

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

No. 41

THE KINGDOM OF CAMBODIA
PHNOM PENH WATER SUPPLY AUTHORITY

**THE STUDY
ON
PHNOM PENH WATER SUPPLY SYSTEM
IN
THE KINGDOM OF CAMBODIA**

FINAL REPORT

VOLUME 1 : SUMMARY

NOVEMBER 1993

TOKYO ENGINEERING CONSULTANTS CO., LTD.
in association with
NIHON SUIDO CONSULTANTS CO., LTD.

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PREFACE

In response to a request from Cambodia, the Government of Japan decided to conduct a Study on Phnom Penh Water Supply System in Cambodia and entrusted the study to the Japan International Cooperation Agency (JICA).

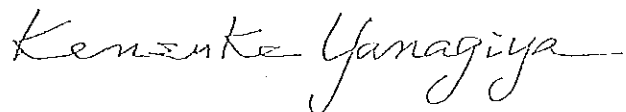
JICA sent to Cambodia a Study Team headed by Mr. Heiichiro Makino, Technical Advisor, Tokyo Engineering Consultants Co., Ltd. and composed of members from Tokyo Engineering Co., Ltd. and Nihon Suido Consultants Co., Ltd. 3 times between February 1993 and November 1993.

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

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

I wish to express my sincere appreciation to the officials concerned of the Royal Government of Cambodia for their close cooperation extended to the team.

November 1993



Kensuke YANAGIYA

President

Japan International Cooperation Agency

THE STUDY
ON
PHNOM PENH WATER SUPPLY SYSTEM
IN
THE KINGDOM OF CAMBODIA

November, 1993

Mr. Kensuke YANAGIYA
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit herewith the Final Report entitled "THE STUDY ON PHNOM PENH WATER SUPPLY SYSTEM IN THE KINGDOM OF CAMBODIA".

This report has been prepared by the Study Team in accordance with the contract signed on 21 January 1993, 10 August 1993 and 26 November 1993 between the Japan International Cooperation Agency and the Joint Venture of Tokyo Engineering Consultants Co., Ltd. and Nihon Suido Consultants Co., Ltd.

The report consists of the Summary in English and Japanese, the Main Report in English, the Urgent Rehabilitation Project Portion in English, and the Appendix in English. The Summary summarizes the result of all studies concisely and clearly includes conclusions and recommendation. The Main Report contains results of survey, analysis and explains about Master Plan. The Urgent Rehabilitation Project Portion explains about Urgent Rehabilitation Projects, and finally. The Appendix includes data, technical details and results of investigations.

All member of the Study Team wish to express grateful acknowledgement to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Health and Welfare, Embassy of Japan and JICA in Cambodia, and also to the officials and individuals of the Royal Government of Cambodia for all assistance extended to the Study Team. The Study Team sincerely hopes that the results of the study will contribute to the urgent rehabilitation and improvement of health and sanitary conditions of people in Phnom Penh City.

Yours faithfully,



Heiichiro MAKINO
Team Leader

EXECUTIVE SUMMARY

1. Present Situation and Problems in Phnom Penh Water Supply System

Phnom Penh City waterworks had the production capacity of 140,000 m³/d and the distribution system to meet the demand. But because of the deterioration of its facilities caused by the destructive activities and the poorest maintenance, the production capacities has decreased to 63,000 m³/day. As a result, the area has been served with low pressure water; The pressure is below 0 m in the 28% of the area and between 0 and only 2.5 m in the 44% of the area. At present, leakage level is 50% in the 276.85 km long distribution pipe. Due to the low pressure, waste water and rain water could enter into the pipe. This phenomenon has caused high water-born diseases.

There are only about 2,300 working meters in the total billed number 24,000, and revenue ratio is as low as about 20%. The deficit of water supply authority in 1992 is about 809 million Riels. Thus the Phnom Penh city waterworks needs the urgent rehabilitation and expansion works so as to anticipate the sustainable development.

2. Master Plan

The target year is 2010. The existing water service area of 77.75 km² (inside area 28.70km² and suburban area) will be the service area for the target year 2010 as well. The water demand is estimated as below.

WATER DEMAND

Year	1992	1995	2000	2005	2010
Served population	532,160	607,710	752,410	957,418	1,254,143
Per Capita Demand (daily average), (lpcd)	200	240	250	250	250
Per Capita Demand (daily maximum), (lpcd)	260	312	325	325	325
Daily Average Demand (m ³ /day)	106,432	145,850	188,103	239,355	313,536
Daily Maximum Demand (m ³ /day)	138,362	189,605	244,533	311,161	407,596
Leakage Ratio (%)	50	50	40	30	20

Population is projected based on the average growth rate of 6% per annum during the past stable era. The current per capita consumption and leakage ratio were obtained from

the measurement. On the other hand, future ones are determined based on the figures in the neighboring countries.

Development plan is set as follows:

PRODUCTION CAPACITY

						Unit : m ³ /day
Treatment Plant	1992	URW Phase 1 Rehabilitation	URW Phase 2 Expansion	EW Stage 1	EW Stage 2	Total
Phum Prek						
Present	56,000					
Improvement		44,000				
Expansion			50,000			150,000
Chamcar Morn						
Present	7,000					
Improvement		3,000				
Expansion		10,000 ^{*1}				20,000
Cham (Proposed)	-	-	-	65,000	65,000	130,000
Total						
Present	63,000					63,000
Improvement		47,000				47,000
Expansion		10,000	50,000	65,000	65,000	190,000
Cumulative	63,000	120,000	170,000	235,000	300,000	300,000

*1 by French government

To correspond to the extension of the production facilities, the existing distribution facilities is needed to improve and extend as well.

2.1 Urgent Rehabilitation Works

The URW project is implemented in two phases as follows:

(1) Phase I Works(1994-1995)

- 1) Rehabilitation of electric facilities of Phum Prek water treatment plant.
- 2) Expansion of reservoir (10,000 m³ capacity),
- 3) Expansion of transmission pumps, and distribution pumps,

- 4) Installation of transmission pipeline (D 500 L = 2.41 km),
- 5) Improvement of existing elevated tank (2,000 m³ capacity),
- 6) Installation of additional distribution facilities,
(Pipelines D 250 L = 1.3 km and D 200 L = 1.3 km),

(2) Phase 2 Works (1995 - 1996)

- 1) Expansion of Phum Prek treatment plant (50,000 m³/day)
- 2) Installation of water meter (D30-D50 N = 3,000 pieces)

2.2 Expansion Works

(1) Stage 1 Works (1997 - 2003)

- 1) Construction of Cham water treatment plant (65,000 m³/day),
- 2) Development of distribution pipes
(D300 - 1,000 mm L = 28.6 km and D100 - 250 mm L = 97.1 km)

(2) Stage 2 Works (2004 - 2010)

- 1) Expansion of Cham water treatment plant (65,000 m³/day),
- 2) Development of distribution pipes

(D300 - 1,000 mm L = 20.35 km and D100 - 250 mm L = 64.70 km)

In addition, the following works are planned between 1993 and 2010 in order to improve house connection and to reduce leakage:

- 1) Installation of meters
D20 - 50 mm 80,000 pieces
- 2) Installation of public taps, 13,497 pieces
- 3) Replacement of distribution pipes with small diameter
- 4) Pipe cleaning and lining

With the URW and the expansion works, about 780 thousands persons will get benefit directly and further about 470 thousands persons will get benefit indirectly in 2010 when

the works are completed. Per capita consumption will increase to 200 lcd in 2010 from 100 lcd in 1992.

2.3 Development of the Manpowers

PPWSA assumes responsibility of implementing the proposed works.

The number of staff in the PPWSA which is 300 in 1992 needs to be increased as shown below to implement the project smoothly.

	Unit: Person			
Staff	Present	After URW 1996	Stage 1 2003	Stage 2 2010
Number	300	344	452	548

PPWSA is improving a management ability with the help of the UNDP. PPWSA is expected to become financially self-autonomous organization as early as possible.

2.4 Project Cost and FIRR

The project cost is estimated as follows.

	Unit: million U.S. Dollar			
	Urgent Rehabilitation Works (URW)	Expansion Works (EW)		Total
		Stage 1	Stage 2	
Investment Cost	36.83	259.98	278.75	575.56
Land Acquisition	-	5.80	-	5.80

The FIRR of the Master Plan is calculated from the beginning of the project year 1994. F.I.R.R. is 3.8% with Grant Aid and F.I.R.R. is 2.7% without Grant Aid and with loan when the unit tariff is set at 400 Riels/m³ (U.S. Dollars 0.16/m³). Therefore, it is desirable to grant aid on the URW. The following is assumed on the above calculated FIRR;

- The water tariff is necessary to be increased 10% every three years from 1994.
- The bill collection ratio should be increased from 22% in 1994 to 91% in 2009. The following is assumed on the above calculated FIRR;

2.5 Environmental Impact

No major impact would be anticipated on the project through the screening and the scoping. However, the PPWSA should take necessary measures especially the following, so as to avoid or minimize the anticipated impact.

- (1) Relocation of the inhabitants in the new treatment plant.
- (2) Water pollution caused by drain from the new treatment plant.
- (3) Formulation of an urban drainage master plan and a water quality monitoring plan.

CONTENTS OF VOLUME 1

TABLE OF CONTENTS

PREFACE

LETTER OF TRANSMITTAL

EXECUTIVE SUMMARY

TABLE OF CONTENTS

ABBREVIATIONS

SUMMARY

	<u>Page</u>
1. INTRODUCTION	S-1
1.1 Background of the Study	S-1
1.2 Objectives Of The Study	S-2
1.3 Study Area	S-2
2. GENERAL CONDITIONS	S-2
2.1 Natural Conditions	S-2
2.2 Present Condition of the Water Supply Authority	S-4
3. EXISTING WATER SUPPLY SYSTEMS	S-4
3.1 Water Production	S-4
3.2 Water Distribution	S-5
4. MASTER PLAN	S-6
4.1 Framework	S-6
4.2 Water Demand	S-6
4.3 Development Plan of the Facilities	S-7
4.4 Development of the Manpowers	S-11
4.5 Project Cost	S-11
4.6 Implementation Schedule	S-11
4.7 Financial Evaluation	S-13
4.8 Environmental Impact	S-13
5. URGENT REHABILITATION WORKS	S-14
5.1 Objectives	S-14

5.2	Selected Urgent Rehabilitation Works	S-14
5.3	Implementation Schedule	S-15
5.4	Effects of URW	S-16
5.5	Operation & Maintenance and Management.....	S-18
6.	CONCLUSIONS AND RECOMMENDATIONS	S-18
6.1	Conclusions	S-18
6.2	Recommendations	S-19

ABBREVIATIONS

CCWTP	Chamcar Morn Water Treatment Plant
CIF	Cost, Insurance and Freight
CIP	Cast Iron Pipe
cmd	Cubic meters per day
COD	Chemical Oxygen Demand
CPI	Consumer Price Index
DCIP	Ductile Cast Iron Pipe
EOJ	Embassy of Japan
EW	Expansion Works
FC	Faecal Coliform
FIRR	Financial Internal Rate of Return
GDP	Growth Domestic Product
IBRD(WD)	International Bank for Reconstruction and Development (World Bank)
JICA	Japan International Cooperation Agency
l/s	Liters per second
Min.	Minutes
Mn	Manganese
NGO	Non-Governmental Organizations
ODA	Official Development Assistant
OXFAM	Oxford Famine
O/M	Operation and Maintenance
PPWSA	Phnom Penh Water Supply Authority
PPWTP	Phum Prek Water Treatment Plant
PVC	Polyvinyl Chloride Pipe
RPM	Revolutions per minute
SS	Suspended Solids
TC	Total Coliform
UNDP	United Nations Development Program
UNHCR	United Nations High Commission for Refugee
UNICEF	United Nations Children's Fund
UNTAC	United Nations Transitional Authority in Cambodia
URS	Urgent Rehabilitation Schemes
URW	Urgent Rehabilitation Works
USAID	United States Agency for International Development
WHO	World Health Organization
WL	Water Level
WTP	Water Treatment Plant

SUMMARY

1. INTRODUCTION

1.1 Background of the Study

The population of Phnom Penh Municipality is now estimated to be about 0.7 million and is the biggest city in the country. The Municipality's water supply system, which was constructed between 1895 and 1960, has deteriorated profoundly. Its capacity has, accordingly, decreased from 140,000 m³ per day before the civil war to 63,000 m³ per day because of destruction of the facilities and its neglected maintenance during the war, lack of spare parts, equipment and other materials and shortage of power supply.

The severe service inadequacy is becoming a keen social problem of the community. The manpower shortage, due to loss of experienced personnel, especially engineers in the civil war, makes it very difficult to operate and maintain the water supply system properly.

Under the circumstances mentioned above, the State of Cambodia made an official request to the Government of Japan for the technical assistance for the rehabilitation and improvement of the water supply system. In response to the request, the Government of Japan has decided to conduct the Master Plan and Feasibility Study on Phnom Penh Water Supply System (hereinafter referred to as "the Study") in accordance with the relevant laws and regulations in force in Japan.

Accordingly, the Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for implementation of the technical cooperation programs of the Government of Japan, has undertaken the Study in close cooperation with authorities concerned of the State of Cambodia.

The Study Team organized by JICA was dispatched to Phnom Penh in February 1993. They stayed in Phnom Penh until May 1993, to conduct the on-site survey and data collection. After the analysis works in Japan from May to July, the Interim Report was submitted to the authorities concerned of the State of Cambodia in August 1993. This Final Report is prepared in accordance with the Scope of Work, and presents the outcome of the Study carried out both in Cambodia and in Japan.

1.2 Objectives Of The Study

The objectives of the Study are:

- (1) to formulate a master plan for water supply system in Phnom Penh city;
- (2) to formulate an urgent rehabilitation project of the existing facilities, and;
- (3) to carry out a feasibility study for the priority project identified in the master plan study.

However, item (3) was not conducted in this study, since a priority project originally considered as a candidate for the feasibility study (expansion of Phum Prek treatment plant) became a part of the urgent rehabilitation works (see Chapter 6) and a feasibility study on other project identified under the Master Plan should be carried out at a later date.

1.3 Study Area

The study area covers the present urbanized area of Phnom Penh Municipality for the master plan. The project area for master plan is shown in Fig-S.1.

2. GENERAL CONDITIONS

2.1 Natural Conditions

Cambodia is located in southwest part of Indochina Peninsula. The area for the state is 181,035 km² and forms a shallow, wide basin, of which central three quarter are named the Central Plain. Phnom Penh, the capital city of the state is situated in the south of the Central Plain at Lat. about 11°35' N and Long. about 105°E. The country is divided by the Mekong river and the Sap river with the "Great Lake" being part thereof. Phnom Penh sits in the west of the confluence of the above two rivers. From there, the Mekong river and Basak, a branch of the Mekong river, flows to its lower delta in Viet Nam and finally to the South China Sea.

The ground height of the city along the Mekong river is more than 10 m above sea level and decreases to about 5 m toward the southwest of the city.

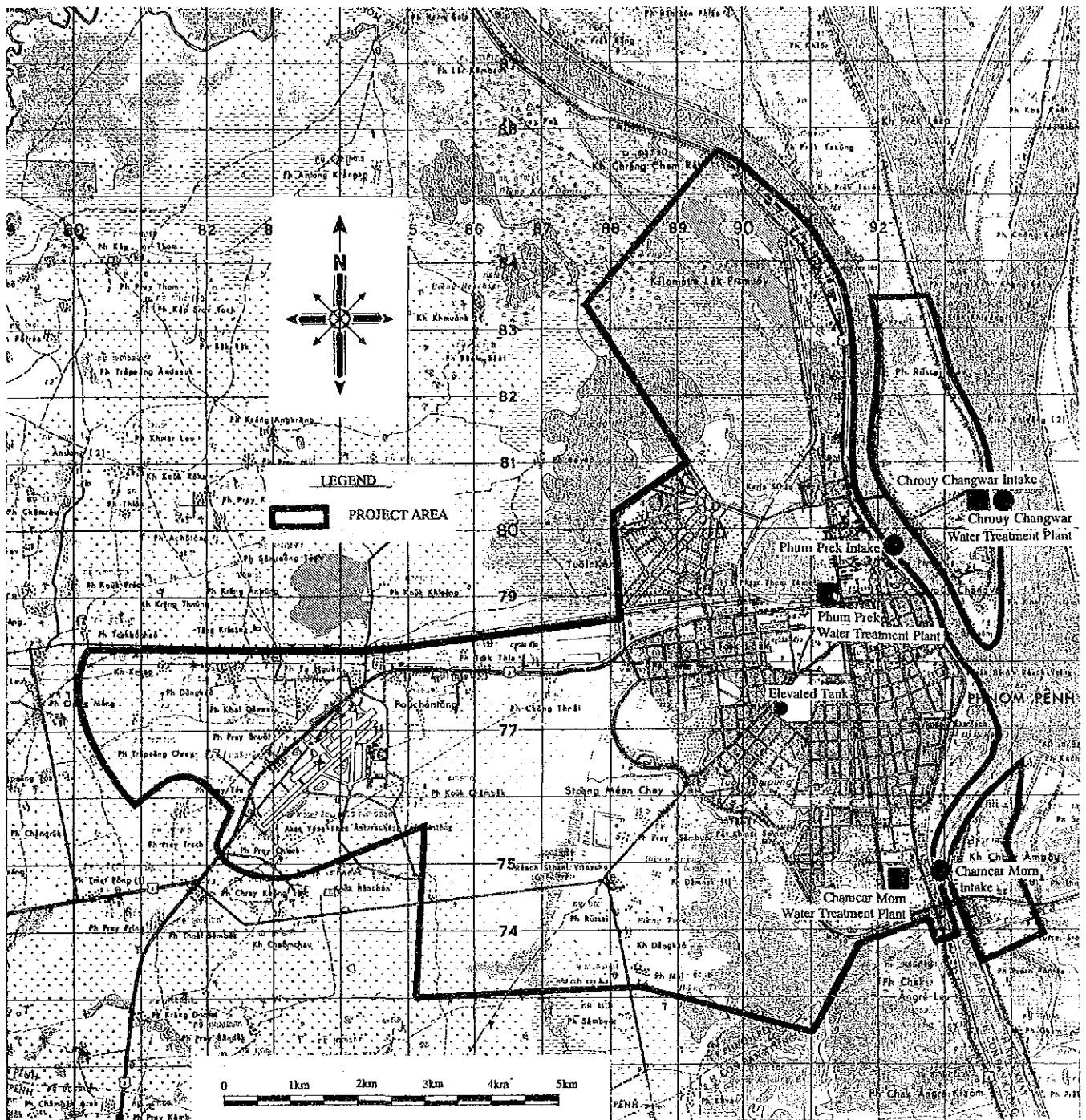


Fig.-S.1 PROJECT AREA

2.2 Present Condition of the Water Supply Authority

Water supply services in Cambodia are ruled by Decree No.32 of the Council of Ministers. From January 1988 to June 1991, the Phnom Penh Water Supply Authority (PPWSA) was managed as an autonomous public enterprise losing money continuously, and in July 1991, being suspended of the autonomy, the PPWSA was placed under control of the Phnom Penh Municipal government.

The deficit ratio to the total expenditure in the PPWSA decreased from 0.97 in 1988 to 0.62 in 1992. The deficit amount was 809 million Riels in 1992. The electricity cost accounted for 0.98 billion Riels out of the total expenditure of 1.3 billion Riels in 1992. The number of the issued bills was about 24,000 out of the total households of 56,000. Among the bills, only 2,800 bills were based on the metered consumption while the rest was merely estimated. The received bill was only 19% out of the issued bills. The water tariff is 166 Riels per cubic meters for domestic use. But the water price is as many times high when people buy water from the water venders in the non-served area.

3. EXISTING WATER SUPPLY SYSTEMS

3.1 Water Production

At present, Phum Prek system and Chamcar Morn system are working. The capacity and water source are as below:

Name of Treatment Plant	Phum Prek	Chamcar Morn	Chrouy Changwar
Treatment Capacity (m ³ /day)	100,000	10,000	30,000
Working Capacity (m ³ /day)	56,000	7,000	0
Water source	Sap river	Bassac river	Mekong river
Construction year	1966	1957	1895
Sedimentation Process	Conventional - Horizontal - Flow basins	Accelerator	
Sand filtration	Rapid gravity type	Rapid pressure type	

Phum Prek Water Treatment Plant (WTP) and Chamcar Morn WTP are already over the depreciation period and are deteriorated profoundly. There is a strong need for rehabilitation. Chrouy Changwar WTP stopped the operation because of totally ruined condition in 1983.

3.2 Water Distribution

The service area of the PPWSA consists of seven districts, four districts (Don Penh, Seven January, Toul Kork and Chamcar Morn) in the inside area and three districts (Russei Keo, Mean Chei and Dang Kor) in the suburban area.

The present distribution pressure is very low in all districts as shown below.

Service Area	Service Area (km ²)	Service Population (person)	Area %	Water Pressure (m)				
				P>5	5.0>P>2.5	2.5>P>0	0>P>-1	No Water
Inside	28.70		100	3	4	46	28	19
		402,000	100	4	4	56	21	15
Suburban	49.05	130,000	100	-	-	-	-	100
Total	77.75	532,000						

Note: Water pressure 0 means ground surface level

Water leakage ratio is estimated about 50% in two ways: one is by the result of the field test and the other is by means of the difference between the estimated supplied quantity and the estimated consumed quantity. The total length of the distribution pipe is 276,850 m ranging from 800 mm to 60 mm diameters, of which 44.5 km was installed in the year 1895 and the rest was installed from 1957 to 1960.

Most of pipes are made of cast iron. Since there are much rust incrustation inside of the pipes, it is recommended to improve their function by pipe cleaning and lining.

People who live in the area where the water pressure level is lower than the ground level install a pit between distribution mains and houses. As a result, waste water and rain water occasionally entered into the distribution pipes, which caused water-born diseases.

4. MASTER PLAN

4.1 Framework

In this study, the target year is set at 2010, considering the current instability and unforeseen social developments.

The annual population growth rate 6% in the stable period is taken as a future rate for the city. The projected population in 2010 is estimated as 1,851,500 person. The seven districts population of the city is estimated on the basis of the past several years records.

The existing service area 77.75 km² is determined as the same for 2010.

SERVICE POPULATION

Year	1992		2010		Unit: person
	Whole city	Service area	Whole city	Service area	Area (km ²)
Inside	402,070	402,070	781,759	781,759	28.70
Suburban	280,866	130,090	1,069,699	472,348	49.05
Total	682,936	532,160	1,851,458	1,254,143	77.75

4.2 Water Demand

Design factors including per capita consumption are set as below. The current per capita consumption and the leakage ratio were obtained from the measurement while the future ones are estimated based on the figure in the neighboring countries.

Year	1992	2000	2010
Per Capital Consumption (daily average)	100 lpcd	150 lpcd	200 lpcd
Max. to ave. daily demand ratio	1.3	1.3	1.3
Per Capital Consumption (daily maximum)	130 lpcd	195 lpcd	260 lpcd
Leakage Ratio	50%	40%	20%
Per Capita Demand (daily average)	200 lpcd	250 lpcd	250 lpcd
Per Capita Demand (daily maximum)	260 lpcd	325 lpcd	325 lpcd
Daily Average Demand (m ³ /day)	106,432	188,103	313,536
Daily Maximum Demand (m ³ /day)	138,362	244,533	407,596

4.3 Development Plan of the Facilities

There are two major problems in the current water supply system; 1) water can not supply adequately to meet the demand due to the deteriorated treatment plants and 2) water is lost in the distribution pipes due again to the deteriorated pipes. To solve them, improvement and extension are needed on both the treatment plants and the distribution system.

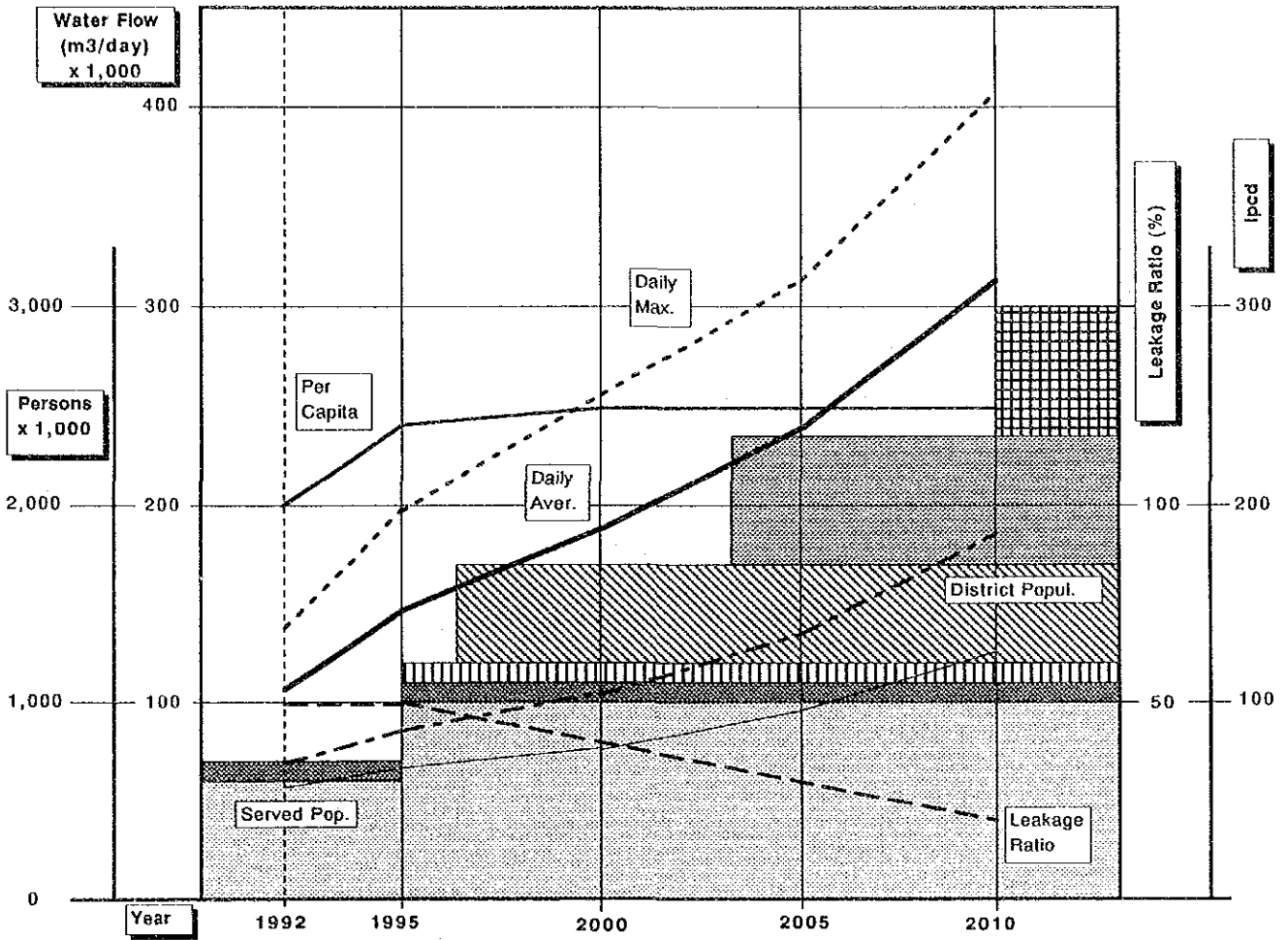
After the extension of 50,000 m³/day in the Phum Prek treatment plant by the year 1996 under the Phase 2 of the URW, the new plant of 130,000 m³/day is needed in two stages, each by 2003 and 2010 to cover the daily average water demand of 2010. The extended capacity is as follows:

PRODUCTION CAPACITY DEVELOPMENT PLAN

						Unit : m ³ /day
Treatment Plant	1992	URW Phase 1 Rehabilitation	URW Phase 2 Expansion	EW Stage 1	EW Stage 2	Total
Phum Prek						
Present	56,000					
Improvement		44,000				
Expansion			50,000			150,000
Chamcar Morn						
Present	7,000					
Improvement		3,000				
Expansion		10,000*1				20,000
Cham (Proposed)	-	-	-	65,000	65,000	130,000
Total						
Present	63,000					63,000
Improvement		47,000				47,000
Expansion		10,000	50,000	65,000	65,000	190,000
Cumulative	63,000	120,000	170,000	235,000	300,000	300,000

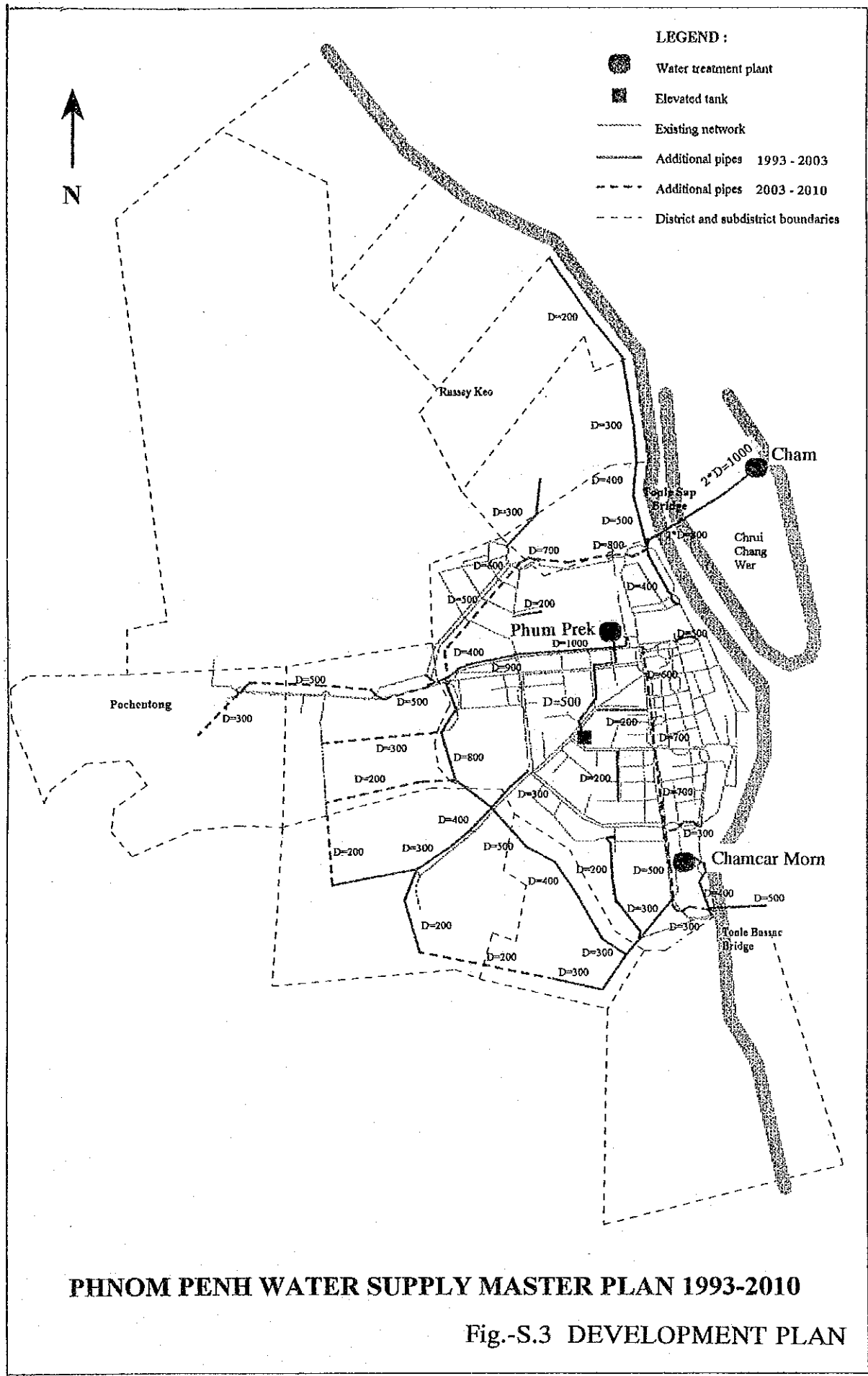
*1 by French government

Fig - S.2 WATER DEMAND AND PLANT CAPACITY



Leakage Ratio(%)	50	50	40	30	20
Daily Max. (m3/day)	138,962	189,605	244,533	311,161	407,596
Daily Aver. (m3/day)	106,432	145,850	188,103	239,355	313,536
Per Capita Dem. (lpcd)	200	240	250	250	250
Served Population	532,160	607,710	752,410	957,418	1,254,143
District Population	682,936	793,635	1,020,500	1,352,798	1,851,458

LEGEND					
Symbol	Facility	Capacity (m3/day)	Symbol	Facility	Capacity (m3/day)
	New Plant (Expansion)	65,000		Chamcar Morn (Expansion)	10,000
	New Plant (Expansion)	65,000		Existing Chamcar Morn	7,000 → 10,000
	Phum Prek (Expansion)	50,000		Existing Phum Prek	56,000 → 100,000



Water sources for the new Cham plant of 130,000 m³/day capacity will be the Mekong River.

To correspond to the extension of the production facilities, the extension of the existing distribution facilities is needed. Considering the total benefits delivered from using the existing elevated tank, the planned growth in the pipe network is as follows:

	Trunk Main Length (m) Additional/Total	Secondaries Length (m) Additional/Total	Total (m) Additional/Total
Additional (- 1993)	- /34,550	- /242,300	- /276,850
Additional (1993 - 2003)	28,600/63,150	97,100/339,400	125,700/402,550
Additional (2003 - 2010)	20,350/83,500	64,700/404,100	85,050/487,600

Note: Trunk Main D1000 ~ D300, Secondaries D250 ~ D100

IMPROVEMENT OF EXISTING DISTRIBUTION AND SERVICE FACILITIES

Item	Description	Unit	Expansion works		
			Stage 1 2003	Stage 2 2010	Total
Cleaning and Lining of Main Distribution Pipe	D300 ~ D800mm	km	--	34.55	34.55
Replacement of Small Distribution Pipe	D100 ~ D250mm	km	100.80	101.75	202.55
Installation of Valve	Main Distribution Pipe	Points	--	53	53
Installation of Air Valve	Ditto	Points	--	53	53
Installation of Fire Hydrant	Ditto	Points	--	37	37
Installation of Washout	Ditto	Points	--	53	53
Installation of Water Meter	D20 ~ D50mm	Points	42,000	38,000	80,000
Installation of Public Tap	D20mm	Points	10,823	2,674	13,497

4.4 Development of the Manpowers

The number of staff in the PPWSA is shown below:

Staff	Unit: Person			
	Present	After URW 1996	Stage 1 2003	Stage 2 2010
Number	300	344	452	548
Required Increase	44	108	96	
Retiring	14	61	159	
Required Recruitment	58	169	255	

In the coming years, recruiting skilled, qualified and competent persons will become more difficult. The training program is important.

4.5 Project Cost

The project cost is estimated as follows.

	Unit: million U.S. Dollar			Total
	Urgent Rehabilitation Works	Expansion works		
		Stage 1	Stage2	
Investment Cost	36.83	259.98	278.75	575.56
Land Acquisition	-	5.80	-	5.80

4.6 Implementation Schedule

The project is implemented in three stages. The URW is completed in 1996. The stage 1 and stage 2 are completed by 2003 and 2010, respectively.

4.7 Financial Evaluation

The financial analysis of the Master Plan is conducted from the beginning of the project year 1994, taking into account of the availability of the grant aid on the URW, financial source, water tariff etc. The result is as follows;

- (1) Special loan with low interest is required for the project implementation.
- (2) The unit tariff is 400 Riels/m³ (U.S. Dollars 0.16/m³).
- (3) The water tariff is necessary to be increased 10% every three years from 1994.
- (4) The bill collection ratio should be increased from 22% in 1994 to 91% in 2009.
- (5) It is desirable to get the grant aid on the URW.

F.I.R.R. becomes 3.8% with Grant Aid and F.I.R.R. becomes 2.7% without Grant Aid and with loan.

4.8 Environmental Impact

No major impact would be anticipated on the project through the screening and the scoping. However, the PPWSA should take necessary measures especially the following, so as to avoid or minimize the anticipated impact.

- (1) Relocation of the inhabitants in the new treatment plant.
- (2) Water pollution caused by drain from the new treatment plan.
- (3) Formulation of an urban drainage master plan and a water quality monitoring plan.

5. URGENT REHABILITATION WORKS

5.1 Objectives

There are serious problems, as shown in followings to be resolved urgently in the Phnom Penh water supply systems.

(1) For water supply aspect

- 1) One treatment plant had stopped its production facility
- 2) Restriction of plant operation by shortage of electric power
- 3) Concentration of population to the city
- 4) Increase of leakage
- 5) Increase of areas with no water supply area
- 6) Insufficiency of water pressure in distribution pipes
- 7) Infiltration of pollutant, such as waste water from domestic and commercial use to distribution pipes
- 8) Modification and disorder of house connection (pit well)
- 9) Inadequateness of metering

(2) For management aspect

- 1) Inadequacy of water charge payment call
- 2) Difficulty of water charge collection by uncertaining of supply
- 3) Uncertaining of purchase of coagulant and disinfectants
- 4) Increase of illegality in water consumption

The objectives of URW project is oriented to solve above problems.

5.2 Selected Urgent Rehabilitation Works

The following approaches and criteria are employed to select the urgent rehabilitation works.

- 1) To increase the supply capacity effectively,
- 2) To take effect instantly after completion of the URW
- 3) To be appropriate in project size, and

- 4) To be of reasonable period in construction

Based on the above items, the URW are listed below:

- 1) Rehabilitation of electrical facilities of the Phum Prek water treatment plant.
- 2) Expansion of the Phum Prek water treatment plant (50,000 m³/day),
- 3) Expansion of the reservoir (10,000 m³ capacity),
- 4) Expansion of the transmission pumps and distribution pumps,
- 5) Installation of transmission pipeline (D500 L = 2.41 km)
- 6) Improvement of existing elevated tank (2,000m³ capacity)
- 7) Installation of additional distribution facilities,
(Pipelines D 250 L = 1.34 km and D 200 L = 1.31 km),
- 8) Improvement of valve arrangement, and
- 9) Rehabilitation of the metering system

5.3 Implementation Schedule

The URW project is implemented in two phases as follows:

(1) Phase 1 Works

All works in the above 9 items except item 2).

(2) Phase 2 Works

Expansion of Phum Prek water treatment plant (50,000 m³/day) and improvement of existing chemical dosing equipment.

5.4 Effects of URW

Rehabilitation of water supply works contribute to the stable supply of a hygienic water and improvement of public health condition as well as the enhancement of city activities.

Year		1992	1996
Direct beneficial population	(1,000 person)	341.5	598.0
Indirect beneficial population	(1,000 person)	200~300	more than 300
Supplied water	(lpcd)	100	120

The following describes possible effects resulting from this project.

1) Effect to Phum Prek water treatment plant

The plant is operating only for 13 hours now, but 24-hours operation will be feasible because the electric power will be restored. As a result, the volume of treated water will increase by about 80% from 56,000 m³/day to 100,000 m³/day. In addition, more stable supply can be expected because the timeworn facilities will be replaced with new ones. Further, expansion of the plant will increase supply capacity by 50,000 m³/day.

2) Effect to transmission, distribution and service facilities

The water pressure will increase as a result of rehabilitating the above facilities. This will make it no longer necessary for the users to receive the service water in the pit first, as is necessary at present, and enables them to receive water through each tap inside the houses. The served water quality is contaminated in the rainy season because waste water enters into the service pipe by way of this pit or through openings in the distribution pipe. This will be eliminated and clean water will be supplied.

3) Effect to water work management

Increase in the volume of treated water and distribution water and decrease in the volume of leakage water will increase the volume of supply water for effective use. Besides, installing the water meters will make it possible to collect water charges properly

depending upon the consumption. Thus, increase in income from the water charges can be expected.

4) Benefits

The aforementioned effects will bring about the following benefits.

a) Expansion of supplied area and increase of population supplied

At present, no water service is provided in the area of 5.45 km² (about 60,000 population to be supplied) within Phnom Penh and 49.05km² (about 130,000 of the same) in the suburbs of the city. As a result of the increased volume of the water treatment and distribution and increase in water pressure, it becomes possible to supply water to a part of the suburbs.

b) Increased water supply per person

People are obliged to refrain from using sufficient service water but must buy from a merchant or bring it into house from other places because they cannot receive it inside the building. Restoration of the water supply allows them to use water even though at a required minimum quantity.

c) Hygienic water quality

In the areas where the pressure is lower than the ground level (804 ha, about 84,500 population) people receive water in a pit, and waste water enters in the supply water by way of the pit in rainy season. Increased water pressure will enables to avoid this mixture of pollutants by stopping use of pit.

d) Expansion of service hours

As the capacity of the treatment plant is restored, operating hours of the plant is extended from 13 hours to 24 hours a day, increasing the supplied quantity.

5.5 Operation & Maintenance and Management

It is strongly requested to strengthen PPWSA's capability of operation & maintenance and management in order to be an autonomous entity under the assistance of UNDP.

- 1) Development of manpower and strengthening of the organization.
- 2) The water tariff should be raised so as to make a balance between revenue and expenditures in early stage.
- 3) The metering system to collect water charge adequately should be expanded by installing and replacing old meters at first from a large consumers such as hotels and offices.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

- (1) The citizens in Phnom Penh city has suffered from the inadequate water supply system; lack of supplied water quantity and poor water quality. This problem can be improved, though, to a minimum required level by implementation of the urgent rehabilitation works on the Phum Prek and Cham Car Mont water treatment plants.

Further, the urgent rehabilitation works on the distribution system can improve the deteriorated system as well.

- (2) The expansion works can meet the increased water demand in accordance with the increased population, even though at a minimum required level.
- (3) The Project cost inducing both the URW and the expansion works is estimated as 575.56 million U.S.Dollars which excludes land acquisition cost. The project should be financed by both a grant aid program and a soft loan program.
- (4) The proposed water supply development plan - both the URW and the expansion works - is environmentally sound, technically feasible and economically reasonable.

- 1) Raw water is abundant in quantity and good in quality.
- 2) Water treatment process technology is simple and appropriate. Further, the usage of the existing elevated tank is a good option for improvement of the distribution system.
- 3) Investment cost is minimized by utilizing the existing facilities effectively. As a result, water tariff is reduced to a level which low-income earners can pay.

By implementing the URW and the expansion works, PPWSA can become an autonomous organization, and sustain the ability to operate its water supply system properly, contributing to the development of the capital city of Phnom Penh.

6.2 Recommendations

PPWSA should devote its effort to the following in order to gain the maximum benefits derived from the above mentioned items.

- (1) Various procedures concerning the PPWSA should be formulated properly and the management on personnel and finance should be strengthened and developed.
- (2) The following should be implemented to improve the financial situation;
 - 1) The water tariff should be increased to cover the required expenditure.
 - 2) The unit tariff should rise in proportion to the increase of consumption so that the system may give users an incentive to water saving.
 - 3) Increase revenue by improving and strengthening the procedures of bills issuing, bills collection etc.
 - 4) Increase revenue by decreasing an unaccounted for water over the project period.
 - 5) Accumulate the depreciated costs in preparation for the future improvement of the facilities.

- (3) Conduct the feasibility study on the expansion/development of the water supply system.
- (4) Manage the water supply system, taking into account of the training programs proposed by the UNDP, and, if necessary, request the dispatch of the experts on the required fields.
- (5) Train staffs actively, both on domestic and on abroad.

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