JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF INDUSTRY, MINES AND ENERGY
PHNOM PENH WATER SUPPLY AUTHORITY

THE STUDY
ON
THE MASTER PLAN
OF
GREATER PHNOM PENH WATER SUPPLY
(PHASE 2)
IN
THE KINGDOM OF CAMBODIA

FINAL REPORT

VOLUME I

SUMMARY REPORT

FEBRUARY 2006

NJS CONSULTANTS CO., LTD.
CTI ENGINEERING INTERNATIONAL CO., LTD.

PREFACE

In response to a request from the Royal Government of Cambodia, the Government of Japan decided to conduct the Study on the Master Plan of Greater Phnom Penh Water Supply (Phase 2) in the Kingdom of Cambodia and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched the study team headed by Mr. Yoshihiko Sato of NJS consultants Co., Ltd. (consisting of NJS Consultants Co., Ltd. and CTI Engineering International Co., Ltd.) to Cambodia, three times between December 2004 and January 2006.

The team held discussions with the officials concerned of the Royal Government of Cambodia, and conducted field surveys at the study area. Upon returning to Japan, the 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 our two countries.

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

February 2006

Takashi Kaneko
Vice-President
Japan International Cooperation Agency

February 2006

Mr. Takashi Kaneko
Vice-President
Japan International Cooperation Agency (JICA)
Tokyo, Japan

Letter of Transmittal

It is a greater pleasure that we submit herewith the Final Report of "The Study of the Master Plan of Greater Phnom Penh Water Supply (Phase 2) in the Kingdom of Cambodia".

The main objective of the Study was placed on the formulation of water supply development plan for Greater Phnom Penh for meeting the water demand up to the year of 2020. The Study conducted 亜 a basic study in Phase I and prepared in Phase II a master plan and successively in Phase III a feasibility study. The Report presents the outcomes of the master plan and feasibility study.

We hope that this Report will be helpful for the realization of the project proposed in this Study. We believe that the successful undertaking of the proposed project would assure stable water supply in Greater Phnom Penh in the long term and thus contribute to the further socio-economic development in the region.

We wish to express our sincere gratitude to the personnel concerned of your Agency for the guidance and support given throughout the Study period. Our deep gratitude is also expressed to the Ministry of Industry, Mines and Energy, Phnom Penh Water Supply Authority, and other concerned authorities of the Royal Government of Cambodia, JICA Cambodia Office and the Embassy of Japan in Cambodia for their close cooperation and assistance extended during the course of the Study.

Very truly yours,

Yoshihiko Sato
Team Leader
The Study on the Master Plan
of Greater Phnom Penh Water Supply
(Phase 2) in the Kingdom of Cambodia
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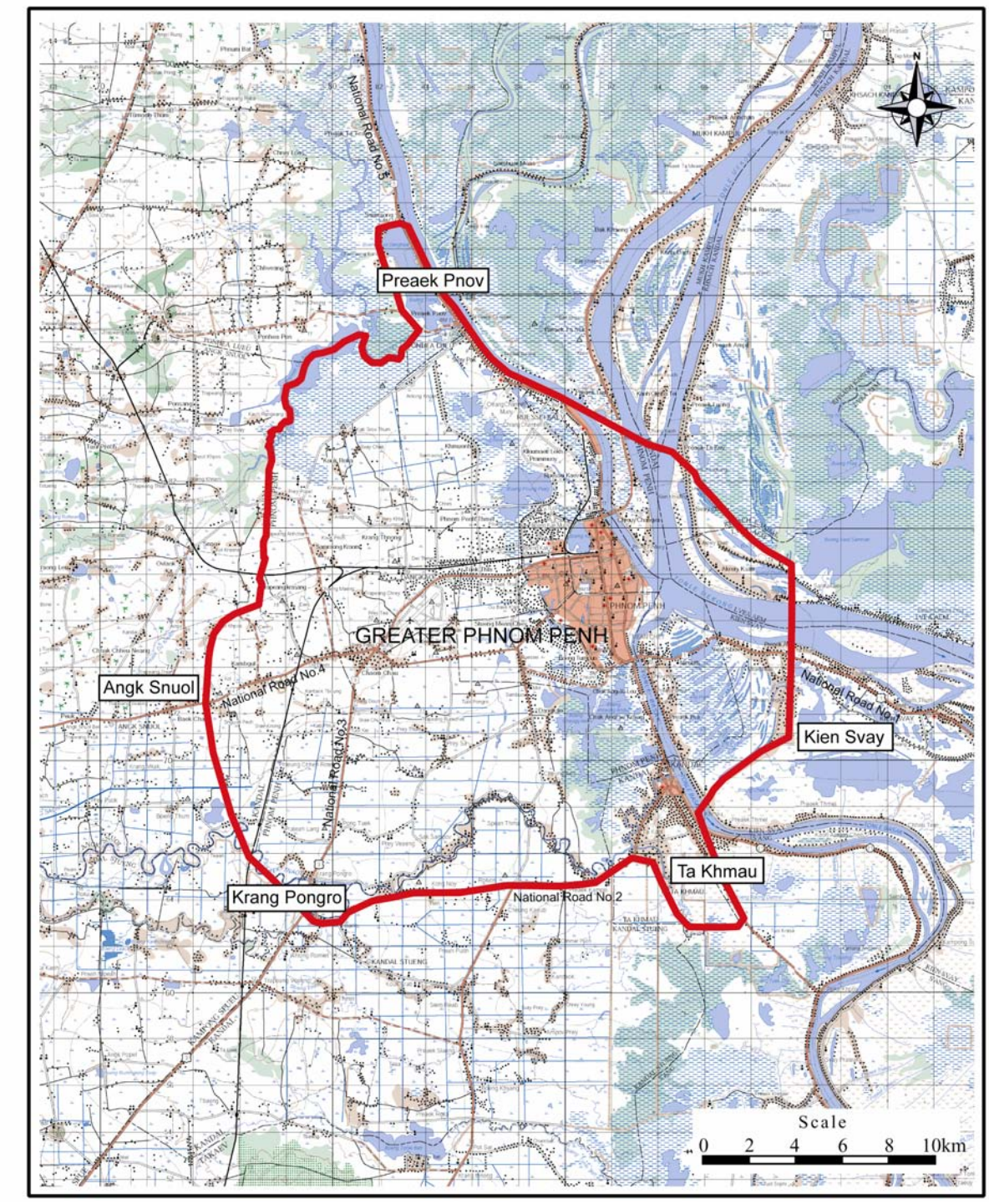


Master Plan (Phase 2) Study Area

Photos

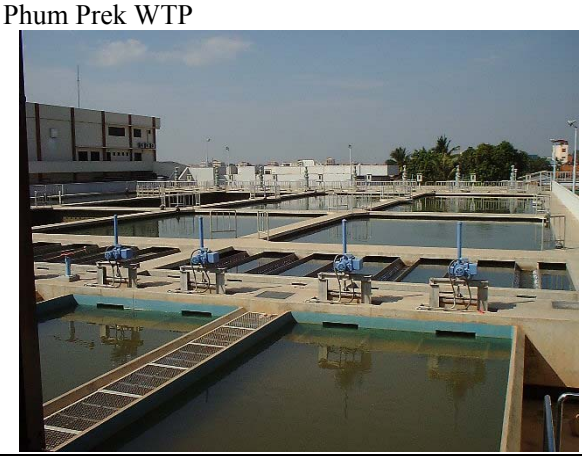
Tonle Sap

Tonle Basak

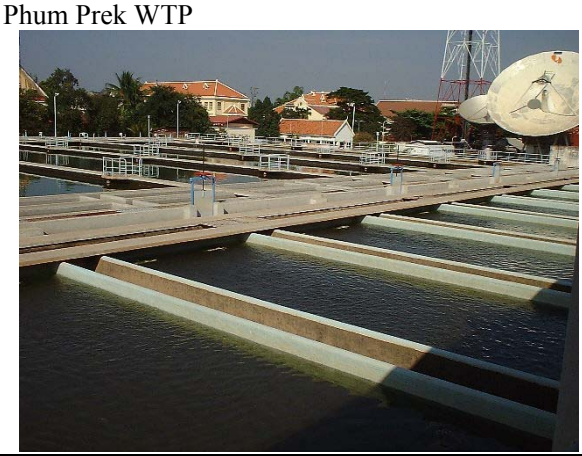
Mekong River, Intake of Chrouy Changva WTP

Tonle Sap, Intake of Preaek Pnov WTP

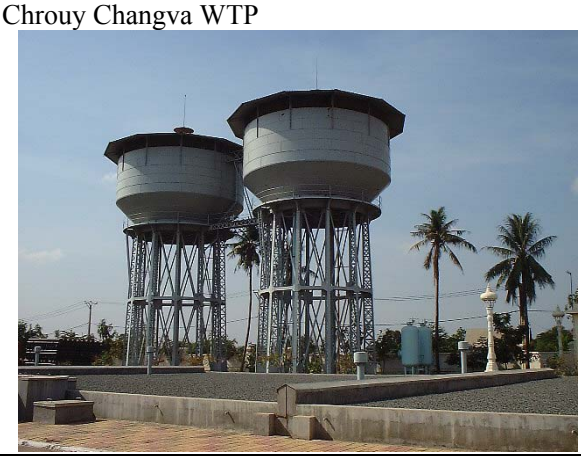
Phum Prek WTP



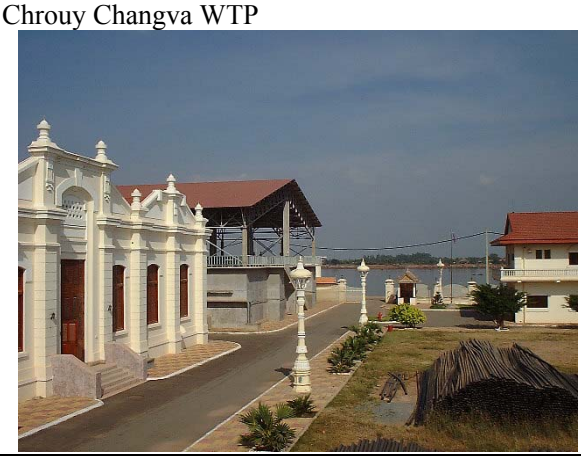
Phum Prek WTP



Chrouy Changva WTP



Chrouy Changva WTP



Photos

Chamkar Mon WTP

Chamkar Mon WTP

Hand Pump in Krang Pongro

Kien Svay WTP

Tumpun Pumping Station

Trabek Pumping Station

Southeast of Phnom Penh (Boeng Cheung Aek)

Northeast of Phnom Penh (Boeng Kbal Damrei)

THE STUDY
ON
THE MASTER PLAN OF GREATER PHNOM PENH WATER SUPPLY (PHASE 2)
IN THE KINGDOM OF CAMBODIA

EXECUTIVE SUMMARY

PART A: MASTER PLAN

1. Background of the Project

The Study on the Master Plan of Greater Phnom Penh Water Supply (Phase 2) was undertaken in accordance with the Minutes of Meeting on the Scope of Work for the Study, signed on 29th July 2004, between the Royal Government of Cambodia, represented by the Ministry of Industry, Mines and Energy (MIME) and the Phnom Penh Water Supply Authority (PPWSA), and the Japan International Cooperation Agency (JICA).

The objectives of the Study are:

1) To formulate a master plan up to the year 2020 for an efficient and sustainable water supply system for Greater Phnom Penh (Municipality of Phnom Penh, Ta Khmau City and urban areas bordering the Municipality of Phnom Penh in Kandal Province), and to conduct a feasibility study on the priority project(s); and

2) To transfer technology to counterpart personnel during the course of the study.

The Study started at the beginning of December 2004 and was completed at the end of January 2006. This Final Report consists of three volumes:

- Volume I : Summary Report
- Volume II : Part A : Master Plan
  Part B : Feasibility Study
- Volume III : Supporting Reports
  Part A : Detailed study documents/data
  Part B : Drawings

2. Project Framework

The Master Plan takes into consideration the relevant national plans, policies and targets, including specifically the Cambodia Millennium Development Goals (CMDGs). The CMDG target of 80% for the urban population with access to a safe water source by 2015 has already been met in urban Phnom Penh and will be sustained above that level to 2020 and beyond. For the peri-urban areas, the target of 80% coverage will be achieved by 2020.

Based on the future urban development scenarios, the population of the central area is expected to decrease from 715,500 in 2005 to 683,400 in 2020. In the suburban area of Metropolitan Phnom Penh (MPP), the population will double from the present 2005 population level of about 620,000 to 1,320,000 in 2020. This population increase of about 700,000 is expected to occur in Dangkao District, 270,000; in Mean Chey District, 160,000; and in Ruessei Kaev District, 270,000.

Under the most likely scenario, water demand will increase from 133,402 m^3/d in 2004 to 271,093 m^3/d in 2020 on a daily average basis and from 204,027 m^3/d in 2004 to 414,612 m^3/d in 2020 on a daily maximum basis. Overall supply coverage for the MPP (including peri-urban) will go from 67.7% in 2004 to 81% in 2020.

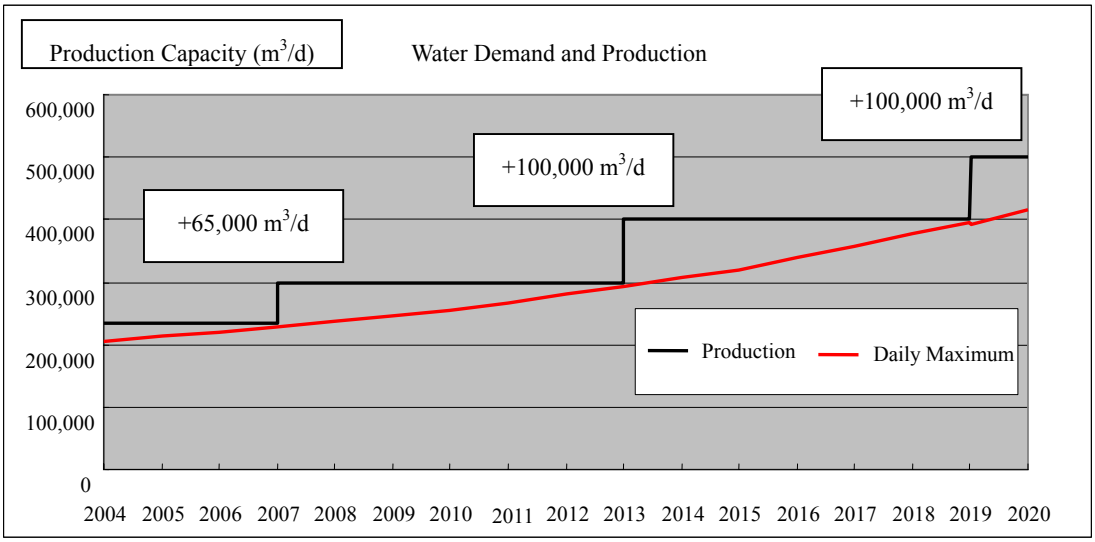
Proposed Water Supply Basic Indicators (unit in m^3/d)

Year	2005	2010	2015	2020
By Central Distribution System (CDS)				
Daily Ave. per capita water demand (lpcd)	80	86	95	104
Peak factor	1.3	1.3	1.3	1.3
Peak Day per capita water demand	104	111	123	135
NRW	15%	15%	15%	15%
Daily Max. per capita demand (lpcd)	122	131	144	158
Total population	1,529,999	1,774,891	2,034,868	2,303,826
Served population	1,035,931	1,244,738	1,491,113	1,866,102
Coverage (%)	67.7	70.1	73.3	81.0
Daily Ave. water demand (m^3/d)	133,402	166,529	209,292	271093
Daily Max. water demand (m^3/d)	204,027	254,691	320,094	414,612
Nos. of served households	105,870	136,540	180,736	247,712
Nos. of non-domestic connections	15,517	18,729	21,640	25,011
Total No. of connections	121,387	155,269	202,376	272,723
By CDS + Well Water Systems				
Total population	1,529,999	1,774,891	2,034,868	2,303,826
Served population	1,070,582	1,321,598	1,641,684	2,082,822
Coverage (%)	70.0	74.5	80.7	90.4
By Well Water Systems				
Served population	34,650	76,860	150,570	216,720
Unit covering population per well	210	210	210	210
Nos. of wells required	165	366	717	1,032
Unit water consumption per capita (lpcd)	40	40	40	40
Well water supply amount (m3/d)	1,386	3,075	6,023	8,668

3. Urban Water Supply Development Plan

3-1 Water Production and Treatment

The total water production requirement for the year 2020 is 500,000 m^3/d. The required production capacity at each stage up to 2020 is illustrated in the figure below based on the daily maximum water demand.



The present production capacity of 235,000 m^3/d can meet the water demand through 2007. With implementation of the Stage I Priority Project to expand the capacity of the Chrouy Changva Water Treatment Plant (WTP) by 65,000 m^3/d (bringing total production capacity to 300,000 m^3/d), the maximum water demand during Stage I and through the year 2013 of Stage II can be met. After 2013, a second project for construction of a new water treatment plant with an initial production capacity of 100,000 m^3/d will be necessary to satisfy the further increased water demand during the latter part of Stage II and beyond. The new plant is proposed to be constructed at Nirouth.

3-2 Water Transmission and Distribution

The objectives for the network expansion plan are to 1) serve the additional demand, while 2) enhancing overall system performance. The strategy for accomplishing these objectives incorporates the following critical concepts: a) division of the network into discrete zones for more intensive and flexible control of flow and pressure, b) creation of transmission network loops for greater redundancy and pressure balancing options, and c) completion of the distribution system, as at present, in closed, metered blocks.

4. Peri-Urban Water Supply Development Plan

The Peri-Urban Water Supply Development Plan has established the clear target of providing safe water coverage to at least 80% of the population of the Phnom Penh peri-urban areas. The strategy for achieving the target entails a combination of piped network extension and development of wells in an appropriate and cost-effective manner.

5. Project Costs

5-1 Capital Costs for Urban Water Supply Development Plan

Based on the water demand, the capital investments for the expansion of the Urban Water Supply Development Plan are estimated in the following table.

Summary of Project Cost

Cost Item	Cost (US$)	
	Breakdown	**Total**
Construction Cost		
Stage I (2010)		**51,865,000**
Chrouy Changva WTP -2nd Stage	22.630,000	
Water Tank	2,555,000	
Transmission/Distribution Pipe	11,880,000	
Monitoring Facility	5,000,000	
Rehabilitation of M&E Equipment	9,800,000	
Stage II (2015)		**100,462,000**
New Intake & WTP -1st Stage	40,106,000	
Clear Water Reservoir Expansion in Phum Prek WTP	1,184,000	
Transmission/Distribution Pipe	23,923,000	
Sludge Treatment Facility for Chrouy Changva & Phum Prek WTP	18,849,000	
Rehabilitation of M&E Equipment	16,400,000	
Stage III (2020)		**44,767,000**
New Intake & WTP -2nd Stage	25,982,000	
Transmission/Distribution Pipe	7,238,000	
Sludge Treatment Facility for Chamkar Mon WTP	3,347,000	
Rehabilitation of M&E Equipment	8,200,000	
Total of Construction Cost		**197,094,000**
Land Acquisition Cost		**3,600,000**
Equipment Procurement Cost		**1,971,000**

Cost Item	Cost (US$)	
	Breakdown	**Total**
Engineering Service Expense		**19,709,000**
Government's Administration Expense		**9,855,000**
Institutional Development Cost		**2,062,000**
Sub Total		**234,291,000**
Physical Contingency		**23,429,000**
Price Contingency		**62,232,000**
Total Project Cost		**319,952,000**

5-2 Capital Costs for Peri-urban Water Supply Development Plan

Based on the water demand, the capital investments to support the expansion of the well program in the peri-urban area are estimated below:

Summary of Project Cost for Well Facility

Cost Item	Cost (US$)			
	Stage I	**Stage II**	**Stage III**	**Total**
Construction Cost				
Well Facility	6,305,000	6,762,000	8,696,000	21,763,000
Total Construction Cost				**21,763,000**
Equipment Procurement Cost	63,000	68,000	87,000	218,000
Engineering Service Expense	631,000	676,000	870,000	2,176,000
Government's Administration Expense	315,000	338,000	435,000	1,088,000
Sub Total	7,314,000	7,844,000	10,088,000	25,245,000
Physical Contingency	731,000	784,000	1,009,000	2,525,000
Price Contingency	848,000	2,125,000	4,949,000	7,921,000
Total Project Cost	**8,893,000**	**10,753,000**	**16,044,000**	**35,691,000**

6. Financial Analysis

The financial viability of the Master Plan (Urban water supply) is assessed by comparing the Financial Internal Rate of Return (FIRR) with the Weighted Average Cost of Capital (WACC, used as a proxy for the Opportunity Cost of Capital). The WACC of the project is 3.84% (in real terms), while the FIRR is 5.19%, so the project is considered financially viable.

The results of the financial projections of PPWSA and the financial analysis of the projects show that the proposed Master Plan projects can be implemented on a sustainable basis. Throughout the economic life

of the proposed projects, PPWSA can generate sufficient revenues to cover the costs of their operation and maintenance, together with the existing assets and on going projects, and repay all its debt service obligations as they fall due.

7. Initial Environmental Evaluation

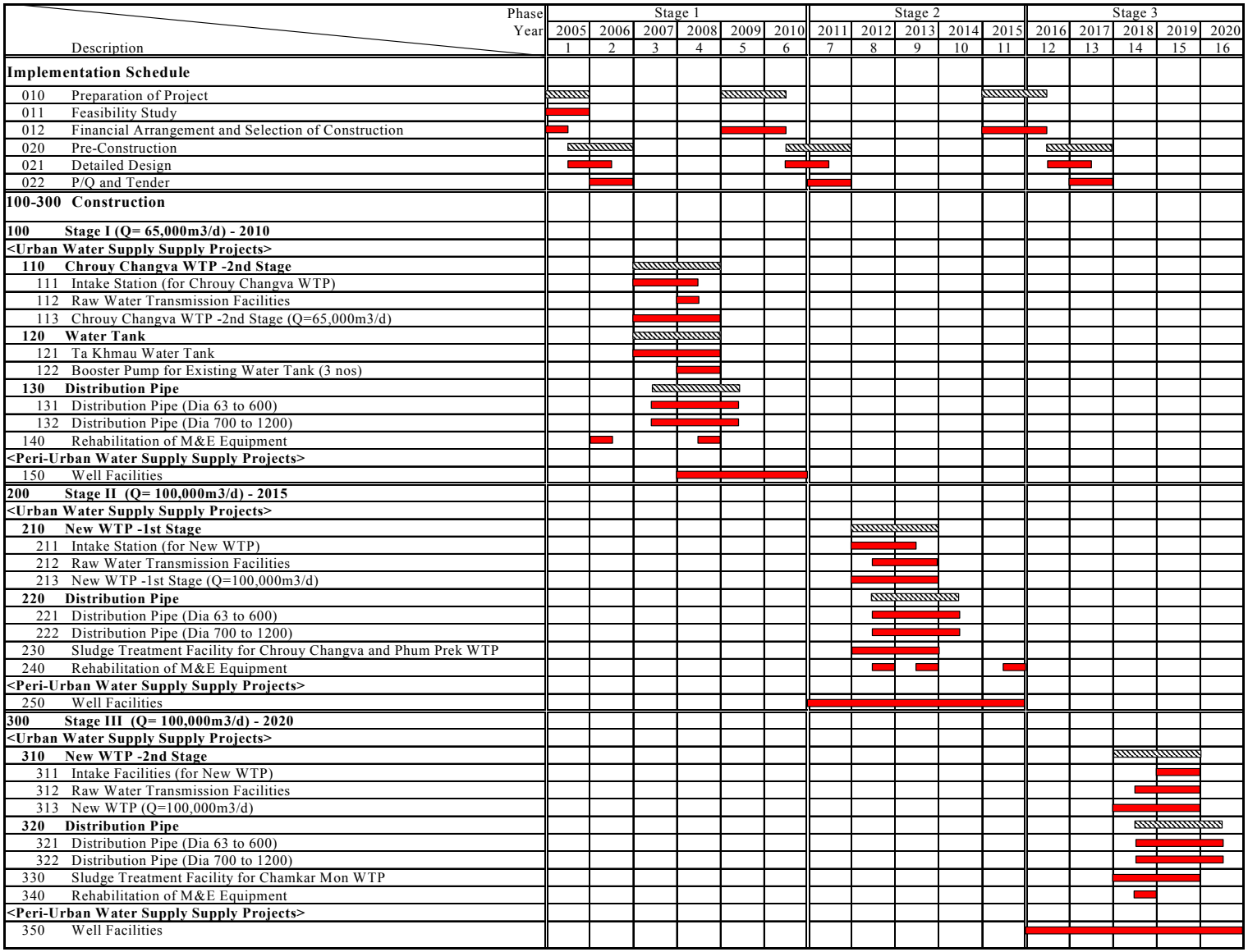
JICA categorized the Master Plan as Category B. The proposed projects will have mostly beneficial impacts. Although some adverse impacts will occur during the construction and operation stage of the project, minimization of environmental disturbances such as noise and dust during construction will be considered in the detailed design, and appropriate environmental management requirements will be incorporated in the specifications of construction contracts.

In order to assure that the proposed mitigation plan, described in "Environment Mitigation Plan" will be adequately conducted, the related agencies should monitor those activities as recommended in "Environmental Monitoring Plan".

8. Implementation Plan

The project is planned to be implemented divided into three stages based on the design target years of 2010 (Stage I) for the feasibility study, 2015 (Stage II) for the intermediate development plan and 2020 (Stage III) for the long term development plan.

The project implementation schedule is presented in the following figure:


Phase
Year
Description
Stage 1
Stage 2
Stage 3
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Implementation Schedule
010 Preparation of Project
011 Feasibility Study
012 Financial Arrangement and Selection of Construction
020 Pre-Construction
021 Detailed Design
022 P/Q and Tender
100-300 Construction
100 Stage I (Q= 65,000m3/d) - 2010
<Urban Water Supply Supply Projects>
110 Chrouy Changva WTP -2nd Stage
111 Intake Station (for Chrouy Changva WTP)
112 Raw Water Transmission Facilities
113 Chrouy Changva WTP -2nd Stage (Q=65,000m3/d)
120 Water Tank
121 Ta Khmau Water Tank
122 Booster Pump for Existing Water Tank (3 nos)
130 Distribution Pipe
131 Distribution Pipe (Dia 63 to 600)
132 Distribution Pipe (Dia 700 to 1200)
140 Rehabilitation of M&E Equipment
<Peri-Urban Water Supply Supply Projects>
150 Well Facilities
200 Stage II (Q= 100,000m3/d) - 2015
<Urban Water Supply Supply Projects>
210 New WTP -1st Stage
211 Intake Station (for New WTP)
212 Raw Water Transmission Facilities
213 New WTP -1st Stage (Q=100,000m3/d)
220 Distribution Pipe
221 Distribution Pipe (Dia 63 to 600)
222 Distribution Pipe (Dia 700 to 1200)
230 Sludge Treatment Facility for Chrouy Changva and Phum Prek WTP
240 Rehabilitation of M&E Equipment
<Peri-Urban Water Supply Supply Projects>
250 Well Facilities
300 Stage III (Q= 100,000m3/d) - 2020
<Urban Water Supply Supply Projects>
310 New WTP -2nd Stage
311 Intake Facilities (for New WTP)
312 Raw Water Transmission Facilities
313 New WTP (Q=100,000m3/d)
320 Distribution Pipe
321 Distribution Pipe (Dia 63 to 600)
322 Distribution Pipe (Dia 700 to 1200)
330 Sludge Treatment Facility for Chamkar Mon WTP
340 Rehabilitation of M&E Equipment
<Peri-Urban Water Supply Supply Projects>
350 Well Facilities

PART B: FEASIBILITY STUDY

The Feasibility Study covers the Implementation of the Stage I Priority Projects identified under the Master Plan of the Greater Phnom Penh Water Supply (Phase 2). Stage I of the Master Plan, the target period for this Feasibility Study, covers the years 2005 to 2010. All of the projects identified as Stage 1 projects in the Master Plan are considered to be Priority Projects.

The Stage I Priority Projects identified in the Master Plan and elaborated in this Feasibility Study encompass the following: 1) water supply augmentation; 2) existing systems rehabilitation; 3) peri-urban water supply; and 4) institutional development.

9. Water Supply Augmentation Project

The Components of the Augmentation Projects are summarized as follows:

9-1 Water Treatment Plant (Chrouy Changva Stage II) Construction Project

The existing Chrouy Changva WTP will be expanded from its present capacity of 65,000 m^3/day up to 130,000 m^3/day. Sufficient space is available at the existing site. The major facilities to be constructed are flocculation /sedimentation tanks, filters and clear water reservoirs. The existing plant achieves proper treatment performance, securing safe and clean clear water meeting the national drinking water standards. The responsible engineers and operators are accustomed to operating the existing plant. It is therefore recommended to apply the same treatment process/ facility, except minor changes for improvement, as necessary.

There is insufficient space within the existing intake tower to install additional intake pumps or change to larger pumps. Therefore, it is recommended to construct a new intake tower with the capacity to meet the total expanded production capacity of 130,000 m^3/day and convert the existing structure and pumping facility for use as a stand-by unit.

The capacity of the clear water reservoir in Chrouy Changva WTP was reviewed and it was identified that the existing reservoir (5,760 m^3, equivalent to 2.1 hours at full production of 65,000 m^3/day) is far smaller than the requirement to cover water demand fluctuation in a day. Therefore, additional reservoirs should be provided with the expansion of the treatment facilities.

9-2 Transmission and Distribution System Augmentation Project

Stage I of the Master Plan, targeting the year 2010, focuses on reinforcing or creating the two main transmission loops by connecting existing branches. By 2010 the system will be upgraded with:

- network extension of 52 km of transmission pipes,
- a new 900 mm pipe from the expanded Chrouy Changva WTP to the Chrouy Changva bridge,
- a new water tank and transmission to supply Ta Khmau area,
- a new safety and sustainable policy with redundancy and energy saving incorporating:
  - loop systems;
  - independent pumping station and reservoirs
  - improved monitoring systems.

10. Rehabilitation Project

The other two existing treatment plants (Chamkar Mon and Phum Prek) are both more than ten years old and due for heavy maintenance and rehabilitation of some components. The rehabilitation works consist of overhaul/repair/replacement of mechanical equipment, electrical equipment, and instrumentation, all of which usually deteriorate over the relatively short period of 10 to 20 years. The actual contents of the works shall be determined by PPWSA considering the budget availability and seriousness of the deterioration of the equipment.

The following are examples:

- Replacement of pump impeller – higher energy consumption (decrease of efficiency)
- Chemical dosing facility – more chemical consumption (leakage or rude dosing)
- Chlorination facility – improve safety (leakage)
- Power supply facility – improve reliability
- Automatic control system – less manpower
- Laboratory – proper water quality control

11. Peri-Urban Water Supply Project

In Stage I, communes and villages with an estimated population of 47,741 inhabitants will be selected for attaining the target of safe water coverage of about 60%. The Peri-Urban Water Supply Project should be started in areas adjacent to urbanized areas of MPP and district towns of Ta khmau and Kien Svay in order to relieve the disparity of water supply between them. Accordingly, Dangkao District in MPP and Takmau District and Kien Svay District in Kandal Province will be prioritized for implementation. Basic design parameters include the following:

- Unit Water Consumption : 40 liter/capita/day
- Water supply facilities : Deep well
- Safe pumping yield of well : 20 liter/minute (=1.2 m3/hour)
- Coverage person per one well : 210 person/well
- Design water supply amount : 8,400 liter/well

- Required number of wells : 229 wells
- Water supply level : Level 1 Tube-well with hand pump (because of low yield and recharging)

12. Institutional Development & Capacity Building Plan

The broad themes for the institutional development and capacity building plan during Stage I are on sharpening of organizational **directions**, strengthening of management **systems,** and promoting more **delegation** of duties and responsibilities. Many of the current systems need to be formalized and standardized as the PPWSA expands. The priority strategy at this stage of growth focuses on enhancing the stability of the organization – so that its present high performance is sustained in spite of whatever events or changes may occur beyond its control.

Stage I institutional development will be done by **organizational restructuring** (to help build a broader team of managers and supervisors with clear roles and responsibilities and set the stage for even higher levels of coordination among the management team and delegation of authority and responsibility); **intensified training** for all staff on all aspects of utility management and operations (not just technical aspects) and **strengthening of existing management information system** (based on the existing Navision Financials).

The objective of the institutional development assistance project is to ensure that PPWSA can sustainably manage the newly-expanded facilities at least as well as it has been managing its existing facilities. The project envisages that starting 2007 until the end of Stage I, external technical support for institutional development will be part of the future investment programs. This external assistance will augment PPWSA's own efforts in selected areas of need. The assistance will mainly take the form of management (and technical) systems review and development and training services.

13. Environmental Impact Assessment

JICA's Office of Environmental and Social Considerations Review categorized the Stage I Priority Projects as Category B. The Priority Projects will have mostly beneficial impacts. Proper mitigation measures must be implemented throughout the planning, construction, and O&M phase of the each project. Monitoring of the environment and the effectiveness of the mitigation measures is also the responsibility of PPWSA.

PPWSA will need to be careful about the following issues in the implementation of the Stage I Priority Project, if necessary.

- PPWSA must revise the scoping checklist for each project on site so that no environmental items are missed from the study.

- PPWSA must update the social and environmental condition around the project site.
- For the construction of distribution pipes, PPWSA must minimize relocation or modification of existing infrastructures and private structures.
- PPWSA must prepare a required cost for environmental mitigation and monitoring measures based on the detailed information of project design and schedule if necessary.
- PPWSA must continue their efforts to distribute information and to negotiate with local communities regarding the design and schedule of construction of each project.
- In case that PPWSA cause forced relocation of settlement or legal businesses, PPWSA must faithfully participate negotiation procedure and consider proper compensation according to the local common sense as well as the international guidelines if necessary.

FINAL REPORT

THE STUDY ON THE MASTER PLAN OF GREATER PHNOM PENH WATER SUPPLY (PHASE 2) IN THE KINGDOM OF CAMBODIA

VOLUME I SUMMARY REPORT

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Abbreviations

ADB	**:**	**Asian Development Bank**
BAU	**:**	**Bureau des Affaires Urbaines**
BOD	**:**	**Biological Oxygen Demand**
BOT	**:**	**Built, Operation, and Transfer**
CDS	**:**	**Central Distribution System**
CMDGs	**:**	**Cambodian Millennium Development Goals**
COD	**:**	**Chemical Oxygen Demand**
DPWT	**:**	**Department of Public Works and Transport**
EIA	**:**	**Environmental Impact Assessment**
F/S	**:**	**Feasibility Study**
GDP	**:**	**Gross Domestic Product**
GNP	**:**	**Gross National Product**
GOJ	**:**	**The Government of Japan**
IEIA	**:**	**Initial Environment Impact Assessment**
MIME	**:**	**Ministry of Industry, Mines and Energy**
MIS	**:**	**Management Information System**
MOE	**:**	**Ministry of Environment**
MOP	**:**	**Ministry of Planning**
MPP	**:**	**Municipality of Phnom Penh**
MPWT	**:**	**Ministry of Public Works and Transport**
MWRM	**:**	**Ministry of Water Resources and Meteorology**
NRW	**:**	**Non-Revenue Water**
PPWSA	**:**	**Phnom Penh Water Supply Authority**
PVC	**:**	**Polyvinyl Chloride Pipe**
RGC	**:**	**The Royal Government of Cambodia**
SEDP	**:**	**Socioeconomic Development Plan (I or II)**
TA	**:**	**Technical Assistance**
UNDP	**:**	**United Nations Development Program**
US$	**:**	**United States Dollar**
WB	**:**	**World Bank**
WHO	**:**	**World Health Organization**
WTP	**:**	**Water Treatment Plant**

PART A : MASTER PLAN

Chapter 1. Background of the Project

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The Study on the Master Plan of Greater Phnom Penh Water Supply (Phase 2) follows the Scope of Work and the Minutes of Meeting on the Scope of Work for the Study, signed on 29th July 2004, between the Royal Government of Cambodia, represented by the Ministry of Industry, Mines and Energy (MIME) and the Phnom Penh Water Supply Authority (PPWSA), and the Japan International Cooperation Agency (JICA). JICA has organized a study team ("the Study Team") to carry out the Study.

The Study started at the beginning of December, 2004, and was completed at the end of January, 2006.

1-1 Objectives of the Study

The objectives of the Study are:

1) To formulate a master plan up to the year 2020 for an efficient and sustainable water supply system for Greater Phnom Penh (Municipality of Phnom Penh, Ta Khmau City and urban areas bordering the Municipality of Phnom Penh in Kandal Province), and to conduct a feasibility study on the priority project(s); and
2) To transfer technology to counterpart personnel during the course of the study.

1-2 Study Area

The study area covers Greater Phnom Penh, defined as the Municipality of Phnom Penh, Ta Khmau City, and urban areas bordering the Municipality of Phnom Penh located inside of the outer-ring-dike road, encompassing an area of approximately 510 km^2 and a population of approximately 1.5 million.

1-3 Target Year

The target year in this study is 2020, divided into three stages: Stage I (2006-2010), Stage II (2010-2015) and Stage III (2015-2020).

1-4 Study Methodology and Components

The methodology envisaged by the Study Team in their Inception Report has been maintained. Since the Study was conducted in three phases, as described below, several reports were prepared during each phase in the course of the Study.

- Phase I (Basic Study) Preparatory work for development of the Master Plan and data collection. The work includes review of the existing information/data including technical, organization, managerial,

and financial aspects. The results are summarized in the Progress Report submitted 9 March 2005.

- Phase 2 (Master Plan) — Preparation of a master plan outlining the development plan for water supply systems to 2020, including organizational improvement, capacity building and drainage and sewerage improvements. The results are presented in the Interim Report submitted in June 2005
- Phase 3 (Feasibility Study) — Conducting a feasibility study of the most important urgent projects in the Master Plan, including preparation of preliminary design of water supply systems, project cost estimates, O&M plan, capacity building plan, and implementation plan.

This Final Report presents the results of the Study for Phase 1 (Basic Study), Phase 2 (Part A: Master Plan) and Phase 3 (Part B: Feasibility Study). The Report consists of Three Volumes:

Volume I: Summary Report

Volume II: Part A: Master Plan
Part B: Feasibility Study

Volume III: Supporting Reports

Part A: Detailed Study Documents/Data

Part B: Drawings

Chapter 2. General Description of the PPWSA Service Area

Chapter 2. General Description of the PPWSA Service Area

The PPWSA service area encompasses the Municipality of Phnom Penh plus parts of neighboring Kandal Province. Phnom Penh, the country's capital city, is located beside the confluence of the Mekong River, Tonle Sap River, and Bassac River. These three rivers form an unusual X-shaped layout that follows a very irregular flow regime during the year. They are also the principal water source since there are limited groundwater resources and no artesian aquifers. Phnom Penh is in the Asian tropical monsoon zone. The wet season occurs from May till November, the dry season from December to April.

The Municipality consists of seven districts, referred to as "Khans." Four of the seven Khans are considered urban and the remaining three Khans are considered rural. Each district consists of 8 to 12 sub-districts, referred to as "Sangkat." The total area of the four Khans in the urban area is 27 km^2 and that of the three Khans in the rural area is 347 km^2, totaling 374 km^2.

An embanked road with an elevation of more than 10 meters above sea level surrounds the southwest side of the city and protects against flooding. Lake Boeng Kak in the north and Lake Boeng Trabek Thom in the south are low swamp areas acting as stabilization ponds for sewage in the dry season and as detention ponds in the rainy season. However, due to infill, their land/surface area, volume and absorption capacity are rapidly disappearing.

Chapter 3. Review of the Phase I Master Plan

Chapter 3. Review of the Phase I Master Plan

The Phase 1 Master Plan Study was conducted with the assistance of the Government of Japan in 1993, following the end of the internal war and the Paris Accords agreed in November 1991. The objectives of the study were to i) formulate a master plan for the water supply system in the Municipality of Phnom Penh, ii) formulate an urgent rehabilitation project for the existing facilities, and iii) conduct a feasibility study for the priority project identified in the master plan study. However, the feasibility study was not carried out since the priority project originally considered as the candidate for the feasibility study was adopted as urgent rehabilitation work under the Master Plan.

The following table summarizes the current situation of PPWSA operations in comparison to the survey results by the previous Master Plan Study Team in 1993.

Table 3-1 Comparison of PPWSA's Performance Indices Between 1993 and 2004

Indicator	1993	2004
Production capacity (m3/day)	65,000	235,000
Coverage (%)	50	85
Distribution network (km)	280	1,084
Supply pressure (bar)	0.2	2.0
Supply duration (hr/day)	10	24
Nos. of connections	26,881	120,000
Nos. of staff/1,000 connections	22	4
Illegal connections	more than 300/year	less than 5/year
Metering ratio (%)	12	100
Collection ratio (%)	50	99.9
NRW (%)	72	15
Total income (billion Riels)	0.7	34
Operating expenditure (billion Riels)	1.4	9.4
Total expenses (billion Riels)	N/A	27

Source: PPWSA

Chapter 4. Project Framework

Chapter 4. Project Framework

4-1 Macro Economy and Industry

Cambodia is one of the poorest countries in the world. The economy is largely agrarian, supported in recent years by rapid growth in tourism and garment exports, the primary foreign exchange earners. The government desperately lacks resources for essential public investments in social and economic infrastructure and faces the prospect of rising debt service obligations in the near future.

The anticipated downturn during 2005 due to the loss of preferential US garment quotas at the beginning of the year failed to materialize and, despite high oil prices and weaker agricultural prospects, overall growth continues to be surprisingly robust. The IMF[1] revised its estimate of real GDP growth for 2004 from 4.3 % to 7.7 %, and for 2005 from 1.9 % to 6.3%. The World Bank is further projecting 2006 growth on the order 6.1%.[2] However, both institutions have doubled their CPI inflation forecasts for the same years to slightly above 5%.

The RGC has set out a comprehensive policy to increase Cambodia's international competitiveness by focusing on development and improvement in physical infrastructure to effectively respond to the increasing demand for basic services, such as low-cost water and power supply, as well as financial, information and telecommunications services. The RGC also has a policy to promote "cultural and natural tourism" development in Cambodia.

4-2 National Plans

Development planning in Cambodia is carried out through a constitutionally-mandated five-year planning process. The 2006-2010 Plan, entitled National Strategic Development Plan (NSDP), is currently under preparation. The NSDP will be based on the Action Plan for Harmonization and Alignment 2004-2008 (also known as "the Rectangular Strategy") and will consolidate the existing Socio-economic Development Plan II (2nd five-year plan) and the National Poverty Reduction Strategy (NPRS), both of which reflect the overarching aims expressed in the Cambodia Millennium Development Goals (CMDGs).

There is some difference between the water and sanitation development targets stated in the previous five-year plan (SEDP-II) and the more recent Cambodia MDGs. The latter are expected to be reflected in the NSDP. The relevant CMDG targets (Goal 7) are summarized in Table 4-1.

[1] Results of October 2004 Article IV Consultation are available on the IMF's web site, <www.imf.org>, revised estimates are on Representative Office site <http://imf.org/external/country/KHM/rr/>.
[2] *East Asia Update: Countering Global Shocks*, The World Bank, November 2005.

Table 4-1 CMDG7 Indicators, Benchmarks and Targets

Indicators	Benchmarks		Targets		
	Value	Year	2005	2010	2015
7.10: Proportion of rural population with access to safe water source	24	1998	30	40	50
7.11: Proportion of urban population with access to safe water source*	60	1998	68	74	80
7.12: Proportion of rural population with access to improved sanitation	8.6	1998	12	20	30
7.13: Proportion of urban population with access to improved sanitation	49	1998	59	67	74

Source: *Cambodia Millennium Development Goals Report 2003*
* Access to piped water in Phnom Penh is presently estimated at 85%, 15% for provincial towns (but 5 of 24 have none).

The population with access to safe drinking water increased from 20% in 1995 to 26% in 2000. An update on progress toward further achievement of the targets will be known when the results of the 2004 Cambodian Socio-Economic Survey (CSES) are released (not available as of this writing).

4-3 National Policy on Water Supply and Sanitation

The National Policy on Water Supply and Sanitation (February 2003) defines a national vision in which "everyone has sustained access to safe water supply and sanitation services and lives in a clean, healthy and sustainable environment." The basic policy on approach to water supply is that "supply driven or demand responsive approaches should be carried out based on local conditions." In general, demand responsive approaches should be favored in the interest of tailoring costs and specifications to local demand, affordability and circumstances.

Private sector participation (PSP) shall be encouraged but it is necessary to define clear guidelines specifying the rights and obligations of private parties.

Tariffs should cover all costs, but there should be a clearly defined tariff policy for subsidies so that the poor can gain access to water supply networks.

In the water sector, only PPWSA operates under the Law on Public Enterprises. Among the other 19 provincial towns that have systems (out of total 24, 5 have nothing), 3 are private and the others operate under "financial autonomy or revenue balancing expenses." Policy in this area is that "mechanisms for decentralization and financial autonomy of public utilities should be pursued" in the interest of ensuring service sustainability, financial accountability; cost recovery, management efficiency and consumer confidence. MIME and Provincial Authorities shall cooperate in defining their respective roles and responsibilities, including provisions for building local public utility capacity and assuring their independence (i.e., from political interference).

The draft water supply and sanitation law proposes a basic framework for provision of water and sanitation services in the country. Compared to the present situation, the key implications of the draft

law are that it would redefine the role of MIME to be overall sector planning and policymaking and create a new sector regulatory body, the Water & Sanitation Authority, to issue operating licenses and regulate tariffs, among other regulatory functions.

4-4 Other Key Sector Policy Developments

Draft Water Resources Law – The proposed water resources law defines the rights and obligations of water users; the basic principles for water resources management; the institutional arrangements for implementation and enforcement; and the role of water user groups. Under the proposal, MOWRAM will maintain a central inventory of water resources and prepare the national water resources plan.

Private Sector Participation – Cambodia has been testing the appropriateness of private sector participation in water supply provision. In some provincial towns, private sector operators have been operating under Build-Operate agreements. Currently, five provincial water supply systems are privately managed.

4-5 City Planning and Population Projection

Based on the future urban development scenarios, population of the central area is expected to decrease from 715,500 in 2005 to 683,400 in 2020. The average population density will drop from 264 persons per hectare in 2005 to 252 persons per hectare in 2020. Population density of Prampir Meakkara District, the most densely populated District at present, is expected to fall from 540 persons per hectare in 2005 to 440 persons per hectare in 2020. Within the central area, only Tuol Kouk District will show a slight increase in population in future.

In the suburban area of MPP, the population will double from the present 2005 population of about 620,000 to about 1,320,000 until 2020. This population increase of about 700,000 is expected to occur in Dangkao District, 270,000; in Mean Chey District, 160,000; and in Ruessei Kaev District, 270,000.

In Kandal Province, the Angk Snuol District, located along National Road No. 4, is expected to experience a population increase of about 46,700 between 2005 and 2020. This is nearly half of the projected population increase of 102,700 for the area during the same period. The Commune of Kamboul, in particular, will show a high population growth rate averaging about 8 %.

Ta Khmau District, which is already urbanized, is expected to grow moderately in future, considering that the area is characterized as a flood plain.

Table 4-2 Population Projections

Year	2005	2010	2015	2020
Phnom Penh	1,334,892	1,551,479	1,776,646	2,006,009
Chamkar Mon	237,822	235,775	233,728	231,680
Doun Penh	156,691	151,587	146,483	141,380
Prampir Meakkara	118,664	111,507	104,350	97,190
Tuol Kouk	202,355	205,941	209,527	213,110
Central Areas	715,532	704,810	694,088	683,360
Dangkao	118,466	206,458	296,599	387,948
Mean Chey	233,348	285,361	339,983	395,779
Ruessei Kaev	267,546	354,850	445,976	538,922
Suburban Areas	619,360	846,669	1,082,558	1,322,649
Kandal within Study Area	195,107	223,412	258,222	297,817
Kandal Stueng (part)	16,068	18,726	21,926	25,459
Kien Svay (part)	57,765	63,382	69,666	76,093
Angk Snuol (part)	37,892	49,314	64,930	84,546
Ponhea Lueu (part)	14,427	16,215	18,276	20,451
Ta Khmau	68,955	75,775	83,424	91,268
Study Area Total	1,529,999	1,774,891	2,034,868	2,303,826

Source: Study Team Estimates based on the NIS Projections and BAU's Targeted Population Density by Commune

Chapter 5. Water Supply Scheme

Chapter 5. Water Supply Scheme

As of 2004, 67.7% of the total population in the Study Area had access to the central distribution system. The service area coverage included 76.8% in the Municipality of Phnom Penh and likely less than 10% in Kandal Province.

In preparing the target supply coverage, two plans are considered. The first plan is the Millennium Development Goals (2005-2015), which aims to increase coverage up to 80% by 2015 in the urban areas. The second is envisaged in the PPWSA strategic plan for target year 2009, in conformity with the policy of the Ministry of Industries, Mines and Energy.

A staged target level is then utilized as shown in the table below, taking into consideration the current state of coverage, schedule of planned project implementation, and the priority of each district/commune. Mean Chey and Ruessei Kaev, to the south and north of the four Phnom Penh Central Districts, are given higher priority than Dangkao District based on the City Plan set by the BAU of MPP. The Kakab and Chaom Chau communes in Dangkao District are given preferential treatment due to their important location along National Road No.4.

Table 5-1 Proposed Supply Coverage

Year	**2005**	**2010**	**2015**	**2020**
Average Supply Coverage for MPP	76.8 (79.4)	77.3 (79.6)	**80.3** (82.2)	88.6 (**91.9**)
Average Supply Coverage of Kandal	5.7	20.0 (38.9)	25.0 (69.9	30.0 (**80.1**)
Coverage of the total Study Area	67.7 (70.0)	70.1 (74.5)	73.3 (80.7)	**81.0** (**90.4**)

Notes:
1)The coverage in 2005 is assumed to be same as the present coverage in 2004.
2)Figures in ( ) show the coverage including both piped water supply of PPWSA and well water supply by MRD.

The total populations served by the Central Distribution System (CDS) and groundwater sources are summarized in the following table.

Table 5-2 Served Population(x 1,000)

Year	2005	2010	2015	2020
Total Population in Study Area	1,529,999	1,774,891	2,034,868	2,303,826
Served Population by Central Distribution Systems (CDS) in Study Area				
Served Population	1,035,931	1,244,738	1,491,113	1,866,102
Coverage	**67.7%**	**70.1%**	**73.3%**	**81.0%**
Served Population by CDS +Well Water Supply in Study Area				
Served Population	1,070,582	1,321,598	1,641,684	2,082,822
Coverage	70%	74.5%	**80.7%**	**90.4%**

Chapter 6. Water Demand Projection

Chapter 6. Water Demand Projection

Under the most likely scenario, water demand will increase from 133,402 m^3/d in 2004 to 271,093 m^3/d in 2020 on a daily average basis and from 204,027 m^3/d in 2004 to 414,612 m^3/d in 2020 on a daily maximum basis. Supply coverage will be 67.7% in 2004 and 81% in 2020; while the NRW ratio will be maintained through the continuous efforts of PPWSA at the current level of 15% through the target year 2020.

Table 6-1 Proposed Water Supply Basic Indicators

Year	2005	2010	2015	2020
By CDS Systems				
Daily ave. per capita water demand (lpcd)	80	86	95	104
Peak factor	1.3	1.3	1.3	1.3
Peak day per capita water demand	104	111	123	135
NRW	15%	15%	15%	15%
Daily max. per capita demand (lpcd)	122	131	144	158
Total population	1,529,999	1,774,891	2,034,868	2,303,826
Served population	1,035,931	1,244,738	1,491,113	1,866,102
Coverage (%)	67.7	70.1	73.3	81.0
Daily ave. water demand (m^3/d)	133,402	166,529	209,292	271093
Daily max. water demand (m^3/d)	204,027	254,691	320,094	414,612
No. of served households	105,870	136,540	180,736	247,712
No. of non-domestic connections	15,517	18,729	21,640	25,011
Total no. of connections	121,387	155,269	202,376	272,723
By CDS + Well Water Systems				
Total population	1,529,999	1,774,891	2,034,868	2,303,826
Served population	1,070,582	1,321,598	1,641,684	2,082,822
Coverage (%)	70.0	74.5	80.7	90.4
By Well Water Systems				
Served population	34,650	76,860	150,570	216,720
Ave. population covered per well	210	210	210	210
No. of wells required	165	366	717	1,032
Unit water consumption per capita (lpcd)	40	40	40	40
Well water supply amount (m^3/d)	1,386	3,075	6,023	8,668

Chapter 7. Urban Water Supply Development Plan

Chapter 7. Urban Water Supply Development Plan

The water supply development plan targeting the year 2020 follows the PPWSA's strategy and water demand projections mentioned above.

Objectives	1) Stable water supply (24-hour/day supply at proper pressure) 2) Safe/clean water (meeting National Drinking Water Quality Standards) 3) Expanding services (meeting service population demand)

The required production capacity at each stage up to 2020 is illustrated in the figure below based on the daily maximum water demand. The present production capacity of 235,000 m^3/d can meet the water demand through 2007. With implementation of the project to expand the capacity of the Chrouy Changva WTP by 65,000 m3/d (bringing total production capacity to 300,000 m3/d), the maximum water demand during Stage I and through the year 2013 of Stage II can be met. After 2013, a second project for construction of a new water treatment plant with a production capacity of 100,000 m^3/d will be necessary to satisfy the further increased water demand during the latter part of Stage II and beyond. Total production capacity during Stage II will reach 400,000 m^3/d, which will meet demand to 2019 in Stage III. The additional production capacity in Stage II of 100,000 m^3/d will ensure sufficiency over the next five years of growth. In addition, it is a suitable size to develop as a project, considering efficient project preparation and physical issues such as extension of related transmission and distribution network. A third augmentation project will be required in 2019, toward the end of Stage III, to fulfill the expected water demand in 2020 and beyond.

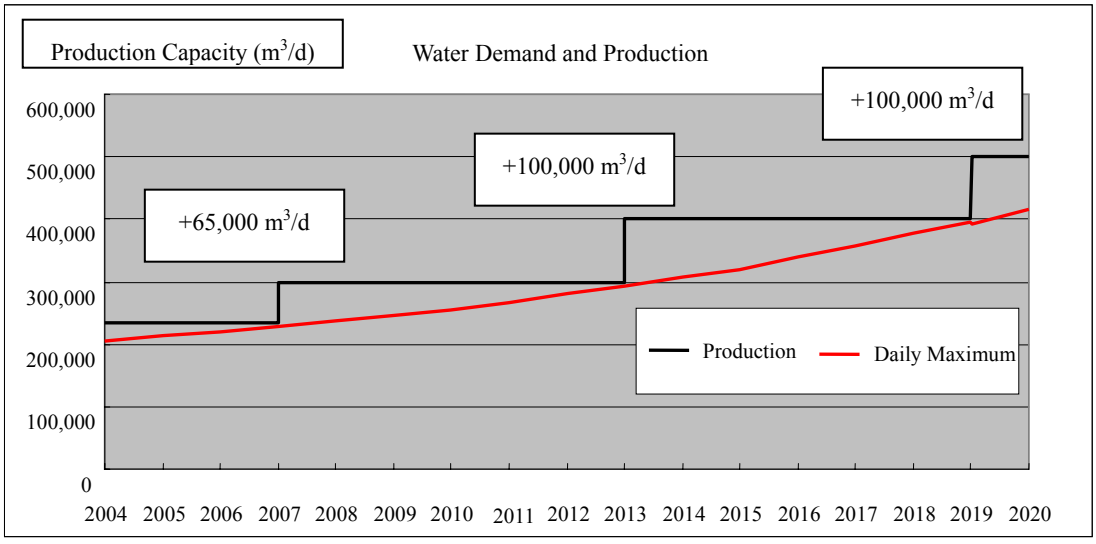


Figure 7.1 Water Demand and Production Capacity

7-1 Water Production and Treatment

The water production requirement for the year 2020 is 500,000 m^3/d. The existing production capacity is 235,000 m^3/d. Therefore, the necessary additional water production capacity will be 265,000 m^3/day. The table below summarizes the existing production capacity and the requirement in 2020.

Table 7-1 Water Production Capacity

Water Production	Capacity (m^3/d)
Water Production in 2020	500,000
Existing Water Treatment Plant	
- Phum Prek	150,000
- Chamkar Mon	20,000
- Chrouy Changva	65,000
Sub-Total	235,000
Necessary Production Increase	265,000

PPWSA has a plan to expand Chrouy Changva Water Treatment Plant within the next few years, raising its capacity by 65,000 m^3/day bringing the total plant capacity to 130,000 m^3/day. The expansion of Chrouy Changva will be the first major project under this Master Plan, followed by construction of a new treatment plant (Nirouth) in two stages, as shown below.

Table 7-2 Expanded Water Production Capacity

Plant	Capacity (m3/d)	Year
Chrouy Changva – 2nd Stage	65,000	2008
Nirouth Plant – 1st Stage	100,000	2013
Nirouth Plant – 2nd Stage	100,000	2019
Production Increase	265,000	-

Water production alternatives are considered in principally two aspects – water source and water treatment plant site. As for water sources, the Tonle Bassac cannot be an alternative because of low flow and high contamination compared with the Tonle Sap and the Mekong River. The location of the water treatment plant should be close to the water source (intake station) and the area where the water will be consumed. Considering these aspects, three alternatives were identified for the new intake station and water treatment plant, as follows:

Table 7-3 Synopsis of Alternatives Studied

Item	Alternative – A (Svay Pak)	Alternative – B (Chrouy Changva)	Alternative – C (Nirouth)
Water Intake			
Location	Tonle Sap	Mekong River Upstream	Mekong River Downstream
Future water quality	Poor	Good	Good
Water Treatment Plant			
Power consumption (Distance to network)	6.18 km/m3 (114 %)	6.28 km/m3 (116 %)	5.43 km/m3 (100 %)
Chemicals	High	Fair	Fair
Overall	3rd	2nd	**1st**

The locations of the alternatives are shown in the figure below. As for water source, Alternatives B and C are advantageous, and Alternative C is superior to B with respect to treatment and distribution. Therefore, Alternative C, a new treatment plant at Nirouth, with production capacity of 200,000 m^3/day, is recommended.

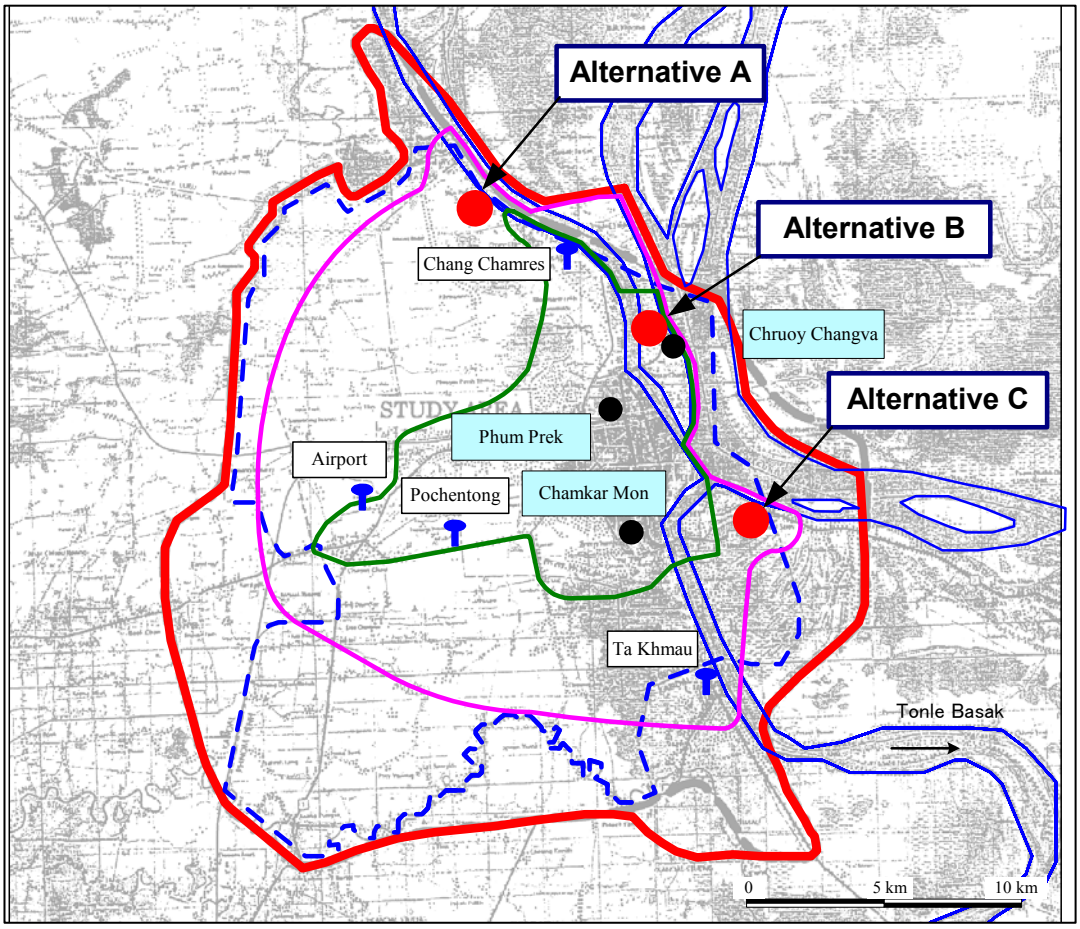


Figure 7.2 Location of Plant & Intake Alternatives

The development sequence for major water production facilities is shown below.

Table 7-4 Production and Treatment Development Sequence

Stage	Production Facility
I (-2010)	Chrouy Changva – 2nd Stage 65,000 m^3/d (2007)
II (2011-15)	Nirouth Plant – 1st Stage 100,000 m^3/d (2013)
III (2016-20)	Nirouth Plant – 2nd Stage 100,000 m^3/d (2019)

7-2 Water Transmission and Distribution

The water transmission and distribution system will be expanded in parallel with the development of additional production facilities, paying close attention to the patterns of demand from the growing areas

and the long term hydraulic requirements of the system itself. The demand forecast adopted for network expansion follows the demand forecast already determined as the basis for this Master Plan.

Any network expansion inevitably comes up against constraints imposed by the limitations of the existing system and above-ground reality. Once transmission lines have been laid and development occurs above ground, it usually becomes increasingly difficult and expensive to increase transmission capacity through those areas. This is problematic in the context of Phnom Penh because the existing treatment plants are sited in the east near the river, naturally enough, but the areas of most rapid development are now to the north, west and south. This means that the existing transmission capacity under the central City is facing increasing demand from the developing suburbs, a situation that is bound to continue. From an operational point of view, this means that transmission pressure near the plant and under the City must be increased in order to maintain adequate pressure in the outlying areas. Higher pressure means more pumping and more leaks, thus higher operating cost and more maintenance. However, the social and economic costs and disruption associated with installing new or additional mains through the central part of the City are so prohibitive as to virtually preclude further consideration or analysis if such a dire scenario can in any way be avoided.

The objectives for the expansion plan outlined below are therefore to 1) serve the additional demand, while 2) enhancing overall system performance. The strategy for accomplishing these objectives incorporates the following critical concepts: a) division of the network into discrete zones, most with their own reservoirs, permitting more intensive and flexible control of flow and pressure, b) creation of transmission network loops for greater redundancy and pressure balancing options, and c) completion of the distribution system, as at present, in closed, metered blocks.

The transmission and distribution system expansion proposed here covers three stages ending in years 2010, 2015, and 2020. The concept-level designs were developed utilizing the WaterCad system modeling software incorporating all available, relevant, actual and forecast data.

7-3 Analysis of Existing Conditions and Future Requirements

The existing transmission and distribution system consists of six principal branches radiating from the three existing treatment plants, as shown in the figure below. The transmission system feeds distribution networks that end in closed, telemetered blocks serving customers.

The main network branches are: Prekleap Branch; Chrang Chamres Branch; Airport Branch; Pochentong" Branch; Dangkao Branch; and, Ken Svey Branch.

In summary, the existing situation presents the following challenges and limitations of the transmission and distribution system:

- Demand is growing at the outer fringes of the network necessitating expansion of the transmission and distribution system overall.

- The transmission network lacks loops to permit treatment plants to redundantly supply branches of the network to which they are not directly connected.
- The existing treatment plants are located east of the major existing demand area, but the new development areas are to the north, west and south, placing a heavy future burden on the transmission network in the existing central area to pass water through to the new areas. Transmission capacity in the central City cannot be easily increased further without undue disruption and cost.

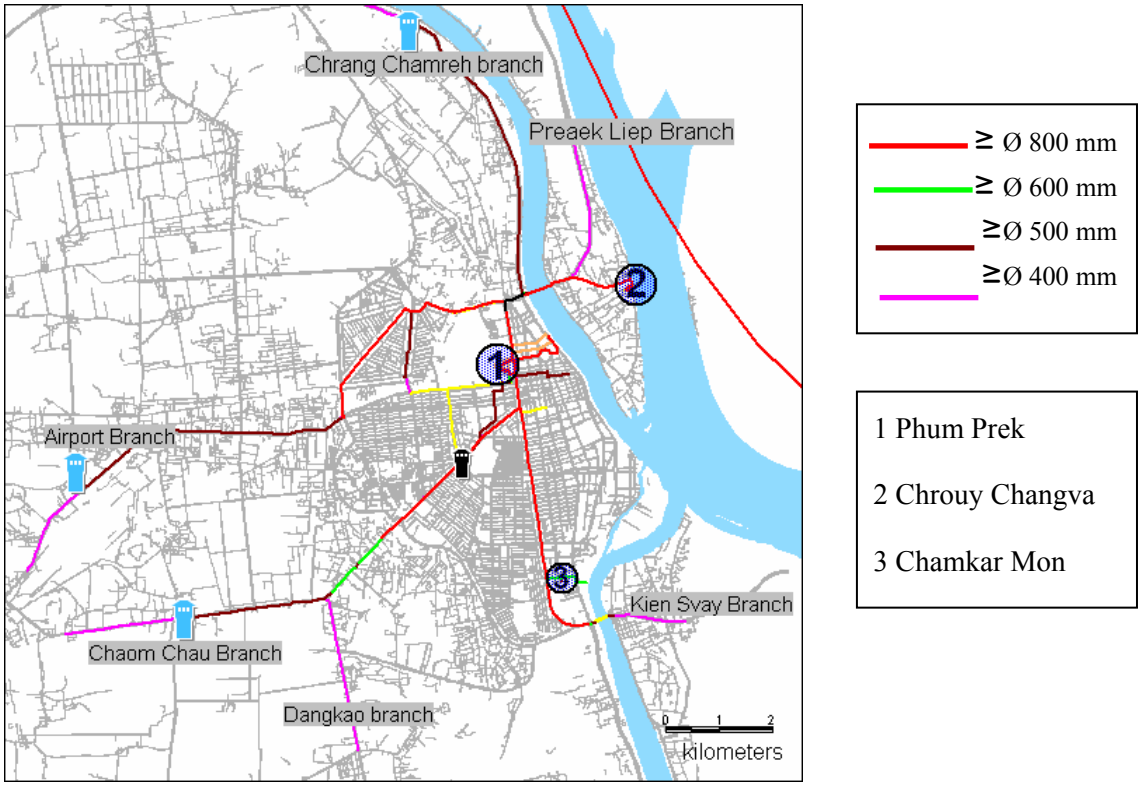


Figure 7.3 The Six Main Network Transmission Branches

The three tower tanks presently under construction will help to alleviate supply and pressure shortfalls in the outlying areas and thus conserve transmission pressure and pumping requirements in the upstream areas under the City and from the plants. The branches and towers constitute the building blocks for the definition of network Zones, as described further below.

7-4 Design Objectives and Strategy

There are two overall objectives for network expansion plan: 1) to meet growing demand; and 2) to improve system performance, specifically, to provide the basis for management of system pressures resulting in balanced operation.

The strategy for realizing the first objective is relatively straightforward. The demand forecast, based on the City Development Plan described elsewhere in this report, provides the basis for estimating short, medium and long term requirements for system expansion in relation to both geographic location and

capacity. The expansion areas and the network capacity increases required to serve them are detailed in the descriptions of the relevant Stages of the expansion plan provided further below.

The second objective is more problematic. Growing demand from outlying areas at increasingly greater distances from the principal treatment plants necessitates raising pressures in the transmission lines closer to the plants and, under certain circumstances, even causing the treatment plants to push against each other. This was actually the case with the pumps at Phum Prek having to work against Chrouy Changva's greater head. The problem has since been alleviated with the installation of a valve on the main connecting the two plants, but this also means that said main is no longer available for Chrouy Changva to supply areas on the other side (i.e., south) of Phum Prek. Such problems will be reduced under the Master Plan. The strategy for achieving the objective of efficient system management is three-pronged and entails:

1) division of the system into zones,

2) creation of loops, and

3) distribution by closed blocks.

These three strategies are summarized in the following three subsections.

7-4-1 Distribution Zones

By dividing the system into discrete Zones, pressure in each Zone can be independently regulated and the requirement to maintain high pressure at the treatment plants will be reduced. The key to realizing this strategy is the construction of reservoirs. Presently, three tower tanks are under construction. Their completion is assumed in the expansion plan presented here. The other Zones are served directly by the clear water reservoirs at the treatment plants. Thus each Zone can be said to have its own reservoir, although in the future additional reservoirs may become necessary as the system continues to expand. The southern location of the proposed new treatment plant at Nirouth will contribute to postponing this necessity, since it will bypass the City and directly supply the growing areas to the south and west.

7-4-2 Loops

The looping strategy, introduced in the Progress Report, encompasses three stages of development that are synchronized with the three stages of development of the Master Plan. These are described as follows:

<u>Inner Loops</u>

The rationale of this first scenario is to join the existing main transmission pipes in order to form loops that will, with limited investment, enable:

- to distribute the water from the expanded/new (north and south) treatment plants,

- to cover a slightly extended area, particularly towards local areas where development is planned,
- to ensure in covered areas the benefits of a meshed system to better balance system pressure and provide alternate routes to supply water when one branch or plant must be temporarily disabled.

The completion of the inner loops will be carried out in Stage I and is illustrated in the following figure:

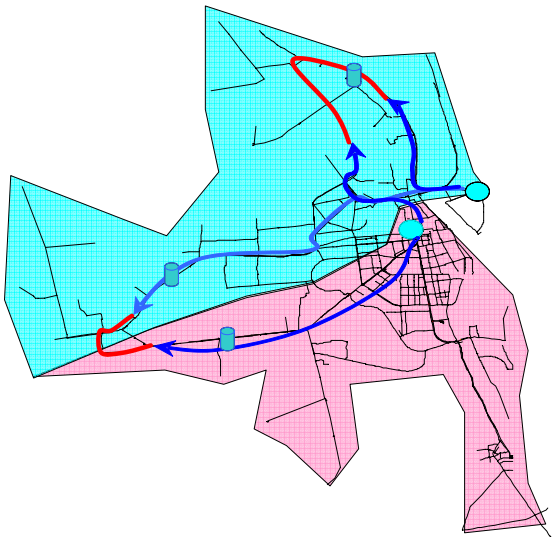


Figure 7.4 Completion of Local Loops

Middle Loop

This second scenario extends the above one to the south, creating a loop across the most populated suburban zone.

This second scenario is compatible and complementary to the first one. Crossing both main transmission lines westwards, it would hence create three more main-line loops. These loops would further improve the meshed quality of the network, while enabling to extend the service area efficiently towards the northwest and southwest.

Outer Loop

This last scenario accounts best for the wide extent of the study area, and of the likely required service area in the long term, by forming a much larger loop around the current city limits, encompassing even the airport. The possibility to ensure an adequate pressure in every branch of these large loops will require adequate installations to be designed, dimensioned and budgeted.

7-4-3 Consumer Blocks

The third prong of the efficiency strategy is blocking. This is to continue the existing practice of completing the distribution system with closed, telemetered blocks, providing detailed control and management of consumption and water loss at the consumer end of the system. The existing telemetering layout is shown in the figure below. Distribution by closed blocks is essential for effective

control of NRW. However, one result compared to an open distribution system is that the network has less absorptive/reactive capacity and is thus subject to greater fluctuations in pressure throughout the day as demand rises and falls and the plants attempt to accommodate. In other words, the blocking strategy requires a higher level of pressure management overall, which in turn necessitates implementation of the above-described Zoning and Looping strategies. The three prongs of the strategy are thus inter-connected and inter-dependent. Implemented together, the result will be an ideal network structure.

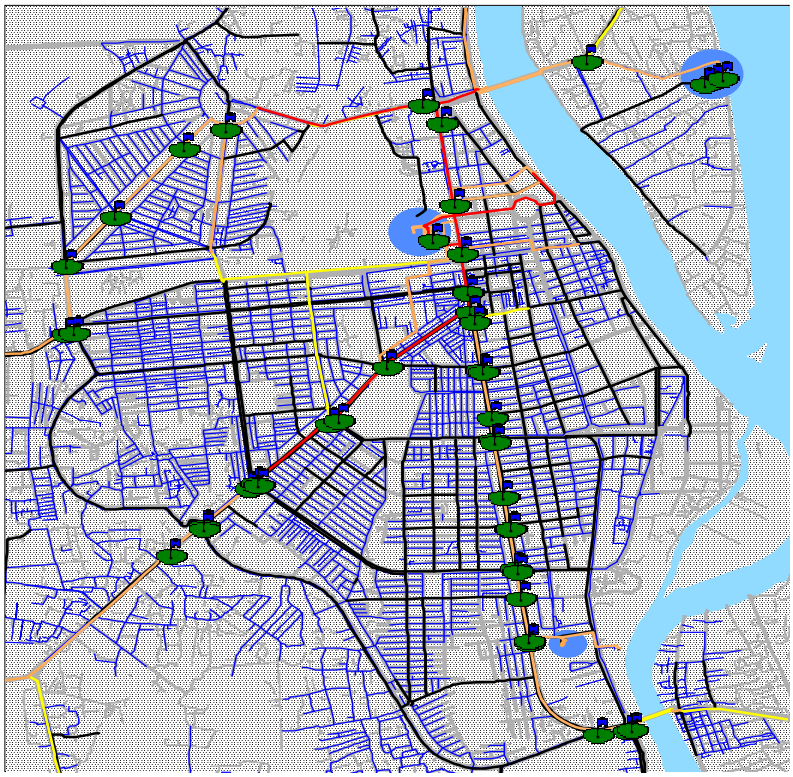


Figure 7.5 Existing Telemetered Blocks

7-5 Proposed CDS for 2005-2010

The 2005-2010 plan is designed to meet short-term demand in new areas up to 2010 and to complete the inner loops described in the strategy above. The pressure gradient at Phum Prek will be reduced so the pumps can function efficiently, maintaining a targeted minimum system pressure of 150 kPa. Major transmission lines (500mm to 600mm) will be extended to the north and to the south, encompassing the following expansion areas: Ta Khmao; Russey Keo nord (Khmuonh); and Dangkao (Kakab, trapeang krasang, Dangkao Branch to Cheung Aek).

Stage I assumes the completion of the three tower tanks and execution of the recommended expansion of the Chrouy Changva water treatment plant. In addition, booster pumps to fill the new storage tanks will be added if water fails to reach the tanks.

The following quantities of transmission pipes will be laid during the first Stage:

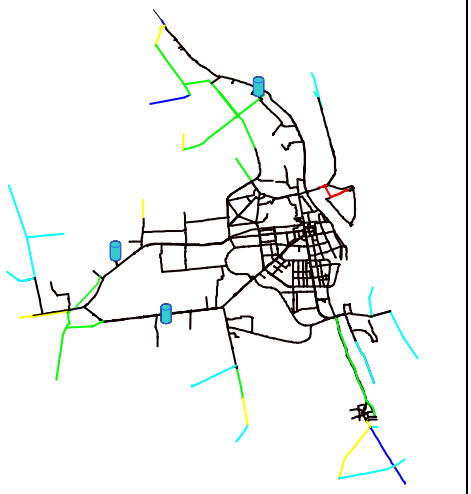
Length (m)	Diameter (mm)	Material	
1955	900	Ductile Iron	
967	800	Ductile Iron	
4572	600	Ductile Iron	
16672	500	Ductile Iron	
10718	400	Ductile Iron	
10056	300	Ductile Iron	
5834	250	Ductile Iron	
1351	225	HDPE	
52,125 meters, total length			

Figure 7.6 Distribution Network, 2005-2010

7-6 Proposed CDS for 2010-2015

The following figure shows the pipes recommended for the period 2010-2015.

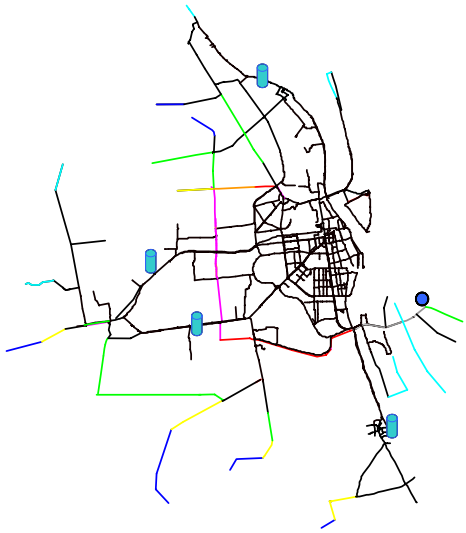
Length (m)	Diameter, (mm)	Material	
3,510	1,200	Ductile Iron	
6,960	1,000	Ductile Iron	
4,340	800	Ductile Iron	
1,370	600	Ductile Iron	
5,100	500	Ductile Iron	
1,720	400	Ductile Iron	
14,570	300	Ductile Iron	
10,140	250	Ductile Iron	
16,320	225	HDPE	
64,030 meters, total length			

Figure 7.7 Distribution Network, 2010-2015

Stage II accompanies the development of the proposed new Nirouth treatment plant with a supplementary capacity of 100,000 m^3. The transmission line (1000 mm diameter) from Nirouth will cross the Tonle Bassac heading toward the west. Once west of the City it will connect to a new north/south line (500-600 mm) that connects at the north end to the transmission line (800 mm) coming from Chrouy Changva. In this way the strategy of the middle loop will be realized, providing a complete route around the City as an alternative to the existing central north/south transmission line. The entire developing western area (north of the airport) will be served by the middle loop, which can be fed by either (or both) of the two largest treatment plants.

The results show that the network does not present any particular problems in its general working in terms of capacity. One notes solely some zones where the service pressure drops to 3 bars, or even to 2 bars. It is important to be aware of these zones in order to take account of them in the development strategy:

7-7 Proposed CDS for 2015 - 2020

Stage III is marked by the expansion (phase 2) of Nirouth, bringing another 100,000 m3/d, and continued growth in demand and service area. More than 80% of the entire Study Area will be covered. The key characteristic of the network expansion plan will be the realization of the outer loop, which will reach from the southwestern corner of the middle loop south, around the airport, then north and finally connecting back to the east toward Chrouy Changva. The result is nested, interconnected loops providing a high level of security, balance and flexibility to the overall system.

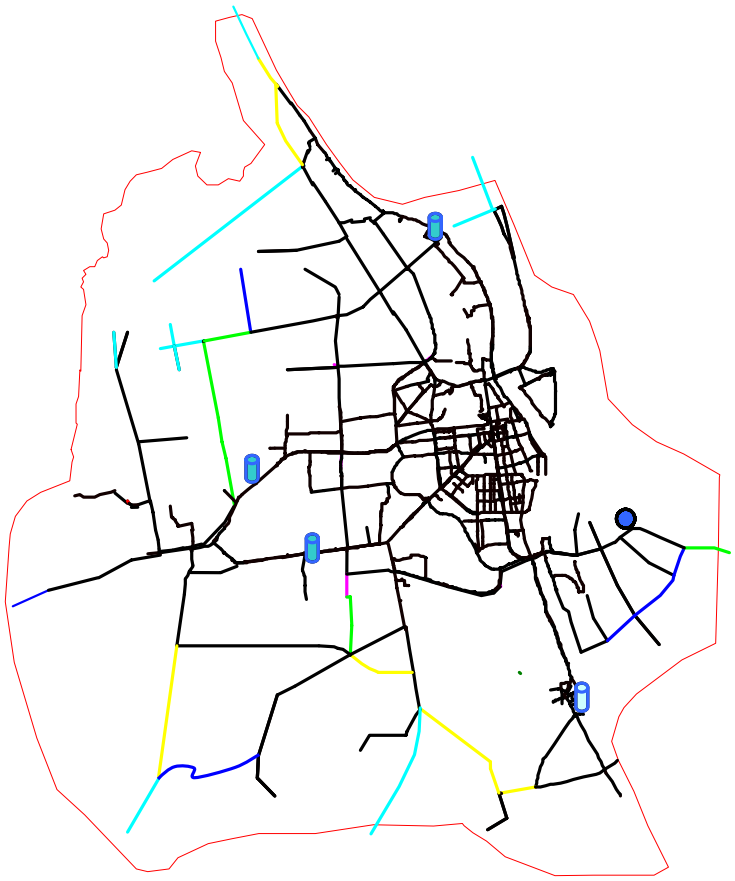


Figure 7.8 Distribution Network, 2015- 2020

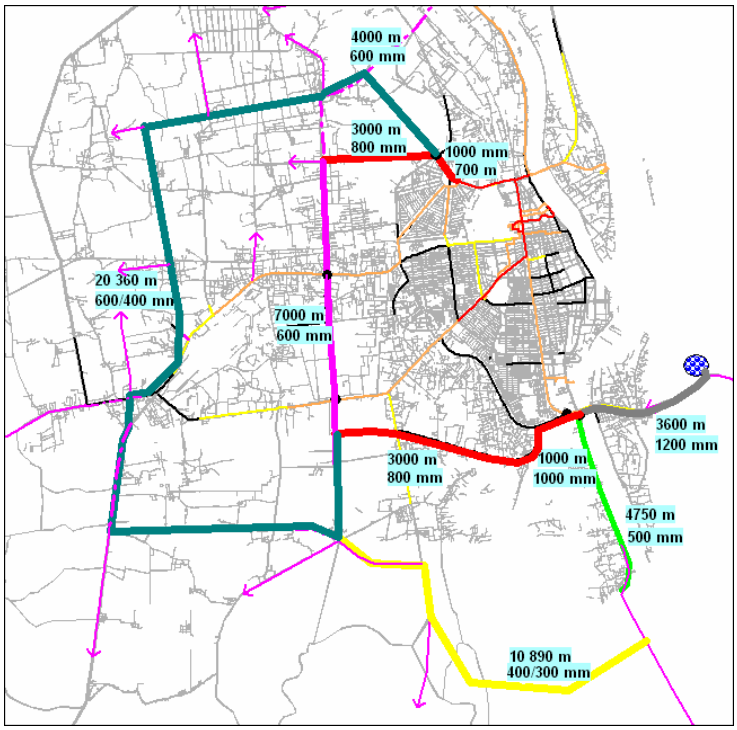


Figure 7.9 Main Transmission Pipelines, 2020

Chapter 8. Peri-Urban Water Supply Development Plan

Chapter 8. Peri-Urban Water Supply Development Plan

The Peri-Urban Water Supply Development Plan has established the clear target of providing safe water coverage to at least 80% of the population of the Phnom Penh peri-urban areas, as shown in the table below. The strategy for achieving the target entails a combination of piped network extension and development of wells in an appropriate and cost-effective manner. Implementation of the Plan will be carried out according to the following schedule:

Table 8-1 Projected Population and Population to be Served by Safe Water in 2020

District	Projected pop.	Population to be served in 2020		Coverage (%)	To be served by well (80% of district)		
		Piped	JICA well		Pop.	Demand (m^3/day)	Coverage (%)
MPP	**2,006,009**	**1,776,757**	**34,650**	**90.3**	**32,760**	**1,310**	**91.9**
Urban 4 districts	683360	683360	0	100	0	0	100
Dangkao	387948	252166	25410	71.5	32760	1310	80.0
Mean Chey	395779	356201	840	90.2	0	0	90.2
Ruessei Kaev	538922	485000	8400	91.6	0	0	91.6
Kandal	**297,817**	**89,345**	**0**	**30.0**	**149,310**	**5,972**	**80.1**
Kandal Stueng	25459	0	0	0	20370	815	80.0
Kien Svay	76093	7,609	0	10.0	53340	2134	80.1
Angk Snuol	84546	25364	0	30.0	42210	1688	79.9
Ponhea Lueu	20451	1611	0	7.9	14910	596	80.8
Ta Khmau	91268	54761	0	60.0	18480	739	80.2
Total	**2,303,826**	**1,866,102**	**34,650**	**82.5**	**182,070**	**7,282**	**90.4**

Table 8-2 Implementation Schedule of Well Construction

Stage		Year	2006	2010	2015	2020
Study	Basic design, Detailed design					
Soft component	Hygine education, Establishment of WPC Cooperation of well construction					
Hard component		Well construction plan*1				
	Province	To be Served in 2020	Target aquifer	Well depth (m)	Implementation schedule	
	District	Target population / Reruired well			2006 2010	2015 2020
	Phnom Penh City	**32,760** / **156**				
	Dangkao	32,760 / 156	Fissure	60		
	Kandal Province	**149,310** / **711**				
	Kandal Stueng	20,370 / 97	Fissure	60		
	Kien Svay	53,340 / 254	Fissure	60		
	Angk Snuol	42,210 / 201	Alluvial	40		
	Ponhea Lueu	14,910 / 71	Fissure	40		
	Ta Khmau	18,480 / 88	Fissure	60		
	Grand Total	**182,070** / **867**				

*1: Target population; to cover 80% of commune population by safe water
*2: four (4) communes are still less than 80% coverage in 2020

Chapter 9. Drainage, Sewerage and Sanitation

Chapter 9. Drainage, Sewerage and Sanitation

The survey results show that the surface area of the North Lake/Marsh has decreased almost by half during the past 2 years. The surface area of each lake/marsh in 2020 is half of the present area in the North and 65% of the present area in the South.

Table 9-1 Surface Area of North and South Lakes/Marshes

Lake/Marsh	2003 (Photo taken in Jan. 2003)	2005 (Present) (Photo taken in Nov. 2004)	2020 (Future)
North	13.3 km^2 (100%)	7.3 km^2 (55%)	3.8 km^2 (29%)
South	15.3 km^2 (100%)	14.3 km^2 (93%)	9.3 km^2 (61%)

Water quality of outflow from the lakes/marshes is estimated as follows. BOD values of outflows from both the North and South Lakes/Marshes in 2005 are lower than allowable limits for pollutant discharge to protected public waters specified in the relevant MOE sub-decree on water pollution. However, BOD values of outflows in 2020 will exceed the allowable limits. It is necessary to study wastewater treatment solutions for 2020 to achieve MOE environmental standards.

Table 9-2 Water Quality of Outflow from Lakes/Marshes: BOD (MoE Standard: OD<30mg/L)

Lake/Marsh	2005 (Present)	2020 (Future)	C_{2020}/C_{2005}
North (Flow to Tonle Sap)	14.3 mg/L	56.9 mg/L	4.0
South (Flow to Tonle Bassac)	29.7 mg/L	71.9 mg/L	2.4

With regard to conservation of water quality in the public water courses, the following measures are recommended:

MPP should make an authorized city development plan and then monitor and control land development based on the authorized plan with the cooperation of national level authorities. All land development should be approved, licensed and registered by MPP. EIA procedures should be strictly applied for all land development and MPP should condition its approval on the satisfactory EIA result. Unapproved, unlicensed or uncontrolled land development should be banned and punished by legislative measures implemented by MPP.

MPP should vest DPWT with stronger authority over drainage and sewerage, including wastewater treatment. DPWT should establish a wastewater quality monitoring system in cooperation with MOE and PPWSA. Wastewater quality should be monitored periodically to confirm the status of the lake/marsh environments. Monitoring parameters should include BOD and COD. Monitoring locations should include the inlets and outlets of the lakes and marshes. MPP should allocate appropriate budget with discretionary powers to DPWT to conduct the recommended monitoring.

Most importantly, the sewerage section of DPWT needs to be strengthened in terms of budget and technical capacity of staff, then a comprehensive master plan study on drainage, sewerage and sanitation should be carried out.

Chapter 10. Initial Environmental Evaluation

Chapter 10. Initial Environmental Evaluation

The Study Team has been following the Guidelines for Environmental and Social Considerations that JICA implemented in 2004. In the Guidelines, water supply projects are listed as projects likely to have significant adverse impact on the environment and society. Also, large-scale involuntary resettlement and large-scale groundwater pumping are listed as sensitive characteristics.

In the Review of Scoping Report for the Master Plan Study, received by the Team on April 14, 2004, JICA categorized this Master Plan project as Category B, signifying that, in accordance with the Guidelines, it is considered that generally the adverse impacts are site-specific and few, if any, are irreversible.

The Team submitted an IEE level study with the Interim Report. JICA reviewed the report and again evaluated the Master Plan project as Category B in August 2005.

10-1 Key Impacts Identified

In the process of scoping of the environmental impacts (see following table), 10 environmental items were identified as possibly affected by the implementation of the Plan, as described in the second table below (Scoping Checklist).

Table 10-1 Key Impacts Identified

Cause of the Impacts / **Affected Environmental Items**	**Planning Phase**			**Construction Phase**		**Operation Phase**			
	Spatial Occupancy	Use of Resource	Distribution of Resource	Reclamation And Spatial Occupancy	Operation of Construction Equipment and Vehicles	Spatial Occupancy	Operation of Vehicles, Ships and Airplanes	Operation and Maintenance of Associated Facilities	Accumulation of people and Goods
The poor, indigenous of ethnic people	Y								
Resettlement	Y								
Existing social infrastructures and services				Y	Y				
Public Health Condition					Y			Y	
Noise and vibration					Y				
Waste								Y	
Water contamination								Y	
Groundwater								Y	

Table 10-2 Scoping Checklist

	Environmental Items	Evaluation	Reason
1	Resettlement	B	The M/P will attempt to minimize involuntary resettlement. Land acquisition, however, may be necessary depending on the choice of facility locations. Procedures for public land acquisition and compensation are not established in the society. The Team observed examples in news papers of speculative purchases of land and protests from the residents of the properties claiming they are not receiving proper compensation.
2	Local Economy such as employment and livelihood	C	Minor impact may occur to small shop-stalls and road-side businesses during construction works. Impact may be avoided if information is well provided to the owners about the date and duration of the construction works. Further study is necessary in the future project phase to determine the level of impacts.
3	Existing social infrastructures and services	B	In Cambodia, there is a custom of 30 m rights-of-way of NR No. 1, 2, 3, 4, 5, 6… in the town area the ROW is 20 m. The government has rights to use roadside for public purposes such as underground pipes. National Route 3 and 4 seems to have enough space reserved for such use on both side of the roads. Traffic congestion caused by road works was observed on National Route 1. National Route 2 may also have difficulty. In the Interview Survey, however, at least ten factories interviewed answered those impacts from the construction for a few weeks works would be tolerable.
4	Land use and utilization of local resources	C	Detailed information is necessary, and project site need to be decided to assess the type and level of impact.
5	Social institutions such as social infrastructure and local decision-making institutions	C	Existing community organization for well management will have great potential for communal water management in the future. Since PPWSA is transferred from municipality institution to a part of national institutions under Ministry of Industry, Mines and Energy, the Team needs to be updating information whether the transfer causes local decision making procedures. New well management organization will be formed in the target villages of the Well Development Project.
6	The poor, indigenous or ethnic people	C	No serious impact is expected by new water supply system. The Team observed one of the three resettlement housing areas in north Phnom Penh. The residents were relocated from the central city after big fires. The residents use well water. The Team would better give consideration on the best way for such communities to provide sufficient access to safe water.
7	Misdistribution of benefit and damage	C	No serious impact is expected by new water supply system, since the service will be provided to where demand exists. PPWSA must, however, closely monitor in the future that low income households are provided with safe water at payable cost, and the water is distributed to those who has most difficulty in obtaining water. Those who may be affected negatively by the projects are those who are selling their piped water to neighbors. According to the Interview Survey, residents' use of private water vendor seemed low.
8	Local conflict of interests	D	No impact is expected
9	Gender	D	(positive impact is expected)
10	Children's rights	D	(positive impact is expected)
11	Cultural Property	D	No impact is expected
12	Water Rights and Rights of Common	C	The M/P proposes intake from river. Consultation with national Mekong Commission will be necessary. The proposed amount of intake, however, will be small compared with the water flow in the rivers. The Team needs to closely monitor the handling of proposed Water Law in the Parliament, and clarify necessary procedure regarding the negotiation with the national Mekong Commission.
13	Public Health Condition	B	The sanitary condition will be improved by clear water supply increase, but may impact water quality of public water bodies because the volume of sewerage water may increase in proportion to water supply. The amount of increase, however, will be small compared with the rainfall in wet season,

Environmental Items		Evaluation	Reason
			and with the water flow in the rivers. The Team has impression that reclamation of wetlands in the city will decrease retention capacity in wet season. By the decrease, the city could be more susceptible for flooding with raw waste water.
14	Infectious diseases such as HIV/AIDS etc.	D	No impact is expected
15	Waste	B	The M/P proposes new water treatment plants, or expansion of the existing ones. In that case, proper disposal of inorganic sludge from those facilities must be taken into consideration. In Phnom Penh, large scale solid waste disposal site is under construction. This is out of the scope of the M/P, but the Team finds necessity of long term monitoring of ground water quality around the site.
16	Hazards (Risk)	B	Construction vehicles may cause traffic jam and increase of traffic accidents.
17	Topography and geology	C	Depending on the site selection for the new water treatment site, landfill may be necessary and existing low wetland may be altered.
18	Soil erosion	D	No large scale construction is expected
19	Groundwater	C	Water supply system using groundwater may be considered in the M/P. In that case, IEE may better be conducted. The Team would need to consider life span of wells, existing and planned, possibility of arsenic pollution, and measures to prevent health damage.
20	Lake/River	C	The M/P propose new intake from rivers. The volume of sewerage water released to rivers may also increase in proportion to water supply. The amount of the intake and therelease, however, will be small compared with the rainfall in wet season, and with the water flow in the rivers. No serious impacts are expected to the habitat of rivers. The wetlands in the city are used for natural treatment and retention pond. The volume of sewerage water may also increase in proportion to water supply. The Team has impression that reclamation of wetlands in the city may cause rise of water level at such wetlands in wet season. There are other ponds and lakes in the Study Area. Also, some areas are planned to be flooded by irrigation dams. These are out of scope of the M/P.
21	Sea/Coastal zone	N/A	N/A
22	Flora and Fauna	C	Depending on the site selection for the new water treatment site, existing flora and fauna may be destroyed.
23	Climate	D	No large scale construction is expected
24	Landscape	D	No large scale construction is expected
25	Air pollution	B	Construction works may occur close to settlement and social infrastructure.
26	Water contamination	B	The M/P proposes new water treatment plants, or expansion of the existing ones. In that case, proper disposal of inorganic sludge from those facilities must be taken into consideration.
27	Soil contamination	D	No impact is expected
28	Noise and vibration	B	Traffic congestion, noise, and vibration may occur during the construction period.
29	Ground subsidence	D	Water supply system using groundwater may be considered in the M/P. The Team interviewed many local managers of existing wells, and did not find occurrence of ground subsidence.
30	Offensive odor	D	No serious impact is expected by new water supply system. In the sewerage and drainage section of the M/P, living condition around the existing wetlands in the city may be assessed considering that reclamation of such wetland will certainly increase, and the surrounding area would be more susceptible for flooding with raw waste water.

Reference: "Environmental Guidelines for Infrastructure Projects", JICA, 1992 (some modifications)

Note : Evaluation classification

A : Expected serious impact
B : Expected somewhat impact
C : Not clear
D : IEE or EIA is not necessary (no expected impact)
( ): Evaluation in the Preparatory Study.

Chapter 11. Institutional Development Plan

Chapter 11. Institutional Development Plan

11-1 Phase of Institutional Development

PPWSA is a relatively young and growing organization. Such organizations tend to move through a series of recognizable phases, as shown in the figure below.[3] Institutions typically grow through cycles of **evolution**, during which they enjoy stable growth, and **revolution**, when the accumulating deficiencies and inadequacies of the prior evolutionary period rise to the surface, producing managerial crisis and, for the survivors, change. There is no single management style or system that is right for all circumstances, an approach that seems ideal for an organization at a certain phase in its evolution may be disastrous applied to the same organization in another phase.

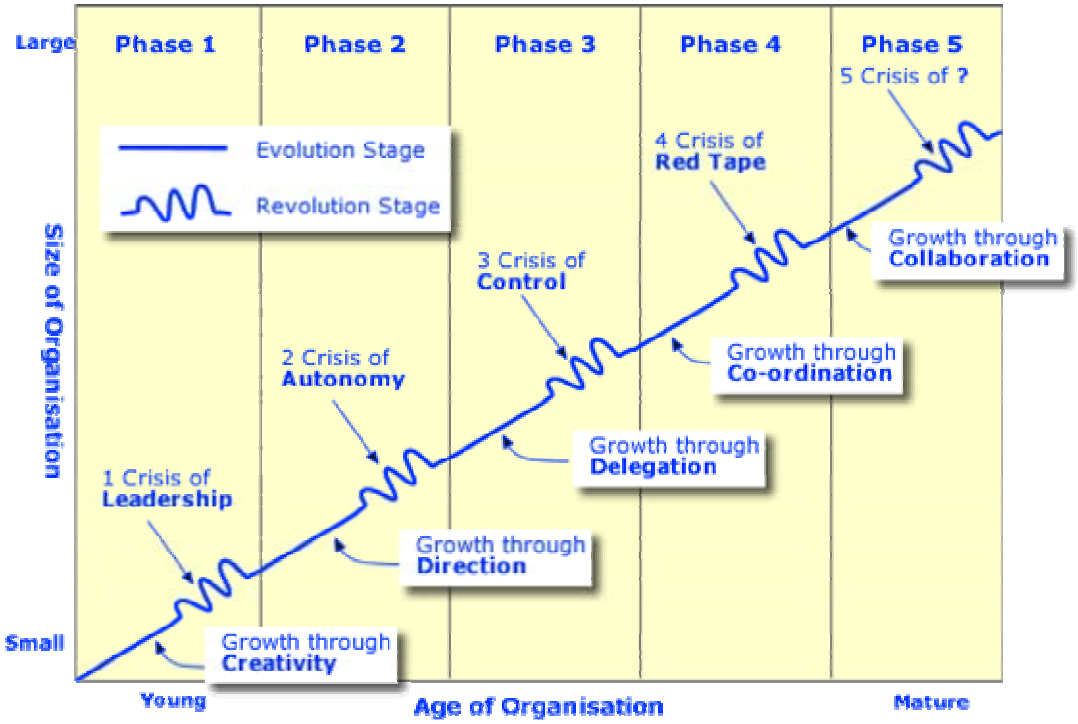


Figure 11.1 Phases of Institutional Growth

PPWSA is clearly identifiable in the early phases of this typology. The institution as we know it today is still operating under its original leadership, whose energy and vision continue to drive the organization's daily operations. Interestingly, the management style today can be fairly described as both creative and directive. PPWSA is in a sense already passing into the second phase, growth through direction. With continued effort and adequate preparation, perhaps it can avoid the crisis of leadership that would otherwise mark its graduation from the first phase. However, this remains to be seen, the issue of succession at the top of the organization is an acknowledged and unresolved concern among PPWSA

[3] Based on the seminal work of Larry Greiner, first presented in "Evolution and Revolution as Organizations Grow," *Harvard Business Review,* 1972.

supporters. In the meantime, PPWSA needs to continue its efforts to strengthen its internal management systems, develop its administrative policies and systematize its operating procedures. These are the focal elements of the Institutional Development Plan presented in the accompanying Feasibility Study, whose central themes are sharpening organizational **direction**, strengthening management **systems** and, looking ahead, promoting more **delegation** of duties and responsibilities.

11-2 Future Directions and Sector Roles for PPWSA (External Considerations)

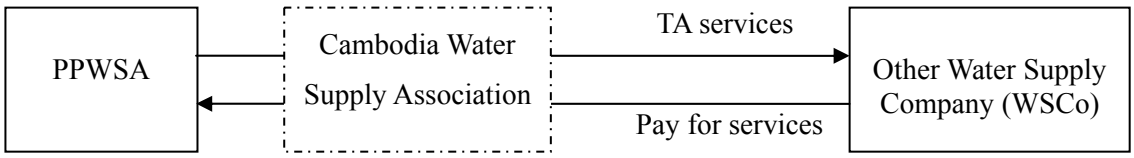
PPWSA up to the present has remained tightly focused on providing water to the residents of Phnom Penh. A basic premise of the following discussion is that the core mission of PPWSA must be protected and not diluted. At the same time, there are growing expectations for PPWSA to play a role in urban sanitation for Phnom Penh City, and there are additional pressures for PPWSA to contribute to improving water supply (and possibly sanitation) nationwide. As a public and publicly-minded institution with unique strengths in service provision, PPWSA has a duty to respond to the demands of society. Both of these added dimensions, discussed below, need to be taken into consideration in relation to outlining a future vision of PPWSA.

11-2-1 PPWSA's National Role

PPWSA occupies a special and unique position as the pre-eminent water services provider in the country and the supplier to the principal city and capital of the country. In terms of sheer volume alone, all of the other water supply systems in the country combined provide a low percentage of what PPWSA delivers in Phnom Penh. PPWSA is the key repository of technical and managerial expertise in the water sector in Cambodia. Therefore, it is natural that the Cambodian government, especially MIME, and the Cambodian people, have certain expectations for PPWSA to expand its role and contribute its knowledge and expertise to helping improve the conditions of urban water supply, and possibly sanitation, throughout the country. Significant sector reform and restructuring are currently under consideration in Cambodia, which will invariably impact on PPWSA and place new demands on the institution. There are many critical issues to be considered, such as speed and timing of introduction of new functions, sources of financing to ensure sustainability, structural and legal dimensions, and the objective assessment of PPWSA's capacity to respond.

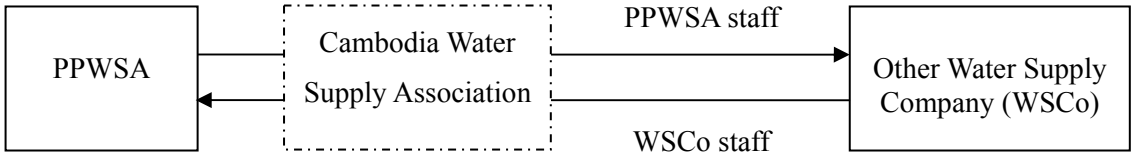
There are several possible modalities for sharing and replication of PPWSA's capabilities to support other water services providers in Cambodia. These modalities include technical assistance, twinning, joint venture/franchising and direct management/operation of other facilities and are briefly outlined below:

Model 1: Technical Assistance Arrangement



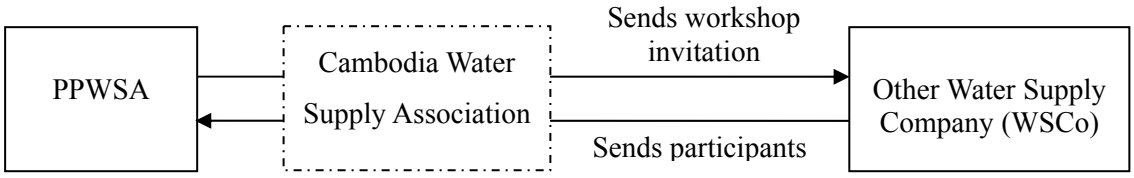
Implementation: A Technical Assistance contract is made between PPWSA and another (specific) WSCo based on clear Terms of Reference. PPWSA provides the services; other WSCo pays for the services based on contract. PPWSA acts like a consultant providing various forms of managerial and technical improvement advice, systems and other services for a fee. As a variation, should the concept of direct contracting prove to be difficult, arrangements may be intermediated by a proposed Cambodia Water Supply Association to which all water companies are envisaged to be members of.

Model 2: Twinning Arrangement



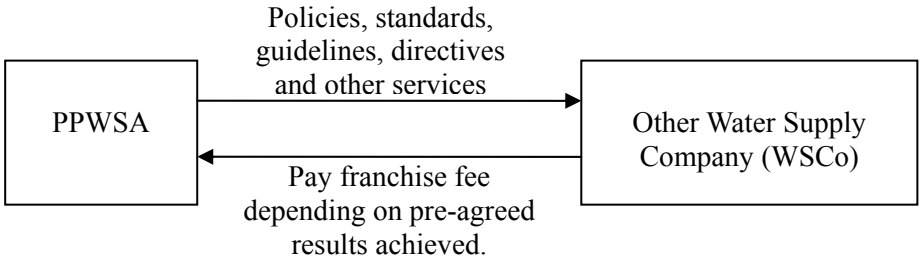
Implementation: A Memo of Agreement (or Twinning Agreement) is made between PPWSA and another (specific) WSCo providing terms for the exchange of staff for the purpose of on-job or formal training. During the period of exchange, staff will do actual work with the other company. No fees are exchanged. As in model 1, this arrangement may also be intermediated and facilitated through the proposed Cambodia Water Supply Association.

Model 3: Training Organizer Arrangement



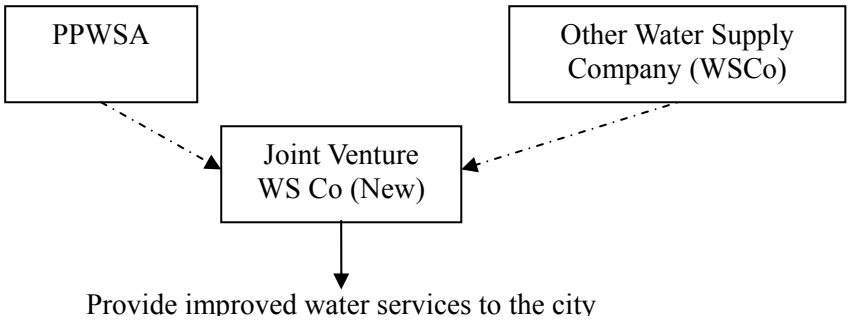
Implementation: The PPWSA, through its Training Center and the proposed Cambodia Water Supply Association, invites other WSCo's to send participants to the relevant courses organized primarily for PPWSA staff. Attendance fees may, or may not, be charged by PPWSA. Other WSCo's provide for travel and accommodation expenses of its staff.

Model 4A: Franchise Arrangement



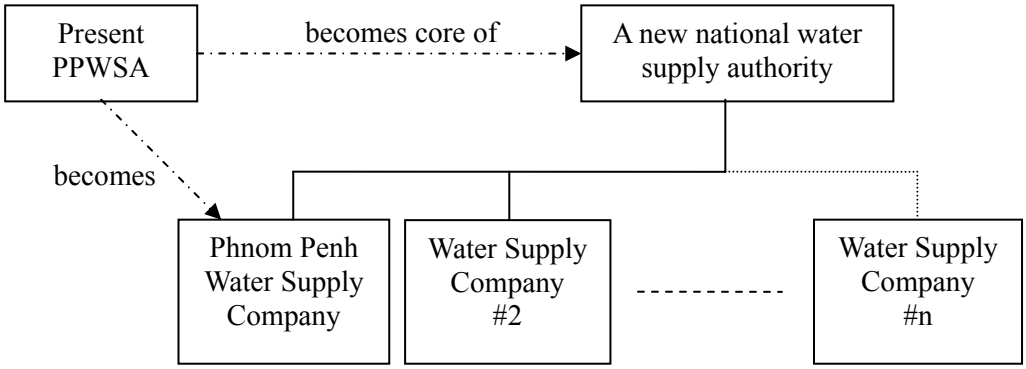
Implementation: A franchise agreement is made between the boards of PPWSA and a specific WSCo. Under this franchise agreement, PPWSA is given the power and authority (based on previous agreement with and on behalf of the Board of the WSCo) to intervene directly in order to "protect PPWSA's reputation" and maintain the high "PPWSA service quality standards". [Such franchise agreement may be made as a condition precedent to the approval of capital investment funds to the WSCo from other sources.

Model 4B: Joint Venture Arrangement



Implementation: The boards of PPWSA and another WSCo enter into a joint venture agreement to form a new company to manage the water services in the city. The JV company acts on behalf of the WSCo. The other WSCo continues to exist legally. It is not abolished and stays on as a partner company. Through the JVC Board, PPWSA exercises some powers to introduce change by holding a majority control. [Note: other parties, like local private investors, may be included in the JVC.]

Model 5: Direct Supervision Arrangement



Implementation: In the direct supervision model, a new national water supply body with responsibility to promote development of services nationwide is established to provide policy guidelines and direct supervision over all other water companies. Each water company exercises some level of autonomy. PPWSA is split into 2 bodies – one, as the national authority; and the other, as the water utility for Phnom Penh.

11-2-2 Sewerage and Sanitation

The urban core of Phnom Penh faces a growing need for sewerage infrastructure, which should be connected to organized wastewater treatment facilities, of which there are presently none. Although the official policy has not been settled, there is some degree of inevitability in the expectation that PPWSA will eventually be brought into the field of sewerage and wastewater treatment. Some of the relevant technologies are already its area of distinctive competence and the combination of water supply and sewerage services is a commonplace throughout the world. At the same time, the challenge of providing sanitation services will require PPWSA to become larger and to gain new competencies in wastewater collection, treatment and disposal (of sludge and septage).

Compared with water supply, sanitation typically entails a greater and more diverse mix of onsite solutions, decentralized community systems, and centralized reticulated systems. Where appropriate, especially in outlying areas, local treatment solutions utilizing simple biological processes may prove to be significantly more cost effective than centralized systems. Distributing the costs in a manner that drives rational behavior and investment decisions can be quite complex, with the need to consider a variety of subsidy mechanisms to support local solutions. In addition, reuse options for agricultural application may be considered. Institutions other than PPWSA would be more appropriate to lead and coordinate such efforts, perhaps the Ministry of Health working with MPWT and MRD as appropriate, in any case with PPWSA focusing on those areas to be served by the primary sewage system, pumping and treatment. Policy formulation and detailed planning involving many stakeholders will be essential,

including preparation of a master plan. PPWSA will need to collaborate more extensively with other concerned institutions than it presently does in the field of water supply.

11-2-3 Privatization (through concession) of PPWSA

The Study conducted a survey on the current status of water systems of many towns and cities in 13 Asian countries which have taken up concession or BOT arrangements in recent years. The rapid survey noted at present, many private operators in Asia and around the world, involved in BOT and concession arrangements for water supply, are struggling with existing contracts. Tariffs have risen to reflect the elimination of subsidies (and higher operating costs of multinational companies).since the anticipated savings or increases in revenues have not, in most cases, materialized. Improved access of poor to improved services has been minimal or questionable. The rate of privatization activities in Asia has, expectedly, been on the decline (since its height in the mid-1990s), except in China.

Opinions about the best management model for the water sector vary significantly. The first key issue revolves around the classification of water as a basic right versus a commodity or a service, the merits and de-merits of public sector reform versus privatization, and market pricing of water versus subsidization.

This survey offers many important lessons for Cambodia (since it is considering the promotion of concessions and BOT's in the water sector). It is important to develop the overall development strategy first and organize practical regulatory arrangements (including tariff review and adjustment procedures, operational performance standards for the private sector, environmental standards to be maintained by the private operator, including procedures, provisions and facilities for their enforcement and penalties for non compliance with covenants, etc.).

In Phnom Penh, the outsourcing and management contract options, mostly to the local private sector businesses, are most promising. This will enable PPWSA to concentrate on its core business.

At this point in its development, it is difficult to make a case for opening PPWSA for concessions and higher forms of PSP. Conditions do not seem to exist warranting such responses. Many reports have, in fact, cited that cities such as Phnom Penh, run by effective public sector water managers, can clearly provide lessons for other water undertakings in Asia.

Chapter 12. Implementation Plan

Chapter 12. Implementation Plan

The project is planned to be implemented divided into three stages based on the design target years of 2010 (Stage I) for the feasibility study, 2015 (Stage II) for the intermediate development plan and 2020 (Stage III) for the long term development plan.

The project implementation schedule is presented in the following figure:

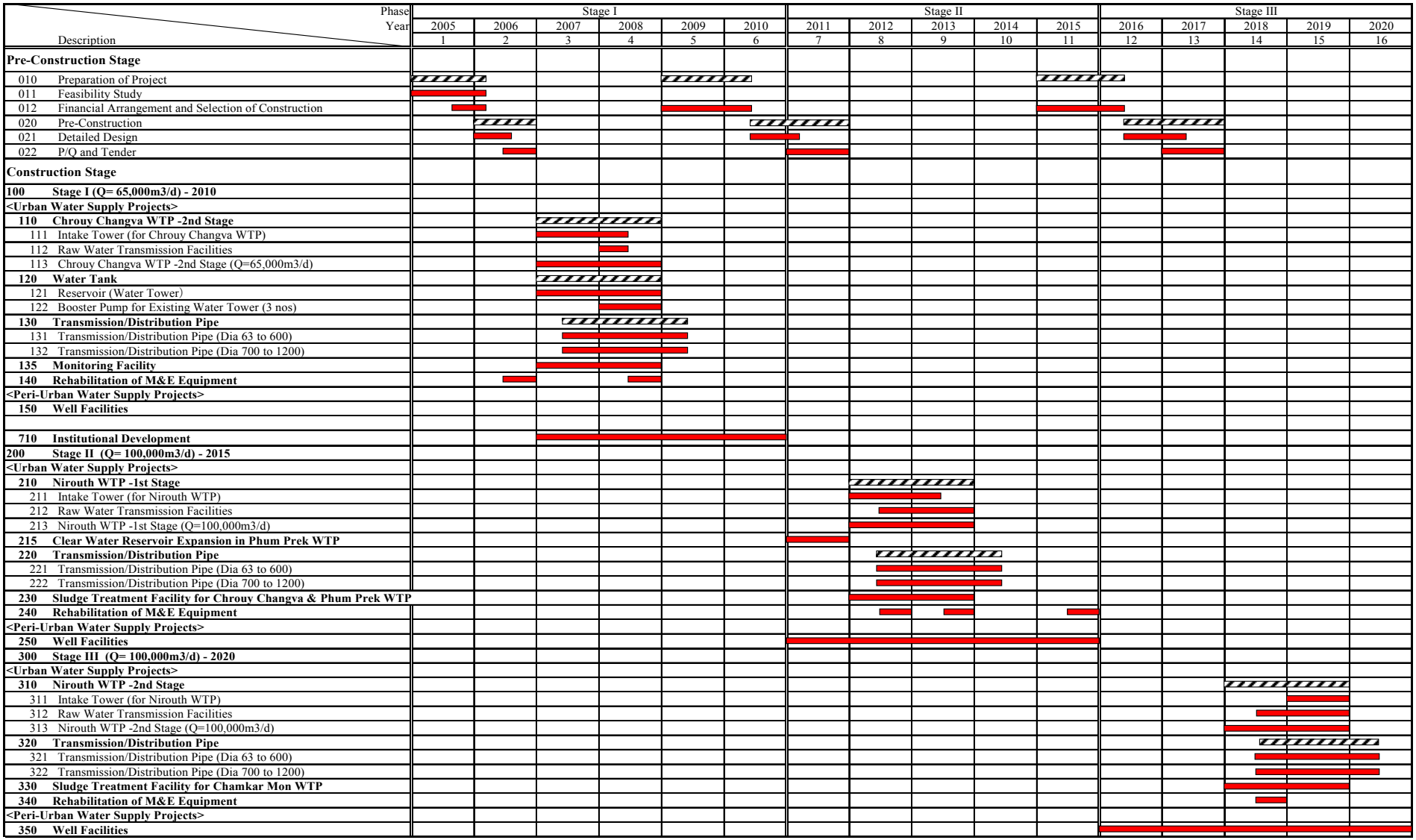


Figure 12.1 Implementation Schedule

Chapter 13. Project Costs

Chapter 13. Project Costs

13-1 Capital Investments – Urban Water Supply Projects

Table 13-1 Summary of Project Cost for Urban Water Supply

	Cost Item	Cost (US$)	
		Breakdown	Total
	<Construction Cost>		
	Stage I (2010)		**51,865,000**
110	Chrouy Changva WTP -2nd Stage	22.630,000	
120	Water Tank	2,555,000	
130	Transmission/Distribution Pipe	11,880,000	
135	Monitoring Facility	5,000,000	
140	Rehabilitation of M&E Equipment	9,800,000	
	Stage II (2015)		**100,462,000**
210	New Intake & WTP -1st Stage	40,106,000	
215	Clear Water Reservoir Expansion in Phum Prek WTP	1,184,000	
220	Transmission/Distribution Pipe	23,923,000	
230	Sludge Treatment Facility for Chrouy Changva & Phum Prek WTP	18,849,000	
240	Rehabilitation of M&E Equipment	16,400,000	
	Stage III (2020)		**44,767,000**
310	New Intake & WTP -2nd Stage	25,982,000	
320	Transmission/Distribution Pipe	7,238,000	
330	Sludge Treatment Facility for Chamkar Mon WTP	3,347,000	
340	Rehabilitation of M&E Equipment	8,200,000	
	Total of Construction Cost		**197,094,000**
400	Land Acquisition Cost		**3,600,000**
500	Equipment Procurement Cost		**1,971,000**
600	Engineering Service Expense		**19,709,000**
700	Government's Administration Expense		**9,855,000**
710	Institutional Development Cost		**2,062,000**
	Sub Total		**234,291,000**
800	Physical Contingency		**23,429,000**
900	Price Contingency		**62,232,000**
	Total Project Cost		**319,952,000**

The additional items beside Construction Cost are explained as follows. Land Acquisition Costs are based on market prices in the area of the construction site with consideration for price escalation. One percent of the construction cost is added to the project cost to procure required operation and maintenance equipment as well as to support the direct costs of implementing the staff training and capacity building plan. Engineering Services expenses are estimated at 10% of the construction cost for tender design and construction supervision. The Government's administration expenses for the project implementation are assumed to be 5% of the construction cost.

Physical contingencies are estimated at 10% of base cost, and price contingencies are calculated assuming average inflation of 3% per year.

13-2 Operation & Maintenance Costs – Urban Water Supply Projects

These costs will be represented anticipated yearly expenditures for:

- Personnel Expense;
- Cost of facilities, equipment, operating costs, materials and supplies; and
- Cost of repairs.

Annual operation and maintenance cost is estimated at US$ 837,000, US$ 1,978,000 and US$ 3,444,000 for each year expansion capacity 2010 (65,000 m3/day), 2015 (165,000 m3/day), 2020 (265,000 m3/day) respectively as shown in the table below. These operation and maintenance costs are explained below based on cost data for Phum Prek WTP, Chrouy Changva WTP -2nd Stage and Chamkar Mon WTP, prevailing market prices, PPWSA recent purchase prices and others in accordance with the proposed program.

Table 13-2 Annual Operation and Maintenance Cost for Urban Water Supply

O&M Cost Items	2010 (Q= 65,000m^3/d)		2015 (Q= 165,000m^3/d)		2020 (Q= 265,000m^3/d)	
	O&M Cost	Ratio	O&M Cost	Ratio	O&M Cost	Ratio
- Personnel Expense	29	2.6%	91	4.1%	125	3.3%
- Power Cost	752	68.4%	1,447	64.8%	2,528	67.7%
- Chemical Cost	90	8.2%	215	9.6%	396	10.6%
- Repairs	78	7.1%	228	10.2%	296	7.9%
- Date Base/ Training	50	4.5%	50	2.2%	50	1.3%
- Other	100	9.1%	203	9.1%	340	9.1%
Total	1,099	100.0%	2,234	100.0%	3,735	100.0%

13-3 Capital Costs for Peri-Urban Water Supply Projects

Based on the estimated demand, the capital investments to support the expansion of the well program in the peri-urban area are estimated below:

Table 13-3 Summary of Project Cost for Peri-Urban Water Supply

Cost Item	Cost (US$)			
	Stage I	**Stage II**	**Stage III**	**Total**
Construction Cost				
150 250 Well Facility 350	6,305,000	6,762,000	8,696,000	21,763,000
Total Construction Cost				**21,763,000**
500 Equipment Procurement Cost	63,000	68,000	87,000	218,000
600 Engineering Service Expense	631,000	676,000	870,000	2,176,000
700 Government's Administration Expense	315,000	338,000	435,000	1,088,000
Sub Total	7,314,000	7,844,000	10,088,000	25,245,000
800 Physical Contingency	731,000	784,000	1,009,000	2,525,000
900 Price Contingency	848,000	2,125,000	4,949,000	7,921,000
Total Project Cost	**8,893,000**	**10,753,000**	**16,044,000**	**35,691,000**

13-4 Operation & Maintenance Costs –Peri-Urban Water Supply Projects

Annual Operation and Maintenance Cost for Peri-Urban Supply is as follows;

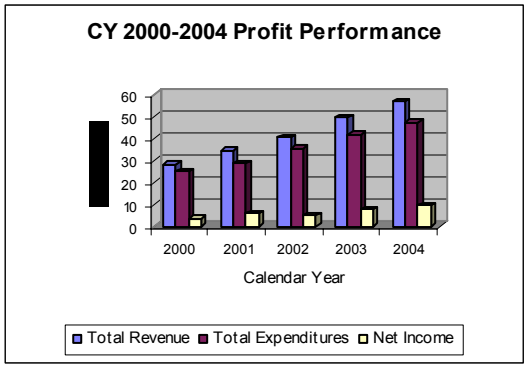
Table 13-4 Annual Operation and Maintenance Cost for Peri-Urban Water Supply

O&M Cost Items	2010 (229 wells)		2015 (497 wells)		2020 (867 wells)	
	O&M Cost	**Ratio**	**O&M Cost**	**Ratio**	**O&M Cost**	**Ratio**
- Hand Pump	98	97.0%	214	97.2%	373	97.1%
- Other	3	3.0%	6	2.8%	11	2.9%
Total	101	100.0%	220	100.0%	384	100.0%

(Tousand US$/year)

Chapter 14. Financial Analysis

Chapter 14. Financial Analysis



14-1 Urban Water Supply

14-1-1 Review of Operations

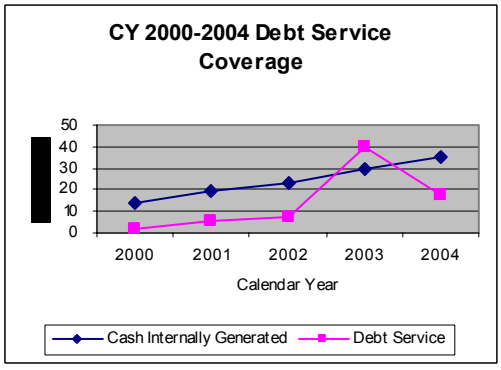
During the past five-year period, Total Revenues grew at an average annual rate of 21% while Total Expenditures (O&M, depreciation, interest and income tax) grew at an average annual rate of 17%. With Total Revenues outgrowing Total Expenditures, Net Income grew significantly from Riels 3.4 billion in 2000 to Riels 9.376 billion in 2004 or an average annual growth rate of 28% over the period. Return on Revenues, defined as the ratio of Net Income to Operating Revenue, grew from 13.2% in 2000 to 17.3 % in 2004. Return on Net Fixed Assets in Service grew from 1.5% in 2000 to 2.3% in 2004 while Return on Equity also grew from 1.3% in 2000 to 2.4% in 2004.

Water sales accounted for 79% of Total Revenue during the period while house connection fee and other revenue contributed 11% and 10%, respectively. With regards to Total Expenditures, O&M cost accounted for 45%, depreciation for 34%, interest expense was 11% and income tax was 4%.

The outstanding results of PPWSA's operations in financial terms could be attributed to the Authority's success in reducing Non-Revenue Water (NRW) during the period. Because NRW was significantly reduced from about 49% in 1999 to about 14% in 2004, more water became available for distribution and consumption. With more water available, the Authority was able to increase the number of its customers at an average annual rate of 24% and volume of water sold at 31% over the period.

14-1-2 Financial Position

The Authority's financial position had been very liquid during the past five years. Except for the drop to 1.4 in 2002, its Current Ratio had been remarkably high at 2.3 to 5.1 during the period. The Working Capital (Current Assets minus Current Liabilities) level during the period was lowest also in 2002 at 18 months of cash operating expenses. However, the 18 month level is still considered a significantly high level of Working Capital.



The liquid financial position of the Authority during the period could be attributed to its success in implementing an efficient billing and collection system. The Average Collection Period of its customers' accounts during the period had been remarkably short at 23 to 63 days.

14-1-3 Cash Flow

The Authority's sources and uses of funds during the five-year period showed significant funding contribution from operations for asset investment. This was due to the remarkable improvement of the Authority's internal cash generation capability which grew at an average annual rate of 26% during the period. With improved internal cash generation, the Authority's Debt Service Coverage Ratios (DSCR) of 2.1 to 6.3 and Self-Financing Ratios (SFR) of 0.2 to 1.0 during the period were significantly high except that in 2003. The Authority's prepayment in 2003 of its loan not yet due lowered the DSCR and SFR for the year.

14-1-4 Tariff Level

The average tariffs for the overall and each customer category since the existing tariff took effect in 2001 are presented below.

Table 14-1 Average Tariff (Riels/m^3 Sold)

Category	2001	2002	2003	2004
Domestic	851	855	857	874
Commercial	1,101	1,102	1,134	1,158
ADM	1,030	1,030	1,030	1,030
RDE-wholesaler	1,030	1,030	1,030	1,030
Overall Average	943	943	954	973

Source: PPWSA Commercial Department

During the same period, the average costs per cubic meter sold were as follows:

Table 14-2 Average Cost (Riels/m^3 Sold)

2001	2002	2003	2004
841	923	897	849

Source: PPWSA Finance Department

From the cost recovery viewpoint, the tariff at present is considered a full cost recovery tariff as shown by the profitable operations of PPWSA. In addition to being a full cost recovery tariff, it is also considered an affordable one. The average monthly household water bill (Riels 20,000) is just 2% of the average monthly household income (Riels 1.14 million) in Phnom Penh. The generally accepted guideline on affordability is that the water supply charges should not exceed 4% of household income. In arriving at the average water bill of Riels 20,000, a household size of 9.5 and a consumption of 80 lpcd were assumed.

PPWSA presently collects a sewerage surcharge from its customers at the rate of 10% of the water bill. The surcharge is not recorded as revenue of PPWSA but is treated as a liability to the Department of Public Works and Transport of the Municipality of Phnom Penh.

14-1-5 Results of Financial Projections

The following are the key observations on the results of the financial projection in the implementation of urban water supply sector of the Master Plan project:

- During the projection period (2005-2045), PPWSA would have net profit each year. This indicates that PPWSA's tariff level during the projection period is a full cost recovery tariff. PPWSA's projected tariff could recover the full cost of its operations plus depreciation and financing charges as long as the tariff keeps pace with inflation.
- PPWSA's financial condition during the projection period is healthy and it is able to repay its debts as they fall due. Should PPWSA be able to secure financing schemes with better conditions in terms of lower interest rate and longer repayment period that those assumed in the financial projection, PPWSA would have a much healthier financial condition. With lower interest rate, financing charges are reduced. With longer repayment period, the annual amount of loan principal repayment is reduced.
- PPWSA can implement on a sustainable basis the proposed Master Plan project, together with its existing assets and on-going projects, with no negative impact on its financial condition even without the benefit of a tariff increase in real terms till 2020.

14-2 Peri- Urban Water Supply

Consistent with the policy of the government for the RWSS sector, the Water and Sanitation Users Group (WSUG) shall be responsible for arranging the counterpart contribution from the community for the capital investment, operation and management of the facilities, the collection of water charges from the beneficiaries and the management of finances. The estimated capital investment shall be financed through grant (about 88% of capital investment) from the government and about 12% equity from the beneficiaries in the form of labor and local materials. It is assumed that the government will secure financing for the grant portion of the investment either in the form also of a grant from bilateral or multilateral institutions or a soft loan having a long repayment period (35 to 40 years) and low interest rate (1% or less).

Based on the affordability limit of 4% of monthly household income, the proposed monthly water charge is Riels 6,500 per household, about 3.8% of household income. The proposed water charge can recover 100% of the O&M cost and about 20% of the annual depreciation charges. The amount collected from the partial recovery of depreciation charges shall be deposited and accumulated for future use in the rehabilitation of the well facility to ensure sustainability of operations.

Chapter 15. Evaluation

Chapter 15. Evaluation

15-1 Technical Evaluation

The population served by PPWSA and well water supply will reach 2.08 million or 90.4% of the total population in the area by 2020. 1.87 million or 81.0% of the area population will receive piped water service from the PPWSA central distribution system.

Total production capacity will be increased to 500,000 m^3/day, which will satisfy the projected maximum daily demand of 414,600 m^3/day in 2020. Water tanks and distribution pipes will be extended and reinforced to secure a reliable, 24-hour water supply. Safe and clean water meeting the National Drinking Water Standards will be supplied by the existing and new water treatment plants with proper and affordable treatment processes.

The water supply development plan fulfills the target of securing a stable water supply up to the year 2020.

To achieve these results, the following measures should be observed:

(1) Periodic review of water supply framework

Since the water demand projection uses some assumptions based on past data and trends, it is necessary to confirm the actual consumption, review the demand projection and, if necessary, for adjust the development plan.

(2) Protection of water sources

Some water sources for water supply are deteriorating due to rapid population growth and urbanization in the area. It is strongly recommended to set up a water sources protection program to minimize the contamination of water sources in the future.

(3) Proper maintenance and periodic replacement/rehabilitation

New construction or expansion projects can be done using assistance of international donor or bilateral funds, but daily maintenance or periodic replacement/rehabilitation is sometimes difficult to implement due to limited local fund. This daily maintenance or periodic replacement/rehabilitation is indispensable to secure the performance of the existing facilities.

(4) Establishment of supplied water quality control

Supplied water at user's end point will deteriorate due to longer transmission. Therefore, it is recommended to monitor water quality at the tap to fully achieve the National Drinking Water Standard.

15-2 Initial Environmental Evaluation

JICA categorized this Master Plan project as Category B. The proposed Master Plan project will have mostly beneficial impacts. Although some adverse impacts will occur during the construction and operation stage of the project, minimization of environmental disturbances such as noise and dust during construction will be considered in the detailed design, and appropriate environmental management requirements will be incorporated in the specifications of construction contracts. All contractors will be required to reinstate affected areas to their original or better condition. Adequately planned preventive maintenance programs will be developed for all facilities constructed under the Project. Safe working practices at international standards will be adopted in both the construction and operational phases.

In order to assure that the proposed mitigation plan, described in "Environment Mitigation Plan" will be adequately conducted, the related agencies should monitor those activities as recommended in "Environmental Monitoring Plan".

15-3 Socio-Economic Evaluation

The Cambodia Millennium Development Goals (CMDGs) establish the key underlying coverage targets for the development of this Master Plan. Actually, the Master Plan envisages exceeding the CMDG with respect to urban coverage ratio in the Phnom Penh City center, which will continue to be supplied as at present with PPWSA safe water at a level of approximately 100%. The peri-urban and rural areas will attain average clean water coverage in excess of 80%, which also meets or exceeds the relevant CMDGs. In this sense the Master Plan fully complies with the relevant national and international targets.

Although difficult to measure, the benefits of improved water supply will be significant in both quantitative and qualitative terms. The economic evaluation presented later in this chapter provides a limited quantification of the benefits of executing the Master Plan, but this must be considered an underestimation in relation to the many unquantifiable benefits to the health and quality of life of the beneficiaries.

The expected benefits from achieving the CMDG clean water coverage targets include improved public health overall and reduction of infant and maternal mortality associated with water-born disease. Improved water supply in rural areas also reduces the burden of fetching water that typically falls on women and children, which may contribute indirectly to greater rural labor force productivity and improved school attendance and educational achievement of children.

In urban and peri-urban areas, improved water supply from the Central Distribution System (CDS) is an aid to industrial development. Water supply is among the critical infrastructure requirements for the types of labor-intensive, light manufacturing industries that the RGC has targeted for promotion in its industrial policy, and such infrastructure expansion is among the specific RGC objectives for supporting the industrial sector.

On the negative side, it must be mentioned that expanded water supply inevitably results in greater production of wastewater. Preparation and implementation of a parallel Master Plan for drainage and sewerage in the Study Area is urgently necessary, in particular to ensure that the health benefits from improved water supply are not lost on account of deterioration in sanitary and environmental conditions. Chapter 7 of the present study documented the dramatic loss of lake and marsh areas, especially in the northern area, that have traditionally provided a certain level of natural treatment of wastewater flowing from the City through the lake/marsh areas to the Tonle Sap and Tonle Bassac rivers, which surround the City. The treatment capacity of these natural bodies is already on the verge of exhaustion. Combined with steady growth in population and probable continued loss of these critical habitats, the quality of the water bodies themselves, as well as the effluent flowing from them into the afore-mentioned rivers, can be expected to deteriorate very significantly during the coming years. Planning and preparation of counter-measures, in addition to those already undertaken previously with JICA's assistance, should begin as soon as possible.

15-4 Financial Evaluation

The financial viability of the Master Plan project is assessed by comparing the project's Financial Internal Rate of Return (FIRR) with the Financial Opportunity Cost of Capital (FOCC). As proxy for the FOCC, the Weighted Average Cost of Capital (WACC) of the project in real terms is used. FIRR is the discount rate that equalizes the present values of costs and revenues over the project life while the WACC represents the cost incurred by PPWSA to implement the project.

15-4-1 Urban Water Supply

The WACC of the project is 3.84% (real terms). The calculation of the WACC is shown in the table that follows.

Table 15-1 Weighted Average Cost of Capital

Particulars	Loan	Grant	Equity	Total
Weight (%)	60.00%	0.00%	40.00%	100.00%
Nominal Cost (%)	8.50%		9.00%	
Tax Rate (%)	20.00%		20.00%	
Tax Adjusted Nominal Cost (%)	6.80%		7.20%	
Inflation Rate (%)	3.00%	3.00%	3.00%	
Real Cost (%)	3.69%	0.00%	4.08%	
Weighted Component of WACC (%)	2.21%	0.00%	1.63%	
Weighted Average Cost of Capital (Real)				3.84%

The results of the FIRR calculation and sensitivity analyses are summarized in the table below.

Table 15-2 FIRR and Sensitivity Analysis – Urban Water Supply

Particulars	NPV @ WACC Million Riels	FIRR (%)	SI *	% Change
Base Case	184,284	5.19%	-	-
10% Increase in Project Costs	115,576	4.64%	1.18	10%
10% Increase in O&M Costs	135,896	4.85%	0.70	10%
10% Decrease in Revenue	48,760	4.22%	2.29	10%

* SI – Sensitivity Indicator

Under the base case scenario, the project's FIRR is higher than its WACC. With its FIRR higher than its WACC, the project is considered financially viable.

The results of the sensitivity analysis show that under the 3 adverse changes (increase in capital and O&M costs and decrease in revenues), the project's financial viability is not greatly affected as the project's FIRR is still higher than the project's WACC. Among the adverse changes, the project's financial viability is most sensitive to decrease in revenues.

The results of the financial projection as described in "Chapter 14 - Financial Analysis" show that the proposed Master Plan project can be implemented, together with PPWSA's existing assets and on going projects, on a sustainable basis. Throughout the economic life of the proposed project, PPWSA can generate sufficient revenues to cover the costs of operating and maintaining the proposed project, together with the existing assets and on going projects, and repay all its debt service obligations as they fall due.

15-4-2 Peri-Urban Water Supply

The proposed project, just like other peri-urban water supply projects, is not financially viable as reflected in the government's policy for the sector. Due to consideration of affordability by the beneficiaries, the water charges cover only the O&M cost and part of the depreciation charges. Under such situation, its FIRR is negative. The proposed project, however, is recommended for implementation on the basis of its economic viability as discussed in the next section.

15-5 Economic Evaluation

The economic analysis is an evaluation of the effectiveness of the proposed project in terms of socio-economic factors not considered in the financial analysis. The analysis aims to assess the attractiveness of the project in terms of both the quantifiable and non-quantifiable benefits and costs that may accrue with its implementation.

With the implementation of the proposed project, significant benefits, both direct and indirect, could be attained. Direct benefits are the delivery of water in greater quantity on a more reliable basis, better water quality, improved health and environmental conditions, and increase in consumer satisfaction. Indirect benefits, on the other hand, are increased productivity of the residents in the service area, employment and livelihood opportunities for the residents of the municipality and outlying areas,

increase in land values in the service area, increase in the marketability of housing and real estate properties in the service area, and reduction in or avoidance of fire damages in the service area.

Correspondingly, the realization of the project will incur, besides costs of the investment and of operating and maintaining the water supply system, other direct and indirect costs. The households who will switch from private water supplier to PPWSA's piped system must pay PPWSA water charges. As large quantities of imports (equipment) are required for the proposed project, the economy of the country must incur foreign exchange costs.

15-5-1 Urban Water Supply

Some of the benefits mentioned are difficult to quantity due to absence of reliable basis for measurement. In the economic analysis, therefore, the benefits of the proposed project which have been quantified are limited to the following items:

- Resource cost savings by new customers from the existing volume of private water supply replaced by PPWSA's piped water, measured in terms of the difference in price between the private supplier (assumed at Riels 2,500/m^3) and PPWSA;
- Expenditure for piped water supply by new customers, measured in terms of PPWSA price; and
- Time saved by new customers in collecting water. This is assumed at 30 minutes per day per household, based on the survey on residents' needs, at daily wage rate of Riels 8,000.

The effects of loss of access and other types of disruption to residents due to works during the construction phase have been excluded because of the difficulties of measurement.

The results of the EIRR calculation and analyses are summarized in the table below.

Table 15-3 EIRR and Sensitivity Analysis – Urban Water Supply

Particulars	NPV @ EOCC Million Riels	EIRR (%)	SI *	% Change
Base Case	184,046	13.31%	-	-
10% Increase in Investment Costs	145,351	12.45%	0.69	10%
10% Increase in O&M Costs	170,967	13.09%	0.17	10%
10% Decrease in Benefits	113,867	12.13%	0.97	10%

* SI – Sensitivity Indicator

Under the base case scenario, the project's EIRR is higher than the EOCC. With its EIRR higher than the EOCC, the project is considered economically viable.

The results of the sensitivity analyses show that under the 3 adverse changes (increase in capital and O&M costs and decrease in benefits), the project's economic viability is not greatly affected as the project's EIRR is still higher than the project's EOCC. Among the adverse changes, the project's economic viability is most sensitive to decrease in benefits.

15-5-2 Peri-Urban Water Supply

The economic benefits which have been quantified in the proposed peri-urban water supply project are limited to the following items:

- Resource cost savings by the beneficiaries measured in terms of the cost of alternative source of water from vendors assumed at Riels 3,750/m^3;
- Time saved by the beneficiaries in collecting water since the proposed well facility will be constructed near houses within a radius of less than 250 meters. This is assumed at 45 minutes per day per household at daily wage rate of Riels 8,000.

The results of the EIRR calculation and sensitivity analyses are summarized in the table below.

Table 15-4 EIRR and Sensitivity Analysis – Peri-Urban Water Supply

Particulars	NPV @ EOCC Million Riels	EIRR (%)	SI *	% Change
Base Case	31,682	20.12		-
10% Increase in Investment Costs	27,332	17.94	1.21	10%
10% Increase in O&M Costs	31,049	19.91	0.10	10%
10% Decrease in Benefits	23,530	17.52	1.48	10%

* SI – Sensitivity Indicator

Under the base case scenario, the project's EIRR is higher than the EOCC. With its EIRR higher than the EOCC, the project is considered economically viable.

The results of the sensitivity analyses show that under the 3 adverse changes (increase in capital and O&M costs and decrease in benefits), the project's economic viability is not greatly affected as the project's EIRR is still higher than the project's EOCC. Among the adverse changes, the project's economic viability is most sensitive to decrease in benefits.

PART B: FEASIBILITY STUDY

Chapter 1. Stage I Priority Projects Introduction

Chapter 1. Stage I Priority Projects Introduction

This Feasibility Study covers the Implementation of the Stage I Priority Projects identified under the Master Plan of the Greater Phnom Penh Water Supply (Phase 2). The Master Plan was presented in Part A of this Volume. Stage I of the Master Plan, the target period for this Feasibility Study, covers the years 2005 to 2010. All of the projects identified as Stage 1 projects in the Master Plan are considered to be Priority Projects.

The Stage I Priority Projects identified in the Master Plan and elaborated in this Feasibility Study encompass the following: 1) water supply augmentation; 2) existing systems rehabilitation; 3) peri-urban water supply; and 4) institutional development.

The Feasibility Study first presents a chapter for each of the four main Priority Projects mentioned above. A subsequent chapter outlines the Project Costs and Implementation Plans. In the last chapter, an Evaluation of the Priority Projects is presented encompassing the technical, financial and environmental dimensions of the projects. In addition, a number of supporting documents are presented separately including a detailed Environmental Impact Assessment in accordance with JICA and RGC requirements.

Chapter 2. Water Supply Augmentation Project

Chapter 2. Water Supply Augmentation Project

The Components of the Augmentation Projects are summarized as follows:

2-1 Water Treatment Plant (Chrouy Changva Stage II) Construction Project

In the Master Plan, it is identified that expansion of Chrouy Changva WTP with intake station and raw water pipe is one of the most important projects in Stage 1 to meet the required total water production capacity of 254,700 m^3/day by the year 2010.

The following are the conditions for Chrouy Changva WTP expansion:

- Production capacity to be added: 65,000 m^3/day
- Location: within the same premises of the existing plant
- Intake tower: new tower with intake capacity of 130,000 m^3/day
- Treatment process: same as the existing process

The existing Chrouy Changva WTP was originally planned to expand from its initial capacity of 65,000 m^3/day up to 130,000 m^3/day. Space was therefore reserved to accommodate a future expansion of 65,000 m^3/day on the same premises. The major facilities to be constructed are flocculation /sedimentation tanks, filters and clear water reservoirs.

As for the existing intake tower, which was renovated in 2002 during the last construction, there is no more space to install additional intake pumps or change to larger pumps. Therefore, it is recommended to construct a new intake tower with the capacity to meet the total expanded production capacity of 130,000 m^3/day. The existing structure and pumping facility will be used as a stand-by unit.

The existing plant achieves proper treatment performance, securing safe and clean clear water meeting the national drinking water standards. The responsible engineers and operators are accustomed to operating the existing plant. It is therefore recommended to apply the same treatment process/ facility, except minor changes for improvement, if necessary.

The capacity of the clear water reservoir in Chrouy Changva WTP was reviewed and it was identified that the existing reservoir (5,760 m^3, equivalent to 2.1 hours at full production of 65,000 m^3/day) is far smaller than the requirement to cover water demand fluctuation in a day. Therefore, additional reservoirs should be provided with the expansion of the treatment facilities.

Also, some treatment facilities for sludge from sedimentation tanks and filter backwash water are required to meet the Cambodian National Sub-Decree, *Water Pollution Control*. It is recommended to construct the facilities, not in Stage 1 but at the earliest affordable stage thereafter.

2-2 Transmission and Distribution System Augmentation Project

Stage I of the Master Plan focuses on reinforcing or creating the two main transmission loops by connecting existing branches. By 2010 the system will be upgraded with:

- network extension from 282 to 353 km of transmission pipes,
- upgraded capacity of Chrouy Changva WTP, from 65,000 to 130,000 m3/day,
- a new 900 mm pipe from this WTP to the Chrouy Changva bridge,
- a new water tank and transmission to supply Ta Khmau area,
- a new distribution security and sustainability policy with redundancy and energy saving incorporating:
    - loop systems;
    - independent pumping station and reservoirs; and
    - monitoring improvements.

Besides the five main projects, in order to make the installations reliable and improve services it appears important to further fit the water tanks with clear water reservoirs.

The ongoing projects (extension of the Chrouy Changva WTP with 2000 meters more transmission lines and the prolongation of some existing lines) will enable the piped water supply to reach some outlying areas with sufficient water demand. This will require a prolongation of the network with about 70 km of new pipes dedicated to transmission in 2010.

Chapter 3. Rehabilitation Project

Chapter 3. Rehabilitation Project

Water treatment facilities, especially mechanical and electrical equipment, suffer a lowering of efficiency after ten to fifteen years due to deterioration and become more easily damaged. Therefore, PPWSA needs to secure the budget for a regular long-term replacement/rehabilitation project. Such a project is necessary about every ten years for water treatment facilities, especially for the mechanical and electrical equipment.

The following plants will pass more than ten years since their construction:

- Chamkar Mon WTP – 1 and 2 (total 20,000 m^3/d)
- Phum Prek WTP – 1 (100,000 m^3/d)

Rehabilitation works are recommended for the above existing treatment plants.

The rehabilitation works consist of overhaul/repair/replacement of mechanical equipment, electrical equipment and instrumentation, which are usually deteriorated after a relatively short period of 10 to 20 years.

The actual contents of the works will be determined by PPWSA considering the budget availability and seriousness of the deterioration of the equipment.

The following outlines some examples:

a. Replacement of pump impeller – higher energy consumption (decrease of efficiency)
b. Chemical dosing facility – more chemical consumption (leakage or inaccurate dosing)
c. Chlorination facility – improve safety (leakage)
d. Power supply facility – improve reliability
e. Automatic control system – reduce manpower
f. Laboratory – proper water quality control

Chapter 4. Peri-Urban Water Supply Project

Chapter 4. Peri-Urban Water Supply Project

The target population of well water supply totals up to 182,070 in the M/P of 2020. In the F/S stage, communes and villages will be selected for attaining the target of safe water coverage of about 60%. The Peri-Urban Water Supply Project should be started adjacent to urbanized areas of MPP and district towns of Ta khmau and Kien Svay to improve the disparity of water supply condition between them. Accordingly, Dangkao District in MPP and Ta kmau District and Kien Svay District in Kandal Province should be prioritized for implementation.

The basic Feasibility Study concept for the Peri-Urban Water Supply Project is set as follows.

Target year:	2010
Coverage of safe water:	about 60% (70% in 2015, 80%in 2020) in peri-urban area
Target population:	47,741 prioritized through screening & qualification
Omitting:	Commune where pipeline will be installed in 2020 and no accessibility
Priority Areas:	Dangkao District: Phleung Chheh Roteh, Pong Tuek, Prey Veaeng, Prey Sa, Krang Pongro, Prateah Lang, and Sak Sampov communes in MPP Takmau District: Ta Kdol, K.Amnanh communes Kien Svay District: P. Aeng, P. Thmei communes in Kandal Province
Unit Water Consumption:	40 liter/capita/day
Water supply facilities:	Deep well
Safe pumping yield of well:	20 liter/minute (=1.2 m^3/hour)
Coverage person per one well:	210 person/well
Design water supply amount:	8,400 liter/well
Required number of well:	229 wells
Water supply level:	Level 1 Tube-well with hand pump (because of low yield and recharging)

Chapter 5. Institutional Development Plan & Capacity Building Plan

Chapter 5. Institutional Development Plan & Capacity Building Plan

The broad themes for the institutional development and capacity building plan during Stage I are on sharpening of organizational **directions**, strengthening of management **systems** and promoting more **delegation** of duties and responsibilities. Many of the current systems will have to be formalized and standardized as the PPWSA expands. There are the capacity concerns directly related to Stage I improvements, as well the ongoing concerns to maintain and enhance the performance of PPWSA as a water company.

5-1 Institutional Development Plan For Stage I Project Implementation

The Report recommends the needed institutional arrangement for the planning, supervision and monitoring of Stage I improvements. This function will clearly have to be led by project management units (PMU), under PPWSA and, possibly, another under MRD.

5-1-1 Project Management Arrangements

In the proposed structure for PPWSA, a Project Management & Construction Section is proposed under the Technical Planning Department, to serve as permanent PMU for both externally and internally-funded projects. One of the responsibilities proposed of this Section is the coordination of Stage I implementation as soon as capital funding can be arranged. At present, this group is called the Tech & Projects Unit of the Planning and Technical Department. This is not a major departure from the existing arrangements and the existing staff of this section may be augmented with specialized expertise from other departments in the company, as needed. The Report suggests some minimum qualification requirements for the Project Management & Construction Section staff.

5-1-2 Preparing For Effective Operation And Maintenance Of New Stage I Facilities

The FS focuses on some of the changes that PPWSA will have to institute to operate and maintain the new facilities.

5-1-2-1 Expanded operations at the Chruoy Changva Water Treatment Plant

The current management systems in the treatment plant are, by and large, satisfactory. Only a slight increase in the size of the work crew shift size will be needed. The control panels for the new facilities will be located in the same room as the controls for the existing facilities. The additional staff for each of the four (4) shifts will be needed to physically maintain the order and cleanliness in the facilities since the new systems are automated. The important skill which must be learned by the shift crew is in being able to identify and anticipate possible operational problems. Laboratory staff (for routine testing) may be increased since the number of samples will increase. An additional laboratory staff is expected to assist the existing Chemist in taking additional samples and performing the chemical analyses. Some

scheduling adjustments will also be needed in the delivery of chemicals and supplies since there in limited space for storing additional supplies.

The cleaning of the filter media and other major maintenance functions should be organized through the central maintenance services. Additional samples for bacteriological testing will be tested at the central laboratory facility.

O&M Manuals for all the Chruoy Changva facilities (and other WTP's) are still not readily available. The development of these manuals is included in the institutional development plan.

5-1-2-2 Expansion of Water Distribution

Generally, the specific requirements raised by the Stage I distribution system improvements should be viewed within the broader context of improved total system operation and maintenance monitoring, response and asset management. The strategy will be towards streamlining maintenance management with higher use of the new technologies, the MIS and better system monitoring systems. These are elaborated in the institutional development plan.

5-1-2-3 Implementation Of The Peri-Urban Project

The principal tasks in the early stages of this component involve the organization and training of the local user groups, provision of training and information about the policies, obligations and rules for participating in the project, and mobilizing the community to support construction activities. It is vital to enhance the awareness and willingness of villagers, particularly in low safe water coverage areas. It is proposed that the implementation will be implemented by DARD in cooperation with PPWSA.

Operation and maintenance of the peri-urban systems is clearly the responsibility of the Water Point Committees (WPC's). A WPC will operate and maintain the well, collect the water tariff, clean the well site, implement hygiene education and coordinate with and submit reports to the service center.

A more robust technical support and monitoring program is needed. A program to procure spare parts to be "re-sold" to the WPC needs to be organized, funded and implemented. This support service should provide WPC's with technical and management advice and training, spare parts procurement support. It will also regularly monitor the physical, institutional and financial condition of these systems.

5-2 Institutional Development Plan For PPWSA Operations

As PPWSA is, at present, a well-functioning organization, the interventions to be introduced into the current arrangements have to be approached with extreme care and planning.

In the Master Plan, a broad framework for organizational growth was explained. Building on that frame, the priority strategy at this stage of growth has to focus on enhancing the stability of the organization – so that its present high performance is sustained in spite of whatever events or changes may occur

beyond its control. Stage I institutional development will be done by **organizational restructuring** (to help build a broader team of managers and supervisors with clear roles and responsibilities and set the stage for even higher levels of coordination among the management team and delegation of authority and responsibility); **intensified training** for all staff on all aspects of utility management and operations (not just technical aspects) and **strengthening of existing management information system** (based on the existing Navision Financials software). This is the basic concept behind this institutional development plan. While it seeks to address some current issues, its bases also lie in taking advantage of opportunities to prepare and organize for its future. An external technical assistance proposal for institutional development is formulated in the FS to assist PPWSA in implementing these improvements.

5-2-1 Organizational Restructuring And Management Levels

As an initial step to organizational restructuring, the Report defines the various management categories and their detailed responsibilities. This management framework is useful for addressing several problems and opportunities. It is used to: promote delegation of authority and responsibility; balance the current responsibilities and job descriptions of managerial positions; build a broader team of managers and supervisors with clear roles and responsibilities; set the stage for even higher levels of coordination among the management team; and develop the performance indicators for the various managerial and supervisory positions in the company. The performance indicators for management staff needs to be strengthened.

In this Study, senior management level includes: the General Director, Deputy General Directors, Department Managers; middle management level includes: Section Managers, Plant Managers and other similar positions; and operational management level includes: Shift Supervisors, Unit Supervisors, Team Leaders and other positions with supervisory responsibilities.

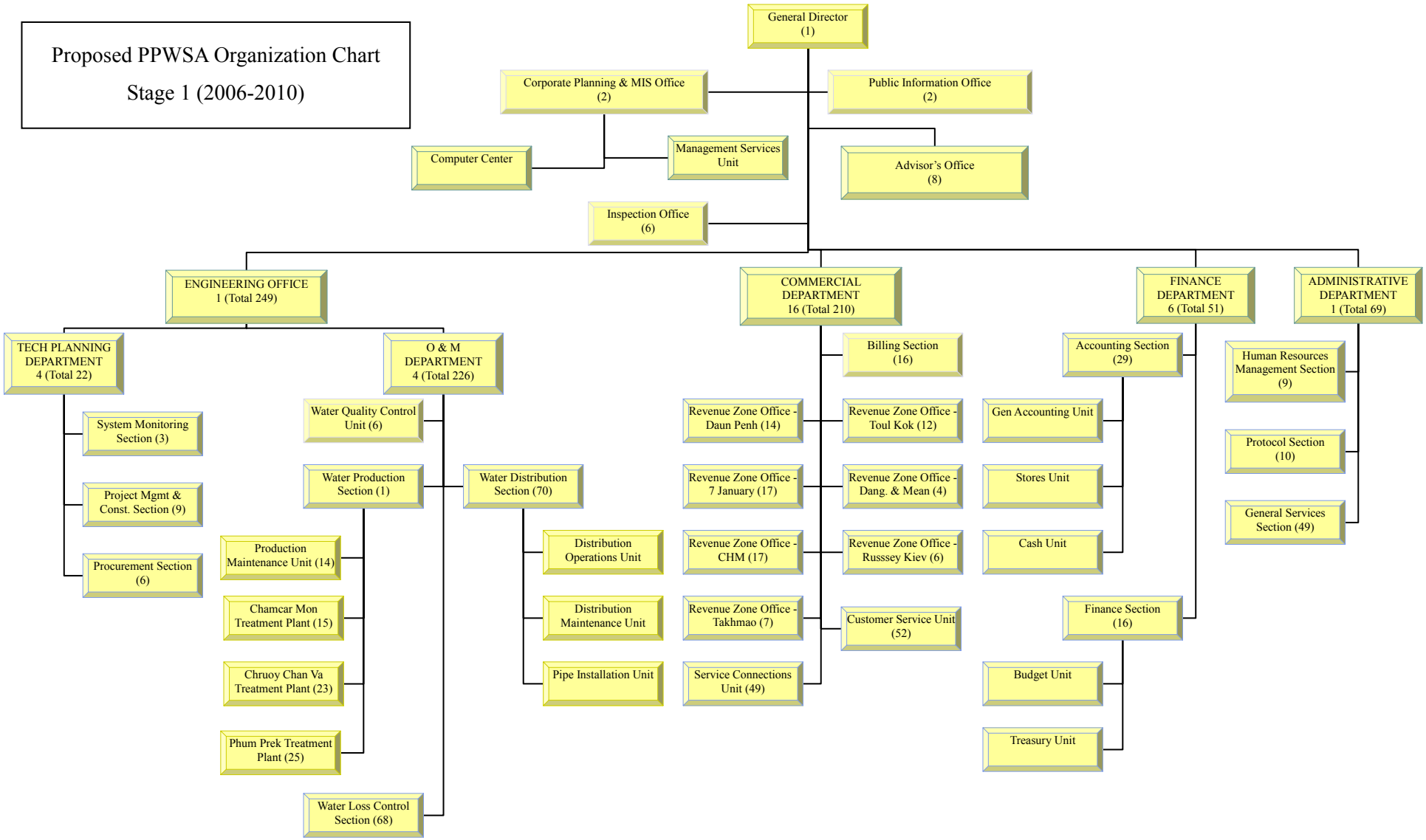
The various managerial and supervisory responsibilities and functions are stratified and correspond with the three management levels. These management responsibilities are also classified with respect to their bearing on: the achievement of PPWSA objectives: the formulation of PPWSA strategies; PPWSA strategic program; and PPWSA strategic and operational budget. The table of management functions and responsibilities by levels is detailed in the FS.

The objective of restructuring is to streamline and “balance” the organization into the 3 levels: a department level, a section level and a unit Level. The proposed new structure, presented in the next page, is envisaged to be implemented gradually during the Stage I period.

5-2-2 Staffing Projections

Based on the anticipated growth of customer base and the need to operate and maintain additional assets, the following staffing projections have been developed. The current staffing ratio of 4.66 staff per

thousand connections (as of October 2005) will gradually be raised up to about 3.7. This is envisaged to be feasible inasmuch as much of the new facilities will be automated and more computers and other labor-saving equipment will be utilized.


Proposed PPWSA Organization Chart
Stage 1 (2006-2010)
General Director (1)
Corporate Planning & MIS Office (2)
Public Information Office (2)
Computer Center
Management Services Unit
Advisor's Office (8)
Inspection Office (6)
ENGINEERING OFFICE 1 (Total 249)
COMMERCIAL DEPARTMENT 16 (Total 210)
FINANCE DEPARTMENT 6 (Total 51)
ADMINISTRATIVE DEPARTMENT 1 (Total 69)
TECH PLANNING DEPARTMENT 4 (Total 22)
O & M DEPARTMENT 4 (Total 226)
System Monitoring Section (3)
Project Mgmt & Const. Section (9)
Procurement Section (6)
Water Quality Control Unit (6)
Water Production Section (1)
Water Distribution Section (70)
Production Maintenance Unit (14)
Chamcar Mon Treatment Plant (15)
Chruoy Chan Va Treatment Plant (23)
Phum Prek Treatment Plant (25)
Water Loss Control Section (68)
Distribution Operations Unit
Distribution Maintenance Unit
Pipe Installation Unit
Billing Section (16)
Revenue Zone Office - Daun Penh (14)
Revenue Zone Office - Toul Kok (12)
Revenue Zone Office - 7 January (17)
Revenue Zone Office - Dang. & Mean (4)
Revenue Zone Office - CHM (17)
Revenue Zone Office - Russsey Kiev (6)
Revenue Zone Office - Takhmao (7)
Service Connections Unit (49)
Customer Service Unit (52)
Accounting Section (29)
Gen Accounting Unit
Stores Unit
Cash Unit
Finance Section (16)
Budget Unit
Treasury Unit
Human Resources Management Section (9)
Protocol Section (10)
General Services Section (49)

5-2-2-1 Organizational sub-system improvements

This section describes the various interventions to be implemented to improve the performance of PPWSA. These are institutional improvements which PPWSA will continue to implement on its own. Other improvements specifically requiring external technical assistance are identified for inclusion in an external Institutional Capacity Building Project Proposal.

The succeeding Table refocuses the Assessment of Strengths and Weaknesses and the new opportunities for preparing PPWSA for the future following the organizational framework model presented in the action plan. The last column defines the expected outcome of the institutional development plan during Stage 1.

5-2-2-2 Proposal for external technical assistance for institutional capacity building

A proposal for external technical assistance has been put together to support PPWSA in implementing the capacity building activities during Stage 1 and is found in the Report.

The Study recognizes that PPWSA has, on its own, been implementing its internal development programs. PPWSA has been financing much of the institutional development activities and the needed manpower time and other resources and will likely continue to do so, having recognized the benefits. It is currently considering extension of the technical service contract with the company which provided the MIS software (and even considering upgrading to a higher version).

JICA has also been supporting PPWSA with the Capacity Building Project to strengthen skills and systems for operation and maintenance of its facilities, principally through training and development of operation and maintenance guidelines. Phase 1 of this project is expected to be completed by 2006.

5-2-2-3 Project objectives and inputs

The objective of this institutional development assistance project is to ensure that PPWSA can sustainably manage the newly-expanded, as well as, the other existing facilities. Specific outcomes are in the next table.

The project envisages that starting 2007 until the end of Stage I, external technical support for institutional development will be part of the future investment programs. This external assistance will augment PPWSA's own efforts in selected areas of need. This assistance may come in the form of management (and technical) systems review and development and training services.

It is anticipated that an annual external support budget in the order of 3% of the projected capital investment cost or about US$ 2.05 million during Stage I. Detailed estimates are in the Report.

The implementation of this external technical assistance is envisaged to begin by 2007 since some time may be needed to arrange for financing and selection of consultants to assist PPWSA.

Current weakness and opportunities to be addressed	Recommended Activities	Expected 2010 Outcome
Physical (operating) system		
▪ Not all O&M procedures and standards written and documented. ▪ Limited operation skills. ▪ Untested maintenance systems and skills. ▪ O&M procedures and standards under preparation ▪ Data management and analysis can be improved. ▪ Untested maintenance systems and skills ▪ Data monitoring and telemetry system is new (for NRW)	A1. Review of existing technical standards used (construction, materials, inspection standards, etc) including comparison with local mandated standards, if any. A2. Adoption and approval of the new PPWSA standards (including construction standards, materials standards, inspection and testing procedures). A3. Review of existing policies, systems and procedures used (procurement, project planning and monitoring, project supervision, etc.) A4. Adoption and approval of a PPWSA Project Management Manual and Standards. A5. Agree on overall scope, content and structure of the PPWSA Operation and Maintenance Guidelines. Organize and assign work groups to draft (or update) various parts of guidelines. A6. Gather and review all existing O&M documents, Draft/update OMGs. A7. Detailed technical review of the OMG drafts. A8. Design & implement a system for regular internal review, upgrading and formal adoption of the OMG by PPWSA. A9. Review of existing asset management system. A10. Introduction of an upgraded asset maintenance management program to integrate a preventive maintenance program for all electro-mechanical assets of PPWSA. A11. Implementation of the Resources Module of the Navision Financials for planning and monitoring of all capital investment activities.	PPWSA will be able to: ▪ Manage capital investment and project management effectively through formally adopted technical & operating standards and procedures and formally established standard project management systems and procedures. ▪ Operate and monitor properly water supply production, treatment and distribution facilities through expanded operation and maintenance standards & guidelines. ▪ Maintain all water supply facilities properly through expanded preventive maintenance programs.
Organization planning system		
▪ Development of next line of managers. ▪ Participation of more managers and supervisors in the company planning process	B1. Update of the formal 5-year and annual business planning process, structure and tools. Identification of information required from the MIS. B2. Facilitate a series of discussion meetings with participation down to section heads and supervisors. B3. Assess and develop the process for due consideration of consumers' views (through a "consumers forum") in the planning. B4. Introduce a system for annual review of organization structure and staff competency mix in each of the working groups.	PPWSA will be able to: ▪ Prepare, update and monitor annual and 5-year plans through more input and participation from more managers and staff; and customer inputs in the process. ▪ Establish a flexible and responsive organization by implementing a policy & system for regular review and updating of departmental and section responsibilities, functions and restructuring.

Commercial system		
▪ Human errors in meter reading. ▪ Some low-income residents still cannot afford to connect (min of $112; equivalent to about 2-3 months salary)	C1. Assess, plan and implement a program to improve accuracy in meter reading.	PPWSA will be able to ▪ Serve customers at their convenience by streamlined procedures and more responsiveness to customer service requests. ▪ Get timely feedback from customers by implementing a systematic customer feedback system and promoting more dialogue with the public.
	C2. Introduce a system for regular reviewing of customer policies, services, standards and practices.	
	C3. Design and implement a more pro-active customer feedback system (Go out and get feedback; do not just wait for it to come; engage in dialogue with customers and customer groups).	
	C4. Assess, formulate and implement an expanded and continuous public relations program for current and prospective customers.	
Financial management system		
▪ Financial analysis skills limited. ▪ Improved affordability of low-income groups to water services	D1. Formulate a simulation model to regularly examine the impact of adjusting tariff structure on consumption patterns of customer groups to forecast revenues.	PPWSA will be able to: ▪ Determine, on an objective and continuing basis, the most appropriate tariff structure (including blocking) with due consideration for access of the low-income groups.
Administrative support system		
▪ Navision module for inventory management not fully utilized	E1. Examine the current inventory planning and control policies and practices in PPWSA.	PPWSA will be able to: ▪ Efficiently manage level of supplies and materials inventories.
	E2. Recommend and implement policy and system management improvements to inventory and property management systems.	

Human resources management system		
▪ Absence of a "back-up" (or understudy) system. ▪ Lack of long-term human resources development plan. ▪ Training plans still under preparation. ▪ Financial analysis skills limited ▪ Navision module for human resources management not fully utilized	F1. Identify and define practical (more job-specific) staffing indicators to be introduced.	PPWSA will be able to: ▪ Implement new methods for planning, recruitment, evaluation of staff, including manpower projection methods; review of job descriptions for all positions; set up practical qualification requirements for each job; establishing a clearer outsourcing policy and implementing a pro-active recruitment program and introduction of additional performance-based incentives. ▪ Provide high quality training opportunities for all staff by expansion of in-company training systems and capacity.
	F2. Conduct simple observation, work load analysis to propose a reasonable initial staffing criteria or target to apply.	
	F3. Propose a system for regular annual updating of manpower needs based on type of skills and competency needs (not only number of staff needed).	
	F4. Review and update existing job descriptions.	
	F5. Propose practical qualification requirements and productivity standards and indicators for each job title.	
	F6. Identify and assess all possible areas of current operations which may be outsourced or provided through service contracts and assess the advantages/benefits.	
	F7. Draft a policy note adopting principles to use in deciding when to outsource: how to outsource, including sample agreements.	
	F8. Formulate and implement a pro-active recruitment program to go out and seek "the best and the brightest" coming out of the country's education system.	
	F9. Develop a systematic applicant screening (testing?) program.	
	F10. Review and adoption of the overall framework for technical and managerial training proposed; Develop and implement training plan following the framework.	
	F11. Adopt a training management system (planning & monitoring) which provides for an annual program of training activities organized and implemented by PPWSA Training Center.	
	F12. Establishment of more linkages with other training and development centers in the country and Asia.	
	F13. Intensify trainer training and materials development.	
	F14. Establish a staff library (for information and research) at a central location with hi-speed Internet access as part of the Training Center for use of all staff.	
Management information system		
▪ Limited familiarity with information systems and information technology. (Navision not fully utilized)	G1. Review and if viable, expand application of existing Navision MIS software – focus on linked applications for the operations department (or replace with new software).	▪ Share and exchange information <u>across</u> departments on a regular and continuing basis for sound decision making.
	G2. Propose an MIS enhancement plan (addressing the information needs for the other system)	

Chapter 6. Project Cost and Implementation

Chapter 6. Project Cost and Implementation

6-1 Project Cost for Stage I Priority Projects (Tentative)

The total project costs of Stage I Priority Projects are as follows;

Urban Water Supply Projects: US$ 72,405,000

Peri-Urban Water Supply Projects: US$ 8,839,000

Project cost has been worked out as summarized in the following tables.

Table 6-1 Cost Estimates for Urban Water Supply Projects

(Thousand US$)

Code	Item	FC Portion	LC Portion	Total
100	**<Construction Cost>**			
110	**Chrouy Changva WTP -2nd Stage**	**17,225**	**5,405**	**22,630**
111	Intake Tower (for Chrouy Changva WTP)	3,385	577	3,962
112	Raw Water Transmission Facilities	176	43	219
113	Chrouy Changva WTP -2nd Stage (Q=65,000m^3/d)	13,664	4,785	18,449
120	**Water Tank**	**1,867**	**688**	**2,555**
121	Ta Khmau Water Tank	1,025	642	1,667
122	Booster Pump for Existing Water Tank	842	46	888
130	**Transmission/Distribution Pipe**	**8,753**	**3,127**	**11,880**
131	Transmission/Distribution Pipe (Dia 63 to 600) *1	6,620	2,506	9,126
132	Transmission/Distribution Pipe (Dia 700 to 1200)	2,133	621	2,754
135	**Monitoring Facility**	**4,800**	**200**	**5,000**
140	**Rehabilitation of M&E Equipment** *1	**9,300**	**500**	**9,800**
	Total Construction Cost	**41,945**	**9,920**	**51,865**
500	Equipment Procurement Cost	419	99	519
600	Engineering Service	4,688	519	5,187
700	Government's Administration*2	0	2,593	2,593
710	Institutional Development	0	2,062	2,062
800	Physical Contingency	4,703	1,519	6,223
900	Price Contingency	2,849	1,108	3,957
	Total Project Cost	**54,584**	**17,821**	**72,405**

Notes

*1: Distribution Pipe (Dia 63 to 600) and Rehabilitation of M&E Equipment are estimated to be implemented by PPWSA's own budget.

*2: Government administration expenses include mitigation costs for social and environmental impacts, such as resettlement, water rights.

Table 6-2 Cost Estimate for Peri-Urban Water Supply Projects

(Thousand US$)

Code	Item	FC Portion	LC Portion	Total
	<Construction Cost>			
150	**Well Facilities**	**1,212**	**5,093**	**6,305**
500	Equipment Procurement Cost	12	51	63
600	Engineering Service	567	63	631
700	Government's Administration	0	315	315
800	Physical Contingency	179	552	731
900	Price Contingency	186	662	848
	Total Project Cost	**2,157**	**6,736**	**8,893**

6-2 Implementation Schedule

In connection with the target years for this Study, Stage I priority projects are expected to be completed by the end of 2010.

Stage I Priority Project

Pre-construction Stage

010: 2005-2006 Preparation of Project

020: 2005-2006 Pre-Construction (Detailed Design, Bidding)

2006 Commencement of Construction & Procurement of Equipment

Construction Stage

110-140: 2007-2009 Construction (Water Supply Facilities)

150: 2008-2010 Construction (Well Facilities)

2009-2010 Commencement of Operation

Chapter 7. Evaluation of the Priority Projects

Chapter 7. Evaluation of the Priority Projects

7-1 Technical Evaluation

The jurisdiction of PPWSA water supply is expanded to over 500 km2 in the Phase 2 Master Plan, approximately five times the area compared to the Phase 1 Master Plan area. By the augmentation project for the Chrouy Changva water treatment plant, a total production capacity of 300,000 m^3/d will be achieved by the year 2010, which will secure the production capacity to meet the water demand by the year 2013. Water tank and distribution pipelines will be extended towards the outskirt of the central city zone and enforced to ensure a reliable 24-hour supply. Peri-urban water supply will be improved by construction of over 200 wells in outlying areas. The total population with access to a safe and clean water supply will be expanded from the present 1.07 million to 1.32 million people in 2010. The coverage will be increased from the present 70.0% to 74.5% in 2010, targeting over 90 % in 2020. The number of service connections will reach approximately 155,000 connections, from 121,000 at present.

It is noteworthy that the coverage will be achieved with continued efforts to control NRW at the level of 15% through well organized operation and maintenance efforts on the transmission/distribution pipelines, including optimization of supplied pressure and making use of the proposed supplied water monitoring system. Preservation of raw water quality is another important issue for both drinking water quality control and minimization of production cost.

7-2 Socio-Economic Evaluation

The Priority Projects will sustain the safe water supply to urban areas of Phnom Penh and will make a substantial contribution toward achievement of the relevant Cambodia Millenium Development Goals in the rural areas, with full achievement targeted under completion of Phase III.

The expected benefits from achieving the CMDG clean water coverage targets include improved public health overall and reduction of infant and maternal mortality associated with water-born disease. Improved water supply in rural areas also reduces the burden of fetching water that typically falls on women and children, which may contribute indirectly to greater rural labor force productivity and improved school attendance and educational achievement of children.

In urban and peri-urban areas, improved water supply from the Central Distribution System (CDS) is an aid to industrial development. Water supply is among the critical infrastructure requirements for the types of labor-intensive, light manufacturing industries that the RGC has

targeted for promotion in its industrial policy, and such infrastructure expansion is among the specific RGC objectives for supporting the industrial sector.

On the negative side, it must be mentioned that expanded water supply inevitably results in greater production of wastewater. Preparation and implementation of a parallel Master Plan for drainage and sewerage in the Study Area is urgently necessary, in particular to ensure that the health benefits from improved water supply are not lost on account of deterioration in sanitary and environmental conditions. The Master Plan documented the dramatic loss of lake and marsh areas, especially in the northern area, that have traditionally provided a certain level of natural treatment of wastewater flowing from the City through the lake/marsh areas to the Tonle Sap and Tonle Bassac rivers, which surround the City. The treatment capacity of these natural bodies is already on the verge of exhaustion. Combined with steady growth in population and probable continued loss of these critical habitats, the quality of the water bodies themselves, as well as the effluent flowing from them into the afore-mentioned rivers, can be expected to deteriorate very significantly during the coming years. Planning and preparation of counter-measures, in addition to those already undertaken previously with JICA's assistance, should begin as soon as possible.

7-3 Financial and Economic Evaluation

7-3-1 Urban Water Supply

7-3-1-1 Financial Evaluation

The WACC of the Priority Projects is 3.84% (real terms). The results of the calculation of the FIRR and sensitivity analyses are summarized in the table below.

Table 7-1 FIRR and Sensitivity Analysis – Urban Water Supply

Particulars	NPV @ WACC Million Riels	FIRR (%)	SI *	% Change
Base Case	108,337	6.73%		-
10% Increase in Project Costs	86,848	6.03%	1.16	10%
10% Increase in O&M Costs	83,162	6.13%	0.99	10%
10% Decrease in Revenue	50,839	5.31%	2.68	10%

* SI – Sensitivity Indicator

Under the base case scenario, the project's FIRR is higher than its WACC. With its FIRR higher than its WACC, the project is considered financially viable.

The results of the sensitivity analysis show that under the 3 adverse changes, the project's financial viability is not greatly affected as the project's FIRR is still higher than the project's WACC. Among the adverse changes, the project's financial viability is most sensitive to decrease in revenues.

7-3-1-2 Economic Evaluation

The results of the EIRR calculation and sensitivity analyses are summarized in the table below.

Table 7-2 EIRR and Sensitivity Analysis – Urban Water Supply

Particulars	NPV @ EOCC Million Riels	EIRR (%)	SI *	% Change
Base Case	178,359	17.55%		-
10% Increase in Investment Costs	163,140	16.52%	0.63	10%
10% Increase in O&M Costs	169,323	17.24%	0.18	10%
10% Decrease in Benefits	136,268	16.08%	0.92	10%

* SI – Sensitivity Indicator

Under the base case scenario, the project's EIRR is higher than the EOCC. With its EIRR higher than the EOCC, the project is considered economically viable.

The results of the sensitivity analyses show that under the 3 adverse changes, the project's economic viability is not greatly affected as the project's EIRR is still higher than the project's EOCC. Among the adverse changes, the project's economic viability is most sensitive to decrease in benefits.

7-3-1-3 Financial Implications for PPWSA

The following are the key observations on the results of the financial projection:

- During the projection period (2005-2035), PPWSA would have net profit each year. This indicates that PPWSA's tariff level during the projection period is a full cost recovery tariff. PPWSA's projected tariff could recover the full cost of its operations plus depreciation and financing charges as long as the tariff keeps pace with inflation.
- PPWSA's financial condition during the projection period is healthy and it is able to repay its debts as they fall due. Should PPWSA be able to secure financing schemes with better conditions in terms of lower interest rate and longer repayment period that those assumed in the financial projection, PPWSA would have a much healthier financial condition. With lower interest rate, financing charges are reduced. With longer repayment period, the annual amount of loan principal repayment is reduced.

PPWSA can implement on a sustainable basis the proposed Priority Project, together with its existing assets and on-going projects, with no negative impact on its financial condition even without the benefit of a tariff increase in real terms.

7-3-2 Peri-Urban Water Supply

7-3-2-1 Financial Evaluation

Consistent with the policy of the government for the RWSS sector, the Water and Sanitation Users Group (WSUG) shall be responsible for arranging the counterpart contribution from the community for the capital investment, operation and management of the facilities, the collection of water charges from the beneficiaries and the management of finances. The estimated capital investment shall be financed through grant (about 88.47% of capital investment) from the

government and about 11.53% equity from the beneficiaries in the form of labor and local materials. It is assumed that the government will secure financing for the grant portion of the investment either in the form also of a grant from bilateral or multilateral institutions or a soft loan having a long repayment period (35 to 40 years) and low interest rate (1% or less).

Based on the affordability limit of 4% of monthly household income, the proposed monthly water charge is Riels 6,500 per household, about 3.8% of household income. The proposed water charge can recover 100% of the O&M cost and about 20% of the annual depreciation charges. The amount collected from the partial recovery of depreciation charges shall be deposited and accumulated for future use in the rehabilitation of the well facility to ensure sustainability of operations.

7-3-2-2 Economic Evaluation

The results of the EIRR calculation and sensitivity analyses are summarized in the table below.

Table 7-3 EIRR and Sensitivity Analysis – Peri-Urban Water Supply

Particulars	NPV @ EOCC Million Riels	EIRR (%)	SI *	% Change
Base Case	9,781,074	18.37%		-
10% Increase in Investment Costs	7,909,029	16.18%	1.36	10%
10% Increase in O&M Costs	9,540,884	18.17%	0.11	10%
10% Decrease in Benefits	6,690,733	15.76%	1.66	10%

* SI – Sensitivity Indicator

Under the base case scenario, the project's EIRR is higher than the EOCC. With its EIRR higher than the EOCC, the project is considered economically viable.

The results of the sensitivity analyses show that under the 3 adverse changes, the project's economic viability is not greatly affected as the project's EIRR is still higher than the project's EOCC. Among the adverse changes, the project's economic viability is most sensitive to decrease in benefits.

7-4 Environmental Impact Assessment

The proposed Stage I Priority Projects will have mostly beneficial impacts. Although some adverse impacts will occur during the construction and operation stage of the projects, minimization of environmental disturbances such as noise and dust during construction will be considered in the detailed design, and appropriate environmental management requirements will be incorporated in the specifications of construction contracts. All contractors will be required to reinstate affected areas to their original or better condition. Adequately planned preventive maintenance programs will be developed for all facilities constructed under the Project, and safe working practices at international standards will be adopted in both the construction and

operational phases. Monitoring of the environment and the effectiveness of the mitigation measures is also the responsibility of PPWSA.

For the Priority Projects, possible impacts are expected on the items listed in the following table.

Priority Project	**Environmental Items Possible Impacts Are Expected**
Chrouy Changva WTP Project	Local Economy such as employment and livelihood Existing social infrastructures and services Water Rights and Rights of Common Waste Hazards (Risk)(Traffic accidents) Water contamination Noise and vibration
Water Tank/Booster Pump Project	Existing social infrastructures and services Noise and vibration
Transmission/Distribution Pipe Construction Project	Local Economy such as employment and livelihood Existing social infrastructures and services The poor, indigenous or ethnic people Misdistribution of benefit and damage Cultural Property Hazards (Risk)(Traffic accidents) Air pollution Noise and vibration
Well Water Development Project	Existing social infrastructures and services

PPWSA will need to be careful about the following issues in the implementation of Stage I Priority Projects, if necessary.

- PPWSA must revise the scoping checklist for each project on site so that no environmental items are missed from the study.
- PPWSA must update the social and environmental condition around the project site.
- For the construction of distribution pipes, PPWSA must minimize relocation or modification of existing infrastructures and private structures.
- PPWSA must prepare a required cost for environmental mitigation and monitoring measures based on the detailed information of project design and schedule if necessary.
- PPWSA must continue their efforts to distribute information and to negotiate with local communities regarding the design and schedule of construction of each project.
- In case that PPWSA cause forced relocation of settlement or legal businesses, PPWSA must faithfully participate negotiation procedure and consider proper compensation according to the local common sense as well as the international guidelines if necessary.

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