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THE GOVERNMENT OF
THE REPUBLIC OF TRINIDAD AND TOBAGO

THE STUDY ON THE IMPROVEMENT OF WATER SUPPLY SUPERVISORY SYSTEM IN TRINIDAD AND TOBAGO

FINAL REPORT

MAIN REPORT

SEPTEMBER 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

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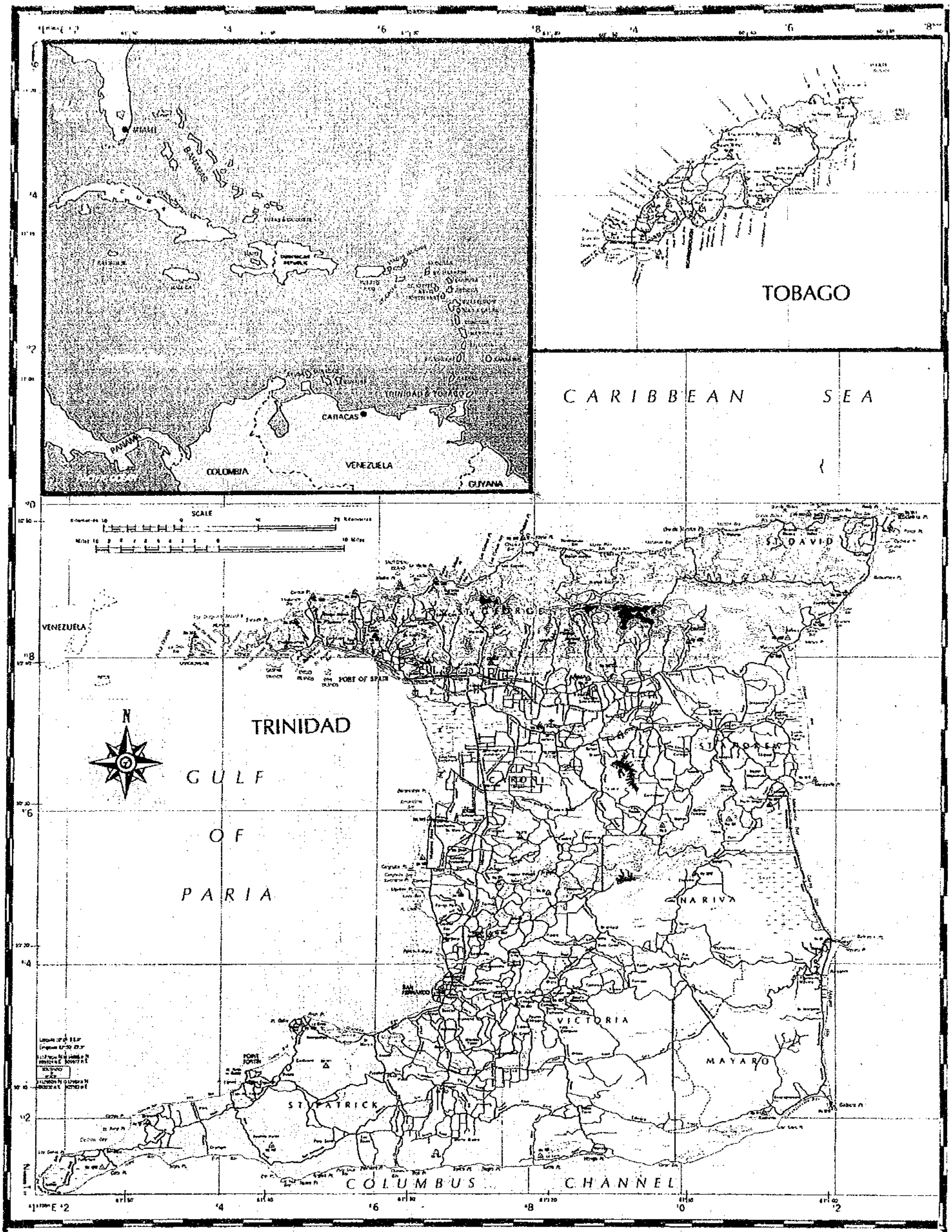

GENERAL LOCATION MAP OF STUDY AREA

PREFACE

In response to the request from the Government of the Republic of Trinidad and Tobago, the Government of Japan decided to conducted a study on the Improvement of Water Supply Supervisory System in Trinidad and Tobago, and entrusted the work to the Japan International Cooperation Agency (JICA).

JICA sent to Trinidad and Tobago a study team headed by Mr. Shoji Sasaki, Nihon Suido Consultants Co., Ltd., three times between October, 1989 and July, 1991. The Team exchanged views and discussions with the officials concerned of the Government of the Republic of Trinidad and Tobago, and conducted field surveys in the study area. After returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to improvement of the Water Supply Supervisory System in Trinidad and Tobago, and promotion of the project of improvement and expansion of the existing Central Supervisory System, and further to the enhancement of friendly relations between our two countries.

I wish to express my sincerest appreciation to the officials concerned of the Government of the Republic of Trinidad and Tobago for their close cooperation extended to the team.

September, 1991

Kensuke Yanagiya
President
Japan International Cooperation Agency

September, 1991

Mr. Kensuke Yanagiya
President
Japan International
Cooperation Agency
Tokyo

Dear Sir,

LETTER OF TRANSMITTAL

We have the pleasure of submitting to you the Final Report of "The Study on the Improvement of Water Supply Supervisory System in Trinidad and Tobago" prepared in compliance with the request of the Government of the Republic of Trinidad and Tobago in implementing the improvement of water supply supervisory system.

This report consists of two volumes. The Main Report describes the results of field survey in the Study Area, the formulation of the master plan of water supply supervisory system in Trinidad and Tobago, and feasibility study on the improvement and expansion of the existing Central Supervisory System. Supporting Report contains discussions in 16 sections to supplement description of respective fields in the Main Report.

All the member of the Study Team wish to express grateful acknowledgement to the personnel of the Advisory Committee, Ministry of Foreign Affairs, Embassy to Trinidad and Tobago as well as officials and individuals of Trinidad and Tobago for their assistance extended to the Study Team.

In conclusion, the Study Team sincerely hopes that the study results would contribute to improvement of water supply supervisory system and to enhancement of socio-economic situation in the Study Area.

Yours sincerely,

Shoji Sasaki
Team Leader
The Study on the Improvement of
Water Supply Supervisory System in
Trinidad and Tobago

THE STUDY ON THE IMPROVEMENT
OF
WATER SUPPLY SUPERVISORY SYSTEM
IN
TRINIDAD AND TOBAGO

FINAL REPORT

MAIN REPORT

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ABBREVIATIONS/ACRONYMS

millimeter	mm
centimeter	cm
meter	m
kilometer	km
square millimeter	mm^2 (sq.mm)
square centimeter	cm^2 (sq.cm)
square meter	m^2 (sq.m)
square kilometer	km^2 (sq.km)
area	a
hectare	h
cubic millimeter	mm^3
cubic centimeter	cm^3
cubic meter	m^3
milligram	mg
gram	g
metric ton	t
liter	l
kilo liter	kl
gallons(imperial)	gal
gallon-US	gal(US)
mean sea level	msl
milligram per liter	mg/l
degree (Centigrade)	°C
milliampere	mA
ampere	A
kiloampere	kA
millivolt	mV
volt	V
kilovolt	kV
kilovolt-ampere	kVA
alternating current	AC
direct current	DC
watt	W
kilo watt	kW
mega watt	mW
kilowatt hour	kWh
mega hertz	mHz
kilometer per hour	km/h
revolutions per minute	rpm
meters per second	m/sec
meter per day	m/day
cubic meter per minute	m^3/min
hour	h
second	sec
cubic meters per second	m^3/sec
cubic meters per day	m^3/day
cubic meters per day	cmd
liters per second	l/sec
liters per capita per day	lpcd
gallon per minute	gpm
million gallons per day	mgd
Nephelometric Turbidity Unit	NTU
kilo byte	kb
kilo byte per second	kb/s
milli second	ms
character per second	c/s
mega byte	mb
mega byte per second	mb/s
bit per second	bps
random access memory	ram

GRTT : the Government of the Republic of Trinidad and Tobago
JICA : Japan International Cooperation Agency
WASA : Water and Sewerage Authority of GRTT
WRA : Water Resources Agency
CSO : Central Statistical Office of GRTT
TGR : Trinidad Government Railway
IDB : Inter-American Development Bank

CURRENCY EQUIVALENTS
As of March 1991

US$ 1 = TT$ 4.25 = ¥ 135, TT$ 1 = US$ 0.24 = ¥ 31.8

SUMMARY

1. INTRODUCTION

The Scope of Work for "The Study on the Improvement of Water Supply Supervisory System in Trinidad and Tobago" (the Study), reached in May 1989 between the Government of the Republic of Trinidad and Tobago (GRTT) and the Japan International Cooperation Agency (JICA), the Government of Japan, stipulates the Study to be carried out by the JICA study team (the Study Team) in two major fields of work, i.e. (1) formulation of a master plan (the Master Plan) for a comprehensive Water Supply Supervisory System (WSSS) in Trinidad and Tobago and (2) preparation of a feasibility study (the Feasibility Study) on the improvement and expansion of the existing Central Supervisory System (CSS).

1.1 REPORT SCOPE AND FORMAT

In compliance with the above scope of work for the present Study, the scope and format of the Main Report are composed as outlined below.

PART ONE covers the background of the Study, objectives and scope; the present conditions of study area; the existing water supply aspects of water sources, facilities, operation and maintenance, and institution and management; and prerequisites for CSS.

PART TWO covers the Master Plan including target year and study area; projection of population and water demand with water balance against existing water sources; basic concept for developing WSSS; proposed WSSS; WSSS operation and management; cost estimates; implementation schedule; and economic project evaluation.

PART THREE covers the Feasibility Study on the identified Phase I Project for initial stage development of the Master Plan improvement program, including design concepts and criteria; preliminary design and proposed specifications; cost estimates and disbursement schedule; implementation schedules; and financial analysis and economic evaluation.

PART FOUR deals with comparative study on Phase I Project implementation based on the results of the feasibility study conducted in Part III. Scope and concept of the recommended option will be briefed for reference.

PART FIVE is a conclusion and recommendation of the present study.

1.2 NATURAL AND SOCIO-ECONOMIC CONDITIONS OF THE STUDY AREA

The study area covers the entire water supply area of Trinidad and Tobago (total 5,128 km^2), which consists of a total of 34 water areas/sub-areas of the Water and Sewerage Authority (WASA). The two islands of Trinidad (4,827 km^2) and Tobago (301 km^2) are located in the southernmost of the Caribbean Sea and share a similar physical characteristics of topography, vegetation and climate. See Fig. General Location Map of Study Area and Fig. I-3.6.

Port of Spain is the capital city of the country which has population of 45,000 in 1989. The city is located on the north west of Trinidad, and is the center of administrative and commercial activities in the country.

Main features of the study area are as follows:

1) Location: Most southerly of Lesser Antilles in the Caribbean Sea.

2) Topography: Trinidad is mostly similar to the topography of eastern part of Venezuela, consisting predominantly a low land with northern hilly ranges of about 900 m above sea level; Tobago is a volcanic origin hilly land with the highest mountain ridge of about 580 m above sea level.

3) Climate: Two islands are influenced by the tropical trade wind climate which has a dry season from January through May and a wet season from June

through December. The average temperature is around 26°C and the annual rainfall is about 2,000 mm.

4) Population: 1,228,800, of which 1,172,600 in Trinidad and 56,200 in Tobago (estimated mid 1990).

5) **Socio-economic Conditions:** General economic characteristics are identified as an agricultural industry based economy before the oil industry was significantly developed and expanded in the 1970's. Gross Domestic Product (GDP) has been mostly dominated by the petroleum industry since 1970, but along with worldwide depression of petroleum market, GDP gradually decreased from TT$ 20,000 million in 1982 to TT$ 16,000 in 1988.

The present conditions of physical-infrastructure are:

Road condition - Ample in length and width with 90% paved satisfactorily covering all over the country.

Public water supply - 95% of population served (92% of total population) in its service area of WASA water system, adequate in its quality, though not satisfactory in supply quantity all over the country.

Sewerage system - Public sewerage system serves at present for limited part of urbanized areas that has about 30% of the total population of the country. Most of the rest depends upon pit latrines and sork-aways.

Electricity - Widely available throughout the country. Generally the capacity is adequate to meet the requirement.

Transportation - Accessible to various locations in two islands by roads, water and air.

1.3. EXISTING WATER SUPPLY

1.3.1 Existing Water Supply System

The existing water supply system is operated and managed by WASA, which was established in 1965 as the sole agency responsible for the development and control of the water and wastewater systems in the country.

In 1990, WASA supplied water to about 1,133,000 of the population in the 34 water areas/sub-areas or water service areas in the country, with an average production amount of about 668,600 m^3/day. See Table I-3.4.

Major features of the existing water supply are summed up in the followings. See Fig. I-3.2.

1) **Water Source/Production Facilities:** WASA has presently 92 separated production facilities including four large-scale waterworks (Caroni/Arena, North Oropouche, Hollis, and Navet) and the same number of water sources which include impounding reservoirs, river waters, groundwater and springs. Out of these, 79 sources are located in Trinidad and 13 in Tobago. The total average daily production amount from all sources in 1988 was estimated at 657,000 m^3/day (including purchased water), of which about 20,000 m^3/day was produced in Tobago. Out of the total production in 1988, an average 466,000 m^3/day (71%) is produced with raw water from impounding reservoirs and river sources. And that from the ground water sources is 191,000 m^3/day (29%). See Table I-3.1 and Table I-3.2.

2) **Transmission/Distribution Facilities:** Existing transmission/distribution system consists of six high lift pumping stations, 52 booster pumping stations, and transmission/distribution pipelines although its total length is unknown. In the service area, 76 service storage reservoirs, out of existing 99, are in use with about 374,700 m^3 of total storage capacity.

3) **Present Water Use:** In 1990, estimated total water demand which covers all categories of water use with the unaccounted-for water (UFW) including

system leakages, is approximately 668,600 m^3/day for the served population of 1,133,000. Refer to above Table I-3.4.

Per capita consumption throughout the country is estimated at 590 liters per capita per day (lpcd) on average, however, serious shortage supply can be seen especially in southern part of Trinidad.

Based on the pilot leakage survey, leakage losses in a typical residential area are estimated in a range of 32% to 84% of the water supplied to this area. See Table I-3.12. Generally, the present total system leakage is estimated at 40% to 50% of the total production and supplied amount of water.

4) **Existing Central Supervisory System (CSS):**

Background

The existing CSS, commissioned in November 1980, was developed as a part of the Caroni/Arena System and a first step of the central supervisory system throughout the country. The objectives of the CSS was to effectively operate and control, under a single operation and management system, the complicated WASA's water supply system which has the above numerous water sources, production facilities and sub-systems. Further, the newly developed CSS was proposed with the necessity of detailed study of the distribution systems and establishment of metering systems on all consumers as early possible. The area covered by CSS, therefore, was limited to the major waterworks, booster pumping stations and service storage reservoirs located in Caroni/Arena System as shown on Fig. I-4.1.

Status

a) The system was merely effective in data acquisition and part of alarm notification, during two years from its start in November 1980 to November 1982. Originally planned remote control system did not function well during the period due to the delay of RTU equipment installation works.

b) After expiration of the two-year maintenance contract in 1982, WASA had a very hard time in carrying out the CSS operation and maintenance, since all spare parts initially supplied were used up in a short period.

c) From 1983 to 1986 the CSS was not normally operated due mainly to troubles on main computers and RTUs. The CSS operation was resumed in 1987, with remote control by repairing them and addition of RTUs.

However, the function of water supply supervisory was not effectively performed, because the number of RTU units were reduced due to cannibalization of its spare parts.

Further, due to the frequent failure of main computers and RTUs with the problems of spare parts supply, despite WASA's effort to repair the computer and restore the CSS function, data/information gathering and recording automatically through the system could not be performed.

d) The existing CSS was stopped in operation after January 1990, mainly due to the problems of devices and spare parts supply for the main computer system. Continuous use of the existing CSS equipment was found almost impracticable because of difficulties for obtaining its spare parts.

5) **Water Rate**: Except for the water use in churches, the water rate are classified for the unmetered use and metered use. September 1990 at present, the almost all of the customers (about 99%) are unmetered. And for the unmetered use, the annual taxable value (ATV) which is the value of a building assessed by the tax office is adopted as the base of billing for a flat rate. The average water rate in 1988-1989, including metered and unmetered accounts, was estimated at TT$ 0.99 per cubic meter based on the records of water sales under present water tariff. As for the average metered account, the average per cubic meter of water sold is estimated at TT$ 1.94 at market price in 1990, based on the adjusted average water for metered account.

6) Institution and Management: WASA is responsible for maintaining and developing the waterworks and sewerage system in Trinidad and Tobago. WASA is under control of the Ministry of Settlements and Public Utilities, and managed by the nine member of Board of Directors.

   Supporting Executive Director for management, the Deputy Executive Director is responsible directory for the daily operation and maintenance through the five administering the technical and management divisions. See, Fig. I-5.1. The four regional offices including the North, South, Cano and Tobago are under the control of the Operation Manager.

   WASA has a total staff of 4,963 (as of January 1991), of which some 2,800 are estimated to be monthly-paid workers and the rest to be daily-paid workers. Out of the total staff, the 2,600 majorities are working for operations and maintenance.

1.3.2 Problems of the Existing Water Supply

Problems found in the overall existing system, during the field survey period of the current Study, are presented in the followings.

1) Regarding the condition of the existing water supply system, most outstanding is aging of the existing facilities. There are systems in use for more than 100 years.

2) According to the pilot leakage survey conducted under the current study, the physical leakage in the system is estimated in a range between 40% to 50% of the water supplied in the distribution system. Thus, the unaccounted for water, including the leakage and wastage, could be estimated at above 50% of the total water produced and distributed.

3) Although some production facilities have been improved to strengthen the supply capacity, the present supply conditions are not sufficient mainly due to inadequate control and an aging inefficiency.

4) Many gate valves were installed as flow control valves on the water mains

and branched pipelines. On the other hand, flow meters installed on the pipelines and at waterworks are very few in numbers. This suggests that the operator(s) of production and transmission/distribution facilities can not monitor and identify actual system flow, water demands or even water production amounts.

5) In the entire existing system, the number of water meters installed at production and transmission/distribution facilities, and service connections are inadequate, and thus no adequate records of water production and consumption are available.

6) Under the present circumstances, WASA is inevitably rationing water supply by manual control of the gate valves on the transmission and distribution mains.

7) Since its installation of the existing CSS facilities, the system could not fulfill the function of the originally planned water supply supervisory system operation, due mainly to the frequent shut-down of the hardwares. Further, due to the short period when the CSS was continuously operated, a historical data accumulation was not made in a certain format.

   Concurrently, the CSS stopped its operation from January 1990 due to the problems of funding the maintenance and improvement of the system. This indicates that, the originally planned water supply supervisory system operation, utilizing the actual operation status data/information through automatic data collection and accumulation will not be executed practically with the existing system.

8) The data collection through the existing CSS were not sufficient in numbers and accuracy. Especially, the basic items of transmission/distribution mains flow and pressure data/information, for its effective use of water distribution, were not monitored/collected nor accumulated, except only one point monitoring.

   Further, it is difficult to prepare an appropriate operation guideline of WASA for the water supply supervisory system, since the existing system can not collect and accumulate the data/information in the system operation.

9) The CSS hardware and its system software for operation were introduced, however, the necessary application software of water supply system simulation and analysis was not provide from the initial stage. Therefore, the original objectives of the CSS could not be fulfilled.

10) Somewhat weak organizational structure for CSS resulted in insufficient back-up activities for developing the water supply management plan and operation/maintenance equipment.

11) Further, because of financial constraint, it seems difficult to obtain materials and spare parts necessary to the normal operation and maintenance in waterworks and pumping stations.

The above problems could be well managed by the proper operation of the water supply system, with an effective application of the CSS which is adequately formulated for proficient supporting system of the sound water supply operation and management for such complicated system of WASA.

2. MASTER PLAN

2.1 GENERAL

For master planning of the Water Supply Supervisory System (WSSS), a period of 15-year from present (1991) up to 2005 is applied for the design period. Further, for the planning period of the master plan, a stepwise development in two phases (Phase I: 1991-1995 and Phase II: 1996-2005) is recommended considering about the present situation of entire water supply system in Trinidad and Tobago, design life of the mechanical equipment and electronic instruments installed for the major facilities of WSSS and also the financial burden of the initial and succeeding investments to the proposed projects in the master plan program. See Fig. II-7.1.

The study area for master plan of WSSS is identical to the entire WASA water supply area, which covers almost all area of Trinidad and Tobago and is presently separated into 34 water areas/sub-areas. See aforementioned Fig. I-3.2.

As for the water demands projection, the future water requirements were estimated with the UFW, including leakage and wastage, which has a prerequisite conditions to reduce its future rate by executing the leakage reduction program. In this Study, the controlled UFW rates are proposed at 50% in 1990, 40% in 1995, 30% in 2000 and 20% in 2005 respectively. Therefore, the total water demand including UFW or the required amounts of supply for served population were projected that in 1990, for the population 1,133,000 and the average daily water of 666,300 m^3/day, and in the target year of 2005, that of 1,463,000 and 639,500 m^3/day. See Table II-2.6.

The total dependable yields of the existing 96 waterworks (including Hillsborough West in Tobago to be constructed) in the study area are estimated at 771,300 m^3/day at the rainy season and 711,100 m^3/day at the dry season as shown in Table II-2.8, which meet the projected water demands/requirements in the design period of 1990 to 2005.

As for the future use of existing water sources and the new water sources development, all existing water sources are adopted and incorporated, but the future water sources development is not considered in the Master Plan. The total available amount of water or dependable yields of existing sources could meet the future demands provided that the recommended leakage reduction program is executed.

Major design figures and items of work are tabulated below.

1) Population of Service Area:

Present	1990:	1,192,000
Projection	1995:	1,299,000
	2000:	1,421,000
	2005:	1,540,000

2) Served Population:

Present	1990:	1,133,000
Projection	1995:	1,234,000
	2000:	1,350,000
	2005:	1,463,000

3) Water Demand:

Present	1990:	666,300 m^3	(UFW 50%)	2000:	637,100 m^3	(UFW 30%)
Projection	1995:	641,900 m^3	(UFW 40%)	2005:	639,500 m^3	(UFW 20%)

4) **Water Sources:** A total of 96 sources, 82 sources are in Trinidad and the rest 14 in Tobago including Hillsborough West.

5) **Water balance:**The estimated water requirements in the design periods (1990-2005) could be satisfied by the water produced and supplied by maximum using of the dependable yields of the existing sources.

Water balance in Trinidad and Tobago for the years 1990, 1995, 2000 and 2005 is summarized as follows:

WATER BALANCE IN TRINIDAD AND TOBAGO (DRY SEASON) Unit: m^3/day

Year	Demand			Supply	Balance
	Net	UFW	Total		
Trinidad					
1990	321,250	321,250	642,500	679,400	+ 36,900
1995	370,400	246,700	617,100	679,400	+ 62,300
2000	427,400	183,100	610,500	679,400	+ 68,900
2005	489,000	122,600	611,600	679,400	+ 67,800
Tobago					
1990	11,900	11,900	23,800	31,700	+ 7,900
1995	14,900	9,900	24,800	31,700	+ 6,900
2000	18,600	8,000	26,600	31,700	+ 5,100
2005	22,300	5,600	27,900	31,700	+ 3,800

2.2 PROPOSED WSSS IN 2005

2.2.1 Target

The proposed Water Supply Supervisory System (WSSS), consistent with the existing CSS, is formulated based on the established target or objective of the existing system, of which major items of target are presented below:

1) Establishment of an effective water supply supervisory system for optimum water production and distribution in the entire system of WASA.

2) Stabilization of the proper distribution pressure in order to achieve equitable water supply to each consumer, off-take flows and pressures.

3) Contribution to the leakage control.

4) Establishment of information flow for quicker decision-making for the water supply management.

To achieve the objectives and targets of the proposed WSSS, an appropriate organization for the WSSS is formulated, which is to coordinate with the present organization of WASA, as presented in Fig. II-5.1.

2.2.2 CSS and LSS

In order to operate and manage the future water supply system effectively, the proposed WSSS consists of two sub-systems namely, 1) Central Supervisory System (CSS) and 2) Local Supervisory System (LSS), which are currently practiced by WASA. See Fig. II-4.1.

The proposed CSS mainly covers the water supply area of four large scale systems of Caroni/Arena, North Oropouche, Navet and Hollis, and its nearby medium and small systems, which has majority of existing facilities with the large amount of water supplied. The proposed LSS covers the other medium and small scale systems covering area, scattered in the present water supply area of WASA, which also has numerous number of small sized facilities with smaller amount of water supplied.

2.2.3 Hardware and Data Communication

Utilizing the existing system with facilities at maximum level, the proposed CSS and LSS are planned to achieve its design functions as presented below. See above Fig. II-4.1 and Fig. II-4.2.

<u>CSS</u>

Proposed CSS function is summarized as presented in the followings. See Table II-4.2.

1) The data signals of water levels, pressure, and flow amounts which are measured at strategic monitoring points including impounding reservoirs,

waterworks and transmission/distribution facilities are transmitted to remote terminal unit (RTU) first, then to CSS building by the radio communication system.

2) As for the proposed data communication system, the existing system of radio communication is applied for the proposed data communication system, taking into account the WASA's sufficient experience of operation, and reliability with economy.

3) Control valves installed at off-takes on the transmission and distribution mains are operated by automatic remote controls, via controller installed at each site by operating valve control panel with mini-graphic display in the CSS building.

4) Pumping units and control valves in booster pumping stations are operated by remote control at the control panel in the CSS building.

5) The pumping units and discharge valves in the existing Tumpuna Storage Lift Pumping Station are operated by remote control by the existing control panel, installed at Caroni Water Treatment Plant under the direction through the main computer in the CSS building.

6) Data signals received at the CSS building are compiled and processing by the main computer system, as they are displayed on the graphic panel as well. The display of collected information is planned for the combined system of the fixed large graphic panel and cathode ray tube (CRT) display.

7) RTUs with uninterrupted power battery units are installed to receive and transmit the data, measured at respective facilities in the system.

8) The computer system and radio communication unit in CSS building and the radio repeater unit are designed as dual-system units, and equipped with uninterrupted power battery units for reliability and safety purposes.

9) The most of newly proposed facilities and equipment are designed as new products or materials, since the existing facilities/equipment are

considered aged and not to be for the future system. However, those equipment which are capable for further usage for the proposed system are considered to be utilized at maximum level so that the project costs could be lowered.

<u>LSS</u>

For the proposed LSS monitoring, flow meters with recorder at each outlet pipe of the production facilities are installed. See Table I-4.3. Installation of work stations at regional office of South, North and Tobago is planned. Each of work stations consist of a computer system equipped with the individual computer/CRT unit, optical character reader (OCR) and the terminal unit of the main computer in CSS building with normal computer functions.

Each work station has the following three functions:

1) Data electronically input by OCR, transmit data to the individual computer on the weekly operation status of LSS under the respective Regional Office.

2) Monitoring the water supply operation status of WASA's entire system, communication to the main computer in CSS building, its system status is monitored by the CRT unit installed at each Regional Offices.

3) Individual computer function; each work station will be installed with the individual computer unit for respective use purposes in Regional Offices.

2.2.4 Step-Wise Development

The proposed development plan for the master plan is designed to be implemented in two phases (Phase I: 1992-1995 and Phase II: 1996-2005), considering about the present conditions of the water supply system in Trinidad and Tobago, and the financial burden of the proposed projects in the master plan. See aforementioned Fig. II-7.1.

In phase I, the major equipment of CSS and the necessary equipment for monitoring system with RTUs and control units of valves are designed for installation. Further, this Phase includes the remote operation units for six booster pumping stations and the remote operation devices to control the existing pumping and valving equipment at Tumpuna Storage Lift Pumping Station. Regarding the control valves for off-takes on the transmission/ distribution mains, in Phase I, the valves and its remote operation devices will be installed in Phase I.

In the initial/first step of system operation, automatic valve operation setting is made by manual input at sites for a trial. After valve control operation is practiced, and the actual operation status data are collected and analyzed, the operation target setting will be established to operate remotely from the CSS building in the second step of system operation.

In Phase II, some equipment and devices especially for CSS related instrument and electronic appliances which are installed in Phase I need to be replaced, which have been in use for more than 10 years. Therefore, such equipment and devices are planned to be replaced with new ones. And, the remote operation devices for the control valves, installed at off-takes on the transmission and distribution mains, are planned to be installed. In addition to this in Phase II, work stations at each Regional Offices and flow meters with recorder for the waterworks in LSS are planned to be installed.

Immediate Projects are recommended in this Study, as a substantial part of the Master Plan, which require to undertake the ongoing "Universal Metering Program" and the planned "Leakage Reduction Program" in an earliest timing in the initial stage of Master Plan improvement program (1992 to 1995).

2.2.5 Major Facilities

Proposed major facilities to be constructed are as follows:

- CSS building, by expanding the existing CSS building
- Central equipment of CSS including main computer and graphic panel
- Repeater station
- Work stations with CRTs at regional offices

- RTU stations
- Remote operation unit of booster pumping stations
- Remote control unit with mini-graphic of flow control valves
- Monitoring equipment (flow meters, level meters & pressure gauges) and flow control valves at strategic points in waterworks and transmission/distribution system.

For details, refer to aforementioned Figs. II-4.1 & II-4.2, and Tables II-4.2 & II-4.3, and Table II-4.1.

2.2.6 Project Cost

Project costs are summarized below. For details, refer to Table II-6.1.

(Unit: in 1,000)

Cost Component	Phase I Project	Phase II Project	Project Cost Total
Foreign(US$)	35,278	30,317	65,595
Local (TT$)	47,129	37,593	84,722
Total (US$)	46,367	39,163	85,530

(Exchange Rates: 1 US$ = TT$ 4.25)
(Costs as of March 1991: not including price inflation)

The project evaluation is conducted through comparing the costs integrating those of CSS, leakage prevention and universal meter and the benefits integrating those corresponding to the above mentioned three cost components.

2.2.7 Benefits Accrued from the Project

The benefits accrued from the Project can be broadly categorized into three aspects: 1) improvement of services to customers, 2) reduction of operational costs while maintaining the services to customers and 3) contribution to planning of water supply systems.

Regarding the improvement of services to the customers, monitoring of the water system and detection of water leakage will contribute to reducing the system leakage, which enable WASA to provide customers with more water in a good pressure and to decrease the areas subject to rationing of water.

Using the WSSS, the leakage will be detected in a short period. In addition, the opportunity could be provided to formulate the cost effective method for the leakage control. Also, the WSSS will get the saved water more effectively distributed to customers. The benefits could not be fully realized if some water is wasted at the level of consumers due to inappropriate distribution.

In addition to the benefits of ordinary operations, the WSSS will contribute to the planning in future. The storage of data collected with the WSSS will be the based on which the plans of water supply systems such as the expansion and improvement of the system will be formulated.

3. FEASIBILITY STUDY

3.1 GENERAL

The Feasibility Study was carried out for the Phase I Project, which aims at improvement and expansion of the existing CSS, mainly by strengthening the monitoring and control system in the project area.

Therefore, this phase includes works to formulate the metering and valving system on the transmission/distribution mains, which aim at not only the indispensable information collection of the main pipelines in the distribution system, but also the basic information collection to effectively provide the new CSS, with the actual data of operation status from the initial step of its system operation.

Such information enables the CSS to work properly as expected for strategic control of the transmission/distribution system. It is especially noted that acquisition and analysis of such data are quite time consuming. Moreover, such data collection can only be possible with the installation and operation of sensing equipment.

Followings are brief summary of Master Plan related to Phase I Project.

Project Area

The area supplied with piped water principally from the four major waterworks (Caroni, North Oropouche, Navet and Hollis) including 16 raw water sources as shown on Fig. III-1.1.

Target Year

The end of 1995, four years after the initiation of the Project implementation in mid 1992.

Population

Population in service area will increase from 1,192,000 in 1990 to 1,299,000 in 1995. Population served within the project area will also show a rapid growth in the said period, i.e., from 825,000 in 1990 to 896,000 in 1995.

Water Demand

On assumption that unaccounted-for water (UFW) ratio would be substantially improved from the present 50% to a rather optimistic ratio of 40% in the year 1995 by conducting intensive wastage control activities, future water demand including UFW in project area will be forecast almost constant with a slight drop from 531,000 m^3/d in 1990 to 513,000 m^3/d in 1995.

Water Balance

Dependable yields in the project area are estimated based on the historical data and information from 602,000 m^3/d in rainy seasons to 546,000 m^3/d in dry seasons. This implies a total of dependable yields will suffice well for the water requirement in 1995 even in dry seasons.

Outline of Phase I Project

Major facilities and instruments contained in the Project will have following functions as shown on Fig. III-2.1.

1) The CSS building will be a center for monitoring and control, equipped with master terminal unit, central processing unit, input/output interface, graphic panel, uninterruptible power supply, remote control panel, etc.

2) The repeater station will perform repeater function of signal and data, which will be equipped with a repeater system and interruptible power supply.

3) RTU stations to be newly constructed on site will encase remote terminal units, an instrument panel and uninterruptible power supply to receive and transfer electrical and mechanical signals to the CSS.

4) Monitoring and control equipment to be installed at the waterworks, pumping stations, service storage reservoirs and water mains are flow meters, pressure gauges, level meters and flow rate controllers.

Major Facilities

The major output of the Phase I Project are presented below:

- Central Data Processing System (CDPS)
- 48 Remote Terminal Units (RTU)
- Data Radio Communication System
- Field Instruments and Equipment
- Remote Control Equipment on Booster Pumping Facilities and Control Valves
- 139 Flow Meters and 106 Motor-driven Valves on Production Facilities and Transmission/Distribution Mains
- 21 Level Meters and 111 Pressure Gauges on Production and Transmission/Distribution Facilities

For details, refer to Fig. III-3.1, Fig. III-3.2, Fig. III-3.3, Fig. III-3.4, Table III-3.1, Table III-3.2 and Table III-3.3.

<u>Project Implementation and Costs</u>

1) Project Implementation: 1992-1995 as seen in Fig. III-5.1.

- Engineering service (detailed design, tendering & award of contract, construction supervision, and operation training), 1992-1993, 1994-1995, and end of 1995.

- Construction and installation, 1994-1995.

- Place facilities in operation, and commissioning, 1994-1995, and end of 1995.

2) Project Costs: See Table III-4.1.

Foreign	(US$)	35,278,000
Local	(TT$)	47,129,000
Total	(US$)	46,367,000

(Exchange Rates: 1 US$ = TT$ 4.25)
(Costs as of March 1991: excluding price inflation)

3.2 ECONOMIC AND FINANCIAL EVALUATION

3.2.1 Economic Evaluation

The economic project evaluation is made by assessing the economic benefit and cost stream generated by the Project implementation. The economic cost is calculated based on the estimated project costs of US$ 46.37 million (TT$ 197.07 million) in total for Phase I, and the associated projects costs are incorporated for the Costs and Benefit analysis. See aforementioned Table II-6.1 and Table III-6.2.

The economic benefit is mainly composed of the tangible benefits on the water saving which is developed by the system monitoring and leakage reduction. The average revenue per cubic meter of water sold is estimated at TT$ 1.94 at market price in 1990, based on the adjusted average water rate for metered account, records of water sales under present water tariff in 1988-1989.

Economic internal rate of return (EIRR) is calculated at 9.6% as shown in Table III-6.5, which is lower than the Opportunity Cost of Capital (OCC) in Trinidad and Tobago (12%). However, the EIRR understates a variety of intangible benefits of the Project and "Associated" benefits of the Universal Metering Program as mentioned before.

3.2.2. Financial Evaluation

Financial cash flow is made from the derived financial benefits and costs as shown in Table III-6.7. The financial evaluation is made in terms of financial internal rate of return (FIRR) and loan repayability. The revenue of the project is calculated on the basis of project incremental volume of water supply and the present average water tariff.

Based on the proposed Project outputs and available data on benefits, FIRR is calculated at 0.3%. Although the benefit is positive, it cannot be judged that the Project is financially sound even if the intangible benefits are not reflected in the figure.

It is worthwhile examining the increase in water revenue to get the Project financially viable. If WASA has its standard of the rate of return to the investment, the standard can be applied to judge the financial viability of the Project. However, there is no such standard at the moment.

Accordingly, an analysis can be made to derive some water rates which get the FIRR of the Project eight, ten and twelve percentages. The result of the analysis is as follows:

FIRR	Average Water Rate (TT$/$m^3$)
8%	1.74
10%	1.98
12%	2.24
(0.3%)	(0.99)

The above water rates are some indices showing the rates at March 1991 prices to be raised by year 1996, the commissioning year of the Project.

The impacts of increase in water rates on the customers are examined, especially for domestic customers, by checking if they can afford to pay for the water charges. To clarify a certain rate of the above FIRR, say 12%, the water rates by customer category in 1995 were estimated to get the average water rate in total TT$ 2.24/m^3, based on the data in 1990. The average water rate of domestic category has to be increased to TT$ 2.64/m^3 from TT$ 1.08/m^3 in 1990. See Table III-6.9.

Assuming the household income constant in real terms until 1995, the proportion of expenditures in water to monthly household income is estimated at 2.7%, based on the available data. The percentage will decline when the GDP grows in real terms. Indeed, it is forecasted to grow from 1991 to 1995 by National Planning Commission. The average household could afford to pay the increased water rates, as the upper limit of the capacity-to-pay for water charges is generally considered three to five percent of the household income.

4. COMPARATIVE STUDY

The scope of the Phase I Project, identified in the Master Plan, covers a vast range of system monitoring, operation, control, data processing and water supply planning by installing CSS instruments and monitoring equipment as described in Part II.

Feasibility Study presented in Part III analyses an early establishment of the CSS in 1995 as Phase I Project, in accordance with the results of mutual discussions between GRTT and Study Team during Master Plan stage.

Notwithstanding, as discussed in Section 6 Project Evaluation, Part III, the implementation of the Phase I Project by the year 1995 is considered too optimistic (or hardly justified its feasibility without conditionality) from financial points of view.

Following to the above result of project evaluation, a comparative study is made on possible options of the project implementation of which outcome is responding to the said scope of work with full-scale CSS improvement and development.

And the study suggests more feasible solution that divides the Phase I Project into three steps as shown on Fig. IV-1.3, even with its longer implementation period as described below.

Option A

1) Installation of primary sensors (flow meters, pressure gauges and level meters) with recorders, construction of meter chambers and computer system for electronic data storage. (1992-1995) See Fig. IV-1.2 and Table IV-1.1.

2) Monitoring and data acquisition for conducting pipe network hydraulic analyses and developing water supply plan. (1996-1997)

3) Installation of CSS instruments, installation of flow control valves, construction of RTU stations and valve chambers, remote control instrumentation for booster pumping station and expansion of the CSS building. This final step totally coincides with the outcome of the following Option B (1997-2000). See above Fig. IV-1.2 and Table IV-1.1.

Option B

1) Unified or single-step installation of primary sensors, control equipment and CSS related instruments (1992-1995) See aforementioned Fig. III-3.1 and Table III-3.1.

Investment costs required for Steps 1 and 3 of Option A are US$ 6.9 million and 41.1 million respectively, which totals to US$ 48 million. On the contrary, the investment cost of Option B for the full scale project of Phase I is estimated at US$ 46.4 million. As seen in the tables, the initial investment cost of Option A is considerably low, about 15% that of Option B. While, its total cost of Phase I is slightly higher than that of Option B. See Table IV-1.2 and Table IV-1.3.

According to the present value evaluation of investments for the above two options, see Table IV-1.4, the investment for Option A excels in every percentage of discount rates. It is advised, therefore, that the Option A is a more feasible solution for Phase I implementation. Economic and financial analyses of the above options are made to verify viability of the project as follows: (Refer to Table IV-2.1 and Table IV-2.2).

	EIRR *	FIRR at Water Rate (TT$/$m^3$)
Option A	12.5%	8% at 1.43
		10% at 1.61
		12% at 1.80
Option B	9.6%	8% at 1.74
		10% at 1.98
		12% at 2.24

*... EIRR is computed using the adjusted average water rate of TT$ 1.94 as unit benefit.

The more feasible plan of Option A, which has even its full-scale CSS improvement and development, is implemented in a longer period (1992-2000) than that of the other optional plan for the Phase I Project (1992-1995).

However, it is more recommendable as the practical and effective implementation schedule, which installs the metering facilities and personal computers, in the Step 1 in Phase I.

Thus, the said indispensable main pipeline information/monitoring system is formulated in several years, using the installed measuring facilities with the aid of personal computers, which collect and accumulate the main pipelines operation status data/information.

The proposed CSS in Phase I is completely developed after realization of the above pipeline information system, which is considered as the most recommendable process of the effective CSS formulation and operation.

RECOMMENDATIONS

In the course of the present Study, following recommendations are considered important to implement the Project. Item 1) below presents recommended option of CSS development, which is less costly and less sophisticated but requires longer period of project implementation. Item 2) is a reproduction from the prerequisite for implementing the Phase I Project or the above option. On the other hand, items 3) and 4) are regarding institutional aspects of WASA and water resource development respectively.

1) Recommended Option of Phase I Project

Feasibility Study presented in Part III analyses an early establishment of the CSS in 1995, in accordance with the results of mutual discussions between GRTT and Study Team during Master Plan stage. As suggested in Section 6 Project Evaluation, Part III, implementation of the Project by the year 1995 is considered too optimistic (or hardly justified its feasibility without conditionality) from financial points of view. Reflecting the above result of project evaluation, recommended option of the project implementation, of which outcome is responding to the scope of Phase I Project with full-scale CSS improvement and development will have three steps of implementation.

Installation of pressure gauges, flow meters and level meters furnished with recorders, and computer system for electronic data storage will be executed as the first step. This initial investment will benefit on providing valuable and reliable operational data in several years of operation as the second step. It is the very analyses and studies regarding actual water supply conditions and consumer's water use patterns, on which future water supply planning including development of CSS will be based. Then the installation of the CSS instruments may follow as third step. This final step is to operate the CSS along with operation manual developed.

Thus, the said indispensable main pipeline information/monitoring system is formulated in several years, using the installed measuring facilities with the said of computers, which collect and accumulate the main pipelines operation status data/information. The new CSS of the Phase I is completely developed after realization of the above pipeline information system, which is considered as the most recommendable process of the effective CSS formulation and operation. As discussed in Part IV Comparative Study, Options A and B have the following steps of project implementation:

Option A

a) Installation of primary sensors (flow meters, pressure gauges and level meters) with recorders, construction of meter chambers and computer system for electronic data storage. (1992-1995)

b) Monitoring and data acquisition for conducting pipe network hydraulic analyses and developing water supply plan. (1996-1997)

c) Installation of CSS instruments, installation of flow control valves, construction of RTU stations and valve chambers, remote control instrumentation for booster pumping station and expansion of the CSS building. This final step totally coincides with the outcome of the following Option A (1997-2000).

Option B

a) Unified or single-step installation of primary sensors, control equipment and CSS related instruments (1992-1995)

Approximate cost required for the first step of Option A is estimated at US$ 6.9 million in total, i.e., about 15% of the Phase I Project (Option B) cost. Table IV-1.4 also shows results of evaluation by present value method. As clearly seen in the table, "Option A" excels in every percentage of discount rates applied (5%, 10%, 12% and 15%). Therefore, it may be concluded that "Option A" is a more feasible solution for Phase I Project implementation.

2) Urgent Implementation of the Immediate Project

The current study suggests that the establishment of the CSS for all systems of WASA throughout the country is somewhat premature if the existing water supply system be left without any proper measures. As identified in the present report, implementation of the immediate project is a prerequisite condition for starting CSS operation. Otherwise, targets set up for the Phase I Project will not be achieved as intended. The immediate project will have the scope of establishment of sound metering system and tariff structure, urgent implementation of leakage reduction, update of data and maps of the existing pipe network, etc. as further described below:

Metering System

The present metering system adopted by WASA covers merely 1,802 connections (or less than 1%) out of the total 250,770 as of September 1990 to charge water tariff based on water consumption. Most consumers use water freely with little awareness on conservation of water resource because of absence of meters. To reduce consumer's wastage which contributes a substantial portion of the present UFW(50%) to an appropriate level, an early establishment of the universal metering system is indispensable, covering entire range of domestic, industrial and commercial consumers. Previous surveys carried out in developed countries suggest that per capita demand decreased significantly to 50% of the previous demand by employing metering system.

Tariff System

Concurrently with establishment of the above, normal tariff structure that charges based on meter reading, or actual water consumption is ideal for reducing water wastage. As detailed in Section 5, Part I, there remains some room to raise water rates in view of the current tariff level and consumers' affordability to pay. Water rates should be determined and the desirable level should reflect WASA's the actual expenditure and assets so far invested. Its early establishment can contribute greatly to strengthening the financial capability and hence institutional management of WASA.

Leakage Reduction

The above two aim at reducing water wastage by improving the institutional and financial aspects of WASA. In addition, it is recommended that WASA conducts a leakage reduction project to reduce physical water losses through the pipe network. According to the pilot leakage survey conducted under the current Study, most of unaccounted-for water is derived from physical leakage through the pipelines and valves. For smooth implementation of the leakage reduction project, objectives and implications of such activities will be recognized clearly by the public as well as WASA. Public understanding and cooperation are of primary importance in conducting the leakage reduction project.

Update of Data and Maps of the Existing Water Supply System

As-built drawings and data based on detailed surveys available in WASA, although very limited, are not always accurate as discussed in Part I of this report. These data and maps sometimes contradict each other. Possible reason for this may be attributable partly to the obscure unit system and base line for survey and measurement. To avoid such circumstances, WASA is recommended to conduct topographical surveys on the existing water supply system throughout the country based on an unified and standardized unit.

Periodical Calibration/Overhaul/Replacement of the Equipment

It is often observed during field reconnaissance that meters, pressure gauges, pumps and valves installed at the waterworks and on the transmission/distribution network are malfunctioning and left without repair. More resources should be assigned to appropriate maintenance and periodical calibration of the installed equipment. Such activities on daily routine basis may be the most cost-effective measures to ensure effectiveness of monitoring and control of the whole water supply system.

Public Campaign to Reduce Water Wastage

As described above, unaccounted-for water reaches to a high ratio of approximately 50% according to the result of field surveys. This implies the half of the production and investment cost are wasted. If such wastage or losses were reduced, the water revenue would significantly increase. To generate further income, it is also an important measure to conduct campaign to enlighten the people how to use effectively the piped water without wastage.

Development of Long and Medium Term Water Supply Master Plan

The present report deals with the Master Plan of Water Supply Supervisory System and Feasibility Study of the identified Phase I Project. The report is prepared in the absence of any comprehensive long-term water supply master plan. In this sense, the current study on development of water supply supervisory system stands unsupported. It is desirable to establish long and medium term water supply master plan as expeditiously as possible: then, review the current study in compliance with the strategy and targets established.

Self-sufficiency of WASA

WASA depends significant part of the financing on the Central Government for project investment and even for routine maintenance. Vast amount of accounts receivable has been accumulated; equivalent to nearly annual water sales at the end 1989. Further, the working ratio (the ratio of operating expenditures less depreciation to operating income), 1.58 in 1989, suggests current critical financial position of WASA. It can be said that the financial capability of WASA is quite vulnerable and weak as sole utility responsible for developing and managing water and sewerage works in Trinidad and Tobago. As seen in SAL agreement concluded between WASA and the World Bank in November 1989, it is fundamental to establish self-sufficiency of WASA in the early stage of the project development.

3) Improvement of Service Level of WASA to the Customers

Customers in some remote areas are suffering from water shortage whereas much water are wasted as leakage particularly in high pressure zone. Current practice by WASA to supply water to such customers is an intermittent supply by valve turncock or by tank truck. It can be said that the existing systems, particularly distribution network, have not been planned on the basis of actual water demand. Moreover, water tariff applied in Trinidad and Tobago is most in practice a flat rate system according to the potential value of property; customers are unmetered (99% in number), therefore pay constant water rate regardless of water consumption. In such a situation, many may not be satisfied with the services rendered by WASA. Much emphasis should be directed to the strengthening institutional aspects to improve WASA's service level.

4) Water Resource Development

As suggested in the present Report, total dependable yields from the existing water sources available in the country is exceeding the water demand of the whole population. This situation will continue up to the target year of 2005, provided that the unaccounted-for water ratio be significantly reduced from the current 50% to 20% in 2005. The field survey conducted in the course of the Study also suggests that the southern rural area of Trinidad rather than the northern urban area, and most part of Tobago are suffering chronic water shortage. Immediate improvement of this situation in a few years might be impossible because of the constraints of physical configuration of the existing water supply systems, such as the transmission and distribution facilities, and the limited availability of water sources. It is therefore recommended that WASA urgently formulates comprehensive water source development plan to cope with this problem.

PART ONE: GENERAL

1. INTRODUCTION

1.1 AUTHORIZATION

The present report is prepared in accordance with the Scope of Work for the Study on Improvement of Water Supply Supervisory System (WSSS) in Trinidad and Tobago, agreed between the Government of the Republic of Trinidad and Tobago (GRTT) and the Japan International Cooperation Agency (JICA), the Government of Japan on May 31, 1989.

1.2 OBJECTIVES AND SCOPE

1.2.1 Objectives

As specified in the Scope of Work, the ultimate objectives of the improvement of water supply supervisory system including the existing Central Supervisory System (CSS) are:

1) to broaden the information and communication base for monitoring of the water supply system and thus further enhancement of its management;

2) to further optimize the use of resources and reduce in operation cost;

3) to achieve better customer satisfaction as a result of the expected higher level of efficiency throughout the system; and

4) in the longer term to provide an environment for technical computation which would facilitate designs and modeling, distribution system analysis, and also assist in leakage control and development of schedules for preventive maintenance.

1.2.2. Scope

The Scope of Work for the present Study defines the following study items:

- to formulate the Master Plan for a comprehensive water supply supervisory system in Trinidad and Tobago, and

- to conduct a Feasibility Study of the improvement and expansion of the existing water supply Central Supervisory System (CSS).

Further, the scope of the Study are referred to the said agreement as follows:

1) review of the existing water supply system including the Central Supervisory System (CSS), for collection and processing of technical data and make recommendation for its improvement;

2) conduct a study for expansion of the existing CSS to strategic installation and points in the distribution system throughout Trinidad and Tobago to meet optimum needs;

3) identification of feasible options and full evaluation of their economic and technical implications;

4) establishment of priorities;

5) proposals for a program of improvements and development;

6) provision of cost estimates;

7) clear identification of components hardware and software requirements and training needs; and

8) make a recommendation for the management of the system with respect to maintenance, spares, skills, manpower, and financial resources.

1.2.3. Study Period and Reports

The present report is prepared on the basis of the field investigations, surveys and interviews with the WASA's (Water and Sewerage Authority) officials concerned which are conducted during the study period in 1989 and 1990.

The field investigations in Trinidad and Tobago and study for formulation of the Master Plan (M/P) of Water Supply Supervisory System (WSSS) were conducted during the months from October 1989 to March 1990. The field investigations and feasibility study for the existing CSS were conducted during the months from July 1990 to March 1991.

The Inception Report of the present Study, which presented the entire schedule of the study activities, was submitted in October, 1989, at the initial stage of the field investigations in Phase 1 study.

The Interim Report which presented a comprehensive M/P of the WSSS in Trinidad and Tobago was submitted to WASA in September 1990. The Progress Report (1) and Progress Report (2), which presented findings of respective phases field investigations and the work progress/status of the Study were submitted to WASA in January and October, 1990, respectively. Further, the Addendum to the Progress Report (2), which describes financial and institutional aspects of WASA, was submitted to WASA in December, 1990.

The present Master Plan and Feasibility Study report is a conglomeration of respective sections of the above reports after minor revision and amendment.

1.3 TERMINOLOGY

Terms and words which are frequently used in this Report are defined hereunder to avoid any errors or misreadings caused from implicit meaning of each word. Accordingly, the defined words are of confined application simply to the present study and not necessarily consistent with the one broadly accepted.

1) Study Area - The whole area of Trinidad and Tobago where the water supply supervisory system is planned to be developed under the Master Plan.

2) Project Area - The area where the project identified in the Master Plan will be implemented.

3) Water Supply Supervisory System (WSSS) - The whole process of monitoring, recording, operation and control of flow rate, pressure (or hydraulic gradient) and water quality including development of water supply target and strategy.

4) Central Supervisory System (CSS) - The supervisory system centered in one place to collect data and information, to process them and to give appropriate direction to the site/operators using equipment and facilities constructed for monitoring, operation and control.

5) Local Supervisory System (LSS) - The supervisory system operated in the WASA regional offices and/or operators stationed locally.

6) Monitoring - Observation of flow rate, water pressure, level and quality at the selected points of the water supply systems including data recording and processing by staff and/or operators stationed locally.

7) Operation - To work the water supply facilities according to the manuals or engineer's directions designed for routine operation to produce and supply treated water with normal quantity, quality and pressure.

8) Control - To work the water supply facilities according to the manuals or directions designed for tentative or emergency operation of water supply facilities under such cases as sudden change or fluctuation of flow conditions.

9) Remote Operation/Control - Operation/control of the water supply facilities from the CSS building or waterworks without direct access to the control equipment to attain the above respective purposes.

10) Total Water Demand - Schedule of the water requirements for water supply which consists of "net water demand" and "unaccounted-for water" described below.

11) Net Water Demand - Water requirements for customers composed of use components such as domestic, industrial and commercial water use.

12) Unaccounted-for Water (UFW) - Water that is taken from a source into a distribution system but which is not delivered to the customers.

13) Dependable Yield - The quantity of raw water from water sources of rivers, impounding reservoirs, wells, etc. which is evaluated, in the Study, to be relied on as future water source for dry and rainy seasons.

14) Production Capacity - The quantity of treated water at waterworks or well fields and water treatment plants for the purpose of water supply.

15) Water Area - Area which is defined and named by WASA especially for the purpose of its nationwide water supply planning.

16) Immediate Project - An emergency project including leakage reduction program and universal metering which is recommended to be implemented preferably before starting operation of Phase I Project facilities.

1.4 COMPILATION OF THE REPORT

Outputs of the present Study are Executive Summary, Main Report, Supporting Report and Basic Data, which are separately compiled. This Main Report of the Study on the Improvement of Water Supply Supervisory System (WSSS) in Trinidad and Tobago attempts to picture the future plan of the WSSS up to 2005 and to verify the feasibility of the Phase I Project based on results of studies and analyses conducted. The Report consists of five parts: Part I General, Part II Master Plan, Part III Feasibility Study, Part IV Comparative Study and Part V Conclusion and Recommendations. Some description made in the present Report is not necessarily detailed. It is recommended to refer to the Supporting Report and Basic Data when further information is required.

Part I General overviews the existing condition of the water supply systems in Trinidad and Tobago based on results of field reconnaissance and review of collected data and information. Special stress will be laid on review of the existing CSS related facilities.

It should be noted that data and information obtained in the course of the Study are not necessarily complete and accurate. Information obtained in WASA head office have been sometimes inconsistent with the one obtained in district offices. In this connection, Part I also proposes prerequisites for implementing the project in view of such problems being encountered by WASA.

Part II Master Plan proposes strategies for establishing water supply supervisory system in Trinidad and Tobago, develops its implementation schedule up to 2005 and identifies the Phase I Project to be immediately undertaken.

Despite limited data on water production and consumption, future water demand is forecasted and used as an input to the study on operation and control of the distribution and transmission system.

Part III of this Report intends to verify viability of the proposed Phase I Project. For this purpose, the proposed facilities and CSS instrumentation will be preliminary designed together with cost estimates. The project viability will be examined from technical, financial and economical standpoints.

Technical examination is on availability of materials and equipment, capability of contractors, ability of WASA for operation and maintenance of the completed facilities.

Profits generated from the project implementation should be large enough to cover the initial cost by operation in the succeeding years. If not, the investment can be judged to be inappropriate in size, scope and/or timing. To this end, financial projection will be made and an internal rate of return of the project will be computed.

Further, the project viability will be confirmed from economical points of view. In case of water supply, economical benefits are generally difficult to evaluate in numerical figure. Therefore, a few of them which are rather easy to express in economic value are focussed on and evaluated in terms of economic internal rate of return.

Part IV, reflecting the results of the evaluation of the planned Phase I project implementation, proposes a recommended plan for Phase I Project implementation through comparative studies. Part V is a conclusion and recommendation focusing on subjects which are deemed essential.

2. PRESENT CONDITIONS OF STUDY AREA

2.1 NATURAL CONDITIONS

The study area is the entire WASA water supply system in Trinidad and Tobago, which has approximately 5,128 sq. km as the total area of the nation. Trinidad and Tobago lies on two islands of the southern part of Lesser Antilles in Caribbean at longitude 60°30' to 61°56' west and 10°02' to 11°12' north of the equator (see General Location Map of Study Area).

Trinidad is approximately 4,827 sq. km in size and predominantly a low land with ranges of low hills in the southern and central sections. A mountain range rising to 900 m above sea level closely parallels the northern coast. Trinidad is geologically a constitution of Venezuelan mainland separated from it by a fault depression in the Caribbean Sea.

Tobago is about 300 sq. km of volcanic origin island and rises to a height of 580 m, where dense forests cover the heights. Plantations also prevail all over the island, especially in the western part of low land.

Trinidad has three mountain ranges in the north, central and south. The northern range consists of metamorphic rock hills with steep slope and covered by deep tropical rain forests. The central range is of limestone hills of about 300 m with gentle slopes. The southern range consists of the Tertiary moraine hills with elevation of approximately 300 m above sea level in the south.

The four existing major water sources, which are Caroni/Arena, North Oropouche, Navet and Hollis, for WASA water supply system are located in the northern and central mountain range areas in Trinidad.

The Arena Impounding Reservoir and Caroni River are in the central mountain range, and its river-course is to the northwestern part of Trinidad. The Navet High and Low Reservoirs are located at the central mountain range. The North Oropouche River starts from the eastern part of the northern mountain range, and flows to the northeastern part of Trinidad. The Hollis

Impounding Reservoir is located in the northern mountain range which is to the north of the Arena Reservoir.

Caroni plain lies in the north between the northern range and the central range. Nariva and Naparima plains lie on the east and west low lands which are located between the central and south ranges. In these three plains are the rivers of Caroni, Navet and Ortoire, and Oropouche (south), which are reached to the Caroni swamp, Nariva swamp, Oropouche swamp, respectively. These swamps are large in size, and are located near by the above mouth of respective rivers.

Tobago is located approximately 32 km to the north-east of Trinidad, and it has older igneous rocks and metamorphic rocks compared with that of Trinidad. The mountain ridges called Main Ridge lie from north-east to the central part of island. While, the central to south-west part of island has gentle slope hills which finally reach to the Caribbean Sea with beautiful coral reef. All area on the island is covered by vegetations of tropical forests and plantations. Tobago has major rivers of Courland, Richmond and Kings Bay, which are utilized for cultivation of the main part of island.

Trinidad and Tobago has a humid tropical climate with north east trade winds, and it has a dry season from January through May, and a wet season from June through December with precipitation during wet season in excess of 1,800 mm per year. The mean annual rainfall of Trinidad is about 2,100 mm, and that of Tobago is about 1,800 mm.

Though the area is located at low latitude, its climate is moderate and the temperature is not much variable throughout the day and year. However, it is rather hot and humid during the wet season with temperatures low from 21°C to high of 29°C. Mean annual temperature is 26.6°C with relative humidity ranging between 50 to 100 percent.

Two islands are hydro-meteorologically influenced by the Caribbean Sea like the neighboring islands of West Indies. However, hurricanes have not frequently been observed there, since two islands are physically located just anti-side the hurricane belt in the Caribbean Sea.

2.2 SOCIO-ECONOMIC CONDITIONS

General economic characteristics are identified as an agricultural industry based economy before the oil industry was significantly developed and expanded in the 1970's.

Gross Domestic Product (GDP) has been mostly dominated by the petroleum industry since 1970, but along with worldwide depression of petroleum market, GDP gradually decreased from TT$ 20,000 million in 1982 to TT$ 16,000 in 1988.

The socio-economic outlook is hopeful for growth and development. However, public infrastructure problems as well as environmental problems in the rural areas, even urbanized ones, exist on various aspects, such as stable potable water supply, waste disposal and drainage, which need immediate attention to cope with local domestic water shortage, and to avoid an accidental health situation in all over the country.

For further information, Supporting Report A "Socio-Economy" is prepared.

2.2.1 Administrative Division

Trinidad and Tobago is administratively divided into nine counties and each county has several wards, the smallest local administrative units as shown in Fig. I-2.1.

Besides counties, there exist two cities and these boroughs as the administrative units. Port of Spain forms a center of administration and economic activity in the country as the capital city. San Fernando is a central city of regional administration and economic activity in the southern area of Trinidad. Arima, Chaguanus and Point Fortin which are the representative boroughs in the country form the center of economic activity in respective regions. However, apart from the aforementioned administrative divisions, WASA has its own area divisions for administration, planning and customers service.

2.2.2 Population

According to the population census, population of the country indicated 1,055,763 in 1980 with a comparatively low growth rate of 1.26% for the period 1970-1980 as shown in Table I-2.1. Lower growth than that of the country appeared for both cities of Port of Spain and San Fernando, i.e. -1.16% and -0.99% respectively, for the same period, and in 1980 the population of both cities were 55,800 and 33,395. Such a minus growth for both cities was due to out-migrants not only to foreign countries but to other areas in the country.

Population density in the country showed 206 persons per sq.km in 1980, while the less developed counties in eastern regions of Trinidad have very low population density, i.e. below 60 persons/sq.km in 1980, under the influence of out-migrants which are caused by lack of employment opportunities.

Population projections made by the Central Statistical Office (CSO) in 1980 showed that population in the country would amount to 1,280,000 in 1990 and 1,520,000 in 2000 at a growth rate of about 1.7% per annum.

2.2.3 Physical Infrastructure

1) Water Supply

Water production and distribution are still deficient in some areas, however overall national water quality serves 95% of population served (92% of total population of the country) in its service area of WASA system in 1990. The level of service must be improved to meet the present day domestic, industrial and agricultural demands.

Further, there are notable regional variations in the quantity of service. Some areas, mostly rural, and particularly in the North East, South East and South West of Trinidad and South West Tobago experience severe shortages against their water requirements.

The 1982 National Physical Development Plan pinpoints the following factors that may be attributable to the present deficiency in water supplies.

- Supply shortage at source, particularly during the dry season;
- Serious deficiencies in the transmission and distribution system;
- Poor water use practices by consumers resulting in a vast amount of wastage;
- Water supply system highly dependent on electricity resulting in a critical water supply situation when electricity supplies are cut for any length of time;
- The over-use of groundwater supplies in parts of North Trinidad with resulting salt water infiltration;
- The failure to develop available supply sources;
- The removal of large tracts of forest and other protective vegetation particularly in upland and valley areas. This is a continuing threat to the ability of water catchment areas to be adequately recharged and is significant in the light of WASA's dependence on groundwater sources of supply;
- The paving of major water courses in key valleys resulting in very little percolation to replenish underground sources.

2) Sewerage

The present sewerage system service covers limited parts of urbanized areas that has about 30% of the total population of the country. These areas are Port of Spain and adjacent suburbs, San Fernando, and Arima. Most of the rest of the country depends upon pit latrines (58%) and soakaways, except in private building developments where small isolated systems have been constructed.

3) Electricity

Electricity is widely available in the country except in some remote rural districts where low demand and high per capita costs of services are expected.

Electricity is generated at three power plants at Port of Spain, Penal and Point Lisas with a total capacity of 980 mW (mega watt) in 1984, sufficient to meet the demands (about 415 mW, in 1984) of the country.

4) Health

The water related infectious diseases with the highest prevalence are skin disease, eye disease, scabies and gastroenteritis.

Health and welfare services are being strengthened to meet the needs of the population. The general hospitals at Port of Spain, San Fernando and Scarborough are to cater to the needs at the national level, of over one million people although they are short of necessary beds numbers.

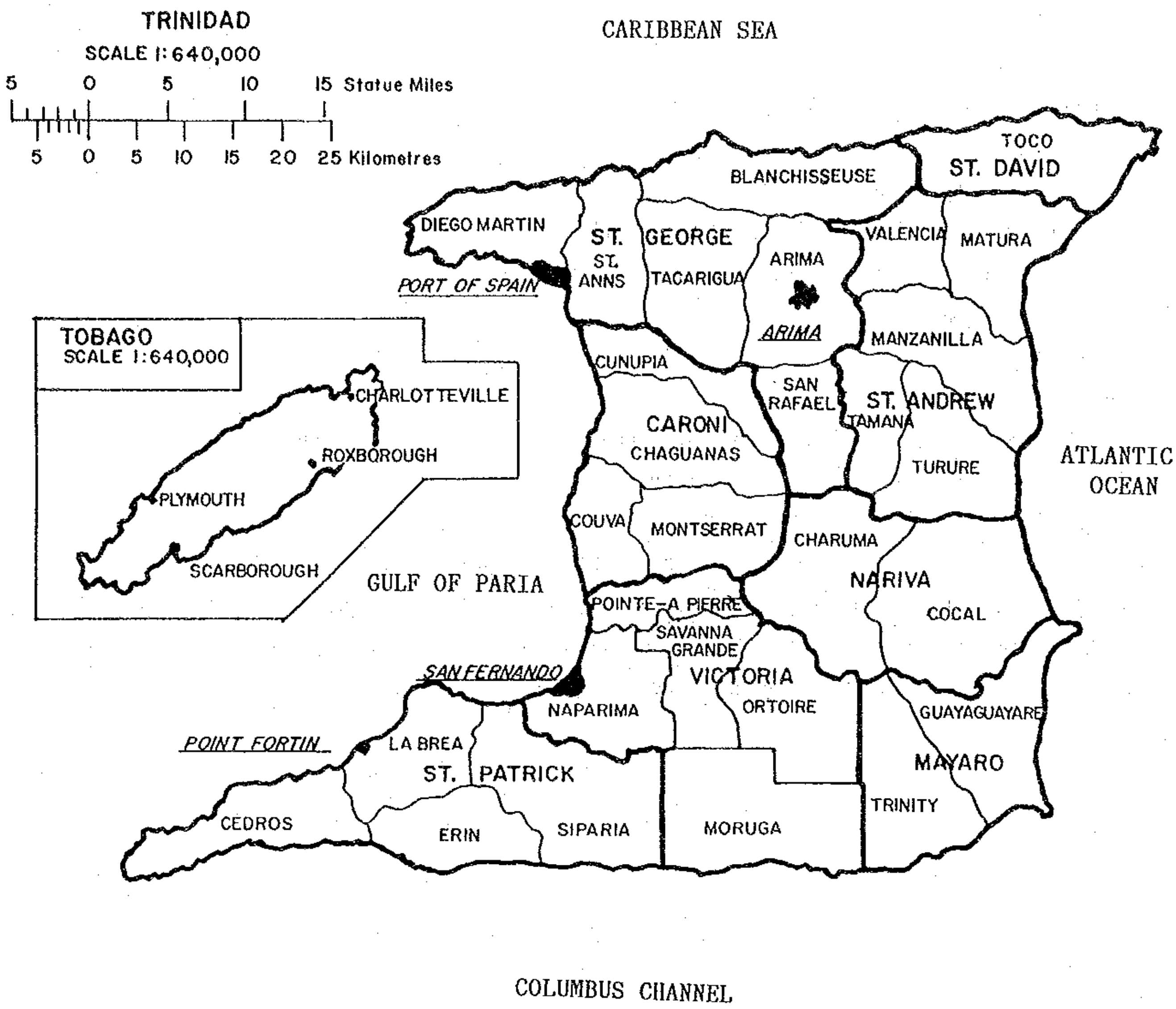

Fig. I-2.1 ADMINISTRATIVE AREAS 1980

Table I-2.1 POPULATION CENSUSES

Administrative Division	Area (ha)	Population			Average Annual Growth Rate (%)		Population Density (per sq. km)		
		1960	1970	1980	1960-1970	1970-1980	1960	1970	1980
Trinidad & Tobago	512,843	827,957	931,071	1,055,763	1.18	1.26	161	182	206
Cities & Towns	2,814	144,766	111,195	113,307	-2.60	0.19	5,144	3,951	4,027
Port of Spain	958	93,954	62,680	55,800	-3.97	-1.16	9,807	6,543	5,825
San Fernando	648	39,830	36,879	33,395	-0.77	-0.99	6,147	5,691	5,154
Arima	1,208	10,982	11,636	24,112	0.58	7.56	909	963	1,996
Counties	510,029	683,191	819,876	942,456	1.84	1.40	134	161	185
St. George*	90,755	256,478	312,085	370,572	1.98	1.73	283	344	408
Caroni	55,423	90,513	115,254	140,385	2.45	1.99	163	208	253
Nariva/Mayaro	91,168	23,306	28,350	30,883	1.98	0.86	26	31	34
St. Andrews/St. David	93,681	38,622	45,080	50,171	1.56	1.08	41	48	54
Victria	81,348	132,721	163,164	187,009	2.09	1.37	163	201	230
St. Patrick**	67,548	108,218	117,189	123,912	0.80	0.56	160	173	183
Tobago	30,106	33,333	38,754	39,524	1.52	0.20	111	129	131

Sources: Population Censuses 1960, 1970 and 1980, Central Statistical Office.
Draft Medium Term Macro Planning Framwork 1989 - 1995, National Planning Commission.

Note : * Excludes Port of Spain and Arima Borough.
** Includes Pt. Fortine Borough.

3. WATER SOURCE AND PRESENT WATER USE

3.1 WATER SOURCE

WASA has presently 95 water sources including 3 purchased water in Trinidad. There are 82 sources located in Trinidad and 13 in Tobago. The average daily production from all the above was approximately 657,000 m^3 in 1988, of which some 20,000 m^3 were produced in Tobago. Fig. I-3.1 graphically shows productions of major water sources of WASA. The production of each source is listed in Tables I-3.1 and I-3.2. The figures in the tables were provided from the Technical Recording Section of WASA. It should be noted that estimated figures are used because the substantial number of the production sources are unmetered. As the individual production largely differs from source to source, the sources are divided into large, medium and small scale groups in terms of production capacity (Refer to 4.1.2 "Production Facilities").

The large-scale sources are Caroni River-Arena Reservoir, Navet Reservoir, Hollis Reservoir and North Oropouche River. These four sources contribute approximately 60% of the total production. Among them, Caroni/Arena provides the nation's largest production, some 260,000 m^3/day in 1988, approximately 40% of the total production.

About 30% of the production is dependent upon groundwater sources and the majority of the wells are located at the northern part of Trinidad where groundwaters of good quality are available. Boreholes have been developed and connected with the distribution network to meet the increasing demands. It has brought the problems of complication of transmission and distribution pipelines.

Major distribution pipelines extend from the large-scale sources and are connected with pipelines from medium-scale sources. On the other hand, small-scale sources are generally defined to be isolated sources which are not linked to the major distribution pipelines and supply water to limited number of inhabitants of rural area. Location of the WASA water sources are shown in Fig. I-3.2 in conjunction with the existing major transmission/distribution pipelines.

Precipitation in the country falls very clearly into two patterns; infrequent rain in the dry seasons and abundant rainfall in the rainy seasons. Rivers in the country are generally short in length with limited catchment area, and the seasonal fluctuations of the discharges are very large due to the different rainfall patterns in seasons. As a result, the productions of North Oropouche, Loango/Naranjo, Aripo, Guanapo, Caura, Acono, Maraval and Toco waterworks which abstract raw water from the northern range rivers tend to decrease during the dry season.

WASA has developed four impounding reservoirs in order to attain constant output to the consumers through a year. Arena and Navet impounding reservoirs were constructed to save river discharges during the rainy seasons with pumping system. These are what is called pumped storage complexes. Although the water levels went down to the serious levels in 1989, the production was kept almost constant on monthly average basis thanks to that pumped storage complexes.

The productions from groundwater sources are generally considered to be relatively constant through a year.

Figs. I-3.3, I-3.4 and I-3.5 indicate seasonal variation of the WASA water productions in terms of ratios of monthly average productions to yearly average productions.

Table I-3.3 shows WASA's daily average water production from January 1976 to October 1989. It is found that the average water production is gradually increasing year by year. Indexes against yearly average are also shown below the figures of water production. The daily average water production for the latest three years fluctuates within 5% of respective yearly average. In 1989, the highest average production was 698,579 m^3/day recorded in September and the lowest was 646,263 m^3/day in October. The average yearly production in 1989 was 677,727 m^3/day.

For further information, Supporting Report B "Water Sources" is prepared.