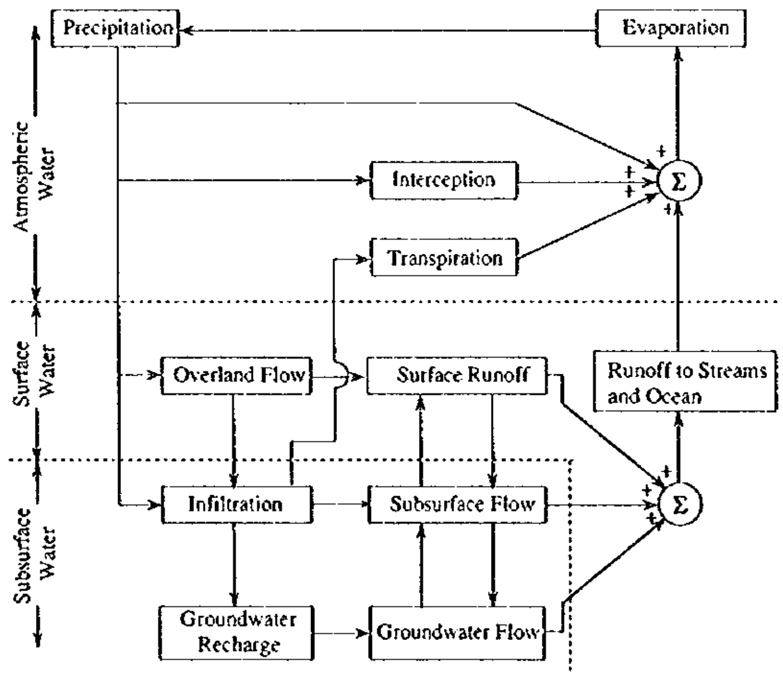


Figure-1.1 Flow Chart for the Study of Water Environment Management





Notation :

*1 : Water Intake, Waste Discharge
*2 : Water Supply System Inventory, Sewer System Inventory, River Inventory, Pumping from wells, and Well Inventory

Source: Chow, Madiment and Mays, 1988

Figure - 1.2 Concept of Hydrologic Cycle

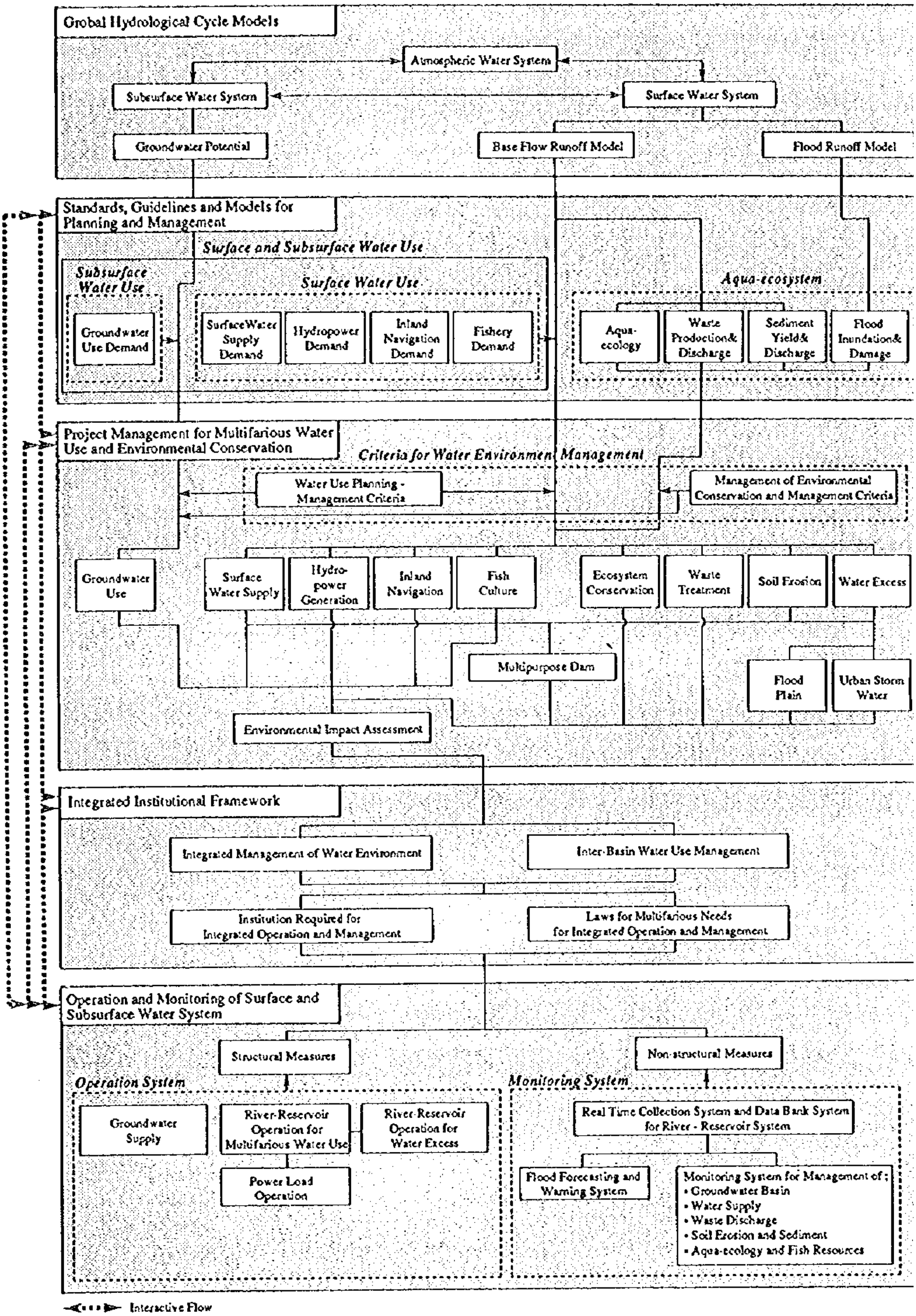


Figure-1.3 Conceptual Diagram for Integrated Management of Water Environmen

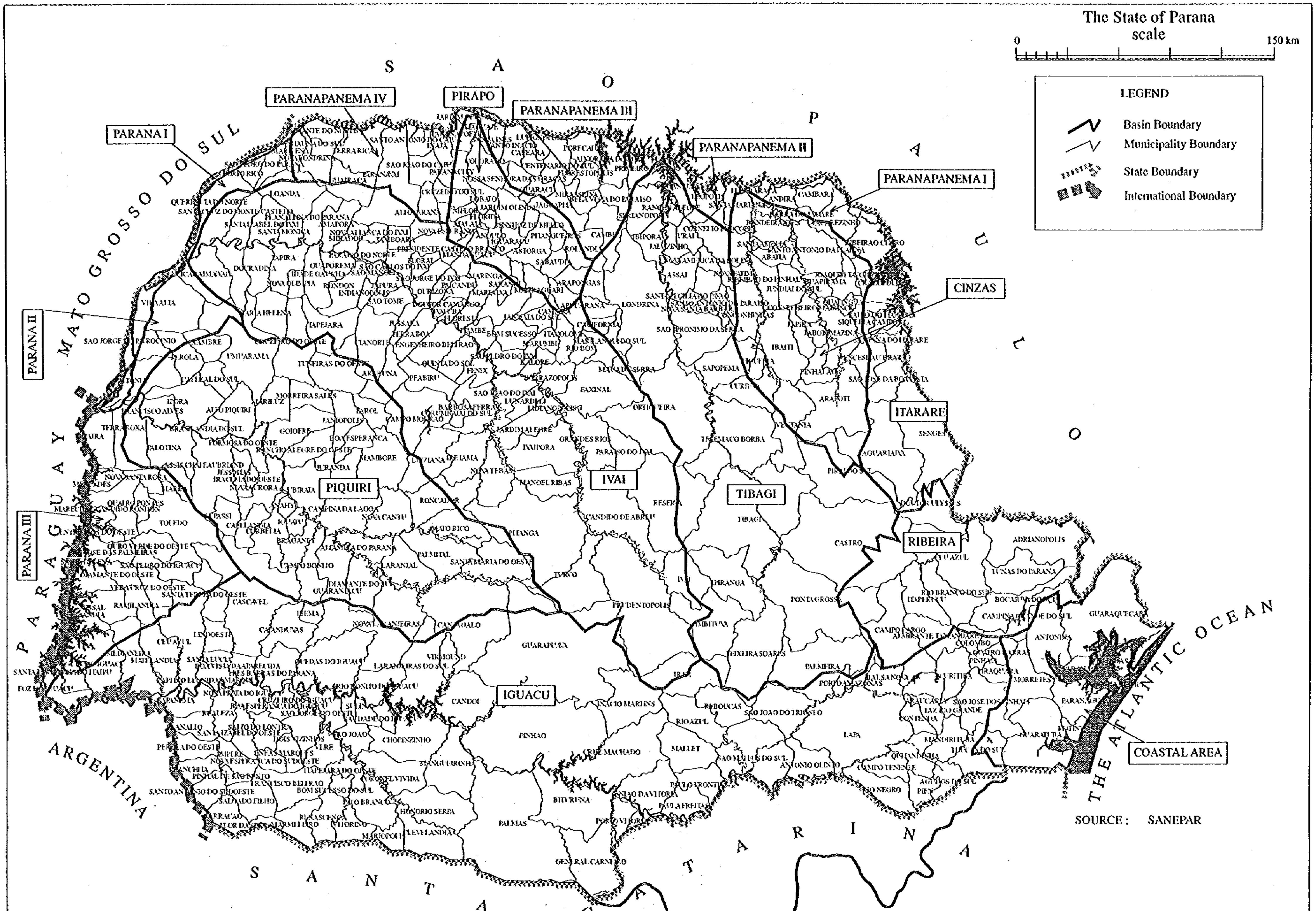


Figure - 2.1 Main River Basin and Municipality Boundary(1991)

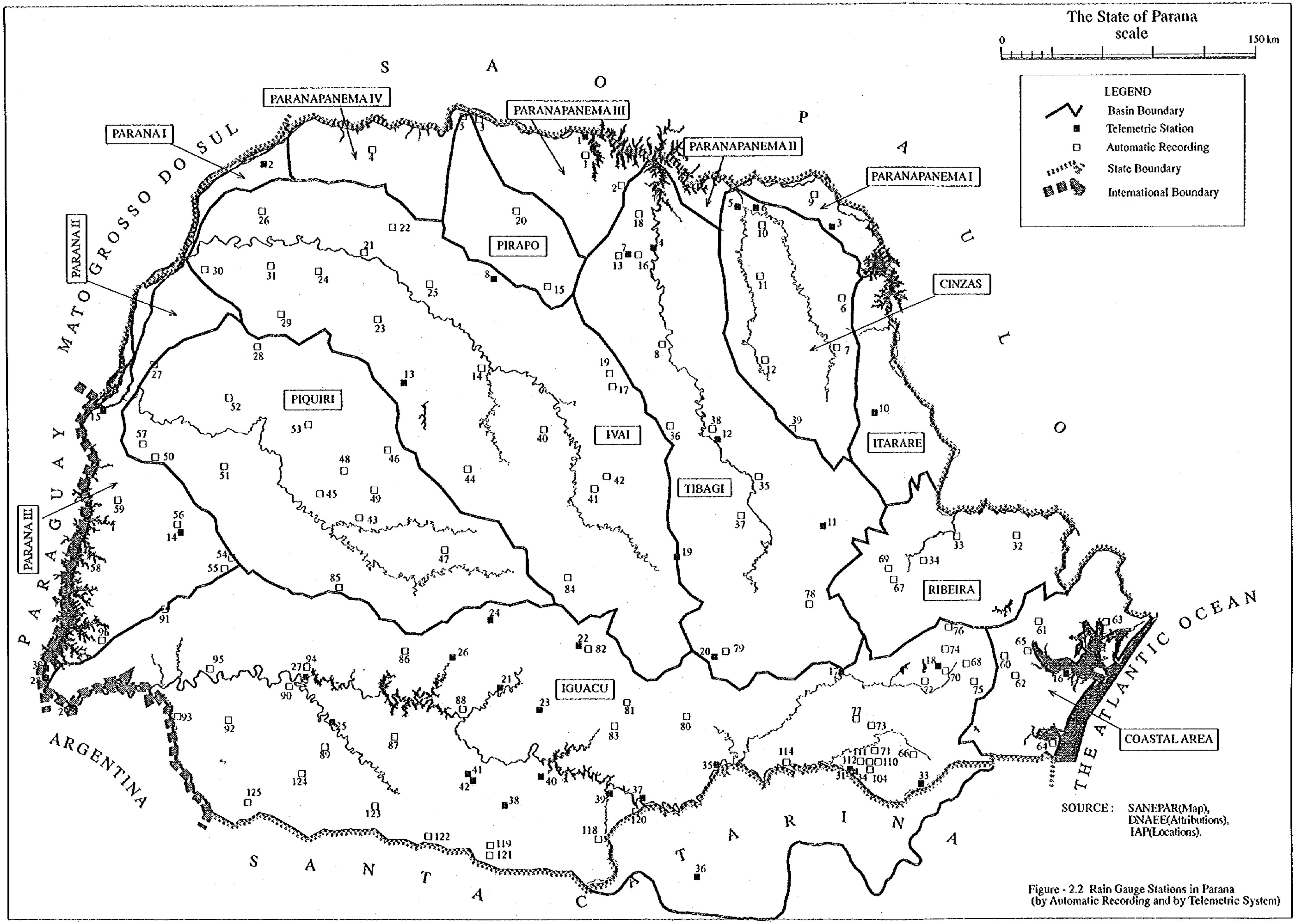


Figure - 2.2 Rain Gauge Stations in Parana
(by Automatic Recording and by Telemetric System)

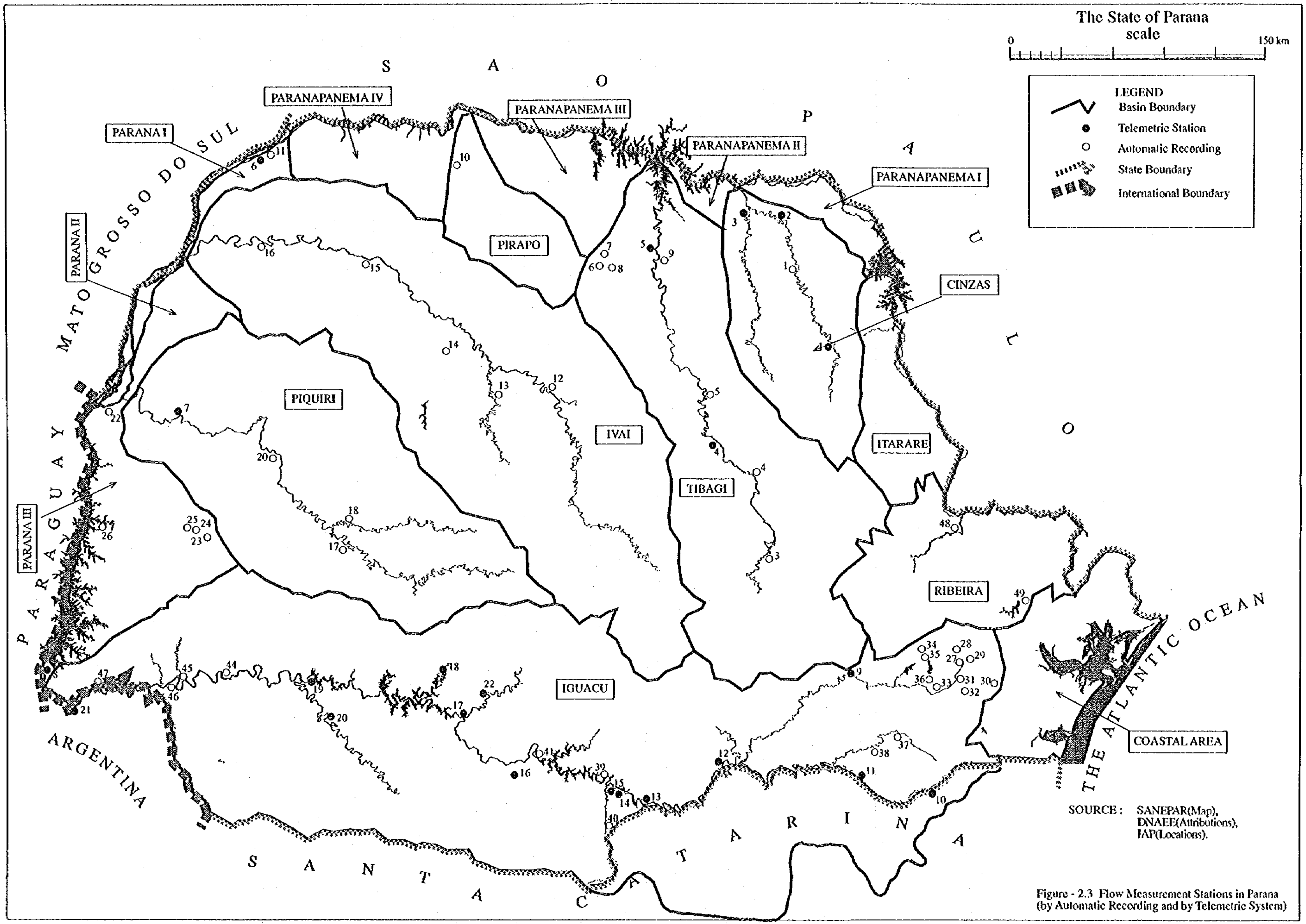


Figure - 2.3 Flow Measurement Stations in Parana (by Automatic Recording and by Telemetric System)

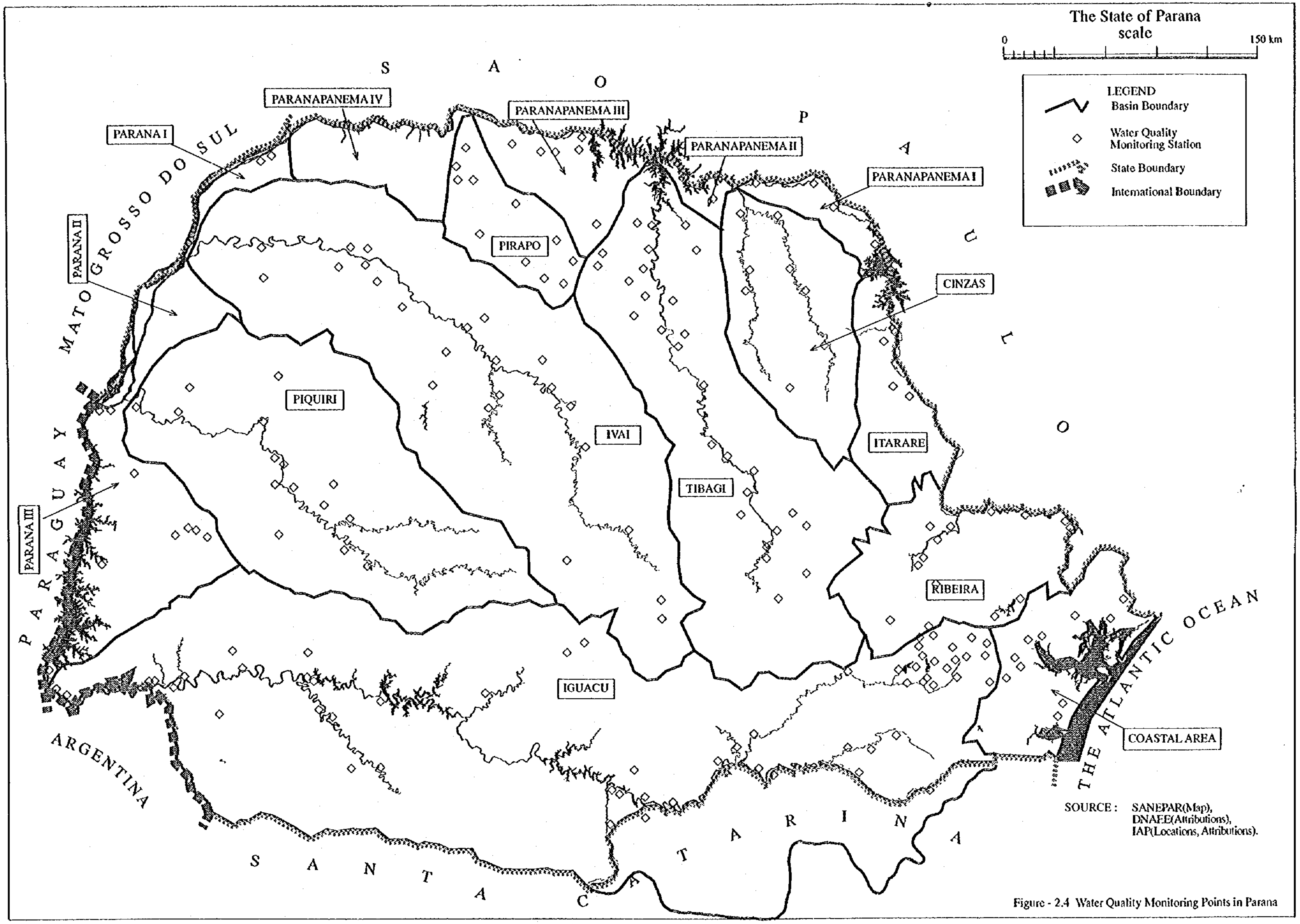
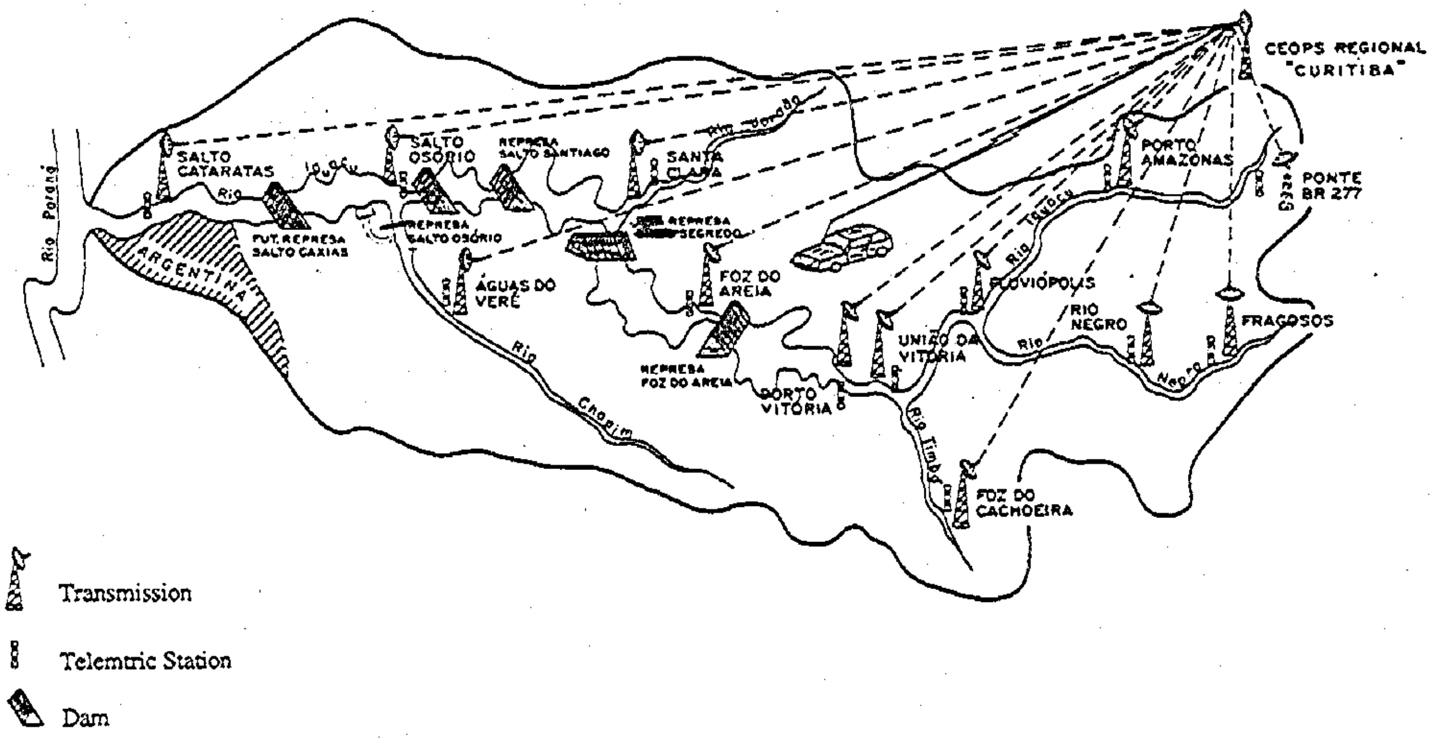


Figure - 2.4 Water Quality Monitoring Points in Parana



Source : CEOPS (Warning System Operation Center) / DNAEE 1993

Figure-2.5 Flood Warning System in the Iguaçu River

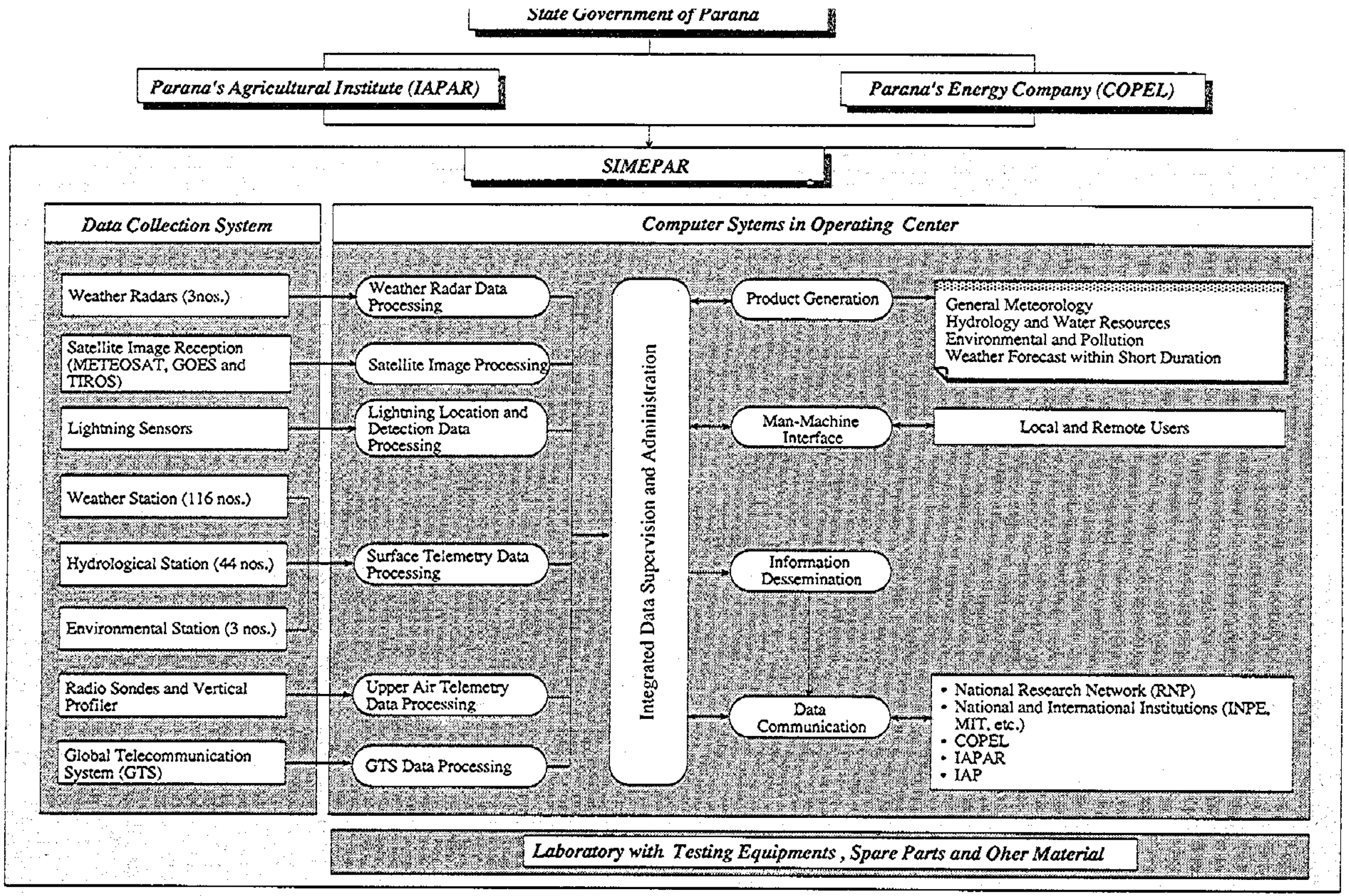


Figure-2.6 Weather System of Parana (SIMEPAR)

Figure-2.7 Implementation Schedule of SIMEPAR

Descriptions	1996	1997	1998	1999	2000
1. Operating Center					
2. Satellite Image Reception					
a) METEOSAT					
b) TIROS					
c) GOES					
3. Weather Radar					
a) Catanduvas					
b) Apucarana					
c) Irati					
4. Lightning Sensor					
5. Upper Air Telemetry					
6. Vertical Profiler					
7. Ground Weather Stations					
a) Phase 1 (6 nos.)					
b) Phase 2 (27 nos.)					
c) Phase 3 (54 nos.)					
d) Phase 4 (29 nos.)					
8. Hydrological Stations					
a) Phase 1 (6 nos.)					
b) Phase 2 (14 nos.)					
c) Phase 3 (24 nos.)					
9. Environmental Stations					
10. Multimedia and Software Equipment					
11. Software Development					
12. Scientific Computing					
13. Communication Antennas					
14. Laboratory					

Source : SIMEPAR's Technical Pre-Specification