JAPAN INTERNATIONAL COOPERATION AGENCY
EAST TIMOR TRANSITIONAL ADMINISTRATION

THE STUDY ON URGENT IMPROVEMENT PROJECT FOR WATER SUPPLY SYSTEM IN EAST TIMOR

FINAL REPORT

Volume Ⅱ: MAIN REPORT

FEBRUARY 2001

TOKYO ENGINEERING CONSULTANTS, CO., LTD.
PACIFIC CONSULTANTS INTERNATIONAL

THE STUDY
ON
URGENT IMPROVEMENT PROJECT
FOR
WATER SUPPLY SYSTEM
IN
EAST TIMOR

DRAFT FINAL REPORT

CONSTITUENT VOLUMES

VOLUME Ⅰ	**SUMMARY REPORT**
VOLUME Ⅱ	**MAIN REPORT**
VOLUME Ⅲ	**APPENDIX**
VOLUME Ⅳ	**QUICK PROJECT IMPLEMENTATION MANUAL**

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PREFACE

In response to a request from the United Nations Transitional Administration of East Timor, the Government of Japan decided to conduct The Study on Urgent Improvement Project for Water Supply System in East Timor and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Kazufumi Momose of Tokyo Engineering Consultants Co., Ltd. in association with Pacific Consultants International to East Timor, twice between February 2000 and February 2001.

The team held discussions with the officials concerned of the East Timor Transitional Administration and Asian Development Bank which is a trustee of East Timor Trust Fund and conducted field surveys in the study area. Based on the field surveys, the Study Team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between Japan and East Timor

Finally, I wish to express my sincere appreciation to the officials concerned of the East Timor Transitional Administration for their close cooperation extended to the Study.

February 2001

Kunihiko SAITO
President
Japan International Cooperation Agency

Mr. Kunihiko Saito
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit you the final report entitled "THE STUDY ON URGENT IMPROVEMENT PROJECT FOR WATER SUPPLY SYSTEM IN EAST TIMOR". This report has been prepared by the Study Team in accordance with the contracts signed on 17 February 2000, between Japan International Cooperation Agency and Tokyo Engineering Consultants Co., Ltd. and Pacific Consultants International.

The report examines the existing conditions concerning water supply system in East Timor, presents urgent improvement projects identified in 15 towns, including conducted Quick Projects

The report consists of the Summary Report, Main Report, Appendix and Quick Project Implementation Manual. The Summery Report summarizes the results of all studies. The Main Report presents the results of the whole study including background conditions, existing water supply situation, selection of priority project and execution of the Quick Project. The Appendix describes in detail the same contents of the Main Report and the Quick Project Implementation Manual shows concrete operation and maintenance procedures of each Quick Project.

All the members of the Study Team wish to acknowledge gratefully to the personnel of your Agency and Ministry of Foreign Affairs, the liaison office of the Government of Japan in East Timor, JICA East Timor Office, and also to the officials and individuals of the East Timor Transitional Administration for their assistance extended to the Study Team. The Study Team sincerely hopes that the results of the study contribute to the improvement of the water supply systems and social and economic development in East Timor.

Yours faithfully,
February 2001

Kazufumi Momose
Team Leader

ABBREVIATIONS USED IN THIS REPORT

ACF	Action Contre la Faim (French)
ADB	Asian Development Bank
AFMET	Alliance of Friends for East Timor
amsl	above mean sea level
AusAID	Australian Agency for International Development
BPAM	Badam Pengelola Air Minum (Bahasa Indonesia) Local Water Utility Agency
CNRT	Conselho Nacional da Resistencia Timorense (Portuguese) National Council of Timorese Resistance
DFID	Department for International Development (United Kingdom)
ETTA	East Timor Transitional Administration
GSP	Galvanized Steel Pipe
GIS	Geographical Information System
GOJ	Government of Japan
GPA	Governance and Public Administration
HP	Horsepower
HDPE	High Density Polyethylene
ICRC	International Committee of the Red Cross
IOM	International Organization for Migration
JICA	Japan International Cooperation Agency
L/s	liters per second
L/c/d	liters per capita per day
NGO	Non Government Organization
OCHA	Office for the Coordination of Humanitarian Affairs
Oxfam	International NGO on environmental health – water, sanitation & public health
PCI	Pacific Consultants International
PKF	Peacekeeping Force
PLN	Perusahaan Listrik Negara (Bahasa Indonesia) Electricity Utility Agency in East Timor
PDAM	Perusahaan Daerah Air Minum (Bahasa Indonesia) Water Utility Agency in Dili
ppm	parts per million
PVC	Polyvinyl Chloride
rpm	revolution per minute
SSF	Slow Sand Filter
TDS	Total Dissolved Solids
TEC	Tokyo Engineering Consultants, Co., Ltd.
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
UNSRSG	United Nations Special Representative of the Secretary General
UNTAET	United Nations Transitional Administration in East Timor
WAET	Water Authority in East Timor
WB	World Bank
WHO	World Health Organization
WTP	Water Treatment Plant

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APPENDIX

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

On February 17, 2000 under the contract with Japan International Cooperation Agency, Tokyo Engineering Consultants Co., Ltd. in association with Pacific Consultants International started the project "The Study on Urgent Improvement Project for the Water Supply System in East Timor." Generally, the Study follows the Scope of Work signed on January 12, 2000 by the SRSG of UNTAET* and the JICA Mission. However, this Scope of Work was then modified and subsequently signed to suit the current situation as a result of the preliminary evaluation on the condition of the existing water supply systems in the study area carried out by the JICA Study Team. Short but extensive field surveys, interviews of subjects related to the study made on UNTAET District Administration officials, employees of the former PDAM, BPAM and NGO's help the Study Team and UNTAET officials in framing the amendments to the Scope of Work. Accordingly, the Minutes of Meeting was signed on March 10, 2000 by the SRSG of UNTAET and the JICA Mission.

1.2 STUDY AREA

Fifteen towns/cities of the districts and sub-districts in East Timor are included in the study area. **Figure 1.1** shows the location of the study area. The 15 towns include Dili, Atauro, Manatuto, Baucau, Viqueque, Los Palos, Same, Aileu, Maubisse, Ainaro, Ermera, Gleno, Liquica, Maliana and Suai. The Study is concentrated on the urban centers of the fifteen towns and occasionally extends into the rural areas mainly due to the geographical location of the water sources.

1.3 STUDY OBJECTIVES

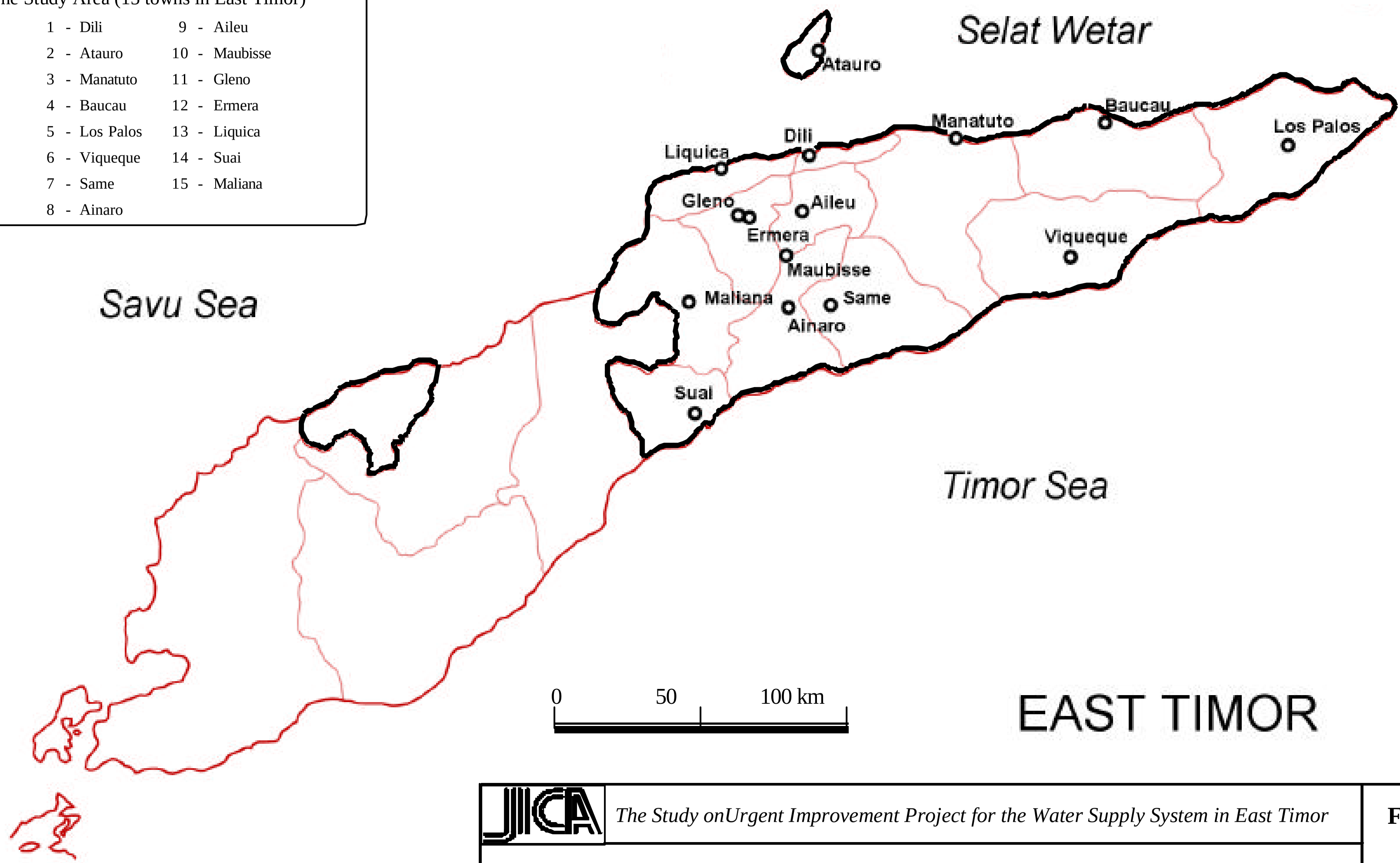
The objectives of the Study are the following:

a.) To plan and undertake "Quick Project" (otherwise known as Quick Impact Project of UNTAET).
b.) To prepare a scope of work for an immediate improvement project of a water supply system, which will be funded by the Japanese government and to be implemented by UNDP.
c.) To set up a comprehensive Geographic Information System of the existing water supply system that includes the physical condition in order to facilitate rehabilitation works and future development program.
d.) To make an assessment of the water resources.
e.) To formulate a rehabilitation and improvement plan of the existing/damaged water supply system for the target year 2003.
f.) To promote water supply, sanitation and hygiene in primary schools of peri-urban and rural areas (this part of the Study is limited to Dili, Aileu and Los Palos).
g.) To pursue capacity building and technology transfer to counterpart personnel in the course of the Study.

** UNTAET lately changed to ETTA (East Timor Transitional Administration)*

The Study Area (15 towns in East Timor)

1 - Dili	9 - Aileu
2 - Atauro	10 - Maubisse
3 - Manatuto	11 - Gleno
4 - Baucau	12 - Ermera
5 - Los Palos	13 - Liquica
6 - Viqueque	14 - Suai
7 - Same	15 - Maliana
8 - Ainaro	



The Study onUrgent Improvement Project for the Water Supply System in East Timor

Figure 1.1

The Study Area

1.4 STUDY CONTENTS AND SCHEDULE

Right after the post-referendum violence, emergency repairs had been carried out by donor countries, NGO's and other humanitarian organizations to restore the water supply system in East Timor. However, the degree of rehabilitation is limited in scope and coverage that there remain a large number of East Timorese deprived of an efficient, safe and potable water supply system. Due to the urgency and existing local condition, the repairs made by these organizations on the system in selected areas vary from high standard to below standard. Additionally, most of the emergency repairs were carried out as an immediate measure to restore the water supply services.

To coincide with the urgent rehabilitation works, the JICA Study Team found it essential that planning of the water supply system for medium/long term program should be given equal importance. As East Timor is on the state of transition from emergency to normal stage, evaluations on the physical condition of the study area and the existing water supply system are necessary in formulate the 3-year rehabilitation plan for East Timor. The Study is being carried out in two phases namely: Phase 1 – Asset Mapping and Evaluation of the Existing Water Supply Systems and Phase II – Master Plan on the Rehabilitation/Improvement of the Water Supply Systems in 15 Towns of East Timor. Phase I, which commenced in mid-February ended up in July. On the other hand, Phase II, which started in October will be completed before the year ends. Refer to **Figure 1.2** for the Plan of Operation.

In most cases, due to the unavailability of records, drawings and other related information of the water supply system in the study area, on-site data gathering and investigations are necessary. Stage I includes extensive on-site survey for asset mapping evaluation of the existing water supply facilities. Investigations of major water supply facilities include water sources and intake structures, transmission and distribution mains, treatment works, storage facilities and service connections. The field data and information gathered will then be superimposed on the GIS maps (either scale 1:2,000 or 1:5,000) to be completed towards the end of Phase II. This GIS activity has started in Dili of which the scale 1:2,000 has been completed. The GIS map of Dili has been very helpful in the implementation of the Leakage Control Program (one of the JICA "Quick Project"). Likewise, this map will be a vital tool in the operation and maintenance of the water supply system not only for Dili but for the rest of the 15 towns.

In the duration of Phase I, the Study Team investigated the existing water sources in terms of quantity and quality that helped in the evaluation for their adequacy of the present and future water requirements. Otherwise, possible alternative or additional water sources were considered for investigation. All data and information collected in Phase I served as basis for the 3-Year Rehabilitation Plan and for the identification of Quick Projects. Although a number of Quick Projects were identified as mentioned below, these projects, which started in Phase I continued until Phase II.

- Leakage Control in Dili
- Construction of Infiltration Gallery and Transmission Main in Manatuto

- Rehabilitation of Water Supply and Sanitation Facilities in Selected Primary Schools of Dili, Aileu and Los Palos

The 3-Year Rehabilitation Plan was formulated in Phase II. The concept of the said plan was discussed in October between JICA Study Team, ETTA's WSS and ADB's PMU.

Investigative activities such as water quality and quantity indicative of the dry season will also be carried out during the Phase II period. Assessment of water resources potential including surface water and groundwater investigation will be conducted by the Study Team. Rehabilitation and improvement of existing boreholes will be conducted to increase its yield. Redrilling maybe carried out on selected wells where rehabilitation is not possible. Borehole camera logging and pumping tests will be done to investigate the physical condition of the well and to evaluate the maximum potential of the borehole. A preliminary design of the water supply facilities will be formulated to include instrumentation, procurement schedule of materials and equipment, construction and implementation schedule, cost estimate, financial planning and O and M plan.

All of the water supply activities in Phases I and II will be carried out in close coordination with the activities for the promotion of hygiene improvement and education in selected schools of Dili, Aileu and Los Palos.

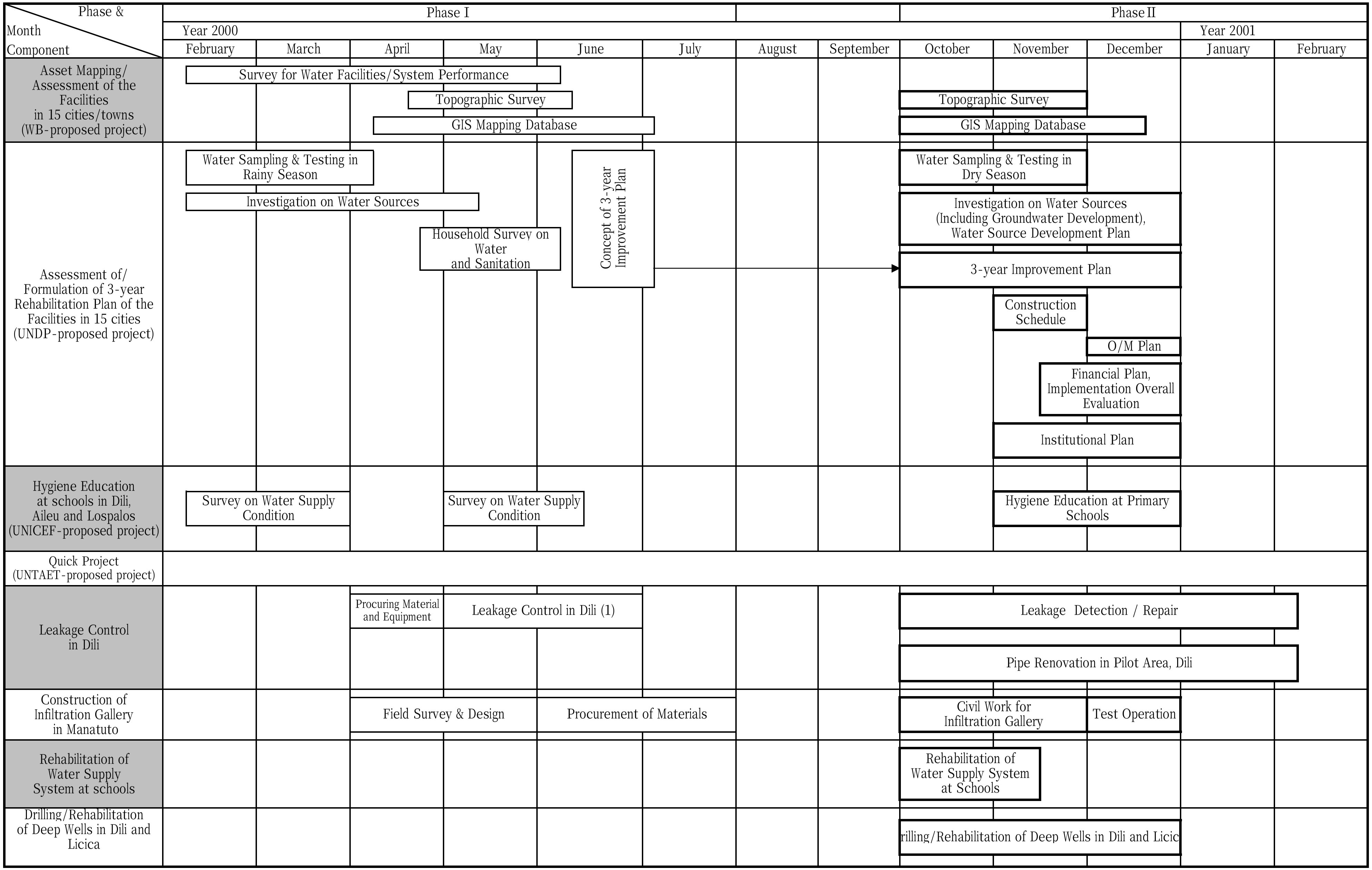


Fig. 1.2 Plan of Operation

CHAPTER 2 JICA's "QUICK PROJECTS"

2.1 QUICK PROJECTS

Several donor countries, NGO's and other humanitarian organizations extended their assistance (otherwise known as Quick Impact Project) for the rehabilitation of the water supply sector in East Timor. Most of these works were emergency repairs and were carried out mainly for the purpose of restoring the damaged water supply system. JICA for its part extended the following "Quick Projects" for East Timor as follows:

- Leakage Control in Dili
- Construction of the Infiltration Gallery and Transmission Main in Manatuto
- Rehabilitation of Water Supply and sanitation Facilities in selected Primary Schools in Dili, Aileu and Los Palos.

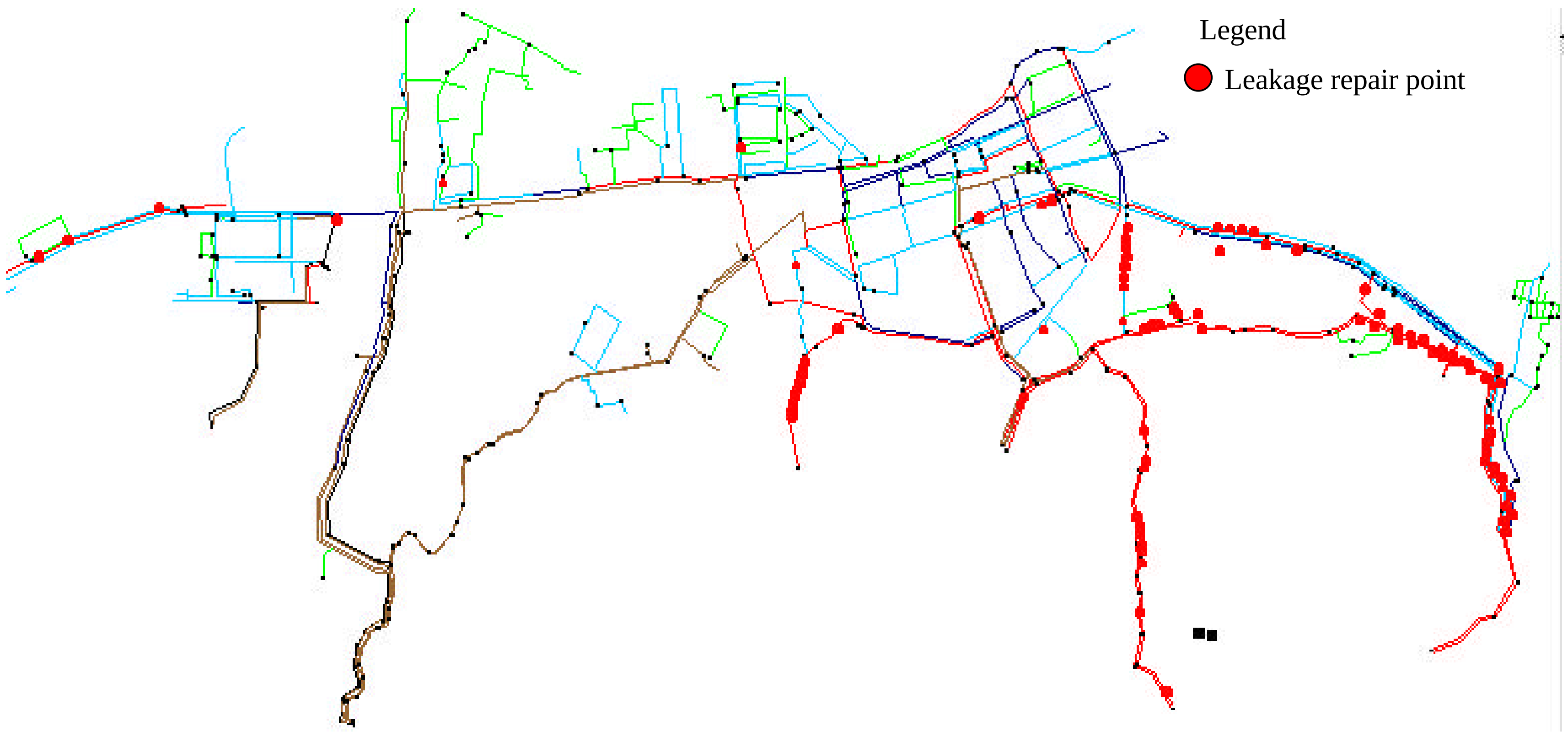
A more detailed discussion on these projects is included in the Appendix C and D.

2.1.1 Leakage Control

The Leakage Control Project in Dili is aimed for the reduction of unaccounted-for-water (estimated at 60%) resulting from numerous pipe leakage, illegal connections and water wastage. This project covers the investigations and repairs of pipe leaks, dismantling and reinstallation of illegal connections and the reconstruction of the existing distribution/reticulation network. The measure for the comprehensive leakage control program of JICA is being carried out by the selection of a model block system that comprise the Dili water supply distribution area. Prior to the implementation of the project, community consultative and informative meetings are carried out in order to attain full cooperation and support from the residents. Relevant investigative works are done on the water network such as water flow and pressure measurement before the implementation of the necessary countermeasures. Since the commencement of the leakage detection and repair project, substantial reduction in water wastage and losses were experienced by the system that resulted to an increase in water distribution to the water consumers of Dili. Figure 2.1 - Leakage Distribution Map shows the location of the completed leakage repair activity in Dili water distribution network. In the duration of the project, 2 technical staffs of ETTA's WSS were actively involved in order to carryout on-the-job training and technology transfer.

2.1.2 Manatuto Infiltration Gallery

Due to the complete breakdown of the town's water supply system, Manatuto is among the towns/cities of East Timor selected for the implementation of JICA's Quick Project. This project, which is scheduled to be operational before the end of 2000 will restore the town's water supply system with the production of safe and reliable water supply from Laclo River thereby abandoning the existing and non-operational water source. Perforated pipes were laid at about 5 m below the river bed to collect naturally-filtered river water. From the river bed, water is drawn into a reinforced concrete water collection



The Study onUrgent Improvement Project for the Water Supply System in East Timor

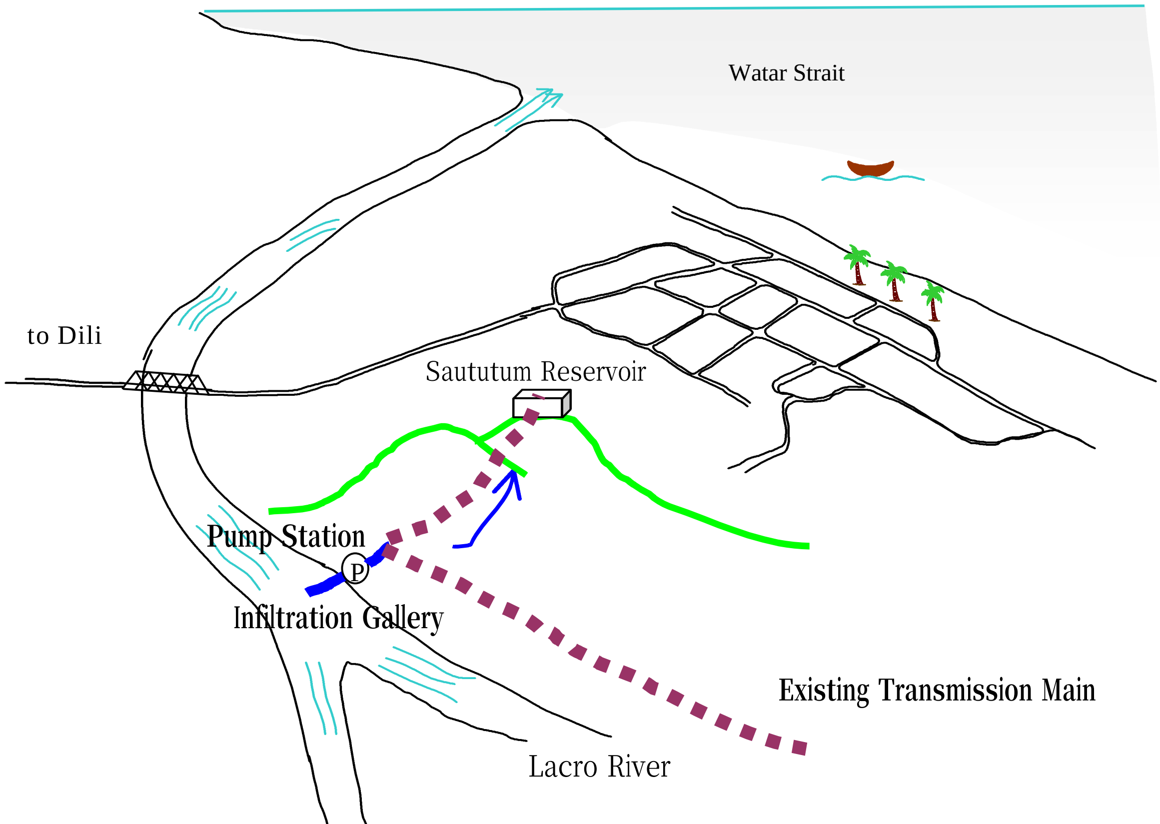
Figure 2.1

Leakage Distribution Map in Dili

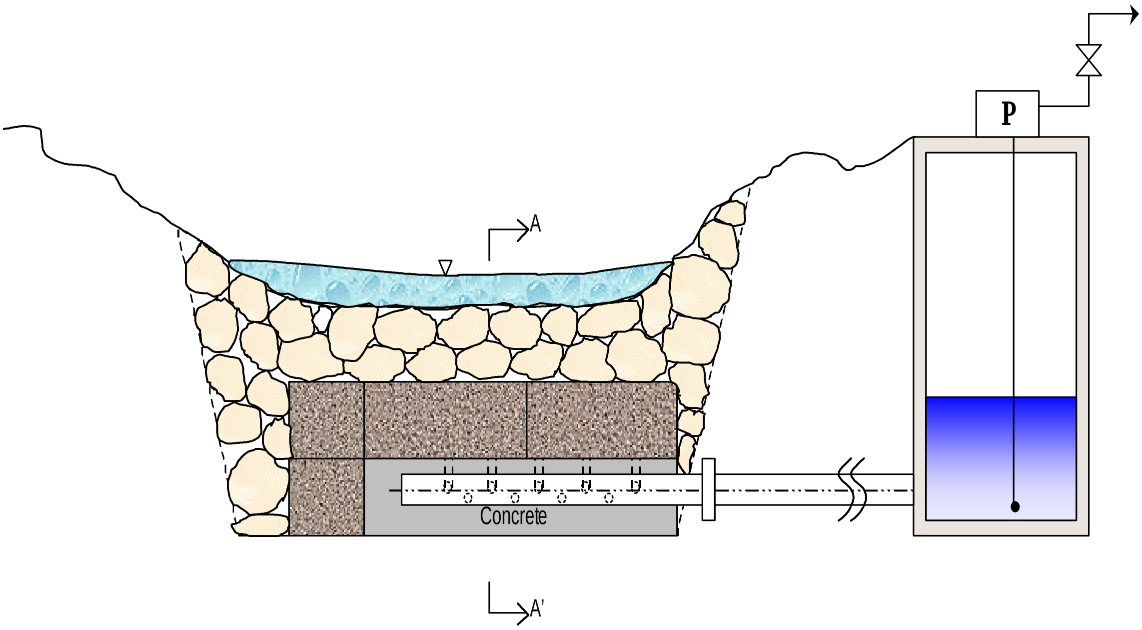
chamber (dia. 2.6 m x 5.9 m depth) via collection pipes (200 m x 8” perforated GSP + 65 m x 8” GSP) and pumped into the existing reservoir located on top of the hill. Pumping of the water is through the existing GSP 6-inch transmission main joined at the section close to the site of the infiltration gallery at about 4-km downstream of the reservoir. Three (3) units of pumps (1 stand by and 2 duty) were installed in the pumping station including 1 generator set (capacity = 60 kW) to supply power to the pumping facility. The Laclo River Infiltration Gallery is designed to produce 15 L/s using 2 pumps operational. The project was completed at the cost US$ 0.6 million and will be officially commissioned in December 17, 2000. Figure 2.2 shows the detail drawings of the project.

2.1.3 Hygiene Improvement and Education in Schools

The post-referendum damages of the schools’ facilities including water supply and sanitation equipment created unhygienic condition to the school children. Primary to JICA’s mission in East Timor is the welfare of school children by protecting their health through clean and hygienically acceptable school environment and the promotion of hygiene, sanitation, health and nutrition awareness through hygiene education in schools. Prior to the implementation of the project, the JICA Study Team conducted field surveys to collect information on the existing condition of the schools and the extent of damages to its facilities. The survey resulted to the selection of 8 primary schools (3 in Dili, 3 in Aileu and 2 in Los Palos) for the implementation of the JICA’s Hygiene Improvement and Education Project. Initially, this project was implemented by the improvement/installation of the schools’ water supply and sanitation facilities (Component 1) and followed by teaching of hygiene education subject to 6^{th} graders (Component 2). The construction and installation of the school’s water supply and sanitation facilities was carried out by engaging the local NGO Bia Hula and Fuiloro Mission, which completed the project in the middle of November. Right after the completion of Component 1 in the 8 selected primary schools, the teaching of Hygiene Education subject followed. Hygiene Education Programme was focused on Grade 6 schoolchildren because they are the most responsible children in the primary schools where the subject could effectively be received and disseminated to the lower grades. This programme was also carried out with the assistance of local and international NGO’s such as Bia Hula, World Vision, and AFMET. The JICA Study Team in cooperation with UNICEF prepared resource materials to effectively carry out the project.



Major Water Supply Facilities



River Section

Cross Section of Infiltration Gallery Facility

JICA	*The Study onUrgent Improvement Project for the Water Supply System in East Timor*	Figure
Construction of the Infiltration Gallery and Transmission Main in Manatuto		**2.2**

2.2 Formulations and Selection of Urgent Grant-Aid Projects

Above-mentioned Quick Projects were implemented within the Study in order to urgently restore water supply and create temporary employment. For the purpose of large-scale reconstructions of the facilities, the Study Team formulated and proposed 5 urgent grant-aid projects to UNTAET in March 2000. The list of the projects is shown as Table 2.1. UNTAET requested the Government of Japan (GOJ) to support these Projects. Among the Projects, GOJ decided to implement the improvement of water supply facilities in Bemos basin of Dili system, which has the highest priority. Detailed design work of the project has already started since November 2000. The Project is scheduled to be completed in October 2002.

Table 2.1 Short-List of Urgent Grant Aid Projects for Water Supply Sector

Project	Rational	Activities	Relation to Urgent plan	Location	Cost
1. Dili City Water Supply System Rehabilitation and Improvement	To rehabilitate and improve the water supply system so as to supply Dili citizens hygienically safe water continuously	Rehabilitate and improve the intake facility, transmission pipe and water treatment plant	Rehabilitate and dig wells to increase the amount of water as part of water resource research	Dili City	JPY 1,100 million (US$10 million)
2. Leakage Control and Meter Installation	To reduce a) ineffective water and b) stolen water	•Dispatch water leakage expert. •Supply water meters and tools	Implement leakage control project as QP in Dili	15 cities	JPY 300 million (US$ 2.7 million)
3. Rehabilitation and Improvement of the Water Supply System in 6 Cities	To rehabilitate and improve the water supply system so as to supply citizens hygienically safe water continuously	•Rehabilitate intake facilities, transmission pipes and water treatment plants •Rehabilitate and establish flocculation basin and filter basin.	Work out a urgent plan for 2003	6 cities (Manatuto, Liqica, Gleno, Ainaro, Same, and Suai)	JPY 1.300 million (US$ 12 million)
4. Establishment of Customers Registration and Tariff Invoice System	To recover cost of water supply from users and to control water demand	•Dispatch expert •Produce customers' list •Produce tariff invoice software •Supply computers and plotters	Implement the water quality analysis in 15 cities	Dili	JPY 2 million (US$ 1.8 million)
5. Establishment of Water Quality Control Center and Workshop	To enable regulate analysis equipment To create a workshop	•Supply water quality analysis equipment •Supply tools and equipment •Dispatch expert •Construct water quality control center and workshop	Build GIS data base of Dili	All Country (Center and workshop are constructed in Dili)	JPY 5 million (US$ 4.5 million)

CHAPTER 3 NATURAL AND DEMOGRAPHIC FEATURES

3.1 PHYSIOGRAPHY

Timor Island is one of the many islands in the South Pacific, which is about 400 km north of the Australian Continent. East Timor is the eastern half of Timor Island with an area of about 8500 km^2 and is located between latitude 8^o and 9^o 30' south and between longitude 124^o and 127^o 30' east.

The whole Timor Island is dominantly an agglomeration of mountains and valleys, which is geologically unstable. The continuous massive movement of the Australian tectonic plate beneath the Asian plate basically creates this geological feature. Geologically speaking, the emergence of the island is considered as a very new event, which occurred somewhere between 8 million to 10 million years ago. The island is still in the process of rising from the seabed. It lies in the northeast to southwest direction with length of approximately 500 km and 100 km width. The topography of the island is generally mountainous characterized by rugged terrain and small narrow valleys. A chain of mountains runs through the island, providing watershed from north to south. The Rameleu Mountain Range extending from west to east has an altitude of over 2000m with the highest peak, Tata Mailau at an altitude of 2,963m. Towards the east, south of the town of Laga in Baucau District there is another cluster of high mountains called the Mate-bian Mountain Range.

In the north, uplifted coral reef stretches along the coast, which shows typical karstic topography. Coral reefs are seen to develop along the shores of Dili and Manatuto and most of the eastern half of the island. The easternmost part of the island is rather flat due to the existence of limestone plateaus. On the plateau northeast of Los Palos there exists a large lake called Ira Lalaro. Alluvial flat plains exist only in small scale, typically in the southern coastal areas along the rivers flowing in the Timor Sea.

The rare alluvial flat lands in East Timor are dominantly used as residential areas and rice paddies. Flat areas on the limestone plateau are largely grass land and used for pastures. The emergence of people living in mountain and hill slopes has brought to the destruction of the forest cover and other vegetation. As a result, most of these slopes had been converted into farms and grasslands with only sporadic growth of tall trees. Soils on these slopes are lateritic due to poor vegetation and strong weathering under tropical climate. When it rains, surface runoff gets the river water quickly cloudy due to soil erosion coming from the deforested slopes. Dense forests are rarely observed. In high mountains of altitude more than 1500m, coniferous trees are dominant.

3.2 CLIMATE

The rainfall intensity and duration in East Timor varies from place to place. Although the Study Team could not get a long-term record that includes the latest observations, the collected information so far as presented in **Table 3.1** includes data from 14 observation points established during the Portuguese Period. The rainfall data recorded from 1952 to

1974 are presented in the table according to their geographical locations such as north coast (Stations 1-3), highlands (Stations 4-12), and south coast (Stations 13-14).

Based on **Table 3.1**, the climate in East Timor is characterized by intense monsoon rain followed by a pronounced dry season. The rainfall in Timor is mainly due to the north west monsoon coming from South China Sea, while the dry southeast trade winds is coming from the Australian Continent. The north coast of the island has a limited rainy season, which starts from December to March; the south coast has a longer rainy period from December through June. The highlands region is dominated by high intensity rainfall mostly over 1500mm yearly that rapidly feeds torrential floods cascading down into meandering rivers and finally into the sea. The rainy season in this mountainous region usually start a bit earlier in November to April for the mid-west up until July for the mid-east region.

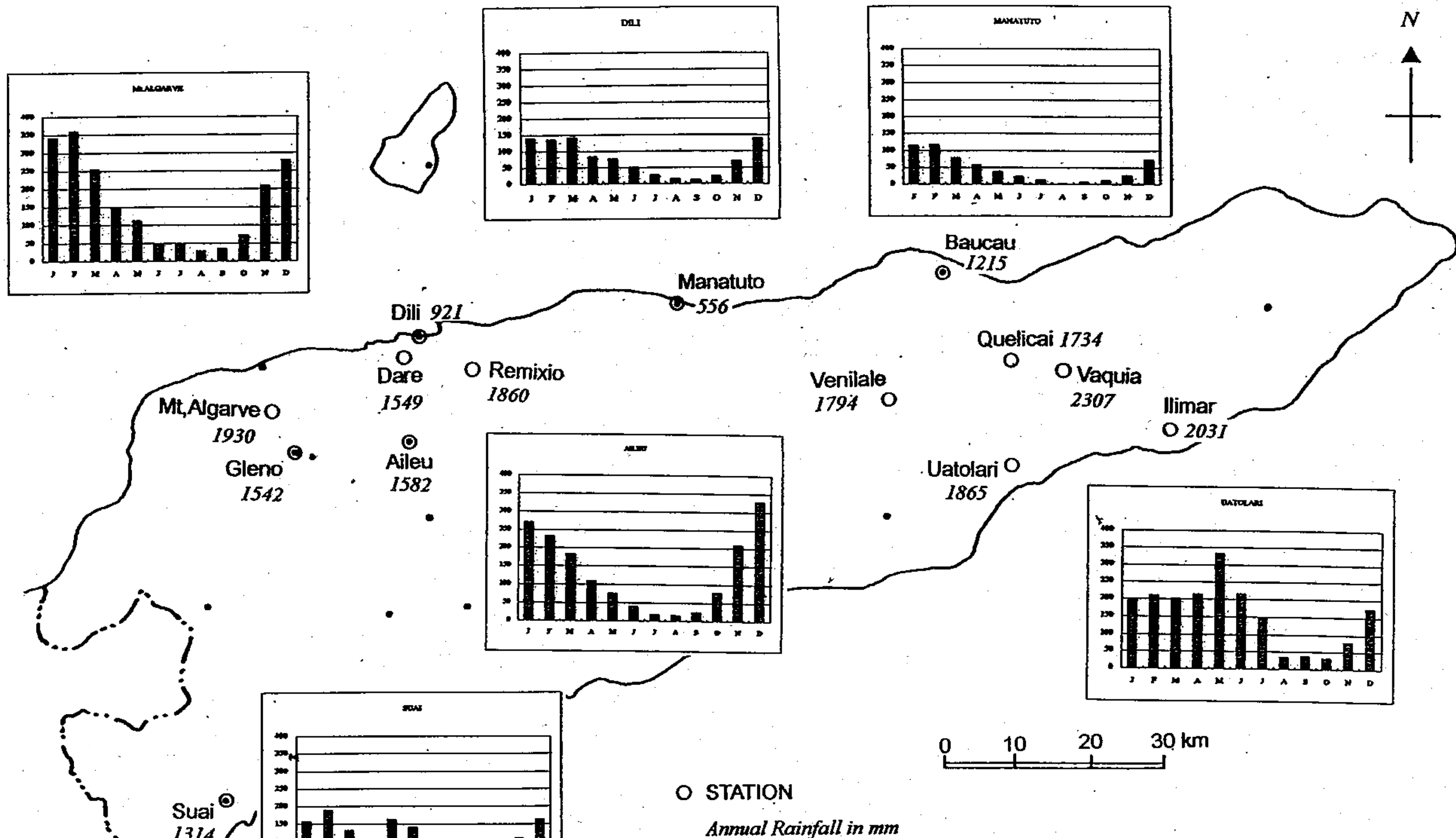
In general, East Timor has an average yearly precipitation of about 1,600mm. August is the driest month with an average mean monthly rainfall of 20mm, while January has the highest precipitation at an average of 243mm.

From among the 14 observation points, Manatuto located in the north coast recorded the lowest mean monthly rainfall of 1mm during the month of August. It is also the driest town with a total yearly rainfall of about 560mm for the observation period between 1957-1974. Mt. Algarve situated in the mid-west recorded the highest mean monthly precipitation of about 341mm during the month of February. The highest total yearly precipitation in East Timor of about 2,397mm recorded between 1957-1974 occurred in Vaquia, which is located in the mid-east region.

Table 3.1 MEAN MONTHLY RAINFALL IN EAST TIMOR FOR PERIOD 1952-1974 (mm)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Max	Min
1. Dili	140	136	141	83	77	52	27	16	11	24	72	141	920	141	11
2. Manatuto	116	118	78	58	38	22	12	***1***	6	11	26	74	560	118	1
3. Baucau	261	272	200	142	83	35	15	4	18	9	89	204	1,332	272	4
4. Mt. Algarve	341	***359***	254	150	112	47	45	28	35	71	208	280	1,930	359	28
5. Gleno	255	242	230	132	92	53	28	21	17	56	157	259	1,542	259	17
6. Dare	263	279	255	125	95	62	28	17	13	42	126	245	1,550	279	13
7. Aileu	271	232	183	109	75	40	18	15	24	79	208	328	1,582	328	15
8. Remexio	301	380	282	152	122	59	41	20	20	54	154	274	1,859	380	20
9. Venilale	312	345	322	130	112	68	42	8	16	20	151	300	1,826	345	8
10. Quelicai	281	248	302	187	152	74	32	11	20	34	144	258	1,743	302	11
11. Vaquia	308	290	295	250	393	244	154	38	42	24	108	251	***2,397***	393	24
12. Iliomar	198	189	181	254	439	297	160	40	28	20	90	146	2,042	439	20
13. Suai	157	190	132	88	162	140	80	30	27	42	110	163	1321	190	27
14. Uatolali	193	210	201	214	332	216	145	35	37	30	79	174	1866	332	30
Average	243	249	218	148	163	101	59	20	22	37	123	221	***1605***	296	16
Max.	341	380	322	254	439	297	160	40	42	79	208	328	2397	439	30
Min.	116	118	78	58	38	22	12	1	6	9	26	74	560	118	1

Figure 3.1 is the Locations of the Rainfall Gauging Stations and **Figure 3.2** is the Isohyetal Map of East Timor.

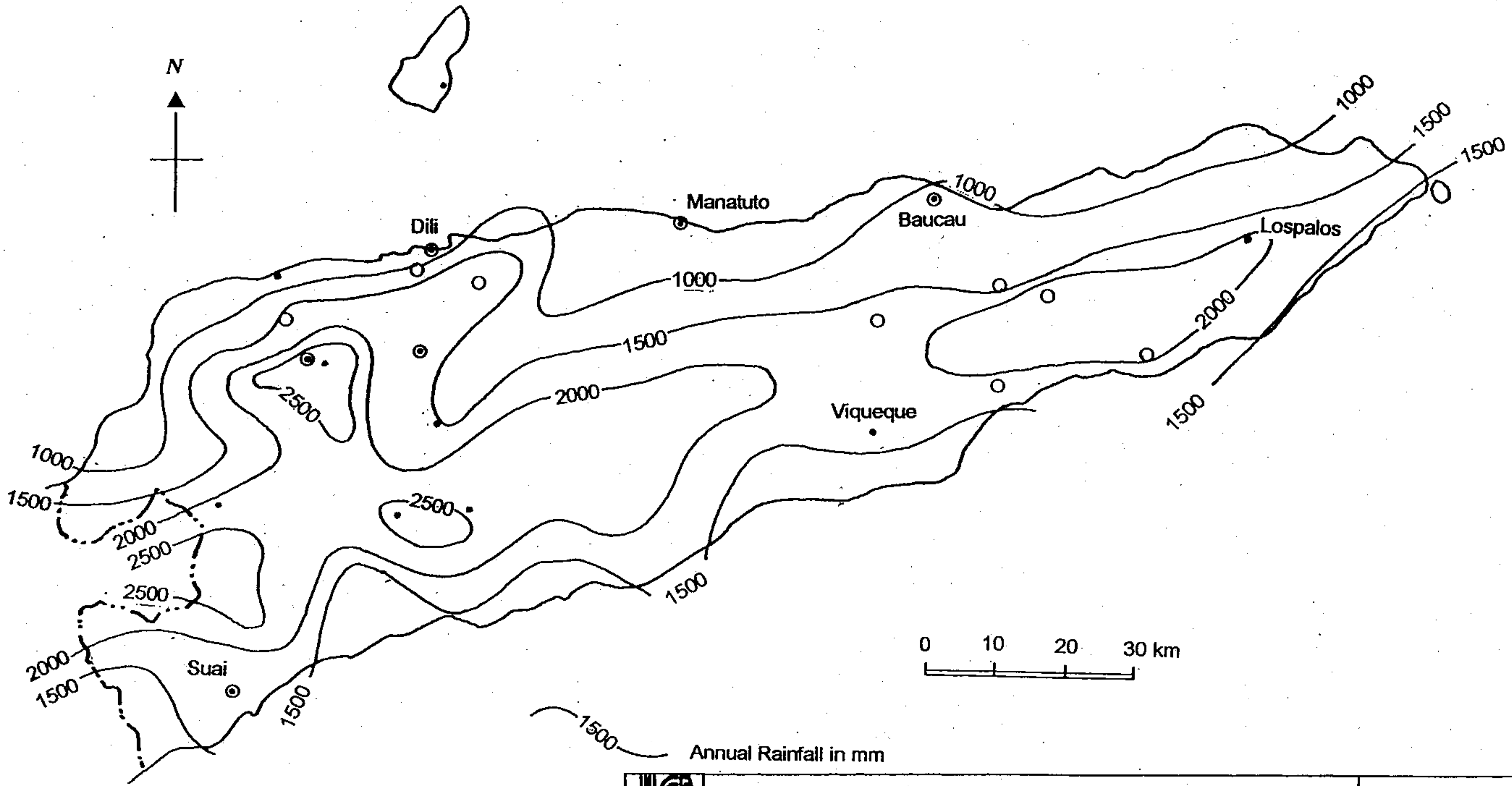


JICA

The Study on Urgent Improvement Project for the Water Supply System in East Timor

Figure 3.1

RAINFALL GAUGE STATIONS AND MONTHLY RAINFALL



The source: Study Reconnaissance Pengembangan sumber - sumber air wilayah, S.Comoro, S.Maloa, S.Bemori, & S.Santana (1986)

The Study on Urgent Improvement Project for the Water Supply System in East Timor	**Figure**
ISOHYETAL MAP IN EAST TIMOR	**3.2**

The temperature in East Timor can also be classified as variable from place to place although, this observation is based on actual experience rather than recorded data. The available records from 5 weather stations other than Dili are inconclusive since these were recorded only for one-year observation period in 1997.

Generally, the highlands region exhibits a much lower temperature than the coastal region. Dili, which is located along the northern coast of East Timor, has an average annual temperature of about 26.1^{o}C. August is the coolest month of the year with a mean monthly temperature of 24.3^{o}C. November & December recorded the warmest temperature of 27^{o}C. **Table 3.2** below shows the available information on temperature that the Study Team obtained. This temperature data is graphed in **Figure 3.3** to show the monthly temperature fluctuations from the 6 observation points.

Table 3.2 MEAN MONTHLY TEMPERATURE (in ^{o}C)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave
Dili: 1953-1983	27.1	26.9	26.8	26.6	26.3	25.4	24.5	24.3	24.8	26.2	27.4	27.4	26.1
Dili Airport: 1997	27.3	26.8	27.4	27.7	27.3	26.6	25.8	25.2	25.2	26.8	28.1	28.2	26.9
Comoro: 1997	27.2	26.8	27.0	27.4	26.8	26.5	25.8	25.1	25.5	27.0	28.3	28.7	26.8
Baucau Airport: 1997	23.6	23.4	23.9	24.1	23.6	-	-	-	-	-	-	-	-
Viqueque Naeboro: 1997	27.4	27.2	27.3	26.6	26.1	25.0	23.5	23.4	24.9	27.2	29.0	28.6	26.6
Pante Makasar: 1997	27.8	26.9	27.2	29.8	28.3	28.1	27.7	26.8	26.9	27.8	29.3	28.9	28.0

3.3 GEOLOGY

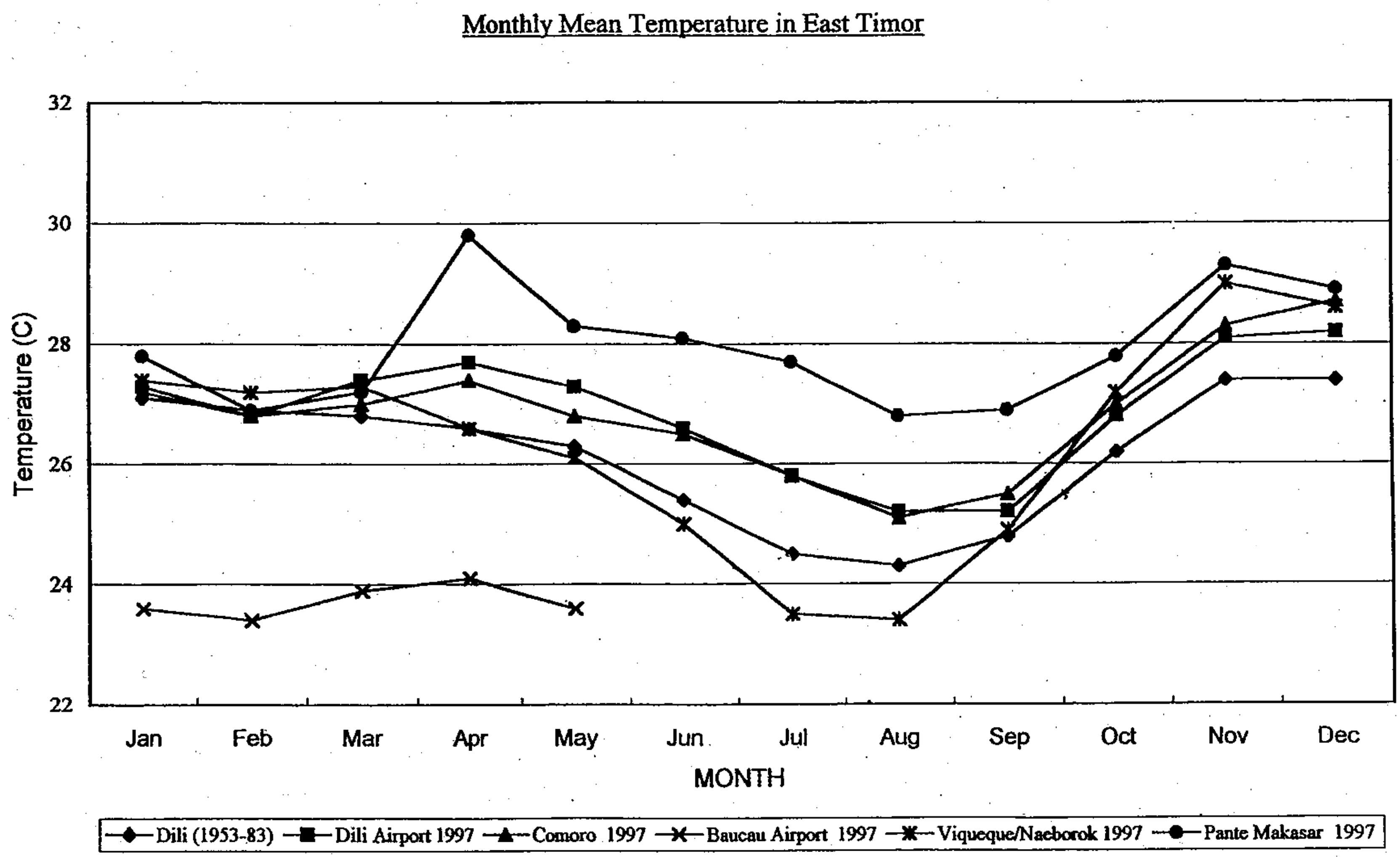
This geology report was compiled based on the following sources and some other available books and reports made on the study area and confirmed through brief field observations by the Study Team.

a.) "Geological Map of Baucau Quadrangle, Timor Timur"
b.) "Geological Map of the Dili Sheet, East Timor"

The Timor Island is part of the Bunda Island Arc System. As described in the previous section, the island is young and active since its emergence. However, unlike many other islands in the Indonesian Territory, the Timor Island has no active volcanoes. Although, large-scale volcanic rocks are deposited in the nearby Atauro Island, which seems to be part of the Sunda Island Arc System.

The presence of abundant limestone formation of various ages as well as the absence of volcanic rocks geologically characterizes East Timor. In addition to the typical reef limestone widely found in Baucau and Los Palos, other formations also contain calcareous rocks of different types.

The dominant orientation of geological structures such as dip-strike beds, folding or anti-cynical and syn-cynical axes has a northeast-east to southwest-west boundary on the different formations. The oldest geological unit is the Lolotoi complex of pre-Permian age (more than 300 million years ago). This complex is distributed mainly in the mid-western part of East Timor around the town of Maubisse and the surrounding mountains. It is composed of metamorphic rocks of volcanic and sedimentary origin. Other old rocks of Permian and early Mesozoic age are also largely distributed in the mid-west. These



The Study onUrgent Improvement Project for the Water Supply System in East Timor

MONTHLY MEAN TEMPERATURE

Figure 3.3

rocks belong to the Maubisse formation of Permian age, Aileu formation of Jurassic to Permian age and the Aitutu formation of Triassic age. In areas around the nation's capital Dili, the Aileu formation is widely distributed. These rocks are metamorphosed sandstone and slate, mica schist and amphibolite. Tight folding and faulting are widespread throughout the formation.

In the eastern half of East Timor, the Bobonaro formation of late Tertiary to Quaternary is widely deposited overlying various formations of older ages. It is composed of sedimentary rocks with scaly matrix and boulder size fragments.

Unconsolidated Quaternary alluvial sediments develop in the southwestern coastal region, where many rivers flowing into the Timor Sea form coastal flat plains. On the other hand, reef limestone of Pleistocene to Recent age form coastal terraces in the northeastern coastal region. Quaternary alluvial sediments are also found sporadically inland. These sediments usually form terraces and their distribution is limited to a small area.

The above-mentioned geological maps that the Study Team obtained do not cover Atauro Island, which is located about 20 kilometers north of Dili. The geological information discussed for Atauro are based on field observation by the Study Team since no written geological reports were available during the study.

In the southern part of Atauro Island, a large deposit of unmetamorphosed volcaniclastic rocks can be found. These rocks are sand-grain size intermediate to acidic tuff with many boulders of gray intermediate volcanic rocks in some parts. Since there is no basis to correlate this formation with that of the main Timor Island, the Study Team calls it the "Atauro formation" for the purpose of the study. Moreover, reef limestone that form coastal terraces develop in the coastal zone of the island.

Table 3.3 summarizes the geological sequences and the general description of each formation.

Table 3.3 SUMMARY ON GEOLOGICAL REPORT OF EAST TIMOR

	Age	Thickness (m)	Formation	Description
Quaternary	Holocene to Pleistocene	600	Recent limestone (uplifted)	Reef limestone, contains many fossils of coral and shellfish.
			Suai	Loose sediment, clay to gravel in size.
		100	Baucau	Reef limestone, calcarenite, calcludite. Contains many fossils of coral and shellfish.
Tertiary	Pliocene	300	Dilor	Conglomerates and sandstone, poorly sorted, containing fragments of Lolotoi formation
		70	Laliguti	Calcarenite and reef limestone, abundant fossils.
	Miocene	800	Viqueque	Marly conglomerate, thinly bedded claystone with intercalation of chalky limestone.
		50	Aliambata	Limestone, poorly bedded.
		600	Cablaci	Clastic limestone, generally crystalline, fine to coarse grained, white to gray or pinkish gray; thickly bedded to massive.
	Oligocene	300	Balique	Volcaniclastic rocks, basaltic tuff containing limestone fragments. Volcanic usually altered.
	Eocene	100	Dartollu	Thickly bedded biocalcarenite
Mesozoic	Cretaceous	200	Borolalo	Thickly bedded or massive limestone and calcareous shale with occasional chert module.
		500	Waibua	Radiolarian shale, bedded chert, calcarenite and calciludite. Manganese deposit found in the chert.
	Jurassic	1,000	Wailuli	Sandstone, shale, siltstone, limestone, marlstone, thin layers of conglomerate in the upper part.
	Triassic	1,000	Aitutu	Well-bedded calciludite, locally alternating with marl or calcareous shale or calcarenite; anti-cynical structure.
Paleozoic	Permian	900	Maubisse	Bedded biocalcarenite and reef limestone, small amount of marl and tuff layers; abundant fossils.
		600	Atahoc	Well-laminated black shale and basaltic rocks with intercalation of thin layers of sandstone and limestone.
		1,000	Aileu	Phyllite, schist, amphybolite, slate, meta-sandstone, with intercalation of thin limestone beds; generally loosely folded deformation prevails in some parts.
	Pre-Permian	1,300	Lolotoi complex	Phyllite, schist and gneiss of sedimentary rock and gabbro to dolorite origin; strongly folded and fractured.

3.4 POPULATION

Historically, Timorese people live in small settlements often in specific areas where available resources can be exploited. This demograhic characteristic of the people is basically due to the rugged and erosion-prone terrain associated with varying rainfall. In most cases, the build-up of populations in large settlements is dominantly located along the coast and in plain areas where resources can easily be exploited. However, local settlements have move from one place to another periodically over long periods possibly due to the unstable condition in the island.

In the aftermath of the result for the 30 August 1999 referendum in East Timor more than 75% of the population was displaced by the widespread destruction to the physical infrastructure and violence to most of the residents. East Timorese had escaped to safer places in fear of their personal safety. With the situation coming to a controlled and stable condition, the displaced residents are coming back to their original domicile where basic infrastructure and utilities are restored. To some extent, the current administration (UNTAET) with the help of NGO's and other concerned organizations are diligently monitoring the movement of the residents in order to maintain a statistical record of the population in East Timor.

Current estimated figures provided by UNOCHA are per district, sub-district and village level. The figures listed may vary from time to time depending on the movement of the East Timorese, the rate of returnees, which are more often subject to the progress of the reconstruction on physical infrastructure and rehabilitation of basic utilities.

3.4.1 District and Sub-district Population

The available population statistics in East Timor are incomplete and inconclusive since all the people who were displaced or voluntarily went into exile for fear of their lives have not returned to their original domicile. However, for purposes of the study the demographic data obtained from UNOCHA was used in estimating the *kota* (town/city)-base population.

The population enumeration carried out during the last referendum is given on the basis of *kabupaten* (district), *kecamatan* (sub-district) and *desa* (village) levels. These pre-referendum data was used as basis in the analysis of the population. Since then, a series of population enumeration and statistical assumptions by sampling method were conducted in some districts by the agencies concerned.

As seen in **Table 3.4**, the national population has decreased by 24% from 901,686 in 1998 to 687,572 in November 1999. The decrease in population has taken place in all districts of East Timor except Viqueque. Covalima District experienced a sharp population drop by 80% caused by the post-referendum violence. The behavior of the present population although increasing in most districts is still uncertain to project a relatively accurate figure.

Table 3.4 POPULATION OF EAST TIMOR

District	Sub-district	Year 1998		November 1999	Growth Rate (%)	Year 2000	
		Household	Population			Population	Household
Dili	***Dili Barat***	***14,947***	***85,439***	***72,618***	***– 15***	-	-
	Dili Timur	***10,002***	***60,182***	***45,911***	***– 24***	-	-
	Atauro	***1,502***	***7,387***	***7,750***	***5***	***7,902***	-
	Metinaro	805	3,480	2,260	– 35	2,091	627
District Total		27,256	156,488	128,539	– 18	-	-
Manatuto	***Manatuto***	***2,545***	***12,759***	***9,223***	***– 28***	***9,173***	***2,193***
	Natarbora	1,098	5,573	5,050	– 9	5,047	1,263
	Laclo	1,330	5,345	6,028	13	6,072	1,393
	Laclubar	1,851	10,404	9,296	– 11	10,073	2,187
	Laleia	714	3,011	3,290	9	3,290	832
	Soibada	467	2,582	2,955	14	2,796	529
District Total		8,005	39,674	35,842	– 10	36,451	8,397
Baucau	***Baucau***	***2,715***	***12,910***	***9,000***	***– 30***	-	-
	Baguia	5,569	29,582	8,123	– 73	-	-
	Laga	2,725	12,675	13,031	3	-	-
	Quelicai	3,155	16,205	9,014	– 44	-	-
	Vemasse	1,483	7,225	6,816	– 6	-	-
	Venilale	3,059	14,954	17,517	17	-	-
District Total		18,706	93,551	63,501	– 32	-	-
Viqueque	***Viqueque***	***3,831***	***20,440***	***20,559***	***1***	***19,534***	***4,022***
	Lacluta	1,226	6,722	6,598	– 2	5,041	1,055
	Ossu	3,429	15,982	15,982	0	18,104	3,831
	Uato-Carbau	3,043	15,457	6,186	– 60	6,729	1,279
	Uato -Lari	1,120	6,026	15,582	159	17,244	3,409
District Total		12,649	64,627	64,907	0	66,652	13,596
Lautem	***Los Palos***	***5,734***	***24,739***	***20,924***	***– 15***	***22,199***	***5,048***
	Fuiloro	2,692	14,000	14,215	2	-	-
	Iliomar	1,328	6,476	6,683	3	-	-
	Lautem/Moro	2,630	12,127	13,758	13	-	-
	Luro	1,210	5,915	6,296	6	-	-
	Tutuala	640	3,230	3,216	0	-	-
District Total		14,234	66,487	65,092	– 2	-	-
Aileu	***Aileu***	***2,609***	***13,103***	***14,078***	***7***	***13,150***	-
	Lau Lara	1,161	5,838	3,801	– 35	3,428	-
	Liquidoe	1,022	4,852	5,294	9	3,827	-
	Remexio	1,435	11,129	9,052	– 19	6,969	-
District Total		6,227	34,922	32,225	– 8	27,374	-
Ainaro	***Maubisse***	***3,201***	***16,841***	***7,060***	***– 58***	-	-
	Ainaro	***2,272***	***15,697***	***10,937***	***– 37***	***10,889***	-
	Hato Builico	1,865	9,827	11,000	12	-	-
	Hato Hudo	1,480	8,717	9,145	5	6,850	1,533
District Total		8,818	51,082	38,142	– 25	17,739	-
Manufahi	***Same***	***4,252***	***23,331***	***18,600***	***– 20***	***21,993***	***4,190***
	Alas	1,384	7,596	7,618	0	5,726	1,087
	Fatu Berliu	1,438	6,997	7,122	2	6,601	1,269
	Turiscai	1,030	5,495	5,604	2	-	-
District Total		8,104	43,419	38,944	– 10	34,320	6,546
	Ermera	***4,773***	***24,812***	***20,912***	***– 16***	-	-

Ermera	Atsabe	3,016	16,410	8,237	– 50	-	-
	Hatolia	5,493	24,750	22,050	– 11	-	-
	Letefoho	3,511	16,451	15,475	– 6	-	-
	Railaco	1,622	8,372	6,720	– 20	-	-
District Total		18,415	90,795	73,394	– 19	-	-
Liquica	***Liquica***	***3,240***	***19,055***	***17,636***	***– 7***	-	-
	Bazartete	3,644	18,919	14,532	– 23	-	-
	Maubara	3,444	17,606	6,435	– 63	-	-
District Total		10,328	55,580	38,603	– 31	-	-
Bobonaro	***Maliana***	***4,345***	***20,798***	***15,019***	***– 28***	***17,503***	-
	Atabae	1,832	10,451	5,990	– 43	5,990	-
	Balibo	2,297	14,240	4,983	– 65	5,521	-
	Bobonaro	4,967	26,069	21,578	– 17	22,126	-
	Kailako	1,540	8,204	7,847	– 4	8,143	-
	Lolotoi	1,469	7,171	7,433	4	7,433	-
District Total		16,450	86,933	62,850	– 28	66,716	-
Covalima	***Suai***	***3,956***	***18,505***	***3,189***	***– 83***	-	-
	Fatu Fulic	432	2,026	676	– 67	-	-
	Fatu Mean	703	3,772	87	– 98	-	-
	Fohorem	927	3,974	2,545	– 36	-	-
	Mape/Zumulai	4,773	25,579	4,174	– 84	-	-
	Tilomar	1,621	6,983	1,562	– 78	-	-
District Total		12,412	60,839	12,233	– 80	-	-
Oecussi	Nitibe	2,091	9,912	5,200	– 48	8,292	2,044
	Oe Silo	2,275	10,383	6,200	– 40	10,429	2,325
	P. Macassar	5,934	28,779	19,000	– 34	23,282	5,554
	Passabe	1,642	8,215	2,900	– 65	4,377	1,060
District Total		11,942	57,289	33,300	– 42	46,380	10,983
NATIONAL TOTAL		**173,546**	**901,686**	**687,572**	**– 24**	**-**	**-**
AVERAGE		**5.2**					

Source: UNOCHA

3.4.2 *Kota*-base Population

The Indonesian method of administrative boundaries still exists in East Timor, such as, *kabupaten* (district), *kecamatan* (sub-district) and *desa* (village). On the other hand, the *kota* (town/city) boundaries are not stable, changing endlessly in consistent with the expansion of the residential areas. This is the main reason why the *kota* boundary is hard to define. However, in order to estimate the population on a *kota*-base level, it is necessary to define *kota* and its boundary as follows:

- *Kota* is a densely populated urban area with relatively high density in comparison with surrounding suburban and rural areas.

- It is the center of administrative, commercial and industrial activities in the District/Sub-district.

- Infrastructure facilities such as transportation, power, water supply, health and education are relatively well developed.

- *Kota* area includes water supply service area and its adjacent populated area.

- Areas thus determined comply with the concept generally accepted by the local people.

Based on the above definition, the *kota*-base population was estimated for each town/city of the Study Area according to the below-mentioned steps.

The water supply service area, obtained from the current asset mapping survey was first superimposed on the topographical maps with a scale of 1:5000. Then, the adjacent populated areas were included and considered as part of the *kota*. In the topographical maps obtained from Mapping Distribution Office, *desa* boundaries are clearly shown. The comparison of the cross-section and the *desa* areas was made carefully in consideration with the length of main roads, size of institutional, commercial and residential areas contained therein. Based on these factors, the following ranks of congestion rate were determined for each *desa*.

- 30 % congestion
- 60 % congestion
- 90 % congestion

In case the entire administrative boundary of the *desa* concerned is clearly within or beyond the boundary of the presumed *kota* area, 0% or 100% are eventually considered as population congestion rate. *Kota* population was estimated multiplying this congestion rate with the 1998 *desa*-base population statistics. The estimated population as shown in **Table 3.5**, although not necessarily reflects the present situation, is considered as a key design factor for the present Study.

Table 3.5 URBAN POPULATION OF 15 TOWNS IN EAST TIMOR

No	Town	Sub-district Area (km2)	Population		Growth Rate (%)	1998 Town's Urban Population
			Pre-Violence	Post-Violence		
01	Dili	143.88	145,621	118,529	– 19%	145,620
02	Atauro (Vila)	151	7,387	7,750	5%	1,250
03	Manatuto	246	12,759	9,223	– 28%	5,420
04	Baucau	312.14	12,910	9,000	– 30%	5,910
05	Los Palos	592.5	24,739	20,924	– 15%	13,350
06	Viqueque	609.58	20,440	20,559	1%	7,210
07	Same	407.25	23,331	18,600	– 20%	10,840
08	Ainaro	233.1	15,697	10,937	– 30%	4,470
09	Aileu	245.8	13,103	14,078	7 %	3,650
10	Maubisse	205.7	16,841	7,060	– 58%	2,510
11	Gleno	114.41	24,812	20,912	– 16%	6,000
12	Ermera	-	-	-	-	3,970
13	Liquica	91	19,055	17,636	– 7%	11,600
14	Suai	421.73	18,505	3,189	– 83%	10,840
15	Maliana	201.88	20,798	15,019	– 28%	8,910
TOTAL		**3,976.0**	**375,998**	**334,136**	**– 23%**	**241,550**

CHAPTER 4 SERVED POPULATION AND WATER DEMAND

4.1 POPULATION CHARACTERISTICS AND LIVING CONDITIONS

The household survey (refer to Appendix I) was conducted in order to supplement and confirm the available information collected from UNTAET officials and local resource persons (former BPAM staff and field survey aids). Valuable information on the population and their characteristics, income, economic, social and other technical parameters are among the main indicators in planning for the water supply system. The recent political upheaval that had caused massive destruction on the infrastructure and the people's lives has been taken into consideration. The survey questionnaires were patterned to suit the turn of events in the East Timor history. Nevertheless, the survey was carried in order to determine the following:

- the knowledge and awareness of the people regarding water supply and sanitation.
- the coverage and condition of service of the municipal water supply system in the pre-violence and post-violence period.
- the effect of the damage caused by the post-referendum violence on the living condition of the people.
- the economic situation and the consumers ability to pay for the water supply service based on their understanding of the issues, such as:

  a) availability of safe and potable water supply
  b) the existing conditions of the water supply system
  c) the efficient and sustainable operation and maintenance of a water supply system
  d) water usage and conservation
  e) health and hygiene issues
  f) sanitary facilities
  g) awareness on the cause and effect of water-borne diseases
  h) household income
  i) economic viability

In order to meet the above-mentioned objectives the questionnaire survey forms was developed containing several response options. From a wide-range of issues such as population, water supply and other infrastructure facilities, economy, etc., the survey also include questions that are related to the service coverage of the existing water supply system. The absence of an established data on the service area necessitates actual field survey on the service population in order to get a more realistic master plan of the water supply system. A computation of the service coverage is similarly done in the succeeding sections based on assumptions and information given by former BPAM staff and concerned officials. This system of check and balance will give a more realistic data.

The survey was carried out on the households spread around the urban area of the 15 towns that comprise the Study Area. A total of 452 respondents were interviewed and 429 effective data were collected and analyzed. In general, the findings of the survey indicate the characteristics and living condition of the population to include as follows:

a.) Population Characteristics

Main Source of Income	:	50% derived from agriculture and private business
Average Monthly Income		
Pre-violence	:	Majority of the respondents (or 40%) receive more than Rp500,000 while 26% receive less than Rp50,000
Post-violence	:	17% receives more than Rp500,000 and 40% receive less than Rp50,000
Religion	:	More than 95% of the respondents are Catholic

b.) Household and Facilities Before the Post-Referendum Violence

Average Household Size	:	8.6 members per household
Type of House	:	55% permanent; 29% semi-permanent; 16% temporary
House Ownership	:	2 or more families share one house (or 95% of the respondents live in a house not their own)
Housing Condition	:	73% damaged by violence (30% non-livable) and 27% not affected
Water Facilities	:	51% piped water; 34% shallow wells; 2% deep wells; 13% from other sources
Type of Service Connection	:	76% non-metered; 24% metered
Water Service Performance	:	36% enjoys 24-hr water supply; 62% with occasional water supply interruptions; 2% no water supply at all
Average Water Bill	:	Rp7,000 per month
Willingness to Pay	:	93% of the respondents
Average Electricity Bill	:	Rp17,000 per month
Sewage Disposal	:	7% by town's sewerage facilities; 31% by individual septic tank; 60% by pit latrine; 2% by other method
Health and Sanitation	:	More than 97% awareness
Occurrence of Diseases	:	79% malaria; 58% Skin infection; 52% Diarrhea; etc.

4.2 SERVED POPULATION IN 1998

The number of individual household connections and public taps are available from the current field survey and interviews with the officials and personnel concerned. Service population in each *Kota* (town/city) is estimated using the following assumptions.

- Each public tap in operation serves 200 people.
- Each service connection is serving 6 people in every household (to be confirmed by the result of the on-going Household Survey).

Using the above assumptions, the served population in 15 towns (Study Area) is estimated at 118,518. This figure is about 49% from the total 241,543 urban population. As discussed previously, which is well consistent with the figures envisaged in the relevant reports.

Table 4.1 shows that the service coverage for each *kota* varies from 13% in Ermera to 97% in Manatuto and Baucau. This condition is evident in the congestion rate. In areas where people has alternative water sources available other than the public water supply, the service coverage rate is low. These conditions are noted in Same (39%) and Ermera (13%). In the case of Los Palos (32%), Liquica (35%) and Atauro (24%), people are reluctant to connect to the water supply system due to poor service such that frequent water rationing is practiced. The service coverage rate in Dili (46%) is close to the national average of 49%.

The estimated service coverage of the water supply system refers to the situation before the post-referendum violence & does not reflect the current circumstances. Considering the current condition of the water supply facilities and the kind of water service that each system is providing to the water consumers it can easily be assumed that the present service coverage rates are far lower than the pre-referendum figures. The findings of the household survey on the service coverage of the piped water supply system in 15 towns averages at 51%.

Table 4.1 SERVED POPULATION OF THE TOWN'S WATER SUPPLY SYSTEM IN 1998

No.	Town	1998 Town's Urban Population	Population Served	Coverage Ratio
01	Dili	145,620	67,000	46%
02	Atauro (Vila)	2,500	600	24%
03	Manatuto	5,420	5,250	97%
04	Baucau	5,910	5,765	97%
05	Los Palos	13,350	4,320	32%
06	Viqueque	7,210	4,455	62%
07	Same	10,840	4,200	39%
08	Ainaro	4,470	2,820	63%
09	Aileu	3,650	3,500	96%
10	Maubisse	2,510	1,200	48%
11	Gleno	6,000	4,380	73%
12	Ermera	3,970	530	13%
13	Liquica	11,600	4,040	35%
14	Suai	10,840	5,360	49%
15	Maliana	8,910	5,410	61%
TOTAL		**241,550**	**118,830**	**49%**

4.3 POPULATION GROWTH AND SERVICE COVERAGE ESTIMATES

The present plan intends to formulate scope, method and implementation schedule of the rehabilitation on the existing water supply systems urgently required up to the year 2003. In formulating the plan, population is one of the key design factors. For the planning period, it is estimated that the population in East Timor will increase by approximately 10-15%. This estimate is rather high compared to some developing countries. However, under the present circumstances the increase is assumed to be the more realistic scenario. East Timor is a special case where factors and the recent political events have to be considered. Many people had fled overseas for fear of their lives. They had completely lost their bases during the violence causing a substantial drop in population of about 30-80% in most areas.

Although many unforeseen factors are considered in the coming next 3 years (up to the year 2003), population growth in the areas will continue in a relatively high growth rate, depending largely on a number of returnees from overseas, progress of housing projects and an increase of employment opportunity. It seems more appropriate to utilize the 1998 population statistics before referendum rather than the 2000 population as base population for projection. In many areas, it is assumed that population will return to the 1998 level in a relatively short period, and will increase gradually thereafter with the annual average growth rate 3.0%.

In Atauro, Viqueque and Aileu sub-districts, however, the present population exceeds the 1998 population. Such an increase in population may be caused by immigrants from other towns/cities on living on temporary status. These immigrants, sooner or later, will return to their original domicile, resulting to some changes in population count. Therefore, a rather lower growth rate of 2.5% is assumed for these towns.

The projection for the service population in 2003 is also based on the 1998 coverage ratio. In setting the target coverage ratio, it is assumed that broken and damaged service connections caused by the post referendum turmoils, will be extensively repaired. There are still many people in the present service area who are reluctant to receive piped water due to some factors such as unacceptable water quality and unreliable water supply service. With the proposed improvement and rehabilitation plan of the existing water supply system, the service coverage ratio will substantially increase in many areas. Thus, expansion to the service area is expected in the next 3 years and onwards. The 2003 coverage ratio is assumed for each of the town covered in the study area.

Table 4.2 POPULATION ESTIMATE AND SERVICE COVERAGE RATIO

City/Town	1998*			2003			2010		
	Population Estimate	% Served	Served Pop	Population Estimate	% Served	Served Pop	Population Estimate	% Served	Served Pop
Dili	145,620	46	67,000	159,100	70	111,400	195,700	80	156,600
Atauro (Vila + Beloi)	2,500	24	600	2,700	50	1,400	3,200	70	2,200
Manatuto	5,420	97	5,250	5,900	100	5,900	7,300	100	7,300
Baucau	5,910	97	5,760	6,500	100	6,500	7,900	100	7,900
Los Palos	13,350	32	4,320	14,600	50	7,300	17,900	70	12,500
Viqueque	7,250	62	4,450	7,800	90	7,000	9,300	100	9,300
Same	10,840	39	4,200	11,800	50	5,900	14,600	70	10,200
Ainaro	4,470	63	2,820	4,900	90	4,400	6,000	100	6,000
Aileu	3,920	96	3,500	4,200	100	4,200	5,000	100	6,000
Maubisse	2,510	48	1,200	2,700	70	1,900	3,400	80	2,700
Gleno	6,000	73	4,380	6,600	90	5,900	8,100	100	8,100
Ermera	3,970	13	530	4,300	50	2,200	5,300	70	3,700
Liquica	11,600	35	4,040	12,700	70	8,900	15,600	80	12,500
Suai	10,840	49	5,360	11,800	70	8,300	14,600	80	11,700
Maliana	8,910	61	5,410	9,700	90	8,700	12,000	100	12,000
TOTAL	243,110	49	118,820	265,300	72	189,900	325,900	82	267,700

** For the purpose of projection the 1998 population is assumed to be equal the 2000 population. figures for the 1998 population of Atauro, Viqueque and Aileu are estimated values.*

It is estimated that the service coverage will increase in 2003 to an average of 72% in the 15 towns. The estimated figures for 2010 are merely for reference purposes. To provide base for forecasting water demand, the estimated service population was further categorized into two; population supplied via individual connections and community population via public taps. In the estimation, it is assumed that all malfunctioning public taps are repaired by the year 2003.

Table3.3 SERVICE POPULATION BASED ON TYPE OF CONNECTION

City/Town	Type of Connection	Number of Connections			Service Population		
		1998	2003	2010	1998	2003	2010
Dili	Individual	11,000	17,487	24,800	66,000	104,920	148,800
	Public Tap	5	54	65	1,000	6,480	7,800
	Total	-	-	-	67,000	111,400	156,600
Atauro (Vila + Beloi)	Individual	50	193	287	600	1,160	1,720
	Public Tap	0	2	4	0	240	480
	Total	-	-	-	600	1,400	2,200
Manatuto	Individual	875	883	1,097	5,250	5,300	6,580
	Public Tap	0	10	12	0	600	720
	Total	-	-	-	5,250	5,900	7,300
Baucau	Individual	927	933	1,137	5,560	5,600	6,820
	Public Tap	1	15	18	200	900	1,080
	Total	-	-	-	5,760	6,500	7,900
Los Palos	Individual	720	1,057	1,883	4,320	6,340	11,300
	Public Tap	0	8	10	0	960	1,200
	Total	-	-	-	4,320	7,300	12,500
Viqueque	Individual	609	967	1,310	3,650	5,800	7,860
	Public Tap	4	10	12	800	1,200	1,440
	Total	-	-	-	4,450	7,000	9,300
Same	Individual	600	863	1,560	3,600	5,180	9,360
	Public Tap	3	6	7	600	720	840
	Total	-	-	-	4,200	5,900	10,200
Ainaro	Individual	470	533	760	2,820	3,200	4,560
	Public Tap	0	20	24	0	1,200	1,440
	Total	-	-	-	2,820	4,400	6,000
Aileu	Individual	583	660	783	3,500	3,960	4,700
	Public Tap	0	4	5	0	240	300
	Total	-	-	-	3,500	4,200	5,000
Maubisse	Individual	200	217	330	1,200	1,300	1,980
	Public Tap	0	5	6	0	600	720
	Total	-	-	-	1,200	1,900	2,700
Gleno	Individual	730	743	1,070	4,380	4,460	6,420
	Public Tap	0	12	14	0	1,440	1,680
	Total	-	-	-	4,380	5,900	8,100
Ermera	Individual	88	267	497	530	1,600	2,980
	Public Tap	0	5	6	0	600	720
	Total	-	-	-	530	2,200	3,700
Liquica	Individual	640	1,223	1,763	3,840	7,340	10,580
	Public Tap	1	13	16	200	1,560	1,920
	Total	-	-	-	4,040	8,900	12,500
Suai	Individual	360	983	1,470	5,360	5,900	8,820
	Public Tap	0	20	24	0	2,400	2,880
	Total	-	-	-	5,360	8,300	11,700
	Individual	901	1,350	1,880	5,410	8,100	11,280

Maliana	Public Tap	0	5	6	0	600	720
	Total	-	-	-	5,410	8,700	12,000
TOTAL	Individual	18,753	28,360	40,627	116,020	170,160	243,760
	Public Tap	14	189	229	2,800	19,740	23,940
	Total	-	-	-	118,820	189,900	267,700

4.4 WATER DEMAND FORECAST

Water demand is estimated multiplying unit water consumption and design population. The unit water consumption is determined on the basis of the household survey and leakage control activities carried out in the course of the present study. As the water usage pattern generally differs from area to area, unit consumption should be assumed for each town. In the present assumption, only Dili is considered to have a larger rate than others.

Table 4.4 PER CAPITA WATER CONSUMPTION ESTIMATES (in lpcd)

Year	Dili		Other Towns/Cities	
	Individual	Public Taps	Individual	Public taps
1998	80	30	70	30
2003	100	30	90	30
2010	120	30	110	30

Non-domestic water for commercial, industrial and institutional usage relates to characteristics of each town. Where commerce and industry dominates, non-domestic water demand accounts for a large percent of the usage. It is therefore assumed that 30% of domestic consumption are consumed under category of the non-domestic in case of Dili (G1), 20% in case of Baucau, Manatuto, Los palos, Viqueque, Gleno, Same, Suai, Liquica, Maliana, Aileu, Ainaro (G2) and 10% for Maubisse, Atauro, Ermera (G3). This ratio may increase according to accelerating activities of the commerce and industry as follows:

Table 4.5 PERCENTAGE OF NON-DOMESTIC WATER DEMAND (in %)

City/Town Grouping	1998	2003	2010
G1 – Dili	30	30	40
G2 – Baucau, Manatuto, Los Palos, Viqueque, Same, Ainaro, Aileu, Gleno, Liquica, Suai and Maliana	20	20	30
G3 – Atauro, Maubisse and Ermera	10	10	20

Efficiency of water supply generally reflects to a size of water losses. It is said that water losses or wastage from water supply facilities account for more than 50% without exception in East Timor. It is of vital importance to decrease the water losses as early as possible. The present plan intends to eliminate a vast number of the non-registered connections, and to decrease water wastage and leakage to an allowable level of 40-50% from present 60% in the coming several years.

Table 4.6 PERCENTAGE OF UNACCOUNTED-FOR-WATER (in %)

City/Town Grouping	1998	2003	2010
G1 – Dili	60	40	25
G2 – Baucau, Manatuto, Los Palos, Viqueque, Same, Ainaro, Aileu, Gleno, Liquica, Suai and Maliana	60	50	30
G3 – Atauro, Maubisse and Ermera	60	50	30

In case of East Timor, seasonal fluctuation in water demand is considered rather small. To estimate daily maximum water demand, a factor of 1.2 is considered appropriate for all towns. The daily maximum water demand in 2003 thus estimated is utilized as a design production capacity of the water supply system.

Table 4.7 WATER DEMAND FORECAST

City/ Town	Year	Domestic (m^3/day)	Non-Domestic (m^3/day)	Water Losses (m^3/day)	Total Water Consumption			
					Daily Average		Daily Maximum	
					(m^3/day)	(L/sec)	(m^3/day)	(L/sec)
Dili	1998	5,310	1,593	10,355	17,258	200	20,709	240
	2003	10,686	3,206	9,262	23,154	268	27,785	322
	2010	18,090	7,236	8,442	33,768	391	40,522	469
Atauro (Vila + Beloi)	1998	42	4	69	116	1	139	2
	2003	112	11	123	246	3	295	3
	2010	204	41	105	349	4	419	5
Manatuto	1998	420	84	756	1,260	15	1,512	18
	2003	548	110	658	1,315	15	1,578	18
	2010	811	243	452	1,507	17	1,808	21
Baucau	1998	451	90	811	1,352	16	1,623	19
	2003	587	117	704	1,409	16	1,691	20
	2010	851	255	474	1,580	18	1,896	22
Los Palos	1998	346	69	622	1,037	12	1,244	14
	2003	663	133	795	1,591	18	1,909	22
	2010	1,392	418	776	2,585	30	3,102	36
Viqueque	1998	316	63	569	948	11	1,138	13
	2003	616	123	739	1,478	17	1,774	21
	2010	986	296	550	1,832	21	2,198	25
Same	1998	306	61	551	918	11	1,102	13
	2003	540	108	648	1,295	15	1,554	18
	2010	1,148	345	640	2,133	25	2,559	30
Ainaro	1998	226	45	406	677	8	812	9
	2003	356	71	427	854	10	1,025	12
	2010	590	177	329	1,096	13	1,316	15
Aileu	1998	280	56	504	840	10	1,008	12
	2003	403	81	484	968	1`1	1,161	13
	2010	573	172	319	1,064	12	1,277	15
Maubisse	1998	84	8	139	231	3	277	3
	2003	135	14	149	297	3	356	4
	2010	239	48	123	410	5	492	6
Gleno	1998	350	70	631	1,051	12	1,261	15
	2003	489	98	587	1,174	14	1,409	16
	2010	821	246	457	1,524	18	1,829	21
Ermera	1998	37	4	61	102	1	122	1
	2003	162	16	178	356	4	428	5
	2010	349	70	180	599	7	719	8

Liquica	1998	313	63	564	940	11	1,128	13
	2003	781	156	937	1,874	22	2,249	26
	2010	1,327	398	739	2,465	29	2,958	34
Suai	1998	429	86	772	1,286	15	1,544	18
	2003	662	132	794	1,589	18	1,907	22
	2010	1,145	343	638	2,126	25	2,551	30
Maliana	1998	433	87	779	1,298	15	1,558	18
	2003	828	166	994	1,987	23	2,385	28
	2010	1,375	413	766	2,554	30	3,065	35
TOTAL	1998	9,342	2,383	17,588	29,314	339	35,176	407
	2003	17,568	4,541	17,478	39,587	458	47,504	550
	2010	29,903	10,701	14,989	55,592	643	66,711	772

Water demand in 2010, estimated in a similar way as stated above, suggests a long-term target of design production to be achieved by each water supply. This figure is useful also for assessment of water sources in each town.

CHAPTER5 EXISTING WATER SUPPLY SYSTEM

5.1 Asset Mapping and Evaluation of the Water Supply System

Field investigations of the existing water supply facilities were conducted on 15 towns of East Timor. The main purpose of the asset mapping and investigations is primarily to collect information and data on the existing condition of the water supply facilities necessary to evaluate the systems performance. These activities are necessary mainly due to the lack of available records, drawings and relative documents concerning the existing water supply system of the 15 towns in East Timor. The Phase I survey which started in March 2000 continued until Phase II. Together with the interviews conducted on local sources field confirmations are vital for a more accurate and realistic evaluations of the data. The survey was carried out with the assistance of counterpart personnel and local hired staff trained by the JICA Study Team on basic water supply engineering. These activities form part of the counterpart training and technology transfer to local staff of East Timor. Supplementary surveys were also conducted on major water facilities such as water sources, treatment plants, reservoirs and pipelines. The collected and surveyed data was compiled as geographic information system (GIS). The first layer is a topographic map. For Dili, used was the map with scale of 1:8,000 which JICA topographic survey study team prepared while, for other 14 towns, the maps made during Indonesian regime with scale of 1:25,000 were used. The second layer is a location of the major water supply facilities including distribution pipes with pipe diameter. The third layer is a plan and section of the major water supply facilities and pictures.

The survey was conducted extensively on the urban water supply system of the 15 towns from the water sources down to the service connections. Data relative to the operation of the water system was also collected during the survey. The gathering of data and information was carried out on different occasion/schedule by two or more teams formed on different aspects of the water supply technology. In some towns outside Dili, there were cases when local guides and interviewees gave conflicting information to the Study Team. This could merely due to language barrier and the unavailability of suitable local persons willing to be interviewed or who could give the desired technical assistance to the Study Team. Detailed discussions on the water supply system in 15 towns of East Timor are done in the succeeding sections of this report.

5.2 Water Sources Evaluation

The table below shows the water sources in 15 towns of the study area including the evaluation of their potential.

Table 5.1 WATER SOURCES AND EVALUATION OF THEIR POTENTIAL

Town	Water Source	Measured Flow in Oct – Nov (L/s)	*Estimated Potential in Dry Season (L/s)	Yr.2000 Average Draw Off (L/s)	Yr. 2003 Max-Day Water Demand (L/s)	Remarks
1. Dili	Benemauk River	45	32	10	-	Supplies Benamauk & Lahane WTP
	Bemori River	29	20	30	-	Supplies Lahane WTP

	Bemos River	282	197	40	-	Supplies Bemos WTP
	Well @ Comoro A	40	40	40	-	Utilized
	" Comoro B	35	35	35	-	Currently used by PKF
	" Comoro C	-	-	-	-	Not presently used
	" Comoro D	31	30	30	-	Utilized
	" Comoro E	(20)	20	-	-	Not operational
	" Kuluhun A	16	16	15	-	Utilized
	" Kuluhun B	36	36	35	-	Utilized
	" Bidau 1	-	-	-	-	Abandoned
	" Bidau 2	-	-	5	-	Used by Dili Gen. Hospital
	T O T A L	514	426	240	322	Production deficit could be supplied from surface and groundwater sources.
	Well @ Hera A	-	5	-	-	Rehabilitation on going
	" Hera B	-	3	-	-	Rehabilitation on going
	" Hera C	-	5	-	-	Rehabilitation on going
2. Atauro	Eklai Spring	1	0.5	0.5	-	Utilized
	Tulai Spring	3	2.5	2.5	-	Utilized
T O T A L		4	3	3	3	Water shortage maybe experienced beyond 2003.
3. Manatuto	Manatuto Spring	116	104	-	-	Not in use
	Laclo River Infiltration Gallery	7,900	3,950	15	-	To be operational in December.
T O T A L		8,016	4,054	15	18	The source has adequate potential to meet the demand.
4. Baucau	Wailia Spring	55	44	15	-	Estimated current abstraction
T O T A L		55	44	15	20	The source has adequate potential to meet the demand.
5. Los Palos	Papapa Spring	99	99	5	-	Limited water due to damage Pumping Station 2 and WTP.
T O T A L		99	99	5	22	The source has adequate potential to meet the demand.
6. Viqueque	Builua (Loihunu) Spring	121	121	10		
T O T A L		121	121	10	21	The source has adequate potential to meet the demand.
7. Same	Carbulau (Darelau)	20	10	2		
	Kotalala Stream	1,120	280	6		
	Mirbute Spring	3	1.5	2		
T O T A L		1,143	291	10	18	The sources have adequate potential to meet the demand.
8. Ainaro	Sarai River	1,130	160	8		
T O T A L		1,130	160	8	12	The source has adequate potential to meet the demand.
9. Aileu	Mantane River Infiltration Gallery	370	370	0		Damaged pumping station
	Sloi Kraik Stream	4	2	2		
	Naufaisaran Spring	1.2	1	1		
	Hularema Spring	0.5	0.5	0.5		
T O T A L		375	373	4	13	The sources have adequate potential to meet the demand.
10. Maubisse	Raikuak Ulun	1.5	0.8	1		
	Bucana Spring	2	2	2		
	Filmou Spring	0.2	0.2	0.5		
	Erulu Spring	0.5	0.5	1		

T O T A L		4	3.5	4.5	4	The sources have adequate potential to meet the demand.
11. Gleno	Mota Boot Stream	1,300	325	0		Damaged intake and pipes
	Mota Kiik Stream	80	10	3		
	Ergrogo Spring	10	7	0		Damaged transmission main
T O T A L		1,390	342	3	16	The sources have adequate potential to meet the demand.
12. Ermera	Lubulala Spring	0.1	0.1	0.2		
	Ersoi Spring	0.6	0.6	0.5		
	Mota Bura Spring	1.0	1.0	1		
T O T A L		1.7	1.7	1.7	5	Production deficit could be supplied from surface water.
13. Liquica	Dato 1	-	-	0		Damaged
	Dato 2	-	-	0		Damaged
	Maumeta 1	-	-	0		Damaged
	Maumeta 2	-	-	0		Damaged
	Laclo	2.3	2	0		Damaged intake pipes
	Lilabu	2	1.5	0		Damaged intake pipes
	Narlolo	0.7	0.5	1		
	Daulo	15.0	10.5	0		Damaged intake and pipes
	Eanlua	3.8	3	0		Damaged intake pipes
	Raisape	5	5	0		Damaged transmission main
	Metagou	2	1.5	2		
	Emilaloa	20	10	0		Damaged intake pipes
T O T A L		50	34	3	26	Production deficit could be supplied from new wells and rehabilitation of Daulo, Eanlua and Manlaka
14. Suai	Olivio Spring	-	1**	1**		
	Ameriko Spring	0.6	0.6	0.5**		
	Maugusu Spring	-	-			
	Kuluai Spring	-	1**	1**		
	Sukabilaran 1 Well	-	6**	6**		
	Sukabilaran 2 Well	-	6**	6**		
T O T A L			14.6**	14.5**	22	Production deficit could be supplied by new well and rehabilitation of surface water and spring sources
15. Maliana	Beamos Spring	-	1**	1**		
	Aikumu Stream	-	37**	1**		
	Dabucci Springs	-	-	2**		
	Beapelu Spring	-	-	2**		
	Beremau Stream	-	-	2**		
	Colegio Stream	-	-	0.5**		
	Irrigation Canal	-	50**	7.5**		
T O T A L			88**	16**	28	Production deficit could be supplied by new well and rehabilitation of surface water and spring sources

** Estimation based on the measured flow rate and interview with the local people.*
*** Values taken from previous reports and investigations made by local staff.*

5.3 DILI Water Supply System

5.3.1 General

Dili has the widest service area of all the water supply system in the country. The water supply requirement of this capital city is supplied from sources such as surface water and groundwater. The surface water sources are drawn from 4 different river catchments and treated in the 3 water treatment plants before distribution to the water consumers. There are 9 wells (12 to include 3 from Hera Sub-district), drilled to abstract water from the groundwater reservoir, although half of the total number is currently out of operation. Except for chlorination of the water supply abstracted from some of the wells (Comoro A, Comoro B and Comoro D) the groundwater sources do not pass any form of treatment prior to distribution to the water consumers.

Prior to the post-referendum violence, approximately 50% of the city's population was served with water from the pipe network, although the operation of the system was not maintained on a 24-hr service. The rest of the population is served either by communal water supply schemes or by individual private system.

With the existing condition of the water supply facilities, the quality and quantity of water production has led to some problems in the service area. Daily disruptions of the water service, low water pressure and unacceptable water quality are among the few problems faced by the water consumers in the city. These conditions are the combined result of the numerous leakages, insufficient treatment, lack of quality control and the absence of regular maintenance on the facilities.

Improvement to the system is taking place with the assistance from the different donor countries, local and international organizations, NGO's, and most notably JICA. This is just the beginning of the tremendous tasks and there is a lot more to be done to improve the water supply system and eventually making the water supply entity in Dili sustainable.

5.3.2 Water Sources

The water requirement of Dili is supplied from a variety of sources. There are four intake points (Bemos, Bemori, Benemauk and Maloa) to collect surface water, nine wells around Dili area (Comoro, Kuluhun and Bidau) and three wells in Hera Sub-district, which is east of the capital. Except for Maloa, which is directly supplied to the water consumers without treatment, the 3 other surface water sources pass through the respective water treatment plants or in extreme cases directly supplied to the consumers without treatment. Three wells in Dili and all in Hera are not operational due to reasons such mechanical fault on the pump and low productivity of the wells. The locations of these sources are shown in Appendix B while the detailed information on water supply facilities are shown in Appendix E.

The site of the Bemos intake structures is located about five kilometers southwest of the city center at an elevation of more than 200 meters above mean sea level (amsl). The water source is from Bemos River, which is a tributary of the Comoro River. The intake structures include a concrete weir that extends 7m width of the stream. The water is then collected into a concrete intake box located at the right bank of the river. From the intake box, water flows by gravity through a pipe 20m downstream to another small tank equipped with a valve. The flow rate was estimated at about 1.0 m^3/s. Raw water is transmitted to the Bemos Water Treatment Plant for treatment.

The site of the Bemori intake structure is located about 3 km south of the city center upstream of Bemori River. The intake structure is equipped with a concrete weir to collect water through the gate at the right bank of the river. The water then flows 100m downstream into a tall concrete reservoir located where the stream branches off at an altitude of 185m amsl. The flow of the stream is about 15 L/s, of which about one-third of it is diverted into the intake. Raw water is transmitted into the Lahane WTP for treatment via 6-inch pipe.

The site of the Benemauk intake structures is located about 5 km southeast from the city center at an altitude of 155m amsl. The abstraction is found in the middle stream of the Benemauk River. This site can be reached by about 400m-walk upstream from the Benemauk WTP. The intake structure is equipped with a concrete weir about 5m width to collect water from the river. River water then flows downstream into a concrete reservoir where it is transmitted through 2 separate 6-inch pipelines for treatment at Benemauk WTP and Lahane WTP. Maloa

The site of the Maloa intake structure is located about 4 km south of the city center at an altitude of 170m amsl. Because of its unreliable yield, which is normally sensitive to seasonal fluctuations, this source is not viable as a major source for Dili.

In the Comoro well field, located west of the city center, a total of 5 wells were drilled to augment the water requirement in Dili. All of the 5 wells except Comoro C are equipped with pumps and pipe installation. As per the local sources the wells were drilled to penetrate the alluvial deposits of the Comoro River. The Comoro River has a total catchment area at about 207.3 km2.

- *Comoro A:* Flow rate = 40 L/s Depth = 135m Construction yr. = 1988
- *Comoro B:* Construction year = 1988
  Remarks: Used exclusively for the PKF with water truck refilling station
- *Comoro C:* Depth = 78m Construction year = 1995
  Remarks: Not presently used
- *Comoro D:* Flow rate = 31 L/s Depth = 78m
  Remarks: Equipped with new generator for emergency operation
- *Comoro E:* Construction year = 1996
  Remarks: Soon to be operational with new set of pump and pipe facilities.

The Kuluhun and Bidau well fields are located on the eastern part of the city center. A total of 4 wells were drilled in this area to supply part of the water requirement in Dili. A brief description of each well is discussed below. All of the wells were drilled in the alluvial deposits of the Santana River, where the total catchment area is about 34.3 km^2.

- *Kuluhun A:* Flow rate = 16 L/s Depth = 100m
- *Kuluhun B:* Flow rate = 36 L/s Depth = 95 L/s
  Construction year = 1998
  Remarks: Located at the right bank of a channel
- *Bidau 1:* Abandoned with pump installations removed.

- *Bidau 2:* Used exclusively for the Dili General Hospital.

There are three wells drilled in Hera located 10 km east of Dili. These wells were primarily drilled to supply water in Hera Sub-district. All of the wells were drilled in the alluvial deposits of the Quik River, where the total catchment area is about 42 km^2. Due to some reasons that include the unavailability of power supply, none of these wells are in use.

- *Hera A:* Flow rate = 5 L/s Depth = 95m
  Remarks: Abandoned but equipped with reservoir and pipe installations.
- *Hera B:* Flow rate = 3 L/s Depth = 75m
  Remarks: Abandoned without any pipe installations.
- *Hera C:* Flow rate = 5 L/s Depth = 85m
  Remarks: Presently out of use but can be put back into operation if power supply becomes available.

Result of Geophysical Survey

Resistivity survey was conducted by the Study team in Bidau, Becora and Hera in Dili, and Liquica. The details of the survey are described in GEOPHYSICAL SURVEY REPORT in Appendix B. The summarized result is described in this section.

Bidau. (Well No. Bidau 1)
Water level is observed around five meters below the ground level. The result indicates the main aquifer occurs in the alluvial deposit from around 12m to 48m in depth. The bedrock underlies the deposit.

Becora
Based on the survey result, Becora-line can be classified into two basic categories "Zone 1, "Zone 2". Zone 1 covers the western part of Santana River, Kuruhun village and eastern part of Bemoli village. Zone 2 covers the eastern of Santana River, Becora village.

"Zone-1" (The western area of the Santana River – Site of Kuluhun A and B)
The layer of sandy deposits from 13m to 70m in depth is considered an aquifer. The layer has high potential of yielding water. Base rock is encountered below the layer. Pumping water level of Kuluhun B was observed 6.5m below the ground level at the pumping rate of 35L/s.

"Zone-2" (The eastern area of the Santana River)
The result indicates that the bedrock may occur about 30m below ground level. It means the permeable deposit is relatively thin in the area while the layer may have some potential of yielding groundwater.

Hera
In the central area of the Hera alluvial plain, the bedrock is considered to occur below 70m in depth, although the boundary between the alluvial deposits and the bedrock is not so clear. The alluvial deposits may be relatively rich in silt and clay, and the bedrock is likely weathered in upper part.

5.3.3 Transmission Mains

The old transmission mains constructed during the Portuguese administration are now considered as distribution pipes. Residents in the area where the mains traverse, normally draws raw water before it reaches the WTP through illegal connection. These transmission mains include the old Maloa – Lahane, Bemori/Benemauk – Lahane and Dili Hospital – Lahane WTP. A new transmission is necessary to replace the old one if reactivation of the Maloa water source is considered. This transmission main should be appropriately designed and installed to minimize damage both natural and man-made. Realignment is necessary to the new transmission mains for other surface water sources such that damaged caused by flood will be avoided. Regular and appropriate maintenance works should be drawn for these transmission mains to include with that of the groundwater sources.

5.3.4 Water Treatment Plant (WTP)

Due to the presence of undesirable substances in the surface water sources of Dili, 3 WTP were constructed primarily to make the water safe and attractive to the consumers. The water treatment plants in Dili were constructed with a total theoretical design capacity of 80 L/s. The treatment process includes coagulation/flocculation, sedimentation, rapid sand filtration and chlorination. All the 3 WTP have their laboratories with limited water testing facility. Originally, these laboratories were installed to conduct water quality analysis for the operation and control of the WTP. The parameters normally measured in the plant's laboratory include temperature, pH, turbidity, color and residual chlorine. Other parameter required for the analysis of the water quality is carried out at the Caicoli Laboratory located in the PLN office complex.

- *Bemos WTP*

Bemos Water Treatment Plant started its operation in 1984. The intake facilities are constructed at the right bank of the Bemos River, (a tributary to Comoro River) located about 8 km upstream from the plant. The 8" transmission main is installed along the footpath on the steep western slope of a mountain. It is reported that the main is frequently damaged by torrents caused by heavy rain. Three operators assigned for operation of the intake facilities control the blow-off valves installed on the main to flush out turbid water particularly after rainfall.

Just before entry into the plant, the transmission main is diverted into two directions. One of the branches is a 4-inch GS pipe that conveys raw water directly to a reservoir, which has a storage capacity of $1000m^3$. The remaining raw water enters into a receiving chamber via the 8-inch main. The raw water regulated at the inlet chamber by a valve is conveyed to a packaged-type treatment plant consisting of two sub-units with dimensions of 1.9m x 6.9m x 3.8m height. Each unit is equipped with the water treatment process such as flocculation, sedimentation and filtration. The total capacity of this plant is designed with a flow rate of 40 L/s. During the site survey it was found out that the flow recorded in the meter is slightly high at 50 L/s.

The treated water reservoir has a storage capacity of $500m^3$ equivalent to 3.5-hour design rate. This reservoir is interconnected to the $1,000m^3$ capacity reservoir in the plant. Due to the lack of flow control equipment, water just pass through large reservoir and immediately flows out into the small reservoir via 4-inch bypass. As a result, low water storage exists and this reservoir does not serve its purpose of balancing the water supply during fluctuations of daily water demand.

The electrical facility of the Bemos WTP was installed in 1995 using the power supplied by PLN at 380/220V, 50Hz for its normal operation. This plant is equipped with an emergency generator that activates in the event of power outages from the PLN. After the violence, all the generators have lost their function.

- *Benamauk WTP*

Before the construction of the Benamauk WTP, raw water from the Benamauk intake is conveyed through two raw water mains of diameters 6” and 8”. One of the mains is used to supply raw water to the consumers via the service reservoir and the other is used to transmit raw to the Lahane WTP for treatment prior to distribution. The service reservoir was constructed in the vicinity of the residential area. These schemes of water distribution are still working under the current condition.

From the 6-inch raw water main, a new diversion was constructed in 1993, packaged with a treatment facility into steel boxes in the nearby reservoir. The treatment facility, consisting of two units, has a total design capacity of 10 L/s. Chemical flocculation, sedimentation with sloping plates, and gravity fed filtration are the major processes applied. Filtered water flows into the newly constructed reservoir. Manual chlorinators are installed on the roof of the reservoirs. There are cases when raw water is distributed to the consumers without passing through the WTP. The operator upon his judgment of clear water intake makes the bypass to the distribution. This normally happen during the dry season.

The electrical facility in the Benamauk WTP is not supplied with power from the PLN. It is equipped with 2 sets of generators for its normal operation. After the violence, all the generators had ceased to operate.

- *Lahane WTP*

The Lahane Water Treatment Plant is the oldest of the 3 WTP constructed in 1954 with a design production capacity of 30 L/s. Treatment process consists of a contact chamber, a mixing chamber, one basin for up flow type sedimentation, and 3 basins for filtration. The contact chamber recently constructed between sedimentation and filtration basins to improve settling efficiency. Chemicals used in the treatment process include aluminum sulphate for coagulation, soda ash as coagulant aid, and calcium hypochlorite for disinfection.

From the treated water reservoir, there are two mains installed. One is 8-inch pipe that directly conveys water by gravity to the service reservoir (storage capacity: 800m^3) constructed 100m downstream of the plant. The other main equipped with two sets of pump supplies the higher zone in the southern part of the service area. During the survey, the pumps were found to be out of operation due to some reasons.

In the Plant, one operator is engaged in a variety of tasks required for the water quality and quantity monitoring, operation and maintenance. This plant, despite its age and the limited workforce is well maintained from the viewpoint of water quality produced.

The electrical facility of the Lahane WTP was installed using the power supplied by PLN at 380/220V/50Hz for its operation.

- Evaluation

The existing WTP's lack the required manpower with appropriate tools and inadequate chemicals and reagents to maintain its performance. The inadequate amount of chemicals stored for a certain period of operation is not properly maintained. In some cases during the dry season, raw water is bypassed from the treatment process and distributed to the city. There is no regular maintenance works carried out on the facilities as evidenced by the accumulation of silt, sand and mud deposited in the tanks. These inadequacies are the main problem of the WTP in Dili. As a result, the prescribed quality of the water supplied to the consumers is not maintained.

5.3.5 Storage Facilities

There are 10 major storage reservoirs in Dili with a total capacity of 4,030m^3. The reservoirs are structurally sound, but the facilities installed therein including the structure itself lack the necessary maintenance. Out of the 10, Bemos II Reservoir and Bidaumasau Reservoir are out of use. Actual production far exceeds the design capacity. When these aspects are considered, the total storage decreases to 2,310m^3 or approximately 2 hours of the water production, apparently insufficient to regulate fluctuations in water demand. Under the present condition the lack of human resources in the Dili water supply system results to the absence of proper operation and maintenance of the storage facilities.

- *Comoro Reservoir*

This reservoir was constructed in 1995 designed to store water from the well sources at Comoro D and Comoro E. It is located on top of the hill west of Dili. It is circular in shape made of steel, covered with vinyl and has a storage capacity of 1,000 m3.

- *Becora Reservoir*

This reservoir located on the eastern part of the service area is designed to store water pumped from the Kuluhun A. It is a similar in shape and structure to the Comoro Reservoir but half in storage capacity. A manual-type chlorinator is installed on the roof but currently not in use.

No.	Name/Location	Water Source	Vol. (m3)
01	Bemos I	Bemos WTP, Bemos II and Comoro A	500
02	Bemos II	Bemos Intake and Comoro B	1,000
03	Lahane	Lahane WTP	800
04	Benemauk I	Benemauk Intake	25
05	Benemauk II	Benemauk WTP	100
06	Comoro	Comoro D and Comoro E	1,000
07	Taibesi	Kuluhun B	30
08	Becora	Kuluhun A	500
09	Bedoisi	Bedoisi well	45

10	Bidaumasau	Bidau 1	30
TOTAL			4,030

5.3.6 Distribution Network

The water distribution network in Dili covered most of the city population. It contains the old network constructed during the Portuguese era and the new network developed during the Indonesian administration period. The old network built in the old city uses AC and GS pipes of diameter ranging from 3-inch to 7-inch. Due to the non-availability of pipe and fittings such as the 7-inch diameter pipes, there is difficulty in carrying out the repairs. Because these pipes are relatively old, numerous water leakages can be expected from the old network.

The new pipe network is generally laid mostly in areas not served by the old network covering the city from east to west. It is widely distributed that almost all of the villages located within Metropolitan Dili are covered. The development of the new network uses pipe material such as PVC, AC and GS with the diameter ranging from 3-inch to 12-inch.

With the rapid growth of the city population, and the economic activity during the pre-referendum period, there are sections of the old and the new network that has become undersize to carry the flow required to satisfy the demand. The inadequate water production and the deteriorated pipe network that leads to water leakage, are the two main factors that contribute to the water shortage in the service area. It is estimated that the unaccounted-for-water exceeds 60% of the total water production.

There are numerous leaking pipes that are left unattended for reasons such as lack of manpower and the technical skills, unavailability of materials, tools and equipment. Leakage often occurs in the old pipe system installed in the old town. There is a difficulty to carry out the repair in the old town because most of the pipes were installed during the Portuguese time where the old system was used. Odd pipe diameters are not anymore available in the market.

The distribution network is not sufficiently designed with appropriate device such as pressure gauges, and valves to carry out regular monitoring of the system and maintenance activities. In some cases, there is difficulty in operating the valves due to the absence of a regular valving operation. Flushing out of the distribution system is not done regularly such that accumulation of silt, sand and mud carried out from the WTP is deposited in the pipelines. The JICA Leakage Control Team discovered a number of illegal connections particularly in the distribution lines. The mixture of the old (Portuguese) and new (Indonesian) system in the network coupled with lack of resources make the maintenance of the distribution network more complicated.

The JICA Leakage Control and Repair project carryed out extensive repair works on the pipe leaks and damage pipelines. A pilot project on pipe reconstruction was selected along the east bank of the Benemauk River. The project aims at reducing pipe leaks and reconstruction of the illegal service connections, which are mostly the cause of water loss and wastage.

5.3.7 Service Pipelines

The activities of the Leakage Control under the Quick Project of JICA provide precious information to carry out the operation and maintenance of the water supply system in Dili. Several illegal connections from the distribution mains were found during the survey. Because these connections are non-registered and not billed, large volume of water is wasted. The existence of illegal connection makes it difficult to attain optimum flow control in the pipe distribution network. Water supply condition in the critical areas of the distribution network has become miserable. Majority of the population in these areas rarely gets piped water from the reticulation.

In the service area, many of the public taps were constructed during the Indonesian period. Mainly due to lack of proper maintenance, most of these hydrants are broken and left unrepaired.

5.4 ATAURO Water Supply System

5.4.1 General

The island of Atauro is one of the sub-districts of Dili located about 20 km off the main Timor Island. There are 5 main villages that comprise the island of which Vila is the capital. The water requirement of this capital village is supplied with water from springs located in the mountain area west of the village. During the time when Vila was enjoying an efficient water supply system, part of the water supply was transmitted to the neighboring Beloi Village. However, with the existing condition of the system, there exists serious water shortage that most of the Vila residents are deprived of a continuous water supply. Moreover, not a single drop reaches the reservoir provided to satisfy part of the water requirement in the neighboring Beloi Village.

The existing water supply service in Vila operates for a limited period of service (0600hrs to 0800hrs and 1800 hrs to 2000hrs) with limited water consumers. During the survey, not one qualified or experienced worker operates and maintains the system. As a result, the quality and quantity of the water supply and the condition of the facilities had continued to deteriorate. With the current condition, only those consumers located in good geographical location of the service area and persons with "authority" can enjoy piped water supply while majority remains not served by the system.

5.4.2 Water Sources

The water requirement of the capital village, Vila and part of the requirement for the neighboring village, Beloi are supplied from 2 springs. Another spring in Beloi called Ehrutar augments the water coming from one of the service reservoir in Vila. Except for the Ehrutar Spring, field surveys were done on the 2 sources in Vila with the following details.

a.) Mota Eklai

The intake structures of these springs are located west of the village about 750m uphill at an elevation of about 150m amsl. It is composed of two tiers of spring seeping out about

10m apart of which two separate concrete boxes are constructed to collect the water via 2-inch GS intake pipes. These spring sources supply a limited number of households in Vila (about 10 households) due to the small yield of these springs (estimated at less than 1 L/s).

b.) Mota Tulai
This source is composed of several springs outcropping at different locations close to each other. It is located about 2 km west of the village uphill at an altitude of about 500m amsl. A total of 4 concrete intake boxes at different locations were constructed to collect the spring water. From these intake boxes, water is transmitted downstream via GS pipes into the village reservoirs passing through a series of break pressure chambers. During the 1st phase survey, the spring water was observed clear with a total yield estimated at than 5 L/s.

As reported by the local sources, there is another spring called Ehrutar located somewhere in the mountains of Beloi. This spring is used to augment the water supply coming from Vila to satisfy the water requirement in Beloi. At present, the water supply system in Beloi is not in operation due to some reasons to include the inadequacy of the sources from Vila.

5.4.3 Water Supply Facilities

a.) Transmission Mains

The transmission pipes constructed from the Eklai spring that supplies water directly to the service area are considered as distribution lines. These are made up of GS pipes with diameters ranging from 1½” to 2”. However, the transmission mains used to convey water from the Tulai spring sources are mainly GS pipes ranging from diameters 2” to 3”.

The galvanized steel transmission mains are often subjected to damage caused by falling rocks, eroded soils and other debris. The pipeline that transmits water from the uphill source to the reservoir downhill traverses unstable and steep mountain slopes that normally become unstable especially during heavy rains. Because of this situation with the pipe installed without appropriate protection, damages usually occur leading to water leaks. The transmission pipeline needs realignment to safe location in order to minimize damage.

b.) Storage Facilities

There are a total of 4 storage reservoirs in Vila and 1 in Beloi with a total design capacity of 157m^3. All of these reservoirs which were constructed of reinforced concrete, are in good working condition. Haronglerang reservoir was constructed during the Portuguese period while Tolelona I and II were constructed during the Indonesian era. The Tangke Cementerio and Lebadoe reservoirs were constructed with funds donated by AusAID.

The several reservoirs lack regular maintenance. Some of them are not properly equipped with valves and washout to carry out tank cleaning and maintenance. The reservoir facilities are not well secured subjecting the water supply to possible contamination.

c.) Distribution Network

The water distribution network in Vila was constructed to serve majority of its households and part of the neighboring Beloi Village. Majority of the water distribution pipes is exposed above ground along the side road. They are made up of galvanized steel pipes with a maximum diameter of 2-inch to a minimum of ½ inch. They are mainly located above ground on the side of the road. Although, thorough investigation of pipe leak could not be made due to the limited water supply, most of the pipes and valves investigated appear to be in good condition.

d.) Service Connections

The service connections in Vila and Beloi are made of GS pipes tapped directly from the distribution network. Most of these connections are branch from the distribution pipe by means of a tee to a diameter of ½ inch. During the survey, the pipelines appear to be in good condition however; an assessment on water-tightness of the pipes and fittings particularly on leakage condition could not be carried out due to the limited water service. Although, a few number of leak repair on the pipes using rubber were noted. As per the local source, there exist a few numbers of illegal service connections done on the transmission mains. In the same manner as the distribution pipes the service pipelines appear to be in good condition.

5.5 MANATUTO Water Supply System

5.5.1 General

The town of Manatuto is located on the north coast of East Timor some 64 km east by road distance from Dili. Manatuto is the administrative capital of the Manatuto District. As can be seen during the site survey, the town also suffered massive infrastructure destruction especially to residential and government buildings. Although, the town has regularly suffered acute water shortages in the past few months or perhaps in recent years, the situation could mainly be due to neglect or lack of proper maintenance to the facilities rather than violence-related causes.

The main source of water supply for Manatuto is a stream located some 12 km southwest of the town. Water from this source flows by gravity via 6" GS pipe to the town's main reservoir located on top of the hill at an elevation of approx. 80m amsl. From this reservoir, water is then distributed to the service area by gravity without any form of treatment. However, during the field survey no water is coming into the reservoir from this source or any other sources mainly due to the eroded section of the main transmission pipe. This is a perennial problem especially during rainy season since the pipes are laid in a flood prone situation without appropriate protection. Recently, most of the residents rely on unsafe water supply from shallow wells and nearby river sources.

5.5.2 Water Source/s

a.) Laclo River Infiltration Gallery

A quick project to rehabilitate the Manatuto water supply system was implemented and an infiltration gallery was installed at the confluence of the Laclo and Sumasse River. A perforated pipe was placed under the riverbed across the 200-meter river course and a pump station was constructed on the right bank.

b.) Sumasse tributary

The town of Manatuto is situated in the alluvial flat land created by the Laclo River. The town's water supply system has one water source that is currently out of use. The site of the intake is located about 12 km southwest of the town on the right bank of the Sumasse River, a tributary to Laclo River. The intake site is situated on a bushy and swampy riverbank about 150m away from the Sumasse River. The site is protected by a broken barbed wire fence constructed to restrict human and animal entry. The intake structure is equipped with a concrete tank, 6-inch pipe and a gate valve. Water flowing out of the bushy river bank is collected into the tank via 6-inch pipe.

5.5.3 Water Supply Facilities

a.) Transmission Mains

One of the transmission mains in Manatuto is the 6-inch GS that is used to convey water by gravity from the Sumasse River intake into the Saututum Reservoir. This pipeline is about 12-km in length from the intake point and traverses through the Laclo River before reaching into the town's reservoir. Because the pipeline is normally laid in a flood-prone riverbank without appropriate protection, it is most often subject to erosion and damage. At present, more than 300m length of the pipe section was eroded, which had caused the town's water supply system to be out of operation. Due to the rugged terrain of the pipe route compounded by the lack of resources makes the repair of this transmission pipeline difficult.

Construction of another transmission pipeline was attempted to convey water from a well in Malain Rem to the town's reservoir. It is made up of GS pipes of diameter 4-inch and 3-inch. Due to the post-referendum violence and for some technical reasons this system was abandoned.

b.) Storage Facilities

The water supply system in Manatuto is equipped with the Saututum Reservoir strategically constructed up in the hill where water is distributed to the water consumers by gravity. This reservoir is made up of reinforced concrete with a total volume of about 200m^3. It has 2 inlet pipes from the surface water (6-inch) and well water (3-inch) sources and 2 distribution pipes of diameters 8-inch and 2-inch. These pipes are equipped with valves basically for flow control of the water. Presently, this reservoir is out of use due to the condition of the sources and the transmission mains.

c.) Distribution Network

The water distribution network in Manatuto covers most of the town's residences. The network is made up of GS and PVC pipes of diameters ranging from 8-inch to 1¾-inch.

From the distribution main 8-inch and 2-inch originating from the town's reservoir, it branches into smaller diameters and spread out around town from east to west. The condition of the pipes appears to be generally good, except for the PVC lines installed along the coastline. However, an assessment on water-tightness of the pipes and fittings particularly on leakage condition could not be carried out due to the unavailability of the water supply. It was, however, noted that some sections of the distribution pipes appear to be vulnerable to damage. If possible, pipes must be buried underground with appropriate earth cover to minimize damage. The local workforce of the WSS with the support from NGO's was carrying out repair work on this distribution network.

d.) Service Pipelines

The service connections in Manatuto are made up of GS and PVC pipes tapped directly from the distribution network. Most of these connections branch from the distribution pipe by means of a tee to a diameter of ½ inch. During the survey, the pipelines appear to be in good condition however; an assessment on water-tightness of the pipes and fittings particularly on leakage condition could not be carried out due to the unavailability of the water supply.

5.6 BAUCAU Water Supply System

5.6.1 General

Situated about 130 km from Dili, Baucau District is the second largest in East Timor in terms of population. Baucau City serves as the key center for the eastern region of East Timor in terms of political and logistical planning. During the survey, it was found out that the city population had dramatically decreased due to the post-referendum violence. Massive destruction to infrastructure can be seen around town such as ruined government buildings, residential houses, churches, business and commercial establishments.

The water supply system in Baucau City was not spared with the damage. Destruction to the water supply facility was mainly noted on the electrical and mechanical facilities and in the reticulation system notably, the service connection. Due to the damage of the facilities, the people in the city are facing water shortage that normally led to low water pressure especially during peak hour. Consumers at the higher are the worst affected by the current condition of the system.

5.6.2 Water Source/s

The city of Baucau spreads over a terraced slope from the sea level to an elevation of about 400m. The main water source, Wailia Spring is found at the center of the town behind the pumping station. Abundant spring water is found flowing out at different spots at the foot of stone wall above which a main street runs. The pump station utilize some of those springs each yielding at about 10 L/s or more. This is another group of springs across the road from the pump station. Water seeps out from the ground at the bottom of a limestone cliff and collected into a concrete structure that serves as the intake. This water is simply transmitted through a concrete channel passing pump station.

5.6.3 Water Supply Facilities

Established by the Portuguese in 1967, the water supply system of the city of Baucau had limited service area located mainly in the northern town center (old town) of lower elevation. Due to population growth and economic activity, the system had undergone several stages of development.

During the period of the Indonesian rule, a two-stage program was implemented. Stage 1, which was completed in 1988 included the construction of pumping stations and reservoirs to supply water to the higher zone. However, shortly after the operation, the pumps started to malfunction that leads to the stoppage of water supply service to the higher zone.

Stage 2, which was completed in 1992, is basically an extension of the first stage with the same purpose of supplying the consumers in the higher zone. The project includes the construction of booster pumping station, main reservoir and transmission mains to extend the service area west of the city. The construction and extension of the transmission line was aimed to form a circular loop that surrounds the city. However, the pipe laying works were not completed and only the booster pumps became operational to convey water to the main reservoir.

a.) Transmission Mains

From the water source located in the city center, water is conveyed by gravity through several transmission mains to the water consumers in the lower zone. On the other hand, majority of the people living in the higher zone can get water distributed from the storage facilities where water is pumped up from the source via the transmission main. The transmission pipelines are made up of GS pipes with diameters ranging from 200mm to 100mm. To attain an effective water distribution in Baucau, the gridiron or belt-line network must be completed.

b.) Pumping Stations

The water supply system in Baucau City has 3 pumping stations to draw water from the source at a lower level and lift them up to the storage facilities for distribution to the water consumers. The expansion of the service area to the higher elevation of the city necessitates the construction of booster pump to lift the water to the main reservoir.

- *Pumping Station No. 1@ Wailia*

This pumping station lifts all the water supply collected from the source into the Lamegua Reservoir and Wainiki Pumping Station for distribution to the water consumers of the city. The electrical facility of this pumping station was installed in 1984 using the power supplied by PLN for its normal operation. It is equipped with emergency generators, which are activated in the event of power outages from PLN. After the violence, one of the generators became non-operational.

- *Pumping Station No. 2 @ Wainiki (Booster Pump)*

The Wainiki booster pumps were mainly installed to pump water to the main reservoir located at high elevation in Adarai. It is equipped with 2 booster pumps (1 duty and 1 standby) and generator. This pumping station operates normally by using the generator. After the violence, the electrical facility was severely damaged resulting to the non-operation of this pumping station.

- *Pumping Station No. 3 @ Lamegua*

This pumping station located uphill a few hundred meters southwest above the source was installed to supply the consumers situated at high elevation of the old town. It is equipped with pumps and operates by using 2 sets of generator. After the violence, the electrical facility was severely damaged resulting to the non-operation of this pumping station.

c.) Storage Facilities

In Baucau, there are 4 reservoirs constructed in strategic areas of the city aimed to satisfy the above-mentioned purposes. Storage volume at the main reservoir is 350 m^3 while the other three has 50 m^3 each. The reservoirs constructed in the different parts of the town appear to be structurally safe. Although, some minor maintenance and cleaning are required. The valves must be regularly checked and maintained. Most of these reservoir facilities are not well secured wherein the risk of possible water contamination is high. It is also necessary to install appropriate flow meter and control valves on these reservoirs.

d.) Distribution Network

With the kind of topographic condition in Baucau, where the service area is located at different elevations, water is pumped into the reservoirs constructed at an area with sufficient elevation in order to reach any part of the distribution system with adequate pressure. From the reservoirs, water is distributed to the different parts of the service area by means of the distribution pipelines made up of GS pipes with diameters ranging from 6-inch to 2-inch. Due to the post-referendum violence several damages to the distribution network were noted during the survey. These destruction include pipe leakage, valve and hydrant damage. With the assistance of several donor countries, local and international NGO's, repairs to the damages of the water distribution network were taking place.

e.) Service Pipelines

With the exception to the pumping stations, the service pipeline is the water supply facility where most destruction was noted. Due to the damage inflicted on the residential commercial and public buildings, the service pipelines were not spared of the destruction. As a result, water is mostly seen leaking out from the pipes where ruined buildings are located. Currently, repairs to pipe leakage in the service pipelines are being carried by the workers with the help of local and international NGOs.

5.7 LOS PALOS Water Supply System

5.7.1 General

The Lautem District is located in the easternmost part of East Timor. This district is mainly bounded by the sea and has the country's longest shoreline extending from west to east and down to the southwest boundary, which is Viqueque. The western boundary is Baucau District. Los Palos, which is the capital town of the district, is approximately 100 km east of Baucau. During the survey it was noted that the massive destruction to infrastructure were on public buildings where most of them are completely destroyed.

The water supply system of Los Palos was first established by the Portuguese in 1950's. The system was constructed mainly to serve the population concentrated at the town center. However, due to population growth and the increase in economic activity in Los Palos, the system had undergone several stages of development. In the aftermath of the post-referendum violence, damages to the water supply facilities are mainly on the electrical and mechanical facilities of the pumping stations. The problem to all other facilities are mostly due to neglect and the lack of regular maintenance, although the distribution network contains uncompleted sections that were left without adequate fittings or joints.

5.7.2 Water Source/s

The town of Los Palos is located on the southeastern edge of the limestone plateau. The topography of the town area may appear to be flat but in reality it slopes gently towards the east. The town's water supply system is coming from one large spring source although there are a number of shallow wells operated privately.

The town's water source is located about 1.5 km west of the town center. It is easily accessible from the main road. Water for the town water supply is collected through a pipe from a large pool of water that originates 500m upstream as springs flowing out in a grassy field. A tiny stream of surface water also flows into the pond at the site. A concrete wall that holds a weir diverts the flow to two separate concrete weirs. The two streams eventually go into three earth channels (two large and one small) and flow down towards the town.

5.7.3 Water Supply Facilities

During the time when the Los Palos water supply system was first established by the Portuguese, the facilities were designed for a limited service area. As the water demand continue to grow in consistent with the growth in population and economic activity the system underwent several stages of development mostly done during the Indonesian time.
The latest development was planned with water treatment facility and an elevated storage reservoir to supply the consumers in the higher zone. However, the project was not completed and during the post-referendum violence, part of the facilities was damaged. As a result, water is distributed to the consumers without treatment and majority of the consumers is not supplied with water except to a limited number of people living in the town center.

a.) Transmission Mains

With a series of development done on the system since the time it was first established there exist several transmission mains. Two on the mains, 2-inch and 3-inch pipelines were abandoned due to broken and missing sections and the 8-inch main is not presently used because of some uncompleted portion. Only the 10-inch, which is reduced to 6-inch downstream, is currently used to convey water to the pumping station No.1 @ Kauto and the distribution network.

b.) Pumping Stations

- *Pumping Station No. 1 @ Kauto (along the main road)*

Constructed during the Portuguese Period, this pumping station is supplied with water by gravity from the spring source and distributes water to the water consumers in Los Palos. It operates normally by using 2 sets of generators. After the violence, the electrical facility was severely damage resulting to the non-operation of this pumping station.

- *Pumping Station No. 2@ Papapa (WTP site)*

This pumping station is composed of 2 systems namely: System 1 pumps raw water to the WTP and System 2 pumps treated water to the overhead reservoir located at the WTP site. During the survey, it was found out this station suffered very severe damage. The electrical and mechanical facility of this pumping station were found missing for unknown reasons.

c.) Water Treatment Plant

The water treatment facility in Los Palos is composed of two slow sand filter units. This facility was constructed in 1999 for the purpose of treating the raw water from the source prior to distribution. It has never been put into operation since the time it was constructed because of the emergence of the post-referendum violence.

d.) Storage Facilities

Storage facilities were constructed as part of the development on the Los Palos water supply system. Recently, an elevated reservoir was constructed in an area higher than the WTP. From the WTP, treated water is pumped via 10-inch transmission pipe into the elevated reservoir. This system is currently out of use but the reservoir is in good condition. Only the service reservoir located close to Pumping Station No.1 remains operational.

e.) Distribution Network

The distribution network in Los Palos has sections that are not interconnected. It is composed of the old GS pipes installed during the Portuguese time and the combination of GS and PVC pipes installed during the Indonesian period. The diameter of the pipes varies from 6-inch to 2-inch. During the survey, leakage was observed dominant in the old pipes.

f.) Service Pipelines

During the violence, the service pipelines was the most affected facility in the network in terms of damage. Most of these pipes were damaged together with the destruction of the buildings (residential or private) where it is usually installed. As a result, a big percentage of the water losses are coming from the damaged service pipelines. The local workforce with the assistance of NGO's was doing repair works on the water service connections. However, there still remains damaged connections and public taps that need to be attended and rehabilitated.

5.8 VIQUEQUE Water Supply System

5.8.1 General

Situated in the southeastern part of East Timor, Viqueque District is bordered by Manatuto in the west, Baucau in the north, Lautem on the east and the Timor Sea in the south. The capital town of the district is Viqueque, which is divided into two parts, namely: old town located in the south, surrounded by S. Cuha River and built during the Portuguese time; new town located in the north just beside the river and built during the Indonesian regime. With most of the population living in the rural area, the rate of returnees to Viqueque is higher in the old town than in the new town.

The water supply system in Viqueque is gravity fed type having the source located at a higher elevation. Although there are minor damages to the facilities, especially in the service pipelines, the water supply system is presently in operational condition. Repair to the damage facilities of the system is currently in progress with the assistance coming mainly from GTZ and the local NGO Bia Hula.

5.8.2 Water Source/s

The town of Viqueque is situated in a flat plain at the middle valley of the Cuha River. The source of water for Viqueque is the Builua (Loihunu) spring with an abundant yield located about 10 km north of the town. This spring can be reached from the road and could easily be located because it is cascading down from the hillside. Water is seen flowing out from limestone cave, at the foot of the high cliff. The water from those springs separates into 2 big streams. Water from the 2 streams is then collected into an intake structure and transmitted by pipeline for distribution in the town's service area. The water source itself has no protection from contamination and other risks.

5.8.3 Water Supply Facilities

The water supply system in Viqueque was first established by the Portuguese in 1967. Water from the source located about 10 km north of the town flows by gravity via the transmission main to the service area. From the original 2-inch diameter transmission main, the system started with a few water consumers. However, to meet the increase in water demand brought about by the growth in population and economic activity the system had undergone several stages of development.

During the Indonesian time, a 3-Stage Program was formulated aimed to increase the conveyance capacity of the transmission and distribution mains. Stage 1 was implemented in 1984 – 1985 while Stages 2 and 3 were implemented in 1986 – 1987 and 1997 – 1998, respectively. Under Stage 1, a 2-inch transmission main and a reservoir were added to the existing facilities. For Stage 2, similar piping works were constructed, which were eventually abandoned because of their limited capacity. Full-scale system expansion and upgrading were carried out in Stage 3. The project included a 6-inch transmission main installed to convey water from the spring source directly to the consumers.

a.) Transmission Mains

The transmission main of the Viqueque water supply system consists of 6-inch GS pipe that conveys water from the source about 10 km to the town area. This transmission pipe was part of the Stage 3 water rehabilitation project constructed in 1998, which replaced the old 2-inch transmission main. During the survey, it was noted that pipe leakage occurs at about 2 km downstream from the spring intake where the pipe traverses a relatively steep slope without adequate protection. The pipes should be installed in safe location to make them less vulnerable to damage.

b) Storage Facilities

There is an existing reservoir located at the old town, which was constructed to provide water storage for the water supply system in Viqueque. During the survey, this reservoir, which is composed of 4 basins having a total capacity of about 340 m^3 is out of use because the pipework was damaged during the post-referendum violence.

c.) Distribution Network

The distribution network in Viqueque is divided into two main branches to supply the old and new towns. These two main branches of the distribution network are made up of GS pipes with diameters of 4-inch. From the main distribution pipe it reduces to smaller diameter down to 1-inch. The old distribution network is still in use where pipe leakage dominantly occurs. The numerous pipe leaks must be repaired to minimize water wastage and the drop in water pressure. The pipes should be installed in safe location to make them less vulnerable to damage.

d.) Service Pipelines

The service pipelines in the Viqueque water supply system are directly connected from the distribution network, which branches out into ½-inch diameter. Due to the damage inflicted on the residential, commercial and public buildings, some of the service pipelines were also damaged. Repairs to pipe leakage in the service pipelines were being carried by the local workers with the help of local and international NGOs.

5.9 SAME Water Supply System

5.9.1 General

The town of Same has abundant spring water due to its favorable geological formation, topography and climate. The water supply system in Same is in good operational condition with adequate water supply despite the destruction of the facilities, such as the service reservoirs, consumer service connections and administrative office (BPAM).

The water supply relies on three springs as its water sources. They are Kotalala Spring developed in 1960's by the Portuguese, the Darelau and Merbati Springs developed by the Indonesian Government in 1990 and 1993, respectively. All three springs are located uphill with sufficient height for gravity supply although some leakage was noted occurring from the transmission mains.

Presently, there are 7 personnel employed by the UNTAET District Administration in Same to operate and maintain the water supply system. They were all technicians and administrators of the former BPAM. Although a few number have not returned to their former post after the violence, the present administration still manages to keep the service to an acceptable level.

5.9.2 Water Sources

The town of Same is situated on an alluvial plain created by the Caraulun River. It has an area of high mountains over 2,000m towards northwest. The town has 3 water sources, namely: Carbulau (Darelau), Kotalala and Merbati.

a.) Carbulau (Darelau)

This water source is located about 6 km north of the town. The site of the intake can be found at an altitude of 760m amsl on the roadside leading to the town of Maubisse. The intake is located in a small stream that has no flow in dry season. Three under current streams were observed to go into the intake. The intake structure is equipped with a concrete tank and pipes to collect and transmit the water. The tank is surrounded by two concrete weirs (inner and outer) on the side of the road. The site is protected with steel fence to restrict human and animal entry.

b.) Kotalala

This water source is located about 3 km northwest of the town at an altitude of 730m amsl. The water source can be easily reached; 5 minutes walk from the car road. The main stream flows as a tributary to the Uelala River. Around the intake, it develops a small scale braided channel system. The intake is on that complex channel system and has a round concrete weir to collect two small streams. The water is conveyed to a concrete tank right downstream the intake through two pipes and distributed to the town. There is a far larger stream flowing beside the intake.

c.) Merbati

This water source is a spring situated about 3 km northwest of the town and about a kilometer west of Kotalala. The water originates as a spring (flowing out of an under current) ground and flows downstream to contribute as one of the tributaries to Uelala River. The intake is located at the left bank of the stream equipped with a concrete structure with galvanized roof (broken at the time of second visit). From this point, water is collected via 3" pipes and flows 30m downstream into a concrete reservoir, where it is then transmitted and distributed to the service area.

5.9.3 Water Supply Facilities

a.) Transmission Mains

The transmission mains of Same water supply system consist of GS pipes with numerous leaks noted during the survey. The leakage occurring in the transmission pipelines should be repaired immediately to prevent the drop in water supply. The location of the Darelau transmission main is vulnerable to natural damage such as falling tree branches. The pipeline must be properly installed including appropriate protection on pipe crossings.

b.) Storage Facilities

There are several reservoirs and break pressure tanks installed for the water supply system in Same. All of these tanks are made of reinforced concrete. Except for the Posto Reservoir, which was damaged by the violence, all the rest are in good working condition. Merbati reservoir has a 150 m3 volume, followed by Hularua reservoir with 30 m3.

c.) Distribution Network

The distribution network in Same consists mainly of GS pipes with diameters ranging from a maximum of 6-inch to a minimum of 2-inch. The reticulation is spread all over town covering a large area of the population. During the survey, several leakages were noted around the distribution area.

d.) Service Pipelines

The leakage in the service pipelines is dominant in ruined buildings, which were affected by the destruction caused by the post-referendum violence. Almost all of these connections are branched from the distribution network into ½-inch. Prior to the violence, there were about 600 registered service connections in Same. After the violence, less than half of 270 were left to be in good working condition.

5.10 AINARO Water Supply System

5.10.1 General

When the Portuguese first established the Ainaro water supply system, it relied its source from Berlesumou Spring located west of the town. This protected spring, although small in yield, produces clean and safe water. But this source was abandoned in 1989 when the Public Works Authority constructed roads and bridges in the town. The authority demolished the 3" GS transmission pipes and used them as bridge railings due to the numerous pipe leaks and its capacity becomes inadequate with the increase in water demand.

Five years later in 1994, the Ainaro water supply system was rehabilitated using surface water from Sarai River and the operation of the newly constructed water treatment plant. The operation of the WTP was stopped after several years of operation due to the lack of regular maintenance. The inadequacy of qualified technical staff and resources had aggravated the situation that has lead to the non-operation of the WTP until now.

Attempts were made to put back the WTP into operation. A grit chamber was constructed in 1997 to remove the grit and undesirable solids from entering the slow sand filter. However, due to the defects in the design such as the unstable inflow and outflow from the grit chamber, this attempt was not successful as intended. Therefore, the filters are currently used as simple channels to convey water. According to the officer in Ainaro, any significant improvement or repair work has not been carried out since then.

There are 10 workers and officers currently involve in the operation of the water supply system in Ainaro as of May 2000. They are employed by UNTAET as operators and plumbers. Out of the 10 workers, 7 persons are former staff of the BPAM Ainaro during the Indonesian Period. Three personnel are newcomers who have little experience in water supply technology and engineering. Under the current situation, they are intensively involved in repair work of the pipe network under guidance from the UNTAET officers.

5.10.2 Water Source/s

The town of Ainaro is situated at the foot of the mountain range Ramelau, which has the nation’s highest peak at Mt. Tata Mailau. Taking a closer look, the town sits on a broad ridge bounded by the Manmali and Sarai Rivers.

The town is currently supplied with water from one source located about 4 km northwest in the Sarai River. The stream originates somewhere deep in the Ramelau Mountain Range. At an altitude of 1,070m where the intake site is located, a 15-meter-wide concrete weir is constructed on the stream. Water is diverted into an intake structure equipped with a metal gate constructed on the left bank of the stream. From the intake, water is transmitted through concrete channels running 800m downstream along the edge of the broad ridge to a grit chamber at an altitude of 1030m. Since the grit chamber is presently out of service, raw water is bypassed and transmitted into a reservoir located at the WTP site.

5.10.3 Water Supply Facilities

Raw water, diverted by a weir constructed across the Sarai river, enters into concrete channel. This channel is subdivided into two: an open channel for irrigation and a box-type conduit for water supply. Due to a broken upper-slab of the conduit, turbid torrential water from the ground infiltrates into the channel resulting to the degradation of the water quality. Before flowing into the water treatment plant, the raw water passes through a 12-inch GS pipe of 12m length. The treatment plant consists of a grit chamber and two basins of slow sand filter. Due to the lack of regular maintenance raw water is bypassed from the grit chamber to a storage reservoir within the WTP site. From the reservoir, water is transmitted via 6-inch GS main into a service reservoir located west of the town. Wherefrom, it is distributed to the respective service area through 3” and 6” mains. The water supply conditions in the service area covered by this system is relatively good, although clogging due to sand accumulation in the pipes occurs.

There is another transmission main that conveys raw water from the irrigation canal to a service reservoir. This system supplies the southern area of the town. According to the officers concerned, water shortage is serious particularly in this area.

a.) Transmission Mains

The transmission mains that are used to convey water from the sources vary from concrete channels used from the Sarai intake to the WTP and GS pipes.

b.) Water Treatment Plant

The plant consists of a grit chamber having a dimension of 13m length x 3m width x 2.4m length and two basins of slow sand filter, which has a total capacity of 20 L/s. Normally, raw water coming from the river passes through this treatment facility prior to distribution. However, due to lack of regular maintenance such as thick layer of silt and clay that had accumulated in the filter media has resulted to the non-operation of the WTP. As a result raw water is bypassed from the grit chamber to the storage reservoir. Reactivation of the water treatment plant is possible once the failure/problem in the transmission channel of the raw water source is rectified. Additionally, for an effective water treatment operation, appropriate improvement works must be carried out on the grit chamber such as the construction of an overflow weir and installation of butterfly valve on the slow sand filter. However, routine maintenance work should be enhanced.

c.) Storage Facilities

During the time when the WTP was still in operation, treated water normally flows into the Kamilaran 2 reservoir where chlorine dosage is added prior to distribution. On the other hand, raw water flows into the Kamilaran 1 reservoir without any form of treatment. With the present condition, water is distributed without any form of treatment except the grit collection in the WTP.

d.) Distribution Network

During the operational period of the plant, there were two types of distribution mains carrying the treated water and the untreated water to the distribution area. Although, it is said that both are interconnected somewhere in the network, but this was not confirmed during the survey. The network mainly consists of GS pipes with diameters ranging from 6-inch to 1-inch. During the survey, it was noted that numerous pipe leakages spread all around the distribution network. The leakage spread all over the distribution network must be repaired. Additional distribution mains maybe necessary in order to carry out an effective water distribution.

e.) Service Pipelines

The leakage in the service pipelines is dominant in ruined buildings, which were affected by the destruction caused by the post-referendum violence. Prior to the violence, there were about 470 registered service connections in Ainaro. Most of the service connections were damaged due to the post-referendum violence. Twenty (20) public hydrants were so far been constructed to cover whole area of the town. However, all are currently out of service or broken mainly due to lack of maintenance.

5.11 AILEU Water Supply System

5.11.1 General

The Aileu water supply system was constructed by the Portuguese administrative government. During that period, the Naufaizaram Spring was the only water source for the town. This spring protected by a collecting chamber is still in use up to now. At that time, a single pipe of diameter 2-inch was used to transmit water from the spring to the service reservoir near the town. Due to the increase in water demand the transmission pipe was upgraded to 3-inch to increase its capacity. Several development works were also done to the system to meet with the increase in population. Additional water sources were constructed, which included the abstraction of water from Maunkri River in 1984-85 and from the Hularema River in 1987. Simultaneously, new transmission mains were constructed together with the service reservoirs to provide storage.

However, the Aileu population, still experiences water shortage especially during dry season. The plan for an additional water source was again implemented by the construction in 1998 to 1999 of an infiltration gallery on the Mantane River. The infiltration gallery appeared to be the solution to the water shortage and operated for some period. However, due to the fault in the design of the pumps and the water abstraction potential from the gallery this facility started to malfunction. At present, the infiltration gallery is not in operation due to the pump malfunction and the damages to the generator caused by the post-referendum violence. As a result, the people of Aileu is limited with the small but stable supply coming from Naufaizaram Spring and the 2 surface water sources, of which the supply is subject to seasonal fluctuations.

5.11.2 Water Sources

The town of Aileu is situated in a small basin created by the Mantane River. As discussed below, the 4 sources that supply the town's water supply system are all located in the north or northwest except the Mantane River.

a.) Mantane River Infiltration Gallery

The intake site is located beside the bridge, on the bank of the Mantane River, a tributary to the Kusiam River. Water from the river is drawn via infiltration galleries constructed in the riverbed and pumped into an intake chamber. The pumping station, which is operated by a generator set also pumps the water from the intake chamber into an elevated reservoir via 6-inch GS pipe with a distance of 2.5 km.

b.) Sloi Kraik

This water source is located about 2.5 km northwest of the town. Water from two stream of the Nunupung River is collected into the intake made of concrete. Then the water is transmitted to the Marele Reservoir at the northern edge of the town. According to the reservoir maintenance worker, the water supply is occasionally interrupted due to pipe clogging and moreover, during dry season when the stream dries up. The observed inflow into the Marele tank was about 3 L/s in Mach 2000.

c.) Naufaisaram

The intake site for this source is located about 5 km north of the town upstream the Kusiam River. The intake can be easily reached by walking from a small community located on the road to Dili. A small concrete housing is found in a tiny stream. There is a concrete tank inside and the water flows out of the concrete lattice filter.

d.) Hularema

The site of the intake is located about 3.5 km northwest of the town. It can be approached on foot in 15 min from the reservoir tank. There is a crude intake structure made with concrete and rocks. It is built on an outcrop of hard rock, which serves as a natural weir. From the intake water is then transmitted into the Hularema tank located 1 km downstream on a small hill. Water inflow into the tank was estimated at 2 L/s.

5.11.3 Water Supply Facilities

a.) Transmission Mains

The old transmission mains of the Aileu water supply system has undergone a series of development in consistent with the increase in water demand. From one transmission pipeline carrying water from a single source, it was increased to the current number of 4 transmission mains conveying water from 4 different sources.

b.) Pumping Station

The Mantane River Pumping Station was constructed for the purpose of drawing water from the infiltration gallery and pumping it up to the elevated reservoir located west of the town. This station is equipped with two centrifugal pumps (1 – duty and 1 – standby) and a standby diesel generator.

The electrical facility in the Mantane Pumping Station was installed in 1997 using power supplied by PLN for its normal operation. In the event of power outages from PLN, the emergency generator is activated. After the post-referendum violence, the generator has lost its function.

c.) Storage Facilities

There are four reservoirs, each corresponding to each water source. The largest is a Government Housing reservoir with a 200 m3 volume, followed by a 120 m3-Hularema reservoir. The water leak that occurs in the Hularema reservoir must be repaired to prevent further water loss. This tank and the 3 other reservoirs must be regularly cleaned and maintained. The tanks appear to be structurally safe.

d.) Distribution Network

The distribution network in Aileu is composed of GS pipes with diameter ranging from 3-inch to 1-inch. During the survey, it was found out that numerous pipe leaks occur in the reticulation, mostly in joints and valves. The local workforce with the assistance from the Portuguese government was engaged in the repair work of the pipeline.

e.) Service Pipelines

Service pipelines are directly tapped from the distribution using clamp and saddle branch to a diameter of ½-inch. During the survey, pipe leakages were noted around the service area. The repair of the service connections and pubic taps are included in the network repair project funded by the government of Portugal.

5.12 MAUBISSE Water Supply System

5.12.1 General

Maubisse has one of the coldest climates in East Timor, mainly due to its high location at an average elevation of 1,430m above mean sea level (amsl). It is one of the sub-districts of Ainaro, with a present population of approximately 7,000. Coffee is the major agricultural product of Maubisse aside from the abundance of fruits and vegetables that the people produce in a small-scale quantity mainly for local consumption. The town of Maubisse, located about 71 km south of Dili is one of the towns that suffered less damage during the post-referendum violence.

The water supply system of Maubisse was developed both by the Portuguese and Indonesian administrative government. The sources of water supply in Maubisse are four springs in which majority of the consumers are supplied from the high-yield Erulu Spring located just a few hundred meters from the service area. The other three springs supply mainly the consumers living in the higher elevation and those outside of the Erulu service area. Problems to the existing system noted during the survey were mainly on the distribution and transmission network, such as leakage and damage to a particular section of the pipe. There is no maintenance being carried out on the system due to lack of materials, pipes and fittings. Most of the leaks have been left not repaired.

5.12.2 Water Sources

The town has four water sources within 2 km radius to the north and northwest.

a.) Erulu

The Erulu spring is located close to the service area, about 50m off the Aileu-Maubisse road at an elevation of about 1,450m. Due to its location, this water source supplies the low-lying areas of Maubisee. The spring is found at the foot of coffee farm. The water comes out from the ground into a concrete intake box equipped with several outlet pipes that distribute water to lower elevations of the service area.

b.) Raikuak Ulun

This spring is located about 2.5 km west of the town. The intake is located on a gentlly sloping farmland beside a small stream. The water seeps out from below the farm forming a small stream. The intake is equipped with 1-inch GS pipe placed under the topsoil of the farm. The water is transmited into the Leputo concrete chamber, located a few kilometers downstream

c.) Bucana

The Bucana Spring is located about 1.5 km from the town, and approximately 1.5 km downstream of Raikuak Ulun. The intake is found on a gentle slope on the foot of a large limestone cliff. The water seeps out from under a coffee farm through a pipe and flows down as a small stream, where it is collected into the concrete intake box. The intake is equipped with 2-inch GS pipe to transmit the water into the Pousada Reservoir in the town area. Similar to the Raikuak Ulun Spring, this water source is primarily used to supply the high elevation water consumers.

d.) Filmou

The Filmou Spring is located about 1 km north of the town in the upstream of the Bederi River. The intake is on a steep slope between two small streams that meet right downstream the intake. A concrete intake tank is built at the point where water seeps out from the slope. The water is transmitted to the town through two small reservoir tanks located nearby. Due to the damage on the pipes and the storage reservoir, consumer supplied from this source is limited to a small number of people residing close to the spring.

5.12.3 Water Supply Facilities

a.) Transmission Mains

Improper installation of the pipe that makes them vulnerable to damage is the major cause of failure for the transmission pipelines in Maubisse. The transmission pipe that is used to transmit water from the Erulu spring to the reservoir is damaged. As a result, there exist water shortage in Maubisse. Water leaks are also dominant in the mains that transmit water from other sources. Numerous service connections could be found along the transmission main especially the main from Bucana.

b.) Storage Facilities

The three storage facilities constructed in strategic locations in Maubisse are all made of reinforced concrete. They appear to be structurally safe.

c.) Distribution Network

The distribution network of the water supply facilities in Maubisse is made up of GS pipes with diameters from 2-inch to ¾-inch. The pipes are mostly exposed on the side road without appropriate cover protection. During the survey, it was found out that numerous pipe leaks occur in the reticulation.

d.) Service Pipelines

Service pipelines are directly tapped from the distribution and transmission lines branch to a diameter of ½-inch. During the survey, pipe leakages were noted around the service area particularly on few damaged buildings.

5.13 GLENO Water Supply System

5.13.1 General

Gleno is one of the towns in the Ermera District situated in the mountainous part of East Timor about 40 km. south of Dili. The town could be reached from Dili by travelling westward through a 12-km plain and smooth road and traversing southward to another 28-km steep mountain slopes uphill. This rice-producing town was founded during the Indonesian Regime, and became the seat of government of the district.

The water supply system in Gleno was established by the Indonesian Government in 1982-1983 during its establishment as the seat of government in the Ermera District. The system is gravity based having its sources at about 5-7 km uphill and flows into the WTP before distribution to the water consumers.

5.13.2 Water Sources

The town of Gleno is situated in a small basin drained by several rivers coming from the south and east flowing westward to form the Gleno River. The town water supply comes mainly from two rivers; Mota Boot (Mauceum) and Mota Kiik (Borhei) and another spring called Ergrogo.

a.) Mota Boot

This water source is located in a large stream popularly called Mota Boot (Mauceum River) at an altitude of 1,015m amsl. The intake structure can easily be reached due to its close proximity (less than 50m) from the main road leading to the town of Ermera. The river is rocky and steep and has a big flow, although it appears that only a small fraction of it is being utilized to supply the town. A 3.5-meter-wide concrete weir is constructed along the stream where the water is transmitted through a pipe into an intake structure at the right bank of the stream. However, during the survey, this water source was out of use due to the broken pipe, possibly due to a flood of the river.

b.) Mota Kiik

This water source is found in a small stream popularly called Mota Kiik (Borhei River). It is about 300m away from Mota Boot on the same road leading to Ermera. The intake structure can also be reached from the main road less than 50m distance. The stream is narrower and steeper than Mota Boot. The intake structure is equipped with a stone-made weir, where water is collected through a pipe that is joined to a Tee 4”x 6” along the side road into the transmission main coming from Mota Boot.

c.) Ergrogo

The intake is located on a mountain slope inside the catchment of Mota Boot at 70m higher place. It can be reached in 15 min. by following a foot path from the bridge over Mota Kiik. Water is flowing out under a rock and a concrete tank is built right at the spring to collect the water. The water is distributed through two pipes one of which only goes to a nearby community. During the survey, it was reported that this source is out of use due to the damage of the pipe.

5.13.3 Water Supply Facilities

a.) Transmission Mains

GS pipes are used to tansmit raw water to the WTP, 6-inch in diameter and 9 km in length from Mota Boot intake and 3-inch and 6 km pipe from Ergrogo intake. The cause of the damage to two of the transmission mains is floodwater that washed certain section of the pipelines. These transmission mains installed without appropriate protection are located in areas subject to damage both natural and man-made. As a result, there is a drop in water production for the water treatment plant. Unless the mains are realigned in a safer location, they become vulnerable to damage.

b.) Water Treatment Plant

The Gleno water supply system is equipped with a slow sand filter unit having a designed capacity of 10 L/s. It is constructed of reinforced concrete at a higher elevation about 1.5 km away from the service area. The water treatment plant in Gleno appears to be structurally safe although there is a danger of possible water contamination because the facility is not well protected. The plant, which is close to the populated area, has no secured fencing thereby creating unlimited access by the people and animals to the plant. Routine maintenance to this plant must be enhanced to improve water treatment operation.

c.) Storage Facilities

The two storage facilities with storage capacities of 400 and 300 m3 each, appear to be structurally safe. The storage facilities were constructed close to the WTP and are made up of reinforced concrete. The tanks are not equipped with ventilation system, flow meter, control valve and water level gauge.

d.) Distribution Network

The distribution main is 6-inch in diameter made up of GS pipe. This branches into smaller diameter down to a minimum of 1-inch. Numerous pipe leaks were noted during the survey. Repair works especially on the leaks were being done with the help of NGO such as ACF.

e.) Service Pipelines

Most pipe leaks in the consumer service connections are dominant in the ruined residential and public buildings. A large amount of water loss is coming from these leaks that the local workers find difficulty to repair. It is time consuming to locate the pipes in the damaged buildings because no plans are available.

5.14 ERMERA Water Supply System

5.14.1 General

Ermera is a mountainous district and one of the highest coffee-producing regions in East Timor. During the post-referendum crisis, this district and the town of Ermera suffered major destruction. During the Portuguese Regime, the town of Ermera was the seat of government of the Ermera District. However, in 1982, the Indonesian Government created a new town and transferred its district seat to the plain area about 12 km north of Ermera called Gleno.

The existing water supply system in Ermera is gravity-based getting its supply from uphill river and springs. At present, Ermera town is experiencing water shortage due to pipe leakage, which are dominant in the distribution system. There is no maintenance being carried out on the system particularly on the distribution and also in the transmission pipes due to lack of materials, pipes and fittings. Repairs on the leaks using rubber is commonly practiced, but this measure is just temporary resulting to a recurring problem.

5.14.2 Water Sources

Ermera is a small town situated on a broad ridge at an altitude of 1,100m amsl. The town is supplied from two main low-yield sources as discussed below. However, one other spring (Lubulala) is exploited to supply the sister's convent and limited households nearby.

a.) Ersoi

The spring is located about one kilometer to the west of the town. The water source is found up on the mountain slope no more than 300m away from Lubulala spring at an altitude of 1,390m amsl. Water seeping out from the ground at two separate points on the right bank of a small stream is collected by placing a pipe at their outlets. The water collected through pipes go into two separate concrete intake boxes.

Apparently, the intake structures are located in a flood-prone zone of the mountain slope that had caused damage to the concrete tank and pipes. During the survey, it was observed that one of the tanks had shifted from its original location. According to the local source the nearby stream dries up during the dry season but the spring continues to flow with a small drop in its yield.

b.) Mota Bura

The intake site of this source is located 800m southwest of the town at an altitude of about 1,235m amsl. It can be reached by walking 300m westward from the main road. The main stream is one of the tributaries of the main Bura River. The water that flows out from a grassy mountain slope is collected into a concrete intake tank. The tank is protected by a broken wire fence and equipped with a V-notch weir.

c.) Lubulala

This water source is located up on the mountain slope at an altitude of 1,450m amsl, more than a kilometer west of the town. Water seeping out from the ground at the right bank of a small stream, is collected through pipes into a concrete intake boxe located right under the spring. There is another tiny stream flowing down a few meters away from the spring. This water is conducted through a bamboo to a nearby community.

5.14.3 Water Supply Facilities

a.) Transmission Mains

The Ermera water supply system is among the many systems in East Timor that is equipped with unreliable transmission mains. The mains installed in unsafe location of the river banks are normally subjected to the dangers of flood waters oftentimes creating serious damage to the pipes. In most cases, repairs to the damaged pipelines are left unattended for a certain period due to the unavailability of materials, tools and spare parts. As a result, it creates serious water shortage to the town's water supply.

The transmission mains is composed of GS pipes of diameter 2-inch. During the survey, it was noted that the numerous pipe leaks were repaired using rubber.

b.) Storage Facilities

Two storage facilities with total capacities of 85 m3 in Poetete, Ermera were constructed in the strategic location of the town during the Portuguese administration period. They are made up reinforced concrete and seem to be structurally safe.

c.) Distribution Network

The distribution network of the Ermera water supply system is made up of GS pipes with diameters ranging from 4-inch to 1-inch. There exists some difficulty in carrying out maintenance works particularly the repair of the leaks and damages in the pipelines due to the lack of materials, spare parts and appropriate tools for the workers. The leakage spread all over the distribution network is most often left unattended and sometimes repaired temporarily using rubber.

d.) Service Pipelines

The consumer service connections in Ermera are completely in GS pipes branched from the distribution network by using a tee mostly in ½-inch. Pipe leaks are evident in the service connections because the repairs are done using rubber. The local workforce had started the repair of the service connections and public taps, however due to lack of resources some still remains unattended.

5.15 LIQUICA Water Supply System

5.15.1 General

Liquica is a coastal town about 34 km west of Dili and the seat of government for the Liquica District. The dispersed urban area of the town of Liquica is divided into 2 parts, namely: old town, west bank of Mota Goularloa River and built during the Portuguese time, and new town, east bank of the said river and built during the Indonesian time. The present population of Liquica town is about 11,600. There are 3 major rivers that drain the town, namely: Carbutaeloa River – eastern part, Goularloa River– central, and Laclo River – western part.

The water supply system of Liquica was developed by the Portuguese and the Indonesian governments. The water sources derive from surface water and a number of wells drilled on the nearby Mota Goularlua and close to the service area. Except those that are abstracted from the Laclo River, all other sources had been abandoned and currently non-operational. Causes of the inoperability and abandonment of the sources include high turbidity of the surface water, erosion of the riverbanks that had washed out the intake structures and transmission mains and major damage on the boreholes and pumping facilities. Right after the post-referendum violence, NGO had tried to restore the system. One of the existing boreholes (Maumeta 2) was attempted to be put back into operation but failed with no clear cause of failure identified. Development of a new spring was successfully completed, which serves as the main source of water supply for the town of Liquica at present. Although, the system has been restored to some extent with limited service area, still major improvement has to be undertaken to have an efficient, safe and sustainable water supply system in Liquica.

At present, there exists an acute water shortage in Liquica because only two out of the more than 10 water sources are in operation. Most of the town's population who are deprived of the safe, piped water supply are becoming miserable in getting water from available sources.

5.15.2 Water Sources

The downtown area is at the mouth of the Goularlua River. Since the mountains are very close to the shoreline, and the alluvial fans are formed at the mouth of the river, this town sits on top of the fan that tilts towards the sea. The town's water supply comes from 8 intakes of surface water, 1 spring and 4 wells. All of the 4 wells are currently abandoned due to the damages on the well and pumps. Most of the surface water sources have damages on their pipelines and intake structures.

a.) Liquica Wells

Liquica is divided into two areas hydrogeologically. One is the area covering Dato and Maumeta, the other one is the eastern side of Maumeta along the Enela (Carbutaelua) River. In the former area, the water level is observed at about 40m below ground level. The aquifer occurs below the level up to about 70m in depth. In the latter area, the aquifer also occurs between 30m and 70m in depth approximately. The geophysical survey conducted in October and November, 2000 and explained in Appendix B indicates this layer is likely more permeable and has higher groundwater potential.

All of the 4 wells in Liquica were drilled in the alluvial fan of Goularlua River. The catchment area at Goularlua is about 14.8 km^2. The existing conditions of the wells are briefly described below.

- *Dato 1:* Drilled depth = 84m Designed discharge rate = 5 L/s
  Remarks: Located at the left bank of the river equipped with concrete reservoir and a metal tank. Presently, the well has been removed of its piping system and completely filled with stones.
- *Dato 2:* Drilled depth = 82m Designed discharge rate = 2.5 L/s
  Remarks: Located at the left bank, close to the river. Presently, the well had been removed of its piping system and completely filled with stones.
- *Maumeta 1:* Drilled depth = 84m Designed discharge rate = 5 L/s
  Remarks: Located at the right bank of the river, equipped with pipes and concrete reservoir. The top of the casing is currently sealed.
- *Maumeta 2:* Drilled depth = 84m Designed discharge rate = 10 L/s
  Remarks: Located at the right bank of the river complete with pumps, piping system and electrical installation. After the conflict, Oxfam tried to reactivate the well and operated the pump for a short period and stopped for some reasons and completely out of operation until now.

b.) Narlolo

The water source is located about 2 km south of the town center in a stream of the Tangkmom River. The stream is conducted with a stone-made weir and equipped with a pipe placed on the gravel-bed to collect the water into the concrete intake structure located about 20m downstream. The intake was rehabilitated by NGO in August 2000 and they also built another intake for rainy season use about 100m downstream.

c.) Metagou

The water source is located 6 km southeast from the town center in a small stream of Mamarai and its branch streams. Water is collected from two small concrete intake weirs. One intake is located a few tens of metes upstream from the other. The water is conducted to a reservoir tank located close to the downstream intake through pipes. Although the transmission line was replaced with plastic one by NGO the situation still remain precarious.

d.) Others

There are other water sources, situated a few km upstream from the town. These are now out of use due to damages resulting from floods.

5.15.3 Water Supply Facilities

a.) Transmission Mains

One of the major causes of water shortage in Liquica is due to the unreliable transmision mains. Most of these mains constructed in unsafe location of the river banks without appropriate protection are normally subjected to the dangers of the flood waters causing serious damage. As a result, only 1 out of the 9 transmission pipes that were installed to transmit water from the 9 surface water sources to the town's reservoirs are currently in use creating serious water shortage in the town. To minimize damage, the transmission mains must be realigned and located in a safe position less vulnerable to damage. Workers from the former BPAM with the help of NGO carried out repair work on the Emilaloa intake and transmission main resulting to an increase in water productivity for Liquica water supply system.

b.) Storage Facilities

The reservoirs constructed in the different parts of the town appear to be structurally safe, except for the absence of regular maintenance.

No.	Name/ Location	Water Source	Vol. (m3)	Remarks
01	Serlema	Daulo & Ean Lua	170	Not in use because no supply from source.
02	Mean	Serlema Reservoir & Narlolo Spring	150	In good working condtion.
03	Kodim	Mean Reservoir	130	In good working condition.
04	Ramtau	Lilabu & Laclo intake	120	Not in use because no supply from source.
05	Raitogoto	Emilalua intake	50	Not in use because no supply from source.
06	Mauboki	Raitogoto	20	Not in use because no supply from source.
07	Maumeta	Metagou, Raesape, Maumeta & Dato wells	75	In good working condition with supply coming from Metagou.
T O T A L			715	

c.) Distribution Network

The distribution pipelines of the Liquica water supply system consist mostly of GS pipes with diameter ranging from 3-inch to 1-inch. It is widely spread around the old and new towns coming from different sources. Generally, there exists an acute water shortage in Liquica since only two water sources are in operation. During the survey, the pipes appear to be in good condition, although a good assessment on water tightness such as pipe leaks could not be made because of the water shortage. All the public hydrants surveyed in the distribution network are either broken or no water is available. Gate valves in the distribution pipelines were broken especially those installed in the water sources that are currently out of service or were damaged during the post-referendum violence.

d.) Service Pipelines

From among the more than 200 service connections previously served by the water system in Liquica only a few percentage is now getting piped water supply. Others are getting water from other sources such as nearby rivers. Most of the service connections are in GS pipes of diameter ½-inch. Although, no pipe leaks were noted during the survey, it appears that the pipelines are in good condition, except those that were damaged together with the buildings.

5.16 SUAI Water Supply System

5.16.1 General

Suai is the capital town of the Cova Lima District where the seat of government is located. The district is the southwesternmost part of the country and borders with West Timor. It suffered massive destruction during the post-referendum violence especially to the public buildings and residences.

Suai, which is a coastal town facing the Timor Sea could be reached by road transport via Aileu and Ainaro traversing very steep and unstable mountain slopes. The water supply system of Suai developed during the Portuguese and Indonesian periods has several surface and groundwater sources. Part of these sources is currently non-operational for reasons such as high turbidity levels, damaged transmission mains, and unfinished pipe connection to the system. Although repairs to the system is currently being carried out with the help of international NGO such as Oxfam, two of the boreholes had been put back to operation by the replacement of the damaged generator sets and pumps. The only treatment applied to the water supply in Suai is chlorination, which is dosed at the Hospital Reservoir and booster pumping station.

For security reasons, the field survey on the water supply system of Suai was conducted by the local counterpart.

5.16.2 Water Sources

The town of Suai sits on a gently sloping surface of a Quarternary coastal deposit. The town's water source comes from the catchment of the Karaulun River. The river flows down in the direction of NW-SE to the north of the town. It flows nearly straight down toward the sea gently meandering and meets its main tributary to the east of the town 1.5 km from the river mouth.

According to the survey result conducted by the team of East Timorese trained by the JICA Study Team, Suai obtains water to supply its reticulated water supply system from six sources. The six water sources in Saui consist of 2 wells, 2 springs and 2 surface waters.

The 2 wells were drilled in the western area of the town called Sukabilaran well field. The pumping rate of these wells is reported to be 6 L/s. The catchment area is estimated at 39.0 km^2.

The 2 springs (Olivio and Maugusu) are located somewhere in the eastern area of the town. Inflow into each intake structure of the springs is a few liters per second.

The two intake sites for the surface water sources (Ameriko and Kuluai) are said to be located in the northwestern tributaries of the main Karaulum River. This river drains the town originating from several tributaries in the north and northwestern mountains of Suai towards the Timor Sea. One of them is not used at present. Another abstraction from the surface water is the intake said to be located at Ameriko River. However, this reported source cannot be traced in the scale 1:25,000 topographic map. And as such the catchment area could not be computed.

5.16.3 Water Supply Facilities

a.) Transmission Mains

There is no significant problem on the transmission mains of Suai, except for few damages and leaks along the pipelines. Workers of the former BPAM and NGO were actively working on the repairs of the water supply facilities including the transmission mains.

No.	Transmission Main (From – To)	Material	Diameter (inches)	Length (m)	Remarks
01	Olivio – Bereluik Reservoir 2	GS	2	3,800	In use
02	Maugaso – Bereluik Reservoir 1	GS	2	3,500	In use
03	Ameriko – Bereluik Reservoir 2	HDPE	4	3,500	In use (some parts leak)
04	Kuluai – Bereluik Reservoir 1	GS	3	7,000	Not in use due to some missing sections of pipe.
05	Sukabilaran 1 – Hospital Reservoir	HDPE	4	3,000	In use
06	Sukabilaran 2 – Hospital Reservoir	HDPE	4	3,200	Not in use
07	Hospital Reservoir – Leugore Reservoir 2	HDPE	4	500	In use
08	Bereluik1 – Leugore Reservoir 1	GS	3 2	5,000 5,000	In use
09	Bereluik 2 – Leugore Reservoir 2	HDPE	3	5,000	In use

b.) Pumping Stations

- *Sukabilaran 1*

Sukabilaran 1 pumping station operates for the Sukabilaran 1 well. It is equipped with a set of generator and submersible pump with the present capacity of 6 L/s. Water from this well is pumped via 4-inch transmission pipe into the Hospital Reservoir for storage. The old electrical and mechanical facilities installed during the Indonesian time were destroyed during the post-referendum violence. NGOs carried out rehabilitation works on this pumping station including installation of generator set. Due to lack of resources, operation of this well is limited for a few hours per day.

- *Sukabilaran 2*

The extensive damage caused by the violence to the pumping facilities and electro-mechanical equipment had rendered this well unproductive. However, through the effort made by the PKF, this well has been put back into operation on temporary basis. A mobile pumping equipment and generator set are used to draw water from this deep well and pumped into the water truck for distribution to the water consumers in Suai.

- *Hospital Pumping Station*

This pumping station is equipped with booster pump that pumps water from the Hospital Reservoir to the Leugore 2 Reservoir located at the higher elevation of the town. From the Leugore Reservoir, water then flows by gravity mostly to the consumers located in the high zone of the service area. NGO carried out rehabilitation works to this pumping station by the installation of generator set and other facilities making this operational.

c.) Storage Facilities

The Suai water supply system is equipped with storage reservoirs strategically located in the service area that provide storage and supplies water to the consumers in the high and low zones. The reservoirs constructed in the different parts of the town appear to be structurally safe. However, these reservoirs are not effectively used due to the limited supply from the water sources.

No.	Name/ Location	Water Source	Vol. (m3)	Technical Specification	Remarks
01	Hospital Res.	Sukabilaran 1 & Sukabilaran 2	196	Circular: ø 10m x 2.5m height Made of steel with vinyl coating.	Australian made tank In use
02	Leugore 1	Bereluik 1	90	Rectangular: 6m x 5m x 3m Made of reinforced concrete.	Old Portuguese tank Not in use
03	Leugore 2	Bereluik 2 & Hospital Res.	96	Circular: ø 7m x 2.5m height Made of steel with vinyl coating.	Australian made tank In use
04	Bereluik 1	Olivio & Ameriko springs	180	Rectangular: 7.4m x 5.5m x 5.0m Made of reinforced concrete.	Old Portuguese tank In use.
05	Bereluik 2	Maugusu & Kuluai springs	96	Circular: ø 7m x 2.5m height Made of steel with vinyl coating.	Australian made tank In use
TOTAL			658		

d.) Distribution Network

The distribution network of Suai previously used a variety of materials with diameters ranging from 4-inch to a minimum of 1-inch. The old network is predominantly made up of GS pipes, but the use of PVC and HDPE was introduced lately. Although the system appears to be in good condition, pipe leakages are still visible around the area. Extensive repair work was being carried out by the local workforce with the assistance from NGO. Pipe leaks and damages were attended resulting to an improved water distribution to the consumers of the town since the post-referendum violence.

e.) Service Pipelines

The service pipelines are mostly in GS pipes but the use of HDPE was lately introduced. Leaks to the consumer service connections are most evident in ruined buildings. The repairs of the service connections and public taps are also part of the rehabilitation project funded by international and local NGOs and other donor countries such as Australia. The local work forces were engaged on this project.

5.17 MALIANA Water Supply System

5.17.1 General

The town of Maliana is the administrative capital of Bobonaro District, which was first developed on a western gentle slope of Mt. Madilwa. During the time when the water supply system of Maliana was established by the Portuguese it was constructed using 3 gravity systems, extracting water from Galusapulu, Dabucci, and Aikumu springs. This system was constructed separately to supply water to the people particularly in the town center. After several years, the Galusapulu system was abandoned because the capacity of the existing transmission main was inadequate to supply the increasing water demand.

During the Indonesian period, the residential area expanded towards the western alluvial plain settling between Sosso and Buipira Rivers. Town population increased significantly in parallel with the town's development.

To cope with the increase in water demand, new water sources were developed to include water abstraction from the irrigation canal, from Colegio Spring and Beremau Stream. The water from the irrigation canal passes through the water treatment plant before distribution to the water consumers. Adding the 3 new sources, the present water supply system in Maliana has a total of 5 sources.

During the last post-referendum violence, the packaged-type water treatment plant suffered extensive damage especially to the pumping facilities, electro-mechanical equipment, laboratory and storage facilities resulting to the non-operation of the WTP. However, NGO's carried out repair works to the plant by bringing it back to operation.
There is no significant problem on the transmission mains of Suai, except for few damages and leaks along the pipelines. Workers of the former BPAM, Oxfam and Bia Hula are actively working on the repairs of the water supply facilities including the transmission mains.

For security reasons, the field survey and investigations on the water supply system of Maliana was conducted by the local counterpart.

5.17.2 Water Sources

According to the water resources survey conducted by the local staff, the Maliana water supply system is supplied with water from different sources, namely: Aikumu spring, Colegio spring, Beremau spring, Dabucci springs (Dabucci, Beapelu and Beamos) and the irrigation canal. The Aikumu and the Colegio springs are reported to be sensitive to seasonal fluctuations in which the flow substantially drops to nil in the dry season. The Beremau spring and Dabucci spring group have reportedly sufficient and reliable flow all-year round. Adequate flow could be abstracted from the irrigation canal, located less than a kilometer from the town center.

5.17.3 Water Supply Facilities

a.) Transmission Mains

There is no significant problem on the transmission mains of Suai, except for few damages and leaks along the pipelines. Workers of the former BPAM and NGO were actively working on the repairs of the water supply facilities including the transmission mains.

No.	Transmission Main (From – To)	Material	Diameter (inches)	Length (m)
01	Beremau Intake – Moduklaun Reservoir	Galvanized Steel	6	6,000
02	Moduklaun Reservoir – TV Station Reservoir 1	Galvanized Steel	6	1,000
03	TV Station Reservoir 1 – TV Station Reservoir 2	Galvanized Steel	3	1,000
04	TV Station Reservoir 2 – Sta. Cruz Resservoir	Galvanized Steel	3 + 2	800
05	Aikumu Intake – Moduklaun Reservoir	Galvanized Steel	3	3,000
06	Dabucci Springs – Lahomea Reservoir	Galvanized Steel	3	2,000
07	WTP – Sta. Cruz Reservoir	Galvanized Steel	6	700
08	Colegio Intake – Colegio Reservoir	Galvanized Steel	1	5,000

b.) Water Treatment Plant

River water from the offtake at Bulobu flows down into town area through a concrete channel. From the open channel at Buepira, raw water is abstracted by pumps into the packaged-type water treatment plant for water supply to the town's population. About 7 L/s is abstracted from the channel for treatment prior to distribution. This treatment plant is composed of the following processes: flocculation, sedimentation and filtration. The production output of this plant is being pumped into the reservoir at Sta. Cruz and distributed to the water consumers in the service area.

The electrical facility of the this WTP was using the power supplied by PLN at 380/220V, 50Hz for its normal operation. This plant was equipped with an emergency generator that activates in the event of power outages from the PLN. After the violence, all the generators have lost their function. But it is working well with the assistance of PKF.The list and description of the electrical facility of this plant with the existing condition are shown in the table below.

Equipment	Specification	Condition
Watt-hour Meter Box	Type: Outdoor wall mounted	In operation
Genarator Panel	Type: Indoor wall mounted	Apparently broken.
Main Power Switch Panel	Type: Indoor wall mounted	Broken. Wires are removed.
Generator		In operation
Pump Mixer Panel	Type: Indoor wall mounted	Rusty, dirty but usable

c.) Storage Facilities

The reservoirs constructed in the different parts of the town appear to be structurally safe. Except for the AusAID-funded tanks, these facilities are not equipped with flow meter, control valve, ventilation and water level gauge. All of them are still in use even those constructed during the Portuguese Period. However, adequate security fence must be constructed around the facility in order to prevent the water supply from contamination.

No.	Name/ Location	Water Source	Vol. (m^3)	Technical Specification	Remarks
01	TV Station 1	Muduklaun Aikumu	90	Rectangular: 8.20m x 6.20m x 1.80m Made of reinforced concrete	In working condition
02	TV Station 2	TV Station 1	360	Rectangular: 12.0m x 12.0m x 2.50m Made of reinforced concrete	In working condition
03	Muduklaun	Beremau	230	Rectangular: 9.0m x 8.5m x 3.0m Made of reinforced concrete	In working condition
04	Santa Cruz	TV Station 2 Lahomea, WTP	95	Rectangular: 8.20m x 5.50m x 2.15m Made of reinforced concrete	In working condition
05	Lahomea	Dabucci springs	70	Rectangular: 5.50m x 6.30m x 2.10m Made of reinforced concrete	In working condition
06	Colegio	Colegio	20*	Rectangular: 6.00m x 2.30m x 1.50m Made of reinforced concrete.	In working condition *Used for the Colegio community water supply system.
TOTAL			845		

d.) Distribution Network

The distribution network of the Maliana water supply system consists of GS pipes with diameters ranging from 6-inch to 2-inch. As per the survey done by the local staff, repair works were extensively carried out by NGO normally replacing the leaking and damaged pipes with HDPE. Pipe leaks and damages were attended resulting to an improved water distribution to the consumers of the town since the post-referendum violence.

e.) Service Pipelines

The service connections are directly branch out from the distribution lines to a diameter of ½-inch. The repairs of the service connections and public taps are also part of the rehabilitation project funded by international and local NGOs and other donor countries such as Australia.