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

EXECUTIVE SUMMARY

SEPTEMBER 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

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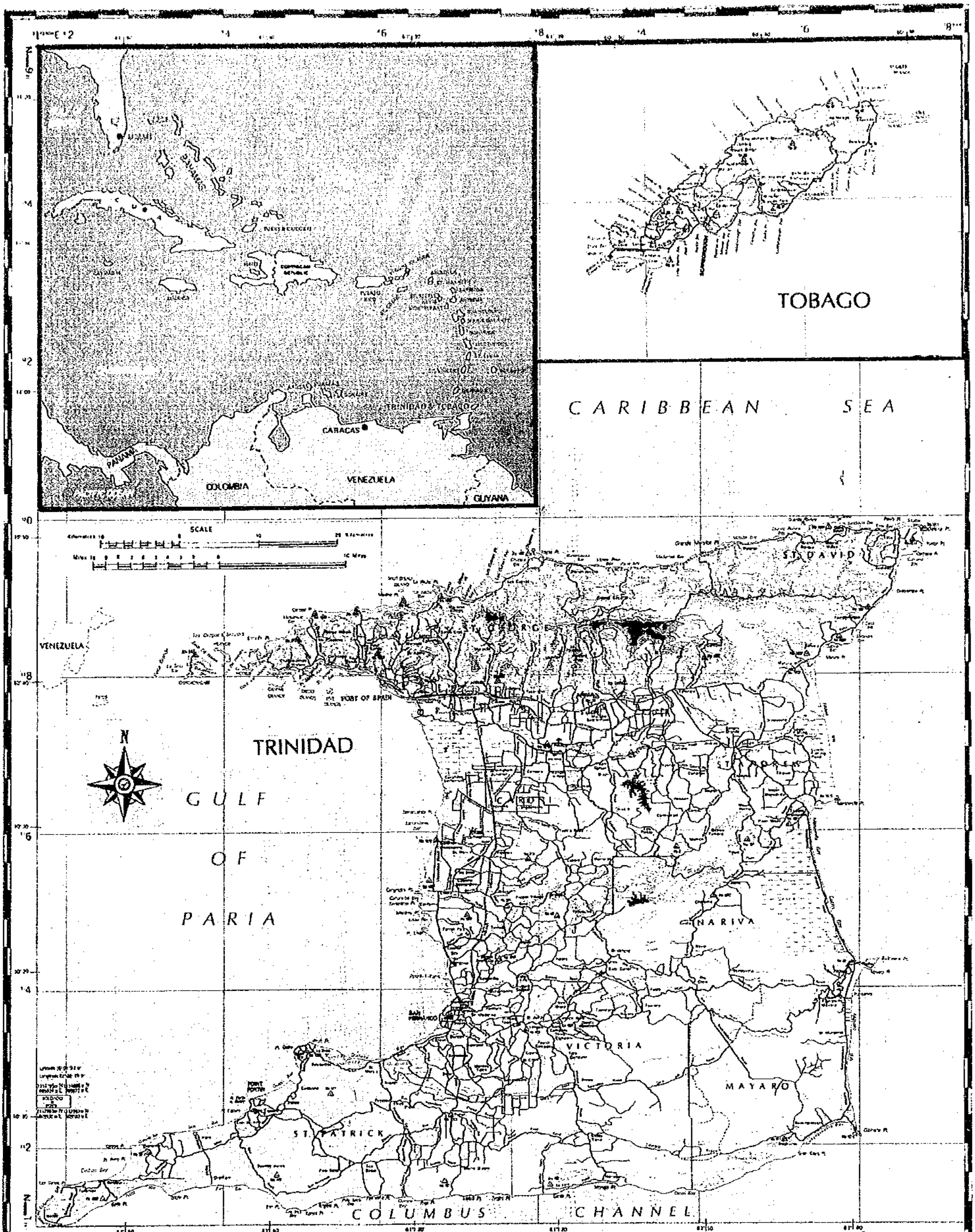

Fig. 1 GENERAL LOCATION MAP OF STUDY AREA

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EXECUTIVE 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.

For details, refer to Fig. 1 General Location Map of Study Area and Fig. 2 Map Showing WASA Water Area.

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.

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 continuous 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.

2. EXISTING WATER SUPPLY

2.1 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 1 Present Water Use by Water Area.

The modern water supply system in Trinidad and Tobago started in the 1850's at the Maraval Waterworks with an approximate water production of 4,500 m^3/day. In 1902, the River Estate Waterworks was developed to provide water to western part of Port of Spain Area.

Thereafter, development and expansions of the water supply were continuously made from the 1920's to 1970's in order to improve the supply in the urban centers namely: Port of Spain, San Fernando, Arima in Trinidad and Scarborough in Tobago.

After the 1970's, WASA and the Ministry of Finance embarked several water supply development projects to meet the increasing water demand of the country. They are construction of Navet Waterworks with a production 77,280 m^3/day completed in 1976, North Oropouche Waterworks with a production 90,920 m^3/day in 1979, package of treatment plants in Northern Range Valley in 1980 and large scale Caroni/Arena with a production 272,760 m^3/day in 1983.

Newly increased water production during this period reached to about 60% to the total. The area covered by these waterworks are illustrated in Fig. 3 Comprehensive Map of Existing Water Supply System.

Major features of the existing water supply are summed up in the followings.

1) **Water Source:** WASA has presently 92 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. See Table 2 List of Existing Large and Medium Scale Production Facilities (1) & (2) and Table 3 List of Existing Small Scale Production Facilities.

2) **Production Facilities:** 92 separate water production facilities are scattered in the country. 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 above Table 2 and Table 3.

3) **Transmission/Distribution Facilities:** Existing transmission/ distribution system consists of six high lift pumping stations, 52 booster pumping stations, transmission and distribution pipelines ranging 50 mm to 1,350 mm in diameter, 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.

   The four major large-scale systems are waterworks at Caroni/Arena, North Oropouche, Hollis, and Navet producing and supplying about 404,300 m^3/day (equivalent to 64% of the total supply amount in Trinidad) through transmission and distribution mains varying from 600 to 1,350 mm in diameter with a total length of over 76 km. See above Fig. 3.

4) **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 1.

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 4 Result of Pilot Leakage Survey.

Generally, the present total system leakage is estimated at 40% to 50% of the total production and supplied amount of water.

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

Background

The existing CSS was 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. 4 Water Supply System under Existing CSS.

Facilities

The existing CSS facilities includes the components of:

- two central computers installed at the existing CSS building, in WASA head office,

- two data radio communication repeaters located at Pepper Hill,

- 12 remote terminal units (RTUs), each of which includes a data two-way communication radio installed at local stations in Caroni/Arena system, and

- field instruments and relay contacts for controlling.

The central computer system was equipped with the following software:

- input/output to RTU,
- alarm processing,
- process control,
- historical data base,
- supervisory on running conditions of the CPU (Central Processing Unit),
- message facility for data processing, and
- man/machine interface.

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) As of November 1989, out of the existing 22 RTUs, 10 are in operation, and out of 87 data items to be collected, only 35 are actually counted for data acquisition and processing.

e) 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.

6) Monitoring, Operation/Control:

The present WASA's water supply supervisory practice of WASA for the operation status monitoring and control of system, other than the above CSS, is described below:

<u>Monitoring</u>

- The daily and hourly records obtained through the existing flow meters, pressure gauges and water level gauges are compiled and sent as monthly operation reports to WASA head office.

- Major items highlighted in the operation reports are water production, water distribution, cost, staff performance, etc. all related to water supply system operation and maintenance.

- Data have not been accumulated/used effectively for the total system operation.

Operation/Control

- The existing production facilities are generally practicing a constant flow rate operation.

- The present water distribution is mainly controlled by manual operation of the existing gate valves, installed at numerous number of off-takes on the transmission and distribution mains in the system. This system is so called as the turncock method.

- Each regional office has developed turncock schedules through long term experiences.

7) **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.

Water rate by categories are estimated as presented below:

(Unit: TT$/$m^3$)

CUSTOMER CATEGORIES	WATER RATE	CUSTOMER CATEGORIES	WATER RATE
Domestic	1.08	Industrial	0.51
Stand Pipe	0.35	Agricultural	0.22
Yard Pipe	0.66	Charitable/	
Internally Served	1.51	Organization	1.02
Commercial	1.87		
Average	0.99		

(Note: 1 TT$ = ¥ 31.8, 1 US$ = TT$ 4.25)

8) Institution and Management:

The Water and Sewerage Authority (WASA) is established as a body corporate and sole agency of water supply, based on the Water and Sewerage Act in 1965, as described before.

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.

Financial operations of WASA has been improved recently as presented in <u>Table 5 Financial Operation of WASA (1985-1989)</u>.

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, <u>Fig. 5 Organization Structure of WASA, December 1990</u>.

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.

2.2 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.

3. MASTER PLAN

3.1 GENERAL

For master planning of the Water Supply Supervisory System (WSSS), a period of 15-year from present (1990) up to 2005 is applied for the design period, considering about the planned implementation schedule of the proposed project and design life of the mechanical equipment and electronic instruments installed for the major facilities of WSSS.

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, and also the financial burden of the initial and succeeding investments to the proposed projects in the master plan program. See Fig. 6 Implementation Schedule.

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. 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 6 Population and Water Demand Projection 1990-2005 (1) & (2).

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 7 Estimated Dependable Yields (1) & (2), 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/d	(UFW 50%)
Projection	1995:	641,900 m^3/d	(UFW 40%)
	2000:	637,100 m^3/d	(UFW 30%)
	2005:	639,500 m^3/d	(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

3.2 PROPOSED WSSS IN 2005

3.2.1 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. 7 Proposed Organization of Water Supply Supervisory System.

3.2.2 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. 8 Concept of Water Supply Supervisory System (Phase II).

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.

3.2.3 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. 8 and Fig. 9 WSSS Hardware and Data Communication.

CSS

Proposed CSS function is summarized as presented in the followings. See Table 8 List of Monitoring and Control Equipment to be Installed for Central Supervisory System (1) & (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.

LSS

For the proposed LSS monitoring, flow meters with recorder at each outlet pipe of the production facilities are installed. See Table 9 List of Monitoring Equipment and Data under Local Supervisory System.

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.

3.2.4 Step-Wise Development

As mentioned in the preceding sub-section, the master plan for WSSS is formulated in two-phase developments (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. 6.

The proposed development plan is designed to be implemented in two phases. 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 and 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).

3.2.5 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. 8 & 9, and Tables 8 & 9, and Table 10 List of WSSS Hardware.

3.2.6 Project Cost

Project costs are summarized below. For details, refer to Table 11 Summary of Cost Estimate for Water Supply Supervisory System.

(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 installation and the benefits integrating those corresponding to the above mentioned three cost components.

3.2.7 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.

4. FEASIBILITY STUDY

4.1 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. 10 Project Area.

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. 11 Concept of Central Supervisory System:

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 (RTUs)
- 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. 12 CSS Hardware and Data Communication, Fig. 13 Water Supply System under New CSS, Fig. 14 Proposed Location of RTU Stations, Fig. 15 CSS Building, Table 12 List of Monitoring and Control Equipment in Phase I by Central Supervisory System, Table 13 Proposed Specifications of CSS Hardware and Table 14 Proposed Specifications of Monitoring and Control Equipment.

Project Implementation and Costs

1) Project Implementation: 1992-1995 as seen in Fig. 16 Construction/ Implementation Schedule.

- 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 15 Summary of Cost Estimate for Phase I Project.

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: not including price inflation)

4.2 ECONOMIC AND FINANCIAL EVALUATION

4.2.1 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 11 and Table 16 Economic Benefit Stream.

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 17 Economic Benefit and Cost Stream, 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.

4.2.2 Financial Evaluation

Financial cash flow is made from the derived financial benefits and costs as shown in Table 18 Financial Benefit Stream. 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 19 Estimated Average Water Rate by Customer Category.

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 ("Medium Term Macro Planning Framework, 1989-1995", September 1990).

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.

5. 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 analyzed and suggested in Section 6 Project Evaluation, Part III, the implementation of the above planned Project by the year 1995 is studied too optimistic (or hardly justified its feasibility without conditionality) from financial points of view.

Following to the above result of project evaluation, a step-wise project implementation is considered as a possible option, of which outcome is responding to the above scope of Phase I Project with full-scale CSS improvement and development. With regard to possible options of the Project implementation, a comparative study is made for the two potions presented in Part IV.

And it suggests that the more feasible solution is to implement the proposed Project in step-wise development, as the Option A below in three steps as shown on Fig. 17 Construction/Implementation (Option A), which alternates the original Project implementation plan (Option B) of single step/stage development by the year 1995.

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. 18 CSS Hardware and Data Communication-Option A and Table 20 List of Monitoring and Control Equipment in Phase I by Central Supervisory System-Option A (1) - (4).

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. 18 and Table 20.

Option B

1) Unified or single-step installation of primary sensors, control equipment and CSS related instruments (1992-1995) See aforementioned Fig. 12 and Table 12.

To evaluate and compare the above two options, the project costs are estimated as summarizes in Table 21 Summary of Cost Estimate for Central Supervisory System (Option A) and Table 22 Summary of Cost Estimate for Central Supervisory System (Option B).

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.

According to the present value evaluation of investments for the above two options, see Table 23 Net Present Value for Options A and B, 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 24 Economic Benefit and Cost Stream (Option A) and Table 25 Financial Cash Flow (Option A).)

	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 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.

In addition to the above, the recommended plan (Option A) will have following advantages and disadvantages:

Advantage

1) In several years of operation during Step 2, the accumulated data will provide valuable information regarding water level fluctuation in the reservoirs, and water flow condition of transmission/distribution mains and off-takes through computerized pipe hydraulic analysis. Therefore, installation of full scale CSS instruments and control equipment are

designed and installed based on actual operation data, relevant studies and analysis.

2) Contribution to the leakage control with the actual flow and pressure fluctuation data in the main pipelines.

3) Moderate in construction cost, not requiring the huge amount of initial investment, and no major negative affection to investment on immediate projects.

4) Comparing with the existing system, flow rate control of water mains and booster pumping stations will be done precisely by local operators and turncockers based on the actual flow and pressure records.

<u>Disadvantage</u>

1) Delayed installation of CSS instruments about five years which affects more time requirement for the comprehensive supervisory system formulation.

2) Delayed improvement of work efficiency by recruiting a large number of turncockers/operators to appropriate posts in the other sections/ departments.

3) Quick response and speedy reaction against abnormal water supply conditions will not be made since installed annunciators, which instruct operators the emergent situation, are not installed yet in Step 1.

4) Slightly moderate in construction cost, however, it requires additional costs for recorders and panel stands, printers, personal computers and their peripherals.

6. 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 Phase I 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.

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 B (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 23 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.

Fig. 2 MAP SHOWING WASA WATER AREA

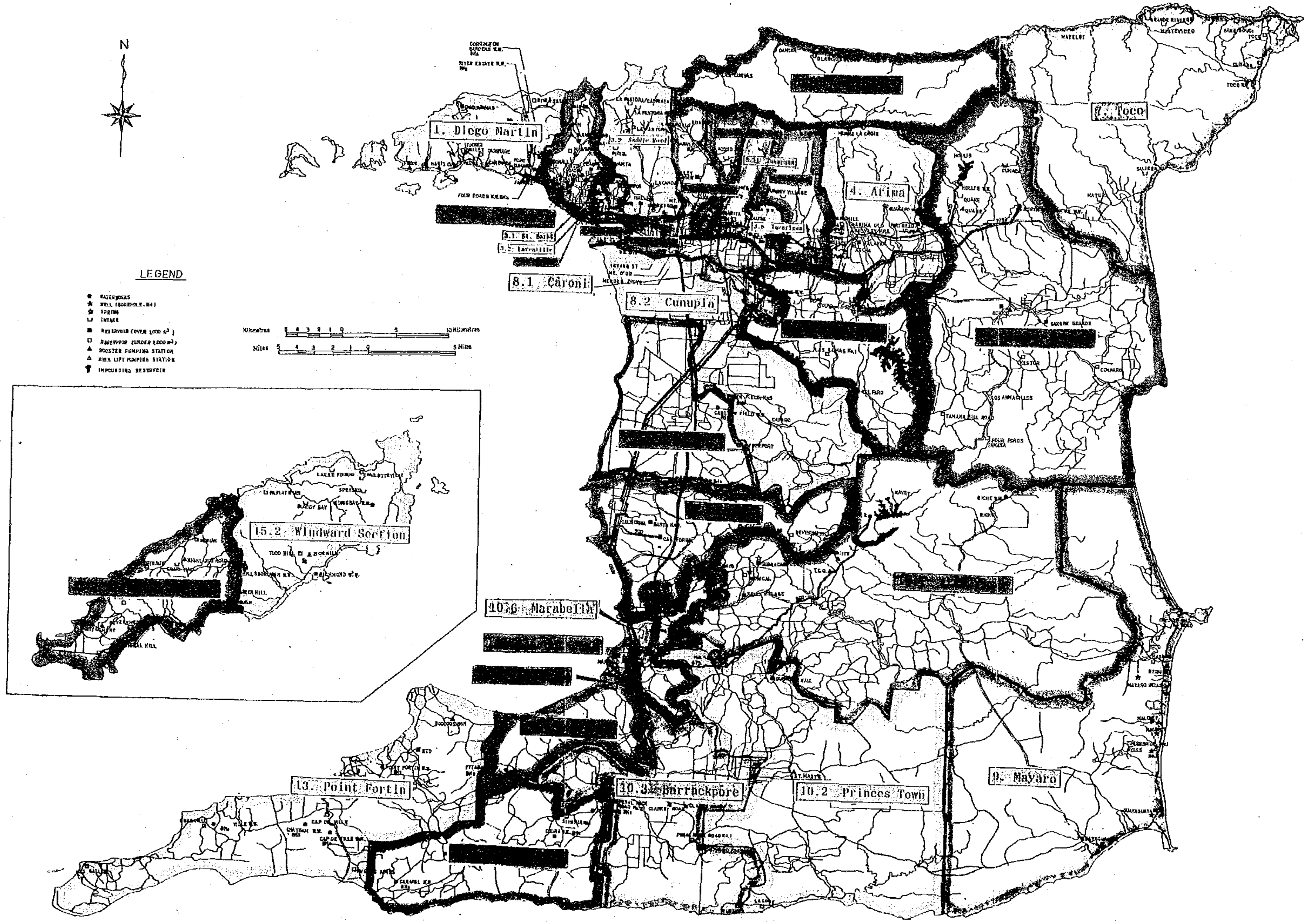
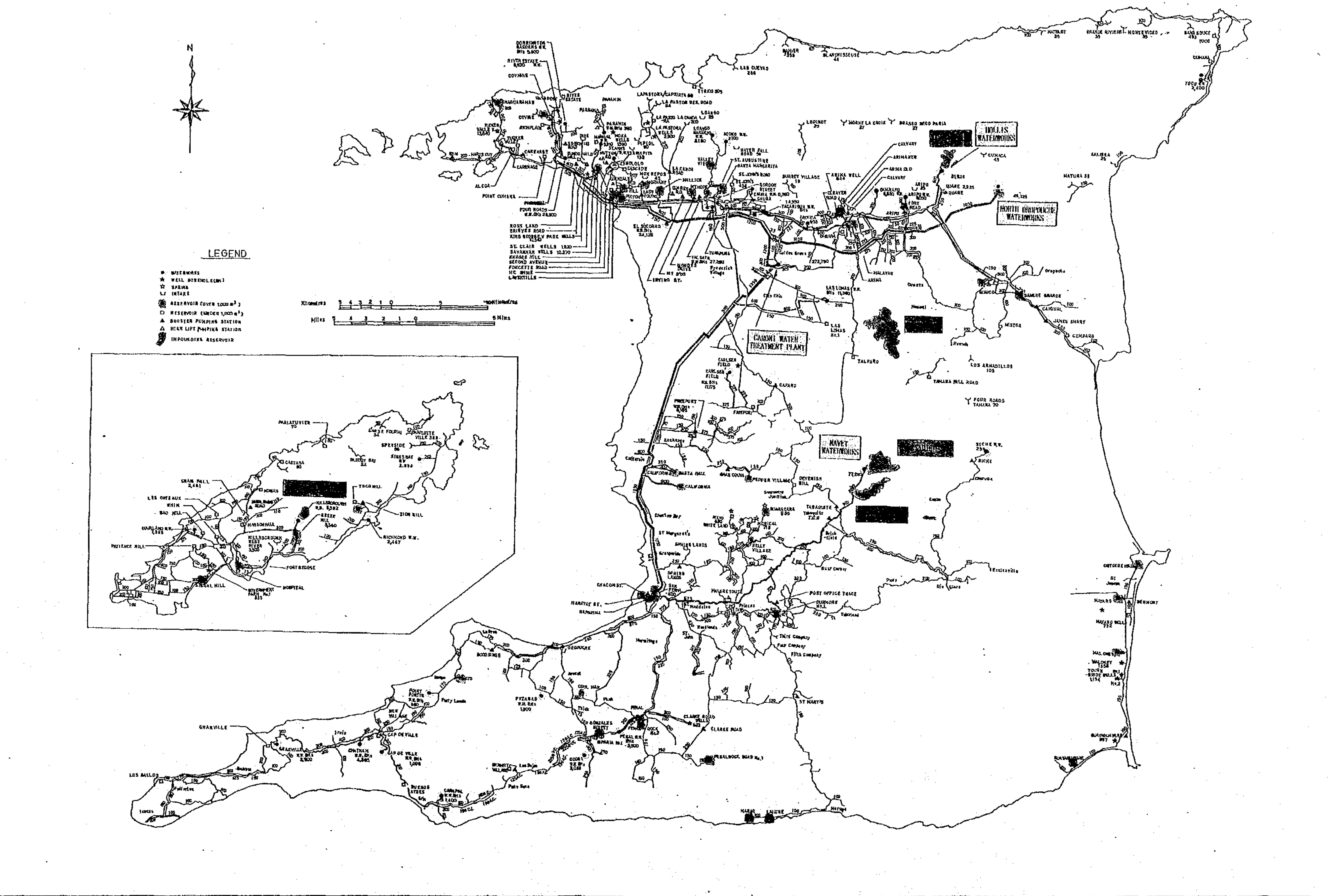


Fig. 3 COMPREHENSIVE MAP OF EXISTING WATER SYSTEM



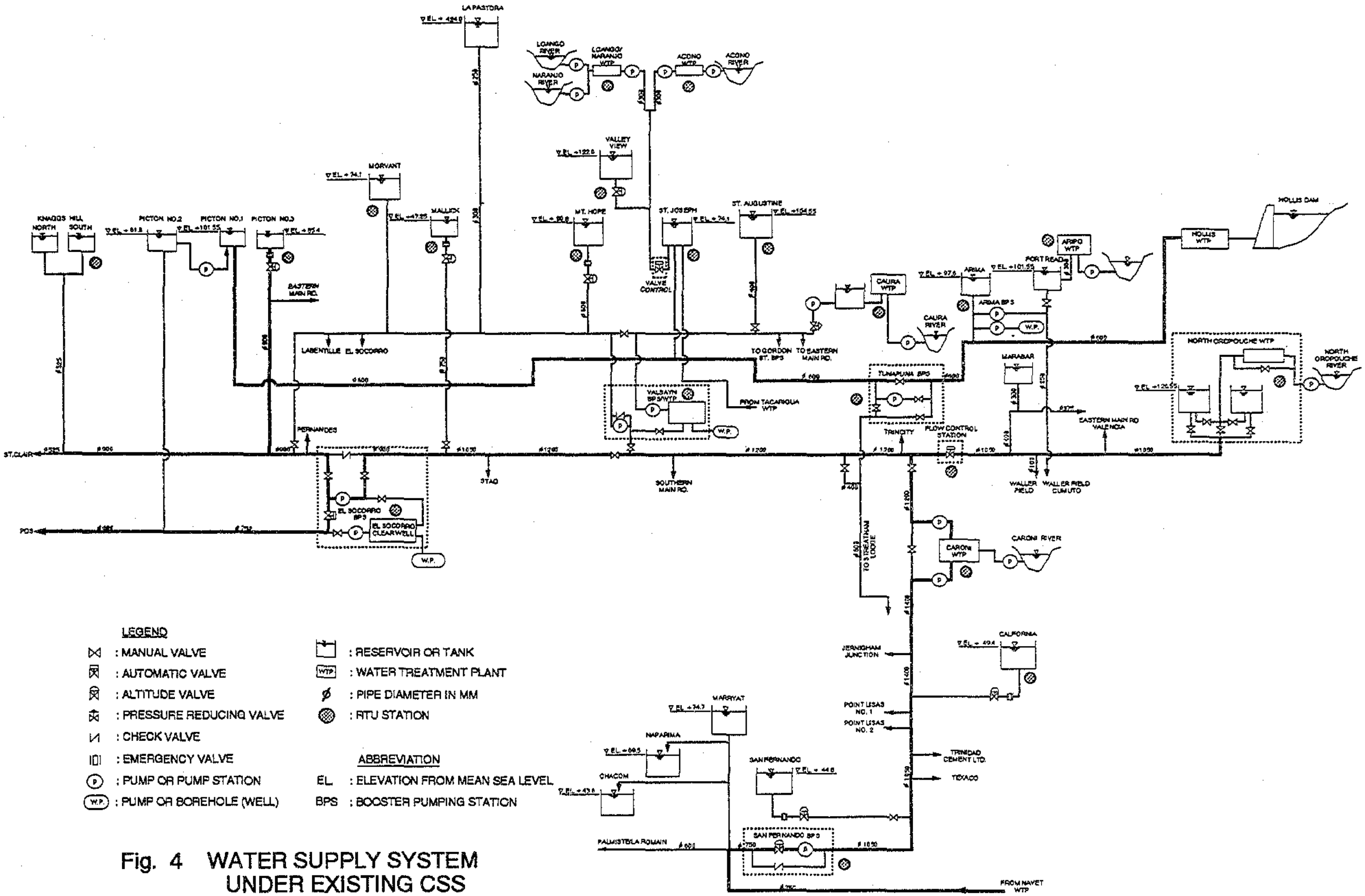


Fig. 4 WATER SUPPLY SYSTEM UNDER EXISTING CSS

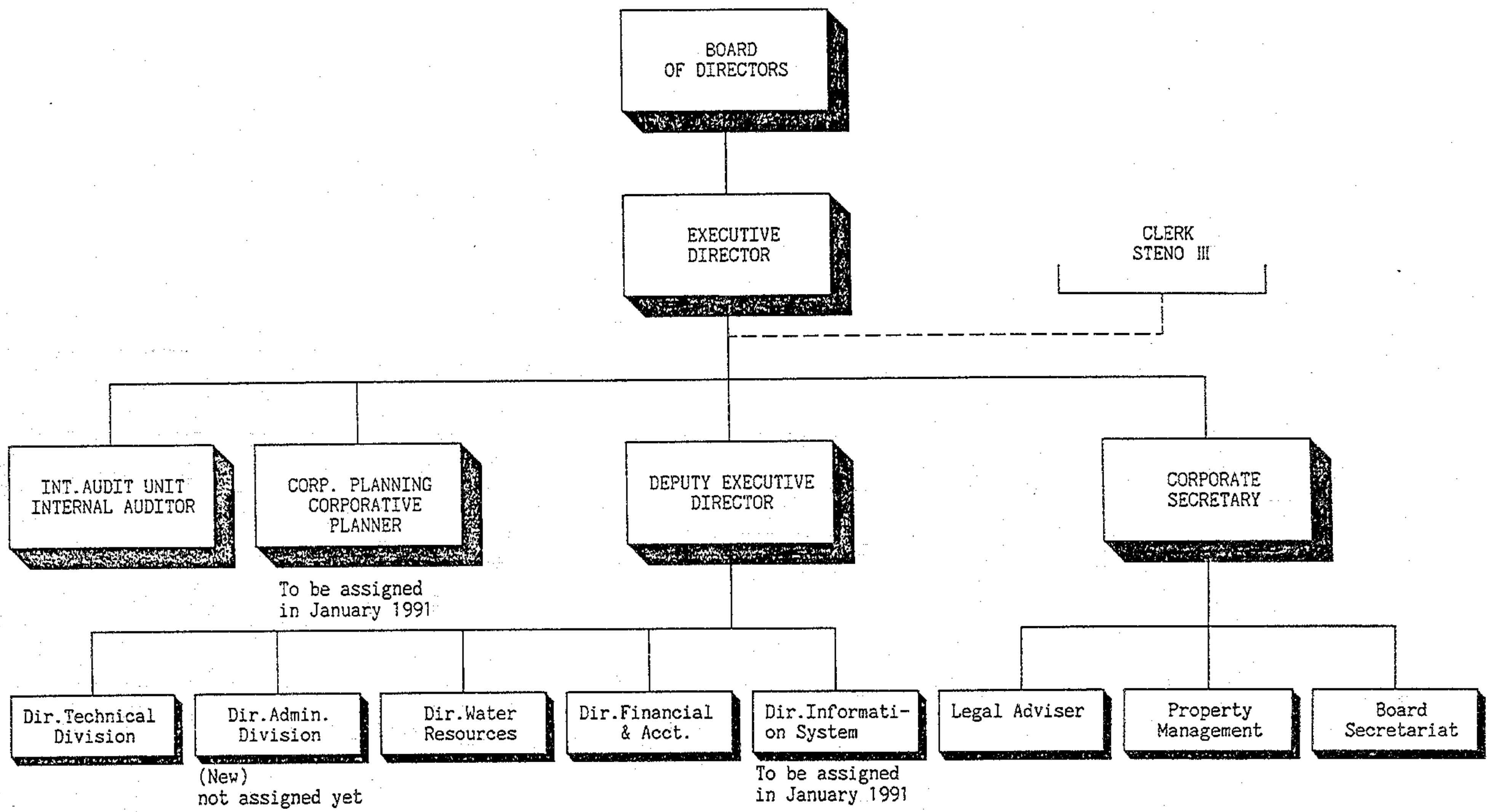
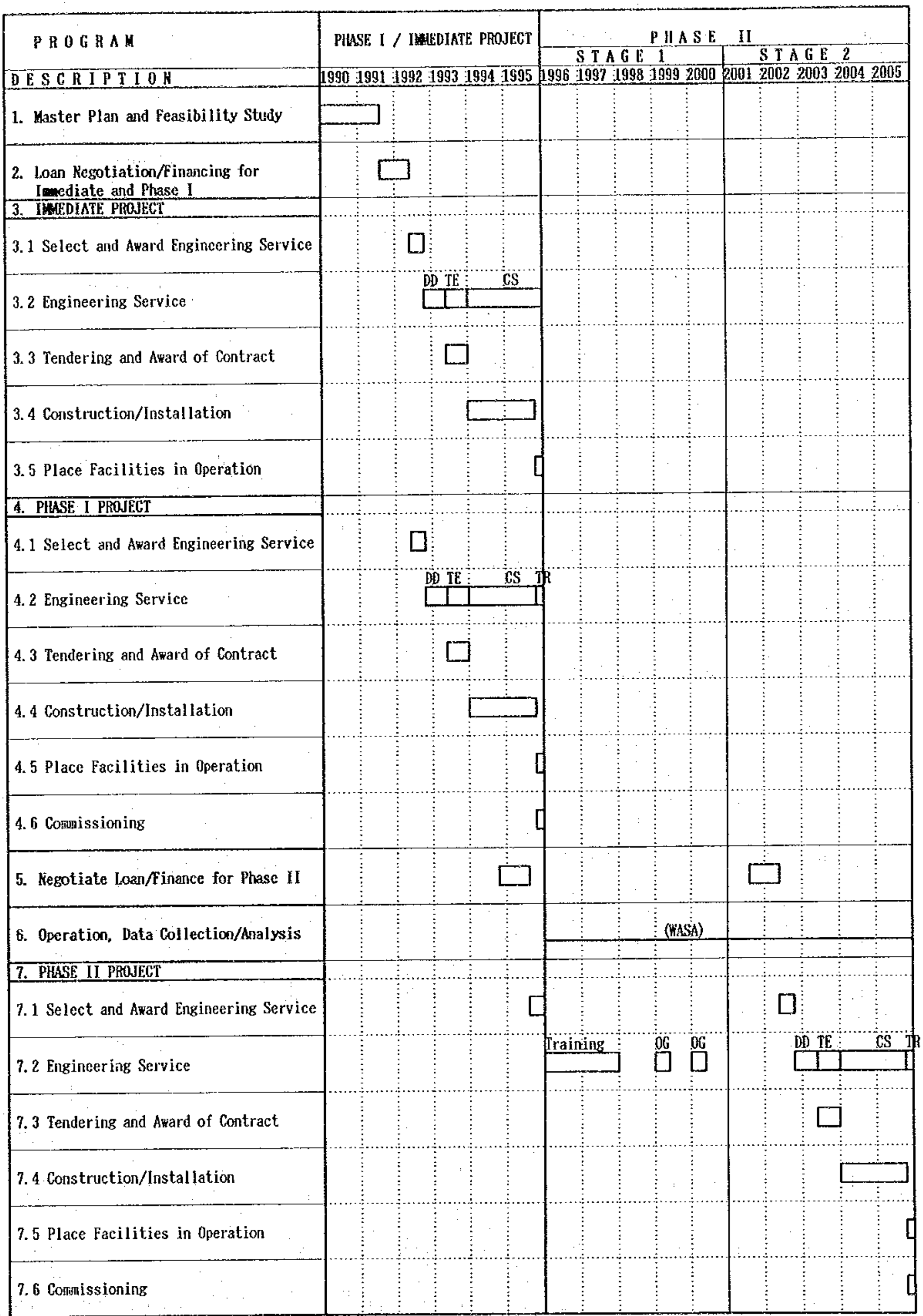


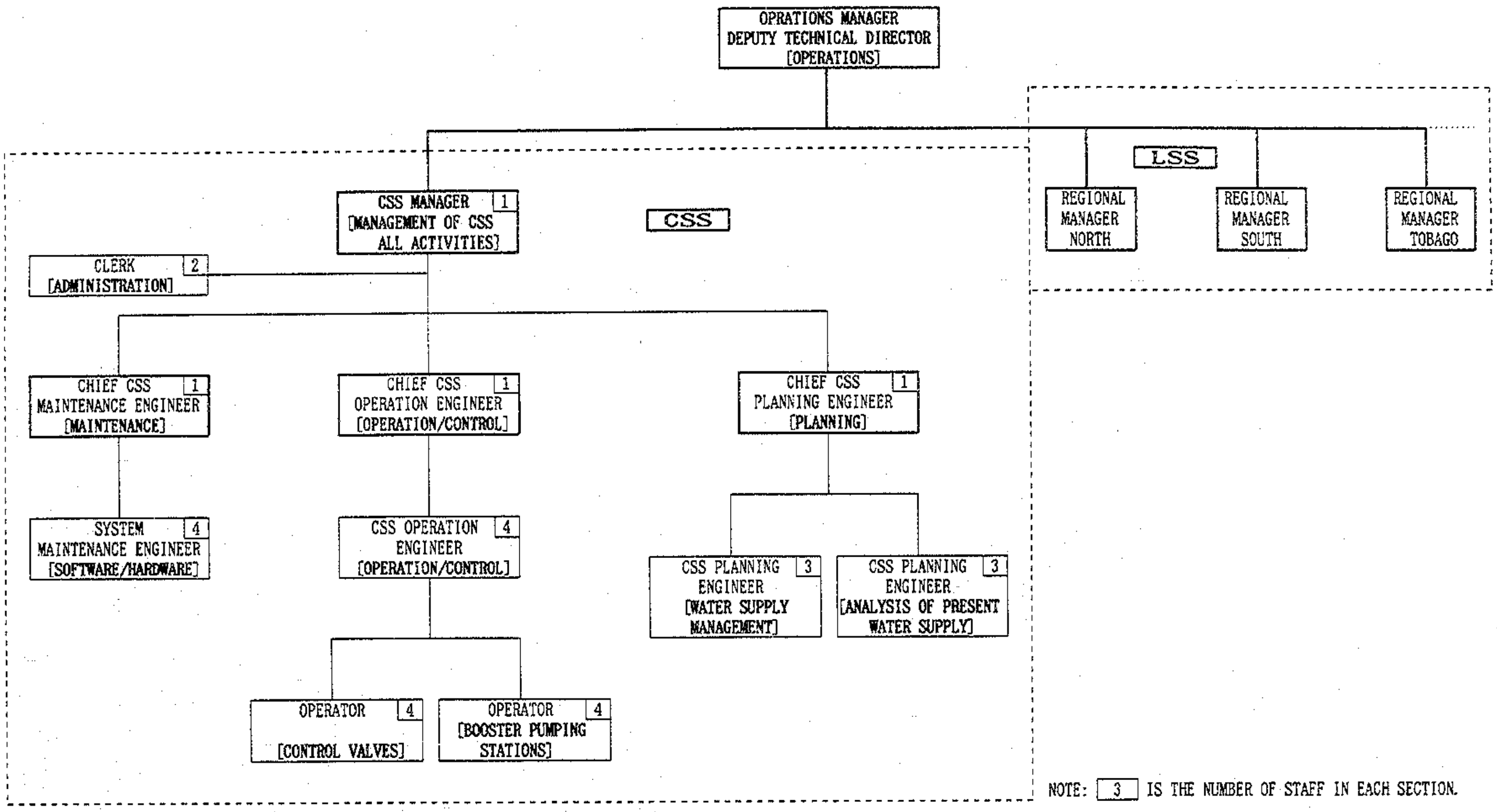
Fig. 5 ORGANIZATION STRUCTURE OF WASA, DECEMBER 1990

Fig. 6 IMPLEMENTATION SCHEDULE



NOTE: DD - Detailed Design
TE - Tender Evaluation
CS - Construction Supervision
TR - Test Run
OG - Water Supply Operation Guideline
(WASA) - Executed by WASA

Fig. 7 PROPOSED ORGANIZATION OF WATER SUPPLY SUPERVISORY SYSTEM



NOTE: [3] IS THE NUMBER OF STAFF IN EACH SECTION.

Fig. 8 CONCEPT OF WATER SUPPLY SUPERVISORY SYSTEM (PHASE II)

WATER SUPPLY SUPERVISORY SYSTEM (WSSS)

CENTER

CENTER				
NAME OF SUPERVISORY SYSTEM	LOCAL SUPERVISORY SYSTEM (LSS) IN NORTH	CENTRAL SUPERVISORY SYSTEM (CSS)	LOCAL SUPERVISORY SYSTEM (LSS) IN SOUTH	LOCAL SUPERVISORY SYSTEM (LSS) IN TOBAGO
Link to CSS	ON-LINE		ON-LINE	ON-LINE
LOCATION OF CENTER	NORTH REGION	EXISTING CSS BUILDING (EXPANSION)	SOUTH REGION	TOBAGO REGION
SUPERVISORY EQUIPMENT TO BE INSTALLED AT CENTER	WORK STATION	COMPUTER SYSTEM AND GRAPHIC PANEL	WORK STATION	WORK STATION WITH MEMORY
MONITORING ITEMS	FLOW	WATER FLOW, WATER LEVEL, WATER PRESSURE, VALVE & PUMP STATUS AND ALARM	FLOW	FLOW
REMOTE CONTROL AND OPERATION EQUIPMENT	NONE	PUMPS & VALVES AT BOOSTER PUMPING STATION ("*" AS SHOWN ON THE BELOW TABLE) FOR REMOTE OPERATION AND CONTROL VALVES AT OFF-TAKE OF STRATEGIC POINTS	NONE	NONE
Link to SITE	WEEKLY REPORT	ON - LINE	WEEKLY REPORT	WEEKLY REPORT

SITE

SITE				
EQUIPMENT TO BE INSTALLED AT SITE	FLOW METER AT EACH PRODUCTION F'TY	FLOW METER, LEVEL METER, PRESSURE GAUGE, CONTROL VALVE AND RTU AT STRATEGIC POINTS	FLOW METER AT EACH PRODUCTION F'TY	FLOW METER AT EACH PRODUCTION F'TY
FACILITIES TO BE SUPERVISED	see below	see below	see below	see below

LSS in North — PRODUCTION FACILITY (45)

N.C.	(7)	MEDIUM-(1)
		SMALL-(6)
N.E.	(12)	MEDIUM-(1)
		SMALL-(11)
N.W.	(16)	MEDIUM-(7)
		SMALL-(9)
POS	(10)	MEDIUM-(5)
		SMALL-(5)

CSS — PRODUCTION FACILITY

N.C.	1	CARONI/ARENA W.T.P.	LARGE
	2	VALSAYN W.W.	MEDIUM
	3	TACARIGUA W.W.	MEDIUM
	4	LAS LOMAS W.W.	MEDIUM
	5	CAURA W.W.	MEDIUM
	6	AROUCA W.W.	SMALL
N.E.	7	NORTH OROPOUCHE W.W.	LARGE
	8	HOLLIS W.W.	LARGE
	9	GUANAPO W.W.	MEDIUM
	10	ARIPO W.W. (NEW)	MEDIUM
	11	ARIPO INT	MEDIUM
	12	QUARE INT (VALENCIA)	MEDIUM
	13	ARIMA WELL #6	SMALL
N.W.	14	EL SOCORRO W.W.	MEDIUM
SF/SC	15	CARLSEN FIELD W.W.	MEDIUM
S.E.	16	NAVET W.W.	LARGE

CSS — BOOSTER PUMPING STATION

N.C.	1	*TUNAPUNA B. P/S
	2	*VALSAYN B. P/S
N.E.	3	ARIMA B. P/S
	4	ARIPO B. P/S
N.W.	5	*EL SOCORRO B. P/S
SF/SC	6	*SAN FERNANDO B. P/S
S.E.	7	*MALGRETOUTE B. P/S
	8	*T.C.O. B. P/S

CSS — STORAGE LIFT PUMPING STATION

N.C.	1	*TUMPUNA S.L. P/S
S.E.	2	NAVET S.L. P/S

CSS — OFF-TAKE CONTROL VALVES

CSS — SERVICE STORAGE RESERVOIR

N.C.	1	MT. HOPE
	2	ST. AUGUSTINE
	3	ST. JOSEPH
N.E.	4	NORTH OROPOUCHE
	5	FORT READ
	6	ARIMA NEW
	7	ARIMA OLD
N.W.	8	MALLIC
POS	9	KNAGGS HILL
	10	PICTON # 1
	11	PICTON # 2
	12	PICTON # 3
SF/SC	13	CALIFORNIA
	14	SAN FERNANDO
	15	MARRYAT St.
	16	NAPARIMA

LSS in South — PRODUCTION FACILITY (21)

SF/SC	(1)	MEDIUM-(1)
S.E.	(8)	MEDIUM-(2)
		SMALL-(6)
S.W.	(12)	MEDIUM-(6)
		SMALL-(6)

LSS in Tobago — PRODUCTION FACILITY (14)

TOBAGO	(14)	MEDIUM-(7)
		SMALL-(7)

NOTE: N.C.; NORTH CENTRAL, N.E.; NORTH EAST, N.W.; NORTH WEST, POS; PORT OF SPAIN, SF/SC; SAN FERNANDO/SOUTH CENTRAL, S.E.; SOUTH EAST, S.W.; SOUTH WEST, W.T.P.; WATER TRATMENT PLANT, W.W.; WATERWORKS, INT; INTAKE, B. P/S; BOOSTER PUMPING STATION, S.L. P/S; STORAGE LIFT PUMPING STATION, (8); THE NUMBER OF FACILITIES IN EACH DISTRICT, MT.; MOUNT, ST.; SAINT, St.; STREET, F'TY; FACILITIES.

Fig. 9 WSSS HARDWARE AND DATA COMMUNICATION

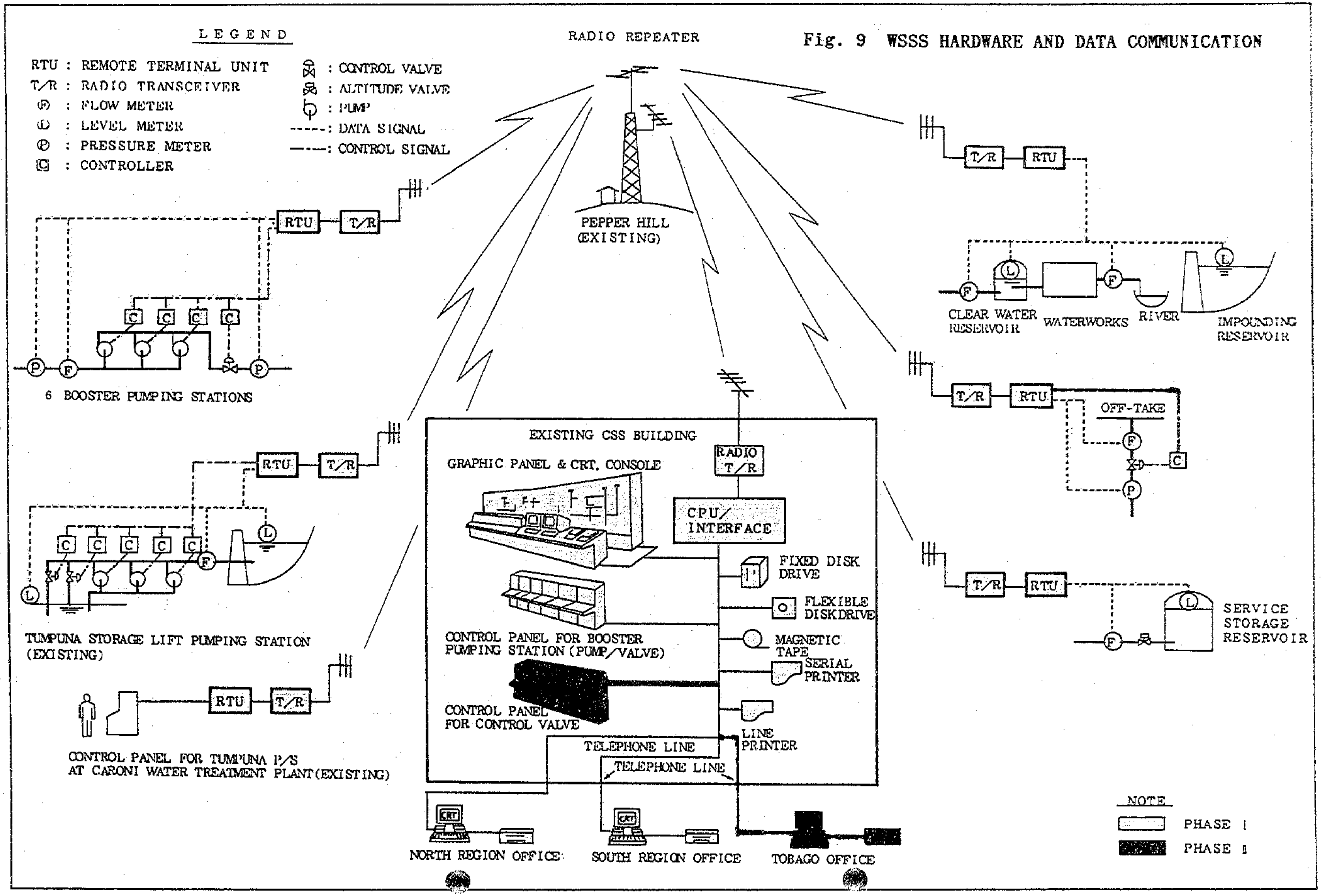


Fig. 10 PROJECT AREA

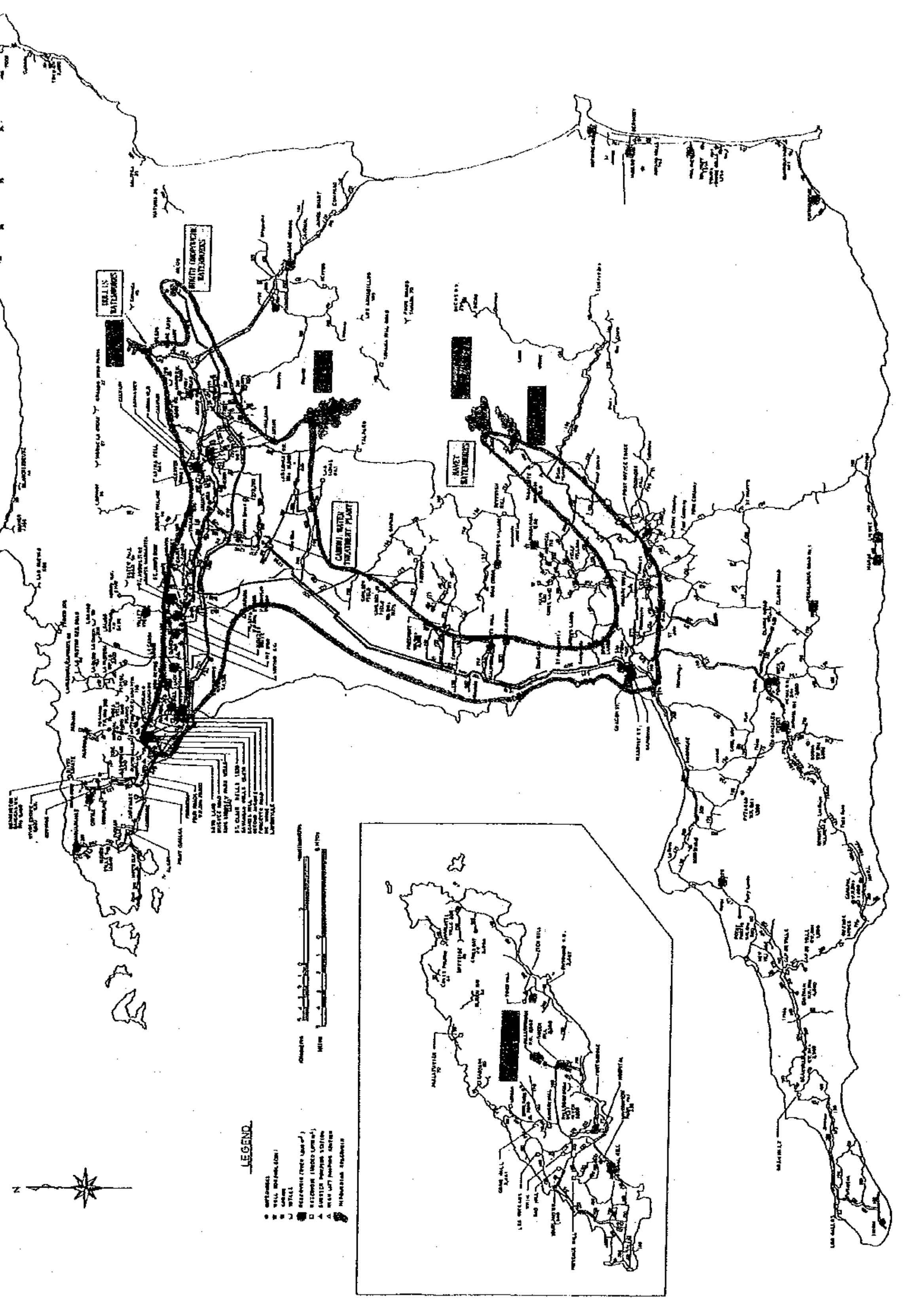


Fig. 11 CONCEPT OF CENTRAL SUPERVISORY SYSTEM

CENTRAL SUPERVISORY SYSTEM (CSS)

ON-LINE — ON-LINE — MONTHLY REPORT

CENTER				
LOCATION OF CENTER	NORTH REGION	EXISTING CSS BUILDING (EXPANSION)	SOUTH REGION	TOBAGO REGION
SUPERVISORY EQUIPMENT TO BE INSTALLED AT CENTER	WORK STATION	COMPUTER SYSTEM AND GRAPHIC PANEL	WORK STATION	NONE
MONITORING ITEMS	FLOW	WATER FLOW, WATER LEVEL, WATER PRESSURE, VALVE & PUMP STATUS AND ALARM	FLOW	FLOW
REMOTE CONTROL AND OPERATION EQUIPMENT	NONE	PUMPS & VALVES AT BOOSTER PUMPING STATIONS FOR REMOTE OPERATION (AS SHOWN ON "*" OF THE BELOW TABLE)	NONE	NONE
	MONTHLY REPORT	ON - LINE	MONTHLY REPORT	MONTHLY REPORT

SITE				
EQUIPMENT TO BE INSTALLED AT SITE	NONE (EXISTINGS TO BE USED)	FLOW METER, LEVEL METER, PRESSURE GAUGE, CONTROL VALVE AND RTU AT STRATEGIC POINTS	NONE (EXISTINGS TO BE USED)	NONE (EXISTINGS TO BE USED)
FACILITIES TO BE SUPERVISED	see tables below	see tables below	see tables below	see tables below

North Region — PRODUCTION FACILITY (45)

N. C.	(7)	MEDIUM-(1)
		SMALL-(6)
N. E.	(12)	MEDIUM-(1)
		SMALL-(11)
N. W.	(16)	MEDIUM-(7)
		SMALL-(9)
POS	(10)	MEDIUM-(5)
		SMALL-(5)

Existing CSS — PRODUCTION FACILITY

N. C.	1	CARONI/ARENA W. T. P.	LARGE
	2	VALSAYN W. W.	MEDIUM
	3	TACARIGUA W. W.	MEDIUM
	4	LAS LOMAS W. W.	MEDIUM
	5	CAURA W. W.	MEDIUM
	6	AROUCA W. W.	SMALL
N. E.	7	NORTH OROPOUCHE W. W.	LARGE
	8	HOLLIS W. W.	LARGE
	9	GUANAPO W. W.	MEDIUM
	10	ARIPO W. W. (NEW)	MEDIUM
	11	ARIPO INT	MEDIUM
	12	QUARE INT (VALENCIA)	MEDIUM
	13	ARIMA WELL #6	SMALL
N. W.	14	EL SOCORRO W. W.	MEDIUM
SF/SC	15	CARLSEN FIELD W. W.	MEDIUM
S. E.	16	NAVET W. W.	LARGE

BOOSTER PUMPING STATION

N. C.	1	*TUNAPUNA B. P/S
	2	*VALSAYN B. P/S
N. E.	3	ARIMA B. P/S
	4	ARIPO B. P/S
N. W.	5	*EL SOCORRO B. P/S
SF/SC	6	*SAN FERNANDO B. P/S
S. E.	7	*MALGRETOUTE B. P/S
	8	*T. C. O. B. P/S

STORAGE LIFT PUMPING STATION

N. C.	1	*TUMPUNA S. L. P/S
S. E.	2	NAVET S. L. P/S

OFF-TAKE CONTROL VALVES

SERVICE STORAGE RESERVOIR

N. C.	1	MT. HOPE
	2	ST. AUGUSTINE
	3	ST. JOSEPH
N. E.	4	NORTH OROPOUCHE
	5	FORT READ
	6	ARIMA NEW
	7	ARIMA OLD
N. W.	8	MALLIC
POS	9	KNAGGS HILL
	10	PICTON # 1
	11	PICTON # 2
	12	PICTON # 3
SF/SC	13	CALIFORNIA
	14	SAN FERNANDO
	15	MARRYAT St.
	16	NAPARIMA

South Region — PRODUCTION FACILITY (21)

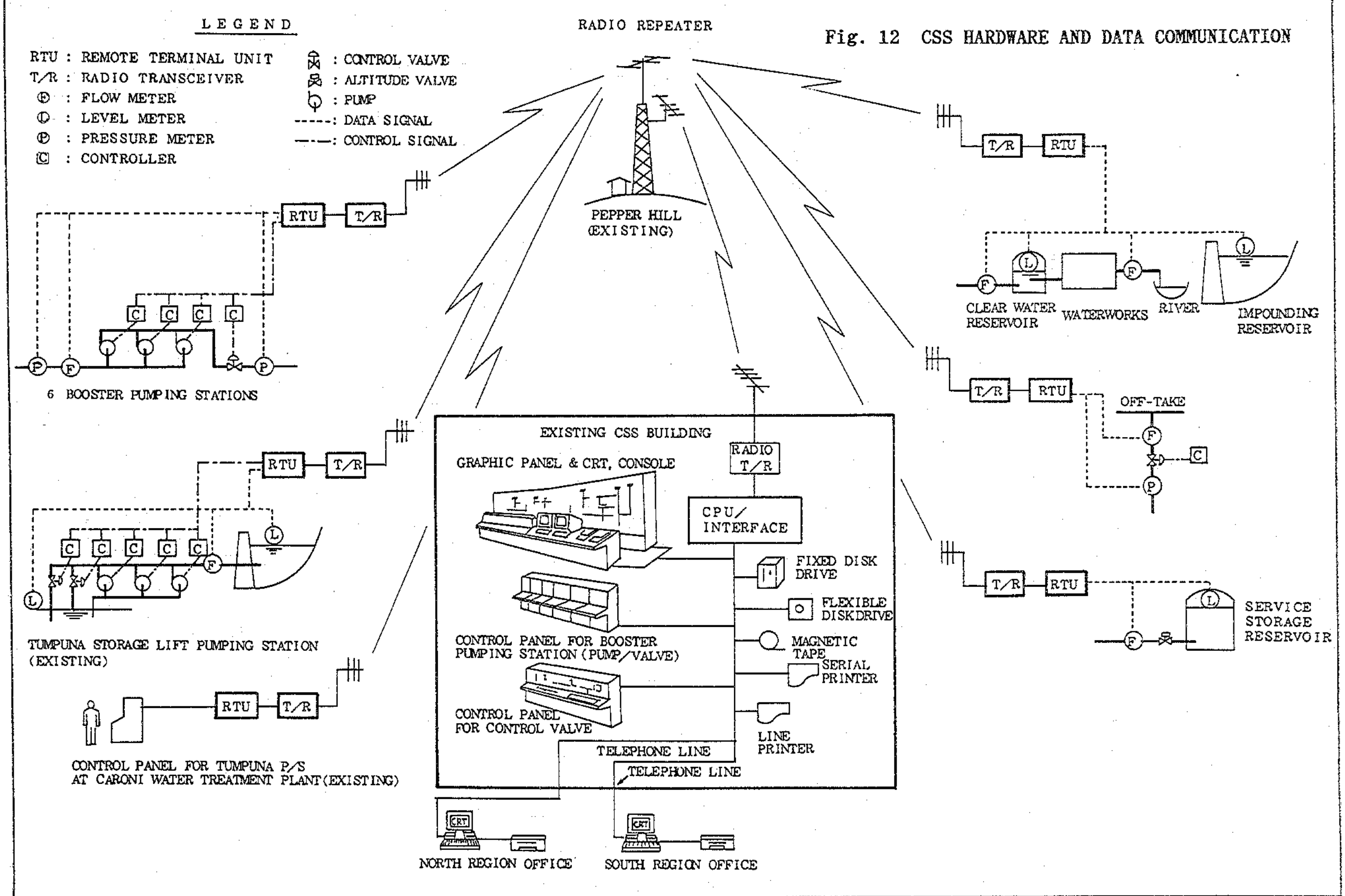
SF/SC	(1)	MEDIUM-(1)
S. E.	(8)	MEDIUM-(2)
		SMALL-(6)
S. W.	(12)	MEDIUM-(6)
		SMALL-(6)

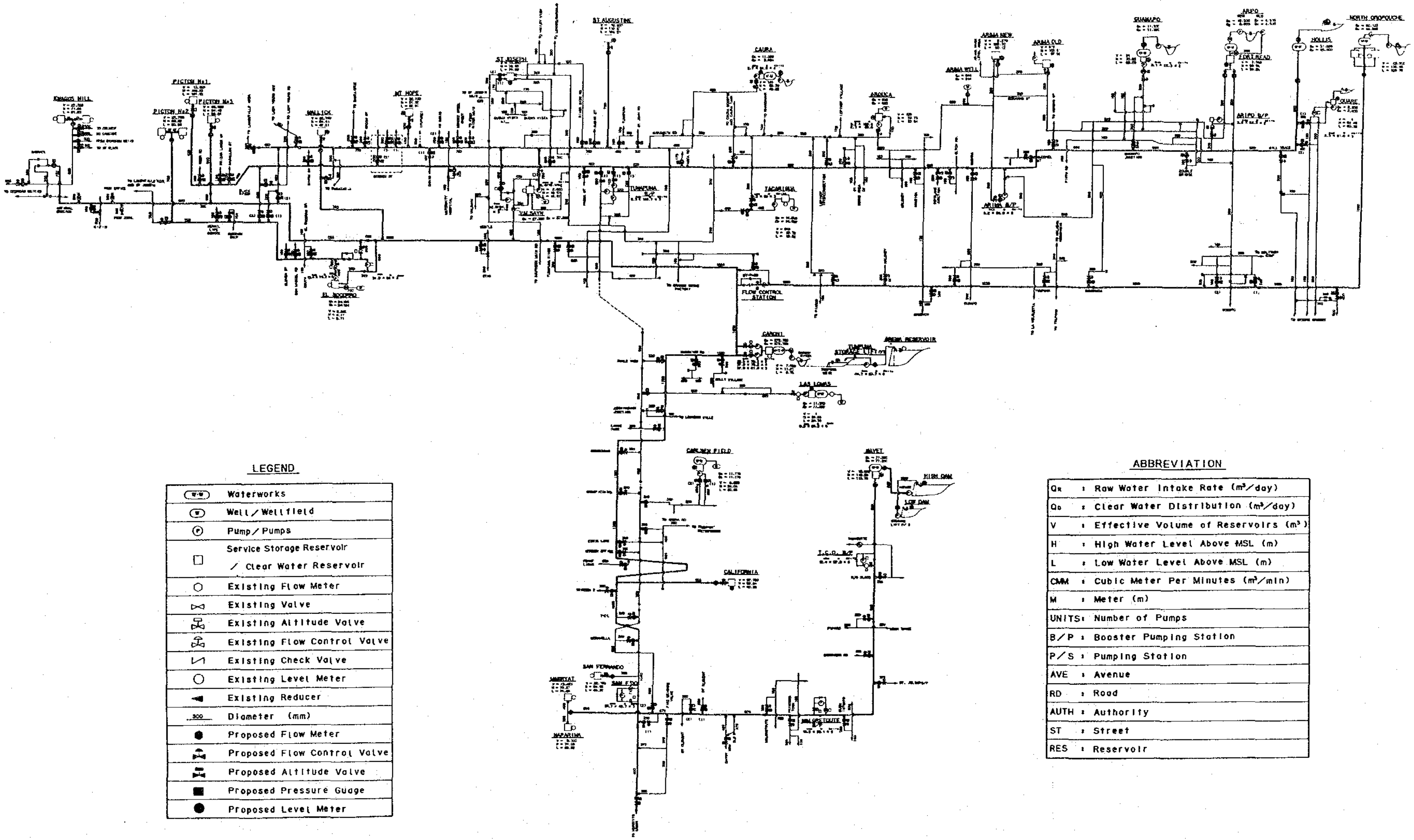
Tobago Region — PRODUCTION FACILITY (14)

TOBAGO	(14)	MEDIUM-(7)
		SMALL-(7)

NOTE: N. C.; NORTH CENTRAL, N. E.; NORTH EAST, N. W.; NORTH WEST, POS; PORT OF SPAIN, SF/SC; SAN FERNANDO/SOUTH CENTRAL, S. E.; SOUTH EAST, S. W.; SOUTH WEST, W. T. P.; WATER TRATMENT PLANT, W. W.; WATERWORKS,
INT: INTAKE, B. P/S: BOOSTER PUMPING STATION, S. L. P/S: STORAGE LIFT PUMPING STATION, (8): THE NUMBER OF FACILITIES IN EACH DISTRICT, MT.; MOUNT, ST.; SAINT, St.; STREET, F'TY; FACILITIES.

Fig. 12 CSS HARDWARE AND DATA COMMUNICATION





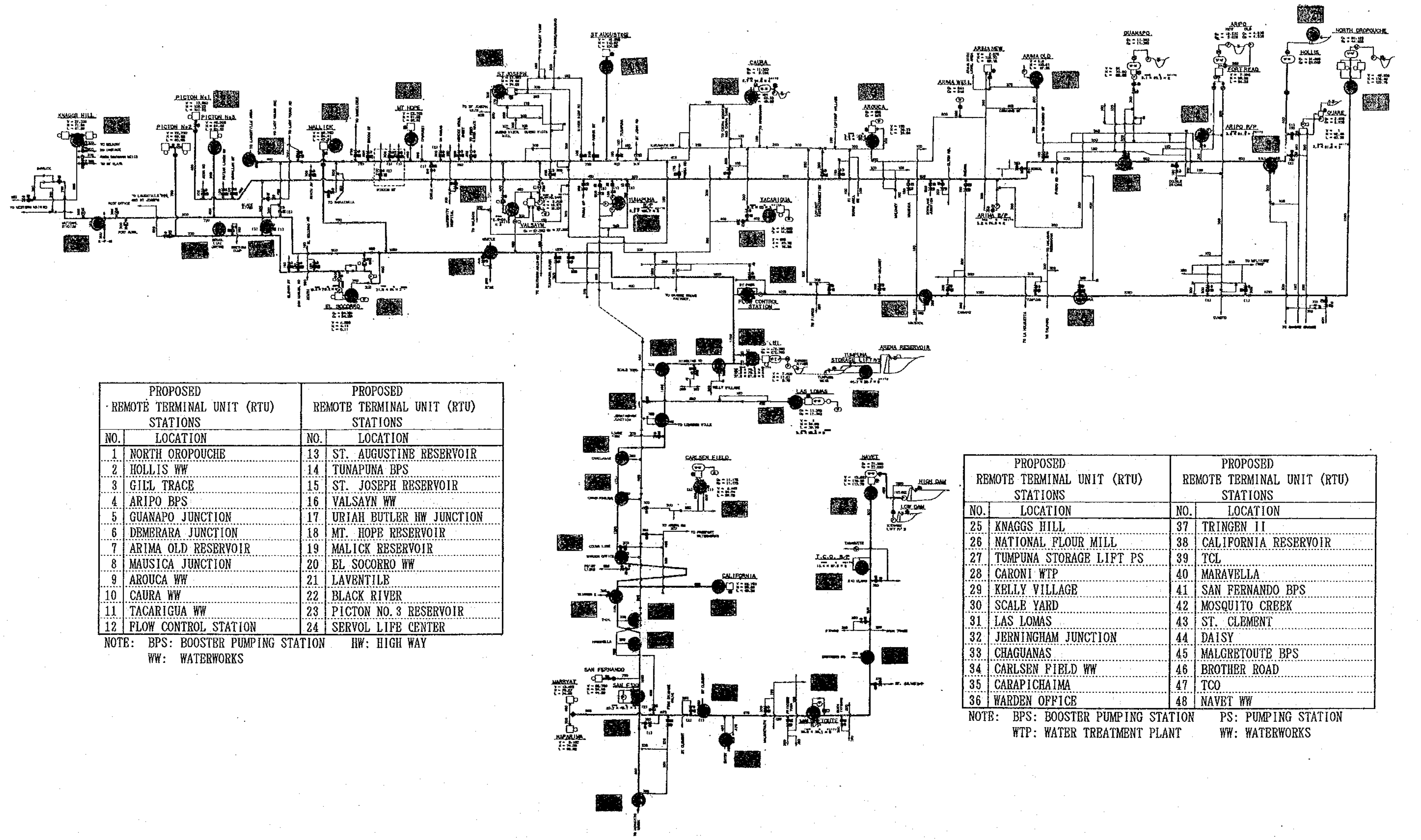
LEGEND

	Waterworks
	Well / Wellfield
	Pump / Pumps
	Service Storage Reservoir / Clear Water Reservoir
	Existing Flow Meter
	Existing Valve
	Existing Altitude Valve
	Existing Flow Control Valve
	Existing Check Valve
	Existing Level Meter
	Existing Reducer
300	Diameter (mm)
	Proposed Flow Meter
	Proposed Flow Control Valve
	Proposed Altitude Valve
	Proposed Pressure Guage
	Proposed Level Meter

ABBREVIATION

QR	: Raw Water Intake Rate (m^3/day)
QD	: Clear Water Distribution (m^3/day)
V	: Effective Volume of Reservoirs (m^3)
H	: High Water Level Above MSL (m)
L	: Low Water Level Above MSL (m)
CMM	: Cubic Meter Per Minutes (m^3/min)
M	: Meter (m)
UNITS	: Number of Pumps
B/P	: Booster Pumping Station
P/S	: Pumping Station
AVE	: Avenue
RD	: Road
AUTH	: Authority
ST	: Street
RES	: Reservoir

Fig. 13 WATER SUPPLY SYSTEM UNDER NEW CSS



PROPOSED REMOTE TERMINAL UNIT (RTU) STATIONS		PROPOSED REMOTE TERMINAL UNIT (RTU) STATIONS	
NO.	LOCATION	NO.	LOCATION
1	NORTH OROPOUCHE	13	ST. AUGUSTINE RESERVOIR
2	HOLLIS WW	14	TUNAPUNA BPS
3	GILL TRACE	15	ST. JOSEPH RESERVOIR
4	ARIPO BPS	16	VALSAYN WW
5	GUANAPO JUNCTION	17	URIAH BUTLER HW JUNCTION
6	DEMERARA JUNCTION	18	MT. HOPE RESERVOIR
7	ARIMA OLD RESERVOIR	19	MALICK RESERVOIR
8	MAUSICA JUNCTION	20	EL SOCORRO WW
9	AROUCA WW	21	LAVENTILE
10	CAURA WW	22	BLACK RIVER
11	TACARIGUA WW	23	PICTON NO. 3 RESERVOIR
12	FLOW CONTROL STATION	24	SERVOL LIFE CENTER

NOTE: BPS: BOOSTER PUMPING STATION HW: HIGH WAY
WW: WATERWORKS

PROPOSED REMOTE TERMINAL UNIT (RTU) STATIONS		PROPOSED REMOTE TERMINAL UNIT (RTU) STATIONS	
NO.	LOCATION	NO.	LOCATION
25	KNAGGS HILL	37	TRINGEN II
26	NATIONAL FLOUR MILL	38	CALIFORNIA RESERVOIR
27	TUMPUNA STORAGE LIFT PS	39	TCL
28	CARONI WTP	40	MARAVELLA
29	KELLY VILLAGE	41	SAN FERNANDO BPS
30	SCALE YARD	42	MOSQUITO CREEK
31	LAS LOMAS	43	ST. CLEMENT
32	JERNINGHAM JUNCTION	44	DAISY
33	CHAGUANAS	45	MALGRETOUTE BPS
34	CARLSEN FIELD WW	46	BROTHER ROAD
35	CARAPICHAIMA	47	TCO
36	WARDEN OFFICE	48	NAVET WW

NOTE: BPS: BOOSTER PUMPING STATION PS: PUMPING STATION
WTP: WATER TREATMENT PLANT WW: WATERWORKS

Fig. 14 PROPOSED LOCATION OF RTU STATIONS

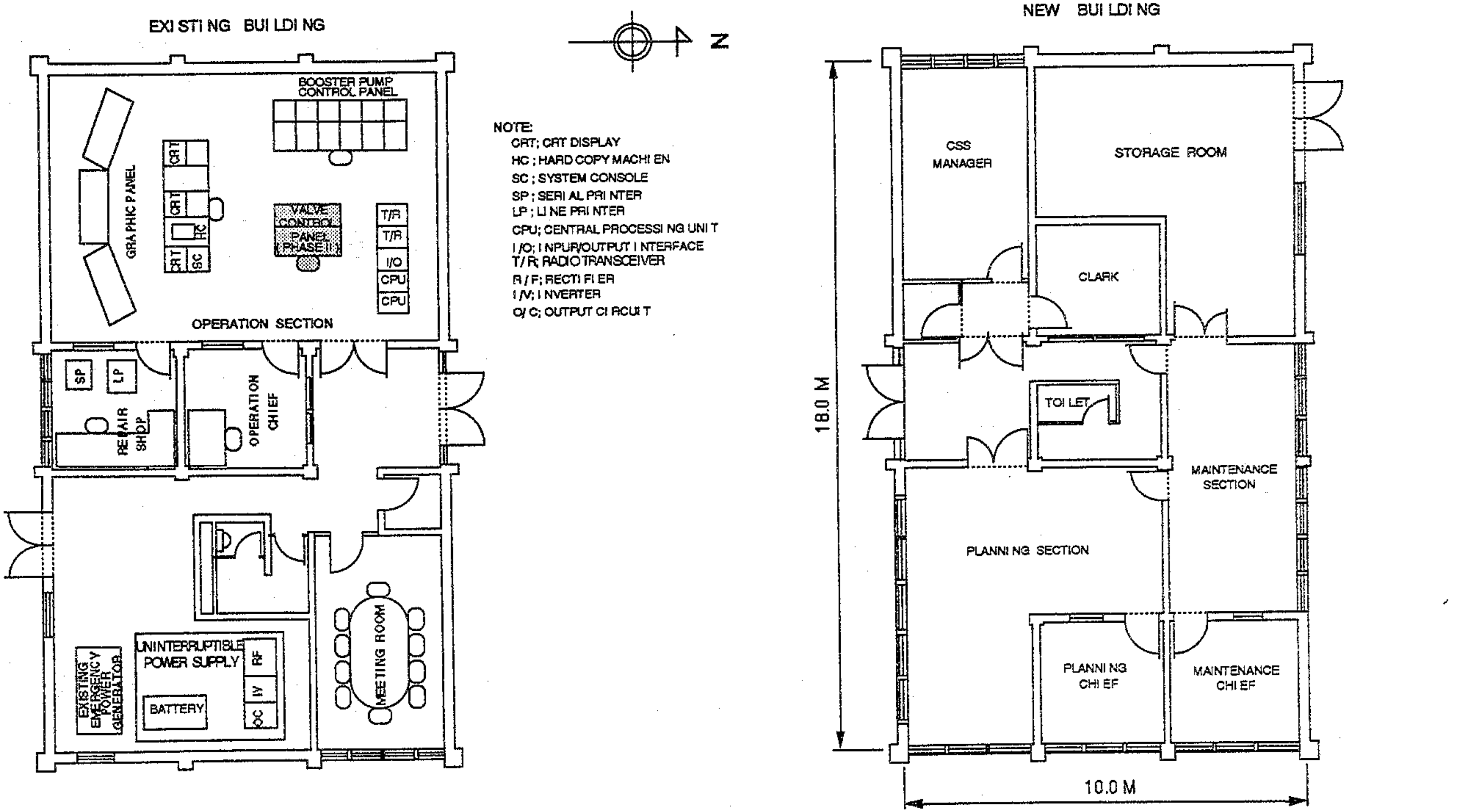
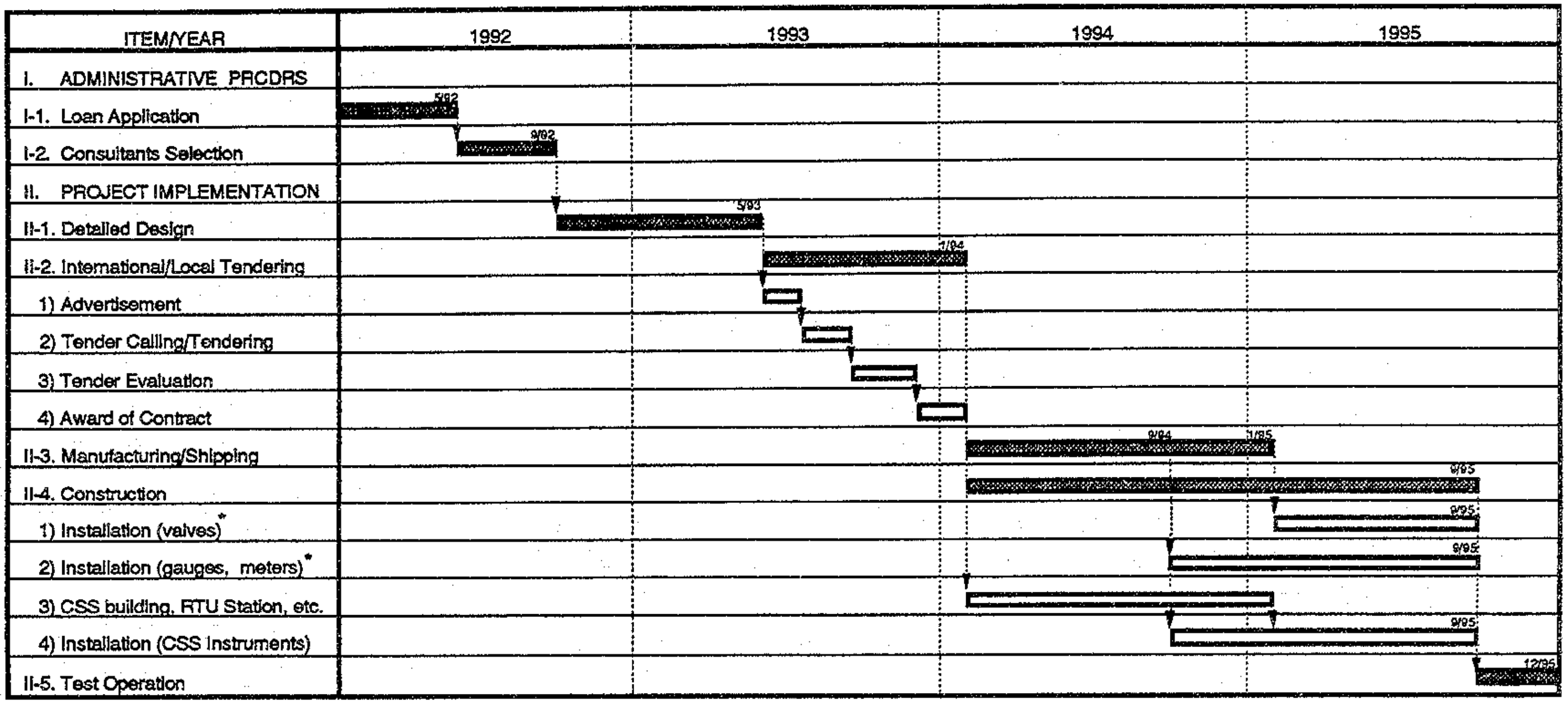


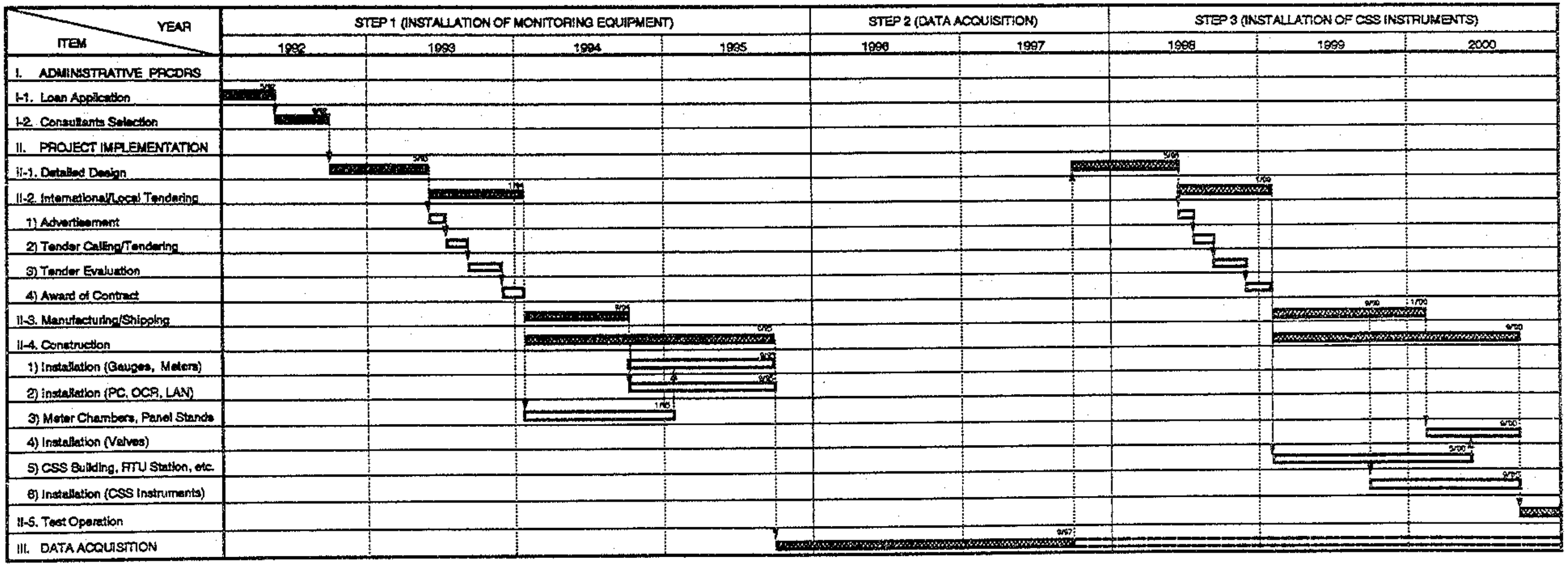
Fig. 15 CSS BUILDING

Fig. 16 CONSTRUCTION/IMPLEMENTATION SCHEDULE



*……. Pressure gauges, flow meters and CSS instruments will be delivered to the site in the first shipment, while valves in the second shipment.

Fig. 17 CONSTRUCTION/IMPLEMENTATION SCHEDULE (OPTION A)



NOTE: PC; Personal Computer, OCR; Optical Character Reader, LAN; Local Area Network

Fig. 18 CSS HARDWARE AND DATA COMMUNICATION - OPTION A

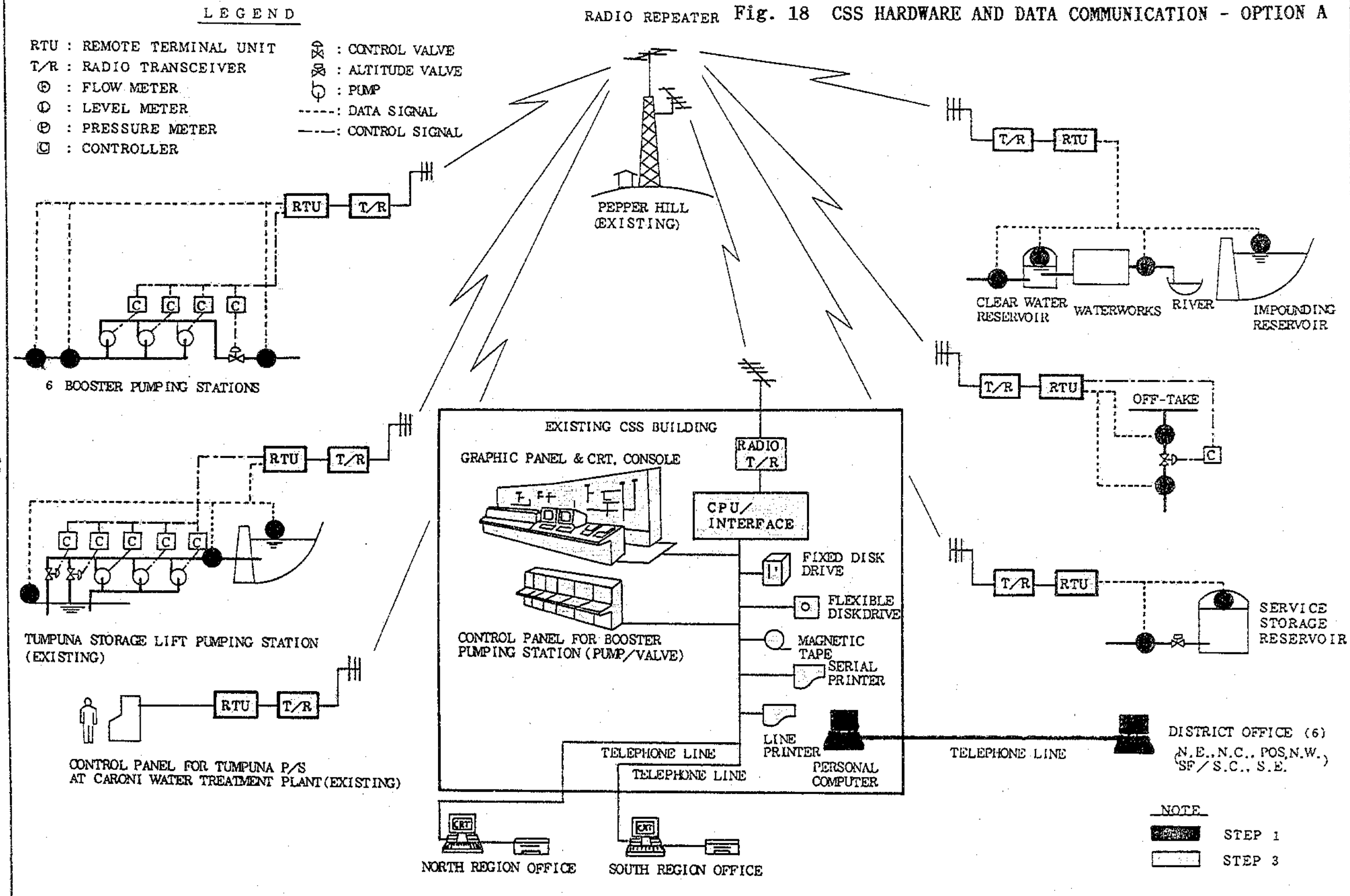


Table 1 PRESENT WATER USE BY WATER AREA

WATER AREA	POPULATION AREA (km2)	DENSITY * (/km2)		POPULATION Total	Service Area	Served	Served by Sources I	Served by Sources II	CONSUMPTION (m3/d) Source Group I	Source Group II	Total	PER CAPITA CONSUMPTION (lpcd) Source Group I	Source Group II	Total	WATER DEMAND (m3/d) Area of Sources I	Area of Sources II	General	Special	Total
1. DIEGO MARTIN	105	666	S	70,161	69,231	65,769	240	65,529	185	45,545	45,731	774	695	695	113	30,799	30,911		30,911
2. PORT OF SPAIN	56	1,473	U	82,530	81,691	77,607	39,610	37,996	30,555	24,783	55,338	771	652	713	29,707	19,378	39,579	9,505	49,085
3. E.M.R COMMUNITIES	302	922		278,073	270,402	256,882	239,562	17,320	172,904	7,757	180,661	722	448	703	157,339	8,152	125,911	39,580	165,491
3.1 St. Barbs	2	3,523	U	6,342	6,342	6,025	5,803	223	4,475	283	4,759	771	1,274	790	2,959	113	3,073		3,073
3.2 Laventille	2	4,112	U	6,496	6,496	6,172	6,172		4,610		4,610	747		747	3,147		3,147		3,147
3.3 Morvant	7	2,912	U	19,658	19,658	18,676	18,613	62	14,388	47	14,435	773	753	773	9,493	32	9,525		9,525
3.4 Picton	9	3,082	U	27,058	27,058	25,705	25,705		19,895		19,895	774		774	13,109		13,109		13,109
3.5 Barataria	13	2,504	U	33,259	33,259	31,596	31,596		23,871		23,871	755		755	25,945		16,114	9,831	25,945
3.6 St. Joseph	58	605	S	34,868	31,563	29,985	23,477	6,508	16,323	3,625	19,948	695	557	665	31,946	3,059	14,093	20,912	35,005
3.7 Arouca	68	355	S	24,269	24,269	23,056	21,578	1,477	14,584	53	14,637	676	36	635	18,979	694	10,836	8,837	19,674
3.8 Tacarigua	13	1,594	U	20,447	19,196	18,236	18,236		12,368		12,368	678		678	9,300		9,300		9,300
3.9 Saddle Road	76	730	S	55,215	54,769	52,031	48,256	3,775	36,475	1,684	38,159	756	446	733	22,680	1,774	24,455		24,455
3.10 St. Augustine	29	813	S	23,601	23,573	22,394	17,120	5,275	11,574	2,065	13,639	676	391	609	8,046	2,479	10,525		10,525
3.11 Tunapuna	26	1,033	U	26,859	24,218	23,007	23,007		14,342		14,342	623		623	11,734		11,734		11,734
4. ARIMA	141	414	S	61,487	58,180	55,271	55,271		43,435		43,435	786		786	25,977		25,977		25,977
5. SANGRE GRANDE	584	85	R	55,755	49,614	47,133	43,037	4,096	27,418	182	27,599	637	44	586	16,010	1,524	17,533		17,533
6. WALLERFIELD	175	143	R	27,365	24,960	23,712	23,712		15,868		15,868	669		669	8,821		8,821		8,821
7. TOCO	370	21	R	8,761	7,821	7,430		7,430		2,611	2,611		351	351		2,764	2,764		2,764
8. CARONI	542	330		186,144	178,931	169,985	147,466	22,518	109,925	4,432	114,357	745	197	673	175,050	10,584	79,893	105,741	185,634
8.1 Caroni	13	648	S	8,461	8,461	8,038	8,038		5,889		5,889	733		733	3,778		3,778		3,778
8.2 Cunupia	201	265	S	55,597	53,426	50,754	49,724	1,030	37,724	203	37,927	759	197	747	23,370	484	23,855		23,855
8.3 Chaguanas	153	400	S	63,264	61,403	58,333	43,298	15,035	32,410	2,959	35,369	749	197	606	20,350	7,066	27,417		27,417
8.4 Couva	174	320	S	58,823	55,642	52,860	46,406	6,453	33,901	1,270	35,171	731	197	665	127,552	3,033	24,844	105,741	130,385
9. MAYARO	478	21	R	10,022	9,752	9,265		9,265		2,950	2,950		318	318		3,446	3,446		3,446
10. RIO CLARO	1,382	199		274,591	271,709	258,123	234,054	24,069	116,528	4,419	120,946	498	184	469	98,783	9,692	108,475		108,475
10.1 Arch Trace	592	80	R	47,531	44,649	42,416	38,413	4,003	14,691	1,027	15,718	382	256	371	14,290	1,489	15,779		15,779
10.2 Princes Town	416	122	R	50,765	50,765	48,227	48,227		18,444		18,444	382		382	17,940		17,940		17,940
10.3 Barrackpore	218	234	R	50,995	50,995	48,445	35,912	12,533	15,604	1,878	17,482	435	150	361	13,359	4,662	18,022		18,022
10.4 Fyzabad	93	642	S	59,523	59,523	56,547	49,924	6,623	36,164	1,281	37,445	724	193	662	23,464	3,113	26,577		26,577
10.5 Palmyra	58	782	S	45,050	45,050	42,798	41,887	911	16,733	233	16,966	399	256	396	19,687	428	20,115		20,115
10.6 Marabella	6	3,681	U	20,726	20,726	19,690	19,690		14,892		14,892	756		756	10,042		10,042		10,042
11. SAN FERNANDO	8	3,787	U	29,842	29,842	28,350	28,350		12,800		12,800	452		452	14,459		14,459		14,459
12. SIPARIA/ERIN	195	175	R	34,125	32,716	31,080		31,080		5,751	5,751		185	185		11,562	11,562		11,562
13. POINT FORTIN	297	173	R	51,368	50,018	47,517	13,727	33,790	10,626	8,714	19,340	774	258	407	5,106	12,570	17,676		17,676
14. NORTH COAST	194	12	R	2,360	1,842	1,749		1,749		718	718		410	410		651	651		651
TOTAL (TRINIDAD)	4,827	243		1,172,586	1,136,708	1,079,872	825,028	254,844	540,244	107,863	648,107	655	423	600	531,364	111,121	487,659	154,826	642,485
15. TOBAGO	301	187		56,195	55,784	52,994					20,492			387			23,781		23,781
15.1 Leeward Sect.	140	311	S	43,689	43,689	41,505					16,594			400			19,507		19,507
15.2 Windward Sect.	161	78	R	12,505	12,095	11,490					3,898			339			4,274		4,274
TOTAL	5,128	240		1,228,780	1,192,491	1,132,867	825,028	254,844	540,244	107,863	668,599	655	423	590	531,364	111,121	511,440	154,826	666,267

Note: U: Urban, S: Semiurban, R: Rural

Table 2 LIST OF EXISTING LARGE AND MEDIUM SCALE PRODUCTION FACILITIES (1)

NO.	NAME OF PRODUCTION FACILITY (WATERWORKS/WATER TREATMENT PLANT, INTAKES AND WELLS)	NAME OF SOURCE AND AQUIFER	DESIGN PRODUCTION CAPACITY (M3/D)	1988's AVERAGE DAILY PRODUCTION (M3/D)	INSTALL FLOW METER	NUMBER OF WELLS	TREATMENT PROCESSES Aer.	Coa.	Sed.	Fil.	Chl.	pH	A.C.	KIND OF CHEMICAL USE	DISTRICT OF WASA
	=SURFACE WATER SOURCE= [LARGE SCALE] T R I N I D A D														
1	CARONI/ARENA TREATMENT PLANT	ARENA RESERVOIR & CARONI RIVER	272,760	259,781	0	--		*	*	*	*	*	*	AL, LM, CL, AC	N.C.
2	NAVET WATERWORKS	NAVET RESERVOIR	77,280	72,100	0	--		*	*	*	*	*	*	AL, LM, CL	S.E.
3	NORTH OROPOUCHE WATERWORKS	NORTH OROPUCHE RIVER	90,920	46,728	0	--		*	*	*	*			AL, CL	N.E.
4	HOLLIS WATERWORKS	HOLLIS RESERVOIR	31,826	25,722	X	--				*	*	*		AL, LM, CL	N.E.
	SUB-TOTAL		472,786	404,331 (63.5 %)	(0-3, X-1)										
	[MEDIUM SCALE] T R I N I D A D														
1	CAURA WATERWORKS	CAURA RIVER	11,360	9,932	0	--		*	*	*	*			AL, LM, CL	N.C.
2	ARIPO (NEW) WATERWORKS	ARIPO RIVER	15,900	8,365	0	--		*	*	*	*			AL, CL	N.E.
3	GUANAPO WATERWORKS	GUANAPO RIVER	11,360	5,776	0	--		*	*	*	*			AL, CL	N.E.
4	MARAVAL WATERWORKS	MARAVAL RIVER	5,910	4,304	X	--		*	*	*	*			AL, LM, CL	P.O.S.
5	QUARE INTAKE (VALENCIA)	QUARE RIVER	6,818	3,295	X	--					*			CL	N.E.
6	LOANGO/NARANJO WATERWORKS	LOANGO & NARANJO RIVERS	3,180	2,488	0	--		*	*	*	*			AL, CL	N.C.
7	TOCO WATERWORKS	TOMPIRE RIVER	4,546	1,851	X	--		*	*	*	*			AL, CL	N.E.
8	ACONO WATERWORKS	ACONO RIVER	2,100	1,699	0	--		*	*	*	*			AL, CL	N.W.
	SUB-TOTAL		61,174	37,710 (5.9 %)	(0-5, X-3)										
	T O B A G O														
9	HILLSBOROUGH WATERWORKS	HILLSBOROUGH RESERVOIR	8,582	7,111	0	--		*	*	*	*	*		AL, LM, CL	TOBAGO
10	COURLAND WATERWORKS	COURLAND RIVER	7,368	6,186	0	--		*	*	*	*			AL, POLY, CL	TOBAGO
11	RICHMOND WATERWORKS	RICHMOND RIVER	2,467	1,749	0	--	*			*	*			CL	TOBAGO
12	KING'S BAY WATERWORKS	KING'S BAY RIVER	2,994	1,483	0	--		*	*	*	*			AL, LM, CL	TOBAGO
13	CRAIG HALL INTAKE	RIVER	2,461	1,367	0	--					*			CL	TOBAGO
14	GREEN HILL INTAKE	RIVER	3,360	1,189	0	--					*			CL	TOBAGO
	SUB-TOTAL		27,232	19,085 (95.2 %)	(0-6)										
	T O T A L (M3/D) (SURFACE WATER SOURCE)		561,192	461,126 [70.2 %]	(0-14, X-4)										
	=GROUNDWATER SOURCE (WELL)= [MEDIUM SCALE] T R I N I D A D														
1	FOUR ROADS WATERWORKS	NORTH-WEST PENINSULA GRAVELS	28,900	29,890	X	12					*			CL	N.W.
2	VALSAYN WATERWORKS	NORTHERN GRAVELS	27,280	25,094	X	9					*			CL	N.C.
3	EL SOCORRO WATERWORKS	NORTHERN GRAVELS	27,270	23,146	X	9					*			CL	N.W.

Table 2 LIST OF EXISTING LARGE AND MEDIUM SCALE PRODUCTION FACILITIES (2)

NO.	NAME OF PRODUCTION FACILITY (WATERWORKS/WATER TREATMENT PLANT, INTAKES AND WELLS)	NAME OF SOURCE AND AQUIFER	DESIGN PRODUCTION CAPACITY (M3/D)	1988's AVERAGE DAILY PRODUCTION (M3/D)	INSTALL FLOW METER	NUMBER OF WELLS	TREATMENT PROCESSES							KIND OF CHEMICAL USE	DISTRICT OF WASA
							Aer.	Coa.	Sed.	Fil.	Chl.	pH	A. C.		
4	TACARIGUA WATERWORKS	NORTHERN GRAVELS	14, 550	15, 887	X	10					*			CL	N. C.
5	CARLSEN FIELD WATERWORKS	CENTRAL SANDS	18, 180	10, 604	0	5	*		*	*	*	*		LM, CL	S. F. & S. C.
6	LAS LOMAS WATERWORKS	CENTRAL SANDS	11, 360	10, 330	0	5	*			*	*	*		LM, CL	N. C.
7	SAVANNAH WELLS	NORTH-WEST PENINSULA GRAVELS	12, 270	9, 501	X	6					*			CL	P. O. S.
8	TUCKER VALLEY WELLS	NORTH-WEST PENINSULA GRAVELS	7, 971	8, 425	X	8					*			CL	N. W.
9	RIVER ESTATE WATERWORKS	NORTH-WEST PENINSULA GRAVELS	6, 820	7, 173	X	5					*			CL	N. W.
10	CHAGUARAMAS WELLS	NORTH-WEST PENINSULA GRAVELS	-	5, 669	X	2					*			CL	N. W.
11	KING GEORGE V PARK WELLS	NORTH-WEST PENINSULA GRAVELS	10, 340	5, 551	X	3					*			CL	P. O. S.
12	FREEPORT WATERWORKS	CENTRAL SANDS	11, 360	5, 236	0	3	*		*	*	*	*		LM, CL	S. F. & S. C.
13	CHATHAM WATERWORKS	SOUTHERN SANDS	11, 360	4, 665	0	5	*	*	*	*	*			AL, CL	S. W.
14	PENAL WATERWORKS	SOUTHERN SANDS	3, 500	3, 009	0	8	*	*	*	*	*			LM, CL	S. W.
15	SIPARIA (COORA) WATERWORKS	SOUTHERN SANDS	3, 033	2, 954	0	8	*			*	*			CL	S. W.
16	GRANVILLE WATERWORKS	SOUTHERN SANDS	2, 800	2, 800	0	7	*			*	*			LM, CL	S. W.
17	DORRINGTON GARDEN WATERWORKS	NORTH-WEST PENINSULA GRAVELS	5, 400	2, 404	X	1					*			CL	N. W.
18	MOKA WELLS	NORTH-WEST PENINSULA GRAVELS	1, 590	2, 090	X	2					*			CL	P. O. S.
19	ST. CLAIR WELL	NORTH-WEST PENINSULA GRAVELS	1, 820	1, 885	X	1					*			CL	P. O. S.
20	FYZABAD WATERWORKS	SOUTHERN SANDS	1, 500	1, 701	0	5			*	*				CL	S. W.
21	LA PASTORA WELLS	NORTHERN GRAVELS	2, 900	1, 451	X	2					*			CL	N. W.
22	CARAPAL WATERWORKS	SOUTHERN SANDS	1, 400	1, 333	0	2				*	*			LM, CL	S. W.
23	MALONEY WELLS	SOUTHERN SANDS	1, 358	1, 294	0	2				*	*			CL	S. E.
24	AMOCO TOURNEBRIDGE WELLS	SOUTHERN SANDS	1, 194	1, 221	0	3				*	*			CL	S. E.
	T O T A L (M3/D) (GROUNDWATER SOURCE)		214, 156	183, 313 [27. 9 %] (28. 8 %)	(0-11, X-13)	123									
	G R A N D T O T A L (M3/D)		775, 348	644, 439 [98. 1 %]	(0-25, X-17)	123									
	[LARGE SCALE]		472, 786	404, 331 [61. 6 %]	(0-3, X-1)										
	[MEDIUM SCALE]		302, 562	240, 108 [36. 6 %]	(0-22, X-16)										

NOTE: - P. O. S. ; PORT OF SPAIN, N. W. ; NORTH WEST, N. E. ; NORTH EAST, N. C. ; NORTH CENTRAL, S. F. & S. C. ; SAN FERNANDO & SOUTH CENTRAL, S. E. ; SOUTH EAST, S. W. : SOUTH WEST,

- Aer. ; AERATION, Coa. ; COAGULATION, Sed. ; SEDIMENTATION, Fil. ; FILTRATION, Chl. ; CHLORINATION, pH ; PH CORECTION, A. C. ; ACTIVATED CARBON,
- AL ; ALUMINIUM SULFATE, LM ; HYDRATED LIME, CL ; CHLORINE (both gaseous and powder), POLY ; POLYMER, AC ; ACTIVATED CARBON,
- EACH DESIGN PRODUCTION CAPACITIES ARE QUOTED FROM "THE WATER SYSTEM BALANCE IN TRINIDAD, JUNE 1985" AND "INFORMATION FROM WASA'S REGIONAL OFFICE IN TOBAGO".
- " 0 " AND " X " MEAN EXISTING AND WITHOUT FLOW METER AT EACH PRODUCTION FACILITYN RESPECTIVELY.
- FIGURES IN [ ] ARE RATIO (%) TO TOTAL AVERAGE DAILY PRODUCTION CAPACITY IN 1988 (656, 854 M3/D).
- FIGURES IN ( ) ARE RATIO (%) TO EACH TOTAL AVERAGE DAILY PRODUCTION CAPACITY IN 1988 OF TRINIDAD AND TOBAGO.