DEPARTMENT OF POTABLE WATER SUPPLY,
MINISTRY OF INDUSTRY, MINES AND ENERGY
KINGDOM OF CAMBODIA

PREPARATORY SURVEY
ON
THE PROJECT ON ADDITIONAL NEW WATER TREATMENT PLANTS
FOR
KAMPONG CHAM AND BATTAMBANG WATERWORKS
IN
THE KINGDOM OF CAMBODIA

FINAL REPORT

MARCH 2013

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

NIHON SUIDO CONSULTANTS CO., LTD.
WATER AND SEWER BUREAU, CITY OF KITAKYUSHU
CTI ENGINEERING INTERNATIONAL CO., LTD.

Summary

1. Overview of the Kingdom of Cambodia

(1) Natural Condition

The total landmass of the Kingdom of Cambodia (hereinafter referred to as Cambodia) is approximately 181,000 km^2 (a little less than the half of Japan's total area). The Mekong River traverses the country from north to south, crossing the boundary with Lao PDR in the north. The Tonle Sap Lake and the river systems are the dominant features forming the Central Plains which cover three quarters of the country's area. The Tonle Sap River runs off the Tonle Sap Lake and joins together with the Mekong River at the capital city of Phnom Penh. To the north and northeast, near the boundaries with Viet Nam and Lao PDR, are mountain ranges with dense virgin forests and diverse wildlife. According to the 2008 census, Cambodia has an estimated population of 1,340,000 people.

Cambodia, lying entirely within the tropics, has a hot and humid climate, which is divided into wet (June to October) and dry (November to May) seasons. Severe heat occurs especially in the second half of the dry season (February to May) and the day time temperature can rise up to 30 to 40 ℃. The annual average precipitation is in the range of 1,000 to 3,000 mm.

(2) Socio Economic Conditions

Cambodia's Gross Domestic Product (GDP) per capita was 912 USD in 2001, according to the estimate by the International Monetary Fund (IMF), which is relatively low in comparison to other countries in the region. Cambodia is still classified as one of the Least Developed Countries, with 33% of the labor force engaged in the primary sector of the economy, 22% and 45% in the secondary and tertiary sectors respectively.

During the past ten years, Cambodia has enjoyed much more political stability and territorial unity than for previous decades. The country has been experiencing significant economic growth. The average growth rate of GDP was more than 10% for four consecutive years from 2004 to 2007. This has stalled since 2008 due to the price escalation of crude oil and food, as a result of the worldwide financial crisis. In spite of this set back, the integration of the national economy with the regional and world economies has been strengthened through the accession to the Association of Southeast Asian Nations (ASEAN) in 1999 and the World Trade Organization (WTO) in 2004. The poor people in Cambodia, who live on less than a dollar a day, are estimated at around 30%, which is still high. Poverty eradication is an important issue in

Cambodia.

2. Background of the Project

The Royal Government of Cambodia (RGC) is committed to the development of the water supply sector. In February 2003, the National Policy on Water Supply and Sanitation set the goal that “Everyone shall have sustained access to safe water supply and sanitation services and shall live in a clean, healthy and sustainable environment”. The National Strategic Development Plan (NSDP), issued in 2006 and reviewed in 2008, aims to boost the urban area access to safe water to 80% by 2015.

After the civil war, with the support of the government of Japan (GOJ) and other donors, water supply capacity in the capital city, Phnom Penh, has improved with the construction and rehabilitation of water supply facilities and related capacity building for operation and maintenance. On the other hand, the water supply capacities in other cities are still inadequate and not everyone in Cambodia is getting safe and clean water.

In 2006 the Asian Development Bank (ADB) implemented the project to upgrade the water supply system in 6 provincial capital cities including Kampong Cham City, the third largest city in Cambodia, and Battambang City, the largest city. Subsequently, the Japan International Cooperation Agency (JICA) carried out the project - Capacity Building for Water Supply Systems in Cambodia (Phase 2) for the relevant staff in 8 cities including Kampong Cham and Battambang from 2007 to 2012. Thus, these two cities benefitted from the infrastructure improvements and technology transfer provided by the GOJ and other donors. However, Kampong Cham and Battambang still have only 33% and 31% safe water access rates respectively, because of insufficient production capacity of the existing facilities and low intake volume in dry season. Therefore, the expansion of water supply facilities in these cities is an urgent matter.

In August 2010, the RGC made a request to the GOJ for Grant Aid for the Project on Additional New Water Treatment Plants for Kampong Cham and Battambang Waterworks, to cope with such circumstances.

The project is implemented with the support of the GOJ to increase the safe water access and improve water supply services by expanding water supply facilities in Kampong Cham and Battambang. The project will contribute to better living environment in both cities. The overall

goal, purpose and output of the project are restated as follows:

Overall Goal: To improve living environment in Kampong Cham and Battambang
Purpose: To improve water supply services in Kampong Cham and Battambang
Output: Expanded water supply facilities in Kampong Cham and Battambang

3. Results of the Preparatory Survey and Scope of Project

(1) Results of the Preparatory Survey

Because of the factors explained above, the JICA dispatched a preparatory survey team to Cambodia three times as shown below.

First Work in Cambodia	:	June 3 to July 22, 2012.
Second Work in Cambodia	:	August 21 to September 17, 2012
Third Work in Cambodia	:	February 10 to February 15, 2013

The survey team conducted investigations on the condition of the existing water supply systems, social situation, project sites and water quality in the target cities of Kampong Cham and Battambang. The size of the project was determined with due consideration to the requests from the Cambodian side. This preparatory survey prepared the basic design, project implementation schedule and the initial cost estimates, bearing in mind the funding criteria of a grant aid project.

The Cambodian side agreed to the increases in the water supply capacities in Kampong Cham and Battambang as shown below, which would raise the water supply ratio in the urban areas of Kampong Cham and Battambang to 84.8% by the target year of 2019.

- Kampong Cham : 11,500 m^3/day
- Battambang : 22,000 m^3/day

(2) Scope of the Project

1) Construction of Water Supply Facilities

The water supply facilities that would be constructed are as follows:

Kampong Cham

Intake and Raw Water Transmission Facilities

Category of Facilities			Category of Facilities
Large	Large	Large	
Intake Facility	Intake Shaft	Main body	Reinforced Concrete Structure Rectangular Shape: W7.65 m x L10.70m (inner dimension) Depth 18.45 m (Depth at HWL 16.75 m)
		Operation Room of Intake Pump	Reinforced Concrete Structure Rectangular Shape: W5.50 m x L11.80 m x H5.10 m (under the beam) (inner dimension) Equipment: Power Receiving Panel, Operating Panel, Switchboard, Secondary Equipment Panel, Circumference Plumbing of Pump, Overhead Crane (3t)
	Intake Pump Facility	Intake Pump	Vertical Shaft Type Mixed Flow Pump 4 sets (Ordinary Use 3 sets, Spare1 set) Q=2.93 m^3/min h=25.8 m P=22 KW 3Φ380V 50Hz
		Generator	Reinforced Concrete Structure Rectangular Shape: W5.50 m x L4.90 m x H4.30 m (under the beam) (inner dimension) Generator: 60 KVA (Soundproofing Type)
	Temporary Work	Sandbag	6 steps stacking, Length: Top of Slope L=90m, Foot of Slope L=15m
		Shielding Sheet Pile	Sheet Pile: SP-Ⅲ l=11m, Installation Length L=80m)
		Riprap Work	1500m^3
		Water Pollution Prevention Fence	Depth 5m, Installation Length L=40m
Raw Water Transmission Facility	Raw Water Transmission Main		DIPΦ400, L≒920 m

Water Treatment Facility

Facility/Equipment		Scale and Structure
Water Treatment Facility	Receiving Well	Reinforced Concrete Structure Internal Dimension: 1.60 m width × 4.10 m length × 4.50 m depth Volume and Detention Time: V=29.5 m3、T=3.4 min in dry season (T≧1.5 min)
	Rapid Mixing Tank	Reinforced Concrete Structure Gravitational force mixing using a weir Internal Dimension: 1.60 m width × 1.50 m length × 3.88 m depth Volume and Detention Time: V=9.3 m3、T=1.1 min (1<T< 5 min)
	Flocculation Basin	Reinforced Concrete Structure Slow Mixing Method: Vertical channel bands flocculator Internal Dimension: 6.90 m width × 3.25 m length × 4.50 m height + 3.46 m average effective depth Quantity: 3
	Sedimentation Basin	Reinforced Concrete Structure Horizontal-Flow Sedimentation Basin Supernatant Collecting System: Collecting Trough + Submerged Orifice Internal Dimension: 6.90 m width × 21.50 m length × 3.99 m average depth Quantity: 3 Surface Loading: Q/A=20.0 mm/min (15-30 mm/min) Mean Velocity: V=0.11 m/min (below 0.40 m/min)
	Rapid Sand Filter	Reinforced Concrete Structure Internal Dimension: 2.50 m width × 7.00 m length Quantity: 6 Filter Sand Thickness: 100 cm Underdrain System: Porous Filter Bed Method Filtration Rate: V=120.5 m/day (120-150 m/day)

Facility/Equipment		Scale and Structure
		Flow Control: Lower Part Control Method Backwash Method: Simultaneous Backwash Method by Air and Water
	Wastewater Basin	Reinforced Concrete Structure Quantity: 2 Effective Volume: V=211 m3 (105.5 m3 × 2) Internal Dimension: 4.00 m width × 11.00 m length × 5.60m height + 2.40m depth
	Sludge Drying Bed (Lagoon)	Reinforced Concrete Structure Quantity: 4 Effective Area: A=790 m2
	Chemical Feeding Facility	Alum, Lime: at Administration Building Chlorine: Chlorine Feeding House (Floor Area 61.3m^2)
	Emergency Generator	450 KVA (Soundproof type, Equipped with Internal Water Tank) At Administration Building
	Administration Building	Reinforced Concrete Structure, Three Stories Building, Total Floor Area: 588 m2 Usage: 1st Floor: Staff Room, Workshop, Storage, Emergency Generator Room, Toilet, Chemical Carry-in Room (1-3 Fl. Open Ceiling) 2nd Floor: Manager Room , Meeting Room, Monitoring Room, Toilet, Chemical Dissolving Tank Room (2-3 Fl. Open Ceiling), Chemical Feeding Pump Room 3rd Floor: Chemical Dissolving Tank Room (2-3 Fl. Open Ceiling) Common: Staircase

Transmission and Distribution Facilities

Category of Facilities			Dimension and Structure
Large	Middle	Small	
Transmission Facilities	Transmission Pump Facilities	Pump	Single Volute Pump 5.00 m^3/min × 38.3 m 30 kW × 3Pumps (1 pump: standby)
		Pump Well	Doubles as Service Reservoir
	Transmission Pipeline		Shallow Well No. 2～Service Reservoir Design Transmission Flow Q=4,200m^3/day HDPE ϕ 200A, L≒900 m
Distribution Facilities	Service Reservoir	Treatment Plant	RC Structure, Rectangle, 2 Reservoirs Effective Capacity: V=1,250 m^3×2 Effective depth: H=3.80 m Water Level: HWL+16.30 m, LWL+12.50 m Foundation: Direct Foundation
	Distribution Pump Facilities	Distribution Pump	Single Volute Pump 1.96 m^3/min × 53.8 m 30 kW × 5Pumps (1 pump: standby) Low-voltage Inverter Equipment
		Pump Well	Doubles as Service Reservoir
	Distribution Pipeline	DCIP	Straight Pipe: T type, Thrust Blocking: Retainer Gland Diameter: ϕ 400A L= 1,060m ϕ 350A L= 1,617m ϕ 300A L= 2,263m ϕ 250A L= 4,237m Total L= 9,177m
		HDPE	PE100 Diameter: ϕ 200A L= 5,173m ϕ 150A L= 5,125m ϕ 100A L= 27,098m ϕ 50A L= 11,223m Total L= 48,619m Bridge-attached Pipe: 6 places
	Distribution Flow Monitoring System	Master Station	Monitoring PC, Printer, Receiver, UPS
		Local Station	Electromagnetic Flow Meter ϕ 300×2, ϕ 200 GSM Logger＋GSM Transmitter×3

Battambang

Intake and Raw Water Transmission Facilities

Category of Facilities			Category of Facilities
Large	Large	Large	
Intake Facility	Intake Shaft	Main body	Reinforced Concrete Structure Rectangular Shape: W 7.65 m x L10.80m (inner dimension) Depth 13.90 m (Depth at HWL 13.20 m)
		Operation Room of Intake Pump	Reinforced Concrete Structure Rectangular Shape: W 5.25 m x L11.70 m x H5.10 m (under the beam) (inner dimension) Equipment: Power Receiving Panel, Operating Panel, Switchboard, Secondary Equipment Panel, Circumference Plumbing of Pump, Overhead Crane (3t)
	Intake Pump Facility	Intake Pump	Vertical Shaft Type Mixed Flow Pump 3 sets (Ordinary Use 2 sets, Spare1 set) Q=8.40 m^3/min h=21.3 m P=55 KW 3Φ380V 50Hz
		Generator	Reinforced Concrete Structure Rectangular Shape: W5.55 m x L5.60 m x H4.30 m (under the beam) (inner dimension) Generator: 260 KV (Soundproofing Type)
	Temporary Work	Sandbag	Sheet Pile: SP-Ⅳ L=21.5m, Installation Length L=64.9m)
		Shielding Sheet Pile	Foot of Slope (Riverside): SP-Ⅳ l=11m, Installation Length L=31m Foot of Slope (Gable): SP-Ⅳ l=11m, Installation Length L=17.6m SP-Ⅲ l=6.5～9.0m, Installation Length L=20.8m Front of Retaining Wall (Top of Slope): SP-Ⅲ l=9m, Installation Length L=32.8m
		Water Pollution Prevention Fence	Depth 5m, Installation Length L=40m
Raw Water Transmission Facility	Raw Water Transmission Main		DIPΦ600、L≒4.4 km

Water Treatment Facility

Facility/Equipment		Scale and Structure
Water Treatment Facility	Receiving Well	Reinforced Concrete Structure Internal Dimension: 2.00 m width × 5.25 m length × 4.45 m depth Volume and Detention Time: V=46.7 m3、T=2.8 min in dry season (T≧1.5 min)
	Rapid Mixing Tank	Reinforced Concrete Structure Gravitational force mixing using a weir Internal Dimension: 2.00 m width × 3.00 m length × 3.81 m depth Volume and Detention Time: V=22.9 m3、T=1.4 min (1<T< 5 min)
	Flocculation Basin	Reinforced Concrete Structure Slow Mixing Method: Vertical channel bands flocculator Internal Dimension: 7.10 m width × 5.90 m length × 4.70 m height + 3.74 m average effective depth Quantity: 4
	Sedimentation Basin	Reinforced Concrete Structure Horizontal-Flow Sedimentation Basin Supernatant Collecting System: Collecting Trough + Submerged Orifice Internal Dimension: 7.10 m width × 30.00 m length × 4.12 m average depth Quantity: 4 Surface Loading: Q/A=20.0 mm/min (15-30 mm/min) Mean Velocity: V=0.14 m/min (below 0.40 m/min)
	Rapid Sand Filter	Reinforced Concrete Structure Internal Dimension: 3.50 m width × 9.10 m length

Facility/Equipment		Scale and Structure
		Quantity: 6 Filter Sand Thickness: 100 cm Underdrain System: Porous Filter Bed Method Filtration Rate: V=126.6 m/day (120-150 m/day) Flow Control: Lower Part Control Method Backwash Method: Simultaneous Backwash Method by Air and Water
	Wastewater Basin	Reinforced Concrete Structure Quantity: 2 Effective Volume: V=230 m3 (115 m3 × 2) Internal Dimension: 4.00 m width × 11.00 m length × 6.50m height + 2.70m depth
	Sludge Drying Bed (Lagoon)	Reinforced Concrete Structure Quantity: 4 Effective Area: A=1,936 m2
	Chemical Feeding Facility	Alum, Lime: at Administration Building Chlorine: Chlorine Feeding House (Floor Area 82.6m^2)
	Emergency Generator	450 KVA (Soundproof type, Equipped with Internal Water Tank) At Administration Building
	Administration Building	Reinforced Concrete Structure, Three Stories Building, Total Floor Area: 588 m2 Usage: 1st Floor: Staff Room, Laboratory, Workshop, Storage, Emergency Generator Room, Toilet, Chemical Carry-in Room (1-3 Fl. Open Ceiling) 2nd Floor: Manager Room , Meeting Room, Monitoring Room, Toilet, Chemical Dissolving Tank Room (2-3 Fl. Open Ceiling), Chemical Feeding Pump Room 3rd Floor: Chemical Dissolving Tank Room (2-3 Fl. Open Ceiling) Common: Staircase

Transmission and Distribution Facilities

Category of Facilities			Dimension and Structure
Large	Middle	Small	
Transmission Facilities			No Facility
Distribution Facilities	Service Reservoir	Treatment Plant	RC Structure, Rectangle, 2 Reservoirs Effective Capacity: V=3,000 m^3×2 Effective depth: H=4.30 m Water Level: HWL+12.60 m, LWL+8.30 m Foundation: Direct Foundation
	Distribution Pump Facilities	Distribution Pump	Single Volute Pump 6.34 m^3/min × 44.0 m 80 kW × 5 Pumps (1 pump: standby) Low-voltage Inverter Equipment
		Pump Well	Doubles as Service Reservoir
	Distribution Pipeline	DCIP	Straight Pipe: T type, Thrust Blocking: Retainer Gland Diameter: ϕ 400A L= 1,323m ϕ 350A L= 811m ϕ 300A L= 254m ϕ 250A L= 5,794m Total L= 8,182m Water Pipe Bridge: 2 places
		HDPE	PE100 Diameter: ϕ 200A L= 6,593m ϕ 150A L= 16,883m ϕ 100A L= 20,122m ϕ 50A L= 13,719m Total L= 57,317m Water Pipe Bridge: 3 places Bridge-attached Pipe: 9 places Across a Railway: 5 places
	Distribution Flow Monitoring System	Master Station	Function Extension (modification)
		Local Station	Electromagnetic Flow Meter ϕ 400, ϕ 150 GSM Logger＋GSM Transmitter×2

2) Procurement of Equipment

To achieve adequate water treatment and conduct sound operation and maintenance of the new water supply facilities and to promote service connections for the low income group, the following equipment will be procured under Japanese grant aid:

Category	Name of Equipment/Material	Specifications	Quantity	
			KMC	BTB
Equipment for Water Quality Analysis	Jar Tester	Jar tester for six samples having adjust function of mixing intensity (20 - 200min-1 digital display)	1 set	1set
	Distillation Apparatus	Water purification system (Distillation type) Product capacity: approx. 1.8L/h	-	1set
	Turbidity Meter	Turbidity meter (digital display direct reading) (0 - 4,000NTU)	-	1set
	Turbidity Continuous Measurement Equipment	Turbidity meter (right angle scattered light type for low concentration) (0.001 - 100 degree)	1set	1set
	Laboratory Table	Steel frame laboratory table (3-way tap stainless steel sink / AC220V outlet)	-	1set
	Residual Chlorine Analyzer	Potable residual chlorine meter (absorption spectrophotometer) (0.00 - 5.00 mg/l)	1set	1set
	Chlorine continuous measurement equipment	Residual chlorine meter (DPD absorption spectrophotometer) (0.00 - 5.00 mg/l)	-	1set
	Uninterruptible Power System (UPS)	Output power capacity：3 kVA	-	1set
	pH Meter (glass electrode)	Desktop pH meter with electrode（pH 0 - 14）	-	1set
	pH Meter (BTB)	BTB type simple pH meter （pH 6.0/6.2/6.4/6.6/6.8/7.0/7.2/7.4）	-	1set
	Reagents	pH4 standard solution, pH7 standard solution, Potassium chloride solution, BTB solution, DPD solution	1set	1set
	Glassware	Beaker, measuring flask, pipette, wash bottle	1set	1set
Tools for Mechanical Equipment	Vibration Checker	Acceleration: 0.02 - 200 m/s^2, Velocity: 0.3 - 1 000 mm/s, Displacement: 0.02 - 100 mm	1set	1set
Equipment and Materials for Service Connections	Socket Fusion Equipment	Diameter 15mm - 63mm for HDPE pipes with a power generator (5 kVA)	1set	1set
	Materials and Equipment for Service Connections	Required pipe materials and equipment from the ferrules with saddles on distribution mains (63mm and 110mm in diameter) to water meters (15mm in diameter)	2,529 sets	5,446 sets

Note) KMC: Kampong Cham, BTB: Battambang

3) Technical Assistance (Soft Component)

Training in the following 3 areas will be provided under the technical assistance (soft component) of this project.

- Operation and Maintenance of Treatment Facility
- Operation and Maintenance of Transmission and Distribution Facility
- Production Management

4. Project Implementation Schedule and Project Cost Estimate

(1) Project Implementation Schedule

The project will be implemented for multiple fiscal years considering scope of the project and time required for respective implementation phases. The detailed design will be carried out over 6.5 months during the first fiscal year, followed by the tendering process, which will take about 3.5 months. The final 26 months would be for equipment procurement and construction.

(2) Project Cost Estimate

The total project cost borne by the Cambodian side by year 2019 will be about 1,760 million Cambodia Riel (KHR). The Cambodian side is responsible for the demolition of the existing structures and land leveling, electrical supply to the new intake facilities and the new water treatment plants, environmental monitoring, contracting process for network connections, the distribution information system, bank arrangement, etc.

5. Project Evaluation

(1) Adequacy of the Project

Project Beneficiaries

The water supply facilities in Kampong Cham and Battambang will be expanded and the water supply services will be improved by the implementation of this project. The service ratio in the urban area of both cities will increase from about 30% in the year 2011 to 84.8% in the year 2019. By 2019 the population served in Kampong Cham and Battambang will increase from 22,000 to 59,000 and 59,000 to 127,000, respectively.

Urgency of Project Implementation

The existing Kampong Cham and Battambang water supply systems are only providing water service to 33% and 31% of the population respectively in 2011 because of insufficient production capacity and low intake volume in the dry season. Therefore, the expansion of water supply facilities in these cities is an urgent matter.

Consistency between the Project and Cambodia Planning

The National Strategic Development Plan (NSDP) issued in 2006 sets the water service target of 80 % in urban areas by year 2015. This project will help Kampong Cham and Battambang achieve this water service ratio. The increase in service ratio for the low income group will also contribute to poverty reduction which is the most important goal of the NSDP.

Compliance with Japan's Assistance Policy for Cambodia

Japan's assistance policy for Cambodia is to support the recipient country in achieving their development goals. "Promotion of Social Development" is a one of priority pillars for its assistance. Development of the water supply system is included in "Promotion of Social Development" and the project conforms to the policy for Japanese assistance in Cambodia.

(2) Effectiveness

The project is expected to provide the following beneficial outcomes:

Quantitative Effects

The expansion of water supply facilities in Kampong Cham and Battambang will result in improvements to the indicators listed in table below.

No.	Indicator	Baseline Data (Year 2011)		Target (Year 2019) (3 years after completion of the new facilities)	
		Kampong Cham	Battambang	Kampong Cham	Battambang
1	Served Population	21,571	45,377	58,719	126,696
2	Water Supply Capacity (daily average basis)	5,155 m^3/day	8,132 m^3/day	13,500 m^3/day	27,518 m^3/day
3	Service Ratio	32.8%	31.1%	84.8%	84.8%
4	Number of Service Connections	4,499	9,065	12,247	25,310
5	NRW Ratio	13%	21%	13%	20%

Qualitative Effects

- Maintaining appropriate residual water pressure and increasing water supply capacity will improve water supply services.
- Public hygiene conditions will be improved by increasing the service ratio. More people will be able to access safe water supply and there will be fewer incidences of water related illness.
- The increase in service ratio would reduce the manual labor required for getting water

and is expected to contribute to the increase in women's employment, children's school attendance and ultimately improve the living standard.

- Existing intermittent water supply is caused by dropping groundwater and river water levels. The project will provide a stable water supply.

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FINAL REPORT

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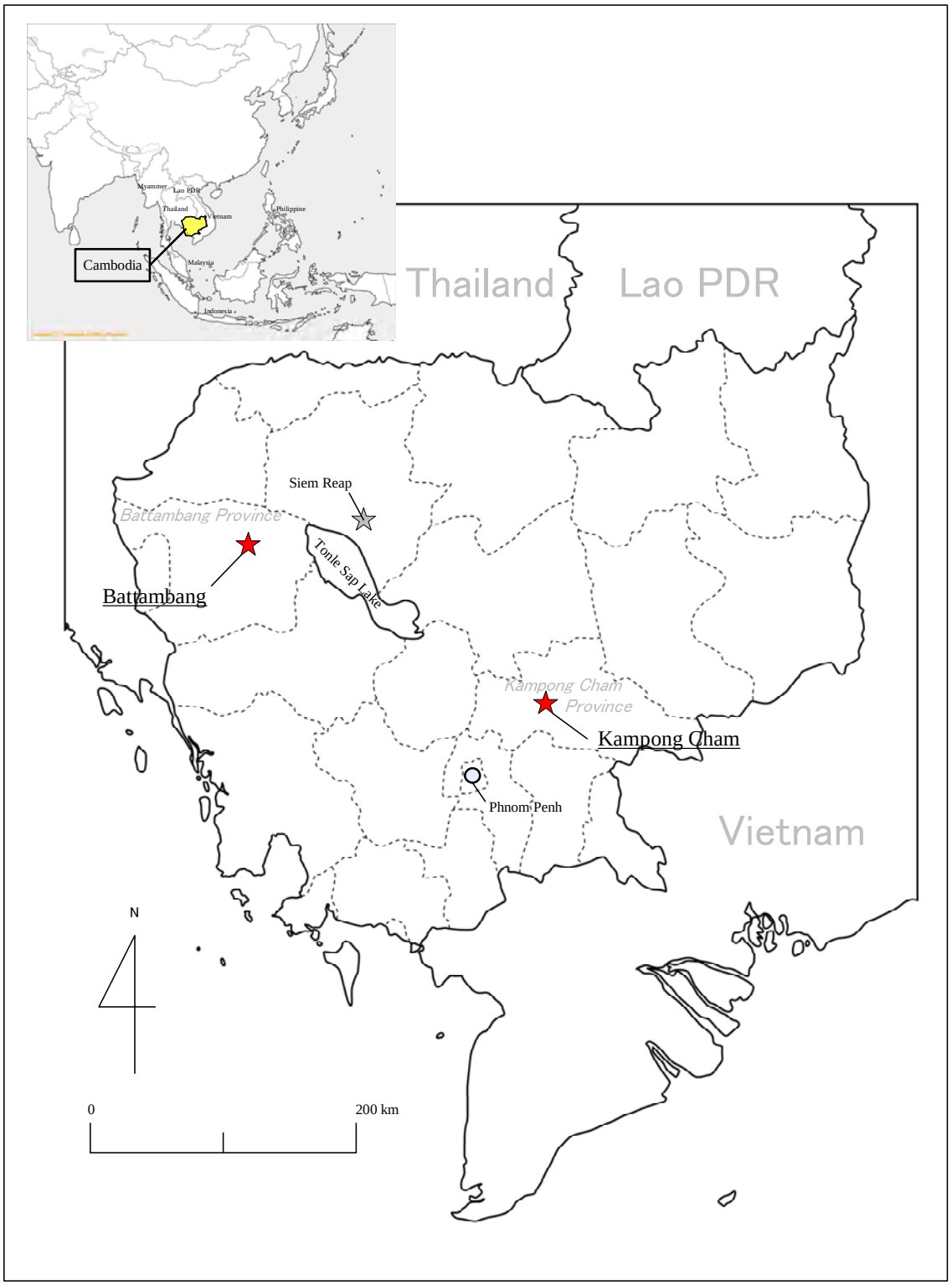
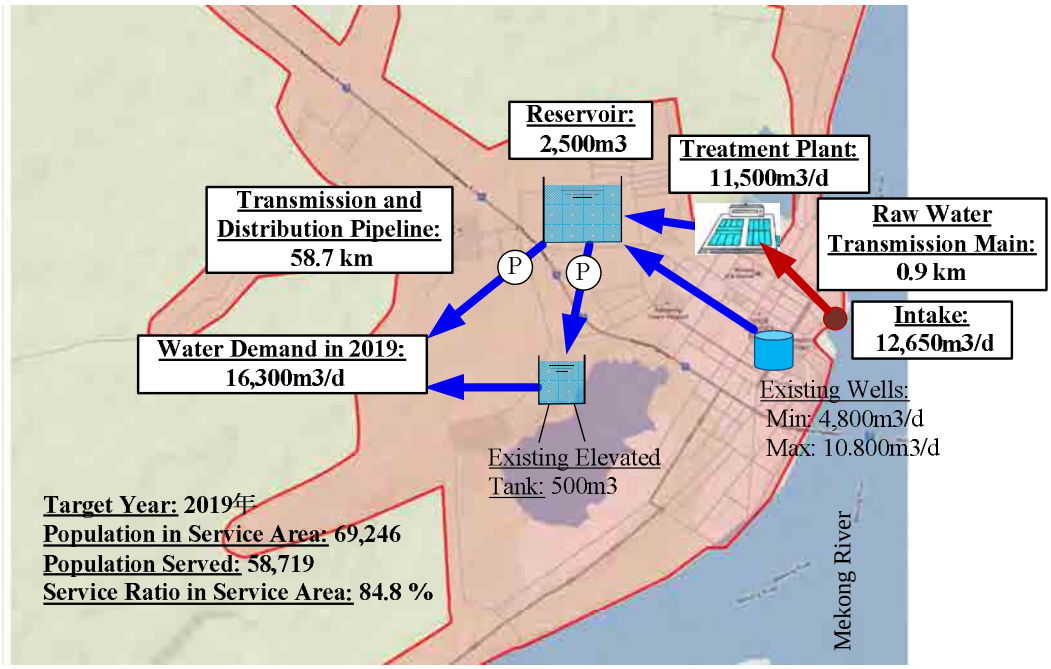
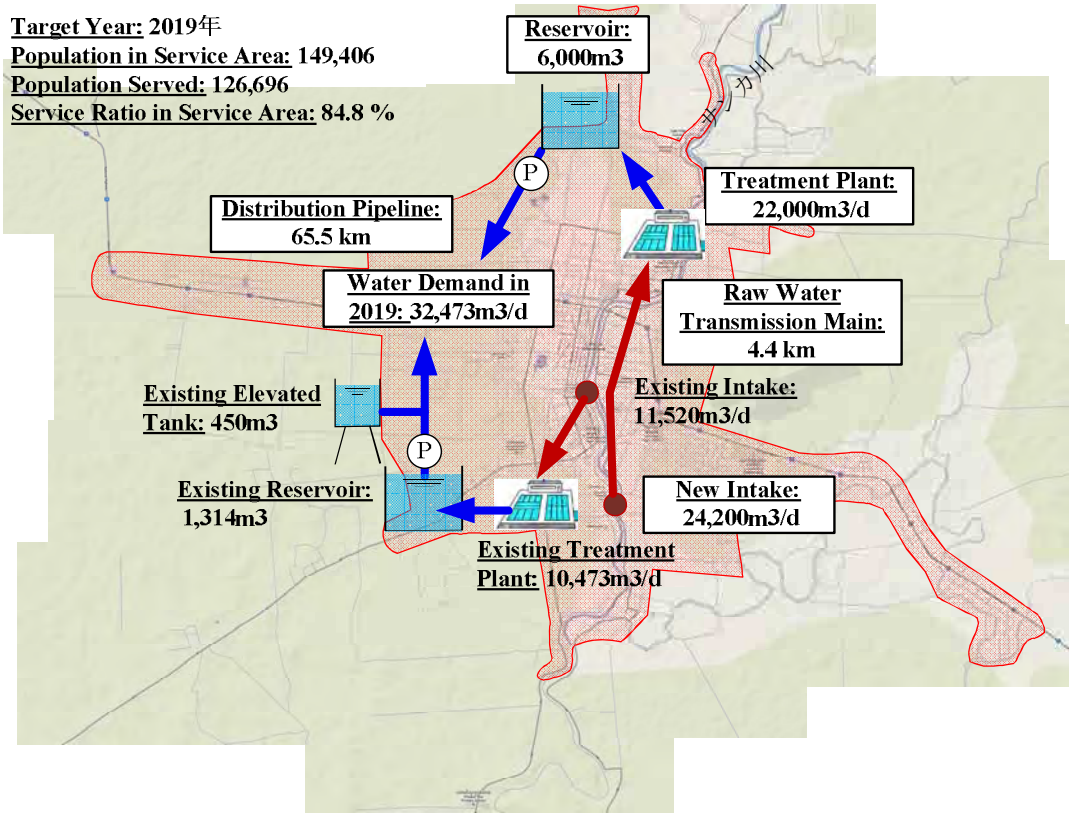


Location Map

Project Outline



Kampong Cham



Battambang

Perspective of Intake and Water Treatment Facilities (Kampong Cham)

Perspective of Intake and Water Treatment Facilities (Battambang)

Photos

Photo-1 Condition of Private Intake from the Sangke River (Battambang)

Photo-2 Condition of Rain Water Use (Kampong Cham)

Photo-3 Condition of Existing Intake Facility of Battambang Waterworks from the Sangke River during Dry Season

Photo-4 Condition of Intake Well (Shallow Well No.2) of Kampong Cham Waterworks during Dry Season

Photo-5 Condition of Proposed New Water Treatment Plant Site for Battambang

Photo-6 Condition of Proposed New Water Treatment Plant Site for Kampong Cham

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Abbreviations

ADB	Asian Development Bank
BTB	Battambang
BWW	Battambang Waterworks
CRC	Complaint Resolution Committee
DIME	Department of Industry, Mines and Energy
DIP (DCIP)	Ductile Cast Iron Pipe
DOWRAM	Department of Water Resources and Meteorology
DPWS	Department of Potable Water Supply, MIME
DPWT	Department of Public Works and Transportation
EAC	Electricity authority of Cambodia
EC	Expropriation Committee
EDC	Electric du Cambodia
EIA	Environmental Impact Assessment
GOJ	Government of Japan
HDPE	High Density polyethylene
HWL	High Water Level
IEE	Initial Environmental Examination
IEIA	Initial Environmental Impact Assessment
IMO	Independent Monitoring Organization
IRC	Inter-ministerial Resettlement Committee
ISO	International Organization for Standardization
IWRM	Integrated Water Resources Management
JICA	Japan International Cooperation Agency
JPST	JICA Preparatory Survey Team
KHR	Cambodia Riel
KMC	Kampong Cham
KWW	Kampong Cham Waterworks
Lpcd (LPCD)	litre per capita day, unit water consumption per day per capita
LWL	Low Water Level
MD	Minute of Discussion
MEK-WATSAN	Mekong Water Supply and Sanitation
MIME	Ministry of Industry, Mines and Energy
MOWRAM	Ministry of Water Resources and Meteorology
MPWT	Ministry of Public Works and Transportation
NRW	Non Revenue Water
NSDP	National Strategic Development Plan
PAP	Project Affected Person/ People
PIU	Project Implementation Unit
PMO	Project Management Office
PPTA	Project preparatory technical assistance
PPWSA	Phnom Penh Water Supply Authority
RAP	Resettlement Action Plan
RD	Resettlement Department
RGC	Royal Government of Cambodia

SEC	Expropriation Sub Committee
TPWs	Targeted Provincial Waterworks
UN	United Nations
WB	World Bank
WWs	Waterworks

Chapter 1 Background of the Project

1.1 Project Background

The Royal Government of Cambodia (RGC) is committed to the development of the water supply sector. In February 2003, the National Policy on Water Supply and Sanitation set the goal that “Everyone shall have sustained access to safe water supply and sanitation services and shall live in a clean, healthy and sustainable environment”. The National Strategic Development Plan (NSDP), issued in 2006 and reviewed in 2008, aims to boost the urban area access to safe water to 80% by 2015.

After the civil war, with the support of the government of Japan (GOJ) and other donors, water supply capacity in the capital city, Phnom Penh, has improved with the construction and rehabilitation of water supply facilities and related capacity building for operation and maintenance. On the other hand, the water supply capacities in other cities are still inadequate and not everyone in Cambodia is getting safe and clean water.

In 2006 the Asian Development Bank (ADB) implemented the project to upgrade the water supply system in 6 provincial capital cities including Kampong Cham City, the third largest city in Cambodia, and Battambang City, the largest city. Subsequently, the Japan International Cooperation Agency (JICA) carried out the project - Capacity Building for Water Supply Systems in Cambodia (Phase 2) for the relevant staff in 8 cities including Kampong Cham and Battambang from 2007 to 2012. Thus, these two cities benefitted from the infrastructure improvements and technology transfer provided by the GOJ and other donors. However, Kampong Cham and Battambang still have only 33% and 31% safe water access rates respectively, because of insufficient production capacity of the existing facilities and low intake volume in dry season. Therefore, the expansion of water supply facilities in these cities is an urgent matter.

In August 2010, the RGC made a request to the GOJ for Grant Aid for the Project on Additional New Water Treatment Plants for Kampong Cham and Battambang, to cope with such circumstances. The GOJ entrusted the Japan International Cooperation Agency (JICA) to examine the viability of the Project. JICA is the official agency for implementing Japanese Government’s technical assistance and expediting proper execution of Japan’s Grant Aid. Hence, JICA decided to conduct a Preparatory Survey and sent the JICA Preparatory Survey Team (JPST) to Cambodia.

1.2 Natural Conditions

Topographical, route alignment, geotechnical and water quality surveys described below were carried out to determine the design conditions for the proposed project sites. The existing environmental conditions for the project sites are described in section "**1.3 Environmental and Social Considerations**".

(1) Topographic and Alignment Surveys

Topographic surveys

Topographic surveys were carried out at the proposed sites for the intake and treatment facilities. At the proposed intake site, a cross sectional survey of the revetments along the Mekong River and the Sangke River were included because the angle of the revetment is relatively small and the feature should be considered when studying the design of the intake facility.

Alignment surveys

The project area has a rolling terrain and it is necessary to consider the direct distribution pumping system in order to ensure enough residual water pressure in all parts of the supply area. Alignment surveys were carried out along the proposed transmission and distribution pipeline routes.

(2) Soil quality surveys

Results of standard penetration tests (N value) are summarized for each site. Depths are referenced to average ground level.

Proposed river intake site

In Kampong Cham, bed rock (50 or more blows) is located at a depth of 10 m. In Battambang, hard clay layer (10 to 30 blows) is located under 10 m.

Proposed treatment plant site

In Kampong Cham, bed rock (50 or more blows) is located at 4 m. In Battambang, hard clay layer (10 to 30 blows) is located under 5 m.

(3) Water quality survey

A water quality survey was conducted for i) existing well in Kampong Cham, ii) raw water from Mekong River and iii) raw water from Sangke River. (Refer to **Tables 1.3-4, 1.3-5** and **1.3-15** for the results)

Mekong River water (Kampong Cham)

Alkalinity is relatively high but total dissolved solids (TDS) and hardness values are normal. The water quality is good for use as a water source. Lime dosage is not necessary because the

pH value is in the intermediate range.

Existing well (Kampong Cham)

Sulfide (S) in the valence state of SO_4 can be detected when dissolved oxygen (DO) is low (3.45 mg/L). Adequate oxidation treatment and chlorination will prevent problems caused by odor. It is necessary to monitor water quality regularly in case the well will be used as raw water. The Mekong River water is more suitable as the water source for Kampong Cham water supply.

Sangke River water (Battambang)

The water has a lot of solids but is still within the normal range for TDS (43～63mg/L), although the total suspended solids value is relatively high (57～114mg/L). Lime dosage is not necessary because the alkalinity is high (128～181mg/L). However, it is necessary to include lime dosage in designing the water treatment facility because lime dosage and pH control are in use at the existing treatment plant in Battambang. The high bacterial count is not a problem because chlorination will be installed. There are no significant impacts to the water quality by the sewage treatment effluent. The values of biochemical oxygen demand (BOD) and chemical oxygen demand (COD) are higher than those upstream but the difference is small.

1.3 Environmental and Social Considerations

1.3.1 Environmental Consideration

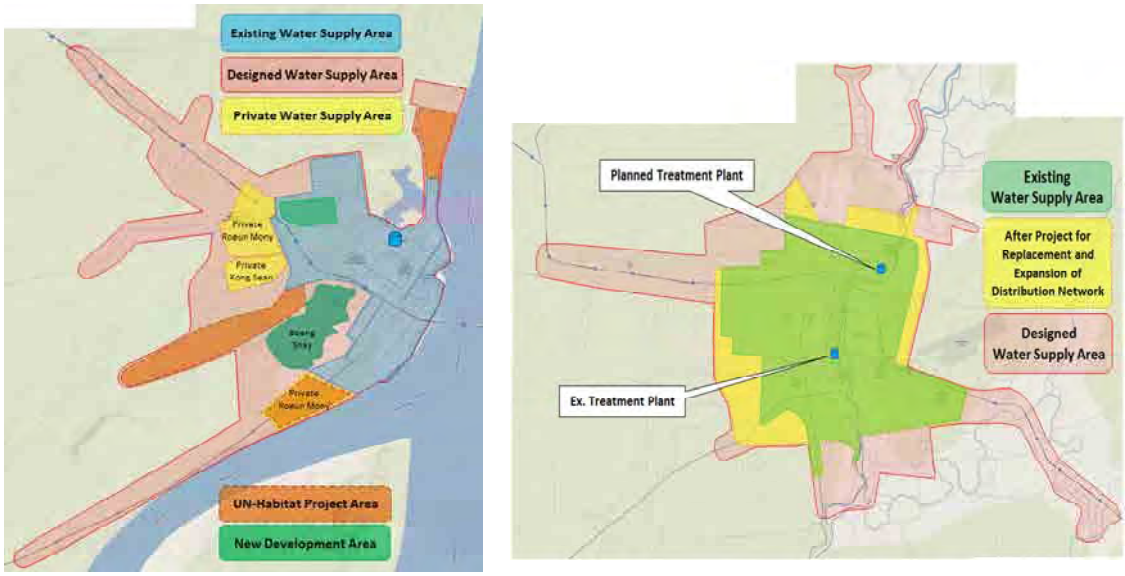
(1) Outline of the Project

a. Name of the Project

Project on Additional New Water Treatment Plants for Kampong Cham and Battambang Waterworks

b. Area of the Project

The Project Areas in both Cities are as hatched by reddish color in the following figure.



Kampong Cham **Battambang**

Figure 1.3-1 Project Area

c. Outline of the major project Components

Outline of the major project Components are described in the following tables.

Table 1.3-1 Major Project Components in Kampong Cham

Major Component	Items	Scale
Intake Facility	Intake structure and pump system	12,650m^3/day
Conveyance Facility	Conveyance pipe and valve chest from intake facility to treatment facility	Length：0.9 km
Treatment Facility	Receiving well, Mixing well, Flocculation basin, Sedimentation basin, Filtration basin with rapid sand filtration facility, Waste pond, Sludge drying bed and Administration building with related appliances.	11,500m3/day
Transmission Facility	Transmission pipe from existing well to Distribution reservoir	Length：0.9 km

Major Component	Items	Scale
Distribution facility	Distribution reservoir, distribution pumps, Flow monitor, Flow control system and etc.	2,500m3
Distribution network	Distribution pipe network from reservoir to supply area, valve chest, water pipe bridge and etc.	Length：57.8km

Table 1.3-2 Major Project Components in Battambang

Major Components	Items	Scale
Intake Facility	Intake structure and pump system	24,200m^3/day
Conveyance Facility	Conveyance pipe and valve chest from intake facility to treatment facility	Length: 4.4km
Treatment Facility	Receiving well, Mixing well, Flocculation basin, Sedimentation basin, Filtration basin with rapid sand filtration facility, Waste pond, Sludge drying bed and Administration building with related appliances.	22,000m^3/day
Distribution Facility	Distribution reservoir, distribution pumps, Flow monitor, Flow control system, etc.	6,000m^3
Distribution Network	Distribution pipe network from reservoir to supply area, valve chest, water pipe bridge, etc.	Length: 65.5km

c.1) Intake Position

Planned intake locations are shown in the following figures.

Figure 1.3-2 (a) Position in Kampong Cham (b) Position in Battambang

c.2) Structure of Intake Facility

The structure of intake facility in both cities is described in the following table.

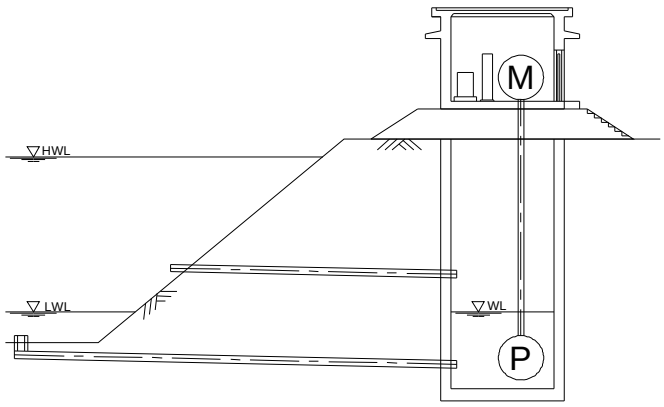
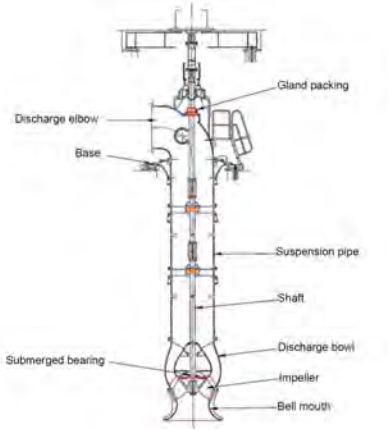
Structure	Pump
	

Figure 1.3-3 Intake Facility Adopted for both Cities

c.3) Treatment Facility

For the treatment process, the following system is adopted for the Project in Kampong Cham.

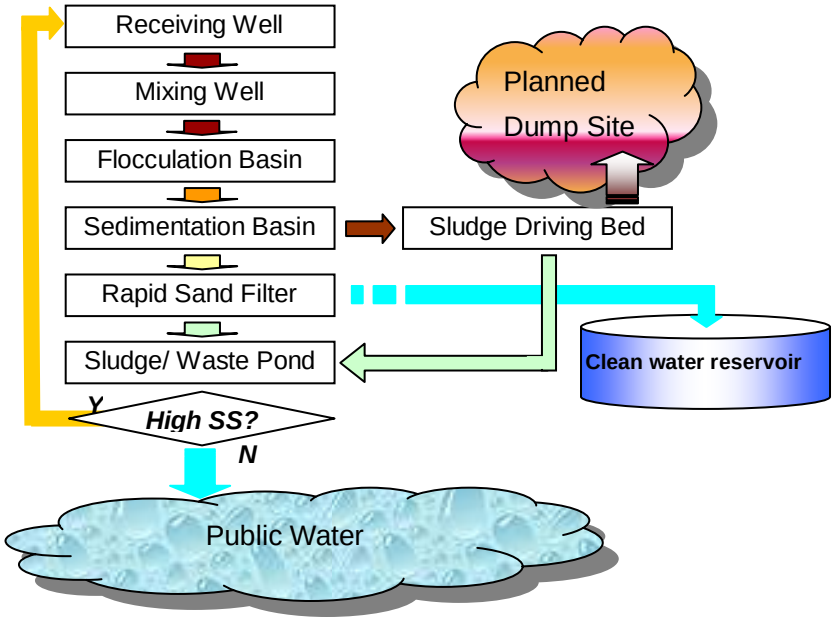


Figure 1.3-4 Treatment Process Adopted for the Project in Kampong Cham

From the results of water quality monitoring conducted for the Project, coagulation - sedimentation method with rapid filtration is adopted as shown in the above figure. After the filtration, supernatant water will be transferred to the waste pond to avoid any direct discharge to the public water. From the waste pond, if the water contains a high concentration of suspended substances, it will be brought back to the mixing pond and processed again. On the other hand, if the water contains not much suspended substances, it will be discharged to the public water system.

c.4) Distribution Network

The distribution networks in both cities are as shown in the following figures.

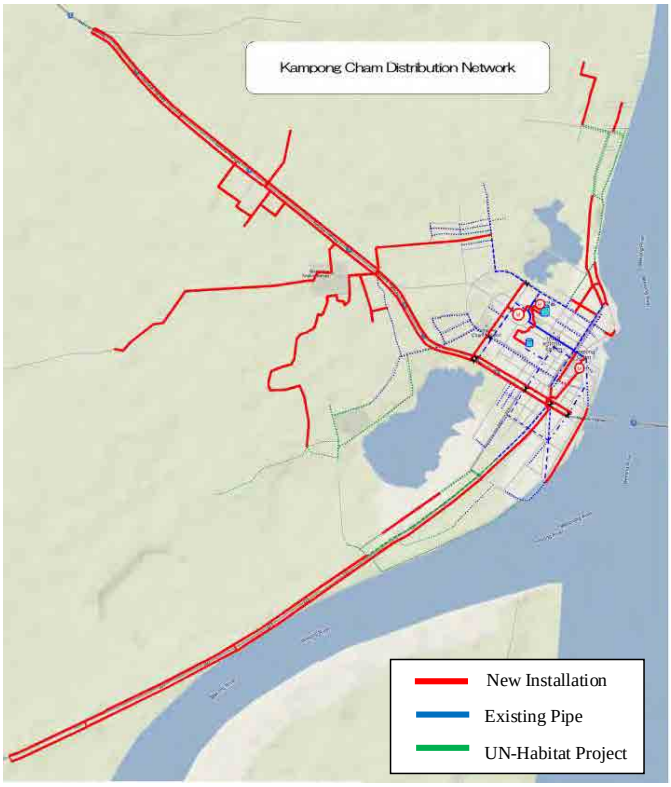


Figure 1.3-5 (a) Distribution Network for the Project in Kampong Cham

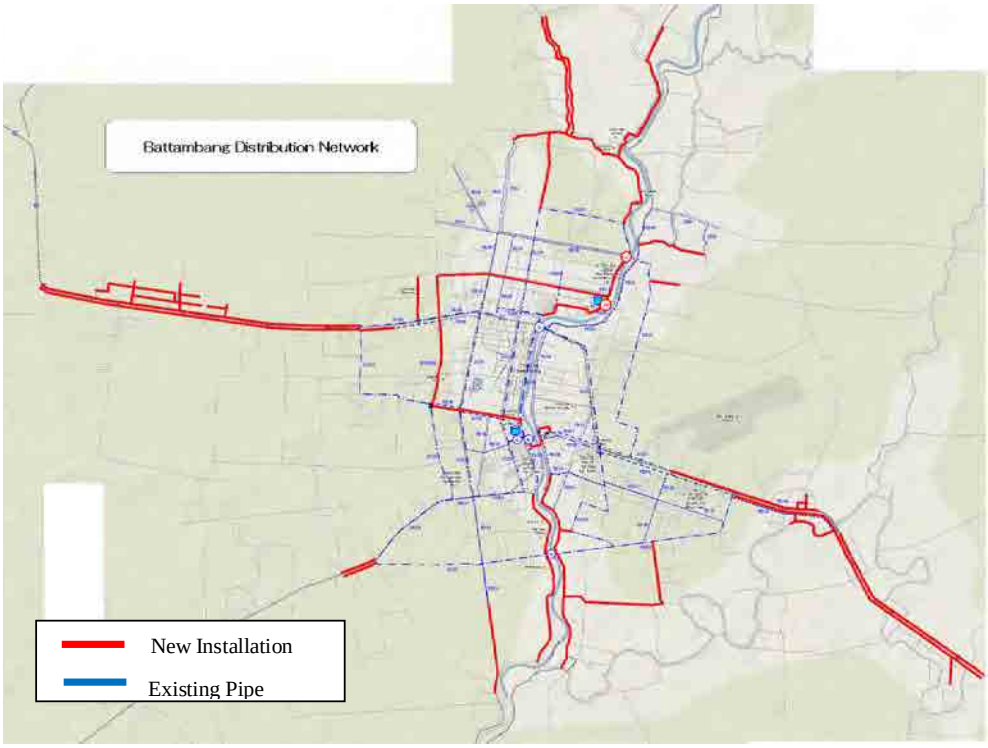


Figure 1.3-5 (b) Distribution Network for the Project in Battambang

d. Project Implementation Schedule

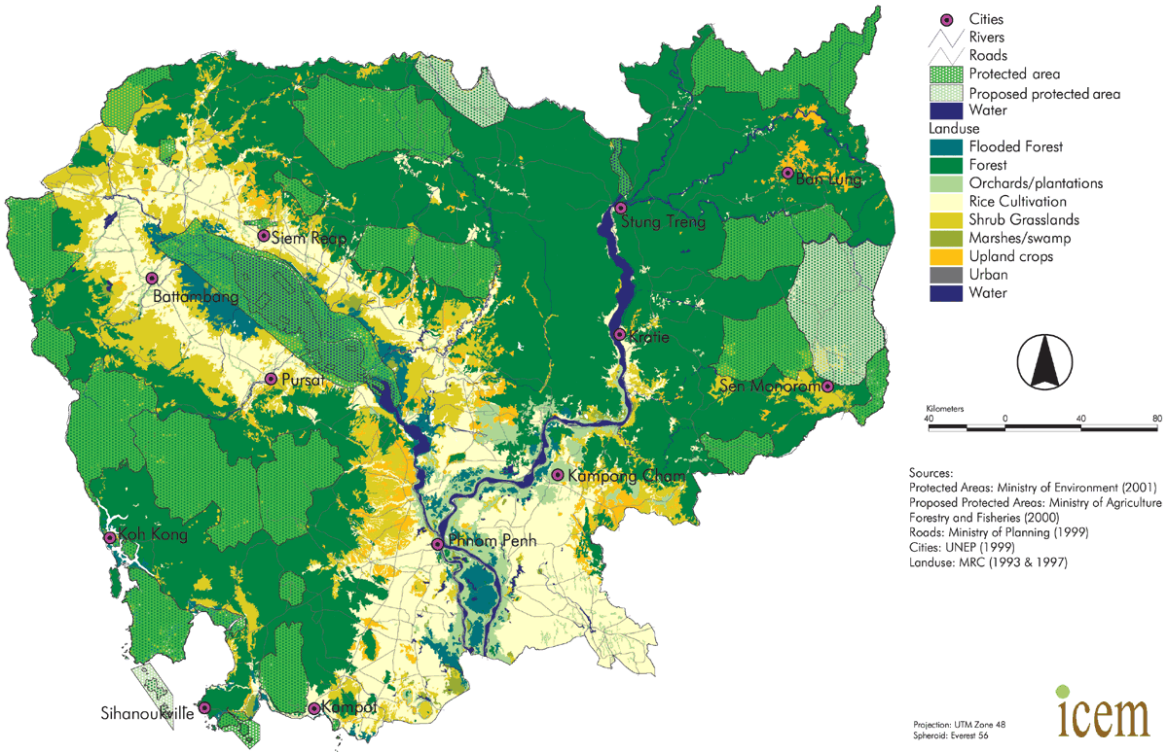
The project will be started from the year 2013 and completed in 2016.

(2) Existing Environmental and Social Conditions

a. Entire Cambodia

Cambodia is situated at the central to southern part of the Indochina Peninsula and surrounded by Thailand on the North-West, Laos on the North and Vietnam on the East to South-East. Mekong River runs through Cambodia from Laos to Vietnam. The Tonle Sap Lake is located in the central lowland and the Tonle Sap River starts from the lake. Mekong River and Tonle Sap River meet at Phnom Penn.

Mountains are dominant in the northeastern, northern and western part of the country. These regions comprise forests growing densely, where various wildlife inhabit. Cambodia falls in the tropical monsoon area with rainy season from June to October and dry season in November to April. It becomes extremely hot in April and May.



(Source: International Centre for Environmental Management)

Figure 1.3-6 Land Use and the Project Area in Cambodia

b Kampong Cham

b.1 Topography, Geology and Soils

The topography of the province is highly variable. Kampong Cham is bisected by the Mekong River. East of the Mekong, the northern areas consist of upland areas including forest, rubber

plantations and agricultural areas. The southern areas of Eastern Kampong Cham consist of low land, paddy fields and areas of lowland/upland mosaic. Around the Mekong River are the river flood plains. In Western Kampong Cham, there are large areas of lowland paddy fields to the South. To the North of Western Kampong Cham, the topography is of lowland/upland mosaic and uplands including forest, rubber plantations and agricultural areas.

In terms of geology, Kampong Cham's primary feature consists of the three basalt outcrops that form the hills. These are surrounded on the Southeast by old alluvium, while all other areas are young alluvium. The soils consist of basal soils of the higher parts of the hilly lands surrounded by the good quality soils formed from deposition around them. The soils in and surrounded project area are of various types such as rugers, great lake, alluvial lithosols, basic lithosols, alumisols, cultural hydromophic, and lithosols as shown in the following figure. In terms of fertility, the basalt soils are highly fertile for a range of cropping and have high water holding capacity, while the alluvial soils are medium fertility.

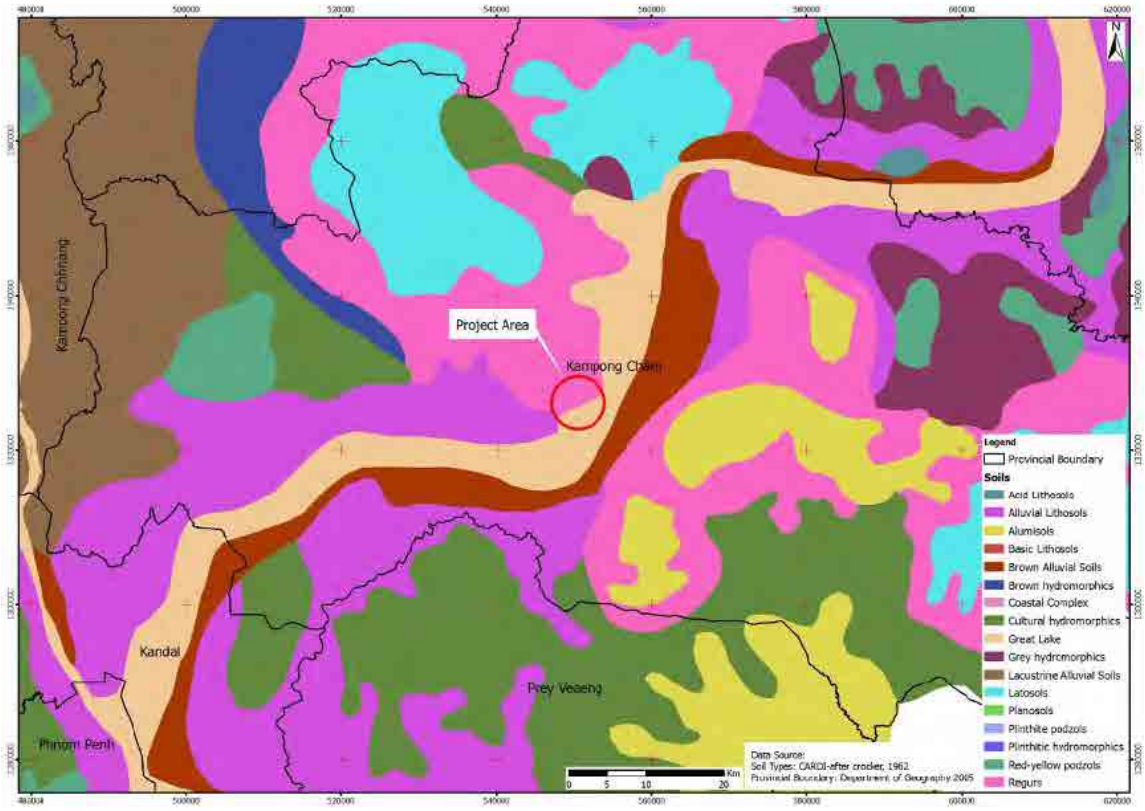


Figure 1.3-7 Soil Type in and around the Project Area

(Source: Cambodian Agricultural Research and Development Institute)

b.2 Climate

The project area has a monsoon-dominant climate, described as tropical wet and dry due to the distinct seasonal variation. Approximately 70-80% of annual rainfall occurs during the southwest monsoon from mid-May to late September or early October. The northeast monsoon brings drier and cooler air from early November to March, the hotter conditions prevail in April

and early May, producing a pronounced dry season. Total annual rainfalls at the Kampong Cham station varies from 1400 to 1800.

The hot season lasts from March to June, with air temperatures in Kampong Cham peaking in April at an average daily maximum of 36°C. The coolest months are December/January with an average daily maximum of 30-31°C.

Table 1.3-3 Climate Data for Kampong Cham Province, Kampong Cham Station

Month	Year 2006			Year 2010		
	Ave. Max Temp (°C)	Ave.Min Temp (°C)	Rainfall (mm)	Ave.Max Temp (°C)	Ave.Min Temp (°C)	Rainfall (mm)
January	31.10	21.30	6.80	31.2	21.0	1.0
February	34.70	23.60	0.00	34.6	22.4	38.2
March	34.80	23.90	7.00	35.4	23.7	68.7
April	36.50	25.90	83.80	35.5	24.3	150.2
May	35.90	26.30	85.20	35.9	25.2	233.4
June	35.00	25.90	122.40	33.9	24.3	152.2
July	32.20	24.80	323.40	32.5	24.0	376.2
August	31.30	25.70	101.90	32.4	32.7	200.3
September	31.20	25.20	361.00	32.4	23.9	287.7
October	31.00	24.80	185.60	31.3	22.6	256.7
November	29.30	24.30	102.80	30.6	23.1	5.4
December	32.90	22.10	26.8	30.6	22.0	0.0
Annual Mean	32.99	21.30	1406.70	33.00	24.10	1770.0

b.3 Air Quality

According to MOE, there is no monitoring activity conducted by RGC, therefore, no concrete numeric data which shows the current air quality condition is available.

On the other hand, the traffic volume in Kampong Cham Town is increasing with cars and motorbikes from year to year and thus, deterioration of air quality is most likely on going.

b.4 Water Quality

b.4.1 Surface Water Quality

Surface water sampling was taken at the new intake site of Mekong River on August 2012. The results of surface water quality measurement are shown in the following table. The results compile both onsite measurements and laboratory analyses (by MoE).

Table 1.3-4 Results of Surface Water Quality Test, July 2012

No.	Parameters	Unit	MIME DWQS	Results
1	pH	-	6.5 – 8.5	7.6
2	Temperature	°C	-	30.2
3	Total Suspended Solid (TSS)	mg/l	25 - 100	64.00

No.	Parameters	Unit	MIME DWQS	Results
4	Total Dissolved Solid (TDS)	mg/l	800	63.00
5	Dissolved Oxygen (DO)	mg/l	2.0 – 7.5	7.14
6	Turbidity	NTU	5	93.90
7	Alkalinity	mg/l	-	249.90
8	Total Hardness	mg/l	300*	28.39
9	Nitrite (NO2)	mg/l	3	ND< 0.1
10	Nitrate (NO3)	mg/l	50	0.98
11	Sulphate (SO4)	mg/l	-	7.63
12	Fluoride (F)	mg/l	-	0.21
13	Chloride (Cl)	mg/l	250	4.14
14	Ammonium (NH4)	mg/l	-	ND< 0.1
15	Sulphide (S)	mg/l	-	0.08
16	Color	TCU	5	5.00
17	Biochemical Oxygen Demand(BOD)	mg/l	1.0 – 10.0	0.85
18	Chemical Oxygen Demand (COD)	mg/l	-	2.13
19	Total Phosphorus (TP)	mg/l	-	0.15
20	Cyanide (CN)	mg/l	0.07	ND< 0.04
21	Aluminium (Al)	mg/l	-	0.004
22	Arsenic (As)	mg/l	0.05	ND< 0.0001
23	Cadmium (Cd)	mg/l	0.003	ND< 0.0002
24	Chromium (Cr)	mg/l	0.05	ND< 0.0005
25	Copper (Cu)	mg/l	1	0.22
26	Iron (Fe)	mg/l	0.3	0.04
27	Lead (Pb)	mg/l	0.01	ND< 0.0002
28	Manganese (Mn)	mg/l	0.1	0.002
29	Mercury (Hg)	mg/l	0.001	0.0003
30	Selenium (Se)	mg/l	0.01	ND, 0.0006
31	Zinc (Zn)	mg/l	3	0.04
32	Total Coliform	Count/100 ml	0	$2.4X10^2$
33	E-Coli	MPN/100 ml	0	0

MIME DWQS – Ministry of Industry Mines and Energy, Drinking Water Quality Standard, January 2004

* Hardness is expressed as mg/L CaCo3

Result by JPST (July 2012)

The results of surface water quality tests show that Total Coliform is higher than drinking water standard while it is zero for E-Coli. These results are related with the natural phenomena as well as the decay of animals, fish, or manure washed out from the forest or deposits in the water body itself.

The turbidity of Mekong River during of study (rainy season) is quite high if compared to the Cambodian drinking water quality standard of 5NTU. During rainy season or after storm event, turbidity is usually higher than normal and most of the turbidity in surface water comes from erosion of materials such as: clay, silt, rock fragment and colloid.

b.4.2 Groundwater Quality

Groundwater sampling was taken in Kampong Cham Water Works on August 2012. The results of groundwater quality sampling conducted by the study team are shown in **Table 1.3-5** and the

results obtained from Kampong Cham Water Works are shown in **Table 1.3-6**.

Table 1.3-5 Results of Groundwater Quality by Study Team, August 2012

No.	Parameters	Unit	MIME DWQS	Results
1	pH	-	6.5 – 8.5	6.7
2	Temperature	^{o}C	-	30.1
3	Total Suspended Solid (TSS)	mg/l	25 - 100	36.00
4	Total Dissolved Solid (TDS)	mg/l	800	306.00
5	Dissolved Oxygen (DO)	mg/l	-	3.45
6	Turbidity	NTU	5.0	0.00
7	Alkalinity	mg/l	-	1092.70
8	Total Hardness	mg/l	300	200.90
9	Nitrite (NO2)	mg/l	3.0	ND< 0.1
10	Nitrate (NO3)	mg/l	50.0	21.97
11	Sulphate (SO4)	mg/l	250	12.42
12	Fluoride (F)	mg/l	1.5	0.20
13	Chloride (Cl)	mg/l	250.0	30.52
14	Ammonium (NH4)	mg/l	1.5	ND< 0.1
15	Sulphide (S)	mg/l	-	0.14
16	Color	TCU	5.0	2.00
17	Biochemical Oxygen Demand(BOD)	mg/l	1.0 – 10	0.11
18	Chemical Oxygen Demand (COD)	mg/l	-	0.59
19	Total Phosphorus (TP)	mg/l	-	0.59
20	Cyanide (CN)	mg/l	0.07	ND< 0.04
21	Aluminium (Al)	mg/l	0.2	0.003
22	Arsenic (As)	mg/l	0.05	ND< 0.0001
23	Cadmium (Cd)	mg/l	0.003	ND< 0.0002
24	Chromium (Cr)	mg/l	0.05	ND< 0.0005
25	Copper (Cu)	mg/l	1	ND< 0.0003
26	Iron (Fe)	mg/l	0.3	0.09
27	Lead (Pb)	mg/l	0.01	ND< 0.0002
28	Manganese (Mn)	mg/l	0.1	0.005
29	Mercury (Hg)	mg/l	0.001	0.0001
30	Selenium (Se)	mg/l	0.01	0.001
31	Zinc (Zn)	mg/l	3.0	0.005
32	Total Coliform	MPN/100 ml	0	0
33	E-Coli	MPN/100 ml	0	0

Result by JPST (July 2012)

Table 1.3-6 Result of Groundwater Quality obtained from Kampong Cham Water Works

No.	Parameters	DWQS* Maximum	Results		
			31/10/10	31/07/11	30/04/12
1	Taste	Acceptable	Ok	Ok	Ok
2	Odor	Acceptable	Ok	Ok	OK
3	Color	5 TCU	0.018	0.071	0.090
4	Turbidity	5 TNU	0.014	0.012	0.58
5	Residual Chlorine	0.2-0.5 mg/L	0.87	1.4	1.1
6	pH	6.5-8.5	7.22	7.26	6.58
7	Total Dissolved Solids	800 mg/L	-	302	261
8	Manganese (Mn)	0.1 mg/L	-	0.1	0.0

No.	Parameters	DWQS* Maximum	Results		
			31/10/10	31/07/11	30/04/12
9	Zinc (Zn)	3 mg/L	0.5	0.21	0.06
10	Sulfate (SO_4)	250 mg/L	11	13	13
11	Copper (Cu)	1 mg/L	0.002	0.016	0.02
12	Hydrogen Sulfide (H_2S)	0.05 mg/L	0.005	0	0
13	Hardness	300 mg/L	200	236	205
14	Aluminum (Al)	0.2 mg/L	0.007	0.008	0.006
15	Chloride (Cl)	250 mg/L	22.78	32.61	23.12
16	Iron (Fe)	0.3 mg/L	-	0.01	0.002
17	Ammonia (NH_3-N)	1.5 mg/L	-	0.04	0.02
18	E.Coli	0	0	0	0
19	Total Coliform	0	0	0	0
20	Arsenic (As)	<50 ppb	-	0	0
21	Alkalinity	mg/L (as $Caco_3$)	214	197	196
22	Conductivity	µs/cm	456	604	522
23	Organic Carbons	mg/L	1	0	0

Source: Kampong Cham Water Works

Note: * Ministry of Industry Mines and Energy, Drinking Water Quality Standard, January 2004

The analysis of groundwater quality result by the study team and the analysis of groundwater quality result obtained from Kampong Cham Water Works show that there are no parameters higher than the Cambodian drinking water quality standards. It can therefore be concluded that groundwater quality in Kampong Cham Water Works are currently polluted by bacteria or chemicals and the reasons include: (i) good environmental conditional around the well; (ii) high technical construction (sealing in joint point between concrete rings, and concrete platform) and good maintenance; and (iii) good soil texture of course sand and sandy soil (Q4).

b.5 Ecological Resources

b.5.1 Fish

There is no available document or resource which tells the aquatic life forms in the Project area while information of fishery is the only source of it. The following table shows confirmed fish species in river system in Cambodia.

Table 1.3-7 Fresh Fish Species Found in Cambodia River System

No.	Local Name	Name in English	Science name
1	Trey Riel	Henicorhynchis spp.	
2	Trey Pro Ma	Boesemania microlepis	Smallscale ardherfish
3	Trey Kantrop	Pristolepisfasciata	Catopra
4	Trey Linh	Thynnichthys thynnoides	Whit lady carp
5	Sloek Russey	Paralaubuca typus	
6	Trey Kanhchos Kdong	Heterobagrus bocourti	
7	Trey Kanhchos Chhot	Mystus micracanthus	
8	Trey Kanhchos Para	Leiocassis siamensis	

No.	Local Name	Name in English	Science name
9	Trey Kanhchos Pruy1	Mystus micracanthus	
10	Trey Kanhchos Pruy2	Mystus micracanthus	
11	Trey Ros/Phtuok	Channa striata	Chevron snakehead
12	Trey Kes	Micronema apogon	Common sheatfish
13	Trey Kes	Micronema micronema	Common sheatfish
14	Trey Kaek	Morulius krysophekadion	Black sharkminnow
15	Trey Chhkok Moul	Cyclocheilichthis enoplos	Soldier river barb
16	Trey Chhkok Kdar	Albulichthys albuloides	
17	Trey Sraka kdam	Cyclocheilichthis lagled	
18	Trey Chrakeng	Puntioplites waandersi	
19	Trey Pruol/kraland	Cirrhinus microlepis(VU)	Small scale mud carp
20	Trey Krom	Osteochilus melanopleura	
21	Trey Chhdor/Diep	Channa micropeltes	Giant snake head
22	Trey Ta aun	Ompok hypophthalmus	Whisker sheatfish
23	Trey Chhpin	Hypsibarbus lagleri(VU)	Tawes
24	Trey Chhpin	Hypsibarbus malcolmi	Tawes
25	Trey Slat	Notopterus notopterus	Bronze featherback
26	Trey Po	Botia spp.	Speckletail botia
27	Trey Kanhchrouk Krohorm	Botia eos	Spotted gouranii
28	Trey Kanhchrouk Chhot	Botia helodes	Spotted gouranii
29	Trey Kanhchrouk Loeung	Botia lecontei	Spotted gouranii
30	Trey Kanhchrouk	Botia morleti	Spotted gouranii
31	Trey Kamphleanh	Mystus nemums	
32	Trey Chhlang	Rasbora tornieri	
33	Trey Changva moul	Rasbora borapetensis	
34	Trey Changva Chhot	Rasbora daniconius	
35	Trey Changva	Rasbora myersi	
36	Trey Kros	Wallago attu (NT)	
37	Trey Sanday	Pangasius larnaudi	
38	Trey Phtong	Xenantodon spp.	
39	Trey Angkat Prak	Puntiua brevis	
40	Trey Pra	Pangasius spp.	Catfish
41	Trey Pra Kandol	Pangasius bocourti	
42	Trey Prawloung	Leptobarbus hoeveni	Hoeven's slender carp
43	Trey Khman	Hampala macrolepidota	
44	Trey Bandol Ampouv	Clupeoides borneensis	
45	Trey Kahae	Barbodes altus	
46	Trey Kranh	Belodontichthys dinema	
47	Trey Klanghay	Trichopocus pectorails	Snakeskin gourami
48	Trey Kanthor	Anabas testudineus	Chmbing perch
49	Trey Kambot Chromioa	Sikukia gudgeri	
50	Trey Ampil Toum	Systomus orphoides	
51	Trey Chanteas Phlouk	Parachela siamensis	
52	Trey Chveat	Pangasius siamensis	
53	Trey Chveat	Pangasius pleurotaenia	
54	Trey Chveat	Pangasius polyuranodon	
55	Trey Kampoul Bay	Cosmochilus harmandi	
56	Trey Damrey	Oxyeleottis mannorata	Sand goby
57	Trey Trawsawk	Probarbus jullieni	Seven-line barb
58	Trey Kol Raing	Catlocarpio siamensis (CE)	Giant Mekong barb

No.	Local Name	Name in English	Science name
59	Trey Reach	Pangasianodon gigas (CE)	Giant Mekong catfish
60	Trey Prawma	Boesemania microlepis (NT)	Smallscale croaker
61	Trey Chunluonh Moan	Coillia macrognathos	Longjaw grenadier enchovy
62	Trey Chhma	Setipinna melanochir	Dusky hairfin enchovy
63	Trey Dang khteng	Macrochirichthys macrochirus (NT)	
64	Trey Chhkok Tituy	Albulichthys albuloides	
65	Trey Phka kor	Cyclocheilichthys armatus	
66	Trey Lolok Saw	Paropuntius deauratus	
67	Trey Changva Ronong	Lobocheilos melanotaenia	
68	Trey Kamphliev	Kryptopterus cryptopterus	Freeklefin eel
69	Trey Khchung	Macrognathus maculatus	Fringed threadfin
70	Trey Kompream	Polynemus multifilis	Small scale archerfish
71	Trey Kancheak sla	Toxotes microlepis	Golden tank goby
72	Trey Khsan	Glossogobius aureus	Mekong blind sole
73	Trey Andat Chhkae	Typhlachirus elongatus	
74	Trey Kampot	Monotetrete cambodgiensis	Iridescent glassy perchlet
75	Trey Kanchanh Chras	Parambassis apogonoides	Duskyfin glassy
76	Trey Kantrang Preng	Parambassis wolffii	Laotian shad
77	Trey Kbork	Tenualosa thibaudeaui(Vu)	
78	Trey Changwa chunh chuak	Crossocheilus reticulatus	
79	Trey Po Khmao Tracheak	Pangasius larnaudii	
80	Trey Po Pruy	Pangasius larnaudiei	
81	Trey Chhviet	Pangasius macornema	
82	Trey Ke	Pangasius nasutus	
83	Trey Po Pruy	Pangasius sanitwongsei (CR)	
84	Trey Khlang Hay	Belodintichthys dinema	
85	Trey Kror Paot/San day	Wallago attu(NT)	
86	Trey Chay Krar Peu	Microphis boaja	
87	Trey Phtaung	Hemiramphus mocguardianus	
88	Trey Priem	Polynemus longipectorialis	
89	Trey Spong	Lates calcarifer	
90	Trey Kantrang Preng	Ambassis wolffi	
91	Trey Kanchanh Chras	Ambassis ranga	
92	Trey Pama	Pseu-dosciaena soldado	
93	Trey Kanhcheak Sla	Toxotes chatareus	
94	Trey Sbaica	Cymbium cambodgiense	
95	Trey Andat Chhker	Cynoglossus microlepis	
96	Trey Pa phak	Scaphognathops bandanensis(VU)	
97	Trey Kap	Thryssocypris tonlesapensis	
98	Trey Kantuy Krohorm	Discherodontus ashmeadi	Redtail barb
99	Trey Khman	Hampala macrolepidota	
100	Trey Saka Keo	Raiamas guttatus	Barilius Guttatus
101	Trey Khla	Systomus partipentazona	Puntus tetrazona
102	Trey Kknang Veng	Dangila sp. cf. auvieri	
103	Trey Khnang Veng	Dangila lineata	
104	Trey Dang Dav	Luciosoma bleekeri	
105	Trey Borbel		
106	Trey Kaok	Arius stormi	Sona sea catfish
107	Trey Kaok	Arius thalassinus	Giant sea catfish
108	Trey Kyar	Mystus wyckioides	

No.	Local Name	Name in English	Science name
109	Trey Tanel	Mystus ilamentus	
110	Trey Andeng Tun	Clarias macrocephalus(NT)	Broad heah catfish
111	Trey Andeng Reong	Clarias batrachus	Walking catfish
112	Angtung	Monopterus albus	Swamp ell
113	Trey Russei Chek	Acantopsis sp. 1	Note: No exact species could be identified, however, several species of "Acantopsis" are ranked as VU and EN.
114	Trey Russei Chek	Acantopsis sp. 2	
115	Trey Russei Chek	Acantopsis sp. 3	
116	Trey Trosak	Probarbus jullieni (EN)	
117	Trey Trosak Sor	Probarbus labeamajor(EN)	
118	Trey Arch Kok	Dangila lineata	
119	Trey Pkhar Char	Cirrhinus jullieni	OSteochilus simus

Source: Fisheries and Aquaculture Development and Environment Impact Review 2001
CR (IUCN Category) : It is considered to be facing an extremely high risk of extinction in the wild.
EN (IUCN Category) : It is considered to be facing a very high risk of extinction in the wild.
VU (IUCN Category) : It is considered to be facing a high risk of extinction in the wild.
NT (IUCN Category) : It is close to qualifying for or is likely to qualify for a threatened category in the near future.

b.5.2 Forest

Due to the nature of the water supply project which aims the expansion of water supply to the residents, the project area designed mainly in build-up area and residential area. Therefore, the Project area consists mainly of build-up area and residential area with its connecting road network. Naturally, primary forest, native bushes do not exist in the Project area.

There are some trees planted by people along road embankments, at pagoda and school compounds, etc. Most of them are fruit trees such as coconut, mango, milk-fruit e, guava, custard apple, jack fruit, grape fruit and banana.

b.5.3 Wildlife

As described in above section, primary forest, native bushes do not exist in the Project area. However, the local people still find some reptiles and amphibians and birds in the project area as listed below.

Table 1.3-8 Reptiles and Amphibians Found in the Project Area

No.	Local Name	Name in English	Science name
1	Kangkeb	Tiger Frog	Hoplobatrachus tigerinus
2	Kingkouk		
3	Kanchanchek		
4	Thlain		
5	Bangkuoy Slab		
6	Bangkuoy Snaeng		
7	Bangkuoy Thamda		
8	Kantrong		
9	Trakuort	Common Monitor	Varanus bengalensis

No.	Local Name	Name in English	Science name
10	Puos Thlan	Burmese Python	Python molurus bivittatus (VU)
11	Puos Prey	Common Rat Snake	Ptyas mucosus
12	Puos Vek (Roneam)	King Cobra	Ophiophagus Hannah (VU)
13	Puos Vek (krabei)	Monocle Cobra	Naja kaouthia
14	Puos Vek (Sra nge)	Indochinese Spitting Cobra	Naja siamensis (VU)
15	Puos Khiev		

Source: Obtained from local people during the field survey in July 2012

VU (IUCN Category) : It is considered to be facing a high risk of extinction in the wild.

Table 1.3-9 Birds Found in the Project Area

No.	Local Name	Science name	Name in English
1	Porpich	Pycnonotus atriceps	Bulbul
2	Pvaeng	Aceros undulatus	Wreathed Hornbill
3	Chab Daun Ta	Acrocephalus orientalis	Oriental Reed Warbler
4	Chab Krok	Megalurus palustris	Striated Grassbird
5	Chab Tet	OrthotomUs sutorius	Common Tailorbird
6	Chab Dankov Chincheum Sor	Prinia inornata	Plain Prinia
7	Chab Phtas	Passer montanus	Eurasian Tee Sparrow
8	Chab Srok	Passer flaveolus	Plain-backed Sparrow
9	Ka ek	Corvus macrorhynchos	Large-billed Crow
10	Meam Tauch Prey	Glaucidium cucoloides	Asian Barred Owlet
11	Kleng Kmao	Vilvus migrans	Black kite
12	Kleng Srak	Tyto alba	Barn Owl
13	Lor Lok Phnom	Macropygia unchall	Barred Cuckoo Dove
14	Lor lok Traeng	Streptopelia tranquebarica	Red Collared Dove
15	Trases Thom Pus Sor	Dryocopus javensis	White-bellied Woodpecker
16	Ta vao	Eudynamys scolopacea	Asian Koel
17	Teav Kiev	Coracias benghalensis	Indian Roller
18	Ti tuy Thom	Bubo nipalensis	Spot-bellied Eagle Owl

Source: Obtained from local people during field survey in July 2012

b.5.4 Protected Areas

In Cambodia, a number of protected conservation areas approximately cover 5.4 million hectares of 7 national parks, 9 wildlife sanctuaries, 3 protected landscape areas, and 3 protected areas. The national parks are located in the coastal, mountain, plateau and lake region covering 742,300 million hectares, and wildlife sanctuaries in these regions cover 4.138 million hectares. The protected landscape areas cover 97,000 hectares including archaeological and cultural sites, and protected areas cover 403,900 hectares.

Based on the above information, there are no protection areas for the construction of a new water treatment plant in Kampong Cham Province.

b.6 Economic Development

b.6.1 Industries

Today, Kampong Cham province has over 3,000 private enterprises. The following table shows the enterprises operating in Kampong Cham city. Major enterprises in Kampong are vegetable production, suppliers of animal feed, agricultural machinery and fertilizer, rice millers, brick manufacturers, furniture makers and other small industrial operations.

Table 1.3-10 Enterprises Operating in Kampong Cham

Activity	Number of Enterprises	Number of Employees
Rubber	27	N/A
Textiles	2	2,000
Cashew processing	2	650
Oil processing	1	50
Tapioca starch	2	125-150
Vegetable processing	2	100-150
Garment manufacturing	2	1,900
Beverage production	1	300
Electricity from biomass	1	N/A
Animal feed	1	35-65

Source: Kampong Cham Investment Profile, 2008

b.6.2 Infrastructural Facilities

b.6.2.(1) Water Supply

The existing Kampong Cham Water Works does not yet supply water to the whole city areas of Kampong Cham City. As described in previous chapter, Kampong Cham City has only 30% safe water access rates at present because of insufficient production capacity of existing facilities. The water supply system at present is mostly located along the main roads and in urban areas. The remaining areas are using hand-dug wells, borehole wells and private water supply facilities.

b.6.2.(2) Waste Management

In Kampong Cham, there is the CINTRI as the private waste collector responsible for disposal, collection, storage and transportation of waste. CINTRI has not covered the whole service area, especially the poor communities where the CINTRI's truck cannot access.

The RGC as well as Phnom Penh Authority has guidelines established by MoE for dealing with solid waste management; however, the management of solid waste in Kampong Cham Province is still riddled with a number of problems. The duties of all the organizations responsible for solid waste management, including the city authority, a public corporation and a private concessionaire, are not clear, resulting in low work efficiency. Uncollected waste is scattered along the streets, spoiling the city's landscape. The final disposal site, which had been used

since a long time ago, is merely a huge waste pile where many waste pickers, including children, are making a living by scavenging for materials despite the dangerous work conditions.

b.6.2.(3) Power Sources and Transmission

The electrical tariff for Kampong Cham is 1195 Riels/KWh. The source of energy supply mainly from generators and imported from Vietnam in Ponhea Krek and Memut district is owned by EDC. Almost all of the electrical infrastructures in rural areas are owned by local investors (from the villages). According to the Kampong Cham Electric Company, there exist a transmission line system within the project site for the new intake and water treatment plant.

b.6.2.(4) Sewerage System

Generally, the sewerage system in Cambodia is very old and most of them have been destroyed during the civil war a long time ago. Since 1993, the sewerage system has been improving in accordance with the economic situation in the Kingdom of Cambodia which has also been improving. Some of the sewerage system in Kampong Cham Town as well as within the project area has been replaced by the new system.

According to the Mr. Sok Srun, Director of Provincial Department of Public Works and Transportation, there is an existing sewerage system located along the road within the project area starting from the new intake to the new water treatment plant site. Mostly, drainage pipes with diameters of about 0.6m to 1m lie along the roads at a depth of about 1.5m to 2m.

b.6.2.(5) Transportation

Kampong Cham locates north-east of Phnom Penh and the distance from the capital city is about 120km. The two cities are connected with national road 6 & 7 and also with Mekong River. The national road 7 stems from national road 6 and leads to Laos while it passes the areas close to Vietnam border.

In Kampong Cham city, build-up area is nestled between national road 7 and Mekong River, and the residential area is nestled along the national road 7 on the east as well as Mekong River on the south. Major transportation method is car and motor cycle. In Cambodia, the number of registered vehicles has been increasing at the rate of 10% every year and most of them are motorbikes (70%).

The traffic volume in Kampong Cham Town is increasing with cars and motorbikes from year to year, especially area close to the local market (Boeung Kok Market) which is in the Project area. Peak volumes coincide with the movement of students, government officials, businesses and tourists.

b.6.3 Tourist Condition

Kampong Cham is Cambodia's most populous province, and it is a major national and international tourism destination due to its proximity with the well-known Norkor Bachey Temple which is a historical site located 2 kilometers from the town along National Road #7. There is another mountain called Phnom Bros Phnom Srey located 7 kilometers from the town where the beautiful scenery of Kampong Cham Province can be viewed at the top. Besides these, Kampong Cham Province also has other attractive resorts such as mountain, waterfall and white sand. Presently, Kampong Cham has 10 resorts, 12 hotels, 75 guesthouses and 130 restaurants. Cambodian tourism is expected to grow at around 15% annually in the medium term and in keeping with these trends tourism in Kampong Cham is also expected to continue to increase. The following table shows the number visitors to Cambodia by land and by boat from 2002-2010.

According to the overview on the transport infrastructure sector in Cambodia, January 2008, the number of foreign tourists to Cambodia has been steadily increasing since 1995, depending on the international situation. However, number of foreign tourists in 2005 is more than 1.4 million or 1.35 times more than the previous year. Mostly, the purpose of visitors to Cambodia in 2005 is 89% for sightseeing, 7% for business, and 4% for other purposes.

Table 1.3-11 Number of Visitors to Kampong Cham

Year	Number of Visitors		
	National	International	Total
2006	69,478.00	6,473.00	75,951.00
2007	10,954.00	7,800.00	18,754.00
2009	237,348.00	13,901.00	251,249.00
2010	253,565.00	11,551.00	265,116.00

Source: Department of Tourism, Kampong Cham Province

b.6.4 Land Use

The total area of Kampong Cham Province is 9,477 km2 (Source: GIS data, Census 2008, Ministry of Interior) including urban and rural settlements, agricultural land, forest land, lakes and rivers.

Due to the characteristics of water supply project, the Project area mostly consists of residential and build-up area connected with main road network. Therefore, the land use of the project area consists of residential area, build-up area and road network along with street trees. Also, within the project area are mango, coconut, jackfruit, flower plants and other trees planted by people in front of their houses.

b.7 Social and Cultural Resources

The aim of the social and cultural resources survey was to create an extensive and realistic picture of the social-economic situation of the project area. However, the main objective was to achieve a great understanding of the socio-economic and environmental factor and to help development actors understand how to minimize possible impacts occurring due to the project development.

b.7.1 Population

The total population in Kampong Cham is 1,680,694 persons (Census 2008) that grow very fast compared to the total population of 1,608,914 persons in year 1998 (Census 1998). At present, the population density is 172 persons per km2. The average per family is 5.1 persons.

b.7.2 Ethnic Group

In Cambodia, ethnic groups depend on the locality, but most of them are Khmer, and the others are Cham, Vietnamese and minority ethnic groups. The minority ethnic groups are mostly settled in very remote areas such as the northeast plateaus of the country (Rattanakiri, Stung Treng, and Mondul Kiri provinces) and the northern parts of the country (in Preash Vihea Province). In the central plain of the country are mostly Khmer and the communities along the rivers are a mixture of Khmer and Cham. In urban areas are a mixture of Khmer, Vietnamese and others.

However, the ethnic group in the project area consists mostly of Khmers who practice Buddhism, but Chinese, Cham and Vietnamese families were also found by the study team during the field survey. The number of ethnic families in Kampong Cham City is shown in the following table.

Table 1.3-12 Ethnic Groups in Kampong Cham City, 2012

No.	Ethnic Group	No. of Families	Total Population	
			Males	Total
1	Khmer	7,983	20,269	41,600
2	Chinese	2	3	5
3	Cham	413	1338	2762
4	Vietnamese	88	282	437
	Total	8,486	21,842	44,804

Source: Kampong Cham Municipality

b.7.3 Public Health

The Ministry of Health (MoH) of the RGC highly pays attention to the health sector, especially the population with 85% living in rural areas, because the health sector plays an important role to the socio-economic development and poverty alleviation in Cambodia. A quarter of the total

population does not have any access to health care and many of those with access could not afford it. The health facility report in Cambodia indicates that most of the communes have health care centers and referral hospitals with the national hospitals located in provinces and the cities. Health facilities including public hospitals and modern international private clinics in Kampong Cham are good with expert technicians too. Presently, Kampong Cham has one provincial hospital, 11 referral hospitals and 141 health care centers.

Several water-related diseases had been recorded in Sangkat Veal Vong and Sangkat Sambour Meas health centers are shown in the following table. Diarrhea, dysentery, skin infections, and eye diseases are common in poor communities in the city.

Table 1.3-13 Water-Related Diseases recorded in Sangkat Veal Vong and Sangkat Sambour Meas Health Centers in 2011

No	Disease	Health Center	
		Sangkat Veal Vong	Sangkat Sambour Meas
1	Simple diarrhea	302	163
2	Severe diarrhea	17	16
3	Dysentery	43	161
4	Malaria	0	0
5	Dengue fever	2	0
6	Skin infections	24	161
7	Eye diseases	25	140

Source: Annual Health Reports in 2011

b.7.4 Education

The education sector is being improved throughout the country. The education level and literacy rates among women are usually much lower than those of men. Also, education in urban and rural areas has been found to be significantly different (CIPS 2008). However, the education sector in Cambodia has significantly improved in recent years with general and professional education offered in primary schools and universities. For 2005-2006, the number of universities and high class institutions in the whole country is 45 (Annual Statistical Data, Cambodia, 2008).

Kampong Cham has a good environment for education because both public and private institutions are located¥. At present, there have 138 kindergarten schools, 593 primary schools, 129 secondary schools and 49 high schools.

b.7.5 Physical and Cultural Heritage

According to the field observation, there is no physical and cultural heritage existing within the project implementation area. On the other hand, there are several Pagodas locate along with roads in which pipe network will be embedded. Therefore, certain cautions during construction operation are required.

c Battambang

c.1 Topography, Geology, and Soils

The topographical condition is generally flat with maximum elevation up to 10 m in and around the project area as shown in the following figure. Not only in Battambang Province, the geology of Cambodia is a complex subject and the geological history is poorly known. Soil type in the province is Alluvium tending to retain water much better than rocky or sandy soils. Generally, the province is well known as a main agricultural products producer since it is located in a highly fertile region situating on the Tonle Sap Lake. A combination of good rainfall, annual flooding and investment in irrigation systems ensures that soils support a very strong agricultural sector.

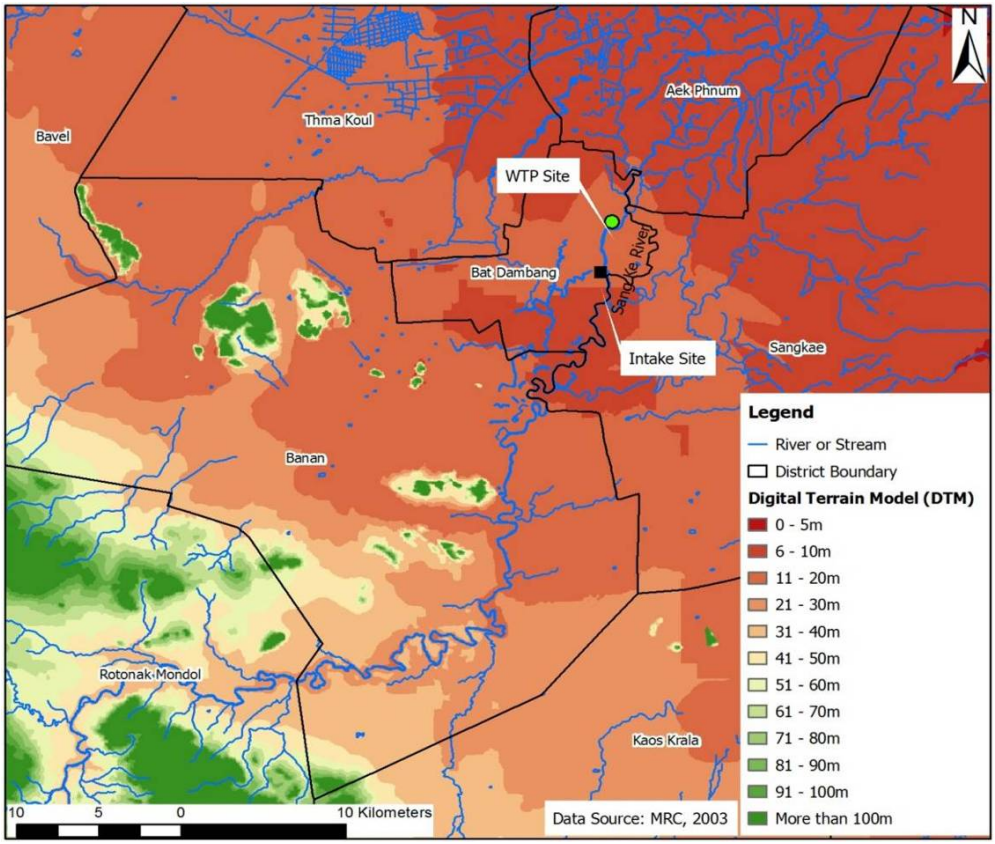


Figure 1.3-8 Topographical Map in and around the Project Area

c.2 Climate

There are two seasons in Cambodia: Dry and Rainy. The rainy season starts from May to October while the dry season starts from November to April. In the rainy season, average yearly rainfall for the period 2000–2011 is 1,280 mm as shown in the following table. In the dry season, little precipitation is also found. Monthly temperature ranges from 40.9 to 41ºC during the hottest months of April and May, to 14.8ºC in January and February, the coldest months.

Table 1.3-14 Climate Data for Battambang Province

Climate Data	Year											
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Average rainfall (mm)	1,450.00	1,146.20	1,197.10	1,229.40	995.40	1,245.70	1,228.90	1,357.10	1,519.80	1,392.10	1,333.00	1,266.10
	Average = 1,280.07											
Temperature (^{o}C)	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum	36.1	37.8	39.0	41.0	40.9	37.5	36.7	34.9	34.3	35.3	34.7	34.7
Minimum	14.8	14.8	14.9	20.0	22.6	22.2	22.0	20.5	20.7	17.6	10.7	10.7

Source: MOWRAM

c.3 Air Quality

No air quality monitoring station is in the city. Therefore, the current air pollution condition in the city is unknown. On the other hand, the traffic volume in Kampong Cham Town is increasing with cars and motorbikes from year to year and thus, deterioration of air quality is most likely on going.

c.4 Water Quality

Surface water sample was taken at the Sangke River on July 2012. The results of surface water quality analysis are shown in the following table. The aim of the water quality examination is to determine existing water quality of the River before construction and operation of the facility.

Table 1.3-15 Results of Water Quality Analysis of Sangke River, July 2012

No.	Parameter	Unit	Standards		(S1)	(S2)	(S3)
			MIME *	MoE**			
1	Temperature	^{o}C	-	-	29.2	29.3	28.3
2	pH	-	6.5 – 8.5	6.5 – 8.5	7.5	7.1	7.6
3	Total Suspended Solid (TSS)	mg/l	25 - 100	25 - 100	114.00	69.00	57
4	Total Dissolved Solid (TDS)	mg/l	800	-	61.00	63.00	43
5	Dissolved Oxygen (DO)	mg/l	2.0 – 7.5	2.0 – 7.5	7.10	7.05	7.09
6	Turbidity	NTU	5	-	47.80	53.20	35.6
7	Alkalinity	mg/l	-	-	181.30	166.60	128.60
8	Total Hardness	mg/l	300*	-	29.40	9.80	18.90
9	Nitrite (NO2)	mg/l	3	-	0.10	ND< 0.10	ND< 0.10
10	Nitrate (NO3)	mg/l	50	-	10.64	0.71	0.69
11	Sulphate (SO4)	mg/l	-	-	3.16	1.10	ND< 0.10
12	Fluoride (F)	mg/l	-	-	0.18	0.17	0.22
13	Chloride (Cl)	mg/l	250	-	5.59	2.77	3.45
14	Ammonium (NH4)	mg/l	-	-	0.13	ND< 0.1	0.11
15	Sulphide (S)	mg/l	-	-	0.05	0.03	0.09
16	Color	mg Pt/l	5	-	100.00	100.00	80.00
17	Biochemical Oxygen Demand(BOD)	mg/l	1.0 – 10.0	1.0 – 10.0	1.16	1.06	1.16
18	Chemical Oxygen Demand (COD)	mg/l	-	1-8	2.17	2.17	2.85
19	Total Phosphorus (TP)	mg/l	-	0.005-0.05	0.12	0.11	0.18

No.	Parameter	Unit	Standards		(S1)	(S2)	(S3)
			MIME *	MoE**			
20	Cyanide (CN)	mg/l	0.07	-	ND< 0.04	ND< 0.04	ND< 0.04
21	Aluminium (Al)	mg/l	-	-	0.008	0.007	0.005
22	Arsenic (As)	mg/l	0.05	-	ND< 0.0001	ND< 0.0001	0.006
23	Cadmium (Cd)	mg/l	0.003	-	ND< 0.0002	ND< 0.0002	ND< 0.0002
24	Chromium (Cr)	mg/l	0.05	-	ND< 0.0005	0.0008	0.005
25	Copper (Cu)	mg/l	1	-	0.10	0.26	0.70
26	Iron (Fe)	mg/l	0.3	-	0.09	0.006	0.33
27	Lead (Pb)	mg/l	0.01	-	ND< 0.0002	ND< 0.0002	ND< 0.0002
28	Manganese (Mn)	mg/l	0.1	-	0.001	0.003	0.004
29	Mercury (Hg)	mg/l	0.001	-	0.0004	0.0003	0.0001
30	Selenium (Se)	mg/l	0.01	-	0.002	0.002	0.0005
31	Zinc (Zn)	mg/l	3	-	0.04	0.001	0.12
32	Total Coliform	MPN/100 ml	0	< 5000	$2.1x10^2$	$1.5x10^2$	$7.4x10^2$
33	E-Coli	MPN/100 ml	0	-	56	< 56	116

Note: ***** MIME DWQS – Ministry of Industry Mines and Energy, Drinking Water Quality Standard, January 2004
****** Water quality standard in public water areas for bio-diversity conservation (for River, Lack and Reservoir) in annex 4 of Sub-decree on Water Pollution and Control, April 06, 1999.
Result by JPST (July 2012)

The results of surface water quality testing showed that Total Coliform slightly exceeds the drinking standard while E-Coli is zero. This result is in relation to the natural phenomena as well as from the decay of animals, or manure washed out into the water body itself. Normally, surface water generally presents a higher concentration of indicator bacteria than groundwater. WHO recommended that for treated water or water in a distribution pipeline network it is likely that the number of microbial aspect per 100 ml shall be around zero. If count exceeds 50 colonies per 100 ml then the water supply is heavily contaminated and requires immediate remedial action.

Turbidity of the river during the study period (the rainy season) is quite high if compared to the Cambodian drinking water quality standard of 5 NTU. During the rainy season, turbidity is usually higher than normal and most of the turbidity in surface water come from erosion of materials such as: clay, silt, rock fragment, and colloid. Increased turbidity levels can cause a variety of problems for people, plants and animals. Water becomes no longer suitable for drinking.

c.5 Ecological Resources

c.5.1 Fish

There is no available document or resource which tells the aquatic life forms in the Project area while information of fishery is the only source of it. Based on the information obtained from local people, 40 fish species were found through family-scale fishing activities. They are as

shown in the following table.

Table 1.3-16 Fish Species caught by Local People in Sangke River

No.	Khmer Name	English Name	Scientific Name
1	Trey Slat	Giant featherback	Chitala lopis
2	Trey Chang Va	Barilius Nanensis	*Opsarius koratensis*
3	Trey Chang Va Phleang	Esomus Goddardi	*Esomus longimanus*
4	Trey Chang Va Moul	Pale Rasbora	*Rasbora aurotaenia*
5	Trey Chang Va Chhnot	Sidestripe rasbora	*Rasbora paviaiana*
6	Trey Chhpin Prak	Tawes	*Barbodes gonionotus*
7	Trey Chhpin Meas		*Hypsibarbus sp. Cf. vernayi*
8	Trey Chhpin		*Hypsibarbus lagleri*
9	Trey Chrakaing		*Scaphognathops stejnegeri*
10	Trey Angkat Prak	Swamp barb	*Systomus aurotaeniatus*
11	Trey Proloung	Mad barb	*Leptobarbus hoeveni*
12	Trey Ka'ek	Black sharkminnow	*Morulius chrysophekadion*
13	Trey Riel Tob	Siamese mud carp	*Henicorhynchus siamensis*
14	Trey Riel Ang Kam	Cirrhinus lineatus	*Henicorhynchus cruptopongon*
15	Trey Lenh		*Thynnichthys thynnoides*
16	Trey Damrey	Marbled sleeper	*Oxyeleotris marmorata*
17	Trey Kanh Chos Thma	Asian bumblebee catfish	*Mystus nemurus*
18	Trey Kanh Chos		*Mystus wolffii*
19	Trey Kanh Chos Chnaut		*Mystus atrifasciatus*
20	Trey Chhlang		*Mystus nemurus*
21	Trey Ta Aon		*Ompok hypophthalmus*
22	Trey Andeng Roeung	Walking catfish	*Clarias batrachus*
23	Trey Andeng Tun	Broad heat catfish	*Clarias macrocephalus(NT)*
24	Trey Russ Chek	*Striped horseface loach*	*Acantopsis sp. 2*
25	Trey Sandai		*Wallago attu(NT)*
26	Trey Klang Hay		*Belodontichthys dinema*
27	Trey Chhdor	Giant snakehead	*Channa micropeltes*
28	Trey Kranh		*Anabas testudineus*
29	Trey Kampot	Redeye puffer	*Carinotetraodon lorteti*
30	Trey Ptoung		*Xenentodon cancila*
31	Antuong	Swamp eel	*Monopterus albus*
32	Trey Kcheung	Zig-zag eel	*Mastacembelus armatus*
33	Trey Chhlonh	Peacock eel	*Macrognathus siamensis*
34	Trey Kantrob	Catopra	*Pristolepis fasciata*
35	Trey Kantrorng Preng	Duskyfin glassy perclet	*Parambassis wolffii*
36	Trey Kanhchanh Chras Tauch	Siamese glassfish	*Pseudambassis notatus*
37	Trey Kam Pleanh Plouk	Moon lisht gourami	*Trichogaster microlepis*
38	Trey Kam Pleanh Samrae	Threespot gourami	*Trichogaster trichopterus*
39	Trey Kanthor	Snakeskin gourami	*Trichogaster pectoralis*
40	Trey Phtuok/Ross	Chevron snakehead	*Channa striata*

Source: Obtained from local people, September 2012

VU (IUCN Category) : It is considered to be facing a high risk of extinction in the wild.

c.5.2 Forestry

Due to the nature of the water supply project which aims the expansion of water supply to the

residents, the project area designed mainly in build-up area and residential area. Therefore, the Project area consists mainly of build-up area and residential area with its connecting road network. Naturally, no primary forest, native bushes do not exist in the Project area.

c.5.3 Wildlife

As described in above section, primary forest, native bushes do not exist in the Project area. However, the local people still find some reptiles and amphibians and birds in the project area as listed bellow.

Table 1.3-17 Reptiles and Amphibians in the Project Area

No.	Local Name	English Name	Science name
1	Kangkeb	Frog	Hoplobatrachus tigerinus
2	Bangkuoy Thamda		
3	Kanchanchek		
4	Kingkouk		
5	Bangkuoy Slab		
6	Bangkuoy Snaeng		
7	Thlain		
8	Kantrong		
9	Puos Thlan	Burmese Python	Python molurus bivittatus (VU)
10	Puos Prey	Common Rat Snake	Ptyas mucosus
11	Puos Vek (krabei)	Monocle Cobra	Naja kaouthia
12	Puos Vek (Sra nge)	Indochinese Spitting Cobra	Naja siamensis (VU)
13	Puos Khiev		

Source: Local people, September 2012

VU (IUCN Category) : It is considered to be facing a high risk of extinction in the wild.

Table 1.3-18 Bird Species in the Project Area

No.	Local Name	English Name	Scientific Name
1	Bro Vek	Lesser Whistling Duck	*Dendrocygna javanica*
2	Chab Don Ta	Oriental Reed Warbler	*Acrocephalus orientalis*
3	Chab Srok	Plain backed Sparrow	*Passer flaveolus*
4	Chab Pouk Troung Loeung	Asian Golden Weaver	*Ploceus hypoxanthus (NT)*
5	Chab Pouk Troung Thnoat	Streaked Weaver	*Ploceus manyar*
6	Chab Pouk Troung Thnoat Liet	Baya Weaver	*Ploceus philippinus*
7	Chab Teit	Common Tailorbird	*Orthotomus sutorius*
8	Khlaeng Srak	Barn Owl	*Tyto alba*
9	Khlom	Watercock	*Gallicrex cinerea*
10	Kok Sor	Little egret	*Egretta garzetta*
11	Kroling Kroloung	Black collared starling	*Sturnus nigricollis*
12	Kruoch Eut	Barred Buttonquail	*Turnix suscitator*
13	Lo Lok Bai	Spotted Dove	*Streptopelia tranquebarica*
14	Lo Lok Bai Thnoat	Oriental Turtle Dove	*Streptopelia orientalis*
15	Lo Lok Khmoach	Emerald Dove	*Chalcophaps indica*
16	Lo Lok Traing	Red Collared Dove	*Streptopelia tranquebarica*
17	Miem	Brown Hawk Owl	*Ninox scutulata*
18	Moin Teuk	White-breasted Waterhen	*Amaurormis phoenicurus*

No.	Local Name	English Name	Scientific Name
19	Po Pich Kbal Khmao	Black-headed Bulbul	Pycnonotus atriceps
20	Po Pich Kbal Khmao Knong Sar	Sooty-headed Bulbul	Pycnonotus aurigaster
21	Po Pich Khmao	Black Drongo	Hypsipetes leucocephalus
22	Po Pich Puk Moit Loeung	Stripe-throated Bulbul	Pycnonotus finlaysoni
23	Po Pich Trachiek Chhnot	Streak-eared Bulbul	Pycnonotus blanfordi
24	Po Pich Trachiek Krahorm-Sar	Red-whiskered Bulbul	Pycnonotus jocosus
25	Ro Neal Sor	Milky Stork	*Mycteria cinerea (VU)*
26	Ro Neal Por	Painted Stork	*Mycteria leucocephala (NT)*
27	Sarika Keo	Common Myna	*Acridotheres tristis*
28	Sarika Keo Kbal Loeung	Golden-crested Myna	*Ampeliceps coronatus*
29	Sarika Keo Krabei	White-vented Myna	*Acridotheres cinereus*
30	Sarika Keo Vorng	Hill Myna	*Gracula religiosa*

Source: Obtained from local people by hearing, September 2012

VU (IUCN Category) : It is considered to be facing a high risk of extinction in the wild.

NT (IUCN Category) : It is close to qualifying for or is likely to qualify for a threatened category in the near future.

c.5.4 Protected Areas

Protected conservation areas cover approximately 5.4 million hectares in Cambodia's territory. They consist of 7 national parks, 9 wildlife sanctuaries, 3 protected landscape areas, and 3 protected areas. The national parks are located in the coastal, mountain, plateau and lake regions covering 742,300 million hectares and 4.138 million hectares for wildlife sanctuaries. The protected landscape areas cover 97,000 hectares including archaeological and cultural sites, and protected areas cover 403,900 hectares. However, there is no protected area in the proposed project location.

c.6 Economic Development

c.6.1 Industry

There are more economic activities, including transportation service. Between 2008 and 2011 there were many new business registrations in the Battambang province: 54 large and medium companies and 364 small businesses. Currently, the province is home to 340 rice mills. A large processing factory is under construction. The factory will process and package rice, maize, beans and other agricultural products and be expected to have a capacity of up to 30 tons per hour. The province also has suppliers of animal feed, agricultural machinery and fertilizer, brick manufacturers, furniture makers and other small industrial operations. The detailed statistics is shown in the following table.

Table 1.3-19 Type and Number of Enterprises in Battambang Province

Activity	Number of Enterprises
Rice milling	340
Brick manufacturing	39
Handicrafts	88
Construction	20
Noodle manufacturing	13
Drinking water	13

Activity	Number of Enterprises
Winery	1
Ice making	22
Fish production	3
Other food processing	15
Restaurants/Food stalls	1,708
Repair shops	632
Professional services (including health)	113
Cotton processing	1
Animal feed	1
Other services	412
Wood processing	5
Ceramic hardware	7
Furniture manufacturing	17
Other manufacturing	74
Construction materials	38
Wholesale	17
Grocery retail	972
Other retail	1,805
Greenhouse/ horticulture	57
Animal husbandry	26

Source: PDIME as of 2011

c.6.2 Infrastructure Facilities

c.6.2.(1) Water Supply

As described in the previous chapter, Battambang City has only 26% safe water access rates at present because of insufficient production capacity of existing facilities and low intake volume in the dry season. The water supply system at present is mostly located along the main roads and in urban areas. Besides this, people within the project area also use open wells or direct intake from Sangkae river for their daily water consumption (Source: Communes' profile in the project area as of December 2011).

c.6.2.(2) Electricity

Access to electricity in the project area is found to be good in terms of service and cost. About 90%, 97% and 84% of the households in the Voat Kor, Svay Poa, and Chamkar Samroang communes have electricity supply, respectively. As gathered from key informants in the project area, the cost of electricity is 1,000 KHR or US$ 0.25 per KWh.

c.6.2.(3) Waste Management

Several waste types are generated from sources such as human activities, commercial businesses and others. In the city, there is a private waste collection company, CINTRI, which is responsible for the disposal, collection, storage and transportation of waste. As reported by the Provincial Department of Environment in August 2012, the company has not covered the whole city especially the poor communities where trucks could not access.

c.6.2.(4) Transportation

Battambang city locates north-west of Phnom Penh and the distance from the capital city is about 300km. The two cites are connected with national road 5 which leads to Thailand. Currently no periodical flight is scheduled. In Battambang city, build-up area is nestled along Sangke river, therefore the road network in the city is developed in a reticular pattern along with Sangke river. Traffic volume is growing rapidly. Buses and cars are widely used as public transportation from the city to other provinces while motorbikes and bicycles are the common transportation means for local people.

c.6.3 Tourism

Battambang is the main hub of the Northwest connecting the entire region with Phnom Penh and Thailand and as such it is a vital link for Cambodia. It is a peaceful and pleasant place. The main parts of the city are situated close to the Sangke River, a tranquil, small body of water that winds its way through Battambang Province. So many attractive places can be seen in the province such as Barseat Temple, Wat Ek Temple, Ba Nan Temple, Prasat Snung, Phnom Sam Pov Resort, Boeng Kam Pinh Puoy Resort, and Sek Sak Resort.

Table 1.3-20 Tourist Arrivals in Battambang Province

Types of Tourist	First Trimester of 2011 (persons)	First Trimester of 2012 (persons)
Local Tourists	60,940	88,178
International Tourists	13,400	19,334
Total	74,340	107,512

Source: Provincial Department of Tourism, Battambang, 2012

c.6.4 Land Use

Due to the characteristics of water supply project, the Project area mostly consists of residential and build-up area connected with main road network. Therefore, the land use of the project area consists of residential area, build-up area and road network along with street trees. Residential areas and commercial facilities are intermingled in the city. There are many shops, restaurants, guesthouses, and hotels in the project area.

c.7 Social and Cultural Resources

c.7.1 Population

The intake site up to the new WTP consists of three communes; namely, Voat Kor, Svay Poa, and Chamkar Samroang (hereinafter called, “the project area”). According to the communes’ profile in 2011, the population of the three communes is 54,365, of which 27,280 or 50.2% are women. It has been reported that population has increased because of economic activities in the city. Almost 100% of the population is Buddhist. Many pagodas are found in and around the project area.

c.7.2 Health Facilities

Basically, the health care system in the project area is composed of three commune health centers: Voat Kor, Svay Poa, and Chamkar Samroang. Poor households normally go to these centers for treatment, mostly free of charge. A provincial hospital, an operational district health center, and a referral health center are also located in Battambang City very close to the project area. The common diseases found in the project area are diarrhea, dysentery, eye diseases, and skin infections. The annual number of patients in 2011 is as shown in the table below. Patients with serious cases are sent to the provincial hospital directly. For medium-class households, they usually go to private clinics for treatment due to good services and medical supply.

Table 1.3-21 Waterborne Diseases recorded in 2011

Disease	Annual Number of Patients in 2011		
	Voat Kor	Svay Poa	Chamkar Samroang
Diarrhea	489	931	459
Dysentery	122	43	74
Malaria	2	0	28
Eye diseases	773	194	287
Skin infections	123	152	78

Based on the communes' profile, 81%, 95% and 89% in Voat Kor, Svay Poa, and Chamkar Samroang communes have access to sanitary latrines, respectively. High percentage of latrines in a commune indicates better living standards and knowledge about health care in that commune.

c.7.3 Educational Facilities

Battambang City is well known as the most attractive destination for education after Phnom Penh City. This is due to the fact that the city has plenty of public and private school institutions. The number of educational institutions as of 2011 is as shown in the following table. School enrolment rates are the highest among the provinces in Cambodia. Over 265,000 students attended 551 primary schools and 104 secondary and high schools in 2011.

Table 1.3-22 Statistical Data on Educational Institutions in Battambang Province

Educational Institution	Number
Kindergartens	134
Primary schools	551
Secondary schools	83
High schools	21
Private schools	38
Universities	9
Teacher training colleges	2
Language training colleges	2
Vocational training institutes	3

Source: Provincial Department of Education, Battambang, 2011

In the project area, there are 9 primary schools, 5 secondary schools and 2 high schools as shown in the following table. In Voat Kor Commune (nearby the intake site), on the average, the distance from the middle of villages to primary schools, secondary schools and high schools is 0.25, 2.25, and 5.08 km, respectively. In Svay Poa Commune (in between the intake site and the WTP site), on the average basis, the distance from the middle of villages to primary schools, secondary schools and high schools is 0.25, 0.25, and 0.5 km, respectively. In Chamkar Samroang Commune (nearby the WTP site), on the average, the distance from the middle of villages to primary schools, secondary schools and high schools is 0.3, 1.4 and 1.2 km, respectively (Source: Communes' profile in the project area as of December 2011).

Table 1.3-23 Number of Schools in the Project Area as of 2011

Commune	School Type		
	Primary School	Secondary School	High School
Voat Kor	5	1	0
Svay Poa	2	3	2
Chamkar Samroang	2	1	0
Total	9	5	2

c.7.4 Physical and Cultural Heritage

According to the field observation, there is no physical and cultural heritage existing within the project implementation area. On the other hand, there are several Pagodas locate along with roads in which pipe network will be embedded. Therefore, certain cautions during construction operation are required.

(3) Laws and Regulations related to Environmental Consideration.

a. Laws and Regulations related to Environmental Consideration

Laws and Regulations related to Environmental Consideration are described as follows.

1) Constitution (1993)

Article 59 of constitution stipulates that the State shall protect the environment and balance of abundant natural resources and establish a precise plan of management of land, water, air, wind, geology, ecological system, mines, energy, petrol and gas, rocks and sand, gems, forests and forestry products, wildlife, fish and aquatic resources.

2) Law on environmental Protection and Natural Resource Management (1996)

The law stipulates that the State shall protect the environment and balance of abundant natural resources and establish a precise plan of management of land, water, air, wind, geology, ecological system, mines, energy, petrol and gas, rocks and sand, gems, forests and forestry products, wildlife, fish and aquatic resources.

3) Sub-Decree on Environmental Impact Assessment Process (1999)

The sub-decree stipulates EIA system, its processes and target sectors.

4) Sub-Decree on Water Pollution Control (1999)

The sub-decree stipulates criteria of water quality and control method for preventing water pollution.

5) Sub-Decree on Solid Waste Management (1999)
The sub-decree stipulates the scope and proper management method of solid waste.

6) Royal Decree on Creation and Designation of Protected Areas (1993)
The decree stipulates the scope, role and the management method for the projected area.

7) Sub-Decree on Air Pollution Control and Noise Disturbance (2000)
The sub-decree stipulates criteria of air quality, noise & vibration and control method for preventing air pollution.

8) Law on Water Resource Management (2004)
The law stipulates the roles and the responsible organization of water resource management. Article 22 of the law stipulates the regulation on discharge to public water.

b. Necessary Assessment for the Project in Cambodia

EIA Process for the Project is described in above mentioned Sub-Decree on Environmental Impact Assessment Process. According to the Sub-Decree, Water supply project which covers more than 10,000 people shall conduct IEIA: Initial Environmental Impact Assessment or EIA: Environmental Impact Assessment. IEIA is compatible to IEE: Initial Environmental Examination in JICA Guideline. According to MOE, IEIA shall be conducted for the Project.

c. EIA/IEIA Procedures

According to the article 7 of Sub-decree of Environmental Impact Assessment, the Project owner, MIME/KWW/BWW shall prepare IEIA and submit to MOE. If the expected impacts are serious toward ecosystem or human health, the Project owner shall prepare EIA report and submit to MOE as stipulated by article 8.

The process differs according to the ownership and condition of the Project. The Project is owned by MIME, KWW and BWW, therefore, it is categorized in Ministry ownership. The process of the case is described in the following figure.

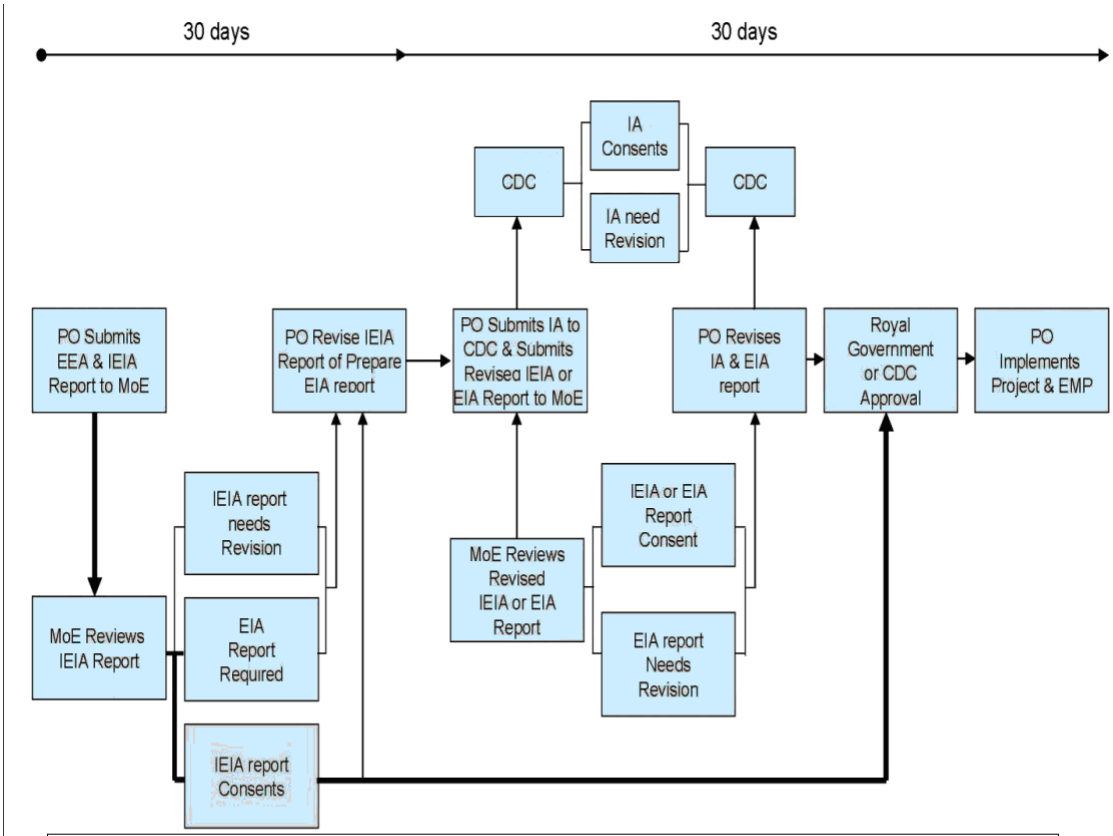


Figure 1.3-9 Flow of EIA/IEIA Process

d. Comparison of Cambodian Laws and Regulations with the JICA Guidelines

Environmental impact assessment process in Cambodia is basically similar to that of JICA guideline while the importance on "Accident", "Global warming", "Employment" and other social considerations are not much shown in Cambodian laws and regulations. Especially, detailed procedures of land acquisition and resettlement have not been defined yet. Especially, Cambodian laws and regulations do not put emphasis on reconstruction of livelihood as previous level or more.

The result of the comparison between Cambodian laws and regulations with the JICA guidelines is described in the following table.

Table 1.3-24 Comparison of Cambodian Laws and Regulation with the JICA Guidelines

No.	JICA Guidelines	Laws & Regulations in Cambodia	Differences	Policy in the Project
1.	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. (JICA GL)	**Constitution (1993)** **Article 44** Legal private ownership shall be protected by the law. The right to confiscate possessions from any person shall be exercised **only in the public interest** as provided for under law and shall require **fair and just compensation in advance**. **Land Law (2001)** **Article 4** The right of ownership, recognized by Article 44 of the 1993 Constitution, applies to all immovable properties within the Kingdom of Cambodia in accordance with the conditions set forth by this law. **Article 5** No person may be deprived of his ownership, **unless it is in the public interest.** An ownership deprivation shall be carried out in accordance with the forms and procedures provided by law and regulations and after the payment of **fair and just compensation in advance**.	Cambodian laws /regulations do not stipulate avoidance of resettlement and loss of means of livelihood while the JICA guidelines stipulate them.	JICA guideline is applied for this section.
2.	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken. (JICA GL)	**Constitution (1993)** **Article 44** **(as described in 1)** **Land Law (2001)** **Article 5** **(as described in 1)**	There is no line in Cambodian laws /regulations which stipulate minimization of resettlement and loss of means of livelihood while JICA guideline stipulates them.	JICA guideline is applied for this section.
3.	People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels. (JICA GL)	**Constitution (1993)** **Article 44** (Refer to 1) **Land Law (2001)** **Article 5** (Refer to 1) **Expropriation Law (2009)** **Article 4** Expropriation refers to confiscation of ownership of, **with fair and just compensation in advance**, immovable property or the real right to immovable property of a physical person or legal entity or legal public entity, which includes land, buildings, and cultivated plants, and for construction, for rehabilitation or for expansion of public physical infrastructure which is in the national and public interests. **Article 22** Financial compensation given to the property owner and/or rightful owner shall be based on a **market price or replacement price** on	Both Cambodian Laws / Regulations and JICA guideline stipulate compensation while no explicit scope for the compensation is given in Cambodian laws /regulations. Also, as described in Section 2, the JICA guidelines the stipulate compensation for loss of means of livelihood while Cambodian laws/regulations stipulate compensation for the property of owner or rightful owner only. In addition to above, the JICA guidelines stipulate the objective of the compensation is that resettled residents can	JICA guideline is applied for this section.

No.	JICA Guidelines	Laws & Regulations in Cambodia	Differences	Policy in the Project
		the date of declaration of the expropriation. The market price or the replacement price shall be determined by an independent committee or agent selected by the Expropriation Committee.	improve or restore their standard of living.	
4.	Compensation must be based on the full replacement cost as much as possible. (JICA GL)	**Expropriation Law (2009)** **Article 22** **(as described in 3)** **Article 23** The owner and/or the rightful owner has the right to compensation for **actual damages** commencing from the last date of declaration of expropriation for which they are entitled to fair and just compensation.	Compensation stipulated by the JICA guidelines include essential costs for recovering livelihood as pre-project conditions while that of the Cambodian laws/regulations is stipulated as "actual damage" without detailed information.	JICA guideline is applied for this section.
5.	Compensation and other kinds of assistance must be provided prior to displacement. (JICA GL)	**Constitution (1993)** **Article 44** **(as described in 1)** **Land Law (2001)** **Article 5** **(as described in 1)** **Expropriation Law (2009)** **Article 19** The expropriation of ownership of immovable property and real right to immovable property can be exercised only if the Expropriation Committee has paid fair and just compensation to the property's owner and/or rightful owner **in advance**, in accordance with the compensation procedures and principles set out in Section 3 of Chapter 4 of this law.	Both the Cambodian laws/regulations and JICA guidelines stipulate that compensation must be provided prior to displacement while the Cambodian laws/regulations do not stipulate "other kinds of assistance".	JICA guideline is applied for this section.
6.	For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. (JICA GL)	No matching regulation or Laws exists.	Cambodian laws/regulations do not stipulate RAP preparation.	JICA guideline is applied for this section.
7.	In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. (JICA GL)	**Expropriation Law (2009)** **Article 16** In conducting this survey, the Expropriation Committee shall **arrange** a **public consultation** with the authorities at provincial, district and commune level, the commune councils and village representatives or the communities or persons affected by the expropriation in order to **give them clear and specific information** and to have all opinions from all concerned parties about the propose for public physical infrastructure	Both stipulate holding public consultation with sufficient information while Cambodian laws /regulations do not stipulate RAP preparation.	Cambodian law/regulation is applied for this section while the languages and the methods during conduction follows the JICA guideline as described in 8.

No.	JICA Guidelines	Laws & Regulations in Cambodia	Differences	Policy in the Project
		project.		
8.	When consultations are held, explanations must be given in a form, manner and language understandable to the affected people. (JICA GL)	**Expropriation Law (2009)** **Article 16** (Refer to 7) *Note: No description exists for manner and language.*	Both stipulate holding public consultation while JICA guideline specifies more detailed manners, especially, accessibility for conducting the consultation.	JICA guideline is applied for this section.
9.	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans. (JICA GL)	**Expropriation Law (2009)** **Article 16** In conducting this survey, the Expropriation Committee shall **arrange** a **public consultation** with the **authorities** at provincial, district and commune level, the commune councils and village **representatives** or the **communities affected** by the expropriation. **Sub-Decree on Environmental Impact Assessment Process (1999)** **Article 1** **Encourage public participation** in the implementation of EIA process and take into account of their conceptual input and suggestion for re-consideration **prior to the implementation** of any project.	Expropriation law stipulates participation of the affected people in public consultation while JICA guideline promotes participation of the affected people in all stages of the project.	JICA guideline is applied for this section.
10.	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities. (JICA GL)	**Expropriation Law (2009)** **Article 14** A Complaint Resolution Committee shall be established and led by representatives of Ministry of Land Management, Urban Planning and Construction, and representatives of other concerned ministries/institutions shall be involved. The organization and functioning of the Complaint Resolution Committee shall be determined by a separate sub-decree.	Both stipulate establishment of grievance mechanisms. Expropriation law is short on applicability for affected people while JICA guideline specifies more detailed manners, especially, accessibility for conducting the consultation.	JICA guideline is applied for this section.
11.	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers	**Expropriation Law (2009)** **Article 16** Before proposing an expropriation project, the Expropriation Committee shall **publicly conduc**t a survey by **recording a detailed description of all rights of the owners and/or rightful owners** to the immovable property and other properties which might be needed for compensation; all other related problems shall be recorded as well.	Both stipulate conduction of precise survey. Expropriation focuses on the rightful property and its owner while JICA guideline following OP4.12 includes affected person who have formal legal rights to land and also affected person who don't have formal legal rights.	JICA guideline following WB4.12 will be applied for this section.

No.	JICA Guidelines	Laws & Regulations in Cambodia	Differences	Policy in the Project
	of others who wish to take advance of such benefits. (WB OP4.12 Para.6)			
12.	Eligibility of benefits includes, the Project Affected Person: PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying. (WB OP4.12 Para.15)	**Expropriation Law (2009)** **Article 16** **Owner of immovable property and/or rightful owner** refers to a physical person, private legal person, or public legal entity including a proprietor, possessor and all persons who have rights to land and are affected by the expropriation project. **Article 18** The following are null and void and cannot be made legal in any form whatsoever: - any **entering into possession of public properties** of the State and public legal entities and any **transformation of possession of** private **properties of the State** into ownership rights that was not made pursuant to the legal formalities and procedures that had been stipulated prior to that time, irrespective of the date of the creation of possession or transformation; - any **transformation of a land concession**, into a right of ownership, regardless of whether the transformation existed **before this law came into effect**, except concessions that are in response to social purposes; - any **land concession** which **fails to comply with the provisions** of Chapter 5; - any **entering into possession of properties** in the private property of the State, through any means, that occurs after this law comes into effect.	Expropriation law stipulates "owner of immovable property and rightful owner" as eligible person for compensation while JICA guideline includes PAPs who don't have formal legal rights to land as eligible person.	JICA guideline following WB4.12 will be applied for this section.
13.	Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based. (WB OP4.12 Para.11)	No matching regulation or law exists.	Cambodian laws /regulations do not stipulate any provision of preference to land-based resettlement strategies.	JICA guideline following WB4.12 will be applied for this section.
14.	Provide support for the transition period (between displacement and livelihood restoration). (WB OP4.12 Para.6)	No matching regulation or law exists.	Cambodian laws /regulations do not stipulate provision of support for the transition period.	JICA guideline following WB4.12 will be applied for this section.
15.	Particular attention must be paid to the needs of the	No matching regulation or law exists.	Cambodian laws /regulations do not stipulate particular	JICA guideline following WB4.12 will be

No.	JICA Guidelines	Laws & Regulations in Cambodia	Differences	Policy in the Project
	vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc. (WB OP4.12 Para.8)		assistance, care or attention toward vulnerable group.	applied for this section.
16.	For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared. (WB OP4.12 Para.25)	No matching regulation or laws exists.	Cambodian Laws /Regulations do not stipulate preparation of RAP nor ARAP.	JICA guideline following WB4.12 will be applied for this section. JICA guideline following WB4.12 will be applied for this section.

PAP: Project Affected Person/ People

(4) Comparison of Alternative Plans

The Project consists of various components as described in previous section. Thus comparison examination of the components was conducted as follows.

a. The Alternative Plans for the Project in Kampong Cham

Table 1.3-25 Comparison of Intake Points in Mekong River, Kampong Cham

Items		Downstream Point	Mid Point-1 **(Proposed Project)**	Mid Point-2	Upstream Point
Outline		Located 0.73km upstream from Kizuna Bridge on Mekong River. 1.16km conveyance pipe is required.	Located 0.96km upstream from Kizuna Bridge on Mekong River. 0.91km conveyance pipe is required.	Located 1.1km upstream from Kizuna Bridge on Mekong River. 1.15km conveyance pipe is required.	Located 1.7km upstream from Kizuna Bridge on Mekong River. 0.92km conveyance pipe is required.
Technical & Economical Aspects	Advantages	Enough depth can be secured during dry season for taking water. No possibility of inflow of sewage water in the site.	Enough space can be secured for intake facility. Enough depth can be secured during dry season for taking water. No possibility of inflow of sewage water in the site. Relatively short distance for conveyance pipe is required.	Enough space can be secured for intake facility. Enough depth can be secured during dry season for taking water. No possibility of inflow of sewage water in the site.	Enough depth can be secured during dry season for taking water. No possibility of inflow of sewage water in the site.
	Disadvantages	Considering the flow rate and topographic features at the site, countermeasures for bank erosion are required and thus, construction and maintenance cost will be higher.		Considering the flow rate during rainy season, a relatively robust structure is required for avoiding damage to intake facility.	Considering the flow rate and topographic features at the site, countermeasures for bank erosion are required and thus, construction and maintenance cost will be higher.
Environmental & Social Aspects	Advantages		No resettlement is required.	No resettlement is required.	
	Disadvantages	There are several households living on the water around the candidate site and those will be required to be resettled if this plan is implemented.			There are several households living on the water around the candidate site and those will be required to be resettled if this plan is implemented.
Judgment and Verification		Not recommended due to the requirement of resettlement as well as less intensity of river bank as foundation of the facility.	Recommended due to no requirement of resettlement and the intensity of river bank as foundation of intake facility.	Not recommended due to the less intensity of river bank as foundation of the facility.	Not recommended due to the requirement of resettlement as well as less intensity of river bank as foundation of the facility.

Table 1.3-26 Comparison of Intake Facilities in Kampong Cham

Items		Vertical Shaft type with Mixed Flow Pump	Inclined Intake Pipe with Submerged Pump System
Outline		Adsorption tank is embedded under the embankment. Adsorption tank and the river channel are connected by intake pipe. Vertical pump is installed in the adsorption tank for uplifting and transmitting the water.	Intake pump is installed beneath water level for uplifting and transmitting the water, and intake pipe is installed along with embankment.
Technical & Economical Aspects	Advantages	There are good track records of implementation of vertical shaft type mixed flow pump in Cambodia. Thus, Cambodia engineers have many operational experiences.	Relatively smaller construction cost is required.
	Disadvantages	Hard rock drilling which is relatively difficult and high cost operation is required. Also, larger noise and vibration is expected due to the above condition. Consolidation of sediment is required.	There is little track record of implementation of this type in Cambodia, especially, for drinking purposes. Only one track record exists in Thailand for the drinking purpose. Due to the structural constraints, the excavation of sediment by pump is difficult. Sediment increases the occurrence of malfunction of the system. Considering the weight of the structure and the current velocity of Mekong River, ensuring stability of the structure is technically difficult. Shifting of height of pump according to the water level cannot be applied due to the technical difficulty.
Environmental & Social Aspects	Advantages	Noise and vibration during the implementation period is planned to be minimized by the construction of facility building.	The excavation and drilling amount is relatively smaller and thus, smaller adverse impacts on local environment are expected. Due to the submerged position of the pump, smaller noise and vibration are expected.
	Disadvantages	During the construction period, relatively high levels of noise and vibration are expected due to drilling of hard rocks and sheet-pile driving. During the operation period, noise and vibration are expected due to the position of the intake pump. (Planned to be minimized as described above)	During the construction period, relatively high level of noise and vibration are expected by drilling of hard rocks and sheet-pile driving.
Judgment and Verification		**Recommended:** Due to the good track record of implementation of this type while the scale of the expected adverse effects is not much different.	Not Recommended: Due to lack of good track record of implementation of this type, difficulties of operation by Cambodian engineers are more than likely while the scale of expected adverse impacts is not much different.

Table 1.3-27 Comparison of Methods for Water Distribution in Kampong Cham

Item		Zero Option	By Elevated Water Tank	**By Transmission Pump (Proposed Project)**
Outline		—	Setting Elevated Water Tank near Phnom Pros Temple for transmitting treated water to supply area.	Setting transmission pump close to the existing treatment facility site for transmitting treated water to supply area.
Technical & Economical Aspects	Advantages	—	24-hour operation is not required. (Easier handling and cheaper operation cost for KWW)	The construction cost will be cheaper.
	Disadvantages	—	Large size of elevated water tank is required and vast ground is essential. In addition to above, longer distance and larger gauge of transmission pipe is required considering the position of candidate site. Therefore, total construction cost becomes much larger.	24-hour operation is required. Therefore, operation cost will be relatively higher.
Environmental & Social Aspects	Advantages	No adverse effect is expected due to zero implementation of any activity.		Extra site for the facility is not require; therefore, less chance to have any environmental and social consideration matters.
	Disadvantages	No expansion of water supply area can be realized and thus, non-supply area for clean water still remains.	Adjacent land of Phnom Pros Temple.	
Judgment and Verification		Not Recommended Non-water-supply area will be kept as pre-project term. Therefore, no improvement of the service is expected.	Not recommended because of the fact that more environmental and social consideration related matters will be required while range of electricity-saving is rather small.	**Recommended** because less environmental and social consideration related matters are required and less construction cost is required.

b. Alternative Plans for the Project in Battambang

Table 1.3-28 Comparison of Intake Points in Sangke River, Battambang

Item		Downstream Point	Mid Point-1	Mid Point-2	**Upstream Point (Proposed Project)**
Outline		Located 2.6km downstream from existing intake site on Sangke River. 0.2km conveyance pipe is required.	Located 0.58km downstream from existing intake site on Sangke River. 2.1km conveyance pipe is required.	Located 1km upstream from existing intake site on Sangke River. 3.7km conveyance pipe is required.	Located 1.7km upstream from existing intake site on Sangke River. 4.4km conveyance pipe is required.
Technical & Economical Aspects	Advantages		No possibility of inflow of sewage water in the site.	No possibility of inflow of sewage water in the site. Enough depth can be secured during dry season for taking water.	No possibility of inflow of sewage water in the site. Enough depth can be secured during dry season for taking water. Enough space can be secured for intake facility.
	Disadvantages	There is possibility of deterioration of water quality by the inflow of sewage. Not enough depth can be secured during dry season for taking water. Raising water level by weir for taking water during dry season cannot be applied due to the height of the water level during wet season and also the necessity of securing ship traffic during dry season.			Longer conveyance distance is required and thus higher cost for construction is required.
Environmental & Social Aspects	Advantages		No resettlement is required.		No resettlement is required.
	Disadvantages	Resettlement is required.		Resettlement is required. There are several houses around the site and also there is a crowded market near the site. Thus, there is technical difficulty for construction works as well as maintenance works for the facility	
Judgment and Verification		Not recommended due to the requirement of resettlement as well as lack of depth for water taking during dry season.	Not recommended due to lack of depth for water taking during dry season.	Not recommended due to the requirement of resettlement as well as requirement of additional care for both construction and maintenance works.	**Recommended** due to no requirement of resettlement and little possibility of deterioration of water quality although relatively longer conveyance pipe required.

Table 1.3-29 Comparison of Intake Facility in Battambang

Items		Vertical Shaft Type with Mixed Flow Pump	Inclined Intake Pipe with Submerged Pump System
Outline		Adsorption tank is embedded under the embankment. Adsorption tank and the river channel are connected by intake pipe. Vertical pump is installed in the adsorption tank for uplifting and transmitting the water.	Intake pump is installed beneath water level for uplifting and transmitting the water and intake pipe is installed along with embankment.
Technical & Economical Aspects	Advantages	There are good track records of implementation of vertical shaft type mixed flow pump in Cambodia. Thus, Cambodian engineers have many operational experiences.	Relatively smaller cost for the construction is required.
	Disadvantages	Relatively larger cost for the construction is required. Periodical excavation of sediment is required.	There is little track record of implementation of this type in Cambodia, especially for drinking purposes. Only one track record exists in Thailand for the drinking purpose. Due to the structural constraints, excavation of sediment of the pump is hard to conduct. This increases the occurrence of malfunction of the system. Considering the weight of the structure and the current velocity of Mekong River, ensuring the stability of the structure is technically difficult. Shifting of height of pump according to the water level cannot be applied due to the technical difficulty.
Environmental & Social Aspects	Advantages	The noise and vibration during the implementation period is planned to be minimized by the construction of facility building.	The excavation and drilling amount is relatively smaller and thus, smaller adverse effects on local environment are expected. Due to the submerged position of the pump, smaller noise and vibration are expected.
	Disadvantages	During operation period, noise and vibration are expected due to the position of the intake pump. (Planned to be minimized as described above.)	
Judgment and Verification		**Recommended** Due to the good track record of implementation of this type while the scale of the expected adverse effects is not much different.	Not Recommended Due to lack of good track record of implementation of this type, difficulties of operation by Cambodia engineers are more than likely while the scale of the expected adverse effects are not much different.

Table 1.3-30 Comparison of Water Treatment Facilities in Battambang

Item		Zero Option	Utilizing Whole Site	Utilizing Part of the Site (Proposed Project)
Outline		—	Allocate water treatment and related facilities throughout the former Pepsi-Cola factory site.	Allocate water treatment and related facilities to part of the former Peps-Cola factory site avoiding occupied residential area.
Technical & Economical Aspects	Advantages	—	Enough space can be secured for allocating all facilities as well as future facility expansion.	Schedule of the construction can be fixed without considering necessary process and terms for resettlement.
	Disadvantages	—	Longer term for resettlement procedures is required and thus the schedule will be restricted by the progress of the resettlement procedures.	There could be certain restriction on the space for maintenance works. In addition to above, the restriction could restrict the design of facilities. Little space for future expansion can be secured.
Environmental & Social Aspects	Advantages	No adverse effect is expected due to zero implementation of any activity.		No resettlement is required.
	Disadvantages	No expansion of water supply area can be realized and thus, non-supply area for clean water still remains.	Involuntary resettlement of more than 10 households will be required.	
Judgment and Verification		Not Recommended Non-water-supply area will be kept as pre-project term. Therefore, no improvement of service is expected.	Not Recommended Enough space can be secured for the facilities while resettlement cannot be avoided by this option. Therefore, longer terms of preparation and construction phases are expected.	**Recommended** This option can minimize the effects of resettlement while other restrictions can be avoided by designing efforts.

Table 1.3-31 Comparison of Methods for Water Distribution in Battambang

Item		Zero Option	Separate Water Distribution System for Each Treatment Plant (**Proposed Project**)	Integrated Water Distribution System
Outline		—	Distribution area will be separated and water is distributed by each treatment plant.	No separation of water distribution area will be made and water is transmitted in a single way.
Technical & Economical Aspects	Advantages	—	Easer control of distribution amount as well as pressure can be achieved due to multiple distribution systems. Leakage or any trouble can be limited within a distribution area; therefore, easy to isolate the cause of accident which leads to easier management.	Easy for securing water pressure due to the multiple distributions of water from each treatment plant to one supply area.
	Disadvantages	—	Architecture of the pipe network becomes complex and thus, the construction cost will be relatively expensive.	There is certain difficulty for controlling and managing the distribution amount and pressure of water by this option.
Environmental & Social Aspects	Advantages	No adverse effect is expected due to zero implementation of any activity.		
	Disadvantages	No expansion of water supply area can be realized and thus, non-supply area for clean water still remains.	Construction for embedding pipes may cause adverse effect on both environmental and social matters.	Construction for embedding pipes may cause adverse effect on both environmental and social matters.
Judgment and Verification		Not Recommended Non-water-supply area will be kept as pre-project term. Therefore, no improvement of the service is expected.	**Recommended** Easer control of distribution amount as well as pressure can be achieved; therefore, easy to isolate the cause of accident which leads to easier management.	Not Recommended Not recommended due to the certain difficulty for controlling and managing the distribution amount and pressure of water by this option.

(5) Scoping

During the second field survey, MIME requested JPST to minimize the scale of resettlement as much as possible. JPST review the proposed plan and selected alternative plan in which no resettlement required. The results of scoping for the selected alternative plan are summarized in the following table.

Table 1.3-32 (a) Scoping（Kampong Cham）

Category	No.	Impacts	Evaluation		Reasons
			Pre-/ At-work	In-use	
Pollution	1	Air Pollution	B-	D	**At-work:** Operation of construction equipment may cause air pollution with the emission of exhaust gas or dust. **In-use:** None of the project components may cause air pollution.
	2	Water Pollution	B-	B-	**At-work:** Drainages from the construction sites, equipment and camps are anticipated to be potential sources of water pollution. **In-use:** Discharging water from water treatment facility may cause water pollution.
	3	Waste	B-	B-	**At-work**: Wastes from the construction work like concrete debris and general waste from workers and camps are expected. **In-use:** Wastes (sand or any deposit) from treatment facility are expected.
	4	Soil Contamination	B-	D	**At-work**: Oil leakage from construction equipment in use may cause soil contamination. **In-use**: No project component may cause soil contamination during its operation.
	5	Noise and Vibration	B-	C	**At-work**: Operation of construction equipment may generate noise and vibration. **In-use:** Operation of water pumps may generate noise and vibration.
	6	Ground Subsidence	D	D	No project component requires intake of ground water, therefore, no ground subsidence is expected.
	7	Offensive Odor	B-	C	**At-work**: Dredging riverbed for the intake facility may cause offensive odor by stirring the bottom sediment of Mekong River. **In-use:** Offensive odor may occur due to discharged sediment by treatment facility.
	8	Bottom Sediment	B-	C	**At-work**: Dredging riverbed for the intake facility may disturb bottom conditions by stirring the bottom sediment of Mekong River. **In-use:** Intake facility may disturb bottom conditions by taking water of Mekong River.
Natural Environment	9	Sanctuary	D	D	There are no national parks or sanctuaries around the project site.
	10	Ecosystem	B-	C	**At-work:** Construction work for intake facility may cause change or adverse effect on sediment condition and hydrological situation of the area and thus, the construction work could cause adverse effect on local ecosystem. **In-use:** Taking water from the river may cause adverse effect on local ecosystem.
	11	Hydrological Situation	B-	C	**At-work:** Construction work for intake facility may cause change or adverse effect on the hydrological situation of the area. **In-use:** Intake structure may cause change in the hydrological situation of the area.
	12	Topography and Geographical Features	D	D	Due to the size of construction, no big cutting, filling, and embankment are planned for the project, therefore, no or little changes in topography and geographical features are expected.
Social Environment	13	Involuntary Resettlement	D	D	No involuntary resettlement is required.
	14	Poverty Group	D	B+	**At-work:** No resettlement required for the project and thus, no adverse impact specific to poverty is expected.

Category	No.	Impacts	Evaluation		Reasons
			Pre-/ At-work	In-use	
					In-use: Expansion of water supply area may increase the chance of access to clean water by poverty groups. Therefore, the project may cause positive effect to poverty groups.
	15	Indigenous and Ethnic People	D	D	There is no ethnic minority or indigenous people in the project area. Therefore, none of the components of the project will cause adverse impact.
	16	Local Economy such as Employment and Livelihood, etc.	B-	B-	**At-work:** Construction work may disturb businesses operating along the roadsides. **In-use:** Expansion of water supply may cause adverse effect on the business of existing water supply companies.
	17	Land Use and Utilization of Local Resources	D	D	Project requires existing utilized land with small size river bank area and thus, no project component causes adverse effect on land use and local resources.
	18	Water Usage or Water Rights and Rights of Common	B-	B-	**At-work:** Construction work for intake facility may disturb the bottom sediment and hydrological conditions. and thus, construction works could cause adverse effects on water utilization of Mekong River. **In-use:** Water utilization from Mekong River may cause adverse effect on water resource of the river.
	19	Existing Social Infrastructures and Services	B-	D	**At-work:** Construction work may require traffic control or restriction and therefore, it may disturb local traffic.
	20	Social Institutions such as Social Infrastructures and Local Decision-making Institutions	D	D	The objective of the project is to expand and enhance the water supply capacity and thus, no project component could cause adverse effect on any social institution.
	21	Misdistribution of Benefit and Damage	D	D	The objective of the project is to expand and enhance the water supply capacity and decrease the non-water supply area. Therefore, the project rather decreases existing misdistribution of benefit and there is no possibility of causing any unevenly distributed damage in local communities.
	22	Local Conflict of Interests	D	B+	The objective of the project is to expand and enhance the water supply capacity and decrease the non-water supply area. Therefore, the project rather decreases the existing local conflict on the supply of water.
	23	Cultural Heritage	C	C	No specific cultural heritage document has been found; however, during the conduct of field survey, the distribution of any cultural heritage will be checked by collecting local information and hearing from local people.
	24	Landscape	C	C	**At-work**: Construction equipment in the work site could disturb the local landscape. **In-use**: Intake facility and embankment may cause adverse impact on local landscape.
	25	Gender	D	D	No resettlement required for the project and thus, no adverse impact specific to gender is expected.
	26	Children's Right	D	D	No resettlement is required for the project and thus, no adverse impact specific to children's right is expected.

Category	No.	Impacts	Evaluation		Reasons
			Pre-/ At-work	In-use	
	27	Infectious Diseases such as HIV/AIDS	B-	D	**At-work**: The construction workers in Cambodia are regarded as high risk group because of their mobility and accessibility to the entertainment industry.
	28	Work Environment (incl. Work Safety)	B-	D	**At-work**: Construction work increases the risk of accidents and occupational injury. **In-use**: No project component will cause adverse impact on work environment and safety.
Others	29	Accident	B-	C	**At-work**: traffic congestion induced by construction work could increase the possibility of accidents. **In-use**: Mishandling of disinfectant chlorine could cause accidents.
	30	Transboundary Impact and Global Warming	D	D	**At-work**: Discharge of certain amount of CO2 is expected by the operation of construction equipment but the effect is considered to be way less than that of global warming. **In-use**: The project objective is to expand the water supply area within Kampong Cham City, therefore, no Transboundary impact is expected by the implementation of the project.

A+/-: Serious positive (+)/negative (-) impact is expected.
B+/-: Some positive (+)/negative (-) impact is expected.
C: Extent of positive/negative impact is unknown (Further examination is needed, and the impact could be clarified as the survey progresses.)
D: No impact is expected.

Table 1.3-32 (b) Scoping (Battambang)

Category	No.	Impact	Evaluation		Reason
			Pre-/ At-work	In-use	
Pollution	1	Air Pollution	B-	D	**At-work:** Operation of construction equipment may cause air pollution by emission of exhaust gas or dust. **In-use:** None of the project components may cause air pollution.
	2	Water Pollution	B-	B-	**At-work:** Drainages from the construction sites, equipment and camps are anticipated to be potential sources of water pollution. **In-use:** Discharge of water from water treatment facilities may cause water pollution.
	3	Waste	B-	B-	**At-work**: Wastes from the construction works like concrete debris and general waste from workers and camps are expected. **In-use:** Wastes (sand or any deposit) from treatment facility are expected.
	4	Soil Contamination	B-	D	**At-work**: Oil leakage from construction equipment in use may cause soil contamination. **In-use**: No project component may cause soil contamination during operation.
	5	Noise and Vibration	B-	C	**At-work**: Operation of construction equipment may generate noise and vibration. **In-use:** Operation of water pumps may generate noise and vibration.
	6	Ground Subsidence	D	D	No project component requires intake of groundwater; therefore, no ground subsidence is expected
	7	Offensive Odor	B-	C	**At-work**: Dredging riverbed for intake facility may cause offensive odor by stirring bottom sediment of Sangkae River.

Category	No.	Impact	Evaluation		Reason
			Pre-/ At-work	In-use	
					In-use: Offensive odor may occur due to sediment discharged by treatment facility.
	8	Bottom Sediment	B-	C	**At-work**: Dredging riverbed for intake facility may disturb bottom conditions by stirring bottom sediments of Sangkae river. **In-use: intake facility** may disturb bottom conditions by taking water of Sangkae river.
Natural Environment	9	Sanctuary	D	D	There are no national parks or sanctuaries in the project site.
	10	Ecosystem	B-	C	**At-work:** Construction work for intake facility may cause change or adverse effect on sediment condition and hydrological situation of the area and thus, the construction work could cause adverse impact on local ecosystem. **In-use:** Taking water from the river may cause adverse impact on local ecosystem.
	11	Hydrological Situation	B-	C	**At-work:** Construction work for intake facility may cause change or adverse impact on hydrological situation of the area. **In-use:** Intake structure may cause change of the hydrological situation of the area.
	12	Topography and Geographical Features	D	D	Due to the size of construction work, no big cutting, filling, embankment are planned for the project; therefore, no or little change in topography and geographical features is expected.
Social Environment	13	Involuntary Resettlement	D	D	Selected alternative plan requires no involuntary resettlement.
	14	Poverty Group	D	B+	**At-work:** No resettlement required for the project and thus, no adverse impact specific to poverty group is expected. **In-use:** Expansion of water supply area may increase the chance of access to clean water by poverty groups. Therefore, the project may cause positive effect to poverty groups.
	15	Indigenous and Ethnic People	D	D	There is no ethnic minority or indigenous people in the project area. Therefore, none of the components of the project will cause adverse impact.
	16	Local Economy such as Employment and Livelihood, etc.	B-	D	**At-work:** Construction work may disturb businesses operating along the roadside. **In-use:** Expansion of water supply may cause adverse impact on the business of existing water supply companies.
	17	Land Use and Utilization of Local Resources	D	D	Project requires existing utilized land with small riverbank area and thus, no project component will cause adverse impact on current land use and local resources.
	18	Water Usage or Water Rights and Rights of Common	B-	B-	**At-work:** Construction work for intake facility may disturb the bottom sediment and hydrological conditions. Therefore, construction work could cause adverse impacts on water utilization of Sangkae River. **In-use:** Water Utilization from Sangkae River may cause adverse impact on water resources of the river.
	19	Existing Social Infrastructures and Services	B-	D	**At-work:** Construction work may require traffic control or restriction and, therefore, it may disturb local traffic. In addition, the burying of drainpipe for water purification facilities may disturb traffic in the alleys used by local communities and food stands.
	20	Social Institutions such as Social	D	D	The objective of the project is to expand and enhance the water supply capacity and thus, no

Category	No.	Impact	Evaluation		Reason
			Pre-/ At-work	In-use	
		Infrastructures and Local Decision-making Institutions			project component could cause adverse impact on any social institution.
	21	Misdistribution of Benefit and Damage	D	D	The objective of the project is to expand and enhance the water supply capacity and decrease the non-water supply area. Therefore, the project rather decreases existing misdistribution of benefit and there is no possibility of causing any unevenly distributed damage in local communities.
	22	Local Conflict of Interests	D	B+	The objective of the project is to expand and enhance the water supply capacity and decrease the non-water supply area. Therefore, the project rather decreases existing local conflicts on the supply of water.
	23	Cultural Heritage	C	C	No specific cultural heritage document has been found; however, the existence of any cultural heritage will be checked during the conduct of field survey by collecting local information and interviewing local people.
	24	Landscape	C	C	**At-work**: Construction equipment in the working site could disturb the local landscape. **In-use**: Intake facility and embankment may cause adverse impact on local landscape.
	25	Gender	D	D	No resettlement is required for the project and thus, no adverse impact specific to gender is expected.
	26	Children's Right	D	D	No resettlement required for the project and thus, no adverse impact specific to children's right is expected.
	27	Infectious Diseases such as HIV/AIDS	B-	D	**At-work**: Construction workers in Cambodia are regarded as high risk groups because of t mobility and accessibility to the entertainment industry.
	28	Work Environment (incl. Work Safety)	B-	D	**At-work**: Construction work increases the risk of accidents and occupational injury. **In-use**: No project component will cause adverse impact on working environment and safety.
Other	29	Accident	B-	C	**At-work**: Traffic congestion induced by construction work could increase the possibility of accidents. **In-use**: Mishandling of disinfectant chlorine could lead to accidental use.
	30	Transboundary Impact and Global Warming	D	D	**At-work**: Discharge of certain amount of CO_2 is expected by the operation of construction equipment but the amount is small and effect is considered to be far less than that of global warming. **In-use**: The project objective is to expand the water supply area within Battambang City; therefore, no transboundary impact is expected by the implementation of the project.

A+/-: Serious positive (+)/negative (-) impact is expected.
B+/-: Some positive (+)/negative (-) impact is expected.
C: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact could be clarified as the survey progresses.)
D: No impact is expected.

(6) Terms of Reference for the Initial Environmental Examination

The Terms of Reference (TOR) for the Initial Environmental Examination (IEE) survey is as summarized in the following table.

Table 1.3-33 Terms of Reference for the Initial Environmental Examination

No.	Items	Survey Items	Method of Survey
1	Air Pollution	1. Confirmation of Ambient Air Standard. 2. Assessment of expected impact of construction works. 3. Survey on current condition of Air Quality.	1. Research on existing data and resources. 2. Collection and confirmation of information on the project works: description, method, period, location/area and equipment.
2	Water Pollution	1. Confirmation of Ambient and Effluent Water Standard. 2. Assessment of expected impacts of construction works. 3. Survey on current condition of Water Quality.	1. Research on existing data and resources. 2. If necessary, conduct of actual measurements. 3. Collection and confirmation of information on the project works (description, method, period, location/area and equipment).
3	Waste	1. Confirmation of process of construction wastes and their destination.	1. Hearing survey of related organizations. 2. Site reconnaissance in project area.
4	Soil Contamination	1. Confirmation of process of construction works, wastes and location of water sources.	1. Hearing survey of related organizations. 2. Site reconnaissance in project area.
5	Noise and Vibration	1. Confirmation of Environmental Standards. 2. Assessment of expected impact of construction works.	1. Research of existing data and resources. 2. Site reconnaissance. 3. Collection and confirmation of information on the project works (description, method, period, location/area and equipment).
7	Offensive Odor	1. Confirmation of Environmental Standards. 2. Assessment of conditions of offensive odor in and around the site.	1. Research of existing data and resources. 2. Site reconnaissance.
8	Bottom Sediment	1. Confirmation of condition of bottom sediment. 2. Assessment of construction method and expected consequences on bottom sediment.	1. Research of existing data and resources. 2. Collection and confirmation of information on the project works (description, method, period, location/area and equipment).
10	Ecosystem	1. Understanding of fauna and flora in and around the project area.	1. Research of existing data and resources. 2. Hearing survey of related organizations. 3. Site reconnaissance.
11	Hydrological Situation	1. Understanding of hydrological situation in the project area.	1. Hearing survey on related organizations. 2. Site reconnaissance.
16	Local Economy such as Employment, Livelihood, etc.	1. Understanding of ongoing businesses and conditions in the project area.	1. Hearing survey on related organizations.
18	Water Usage or Water Rights and Common Rights	1. Understanding of related laws and regulations in Cambodia. 2. Understanding of current condition of water usage.	1. Survey of related laws and regulations. 2. Field reconnaissance to understand the current situation of water utilization.

No.	Items	Survey Items	Method of Survey
19	Existing Social Infrastructures and Services	1. Understanding of existing infrastructures in and around the project area.	1. Site reconnaissance to understand the current situation in and around the project area.
23	Cultural Heritage	1. Understanding of current laws/regulations and measures against infectious diseases in Cambodia.	1. Research on existing data and resources.
24	Landscape	1. Understanding of current laws/regulations and measures against infectious diseases in Cambodia.	1. Research on existing data and resources.
27	Infectious Diseases such as HIV/AIDS	1. Understanding of current laws/regulations and measures against infectious diseases in Cambodia.	1. Research on existing data and resources.
28	Work Environment (incl. Work Safety)	1. Understanding of current laws/regulations and measures for protecting working environment in Cambodia.	1. Research on existing data and resources.
29	Accidents	1. Understanding of current laws/regulations and measures against traffic accidents in Cambodia.	1. Research on existing data and resources.
30	Transboundary Impact and Global Warming	1. Figuring out possible amount of emission through the construction work. 2. Assessment of extent of impact of construction works.	1. Research on existing data and resources. 2. Confirmation of extent of construction and utilized equipment for the Project.
Others			
a	Consideration of Alternatives	1. Consideration on architecture and allocation of facilities. 2. Consideration on construction methods.	1. Proposal of alternative plans for minimizing resettlement size and extent. 2. Proposal of alternative plans for minimizing adverse effects of project activities.
b	Stakeholder Meeting	1. Stakeholder meeting on affected households and related local authorities. 2. Collection/Analysis/ Reflection of stakeholder's opinions.	1. Holding of stakeholder meetings by MIME/DIME/BWW. 2. Analysis of opinions collected from stakeholders and reflecting them in the project plan, if necessary.

(7) Results of Survey based on TOR

The results of the survey defined in the previous TOR are described as follows.

Table 1.3-34 (a) Results of the Survey（Kampong Cham）

<table>
<tr><th>Impact</th><th>Result</th></tr>
<tr><td>Air Pollution</td><td>
・ Major points of Cambodian environmental standard for ambient air are as described in the following table.
<table>
<tr><th></th><th>CO (1hr mg/m^3)</th><th>NO_2 (1hr m /m^3)</th><th>SO_2 (1hr mg/m^3)</th><th>O_3 (1hr mg/m^3)</th><th>Pb (24hr)</th><th>TSP 24hr)</th></tr>
<tr><td>Ambient Air Quality Standard</td><td>40</td><td>0.3</td><td>0.5</td><td>0.2</td><td>0.005</td><td>0.33</td></tr>
</table>
・ No document describing the ambient air quality of Kampong Cham City was found; therefore, the current condition cannot be evaluated by numerical data.
・ The project contains the construction of intake facility, treatment facility with pumping system and pipe networks. Therefore, certain amount of transportation of materials using dump truck, construction works utilizing construction equipment, and other works accompanied by exhaust gas, especially SO2 close to residential area, are expected. The works may cause adverse effects.
</td></tr>
<tr><td>Water Pollution</td><td>
・ The results of water quality measurement in Mekong River near the intake point and the drinking water quality standard are as described in the following table.
<table>
<tr><th>No.</th><th>Parameters</th><th>Unit</th><th>MIME DWQS</th><th>Results</th></tr>
<tr><td>1</td><td>pH</td><td>-</td><td>6.5 – 8.5</td><td>7.6</td></tr>
<tr><td>2</td><td>Temperature</td><td>°C</td><td>-</td><td>30.2</td></tr>
<tr><td>3</td><td>Total Suspended Solid (TSS)</td><td>mg/l</td><td>25 - 100</td><td>64.00</td></tr>
<tr><td>4</td><td>Total Dissolved Solid (TDS)</td><td>mg/l</td><td>800</td><td>63.00</td></tr>
<tr><td>5</td><td>Dissolved Oxygen (DO)</td><td>mg/l</td><td>2.0 – 7.5</td><td>7.14</td></tr>
<tr><td>6</td><td>Turbidity</td><td>NTU</td><td>5</td><td>93.90</td></tr>
<tr><td>7</td><td>Alkalinity</td><td>mg/l</td><td>-</td><td>249.90</td></tr>
<tr><td>8</td><td>Total Hardness</td><td>mg/l</td><td>300*</td><td>28.39</td></tr>
<tr><td>9</td><td>Nitrite (NO2)</td><td>mg/l</td><td>3</td><td>ND< 0.1</td></tr>
<tr><td>10</td><td>Nitrate (NO3)</td><td>mg/l</td><td>50</td><td>0.98</td></tr>
<tr><td>11</td><td>Sulphate (SO4)</td><td>mg/l</td><td>-</td><td>7.63</td></tr>
<tr><td>12</td><td>Fluoride (F)</td><td>mg/l</td><td>-</td><td>0.21</td></tr>
<tr><td>13</td><td>Chloride (Cl)</td><td>mg/l</td><td>250</td><td>4.14</td></tr>
<tr><td>14</td><td>Ammonium (NH4)</td><td>mg/l</td><td>-</td><td>ND< 0.1</td></tr>
<tr><td>15</td><td>Sulphide (S)</td><td>mg/l</td><td>-</td><td>0.08</td></tr>
<tr><td>16</td><td>Color</td><td>TCU</td><td>5</td><td>5.00</td></tr>
<tr><td>17</td><td>Biochemical Oxygen Demand(BOD)</td><td>mg/l</td><td>1.0 – 10.0</td><td>0.85</td></tr>
<tr><td>18</td><td>Chemical Oxygen Demand (COD)</td><td>mg/l</td><td>-</td><td>2.13</td></tr>
<tr><td>19</td><td>Total Phosphorus (TP)</td><td>mg/l</td><td>-</td><td>0.15</td></tr>
<tr><td>20</td><td>Cyanide (CN)</td><td>mg/l</td><td>0.07</td><td>ND< 0.04</td></tr>
<tr><td>21</td><td>Aluminium (Al)</td><td>mg/l</td><td>-</td><td>0.004</td></tr>
<tr><td>22</td><td>Arsenic (As)</td><td>mg/l</td><td>0.05</td><td>ND< 0.0001</td></tr>
<tr><td>23</td><td>Cadmium (Cd)</td><td>mg/l</td><td>0.003</td><td>ND< 0.0002</td></tr>
<tr><td>24</td><td>Chromium (Cr)</td><td>mg/l</td><td>0.05</td><td>ND< 0.0005</td></tr>
<tr><td>25</td><td>Copper (Cu)</td><td>mg/l</td><td>1</td><td>0.22</td></tr>
<tr><td>26</td><td>Iron (Fe)</td><td>mg/l</td><td>0.3</td><td>0.04</td></tr>
<tr><td>27</td><td>Lead (Pb)</td><td>mg/l</td><td>0.01</td><td>ND< 0.0002</td></tr>
<tr><td>28</td><td>Manganese (Mn)</td><td>mg/l</td><td>0.1</td><td>0.002</td></tr>
<tr><td>29</td><td>Mercury (Hg)</td><td>mg/l</td><td>0.001</td><td>0.0003</td></tr>
<tr><td>30</td><td>Selenium (Se)</td><td>mg/l</td><td>0.01</td><td>ND, 0.0006</td></tr>
<tr><td>31</td><td>Zinc (Zn)</td><td>mg/l</td><td>3</td><td>0.04</td></tr>
<tr><td>32</td><td>Total Coliform</td><td>Count/100 ml</td><td>0</td><td>2.4X10^2</td></tr>
<tr><td>33</td><td>E-Coli</td><td>MPN/100 ml</td><td>0</td><td>0</td></tr>
</table>
MIME DWQS – Ministry of Industry Mines and Energy, Drinking Water Quality Standard, January 2004
Results by JPST'(July 2012)
・ Based on the above results, it can be said that the water quality of Mekong River is suitable for drinking utilization.
・ The construction of intake facilities requires dredging and breaking of bedrock beneath the water level. The work could increase suspended substances in the water and could lead to the deterioration of water quality. In addition, discharges from construction camp could contribute to the deterioration of water quality.
・ During the operation term, by introducing the waste pond which will reduce sedimentation of solids before discharging water into public water, little water pollution is expected.
</td></tr>
</table>

<table>
<tr><th>Impact</th><th>Result</th></tr>
<tr><td>Waste</td><td>・ Expected wastes generated by the construction works consist of dredged sludge and debris from the riverbed, soil (excavation work for setting pipe), concrete debris, wood chips, etc.
・ Expected wastes generated by facility operation consist of sludge from intake facility although the amount is rather smaller compared to construction waste.
・ MIME/PDIME/KWW and Kampong Cham City have selected and proposed several sites owned by the province for waste disposal.</td></tr>
<tr><td>Soil Contamination</td><td>・ No project component requires any hazardous materials or construction method at risk of soil contamination.</td></tr>
<tr><td>Noise and Vibration</td><td>・ Noise standards in Cambodia are as summarized in the following table.
<table>
<tr><th rowspan="2">Areas</th><th colspan="3">(dB(A))</th></tr>
<tr><th>6:00-18:00</th><th>18:00-22:00</th><th>22:00-6:00</th></tr>
<tr><td>Quiet Area</td><td>45</td><td>40</td><td>35</td></tr>
<tr><td>Residential Area</td><td>60</td><td>50</td><td>45</td></tr>
<tr><td>Commercial and Service Area</td><td>70</td><td>65</td><td>45</td></tr>
<tr><td>Industrial Area</td><td>75</td><td>70</td><td>50</td></tr>
</table>
Sub-Decree on the Control of Air Pollution and Noise Disturbance (2000)
・ For vibration disturbance, no standard is stipulated in Cambodian laws/regulations.
・ No existing measurement result can be obtained for both noise and vibration in Kampong Cham City, and thus, current conditions cannot be evaluated numerically.
・ The project area mainly consists of commercial, service and residential area with surrounding suburbs.
・ Considering the construction plan and the distance toward houses at each site, the laying of pipes as well as transporting materials through residential area could cause noise and vibration disturbance.
・ As in the operation of facilities, the pump system may cause noise and vibration disturbances if no preventive measures are taken.</td></tr>
<tr><td>Offensive Odor</td><td>・ No standard for offensive odor is stipulated in Cambodian laws and regulations.
・ Perceived odor at the intake site is exhaust gas from vehicles, foul odor from sewage water which cannot be detected elsewhere but close to points where sewage inflows to Mekong River.
・ The intake facility is planned to be constructed on the edge of Mekong River which consists of basalt with little sediment expected. Therefore, little offensive odor from bottom sediment is expected from construction and operation.
・ Based on the results of water quality monitoring, there is little possibility of occurrence of offensive odor by the deposits of treatment facility.</td></tr>
<tr><td>Bottom Sediment</td><td>・ No document describing bottom sediment of the project area was found; therefore, the current condition cannot be evaluated directly.
・ Intake facility is planned to be constructed on the edge of Mekong River to the river bank.
・ Based on the results of field measurement and boring survey, the foundation of the site consists of basalt which is hard rock and located in the slope of the riverbed.
・ In consideration of the fast current velocity around the intake point and the position of the intake, little to small sediment accumulation is expected.
・ No major impact on bottom sediment is expected.</td></tr>
<tr><td>Ecosystem</td><td>・ There are article reports that the Mekong giant catfish and the Irrawaddy dolphin inhabit the downstream of Mekong River near the Cambodia-Laos border but there is no report that they exist near the project area.
・ There are several reptiles, amphibians and birds recognized by local residents. Several species are categorized as Vulnerable by ICUN.
・ The project area basically consists of residential area and utilized land use area. Also, the intake facility is planned to be constructed on the edge of Mekong River.
・ Based on the result of field reconnaissance, fauna around the intake site is second growth wood and shrubs with no precious bird recognized.
・ Considering the above facts, no major impact on ecosystem is expected.</td></tr>
<tr><td>Hydrological Situation</td><td>・ Intake facility is planned to be set on the edge of water bed and thus, the construction work could cause adverse impact on the hydrological situation. Considering the size of the facility compared to the river width, depth and flow rate, the impact of the construction work is considered to be not substantial but minor.</td></tr>
<tr><td>Local Economy such as</td><td>・ During the laying of pipes, access to commercial facilities could be disturbed or restricted due to excavation work. Also, traffic control or restriction could be required, so that adverse impact on the commercial facilities running along the road.</td></tr>
</table>

Impact	Result
Employment and Livelihood, etc.	・ Two water supply companies exist in the project area, one is supplying water to about 110 households and the other is supplying water to about 50 households. On the other hand, during the implementation period, non-supply areas around the project site will remain. However, considering the size of businesses, the impact is rather limited.
Water Usage or Water Rights and Rights of Common	・ Drilling and dredging are required in the construction of intake facility in the Mekong River; however, the site consists of basalt which is hard rock and sits in the slope of the riverbed where little sedimentation is expected. Therefore, little impact on other water utilization is expected. ・ Considering the utilization amount and flow rate of Mekong River, little impact is expected on other water utilization.
Existing Social Infrastructures and Services	・ Since construction work for underground pipes, traffic control or restriction will be required, local traffic may be disturbed to a certain level. ・ It is possible to minimize traffic disturbance by securing a lane and access to commercial facilities during the construction work by utilizing panels to cover excavations and prompt refilling. Therefore, with the mitigation measures, the impact becomes minor.
Cultural Heritage	・ No designated cultural heritage exists in the Project area while local temples exist near the Project area.
Landscape	・ No designated landscape exists in the Project area.
Infectious Diseases such as HIV/AIDS	・ Law on the prevention and control of HIV/AIDS in Cambodia stipulates the importance of education, information dissemination and preparation of guidelines by the National AIDS authority. The law also stipulates that all practices and procedures shall comply with the guidelines. ・ According to the guideline, construction workers are categorized as high risk groups on infectious diseases because of their movability and access to the entertainment industry. ・ Thus, the guideline put emphasis on promoting preventive measures by supplying proper information to those in high risk groups.
Work Environment (incl. Work Safety)	・ Article 22 of the Labor Law (2002) in Cambodia stipulates setting of internal regulations and Article 230 stipulates that all establishments and work places must guarantee the safety of workers ・ In the Project, above stipulated laws and regulations will be followed strictly and therefore, proper working condition will be secured.
Accident	・ The Traffic Law (2006) in Cambodia stipulates measures for maintaining order and safety in road traffic, protecting human and animal lives, curbing the effect on human health, damage and offenses stemmed from the use of the roads. ・ On the other hand, no provision in the law stipulates any obligation of setting or allocating traffic signs and related measures for preventing disturbances, but safety measures by driver are stipulated. ・ The traffic volume is increasing in Kampong Cham and, considering above conditions, this could lead to the increase of traffic accidents. ・ In the previous JICA project, a chlorine handling manual was prepared and necessary training has been provided by the long-term JICA expert. As far as KWW complies with the manual and keep training periodically, little possibility of occurrence of related accidents is expected.
Transboundary Impact and Global Warming	・ The project area is within the city boundary of Kampong Cham and no big scale construction work is planned. Rather small scale construction works are planned for each facility on a day-to-day basis. ・ Thus, no transboundary impact is expected.
Considering Alternatives	・ Refer to Subsection 2.6.1, “Alternative Plans”
Stakeholder Meeting	・ Stakeholder meeting was held at KWW on August 14, 2012. Basically, the residents welcome the project provided there is reduction of the water charge and little adverse impact on them. ・ For details, refer to Chapter 6.

Table 1.3-34 (b) Results of the Survey（Battambang）

<table>
<tr><th>Impact</th><th>Result</th></tr>
<tr><td>Air Pollution</td><td>
・ Major points of Cambodian environmental standard for ambient air are shown in the following table.
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<tr><th></th><th>CO (1hr mg/m^3)</th><th>NO_2 (1hr mg/m^3)</th><th>SO_2 (1hr mg/m^3)</th><th>O3 (1hr mg/m^3)</th><th>Pb (24hr)</th><th>TSP (24hr)</th></tr>
<tr><td>Ambient Air Quality Standard</td><td>40</td><td>0.3</td><td>0.5</td><td>0.2</td><td>0.005</td><td>0.33</td></tr>
</table>
・ No document describing the ambient air quality of Battambang City was found; therefore, the current condition could not be evaluated by numerical data.
・ The project contains construction of intake facility, treatment facility with pumping system and pipe networks. Therefore, certain amount of transportation of materials using dump truck, construction works utilizing construction equipment, and other works accompanied by exhaust gas, especially SO2 through residential area, are expected. The works may cause adverse effects.
</td></tr>
<tr><td>Water Pollution</td><td>
・ The results of water quality measurement in Sangkae River near the intake point and the drinking water quality standard are as summarized in the following table.
<table>
<tr><th rowspan="2">No.</th><th rowspan="2">Parameter</th><th rowspan="2">Unit</th><th colspan="2">Standards</th><th rowspan="2">(S1)</th><th rowspan="2">(S2)</th><th rowspan="2">(S3)</th></tr>
<tr><th>MIME *</th><th>MoE**</th></tr>
<tr><td>1</td><td>Temperature</td><td>ºC</td><td>-</td><td>-</td><td>29.2</td><td>29.3</td><td>28.3</td></tr>
<tr><td>2</td><td>pH</td><td>-</td><td>6.5 – 8.5</td><td>6.5 – 8.5</td><td>7.5</td><td>7.1</td><td>7.6</td></tr>
<tr><td>3</td><td>Total Suspended Solid (TSS)</td><td>mg/l</td><td>25 - 100</td><td>25 - 100</td><td>114.00</td><td>69.00</td><td>57</td></tr>
<tr><td>4</td><td>Total Dissolved Solid (TDS)</td><td>mg/l</td><td>800</td><td>-</td><td>61.00</td><td>63.00</td><td>43</td></tr>
<tr><td>5</td><td>Dissolved Oxygen (DO)</td><td>mg/l</td><td>2.0 – 7.5</td><td>2.0 – 7.5</td><td>7.10</td><td>7.05</td><td>7.09</td></tr>
<tr><td>6</td><td>Turbidity</td><td>NTU</td><td>5</td><td>-</td><td>47.80</td><td>53.20</td><td>35.6</td></tr>
<tr><td>7</td><td>Alkalinity</td><td>mg/l</td><td>-</td><td>-</td><td>181.30</td><td>166.60</td><td>128.60</td></tr>
<tr><td>8</td><td>Total Hardness</td><td>mg/l</td><td>300*</td><td>-</td><td>29.40</td><td>9.80</td><td>18.90</td></tr>
<tr><td>9</td><td>Nitrite (NO2)</td><td>mg/l</td><td>3</td><td>-</td><td>0.10</td><td>ND< 0.10</td><td>ND< 0.10</td></tr>
<tr><td>10</td><td>Nitrate (NO3)</td><td>mg/l</td><td>50</td><td>-</td><td>10.64</td><td>0.71</td><td>0.69</td></tr>
<tr><td>11</td><td>Sulphate (SO4)</td><td>mg/l</td><td>-</td><td>-</td><td>3.16</td><td>1.10</td><td>ND< 0.10</td></tr>
<tr><td>12</td><td>Fluoride (F)</td><td>mg/l</td><td>-</td><td>-</td><td>0.18</td><td>0.17</td><td>0.22</td></tr>
<tr><td>13</td><td>Chloride (Cl)</td><td>mg/l</td><td>250</td><td>-</td><td>5.59</td><td>2.77</td><td>3.45</td></tr>
<tr><td>14</td><td>Ammonium (NH4)</td><td>mg/l</td><td>-</td><td>-</td><td>0.13</td><td>ND< 0.1</td><td>0.11</td></tr>
<tr><td>15</td><td>Sulphide (S)</td><td>mg/l</td><td>-</td><td>-</td><td>0.05</td><td>0.03</td><td>0.09</td></tr>
<tr><td>16</td><td>Color</td><td>mg Pt/l</td><td>5</td><td>-</td><td>100.00</td><td>100.00</td><td>80.00</td></tr>
<tr><td>17</td><td>Biochemical Oxygen Demand(BOD)</td><td>mg/l</td><td>1.0 – 10.0</td><td>1.0 – 10.0</td><td>1.16</td><td>1.06</td><td>1.16</td></tr>
<tr><td>18</td><td>Chemical Oxygen Demand (COD)</td><td>mg/l</td><td>-</td><td>1-8</td><td>2.17</td><td>2.17</td><td>2.85</td></tr>
<tr><td>19</td><td>Total Phosphorus (TP)</td><td>mg/l</td><td>-</td><td>0.005-0.05</td><td>0.12</td><td>0.11</td><td>0.18</td></tr>
<tr><td>20</td><td>Cyanide (CN)</td><td>mg/l</td><td>0.07</td><td>-</td><td>ND< 0.04</td><td>ND< 0.04</td><td>ND< 0.04</td></tr>
<tr><td>21</td><td>Aluminium (Al)</td><td>mg/l</td><td>-</td><td>-</td><td>0.008</td><td>0.007</td><td>0.005</td></tr>
<tr><td>22</td><td>Arsenic (As)</td><td>mg/l</td><td>0.05</td><td>-</td><td>ND< 0.0001</td><td>ND< 0.0001</td><td>0.006</td></tr>
<tr><td>23</td><td>Cadmium (Cd)</td><td>mg/l</td><td>0.003</td><td>-</td><td>ND< 0.0002</td><td>ND< 0.0002</td><td>ND< 0.0002</td></tr>
<tr><td>24</td><td>Chromium (Cr)</td><td>mg/l</td><td>0.05</td><td>-</td><td>ND< 0.0005</td><td>0.0008</td><td>0.005</td></tr>
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<tr><td>28</td><td>Manganese (Mn)</td><td>mg/l</td><td>0.1</td><td>-</td><td>0.001</td><td>0.003</td><td>0.004</td></tr>
<tr><td>29</td><td>Mercury (Hg)</td><td>mg/l</td><td>0.001</td><td>-</td><td>0.0004</td><td>0.0003</td><td>0.0001</td></tr>
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<tr><td>31</td><td>Zinc (Zn)</td><td>mg/l</td><td>3</td><td>-</td><td>0.04</td><td>0.001</td><td>0.12</td></tr>
<tr><td>32</td><td>Total Coliform</td><td>MPN/100 ml</td><td>0</td><td>< 5000</td><td>2.1x10^2</td><td>1.5x10^2</td><td>7.4x10^2</td></tr>
<tr><td>33</td><td>E-Coli</td><td>MPN/100 ml</td><td>0</td><td>-</td><td>56</td><td>< 56</td><td>116</td></tr>
</table>
Note: * MIME DWQS – Ministry of Industry Mines and Energy, Drinking Water Quality Standard, January 2004
Results by JPST'(July 2012)
・ Based on the above results, it can be said that the water quality of Sangkae River is suitable for drinking utilization.
・ The construction of intake facilities requires dredging and breaking of bedrock beneath the water level. The work could increase suspended substances in the water and could lead to the deterioration of water quality. In addition, discharges from the construction camp could contribute to the deterioration of water quality.
・ During the operation term, by introducing the waste pond which will reduce sedimentation of solids before discharging the water into public water, little water pollution is expected.
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<tr><td>Waste</td><td>・ Expected wastes generated by the construction work consist of dredged sludge and debris from the riverbed, soil (excavation work for setting pipe), concrete debris, wood chips, etc.
・ Expected wastes generated by facility operation consist of sludge from intake facility, although the amount is rather small compared to construction waste.
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・ Considering the construction plan and the distance to houses at each site, the laying of pipes as well as transporting materials through residential areas could cause noise and vibration disturbance.
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<tr><td>Offensive Odor</td><td>・ No standard for offensive odor is stipulated in Cambodian laws and regulations.
・ Perceived odor at the intake site is exhaust gas from vehicles, foul odor from sewage water which cannot be detected elsewhere but close to points where sewage inflows to Sangkae River.
・ The construction of intake facilities requires dredging beneath the water level. Therefore, stirred bottom sediment could cause offensive odor in the site.
・ Based on the results of water quality monitoring, there is little possibility of occurrence of offensive odor by the deposits of treatment facility.</td></tr>
<tr><td>Bottom Sediment</td><td>・ No document describing bottom conditions at intake site was found; therefore, current conditions cannot be evaluated directly.
・ The construction of intake facilities requires dredging beneath the water level. Therefore, the construction work stirs bottom sediment and this could lead to deterioration of bottom conditions.</td></tr>
<tr><td>Ecosystem</td><td>・ There is no existing document stating the details of ecosystem in the Project area.
・ There are several reptiles, amphibians and birds recognized by local residents. Several species are categorized as Vulnerable by ICUN.
・ The project area basically consists of residential area and utilized land use area. Intake facility is planned to be constructed on the edge of Sangke River.
・ Based on the result of field reconnaissance, fauna around intake site is second growth wood and shrubs with no precious bird recognized.
・ In consideration of the above facts, no major impact on ecosystem is expected.</td></tr>
<tr><td>Hydrological Situation</td><td>・ Intake facility is planned to be set on the edge of water bed so that the construction work could cause adverse impact on the hydrological situation.</td></tr>
<tr><td>Local Economy such as Employment and Livelihood, etc.</td><td>・ During the laying of pipes, access to commercial facilities may be disturbed or restricted due to the excavation work. Traffic control or restriction would also be required and cause adverse impact on the commercial facilities running along the road.</td></tr>
<tr><td>Water Usage or Water Rights and Common Rights</td><td>・ Considering the utilization amount and flow rate of Sangkae River in the dry season, adverse impact on other water utilization could be caused.</td></tr>
</table>

Impact	Result
Existing Social Infrastructures and Services	・ During construction works for embedding underground pipes, traffic control or restriction will be required so that local traffic may be disturbed to a certain extent. ・ The burying drainpipe for water purification facilities may disturb traffics in alleys in the local community which are utilized by local people and food stands.
Cultural Heritage	・ No designated cultural heritage exists in the Project area while local temples exist near the Project area.
Landscape	・ No designated landscape exists in the Project area.
Infectious Diseases such as HIV/AIDS	・ The law on prevention and control of HIV/AIDS in Cambodia stipulates the importance of education, information dissemination and preparation of guidelines by the National AIDS authority. The law also stipulates that all practices and procedures shall comply with the guidelines. ・ According to the guideline, construction workers are categorized as a high risk group for infectious diseases because of their movability and access to the entertainment industry. ・ Thus, the guideline put emphasis on promoting preventive measures by supplying proper information to those in high risk group.
Work Environment (incl. Work Safety)	・ Article 22 of the Labor Law (2002) of Cambodia stipulates the setting of internal regulations and Article 230 stipulates that all establishments and work places must guarantee the safety of workers. ・ In the Project, above stipulated laws and regulations will be followed strictly and therefore, proper working condition will be secured.
Accident	・ The Traffic Law (2006) of Cambodia stipulates measures for maintaining order and safety in road traffic, protecting human and animal lives, curbing the effect on human health, damage and offenses stemmed from the use of the roads. ・ On the other hand, no provision in the law stipulates any obligation of setting or allocating traffic signs and related measures for preventing disturbances, although safety measures by drivers are stipulated. ・ The traffic volume is increasing in Battambang and, considering the above conditions, this could lead to increase of traffic accidents. ・ Chlorine handling manual has been prepared for the operation term, and necessary training have been given by the long-term JICA expert in the previous JICA project. As far as BWW complies with the manual and the training is kept periodically, little possibility of occurrence of related accidents is expected.
Transboundary Impact and Global Warming	・ The project area is within the city boundary of Battambang City and no big scale construction work is planned. Rather, small scale construction works are planned for each facility on a day-to-day basis. ・ Thus, no transboundary impact is expected.
Consideration of Alternatives	・ Refer to Section 2.6.1, Alternative Plans.
Stakeholder Meeting	・ A stakeholders' meeting was held in BWW on August 7, 2012. Basically, the residents welcome the project provided there is a reduction of water charge and little adverse impact on them.

(8) Results of Evaluation

The evaluation results as reflected the previous survey are as summarized in the following table.

Table 1.3-35 (a) Results of Evaluation (Kampong Cham)

Category	No.	Impacts	Evaluation at Scoping		Evaluation by the Results of survey		Reasons
			Pre-/ At-work	In-use	Pre-/ At-work	In-use	
Pollution	1	Air Pollution	B-	D	B-	D	**At-work:** Operation of construction equipment may cause air pollution by emission of exhaust gas or dust to a certain extent.
	2	Water Pollution	B-	B-	B-	B-	**At-work:** Drainages from the construction sites, equipment and camps are anticipated to be potential sources of water pollution. **In-use:** By introducing waste pond to reduce

Category	No.	Impacts	Evaluation at Scoping		Evaluation by the Results of survey		Reasons
			Pre-/ At-work	In-use	Pre-/ At-work	In-use	
							sedimentation of solids before discharging water into public water, little water pollution is expected.
	3	Waste	B-	B-	B-	B-	**At-work:** MIME/PDIME/KWW have secured the proper dump site and have control over the contractor for conducting proper waste management. **In-use:** MIME/PDIME/KWW shall secure the proper dump site for waste soils generated from treatment procedures and shall manage wastes properly.
	4	Soil Contamination	B-	D	D	D	No project component requires any hazardous material and construction method at risk of soil contamination.
	5	Noise and Vibration	B-	C	B-	B-	**At-work:** Laying of pipes as well as transporting materials through residential area could cause noise and vibration disturbance. **In-use:** Pump system may cause noise and vibration disturbances if no preventive measure is taken.
	6	Ground Subsidence	D	D	D	D	Same evaluation as conducted in scoping.
	7	Offensive Odor	B-	C	D	D	**At-work:** The intake facility is planned to be constructed on the edge of Mekong River which consists of basalt with not much sediment expected. Therefore, little offensive odor from bottom sediment is expected with the construction work. **In-use:** Considering the results of water quality analysis with above-mentioned condition of intake site, little offensive odor is expected but conduct of monitoring is recommended.
	8	Bottom Sediment	B-	C	B-	D	**At-work:** The construction of intake facilities requires dredging and breaking bedrock beneath the water level. Therefore, the construction may cause some adverse effect on bottom sediment but the extent is expected to be small. **In-use:** Considering the foundation of the site and the structure of intake, no adverse effect on bottom sediment is expected.
Natural Environment	9	Sanctuary	D	D	D	D	Same evaluation as conducted in scoping.
	10	Ecosystem	B-	C	B-	D	**At-work:** The construction of intake facilities requires dredging and breaking bedrock beneath the water level accompanied by stirring water and bottom environment. Therefore, the construction may cause some adverse effect on ecosystem in the site but the extent is expected to be small. Therefore, periodical monitoring is recommended. **In-use:** Considering the structure of intake and intake amount, little adverse effect on the ecosystem is expected.
	11	Hydrological Situation	B-	C	B-	D	**At-work:** The construction of intake facilities requires dredging and breaking bedrock beneath the water level. Therefore, the construction may cause some adverse effect on hydrological situation but the extent is expected to be small. **In-use:** Considering the foundation of the site and

Category	No.	Impacts	Evaluation at Scoping		Evaluation by the Results of survey		Reasons
			Pre-/ At-work	In-use	Pre-/ At-work	In-use	
							the structure of intake, no adverse effect on the situation is expected.
	12	Topography and Geographical Features	D	D	D	D	Same evaluation as conducted in scoping.
Social Environment	13	Involuntary Resettlement	D	D	D	D	Same evaluation as conducted in scoping.
	14	Poverty Group	D	B+	D	B+	Same evaluation as conducted in scoping.
	15	Indigenous and Ethnic People	D	D	D	D	Same evaluation as conducted in scoping.
	16	Local Economy such as Employment and Livelihood, etc.	B-	B-	B-	B-	**At-work:** Access to commercial facilities could be disturbed or restricted due to excavation work. Also, traffic control or restriction could be required, and, therefore, it may cause adverse impact on commercial facilities along the road. **In-use:** Existing water supply company may receive adverse effects to some extent with the expansion of supply area but other possible markets exist in the surrounding area.
	17	Land Use and Utilization of Local Resources	D	D	D	D	Same evaluation as conducted in scoping.
	18	Water Usage or Water Rights and Rights of Common	B-	B-	D	D	**At-work:** Considering the extent of construction as well as the condition of foundation and the water flow/ amount of Mekong River, the impact on water usage is expected to be minor. **In-use:** The intake amount is very small compared to the flow amount of Mekong River. Therefore, little adverse impact is expected.
	19	Existing Social Infrastructures and Services	B-	D	B-	D	**At-work:** Construction work for underground pipes, traffic control or restriction will be required, so that local traffic may be disturbed to a certain extent.
	20	Social Institutions such as Social Infrastructures and Local Decision-making Institutions	D	D	D	D	Same evaluation as conducted in scoping.
	21	Misdistribution of Benefit and Damage	D	D	D	D	Same evaluation as conducted in scoping.
	22	Local Conflict of Interests	D	B+	D	B+	Same evaluation as conducted in scoping.
	23	Cultural Heritage	C	C	D	D	**At-work:** Although Phnom Pros Temple, one of the famous tourist attractions in Kampong Cham, is near the project site, no adverse effect is expected considering the distance from the construction site. **In-use**: Considering the size of facilities and land

Category	No.	Impacts	Evaluation at Scoping		Evaluation by the Results of survey		Reasons
			Pre-/ At-work	In-use	Pre-/ At-work	In-use	
							use as well as the current condition of the site, little adverse effect on local landscape is expected.
	24	Landscape	C	C	D	D	**At-work**: Considering the size of construction work and site characteristics, little adverse effect on local landscape is expected. **In-use**: Considering the size of facilities, land use and current condition of the site, little adverse effect on local landscape is expected.
	25	Gender	D	D	D	D	Same evaluation as conducted in scoping.
	26	Children's Right	D	D	D	D	Same evaluation as conducted in scoping.
	27	Infectious Diseases such as HIV/AIDS	B-	D	B-	D	**At-work**: Construction workers in Cambodia are regarded as high risk group because of their movability and accessibility to the entertainment industry. Therefore, the worker should be a contributing factor for increasing the rate of infection with related diseases.
	28	Work Environment (incl. Work Safety)	B-	D	B-	D	**At-work**: Construction work increases the risk of occurrence of accident and occupational injury. Although the risk can be reduced by following the provisions of the labor law, certain risks still remain.
Others	29	Accident	B-	C	B-	B-	**At-work**: Construction work requires traffic control and restriction since the traffic in Kampong Cham is increasing. The work could increase traffic accidents. **In-use**: In the previous JICA project, a chlorine handling manual was prepared and necessary training has been provided by the long-term JICA expert. As far as KWW complies with the manual and keep training periodically, little possibility of occurrence of related accidents is expected.
	30	Transboundary Impact and Global Warming	D	D	D	D	**At-work**: During construction the work, CO_2 will be emitted by operating equipment and transporting materials. However, the size of construction is rather small scale and the extent limited in Kampong Cham City. Therefore, little adverse effect is expected. **In-use:** In the operation of related facilities, CO_2 will be emitted by utilizing supplied electricity for the operation. However, the size is rather small scale and the extent limited in Kampong Cham City, so that little adverse effect is expected.

A+/-: Serious positive (+)/negative (-) impact is expected.
B+/-: Some positive (+)/negative (-) impact is expected.
C: Extend of positive/negative impact is unknown (A further examination is needed, and the impact could be clarified as the survey progresses).
D: No impact is expected.

Table 1.3-35 (b) Results of Evaluation (Battambang)

Category	No.	Impacts	Evaluation at Scoping		Evaluation by the Results of Survey		Reasons
			Pre-/ At-work	In-use	Pre-/At -work	In-use	
Pollution	1	Air Pollution	B-	D	B-	D	**At-work:** Operation of construction equipment may cause air pollution with the emission of exhaust gas or dust to a certain extent.
	2	Water Pollution	B-	B-	B-	B-	**At-work:** Drainages from construction sites, equipment and camps are anticipated to be potential sources of water pollution. **In-use:** By introducing the waste pond which reduces sedimentation of solids before discharging water into public water, little water pollution is expected.
	3	Waste	B-	B-	B-	B-	**At-work:** MIME/PDIME/BWW has secured the proper dump site and has control over the contractor for conducting proper waste management. **In-use:** MIME/PDIME/BWW shall secure the proper dump site for waste soils generated from treatment procedures and will manage wastes properly.
	4	Soil Contamination	B-	D	D	D	No project component requires any hazardous material and construction method at risk of soil contamination.
	5	Noise and Vibration	B-	C	B-	B-	**At-work:** Construction works for laying pipes as well as transporting materials through residential area could cause noise and vibration disturbance. **In-use:** Pump system may cause noise and vibration disturbance if no preventive measure is taken.
	6	Ground Subsidence	D	D	D	D	Same evaluation as conducted in scoping.
	7	Offensive Odor	B-	B-	B-	D	**At-work:** The construction of intake facilities requires dredging beneath the water level. Therefore, stirred bottom sediment could cause offensive odor in the site. **In-use:** Considering the results of water quality analysis with the above-mentioned condition of intake site, little offensive odor is expected.
	8	Bottom Sediment	B-	C	B-	D	**At-work:** The construction of intake facilities requires dredging beneath the water level. Therefore, the construction work stirs bottom sediment and it could lead to deterioration of bottom conditions. **In-use:** Considering the size of intake facility and the intake amount, little disturbance on bottom sediment is expected.
Natural Environment	9	Sanctuary	D	D	D	D	Same evaluation as conducted in scoping.
	10	Ecosystem	B-	C	B-	D	**At-work:** The construction of intake facilities requires dredging accompanied by stirring water and bottom environment. Therefore, the construction may cause some adverse effect on ecosystem in the site while the extent is expected to be small. Therefore, conduction of periodical monitoring is recommended.

Category	No.	Impacts	Evaluation at Scoping		Evaluation by the Results of Survey		Reasons
			Pre-/ At-work	In-use	Pre-/At -work	In-use	
							In-use: As considering the structure of intake and intake amount, little adverse effect on the ecosystem is expected.
	11	Hydrological Situation	B-	C	B-	B-	**At-work:** The construction of intake facilities requires dredging and breaking bedrock beneath the water level. Therefore, the construction may cause adverse effect on hydrological situation by changing the bottom conditions especially during dry season as considering flow rate. **In-use:** As considering the size of structure of intake facility as well as flow rate/ amount in dry season, the structure may cause adverse effect on hydrological situation while although the extent is expected to be minor.
	12	Topography and Geographical Features	D	D	D	D	Same evaluation as conducted in scoping.
	13	Involuntary Resettlement	D	D	D	D	Same evaluation as conducted in scoping.
Social Environment	14	Poverty Group	D	B+	D	B+	Same evaluation as conducted in scoping.
	15	Indigenous and Ethnic People	D	D	D	D	Same evaluation as conducted in scoping.
	16	Local Economy such as Employment and Livelihood, etc.	B-	D	B-	D	**At-work:** Access to commercial facility could be disturbed or restricted due to excavation works. Also traffic control or restriction could be required, and, therefore, it may cause adverse impact on commercial facilities along the road.
	17	Land Use and Utilization of Local Resources	D	D	D	D	Same evaluation as conducted in scoping.
	18	Water Usage or Water Rights and Rights of Common	B-	B-	B-	B-	**At-work:** For The construction of intake facility in the Sangkae river in which drilling and dredging required. It could cause the deterioration of water quality by stirring bottom sediment. The deterioration of water quality could cause adverse effect on water utilization of down stream. **In-use:** As considering the utilization amount and flow rate of Sangke river in dry season, it could cause adverse impact on other water utilization.
	19	Existing Social Infrastructures and Services	B-	D	B-	D	**At-work:** As conducting construction works for underground pipe, will e require traffic control or restriction; will be required, and therefore, it may disturb local traffics at a certain level.
	20	Social Institutions such as Social Infrastructures and Local Decision-making Institutions	D	D	D	D	Same evaluation as conducted in scoping.

Category	No.	Impacts	Evaluation at Scoping		Evaluation by the Results of Survey		Reasons
			Pre-/ At-work	In-use	Pre-/At -work	In-use	
	21	Misdistribution of Benefit and Damage	D	D	D	D	Same evaluation as conducted in scoping.
	22	Local Conflict of Interests	D	B+	D	B+	Same evaluation as conducted in scoping.
	23	Cultural Heritage	C	C	D	D	**At-work**: No protected temples or any cultural heritage exist in Project Area. Although, there are some temples and famous market exist, the extent of the construction does not include those them; and therefore, no adverse effect is expected.
	24	Landscape	C	C	D	D	**At-work**: Considering the size of construction work and site characteristics, little adverse effect on local landscape is expected. **In-use**: Considering the size of facilities, land use and current conditions of the sites, little adverse effect on local landscape is expected.
	25	Gender	D	D	D	D	Same evaluation as conducted in scoping.
	26	Children's Right	D	D	D	D	Same evaluation as conducted in scoping.
	27	Infectious Diseases such as HIV/AIDS	B-	D	B-	D	**At-work**: Construction workers in Cambodia are regarded as high risk groups because of their movability and access to the entertainment industry. Therefore, the workers could be a contributing factor for increasing the rate of infection of related diseases.
	28	Work Environment (incl. Work Safety)	B-	D	B-	D	**At-work**: Construction work increases the risk of occurrence of accidents and occupational injury.. Although the above risk can be reduced by following the items stipulated in the labor law, certain risk still remain.
	29	Accident	B-	C	B-	B-	**At-work**: Construction work requires traffic control and restriction since traffic in Battambang is increasing. Construction work could increase traffic accidents. **In-use**: In the previous JICA project, a chlorine handling manual was prepared and necessary training have been given by the long--term JICA expert. As far as BWW complies with the manual and keep training periodically, little possibility of occurrence of related accidents is expected.
Others	30	Transboundary Impact and Global Warming	D	D	D	D	**At-work**: During construction works, CO_2 will be emitted by the operation of equipment and in transporting materials. However, the size of the construction work is rather small scale and the extent limited in Battambang City. Therefore, little adverse effect is expected. **In-use:** With the operation of related facilities, CO_2 will be emitted by utilizing supplied electricity for operation. However, the size is rather small scale

Category	No.	Impacts	Evaluation at Scoping		Evaluation by the Results of Survey		Reasons
			Pre-/ At-work	In-use	Pre-/At -work	In-use	
							and the extent limited in Battambang City., Therefore, little adverse effect is expected.
	30	Transboundary Impact and Global Warming	D	D	D	D	**At-work**: During construction work, CO_2 will be emitted by the operation of equipment and in transporting materials. However, the size of construction work is rather small scale and the extent limited in Battambang City. Therefore, little adverse effect is expected. **In-use:** With the operation of related facilities, CO_2 will be emitted by utilizing supplied electricity for operation. However, the volume of work is rather small and the extent limited in Battambang City. Therefore, little adverse effect is expected.

A+/-: Serious positive (+)/negative (-) impact is expected.
B+/-: Some positive (+)/negative (-) impact is expected.
C: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact could be clarified as the survey progresses.)
D: No impact is expected.

(9) Mitigation Measures

Mitigation measures are as summarized in the following table.

Table 1.3-36 (a) Mitigation Measures (Kampong Cham)

No.	Impacts	Mitigation Plan	Implementing Organization	Responsible Organization
At-work				
1	Air Pollution	1. Keep the equipment in good condition by **providing proper maintenance**. 2. Implement the construction plan/schedule properly to **minimize** occurrence of **unnecessary equipment operation**. 3. For selecting equipment, those **following environmental standards** shall be picked up. 4. For selecting transportation route for construction material as well as wastes, **shortest route** while **avoiding crowded area** as much as possible shall be taken. 5. Conduct monitoring of construction equipment periodically for verifying that conditions of equipment follow Cambodian environmental standards.	Contractor	MIME/ DIME/ KWW
2	Water Pollution	1. Keep equipment in good conditions by **providing proper maintenance** to avoid oil leakage and any other unnecessary discharges into public water. 2. Conduct monitoring of construction equipment periodically for verifying that conditions of equipment follow Cambodian environmental standards. 3. Mitigation methods such as minimizing the dredging areas and setting pollution prevention fence are planned to be applied for minimizing the scale of stirring bottom sediments.	Contractor	MIME/ DIME/ KWW
3	Waste	- Construction debris 1. Conduct proper treatment and transport them to dump site specified by MIME/PDIME/KWW and	Contractor	MIME/ DIME/ KWW

No.	Impacts	Mitigation Plan	Implementing Organization	Responsible Organization
		local authorities. - General garbage 2. Follow the guidance of local authorities and pile up garbage at the designated place. 3. Provide guidance and instructions to the workers for keeping the work site/ surrounding environment clean constantly.		
5	Noise and Vibration	1. Avoid night-time construction work. If it can not be avoided, take preventive measures like usage of noise-proof sheet for minimizing noise and vibration. 2. As soon as complaints by the residents arise, abort construction work. Contractor shall hold meetings with project owner for discussing and seeking breakthrough measures. 3. Use noise-proof sheet covering for loud construction equipment to reduce noise generation as much as possible. For piling work, apply the method not using a hammer-type pile driver. 4. Conduct monitoring arbitrarily for verifying that conditions follow Cambodian environmental standards. As soon as the condition exceeds the standards, abort construction work. Contractor shall hold meetings with project owner for discussing and seeking breakthrough measures.	Contractor	MIME/ DIME/ KWW
7	Offensive Odor	1. Dehydrate dredged sludge as much as possible and convey the treated sludge to the deposit station promptly. 2. On the way to the station, cover the carrier vehicle with sheets in order not to scatter the sludge and odors on the route. 3. As soon as complaints by residents arise, abort construction work. Contractor shall hold meetings with project owner for discussing and seeking breakthrough measures.	Contractor	MIME/ DIME/ KWW
8	Bottom Sediment	1. Apply the work method that minimizes the extent and size of dredging to reduce stirring bottom sediment.	Contractor	MIME/ DIME/ KWW
10	Ecosystem	1. Apply the work method that minimizes the extent and size of dredging to reduce stirring bottom sediment and also avoid disturbing fish pass by structures and construction works. 2. In case a number of dead fish or other dead organisms is found in the project site, abort the construction work and conduct water quality test to determine the cause. The project owner and contractor shall also take appropriate measures if necessary. 3. In bank protection works (embankment), the contractor shall survey the construction site to ensure there is no wildlife to be protected. In case that the contractor finds necessity of protection for precious organisms, the contractor shall rapidly report to MIME/PDIME/KWW and wait for next action.	Contractor	MIME/ DIME/ KWW
11	Hydrological Situation	1. Apply the work method that minimizes the extent and size of dredging to reduce the impacts on the hydrological situation.	Contractor	MIME/ DIME/ KWW
16	Local Economy such as Employment and Livelihood, etc.	1. In excavation works near local shops and market, access to facilities should be secured always by setting covering panels or any appropriate material on the excavated area. 2. Also, the length of excavation should be shorter and backfill shall be conducted promptly to minimize	Contractor	MIME/ DIME/ KWW

No.	Impacts	Mitigation Plan	Implementing Organization	Responsible Organization
		transition term until restoration.		
18	Water Usage or Water Rights and Rights of Common	1. Apply the work method that minimizes the extent and size of dredging to reduce any disturbance to water quality conditions.	Contractor	MIME/ DIME/ KWW
19	Existing Social Infrastructures and Services	1. In excavation works, placing covering panels or any suitable material on the excavated area and backfilling should be conducted promptly. 2. Consult with local authorities and the local police for seeking optimum measure for preventing traffic congestion. 3. Allocate traffic signs and traffic controllers properly to minimize the impacts of construction work and any possibility of occurrence of accident. 4. Set speed limit for construction vehicles.	Contractor	MIME/ DIME/ KWW
27	Infectious Diseases such as HIV/AIDS	1. Hold training seminars arbitrarily to learn the correct knowledge about the diseases.	Contractor	MIME/ DIME/ KWW
28	Work Environment (incl. Work Safety)	1. Comply with the labor law of Cambodia. 2. Stipulate working and safety regulations. 3. Stipulate wearing working suit, helmet or any protective gear to prevent injury. 4. Practice educational activity regarding work safety through holding morning assembly or any possible occasion. 5. Establish emergency response system.	Contractor	MIME/ DIME/ KWW
29	Accident	1. Allocate traffic signs for securing smooth traffic around construction site. 2. Allocate traffic controllers for securing smooth traffic around construction site. 3. Consult with local authorities and the local police for seeking optimum measure for preventing traffic congestion. 4. Set speed limit for construction vehicles to prevent any happening of accident.	Contractor	MIME/ DIME/ KWW
30	Transboundary Impact and Global Warming	1. Estimate the emission of global warming gases generated during the project. 2. Specify a potential factor to reduce emission based on the estimated values, and strive to reduce the emission as much as possible (vehicles, work equipment, etc.).	Contractor	MIME/ DIME/ KWW
In-use				
2	Water Pollution	1. Conduct periodical water quality monitoring according to the monitoring plan. 2. If the values exceed Cambodian standard, abort the operation and seek the cause of the phenomenon. After the conduct of necessary treatment, confirm that water quality does not exceed the standard and restart operation.	KWW	MIME/ DIME/ KWW
5	Noise and Vibration	1. Conduct monitoring near and around pumping facilities according to the monitoring plan. 2. If the values exceed Cambodian standard, abort the operation and seek the cause of the phenomenon. After the conduct of necessary treatments, confirm that the value does not exceed the standard and restart operation.	KWW	MIME/ DIME/ KWW
8	Bottom Sediment	1. If any unusual condition like floating of sludge or high turbidity is found, abort the operation and seek the cause of the phenomenon. 2. After conducting necessary treatments like re-dredging or packing, confirm the stability of bottom condition, and restart full operation.	KWW	MIME/ DIME/ KWW
10	Ecosystem	1. If any unusual condition like number of floating dead	KWW	MIME/

No.	Impacts	Mitigation Plan	Implementing Organization	Responsible Organization
		fish or any organism is found, abort the operation and seek the cause of the phenomenon. 2. After conducting necessary treatments like re-dredging or packing, confirm the surrounding condition, and restart operation.		DIME/ KWW
16	Local Economy such as Employment and Livelihood, etc.	1. Supply necessary information such as expansion area and implementation plan to private supplier. 2. Introduce other possible area for water supply or if necessary, support outplacement.	KWW	MIME/ DIME/ KWW
29	Accident	1. Comply with the "Chlorine Handling Manual" arranged by the JICA long-term expert. If necessity arises, revise the manual. 2. Conduct periodical training.	KWW	MIME/ DIME/ KWW

Table 1.3-36 (b) Mitigation Measures (Battambang)

No.	Impacts	Mitigation Plan	Implementing Organization	Responsible Organization
Pre-/At-work				
1	Air Pollution	1. Keep the equipment in good condition by **providing proper maintenance work**. 2. Implement the construction plan/ schedule properly to minimize occurrence of unnecessary equipment operation. 3. For the selection of equipment, those following environmental standards shall be selected. 4. For the selection of transportation route for construction materials as well as wastes, shortest route while avoiding crowded area as much as possible shall be taken. 5. Conduct monitoring of construction equipment periodically for verifying the conditions of equipment following Cambodian environmental standards.	Contractor	MIME/DIME/ BWW
2	Water Pollution	1. Keep equipment in good condition by providing proper maintenance work for avoiding oil leakage and any other unnecessary discharge into public water. 2. Conduct monitoring of construction equipment periodically for verifying the conditions of equipment whether or not they follow Cambodian environmental standards. 3. Mitigation methods such as minimizing the dredging areas and setting pollution prevention fence are planned to be applied for minimizing the scale of stirring bottom sediments.	Contractor	MIME/DIME/ BWW
3	Waste	- Construction debris 1. Conduct proper treatment and transport them to dump site specified by MIME/PRIME/BWW and Local authorities. - General garbage 2. Follow the guidance of local authorities and pile up garbage at the designated place. 3. Provide guidance and instructions to the workers for keeping the worksite/surrounding environment clean constantly.	Contractor	MIME/DIME/ BWW
5	Noise and Vibration	1. Avoid night-time construction work. If it	Contractor	MIME/DIME/

No.	Impacts	Mitigation Plan	Implementing Organization	Responsible Organization
		cannot be avoided, take preventive measures like usage of noise-proof sheet for minimizing noise and vibration. 2. As soon as complaint by residents arises, abort construction work. Contractor shall hold meetings with project owner for discussing and seeking breakthrough measures. 3. Use noise-proof sheet covering for loud construction equipment to reduce noise generation as much as possible. For piling work, apply the method not using a hammer-type pile driver. 4. Conduct monitoring arbitrarily for verifying that conditions follow Cambodian environmental standards. As soon as the condition exceeds the standards, abort construction work. Contractor shall hold meetings with project owner for discussing and seeking breakthrough measures.		BWW
7	Offensive Odor	1. Dehydrate dredged sludge as much as possible and convey the treated sludge to the deposit station promptly. 2. On the way to the station, cover the carrier vehicle with sheets in order not to scatter the sludge and odors on the route. 3. As soon as complaint by residents arises, abort construction work. Contractor shall hold meetings with project owner for discussing and seeking breakthrough measures.	Contractor	MIME/DIME/ BWW
8	Bottom Sediment	1. Apply the work method that minimizes the extent and size of dredging to reduce stirring bottom sediment.	Contractor	MIME/DIME/ BWW
10	Ecosystem	1. Apply the work method that minimizes the extent and size of dredging to reduce stirring bottom sediment and also avoid disturbing fish pass by structures and construction works. 2. In case a number of dead fish or other dead organisms is found in the project site, abort the construction work and conduct water quality test to determine the cause. Also take appropriate measures by the project owner and contractor if necessary. 3. In the work of bank protection (embankment), the contractor shall survey at the construction site to ensure there is no wildlife to be protected. In case that the contractor finds necessity of protection for precious organisms, the contractor shall rapidly report to MIME/PDIME/BWW and wait for next action.	Contractor	MIME/DIME/ BWW
11	Hydrological Situation	1. Apply the work method that minimizes the extent and size of dredging to reduce the impacts on the hydrological situation.	Contractor	MIME/DIME/ BWW
16	Local Economy such as Employment and Livelihood, etc.	1. In excavating works near local shops and markets, access to those facilities should be secured always by setting covering panels or any materials on the excavated area. 2. Also, the length of excavation should be shorter and backfill shall be conducted promptly to minimize transition term until	Contractor	MIME/DIME/ BWW

No.	Impacts	Mitigation Plan	Implementing Organization	Responsible Organization
		restoration.		
18	Water Usage or Water Rights and Common Rights	1. Apply the work method that minimizes the extent and size of dredging to reduce any disturbance to water quality conditions.	Contractor	MIME/DIME/ BWW
19	Existing Social Infrastructures and Services	1. In excavation works, placing covering panels or any material on the excavated area and backfilling should be conducted promptly. 2. Consult with local authorities and the local police for seeking optimum measure for preventing traffic congestion. 3. Allocate traffic signs and traffic controller properly to minimize the impacts of construction work and any possibility of occurrence of accidents. 4. Set speed limit for construction vehicles.	Contractor	MIME/DIME/ BWW
27	Infectious Diseases such as HIV/AIDS	1. Hold training seminars arbitrarily to learn the correct knowledge about the diseases.	Contractor	MIME/DIME/ BWW
28	Work Environment (incl. Work Safety)	1. Comply with labor law of Cambodia. 2. Stipulate working and safety regulations. 3. Stipulate wearing working suit, helmet or any protective gear to prevent injury. 4. Practice educational activity regarding work safety through holding morning assembly or any possible occasion. 5. Establish emergency response system.	Contractor	MIME/DIME/ BWW
29	Accident	1. Allocate traffic signs for securing smooth traffic around construction site. 2. Allocate traffic controllers for securing smooth traffic around construction site. 3. Consult with local authorities and the local police for seeking optimum measure for preventing traffic congestion. 4. Set speed limit for construction vehicles to prevent any happening of accident.	Contractor	MIME/DIME/ BWW
30	Transboundary Impact and Global Warming	1. Estimate the emission of global warming gases generated during the project. 2. Specify a potential factor to reduce emission based on the estimated values, and strive to reduce the emission as much as possible (vehicles, work equipment, etc.).	Contractor	MIME/DIME/ BWW
In-use				
2	Water Pollution	1. Conduct periodical water quality monitoring according to the monitoring plan. 2. If the value exceeds Cambodian standards, abort the operation and seek the cause of the phenomenon. After conduct of necessary treatments, confirm that water quality does not exceed the standard and restart operation.	BWW	MIME/DIME/ BWW
5	Noise and Vibration	1. Conduct monitoring near and around pumping facilities according to the monitoring plan. 2. If the value exceeds Cambodian standards, abort the operation and seek the cause of the phenomenon. After the conduct of necessary treatments, confirm that the value does not exceed the standard and restart operation.	BWW	MIME/DIME/ BWW
8	Bottom Sediment	1. If any unusual condition like floating of sludge or high turbidity is found, abort the operation and seek the cause of the	BWW	MIME/DIME/ BWW

No.	Impacts	Mitigation Plan	Implementing Organization	Responsible Organization
		phenomenon. 2. After the conduct of necessary treatments like re-dredging or packing, confirm the stability of bottom condition, and restart full operation.		
10	Ecosystem	1. If any unusual condition like number of floating dead fish or any organism is found, abort the operation and seek the cause of the phenomenon. 2. After the conduction of necessary treatment like re-dredging or packing, confirm the surrounding condition, and restart operation.	BWW	MIME/DIME/ BWW
11	Hydrological Situation	1I. if any unusual condition like low water level or floating of sludge or high turbidity is found, abort the operation and seek the cause of the phenomenon. Restart operation after necessary measures are taken.	BWW	MIME/DIME/ BWW
18	Water Usage or Water Rights and Common Rights	1. If water level of Sangke River becomes lower than the sustainable level, impose restrictions on water intake from river.	BWW	MIME/DIME/ BWW
29	Accident	1. Comply with "Chlorine Handling Manual" introduced by the JICA long-term expert. If necessity arises, revise the manual. 2. Conduct periodical training.	BWW	MIME/DIME/ BWW

(10) Monitoring Plan

The Monitoring Plan for the Project in Kampong Cham is as summarized in the following table.

Table 1.3-37 (a) Monitoring Plan (Kampong Cham)

Item	Monitoring Item	Location	Frequency	Responsible Organization
Pre-work				
Ecosystem (Fauna & Flora)	Confirmation of existence of precious or protected species in the project site	Project Area	Once	Contractor
At-work				
Air Pollution	TSP, CO, NO_2, and SO_2	On property line of closest house or residential area in each construction site.	Monthly or as construction site moves	Contractor
Water Pollution	pH, DO, SS, BOD, Oil and Coliform with visual observation of surface condition	2 points; one for upstream of intake facility, the other is downstream.	Monthly	Contractor
Noise and Vibration	Noise level (L_{max})	On property line of closest house or residential area in each construction site.	Monthly or as construction site moves	Contractor
Bottom Sediment	Field reconnaissance for confirming presence or absence of dead body of aquatic organism and suspended substance.	Intake facility site	Weekly	Contractor
Ecosystem	Field reconnaissance for confirming presence or absence of protected animals, plants or any precious organisms around the	Whole project area	Once	Contractor

Item	Monitoring Item	Location	Frequency	Responsible Organization
	construction site.			
Hydrological Situation	Field reconnaissance for confirming presence or absence of dead body of aquatic organism and suspended substance.	Intake facility site and its surrounding water area	Weekly during construction term of the facility.	Contractor
Local Economy such as Employment and Livelihood, etc.	Hearing survey for confirming presence or absence of complaints or disturbance on commercial activities.	Each construction site	One time in each construction site.	Contractor
Water Usage or Water Rights and Rights of Common	Field reconnaissance for confirming presence or absence of complaints.	Whole Project Area	Monthly during the construction of intake facility	Contractor
Existing Social Infrastructures and Services	Field reconnaissance for confirming presence or absence of traffic disturbances.	Each construction site and its surrounding/ connecting roads.	Weekly or as construction site moves	Contractor
HIV	Holding meeting for providing necessary instructions to workers	Each construction site.	Monthly	Contractor
Work Environment (incl. Work Safety)	Inspection for construction sites regarding stipulated rules are followed or not.	Each construction site.	Weekly or as construction site moved.	Contractor
Accident	Field reconnaissance for confirming presence or absence of any accident.	Each construction site.	Weekly or as construction site moves.	Contractor
In-use				
Air Pollution	TSP, CO, NO_2, SO_2	On property line of closest house or residential area at intake pump and conveyance pump	Biannual (For 2 years from the start of service)	MIME/DIME/ KWW
Water Pollution	Water quality monitoring of Items listed in Water Quality standard for drinking water and surface conditions at the site.	2 points; one is upstream of Waste pond outlet and the other is downstream.	Biannual (For 2 years from the start of service)	MIME/DIME/ KWW
Waste	Field reconnaissance for confirming whether the process of generated waste from treatment facility is properly conducted.	Treatment facility and Waste disposal site	Monthly	
Noise and Vibration	Noise level (L_{max})	On property line of closest house or residential area at intake pump and conveyance pump	Biannual (For 2 years from the start of service.)	MIME/DIME/ KWW
Local Economy such as Employment and Livelihood, etc.	Conditions and the activity of the local commercial facilities.	Commercial Area in the project Area	Biannual (For 2 years from the start of service.)	MIME/DIME/ KWW
Accident	Confirm that the procedures for Chlorine handling follows the Chlorine handling manual.	Treatment facility	Biannual	MIME/DIME/ KWW

Table 1.3-37 (b) Monitoring Plan (Battambang)

Item	Monitoring Item	Location	Frequency	Responsible Organization
Pre-work				
Ecosystem (Fauna & Flora)	Confirmation of existence of precious or protected species in the project site.	Project Area	Once	Contractor
At-work				
Air Pollution	TSP, CO, NO_2, and SO_2	On property line of closest house or residential area in each construction site.	Monthly	Contractor
Water Pollution	pH, DO, SS, BOD, Oil and Coliform with visual observation of surface condition.	2 points; one for upstream of drainage outlet site, one is downstream of the outlet site.	Monthly	Contractor
Waste	Field reconnaissance for confirming whether or not the process of generated wastes (both industrial and general) is properly conducted.	Waste disposal site	Monthly	
Noise and Vibration	Noise level (L_{max})	On property line of closest house or residential area in each construction site.	Monthly	Contractor
Offensive Odor	Field reconnaissance for confirming presence or absence of offensive odor.	Waste pond outlet at Sangkae river.	Weekly	Contractor
Bottom Sediment	Field reconnaissance for confirming presence or absence of dead body of aquatic organism and suspended substance.	Intake facility site.	Weekly or each time in movement of construction site from one place to another.	Contractor
Ecosystem	Field reconnaissance for confirming presence or absence of protected animals, plants or any precious organisms	Project Area, especially, the surrounding area of each construction site.	Once	Contractor
Hydrological Situation	Field reconnaissance for confirming presence or absence of dead body of aquatic organism and suspended substance.	Intake facility site and its surrounding water area.	Weekly during construction term of the facility.	Contractor
Local Economy such as Employment and Livelihood, etc.	Hearing survey for confirming presence or absence of any complains or disturbance on their commercial activities.	Each construction site.	One time in each construction site.	Contractor
Water Usage or Water Rights and Common Rights	Field reconnaissance for confirming presence or absence of any complains.	Project Area	Monthly	Contractor
HIV	Holding meeting for providing necessary instructions to workers	Each construction site.	Monthly	Contractor
Work Environment (incl. Work Safety)	Inspection for construction sites regarding stipulated rules are followed or not.	Each construction site.	Weekly or as construction site moved.	Contractor
Existing Social	Field reconnaissance for	Each construction site	Weekly or as	Contractor

Item	Monitoring Item	Location	Frequency	Responsible Organization
Infrastructures and Services	confirming presence or absence of any traffic disturbances.	and its surrounding/ connecting roads.	construction site moved	
Accident	Field reconnaissance for confirming presence or absence of any traffic disturbances.	Each construction site and its surrounding / connecting roads.	Weekly or each time in movement of construction site from one place to another.	Contractor
In-use				
Air Pollution	TSP, CO, NO_2, SO_2	On property line of closest house or residential area at intake pump and conveyance pump	Biannual (For 2 years since the start of service.)	MIME/DIME /BWW
Water Pollution	Water quality monitoring of Items listed in Water Quality standard for drinking water and surface conditions at the site.	2 points; one is upstream of Waste pond outlet and the other is downstream.	Biannual (For 2 years since the start of service.)	*MIME/DIME /BWW*
Waste	Field reconnaissance for confirming whether the process of generated waste from treatment facility is properly conducted or not.	Treatment facility and Waste disposal site	Monthly	
Noise and Vibration	Noise level (L_{max})	On property line of closest house or residential area at intake pump and conveyance pump	Biannual (For 2 years since the start of service.)	MIME/DIME /BWW
Hydrological Situation	Field reconnaissance for confirming presence or absence of dead body of aquatic organism and suspended substance.	Intake site of Sangke River	Biannual (For 2 years since the start of service.)	MIME/DIME /BWW
Water Usage or Water Rights and Rights of Common	Hearing survey for confirming presence or absence of any complains.	Adjacent Area of Battambang City	Monthly	MIME/DIME /BWW
Accident	Confirm that procedure for Chlorine handling is following the Chlorine handling manual.	Treatment facility	Biannual	MIME/DIME /BWW

(11) Stakeholder Meeting

During the first field survey, JST requested MIME, KWW and BWW to hold a stakeholder meeting. The Cambodian side responded to the request and held stakeholder meetings in both cities as shown in the following tables.

Table 1.3-38(a) Outline of the Stakeholders Meeting in Kampong Cham

Date / Place	Target / Subject	Comments from the Residents	Responses to the Comments
Aug. 14, 2012 Kampong Cham Water Works (KWW)	Residents in Project Area Project Objective, Outline, Area and Schedule in Kampong Cham	The residents welcomed the project, but suggested that impacts should be minimized. The residents requested that the project owner shall charge a water tariff lower than the present rate. The residents suggested that during the laying of conveyance route pipes under the ground, the contractor must make sure that excavations be filled up immediately and shall also ensure that the installation site be properly cleaned after pipe installation. If reconnection is necessary, they will not support the project If possible, the project owner shall change the conveyance pipe route from Kampuchea Krom Road to another road because traffic in this road is very heavy. The residents expressed 100% support on the project and want to see that all people in Kampong Cham Town have access to safe water from the project.	By taking mitigation measures such as selection of area, adjustment of construction method, scale, timing, driving sheet-pile, setting panels, etc, with the conduct of monitoring, adverse impacts can be minimized. For the waste management, provide the contractors thorough instruction in waste management. Since water tariff is already the lowest level in Cambodia, it cannot be lower than the present rate while making additional considerations toward poor households. No reconnection is required by the Project.
Jul. 24-27, 2012 KWW and other Department Offices	Director of KWW, Director of PD of LMUPC Director of PD of PWT Director of PD of Environment Director of PD of Agriculture Project Objective, Outline, Area and Schedule in Kampong Cham	Welcome the project, willing to help if requested, and strongly support the project. Would like to see it implemented as soon as possible. Make sure that land conflict with people should be avoided during the construction phase and the construction contractor has to take care of traffic jams, especially near the market. Also, try to minimize all impacts such as air and noise pollution. Take special consideration of demand expansion for the future.	By taking mitigation measures such as selection of area, adjustment of construction method, scale, timing, driving sheet-pile, setting panels, etc., with the conduct of monitoring, adverse impact can be minimized. The project is designed considering the demand in 2019.

Table 1.3-38(b) Outline of the Stakeholders Meeting in Battambang

Date / Place	Target / Subject	Comments from the Residents	Responses to the Comments
Aug. 7, 2012 Open space in Ex-Pepsi Factory	Residents in Project Area Project Objective, Outline, Area and Schedule in Battambang	The proposed project is good for people in Battambang City since they can use safe/clean water. The resident also suggested that water price should be cheaper or at least the same as the present price. The residents suggested that the project owner should carefully consider the affected households. If reconnection is necessary, they will not support the project. The residents are happy to hear about the new project and thus support the project. If possible, water price should be discounted.	Responding to the request of the residents and local authorities, alternative plan in which no resettlement is required is carefully selected. No reconnection is required by the Project. Considering operation cost of planned facilities, it is difficult to lowering the price. On the other hand, the current water price will be maintained.
Aug. 6-8, 2012	Director of BWW D.Director of PD. of PWT Director of PD of	Provide full support for the project in all project phases. Would like to see the implementation and connection to the safe water as soon as	Alternative plan in which no resettlement is required is carefully selected. By taking mitigation measures such

Date Place	Target Subject	Comments from the Residents	Responses to the Comments
	Planning Director of PDIME Officer of PD of Environment D. Director of PD. of Agriculture Chamkar Samoroang Commune Leader	possible. Make sure that land conflict with people is avoided. Also, try to minimize all impacts such as air and noise pollution with proper preventive methods. Take special consideration on health issues during the construction phase	as selection of area, adjustment of construction method, scale, timing, driving sheet-pile, setting panels, etc., with of the conduct of monitoring, adverse impact can be minimized.
KWW and other Departme nt Offices	Project Objective, Outline, Area and Schedule in Battambang		

1.3.2 Land Acquisition and Resettlement

(1) Necessity of Land acquisition and resettlement

a. Project in Kampong Cham

Intake facility and treatment facilities are planned to be constructed in public own unutilized area and the pipe network is planned to be embedded beneath the road network. Therefore, no land acquisition nor resettlement is required for implementation of the Project in Kampong Cham.

b. Project in Battambang

There are several households living in the planned treatment facility site. As respond to the request of MIME, JST selected the alternative plan in which no resettlement is required. In addition to this, intake facility is planned to be constructed in public own unutilized area and the pipe network is planned to be embedded beneath the road network. Therefore, no land acquisition nor resettlement is required for implementation of the Project in Battambang also.

(2) Legal framework for Land Acquisition and Resettlement

Under the Pol Pot regime, all private possession of the land was prohibited and most of the records for the land were demolished. Therefore, there are many cases that no evidences for the land ownership even now. Beside, there are also many cases that people have settled wherever practically feasible since above mentioned time without legal right.

In response, Cambodia enacts constitution (1993), Land Law (2001) and Land Acquisition Law (2009). The outline of these are described as follows.

a. Constitution (1993)

Article 44 secures the right of the land possession of Cambodia people and prohibits the possession by foreign people and company. Article 58 stipulates that the natural resources such as water, river, mine, geology, forest, shore and etc belongs to the state or local authority.

b. Land Law (2001)

Article 4 also secures the right of the land possession of Cambodian people as article 44 of Constitution while Article 5 stipulates that the right is secured except for the benefit for the public purpose.

Article 12 stipulates that the State is the owner of the properties in the territory of the Kingdom of Cambodia enumerated in Article 58 of the 1993 Constitution and of all properties that are escheat, or that are voluntarily given to the State by their owners, or that have not been the subject of due and proper private appropriation or that are not presently being privately occupied.

Article 15 stipulates that the property such as river, lake, structure for public service such as road and etc falls within the public property of the State and public legal entities.

Article 35 stipulates that only the competent authorities may, on behalf of the State and public legal entities, force occupants without title or insufficient titles to vacate the immovable property.

c. Expropriation Law (2009)

Article 1 stipulates the objective of the law, such as defining principle, mechanisms and procedures.

Article 3 stipulates that the law shall be applied to expropriations involving public physical infrastructure projects in the Kingdom of Cambodia not for expropriations investment by partner countries..

Article 5 stipulates the target projects.

Article 12 to 14 stipulate the expropriation mechanism, such as Expropriation Committee: EC, Expropriation Sub Committee: SEC and Complaint Resolution Committee.

Although, the articles stipulate that the details of the mechanisms and functions shall be defined in sub-decree, the said sub-decree has not been enacted yet.

Article 19 stipulates that The expropriation of the ownership of immovable property and real right to immovable property can be exercised only if the Expropriation Committee has paid fair and just compensation to the property's owner.

Article 22 stipulates that Financial compensation given to the property owner and/or rightful owner shall be based on a market price or replacement price on the date of declaration of the expropriation.

(3) Scale of Land Acquisition and Resettlement

No resettlement and land acquisition is required for the Project.

(4) Compensation

No compensation is required for the Project.

(5) Grievance Mechanism

No grievance mechanism is required for the Project.

(6) Implementation Structure for Land Acquisition and Resettlement

No implementation structure is required for the Project.

(7) Budget and Financial source

No budget for land acquisition and resettlement is required.

(8) Monitoring framework of implementation organization and monitoring form

No monitoring framework nor the monitoring form is required for the Project.

(9) Stakeholder Meeting

The stakeholder meeting was conducted before the selection of alternative plan. The result of the meeting is described as follows.

a. Before the Project

A stakeholder meeting was held by the Royal Government of Cambodia (RGC) in 2010 for the dissemination of future utilization of the land, ex-Pepsi factory site, to the residents. The attendants in April, 2010 were the leaders of the communes and the residents while the attendants in May 2010 were the Vice Governor of Battambang and the commune leader. The government proposed providing 70m^2 of land in the factory site to each household.

b. After the Project Started

A public consultation meeting was held in August, 2012 at the ex-Pepsi factory site after the Project was started. The outline of the meeting is described in the following table.

Table 1.3-39 Public Consultation Meeting

Date	Place	Target	Subject	Results
Aug. 9, 2012	Open space in Ex-Pepsi Factory site	Residents in Project Area	Project Objective, Outline, Area of Resettlement and Schedule	Resettlement shall be avoided. The residents have no choice if the government proceeds properly, however, reasonable compensation or enough land space shall be provided. Connection to roads with more than 3m in width shall be secured The proposed resettlement area is at the back of another settlement so that the space is not appropriate.

1.3.3 Others

(1) Monitoring Form (Draft)

Drafts of the monitoring forms are shown as follows.

a. Air Quality : Ambient Air (For both Construction & In-service period)

Item	Measured Value (Mean)	Measured Value (Max.)	Cambodian STD 1-hour mean	Japanese STD 1hour Value	WHO Guideline	Remarks (Measurement Point, Frequency, Method, etc.)
CO			<40mg/m^3	<10ppm	-	1 site including sensitive receptors near the project site or others Frequency: Monthly Method: Authorized methods in Cambodia, WHO.
NO_2			<0.3mg/m^3	< 0.04ppm	<0.2mg/m^3 1-hour mean	
SO_2			<0.5mg/m^3	< 0.04ppm	<0.5mg/m^3 1-hour mean	
O_3			<0.2 mg/m^3	<0.06ppm As Ox	<0.1mg/m^3 8-hour mean	
Pb			<0.005 mg/m^3 8-hour mean	-	-	
TSP			<0.33 mg/m^3	<0.2mg/m^3 as SPM	<0.05mg/m3 as PM_{10} 24-hour mean	

b. Water Quality

b-1) Construction Period: Ambient Water Quality

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Cambodian STD	Japanese STD Class AA	WHO Drinking Water Guideline	Remarks (Measurement Point, Frequency, Method, etc.)
pH	-			6.5 – 8.5	6.5 – 8.5	-	Each up & downstream of the center of construction (2 points in total) Frequency: Monthly during construction. Biannual in use. In use, Drinking items shall be monitored. Method: Authorized methods in Cambodia, WHO.
TSS	mg/l			25 - 100	< 25	-	
BOD	mg/l			1.0 – 10	< 1.0	-	
DO	mg/l			2.0-7.5	> 7.5	-	
Coliform	MPN /100 ml			< 100ml	< 50 MPN/100ml	< 0	

b-2) In-service period: Ambient Water Quality (pH to DO) and Drinking Water Quality

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Cambodian STD	Japanese STD	WHO Guideline	Remarks (Measurement Point, Frequency, Method, etc.)
pH	-			6.5 – 8.5	6.5 – 8.5	-	Each up & downstream of the center of construction (2 points in total) Frequency: Monthly during construction. Biannual in use. In use, Drinking items shall be monitored. Method: Authorized methods in Cambodia, WHO.
TSS	mg/l			25 - 100		-	
BOD	mg/l			1.0 – 10	< 1.0	-	
DO	mg/l			2.0-7.5	> 7.5	-	
Coliform	MPN /100ml			< 0	< 0	< 0	
TDS	mg/l			< 800	< 500	<1000	
Turbidity	NTU			< 5	0.1(degree)	< 5	
T. Hardness	mg/l			< 300	< 300	-	
NO2	mg/l			< 3.0	-	< 0.2	
NO3	mg/l			< 50.0	< 10 as nitrate	< 50	

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Cambodian STD	Japanese STD	WHO Guideline	Remarks (Measurement Point, Frequency, Method, etc.)
					-nitrogen & nitrite -nitrogen		
SO4	mg/l			< 250	-	< 250	
F	mg/l			< 1.5	< 0.8	< 1.5	
Cl	mg/l			< 250.0	< 200	< 250	
NH4	mg/l			< 1.5	-	< 1.5	
Color	TCU			< 5.0	5(degree)	15	
CN	mg/l			< 0.07	< 0.01	< 0.07	
Al	mg/l			< 0.2	-	< 0.2	
As	mg/l			< 0.05	< 0.01	< 0.01 provisional value	
Cd	mg/l			< 0.003	< 0.01	< 0.003	
Cr	mg/l			< 0.05	< 0.05 as Hexavalent chromium	< 0.05 provisional value	
Cu	mg/l			< 1	< 1	< 2 provisional value	
Fe	mg/l			< 0.3	< 0.3	< 0.3	
Pb	mg/l			< 0.01	< 0.01	< 0.01	
Mn	mg/l			< 0.1	< 0.05	< 0.5 provisional value	
Hg	mg/l			< 0.001	< 0.0005	< 0.001	
Se	mg/l			< 0.01	< 0.01	< 0.01	
Zn	mg/l			< 3.0	< 1	< 3	

c. Wastes

c-1) Construction Period

Basic Information	Monitoring Item	Remarks
Date/Time Surveyor's Name Description of the general condition Map	Check whether the procedures for dumping the sludge/waste soils and general wastes generated by construction works are conducted properly or not.	Note: If the procedures are not conducted as designated, additional training session or morning session shall be hold to remind proper procedures.

c-2) In-service period

Basic Information	Monitoring Item	Remarks
Date/Time Surveyor's Name Description of the general condition Map	Check whether the procedures for dumping the sludge generated by drying bed are conducted right or not.	Note: If the procedures are not conducted as designated, additional training session or morning session shall be hold to remind proper procedures.

d. Noise & Vibration (For both Construction and In-service period)

Basic Information	Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Remarks (Measurement Point, Frequency, Method, etc.)
Date/Time Surveyor's Name	Noise level (Lmax)	dB(A)			60dB(A) (depend on the time)	1 sites including sensitive receptors near the project site or others Frequency: See *1
Description of the general condition	Vibration level (Lmax)	dB			-	

e. Offensive Odor (Construction Period)

Basic Information	Monitoring Item	Remarks
Date/Time Surveyor's Name Description of the general condition	Floating substances such as dead body of living organism.	Note: Visual observation for checking of existing floating materials like dead body or any organisms, suspended substances with confirmation of any occurrence of offensive odor shall be conducted.
Map	Occurrence of offensive odor.	

f. Bottom Sediment (Construction Period)

Basic Information	Monitoring Item	Remarks
Date/Time Surveyor's Name Description of the general condition	Floating substances such as dead body of living organism.	Note: Visual observation for checking of existing floating materials like dead body or any organisms, suspended substances shall be conducted.
Map	Rapid increase of Turbidity	
	Rapid increase/decrease of current speed, flaw rate.	

g. Ecosystem (For Pre-construction/Construction Period/In-service period)

Date/time Date: Time:	Place	Fauna										Flora							
		Mamal		Bird		Reptile		Amphibian		Fish		Insect /Others		tree				herbaceous plant	
														Coniofer		Deciduouse		Evergreen	
Habitat Condition		Sp. Name	Num																
scription; eg gregarious/ solita																			
Picture																			
Map																			

h. Hydrological Situation (For both Construction and In-service period)

Basic Information	Monitoring Item	Remarks
Date/Time Surveyor's Name Description of the general condition Map	Rapid increase of Turbidity	Note: Visual observation for checking of existing river conditions, such as flow rate, flow amount and floating materials like dead body or any organisms, suspended substances shall be conducted.
	Rapid increase/decrease of current speed, flaw rate.	
	Floating substances such as dead body of living organism.	

i. Local Economy such as Employment and Livelihood, etc.

i-1) Construction Period

Basic Information	Monitoring Item	Remarks
Date/Time Surveyor's Name	Occurrence of any disturbances to access to commercial facilities near by the construction site.	Note: Visual observation for checking of occurrence of any disturbance while checking whether any complains has been arisen.
Description of the general condition	Occurrence of any complaints from the owner/shop keeper of commercial facilities near by the construction site.	
Map	Floating substances such as dead body of living organism in the river which may disturb the local fishery.	

i-2) In-service period

Basic Information	Monitoring Item	Remarks
Date/Time Surveyor's Name Description of the general condition	Occurrence of any disturbances on the business of existing private water supply companies and checking their responses to the condition.	Note: checking whether any complains has been arisen and conduct hearing if necessary.

j. Water Usage or Water Rights and Rights of Common

(For both Construction and In-service period)

Basic Information	Monitoring Item	Remarks
Date/Time Surveyor's Name Description of the general condition Map	Rapid decrease of current speed, flaw rate. Rapid increase of Turbidity Floating substances such as dead body of living organism. Occurrence of any complaints from the residents/officer of other supply area.	Note: Visual observation for checking of existing river conditions, such as flow rate, flow amount and floating materials, turbidity and existence of any complains regarding water utilization.

k. Existing Social Infrastructures and Services （Construction Period）

Basic Information	Monitoring Item	Remarks
Date/Time Surveyor's Name Description of the general condition Map	Occurrence of any disturbances to access roads close to the construction site. Occurrence of any complaints from the driver/ residents	Note: Visual observation for checking of occurrence of any disturbance while checking whether any complains has been arisen.

l. Infectious Diseases such as HIV/AIDS（Construction Period）

Basic Information	Monitoring Item	Remarks
Date/Time Surveyor's Name Description of the general condition	Checking whether holding morning session or any training sessions for reminding the risk of infectious diseases and preventive measures.	Note: number of holding sessions, and participants shall be monitored.

m. Working Environment （Construction Period）

Basic Information	Monitoring Item	Remarks
Date/Time Surveyor's Name Description of the general condition Map	Checking whether morning session or any training sessions for reminding the risk of occurrence of accidents and preventive measures are properly conducted. Checking whether proper rest is provide.	Note: number of holding sessions, and participants shall be monitored.

n. Accident

n-1) Construction Period

Basic Information	Monitoring Item	Remarks
Date/Time Surveyor's Name Description of the general condition Map	Checking whether holding morning session and any training sessions for reminding the risk of occurrence of accidents and preventive measures. Checking whether necessary traffic signs and traffic control personnel are properly allocated.	Note: number of holding sessions, and participants as well as proper treatment such as allocation of traffic signage shall be monitored.

n-2) In-service period

Basic Information	Monitoring Item	Remarks
Date/Time Surveyor's Name Description of the general condition Map	Checking whether proper treatment of chlorine is conducted as defined in the treatment manual.	Note: number of holding sessions, and participants shall be monitored.

(2) Environmental Checklist

Environmental Checklist is shown in the following table.

Table 1.3-40 Environmental Checklist

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a) Y (b) N (c) N (d) N	(a) IEE instead of EIA is required for the Project. IEE has been prepared. (b) IEE has been prepared and expected to be approved by June 2013. (c) No condition is imposed for the approval of IEE. (d) Permission of intake from Mekong and Sangkae river will be requested to MOWRAM by MIME and expected to be approved by February 2013.
	(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders? (b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?	(a) Y (b) Y	(a) Public hearings for local residents were held on Aug. 14th, 2012 in Kampong Cham and on Aug. 7th 2012 in Battambang. (b) The comments of the residents are reflected as taking counter measures for noise & vibration, minimization of the expected traffic disturbances by securing access during construction and setting poverty considered water prices on the Project.
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	(a) Y	(a) Alternative plans for intake positions/ facilities and distribution networks were examined. As the results, the plans in which least adverse effects are expected are selected.
2 Pollution Control	(1) Air Quality	(a) Is there a possibility that chlorine from chlorine storage facilities and chlorine injection facilities will cause air pollution? Are any mitigating measures taken? (b) Do chlorine concentrations within the working environments comply with the country's occupational health and safety standards?	(a) N (b) Y	(a) By taking preventive measure such as conduction of treatment trainings, occurrence of pollution or leakage can be prevented. (b) Trainings have been conducted as designated and this complies the condition.
	(2) Water Quality	(a) Do pollutants, such as SS, BOD, COD contained in effluents discharged by the facility operations comply with the country's effluent standards?	(a) Y	(a) With proper conduction of mitigation measures, water quality standard can be attained.
	(3) Wastes	(a) Are wastes, such as sludge generated by the facility operations properly treated and disposed in accordance with the country's regulations?	(a) Y	(a) With proper conduction of mitigation measures, proper procedures of planned waste management can be secured.
	(4) Noise and Vibration	(a) Do noise and vibrations generated from the facilities, such as pumping stations comply with the country's standards?	(a) Y	(a) With proper conduction of mitigation measures, the standard of noise and vibration can be attained
	(5) Subsidence	(a) In the case of extraction of a large volume of groundwater, is there a possibility that the extraction of groundwater will cause subsidence?	(a) N	(a) No intake of ground water is required for the Project.
3 Natural Environment	(1) Protected Areas	(a) Is the project site or discharge area located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a) N	(a) No protected area exists within the Project area.
3 Natural Environment	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site or discharge area encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? (d) Is there a possibility that the amount of water used (e.g., surface water, groundwater) by project will adversely affect aquatic environments, such as rivers? Are adequate measures taken to reduce the impacts on aquatic environments, such as aquatic organisms?	(a) N (b) Y (c) Y (d) Y	(a) The Project area consists of urban & residential area and thus, no precious fauna and flora exit. (b) Although, Mekong giant catfish and the Irrawaddy dolphin inhabit in Mekong River near the Cambodia-Laos border but there is no report that they exist near the project area. (c) Mitigation methods such as minimizing the dredging areas and setting pollution prevention fence are planned to be applied for minimizing the scale of stirring bottom sediments. (d) No serious adverse effect is expected while mitigation measures are planned to be conducted.
	(3) Hydrology	(a) Is there a possibility that the amount of water used (e.g., surface water, groundwater) by the project will adversely affect surface water and groundwater flows?	(a) Y	(a) No serious adverse effect is expected. In Mekong river; the intake amount is very low comparing to the flow rate of the river, therefore, the effects of the intake is very small. In Sangkae river; although the flow rate during dry season is very small, the effects of the intake can be minimized by controlling the intake amount during the term.
4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Is the compensations going to be paid prior to the resettlement? (e) Is the compensation policies prepared in document? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is the grievance redress mechanism established?	(a) Y (b) Y (c) - (d) - (e) - (f) - (g) - (h) - (i) - (j) -	(a) Alternative plan is selected in which no resettlement nor land acquisition is required. (b) Public consultation meeting was held for explaining the plan of the Project (c) Alternative plan in which no resettlement nor land acquisition is required is selected and thus, resettlement plan is not required. (d) No compensation is required. (e) No compensation is required. (f) No adverse impact on vulnerable is expected. (g) No resettlement is required. (h) No resettlement is required. (i) No resettlement is required. (j) No resettlement is required.
4 Social Environment	(2) Living and Livelihood	(a) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary? (b) Is there a possibility that the amount of water used (e.g., surface water, groundwater) by the project will adversely affect the existing water uses and water area uses?	(a) Y (b) Y	(a) Construction works may affect on commercial activity by disturbing the access to commercial facilities and therefore, mitigation measures such as securing traffics are planned to be applied for minimizing the impacts. (b) Limitation of intake amount will be applied as the river follow goes lower than certain level.
	(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a) N	(a) No precious heritage or historical site exits within the Project area.
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a) N	(a) No precious landscape exits within the Project area.
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected?	(a) N (b) N	(a) No Project component gives adverse effects on minority and native inhabitants. (b) No Project component gives adverse effects on poor.
	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?	(a) - (b) - (c) - (d) -	(a) The project owner plans to request the contractor to take necessary measures such as holding morning assembly and training sessions for securing proper working conditions defined in laws and regulations in Cambodia. (b) The project owner plans to request the contractor to take necessary measures such as holding morning assembly and training sessions which help promote taking necessary safety procedures such as wearing gears. (c) The project owner plans to request the contractor to take necessary measures. (d) The project owner plans to request the contractor to take necessary measures for preventing any violations of safety measures.
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts? (d) If the construction activities might cause traffic congestion, are adequate measures considered to reduce such impacts?	(a) Y (b) Y (c) Y (d) Y	(a) Mitigation measures such as selection of proper construction method and equipment are planned to be applied for reduce the impacts. (b) Mitigation measures such as selection of proper construction method and equipment can reduce the adverse impacts. (c) Mitigation measures such as selection of proper construction method and equipment can reduce the adverse impacts. (d) Mitigation measures such as selection of proper construction method and equipment can reduce the adverse impacts such as traffic congestion.
5 Others	(2) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	(a) Y (b) Y (c) Y (d) Y	(a) Conduction of monitoring activities will be requested according to proposed monitoring plan. (b) By Cambodian standards for air and water quality. (c) GOC will secure the budget for the monitoring activities and request the contractor to conduct properly. (d) Those should be stipulated in Monitoring plan.
6 Note	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Dam and River Projects checklist should also be checked.	(a) -	-
	Note on Using Environmental Checklist	(a) If necessary, the impacts to Transboundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as Transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a) N	No serious adverse impact is expected.

Chapter 2 Contents of the Project

2.1 Basic Concept of the Project

2.1.1 Overall Goal and Project Objective

The project is implemented with the support of the Government of Japan to increase the safe water access and improve water supply services by expanding water supply facilities in Kampong Cham and Battambang. The project will contribute to better living environment in both cities. The overall goal, purpose and output of the project are restated as follows:

Overall Goal: To improve living environment in Kampong Cham and Battambang
Purpose: To improve water supply services in Kampong Cham and Battambang
Output: Expanded water supply facilities in Kampong Cham and Battambang

2.1.2 Project Description

This project to develop the water supply system in Kampong Cham and Battambang includes: a) construction of water supply facilities, such as intake facilities, raw water conveyance pipelines, treatment facilities and clear water transmission and distribution facilities, b) equipment procurement for water quality control and service connections for poor families, and c) technical assistance, for operation and maintenance of water supply facilities and water flow management and control. It is anticipated that water supply to 84.8% of the population in urban areas in Kampong Cham and Battambang will be achieved by the target year of 2019.

The major components of Japanese assistance are as follows:

(1) Construction of Water Supply Facilities

<Kampong Cham> Water Supply Capacity: 11,500 m3/day

- Intake Facility, 12,650 m^3/day
- Raw Water Transmission Pipeline, 0.9 km
- Water Treatment Plant, 11,500 m^3/day
    - Rapid Mixing Basin
    - Flocculation Basin (up-down flow type, 3 basins)
    - Sedimentation Basin (3 basins)
    - Rapid Sand Filters (6 filter beds)
    - Distribution Reservoir (2,500 m^3)
    - Transmission Pump (3 pumps including one stand-by)
    - Distribution Pump (5 pumps including one stand-by, low-voltage inverter)
    - Electrical Facilities, Chemical Feeding Facility

    - Operation Building, Sludge Drying Bed (lagoon), Others
- Transmission Pipeline, 0.9 km
- Distribution Pipeline, 57.8 km

<Battambang> Water Supply Capacity: 22,000 m3/day

- Intake Facility, 24,200 m^3/day
- Raw Water Transmission Pipeline, 4.4 km
- Water Treatment Plant, 22,000 m^3/day
    - Rapid Mixing Basin
    - Flocculation Basin (up-down flow type, 4 basins)
    - Sedimentation Basin (4 basins)
    - Rapid Sand Filters (6 filter beds)
    - Distribution Reservoir (6,000 m^3)
    - Distribution Pump (5 pumps including one stand-by, low-voltage inverter)
    - Electrical Facilities, Chemical Feeding Facility
    - Operation Building, Sludge Drying Bed (lagoon), Others
- Distribution Pipeline, 65.5 km

(2) Equipment Procurement

- Equipment for Water Quality Control
- Equipment for Mechanical Facility
- Equipment and Materials for Service Connection

(3) Soft Component (Technical Assistance)

- Operation and Maintenance for Water Treatment Facilities
- Operation and Maintenance for Water Distribution Facilities
- Production Management

2.2 Outline Design of the Japanese Assistance

2.2.1 Design Policy

2.2.1.1 Basic Principles

This project aims to improve the water supply services and increase the rate of access to safe water for the people in Kampong Cham and Battambang. In accordance with the official request from the GOC and the results of the preparatory survey, the water supply systems in both cities will be expanded based on the following design targets and principles.

a. The target year of the project is 2019, three years after the completion of the project.
b. The increase of water supply capacities required is 11,500 m3/day for Kampong Cham and 22,000 m3/day for Battambang, in accordance with the water demand projected for 2019 and the existing water supply capacity.
c. Standards to be applied are ones widely used in Cambodia by the Phnom Penh Waterworks and those used for the on-going Japanese Grant Aid Project - "Project on Replacement and Expansion of Water Distribution System for Pursat, Sihanoukville and Battambang". Reference to "Design Criteria for Waterworks Facilities" prepared by the Japan Water Works Association will also be made.
d. Equipment provision is only for minimum required equipment for operation and maintenance of the facilities to be constructed in consideration of the official request from the GOC and the equipment that is currently available.
e. In order to increase the water service ratio for the poor, as is the case with the on-going Japanese Grant Aid Project and the projects by other donors, this project also provides equipment and materials for service connections for poor families.
f. Local contractors, under the supervision of the Japanese contractor, will be utilized as sub-contractors for the construction of the water supply facilities. There will be appropriate scrutiny of their abilities, company sizes and experience.
g. Implementation schedule is planned with careful consideration of the water level of the river in wet season and as much as possible, the intake facilities will be constructed during dry season.
h. By the soft component (technical assistance), staff in Kampong Cham and Battambang will be trained to conduct the operation and maintenance of the facilities constructed by the project.

2.2.1.2 Environmental Factors

<u>Rainfall</u>

Kampong Cham and Battambang have tropical monsoon climate. The average temperature is

28.3 degree centigrade in Kampong Cham and 28.4 degree centigrade in Battambang. The wet season is from June to October and the dry season is from November to May. Kampong Cham and Battambang had annual rainfalls of 1,417 and 1,297 mm respectively in 2011. There are many rain-related unworkable days and the construction would be scheduled based on the workable days of the year.

Water Flow and Level

The Mekong River is the source of raw water for the new water treatment plant in Kampong Cham. The Sangke River is the source of raw water for the existing and new water supply systems in Battambang. There is a big difference between the water levels of the Mekong River in wet and dry seasons. The construction of the intake facilities should be implemented during the period of lower water level from December to April, as much as possible.

Topographical and Geological Conditions

Since the urban areas of Kampong Cham and Battambang are relatively flat, water distribution from the reservoirs would require pumping to reach the wider area to be covered in future. Geological surveys were conducted and topographical conditions analyzed to provide the basic understanding for the design of the new facilities.

Water Quality

Water quality test results did not detect any toxic substances such as heavy metals and cyanide. The water of the Mekong River and the Sangke River is safe for use as a source of raw water for the treatment plants. Both rivers contain high alkalinity, but not high enough to require lime injection for pH adjustment. However, since the existing treatment plants in Cambodia utilize the lime injection process, the new treatment plants would follow suit. Both rivers contain bacteria which would be dealt with the disinfection process during treatment.

Water quality data for the design of the chemical feeding facilities are provided by the existing Chrouy Changwar Plant at Phnom Penh which takes raw water from the Mekong River for Kampong Cham plant and the existing Battambang Plant which takes raw water from the Sangke River. The chemical feeding rates applied at these two plants were used as a reference.

2.2.1.3 Socio Economic Factors

In 2001, the Kizuna Bridge, the first crossing over the Mekong River in Cambodia, constructed with Japanese assistance, was opened in Kampong Cham, linking eastern and western Cambodia by road for the first time. This together with the planned expansion of National Road No. 7 will cause increased traffic volume around Kampong Cham. Battambang is located near the border with Thailand and the planned expansion and bypass of National Road No.5 is making Battambang a key transportation hub between Cambodia and Thailand. Coping with

traffic congestion and safety along the roads will be a major concern during pipe installation. Good coordination among relevant agencies regarding pipe installation locations will be critical and essential.

Cambodia has a high poverty ratio and reducing poverty is one of the key issues. Currently the poverty ratios in Kampong Cham and Battambang are 29.1% and 31.5% respectively according to "Identification of Poor Households Program" carried out by the Ministry of Planning. It is difficult for poor people to pay the charges for service connections, such as the cost of materials for service pipes and water meters and installation fees. In order to increase the service ratio for poor people, this project provides materials and equipment for service connections similar to the on-going Japanese Grant Aid Project and projects by other donors.

2.2.1.4 Construction and Procurement Factors

In Cambodia, ductile cast iron pipe (DIP) is used for pipelines over 250 mm diameter and high density polyethylene (HDPE) pipe for the pipelines less than 250 mm diameter. The pipe materials are selected in terms of reliability, resistance under pressure, ease of handling, cost, and availability in Cambodia. Pipe materials with larger diameter will be imported from Japan or third countries.

2.2.1.5 Utilization of Local Contractors

Several large local contractors in Cambodia have experience in the construction of treatment plants, river intake facilities, reservoirs, and transmission and distribution pipelines. These local contractors will be sub-contractors under the management of the Japanese contractor.

2.2.1.6 Operation and Maintenance

The staff capability in Kampong Cham and Battambang should be trained so that they can manage the new water supply systems which will have capacities several times more than the existing facilities. Especially in Kampong Cham, the new water treatment plant will use surface water from the Mekong River, in addition to using groundwater. Under the "Soft Component" of the Japanese Grant Aid Project, technical assistance will be provided to build the capability for sound operation and maintenance of the new water supply facilities.

2.2.1.7 Facilities and Equipment to be installed

The water treatment plant is designed to operate with the minimal required mechanical and electrical equipment and the chemicals available in the country. Transmission and distribution pipelines are designed to be installed away from paved roads to avoid excessive vehicle load.

Depth of pipe installation would conform to Cambodia standards applied by PPWSA in Phnom Penh and the on-going Japanese Grand Aid Project. For road and river crossings, existing culverts will be used and external concrete protection will be applied where there is no culvert.

2.2.1.8 Construction and Procurement Method and Schedule

Dry excavation using sheet-piling or caissons are considered for the construction of the water intake facilities. The results of soil investigation will be considered for the selection of foundation type for the structure. The construction of intake facilities should be carried out as much as possible during dry season when the water levels of the Mekong River and the Sangke River are low. Since a lot of pipes have to be laid during this short time period, it is necessary to install multiple sections simultaneously. Therefore, construction supervision must be planned carefully and inspectors deployed.

2.2.2 Basic Plan

2.2.2.1 Water Demand Projection

(1) Kampong Cham

a. Supply Area

According to the draft master plan prepared by the Project on the Capacity Building for Water Supply Systems in Cambodia (Phase 2), consultations at the waterworks, supply area for UN-Habitat Project and the field survey by the JPST, the future water supply area in Kampong Cham was selected as shown in **Figure 2.2.2.1-1**.

Figure 2.2.2.1-1 Future Water Supply Area in Kampong Cham

b. Population and Growth Rate

The 1998 and 2008 population data for each commune in Kampong Cham affected by the project is listed in **Table 2.2.2.1-1**, as sourced from the census data (source: Analytical Report No.2 Spatial Distribution and Growth of Population in Cambodia, National Report of Final Results of Cambodian 2008 Population Census, National Institute of Statistics, Ministry of Planning, Cambodia, 9 Dec 2009). Population in the supply area for each commune was estimated based on the actual residential area in the supply area as investigated during the field survey by the JPST.

Population served in each commune =

(residential area within service area in commune) / (total residential area in commune)

×population in commune

The total population of the 7 communes in the administrative area was 73,535 in 1998 and 78,803 in 2008. The average annual population growth rate was calculated to be 0.69%, much lower than the national average of 2.24%. The rate of 0.69% is used in the water demand projections.

Table 2.2.2.1-1 Population and Growth Rate in Kampong Cham

		Population in Administrative Area			Population in Service Area	
		1998	2008	APGR	% of Service Area	2008
0305	**Krong Kampong Cham**					
030501	Boeng Kok	8,531	8,990	0.53%	100%	8,990
030502	Kampong Cham	8,808	8,878	0.08%	100%	8,878
030503	Sambuor Meas	12,138	13,454	1.03%	100%	13,454
030504	Veal Vong	15,877	15,978	0.06%	100%	15,978
0306	**Kampong Siem**					
030601	Ampil	13,131	14,939	1.30%	80%	11,951
030606	Kaoh Roka	6,085	6,339	0.41%	20%	1,268
030611	Roang	8,965	10,225	1.32%	40%	4,090
	Total	73,535	78,803	0.69%	82%	64,609

c. Population in the Supply Area

Based on the growth rate mentioned above, future population is estimated as shown in **Table 2.2.2.1-2**.

Table 2.2.2.1-2 Future Population for Each Commune in the Supply Area

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Krong Kampong Cham												
Boeng Kok	8,990	9,036	9,082	9,128	9,174	9,219	9,265	9,311	9,357	9,402	9,448	9,494
Kampong Cham	8,878	8,884	8,889	8,894	8,899	8,904	8,909	8,913	8,917	8,921	8,924	8,928
Sambuor Meas	13,454	13,591	13,729	13,869	14,009	14,150	14,293	14,436	14,580	14,726	14,873	15,020
Veal Vong	15,978	15,986	15,993	16,000	16,006	16,013	16,018	16,023	16,028	16,032	16,036	16,040
Kampong Siem												
Ampil	11,951	12,105	12,260	12,416	12,575	12,735	12,896	13,060	13,225	13,392	13,560	13,731
Kaoh Roka	1,268	1,273	1,278	1,283	1,288	1,293	1,298	1,303	1,307	1,312	1,317	1,322
Roang	4,090	4,144	4,198	4,252	4,308	4,364	4,420	4,477	4,535	4,593	4,652	4,712
Total	64,609	65,017	65,428	65,842	66,258	66,677	67,099	67,523	67,950	68,379	68,811	69,246
APGR		0.63%	0.63%	0.63%	0.63%	0.63%	0.63%	0.63%	0.63%	0.63%	0.63%	0.63%

d. Service Ratio

The NSDP says that the target service ratio (the rate of access to safe water) in urban areas should increase from 68% in 2005 to 80 % in 2015, at a rate of 1.2% per year. The Cambodian side explained that if the target year of the project is 2019, the target service ratio at 1.2% annual increase would be 84.8% (an additional 4.8% for 4 more years). The Cambodian side also explained that national discussions for setting target service ratio beyond the year 2015 were just underway and that a 1.2% per annum increase in service ratio would be acceptable for project design.

e. Per Capita Water Consumption

The average family size is 4.79, calculated from total population (78,803) and number of households (16,436). Average water consumption per household is calculated from total domestic water consumption and number of domestic connections. From average family size and average water consumption per household, per capita water consumption is calculated as

153 lpcd in 2010 and in 2011, as shown in **Table 2.2.2.1-3**.

Table 2.2.2.1-3 Per Capita WaterConsumption in Kampong Cham

		2010	2011
Domestic Consumption	m^3/day	3,128	3,298
Domestic Connections	Nos.	4,262	4,499
Unit Population per Household	Nos.	4.79	4.79
Served Population	Nos.	20,434	21,571
Per Capita Water Consumption	lpcd	153.1	152.9

Source: Kampong Cham Waterworks

In Cambodia, there are no standards or guidelines related to water supply planning and design. The on-going Japanese Grant Aid Project uses 125 to 140 lpcd for per capita water consumption. In Kampong Cham, therefore, future per capita consumption is set at 150 lpcd.

f. Domestic Water Demand

Based on the actual data from Kampong Cham Waterworks, **Table 2.2.2.1-4** shows the breakdown of water consumption by category. Domestic water consumption is about 75 % of total water consumption. This water consumption ratio is applied to the calculations for demand projections.

Table 2.2.2.1-4 Breakdown of Water Consumption in Kampong Cham

Consumption (billed)		2008	2009	2010	2011	Total
Domestic	m^3/day	2,224	2,696	3,128	3,298	11,346
Commercial	m^3/day	284	372	508	673	
Public	m^3/day	422	491	570	514	
Total	m^3/day	2,930	3,559	4,206	4,485	15,180
Ratio of Domestic	%	75.9%	75.8%	74.4%	73.5%	**74.7%**

Source: Kampong Cham Waterworks

g. Leakage Ratio

The NRW (non-revenue water) ratio of Kampong Cham Waterworks is about 13% in 2011. The level is relatively low and is expected to be maintained in future. There is no data for estimating leakage ratio from NRW. Future water demand is, therefore, calculated based on 13 % leakage ratio, same as the NRW, up to the year 2019.

h. Peak Factor

According to the data of water distribution in years 2009 to 2011, the peak factor (ratio of daily maximum to daily average) was 1.21 as shown in **Table 2.2.2.1-5**. In this projection, peak factor is set at 1.2.

Table 2.2.2.1-5 Peak Factor in Kampong Cham

Kampong Cham			**2009**	**2010**	**2011**	**Average**
Daily Average		m^3/day	4,148	4,863	5,131	
Daily Max.	amount	m^3/day	4,608	6,960	5,649	
	day	-	7-Aug	16-May	15-May	
Peak Factor		-	1.11	1.43	1.10	**1.21**

Source: Kampong Cham Waterworks

i. Daily Maximum Water Demand

The peak factor described above, the daily average water demand and the daily maximum water demand are projected as shown in **Table 2.2.2.1-6**. Daily maximum water demand in 2019 is estimated at 16,200 m3/day. Since the safe yield of the existing groundwater system in dry season is about 4,800 m3/day (see section "**2.2.2.2 Plan for New Water Sources**", the safe yield of two shallow wells: 4,100 m3/day, and the safe yield of the deep well: 700 m3/day), the necessary water treatment plant capacity will be 11,500 m3/day. The relationship between the water demand and the supply capacity is shown in **Figure 2.2.2.1-2**.

Table 2.2.2.1-6 Water Demand up to 2019 in Kampong Cham

		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Population in Service Area	person	64,609	65,017	65,428	65,842	66,258	66,677	67,099	67,523	67,950	68,379	68,811	69,246
Population Growth Rate	%	0	0.63%	0.63%	0.63%	0.63%	0.63%	0.63%	0.63%	0.63%	0.63%	0.63%	0.63%
Service Ratio in Service Area	%	26.8%	29.2%	31.2%	32.8%	34.7%	36.7%	38.6%	42.9%	52.5%	63.4%	74.2%	84.8%
Population Served in Service Area	person	17,284	19,010	20,434	21,571	23,009	24,447	25,886	28,993	35,705	43,376	51,047	58,719
Per Capita Consumption	L/day/person	129	142	153	153	150	150	150	150	150	150	150	150
Domestic Consumption	m3/day	2,224	2,696	3,128	3,298	3,451	3,667	3,883	4,349	5,356	6,506	7,657	8,808
Number of Domestic Connection	no.	3,605	3,965	4,262	4,499	4,799	5,099	5,399	6,047	7,447	9,047	10,647	12,247
Increase of Domestic Connection	no.	0	360	297	237	300	300	300	648	1,400	1,600	1,600	1,600
Ratio of Domestic Comsumption	%	76%	76%	74%	74%	75%	75%	75%	75%	75%	75%	75%	75%
Total Consumption	m3/day	2,930	3,559	4,206	4,485	4,602	4,889	5,177	5,799	7,141	8,675	10,209	11,744
NRW Ratio	%	17%	14%	14%	13%	13%	13%	13%	13%	13%	13%	13%	13%
Leakage Ratio	%	17%	14%	14%	13%	13%	13%	13%	13%	13%	13%	13%	13%
Day Average Demand	m3/day	3,530	4,138	4,891	5,155	5,289	5,620	5,951	6,665	8,208	9,972	11,735	13,499
Day Max. Factor		1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Day Max. Demand	m3/day	4,236	4,966	5,869	6,186	6,347	6,744	7,141	7,998	9,850	11,966	14,082	16,198
Existing Capacity	m3/day	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800
Capacity needed by the Project	m3/day	-564	166	1,069	1,386	1,547	1,944	2,341	3,198	5,050	7,166	9,282	11,398

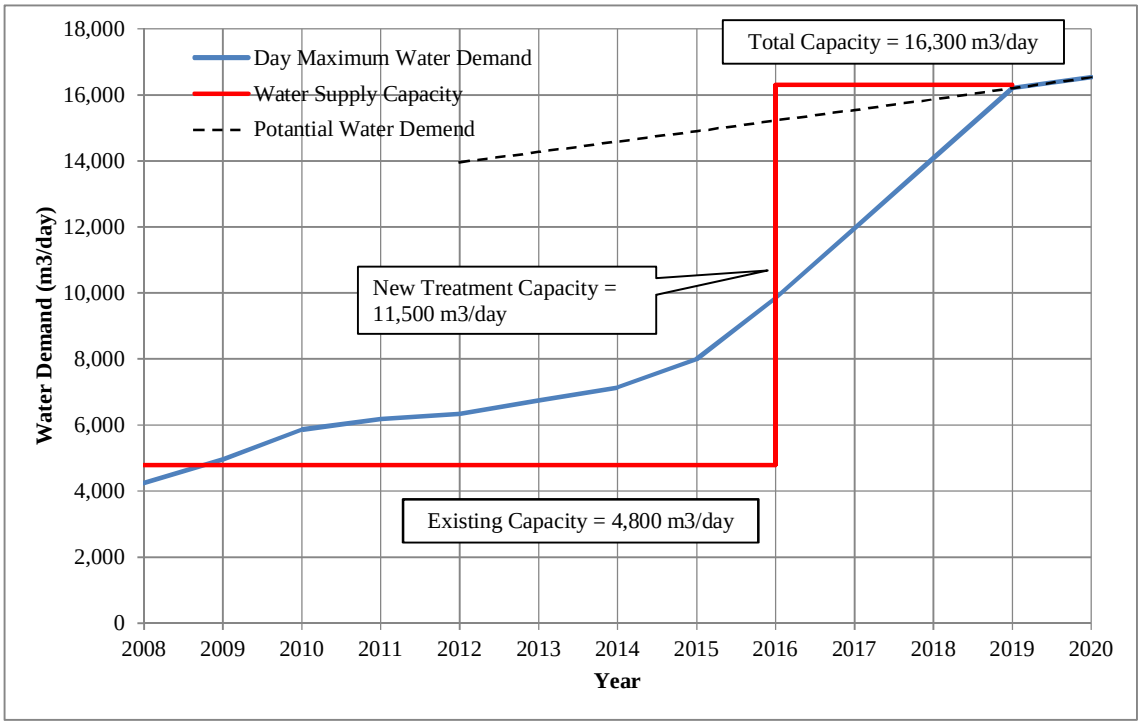


Figure 2.2.2.1-2 Relationship between Water Demand and Supply Capacity in Kampong Cham

(2) Battambang

a. Supply Area

According to the draft master plan prepared by the Project on the Capacity Building for Water Supply Systems in Cambodia (Phase 2), consultations at the waterworks, supply area for the on-going Japanese Grant Aid Project and the field survey by the JPST, the future water supply area in Battambang was selected as shown in **Figure 2.2.2.1-3**.

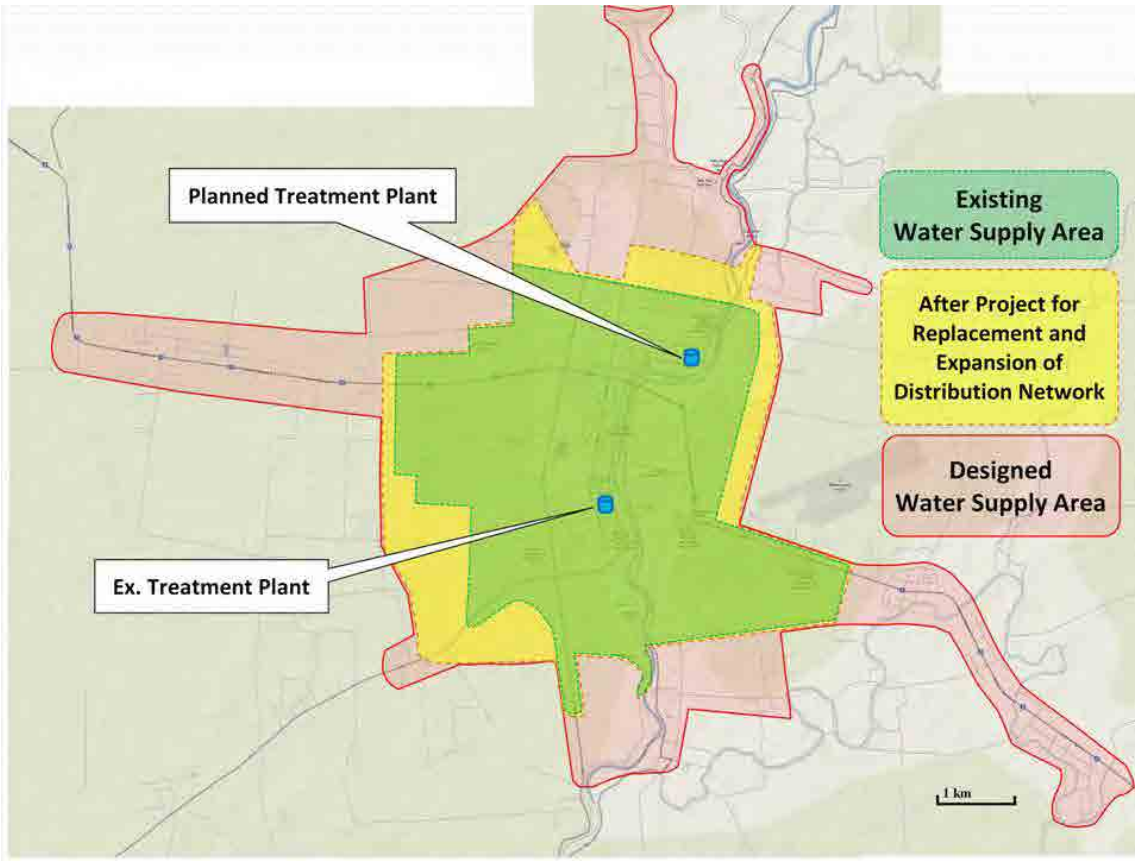


Figure 2.2.2.1-3 Future Water Supply Area in Battambang

b. Population and Growth Rate

The 1998 and 2008 population for each commune affected by the project in Battambang is listed in **Table 2.2.2.1-7**,as sourced from the census data (source: Analytical Report No.2 Spatial Distribution and Growth of Population in Cambodia, National Report of Final Results of Cambodian 2008 Population Census, National Institute of Statistics, Ministry of Planning, Cambodia, 9 Dec 2009). Population in the supply area for each commune was estimated based on the actual residential area in the supply area as investigated during the field survey by the JPST.

Population served in each commune =

(residential area within service area in commune) / (total residential area in commune)

×population in commune

The total population of 15 communes in the administrative area was 200,061 in 1998 and 206,367 in 2008. The average annual population growth rate was calculated to be 0.31%. It is low compared to the national average of 2.24%. The rate of 0.31% is used in the water demand projections.

Table 2.2.2.1-7 Population and Growth Rate in Battambang

		Population in Administrative Area			Population in Service Area	
		1998	2008	APGR	% of Service Area	2008
0202	**Thma Koul**					
020204	Chrey	13,523	14,215	0.50%	40%	5,686
0203	**Krong Bat Dambang**					
020301	Tuol Ta Aek	16,443	15,482	-0.60%	100%	15,482
020302	Preaek Preah Sdach	14,609	15,024	0.28%	100%	15,024
020303	Rotanak	15,684	16,123	0.28%	100%	16,123
020304	Chamkar Samraong	17,444	17,927	0.27%	100%	17,927
020305	Sla Kaet	7,241	7,949	0.94%	100%	7,949
020306	Kdol Doun Teav	8,001	8,442	0.54%	80%	6,754
020307	Ou Mal	9,710	10,104	0.40%	20%	2,021
020308	Voat Kor	14,982	16,044	0.69%	60%	9,626
020309	Ou Char	15,376	16,027	0.42%	80%	12,822
020310	Svay Pao	20,474	21,201	0.35%	100%	21,201
0208	**Sangkae**					
020801	Anlong Vil	15,986	16,749	0.47%	40%	6,700
020802	Norea	5,004	5,609	1.15%	40%	2,244
020808	Ou Dambang Muoy	13,989	13,340	-0.47%	20%	2,668
020809	Ou Dambang Pir	11,595	12,131	0.45%	20%	2,426
	Total	200,061	206,367	0.31%	70%	144,652

c. Population in the Supply Area

Based on the growth rate mentioned above, future population is estimated as shown in **Table 2.2.2.1-8**.

Table 2.2.2.1-8 Future Population for Each Commune in the Supply Area

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Thma Koul												
Chrey	5,686	5,714	5,742	5,770	5,798	5,826	5,854	5,883	5,911	5,939	5,968	5,996
Krong Bat Dambang												
Tuol Ta Aek	15,482	15,388	15,294	15,200	15,107	15,014	14,921	14,829	14,737	14,646	14,554	14,464
Preaek Preah Sdach	15,024	15,065	15,106	15,146	15,187	15,227	15,267	15,307	15,347	15,387	15,427	15,466
Rotanak	16,123	16,166	16,209	16,252	16,295	16,337	16,380	16,422	16,464	16,507	16,548	16,590
Chamkar Samraong	17,927	17,974	18,022	18,069	18,116	18,163	18,209	18,256	18,302	18,349	18,395	18,440
Sla Kaet	7,949	8,023	8,097	8,172	8,248	8,324	8,400	8,477	8,555	8,634	8,713	8,792
Kdol Doun Teav	6,754	6,789	6,825	6,861	6,897	6,933	6,969	7,006	7,042	7,078	7,115	7,151
Ou Mal	2,021	2,029	2,037	2,044	2,052	2,060	2,068	2,076	2,084	2,092	2,100	2,107
Voat Kor	9,626	9,692	9,757	9,823	9,889	9,956	10,023	10,090	10,157	10,225	10,293	10,361
Ou Char	12,822	12,874	12,926	12,978	13,030	13,082	13,135	13,187	13,239	13,291	13,344	13,396
Svay Pao	21,201	21,273	21,345	21,418	21,489	21,561	21,633	21,705	21,777	21,848	21,920	21,991
Sangkae												
Anlong Vil	6,700	6,730	6,761	6,792	6,823	6,854	6,884	6,915	6,946	6,977	7,008	7,039
Norea	2,244	2,269	2,295	2,321	2,347	2,374	2,401	2,428	2,455	2,483	2,511	2,539
Ou Dambang Muoy	2,668	2,655	2,642	2,629	2,617	2,604	2,591	2,578	2,566	2,553	2,540	2,528
Ou Dambang Pir	2,426	2,437	2,448	2,459	2,469	2,480	2,491	2,502	2,513	2,524	2,534	2,545
Total	144,652	145,078	145,506	145,935	146,365	146,796	147,228	147,661	148,096	148,531	148,968	149,406
APGR		0.29%	0.29%	0.29%	0.29%	0.29%	0.29%	0.29%	0.29%	0.29%	0.29%	0.29%

d. Service Ratio

As explained for Kampong Cham, the target service ratio for the project in 2019 would be 84.8%.

e. Per Capita Water Consumption

The average family size is 5.01, as calculated from total population (206,367) and number of households (41,226). Average water consumption per household is calculated from total

domestic water consumption and number of domestic connections. From average family size and average water consumption per household, per capita water consumption is calculated as 100 lpcd in 2010 and 97 lpcd in 2011, as shown in **Table 2.2.2.1-9**.

Table 2.2.2.1-9 Per Capita WaterConsumption in Battambang

		2009	2010	2011
Domestic Consumption	m^3/day	3,639	4,265	4,403
Domestic Connections	Nos.	8,334	8,524	9,065
Unit Population per Household	Nos.	5.01	5.01	5.01
Served Population	Nos.	41,718	42,669	45,377
Per Capita Water Consumption	lpcd	87.2	100.0	97.0

Source: Battambang Waterworks

In Cambodia, there are no standards or guidelines related to water supply planning and design. Confirmation Study on Basic Information Gathering for Waterworks Sector in Cambodia estimated per capita consumption in 2025 at 120 lpcd and the on-going Japanese Grant Aid Project uses 140 lpcd for Battambang in 2016 as shown in **Table 2.2.2.1-10**. In this project, therefore, future per capita consumption is projected to increase gradually to 120 lpcd by 2019 as shown in **Table 2.2.2.1-11**.

Table 2.2.2.1-10 Per-Capita Water Consumption estimated by Other Projects

Project Title	Study Year	Per-Capita Water Consumption（lpcd）	
		Actual Data	Figure used
Confirmation Study on Basic Information Gathering for Waterworks Sector	2010	89.4 (2008)	120 (Target Year: 2025)
Project on Replacement and Expansion of Water Distribution System for Pursat, Sihanoukville and Battambang (on-going Japanese Grant Aid Project)	2010～2011	133 (2009)	140 (Target Year: 2016)
This Project; Project on Additional New Water Treatment Plants for Kampong Cham and Battambang Waterworks	2012～2013	87 (2009) 100 (2010) 97 (2011)	120 (Target Year: 2019)

Table 2.2.2.1-11 Target Per-Capita Water Consumption in Battambang

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Per-Capita Water Consumption (lpcd)	87	100	97	102.5	105.0	107.5	110.0	112.5	115.0	117.5	120.0

f. Domestic Water Demand

Based on the actual data from Battambang Waterworks, **Table 2.2.2.1-12** shows the breakdown of water consumption by category. Domestic water consumption is about 65 % of total water consumption. This water consumption ratio is applied to the calculations for demand projections.

Table 2.2.2.1-12 Breakdown of Water Consumption in Battambang

Consumption (billed)		2008	2009	2010	2011	Total
Domestic	m^3/day	3,329	3,639	4,265	4,403	15,636
Commercial	m^3/day	987	1,085	1,240	1,391	
Industrial	m^3/day	10	11	17	21	
Public	m^3/day	871	986	964	1,036	
Total	m^3/day	5,197	5,721	6,486	6,851	24,255
Ratio of Domestic	%	64.1%	63.6%	65.8%	64.3%	**64.5%**

Source: Battambang Waterworks

g. Leakage Ratio

The current level of NRW ratio in Battambang is relatively low. The ratio was 21% in 2011. Since there is no data showing the ratio of leakage to NRW in Cambodia, the leakage ratio is speculated based on the past experiences in other developing countries. In the situation that NRW ratio is high (e.g. around 50%), the ratio of other NRW components than leakage (i.e. meter error, illegal usage, etc.) is high in general. The ratio of leakage to NRW would be as low as 50%. However, in the situation that NRW ratio has been lowered by implementing some NRW reduction activities, the reduction of the other NRW components are usually more than the reduction of leakage. This results in a higher ratio of leakage to NRW. Therefore, the leakage ratio to NRW used in the demand projection for Battambang, where the NRW ratio is currently low, was assumed to be 75%. As shown in **Table 2.2.2.1-13**, the target leakage ratio in 2019 is set at 15% with an assumption that the NRW ratio will be kept as high as the current NRW ratio in the future.

Table 2.2.2.1-13 Leakage Ratio in Battambang

	2011	2012	2013	2014	2015	2016	2017	2018	2019
NRW Ratio (%)	21	20	20	20	20	20	20	20	20
Leakage Ratio (%)	15.8	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0

h. Peak Factor

According to the data of water distribution for years 2006 to 2010, the peak factor (ratio of daily maximum to daily average) was 1.17 as shown in **Table 2.2.2.1-14**. In this projection, peak factor is set at 1.17.

Table 2.2.2.1-14 Peak Factor in Battambang

Battambang			2006	2007	2008	2009	2010	Average
Daily Average		m^3/day	4,587	7,452	7,412	7,903	8,243	
Daily Maximum	amount	m^3/day	5,720	8,100	8,700	9,215	9,564	
	day	-	17-Aug	8-Apr	10-Mar	30-Apr	6-Apr	
Peak Factor		-	1.25	1.09	1.17	1.17	1.16	**1.17**

Source: Battambang Waterworks

i. Daily Maximum Water Demand

The peak factor described above, the daily average water demand and the daily maximum water demand are projected as shown in **Table 2.2.2.1-15**. Daily maximum water demand in 2019 is estimated at 32,200 m3/day. Since the capacity of the existing water treatment plant is 10,473 m3/day (11,520m3/day/1.1), the necessary water treatment plant capacity will be 22,000 m3/day. The relationship between the water demand and the supply capacity is shown in **Figure 2.2.2.1-4**. As shown in **Figure 2.2.2.1-4**, the water supply capacity will be more than the demand, once the project is completed in 2016. Before that, however, the capacity is below the demand.

Table 2.2.2.1-15 Water Demand up to 2019 in Battambang

		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Population in Service Area	person	144,652	145,078	145,506	145,935	146,365	146,796	147,228	147,661	148,096	148,531	148,968	149,406
Population Growth Rate	%		0.29%	0.29%	0.29%	0.29%	0.29%	0.29%	0.29%	0.29%	0.29%	0.29%	0.29%
Service Ratio in Service Area	%	26.9%	28.8%	29.3%	31.1%	33.1%	35.0%	38.6%	43.8%	51.1%	62.4%	73.6%	84.8%
Population Served in Service Area	person	38,925	41,718	42,669	45,377	48,381	51,384	56,890	64,624	75,637	92,656	109,676	126,696
Per Capita Consumption	L/day/person	86	87	100	97	102.5	105.0	107.5	110.0	112.5	115.0	117.5	120
Domestic Consumption	m3/day	3,329	3,639	4,265	4,403	4,959	5,395	6,116	7,109	8,509	10,655	12,887	15,203
Number of Domestic Connection	no.	7,776	8,334	8,524	9,065	9,665	10,265	11,365	12,910	15,110	18,510	21,910	25,310
Increase of Domestic Connection	no.	0	558	190	541	600	600	1,100	1,545	2,200	3,400	3,400	3,400
Ratio of Domestic Comsumption	%	64.1%	63.6%	65.8%	64.3%	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%
Total Consumption	m3/day	5,197	5,721	6,486	6,851	7,629	8,300	9,409	10,936	13,091	16,393	19,826	23,390
NRW Ratio	%	29.9%	27.6%	26.0%	21.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%
Leakage Ratio	%	22.4%	20.7%	19.5%	15.8%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
Day Average Demand	m3/day	6,699	7,214	8,057	8,132	8,976	9,765	11,069	12,866	15,401	19,286	23,325	27,518
Day Max. Factor		1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17
Day Max. Demand	m3/day	7,838	8,441	9,427	9,514	10,501	11,425	12,951	15,054	18,019	22,565	27,290	32,196
Existing Capacity	m3/day	10,473	10,473	10,473	10,473	10,473	10,473	10,473	10,473	10,473	10,473	10,473	10,473
Capacity needed by the Project	m3/day	-2,635	-2,032	-1,046	-959	29	953	2,478	4,581	7,547	12,092	16,817	21,723

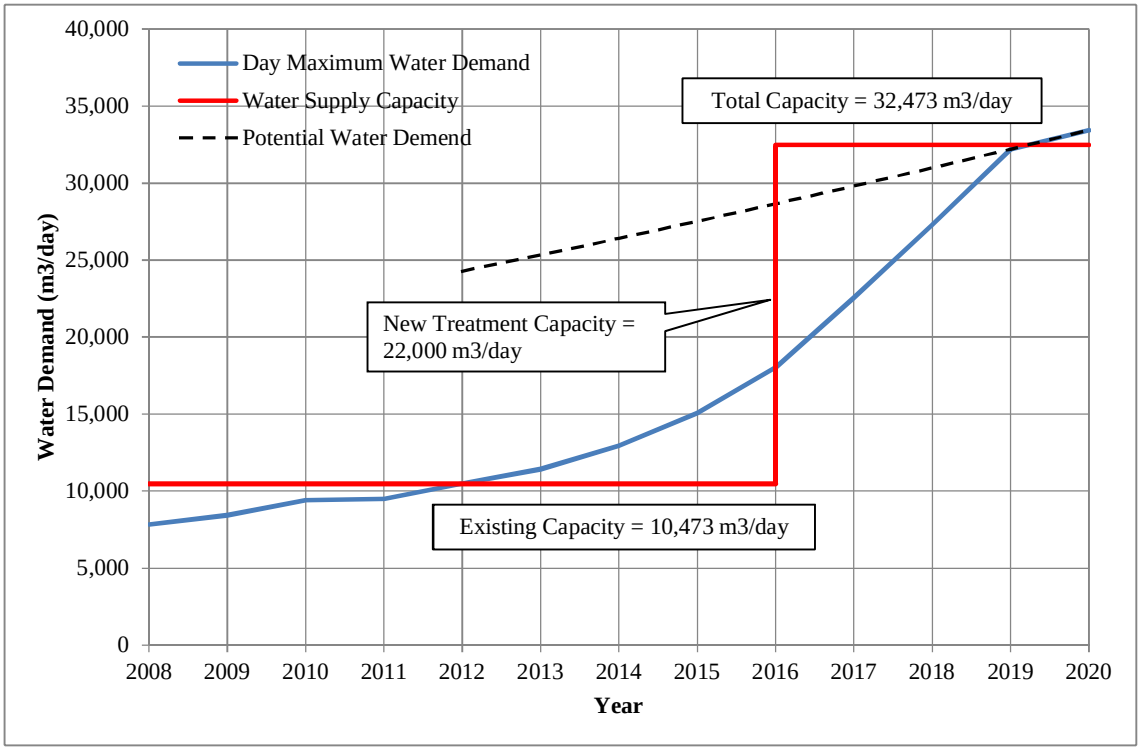


Figure 2.2.2.1-4 Relationship between Water Demand and Supply Capacity in Battambang

2.2.2.2 Plan for New Water Sources

(1) New Water Source for Kampong Cham

New raw water sources from the Mekong River in Kampong Cham have been studied. The following three items are described below: (1) Characteristics of the Mekong River; (2) Appropriate Site for New Water Intake from the Mekong River; and (3) Conditions and Problems of the Existing Wells.

1) Characteristics of the Mekong River in Kampong Cham

The Mekong River is the longest river in Southeast Asia originating from Tibet and flowing through China, Myanmar, Thailand, Laos, Cambodia and Vietnam. The length of the Mekong River is 4,200km and its catchment area is 783,000km2. Its catchment area in Cambodia is 154,895km2, which includes the sub-river basin of the Mekong River Main Stream (61,337km2) and the Tonle Sap River Basin (79,310km2), one of the major tributary basins.

Width of the Mekong River in the upstream reach of Kampong Cham is about 1.8km, but the river forms a narrow portion with about 550m in width around 1km upstream of the "Kizuna Bridge." The water level gauging station of the Ministry of Water Resources and Meteorology (MOWRAM) is located on the right bank at this narrow river portion.

Figure 2.2.2.2-1 show variations of daily water level of the Mekong River at the above water level gauging station in Kampong Cham from 1990 to 2011 and the estimated daily discharge based on the water level; whereas, **Figure 2.2.2.2-2** show the monthly average and the maximum and minimum water level in the same period.

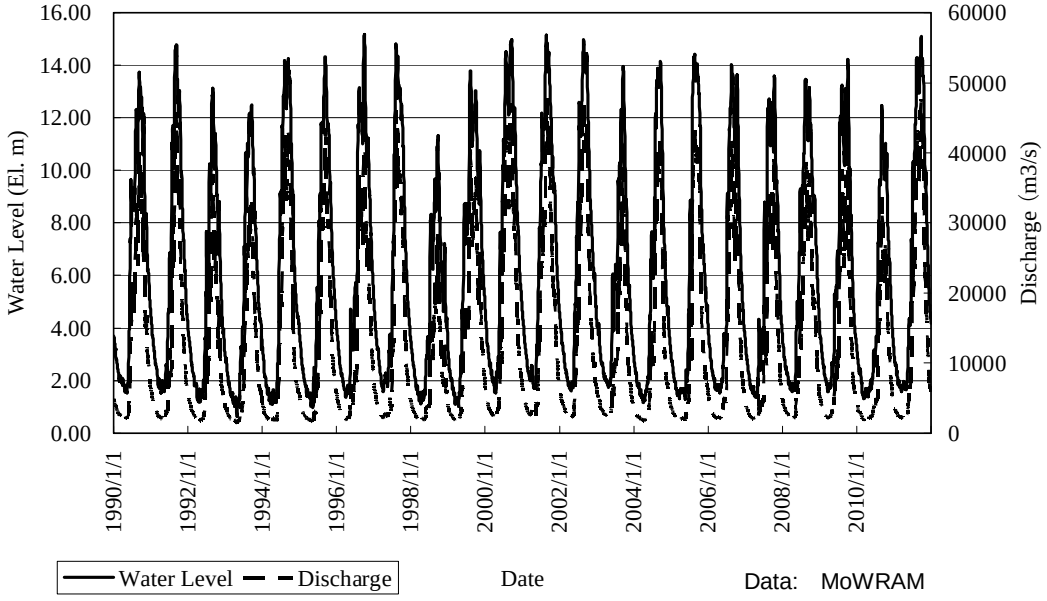


Figure 2.2.2.2-1 Daily Water Level and Discharge of the Mekong River at Kampong Cham (1990 – 2011)

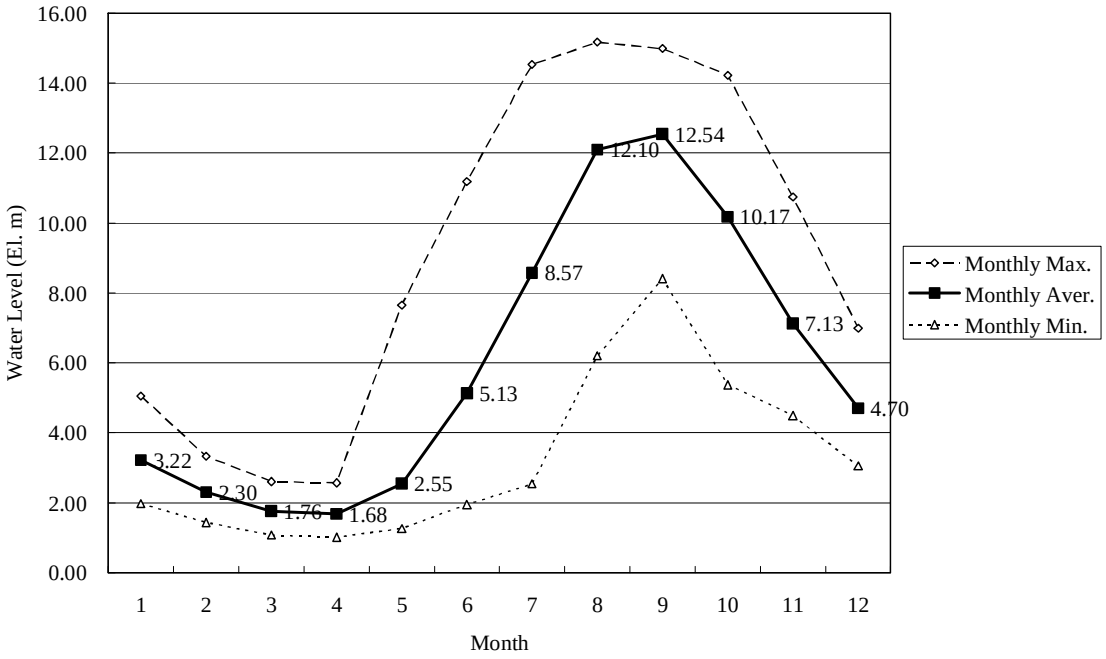


Figure 2.2.2.2-2 Monthly Average, Maximum and Minimum Water Level of the Mekong River at Kampong Cham (1990 – 2011)

The maximum water level of El. 15.18m at the above narrow portion was recorded in September 1996, and the minimum of EL 0.63m in April 1993. The highest monthly average water level EL 12.54m was in September, and the lowest monthly average of EL 1.68m was in April. The difference of water level between the rainy season and the dry season is about 11m. The maximum discharge in this period was recorded at 48,200m3/s and the minimum was 1,300m3/s. Monthly average discharge changes seasonally with the maximum of 34,400m3/s in September and the minimum of 2,200m3/s in April.

2) New Intake Site

The Mekong River at Kampong Cham is characterized by big seasonal water level change with maximum difference of 14m, high flood water level reaching up to the top of the banks (slight overflow to the city by the 2000 Flood), fast flood velocity in the river at the narrow portion, and possibility of bank erosion. In addition, navigation is actively conducted in the river.

The following items shall be considered for the selection of intake site of the new water source:

- Stable site against bank erosion and scouring.
- Distance from the river bank at the site to the water surface is as short as possible even in the case of low water level during dry season where intake of water can be easily conducted.
- Not disturb navigation as much as possible.
- Not affected by the discharge of sewage from the City.

a) Site at the Small Cape: Site A

Kampong Cham Waterworks had recommended the site at the small cape on the right bank of the narrow river portion in view of the stable river bank. According to the agency, some 80 years ago during the French Era, many large boulders of 0.5 to 1m in diameter were disposed at this site as protection against bank erosion and the bank has been stable since then. Ocular observation was conducted in this study during the survey on the condition of bank erosion, but no trace of erosion at the small cape was observed. Hence, it is assumed that this site has a stable topography. In addition, since some small particles of soil and sands cover the surface of the site, it is also assumed that sand and soils were deposited in the past floods. Furthermore, it is estimated that the horizontal distance from the top of the bank to the water surface during the lowest water level in dry season is around 30m. Therefore, this site has a relatively short distance to the water surface. Considering these circumstances, it would be possible to install an intake facility at this site.

b) Site at Just Upstream of the Small Cape: Site B

It is estimated that the site of about 130m upstream from the above cape is also stable. However, this site and the surrounding banks are utilized as landing stage for boats. Hence, there is a small possibility for installing an intake facility at this site. Furthermore, the horizontal distance from the top of the bank to the water surface during dry season is long, around 60m.

c) Site at about 800m Upstream from the Small Cape: Site C

The site on the right bank of around 800m upstream from the cape forms a gently curved concave portion of the river bank. Horizontal distance from the top of the bank to the water surface is relatively short, about 40m. However, this site has experienced large scale bank erosion in the first half of the 2000s. For this reason, bank protection works were provided using big boulders with the diameter of about 1m. However, these big boulders have slid down into the water. Hence, it is anticipated that large bank erosion will occur again. Due to this reason, this site is not appropriate for the installation of an intake facility.

d) Downstream of the above Small Cape forming a Small Bay Shaped Area: Site D

The right bank side of the downstream area from the above small cape forms a small bay shaped topography. It is not clear how this bay was formed. However, it may be possible that this bay was formed by erosion during the past floods. Land reclamation has been conducted at the interior portion of the bay where bank protection by gabion mats was constructed. However, the bay shaped topography may be in unstable condition against water flow and it is possible that this area will erode again. Therefore, this site is not appropriate for the installation of an intake facility.

e) Recommendable Intake Site

Based on the above circumstances, only the small cape (Site A) is recommendable for installing

an intake facility. **Figure 2.2.2.2-3** shows the above four places including the recommendable site. It should be mentioned in this connection that about 20 to 30% of the sewage from the urban area in Kampong Cham City is discharged at around 100m downstream of the right bank from the "Kizuna Bridge" and also discharged into the pond located in the western side of the City. Since the proposed Site A is located on the right bank at around 1km upstream from the "Kizuna Bridge," it is supposed that this site is not affected by the sewage.

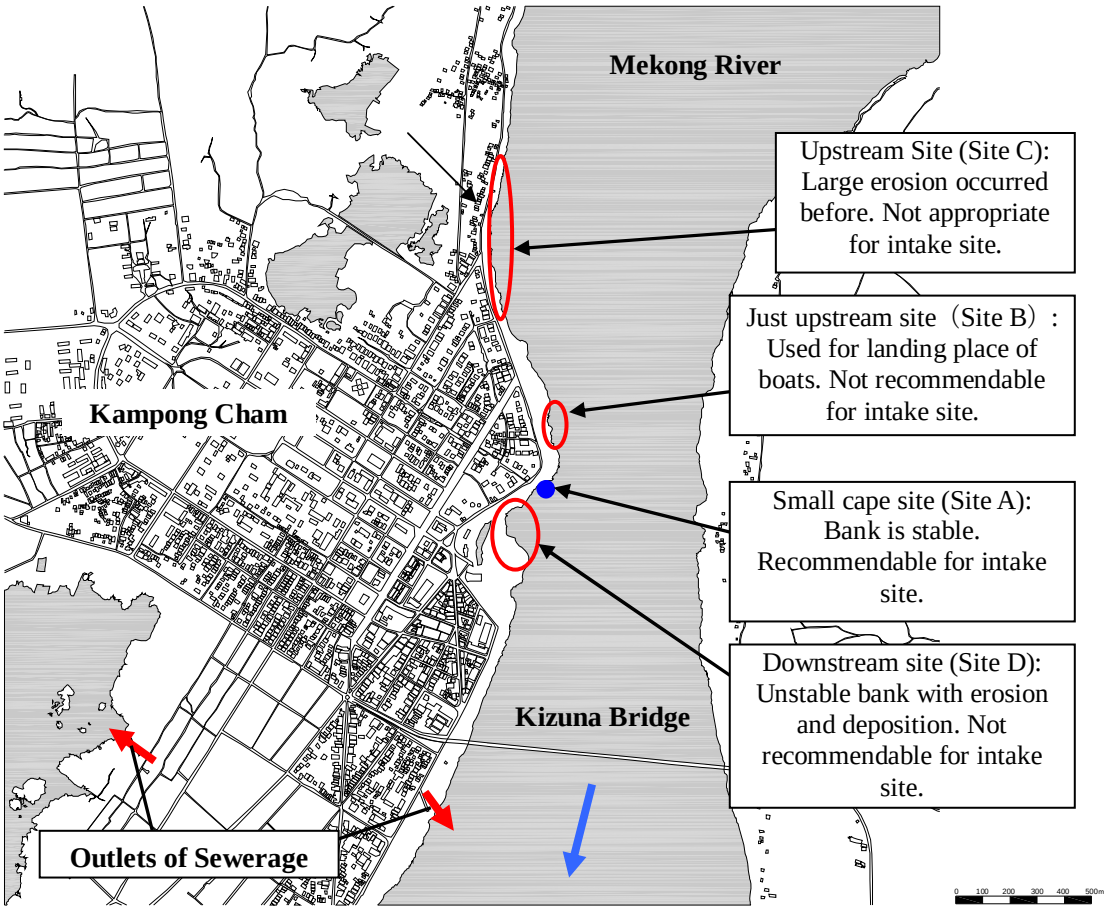


Figure 2.2.2.2-3 Recommendable Intake Site of the Mekong River at Kampong Cham and Characteristics of the Surrounding Places

Points of Attention for Installing the Intake Facility

a) Avoidance of Direct Hit by Flood Flow

In order not to be damaged by the direct hit of flood flow, it is necessary to consider that the intake facility does not face the main stream of the Mekong River having high velocity, but has to be placed in an area with relatively slower flood velocity. **Figure 2.2.2.2-4** shows the estimated range with high flood velocity and the appropriate place for installing an intake facility.

b) Countermeasures against Bank Erosion and Scouring

To protect the intake facility and the surrounding river bank from bank erosion and scouring, it

is necessary to provide bank and foot protection works.

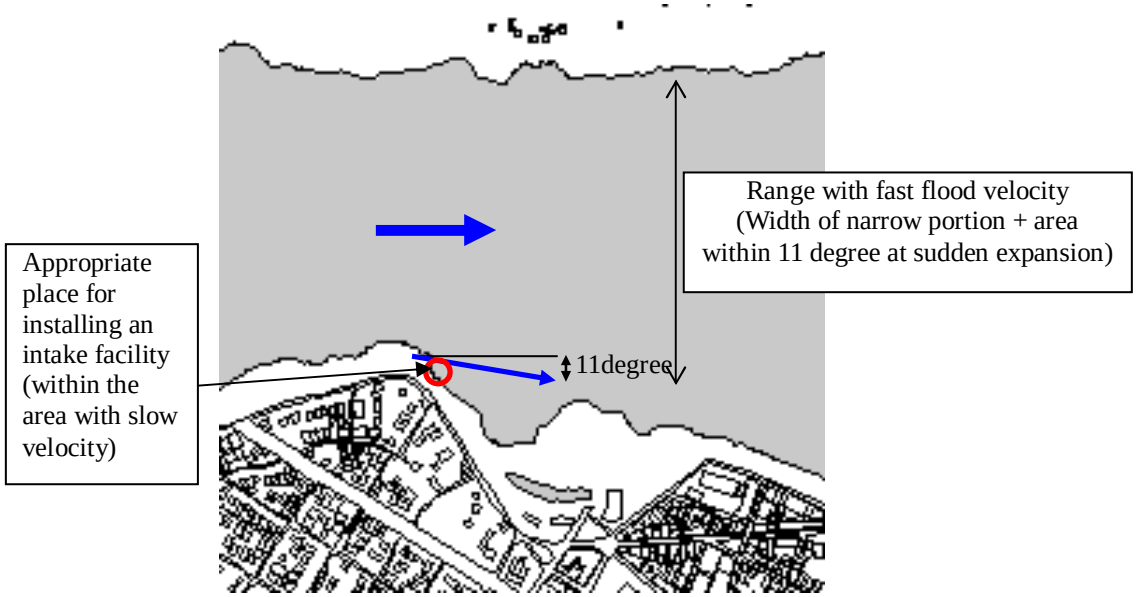


Figure 2.2.2.2-4 Estimated Range with Fast Flood Velocity in the Mekong River and the Appropriate Place for Installing An Intake Facility

3) Condition and Problems of Existing Wells

a) Existing Wells

The existing water sources for Kampong Cham City are the three groundwater wells composed of a shallow well in the compound of the waterworks (Shallow Well No. 1), another shallow well (Shallow Well No. 2) located at about 900m distance from the compound, and a deep well in the compound. Among these wells, Shallow Well No. 1 and Shallow Well No. 2 are utilized throughout the year. The Deep Well is used only in April and May during the dry season. **Table 2.2.2.2-1** shows the basic dimensions, design abstraction capacity and operation hours of these three wells.

Table 2.2.2.2-1 Existing Groundwater Wells of Kampong Cham

Well	Inner Size	Depth	Pump Type	Design Capacity	Operation Hours
Shallow Well No.1	4m x 4m	15.5m	Vertical Mixed Flow Pump	244m3/h (235 m3/h)	Rainy season: 20hr/day; Dry season: 24hr/day (intermittent operation)
Shallow Well No.2	4m x 4m	15.5m	Vertical Mixed Flow Pump	244m3/h (175 m3/h)	Rainy season: 7hr/day; Dry season: 24hr/day (intermittent operation)
Deep Well	φ200mm	40m	Submersible Pump	40m3/h	Operated only in April and May during dry season (less than 20hr/day)

Note: Figure in parenthesis is the actual pumping capacity compared to the official capacity.
Data: Kampong Cham Waterworks

Groundwater level/depth of Shallow Well No. 1 and Shallow Well No. 2 is significantly influenced by the fluctuation of water level of the Mekong River. According to Kampong Cham Waterworks, the groundwater in rainy season is deep, around 3 to 7m. However, groundwater depth in dry season becomes shallow, down to around 0.3m. In dry season, water abstraction is conducted until the water depth of 0m in Well No. 1 and Well No. 2. Operation of pumps is then stopped while waiting for the recovery of groundwater depth, and then the pumps are started again. Hence, Well No. 1 and No. 2 are utilized for long hours. The pumps of Well No. 1 and Well No. 2 have to be operated intermittently in dry season, which causes problems of groundwater abstraction in dry season.

According to Kampong Cham Waterworks, they have been measuring the groundwater depth once a month since 2007 and the starting groundwater levels of shallow well No. 1 and shallow well No. 2 have been the same level before the pump operation. **Figure 2.2.2.2-5** shows the monthly groundwater depths before pump operation of the existing shallow wells and the fluctuation of monthly average water level of the Mekong River. There is a very high correlation of 96% between these two values.

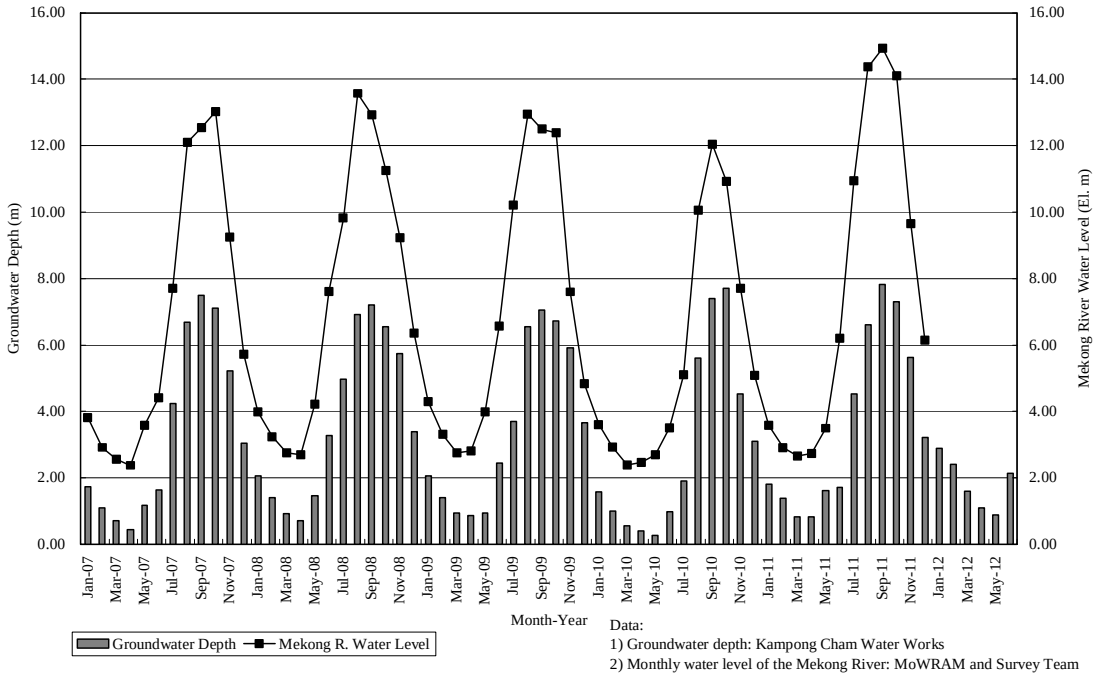


Figure 2.2.2.2-5 Kampong Cham: Monthly Groundwater Depth of the Shallow Wells before Pump Operation and the Monthly Water Level of the Mekong River

b) Abstracted Water Quantity from the Existing Wells

i) Abstracted Water Quantity in Rainy Season

The possible pumping volume in the rainy season in Kampong Cham is estimated to be 10,800m3/day based on the survey result.

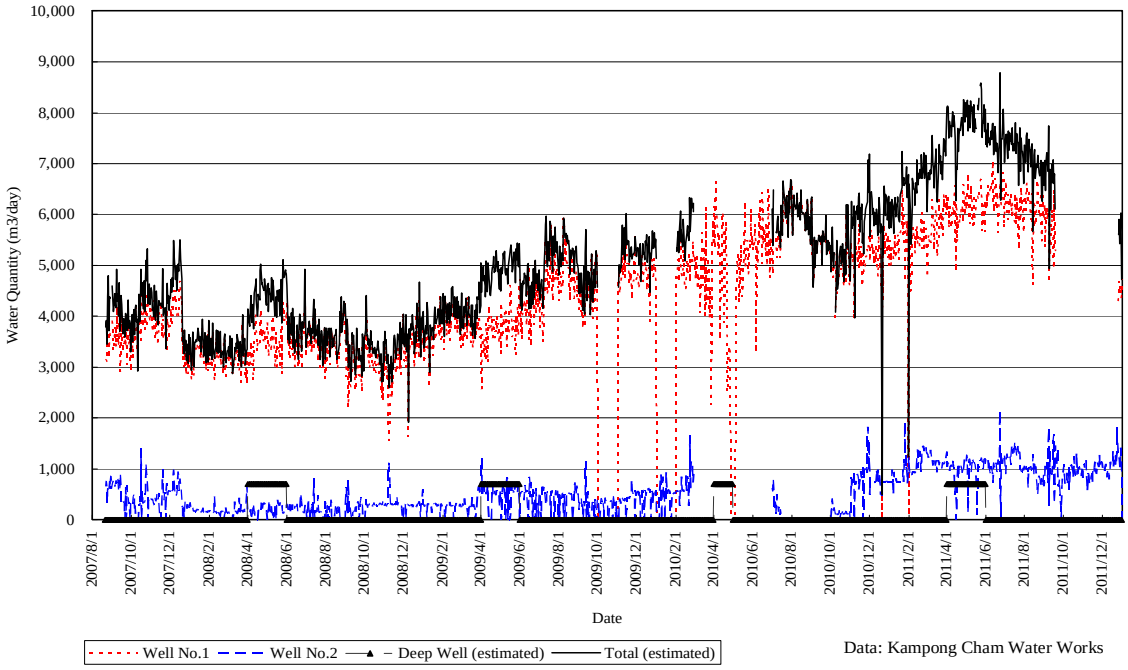


Figure 2.2.2.2-6 Daily Abstracted Water Quantity from the Existing Wells of Kampong Cham

In the above figure, abstracted water quantity from Shallow Well No.2 is much less than that of Shallow Well No.1. This shows that the water demand does not reach to the full capacity of wells in rainy season and the great portion of abstracted water is occupied by the discharge from Shallow Well No.1. However, abstracted water quantity in dry season does not reach to the water demand and the well capacity in total in dry season is assumed to be 4,800m3/day.

Shallow Well No. 1 is mainly used in the rainy season and Shallow Well No. 2 is used as the supplement. The reason for the substantially smaller yield of Shallow Well No. 2 compared to Shallow Well No. 1 is, that the water demand is not large to put both shallow wells in full operation. In addition, in the rainy season, the Deep Well is not operated due to the same reason.

The Study Team had examined the pumping capacity of existing pumps in Kampong Cham and the results are as shown in the **Table 2.2.2.2-1**.

The records to date keep no available data that all the above pumps were simultaneously operated for 24 hours. Assuming that 24-hour operation has been performed, the possible yield is estimated as follows:

Shallow Well No. 1: 235m3/h x 24h = 5,640m3/day
Shallow Well No. 2: 175m3/h x 24h = 4,200m3/day
Deep Well: 40 m3/h x 24h = 960m3/day
Total = 10,800m3/day

Based on the figures above and the performance records so far obtained, it would be possible to attain the yield of 5,640m3/day with only Shallow Well No. 1.

As to the Deep Well, it is not operated during the rainy season since the current demand is not large. During the dry season, however, the operation is continuous. Currently, 700m3/day is produced with less than 20 hours of operation (estimated as approx. 40 m3/h x 17.5h), which means that 960m3/day can be produced when the borehole is operated for 24 hours.

For Shallow Well No. 2, the average yield is about 1,100 to 1,200m3/day with 6 to 7 hours of operation, since the demand is not large similar to the borehole. In the rainy season, a larger yield is considered to be possible by increasing the operation hours.

The daily operation records show that 6 hours of operation in May (the beginning of rainy season) has secured the yield of 1,120 to 1,160m3/day. The records show that the yield is stable during the operation of pump with the exception of 2-3 hours of suspension. Assuming that the operation is not intermittent and Shallow Well No. 2 is operated for 24 hours, the 4,200m3/day estimated above could possibly be achieved. From these reasons, if the current facilities are fully operated during the rainy season, the above estimated yield of 10,800m3/day would be possible.

ii) Abstracted Water Quantity in Dry Season

Hourly data of water abstraction from the shallow wells (Shallow Well No. 1 and Shallow Well No. 2) in 2007 to 2011 have been collected from Kampong Cham Waterworks. According to the waterworks, although there is no data on abstracted water quantity from the wells, the estimated water quantity abstracted in April and May is 700m3/day. Based on these data and information, the water quantity abstracted daily has been estimated, as shown in **Figure 2.2.2.2-6**.

The abstracted water quantity shows the tendency of gradual increase from 2007 to 2011. In 2010 to 2011, the abstracted water quantity was around 5000m3/day to 8000m3/day in the dry season. However, since the abstracted water quantity in the dry season was the result of long-duration of use of two shallow wells with intermittent pump operation as described above, it is impossible to abstract above volume of water stably during the annual dry season for five months.

At present, Shallow Well No. 1 and Shallow Well No. 2 are used with intermittent operation by operation staff in pump facility for 24 hours. Since the yield of wells is less than the pumping capacity, the water level of wells descends during pumping operation. Therefore, in case the water level of wells becomes below the allowable lowest low water level, the pumps are once turned off and the water level is recovered again to the original water level, the pump is turned

on again. Thus, ON & OFF of the pumps is repeated and the actual operation time of pumps in a day doesn't reach to 24 hours.

Supposing that the intermittent operation of Shallow Well No. 1 and Shallow Well No. 2 will not be necessary in case of operating the pumps for 27 hours (Shallow Well No.1:20hr, Shallow Well No.2:7hr => Total 27hr) in the dry season like the period of rainy and transition season, the appropriate water quantity abstraction is estimated as: (8,000 - 700) x 48hr/27hr = 4,806m3/day (about 4,800m3/day).

In addition, Shallow Well No.1 & No.2 cannot demonstrate original pumping capability 235m3/h and 175m3/h in the dry season, and total proper pumping discharge volume including the discharge of deep well are considered to be 4,800m3/ day.

In case the water demand in the dry season increases from the present condition, the pumping yield cannot exceed the pumping capacity of well pumps. Based on the abstracted water volume data of 8000m3/day with intermitted operation of pumps for 24 hours, the proper pumping discharge volume is estimated to be 4,800m3/day on the basis of assumption that the balance of yield volume and discharge volume will be secured on the condition of usual operation time (20hr+7hr=27hr).

c) Water Quality of the Existing Wells

In terms of water quality of the existing wells, the reason why Kampong Cham Waterworks had measured the water quality of treated water in recent years is that the quality of raw water and the treated water shall be almost the same. From the turbidity shown in **Figure 2.2.2.2-7**, it can be said that the water of the existing wells is clean.

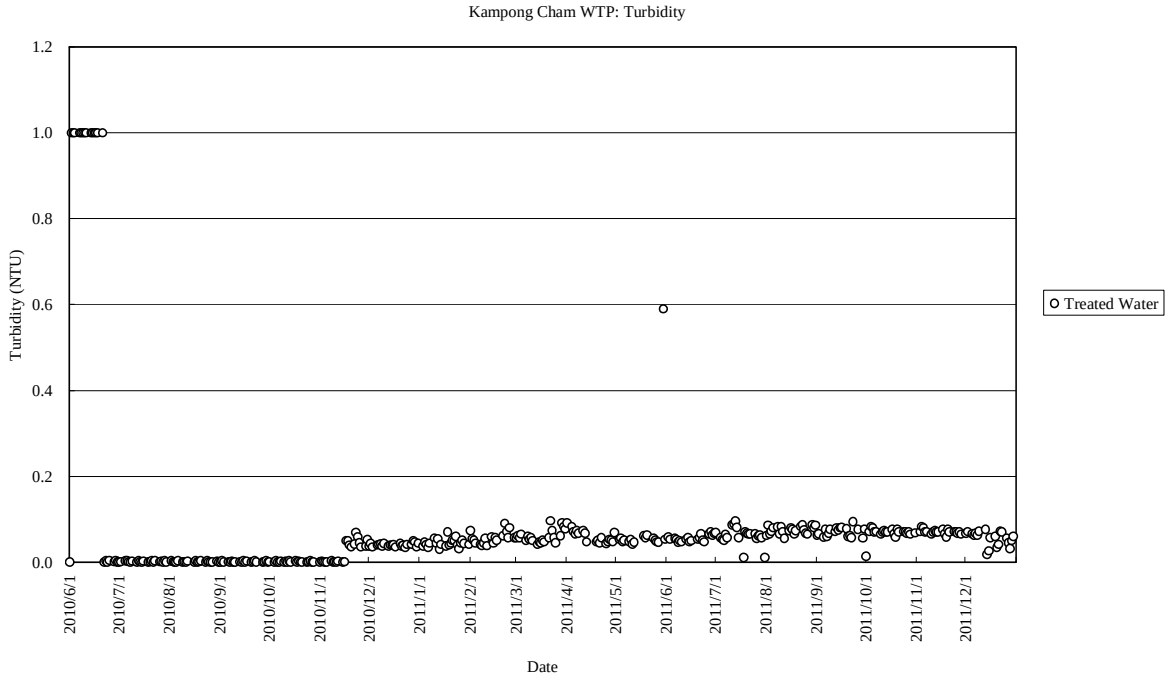


Figure 2.2.2.2-7 Turbidity of Treated Water of the Existing Wells of Kampong Cham

(2) New Water Source for Battambang

A new water source for the new water treatment plant of Battambang was studied under the condition that the source will be the Sangke River flowing through the City, which is the same as the water source of the existing water treatment plant. Described below are: 1) Characteristics of Sangke River and its discharge; 2) Problems on the present intake; 3) Appropriate new intake site and possible water quantity for the intake, including groundwater use in and around Battambang City; and, finally, 4) Long-term possible water source. In addition, as reference data, meteorological condition of Battambang and water quality condition of the raw and treated water of the existing water treatment plant are shown in 5) Candidate Sites for Future Alternative Water Sources.

1) Characteristics of the Sangke River and Its Discharge

The Sangke River is one of the major tributaries of the Tonle Sap River. It flows through Battambang City, and into the northwestern part of the Tonle Sap Lake from the western direction. The catchment area of the Sangke River is 6,053km2. There is a water level and discharge gauging station of MOWRAM at the Hen Sen Bridge, which is located at just upstream of the existing intake facility in Battambang City. Upper part catchment area of the Sangke River Basin from the water level and discharge gauging station is 3,194km2 among the whole Sangke River Basin catchment area of 6,053km2.

Other characteristics of the Sangke River are the active boat navigation and fishing.

Furthermore, the intake of water from the river is conducted by the inhabitants living along it.

a) Historical Variation of Daily Discharge

The Sangke River has a relatively large discharge during the rainy season, but relatively small in the dry season. Daily discharge data from 1997 to 2010 have been collected from MOWRAM, and **Figure 2.2.2.2-8** show the historical variation of daily discharge based on these data. During this period, the maximum discharge of 988m3/s was recorded in August 2006 and the minimum discharge of 0.87m3/s in March 2005. Although no data is available, during the flood in August or September 2011, the water level reached up to the top of the river banks in the City, and some areas experienced inundation of about 0.1m in water depth.

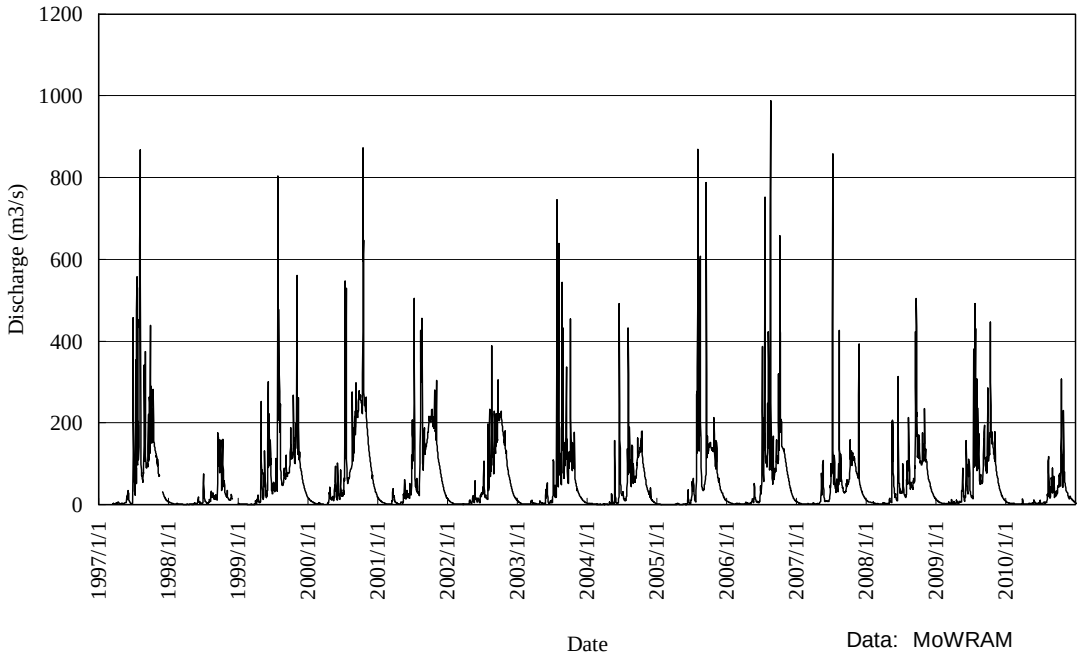


Figure 2.2.2.2-8 Daily Discharge of the Sangke River in Battambang City (1997-2010)

b) Monthly Average Discharge

Figure 2.2.2.2-9 show the monthly average, maximum and minimum discharges during the period 1997 2010. Monthly average discharge becomes small from January to April, especially in February when the monthly average discharge becomes 2.44m3/s, the smallest discharge in a year. The monthly average discharge becomes biggest in October with 154.42m3/s.

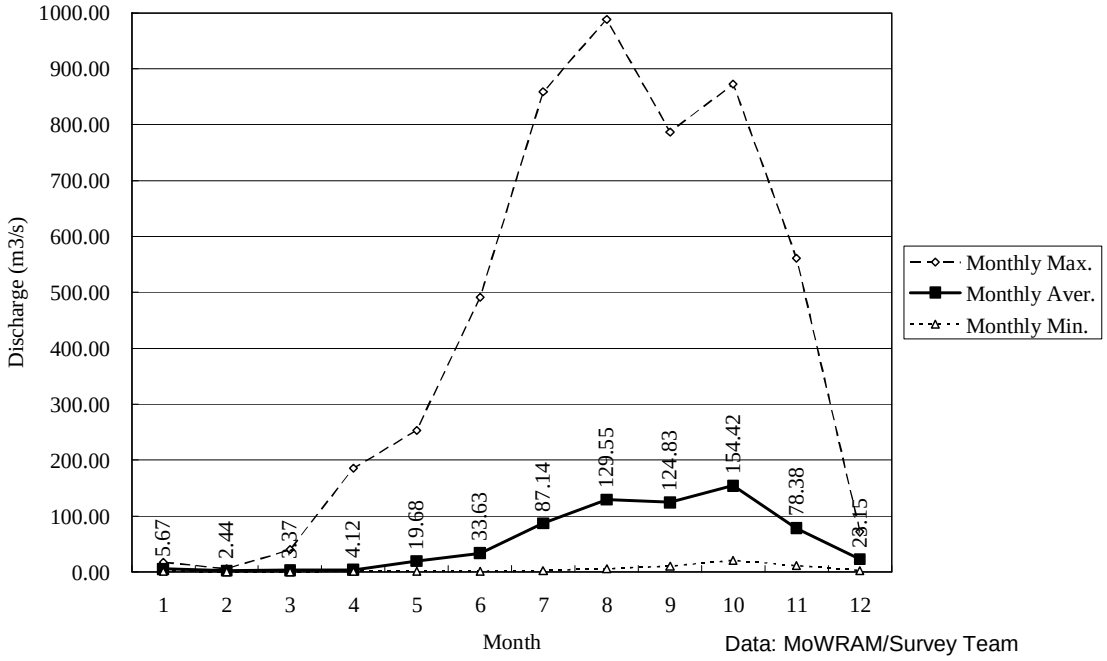


Figure 2.2.2.2-9 Monthly Average, Maximum and Minimum Discharges of the Sangke River in Battambang City (1997– 2010)

c) Probable Drought Discharge

Probable drought discharge has been estimated based on the effective annual minimum discharge data, which exclude the data of the years of no measurement of the relatively small discharge. **Table 2.2.2.2-2** shows the effective data for analyzing the probable drought discharge. Number of years of effective data is only 11 years.

Table 2.2.2.2-2 Annual Minimum Daily Discharge of the Sangke River

Year	Annual Minimum Discharge (m^3/s)	Year	Annual Minimum Discharge (m^3/s)
1997	-	2004	1.32
1998	1.35	2005	0.87
1999	1.25	2006	1.64
2000	-	2007	-
2001	1.67	2008	2.48
2002	1.54	2009	2.71
2003	1.62	2010	2.16

Shown below are the probable daily drought discharges calculated by the Gumbel Distribution Function based on the daily annual minimum discharge.

2-year return period of drought: 1.62m3/s

5-year return period of drought: 1.16m3/s

10-year return period of drought: 0.97m3/s

20-year return period of drought: 0.83m3/s

In Cambodia, guidelines for setting the “safety level (return period of drought) for water use” have not been formulated yet. In general, since many countries adopt the 10 year return period of drought as the safety level for domestic water supply, it is also recommendable to adopt the 10 year return period of drought as the safety level for domestic water supply for this project.

(Reference) Duration of Drought Discharge

The drought discharge of the Sangke River is estimated by probability analysis based on the effective data of annual minimum discharge of 11 years. If drought discharge is estimated through runoff analysis based on annual rainfall amount in the river basin, the seasonal pattern of drought discharge throughout a year can be estimated. However, since the drought discharge is analyzed based on the annual minimum discharge which happens only once or so in a year, it is difficult to estimate the seasonal pattern of drought discharge in a year.

However, since drought which was more severe than a 10 year drought occurred in 2005, the discharge pattern in 2005 can be a good reference of duration of drought. **Figure 2.2.2.2-10** shows the daily discharge at the water level and discharge gauging station of the Sangke River located just upstream of the existing intake facility of water supply. The annual minimum discharge in 2005 was 0.87m3/s, which corresponds to about 10 to 20 year return period of drought. In 2005, the discharge smaller than 0.97m3/s continued for around 6 days, while discharges larger than 0.97m3/s occurred in other periods. Considering this fact, it is possible that the discharge smaller than that of 10-year return period of drought can occur for around one week.

The total volume of environmental flow (0.60m3/s) and proposed intake water quantity (0.42m3/s) for the existing and the new water treatment plants is 1.02m3/s. The duration for which the river discharge is smaller than 1.02m3/s is estimated for around 9 days in the year of 10-year return period of drought.

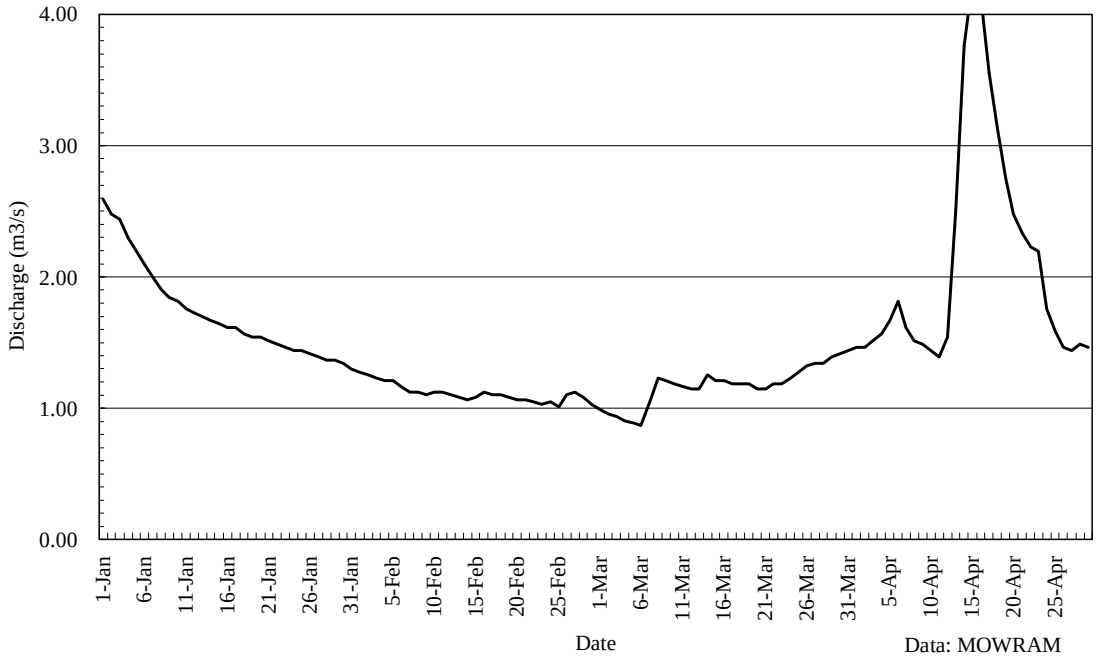


Figure 2.2.2.2-10 Daily Discharge of the Sangke River during the Dry Season in 2005

2) Condition and Problems of Present Intake

a) Abstracted Water Quantity by the Existing Intake Facility

Battambang Waterworks does not measure the quantity of abstracted raw water, but they estimate the quantity of raw water as 1.1 times of the water treated by the existing water treatment plant. **Figure 2.2.2.2-11** shows the daily quantity of treated water and the estimated quantity of abstracted water. Based on the figure, it can be known that the quantity of treated water from 2010 to 2011 is around 9,000m3/day and the estimated quantity of abstracted water is around 10,000m3/day.

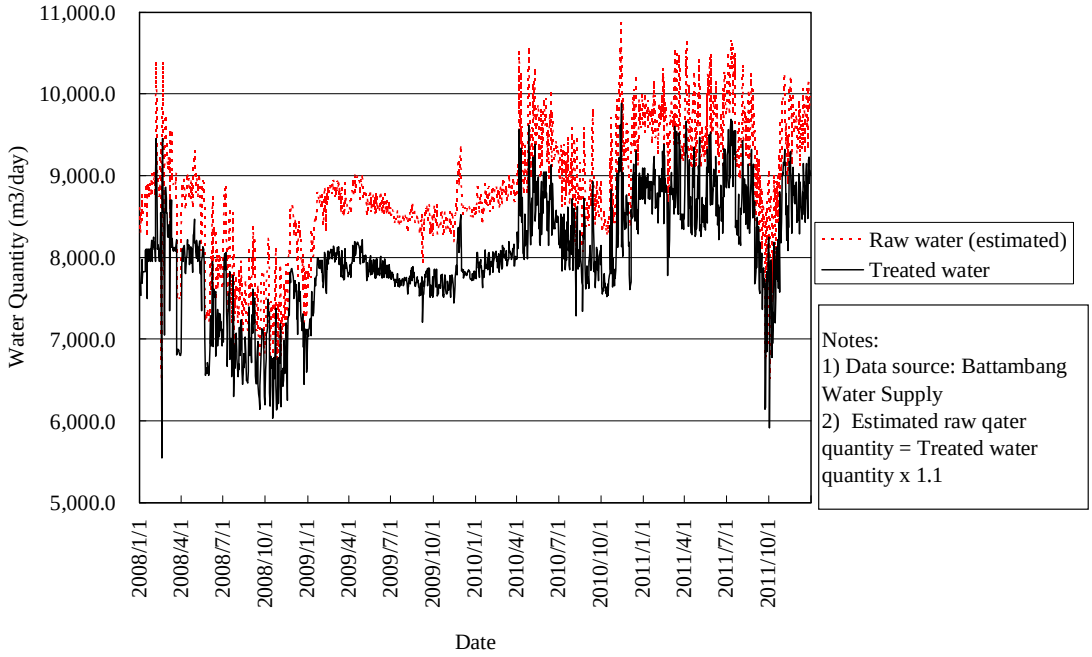


Figure 2.2.2.2-11 Daily Treated Water Quantity and Estimated Abstracted Water Quantity of the Existing Battambang Water Treatment Plant (2008–2011)

b) Water Quality of Raw Water and Treated Water

Figure 2.2.2.2-12 shows the turbidity of raw water and the treated water. The turbidity of raw water is high while that of the treated water is 1 to 2NTU.

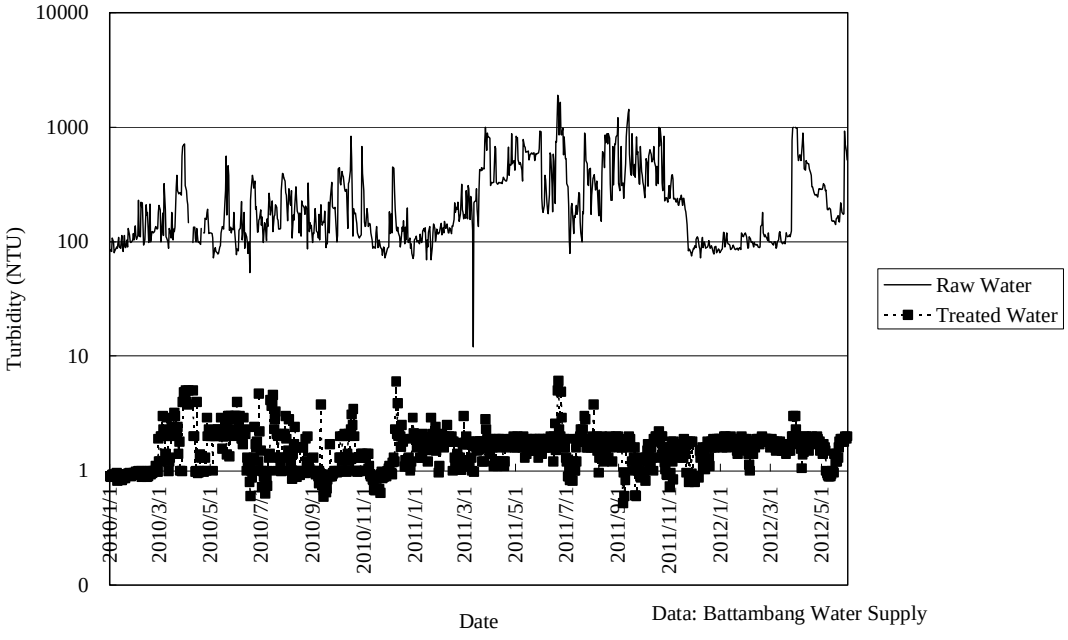


Figure 2.2.2.2-12 Turbidity of Raw Water and Treated Water of the Existing Battambang Water Treatment Plant (2010-2012/5)

c) Problems of the Present Abstraction of Water

The problems on water abstraction by the existing intake facility are as follows:

Difficulty of taking water during dry season especially during drought period due to small water depth

During the dry season, especially during once in two to three-year drought, water depth of the river at the existing intake facility becomes small, and it becomes difficult to inflow water from the inlet of the intake facility placed on the riverbed. Therefore, in order to raise the water level around the inlet portion of the intake and to abstract water, the Battambang Waterworks placed sand bags to temporarily close the river. However, the sand bags are insufficient for raising the water level around the inlet portion.

Problem of causing damage to the pumps by inflowing sediment from the inlet portion of the intake facility during dry season

The existing intake facility has two inlets. One is located on the riverbed, and the other one is located at about 2m above the riverbed on the surface of the bank protection works. In every dry season, it is necessary to take water from the inlet on the riverbed due to shallow water depth of the river. In this case, the bed load of sand of about 1mm in diameter, which are moved over the riverbed by the water flow, enter through the inlet and cause damage to the pumps. For this reason, the Battambang Waterworks has been repairing the pumps every year.

3) Appropriate New Intake Site and Possible Water Quantity for the Intake

Since navigation and fishing are actively conducted in the Sangke River, it is not appropriate to install closing structures such as fixed or gated weir on the river. Furthermore, installing a weir will also raise the flood water level so that it will be necessary to raise the existing wall along the river by 1m or more. Therefore, it is not appropriate to install a weir for newly taking water for water supply. Direct abstraction of water from the river by pumps is the only applicable method.

Based on the present problems on water abstraction, the following are considered for selecting the optimum site for the direct abstraction of water by pumps from the Sangke River:

- As a stable water source, the water shall be sufficiently deep (more than 1m) for abstracting water easily during dry season and especially in drought period.
- Water quality at the intake site shall be good.
- Resettlement of residents for installing the intake facility shall not occur as much as possible.
- Space for the intake facility shall be secured and the surrounding areas shall be quiet to easily conduct maintenance and provide security for the intake facility.

a) New Intake Site

Considering the above, the following four alternative sites of the new water intake facility are compared as below (see **Figure 2.2.2.2-13** and **Table 2.2.2.2-3**).

- Downstream Site: The site near the new water treatment plant.
  Water depth during dry season is about 0.5m. This site has a possibility to be affected by sewage.
- Middle Site – 1: The site at about 580m downstream from the existing intake site.
  Water depth during dry season is about 0.5m. This site is not affected by sewage.
- Middle Site – 2: The site at about 1,000m upstream from the existing intake site.
  Water depth during dry season is about 4m. Houses densely exist on the left bank. There is a market nearby and the condition is congested.
- Upstream Site: The site at about 1680m upstream from the existing intake site.
  Water depth during dry season is about 1.5 to 2m. There are spaces along the river banks.

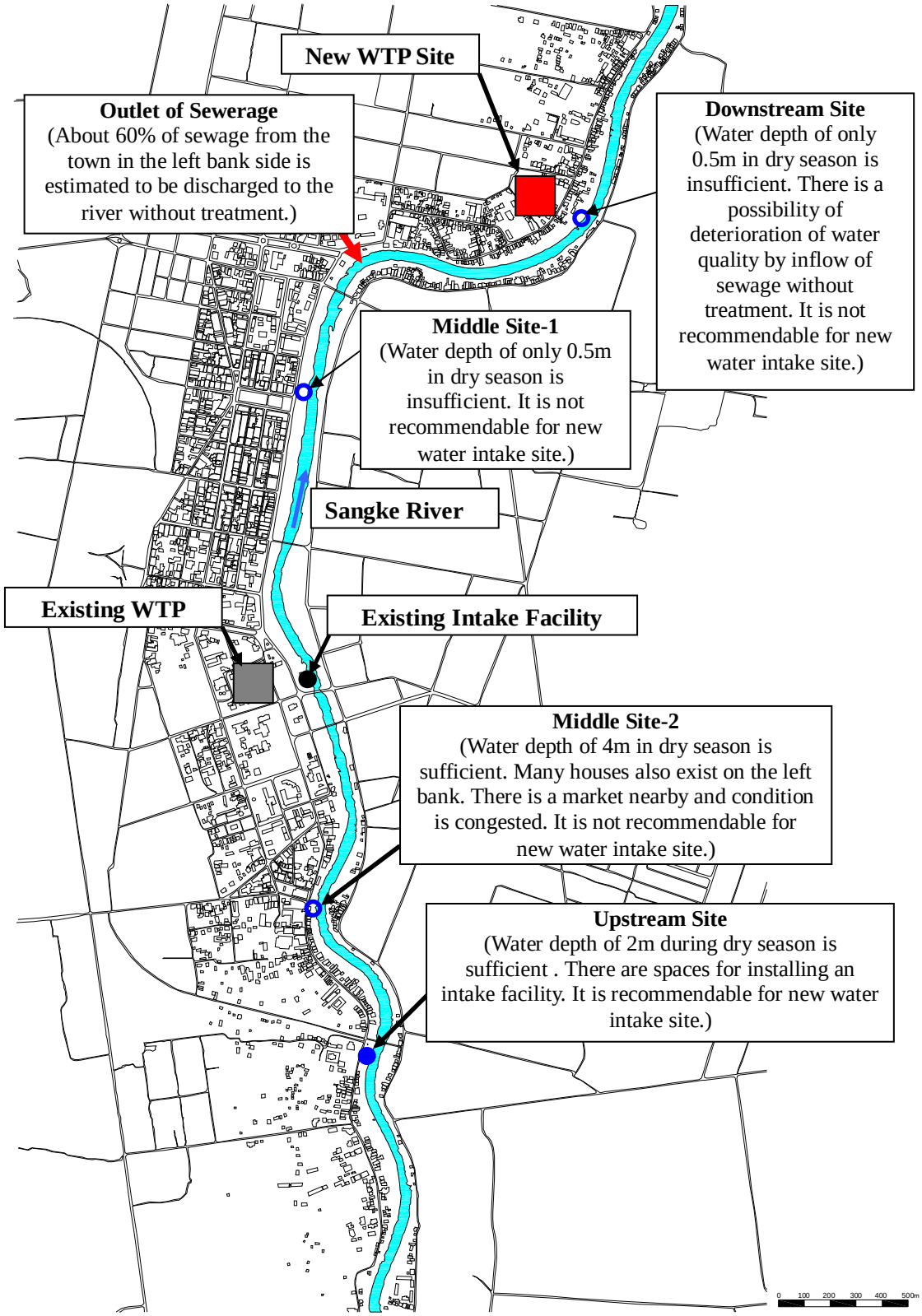


Figure 2.2.2.2-13 Alternative Sites of New Water Intake Facility along the Sangke River in Battambang City

Table 2.2.2.2-3 Comparison of Alternative Sites for Surface Water Sources along the Sangke River in Battambang City

Item	Downstream Site	Middle Site-1	Middle Site-2	Upstream Site
1. Location of Site	Near the new water treatment plant and about 2560m downstream from the existing intake site.	About 580m downstream from the existing intake site.	About 1000m upstream from the existing intake site.	About 1680m upstream from the existing intake site.
2. Length of Water Transmission Pipe	About 0.2km	About 2.1km	About 3.7km	About 4.4km
3. Average Water Depth in Dry Season (based on information from people)	About 0.5m	About 0.5m	About 4m	About 2m
4. Inflow of Sewage	About 60% of sewage from the town in the left bank side inflows without treatment from 620m upstream. There is no sewerage system in the town at right bank side and no inflow to the river.	About 770m upstream from the inflow point of the sewerage. There is no inflow of sewage from the town.	No inflow of sewage from the town.	No inflow of sewage from the town.
5. Utilization of River	Navigation, fishing and some houses along the river banks.	Navigation, fishing and parks along the River.	Navigation, fishing and many houses along the river banks.	Navigation, fishing and some houses along the river banks.
6. Floodwater Level	Nearly equal to the top of the banks.	Nearly equal or slightly above the top of the banks.	Nearly equal to the top of the banks.	Nearly equal to the top of the banks.
7. Advantage and Disadvantage as Intake Site	1) Possibility of water pollution by inflowing sewage in dry season. 2) Possibility of difficulty of taking water during dry season due to shallow water depth. 3) Impossible to raise water level by installing a fixed or gated weir due to navigation and high flood water level.	1) Possibility of difficulty of taking water during dry season due to shallow water depth. 2) Impossible to raise water level by installing a fixed or gated weir due to navigation and high flood water level. 3) No water pollution problem is expected.	1) Easy for taking water due to sufficient water depth during dry season. 2) No water pollution problem is expected. 3) Many illegal houses on the river banks. Market exists at a nearby place, and congested condition. 4) There are problems on maintenance and security of the intake structure. 5) Relatively far from the new water treatment site.	1) Easy for taking water due to sufficient water depth during dry season. 2) No water pollution problem is expected. 3) There are some spaces on the river banks. There may be no problem for installing the intake facility and maintenance of the structure. 4) Relatively far from the new water treatment site.
8. Necessity of Resettlement of People	Resettlement necessary for installing an intake facility.	No necessity of resettlement.	Resettlement necessary for installing an intake facility.	No necessity of resettlement.
9. Conclusion	Not recommendable for new intake site due to shallow water depth and especially due to the possibility of water pollution.	Not recommendable for stable surface water source due to shallow water depth.	Possible for a stable water source, but not recommendable as new intake site due to many illegal houses.	Recommendable for new intake site due to possibility of stable water source.

Although the downstream site is near the new water treatment plant, it is insufficient from the viewpoint of stable water source due to the shallow water depth during the dry season. Moreover, there is the sewage inflowing at about 620m upstream from the left bank so that there is a possibility of water pollution during the dry season. For these reasons, this site is not recommendable as the new intake site. If the Sara Ta Orn Dam, which will be a weir for irrigation, flood control and electric power generation, is constructed at about 4.9km downstream from this downstream site, sufficient water depth at the site is estimated to be secured even during the dry season. However, sewage will be stored in the river channel storage of the dam and hence, it is possible that the water quality at this downstream site will deteriorate. Therefore, the downstream site is again not recommendable for the new intake facility site.

Middle Site-1 is the site not affected by the sewage and it is very near the new water treatment plant. However, the water depth in the dry season is shallow so that it is not recommendable from the viewpoint of stable water source.

Middle Site-2 is the nearest among the four sites and it has sufficient water depth during the dry season. However, local ferry navigation and fishing are actively conducted around this site. Furthermore, many illegal settlements exist on the banks, which would make it difficult to acquire space for installing an intake facility. In addition, there is a market nearby, and the area is congested. This site is possible in terms of stable water source, but the resettlement of people will be necessary for installing the intake facility. Furthermore, the space is insufficient for the facility, and it is necessary to be more careful for the maintenance and security of the intake structure. Due to these reasons, this site is not recommendable for the new intake facility site.

The Upstream Site has sufficient water depth of 1.5m to 2m in every dry season. Therefore, this site is possible as a stable water source. Furthermore, although illegal settlements exist along the left bank, since there is some space near the existing railway bridge for installing the intake facility, the resettlement of people will not be necessary. Considering these reasons, this Upstream Site is recommendable for the new intake facility site.

Existing Sewerage System in Battambang City (for Reference)

There is only one combined type sewerage system existing in the left bank side area of the town which was constructed during the French Era. About 20 to 30% of residences in that area are connected with the sewerage system. In principle, sewage should be treated by the lagoon type wastewater treatment plant and then discharged to the surrounding farmlands, etc. In addition, rainfall runoff should be discharged to the Sangke River from the above outlet on the left bank. However, there may be problems such as clogging of the existing sewerage pipes. About 60% of the sewage from the town in the left bank area flow into the Sangke River without treatment from the above outlet of rainfall runoff based on the ocular observation by the Survey Team. In

addition, the lagoon has not been used because the pump in the treatment plant has been out of order. Due to this reason, the rest of the 40% of sewage is also discharged into the farmlands in the northern part of the city without treatment. Furthermore, there is no outlet of sewerage on the right bank side of the river. ADB had formulated a future development plan for the sewerage systems in the right bank side of the river, but there is no schedule for the implementation of the plan.

b) Possible Quantity of Water Abstraction

Based on the probable drought discharge described in Item (1)-c), the possible quantity of water abstraction from the Sangke River has been estimated. The following shows the estimated possible quantity for water abstraction, which is the sum of the quantity of water abstraction by the existing intake facility and that of the new intake facility.

Possible quantity of water abstraction for water supply =
Probable drought discharge – Environmental discharge

Environmental discharge = Maintenance discharge (for ecosystem such as fish habitats, scenery along the river, maintenance water quantity for navigation) + Water use quantity in the downstream reaches

Environmental discharge is the minimum discharge to be ensured for ecosystem, scenery, navigation and water use in the downstream reaches even in drought period.

Environmental discharge was estimated at $0.5m^3/s$ supposing that the width of water surface is 10m, water depth is 0.5m with triangle shape and velocity is 0.2m/s (W10m x D0.5m÷2 x 0.2m/s=$0.5m^3/s$, the water depth of 0.5m is set as the depth for swimming of large size fish). Water abstraction for irrigation is not conducted in the downstream reaches. Only private water abstractions are conducted in the downstream reaches. Based on the site reconnaissance along the river, it is estimated that the private water abstraction is $0.1m^3/s$ from the Upstream Site to the most downstream part of the Sangke River. As a result, the environmental discharge is estimated at $0.6m^3/s$.

Based on the above analysis, the possible quantity of water abstraction for domestic water supply has been estimated as shown in **Table 2.2.2.2-4**. It is estimated that about 32,000m3/day can be abstracted under 10-year drought. In addition, if service rate of water supply is increased in the future, number of people who are abstracting water directly from the river will decrease, and amount of water use in the downstream reaches will decrease.

Table 2.2.2.2-4 Possible Quantity for Water Abstraction for Water Supply from the Sangke River in Battambang City

Case	River Discharge	Environmental Discharge	Possible Discharge/ Quantity for Water Abstraction for Water Supply
Annual Average Minimum Discharge	2.44m^3/s	0.6m^3/s	1.84m^3/s (159,000m^3/day)
5-year Return Period of Drought	1.16m^3/s	0.6m^3/s	0.56m^3/s (48,400m^3/day)
Intake Water Quantity for Existing and New Water Treatment Plants	1.02m3/s	0.6m3/s	0.42m3/s (36,200m3/day)
10-year Return Period of Drought	0.97m^3/s	0.6m^3/s	0.37m^3/s (32,000m^3/day)

There is seasonal change of river discharge of the Sangke River. Except January to April in dry season, the river has a relatively bigger discharge than the discharge during eight months in a year. Therefore, even if the necessary intake water quantity becomes a little bigger than the discharge of the river minus the necessary discharge to ecosystem, navigation and private intake, the river discharge can cope with the required water quantity, at least, during the eight months. It will be necessary to take some countermeasures during the rest of four months, so that the river water quantity and the intake water quantity will be balanced. One of the countermeasures is to temporarily reduce the quantity of water abstraction and supply for domestic water supply until the recovery of river discharge. Another countermeasure is to have meetings between the future water management body and water users such as irrigation, domestic water supply and others, which is like the coordination committee meetings against drought in Japan, for putting priorities to the water abstraction, and to ensure water quantity for domestic water supply as much as possible. For information, there is no actual water management body at present. MOWRAM is currently studying the future water management system including water management body, which will belong to MOWRAM.

4) Groundwater Use in and around Battambang City

According to the Battambang Waterworks, there is no groundwater abstraction in Battambang City by private water selling companies. Private water selling companies abstract water from the Sangke River. In addition, inhabitants who do not receive public water supply service purchase water from the water selling companies or abstract water directly from the Sangke River. Hence, there is a possibility that no promising groundwater source exists inside the City.

According to the Battambang Waterworks, at 30 to 40km from the City, there is a site where a private water supply company abstracts water from groundwater or from nearby ponds. However, hardness of the water is high (information from Battambang Waterworks).

Furthermore, according to "Battambang Urban Water Development, Water Sources Sector Report, 1994" of the Overseas Development Administration of the United Kingdom, there are three big groundwater aquifers around Battambang City. They are composed of the area of alluvial deposits at around 30km upstream along the Sangke River from the City, the sandstone area at around 50km upstream from the City, and the limestone area around Kamping Puoy Reservoir at about 30km from the City.

5) Candidate Sites for Future Alternative Water Sources

Except the existing and new water intake sites along the Sangke River, information on candidate sites for future alternative water sources has been collected from MOWRAM. **Figure 2.2.2.2-14** shows the candidate sites for the alternative water sources and **Table 2.2.2.2-5** shows general descriptions and possibilities of the alternative water sources. Among these water sources, although the distance is around 50km from Battambang City, Battambang I Dam will have a possibility for a stable water source in the future, because the dam will have the possibility of allocating storage volume for domestic water supply.

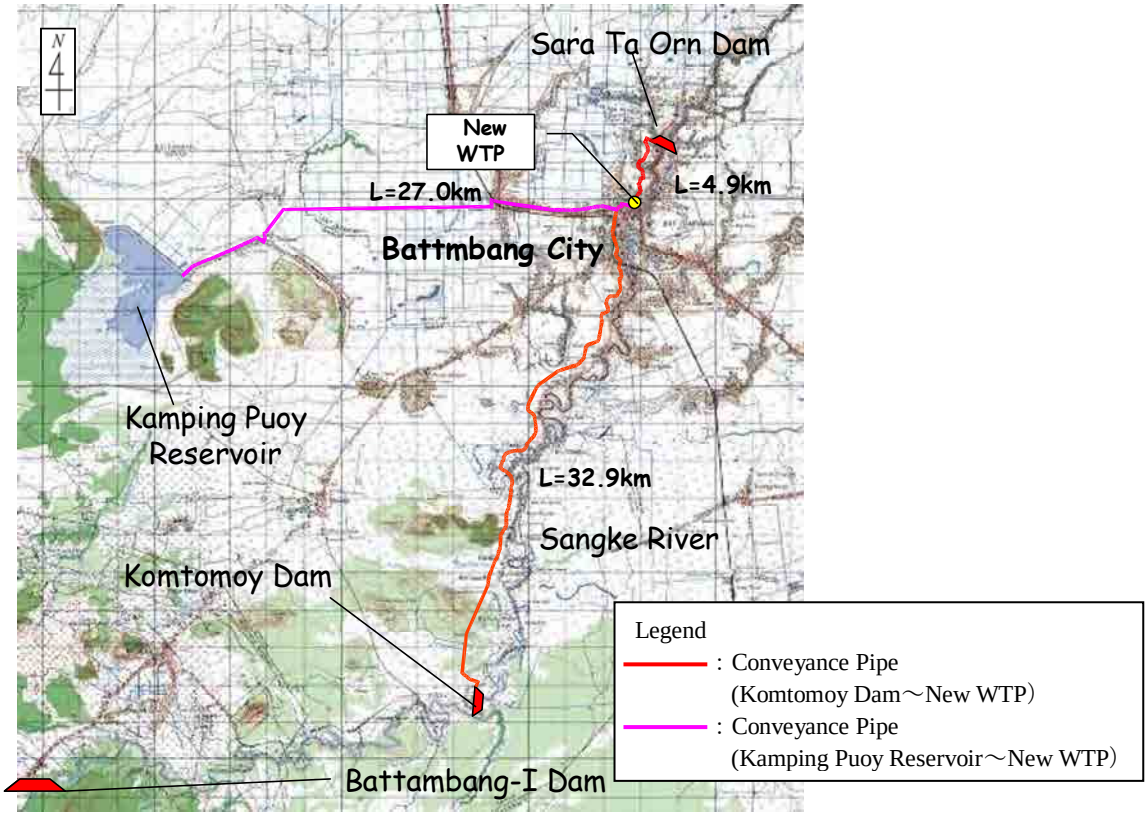


Figure 2.2.2.2-14 Candidate Sites of Alternative Water Sources for Battambang City in the Future

Table 2.2.2.2-5 Candidate Sites of Alternative Water Sources for Battambang City in the Future

Water Source	General Description	Current Stage and Future Movement	Maintenance Discharge and Environmental Discharge	Possibility for Alternative Water Source
Kamtomoy Dam (A weir of Kanghot Irrigation Project)	Water intake by a gated weir. Storage is only in the river channel. Under construction in the Sangke River Basin	Under construction	Environmental discharge of 5.5m^3/s including maintenance discharge of 4.75m^3/s and water use in the downstream reach of 0.6m^3/s and private water abstraction 0.15m^3/s from the river by the residents.	No possibility
Sara Ta Orn Dam	Irrigation water intake and hydropower generation by a gated weir. Storage is only in the river channel. Storage capacity: 10.65 x 10^6 m^3. Under planning in the Sangke River Basin (Under re-examination)	Under reconsideration of the necessity of construction by MOWRAM.	Maintenance discharge: 0.2m^3/s	No possibility
Kamping Puoy Reservoir	Existing irrigation reservoir in the Sangke River Basin. Gross storage capacity: 80 x 10^6 m^3. It is planned to increase the storage capacity to 110 x 10^6 m^3 in the near future by inter-basin water transfer from other river basin.	Existing reservoir. Storage water volume was small from 1999 to 2003.	-	No possibility in the present. There is a possibility of securing domestic water supply quantity for Battambang City after increasing the quantity of inflow water.
Battambang-I Dam	Dam for irrigation and hydropower generation. Provisional Storage capacity will be 200 to 300 x 10^6 m^3. Final storage capacity will be 500 x 10^6 m^3. Proposed in the Sangke River Basin.	To be implemented from 2012 by using Chinese Fund. Loan agreement was already signed with the Chinese Government in June 2012.	Maintenance discharge: 3.0m^3/s.	High possibility of securing water storage capacity of domestic water supply for Battambang City.

6) Summary of Sala Ta Orn Dam Project

a) Summary of Sala Ta Orn Dam Project

The scope of Sala Ta Orn Dam Project consists of the following four items as shown in **Table 2.2.2.2-6**, i) Construction of Sala Ta Orn Dam and other irrigation facility, ii) irrigation canal rehabilitation, iii) construction of hydropower plant and iv) provision of consulting services.

Table 2.2.2.2-6 Project Work Scope of Sala Ta Orn Dam Project

Components	Description
Dam Construction	Construction of concrete gravity type dam ・Height 10.1m, Length 114.0m ・Effective storage 10.6 million m^3 ・4 roller gates
Hydropower Plant	Half basement type ・Normal capacity 500KW x 2Units ・Annual power generation 5.7GWh
Irrigation Canal Rehabilitation	Existing canal of 10km in length ・Rehabilitation of the existing canal ・Construction of 3 water gates ・Construction of 2 pumping stations ・Construction of irrigation facilities including cross bridges on the main canals
Consulting Services	・Detailed design (including field survey) ・Assistance in preparation and evaluation of bidding documents ・Supervision of construction ・Other assistances in project management ・Education for the Famer Water Users Committee

Notes: The detailed Project work scope could be adjusted according to the result of detailed design or work scope alternation upon the consent of the Bank.

Source: Sala Ta Orn Project Feasibility Study Report

b) Progress of Sala Ta Orn Dam Project

The Royal Government of Cambodia has requested the Government of South Korea to provide financial support for Sala Ta Orn Dam Project under the Economic Development Cooperation Fund (EDCF). Pursuant to the request of the Korean Government, the Export-Import Bank of Korea, the government agency for the EDCF, dispatched the appraisal mission from November 19th to November 23rd, 2012 to Phnom Penh, Cambodia in order to conduct appraisal for the proposed Project. The main objectives of the mission are as follows;

- to evaluate the feasibility of the Project by the Export-Import Bank of Korea and the extent of the preparation for its implementation, and conduct site surveys
- to verify and analyze the work scope, cost estimates, and financing plans
- to review the environmental impact of the Project implementation
- to discuss the scope of assistance and terms and conditions of the loan
- to discuss procurement plan and other related issue
- to discuss the legal matters and explain the major points of the loan agreement (L/A) with the officials of the Government of Cambodia

The mission held discussions with the representatives of the relevant departments of the

Government of Cambodia such as the Ministry of Economy and Finance and Ministry of Water Resources and Meteorology. On November 23rd 2012, the Minutes of Discussion summarizes the findings of the mission, points discussed and agreements reached between the Government of Cambodia and the mission.

The detailed design will start trough the conclusion of L/A and consultant selection from now on. Then construction will start through the public announcement, pre-qualification, tendering and conclusion of contract. The construction period is assumed to be 42 months.

c) Agricultural Water Demand on Sala Ta Orn Dam

The agricultural water volume supplied from Sala Ta Orn Dam is estimated as following **Table 2.2.2.2-7** in Sala Ta Orn Project Feasibility Study Report.

Table 2.2.2.2-7 Agricultural Water Demand on Sala Ta Orn Dam

(5-year return period of drought) **Unit : million m^3**

Month	1	2	3	4	5	6	7	8	9	10	11	12	Total
Water Volume	4.34	4.40	4.46	13.30	21.54	16.44	13.89	7.34	7.99	10.97	16.10	4.11	125.0

Source: Sala Ta Orn Project Feasibility Study Report

On the feasibility study report, the storage capacity of Sala Ta Orn Dam is determined based on the water balance analysis between the inflow discharge and the outflow discharge (agricultural water demand + hydro power generation discharge + environmental discharge (0.3m3/s)) using the 10 years river discharge data, and the storage capacity is satisfied with the 5-year return period of drought. Therefore, Sala Ta Orn Dam has the capability that the water for agricultural use, hydro power generation and environmental discharge (0.3m3/s) can be supplied also under the condition of the 5-year return period of drought. However, the detail procedure of water balance analysis on the feasibility study is unknown, and besides this point, since the feasibility study by the Export-Import Bank of Korea was completed in 2009, the influence which the Japanese Grant Aid Project affects water discharge and water quality of Sangke River is not taken into consideration on this feasibility study report. Moreover, there is no description under the condition of severe 10-year return period of drought etc. on this report and the storage volume of Sala Ta Orn Dam will decrease and water supply restriction shall be necessary for agricultural use.

At the time of explanation for draft final report on this preparatory survey in February, 2013, Japanese side reported the enforcement of this Grant Aid Project once again to General Director who is in charge of Sala Ta Orn Dam Project in MOWRAM, and confirmed that Cambodian side have agreed the minutes of Korean appraisal mission conducted from November 19th to November 23rd, 2012 based on the premise of enough recognition for this Japanese Grand Aid Project. Therefore, it is not necessary that the Japanese side considers superfluously about the influence which this Japanese Grant Aid Project affects to the Sala Ta Orn Dam Project.

According to MOWRAM, MOWRAM has an idea that they will re-examine the water balance plan taken into consideration the water demand of up-and-downstream of the proposed Dam on the detailed design stage. In this stage, MOWRAM recognizes the necessity to consider the procedure of water intake restriction, water supply restriction by temporal water supply, coordination between the water management body (MOWRAM) and the water users under the severe condition such as 5-year or 10-year return period of drought. Therefore, if necessary, the information of this Grant Aid Project will be provided to the stakeholder of Sala Ta Orn Dam Project .

(3) Water Management System in Cambodia

Based on the "Law on Water Resources Management of the Kingdom of Cambodia" enacted in 2007, there is a target for implementing the Integrated Water Resources Management (IWRM) in Cambodia. The responsible agency of the IWRM will be the MOWRAM. The IWRM will include management of quantity and quality of surface water and groundwater as well as risk management against flood and sediment disasters. For the implementation of IWRM, MOWRAM has received technical assistance from the Asian Development Bank (ADB) in 2011 for the "Cambodia Water Resources Management Sector Development Program." The project aims to support MOWRAM in formulating the policy on water resources management, establishing river basin management system, water quality management system, rehabilitation of medium to small irrigation systems, and the related capacity developments.

The water law for the approval and licensing system administrated by MOWRAM has not established yet and that was not adopted on Cambodian cabinet for several years so far. Moreover, the establishment schedule of approval and licensing system is not clear. Therefore, the water intake right system does not exist legally on the present situation and MOWRAM does not have the authority to manage the water intake. However, under the above present condition, MOWRAM encourages reporting the information such as intake discharge, intake location etc. from the organizations and entrepreneurs who extract water from river, and if necessary, issue the endorsement letter for water intake in order to grasp the current intake situation as the managing body for water resources.

Preparatory survey team confirmed that information shall be fully shared with MOWRAM about water intake from Sangke River and Mekong River on this Grant Aid Project and MIME will provide the information for the water intake on this project by document and receive the endorsement letter from MOWRAM in order to get the prompt water intake permission in case of establishment for water intake approval and licensing system.

2.2.2.3 Plan for Water Intake Facilities

2.2.2.3.1 Condition of Existing Facilities

(1) Condition of Existing Facilities in Kampong Cham

Currently, three operating officers or operators are employed for the operation and maintenance of well pumps and the water tower. Among their responsibilities are to manually switch the facilities on and off. The monitoring of water level at the water tower is carried out by visual observation. When the water level at the water tank has reached the HWL, the pumping system automatically stops.

Day to day cleaning around the intake facilities and the maintenance of pumps are also carried out by these three operators. In case of breakdown of pumps, three operators are additionally assigned to help solve the problem. Power for the intake facilities is supplied by a generator kept in the premises of the waterworks in Kampong Cham.

Photo 2.2.2.3-1 Inside of Existing Shallow Well

Photo 2.2.2.3-2 Vertical Axis Pump at the Existing Intake Facility

Photo 2.2.2.3-3 Existing Deep Well

Photo 2.2.2.3-4 Existing Chlorination Facility

The intake pump shown above was made by the US ELECTRICAL MOTORS in the USA. In case a shallow well breaks down, the waterworks operators repair it by themselves.

The logistics route is well established for the procurement of spare parts. Spare parts are procured by the waterworks through a local dealer selling imported goods in Phnom Penh. Problems such as clogging have not been found in the raw water transmission main, from the existing intake facility to the water tower.

(2) Condition of Existing Facility in Battambang

The existing intake facility at Sangke River pumps up water by the vertical shaft type mixed flow pump. Intake pipes installed by the river bank convey water by gravity flow into an underground intake shaft installed by the bank. Three pumps have been installed and, additionally, a spare pump has been provided as a standby pump.

The pumping capacity per pump is 240m3/h. Two of the pumps are supposed to operate for 24 hours with the design intake flow calculated as 240m3/h x 24h x 2 pumps = 11,520m3/day. The actual operation hours are 22h/day.

However, the headwater level can be about 0.5m at the current intake point during the dry season. As a temporal measure, water is taken from the intake pit placed at the riverbed. Bed load may, however, flow from this pit, and cause pump failures.

Currently, at each intake and distribution pump station, one operator is assigned to switch the facilities on and off manually. When the river water level falls below a certain level, the pumps are stopped automatically.

Daily maintenance, such as the maintenance of pumps and cleaning of intake facilities is carried out by these operators. If the need arises, two or three additional operators are assigned depending on the workload. Power is supplied from the outside. As a precaution against power failure, a generator is installed within the premises of the waterworks.

Photo 2.2.2.3-5 Existing Intake Facilities (Temporary Weir made of Sand Bags during the Dry Season)

Photo 2.2.2.3-6 Vertical Axis Pump at the Existing Intake Facility

The pump shown above was made by the US ELECTRICAL MOTORS in the USA. In the event of failure, repair is made using domestically manufactured substitutes to replace the original parts without purchasing the original ones from the manufacturer. In general, Cambodia maintains a good trading relationship with its neighboring countries such as Vietnam and Thailand for the procurement of goods.

Battambang Waterworks also has a track record of procurement of consumable goods such as bearings and bolts from the neighboring countries through domestic dealers. Raw water transmission main consisting of φ500mm DCIP (Ductile Cast Iron Pipe) have been laid from the existing intake pump station to the water treatment facility in the waterworks premises. No trouble such as clogging has been reported involving the raw water transmission main.

2.2.2.3.2 Selection of Intake System for the Planned New Intake Facility

(1) Intake System at Kampong Cham

The intake system of the new intake facility has to be selected in consideration of several factors such as the annual fluctuation of water level at Mekong River, workability, and impact to the surrounding areas. Systems such as intake weir and intake gate are not applicable in Kampong Cham due to the river width and the flooding circumstances, in addition to the fact that the annual water level at Mekong River fluctuates up to 14m.

The following three plans are considered for the intake system.

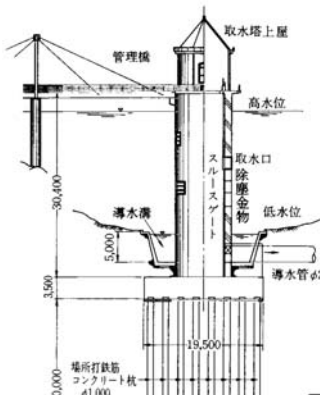
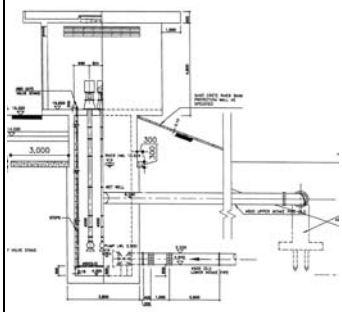
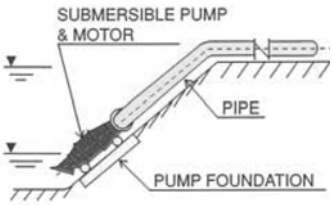
a) Intake Tower: To install the intake tower made of either reinforced concrete or steel in the river at approximately 50m outside of the current bank to pump up water from a water intake facility installed at the tower.

b) Intake Shaft with Horizontal Pipe: To install the intake pipe from inside of the bank towards the river to convey water by gravity flow to the intake shaft that will pump the water up.

c) Inclined Intake Pipe: To install the intake pipe along the bank slope and to pump up water by a submersible inclined pump.

Table 2.2.2.3-1 shows the options for the Intake System.

Table 2.2.2.3-1 Selection of Intake System (1) – (Kampong Cham)

	Plan A：Intake Tower	Plan B：Intake Shaft with Horizontal Pipe	Plan C：Inclined Intake Pipe
Photo (Ex.)			
Figure (Ex.)			
Estimated facilities and construction type	• Control bridge: L=50m • Intake tower: H=22m • Foundation works：Spread foundation • Operation room • Revetment works (Gabion works): A=1500m^2 • 4 Vertical shaft type mixed flow pump (including 1 reserve pump) 200mm, 22kW • Electro-mechanical equipment: 1 set • Temporary works: Sheet pile cofferdam, L=60m (Difficult placement)	• Intake shaft : H=19m • Foundation works：Spread foundation • Operation room • Revetment works (Gabion works): A=500m^2 • 4 Vertical shaft type mixed flow pump (including 1 reserve pump) 200mm, 22kW • Electro-mechanical equipment: 1 set • Temporary works: large sand bag	• Foundation works : spread foundation • Operation room • Revetment works (Gabion works): A=1500m^2 • 4 Vertical shaft type mixed flow pump (including 1 reserve pump) 200mm, 22kW • Electro-mechanical equipment: 1 set • Temporary works: sheet pile cofferdam: L=30m (Difficult placement)
Overview of facilities	• An intake tower made of either reinforced concrete or steel to pump up water from an intake at the tower wall. • Shape of water tower is round. • Vertical axis pump or submersible motor pump	• An intake pipe from inside the bank towards the river to convey water to an intake shaft which will pump up water by vertical axis pump or submersible motor pump.	• An intake pipe along the bank slope with a sufficient draft to pump up water by an inclined submersible pump.
Intake performance	• Stable water intake is possible if the water depth is over 2m even with large water level fluctuations • High economic advantage, especially in the case of massive intake • It is generally used in large rivers.	• Need of an intake shaft placed at a depth deeper than the probable low water level. • For stable water intake, mud discharge pit is needed at the intake shaft.	• Possible to accommodate large water level fluctuations • For stable water intake, a water pump is installed with a sufficient draft from the low water level (LWL). • It is generally used for medium intake volume

	Plan A：Intake Tower	Plan B：Intake Shaft with Horizontal Pipe	Plan C：Inclined Intake Pipe
Workability	• It requires installation of heavy components such as a control bridge. • The construction is underwater thus there is a need for temporary water stop works during construction. However, the foundation ground is rock so that placement of sheet piles for stopping water is difficult. • A long span control bridge on the slope of bank is required with a bridge pier in the middle.	• Installation of an intake shaft inside the bank is needed • Excavation of rocks is needed inside the existing bank to install intake shaft and horizontal intake pipes • Part of orifice works is included in underwater works.	• The scale of the structure and foundation is relatively small. • An embankment is constructed **for** scour prevention at the up- and downstream of the structure • Part of works for the intake pit is involved in underwater construction.
Environment	• Boat transport is hindered.	• A wide area of excavation is needed inside the bank. • No hindrance to boat transport.	• The operation room can be small since the pump is submersible in the water. • No hindrance to boat transport.
O&M	• The structure itself is durable. • Regular maintenance of intake pump is required. • Sand sediment in the tower is removed when required	• Intake pumps need regular maintenance. • Operation and maintenance is required for such work as removal of dirt and sand.	• Intake pumps need regular maintenance. • Operation and maintenance such as removal of dirt and sand is required.
Economic efficiency	1.4	1.3	1.0

Note: The photos and figures of intake system in the table are shown as examples.
Source: JICA Survey Team

With regard the three options, most of the works for Plan B (Intake Shaft with Horizontal Pipe) and Plan C (Inclined Intake Pipe) could be constructed above the ground. On the other hand, most of the parts of Plan A (Intake Tower) will require underwater work.

The soil condition at the intake point has been examined. Through the drilling survey, a layer of bedrock (basalt) has been identified at approximately 10m below the surface. Under this soil condition, sheet piles could not stop water during the framework construction for the intake tower system option (Plan A). The rock also hinders the laying of cutting edges underground for caissons. Therefore, Plan A is excluded from the prospective options. Plan B (Intake Shaft with Horizontal Pipe) and Plan C (Inclined Intake Pipe) were thus further examined to select the optimal option. More detailed descriptions of Plans B and C are provided below.

Plan B: Intake Shaft with Horizontal Pipe

The intake shaft with horizontal pipe is laid underground at an open space behind the top of the bank slope. Underground structures are required deep underground, but due to the difficulty of

driving sheet piles into the bedrock, work is carried out by the open-cut excavation method.

At the upper part of the intake shaft, an operation room is planned, where electro-mechanical equipment for the pump, pump chain hoist, and slurry discharge pump for O&M are installed. For laying the intake pipes from the underground intake shaft inside the bank to the water edge outside the bank, open-cut excavation works are carried out keeping a sufficient cutting width to lay the horizontal pipes. Since the water edge area of the intake pipe (water inlet) may get scoured by river flow, a revetment is constructed to provide protection against scouring. In addition, for operation and maintenance, a slurry pit is installed for desludging at the bottom of intake shaft.

Plan C: Inclined Intake Pipe

A pump in inclined position is ideally embedded in revetment for the purpose of protection from river water. However, this may reversely contribute to sediment disposition around the pump which hinders water intake. Therefore, the pump including the pipes and hanging wires are installed in the inclined position on the slope and exposed on the revetment. There are some examples that a slight inclination is made to form a concavity on the revetment to avoid the direct impact of water flow.

To prevent pumps from getting clogged with leaves and debris in the water, a screen is placed at the water inlet. The highest turbidity (TSS) of the river water in the Mekong River is about 250mg/ℓ. To maintain the durability of pumps against fine grains in the river, materials for the pump impeller are selected according to the turbidity of water. A careful maintenance to regularly clean the surroundings of the water inlet is necessary during the dry season to prevent intake failure due to dirt or sand. Comparisons and reviews were made for the above “intake shaft with horizontal pipe” and the “inclined intake pipe,” and the following table shows the results.

Table 2.2.2.3-1 Selection of Intake System (2) – (Kampong Cham)

	Intake Shaft with Horizontal Pipe	Inclined Intake Pipe
Advantages	• No failure has been found with submersible pumps and vertical shaft type mixed flow pumps in past installations at the Mekong River. (Minimum negative factors for intake facilities.)	• Possible to minimize the scale of civil engineering structures. (Avoid deep underground structures and foundation structures.)

	Intake Shaft with Horizontal Pipe	Inclined Intake Pipe
Disadvantages	• Due to the presence of bedrock and boulder stones on the bank slope, rock excavation will take longer. • Large scale facilities for underground structures. • Installation of backwashing facilities and manhole for inspection is required as countermeasure against blockage of horizontal intake pipes.	• There is a possibility of intake failure due to the suction of sediment. • The pump in inclined position that is selected for the Project is relatively light with small diameter (φ200) so that the pump may not be able to ensure stability against velocity, surges and waves. • Embedment of pump in revetment to protect the pump from flowing water will contribute to sedimentation and water intake failure. Therefore, the exposed pump is generally installed. • Generally, no sludge pit is installed so that the pump bears a great burden by directly inletting river water. • Due to unevenness over time, the pipes on the slope and the detachable flange at the pump joints may be displaced and thus cause leakages. • The height of the pump is fixed so that intake height could not be selected. • Slope gradient in terrain is loose which might interfere with intake. • There are few manufacturers which produce the inclined submergible pump and there is no manufacturer which produces the inclined submergible pump with water sealed motor. • Inclined submergible pump is converted so that the common vertical submergible pump could be installed saliently. However, since there are few track records in Cambodia regarding the use of submergible motor pump, operation and maintenance would be difficult.
Implementation record	• There are records of construction in Cambodia (Mekong River).	• Implemented in Vietnam, Laos and Thailand. • There is one implementation record of piped water supply. (Intake of raw water at Rojana Industrial Park in Thailand) Facility Name: ROJANA WATER TREATMENT PLANT PASAK RAW WATER INTAKE PUMPING STATION Owner: ROJANA INDUSTRIAL MANAGEMENT CO. LTD. Completion year: 2004 Spec.: φ300 x 4 Sets x 650m3/hr x 30m x 90kW
Challenges with O&M	• Regular desludging of pits. • Irregular backwash of horizontal intake pipes and inspection from the inspection manhole.	• There is a site where sedimentation blocked the pump leading to poor water intake. • The inclined pump installed in Mukdahan in Thailand sucked sand which caused abrasion to the mechanical seal and the intrusion of water into the motor to pump which eventually stopped. Therefore, the prevention of sand deposition is an absolute condition.

Source: JICA Survey Team

As shown in the table above, the scale of civil engineering structures deep underground can be minimized using the “inclined intake pipe.” However, there are the following negative factors with regard to its use as the intake facility for the Project.

・ Poor intake due to sand suction.

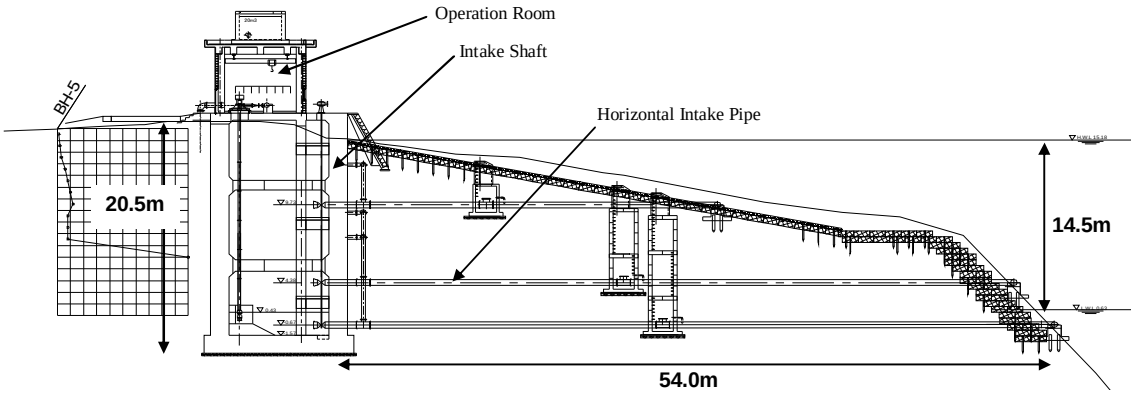
- Challenges about stable intake of water from the river.
- Water leakage from the flange between pump and pipeline along with the uneven slope of the revetment.
- If the flange is fixed by screw (fixed pump) to avoid the influence of the above water flow or the water leakage from the flange, it becomes difficult to pull up the pump. (There is need to remove the screw by diving operation.)
- No manufacturer is producing the inclined submergible pump with water sealed motor.
- Since there are few track records in Cambodia regarding the use of submergible motor pump, operation and maintenance would be difficult.

From the factors above, the implementation of "inclined intake pipe" is not feasible in terms of intake certainty and daily maintenance. The "intake shaft with horizontal pipe" is thus recommended for the Project.

The "intake shaft with horizontal pipe" does not have negative factors as an intake facility; however, there are the following requirements:

- Underground structures at a depth of 15 to 20m inside the bank terrain.
- Countermeasures against blockage due to long horizontal intake pipe.

The results of the natural condition survey show that the basalt aquifer lies 10m below the soil surface. To drill this aquifer, a large breaker (Iron Jack) shall be used and the hydraulic rock splitter is to be used to split the rocks and remove them. On the other hand, the jackhammer shall be used for the excavation of smaller rocks. Measures against the blockage of horizontal intake pipes are to be taken such as the installation of backwashing facilities and inspection manholes. In order to prevent involvement of persons at the intake part, a screen shall be installed at the intake mouth of the horizontal pipe. The installation of facilities is as illustrated in the figure below.



Source: JICA Survey Team

Figure 2.2.2.3-1 Intake Shaft with Horizontal Pipe (Kampong Cham)

(2) Intake System in Battambang

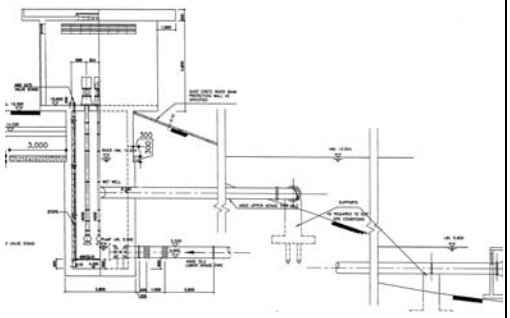
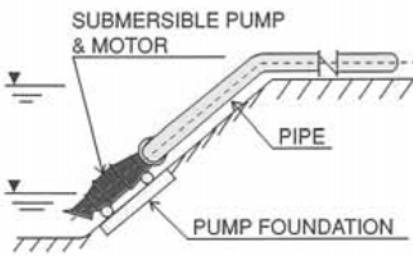
The intake weir, intake tower and floating are not appropriate intake methods for the Sangke River because of the frequent boat navigation. Since the past floods almost reached up to the levee crown, a fixed weir is not recommended because the existing revetment needs to be further heightened as a protection against the increase of flood level due to the influence of backwater.

The intake system will thus be the intake pipe method which is the same as the existing intake facility. As for the type of facility, the two options below were examined.

- Intake shaft with horizontal pipe: Intake pipes are laid from inside the bank towards the river and river water is conveyed by gravity flow until the intake shaft installed underground inside the bank which will pump the water up.
- Inclined intake pipe: Intake pipe is laid on the slope of the bank towards the river and water is pumped up by an inclined submersible pump.

These two plans have been carefully examined in consideration of intake capacity, operation and maintenance, workability, and economic efficiency. **Table 2.2.2.3-2** gives a comparison between the two plans of intake system.

Table 2.2.2.3-2 Selection of Intake System (Battambang)

	Plan A：Intake Shaft with Horizontal Pipe	Plan B：Inclined Intake Pipe
Photo (Ex.)		
Design (Ex.)		

	Plan A : Intake Shaft with Horizontal Pipe	Plan B : Inclined Intake Pipe
Estimated facilities construction type	• Intake Shaft: H=13m • Foundation works • Operation room • Revetment works (stone lining): A=150m^2 • 3 Vertical shaft type mixed flow pump (including 1 reserve pump) 300mm, 55kW • Electro-mechanical equipment: 1 set • Temporary works: Sheet pile cofferdam, L=80m	• Foundation works • Operation room • Revetment works (stone lining): A=1200m^2 • 3 Inclined submergible pump (including 1 reserve pump) 300mm, 55kW • Electro-mechanical equipment: 1 set • Temporary works: Sheet pile cofferdam, L=55m
Overview of facilities	• Intake pipe is laid from inside the bank towards the river through the bank to convey water to the underground intake shaft placed inside the bank. • Water is pumped up by either vertical axis pump or submersible pump thereafter	• Intake pipe is laid from inside the bank towards the river along the bank slope with sufficient draft for low water level to pump up water by an inclined submersible pump.
Intake capacity	• Intake shaft is needed at a sufficient depth below the low water level for intake pump. • A desludging pit is required at the intake shaft for stable water intake.	• Possible to accommodate large water level fluctuations. • Installation of a submersible pump is necessary to ensure the required depth from low water level (LWL), but the water depth at the site makes it difficult to ensure sufficient draft. • Generally used for medium volume water intakes.
Workability	• Construction of intake shaft is needed inside the bank. • Excavation of the bank is required to lay intake pipes from the intake shaft inside the bank to the water edge. • Temporary works for water stoppage is needed for the installation of intake pipes and orifice protection	• The scale of structure and foundation can be relatively small. • A revetment is constructed at the up- and downstreams of the structure to prevent scouring. • The construction is underwater so that there is a need for temporary water stopping works during construction.
Environment	• Noise and vibration are generated through the placement of temporary sheet piles to construct an operation room and an intake shaft inside the bank. • No hindrance to boat navigation.	• The operation room can be relatively small since the pump itself is submerged in the water. • No hindrance to boat navigation.
O&M	• Regular maintenance is needed for intake pumps. • Protection of the intake from bank erosion (revetment) is required. • Operation and maintenance is required for such works as the removal of dirt and sand.	• Regular maintenance is needed for intake pumps. • Protection of the intake from bank erosion (revetment) is required. • Operation and maintenance is required for such works as the removal of dirt and sand.
Economic efficiency	1.0	1.0

Note: The photos and figures of intake system are shown only as examples.

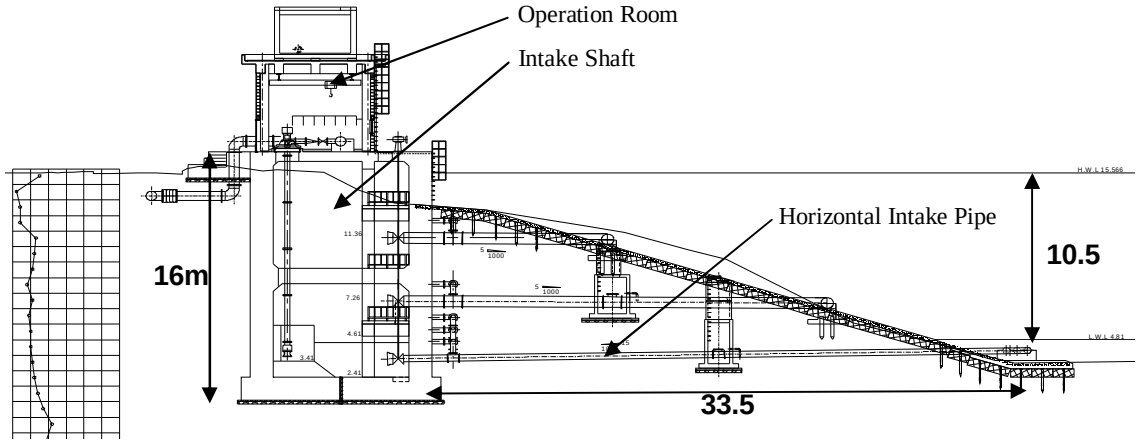
Source: JICA Survey Team

Out of the two options presented above, Plan A is recommended in consideration of the following conditions:

- The intake point is at the curve (outside) of the river where the revetment is susceptible to erosion and water flow hits the pump directly;
- Damage to revetment and ground collapse under the rail and pumps are expected at the water colliding front;
- The shallow water depth can form a sandbank at the intake, resulting in poor water intake;
- The top of the revetment faces the road so that land acquisition is difficult for the pulling out of pumps and maintenance; and
- Compared to the Mekong River, the water level during the dry season is shallow (about 1.5 to 2m) so that the pump cannot secure a sufficient draft.

Plan A, Intake Shaft with Horizontal Pipe, applies the same water intake method as the existing facility. With this system, streambed sediment flow in from the intake pit at the riverbed and cause the failure of pumps. During the dry season, water depth is only about 0.5m at the existing intake point so that water intake is carried out from the riverbed.

On the other hand, the headwater level of about 1.5 to 2.0m can be assured even in the dry season. Therefore, water with relatively small amount of silt should be taken from the side of revetment avoiding intake from the bottom of the riverbed. For this purpose, the intake shaft is provided with a de-sludge pit so that the pump will not suck the silt in the water taken from the intake pipe by gravity flow. In order to prevent involvement of persons at the intake part, a screen shall be installed at the intake mouth of the horizontal pipe.



Source: JICA Survey Team

Figure 2.2.2.3-2 Intake Shaft with Horizontal Pipe (Battambang)

2.2.2.3.3 Construction Method of Intake Facility

(1) Construction of Intake Facility in Kampong Cham

(a) Construction of Intake Shaft

The foundation at the intake point in Kampong Cham is bedrock (basalt) and hence the

placement of sheet piles for the construction of intake shaft is difficult. For this reason, the open excavation method is applied with sufficient gradient of excavation surface. During the open excavation work, scaffold with the width of about 2m from the frame is provided at the gradient of 1.0.3 for rock layers and 1.0.6 for gravel layers. During excavation, a small stage of 1m is provided for each 5m drilling height.

The order of construction shall be as follows:

Firstly, excavation for the intake shaft and the horizontal intake pipe shall be carried out before the dry season when the river water level reaches the lowest level. Secondly, the horizontal intake pipes shall be laid before the intake shaft at the time of low water level. After the installation of pipelines, the horizontal intake pipes shall be backfilled before the river water level rises to avoid the influx of river water into the intake shaft. The intake shaft has to be constructed at the same time as the installation of horizontal intake pipes. To execute all-year construction, large sandbags are to be placed at the river side and water stop measures are to be carried out by sheet piles. The height of sandbags shall be set at 2m to ensure the height margin from HWL of the Mekong River. The crown width shall be about 3m.

(b) Horizontal Intake Pipe Laying Work

The horizontal intake pipes are to be laid prior to the intake shaft at the time of low water level in the dry season. Excavation for laying the horizontal pipes shall be commenced from inside of the bank. Except for the tip, the horizontal pipes are to be laid in a state where rocks for the water-stop for pipe placement are partly left on the river side. Inspection manholes are also constructed at this stage. Further, the section where pipe laying has been completed is to be backfilled before the river level rises to keep the inside of the bank always dry for the intake shaft construction. Finally, rocks that are left at the riverside are to be crushed by a large breaker mounted on a barge in order to lay the tip of horizontal pipes. These works may partially involve underwater works.

In case the jacking method is applied as the construction method for the horizontal intake pipe, the erection of vertical shaft would be difficult because the base foundation consists of hard rock (basalt). In addition, the construction cost would be higher than the other construction methods and the importation of jacking machine from another country would also be necessary. Therefore, the general open-cut method shall be applied for the laying of horizontal intake pipes.

(c) Others

Since the ground is rocky, it is considered to be resistant against scouring by river flow. However, partial scouring is presumed at the backfilled section after the placement of horizontal

intake pipes. At the orifice of intake pipe, gabion and concrete are to be placed to protect it from scouring.

The intake shaft is to be planned at a planer location at the fore part of the existing bank alignment to shorten the length of horizontal pipes as much as possible and to minimize the impact on the park. For this reason, the revetment is to be constructed of mortar masonry to prevent scouring by river flow of the upper part of intake shaft during the high-water season.

(2) Construction of Intake Facility in Battambang

In Sangke River, 2m is the estimated water level from the riverbed in the dry season. Sheet piles are then placed during the construction work and excavations of the bank and the high-water channel are needed from the top of the bank to the river water edge to install the intake shaft and the intake pipes.

There is a two-lane asphalt pavement road behind the intake facility. Sheet piles are then placed for the excavation work to avoid hindrance to road traffic. For the intake pipe placement at the high-water channel, the work is to be conducted by open excavation since there are no apparent obstacles.

For the installation of intake shaft, placement of sheet piles and operation room construction at the upper intake shaft, a driveway is required for the construction vehicles. Since the general traffic will use one lane for passage, color cones and traffic control staff will be required.

Two or more horizontal intake pipes shall be installed to prevent clogging by floating waste and the selective intake method is to be applied. For continuous operation, two horizontal intake pipes are to be installed at separate locations below the average water level (EL+7.34m) so that one of them could function when the other location of pipe is blocked in the most frequency water level (average water level). A total of three locations of intake pipe shall then be installed.

The diameters of intake pipe are set to φ700mm and the velocity of more than 0.6m/s shall be secured to prevent the clogging by sand deposition in the horizontal pipe. The intake pipes of bottom level shall be φ400mm x 3 which area is equal to φ700mm x 1 in order to secure the distance from the river bed to prevent suctioning of stream bed sand. And since the stream bed is close to the intake mouth of horizontal pipe on Battambang intake facility, the pipes shall be inclined to prevent the sand deposition.

On the design criteria, 2.5D (Diameter) of distance from the center of suction and discharge pipe to the water surface shall be secured. At the discharge portion in the intake shaft, securing of 2.5D (=1000mm) is possible. However, it is impossible to secure the distance of 2.5D at the intake portion because of the shallow water depth of the river in the dry season. Therefore, there

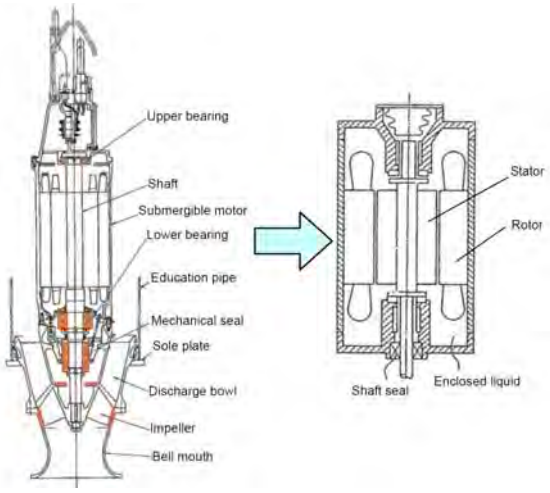
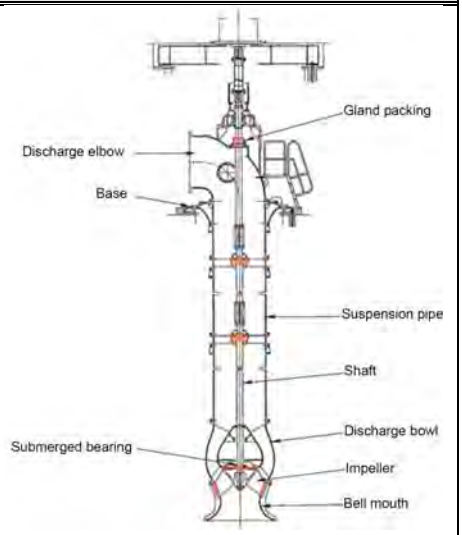
is a gap between the intake portion and discharge portion of horizontal pipe and the pipe shall be installed slantingly. In case these pipes are installed on a level, the intake mouths become so close to the river bed and suction of river bed sand will be promoted. Moreover, the sand deposition in the middle of intake pipe will be prevented by the inclination of pipes.

In case the jacking method is applied as the construction method for horizontal intake pipes, the construction cost would be higher than the other construction methods and the importation of jacking machine from another country would also be necessary. Therefore, the general open-cut method shall be applied for the laying of horizontal intake pipes.

2.2.2.3.4 Types of Intake Pump

The Submersible Motor Pump and the Vertical Axis Pump with Inclined Flow shown in the table below have been examined for the selection of intake pump. Specifications, operation and maintenance are as shown in the following table.

Table 2.2.2.3-3 Comparison of Intake Pumps

	Submersible Motor Pump	Vertical Shaft Type Mixed Flow Pump
Overview of Design		
Structure (Installation method)	Installed in the intake chamber together with pump and motor. The motor is resistant to water since it is usually filled with fluid except for the stator unit. Therefore, when water enters from outside through the sealed shaft, immediate failure does not occur.	Placed on the floor of the intake chamber and the pump are suspended in the intake chamber.
Reparation	The lifting pipe at the top of submersible pump is pulled out. (Casing and main shaft are not necessary as in mixed flow pump.) After removing the impeller cap and the casing, the mechanical seal is replaced by loosening the bolt.	The casing and main shaft are disassembled and pulled out. There are many submerged bearings (one at 2.5m-4m intervals) at the main shaft, which requires time to repair.

	Submersible Motor Pump	Vertical Shaft Type Mixed Flow Pump
	After removing the impeller cap, the casing and mechanical seal are replaced by loosening the bolt	The bearing is made of rubber or ceramic. They must be replaced periodically due to abrasion over time. The motor is set over the pump. The pump is repaired by removing the motor.
Accessories	The module is connected with a water hose. If muddy water is mixed into the module, it can be monitored at the head tank.	An extra pump for lubricating water will be required to pour external lubricating water to the bearing.
Noise	Noise leaking to outside is minimal since the generator is underwater.	The electric motor is set on the floor. Noise measures may be necessary. The electric motor is stored in the shed to avoid leakage of noise.
Cavitation	There is less worry of cavitation since the impeller is in the water.	Same as on the left.
Imple-mentation record	Many intake pumps are constructed for water supply and industrial water.	Same as on the left
Operation and maintenance	Motor and pump are submerged in the water. For maintenance they have to be pulled out. Consumables for replacement are the mechanical seal, bearing, sleeve, ring balance, and casing liner.	The operation of electric motor is possible in the operation room. To repair the pump, the casing and the main shaft are pulled out. Consumables for replacement are the gland packing, water bearing, sleeve, ring balance, and casing liner.
Spare parts	Spare parts can be procured from a supplier in Phnom Penh.	Spare parts can be procured from a supplier in Phnom Penh.

Source: JICA Survey Team

Submersible pumps are used in many other countries, but there is little experience on them in Cambodia and even with Phnom Penh Waterworks. Therefore, Phnom Penh Waterworks could not technically support the operation and maintenance of submersible pumps. Since the Royal Government of Cambodia had strongly requested the selection of vertical shaft type mixed flow pump, the vertical shaft type mixed flow pump is to be selected.

2.2.2.3.5 Operation Method of Intake Pumps

(1) Control System of Intake Pumps

The discharge flow of pumps at each pump station is as follows:

- Planned capacity for Kampong Cham:
  In dry season 12,650m^3/day: (16,300-4,800) x 1.1=12650

In rainy season 6,050m^3/day: (16,300-10,800) x 1.1=6050

- Planned capacity for Battambang: 24,200m^3/day throughout the year

Since the pumps will be constantly operated at the above discharge flow, it is not necessary to apply the pump number control based on discharge water level, or the pump speed control methods to water flow control. The control is by the discharge valve control.

[Kampong Cham]

In the rainy season, two pumps selected from the four pumps (spare pump included) are to be manually operated from their pump control panel. Starting of a pump is to be performed by sequential start operation.

- Sequential start operation: Start command → Start of a water lubrication pump for submergible bearings → solenoid valve open → flow relay ON → starter ON → accretion → switching to full voltage after some seconds → full speed → change to self-lubrication system from external water → lubrication pump OFF, and the discharge valve of the pump is fully opened at the same time.

In dry season, three pumps selected from the four pumps are to be operated in the same method.

[Battambang]

The start of two pumps selected from three pumps (spare pump included) is to be performed by the same sequential starting method as the Kampong Cham Pump Station.

The starting condition of pumps is as follows:

- The suction water level is more than the specified water level (LWL).
- The discharge valve is fully closed.
- The protection relays are reset.
- The other pumps are not in operation.
- The pump starter is in start position.

In case the pumps stop, they are manually operated from their pump control panel by sequential stop operation.

- Sequential stop operation: Stop command → discharge valve close → fully closed → Starter OFF → solenoid valve of water lubrication for submergible bearings closed → Pump starter is set to the start position.

When the protection relays are activated, the pumps will stop automatically in case of emergency or when the suction water level falls below the specified water level (LWL).

Protection relays of the pumps function when any of the following items occur:

- Reduction of quantity of lubrication water.
- Over-current of motor.
- Temperature of pump bearings is high.

(2) Operation of Flow Control Valve

The discharge flow of pumps will change widely due to the fluctuation of suction water level depending on the season. The pump operation point goes to the large flow when the water level turns up, and goes to the small flow when the water level turns down. Therefore, while watching the flow meter, the discharge flow is to be controlled by the flow control valve to make the discharge constant. As for the adjustment of flow control valve, it is not assumed daily frequent operation because the flow control valve shall be operated periodically corresponding to a seasonal change of the quantity of abstracted river water volume. Manual operation is assumed and delicate adjustment can be performed while the operation staff reads the numerical value of a flow meter scale. In case the operation of flow control valve is performed at each 1m fluctuation of water level, approximately 22 times per year in Battambang and approximately 30 times per year in Kampong Cham is expected, because there is 10.76m fluctuation in a year at the Sangke River (10.76*2=21.52≒22times/yr) and 14.55m fluctuation in a year at the Mekong River (14.55*2=29.1≒30times/yr).

(3) Leveling of Pump Operation Hours

For the uninterrupted operation and equal time operation of pumps, there is a need to replace each pump with the standby pump, periodically. For equal operation time, a time counter is to be equipped at each pump panel and pumps are to be switched on upon close observation of the time counter.

2.2.2.3.6 Monitoring System of Intake Pumps

(1) Monitoring Device

Since the intake pumps adopt the manual operation system, the pump start-stop operation is not performed from the administration building in the water treatment plant. However, the states shown below are to be supervised from the administration building.

- Status of each pump start-stop.
- Signal of low water level at the intake shaft.
- Package failure signal of each pump.
- Discharge flow.

(2) Signal Transmission System

The General Packet Radio Service (GPRS) by the Global System for Mobile Communications (GSM) is to be adopted as the signal transmission system, and the following monitoring devices are to be installed at each station:

- GSM Modem
- Programmable Logic Controller (PLC)
- Data Logger
- Uninterruptible Power Supply (UPS)
- Monitor Panel

The data collected at each pump station is to be transmitted to the administration building in every 30 minutes. Moreover, only the amount of discharge flow is to be stored in the data logger.

2.2.2.4 Plan for Raw Water Transmission Main

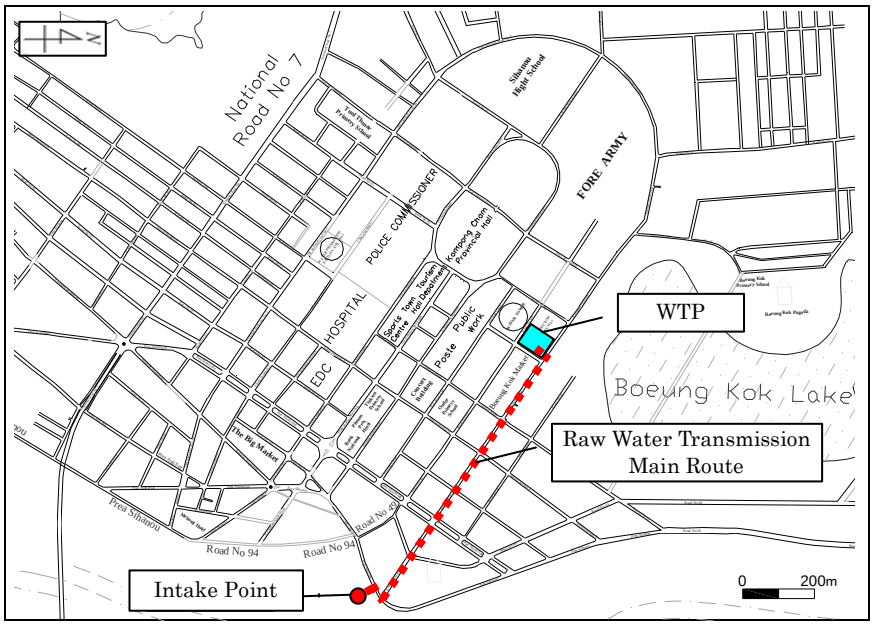
2.2.2.4.1 Route of Raw Water Transmission Main

(1) Raw Water Transmission Main Route in Kampong Cham

The raw water transmission main route in Kampong Cham is planned on the straight road of approximately 900m to the northwest from the access road to the intake point which is the shortest route to the water treatment plant. The pipelines are to be connected to the receiving well in the water treatment plant by removing some of the outer walls of the site.

Almost all sections on the route are asphalt-paved roads. The route crosses a boulevard (2 lanes, middle green zone) of 30m in width. There are small shops on both sides of the road at some straight sections, so that the project needs to be duly explained to these shops.

The following map shows the raw water transmission main route.



Source: JICA Survey Team

Figure 2.2.2.4-1 Raw Water Transmission Main Route (Kampong Cham)

	
Photo 2.2.2.4-1 Asphalt Pavement	**Photo 2.2.2.4-2 Shops on the Road Side**

(2) Raw Water Transmission Main Route in Battambang

The raw water transmission main route in Battambang runs for 4.4km along the Sangke River, approximately from the intake point to the newly planned water treatment facility at the former Pepsi factory site. Most sections are asphalt paved roads under the supervision of the Provincial Government, and there is a green road zone of 1.2km parallel to the road.

To pursue workability, this green zone is to be used for the laying of pipes. This green zone is closely situated at the center of the city with a wider road width compared to the other road sections and traffic is heavy. The traffic congestion that may be caused by roadblocks and one-way passage during the day could be minimized by using this green zone to lay the pipes.

Also, pipeline laying work under the road will involve the removal and restoration of the existing asphalt road. If the pipeline laying is on the green zone, the removal and restoration of road tiles and green lawn will be comparatively cheaper. Since there are obstacles such as trees, street lights, fountains and monuments on the road in the green zone, the work shall be planned to minimize the impact on these items.

The Director of Battambang Waterworks had requested the selection of a pipe laying route that would affect the local population as little as possible. Therefore, the main roads and green zones are more suitable than the local roads where more population is affected.

The Provincial Government is to issue the approval for the works on these main roads and green zones. The position of the raw water transmission main shall be planned on one lane of the two-lane road at the riverside to allow traffic during the construction work. At 40m downstream, a railway is crossing the route under which the raw water transmission main needs to be laid. Currently, this railway is not in use, but there is a plan to use it in the near future. Therefore, at the commencement of construction work, discussions need to be held with the Ministry of Public Works and Transportation and the cooperation of all entities concerned should be obtained.

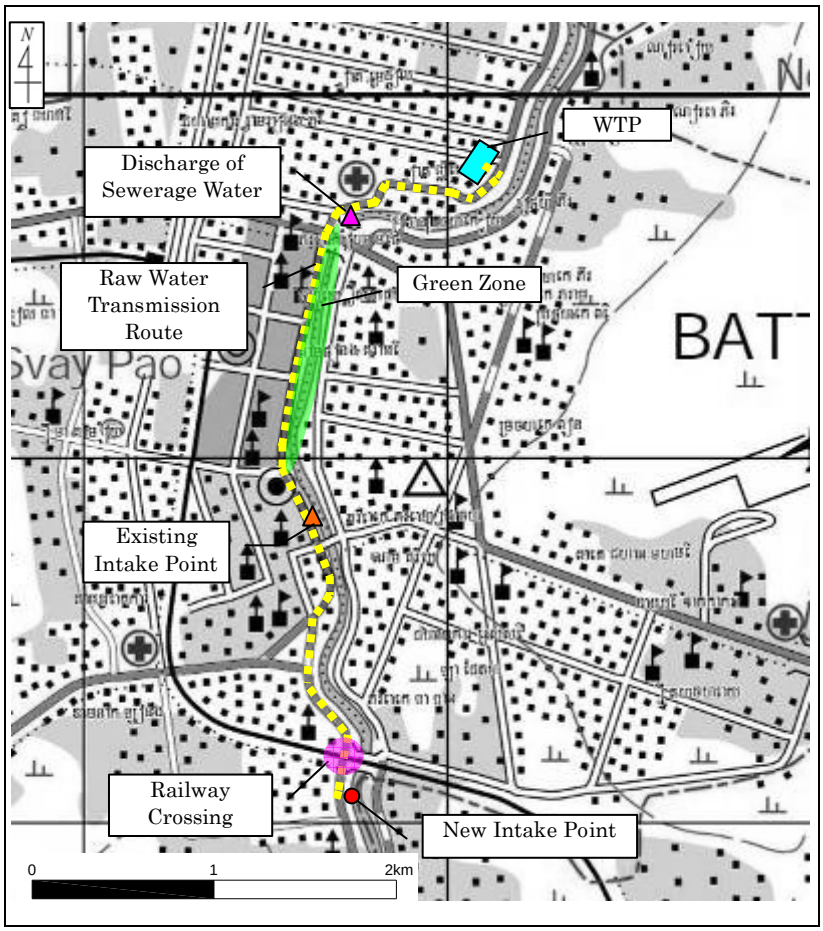
The route for raw water transmission main is as shown in the following photographs.

Photo 2.2.2.4-3 Railroad Crossing

Photo 2.2.2.4-4 Railroad Crossing to Green Zone

Photo 2.2.2.4-5 Green Zone

Photo 2.2.2.4-6 Green Zone to the Planned Site for Water Treatment Facility



Source: JICA Survey Team

Figure 2.2.2.4-2 Raw Water Transmission Main Route (Battambang)

2.2.2.4.2 Materials, Layout Places and Depths of Raw Water Transmission Main

(1) Materials for Raw Water Transmission Main

In Cambodia, PE (polyethylene) pipes are used for small inner diameter pipes up to 200mm and ductile cast iron pipes (DCIP) are mainly employed for larger diameters. The comparison between various water supply pipes is given in the following table.

Table 2.2.2.4-1 Comparison of Piping Materials

Piping Materials	Ductile Cast Iron Pipe (DCIP)	Polyethylene Pipe (PE)	Coated Steel Pipes for Water Service (SPA)
Pipe Type	Type D3-T or D4-T	Type 1 or Type 2	STW370 (80-300mm) STW400 (350mm and above)
Durability	Strong and corrosion resistant.	Excellent corrosion resistance. Ultra-violet rays resistant.	Strong against shock but easily corroded when the surface protection is damaged.

Piping Materials	Ductile Cast Iron Pipe (DCIP)	Polyethylene Pipe (PE)	Coated Steel Pipes for Water Service (SPA)
Workability	Pipe weight is heavy; Workable with the push-in fitting type.	Light and high workability. The applicable size of butt welding machine in Cambodia is up to φ200mm.	It takes time and skills for welding joints.
Implementation result	Many usages for pipelines larger than φ250mm or more.	φ200mm is generally used in Cambodia.	Minimal usage in Cambodia.
O&M	Many usages for pipelines larger than φ250mm. Easy procurement of spare parts with a wide market.	Accessibility of spare parts may be limited since the usage of φ250mm or more is minimal.	Repair needs time since there are not many users.
Others	Within allowable bending angles of the pipes; pipes are laid along the ground shape.	Pipes are flexible to lay along the ground shape.	Pipes are integrated by welded joints to be laid along the ground shape.
Selected	O	-	-

Source: JICA Survey Team

Based on the comparison above, ductile cast iron pipe (DCIP) shall be used for the pipeline with more than φ250mm diameter since there are many usages of this type in Cambodia. Since the polyethylene (PE) pipe has minimal usage records for pipelines larger than φ250mm, the route for spare parts procurements has not been established. Further, the waterworks has no applicable joint fusion machine. Although coated steel pipe for water service (SPA) is equivalent to ductile cast iron pipe (DCIP) in terms of price, they should not be used for the project due to difficult workability and skill is needed for the welding work.

(2) Placement Position of Raw Water Transmission Main

To reduce the impact on such structures as houses on both sides of the road, the pipes shall be buried on the roadside in single-lane roads. For a two-lane road, pipes are to be laid on one roadside and the other side is kept as the pathway in case of one-way passage.

In Kampong Cham, a one-lane asphalt pavement road connects from the intake point of the Mekong River to the planned water treatment facility. Therefore, the pipelines are to be laid at one roadside.

In Battambang, a two-lane asphalt pavement connects from the intake point of the Sangke River to the planned water treatment facility at the former Pepsi factory. Therefore, the pipelines are to be laid at the roadside to the Sangke River side. In the green zone part of the road, tiles and lawn of the pathways are to be removed for pipe laying work. Since there are obstacles such as trees, street lights, fountains and monuments on the road in the green zone, the work is to be planned to minimize the impact on these items.

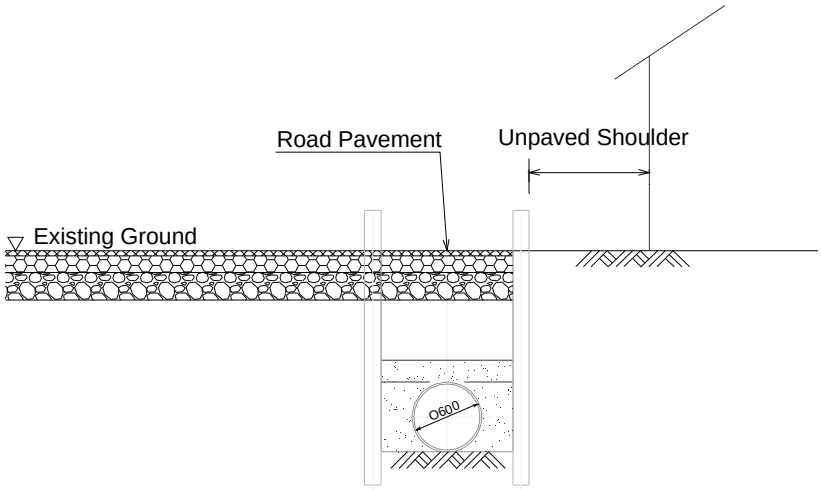


Figure 2.2.2.4-3 Placement Position of Raw Water Transmission Main

As shown in Figure 2.2.4-3, raw water transmission main shall be set at the edge of the existing pavement. The unpaved area next to the asphalt pavement edge shall be maintained and the pipe-laying should not obstruct access to houses, shops, etc., along the road. Sidewalks adjacent to the pavement shall be excluded from the pipe laying locations, because there are some existing pipes, newly installed pipes, utility lines, etc., in the area.

(3) Placement Depth of Raw Water Transmission Main

Raw Water Transmission Main is to be laid under driveways. However, under the same road, other pipes for public infrastructure may be laid in the future. Therefore, 1.2m of earth covering shall be placed over the pipes to avoid intersection with other public pipelines.

2.2.2.4.3 Planning Condition of Raw Water Transmission Main

(1) Design Intake Flow

Design intake flow is to be determined by the design maximum daily water supply in the target year (2019) together with 10% of excess water flow.

(a) Kampong Cham
Design intake flow ＝ 11,500m3/day x 1.1 ＝ 12,650 m3/day
(b) Battambang
Design intake flow ＝ 22,000m^3/day x 1.1 ＝ 24,200 m^3/day

(2) Water Level Condition

In consideration of the interview results and measuring records at the observation point near the planned site, water level conditions are to be set as below.

(a) Kampong Cham

Water level conditions for water intake from the Mekong River in Kampong Cham are set as follows on the basis of data from 1990 to the 2011:

i) Start Water Level

・HWL: the highest water level during the measuring period: = 15.18m

・LWL: the lowest water level during the measuring period = 0.63m

ii) Arrival Water Level

・Water level at the receiving well of the water treatment facility: 20.20m

(b) Battambang

The water level conditions for water intake at the Sangke River in Battambang is determined as follows based on the interview survey results:

i) Start Water Level

・HWL: Road height at the top of slope = 15.57m

・LWL: Present river bed height + 1.5m (intake point dry water level) = 4.81m

ii) Arrival Water Level

・Water level at the receiving well of the water treatment facility: 16.80m

2.2.2.4.4 Diameter

(1) Calculation Formula for Diameters

Diameter is to be determined using the following Hazen-Williams Formula. The optimal velocity for each diameter is to be calculated to determine the appropriate diameter. Hazen-Williams Formula is to be used to calculate the pipe flow velocity and friction head loss.

$V = 0.849C \times R0.63 \times I\ 0.54$

V: Average velocity (m/s);

C: Coefficient of velocity

(Generally employed are 130 for ductile cast iron pipes (DCIPs) and 150 for Fiberglass Reinforced Plastic Mortar Pipes (FRPMs). C = 110 is used for the conduit as a whole, including the loss at the bent area.)

R: Hydraulic radius

I: Hydraulic Gradient

The following equations are to be considered for circular tubes:

$V = 0.355C \times D0.63 \times I\ 0.54$

$Q = 0.279C \times D2.63 \times I\ 0.54$

$D = 1.626C-0.38 \times Q0.38 \times I -0.21$

$I = hf / L = 10.67C - 1.85 \times D - 4.87 \times Q1.85$

$hf = 10.67C -1.85 \times D -4.87 \times Q1.85 \times L$

D: Diameter (m)

hf: Friction head loss (m)

Q: Volume flow (m3/s)

L: Length of pipeline (m)

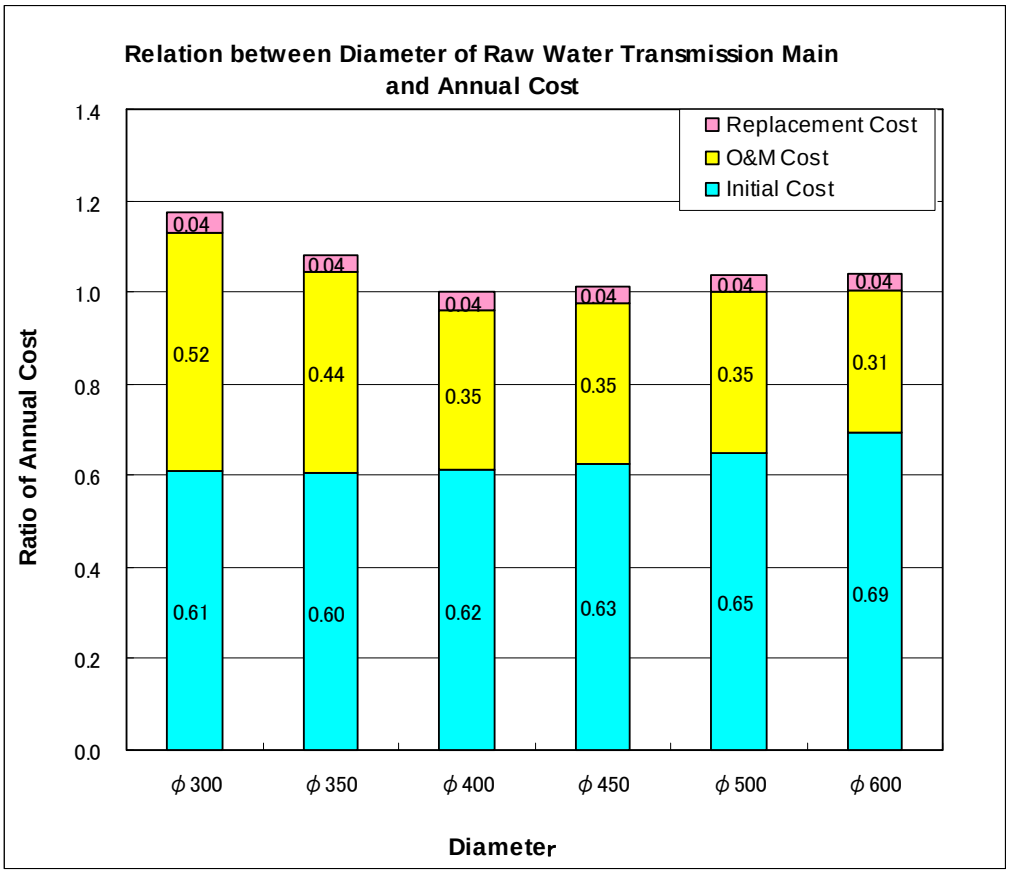
(2) Conditions for Diameter

The following costs are considered to determine the specifications of raw water transmission main and the diameter.

- Initial Cost:
  - Cost of pumps
  - Cost of Raw Water Transmission Main:
    Kampong Cham: All pipes are to be laid under driveways, so that sheet piles are also employed.
    Battambang: All pipes larger than φ700 are to be used together with sheet piles. Smaller than φ600 pipes do not use sheet piles at green zones, so that the works are to be done by unlined excavation.
- Cost for O&M:
  - O&M cost for pump (2% of initial costs)
  - O&M cost for pipelines (1% of initial costs)
  - Public electricity bill (Kampong Cham: 850R/kwh; Battambang: 750R/kwh)
- Replacement Cost:
  - Replacement Cost for vertical axis pump with inclined flow is estimated by pump life (22 to 26 years). The cost for replacement is the cost incurred by replacement taking the discount rate at the time of replacement into account to calculate the present value. The discount rate is calculated by the following formula:
    Discount Rate = 1/(1+r)n; where, r: Interest Rate, n: Operation Years
- Others
  - The initial costs are calculated by annual expense ratio (cost ratio for 1 year) during the life cycle (40 years). The annual expense ratio is calculated by the following equation:
    Annual expense ratio = r/(1-(1+r)-n), where, r: Interest Rate, n: Operation Years
  - The O&M cost is the present value of the annual O&M cost taking the discount rate as well as annual expense ratio into account.

(3) Diameter of Raw Water Transmission Main for Kampong Cham

The figure below shows the estimation of costs for Kampong Cham.



Source: JICA Survey Team

Figure 2.2.2.4-4 Relation between Diameter of Raw Water Transmission Main and Annual Cost (Kampong Cham)

The figure above shows that the initial costs are the sum of pump and pipeline construction costs. Costs for pumps become smaller with larger diameter raw water transmission main since pipeline loss becomes less, but the construction costs are higher for the laying of pipelines. Considering these factors, the initial costs will slightly increase when the diameter of raw water transmission main becomes larger.

The cost for O&M is the sum of maintenance of pumps and pipelines and the power supply. The smaller is the diameter, the higher is the cost of pumps. In the same token, the power supply becomes higher, but considering the O&M costs for pumps and pipelines, φ400 is comparatively the least expensive.

On the other hand, in case the yield from the existing wells increases during the rainy season, the amount of intake water needed from the river will decrease. With this condition, the minimum velocity (V=0.3m/s) needs to be secured to prevent the deposition of suspending sand in the pipe for the minimum amount of intake water (6,050m^3/day). The table below

summarizes the relation of diameter of raw water transmission main and velocity.

Table 2.2.2.4-2 Diameter of Raw Water Transmission Main and Velocity with the Minimum Flow Rate (Kampong Cham)

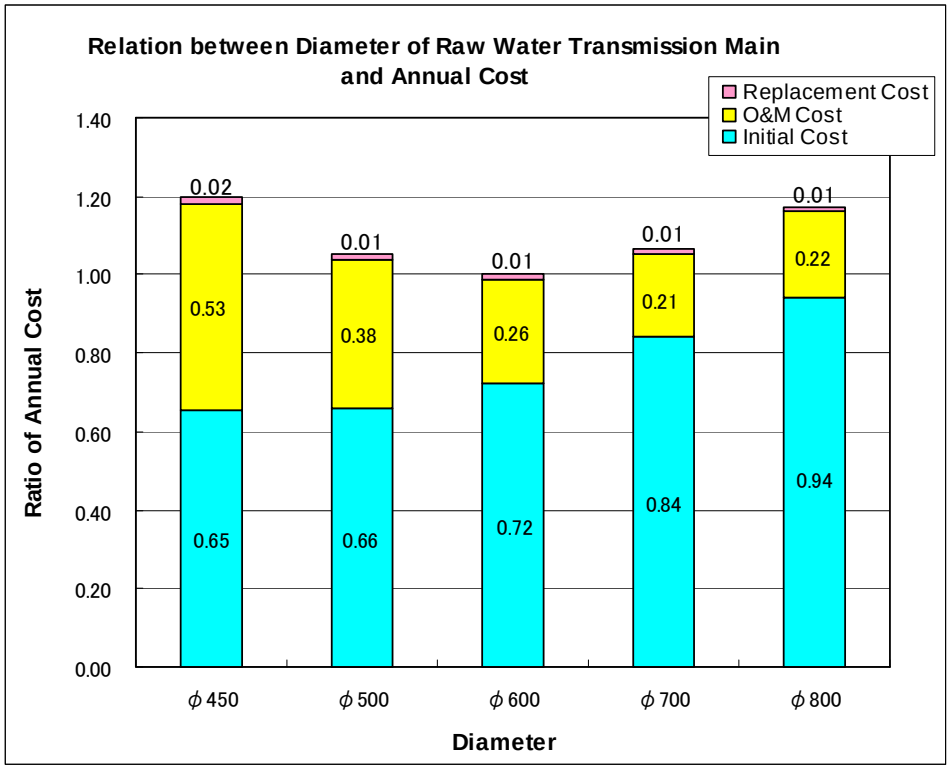
Diameter	Velocity
φ300	0.991 m/s
φ350	0.728 m/s
φ400	0.558 m/s
φ450	0.441 m/s
φ500	0.357 m/s
φ600	0.248 m/s

Source: JICA Survey Team

The table above shows that diameters less than φ500 are needed to secure the minimum velocity and φ400 is economically the most advantageous. Therefore, φ400 is selected for the diameter of raw water transmission main for Kampong Cham.

(4) Diameter of Raw Water Transmission Main for Battambang

The figure gives a comparison of costs in Battambang.



Source: JICA Survey Team

Figure 2.2.2.4-5 Relation between Diameter of Raw Water Transmission Main and Annual Cost (Battambang)

Since the length of raw water transmission main in Battambang is longer than in Kampong Cham, the total cost would be larger. This means that the initial investment cost will become higher as the raw water transmission main diameter becomes larger. However, the smaller is the diameter, the higher is the costs for O&M and power supply. The best economical option of raw water transmission main is φ600 considering the initial cost and O&M cost.

The table below summarizes the relation of diameter of raw water transmission main and velocity.

Table 2.2.2.4-3 Diameter of Raw Water Transmission Main and Velocity with the Minimum Flow Rate (Battambang)

Diameter	Velocity
φ450	1.762 m/s
φ500	1.427 m/s
φ600	0.991 m/s
φ700	0.728 m/s
Φ800	0.558 m/s

Source: JICA Survey Team

The table above shows that all cases of diameter can secure the allowable velocity criteria (V=0.3～2.0m/s) and φ600 is economically the most advantageous. Therefore, φ600 is selected for the diameter of raw water transmission main in Battambang.

2.2.2.4.5 Typical Cross Sections

(1) Typical Cross Section of the Raw water Transmission Main in Kampong Cham

All pipes in Kampong Cham are to be laid under the driveway of roads. Earth covering is planned to be 1.2m and sheet piles are to be used during the work. Excavation width is 1.0m and drilling depth is 1.63m. Top of pipe is to be backfilled with 20cm of sand. Since the drilling work will be as small as less than 3m, Type 3 lightweight steel sheet piles shall be used for earth retaining works.

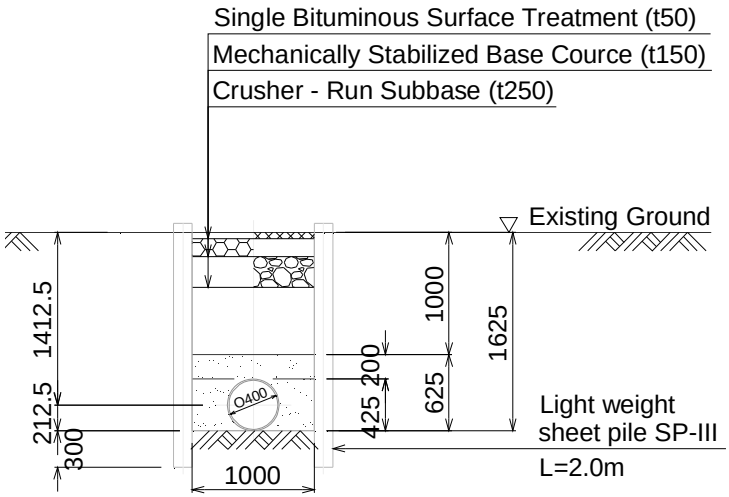


Figure 2.2.2.4-6 Typical Cross Section of Raw Water Transmission Main (Kampong Cham)

(2) Typical Cross Section of Raw Water Transmission Main in Battambang

For driveways, 1.2m of earth covering is planned and sheet piles are to be used during the pipe laying work. For the pipe laying work in the green zone (sidewalk), 0.8m of earth covering for the open cut excavation shall be applied without using sheet piles. Excavation width shall be 1.2m, and drilling depths shall be 1.43m at driveways and 1.83m at sidewalks.

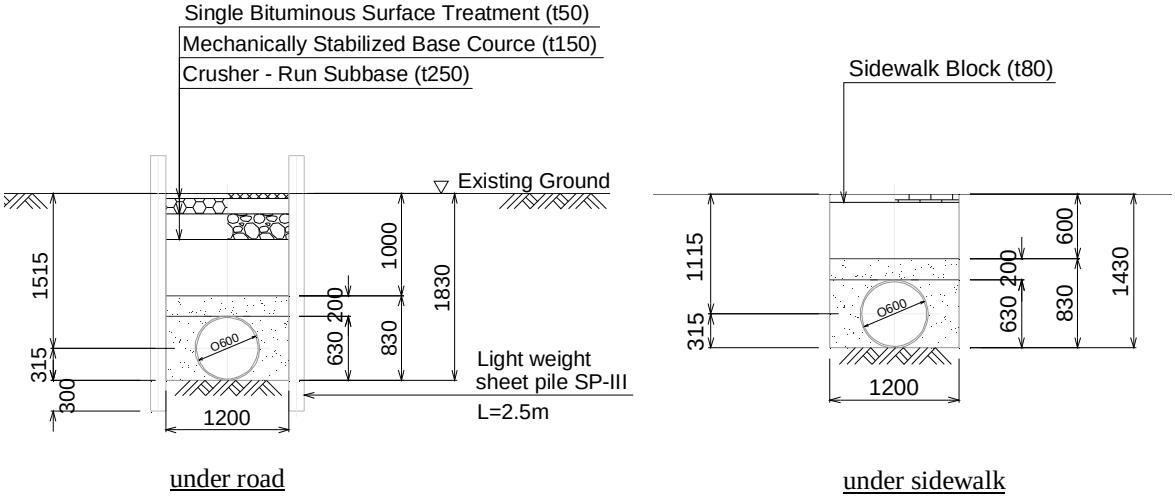


Figure 2.2.2.4-7 Typical Cross Section of Raw Water Transmission Main (Battambang)

2.2.2.4.6 Appurtenant Structures

(1) Siphon Culvert

Along the raw water transmission main route, a railroad crossing exists near the intake location. The raw water transmission main at the railroad crossing point shall be secured necessary earth

covering and protected with reinforced concrete.

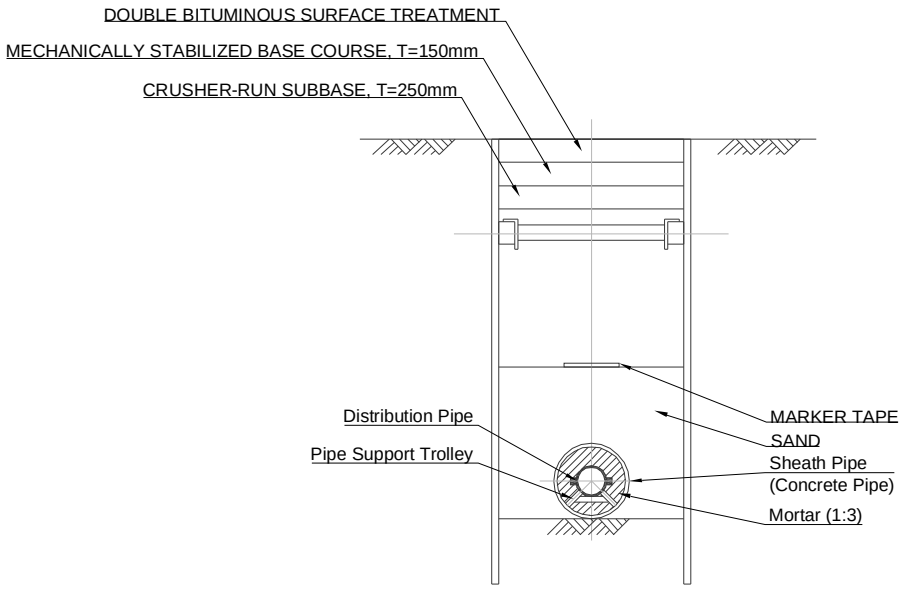


Figure 2.2.2.4-8 Protection at Railroad Crossing Portion

(2) Air Valve

The function of the air valve is for the discharge of air accumulated inside the pipes and for the required air intake in case of flushing the water out of the pipe. Smooth water conveyance and flush out shall be performed. The installation location shall be set at the convex portion of pipes. An example of air valve is shown in **Figure 2.2.2.4-9**.

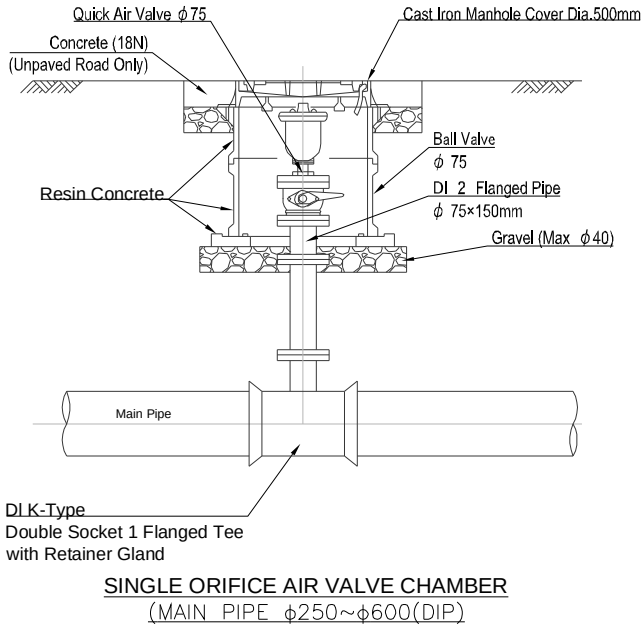


Figure 2.2.2.4-9 Example of Air Valve

(3) Drainage Facility

The function of drainage facility is to wash out the impure substances accumulated on the occasion of pipe laying and to discharge the turbid water from the pipes on the occasion of emergency. The installation location shall be set at the concave portion of the pipes. An example of drainage facility is shown in **Figure 2.2.2.4-10**.

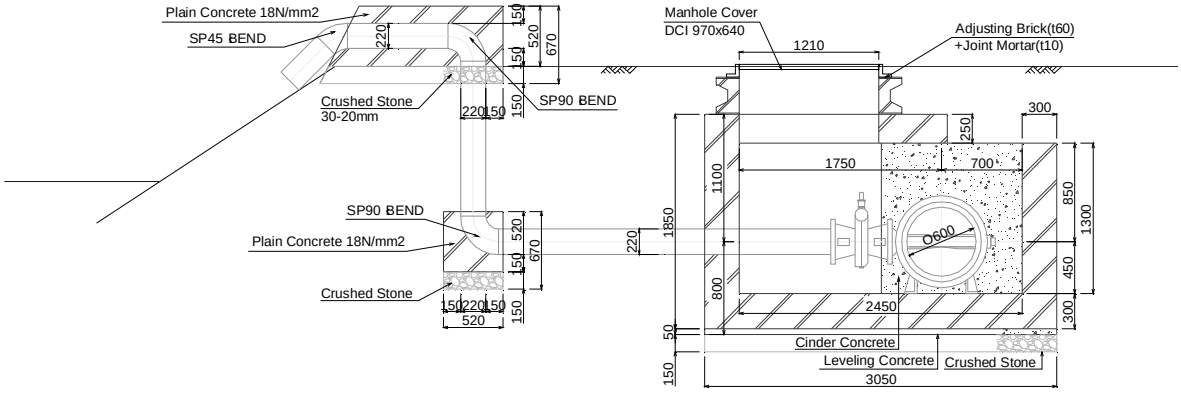
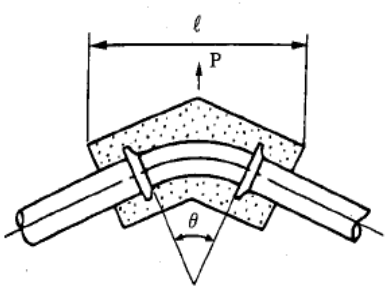


Figure 2.2.2.4-10 Example of Drainage Facility

(4) Protection of Deformed Pipes

Thrust block or restraint fitting shall be installed at bending parts, bifurcating parts and the portion with valves, since these will be affected by the uneven force of water pressure. An example of thrust block is shown in Figure 2.2.4-11 and an example of restraint fitting is shown in Figure 2.2.4-12.

There are some examples on the installation of thrust blocks, but since several days will be needed from installing the block up to backfilling and the influence on circumferential road traffic cannot be disregarded, the application of restraint fitting will be appropriate.



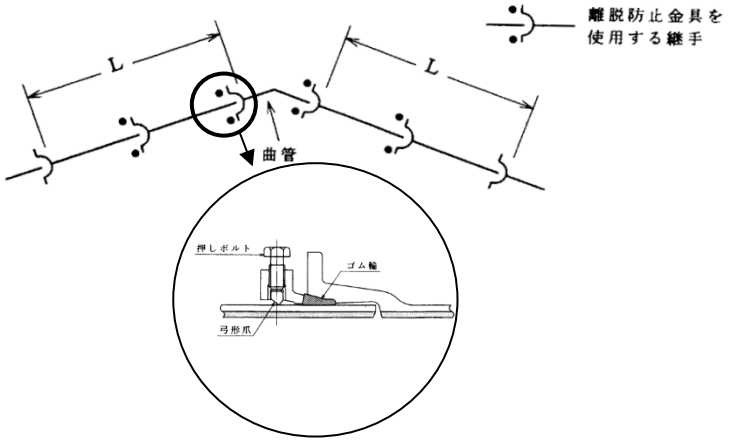


Figure 2.2.2.4-11 Example of Thrust Block Figure 2.2.2.4-12 Example of Restraint Fitting

2.2.2.4.7 Intake Pump

In accordance with the design condition (design flow, water level) in section 2.2.4.3 and the relation between the pump specification and pipe diameter discussed in the previous section 2.2.4.4, the specifications of pumps in Kampong Cham and Battambang are set as follows:

(a) Kampong Cham

i) Pumping Head

Actual pumping head: 20.20 (HWL of Receiving Well) - 0.63 (LWL of Mekong River)= 19.57m

Pipeline loss: 4.25m

Pump surrounding head loss: 0.21m

Total = 24.03m

ii) Pump Specifications

Yield: Q = 12,650m^3/day = 8.785m^3/min

Pumping head: H = 24.03m

Number: 4 pumps (1 pump is for reserve); Pump discharge: 2.928 m^3/min/1 pump

Output: P = 22kw

Diameter: φ200

The amounts of intake water in the rainy season and dry season are as follows:

Daily maximum water supply: 16,198m3/day

Dry season: 16,198 – 4800 = 11398 ≒ 11,500

11,500 x 1.1 = 12,650 m3/day

Rainy season: 16,198 – 10,800 = 5,398 ≒ 5,500

5,500 x 1.1 = 6,050 m^3/day

Based on the calculation above, the ratio of the amount of intake water between the rainy season and dry season is approximately 2:1. However, it is not very frequent that actual operation would require the full operation rate of 12,650m^3/day in the dry season and 6,050m^3/day in the rainy season. Therefore, 3 pumps are to be installed to adjust the yield by 3 levels. As for the adjustment of flow control valve, it is not assumed daily frequent operation because the flow control valve shall be operated periodically corresponding to a seasonal change of the quantity of abstracted river water volume. The flow control shall be conducted by unit control and valve control depending on the fluctuation of river water level.

(b) Battambang

i) Pumping Head

Actual pumping head: 16.80 (HWL of Receiving Well) - 4.806 (LWL of Sangke River)= 11.99m

Pipeline loss: 8.97m

Pump surrounding head loss: 0.10m
Total = 21.06m

ii) Pump Specifications
Yield: Q = 24,200m^3/day = 16.806m^3/min
Pumping Head: H = 21.06m
Number: 3 pumps (including 1 reserve pump); Pump discharge rate: 8.403 m^3/min/1 pump
Output: P = 55kw
Diameter: φ300

2.2.2.4.8 Composition and Specification of Intake Facility

Table 2.2.2.4-8 Composition and Specification of Intake Facility (Kampong Cham)

Facility			Scale and Structure
Bread Category	Middle Category	Small Category	
Intake Facility	Intake Shaft	Main body	Reinforced Concrete Structure Rectangular Shape: W7.65 m x L10.70m (inner dimension) Depth 18.45 m (Depth at HWL 16.75 m)
		Operation Room of Intake Pump	Reinforced Concrete Structure Rectangular Shape: W5.50 m x L11.80 m x H5.10 m (under the beam) (inner dimension) Equipment: Power Receiving Panel, Operating Panel, Switchboard, Secondary Equipment Panel, Circumference Plumbing of Pump, Overhead Crane (3t)
	Intake Pump Facility	Intake Pump	Vertical Shaft Type Mixed Flow Pump 4 sets (Ordinary Use 3 sets, Spare1 set) Q=2.93 m^3/min h=25.8 m P=22 KW 3Φ380V 50Hz
		Generator	Reinforced Concrete Structure Rectangular Shape: W5.50 m x L4.90 m x H4.30 m (under the beam) (inner dimension) Generator: 60 KVA (Soundproofing Type)
	Temporary Work	Sandbag	6 steps stacking, Length: Top of Slope L=90m, Foot of Slope L=15m
		Shielding Sheet Pile	Sheet Pile: SP-Ⅲ l=11m, Installation Length L=80m)
		Riprap Work	1500m^3
		Water Pollution Prevention Fence	Depth 5m, Installation Length L=40m
Raw Water Transmission Facility	Raw Water Transmission Main		DIPΦ400, L≒920 m

Table 2.2.2.4-9 Composition and Specification of Intake Facility (Battambang)

Facility			Scale and Structure
Bread Category	Middle Category	Small Category	
Intake Facility	Intake Shaft	Main body	Reinforced Concrete Structure Rectangular Shape: W 7.65 m x L10.80m (inner dimension) Depth 13.90 m (Depth at HWL 13.20 m)
		Operation Room of Intake Pump	Reinforced Concrete Structure Rectangular Shape: W 5.25 m x L11.70 m x H5.10 m (under the beam) (inner dimension) Equipment: Power Receiving Panel, Operating Panel, Switchboard, Secondary Equipment Panel, Circumference Plumbing of Pump, Overhead Crane (3t)
	Intake Pump Facility	Intake Pump	Vertical Shaft Type Mixed Flow Pump 3 sets (Ordinary Use 2 sets, Spare1 set) Q=8.40 m^3/min h=21.3 m P=55 KW 3Φ380V 50Hz
		Generator	Reinforced Concrete Structure Rectangular Shape: W5.55 m x L5.60 m x H4.30 m (under the beam) (inner dimension) Generator: 260 KV (Soundproofing Type)
	Temporary Work	Sandbag	Sheet Pile: SP-Ⅳ L=21.5m, Installation Length L=64.9m)
		Shielding Sheet Pile	Foot of Slope (Riverside): SP-Ⅳ l=11m, Installation Length L=31m Foot of Slope (Gable): SP-Ⅳ l=11m, Installation Length L=17.6m SP-Ⅲ l=6.5～9.0m, Installation Length L=20.8m Front of Retaining Wall (Top of Slope): SP-Ⅲ l=9m, Installation Length L=32.8m
		Water Pollution Prevention Fence	Depth 5m, Installation Length L=40m
Raw Water Transmission Facility	Raw Water Transmission Main		DIPΦ600、L≒4.4 km

2.2.2.5 Plan for Water Treatment Facility

(1) Treatment Process

The treatment process was designed to achieve operational and energy efficiency, as well as for ease of operation and maintenance. In other words, the integrated operation of the components of the treatment process (such as sedimentation, filtration and disinfection) would be efficient and effective.

The key factors to consider in designing the treatment process are the quality of the raw water, the desired quality of the treated water, the quantity of water to be treated, and the level of technology required for proper operation and maintenance. The conventional treatment process (coagulation – sedimentation – rapid sand filtration), similar to that used at the existing Battambang plant, Phum Prek plant in Phnom Penh and other plants in Cambodia, is deemed most appropriate. The chemical feeding system uses aluminium sulfate for coagulant, lime for pH and alkalinity adjustment and chlorine gas for disinfection. **Figure 2.2.2.5-1** shows the flow chart of the treatment process.

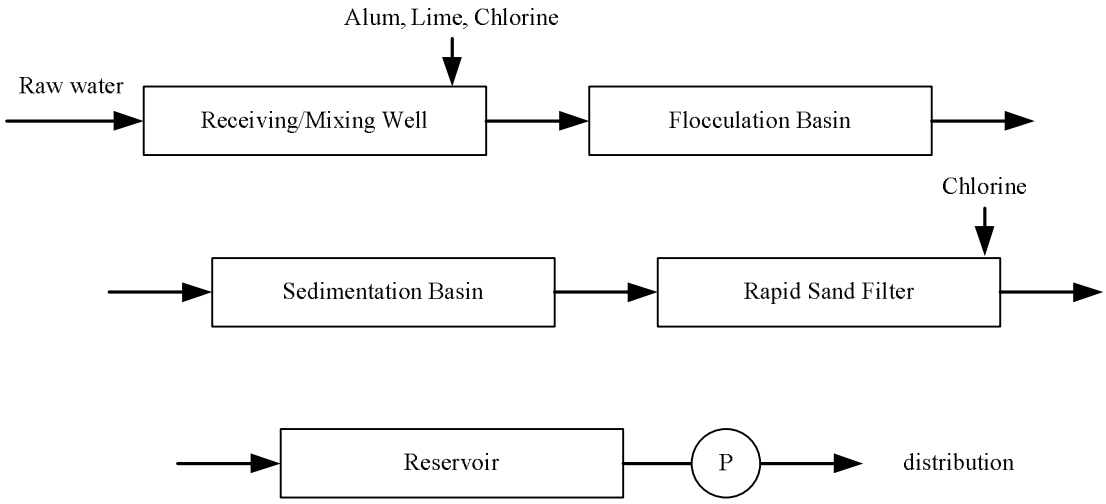


Figure 2.2.2.5-1 Water Treatment Process

(2) Details of Each Component of the Treatment Process

a. Mixing Well

There are three stages to the coagulation-sedimentation process: mixing, flocculation and sedimentation. Thorough and rapid mixing of the raw water with the added coagulants is necessary to promote coagulation of the fine particles to form flocs.

The three mixing methods listed below (and see **Figure 2.2.2.5-2**) were considered:

a. Mechanical mixing

b. Mixing using pumps
c. Gravitational force mixing using a weir

The gravitational force mixing method is preferred because of the minimum operation and maintenance requirements. The existing plants in Phnom Penh also use this method. This is a well-established method widely used at other plants outside of Cambodia.

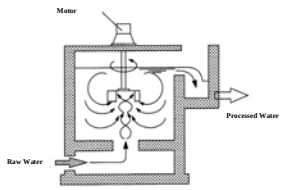
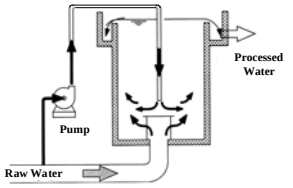
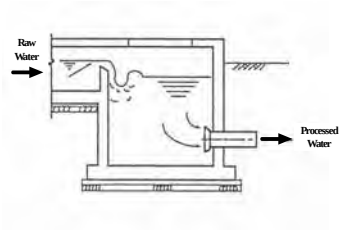
Mechanical Mixing	Mixing using Pump	Gravitational force mixing using a weir
		

Figure 2.2.2.5-2 Types of Mixing Method

b. Flocculation Basin

It is proposed that the flocculation basin will be a vertical baffled channel type. The mechanical agitation type basin is not recommended because of its operation and maintenance requirements. **Figure 2.2.2.5-3** shows the vertical baffled channel type basin and the mechanical agitation type basin. The existing plants in Battambang also use the baffled channel type. This is a well-established method widely used at other plants outside of Cambodia

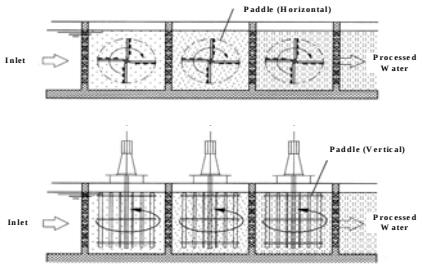
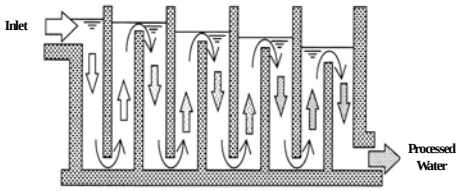
Mechanical Agitation (Flocculator)	Baffled Channel
	

Figure 2.2.2.5-3 Types of Flocculation Basin

c. Sedimentation Basin

The efficiency of the sedimentation basin (E) is determined using the following equation:

$$E = v0 / (Q / A)$$

where A : horizontal area of the sedimentation basin
Q : flow rate into the sedimentation basin

v 0 : velocity of floc sedimentation
Q／A : overflow rate (surface loading)

The above equation indicates that the efficiency of the sedimentation basin can be improved by:

1. increasing the area of the sedimentation basin;
2. increasing the velocity of floc sedimentation; or
3. decreasing the flow rate into the sedimentation basin.

The different types of sedimentation basin can be classified according to the above variables, as shown in **Table 2.2.2.5-1**. The "conventional type, uni-flow sedimentation basin" is recommended for this project. The existing plants in Phnom Penh and Battambang also use this type of sedimentation basin. This is a well-established method widely used at other plants outside of Cambodia.

Table 2.2.2.5-1 Efficiency Improvement by Types of Sedimentation Basin

<table>
<tr><td rowspan="6">Horizontal flow sedimentation basin</td><td colspan="2">Conventional type – uni-flow sedimentation basin</td><td>decrease water quantity inflow to the sedimentation basin</td></tr>
<tr><td rowspan="2">Multi-layer sedimentation basin</td><td>Dual layer</td><td rowspan="4">increase area of sedimentation basin</td></tr>
<tr><td>Triple layer</td></tr>
<tr><td rowspan="2">Inclined plate/pipe sedimentation basin</td><td>Horizontal flow type</td></tr>
<tr><td>Up-flow type</td></tr>
<tr><td rowspan="3">Suspended solid contact type sedimentation basin</td><td colspan="2">Slurry circulation type suspended solid contact type sedimentation basin</td><td rowspan="3">increase velocity of floc sedimentation</td></tr>
<tr><td colspan="2">Sludge blanket type sedimentation basin</td></tr>
<tr><td colspan="2">Combined type of above types</td></tr>
</table>

d. Rapid Sand Filtration Basin

The rapid sand filtration basin is the final turbidity removal step in the water treatment process. The following two types of filtration basin were considered for this project (see **Figure 2.2.2.5-4**):

a. Rapid sand filtration, air scouring type
b. Standard rapid sand filtration type

The standard rapid sand filtration type is not recommended because it requires relatively high level of technical knowledge to adjust the volume of water being filtered, as well as for other operational control. The rapid sand filtration, air scouring type is simple to operate, uses less backwash water and is used at existing plants in Cambodia. Staff would have the expertise to operate and maintain the system. Therefore, the rapid sand filtration, air scouring type is recommended as the preferred option for this project.

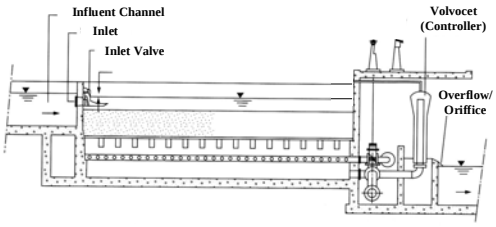
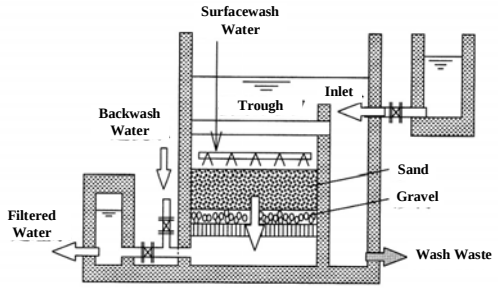
Air Scouring Type	Standard Type
	

Figure 2.2.2.5-4 Types of Rapid Sand Filtration Basin

e. Layout of Treatment Facility

The layout of the proposed water treatment facilities of Kampong Cham and Battambang are shown in **Figures 2.2.2.3-5** and 2.**2.2.3-6**, respectively.

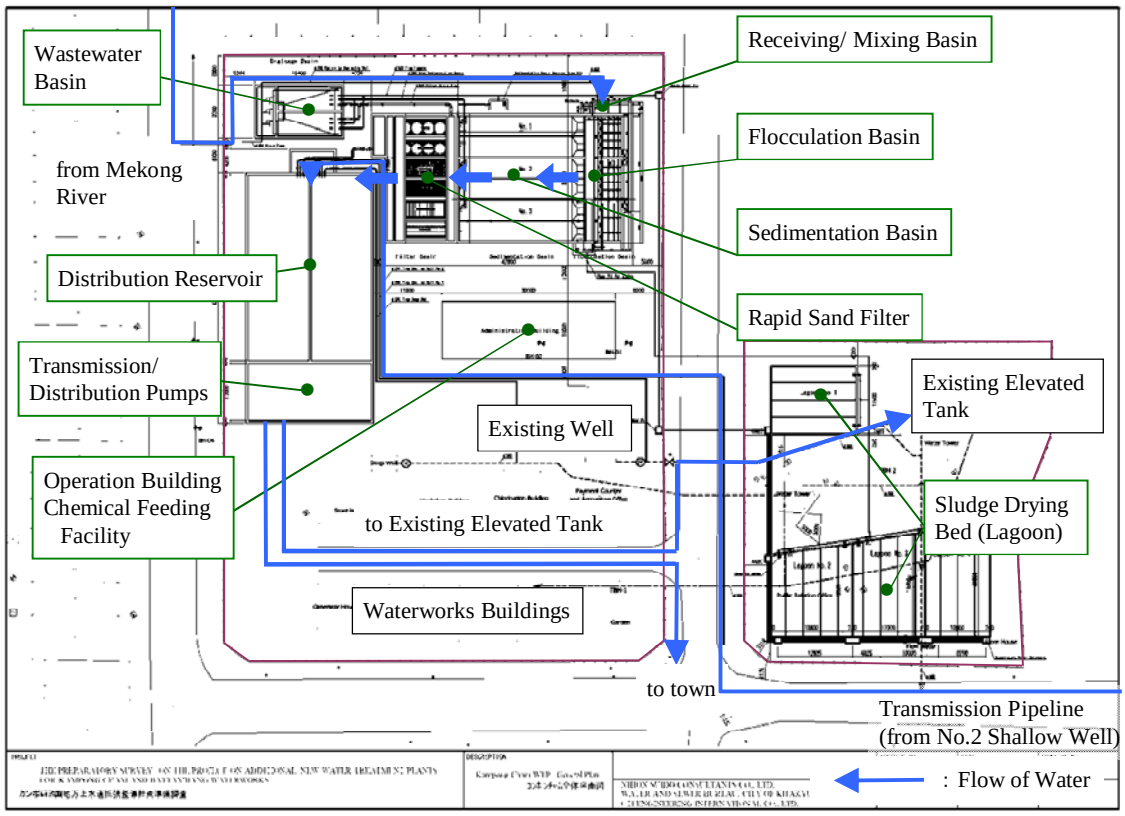


Figure 2.2.2.5-5 Layout of Kampong Cham Treatment Plant

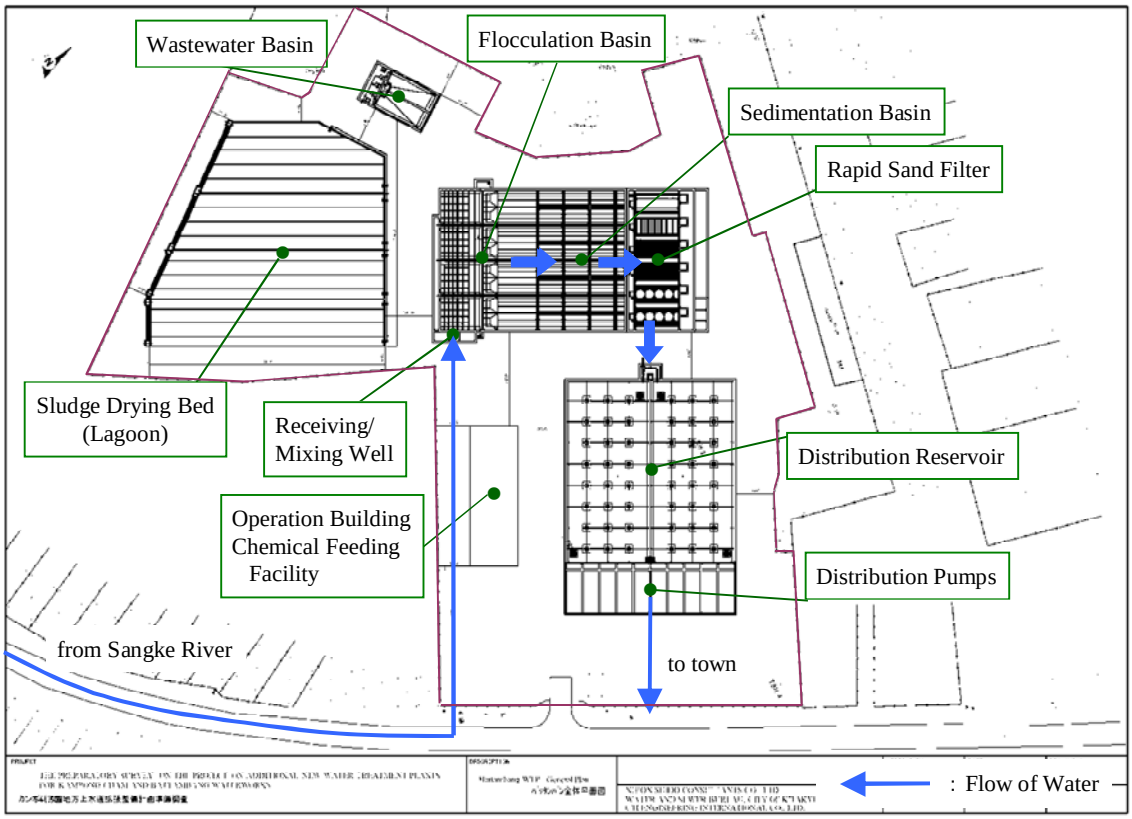


Figure 2.2.2.5-6 Layout of Battambang Treatment Plant

(3) Operation Management of Kampong Cham Plant

At present groundwater is used as the water source for the existing water supply system in Kampong Cham, requiring no water treatment facility and no large electricity consumption or chemical cost. There is enough groundwater in the wet season, but in the dry season the groundwater level is rather low. Therefore, in order to secure a stable water supply in the dry season and to increase water supply capacity to meet future demand, construction of the new water treatment plant must use surface water from the Mekong River. The operation of the new water treatment plant will increase the electricity and chemical costs and would require the management of Kampong Cham Waterworks to raise the water tariff. Therefore, to minimize operation and maintenance costs, the Cambodian side requested that the system be designed to use groundwater as much as possible in wet season.

Safe yield of the existing groundwater system is estimated as follows;

Safe yield in wet season (capacity of well pumps) : 10,800 m^3/day

Safe yield in dry season : 4,800 m^3/day

The treatment capacity of the new water treatment plant at 11,500 m3/day, is based on the future water demand in 2019 of 16,300 m3/day and safe yield in the dry season of 4,800 m3/day. In the wet season, however, only 5,500 m3/day from the new plant will be needed for the system, because the

groundwater system can supply 10,800 m3/day. Therefore, the treatment flow of the new plant would fluctuate from 5,500 m3/day to 11,500 m3/day.

The new plant would have three parallel treatment trains which would correspond to the water supply changes. In the wet season, two trains will be operated and in the dry season, three trains will be operated. Three intake pumps (plus one stand-by) will be installed as well in the intake facilities to correspond to the plant operations.

(4) Design for Sludge Treatment and Wastewater Discharge

Sludge from the sedimentation basin will be treated and disposed of in the following manner in compliance with discharge standards:

- During washing of the basin, the supernatant of the basin which is of low turbidity will be discharged to the Mekong River in Kampong Cham and the Sangke River in Battambang.
- Settled sludge and high turbidity water is pumped to a sludge drying bed.
- Supernatant of the drying bed will be discharged to the nearby rivers and the dried sludge will be disposed of at a pre-determined location for each city.

Backwash water from the filtration basin will be retained at the wastewater basin and discharged by pump to the nearby river in a control manner to avoid releasing large volumes of wastewater in a short period of time. Especially at the Kampong Cham Plant, supernatant of the sludge drying bed and wastewater basin can return to the receiving well, if the supernatant still has high turbidity.

(5) Design for Other Components of the Treatment Facilities

Distribution Pumping Facilities

- A foot valve will be installed at the suction of the distribution pump rather than a complicated vacuum pump system.

Electrical and Control Facilities

- New power transmission facilities will be installed.
- An emergency generator will be required.

Yard Piping and Landscaping

- Maintenance roads will be constructed around treatment facilities.
- Inter-connecting pipelines of appropriate diameters will be installed between treatment facilities.
- Lightning rod will be installed at each building to prevent lightning damage

(6) Design for Components of Water Treatment Facility

Tables 2.2.2.5-2 and **2.2.2.5-3** show components of water treatment facility plans for Kampong Cham and Battambang respectively.

Table 2.2.2.5-2 Component of Water Treatment Facility Plan (Kampong Cham)

Facility/Equipment		Scale and Structure
Water Treatment Facility	Receiving Well	Reinforced Concrete Structure Internal Dimension: 1.60 m width × 4.10 m length × 4.50 m depth Volume and Detention Time: V=29.5 m3、T=3.4 min in dry season (T≧1.5 min)
	Rapid Mixing Tank	Reinforced Concrete Structure Gravitational force mixing using a weir Internal Dimension: 1.60 m width × 1.50 m length × 3.88 m depth Volume and Detention Time: V=9.3 m3、T=1.1 min (1<T< 5 min)
	Flocculation Basin	Reinforced Concrete Structure Slow Mixing Method: Vertical channel bands flocculator Internal Dimension: 6.90 m width × 3.25 m length × 4.50 m height + 3.46 m average effective depth Quantity: 3
	Sedimentation Basin	Reinforced Concrete Structure Horizontal-Flow Sedimentation Basin Supernatant Collecting System: Collecting Trough + Submerged Orifice Internal Dimension: 6.90 m width × 21.50 m length × 3.99 m average depth Quantity: 3 Surface Loading: Q/A=20.0 mm/min (15-30 mm/min) Mean Velocity: V=0.11 m/min (below 0.40 m/min)
	Rapid Sand Filter	Reinforced Concrete Structure Internal Dimension: 2.50 m width × 7.00 m length Quantity: 6 Filter Sand Thickness: 100 cm Underdrain System: Porous Filter Bed Method Filtration Rate: V=120.5 m/day (120-150 m/day) Flow Control: Lower Part Control Method Backwash Method: Simultaneous Backwash Method by Air and Water
	Treated Water Reservoir	Reinforced Concrete Structure using Flat Slab Structure Quantity: 2 Effective Volume: V=2,500 m3 (1,250 m3 × 2) Effective Water Depth: H=3.80 m (3-6 m) Detention Time: T=5.2 hours Internal Dimension: 10.40 m width × 32.00 m length × 4.50m height
	Wastewater Basin	Reinforced Concrete Structure Quantity: 2 Effective Volume: V=211 m3 (105.5 m3 × 2) Internal Dimension: 4.00 m width × 11.00 m length × 5.60m height + 2.40m depth
	Sludge Drying Bed (Lagoon)	Reinforced Concrete Structure Quantity: 4 Effective Area: A=790 m2
	Chemical Feeding Facility	Alum, Lime: at Administration Building Chlorine: Chlorine Feeding House (Floor Area 61.3m^2)
	Emergency Generator	450 KVA (Soundproof type, Equipped with Internal Water Tank) At Administration Building
	Administration Building	Reinforced Concrete Structure, Three Stories Building, Total Floor Area: 588 m2 Usage: 1st Floor: Staff Room, Workshop, Storage, Emergency Generator Room, Toilet, Chemical Carry-in Room (1-3 Fl. Open Ceiling) 2nd Floor: Manager Room , Meeting Room, Monitoring Room, Toilet, Chemical Dissolving Tank Room (2-3 Fl. Open Ceiling), Chemical Feeding Pump Room 3rd Floor: Chemical Dissolving Tank Room (2-3 Fl. Open Ceiling) Common: Staircase

Table 2.2.2.5-3 Component of Water Treatment Facility Plan (Battambang)

Facility/Equipment		Scale and Structure
Water Treatment Facility	Receiving Well	Reinforced Concrete Structure Internal Dimension: 2.00 m width × 5.25 m length × 4.45 m depth Volume and Detention Time: V=46.7 m3、T=2.8 min in dry season (T≧1.5 min)
	Rapid Mixing Tank	Reinforced Concrete Structure Gravitational force mixing using a weir Internal Dimension: 2.00 m width × 3.00 m length × 3.81 m depth Volume and Detention Time: V=22.9 m3、T=1.4 min (1<T< 5 min)
	Flocculation Basin	Reinforced Concrete Structure Slow Mixing Method: Vertical channel bands flocculator Internal Dimension: 7.10 m width × 5.90 m length × 4.70 m height + 3.74 m average effective depth Quantity: 4
	Sedimentation Basin	Reinforced Concrete Structure Horizontal-Flow Sedimentation Basin Supernatant Collecting System: Collecting Trough + Submerged Orifice Internal Dimension: 7.10 m width × 30.00 m length × 4.12 m average depth Quantity: 4 Surface Loading: Q/A=20.0 mm/min (15-30 mm/min) Mean Velocity: V=0.14 m/min (below 0.40 m/min)
	Rapid Sand Filter	Reinforced Concrete Structure Internal Dimension: 3.50 m width × 9.10 m length Quantity: 6 Filter Sand Thickness: 100 cm Underdrain System: Porous Filter Bed Method Filtration Rate: V=126.6 m/day (120-150 m/day) Flow Control: Lower Part Control Method Backwash Method: Simultaneous Backwash Method by Air and Water
	Treated Water Reservoir	Reinforced Concrete Structure using Flat Slab Structure Quantity: 2 Effective Volume: V=6,000 m3 (3,000 m3 × 2) Effective Water Depth: H=4.30 m (3-6 m) Detention Time: T=6.5 hours Internal Dimension: 17.60 m width × 40.10 m length × 5.00m height
	Wastewater Basin	Reinforced Concrete Structure Quantity: 2 Effective Volume: V=230 m3 (115 m3 × 2) Internal Dimension: 4.00 m width × 11.00 m length × 6.50m height + 2.70m depth
	Sludge Drying Bed (Lagoon)	Reinforced Concrete Structure Quantity: 4 Effective Area: A=1,936 m2
	Chemical Feeding Facility	Alum, Lime: at Administration Building Chlorine: Chlorine Feeding House (Floor Area 82.6m^2)
	Emergency Generator	450 KVA (Soundproof type, Equipped with Internal Water Tank) At Administration Building
	Administration Building	Reinforced Concrete Structure, Three Stories Building, Total Floor Area: 588 m2 Usage: 1st Floor: Staff Room, Laboratory, Workshop, Storage, Emergency Generator Room, Toilet, Chemical Carry-in Room (1-3 Fl. Open Ceiling) 2nd Floor: Manager Room , Meeting Room, Monitoring Room, Toilet, Chemical Dissolving Tank Room (2-3 Fl. Open Ceiling), Chemical Feeding Pump Room 3rd Floor: Chemical Dissolving Tank Room (2-3 Fl. Open Ceiling) Common: Staircase

2.2.2.6 Plan for Transmission and Distribution Facilities

The plan for transmission and distribution facilities was developed based on the "Water Master Plan" (Battambang Water Supply in 2008, Kampong Cham Water Supply in 2010), which was formulated under The Project on Capacity Building for the Water Supply System in Cambodia Phase 2 and other related project plans.

(1) Kampong Cham Water Supply

1) Outline of Transmission and Distribution Facilities

Existing System

The water sources for the Kampong Cham Water Supply (hereinafter, "KMC") are two shallow wells (No. 1, No. 2) and one deep well, and Shallow Well No. 2 is located around 900m away from the KMC treatment plant. Water from Shallow Well No. 1 and Deep Well in the KMC treatment plant is pumped up to an elevated tank at the same site which supplies water with gravity flow. Shallow Well No. 2 supplies water to the city directly. The outline of the existing KMC transmission and distribution system is shown in **Figure 2.2.2.6-1**.

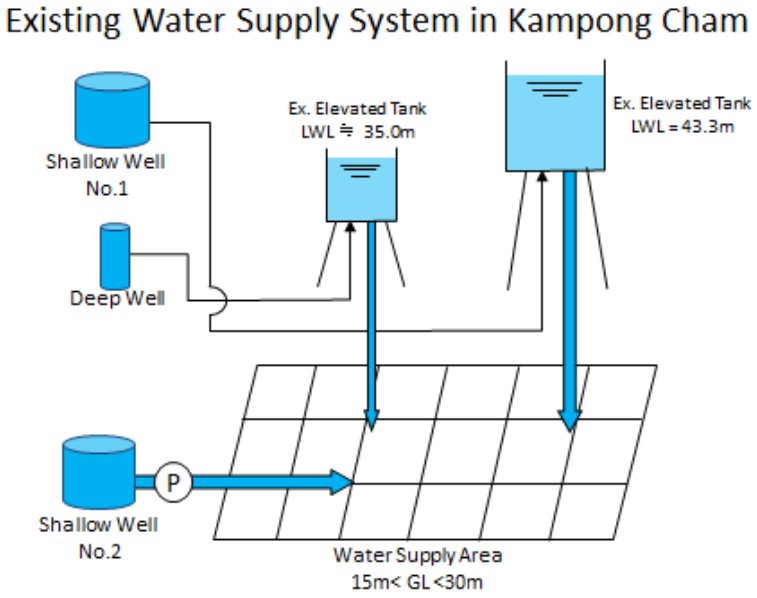


Figure 2.2.2.6-1 Outline of KMC system

Transmission System

In order to correspond to the fluctuation of the amount of well water between dry and rainy seasons, all well water is gathered in the new service reservoir. The transmission pipe will be prepared between Shallow Well No. 2 and a new service reservoir which is located in the KMC treatment plant. The transmission pump utilizes an existing well pump and the designed transmission flow is 4,200m^3/day according to the past record. The new transmission pipe will

be installed with a φ200A HDPE pipe, based on the result of hydraulic calculations using the Hasen-Williams formula, with a coefficient of flow velocity of C = 110.

Also, the existing pump will be used to supply water from Shallow Well No. 1 to the newly established reservoir. As it's possible for the existing pump for Shallow Well No. 1 to pump water directly to the elevated tank during the rainy season, at that time water will be pumped directly from the shallow well to the elevated tank as is done currently. However, in the event that the water level in the well falls to the point that water cannot be pumped to the elevated tank (during the dry season), water will be pumped to the elevated tank after being temporarily sent to the newly established reservoir. In this way a system that provides a stable water supply while effectively utilizing the existing facilities can be constructed.

Distribution System

The design for the water supply area planned by this project is shown in **Figure 2.2.2.6-2**. The pressure supply from the existing elevated tank will be low since the designed distribution flow and supply area will be expanded by a factor of three. The elevation of the designed water supply area is higher along to the National road No.7 from the Mekong River, and the highest point is around 48m which is approximately 20m higher than the highest place of the existing water supply area. Therefore the water supply area shall be divided into two supply areas, one is the low elevation area along to the Mekong River which can be supplied from the existing elevated tank and the other is the high elevation area which cannot be supplied from the existing elevated tank.

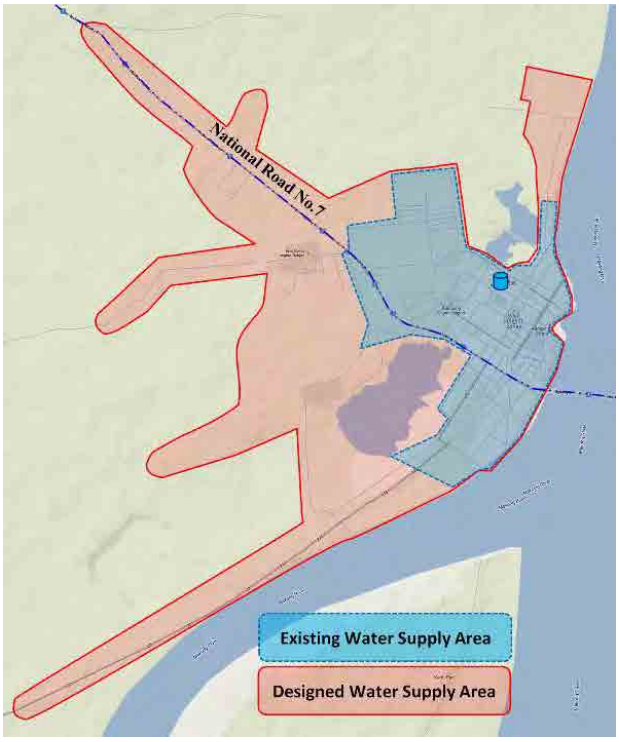


Figure 2.2.2.6-2 Designed water supply area (KMC)

2) Study for Distribution System

The following two proposals are considered for supplying water to the high elevation area.

One alternative, “Plan A”, is to construct a new elevated tank in the high elevation supply area and supply water through gravity flow. The new elevated tank for the high elevation supply area is not able to be constructed with enough height at the KMC treatment plant due to its elevation being only 20m. Therefore land for the new elevated tank in the high elevation supply area will need to be secured, but as of July 2012, the land has not been secured yet, so it is assumed that the land for the new elevated tank will be located along National road No.7 and be 3.5km away from the KMC treatment plant as shown in **Figure 2.2.2.6-3.**

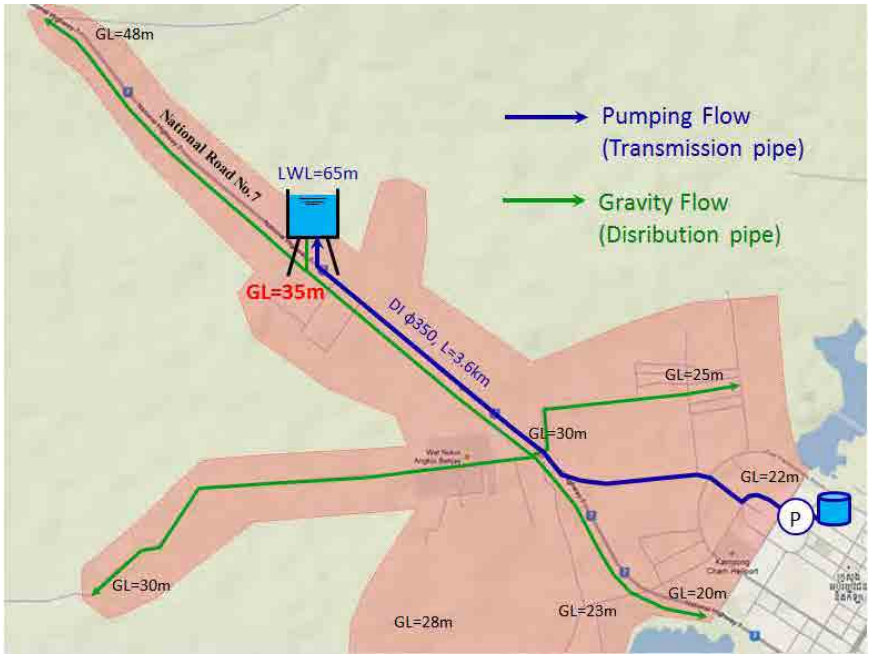


Figure 2.2.2.6-3 Gravity flow (New elevated tank) plan

The other alternative, “Plan B”, is to supply water with a pump directly. Construction of a new elevated tank and securing land is not necessary, but a controllable distribution pump to respond to water demand, which is always changing, is required. The outline of each plan is shown below.

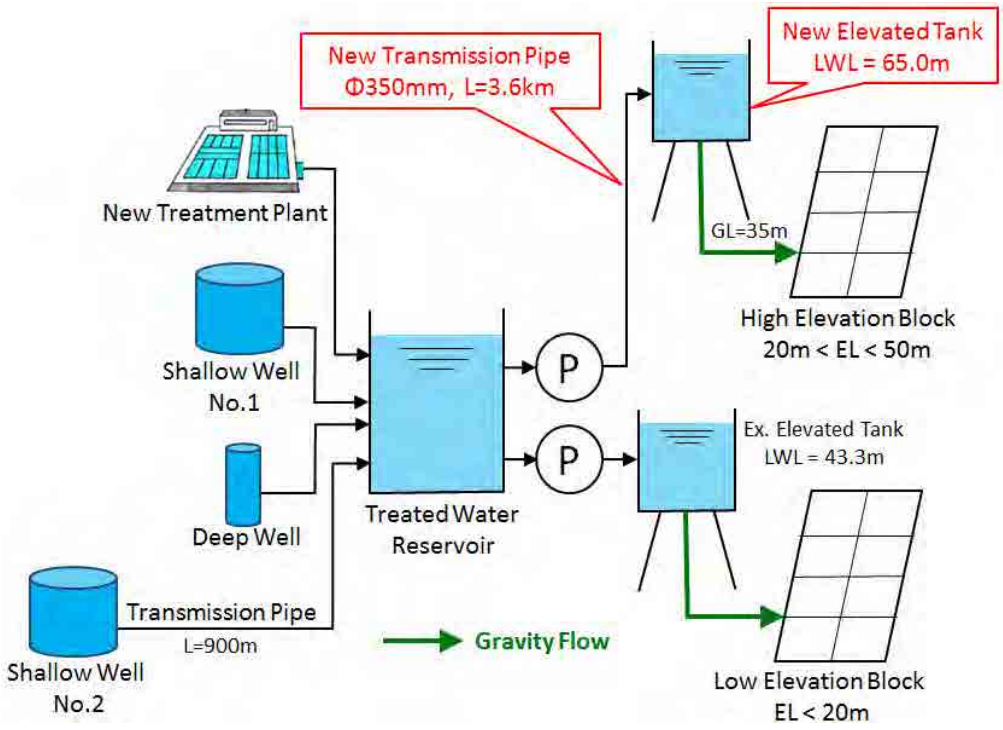


Figure 2.2.2.6-4 Plan A

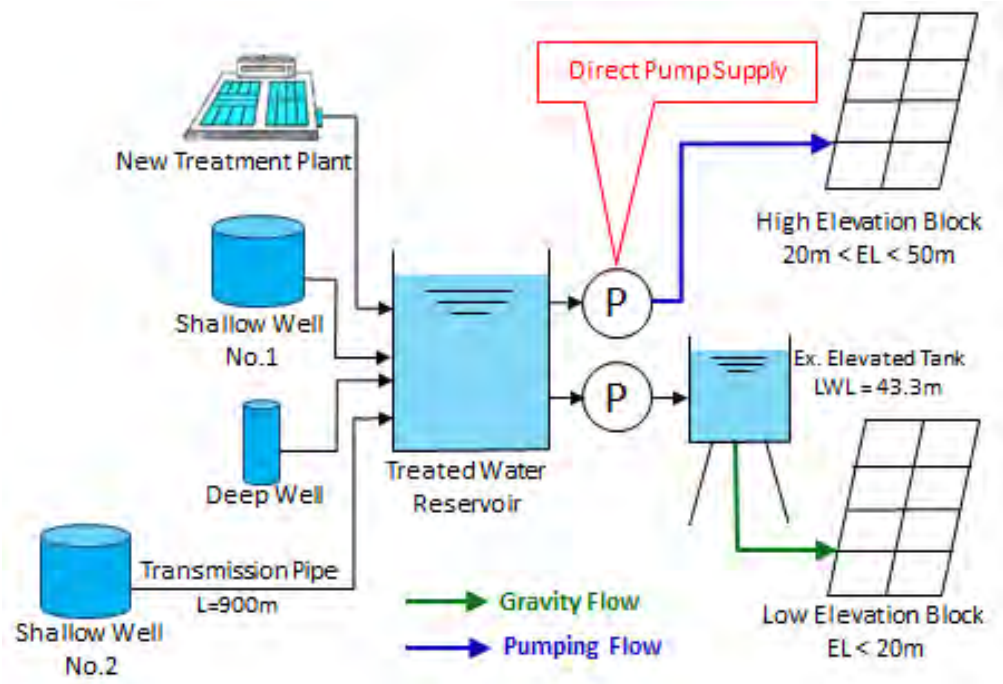


Figure 2.2.2.6-5 Plan B

The Plan Comparison

	Plan A	Plan B
Construction cost	108	100
	×	○
O&M cost	107	100
	×	○
Ease of operation	Management of water level needed for elevated tank only. However, water level monitoring by staff is necessary	Automatic control and efficient operation is available by installation of inverter equipment.
	△	○
Land acquisition	Necessary	Not necessary
	×	○
Judgment	×	○

The cost of Construction and O&M is shown as the ratio of Plan A in the case where Plan B is 100.

Legend : ○= Advantage, ×= Disadvantage, △= No clear advantage

Plan B is adopted as Plan B has an advantage and the land for the new elevated tank has not yet been acquired.

3) Network Calculation

The purpose of this project is to expand the water supply system to improve the water supply coverage ratio while utilizing existing facilities as much as possible. After this project, however, the distributed amount of water and water supply area will be expanded by a factor of three, so it is difficult to secure more than 150kPa at peak demand in the fringe and suburb water supply areas even if a new distribution main is prepared. Therefore, to give first priority to achieving the target water supply coverage ratio of 84.8% in 2019, the water pressure (minimum dynamic pressure) that should be ensured is as shown in **Table 2.2.2.6-1**.

Table 2.2.2.6-1 Planned Daily Minimum Dynamic Water Pressure

At peak demand	
Urban area and Dis main	100kPa and up
Suburb area	50kPa and up
At average demand	
Urban area and Dis main	150kPa and up
Suburb area	100kPa and up

Hourly Factor

Only the Phnom Penh Water Supply Authority (PPWSA) has measured hourly factor in Cambodia and the measuring area is the downtown area in Phnom Penh. Thus it is hard to use it as a reference as the circumstances of water demand are very different between Phnom Penh and Kampong Cham, Battambang. Therefore, for the estimation of hourly factor for the two targeted cities, the regression formula is utilized showing the relation between daily supply amount and hourly factor of Japanese waterworks in "The Design Criteria for Water Supply Facilities" published by the Japan Waterworks Association.

Table 2.2.2.6-2 Hourly Factor

Item	Kampong Cham	Battambang
Regression formula (daily amount and hourly factor)	$K=2.6002\times(Q/24)^{-0.0628}$ (K : Hourly factor, Q : Daily supply amount)	
Planned maximum daily supply (2019)	16,200 m^3/day	32,473 m^3/day
Hourly factor: K	1.72	1.65
	Hourly maximum amount ÷ Hourly average amount	

Source: The Design Criteria for Water Supply Facilities

Network Calculation

The Network calculation was calculated by EPANET ver 2.0 with the above conditions.

- Hazen-Williams formula
  $H = 10.666 \times C^{-1.85} \times D^{-4.87} \times Q^{1.85} \times L$
  Where
  H: Friction Head Loss (m)
  C: Coefficient of flow velocity
  D: Internal diameter of pipe (m)
  Q: Flow rate (m^3/s)
  L: Length (m)

The effective pressure at the peak demand of the designed water supply area in KMC is shown in **Fig 2.2.2.6-6**. The effective pressure at the blue circle in Fig 2.2.6-6 is less than 5.0m. The reason for this is increased friction loss by the under capacity of the existing distribution pipe installed by the UN-Habitat project. According to Kampong Cham Waterworks, to increase the diameter of the existing distribution pipe, or the pump discharge head are not necessary since

the area of the blue circle is low population density.

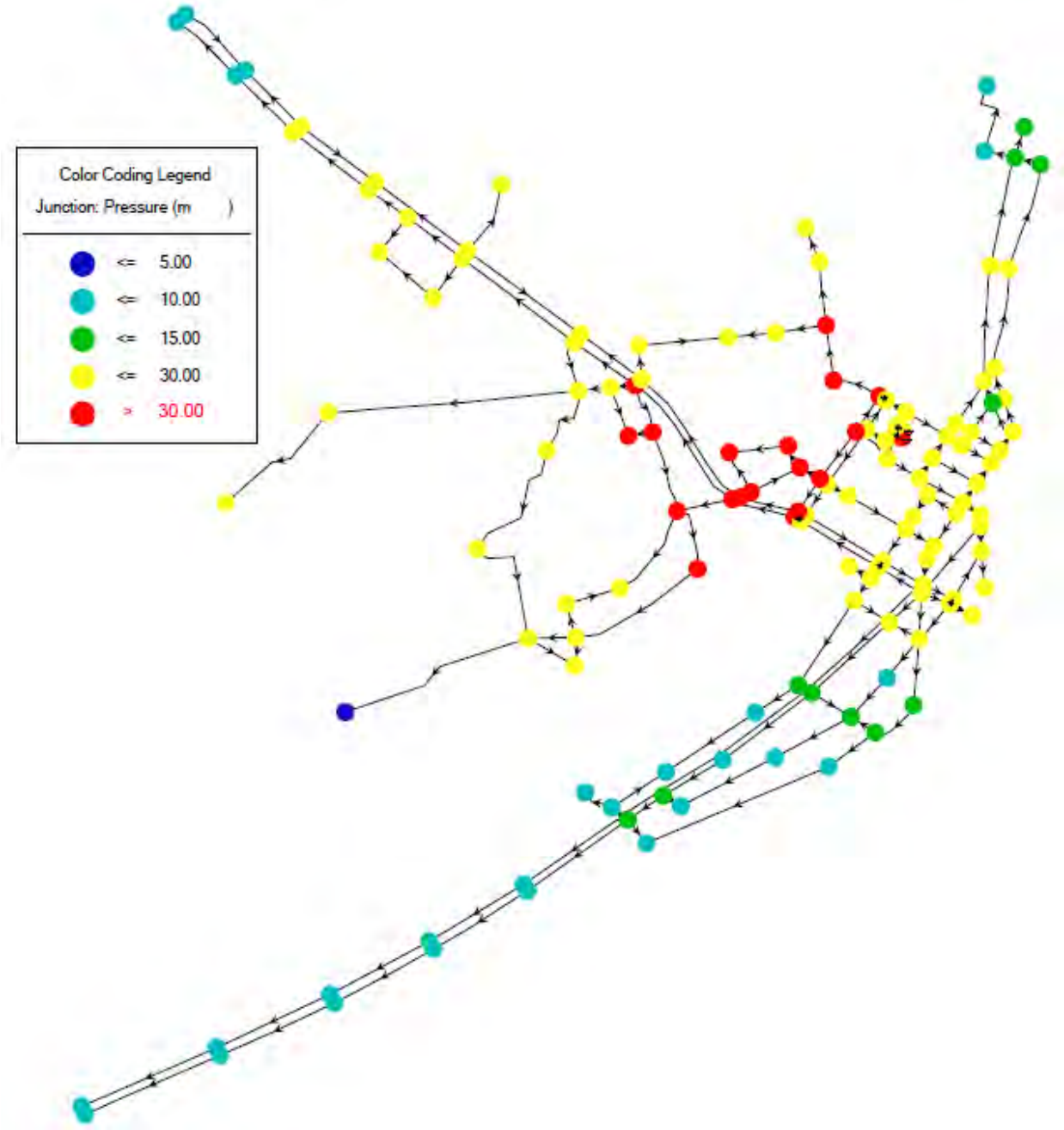
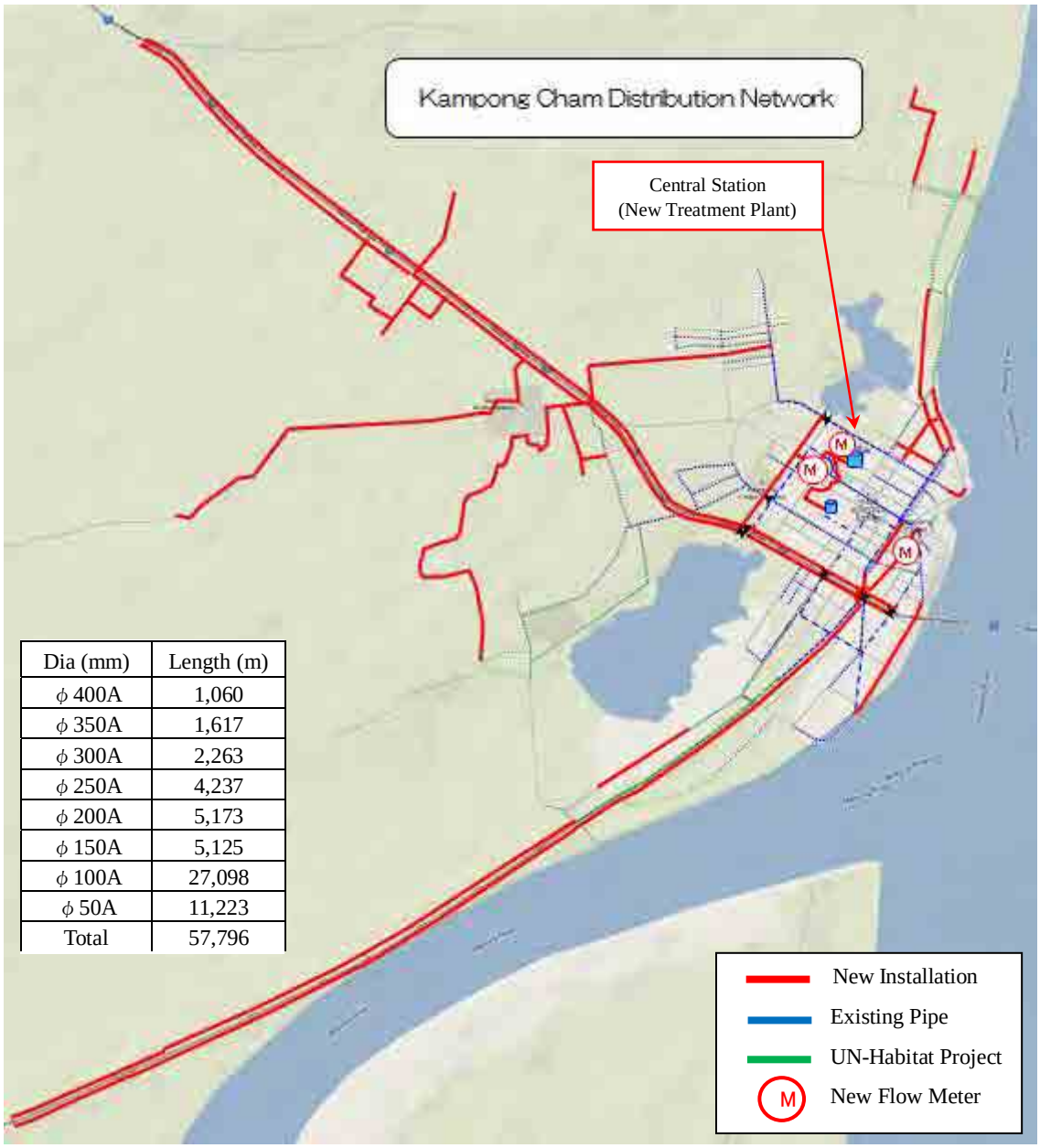


Figure 2.2.2.6-6 Effective pressure at peak demand (KMC)

4) Transmission and Distribution Pipe Arrangement Plan

Based on the result of the network calculation, transmission and distribution pipes are designed as shown in **Figure 2.2.2.6-7**.



Dia (mm)	Length (m)
ϕ 400A	1,060
ϕ 350A	1,617
ϕ 300A	2,263
ϕ 250A	4,237
ϕ 200A	5,173
ϕ 150A	5,125
ϕ 100A	27,098
ϕ 50A	11,223
Total	57,796

Figure 2.2.2.6-7 Transmission and distribution pipe design (KMC)

(2) Battambang Water Supply

1) Outline of Transmission and Distribution Facilities

Existing System

The Battambang Water Supply (hereinafter, "BTB") distributes treated water utilizing an existing elevated tank. However, there should be two pipelines as inlet and outlet for the elevated tank, but one pipe is missing. Therefore, the function of this elevated tank is that of a surge tank to absorb the pressure change and stock water. The outline of the existing BTB transmission and distribution system is shown in **Figure 2.2.2.6-8**.

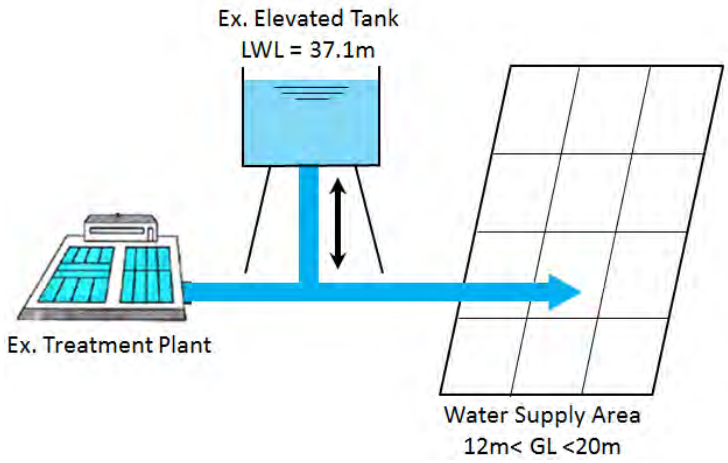


Figure 2.2.2.6-8 Outline of BTB system

Distribution System

The designed water supply area planned by this project is shown in **Figure 2.2.2.6-9**. The pressure supply from the existing elevated tank will be low since the designed distribution flow and supply area will be expanded by a factor of three. The elevation of the designed water supply area is almost flat, between 12m and 20m. The designed water supply area for the existing and new treatment plants for which is taken into account both capacity, distribution network, geographical conditions such as roads, rivers, etc. is shown in **Figure 2.2.2.6-10**.

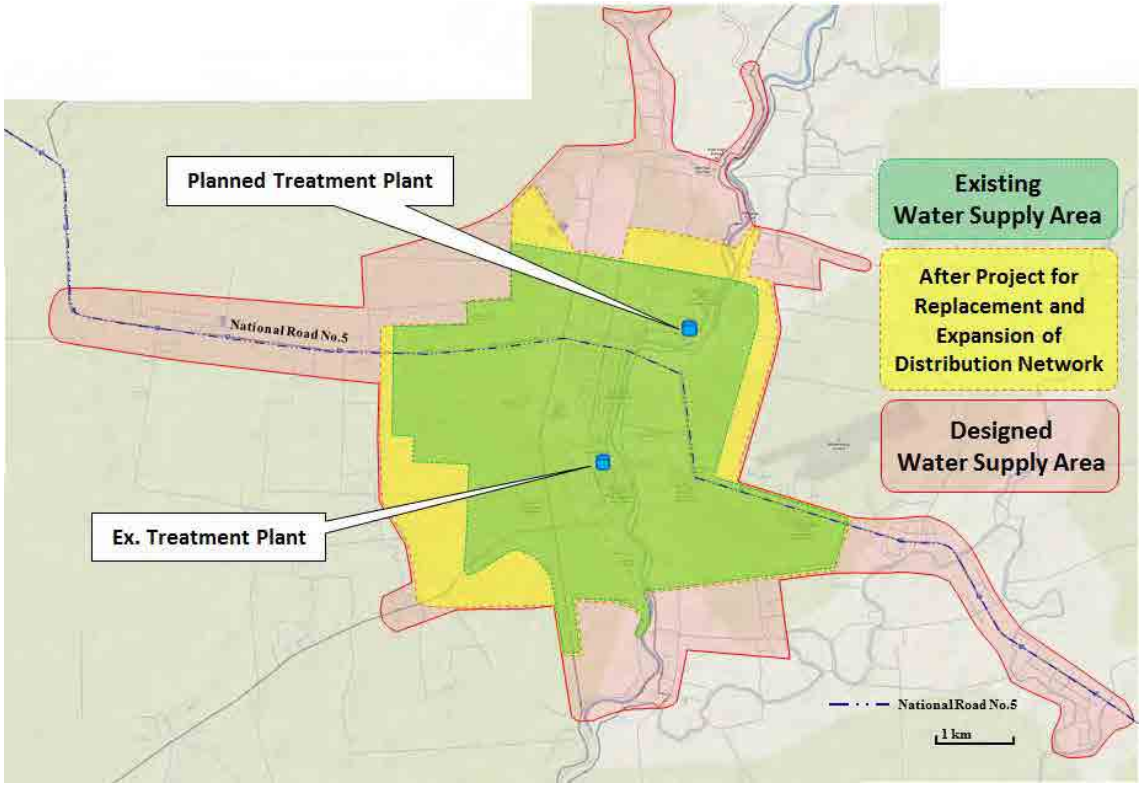


Figure 2.2.2.6-9 Designed Water Supply Area (BTB)

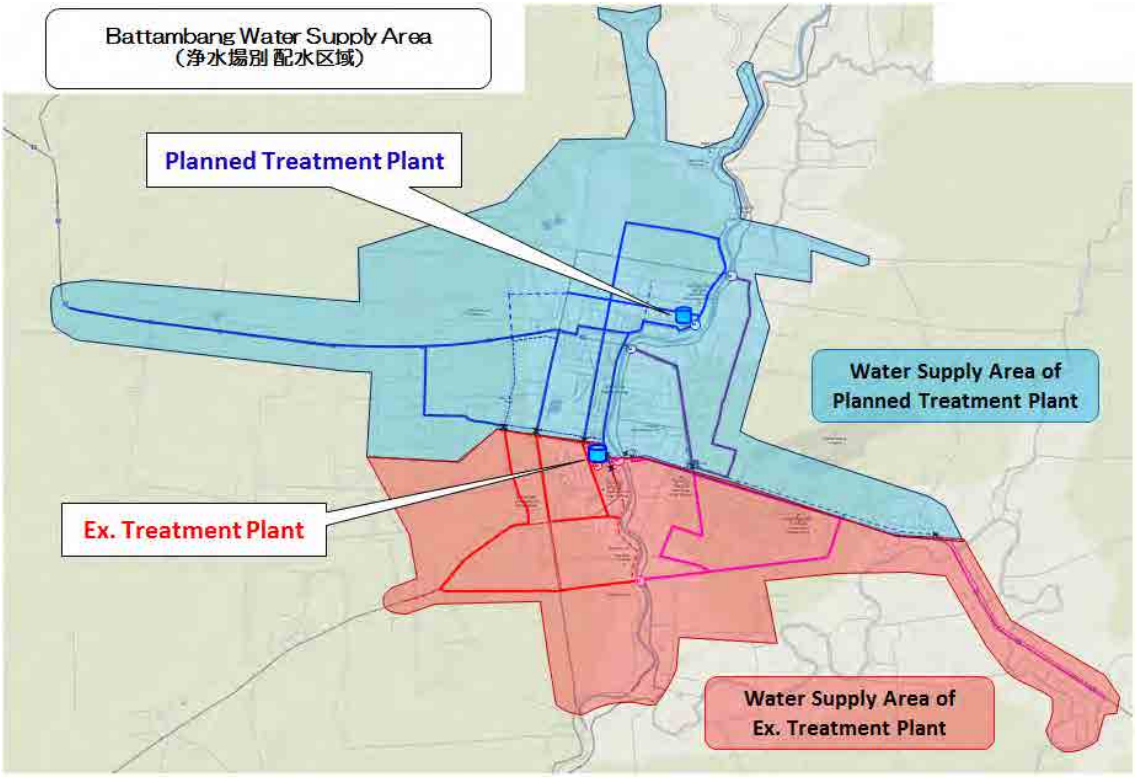


Figure 2.2.2.6-10 Designed Water Supply Area of Each Treatment Plant (BTB)

Houses in the suburb area of KMC and BTB are crowded only along the road and river similar to other provinces in Cambodia. Therefore, a one-way long distance distribution pipe must be installed which makes it difficult to keep enough pressure supply from only the elevated tank as the maximum height of the elevated tank is around 30m because of its structure. The water supply area of the new treatment plant is wider and water friction loss is greater. Thus the pressure of the elevated tank is insufficient. Hence a direct pump supply system will be adopted for the new treatment plant. The existing treatment plant will utilize the existing elevated tank as before. The outline of the BTB system is shown in **Figure 2.2.2.6-11**.

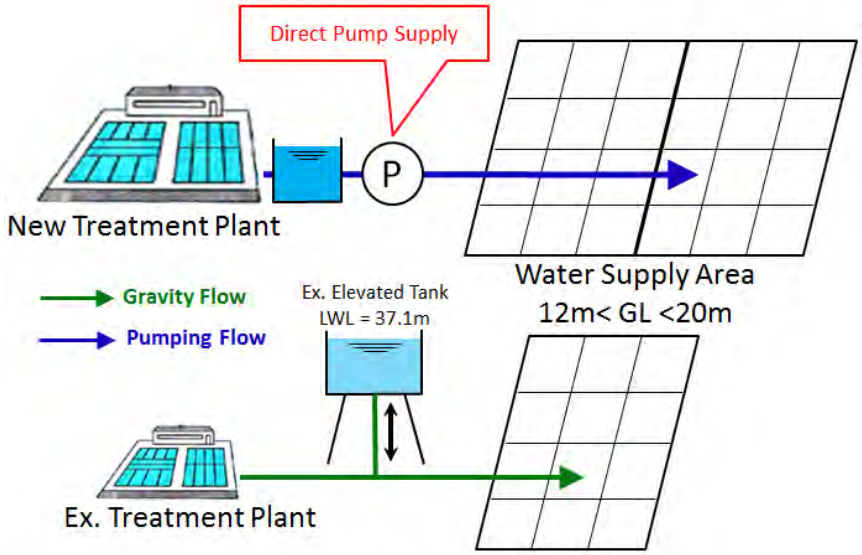


Figure 2.2.2.6-11 Outline of BTB system

2) Network Calculation

The Network calculation was calculated by EPANET ver 2.0 with the following conditions.

- Hazen-Williams formula
- Coefficient of flow velocity C=110
- Minimum dynamic pressure: 50kPa (**Table 2.2.2.6-1**)
- Hourly Factor: 1.65 (**Table 2.2.2.6-2**)

The effective pressure at the peak demand of the designed water supply area in BTB is shown in **Figure 2.2.2.6-12**. By this project, the effective pressure in the downtown area of BTB will be improved.

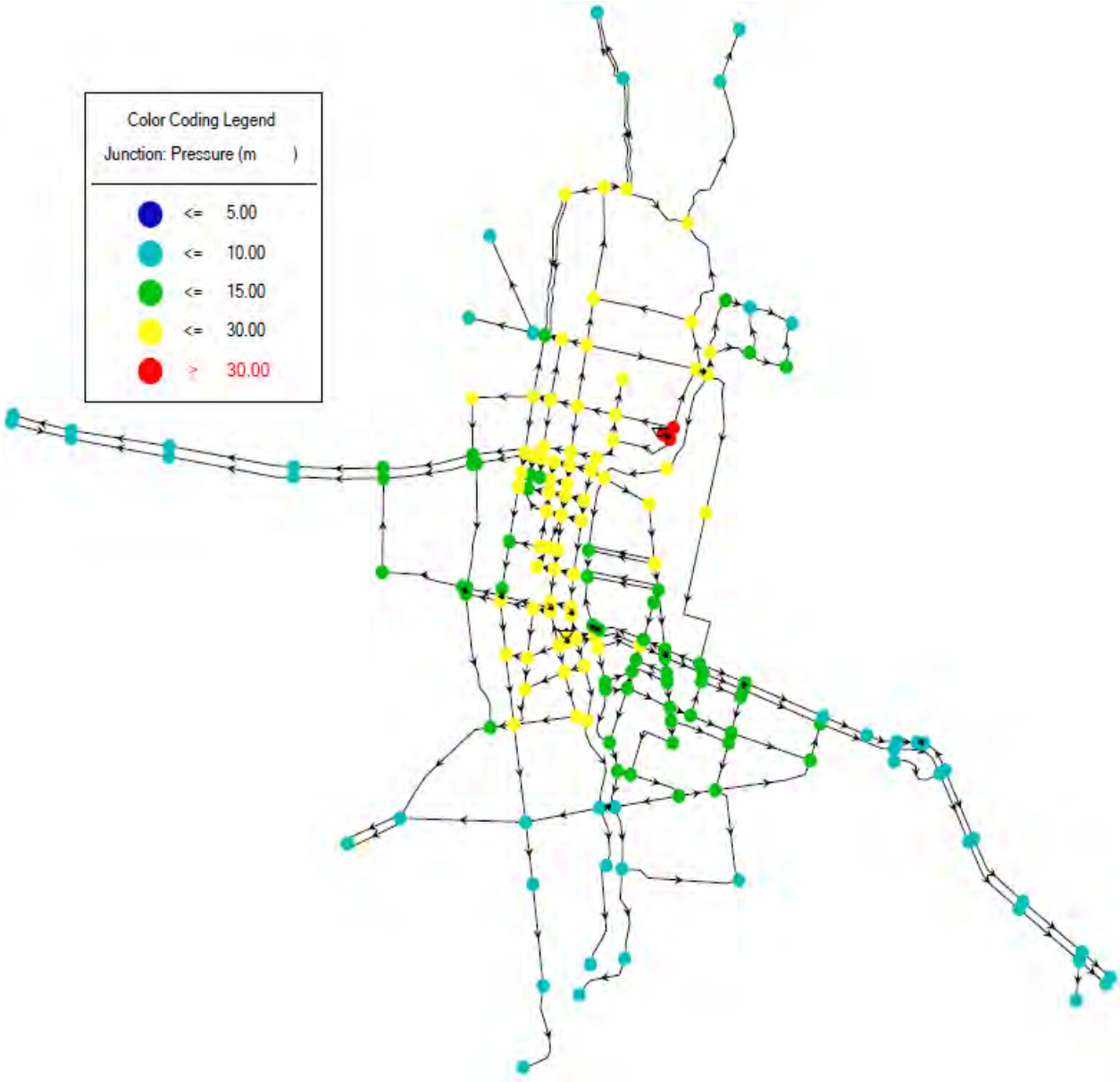


Figure 2.2.2.6-12 Effective pressure at peak demand (BTB)

3) Transmission and Distribution Pipe Arrangement Plan

Based on the result of calculations for the pipe network, transmission and distribution pipes are designed as shown in **Figure 2.2.2.6-13**.

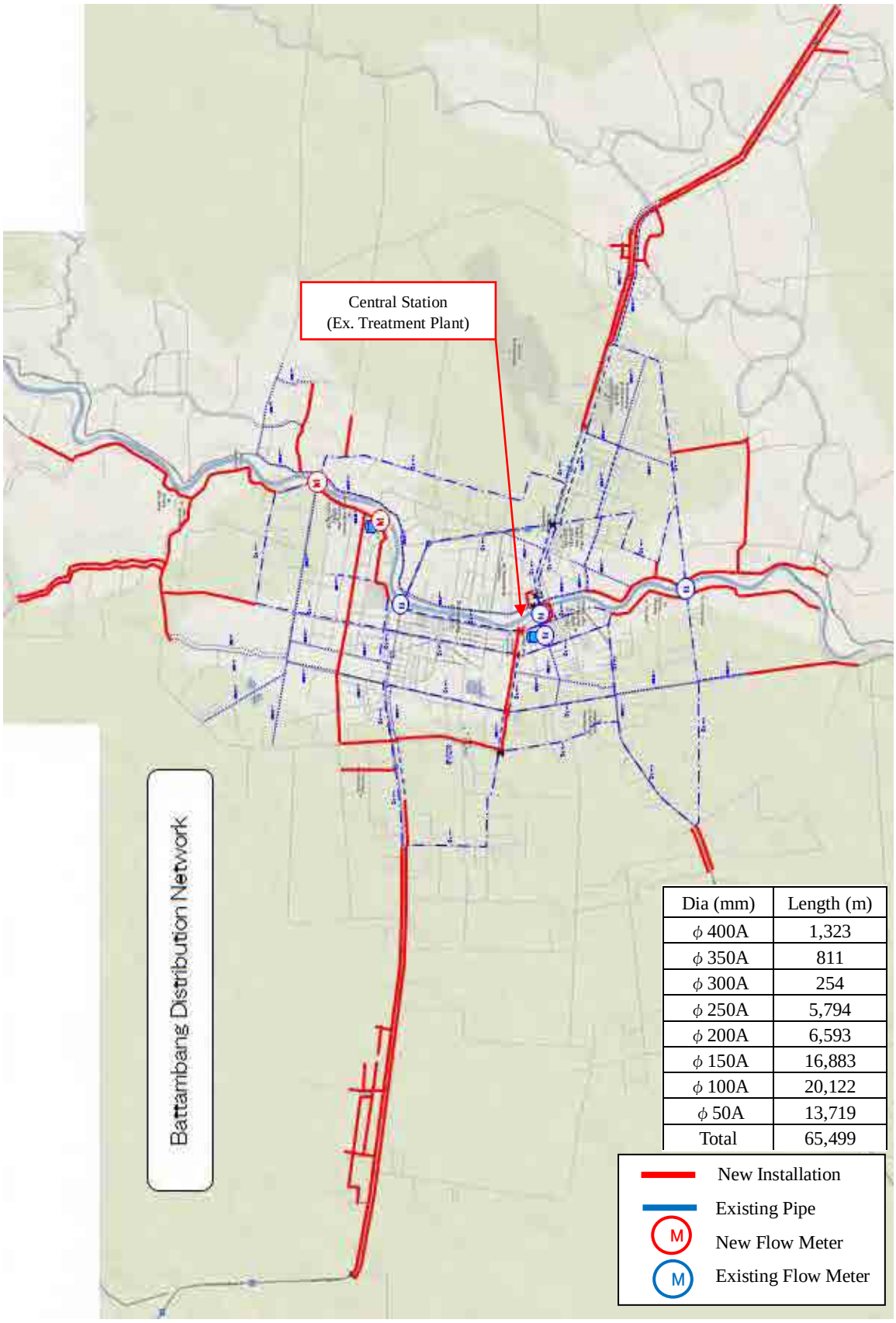


Figure 2.2.2.6-13 Transmission and distribution pipe design (BTB)

(3) Distribution Flow Monitoring System

The distribution flow monitoring system is installed for the purpose of understanding the distribution flow, centralizing the flow data management and for efficient operation and Non-Revenue Water reduction. As of 2012, "The Project on Replacement and Expansion of Water Distribution Systems in Provincial Capitals" has been conducted in Battambang and two other provincial cities by JICA. This project will install the same system as current ongoing projects for the following reasons.

Kampong Cham

The 3 electromagnetic flow meters and the 3 local stations will be installed at the inlet point of the each block, and transfer the flow data to the central station located in the new treatment plant. The technical homogenization and cheap procurement of spare parts through group purchasing are expected results from the installation of the same system. The system operators are then able to cooperate mutually with other utilities.

Battambang

At Battambang, the installation of the distribution flow monitoring system was decided under "The Project on Replacement and Expansion of Water Distribution System in Provincial Capitals". The 2 electromagnetic flow meters and local stations will be installed at the crossing point of the Sangke River and the outlet point of the new treatment plant, and transfer the flow data to the central station located in the existing treatment plant. By expanding the system's facilities as part of this project, redundant machinery will be avoided to suppress the initial costs. It will be possible to centralize the flow data after modifications are complete to utilize the same system and data format.

(4) Block Distribution System

The intent of the block distribution system is to divide the water supply area into several appropriate areas. The advantages of this system are equalization and proper pressure, advanced water supply management such as distribution flow measurement, water loss management, and limitation of the effect of accident damage. The boundaries of the block distribution areas are decided in consideration of the existing pipe network and geographical formations such as roads, rivers, etc, in the way that the existing system can be fully utilized.

Kampong Cham

In order to make pressure properly, the water supply area is divided into a high elevation area and a low elevation area. In addition, the low elevation area is divided into two blocks by National road No.7. The block distribution system in Kampong Cham is shown in **Figure 2.2.2.6-14**.

Battambang

The water supply area is divided into four blocks by the Sangke River and the border of the water supply area, between the new and existing treatment plants, because the water supply area in Battambang is flat. The block distribution system in Battambang is shown in **Figure 2.2.2.6-15**.

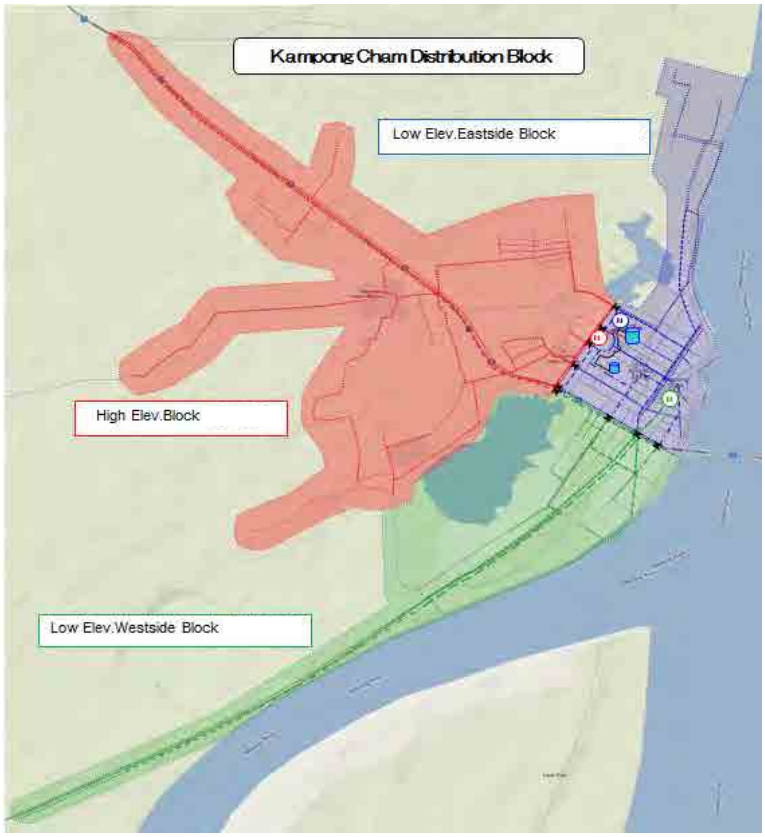


Figure 2.2.2.6-14 Block distribution area in Kampong Cham

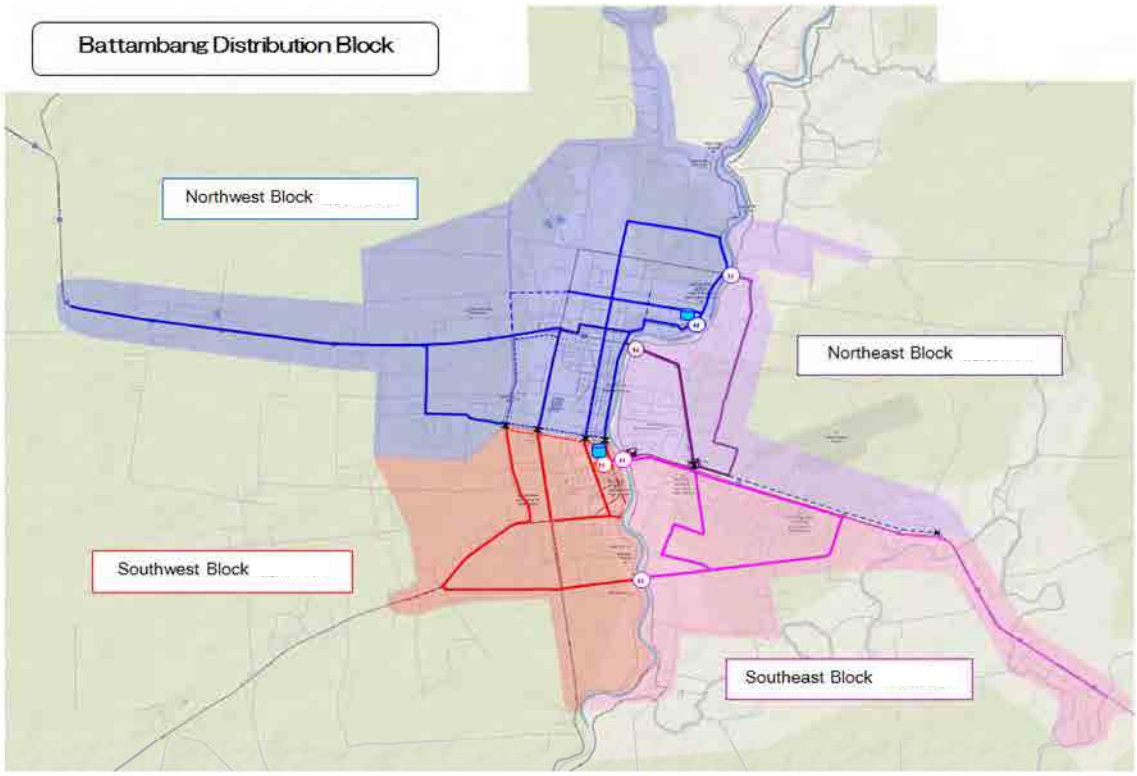


Figure 2.2.2.6-15 Block distribution area in Battambang

(5) Design Criteria for Transmission and Distribution Facilities

Pipe Installation Location

The majority of transmission and distribution pipelines are planned to be installed along a road. The installation location of pipeline being basically under the sidewalk or road shoulder was decided after consultation between KMC and BTB. The common installation location is shown in **Figure 2.2.2.6-16**.

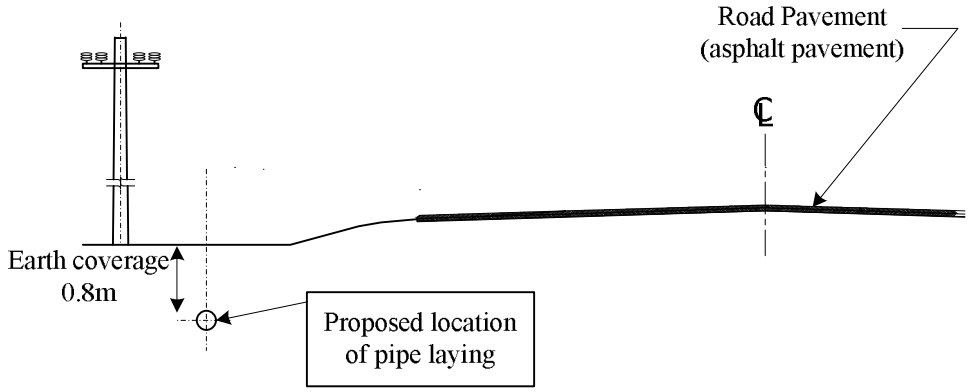


Figure 2.2.2.6-16 Common installation location of pipeline

Photo 2.2.2.6-1 Current state of installation location of pipeline

Due to the other underground facilities such as drainage, cable, etc., in the event that there is no space for pipe installation, pipe will be installed under asphalt road. This is shown in **Figure 2.2.2.6-17**.

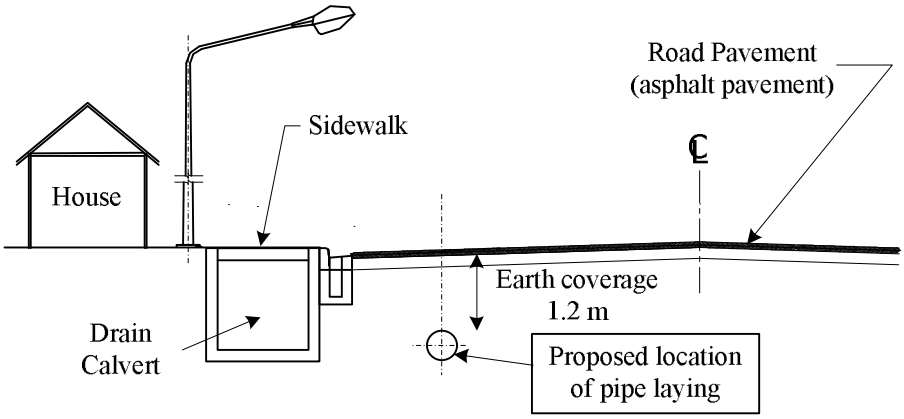


Figure 2.2.2.6-17 Pipe installation location under asphalt road

Photo 2.2.2.6-2 Current state of pipe installation location under asphalt road

Pipe Material

Taking into consideration the past records in Cambodia, the pipe materials utilized for transmission and distribution pipes are as follows.

- More than φ250mm diameter pipeline : Ductile Cast Iron Pipe (DCIP)
- Less than φ200mm diameter pipeline : High Density Polyethylene Pipe (HDPE)

However, a special kind of pipe, such as for water pipe bridges, exposed pipes, etc. utilizes steel pipe which is able to be installed with comparative flexibility.

Excavation and Backfilling

The specifications for excavation and backfilling follow the standards set by the Phnom Penh Water Supply Authority and the past construction records of both water bureaus. In principal, in the case of laying pipe under a road, the earth covering is 1.2m, and in the case of laying pipe under sidewalk or a road shoulder, the earth covering is 0.8m.

(6) The Major Points of the Other Facility Plan

Transmission and Distribution Pump

Kampong Cham

A direct pump supply system is adopted for the high elevation water supply area and a gravity flow system from the existing elevated tank is adopted for the low elevation water supply area. The distribution pump and transmission pump for the elevated tank are installed in the pumping station located in front of the service reservoir. As for the distribution pump for the high elevation water supply area, inverter equipment which enables the pump to be controlled automatically, smoothly and operate with high efficiency will be installed for power-saving and labor-saving.

- Distribution pump for high elevation water supply area (inverter equipment)
  Q 1.96 m^3/min × H 53.8m ×5 pumps (1 pump: standby)
- Transmission pump for existing elevated tank
  Q 5.00 m^3/min × H 38.3m ×3 pumps (1 pump: standby)

Battambang

The designed water supply area and distribution amount of the new treatment plant is around twice as large as the current water supply area. In order to keep more than a minimum pressure in the fringe water supply area, the direct pump supply system is adopted in the new treatment plant. The existing treatment plant utilizes the gravity flow from the existing elevated tank same as before. Also, as for the distribution pump in the new treatment plant, inverter equipment which enables the pump to be controlled automatically, smoothly and operate with high efficiency will be installed for power-saving and labor-saving.

- Distribution pump in the new treatment plant (inverter equipment)
  Q 6.34 m^3/min × H 44.0m ×5 pumps (1 pump: standby)

Service Reservoir Capacity

The basic function of a service reservoir is the adjustment between the amount of treated water and the distributed amount. The effective capacity of a service reservoir is decided by considering the capacity to respond to hourly distribution flow changes for achieving a balance between water demand and supply from the treatment plant. Having made calculations based on the distribution flow trend data gathered by the Phnom Penh Water Supply Authority, the only organization in Cambodia taking 24 hour continuous measurements, the plan is to be able to guarantee a 4.3 hour amount of the daily maximum water supply.

Kampong Cham

The designed maximum water supply amount in 2019 is 16,300m^3/day, and the designed average water supply amount is 679m^3/hour. The necessary capacity of the new KMC service reservoir is 2,902 m^3 which exceeds the designed average water supply amount. This is represented by the darkened area in **Figure 2.2.2.6-18**.

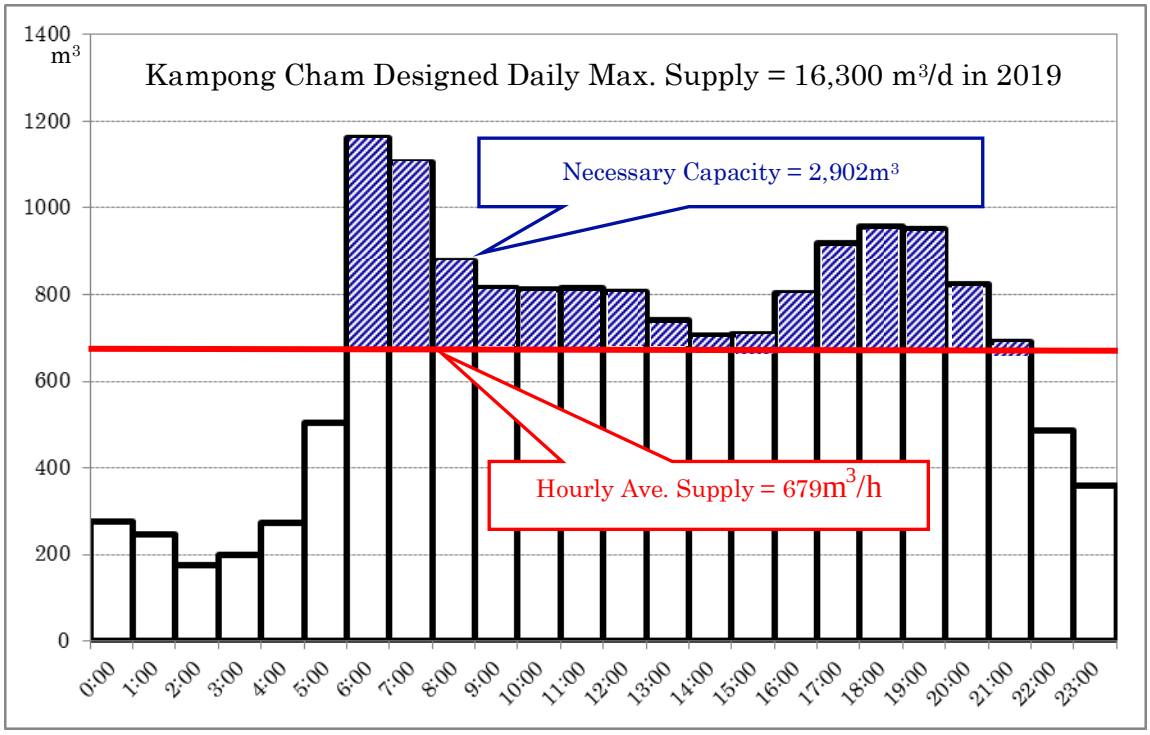


Figure 2.2.2.6-18 Necessary amount of the new service reservoir in KMC

Battambang

The designed maximum water supply amount of the new treatment plant in 2019 is 22,000m^3/day, and the designed average water supply amount is 917m^3/hour. The necessary capacity of the new BTB service reservoir is 3,916 m^3 which exceeds the designed average water supply amount. This is represented by darkened area in **Figure 2.2.2.6-19**.

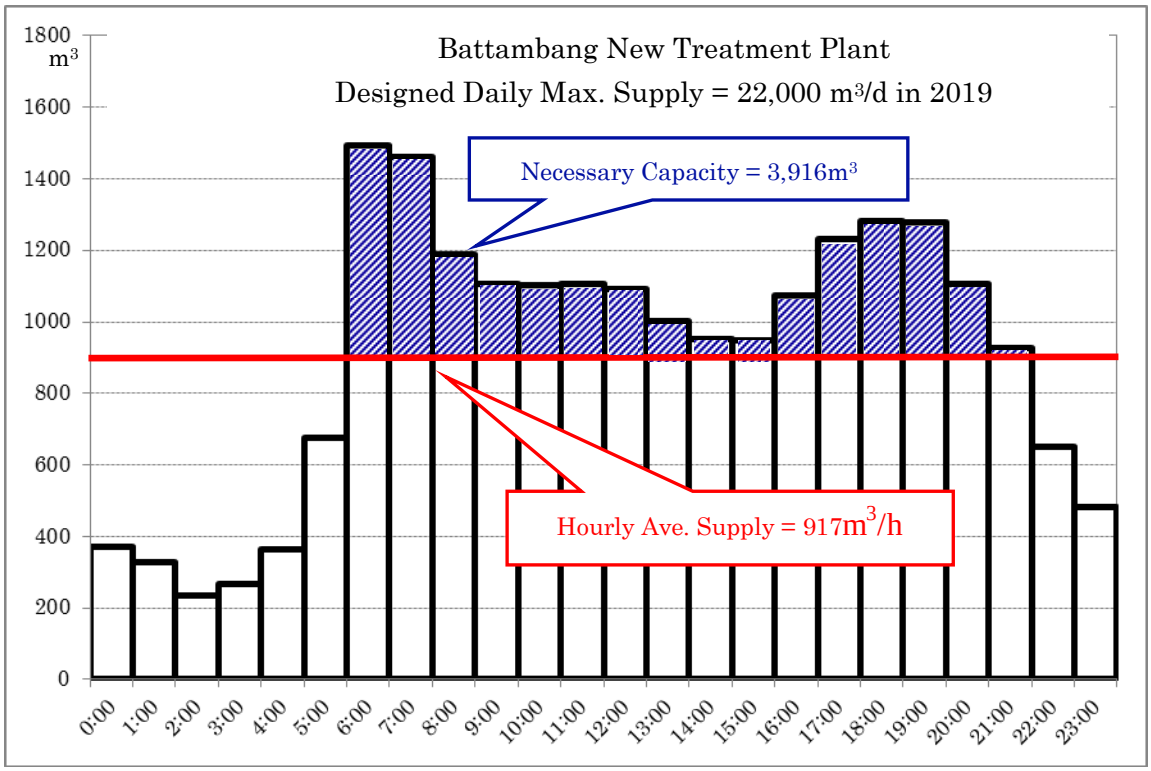


Figure 2.2.2.6-19 Necessary amount of the new service reservoir in BTB

However, at Battambang, the designed intake amount of 4,230m^3/day will run out during a drought on the same level as the severest drought year in the past 10 years of the Sangke River, which is the water source for the BTB. Therefore, as a measure to prevent a shortage of intake flow during a drought year, the capacity of the new BTB service reservoir will be increased by 2,000 m^3 (**Table 2.2.2.6-3~ 2.2.2.6-4**).

Table 2.2.2.6-3 Outline of Capacity of Facilities (KMC)

Kampong Cham		
Necessary Capacity	Planned Capacity	Outline of Facility
2,902 m^3	3,000 m^3	2,500 m^3 (1,250 m^3×2 reservoirs)
		(existing elevated tank 500 m^3)

Table 2.2.2.6-4 Outline of Capacity of Facilities (BTB)

Battambang		
Necessary Capacity	Planned Capacity	Outline of Facility
3,916 m^3 (Capacity to respond to hourly changes)	6,000 m^3	6,000m^3 (3,000m^3×2 reservoirs)
2,000 m^3 (Capacity for drought)		

(7) Outline of Facilities

The outlines of transmission and distribution facilities are shown in **Table 2.2.2.6-5** and **Table 2.2.2.6-6**.

Table 2.2.2.6-5 Outline of transmission and distribution facilities (KMC)

Category of Facilities			Dimension and Structure
Large	Middle	Small	
Transmission Facilities	Transmission Pump Facilities	Pump	Single Volute Pump 5.00 m^3/min × 38.3 m 30 kW × 3Pumps (1 pump: standby)
		Pump Well	Doubles as Service Reservoir
	Transmission Pipeline		Shallow Well No. 2～Service Reservoir Design Transmission Flow Q=4,200m^3/day HDPE φ 200A, L≒900 m
Distribution Facilities	Service Reservoir	Treatment Plant	RC Structure, Rectangle, 2 Reservoirs Effective Capacity: V=1,250 m^3×2 Effective depth: H=3.80 m Water Level: HWL+16.30 m, LWL+12.50 m Foundation: Direct Foundation Doubles as Treated Water Reservoir
	Distribution Pump Facilities	Distribution Pump	Single Volute Pump 1.96 m^3/min × 53.8 m 30 kW × 5Pumps (1 pump: standby) Low-voltage Inverter Equipment
		Pump Well	Doubles as Service Reservoir
	Distribution Pipeline	DCIP	Straight Pipe: T type, Thrust Blocking: Retainer Gland Diameter: φ 400A L= 1,060m φ 350A L= 1,617m φ 300A L= 2,263m φ 250A L= 4,237m Total L= 9,177m
		HDPE	PE100 Diameter: φ 200A L= 5,173m φ 150A L= 5,125m φ 100A L= 27,098m φ 50A L= 11,223m Total L= 48,619m Bridge-attached Pipe: 6 places
	Distribution Flow Monitoring System	Master Station	Monitoring PC, Printer, Receiver, UPS
		Local Station	Electromagnetic Flow Meter φ 300×2, φ 200 GSM Logger＋GSM Transmitter×3

Table 2.2.2.6-6 Outline of transmission and distribution facilities (BTB)

Category of Facilities			Dimension and Structure
Large	Middle	Small	
Transmission Facilities			No Facility
Distribution Facilities	Service Reservoir	Treatment Plant	RC Structure, Rectangle, 2 Reservoirs Effective Capacity: V=3,000 m^3×2 Effective depth: H=4.30 m Water Level: HWL+12.60 m, LWL+8.30 m Foundation: Direct Foundation Double as Treated Water Reservoir
	Distribution Pump Facilities	Distribution Pump	Single Volute Pump 6.34 m^3/min × 44.0 m 80 kW × 5 Pumps (1 pump: standby) Low-voltage Inverter Equipment
		Pump Well	Doubles as Service Reservoir
	Distribution Pipeline	DCIP	Straight Pipe: T type, Thrust Blocking: Retainer Gland Diameter: ϕ 400A L= 1,323m ϕ 350A L= 811m ϕ 300A L= 254m ϕ 250A L= 5,794m Total L= 8,182m Water Pipe Bridge: 2 places
		HDPE	PE100 Diameter: ϕ 200A L= 6,593m ϕ 150A L= 16,883m ϕ 100A L= 20,122m ϕ 50A L= 13,719m Total L= 57,317m Water Pipe Bridge: 3 places Bridge-attached Pipe: 9 places Across a Railway: 5 places
	Distribution Flow Monitoring System	Master Station	Function Extension (modification)
		Local Station	Electromagnetic Flow Meter ϕ 400, ϕ 150 GSM Logger＋GSM Transmitter×2

2.2.2.7 Procurement of Equipment

The RGC requested that the GOJ procure the equipment shown in **Table 2.2.2.7-1**. Based on a series of discussions with the Cambodian side (6th June, 26th June and 10th July, 2012) during the first survey, a list of required equipment was selected with due consideration of what currently exists at both waterworks, as described in the following sections.

Table 2.2.2.7-1 Equipment requested by the RGC

Items	Requested Equipment	
	Kampong Cham	Battambang
Equipment for Water Quality Analysis	Optical analyzer, Distillation apparatus, Reagents, Glassware, pH meter, Turbidity meter, UPS and Others	Atomic absorption spectrophotometer, Distillation apparatus, Cultivator, Microscope, Reagents, Glassware, pH meter, Turbidity meter, UPS and Others
Maintenance Tools for Electrical and Mechanical Equipment	Electroscope, Vibration checker, Torque wrench, Earth checker, Insulation checker, Database system for maintenance and Other tools	Electroscope, Power tester, Digital recorder, Vibration checker, Torque wrench, Handy flow meter, Earth checker, Insulation checker, Filtration sand tester, Database system for maintenance and Other tools
Equipment for Accounting System	Hardware	Hardware and software
Tools for Distribution Management	Leakage locating equipment, Pipe locator, Pipe laying and Pipe network information system	Leakage locating equipment, Pipe locator, Pipe laying and Pipe network information system

(1) Equipment for Water Quality Analysis

There is an existing water testing laboratory on the premises of the new water treatment plant in Kampong Cham. Most of the requested equipment was already available in the laboratory. As for Battambang, the provision of the minimum equipment required for the O&M of the new water treatment plant is planned.

Only the test reagents and glassware required during the implementation of the soft component will be provided. The Cambodian side will bear the costs of test reagents and glassware required for the on-going O&M of the water treatment plants.

(2) Maintenance Tools for Electrical and Mechanical Equipment

It was explained to the Cambodian side that the maintenance tools for electrical and mechanical equipment listed in the table above are basically those required for regular general maintenance and should be provided by the Cambodian side. However, vibration checkers would be provided by this project because these are special tools required for the O&M of the pumping equipment to be installed and are difficult to obtain by the Cambodian side.

(3) Equipment for Accountant System

It was explained to the Cambodian side that equipment for the accounting system cannot be provided under a grant aid project engaged in facility construction.

(4) Tools for Distribution Management

Only the equipment required for the socket fusion of HDPE pipes will be provided by this project. Most of the other tools for distribution management listed in their request have already been provided in past JICA projects.

(5) Support Measures for Poverty Groups

The requirements to support poverty groups in facilitating their connections to services were confirmed with MIME and the waterworks of Kampong Cham and Battambang. The Japanese side agreed to provide materials and equipment for service connections, including water meters, pipe materials and fittings, similar to the ongoing JICA grant aid projects and MEK-WATSAN projects of UN-Habitat. The Cambodian side will bear the installation costs. The number of equipment to be provided was estimated based on the data from "Identification of Poor Household Program" which is being implemented by the Ministry of Planning in Cambodia since 2008 with help of UNICEF, Germany and Australia.

In Battambang, 14 of the 15 communes targeted for future water supply in this project are already covered by the study to identify poor households. The results of this study on poor households are shown in **Table 2.2.2.7-2**. As for Kampong Cham, the study to identify poor households has not been conducted in the target communes. Therefore, the number of poor households was estimated based on the results of the study conducted in other parts of Kampong Cham Province. The estimated number of the poor households is shown in **Table 2.2.2.7-2**. The number of the households supplied by this project is calculated as shown in **Table 2.2.2.7-3**.

Table 2.2.2.7-2 Ratio of Poor Households and Number of Equipment to be Provided for Service Connections

City	Results of the Study by the Ministry of Planning*				Number of the Households supplied by this project	Number of Equipment to be provided
	Number of Target Communes	Household Number	Poor Household Number	Ratio of Poor Households		
Kampong Cham	83	187,710	54,545	29.1%	8,703	2,529
Battambang	14	37,398	11,787	31.5%	17,280	5,446

* : Source ; Ministry of Planning, Cambodia, 2012

Table 2.2.2.7-3 Number of Households supplied by the Project

Items	Unit	Kampong Cham	Battambang
Day Maximum Demand	m^3/day	11,500	22,000
Day Maximum Factor	—	1.20	1.17
Day Average Demand	m^3/day	9,583	18,803
Leakage Ratio	%	13%	15%
Total Consumption	m^3/day	8,338	15,983
Ratio of Domestic Consumption	%	75%	65%
Domestic Consumption	m^3/day	6,253	10,389
Per Capita Consumption	Lpcd	150	120
Population Served	Person	41,688	86,574
Family Size	Person	4.79	5.01
Number of Households	Nos	8,703	17,280

(6) Equipment Provision Plan

Table 2.2.2.7-4 shows the plan for equipment provision in this project based on the considerations described above.

Table 2.2.2.7-4 Outline of the Plan for Equipment Provision

Category	Name of Equipment/Material	Specifications	Quantity	
			KMC	BTB
Equipment for Water Quality Analysis	Jar Tester	Jar tester for six samples having adjust function of mixing intensity (20 - 200min-1 digital display)	1 set	1set
	Distillation Apparatus	Water purification system (Distillation type) Product capacity: approx. 1.8L/h	-	1set
	Turbidity Meter	Turbidity meter (digital display direct reading) (0 - 4,000NTU)	-	1set
	Turbidity Continuous Measurement Equipment	Turbidity meter (right angle scattered light type for low concentration) (0.001 - 100 degree)	1set	1set
	Laboratory Table	Steel frame laboratory table (3-way tap stainless steel sink / AC220V outlet)	-	1set
	Residual Chlorine Analyzer	Potable residual chlorine meter (absorption spectrophotometer) (0.00 - 5.00 mg/l)	1set	1set
	Chlorine continuous measurement equipment	Residual chlorine meter (DPD absorption spectrophotometer) (0.00 - 5.00 mg/l)	-	1set
	Uninterruptible Power System (UPS)	Output power capacity：3 kVA	-	1set
	pH Meter (glass electrode)	Desktop pH meter with electrode（pH 0 - 14）	-	1set
	pH Meter (BTB)	BTB type simple pH meter （pH 6.0/6.2/6.4/6.6/6.8/7.0/7.2/7.4）	-	1set
	Reagents	pH4 standard solution, pH7 standard solution, Potassium chloride solution, BTB solution, DPD solution	1set	1set
	Glassware	Beaker, measuring flask, pipette, wash bottle	1set	1set
Tools for Mechanical Equipment	Vibration Checker	Acceleration: 0.02 - 200 m/s^2, Velocity: 0.3 - 1 000 mm/s, Displacement: 0.02 - 100 mm	1set	1set

Equipment and Materials for Service Connections	Socket Fusion Equipment	Diameter 15mm - 63mm for HDPE pipes with a power generator (5 kVA)	1set	1set
	Materials and Equipment for Service Connections	Required pipe materials and equipment from the ferrules with saddles on distribution mains (63mm and 110mm in diameter) to water meters (15mm in diameter)	2,529 sets	5,446 sets

Notes: KMC; Kampong Cham, BTB; Battambang

(7) Sources for Equipment Procurement

The equipment for water quality analysis and the vibration checkers will be procured in Japan because these are special equipment that must be of high quality. The materials and equipment for service connections will be procured in Cambodia because the waterworks need to procure these materials and equipment regularly after the implementation of the project. The specifications of these materials and equipment are similar to those already in use Cambodia and in other ongoing grant aid project.

(8) Timing of Equipment Procurement

The equipment for water quality analysis and the vibration checkers will be procured prior to the implementation of the soft component so that they are available for use during the training sessions.

The Cambodian side needs to begin the installation of service connections at least one year before the completion of this project (starting from the connections with existing distribution mains and then onto the connections with new distribution mains installed by this project). Therefore, the materials and equipment required for the service connections will be procured one year before the completion of this project.

2.2.3 Outline Design Drawing

Selected drawings of schematic design are attached in **Appendix 7.1**. The drawing list of the schematic design is shown in **Table 2.2.3-1.**

Table 2.2.3-1 List of Outline Design Drawings

No.	Facility	Drawing Title	Dwg No.	
			KMC	BTB
1.	General (G)	General Layout	K-G1	B-G1
2.	Intake (I)	Layout of Intake Facility (1)	K-I1	B-I1
		Layout of Intake Facility (2)	K-I2	B-I2
		Section View of Intake Facility	K-I3	B-I3
		Front View of Intake Facility	K-I4	B-I4
3.	Conveyance Pipe (R)	Route of Conveyance Pipe	K-R1	B-R1
		Typical Cross Section for Conveyance Pipe	K-R2	B-R2
		Valve Chamber for Conveyance Pipe	K-R3	B-R3
4.	Treatment Facility (T)	General Layout Plan of WTP	K-T1	B-T1
		Water Level Profile of Water Treatment Plant	K-T2	B-T2
		Plan of Receiving well, Flocculation Basin, Sedimentation Basin, Flocculation Basin	K-T3	B-T3
		Section of WTP (1)	K-T3	B-T4
		Section of WTP (2)	K-T5	B-T5
		Section of WTP (3)	K-T6	B-T6
		Section of WTP (4)	K-T7	B-T7
		Service Reservoir and Pumping Station Structure (1)	K-T8	B-T8
		Service Reservoir and Pumping Station Structure (2)	K-T9	B-T9
		Drainage Basin Structure	K-T10	B-T10
		Lagoon (1)	K-T11	B-T11
		Lagoon (2)	K-T12	-
5.	Transmission and Distribution Facility (D)	Location Map	K-D1	B-D1
		Plan (1)	K-D2	B-D2
		Plan (2)	K-D3	B-D3
		Plan (3)	K-D4	B-D4
		Plan (4)	K-D5	B-D5
		Plan (5)	K-D6	B-D6
		Plan (6)	K-D8	B-D7
		Plan (7)	K-D9	B-D8
		Plan (8)	K-D10	B-D9
		Plan (9)	-	B-D10
		Plan (10)	-	B-D11
		Plan (11)	-	B-D12
		Plan (12)	-	B-D13
		Plan (13)	-	B-D14
		General Earth Work for Pipe Laying	K-D11	-
		Typical Drawing for Installation of Sluice Valve	K-D12	-
		Typical Drawing for Installation of Air Valve and Washout	K-D13	-
		Typical Drawing for Branch of Service Pipe	K-D14	-
		Typical Drawing for Structure Crossing	K-D15	-
		Typical Drawing for New Pipe and Existing Pipe (1)	K-D16	-
		Typical Drawing for New Pipe and Existing Pipe (2)	K-D17	-
		Single Mouth Type Fire Hydrant	K-D18	-
		Double Mouth Type Fire Hydrant	K-D19	-
		Standard Drawing for Bridge Attached Pipe	K-D20	-
		Standard Drawing for Pipe Beam	K-D21	-
		Standard Drawing for Flow Meter Chamber	K-D22	-

2.2.4 Implementation Plan

2.2.4.1 Implementation Policy

(1) Organization for Project Implementation

The project will be executed according to the scheme for Japanese Grant Aid. After the Exchange of Note between the two governments, the Royal Government of Cambodia (RGC) will select the consultant and contractor who must be Japanese corporations for the implementation of the project. **Figure 2.2.4.1-1** shows the conceptual organization of the project.

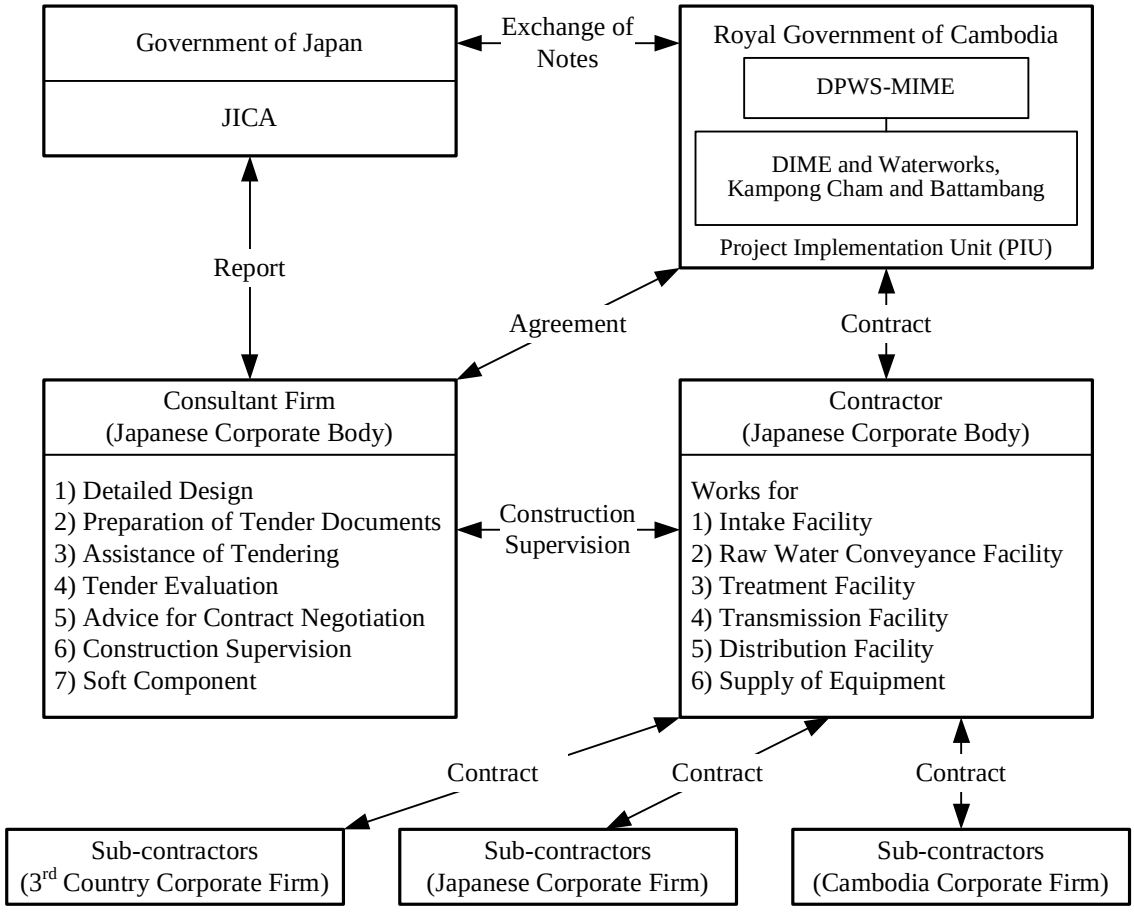


Figure 2.2.4.1-1 Organization for Project Implementation

(2) Implementing Agency

The responsible agency is MINE: Ministry of Industry, Mines and Energy. The implementing and operating agencies are Department of Industry, Mines and Energy (DIME), and the Waterworks in Kampong Cham and Battambang Provinces. DIME is a local agency of MIME and the Waterworks operate under the auspice of DIME. Kampong Cham Waterworks and Battambang Waterworks are responsible for the smooth implementation of the Project,

operation and maintenance of the water supply facilities. Cooperation and coordination with DPWS-MINE and DIME is indispensable.

(3) Consulting Firm

The detailed design and construction supervision for the work financed by the Japanese side will be carried out by a Japanese consulting firm.

(4) Construction Contractor

The contractor carrying out the construction financed by the Japanese side should also be a Japanese corporation. The contractor would carry out mainly civil construction of raw water intakes, raw-water transmission, water treatment, treated-water transmission and distribution facilities, as well as procurement of equipment. The company must be a general construction company that has sufficient capacity and experience and is capable of dispatching qualified engineers, procuring construction materials and heavy machinery necessary for the undertaking.

(5) Japanese Experts

It is necessary to dispatch Japanese engineers with specialized expertise in the construction of treatment facilities, installation of electrical and mechanical equipment, conducting test operations and testing the water tightness of structures and pipelines. The following engineers are needed to be dispatched as Japanese experts:

- One representative in charge of overall construction activities
- Site Manager for each site
- Civil Engineers
- Architects
- Pipeline Engineers
- Mechanical Engineers
- Electrical Engineers

2.2.4.2 Implementation Conditions

The following conditions would apply in the implementation of the project at both construction sites:

- Extra effort will be devoted to coordination and information sharing because there are a number of parties involved and because construction will take place at two separate locations simultaneously. The Cambodian side, the construction contractor, the consultant and the related donor organizations would meet regularly to review progress. Other means of communications will also be used. .
- The consultant would share information with the involved parties continuously and deploy one project manager and one resident engineer at each site to ensure smooth implementation of the project.

- The construction contractor would also deploy one representative and one site manager at each site.
- The consultant and the construction contractor would have offices set up at appropriate locations.
- Consultations with the Cambodian side would be required since the coordination with the national and state governments is indispensable for approvals of IEE, water rights, construction of intake facilities, seeking permissions for occupancy of roads, etc.
- Construction of intake facilities is recommended to be executed between November and June when the water level is low. Between July and October when the water level is higher, no works should be conducted unless water can be blocked. During the first dry season of the contract period, temporary water stop should be constructed. Then excavation and concrete placing can follow.
- Total length of pipes for transmission, transition and distribution will be approximately 130 km. The main sites are urban areas with busy roads, commercial and residential sectors. Accordingly, the pipe installation would require special considerations for safety and to minimize disruption of traffic and daily activities in the area.
- Residents should receive water even during the construction period because the project is only expanding existing facilities. Should water shutdowns be required, it is necessary to announce the shutdown period and warn residents of possible turbidity in the water, to obtain their understanding and cooperation.
- The construction will be done in the day time. In case night-time construction cannot be avoided, for example during pipe laying operations in the markets, restaurants, offices, etc., consultation with the Cambodian side is indispensable.
- Materials and equipment will be procured locally. If this is not possible, procurement from Japan or third countries would be considered sequentially.
- Materials for service connections to be provided by JICA should be products manufactured in neighboring countries and sold in Cambodia. These are likely already used by the Waterworks for existing pipes.

2.2.4.3 Scope of Works

The Japanese side will be responsible for the construction of the facilities. The Cambodian side will take care of the storage of the procured equipment (especially materials for service connections) and installation of service connections between distribution pipes and households.

Details of the obligations of the Cambodian side are described in **Chapter 2.3**.

2.2.4.4 Consultant Supervision

(1) Detailed Design

Detailed site surveys including line survey and spot detail survey of distribution facilities and cost quotations for local products will be conducted in Cambodia at the start of the detailed design. After the site surveys in Cambodia, the detailed design will be carried out in Japan and comparison between estimated costs of the outline design and detailed design will be studied. Based on the comparison, the detailed design is finalized and tender documents are prepared for the approval of the Cambodian side. Schedule of the detailed design is shown in **Table 2.2.4.4-1**. Total period of the detailed design is expected to be 6.5 months.

For the detailed design, in addition to the project manager, engineers will be assigned to be in charge of 1) intake facility, 2) treatment facility, 3) transmission and distribution facility, 4) mechanical and electrical facility, 5) architecture, 6) implementation schedule and cost estimates, and 7) tender documents.

(2) Tendering Process

Announcement of tender and prequalification and distribution of tender documents will be conducted after the approval of the tender documents. The schedule and the flow chart of the tendering process are shown in **Table 2.2.4.4-1** and **Figure 2.2.4.4-1** respectively. The consultant will act as the agent for the Cambodian side in this process. It will take 3.5 months from the announcement of Pre-Qualification (PQ) to the awarding of the contract and approval by the Ministry of Foreign Affair, Japan.

Table 2.2.4.4-1 Schedule of Detailed Design and Tender Works

month	1	2	3	4	5	6	7	8	9	10
Detailed Design										
Consultant Agreement/ Approval by GOJ										
Site Survey										
Site Survey by sub-contractor										
Detailed Design in Japan										
Preparation of Tender Documents										
Approvals of Tender Documents by GOC										
Tendering										
Pre-qualification										
Tendering (Distribution of Tender Documents, Tender Opening, Evaluation)										
Contract/ Approval by GOJ										

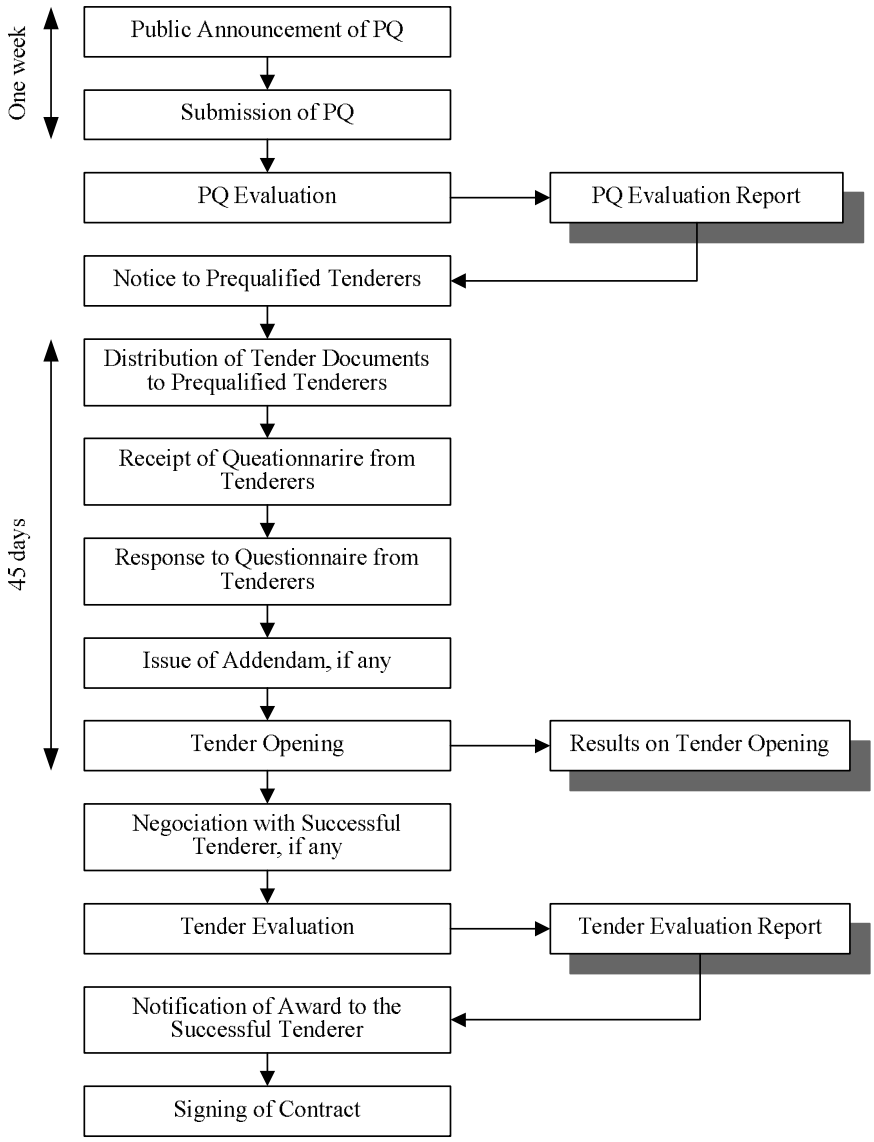


Figure 2.2.4.4-1 Flow of Tender Process

(3) Construction Supervision

The selected consultant will perform the following supervisory work:

- Check and approve shop drawings,
- Inspect major equipment and materials at the factories before shipping,
- Supervise construction activities,
- Inspect completed structures,
- Test facility operations and evaluate performance,
- Inspect construction materials,
- Report on construction progress to Japanese and Cambodian sides,
- Advise on work to be carried out by the Cambodia side,
- Technical assistance (capacity building) on operation and maintenance of the facilities,
- Assist the Cambodian side on the necessary procedures and responsibilities in the execution

of the Japan's Grant Aid project.

In order to supervise the activities throughout the construction period, it is necessary to deploy one resident engineer in each city from the start of construction to the commissioning of the facilities. In addition, various specialists (as listed below) are required for on-site supervision of the construction of the different facilities as described in details below.

Project Manager

The major scope of work of the Project Manager is as follows:

- Prior to the commencement of the construction, confirm obligations of each party, scope of the project, and implementation schedule, by holding meetings with Cambodian agencies , consultants and contractors.
- Confirm satisfactory completion of the work.
- Assist the Cambodian side in the handover of the facility operation to the Cambodian side.

Resident Engineer

The resident engineer will supervise all the work especially in the aspect of quality control and adherence to schedule. The engineer will assist and provide instruction to the contractors and will prepare monthly progress reports to the Japanese and Cambodian sides. The major scope of work of the resident engineer is as follows:

- Maintain tender documents, drawings, standards, specifications, results of surveys and soil investigations, and documents prepared and submitted by the contractors.
- Check and approve construction schedule/plan and shop drawings.
- Inspect and approve materials and equipment for the project.
- Inspect and approve construction work executed by the contractors.
- Monitor and manage the progress of the project.
- Inspect safety provisions.
- Hold periodical or ad-hoc meetings with the Cambodian side, consultants, and contractors.
- Check and approve as-built drawings.
- Assist with the work which should be executed by the Cambodian side.

Specialists

The following specialists will be assigned as required and they will also provide technology transfer during the testing period.

a. Civil Engineer (for intake/raw water transmission facilities)

Check shop drawings, supervise construction activities as well as test procedures, provide instruction and advice concerning intake/transmission facilities.

b. Civil Engineer (treatment facilities)

Check shop drawings, supervise construction activities as well as test procedures, provide instruction and advice concerning treatment facilities.

c. Civil Engineer (clear water transition/distribution facilities)

Check shop drawings, supervise construction activities as well as test procedures, provide instruction and advice concerning transition/distribution facilities.

d. Architect

Check shop drawings, supervise installation of electrical equipment as well as test procedures, provide instruction and advice concerning architectural facilities.

e. Mechanical and Electrical Specialist

Check shop drawings, supervise installation of mechanical equipment as well as test procedures, provide instruction and advice concerning mechanical and electrical equipment/facilities.

f. Specialist for procurement of equipment

Check approval procedure, supervise the procurement of equipment, provide instruction and advice.

2.2.4.5 Quality Control Plan

Quality control during construction consists largely of ensuring conformance to planning decisions and the technical specifications in the original design. The major items to be scrutinized are listed in **Table 2.2.4.5-1** together with indicators, control methods, and standards to be adopted. In principle, JIS or other equivalent International Standards will be followed for quality control.

Table 2.2.4.5-1 Major Work Items and Methods for Quality Control

Category	Control Item	Control	Method of Control	Applicable Standards	Frequency of Test	Records	Remarks
Pump Facilities	Pump	Conform to the Standards	Observation Shop-Drawing Test Report	JIS B 8301 JIS B 8302	When Received Factory Inspection	Record Test Result Table Approval Drawings	In the presence of Consultant
Pipe Material	Ductile Cast Iron Pipe	Conform to the Standards	Shop-Drawing	JIS G 5526 JIS G 5527	For each pipe laying section	Approval Drawings	
		Type	Observation		For each type、when received	Record	In the presence of Consultant
Pipe Laying Work	Joint	Joint Condition	Observation	—	During the course of Jointing Work	Report	In the presence of Consultant
			Pressured Leakage Test	No leakage observed	For each pipe laying section	Test Result Table	In the presence of Consultant
			Ultra Sonic Test		At one time for every 10 joints	Test Result Table	
Concrete Material	Reinforcing Bars	Type of Re-bar （deformed, round）	Observation	JIS G 3112 JIS G 3117	When received for each type		In the presence of Consultant
		Conform to the Standards	Test Report			Test Result Table	

Category	Control Item	Control	Method of Control	Applicable Standards	Frequency of Test	Records	Remarks
	Cement	Type of Cement	Observation	JIS R 5210	When received.	Record	In the presence of Consultant
		Conform to the Standards	Test Report			Test Result Table	
	Water	Piped Water or Clear River Water	Observation	—	When mixed	Concrete Mixture Table	In the presence of Consultant
		Water Quality （River Water）	Water Quality Test	JIS A 5308 Appendix 9	Before mixture design	Test Result Table	
	Aggregates	Maximum diameters of Aggregates	Observation	Reinforced Concrete： 25mm	When Received.	Record	In the presence of Consultant
		Grain Size	JIS A 1102	JIS A 5005	Before mixture design	Test Result Table	
	Concrete Mixture	Conform to the Standards	Test Report	JIS A 6201-6207	When received	Test Result Table	When necessary.
	Storage of Materials	Place and Storage Conditions	Observation	—	When necessary.	Report	In the presence of Consultant
Concrete Placing Work	Concrete Design Mixture （Major Structures）	Test Mixture	Confirmation of Quality	28 day strength： 21N/mm2 Slump:10.0±2.5cm Air Content:±1.5% W/C Ratio : less than 65% (less than 55% for water retaining structure Cement:: more than 270kg/m^3)	1 time before placing	Test Result Table	In the presence of Consultant
	On-site Concrete Mixture	Water Content of Small Aggregate Surface	JIS A 1111,1125	—	Each mixing	Test Result Table	In the presence of Consultant
		Grain Size of Aggregate	JIS A 1102	JIS A 5005	When received	Test Result Table	
		Temperatures of Water and Aggregates	Temperature Measurement	—	Each mixing	Test Result Table	In the presence of Consultant
		Water and Cement Volumes		Error: less than 1 %			
	Slump	Conform to the Specifications	JIS A 1101	10.0±2.5cm	Each placing	Test Result Table	In the presence of Consultant
	Air	Conform to the Specifications	JIS A 1128	±1.5%	Each placing	Test Result Table	In the presence of Consultant
	Compressive Strength	Laboratory	—	Approval of Consultant	Prior to the test	—	
		Sampling	JIS A 1132	7day Strength: 3 pcs 28day strength : 3pcs	Every 50m^3 placing or 1 time per day 1time for one consecutive placing work	—	In the presence of Consultant
		Conform to the Specifications	JIS A 1108	Design Strength= 21 N/mm2	Every 50m^3 placing or 1 time per day 1time for one consecutive placing work	Test Result Table	
	Leakage Test （Reservoir）	Conform to the Specifications	Water Level Measurement, Observation	No water level draw-down after 24 hours	After the structure is constructed	Test Result Table	In the presence of Consultant

2.2.4.6 Procurement Plan

(1) Procurement of Materials and Equipment

Construction materials and equipment for the Project will be procured in Cambodia, Japan or other countries, according to the following considerations. Quality of materials and equipment should conform to the requirements.

- For local materials and equipment, quality and capacity of supply should be at the acceptable level
- Easy operation and maintenance taking into account availability of spare parts
- Appropriate price
- Availability of after-sale service

Local procurement in Cambodia is preferable. Almost all materials for construction works are available in Cambodia and have appropriate quality. But, procurement from Japan or other countries is considered when materials or equipment cannot be procured in Cambodia, especially for mechanical and electrical equipment and pipe materials. Pipe materials, not available in Cambodia and being the larger part of the project cost, would be procured from neighboring countries such as India, Malaysia, Taiwan, etc. where the price is lower.

Equipment and materials for service connections should be procured in Cambodia, because those will be needed on a long term basis even after the project completion. The procurement plan for construction materials is shown in **Table 2.2.4.6-1**.

Table 2.2.4.6-1 Procurement Plan for Construction Materials

Name of Materials	Source of Procurement			Remarks
	Cambodia	Japan	Third Countries	
1. Construction Materials				
Ready Mix Concrete, Sand, Gravel, Cement	○			
Steel Bar	○			
Formwork Wooden Plate, Wood	○			
Steel Sheet Pile and H-shape Steel Pile	○			
Pre-stressed Concrete Pile	○			
Galvanized Steel Plate	○			
Paints, Lubricant, Fuel	○			
Water Stops	○			
Filter Sand	○			
Scaffolding and Support	○			
2. Mechanical and Electrical Equipment				
Pumps		○		
Overhead traveling crane		○		
Water Treatment Equipment including Chemical Feeding Equipment		○		
Electrical Equipment and Panels		○		
Lighting equipment, Cables and Cable Pipes	○			

Monitoring and Control Devises		○		
Air Conditioner, Inter Phone, etc	○			
Distribution Flow Monitoring System		○		
3. Pipe Materials				
Pipe Material（DIP）			○	India, etc
Pipe Material（HDPE）, Fittings	○		○	Malaysia, etc
4. Equipment Procurement				
Water Quality Testing Equipment		○		
Mechanical Maintenance Tool		○		
Equipment for Service Connections	○		○	Malaysia, etc

(2) Transportation Plan

Equipment procured in Japan and other countries will be transported to Sihanoukville by ship. After import custom clearance, it will be transported to stock yards in Kampong Cham and Battambang by truck. The truck route to Kampong Cham is approximately 360 km via Route 4 and 7, and takes around 6 hours. The route to Battambang goes on Route 4 and 5. The distance is approximately 550km and it takes around 9 hours. The routes of transportation are shown in **Figure 2.2.4.6-1**.

Figure 2.2.4.6-1 Routes for Transportation

2.2.4.7 Operation Guidance Plan

The contents for guidance for each facility and initial operation instructions will be provided by a construction worker when the facilities are handed over. Operation guidance required to

properly maintain the new water treatment plant will be provided before the start of service in 2016, by Japanese local government employees who have experience with business operation.

2.2.4.8 Soft Component (Technical Assistance) Plan

The project on the capacity building for water supply system in Cambodia (phase 2) was conducted in eight targeted provincial waterworks including Battambang and Kampong Cham by the Japan International Cooperation Agency (JICA). As a result, the skill level of the staff at the water bureaus increased dramatically, and at the end of the project it was concluded that "Due to the considerable increase in the capability of the water service personnel, which had been exceedingly limiting, it has become possible to provide a safe and stable water supply in the Targeted Provincial Waterworks (TPWs)". Therefore the TPWs have the basic skills required to operate the existing water treatment plant.

On the other hand, the capacity to operate the new facilities will be required in addition to the current facilities. This is especially so at the TPWs in Kampong Cham, which up to now has utilized high quality groundwater and doesn't have the capacity to operate and maintain a Water Treatment Plant (WTP) with river water. Taking their skills into consideration, the problems concerning operation and maintenance and proposed solutions are shown in **Table 2.2.4.8-1.**

Table 2.2.4.8-1 Operation and Maintenance Problems and Solutions

No	Problem	Solution	Plan
1	The staff at the Kampong Cham WTP does not have experience operating a rapid filtration system.	Implementation of training with all staff who will operate and maintain a WTP.	Operation and maintenance training for water distribution facilities
2	Due to the expansion of the service area, there will be a rapid increase in the construction of water pipe connections, and the newly employed staff will need the necessary abilities related to the connection of water pipes.	The new employees will be paired with experienced employees put in charge of constructing water pipe connections, and by building experience they will gain the necessary skills for connecting water pipes.	―
3	Due to the increase of customers, to accurately manage customer information, ledger maintenance will be necessary.	Implementation of the project on the capacity building for water supply system in Cambodia (phase 3) is being carried out by JICA.	Utilization of other project
4	The Kampong Cham WWs doesn't have rapid filtration facilities now, so it is difficult to implement onsite training during construction.	Training is being carried out making use of the existing water purification plant in Battambang.	Operation and maintenance training for water distribution facilities
5	Maintenance of asset ledgers and financial statements is necessary for the sound management of the waterworks.	Implementation of the project on the capacity building for water supply system in Cambodia (phase 3) is being carried out by JICA.	Utilization of other project
6	To be able to install the water flow monitoring system, it will be necessary to	Implementation of training regarding the flow monitoring system.	Operation and maintenance training

	exchange skills needed for the application of the system.		for water distribution facilities
7	A distribution system that uses a direct pressure pumping method will be required.	Implementation of training for operational maintenance management for the appropriate pump according to the secondary pressure of the pump.	Operation and maintenance training for water distribution facilities
8	In addition to a drastic increase of water consumption, the two WTPs must be operated continuously by themselves.	Implementation of training regarding chemical stock management and the water treatment plan etc…	Product management training

Therefore, the following three soft components should be implemented in this project.

(1) Operation and maintenance of water treatment facilities

In order to produce clean water at new water treatment plant constructed by this project properly and effectively, the training for operation and maintenance of water treatment facilities will be carried out during the project. New O&M staff must be properly trained to ensure that the facility would be operated consistently in an efficient manner.

The contractor responsible for procurement and construction will only explain the operation of individual equipment such as valves or pumps, at the commissioning of the facility. The training on the integrated operation of the treatment process would be carried out by the consultant who designed the WTP.

Data necessary for controlling the operation, such as chemical dozing rate, backwash, and flow rate inside the WTP, should be recorded completely and stored systematically. Staff will also be, therefore, trained on routine data acquisition, recording and archiving of records, retrieval and use of data for control and maintenance. Finally, the O&M manual for the WTP will be prepared. Water quality analysis and control, and the related training will be also conducted by the project. Through the training, staffs waterworks can improve their performance for:

- water quality analysis and control
- operation and maintenance of new treatment plants
- operation and maintenance of new mechanical and electrical equipment

(2) Operation and maintenance of water transmission and distribution facilities

Treated water from the new WTP should be distributed to the existing service area and new service area and also pumped to the existing elevated tank for Kampong Cham. In order to distribute treated water to the service areas corresponding to water demand, the training for operation and maintenance of water transmission and distribution facilities will be conducted.

The contractor will explain the operation of individual machinery equipment including transmission and distribution pumps and flow control valves at the commissioning of the facility. Staff will be trained under the soft component of the project on integrated pump operations, data

collection, record keeping and other related skills. Finally, the pump operation plans for transmission and distribution systems will be prepared. Through the training, staffs waterworks can improve their performance for:

- operation and maintenance of transmission and distribution pumps
- utilization of distribution flow monitoring system

(3) Production Management

Necessary training for inventory control of consumable chemicals, sludge disposal plan, and so on will be carried out in order to produce clear water sustainably. In addition, for Kampong Cham, the training of plant operation planning to use groundwater as much as possible will be conducted for minimizing operation and maintenance costs. Through the training, staffs waterworks can improve their performance for:

- management of two treatment plants effectively
- management of water supply facilities

The implementation schedule is as shown in **Table 2.2.4.8-2**

Table 2.2.4.8-2 Implementation Schedule of Soft Component

	Months	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	M/M Cambodia	M/M Japan
EXPERT	Expert for O&M of Water Treatment Facility			1.0					1.0							2.0	4.00	0.00
EXPERT	Expert for O&M of Transmission and Distribution Faciity								1.0							2.0	3.00	0.00
EXPERT	Expert for Production Management								1.0							2.0	3.00	0.00
EXPERT																	10.00	0.00
LOCAL	Interpreter/Supporting Staff (Treatment Facility)			2.0					2.0							3.0	7.00	0.00
LOCAL	Interpreter/Supporting Staff (Transmission and Distribution Facility)								2.0							3.0	5.00	0.00
LOCAL	Interpreter/Supporting Staff (Production Management)								2.0							3.0	5.00	0.00
LOCAL																	17.00	0.00
Report			△ Progress Report						△ Progress Report							△ Final Report		

2.2.4.9 Implementation Schedule

The implementation schedule is shown in **Figure 2.2.4.9-1**. The detailed design period will be about 6.5 months, pre-qualification and tendering period will be about 3.5 months, and procurement and construction will be 26 months.

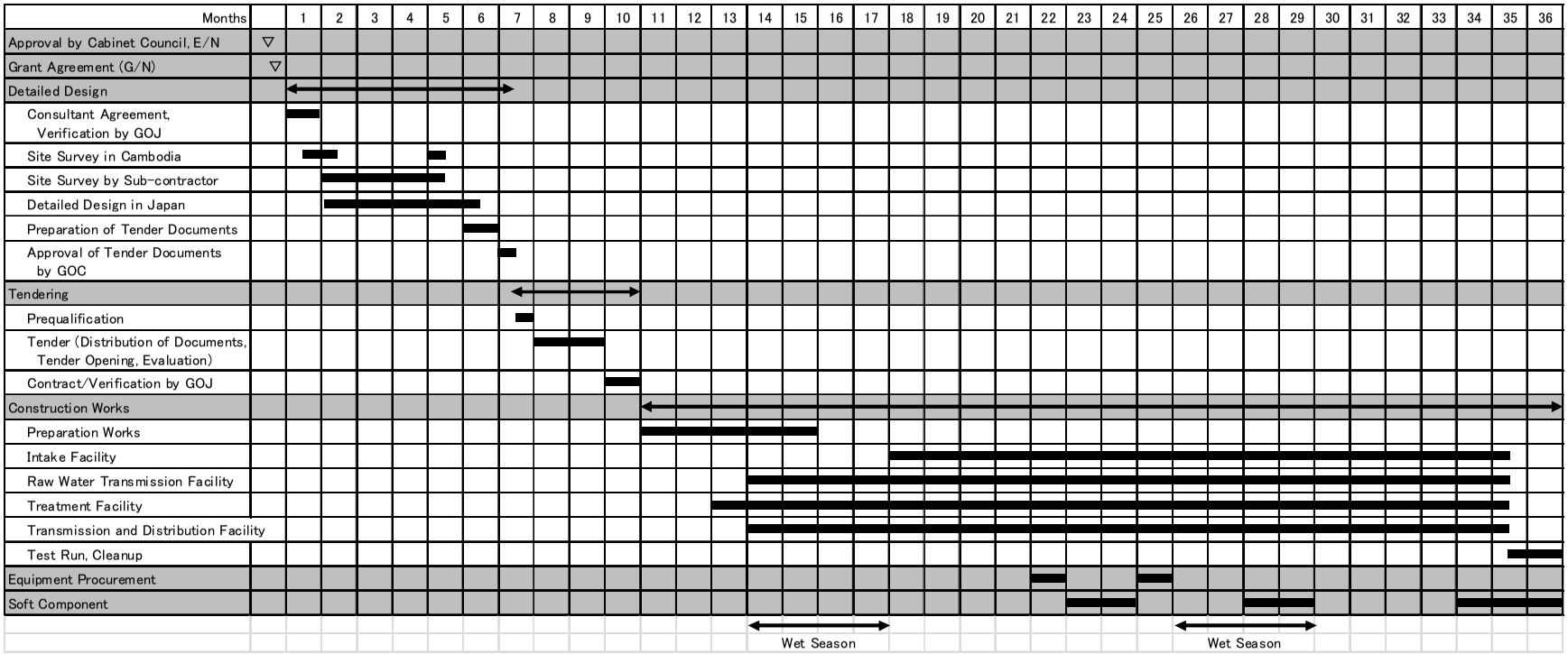


Figure 2.2.4.9-1 Implementation Schedule

2.3 Obligations of Recipient Country

2.3.1 Land Acquisition for Water Treatment Plant and Land Preparation

(1) Kampong Cham

The land required for the new water treatment plant has been identified by the Cambodian side. Since the site of the well facilities and existing main waterworks office is not sufficient, the site across the street where there are elevated water tanks and another office building, is also considered. The office building (see **Photo 2.3.1-1**) on the site where the elevated water tanks are located needs to be demolished and the land leveled for the construction of the new water treatment plant. The Cambodian side agreed that Kampong Cham DIME will remove the office building by June, 2013. It was also confirmed that new office space will be included in the new administration office building to replace the office space lost from demolishing the building.

Photo 2.3.1-1 Separate Office Building to be Demolished in this Project

(2) Battambang

Although the area of the land selected for the new water treatment plant of Battambang is sufficient, there is an abandoned factory at this location (see **Photo 2.3.1-2**). This abandoned factory needs to be demolished and the land leveled by the Cambodian side for the project implementation. It was confirmed that the Cambodian side will take responsibility for removing this factory.

Photo 2.3.1-2 Abandoned factory to be demolished in this Project

2.3.2 Intake Permission from the River

2.3.2.1 Water Management System in Cambodia

Based on the "Law on Water Resources Management of the Kingdom of Cambodia" enacted in 2007, there is a target for implementing the Integrated Water Resources Management (IWRM) in Cambodia. The responsible agency of the IWRM will be the MOWRAM. The IWRM will include management of quantity and quality of surface water and groundwater as well as risk management against flood and sediment disasters. For the implementation of IWRM, MOWRAM has received technical assistance from the Asian Development Bank (ADB) in 2011 for the "Cambodia Water Resources Management Sector Development Program." The project aims to support MOWRAM in formulating the policy on water resources management, establishing river basin management system, water quality management system, rehabilitation of medium to small irrigation systems, and the related capacity developments.

Hence, water management is not currently being conducted in Cambodia. For this reason, as can be seen in the Sangke River in Battambang, public and private intake of water and discharge of wastewater are freely conducted. However, in the near future, water management by MOWRAM will be started.

Therefore, in order to conduct water abstraction for domestic water supply in Kampong Cham and Battambang, it is necessary to request the management of both existing water abstraction and the new water abstraction from the Ministry of Industry, Mines and Energy (MIME) to MOWRAM. MIME already understands this procedure.

2.3.2.2 Land Acquisition Procedure for Intake Facilities

The waterworks in Kampong Cham and Battambang have to file an application with the Department of Industry, Mines and Energy (DIME) for the processing of land acquisition procedures to obtain approval from the Provincial Government. The Provincial Government will then inform the Department of Water Resources and Meteorology (DOWRAM) about the construction of intake facilities.

The land acquisition procedure for the intake location is as shown below.

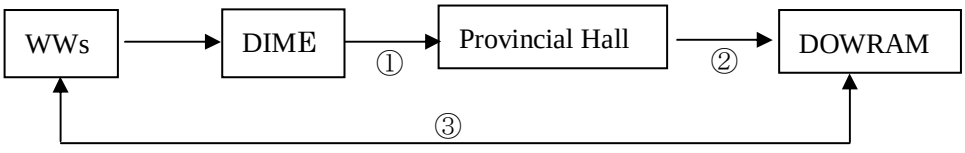


Figure 2.3.2-1 Land Acquisition Procedure for Intake Facility

① The Waterworks shall file an application to DIME for the processing of land acquisition procedures to obtain approval from the Provincial Government and shall contain the following information:

・Information on the construction site of the intake facility
・Information on the construction method of the intake facility

② The Provincial Government shall inform DOWRAM about the construction of intake facilities including the above information.

③ DOWRAM will ask the waterworks directly about unknown matters including the improvement point of the above construction application.

To commence the works, the waterworks shall report to the Provincial Government about the Project and ask for the launch of a project committee. The committee shall then be organized with the Provincial Governor as the chairperson. The members shall be composed of officers from the following authorities. The waterworks shall also issue a cooperation request to every authority.

・ Department of Public Works and Transportation
・ Provincial Government
・ EDC (Electric du Cambodia)
・ Department of Telecommunication and Post
・ Department of Water Resources and Meteorology

According to the inquiring survey from waterworks, steering committee constituted by two or more related organizations shall be established under the direction of Provincial Governor for the implementation of large scale project. The deliberation and decision items on this committee meeting are reflected to the implementation of the project. And the matters which some coordination is necessary between the related organizations shall be discussed in this committee meeting.

2.3.3 Transmission of Electricity to the New Intake Facilities and Water Treatment Plants

The Japanese side explained to the Cambodian side that Japanese Grant Aid will provide and install the transformers at the sites of the new intake facilities and water treatment plants. However, the Cambodian side has to construct the power transmission facilities to the transformers. Both waterworks are having talks with Electric du Cambodia (EDC).

The power supply augmentation project in Kampong Cham will complete in June, 2013 and the power transfer will be possible in July, 2013. A similar project was implemented in Battambang and the power transfer was scheduled to start in the end of 2012. Therefore, the power conditions in both cities are expected to improve.

The Japanese and Cambodian sides agreed that the installation of power receiving transformers and emergency electric generators should be considered after confirming the power conditions in both cities. The Japanese side agreed with both waterworks to procure and install power receiving transformers at water intake and purification facilities in both cities. It was also agreed that the capacity of emergency power generators to be installed at intake facilities should be the capacity required for one intake pump at each intake facility. The capacity of emergency power generators to be installed at water purification plants was agreed to be the capacity required for the partial operation of related facilities with the raw water transmitted from the single intake pump during the emergency.

2.3.4 Land Acquisition Procedure for Pipeline Routes

The land acquisition procedure for transmission and distribution pipes is different between the laying under local roads and the laying under national roads, bridges or railways. Each procedure is as described below.

(1) Land Acquisition Procedure under National Roads, Bridges and Railways

The waterworks in Kampong Cham and Battambang have to file an application with the Department of Industry, Mines and Energy (DIME) for the processing of land acquisition procedures to obtain approval from the Ministry of Public Works and Transportation (MPWT) and shall contain information on the construction site and the construction method. MPWT shall inform the Department of Public Works and Transportation (DPWT) about the construction of pipes after the approval of the application from MIME.

The land acquisition procedure for pipe-laying under national roads, bridges and railways is as shown in the following figure.

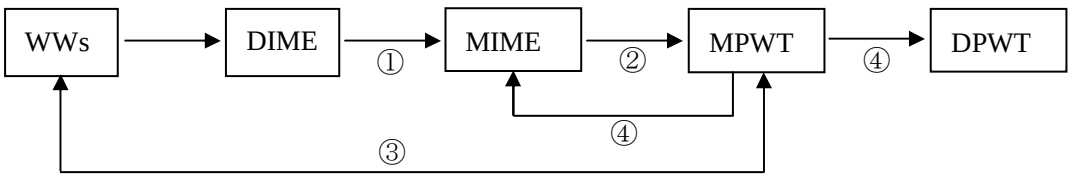


Figure 2.3.4-1 Land Acquisition Procedure under National Roads, Bridges and Railways

① Every waterworks shall provide the following information to MIME through DIME.

・Information on national road, bridge and railway affected by pipe laying.
・Pipe laying location
・Construction Method

② MIME shall file an application for pipe laying with the above information to MPWT.

③ MPWT shall ask waterworks directly about unknown matters including improvement of the above construction application.

④ MPWT shall recognize the application of MIME and issue a cooperation request to DPWT.

(2) Land acquisition procedure under local roads

The waterworks of Kampong Cham and Battambang have to file an application with the Department of Industry, Mines and Energy (DIME) for the processing of land acquisition procedures to obtain approval from the Provincial Government. The Provincial Government shall inform the Department of Public Works and Transportation (DPWT) about the construction of pipes which shall contain information on the construction site and the construction method.

The land acquisition procedure for the pipe laying under local roads is as shown below.

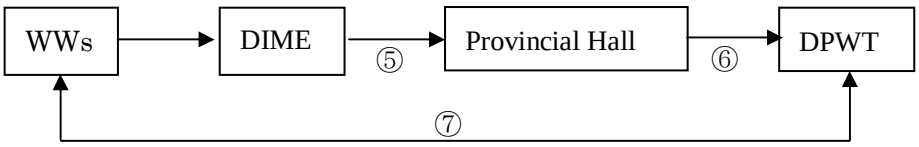


Figure 2.3.4-2 Land Acquisition Procedure under Local Roads

⑤ The waterworks shall file an application with DIME for the processing of land acquisition procedures to obtain approval from the Provincial Government and shall contain the following information:

・Information of local road affected by pipe laying.
・Pipe laying location
・Construction Method

⑥ The Provincial Government will then inform DPWT about the pipe-laying which shall contain the above information.

⑦ DPWT shall ask waterworks directly about unknown matters including improvement of the above construction application. Waterworks will then provide detailed information on the construction work to DPWT one week before the commencement of construction work.

To commence the works, the Waterworks companies shall ask the Provincial Government to launch a project committee and shall also issue a cooperation request to every authority.

2.3.5 Individual Service Connections

The facilities after distribution mains, such as service pipes and water meters shown in **Figure 2.3.5-1,** are installed by the waterworks at the customer's request. The typical size of service pipe and water meter is 25 mm and 15 mm in diameter, respectively. Larger service pipes and water meters are required for those customers using a large amount of water. The materials and equipment costs and their installation costs (connection fee) are borne by the customers.

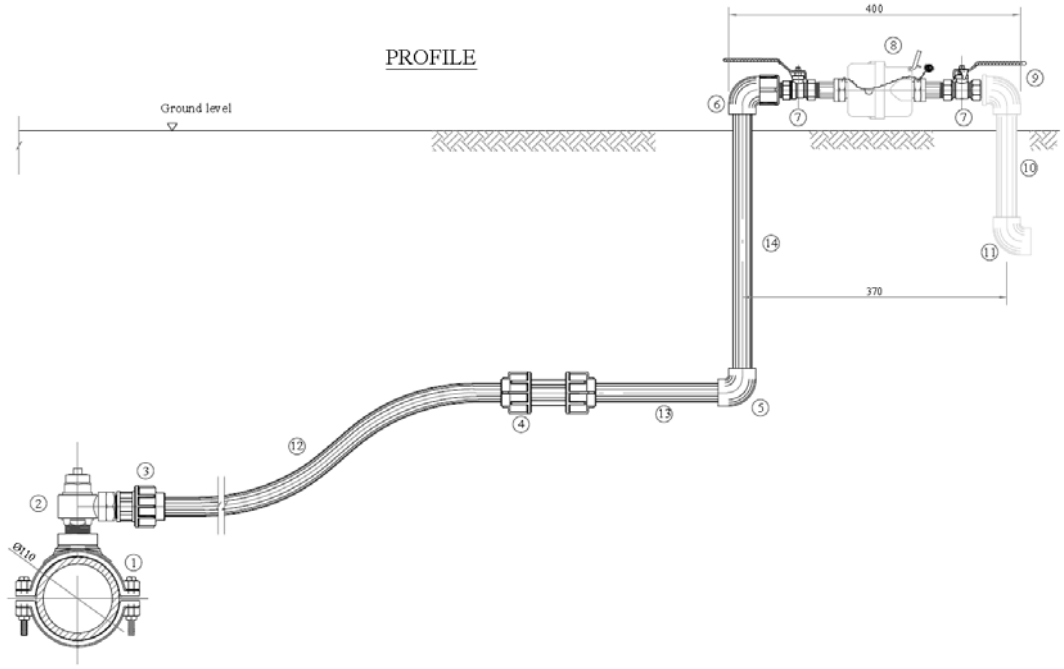


Figure 2.3.5-1 Typical Drawing of an Individual Service Connection in Cambodia

The connection of service pipes, the procurement and installation of water meters are required for new applicants for service connections.

This task will be implemented by the technical personnel of the waterworks at the expense of the new applicants. The current number of service connections in Kampong Cham and Battambang (2009 to 2011) are about 300 and 600 respectively. **Table 2.3.5-1** shows the projected number of new connections per year for achieving the target water supply connection

ratio.

Table 2.3.5-1 Draft Schedule of Connecting Service Pipes and Procuring & Installing Water Meters

Year	- 2013	2014	2015	2016	2017	2018	2019
Kampong Cham	300	300	648	1,400	1,600	1,600	1,600
Battambang	600	1,100	1,545	2,200	3,400	3,400	3,400

Source：JICA Study Team

In order to increase service connections among low income groups, the provision of service connection materials (i.e. water meters, service pipes and other accompanying items) is included in this project. The installation costs of the connections will be covered by the Cambodian side (customers).

2.3.6 Necessary Process for Environmental and Social Considerations

2.3.6.1 Approval of IEE/IEIA Report

According to Article 7 of Sub-Decree on Environmental Impact Assessment and the comments of MOE, the Project Owner, MIME/KWW/BWW, shall prepare a Draft IEIA and submit an IEIA report and a pre-feasibility study report to MOE. If the expected impacts are judged to be serious against the ecosystem or human health, the Project Owner shall additionally submit an EIA report and a pre-feasibility report to MOE.

The process differs according to the ownership of the Project. Since the Project is owned by MIME/KWW/BWW, it is categorized as Public Project. After the submission date, MOE shall review the IEE/EIA report within 30 days. If all items and contents satisfy the required information, MOE shall conduct the approval process within another 30 days; otherwise, MOE shall request the Project Owner to revise the report. Should the expected impacts are judged as serious toward the environment or human health, MOE shall request the Project Owner to prepare and submit an EIA report.

2.3.6.2 Stakeholder Meetings

According to the Environmental Assessment Law of Cambodia and the JICA Guidelines, the Project Owner, MIME/KWW/BWW, shall hold stakeholder meetings to disseminate information on the project and to obtain the consent of residents and stakeholders in the project area. Responding to the request of JST, KWW as well as BWW held stakeholder and public consultation meetings in each city.

If any modification of the project plan was conducted, additional stakeholder meetings and public hearings shall be hold upon modified plan.

2.3.6.3 Monitoring Activities

To ensure the proper implementation of mitigation measures, monitoring activities by the Project Owner, MIME/KWW/BWW, are essential.

Although no big scale construction work is required, construction work close to residential and commercial areas cannot be avoided due to the nature of the water supply project. Therefore, precise caution and preventive measures against any adverse impact such as noise, air pollution, waste disposal and traffic disturbance shall be applied during the construction period, including those produced by the intake and conveyance pumps. During the operation period, intake pump as well as transmission pump may generate noise and vibration. Thus preventive measures as well as the monitoring activities shall be conducted.

In Battambang, the amount of Sangkae river flow during the dry season becomes small so that the precise control of intake amount will be required. Also, due to the low flow rate, the effect of disturbance caused by the construction work becomes larger compared to that of Mekong River.

2.3.7 Others

In addition to the above, the following components are designated as the responsibilities of the Cambodian side for the implementation of this project.

- Establishment of PIU organized by MIME, DIME and the waterworks
- Budgeting for the project components for which the Cambodian side is responsible
- Bank arrangements
- Procedure of tax exemption
- Contracting process of network connection for the distribution information system
- Increasing the number of personnel in the waterworks, optimization of personnel distribution and training
- Stock management of procured materials and equipment and proper O&M of the constructed facilities
- Continuously acquiring and accumulating the values of the indicators set for project monitoring.

2.4 Project Operation Plan

2.4.1 Organization after Completion of the Project

Battambang

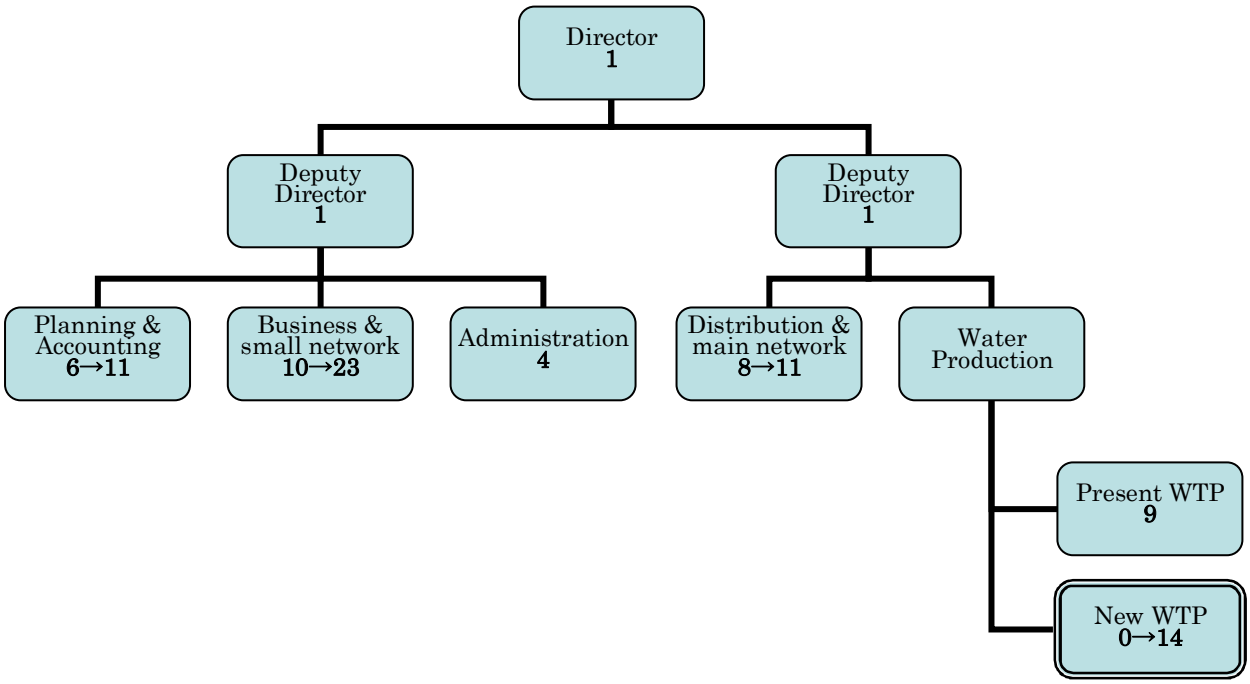


Figure 2.4.1-1 Proposed Organization (Battambang)

In order to operate a new water treatment plant, an additional 14 persons will be required for the Water Production Division. The new treatment plant will be constructed 5 km away from the present plant. Therefore a chief who has been given the authority to administer the operation of a new treatment plant will be required.

In the Planning & Accounting Division, five persons are in charge of reading meters for 9,665 houses. According to the predicted increase of supply area, meter readers for 25,300 houses will be required in 2019. Moreover it is estimated that the maximum number of pipe connections will peak at 3,400 houses in order to achieve the targeted coverage of the water supply. Thus, an additional 13 persons will be required for the Business & Small Network Division.

An additional person for the flow monitoring system and an additional two persons for water leakage surveying will be required for the Distribution & Main Network Division.

Furthermore, according to the projected increase of connections year by year, it is recommended to increase the number of staff to 75 in total by the target year as shown in **Table 2.4.1-1**.

Table 2.4.1-1 Proposed Staff Number: Battambang WWs

	2012	2013	2014	2015	2016	2017	2018	2019
	Actual							Target
Director	1	1	1	1	1	1	1	1
Deputy Director	2	2	2	2	2	2	2	2
Administration	4	4	4	4	4	4	4	4
Planning & Accounting	6	6	7	7	8	9	10	11
Business & Small network	10	13	14	15	17	20	21	23
Distribution & Main network	8	8	8	11	11	11	11	11
Water Production	9	9	9	23	23	23	23	23
T o t a l	40	43	45	63	66	70	72	75
Service Connections	9,665	10,265	11,365	12,910	15,110	18,510	21,910	25,310
Annual Connections	600	600	1,100	1,545	2,200	3,400	3,400	3,400

Kampong Cham

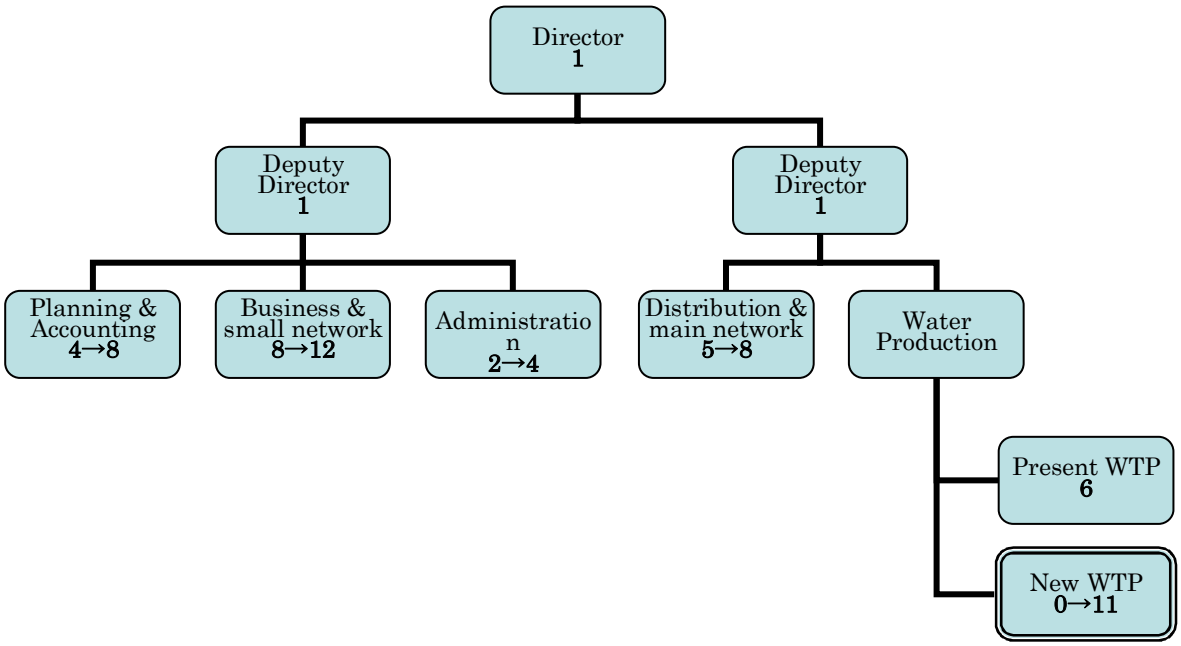


Figure 2.4.1-2 Proposed Organization (Kampong Cham)

In order to operate the new water treatment plant, an additional 11 persons will be required for the Water Production Division.

The new treatment plant will be constructed near the present plant. Therefore an additional chief will not be required

In the Planning & Accounting Division, five persons are in charge of reading meters for 4,799 houses. According to the projected increase of supply area, meter readers for 12,247 houses will

be required in 2019. Moreover it is estimated that the maximum number of pipe connections will peak at 1,600 houses in order to achieve the targeted coverage of the water supply. Thus, an additional four persons will be required for the Business & Small Network Division.

An additional person for the flow monitoring system and an additional two persons for water leakage surveying will be required for the Distribution & Main Network Division.

Furthermore, according to the predicted increase of connections year by year, it is recommended to increase the number of staff to 52 in total by the target year as shown in **Table 2.4.1-2**.

Table 2.4.1-2 Proposed Staff Number: Kampong Cham WWs

	2012	2013	2014	2015	2016	2017	2018	2019
	Actual							Target
Director	1	1	1	1	1	1	1	1
Deputy Director	2	2	2	2	2	2	2	2
Administration	2	2	2	4	4	4	4	4
Planning & Accounting	4	4	4	5	6	7	8	8
Business & Small network	8	9	9	9	10	10	11	12
Distribution & Main network	5	5	5	8	8	8	8	8
Water Production	6	6	6	17	17	17	17	17
T o t a l	28	29	29	46	48	49	51	52
Service Connections	4,799	5,099	5,399	6,047	7,447	9,047	10,647	12,247
Annual Connections	300	300	300	648	1,400	1,600	1,600	1,600

2.4.2 Project Maintenance Plan

Upon implementation of the project, the proposed operation and maintenance is shown in **Table 2.4.2-1**.

Table 2.4.2-1 Contents of Operation and Maintenance

Work Contents	Frequency	Note
■Water Treatment Management		
●Water Quality Analysis		
－Essential analytical items	Daily	Temperature, pH, Turbidity, Residual Chlorine etc
－Daily record of water quality	Daily	
－Important analytical items	Once/3month	Iron, Manganese, Aluminum, Copper etc
－Jar test	Weekly	Or when raw water turbidity rises
－Residual Chlorine in tap water	Twice/month	Several places
－Monthly record of water quality	Monthly	
●Water Treatment		
－Intake pump operation	Daily	
－Condition of coagulation	Daily	
－Dosing rate of Alum	Daily	Based on Jar test and floc

Work Contents	Frequency	Note
－Dosing rate of Lime	Daily	Based on pH
－Dosing rate of Chlorine	Daily	Residual chlorine (pre and post)
－Operation of sludge valve	Weekly	
－Cleaning of sedimentation	Yearly	
－Sludge pump operation	Daily	
－Sludge drying bed checking	Daily	Water Content
－Presence of sludge conveyance	Monthly	
－Filtration operation	Daily	
－Washing filter sand	Daily	
－Measurement of filter layer	Yearly	
－Quality of filter sand	Yearly	Effective size, Uniformity Coefficient
－Monitoring water level	Daily	Sedimentation, Filtration, Reservoir, etc
－Cleaning reservoir	Yearly	
－Recording daily operation	Daily	
●Electrical and mechanical facilities		
－Routine maintenance check	Daily	Thermometer, vibration meter
－Washing chemical pipe	Daily	
－Minor fault repairing	Daily	
－Regular check of pump and motor	Yearly	
－Regular check of chemical equip.	Yearly	
－Regular check of motor valve	Yearly	
－Regular check of rapid mixing	Yearly	
－Regular check of level gauge	Twice/year	Sedimentation, Filtration, Reservoir, etc
－Insulation and earth test	Yearly	Electrical facilities
●Others		
－Cleaning work	Daily	
－Security duties	Daily	
■Distribution Management		
●Distribution pump operation		
－Recording pump operation	Daily	
－Operation daily schedule	Daily	
－Operation monthly schedule	Monthly	
●Distribution flow monitoring system		
－Record and analysis of water flow	Daily	
－Implementation of leakage survey	Monthly	
■Production Management		
●Maintenance Duties		
－Making annual operation plan	Yearly	2 WTP
－Chemical stock management	Daily	Alum, Lime, Chlorine
－Sludge treatment plan	Daily	

2.5 Project Cost Estimation

2.5.1 Initial Cost Estimation

(1) Project Cost borne by Cambodian Side

Total Project Cost borne by the Cambodia by 2019 side is estimated at about 1,760 million Cambodia Riel (KHR). **Table 2.5.1-1** shows its breakdown.

Table 2.5.1-1 Project Cost borne by Cambodian Side

Items	Contents	Estimated Cost					
		For KMC System		For BTB System		Total	
		KHR (million)	Yen (1,000)	KHR (million)	Yen (1,000)	KHR (million)	Yen (1,000)
Land Preparation for WTP	Demolishment of existing structures and land leveling	42.7	811.8	1,328.6	25,242.8	1,371.3	26,054.6
Environmental Consideration	Environmental Monitoring for Air, Water, Noise and Vibration（2016-2019）	59.2	1,124.2	85.2	1,619.6	144.4	2,743.7
Information System	Contracting process of network connection for the distribution information system	6.9	131.0	6.9	131.0	13.8	262.0
Electricity Supply	Transmission of electricity to the new intake facilities and WTPs	64.4	1,224.3	79.3	1,506.8	143.7	2,731.1
Bank Charge	Bank arrangement for the project	-	-	-	-	86.4	1,641.5
					Total	1,759.6	33,432.9

KHR 1 = 0.019 yen

(2) Conditions for Cost Estimates

1) Date of Estimates: As of September, 2012

2) Exchange Rate: US$ 1 = 81.09 yen
KHR 1 = 0.019 yen

3) Period of Construction: Total: 36 months
Detailed Design: 6.5 months
PQ and Tendering: 3.5 months
Construction/Procurement: 26.0 months

4) Others: The Project should be implemented in accordance with the procedures of Japan's Grant Aid Scheme.

2.5.2 Operation and Maintenance Cost

(1) Operation Cost

The future operation and maintenance cost in Battambang WTP is estimated based on three years of performance of the current operation. Distribution flow monitoring cost and sludge conveyance cost, which is a new item, are added in this estimation.

Kampong Cham WTP needs to operate and manage two different treatment processes.
The treatment process with well water can keep operation and maintenance cost low compared to river water. Therefore, operation and maintenance costs in Kampong Cham WTP are estimated based on the utilization of well water as much as possible.

Operation and maintenance cost will be calculated depending on the conditions shown in **Table 2.5.2-1** in the target year.

Table 2.5.2-1 Condition of O&M cost

Item	Battambang	Kampong Cham
Personal expense	Staff number: 75 in total (2019) Increase rate of salary: 5%/year	Staff number: 52 in total (2019) Increase rate of salary: 5%/year
Chemical cost	Alum Average dosage: 70ppm Inflation rate: 5%/year Lime Average dosage: 15ppm Inflation rate: 5%/year Chlorine Average dosage: 4ppm Inflation rate: 5%/year Note: Based on the records for the past three years in Battambang WTP	Alum Average dosage: 11ppm Inflation rate: 5%/year Lime Average dosage: 10ppm Inflation rate: 5%/year Chlorine Average dosage: 2ppm (well) Average dosage: 1.8ppm (river) Inflation rate: 5%/year Note: Based on the records for the past three years in Chrouy Chang War WTP, which depends on the Mekong River as a water source
Power cost	Main power: Electricity (High Voltage) Electricity consumption: 0.43kWh/m3 Inflation rate: 5%/year	Main power: Electricity (High Voltage) Electricity consumption: 0.43kWh/m3 Inflation rate: 5%/year
Fuel cost	Emergency power supply Inflation rate: 5%/year	Emergency power supply Inflation rate: 5%/year
Repair cost	20% of total operation cost	
Flow monitoring cost	Circuit usage fee Maintenance fees	
Sludge Conveyance	Average turbidity: 170NTU Alum dosage: 69mg/L Moisture content: 60% Disposal cost: Not booked	Average turbidity: 110NTU Alum dosage: 11mg/L Moisture content: 60% Disposal cost: Not booked
Office Articles	10% of personal expense	10% of personal expense

Based on the above plan, operation and maintenance costs will be expected as shown in **Table 2.5.2-2**. These are to be the target figures for the project.

Table 2.5.2-2 Annual O&M Cost Unit: million KHR

Item	O&M cost	
	Battambang	Kampong Cham
Personal Expense	919	465
Chemical Cost	2,976	339
Power Cost	4,558	2,538
Fuel Cost	564	261
Repair Cost	2,333	932
Sludge Conveyance Cost	113	17
Flow Monitoring Cost	18	18
Office Supplies	184	93
Total	11,665	4,663

(2) Cash Forecast

The existing fee structure of Battambang WWs is a fixed charge structure and the fee structure of Kampong Cham WWs is a commodity charge structure. In the current fee structure, the cash forecast for each year until the target year is as shown in **Table 2.5.2-3**.

Table 2.5.2-3 Cash Forecast Unit: million KHR

Year	2013	2014	2015	2016	2017	2018	2019
Battambang							
Maintenance Cost	3,327	3,893	4,871	6,059	7,733	9,581	11,665
Water Revenue	4,317	4,894	5,688	6,809	8,526	10,312	12,166
Balance	990	1,001	817	750	793	731	501
Kampong Cham							
Maintenance Cost	1,746	1,922	2,383	2,620	3,238	3,238	4,663
Water Revenue	1,482	1,569	1,757	2,164	2,629	3,094	3,559
Balance	-264	-353	-626	-456	-609	-833	-1,104

Battambang WWs will be able to be in the black until the target year. On the other hand, Kampong Cham WWs will be in the red until the target year, thus it is necessary to raise the water tariff.

So for both WWs, a fee structure with consideration to the impoverished shall be reviewed.

Kampong Cham

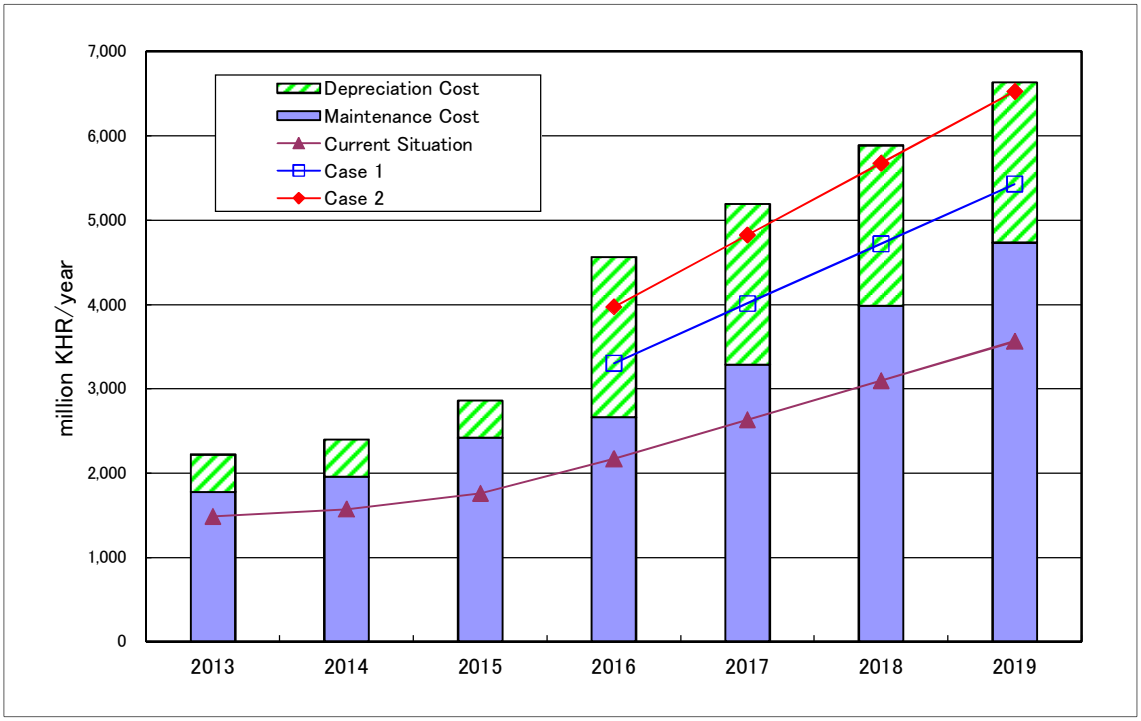


Figure 2.5.2-1 Maintenance cost and water revenue (Kampong Cham)

Table 2.5.2-4 Water Tariff (KMC) **(KHR/m3)**

Class		Current Situation	Case 1	Case 2
Ordinary	Less than 10m^3	550	900	900
	More than10m^3	900	1,500	1,800
Business		900	1,500	2,000
Institution		1,500	1,500	2,000

Both cases in **Table 2.5.2-4** show the price in consideration of low income group. As shown in **Figure 2.5.2-1**, the depreciation will be increased by an increase of asset for this project. Case 1 is recommendable only when the maintenance cost is considered for water tariff structure. However, to keep internal reserves for the renewal of facilities in the future, Case 2 could be better than Case 1.

The average quantity of water consumption per household is 21.6m^3/month. Supposing implementation of case 2, the water tariff could be 29,880 KHR/month. This price is less than 2% of 1,326,000 KHR/month, which was derived from the results of a social survey conducted during a feasibility study. Therefore, it is possible for the citizens to pay this amount.

Battambang

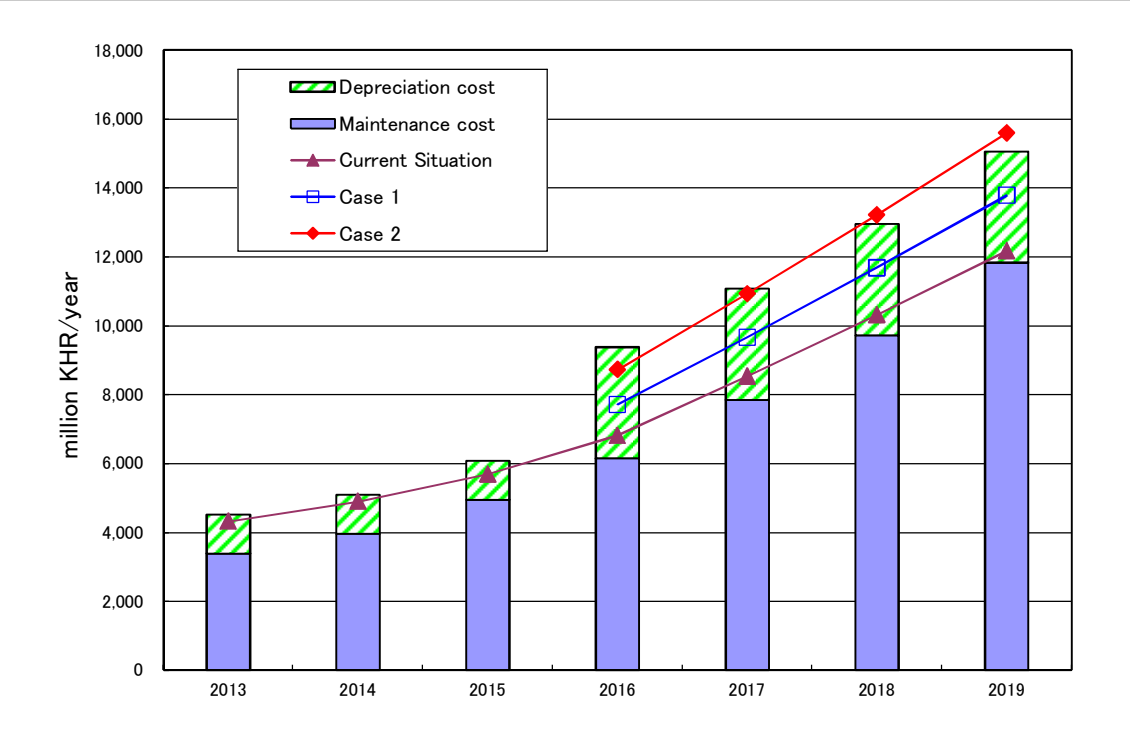


Figure 2.5.2-2 Maintenance cost and water revenue (Battambang)

Table 2.5.2-5 Water Tariff (BTB) **(KHR/m3)**

Class		Current Situation	Case 1	Case 2
Ordinary	Less than 10m^3	1,500	1,100	1,100
	More than10m^3	1,500	1,800	2,000
Business		1,500	2,000	2,400
Institution		1,500	2,000	2,400

Both cases in **Table 2.5.2-5** show the price in consideration of low income group. As shown in **Figure 2.5.2-2**, the depreciation will be increased by an increase of asset for this project. Case 1 is recommendable only when the maintenance cost is considered for water tariff structure. However, to keep internal reserves for the renewal of facilities in the future, Case 2 could be better than Case 1.

The average quantity of water consumption per household is 18.0m3/month. Supposing implementation of case 2, the water tariff could be 27,000 KHR/month. This price is less than 3% of 804,300 KHR/month, which was derived from the results of a social survey conducted during a feasibility study. Therefore, it is possible for the citizens to pay this amount.

Chapter 3 Project Evaluation

3.1 Preconditions

Preconditions and responsibilities by the Cambodian side for project implementation are described in "**Chapter 2-3 Obligations of Recipient Country**". Major conditions are listed as follows.

Land Preparations for New Water Treatment Plants

Although the land selected for the new water treatment plants in Kampong Cham and Battambang are secured, there are existing facilities at these locations. These facilities need to be demolished and the land leveled by the Cambodian side before the construction of the facilities. It was confirmed that the Cambodian side would remove the existing facilities by June 2013.

Water Intake Permissions

The current laws and regulations in Cambodia do not specify who water rights for the rivers. Water management is not being conducted currently. The MOWRAM will start to manage the water resources in the near future. It will be necessary for the MIME to obtain permission from the MOWRAM to take water from the Mekong River in Kampong Cham and the Sangke River in Battambang for this project. The MIME understood and agreed to submit official letter from MOWRAM which assure MIME can extract necessary volume of raw water for the project by the end of February 2013.

Approval of IEIA Report

According to Article 7 of Sub-Decree on Environmental Impact Assessment and the comments of the MOE, the Project Owner, MIME/KWW/BWW, shall prepare and submit an IEIA report and a pre-feasibility study report to the MOE for approval. The MIME understands this procedure and will get the approvals from the MOE by the end of June 2013.

Electric Transmission Lines to the New Intake Facilities and Water Treatment Plants

Japanese Grant Aid will provide and install the transformers at the sites of the new intake facilities and water treatment plants. The Cambodian side has to construct the power transmission facilities to the transformers.

Right of Way for Pipelines

Water transmission and distribution pipes will be installed along public roads. Therefore, land acquisition for pipe laying will not be required, but permission of pipe installation should be obtained from the MPWT for national roads and from the Provincial Government for local roads.

3.2 Necessary Inputs by Recipient Country

Installation of Service Connections

The Japanese side will install the distribution pipelines. At the customers' requests the Cambodian waterworks will install the service pipes from the distribution pipelines and water meters. The materials, equipment and installation costs (connection fee) are borne by the customers.

Staff Increase

It is necessary for the waterworks in Kampong Cham and Battambang to increase their staff to operate and maintain the new water supply facilities. The necessary staff should be allocated one year before the completion of construction so that they can be trained under the technical assistance (soft component) of the project.

Proper Water Tariff

The operation and maintenance costs in Kampong Cham will increase after the construction of the new water treatment plant which takes raw water from the Mekong River and adopts the coagulation-sedimentation method with rapid sand filtration. The Cambodian side understood and agreed to consider the revision of the water tariff in order to cover the necessary costs. In addition, under the on-going project which is "the Project on Capacity Building for Urban Water Supply System (Phase 3)", advice for setting proper water tariff to the waterworks will be conducted in line with the actual conditions.

3.3 Important Assumptions

The desired project outcomes can only be achieved if the following assumptions remain true:

- Serious natural disaster will not occur.
- Serious deterioration of economy will not occur.

3.4 Project Evaluation

3.4.1 Adequacy of the Project

Project Beneficiaries

The water supply facilities in Kampong Cham and Battambang will be expanded and the water supply services will be improved by the implementation of this project. The service ratio in the urban area of both cities will increase from about 30% in the year 2011 to 84.8% in the year 2019. By 2019 the population served in Kampong Cham and Battambang will increase from 22,000 to 59,000 and 59,000 to 127,000, respectively.

Urgency of Project Implementation

The existing Kampong Cham and Battambang water supply systems are only providing water service to 33% and 31% of the population respectively in 2011 because of insufficient production capacity and low intake volume in the dry season. Therefore, the expansion of water supply facilities in these cities is an urgent matter.

Consistency between the Project and Cambodia Planning

The National Strategic Development Plan (NSDP) issued in 2006 sets the water service target of 80 % in urban areas by year 2015. This project will help Kampong Cham and Battambang achieve this water service ratio. The increase in service ratio for the low income group will also contribute to poverty reduction which is the most important goal of the NSDP.

Compliance with Japan's Assistance Policy for Cambodia

Japan's assistance policy for Cambodia is to support the recipient country in achieving their development goals. "Promotion of Social Development" is a one of priority pillars for its assistance. Development of the water supply system is included in "Promotion of Social Development" and the project conforms to the policy for Japanese assistance in Cambodia.

3.4.2 Effectiveness

The project is expected to provide the following beneficial outcomes:

(1) Quantitative Effects

The expansion of water supply facilities in Kampong Cham and Battambang will result in improvements to the indicators listed in **Table 3.4.2-1**.

Table 3.4.2-1 Quantitative Effects

No.	Indicator	Baseline Data (Year 2011)		Target (Year 2019) (3 years after completion of the new facilities)	
		Kampong Cham	Battambang	Kampong Cham	Battambang
1	Served Population	21,571	45,377	58,719	126,696
2	Water Supply Capacity (daily average basis)	5,155 m^3/day	8,132 m^3/day	13,500 m^3/day	27,518 m^3/day
3	Service Ratio	32.8%	31.1%	84.8%	84.8%
4	Number of Service Connections	4,499	9,065	12,247	25,310
5	NRW Ratio	13%	21%	13%	20%

(2) Qualitative Effects

- Maintaining appropriate residual water pressure and increasing water supply capacity will improve water supply services.
- Public hygiene conditions will be improved by increasing the service ratio. More people will be able to access safe water supply and there will be fewer incidences of water related illness.
- The increase in service ratio would reduce the manual labor required for getting water and is expected to contribute to the increase in women's employment, children's school attendance and ultimately improve the living standard.
- Existing intermittent water supply is caused by dropping groundwater and river water levels. The project will provide a stable water supply.

Based on the above, it is concluded that the adequacy of the project is highly evaluated and effectiveness of the project will be expected.