MINISTRY OF INDUSTRY, MINES AND ENERGY
SIEM REAP WATER SUPPLY AUTHORITY
THE KINGDOM OF CAMBODIA

THE PREPARATORY STUDY ON THE SIEM REAP WATER SUPPLY EXPANSION PROJECT IN THE KINGDOM OF CAMBODIA

FINAL REPORT 1

VOLUME I

SUMMARY

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JAPAN INTERNATIONAL COOPERATION AGENCY

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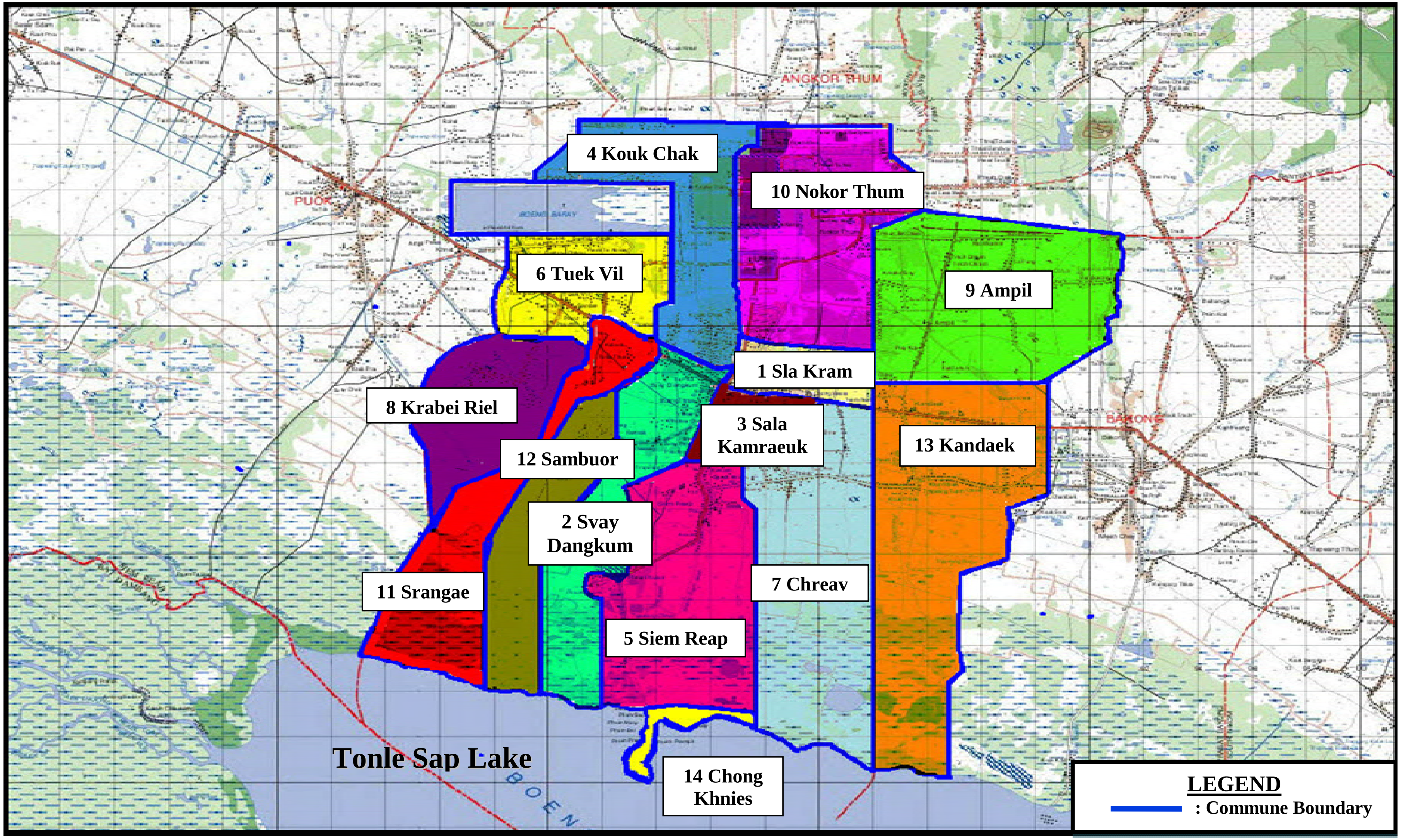


THE STUDY AREA (Siem Reap City + 1 adjacent commune)

PHOTOS OF THE STUDY AREA

Photo-1:Tonle Sap Lake in dry season
(Line of the green belt is the line of lowest water level)

Photo-2:Tonle Sap Lake in rainy season
(Upper-Left;Phnum Kraom, Upper-Right; Siem Reap Town)

Photo-3: Overview of the candidate WTP site
(Upper-side; Tonle Sap Lake, Lower-side; Siem Reap town)

Photo-4:West Baray Lake
(Water surface of upper side)

Photo-5: Existing Temple in Tonle Sap Lake

Photo-6: East-side of Siem Reap City

Photo-7: West-side of Siem Reap City

Photo-8: Whole view of Angkor Wat

EXECUTIVE SUMMARY

1. Project Framework

1.1 Proposed Service Areas

The service area covers the central urbanized areas and the peri-urban areas in the SRWSA jurisdiction area. The proposed service area of the SRWSA is comprised of the following thirteen communes. Chong Khnies commune of the Siem Reap City will be excluded from the proposed service areas. Remaining part of the study areas will be supplied by individual wells or some other measures.

Proposed Service Areas

Item	Communes	Item	Communes
1	Sla Kram	8	Krabei Riel
2	Svay Dangkum	9	Ampil
3	Sala Kamraeuk*	10	Nokor Thum
4	Kouk Chak	11	Srangae
5	Siem Reap	12	Sambuor
6	Tuek Vil	13	Kandaek
7	Chreav		

Notes: 1) All communes are in Siem Reap City, except for Kandaek commune which belongs to Prasat Bakong District.
2The entire area of Sala Kamraeuk* commune is included in the proposed service area, however, the other communes are partly covered by the SRWSA water supply systems
3) Chong Khnies will be excluded from the proposed service areas due to its location.

1.2 Population and Tourist Projection

Population projection in the proposed service areas was carried out by applying the exponential curve trend analysis which can be applicable for ordinal cities with moderate development. Projected population and calculated population growth rate is shown below:

Projected Populations and Growth Rate in the Study Area, 2010-2030

Year	2010	2015	2020	2025	2030
Projected Population	178	221	265	312	359
Growth rate	3.72% to 4.24%	4.11% to 3.65%	3.55% to 3.19%	3.10% to 2.82%	2.71%

Note: Population is shown in thousand.

Tourist projection was carried out by applying a time series trend analysis which can be applicable for estimation of growing aspect with a uniform rate for a certain period of time. In the calculation, tourist growth was modeled at the annual constant growth rates of 3 percent.

Projected Tourists, 2010-2030

Year	2010	2015	2020	2025	2030
Projected tourists	2,323	2,693	3,122	3,619	4,195
Rate for 2008	1.03	1.19	1.38	1.60	1.86

Note: 1) Unit in thousand.
2) Rate for 2008 means that the rate between the projected figures and actual record of 2,255,134 in 2008.

In calculating the water demand projection, the average length of stay for both local and international visitors was pegged to 3.5 days, allowing enough room for future increase of tourists' water demand.

1.3 Proposed Supply Coverage

The proposed supply coverage is considered in reference to the CMDGs target coverage 80 percent in 2015 and practical project implementation schedule as summarized below:

Proposed Supply Coverage

Year	2010	2015	2020	2025	2030
Resident	30 %	55 %	80 %	85 %	90 %
Tourist	30 %	55 %	80 %	95 %	100 %

1.4 Population Served

Applying the proposed coverage and the projected population, the population served was estimated to be over 200 thousand in 2020 and 300 thousand in 2030, respectively.

Population Served

Year	2010	2015	2020	2025	2030
Projected Population* (a)	178	221	265	312	359
Coverage (%) (b)	30 %	55 %	80 %	85 %	90 %
Population Served* (a x b/365)	54	122	212	265	323

Note: Unit is x 1000.

1.5 Tourists Served

Applying the proposed coverage and the projected population, the number of tourists served daily was estimated to be over six thousand in 2020 and eleven thousand in 2030, respectively.

Tourists Served

Year	2010	2015	2020	2025	2030
Coverage (b)	**30 %**	**55 %**	**80 %**	**95 %**	**100 %**
Projected Yearly Tourists (a)	2,323	2,693	3,122	3,619	4,195
Projected Daily Tourists (a/365)	6.4	7.4	8.6	10.0	11.5
Daily Tourists Served (a x b)	1.9	4.1	6.9	9.5	11.5

Note: Unit in x 1000.

1.6 NRW Reduction

Past experience confirms that the NRW of SRWSA can be controlled and maintained below 10 percent after the target year of 2020.

Proposed NRW Reducing Plan

Year	2010	2015	2020	2025	2030
NRW	17 %	12 %	10 %	10 %	10 %

2. Water Demand Projection

2.1 Applied Unit Water Consumption Rate for Domestic Water Use

In the unit consumption rate projection, the following assumptions were made:

⇒ Baseline for the unit consumption rate in 2010 is set at 110 litter per capita per day (lpcd) to prevent overestimation. The 110 lpcd of unit consumption rate includes the administrative water use in the water demand projection; and

⇒ Based on past experience in Siem Reap and from other countries, growth in per capita consumption is being modeled applying respective annual growth rates of 2 lpcd towards 150 lpcd.

Domestic Unit Consumption Rate 2010-2030

2010	2015	2020	2025	2030
110	120	130	140	150

2.2 Domestic Water Demand Projection

Average daily domestic water demand was obtained as shown hereunder:

Average Daily Domestic Water Demand (m^3/d)

Year	2010	2015	2020	2025	2030
Projected population*	178	221	265	312	359
Population Served*	54	122	212	265	323
Proposed coverage	30 %	55 %	80 %	85 %	90 %
Water Demand (m^3/d)	5,900	14,600	27,500	37,100	48,400
Unit consumption rate	110	120	130	140	150

Note: Figures are rounded in x 1000, based on population projection.

2.3 Applied Unit Consumption Rate for Commercial Water Use

In the unit consumption rate projection, the following assumptions were made:

Unit Consumption Rate of Tourist 2010-2030

2010	2015	2020	2025	2030
300	310	320	330	340

⇒ Baseline for the unit consumption rate for tourists in 2010 was set at 300 lpcd which includes a 10 percent allowance for unforeseen situations to the surveyed average unit consumption rate as the water demand projection;

⇒ Annual growth in per capita consumption is being modeled applying 2 lpcd and

⇒ The increasing scenarios were set, provided that miscellaneous water use such as gardening, car washing, and laundry services at hotel business in the hotel zone grows towards target year 2030.

⇒ The proposed unit consumption rate for tourist was estimated based on a field survey result at the selected five hotels. The survey showed that average unit water consumption rate by tourist was 276 lpcd.

2.4 Commercial Water Demand

Average daily commercial water demand was obtained as shown below:

Average Daily Commercial Water Demand (m^3/d)

Year	2010	2015	2020	2025	2030
Projected tourist (x1000)	6.37	7.38	8.56	9.92	11.50
Tourist Served (x1000)	1.91	4.06	6.85	9.42	11.45
Proposed coverage	30 %	55 %	80 %	95 %	100 %
Unit consumption rate (lpcd)	300	310	320	330	340
Average length of stay (days)	3.5				
Water Demand (m^3/d)	2,000	4,400	7,700	10,900	13,700

2.5 Total Water Demand Projection

The water demand will be increased from 9,500 m^3/d in 2010 to 69,000 m^3/d in 2030 on a daily average basis and from 11,900 m^3/d in 2010 to 86,300 m^3/d in 2030 on a daily maximum basis.

Total Water Demand Projection

Descriptions/Year	2010	2015	2020	2025	2030
Domestic water demand (m^3/d)					
Projected Pops. (x1000)	178	221	265	312	359
Coverage	30 %	55 %	80 %	85 %	90 %
Population served (x1000)	54	122	212	265	332
Water Demand (m^3/d)	5,900	14,600	27,500	37,100	48,400
Commercial water demand (m^3/d)					
Projected tourists per year (per day in parenthesis)					
Projected tourists (x 1000)	2,323 (6.4)	2,693 (7.4)	3,122 (8.6)	3,619 (10.0)	4,196 (11.5)
Coverage	30 %	55 %	80 %	95 %	100 %
Average length of stay	3.5				
Water Demand (m^3/d)	2,000	4,400	7,700	10,900	13,700
Total water demand (domestic +commercial; m^3/d)					
Scenario 2 (m^3/d)	7,900	19,000	35,200	48,000	62,100
NRW	17 %	12 %	10 %	10 %	10 %
Average water demand (m^3/d)					
Scenario 2 (m^3/d)	9,500	21,500	39,100	53,300	69,000
Peak factor	1.25				
Maximum water demand (m^3/d)					
Scenario 2 (m^3/d)	**11,900**	**26,900**	**48,900**	**66,600**	**86,300**

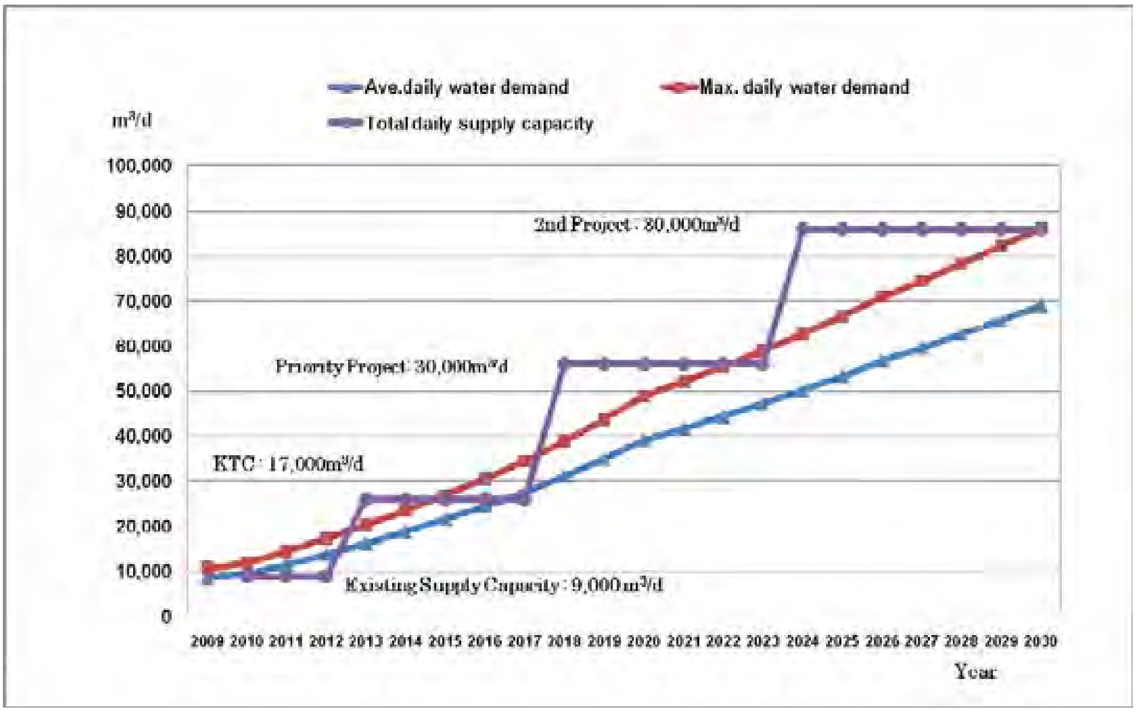
2.6 Proposed Long Term Development Plan

The required production capacity at each phase up to 2030 is illustrated in the following figures in accordance with the proposed daily average and maximum water demand.

The present nominal design capacity of 8,000 m^3/d is obviously inadequate against the estimated water demand. The implementation of the urgent projects to expand the existing capacity of SRWSA by increasing numbers of wells producing 1,000 m^3/d (bringing total production capacity to 9,000 m^3/d) and the KTC project (a bulk water supply project by a Korean company) of 17,000 m^3/d, provides a total production capacity of 26,000 m^3/d in 2011 or 2012. This meets the estimated water demand through the year 2016 at average water demand basis.

The water supply development plan will have a total water production capacity of 86,000 m^3/d in the target year 2030 to include: (i) the existing production capacity of 9,000 m^3/d, (ii) 17,000 m³/d by KTC project, and (iii) 60,000 m³/d to be implemented in two phases under the Project.

Priority Project is then recommended to develop 30,000 m³/d as an urgent project by year 2016 or 2017 to supplement to the current water production capacity, and the expected KTC production capacity to meet the projected maximum water demand in 2022. Second project, which will see completion in 2022, will provide another 30,000 m³/d where the final daily production capacity is 86,000 m³ fulfilling the expected maximum water demand through 2030.



Water Demand and Production Capacity

3. Selection of Raw Water Source

Tonle Sap Lake, West Baray and Groundwater were selected as target water source for the proposed system.

As a result of detailed comparison in technical, economical, and environment as summarized in the following table, **Tonle Sap Lake** was recommended to be employed as the most appropriate raw water for the proposed water supply development scheme.

Selection of the Proposed Water Source

Water Source	Tonle Sap Lake	West Baray	Ground Water
Structural Design and Work Plan	✓ **Possible long term plan** ✓ **Ideal water supply scheme from existing WEST and proposed EAST WTPs.** <u>Issues and Concerns</u> - Intake chamber and pump station are needed. - Water level fluctuation of the lake is to be considered. - Location of intake pumping station is to be considered. - Proposed WTP site is close to those areas where major water demand increase is projected. - Easy access to the existing distribution network. - Conventional water treatment process is needed.	✓ **Short term plan only** ✓ **Rehabilitation of the existing weirs and environmental issues** ✓ **Overlapped WTSs in west** <u>Issues and Concerns</u> - Land acquisition is troublesome. - Weir for water level control is necessary. - Rehabilitation for existing facilities such as weir is needed. - Far from the eastern part where major increase in future demand is expected. - Available water is limited but future expansion is impossible. - Conventional water treatment process is needed.	✓ **Short term plan only** ✓ **Considerable numbers of wells and connection pipelines** ✓ **Unavoidable environmental issues** <u>Issues and Concerns</u> - Considerable number of wells are needed. - Monitoring facilities for ground water and land subsidence are needed. - Conventional water treatment process excluding the sedimentation basin. - Land acquisitions for each well are difficult. - Site can be located in the southern part of town. - Easy access to the existing distribution network.
Construction Method and Schedule	✓ **Careful construction due to water level fluctuation** <u>Issues and Concerns</u> - Construction schedule for intake chamber shall be considered. - Seasonal water level changes shall be considered.	✓ **Permission from related agencies** ✓ **Land acquisition** <u>Issues and Concerns</u> - Permission for rehabilitation of the existing facilities is required from many agencies concerned. - Land acquisition for the water treatment plant is troublesome.	✓ **Long ACCESS ROAD to wells** ✓ **Land acquisition** <u>Issues and Concerns</u> - Construction period is long due to the considerable number of wells. - Access roads to each wells are necessary.
Construction, Operation and Maintenance Costs	✓ **Careful O&M** ✓ **Annual O&M cost is estimated USD1.6 Mill.** ✓ **Comparative cost is estimated US$99 Mill.** <u>Issues and Concerns</u> - Careful operation for seasonal water quality fluctuation is required. - Land price is reasonable.	✓ **Careful O&M** ✓ **Annual O&M cost is estimated USD1.7 Mill.** ✓ **Comparative cost is estimated US$100 Mill.** <u>Issues and Concerns</u> - Operation for the water level fluctuation of West Baray and canal is troublesome. - Long distribution/transmission pipelines to the city are necessary and costly. - Land acquisition is tedious and costly.	✓ **Well water level monitoring** ✓ **Security for numerous scattered wells** ✓ **Annual O&M cost is estimated USD2.2 Mill.** ✓ **comparative cost is estimated USD104 Mill.** <u>Issues and Concerns</u> - Raw water conveyance pipelines are long and costly. - Tough O & M for many wells. - O & M for monitoring facilities is must. - Security for many wells is required.
Evaluation	<u>**Generally good for short/long term plan**</u>	**Not applicable for long term plan**	**Not applicable for long term plan**

4. Feasibility Study on Priority Project

4.1 Scope of Work

The Priority Project will provide a new intake facility, a treatment plant, a transmission/distribution systems to supply additional water required for the existing Siem Reap service area, elevated water tank with clear water lifting pump facilities, distribution pipelines from the proposed elevated water tank to the existing distribution system, and expansion of distribution network to un-served areas.

From the long-term water supply development plan proposed in the previous chapter, it is concluded that the nominal design capacity for the priority project is 30,000m^3/d which will meet the water demand in 2022.

Key indicators in 2022, the target year of F/S for the long-term water supply development plan are summarized below:

･Water use	Domestic	Tourists
･Projected Pops./Tourists	283,290	9,073
･Coverage	82 %	86%
･Pops./Tourists served	232,300	7,803(*27,300)
･Unit consumption rate (lpcd)	134	324
･Water demand (m^3/d)	31,128	8,848
･Total daily water demand (m^3/d)	39,976	
･NRW (%)	10	
･Ave. daily water demand (m^3/d)	44,420	
･Peak factor	1.25	
･Max. daily water demand (m^3/d)	55,530 (=43,230 + 12,300)	
･Available water supply capacity (m^3/d)	26,000 (= existing 9,000+KTC17,000)	
･Development capacity (m^3/d)	30,000	

Notes: Details are referred to **S.R.3.2-2**

*Daily actual numbers of tourists are calculated to be 7,803 x 3.5 =27,300, in applying 3.5 days of stay.

After completion of the Priority Project, water production capacity of the Project will be 30,000m^3/d. However, main part of raw water conveyance pipelines, water intake structure, and administrative common facilities will be sized for the long-term water supply development plan capacity, which nominal design capacity would be 60,000m^3/d. Ten percent allowances will be added to design the works for loss through the works. Distribution of water to Siem Reap service areas under the Priority Project will be for those communes as Sla Kram, Svay Dangkum, Sala Kamraeuk, Kouk Chak, Siem Reap, Chreav, and Nokor Thum.

a) Raw water conveyance pipelines : Capacity of raw water conveyance pipelines will be 66,000 m^3/d including 10% allowances for the nominal design capacity for second project;

b) Raw water intake pump station : Space of the pump station is sized for the second project. Priority facilities includes only for capacity of 33,000 m^3/d (additional pumps will be expanded in the 2nd Project);

c) Raw water intake pipe : Pipes used for raw water transmission main from raw water

			transmission pump station to WTP should be of 800 mm dia. DI pipes of 3,400 m length to satisfy a capacity of 33,000 m^3/d (additional pressure main will be expanded in the 2nd Project);
d)	WTP	:	Production capacity of 30,000 m^3/d;
e)	Clear water pumps	:	Deliver 30,000 m^3/d to the elevated water tank;
f)	Clear water pump station, chemical building, administration building, etc.;		
g)	Elevated water tank	:	1,000 m^3 will be allocated in WTP
h)	Distribution main from treatment plant to service areas	:	Approximately 21 km. of distribution main system. DI pipes with diameters from 250 mm to 800 mm and PE pipes with diameters from 50 mm to 200 mm will be used;
i)	Distribution pipelines	:	In the distribution system 14 km of DI pipes and 325 km of PE pipes will be used, dependent on pipe sizes;
j)	Communication and power supply to intake, pumping station and WTP; and		
k)	Plant and equipment necessary for operation and maintenance.		

4.2 Design of Priority Project

The aim of a water supply system is to basically assure users of a constant supply of hygienic, safe and clean water at their service taps, free from trouble regarding the quality of water or other inconveniences. The use of proven water treatment plant technologies commonly utilized in other countries, particularly those where land is unavailable and where an excellent high-technology service support infrastructure exists, may be inappropriate. For example, fully automated operation of the plant may not necessarily be appropriate for the Project as this is capital intensive and, when there is an abundance of unskilled labor this makes labor-intensive operation more attractive. However automatic control of systems could be installed at a later date if considered necessary and desirable.

Thus, the following technical principles are applied in the preliminary design of water treatment equipment and facilities for the Project;

- to the extent possible, the use of mechanical equipment should be limited to that produced locally for easy operation and low maintenance cost;
- hydraulically based devices that use gravity for such work as rapid mixing, flocculation, and filter rate control are preferred over mechanized or automated equipment, but subject to the hydraulic head requirement;
- mechanization and automation are appropriate only where operations are not readily done manually, or where they greatly improve reliability to assure safe and stable water supply;
- indigenous materials and manufactured goods that allow easy and safe construction should be used to reduce costs and to assist the local economy and expand industrial development.

The following hydraulic design horizon is adopted. These are summarized in the following Table and include for ten percent production loss for the design of the intake facilities, receiving well/distribution chamber, flocculation basins, sedimentation basins, filter units, and chemical, and chlorination facilities.

Design Horizon

Facilities	Priority Project
1) Intake Chamber	66,000 m^3/day
2) Raw Water Conveyance Pipeline	66,000 m^3/day
3) Raw Water Transmission Pipeline	33,000 m^3/day
4) Raw Water Intake Pump Station	33,000 m^3/day
5) Distribution Chamber	33,000 m^3/day
6) Flocculation Basins	33,000 m^3/day
7) Sedimentation Basins	33,000 m^3/day
8) Filter Units	33,000 m^3/day
9) Clear Water Reservoir	33,000 m^3/day
10) Distribution pipelines	*56,000 m^3/day

Notes:* Hourly peak factor will be applied to 56,000m^3/d in design of the distribution pipelines.

5. Priority Service Areas for the Priority Project

The population served by the Priority Project is estimated to be 232 thousand residents and 27 thousand tourists, respectively.

F/S Priority Service Areas and Population Served

Item	Commune / Village	F/S	Item	Commune / Village	F/S	Item	Commune / Village	F/S
1.	**Sla Kram**	**81,070**	**5.**	**Siem Reap**	**21,030**	**9.**	**Ampil**	**0**
1-1	Slor Kram**	○	5-1	Pou	△	9-1	Kouk Chan	×
1-2	Boeng dunpa*	○	5-2	Phnom krom	×	9-2	Thnal Chak	×
1-3	Chong Kavsu*	△	5-3	Pror Lay	×	9-3	Tanot	×
1-4	Dork pou*	○	5-4	Korkragn	△	9-4	Trapang Run	×
1-5	Bantay chas**	○	5-5	Kra Sangroleung	×	9-5	Ta Pang	×
1-6	Trang*	△	5-6	Spean Chreav	△	9-6	Prei Kuy	×
1-7	Mondol 3**	○	5-7	Arragn	△	9-7	Bang Koung	×
2.	**Svay Dangkum**	**59,130**	5-8	Treak	×	9-8	Kiri Manon	×
2-1	Pngea Chei	×	**6.**	**Tuek Vil**	**0**	9-9	Bos Tom	×
2-2	Kantrork	×	6-1	Kouk doung	×	9-10	Trach Chrom	×
2-3	Kouk Krasang	×	6-2	Sandan	×	**10.**	**Nokor Thum**	**0**
2-4	Svay Chrei	×	6-3	Chrei	×	10-1	Rohal	×
2-5	Pou Bos	×	6-4	Prayut	×	10-2	Sras srang	×
2-6	Tmei	△	6-5	Bantay Cheu	×	10-3	Sras srang	×
2-7	Svay Dangkum*	○	6-6	Teuk Vil	×	10-4	Kravan	×
2-8	Salakanseng*	○	6-7	Pri Chas	×	10-5	Arak svay	×
2-9	Krous*	△(○)	6-8	Tuek Tla	×	10-6	Ang Chang	×
2-10	Vihear Chin*	○	6-9	Pri Tmei	×	**11.**	**Srangae**	**3,370**
2-11	Steng Tmei*	△(○)	6-10	Chei	×	11-1	Kasikam*	△
2-12	Mondol 1**	○	**7.**	**Chreav**	**7,190**	11-2	Tnal	×
2-13	Mondol 2**	○	7-1	Chreav	×	11-3	Roka Thom	×
2-14	Ta Phoul**	○	7-2	Knar	△	11-4	Prei Thom	×
3.	**Sala Kamraeuk**	**45,100**	7-3	Bos Kralang	×	11-5	Srangie	×
3-1	Vat Bo**	○	7-4	Ta Chek	×	11-6	Chanlong	×
3-2	Vat Svay	○	7-5	Veal	×	11-7	Ta Chouk	×
3-3	Vat Damnak*	○	7-6	Kra Sang	×	**12.**	**Sambuor**	**0**
3-4	Sala Kam reak	○	7-7	Boeng	×	12-1	Pnouv	×
3-5	Chun long	△	**8.**	**Krabei Riel**	0	12-2	Sambour	×
3-6	Ta Vean	○	8-1	Ta Ros	×	12-3	Veal	×
3-7	Trapang Treng	○	8-2	Roka	×	12-4	Chrei	×
4.	**Kouk Chak**	**15,410**	8-3	Prei Pou	×	12-5	Ta kong	×
4-1	Trapang Ses*	△	8-4	To Tear	×	**13.**	**Kandaek**	**0**
4-2	Veal*	△	8-5	Krasang	×	13-1	Kouk Tlouk	×
4-3	Kasin tabong*	○	8-6	Popil	×	13-2	Trapang Tem	×
4-4	Kouk Chan	×	8-7	Trapang Veng	×	13-3	Khun Mouk	×
4-5	Khatean	×	8-8	Kouk Doung	×	13-4	Chras	×
4-6	Kouk Beng	×	8-9	Boeng	×	13-5	Ou	×
4-7	Kouk Tanot	×	8-10	Prorma	×	13-6	Spean Ka Ek	×
4-8	Nokor krav	×	8-11	Khnar	×	13-7	Trang	×
Notes	○: all areas prioritized		8-12	Prei Kroch	×	13-8	Chrei	×
	: partial areas prioritized		**: all areas covered by the existing systems			13-9	Kouk Tanot	×
	×: all areas not covered		*: partial areas covered by the existing systems			13-10	Lo Ork	×
Total Population Served for F/S						**232,300**		

6. Institutional Development

The SRWSA institutional development plan follows the timeline of the three physical improvements plans being proposed in this Study, as follows: (i) the availability of KTC Bulk Water in 2012-13, (ii) the completion of the facilities under the Priority Project in 2017, and (iii) the completion of the facilities under 2nd Project in 2022.

6.1 Organization Structure for each Growth Phase

The institutional development plan recommends the most optimum organization structure and number of human resources for each phase as shown in the Table below:.

TIME FRAME	# DGD	DEPARTMENT	OFFICE	SECTION (OPTIONAL)
Current 2010	1	1 – Administration and Financial	Administration and Human Resources	None
			Financial and Accounting	
	1	2 – Production and Distribution	Water Production	
			Water Distribution	
			Customer Service	
		3 – Planning and Technical	Planning	
			Technical and Project	
KTC Bulk 2012-2013	1	1 – Administration and Finance	Administration and Human Resources	
			Accounting and Finance	
	1	2 – Production and Distribution	Water Production	
			Water Distribution	
			Service Connection	
		3 – Planning and Technical	Planning and Design	
			Technical and Project	
	Under the General Director		Commercial Operations	
Priority Project 2016-17	1	1 – Administration	Administrative Services	Procurement and Property Management
				General Services
			Human Resources	Compensation, Benefits and Performance Appraisal
		2 – Finance	General Accounting	None
			Finance and Budget	None
	1	3 – Water Supply Operations	Production	Operation and Maintenance
				Water Quality
			Distribution	Network Installation and Maintenance
				Leakage Reduction
			Service Connection	Water Meter Repair and Maintenance
		4 – Planning and Development	Planning and Design	None
			Project Management	None
	Under GD	5 – Commercial Operations	Customer Accounts	None
			Customer Service	None
	Under GD			Management Services
2nd Project 2022-23	1	1 – Administration	Administrative Services	Procurement and Property Management
				General Services
			Human Resources	Recruitment, Selection and Placement
				Compensation, Benefits and Performance Appraisal
		2 –Finance	Accounting	General Accounting
				Bookkeeping and Cashiering
			Budget and Treasury	Cash Management
	1	3 – Commercial	Customer Accounts	Meter Reading

		Operations		Billing and Collection
			Customer Service	Water Services Processing
				Customer Relations and Marketing
	1	4 – Water Supply Operations	Water Production	Operation and Maintenance
				Water Quality
				Stores Management
			Water Distribution	Network Installation and Maintenance
				Leakage Reduction
			Service Connection	Connections and Disconnections
				Water Meter Repair and Maintenance
		5 – Planning and Development	Planning and Design	None
			Project Management	None
	Under the General Director		Management Services	None

6.2 Human Resources Requirement for Each Phase

The organization should be manned with the right number and quality of human resources, in keeping with the organization structures proposed for each phase. The staff productivity index, a measure of staff productivity and a predictor / indicator of organizational efficiency, was utilized to ensure that the size of the organization is kept to the minimum. The proposed SPI for SRWSA was arrived at by comparing it with other Asian utilities of the same size in each growth phase, and is below the utilities' averages (or below SPI 5 per 1,000 connections) as shown below:

Year	Phase	Production Volume (m^3/day)	Projected Number of Connections	Projected Number of Employees		Staff Productivity Index
				By Phase	Total	
2010	Current Facilities	8,000	4,525	40	40	8.83
2012-13	Bulk Water from KTC	25,000	16,218	38	78	4.80
2017-18	Start of Phase 1	55,000	27,318	63	141	5.16
2022-23	Start of Phase 2	85,000	41,331	42	183	4.42

6.3 Capacity Building Program

To keep pace with the requirements and responsibilities of a growing water utility, capacity building is required for all SRWSA staff in the short and medium term. Thus, training that will be made to cover the entire organization, by department and offices based on unit functions and responsibilities, and by individual employee based on job function and position held. Training methodologies (counterpart coaching, mentoring, on-the-job, seminar-workshop) will be customized to fit the participants' needs and levels to optimize learning.

A multi-discipline team of international consultants will undertake the capacity building program that will run on a staggered basis from 2012 to 2014, for a total of 25 man-months. After an in-depth training needs assessment, eight specialized training courses will be conducted aimed at equipping, upgrading and honing employee knowledge and skills. These will be run for five days to two weeks and funded either through grant or through the SRWSA internal budget, and conducted by the PPWSA Training Center, or by local training institutions with a reputable track record, or by training subject matter experts (SME) or consultants.

6.4 Project (Operation) Implementation System

It is proposed that the Steering Committee earlier organized for the preparatory study be reconstituted to become the *Project Coordinating Committee for the Implementation of the Siem Reap Water Supply Expansion Project*, but with increased membership to include the representative of the ministers of Ministry of Economy and Finance (MOEF) and Ministry of Water Resources and Meteorology (MOWRAM). JICA will no longer be part of the PCC, as it becomes the financing institution of the Project.

Ministry of Industry, Mines and Energy (MIME) will supervise over SRWSA and has wider experience in implementing ODA projects compared to SRWSA, which still has to develop this type of institutional capacity. As the supervising agency, MIME has its own set of responsibilities, which will be detailed in the Loan Agreement.

As the project beneficiary, and ultimately the institution responsible for repaying the loan, SRWSA will be the *project implementer and manager*. For this purpose, it will establish a project management unit (PMU) within its Department of Planning and Technical for the duration of project implementation. It will also be in this department that the project consultants' team (PCT) will be lodged to provide consulting and advisory services for project implementation as specified in the Loan Agreement.

The Project will, therefore, be coordinated, monitored, and managed by three project organizations, as shown:

Project Organization	Level	Membership or Institution / Department	Role in Project Implementation	Responsibility
Project Coordination Committee	Inter-Agency Level	MIME, MOEF, MOWRAM, SRWSA, APSARA, Provincial Government	Over-all **strategic inter-agency coordination** and provision of policy guidelines of Project implementation	General Financial Implementation Legal
Project Monitoring	Ministry Level	MIME *Department of Water Supply*	Over-all responsibility for **monitoring Project implementation** against technical and financial	Monitoring Reporting
Project Management Unit	Institution Level	SRWSA *Department of Planning and Technical*	Directly responsible for **project execution and for undertaking actual field supervision and management** of Project implementation	General Project Implementation Project Closure

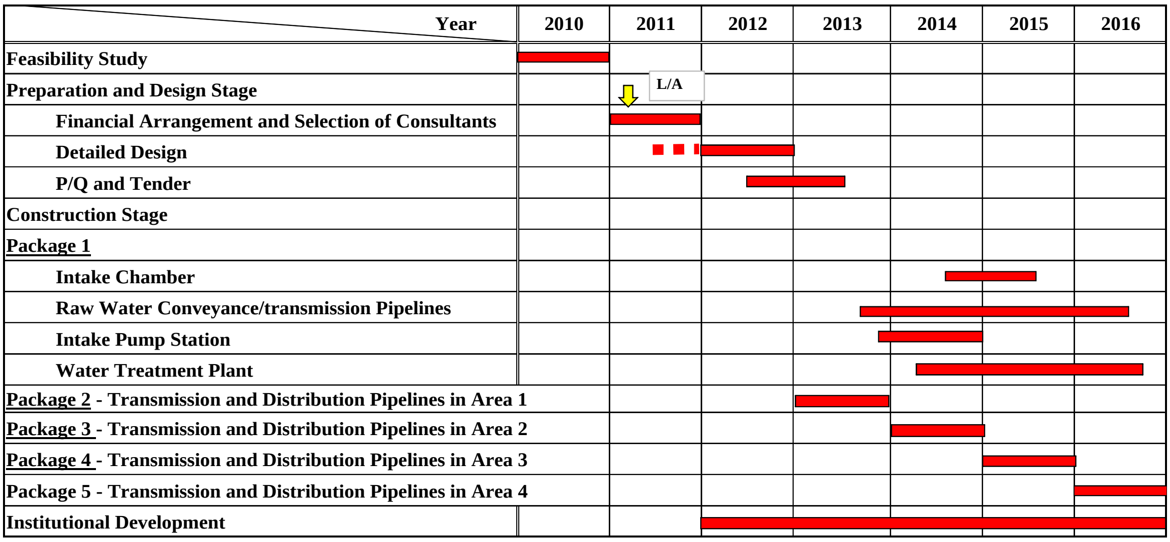
7. Implementation Plan

The construction works for the Priority Project should be carried out by selected contractor/s upon international/local competitive bidding (ICB/LCB) on the following tender package which has been decided taking into account the advantages in technical and economical aspects. The major consideration in packaging was put on the nature of works, the size of contract and to avoid less attractive to the international construction companies

- Package 1 : Construction of Intake Chamber, Raw Water Conveyance Pipeline, Intake Pump Station, and WTP (ICB)
- Package 2 : Construction of Transmission and Distribution Network Area 1 (Q4) (LCB)
- Package 3 : Construction of Transmission and Distribution Network Area 2 (Q3) (LCB)
- Package 4 : Construction of Transmission and Distribution Network Area 3 (Q2) (LCB)
- Package 5 : Construction of Transmission and Distribution Network Area 4 (Q1) (LCB)

The pre-qualification of tenders will be carried out for all the packages to select the qualified construction firms with sufficient capacity in terms of financial, technical and staffing.

The implementation schedule is shown in the following table.



8. Project Cost

A total project cost was estimated approximately US$ 81 million, including direct construction costs for the new water supply systems, engineering services, institutional development, land acquisition, physical contingency, and price contingency.

Priority Project Cost

Item	Cost(1,000US$)				
	FC	TAX(FC)	LC	TAX(LC)	Total
Civil Works	**16,932**	**0**	**23,399**	**2,340**	**42,672**
Intake Chamber	16	0	132	13	162
Water Conveyance Pipe	1,448	0	11,710	1,171	14,328
Intake Pump Station	555	0	739	74	1,368
Water Treatment Plant	2,507		5,627	563	8,697
Elevated Water Tank	228	0	553	55	836
Transmission/Distribution Pipelines	12,178	0	4,638	464	17,280
Mechanical/Electrical Works	**8,148**	**0**	**1,136**	**114**	**9,397**
Intake Pumping Station	2,086	0	259	26	2,371
Water Treatment Plant	6,062	0	877	88	7,027
Direct Construction Cost : (A)	**25,080**	**0**	**24,535**	**2,454**	**52,069**
Physical Contingency (10%) for (A) : (A)'	**2,508**	**0**	**2,454**	**245**	**5,207**
Price Contingency (FC:1.8%, LC;7.9%) for (A)+(A')	**2,215**	**0**	**11,423**	**1,142**	**14,780**
Engineering Services : (B)	**4,200**	**0**	**954**	**96**	**5,250**
Physical Contingency (5%) for (B) : (B')	**210**	**0**	**48**	**5**	**263**
Price Contingency (FC:1.8%, LC;7.9%) for (B)+(B')	**278**	**0**	**304**	**30**	**612**
Institutional Development : (C)	**860**	**0**	**55**	**5**	**920**
Physical Contingency (5%) for (C) : (C')	**43**	**0**	**3**	**0.3**	**46**
Price Contingency (FC:1.8%, LC;7.9%) for (C)+(C')	**68**	**0**	**22**	**2**	**91**
Land Acquisition : (D)	**0**	**0**	**273**	**27**	**300**
Physical Contingency (10%) for (D) : (D')	**0**	**0**	**27**	**3**	**30**
Price Contingency (FC:1.8%, LC;7.9%) for (D)+(D')	**0**	**0**	**24**	**2**	**26**
Social Compensation; (E)	**0**	**0**	**83**	**8**	**91**
Price Contingency (FC:1.8%, LC;7.9%) for (E)	**0**	**0**	**7**	**1**	**7**
Administration Cost (1.5% of the above total)	**0**	**0**	**864**	**86**	**951**
Total Project Cost	**35,461**	**0**	**41,074**	**4,108**	**80,642**

Notes: Project cost is rounded in 100 thousand US$. Price Contingency is based on compound interest.

9. Financial and Economic Aspects of the Project

The evaluation on the financial and economic aspects was accomplished by looking into the following aspects:

a. The past financial performance and condition of SRWSA which provides valuable insights on the financial capacity of SRWSA to provide the requisite financial resources;

b. The required full cost recovery water tariffs that satisfy affordability and acceptability considerations of both households and businesses in Siem Reap.

c. Financial desirability in terms of SRWSA's capacity to sustain the financial requirements of the Project in terms of equity contribution and the debt servicing requirement; and,

d. The economic impact of the project as it involves substantial support from the central government.

Summary of Findings

The evaluation of the past and present financial performance and condition shows the following highlights.

a. Financial status and condition is financially sound, stable and very solvent. It is awash with cash – equivalent to 9 months of its operating budget. Working capital is even more substantial at the equivalent of 11.8 months of its operating budget. Liabilities are practically none existent at only 10% of total assets amounting to a little less than KHR20 million as of year-end 2009. SRWSA's only liabilities are the guarantee deposits of its customers and short-term credits from its suppliers/and service providers. Given this picture of financial condition, the authority can leverage its financial resources to secure long-term debt capital for its expansion needs.

b. Operational and financial performance shows contrasting outcome during the past 3 years. Operational performance indicators relating to NRW and staff productivity show improving efficiency while financial performance on collection, cost control and profitability show declining efficiency.

   i. Last year, NRW went down to 14 percent from 20 percent of total production in 2007.

   ii. Staff productivity has improved from 14 personnel per 1,000 connections in 2007 to 11 personnel per 1,000 connections in 2009.

   iii. Collection performance has gone down as reflected by the increasing amount of unpaid water bills. Last year, total customer accounts receivable has increased not only in terms of amount but also in the equivalent number of days in terms of total water sales. In 2009, customer receivable turn over went up to 40 days, which was only 15 days in 2007.

   iv. Operational ratio, which measures how much of total revenue is eaten up by operating expenses, has gone up to a precarious proportion. From only 75 percent in 2008, this has shot up to 97 percent last year.

v. Obviously, the profitability of SRWSA was affected by the rising cost of operations. Return on revenue or that portion of revenue that is transformed into profit fell down to only 9% from the 20 percent ROR of the previous year.

vi. SRWSA has however recognized the declining profitability of its operation as it implemented an increase in its water tariff starting last November 2009. With the new water tariff, the financial projection shows an improvement in profitability beginning this year.

The existing water tariff schedule of SRWSA is a single unified tariff for all connection categories. It is based on a rising price structure composed of 4 levels, as shown below.

1 – 7 m^3	KHR1,100.00 per m^3
8 – 15 m^3	KHR1,500.00 per m^3
16 – 30 m^3	KHR1,800.00 per m^3
Over 30 m^3	KHR2,000.00 per m^3

Financial evaluation of the of the Priority Project shows that the existing water tariff needs to be adjusted to sustain the growing financial needs of the water utility.

a. Average tariffs per cubic meter that would sustain the financial efficiency of SRWSA are: KHR1,999 per m^3 in 2012, KHR2,541 per m^3 in 2017 and KHR2,624 per m^3 in 2022 onwards.

b. Said tariffs meet affordability and acceptability tests parameters of residents and businesses.

The financial desirability of the Priority project was ascertained on the basis of financial efficiency parameters relating to:

a. Financial Autonomy – SRWSA will not require equity infusion by the RGC during and after project implementation; and

b. Creditworthiness - debt service coverage ratio is more than one throughout the study period.

The economic benefit-cost analysis shows that the project shall be economically beneficial to the local economy with an economic internal rate of return (EIRR) of 37 percent and a benefit-cost ratio of 4.5. The economic benefits considered attributable to water supply projects are consumer surplus, health cost savings and tourism multiplier effects. Economic costs on other hand consisted of the project cost, replacement cost of mechanical /electrical equipment and operating cost.

Conclusion

Based on the above findings, the Priority Project is viable – both financially attractive and economically beneficial.

a. The required water tariffs are affordable and acceptable to both residential users and commercial establishments.

b. The forecast of the operations of SRWSA shows it can sustain the financial requirements for debt servicing of the JICA loan and cost recovery objectives of the central government for SRWSA as an autonomous public enterprise.

vii. Cash position will not be affected during construction. SRWSA shall not require additional capital infusion from the government.

viii. Debt service ratio or the ability to meet maturing loan obligations does not go below 1.0 throughout the study period.

c. The project is economically beneficial with benefit-cost ratio of 4.5 and an economic internal rate of return of 37 percent, which is higher than the 12 percent social cost of capital for infrastructure projects.

Recommendation

Following on the positive findings on the financial and technical aspects of the Project, implementation of the expansion of the water supply system of Siem Reap Province is thereby recommended.

10. Drainage, Sewerage and Sanitation System in the Study Area

10.1 Current Status of Drainage & Wastewater Master Plan for Siem Reap

The following are three major wastewater management plans available for Siem Reap City:

1. Mekong Tourism Development Project Part A1 : Siem Reap Wastewater Management Final Design Report (MTDP SRWM: ADB Loan No. 1969-CAM (SF), April 2006)

   This project was completed in December 2009 and its service area is the city center area located west of Siem Reap River. The major scope of work was the reconstruction of Town Center Drain (TCD), the construction of the interceptor sewer system, the construction of the pumping station, and the installation of force mains and construction of a wastewater treatment plant.

2. Feasibility Study Report on the Siem Reap Sewerage System and Improvement of Siem Reap River in the Kingdom of Cambodia (KOICA, July 2008)

   This project is scheduled to be completed in 2015. The service area covers the city core area surrounding ADB service area. The major scope of work is the installation of a sanitary sewer, the construction of a pumping station, the expansion of ADB pumping station and the expansion of a wastewater treatment plant.

3. Siem Reap Urban Development Project Drainage & Sewerage Master Plan for the District of Siem Reap Priority Works Draft Master Plan (SRDSMP: AFD, December 2009)

   This Draft Master Plan was completed in December 2009. Its proposed service area covers almost the whole urban and peri-urban area of Siem Reap City.

10.2 Potentials in Japanese Grant Aid Assistance

Even if the KOICA project is completed, there will still be a portion of the urban area which will not be served by the sewerage system. This situation is similar to the drainage system. As the remaining area is huge, the results are a higher estimated system development cost and a longer construction period. The majority of remaining area is peri-urban area where centralized system might not always be feasible.

Considering the relevance of the Japanese Grant Assistance, the Study Team proposes a supporting project aimed at maintaining the existing system including septic tanks and sewer network. The following is the proposed scope of work for this project:

- ♦ Provision of Sewer Cleaning Equipment
- ♦ Provision of Septage Collection Vacuum Tanker Truck
- ♦ Construction of Septage Treatment Facility
- ♦ Technical Assistance Project for Capacity Building towards Counterpart Agency

11. Environmental and Social Considerations

The Siem Reap City is surrounded with the World Heritage sites of Angkor and other protected areas where conservation measures of natural resources are imperative. Therefore, these protected areas should be taken into account when implementing the water supply system expansion project.

The provision of safe water for drinking and other domestic uses is a pressing issue for the local people and is an important ingredient to raising their standard of living. The lack of safe and potable water has also its own impact on the tourism sector. Yearly, about two million tourists visit the city and to service the influx of tourists, new hotels have been sprouting and digging wells to supply itself of much needed water. This has resulted in uncontrolled abstraction of groundwater sources and the heritage sites are under threat of land subsidence. Therefore, the expansion of the water supply system is an urgent necessity.

In this Study, the alternatives of water supply from groundwater, west baray, river and Tonle Sap Lake were examined and finally surface water from Tonle Sap Lake was selected as a water source because little impact would be expected on World Heritage of Angkor. From intake in the Tonle Sap Lake to pump station, conveyance pipes go through several protected areas and some impacts cannot be set aside, while the impacts can be minimized by paying attention for adoption of mitigation measures of minimization of construction site in protected areas, and the project, as a sustainable development, will be able to support local people to improve their living and livelihood condition.

12. Evaluations

12.1 Socio-Economic Evaluation

The *Cambodia Millennium Development Goals* (CMDGs) establishes the key underlying coverage targets for the development of water supply sector and, therefore, becomes one of the viable guides in evaluating the project. There are two main quantitative evaluation indicators utilized – water supply coverage[1], and served population[2]. The long-term water supply development plan envisages exceeding the CMDG with respect to urban coverage ratio in the Siem Reap City and its surroundings by a five-year delay in 2020, which will continue to be supplied as at present with SRWSA safe water at a level of 90 percent in 2030. As for water supply to tourists, 80 percent coverage will be achieved in the same year as domestic water supply in 2020 and 100 percent in 2030. In this sense, the long-term water supply development 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 provides a limited quantification of the benefits of executing the Priority Project, 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 overall health of the project beneficiaries, measured by evaluation indicators as the reduction of water diseases' outbreaks and the reduction of infant and maternal mortality associated with water-borne diseases. Improved water supply in the areas also reduces the burden of fetching water that typically falls on women and children, contributing indirectly to greater rural labor force productivity and improved school attendance and educational achievement of children.

Improved water supply from the Central Distribution System (CDS) aids the development of the tourism industry in Siem Reap City, particularly in the tourism-related service businesses such as hotels and restaurants. In this connection, the growing number of hotels and guesthouses in the service area are waiting to be connected to the system. Water supply is also among the critical infrastructure requirements for labor-intensive, light manufacturing industries that the RGC has targeted for promotion in its industrial policy.

Expansion of water supply inevitably results in greater production of wastewater. Preparation and implementation of the Priority Project for drainage and sewerage in the Study Area is urgently necessary, to ensure that the health benefits from improved water supply are not lost on account of

[1] Water supply coverage (%) = [population served] x 100 / [total population in the present service area] is an important evaluation indicator because any water utility is mandated to serve a given and defined service area.

[2] Served population is the production/population (m3/d/c) = [annual production volume (m3) /365] / [number of people served]. It shows the capacity of the present system to supply water to all types of customers in its service area.

deterioration in sanitary and environmental conditions. 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 Tonle Sap Lake, 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.

12.2 Technical Evaluation

By the Priority Project, which includes construction of raw intake facilities, water treatment plant, and clear water transmission/distribution pipelines, a daily total water supply capacity of 56,000 m^3 will be achieved in early 2017. The project will secure the supply capacity to meet the water demand up to the year 2022. The jurisdiction of SRWSA water supply is expanded to 33.6 km^2 in the proposed Priority Project, approximately five times the area compared to 6.9 km^2 of the current water supply covering areas.

Served population will reach 233 thousand or 82 percent as well as 7.8 thousand or 86 percent of tourists of the projected population in 2022 in the long-term water supply development plan in cooperate with the existing water supply systems. Water tank and distribution pipes will be extended and enforced to secure reliable water supply. The number of service connections will reach approximately 41,000 connections, from approximately 4,500 at present.

Safe and clean water meeting the Cambodia Drinking Water Standard will be supplied by the existing and new water treatment plants with proper and affordable treatment processes.

It is noteworthy that the coverage will be achieved with continued efforts to control non-revenue water[3] at the level of 10 percent through 100 percent metering of all service connections[4], 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 to reduce annual operation and maintenance costs[5]. Preservation of raw water quality is another important issue for both drinking water quality control and minimization of production cost.

12.3 Financial Evaluation

Financial soundness is a key element for pursuing and attaining the CMDGs for the water supply sector. With the implementation of the project and the financial support of the MOEF by way of the JICA loan, SRWSA can attain full financial autonomy as envisioned in the National Water

[3] Non revenue water (%) = [total annual production (m3) - total billed consumption (m3)] x 100/[total annual production (m3)]

[4] No. of metered connections (%) = metered connection / unmetered connections

[5] Unit production cost (US$/m3) = [annual O&M cost (US$)] / [total annual production (m3)]

Sector Policy and incorporated in the sub-decree creating SRWSA as an autonomous public enterprise. This can be achieved by having a water tariff[6] that is pro- poor, but balances the need for SRWSA to be financially viable as an institution. Periodic adjustment of water tariffs is, however, a necessary consequence due to increasing cost as well as supporting the repayment of the loan. The required tariffs proposed in this study are found to be affordable to both residential and commercial customers. With the water tariffs adjusted on a regular basis, the financial effectiveness of SRWSA may be sustained.

The implementation of the project widens the customer base, which can boost the revenue potential of SRWSA, thus cost per service connection[7] should be affordable to all types of customers. In addition, collection efficiency[8] of water fees must be sustained at the highest levels possible. The result would be a low operating ratio[9] that will indicate the efficiency of SRWSA as an institution.

12.4 Institutional Evaluation

Institutional development is inherently difficult as this is only achieved over the long-term. One project, therefore, may not immediately achieve the capacity building objectives. However, this priority project provides clear avenues to jumpstart building organizational capacity of the SRWSA, as well as the capacities of its staff. Training undertaken by SRWSA personnel can be measured by the actual number of training hours, or cost of training per employee; however, the "return on training" has always been difficult to quantify and measure. Translating the training investment into impacts will have to go beyond traditional measures.

The staff productivity index[10] is, therefore utilized as one indicator of organizational efficiency. It not only was used in planning the number of SRWSA personnel in each important development phases, where accompanying organization structures are recommended, but also in targeting organizational efficiency when comparing SRWSA with other Asian water utilities of the same size.

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[6] Average tariff (US$/m3) = [total annual billing (US$)] / [total annual consumption (m3)]
[7] Capital expenditure/connection (US$) = [total capital expenditure over the last 5 years (US$) / 5] / [number of utility connections]
[8] Collection efficiency (%) = [total annual collections (US$) / total annual billings (US$)] x 100
[9] Operating ratio = [annual O&M cost (US$)] / [annual revenue (US$)]
[10] Staff/1,000 connections ratio = [number of utility staff] / [number of utility connections/1,000]

13. Conclusion and Recommendations

The Project aims to meet the existing and projected shortfall in water supply with the immediate construction of the Project facilities. Thus, the Project offers not only tangible impacts, but also intangible benefits, such as:

- Improving the quality of life of the people of Siem Reap, particularly those in the service area, by (i) supplying potable water, therefore reducing health problems brought about by unsafe water, and (ii) providing reliable water service, thereby contributing to better productivity of the residents in the service area.
- Stimulating the growth of the local economy with the enhancement / development of the present and future tourism-related businesses and light industries, all of which will rely mainly on safe and adequate water from SRWSA, especially when the extraction of groundwater will be discontinued to protect the Angkor Wat heritage area.
- Contributing to the growth of the national economy by increased tourism arrivals, which will impact on job generation and higher levels of education.
- Supporting the policies set out in the CMDG, particularly in reducing “poverty rates in urban and more accessible rural areas” and improving “urban access to safe water and rural access to improved sanitation”.

It can also be concluded that the proposed Priority Project is viable – both financially sustainable and economically beneficial. The required water tariffs are affordable and acceptable to both residential users and commercial establishments. The forecast of the operations of SRWSA shows it can sustain the financial requirements for debt servicing of the JICA loan and cost recovery objectives of the central government for SRWSA as an autonomous public enterprise. Infusion of additional equity by the RGC of Cambodia is not required during construction of the Project. Average debt service coverage ratio is more than 1.2, which exceeds the minimum requirement of 1.0.

Furthermore, the project is economically beneficial with a benefit-cost ratio that is more than 4 and an economic internal rate of return of not less than 30 percent at all scenarios tested in the economic analysis- the EIRR being higher than the widely accepted 12 percent social cost of capital for infrastructure projects.

Consequently, it would be imperative and urgent for the Project to be implemented with loan assistance from the Government of Japan. It should be realized that in the course of executing the long-term water supply development plan, the following important activities should be prioritized.

13.1 Before the Project Implementation

1) Project organizations

The project organizations, such as *Project Coordinating Committee* (PCC), the *Project Management Unit* should be set up to be ready to discharge their roles and functions according to the requirements of the Project.

In addition, the office of the *Project Consultant Team* should be organized to mark the start of the tendering phase upon completion of detailed design review stage.

2) Land acquisition

Necessary land acquisition for the project sites should be carried out by the project organizations as soon as possible before the Project be implemented.

3) Clearance of the relevant laws and regulations

SRWSA/MIME should facilitate the required clearances needed for the Project implementation in accordance with the relevant laws and regulations in Cambodia.

4) Protection of water sources

Tonle Sap Lake 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.

5) Project monitoring and reporting system

The development of a tri-level (inter-agency level, ministry level, and institution level) project monitoring and evaluation system is essential to maintain efficient work relationships among the project organizations, and to minimize conflicts among project partners.

13.2 During the Project Implementation

6) Manpower hiring schedule and staff review and assessment

The SRWSA institutional development plan follows the timeline of the three physical improvements plans being proposed in this Study and recommends the most optimum organization structure and number of human resources for each phase, as follows: (i) the availability of KTC Bulk Water in 2012-13, (ii) the completion of the facilities under the Priority Project in 2017, and (iii) the completion of the facilities under Phase 2 in 2022. The need is translating this into a manpower-hiring schedule based on actual requirements after a thorough staff review and assessment to ensure proper matching of qualifications with job functions of the present personnel.

7) Orientation and/or Training

Aside from the trainings recommended under the capacity building program, there is a need to provide the following: (i) orientation training to all employees to prepare them for Project implementation; (ii) training on the monitoring and evaluation system, and (iii) training on the disbursement procedures.

8) Proper maintenance and periodic replacement/rehabilitation

New construction or expansion projects can be done using Japan's ODA loan and/or assistance of international donor, 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 including the groundwater and land subsidence monitoring facilities.

9) 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 Cambodia Drinking Water Standards.

10) Regulation over the exploitation of groundwater sources

RGC in cooperate with SRWSA should enact regulatory measures with regard to the control of future groundwater development and imposition of sanctions to continued groundwater extraction in Siem Reap City once the Project is implemented.

11) Water tariff

SRWSA should keep sound financial background so that a consumption-based tariff structure should be retained. The water supply to domestic and commercial users should be expanded based on the proposed long-term water supply development plan. The revenue from tariffs will cover O&M costs, capital development plus debt servicing properly to achieve operational and financial viability.

13.3 After the Project Implementation

12) 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.

13) Improvement of drainage, sewerage, and sanitation in the study area

The proposed "Drainage, Sewerage, and Sanitization Project" should be implemented as scheduled to preserve the public water bodies clean and eventually to connect to prevent the Tonle Sap Lake be in good condition as raw water source of the public water supply systems.

SUMMARY REPORT 1

THE PREPARATORY STUDY ON
THE SIEM REAP WATER SUPPLY EXPANSION PROJECT
IN THE KINGDOM OF CAMBODIA

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ABBREVIATIONS

ADB	:	Asian Development Bank
APSARA	:	Authority for the Protection and Management of Angkor and the Region of Siem Reap
BOD	:	Biological Oxygen Demand
BOT	:	Built, Operation, and Transfer
CDC	:	Council for Development of Cambodia
COD	:	Chemical Oxygen Demand
DI	:	Ductile Iron Pipe
DO	:	Dissolved Oxygen
DOA	:	Siem Reap Provincial Department of Agriculture
DOE	:	Siem Reap Provincial Department of Environment
DOFi	:	Siem Reap Provincial Department of Fisheries
DOFo		Siem Reap Provincial Department of Forest
DPWT	:	Department of Public Works and Transport
DSD	:	Drainage and Sewerage Division
EdC	:	Electricite du Cambodge
EIA	:	Environmental Impact Assessment
F/S	:	Feasibility Study
GDP	:	Gross Domestic Product
GNP	:	Gross National Product
GOJ	:	The Government of Japan
IEE	:	Initial Environmental Examination
JICA	:	Japan International Cooperation Agency
KOICA	:	Korean International Cooperation Agency
KTC	:	Name of a Korean Private Company
MIME	:	Ministry of Industry, Mines and Energy
MOE	:	Ministry of Environment
MOEF	:	Ministry of Economy and Finance
MOAFF	:	Ministry of Agriculture, Forest and Fisheries
MOP	:	Ministry of Planning
MPWT	:	Ministry of Public Works and Transport
MOWRAM	:	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 II	:	Second Five Year Socioeconomic Development Plan 2001-2005
SRWSA	:	Siem reap Water Supply Authority
SS	:	Suspended Solid
SR	:	Supporting Report
TA	:	Technical Assistance
TSBA	:	Tonle Sap Basin Authority
TSBR	:	Tonle Sap Biosphere Reserve
UNDP	:	United Nations Development Program
US$	:	United States Dollar
WB	:	World Bank
WTP	:	Water Treatment Plant

Chapter 1.
Background of the Project

Chapter 1. Background of the Project

1-1 Authorization

The Study on the Preparatory Study on the Siem Reap Water Supply Expansion Project in the Kingdom of Cambodia is in pursuance of the Scope of Work, signed on 29th January 2009, between the Ministry of Industry, Mines and Energy (MIME), the Siem Reap Water Supply Authority (SRWSA), and Japan International Cooperation Agency (JICA). JICA has organized a study team ("the Study Team") consisting of NJS Consultants Co., Ltd in association with Kokusai Kogyou Co., Ltd.

The Study started in May 2009, and completed in December 2010. During the approximately 20-month period, the Study Team has undertaken the study in close cooperation with the MIME and SRWSA counterpart officials.

This Final Report 1 compiles the results of the activities implemented during the period from May 2009 to December 2010, based on an agreement for the scope of works for Feasibility Study confirmed in the Steering Committee held on 27 May 2010.

1-2 Background

The city of Siem Reap, the object area of this Study, with a population of over 200 thousand in 2009 is situated approximately five kilometers south of the Angkor World Heritage Site and about two million tourists visit the city yearly. The existing water treatment facility which was constructed under Japanese grant aid in 2006 has a nominal design capacity of 8,000m^3/d. This water supply capacity is too small compared with 43,200m^3/day which is the water demand in 2015 projected by SRWSA. In addition, Siem Reap is under threat of land subsidence which is a social problem, caused largely by the many hotels operating around the heritage site coupled with a sharp increase in tourism related industries which has resulted in uncontrolled abstraction of groundwater sources in the area.

As a result of the circumstances mentioned above, JICA conducted the pre-preparatory study in January 2009 and the Minutes of Meeting (MM) was signed in cooperation with the Cambodian authorities regarding the necessity of expanding the water supply system, as well as and a Feasibility Study (F/S) whose scope included groundwater management, and other related matters.

In fulfillment of this agreement, JICA decided to conduct this Study for the expansion of the water supply system in Siem Reap City.

1-3 Objectives of the Study

The objectives of the Study are:

1) To select new water source(s) for an efficient and sustainable water supply system in Siem Reap;
2) To conduct surveys of existing wells and assess the potential yield of groundwater;
3) To identify an urgent water supply expansion project to satisfy the estimated water demand for Siem Reap up to a selected target year of the Project;
4) To conduct a feasibility study for the proposed water supply expansion project, provided that the Project is to be implemented under a finance by the Japan's ODA loan;
5) To formulate a long-term water supply development plan up to year 2030; and
6) To pursue technology transfer to the Cambodian counterpart during the course of the Study.

1-4 Study Area

The Study Area covers all the communes of the newly established Siem Reap City and one adjacent commune of the City, a total of 14 communes as shown in the map of the Study Area.

1-5 Target Year

The target year for Feasibility Study (F/S) in this study is set at year 2022 taking into consideration of the projected water demand and the proposed water supply development plan which targets year 2030 as agreed between the JICA mission for the preparatory study and Cambodian side in January 2009.

1-6 Study Organization

The Study has been conducted in three phases, as described below, several reports were prepared during each phase in the course of the Study.

Phase 2 was conducted based on an agreement on a result of Phase 1 which was confirmed in a steering committee held on 9th December 2009. Phase 3 has been conducted in parallel to Phase 1 and Phase 2 activities.

- **Phase 1** — **Alternative study on water sources and intake methods.**
- **Phase 2** — **Preparation of facility development plans and the Feasibility Study**
- Phase 3 — Study on groundwater uses conditions

1-7 Contents of the Final Report 1

This Final Report 1 deals with the result of the study for Phase 1 and Phase 2.

1-8 Study Team Organization

It has been the basic understanding between JICA and MIME/SRWSA that the Study should be undertaken with close coordination between both parties. SRWSA has created a Counterpart Team soon after the commencement of the Study in Cambodia. Since then, vital assistance has been provided to the Study Team by all the departments of SRWSA related to the Study.

The Study Team consists of the following 15 members:

JICA Study Team:

	Position	Name
1.	Team leader/Water supply plan	Yoshihiko **SATO**
2.	Water source for water supply	Hiroshi **OKADA**
3.	Hydro-geology 1	**LEI** Peifeng
4.	Hydro-geology 2	Naoki **YASUDA**
5.	Drilling	Roland A. **GROSPE**
6.	Groundwater analyses	Kenji **TAKAYANAGI**
7.	Design of Intake facility	Nobuki **ABE**
8.	Design of water treatment plant	Kentaro **SATO**
9.	Design of Pipelines	Atsushi **KANAYA**
10.	Design of mechanical facilities	Yasuaki **KONDA**
11.	Sewerage/drainage planning	Takashi **WATANEBE**
12.	Construction plan and cost estimate	Satoshi **YAMAMOTO**
13.	Institutional study and O & M management	Consuelo B. **ESTEPA**
14.	Economic and financial analyses	George M. **CALDERON**
15.	Environmental and social considerations	Shinya **KAWADA**

SRWSA Counterpart Team:

	Position	Name
1.	General Director/Water Supply Planning	Mr. Som **KUNTHEA**
2.	Deputy General Director/Water Supply Facilities	Mr. Cheav **CHANNY**
3.	Deputy general Director/Financing	Mr. Chan **SENGLA**
4.	Department Manager/Administration and Finance	Mr. Yay **MONIRATH**
5.	Department Manager/Production and Water Supply	Mr. Kong **SOKVAN**
6.	Production chief/Water treatment &pipelines	Mr. Kot **NIMOL**
7.	Laboratory staff/Water quality	Mr. **MONOROM**

Chapter 2.
Project Framework

Chapter 2. Project Framework

2-1 Planning Framework

The basic principle for the expansion of the water supply scheme of the study areas was finalized taking into consideration the projected water demand in the priority supply areas in five year intervals up to the target year. The basic design policy includes the following:

1) Set up of the service areas

Based on the priority analysis of the service areas in consultation with SRWSA counterparts, the service areas to be extended in addition to the existing service areas are finally established. The high-priority regions for water supply are studied taking into consideration city planning for the future preservation of the water environment, needs of residents/business and the efficiency of service improvement.

2) Population served

The total service population is computed according to the finalized service areas and their population projections. Number of tourists visiting to the study areas is analyzed based on the past trend and future economic growth expectation in the Study Area.

3) Unit consumption rate

The unit consumption rates are determined based on analyses on realistic water consumption analyses in order to aim at improving the water supply service level in comparison with the existing and planned water supply capability in the service areas.

4) Supply coverage

Water supply coverage is determined using the comparison study between the supply capability and the goals established in the Cambodia Millennium Development Goals.

5) Service level

As to the existing service areas, the improvement of the water supply service, such as increasing the water supply pressure, is considered. As to the non-supplied areas, a piped water supply system is planned targeting to cover the greatest number of people as possible at its earliest stage in consideration of the respective areas' social and economic importance as well as the investment efficiencies therein.

6) Projection of water demand

On the basis of the determined population served including tourists and unit consumption rate by categories of users (domestic and commercial), the proposed water demands in the priority areas are computed up to the target year.

2-2 Proposed Service Areas

Only the part of the central communes including Sla Kram, Svay Dangkum, Sala Kamraeuk, Kouk Chak, and Srangae communes are supplied by the SRWSA water supply system; while the rest of the commune is yet to be served by SRWSA.

The service area covers the central urbanized areas and its peri-urban areas in the SRWSA jurisdiction area. The service area of the SRWSA is thus comprised of the thirteen communes as shown in Table 2.1. Chong Khnies of the Siem Reap City and fringe areas of the peri-urban areas will be excluded from the proposed service areas as illustrated in Figure 2.1.

Table 2.1 Proposed Service Areas

Item	Communes	Item	Communes
1	Sla Kram	8	Krabei Riel
2	Svay Dangkum	9	Ampil
3	Sala Kamraeuk*	10	Nokor Thum
4	Kouk Chak	11	Srangae
5	Siem Reap	12	Sambuor
6	Tuek Vil	13	Kandaek
7	Chreav		

Notes: 1) All communes are in Siem Reap City, except for Kandaek commune which belongs to Prasat Bakong District.
2) All area of Sala Kamraeuk* commune is included in the proposed service area, however, the other communes are partly covered by the SRWSA water supply systems
3) Chong Khnies will be excluded from the proposed service areas due to its location.

2-3 Population Projection

The population projection for Siem Reap Province is extracted as shown in Table 2.2. The recorded population data in 2008 shows 896,443 population and the present population is estimated to be approximately 1.3 million.

Table 2.2 Population Projection 1998-2020, Siem Reap Province

Year	2000	2005	2010	2015	2020
Projected population	767,768	861,214	970,666	1,094,897	1,229,432
Growth rate	2.4%	2.5%	2.6%	2.5%	N/A

Note: Population projections for Cambodia 1998-2020, NIS, MOP

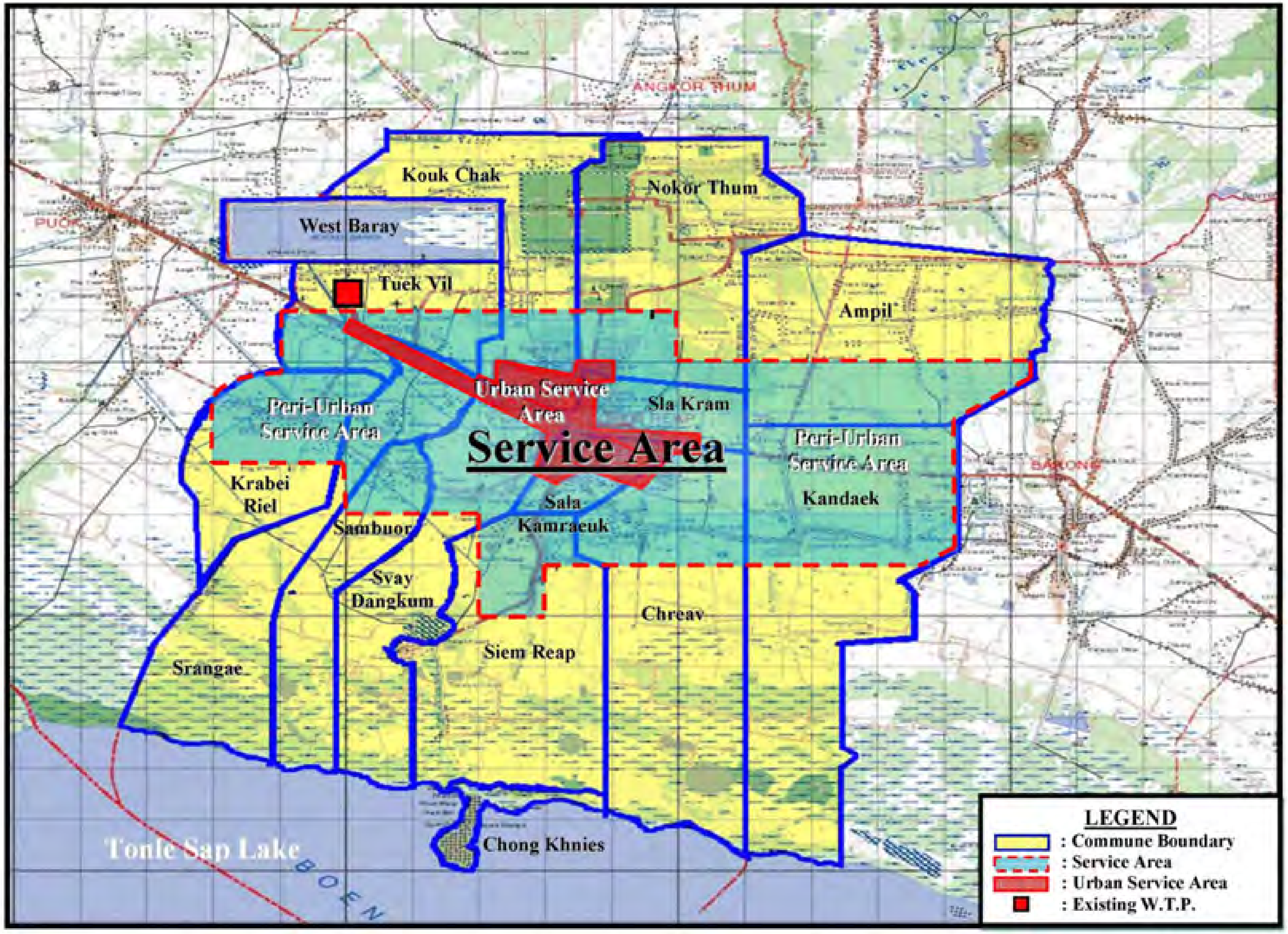


Figure 2.1 Proposed Service Areas

Table 2.3 presents the recorded data from 2003 through 2009 of 13 communes of Siem Reap City plus one adjacent commune Kandaek commune in Prasat Bakong District in the Study Area. The data shows the population increase trend of the City is quite different from that of the province. The population growth rate varies from 2.8 percent to 7.8 percent dependent on status of each commune, which is much higher than 2.4 to 2.5 percent of the Provincial growth rate. For example, the populations in Sla Kram commune and Svay Dangkum commune have increased over 14 thousand and 10 thousand or 7.7 percent and 6.5 percent of annual average growth rate, in the last six years. A total of 53,000 populations and an average of 4.9 percent in the Study Area have increased from 2003 through 2009. This trend shows a typical population increase in urban areas in Cambodia. The population increase is caused by migration into Siem Reap City due to that sharp increase of economic activities through tourism industries would be taken place in the Study Area.

Table 2.3 Recorded Population in the Study Area, 2003 to 2009

No.	Commune/Year	2003	2004	2005	2006	2007	2008	2009	2003-2009
1	Sla Kram	26,079	26,550	27,910	31,130	33,824	38,475	40,473	14,394
2	Svay Dangkum	24,493	27,333	26,267	26,985	27,630	34,778	34,878	10,385
3	Sala Kamraeuk	14,960	15,655	17,319	17,781	18,293	20,435	21,600	6,640
4	Kouk Chak	16,228	16,523	18,068	18,230	18,578	19,214	19,367	3,139
5	Siem Reap	14,374	14,654	14,820	16,756	17,018	17,296	17,564	3,190
6	Tuek Vil	7,568	7,854	8,285	8,629	8,934	9,514	9,890	2,322
7	Chreav	7,402	7,607	7,790	7,907	9,407	9,164	9,492	2,090
8	Krabei Riel	6,464	7,152	6,919	6,958	7,357	7,464	7,604	1,140
9	Chong Khnies	4,678	5,812	6,057	6,210	5,857	6,167	6,866	2,188
10	Ampil	5,705	5,946	6,065	6,055	6,062	6,412	6,788	1,083
11	Nokor Thum	4,259	4,612	5,332	5,752	6,072	6,279	6,644	2,385
12	Srangae	4,822	5,109	5,165	5,391	6,405	6,153	6,430	1,608
13	Sambour	2,796	2,965	3,160	3,316	3,295	3,487	3,553	757
14	Kandaek	10,142	10,674	11,027	11,472	11,468	11,960	12,334	2,192
Total		**149,970**	**158,446**	**164,184**	**172,572**	**180,200**	**196,798**	**203,483**	**53,515**

Source : Department of Planning Siem Reap Province.

Table 2.4 Recorded Population Growth Rate of Communes in the Study Area, 2003 to 2009

No.	Commune/Year	2003	2004	2005	2006	2007	2008	2009-2003 Ave
1	Sla Kram	1.8%	5.1%	11.5%	8.7%	13.8%	5.2%	7.7%
2	Svay Dangkum	11.6%	-3.9%	2.7%	2.4%	25.9%	0.3%	6.5%
3	Sala Kamraeuk	4.6%	10.6%	2.7%	2.9%	11.7%	5.7%	6.4%
4	Kouk Chak	1.8%	9.4%	0.9%	1.9%	3.4%	0.3%	3.0%
5	Siem Reap	1.9%	1.1%	13.1%	1.6%	1.6%	1.5%	3.5%
6	Tuek Vil	3.8%	5.5%	4.2%	3.5%	6.5%	4.0%	4.6%
7	Chreav	2.8%	2.4%	1.5%	19.0%	-2.6%	3.6%	4.4%
8	Krabei Riel	10.6%	-3.3%	0.6%	5.7%	1.5%	1.9%	2.8%
9	Chong Khnies	24.2%	4.2%	2.5%	-5.7%	5.3%	11.3%	7.0%
10	Ampil	4.2%	2.0%	-0.2%	0.1%	5.8%	5.9%	3.0%
11	Nokor Thum	8.3%	15.6%	7.9%	5.6%	3.4%	5.8%	7.8%
12	Srangae	6.0%	1.1%	4.4%	18.8%	-3.9%	4.5%	5.1%
13	Sambour	6.0%	6.6%	4.9%	-0.6%	5.8%	1.9%	4.1%
14	Kandaek	5.2%	3.3%	4.0%	0.0%	4.3%	3.1%	3.3%
Total		**5.7%**	**3.6%**	**5.1%**	**4.4%**	**9.2%**	**3.4%**	**4.9%**

Source : Department of Planning Siem Reap Province.

Projected figures show an estimated total population of 256 thousand in 2015, of 303 thousand in 2020, of 350 thousand in 2025, and of 399 thousand in 2030, respectively for the whole Study Area. The population of the Study Area will grow at the rate of 3.01 percent to 3.89 percent (2010-2014), 3.76 percent to 3.32 percent (2015-2019), 3.23 percent to 2.89 percent (2020-2024), and 2.82 percent to 2.56 percent (2025-2029) as summarized in Table 2.5. By the long term development plan target year of 2030, the population in the whole study area is projected to be 399 thousand or 1.90 times of the current population level. Total increase of population will be 189 thousand.

Table 2.5 Projected Populations and Growth Rate in the Study Area, 2010-2030

Year	2009	2010	2015	2020	2025	2030
Projected Population	203*	210	256	303	350	399
Growth rate	N/A	3.01% to 3.89%	3.76% to 3.32%	3.23% to 2.89%	2.82% to 2.56%	2.50%

Note: Population is shown in thousand. * data in 2009 is of Department of Planning, Siem Reap province

As same manner as the population projection in the whole Study Area, population projection in the proposed service areas was made by reducing the whole population of Chong Khnies Commune and those fringe areas' population as resided out of the proposed service areas from the projected population in the whole Study Area.

Table 2.6 Projected Populations and Growth Rate in the Proposed Service Areas, 2010-2030

Year	2010	2015	2020	2025	2030
Projected Population	178	221	265	312	359
Growth rate	3.72% to 4.24%	4.11% to 3.65%	3.55% to 3.19%	3.10% to 2.82%	2.71%

Note: Population is shown in thousand.

Projected figures show an estimated total population of 221 thousand in 2015, of 265 thousand in 2020, of 312 thousand in 2025, and of 359 thousand in 2030, respectively for the proposed service areas. The population of the proposed service areas will grow at the rate of 3.72 percent to 4.24 percent (2010-2014), 4.11 percent to 3.65 percent (2015-2019), 3.55 percent to 3.19 percent (2020-2024), and 3.10 percent to 2.82 percent (2025-2029) as summarized in Table 2.5. By the long term development plan target year of 2030, the population in the proposed service areas is projected to be 359 thousand or 2.02 times of the current population level. Total increase of population will be 181 thousand.

2-4 Tourist Projection

In 2008, there were approximately 1.20 million of local tourists and 1.05 million of international tourists, a total of 2.25 million of tourists. Local tourists were increased more than double compared to the previous years in 2003 and 2005 dependent on the local economic growth. The growth rate of international tourists keeps relatively stable between 20 to 40 percent except for in 2002 and 2007 as summarized in Table 2.7.

Table 2.7 Yearly Tourist Arrival to Siem Reap Province, 2002 - 2008

Year	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Local	93,942	109,186	384,201	209,524	782,895	892,226	1,195,264
Growth rate	16.2%	251.9%	-45.5%	273.7%	14.0%	34.0%	N/A
International	453,148	402,780	560,947	692,004	856,157	1,120,586	1,059,870
Growth rate	-11.1%	39.3%	23.4%	23.7%	30.9%	-5.4%	N/A
Total	547,090	511,966	945,148	901,528	1,639,052	2,012,812	2,255,134
Growth rate	-6.4%	84.6%	-4.6%	81.8%	22.8%	12.0%	N/A

Source: Tourism Statistics, Ministry of Tourism Annual Report

In the tourist projection, the following assumptions are made:

⇒ Based on the past experience in Siem Reap and from other countries, tourist growth will be modeled according to three scenarios, low, medium and high, applying respective annual constant growth rates of 2%, 3%, and 4%;

⇒ Tourist arrivals in 2009 will be the same as recorded in 2008.

Projected figures in scenario 1 show an estimated total tourist of 2.8 million in 2020 and of approximately 3.4 million in 2030 or 1.51 times of that of year 2008. Scenario 2 shows in between 2015 and 2020 tourists' arrivals to Siem Reap will be of 3 million and reach at 4 million in between 2025 and 2030. The projected tourist in 2030 in scenario 2 will be 1.86 times of that of 2008. Scenario 3 indicates that tourists will exceed by 3 million after 2015 and 4 million after 2020 and reach at 5 million before 2030. Under scenario 3, the projected tourist in 2030 will be more than double of 2008.

Average length of stay in Cambodia increases more than one day from 5.2 in 1998 to 6.65 in 2008 according to the Tourism Statistics, Annual Report 2008. 49.87 percent visitors visited Siem Reap and 50.1 percent visited Phnom Penh and the rest visited other destinations. Particularly for international visitors to Siem Reap, group tour spent a 3.62 day, individual tour spent 3.98 day, and an average length of stay in Siem Reap is 3.76 days.

Table 2.8 Projected Tourists 2010-2030

Year	**2010**	**2015**	**2020**	**2025**	**2030**
Scenario 1	**2 % growth**				
Projected tourists	2,282	2,520	2,782	3,072	3,391
Rate for 2008*	1.02	1.12	1.24	1.37	1.51
Scenario 2	**3 % growth**				
Projected tourists	2,323	2,693	3,122	3,619	4,196
Rate for 2008	1.03	1.19	1.38	1.60	1.86
Scenario 3	**4 % growth**				
Projected tourists	2,327	2,831	3,445	4,191	5,099
Rate for 2008	1.04	1.26	1.53	1.87	2.27

Note: 1) Unit in thousand.
2) Rate for 2008 means that the rate between the projected figures and actual record of 2,255,134 in 2008.

In preparation of water demand projection, an average length of stay for both local and international visitors is accounted to be 3.5 days which should allow enough room for future increase of tourists' water demand.

Water use by other commercial industries is very small in scale compared to the tourism industries in Siem Reap. Small businesses other than tourism industries then should be accounted as a part of domestic water use. According to the surveys on hotel water use conducted by the Study Team suggested that the hotel water use amount includes not only for tourists' consumption but also miscellaneous water consumption by the hotel employees. The miscellaneous hotel employees' water consumption should be accounted as domestic water use to avoid overestimate in the water demand projection. The details will be discussed in the following chapter.

The existing capacity of accommodations available in Siem Reap is summarized in the following table. The data shows main accommodations are situated along with the national road No. 6 and its surrounding communes.

Table 2.9 Existing Hotels and Guesthouses and Their Capacity in Siem Reap City (Dec. 2008)

No.	Commune	Nos. of Hotels	Capacity of Hotels (beds)	Nos. of Guest Houses	Capacity of Guest of House (beds)	Total of Hotels and Guest Houses	Total Cap. (beds)
1	Sla Kram	32	2,909	47	998	79	3,907
2	Svay Dangkum	58	8,859	111	2,327	169	11,186
3	Sala Kamraeuk	17	1,140	41	787	58	1,927
4	Kouk Chak	1	378	4	75	5	453
5	Siem Reap	0	0	1	16	1	16
6	Tuek Vil	0	0	0	0	0	0
7	Chreav	0	0	3	99	3	99
8	Krabei Riel	0	0	0	0	0	0
9	Chong Khnies	0	0	0	0	0	0
10	Ampil	0	0	0	0	0	0
11	Nokor Thum	5	1,414	1	13	6	1,427
12	Srangae	0	0	0	0	0	0
13	Sambour	0	0	0	0	0	0
14	Kandaek	0	0	0	0	0	0
Total		**113**	**14,700**	**208**	**4,315**	**321**	**19,015**

Source : Ministry of Tourism, Siem Reap Tourism Department.

2-5 Proposed Supply Coverage

2-5-1 Present Supply Coverage and Unit Consumption Rate

The Study Team referred results of a social survey for residents in the service areas of SRWSA conducted by the Study Team. The result summarized in Table 2.10 shows that unit consumption rates are 52 lpcd for low income level, 92 lpcd for middle income level, and 150 lpcd for high income level, respectively. An average number of populations for one house connection are computed to be 7.3, much higher than 5.7 of an average size of household.

Table 2.10 Social Survey Result on Unit Water Consumption Rate in Service Areas

Income Class	Surveyed connections (a)	Total pops. used the connections (b)	Served pops. per connection (b/a)	Total water consumption (m^3) (c)	**Unit consumption rate (lpcd:c/b))**
Low	27	127	4.7	6.5	52
Middle	38	224	5.9	20.5	92
High	35	383	10.9	57.3	150
Average	100	734	7.3	84.3	115

Note: lpcd indicates litter per capita per day.

In applying the estimated unit consumption rate of middle income level of 92 lpcd, say 100 lpcd, service population is roughly estimated to be 48,900 (= 4,890 m^3/d/100 lpcd) or 24 percent of the total population of 203 thousand. Hotel water use survey conducted by the Study Team suggested that the current water consumption rate for tourists including hotel employees are 418 to 435 lpcd dependent on seasons, say 430 lpcd, tourists' served is roughly estimated to be 1,860 tourists (=2,800 m^3/d/430 lpcd /3.5) or approximately 30 percent of the recorded tourists arrivals in Siem Reap, assuming that all the commercial water use of 2,800 m^3/d were consumed by the tourists.

2-5-2 Planned Supply Coverage

The Millennium Development Goals (MDGs), unanimously adopted by the UN General Assembly in 2000, have been localized with specific targets for Cambodia. The RGC has adopted and localized the MDGs into the Cambodia MDGs (CMDGs). MDG Seven aims to reverse the loss of environmental resources, maintain forest coverage, promote access to safe drinking water and secure land tenure. Table 2.11 shows the quantitative benchmarks and targets for the relevant CMDG7 indicators.

Table 2.11 CMDGs Indicators, Benchmarks and Targets

Indicators	Benchmarks		**Targets**		
	Value	Year	2005	2010	**2015**
7.11: Proportion of urban population with access to **safe water source**	60%	1998	68%	74%	**80%**

Source: Cambodia Millennium Development Goals Report 2003

SRWSA prepared its business plan toward 2015 which follows the CMDGs in its policy and strategy with revisions in the coverage and served population in reflection to their estimated population data.

Table 2.12 SRWSA Plan and Present Supply Coverage

Descriptions	Target Year	Rate	Served Population[1)]
Supply Coverage in 2009	N/A	24 %[1)]	Estimated 48,900
SRWSA	2015	90 %	N/A

Notes : Estimated by a social survey result conducted by the Study Team.

However, there are still so many constraints in the SRWSA plan to fulfill the target in the year 2015. For example, considerable delay in the provision of distribution pipelines, water source and water treatment plant augmentation, as well as a relative high NRW level, in addition to other institutional, managerial, and financial constraints.

2-5-3 Proposed Supply Coverage

The supply coverage in year 2015, which is the SRWSA' target year, is proposed to be 55 percent, taking into realistic development progress from the based year 2010 which is estimated at 30 percent taking into the current situation of SRWSA's supply coverage.

Table 2.13 Proposed Supply Coverage

Year	2009	2010	2015	2020	2025	2030
Resident	24%*	30 %	55 %	80 %	85 %	90 %
Tourist	30%*	30 %	55 %	80 %	95 %	100 %

Notes: *The supply coverage in 2009 was estimated based on the social survey results conducted by the Study Team

2-6 Population/Tourists Served

2-6-1 Population Served

A population projection is made as the basis for estimating future water demand in the service area as summarized in Table 2.6. Applying the proposed coverage and the projected population, population served is summarized in Table 2.14.

Table 2.14 Population Served

Year	2010	2015	2020	2025	2030
Projected Population* (a)	178	221	265	312	359
Coverage (%) (b)	30 %	55 %	80 %	85 %	90 %
Population Served* (a x b)	54	122	212	265	323

Note: Unit is x 1000.

2-6-2 Tourists Served

A tourist projection is made as the basis for estimating future water demand in the service area as summarized in Table 2.7. Applying the proposed coverage and the projected tourists' arrivals, tourist served is shown in Table 2.15.

Table 2.15 Tourists Served

Year	2010	2015	2020	2025	2030
Coverage	30 %	55 %	80 %	95 %	100 %
Scenario 1 (2% growth)					
Projected Yearly Tourists (a)	2,282	2,520	2,782	3,072	3,391
Projected Daily Tourists (a/365)	6.3	6.9	7.7	8.5	9.3
Daily Tourists Served (a x b)	1.9	3.8	6.1	8.0	9.3
Scenario 2 (3% growth)					
Projected Yearly Tourists (a)	2,323	2,693	3,122	3,619	4,196
Projected Daily Tourists (a/365)	6.4	7.4	8.6	10.0	11.5
Daily Tourists Served (a x b)	1.9	4.1	6.9	9.5	11.5
Scenario 3 (4% growth)					
Projected Yearly Tourists (a)	2,327	2,831	3,445	4,191	5,099
Projected Daily Tourists (a/365)	6.4	7.8	9.5	11.5	14.0
Daily Tourists Served (a x b)	2.0	4.3	7.6	11.0	14.0

Note: Unit in x 1000.

Chapter 3.
Water Demand Projection and Proposed Long-Term Water Supply Development Scheme

Chapter 3. Water Demand Projection and Proposed Long-Term Water Supply Development Scheme

3-1 General

Water demand projection serves as the fundamental basis for selection of raw water source and preparing the long-term water supply development plan, targeting year 2030. The projection is largely dependent on the past trend which forecasts the future from past experience. However, the existing water supply systems with a nominal design capacity of 8,000 m^3/d has been just operated since April 2006 and the water demand projection is based on the actual water use trends recorded by SRWSA and is adjusted using those data given by a social survey work conducted by the Study Team. The social survey were conducted to find out i) actual amount of low medium, and high water consumptions in the service areas and non service areas, ii) peoples' willingness to connect to the proposed water supply systems in non service areas, and iii) actual water consumption and affordable water rates.

Classification by use is categorized into domestic and commercial in preparation of the water demand projection. Administrative water use, which is only 2.9 percent of the domestic water use as recorded in 2008, as well as small business sector are assumed to be a part of the domestic water use. Other water use such as industrial water use is minimal in the study areas so that commercial water use is regarded to include all the remaining water use, except for the domestic water use.

In addition to this classification, the estimated NRW will be summed up for the total water demand. Peak factor will be applied to an average water demand to secure the maximum water demand projection.

3-2 Unit Consumption Rate of Domestic Water Use

Water use in the present water supply study areas is estimated to be an average of 115 lpcd through a field survey results conducted by the Study Team as referred to **SR 3.1(Supporting Report 3.1).**

While in non service areas, according to the social survey, water use in dry season is slightly higher than that of in rainy season due to that people consume their well water for gardening and raising domestic animals in addition to the general water use purposes such as cooking, washing, bathing, and drinking. The survey results shows that water use trend in non service areas is generally same level as the service areas.

It is noted that high income level in both service and non service areas uses almost 150 lpcd, while the low income level in the service areas, consuming only 52 lpcd compared to 99 to 108 lpcd of that of non service areas, is considered to save their water expenses due to their economic reasons.

Table 3.1 Estimated Unit Consumption Rate of Residents in Non Service Areas

Income level	Low	Medium	High
Dry season			
Ave. water use	108	120	146
Rainy season			
Ave. water use	89	92	117

Note: Unit in litter per capita per day

In the unit consumption rate projection, the following assumptions are made:

⇒ Baseline for the unit consumption rate in 2010 will be set at 110 lpcd to prevent overestimation. The 110 lpcd of unit consumption rate will be regarded to include the administrative water use in the water demand projection.

⇒ Based on past experience in Siem Reap and from other countries, growth in per capita consumption will be modeled according to three scenarios, low, medium and high, applying respective annual growth rates of 1lpcd, 2 lpcd, and 3 lpcd, respectively.

Based on the estimated unit consumption level of 110 lpcd in 2010, unit consumption in the target year 2030 is computed at three consumption levels; namely 130, 150, and 170 lpcd in accordance with the applied constant annual growth rate of 1lpcd, 2 lpcd, or 3 lpcd as shown in Table 3.2.

Table 3.2 Applied Scenarios for Domestic Unit Consumption Rate 2010-2030

2010	**2015**	**2020**	**2025**	**2030**
Scenario 1 : 1 lpcd growth per year				
110	115	120	125	130
Scenario 2 : 2 lpcd growth per year				
110	**120**	**130**	**140**	**150**
Scenario 3 : 3 lpcd growth per year				
110	125	140	155	170

3-3 Domestic Water Demand Projection

Total domestic water demand in average was obtained for each scenario as shown in Table 3.3.

Table 3.3 Average Daily Domestic Water Demand (m^3/d)

Year	**2010**	**2015**	**2020**	**2025**	**2030**
Projected population*	178	221	265	312	359
Population Served*	54	122	212	265	323
Proposed coverage	30 %	55 %	80 %	85 %	90 %
Scenario 1	5,900	14,000	25,400	33,000	42,000
Unit consumption rate	110	115	120	125	130
Scenario 2	5,900	14,600	27,500	37,100	48,400
Unit consumption rate	110	120	130	140	150
Scenario 3	5,900	15,200	29,700	41,000	54,800
Unit consumption rate	110	125	140	155	170

Note: Figures are rounded in x 1000, based on population projection.

3-4 Unit Consumption Rate of Commercial Water Use

The amount of water consumed daily per tourist was estimated to be an average of 276 lpcd. Each data obtained is summarized in Table 3.4. The estimation is conducted based on the discharge data from shower heads and faucets that are fully open and thus the results are a conservative estimation in terms of water demand.

Table 3.4 Surveyed Data on Average Water Use by Tourist

Descriptions	Shower	Bath	Toilet	Wash basin	Remarks
Duration (min)	8.05	N/A	N/A	0.25	duration of water flowing
Times per day	2.13	0.26	3.76	7.76	4 times use of basin plus at time of rest room use
Discharge (l/s)	0.17	NA	10	0.14	measured with faucet fully open standard toilet tank assumed
Tub volume (l)	NA	181.3	NA	NA	measured
Total daily use (l)	**174.9**	**47.1**	**37.6**	**16.3**	**= 276 lpcd**

Thus, in the unit consumption rate projection, the following assumptions are made:

⇒ Baseline for the unit consumption rate of tourist in 2010 will be set at 300 lpcd which includes 10 percent allowances for unforeseen situation in the future to the surveyed average unit consumption rate as the preliminary water demand projection;

⇒ As same manner as the domestic water use, growth in per capita consumption are modeled according to three scenarios, low, medium and high, applying respective annual growth rates of 1lpcd, 2 lpcd, and 3 lpcd towards 320 lpcd, 340 lpcd, and 360 lpcd, respectively; and

⇒ The increasing scenarios are set provided that miscellaneous water use such as gardening, car washing, and laundry services at hotel bussiness in the hotel zone grows towards target year 2030.

Table 3.5 Applied Scenarios for Unit Consumption Rate of Tourist, 2010-2030

2010	2015	2020	2025	2030
Scenario 1 : 1 lpcd growth per year				
300	305	310	315	320
Scenario 2 : 2 lpcd growth per year				
300	**310**	**320**	**330**	**340**
Scenario 3 : 3 lpcd growth per year				
300	315	330	345	360

3-5 Commercial Water Demand Projection

Total commercial water demand in average was obtained for each scenario as shown in Table 3.6.

Table 3.6 Average Daily Commercial Water Demand (m^3/d)

Year	2010	2015	2020	2025	2030
Proposed coverage	**30 %**	**55 %**	**80 %**	**95 %**	**100 %**
Scenario 1 (m^3/d)	2,000	4,000	6,700	8,900	10,400
Projected yearly tourists (x 1000)	2,282	2,520	2,782	3,072	3,391
Projected daily tourists (x 1000)	6.3	7.0	7.7	8.5	9.3
Daily tourist served (x 1000)	1.88	3.80	6.10	8.00	9.29
Unit consumption rate (lpcd)	300	305	310	315	320
Scenario 2 (m^3/d)	**2,000**	**4,400**	**7,700**	**10,900**	**13,700**
Projected yearly tourists (x1000)	2,323	2,693	3,122	3,619	4,196
Projected daily tourists (x1000)	6.37	7.38	8.56	9.92	11.50
Daily tourist served (x 1000)	1.91	4.06	6.85	9.42	11.50
Unit consumption rate (lpcd)	300	310	320	330	340
Scenario 3 (m^3/d)	2,000	4,800	8,800	13,200	17,600
Projected yearly tourists (x1000)	2,327	2,831	3,445	4,191	5,098
Projected daily tourists (x1000)	6.38	7.76	9.44	11.48	13.97
Daily tourist served (x 1000)	1.92	4.27	7.55	10.91	13.97
Unit consumption rate (lpcd)	300	315	330	345	350

3-6 NRW Reduction

Past experience confirms that it is reasonable to assume that the NRW of SRWSA can be controlled and maintained below 10 percent after the target year of 2020, assuming 17 percent of NRW in 2010.

Table 3.7 Proposed NRW Reducing Plan

Year	2010	2015	2020	2025	2030
NRW	17 %	12 %	10 %	10 %	10 %

3-7 Peak Factor

1.25 will be applied for the maximum day demand factor. The loading ratio, reciprocal number of the maximum day demand factor, is computed to be 80 percent.

3-8 Total Water Demand Projection

Summarizing the above study, the three scenarios in improving domestic water consumption, the three scenarios in targeting tourists' growth related to improvement of commercial water consumption, and other scenarios such as improving water supply coverage and reduction of NRW by the target year of 2030, provides us with three scenarios, which is summarized in Table 3.8 and illustrated in Figure 3.1. Details are referred to **SR 3.2**.

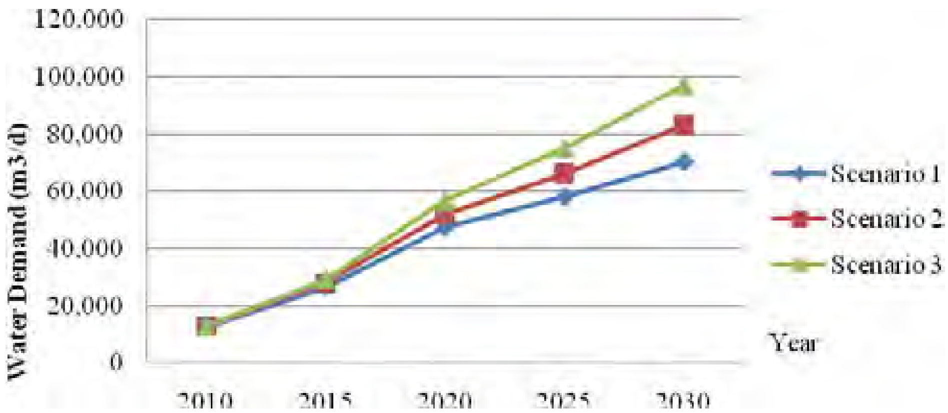


Figure 3.1 Maximum Daily Water Demand Increase by Scenario

Each scenario is characterized as shown below:

Scenario 1 is conservative scenarios in improving the domestic water unit consumption rate to 130 lpcd in 2030. The growth rate of tourists is limited at two percent only which is pessimistic scenario adopted in consideration of delay in recovery of world economy and development of the basic infrastructures such as the international airport in Siem Reap.

Scenario 2 is technically encouraging and financially moderate scenario, including improvement of the domestic water unit consumption rate to 150 lpcd and three percent growth of tourists which targets three million tourists in 2020 and over four millions of tourists in 2030. A permanent reduction in leakage losses is expected to be achievable through the prevention of leakage occurrence. This implies pipeline renewal before the end of its useful life in addition to expansion of new distribution network. So, 10 percent NRW level, which could be achievable and will be set as a target level for the year 2017 when the proposed water supply systems be commenced.

Scenario 3 is very much optimistic in improving the domestic water unit consumption rate and growth of tourism so that it will be financially heavy burden in comparison to scenario 1 and 2 .

As a conclusion, **Scenario 2** is the most practical recommendation for the long-term water supply development plan as it fulfills the national sector plans by delaying five years. The following analysis regarding the development plan will be based on the conditions assumed in Scenario 2. Thus, the water demand will be increased from 9,500 m^3/d in 2010 to 69,000 m^3/d in 2030 on a daily average basis and from 11,900 m^3/d in 2010 to 86,300 m^3/d in 2030 on a daily maximum basis. Supply coverage of the population in the study area will be improved to 90 percent in the long-term water supply development plan target year 2030 from 30 percent in 2010; while NRW ratio will be reduced from 17 percent in 2010 to 10 percent in 2030, which will contribute to improvement of financial soundness of SRWSA.

Table 3.8 Summary of Water Demand Projection in the Proposed Service Area

Year	**2010**	**2015**	**2020**	**2025**	**2030**
Domestic water demand (m^3/d)					
Projected Pops. (x1000)	**178**	**221**	**265**	**312**	**359**
Coverage	**30 %**	**55 %**	**80 %**	**85 %**	**90 %**
Population served (x1000)	**54**	**122**	**212**	**265**	**323**
Scenario 1 (m^3/d)	5,900	14,000	25,400	33,000	42,000
Scenario 2 (m^3/d)	**5,900**	**14,600**	**27,500**	**37,100**	**48,400**
Scenario 3 (m^3/d)	5,900	15,200	29,700	41,000	54,800
Commercial water demand (m^3/d)					
Projected tourists per year (per day in parenthesis)					
Scenario 1 (x 1000)	2,282 (6.3)	2,520 (7.0)	2,782 (7.7)	3,072 (8.5)	3,391 (9.3)
Scenario 2 (x 1000)	**2,323 (6.4)**	**2,693 (7.4)**	**3,122 (8.6)**	**3,619 (10.0)**	**4,196 (11.5)**
Scenario 3 (x 1000)	2,327 (6.4)	2,831 (7.8)	3,445 (9.5)	4,191 (11.5)	5,099 (14.0)
Coverage	30 %	55 %	80 %	95 %	100 %
Average length of stay	3.5				
Scenario 1 (m^3/d)	2,000	4,000	6,700	8,900	10,400
Scenario 2 (m^3/d)	**2,000**	**4,400**	**7,700**	**10,900**	**13,700**
Scenario 3 (m^3/d)	2,000	4,700	8,700	13,200	17,600
Total water demand (domestic +commercial; m^3/d)					
Scenario 1 (m^3/d)	7,900	18,000	32,100	41,900	52,400
Scenario 2 (m^3/d)	**7,900**	**19,000**	**35,200**	**48,000**	**62,100**
Scenario 3 (m^3/d)	7,900	19,900	38,400	54,200	72,400
NRW	**17 %**	**12 %**	**10 %**	**10 %**	**10 %**
Average water demand (m^3/d)					
Scenario 1 (m^3/d)	9,500	20,500	35,600	46,500	58,200
Scenario 2 (m^3/d)	**9,500**	**21,500**	**39,100**	**53,300**	**69,000**
Scenario 3 (m^3/d)	9,500	22,500	42,600	60,200	80,500
Peak factor	**1.25**				
Maximum water demand (m^3/d)					
Scenario 1 (m^3/d)	11,800	25,600	44,600	58,200	72,800
Scenario 2 (m^3/d)	**11,900**	**26,900**	**48,900**	**66,600**	**86,300**
Scenario 3 (m^3/d)	11,900	28,200	53,400	75,300	100,700

3-9 Long-Term Water Supply Development Plan

Long-term water supply development plan is to achieve the mission of SRWSA set as shown below:

> **SRWSA Mission**
>
> To produce, supply and distribute safe and potable water supply and reliable water service to the population of Siem Reap town, and other areas within the political jurisdiction of Siem Reap province.

This long-term development plan will discuss four ways of improving water supply service by providing a 24-hour potable water supply:

- the reinforcement of the existing water supply system;
- the possibility of extension from the existing water supply system;
- the existing distribution areas whose water supply sources will be switched from groundwater to the existing or a newly developed piped water supply system; and
- the expansion of water supply network dependent on the population increase in connection to a new water supply systems to be developed.

As to the existing service areas, water service will be improved by increasing water pressure. In the non-supplied areas, completion of a piped water supply will mean serving the most number of people within the shortest time frame giving due attention to the areas' social and economic importance as well as its investment efficiency and effectiveness.

The required production capacity at each phase up to 2030 is illustrated in Figure 3.2 in accordance with the daily average and maximum water demand.

A 30,000 m^3/d water supply development plan is proposed to be implemented in two phases. A total water production capacity in the target year 2030 will be of 86,000 m^3/d including the existing production capacity of 9,000 m^3/d, which is 1,000m^3/d overloading to the nominal design capacity of 8,000 m^3/d, 17,000 m^3/d by KTC project (a bulk water supply project by a Korean company), and 60,000 m^3/d to be expanded in two phases under the Project. This will meet the projected water demand in 2030.

The Priority project is then recommended to develop 30,000 m^3/d as an urgently project by year 2016 or 2017 to supplement to the current water production capacity of 9,000 m^3/d and the expected KTC production capacity of 17,000 m^3/d, totaling 56,000 m^3/d to meet the projected maximum water demand in 2022. The following indicators are achieved in the Priority Project._

Table 3.9 Indicators Achieved by the Priority Project in 2022

Water use	Projected pops/tourists (daily basis)	Coverage (%)	Served Pops./ tourists	Unit consumption rate (lpcd)	Water demand (m^3/d)
Domestic	283,290	82	232,300	134	31,128
Commercial	9,073	86	7,803	324	8,848

The incremental addition of production capacity in the following phase is recommended completing in 2022 with a capacity of another 30,000 m^3/d in order to ensure that will cover the growth towards the end of the proposed long-term water supply development plan. It is a suitable size to develop as a similar project as the Priority Project, considering efficient project preparation and physical issues such as extension of related transmission and distribution network. The final daily production capacity will be a total of 86,000 m^3 that fulfills the expected maximum water demand through 2030 at the projected maximum water demand basis.

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 set by the long-term water supply development plan.

To achieve easy operation and maintenance of the distribution networks, the proposed service area will be separated into three zones, namely West Zone, Central Zone, and East Zone towards 2030. Each Zone will be supplied by an independent elevated water tank with a fill and draw system to which necessary amount of clear water will be transmitted. The Central Area will be further separated into four blocks, Q1 (Northwestern block), Q2 (Southwestern block), Q3 (Northeastern block), and Q4 (Southeastern block) in consideration of the existing water supply block system and geographical conditions of the City which is separated north and south by the national road No. 6 and west and east by the Siem Reap river. East Area will be further separated into Q5 (North block) and Q6 (South block). Each block includes the following communes as detailed in **S.R 4.16 and 17 ,**Water Demand Allocation.

The water demand of Central Zone, East Zone, and West Zone will be 69,380 m^3/d, 5,930 m^3/d, and 10,940 m^3/d, respectively. In year 2030, referring to Figure 3.3, allocated water supply amounts to each block are summarized in the following table.

Table 3.10 Max Daily Water Demand for Each Block in 2030

Blocks	Water use	Population Served (Nos.)	Water Demand (m^3/d)	Belonging Communes*
Q1	Domestic	56,610	11,790	Sla Kram, Svay Dangkum, Kouk Chak, Tuek Vil, Srangae
	Commercial	9,360	4,420	
	Sub Total	**65,970**	**16,210**	
Q2	Domestic	60,100	12,520	Svay Dangkum, Sala Kamraeuk, Siem Reap, Srangae
	Commercial	7,220	3,410	
	Sub Total	**67,320**	**15,930**	
Q3	Domestic	48,460	10,090	Sla Kram, Nokor Thum
	Commercial	18,190	8,590	
	Sub Total	**66,650**	**18,680**	
Q4	Domestic	78,320	16,320	Sla Kram, Sala Kamraeuk, Siem Reap, Chreav
	Commercial	4,750	2,240	
	Sub Total	**83,070**	**18,560**	
Total of Central Zone	Domestic	243,490	50,720	
	Commercial	39,520	18,660	
	Total	**283,010**	**69,380**	
Q5	Domestic	25,000	5,210	Ampil, Kandaek
	Commercial	0	0	
	Sub Total	**25,000**	**5,210**	
Q6	Domestic	3,460	720	Kandaek
	Commercial	0	0	
	Sub Total	**3,460**	**720**	
Total of East Zone	Domestic	28,460	5,930	
	Commercial	0	0	
	Total	**28,460**	**5,930**	
Q7 (West Zone)	Domestic	50,890	10,600	Svay Dangkum, Tuek Vil
	Commercial	710	340	
	Sub Total	**51,600**	**10,940**	
Grand Total	Domestic	322,840	67,250	*The detailed allocation in each commune is referred to **S.R5.14.**
	Commercial	40,230	19,000	
	Total	**363,070**	**86,250**	

Notes: 322,840(residents)= 358,710 x 90%; 40, 230 (tourists) =11,494 x 3.5

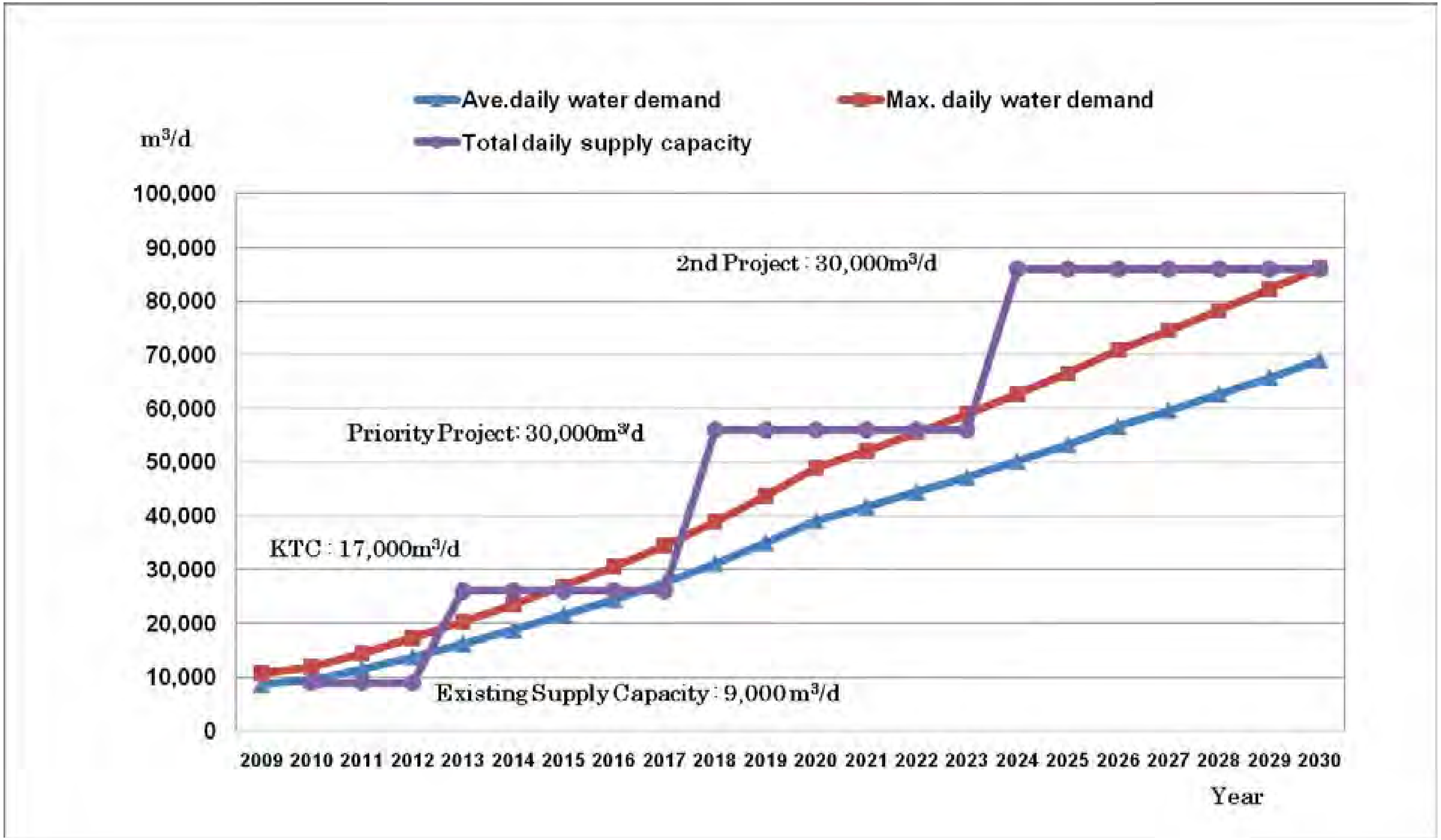


Figure 3.2 Maximum/Average Water Demand and Production Capacity

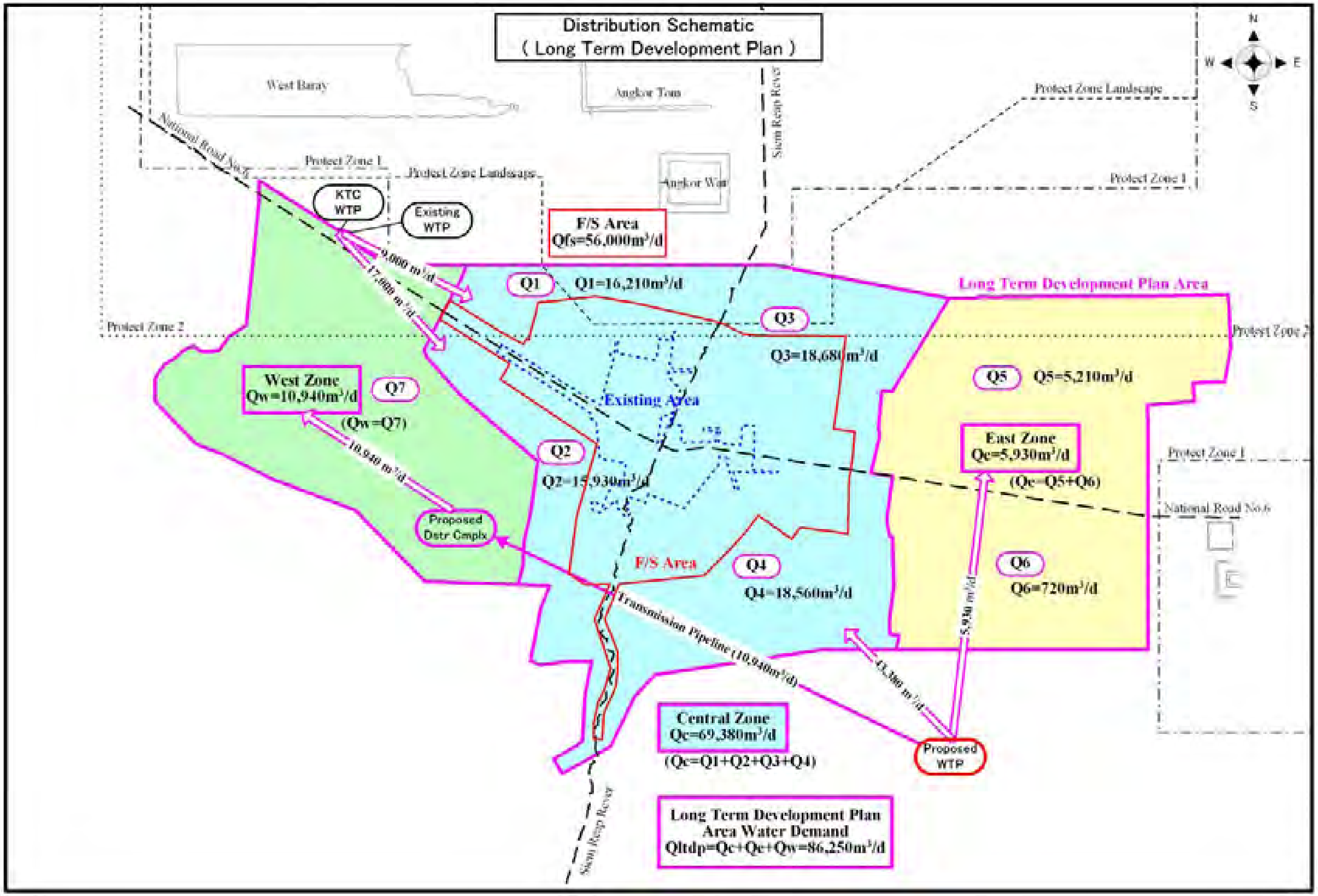


Figure 3.3 Long-Term Water Supply Development Plan

Chapter 4.
Feasibility Study on Priority Project

Chapter 4. Feasibility Study on Priority Project

4-1 Scope of Work

Key indicators in 2022 of the long-term water supply development plan are summarized below:

・Water use	Domestic	Tourists
・Projected Pops./Tourists	283,290	9,073
・Coverage	82 %	86%
・Pops./Tourists served	232,300	7,803(*27,300)
・Unit consumption rate (lpcd)	134	324
・Water demand (m^3/d)	31,128	8,848
・Total daily water demand (m^3/d)	39,976	
・NRW (%)	10	
・Ave. daily water demand (m^3/d)	44,420	
・Peak factor	1.25	
・Max. daily water demand (m^3/d)	55,530 (=43,230 + 12,300)	
・Available water supply capacity (m^3/d)	26,000 (= existing 9,000+KTC17,000)	
・Development capacity (m^3/d)	30,000	

Notes: Details are referred to **S.R.3.2-2**

*Daily actual numbers of tourists are calculated to be 7,803 x 3.5 =27,300, in applying 3.5 days of stay.

After completion of the priority project, water production capacity of the Project will be 30,000m^3/d. However, main part of raw water conveyance pipelines, water intake structure, and administrative common facilities will be sized for the long-term water supply development plan capacity, which nominal design capacity would be 60,000m^3/d. Ten percent allowances will be added to design the works for loss through the works. Distribution of water to Siem Reap service areas under Phase 1 will be for those communes as Sla Kram, Svay Dangkum, Sala Kamraeuk, Kouk Chak, Siem Reap, Chreav, and Nokor Thum.

a) Raw water conveyance pipelines : capacity of raw water conveyance pipelines will be 66,000 m^3/d including 10% allowances for the nominal design capacity for the long-term water supply development plan;

b) Raw water intake pump station : space of the pump station is sized for the long-term water supply development plan. The Project facilities includes only for capacity of 33,000 m^3/d (additional pumps will be expanded for the long-term water supply development plan);

c) Raw water intake pipe : pipes used for raw water transmission main from raw water transmission pump station to WTP should be of 800 mm dia. DI pipes of 3,400 m length to satisfy a capacity of 33,000 m^3/d (additional pressure main will be expanded in the long-term water supply development plan);

d) Water treatment plant (WTP) : production capacity of 30,000 m^3/d;

e) Clear water pumps : deliver 30,000 m^3/d to the elevated water tank;

f) Clear water pump station, chemical building, administration building, etc.;

g)	Elevated water tank	:	1,000 m^3 will be allocated in WTP
h)	Distribution main from treatment plant to service areas	:	approximately 32 km. of distribution main system. DI pipes with diameters from 250 mm to 800 mm and PE pipes with diameters from 50 mm to 200 mm will be used;
i)	Distribution pipelines	:	in the distribution system 19 km of DI pipes and 433 km of PE pipes will be used, dependent on pipe sizes;

j) Communication and power supply to intake, pumping station and WTP; and

k) Plant and equipment necessary for operation and maintenance.

4-2 Target Year of the Project

The target year for the Feasibility Study is being set at 2022 in accordance with the long-term water supply development plan for the proposed service areas.

4-3 Priority Service Areas for the Feasibility Study and Population Served

Table 4.1 summarizes selected priority service areas for the F/S study. Most of the areas in Sla Kram and Sla Kamraeuk communes located in the central area of the City will be covered by the F/S new water supply scheme. Other communes such as Svay Dangkum, Kouk Chak, Siem Reap, and Chreav will be covered partially in applying the following long-term water supply development policy as discussed in the previous sections.

- the reinforcement of the existing water supply system;
- the possibility of extension from the existing water supply system;
- the existing distribution areas whose water supply sources will be switched from groundwater to the existing or a newly developed piped water supply system; and
- the expansion of water supply network dependent on the population increase in connection to a new water supply systems to be developed.

The population served by the F/S Project will be 232 thousand of residents and 27.3 thousand of tourists, respectively as mentioned in the key indicators. The proposed population served for the F/S are tabulated in

Table 4.1and delineated in Figure 4.1**.**

4-4 Preliminary Design Drawings

Preliminary design drawings for raw water intake chamber, raw water conveyance pipelines, raw water transmission pump station, water treatment plant, and transmission/distribution pipelines are attached in **SR 4.1** which are the basis of the Engineers' Cost Estimates .

Table 4.1 F/S Priority Service Areas and Population Served

Item	Commune / Village	F/S	Item	Commune / Village	F/S	Item	Commune / Village	F/S
1.	**Sla Kram**	**81,070**	**5.**	**Siem Reap**	**21,030**	**9.**	**Ampil**	**0**
1-1	Slor Kram**	○	5-1	Pou		9-1	Kouk Chan	×
1-2	Boeng dunpa*	○	5-2	Phnom krom	×	9-2	Thnal Chak	×
1-3	Chong Kavsu*		5-3	Pror Lay	×	9-3	Tanot	×
1-4	Dork pou*	○	5-4	Korkragn		9-4	Trapang Run	×
1-5	Bantay chas**	○	5-5	Kra Sangroleung	×	9-5	Ta Pang	×
1-6	Trang*		5-6	Spean Chreav		9-6	Prei Kuy	×
1-7	Mondol 3**	○	5-7	Arragn		9-7	Bang Koung	×
2.	**Svay Dangkum**	**59,130**	5-8	Treak	×	9-8	Kiri Manon	×
2-1	Pngea Chei	×	**6.**	**Tuek Vil**	**0**	9-9	Bos Tom	×
2-2	Kantrork	×	6-1	Kouk doung	×	9-10	Trach Chrom	×
2-3	Kouk Krasang	×	6-2	Sandan	×	**10.**	**Nokor Thum**	**0**
2-4	Svay Chrei	×	6-3	Chrei	×	10-1	Rohal	×
2-5	Pou Bos	×	6-4	Prayut	×	10-2	Sras srang	×
2-6	Tmei		6-5	Bantay Cheu	×	10-3	Sras srang	×
2-7	Svay Dangkum*	○	6-6	Teuk Vil	×	10-4	Kravan	×
2-8	Salakanseng*	○	6-7	Pri Chas	×	10-5	Arak svay	×
2-9	Krous*	(○)	6-8	Tuek Tla	×	10-6	Ang Chang	×
2-10	Vihear Chin*	○	6-9	Pri Tmei	×	**11.**	**Srangae**	**3,370**
2-11	Steng Tmei*	(○)	6-10	Chei	×	11-1	Kasikam*	
2-12	Mondol 1**	○	**7.**	**Chreav**	**7,190**	11-2	Tnal	×
2-13	Mondol 2**	○	7-1	Chreav	×	11-3	Roka Thom	×
2-14	Ta Phoul**	○	7-2	Knar		11-4	Prei Thom	×
3.	**Sala Kamraeuk**	**45,100**	7-3	Bos Kralang	×	11-5	Srangie	×
3-1	Vat Bo**	○	7-4	Ta Chek	×	11-6	Chanlong	×
3-2	Vat Svay	○	7-5	Veal	×	11-7	Ta Chouk	×
3-3	Vat Damnak*	○	7-6	Kra Sang	×	**12.**	**Sambuor**	**0**
3-4	Sala Kam reak	○	7-7	Boeng	×	12-1	Pnouv	×
3-5	Chun long		**8.**	**Krabei Riel**	0	12-2	Sambour	×
3-6	Ta Vean	○	8-1	Ta Ros	×	12-3	Veal	×
3-7	Trapang Treng	○	8-2	Roka	×	12-4	Chrei	×
4.	**Kouk Chak**	**15,410**	8-3	Prei Pou	×	12-5	Ta kong	×
4-1	Trapang Ses*		8-4	To Tear	×	**13.**	**Kandaek**	**0**
4-2	Veal*		8-5	Krasang	×	13-1	Kouk Tlouk	×
4-3	Kasin tabong*	○	8-6	Popil	×	13-2	Trapang Tem	×
4-4	Kouk Chan	×	8-7	Trapang Veng	×	13-3	Khun Mouk	×
4-5	Khatean	×	8-8	Kouk Doung	×	13-4	Chras	×
4-6	Kouk Beng	×	8-9	Boeng	×	13-5	Ou	×
4-7	Kouk Tanot	×	8-10	Promma	×	13-6	Spean Ka Ek	×
4-8	Nokor krav	×	8-11	Khnar	×	13-7	Trang	×
Notes	○: all areas prioritized/included		8-12	Prei Kroch	×	13-8	Chrei	×
	: partial areas prioritized/included		**: all areas covered by the existing systems			13-9	Kouk Tanot	×
	×: all areas not covered		*: partial areas covered by the existing systems			13-10	Lo Ork	×
Total Population Served for F/S						**232,300**		

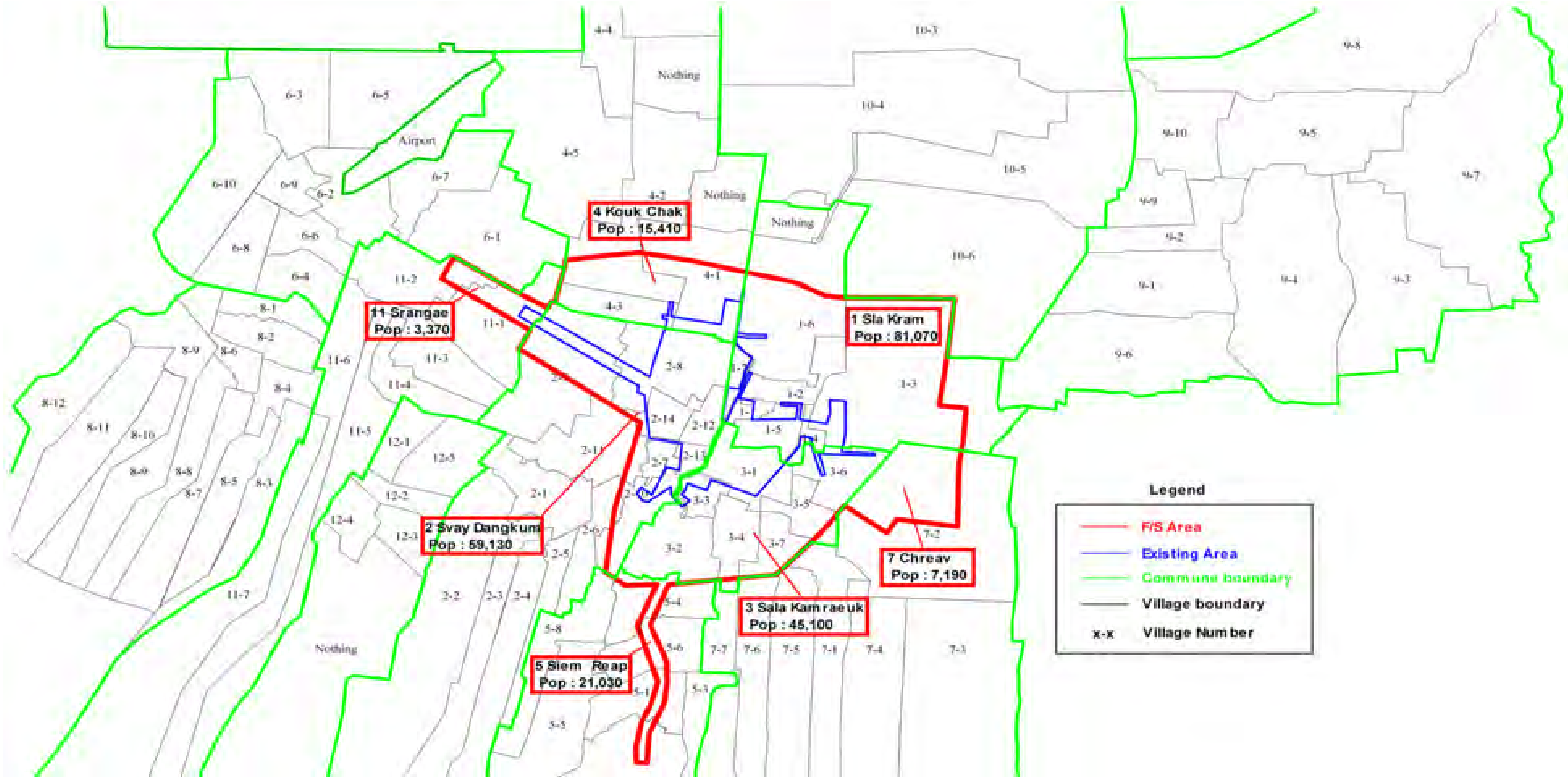


Figure 4.1 F/S Water Supply Service Areas and Population Served

4-5 Design of Priority Project

The following technical principles are applied in the preliminary design of water treatment equipment and facilities for the Project;

- ♦ to the extent possible, the use of mechanical equipment should be limited to that produced locally for easy operation and low maintenance cost;
- ♦ hydraulically based devices that use gravity for such work as rapid mixing, flocculation, and filter rate control are preferred over mechanized or automated equipment, but subject to the hydraulic head requirement;
- ♦ mechanization and automation are appropriate only where operations are not readily done manually, or where they greatly improve reliability to assure safe and stable water supply;
- ♦ indigenous materials and manufactured goods that allow easy and safe construction should be used to reduce costs and to assist the local economy and expand industrial development.

Hydraulic design criteria summarized in Table 4.2 is applied and include for ten percent production loss for the design of the intake facilities, receiving well/distribution chamber, flocculation basins, sedimentation basins, filter units, and chemical, and chlorination facilities.

Table 4.2 Design Horizon

Facilities	Priority Project
1) Intake Chamber	66,000 m^3/day
2) Raw Water Conveyance Pipeline	66,000 m^3/day
3) Raw Water Transmission Pipeline	33,000 m^3/day
4) Raw Water Intake Pump Station	33,000 m^3/day
5) Distribution Chamber	33,000 m^3/day
6) Flocculation Basins	33,000 m^3/day
7) Sedimentation Basins	33,000 m^3/day
8) Filter Units	33,000 m^3/day
9) Clear Water Reservoir	33,000 m^3/day
10) Distribution pipelines	*56,000 m^3/day

Notes:* Hourly peak factor will be applied to 56,000m^3/d in design of the distribution pipelines.

4-6 Selected Raw Water Source

4-6-1 Recommendation for the Raw Water Source for the Project

As a result of Stage 1 and Stage 2 selection processes as shown in the following sections, **Tonle Sap Lake water** was selected as the most appropriate raw water for the proposed water supply development scheme.

The Project aims stable water supply without interruption of water supply, with drinkable water quality to meet the Cambodia drinking water standards, and with reasonable cost (water tariff). To achieve the target as public water supply systems, the **Tonle Sap Lake** water is most suitable water source for the Project. It is inevitable that the raw water intake facility from the Lake passes through the environmental restricted areas under control of the relevant authorities so that the practical measures should be taken properly to mitigate such impacts with close coordination with the relevant authorities concerned. Details are referred to Section 10-5 Environmental Impact Analysis and Mitigation Measures.

4-6-2 Selection Flow of New Water Sources

Stage 1

A wide range of alternatives of new water sources was identified as preliminary screening by means of rough comparative study to come up with selected alternatives for Stage 2.

Table 4.3 presents evaluation of alternatives new water sources. Among seven (7) alternative water sources in Stage 1, the rough evaluation based on engineering consideration concludes that the following four (4) alternatives are not competitive, especially on the cost and water volume availability, in comparison with the selected three (3) alternatives of Tonle Sap Lake, West Baray and Groundwater for Stage 2.

- Siem Reap River
- Other rivers
- Other existing barays/ponds/reservoirs
- Reservoirs to be newly constructed

Table 4.3 Evaluation of Alternative New Water Sources

Water source		Water quantity	Water quality	Construction (Cost and Difficulty)	O&M (Cost and Difficulty)	Overall Judgment
Alt. 1	Tonle Sap Lake	Sufficient	Acceptable	Not sure	Not sure	**Selected**
Alt. 2	West Baray Reservoir	Acceptable	Good or Acceptable	Low or Medium	Low	**Selected**
Alt. 3	Groundwater	Sufficient or Acceptable	Good or Acceptable	Low or Medium	Low or Medium	**Selected**
Alt. 4	Siem Reap River	Insufficient	Acceptable or Not suitable	Low or Medium	Low or Medium	**Not Selected**
Alt. 5	Other Rivers	Insufficient	Good or Acceptable	Medium or High	Medium or High	**Not Selected**
Alt. 6	Other Existing Barays/ Ponds/ Reservoirs	Insufficient	Good or Acceptable	Medium or High	Low or Medium	**Not Selected**
Alt. 7	Reservoir to be newly constructed	Sufficient or Acceptable	Good or Acceptable	Medium or High	Low or Medium	**Not Selected**

Stage 2

Stage 2 carried out detailed and accurate comparative study to identify a short list from the long list prepared in Stage 1.

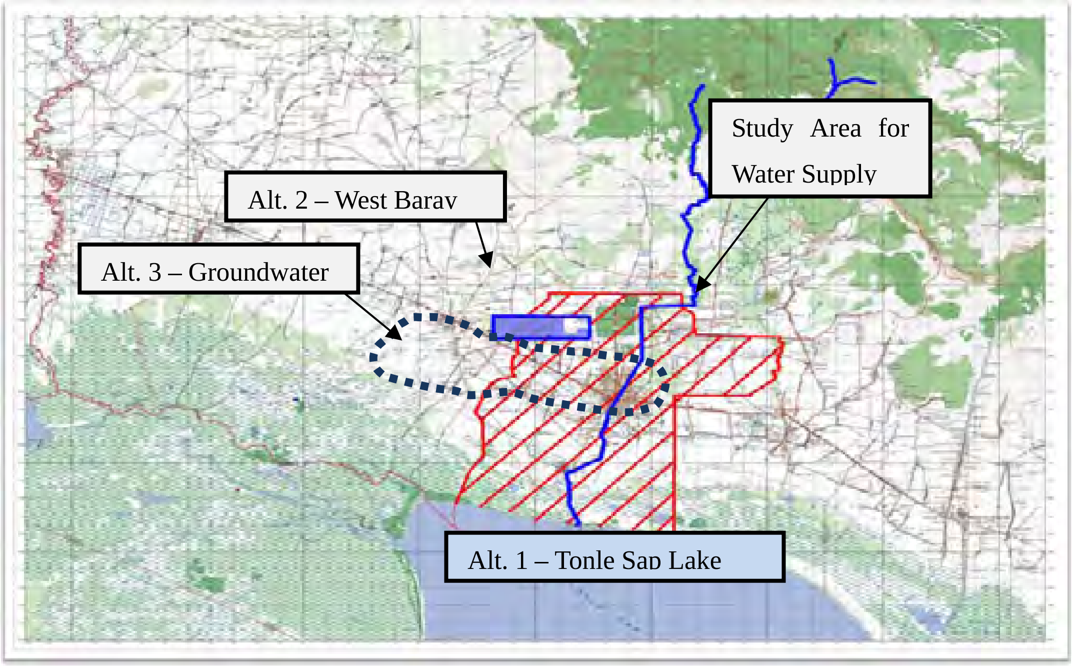


Figure 4.2 Location of Alternative Water Sources

4-6-3 Stage 1 Selection of New Water Sources and Intake Methods

Selected water sources for Stage 1 were Tonle Sap Lake, West baray, and Groundwater sources in combination with the following intake methods.

Water Source	Location of Intake	Intake Method
Tonle Sap Lake	Water body within the Lake	Intake tower
		Intake frame box
		Collecting pipe
	Canal connected to the Lake (Newly constructed)	Intake tower
		Intake gate + Culvert
West Baray Reservoir	Existing canal	Diversion weir +Intake gate
Groundwater	Groundwater in the lake side	Well
		Well + collecting pipes

Stage1-Step 1 process was for evaluation of the significant issues for each candidate raw water source as public water supply systems which was related to stable water supply with reasonable water quality in consideration of the capital investment cost with easy O&M.

Stage1-Step 2 process focused on evaluation of legal issues for implementation of the project and environmental issues as summarized below:

Stage 1 Selection Parameters:

Stage 1-Step 1 evaluation : Significant/Priority Parameters

1) Water volume for intake
2) Water quality
3) Construction Cost (including difficulties)
4) Operation & Maintenance Cost (including difficulties)

Stage 1-Step 2 evaluation : Other Parameters Confirmed

5) Water management laws/acts (including water right)
6) Relation with the other purposes of water uses
7) Impacts to archeological sites
8) Impact to ecology
9) Impact to life and land uses of inhabitants
10) Land acquisition and resettlement
11) Related organization/ group

The intake methods were narrowed down by means of the following parameters.

General Parameters :

1) Capacity of intake volume
2) Flexibility to variation of water level
3) Construction cost and difficulties
4) O & M Cost and difficulties
5) Future expansion
6) Archeological site
7) Environmental impacts

Special parameters in case of Tonle Sap Lake

1) Water level fluctuation (large)
2) Lake shoreline movement
3) Shallow water level
4) Fishery, Tourism, Navigation
5) Related organization

4-6-4 Stage 2 Selection of New Water Source

Stage 2 selection was in depth analysis by 2 steps, Part A and Part B to select most appropriate water source for the Project.

Part A: Detailed study on the fundamentals as public water supply systems, including stability and availability of water amount, raw water quality, environmental aspects such as protected area/legal restriction, ground subsidence in the heritage sites, and opinion from related organizations/groups.

The results summarized in the following:

Parameter	**Water Source Alternatives**		
	Tonle Sap Lake	**West Baray (canal)**	**Groundwater (lake side)**
Water Volume	A	N/A	N/A
Water Quality	B	B	B
Protected Area	B	N/A	N/A
Ground Subsidence (Historical heritages)	A	A	N/A
Impacts to Ecology	B	A	A
Impacts to Land acquisition and Resettlement	B	B	B
Other Environmental Impacts	B	B	B
Opinion by Organizations	B	B	N/A

A: Sufficient, good, or no-impacts
B: Acceptable or, no significant adverse impacts
C: Not acceptable or significant adverse impacts
N/A: Reliable evaluation is difficult without further study or confirmation

Part B: Detailed study on reality of the total water supply systems including structural & work plan/design, construction method and schedule, construction cost, and O&M cost.

The summary of **Part B** analysis is summarized in the following Table 4.4:

Table 4.4 Part B, Stage 2 Selection of New Water Source

Water Source	Tonle Sap Lake	West Baray	Ground Water
Structural Design and Work Plan	✓ **Possible long term plan** ✓ **Ideal water supply scheme from existing WEST and proposed EAST WTPs.** Issues and Concerns - Intake chamber and pump station are needed. - Water level fluctuation of the lake is to be considered. - Location of intake pumping station is to be considered. - Proposed WTP site is close to those areas where major water demand increase is projected. - Easy access to the existing distribution network. - Conventional water treatment process is needed.	✓ **Short term plan only** ✓ **Rehabilitation of the existing weirs and environmental issues** ✓ **Overlapped WTSs in west** Issues and Concerns - Land acquisition is troublesome. - Weir for water level control is necessary. - Rehabilitation for existing facilities such as weir is needed. - Far from the eastern part where major increase in future demand is expected. - Available water is limited but future expansion is impossible. - Conventional water treatment process is needed.	✓ **Short term plan only** ✓ **Considerable numbers of wells and connection pipelines** ✓ **Unavoidable environmental issues** Issues and Concerns - Considerable number of wells are needed. - Monitoring facilities for ground water and land subsidence are needed. - Conventional water treatment process excluding the sedimentation basin. - Land acquisitions for each well are difficult. - Site can be located in the southern part of town. - Easy access to the existing distribution network.
Construction Method and Schedule	✓ **Careful construction due to water level fluctuation** Issues and Concerns - Construction schedule for intake chamber shall be considered. - Seasonal water level changes shall be considered.	✓ **Permission from related agencies** ✓ **Land acquisition** Issues and Concerns - Permission for rehabilitation of the existing facilities is required from many agencies concerned. - Land acquisition for the water treatment plant is troublesome.	✓ **Long ACCESS ROAD to wells** ✓ **Land acquisition** Issues and Concerns - Construction period is long due to the considerable number of wells. - Access roads to each wells are necessary.
Construction, Operation and Maintenance Costs	✓ **Careful O&M** ✓ **Annual O&M cost is estimated USD1.6 Mill.** ✓ **Comparative cost is estimated US$99 Mill.** Issues and Concerns - Careful operation for seasonal water quality fluctuation is required. - Land price is reasonable.	✓ **Careful O&M** ✓ **Annual O&M cost is estimated USD1.7 Mill.** ✓ **Comparative cost is estimated US$100 Mill.** Issues and Concerns - Operation for the water level fluctuation of West Baray and canal is troublesome. - Long distribution/transmission pipelines to the city are necessary and costly. - Land acquisition is tedious and costly.	✓ **Well water level monitoring** ✓ **Security for numerous scattered wells** ✓ **Annual O&M cost is estimated USD2.2 Mill.** ✓ **comparative cost is estimated USD104 Mill.** Issues and Concerns - Raw water conveyance pipelines are long and costly. - Tough O & M for many wells. - O & M for monitoring facilities is must. - Security for many wells is required.
Evaluation	**Generally good for short/long term plan**	**Not applicable for long term plan**	**Not applicable for long term plan**

4-7 Raw Water Intake

4-7-1 Water Level of Tonle Sap Lake

(1) Design Water Level by Frequency Analysis

The datum for levels in this study is the Mean Sea Level at Ha Tien in Vietnum as shown in Figure 4.3.

The design HWL and LWL for the preliminary design of the proposed project in F/S were determined as below, based on the recorded water levels at Kampong Luon.

- Design HWL : +11.00 m (masl)
- Design LWL : +1.00 m (masl)

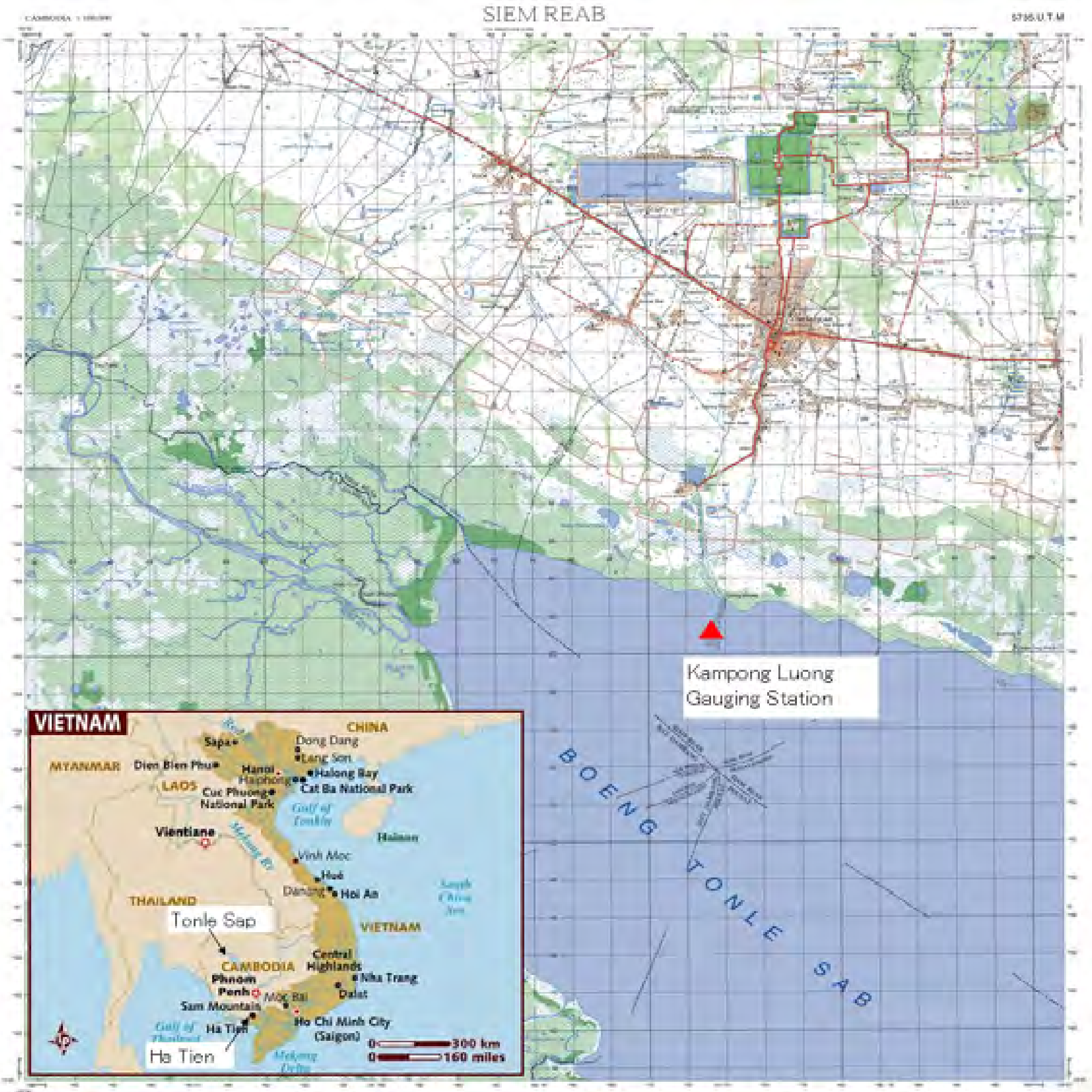


Figure 4.3 Location of Kampong Luong Gauging Station and Ha Tien

(2) Seasonal Change of Water Level of Tonle Sap Lake

Figure 4.4 present the monthly maximum and minimum water levels of Tonle Sap Lake for recent 10 years (2000 - 2009), although the records for 2000-2003 are incomplete. The highest water level of 10.33 m was recorded in September 2000, which almost coincides with 10.36 masl described above. Thus, water levels measured by DOWRAM are considered to be also tied in to Ha Tien datum.

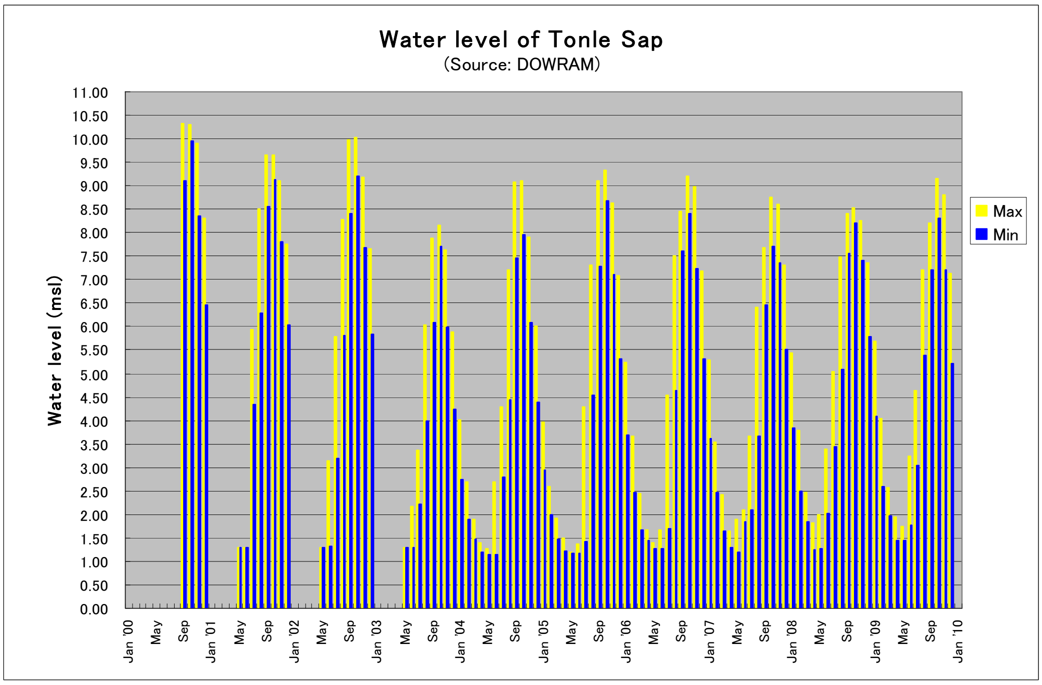


Figure 4.4 Monthly Max. and Min. Water Level of Tonle Sap Lake (2000-2009)

On the other hand, the following figure shows mean high water level and mean low water level of last 6 years (2004 - 2009) having a complete set of data.

Thus, the tendency of water level fluctuation will be a basic data for planning appropriate construction period of the concerned facilities.

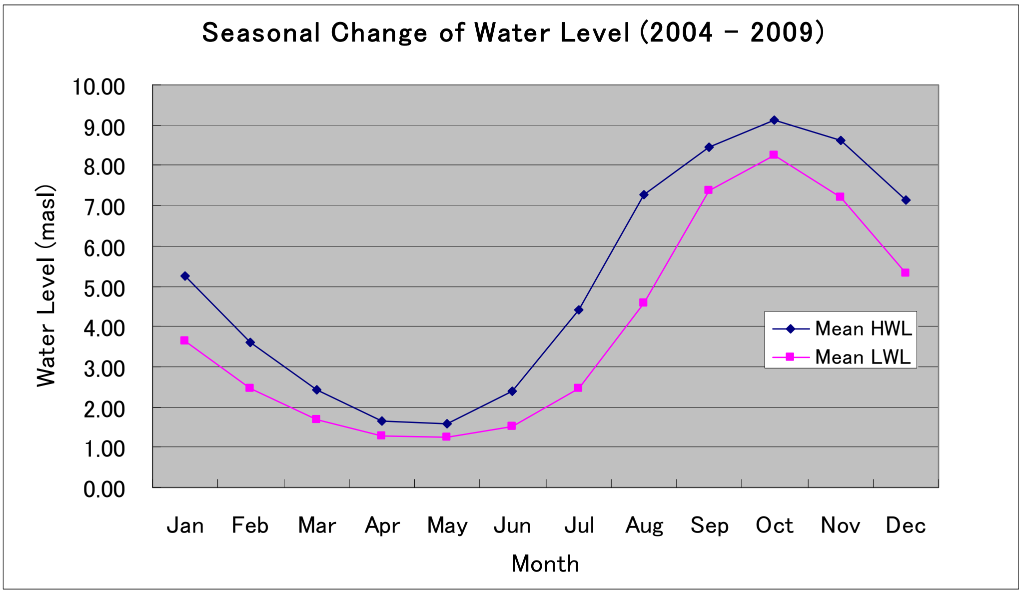


Figure 4.5 Seasonal Change of Water Level

4-7-2 Optimum Location of Pumping Station

Figure 4.6 shows the location of the proposed facility from intake to WTP in the priority project.

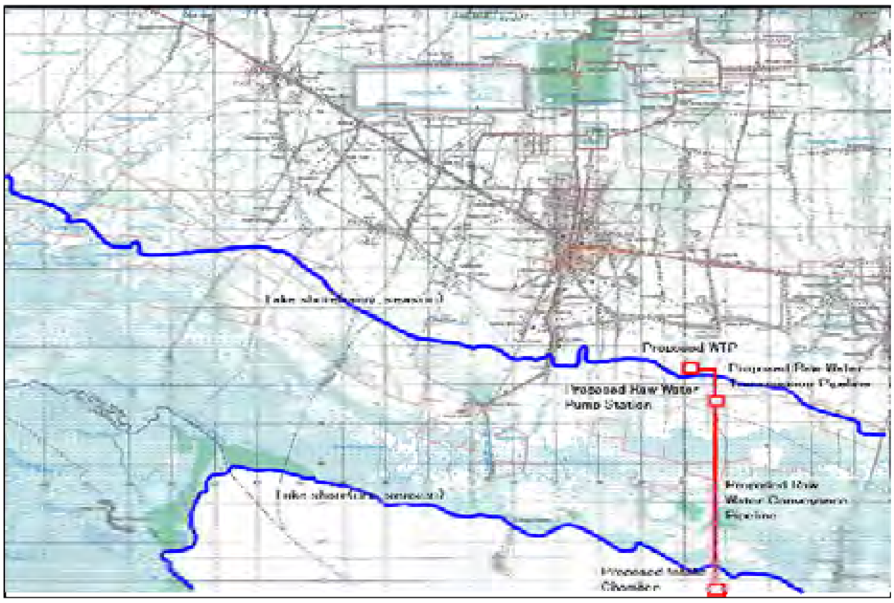


Figure 4.6 Location of the Proposed Facility

In selection of raw water pump station site, the construction cost of overall intake facilities by different location of the pump station was examined and it revealed that the least construction cost can be realized at the pumping station where locates around 6 km away from the intake site as shown in Figure 4.7. Detailed analysis is referred to **SR 5.3** and **SR 5.4**.

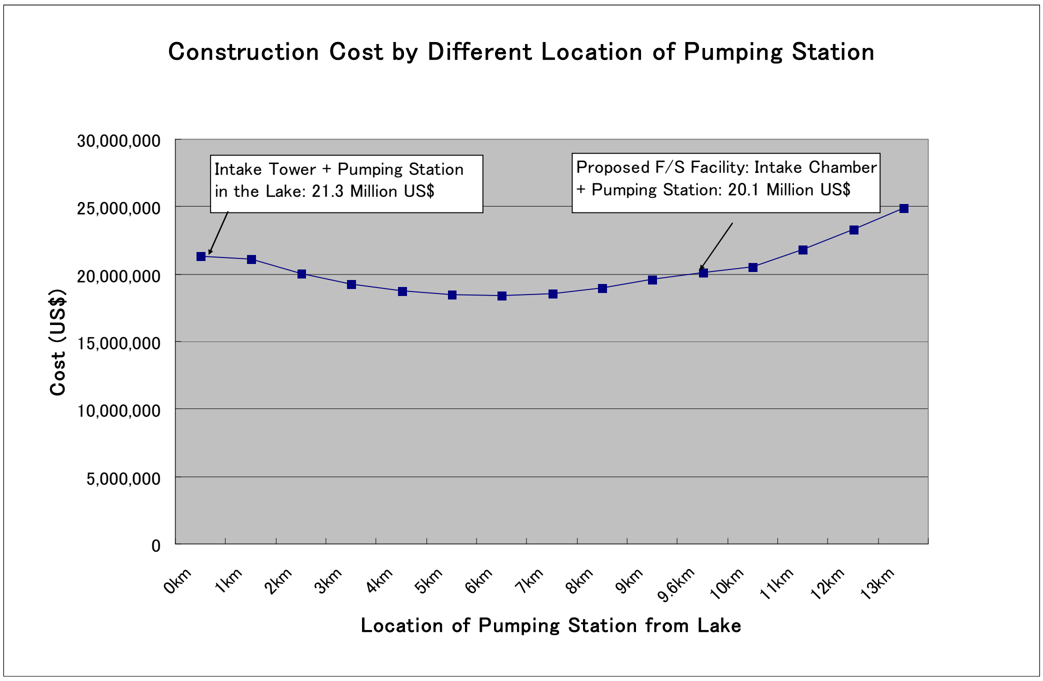


Figure 4.7 Construction Cost Variations by Locations of Pump Station

4-7-3 Raw Water Intake and Conveyance Facility

In Phase 2 study, “route B” situated east was selected as the raw water conveyance route in comparison of route A and route B which were selected as alternatives in Phase 1 study, after discarding “route C” due to difficulty in land acquisition and construction cost required for longer distance to the candidate WTP site.

In comparison between route A and B, route B is situated out of Provincial Natural Conservation Area and Provincial Fish Conservation Area. Thus, “route B” was recommended as the raw water conveyance route to minimize the influence in the said area.

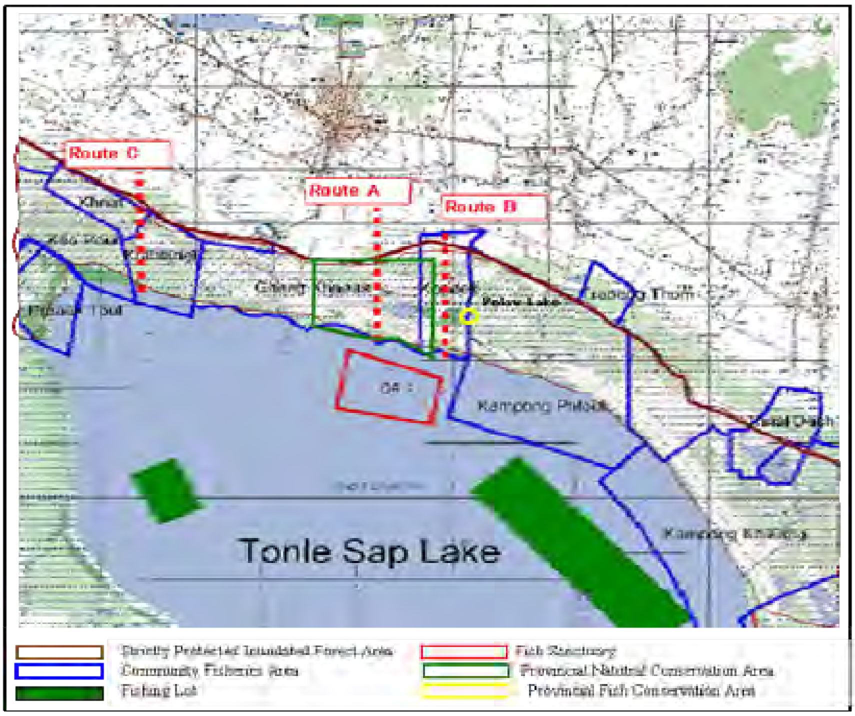


Figure 4.8 Raw Water Conveyance Route

As for intake method, the construction of intake chamber at 1 km away from the lakeshore of dry season is recommended based on the comparison as shown in the above figure. Thus, raw water is to be extracted at fixed level almost same as the lake bed.

Figure 4.9 illustrates the profile of the proposed raw water intake and conveyance facility of the proposed project.

Intake chamber is designed as below.

- Structure: Reinforced concrete intake chamber

  The platform with 3 floors is to be constructed on the intake chamber for gate operation as required and cleaning the screen during the time when water level reaches low enough. This platform is also designed as a sign for protection from fishing boat approaching to the chamber, since the other kinds of sign such as buoy and signpost in the lake are not applicable for operation and maintenance of the intake facility.

- Gate: Manual type gate is to be provided for maintenance purpose.
- Screen: 30 - 50 mm size of screen is to be equipped.
- Dimension of intake chamber: (W) 2.75 m x (L) 6.0 m x (D) 3.3 m
- Height of roof floor of the platform: +14.0 msl.

From intake chamber to pump station, the raw water is to be conveyed by gravity flow. The length is 9.6 km and 1,200 mm diameter of the concrete pipe was determined as shown below.

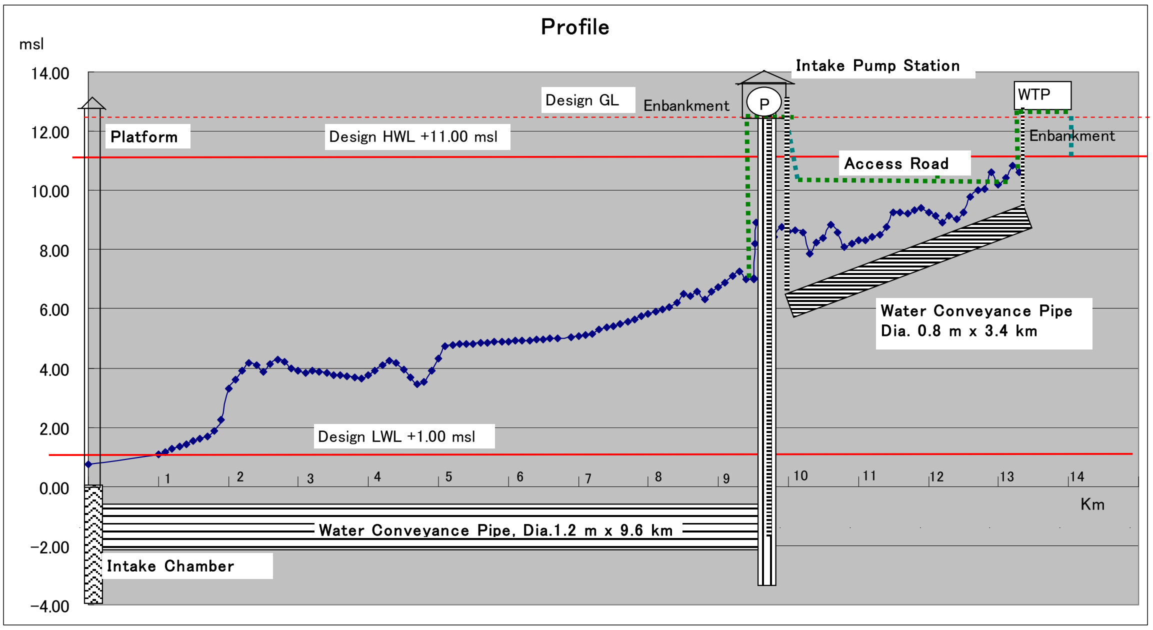


Figure 4.9 Schematic Diagram of the Raw Intake and Conveyance Facility

- Design flow: 66,000 m^3/day for Year 2030

  Maximum water demand of 60,000 m^3/day + 10 % of water loss in the pipeline and WTP

- Pipe material: Concrete pipe

  Concrete pipe will be enough for delivering raw water with lower pressure due to water level of the lake (HWL 11.00 masl – LWL 1.00 masl).

- Pipe diameter and number of pipeline

  In selection of pipe diameter, the required velocity to avoid settling sediments in the pipeline as well as number of pipeline were examined.

  It is recommended that the required capacity for the long term development plan of the water supply will be secured in the Priority Project, because it is considered that technical and environmental risk might be accompanied in implementation of long term development plan, if the additional one be installed close to the pipeline firstly installed in the Priority Project. Furthermore, single pipeline is considered to be more risky if serious accident occurs, compared to the double pipelines especially for the case of water intake from the Tonle Sap Lake. Thus, installation of 2 lines of raw water conveyance pipe in parallel to meet the ultimate water volume (33,000 m^3/day x 2 = 66,000 m^3/day) is recommended.

On the other hands, 3.4 km length raw water transmission pipeline from pump station to WTP is designed as below.

- Design flow: 33,000 m^3/day (for the proposed project)
- Pipe material:
  Either Ductile Iron or Steel pipe will be recommended considering raw water transmission in pumping system, however, Ductile Iron pipe is assumed to be employed in this F/S.
- Pipe diameter:
  800 mm of diameter is recommended due to economical pipe velocity in pumping system.
- Number of pipeline: one line

4-7-4 Raw Water Intake Pump Station

The proposed specifications for the Intake Pumps will be as follows;

Number:	:	3 sets (including 1 set for standby), with additional spaces provided for 2set for the 2nd Project
Type	:	Horizontal double suction volute pump with dry sump
Capacity:	:	191 l/s each
Head	:	26 m (operation range: 16 m to 26 m)

By providing speed control for the intake pumps and monitoring flow, the flow adjustment of raw water can be accomplished automatically.

Figure 4.10 illustrates the proposed control system.

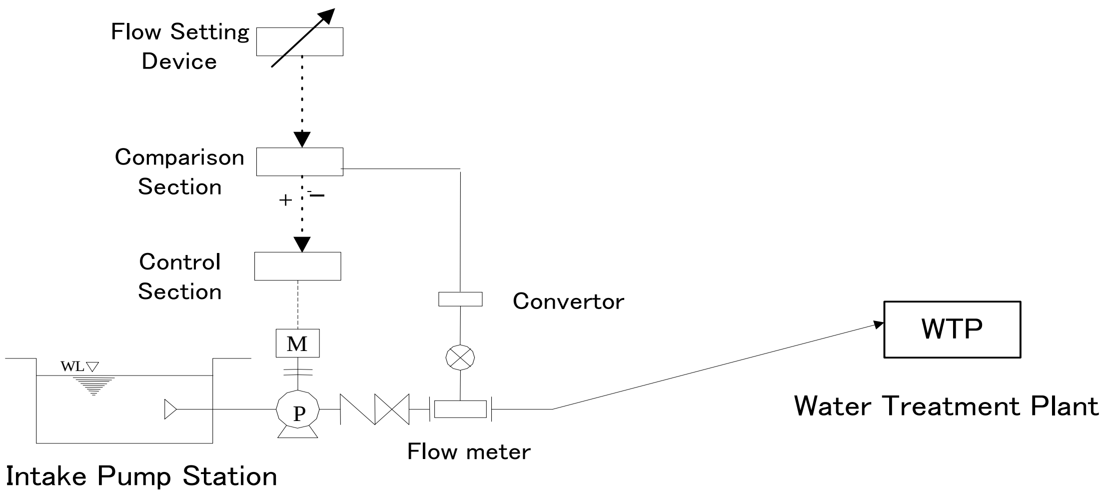


Figure 4.10 Intake Pump Control System

4-8 Water Treatment Process Design

This Feasibility Study considers the possible treatment process for the Project as either chlorination only, slow sand filtration, or rapid sand filtration based on the raw water quality characteristics. However a clear categorization in selection of these processes by numerical criteria is difficult, since the quality of the raw water varies greatly between seasons. The practical design guidelines for selection of treatment process are recommended by many water organizations in the world. The followings are the general guidelines for selection of basic process design from the Japan Water Works Association (JWWA):

- when the water quality conforms to the standard like E. coli of not more than 50 (in 100 ml, MPN), total colonies not more than 500 (in 1 ml) and other items of quality tests conform to the standard, chlorination only may be applied;
- when raw water quality has annual average turbidity of below 10 NTU, BOD below 2 mg/l, E. coli. below 1,000 (100 ml, MPN) slow sand filtration can be employed. In general, when the average annual turbidity of raw water is below 10 NTU, chemical coagulation is not necessarily effective. Further, the purifying effect of slow sand filtration is good due to absorption and biochemical action, and a certain amount of ammonia, manganese and odour-emitting matter can be removed, resulting in superior water quality to that of rapid sand filtration;
- when the quality of raw water does not meet the above two criteria, rapid sand filtration will be better adopted and necessary equipment for pre-treatment such as chemical coagulation must be provided.

As a result of series of Jar Test on the Tonle Sap water made during the Phase 2 study, and the updated data analysis conducted by the Study Team, the proposed principle of treatment process should be a rapid sand filtration system. This treatment is widely used in Cambodia with river sources. The process comprises pre-treatment, such as pH adjustment, pre-chlorination, and coagulation, flocculation, sedimentation, filtration, and disinfection. The details of Jar Test results are referred to **SR 4.3**.

Detailed calculations for the facilities are referred to **SR 4.10** through **4.13.**

4-9 Pretreatment

Coagulation, as a pre-treatment process will be provided in the distribution chamber at the head of the plant so that the destabilization of charges on colloids and suspended solids, including bacteria and viruses, may be achieved. The coagulation process will be achieved by a rapid mixing system which will disperse 10 percent alum sulphate solution, $Al_2(SO_4)_3 \cdot 18H_2O$ as a coagulant uniformly throughout the water as rapidly as possible.

The preliminary design criteria of the pre-treatment process are:

Type	:	Distribution chamber with hydraulic rapid mixing by weirs, two weirs are duty for Phase I
G value for rapid mixing	:	Approx. 400 s^{-1} (>350 s^{-1})
Dimensions	:	Receiving well 3.0 m x 3.0 m x 4.0 m depth Mixing chamber 2.0 m x 2.5 m x 2 chambers
Incidental facilities	:	Raw water inflow pipe: 800 DI, Drainage pipe: 300 DI Backwash water return pipe: 250 DI 2 raw water outlet pipe: 500 DI 1-overflow weir, 2-outlet gates

Applied chemicals	:	Pre chlorination	Liquid chlorine (99.9 %)
		pH control	Lime (10 % solution)
		Coagulant	Alum (10% solution)

4-10 Flocculation

Vertical-flow baffled channel flocculators, which can adjust the velocity by manipulating the opening space, with a detention time of approximately 20 to 30 min are proposed. Two trains will be provided so that in case of lower flows than the designed capacity, or maintenance works, one train may be shut down accordingly to attain a suitable flocculation intensity G-value range from 70 to 10 s^{-1}. The width of the flocculation channels will be sized in thirds to adjust the hydraulically required flocculation intensity from 70 to 10 s^{-1} i.e. higher intensity to gentle mixing towards sedimentation process.

The preliminary design criteria for the flocculation process are:

Type	:	Vertical-flow baffled channels
Number	:	2 trains with 3 staged tapered flocculation
Detention time	:	23 min (20 to 30 min)
G value	:	25 to 75 s^{-1}
Dimensions	:	1.1 m width x 8.0 m length x 3.60 m depth x 2 channels
		1.5 m width x 8.0 m length x 3.65 m depth x 2 channels
		1.9 m width x 8.0 m length x 3.70 m depth x 2 channels
Incidental facilities	:	2- inflow chambers with baffle wall

4-11 Sedimentation

The available site space is about 4 ha plus fringe areas which allows for construction of a total of 60,000 m^3/d of conventional horizontal flow sedimentation units by means of a full gravity system from pre-treatment to filtration and through disinfection processes.

The preliminary design criteria for the sedimentation process are:

Type	:	Rectangular plug flow
Number	:	2 trains with hydraulic sludge removal pipes
Surface loading	:	23.9 mm/min <30 mm/min
Passing velocity	:	0.358 mm/min < 0.4 m/min
Sludge collection	:	Discharge to sludge discharge tank by gravity
Collecting trough	:	300 mm width x 350 mm depth x 6 m length x 8 nos., 343 m^3/m/d <400 m^3/m/d
Baffle wall	:	1 for inflow and 1 for effluent of basins
Dimensions	:	8 m width x 60 m length x 4 to 5 m effective depth x 2 trains
Incidental facilities	:	6 sludge extraction pipes 150 mm dia.
	:	1 sludge extraction pipe 250 mm dia.
	:	1 drainage pipe 250 mm dia.

4-12 Rapid Sand Filters

4-12-1 Type of Filter Media and Filtration Rate

The proposed filtration rate is recommended to be conservative taking into consideration of raw water quality fluctuations of the Tonle Sap Lake.

The required filter area and number of units are interrelated. The maximum size of filter bed should be limited less than 150 m^2 so that uneven flow of air scoring and washwater can be avoided. The filter media should be manganese sand which will ensure the contact filtration systems to remove manganese carried over from the settled water tank to the filter units.

The design parameters for filtration are:

Type	:	constant-rate filter with influent splitting and varying water level
Number	:	4 filters
Dimensions	:	8.0 m x 8.5 m (= 68 m^2 per unit)
Total filtration area	:	272 m^2
Filter media	:	800 to 1000mm thickness, E.S. 0.8 mm to 1.0 mm U.C. <1.5, Manganese sand
Filtration rate	:	120 m/d (approx. 161 m/d during washing)

4-12-2 Filter Wash Arrangements

The proposed deep filter bed is not compatible with surface wash system, even fixed grid or rotating arm types, because the mixing energy provided by the surface wash may not reach towards the deeper portion of the bed where the retained material is clogged. A rotating arm type with dual-arm agitators is available for deep or dual media filters, however this is not recommended due to the more complex structure and the inevitable maintenance of the rotating parts. The air scoring system is applicable in this case and is widely employed in existing plants in Cambodia including Phum Prek WTP.

The preliminary design criteria for the filter wash arrangement are:

Backwash rate	:	0.25 $m^3/m^2/min$
Auxiliary wash	:	Air-scoring, 1.0 $m^3/m^2/min$
Backwash water	:	Tapping filtered water stored at the backwash water tank

4-12-3 Type of Filter Rate Control

An obvious fact for the sustainable operation of filters is to distribute the settled water evenly into each filter and to backwash regularly if the loss of head reaches the designed level or 24 to 48 hours of filter run, dependent on the settled water quality. Unexpected backwashing will be inevitable in cases where the turbidity of the settled water is beyond the desirable level of 5 NTU. Inflow weirs, without filter controllers, are recommended to hydraulically distribute the designed settled water amount evenly to each filter unit. This system still allows the filtration process can be managed easily without control any devices. Thus, the constant-level filtration system, with influent splitting and varying water level system is recommended rather than the other filtration system.

The preliminary design criteria for the filter control system are:

Filtration system	:	Constant rate filtration, level sensor
Inflow/effluent control	:	Weirs

4-12-4 Auxiliary Arrangements

The filter underdrain system will be selected based on the combination of filter media and washing system, from strainers, dual lateral blocks, and precast concrete perforated underdrains, as commonly adopted. The selection criteria are reliability, simplicity of design/construction, durability, and low head loss during washing. For this project, some sort of nozzle type is possibly the most appropriate strainer to provide easy installation and most stable underdrain in combination with the proposed air scouring and washing systems. Supporting gravel is not necessarily required for the strainer underdrain system.

The preliminary design criteria for the underdrain system are:

Underdrain system	:	Strainer type
Supporting gravels	:	Not applicable
Valves	:	Electrical operation type

4-13 Chemical Applications and Chlorination

Alum as a coagulant, lime for pH control, and liquid chlorine as a disinfectant and/or oxidant will be employed on the Project, the same as the existing Phum Prek or other PPWSA WTPs. The dosages (in mg/l) and applied points of each chemical will be as shown below based on the jar test results conducted by the Study Team.

	Max.	Ave.	Min.	Dosing Points
Alum	60	15	10	Distribution Chamber
Pre- lime	30	10	5	Ditto
Post-lime	30	5	5	Back wash water tank
Pre chlorine	5	2	1	Ditto
Post chlorine	2	1	1	Clearwater reservoir

4-14 Sludge Treatment

Sludge from the sedimentation basins is conveyed to sludge discharge tank by gravity and pumped to sludge drying bed. The dried sludge will be disposed outside of the treatment plant, periodically, by trucks.

The design parameter for the sludge discharge tank are:

Tank Capacity	:	210 m^3
No. Of Tank	:	2 tanks (105 m^3 each)
Dimensions	:	10 m x 5.0 m x 2.1 m effective depth
Discharge Pump	:	0.828 m^3 /min x 2, 1 duty, 1 standby

The design parameters for the drying bed are:

Sludge Drying Bed	:	5- beds: 25 m x 23 m x 0.6 m effective depth
Unit volume of lagoon	:	Approx. 345 m^3 each (total of 1725 m3)

4-15 Clearwater Reservoir

The clear water reservoir, near the entrance to the Plant site, is constructed with two compartments for the Project. The capacity of 5700 m^3 accommodates more than four hours of production and fluctuation of hourly maximum water demand, plus the amount needed for in plant use for mechanical, chemical dissolving, administration, and residential. The same capacity will be constructed in the second Project. The confirmation of detention time analysis is attached in **S.R 4.10.**

The design parameters for the clear water reservoir are:

Detention time	:	4.14 hrs.
No of reservoirs	:	2 reservoirs (2,850 m^3 each)
Dimensions	:	48 m x 12 m x 5 m effective depth x 2

4-16 Clear Water Pumping Station

Similar to the raw water intake pumps, three units will be provided, one as a standby, with a total pumping 1.6 times of 30,000 m^3/d to meet the Phase 1 hourly peak water demand.

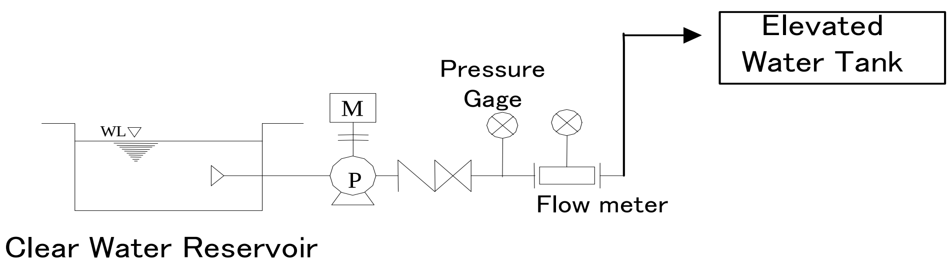


Figure 4.11 Clear Water Pump Control

Horizontal double suction volute pumps are of similar type as the proposed raw water intake pumps as well as the existing facility. The proposed pump has the same superior advantages as listed for the intake pumps. The number of pumps is determined by the availability of low voltage motors up to approx. 400 kW which has advantages that could be locally repaired. The proposed specifications for the clear water pumps areas are as follows;

Number:	:	3 sets (including 1 set for standby)
Type	:	Horizontal double suction volute pump with dry sump
Capacity:	:	283 l/s each
Head	:	48 m

4-17 Elevated Water Tank

To fulfill the requirements proposed by the long-term water supply development plan, an elevated water tank with a fill and draw system will be constructed in the premises of the proposed WTP. The required capacity is of minimal of 1,000 m^3 in corporate with operation of the proposed clear water pump units.

Number:	:	1 tank
Type	:	Fill and draw system
Capacity:	:	1,000 m^3
HWL	:	+53.85 m

4-18 Other Facilities

4-18-1 Sampling of Process Water

Samples of raw, settled, and treated water are pumped to the laboratory in the Administration Building, to enable monitoring of the main parameters of water quality.

4-18-2 Laboratory Equipment

A plant laboratory is provided in the Administration Building and consists of a physico-chemical area, a biological area, a chemical storage room, and a chemist’s office. Sufficient equipment, glassware and chemicals will be provided to enable the determination of the main physical and chemical parameters of the water. Since this plant will be the first major surface water treatment facility using the lake water should be undertaken on optimization of chemical dose rates etc. so as to derive the best operating regime for the plant and to develop essential operating data to assist in the design of the second Project.

4-18-3 Pipework

In-plant piping consists of underground pipes between structures, or process units, carrying liquids used throughout the plant. These include:

Descriptions	Size (mm)	Materials
Raw water	800	DI
Distribution chamber to flocculation/sedimentation basins	500 x 2	DI
Settled water to filter units	700	DI
Filtered water to clear water reservoir	1400	DI
Treated water transmission	1000	DI
Sludge to lagoons	250	DI
Backwash water drainage to backwash water recovery tank	800	DI
Backwash water return to distribution chamber	250	DI
Distribution chamber overflow	800	DI
Sedimentation basin overflow	1000	DI
Clear water reservoir overflow	800 x 2	DI
In-plant water service	150	DI/PVC
Chlorine solution pipe	100	PVC/PE
Alum solution pipe	100	PVC
Lime solution pipe	100	GS/PVC

4-18-4 Standby Power Generation

Electrical power supply to the site comprises one feed, and, therefore, standby power generators are provided for the intake pump station and the treatment plant to ensure continuity and security of water supply. A building is provided for the stand by generators. The building also houses the main power supply to the plant and step-down transformers.

4-18-5 Administration Facilities

A two storey building is located near to the entrance to the plant. The ground floor includes an entrance with receptionist alcove, stairs to the second floor, the laboratory and laboratory chemical storage room, Chemist’s office, a general office area and toilets. Upstairs includes offices for the General and Deputy Director, Department Chief, and Engineers and the plant monitoring room. A conference room, staff meeting room space, a small library for drawings, engineering manuals and archives, an exhibition/training area, toilets and stairs to the lower floor are also provided.

4-18-6 Maintenance Building

The single storey maintenance building includes a garage area, workshop, storage for pipes/fittings and mechanical lockers for operators, showers, toilets, tool storage and an office area on the grand floor.

4-19 Transmission/Distribution Pipelines

4-19-1 Zoning

Water supply to the priority service area in the Central Zone will be distributed by a proposed elevated water tank constructed in the premises of the proposed WTP.

4-19-2 Loop

The looping strategy will be applied to expansion of the existing distribution network in the Central Zone.

4-19-3 Blocks

Major distribution pipelines (500 to 800 mm) will be extended to the north and to the south, encompassing the following expansion areas: Block Q1 for Kouk Chak; Block Q2 for Svay Dangkum; and Block Q3 for Sla Kram and Nokor Thum; and Block Q4 for Sla Kamraeuk and Chreav.

4-19-4 Water Demand Applied for F/S Priority Project

Table 4.5 shows the maximum daily water demand estimated in the long-term water development plan for each block in target year 2022. The details of population and water demand of each block are referred to Supporting Report **SR 4.17**.

The relative part of peripheral zones in the whole water supply coverage will grow from about current 30 percent to over 80 percent in 2022.

Figure 4.12 schematizes the proposed F/S Distribution Schematic.

Table 4.5 Max Daily Water Demand for Each Block in 2022

Distribution Blocks	Item	Population	Water Demand
		(Nos.)	(m^3/d)
Qfs1	Domestic	56,360	10,490
	Commercial	6,630	2,990
	Sub Total	**62,990**	**13,480**
Qfs2	Domestic	58,090	10,810
	Commercial	4,810	2,170
	Sub Total	**62,900**	**12,980**
Qfs3	Domestic	46,720	8,700
	Commercial	12,580	5,660
	Sub Total	**59,300**	**14,360**
Qfs4	Domestic	71,130	13,240
	Commercial	3,280	1,480
	Sub Total	**74,410**	**14,720**
Total (F/S Area)	Domestic	232,300	43,240
	Commercial	27,300	12,300
	Total	**259,600**	**55,540**

4-19-5 Distribution Network Analysis

Pipelines were sized to be 150 kPa of the minimum supplied pressure at the end of pipelines using the exponential formula developed by Hazen and Williams shown below in metric unit.

Table 4.6 Applied Design Conditions For F/S Distribution Network

Descriptions	Design	Remarks
Target year	2022	F/S
Design capacity	Q = 56,000 m^3/d	F/S Area daily maximum distribution capacity
Peak factor	K = 1.6	hourly
Design distribution capacity	q = 3,733 m^3/h	Hourly maximum distribution capacity
Elevated water tanks volume and hydraulic grade	Existing T1 : 500 m^3 , +48.00m KTC T2 : 500 m^3 , +53.85m Proposed T3 : 1,000 m^3 , +53.85m	
Applied formula	$H = 10.666 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L$ H : friction loss (m) C : friction coefficient (= 110) D : diameter of pipe (m) Q : rate of flow (m^3/s) L : pipe length (m)	Hazen Williams formula
Minimum hydraulic pressure	＞ 150 kPa	At the end of distribution pope
Analysis software	WaterCAD V8i Edition	Bentley Systems, Incorporated

Peak factor is set at 1.6 in reference to a trend of PPWSA and a typical fluctuation trends analyzed as “mixed housing area and industrial or commercial area” in the design book of Japan Water Works Association (JWWA).

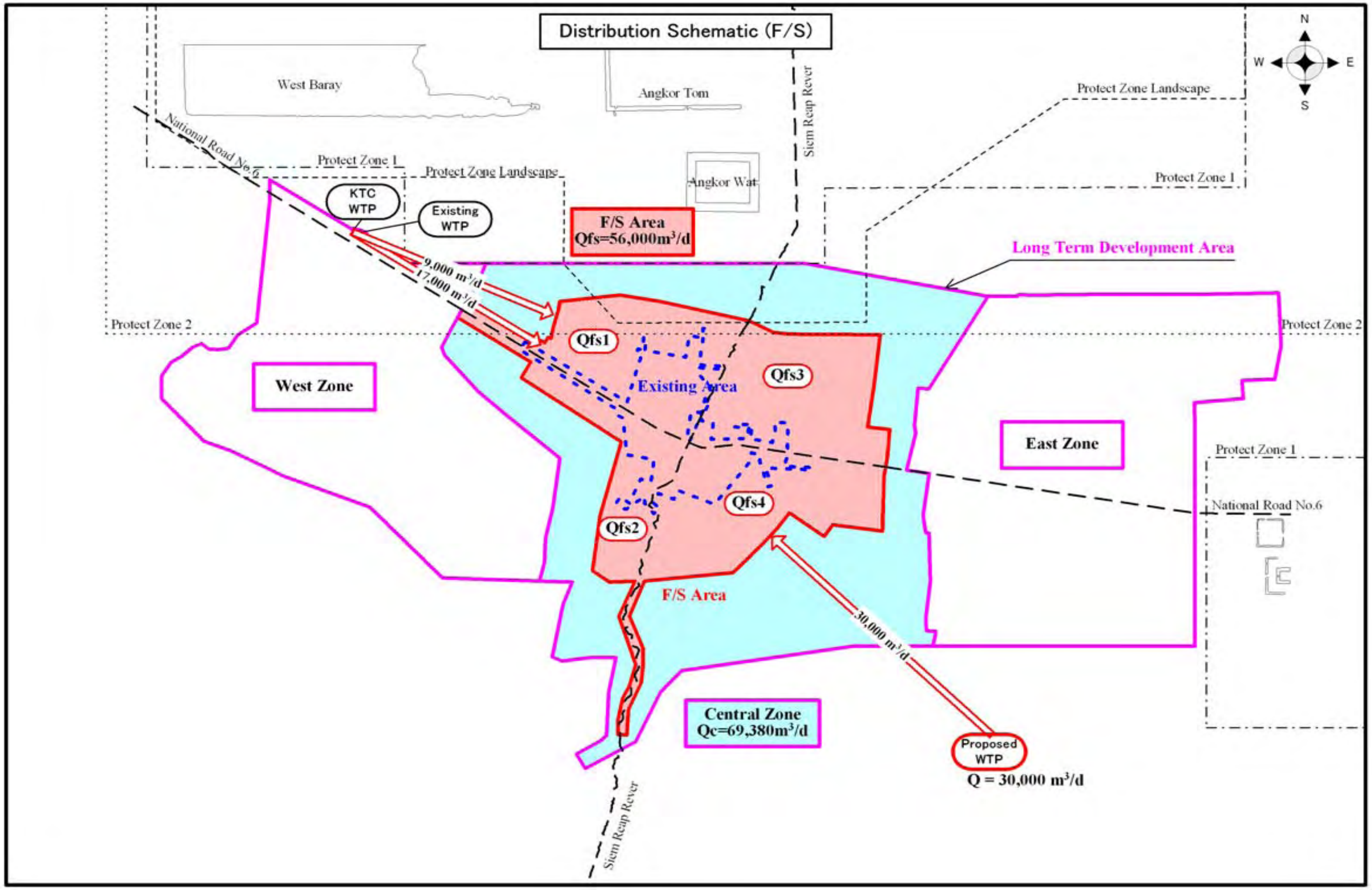


Figure 4.12 F/S Transmission/Distribution Schematic

The details of population and water demand of each village are referred to **SR 4.17**.

Main and sub-main pipe sizes for the priority project and second project are simply segregated to maintain the same hydraulic performance analyzed for the long-term water supply development plan to meet the following design capacity.

Priority Project:	56,000m^3/d	To meet F/S target year 2022
2nd project :	13,380m^3/d	To meet the long term development plan in 2030
Total :	69,380m^3/d	2030 requirements for the Central Zone

The details of pipe length in each block and supply pressures are designed as shown in the following table;

Block	Designed pipe length (m)	Designed supply pressure (kPa)	Area (ha)
Q1	83,680	Max : 380 to Min : 180 > 150	860
Q2	47,040	Max : 430 to Min : 190 > 150	620
Q3	97,700	Max : 390 to Min : 180 > 150	880
Q4	131,350	Max : 420 to Min : 170 > 150	1,000
Total	**359,770**		**3,360**

Categories and materials to be applied of pipelines for the priority project are shown below:

Priority Project	Pipe Sizes (mm)	Designed length (m)	Material
Main Pipe	800	4,450	DI
	700	16,250	DI
Sub Main Pipe	300	20	DI
	250	13,240	DI
	200	10,440	PE
	150	41,820	PE
Branch Pipe	100	1,400	PE
	80	272,150	PE
Total		**359,770 m**	

Chapter 5.
Institutional and Managerial Considerations

Chapter 5. Institutional and Managerial Considerations

The SRWSA institutional development plan follows the timeline of the three physical improvements plans being proposed in this Study, as follows: (i) the availability of KTC Bulk Water in 2012-13, (ii) the completion of the facilities under Priority Project in 2017, and (iii) the completion of the facilities under 2nd project in 2022. The institutional development plan recommends the most optimum organization structure and number of human resources for each phase. It also provides the workable project implementing framework and organization for Phase 1 and 2. Lastly, it presents approaches to developing the capacities of the officers and staff of SRWSA individually and as part of the organization.

5-1 Organization Structure for each Growth Phase

SRWSA should be prepared to operate the expanded system and serve its growing customers with the appropriate organization structure based on the basic functions of a water utility suitable to its size, goals and objectives. Shown below is the summary of the units under the proposed organization structure for each growth phase (number of deputy director generals, the departments and offices):

TIME FRAME	# DGD	DEPARTMENT	OFFICE	SECTION (OPTIONAL)
Current 2010	1	1 – Administration and Financial	Administration and Human Resources	None
			Financial and Accounting	
	1	2 – Production and Distribution	Water Production	
			Water Distribution	
			Customer Service	
		3 – Planning and Technical	Planning	
			Technical and Project	
KTC Bulk 2012-2013	1	1 – Administration and Finance	Administration and Human Resources	
			Accounting and Finance	
	1	2 – Production and Distribution	Water Production	
			Water Distribution	
			Service Connection	
		3 – Planning and Technical	Planning and Design	
			Technical and Project	
	Under the General Director		Commercial Operations	
Priority Project 2016-17	1	1 – Administration	Administrative Services	Procurement and Property Management
				General Services
			Human Resources	Compensation, Benefits and Performance Appraisal
		2 – Finance	General Accounting	None
			Finance and Budget	None
	1	3 – Water Supply Operations	Production	Operation and Maintenance
				Water Quality
			Distribution	Network Installation and Maintenance
				Leakage Reduction

			Service Connection	Water Meter Repair and Maintenance
		4 – Planning and Development	Planning and Design	None
			Project Management	None
	Under GD	5 – Commercial Operations	Customer Accounts	None
			Customer Service	None
	Under GD			Management Services
2^{nd} Project 2022-23	1	1 – Administration	Administrative Services	Procurement and Property Management
				General Services
			Human Resources	Recruitment, Selection and Placement
				Compensation, Benefits and Performance Appraisal
		2 –Finance	Accounting	General Accounting
				Bookkeeping and Cashiering
			Budget and Treasury	Cash Management
	1	3 – Commercial Operations	Customer Accounts	Meter Reading
				Billing and Collection
			Customer Service	Water Services Processing
				Customer Relations and Marketing
	1	4 – Water Supply Operations	Water Production	Operation and Maintenance
				Water Quality
				Stores Management
			Water Distribution	Network Installation and Maintenance
				Leakage Reduction
			Service Connection	Connections and Disconnections
				Water Meter Repair and Maintenance
		5 – Planning and Development	Planning and Design	None
			Project Management	None
	Under the General Director		Management Services	None

5-2 Human Resources Requirement for Each Phase

The organization should be manned with the right number and quality of human resources, in keeping with the organization structures proposed for each phase. The staff productivity index, a measure of staff productivity and a predictor / indicator of organizational efficiency, was utilized to ensure that the size of the organization is kept to the minimum. The proposed SPI for SRWSA was arrived at by comparing it with other Asian utilities of the same size in each growth phase, and is below the utilities' averages (or below SPI 5 per 1,000 connections) as shown below:

Year	Phase	Production Volume (m^3/day)	Projected Number of Connections	Projected Number of Employees		Staff Productivity Index
				By Phase	Total	
2010	Current Facilities	8,000	4,525	40	40	8.83
2012-13	Bulk Water from KTC	25,000	16,218	38	78	4.80
2017-18	Start of Priority Project	55,000	27,318	63	141	5.16
2022-23	Start of 2^{nd} Project	85,000	41,331	42	183	4.42

5-3 Capacity Building Program

To keep pace with the requirements and responsibilities of a growing water utility, capacity building is required for all SRWSA staff in the short and medium term. Thus, training that will be made to cover the entire organization, by department and offices based on unit functions and responsibilities, and by individual employee based on job function and position held. Training methodologies (counterpart coaching, mentoring, on-the-job, seminar-workshop) will be customized to fit the participants' needs and levels to optimize learning.

A multi-discipline team of international consultants will undertake the capacity building program that will run on a staggered basis from 2012 to 2014, for a total of 25 man-months. After an in-depth training needs assessment, eight specialized training courses will be conducted aimed at equipping, upgrading and honing employee knowledge and skills. These will be run for five days to two weeks and funded either through grant or through the SRWSA internal budget, and conducted by the PPWSA Training Center, or by local training institutions with a reputable track record, or by training subject matter experts (SME) or consultants.

5-4 Project (Operation) Implementation System

The Steering Committee earlier organized for the preparatory study shall be reconstituted to become the *Project Coordinating Committee for the Implementation of the Siem Reap Water Supply Expansion Project*, but with increased membership to include the representative of the ministers of MOEF (Ministry of Economy and Finance) and MOWRAM (Ministry of Water Resources and Meteorology). JICA will no longer be part of the PCC, as it becomes the financing institution of the Project. The PCC shall be the inter-agency coordinating committee charged with the *main role of providing policy guidelines for strategic coordination for Project implementation*. As such, it has no supervisory authority, but its existence is for over-all coordination of project implementation among the major stakeholders, as well as for resolving emerging concerns, major issues and conflicts that may arise during project implementation.

The *project monitoring agency* (PMA) shall be MIME, being the Government agency that has technical supervision over SRWSA. Its role will be over-all monitoring of Project implementation against the financial and technical plan.

As the project beneficiary, and ultimately the institution responsible for repaying the loan, SRWSA will be the *project executing agency as well as project implementer and manager*. For this purpose, it will establish a project management unit (PMU) within its Department of Planning and Technical for the duration of project implementation. It will also be in this department that the project consultants' team (PCT) will be lodged to provide consulting and advisory services for project implementation as specified in the Loan Agreement.

The Project will, therefore, be coordinated, monitored, executed and managed by three project organizations, as shown:

Project Organization	**Level**	**Membership or Institution / Department**	**Role in Project Implementation**	**Responsibility**
Project Coordination Committee	Inter-Agency Level	MIME, MOEF, MOWRAM, SRWSA, APSARA, Provincial Government	Over-all **strategic inter-agency coordination** and provision of policy guidelines of Project implementation	General Financial Implementation Legal
Project Monitoring	Ministry Level	MIME *Department of Water Supply*	Over-all responsibility for **monitoring Project implementation** against technical and financial	Monitoring Reporting
Project Management Unit	Institution Level	SRWSA *Department of Planning and Technical*	Directly responsible for **project execution and for undertaking actual field supervision and management** of Project implementation	General Project Implementation Project Closure

Chapter 6.
Implementation Plan

Chapter 6. Implementation Plan

6-1 Implementation Plan

The phases of the project are developed according to the following sizes of requirement in order to meet the water demand.

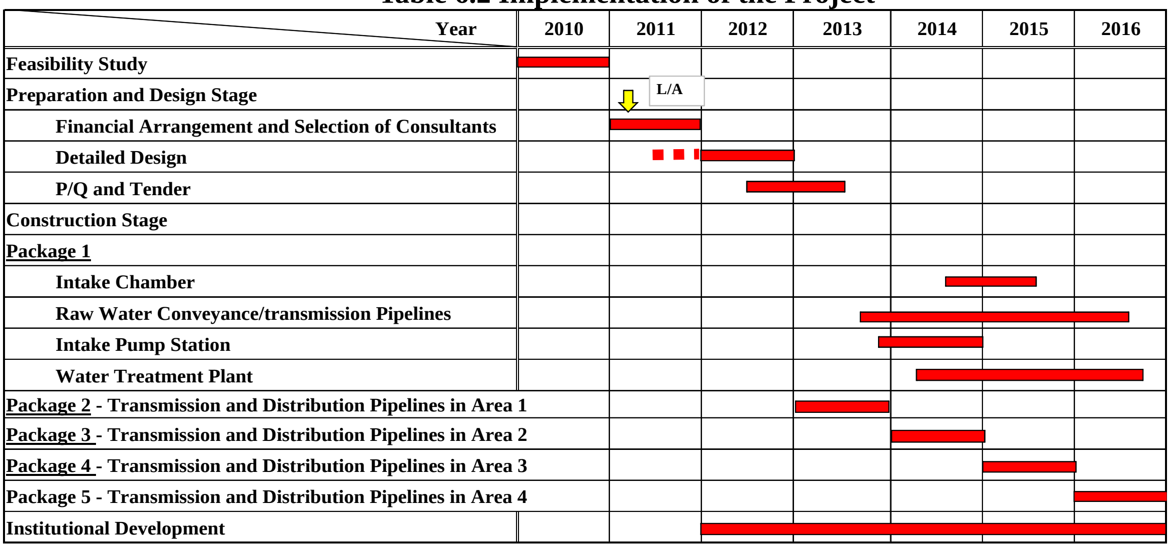
Table 6.1 Phasing of the Project (Nominal Design Capacity, m^3/d)

Items	Priority Project	2nd Project	Total
Target Year	2022	2030	N/A
Intake chamber	60,000	-	60,000
Structure of intake pump station	60,000	-	60,000
Administration building in WTP	60,000	-	60,000
Mechanical and electrical works for raw water intake pump station	30,000	30,000	60,000
Raw water conveyance pressure main	30,000	30,000	60,000
Water treatment facilities	30,000	30,000	60,000
Clear water reservoir	30,000	30,000	60,000
Elevated water tank	30,000	30,000	60,000
Mechanical and electrical works for WTP	30,000	30,000	60,000
Mechanical works for chemical devices	30,000	30,000	60,000
Transmission/distribution pipelines	30,000	30,000	60,000
Elevated water tanks	30,000	30,000	60,000

6-1-1 Implementation Schedule

The implementation schedule is shown in Table 6.2 and detailed in **SR 6.1**.

Table 6.2 Implementation of the Project



6-1-2 Mode of Implementation

The construction works for the Priority Project will be carried out by selected contractor/s upon international/local competitive bidding (ICB/LCB) on the following tender package which has been decided taking into account the advantages in technical and economical aspects. The major consideration in packaging was put on the nature of works, the size of contract and to avoid less attractive to the international construction companies

- Package 1 : Construction of Intake Chamber, Raw Water Conveyance Pipeline, Intake Pump Station, and WTP (ICB)
- Package 2 : Construction of Transmission and Distribution Network Area 1 (Q4) (LCB)
- Package 3 : Construction of Transmission and Distribution Network Area 2 (Q3) (LCB)
- Package 4 : Construction of Transmission and Distribution Network Area 3 (Q2) (LCB)
- Package 5 : Construction of Transmission and Distribution Network Area 4 (Q1) (LCB)

6-1-3 Condition for Construction Execution

(1) Topography, Meteorology, Hydrology and Geology

The site for major works is located on a flat alluvial plain. The current ground elevation for the proposed WTP is 11 meters above the mean sea level at Ha Tiem (MSL). The ground elevation gently decreases toward Tonle Sap Lake within 11.5 kilo-meters of distance where the proposed water conveyance pipe line will be installed. The current ground elevation for the proposed distribution pipe line gently expanses from 12 meters to 20 meters above MSL.

The wet season occurs from May till November. The dry season occurs from December to April. The water level of Tonle Sap Lake in the wet season becomes high which reaches 11 meter above MSL. The construction works of Intake Chamber, Conveyance Pipe Line and Intake Pumping Station should be completed within the dry season, otherwise some auxiliary work will increase the construction cost and extend the construction period.

The ground water level is high in connection with the water level of Tonle Sap Lake. The intake chamber, a part of the proposed water conveyance pipe line and the proposed intake pumping station, will be installed completely under the ground water. Dewatering should be necessary for earth works.

(2) Infrastructure

The ports of Phnom Penh and Sihanoukville are the available ports to unload equipment from Japan and other countries. The materials and equipments which are imported and/or procured in Phnom Penh should be transported by an inland transport, because the construction site in Siem Reap locates 250 kilo-meter far from Phnom Penh.

(3) Labor Force

Skilled and semi-skilled laborers can be recruited in the Phnom Penh area. However, sufficient numbers of engineers for the construction will not be obtained in Cambodia. It will be necessary to employ additional engineers from other countries.

6-2 Permission and Legal Procedures

6-2-1 Authorization to Commence Water Supply Expansion

In order to obtain the authorization to commence the water supply expansion, the procedure does not require long time, because the SRWSA Board Council consists of representatives of seven public organizations which include the representatives of MIME and MOEF. The seven representatives are as follows:

1) MIME
2) MOEF
3) APSARA
4) Siem Reap Governor
5) Council of Ministers
6) General Director of SRWSA
7) Employee Representative of SRWSA

In addition, this project is under supervision of the Steering Committee which consists of five members. The representatives of the five members are from almost same organizations of the Board Council. Namely:

1) MIME
2) APSARA
3) Siem Reap City
4) JICA
5) General Director of SRWSA

The existence of this Steering Committee is also one factor to enable smooth promotion of the Project.

6-2-2 Procedures before Project Commencement

Above mentioned proceedings are prerequisite of all other subsequent procedures. Based on the authorization of MIME and MOEF, the following procedures are taken.

1) EIA
2) Water Intake Activity
3) Occupation of Civil Structures in the Lake, Community Fisheries, Inundated Forest Area, Multiple Use Area, Biosphere Reserve
   Note: As to the designated areas above zones and areas, see maps in Chapter 11.
4) Land Acquisition
5) Loan Agreement
6) Permission of Construction

6-2-3 Land Acquisition

On negotiations SRWSA, to begin with, talks with the chief of commune and then the chief of commune negotiates with the landowners. When the negotiation could not reach agreement, SRWSA needs to change the candidate lands to other places. Although it sometimes seems to require time, the time required to buy will be about three months, because the fund is of SRWSA and approvals is gotten only from SRWSA Board.

Public land is relatively easy to obtain and the payment will not be accrued.

According to the SRWSA, they are very prudent to acquire lands because it requires the big fund and their responsibility of acts. In the scheduling of respective proceedings, the timing relations among the permission of EIA, negotiation with landowners, securing of fund for land acquisitions and compensations, and negotiation with international funding institute are intricately-intertwined with each other. Therefore, the scheduling and its executions have to be done carefully.

6-2-4 Main Procedures during Detailed Design and Construction Stage

Building Permission

Building permission is done according to the Sub-Decree 86 named “Sub-decree on construction permit”. According to the Department of Land Management, Urban Planning and Construction (DLMUPC), they don’t have an upper decree of the Sub-Decree 86.

For the procedure of permission, the owner of the project submits three applications as follows:

1) Permission for construction,
2) Permission for opening site, and
3) Permission for closing site.

The permission for construction requires 45 working days from the application, but the permission in case of SRWSA presupposes to obtain the permissions from MIME beforehand.

For the application of permission for construction the owner prepares the organization of the construction and drawings. The drawings to submit consist both of architectural drawings and structural drawings but structural calculation is not necessary to submit. All drawings for submission must be written in Khmer language according to DLMUPC.

6-2-5 Application of Electricity Leading-In

All the flow of the procedure is as follows:

- Application is submitted to EdC.
- Site survey of EdC.
- In case the result of survey has no problem, license is given from EdC.
- Detailed design by the Consultant.
- Consultation with EdC on standards of electric design.
- Construction starts.
- EdC controls the construction from the start to the end.
- If the construction conforms to EdC’s standards, EdC approves the construction.
- SRWSA submits the application of connection.
- SRWSA concludes the contract with EdC.

6-2-6 Procedures of Distribution Pipeline Works

For the implementation of the construction, the following matter will be considered.

- Occupying work pieces documents must be submitted and permitted from the Provincial Hall. Exact plan is required and any kind of change must be updated.
- Construction site must be well organized, cleaned and arranged, especially for tourism.
- Safety control must be done by experts and be specialized. For safety construction in roads, DPWT doesn't have exact technical standards. In the construction inside the downtown side, the police department has to involve for working process, but it is in the country side putting the sign boards is usual.
- In the construction stage buried structures such as telecommunication cable, electric cable and optical fiber cable must be paid attention and the contractor must request witnesses.
- In case detour is necessary, the contractor shall manage for that and put the signs.
- Before the construction commencement the contractor side should announce to the people around the sites by letter and the like regarding the site location, length of construction, construction influences and the project benefit. The notice of benefit is important to obtain their attention and cooperation. Public relations and explanation to commune chief is also important.

Table 6.3 List of Proceedings

No.	Proceedings	Competent Authority	Required Time	Remarks
(1 stage): Authorization of Expansion				
1	Authorization of water supply expansion	MIME, MOEF	2-3 weeks (2months)	-When 2 months elapse, the application will be approved automatically.
(2 stage): After MIME permission before Land Acquisition				
2	Permission for taking water in and occupation work pieces	TSA	1 month	-Intake chamber/Tower and Raw water conveyance pipeline.
3	Permission for taking water in	MOWRAM		
4	Biosphere Reserve's permission	Tonle Sap Biosphere Reserve Office of UNESCO (MOE)	Included in the No. 2 procedure	-Construction of raw water conveyance pipeline in Buffer Zone.
5	EIA permission	Department of EIA (MOE)	2-3months	-Refer to Chapter 11.
6	Landscape Protection Area's permission for water main works	Department of Protected Area (MOE)	Included in EIA	-Refer to Chapter 11.
7	Multiple Use Area's permission	Department of National Park (MOE)	1 month	-Refer to Chapter 11.
8	Community Fisheries' permission	Fisheries Administration (MOAFF)	1 month	-Refer to Chapter 11. -Pump station and raw water conveyance pipeline. (Beforehand negotiations for compensation and land acquisition are necessary)
9	Strictly Protected Inundated Forest Area's permission	Fisheries Administration (MOAFF)		-Refer to Chapter 11
(3 stage): After Loan Agreement and during Detailed Design				
10	Permission for construction (of building)	Department of Land Management, Urban Planning and Construction (DLMUPC)	45days before construction	-If architectural design is conform to Cambodian style, other examinations can be smooth. Before construction, but before closing detailed design work.
11	Application of electricity leading-in	Electricité du Cambodge （EdC）	1 week	-The first application is to be done at the beginning of the detailed design stage and discussion is to be done on the standards.
12	Occupying work pieces permission for water mains	Siem Reap Provincial Hall	Short term	
13	Negotiation for repair payment of road pavements	Department of Public Works and Transport (DPWT)	1-2months	-Approval and negotiation of road repair payment.
(4 stage): During Construction				
14	Permission for opening site/closing site	DLMUPC	1 week	-Applications are sent at the beginning and the end of the construction.
15	Permission for connection of electricity	EdC	1 week	-EdC controls from start to end. -Finally the contract is concluded.

Note: ■ marks denote activiteis of procedures.

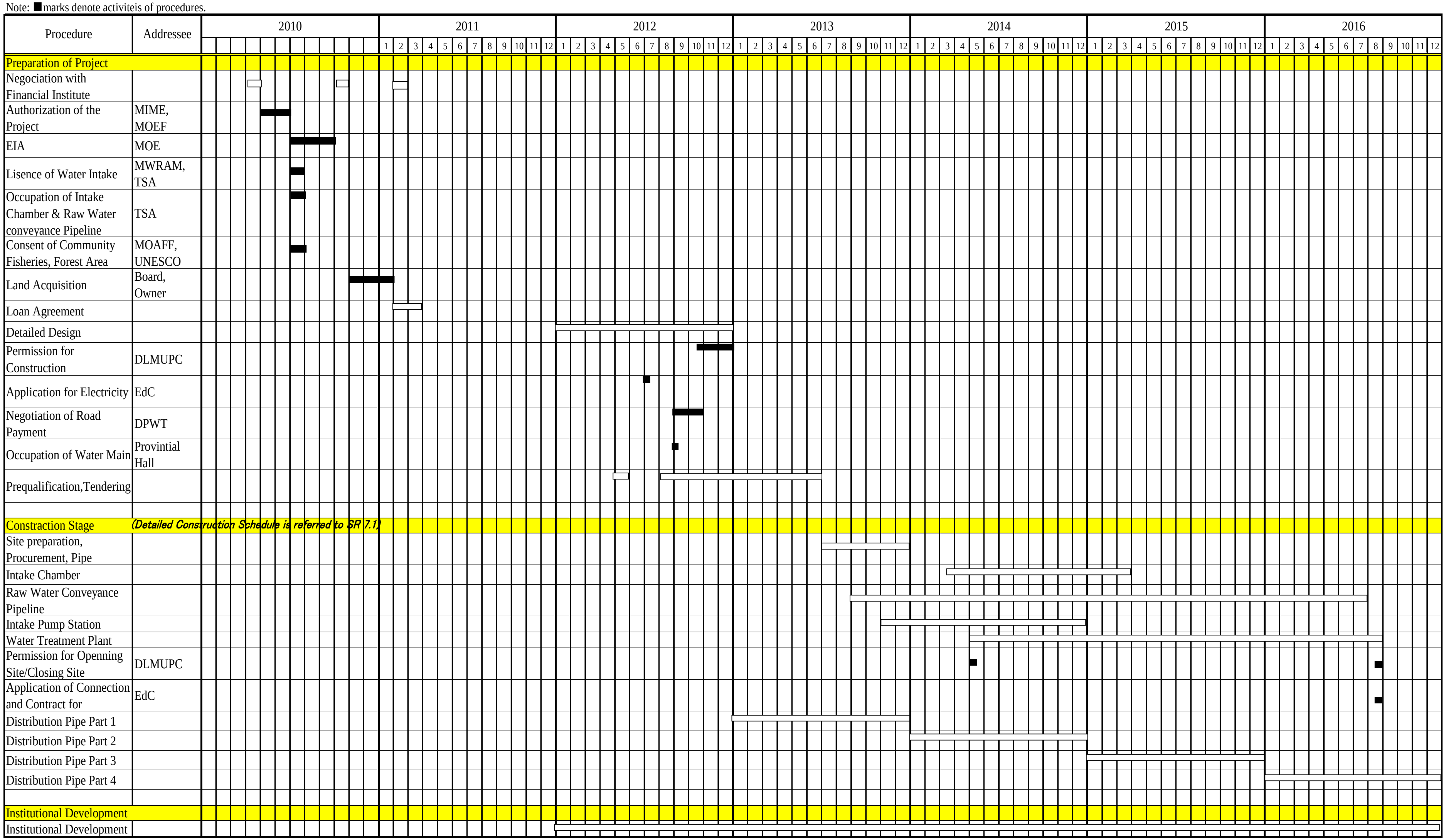


Figure 6.1 Proposed Legal Procedures for Obtaining Permissions

6-3 Procedures for Sound Management

Main issues of the captioned matter are restriction for groundwater collection and revision of water rate of commercial use. The followings are the current situations and regulations regarding these issues.

6-3-1 Restriction for Groundwater Collection and Switch to SRWSA Water

There are four organizations which are thought to have relations with groundwater resources of hotels, namely:

- MOWRAM/ DWRAM
- SR Provincial Governor
- APSARA
- SRWSA

According to the Water Resources Management Law;

Water and water resource belong to the Government of Cambodia (Article3), practicing the water resource management law is under MOWRAM jurisdiction (Article 6), MOWRAM has a duty to keep the balance of water demand on economic development and regional environment in the present and future (Article 9), MOWRAM has a duty to groundwater management (Article 10), using water resource over limited in domestic or small scale usage must be applied for license (Article 12), the government can amend the water license for public advantage (Article 16), MOWRAM can cancel the water license in the cases that negative impact on public health or the environment (Article 17), and non-drilling zones for groundwater collection shall be defined in Sub-decree (Article 20).

Although MOWRAM has all groundwater related rights and the restriction of groundwater collection is stipulated in the Article 20, as “non-drilling zones for groundwater collection shall be defined in Sub-decree”, the decree has not determined/published yet. Regarding this matter DWRAM answered to the study team like following;

“MOWRAM/Cambodia has no strict rules because we don’t have enough supplied-water. Even if we have enough supplied-water, when the price is high, we can not prohibit people to use groundwater. MOWRAM has no Sub-decree of Article 20 at the moment. Now MORAM is preparing the Sub-decree for water resource management. As to the policy/decree to make hotels switch their water source to SRWSA water in order to keep the groundwater level, there is no strict rule.”

For these legal situations the General Director of SRWSA answered in the interview on 19 March, 2010, SRWSA and MOWRAM will consider and enact the Sub-decree of Article 20 for prohibiting all the hotels and commercial entities from using groundwater and enforce to switch water from well to water works. In addition he mentioned that prior to this Project, the project of KTC (a Korean private company) will start its construction of water treatment facilities of 17,000 m^3/day and then will start the operation earlier than the Project of this JICA Feasibility Study, therefore the above mentioned Sub-decree will have been enacted when this JICA Project completes.

It is then recommended that the following actions should be taken by each organization to ensure passage of a law and/or decree that bans the absorption of groundwater once the Project is implemented.

Firstly, SRWSA should request MOWRAM to take legal actions to enact the sub-decree for restriction of groundwater collection under Article 20 of the “Water Resources Management Law”, which shall identify “non-drilling zones for groundwater collection and prohibit extraction of the groundwater sources in the SRWSA service areas in Siem Reap City. The sub-decree would be enacted once the Project is implemented so that SRWSA should coordinate with MOWRAM to enact the sub-decree in accordance with the proposed water supply development plan.

Secondly, SRWSA should make effort to disseminate the following advantages of switching from their current groundwater use to the SRWSA new water.

- SRWSA is not a profitable organization but its water production cost should be properly and fully supported by the water users/beneficiaries,
- SRWSA water tariff for residents is not costly compared to the alternative water supplies such as sold drinks as bottled waters, water sold by water seller, etc.,
- SRWSA water tariff for commercial is not costly compared to their current water production cost including the O&M and regular rehabilitation costs of their own water production facilities,
- SRWSA water is clean and safe to meet the drinking water standards, which bring about many unquantifiable benefits to the health and quality of life of the water users/beneficiaries,
- SRWSA water with a sufficient pressure can reduce the burden of fetching water that typically falls on women and children, contributing indirectly to greater labor forces productivity especially in the non-service areas. As a result, school attendance and educational achievement of children could be improved,

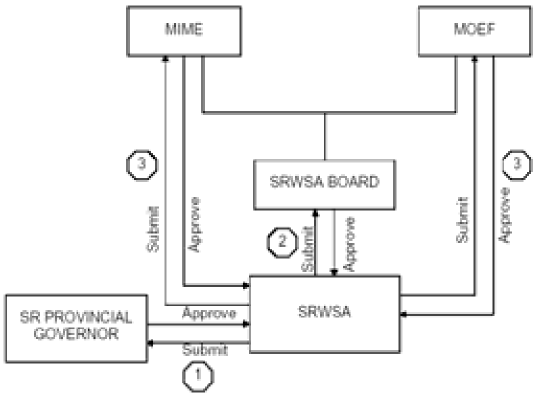
- Eventually, beneficiaries switching over from groundwater sources to the SRWSA new water supply systems will be able to contribute to the promotion of elimination of land subsidence thread in the area which possibly causes a positive impact to the Angkor heritages.
- Preservation of the Angkor heritages will be an aid of tourism industry development in Siem Reap City. Development of tourism industry will eventually support and reinforce of the local economy in Siem Reap.

Likewise, the Siem Reap Province should play an important role to issue the following provincial ordinance to the current groundwater users to encourage using the SRWSA water in close coordination with SRWSA as well as APSARA.

- Transition period for switching to SRWSA water from the current groundwater use should be considered to implement switching to the SRWSA water smoothly in mitigation of the financial burden of the current groundwater users, and on the other hand
- Taxation for groundwater use can be considered to impose the current groundwater users to switch to the SRWSA water as a kind of penalty for the groundwater use.

6-3-2 Revision of Water Rate

Fist SRWSA requests the approval of the Provincial Governor, and then SRWSA submits the proposal of the revision to the SRWSA Board Council and finally request the final approval to MIME and MOEF. The flow of the revision is shown in Figure 6.2.



Note: Numbers of 1,2,3 denote the sequence of procedures

Figure 6.2 Flow of Water Rate Revision

6-4 Construction Plan and Schedule

6-4-1 Intake Facilities and Raw Water Conveyance Facilities

(1) General

- Construct access road to the site by cutting and/or filling with imported earth and/or gravels
- Provide temporary fencing
- Clear site and provide site office, stores, workshop, and parking area for vehicles, plant and equipment
- Establish water, electricity and telephone services
- Divert waterways as required
- Remove the trees from the route of access road

(2) Raw Water Intake Chamber, Raw Water Conveyance Pipelines, Raw Water Intake Pump Station, Raw Water Conveyance Main

- Place access road to the Tonle Sap Lake site and pump station site
- Place coffer dam at the construction area within the Tonle Sap Lake
- Provide dewatering and excavate soil to the required formation level
- Cast the concrete structure with openings left for pipe works, penstocks etc.
- Install pipes, gates, penstocks, ladders, pumps and other M & E works.
- Test for water tightness and repair if there are leakages.
- Remove coffer dam
- Remove surplus earth, debris etc. and dispose of at an approved location
- Commission the plant.
- Remove top soil and fill and compact site to the base level
- Set out the structure
- Drive bored/in-situ R.C piles socketed into the bed soil
- Build the structure leaving openings for pipeworks, valves, penstocks, gates,etc.
- Install pipeworks, valves, penstocks, instrumentation, electrical wiring and other mechanical/electrical works.
- Test the structure for water tightness and repair if there are leakages.
- Provide landscaping
- Disinfect and test run the structure
- Commission the structure.

6-4-2 Water Treatment Plant

(1) General

- Provide temporary access road to the site by cutting and/or filling with imported earth
- Provide the residents with casual roads with imported earth or gravel
- Clear site where necessary
- Execute earthwork for the internal roads
- Divert waterways as required.
- Provide temporary fencing
- Establish site office, toilets, stock piling area, workshops, and parking area for vehicles, plant and equipment.
- Provide water, electricity and telephone services to the site

(2) Distribution Chamber/Flocculation Basin/Sedimentation Basin/Filtration Unit/Clear Water Reservoir/Transmission Pump Station/Administration Building/Chemical Building

- Remove top soil and fill approximately 3 to 5 m and compact site to the base level
- Set out the structure
- Drive bored/in-situ R.C piles socketed into the bed soil
- Build the structure leaving openings for pipeworks, valves, penstocks, gates,etc.
- Install pipeworks, valves, penstocks, instrumentation, electrical wiring and other mechanical/electrical works.
- Test the structure for water tightness and repair if there are leakages.
- Provide landscaping
- Disinfect and test run the structure
- Commission the structure.

(3) Clear Water Reservoir, Clear Water Pump Station, Backwash Recovery Facility, and Maintenance Building

- Remove top soil and level site as required
- Sheet pile, if any, and excavate to the formation level of the structure
- Arrange for dewatering system, if any
- Build the concrete structure providing openings for pipe installations.
- Install pipeworks, valves, pumps, instrumentation, electrical wiring and other mechanical and electrical works.
- Test the structure for water tightness and repair if there are any leakages.
- Provide landscaping
- Disinfect and test run the structure
- Commission the structure

(4) Sludge Drying Beds

- Remove top soil and level site as required
- Excavate to the foundation level
- Excavate the bottom 1 - 2 m below the foundation level
- Install dewatering
- Improve the ground by filling with moist compacted sand up to foundation level.
- Fill and compact the interspace in between the beds to the shape in stages up to the top level.
- Rubble pack the walls
- Tidy up the site and landscape
- Commission the beds

(5) Landscaping

- Relocate the existing stream, if any
- Construct access roads
- Complete all structures and pipe works
- Tidy up the site
- Landscape

6-4-3 Distribution Facilities

(1) Distribution Pipes

- Obtain road authority approval for trenching and culvert/ bridge crossings
- Obtain police approval for the commencement of work and traffic control arrangements.
- Notify respective local authority, public and private transport companies etc.
- Inform public utility agencies (e.g. SRWSA, Telecom, EdC), and obtain their services to identify the locations of their underground utilities, and to assign their staff to stay with

the contractor in critical areas of likely damage. Furthermore, these authorities should be kept informed to attend to any damage to the services promptly

- Notify residents/general public/traffic about the impending work and the likely inconveniences that may cause to them during the construction period by paper advertisements, electronic media, public address system and by hand bills.
- Study the road safety requirements and procure all necessary sign boards and other implements to comply with the requirements laid down by the Police.
- Investigate and decide locations where machine excavation, manual excavation, rock excavation, shoring, sheet piling, dewatering etc, will be required. The type of excavators, the suitability of excavated earth for backfilling or not etc., also could be ratified.
- Decide on the most appropriate dewatering system (e.g. well point system, sump method, direct dewatering)
- Study areas where any existing structures/properties are likely to be damaged and decide suitable methods to avoid such damages
- Study areas where any temporary relocation of people living around is needed and take necessary measures in this regard.
- Investigate on the need to divert/relocate existing services to facilitate the pipe laying and arrange for such diversions/relocations with the respective agencies.
- Arrange a suitable borrow pit in a nearby convenient area to procure imported earth if necessary.
- Arrange a stockpiling area for bulk storage of river sand, borrow earth, bedding materials, road reinstatement materials etc., These materials should be protected from rain by covering with polythene sheets/ tarpaulins or by other approved methods.
- Arrange a tipping area for disposing of surplus/unsuitable excavated earth, excavated road materials, and debris.
- Establish site offices (mobile or otherwise) complete with water, electricity, telephone and toilet facilities.
- Carry out trial holing to identify the configuration of the existing underground utilities and to decide on the most suitable route for the pipe laying causing minimum damage/disturbance to these services.
- Barricade the site and mobilize pipe laying crews and machinery
- Barricade the sites and mobilize chamber construction/manhole construction/bridge crossing/culvert crossing crews.
- Pipe laying to be followed by earth compaction tests.
- Carry out temporary reinstatement of the road along with the progress of pipe laying by the Contractor.
- Dispose of all surplus/unsuitable excavated earth and other debris.
- Install different types of valves.
- Flush and pressure test the main in sections and repair any leakages.
- Disinfect the main
- Carry out pressure test over the whole section in one operation
- Carry out permanent reinstatement of the road by the Contractor or respective road authorities
- Tidy up the site

(2) Water Pipe Bridge

- Inform the authorities about the commencement of this work
- Provide temporary access road and working area for the machines (cranes, pile driving rig, concrete truck mixers, pump cars, trucks) on either side of the riverbanks by filling with imported earth.

- Provide fencing
- Set out the bridge and provide coffer damming for the pier foundations
- Drive bored piles for the end pier foundations socketed into the bedrock.
- Excavate to the bedrock for the centre pier with dewatering arrangement
- Cast the foundation of the centre pier socketed into the bedrock and continue to the top
- Backfill the foundation excavation with rock fill.
- Cast the pile caps to the two end piers and continue to the top.
- Transport and install the prefabricated bridge on the piers, by the cranes.
- Provide backfilling where necessary
- Provide painting of the bridge against corrosion (if not done before)
- Install the water main.
- Remove the sheet piles/coffer damming and tidy up the site and remove site office
- Restore the original waterway of the river.

6-4-4 Elevated Water Tank

- Excavate for foundations
- Drive bored/in-situ R.C piles socketed into the bed sand (piles for filter units for future extension will be included), if any
- Construct the circular foundation and ring beam with reinforcement starter bars for ring wall
- Construct the ring wall
- Erect a temporary platform to support the formwork for the tank
- Form and place concrete for the tank base dome and conical section
- Form and place concrete for the tank base beam, tank wall and the beam at the top
- Construct the piping gallery within the tank area
- Form and concrete the top dome
- Construct platforms and stairs inside the tower
- Install tower piping and connect to yard piping
- Clean the tank
- Fill the tank with clean water and test for leakage
- Disinfect the reservoir
- Connect the old tank if appropriate
- Connect outlet to distribution system

6-5 Procurement Plan

(1) Concrete, Pile, Sand, Gravel, Brick

These materials are easily procured in Siem Reap/Phnom Penh since they are manufactured in the city.

(2) Reinforcement Bar, Sheet Pile, Form

These materials are not produced in Cambodia. However, they can be obtained from local agencies in Siem Reap/Phnom Penh without difficulty. While a brand new sheet pile can be purchased from the agencies, it cannot be obtained as a leased material.

(3) Pipe

DCIP, HDPE and Steel pipe are not produced in Cambodia. These pipes should be imported from other countries. Concrete pipe is manufactured in Cambodia. They can be obtained from local agencies in Siem Reap/Phnom Penh without difficulty.

(4) Mechanical and Electrical Equipment

Major mechanical and electrical equipment such as pumps, chemical equipment, valves, control panels and power receiving/transforming equipment are not produced in Cambodia. These equipments must be imported from other countries.

(5) Construction Machinery

Construction machinery, such as backhoes, bulldozer, dump trucks and pile drivers, can be leased in Siem Reap/Phnom Penh.

Chapter 7.
Project Cost Estimates

Chapter 7. Project Cost Estimates

7-1 Composition of Project Costs

The project cost consists of following cost items.

1) Direct construction cost,
2) Engineering service cost,
3) Institutional Development Cost,
4) Land Acquisition cost,
5) Physical contingency; 10 % of 1) + 4), 5 % of 2)+ 3)
6) Compensation,
7) Administration Cost; 1.5% of the direct construction costs plus all the physical contingencies, and
8) Price contingency; (1.8% of FC portion and 7.9% of LC portion)

The project cost is estimated based on market prices of 2010.

7-2 Conditions and Assumptions for Cost Estimates

Construction conditions are considered availability of locally hiring heavy equipment and locally acquiring construction materials as well as suitability of the construction method. Some materials which are not available to be procured in Cambodia must be imported from other countries. Costs of those imported materials are included import/transport cost.

The price includes the entire Contractor's financial and administrative costs including costs of liaison with external agencies, profits, and overheads.

Table 7.1 Component Division of Foreign and Local Portion

Item	Material	Foreign Portion	Local Portion
(1) Civil Works	Labor		O
	Sand, Gravel		O
	Concrete		O
	Form	O	O
	Reinforcement Bar	O	
	Pile		O
(2) Pipe and Fittings	DCIP	O	
	HDPE	O	
(3) Mechanical/Electrical Equipment	Pump	O	
	Sludge Collector	O	
	Valve	O	
	Control Panel	O	
	Transformer	O	
(4) Construction Machinery			O
(5) Building Works	Brick		O
	Indoor Materials	O	O

The project cost estimates are divided into the foreign currency portion (FC) and local currency portion (LC). The unit construction costs are divided into foreign and local currency portions according to certain ratios that take account of market conditions in Cambodia and other water supply projects currently being implemented. Local currency is denominated in US dollars, which are widely circulated and commonly used for daily transactions in Cambodia.

The division of foreign and local portions for each project component is shown in Table 7.1.

7-3 Estimate Approach

The project cost is estimated based on engineering designs and quantities as shown in Table 7.2. The engineering design indicates typical general drawings for facilities and the drawings indicates structural drawings for facilities. The engineering plans are established by a theoretical trial calculation such as hydraulic pipe network calculation.

Table 7.2 Base of Construction Quantities

Facilities	Base of Estimation
Intake Chamber	Engineering Design & Drawings
Raw Water Conveyance Pipe Line	Engineering Design
Intake Pumping Station	Engineering Design & Drawings
Raw Water Conveyance Pressure Main	Engineering Design
Water Treatment Plant	Engineering Design & Drawings
Water Distribution Complex	Engineering Plans
Water Transmission Pipe Line	Engineering Plans
Water Distribution Pipe Line	Engineering Plans

Unit prices and lump sum prices are collected from international constructors which have the real construction experience in Cambodia and took into consideration recent award contracts prices in Cambodia. Furthermore the unit cost was referred to the Project cost estimation for Water Supply Project in Phnom Penh. The costs are inclusive of 10 percent VAT (value added tax) of the LC portion.

7-4 Direct Construction Cost

The direct construction costs for the Priority Project are shown in Table 7.3. The direct cost consists of civil works and electro-mechanical works. The detailed cost estimation is referred to **SR 7.1.**

7-5 Engineering Service Cost

The engineering service covers Detailed Design, P/Q and Tendering and Construction Supervision. The costs are estimated at around US$5.25 million.

7-6 Institutional Development Cost

The management of water treatment facilities requires suitable number of staffs, an individual skill and an institutional system. The institutional development cost is estimated at US$920 thousand.

7-7 Land Acquisition and Compensation Costs

The required land area for the project is approximately 6 hectares as shown bellow.

1) Intake Pumping Station (80 m x 80m) = 0.64 ha
2) Water Treatment Plant (220 m x 180 m) =3.96 ha
3) Access Road from WTP to PS (width 3.5 m x 2 Lines x 3,000 m) = 2.1 ha
4) TOTAL AREA = 0.64 + 3.96 +2.10 = approx.6 ha

The land acquisition cost is estimated at US$300,000 based on the recent local land sales price which is provided by SRWSA.

7-8 Physical Contingency

The physical contingency is fundamental counter measure against increase of work amounts and material quantities caused by unpredictable matters through the project. 10 percent of the direct cost and land acquisition cost and 5 percent of engineering services and institutional development costs are employed in this study.

7-9 Compensation

The construction works will affect local resident's activities which are supposed to be an agriculture and fishery. The project includes compensations for concerned resident. The concept of compensations for them is shown bellow.

- Agriculture

  Occupation Area (Law Water Conveyance Pipeline); 9,600 m x 30 m
  =28.8 ha
  Occupation Period; 3 years (same as construction period)
  Farming Productivity; 4 t/ha, 1,000 Riel/kg (4,165 Riel = 1 USD)
  28.8 x 4 x 1,000 x 1,000 x 3 ÷ 4,165 = <u>83,000 USD</u>

- Fishery

  Occupation Width (Law Water Conveyance Pipeline);
  Construction width + Clearance = 150 m
  Existing Total Width of Fisheries = 1,500 m
  Occupation Period; 5 years (Forest Recovery Time)
  Fishing Productivity; 3t/year, 5 USD/kg
  150 ÷ 1,500 x 3,000 x 5 x 5 = <u>7,500 USD</u>

7-10 Administration Cost

Cambodia concerned authorities will pay extra administrative cost for dealing with the project. The administration cost is estimated 1.5 percent of the direct construction costs plus all the physical contingencies.

7-11 Price Contingencies

Price contingencies applied in this study are those escalation rates of 1.8 percent for FC portion and 7.9 percent for LC portion, respectively.

7-12 Priority Project Cost

The priority project costs are shown in the following tables.

Table 7.3 Priority Project Cost

Item	Cost(1,000US$)				
	FC	TAX(FC)	LC	TAX(LC)	Total
Civil Works	**16,932**	**0**	**23,399**	**2,340**	**42,672**
Intake Chamber	16	0	132	13	162
Water Conveyance Pipe	1,448	0	11,710	1,171	14,328
Intake Pump Station	555	0	739	74	1,368
Water Treatment Plant	2,507		5,627	563	8,697
Elevated Water Tank	228	0	553	55	836
Transmission/Distribution Pipelines	12,178	0	4,638	464	17,280
Mechanical/Electrical Works	**8,148**	**0**	**1,136**	**114**	**9,397**
Intake Pumping Station	2,086	0	259	26	2,371
Water Treatment Plant	6,062	0	877	88	7,027
Direct Construction Cost : (A)	**25,080**	**0**	**24,535**	**2,454**	**52,069**
Physical Contingency (10%) for (A) : (A)'	**2,508**	**0**	**2,454**	**245**	**5,207**
Price Contingency (FC:1.8%, LC;7.9%) for (A)+(A')	**2,215**	**0**	**11,423**	**1,142**	**14,780**
Engineering Services : (B)	**4,200**	**0**	**954**	**96**	**5,250**
Physical Contingency (5%) for (B) : (B')	**210**	**0**	**48**	**5**	**263**
Price Contingency (FC:1.8%, LC;7.9%) for (B)+(B')	**278**	**0**	**304**	**30**	**612**
Institutional Development : (C)	**860**	**0**	**55**	**5**	**920**
Physical Contingency (5%) for (C) : (C')	**43**	**0**	**3**	**0.3**	**46**
Price Contingency (FC:1.8%, LC;7.9%) for (C)+(C')	**68**	**0**	**22**	**2**	**91**
Land Acquisition : (D)	**0**	**0**	**273**	**27**	**300**
Physical Contingency (10%) for (D) : (D')	**0**	**0**	**27**	**3**	**30**
Price Contingency (FC:1.8%, LC;7.9%) for (D)+(D')	**0**	**0**	**24**	**2**	**26**
Social Compensation; (E)	**0**	**0**	**83**	**8**	**91**
Price Contingency (FC:1.8%, LC;7.9%) for (E)	**0**	**0**	**7**	**1**	**7**
Administration Cost (1.5% of the above total)	**0**	**0**	**864**	**86**	**951**
Total Project Cost	**35,461**	**0**	**41,074**	**4,108**	**80,642**

Notes: Project cost is rounded in 100 thousand US$. Price Contingency is based on compound interest.

7-13 Disbursement Schedule

The disbursement schedule for the project is shown in Table 7.4.

Table 7.4 Disbursement Schedule

	Total	2009	2010	2011	2012	2013	2014	2015	2016
Total Direct Construction Cost	52,069	-	-	-	-	11,108	15,119	16,226	9,615
- Foreign Component	25,080	-	-	-	-	7,287	6,570	7,177	4,046
- Local Component	24,535	-	-	-	-	3,474	7,772	8,227	5,063
- Tax on Local Comp	2,454	-	-	-	-	347	777	823	506
Physical Contingency	5,207	-	-	-	-	1,111	1,512	1,623	962
- Foreign Component	2,508	-	-	-	-	729	657	718	405
- Local Component	2,454	-	-	-	-	347	777	823	506
- Tax on Local Comp	245	-	-	-	-	35	78	82	51
Price Contingency	14,780		-	-	-	1,518	3,877	5,341	4,044
- Foreign Component	2,215		-	-	-	441	535	737	503
- Local Component	11,423		-	-	-	979	3,039	4,186	3,219
- Tax on Local Comp	1,142		-	-	-	98	304	419	322
Engineering Services	5,250	-	-	545	1,091	1,091	1,091	1,091	341
- Foreign Component	4,200	-	-	436	873	873	873	873	272
- Local Component	954	-	-	99	198	198	198	198	63
- Tax on Local Comp	96	-	-	10	20	20	20	20	6
Physical Contingency	263	-	-	27	55	55	55	55	17
- Foreign Component	210	-	-	22	44	44	44	44	14
- Local Component	48	-	-	5	10	10	10	10	3
- Tax on Local Comp	5	-	-	1	1	1	1	1	0
Price Contingency	612	-	-	17	71	109	149	191	74
- Foreign Component	278	-	-	8	33	50	68	86	32
- Local Component	304	-	-	8	34	53	74	96	38
- Tax on Local Comp	30	-	-	1	3	5	7	10	4
Instituional Capacity Developm	920	-	-	-	183	183	183	183	188
- Foreign Component	860	-	-	-	172	172	172	172	172
- Local Component	55	-	-	-	10	10	10	10	15
- Tax on Local Comp	5	-	-	-	1	1	1	1	1
Physical Contingency	46	-	-	-	9	9	9	9	9
- Foreign Component	43	-	-	-	9	9	9	9	9
- Local Component	3	-	-	-	1	1	1	1	1
- Tax on Local Comp	0	-	-	-	0.1	0.1	0.1	0.1	0.1
Price Contingency	91	-	-	-	9	13	17	22	30
- Foreign Component	68	-	-	-	7	10	13	17	20
- Local Component	22	-	-	-	2	3	4	5	9
- Tax on Local Comp	2	-	-	-	0.2	0.3	0.4	0.5	1.0
Land Acquisition	300	-	-	300	-	-	-	-	-
- Foreign Component	0	-	-	0	-	-	-	-	-
- Local Component	273	-	-	273	-	-	-	-	-
- Tax on Local Comp	27	-	-	27	-	-	-	-	-
Physical Contingency	30	-	-	30	-	-	-	-	-
- Foreign Component	0	-	-	0	-	-	-	-	-
- Local Component	27	-	-	27	-	-	-	-	-
- Tax on Local Comp	3	-	-	3	-	-	-	-	-
Price Contingency	26	-	-	26	-	-	-	-	-
- Foreign Component	0	-	-	0	-	-	-	-	-
- Local Component	24	-	-	24	-	-	-	-	-
- Tax on Local Comp	2	-	-	2	-	-	-	-	-
Social Compensation	91	-	-	91	-	-	-	-	-
- Foreign Component	0	-	-	0	-	-	-	-	-
- Local Component	83	-	-	83	-	-	-	-	-
- Tax on Local Comp	8	-	-	8	-	-	-	-	-
Price Contingency	7	-	-	7	-	-	-	-	-
- Foreign Component	0	-	-	0	-	-	-	-	-
- Local Component	7	-	-	7	-	-	-	-	-
- Tax on Local Comp	1	-	-	1	-	-	-	-	-
Project Administration	951	-	-	1	1	203	275	296	175
- Foreign Component	0	-	-	-	-	-	-	-	-
- Local Component	864	-	-	1	1	184	250	269	159
- Tax on Local Comp	86	-	-	0	0	18	25	27	16
Total project Cost	80,642	-	-	1,045	1,419	15,399	22,288	25,037	15,455
- Foreign Component	35,461	0	0	466	1,137	9,614	8,940	9,830	5,473
- Local Component	41,074	0	0	526	255	5,259	12,134	13,824	9,075
- Tax on Local Comp	4,108	0	0	53	26	526	1,214	1,383	907

Notes : Figures are rounded.

7-14 Operation and Maintenance Cost

The water supply facilities should be kept such conditions through proper operation and maintenance as to show the given function at any time, namely so to supply enough good water demand with pressures and quality required.

The daily operation of the facilities requires chemicals for water treatment processes and electricity for mechanical plant operations. The maintenance of the facilities requires periodical check, cleaning, repair and replacement of parts/devices/functions.

The operation and maintenance are implemented by well trained technical staffs and the management of such operation and maintenance is conducted by administrative personnel.

The operation and maintenance cost for the water supply system consists of following items.

1) Salaries & Wages Cost,
2) Power (Electricity) Cost,
3) Chemical Cost,
4) Maintenance Expense Cost,
5) Administrative & General Expense Coast

The annual operation and maintenance cost is total of the above costs.

7-14-1 Salaries & Wages Cost

The real personnel cost of SRWSA in 2009 was 139,000 USD/year reported by SRWSA Data. It was based on a total of 40 staffs and 290 USD/Month/Person of average salary. The number of staffs for the operation and maintenance of Priority Project's facilities will be increased according to the raise of service connection number. The personnel cost in 2017 is estimated at 345,000 USD/year.

7-14-2 Power Cost

The current power cost for the existing WTP is 183,000 USD/year with 3,285,000 m^3 of annual water production reported by SRWSA Data. The power cost for Priority Project is estimated based on an electric consumption (kW/h) for the proposed mechanical/electrical plants. The water productivity of Priority Project gradually rises up to 30,000 m^3/d in accordance with the water demand and the service connection increase. The total power cost in 2017 is estimated at 220,000 USD/year.

7-14-3 Chemical Cost

The current chemical cost for the existing WTP is 37,000 USD/year with 3,285,000 m^3 of annual water production reported by SRWSA Data. The consumption of the chemicals for Priority Project as well as the power consumption is gradually increased. The total chemical cost in 2017 is estimated at 47,000 USD/year.

7-14-4 Maintenance Expense Cost

The water supply facilities require regular maintenances such as machinery repair, replacement of small scale devices, lubricants and fuels. SRWSA currently costs 6 percent of the gross value of utility plants for the maintenance reported by SRWSA Data. The total maintenance cost in 2017 is estimated at 252,000 USD/year.

7-14-5 Administrative & General Expense Cost

The management of the water supply system requires budgets for administrative activities and other miscellaneous expenses. The current administration cost for the existing WTP is 265,000 USD/year reported by SRWSA Data. The total administrative cost in 2017 is estimated at 207,000 USD/year.

Chapter 8
Financial and Economic Analysis on Priority Project

Chapter 8. Financial and Economic Analysis on Priority Project

8-1 Introduction

This report discusses the financial and economic considerations of the recommended Priority Project (The Project). In particular, the following aspects have been taken into consideration:

(1) The past and present financial performance and condition of SRWSA;

(2) Sources of Funds;

(3) Water tariff and Affordability Consideration;

(4) Financial Internal Rate of Return (FIRR) and debt service coverage ratio; and

(5) Economic Internal Rate of Return (EIRR).

8-2 Past and Present Financial Performance

The past and present financial performance and condition of SRWSA was undertaken to assessed it's financial capability to contribute counterpart funding, implement the Project; and provide adequate funds to operate and maintain the new infrastructure on a sustainable basis. The review covered the immediate past 3 years – 2007, 2008 and 2009.

Table 8.1 Past and Present Financial Performance, 2007 to 2009

Performance Parameters	2007	2008	2009
Operating Results			
No. of of Billed Connections (SC)	3,146	3,720	3,926
Water Production, m3/year	2,265,545	3,169,208	3,281,897
Water Sold, m3/year	1,821,029	2,766,178	2,822,752
Average Water Tariff, KHR / m3	1,244	1,253	1,360
Number of Staff	44	43	43
Operating Revenue, KHR x million	3,008	3,809	3,885
Operating Expenses, KHR x million	1,836	2,352	3,178
Net Income, KHR x million	559	838	183
Operational Efficiency			
Operating Ratio	81%	75%	96%
Non-Revenue Water	20%	13%	14%
Customer Receivable Turn-over (Days)	15	14	40
Staff Productivity Index	14	12	11
Return on Revenue (ROR)	19%	28%	9%
Financial Status and Condition			
Days of Cash Position	315	386	273
Current Ratio	7.17	4.42	2.33
Days of Working Capital	382	408	285
Capitalization Ratio	1%	4%	10%
Net Worth, KHR x Million	23,061	21,382	19,590

8-2-1 Financial Status and Condition

On the overall, SRWSA's status and condition is financially sound. It is stable, very liquid and highly solvent. SRWSA is in a very good financial position in terms of meeting day-to-day operating needs and has the financial capacity to absorb long-term debt.

- *Cash Position is excellent*. Over the past 3 years, SRWSA has maintained a highly liquid position. In 2009, available cash remains excellent at 273 days supply.

- SRWSA's *Days of Working Capital* has consistently been very good. It averages 11.8 months of its annual operating needs during the past 3 years. Although decreasing to 285 days in 2009, it is still considered more than adequate.
- *Current Ratio* is generally considered adequate at a little over 2 at the end of 2009. A decreasing trend is however observed during the past 3 years.
- The *Capitalization Ratio* is excellent. Currently, the SRWSA remains loan free with its only liabilities are short-term payables.
- SRWSA's *Net Worth* has consistently been excellent during the past 3 years. The utility firm has benefited tremendously from the JICA-grant financing for its existing physical assets.

8-2-2 Operational Efficiency

In general, SRWSA's operational performance is quite good considering its relatively young age as an autonomous entity.

- *Operating ratio* of SRWSA is rather on the high side but expected to improve with the implementation of a new tariff effective November 2009.
- SRWSA's volume of *non-revenue water* (NRW) is very good. It is exceptionally good when compared to the 27% average NRW of some 40 water utilities in Southeast Asia[11], its performance still needs to be improved when compared to the below 10% NRW record of Phnom Penh Water Supply Authority.
- SRWSA's collection performance shows a declining efficiency. In 2009, the number of days of customer accounts receivable is equivalent to 40 days of operating income while the previous two years customer receivables is only 14-15 days.

  The existing guarantee deposit should be reviewed in terms of its effectiveness in covering prospective defaulting water bills. SRWSA should adjust the guarantee deposit from its customers based on the average water bill for say every 6 months. If average water bills exceed the amount of deposit, additional deposit should be required from its customers.
- *Return on Revenue* has declined during the past year. But this is expected to be reversed with the implementation of the new water tariff in November 2009.
- SRWSA's *staff productivity index* (SPI) for the past 3 years show improving efficiency with 11 staff per 1000 in 2009 from 14 staff per 1000 connections in 2007. Further improvement in the SPI can be attained with the increase in customer base.

8-2-3 Prognosis

SRWSA's financial status and condition is sufficiently strong and stabl**e**. Its financial resources in terms of capitalization are more than adequate to fully support long-term debt for its capital expansion program.

8-3 Present and Future Sources of Funds

The SRWSA's sources of funds come primarily from internally generated funds as a consequence

[11] Average NRW of 40 participating utilities as reported in the 2005 Data Book of South East Asia Water Utilities Network published by the Asian Development Bank in 2007 is 27%.

of its operation and donated or Official Development Assistance funds mainly from JICA. Internally generated funds come mainly from water revenues, which is primarily influenced by the water tariff. A small portion comes from other charges consisting of meter maintenance fees, new connection fee, guarantee deposit and surcharge on late payment of customer bills. Together with existing water tariff, these are discussed in the next sections of this report.

8-3-1 Existing Water Tariff

(1) Characteristics

The existing water tariff of SRWSA, which took effect in November 2009, is presented below. It includes the previous tariff for purposes of comparison.

Table 8.2 Water Tariff (KHR/m^3)

Category	Consumption (m^3)	Effective 2006	Effective November 2009
Domestic/ Government	0 to 7	1,200	1,100
	8 to 15	1,200	1,500
	16 to 30	1,200	1,800
	30<	1,200	2,000
Industrial and Commercial	0 to 7	1,400	1,100
	8 to 15	1,400	1,500
	16 to 30	1,400	1,800
	30<	1,400	2,000

Source: SRWSA Commercial Office

(2) Tariff Level

The following table shows the average tariffs for the overall and each customer category with associated unit cost of operation during the past 3 years. As shown below, the commercial/industrial consumers provide a cross-subsidy to both domestic and administration (government) consumers.

Table 8.3 Average Tariff (KHR/m^3 Sold)

Descriptions	2007	2008	2009
Water Sales			
- Domestic	1,200	1,200	1,264
- Commercial	1,400	1,400	1,553
- Administration (Gov't)	1,200	1,200	1,200
- Overall Average	1,244	1,253	1,360
Operating Costs			
Overall Average	810	742	975

Source: SRWSA Commercial Office and Accounting Unit

From the cost recovery viewpoint, SRWSA's water tariffs are considered full cost recovery tariffs as shown by its profitable operations. Overall average tariff in 2009 was KHR1,360 or US$0.33 per m^3 using the exchange rate of KHR4,165 to a US$.

In terms of affordability, the water tariffs are considered affordable. The average monthly water bill of KHR12,804.00[12] is only 0.8 percent of the average monthly income (KH1,594,120) of households in Siem Reap. The generally accepted guideline on affordability is that the water supply charges should not exceed 4 percent of the monthly income of households.

8-3-2 Other Charges

Other charges provide SRWSA some supplemental revenue for its operating requirements. These consist of:

(1) Meter Maintenance Fee

This is a monthly charge applied to connections with no billable water consumption. Monthly charge is only KHR50.00, which is quite miniscule.

(2) New Connection Fee

SRWSA charges a uniform new connection fee of KHR517,500.00 (US$124.25) regardless of category. The fee covers materials from tapping point to owner's property line. In excess of the equivalent amount of the connection, additional cost is to the account of the new connection applicant.

SRWSA's connection fee which is equivalent to 32% of the average income of KHR1,594,120 per month of households in Siem Reap is relatively high and unaffordable to households earning below the average income. This is therefore foreseen as a major obstacle for accessing safe, potable and affordable water particularly that the proposed priority project shall be targeting the rural fringe areas of Siem Reap as the expansion area.

To enable the poor families to have access to the SRWSA's piped water system, the authority has two possible options for promoting individualized house connections among poor families in Siem Reap: (1) installment payment plan for service connection; or (2) special subsidy for financing the individual service connections of poor families.

(3) Guarantee Deposit

Each new connection applicant is required to shell out the amount of KHR77,000.00 (US$18.49) as a guarantee deposit for non-payment of monthly water bills.

(4) Surcharge or Penalty Fee

SRWSA imposes a 1% surcharge (penalty fee) per day for water bills paid beyond the payment due date. Notice of disconnection including amount of surcharge is given to the customer after 10 days. At 1% per day penalty fee for 10 days, this results to an average 10% surcharge for delayed payments.

[12] The existing number of persons per household connection of 5.7 and the average domestic consumption of 60 lpcd for connected households were used. Total monthly consumption is 10.4 cubic meters per month = 5.7 persons x 60 liters per day per person x 1 cubic meter per 1000 liters x 365 days and divided by 12 months. KHR12,804 = 7 m3 x KHR1,100/m3 + 3.4 m3 x KHR1,500/m3.

8-4 Financial Evaluation of the Priority Project

8-4-1 Analytical Approach and Methodology

The analytical approach employed in evaluating the financial desirability of the Project is described as follows:

(1) Revenue Analysis

Per its charter, the SRWSA operates under the principle of full cost recovery, which simply means that all expenses related to providing the water service in Siem Reap plus a reasonable surplus shall be recovered through its water tariffs. In compliance, the following aspects were considered in the estimation of the water tariff per cubic meter:

- All cost - operating cost, depreciation expense, interest expense and taxes shall be recovered from the sale of water. The sum of these estimated costs divided by the total volume of water billed shall be the required average water tariff per m^3.
- No equity infusion by the government. Cash generated from water sales and contracted loans/debts should be sufficient to fund all capital requirements including debt repayment.
- Debt service coverage ratio (DSCR) in any year is not less than one. Cash from operations shall be able to cover interest and principal repayment (debt service).

(2) Affordability of Water Tariffs

The affordability of water tariff is determined on the basis of the following 2 sets of parameters:

i) Affordability Parameter for Residential Connections

This is measured by computing the ratio of the average monthly water bill of families to their average monthly income. Per World Bank studies, a ratio not exceeding 4% of the average monthly income of families is deemed as the maximum amount affordable for water consumption.

Using raw data from the Social Survey Report for Siem Reap, the average income of families in the city was computed at KHR1,594,120 or about US$382.74 using the exchange rate of KHR4,165 to a US$.

ii) Affordability Indicators for Commercial Connections.

This is measured in the following two ways:

- By comparing the ratio of SRWSA's average unit cost of water for commercial connections to average own-unit production cost of commercial establishments. Using data gathered previously from the surveys conducted on hotels, guesthouses and restaurants in 2009, the Study Team estimated the average cost incurred by commercial establishments with their own in-house water system ranges from US$0.70-1.00 per cubic meter. Water tariff is deemed affordable if the ratio is less than the maximum range of the own-unit cost of commercial establishments.

- By comparing the ratio of average cost of water per tourist to the average expenditure per tourist in Cambodia. The objective here is to show that the proposed water tariffs for commercial establishments have minimum financial impact to tourists. Per Ministry of Tourism data, average expenditure of tourists is US$425for an average stay of 3.5 days. Water tariff by the tourists is considered to be acceptable if total water bills during the 3.5 days stay is just small amount of the total expenditure of US$425.

  Likewise, acceptability can be likened to percentage of the water bill per tourist to the room rates of hotels and guesthouses. Since there is no actual data on the average room rate in Siem Reap, this study assumes US$15 is the average rate of guesthouses per day.

iii) Financial Internal Rate of Return

Financial internal rate of return shall be determined on the basis of the incremental revenue and costs arising from the operation of the new WTP of the priority project. Tariff determination is however limited to the debt service coverage ratio and the no equity infusion by the RGC.

(3) Financial Model

In carrying out the financial analysis as described above, the Study Team prepared a financial model that simulates the financial operation of the SRWSA on a year-to-year basis. The financial model generates the three basic financial statements of profit & loss statements, cash flow statements and balance sheets. In addition, it provides a summary table of key performance indicators for easy evaluation of the results of the financial forecast.

The financial forecast covers thirty years 2011 to 2040. It was accomplished based on constant 2010 price level. This is resorted to minimize the effects of many assumptions and conditions that cannot be ascertained as to their validity and appropriateness. By not considering the effects of inflation, the financial projections can be evaluated on the basis of real growth in terms of revenue and expenses.

(4) Assumptions Used in the Financial Forecast

The financial forecast was accomplished by using a number of assumptions formulated on the basis of actual data provided by the SRWSA:

i) Other Operating Revenue

This is estimated on the basis of the following fees and charges currently imposed and recommended for adaption by the SRWSA:

- Meter maintenance fee of KHR50 per connection per month, the purpose of which is to cover the cost of operation related to inactive connections (connected to the water system but with no water consumption as per water meter reading).
- Surcharges for late payments of water bills. For simplicity, 10% of water bills are assumed

to incur delayed payments and is therefore subject to a 10% surcharge, equivalent to 1%/day x 10 days.

- New connection fees. SRWSA currently charges a fee of KHR517,500 per new water connection equivalent to US$124.25 regardless of connection category. The Study Team however proposes a higher connection fee of US$500 for new commercial connections.

ii) Customer Guarantee Deposits

This represents monies advanced by customers for the mandatory guarantee deposit of KHR77,000 equivalent to US$18.49 per connection (KHR4,165=US$1.00). Like the connection fees, a higher deposit of US$150 is recommended to be collected from new commercial connections beginning 2012.

iii) Inventory of Supplies and Materials

Representing the value of materials and supplies in SRWSA's inventory at the end of the accounting period, it is estimated at 1.5 months of the combined expenses for chemicals and other operating cost excluding salaries and power for pumping expense.

iv) Accrued Payables

This represents the combined value of all amounts owed to suppliers/service providers and is due to be paid within a period of one year or less. It is estimated at about one and a half months of operating expenses but excludes salaries and wages.

v) Ending Cash Balance

SRWSA is assumed to maintain a mandatory cash balance (in banks) equivalent to half a month of total operating expenses (Total Operating expenses x 1/12 x 0.5).

vi) Customer Accounts Receivable

SRWSA is assumed to maintain its currently excellent collection performance thus the level of accounts receivable is forecasted at one month of annual revenues.

vii) On-time Collection of Water Bills

With the increase in number of connections particularly households, the collection performance will most likely suffer and is therefore presumed at 90% of water bills. Water bills in default would therefore be equivalent to 10% of total water sales.

viii) Capital and O&M Costs

Costs for operating and expanding the water services of SRWSA consist of capital investments from the Project and the KTC pipeline extension project, interest capitalized during construction, amortization of loans, replacement of electro-mechanical equipment during the forecast period, operating expenses, depreciation expense and income taxes. Estimates of these cost and expense items are provided for in the financial evaluation, as discussed below.

(5) Capital Investment Cost and Financing Plan

Capital investment needs of SRWSA consist of the Priority Project and the KTC pipeline extension.

- Priority Project. The total investment cost amounts to US$85.5 million, the details of which is discussed and described below.

Price contingency was estimated using the escalation rates of 1.8% for foreign cost components and 7.9% for local cost components. The annual breakdown is presented in the attached Financial Study 1 – Annual Project Cost.

Table 8.4 Priority Project Cost Components

Descriptions	Million US$	% Total
Eligible Project Cost Components		
Direct Cost Items, net of taxes	49.61	58.0%
Engineering Services, net of taxes	5.15	6.0%
Institutional Dev, net of taxes	0.91	1.1%
Subtotal, 2010 Price Level	**55.68**	65.1%
Physical Contingency	5.26	6.2%
Price Contingency	14.30	16.7%
Total Eligible Components, Current Prices	**75.25**	88.0%
Ineligible Project Cost Components		
Land Acquisition	0.30	0.4%
Social Compensation	0.09	0.1%
Project Administration	0.95	1.1%
Subtotal 2010 Price Level	**1.34**	1.6%
Physical Contingency	0.03	0.0%
Price Contingency	0.03	0.0%
Tax of Direct Cost Items	3.84	4.5%
Tax of Engineering Services	0.13	0.1%
Tax for Institutional Deve.	0.01	0.1%
Total Ineligible Components	**5.38**	6.3%
Total Project Cost, current prices	**80.64**	**94.3%**
Add: Capitalized Interest During Construction	4.85	5.7%
Total Investment Cost for the Project	**85.50**	**100%**

Notes: Figures are rounded based on S.R. 2 cost analysis.

Table 8.5 Priority Project Financing Resources

Descriptions	Million US$	%Share
Eligible Cost Items	75.25	88.0%
Capitalized Interest	4.85	5.7%
JICA Loan	**80.11**	**93.7%**
SRWSA Equity Contribution	5.38	6.3%
Total Financing Resources	**85.50**	**100%**

Notes: Figures are rounded based on S.R.2 cost analysis.

The Project shall be financed through a combination of loan and counterpart funds of SRWSA.

The loan shall come from the Government of Japan through the JICA, which shall be on lent to SRWSA by the Royal Government of Cambodia (RGC) through the MEF. The financing plan for the Project was prepared on the basis of the estimated amounts of eligible and ineligible expense items for JICA funding assistance.

Eligible expense items consist of the direct cost items, engineering services and institutional capacity building component. Local taxes of these expense items are not eligible for funding assistance and were deducted from their total value. Also considered eligible expense items are the physical and price contingencies. Total eligible expense items amount to US$75.3 million.

Ineligible expense items for SRWSA counterpart funding consist of the local taxes of the eligible expense items, cost of land acquisition, social compensation and project administration expense. Total cost of ineligible expense items amount to US$5.38 million.

- KTC Pipeline Extension Project. The authority is set to receive treated water from the KTC bulk water system is scheduled to be on-line not later than 2012 initially at 40% capacity. Total bulk supply capacity of 17,000 m3/day shall be attained gradually to 60% in 2013 and 100% full capacity by 2014.

This requires SRWSA to implement urgent works to expanding its distribution pipelines with total project cost at US$9.9 million, the break down of which is shown in the following table.

Table 8.6 KTC Pipeline Extension Cost

Descriptions	Million US$	%Total
Basic Construction Cost	7.31	65.0%
Physical Contingency	0.73	6.5%
Price Contingency	1.88	16.7%
Total Project Cost	**9.91**	**88.2%**
Add: Capitalized Interest	1.34	11.8%
Total Investment Cost - Pipelines	**11.26**	**100 %**

Notes: Figures are rounded.

Said cost estimates were computed assuming a 10% physical contingency and 7.9% annual inflation rate for the price contingency.

Table 8.7 KTC Pipeline Extension Financing Resources

Descriptions	Million US$	%Share
KTC Pipeline Disbursement	8.92	79.0%
Capitalized Interest	1.34	12.0%
Total KTC Pipeline Extension Project Loan	**10.26**	**91.0%**
SRWSA Equity Contribution	1.0	9.0%
Total Financing Resources	**11.26**	**100.0%**

Notes: Figures are rounded.

The KTC pipeline extension project is assumed funded by a loan from bilateral and multi-lateral financing agencies other than JICA. The loan is assumed to carry terms and conditions of the World Bank (Adaptive Program Loan) and/or the Asian Development Bank (Development Policy

Loan). Maximum loan amount is 90% of total project cost plus capitalized interest during construction.

(6) Debt Servicing Needs

This is estimated on the basis of the financing plan for the capital investment program of SRWSA consisting of the priority and pipeline extension projects.

i) Priority Project Loan

The projected annual debt service schedule of the project loan from JICA shall be subject to an on-lending interest rate of 4.5%. However due to concerns on the impact of the loan to the water tariff, it was decided to adapt "step-ladder" interest rates that would achieve the same net present value of total debt service payments under a constant 4.5% interest rate.

Total debt service under a constant 4.5% interest rate amounts to US$166.85 million with a net present value of US$57.91 million using a discount rate of 5.25%.

An initial interest rate of 3% was arbitrarily decided to accommodate SRWSA concerns regarding the impact of interest payments to its finances. A gradual rise in the interest rates is proposed: 3.75% for the period 11th to 20th year, 7.5% for the 21st to 30th year, and 10.405% for the 31st to 40th year of the loan. The total debt service payments sums up to US$185.41 million, with a net present value of US$57.91 million using the discount rate of 5.25%.

On top of the interest rate, the other terms and conditions of the loan are as follows:

- Loan maturity period is 40 years inclusive of 10 years grace on principal repayment;
- 100% of interest charges during construction are capitalized. Principal repayment is for 30 years to start on the 11th year from initial loan drawdown.

ii)KTC Pipeline Extension Project Loan

The KTC pipeline project loan is assumed to carry the following terms and conditions:

- Eight percent (8%) interest rate;
- Interest during construction shall be capitalized in order to allow the authority to muster sufficient cash for its equity contribution to the pipeline extension and to the Project;
- 30 years maturity period inclusive of 4 years grace on principal repayment; and
- 26 years repayment period.

(7) Operating and Maintenance Costs

The operating and maintenance expenses consist of salaries, cost of power and fuel, cost of water treatment, maintenance and miscellaneous overhead costs. These are projected yearly by applying actual cost data on cost parameters directly related to the recommended technical development scheme of the SRWSA as presented and discussed in Section 7.

(8) Replacement Costs

In consonance with the 30-year coverage for evaluating the project, replacement of electro-mechanical equipment exceeding their 15-year economic life is included among the capital investment needs of the SRWSA. The total cost of electro-mechanical equipment at constant 2010 prices is US$10.34 million.

Table 8.8 Replacement Cost

Million US$	**Total**	**2028**	**2029**	**2030**	**2031**
Electro-Mechanical Equipment	9.40	0.34	4.04	3.01	2.01
Physical Contingency (10%)	0.94	0.03	0.40	0.30	0.20
Total Cost, 2010 Prices	**10.34**	**0.37**	**4.44**	**3.31**	**2.21**

(9) Depreciation Cost

In the financial projection, existing assets are depreciated at 3% while that for new assets from the Project and the pipeline extension is estimated at 3.33% (1/30) assuming that the average economic life of the water system facilities is 30 years.

(10) Income Tax

In line with its autonomous character, the SRWSA is subject to income tax assessment computed at 20% of the net profit after deducting depreciation expense and interest charges. A net operational loss exempts the SRWSA from paying income tax for the said taxable year.

8-4-2 Revenue and Tariff Analysis

The SRWSA derives its water revenue from the operation of the existing water treatment plant with a capacity of 9,000 m^3/day or 3,285,000 m^3/year, which is serving currently the needs of 4,129 connections (4,030[13] domestic/government and 99 hotels). Per technical evaluation, the existing capacity is fully saturated with only the reduction of water losses affords the SRWSA to accommodate limited number of new connections, if ever. It is for this reason that SRWSA is seeking to develop new water resources and expand its water services in the city.

(1) Revenue Requirements

Following on the program for the expansion of its facilities, SRWSA is projected to raise badly needed funds through adjustment of water tariffs in line with its full cost recovery mandate under its charter.

[13] Total connections is 4,129 coming from actual January 2010 data of 4,030 domestic connections plus 30% of 321 hotels increasing by 3% thereafter.

Table 8.9 Milestones of Activities

Year	Stage	Financial Study No.	Cash Req. US$ million	Milestone of Activities
2011	Engineering Design	1, 3, 4 & 5	0.086 0.467	Pipeline expansion project commences. Engineering Design Starts on Priority Project. Land purchase for Treatment Plant, pd compensation
2012	Start of KTC Project	1, 3, 4 & 5	0.027 0.336	KTC- SRWSA receives 40% of total plant capacity Engineering Design Works on Priority Project.
2013	Start up of Priority Proj	1, 3, 4 & 5	0.262 0.710	KTC continues to expand – additional 20% Actual Priority Project Starts.
2014	KTC complete	1 & 4	0.308 1.464	KTC pipeline completed – KTC 100% operational Works for priority project continues.
2015	KTC Loan pmt starts	1 & 4	1.651 0.950	Continue Project works. KTC fully operational. Pipeline loan payment on starts.
2016	Proj. finish	1 & 5	1.006 0.950	Project completion, startup, testing Pipeline loan payments continue.
2017	WTP Starts	3 & 5	2.400 0.950	Priority Project is operational. Payment of interest on JICA loan starts. Pipeline loan amortization continues.
2022	Pay on 2 Loans	3 & 5	4.490 0.950	Loan Amortization starts on JICA Loan. Pipeline Loan amortization continues.
2026	Full utilization of capacity is achieved.			
2031	Interest Rate up	3 & 5	6.120 0.950	Higher Debt Service Payments due to adjustment in interest rate. Pipeline Loan amortization continues.
2041	Interest Rate up	3 & 5	6.960	Higher Debt Service Payments due to adjustment in interest rate.

(2) **Proposed Water Tariffs**

The proposed adjustment in water tariffs has been formulated on the basis of the following principles:

Please note that the proposed water tariffs are computed based on real terms – allowance for price fluctuation due to inflation is not included in the derivation of the water tariffs.

- Water tariff must insure financial stability and growth of SRWSA without subsidy from the government.
- Water tariff must meet the debt service coverage ratio (DSCR) of not less than one.

<u>**Tariff Adjustment Cycle**</u>

Grouping years with similar financial cash requirements into tariff cycles, current situations appear to have five year cycles.

- In 2012, the operation of the KTC bulk water system results to water service for additional number of connections.
- In 2017, the operation of the Priority Project opens up water service to more people. Additionally, SRWSA starts paying interest charges for the JICA loan.
- In 2022, introduction of principal repayment plus interest payment for the JICA loan.
- Beyond 2026, maximum production capacity is attained requiring new expansion plan.

The proposed tariff for each 5-year tariff period have been computed by adding all corresponding costs, expenses and some profit for said period, then dividing the net amount with the total volume of planned water sales for the 5-year period.

A series of financial runs were conducted and tested to meet cash flow and debt servicing parameters to arrive at the recommended average tariff per cubic meter. The results of each trial run are presented below.

- Trial Runs 1 & 2 were found to require Cash Infusions from the RGC.
- Trial Runs 3 & 4 eliminated the need for Capital Infusion in future years.

Table 8.10 indicates reason and results of four trial runs.

Table 8.10 Revenue Requirements – Tariff Planning Chart (US$ million)

Descriptions	**Trial Run 1** From Financial Study 7 to 9		**Trial Run 2** From Financial Study 10to 12		**Trial Run 3** From Financial Study 13 to 15		**Trial Run 4** From Financial Study 16 to18		
Years	2012-2016	From 2017	2012-2016	From 2017	2012-2016	From 2017	2012-2016	2017-2021	From 2022
Operating Expenses (5 yr)	8.594	14.170	8.594	14.170	8.594	14.170	8.594	14.170	18.146
Depreciation Expenses (5 yr)	1.421	15.397	1.421	15.397	1.421	15.397	1.421	15.397	15.397
Interest Charges (5 yr)	1.633	16.488	1.633	16.488	1.633	16.488	1.633	16.488	17.598
Income Taxes (5 yr)	0.986	0	1.047	0	1.108	0	1.108	0	0.658
Net Operating Profit (5 yr)	3.944	-9.986	4.188	-9.407	4.432	-8.249	4.432	-8.828	1.930
Total Revenue Requirement (5 yr)	16.578	36.069	16.883	36.648	17.188	37.806	17.188	37.227	53.729
LESS: Other Operating Revenue	2.690	2.253	2.693	2.259	2.696	2.270	2.696	2.265	1.767
Water Sales Required (5 years)	13.887	33.816	14.189	34.389	14.491	35.536	14.491	34.962	51.961
Total Billed Water Million m^3 (5yr)	30.190	57.316	30.190	57.316	30.190	57.316	30.190	57.316	82.478
Required Average Tariff US$/$m^3$	0.46	0.59	0.47	0.60	0.48	0.62	0.48	0.61	0.63
Tariff in KHR (US$ x 4,165)	1,916	2,457	1,958	2,499	1,999	2,582	1,999	2,541	2,624
Indicators									
RGC Equity Infusion	Required in 2015, 2016 & 2017		Required in 2015, 2016 & 2017		**Not Required**				
Debt Service Coverage Ratio	**Less than 1.0 in 2021 & 2037**		**Greater than 1.0**		**Greater than 1.0**				

Notes: Tariff is computed based on real terms.

8-4-3 Financial Status and Condition for the Proposed Water Tariffs

(1) Liquidity of Operation

SRWSA is expected to experience some cash deficits during the 30-year projection period. The cash deficits however can be covered by the accumulated cash balances of previous years.

Hence, government capital infusion is not needed in both Trial Runs 3 & 4 as shown in Financial Studies 13 and 16.

(2) Debt Service Coverage Ratio (DSCR)

As defined, the debt service coverage ratio is that portion of revenue after deducting operating expenses that can cover the debt servicing needs of outstanding loan obligations. Creditworthiness parameters warrant that net revenue after expenses is equivalent to no less than the amount of the annual debt service. Per the results of the recommended Trial Runs, the DSCR is more than one in both 3 and 4.

(3) Profitability of Operation

The financial forecast shows SRWSA shall sustain its very good financial performance with the implementation of the minimum tariffs adjustments recommended in Trial Runs 3 and 4. This continuing profitability is attained with the tariff adjustment in 2012 and 2017. As for recommended Trial Run 3 and Trial Run 4, the SRWSA shall still experience some losses even with the recommended tariffs adjustments in 2017. Under both Trial Runs 3 and 4, SRWSA will incur losses in 2017 to 2023 and again in 2031 to 2037. The losses are however manageable as SRWSA would still be accumulating extra cash from its operations. Thus, despite the losses, SRWSA remains financially solvent since accumulated surplus funds would carry it over during the years when losses are incurred.

Notice that for both recommended tariff options, losses are tolerated to occur mainly to avoid higher increase in tariffs.

(4) Recommended Trial Runs

On the basis of the financial results, both Trial Runs 3 and 4 satisfy the financial parameters established for this project. These are adapted in this study for the purpose of formulating and evaluating the required water tariff schedules that would allow SRWSA to operate on a financial sustainable manner.

8-4-4 Proposed Water Tariff Schedules

SRWSA's financial health and condition is achieved not only due to the additional benefits derived from the increase in customer base but with the timely adjustment of tariffs assumed in the financial forecast. It must therefore be emphasized that the financial soundness of the water authority is critically dependent on the adjustment of the water tariffs as proposed.

(1) Social Consideration

In establishing tier levels we are able to ease the payments of poor households by using higher tariff for high volume household and commercial users.

(2) Ratio Between Residential and Commercial Consumption

In formulating separate water tariffs for residential and commercial connections, the ratio of the projected water consumption between the two classifications of water connections were derived based on the water demand projection. These are as shown below.

Connection Classification	2012	2017	2022
Residential Connections	76.5%	77.9%	77.4%
Commercial Connections	23.5%	22.1%	22.6%

Note: Ratios is calculated in five years' average water demand between residential and commercial connections.

(3) Consumption Ratio

The tariff schedules were computed using consumption ratios that are based on the actual metered billing data of SRWSA covering the period January to December of 2009, as tabulated below:

Table 8.11 Applied Consumption Ratio for Residential Water Tariff

Consumption Blocks	Actual Consumption Ratio	Applied in Study
1 – 7 m^3	10%	10%
8 – 15 m^3	15%	20%
16 – 30 m^3	25%	30%
Over 30 m^3	50%	
Proposed 30 – 60 m^3		30%
Proposed Over 60 m^3		10%

Higher consumption ratios are applied in the study for the 8-15 m^3 and 16-30 m^3 consumption blocks. This is to account for the increase in the number of connections to be served in the presently un-served areas of the SRWSA that shall be having water consumption within the range of the two consumption blocks. With the expansion of services to the fringe areas of Siem Reap, average consumption volumes shall be lower compared to the present, which currently services the core area of the city. The increase in consumption ratios for the 8-15 m^3 and 16-30 m^3 consumption blocks would result to a corresponding decrease of 10 percentage points for the consumption ratio for over 30 m^3 consumption block.

Also shown in Table above, one more consumption block (30 to 60 m^3) is being proposed. The purpose here is to provide tariffs for all residential connections up to 60 m^3. Consumption beyond 60 m^3 should be considered as commercial volume.

For commercial connections, the ratio per consumption block is structured on the basis of actual hotel data of the Ministry of Tourism, as shown below:

Table 8.12 Hotel Consumption Ratio

Tourist Accommodations	No. of Units	Bed Cap.	Bed per Hotel	Per 60% Occupancy	Water Use (a)	Min. (a) / 1.25	Max. (a) x 1.25
Guesthouses	208	4,315	21	12	108m^3	86 m^3	135 m^3
Ordinary Hotels	95	9,341	98				
High-end Hotels	18	5,359	298	179	1,620m^3	1,200m^3	2,000m^3
Totals	**321**	**19,015**	Notes: Daily consumption rate for a tourist is assumed to be 300 lpcd.				

High-end Hotels. At average 60% occupancy rate, high-end hotels are serving 179 beds per hotel (298 x 60%). With an average per capita consumption of approximately 300 liters per day, total volume of water used up by tourists per high-end hotel is 1,620 m^3/month (179 x 300 lpcd x 30 days x m^3/1000 liters). Applying the peak factor of 1.25, consumption ranges from maximum 2,000 m^3/month to a minimum 1,200 m^3/month.

Guesthouses. At average 60% occupancy rate, guesthouses are serving 12 beds each (21 beds x 60%). With an average per capita consumption of 300 liters per day, total volume of water used by tourists staying in guesthouses is 108 m^3/month (12 x 300 lpcd x 30 days x m^3/1000 liters). Also, applying the peak factor of 1.25, consumption ranges from maximum 120 m^3/month to minimum less than 100 m^3/month. The maximum volume may be accounted during high season and the minimum would account for the low season of tourism activities in Siem Reap.

On the basis of the foregoing, the proposed tariff blocks for commercial connections were formulated as shown in Table 8.15. The first block represents consumption by guesthouses, the 2nd block represents consumption in between the guesthouses and the high-end hotels, and the last block is the high-end or 4 to 5-star hotels.

(4) Water Tariff Schedules

The recommended average tariffs that would meet the cash requirements of SRWSA are presented in Table 8.13, "Case 1 Water Tariff" and Table 8.14, "Case 2 Water Tariff". In both proposed water tariff "Case 1 and Case 2", two options were formulated as described below.

- **Option 1** tariff schedule carries a lower increase in residential tariffs as the required increase is borne by the commercial tariff specifically from high-volume residential connections and commercial connections.
- **Option 2** implements a lower increase in commercial tariffs as increase is also shared by the residential tariffs. Also, a separate tariff schedule for commercial connections is not required under this option.

Table 8.13 Case 1 Water Tariff (KHR/m^3)

Trial Run 3				
Residential	**Consumption Ratio**	**2012**	**2017**	
			Option 1	**Option 2**
0 to 7 m^3	10%	1,100	1,300	1,550
8 to 15 m^3	20%	1,500	1,800	2,100
16 to 30 m^3	30%	1,800	2,300	2,500
31 to 60 m^3	30%	2,000	2,700	2,800
61 m^3 & up	10%	2,000	3,100	3,000
Average/m^3		**1,750**	**2,300**	**2,464**
Commercial				
0 to 100 m^3	20%	2,300	3,240	3,000
100 to 1,200 m^3	50%	2,770	3,600	3,000
>1,200 m^3	30%	3,220	3,765	3,000
Average/m^3		**2,811**	**3,578**	**3,000**
Overall Average		**1,999**	**2,582**	

Note: Proposed tariffs are in real terms. Tariffs do not include price escalation due to inflation.

Table 8.14 Case 2 Water Tariff (KHR/m^3)

Trial Run 4					
Residential	**2012**	**2017**		**2022**	
		Option 1	**Option 2**	**Option 1**	**Option 2**
0 to 7 m^3	1,100	1,270	1,520	1,280	1,840
8 to 15 m^3	1,500	1,750	2,000	1,780	2,200
16 to 30 m^3	1,800	2,250	2,500	2,310	2,500
31 to 60 m^3	2,000	2,650	2,700	2,765	2,800
61 m3 & up	2,000	3,100	3,000	3,250	3,000
Average/m^3	**1,750**	**2,257**	**2,412**	**2,332**	**2,514**
Commercial					
0 to 100 m^3	2,300	3,100	3,000	3,300	3,000
100 to 1,200 m^3	2,770	3,500	3,000	3,600	3,000
>1,200 m^3	3,220	3,900	3,000	3,880	3,000
Average/m^3	**2,811**	**3,540**	**3,000**	**3,624**	**3,000**
Overall Average	**1,999**	**2,541**		**2,624**	

Note: Proposed tariffs are in real terms. Tariffs do not include price escalation due to inflation.

8-4-5 Affordability Analysis

(1) Case 1 Water Tariff

Affordability of Water Tariffs for Residential Connections: The results as illustrated below show the required tariff schedule for 2017 as being affordable. The average monthly water bill represents only 2.35% in 2012 to approximately 3.6% in 2017 of average family income. The ratio of water bills to total income for the said tariff year is below the maximum 4% of average family income.

Table 8.15 Affordability Test for "Case 1 Water Tariff", Residential

Residential	**2012**	**2017**	
		Option 1	**Option 2**
Ave. Residential Tariff (KHR/m^3)	1,750	2,300	2,464
Unit Consumption Rate (lpcd)	114	124	124
Average Nos. of Household	5.7		
Ave. Monthly Consumption (m^3/family)	19.5	21.2	21.2
Ave. Monthly Bill (*KHR)	37,511	53,625	57,462
% of Ave. Income	**2.35%**	3.36%	**3.60%**
Ave. Monthly Family Income (KHR)	1,594,120		

Note: *10% VAT is included.

Table 8.16 Affordability Test 1 for "Case 1 Water Tariff", Commercial

Commercial	**2012**	**2017**	
		Option 1	**Option 2**
SRWSA Unit Cost (KHR/m^3)	3,093	3,936	3,299
Own System Unit Cost (KHR/m^3)			
Max. US$1.0	4,165		
% of SRWSA to Hotel Own Unit Cost*	74%	94%	79%

Note: *10% VAT is included.

Affordability of Water Tariff for Commercial Connections: The two affordability test parameters show the proposed tariffs are affordable to businesses and shall not be a burden to tourists. The test on the ratio of average SRWSA unit cost to own-unit cost of commercial establishments shows that the tariff schedules for both Options 1 and 2 are acceptable to commercial users, as shown below.

The test on ratio of cost of water per tourist to total expenditure/tourist shows that the proposed water tariffs of SRWSA have no effect or impact on tourists, as shown below.

Table 8.17 Affordability Test 2 for "Case 1 Water Tariff", Commercial

Commercial	**2012**	**2017**	
		Option 1	**Option 2**
SRWSA Unit Cost (US$/m^3)	0.74 (KHR3,093)	0.94 (KHR3,936)	0.79 (KHR3,299)
Tourist Unit Consumption (lpcd)	304	314	
Ave. Days of Stay per Trip (days)	3.5		
Tourist Ave. Consumption (m^3/trip)	1.06	1.10	
A. Water Cost(*US$/trip/tourist)	0.79	1.04	0.87
Ave. Tourist Expenditure (US$/trip)	425		
% Cost of Water/Tourist Expenditure	0.19%	**0.24%**	0.20%
B. Water Cost per Day(*US$/d/tourist)	0.23	0.30	0.25
Water Cost/Room Rate			
- US$15	1.50%	**1.98%**	1.66%

Note: *10% VAT is included.

(2) Case 2 Water Tariff

Affordability of Water Tariffs for Residential Connections. The results show that the required tariff schedule for 2017 is affordable. The average monthly water bill represents only 2.35% and 3.97% of the average family income in 2012 and 2022, respectively. The derived ratio of water bills to total income for the said tariff year is below the maximum 4% of average family income that can be allocated to water usage as per previous studies by the World Bank and the Asian Development Bank.

Table 8.18 Affordability Test for "Case 2 Water Tariff", Residential

Residential	**2012**	**2017**		**2022**	
		Option 1	**Option 2**	**Option 1**	**Option 2**
Ave. Residential Tariff (KHR/m^3)	1,750	2,257	2,412	2,332	2,514
Unit Consumption Rate (lpcd)	114	124		134	
Ave. Nos. of Household	5.7				
Ave. Mon. Consumption (m^3/family)	19.5	21.2	21.2	22.9	22.9
Ave. Monthly Bill(*KHR)	37,511	52,653	56,248	58,789	63,366
% of Average Income	**2.35%**	3.30%	3.53%	3.69%	**3.97%**
Ave. Mon. Family Income (KHR)	1,594,120				

Note: *10% VAT is included.

Affordability of Water Tariff for Commercial Connections

- The test on ratio of average SRWSA unit cost to own-unit cost of commercial establishments shows that the tariff schedule for both 2017 and 2022 under Option 2 is more acceptable to commercial users than the higher tariffs under Option 1.

Table 8.19 Affordability Test 1 for "Case 2 Water Tariff", Commercial

Commercial	2012	2017		2022	
		Option 1	Option 2	Option 1	Option 2
SRWSA Unit Cost (KHR/m^3)	3,093	3,894	3,300	3,986	3,300
Own System Unit Cost (KHR/m^3)					
Max. US$1.0	4,165				
% of SRWSA to Hotel Own Unit Cost	74%	94%	79%	96%	79%

Note: *10% VAT is included.

- The test on ratio of cost of water per tourist to total expenditure/tourist shows that the proposed water tariffs of SRWSA have no effect or impact on tourists. Total expenditures for water per tourist is just a drop in the bucket so to say at maximum 0.26% for cost of water per tourist and approximately 2.1% for cost of water per room rate in 2022.

Table 8.20 Affordability Test 2 for "Case 2 Water Tariff", Commercial

Commercial	2012	2017		2022	
		Option 1	Option 2	Option 1	Option 2
SRWSA Unit Cost (US$/m^3)	0.74	0.94	0.79	0.96	0.79
Tourist Unit Consumption (lpcd)	304	314		324	
Ave. Days of Stay per Trip (days)	3.5				
Tourist Ave. Consumption (m^3/trip)	1.06	1.10		1.13	
A. Water Cost (*US$/trip/tourist)	0.79	1.03	0.87	1.09	0.90
Ave. Tourist Expenditure (US$)	425				
% Cost of Water/Tourist Expenditure	0.19%	0.24%	0.20%	**0.26%**	0.21%
B. Water Cost per Day (*US$/d/tourist)	0.23	0.29	0.25	0.31	0.26
Water Cost/Room Rate					
- US$15	1.50%	1.96%	1.66%	**2.07%**	1.71%

Note: *10% VAT is added.

8-4-6 Prognosis

All of the proposed tariffs are affordable. The selection of the proposed "Case 2 Water Tariff" over that of the "Case 1 Water Tariff" would provide an easier transition with three tariff increments from 2012 up though 2026. The selection of Option 2 over Option 1 would provide simplicity of unified tariff for all commercial users. However, the selection of Option 1 over Option 2 is preferred since it would afford lower tariff for low volume residential users.

8-5 Financial Internal Rate of Return for the Priority Project

The financial internal rate of return for the Project is approximately 2.6% as shown in Financial Study 19 and 20 for Proposed Tariff Studies 1 and 2, respectively. This is subjected to a sensitivity tests to determine the effect of variances on some key assumptions. The selected sensitivity scenarios and the results of the tests are described and presented below.

- Scenario 1: Investment Cost increasing by 15 percent more than the base hypothesis results to a FIRR of 1.86% for Proposed Tariff Study 1 and 1.98% for Proposed Tariff Study 2;
- Scenario 2: Operating and Maintenance Costs increasing by 15 percent more than the base hypothesis results to an FIRR of 2.22% for Proposed Tariff Study 1 and 2.3% for Proposed Tariff Study 2; and,

- Scenario 3: Revenues decreasing by 15 percent less than the base hypothesis results to a FIRR of 1.34% for the proposed “Case 1 Water Tariff” and 1.47% for the proposed “Case 2 Water Tariff” .

The FIRR could be higher under a tariff based on maximum capacity to pay of 4% of average monthly income of households in Siem Reap. Using optimum tariffs, the FIRR is 3.32% as shown in Financial Study 21.

8-6 Financial Conclusion

(1) The results of the financial evaluation show that the Project is financially feasible, as shown by the following indicators:

- SRWSA’s financial condition shall not be adversely affected by the implementation of the project. Rather, long-term financial condition is enhanced with the expansion of its revenue base, which in turn provides better potential for attaining full cost recovery of operation in consonance with its charter as an autonomous self-sufficient government entity.
- Debt service ratio of SRWSA or its ability to meet maturing loan obligations does not go below 1.0 throughout the study period.
- Cash position will not be affected during construction. SRWSA shall not require additional capital infusion from the government.
- The required water tariffs are affordable as these pass affordability parameters for residents and businesses.

8-7 Economic Benefit-Cost Analysis

8-7-1 Introduction

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.

8-7-2 Methodology for the Economic Analysis

The economic benefit-cost analysis utilized two methods of analysis: the benefit-cost ratio and the economic internal rate of return. These are discussed in more detail in the next sections.

(1) Benefit-Cost Ratio (BCR)

The BCR computes the present value of economic benefits generated by a project per unit of the present value of the economic costs associated with the project. This requires the prior discounting of benefits and costs. For infrastructure projects like water supply system, the applicable social discount rate is 12%. A project is considered economically viable with a benefit-cost ratio equal to or greater than 1.

(2) Economic Internal Rate of Return (EIRR)

The EIRR is the discount rate at which the present value of economic benefits attributable to the project is equal to the present value of economic costs. It is differentiated from the BCR in that it avoids prior determination of the discount rate.

A project is considered economically feasible if the EIRR is greater than the social discount rate of 12%.

8-7-3 Economic Benefits

The implementation of the water supply project in Siem Reap is expected to provide significant benefits and desirable long-term effects. This includes both direct and indirect benefits.

The direct and immediate benefits are: the delivery of water in greater quantity and closer to home on a more reliable basis; better water quality; improved environmental conditions; and increase in consumer satisfaction.

On the other hand, the indirect benefits are: increased productivity of the residents of the service area; employment and livelihood opportunities for the residents of the municipality and outlying areas; increase in land values; increase in the marketability of housing and industrial park projects; reduction in fire damages; and tourism benefits.

Among the above, the quantification of benefits is concentrated to “increase” in consumer satisfaction. Said benefit was considered since the methodology for its quantification has long been established and accepted in the water supply industry.

The economic benefit of the project is measured as the incremental increase in the value of certain socio-economic variables on a "with" and "without" project basis.

(1) Convenient and Reliable Service

The improvement of the water supply system will provide residents with a reliable water service. Additionally, a piped-water system arising from the availability of adequate supply of water will result to immeasurable convenience for the residents.

(2) Consumer Satisfaction

Consumer satisfaction benefit is computed as the economic value of the incremental water production directly arising from the project. In Siem Reap, the economic value of water is estimated to be 30% higher than the existing average tariff of SRWSA. This cost premium is based on past studies for water supply expansion projects that found households in areas without piped water pay a higher price per cubic meter for their supply of potable water. The higher price premium ranges from a low of 140% to as high as 400% higher than the corresponding cost of piped water[14]. Total benefit arising from an increase in consumer satisfaction is estimated with a net present value (using a 12% discount rate) of US$34.86 million.

[14] ADB Water for All website. Country water action: Philippines reaching out to peri-urban villages.

(3) Health Benefits

Health benefits attributable to the project are measured on the basis of the following:

- Savings in household cost of medical health care due to water-borne diseases; and
- Savings in government health care expenditures due to water-borne diseases.

Based on the ADB-funded study on the development of the sewerage system in Siem Reap Province, the estimated cost of individual health care is US$5.33 yearly for private households and US$3.80 per person under the government's health care program. Of this amount, only 10% is assumed for health care expenses due to water-borne diseases of both individuals and the local government. The economic benefit of the water supply project is assumed at 33%.

The total health-related benefit that can be achieved in the province is estimated at US$27 million.

(4) Tourism Benefits

A major benefit attributable to an improved water supply system in Siem Reap is related to the tourism industry which is centered on the Angkor Wat ruins. The impact of tourism in Siem Reap is tremendous that it affects not only the local economy but also the entire country. As such, the improvement and expansion of the water system has indirect effect on the tourism industry. The benefits attributable to the project are:

- Increased tourist spending due to an extended stay as a result of improved amenities and comfort for tourists staying in hotels with water service from SRWSA.
- Multiplier effect of the increased tourist spending to local employment.

Data of the Tourism Office in Siem Reap reports that on the average, tourist stay in Siem Reap for 3.5 days and spend a total of US$425. With the improved water supply, tourist stay is extended by one day or 4.5 days total stay and results to increased average tourist spending of US$546.30 (US$425/3.5days x 4.5 days). Assumed net tourist spending ratio is 30% as per estimate of the tourism office.

The multiplier effect to local employment is measured through the net effect of the increased tourist spending to unskilled labor in Siem Reap. In the study, 20% of increased spending is assumed to benefit the unskilled labor market. Due to underemployment as well as unemployment situation in the province, said spending benefitting the unskilled labor market is adjusted to its competitive value by applying the shadow price factor of 0.75% for unskilled labor. Net benefit of the water supply project is assumed at 27%, which is 90% of 30%.

The benefit on tourist spending is estimated at US$304 million using a discount rate of 12 percent.

8-7-4 Economic Costs

The direct costs of the project consist of the project, replacement, and operating and maintenance costs. These are converted into economic costs as will be discussed in the next sections.

(1) Project Cost

In the economic analysis, the project cost considered is at constant price level. Price contingencies are therefore excluded. Furthermore, the project cost estimates are adjusted to arrive at the true economic value of the project. Such adjustment is considered on account of the imperfections in the local market economy. The factors considered are given below:

- Taxes are netted out since they just constitute transfer payments;
- Foreign exchange premiums are a result of the interplay of the supply and demand for foreign currency (particularly the US$). In Cambodia, the US$ is valued at its going rate since it is publicly circulating being the “unofficial” form of currency in the country;
- Wages of unskilled labor like foreign exchange premium is usually set by government under a minimum wage law to protect the welfare of such workers. This results in wages having higher value than when it is left free to the forces of demand and supply in the free market. To correct this overvaluation, a social conversion factor of 0.75 is applied; and
- Salaries and wages of skilled labor are priced at the going market rate.
- By applying the foregoing factors, the project economic cost is estimated at US$56.521 million.

(2) Replacement Costs

The economic life of water supply equipment ranges from 15 years (i.e., centrifugal pumps, valves, chlorinators, etc.), to 30 years (i.e. pump house structures, well structures, etc.) up to 50 years (i.e. ductile iron pipes, most civil work items like pumping stations, reservoirs, etc.).

Based on the estimated service life of the water supply facilities, the total replacement cost for facilities (both civil works and equipment) with an economic life of 15 years or less is estimated at US$10.182 million.

(3) Operating and Maintenance Cost

In the economic analysis, only incremental operating and maintenance costs are considered. Unlike the financial project costs, these are subjected to shadow pricing to account for the imperfect pricing attributable to a market economy. The total incremental operating and maintenance cost is estimated at US$21.83 million.

8-7-5 Benefit Cost Ratio and Economic Internal Rate of Return

(1) Benefit-Cost Analysis

A BCR of 4.5 is attained for the project using a discount rate of 12% based on a total net present value of benefits of US$156.71million and total net present value of economic costs of US$34.82

million, also using a discount rate of 12%.

(2) Economic Internal Rate of Return (EIRR)

The EIRR of the project is 36.62%**.**

(3) Sensitivity Analysis

The EIRR is subjected to a sensitivity analysis to test the effects of variances to the assumptions in the base hypothesis. The factors considered in the sensitivity tests as well as the results of the tests are presented in tabular form below.

Table 8.21 Economic Internal Rate of Return

Sensitivity Test Scenarios	**EIRR**
Scenario 1 - 15% Increase in Project Cost	33.73%
Scenario 2 - 15% Increase in O & M Costs	36.57%
Scenario 3 - 15% Reduction in Revenues	33.21%

8-7-6 Prognosis

Since the calculated BCR is more than one and the EIRR is higher than the 12% social discount rate for infrastructure projects[15], the recommended priority expansion project for the water supply system of Siem Reap City is economically feasible.

8-8 Recommendation

The recommended development program for the priority expansion of the water supply system of the SRWSA is viable financially and economically under the assumptions used in the evaluation.

- With the Project, SRWSA can achieve financial sustainability with the implementation of the recommended water tariff as per water tariff study 2: KHR1,999 per m^3 in 2012, KHR2,541 per m^3 in 2017 and KHR2,624 per m^3 in 2022 onwards
- Implementation of the said required water tariffs is recommended under Option 1 since it affords lower tariffs for residential users.
- Tariff adjustment shall be carried out in accordance with the procedures to keep sound financial background so that a consumption-based tariff structure is fair to all. The revenue from tariff will cover O&M costs, capital development plus debt servicing properly to achieve operational and financial viability.
- With the Project, significant socio-economic benefits can be realized in terms of:
  - Reducing poverty rate by providing access to safe and potable water to the un-served areas of Siem Reap particularly the urban fringes and the rural outskirts of the city.

[15] This is a widely accepted social discount rate as adapted by ADB in many of its infrastructure projects.

  - Reduction of health problems brought about by unsafe water thereby contributing to better productivity of the residents in the service area.
  - Stimulating the growth of the local economy with the development of the tourism-related businesses and light industries, all of which will rely mainly on safe and adequate water from SRWSA, especially when the extraction of groundwater will be discontinued to protect the Angkor Wat heritage area.
  - Contributing to the growth of the national economy by increased tourism arrivals, which will impact on job generation and higher levels of education.

- SRWSA should enact regulatory measures with regards to the control of future groundwater development in reference to the procedure as mentioned in previous section for groundwater collection and switch to SRWSA water in cooperate with RGC related authorities.

Chapter 9.

Drainage, Sewerage, and Sanitation Systems In The Study Area

Chapter 9. Drainage, Sewerage, and Sanitation Systems in The Study Area

9-1 Current Status of Drainage & Wastewater Master Plan for Siem Reap

Currently, the following three major wastewater management plans are available in Siem Reap City:

1. Mekong Tourism Development Project Part A1 : Siem Reap Wastewater Management Final Design Report (**MTDP SRWM**: ADB Loan No. 1969-CAM (SF), April 2006): Refer to 9-2 for detail
2. Feasibility Study Report on the Siem Reap Sewerage System and Improvement of Siem Reap River in the Kingdom of Cambodia (**KOICA**, July 2008): Refer to 9-3 for detail
3. Siem Reap Urban Development Project Drainage & Sewerage Master Plan for the District of Siem Reap Priority Works Draft Master Plan (**SRDSMP**: AFD, December 2009): Refer to 9-4 for detail

9-2 MTDP SRWM: ADB Loan No. 1969-CAM (SF), April 2006

As to **MTDP SRWM**, the proposed sewerage facilities were completed on 31 December 2009 with additional works and now being operated and maintained by Siem Reap Sewerage and Wastewater Treatment Plant Unit under the Ministry of Public Works and Transport.

This project was proposed to mitigate the following problems which Siem Reap District has been suffered for long time:

- Frequent flooding in the central commercial and tourist accommodation area
- Inundation of properties by the combined stormwater runoff and wastewater
- The existing Town Center Drain (TCD) receives raw sewage, septic tank effluent, sullage wastewater, and municipal solid waste resulting in its gross contamination and reduced capacity for the conveyance of stormwater and wastewater flow
- Consequent negative impacts on public safety, access, public health and the aesthetic quality of the urban environment significantly diminish the amenity of the area for support of tourism

The proposed sewerage facilities are as follows:

- Rehabilitation of Town Center Drain L = 2.1 km
- Interceptor Sewer System includes interception chambers, interceptor connection sewers and interceptor sewer. Interceptor main sewer with diameter of 600 to 700 mm and total length of 3,658 m.
- Sanitary sewer with diameter of 200 to 400 mm and total length of 2,820 m.
- 77 service connections

- Improvement of water course of exiting irrigation canal from TDC junction to Town-Ring-Road, L = 900 m
- Wastewater Pumping Station with capacity of 160 L/sec
- Sewer force main with diameter of 450 mm, total length of 2,812 m
- Wastewater Treatment Plant (3 stage Wastewater Stabilization Pond) with capacity of 2,776 m3/day (Stage-1) to be expanded to 5,552 m3/day in Stage-2 scheduled to be completed in 2015
- Additional Works (Variation Order No. 5)
  - Additional interceptor connecting sewer and sanitary sewer of 2,994 m with 116 service connections
  - Road/Access improvement of 786 m long in Stoeng Thmey Village
  - 4 debris traps connects to TCD
  - 2 new storm drain, L = 679 m
  - Rehabilitation/repair/replace of 60 stormwater collection chambers within storm drain collection area to TCD
- Extra Additional Works (Variation Order No. 6)
  - Repair/replace of additional 40 stormwater collection chambers and inlet structures along Sam Dech Tep Vong Street
  - Improvement of irrigation canal from TCD end to Ring-Road

Improvement of water course of exiting irrigation canal from TCD end to Psar Kraom Market

Total service area is 265 ha. Design data for WWTP is as follows:

Table 9.1 Design Data of Wastewater Treatment Plant

Influent	
- Service Population	40,059 persons equivalent
- Unit Sewage Flow	126 L/c.day
- BOD load	364 mg/L
- Ambient Temperature	24 ℃
Wastewater Stabilization Pond	
- WWTP Area	20.3 ha
- Plant Design Capacity	2,776 m^3/day (Stage-1)
	5,552 m^3/day (Stage-2)
- Dimension of Facilities	
Anaerobic Pond	W 29.86 m×L 58.86 m×H 4.5 m×2 units (existing)
Facultative Pond	W 44.50 m×L 119.00 m×H 2.25 m×2 units (existing)
Maturation Pond	W 81.00 m×L 221.00 m×H 2.0 m×2 units (existing)
Sludge Drying Bed	W 24.28 m×L 58.86 m×1 unit (existing)
- BOD Removal Rate	95 %
- Coliform Removal Rate	99 %
Effluent	
- BOD load	18.2 mg/L
- Allowable Limit of BOD	80 mg/L *)

*) Source : Cambodian Water Pollution Control Sub-decree No. 27 on April 1999

SRWM WWTP has a septage reception facility.

This project also involved Institutional Development Program and the results are as follows:

- Siem Reap Sewerage and Wastewater Treatment Plant Unit was officially established by MPWT-PRAKAS No. 074 dated 11 February 2008
- PRAKAS on the establishment and operation of Siem Reap Sewerage and Wastewater Treatment Plant Unit approved by MPWT-PRAKAS No. 092 dated 20 March 2008
- Organization chart and staffing for Siem Reap Sewerage and Wastewater Treatment Plant Unit approved with MPWT-PRAKAS No. 092 dated 20 March 2008
- Inter-ministerial PRAKAS on service charge for connection and monthly user fee for the sewer collection and treatment of Siem Reap Sewerage and Wastewater Treatment Plant Unit approved by the Minister of Ministry of Economics and Finance inter-ministerial PRAKAS No. 132 dated 02 March 2008
- Developed documents and forms for administrative operation of the Unit dealing with service users such as Application Form, Agreement and Technical Form, etc
- Established/furnished office and recruited 24 staff for Siem Reap Sewerage and Wastewater Treatment Plant Unit and currently received trainings from the project under capacity building program comprised of the following activities:
  - 22 July – 23 August 2009 : Training session on computerized accounting/billing and financial management system of SRSWTPU
  - 14 – 16 September 2009 : Training session on administrative management of newly established SRSWTPU
  - 16 – 17 September 2009 : Technical training session on basic design and construction concept of sewers/drains and plumbing works of SRSWTPU
  - 30 September – 3 October 2009 : Four days study tour to Sihanoukville Sewerage and Wastewater Treatment Plant as well as visit production process plant and wastewater management of Angkor Beer Brewery
  - 17 December 2009 : Training session on benefit monitoring and evaluation (BME) of the project for SRSWTPU

The total project cost (Contract Amount) was 14.37 million US Dollar.

This project aimed the reconstruction and modification of TCD and incoming combined sewers

- Construct “Interception Chamber” in course of existing combined sewer
- As interception chamber has diversion weir, all incoming wastewater during dry weather is diverted to Interceptor Sewer
- In case of wet weather, 4 times of Dry Weather Flow is diverted to Interceptor Sewer and remaining flow is discharged to TCD

Project Benefits

Before the project completion, some parts of Town Center Drain were non-sealed earth drain and all generated wastewater and stormwater has been connected to TDC through the existing combined sewerage network. As major potable water source is tube wells, some wells located near by TCD was heavily contaminated by wastewater infiltration and also by flooding during rainy season. This was proven by the morbidity rate of water-borne diseases. But after the completion of this project, morbidity rate was drastically decreased and this apparently shows the benefit of the Project. The transition of morbidity rate is shown in Table 9.2.

Table 9.2 Transition in Water-borne Disease Morbidity Ratio in Siem Reap City

Name of Diseases	2006	2007	2008
Normal Diarrhea	4,201	3,011	2,490
	(1.000)	(0.717)	(0.593)
Strong Diarrhea	319	192	197
	(1.000)	(0.602)	(0.618)
Decentria	8,457	8,317	7,342
	(1.000)	(0.983)	(0.868)
Skin Disease	3,483	3,391	3,192
	(1.000)	(0.974)	(0.916)

Source) Siem Reap Provincial Hospital

Morbidity of typical water-borne disease Diarrhea was decreased to almost 60%. Flooding was also mitigated by the reconstruction of Town Center Drain.

Sewerage tariff has not been collected in Siem Reap City but the Unit has a plan to charge the tariff together with public service tariff such as water supply and garbage collection. Proposed sewerage tariff table is shown in the following table.

Table 9.3 Sewerage Tariff Table

Type of Consumers	Connect Service	Monthly Service Charge
Private House		Unit: Cambodian Riel
House Size less than 70 m^2 (Type-1)	42,000	4,000
House Size from 70 m^2 to 300 m^2 (Type-2)	123,000	13,000
House Size larger than 300 m^2 (Type-3)	205,000	35,000
Hotel		
With room number of 1 to 20 (Type-1)	164,000	110,000
With room number of 21 to 40 (Type-2)	246,000	123,000
With room number of 41 to 60 (Type-3)	287,000	186,000
With room number of 61 to 100 (Type-4)	410,000	522,000
With room number larger than 101 (Type-5)	902,000	1,260,000
Guest House		
With room number of 1 to 7 (Type-1)	82,000	30,000
With room number of 8 to 15 (Type-2)	164,000	58,000
With room number larger than 16 (Type-3)	287,000	145,000
Restaurant		
With chair number of 1 to 40 (Type-1)	164,000	37,000
With chair number of 41 to 100 (Type-2)	205,000	46,000
With chair number larger than 101 (Type-3)	246,000	187,000
Others		
Store House/Car Parking	205,000	41,000
Gas Station/Work Shop/Machinery Repair Factory	164,000	73,000
Massage Club/Karaoke Club/Night Club	205,000	42,000
Governmental (Public) Building	164,000	44,000
Pagoda	82,000	22,000
School (Private/Public)	41,000	41,000
Hospital/Clinic (Private/Public)	205,000	62,000
Small Factory	287,000	68,000
Car Washing Station	205,000	57,000
Bank	205,000	90,000
Company Office/Governmental Office	164,000	69,000
Souvenir Shop/Super Market	144,000	25,000
Game Center	144,000	25,000
Other Business Center	164,000	208,000
Small Business House	123,000	11,000
Central Mart	287,000	473,000
Old Mart	746,000	174,000
nge Mart	213,000	50,000
Public Toilet	41,000	9,000
Septic Tank Clean Service - Public Wastewater (Contract)		
Septic Tank Type I (Private House)		120,000/Truck
Septic Tank Type II (Hotel Type-1 and 2, Guest House, Restaurant, Public Bldg)		200,000/Truck
Septic Tank Type III (Guest House Type-3, 4, 5 and Restaurant)		400,000/Truck
Septic Tank outside of Service Area		250,000/Truck

9-3 KOICA Feasibility Study, July 2008

Feasibility Study of **KOICA**, they proposed additional service area surrounding that of MTDP SRWM under ADB Loan. Total service area is 934 ha including 265 ha of ADB project service area. They planned sewerage facilities for East District and West District, respectively. East/West District is urban area divided by Siem Reap River.

KOICA planned their WWTP next to MTDP SRWM WWTP. They also employed 3 stage wastewater stabilization pond and its total site area is 40 ha. The following figure shows the layout of the proposed wastewater facilities:

The followings are the proposed sewerage facilities:

✧ Sanitary Sewers :

Diameter (mm)	East District (m)	West District (m)
200	23,240	14,335
250	1,615	640
300	175	1,565
350	-	1,430
400	725	715
500	2,160	665
Total	27,915	19,350

✧ Stormwater Drainage :

Dimension	East District (m)	West District (m)
Box 3.0 m × 2.0 m	1,380	4,690

✧ Pumping Stations :

New Relay Pumping Station

Item	Specifications	Remarks
Service Area	299 ha	
Total Capacity	5,390 m^3/day	Hourly Maximum
Pump House Dimension	B4.0 m×W4.0 m×H2.5 m	
Pump Specifications	1.9 m^3/min×20 mH×3 (1) units	( ) for stand-by

Modification of ADB existing Relay Pumping Station

Item	Specifications	Remarks
Service Area	934 ha (365 ha in East, 569 ha in West)	
Total Capacity	23,250 m^3/day	Hourly Maximum
Pump House Dimension	B4.7 m×W7.0 m×H1.0 m×2	
Pump Specifications	4.8 m^3/min×25 mH×2 units (Existing) 6.55 m^3/min×25 mH×2 (1) units (New)	( ) for stand-by

Design data for WWTP is as follows:

- Service Population	52,758 persons in 2020
- Tourism Population	54,150 persons (Overnight) 27,113 persons (Returning)
- Unit Wastewater Flow	160 L/c.day (Domestic WW) 80 L/c.day (Overnight Tourists WW) 24 L/c.day (Returning Tourists WW)
- Incoming Wastewater Flow	14,767 m^3/day in 2020
- BOD load	182 mg/L
- Ambient Temperature	24 ℃
- WWTP Area	40 ha
- Plant Design Capacity	10,000 m^3/day (Adding ADB Plant = 15,500 m^3/day)
- Dimension of Facilities	
Pershall Flume	Throat width 12 inch×2 (Inflow, Outflow)
Anaerobic Pond	W 29.86 m×L 58.86 m×H 4 m×4 units
Facultative Pond	W 47.0 m×L 119.0 m×H 1.75 m×4 units
Maturation Pond	W 81.0 m×L 208.0 m×H 1.5 m×4 units
Sludge Drying Bed	
Administration Building	W 22.4 m×L 12.4 m
- BOD Removal Rate	95 %
- Coloform Removal Rate	99 %
Effluent	
- BOD load	9.1 mg/L
- Allowable Limit of BOD	80 mg/L *)

*) Source : Cambodian Water Pollution Control Sub-decree No. 27 on April 1999

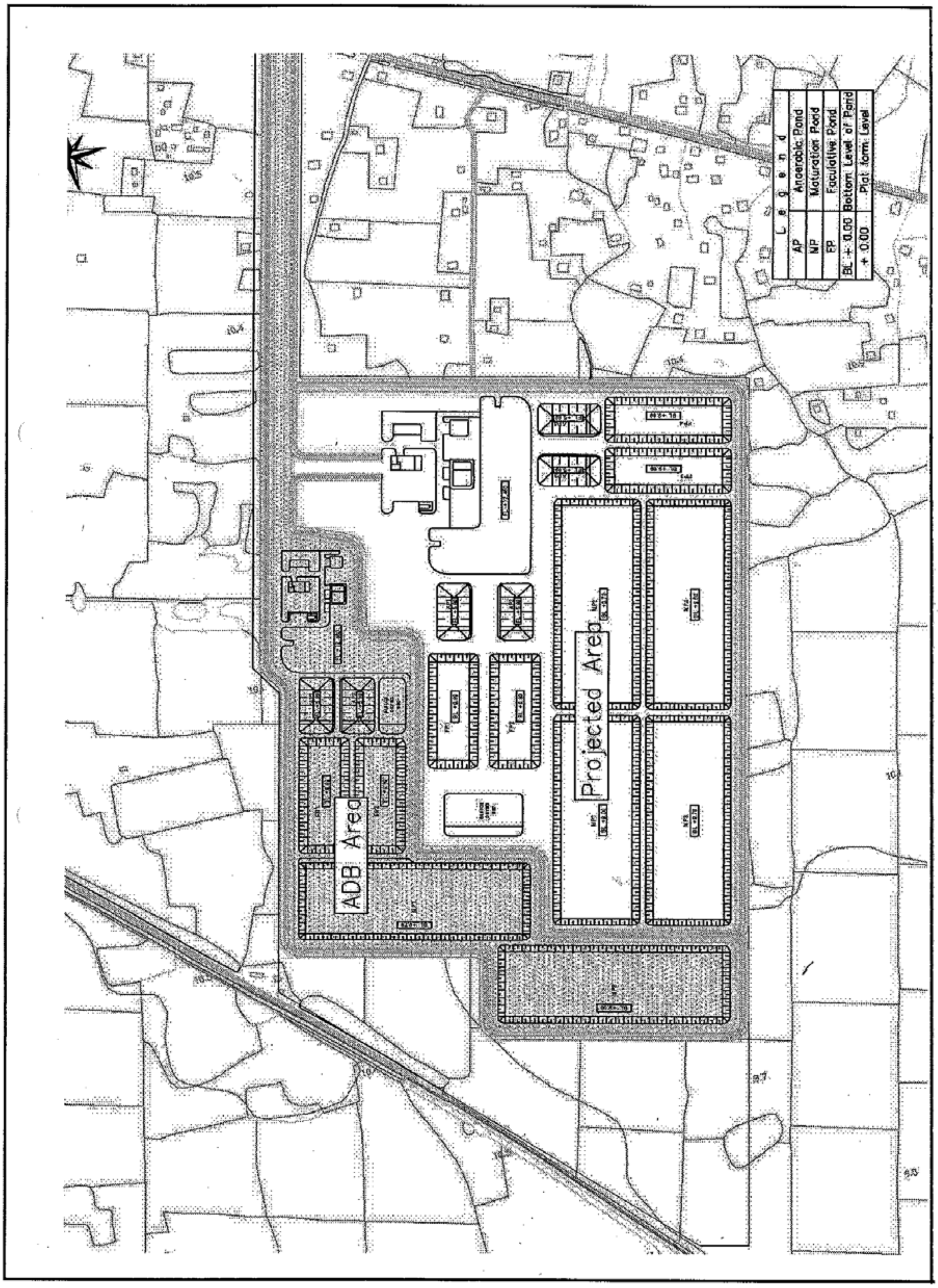


Figure 9.1 KOICA WWTP General Plan

Source of these Tables is "Feasibility Study Report on the Siem Reap Sewerage System and Improvement of Siem Reap River in the Kingdom of Cambodia, July 2008, Korea Exim Bank".

Estimated project cost is US$ 44,546,000 of which US$ 29,908,000 is funded from Korean EDCF Loan and remaining US$ 14,638,000 is funded by the Cambodian Government. Detailed project cost breakdown in shown in the Table below:

Table 9.4 Estimated Project Cost

Item	EDCF				Recipient Country	Total
	Foreign Currency	Local Currency	The 3rd Country	Subtotal		
1. Direct Construction Cost	7,956	12,512	1,000	21,468	-	21,468
a. Sanitary Sewer	1,519	3,086	815	5,420	-	5,420
b. Storm Drain	2,161	3,086	-	4,577	-	4,577
c. Relay Pumping Station	538	326	85	949	-	949
・Civil Works	181	182	-	363	-	363
・Architectural Works	-	34	-	34	-	34
・Mechanical Works	298	21	-	319	-	319
・Electrical Works	-	82	85	167	-	167
・Instrumentation Works	59	7	-	66	-	66
d. Wastewater Treatment Plant	3,111	5,521	96	8,728	-	8,728
・Civil Works	2,870	3,864	-	6,734	-	6,734
・Architectural Works	-	1,588	-	1,588	-	1,588
・Mechanical Works	73	9	-	82	-	82
・Electrical Works	-	52	96	148	-	148
・Instrumentation Works	168	8	-	176	-	176
e. Floodgates	236	59	4	299	-	299
・Civil Works	-	27	-	27	-	27
・Mechanical Works	90	21	-	111	-	111
・Electrical Works	-	1	4	5	-	5
・Instrumentation Works	146	10	-	156	-	156
f. Revetment Improvement	391	1,104	-	1,495	-	1,495
2. Consulting Services	1,799	502	-	2,301	-	2,301
3. Direct Project Cost (1+2)	9,755	13,014	1,000	23,769	-	23,769
4. Taxes and Duties	-	-	-	-	3,273	3,273
VAT (10% of 1+2)	-	-	-	-	2,377	2,377
Custom Duties (10% of Foreign Materials)	-	-	-	-	896	896
5. Physical Contingencies (5% of 3)	488	651	50	1,189	-	1,189
6. Price Contingencies	1,024	3,739	158	4,921	-	4,921
7. Project Management Cost (2% of 3)	-	-	-	-	475	475
8. Service Charge (0.1% of 3+5+6)	29	-	-	29	-	29
9. Land Compensation and Resettlement Cost	-	-	-	-	10,890	10,890
10. Total Project Cost (3+4+5+6+7+8+9)	11,296 (38%)	17,404 (58%)	1,208 (4%)	29,908 (100%)	14,638	44,546

Note) All monetary units is thousand US Dollars

Source) "Feasibility Study Report on the Siem Reap Sewerage System and Improvement of Siem Reap River in the Kingdom of Cambodia, July 2008, Korea Exim Bank"

The project implementation will start after the Korean EDCF Loan Agreement becomes effective and implementation period is estimated as 4 years including detailed design and selection of contractor. (* L/A was signed on 4th June 2009)

Appropriate sewerage tariff shall be proposed through the consultation with MPWT at detailed design stage.

Further, the project includes the following Capacity Building Program:

- Community sanitation and health awareness program
- Preparation of Initial Environment Examination (IEE)
- Preparation of Environment Management Plan (EMP)
- Recommendation on organizational structure and functions for an entity to operate and maintain the sewerage system
- Preparation of legal documents to create the entity
- Establishment of fee structure for the purpose of cost recovery by the entity

9-4 SRDSMP: AFD, December 2009

9-4-1 Current Status of AFD Sewerage Master Plan

1. Target Study Areas for Centralized Wastewater Management System

Siem Reap development area consists of two distinct service areas: the Urban Area and the Peri-urban/Rural Area. The urban area can be defined by the following features:

- Central business district
- Area having gross population density exceeding about 20 persons/ha
- Hotel, tourism and commercial areas
- Major water service area: within the urban service area it is intended to provide wastewater collection service wherever an off-site wastewater stream is generated

Urban area is target service area for centralized wastewater management system.

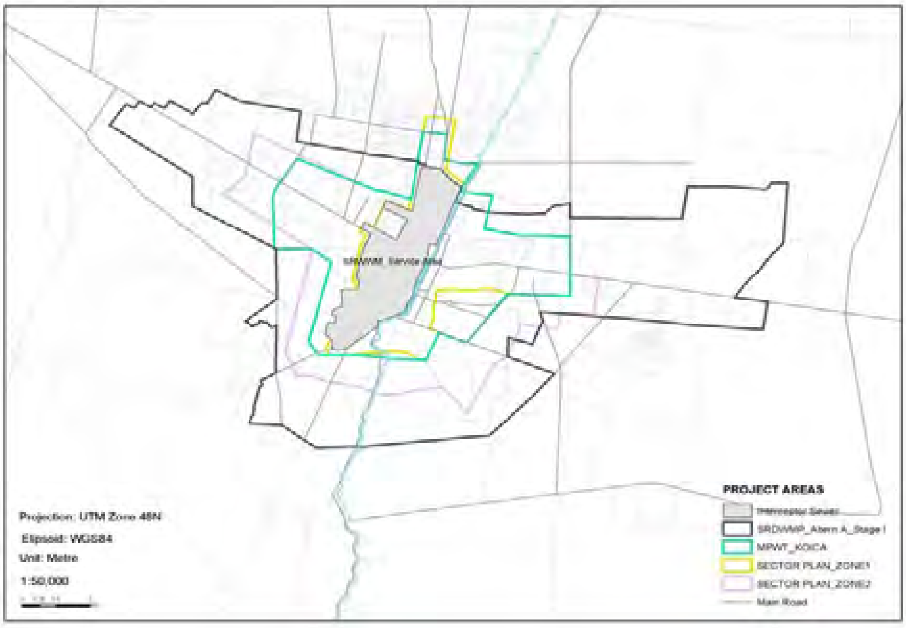


Figure 9.2 Related Project Areas

Figure 9.2 shows the project areas of three other related projects all having 2020 as target planning year.

- Integrated Mater Plan for Sustainable Development (IMPSD) Sector Plan Zone 1 and 2 (598 ha and 1,322 ha, respectively)
- MTDP SRWM Service Area (ADB: 265 ha)
- Feasibility Study KOICA (934 ha included ADB's 265 ha)

While Stage-1 of SRDSMP proposed for completion in 2015 with target planning year of 2035 has an area about 2,672 ha.

The following figures show two alternative implementation programs, Alternative A and B. Alternative A is a three stage program:

- Stage 1: to be completed in year 2015, targets the urban development area plus the tourism accommodation and commercial areas.
- Stage 2: to be completed in 2020, extends the service area to include the indicated area to the north (developing cultural-tourism-hotel zone), southwest (contiguous settlement area) and southeast (developing extended settlement area)
- Stage 3: to be completed in 2025, complete the provision of service to entire 6,009 ha urban service area
  Note) The total Urban Service Area of 6,009 ha includes the service area of KOICA, 934 ha.

Alternative B is a two stage program:

- Stage 1: to be completed in 2015, incorporates Alternative A Stage 1 and 2
- Stage 2: to be completed in 2025, is identical to Alternative A Stage 3

2. Trunk Sewers, Reticulation Sewers and other related sewerage facilities

Reticulation sewers and related facilities were designed by abovementioned service sub-area wise. The elements of the system include:

- Service connections: 100 mm and 150 mm diameter, totaling 634 km located at about 10 m intervals along with the reticulation sewers
- Inspection chambers: to be provided on each service connection
- Reticulation sewers: 150 mm, 200 mm, 250 mm and 300 mm diameter, totaling 653 km
- Manholes: totaling about 9,400 pieces spaced at 70 m intervals along with the reticulation sewers

Table 9.5 is a schedule of trunk sewers having total length of about 40.7 km with 490 manholes with intervals of 100 m approximately.

3. Pumping Stations

Table 9.6 is a schedule of pumping stations required. There are a total of 23 pump stations ranging in peak flow capacity from 1,128 m^3/day to 71,619 m^3/day.

Table 9.5 Trunk Sewers

Service Sub Area	Trunk Sewer Length, m									Av. Depth (m)
	300 mm	350 mm	400 mm	500 mm	600 mm	700 mm	800 mm	1000 mm	1200 mm	
SA_E2							2211	1708		3.1
SA_E3					1880					3.8
						362				4.0
SA_E4										
SA_E5			2122							3.6
				1602						4.2
SA_E6			1916							3.0
			1685							4.7
SA_E7		1720								3.3
SA_E8										
SA_E9				1737	1648					3.4
SA_E10										
SA_E11-R										
SA_E11-L	1432									4.1
SA_E11-L	2333									6.5
SA_E13				1204						3.2
(FM)				1704						5.2
SA_E14			1213							3.2
SA_E15			1296							3.4
SA_W1-R						2019				2.5
SA_W1-L								1157		2.9
SA_W2-R			1472							3.0
			1213							5.9
SA_W2-R	703									2.1
SA_W2-L				1601						2.8
SA_W3				1685						5.6
SA_W7									3063	4.4

Table 9.6 Schedule of Pumping Stations

Pump Station	2035 Peak Flow Rate	TDH	Station Type	Total Pumps (1 pump standby)	Initial Year	Initial Duty Pump Sets	2035 Duty Pump Sets	Pump Set Power Rating
	m^3/d	m ww		nr		nr	nr	kW
W4	2334	4.0	Submersible	2	2020	1	1	1.5
W3	9554	4.4	Submersible	2	2015	1	1	6.7
W5	1559	3.9	Submersible	2	2015	1	1	1.0
W6	3097	3.8	Submersible	2	2015	1	1	1.9
W2	20122	6.2	Submersible	2	2015	1	1	19.8
E12	1166	3.8	Submersible	2	2025	1	1	0.7
E11	4916	6.2	Submersible	2	2025	1	1	4.9
E10	3588	5.3	Submersible	2	2025	1	1	3.1
E9	5697	3.2	Submersible	2	2015	1	1	2.9
E8	1128	3.9	Submersible	2	2015	1	1	0.7
E7	5178	6.3	Submersible	2	2015	1	1	5.2
E6-1	3750	6.0	Submersible	2	2020	1	1	3.6
E6-2	7036	3.1	Submersible	2	2020	1	1	3.5
E5	12774	4.8	Submersible	2	2020	1	1	9.8
E4	5176	4.1	Submersible	3	2020	1	2	1.7
E3	38227	3.9	WW/ DW	4	2015	2	3	7.8
E2	47601	4.2	WW/ DW	4	2015	2	3	10.7
E16	5000	6.0	Submersible	2	2025	1	1	4.8
E15	2855	4.0	Submersible	2	2025	1	1	1.8
E14	5108	3.2	Submersible	2	2025	1	1	2.6
E13	6872	3.2	Submersible	2	2025	1	1	3.5
E1	51459	3.4	WW/ DW	4	2015	2	3	9.3
WWTP	71619	6.9	WW/ DW	4	2015	2	3	26.2

Source) "Drainage & Sewerage Master Plan for the District of Siem Reap Priority Works Draft Master Plan, AFD, December 2009"

Two further alternatives on Alternative A with different Wastewater Treatment Plant allocation:

- Option 1 : Provides treatment of all wastewater at a location to the east of the existing 20 ha WWTP site constructed under MTDP SRWM. The total site area required is 160 ha, including 40 ha for the KOICA site.
- Option 2 : Provides independent treatment facilities for the East and West service areas. West WWTP needs additional 8 ha excluding 40 ha for the KOICA site. East WWTP requires 112 ha in total.

Their staged construction schedule for the treatment facilities are shown as follows:

Table 9.7 Staged Construction Schedule for WWTP

Options	Stage 1 : 2015	Stage 2 : 2018	Stage 3 : 2028	Total Additional Capacity (m^3/day)
Option1 All West	10,000	10,000	10,000	30,000
	Stage 1 : 2015	Stage 2 : 2025		
Option 2 East	14,000	14,000		28,000
Option 2 West		2,000		2,000

4. Estimated Construction Cost of Alternative A1

Table 9.8 summarized the estimated cost of Option 1 of Alternative A.

Table 9.8 Estimated Investment Cost Wastewater Master Plan Alternative A1

System Components	Alternative A1				
	2015	2018	2020	2025	2035
Wastewater Treatment Plant Costs	7,650,000	7,650,000		7,650,000	
Trunk Sewer Costs	5,370,341		2,241,348	3,464,607	
Trunk Sewer Manholes	687,616		286,981	443,606	
Pump Station Costs	8,748,036		3,651,051	5,643,683	
Reticulation and Property Connection Costs	75,302,901		31,428,164	48,580,703	
Total	97,758,894	7,650,000	37,607,543	65,782,599	
Cumulative Total	97,758,894	105,408,894	143,016,437	208,799,037	208,799,037

Note 1) Abovementioned project cost was estimated to cover un-served urban service area just excluding MTDP SRWM project, since the progress of KOICA project is still not obvious.

Note 2) Source of these Tables is “Drainage & Sewerage Master Plan for the District of Siem Reap Priority Works Draft Master Plan, AFD, December 2009”

9-4-2 Current Status of AFD Storm Water Drainage Master Plan

1. General

Siem Reap is located in a very flat and low-laying area close to Tonle Sap Lake. The Siem Reap River flows through the city dividing it into East and West drainage areas and main river system further to east and west are the Roulous River and the Puok River, respectively. The rivers and ultimately all stormwater drainage flow into Tonle Sap Lake.

The Siem Reap River has natural gradient of about 1/1,000 from North to South towards Tonle Sap Lake. During rainy season, the river carries significant flows. In September 2009, the river flows was estimated to be 133 m^3/sec and many areas adjacent to the river were flooded for a period.

The level of the river through the town is controlled by the downstream Crocodile Dam, from where irrigation canals deliver river water to both the east and west banks.

However, the current stormwater drainage infrastructure cannot deal with heavy storm. Heavy storms can cause widespread flooding and water levels in drain and in Siem Reap River rise considerably. In poorly drained areas, urban runoff mixes with sewage from overflowing latrines and sewers, causing pollution. Doe to the flat topography, the existing drainage system does not have sufficient gradient and this makes it vulnerable to blockage from settled solids and dumped wastes.

National Road 6 (NR6) acts as a hydraulic bottleneck causing flooding, due to insufficient and clogged culverts and drains installed beneath the road over most of its entire length from east to west in the city area. This was reported by the previous study including Integrated Mater Plan for Sustainable Development (IMPSD) of Siem Reap and Angkor Town in the Kingdom of Cambodia (2006, JICA) but up to now the situation is the same and the city area has expanded.

The existing drains in the older developed part of Siem Reap town center were constructed in the 1950s and are in poor state of repair due to lack of maintenance and deterioration of the infrastructure. As states in the previous section, the KOICA proposed the construction of stormwater drainage with the following dimension and length in East and West District.

Dimension	East District (m)	West District (m)
Box 3.0 m × 2.0 m	1,380	4,690

2. Irrigation Canal

A number of existing agricultural irrigation canals, some of them date back to ancient Angkor civilizations, cross the project area. Though many of theses are in a state of disuse, others are still functioning and carry water to agricultural areas located in southwest and southeast of the city. This canal network has a base flow even during dry season and consequently reduces the capacity for stormwater drainage.

3. Current Status of Western Siem Reap District

There are two major drainage called Town Center Drain (TCD) and the Western Drain. Neither has sufficient capacity for the flows generated in their catchment area but TCD was reconstructed through KTDP SRWM (ADB) project to have sufficient hydraulic capacity.

The northern part of the Western Drain currently connects into inadequate system located in the south of NR 6 and as the road acts like dike, large areas have been suffered by chronic flooding.

4. Current Status of Eastern Siem Reap District

On the eastern bank of the river, there are three major existing drains, namely D7, D2 and D10. However, since these drains are connected to inadequate systems crossing or located in the south of NR 6, road acts like dike and large areas have been suffered by chronic flooding.

To mitigate such flooding damages, the Priority Works was proposed.

5. Stormwater System Concepts

Stormwater in urban area is generated from building roofs, paved areas and roads during rainfall events. The amount of stormwater is related to the amount of rainfall precipitation as well as the nature of ground surface. Vegetated surfaces decrease the rate of stormwater runoff and also allow rainfall to penetrate into soil. While, impervious surfaces do not act like this and produce more runoff.

The volume of stormwater generated in urban area shall be reduced, or at least controlled. This can be achieved by using more pervious materials for streets, sidewalks and parking areas. Designing of urban landscape that provides parks, grass turf for local infiltration is also effective. Land developments might increase runoff amount, shall be required to provide stormwater detention ponds to reduce peak flows and impacts to water conveyance facilities located downstream.

As rainfall intensity is relatively high in Siem Reap, the volume of generated stormwater is also huge. However, the hydraulic capacity for the proposed drainage is limited owing to the flat topography and high water levels at Tonle Sap Lake, the ultimate outlet.

The only practical way to prevent flooding is to provide large capacity stormwater drains (inline storage) or to provide stormwater detention (storage) facilities. To minimize the size of downstream drains, previous studies have recommended stormewater detention in various catchment areas.

However, owing to high rainfall intensity, the calculated storage volume is huge and seemed to be inapplicable.

6. Priority Works

The project will be implemented in phases. The first phase comprises drain D23, D10, part of D3, D21, additional D3A (cleaning), D3B and overflowing structures.

Now construction contract of these drainage facilities are under tendering and scheduled to be awarded on the end of March 2010 and planned to be completed in 810 days (2 years and 3 months) after the issuance of Letter of Acceptance.

The remaining drains are to be constructed when funding is obtained.

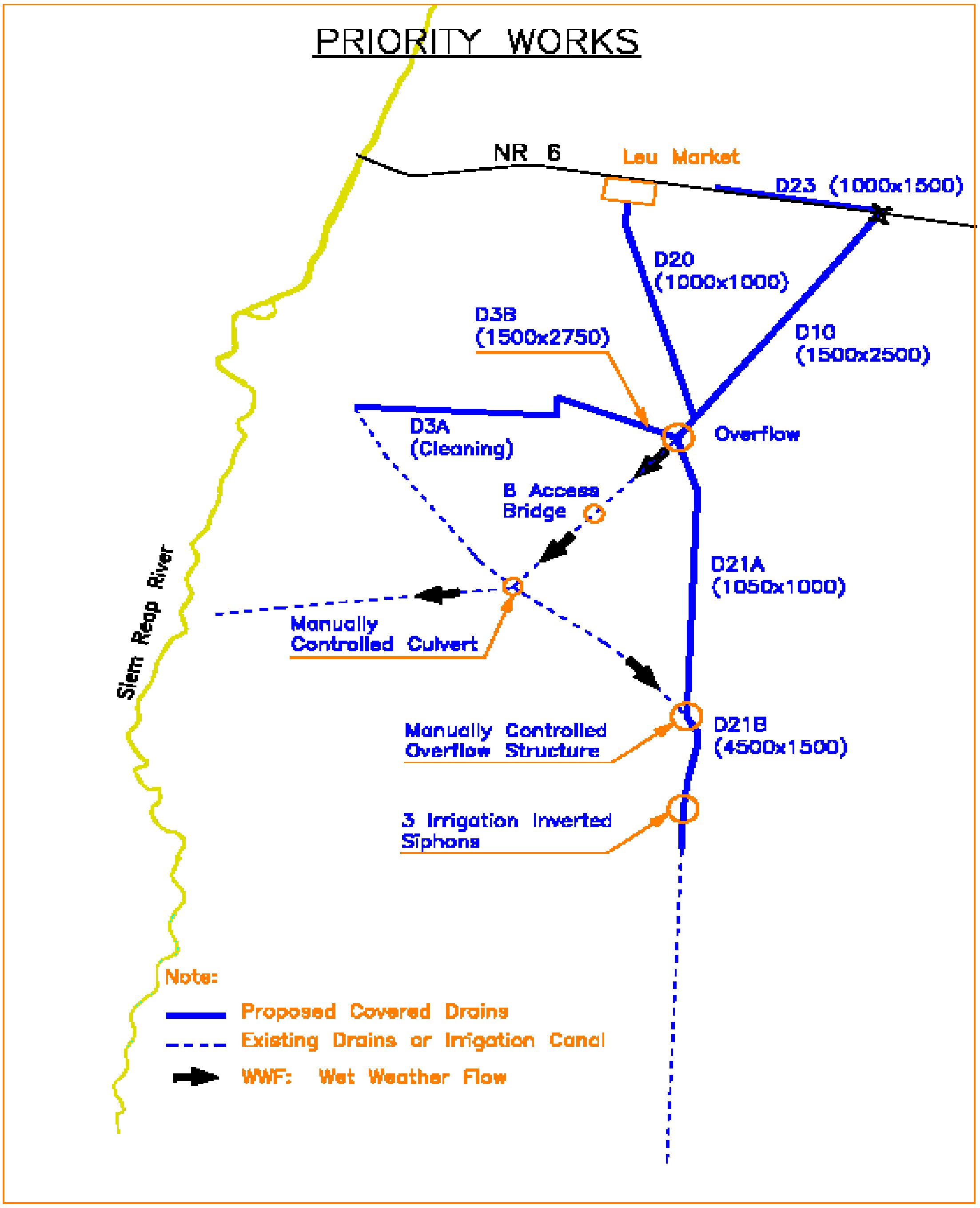


Figure 9.3 Priority Works – Phase 1

7. Stormwater Retention Basins

As discussed in the previous section, retention basins can reduce the peak flows poured into drainage system. Storage capacity can be:

- "Off-line" in detention basins, however finding suitable locations where this will be feasible might be difficult
- "In-line" as that provided in wide canals constructed along with the roads having large road reserve in the hotel area
- "On-site" storage

The only possible areas suitable for "off-line" storage are undeveloped areas or those not to be developed within the Archaeological Park Area.

"In-line" detention will be possible along roads with sufficient reserve width for construction of canal or basin and this only possible on the roads extension to Hotels and Tourist Zones.

"On-site" storage is possible in large land development zones such as hotels and cultural zones. They should be designed with individual on-site storage can store all stormwater runoff to minimize the impact to downstream areas and to promote rainwater harvesting. Hotels in those zones shall minimize the use of impervious areas to limit runoff and shall recycle stormwater for gardening and landscaping. All commercial developments should also store rainwater for this purpose.

8. Stormwater Drainage System Alternatives

1) Western Siem Reap

Table 9.9 shows the dimension of necessary drain in Western Siem Reap:

Table 9.9 Western Drain Dimensions (m) (All drains with 1.5 m flow depth)

Nodes		Without Detention Basins				With Detention Basins	
		2 Year Frequency Storm		5 Year Frequency Storm			
		Earth Drain Bottom Width	Concrete Drain Width	Earth Drain Bottom Width	Concrete Drain Width	Earth Drain Bottom Width	Concrete Drain Width
Western Drain - TCD Extension (1)							
TCD1a	TCD1b	Concrete	5.0	Concrete	5.0	Concrete	5.0
TCD1b	TCD1c	20.0	12.0	23.0	12.0	22	12.0
TCD1c	TCD2f	20.0	12.0	23.0	12.0	22	12.0
Western Drain 1 - WD1							
WD1a	WD1b	11.5	6.0	14.5	7.1	1.3	1.8
WD1b	WD1c	12.3	7.0	15.5	7.1	1.5	2.0
WD1c	WD1d	19.0	9.5	23.0	11.5	2.8	2.8
WD1d	WD1e	19.0	10.0	23.0	11.5	3.0	2.9
WD1e	WD2e	19.0	10.0	23.0	11.5	3.2	3.0
Western Drain 2 - WD2							
WD2a	WD2b	12.0	7.0	15.8	8.5	1.8	1.8
WD2b	WD2c	14.0	8.0	18.0	10.2	2.1	2.1
WD2c	WD2d	15.0	9.0	20.5	11.5	2.4	2.4
WD2d	WD2e	18.0	11.0	23.5	13.7	2.8	2.8
WD2e	WD2f	55.0	28.0	71.0	35.0	11.5	7
Western Drain 3 – WD3							
WD3a	WD3b	15.0	8.5	20.0	9.5	1.8	1.8
WD3b	WD3c	19.0	11.5	25.5	13.0	2.5	2.5

Note (1) Limited flow into upper reaches of TCD Extension from existing TCD
Because of land constraints 1a to 1b must be a concrete drain

2) Eastern Siem Reap

Table 9.10 shown the dimension of necessary drain in Eastern Siem Reap:

Table 9.10 Eastern Drain Dimensions (m)   (All drains with 1.5 m flow depth)

Nodes		Without Detention Basins				With Detention Basins	
		2 Year Frequency Storm		5 Year Frequency Storm			
		Earth Drain Bottom Width	Concrete Drain Width	Earth Drain Bottom Width	Concrete Drain Width	Earth Drain Bottom Width	Concrete Drain Width
Eastern Drain ED1[(1)]							
ED1a	ED1b	-	-	-	-	Concrete	6
ED1b	ED1c	-	-	-	-	Concrete	7
ED1c	ED1d	-	-	-	-	11	7
Eastern Drain ED2							
ED2a	ED2b	44	23	58	29	3	3
ED2b	ED2c	44	28	58	37	5	5
ED2c	ED2d	44	30	58	66	6	6
ED2d	ED2e	26	21	35	27	5	5
ED2e	ED2f	34	27	46	35	6	6
ED2f	ED2g	40	31	53	65	7	7
ED2g	ED2h	43	34	53	77	9	9
Eastern Drain ED3							
ED3a	ED3b	130	63	167	68	21	11
ED3b	ED3c	110	68	144	77	30	16
ED3c	ED3d	65	42	85	48	30	16

Note (1)   Limited flow into upper reaches of ED1 from existing Priority Works drainage programme

3) Estimated Construction Cost of Western and Eastern Drains

The following Table indicates the project cost needed for Western and Eastern Drains, with and without detention basins.

Table 9.11 Costs - Western Drain Systems Without Detention Basins (US$ 1000)

System	Without Detention Basins			
	2 Year Frequency Storm		5 Year Frequency Storm	
	Earth Drain	Concrete Drain	Earth Drain	Concrete Drain
Eastern Drain System TCD Extension				
Drains - concrete	686.8	686.8	834.2	834.2
Drains - downstream	289.4	1 855.5	305.3	2 248.8
Land costs	143.6	74.2	157.6	75.0
Sub total	**1 119.8**	**2 616.5**	**1 297.1**	**3 158.0**
Western Drain System WD 1				
Drains - concrete	5 221.8	5 221.8	6 596.7	6 596.7
Land costs	125.5	125.5	139.0	139.0
Sub total	**5 349.4**	**5 349.4**	**6 735.7**	**6 735.7**
Western Drain System WD 2				
Drains	3 352.7	23 769.7	3 705.8	27 242.9
Land costs	1 661.0	801.6	2 085.1	347.2
Sub total	**5 013.7**	**24 571.3**	**5 790.9**	**22 590.1**
Western Drain System WD 3				
Drains	1 476.8	16 643.3	6 270.0	55 714.0
Land costs	732.6	375.2	889.0	410.7
Sub total	**2 209.4**	**17 018.5**	**7 159.0**	**56 124.7**
Grand Total	**13 692.3**	**49 555.7**	**20 982.7**	**88 608.5**

Table 9.12 Costs - Western Systems With Detention Basins (US$ 1000)

System	With Detention Basins	
	Earth Drain	Concrete Drain
Western Drain – TCD Extension		
Detention Basins	209.5	209.5
Drains	596.8	1 086.4
Land costs - basins	547.6	547.6
Land costs - drains	153.0	89.8
Sub total	**1 506.9**	**1 933.3**
Western Drain System WD 1		
Detention Basins (none)	0	0
Drains	285.2	1 412.4
Land costs - basins	0	0
Land costs - drains	137.6	66.8
Sub total	**422.8**	**1 479.2**
Western Drain System WD 2		
Detention Basins	2 033.4	2 033.4
Drains	1 654.0	8 450.3
Land costs - basins	547.6	547.6
Land costs - drains	818.7	100.8
Sub total	**5 053.7**	**11 132.1**
Western Drain System WD 3		
Detention Basins	2 419.4	2 419.4
Drains	690.9	7 284.0
Land costs - basins	411.4	411.4
Land costs - drains	333.6	159.3
Sub total	**3 855.3**	**10 274.1**
Grand Total	**10 838.7**	**24 818.7**

Table 9.13 Costs - Eastern Drain Systems Without Detention Basins (US$ 1000)

System	Without Detention Basins			
	2 Year Frequency Storm		5 Year Frequency Storm	
	Earth Drain	Concrete Drain	Earth Drain	Concrete Drain
Eastern Drain System ED 1 (Priority Works Extension)				
No detention basins in Priority Works system – costs from Table below				
Sub total	**1 521.1**	**2 482.1**	**1 521.1**	**2 482.1**
Eastern Drain System ED 2				
Drains	4 252.5	26 301.0	4 845.4	33 984.2
Land costs	2 336.7	1 500.8	2 852.2	2 563.4
Sub total	**6 589.2**	**27 801.8**	**7 697.6**	**36 547.6**
Eastern Drain System ED 3				
Drains	9 552.8	40 790.9	11 024.7	45 440.0
Land costs	5 066.3	2 909.3	6 346.2	3 621.8
Sub total	**14 619.1**	**43 693.8**	**17 370.9**	**49 061.8**
Grand Total	**36 419.4**	**73 977.7**	**40 279.6**	**88 091.5**

Table 9.14 Costs - Eastern Drain Systems With Detention Basins (US$ 1000)

System	With Detention Basins	
	Earth Drain	Concrete Drain
Eastern Drain System ED 1 (Priority Works Extension)		
Drains	1 521.1	2 482.1
Land costs - drains	Not applicable – in roads	
Sub total	**1 521.1**	**2 482.1**
Eastern Drain System ED 2		
Detention Basins	2 331.2	2 331.2
Drains	1 435.4	6 286.2
Land costs - basins	141.9	141.9
Land costs - drains	659.1	411.6
Sub total	**4 567.6**	**9 170.9**
Eastern Drain System ED 3		
Detention Basins	4 864.5	4 864.5
Drains	5 721.3	23 223.3
Land costs - basins	1 325.1	1 325.1
Land costs - drains	2 115.1	951.6
Sub total	**14 026.0**	**30 364.5**
Grand Total	**20 114.7**	**42 017.5**

4) Recommended Drain Scheme

From the technical aspect, the recommended drain scheme was tabulated in Table 9.15 with the following premises:

- Detention basin design was based on 5-year storm frequency storage
- Drains with no detention basins were designed for 2-year frequency storm

Table 9.15 Recommended Drain Scheme

Drainage System	Component	Costs (US$)	
		Sub Total	Total
Western Siem Reap			
TCD Ext.	No detention basins		
	TCD Extension to 1b - concrete	686 800	
	Extension from 1b – earth drain	289 400	
	Cost of TCD Extension		976 200
WD1	No detention basins all concrete channels	5 221 800	
	Land costs	125 500	
	Cost of WD1		5 349 400
WD2	All detention basins, all earth drains		
	Detention basins	2 033 400	
	Drains	1 654 000	
	Land costs	1 366 300	
	Cost of WD2		5 053 700
WD3	All detention basins, all earth drains		
	Detention basins	2 419 400	
	Drains	690 900	
	Land costs	745 000	
	Cost of WD3		3 855 300
	Total Cost for Western Drains		**15 234 600**
Eastern Siem Reap			
ED1	No detention basins		
	Priority Works Extension	1 521 100	
	Cost of ED1		1 521 100
ED2	All detention basins, all earth drains		
	Detention basins	2 331 200	
	Drains	1 435 004	
	Land costs	801 000	
	Cost of ED2		4 567 600
ED3	All detention basins, all earth drains		
	Detention basins	4 864 500	
	Drains	5 721 300	
	Land costs	3 440 200	
	Cost of ED3		14 026 000
	Total Cost for Eastern Drains		**20 114 700**
	Total Cost for all Drains		**35 349 300**

Note) Source of these Tables is “Drainage & Sewerage Master Plan for the District of Siem Reap Priority Works Draft Master Plan, AFD, December 2009”

9-5 Japanese Grant Aid Assistance Needs in Sewerage and Drainage Sector

Past investment in sewerage and drainage sector in Siem Reap has been at a level well below that needed for sustainability. As a consequence, the current infrastructure cannot meet the standards needed to achieve compliance with the environmental requirement and in particular:

- Increasing pollution of Siem Reap River due to discharge of untreated wastewater into the river
- Open drains have insufficient capacity for stormwater
- Open drains are abused with the discharged garbage
- Some of the drains have been filled for construction and/or insufficient pipes have been installed diminishing the capacity of network
- Flooding by stormwater combined with wastewater causes sanitary and health problems
- Streets are flooded by heavy rain

- Effluent from septic tanks are discharged directly into drains
- Eventually, the Tonle Sap Lake the proposed water source has been heavily polluted

However, the following criteria are employed to identify the relevancy as Japanese Grant Aid Project:

- Restriction in project implementation period, basically single fiscal year
- Limitation in project budget
- Project sustainability
- Financial feasibility
- Environmental viability
- Stable and early display of project benefits

Based on the abovementioned Grant Aid Assistance introduction criteria, the Study Team recommends the feasible assistance by Japanese Grant Aid.

9-5-1 Sewerage Sector

Figure 9.4 shows the relationship between the target areas of available Sewerage Master Plans:

- MTDP SRWM: A = 265 ha, completed on December 2009
- KOICA: A = 934 ha, including that of MTDP SRWM, Now on-going
- SRDSMP: A = 6,009 ha, including that of KOICA, Draft Master Plan was prepared on December 2009

Characteristics of service areas proposed by each project, study are as follows:

- MTDP SRWM target area covers the City Center located along with the west side of Siem Reap River
- Proposed KOICA target area covers the eastern and western areas surrounding MTDP SRWM target area
- SRDSMP covers further wide area surrounding KOICA target area

As shown in Figure 9.4, most of core urban area is to be served by KOICA project and the most of the remaining un-served area can be regarded as Peri-Urban Area where centralized sewerage system might not be always feasible. As Siem Reap City has extremely flat topography, 23 pumping stations including one in WWTP are needed to collect the generated sewage and this also attributed to the huge project cost.

Since the Sewerage Master Plan was prepared by the assistance of AFD, possible assistance by Japanese Grant Aid in facility construction is “Cooperative Assistance” sharing service area with other Donor Agencies.

Figure 9.5 shows the relationship between service areas of:

- MTDP SRWM: A = 265 ha
- KOICA: A = 934 ha and
- JICA Siem Reap Water Supply Expansion Project: A = 3,360 ha

Whole JICA F/S Area was divided into four areas and their respective area, estimated water consumption and unit area water consumption is shown in Table 9.16:

Table 9.16 Unit Area Water Consumption

F/S Area	Water Consumption (m^3/day)	Area (ha)	Unit Area Water Consumption (m^3/day/ha)
Area 1	13,600	860	15.67
Area 2	13,100	620	20.94
Area 3	14,500	880	16.32
Area 4	14,800	1,000	14.72
Total	56,000	3,360	

Based on the estimated area-wise unit area water consumption, total water consumption within KOICA project sewerage service area was estimated:

Table 9.17 Water Consumption within KOICA Service Area

KOICA Area	Unit Area Water Consumption (m^3/day/ha)	Area (ha)	Water Consumption (m^3/day)
Area 1	17.48	318	5,559
Area 2	19.17	293	5,617
Area 3	18.98	114	2,164
Area 4	14.02	209	2,930
Total		934	16,270
			(1.046)
WWTP Capacity (ADB + KOICA)			15,552
			(1.0000)

The estimated total water consumption is slightly exceeding the total WWTP capacity. However, whole amount of consumed water will not turn to sewage. According to the available sewerage studies, the conversion ratios are as follows:

Table 9.18 Sewage Conversion Ratio

Name of Study	Conversion Ratio
KOICA Feasibility Study	0.85
Drainage & Sewerage Master Plan for the District of Siem Reap (AFD)	0.80

In both study, groundwater infiltration was counted and the rate was 10% of generated sewage.

Therefore, total incoming sewage amount can be calculated as:

16,270 (water consumption within KOICA sewerage service area)×0.85×1.10

= <u>15,212 m^3/day</u> < 15,552 m^3/day (WWTP Capacity)

Therefore, even if water consumption is increased by water supply system expansion in the future, generated sewage within KOICA sewerage service area can be properly treated by the expanded WWTP. The following shows future comparison between water discharge and WWTP capacity.

Year	2015	2020)	2025	Remarks
Supply amount (m^3/d)	18,939	35,215	47,917	Daily ave. amount (Qw)
Sewerage amount (m^3/d)	17,708	32,926	44,802	
WWTP cap. (m^3/d)				
ADB project	5,552			
KOICA project	10,000			
AFD project	10,000	10,000	10,000	
Total WWTP capacity (m^3/d)	25,552	35,552	45,552	
Ratio	0.693	0.926	0.984	Qs/WWTP cap.

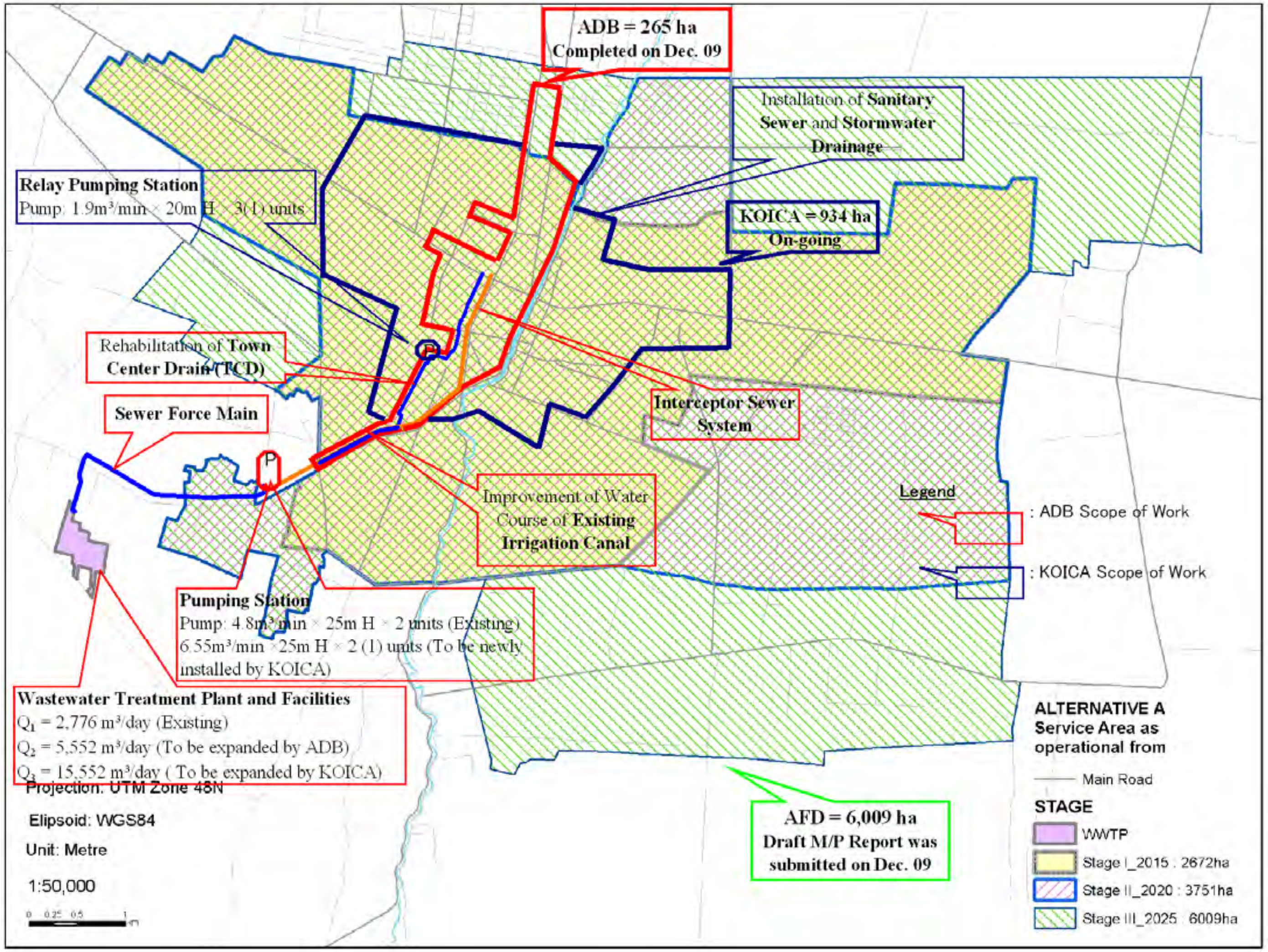


Figure 9.4 Target Sewerage Service Area

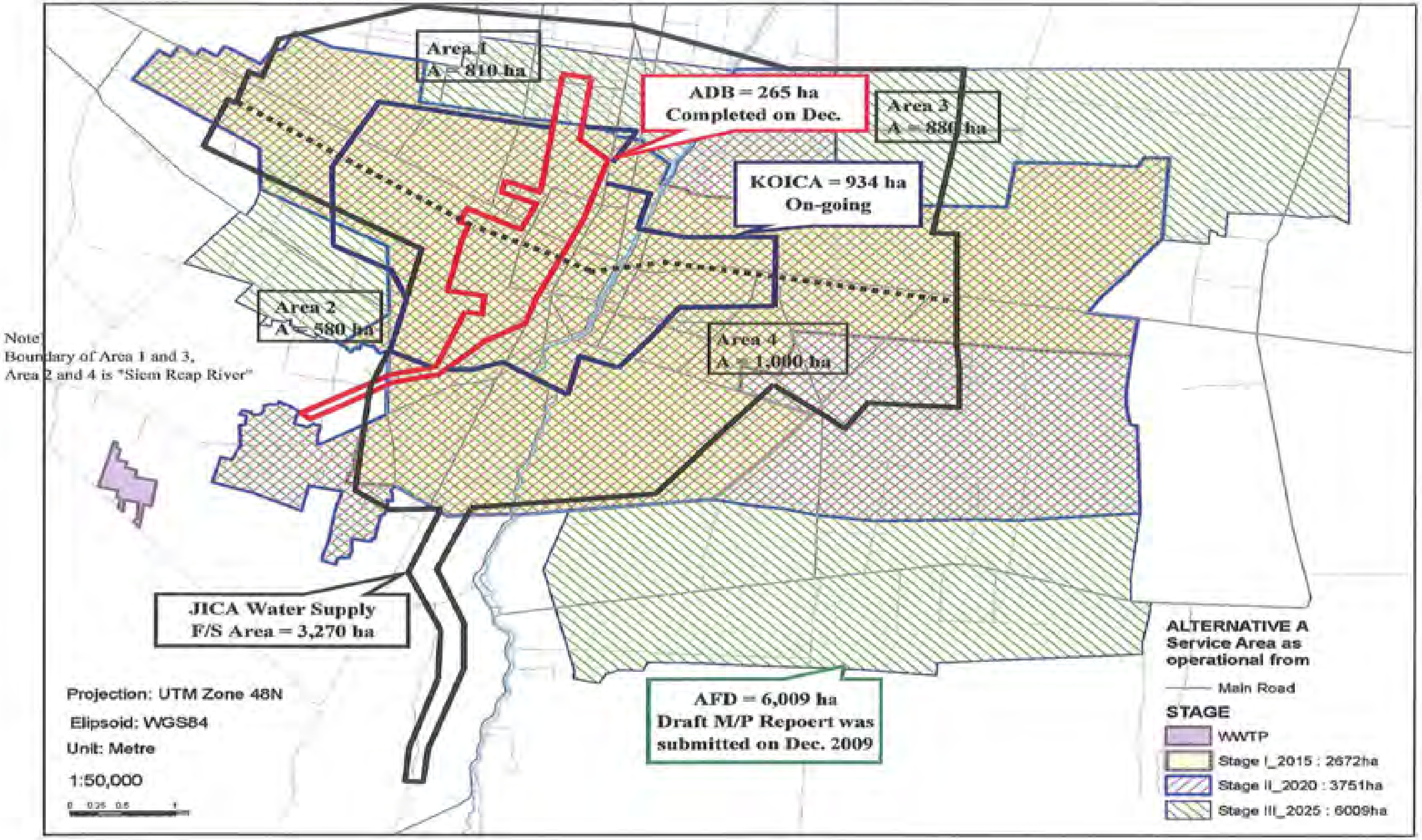


Figure 9.5 Relationship Between Sewerage and Water Supply Service Area

9-5-2 For Drainage Sector

As aforementioned in previous section, proposed first phase of Priority Works programmed to drain the east urban extension area are now under tendering and supposed to be completed in 2 years and 3 month (810 days) after the issuance of Letter of Acceptance. The remaining second phase will be implemented when appropriate fund is found.

However, even if second phase of Priority Works are completed, total drainage system capacity is still insufficient and project cost of additional drainage facility was estimated as **35,349,300 US$**.

Likewise in case of Sewerage Master Plan, Drainage Master Plan was also prepared by the assistance of AFD, possible assistance by Japanese Grant Aid in facility construction is "Cooperative Assistance" sharing service area with other Donor Agencies.

9-5-3 Proposed Japanese Grant Aid Assistance

Since the remaining un-served area in AFD study is huge (in case of sewerage area, A = 6,009 ha – 934 ha = 5,075 ha), total project cost became huge. Also, as electricity in Cambodia is expensive, operation cost of pumping station will also be huge. For reference, electricity is 19 yen/kWH in Cambodia and 12 yen/kWH in Japan.

Further, as the most of remaining un-served area can be regarded as "Peri-urban area", the optimim sewage management system shall be properly employed for sustainable and stable system operation. In peri-urban area with less population density, centralized sewerage system might not be always feasible. Therefore, zone-wise priority study is needed at minimum to screen the target area because specific "Priority Project" was not proposed in AFD Master Plan.

Accordingly, the introduction of Japanese Grant Aid in sewerage and drainage system development is not deemed as realistic, because potential project benefit is estimated to be less.

Peri-urban area shall be served by the existing "On-site System" and then, the possible assistance direction of Japanese Grant Aid shall be supporting project maintaining these existing system including said On-site System and sewer network. They must be appropriately maintained through the future because effluent of the existing On-site System flows into the drains nearby and eventually flows into Tonle Sap Lake until the areas are served by separate sewers.

Further, provision of sewer cleaning equipment is needed as well since the length of sewer will increase through the future.

Capacity building for the counterpart agency through Japanese Technical Assistance Project is also effective to keep sustainable function of the completed facilities.

1. Provision of Sewer Cleaning Equipment

If KOICA project is completed, diameter-wise breakdown of sewer length will be approximately as follows:

Table 9.19 Overall Sewer Length by Diameter

Diameter	200	250	300	350	400	500	600	700
Length	40,370	2,767	1,754	1,430	1,667	2,840	632	3,931
Note) Length unit is Meter							Total	55,390

ADB SRWM project also provided one set of sewer cleaning equipment and one unit of septage collection vaccum truck with tank capacity of 6 m^3 and now they are operated and maintained by Siem Reap Sewerage and Wastewater Treatment Plant Unit (SRSWTPU) newly established under the Ministry of Public Works and Transport. Their photos and specifications are shown in Table 9.2 in the Main Report.

To maintain sound functions of completed sewers, systematic and periodical sewer cleaning is essential. Although SRSWTPU owns one set of sewer cleaning equipment, it's not sufficient. Provision of plural sets of sewer cleaning equipment with accessories and preparation of sewer cleaning plan is needed for stable sewer function.

2. Provision of Septage Collection Vacuum Tanker Truck

Even if the remaining urban areas are to be served by separate sewerage system, construction works will take long time period and until the time of system completion, service areas are to be served by the existing on-site system represented by Septic Tanks. Further, in peri-urban/rural areas where the centralized sewerage system is not feasible, service by on-site system will be continued. As such on-site system shall be properly maintained through the future to preserve sound hygiene and living environment, appropriate maintenance activities shall be practiced.

Typical septic tank has three compartments and the last one is soak pit for ground infiltration. To maintain sound tank function, periodical septage removal is essential. Septage is sludge accumulated in septic tanks. Typical removal frequency is once in every two or three years.

Therefore, provision of septage collection equipment is indispensable. Currently SRSWTPU owns one septage collection vaccum truck but it not enough. According to the AFD wastewater master plan, daily septage generation amount was estimated in Table 9.20.

Providing that the existing SRWM 6 m^3 capacity septage collection tanker collects septage by three round trip per day, collected septage amount will be 18 m^3/day. Based on the daily septage generation amount, three additional 6 m^3 capacity septage collection tankers are required.

As ADB SRWM WWTP has septage receiving facility but allowable septage amount is 10 m^3/day.

For stable and appropriate septage treatment, WWTP to be designed and constructed in future shall have such septage receiving facility.

Table 9.20 Septage Service Population and Quantities Projection

Year	Septage service population (1)	Projected septage quantities, m^3 /day
2010	61,762	62
2015	66,583	67
2020	71,685	72
2025	77,064	77
2030	73,307	73
2035	66,742	67

(1) The septage service area population includes the rural and peri-urban area, and the unserved population in the urban service area.
Source) Drainage & Sewerage Master Plan for the District of Siem Reap Priority Works Draft Master Plan (December 2009)

3. Construction of Septage Treatment Facility

As aforementioned, the allowable septage amount in the existing WWTP is 10 m^3/day and it's apparently insufficient compared with daily septage generation amount estimated in Table 9.20.

Therefore, this capacity shortage shall be covered by the construction of septage treatment facility. This facility shall be designed to treat septage exclusively.

4. Technical Assistance Project for Capacity Building towards counterpart Agency

Further, Japanese Technical Assistant Project for capacity building in the following fields is needed to maintain the sound functions of completed facilities:

Table 9.21 Proposed Capacity Building through Technical Assistance Project

Task	Counterpart Agencies	Specific Fields
Capacity Development	Siem Reap Sewerage and Wastewater Treatment Plant Unit (SRSWTPU) under the Ministry of Public Works and Transport	➢ Training on computerized accounting/billing and financial management system ➢ Training session on administrative management ➢ Training on basic design and construction concept of sewers/drains and plumbing works ➢ Formulation of "Annual Sewer Cleaning Plan" ➢ Collect and maintain documents and drawings of the completed facilities in digital files ➢ Prepare daily record on incoming and outgoing sewage flow and quality in WWTP ➢ Prepare repair record on sewerage facilities ➢ Establish Inventory System for stored materials and equipment ➢ Enlightenment campaign on benefits generated by sewerage and drainage system and on elimination of garbage dumping into sewers and open drains ➢ Encourage Sanitary/Hygiene education in Schools ➢ Official registration of private contractors currently undertaking septage collection. Reportedly, some of them are dumping collected septage into open drain or open land without any treatment. To eliminate such illegal environmental contamination, they shall be registered by Governmental offices and they must follow the legal instructions and regulations. Further, their work shall be periodically monitored. In case of infringement, penalties are enforceable. As Department of Public Works and Transport in Siem Reap owns their Septage Disposal Site located 6 km west of the City, collected septage shall be disposed here.

9-5-4 Conclusion and Recommendations

The Study Team proposes the following should be done as the Japan's Grant Aid Project:

1. **Provision of Sewer Cleaning Equipment**
2. **Provision of Septage Collection Vacuum Tanker Truck**
3. **Construction of Septage Treatment Facility**
4. **Technical Assistance Project for Capacity Building towards counterpart Agency**

Sewerage system development project needs long time period. For instance, in case of KOICA project, 4 years are needed after the L/A signing including the selection of Consultants, Contractor, Construction Supervision and Plant Commissioning Test.

While, execution of the proposed on-site/sewerage system maintenance project needs much less period and therefore, project benefit will also be displayed in very early stage.

The proposed project can be "Model Project" applicable to other Provinces with modifications owing to their locality.

Further, the Study Team would like to strongly recommend the Dispatch of JICA Expert in Sewerage Sector. As described in former sections, three donor agencies are implementing sewerage system construction project and are preparing sewerage feasibility study and sewerage master plan. Some of them are overwrapping.

Such issues attribute that no one was assigned to collect the relevant report, study and information to make mutual adjustment between plural donor agencies.

To mitigate such inefficient project and study progress, JICA Expert in sewerage sector shall be dispatched.

Chapter 10.
Environmental and Social Considerations

Chapter 10. Environmental and Social Considerations

The result of environmental and social considerations is summarized as follows.

(1) Air quality

From water intake to water treatment plant through pumping station, little impact is expected due to dust because there is no residential area along the pipeline. Consideration should be made to lay down the pipe and fill in the trench in a short while after excavation and not to leave it open for a long time in case of construction of distribution pipe in the town. In order to avoid risk by accident of chlorine treatment during operation, a trench is planned next to gas container and the container can be thrown into the water in the trench in case of emergency to dis-acidify chlorine with $CaCO_3$.

(2) Water Quality

Prior to construction of water intake, a sheet pile coffer dam is constructed. Since the water discharged from the coffer dam is the same as that of Tonle Sap Lake, little impact is given on the lake water. As regards construction of conveyance pipe in the water, if much turbid water is discharged, the water is discharged once into a lagoon prepared on the land and flown away to the lake to prevent turbid water from spreading out directly in the lake.

The pollutants, such as SS, BOD and COD contained in effluents discharged from water treatment facility during operation can comply with the effluent standards in Cambodia and originally the quantity of wastewater is very small. Moreover, environmental monitoring will be conducted by SRWSA.

(3) Waste

Prior to construction of facilities some forest trees are cut and the roots taken up, and the site for the facilities are excavated. The trees can be sold as material for buildings or firewood, while the roots and surplus soil will be disposed on the proper disposal site in accordance with the regulation.

The sludge, which is not hazardous and not toxic, is discharged from water treatment plant. The project owner can order the solid waste management company to collect and transport the sludge to the final disposal site.

(4) Noise & Vibration

Little impact is expected due to noise and vibration from construction site up to water treatment plant from the intake because there is no residential area along the site. However, construction in urban area should be stopped at night and on holiday. Particularly consideration should be made not to give significant impact on tourists.

Noise emitted from pumping station and water treatment plant during operation is not so big.

(5) Hydrology

The wastewater discharged from central district of the area covered by this project is collected and treated by the wastewater treatment system improved by ADB and KOICA projects and the rest of the area will be covered by the project of AFD. As the surface water from the lake is utilized as the water source for this project, water is circulated from/to the lake and the amount of water is basically balanced.

(6) Protected Areas

There are many protected areas in the study area. Impact on provincial conservation areas of Boeng Peareang Natural Conservation Area and Polav Fish Conservation Area can be avoided after review of alternatives. However, the project cannot keep from some protected areas.

Pipeline is laid down 8km long in the Strictly Protected Inundated Forest Area (MOAFF), 1.7km in gallery forest and 2km in the area mixed with bush and shrub. The arears would be lost and not reforested permanently if an open canal is planned. Therefore, pipeline system was taken into consideration in spite of difficult maintenance. The forest area would be disturbed only 30m wide including whole construction site and the forest area would be reforested some years later after the trench is filled with soil as same as before.

The project owner should minimize the alteration of the forest for the project site, and for a few years after construction, set up a barrier which prevents people from entering the water area over the pipeline for fishing or for firewood to promote the reforestation. At the same time the gallery forest area will be reforested by young trees and the regrowth of the forest will be monitored by the project owner.

Pipeline is laid down 4km long in the Multiple Use Area (MOE) and Buffer Zone of Tonle Sap Biosphere Reserve (UNESCO) at the same time. Since it is laid down 2-3m deep under ground, little impact on land use is expected after construction.

As pipeline is laid down 9 km long in the Community Fisheries (MOAFF) area, some impact may be expected on fishery domain. The project owner, SRWSA, is ready to offer compensation to the Community Fisheries.

When the pipes are laid down outside of the existing road in Zone 2 and Zone 3 of APSARA Protected Area or in the Landscape Protected Area (MOE) respectively, the project owner should inform APSARA or MOE of the construction schedule and location prior to construction to get some advice.

(7) Ecosystem and Biota

The dykes and dams of the reservoir should be restored after completion of construction.

There is no major concern over the possible impact of the project on the fishery ecology or species loss as pipeline will not cause any change in terms of obstruction of migratory route or disturbance to fish reproduction.

No major impact of the project is foreseen as many amphibians reproduce quickly even in this much disturbed areas, which are not significant habitats for mammal species, including species of global conservation as the areas are highly disturbed by human activities such as dry season rice, forest encroachment, firewood collection, wildlife hunting and fishing. Like other fauna species, it is not the breeding area for water birds of global significance. Many birds migrate here during the dry season for food and are mainly concentrated in Boeng Peareang where water is permanently available year round. It is same condition for reptile species.

(8) Living & Livelihood

The project owner has to prevent accident of fishing boats by posting construction activities. Construction during dry season gives some impact on recession rice area. The project owner, SRWSA, is ready to offer compensation to the farmers although cultivation is possible same as usual after pipe is laid down and the trench is filled with soil. The areas necessary for pumping station and water treatment plant are 0.5 ha and 4ha only respectively and little impact might be on the land owner.

A tower will be built on the intake to prevent accident by boats, and even in rainy season local people can identify the location of the intake and prevent accident from occurring. Little impact may be given on fishing and transportation by water.

(9) Heritage

There is the cultural heritage of an old canal on the way from the Water Treatment Plant to existing road. The project owner should inform construction schedule to APSARA prior to crossing the old canal.

(10) Landscape

Although an intake tower will appear outside of inundated forest area, there would be little impact of the landscape because at present there is a large building outside of the area. A new pumping station and a new water treatment plant will give little impact on the surrounding landscape because two sites are located on plain land respectively far from residential area.

(11) Monitoring

At the phase of construction, impacts on ecosystem & biota will be mainly monitored. Tall trees to be cut down should be minimized and the number of felled tall trees should be recorded. The data will be of help to reforestation in the future.

At the phase of operation, every four months the quality of wastewater discharged from the Water Treatment Plant is analyzed by SS, BOD and COD, while the quantity is small because the wastewater is reused in principle in the water treatment system. Proper disposal of the sludge should be monitored at the same time.

The ecosystem around the raw water intake facility should be monitored regularly. Since fishermen belonging to Kandaek Community Fisheries always come by the area near the intake by boat and are ware of the natural condition, the project owner will conduct hearing from the representatives of the Community Fisheries regarding impact on the surrounding area two times in dry season and wet season respectively. After reforestation in the gallery forest area surrounded by a barrier, the number of young trees should be counted and the height be measured by visual observation per year for five years.

Chapter 11.
Evaluation of Priority Project

Chapter 11.Evaluation of Priority Project

11-1 Socio-Economic Evaluation

The *Cambodia Millennium Development Goals* (CMDGs) establishes the key underlying coverage targets for the development of water supply sector and, therefore, becomes one of the viable guides in evaluating the project. There are two main quantitative evaluation indicators utilized – water supply coverage[16], and served population[17]. The long-term water supply development plan envisages exceeding the CMDG with respect to urban coverage ratio in the Siem Reap City and its surroundings by a five-year delay in 2020, which will continue to be supplied as at present with SRWSA safe water at a level of 90 percent in 2030. As for water supply to tourists, 80 percent coverage will be achieved in the same year as domestic water supply in 2020 and 100 percent in 2030. In this sense, the long-term water supply development plan fully complies with the relevant national and international targets.

The expected benefits from achieving the CMDG clean water coverage targets include improved overall health of the project beneficiaries, measured by evaluation indicators as the reduction of water diseases' outbreaks and the reduction of infant and maternal mortality associated with water-borne diseases. Improved water supply in the areas also reduces the burden of fetching water that typically falls on women and children, contributing indirectly to greater rural labor force productivity and improved school attendance and educational achievement of children.

Improved water supply from the Central Distribution System (CDS) aids the development of the tourism industry in Siem Reap City, particularly in the tourism-related service businesses such as hotels and restaurants. In this connection, there are over 300 number of guesthouses and hotels in the service area, all of which are waiting to be connected to the system. Water supply is also among the critical infrastructure requirements for labor-intensive, light manufacturing industries that the RGC has targeted for promotion in its industrial policy.

Expansion of water supply inevitably results in greater production of wastewater. Preparation and implementation of the priority project for drainage and sewerage in the Study Area is urgently necessary, to ensure that the health benefits from improved water supply are not lost on account of deterioration in sanitary and environmental conditions. 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 Tonle Sap Lake, can be expected to

[16] Water supply coverage (%) = [population served] x 100 / [total population in the present service area] is an important evaluation indicator because any water utility is mandated to serve a given and defined service area.
[17] Served population is the production/population (m3/d/c) = [annual production volume (m3) /365] / [number of people served]. It shows the capacity of the present system to supply water to all types of customers in its service area.

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.

11-2 Environmental Evaluation

JICA categorized this Plan project as Category B. The proposed long-term water supply development 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, and 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 the previous section, Environment Mitigation Measures will be adequately conducted, the related agencies should monitor those activities as recommended in Environmental Monitoring Measures.

11-3 Technical Evaluation

By the Priority Project augmentation project, which includes construction of raw intake facilities, water treatment plant, and clear water transmission/distribution pipelines, a daily total water supply capacity of 56,000 m^3 will be achieved in early 2017. The project will secure the supply capacity to meet the water demand up to the year 2022. The jurisdiction of SRWSA water supply is expanded to 33.6 km^2 by the Priority Project in the long-term water supply development plan, approximately five times the area compared to 6.9 km^2 of the current water supply covering areas.

Served population will reach 233 thousand or 82 percent as well as 7.8 thousand or 86 percent of tourists of the projected population in 2022 in the long-term water supply development plan in cooperate with the existing water supply systems. Water tank and distribution pipes will be extended and enforced to secure reliable water supply. The number of service connections will reach approximately 41,000 connections in 2022, from approximately 4,500 at present.

Safe and clean water meeting the Cambodia Drinking Water Standard will be supplied by the existing and new water treatment plants with proper and affordable treatment processes.

It is noteworthy that the coverage will be achieved with continued efforts to control non-revenue water[18] at the level of 10 percent through 100 percent metering of all service connections[19], 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 to reduce annual operation and maintenance costs[20].

Preservation of raw water quality is another important issue for both drinking water quality control and minimization of production cost.

11-4 Financial Evaluation

Financial soundness is a key element for pursuing and attaining the CMDGs for the water supply sector. With the implementation of the project and the financial support of the MOEF by way of the JICA loan, SRWSA can attain full financial autonomy as envisioned in the National Water Sector Policy and incorporated in the sub-decree creating SRWSA as an autonomous public enterprise. This can be achieved by having a water tariff[21] that is pro- poor, but balances the need for SRWSA to be financially viable as an institution. Periodic adjustment of water tariffs is, however, a necessary consequence due to increasing cost as well as supporting the repayment of the loan. The required tariffs proposed in this study are found to be affordable to both residential and commercial customers. With the water tariffs adjusted on a regular basis, the financial effectiveness of SRWSA may be sustained.

The implementation of the project widens the customer base, which can boost the revenue potential of SRWSA, thus cost per service connection[22] should be affordable to all types of customers. In addition, collection efficiency[23] of water fees must be sustained at the highest levels possible. The result would be a low operating ratio[24] that will indicate the efficiency of SRWSA as an institution.

11-5 Institutional Evaluation

Institutional development is inherently difficult as this is only achieved over the long-term. One project, therefore, may not immediately achieve the capacity building objectives. However, this priority project provides clear avenues to jumpstart building organizational capacity of the SRWSA, as well as the capacities of its staff. Training undertaken by SRWSA personnel can be measured by the actual number of training hours, or cost of training per employee; however, the

[18] Non revenue water (%) = [total annual production (m3) - total billed consumption (m3)] x 100/[total annual production (m3)]
[19] No. of metered connections (%) = metered connection / unmetered connections
[20] Unit production cost (US$/m3) = [annual O&M cost (US$)] / [total annual production (m3)]
[21] Average tariff (US$/m3) = [total annual billing (US$)] / [total annual consumption (m3)]
[22] Capital expenditure/connection (US$) = [total capital expenditure over the last 5 years (US$) / 5] / [number of utility connections]
[23] Collection efficiency (%) = [total annual collections (US$) / total annual billings (US$)] x 100
[24] Operating ratio = [annual O&M cost (US$)] / [annual revenue (US$)]

"return on training" has always been difficult to quantify and measure. Translating the training investment into impacts will have to go beyond traditional measures.

The staff productivity index[25] is, therefore utilized as one indicator of organizational efficiency. It not only was used in planning the number of SRWSA personnel in each important development phases, where accompanying organization structures are recommended, but also in targeting organizational efficiency when comparing SRWSA with other Asian water utilities of the same size.

11-6 Evaluation by DAC 5 Indices

The criteria for the technical, financial and institutional evaluation for the Priority Project are anchored on the DAC Framework for evaluating development assistance – relevance, efficiency, effectiveness, impact and sustainability. Towards this end, questions to be ascertained are shown below:

EVALUATION MATRIX
(Technical, Financial and Institutional)

EVALUATION CRITERIA	FOCUS AREA	QUESTIONS	INFORMATION REQUIRED
RELEVANCE (Technical and Financial)	Project Formulation / Design	Was the economic rationale for the Project based on sound analysis?	Economic / Household surveys
		Did the project formulation and design incorporate lessons from related projects?	Content analysis of past projects and key informant interviews
		Did the project avoid duplication of efforts in other projects?	Results from key informant interviews with local offices and organizations such as SRWSA. Content analysis of meetings and consultations with national-level organizations
		Did the project formulation (design) adopt correct solution to identified problem?	
		Is the project design sound in terms of a series of necessary conditions being met?	
	Stakeholder Consultation and Coordination	Were the stakeholders consulted and do they "own" the project design?	Consultation process used and local stakeholder representation in project formulation Establishment and meeting minutes of the Project Steering Committee
		How well does project formulation / design address local needs and priorities and formulated with appropriate strategies?	Role of stakeholder agencies and organizations in needs assessment and project implementation Consistency with stakeholders' objectives and government structures
		Did the project provide for coordination with and/or complementarities with development partners?	
	Risks Mitigation	Did the project identify relevant risks and provide mitigation measures?	Types of risks identified and safeguard / mitigation measures envisaged in project design
RELEVANCE (Institutional)	Organization Structure	Is the proposed organization structure relevant to SRWSA as a water utility so that its mission and objectives can be realized?	Organization structure, mission and objectives
		Is the organization set-up reflective of the type and the design of water system?	Unit functions

[25] Staff/1,000 connections ratio = [number of utility staff] / [number of utility connections/1,000]

	Human Resources	Is the SRWSA human resources plan relevant to the number and quality required to manage, operate and maintain the utility?	HR Inventory
	Implementation Arrangements	Are the implementation arrangements appropriate for the various stakeholders and their levels of interest in SRWSA?	Government structures and mandates
	Capacity Building	Are the training approaches and methodologies relevant to the actual and emerging needs of the organizational units?	Needs assessments
		Do the training programs and courses address the training needs of the staff?	Personnel training history
EFFICIENCY (Technical and Financial)	Assumptions	Were these assumptions valid: (i) Projected number of connections; (ii) Service coverage; (iii) number of beneficiaries; (iv) procurement and management costs; (v) input costs, risks, and others	EIRR, FIRR calculation and documents List of key assumptions, economic and financial parameters
	Project management	Have all the project partners and organizations been identified together with their mandated roles?	Clarification of the roles and responsibilities of project partners Composition and frequency of project steering committee meetings
	Project implementation	How effective was the intra and inter-agency coordination mechanisms in the project?	
EFFICIENCY (Institutional)	Assumptions	Were these assumptions valid: (i) Projected number of connections; (ii) Service coverage	Technical and financial projections
	Staff and organizational efficiency	What is the projected staff productivity index (SPI)?	Projections on the number of service connections
	Project implementation and management	How effective was the intra and inter-agency coordination mechanisms in the project?	Clarification of roles and responsibilities of project organizations
EFFECTIVENESS Technical and Financial)	Project achievements	Will the project achieve what it intended to do?	List of project outputs Baseline data on key performance indicators compared to initial data Beneficiaries' perception about project benefits
		What factors will contribute to the success (or weakness) of the project?	Incentives or Constraints, if any
EFFECTIVENESS (Institutional)	Capacity Building	Were capacity building objectives achieved?	Capacity building outputs
		What factors contributed to the success (or weakness) of capacity building?	Constraints, if any
IMPACT (Technical and Financial)	Socio-economic impact	What are the impacts of the project on beneficiaries' health?	Perceptions about project benefits and negative impacts expressed by beneficiaries
		How much impact will the project have on industries and businesses, such as tourism-related service and light manufacturing?	Tourism arrivals, increased number of businesses serviced by SRWSA, jobs created
	Environmental impact	How much over-all impact is seen in Siem Reap through the water supply project?	List of environmental safeguards Protection of heritage sites through conservation of groundwater
IMPACT	Organizational Effectiveness	What are the impacts of the training program/courses on organizational effectiveness?	Key performance indicators of SRWSA
	Customer Perception of SRWSA	How much improvement is recognized in terms of public's awareness towards SRWSA service?	Perceptions about the project benefits and negative impacts expressed by beneficiaries

SUSTAINABILITY (Technical and Financial)	Viability of SRWSA	Is there availability of adequate and effective demand for the project's water supply services?	Growth in service coverage area Mechanism to reflect consumers' wants and complaints in the service delivery
	Water tariff	Are there appropriate policies and procedures, particularly on tariff-setting, to ensure self-reliance of SRWSA?	Affordability of water tariff as against financial sustainability of SRWSA Frequency and amounts collected as water service fee from consumers
	Other policies	Are there other policies – financial, human resources, technical operations and management – to ensure continued operations of SRWSA?	Policies and Procedures issued by SRWSA Board of Directors and Management Water resource management-related laws, regulations and procedures
	Adequacy of policies and regulatory conditions	Are there appropriate policies to ensure continued funding of SRWSA?	
	Political will	Is there political will to ensure national and local governments' ownership and commitment to the project?	Results of meetings of the project steering (coordinating) committee, executing agency and project management unit
	Environmental, social and technological, and natural resource risks	Are all risks identified and mitigation measures recommended?	
SUSTAINABILITY	Institutional life cycle	Is there availability of adequate and effective demand for the project's water supply services?	Service coverage area Mechanism to reflect consumers' wants and complaints in the service delivery
	Institutional policy on management systems	Are there appropriate policies and procedures present to ensure continued management, operation and maintenance of SRWSA?	Revisions of human resources, financial and technical manuals
	Institutional policy on human resources	Is there application of appropriate policies to ensure the maintenance of required human resources?	

11-6-1 Relevance

The mission of SRWSA is to produce, supply and distribute safe and potable water supply and reliable water service to Siem Reap and other areas within the political jurisdiction of Siem Reap province.

The Priority Project aims to develop a daily water supply capacity of 30,000 m^3 fulfilling the 2022 water demand proposed in the long-term water supply development plan targeting year 2030. The Project will achieve 80 percent of water supply coverage of the proposed service areas in 2020 in Siem Reap city, contributing to the goal set by the Cambodia Millennium Development Goals (CMDGs).

The Project will benefit the population in the service areas in Siem Reap city to meet the fundamental development challenges of reducing poverty and the stabilization of the people's livelihood. The Project will benefit an improvement in the health status and quality of life of the people of Siem Reap city through providing a safe water supply.

Judging from that the Project should be implemented as an urgent project to cope with the increasing water demand in the area. The Project is eventually expected to mitigate a social problem on thread of land subsidence caused by the many hotels operating around the heritage site couples with a sharp increase in tourism related industries which has resulted in uncontrolled abstraction of groundwater source in the area.

11-6-2 Effectiveness

The proposed water supply systems with a design capacity of 30,000 m^3/d includes construction of new raw water intake facilities, raw water conveyance pipelines, raw water transmission pump station, water treatment plant, transmission/distribution pipelines.

The additional water supply capacity will be able to cover the water demand of residents and tourists by the year 2022 projected in the long-term water supply development plan in cooperate with the existing and planned water supply systems.

By augmenting the water supply capacity, service coverage will reach 80 percent in 2020 to fulfill the target set by the CMDGs. The proposed water supply system will contribute to improvement of level of service such as distribution of 24/7 potable water and reliable water service to all households, businesses and institutional consumers within its jurisdiction.

Likewise, the Project will reinforce management systems of SRWSA to ensure the backbone of water utility operations and human resources as the brain of the organization. The reinforced management systems should reflect the country's water sector policies and the downstream policies and procedures. The reinforced work force will aim for a professional highly trained and motivated work force to ensure highest productivity and customer satisfaction.

11-6-3 Efficiency

The implementation of the Siem Reap Water Supply Expansion Project will be funded out of a loan from the Government of Japan, through the Japan International Cooperation Agency, to the Royal Government of Cambodia (RGC).

Ensuring the successful implementation of the Project necessitates setting up a rational project implementation system that would take into consideration the requirements of, and the agreements between, both the lender (GOJ) and borrower (RGC).

SRWSA should be tasked to provide day-to-day supervision over the project at the field level. While it shall be working very closely with the project Consultants, SRWSA's tasks relate to project management as a discipline, applying project management principles, concepts, tools and techniques to improve project performance and organizational effectiveness. SRWSA will become involved in the entire cycle of the Project as reflected in the whole range of services to be provided by the Consultant. Providing day-to-day supervision over the implementation of the Project includes addressing technical skills like scheduling, cost estimating, and risk management; and also encompasses other disciplines such as scope definition, procurement management, financial management, asset management, human resource management, environmental and social considerations, and communications.

11-6-4 Impact

The expected impacts from the Project are to achieve the CMDG clean water coverage targets include improved public health overall and reduction of infant and maternal mortality associated with water-borne disease. Improved water supply in the 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.

Improved water supply from the Project is an aid to tourism industry development in Siem Reap city. Development of tourism industry will eventually support financial soundness of SRWSA by using up the projected water demand. 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.

Providing new water supply systems taking water from the Tonle Sap Lake, a switching over from groundwater sources will be promoted to eliminate the threat of land subsidence which possibly causes a positive impact to the Angkor Heritages' preservations. Eventually, tourism industry will be enhanced in the region and comprehensive growth in economy can be expected.

On the negative side, it must be mentioned that expanded water supply inevitably results in greater production of wastewater. Preparation and implementation of projects 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. 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 Tonle Sap Lake, 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.

11-6-5 Sustainability

A major key of successful implementation of the Project are in several stakeholder-institutions with complementary interests. These are the following: i) MOEF, which will guarantee the loan to

SRWSA, and will, therefore, want to ensure that the loan will be repaid; ii) MIME, which has technical supervision over SRWSA, particularly over its future plans and projects involving government-guaranteed loans, and would, therefore monitor project implementation; and, iii) MOWRAM, which has a mandate over the sustainable utilization of Cambodia's water resources, iv) SRWSA which is the project beneficiary, the re-payer of the loan, and the project implementer; v) the Provincial Government of Siem Reap, as the location of the Project is within its political jurisdiction; and vi) APSARA, because it has legal mandate over projects within its designated protected zones.

As an operator of the proposed water supply systems, which is new facilities and entail the development of new and/or revised policies, SRWSA should build up or develop their capacity to prepare for the requirements, results and impacts to be brought about by the upcoming improvement and expansion of its water supply system. Current SRWSA staff must be ready for this eventuality. However, the resultant rapid growth in the number of customers will necessitate a proportionate increase in the number of staff and a change in SRWSA's organization structure. It is very inevitable, therefore, to provide training to identified key personnel to equip them with skills required to operate the expanded system, as well as to the staff of the new and/or reconstituted departments and offices. SRWSA must be able to transform organizational and individual potentials into actuality.

In addition, SRWSA should keep sound financial background so that a consumption-based tariff structure that is fair for all –residential, commercial/business and industrial consumers should be retained. The revenue from tariffs will cover O&M costs, capital development plus debt servicing properly to achieve operational and financial viability.

11-7 Proposed Objectively Verifiable Indicators for Measurement of Project Operations and Effects

The following summarizes base line indicators for year 2010, 2017, and 2022.

Descriptions/Year	2010	2017	2022
Estimated numbers of connections	4,525	27,392	41,159
Projected population served (residents)	53,350	154,630	232,300
Turbidity of treated water quality* (NTU)	5	5	5
Color of treated water quality *(TCU)	5	5	5
Proposed water production capacity (m^3/d)	9,000	56,000	56,000 to 86,000

Table 11.1 summarizes proposed performance indicators for monitor of project operations and effects.

Table 11.1 Performance Indicators for Measurement of Project Operations and Effects

	Performance Indicator (Evaluation Index)	Formula	Relevance
1.	Water Supply Coverage	Water supply coverage (%) = [population served] x 100 / [total population in the present service area]	Any water utility must be able to supply the entire population in its mandated service area or jurisdiction. For SRWSA, it must be able to improve supply coverage for all types of customer (domestic, business/commercial, institutional) as well as the growing population in its service area. In addition to safe water, service supply service must 24-hours per day.
2.	Per capita consumption	Per capita consumption (l/c/d) = [total annual domestic consumption (m3) x 1,000/365] / [number of people served]	
3.	Served Population	Production/population (m^3/d/c) = [annual production volume (m3) /365] / [number of people served]	
4.	Non-revenue water	Non revenue water (%) = [total annual production (m3) - total billed consumption (m^3)] x 100/[total annual production (m^3)]	Non-revenue water is unbilled, therefore is lost revenue. The lower NRW, the better for SRWSA.
5.	Average Tariff	Average tariff (US$/$m^3$) = [total annual billing (US$)] / [total annual consumption (m^3)]	Tariff is dependent on many factors, however, average tariff should be pro-poor, and should be adequate to cover all expenses, including debt servicing.
6.	Unit Cost of Production	Unit production cost (US$/$m^3$) = [annual O&M cost (US$)] / [total annual production (m^3)]	The lower the cost of production, the better, as it means that the utility is more efficient.
7.	Operating ratio	Operating ratio = [annual O&M cost (US$)] / [annual revenue (US$)]	The lower the operating ratio, the more efficient the water utility.
8.	Collection efficiency	Collection efficiency (%) = [total annual collections (US$) / total annual billings (US$)] x 100	The higher collection efficiency, the better. Actually, collection efficiency should be 100% to ensure that there is revenue to run the utility.
9.	Accounts Receivable	Accounts receivable (months equivalent) = [accounts receivable at end of the fiscal year] / [total annual billings/12]	Accounts receivable is also used as a measure since it means that services are billed. This is also connected to collection efficiency.
10.	Staff Productivity Index	Staff/1,000 connections ratio = [number of utility staff] / [number of utility connections/1,000]	SPI is a measure of organizational efficiency, since less staff is needed to operate and manage the water utility, meaning staff is efficient.
11.	Cost per service connection	Capital expenditure/connection (US$) = [total capital expenditure over the last 5 years (US$) / 5] / [number of utility connections]	Cost per service connection should be affordable to all customers so that every customer can be motivated to connect to the system
12.	Metering	No. of metered connections (%) = metered connection / unmetered connections	To ensure that production is billed properly and there is low NRW, all connections should be metered.
13.	Management Salaries		This reflects whether the utility can hire and retain the required qualified staff to operate and manage the system.
14.	Others: Leaks repaired Complaints received No. of new connections Annual Operation and Maintenance Costs O&M Cost Components Water diseases Outbreaks		

Chapter 12.
Conclusion and Recommendations

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12-1 Conclusion

The Project aims to meet the existing and projected shortfall in water supply with the immediate construction of the Project facilities. Thus, the Project offers not only tangible impacts, but also intangible benefits, such as:

- Improving the quality of life of the people of Siem Reap, particularly those in the service area, by (i) supplying potable water, therefore reducing health problems brought about by unsafe water, and (ii) providing reliable 24 hr water service, thereby contributing to better productivity of the residents in the service area.
- Stimulating the growth of the local economy with the enhancement / development of the present and future tourism-related businesses and light industries, all of which will rely mainly on safe and adequate water from SRWSA, especially when the extraction of groundwater will be discontinued to protect the Angkor Wat heritage area.
- Contributing to the growth of the national economy by increased tourism arrivals, which will impact on job generation and higher levels of education.
- Supporting the policies set out in the CMDG, particularly in reducing “poverty rates in urban and more accessible rural areas” and improving “urban access to safe water and rural access to improved sanitation”.

Consequently, it would be imperative and urgent for the Project to be implemented with loan assistance from the Government of Japan.

However, there are certain realities that must be recognized to guarantee a better success ratio in implementing the Project. Foremost is that the capabilities of the existing staff of the Siem Reap Water Supply System are presently lacking both in terms of numbers and experience to enable the new water supply scheme to be operated and maintained effectively, which necessitates a capacity building program. Next is the provision by SRWSA of sufficient budget to increase the required manpower to enable the skills base to be strengthened through the training and development activities under the proposed project components. Last is the necessity of increasing water rates in the medium term to ensure SRWSA’s continued sustainability and financial autonomy.

12-2 Recommendations

In the course of executing the long-term water supply development plan, the following important activities should be prioritized:

12-2-1 Before the project implementation

1) Project organizations

The project organizations, such as *Project Coordinating Committee* (PCC), the Executing *Agency* and the *Project Management Unit* should be set up to be ready to discharge their roles and functions according to the requirements of the Project.

In addition, the office of the *Project Consultant Team* should be organized to mark the start of the tendering phase upon completion of detailed design review stage.

2) Land acquisition

Necessary land acquisition for the project sites should be carried out by the project organizations before the agreement is made between RGC and GOJ.

3) Clearance of the relevant laws and regulations

SRWSA/MIME should facilitate the required clearances needed for the Project implementation in accordance with the relevant laws and regulations in Cambodia.

4) Protection of water sources

Tonle Sap Lake 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.

5) Project monitoring and reporting system

The development of a tri-level project monitoring and evaluation system is essential to maintain efficient work relationships among the project organizations, and to minimize conflicts among project partners.

12-2-2 During the project implementation

6) Manpower hiring schedule and staff review and assessment

The SRWSA institutional development plan follows the timeline of the three physical improvements plans being proposed in this Study and recommends the most optimum organization structure and number of human resources for each phase, as follows: (i) the availability of KTC Bulk Water in 2012-13, (ii) the completion of the facilities under Phase 1 in 2017, and (iii) the completion of the facilities under Phase 2 in 2022. The need is translating this into a manpower-hiring schedule based on actual requirements after a thorough staff review and assessment to ensure proper matching of qualifications with job functions of the present personnel.

7) Orientation and/or Training

Aside from the trainings recommended under the capacity building program, there is a need to provide the following: (i) orientation training to all employees to prepare them for Project implementation; (ii) training on the monitoring and evaluation system, and (iii) training on the disbursement procedures.

8) Proper maintenance and periodic replacement/rehabilitation

New construction or expansion projects can be done using Japan's ODA loan and/or assistance of international donor, 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.

9) 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 Cambodia Drinking Water Standards.

10) Regulation over the exploitation of groundwater sources

RGC in cooperate with SRWSA should enact regulatory measures with regard to the control of future groundwater development and imposition of sanctions to continued groundwater extraction in Siem Reap City once the Project is implemented.

11) Water tariff

SRWSA should keep sound financial background so that a consumption-based tariff structure should be retained. The water supply to domestic and commercial users should be expanded based on the proposed long-term water supply development plan. The revenue from tariffs will cover O&M costs, capital development plus debt servicing properly to achieve operational and financial viability.

12-2-3 After the project implementation

12) 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.

13) Improvement of drainage, sewerage, and sanitation in the study area

The proposed "Drainage, Sewerage, and Sanitization Project" should be implemented as scheduled to preserve the public water bodies clean and eventually to connect to prevent the Tonle Sap Lake be in good condition as raw water source of the public water supply systems.