MINISTRY OF INDUSTRY, SCIENCE,
TECHNOLOGY & INNOVATION (MISTI)
KINGDOM OF CAMBODIA

PREPARATORY SURVEY ON THE PROJECT FOR EXPANSION OF WATER SUPPLY SYSTEM IN SVAY RIENG

FINAL REPORT

FEBRUARY 2022

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

CTI ENGINEERING INTERNATIONAL CO., LTD.
WATER AND SEWER BUREAU, CITY OF KITAKYUSHU
TEC INTERNATIONAL CO., LTD.

GE
JR
22-030

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EXCHANGE RATE (based on the average exchange rate June, 2021)

USD 1 = JPY 109.97

PREFACE

Japan International Cooperation Agency (JICA) decided to conduct the preparatory survey and entrust the survey to Consortium consist of CTI Engineering International Co., Ltd., Water and Sewer Bureau, City of Kitakyushu and TEC International Co., Ltd.

The survey team held a series of discussions with the officials concerned of the Royal Government of Cambodia and conducted field investigations. As a result of further studies in Japan, the present report was finalized.

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

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

February,2022

EIJI IWASAKI
Director General,
Global Environment Department
Japan International Cooperation Agency

Summary

1. Overview of the Kingdom of Cambodia

(1) Natural Condition

The Kingdom of Cambodia (hereinafter referred to as Cambodia) is located on the Indochinese peninsula, bordering Thailand in the northwest, Laos in the northwest and Vietnam in the southeast. In 2019, Cambodia had the total population of 15.28 million and land area of 181,035 km^2 (Cambodia Ministry of Planning Statistic Bureau). The Tonle Sap River originating from the Tonle Sap Lake which is the largest freshwater lake on the Indochinese Peninsula, and the Mekong River originating in the Tibetan Plateau, are the two largest rivers. These two major rivers join in the capital Phnom Penh. Most of the land consists of plains, but there are mountain ranges in the northeast, northern and northeast of Cambodia. In addition, the northern and northeastern border with Vietnam and Laos are covered with deep forests and become treasures of wildlife and virgin forests. The climate of Cambodia belongs to the tropical monsoon climatic zone, and the rainy season and dry season are divided clearly. Generally, the former is from May to October and the latter is from November to April. The average annual rainfall in the period of 2000 to 2019 was 1,480mm, and the highest average annual rainfall in this period was 2,161mm in 2019.

(2) Socio-Economic Condition

The economy of Cambodia has been showing a high growth rate since the new government started under the new constitution in 1993 after the end of the civil war. Agriculture, manufacturing industry, construction industry and service industry in Cambodia were particularly excellent from 2004 to 2007, and its economic growth rate exceeded 10% continuously for four consecutive years. Since the manufacturing industry and construction industry has fallen to negative economic growth in 2009 due to the Lehman Shock, the economic growth rate slowed down to 0.1%. However, the economic growth rate recovered afterward and showed a high rate of more than 7% for nine consecutive years from 2011 to 2019. Sectoral factors that triggered the economic growth of Cambodia in recent years are regarded as the garment product export to North America in the manufacturing industry, the construction rushes of condominium or resort facilities in the construction industry, and the growth of tourism and retail sales in the service industry. The impact of the COVID-19 pandemic has seriously affected the economic conditions in the world, and it brought about the -3.1% growth in 2020 in Cambodia. However, according to the prospect of IMF in September 2021, the economic growth rate will become positive from 2021 and will recover to about 5% in 2022. On the other hand, poverty reduction is still an important issue in Cambodia although the ratio of 53.2% in 2004 improved to 13.5% in 2018.

2. Background of the Project

After the improvement of drinking water supply system in Phnom Penh by the Royal Government of Cambodia (RGC), the government had kept improving the system in provincial cities by expanding the accomplishment of water supply system in Phnom Penh. JICA has been supporting the government through Technical Cooperation, Grant Aid and ODA Loan.

"The Master Plan of Greater Phnom Penh Water Supply in the Kingdom of Cambodia" was formulated under the support of JICA in 1993 after the civil war. Based on the master plan, the drinking water treatment plant (WTP) and distribution water pipe networks were constructed through Japanese Grant Aid. The strengthening of management, operation and maintenance for the water supply system has progressed through the technical cooperation with Water and Sewer Bureau, City of Kitakyushu and so on.

Synergistic effects with other donor's support made the Phnom Penh Water Supply Authority (PPWSA) as one of the best water supply corporations in Asia (90% of water supply coverage ratio, 8% of water loss rate and 24-hour water supply in 2006). Meanwhile, the water supply coverage ratio in the provincial cities of Cambodia was at 35% in 2005.

The target for water supply ratio in urban areas of provincial cities, i.e., 100% by 2025, has been propagated in the Ministry of Industry and Handicrafts (MIH, then ministry in charge)[1], and the RGC proceeded with the expansion of water supply facilities in provincial cities.

It will then become possible to operate water supply systems fairly. However, the water supply coverage ratio of provincial cities is presently low because of the low production capacity. For example, in Svay Rieng City which has approximately 100,000 people in the administrative area[2] of Waterworks (WWs), could only supply water to approximately 24,000 people (in 2019), and the water supply coverage ratio was approximately 23.6% in Svay Rieng City.

Under the circumstances, to achieve the target of 100% water supply coverage ratio by 2025, the expansion of the water supply systems is an urgent issue requiring a definite and workable solution. In August 2016, the RGC made an official request for Japanese Grant Aid for "The Project for Expansion of Water Supply Systems in Pursat and Svay Rieng City in the Kingdom of Cambodia", to improve the water supply services in Pursat City and Svay Rieng City. (The official request letter was submitted in June 2017).

[1] MIH was renamed as Ministry of Industry, Science, Technology and Innovation (MISTI) in 2020.
[2] The definition of administrative area in this case is based on the area reviewed in October 2015 for the provincial Waterworks (WWs) that will be allowed to supply water under the administrative responsibility of the former Secretary of State H.E. Ek Sonn Chan of MISTI.

According to the discussion results with the Cambodian officials during the first field survey from June to September in 2017, both sides agreed as follows:

- Preparation for grant aid on the expansion of water supply system in Pursat City based on the request will start; and
- Although the field survey on Svay Rieng City had started as the premise for using surface water from Vay Kor Lake, it became clear through the field survey and analysis in Japan that the surface water development from the lake is almost impossible because of the unsteadiness of Vay Kor Dam, the insufficient embankment height of the access road to the dam against flood, and the low discharge capacity of its downstream.
- Therefore, the possibility of groundwater as the water source for this project should be checked by conducting additional groundwater surveys with some extension of the total schedule.

Based on the above background, the Pursat City portion of the project has to be separately carried out and completed, while the Svay Rieng City portion with the target year of 2027 has to be studied alone. This project (hereinafter referred to as "this project") aims to improve the access rate to safe water, provide stable water supply services and improve the quality of life of residents by expanding and improving the water supply systems in Svay Rieng City.

3. Results of Preparatory Survey and Scope of the Project

(1) Results of the Preparatory Survey

The Japan International Cooperation Agency (JICA) dispatched the Preparatory Survey Team (Survey Team) to Cambodia five times to carry out activities including the joint survey of Pursat and Svay Rieng based on the above-mentioned background.

【Survey for Pursat and Svay Rieng】

The first field work: From May 21, 2017 to July 23, 2017
(Including inception meeting)
The second field work: From August, 9 2017 to October 15, 2017
(Including the meeting of Minutes of Discussions (MD) as for the first and second field survey result)

【Survey for Svay Rieng after determination of water source】

The third field work: From November 5, 2019 to December 22, 2019
The fourth field work: From January12, 2020 to March 8, 2020

Online meeting April 12, 2021
(Meeting for resume of the project)
The fifth field work: From November 28, 2021 to December18, 2021
(Including draft outline design (DOD) meeting)

The team conducted the measuring survey, geological survey, water quality survey and the present conditions of the existing water supply facilities, as well as environmental and social condition in Svay Rieng City.

A detailed survey on the soundness of the Vay Kor Dam was conducted by the Japan Water Agency in 2018, and it was concluded that there was no need for urgent reconstruction of the Vay Kor Dam with the appropriate maintenance by the Cambodian side. Therefore, both parties agreed to switch the water source from groundwater to surface water in 2019, and continued the survey. Therefore, this preparatory survey for Svay Rieng consists of the appropriate outline design as a grant aid project by formulating the project implementation plan and carrying out project cost estimation after confirming the requested contents from the Cambodian side and evaluating the validity of the project scale.

As a result, by the target year 2027 in Svay Rieng, the stable water supply of 13,360 m^3 (maximum per day) combined with the capacity of the existing facility is expected for 86.7% of the urban area[3] population, 18.5% of the rural area population by constructing new WTP with the capacity of 6,800 m^3/day on this project.

(2) Scope of the Project

1) Construction of Water Supply Facilities

The water supply facilities to be constructed are as follows:

Intake and Raw Water Transmission Facilities

Classification of Facilities			Structure
Major Items	Middle Items	Minor Items	
Water Supply 7,480m^3/day	Intake Pump station	Pump House	Reinforced concrete, Rectangle, Basement structure Ground floor: B11.6m × L16.0m × H3.3m（Under beam） Bacement floor: B7.5m × L10.5m × H6.9m（Under beam） : Electrical room, Generator room, Pump room, Office, Toilet, Suction pit, Intake pump (5.2m^3/m, 19m, 2 pumps)
Conveyance Facility	Conveyance Pipe	Conveyance Pipe	DIP, Diameter 350mm L=2.9km

Source: Survey Team

[3] The definition of urban area is based on "Reclassification of Urban Areas in Cambodia, 2011" published by the Ministry of Planning (MOP). (1) The population density is over 200 people / km^2, (2) The population of farmers is less than 50%, and (3) The total population of the commune is over 2000 people.

Water Treatment Plant

Items	New Svay Rieng WTP Design Water Treatment Capacity: 7,480m^3/day, Design Maximum Daily Demand: 6,800m^3/day	
	Contents	Qty
Receiving Well	Reinforced Concrete Structure Internal Dimension: Width 1.50m×Length 3.90m×Depth 4.60m Volume (V): 26.9m^3, Retention Time (T): 5.2min (Criteria: T ≧1.5min)	1 Basin
Mixing Well	Reinforced Concrete Structure The method to utilize the energy of water flow itself Internal Dimension: Width 1.50m×Length 1.50m×Depth 4.19m Volume (V): 9.43 m^3, Retention Time (T): 1.82min (Criteria: 1＜T＜5min)	1 Basin
Flocculation Basin	Reinforced Concrete Structure Slow Mixing Method: Up-and-Down Roundabout Type (zigzag flow) Number of Stage: five (5) Stages Internal Dimension per Basin: Width 7.00m × Length 3.65m × Average Effective Water Depth 3.78m (Height 4.50m) G Value: 10 – 75 (1/s) GT Value: 23,000 – 210,000	2 Basins
Sedimentation Basin	Reinforced Concrete Structure Horizontal Flow Sedimentation Type Supernatant Water Collecting System: Collecting Trough + Submerged Orifice Internal Dimension per Basin: Width 7.00m × Length 20.00m × Average Water Depth 4.4m Surface Loading: Q/A=18.6mm/min (Criteria:15-30mm/min) Mean Velocity (V): 0.08m/min (Criteria: 0.40m/min or below)	2 Basins
Rapid Sand Filter (Reference) *	Reinforced Concrete Structure Type: Self-Balancing Type Internal Dimension per Basin: Width 2.50m×Length 6.00m Filter Sand Thickness: 1.0m Underdrain System: Perforated Block Filtration Rate (V): 124.7m/day (Criteria: 120-150m/day) Backwash Method: Air Wash + Water Wash	4 Basins
Service Reservoir	Reinforced Concrete Structure using Flat Slab Structure Effective Volume per Basin (V): 2,188m^3 (1,094m^3 × 2Basins) Effective Water Depth (H): 3.8m (Criteria:3-6m) Retention Time (T): 8hours (Set from daily-water demand fluctuation) Internal Dimension per Basin: Width 12.00m × Length 24.00m × Height 4.50m	2 Basins
Drainage Basin	Reinforced Concrete Structure Volume (V): 198.0m^3 (99.0m^3 × 2Basins) (Volume per Basin: More than one-time wastewater volume) Internal Dimension per Basin: Width4.00m × Length 11.00m × Effective Water Depth 2.25m (Height 5.60m)	2 Basins
Drying Bed	Reinforced Concrete Structure Effective Area (A):550.4m^2 (Area per bed: Width 8.6m×Length 16m＝137.6m^2) (Average Turbidity: After calculating the amount of generated sludge from the coagulant injection rate, the area from the planned sludge load is calculated.)	4 Beds
Chemical Feeding Facilities (In Chemical Building)	Coagulant: PAC Injection Method: Gravity Flow from Constant Water Level Tank. Acid and Alkali Agents: Lime (for supplementing the alkali content consumed by the coagulant)	1 Unit

Items	New Svay Rieng WTP Design Water Treatment Capacity: 7,480m^3/day, Design Maximum Daily Demand: 6,800m^3/day	
	Contents	Qty
	Injection Method: Gravity Flow (The agents are quantified with a powder quantifier and dissolved by water flow.) Chlorine Agents: Calcium Hypochlorite (Bleached Powder) Injection Method: Gravity Flow from Constant Water Level Tank.	
Power Generator Equipment (In Chemical Building)	Capacity: Long Running Type 350KVA Type : Low Noise Cubicle Type	1 Unit
Chemical Building	Reinforced Concrete Structure, 3Storey Building, Total Floor Area (A):425.8m^2 (Usage) Ground Floor: Workshop, Storage, Emergency Generator Room, Toilet Chemical Delivery Facility (1-3 Fl. Open Ceiling) 1st Floor: Waste Solution Reservoir, Chemical Injection Equipment 2nd Floor: Chemical Dissolving Tank Room	1 Unit
Administration Building	Reinforced Concrete Structure, One (1) Story Building, Total Floor Area (A): 266.7m^2 (Usage) Ground Floor: Office Room, Meeting Room, Monitoring Room, Laboratory, Toilet	1 Unit

Note: * As stated in section 2-2-2-5-(4)-4), since the specification and structure of rapid sand filter is based on bidder's proposal, the description on the above table is for reference.

Source: Survey Team

Distribution Facilities

Facility	Type and Structure	Quantity
Service Reservoir (Inside the new WTP)	Reinforced concrete (RC) Structure, Rectangle, two reservoirs Effective Capacity: V=1,094 m^3 × 2 Effective depth: H=3.80 m Water Level: HWL+3.90m, LWL+0.10m Foundation: Direct Foundation	1 set
Distribution Pump Facilities (Inside new WTP)	Horizontal Volute Pump 3.5m^3/min H=55m 75kW Inverter Equipment	3 Pumps (including one standby pump)
Distribution Pipes	DCIP Straight Pipe: T type, Thrust Blocking: Retainer Gland φ400mm L= 0.1km / φ350mm L= 0.4km / φ300mm L= 0.4km	0.9 km
	HDPE φ250mm L= 6.6km / φ200mm L= 2.9km / φ150mm L= 9.5km / φ100mm L= 15.4km / φ 80mm L= 33.2km / φ 50mm L= 43.3km	110.9km
	Bridge-piggybacked Water Main SP (corrosion prevention coating) φ 80mm 5 places / φ 50mm 1 place	6 Places
Monitoring System of Water Distribution	・Central monitoring station: data transmission equipment, monitoring computer, printer & ancillary equipment ・Flow monitoring station: Distribution pipeline 2 stations (For each station; φ200 flow meter 1 unit, φ250 flow meter 1 unit, data transmission equipment & ancillary equipment) Existing water treatment plant 1 station (data transmission equipment & ancillary equipment, 1 unit of flow signal will be received from existing flow meter) ・Pressure monitoring station: Distribution pipeline 4 stations (For each station; 1 pressure transmitter, data transmission equipment & ancillary equipment) ・Outline of equipment specification: Data transmission equipment(center): PLC, Router 1 set Data transmission equipment(local): RTU, GPRS router 7 sets Flowmeter: Electromagnetic flow meter φ250 2 sets φ200 2 sets Pressure Transmitter: 2 wire type transmitter 4 sets	1 LS

Note: Pipe length of water main bridges and the bridge-piggybacked water mains shall be included in the length of ductile cast iron pipes and HDPE pipes.

Source: Survey Team

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 household, the following equipment will be procured under Japanese grant aid:

Item	Equipment/Material	Specification	Qty
Equipment for Water Quality Analysis	Water Quality Instruments	Distillation apparatus, Turbidity meter, pH meter, Electric conductivity meter	1 set
	Uninterruptible Power System (UPS)	Output capacity: 3kVA	1 set
	Continuous Measurement Water Quality Analyzer	Analyzer that continuously measures the turbidity of treated water. Measurement range: 0-100NTU (Turbidity), 0-3mg/L (Residual	1 set

Item	Equipment/Material	Specification	Qty
		chlorine)	
	Reagents	pH standard solution, BTB reagent, DPD reagent, etc.	1 set
	Glassware	Beaker, Measuring flask, Pipette, burette, etc.	1 set
	Laboratory Table	Central laboratory table (including reagent shelf, socket outlet, piping and wiring), Side laboratory table and sink	1 set
	Other	Storage shelf, Refrigerator and desk/chair	1 set
Tools for Electrical Machinery Equipment	Clamp Power Meter	Voltage range: AC600V Current range: AC600mA-AC 1,000mA (or above)	1 set
	Insulation Resistance Meter	For analog indication Value 250V Range : 0 – 50MΩ 500V Range : 0 – 100MΩ 1000V Range : 0 – 2000MΩ For digital indication Value 250V Range : 0 – 500MΩ 500V Range : 0 – 2000MΩ 1000V Range : 0 – 4000MΩ	1 set
	Ground Resistance meter	0 – 1000Ω	1 set
	Vibration Checker	Acceleration: 0.02 – 200m/s^2、Velocity:0.3 – 1,000mm/s Displacement: 0.02 – 100mm	1 set
	Mechanical Torque Wrench	Measurement Range: 50 – 300Nm	1 set
	Portable Ultrasonic Flow meter	Measurement Range of Pipe Diameter: 13 – 600mm	1 set
	Sieve Shaking Machine	Effective Diameter: 0.8mm – 1.0mm	1 set
Maintenance for Distribution Pipes	Electrofusion Machine and Accessories for PE Pipes	φ63 – 280mm	1 set
Accounting System Equipment	SUMS System	Three (3) Computers (for billing, accounting and casher, one PC for one software), one (1) UPS, one (1) Printer, SUMS Software (two (2) Full Licenses, one (1) Light License) Software of full license includes “Billing “and “Accounting”. Software of light license includes “Casher”. Since each software of “Billing”, “Accounting”, “Casher” is operated by separated PCs, three (3) PC will be required.	1 set
Service Connection Installations	Water Supply Equipment	Per 1 set ・ Snap taps with saddle from distribution pipes (DN350mm~OD63mm) ・ HDPE water supply pipe (diameter 25mm) 30m ・ Water meter (diameter 15mm, Tangential flow impeller type, Single-jet, Class C, Rotatable display (Max.270 degree)) ・ Stopcock (diameter 15mm) ・ Attachment (joint, coupling, etc.)	375 sets

Source: Survey Team

3) Technical Assistance (Soft Component)

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

- Operation and maintenance of water treatment facilities
- Operation and maintenance of water transmission and distribution facilities
- Production management (Water supply facility management)

4. Implementation Plan and Cost Estimation

(1) Implementation Plan

The project will be implemented under Japanese's Grant Aid based on the Grant Agreement (G/A) between the RGC and JICA after the Exchange of Notes (E/N) has been concluded between the RGC and GOJ. The project will begin with the detail design study immediately after the signing of contract for consultancy services. The consultancy services will require 12 months including E/N, engineering design services, preparation of tender documents and tender administration. The total construction period will be 23 months including the construction of facilities and procurement of equipment.

(2) Approximate Project Cost

Total expenses of the Cambodian side will be approximately 668,229 USD. The expense items will be ground leveling for intake facility and drinking WTP, UXO survey, environmental monitoring survey, information and communication, electric power lead-in to new intake plant and new drinking WTP, bank arrangement, house connection works using procured equipment for poverty households and so on.

5. Project Evaluation

(1) Validity of the Project

Beneficiary of the Project

The water supply capacity to residents in Svay Rieng City will be improved under the project. The water supply ratio in the administrative area has been 23.6% in 2019 and will increase by 52.6% in the target year of 2027. The water supply ratio in the urban areas, which MISTI targets, will be 86.7%. The number of beneficiaries increase (population newly served) will be approximately 32,419 persons (22,543 persons in the urban areas while it will be 9,876 persons in rural areas).

Urgency of the Project

Although Svay Rieng City operates an existing water service system, its water supply ratio remains at 23.6% as of 2019. Accordingly, the expansion of water supply facilities is urgently needed to further improve the water supply ratio.

Consistency with the National Strategic Development Plan

The National Strategic Development Plan (NSDP) 2019-2023 has set the target of achieving 100% water supply ratio in urban areas by 2025. Ninety percent (90%) of the urban population

served are presently covered by water pipes, while the remaining 10% are covered by other means. This target will be more or less achieved when the area is limited to the urban population in the administrative area managed by the SWWs and the project will help achieve this aim in Svay Rieng City. Moreover, the project will procure materials and equipment for poor households to encourage them to connect to the service pipes, the installation cost of which will be borne by the Cambodian side. Accordingly, the project will ensure consistency with the measures for the poor, the largest target group in the NSDP.

Consistency with Japan's ODA Policy

"Improving the quality of life" is also included in the priority areas of the Country Assistance Policy for Cambodia (July 2017) of the Government of Japan, support for which will be provided in sectors that help improve the urban living environment, such as water supply and sewage, water discharge, electric power (reducing areas with no electricity), urban transportation (urban railway, bus and vehicle registration). Accordingly, the project implementation is consistent with Japan's assistance policy.

(2) Effectiveness

The following quantitative and qualitative effects are expected to confirm the effectiveness of the project:

Quantitative Effects

By expanding the water supply facility in Svay Rieng City, the effects as shown in the table below are expected.

No.	Indicator		Baseline (Measured in 2019)	Target (in 2027) [Two years after Completion]
1	Daily average water supply amount (m^3/day)		4,627	10,009
2	Population served (persons)[4]		23,545	55,964
3	Water supply ratio	Whole administrative area	23.6	52.6
		Urban area	48.9	86.7
4	Water pipe connection to poor households (Poor levels 1 and 2)		53	1,254

Note: For calculation method, see 2-2-2-1.

Source: Survey Team

Qualitative Effects

The qualitative effects of the project are as follows:

[4] When the population in the service area increases as expected, the water supply ratio will increase from 23.6% in 2019 to 52.6% in the administrative area and 86.7% in the urban area in the administrative area in 2027.

- Improving the living environment of residents (improving the public health environment of residents who used to use rainwater, etc., and improving convenience)

As above, the validity of the project is high, and its effectiveness is expected.

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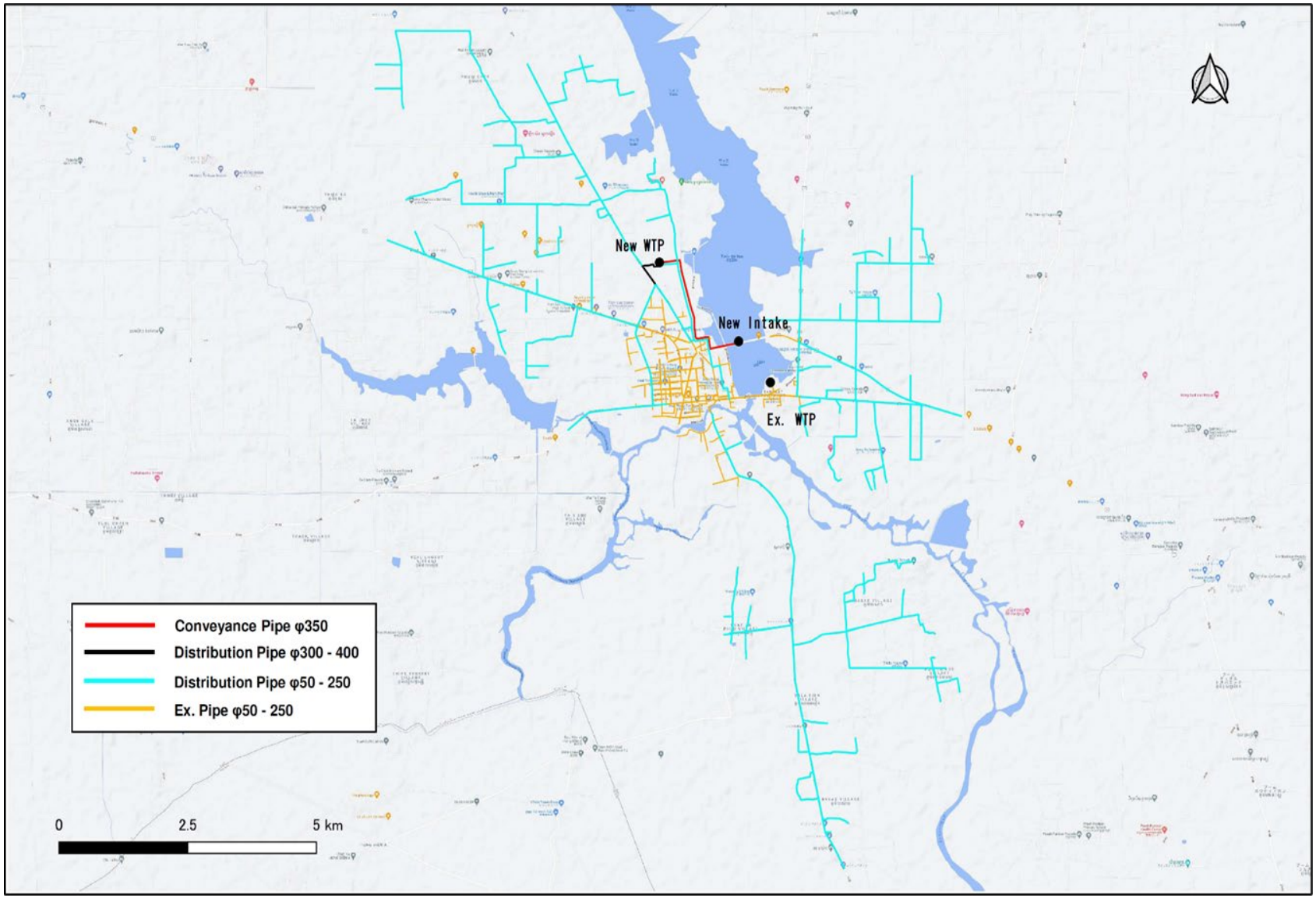
[APPENDECES]

Location Map



Facility Layout Plan of the Project Area

【Intake Facility】

【Water Treatment Facility】

Perspective View of Intake and Water Treatment Facilities

■Photos

Planned Site for New Facilities

Photo-1 : Proposed intake site (North side of Vay Kor Lake across National Highway No.1)

Photo-2 : Road condition near the proposed intake site. Conveyance pipes will be laid on the shoulder of the road.

Photo-3 : Near the proposed intake site. Repair of road shoulders by the Cambodian side.

Photo-4 : Repair of riverbed scouring on the downstream side of Vay Kor Dam by the Cambodian side.

Photo-5 : Proposed WTP site. Originally a wooded area, tree trimming has been completed.

Photo-6 : Road shoulder where distribution pipes will be laid.

Situation of Water Utilization

	
Photo-7 : A motor pump is installed in the riser pipe of the original hand pump.	Photo-8 : A motor pump is installed in a hand pump well constructed by UNICEF.
	
Photo-9 : Drinking water is used through a sand filter when the well water is turbid.	Photo-10 : Especially in the rainy season, rainwater is stored in jars and used for drinking.

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ABBREVIATIONS

ADB	Asian Development Bank
ADCP	Acoustic Doppler Current Profiler
AFD	Agence Française de Développement
A/P	Authorization to Pay
APGR	Annual Population Growth Rate
ARAP	Abbreviated Resettlement Action Plan
B/A	Banking Arrangement
BM	Benchmark
CDC	Council for the Development of Cambodia
CMAC	Cambodia Mine Action Center
CMDGs	Cambodia Millennium Development Goals
CRC	Complaint Resolution Committee
DD	Detailed Design
DIH	Department of Industry and Handicraft
DIP (DCIP)	Ductile Cast Iron Pipe
DISTI	Department of Industry, Science, Technology and Innovation
DOA	Department of Agriculture
DOWRAM	Department of Water Resources and Meteorology
DOE	Department of Environment
DPWS	Department of Potable Water Supply
DPWT	Department of Public Works and Transport
EAC	Electricity Authority of Cambodia
EC	Expropriation Committee
EDC	Electric du Cambodia
EMP	Environmental Management Plan
EMOP	Environmental Monitoring Plan
E/N	Exchange of Notes
EIA	Environmental Impact Assessment
EL	Elevation
EPC	Environmental Protection Contract
FS (F/S)	Feasibility Study
G/A	Grant Agreement
GOJ	Government of Japan
GPRS	General Packet Radio Service
GRET	Groupe de Recherche et d'Échanges Technologiques
HDPE	High Density Polyethylene
HH	Household
HW	Headworks
HWL	High Water Level
IBA	Important Bird Area
IEC	International Electrotechnical Commission
IEE	Initial Environmental Examination
IEIA	Initial Environmental Impact Assessment
IMO	Independent Monitoring Organization
IRC	Inter-ministerial Resettlement
ISO	International Organization for Standardization
IUCN	International Union for Conservation of Nature and Natural Resources
IWRM	Integrated Water Resources Management
JEC	Japanese Electrotechnical Committee

JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standard
KBA	Key Biodiversity Area
KHR	Cambodia Riel
LCC	Life-cycle Cost
Lpcd (LPCD)	litre per capita day, unit water consumption per day per capita
LWL	Low Water Level
MCM	Million Cubic Meter
M/D	Minute of Discussion
MEK-WATSAN	Mekong Region Water Supply and Sanitation Initiative
MEF	Ministry of Economic and Finance
MIH	Ministry of Industry and Handicraft
MIME	Ministry of Industry, Mines and Energy
MISTI	Ministry of Industry, Science, Technology and Innovation
MOA	Ministry of Agriculture
MOE	Ministry of Environment
MOP	Ministry of Planning
MOWRAM	Ministry of Water Resources and Meteorology
MP (M/P)	Master Plan
MPWT	Ministry of Public Works and Transport
MRD	Ministry of Rural Development
MWL	Mean Water Level
NCDD	National Committee for Sub-National Democratic Development
NPRS	National Poverty Reduction Strategy
NRW	Non-Revenue Water
NSDP	National Strategic Development Plan
NTU	Nephelometric Turbidity Units
OJT	On the Job Training
OP	Operating Policy
PAC	Poly-Aluminium Chloride
PAP	Project Affected Person / People
PE	Polyethylene
PIU	Project Implement Unit
PMO	Project Management Office
PMR	Project Monitoring Report
PPWSA	Phnom Penh Water Supply Authority
PVC	Polyvinyl Chloride Pipe
RAP	Resettlement Action Plan
RD	Resettlement Department
RGC	Royal Government of Cambodia
ROW	Right of Way
SCADA	Supervisory Control and Data Acquisition
SDGs	Sustainable Development Goals
SEC	Expropriation Sub Committee
SEDP	Socioeconomic Development Plan
SEZ	Special Economic Zone
SOP	Standard Operating Procedure
SPM	Suspended Particulate Matter
SUMS	Synergistic Utility Management System
SUR	Svay Rieng
S/V	Supervision

SWWs	Svay Rieng Water Works
TOR	Terms of Reference
TPW	Targeted Provincial Waterworks
TSP	Total Suspended Particulate
UN	United Nations
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UN-OCHA	United Nations Office for the Coordination of Humanitarian Affairs
USGS	United States Geological Survey
UPS	Uninterruptible Power System
UXO	Unexploded Ordnance
WB	World Bank
WTP	Water Treatment Plant
WWs	Waterworks

MEASUREMENT UNITS

Length /Thickness	:	km, m, cm, mm, μm
Weight	:	mg, g, kg, t
Time	:	second: s, sec・minute: min・hour: h, hr・day: d・year: y, yr
Pressure	:	Pa, kPa, MPa, mmAq, atm,bar
Volume	:	cm^3, m^3, L (L: liter), MCM
Flow Rate (volume)	:	m^3/h, m^3/min, m^3/d, L/min, mL/min
Flow Rate (mass)	:	kg/h, t/h
Density	:	kg/m^3, g/cm^3, mg/L
Velocity	:	cm/s, m/s, km/h
Viscosity	:	Pa・s, mPa・s
Area	:	mm^2, cm^2, m2, km^2, ha
Frequency	:	Hz
Power	:	W, kW
Voltage	:	V, kV
Electric Current	:	A, mA, kA
Temperature	:	degree C , degC, ℃
Torque	:	N・m
Rotation Speed	:	min-1
Force	:	N
Efficiency	:	%

Chapter 1. Background of the Project

1-1 Background of the Project

The National Strategic Development Plan (NSDP, 2019-2023) of the Royal Government of Cambodia (RGC) has set the target of 100% water supply ratio in urban areas by 2025 (90% water supply ratio by piped water), while the Government of Japan (GOJ) keeps on developing water supply facilities in provincial cities of Cambodia.

In 2007, the GOJ, through the Japan International Cooperation Agency (JICA), the implementation agency of Japanese ODA, in cooperation and collaboration with other donors and the City of Kitakyushu, Japan, etc., started technical cooperation in Cambodia, targeting public water supply entities in eight (8) provincial cities where water treatment plants (WTPs) were constructed, namely; Battambang, Kampot, Kampong Cham, Kampong Thom, Pursat, Svay Rieng, Sihanoukville and Siem Reap. In addition, JICA promoted support for the strengthening of operation and maintenance technology and management capabilities. As a result, the operation of water supply facilities was able to reach a certain level, but due to the small water supply capacity, the water supply ratio in these provincial cities is still low.

In Svay Rieng, the population in the administrative area[1] is about 100,000 people as of 2019, but only about 24,000 people are supplied with piped water while the others rely on the groundwater and rainwater, which have an iron and muddy odor. Therefore, the water supply ratio in the administrative area is only about 23.6% (the water supply ratio in urban areas is 48.9%), so that the expansion of water supply facilities is an urgent issue for Svay Rieng to achieve the NSDP target of 100% water supply ratio by 2025.

Under the above circumstances, the RGC requested the GOJ, in August 2016, to provide financial and technical cooperation for the “Preparatory Survey on the Project for Expansion of Water Supply Systems in Pursat and Svay Rieng” as a Grant Aid project under Japanese ODA, aiming at the improvement of water supply services in Pursat and Svay Rieng.

Based on the request from the Cambodian side, it was decided to conduct this project, and the JICA Survey Team (Survey Team) conducted the preparatory survey, formulated a project plan and conducted the outline design for the purpose of estimating the approximate project cost after examining the validity of the project scale.

However, based on the above request, and as a result of the field survey conducted from May to September 2017, it was found that there was an issue in applying surface water (Vay Kor Lake: reservoir of Vay Kor Dam) due to concerns on the stability of the Dam, which was originally expected in the request, as the water source for Svay Rieng City. Therefore, it became necessary to change the water source from surface water to groundwater and to conduct additional field surveys, deciding to separate the survey for Svay Rieng from that of the Pursat project. The survey for the project in Pursat has been

[1] The definition of administrative area in this case is based on the area reviewed in October 2015 for the provincial Waterworks (WWs) that will be allowed to supply water under the administrative responsibility of the former Secretary of State H.E. Ek Sonn Chan of MISTI.

completed, and the E/N was signed in December 2019. This report is thus prepared only for the Survey of the Project in Svay Rieng which has been officially named as the “Preparatory Survey on the Project for the Expansion of Water Supply System in Svay Rieng”.

In this connection, it should be noted that a detailed survey on the soundness of the Vay Kor Dam was conducted by the Japan Water Agency in 2018, which concluded that there was no need for the urgent reconstruction of the Vay Kor Dam because the Dam could be maintained by simple technologies, such as the addition of concrete and protection of streambed which are applicable in Cambodia. Based on this, the field survey was resumed in November 2019 to update the first field survey results of 2017 under the mutual understanding that the Cambodian side will appropriately maintain the Dam by themselves.

The second field survey was conducted in February 2020, and it was decided that the project scope needs agreement with the Ministry of Industry and Handicraft (MIH ; a then ministry in 2017), the executing agency of the RGC. However, due to the relation with other grant aid project budgets, it was agreed to suspend the project during the field survey, and the agreement on the project scope was once again also postponed, although 2027 was still agreed as the target year of 2027 together with the policy of supplying water to 90% of the urban area.

After that, it was found that a WTP, which has the capacity of 9,000 m^3 and with the intake capacity of 11,000m^3/day and 31km transmission/distribution piping network, will be built for the suburbs of Svay Rieng with a loan from the Asian Development Bank (ADB). In December 2020, the facts were confirmed from Ministry of Industry, Science, Technology & Innovation (MISTI ; renamed from MIH in around April 2020) that the water supply area by the ADB expansion facility does not overlap with the water supply area expected to be implemented by JICA. Both parties agreed on the basic scope of each project and the undertakings of the Cambodian side.

1-2 Natural Conditions

The Survey Team conducted measurement soil and water quality surveys in the project site to obtain basic data. Each survey is outlined as follows and the section “1-3 Environmental and Social Considerations” details the state of natural and project site conditions.

1-2-1 Measurement Survey

Topographic survey

Measurement surveys were conducted in the intake facility site and WTP site. The process of measuring the planned intake facility site included consideration to allow the riverbed shape around the riverside to be recognized, including a cross-sectional survey of the shore of Vay Kor Lake. In addition, a plane survey was also conducted to help determine the shape of the revetment to be installed to the front and rear of the intake facility and the planned scope for the coffer dam installed during the revetment work for intake facility.

Route survey

A route survey was conducted on each major route to be installed, with fewer rough geographical features and most of them relatively flat. Accordingly, there was water distribution to secure sufficient supply pressure and other elements as planned.

1-2-2 Soil Investigation

Planned site for the intake facility

The soils in the intake facility site are as follows: soil from the surface to layers 6.3 m thick on average, comprising loose clay with an average N value of 5, under which lies a secondary layer of average thickness 3.1 m and comprising loose to medium-silty sand with an average N value of 13. The third layer is an average of 3.3 m thick comprising hard clay with the average N value of 9 and the fourth, 4.2 m thick on average, comprises medium to dense silty sand with an average N value of 18. Although each layer can be excavated by backhoe, the bedding of the intake facility constitutes loose clay with an average N value of 5, hence a proper foundation structure is required.

Planned site for the WTP

Soils in the WTP site are as follows: soil from the surface to the average layer thick of 7.3 m is composed of hard sandy clay with the average N value of 15 whereunder the second layer is an average of 6.4 m is hard to very hard clay with sand with the average N value of 18. The third layer is an average of 3.1 m is medium silty sand with the average N value of 23 while the fourth layer with its average thick 17.1 m is hard to very hard salty sand with the average N value of 14. Similar to the planned intake facility site conditions, any layer in the planned WTP site can be excavated by backhoe.

1-2-3 Water Quality Monitoring

Supply water monitoring (wells for domestic use)

Many households within the project area own wells and tap into groundwater for their domestic use. Although no residents consider the well water quality particularly bad, many would prefer to shift to a piped water supply service with convenience, cost and hygiene in mind.

Work to monitor the water quality of wells used in the project site conducted in August 2017 revealed that the turbidity and manganese content of some wells exceeded the drinking water standards.

Supply water monitoring (water source: groundwater)

The quality monitoring of raw and treated water of the Water Works service from July 2017 to May 2018 did not detect any E. Coli and only detected toxic metals on rare occasions. A low-level arsenic concentration was confirmed in the raw water, within the range of 0.012 to 0.028 mg/l, but acceptable levels were achieved when a treatment process was applied.

Iron and manganese concentrations were both high in raw water, while those of treated water did not meet the water quality standards until the membrane filtration facility with a capacity of 2,000 m^3/day was put into service in April 2020. The groundwater is thought to be in a reductive environment and when it comes into contact with air after pumping, the iron it contains starts precipitating. Accordingly, the water treatment process must include sufficient oxidation when the water sourced is groundwater.

The background to the introduction of the 2,000 m^3/day membrane filtration plant will be described later in subsection "2-2-2-5, Plan of WTP".

Supply water monitoring (water source: surface water of Vay Kor Lake)

Between July 2019 and May 2020, the Survey Team monitored the water quality of Vay Kor Lake, earmarked as the water source for the project. Monitoring surveys revealed that clean water was obtainable from Vay Kor Lake by general treatment, although the water was not directly usable for domestic purposes, given ongoing high levels of turbidity and aluminum and iron concentrations. Since a certain level of ammonia concentrations is consistently detected, a sufficient level of free chlorine must be maintained during the water treatment process when the concentration is high.

Supply water monitoring (agrochemicals)

The Survey Team took samples on 20 July 2017, which was considered to be the time the level of agrochemicals peaked. The analysis checked for all 18 pesticides in the Drinking Water Quality Standards of Cambodia (2004) as well as 328 pesticides frequently detected at the Japanese quarantine station and no pesticides were detected.

1-2-4 Flood flow in Vay Kor River

The water level and flood discharge volume of the Vay Kor River will be described later in section 2-2-2-2- (1) -3).

1-2-5 Vay Kor Lake's potential for water source

The water storage capacity of Vay Kor Lake, the water usage status from Vay Kor Lake, and the possibility of water intake from Vay Kor Lake in terms of water volume will be described later in section 2-2-2-2- (1) -4) to 2-2-2-2- (1) -6). In conclusion, the water storage capacity of Vay Kor Lake at the time of the most drought condition is about 10MCM, and it is possible to secure a total required intake volume of 3.8MCM for existing WTP and new WTP.

1-3 Environmental and Social Considerations

1-3-1 Project Components and JICA Environmental Categories

1-3-1-1 Overview of the Project Components that have an Environmental and Social Impact

This is a project for expanding the existing water supply system in response to the request of the RGC. The proposed project is classified as Category B, based on the JICA Guidelines for Environmental and Social Consideration (April 2010; hereinafter JICA Environmental Guidelines), because the potential adverse impacts on the environment and society are less adverse than those of Category A projects.

In consultations with MIH and Ministry of the Environment (MOE), the Survey Team confirmed that an Initial Environmental Impact Assessment (IEIA) is required for this project in the accordance with the Cambodian regulations. As such, the Survey Team assisted in preparing the IEIA.

At the stage of the 2017 survey, the long-term stability of the dam structure which makes Vay Kor Lake as a dam reservoir was questioned. Therefore, the Survey Team decided on the use of groundwater as the source of water instead of the surface water of Vay Kor Lake.

However, as a result of the detailed survey on the Vay Kor Dam conducted by the Japan Water Agency in 2018, it was concluded that there is no need for urgent reconstruction of the Vay Kor Dam and, besides, the use of Vay Kor Lake as water source became possible, so that the policy was changed again to the use of surface water.

There were three components which are considered to make impact on the environment and social conditions, namely; (1) construction of intake facilities, WTP and pipe laying work; (2) operation of intake facilities and WTP ; and (3) equity of beneficiaries.

1-3-1-2 Basic Environmental and Social Circumstances

Cambodia (official name: Kingdom of Cambodia) is a country located in the south of Indochina Peninsula in Southeast Asia. It belongs to the tropical monsoon of climate zone and has clear rainy season and dry season. The project area is as shown in the following figure.

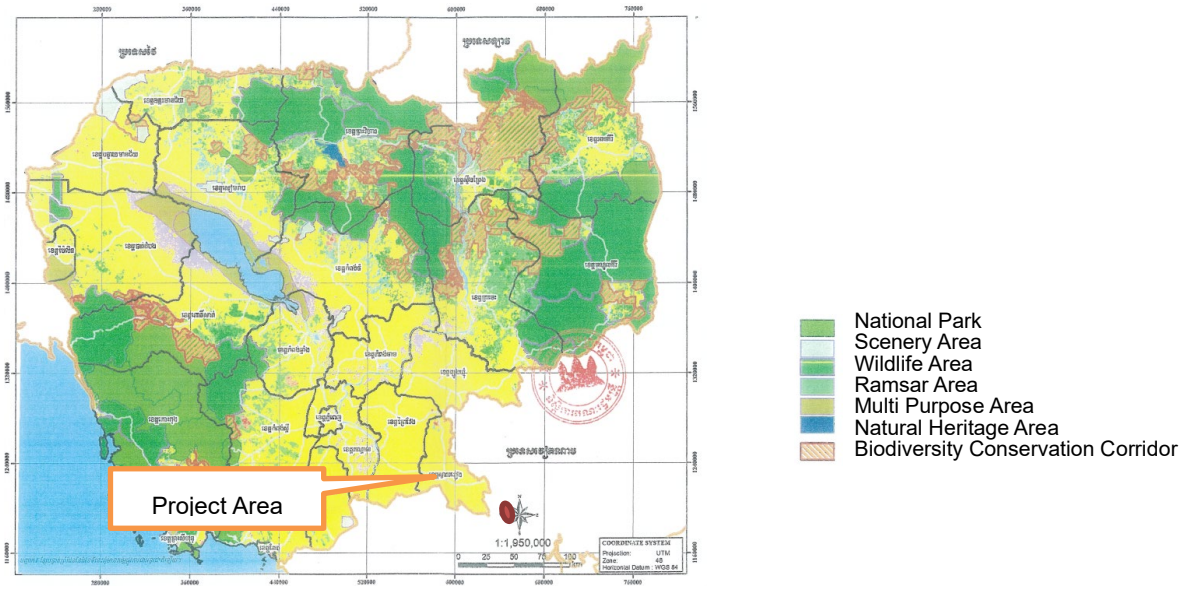
Source: Survey Team

Figure 1-3-1 Project Area

Svay Rieng Province protrudes into the land of Vietnam and holds a long border with Vietnam. Therefore, this place has been hit by heavy air strikes during the Vietnam War, and many unexploded ordnances were found in addition to land mines.

(1) Protected Area

In Cambodia, the “Royal Decree on the Protection of the Natural Area, 1993” was the first regulation determining the natural protection area. The Decree defines 23 natural protection areas into four categories.



Source：Sub-Decree on Establishment of Biodiversity Conservation Corridor in Natural Protected Area

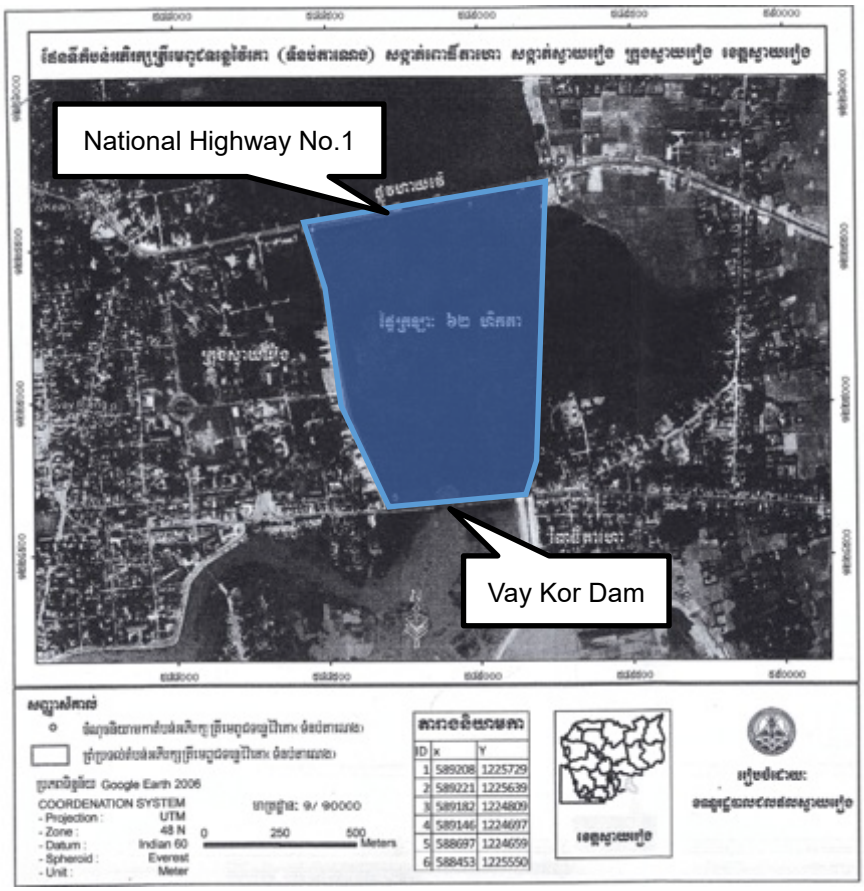
Figure 1-3-2 Protected Areas in Cambodia

In 2008, the "Law on Natural Protected Areas" was enacted, and it defines eight (8) categories for protection purposes and four (4) management zones. Furthermore, in 2017, the "Sub-Decree on Establishment of Biodiversity Conservation Corridor in Natural Protected Area" was enacted to determine the biodiversity conservation corridor, which resulted in about 40% of the country declared as natural protected area.

The following map shows the protected areas. There is no protected area designated by the sub-decree in the vicinity of Svay Rieng. There are 40 areas of Key Biodiversity Areas (KBAs) considered as important places for the protection of biodiversity, and 36 places out of the KBAs are Important Bird Areas (IBAs) in Cambodia.

The closest protected area in the neighboring country, Vietnam, is the Lang Sen Wetland Reserve, which is registered under the Ramsar Convention, but it is about 30 km away and no environmental impact is considered.

On the other hand, information on the protected area, the lower lake area between National Highway No.1 and Vay Kor Dam, was gathered through the interview with the Department of Environment of Svay Rieng The protected area of about 62 ha is indicated in blue color in the following Figure.



Source: DOA, Copy of provincial ordinance

Figure 1-3-3 Protected Area of Vay Kor Lake (Part with Blue Color)

This protected area has been determined by the provincial ordinance that prohibits the capture of any fish in the area for the purpose of preserving the fishery resources of Vay Kor Lake, and allows only traditional fishing outside of the area. Therefore, only the activity related fishing is banned. The Survey Team had several discussions with responsible organizations managing natural resources, such as the Department of Agriculture, Forest and Fishery and the Department of Environment. They mentioned that construction in the area is not prohibited when the mitigation measures are considered well. In fact, the revetment park project is currently under construction at the surrounding bank of the protected area. On the other hand, the location of the water intake for this Svay Rieng Project is planned at the upper stream side of National Highway No. 1 and is outside of the protected area.

(2) Cultural Heritage, etc.

There are three (3) important heritages registered as World Heritage by UNESCO, such as Angkor, but their locations are more than 200km far from the project site. In addition, there are no areas which are unique archaeological, historical, and cultural values around the project site under Cambodian laws and regulations.

(3) State of Natural Environment

Cambodia has very rich natural environment and there are ecologically important places such as Tonle Sap Lake, Mekong River and its tributaries. As described above, the Cambodian government had declared more than 40 % of land as protected area, so that they endeavor to conserve the natural environment.

In this rich environment, there are many kinds of threatened species. The next table shows the species of critically endangered and endangered species in Cambodia.

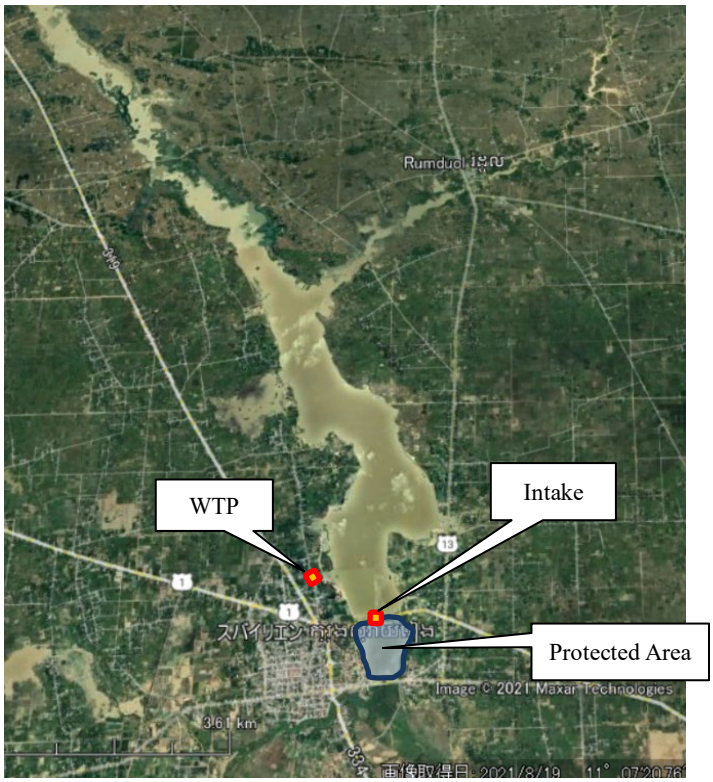
Table 1-3-1 Endangered Species in Cambodia

Status		Class	Number	Species
Critically Endangered CR	Fauna	Mammalia	8	Sumatran Rhinoceros, etc.
		Birds	8	Indian Black Vulture, etc.
		Fishes	18	Mekong Giant Catfish, etc.
		Amphibian	1	Damleis
		Reptiles	5	Common Batagur, etc.
	Flora	Vascular plant	3	Agar Wood, etc.
Endangered EN	Fauna	Mammalia	16	Indian Hog Deer, etc.
		Birds	10	Yellow-breasted Bunting, etc.
		Reptiles	5	Elongated Tortoise, etc.
		Amphibian	3	Musical leaf-litter toad, etc.
		Fishes	20	Jullien's Golden Carp, etc.
		Corals, sea cucumber	7	Golden Sandfish, etc.
	Flora	Vascular plant	22	White Meranti, etc.

Source: IUCN Red List

As a result of interviews with the Department of Environment and the Department of Agriculture, Forestry and Fisheries, it was found that the Giant Barb (scientific name: *Catlocarpio siamensis*) inhabits the Vay Kor Lake. The Giant Barb is the largest fish in the subfamily Cyprininae, and because it is delicious, its population has decreased due to capture; therefore, this species is categorized into “Critically Endangered” species in the IUCN red list. There is no commercial fishing on Lake Vay Kor, but the Department of Agriculture, Forestry and Fisheries is working to educate anglers on the conservation of the fish.

Figure 1-3-4 shows the entire Vay Kor Lake. Vay Kor Lake is divided into the northern pond and the southern pond by National Highway No.1, and the protected area mentioned above is the southern pond. Since the water intake is planned to be installed in the northern pond which is in the opposite side of the road/protected area and in the shallow area beside the road, the direct impact such as decrease in habitat is little. However, mitigation measures to protect fish from invading or being inhaled by the water intake should be considered.



Source: Survey Team

Figure 1-3-4 Vay Kor Lake and Protected Area

The survey on the ecosystem has been conducted as a hearing and practical survey at the site. The result is summarized below.

1) Birds

There are 57 species of birds recorded as shown in Table 1-3-2. Among them, 55 species are listed as Least Concern (LC) in the IUCN Red list and two (2) species are not listed. These are common and widely spreading species. Typical species recognized in the survey area are sparrows, spotted doves, yellow-vented bulbuls, etc., and many species prefer open areas, farmlands, and wetlands. The habitats near the project target area are already developed and the population density of birds is not high. According to interviews with officials of the concerned department, some species have been declining in number due to illegal hunting and increasing temperatures due to climate change in recent years.

By comparing with the list of appendices of CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora, also known as the Washington Convention), the two species (Common Barn-owl and Black-shouldered Kite) are included in the Appendix II list, that is, of species not necessarily threatened with extinction but may become so unless trade in specimens of such species is subject to strict regulation. Additionally, Cattle Egret is included in the Appendix III list, that is, of species not necessarily threatened with extinction globally, but trade in these species is permitted with an appropriate export permit. These three species were recognized in the hearing survey.

Table 1-3-2 Results of Bird Survey

No.	Khmer Name	Scientific Name	English Name	MAFF *	IUCN**	CITES***
1	ក្អែកទឹកតូច	*Phalacrocorax niger*	Little Cormorant	C	LC	NA
2	កុកគោ	*Bubulcus ibis*	Cattle Egret	C	LC	III
3	កុកក្រកក្បាលស្នោតខ្ចី	*Ardeola speciose*	Javan Pond Heron	C	LC	NA
4	កុកម្ទេសទុំ	*Ixobrychus cinnamomeus*	Cinnamon Bittern	C	LC	NA
5	កុកសំបកត្រពាំង	*Ixobrychus sinensis*	Yellow Bittern	C	LC	NA
6	ក្រួចអិន	*Mirafra marionae*	Indochinese Bushlark	C	LC	NA
7	ក្រួចអ៊ិនចុងខ្មៅឆ្នូត	*Anthus cervinus*	Red-throated Pipit	C	LC	NA
8	ក្រួចអ៊ិនជើងវែង	*Anthus richardi*	Richard's Pipit	C	LC	NA
9	ក្រួចអ៊ិនទ្រូងឆ្នូតខ្មៅ	*Anthus hodgsoni*	Olive-backed Pipit	C	LC	NA
10	ក្រួចអ៊ិនទ្រូងលាត	*Mirafra javanica*	Horsfield's Bushlark	C	LC	NA
11	កញ្ជក់ស្លាវ៉ែ្លកខ្មៅ	*Rhipidura javanica*	Sunda Pied Fantail	C	LC	NA
12	ក្រួចអ៊ីត	*Turnix suscitator*	Barred Buttonquail	C	LC	NA
13	ខ្លែងស្រាក់	*Tyto alba*	Common Barn-owl	C	LC	II
14	ខ្វែក	*Nycticorax nycticorax*	Black-crowned Night Heron	C	LC	NA
15	ខ្វែកខ្យល់	*Botourus stellaris*	Great Bittern	C	LC	NA
16	ខ្វែកក្រោក	*Gallinago gallinago*	Common Snipe	C	LC	NA
17	ខ្វែកក្រោកកន្ទុយម្ជល	*Gallinago stenura*	Pintail Snipe	C	LC	NA
18	ខ្វែកសំបកត្រពាំង	*Gorschius melanolophus*	Malayan Night Heron	C	LC	NA
19	ក្រលឹងក្រលោង	*Sturnus nigricollis*	Black-collared Starling	C	LC	NA
20	ចចាតក្រចៀកខៀវ	*Alcedo meninting*	Blue-eared Kingfisher	C	LC	NA
21	ចាបដូនតាកន្ទុយវែង	*Lanius schach*	Long-tailed Shrike	C	LC	NA
22	ចាបដូនតារាលស្រែ	*Acrocephalus tangorum*	White-browed Reed-warbler	C	LC	NA
23	ចាបដង្ហូរលឿង	*Prinia flaviventris*	Yellow-bellied Prinia	C	LC	NA
24	ចាបស៊ីរុយខ្មៅស្នោត	*Muscicapa dauurica*	Asian Brown Flycatcher	C	LC	NA
25	ចាបស៊ីរុយតូច	*Niltava davidi*	Fujian Niltava	C	LC	NA
26	ចាបស៊ីរុយតូចខ្មៅស	*NA*	NA	C	LC	NA
27	ចាបស៊ីរុយទ្រូង ឆ្នូតស្នោត	*NA*	NA	C	LC	NA
28	ចាបអ៊ីរ៉ុប	*Passer domesticus*	House Sparrow	C	LC	NA
29	ចាបផ្ទះ	*Passer montanus*	Eurasian Tree Sparrow	C	LC	NA
30	ចាបតេត	*Orthotomus sutorius*	Common Tailorbird	C	LC	NA
31	ចាបព្រៃវែង	*Emberiza aureola*	Yellow-breasted Bunting	C	LC	NA

No.	Khmer Name	Scientific Name	English Name	MAFF *	IUCN**	CITES***
32	ចាបក្រចៃ	*Pycnonotus goiavier*	Yellow-vented Bulbul	C	LC	NA
33	ចចាតក្រឹម	*Alcedo atthis*	Common Kingfisher	C	LC	NA
34	លលកតូច ឬលលកដី	*Geopelia striata*	Peaceful Dove	C	LC	NA
35	លលកជាយ	*Streptopelia chinensis*	Spotted Dove	C	NA	NA
36	លលកខ្មោច	*NA*	NA	NA	NA	NA
37	លលកទ្រាំង	*Streptopelia tranquebarica*	Red Collared Dove	C	LC	NA
38	ល្វាចេក	*Copsychus saularis*	Oriental Magpie-robin	C	LC	NA
39	ល្វាចេកសខ្មៅ	*NA*	NA	C	LC	NA
40	ល្អែតធំ	*Centropus sinensis*	Greater Coucal	C	LC	NA
41	ល្អែតស្សរ	*Centropus bengalensis*	Lesser Coucal	C	LC	NA
42	ជាកូ	*Upupa epops*	Common Hoopoe	C	LC	NA
43	ពពិចក្បាលខ្មៅ	*Pycnonotus atriceps*	Black-headed Bulbul	C	LC	NA
44	រីក ឬ សារិកាកែវគោ	*Acridotheres tristis*	Common Myna	C	LC	NA
45	ស្ទាំងលលក	*Elanus caeruleus*	Black-shouldered Kite	C	LC	II
46	ត្រចៀកកាំ	*Hirundo rustica*	Barn Swallow	C	LC	NA
47	ត្រចៀកកាំចុងខ្ទងស	*Apus affinis*	Little Swift	C	LC	NA
48	ត្រចៀកកាំដើមត្នោត	*Cypsiurus balasiensis*	Asian Palm-swift	C	LC	NA
49	ត្រដេវតូច	*Merops orientalis*	Green Bee-eater	C	LC	NA
50	ត្រដេវក្បាលបៃតង	*Merops philippinus*	Blue-tailed Bee-eater	C	LC	NA
51	ត្រដេវក្បាលត្នោតខ្ចី	*Merops leschenaulti*	Chestnut-headed Bee-eater	C	LC	NA
52	តារោខ្មៅ	*Surniculus lugubris*	Drongo Cuckoo	C	LC	NA
53	ប្រទីក	*Dendrocygna javanica*	Lesser Whistling-duck	C	LC	NA
54	ពពិចក្បាលខ្មៅកំប៉ោយ	*Pycnonotus melanicterus*	Black-capped Bulbul	C	LC	NA
55	ពពិចត្រចៀកឆ្នូត	*Pycnonotus blanfordi*	Streak-eared Bulbul	C	LC	NA
56	ពពិចក្បាលខ្មៅចុងខ្ទងស	*Pycnonotus aurigaster*	Sooty-headed Bulbul	C	LC	NA
57	អន្ទេបខ្មៅ	*Dicrurus macrocercus*	Black Drongo	C	LC	NA

*List of Ministry of Agriculture, Forestry and Fishery
R:Rare, C:Common
**IUCN Red list
***Appendices of CITES
Least Concern : LC, Data Deficient : DD, Vulnerable : VU

2) Fishes

The survey was conducted at the Vay Kor Lake by hearing and practical capture survey. The results are as shown in Table 1-3-3, namely; 37 species of fish and 8 aquatic creatures such as freshwater

shrimps and crabs. Among the total 45 species, *Mystas bocourti* which is a kind of catfish, is categorized into vulnerable species in IUCN. The others are low risk species or not listed.

On the other hand, an official of the Department of Fishery mentioned the presence of Giant Barb which is an endangered species in the lower pond of Vay Kor Lake.

Table 1-3-3 Results of Fish Survey

No.	Khmer Name	Scientific Name	English Name	MAFF *	IUCN**	CITES***
1	ត្រីចង្វាអង្គរ	*Garra cambodgiensis*	Stonelapping minnow	NA	LC	NA
2	ត្រីចង្វាស្រែ	*Amblypharyngodon chulabhornae*	NA	NA	LC	NA
3	ត្រីចង្វាស្ទឹង	*Chela caeruleostigmata*	Leappian glass barb	NA	NA	NA
4	ត្រីចង្វាភ្លៀងស្រែ	*Esomus longimanus*	Long-fin flying minnow	NA	DD	NA
5	ត្រីចង្វាភ្លៀងឆ្នូត	*Esomus metallicus*	Flying minnow	NA	LC	NA
6	ត្រីចង្វាមូល	*Rasbora hobelmani*	Kottelat rasbora	NA	NA	NA
7	ត្រីចង្វាឆ្នូត	*Rasbora paviana*	Pavie's rasbora	NA	LC	NA
8	ត្រីកញ្ចាញ់ច្រាសធំ	*Parambasis apogonides*	Iridescent glassy perchlet	NA	NA	NA
9	ត្រីកញ្ចាញ់ច្រាសតូច	*Parambassis siamensis*	NA	NA	LC	NA
10	ត្រីកន្ត្រែងប្រេង	*Parambassis wolffii*	Duskyfin glassy perchlet	NA	LC	NA
11	ត្រីកន្ត្រៃប់	*Catopra*	Pristolepis fasciata	NA	LC	NA
12	ត្រីក្រាញ់	*Anabas testudineus*	Climbing perch	NA	DD	NA
13	ត្រីផ្ទោង	*Zenarchopterus buffonis*	Buffon's river-garfish	NA	NA	NA
14	ត្រីផ្ទោង	*Zenarchopterus ectuntio*	Halfeak	NA	NA	NA
15	ត្រីក្រីមក្តា	*Trichopsis vittata*	Croaking gourami	NA	LC	NA
16	ត្រីក្រីមព្រៃ	*Betta prima*	NA	NA	LC	NA
17	ត្រីផ្ទក់ / ត្រីរ៉ស់	*Channa striata*	Striped snakehead	NA	LC	NA
18	ត្រីឆ្ពញ	*Macrognathus siamensis*	Peacokck eel	NA	LC	NA
19	ត្រីឆ្ពញភ្នែរ	*Macrognathus semiocellatus*	Eyespot spiny eel	NA	LC	NA
20	ត្រីកំភ្លាញស្រែ	*Trichohodus trichopterus*	Three spot gourami	NA	NA	NA
21	ត្រីកំភ្លាញភ្លឺក	*Trichohodus microlepis*	Moonlight gourami	NA	NA	NA
22	ត្រីឆ្លាំង	*Hemibagrus sp.(cf.nemarus)*	Asian redtail catfish	NA	NA	NA
23	ត្រីឆ្លាំងអុចខ្មៅ	*Hemibagrus spilopterus*	Blackspotted catfish	NA	LC	NA
24	ត្រីកញ្ជះបាយ	*Mystus albolineantus*	White-line catfish	NA	NA	NA
25	ត្រីកញ្ជះស្ទឹង	*Mystus atrifasciatus*	NA	NA	LC	NA

No.	Khmer Name	Scientific Name	English Name	MAFF *	IUCN**	CITES***
26	ត្រីកញ្ឆេះក្តោង	*Mystus bocourti*	NA	NA	VU	NA
27	ត្រីកញ្ឆេះកណ្តរ	*Mystus rhegma*	Rat-face mystus	NA	LC	NA
28	ត្រីកញ្ឆេះជោយស	*Mystus singaringan*	NA	NA	LC	NA
29	ត្រីកញ្ឆេះ	*Mystus wolffi*	NA	NA	NA	NA
30	ត្រីអណ្តែងរិង	*Clarians batrachus*	Walking catfish	NA	NA	NA
31	ត្រីអណ្តែងទន់	*Clarians macrocephalus*	Bighead waiking catfish	NA	NA	NA
32	ត្រីអណ្តែងស្លីក	*Clarias meladerma*	Blackskin catfish	NA	LC	NA
33	ត្រីត្រឌិន	*Ompok eugeneiatus*	NA	NA	NA	NA
34	ត្រីឆ្ពិន	*Hypsibarbus pierrei*	Makong silver barb	NA	DD	NA
35	ត្រីឆ្ពិនប្រាក់	*Barbonymus gonionotus*	Java/Silver Barb	NA	LC	NA
36	ត្រីក្រុសមេម៉ាយ	*Osteocchilus hasseltii*	NA	NA	NA	NA
37	ត្រីក្រុស	*Osteochilus lini*	Dusky face carp	NA	LC	NA
38	កំពីស	*Macrobrachium nipponese*	NA	NA	NA	NA
39	កំពីសស្រែ	*Neocaridina sp.*	NA	NA	NA	NA
40	កំពីសអង្គាម	*Neocaridina serrata*	NA	NA	NA	NA
41	កំពីសដៃធំ	*Macrobrachium ohione*	NA	NA	LC	NA
42	ក្តាមព្រោល	*Johora tiomanesis counsilmani*	NA	NA	NA	NA
43	ក្តាមក្រោង	*Somaniathelpusa sexpunctata*	Black rice crad	NA	NA	NA
44	ក្តាមស្រែ	*Somaniathelpusa sp.*	Black rice crad	NA	NA	NA
45	ក្តាមស្រងែ	*Somaniathephusa sp.*	Black rice crad	NA	NA	NA

*List of Ministry of Agriculture, Forestry and Fishery
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(4) Air Quality

The scheduled monitoring of air quality in this area has not been conducted since the Department of Environment of Svay Rieng has no equipment and manpower to carry out the air quality monitoring. Air quality measurements are conducted by the MOE survey team if need arises.

The project area has not been industrialized, so that the discharge of air pollutants from industrial activities is expected to be very low. The major source of air pollution would be exhaust gas of vehicles. National Highway No. 1 passes through the Svay Rieng City, but traffic is not so much and the emission from vehicles is limited. The topography of this area does not allow the stay of pollutants in the area. For these reasons, the ambient air quality in this area is expected to be good.

The Survey Team conducted an air quality survey on the 3rd of April 2020 to obtain the baseline data and the results are summarized in following table.

Table 1-3-4 Results of Air Quality Measurement (mg/m^3)

Parameters		Planned Site of WTP	Planned Site of Intake	Cambodian Standards	Environmental Standards in Japan (24 hours average)
Carbon oxide	CO	0.44	0.58	20 (8 hours average)	10
Nitrogen dioxide	NO2	0.013	0.024	0.1 (24 hours average)	0.04～0.06 or less
Sulfur dioxide	SO2	0.009	0.001	0.3 (24 hours average)	0.04
Total suspended particulate matter	TSP	0.08	0.17	0.33 (24 hours average)	0.1 (SPM:10μm >)
Ozone	O3	0.023	0.027	0.2(24 hours average)	—
Lead	Pb	ND	ND	0.005 (24 hours average)	—
PM10	PM10	0.03	0.03	0.05 (24 hours average)	—
PM2.5	PM2.5	0.02	0.013	0.025 (24 hours average)	—

Source: Survey Team

The results of parameters meet the Cambodian standards requirements. These are also less than the Japanese environmental standards. Japanese standard of suspended particulate matter is for particles of less than 10μm in diameter, so that it is not referable directly. The TSP include bigger sizes of particles and it might give larger values, so that the TSP is in an acceptable level.

(5) Water Use and Water Quality

The main sources of surface water in the area are the Vay Kor River and the Vay Kor Lake, and there are other small rivers that dry up during the dry season. The area is relatively rich in groundwater; therefore, the existing water supply depends on the groundwater source, and many households in the project area have their own wells for their daily lives.

Almost all households in the area own shallow wells because the cost of digging well is affordably low. According to the result of interview survey, there is no particular complaint regarding water quality, but there are many requests for switching water from well water to piped supply water, from the viewpoint of convenience, economy and hygiene.

The following table shows the results of water quality test of the well conducted in the target area. in August 2017 Turbidity exceeds drinking water standards in 4 of the 10 well samples.

Table 1-3-5 Water Quality of Private Well

Parameter	Sample / date / Unit	GW-1	GW-2	GW-3	GW-4	GW-5	GW-6	GW-7	GW-8	GW-9	GW-10	NDWQS	Japanese drinking water standards	WHO guidelines
	date	8//4	8/5	8/5	8/5	8/5	8/5	8/5	8/5	8/5	8/5			
	Unit													
Turbidity	NTU	16	4	2	30	2	2	4	6	4	22	<5.0	< 2	–
Nitrite (NO2)	mg/L	0	0	0	0	0	0	0.099	0	0.063	0	<3.0	NO2+NO3 <44	–
Nitrate (NO_3^-)	mg/L	0.034	0.15	0.076	0.078	0.032	0.049	1.53	0.037	1.54	0.103	<50		–
Iron (Fe)	mg/L	0.04	0.06	0.01	0.13	0.15	0.17	0.06	0.02	0.02	0.1	<0.3	<0.3	–
Manganese (Mn)	mg/L	0.2	0.15	0.02	0.19	0.05	0.1	0.15	0.24	0.26	0.29	<0.1	<0.05	–
Total Coliform	MPN/100ml	0	0	0	0	0	0	0	0	0	0	0	–	–
E-Coli	MPN/100ml	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: Survey Team

In the early stage of the survey, groundwater was assumed to be the source water; therefore, the Survey Team conducted the water quality monitoring of raw water and treated water of the existing supply system from July 2017 to May 2018. E. Coli was not detected, and toxic metals were rarely detected. Low level concentration of Arsenic was detected in the raw water in the range of 0.012 to 0.028 mg / l, but it was removed to the acceptable level by the treatment process. Iron and manganese concentration is high both in raw and treated water. It is, therefore, thought that the groundwater is in a reductive environment, and when it contacts with the air after pumping, iron starts making precipitation, becomes turbid with coloration. Therefore, sufficient oxidation treatment is required in the water treatment process. The groundwater monitoring results are as shown in Table 1-3-6 and Table 1-3-7.

As mentioned above, the Survey Team had decided on the use of groundwater for the raw water, thus the survey on the water quality of surface water was not conducted until the change of policy of water source from groundwater to surface water. The monitoring of surface water quality was then conducted from July 2019 to May 2020 with a break in the middle.

The surface water monitoring results have been shown in Table 1-3-8. The characteristics of surface water are described as follows.

- No hazardous parameters have been detected.
- The concentration of iron and manganese is high.
- COD, an indicator of organic pollution, is high, and annual average is 4.2 mg /l.
- E.Coli and ammonia which are parameters indicating domestic pollution have been detected.
- High concentration of total nitrogen (1.67mg/l in annual average) and total phosphorus (0.14mg/l in annual average) indicate the progress of eutrophication.
- Ammonia is detected throughout the year ; its annual average is 0.22mg/l.
- The turbidity near the intake is 102 on annual average and tends to be low in winter. The lowest observed turbidity is 32. It is high in the first half of the rainy season from May to August.

The water quality is not suitable for direct use of water as domestic water due to its high turbidity and high concentration of aluminum and iron, but it will be in acceptable quality after the conventional water treatment process. Ammonia is always detected, so that breakpoint treatment may be required at high concentrations.

The data in gray shaded cells in the table are not reliable. Since the doubtful results were observed in the reported analysis data of the MOE of Cambodia, the Survey Team checked the situation at the laboratory and found some erroneous analysis procedures. Therefore, the metal analysis data of MOE is shown as reference only. The Survey Team brought the sample and requested its analysis by a certified laboratory in Japan from December 2019.

Table 1-3-6 Results of Water Quality Survey (1) Groundwater (Raw Water of WTP)

No	Parrameter	Site	Raw water of WTP											NDWQS	Japanese drinking water standards	WHO guidelines
			2017						2018							
		Month	7	8	9	10	11	12	1	2	3	4	5			
1	pH	-	6.39	8.09	6.57	6.58	6.27	6.19	6.26	6.5	6.6	6.8	6.7	6.5-8.5	5.8-8.6	–
2	Water Temperature	oC	31	31	31	31	30	31	28	31	32	30.2	31.5	–	–	–
3	Electrical Conductivity(EC)	µs/cm	297	314	317	318	317	309	338	307	304	314	314	–	–	–
4	Total Dissolve Solids (TDS)	mg/L	284	301	303	305	305	296	324	295	298	307	312	<800	<500	–
5	Dissolved Oxygen(DO)	NTU	30	20	2	8	4	4	0	2	4	2	4	<5.0	< 2	–
6	Turbidity	mg/L Pt	205	210	45	105	40	275	90	140	95	10	65	<5.0	<5	–
7	Color	mg/L	38	30	7	16	2	9.17	19.5	8.5	5	3.5	3	–	–	–
8	Total Suspended Solid(TSS)	mg/L	55	62	23	140	135	145	135	140	130	120	170	<300	<300	–
9	Total Hardness(as CaCO3)	mg/L	0.58	0.58	0.54	1.56	0.11	0.19	0.98	0.58	0.39	0.58	0.98	–	–	–
10	Cyanide(CN-)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.02	<0.01	–
11	Chloride (Cl^-)	mg/L	18.2	28.6	18.2	10.2	8.32	0.06	8.58	15.6	12.5	9.2	20.2	<250	<200	–
12	Ammonia (NH_3)	mg/L	0.03	0.05	0.03	0.35	0.47	0.34	0.21	0.24	0.25	0.24	0.29	<1.5	–	–
13	Fluoride (F)	mg/L	0.36	0.36	0.36	0.32	0.56	0.35	0.35	0.5	0.05	0.25	0.25	<1.5	<0.8	<1.5
14	Nitrite (NO2)	mg/L	ND	ND	ND	0	0.02	0.08	0	0	0	0.03	0.09	<3.0	<44*	<3
15	Nitrate (NO_3^-)	mg/L	0.47	0.63	0.47	0.21	0.5	0.35	0	0.02	0.08	0.42	0.18	<50	as NO_2 + NO_3	<50
16	Aluminum (Al)	mg/L	0.01	ND	0.26	0.02	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.2	<0.2	–
17	Arsenic (As)	mg/L	ND	ND	ND	ND	ND	0.012	0.012	0.012	0.014	0.015	0.028	<0.05	<0.01	<0.01
18	Barium (Ba)	mg/L	ND	1.09	0.09	0.04	0.03	0.10	0.11	0.11	0.11	0.12	0.11	<0.7	–	<1.3
19	Cadmium (Cd)	mg/L	ND	ND	ND	ND	ND	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.003	<0.003	<0.003
20	Chromium(Cr)	mg/L	ND	ND	0.001	0.004	ND	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.05	<0.05 as Cr^{6+}	<0.05
21	Iron (Fe)	mg/L	0.01	0.3	0.09	0.11	0.09	2.90	3.64	4.12	4.00	3.85	3.67	<0.3	<0.3	–
22	Lead (Pb)	mg/L	ND	ND	0.008	ND	ND	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.01	<0.01
23	Manganese (Mn)	mg/L	0.001	0.01	0.07	0.09	0.06	0.28	0.26	0.27	0.27	0.28	0.27	<0.1	<0.05	–
24	Mercury (Hg)	mg/L	ND	ND	ND	ND	ND	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.001	<0.0005	<0.006
25	Nickel (Ni)	mg/L	ND	ND	0.003	0.0005	0.001	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.02	–	<0.07
26	Selenium (Se)	mg/L	Missing	Missing	Missing	Missing	Missing	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.01	<0.01	<0.04
27	Total Coliform	MPN/100ml	0	0	0	0	0	0	0	0	0	0	0	0	–	–
28	E-Coli	MPN/100ml	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* Japanese standard defines value of sum of nitrate nitrogen and nitrite nitrogen as 10mg/l. This is a converted value as nitrate concentration.
Source: Survey Team

Table 1-3-7 Results of Water Quality Survey (2) Groundwater (Treated Water of WTP)

No	Parrameter	Site	Treated water of WTP											NDWQS	Japanese drinking water standards	WHO guidelines
			2017						2018							
		Month	7	8	9	10	11	12	1	2	3	4	5			
1	pH	-	7.69	6.78	6.74	6.78	6.6	6.68	6.6	6.7	6.4	7.5	7	6.5-8.5	5.8-8.6	–
2	Water Temperature	oC	30	30.88	32	31.5	30	31	28	30	31.9	31.8	32	–	–	–
3	Electrical Conductivity(EC)	µs/cm	303	316	309	317	312	311	308	305	325	304	299	–	–	–
4	Total Dissolve Solids (TDS)	mg/L	289	298	297	303	300	309	295	293	319	297	295	<800	<500	–
5	Dissolved Oxygen(DO)	NTU	0	0	0	4	2	4	4	0	4	2	0	<5.0	< 2	–
6	Turbidity	mg/L Pt	55	69	25	65	0	0	30	0	0	0	0	<5.0	<5	–
7	Color	mg/L	1	10	11	13	8	3.89	16	2.5	3.5	4	2	–	–	–
8	Total Suspended Solid(TSS)	mg/L	85	93	37	110	108	105	105	110	110	125	185	<300	<300	–
9	Total Hardness(as CaCO3)	mg/L	0.19	0.19	0.39	1.17	0.19	0.39	1.17	0.98	0.78	0.98	1.17	–	–	–
10	Cyanide(CN-)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.02	<0.01	–
11	Chloride (Cl^-)	mg/L	22.06	25.4	22.06	11.07	10.3	0.27	7.5	7.5	11.2	17.1	19.8	<250	<200	–
12	Ammonia (NH_3)	mg/L	0.01	0.02	0.01	0.21	0.17	0.22	0.29	0.12	0.13	0.08	0.27	<1.5	–	–
13	Fluoride (F)	mg/L	0.18	0.15	0.18	0.31	0.32	0.4	0.37	0.4	0.4	0.4	0.4	<1.5	<0.8	<1.5
14	Nitrite (NO2)	mg/L	ND	ND	ND	0	0	0.02	0.07	0.02	0.02	0.07	0.29	<3.0	<44*	<3
15	Nitrate (NO_3^-)	mg/L	ND	0.51	ND	0.28	0.072	0.48	0.21	0.13	0.13	0.12	0.53	<50	as NO_2 + NO_3	<50
16	Aluminum (Al)	mg/L	0.02	ND	0.78	0.05	0.003	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.2	<0.2	–
17	Arsenic (As)	mg/L	ND	ND	ND	ND	ND	<0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.05	<0.01	<0.01
18	Barium (Ba)	mg/L	ND	1.28	0.19	0.09	0.02	0.09	0.09	0.09	0.09	0.09	0.09	<0.7	–	<1.3
19	Cadmium (Cd)	mg/L	ND	ND	ND	ND	ND	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.003	<0.003	<0.003
20	Chromium(Cr)	mg/L	ND	ND	0.001	0.003	ND	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.05	<0.05 as Cr^{6+}	<0.05
21	Iron (Fe)	mg/L	0.02	0.28	0.02	0.023	0.004	0.14	1.43	0.68	0.17	0.36	0.14	<0.3	<0.3	–
22	Lead (Pb)	mg/L	ND	ND	0.01	0.001	ND	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.01	<0.01
23	Manganese (Mn)	mg/L	0.08	0.26	0.04	0.003	0.06	0.24	0.27	0.25	0.24	0.23	0.26	<0.1	<0.05	–
24	Mercury (Hg)	mg/L	ND	ND	ND	ND	ND	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.001	<0.0005	<0.006
25	Nickel (Ni)	mg/L	ND	ND	0.001	0.001	ND	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.02	–	<0.07
26	Selenium (Se)	mg/L	Missing	Missing	Missing	Missing	Missing	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.01	<0.01	<0.04
27	Total Coliform	MPN/100ml	0	0	0	$2.3X10^2$	0	36	0	0	0	0	0	0	–	–
28	E-Coli	MPN/100ml	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* Japanese standard defines value of sum of nitrate nitrogen and nitrite nitrogen as 10mg/l. This is a converted value as nitrate concentration.

Source: Survey Team

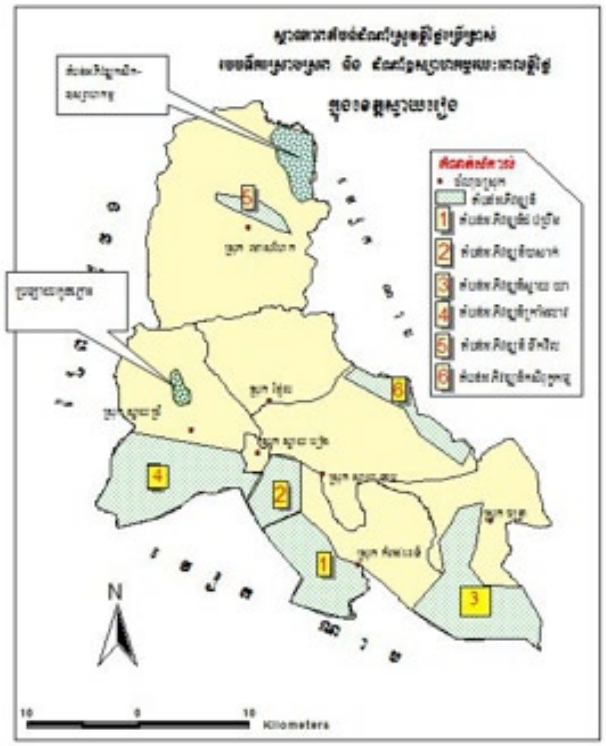
Table 1-3-8 Results of Water Quality Survey (3) Surface water (Near Planned Intake Site)

No	Parrameter	Site	Planned Intake Site											NDWQS	Japanese drinking water standards	WHO guidelines
			2017					2019	2020							
		Month	7	8	9	10	11	12	1	2	3	4	5			
1	pH	-	7.73	6.81	6.49	6.56	6.43	6.73	6.58	6.8	6.86	6.95	6.76	6.5-8.5	5.8-8.6	–
2	Water Temperature	oC	28.2	30	32	30.5	28	26.4	25.6	27	29.5	31.5	31.3	–	–	–
3	Electrical Conductivity(EC)	µs/cm	44.4	33.6	38	42.3	19.2	28.7	30.4	33.5	42.7	43.3	67.4	–	–	–
4	Total Dissolve Solids (TDS)	mg/L	42	32	36	41	19	13	13	15	19	19	30	<800	<500	–
5	Dissolved Oxygen(DO)	mg/L	5.06	5.06	6.76	6.33	5.9	5.07	5.09	5.05	5.06	5.38	5.24	–	–	–
6	Turbidity	NTU	350	230	50	56	48	32	36	38	46	80	155	<5.0	< 2	–
7	Color	mg/L Pt	100	310	430	>>500	230	340	320	320	210	270	200	<5.0	<5	–
8	Total Suspended Solid(TSS)	mg/L	40	83	37	22	28	26	20	30	33	55	123	–	–	–
9	Total Hardness(as CaCO3)	mg/L	22	28	6	95	90	11	8	7	9	15	7	<300	<300	–
10	COD	mg/L	8.23	8.23	5.09	2.35	3.33	1.76	1.76	3.18	4.51	3.8	4.2	–	–	–
11	Cyanide(CN-)	mg/L	ND	ND	ND	ND	ND	ND	0.005	0.006	0.007	0.007	ND	<0.02	<0.01	–
12	Chloride (Cl^-)	mg/L	12.4	10.98	12.4	2.56	1.52	7.5	3.7	4.5	4.5	11.4	12	<250	<200	–
13	Ammonia (NH_3)	mg/L	0.004	0.005	0.004	0.07	0.26	0.35	0.45	0.32	0.32	0.38	0.31	<1.5	–	–
14	Fluoride (F)	mg/L	0.27	0.22	0.27	0.13	0.19	ND	ND	ND	ND	ND	ND	<1.5	<0.8	<1.5
15	Nitrite (NO2)	mg/L	ND	ND	ND	0	0	0.08	ND	ND	0.04	0.08	0.02	<3.0	<44*	<3
16	Nitrate (NO_3^-)	mg/L	0.18	0.11	0.078	0.09	0.04	3	2.1	3.5	4.6	1.9	3.6	<50	as NO_2 + NO_3	<50
17	Aluminum (Al)	mg/L	欠測	欠測	欠測	欠測	欠測	0.50	0.42	0.67	0.93	0.84	1.41	<0.2	<0.2	–
18	Arsenic (As)	mg/L	ND	ND	ND	ND	ND	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.05	<0.01	<0.01
19	Barium (Ba)	mg/L	ND	欠測	0.02	0.17	0.003	0.02	0.02	0.02	0.02	0.02	0.04	<0.7	–	<1.3
20	Cadmium (Cd)	mg/L	0.0009	ND	ND	ND	ND	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.003	<0.003	<0.003
21	Chromium(Cr)	mg/L	0.02	ND	0.004	0.004	ND	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.05	<0.05 as Cr^{6+}	<0.05
22	Iron (Fe)	mg/L	0.58	0.22	0.13	0.013	0.03	1.20	1.05	0.97	0.99	1.54	2.61	<0.3	<0.3	–
23	Lead (Pb)	mg/L	0.005	ND	0.008	0.001	ND	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.01	<0.01
24	Manganese (Mn)	mg/L	0.03	0.009	0.007	0.005	0.004	0.01	0.01	0.01	0.02	0.02	0.04	<0.1	<0.05	–
25	Mercury (Hg)	mg/L	ND	ND	ND	ND	ND	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.001	<0.0005	<0.006
26	Nickel (Ni)	mg/L	0.009	ND	0.003	0.001	ND	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.02	–	<0.07
27	Selenium (Se)	mg/L	Missing	Missing	Missing	Missing	Missing	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.01	<0.01	<0.04
28	Total Coliform	MPN/100ml	$2.0X10^2$	$1.0X10^4$	$2.0X10^2$	$2.3X10^2$	$2.1X10^2$	$7.2X10^1$	$1.1x10^4$	$9.3x10^2$	$2.3x10^2$	92	92	0	–	–
29	E-Coli	MPN/100ml	72	270	72	61	72	36	$1.5x10^3$	$2.1x10^2$	92	< 30	36	0	0	0
30	T-N	mg/L	4	5.9	1.1	3.5	0	0.72	0.27	0.56	0.68	0.47	1.36	–	–	–
31	T-P	mg/L	0.78	0.03	0.06	0.14	0.08	0.15	0.03	0.05	0.06	0.1	0.09	–	–	–

* Japanese standard defines value of sum of nitrate nitrogen and nitrite nitrogen as 10mg/l. This is a converted value as nitrate concentration.

Source: Survey Team

The main industry in Say Rieng is agriculture, especially rice farming. Farmers grow rice once, twice, or thrice a year according to water availability. The yellow part shown in Figure 1-3-5 is the rice farming area of single cropping a year, and the part shown in light green is the area of multi-cropping a year. The area surrounding Vay Kor Lake and upstream of the lake is a single cropping area, which is basically rainfed agriculture.



Legend: Yellow: single-cropping area Light Green: multi-cropping area
Source: DOA

Figure 1-3-5 Rice Cropping Pattern in Svay Rieng

The rice cropping patterns in this area are as follows:

① Middle of July to Middle of November
② Middle of November to Middle of February
③ March to July

Most of the pesticides used in this area are products of Vietnam. Only the fertilizers registered with MOE are allowed to be used in Cambodia, but the illegal use of unregistered pesticides has been reported[2]. Usually, farmers apply fertilizers and pesticides mainly about two weeks after seeding, because they do not transplant seedlings. They sometimes additionally apply pesticides during the sprouting season.

The Survey Team took samples on the 20th of July 2017 at a time considered to be the highest pollution period of agrochemicals in accordance with the result of interview with the Provincial Department of Agriculture (DOA) and farmers. Since there is no laboratory which has the capability

[2] V. Preap, et. Al. (2015), "Current use of pesticides in the agricultural products of Cambodia", FFTC-KU International

to analyze trace levels of pesticides in Cambodia, the Survey Team brought samples to Japan to be analyzed by a certified and experienced laboratory.

All the 18 pesticides of Drinking Water Quality Standards of Cambodia (2004)[3] and the 328 pesticides which are frequently detected at the Japanese quarantine station were analyzed, and no pesticide was detected. Therefore, it is considered that pesticides from rice production do not significantly pollute the water source.

MISTI has already obtained an official permission from Ministry of Water Resources and Meteorology (MOWRAM) to take water from Vay Kor Lake: for the project in September 2017 and for the ADB expansion facility in July 2021. At the draft outline design (DOD) meeting of Minutes of Discussions (MD) held in December 2021, it was confirmed that MOWRAM would maintain and manage the Vay Kor Dam, while MISTI would work with MOWRAM to keep the water level needed to take water.

There is no commercial fishing activity on Vay Kor Lake, but there are anglers for domestic consumption or hobby. At the time of the field survey, the Survey Team interviewed the residents on catching fishes with cast nets. The answer was that they intended to eat the fish at home, but they sell the excess at the market in case of catching excessively. They know that there are precious species of fish and are requested to release them when they catch them with the guidance of the Department of Fishery. When the Survey Team talked about the possibility of construction work in the vicinity, there was no particular request.

(6) Noise and Vibration

The project area is not industrialized, and the traffic is not much except on the national highway, so that the source of noise and vibration is limited. On the other hand, the registered number of vehicles is rapidly increasing, which was reported as 14% increasing rate in 2015. Therefore, a certain level of road noise is expected alongside the main road. There was no available monitoring data, so that the Survey Team conducted surveys on noise and vibration on the 3rd and 4th of April 2020 at the WTP site and on the 4th to 5th of April at the intake site as the baseline survey. The results of the surveys which were done continuously for 24 hours are as summarized in the following table. The table shows the equivalent continuous sound (vibration) levels, and maximum levels are indicated in parentheses.

Table 1-3-9 Results of Noise and Vibration Survey

	WTP	Intake	Referable Standards		
Noise（6:00～18:00）	54.6 (118.4)	49.7 (101.5)	II	III	Cambodian noise standards II：Residential area III：Commercial area
			60	70	
Noise（18:00～22:00）	46.5 (54.9)	46.1 (54.9)	50	65	
Noise（22:00～6:00）	42.7 (49.9)	42.3 (38.3)	45	50	
Vibration（6:00～18:00）	27.3 (32.6)	12.9 (42.5)	65		Cambodian standards[4]
Vibration（18:00～6:00）	25.9 (42.5)	12.5 (40.7)	60		

[3] The Drinking Water Quality Standards of Cambodia (2004) was updated in 2015. The new standards do not include pesticides because parameters which cannot be monitored in Cambodia were omitted. The Survey Team refer to the old standards because there is no referable document.

[4] Prakas on the Using of Sample Term of Reference for Infrastructure and Tourism Development Project dated on 11 April, 2018.

Source: Survey Team

The Cambodian noise level standards have categories, namely; I: Quiet area ; II: Residential area ; III: Commercial and service areas and mix ; and IV: Small industrial factories intermingling in residential areas. The Department of Environment (DOE) of Svay Rieng consulted the Survey Team if the project area falls under Category II. The results of the survey shows that it meets the standards of Category II

There are no environmental standards of vibration in Cambodia, but the required level of vibration is shown in the Prakas Using of Sample Term of Reference for Infrastructure and Tourism Development Project (2018). Both noise and vibration are recorded as low level, and the environment in these terms is good.

(7) Economic Indicators

The main industry in Svay Rieng is agriculture, and the area of paddy field is the largest. The second largest farming product is cassava, but the planting area is less than 3% of the area of rice. In addition, a small amount of beans and vegetables are planted.

The administrative units of Cambodia are in the order of province, district, commune, and village. The district-wise occupation in the project area is shown in following table. Svay Rieng District contains the project area and the relating urbanized area, and the ratio of employed workers is higher than the other districts, but still the ratio of farmers is more than half. Most of the beneficiaries of the Project will be farmers.

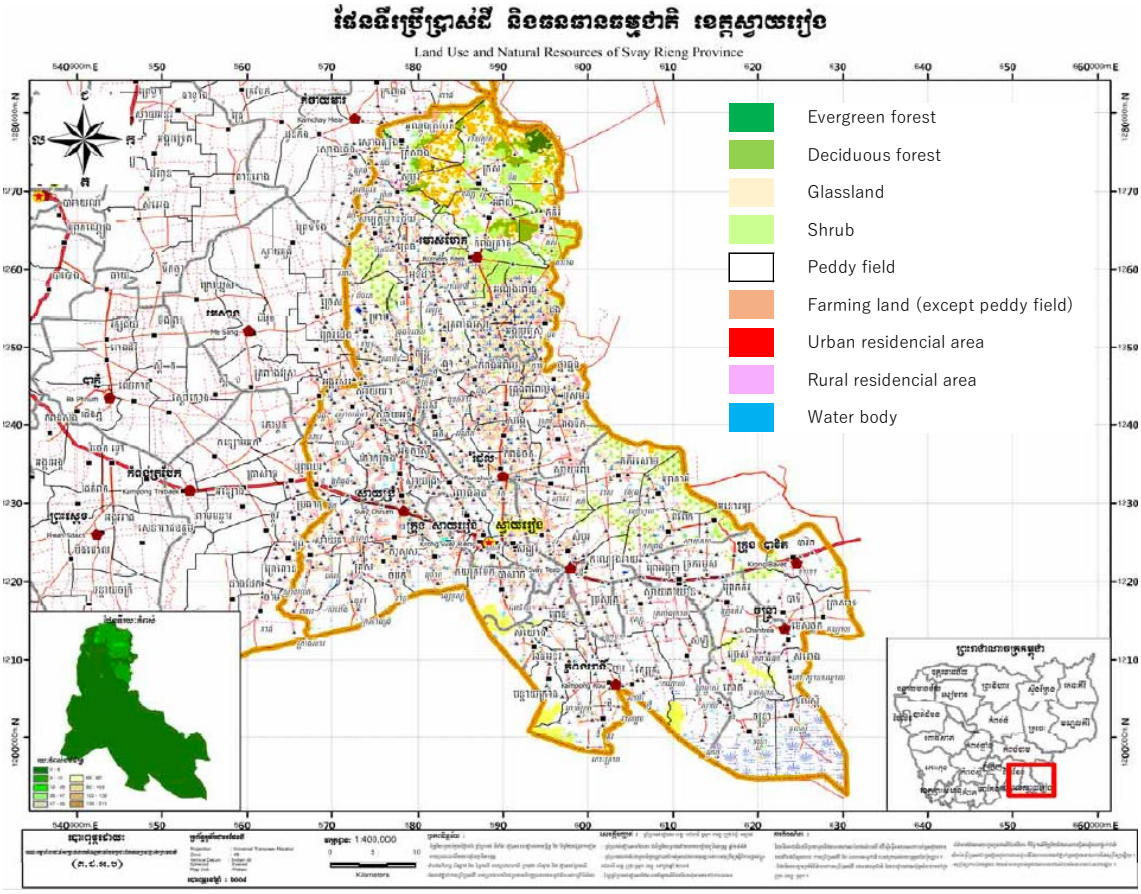
Table 1-3-10 Occupation (%)

District	Agriculture	Craft work	Service	Unknown
Svay Rieng Province	90.9	0.05	4.2	4.8
Svay Rieng	53.9	0.28	22.7	23.2
Svay Chrum	94.4	0.04	1.8	3.8

Source: National Committee for Sub-National Democratic Development (NCDD), Commune Database Online, Survey Team

(8) Land Use

The following figure shows land use in Svay Rieng Province and the table shows the area of the purpose of use.



Source: Based on Svay Rieng Data Book 2009

Figure 1-3-6 Land Use Area by Category

Table 1-3-11 Area by Land Use

Land Type	Area（ha）	%
Settlement	5,304.65	1.8
Paddy Field	225,855.47	78.7
Farming Land	9,996.62	3.5
Evergreen Forest	714.67	0.2
Deciduous Forest	0.00	0.0
Mixed Forest	0.00	0.0
Other Forest	2,840.88	1.0
Grassland	3,575.62	1.2
Scrub	856.77	0.3
Barren Land	23,610.36	8.2
Water	14,070.16	4.9

Source: Based on Svay Rieng Data Book 2009

In Svay Rieng Province, 78.7% of land is used as paddy field. It is clearly shown in the land use map that the forest coverage is less in this area, and the rice fields spread out on flat land.

(9) Solid Waste

Construction waste can be disposed into the land owned by the project proponent or a private land with the permission of the owner if the waste is not hazardous. If there is hazardous material, the waste is analyzed by MOE.

Currently, sludge of water treatment generated by the Svay Rieng WTP is discharged into the wetland in the land of WTP. The sludge is a mixture of turbid materials of raw water and coagulant; thus, the existence of hazardous materials is not expected. MISTI indicated that the landowners accepted to receive such materials for land filling as countermeasure against flooding ; therefore, the dumping of sludge will not be a problem.

(10) Poverty

The Ministry of Planning of the Royal Government of Cambodia had carried out a household survey nationwide to identify poor households in accordance with a poverty reduction program, with the help of the German Federal Ministry for Economic Cooperation and Development (BMZ), the Australian Department of Foreign Affairs and Trade, and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. The program was to define households as Poor Level 1 (very poor) and Poor Level 2 (poor), and it provides Equity Cards to such households to enable them receive appropriate support and benefits. The latest survey in Svay Rieng Province was conducted in 2020.

The following table shows the situation of the project area.

Table 1-3-12 Poverty Households in Project Area

District	Commune	Poverty Level 1		Poverty Level 2		Total
		Number	%	Number	%	Number
Krong Svay Rieng	Svay Rieng	74	2.3%	123	3.9%	3168
	Prey Chlak	32	3.7%	32	3.7%	863
	Koy Traback	45	5.9%	39	5.1%	763
	Pou Ta Hao	26	4.7%	57	10.2%	559
	Chek	69	2.4%	108	3.8%	2880
	Svay Toea	59	3.1%	96	5.1%	1874
	Sangkhoar	44	1.8%	120	4.9%	2458
Svay Chrum	Basak	153	6.2%	303	12.2%	2482

Source: Ministry of Planning, Identification of Poor Households Programme database

(11) Minority

The ethnic composition in Cambodia is 97.6% Khmer, 1.2% Cham, 0.1％ Chinese, 0.1％ Vietnamese and 0.9％ of others (CIA World Fact Book, 2013 estimation). According to the hearing survey with DOE and the City Hall, there is no minority group in the project area.

(12) Education and Literacy Rate

The following table shows the literacy rate in Svay Rieng Province.

Table 1-3-13 Literacy Rate (2008 to 2018)(%)

District	Literacy Rate (2008)	Literacy Rate (2013)
Total	80.1	83.3
Male	88.7	89.9
Female	72.3	77.1

Source: Cambodia Intercensal Population Survey 2013

The literacy rate in Svay Rieng Province is over 80% and is increasing year by year. The school enrollment rate is also higher than that of the whole Cambodia.

According to the results of a social survey in the project area, 86% of the owners were enrolled in schools, and 20% were educated in high schools or higher.

(13) State of Health and Hygiene

The data related health and hygiene obtained by the social survey are summarized in the following table. The samples consist of two groups, i.e., the group of households receiving water supply from provincial WWs (Connected HHs) and the group of households living outside of the supply area (Non-connected HHs).

Table 1-3-14 State of Health and Hygiene in Project Area

	Total	Connected HHs	Non- Connected HHs
Ratio of owning Toilet (%)	96	97	94
Morbidity by Waterborne Disease （last three years）(%)	4	2	6

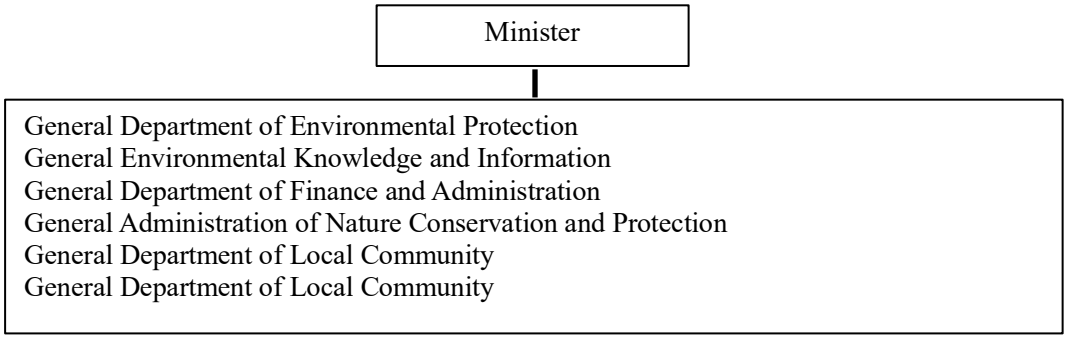
Source: Result of Social Survey, Survey Team

The ownership of toilet is relatively high in Cambodia. The morbidity by waterborne diseases in the last three years is significantly lower in connected households (HHs) than in non-connected HHs. According to the database of National Committee for Sub-National Democratic Development (NCDD), infant mortality (death of under 5-year-old per 1,000 birth) is 23.6 in Svay Rieng Province and 12.0 in Svay Rieng District. The health and hygiene conditions in urban areas seem better than in rural areas.

1-3-1-3 Environmental and Social Consideration Systems and Organizations in Cambodia

(1) Environmental and Social Consideration Systems and Organizations

The Cambodian agency in charge of environmental issues is the Ministry of Environment (MOE). Under the Minister of MOE, five departments work on their own subject of responsibility. Each province has a DOE, which is responsible for the environmental issues in the province.



The legal framework in Cambodia is as summarized in the following table.

Table 1-3-15 Laws and Environmental Regulations in Cambodia

Name	Purpose
Constitution（1993）	Article 59 stipulates the preservation and protection of environment and natural conditions by organizing a precise planning for the management.
Royal Decree on Creation and Designation of Protected Areas (1993)	This decree define the areas for projection, designation, management and responsibility.
Law on the Establishment of the Ministry of Environment (1996)	The Law states the establishment of the Ministry of Environment and its obligations.
Law on Environmental Protection and Natural Resource Management (1996)	The Law was created to protect and promote environmental quality and public health.
Law on Protection of Cultural Heritage (1996)	The Law is for the protection of national cultural heritage and cultural property.
Law on the Adoption of the Convention on Wetlands of International Importance (1996)	The Law was created for the protection of wetlands, especially in line with the Convention of Ramsar.
Sub-Decree on Environmental Impact Assessment Process (1999)	The Sub-Decree clarifies environmental assessment, application, procedure, etc.
Sub-Decree on Water Pollution Control (1999)	The Sub-Decree defines the management of ambient water quality, effluent regulation, etc.
Sub-Decree on Solid Waste Management (1999)	The Sub-Decree defines appropriate solid waste disposal, and related issues.
Sub-Decree on Air Pollution Control and Noise Disturbance (2000)	The Sub-Decree defines management of ambient air quality, controlling noise, vibration, and exhaust gas.
Law on Forestry (2002)	The Law was created for the protection of forest and wildlife.
Law on Water Resource Management (2007)	The Law clarifies principles of water management and organization in charge.
Protected Areas Law (2008)	The law defines the framework of management, conservation and development of protected areas.
Prakas on Registration of Consulting Firms for Studying and Preparing Environmental and Social Impact Assessment Reports（2014）	The Prakas (declaration) declares the necessity of registration of consulting firms for EIA surveys and preparation.
Sub-Decree on Establishment of Biodiversity Conservation Corridor in Natural Protected Area (2017)	The Sub-Decree declares the conservation corridor for the protection of natural environment.
Prakas 120, Terms of Reference on Infrastructure and Tourism Development Project (2018)	Guidance of making EIA/IEIA report for projects related to infrastructure and tourism
PrakasNo.21, Classification of Environmental Impact Assessment of Development Project (2020)	Clear description of the necessary environmental permission by type and size of project

Source: Survey Team based on Laws and Regulations of Cambodia

(2) Environmental Standards

The environmental and emission standards are as summarized in the following tables.

Table 1-3-16 Environmental Standards

Target		Parameters	Remarks	Source
Air	Ambient air quality	CO, NO2, SO2, O3, Pb, TSP		Sub-decree on Control of Air Pollution and Noise Disturbance
	Ambient air (hazardous)	30 hazardous materials		
	Emission (Immobile source)	66 parameters		
	Emission (Mobile source)	CO, HC	Emission for vehicle type	
	Content of fuel and coal	S, Pb		
Noise	Noise of vehicle	Noise level	Maximum level of type of vehicles	
	Public and residential area noise	Noise level	Permissible level at 4 types of areas	
	Noise level at factory	Noise level	Maximum period at levels	
Water	Discharge standards	52 parameters		Sub-decree on Water Pollution Control, 1999
	Ambient water	5 to 7 parameters for waterbodies	Conservation of biodiversity at public water areas	
	Ambient water	25 parameters	Protection of public health at public water areas	

Source: Survey Team based on Sub-Decrees of Cambodia

The maximum permissible level of noise by area is as shown below. There are no standards and regulatory limits for vibration in Cambodia. This standard is applied to control noise level of any source of activity that emits noise into the public and residential areas. The project area falls under Category 3.

Table 1-3-17 Maximum Permissible Level of Noise dB(A)

Category	Area	Period of Time		
		From 6am to 18pm	From 18pm to 22pm	From 22pm to 6am
1	Quiet Areas -hospitals, Libraries, School, Kindergarten	45	40	35
2	Residential Areas -Hotels, Administration offices, Houses	60	50	45
3	Commercial and service areas and mix	70	65	50
4	Small industrial factories intermingling in residential areas	75	70	50

Source: Sub-decree on Control of Air Pollution and Noise Disturbance

These noise standards are applicable to the management of all noise sources in public and residential areas. The target area of this project is categorized under Category 2.

The Provincial DOE of Svay Rieng does not monitor the above standards and regulatory limits since they do not have instruments for measuring, facilities and capacity. Discharge standards have many parameters but there are limited number of laboratories which can measure them, and DOE is also not able to measure them. Therefore, these parameters are practically not managed. The existing WTPs in Cambodia usually discharge treatment sludge into the river directly on the basis of agreement with DOE.

The Annex on the "Sub-Decree on Water Pollution Control (1999)" defines 67 types of pollution sources which need the permission of MOE before discharging or transporting their wastewater. Category I source needs permission when its discharge amount exceeds $10m^3$/day. Category II source always needs permission. "Pure drinking water manufacturing" is included in Category I, but the wastewater generated by the Project will be much less than this level and does not require permission.

(3) Environmental Impact Assessment Procedure

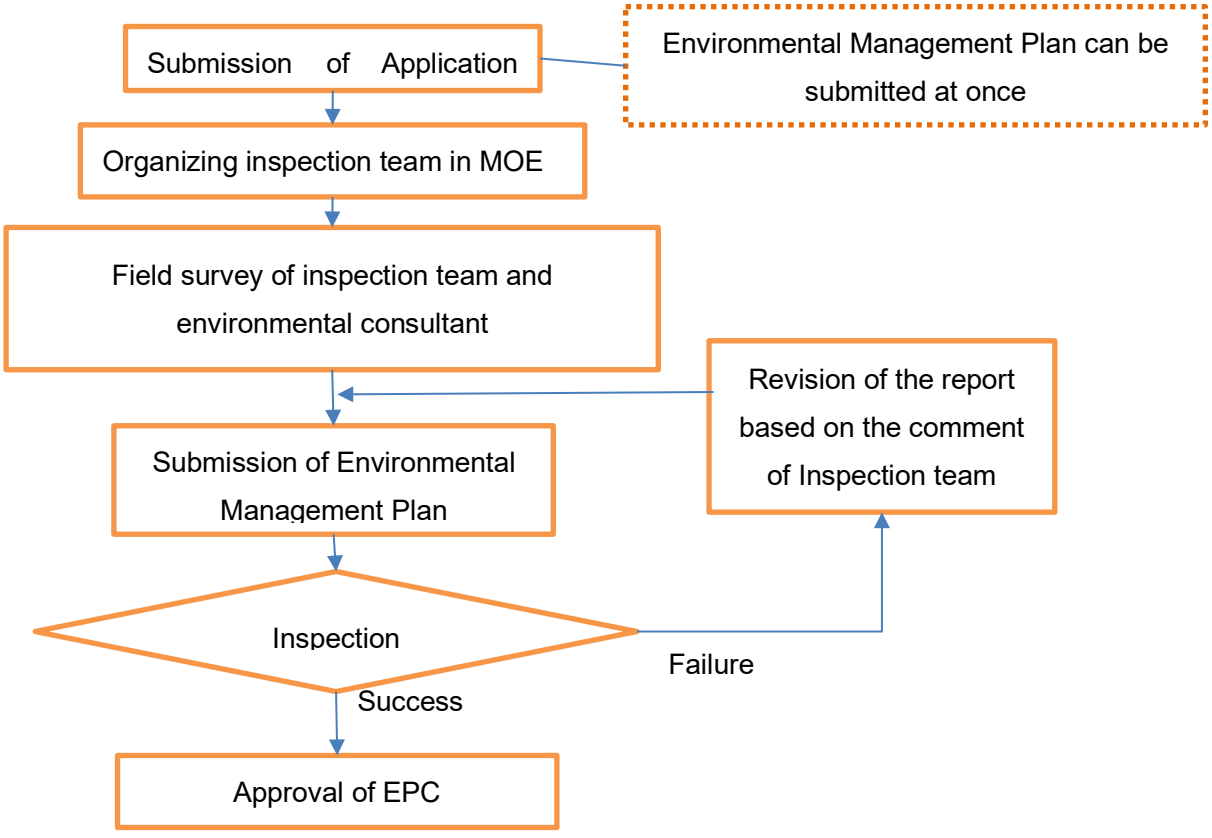
The Sub-Decree on Environmental Impact Assessment Process (1999) has a list of projects that require EIA or IEIA as an annex. However, there is no clear description of EIA or IEIA, therefore, it has to be decided by MOE.

In addition, the project proponent of a project that does not require EIA / IEIA is required to have an environmental protection contract (EPC) with the MOE. However, the conditions are unclear. To solve such an unclear condition, the Ministerial Ordinance, "Prakas No.21, Classification of Environmental Impact Assessment of Development Project", was issued under the name of the Minister of Environment on February 3, 2020 and came into effect on the same day. According to this Ministerial Ordinance, all WTPs and water distribution system projects are subject to EPC. In case of IEIA/EIA, changes of plan described in the report need to be consulted with the MOE, but in case of EPC, minor changes are not of concern.

There is no specific document which describes the procedure for obtaining the EPC. The following descriptions of particular differences from EIA were prepared by a local environmental consultant.

- Project proponent can submit an application form before creating a report.
- The examination takes 28 business days.
- MOE organizes a technical team with 12 members for examination of EIA /IEIA, but only 3-4 members for EPC.
- EPC does not require actual measurement of water quality, air quality, noise, etc.

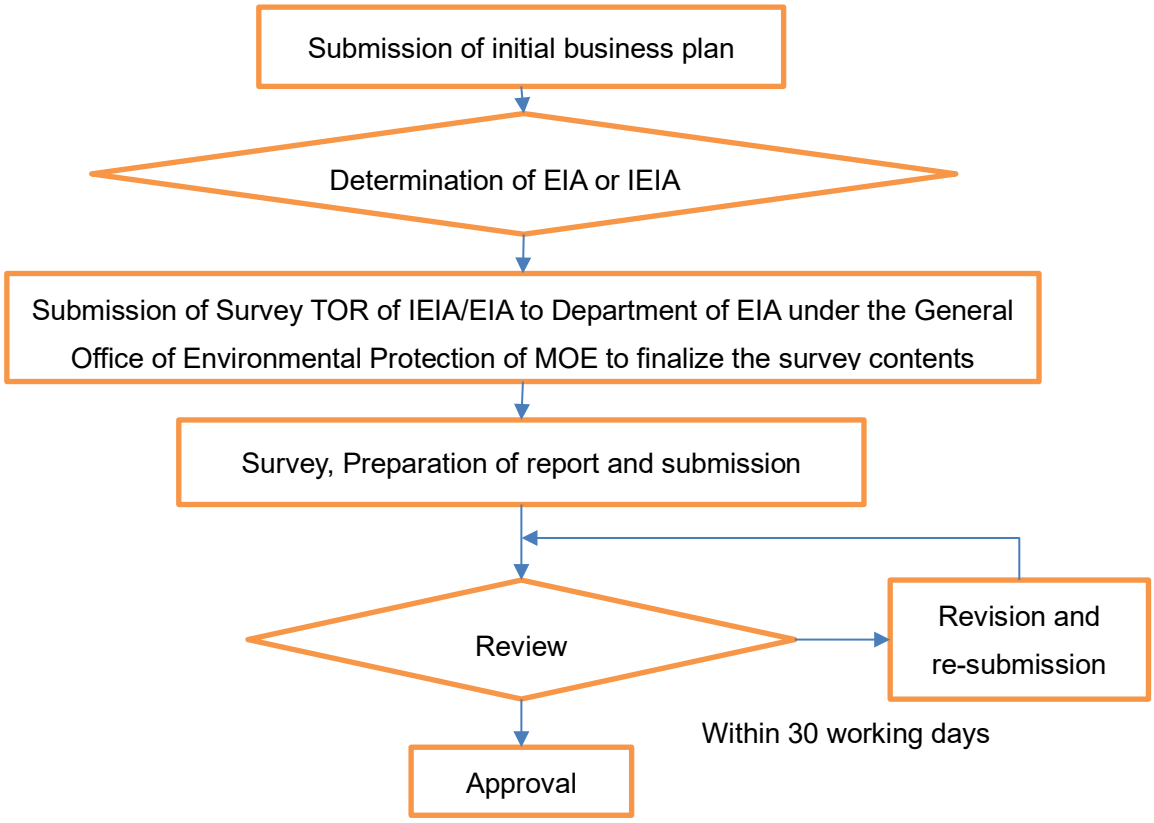
The EPC procedure is as shown in the following figure



Source: Survey Team based on interviews with environmental consultant of Cambodia

Figure 1-3-7 Process of EPC Approval

The flow of the EIA/IEIA approval procedure is as shown in the following figure for reference.



Source: Sub-Decree on Environmental Impact Assessment Process (1999) together with the hearing survey

Figure 1-3-8 Process of EIA/IEIA Approval

The Parkas (declaration) on the Registration of Consulting Firms for Studying and Preparing Environmental and Social Impact Assessment Reports was enacted in May 2014, and EIA/IEIA survey and report preparation should be conducted by a registered consulting firm.

On the other hand, there is no document on the designation of the responsible entity for the preparation of the EPC document. However, environmental consultants are implementing it because of the necessity of preparing the environmental management plan.

(4) Comparison between Cambodian Regulations and JICA Guidelines

There are no big gaps between the Cambodian environmental regulation system and the JICA Guidelines. The following table shows the gaps between the Cambodian system and JICA guidelines, and the defined policy of the Project.

Table 1-3-18 Gap Analysis between Cambodian Regulations and JICA Guidelines

Item No.	JICA Guidelines	Cambodian Laws and Regulations	Gap	Policy of the Project
Underlying Principles	Environmental impacts that may be caused by projects must be assessed and examined in the earliest possible planning stage; Alternatives or mitigation measures to avoid or minimize adverse impacts must be examined and incorporated into the project plan.	Law on Environmental Protection and Natural Resources Management Article 6: The EIA shall be carried out on every project and activity of either private or public and shall be examined and evaluated by Ministry of Environment (MoE) before it is submitted to the RGC for decision. This assessment shall also be applicable for those existing activities and those which are being under process and which their environmental impacts have yet not been assessed.	There are no big gaps but Cambodian laws /regulations do not stipulate the assessment in the earliest stage while the JICA guidelines stipulate them.	The project applies JICA policy.
Examination of Measures	1. Multiple alternatives must be examined in order to avoid or minimize adverse impacts and to choose better project options. 2. Appropriate follow-up plans and systems, such as monitoring plans and environmental management plans, must be prepared	Sub-decree on Environmental Impact Assessment Process Article 3: The MoE has responsibilities as s follows: a)Scrutinize and review the report of the Environmental Impact Assessment in collaboration with other concerned ministries; b) Follow up, monitor and take appropriate measures to ensure a Project Owner will follow the Environmental Management Plan (EMP) while project construction is taking place and accede to their EIA report's approval.	Cambodian laws /regulations define the necessity of follow-up, but not mention the multiple alternatives of examination.	The project applies JICA policy.
Scope of Impacts to be Assessed	The impacts to be assessed with regard to environmental and social considerations include impacts on human health and safety, as well as on the natural environment, that are transmitted through air, water, soil, waste, accidents, water usage, climate change, ecosystems, fauna and flora, including trans-boundary or global scale impacts. These also include social impacts, including migration of population and involuntary resettlement,	Law on Environmental Protection and Natural Resources Management Article 6: Natural resources of the KoC which primarily consist of land, water, airspace, air, geology, ecological systems, minerals, energy, petroleum and gas, rocks and sand, gems and stones, forests and forest subproducts, wildlife, fish and aquatic resources, shall be preserved, developed and managed to use in a rational and sustainable manner.	JICA guidelines insists the assessment not only for environment but also social conditions, but Cambodian laws/regulations do not emphasize the social considerations.	The project applies JICA policy.

Item No.	JICA Guidelines	Cambodian Laws and Regulations	Gap	Policy of the Project
	local economy such as employment and livelihood, utilization of land and local resources, social institutions such as social capital and local decision-making institutions, existing social infrastructures and services, vulnerable social groups such as poor and indigenous people, equality of benefits and losses and equality in the development process, gender, children's rights, cultural heritage, local conflicts of interest, infectious diseases such as HIV/AIDS, and working conditions including occupational safety.			
Social Acceptability	1. Projects must be adequately coordinated so that they are accepted in a manner that is socially appropriate to the country and locality in which they are planned. For projects with a potentially large environmental impact, sufficient consultations with local stakeholders, such as local residents, must be conducted via disclosure of information at an early stage, at which time alternatives for project plans may be examined. The outcome of such consultations must be incorporated into the contents of project plans. 2. Appropriate consideration must be given to vulnerable social groups, such as women, children, the elderly, the poor, and ethnic minorities, all members of which are susceptible to	Law on environmental impact assessment, Article 37; The main objective of public participation is to ensure that project-affected people and relevant stakeholders: - are well informed about the project, - have the opportunity to be involved in the discussion and decision-making process related to the project, and - have the opportunity to participate in the project monitoring. Project Proponents that are required to conduct an EIA shall include public involvement and consultation from local administrations, civil society, community representatives, the project-affected people and other relevant stakeholders in the EIA process during project planning in order to: - identify areas of significance of environment, economy, society and culture - collect opinions of stakeholders and integrate such opinions into the decision-making process	Cambodian laws/regulations state the importance of public participation and the difference from JICA guidelines seem very less. However, JICA guidelines explains more detail about the vulnerable people and minority.	The project applies JICA policy.

Item No.	JICA Guidelines	Cambodian Laws and Regulations	Gap	Policy of the Project
	environmental and social impacts and may have little access to decision-making processes within society.	- review the project proposal and explain impacts on environment, economy, society, and culture. - consider a wider range of alternatives and mitigation measures. The public participation process in the stage of studying, consulting and reviewing the EIA report and project monitoring shall be determined by Prakas of MOE.		
Ecosystem and Biota	1. Projects must not involve significant conversion or significant degradation of critical natural habitats and critical forests. 2. Illegal logging of forests must be avoided. Project proponents etc. are encouraged to obtain certification by forest certification systems as a way to ensure the prevention of illegal logging.	Constitution of Kingdom of Cambodia, Article 59: The State shall protect the environment, balance 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	Cambodian laws/regulations state the protection of environment and nature, but not clearly mention about the measures against illegal logging.	The project applies JICA policy.
Monitoring	1. After projects begin, project proponents etc., monitor whether any unforeseeable situations occurs and whether the performance and effectiveness of mitigation measures are consistent with the assessment's prediction. They then take appropriate measures based on the results of such monitoring. 2. In cases where sufficient monitoring is deemed essential for appropriate environmental and social considerations, such as projects for which mitigation measures should be implemented while monitoring their effectiveness, project proponents etc. must ensure that project plans include feasible monitoring plans.	Sub-decree on Environmental Impact Assessment Process (1999) ; Article 3: The MoE has responsibilities as s follows: a) scrutinize and review the report of the Environmental Impact Assessment in collaboration with other concerned ministries; b)follow up, monitor and take appropriate measures to ensure a Project Owner will follow the Environmental Management Plan (EMP) while project construction is taking place and accede to their EIA report's approval.	Cambodian laws/ regulations stipulate the monitoring based on the EMP ant not big difference with JICA guidelines. JICA guidelines describe more detail.	The project applies JICA policy.

Item No.	JICA Guidelines	Cambodian Laws and Regulations	Gap	Policy of the Project
	3. Project proponents etc. should make efforts to make the results of the monitoring process available to local project stakeholders. 4. When third parties point out, in concrete terms, that environmental and social considerations are not being fully undertaken, forums for discussion and examination of countermeasures are established based on sufficient information disclosure, including stakeholders' participation in relevant projects. Project proponents, etc., should make efforts to reach an agreement on procedures to be adopted with a view to resolving problems.			
Land acquisition and involuntary resettlement				
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	Cambodian laws /regulations do not stipulate avoidance of resettlement and loss of means of livelihood while the JICA guidelines stipulate them.	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives

Item No.	JICA Guidelines	Cambodian Laws and Regulations	Gap	Policy of the Project
		advance.		
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: (Refer to 1) Land Law (2001) Article 5: (Refer to 1)	There are no provisions in Cambodian laws /regulations which stipulate minimization of resettlement and loss of means of livelihood while the JICA guidelines stipulate them.	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken.
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 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.	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 stipulate compensation for loss of means of livelihood while the 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 improve or restore their standard of living.	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.
4.	Compensation must be based on the full replacement cost as much as possible. (JICA GL)	Expropriation Law (2009) 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 JICA guidelines includes essential costs for recovering livelihood as pre-project conditions while Cambodian laws / regulation stipulate as "actual damage" without detailed	Compensation must be based on the full replacement cost as much as possible.

Item No.	JICA Guidelines	Cambodian Laws and Regulations	Gap	Policy of the Project
			information.	
5.	Compensation and other kinds of assistance must be provided prior to displacement. (JICA GL)	Constitution (1993) Article 44: (Refer to 1) Land Law (2001) Article 5: (Refer to 1) Expropriation Law (2009) Article 19: 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 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 the JICA guidelines stipulate that compensation must be provided prior to displacement while the Cambodian laws/regulations do not stipulate "other kinds of assistance".	Compensation and other kinds of assistance must be provided prior to displacement.
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 regulations or Laws exist.	Cambodian laws/regulations do not stipulate RAP preparation.	In case of large-scale involuntary resettlement, RAP shall be prepared.
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 people 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 project.	Both stipulate holding public consultation with sufficient information while Cambodian laws/regulations do not stipulate RAP preparation	In preparing RAP, public consultation shall be held with consideration of language and procedure.
8.	When consultations are held, explanations must be given in a form, manner, and language that are 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 guidelines specifies more detailed manners, especially, accessibility for conducting the consultation.	Consultation meeting is conducted by understandable language and procedure for the residents.

Item No.	JICA Guidelines	Cambodian Laws and Regulations	Gap	Policy of the Project
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 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 guidelines promotes participation of the affected people in all stages of the project.	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of RAP.
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 the 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 the JICA guidelines specifies more detailed procedures, especially, accessibility for conducting the consultation.	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.
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 of others who wish to take	Expropriation Law (2009) Article 16: Before proposing an expropriation project, the Expropriation Committee shall publicly conduct 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 the conduct of precise survey. Expropriation focuses on the rightful property and its owner while the JICA guidelines following OP4.12 includes affected people who have formal legal rights to land and also affected people who do not have formal legal rights.	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey.

Item No.	JICA Guidelines	Cambodian Laws and Regulations	Gap	Policy of the Project
	advantage 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 do not 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 4 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 were 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 the JICA guidelines includes PAPs who do not have formal legal rights to land as eligible person	Eligibility shall be given not only for PAP having legal rights but also PAP not having legal rights.
13.	Preference should be given to land-based resettlement strategies for displaced people 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.	Preference should be given to land-based resettlement strategies for displaced people whose livelihoods are land-based.
14.	Provide support for the transition period	No matching regulation or Law exists.	Cambodian laws /regulations do not	PAP will receive support during

Item No.	JICA Guidelines	Cambodian Laws and Regulations	Gap	Policy of the Project
	(between displacement and livelihood restoration). (WB OP4.12 Para.6)		stipulate provision of support for the transition period.	transition period.
15.	Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities, etc. (WB OP4.12 Para.8)	No matching regulations or Law exist.	Cambodian laws /regulations do not stipulate assistance, care or attention toward vulnerable groups.	Particular attention shall be given to minority and indigenous people.
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 Law exists.	Cambodian Laws /Regulations do not stipulate preparation of RAP nor ARAP.	ARAP shall be prepared for small scale land acquisitions and involuntary resettlements.

Source: Survey Team by Cambodian Laws and Regulations

1-3-1-4 Comparison of Alternatives

This project aims at expanding the existing water supply system in Svay Rieng, and it is important to maximize the benefit with consideration on harmonization with existing systems, future population growth and urbanization. Moreover, it is considered to maximize the positive impact and minimize negative impact to the environmental and social conditions. The regular water supply will improve the hygiene and basic living standards.

The result of comparison of alternatives is described as follows.

(1) Alternative of Without Project

The results of comparison between without project and with project conditions are shown in the following table.

Table 1-3-19 Comparison of Alternatives (Without Project)

Item		Alternative 1	Score	Alternative 2	Score
Summary		With project		Without project	
Supplied households		9,954HHs in 2027	3	I will not be much better than current supply condition as 4,709HHs	1
Water Quality		Water supply by surface water as raw water will start, and the problem of iron and manganese caused by groundwater will be solved.	3	Sometimes necessity of overload operation occurs, and there are complaints due to high concentration of iron and manganese.	2
Target of government		Government of Cambodia sets the goal of 100% water supply in urban areas and the project will achieve 86.7% supply in urban areas within the controlled area by 2027.	3	The expected supply ratio will be 44.3% by 2027 and the target will not be achieved.	1
Hygiene		The water supply ratio will increase and the use of clean water will be promoted.	3	The use of supplied water will not progress, and the sanitary situation will not change significantly from the current situation.	2
Environmental & Social	Ecosystem	The impact on fish of water intake from Lake Vay Koh needs to be minimized.	2	There is no additional negative impact.	3
	Natural Environment	The impact of noise and vibration need to be minimized.	2	There is no additional negative impact.	3
	Land acquisition and resettlement	There is no land acquisition and resettlement.	3	There is no land acquisition and resettlement.	3
	Socioeconomic	Infrastructure development will increase employment and improve the level of social services.	3	There are no big changes.	2
Evaluation		22		17	

Source: Survey Team

The above comparisons reject the alternative of Without Project. The coverage of water supply in Svay Rieng is about 23% in 2019. On the other hand, MISTI has set the target of 100% supply in urban area by 2025. To achieve the target, implementation of this project is essential. “Ensure availability and sustainable management of water and sanitation for all” is one of the SDGs goals. To achieve the goal, basic infrastructure should be constructed for safe, accessible and affordable water supply.

(2) Alternatives of Water Source

In Svay Rieng, many families have their own wells. According to the results of the social survey conducted in 2017, 79% of households in non-connected areas use well water as drinking water. This is followed by rainwater use at 17% and water supply by water trucks at 7%. On the other hand, 37% of well users answered that there is no particular problem, but 45% answered that the quality of well water is getting worse and worse. Twenty-one percent (21%) of the respondents said that the groundwater level is falling.

Respondents are highly motivated to connect to water, with 78% saying they want to connect to water. According to the survey results of households in connected areas, 100% answered that they are satisfied with the current water supply service level. The results of comparison of alternatives for water sources are as shown below. The Survey Team examined the water sources and put the score in 3 degrees (3 is the best), as shown in the following table.

Table 1-3-20 Comparison of Alternative Water Sources

Item		Alternative1	Score	Alternative2	Score
Summary		Surface water from Vay Kor Lake		Groundwater	
Water Source		Amount is enough; Water quality is acceptable.	3	Considering the existing groundwater survey results, there is enough capacity . Groundwater has a high concentration of iron and manganese, and the existing facilities may not be able to remove it sufficiently, so the Cambodian side hopes to shift to a surface water source.	2
Environmental & Social	Impact of construction to surroundings	Measures must be taken to mitigate the impact on Vay Kor Lake where critically endangered species live.	2	Since the construction of certain number of production wells is required, it is necessary to find a good location that can secure sufficient production volume without any negative impact.	2
	Natural environment	Part of Lake Vay Kor has been designated as a protected area by Svay Rieng Province, so that sufficient mitigation measures need to be taken, including the conservation of endangered species.	2	The target area is urban area or agricultural land, and there is no major problem in terms of impact on the ecosystem. It is necessary to consider the impact of pumping water on the surrounding water environment.	2
	Land acquisition and resettlement	Resettlement is not required.	3	Acquiring private land that does not cause relocation of residents is necessary for the construction of wells.	2
Evaluation		10		8	

Source: Survey Team

The existing WTP uses groundwater as a water source, but the shift to a surface water source is desired for WWs due to the water quality problem. In the field survey conducted in 2017, there was concern about the structural fragility of the Vay Kor Dam, so that it was once decided to utilize the groundwater source. However, the Japan Water Agency conducted a detailed soundness survey in 2018 and judged that there will be no problem if appropriate repairs and maintenance were carried out. Therefore, the doubt about the dam was removed.

(3) Distribution Area

The distribution area of the project has been evaluated based on the request of MISTI as well as in consideration of the effectiveness of the project. The results are shown in Subsection “2-2-2-1-(12), Study on Design Water Supply Area”.

The MISTI requested that the coverage area shall include the less populated area, which was evaluated as low profitability. The irrational extension would lead to an increase in the water rate, so the negative social impact will also increase. For this reason, the supply area was carefully examined, considering the water supply coverage in urban areas, the high-priority villages set by the WWs, and

the benefit/cost of construction. Considering the effectiveness and efficiency, the decision was made after comparing three cases (See Section 2-2-2, Basic Plan).

(4) Study on Intake Method

The open channel water intake method with an intake gate, which has a low risk of invasion of fish and small animals and considered to be advantageous in terms of maintenance and security, was adopted (See Subsection "2-2-2-3-(2), Water Intake Method").

1-3-1-5 Results of Scoping and the Environmental and Social Survey TOR

The following tables show the scoping results and the draft TOR.

Table 1-3-21 Results of Scoping

Category	Impacts		Selection		Reasons for Assessment
			Design/ Construction	Operation	
Pollution	1	Air Pollution	✔		Construction: Although the operation of construction machinery and vehicles is temporary, it is expected to worsen air quality. Operation: The operation of WTP has no impact on ambient air.
	2	Water Pollution	✔	✔	Construction: Turbid water from the work site might cause pollution. Operation: The construction of structures in the lake may affect the flow of lake water, which may affect the water quality.
	3	Solid Waste	✔	✔	Construction: Asphalt and concrete waste will be generated at road pipe laying, and construction waste of earth materials will be generated by the construction of WTP and Intake. Domestic waste will also increase due to workers. Operation: Dried sludge should be disposed appropriately.
	4	Soil Pollution			Construction/Operation: No work is expected to cause soil pollution.
	5	Noise and Vibration	✔	✔	Construction: Noise and vibration are expected from the operation of construction equipment and vehicles. Operation: Noise and vibration will be generated by pumping station.
	6	Ground Subsidence			Construction/Operation: No work or other factors are expected to cause ground subsidence.
	7	Offensive Odor			Construction/Operation: No work or other factors are expected to cause offensive odor.
	8	Sediment	✔		Construction: Construction work of intake in the river may stir up bottom sediment. Operation: No possibility of impact on sediment.
Natural Environment	9	Protected Area	✔	✔	Construction/Operation: The downstream side of the intake point of Vay Kor Lake is subject to fishery resource conservation.
	10	Ecosystem	✔		Construction: Impact on ecosystem by construction work is not significant because the project area is located in the urbanized area and farm land; however, ecological survey will be conducted to check the existence of important species and habitat. Operation: Impact on ecosystem is not significant.
	11	Hydrology	✔	✔	Construction: Construction work of intake in the

Category	Impacts		Selection		Reasons for Assessment
			Design/ Construction	Operation	
					reservoir might affect the water flow. Operation: It is necessary to consider the impact of the intake structure on the water flow of the lake .
	12	Topography and geology			Construction/Operation: Construction work does not change the topography and geology significantly.
Social Environment	13	Resettlement			Construction/Operation: There is no resident in the project area, and no necessity of resettlement.
	14	Poverty	✔		Construction: The extent of the impact is unknown and future confirmation studies are needed. Operation: Water supply to poverty group will be enhanced by the MISTI policy.
	15	Ethnic minorities and indigenous peoples			Construction/Operation: There is no ethnic minority and indigenous people to be taken-cared of in the project area.
	16	Employment, livelihood and local economy			Construction: Construction employment will be a plus for the local economy. Operation: The expansion of water supply will have a positive effect on the local economy.
	17	Land and local resource usage			Construction: Temporary land lease around the construction site will be required, but since the candidate site is unused land, there will be no significant impact. Operation: The project involves the expansion of the water supply system, and the impact on land and local resource usage is not expected.
	18	Water Usage			Construction: The water source is lake water, which is also used for irrigation, but it is not the amount of water intake that affects the current irrigation use. An additional water intake permit based on the facility expansion plan by ADB will be obtained from MOWRAM, which has jurisdiction over water use. Operation: The amount of water intake is small compared to the use of irrigation, and the impact on existing facilities is small. The impact on water flow of river is discussed under “hydrology”.
	19	Existing social infrastructure and services	✔		Construction: Disturbance to traffic will occur due to construction vehicles, temporary blockage during pipe laying, etc. Operation: No particular negative impact is expected. The improvement of water supply may enhance the improvement of existing social infrastructure and social services.
	20	Social capital, local decision-making bodies and other social organizations			Construction/Operation: The Project is not expected to impact social capital or social organizations.
	21	Misdistribution of benefits and damages			Construction/Operation: No element of the Project will impact distribution of benefits and damages in the local area.
	22	Local conflicts of interest			Construction/Operation: The Project will not create any local conflicts of interest.
	23	Cultural heritage			Construction/Operation: There is no cultural heritage in and around the project site.
	24	Landscape	✔	✔	Construction: The intake will be constructed at the side of road that crosses the lake, and it is necessary to consider the impact on the entire landscape of the lake. Operation: It is necessary to consider the design of the intake structure so as not to disturb the entire landscape of the lake.

Category	Impacts		Selection		Reasons for Assessment
			Design/ Construction	Operation	
	25	Gender			Construction/Operation: The Project is not expected to have any particular negative impact on gender relations.
	26	Children's right			Construction/Operation: The Project is not expected to have any particular negative impact on children's rights.
	27	HIV/AIDS and other infectious diseases	✔		Construction: Although the scale of construction is not so large, the possibility of increased infectious disease due to influx of construction workers shall be reviewed. Operation: No possibility of impact.
	28	Working conditions (incl. occupational safety)	✔		Construction: Working environment for construction workers must be considered. Operation: No possibility of impact
Other	29	Accidents	✔	✔	Construction: Measures should be considered for preventing accident of construction vehicles and work-related injury. Operation: In case of the use of chlorine gas for disinfection, the possibility of gas leak is expected.
	30	Transnational impacts and climate change			Construction: The transnational impact or negative impact on climate change on this project is extremely limited. Operation: The design policy is to save energy by adopting a gravity flow type and using a high-efficiency pump, and the impact is limited.

Source: Survey Team

Table 1-3-22 TOR

Impacts		Study Items	Objectives
1	Air Pollution	(1) Applicable standards (2) Current air quality (3) Impacts during construction (4) Impact of operation	(1) Literature research, precedents, hearings (2) Literature research, interviews, measurement of ambient air (3) To estimate emissions for construction vehicles/ machinery, generators, etc. (4) Study of previous case
2	Water pollution	(1) Turbid water (2) Discharge by operation	(5) To check construction methods and work which could cause turbid water, estimate scale, study water quality (6) Prediction of possibility of pollution of discharge water by operation
3	Solid Waste	(1) Construction waste (2) General waste (3) Treatment sludge	(1) To estimate type/volume of construction waste. Study of procedure of construction waste disposal. (2) To estimate type/volume of domestic waste and procedure to discard (3) To check the procedure of method of disposing the sludge, study precedents
5	Noise and Vibration	(1) Applicable standards (2) Current noise and vibration (3) Impacts during construction (4) Impacts during service	(1) Literature research, precedents, hearings (2) Literature research, interviews, measurement at the site. (3) To study the impact of construction vehicles/ machinery, generators, etc. (4) To study the impact of pumping station
8	Sediment	(1) Effect of construction	(1) Survey of literature and precedent
9	Protected area	(1) Scope of protection	(1) Hearing survey with stakeholders and experts

Impacts		Study Items		Objectives	
		(2)	Impact	(2)	Literature survey, information collection through internet
10	Ecosystems	(1)	Ecosystems	(1)	Site survey for flora and fauna, literature survey about important species in and vicinity of project site
11	Hydrology	(1)	Impact of construction	(1) (2)	River flow condition, study of construction method Study of the impact of structure on water flow.
14	Poverty	(1)	Poverty group and necessary support	(1)	Poverty group in the site by literature and site survey, and interviews
19	Existing social infrastructures and services	(1) (2)	Construction vehicle Duration of construction on the road	(1) (2)	To estimate the impact on traffic by construction vehicles Duration of construction work on road, study of countermeasure for disturbance of traffic
24	Landscape	(1)	Landscape of the construction site	(1) (2)	Site survey of current landscape Hearing of stakeholders
27	HIV/AIDS and other infectious diseases	(1) (2)	Current state of infectious diseases Impact from the Project	(1) (2)	Interviews on current state of infectious diseases Estimate scale and duration of the work
28	Working conditions (incl. occupational safety)	(1) (2)	Current status of work-related injury Current status of implemented work safety measures	(1) (2)	Literature research, interviews Interviews
29	Accidents	(1) (2)	Current traffic accident status Chlorine gas leak	(1) (2)	Literature survey, interviews To check the procedure and facilities of disinfection, study of precedent
30	Stakeholder meeting	(1) (2)	At the stage of scoping At the time of report drafting	(1) (2)	Interview, group discussion Public hearing
31	Land acquisition and resettlement	(1) (2)	Presence of POP Preparation of ARAP in case	(1) (2) (3)	To check the existing laws and regulations Site visit Hearing

Source: Survey Team

1-3-1-6 Results of Environmental and Social Study (Including Projection)

The following table show the results of site survey, environmental and social survey and projection study of impacts.

Table 1-3-23 Results of Environmental and Social Study

<table>
<tr><th>Items</th><th>Impacts</th><th>Results</th></tr>
<tr><td>Pollution Control</td><td>Air Pollution</td><td>
An ambient air quality monitoring system has not been established in Cambodia, and there is no basic data on air quality in Svay Rieng. The Survey Team conducted the survey to obtain baseline data, and all measured parameters meet the requirements of Cambodian standards. The current air quality condition is good.
Svay Rieng has not industrialized and the main emission sources of air pollution are the vehicles. It is a small provincial city and the traffic is not much without the national highway. The baseline air quality is good, therefore, the air pollution caused by the construction work will be in an acceptable range. On the other hand, the vehicles used for the project must follow the emission standards of Cambodia as shown below. The construction machinery and vehicles should be maintained in good condition so that the exhaust gas is within the acceptable range.

Table: Gas Emission Standards of Mobile Sources (Cambodia)
<table>
<tr><th rowspan="2">Type</th><th rowspan="2">Fuel</th><th colspan="5">Level of Emission</th></tr>
<tr><th colspan="2">CO (%)</th><th colspan="2">HC (ppm)</th><th>Fume (%)</th></tr>
<tr><th></th><th></th><th>A</th><th>B</th><th>A</th><th>B</th><th>(%)</th></tr>
<tr><td>Motorcycle (2 stroke engine)</td><td>Petrol</td><td>5</td><td>4</td><td>10</td><td>3,000</td><td></td></tr>
<tr><td>Motorcycle (4 stroke engine)</td><td>Petrol</td><td>5</td><td>4</td><td>10</td><td>2,400</td><td></td></tr>
<tr><td>All kinds of vehicles</td><td>Petrol</td><td>5</td><td>4</td><td>1,200</td><td>800</td><td></td></tr>
<tr><td>All kinds of vehicles</td><td>Diesel</td><td></td><td></td><td></td><td></td><td>50</td></tr>
</table>
(A: refers to all kinds of vehicles used over 5 years as from production, B: refers to less than A)
Source: Sub-decree on Control of Air Pollution and Noise Disturbance

The intake construction site will be at the side of the road that crosses the lake, and there are no residents affected, so it will not be a particular problem. Although there is a certain distance to the road, it is necessary to pay attention to the generation of dust when vehicles enter and exit, and construction vehicles are required to use a cover when transporting earth and sand. At the pipe laying work, the road pavement will be removed temporarily. This will generate dust and may affect people at the roadside.
The emission of chlorine gas from water disinfection may affect air quality. However, this project plans to use bleaching powder and dissolve it for disinfectant. Therefore, chlorine gas leak is not expected.
The target concentration of chlorine gas in air in Japan is set as 0.5 ppm, but there are no such similar standards in Cambodia. On the other hand, there is maximum allowable standards of pollution substance for immobile sources in Cambodia, and the maximum level of discharge is set as 20mg/m3 (30mg/m in Japan) for chlorine gas.
Bleaching powder is stable as a disinfectant, and the emission to air is limited, so that the impact on air quality is not significant.
</td></tr>
<tr><td></td><td>Water Pollution</td><td>
Some parts of construction work of intake will be done in the lake, and it may increase turbidity of water. The construction at the lake will be conducted inside of temporary coffer dam, so that the chance of impact on water is little.

At the stage of operation, sludge will be generated from the treatment process. The moisture will be separated and recycled to treatment after liquid-solid separation, so wastewater is not generated by this system.
Operators will generate domestic wastewater and it is limited. The domestic wastewater will be treated by a septic tank and the top clear layer will soak into the ground. The wastewater discharge to the river is zero, and only rainwater discharging facilities connected to the Vay Kor Lake is planned.
</td></tr>
<tr><td></td><td>Solid Waste</td><td>The regulations for solid waste in Cambodia are “Sub-decree in Solid Waste Management (1999)” and related ministerial orders. The Ministry responsible for waste administration is MOE and implementing agency is the local government. According to the census of 2008, the coverage of solid waste collection is as low as 29% in Svay Rieng City, but it is</td></tr>
</table>

<table>
<tr><th>Items</th><th>Impacts</th><th>Results</th></tr>
<tr><td></td><td></td><td>improving. The city hall makes contract with private company for general solid waste. There are no regulations for construction waste, and it is said that the incombustible material is usually used for back-filling purpose and wood scrap is incinerated. It is flood suffering area and the land owners prefer land filling, so that soil dumping is easy in this area.
Table: Expected Construction Waste
<table>
<tr><th>Material</th><th>Amount (m3)</th><th>Source</th><th>Handling Method</th></tr>
<tr><td>Surplus soil</td><td>10,500</td><td>Intake</td><td>landfill</td></tr>
<tr><td>Surplus soil</td><td>11,000</td><td>WTP</td><td>landfill</td></tr>
<tr><td>Surplus soil, concrete waste, asphalt waste</td><td>16,000</td><td>Pipe laying work</td><td>landfill</td></tr>
<tr><td>Formwork</td><td>1,400</td><td>Intake</td><td>incineration</td></tr>
<tr><td>Formwork</td><td>15,000</td><td>WTP</td><td>incineration</td></tr>
</table>
Source: Survey Team

At the time of operation, it is necessary to treat the sludge generated in the WTP. The sludge is dried in the sun, reduced in weight, and then landfilled at a disposal site provided by WWs. Assuming that the facility is fully operated, the raw water turbidity is 100 NTU, and the water content of the sludge is 60%, the annual amount of sludge will be 558 tons in weight and 626 m3 in volume. Sludge can be regarded as a mixture of turbid material in raw water and coagulant, so it is not harmful. There are needs of such a material for landfilling in Cambodia. The Svay Rieng Waterworks (SWWs) is currently considering a place.</td></tr>
</table>

<table>
<tr><th>Items</th><th>Impacts</th><th>Results</th></tr>
<tr><td></td><td>Noise and vibration</td><td>
The current noise level at the project site meets the requirement of category II for residential area.
Neighboring houses are most affected by construction noise and vibration. Since the planned intake site is at the side of the road that crosses Vay Kor Lake, there are no residents to be affected. The area around the planned WTP is agricultural land and there are few residences, but the closest house from the boundary of the WTP is about 30m, and the next is 50m. There is a forest area between the house and the construction site, and it is expected that the noise will be reduced significantly, but if there is a complaint, immediate action is required.
The construction vehicles will generate road noise. The noise emission standards for the vehicles in public and residential area in Cambodia is shown below. The vehicles should be maintained and managed to keep the noise within the permitted level.

Table: Maximum Noise Level of Vehicles in Public and Residential Area
<table>
<tr><th>Category of vehicle</th><th>Maximum permitted noise level（dB(A))</th></tr>
<tr><td>Motorcycle, cylinder capacity <125cm3</td><td>85</td></tr>
<tr><td>Motorcycle, cylinder capacity >125cm3</td><td>90</td></tr>
<tr><td>Motorize tricycle</td><td>90</td></tr>
<tr><td>Cars, taxi, passenger vehicle not more than 12 passengers</td><td>80</td></tr>
<tr><td>Cars, taxi, passenger vehicle more than 12 passengers</td><td>85</td></tr>
<tr><td>Truck maximum weight: <3.5 ton</td><td>85</td></tr>
<tr><td>Truck maximum weight: >3.5 ton</td><td>88</td></tr>
<tr><td>Truck engine capacity: > 150 kw</td><td>89</td></tr>
<tr><td>Other trucks and tractors</td><td>91</td></tr>
</table>
Source: Sub-decree on Control of Air Pollution and Noise Disturbance

In the stage of operation, the noise and vibration level should be kept at acceptable level. The following table shows the list of machineries which generate noise and vibration, and the measures considered in design. The generators are emergency source-s for power failure, and only used temporarily.

Table: Noise Generating Machinery and Measures of Impact Reduction
<table>
<tr><th>Facility</th><th>Machinery</th><th>Specification</th><th>Mitigation Measures</th></tr>
<tr><td>WTP</td><td>Blower of filter basin</td><td>15kW×2</td><td>Installed at basement</td></tr>
<tr><td></td><td>Distribution Pump</td><td>75kW×3</td><td>Installed at basement (including one Stand-by)</td></tr>
<tr><td></td><td>Generator (Backup)</td><td>350kVA</td><td>Bonnet type、Sound absorption wall at generator room</td></tr>
<tr><td>Intake</td><td>Pump</td><td>30kW×2</td><td>Installed at basement</td></tr>
<tr><td></td><td>Generator (Backup)</td><td>125kVA</td><td>Bonnet type、Sound absorption wall at generator room</td></tr>
</table>
Source: Survey Team

The above reduction measures are reflected in the design.
</td></tr>
<tr><td></td><td>Soil</td><td>The potential risk of oil leak of fuel from generator will be mitigated by the oil retaining wall at the fuel storage tank.</td></tr>
</table>

<table>
<tr><th>Items</th><th>Impacts</th><th>Results</th></tr>
<tr><td>Natural Environment</td><td>Ecosystem</td><td>
The project area is an urban area or agricultural land. Therefore, it is not an excellent habitat for animals, and there are many common species.
The following table shows the summary of the species found in the project area by the site survey.
Table: Summary of Fauna Survey
<table>
<tr><th></th><th>Critically Endangered (CR)</th><th>Endangered (EN)</th><th>Vulnerable (VU)</th><th>Least Concern (LC)</th><th>Others</th></tr>
<tr><td>Birds</td><td>0</td><td>0</td><td>0</td><td>55</td><td>2</td></tr>
<tr><td>Fishes</td><td>1</td><td>1</td><td>0</td><td>20</td><td>24</td></tr>
</table>
Source : Survey Team

As the result of bird survey, a total of 57 species were identified. Out of the 57, 55 species are categorized in LC. There are two species listed in CITES Annex II and one species listed in Annex III. There are no species that require special attention for conservation, and since the project site is a former agricultural land and a roadside, the impact on birds is considered to be limited.
The fish survey resulted in the recognition of 46 species including one CR, one EN, 20 LC and 24 Others. The Catlocarpio siamensis of CR and Mystus bocourti of EN has not been confirmed in the catch survey, but its existence was mentioned by the official of the Department of Fishery.
The location of the intake is along the shallow shoreline, and the impact of the intake on fish is limited. Regarding the impact of turbid water caused by the construction work, the turbidity of the baseline is high throughout the year, so it is considered that there will be little impact beyond this. On the other hand, it is considered that workers should be instructed not to do fishing or hunting during the construction period, and the capture of living things should be strongly prohibited. In particular, the lower side pond is designated as a protected area for the protection of fishery resources, so not only guidance but also patrol should be carried out.
Both sites of WTP and intake have no natural visitation, thus no impact on flora is expected. The pipe will be buried under the road or side strip, so the project will not affect any vegetation.
</td></tr>
<tr><td></td><td>Hydrology</td><td>
The intake structure will be constructed within the temporary coffer dam. A part of intake structure and coffer dam jut into the lake. However, these are not expected to disturb the hydrological condition because the location is shallow part of the lake and flow velocity is extremely low. Therefore, the impact on flow condition is not significant.
The intake amount of water supply is much smaller than the water for irrigation. The impact of taking water is not significant.
</td></tr>
<tr><td>Social Environment</td><td>Land use</td><td>
The land for WTP has already been acquired by the SWWs. The land for intake is public land. Both areas are less than 1 ha and impact of land use is limited.
The land for the WTP was privately owned farmland and no residents. SWWs and Department of Industry, Science, Technology and Innovation (DISTI) discussed the terms and conditions of the sale with the landowner, obtained the approval of the parties concerned, and concluded and paid the sale contract at a price higher than the replacement price. There is no discrepancy with the JICA guidelines in land acquisition.
Land for intake is public land and the permission of use was given by the Provincial Hall.
Land for temporary use of construction by lease is necessary for stockyard, office, etc. It is mentioned in the minutes that the MISTI is responsible for preparing the land by the announcement of PQ.
SWWs will fairly make a contract with landowner for the lease of land with the consideration of actual price in neighborhood and pay monthly.
The project will use the existing borrow pit owned by private company, so
</td></tr>
</table>

Items	Impacts	Results
		environmental impact will not be newly created.
	Poverty	Poverty group exists at a certain level in the project area, it varies from 6 % to 18 % village-wise. MISTI has a policy to support poverty group by the exemption of connection fee. The poverty group will also be able to receive the benefit. Moreover, the project will provide equipment for connection to the poverty group.
	Existing social infrastructure and services	The number of construction vehicles is estimated as follows. Pipe laying work: 5 Construction of intake: 5 The site is provincial city and baseline traffic is not much. The increase of estimated number of vehicles will not seriously affect traffic. On the other hand, the pipe laying work will create traffic disturbance in case of temporary one-way traffic. In addition, since construction of the intake will be carried out on road crossing the Vay Kor Lake, the management of passing route is important. Regarding access road to the WTP construction site, there is possibility of expansion at the crank part of the existing road, but the widened land will be rented only during the construction period.
	Landscape	The new structures of this project are WTP and intake facilities. The area around the WTP is a field, and it is not a place to enjoy the scenery, and there are no houses or buildings affected by the surrounding area in the view. Therefore, the impact of the project on the landscape can be ignored. On the other hand, the intake is a roadside site that crosses Vay Kor Lake. and the Provincial Hall has requested that the design should be harmonized with the landscape of lake, which was reflected on the design.
	Infectious diseases	HIV epidemic in Cambodia recorded a peak around 1995, and there were 14,000 incidents of HIV infection. GOC has taken the measures strongly and the number of new incidents is about 1,000 to 1,200 (by UNAIDS), currently, as the outcome of educational activities, increase of medical care station, enhancement of medical check, etc. However, the new patients still appear mainly in sex workers. GOC continuously strengthens the preventive action to eradicate new infection. The number of workers of the construction is estimated as 140 at maximum. Many of them will be hired in the project area, and the new inflow population will not be large. However, the project should take awareness raising activities of workers to prevent new infections by workers from the outside.
	Working Environment	The legal basis of occupational safety in Cambodia is “Labor Law (1997)” and there are supporting ministerial regulations and ILO conventions which Cambodia ratified. The workers at the construction site in Cambodia usually put helmet and safety goods. The working condition seems relatively good. Compliance with laws and regulations is necessary. The following measures are considered to protect workers from accidental injury: 1: Installation of a lightning rod for lightning prevention; 2: Installation of earth leakage circuit breaker; 3: Installation of lighting equipment for night activities; and 4: Installation of fall preventive handrail.
	Accident	The Number of casualties by traffic accident in Cambodia recorded a peak as 27,403 people in 2007. It has been decreasing and 18,287 people in 2010. The total number of casualties is decreasing; however, the number of fatalities is increasing. The project activities could increase risk of accidents due to the increase in traffic by construction vehicles. However, the location of the site is not facing main road and it is a place of good visibility, so the effect is not significant. Since the project uses bleaching powder as disinfectant, the risk of gas leak does not occur. Countermeasures for occupational safety is described above in working environment.

Source: Survey Team

1-3-1-7 Impact Assessment

The results of impact assessment are as shown in the following table on the basis of site visit, environmental and social survey, and discussions with stakeholders.

Table 1-3-24 Impact Assessment

Impact	Impact Assessment at Scoping		Impact Assessment Based on Study Results		Reasons for Assessment
	Design/ Construction	Operation	Design/ Construction	Operation	
Air Pollution	✔		B-	D	Construction: By removing the road pavement and from the pipe laying work, dust is expected. Air pollution is also expected from the exhaust gas emitted by the construction vehicles and machineries. Operation: No work which causes air pollution is expected.
Water Pollution	✔	✔	B-	D	Construction: Basement construction of intake may generate turbid water. Operation: The wastewater generated at the treatment process will be recycled, and there will be no discharge to outside of the system. In addition, since wastewater such as domestic wastewater by staff is guided to the septic tank and let go to underground, it does not flow into the water area. Thus, the post survey evaluation is D.
Solid Waste	✔	✔	B-	B-	Construction: Construction work generates solid waste, such as removed road pavement and form, scrap. Construction workers will also generate domestic waste. Operation: Treatment sludge will be dried and become solid waste; therefore, it shall be treated appropriately.
Noise and Vibration	✔	✔	B-	B-	Construction: Construction vehicles and machinery generate noise and vibration, but it is temporary and there is no resident in the circle of influence. The site and its surroundings are rice fields, and there are no animals to be affected. Therefore, the post survey evaluation is D. Operation: Pumping station and WTP generate noise and vibration during operation, but there is no person living in the circle of influence at present. However, countermeasures should be considered to keep the appropriate level of noise and vibration. The facilities which generate noise and vibration will be installed at basement and treated by use of absorbing materials.
Sediment	✔		B-	D	Construction: Construction work of intake could increase the turbidity due to disturbing sediment. Operation: No impact on sediment.

Impact	Impact Assessment at Scoping		Impact Assessment Based on Study Results		Reasons for Assessment
	Design/ Construction	Operation	Design/ Construction	Operation	
Protected Area	✔	✔	B-	D	Construction: The southern pond of Lake Vay Kor is a fishery resource reserve, but the intake facility is located in the northern pond across the road and has no direct impact. There is no violation of laws and regulations. However, it is necessary to strictly prohibit the capture by construction workers. The impact will be mitigated by conducting patrols and training. Considering the impact on fishes, construction work which may generate turbid water will be done within the temporary coffer dam and will be mitigated by slope protection and cage mat use. Consider the impact on fish and eliminate the possibility of turbid water generation during construction as much as possible. Operation: A bar screen will be installed and the maximum inflow speed will be set to 0.1 m/s or less, which is extremely slow, so that the impact on the ecosystem will be mitigated and there will be no significant impact on the protected area.
Ecosystem	✔		B-	D	Construction: There are valuable species of fish, thus workers should avoid fishing and hunting to catch valuable creatures in the area. Awareness programs and patrol will be taken. Operation: A bar screen will be installed and the maximum inflow speed will be set to 0.1 m/s or less, which is extremely slow, so that the impact on the ecosystem will be mitigated.
Hydrology	✔		D	D	Construction: Construction of intake will be conducted within temporary coffer dam. The coffer dam will not disturb the water flow because the site is shallow and flow rate is very low. Thus, the hydrological impact is limited, and post-study evaluation is D. Operation: A part of intake structure exists in the lake, but the flow rate is very low, so that the impact could be disregarded.
Poverty Group	✔		D	B+	Construction: A Certain number of poverty group exists in the project site, but they will not incur any problem by the project. No relocation of unauthorized residents (occupants) will occur. Operation: The poverty group will receive benefit because of the enhancement of water supply.
Existing social infrastructure and services			B-	B+	Construction: Detours for road users will be temporarily required during the construction period. Operation: Standard social service level will be improved by the expansion of the water supply facilities.

Impact	Impact Assessment at Scoping		Impact Assessment Based on Study Results		Reasons for Assessment
	Design/ Construction	Operation	Design/ Construction	Operation	
Landscape	✔	✔	B-	D	Construction (at the design stage): The intake is planned to be installed on the side of the road that crosses the lake, and there are concerns about the impact of buildings on the landscape of the lake, Therefore, the facility design should harmonize with the environment. Operation: The design of the intake will be determined with the coordination of the Provincial Hall, to avoid any future problem that would arise.
HIV/AIDS and other infectious diseases	✔		B-	D	Construction: The extent of the construction is not large but the influx of workers will increase the possibility of infectious diseases. Operation: There is no component to increase infectious diseases.
Working conditions (incl. occupational safety)	✔		B-	D	Construction: It is necessary to consider the workers' working conditions. Operation: The facilities are designed with consideration of safely including countermeasures. Considerable danger does not exist.
Accidents	✔	✔	B-	D	Construction: Measures are to be taken for preventing accidents of construction vehicles and work-related accidents. Operation: This project does not use chlorine gas for disinfection. Thus, there is no possibility of gas leak. The post study evaluation is D.

Evaluation : A: A big impact is expected. B: Some impact is expected C: The extent of the impact is unknown and further confirmation is necessary. D: The impact is minor and no further investigation is required.
＋: Positive impact, －: Negative impact
Source: Survey Team

1-3-1-8 Mitigation Measures and their Implementation Cost

The mitigation measures to be taken based on the results of the environmental, social and impact assessments given above are as outlined in the table below.

Table 1-3-25 Impacts and Mitigation Measures (Before Construction)

Impacts	Mitigation Measures (Before Construction)	Implementing Body	Supervisory Authority	Costs
Noise and vibration	Measures for reducing noise and vibration shall be considered for the facilities able to generate noise and vibration	Consultant	MISTI/DISTI,SWWs	Design cost
Ecosystem	Appropriate design shall be considered to prevent fish from entering into intake facilities.	Consultant	MISTI/DISTI,SWWs	Design cost
Working	Safety design and tools shall be taken into account.	Consultant	MISTI/DI	Design cost

Impacts	Mitigation Measures (Before Construction)	Implementing Body	Supervisory Authority	Costs
condition			STI,SWWs	

Table 1-3-26 Impacts and Mitigation Measures (Construction)

Impacts	Mitigation Measures (During Construction)	Implementing Body	Supervisory Authority	Costs
Air pollution	Dust will be minimized by sprinkling water during the work expected to generate dust. Soil materials should be covered to prevent dust flying during transportation by vehicles. Exhaust gas emitted by construction vehicles and machinery shall be reduced by enforcing registration of vehicles and machinery and keeping them well maintained and managed.	Contractor	MISTI/DISTI/ Svay Rieng Water Works (SWWs)	Construction cost
Water pollution	Construction work of intake may generate turbid water. It shall be done inside temporary coffer dam to prevent the direct discharge to the lake. Contractor shall monitor and control water quality, especially turbidity and oil spill by visual inspection. If anything is found to be abnormal, work should be stopped immediately, and check the water quality by laboratory examination, then the result should be reported to DISTI.	Contractor	MISTI/DISTI/SWWs	Construction cost (Slope protection + Gabion: USD391,340)
Solid waste	Main part of construction waste is surplus soil. The contractor should re-use the construction waste as much as possible. The soil which could not be reused will be used at landfill site. SWWs has the obligation to prepare the landfill site. For domestic waste from the workers, disposal shall be outsourced at a fee according to local rules for general waste disposal.	Contractor	MISTI/DISTI/SWWs Svay Rieng City Hall	Construction cost
Noise and vibration	Construction vehicles and machinery should be registered and maintained well to keep the noise and vibration level in acceptable range. Operators should be trained for the proper procedure of operation to prevent generating abnormal noise and vibration.	Contractor	MISTI/DISTI/SWWs	Construction cost
Sediment	It is included in the measures of water quality.	Contractor	MISTI/DISTI/SWWs	Construction cost
Ecosystem	Workers should be guided that they do not hunt and do fishing for the preservation of important species. They should attend the education program periodically.	Contractor	MISTI/DISTI/SWWs	Construction cost
Land and local resource usage	MISTI is responsible for renting land for temporary use of construction work around the site.	MISTI/DISTI/SWW	MOP	GOC budget (300USD/month)
Existing social infrastructure and services	Impacts from traffic congestion and detours arising from the work should be minimized by posting signboards, deploying traffic guides, and making public announcements to local residents.	Contractor	MISTI/DISTI/SWWs	Construction cost
	Necessity of preparation of access roads for WTP construction should be examined carefully, if necessary, the land beside the road should be borrowed temporally.	MISTI, DISTI, SWW	Provincial Hall	GOC budget
HIV/AIDS and other infectious disease	The working parties should be educated on a periodic basis in efforts to prevent infectious diseases.	Contractor	MISTI/DISTI/SWWs	Construction cost
Working	The workers should be educated on a periodic basis in efforts	Contractor	MISTI/DIS	Construct

Impacts	Mitigation Measures (During Construction)	Implementing Body	Supervisory Authority	Costs
condition	to prevent work accidents. Safety tools should be supplied as necessary.		TI/SWWs	ion cost
Accident	For construction vehicle operation, a safe driving plan should be prepared, and drivers should attend safety classes to prevent accidents.	Contractor	MISTI/DISTI/SWWs	Construction cost

Source: Survey Team

Table 1-3-27 Impacts and Mitigation Measures (Operation)

Impacts	Mitigation Measures (During Construction)	Implementing Body	Supervisory Authority	Costs
Solid waste	Disposal of solid waste should be monitored and recorded to manage it. SWWs should confirm that the dried sludge is transferred to the appropriate dumping yard.	SWWs	DISTI Svay Rieng City hall	SWWs
Noise and vibration	SWWs should standardize the procedure to check acceptability of noise and vibration level and monitor it. SWWs should guide operators on the procedure in case of occurrence of abnormal noise and vibration.	SWWs	MISTI/DISTI/SWWs	SWWs

Source: Survey Team

1-3-1-9 Monitoring Plan

The monitoring plan should be made on the basis of the above survey. Considering the availability of equipment and capacity of staffs in Cambodia, a realistic monitoring method has to be adopted. In addition, it is highly recommended that the complaint record should be analyzed regularly and the monitoring frequency and items should be reviewed.

Table 1-3-28 Monitoring Plan (Tentative)

Impact	Parameter	Monitoring Method	Monitoring Point	Frequency	Responsibility	Cost
Construction						
Air Pollution	Dust	Visual observation	Vicinity of construction site	Daily	Contractor	Construction cost
	Exhaust gas	Inspection of registered vehicle	Construction Office	Monthly	Contractor	Construction cost
Noise and vibration	Working time	Working record	Construction site	Daily during construction	Contractor	Construction cost
	Management of vehicles	Inspection of registered vehicles	Construction Office	Monthly	Contractor	Construction cost
	Guidance to operator	Training record	Construction Office	Once during construction	Contractor	Construction cost
Water Pollution and sediment	Turbidity, oil	Visual inspection	Inlet of discharge	Weekly but daily during construction of foundation	Contractor	Construction cost

Impact	Parameter	Monitoring Method	Monitoring Point	Frequency	Responsibility	Cost
	Water quality	pH, EC, COD, turbidity, oil	Outlet of discharge	When abnormal incident is observed	Contractor	Construction cost
Solid Waste (domestic)	Proper management	Visual inspection	Domestic waste	Weekly	Contractor	Construction cost
Solid Waste (Construction)	Proper dumping	Visual inspection	Temporary damping yard	At the time of damping	Contractor	Construction cost
	Preparation of dumping site	Contract document	Dumping site for soil waste	At the time of contract	SWWs, MISTI	No charge
Ecosystem	Ban of hunting and fishing (Training)	Training record	Construction Office	Once during construction	Contractor	Construction cost
	Ban of hunting and fishing (Patrol)	Monthly construction report	Construction Office	Weekly	Contractor	Construction cost
Land and local resource usage	Lease of land	Contract document	Construction Office	At the time of contract of lease	SWWs 、MISTI	About 300 USD/month
Existing social infrastructure and services	Mitigation measures to prevent traffic disturbance	Monthly construction report	Construction Office	Monthly	Contractor	Construction cost
HIV/AIDS and other infectious disease	Management of occupational safety and hygiene	Monthly construction report	Construction Office	Monthly	Contractor	Construction cost
Working condition	Management of occupational safety and hygiene	Monthly construction report	Construction Office	Monthly	Contractor	Construction cost
Accident	Traffic plan of construction vehicle	Plan	Construction Office	At planning	Contractor	Construction cost
	Safety training	Monthly construction report	Construction Office	Monthly	Contractor	Construction cost
Miscellaneous	Complaint management	Analysis of complaint	Construction Office	Monthly	Contractor	Construction cost
Operation						
Waste	Appropriate treatment of sludge	Monitoring record	WTP	Every three months	SWWs	O&M cost
	Preparation of dumping site for sludge	Contract document	SWWs	At the time of contract	SWWs	No charge
Noise and vibration	Monitoring with standard operating procedure (SOP)	SOP and monitoring record	Pumping station	Every three months	SWWs	O&M cost
	Guidance for operators	Training record	Pumping station	Every three months	SWWs	O&M cost

Source: Survey Team

1-3-1-10 Stakeholder Meetings

The following table is a summary of stakeholder meetings.

Table 1-3-29 Summary of Stakeholder Meetings

Source / Agenda	Date/Place	Participants	Format	Details Discussed
Svay Rieng Department of Environment (DOE)	2017/7/3 DOE office	DOE SWWs Survey Team Total 4	Meeting	Explanation of project plan and possible impact. Q & A on project implementation. There were no particular remarks.
Svay Rieng Department of Agriculture, Forestry and Fisheries (DOA)	2017/7/3 DOA Office	DOA SWWs Survey Team Total 7	Meeting	Explanation of project plan and possible impact. Exchange of opinion about the effect on activities of agriculture and fishery, water source, and protection. Q & A on project implementation. There were no particular remarks.
Resident who was fishing in Vay Kor Lake	2017/7/3 Vay Kor Lake	Resident SWWs Survey Team Total 5	Interview	Interviews on the status of fish harvesting at Vay Kor Lake and how to deal with rare species. The resident thought that there is no problem with the impact of construction on fishing.
Stakeholder meeting of DOE, DOA, SWW, City hall	2017/7/12 Office of SWW	DOE DOA City Hall SWW Survey Team Total 10	Meeting	Explanation of outline of the project and the possibility of environmental impact. Q & A about the project. Q & A about the development plans for Svay Rieng and Vay Kor Lake. The possibility of use of water from Vay Kor Lake. The mitigation measures were taken by the location setting and design of intake. There was an opinion to take mitigation measures for the conservation of precious species. In addition, there was a comment from the residents that the well water is contaminated. Discussion of how to dispose construction waste and domestic waste. There are needs for landfilling materials, so the waste will be reused as much as possible.
DOE	2019/12/12 DOE	DOE SWWs Survey Team Total 5	Meeting	Confirmation of necessary environmental considerations based on scope changes. Confirmation that there have been no changes to the protected area / environmental law since the 2017 survey. There is no problem with the development of the upper pond on Vay Kor Lake. Regarding the construction of the water intake facility, DOE has no particular opinion, and suggested that it will depend on Department of Water Resources and Meteorology (DOWRAM).
Svay Rieng City Hall	2019/12/12 City Hall	Chief of Administration Survey Team Total 4	Meeting	Explanation of project plan and possible impact. Q & A on project implementation, licensing and land acquisition, surrounding development plans, waste treatment, etc. The city hall has no authority over licensing. The city is in charge of the resident briefing session. Water supply extension projects are welcome.
Svay Rieng Provincial Hall	2019/12/19 Provincial Hall	Deputy Governor DISTI SWWs Survey Team Total 7	Meeting	Explanation of project plan and possible impact. Q & A on project implementation, licensing and land acquisition, surrounding development plans, waste treatment, etc. Regarding the water intake facility, the Deputy Governor said that he wanted to give due consideration to the landscape, so

Source / Agenda	Date/Place	Participants	Format	Details Discussed
				he requested for the design plan of the structure. The Survey Team showed the design concept and it was agreed upon. The provincial hall will convene a meeting of relevant agencies. He said he had been waiting for the spread of water supply for a long time
Public hearing	2020/2/28 Chek commune center	Chek Commune Chief, Vilage Chief, residents, police, SWWs Survey Team Total 38 (female 13)	Public hearing	Explanation of project plan and possible impact. Expectations for project and strong demand for early start of water supply. There is also a request to expand the water supply range. The Survey Team explained that there is a limit to expanding the water supply range due to budget restrictions. Residents expressed concern about the burden of connection charges, but the SWW explained assistance to the poor. There was no dissenting opinion on the implementation of the project, and social consensus was confirmed.
Public hearing	2020/2/28 Prey Chlak	Prey Chlak Commune Chief, Village Chief, residents, SWWs Survey Team Total: 21 (female 7)	Public hearing	Explanation of project plan and possible impact. Expectations for project and strong demand for early start of water supply. Expectation to improve water quality by switching from well water to water supply. Requests for shortening the construction period and proper management of construction vehicles. The project will appropriately manage construction vehicles by monitoring. Request for advance publication of construction plan. There was no dissenting opinion on the implementation of the project, and social consensus was confirmed.

Source: Survey Team

1-3-2 Land Acquisition and Resettlement

1-3-2-1 Need for Land Acquisition and Resettlement

The project need land for the WTP and the water intake site. The existing WTP site is not large enough for expansion, but about 1ha is required for the new WTP site and about 1 ha for the water intake installation. SWWs has acquired farmland owned by private people. There are no authorized/ unauthorized residents on this land and no relocation will be required. No peasants are employed, and no one has lost his livelihood due to the loss of land. The landowner harvested all the products from the land during the contracting process and no damage occurred. On the other hand, the intake will be installed on public land and will be used with the permission of the Provincial Hall. It is a land beside a road that crosses the lake, and there are no residents or users.

1-3-2-2 Legal Framework on Land Acquisition and Resettlement

The legal basis of the land ownership, acquisition and resettlement are the Constitution (1993), Land Law (2001), and Expropriation Law (2009). The main contents of these laws are explained as follows.

(1) Constitution (1993)

Article 44 states that all persons shall have the right to land ownership, as well as expropriation shall be possible only if public utility demands in the cases stipulated by the law and if prior appropriate and fair compensation is granted.

Article 58 states that State property notably consists of land, underground, mountains, sea, sea-bed, undersea-bed, coastline, airspace, islands, rivers, canals, streams, lakes, forests, natural resources, economic and cultural centers, national defense bases, and other building facilities belonging to the State.

(2) Land Law 2001

Article 4 refers to Article 44 of the Constitution and ensures ownership.

Article 5 states that no person may be deprived of his ownership, unless it is in the public interest, as well as an ownership deprivation shall be carried out in accordance with the forms and procedures provided by law and regulations and only after the payment of just and equitable compensation.

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

Article 15 defines the property that falls within the public property of the State and public legal entities.

Article 35 states 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.

(3) Expropriation Law, 2009

Article 1 explains aims of this law.

Article 3 describes applicability of the law, and states that the law does not govern any issues on expropriation in any agreement or memorandum on supporting investment between the Royal Government of Cambodia and partner countries.

Article 5 defines public physical infrastructure which will be target of expropriation.

Articles 12, 13 and 14 explain the mechanism of expropriation, i.e., establishment of Expropriation Committee (EC), Expropriation Sub Committee (ESC), and Complaint Resolution Committee (CRC). Article 13 states that the establishment and functioning of the sub-committee shall be determined by the sub-decree, however, the sub-decree has not been issued yet.

Article 19 states that the expropriation 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.

Article 22 defines that financial compensation shall be based on the market price or replacement price on 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.

1-3-2-3 Need for Land Acquisition and Resettlement

SWWs procured the land for new WTP in December 2017. The landowner agreed to sell the 10,513m^2 land and already fully paid to the seller. The land was farmland and there were no authorized/ unauthorized residents and buildings, thus, resettlement was not required. In selecting a candidate site for a WTP, the SWWs held discussions with multiple landowners on prices and sales conditions, and concluded a sales contract with the approval of a committee formed by related organizations. The purchase cost has already been paid, and discussions with the owner about the sale was conducted smoothy. According to the copy of the sales contract, there are signatures of the wife of the owner and the commune chief as witnesses in concluding the contract. Since the land price is 120% compared with the land in the neighborhood of similar conditions, it is considered that the sales contract was at an appropriate price and equivalent to the replacement cost. Therefore, the land acquisition procedure was properly implemented. The landowner has harvested all the crops on the farmland during the contract process and no damage has occurred. Also, no tenant farmer made a living on this farmland. The pipes will be laid under the road and land acquisition is not required.

The intake facility will be provided on the side of the national highway that crosses the Vay Kor Lake. It is a public land and permission to occupy this land will be obtained from the provincial government before notice of the bidding document. Although verbal agreement has been obtained from the provincial government, MISTI is responsible for obtaining formal permission by the prequalification evaluation of the bidding procedure.

On the other hand, service pipes will be laid basically in the road area, and if there are buildings in the ROW of the road area, the pipes will be laid in the roadside zone so that they will not affect the existing buildings and residential houses.

1-3-2-4 Compensation and Support

The persons who are the target of land acquisition were only two in this case, and the process followed usual land sales, therefore, the EC and CRC were not specially established. The grievance response follows the process of (1) Commune chief is the first window of complaint, (2) Commune chief will hold a meeting to solve a problem with SWW and DISTI, (3) When (2) does not work, the upper authority such as MISTI and City Hall will be involved. In this case, the price was already paid and there were no grievances.

As a result, all the processes meet the requirements of the JICA guidelines, and completed.

1-3-3 Others

1-3-3-1 Monitoring Form (Draft)

On the basis of the above discussion, the monitoring form was drafted and the following tables show both the time of construction and operation. The reference value of water quality is different from the national standards, because it is known from the monitoring result of water quality from July 2017 that the current water quality does not meet the standards in some parameters. The reference values of such parameters are determined by the observed range of monitoring result.

Table 1-3-30 Monitoring Form (Construction)

Construction Site (Daily Monitoring)

Monitoring Items		Procedures	Results	Measures to be Taken	Reference Standard		Frequency
Dust		Visual inspection			Acceptable or not		Daily
Noise		Sensory inspection			Acceptable or not		Daily
		Operation time check			Stated operation time in EMP		Daily
Water Quality (turbidity, oil)		Visual inspection			Acceptable or not		Daily (during foundation work)
Water Quality	pH	Laboratory test			6 - 8	Determined by the monitoring result	In case of abnormal observation of turbidity or oil
	EC				80		
	COD				10		
	Turbidity				500		

Construction Site (Weekly Monitoring)

Monitoring Items	Procedures	Results	Measures to be Taken	Reference Standard	Frequency
Waste (Domestic)	Patrol			Acceptable or not	Weekly

Construction Site (Monthly Monitoring)

Monitoring Items	Procedures	Results	Measures to be Taken	Reference Standard	Frequency
Condition of construction machinery and vehicles	Maintenance record check			Acceptable or not (Exhaust gas, noise, vibration, and usual safety check)	
Traffic management	Patrol			Stated procedure in EMP	Monthly
Accident	Patrol			Acceptable or not	Monthly
Training and educational meetings with workers	Report check			Stated procedure in EMP (frequency, contents, target, etc.)	
Claim and comment	Report check			Acceptable or not	Monthly

Others

Monitoring Items	Procedures	Results	Measures to be Taken	Reference Standards	Frequency
Land for waste dumping Land for temporary use	Lease condition			Appropriate or not (Size, location, permission (if necessary))	Contract of lease
Plan of safety transportation	Plan check			Acceptable or not	At planning

Source: Survey Team

Table 1-3-31 Monitoring Form (Operation)

Monitoring Items	Procedures	Results	Measures to be Taken	Reference Standards	Frequency
Waste (treatment sludge)	Patrol			Appropriate or not	Monthly
Land for waste dumping	Procedure check			Appropriate or not (Size, location, permission (if necessary))	At contract agreement
Noise and vibration*	Patrol and maintenance			Normal condition or not	Daily

*Noise and vibration of pump shall be checked in an operation record every day.
Source: Survey Team

1-3-3-2 Environmental Checklist

The environmental checklist has been prepared based on the above discussion and shown as follows.

Table 1-3-32 Environmental Checklist

Category	Environmental Item	Main Check Items	Yes: Y No: N	Specific Environmental and Social Considerations (Reasons for Yes or No, Rationale, Mitigation Measures, etc.)
1 Approvals, explanations	(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) Y (c) N (d) Y	(a) (b) MISTI submitted the report pursuant to the requirement to MOE. MOE inspected and approved the report, and the EPC was agreed on March 30, 2021. (c) No conditions. (d) MISTI will obtain official permission letter of water extraction from Vay Kor Lake by MOWRAM by December 2021, and permission letter of construction of water intake by Provincial Hall.
	(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) All related departments of the development project understood the project purpose and contents, and they agreed on the implementation. At the public hearing, the villagers welcomed the project. They wished early project start. There is no particular objection. (b) The design of the intake facility is considered for the suitable appearance to meet the lake environment with comments from Provincial Hall. The water intake is designed with the consideration to prevent fish invasion by the request from the DOE.
	(3) Examination of Alternatives	(a) Have multiple alternative plans for the Project been analyzed? (Including analysis of items related to the environment/society.)	(a) Y	(a) Alternatives have been examined for the water source, site selection of intake and WTP, and extent of the supply area.
2 Pollution Measures	(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) The Project plans to use breaching power for disinfection. This reagent is stable, and occurrence of air pollution is considered less. The exhaust fan will be situated at the facilities of disinfection. (b) The above measures serve to keep appropriate working 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) N/A	Discharge generated at the treatment process will be recycled, and sludge will be dried. Therefore, any effluent from treatment process will not be generated. Sewage will be treated by septic tanks and clear upper portion will

Category	Environmental Item	Main Check Items	Yes: Y No: N	Specific Environmental and Social Considerations (Reasons for Yes or No, Rationale, Mitigation Measures, etc.)
				be infiltrated into ground. Therefore, discharge water is not generated.
	(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) Sludge will be treated and dried at dry-bed, then dry sludge will be disposed at an appropriate site with the permission of the landowner. MISTI is responsible for the arrangement.
	(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) The pump will be installed at basement made by the RC with noise reducing walls. The noise will be controlled within the limit of RGC requirement. Therefore, noise and vibration will be controlled to the permissible limit by the above measures.
	(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) The Project does not use groundwater.
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) Y	(a) The Vay Kor Lake is divided in two parts by the national highway No.1. The intake will be constructed at the upper side but the lower side is designated as protected area for the protection of fishery resources. Measures will be taken to prevent the occurrence of turbid water during construction. In addition, education and training will be provided to the workers so that they will not do the fishing activities. In the design of the water intake, a bar screen will be installed, and the maximum inflow speed is set to 0.1 m/s or less, which is extremely slow, to prevent fish from entering. With the above measures, the impact of project implementation can be avoided.
	(2) Ecosystems	(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?	(a) N (b) N (c) N (d) N	(a) The site does not contain any virgin forests, tropical old - growth forests, or important ecological habitats. (b) No habitats for any rare species are present in the site. (c) No major concerns. (d) No major concerns

Category	Environmental Item	Main Check Items	Yes: Y No: N	Specific Environmental and Social Considerations (Reasons for Yes or No, Rationale, Mitigation Measures, etc.)
		Are adequate measures taken to reduce the impacts on aquatic environments, such as aquatic organisms?		
	(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) N	(a) Impact on groundwater is not expected. The amount of water taken from the lake is small compared to the capacity, and the effect on surface water is limited.
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) Are the compensations going to be paid prior to the resettlement? (e) Are 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)N (b) N/A (c) N/A (d) N/A (e) N/A (f) N/A (g) N/A (h) N/A (i) N/A (j) N/A	(a) SWW purchased about 1ha of land for the WTP from the landowner. The land was agricultural land and there were no authorized/unauthorized residents, and there is no relocation of residents. (b) Land sales were conducted in the presence of the village chief and sufficient explanations were given. (c) The sale price of land is about 1.2 times the price of the surrounding land and is considered to be the replacement price. (d) SWW already paid the full amount. (e) Conducted as a general land sale. (F) The landowner is a farmer, and his family (wife only) participated in the contract process and agreed to the sales contract. (g) No relocation occurred. (h) DISTI and the village chief were involved, and land sales were carried out appropriately. (i) The full contract amount has already been paid and no monitoring is performed. (j) If there is a complaint, it will be communicated to DISTI or MISTI via the village chief, but no complaint has occurred in this sale.
	(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) N (b) N	(a) The project has positive impact to improve basic human needs. There is no particular negative impact. (b) The Svay Rieng River has enough discharge capacity and the intake of water supply does not affect significantly.
	(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	(a) N	(a) No anthropological, historical, cultural, religiously important heritages or historical remains have been identified in the project

Category	Environmental Item	Main Check Items	Yes: Y No: N	Specific Environmental and Social Considerations (Reasons for Yes or No, Rationale, Mitigation Measures, etc.)
		protect these sites in accordance with the country's laws?		site.
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a) N	(a) The intake will be constructed at the roadside, and it will be designed to harmonize with the environment to meet the request of the stakeholders.
	(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/A (b) N/A	(a)(b) There are no ethnic minorities or indigenous peoples living near the project site.
	(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) Y (b) Y (c) Y (d) Y	(a) Adherence to laws concerning working conditions will be made explicit in contracts with contractors and managed. (b) Countermeasures such as installation of safety handrail are taken. (c) It will be achieved to set as an obligation of contractor in contract document. (d) Security guards will be included in target members of worker training.
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)N (c) Y (d)Y	(a) Mitigation measures will be taken under EPM for managing all noise, vibration, turbid water, dust, gas emissions, and waste discharged from the work site. (b)Particular negative impact is not expected. (c) Temporary traffic disturbance will occur. The negative effect will be minimized by the measures such as setting of detours, assignment of traffic guide, installation of signboard, appropriate information sharing. (d) Since the water intake facility will be constructed along the national highway crossing the lake, the temporary reduction of the number of lanes will be required, and it may cause traffic

Category	Environmental Item	Main Check Items	Yes: Y No: N	Specific Environmental and Social Considerations (Reasons for Yes or No, Rationale, Mitigation Measures, etc.)
				congestion. The measures to be taken are as described above.
	(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) MISTI is responsible for the monitoring as in previous similar project which they are experienced. (b) It will be determined in the EMoP. (c) Monitoring by proponent is a part of usual operation activities. The training will be given as a part of soft component. (d) It is stipulated in the EMP.
6 Focal points	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Dam and River Projects checklist should also be checked.	(a) N/A	(a) The intake amount is not much, and the intake structure is small scale at the upper flow of existing headwork. Therefore, it is not necessary to refer to the checklist of Dam and River Projects
	Precautions when using the 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	(a) None

Source: Survey Team

Chapter 2. Contents of the Project

2-1 Basic Concept of the Project

This project will improve the access rate to safe water and provide a stable water supply service by constructing water intake facilities, conveyance pipes, WTP, transmission pipes and distribution pipes, and by providing various materials and equipment, water quality management and service pipe connections, and implementing soft components that will contribute to the smooth operation and maintenance of various facilities in Svay Rieng City. The project purpose is to contribute to the improvement of the quality of life of the residents in Svay Rieng.

As a result, by the target year of 2027 for Svay Rieng, stable water supply of 13,360 m^3 (maximum per day) combined with the capacity of existing facilities is expected for 86.7% (46,088 people) in the urban area[1] population of 53,141 people (in 2027), 18.5% (9,876 people) of the rural area population of 53,340 people, 52.6% (55,964 people) of the total administrative area population of 106,481people.

The definition of administrative area in this case is based on the area reviewed in October 2015 for the provincial Waterworks (WWs) that will be allowed to supply water under the administrative responsibility of the former Secretary of State H.E. Ek Sonn Chan of MISTI. The main components of the projects to be cooperated are as follows.

Table 2-1-1 Main Components of the Project to be Cooperated

Items	Contents	
Water Supply Facilities	Daily Maximum Water Supply Amount : 6,800m^3/day	
	Intake Facility: 7,480m^3/day	Intake Gate : 2 gates Pump Room Administration Building Intake Pump : 2 sets (including 1 standby)、Electrical Equipment
	Conveyance Pipe, L=2.9km	Ductile Cast Iron Pipe (DCIP) ϕ 350mm
	WTP (Design Capacity*1 : 7,480m^3/day, Daily Maximum Water Supply Amount : 6,800m^3/day)	Mixing Well (1 basin) Flocculation Basin (2 basins) Sedimentation Basin (2 basins) Rapid Sand Filter (4 basins) Service Reservoir (2,200m^3) Distribution Pumps : 3 sets（including 1 standby, with flow control） Electrical Equipment, Administration Building, Chemical Building, Drying Bed, etc.
	Transmission and distribution Pipe L=111.8km	Ductile Cast Iron Pipe (DCIP) ϕ 300mm~400mm High density polyethylene pipe (HDPE) : ϕ 50mm to 250mm
Procurement of Equipment	Equipment for Water Quality Management Equipment for Electric Machine Equipment and Materials for House Connection to Poverty Households	

[1] The definition of urban area is based on "Reclassification of Urban Areas in Cambodia, 2011" published by the Ministry of Planning (MOP). (1) The population density is over 200 people / km^2, (2) The population of farmers is less than 50%, and (3) The total population of the commune is over 2000 people.

Items	Contents
Soft Component	Operation and Maintenance of Water Treatment Facilities Maintenance of Distribution Facilities Production Management

Note : *1) The proposed amount of treated water is determined based on the design daily maximum water supply amount, and the amount of miscellaneous wastewater, and other lost water in the WTP is taken into consideration. In this project, the design daily maximum water supply amount is expected to have a margin of 10%, and the design daily maximum water supply amount of 6,800 m^3 / day x 1.1 = 7,480 m^3 / day is set as the design water treatment amount.
Source : Survey Team

2-2 Outline Design of the Requested Japanese Assistance

2-2-1 Design Policy

2-2-1-1 Basic Policy

The purpose of this project is to expand and improve the waterworks facility in Svay Rieng City, thereby contributing to efforts of the RGC which is aiming to increase the number of people in urban areas who have access to safe drinking water. The Survey Team had conducted an outline design based on the request of the government, consultation with government officials and field survey.

1) The target year for this project has been set as 2027 based on the meeting of M/D with the Cambodian side held in April 2021. This target year was set based on the relation between the budget scale of the grant aid project and the facility scale derived from the water demand projection. This year will be two years after 2025, when MISTI has set a disseminated target of 100% water supply ratio in urban areas.

2) The scale of expansion capacity will be a daily maximum water supply amount of 6,800 m^3/day, taking into consideration the water demand in 2027 and the water supply capacity of existing facilities.

3) Outline design shall be based on following design criteria:

   ・The design criteria which Phnom Penh Water Supply Authority (PPWSA) adopts and are widely applied in Cambodia;
   ・The design criteria which have been applied in other ongoing grant aid projects; and
   ・”The Design Criteria for Water Supply Facilities 2012” (Japan Waterworks Association).

4) The equipment shall be procured for the equipment that is considered to be the minimum necessary for the operation and maintenance of the facilities constructed in this project, taking into consideration the contents of Cambodia's request and the current status of existing equipment that are currently possessed in Cambodia.

5) In the outline design, high quality materials and equipment shall be applied to the extent locally available in Cambodia, and applicable construction methods that are often conducted in Cambodia shall be adopted as much as possible.

6) The design height and location of the intake facility shall be decided in consideration of the future raising of the dike embankment height around Vay Kor Lake and the widening of National Highway No. 1.

7) The water intake facility shall be designed with consideration for the landscape, taking into consideration, the people coming and going during the annual water festival on the shores of Vay Kor Lake.

8) Corrosion-resistance material shall be selected as materials of WTP and distribution facilities from the point of life-cycle cost (LCC). Also, the design shall be prepared by emphasizing economic efficiency and not requiring high-skilled technique.

9) In order to assist in improving the water supply ratio of the poverty group, materials and equipment of water supply to the poor households shall be procured.

10) Local construction firms shall be effectively utilized under a Japanese general contractor considering their ability, scale of the business and past performances.

11) Seismic design shall not be applied in this project because the earthquake risk in Cambodia is low and there are no past records of earthquake.

12) Soft component shall be delivered for SWWs to be able to operate and maintain new facilities appropriately and supply safe water which meets the water quality standard.

2-2-1-2 Natural and Environmental Conditions

(1) Precipitation

The situation of precipitation in Cambodia is as shown in section "2-2-2-2, New Surface Water Source". Table 2-2-16 and Figure 2-2-6 show monthly precipitations in Svay Rieng from 2000 to 2019. Since the rainy and dry seasons in the region are clearly divided, as shown in the figure, the project should take such high precipitation periods, in particular, into consideration in the construction of works, such as concrete placement and other works affected by weather condition.

(2) Water Level of Vay Kor Lake

With respect to the intake level, the height of the intake facility should be set such as to allow the inflow of water, even during the lowest water level, considering the previous lowest water level of EL +1.6m (in July 2020) and the highest water level of EL +4.35m (October 2011) while configuring the embankment elevation and pump room by adding a freeboard to the water level on the 10-year return period to ensure that they will not be submerged. There is also a plan to elevate the Vay Kor Dam and the lake shore embankment of the Vay Kor Lake to boost the reservoir capacity of the lake, based on which the peak water level of the lake is expected to rise. Since the plan will not raise the level sufficiently to submerge National Highway No. 1 according to the Department of Water Resources and Meteorology (DOWRAM), the embankment elevation in the intake pump station is planned to correspond to EL+5.8 m, which is the elevation of the road shoulder of National Highway No. 1.

(3) Topographical / Geological Features

Geographical features in Cambodia can be divided into three regions: northeast, middle and southwest. Svay Rieng is located in the middle region which is equivalent to the Tonle Sap-Mekong lowlands, established by basalt between the Neogene and Quaternary periods in the Cenozoic era, the top of which is covered by alluvial deposits of the Quaternary period.

Since the bedding of intake facility comprises loose clay with an average N-value of 5, it shall be supported by a pile foundation. The bedding of the WTP comprises hard sandy clay with an average N-value of 15, constituting relatively good soil condition but pile foundations may be applied depending on the design condition of the facilities. The soil quality in both facilities accepts using backhoes for drilling.

(4) Earthquakes

Earthquakes in Cambodia are recorded in the research results of the National Institute for Land and Infrastructure Management in Japan and the hazard maps created by the UN-OCHA and the United States Geological Survey (USGS). In these documents, Cambodia is categorized as a region with minimal earthquakes and no past earthquake data recorded. Accordingly, the project shall not apply seismic design.

(5) Water Quality

The water quality was surveyed as follows. Since the survey did not detect any heavy metals, pesticides or other hazardous substances, and there is no change of water sources, particular water treatment or other arrangements were initiated. Meanwhile, facilities shall be designed taking into consideration the features of raw water quality (turbidity, iron detection, etc.).

(Overview)

The quality test of the raw water did not detect any hazardous substances which would be difficult to remove. Turbidity was highest in July and August, peaking at 350 NTU and with a low point of between 30 and 50 NTU, showing little year-round fluctuation and not declining from a certain concentration level. The turbidity is derived from iron, with a high concentration but removable by general purifying treatment. In Vay Kor Lake, although no commercial fishing is allowed, locals do fish for home cooking and enjoyment. At present, there is no confirmed instance related to health damage.

(Jar test and chlorine requirement)

The optimal PAC injection rate ranges between 11 and 18 mg/l, while the chlorine requirement peaks at around 1.5 mg/l.

(Tap water quality)

In 2017, turbidity and residual chlorine in tap water were inspected. Bacteriological examination was performed when no residual chlorine was detected. Thirty nine (39) out of 100 surveyed points showed a residual chlorine level below 0.2 mg/l, with coliform bacteria detected at four points, but no fecal coliforms at any of the points. Compared with 5NTU, which is the drinking water quality standard for Cambodia, two out of 100 surveyed points exceeded acceptable turbidity levels, 6NTU and 8NTU, respectively.

2-2-1-3 Social Conditions

(1) Industry

Svay Rieng City is the capital of Svay Rieng Province and its industry centers on agriculture. Most of the planted area is used for paddy rice, followed by cassava, although the latter occupies less than 3%. Beans and vegetables are also produced, even in small amounts. Since over 90% of those living there are farmers, they will comprise the majority of beneficiaries of the waterworks facility to be expanded under this project.

(2) Traffic Conditions

There are plans to construct a highway which will extend from the border with Vietnam in Svay Rieng Province to Phnom Penh City to boost the transport capacity of the Southern Economic Corridor in Cambodia and a feasibility study was conducted. The currently planned route does not overlap with the target area of this project, and it is planned to cross about 3 km north of the city area.

Meanwhile, more information concerns a plan to widen areas along National Highway No. 1, where an intake facility will be constructed in the project. Accordingly, the location of the intake facility should be planned, taking the scope of road widening into consideration.

(3) Electricity Supply

Electricity in Cambodia is supplied by the Electricite de Cambodge (EDC) company. As part of the Project for Expansion of Distribution Lines in Southern Economic Corridor in Cambodia, transmission lines have been constructed in Svay Rieng to import electricity from Vietnam. Since a substation to supply electricity to the project facility should follow the standards and specifications of the EDC, the latter is responsible for supplying the construction materials needed, while the cost is borne by the contractor. The monthly frequency of power outages is expected to be a few times due to lightning in the rainy season and short circuit accidents.

(4) Land Acquisition and Relocation of Residents

Premises for the WTP and intake facility are needed in the project site in Svay Rieng. The former premises were acquired from the original landowner in December 2017, while the planned site for the latter premises is on the road traversing the lake. This is land for public use, permission for use of which shall be obtained from the Provincial Government.

In the interview with the vice provincial governor held on December 19, 2019, the consent was obtained for the use of the land, but the Cambodian side granted a formal use permit from the provincial government before the announcement of the qualification examination and before bidding for construction. The project will not entail any need to relocate residents.

(5) Health and Sanitary Condition

The toilet possession rate is high, even in households of unconnected districts, which are home to many suburban residents. The prevalence of waterborne diseases among households with water

connections has been lower than that of unconnected households over the past three years. According to the database provided by the NCDD (as of 2019), the infant mortality rates (per 1,000 births up to five years old) in the Svay Rieng Province as a whole and in the Svay Rieng District were 23.6 and 12.0, respectively, suggesting a lower infant mortality rate in urban areas.

(6) Waste

Except for the hazardous materials, construction residues and other construction waste can be disposed on private land. When the contents are likely to include hazardous material, such materials can be similarly disposed after the MOE inspects its quality and confirms no hazard. The project will not generate any hazardous waste. Broken asphalt and concrete and other construction waste are disposed by landfill. Given the prevalence of lowland within the area, landfill disposal is preferable, and many candidate sites can be provided by the province.

2-2-1-4 Construction / Procurement Circumstances

As a general rule, the materials and equipment used will be locally procured.

Within Cambodia, many intake facilities, WTPs and distribution facilities have been constructed and several operators in Phnom Penh have relevant work experience. Accordingly, locally sourcing workers and construction machinery appears feasible.

The major construction materials are cement, quarries, reinforcing bars and pipe materials, all of which can also be procured in Cambodia.

However, ductile cast iron pipes are not produced in Cambodia and are instead procured in Japan or from a third country. Likewise, pumps and distribution flow systems, etc. are not produced in Cambodia, but procured in Japan.

2-2-1-5 Utilizing Local Operators

In Cambodia, many projects related to WTPs, intake facilities, conduit/supply and distribution pipes and reservoir constructions have been implemented. Several construction firms have relevant work experience in this area and some also own general purpose construction machinery. Accordingly, the project utilizes local construction company procedures, quality and safety governed by a Japanese construction company.

2-2-1-6 Operation and Management Capacity of the Implementation Agency

To operate and manage the water supply system to be newly constructed and expanded, there is a need to refine the organization of the SWWs. A proper operation and management system, sufficient staff and a process to establish the system are all taken into consideration and soft component is provided.

2-2-1-7 Grade of Facility, Machinery, etc.

Under circumstances whereby equipment and materials are procurable, and construction skill and capacity are arranged, other relevant criteria include the water volume and quality, power supply conditions, land area and staffing capacity for facility management and the construction of a rapid-

filtration type WTP, as the most common issues in Cambodia. Moreover, to minimize both operational and management costs, as well as the initial facility investment, the scope of mechanical and electrical equipment within the WTP is also reduced as far as possible.

Chemical handling uses locally available chemicals whenever possible. Energy efficiency is also taken into consideration and facilities are designed, located and constructed to ensure water treatment can proceed utilizing gravity.

2-2-1-8 Construction / Procurement Methods and Construction Period

Construction works in the project can be roughly classified into three (3) types: intake facilities, WTP and conveyance/distribution pipe-laying work. There is a possibility to execute them either simultaneously or throughout the year.

Since conveyance/distribution pipe-laying work involves long distances (with a total length of 115 km), construction by multiple teams is planned and personnel allocation is also considered to handle their construction supervision. As a general rule, distribution pipes are laid on road shoulders, unexposed to any significant external pressures, while earth coverings should follow the design policy of PPWSA. Road crossings, water channels, drainage and other siphon parts should be protected by concrete and an air valve installed as required.

2-2-2 Basic Plan

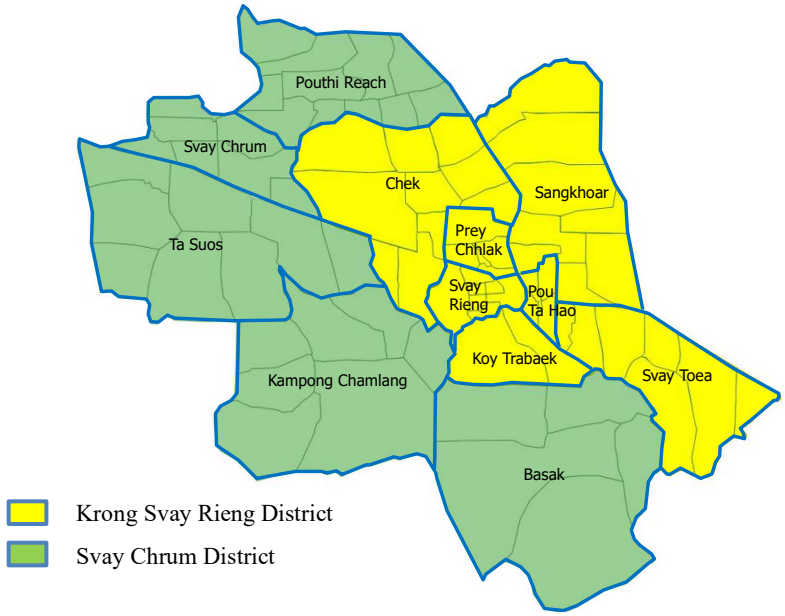
2-2-2-1 Water Demand Projection

(1) Target Year

In MISTI, the target water supply ratio of 100% by 2025 in urban areas of provincial cities is set and widely known, and the RGC is proceeding with the expansion of water supply facilities in provincial cities. On the other hand, this project is expected to be completed in 2025. As a result of the M/D held in April 2021, it was agreed that the target year would be 2027 based on the relation between the budget scale of the grant aid project and the facility scale derived from the water demand projection. This target year will be two years after the completion of the facilities of this project.

(2) Administrative Area of Svay Rieng Waterworks (SWWs)

The administrative area under the management of SWWs is shown in the figure below. A review of administrative area has been conducted under the direction of RGC in 2015, and the area consists of 2 districts and 12 communes. The administrative area is the licensed area where the WWs is permitted by MISTI to supply water. In addition, urban areas are based on the “Reclassification of Urban Areas in Cambodia, 2011, by the National Institute of Statistics, Ministry of Planning”. The yellow-colored area “Krong Svay Rieng District”, shown in Figure 2-2-1 corresponds to the urban area.



Source: Survey Team

Figure 2-2-1Administrative Area under the Management of SWWs

Table 2-2-1 District and Communes in the Administrative Area

District	Commune	Number of Villages	Urban area/ Rural area
Krong Svay Rieng	Svay Rieng	7	Urban area
	Prey Chhlak	5	
	Koy Trabaek	2	
	Pou Ta Hao	4	
	Chek	10	
	Svay Toea	7	
	Sangkhoar	8	
Svay Chrum*	Basak	5	Rural area
	Kampong Chamlang	7	
	Ta Suos	8	
	Pouthi Reach	11	
	Svay Chrum	7	

* Of the 16 communes in the Svay Chrum district, only 5 communes are in the administrative area
Source: Survey Team

(3) Present Condition of Water Supply and Summary of Existing Water Supply Facilities

As of 2019, the population in the administrative area of the SWWs has been estimated to be less than 100,000 people, and the currently served population for water supply is about 23,000 people which is only 23 % of the population. In addition, NRW ratio is as low as about 9 %, and it is not expected that the water supply flow will increase by implementing measures for NRW reduction. In order to approach the goal, set by RGC, “water supply ratio in urban areas of provincial cities to be 100%”, it is necessary to increase the capacity of existing water supply facilities and expand the water supply area to increase the served population.

However, it is practically difficult to supply all areas requested by the Cambodian side because a huge budget is required. The design water supply area has been decided comprehensively as the appropriate scope of the grant aid project based on the balance among the efficiency of the project, population density and future extensibility.

The present condition of water supply and existing water supply facilities in Svay Rieng are as shown Table 2-2-2 and Table 2-2-3. The administrative area of the SWWs was set based on the "Nationwide review of the administrative area for provincial WWs" conducted by MISTI in October 2015. In addition, the range of urban areas is based on the "Reclassification of Urban Areas in Cambodia, 2011 by the National Institute of Statistics" set by the Ministry of Planning (MOP). In Japan, it is generally defined as "water supply ratio in administrative area = water supply population ÷ population in governorate area" and "water supply ratio in service area = water supply population ÷ population in water supply area". In this project, "administrative area" is treated as synonymous with the above "governorate area".

Table 2-2-2 Present Condition of Water Supply in Svay Rieng (2019)

Symbol	Items	Amount	Note
a	Population in administrative area	99,571 persons	Population in administrative area under the management of SWWs
a1	Population in urban area of administrative area	48,141 persons	Urban population in administrative area under the management of SWWs
b	Population in service area	50,962 persons	Population in the area where water distribution pipes are laid and can receive water supply service
b1	Population in urban Area of service area	40,935 persons	Urban population in the area where water distribution pipes are laid and can receive water supply service
c	Population served	23,545 persons	Population receiving water supply services
c1	Population served in urban area	23,545 persons	Urban population receiving water supply services
	Water supply ratio in administrative area (=c/a)	23.6 %	Ratio of population served in the population in administrative area
	Water supply ratio in urban area of administrative area (=c1/a1)	48.9 %	Ratio of population served in urban area in the population in urban area of administrative area
	Water supply ratio in service area (=c/b)	46.2 %	Ratio of population served in the population in service area
	Water supply ratio in urban area of service area (=c1/b1)	57.5 %	Ratio of population served in urban area in the population in urban area of service area
	Household served water supply	4,709 houses	Number of connections in SWWs

Source：SWWs (October, 2019), Survey Team

Table 2-2-3 Existing Water Supply Facilities in Svay Rieng
(Including Facilities scheduled for Operation)

Items	Structure and Scale	
	As of October, 2019	Scheduled to operate from mid-2022 (Extension by ADB)
Water source	Groundwater, 3 wells	Surface Water of Vay Kor Lake
Intake, Conveyance Facilities	Intake pump: 15kW x 3pumps, Conveyance pipe: L=1.3km	Intake Facility: 11,000m^3/day, Conveyance pipe: L=63m
WTP	Oxidation, Gravity Rapid Sand filtration Capacity of WTP: 4,560m^3/day (Expanded 2,000m^3/day in 2020, Total: 6,560m^3/day)	Rapid Sand filtration Capacity of WTP: 9,000m^3/day
Distribution Facilities	Ground tank: 1,000m^3, Elevated tank: 350m^3 Distribution Pump: 30kW x 3pumps	
	Distribution Pipe: 250mm - 20mm, L= 65km (DIP、HDPE)	Distribution Pipe: 30.6km

Source: SWWs and MISTI, Survey Team

(4) Population and Population Growth Rate

In Cambodia, census was conducted in 1998 and 2008, and interim census was carried out in 2013. The latest census was conducted in March 2019 and population data has been reported as preliminary figures. However, the population of communes was not disclosed in the census of 2013 and 2019, so that the actual population in SWWs management area could not be clarified.

Meanwhile, SWWs has demographic data for each village provided by the Provincial Hall. The Survey Team had calculated the population growth rate in each village using the data from 2010 to 2019. The population and growth rate calculated by census is as shown in Table 2-2-4, while the population and growth rate calculated by data provided by the Provincial Hall is as shown in Table 2-2-5.

Table 2-2-4 Population of Cambodia and Svay Rieng Province (Census Data)

Classification	Population				Growth Rate
	1998	2008	2013*	2019	2008-2019
Cambodia	11,437,656	13,395,682	14,676,591	15,288,489	1.21%
Svay Rieng Province	478,252	482,788	578,380	524,554	0.76%

*Not used due to unreliable values of Population of Svay Rieng from 2013 interim census
Source: National Institute of Statistics, Ministry of Planning, Cambodia

Table 2-2-5 Population of SWWs Management Area (Data from Provincial Hall)

Classification	Population		Growth Rate
	2010	2019	2010 - 2019
SWWs Management Area	93,783	99,571	0.67%
Urban Area (Krong Svay Rieng District)	44,767	48,141	0.81%
Rural Area (Svay Chrum District)	49,016	51,430	0.54%

Source: SWWs

Population growth rates of the census data and the data provided by the Provincial Hall show close values. (The data provided by Provincial Hall is from 2010 to 2019, hence, the census data used population from 2008 and 2019).

Census Data : Growth rate in Province [+0.76%]
Data from Provincial Hall : Growth rate in SWWs Management Area [+0.67%]
: Growth rate in SWWs Management Area (Urban) [+0.81%]
: Growth rate in SWWs Management Area (Rural) [+0.54%]

Since the latest census was relatively old in 2008, and the interim census in 2013 and 2019 do not provide the statistical population data on the commune basis, the population data owned by the SWWs was utilized in this study without using the census data.

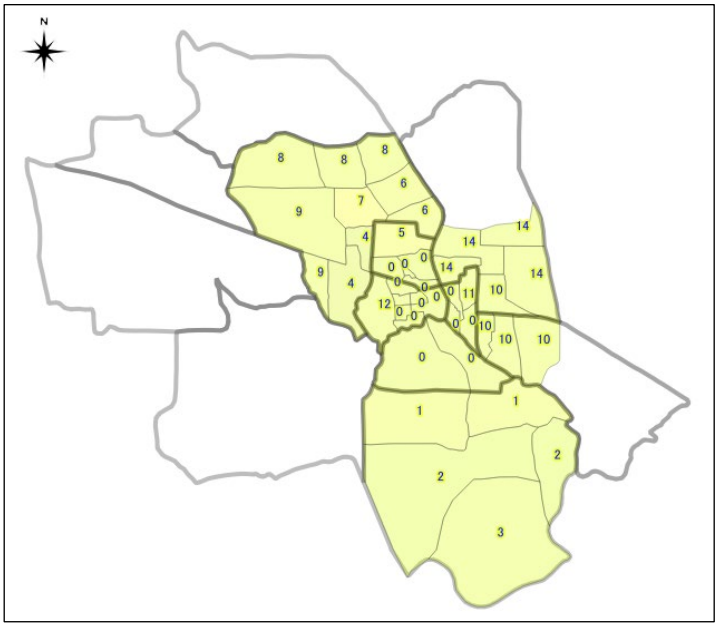
(5) Design Water Supply Population and Target Water Supply Ratio in Urban Area

The population of each year until 2027 had been projected using the above average annual population growth rate for each village. Since the population in 2019 that was collected from SWWs has a large difference from the past years, the population projection was calculated by approximating the increase and decrease of the village population from 2010 to 2018. The result of projected population in target year (2027) is as follows.

Population in administrative area	:	106,481 persons
Population in urban area of administrative area	:	53,141 persons
Population in urban rural of administrative area	:	53,340 persons

Further, the water supply area is set by selecting the villages with high priority instead of selecting the whole administrative area to make certain that water supply service be delivered to all the residents in the selected area. This policy sets a design water supply area (a range where there is already a distribution of residential houses and water demand is expected) that is set separately from the administrative area, and water supply is carried out by promoting the development of water supply facilities within this area. It was considered appropriate to increase the water supply ratio in this area from the viewpoint of high investment effect.

Case 3 in Figure 2-2-2 is selected as the target water supply area in this project, in accordance with Section 2-2-2-1-(12) mentioned below, a comparison study on setting water supply area. In this case, the water supply population in the target year will be 55,964 persons as shown in Table 2-2-6.



Source: Survey Team

Figure 2-2-2 Target Water Supply Area in the Project

Table 2-2-6 Projected Population in 2027 in the Target Water Supply Area

Commune	Village	Urban/Rural	Existing/New	Priority	Water Supply Population (2027)
Svay Rieng	Veal Yon	Urban	Existing	0	3,119
	Svay Rieng	Urban	Existing	0	1,640
	Kien Sang	Urban	Existing	0	1,524
	Me Phleung	Urban	Existing	0	2,208
	Srah Vong	Urban	Existing	0	2,161
	Roung Banlae	Urban	Existing	0	2,202
	Chong Preaek	Urban	Existing	12	2,517
Prey Chhlak	Suon Thmei	Urban	Existing	0	528
	Rub Kou	Urban	Existing	0	1,495
	Sala Srok Chas	Urban	Existing	0	816
	Prey Chhlak	Urban	Existing	0	579

Commune	Village	Urban/Rural	Existing/New	Priority	Water Supply Population (2027)
	Andoung Ta Sei	Urban	Existing	5	955
Koy Trabaek	Koy Trabaek	Urban	Existing	0	2,217
	Tarang Bal	Urban	Existing	0	1,568
Pou Ta Hao	Kbal Spean	Urban	Existing	0	395
	Thnal Kaeng	Urban	Existing	11	836
	La	Urban	Existing	0	1,942
	Pou Ta Hao	Urban	Existing	0	265
Chek	Chek	Urban	New	8	1,791
	Chambak	Urban	New	9	1,866
	Svay	Urban	New	9	1,249
	Thmol	Urban	Existing	4	1,181
	Svat	Urban	Existing	4	184
	Totea	Urban	New	7	1,838
	Kandal	Urban	New	6	466
	Meloung	Urban	New	6	798
	Khleang	Urban	New	8	694
	Kok Pae	Urban	New	8	674
Svay Toea	Ta Chour	Urban	Existing	10	397
	Ta Nar	Urban	Existing	10	1,649
	Khousang	Urban	New	10	931
Sangkhoar	Bak Ronoas	Urban	Existing	14	1,209
	Thlok	Urban	New	14	813
	Chambak Peam	Urban	New	14	693
	Thmei	Urban	Existing	10	1,942
	Srama Chrum	Urban	New	14	746
Basak	Svay Ta Phlo	Rural	New	1	1,922
	Sala Rien	Rural	New	2	2,509
	Payab	Rural	New	3	2,224
	Basak	Rural	New	1	1,898
	Pou Ta Ros	Rural	New	2	1,299
Total					55,964

Source: Survey Team

(6) Changes in Water Supply Ratio and Water Supply Area by Implementation of the Project

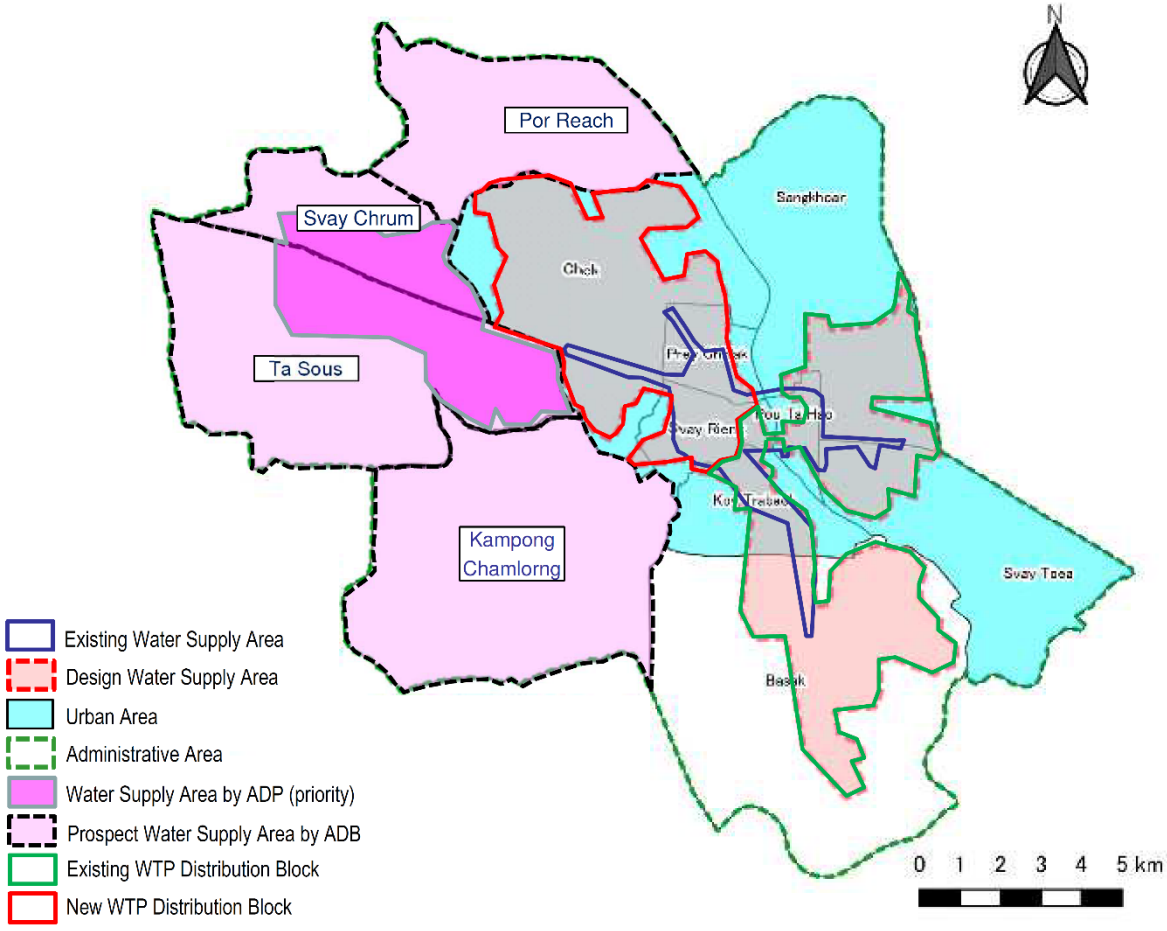
The population in the administrative area in 2027 is projected as 106,481 persons, and water supply ratio in the administrative area is calculated as 52.6% even after the implementation of this project.

The reason why the water supply ratio remains at around 50% even after the project implementation is that when a specific area within the whole administrative area is set as a design water supply area, it is limited to the area where efficient water distribution is possible, because there is a continuous distribution of currently existing residential houses, and reliable water demand is expected. However, since the population in the administrative urban area is projected as 53,141 persons and the population served in the urban area is projected as 46,088 persons, the water supply ratio in the urban administrative area is estimated as 86.7%. This value approaches the above-mentioned target of 100% water supply ratio in urban areas by 2025, which is the disseminated target in MISTI.

Table 2-2-7 Comparison of Water Supply Ratio by Effectiveness of the Project

Symbol		Items		Present (2019)	At the stage of ADB facility expansion (Scheduled in 2022)	After the Project (2027)	Benefit from the Project (Increment from 2019)
-		Water Supply Capacity		6,560 m^3/day =4,560 m^3/day + 2,000 m^3/day[*1]	15,560 m^3/day =6,560 m^3/day + 9,000 m^3/day [*2]	22,360 m^3/day =15,560 m^3/day + 6,800 m^3/day	6,800 m^3/day
a		Population in Administrative Area		99,571 persons	102,660 persons	106,481 persons	-
	a1	(Urban Area)		48,141 persons	50,643 persons	53,141 persons	-
	a2	(Rural Area)		51,430 persons	52,017 persons	53,340 persons	-
b		Population in Service Area		50,962 persons	62,380 persons =53,530+8,850 persons [*3]	65,368 persons =55,964+9,404 persons	-
	b1	(Urban Area)		40,935 persons	43,771 persons	46,088 persons	-
	b2	(Rural Area)		10,027 persons	18,609 persons =9,759+8,850 persons	19,280 persons =9,876+9,404 persons	-
c		Population Served		23,545 persons	32,395 persons =23,545+8,850 persons	65,368 persons =55,964+9,404 persons	+ 32,419 persons
	c1	(Urban Area)		23,545 persons	23,545 persons	46,088 persons	+ 22,543 persons
	c2	(Rural Area)		0 persons	8,850 persons	19,280 persons 9,876+9,404 persons	+ 9,876 persons
		Household Served Water Supply	JICA	4,709 houses	4,709 houses	12,087=55,964/4.63 persons	+ 7,378houses
			ADB		1,911=8,850/4.63 houses	2,031=9,404/4.63 houses	
			Total	4,709 houses	6,620 houses	14,118 houses	
e=(c/a) x100		Water Supply Ratio in Administrative Area	JICA	23.6 % =23,545/99,571	22.9% =23,545/102,660	52.6% =55,964/106,481	+ 29.0 %
			ADB		8.6% =8,850/102,660	8.8% =9,404/106,481	
			Total	23.6 %	31.5 %	61.4%	
f=(b/c) x100		Water Supply Ratio in Service Area	JICA	46.2 % =23,545/50,962	44.0 % =23,545/53,530	100.0 % =55,964/55,964	+ 53.8 %
			ADB		100.0 % =8,850/8,850	100.0 % =9,404/9,404	
			Total		51.9% = (23,545+8,850 /53,530+8,850)	100.0 % = (55,964+9,404 /55,964+9,404)	
g=(a1/c1) x100		Water Supply Ratio in Urban Area of Administrative Area		48.9 % =23,545/48,141	46.5 % =23,545/50,643	86.7 % =46,088/53,141	+ 37.8 %

Note: [*1] It is an expansion facility of an existing WTP by the Cambodian side, and has been in operation since April 2020.
[*2]The Cambodian side (ADB) is expanding the existing water purification plant, and the operation is scheduled to start in the middle of 2022.
[*3]Blue text indicates information in the design water supply area of ADB project. These values are under the condition that the household connection of each household in the priority water supply area will be completed within 2022.
Source: Survey Team



Source: Survey Team

Figure 2-2-3 Design Water Supply Area and Administrative Area in Svay Rieng

On the other hand, the WTP with a capacity of 9000m^3/day, that was been expanded by ADB and scheduled to start operation from the middle of 2022 aims to supply water to the four (4) communes (Svay Chrum, Ta Sous, Por Reach and Kampong Chamlorng) located to the western side of the administrative area as shown in Figure 2-2-3 above.

For the time being, the priority water supply areas are the three (3) villages in the Svay Chrum commune (Thma Sa, Trabaek, Svay Kngao) and the three (3) villages in the Ta Sous commune (Pnov, Angkeas Dei, Ta Pa). The distribution pipe of 30.6km will be laid to supply water to these priority areas.

The water supply population in the target year (2027) of the water supply area that has been preferentially expanded by the ADB is expected to be 9,404 persons. If these water supply populations are added to the water supply population from the implementation of this project, the water supply ratio of 52.6% in the above-mentioned administrative area will increase to 61.4%.

In addition, it was confirmed in the meeting of M/D in April 2021 that the water supply area from the WTP which was be constructed by JICA and the water supply area from the WTP to be constructed by ADB do not overlap.

(7) Unit (Amount of Water Supply per Person per Day)

The average amount of water used by one person per day calculated from the water supply population and the average amount of water used in a single day at home is as shown in Table 2-2-8.

Table 2-2-8 Average Water Consumption per Person per Day for Domestic Use

Item	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019*1
Average domestic water consumption per day	m^3/day	749	912	1,015	1,268	1,544	1,880	2,319	2,632	3,016	3,430
Population Served	Persons	7,240	7,630	8,960	10,690	12,745	14,685	17,765	20,020	21,975	23,545
Average domestic water consumption per person per day	L/day/person	103.4	119.5	113.3	118.6	121.1	128.0	130.5	131.5	136.1	145.7
Average domestic water consumption per person per day for last 10 years	L/day/person	124.8									
Average domestic water consumption per person per day for last 5 years	L/day/person	115.2					134.4				

*1: Data as of October 2019
Source: SWWs

According to the water supply records of SWWs, the unit average for the last 10 years is 124.8 L/day/person, which is increasing year by year.

Factors for increase of Unit include the following: 1) Increase of urban water supply population, 2) Increase of household income, 3) Changes in lifestyle, and so on. However, this increase of unit is only for existing water supply area, since there is a difference of household income and lifestyle between the existing water supply area and the target water supply urban area. Therefore, the Unit shall be set, respectively.

As the result of discussions with the SWWs, the Unit for existing water supply areas is 135 L/day/person, which is the average for the last 5 years (2015 – 2019), and the Unit for new water supply areas is 115 L/day/person, which is the average for the past 5 years (2010 – 2014). Although the average of water consumption is increasing year by year, the average value is adopted for the following reasons:

- According to the 2017 social condition survey conducted by the Survey Team, many households that are connected to the existing water supply belong to the wealthier class. In the target year of this project, 2027, water supply will be served to all households in the area. Therefore, it includes not only the rich but also the poor households. Considering the differences of lifestyle between these classes, it is not reasonable to assume a trend of increase evenly until 2027.
- In the new water supply area, the size of house and lifestyle is significantly different from the existing water supply area. Besides, the water demand in the new supply area is totally different from the water demand in the existing supply area. Therefore, the water demand of the new

supply area should adopt the water demand value during the period when the population served was few.

- As described in Section 2-2-2-1-(9), the value of Non-Revenue-Water ratio is set higher (smaller effective rate) than the actual NRW ratio, so that the design is on safer side for the required amount of water. Therefore, the design water supply amount calculated based on the existing water supply area with unit of 135L/day/person is expected to have a certain surplus amount against actual water demand.

(8) Average Water Consumption per Day for Industrial and Commercial Use

Daily water consumption classified by application is as shown in Table 2-2-9.

As the result of interviews with the SWWs and the Svay Rieng Provincial Hall, the following situations for industrial and commercial water use in administrative area were found:

- There was a plan to construct a new market by reclaiming the eastern part of Lake Vay Kor. However, according to interviews with the SWWs and the Provincial Hall, the market construction plan has been canceled due to no progress of land expropriation.
- There is a clothing factory in the industrial estate about 4 km west from the city center. However, factories will not use public water services because they have their own groundwater sources.
- There are no detailed development plans about the expansion of industrial estates.

In Svay Rieng, the ratio of domestic water consumption to the total water consumption tends to increase due to the rapid increase in the water supply population. The main customers for non-domestic connection are restaurants, guest houses, schools, ice factories, and so on. In addition, there is no concrete plan to construct large-scale schools such as universities, factories, etc., with high water demand. Since the amount of water consumption by application is set based on 78.2%, which is the average ratio of domestic consumption for the past 5 years, the amount of domestic water consumption is set as 80% of the total amount, and non-domestic water consumption is set as 20% of total amount.

Table 2-2-9 Daily Water Consumption Classified by Application

Item	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Average
Domestic	m^3/day	749	912	1,015	1,268	1,544	1,880	2,319	2,632	3,016	3,430	1,877
Commercial	m^3/ day	188	194	308	349	388	330	326	359	276	276	299
Public	m^3/ day	221	226	259	273	319	326	376	389	449	509	335
Total	m^3/ day	1,158	1,332	1,582	1,890	2,251	2,536	3,021	3,380	3,741	4,215	2,511
Non-Domestic Subtotal	m^3/ day	409	420	567	622	707	656	702	748	725	785	634
Ratio of Domestic	%	64.7	68.5	64.2	67.1	68.6	74.1	76.8	77.9	80.6	81.4	73.8
Ratio of Non-Domestic	%	35.3	31.5	35.8	32.9	31.4	25.9	23.2	22.1	19.4	18.6	27.6
Average ratio of domestic consumption	%						78.2					
Yearly Increase of Non-Domestic Consumption	m^3/ day		11	147	55	85	-51	46	46	-23	60	41.7m^3/ day/year

Source: SWWs

(9) Leakage Ratio and Effective Water Ratio

According to the actual data of SWWs, NRW ratio is decreasing year by year from 24.3% in 2010 to 8.9% in 2019 as shown in Table 2-2-10.

This achievement is due to the improvement of the capacity of operation and maintenance of SWWs through the support of the JICA project, "The Project on Capacity Building for Urban Water Supply System (Phase 2 and 3)".

Non-revenue water consists of unbilled authorized consumption, apparent loss (illegal connections, inaccuracies of meter, data handling errors, etc.) and real loss (leakages of distribution pipes, service connections, meters and tanks). However, the amount of leakage, which accounts for most of the real loss, has not been calculated by the SWWs. In addition, illegal connections are not found in the recent SWWs operations.

Based on the above, the amount ratio of leakage water within NRW amount is 75% with reference to the records of WWs[2] having 10% NRW ratio. On the other hand, the Cambodian government has set the NRW ratio as 15% for determining the design capacity of new WTP due to the following reasons:

- NRW ratio is likely to increase in the future due to the aging of existing pipes.
- The exact portion of leakages in NRW is unknown and uncertain.

Based on the above, assuming that the amount of leakage is 75% of the NRW amount, the leakage ratio for 2027, the target year shall be set at 11.3% (15% x 75%), and the effective water rate shall be set at 88.7%.

[2] Few countries calculate the amount of water leakage in the amount of non-revenue water. It was judged comprehensively from the estimation results of the non-revenue water rate and water leakage rate of Japanese entities conducted by the Japan Water Research Center in 2014 and the interview surveys with MISTI.

Table 2-2-10 NRW Ratio in SWWs

Items	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019*1
Annual distributed water amount	m^3/year	558,140	592,817	678,423	791,086	921,848	1,032,654	1,222,695	1,365,730	1,502,783	1,689,002
Annual amount of Billed consumption	m^3/year	422,580	485,931	577,779	690,114	821,546	925,563	1,102,723	1,234,099	1,365,890	1,538,547
Annual amount of NRW	m^3/year	135,560	106,886	100,644	100,972	105,921	107,091	119,972	131,631	136,893	150,455
NRW ratio	%	24.3	18.0	14.8	12.8	11.5	10.4	9.8	9.6	9.1	8.9

*1: The annual actual values were calculated by adding the actual values up to October 2019 and the value estimated based on the latest data.
Source: SWWs

(10) Load Factor

The load factor is defined as the ratio of average daily water supply volume to daily maximum water supply volume. The load factor in SWWs for the last 10 years is as shown in Table 2-2-11. From the actual records, the load factor has decreased since 2016. Previously, it was calculated based on the water distribution pump capacity and the operating time, so it was significantly different from the actual situation. The flow meter for distribution was installed in 2016, and it could measure the distributed water amount. Therefore, the load factor will be 75.4%, which is the average value for the past four years since 2016.

Table 2-2-11 Past Records of Load Factor

Item	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Daily Average Water Supply	m^3/day	1,529	1,624	1,859	2,167	2,526	2,829	3,350	3,742	4,117	4,627
Daily Maximum Water Supply	m^3/day	1,529	1,654	1,859	2,467	2,557	3,234	4,558	4,725	5,702	6,037
Load Factor	%	100.0	98.2	100.0	87.9	98.8	87.5	73.5	79.2	72.2	76.7
Average	%							75.4			

Source: SWWs

(11) Future Water Demand

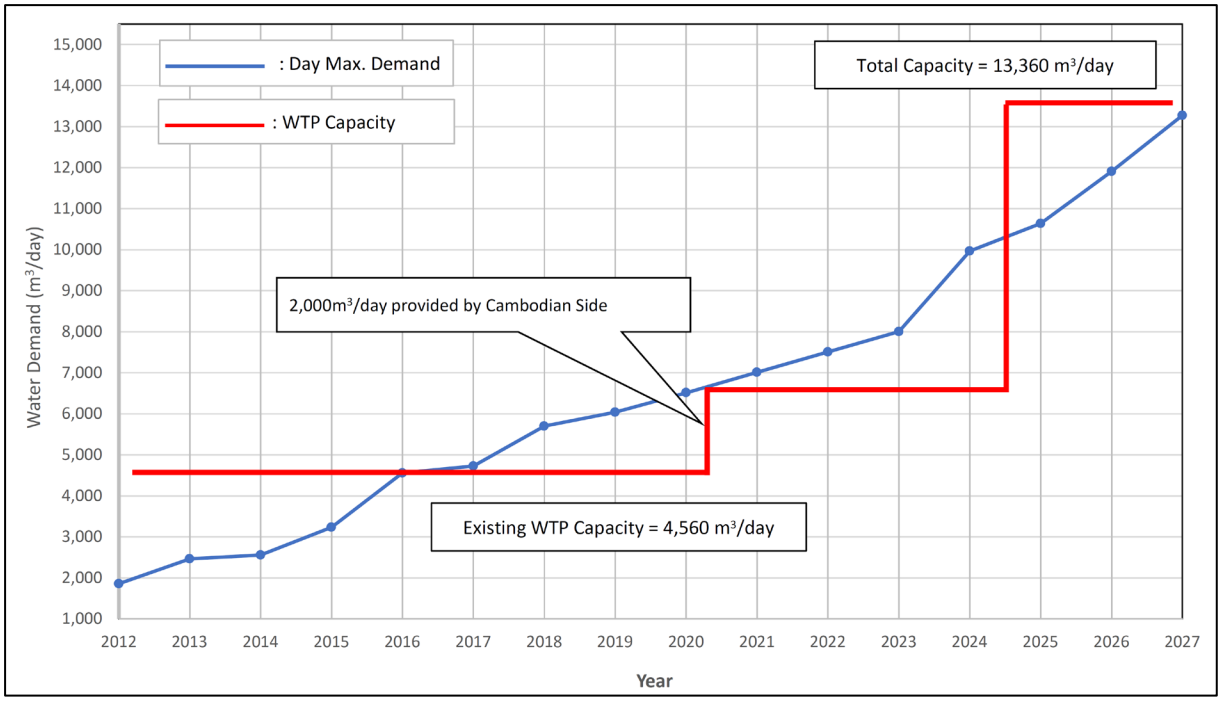
Based on the above-mentioned data, the result of the future water demand of Svay Rieng is estimated as shown in Table 2-2-12. The maximum daily water supply for the target year (2027) was calculated as 13,275 m^3/day. Since the capacity of existing WTP is estimated to have 6,560 m^3/day, the water supply amount to be increased in this project is 6,715 ≅ 6,800m^3/day.

Figure 2-2-4 shows the relationship between the daily maximum water demand and the capacity of WTP based on the results of population projection. The capacity of WTP is far below the demand even after starting the 2,000 m^3/day membrane filtration facility newly introduced by a Chinese private company in April 2020. Therefore, water shortages and overloads at WTP are frequently occurring. The background of the introduction of the membrane filtration plant by a Chinese private company will be described later in "2-2-2-5-(1), Existing WTP".

Table 2-2-12 Actual and Forecast Table of Water Demand in Svay Rieng

Item		Unit	2012	2013	2014	2015	2016	2017	2018	2019 (Actual ←)	2020 (→ Projection)	2021	2022	2023	2024	2025	2026	2027
Population in Administrative Area	Total	person	95,168	95,357	96,763	97,545	97,545	99,301	99,301	99,571	101,130	101,892	102,660	103,423	104,192	104,954	105,714	106,481
	Urban	person	45,495	46,132	46,698	47,296	47,296	48,419	48,419	48,141	49,646	50,143	50,643	51,143	51,648	52,145	52,640	53,141
	Rural	person	49,673	49,225	50,065	50,249	50,249	50,882	50,882	51,430	51,484	51,749	52,017	52,280	52,544	52,809	53,074	53,340
Population in Water Supply Area	Total	person	48,542	49,144	49,651	50,201	50,201	51,414	51,414	50,962	52,559	53,043	53,530	54,018	54,509	54,993	55,477	55,964
	Urban	person	39,024	39,625	40,109	40,649	40,649	41,710	41,710	40,935	42,849	43,309	43,771	44,236	44,704	45,165	45,625	46,088
	Rural	person	9,518	9,519	9,542	9,552	9,552	9,704	9,704	10,027	9,710	9,734	9,759	9,782	9,805	9,828	9,852	9,876
Population in Water Supply Area	Total	person	48,542	49,144	49,651	50,201	50,201	51,414	51,414	50,962	52,559	53,043	53,530	54,018	54,509	54,993	55,477	55,964
	Existing Area	person	27,530	28,100	28,477	28,955	28,955	29,857	29,857	28,966	30,808	31,194	31,583	31,973	32,366	32,753	33,140	33,529
	New Area	person	21,012	21,044	21,174	21,246	21,246	21,557	21,557	21,996	21,751	21,849	21,947	22,045	22,143	22,240	22,337	22,435
Water Supply Population	Total	person	8,960	10,690	12,745	14,685	17,765	20,020	22,160	23,545	25,830	27,802	29,764	31,736	40,882	43,994	49,929	55,964
	Urban	person	8,960	10,690	12,745	14,685	17,765	20,020	22,160	23,545	25,830	27,802	29,764	31,736	33,528	36,132	41,063	46,088
	Rural	person												0	7,354	7,862	8,867	9,876
Water Supply Population	Total	person	8,960	10,690	12,745	14,685	17,765	20,020	22,160	23,545	25,830	27,802	29,764	31,736	40,882	43,994	49,929	55,964
	Existing Area	person	8,960	10,690	12,745	14,685	17,765	20,020	22,160	23,545	25,830	27,802	29,764	31,736	31,736	31,736	31,736	33,529
	New Area	person												0	9,146	12,258	18,193	22,435
Water Supply Ratio in Administrative Area	Total (Existing Area)	%	9.4	11.2	13.2	15.1	18.2	20.2	22.3	23.6	25.5	27.3	29.0	30.7	39.2	41.9	47.2	52.6
	Urban (New Area)	%	19.7	23.2	27.3	31.0	37.6	41.3	45.8	48.9	52.0	55.4	58.8	62.1	64.9	69.3	78.0	86.7
	Rural	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0	14.9	16.7	18.5
Water Supply Ratio in Water Supply Area	Total	%	18.5	21.8	25.7	29.3	35.4	38.9	43.1	46.2	49.1	52.4	55.6	58.8	75.0	80.0	90.0	100.0
	Urban	%	23.0	27.0	31.8	36.1	43.7	48.0	53.1	57.5	60.3	64.2	68.0	71.7	75.0	80.0	90.0	100.0
	Rural	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	75.0	80.0	90.0	100.0
Water Supply Household	Total	house	1,792	2,138	2,549	2,937	3,553	4,004	4,432	4,709	5,579	6,005	6,429	6,854	8,830	9,502	10,784	12,087
	Existing Area	house	1,792	2,138	2,549	2,937	3,553	4,004	4,432	4,709	5,579	6,005	6,429	6,854	6,854	6,854	6,854	7,242
	New Area	house	0	0	0	0	0	0	0	0	0	0	0	0	1,975	2,648	3,929	4,846
Average Water Consumption per person per day for Domestic (Existing)		L/day/person	113.3	118.6	121.1	128.0	130.5	131.5	136.1	145.7	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0
Average Water Consumption per day for Domestic (Existing)		m3/day	1,015	1,268	1,544	1,880	2,319	2,632	3,016	3,430	3,487	3,753	4,018	4,284	4,284	4,284	4,284	4,526
Average Water Consumption per person per day for Domestic (New)		L/day/person									115.0	115.0	115.0	115.0	115.0	115.0	115.0	115.0
Average Water Consumption per day for Domestic (New)		m3/day									0	0	0	0	1,052	1,410	2,092	2,580
Average Water Consumption per day for Domestic (Total)		m3/day	1,015	1,268	1,544	1,880	2,319	2,632	3,016	3,430	3,487	3,753	4,018	4,284	5,336	5,694	6,376	7,106
Average Water Consumption per day for Non-Domestic		m3/day	567	622	707	655	702	748	725	785	872	938	1,005	1,071	1,334	1,424	1,594	1,777
Effective Water Amount		m3/day	1,582	1,890	2,251	2,535	3,021	3,380	3,741	4,215	4,359	4,691	5,023	5,355	6,670	7,118	7,970	8,883
Ineffective Water Amount		m3/day	207	207	206	220	247	270	281	309	553	595	637	679	845	902	1,010	1,126
Daily Average Water Supply Amount		m3/day	1,859	2,167	2,526	2,829	3,350	3,742	4,117	4,627	4,912	5,286	5,660	6,034	7,515	8,020	8,980	10,009
Average Water Consumption per person per day		L/day/person	207	203	198	193	189	187	186	197	190	190	190	190	184	182	180	179
Daily Maximum Water Supply Amount		m3/day	1,859	2,467	2,557	3,234	4,558	4,725	5,702	6,037	6,514	7,010	7,506	8,002	9,967	10,637	11,910	**13,275**
Maximum Water Consumption per person per day		L/day/person	207	231	201	220	257	236	257	256	252	252	252	252	244	242	239	237.2
Revenue Water Ratio		%	85.2	87.2	89.1	89.6	90.2	90.4	90.9	91.1	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2
Effective Water Ratio		%	88.9	90.4	91.8	92.2	92.6	92.8	93.2	93.3	88.8	88.8	88.8	88.8	88.8	88.8	88.8	88.8
Leakage Water Ratio		%	11.1	9.6	8.2	7.8	7.4	7.2	6.8	6.7	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3
Load Factor		%	100.0	87.9	98.8	87.5	73.5	79.2	72.2	76.7	75.4	75.4	75.4	75.4	75.4	75.4	75.4	75.4
Construction Period														←	—	→		
Existing WTP Capacity		m3/day	4,560	4,560	4,560	4,560	4,560	4,560	4,560	4,560	6,560	6,560	6,560	6,560	6,560	6,560	6,560	6,560
Capacity required by this Project		m3/day	- 2,701	- 2,093	- 2,003	- 1,326	- 2	165	1,142	1,477	- 46	450	946	1,442	3,407	4,077	5,350	**6,715**

Source: Survey Team



Source: Survey Team

Figure 2-2-4 Daily Maximum Demand and WTP Capacity

(12) Study on Design Water Supply Area

It was decided that the Design Water Supply Area does not cover all administrative areas managed by SWWs as water supply area, but the following three (3) cases were compared in consideration of water supply ratio in urban area, high priority villages set by SWWs, the cost-effectiveness of construction cost, and the efficiency of piping. The reason for giving priority to the water supply ratio in urban areas is that improving the water supply ratio in urban areas is the target of NSDP and also a disseminated target in MISTI. In addition, rural areas, which have the same or higher investment effect (determined by the water supply population per unit project cost and unit water distribution pipe length) as urban areas, are also included in the design water supply area because they are also priority development areas of the SWWs.

【Case 1】

Set the water supply ratio in urban area in target year (2027) to 90%, and select the villages with high priority of urban villages.

【Case 2】

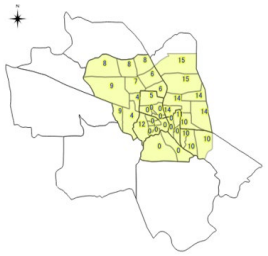
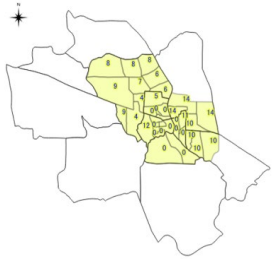
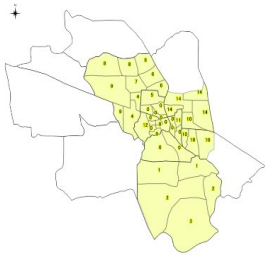
Set the water supply ratio in urban area in target year (2027) to 85%, and select the villages with high priority of urban villages.

【Case 3】

Set the water supply ratio in urban area in target year (2027) close to 90%, and select the villages with high priority of urban and rural villages.

The results of the comparative study are as shown in Table 2-2-13. Case 3 shall be adopted after comprehensively considering the beneficiary population, water supply ratio in urban area, piping efficiency and cost effectiveness.

Table 2-2-13 Comparative Study on Design Water Supply Area

Item	Case 1	Case 2	Case 3
a) Design service area	 Expand water supply area to improve the service ratio in urban area aiming 90%. (38 villages with priority Nos. 4 –12, 14, 15 out of 81 of all villages) ※There are multiple villages of the same priority rank number.	 Expand water supply area to improve the service ratio in urban area aiming 85%. (36 villages with priority Nos. 4 –12,14 out of 81 of all villages)	 Expand water supply area to improve the service ratio in urban area aiming nearly 90%, while focusing on more higher priority villages in rural area than villages in urban area. (41 villages with priority Nos. 1 - 12, 14 out of 81 of all villages)
b) Design population served in 2027 (Design year) *(Number of Beneficiaries: Increased population servedbetween 2019 and 2027)*	47,827 (24,282) **[B]**	45,170 (21,625) **[C]**	55,964 (32,419) **[A]**
c) Service ratio in urban area (Population served as % of population in urban area) *(Increased service ratio in urban area between 2019 and 2027)*	90.0 (41.1) **[A]**	85.0 (36.1) **[C]**	86.7 (37.8) **[B]**
d) Required water supply capacity (m^3/day)	11,526	10,955	13,275
Capacity of Existing WTP (m^3/day)	6,560	6,560	6,560
Capacity of New WTP (m^3/day)	5,000 (4,966)	4,400 (4,395)	6,800 (6,715)
e) Required distribution pipe extension (km) (φ50 or more)	128.0	107.0	127.8
f) *Pipe laying efficiency (Increased population served per required distribution pipe extension (persons/100m)*	19.0 (=24,282÷1,280) **[C]**	20.2 (=21,625÷1,070) **[B]**	25.4 (=32,419÷1,278) **[A]**
g) Initial construction cost (including intake, raw water transmission mains, WTP, distribution system) (million yen)	1,868	1,756	1,913
h) *Investment efficiency (Increased population servedper initial construction cost) (Persons per 1 million yen)*	13.0 (=24,282÷1,868) **[B]**	12.3 (=21,625÷1,756) **[C]**	16.9 (=32,419÷1,913) **[A]**
i) Evaluation			**Appropriate from a comprehensive evaluation**
Advantage	・Service ratio in urban area is the highest, 90%.	・Construction cost is the lowest.	・Number of Beneficiaries is the biggest. ・Pipe laying efficiency is the highest. ・Investment efficiency is the highest.
Disadvantage	・Pipe laying efficiency is the lowest. ・Investment efficiency is lower than Case2.	・Number of Beneficiaries is the lowest. ・Service ratio in urban area is less 90% but close to the target value. ・Pipe laying efficiency is lower than Case3. ・Investment efficiency is the lowest.	・Service ratio in urban area is less than 90% but close to the target value.

Note:

1) Number of villages in the administrative area by Svay Rieng WWs: 81 (Existing water supply area: 15, Villages prioritized by Svay Rieng WWs: 45, Villages that are not prioritized by Svay Rieng WWs: 21)
2) Pipe laying efficiency (Increased population served per required distribution pipe extension (persons/100m) shows the degree of population density.
3) Item of the italics are to be evaluated
4) Evaluation criteria for each item to be evaluated, [A]: high, [B]: medium, [C]: low

Source: Survey Team

The basic design specifications of this project based on the above result for Svay Rieng are as listed in Table 2-2-14 and Table 2-2-15, respectively.

Table 2-2-14 Proposed Design Specifications of the Project (1)

Item	Unit	Actual/Design Value		
		Present (2019)	Increase by the Project	After Completion of the Project (2027)
Population in administrative area	person	99,571	-	106,481
Population in urban area of administrative area	person	48,141	-	53,141
Population in water supply area	person	50,962	-	55,964 (65,368)*
Water supply population	person	23,545	32,419	55,964 (65,368)
No. of HHs connections	house	4,709	7,378	12,087 (14,118)
Water supply ratio in administrative area	%	23.6	29.0	52.6 (61.4)
Water supply ratio in urban area of administrative area	%	48.9	37.8	86.7
Water supply ratio in water supply area	%	46.2	53.8	100.0
Water supply capacity	m^3/day	6,560	6,800	13,360 (22,360)
Length of distribution pipe	km	65	111.8	176.8 (207.4)

Note: Values in parentheses indicate the case where the numerical value in the design water supply area to be expanded preferentially by the ADB WTP is included.
Source: Survey Team

Table 2-2-15 Proposed Design Specifications of the Project (2)

Item	Unit	Design Value
Design Water Supply Population (2027)	person	55,964
Unit Consumption for Domestic Water	L/day/person	Existing Area: 135 New Area: 115
Domestic Water Demand	m^3/day	7,106
Non-domestic Ratio among whole Water Demand	%	20.0
Non-domestic Water Demand	m^3/day	1,777
Total Water Demand (Domestic + Non-domestic)	m^3/day	8,883
Leakage Ratio	%	11.3
Design Daily Average Water Supply Amount	m^3/day	10,009
Load Factor	%	75.4
Design Daily Maximum Water Supply Amount	m^3/day	13,275
Peak (Time) Factor	-	1.3 [3]
Design Hourly Maximum Water Supply Amount	m^3/hour	720

Source: Survey Team

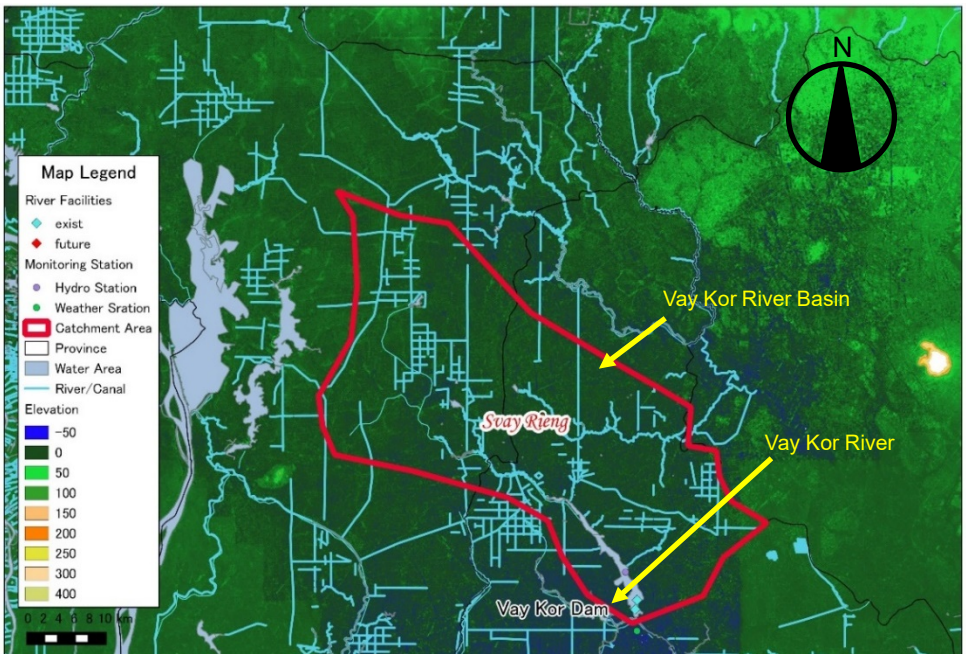
[3] The time coefficient of 1.30 above has been adopted based on the discussions with MISTI with reference to the actual value of 1.30 in the other similar cities in Cambodia.

2-2-2-2 New Surface Water Source

(1) Development of New Water Source

1) Vay Kor Lake and River

The Vay Kor River passes through Svay Rieng in the southeastern part of the Mekong Delta in Cambodia from North to South. The basin area on the upstream side of Svay Rieng is about 1500 km^2, and the river length is about 60 km. At the southern end of Svay Rieng is the Vay Kor Dam. This is an artificial reservoir built by damming the Vay Kor River for a length of about 20 km, a depth of 3 to 7 m, and a total water storage capacity of about 30 MCM (30 million m^3).



Source: Survey Team

Figure 2-2-5 Vay Kor River and the Basin

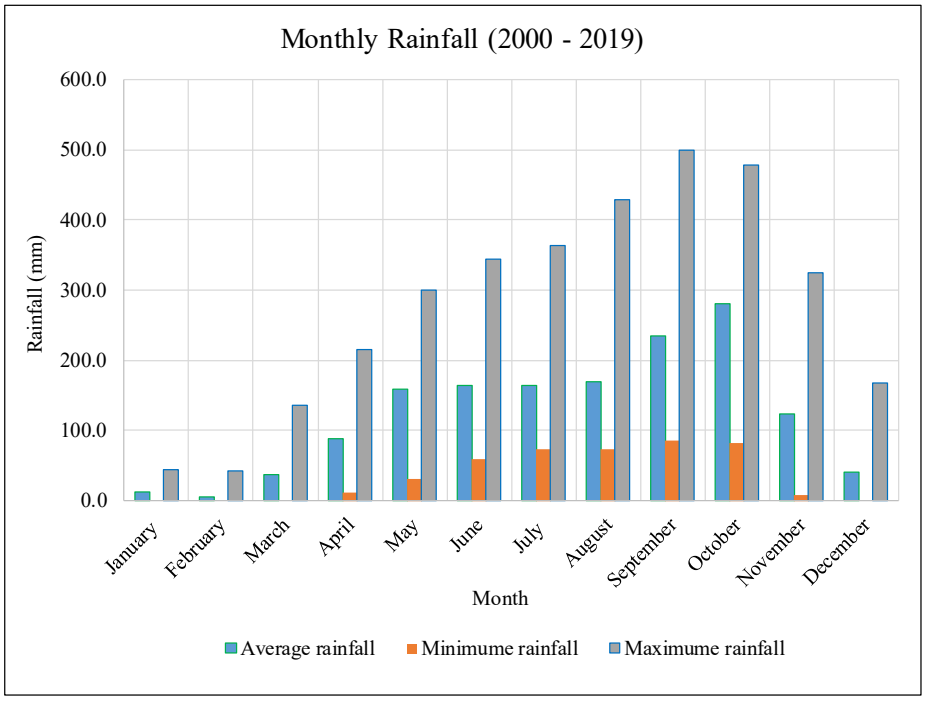
2) Weather and Rainfall Conditions

Table 2-2-16 shows the rainfall in Svay Rieng over the past 20 years. The average annual rainfall is about 1,480 mm, and the monthly rainfall during the dry season (November to April) is about 310 mm. The total rainfall for the six (6) months of the dry season from 2015 to 2016 has a minimum of 81.8 mm, and it is estimated that this year was a drought year once every 20 years.

Table 2-2-16 Monthly and Annual Rainfall in Svay Rieng

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total	Nov. to Apr
2000	0.0	0.0	18.0	125.0	164.0	222.0	99.0	111.0	86.0	191.0	111.0	20.0	1,147.0	
2001	24.0	0.0	136.0	106.0	142.0	222.0	150.0	153.0	244.0	370.0	38.0	42.0	1,627.0	397.0
2002	0.0	0.0	0.0	119.0	50.0	198.0	151.0	130.0	240.0	244.0	302.0	158.0	1,592.0	199.0
2003	0.0	0.0	2.0	22.0	300.0	187.0	364.0	99.0	267.0	297.0	70.0	0.0	1,608.0	484.0
2004	2.0	0.0	8.0	93.0	204.0	114.0	144.0	203.0	329.0	244.0	216.0	0.0	1,557.0	173.0
2005	0.0	0.0	0.0	11.0	32.0	232.0	111.0	97.0	251.0	478.0	324.0	168.0	1,704.0	227.0
2006	7.0	10.0	55.0	161.0	206.0	264.0	199.0	185.0	250.0	424.0	22.0	9.0	1,792.0	725.0
2007	32.0	0.0	50.0	92.0	189.0	74.0	242.0	249.0	260.0	388.0	122.0	5.0	1,703.0	205.0
2008	45.0	43.0	135.0	215.0	266.0	228.0	145.0	129.0	243.0	416.0	184.0	121.0	2,170.0	565.0
2009	0.0	26.3	118.0	147.8	288.3	60.2	159.4	185.5	285.7	178.0	9.0	17.4	1,475.6	597.1
2010	20.7	0.0	11.5	98.4	126.6	239.0	299.0	284.9	209.1	449.7	241.3	0.0	1,980.2	157.0
2011	3.9	1.2	92.3	94.6	245.5	170.1	103.0	248.2	251.2	378.6	252.3	0.0	1,840.9	433.3
2012	29.9	0.8	18.4	82.0	220.0	144.9	73.4	164.3	499.1	399.5	98.3	0.0	1,730.6	383.4
2013	1.9	6.8	16.0	65.5	125.5	96.8	111.3	107.7	97.5	100.7	62.1	5.4	797.0	188.4
2014	1.7	2.4	15.9	90.7	93.1	98.9	114.7	96.5	105.3	141.4	43.5	26.6	830.7	178.2
2015	3.5	0.7	6.0	68.2	108.2	91.5	88.5	128.5	144.3	82.2	38.9	14.8	775.2	148.5
2016	1.6	0.5	0.1	25.8	67.5	105.3	90.8	73.7	117.0	147.3	51.1	67.3	748.3	81.8
2017	26.0	14.3	17.7	63.5	131.8	97.1	132.0	164.2	158.3	148.4	71.7	29.6	1,054.6	240.1
2018	29.8	1.6	9.3	39.8	71.5	109.0	172.2	162.6	197.4	313.9	110.8	100.6	1,318.5	181.8
2019	27.3	0.2	23.2	59.1	141.6	343.9	331.7	429.8	452.1	230.9	121.0		2,160.8	321.2
Average	12.8	5.4	36.6	89.0	158.6	164.9	164.0	170.1	234.3	281.1	124.4	41.3	1,480.6	309.8
Minimume	0.0	0.0	0.0	11.0	32.0	60.2	73.4	73.7	86.0	82.2	9.0	0.0		
Maximume	45.0	43.0	136.0	215.0	300.0	343.9	364.0	429.8	499.1	478.0	324.0	168.0		

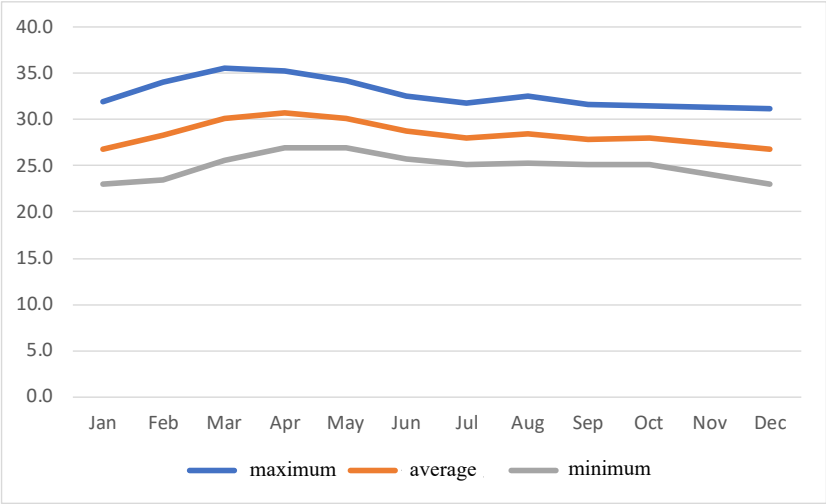
Source：Institute of Technology of Cambodia



Source：Institute of Technology of Cambodia

Figure 2-2-6 Average Precipitation Over the Last 20 Years

The following figure shows the monthly average temperature for the past 10 years from 2009 to 2019. Cambodia has a tropical monsoon climate and a hot climate throughout the year. In particular, the dry season from February to April corresponds to the hottest period of the year.



Source：Institute of Technology of Cambodia

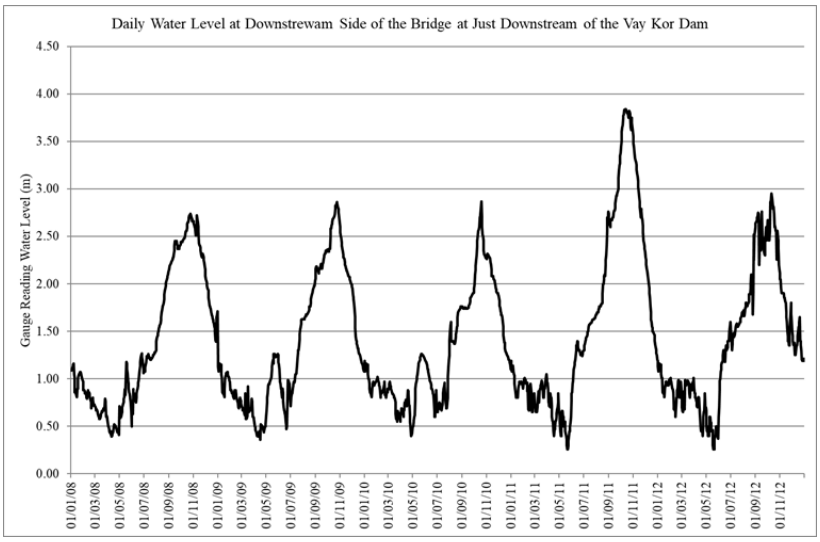
Figure 2-2-7 Average Temperature Over the Last 10 Years

3) Water Level Status of Vay Kor River and Vay Kor Lake

MOWRAM does not observe the water level in Lake Vay Kor. However, the water level of the Vay Kor River has been observed at the Berry Bridge downstream of the Vay Kor Dam even before the Vay Kor Dam was completed in 2007. Even now, water level observations using water level markers continue at the downstream side of the bridge.

The highest water level on the downstream side of the bridge is EL.+3.84m (October 13-14, 2011). Considering the differences among the maximum water levels at the upper part of the bridge and the overflow depth of the dam, it is estimated that the maximum water level may have exceeded EL. + 4.00m.

Assuming that the water level difference between the upstream and downstream of the bridge during the 2011 flood is 20 cm, and calculating the Manning roughness coefficient as 0.04, the passing flow rate of the bridge is estimated as 243 m^3/sec and the flow velocity is estimated to be 1.26 m/sec. Under the above conditions, the water levels on the downstream and upstream sides of the bridge are calculated as EL.+3.84m and EL.+4.04m, respectively, and the overflow depth of the dam is calculated as 1.02m (the overflow of a thin weir). From the elevation of the top of the dam (EL.+3.33), the maximum water level of the lake can be estimated as about EL.+4.35m. The water level difference of about 20 cm before and after the bridge is the water level difference that can be seen in other road bridges that cross the floodplain.



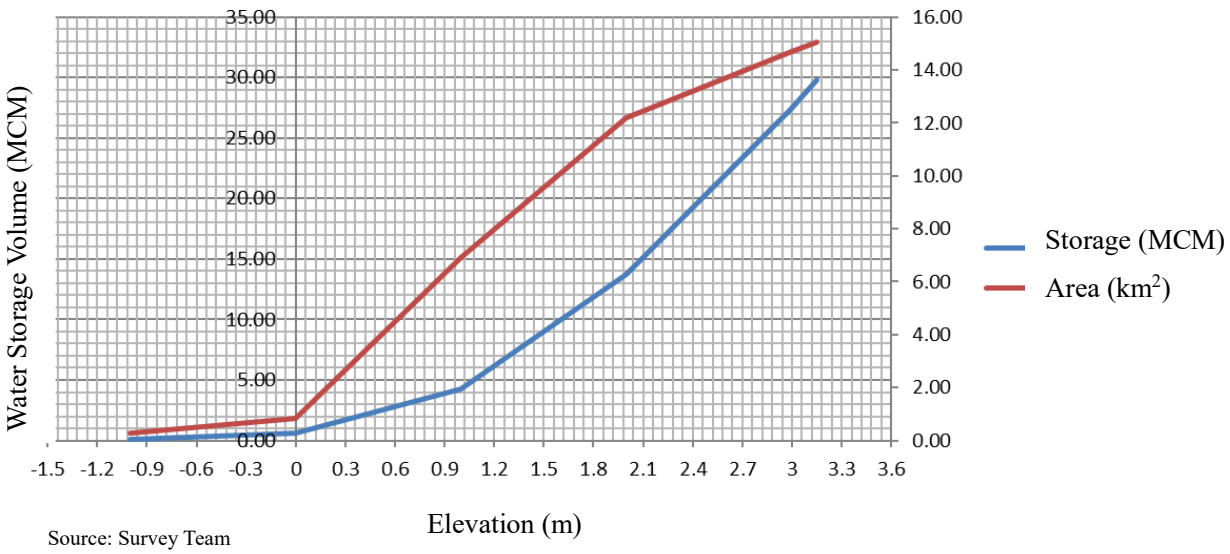
Source：MOWRAM

Figure 2-2-8 Daily Average Water Level on the Downstream Side of the Bridge Downstream of the Vay Kor Dam

4) Water Storage Capacity of Vay Kor Lake

The Survey Team conducted a cross-sectional survey of Vay Kor Lake in 2017. This is a record of the lake surface water level and water depth by setting the cross section at 1km intervals in the longitudinal direction of Vay Kor Lake. The "Water Height- Water Area - Water Volume (H-A-V curve)" obtained from the result is as follows. Since the survey was conducted from the top of the sediment deposited on the bottom of the lake, the V value is considered to correspond to the effective water storage capacity.

Since the top elevation of the overflow part of the Vay Kor Dam is EL.+ 3.30m, the water storage capacity of the water level EL. + 3.33m can be estimated to be about 30MCM (30 million m^3) from the H-A-V curve. According to the DOWRAM in Svay Rieng Province, the lowest water level of the lake in 2015, which is said to be the most severe drought year in recent years, was 2.15 m. The minimum water storage capacity at that time can be estimated to be about 15.5 MCM (15.5 million m^3) from the H-V curve.



Source: Survey Team

Figure 2-2-9 HAV Graph of Vay Kor Lake

5) Water Use Condition in Vay Kor Lake

Irrigation water is taken from Vay Kor Lake. The existing irrigation area is 5,500 ha, but due to insufficient irrigation system, only one-third of the entire irrigation area is supplied with water during the dry season (DOWRAM information).

The irrigation period is three (3) months from January to March, and the basic unit of water volume is 10,000 to 12,000 m^3 / ha (DOWRAM information). If irrigation water is supplied to two-thirds of 5,500 ha in the future, the amount of irrigation water will be 36 to 44 MCM (36 million to 44 million m^3), which exceeds the estimated effective storage capacity (30 MCM) of Vay Kor Lake. For this reason, it is important for the Cambodian side to manage the water use appropriately for the water resources of Vay Kor Lake.

6) Possibility of Water Intake from Vay Kor Lake in terms of Water Volume

Regarding the amount of new water intake from Vay Kor Lake, MOWRAM approved the intake of 7,500 to 12,000 m^3/day in September 2017. This amount of water corresponds to a maximum of about 2.3 MCM during the 6 months of the dry season. Furthermore, after the start of operation (scheduled for mid-2022) of the WTP currently under construction by ADB, the amount of water intake is expected to be about 21,000 m^3 / day, which is equivalent to 3.8 MCM.

On the other hand, the amount of residual water in the lake during the dry season in 2015 was about 15.5 MCM and, the water volume with a minimum water level of 1.6 m observed by the survey team in July 2020 is about 10 MCM.

From the above, as long as the current amount of irrigation water is maintained, the amount of water intake for domestic water of 3.8 MCM can be secured.

7) Future Plan around Vay Kor Dam

a) Outline of the Plan

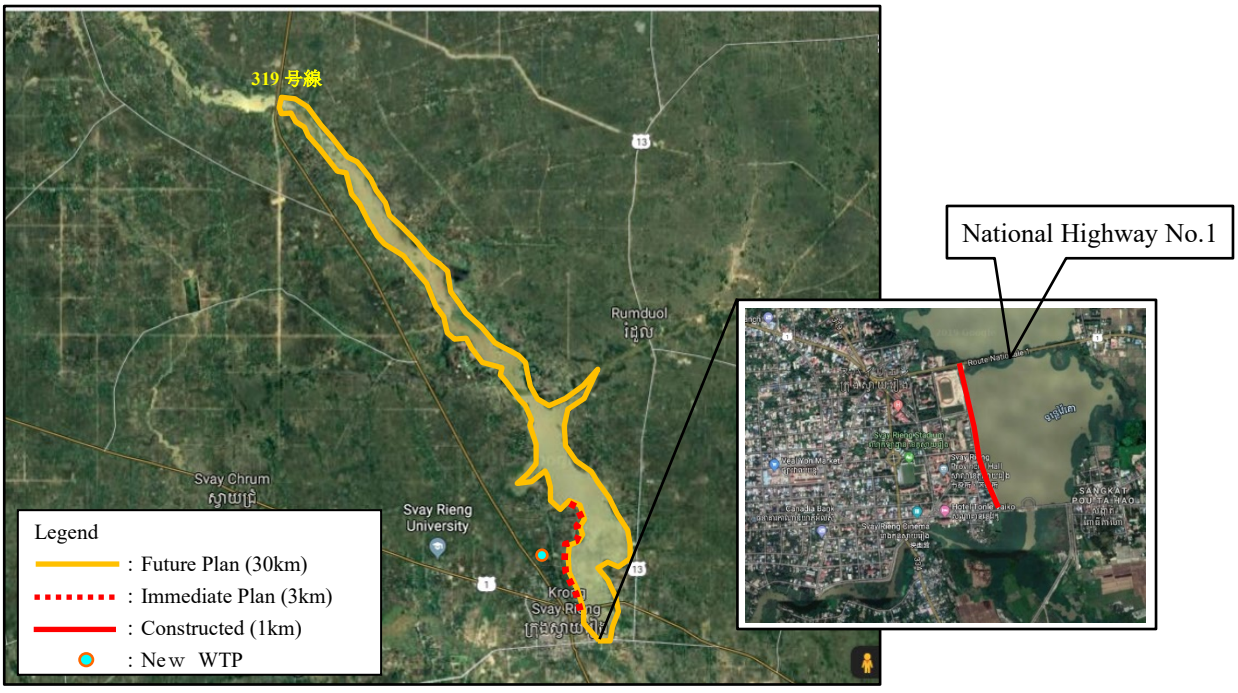
According to DOWRAM, two (2) reservoirs (dam lake, total capacity 3-5MCM) upstream of Prefectural Road 319 and one (1) reservoir downstream of Vay Kor Dam are planned. Furthermore, in the future, the amount of irrigation water will be increased by raising the circumference of the lake (about 30km) from the current location of the Vay Kor Dam to Prefectural Route 319, with a lake shore embankment.

In addition, there is a dam with the same shape as the current Vay Kor Dam near Prefectural Road 319, and it is planned to construct a lake shore embankment in the upstream area from Prefectural Road 319.

However, planning for this upstream embankment has not yet progressed. Currently, the Provincial Hall is in the process of acquiring land to build a lake bank. In this way, the goal is to irrigate 16,000 ha of agricultural land in the future by constructing a lake shore embankment and raising the existing dam (weir) (see Figure 2-2-10).

On the other hand, according to the Provincial Hall, which has a maintenance budget, priority is given to parks and revetment maintenance on the downstream side of National Highway No. 1. The timing of the raising work for the entire Vay Kor Lake is undecided.

The Vay Kor Lake Development Project will first build the surrounding lake levee, and then raise the Vay Kor Dam. For the time being, it is unlikely that the water level at the Vay Kor Dam will rise above the current HWL. In addition, even if the lake levee is raised, it is considered that it will not exceed the road height of National Highway No. 1. These shall be taken into consideration when designing the intake facility.



Source：Google Earth, arranged by Survey Team

Figure 2-2-10 Vay Kor Lake Bank Plan

b) Downstream Side (South Side) of National Highway No. 1

On the right bank downstream from National Highway No. 1, the construction of a lakeside park and revetment is already underway, utilizing the budget of the Provincial Hall which took over the business from DOWRAM. The standard cross section of this work is as shown in Figure 2-2-11, and the construction status is as shown in Figure 2-2-12.

The construction is basically focused on the effective use of the lake shore (parking). There is no plan to raise the embankment, and the height of the top of the revetment remains at a level commensurate with the current road height.

In the vicinity of the new water intake facility along National Highway No. 1, there is a plan to widen the road width by about 2 m to the South along with this lake shore development.

c) Upstream Side (North Side) of National Highway No. 1

As mentioned above, the timing of the lake shore embankment is undecided.

Source：Provincial Hall

Figure 2-2-11 Standard Cross Section of Parks and Revetments around Vay Kor Lake

Source：Survey Team

Figure 2-2-12 Construction Status of the Park and Revetment of Vay Kor Lake (February 2020)

8) Road Expansion Plan

In the vicinity of the new intake point, there are plans to construct a new expressway and renovate National Highway No. 1. Neither currently affects the design of the intake facility. However, after the location of the intake point is confirmed, it is necessary to share the layout of the intake facility with the Cambodian officials and obtain approval by the required procedure. The outline of the road improvement plan is given below.

a) New Highway Plan

In the suburbs of Vay Kor Lake, there is a plan for the Phnom Penh-Bavet Expressway about 3 km north of National Highway 1. This plan is currently under consideration by Ministry of Public Works and Transport (MPWT). Since it is a completely a different route from National Highway No. 1, there is no impact on water intake.

b) Expansion Plan of National Highway No.1

According to the Department of Public Works and Transport (DPWT), the ROW of the national highway is 30m on one side, i.e., 60m for both sides. The current National Highway No. 1 has a total width of 11 m, and DPWT has hopes for widening the road.

Since there is information that widening from the current two lanes to four lanes will be carried out in the near future, the location of the water intake facility (pump room) shall be a location that will not be affected by the widening of the roadway.

(2) Existing Intake Facility

The existing intake facility in Svay Rieng uses a groundwater water source and pumps water from three wells, as shown in Figure 2-2-13. The well structure involves excavation to a depth of 200 m and screen installation on major aquifers, as shown in Figure 2-2-14. A submerged pump is installed at the depth of 27 m, with a water pipe 114 mm in diameter. Well No. 1 is supposed to have been utilized existing well, but the detailed structure remains unknown.

The major aquifers comprise gravel layers of alluvium formed during ancient times, more than 150 m deep and nearly 30 m thick. Up to a depth of 30 m or so, a thick clay layer of alluvium prevails, which was formed after the Mesozoic era, followed by alternating layers of fine sand and clay between the alluvium and gravel layers. The existing wells used by residents in Svay Rieng take in water from the fine-sand layer, sedimented under that of alluvium clay.

The volume pumped from each well is 95 m^3/hour. As Figure 2-2-15 shows, three wells respectively operate for 16 consecutive hours, followed by an eight-hour interval for downtime. Under this operating pattern, two wells operate while the other well remains down. The period of downtime is arranged to prevent the pump from being over-used and from overheating, as well as allowing sufficient time for operating staff to maintain and work on the equipment.

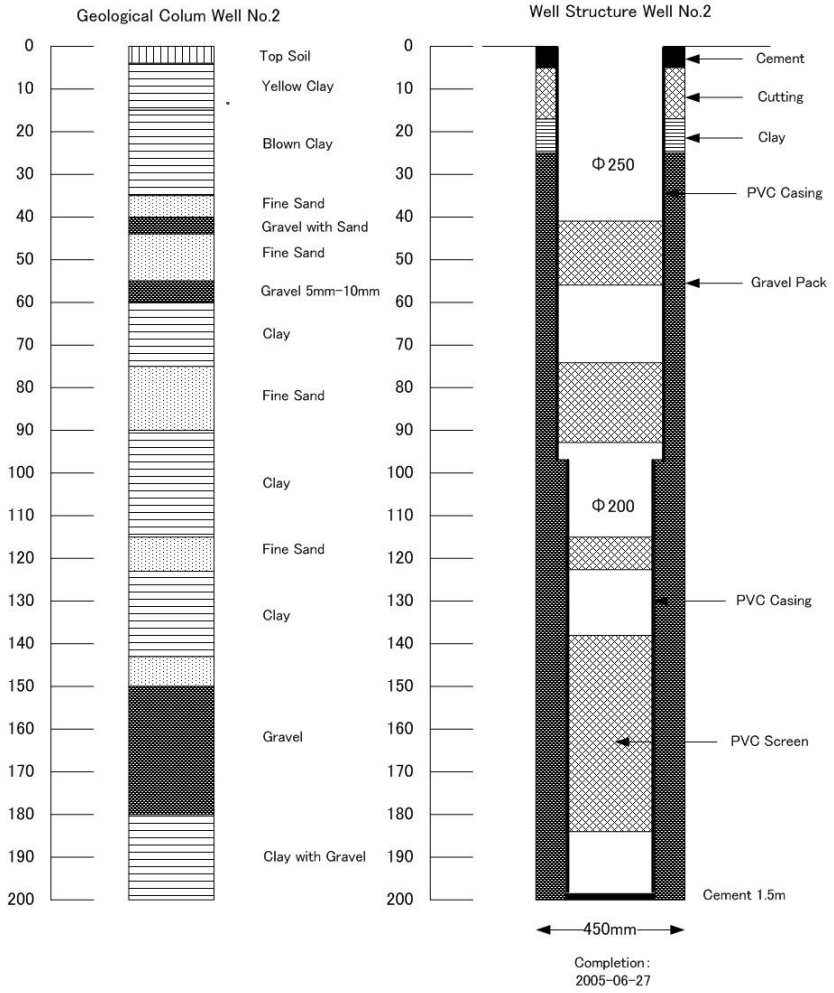
The groundwater level in each well was measured monthly before and after pumping (i.e. after downtime and after operation respectively). According to the data for three years (2014 to 2016), the

water level decreased by 3 to 8 m after pumping, before recovering to the original level, which suggests that the current hourly pumping volume and pumping pattern fit the aquifer capacity.

This indicates that each well secures a pumping volume of 1,520 m^3/day (95m^3/hour x 16 hour/day). Overall, this system secures a pumping volume peaking at 4,560 m^3/day (1,520 m^3/day x three wells).

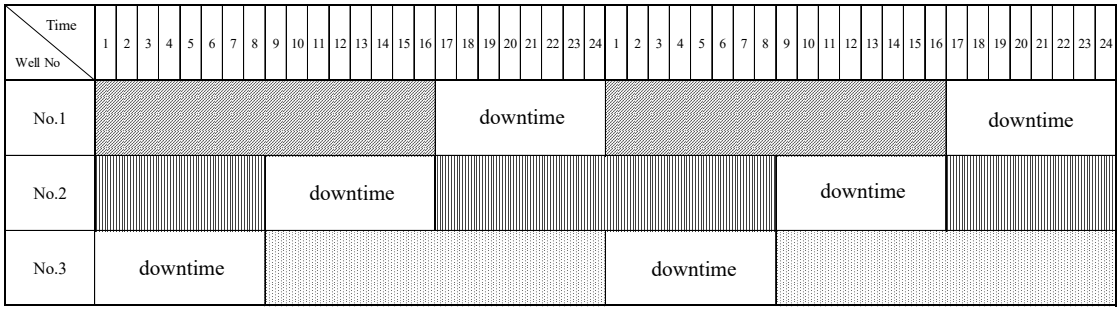
Source: Survey Team, Satellite image: Google Earth

Figure 2-2-13 Location of Intake Facility and Three Wells in Svay Rieng



Source: Final Report on Wells Construction and Testing in Svay Rieng （Dec. 1, 2005）

Figure 2-2-14 Well Structure and its Geological Column for WTP in Svay Rieng (Well No. 2)



Source: prepared by Survey Team based on the survey result

Figure 2-2-15 Operating Pattern of Production Wells for WTP in Svay Rieng

(3) New Intake Facility

1) Selection of Water Intake Point

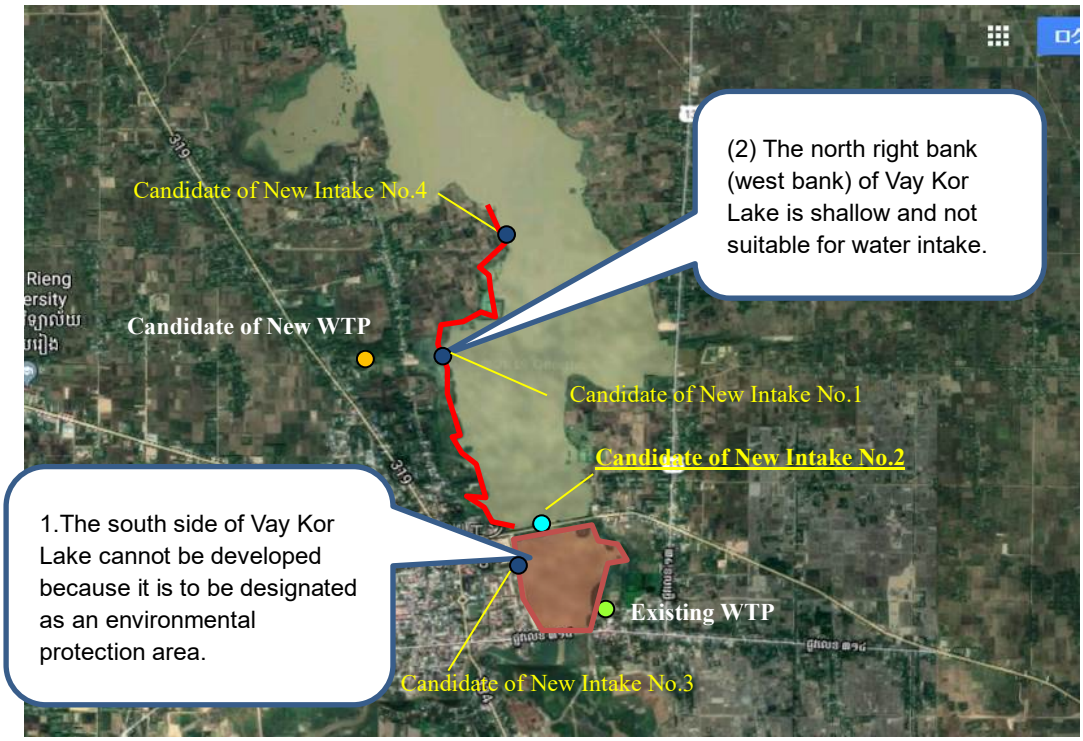
SWWs presented four (4) water intake candidate points. The Survey Team selected the appropriate site from the four candidate sites based on the following conditions.

- There is no legal restriction, and the site can be constructed.
- There is sufficient water depth to allow water intake from below LWL (EL + 2.15m) of Vay Kor Dam.

The location map of the four (4) candidate water intake points is shown hereafter. For environmental protection, the water source of Vay Kor Lake is restricted for development in the lake on the South side of National Highway No. 1 (see Figure 1-3-3, for details, see "1-3 Environmental and Social Consideration"). As a result, Candidate Site No. 3 posted by the Cambodian side is excluded.

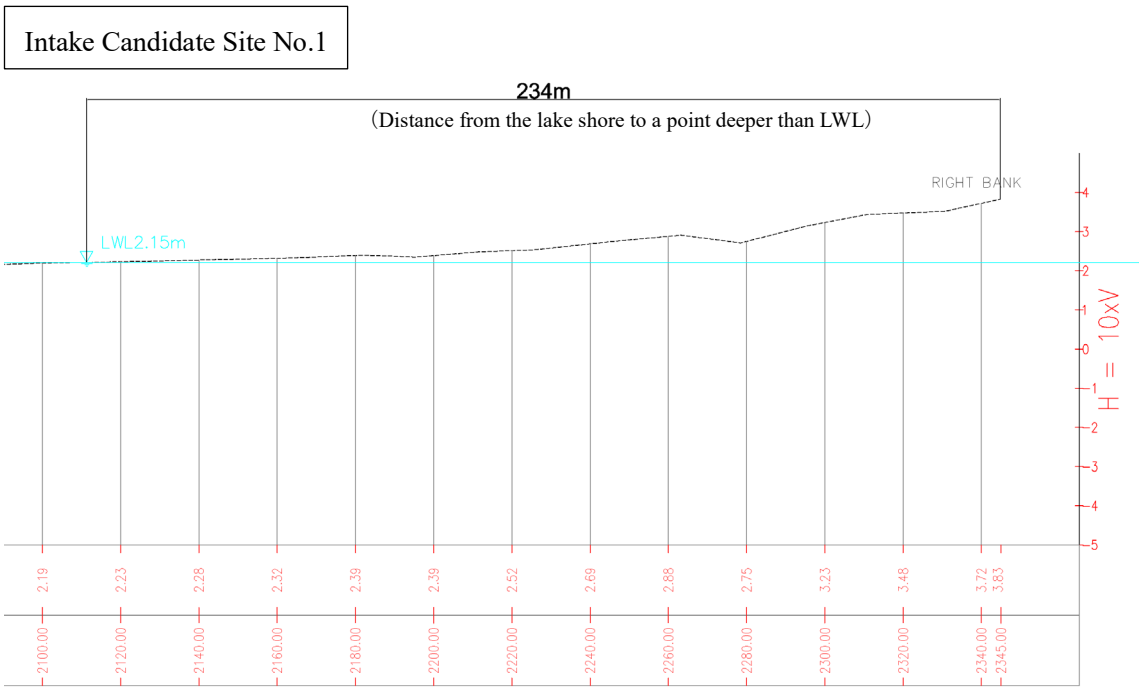
In addition, according to the results of cross-sectional survey, the Northwestern shore of Vay Kor Lake is shallow (see Figure 2-2-17 and Figure 2-2-18), and the points with sufficient water depth are limited. Therefore, Candidate Point No. 1 and Candidate Point No. 4 are excluded. On the other hand, as will be described later, it was confirmed that Candidate Site No. 2 is relatively easy to construct and has the required water depth.

Based on the above, Candidate Site No. 2 (North side of National Highway No. 1) is considered to be the most suitable candidate site. There is a distance of about 3.3km between this Candidate Site No. 2 and the candidate site for the new WTP.



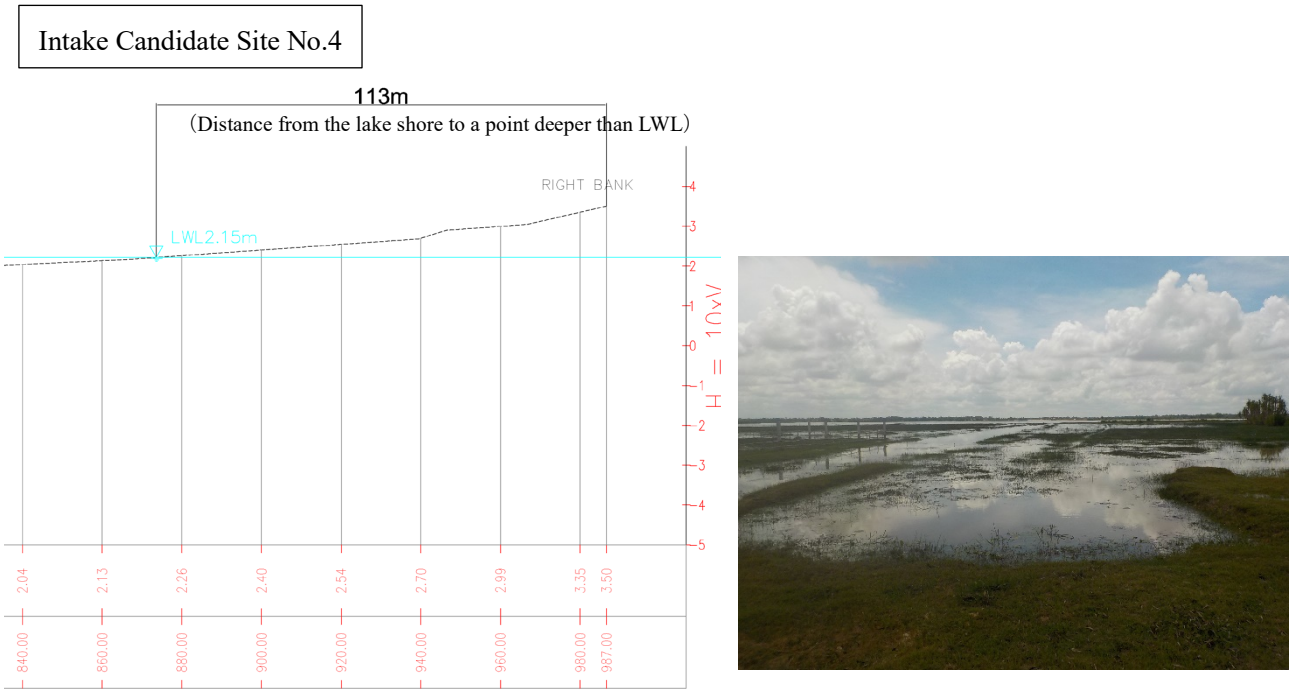
Source：Google Earth, arranged by Survey Team

Figure 2-2-16 Location Map of New Intake Facility and WTP



Source： Created by Survey Team

Figure 2-2-17 Cross Section of the Northwestern Shore of Vay Kor Lake (East-West Direction) (1/2)



Source：Created by Survey Team based on subcontract results

Figure 2-2-18 Cross Section (East-West Direction) and Photo of the Northwestern Shore of Vay Kor Lake（2/2）

2) Detailed Location of Water Intake Facility

Regarding the detailed location of the water intake facility, a point (riverbed height EL+1.00 m) where water intake can be secured at LWL 2.15 m or less is selected with reference to the opinions of related organizations.

a) Conditions for Water Intake Position

i) Confirmation of Conditions in the Parallel Direction of the Road

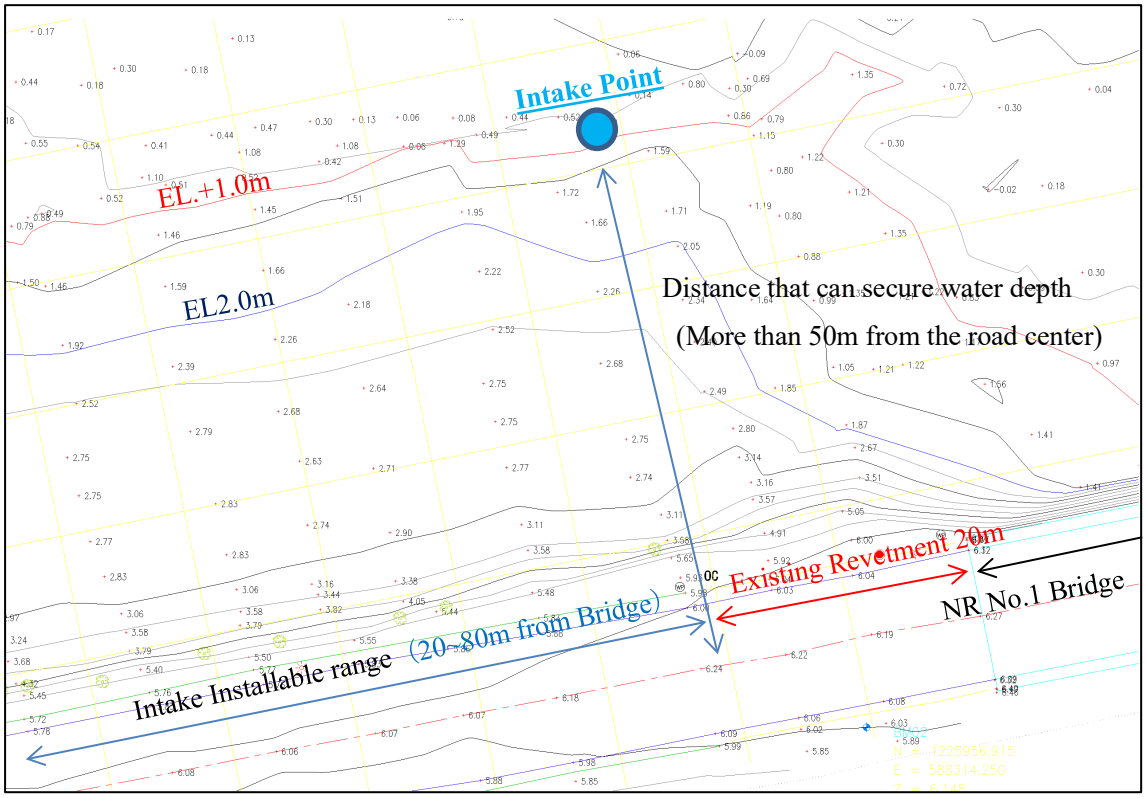
- According to the survey results in Vay Kor Lake, the vicinity of the existing bridge on National Highway No. 1 tends to become deeper from West to East.
- It is presumed that aquatic plants are overgrown 80m west of the existing bridge on National Highway No. 1 and that it is shallow. It is not recommended because there is a concern that suction of aquatic plants will adversely affect water intake.
- At the request of Provincial Hall, the intake facility will be located within 115m from the existing bridge on National Highway No. 1. In addition, the existing condition of revetment of the bridge (about 20 m from the abutment) will be maintained.

ii) Confirmation of Conditions in the Direction of Road Crossing

- It is not possible to secure a water depth below LWL near the shoulder of National Highway No. 1.
- According to the survey results in Vay Kor Lake, sufficient water depth can be secured if it is about 50 m offshore from the center line of National Highway No. 1.

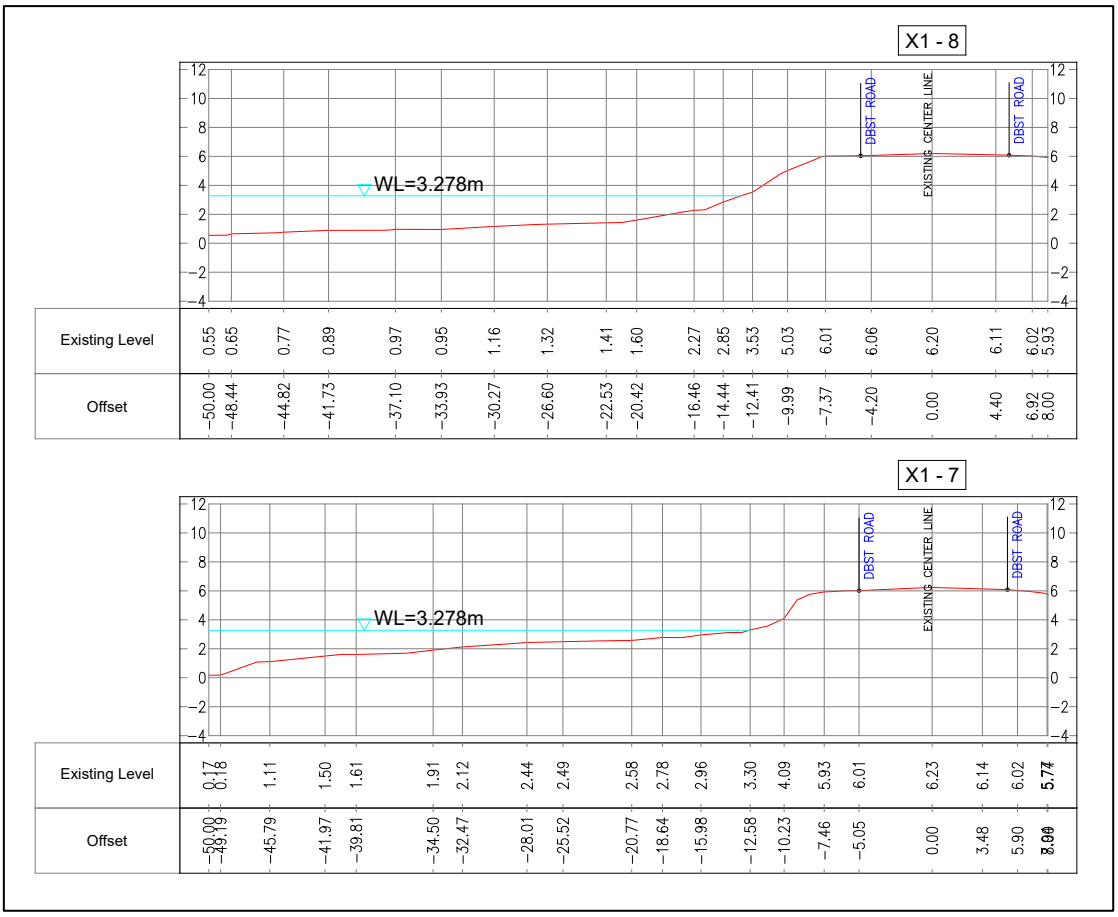
b) Intake Location

Considering the above setting conditions for the water intake position, the water intake point has been set as follows:



Source：Survey Team

Figure 2-2-19 Topographic Map around the Intake Facilities



Source：Survey Team

Figure 2-2-20 Cross-Sectional View of Vay Kor Lake Intake Candidate Site No. 2

The status of No. 2 candidate site for new water intake is as shown below. Since the site faces National Highway No. 1, large-scale construction involving excavation of the shoulder must be avoided. A width of about 3.0 m is secured on the shoulder of the existing road, but it is difficult to construct an electric room and a generator room of the water intake facility in this width. Therefore, it is necessary to reclaim the lake.

Source：Survey Team

Figure 2-2-21 Status of Candidate Site for Intake Facilities (December 2019)

Photo Source：Survey Team

Figure 2-2-22 Status of Candidate Construction Sites for Water Intake Facilities (Aerial Photograph)

3) Land Acquisition and Construction Permit

The new water intake point is public land and does not require land purchase. However, the construction permit for the water intake facility needs to be approved in the order of "WWs ⇒ DISTI ⇒ Provincial Hall ⇒ MOWRAM".

2-2-2-3 Intake Facility Plan

(1) Water Level

The water level conditions are as follows:

Table 2-2-17 Designed Elevation of Intake Facilities

Subject	Design Elevation	Note
Vay Kor Lake HWL*	+4.35 m	Set by the Survey Team in consideration of the highest water level in the past (EL3.84m, 2011) and the overflow depth of the dam.
Vay Kor Lake LWL*	+2.15m	Water level during drought in 2015
Design HWL	+4.40 m	Round up of HWL
Design LWL	+1.60m	Lowest observed water level (July 2020)
Freeboard	+0.80 m	Clearance when the maximum discharge is 243 m^3/s (River Management Facility Structure Ordinance, Japan)
Planned Ground Elevation in Intake Facility	+5.80 m	After satisfying the design HWL and clearance, the height of the road shoulder was adjusted in consideration of the entry of vehicles.
Road Elevation	+5.80 m +6.20 m	Road Shoulder Road Center

* Hearing from DOWRAM about the water level of Vay Kor Lake
Source：Survey Team

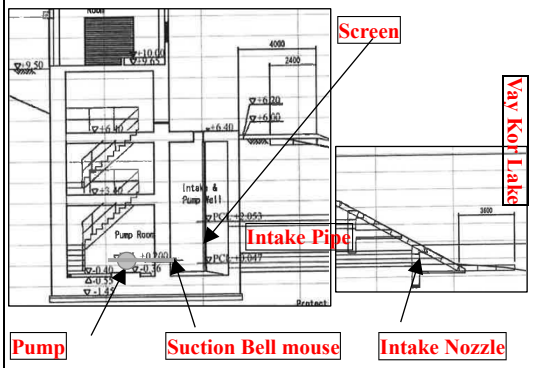
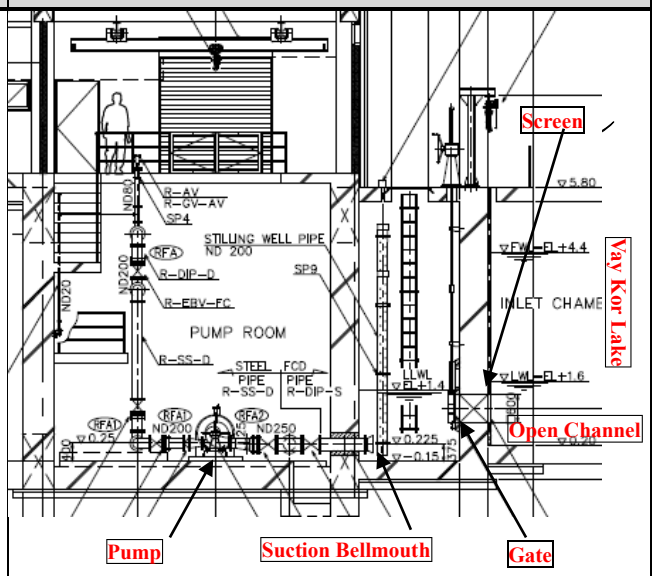
In July 2020, a water level lower than the LWL (observed lowest water level in 2015) set by DOWRAM was observed. Therefore, when designing the intake facility, the water level in July 2020 shall be adopted as the design LWL.

(2) Water Intake Method

Considering the topographical restrictions of the planned water intake location and the shallow lake bottom far away, two (2) water intake methods can be selected: "Horizontal Intake Pipe" and "Open Channel with Gate".

The features of the two water intake methods are as follows:

Table 2-2-18 Comparison of Horizontal Intake Pipe and Open Channel with Gate Type

	Horizontal Intake Pipe (Adopted in the Existing)	Open Channel with Gate
Schematic		
Overview	It is the method of transporting lake water to the pump suction pit by water intake pipe. The pump station can be constructed along the road of Route No.1, but the distance from the pumping station to the point where the water level is deep is as long as about 30m. The screen is installed in the pump suction pit to prevent fishes, waterweeds, and animals from entering.	The suction pit of the pump station is constructed as deep as possible in the lake. For that reason, the pump station is constructed about 40m off the lake from the side of the road. The bar screens are installed at the end of open channel and the intake gates are installed in the suction pit to prevent the invasion of fishes, waterweeds, and animals. The open channel is 4m wide and 9m long.
Feature	It can be expected that there will be little sedimentation inside of the intake pipe. The screen cannot be attached at the inlet of pipe because maintenance from the water surface of the lake is difficult. Therefore, there is a risk to invasion of waterweeds, fishes, and small animals. Since the amount of embankment is smaller than that of the open channel, the construction cost will be slightly lower.	Waterweeds that gathered to the open channel can be removed easily. The screen panel that attached at the end of open channel can be pulled up to the ground. Therefore, the trash can be easily removed. By dividing the suction pit into two, it is possible to clean each tank.
Judgement	It is possible to avoid the risk of clogging of the intake pipe. In addition, by constructing the pump station in the lake, it will be easier to construct the intake pump station, and it will be advantageous in terms of maintenance and safety because there is an area for vehicles to enter. Furthermore, it is easy to remove waterweeds. Based on the above, the "**Open Channel with Gate**" is selected as type of intake water.	

Source: Survey Team

(3) Plan of Pump Station

1) Pump Type

From the viewpoint of the planned "Total Head" and "Discharge Capacity", the preferred pump type is as follows.

Table 2-2-19 Type and Characteristics of Intake Pump

Type of Intake Pump	Characteristics of Intake Pump
・Horizontal, double suction volute	Easy maintenance, better suction performance and better efficiency
・Horizontal, end suction centrifugal	Inferior to double suction pump on efficiency and maintenance
・Vertical, mixed flow	Due to a lot of parts for lubrication system of submersible bearings, great care is required for maintenance and inspection.
・Submersible	The service life is shorter than other types, and replacement work of mechanical seals is required about once every two years.

Source: Survey Team

As a result of the above comparison, "Horizontal, Double Suction Volute Type" has been selected for its excellence in terms of efficiency and maintenance and it is requested by the WWs.

2) Number of Pumps

The pump suction diameter is reduced by increasing the number of pumps. Therefore, the screen clear spacing becomes narrower and the frequency of cleaning work increases. In addition, the pump efficiency tends to decrease. Since the planned transmission water volume is small, the number of pumps in operation is preferably one or two. The table below shows a comparison.

Table 2-2-20 Comparison of the Number of Intake Pumps

Items	One Duty Pump	Two Duty Pumps
Pump Capacity (m^3/min)	5.2	2.6
Suction Diameter (mm)	200	150
Rated power of motor (kW)	30	15
Maximum efficiency of pump (%)	81	78
Impeller outlet width (mm)	20	15
Required installation space (%)	100% (2sets：5.67m^2)	110% (3sets：6.27m^2)
Result	From the viewpoints of higher efficiency, less clogging, and easy speed control, **the number of duty pump is set to one.** One spare pump is added, so that a total of two shall be installed.	

Source: Survey Team

3) Calculation of Pump Total Head

The calculation of pump total head is as shown in Appendix 7-3. The pump total head is 19m based on the calculation result.

4) Operation Method of Intake Pump

The rotation speed of the pump is controlled so that the required flow rate instructed from the intake pump station, or the WTP, is equal to the actual flow rate. The instructed flow and actual flow are displayed on the control panel installed in the intake pump station.

The start/stop command of the pump is given at the intake pump station, but it can be operated from the WTP by switching the “Local / Remote” changeover switch of the intake pump station to “Remote”.

5) Design Specification of Intake Pump

The design specification of the intake pump is as shown in the following table.

Table 2-2-21 Design Specifications of Intake Pump

Item	Design Specifications
Type of Pump	Horizontal, double suction volute pump
Quantity	2 sets (including one standby)
Flow Rate	7,480m^3/day (5.2m^3/min)
Total Head	19m
Rated Power of Motor	30kW
Suction Diameter	200mm
Synthetic Speed	1,500min^{-1}
Speed Control	Inverter

Source: Survey Team

6) Water Hammer Analysis

The results of water hammer analysis are as shown on Appendix 7-4. According to the results of the analysis, dangerous negative pressure appears in a wide range of water pipes. Therefore, as a measure to control the negative pressure, the most reliable flywheel device shall be installed between the pump and the motor.

The capacity of the flywheel shall be 50 kg/m^2 based on the analysis results.

(4) Electric Equipment Planning

1) Substation

A new substation facility shall be installed in the intake pumping station. Electric power shall be distributed from the EDC's 22kV transmission line about 600m away.

2) Emergency Diesel Generator Facility

Since short-circuit accidents occur several times a month, an emergency diesel generator facility with the full load capacity required by the intake pumping station shall be installed.

The approval of the WWs has been obtained, that is, the fuel tank capacity should be of 10 hours or more operation. In order to omit the installation of a separate fuel service tank, a power generator unit with a fuel tank capacity of 10 hours or more operation shall be selected.

3) Instrumentation

The following instrumentations shall be installed so that the pump can be operated safely, and the operating status of the pump can be monitored at the WTP:

a) Water level meter of Vay Kor Lake : 1set in each suction pit

b) Electromagnetic flowmeter for measuring water intake : 1 set in pump room

4) Remote Monitoring and Control System

A remote monitoring and control system shall be installed so that it is possible to monitor the operating status not only from the intake pump station but also from the water purification plant, and to operate "Start/Stop" of pumps.

The internet service (IPLL method) shall be used for signal transmission between the intake pump station and the WTP.

The remote monitoring items shall be as follows.

【To WTP from Intake Pump Station】

a) Pump Failure, contact signal : 2
b) Priming detect of pump, contact signal : 2
c) Remote/Local switching, contact signal : 2
d) LWL of lake, contact signal : 2
e) Actual flow, analog signal : 1
f) Pump Start/Stop, contact signal : 4
g) Grid or Generator Power, contact signal : 2

【To Intake Pump Station from WTP】

a) Request (demand) water volume, analogue signal : 1
b) Pump Start/Stop, contact signal : 4

(5) Other Design Conditions

1) Access to the Pump Room

Access to the pump room shall be embankment instead of bridges so that it will not be affected when the road is widened.

2) Landscape of the Pump Room

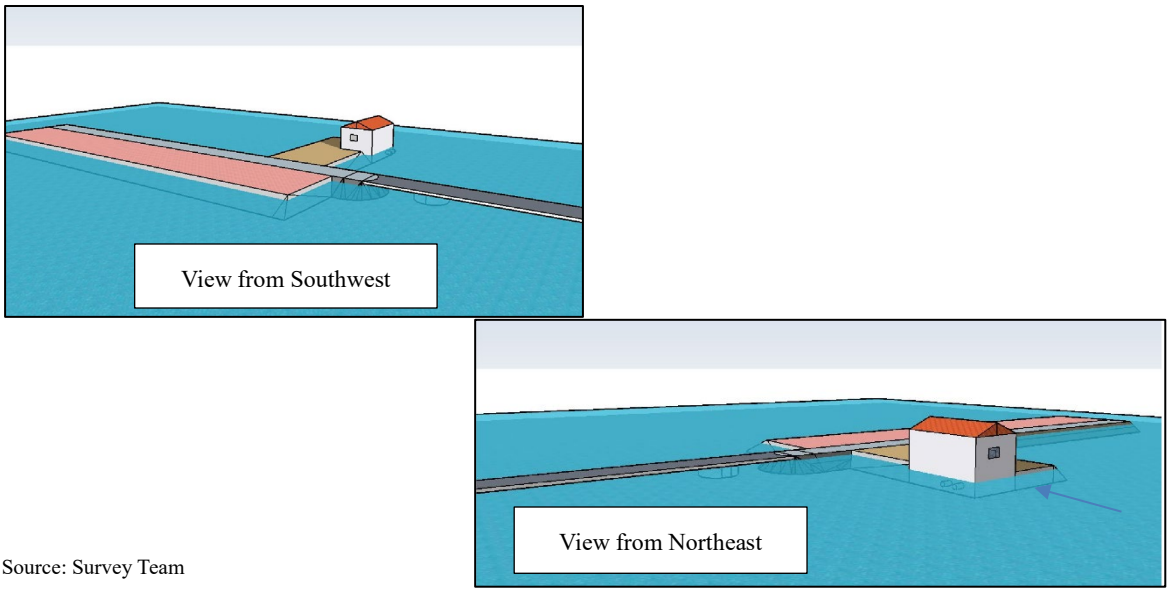
Since the ceremony is held on the shores of Vay Kor Lake during the water festival held in Svay Rieng around November every year, the Provincial Hall attaches great importance to securing the water level and landscape of Lake Vay Kor.

Since the planned construction site for the new water intake facility is in a prominent location along National Highway No. 1, there is a strong request from the Cambodian side to consider the design and landscape of the pump facility.

Based on these demands, the general building shape in Cambodia shall be adopted. It shall be designed in detail at the time of the detailed design phase with reference to the existing pump facility in Phnom Penh (Riverside). A photo of the existing pump facility and a perspective (draft) created based on it are shown hereafter.

Source: Survey Team

Figure 2-2-23 Existing Pump Facility in Phnom Penh Metropolitan Area



Source: Survey Team

Figure 2-2-24 3D Perspective of Intake Facility (Draft)

(6) Outline of Intake Pump Facility

Table 2-2-22 shows the facilities required for the intake pump station.

Table 2-2-22 Outline of Intake Pump Facilities

Classification of Facilities			Structure
Major Items	Middle Items	Minor Items	
Water Supply 7,480m^3/day	Intake Pump Station	Pump House	Reinforced concrete, Rectangular, Basement structure Ground floor: B11.6m × L16.0m × H3.3m（Under beam） Basement floor: B7.5m × L10.5m × H6.9m（Under beam） Electrical room, Generator room, Pump room, Office, Toilet, Suction pit

Source: Survey Team

2-2-2-4 Conveyance Pipe

(1) Existing Conveyance Pipe

The existing conveyance pipe connects between three existing wells and the existing WTP. The material of conveyance pipe is Ductile Iron pipe and the diameter is 250mm. The total length of the conveyance pipe is about 1,400m. Each of the three wells has been operated at 95m3/hour for 16 hours a day, and there has been no leakage or insufficient capacity in the water pipes.

(2) Basic Conditions for Designing of Proposed Conveyance Pipe

1) Design Flow of Conveyance Pipe

Based on the design flow of raw water intake that has been set out considering ten percent of safety factor to the design daily maximum water supply, the design flow of conveyance pipe shall be 7,480 m^3/ day[4].

2) Type of Conveyance Pipe

The type of conveyance pipe shall be the pumping type, considering the difference in elevation[5] between its beginning point (i.e., the raw water intake facility) and its terminal point (i.e., the WTP), the topography requiring the river crossing, and the geography that is a nearly flat terrain. The conveyance pipes shall be laid under public roads to convey raw water.

3) Route of Conveyance Pipe

The route of the conveyance pipe shall be selected along public roads and the route shall be the shortest distance between the water intake facility and the WTP, considering economic efficiency, ease of construction, and ease of maintenance and management.

(3) Pipe Material

With regard to the pipe material[6], it is selected by considering the applicable pipe diameter, the economic benefits, ease of construction work[7], and precedence of water pipe materials used in Cambodia. The materials for the conveyance pipe shall be ductile cast iron pipe (T-type) for general buried sections, and steel pipe (with corrosion prevention) or stainless-steel pipe for the river crossing sections. ISO standards shall be adopted.

[4] The design flow of conveyance pipe = 6,800 m^3 / day ×1.1 = 7,480 m^3 / day
[5] The difference in water level between the planned intake pump well (HWL + 4.40 m, LWL + 1.60 m) and the planned receiving well (WL+ 7.90 m) is from 3.50 to 6.30 m, the geography along the route of conveyance pipe almost flat.
[6] The selection of pipe material is shown in Appendix 7-6 (Selection of pipe material).
[7] Corrosion is a concern for buried steel pipes, and on-site welding work may cause poor finishing as compared with ductile cast iron pipe.

(4) Pipe Diameter

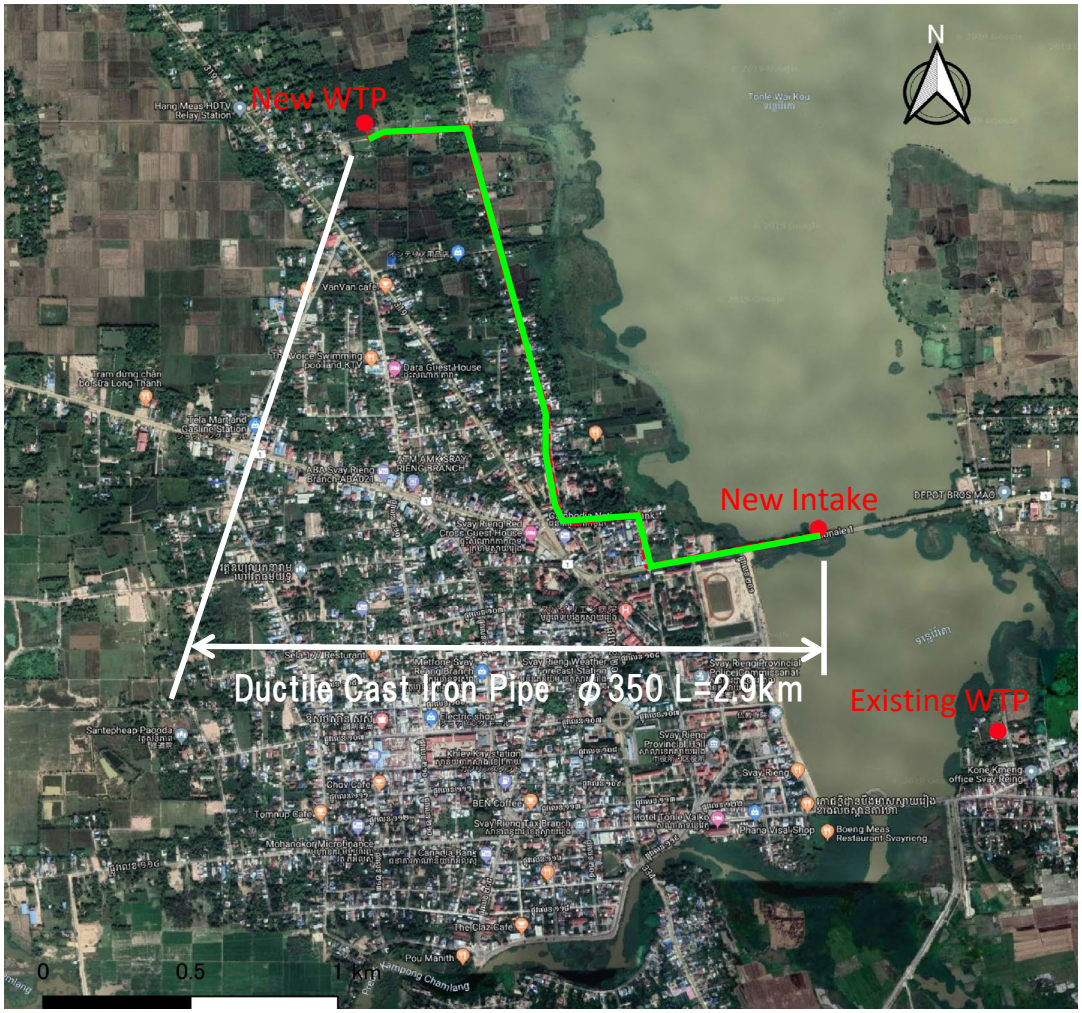
The pipe diameter for conveyance pipe shall be 350mm, considering economic relationship[8] between appropriate flow velocity[9], reasonable pipe loss or pump head and pipe diameter, and hydraulic calculations under the conditions of the design water level[10].

(5) Design Criteria for Conveyance Pipe Route

The design criteria for conveyance pipe shall conform to the design criteria for distribution mains.

(6) Conveyance Pipe Route

To summarize the above, the design for conveyance pipe route (excluding the intake pump equipment for conveyance pipe) is as shown in Figure 2-2-25 and Table 2-2-23.



Source: Survey Team

Figure 2-2-25 Route of Conveyance Pipe

[8] See Appendix 7-5 (Hydraulic Calculation of Conveyance Pipe)
[9] The minimum flow velocity shall be set at about 0.3 m/s so that small grains of sand would not settle in the pipeline. Economical pipe diameter is about 1 m/sec in flow velocity
[10] Design water level: The planned intake pump well (LWL + 1.60 m), the planned receiving well (WL+7.90 m)

Table 2-2-23 Specifications of Conveyance Pipe

Facility	Type and Structure	Quantity
Conveyance Pipe	DIP, Diameter 350mm	2.9 km

Source: Survey Team

2-2-2-5 Plan for WTP

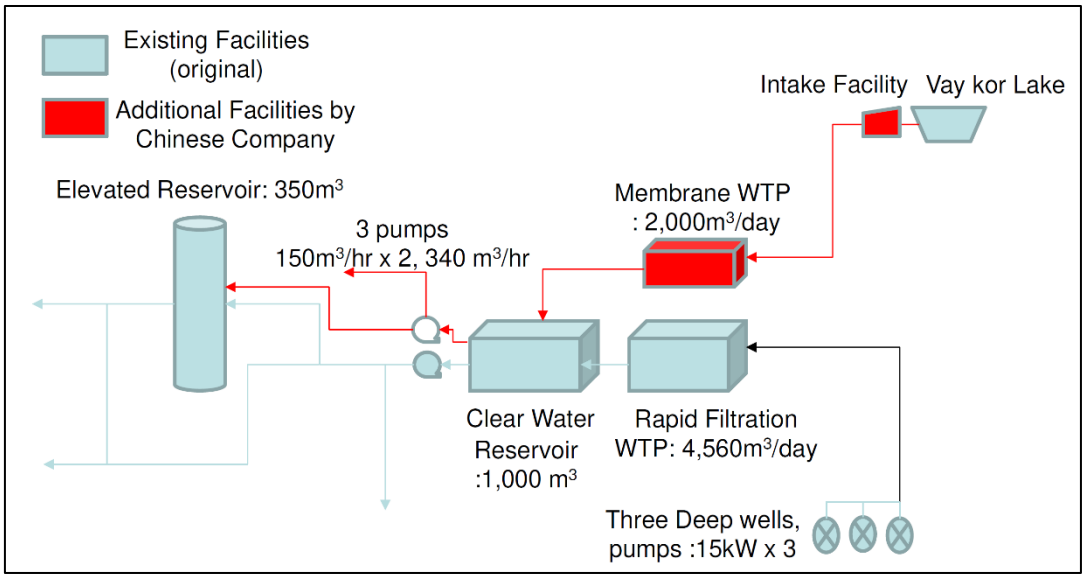
(1) Existing WTP

The layout map of existing WTP in Svay Rieng is shown in Figure 2-2-27 , the photographs are shown in Figure 2-2-28 and Figure 2-2-29, and the facility summary is shown in Table 2-2-24 and Table 2-2-25. The existing WTP in Svay Rieng City was constructed with ADB funds for the Provincial Towns Improvement Project (2000 - 2006) which covered Battambang, Pursat, Kampong Cham, Kampong Thom, Svay Rieng, and Kampot provinces. The WTP started operation in 2007 with an initial capacity of 4,800 m^3/d. Thereafter, the WTP were rehabilitated through a follow-up project supported by ADB, and the work was completed in September 2019.

The existing WTP has a treatment capacity of 4,800 m^3/day for the filter, but due to the limited capacity of the intake pumps (95 m^3/hour x 2 units in operation), the actual water treatment volume is 4,560 m^3/day. In regard to operation and maintenance, there have been no long-term water outages, and no complaints or serious water quality incidents have been observed. The iron and manganese concentration of treated water exceeds the Cambodian drinking water standard values, which had become concerning. In April 2020, a new membrane filtration system with capacity of 2,000 m^3/day taking water from the Vay Kor River went into operation, since which time the treated water quality has been improving.

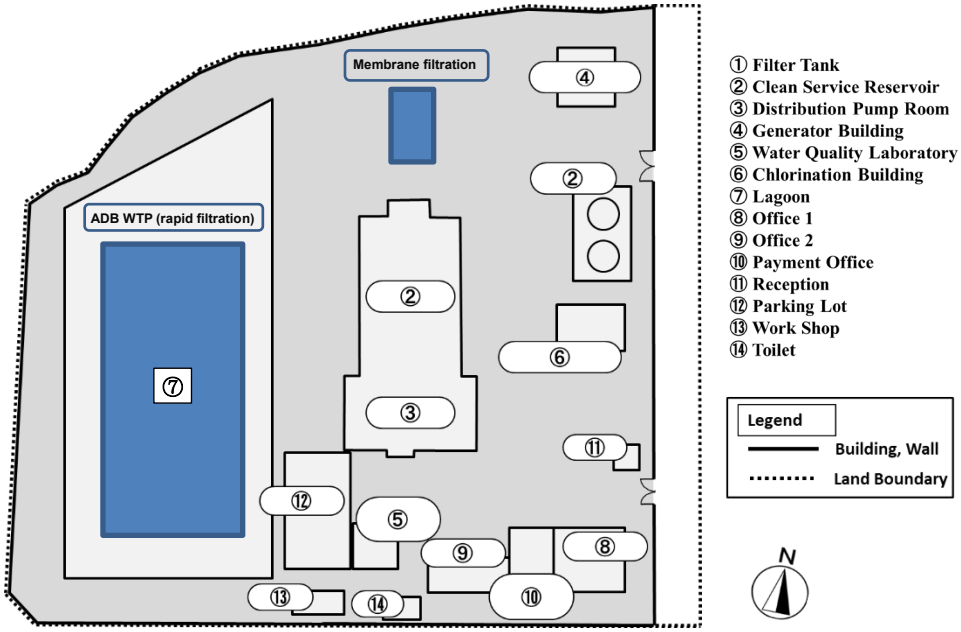
This membrane filtration facility was constructed by a Chinese company in July 2019 when a water supply contract was signed between a Chinese private company and MIH (present MISTI) to meet the increasing water demand in Svay Rieng. The operation started in April 2020, and the operation of this facility increased the treatment capacity of the existing WTP from 4,560 m^3/day to 6,560 m^3/day. The contract type is a 20-year BOT (Build Operate Transfer) contract, and normal operation is performed by the operation staff of the water treatment section of the SWWs, but if there is a problem with the facility, the Chinese company will handle it. The SWWs pays Chinese company the cost of purchasing water on a monthly basis.

The treated water is flowing into the existing reservoir, increasing the supply water volume in the existing distribution facility. The membrane module section, however, could not be observed as it was sealed. Concentrated water is regularly discharged into the Vay Kor River. ADB is currently constructing a rapid sedimentation and filtration facility with capacity of 9,000 m^3/day and a distribution facility in the lagoon area which will take water from the Vay Kor River. With these facilities, a water supply service is scheduled to start in autumn 2022.



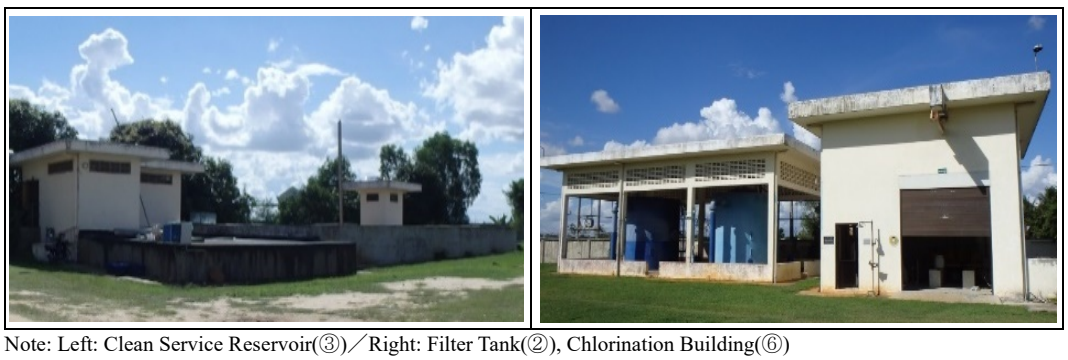
Source: Survey Team

Figure 2-2-26 Schematic of Existing WTP Syatem



Source: Survey Team

Figure 2-2-27 Layout Map of the Facilities at the Existing WTP



Note: Left: Clean Service Reservoir(③)／Right: Filter Tank(②), Chlorination Building(⑥)
(Facility corresponding to each ID is presented in Figure 2-2-26)
Source: Survey Team

Figure 2-2-28 Existing WTP (gravity rapid sand filter)

Note: Left: Intake Facility／Center & Right: Membrane Filter
Source: Survey Team

Figure 2-2-29 Existing WTP (membrane filter)

Table 2-2-24 Summary of Facilities at the Existing WTP (Rapid Filtration)

No.	Item	Facility Outline	Contents
1	Filter Tank	Gravity Type Steel Filter Tank × 2 units Installed on a concrete foundation above ground. (with roof) Filtration Capacity: 100m^3/h × 2 units = 200m^3/h Wash method: Backwash Wash pump: 9.0m^3/min × 2 units (Installed in the water distribution pump room)	• No significant deterioration or water leakage was observed in the tank. • The backwash is manually operated every 5 to 6 hours.
2	Clean Service Reservoir	Reinforced Concrete Construction 2 Basins Total 1,275m^3 (Effective Depth Approx.5m, Nominal 1,000m^3)	• No significant deterioration or water leakage was observed in the structure. • The water level gauge that was used at the beginning of operation in 2007 has been damaged, but a float-type water level gauge has been installed to control the water level.
3	Distribution Pump Room	Reinforced Concrete Construction 1 story & 1 basement story Distribution Pump 75.7m^3/h × 3 units	• The flow meter was installed from the beginning of operation, but is now damaged. • The water distribution pump room is an integrated structure with the clear water reservoir. • The backwash pump and the pressurized water pump for chlorination are also installed in the water distribution pump room.
4	Generator Building	Reinforced Concrete Construction 1 story Generator 2 units	• The generation facilities are operated and maintained in good condition.
5	Water Quality Laboratory	Reinforced Concrete Construction 1 story	• Water quality testing equipment was provided and updated by ADB in 2018. Those is properly managed and covers the water testing items of the WTP.
6	Chlorination Building	Reinforced Concrete Construction Pressurized Water Pump for Chlorination 2 units (Installed in the water distribution pump room)	• No significant deterioration or water leakage was observed in the structure. • At the time of construction (2007), chlorine gas was used, but the equipment was damaged in 2015 and is no longer in use. • Calcium hypochlorite (bleaching powder) was dissolved in a PE tank installed in the chlorination building with its own funds since 2015, and chlorination has been performed. The chlorination facilities were upgraded by ADB in September 2019.
7	Lagoon	Area：Approx.1600 m^2 Depth：Approx.1 m	• Sedimentation basin, filtration basin, and distribution reservoir with processing capacity of 9,000 m^3 / day are under construction by ADB.
8	O&M conditions	• Number of maintenance staff: 5 people are engaged in O&M. • No serious maintenance problems such as prolonged water shutdown or water quality accidents were observed. However, the iron ion concentration sometimes exceeded the standard value.	

Source: Survey Team

Table 2-2-25 Summary of Facilities at the Existing WTP (Membrane Filtration)

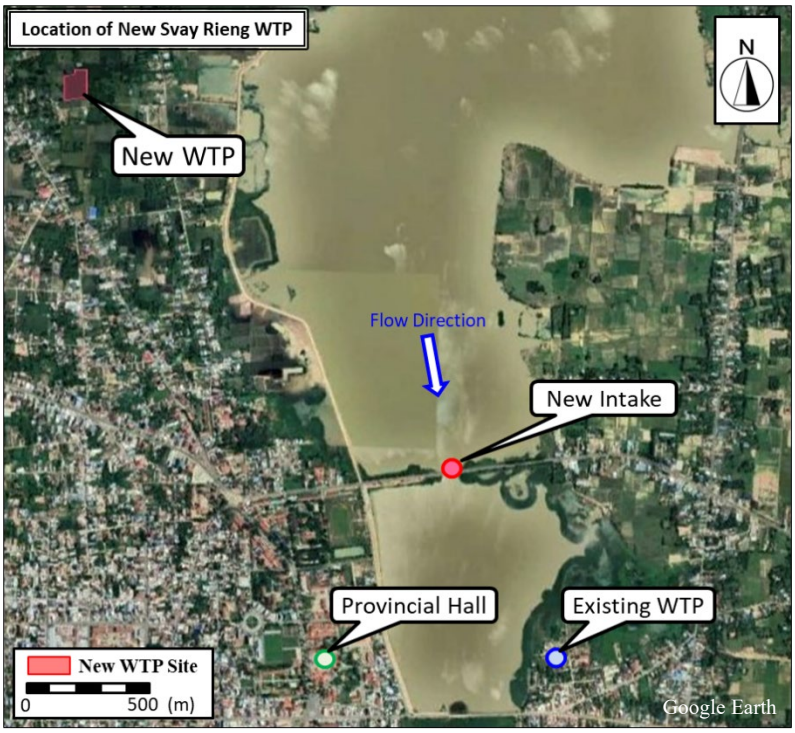
No.	Items	Facility Outline	Contents
1	Intake Facility	Pontoon (float type): 1 barge Intake capacity: >2,000m^3/day Two intake pumps	• Since the upper part of the pump has no roof, a blue tarp is used. • The pump specifications are unknown. Maintenance is carried out by the maintenance staff moving to the pontoon by boat.
2	Conveyance Pipe	Polyethylene pipe (diameter: 250 mm)	• Above-ground piping
3	Membrane Filtration Facility	Loaded in the container box. First story: - Control panel - Membrane filtration tank - Backwash pump (for membrane cleaning) - Blower (for membrane cleaning) - Compressor (for air valve operation) - Chemical tank (calcium hypochlorite injected when sterilizing treated water and cleaning membrane) Second story: - Main membrane filtration system (unconfirmed)	• The membrane module part could not be observed as it was sealed.
4	Drain Pit	Primary tank for concentrated (wash) water from the membrane filtration facility.	• The discharging cycle could not be confirmed but the discharging time was around 30 minutes.
5	Power	Power is installed from the WWs.	• Electric rate is also incurred by the WWs.
6	Purchasing Water from the Chinese Company	An electromagnetic flow meter is used to measure the volume of treated water, after which water is flowing into the existing reservoir.	• Contract period: A monthly-paid contract for 20 years.
7	Operation and Maintenance Status	(Monitoring / Operation and Maintenance System, Response to Abnormal Situations) • The intake facility is usually monitored in Phnom Penh via a mobile phone connection. When an abnormality is detected, the WWs are called and requested to handle the situation. When a serious abnormality occurs, the person in charge visits Svay Rieng to respond. • Those staff left the WWs earlier and were hired by the abovementioned Chinese private company to respond to any anomalies. In August 2021, the filtration volume decreased by 10% (60,000m^3 to 54,000m^3/month), which was addressed via the abovementioned approach. This event was considered attributable to the intake facility having to handle high-turbidity raw water since August at the beginning of the rainy season. (Water Quality) • Water quality analysis is carried out by the operation and maintenance section and the water quality test section of the WTP Division of SWWs. • Currently, the outlet turbidity of the membrane filtration unit is 0.008NTU which shows a good level.	

Source: Survey Team

(2) Proposed Site for the New WTP

The planned site for the new WTP was chosen from a list provided by the Cambodian side in which checked the ease of site acquisition and positional relationship between the new intake site and the water distribution area. The site (rectangular; about 1.0ha) is shown in Figure 2-2-30. The site is

currently a forest of small trees, and the area around the site is flat but adjacent to waterways and swamps. The land for the construction of the new WTP was purchased by the Cambodian side (SWWs) after the on-site survey in 2017. The land is unused; therefore, no resettlement is required.



Source: Study Team

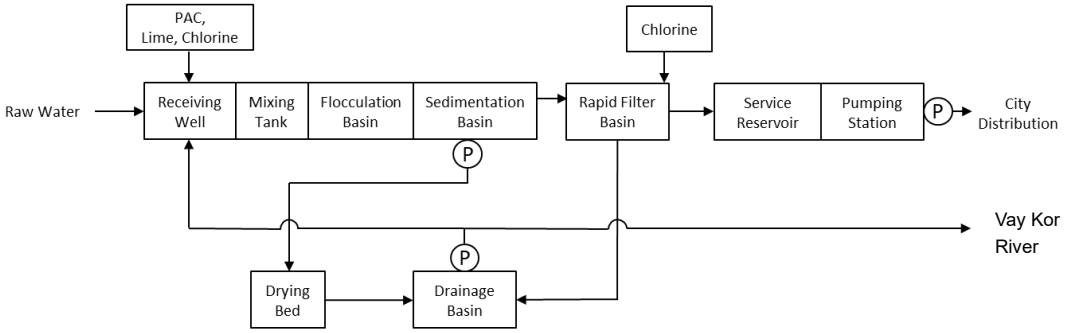
Figure 2-2-30 Location map of the planned site of the new WTP

(3) Treatment Process

The treatment process is designed to achieve high treatment and energy efficiency, and ease of operation and maintenance as well, so that the integrated operation components of the treatment process, such as sedimentation, filtration and disinfection, will be efficient and effective.

The key factors to consider for designing the treatment process shall be the quality of the raw water, the target 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 Phum Prek plant in Phnom Penh and other plants in Cambodia, is deemed the most appropriate. The chemical feeding system uses PAC for coagulant, lime for pH and alkalinity adjustment and chlorine powder for disinfection.

PAC is widely used in other WTPs in Cambodia. Lime is rarely used nowadays, but its purpose is to replenish the alkalinity consumed during high coagulant injection in response to high turbidity. Chlorine powder (Calcium hypochlorite) is a less hazardous chemical used by the SWWs as an alternative to disinfection with chlorine gas. As for the process, two-stage chlorine injection is planned to cope with high concentrations of iron/manganese, ammonia and organic matter in raw water. Figure 2-2-31 shows the flow chart of the treatment process.



Source: Survey Team

Figure 2-2-31 Water Treatment Process Flow

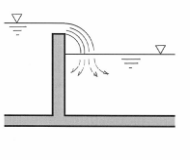
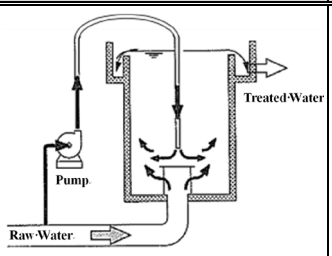
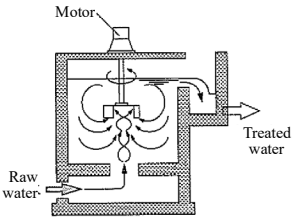
(4) Study on Water Treatment System

1) Selection of Mixing Well

The role of the mixing well is to allow a quick and uniform mix of the agents added into the raw water to form micro flocs. Based on the energy requirements, the mixing methods can be divided into two types: (1) one type utilizes the energy of the flowing water (e.g., weir method); and (2) the other type utilizes external mechanical energy (e.g., pump mixing or mechanical mixing). After due consideration, the weir method, which is widely used at other plants in Cambodia, is adopted because of the minimum operation and maintenance requirements, and less construction cost.

Table 2-2-26 shows the comparison of mixing methods.

Table 2-2-26 Comparison of Mixing Methods

Item	Method that utilizes the energy of the flowing water		Method that utilizes external mechanical energy			
	Weir Method		Pump Mixing Method		Mechanical Mixing Method	
Structure						
Mixing Effect	Large effect due to large water falling	◎	Flexible due to change of water circulation volume	◎	Flexible due to change of impeller rotation	◎
Effect of Flow Rate Change	Intensity of mixing will change	○	Intensity of mixing will slightly change	○	Intensity of mixing will be constant	◎
O&M Cost	Easy due to no mechanical parts required and less costly	◎	Needs operation and maintenance of mechanical parts.	△	Needs operation and maintenance of mechanical parts.	△
Area	Small	◎	Large (Need Pump Room)	△	Small	◎
Construction Cost *1	0.1	◎	1.6	△	1.0	○
Overall	◎*2		△		○	

*1 The Comparative values assuming mechanical mixing method which has been widely used in Japan, as 1.0.
*2 ◎: Excellent, ○: Good, △: Fair
Source: Survey Team

2) Selection of Flocculation Basin

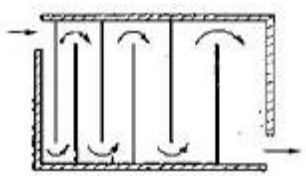
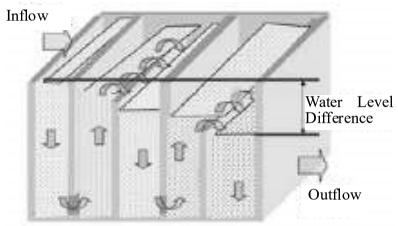
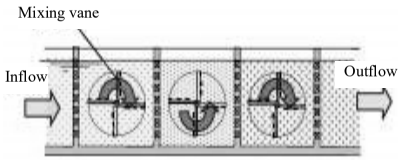
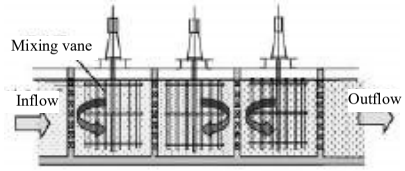
The role of a flocculation basin is to gently stir the micro flocs generated in the mixing well, allowing them to grow large for efficient settling and separation in the latter sedimentation process. The flocculation methods are mainly divided into two methods: methods that utilize the energy of the flowing water (zigzag flow method, up-and-down roundabout method), and methods that utilize external mechanical energy (e.g., horizontal shaft turbine method, vertical shaft turbine method). After due consideration, a combination of up-and-down roundabout method using zigzag flow, which is used in other plants in Cambodia, is adopted, because of the absence of mechanical drive resulting in minimum operation and maintenance requirement, and less construction cost. Table 2-2-27 shows the comparison of flocculation methods.

3) Selection of Sedimentation Basin

The role of a sedimentation basin is to settle and separate large flocs formed in the flocculation basin by gravity sedimentation. Sedimentation basins are mainly divided into horizontal flow type, horizontal flow with inclined plate type, upward flow with tube settler type, and suspended solid contact type.

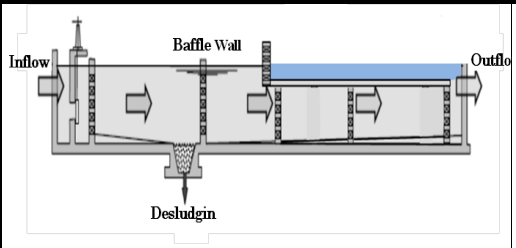
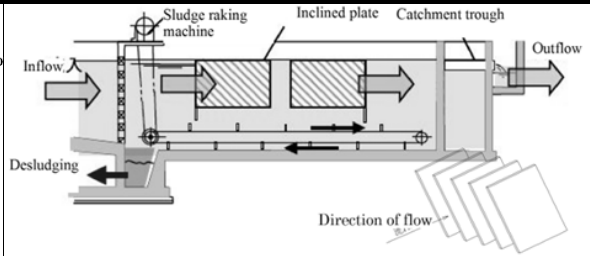
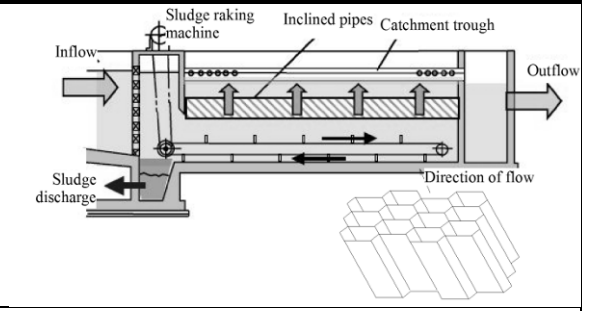
Suspended solid contact type is, however, excluded from consideration since it requires high-level operational technique and has not been constructed in Cambodian WTPs since the 2000s. Table 2-2-28 shows the comparison of type of sedimentation basins. Horizontal flow with inclined plate type and upward flow with tube settler type is superior to horizontal flow type in terms of turbidity fluctuation of the raw water. Since construction land is not restricted for this project, placing priority on the construction cost, horizontal flow type (intermediate flow uniform wall type), which is also applied in other plants in Cambodia, is preferred.

Table 2-2-27 Comparison of Flocculation Methods

Item	Method that Utilizes the Energy of Water Flow Itself				Method that Utilizes Mechanical Energy			
	Zigzag Flow Method		Up-and-Down Roundabout Method using Zigzag Flow		Horizontal Shaft Turbine Method		Vertical Shaft Turbine Method	
Structure								
Mixing Effect	Appropriate level difference is necessary to obtain sufficient mixing effect.	○	Appropriate level difference is necessary to obtain sufficient mixing effect.	○	Ideal mixing and floc formation can be performed by changing the revolution speed at each stage.	◎	Ideal mixing and floc formation can be performed by changing the revolution speed at each stage.	◎
Effect of Flow Rate Change	Intensity of mixing (G value*2) fluctuates	△	Intensity of mixing (G value) fluctuates (The intensity of mixing is higher than that of the horizontal flow of the same area.)	○	Intensity of mixing (G value) is constant and is not affected.	◎	Intensity of mixing (G value) is constant and is not affected	◎
O&M Cost	Easy due to an absence of mechanical parts and less cost	◎	Easy due to absence of mechanical parts and less cost	◎	Needs operation and maintenance of mechanical parts. Durability is somewhat inferior due to submerged drive part.	△	Needs operation and maintenance of mechanical parts. Durability is somewhat superior since drive part is not submerged.	○
Required Area	Large	△	Medium	○	Small	◎	Small	◎
Construction Cost *1	0.2	◎	0.2	◎	1.0	△	0.6	○
Overall	○*3		◎		△		○	

*1 Comparative values assuming horizontal-shaft turbine mixing method which has been widely used in Japan, as 1.0.
*2 G value: It is a stirring gradient and indicates an index of stirring strength.
*3 ◎: Excellent, ○: Good, △: Fair
Source: Survey Team

Table 2-2-28 Comparison of Sedimentation Basin Type

Item	Horizontal Flow (Intermediate Flow Uniform Wall Type)		Horizontal Flow with Sedimentation Effect Enhancement			
			Horizontal Flow with Inclined Plate		Upward Flow with Tube Settler	
Structure						
Retention Time	3-5 hours		Approximately 1 hour		Approximately 1 hour	
Surface Loading	15-30 mm/min		4-9 mm/min		7-14 mm/min	
Velocity	Less than 0.4 m/min		Less than 0.6 m/min		Less than 0.08 m/min	
Basin Depth	3-4m		4-5m		4-5m	
Area	Large (100%)	△	Small (30-40%)	◎	Medium (50-70 %)	○
Turbidity of Settled Water	Low due to intermediate flow guiding wall, however, sometimes not low due to short-circuit and/or density flows	△	Low due to uniform flow	◎	Low due to uniform flow	◎
Flexibility to variation	Not good for variation in raw water turbidity. Not good for variation in raw water temperature. Good for variation in raw water flow rate.	△	Good for variation in raw water turbidity. Good for variation in raw water temperature. Good for variation in raw water flow rate	◎	Good for variation in raw water turbidity. Good for variation in raw water temperature. Good for variation in raw water flow rate	◎
O&M Cost	Continuous monitoring is required because density flow and short-circuit flow may occur often. Cleaning is easy.	◎	Periodical cleaning is required to remove settled sludge on the plates. Removal of plates is required during cleaning.	△	Periodical cleaning is required to remove settled sludge on the tubes. Cleaning is not difficult.	○
Construction Cost *1	1.0	◎	2.5	△	2.0	○
Overall	◎*2		○		○	

Design Criteria: The Japanese Design Criteria for Water Supply Facilities

*1 Comparative values assuming conventional horizontal flow basin as 1.0. As for this project, the Survey Team decided to prioritize construction cost because there are no particular restrictions on the construction site.

*2 ◎: Excellent, ○: Good, △: Fair

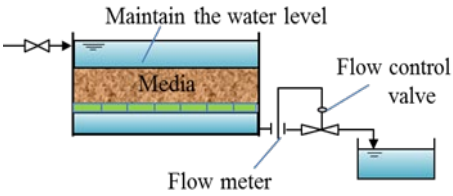
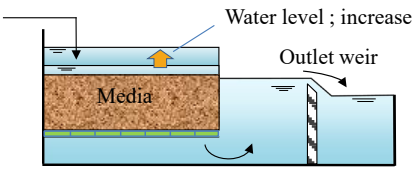
Source: Survey Team

4) Selection of Filter Basin

After converting the suspended matters into flocs by coagulation and flocculation, rapid sand filter basin mainly removes turbidity by adherence to filter media and sieving with filter layer, while water passes through the granular layer at a relatively high flow rate.

The flow rate control methods are divided into three (3) methods: the flow control method, the water level control method and the self-balancing method. Table 2-2-29 shows a comparison between the flow control method and the self-balancing method that are applied in Cambodia. This project places particular emphasis on ease of maintenance including construction costs, control stability, and pump / valve renewal costs. In addition, self-balancing method will be adopted so that the skills and experience of the staff of existing facilities constructed in other grant aid projects etc. can be utilized more easily.

Table 2-2-29 Comparison of Control Methods of Filtration Flow

Item	Flow Control Method	Self-Balancing Method
Structure		
Flow Control Method	Constant control of filtered water volume (Filtration basin outflow side)	Since there is no flow control mechanism, the inflow water is evenly distributed to each basin at the inflow, then the amount of inflow water and the amount of outflow water naturally equilibrate.
Related Equipment	Flow meter, electric adjustment valve and automatic control circuit (Increase the number of equipment)	The surface water level in the basins rises in response to the increase of water head loss.
Concrete Structure	Concrete structure is approximately 1-2m lower than self-balancing method.	Concrete structure is approximately 1-2m higher than flow control method.
O&M Cost	Maintenance cost is high due to flow meter, control valve, large motor valve and large pump. It is necessary to replace the flow meter / control valve after the useful life.	Maintenance cost is low due to no flow meter, control valve, large motor valve and large pump.
Construction Cost *1	Civil Engineering Cost: 1.0 Mechanical Engineering Cost: 1.0 (Flow Meter, Control Valve) Electric Instrument Cost: 1.0 (Flow Control Circuit)	Civil Engineering Cost: 1.1 Mechanical Engineering Cost: 0.05 (Inlet Weir, Outlet Weir) Electric Instrument Cost: 0 (None)
Overall	○*2	◎

*1 Comparative values assuming flow control method as 1.0.
*2 ◎: Excellent, ○: Good, △: Fair
Source: Survey Team

Self-Balancing method is divided into three (3) methods, namely; siphon type, valve and gate, and a combination of siphon and valve and gate type, for controlling processes such as inflow, outflow, washing, and washing drainage, etc. Since these are technically established and proven methods, the Survey Team does not specify a particular method for this study. Instead, it will leave the bidders propose the method during the bidding process.

In addition, there are three (3) types of feeding system into the filtration basin, namely; from other basin(s), using a backwash pump, and from a supply tank. The Survey Team decided to avoid feeding using backwash pump, which incurs large operation and maintenance costs, and not to specify a particular method, but left the bidders propose between the remaining two methods. Furthermore, the backwash tank type is divided into an internal and an external type. The Survey Team did not also specify a particular method for this study. Instead, it left the bidders propose during the bidding process.

The filtration basins shown in Appendix 7-2, "Outline Design Drawings", in this report are reference drawings only. The process control of these basins is a combination type, i.e., both siphon and valve and gate type; whereas the feeding system is a backwash type that has an internal tank within the filtration area.

However, bidders may propose a different shape and type of filtration basins as long as they satisfy the "Prerequisite of filtration basin" and the "Basic specification of filtration basins" shown in Table 2-2-30 and Table 2-2-31.

Table 2-2-30 shows the design preconditions of the filtration basin.

Table 2-2-30 Design Preconditions of the Filtration Basin

No.	Contents
1.	Raw Water: Surface Water of the Vay Kor River
2.	Design Water Treatment Output: 7,480 m^3/day
3.	Outline of intake facility, the construction site for the intake facility, route for laying the water conveying pipe, the construction site for the WTP: Refer to the outline design drawings (Drawing number G1, SI-1 to SI-6, SR-1 to SR-4)
4.	Shape and dimensions of the construction site of the WTP: Refer to the design drawing (Drawing number ST-1)
5.	Construction plan of WTP facilities other than filtration basin: Refer to the schematic design drawing (Drawing numbers ST-1 to ST-16)
6.	Hydraulic Profile of the WTP located upstream of the filtration basin: Refer to the schematic design drawing (Drawing number ST-2)
7.	Transmission/distribution system from the WTP: Water supply to customers by the water distribution pump direct delivery system

Source: Survey Team

Table 2-2-31 shows the basic specifications of the filtration basin based on the following concept.

i. Since it is not a bidding for the performance guarantee method, the contents of the basic specification are to be relatively conservative, with top priority for minimizing risks of O&M.

ii. Since the bid evaluation is basically based on the bid price (construction cost of the facility), the method, whose O&M cost (i.e., the backwash pump method on filtration basins) is expected to be relatively large and shall be excluded from the options in advance.

iii. The contents of the basic specifications shall be in accordance with the contents of "Waterworks Facility Design Guidelines 2012 (Japan Waterworks Association)" as much

as possible, in order to provide all bidders a fair bidding condition. Also, the specifications of previous grant aid projects in Cambodia so far are to be referred.

Table 2-2-31 Specifications of the Filtration Basin

No.	Contents
1.	Filtration basin is the final process facility of clarification in the treatment process and removes suspended matters which could not be removed by the coagulation sedimentation process at the preceding stage. It shall also have a function to keep the turbidity of the filtered water stably below the Cambodia Drinking Water Quality Standard.
2.	The filtration basins shown in the outline design drawings (Drawing numbers ST-2 to ST-5, ST-10, ST-11) are reference figures only, and as long as the bidders satisfy the above planning prerequisite and the basic specifications specified below, they may propose filtration basins of shape and type different from that of the filtration basin shown in the outline design drawings.
3.	When proposing filtration basins of shape and type different from the filtration basin shown in the outline design drawings, the bidder shall prepare the detailed design book of the proposed filtration basin (specifications of filter basin and structure diagram, equipment list, etc.) at their own expense and submit it at the time of bidding.
4.	When proposing filtration basins with shape and type different from the outline design drawings, the bidder shall propose the extraction position of the washing drain pipe and the filtration water pipe from the filtration basins, the pipe diameter and the laying route of the pipe.
5.	Regarding the interpretation of items not specifically defined below and the technical terms used below, the bidders shall comply with the interpretation of technical guidelines and technical terms specified by "The Design Criteria for Water Supply Facilities 2012 (Japan Water Works Association)".
6.	The filtration basins shall be a single-story type, gravity type, downward flow and rectangular in shape.
7.	The control method of filtration flow rate shall be a self-balancing method with constant flow rate filtration.
8.	The standard filtration rate shall be from 120 m/d to 150 m/d.
9.	The maximum head loss shall be 1.5 meters or more and 2.0 meters or less.
10.	The inlet and outlet flow shall be cascade type.
11.	A weir shall be installed on the cascade on the outlet flow side at a level higher than the sand surface.
12.	A weir shall be installed on the cascade on the inlet flow side to make it possible to uniformly distribute inflow water to each filtration basin during operation and ensure that the cascade can be retained even in the situation where the head loss is approaching the plan maximum value.
13.	The cleaning method is "backwash by water flow + air wash" that allows simultaneous cleaning and combined use of water and air.
14.	The depths of gravel layer and sand layer should be 80 – 100 cm, the effective sand grain diameter should be 0.8 ～1.0 mm, and the uniformity coefficient should be 1.6 or less.
15.	The backwash water shall be either filtered water from other filtration basins in operation or supplied water from a backwash storage tank.
16.	When adopting a backwash storage tank, the bidder shall propose the installation place and the way to obtain the washing water.
17.	Backwash water shall be either treated water or treated water with residual chlorine.
18.	Wastewater discharging mechanism shall be installed immediately after the washing.
19.	The underdrain system shall either be a perforated block or a strainer type.
20.	Process control of inlet flow, outlet flow, washing, washing discharge, etc., shall be conducted by siphon or a valve.
21.	When controlling process such as inlet flow, outlet flow, washing, washing discharge, etc., is carried out by a valve, it shall be equipped with an electric opening/closing machine, which can be opened and closed manually at the time of a power outage or failure of the opening and closing machine.

No.	Contents
22.	When a controlling process such as inflow, outflow, washing, washing drainage, etc., is conducted by siphon, 2 pieces of air valves for creating vacuum, 2 pieces of air valves for breaking vacuum and 2 pieces of 3-way solenoid valves shall be provided as spare parts for each siphon, and the expenses shall be included in the bid price in advance.
23.	The washing operation shall be able to perform both manual washing on the local operation panel and automatic washing through sequence control.

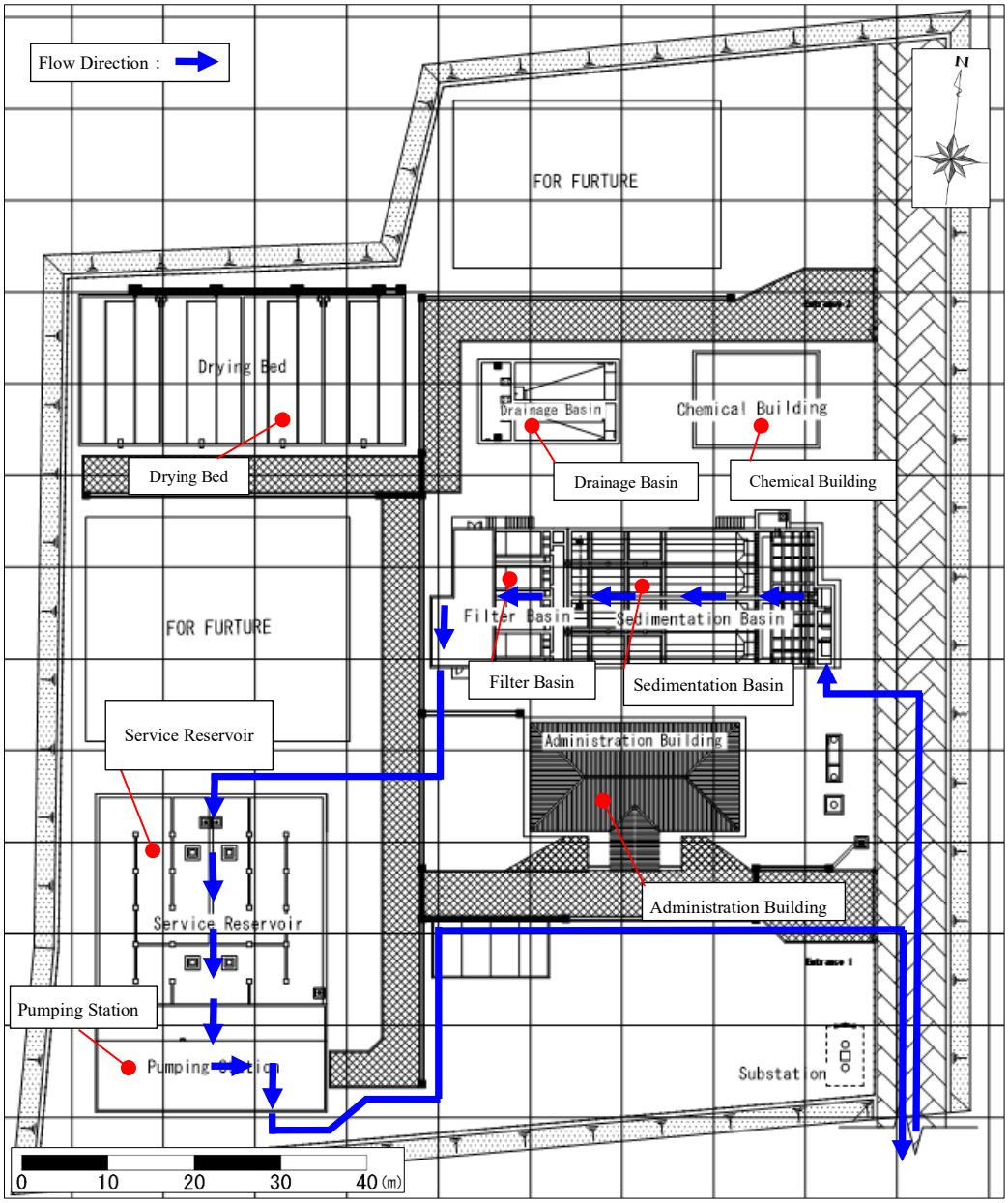
Source: Survey Team

(5) New WTP Layout

The new WTP shall be designed for a capacity of 7,480 m^3/day based on the site area and the land shape, and then the facility layout shall be proposed taking account of the following matters. The layout and the flow diagram of the proposed new water treatment facilities shall be as shown in Figure 2-2-32 and Figure 2-2-33, respectively.

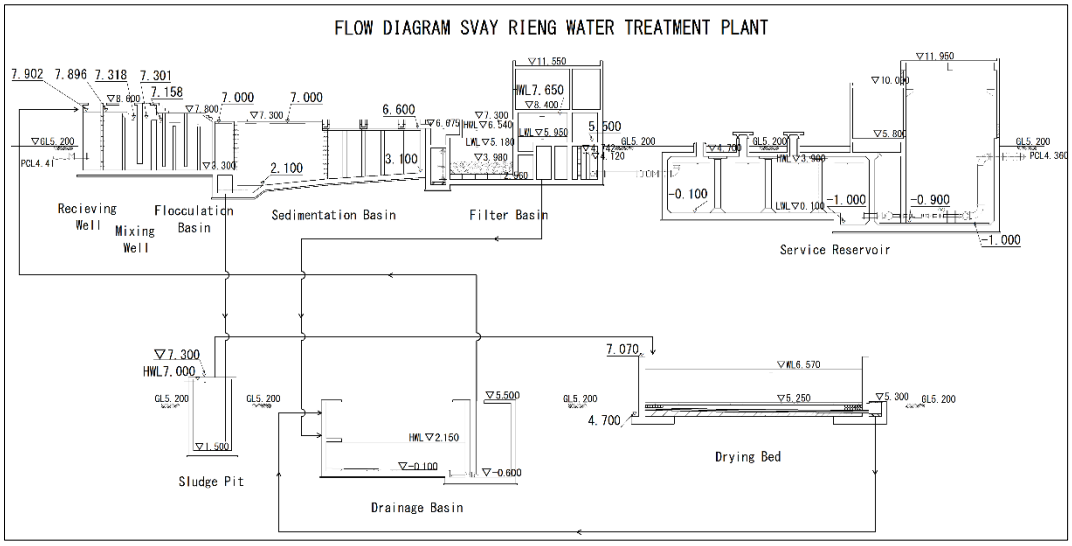
(Consideration Item)

- Facility layout considering the inflow direction of raw water, difference of water level between treatment processes (energy efficient), water supply direction, the location of the substation, accessibility, etc.
- Minimum land development area, and earthworks reduction
- Future facility extensibility



Source: Survey Team

Figure 2-2-32 New WTP Layout



Source: Survey Team

Figure 2-2-33 Hydraulic Profile of the New WTP

(6) Chemical Feeding Facilities

The chemical feeding facilities shall be installed at the 2nd floor of the chemical building, and the feeding method shall be the gravity flow method without using a pump. The chemicals are planned to be carried in from the ground floor to the 2nd floor using electric chain blocks.

1) Polyaluminum Chloride (PAC) Feeding Facility

Polyaluminum chloride (PAC) shall be used as a coagulant in consideration of its ease of procurement and storage management, ease of handling, and past use in Cambodia. Dissolution is to be done by manually feeding PAC into the solution tank, adding water, and using an agitator. The feeding volume is to be adjusted by using a constant water level tank.

2) Lime Feeding Facility

Lime is to be used as lime agent in consideration of its ease of procurement and storage management, ease of handling, and past use in Cambodia. Lime is to be weighed and supplied by a lime injector of the powder metering and supply type and mixed with water in a lime solution tank.

3) Calcium Hypochlorite Feeding Facility

Calcium hypochlorite is to be used as a chlorine agent in consideration of its ease of procurement and storage management, ease of handling, and past use in Cambodia. Dissolution is to be done by manually feeding calcium hypochlorite into the solution tank, adding water, and using an agitator. The feeding volume is to be adjusted by using a constant water level tank.

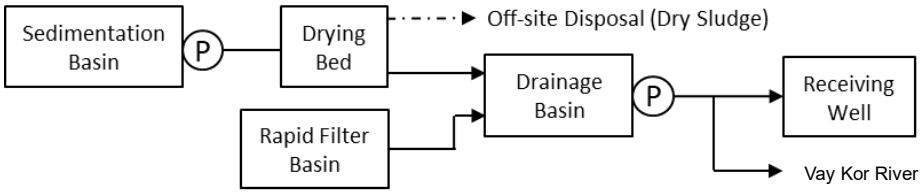
(7) Design for Other Water Treatment Facilities

1) Drainage Facilities

From the viewpoint of compliance with the effluent standards of Cambodia, the following three items shall be considered in the design.

- Sedimentation sludge is to be transferred to a drying bed to dry and then transported off-site as dewatered cake for disposal.
- The backwash water from the filtration basin is to be retained at the drainage basin and then returned to the receiving well by the return pumps.
- In case of emergencies or abnormalities of filtration process, wastewater from the WTP can be discharged to Vay Kor River by pump.

Figure 2-2-34 shows the drainage and sludge treatment process.



Source: Survey Team

Figure 2-2-34 Drainage and Sludge Treatment Process

- Sedimentation :

Since a large portion of sludge settles in the upstream part of the sedimentation basin, it is to be discharged from the sludge pit located in the upstream part of the sedimentation basin. During cleaning, sludge accumulated downstream is to be drained by using water taken from the receiving well and pumped to the sedimentation basin as cleaning water. The following considerations for periodic cleaning of sedimentation basins (every 6 to 12 months) in the plan is required.

- The intermediate drainage water can be returned to the receiving well via the drainage basin and can be reused as much as possible.
- The time required for intermediate drainage, sludge discharge, cleaning, and water filling shall be approximately one day if all intermediate drainage is to be reused, and a minimum of half a day if it is not to be reused.
- The other sedimentation basin, where normal water treatment is conducted, is secured 75% treatment capacity.

- Sludge Drying Bed :

Dry cakes are to be removed by manpower and disposed in an appropriate place outside the site. The area of the sludge drying bed shall be planned based on the raw water quality data and the performance of the past Japan's Grant Aid water supply projects in Cambodia. Average turbidity is 100 NTU, and sludge load is 25 kg-DS/m^2, referring to the Japanese Water Supply Facility Design Guidelines 2012.

- Drainage Basin :

The sludge accumulated at the bottom of the basin is to be periodically washed out of the drainage basin by pressurized water from the drainage basin's return pump side to the drainage side and returned to the receiving well.

The capacity of one drainage basin shall be based on the backwash water amount of one filtration basin and shall be planned by taking into account the water level profile, the discharge amount of the supernatant water of the sedimentation basin, and the return water amount by the return pumps. In addition, a drainage pipe from the new WTP to Vay Kor River shall be installed as an emergency measure for rainwater drainage and water quality accidents.

Figure 2-2-35 shows the drainage pipe route from the new WTP to the Vay Kor River.

Source：Google Earth, arranged by Survey Team

Figure 2-2-35 Drainage Pipe Route

2) Yard Piping / Landscaping

- Maintenance roads shall be constructed around the treatment facilities.
- Inter-connecting pipelines of appropriate diameters shall be installed in treatment facilities.
- Concrete block fence and entrance gate shall be installed for security.

(8) Electric and Instrumentation Facilities

1) Substation Facilities

New substation shall be installed in the new plant. The power source shall be drawn from the 22kV, 50 Hz power line of the nearby EDC, stepped down to 400V by the transformer, and then drawn into the power receiving board in the electric room of the pumping station.

2) Emergency Electric Power Generating Facilities

Since power outage occurs several times a month, an emergency generator with power generation capacity sufficient to operate water treatment facilities and distribution pumps shall be installed. The fuel tank shall be of the operation capacity for 10hours, in consideration of reduction in replenishment frequency. The generated power at 400V shall be drawn into the changeover board in the electric room of the pump station.

3) Electric Power Distribution Facilities

The 400V power supply drawn from the substation and the emergency generator equipment shall be supplied to various loads in the plant via the distribution pump board and the motor control center in the electric room in the pumping station.

4) Instrumentation Facilities

In order to operate the WTP properly, the following instrumentation facilities shall be installed in the WTP:

a) Flow Meter of Filtration : 1 set
b) Water Level Meter of Service Reservoir : 2 sets at each reservoir
c) Distribution Pressure Meter : 1 set
d) Distribution Flow Meter : 1 set

5) Central Monitoring Facilities

The operational status of the equipment of the water intake pumping station, various WTPs, and various measurement values shall be displayed on the graphic monitoring board installed in the monitoring room of the administration building, enabling supervision of the overall water treatment facilities. The graphic monitoring board can also be used to remotely control the intake pump and the distribution pump. Table 2-2-32 shows the monitoring and control items in the graphic monitoring panel.

Table 2-2-32 Monitoring and Control Items

Facility	Group	Item	Signal	Nos	Facility	Group	Item	Signal	Nos
Intake Pump Station	Monitoring	Intake Pump Fault	Contact	2	Water Treatment Plant	Monitoring	PAC SolutionTransfer Pump Suction Pit LLWL	Contact	1
		Pump Full Water	Contact	2			PAC Solution Tank HHWL	Contact	2
		Location of Operation WTP/IPS	Contact	2			PAC Solution Tank LLWL	Contact	2
		River LWL	Contact	2			Hypo Mixer Fault (grouping)	Contact	1
		Intake Pump Distribution Flowrate	Analog	1			Hypo Solution Transfer Pump ON/OFF	Contact	1
		Intake Pump ON/OFF	Contact	4			Hypo Solution Transfer Pump Fault	Contact	1
		Power Commercial/Emercency Generator	Contact	2			Hypo Solution Transfer Pump Suction Pit HHWL	Contact	1
	Control	Intake Flowrate Setting Value	Analog	1			Hypo Solution Transfer Pump Suction Pit LLWL	Contact	1
		Intake Pump ON/OFF	Contact	4			Hypo Solution Tank HHWL	Contact	2
Water Treatment Plant	Monitoring	Distribution Pump ON/OFF	Contact	3			Hypo Solution Tank LLWL	Contact	2
		Location of Operation Center/Local	Contact	2			Return Pump Fault	Contact	3
		Distribution Pump Stand-by	Contact	3			Return Pump ON/OFF	Contact	3
		Distribution Pump Fault	Contact	3			Drainage Basin HHWL	Contact	1
		Distribution Control Fault	Contact	1			Drainage Basin HHWL	Contact	1
		Distribution Pressure Fault	Contact	1			Filter Status Filtering	Contact	4
		Service Resorvoir HHWL	Contact	2			Filter Status Washing	Contact	4
		Service Resorvoir LLWL	Contact	2			Filter Status Stand-by	Contact	4
		DP Delivery Valve Open/Close	Contact	6			Filter Status Out of Service	Contact	4
		DP Delivery ValveFault	Contact	3			Filter Control Fault	Contact	1
		Supply Pump ON/OFF	Contact	2			Commercial Power	Contact	1
		Supply Pump Fault	Contact	2			Emergenc Generator	Contact	1
		Sump Pump	Contact	1			MCC Fault	Contact	5
		Sed. Basin Wash Pump ON/OFF	Contact	1			UPS Fault	Contact	1
		Sed. Basin Wash Pump Fault	Contact	1			Distribution Monitoring System Fault	Contact	1
		Sed. Basin Sludge Transfer Pump ON/OFF	Contact	3			Distribution Flow Rate	Analog	1
		Sed. Basin Sludge Transfer Pump Fault	Contact	3			Distribution Integrated Flow	Pulse	1
		Sludge Pit LLWL	Contact	1			Distribution Pressure Fault	Analog	1
		Air Backwash Blower ON/OFF	Contact	2			Service Resorvoir WL	Analog	1
		Air Backwash Blower Fault	Contact	2			Filtered Water Flowrate	Analog	1
		Filter Auxiliary Panel Fault	Contact	1			Incomming Voltage,Current, Power,Power Factor	Analog	4
		PAC Solution Mixer Fault(grouping)	Contact	1			Incomming Wat Hour	Pulse	1
		PAC SolutionTransfer Pump ON/OFF	Contact	1		Control	Distribution Pump Auto Start	Contact	1
		PAC SolutionTransfer Pump Fault	Contact	1			Distribution Pump Auto Stop	Contact	1
		PAC SolutionTransfer Pump Suction Pit HHWL	Contact	1			Distribution Pressre Setter	Analog	1

Source: Survey Team

6) Remote Monitoring and Control System of Intake Pump Facilities

A remote monitoring and control system using telecommunication lines of telecommunication companies shall be installed in the WTP monitoring room to monitor the remote operation of the intake pumping station, operation status and pump distribution flow rate, etc. at the WTP monitoring room.

7) Distribution Monitoring System

The flow rate data of the water intake pump station, filtration flow rate, distribution flow rate and distribution pressure in the WTP, distribution water flow (four locations) and distribution pressure (four locations) at the local stations, and information on the flow of the existing WTP shall be imported into the personal computer of the monitoring system in the monitoring room of the administration building, enabling unified management of intake, treatment and distribution. As for the data collection at off-site roadside stations and the old WTP, the mobile network shall be used as in the existing system.

8) Summary of the WTP Plan

Table 2-2-33 shows the components of the necessary facilities and instruments discussed in the new WTP plan.

Table 2-2-33 Specifications of the New WTP

Items	New Svay Rieng WTP Design Water Treatment Capacity: 7,480m^3/day, Design Maximum Daily Demand: 6,800m^3/day	
	Contents	Qty
Receiving Well	Reinforced Concrete Structure Internal Dimensions: Width 1.50m × Length 3.90m × Depth 4.60m Volume (V): 26.9 m^3, Retention Time (T): 5.2min (Criteria: T ≧1.5min)	1 basin
Mixing Well	Reinforced Concrete Structure The method to utilize the energy of water flow itself Internal Dimensions: Width 1.50m × Length 1.50m × Depth 4.19m Volume (V): 9.43 m^3, Retention Time (T): 1.82min (Criteria: 1＜T＜5min)	1 basin
Flocculation Basin	Reinforced Concrete Structure Slow Mixing Method: Up-and-Down Roundabout Type (zigzag flow) Number of Stages: five (5) stages Internal Dimensions per Basin: G Value: 10 – 75 (1/s) GT Value: 23,000 – 210,000 Width 7.00 m × Length 3.65 m× Average Effective Water Depth3.78m (Height 4.50m)	2 basins
Sedimentation Basin	Reinforced Concrete Structure Horizontal Flow Sedimentation Type Supernatant Water Collecting System: Collecting Trough + Submerged Orifice Internal Dimensions per Basin: Width 7.00m × Length 20.00m × Average Water Depth 4.4m Surface Loading: Q/A=18.6mm/min (Criteria:15-30mm/min) Mean Velocity (V): 0.08m/min (Criteria: 0.40m/min or below)	2 basins

Items	New Svay Rieng WTP Design Water Treatment Capacity: 7,480m^3/day, Design Maximum Daily Demand: 6,800m^3/day	
	Contents	Qty
Rapid Sand Filter (Reference) *	Reinforced Concrete Structure Type: Self-Balancing Type Internal Dimensions per Basin: Width 2.50m × Length 6.00m Filter Sand Thickness: 1.0m Underdrain System: Perforated Block Filtration Rate (V): 124.7m/day (Criteria: 120-150m/day) Backwash Method: Air Wash + Water Wash	4 basins
Service Reservoir	Reinforced Concrete Structure using Flat Slab Structure Effective Volume per Basin (V): 2,188m^3 (1,094m^3 × 2Basins) Effective Water Depth (H): 3.8m (Criteria:3-6m) Retention Time (T): 8hours (Set from daily-water demand fluctuation) Internal Dimension per Basin: Width 12.00m × Length 24.00m × Height 4.50m	2 basins
Drainage Basin	Reinforced Concrete Structure Volume (V): 198.0m^3(99.0m^3 × 2Basins) (Volume per Basin: More than one-time wastewater volume) Internal Dimension per Basin: Width4.00m × Length 11.00m × Effective Water Depth 2.25m (Height 5.60m)	2 basins
Drying Bed	Reinforced Concrete Structure Effective Area (A): 550.4m^2 (Area per bed: Width 8.6m × Length 16m＝137.6m^2) (Average Turbidity: After calculating the amount of generated sludge from the coagulant injection rate, the area from the planned sludge load is calculated.)	4 beds
Chemical Feeding Facilities (In Chemical Building)	Coagulant: PAC Injection Method: Gravity Flow from Constant Water Level Tank. Acid and Alkali Agents: Lime (for supplementing the alkali content consumed by the coagulant) Injection Method: Gravity Flow (The agents are quantified with a powder quantifier and dissolved by water flow.) Chlorine Agents: Calcium Hypochlorite (Bleached Powder) Injection Method: Gravity Flow from Constant Water Level Tank.	1 unit
Power Generator Equipment (In Chemical Building)	Capacity: Long Running Type 350KVA Type : Low Noise Cubicle Type	1 unit
Chemical Building	Reinforced Concrete Structure, 3-Storey Building, Total Floor Area (A): 425.8m^2 (Usage) Ground Floor: Workshop, Storage, Emergency Generator Room, Toilet Chemical Delivery Facility (1-3 Fl. Open Ceiling) 1st Floor: Waste Solution Reservoir, Chemical Injection Equipment 2nd Floor: Chemical Dissolving Tank Room	1 unit
Administration Building	Reinforced Concrete Structure, 1 Story Building, Total Floor Area (A): 266.7m^2 (Usage) Ground Floor: Office Room, Meeting Room, Monitoring Room, Laboratory, Toilet	1 unit

Note: * As stated in Section 2-2-2-5-(4)-4), since the specification and structure of rapid sand filter is based on bidder's proposal, the description on the above table is for reference.
Source: Survey Team

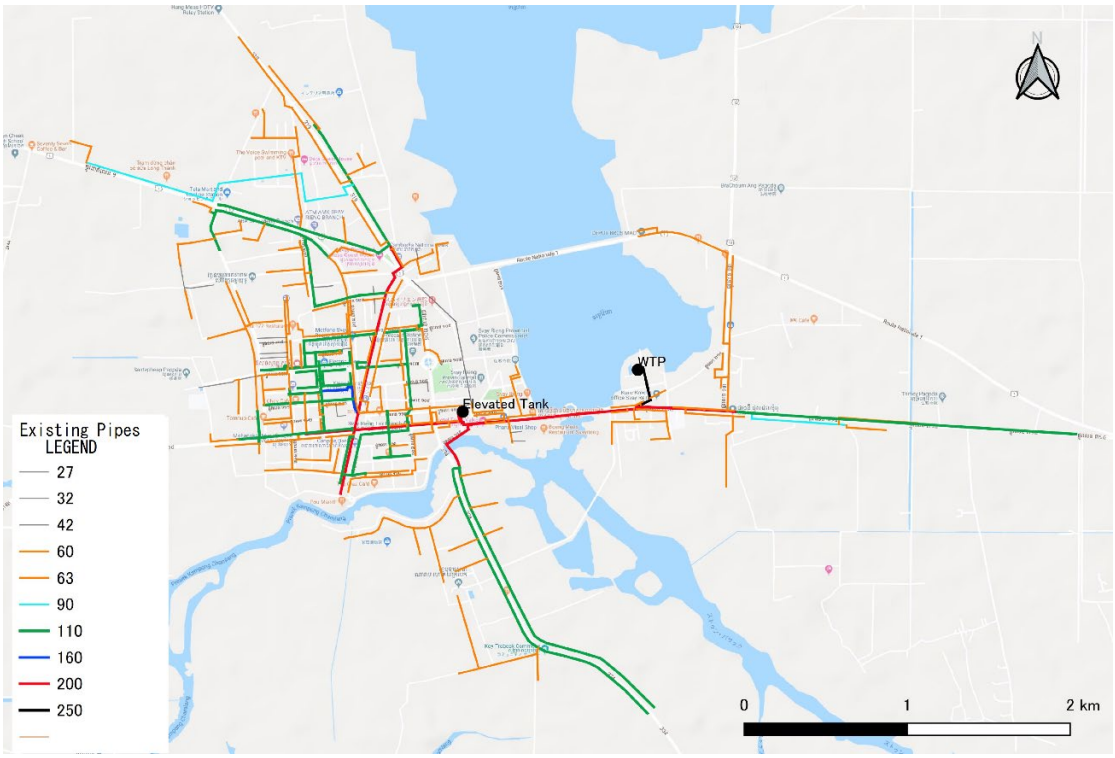
2-2-2-6 Distribution Facilities

(1) Existing Water Distribution System

Figure 2-2-36 shows the outline of the existing distribution system. At present, water is mainly distributed directly by the distribution pumps from the existing WTP, and only when the distribution pumps are stopped during power outages or at night when demand is low, water is distributed from the elevated water tank.

- Distribution pumps: 150 m^3/hour x 2 units, 340 m^3/hr x 1 unit (no reserve)
- Maximum daily supply: 4,560 m^3/day
- Distribution pipe network: DN φ50 mm to φ250 mm (DIP, HDPE), 24-hour water supply

The water pressure of the distribution pumps is monitored by humans 24 hours a day, and the number of pumps is controlled according to fluctuations in water demand to maintain a discharge pressure of about 0.50 MPa.



Source：Survey Team

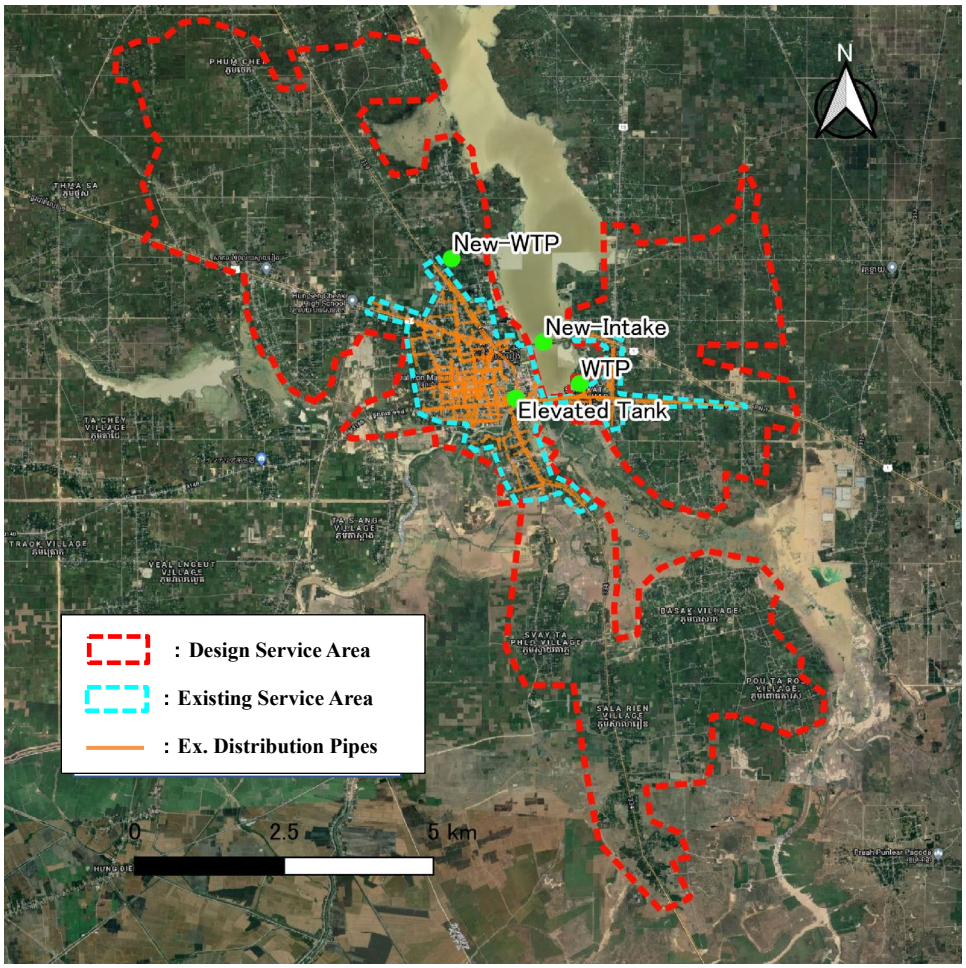
Figure 2-2-36 Outline of Existing Water Distribution System

(2) Basic Conditions for Designing of Proposed Distribution Facilities

1) Design Service Area

The design service area[11] excluding the existing service area shall be expanded and shall be the extended service area as shown in Figure 2-2-37.

[11] The design service area had been considered from the viewpoint of the Cambodian policy goal, the scale of the project, the sustainability of operation and maintenance, and it has been decided based on the discussions with MISTI.



Source: Survey Team

Figure 2-2-37 Design Service Area

2) Design Distribution Flow

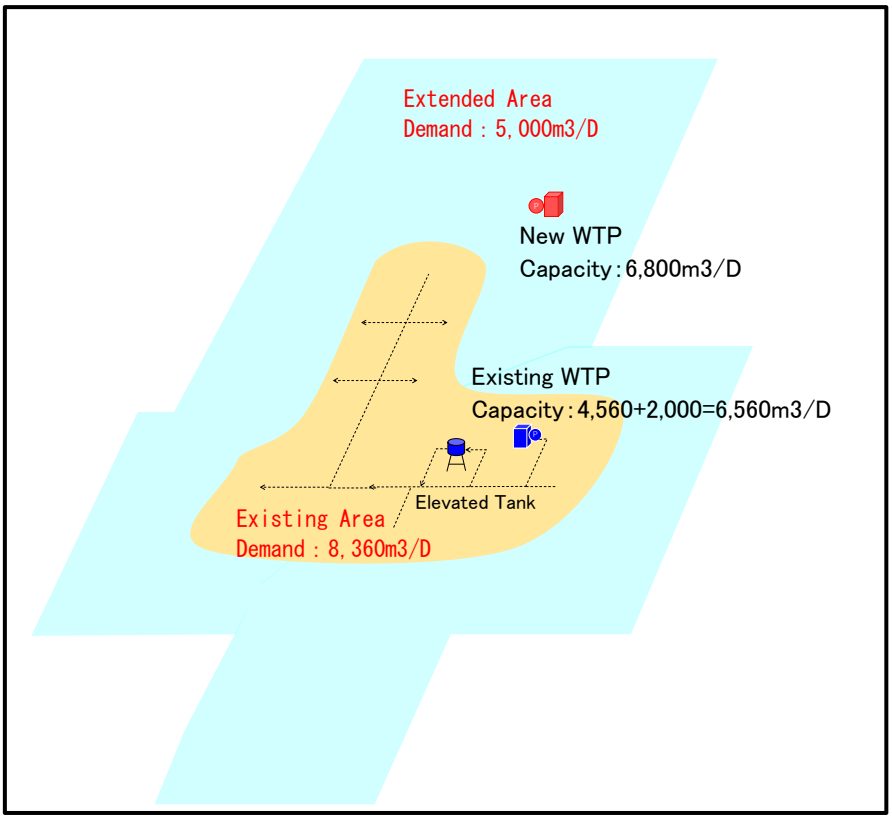
The design distribution flow shall be 368.3m^3/hr which is the design maximum hourly distribution flow in the design service area calculated from the design maximum daily supply of 6,800 m^3/day divided by 24hr and multiplied by the time coefficient of 1.3[12].

(3) Water Distribution System

1) Reorganization of Water Distribution Systems

Figure 2-2-38 shows the relation between the location and water demand in the existing and extended service areas. The existing service area shown in yellow is located in the center of the figure, and the extended service area shown in light blue surrounds the existing water supply area. The existing facility capacity is 6,560 m^3/day against the planned water demand of 8,360 m^3/day in the existing area, and the new facility capacity is 6,800m^3/day against the planned water supply of 5,000 m^3/day in the extended area, so that the facility capacity and the demand of target area do not match. Therefore, it is necessary to reorganize the distribution system in the existing area and the extended area.

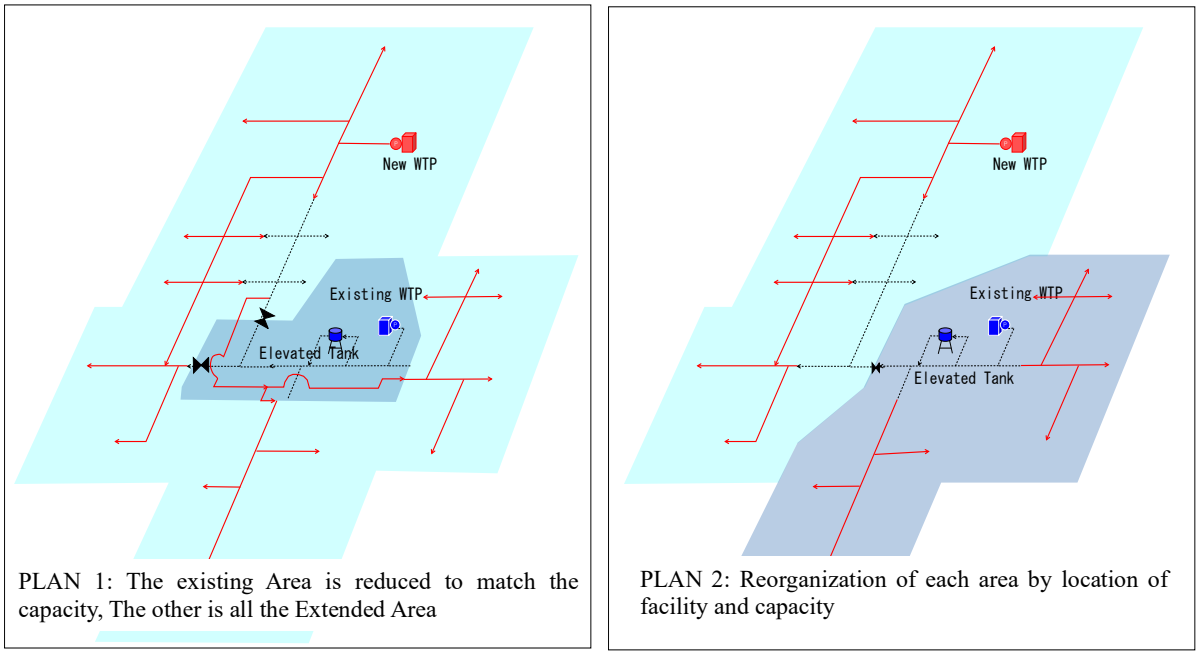
[12] Since the facility of Svay Rieng City is similar in scale and condition to that of Pursat City, which is being implemented as a similar project, the time coefficient will be set to 1.30 adopted to the facility of Pursat.



Source: Survey Team

Figure 2-2-38 Relation between Location and Demand in Existing and Extended Service Areas

Figure 2-2-39 shows two proposals for the reorganization of the distribution systems in the existing and extended areas. “PLAN 1” is to completely separate the existing system from the new system, and “PLAN 2” is to reorganize each system according to capacity and location. “PLAN 1” requires the reinforcement of existing pipes with insufficient capacities and the construction of new pipes on the same line as the existing pipes, which will result in double piping that is unnecessary, and the boundary between the existing and new areas is complicated and difficult to understand. Therefore, “PLAN 2” shall be adopted.



PLAN 1: The existing Area is reduced to match the capacity, The other is all the Extended Area

PLAN 2: Reorganization of each area by location of facility and capacity

Source: Survey Team

Figure 2-2-39 Two Proposals of Reorganization of Water Distribution System

2) Type of Water Distribution

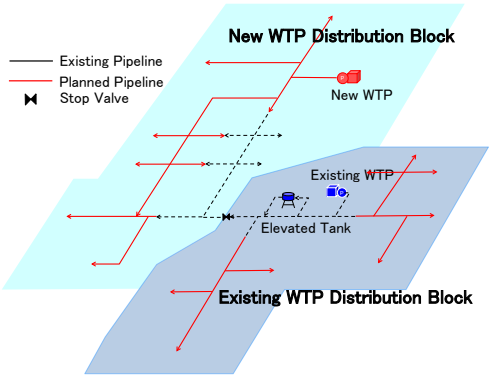
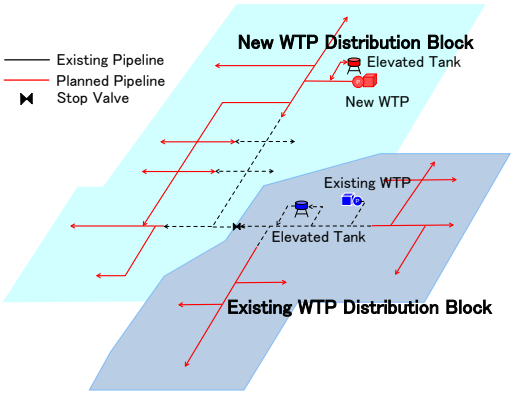
As shown in Table 2-2-34, the type of water distribution[13] shall be the pumping type, and water shall be supplied by pumps with the inverter control in the new WTP. Compared to Plan A, Plan B, which distributes water in combination with a water distribution pump at a WTP and an elevated water tank, has the following concerns:

- It is necessary to secure additional land for the construction of the elevated water tank, and the construction cost is high.
- Although it is a method to save energy by using gravity flow distribution from an elevated water tank, it cannot be expected to be as effective as Plan A.
- Since it is necessary to adjust the flow rate and water level by controlling the water distribution pump or valve, the operation becomes complicated, which is disadvantageous compared to Plan A in terms of both initial cost and operation cost.
- Plan B may become unusable due to insufficient water pressure in the water distribution from the elevated water tank due to future expansion, etc., and as a result, it may hinder appropriate system changes.

Based on the above, Plan A, which has a simple system and high energy-saving effect, has to be adopted.

[13] The plan to install the elevated tank in the planned WTP is not realistic because the elevated tank is raised about 50 m above the altitude and the capacity is large. In the existing distribution system, initially, the elevated tank was installed around the WTP and distributed with the pumping, but due to the expansion of the service area and the increase of the distribution flow, the water pressure from the elevated tank became insufficient, and it is currently not operated. Distribution from the elevated tank may not be able to respond to changes such as the distribution flow and area, and it may become an obstacle to appropriate system change in future expansion etc.

Table 2-2-34 Comparison of Water Distribution Type

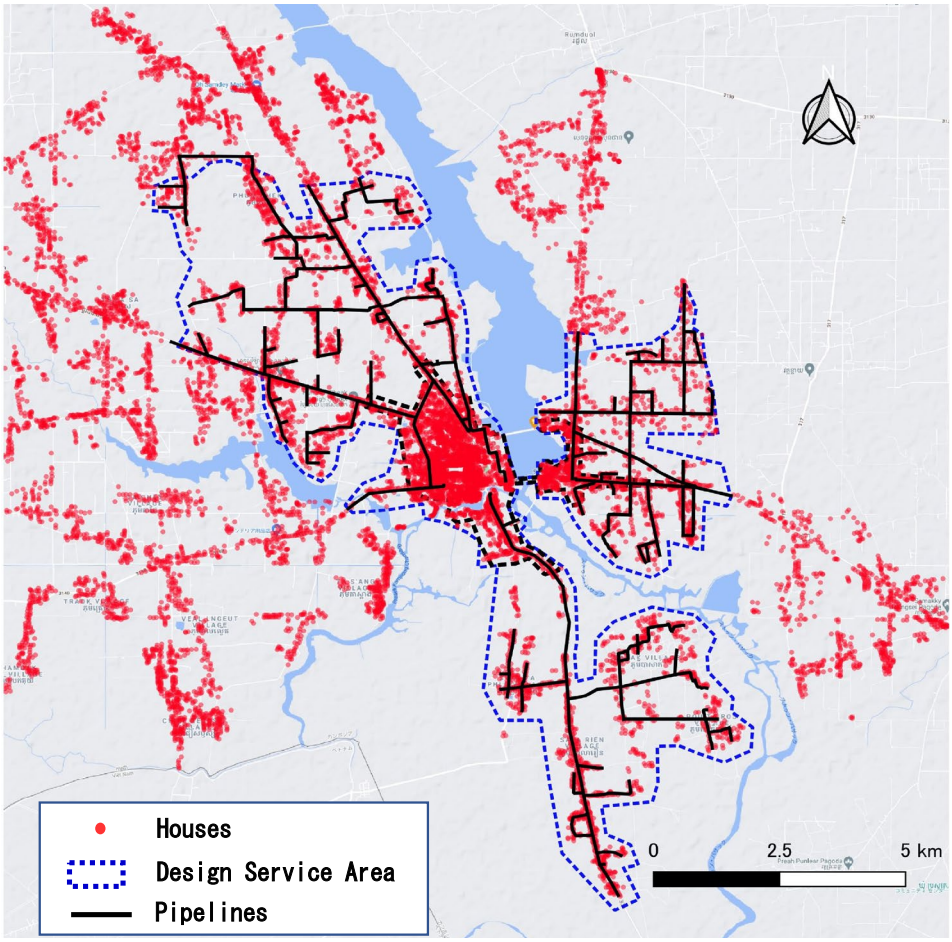
Case	**Plan A**: Pumping (inverter control) type from the WTP	**Plan B**: Combined type (pumping from the WTP and gravity flow from elevated tank)
Description	−Directly conveys water from the new pump to the planned distribution block. −Directly conveys water from the existing pump to the existing distribution block. −Facilities (Service Reservoir, Distribution Pump, Distribution Trunk Mains, Operation Control System).	−Directly conveys water from the new pump to around the WTP in the planned distribution block, and gravity flow from the elevated tank to the distance area of the planned distribution block. −Directly conveys water from the existing pump to the existing distribution block. −Facilities (Service Reservoir, Distribution Pump, Elevated Tank, Distribution Trunk Mains, Operation Control System)
Conceptual Illustration		
Ease of operation and maintenance	−It is easier than Plan B.	−Water level control of the elevated tank is necessary. −Pump operation to cover water distribution for demand is necessary, and water transmission to the elevated tank becomes complicated. −There are two facilities, which makes maintenance slightly difficult.
Necessity of site acquisition	−It is unnecessary to acquire a new site.	−It is necessary to acquire the site for the elevated tank.
Construction cost	−It is slightly cheaper than Plan B.	−It is slightly more expensive than Plan A.
Electricity consumption	−The electricity usage of the distribution pump according to demand can be expected to be minimized by inverter control.	−Water distribution by the elevated tank can suppress the pump energy at the maximum time period, but it is over Plan A at the time of water distribution to the elevated tank during the small water distribution period such as late night. −Overall, Plan B cannot expect energy saving beyond Plan A.
Comprehensive evaluation	−Compared to Plan B, there are few facilities and equipment, it is a simple system, and energy saving effect is high.	−Compared to Plan A, there are many facilities and equipment, controlling the system is complicated, and energy saving effect is lesser.
	○*1	△

*1 ◎: Excellent, ○: Good, △: Fair

Source: Survey Team

(4) Route of Distribution Pipes

The route of distribution pipes shall be decided by selecting the route with high density of houses and then confirming the road width, obstacles, etc., by field survey. The proposed distribution pipe route is as shown in Figure 2-2-40.



Source: Survey Team. Created by plotting houses based on Google Earth

Figure 2-2-40 Route of Distribution Pipes

(5) Distribution Pump

a) Type of Control

Water shall be directly supplied to the service area by distribution pumps. The distribution pumps shall be installed in the pump room of the WTP. The distribution pumps shall be operated by inverter control that enables smooth control and high efficiency operation against constantly changing water demand to reduce power consumption cost and simplify pump operation.

b) Specifications of Distribution Pump

The design specifications of the distribution pump are as follows and shown in the following table.

- Horizontal, end suction volute pump with high efficiency and high stability to be adopted.
- Since inverter control devices are used, it becomes more economical when smaller number of devices are adopted. Therefore, the number of units is to be two (2) at all times, which is the minimum number of devices that can cope with time-varying distribution, and one (1) spare device is added.
- Considering cooperation with the existing distribution system in the future, the total head is 55m, which is comparable to that of existing pumps.

Table 2-2-35 Specifications of Distribution Pump

Items	Specifications
Type	Horizontal, end suction volute pump
Quantity	3 sets (including one set of standby)
Capacity of pump	5,040m^3/day (3.5m^3/min)
Total head	55m
Output of motor	75kW
Diameter	200mm x 100mm
Speed	SS1500min^{-1}
Accessory equipment	Flywheel GD^2=200kgm^2

Source：Survey Team

(6) Capacity of Service Reservoir

In order to achieve stable water supply during normal times and emergency, the capacity of the service reservoir shall be 8 hours[14] volume equivalent of the maximum daily supply of the service area; 2,200 m^3 (6,800 m^3 × 8/24).

(7) Pipe Diameter for Distribution Mains

The pipe diameter in which the minimum dynamic water pressure shall not become lower than the minimum standard pressure[15], and shall be determined, based on hydraulic network analyses for normal operation and at the time of fire. Appendix 7-9 presents the results of the hydraulic network analyses.

(8) Pipe Material for Distribution Mains

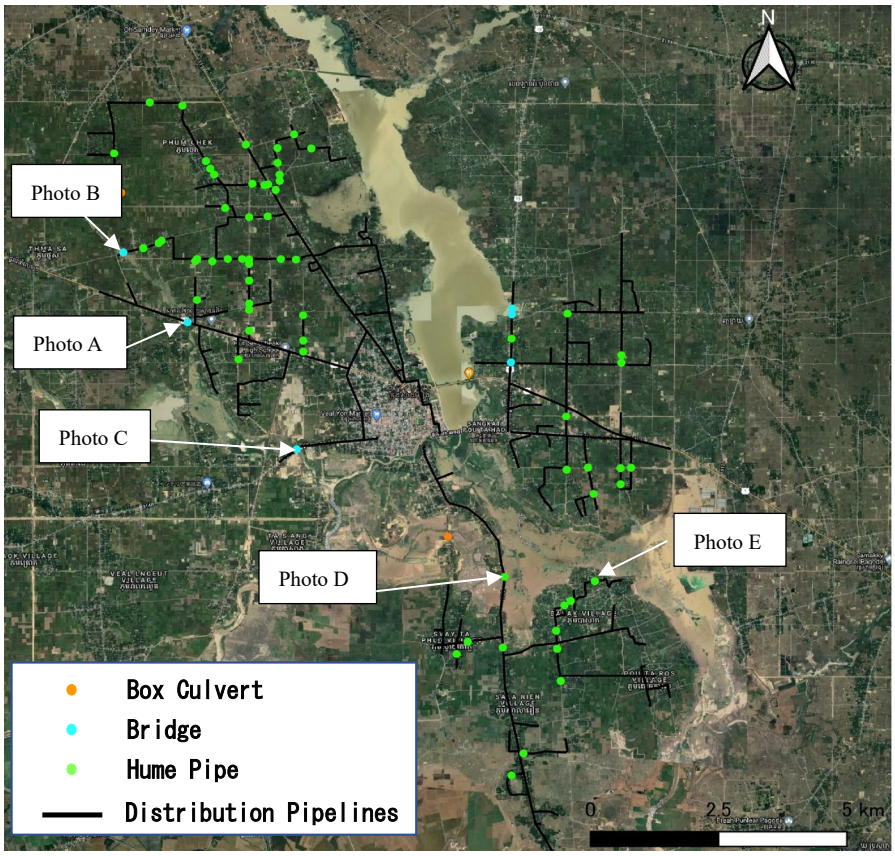
The materials and standards for the distribution mains, buried sections in general, shall be as follows. In case the diameter 300 mm or more, the pipe shall be DIP and the ISO standard (push-on joint excellent in workability even in narrow excavation width) shall be adopted. In case the diameter is 250 mm or less, it shall be HDPE pipe of PN 10 class. In the case of river crossing sections, the materials for the distribution mains shall be SP with corrosion prevention.

(9) Crossing River and Other Water Channel

Figure 2-2-41 shows the main points on the distribution pipeline that require special piping such as river crossings and culverts (box culverts, hume pipes). There are 6 steel / concrete bridges, 3 culverts (boxes), and 65 culverts (hume pipes). The construction method for each location is shown as follows.

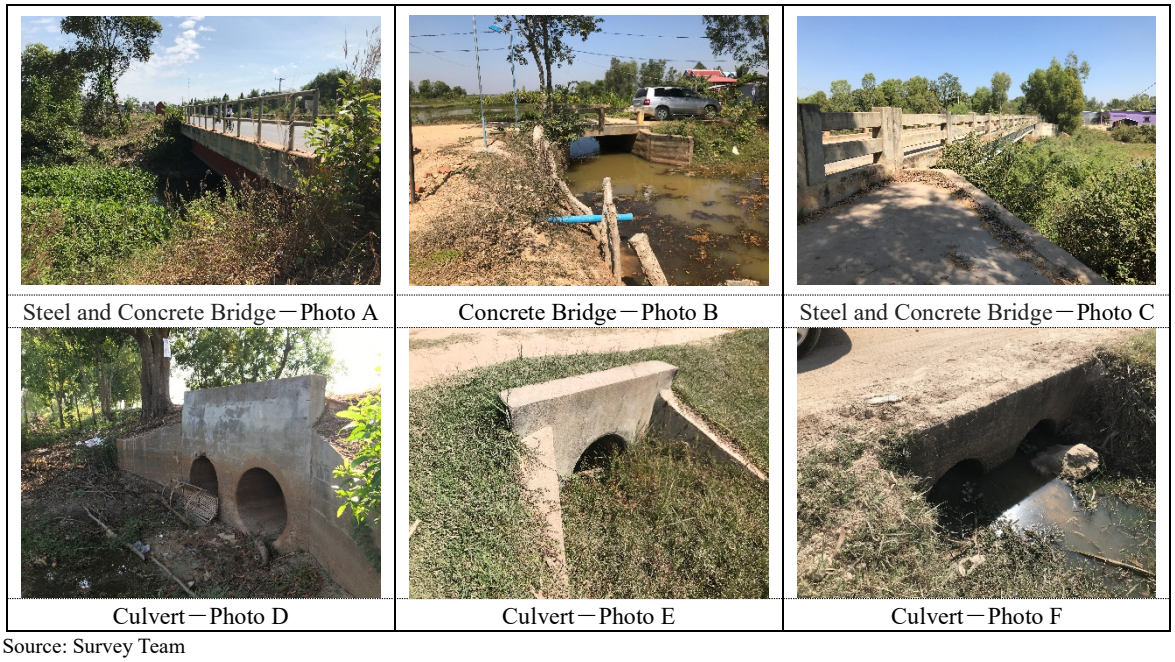
[14] With regard to the service reservoir capacity, it shall be decided by coordination with MISTI with reference to 4 hours of the design maximum daily supply which is actual value of existing distribution facilities and other cities. See Appendix 7-8.

[15] Minimum pressure: 0.05MPa. The distribution pipe network is designed to ensure the adequate residual water pressure throughout the terminal area, highlands, etc. The target area is flat with the elevation difference of approximately 5m across the whole area and there is no highland. Under such conditions, it is efficient and economical to secure a minimum water pressure at the end of the pipeline by gradually increasing the loss water pressure according to the length of the pipeline.



Source: Survey Team, created by means of plotting river crossings etc. on Google Earth image

Figure 2-2-41 Locations Map of Crossing Rivers and Other Structures



Source: Survey Team

Figure 2-2-42 Photographs of Bridges and Culverts

Table 2-2-36 Pipe Installation Methods for Each Crossing

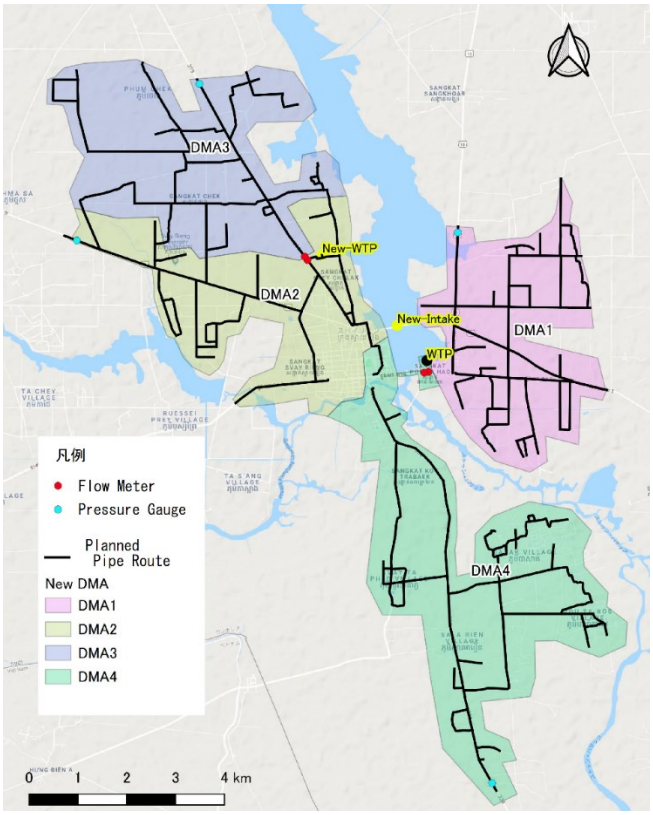
Crossing Structure	Construction Method
Steel and concrete bridge	Methods for crossing rivers, canals and others are generally the bridge-piggybacked water main, the water main bridge and the pipe jacking method. Among them, the bridge-piggybacked water main is the most economical construction method regardless of the diameter. As results of discussions with DPWT, it was confirmed that the bridge-piggybacked water main up to 500 mm is possible. Therefore, for steel and/or concrete bridges that are considered not to be deteriorated and have no problem in terms of strength are selected based on the field survey and the bridge-piggybacked water main shall be adopted.
Culvert (centrifugal reinforced concrete pipe and others)	Crossing of culverts shall be carried out by the invert siphon with the concrete protection.
National highway	Crossing of the national highway shall be carried out by the open cut method. The pipes to be laid inside shall be centrifugally cast reinforced concrete pipes.

Source: Survey Team

(10) Monitoring System for Water Distribution

A water distribution monitoring system shall be introduced for the purpose of grasping the water distribution flow rate and water distribution pressure and centrally managing data, as well as efficient water operation, reduction of water leakage, and response to emergencies such as pipeline accidents. The water pipe network shall be constantly monitored at the following locations:

- Flow rate monitoring: 4 locations on the distribution trunk line of the distribution block (DMA) divided into 4.
- One place in the WTP (included in the equipment for WTP).
- Water pressure monitoring: 4 locations on the terminal water pipes of DMA divided into 4 as show in Figure 2-2-43.



Source: Survey Team

Figure 2-2-43 Distribution Block (DMA) for Water Distribution Monitoring and Installation Location of Flow Meter / Pressure Gauge

(11) Design Criteria for Distribution Mains

The design criteria for distribution mains are as shown in Table 2-2-37.

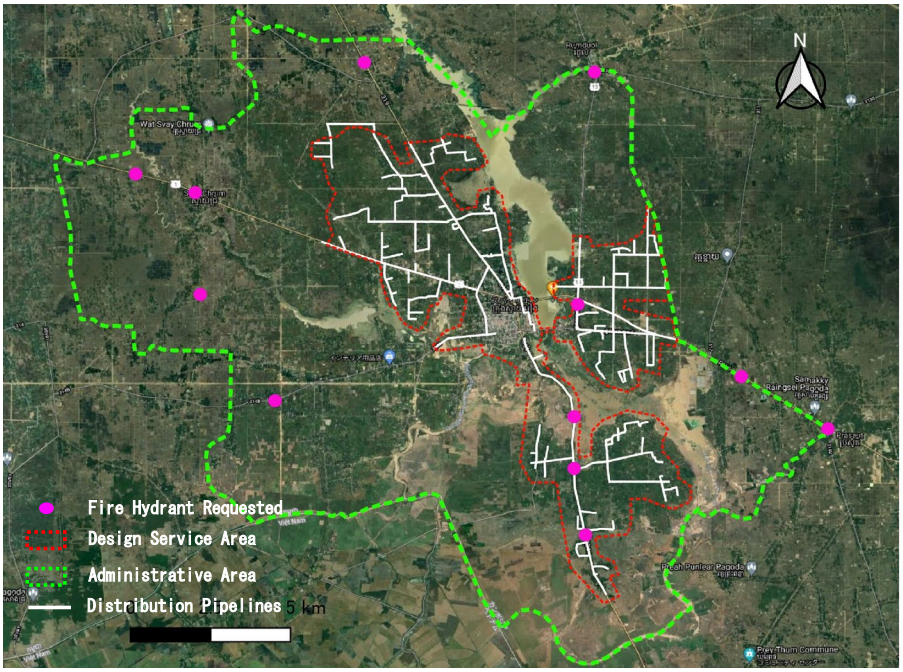
These were set based on the results of discussions with the Department of Public Works and Transports (DPWT), Svey Rieng Provincial Police Commission (Firefighting authority) and MISTI. Also, the conveyance pipe shall conform to the design criteria in the following table.

Table 2-2-37 Design Criteria for Distribution Mains

Classification		Design Criteria
Location of pipe laying		・The pipes shall be laid under the road shoulder. ・The route of pipe laying shall not move to the left or right side on the road at short intervals to facilitate management.
Earth covering		・National highway crossing only: H=1.2m ・Other roads: for φ400, H=1.0m, for φ350 or less H=0.8m ・In case that pipes are laid along a national highway, they shall be laid outside the pavement at the normal depth.
Excavation / Backfilling		・For the upper surface of the pipe, 0.1 m of sand shall be backfilled to protect the pipe. ・When there are many cobble stones and there is irregularity between the pipe material and the ground, the bottom layer of the pipe shall be backfilled with sand of 0.1 m or more. ・If the excavation depth is deeper than 1.5 m, lightweight steel sheet pile (Type III) shall be constructed.
Ancillary facilities	Closure valves	・Closure valves shall be installed at locations, such as start points, end points, branches, inverted siphons, bridge-piggybacked water mains, water main bridges and others. ・The gate valve and the round valve box shall be adopted.
	Air valves	・The air valves shall be installed at locations, such as ridge-piggybacked water mains and water main bridges.

Classification		Design Criteria
		・For φ200 or more, the air valves shall be installed at locations, such as topographical convex parts, inverted siphons and others.
	Drainage facilities	・The drainage facilities shall be installed at pipe concave sections and/or near rivers and irrigation canal etc.
	Protection of special fittings	・The anti-escapement fixture shall be adopted. (This is a countermeasure to suppress the damage of pipe due to the imbalanced forces generated by the bent parts, the branch parts, the gate valves and others. The protection by concrete blocks as another method requires curing period of concrete. Therefore, it shall not be adopted considering the workability based on road conditions.)
	Hydrants	・The hydrant (ground type) shall be installed at eight places where the distribution mains are laid out among the 4 places requested. (See Figure 2-2-44).

Source: Survey Team

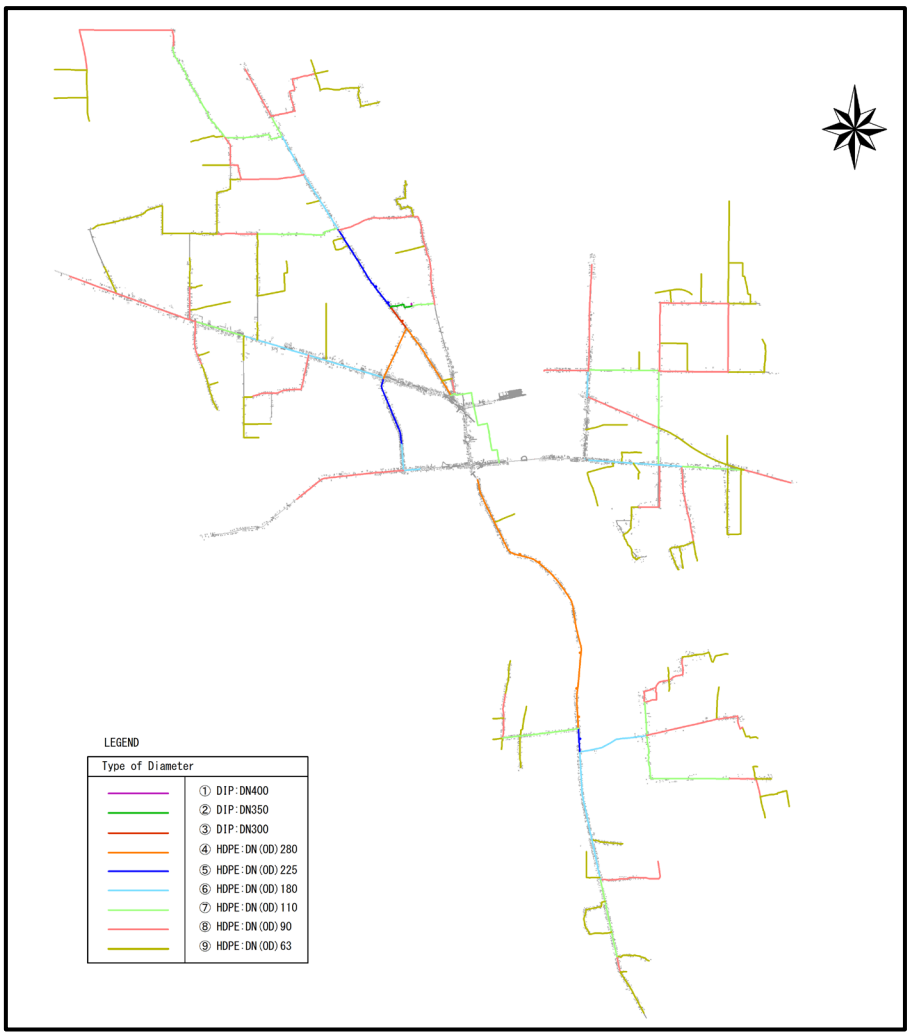


Source: Survey Team, Satellite image: Google Earth

Figure 2-2-44 Location of Hydrants to be Installed

(12) Plan for Distribution Facilities

Based on the above, the plan for distribution facilities is summarized as shown in Figure 2-2-45 and Table 2-2-38.



Source: Survey Team

Figure 2-2-45 Plan for Distribution Mains

Table 2-2-38 Specifications of Distribution Facilities

Facility	Type and Structure	Quantity
Service Reservoir (Inside new WTP)	Reinforced concrete (RC) Structure, Rectangle, two reservoirs Effective capacity: V=1,094 m^3×2 Effective depth: H=3.80 m Water level: HWL+3.90m, LWL+0.10m Foundation: Direct foundation	1 set
Distribution Pump Facilities (Inside new WTP)	Horizontal volute pump 3.5m^3/min H=55m 75kW Inverter equipment	3 Pumps (Including one standby pump)
Distribution Mains	DCIP Straight pipe: T type, Thrust blocking: Retainer gland φ400mm L= 0.1km / φ350mm L= 0.4km / φ300mm L= 0.4km	0.9 km
	HDPE φ250mm L= 6.6km / φ200mm L= 2.9km / φ150mm L= 9.5km / φ100mm L= 15.4km / φ 80mm L= 33.2km / φ 50mm L= 43.3km	110.9km
	Bridge-piggybacked Water main SP (corrosion prevention coating) φ 80mm 5 places / φ 50mm 1 place	6 Places
Monitoring System of Water Distribution	・ Central monitoring station: data transmission equipment, monitoring computer, printer & ancillary equipment ・ Flow monitoring station: Distribution pipeline 2 stations (For each station; φ200 flow meter 1 unit, φ250 flow meter 1 unit, data transmission equipment & ancillary equipment) Existing water treatment plant 1 station (data transmission equipment & ancillary equipment, 1 unit of flow signal will be received from existing flow meter) ・ Pressure monitoring station: Distribution pipeline 4 stations (For each station; 1 pressure transmitter, data transmission equipment & ancillary equipment) ・ Outline of equipment specification: Data transmission equipment (center): PLC, Router, 1 set Data transmission equipment (local): RTU, GPRS router, 7 sets Flowmeter: Electromagnetic flow meter φ250 2 sets φ200 2 sets Pressure transmitter: 2 wire type transmitter, 4 sets	1 LS

Note: Pipe length of water main bridges and the bridge-piggybacked water mains shall be included in the length of ductile cast iron pipes and HDPE pipes.
Source: Survey Team

2-2-2-7 Procurement Plan of Equipment and Materials

Based on the initial request from the Cambodian side and the discussion results at the inception stage or the on-site explanation stage about the outline of survey results, the minimum required equipment and materials for this project are selected as shown in Table 2-2-39.

Table 2-2-39 Initial Request from Cambodian Side and Field Survey Results

Classification of Equipment to be Procured		Contents of Initial Request	Equipment to be Procured based on Field Survey Results
Procurement of Equipment	Equipment for Water quality management	Atomic absorption photometer, distillation equipment, microscope, reagents, glassware, turbidimeter, pH meter, UPS, etc.	Distilled water maker, portable turbidity meter, turbidity meter, pH meter (glass electrode type), electrical conductivity meter, UPS, continuous water quality analyzer for conductivity and residual chlorine, reagents, glassware, center laboratory table, side laboratory table, chemical cabinet, refrigerator, desk and chair.
	Equipment for electric	Power tester, detector, vibrometer,	Clamp power meter, insulation

Classification of Equipment to be Procured		Contents of Initial Request	Equipment to be Procured based on Field Survey Results
	machine	torque wrench, handy flowmeter, filter sand tester, insulation checker, etc.	resistance meter, ground resistance meter, vibration checker, mechanical torque wrench, portable ultrasonic flow meter and sieve shaker
	Equipment for management of distribution pipes	Leak detector, pipe detector, laying pipe equipment, pipe network information system etc.	Electrofusion Machine and accessories for PE Pipes
	Equipment and materials for house connection to poor households	-	Water supply pipes, water meters and accessories
	Accounting system	-	SUMS System (PC and extra software license)

Source: Survey Team

(1) Water Quality Analysis Devices

As for water quality control equipment, the minimum necessary equipment for operation and maintenance of the new WTP are planned to be procured.

The Survey Team investigated the equipment already placed in the Svay Rieng WTP, and utilized the results of that investigation as reference for planning the provision of equipment. The results of the investigation are as shown in Table 2-2-40.

Table 2-2-40 Water Quality Analysis Devices in the Existing WTP

Equipment currently in use (As of August 2017, excluding equipment malfunction)	Remarks
Jar Tester, Turbidity Continuous Measurement Analyzer, Laboratory Tables, Chlorine Continuous Measurement Analyzer, Electrical Conductivity Meter, ***Absorptiometer***, pH Meter, ***Residual Chlorine Meter***, Distillation Apparatus, Glassware, Microscope, Bacteria Test Equipment, Electric Balance, Magnetic Stirrer, Autoclave, Electric Furnace, Drying Machine, Refrigerator, Centrifugal Machine, Color Meter, Vacuum Filtration Apparatus	The items in ***bold italics*** are to be transferred to the new WTP

Source: Survey Team

The water quality analyzing equipment such as jar tester, residual chlorine analyzer, turbidity meter, glassware, pH/electrical conductivity meter and distilled water production equipment, are frequently used and indispensable for the operation management of the new WTP. In addition, they are also used at the training of the operation management in soft components. Therefore, it is necessary to procure the equipment in this project. Based on the above, the plan shall be formulated with the basic policy to procure a complete set of the equipment necessary for the O&M of the new WTP.

(2) Tools for Electric Machine Facilities

Maintenance tools for electrical and mechanical equipment, namely; clamp power meter, insulation resistance meter, ground resistance meter, vibration checker, mechanical torque wrench portable ultrasonic flow meter, and sieve shaker, are to be procured and provided to the Cambodian side.

(3) Equipment for Management of Distribution Pipe

Leak detector, pipe detector and laying pipe equipment have been procured through other past technical cooperation of Japan and it was confirmed that the above-mentioned equipment are used and stored in good condition in the SWWs. Therefore, they shall be excluded from the procurement list of this project.

Meanwhile, as for the pipe laying equipment, butt fusion machine for PE pipes shall be procured. The pipe network information system shall be included as a water-distribution management system for construction work.

(4) Service Connection Installations

Service connection installations are granted to the poor households (Poor Level 1): 375 in the planned water supply area. Connecting poor households to piped water supply is the obligation of the RGC. For all beneficiaries except poor households, the beneficiaries will pay labor cost and the cost of connection materials.

The connection fee including pipe material cost is about 290,000KHR. Out of this connection fee, labor cost is 4,000KHR/m. Therefore, the cost of connection for a 5m length service pipe is about 20,000 KHR (5USD). So far, the poor households have been exempted from paying or paid in installments up to 12 times.

The number of poor households in the area is estimated by the following formula based on the poverty group data from “Identification of Poor Household Programme” conducted in 2010 to 2011 by the Ministry of Planning.

Poor Household Number (F) = Σ{Poverty Ratio of Village (C)×Household Number of Village (E)}

The number of Poor Level 1 households in the design water supply area in 2027 has been estimated to be 410 households.

The number of poor households eligible for grant aid (house connection materials) is 375, which was calculated by subtracting 35 households connected at the time of survey in December 2019 from 410 in the design water supply area in 2027. The estimation results of the number of poor households are shown in Appendix 7-10.

(5) SUMS System

Synergistic Utilities Management System (SUMS) is an integrated business data processing system which has features of issuing invoice by use of reading data of water meter, accounting and automated payment. Although the SWWs have already installed a PC with software for billing, accounting and casher through the Project on Capacity Building for Urban Water Supply System (Phase 3), additional software license and a client PC shall be procured because the number of water-supplied households will increase.

(6) Equipment Procurement Countries

Water quality analysis equipment and vibration checker, etc. are special devices and the quality of these equipment is particularly important. As a matter of fact, in Cambodia, high-quality third-country water quality instruments such as those made in the United States are also distributed through local distributors. This equipment shall be continuously procured by the WWs even after the project is implemented.

Therefore, the procurement source of the equipment shall not be limited to procurement in Japan and Cambodia, considering the procurement record of equipment in the other grant aid project currently being implemented and the compatibility with the existing equipment made in a third country and distributed in Cambodia.

In conclusion, if the specifications can be satisfied, it is considered that third country procured products can be applied.

(7) Procurement Timing of Equipment

Water quality analysis equipment, mechanical equipment and accounting system equipment shall be procured at the time prior to the implementation of the soft component because training on how to handle and maintain this procured equipment is planned during the activity of soft component.

The service connection materials shall be provided before the completion of the project because it is necessary to have the Cambodian side conduct service connection work before the completion of the project in order to increase the water supply ratio in the target water supply area.

Table 2-2-41 shows the summary of equipment to be provided in this project based on the considerations described above.

Table 2-2-41 Summary of Equipment to be Provided

Item	Equipment/Material	Specification	Qty
Equipment for Water Quality Analysis	Water Quality Instruments	Distillation apparatus, Turbidity Meter, pH Meter, Electric Conductivity Meter	1 set
	Uninterrupted Power System (UPS)	Output Capacity: 3kVA	1 set
	Continuous Measurement Water Quality Analyzer	Analyzer that continuously measures the turbidity of treated water. Measurement Range: 0-100NTU (Turbidity), 0-3mg/L (Residual Chlorine)	1 set
	Reagents	pH Standard Solution, BTB reagent, DPD reagent, etc.	1 set
	Glassware	Beaker, Measuring Flask, Pipette, burette, etc.	1 set
	Laboratory Table	Central Laboratory Table (including reagent shelf, socket outlet, piping and wiring), Side Laboratory Table and Sink	1 set
	Other	Storage Shelf, Refrigerator and Desk/Chair	1 set
Tools for Electrical Machinery Equipment	Clamp Power Meter	Voltage Range: AC600V Current Range: AC600mA-AC 1,000mA (or above)	1 set
	Insulation resistance meter	For analog indication Value 250V Range : 0 – 50MΩ 500V Range : 0 – 100MΩ 1000V Range : 0 – 2000MΩ For digital indication Value 250V Range : 0 – 500MΩ	1 set

Item	Equipment/Material	Specification	Qty
		500V Range : 0 – 2000MΩ 1000V Range : 0 – 4000MΩ	
	Ground resistance meter	0 – 1000Ω	1 set
	Vibration Checker	Acceleration: 0.02 – 200m/s^2 ; Velocity:0.3 – 1,000mm/s Displacement: 0.02 – 100mm	1 set
	Mechanical Torque Wrench	Measurement Range: 50 – 300Nm	1 set
	Portable Ultrasonic Flow meter	Measurement Range of Pipe Diameter: 13 – 600mm	1 set
	Sieve Shaking Machine	Effective Diameter: 0.8mm – 1.0mm	1 set
Maintenance for Distribution Pipes	Electrofusion Machine and Accessories for PE Pipes	φ63 – 280mm	1 set
Accounting System Equipment	SUMS System	Three (3) Computers (for billing, accounting and casher, one (1) PC for one software), one (1) UPS, one (1) Printer, SUMS Software [two (2) Full Licenses, one (1) Light License] Software of full license includes “Billing “and “Accounting”. Software of light license includes “Casher”. Since each software of “Billing”, “Accounting”, and “Casher” is operated by separate PCs, three (3) PC will be required.	1 set
Service connection installations	Water Supply Equipment	Per 1 set ・ Snap taps with saddle from distribution pipes (DN350mm~OD63mm) ・ HDPE service pipe (diameter 25mm) 30m ・ Water meter (diameter 15mm, Tangential flow impeller type, Single-jet, Class C, Rotatable display (Max.270 degree)) ・ Stopcock (diameter 15mm) ・ Attachment (joint, coupling, etc.)	375 sets

Source: Survey Team

2-2-3 Outline Design Drawings

Selected drawings of outline design are attached in Appendix 7-2. The drawing list of the outline design as shown in Table 2-2-42.

Table 2-2-42 List of Outline Design Drawings

No.	FACILITY CLASIFICATION	Description	DRAWING No
1.	General (G)	General Layout of Svay Rieng	G1
2.	Intake Facility (I)	Intake Facilities (1)	PI-1
		Intake Facilities (2)	PI-2
		Intake Facilities (3)	PI-3
		Intake Facilities (4)	PI-4
		Intake Facilities (5)	PI-5
		Pump House Plan	PI-6
		Pump House Section	PI-7
3.	Raw Water Transmission Facility (R)	Conveyance Pipeline Plan	SR-1
4.	Treatment Facility (T)	Water Treatment Plant General Plan	ST-1
		Hydraulic Profile of Svay Rieng Water Treatment Plant	ST-2
		Water Treatment Facilities Structure (1)	ST-3
		Water Treatment Facilities Structure (2)	ST-4
		Water Treatment Facilities Structure (3)	ST-5
		Water Treatment Facilities Structure (4)	ST-6
		Water Treatment Facilities Structure (5)	ST-7
		Water Treatment Facilities Structure (6)	ST-8
		Water Treatment Facilities Structure (7)	ST-9
		Water Treatment Facilities Structure (8)	ST-10
		Water Treatment Facilities Structure (9)	ST-11
		Service Reservoir and Pumping Station Structure (1)	ST-12
		Service Reservoir and Pumping Station Structure (2)	ST-13
		Service Reservoir and Pumping Station Structure (3)	ST-14
		Drainage Basin Structure	ST-15
		Drying Bed Structure	ST-16
		Water Treatment Plant Process Flow Diagram (1)	ST-17
		Water Treatment Plant Process Flow Diagram (2)	ST-18
		Chemical Feeding Facility Plan (1)	ST-19
		Chemical Feeding Facility Plan (2)	ST-20
		Instrument & Control Flow Diagram	ST-21
		Intake PS Monitoring System & Distribution Monitoring System	ST-22
5.	Distribution Facility (D)	Location Map for Distribution Pipeline	SD-1
		Distribution Pipe Plan (1)	SD-2
		Distribution Pipe Plan (2)	SD-3
		Distribution Pipe Plan (3)	SD-4
		Distribution Pipe Plan (4)	SD-5
		Distribution Pipe Plan (5)	SD-6
		Distribution Pipe Plan (6)	SD-7
		Distribution Pipe Plan (7)	SD-8
		Distribution Pipe Plan (8)	SD-9
		Distribution Pipe Plan (9)	SD-10

No.	FACILITY CLASIFICATION	Description	DRAWING No
		Distribution Pipe Plan (10)	SD-11
		Distribution Pipe Plan (11)	SD-12
		Distribution Pipe Plan (12)	SD-13
		Distribution Pipe Plan (13)	SD-14
		Distribution Pipe Plan (14)	SD-15
		Distribution Pipe Plan (15)	SD-16
		Distribution Pipe Plan (16)	SD-17
		Distribution Pipe Plan (17)	SD-18
		Distribution Pipe Plan (18)	SD-19
		Distribution Pipe Plan (19)	SD-20
		Distribution Pipe Plan (20)	SD-21
		Distribution Pipe Plan (21)	SD-22
		Typical Drawing for Pipe Laying (1)	TYP-1
		Typical Drawing for Pipe Laying (2)	TYP-2
		Typical Drawing for Pipe Laying (3)	TYP-3
		Typical Drawing for Pipe Laying (4)	TYP-4
		Typical Drawing for Pipe Laying (5)	TYP-5
		General Earth Work for Pipe Laying	TYP-6
		Typical Drawing for Sluice Valve	TYP-7
		Typical Drawing for Installation of Air Valve and Washout	TYP-8

Source: Survey Team

2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

(1) Basic Policy of Project Implementation

- Should the project be implemented under the Japan's Grant Aid Scheme, Japan's Grant Aid is provided through the following procedures:
- The client of the project is MISTI. Agreements for Contract Documents and Certificate of Completion shall be issued by the Signer of MISTI.
- The organization for management, operation and maintenance of this project is DISTI and the WWs under the DISTI, which consistently makes technical decisions, and perform various practices such as process control and quality control from the design stage to the operation and maintenance stage.
- The RGC shall enter into contract with the Consultant for consulting services with regard to designing, tendering, cost estimation and supervision of the procurement and construction works for the project. The Consultant shall be a Japanese consulting firm, which shall be selected by JICA and recommended to the RGC for the project in order to maintain technical consistency.
- The RGC shall enter into contract with the contractor which shall be selected through competitive tendering, and the contract shall be verified by JICA to fulfil accountability to Japanese taxpayers. The contractor shall be a Japanese firm which is capable of procuring the products and of construction in a proper manner under Japan's Grant Aid.
- To establish a smooth and safe construction method and schedule, the following conditions shall be considered: (i) Natural Environment: meteorology, topography and geology; (ii) Social Environment: traffic control, underground facilities and other negative impacts against residents.

(2) Construction and Procurement Policy

In Phnom Penh, there are over 15 local construction firms. Some of these firms have experience in Japan's Grant Aid project as subcontractors of Japanese general contractors. Common technique is required for civil works to implement the construction of water intake facilities and the WTP including building and pipe installation. Although, this project will be carried out in Svay Rieng, it is possible to dispatch workers from the above-mentioned construction companies in Phnom Penh. Therefore, caretakers, machine operators, form workers, concrete workers, and other workers can be dealt with by hiring local people in principle, and there is no need to dispatch special workers from outside Cambodia.

The civil engineering work carried out in this project mainly consists of the construction of water intake facilities, the construction of WTP facilities, and the construction of new water transmission and distribution pipelines and does not require special construction techniques. The office in the water intake facility, the administration building (office) in the WTP facility, and the chemical injection

building will be constructed. In addition, the water quality analysis equipment used at the WTP and the water supply equipment for the poor households are equipment procurement and do not require special construction technology.

However, since the construction in this project will be carried out in multiple areas, in order to carry out construction management in consideration of safety, environment and quality, Japanese engineers who shall be in charge of management of each construction area including the site office manager shall be dispatched. Japanese engineers for construction management also serve as procurement management for water quality analysis equipment. In addition, construction materials, equipment and labor shall be procured locally.

2-2-4-2 Implementation Conditions

The following conditions shall apply to the implementation of the project at construction sites:

- Great effort will be devoted to coordination and information sharing because there are a number of parties involved. The Cambodian side, the construction contractor, the consultant and the related donor organizations shall meet regularly to review the progress of the project. Other means of communications shall also be used.
- The consultant shall share information with the involved parties continuously and deploy one project manager and one resident engineer on site to ensure smooth implementation of the project.
- The construction contractor shall also deploy one representative and one site manager on site.
- The consultant and the construction contractor shall have offices set up at appropriate locations.
- Consultations with the Cambodian side shall be required since coordination with the national and state governments is indispensable for approvals of water rights, construction permission for intake facilities, seeking permissions for occupancy of roads, etc.
- It is planned to install temporary water coffers so that the construction of intake facilities could be executed throughout the year, even in July and October when the water level is higher.
- The total length of pipes for conveyance pipe, clear water transmission and distribution will be approximately 115 km. Although the main sites are residential areas with unpaved roads, busy paved roads with heavy traffic are also included. Accordingly, the pipe installation shall require special considerations for safety, and disruption of traffic and daily activities in the area shall be minimized.
- The Cambodian side shall assure the safety of the construction work sites from landmines and unexploded ordinance (UXO) by submitting an official report to the JICA Cambodia Office by the commencement of the construction work.

- The construction shall be done in the day time. In case night-time construction cannot be avoided, consultation with the Cambodian side is required.
- Materials and equipment shall be procured locally. If that is not possible, procurement from Japan or third countries shall be considered sequentially.
- Materials for service connections to be provided by the Japanese side shall be products manufactured in neighboring countries and sold in Cambodia. These are likely already used by the WWs for existing pipes.

2-2-4-3 Scope of Works

The Japanese side shall be responsible for the construction of facilities. The Cambodian side shall be responsible for the storage of 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 Section "2-4, Obligations of Recipient Country".

2-2-4-4 Consultant's Supervision

The consultant shall provide professional services to the RGC with regard to detailed design, cost estimation, tendering and supervision of the procurement and construction works for the project in accordance with a contract with the RGC.

(1) Detailed Design

The consultant shall conduct the detailed design study for the project, including the following:

- Kick-off meeting with the executing agency and site investigation
- Detailed design study on civil and architectural structures and preparation of detail design drawings
- Detailed design study on mechanical and electrical works and preparation of detail design drawings
- Cost estimation

(2) Tendering Management

The consultant shall assist the RGC in conducting the procurement tendering in fair and proper manner, as follows:

- Preparation of tender documents
- Notice for Prequalification
- Evaluation of Prequalification Documents
- Tender Notice
- Execution of tendering and Evaluation of tendering
- Facilitation of contract between the Client and the contractor

(3) Construction Supervision

The consultant shall provide appropriate supervision and guidance to the contractor, on behalf of the RGC, as follows:

- 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 the procured equipment
- Report on construction progress to the Japanese and Cambodian sides
- Safety guidance on the construction work and supervision of the construction quality
- 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 from the start of construction to the commissioning of facilities. In addition, various specialists (as listed below) are required for on-site supervision of the construction of the different facilities as described in detail hereafter.

i) Civil Engineer (conveyance/transmission and distribution facilities)

Check shop drawings, supervise construction activities as well as test procedures, provide instruction and advice concerning conveyance/transmission and distribution facilities.

ii) Civil Engineer (Intake facilities / WTP facilities)

Check shop drawings, supervise construction activities as well as test procedures, provide instruction and advice concerning intake facilities and WTP facilities.

iii) Architect (office, administration building, chemical room)

Check shop drawings, supervise installation of electrical equipment as well as test procedures, provide instruction and advice concerning architectural facilities.

iv) Mechanical Specialist / 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.

v) Specialist for Procurement of Equipment

Check approval procedures, supervise the procurement of equipment and provide instruction and advice.

vi) Defect Inspection Engineer

Defect Inspection Engineer shall be dispatched to engage in defect inspection implemented a year after project completion.

2-2-4-5 Quality Control Plan

Quality control during construction consists of ensuring conformance to planning decisions and the technical specifications in the original design. The major items to be scrutinized are as listed in the Table below, together with indicators, control methods and the standards to be adopted. In principle, JIS or other equivalent International Standards shall be followed for quality control.

Table 2-2-43 Major Work Items and Methods for Quality Control

Category	Material/ Equipment	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, Approved 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	Approved Drawings	In the presence of consultant
		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	Record	In the presence of consultant
		Conform to the Standards	Test Report			Test Result Table	
	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 diameter 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 days strength: 21N/mm^2 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	One time before placing	Test Result Table	In the presence of consultant
	On-site Concrete Mixture	Water Content of Small	JIS A 1111, 1125	—	Each mixing	Test Result Table	In the presence of consultant

Category	Material/ Equipment	Control	Method of Control	Applicable Standards	Frequency of Test	Records	Remarks
		Aggregate Surface					
		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 than1%			
	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/mm^2	Every 50m^3 placing or 1 time per day, 1time for one consecutive placing work	Test Result Table	
	Leakage test (watertight structure such as distribution reservoir)	Conform to the Specifications	Observation and water level measurement	There is no water leakage. There should be no drop in water level for more than 24 hours.	One time after placing	Test Result Table	

Source: Survey Team

2-2-4-6 Procurement Plan

The following major construction materials and equipment shall be procured locally. As a general rule, other materials and equipment shall be procured locally, but if local procurement is difficult, they shall be procured in Japan or in a third country.

a) Cement

Cement products of Thailand circulate freely in the local market. The cement has a good reputation on both quality and quantity to satisfy the demands in Phnom Penh.

b) Steel Materials

Common steel materials, such as reinforcing bars, are available in the local market of Cambodia. These products are imported from Thailand and Vietnam. Recently, Vietnamese iron bars are popular in Cambodia.

c) Electromechanical and Operation Equipment

Equipment which needs frequent change or maintenance shall be procured in Cambodia to make the maintenance easy.

d) Construction Equipment

Common construction equipment, such as backhoe, truck with crane, dump truck, is available in Cambodia. Recently, Silent Pile Driver is also available in Cambodia.

e) Water Meters

Water meters can be procured in Cambodia.

f) Others

Construction materials and equipment for the project shall be procured in Cambodia, Japan or other countries, according to the following considerations. Quality of materials and equipment shall conform to the requirements.

- For local materials and equipment, quality and capacity of supply shall be at the acceptable level
- Sufficient supply in the Cambodian market
- Easy operation and maintenance taking into account availability of spare parts
- Appropriate price
- Availability of after-sales service

Pipe materials, not available in Cambodia and being the larger part of the project cost, shall be procured from other countries where the price is lower. It is desirable that there is an experience of procurement record in Japan's Grant Aid project.

The transportation route for materials and equipment procured in Japan shall be sea transportation from Yokohama Port to Sihanoukville Port, and land transportation from Sihanoukville Port to Svay Rieng City.

2-2-4-7 Operation Guidance Plan

The manuals and instructions introduced in this project for the operation and maintenance of each facility by the contractor after the facilities are transferred shall fall within the scope of the initial operation instructions.

The operation guidance covers several fields that are difficult to include in the initial operation instructions, such as actual operation in response to changes in water quality and demand, maintenance of facilities to ensure optimal operation, and efficient management to guarantee the sustainable water supply business. The operation guidance shall be implemented by highly skilled experts and engineers with considerable experience in WWs as a soft component of this project.

Table 2-2-44 Roles and Responsibilities of Soft Component

Instruction Items	Initial Operation	Operation Guidance
	Instructions by Contractor	via Soft Component
Provisions of manuals	O	-
Instructions on the operation and maintenance of each facility	O	-
Actual operation of facilities	-	O
Actual maintenance of facilities	-	O
Efficient management for sustainable business	-	O

Source: Survey Team

2-2-4-8 Soft Component (Technical Assistance) Plan

The SWWs are provincial waterworks agencies that are the targets of a project on capacity building for urban water supply system in Cambodia (Phase 2 and 3) by JICA. Technical transfer associated with the operation and maintenance of the WTPs, water quality tests, and the operation and maintenance of

distribution facilities have been implemented for five years from 2007 to 2012, and technical transfer related to the improvement of management has been carried out from 2012.

Although local staff can operate and maintain the existing WTP by following the prescribed procedures, they may not necessarily have the advanced technical knowledge required for their work. Since the water treatment facilities constructed in this project have different water treatment methods from the existing WTP, the SWWs have not reached the technical ability to formulate appropriate operation and maintenance methods for the new facilities. Challenges in the operation and maintenance of the new facilities, and current situations are as shown in Table 2-2-45.

Table 2-2-45 Challenges and Current Situations of SWWs

Challenges	Current Situations
Operation and maintenance of new facilities	Treatment process for the new WTP adopts a rapid filtration system, which is different from the existing one operation and maintenance, may be more complicated. Therefore, it is necessary to understand the basic knowledge with OJT using the facility. As for water quality test, the staff have no knowledge and experience of jar test. Procedures for water quality test using the newly installed equipment shall be developed with the assistance of experts. The planning of operation and maintenance procedures is difficult for the staff of the SWWs to carry out alone because it requires specialized knowledge of water treatment and waterworks technology based on extensive experience.
Facility maintenance based on water distribution monitoring and water distribution flow analysis	Since the new water distribution monitoring system shall be installed by this project, it is necessary to learn the basics of the system, including its operation and maintenance. By operating the water distribution monitoring system, they should acquire skills in interpreting information and analyzing flow data and use them to maintain the water distribution facilities.
Ensuring quality of service connection installations	The staff is accustomed to service connection installations. However, no special efforts have been made to ensure quality. To prevent leakage from service connections which are expected to increase rapidly with the implementation of this project, review of work procedure and improvement of construction management skills for service connection installations with assistance from experts are necessary.
Promotion of applications for service connections	Although SWWs carries out educational activities for residents, in order to achieve the target number of service connections in this project, assistance for preparation of more effective materials and plans for educational activities is necessary.
Improvement of production management	Since SWWs have no experience to manage plural WTPs, principles of efficient management of two WTPs must be studied, formulated and understood. Since the existing WTP has no sludge treatment process, formulation of a sludge treatment plan and work procedure and OJT are necessary.
Revision and creation of SOP	Although there are SOP which were formulated on the premise of use of the existing facilities and equipment, to make the staff understand the operation and maintenance of the new facilities and equipment, it is important that procedures, principles, key points and precautions are simply compiled in SOP. They should be referred at any time as necessary for the staff as well. Therefore, creation and revision of SOP are necessary.

Source: Survey Team

WWs needs to operate the facilities immediately after the completion of construction through this project. As shown in the Table 2-5-1, the number of staff members in the water production and network sections will increase by eleven (11) and five (5) staffs, respectively, as operation and maintenance staff and most of them are expected to be newly employed. It is difficult to confirm that the implementation system is at a level which can ensure that the staff members can properly operate the facilities on their own within a short time, including enhancing the ability of the new staff.

To smoothly launch this project and verify that the outcomes of this project remain effective for a minimal period, support from highly skilled technical experts with considerable experience is essential. Therefore, the transfer of knowledge and technical skills for the operation and maintenance of the water supply facility for SWWs shall be implemented as a soft component of this project.

(1) Objective of the Soft Component

This soft component aims for the "steady supply water that meets water quality standards while SWWs properly operate, maintain and manage the new water supply facilities and effectively utilize the existing facilities".

(2) Outcome of the Soft Component

The outcome of the soft component shall be set out as follows:

(i) Formulation and understanding of procedures for operation and maintenance of the new WTP;
(ii) Formulation and understanding of procedures for water quality tests using new equipment;
(iii) Acquired capability in water distribution monitoring;
(iv) Strengthening construction supervision system for service connection installation;
(v) Implementation of educational activities to promote applications for service connections;
(vi) Improved capability of production management; and
(vii) Revision and creation of SOP.

(3) Input Plan

The input of this soft component shall be carried out in three steps.

In the first input, training shall be carried out for the purpose of acquiring basic knowledge before the water facilities are completed. In the second input, OJT shall be conducted at a period that overlaps with the trial run by facility construction and equipment procurement. In the third input, training for the purpose of follow-up shall be carried out at the time when a certain period of time has passed since the facility started operation. At the time of each input, the Survey Team shall also support the revision and creation of various SOPs.

Support for planning of new facility operation and maintenance, training, revision and creation of SOP, and other tasks that require technology and theoretical thinking based on specialized knowledge and experience, shall be carried out by Japanese experts. By utilizing the local human resources

developed in the capacity building project as part of the support, the Survey Team shall carry out technology transfer unique to local engineers.

The human resources involved shall include Japanese experts, local engineers, local staff. Their roles are as generally outlined below.

1) Japanese Expert

Summary of each training course, analysis of work content and work volume necessary for the management of new facilities, training course management, formulation of procedures for operation and maintenance, basic training, OJT, assistance for revision and creation of SOP, preparation of training materials, and evaluation of achievements.

2) Local Engineer

Training based on experience in Cambodia, and training outside SWWs, preparation of training materials in Khmer.

3) Local Staff

Preparation of materials and training materials in Khmer, providing coordination with counterparts, interpreter for Japanese expert, and translation of documents.

Table 2-2-46 shows the activities in each field; Figure 2-2-46 shows the draft schedule of the soft component.

Table 2-2-46 Activities of the Soft Component (Input Plan)

Field	Outcomes	Activities	Trainees	Inputs
Operation and maintenance of water treatment facilities	(1) Formulation and understanding of procedures for operation and maintenance of the new WTP	1. Formulation of procedures for operation and maintenance 2. Basic training of operation and maintenance 3. OJT of operation and maintenance - Water treatment - Operation records - Chemical injection - Back washing of filtration basin - Operation of pumps, etc. - Maintenance - Handling of facilities - Accident and malfunction handling	23 people from Water production Section	Japanese Expert - One person×2.03 P/M First Input - Basic training of operation and maintenance - Basic training of water quality test - SOP revision guidance Second Input - Training of operation and maintenance - Training of water quality test - SOP revision guidance Third Input - Review - Follow-up training - SOP revision guidance Local Engineer - One person×0.17 P/M Local Staff - One person×1.79 P/M
	(2) Formulation and understanding of procedures for water quality tests using new equipment	1.Formulation of procedures for water quality test 2. Basic training of water quality test 3. OJT of water quality test - Water quality test - Analysis and records		
	(7) Revision and creation of SOP	1. Assistance for revision and creation of SOP - Operation and maintenance of water treatment facilities - Water quality test		
Maintenance of water distribution facilities	(3) Acquired capability in water distribution monitoring	1. Formulation of procedure for water distribution monitoring 2. Basic training of water distribution monitoring 3. OJT of water distribution monitoring - Distribution flow monitoring and records - Minimum night flow analysis - Operation of monitoring system - Distribution flow analysis	10people from Network Section	Japanese Expert - One person×2.03 PM First Input - Basic training of water distribution flow monitoring - Basic training of service connection installation - SOP revision guidance Second input

Field	Outcomes	Activities	Trainees	Inputs
		- Maintenance of distribution facilities (Leakage survey)		-Training of water distribution flow monitoring - Training of service connection installation - SOP revision guidance Third Input - Review - Follow-up training - SOP revision guidance <u>Local Engineer</u> - One person×0.17 P/M <u>Local Staff</u> - One person×1.79 P/M
	(4) Strengthening construction supervision system for service connection installation	1. Study of construction supervision system 2. Review of procedure for installation of service connections 3. OJT for installation of service connection - Installation of service connection - Supervision of construction	5 people from Business Section (Director, Deputy Director, Service connection 3)	
	(7) Revision and creation of SOP	1. Assistance for revision and creation of SOP - Water distribution monitoring - Installation of service connections	10 people from Network Section 5 people from Business Section	
Production management	(5) Improved capability of production management	1. Formulation of efficient management 2. Formulation of sludge treatment plan 3. OJT of production management - Consumption unit - Water supply revenue and cost - Management of WTP - Inventory control - Sludge treatment - Utilization of SOP	9 people (Director General, Deputy Director General, Director of each section) 23 people from Water production Section for the sludge treatment	<u>Japanese Expert</u> - One person×1.43 P/M Second Input - Training of WTP management - Training of sludge treatment - Training of service connection application promotion - SOP creation guidance Third Input - Review - Follow-up training - SOP creation guidance <u>Local Staff</u> - One person×0. 00 P/M (Concurrently serves as operation and maintenance of water distribution facility)
	(6) Implementation of educational activities to promote applications for service connections	1. Assistance for preparing public awareness materials 2. Assistance for implementation of educational activities		
	(7) Revision and creation of SOP	3. Assistance for creation of SOP - Efficient management of WTPs - Sludge treatment		

Source: Survey Team

Item	18	19	20	21	22	23	24	25	26	27	28	29	30	Person / Month	
														Cambodia	Japan
Operation and maintenance of water treatment facilities															
Japanese Expert			0.60P/M				0.80P/M					0.63P/M		—	2.03
Local Engineer							0.17P/M							0.17	—
Local Staff			0.53P/M				0.73P/M					0.53P/M		1,79	—
Maintenance of water distribution facilities															
Japanese Expert			0.60P/M				0.80P/M					0.63P/M		—	2.03
Local Engineer			0.17P/M											0.17	—
Local Staff			0.53P/M				0.73P/M					0.53P/M		1.79	—
Production management															
Japanese Expert							0.80P/M					0.63P/M		—	1.43
Local Engineer														0	—
Local Staff														0	—
Report			▲ Progress Report				▲ Progress Report					▲ Final Report			

Note: The numerical value of the header on the above table shows the number of months since the commencement of construction.
Source: Survey Team

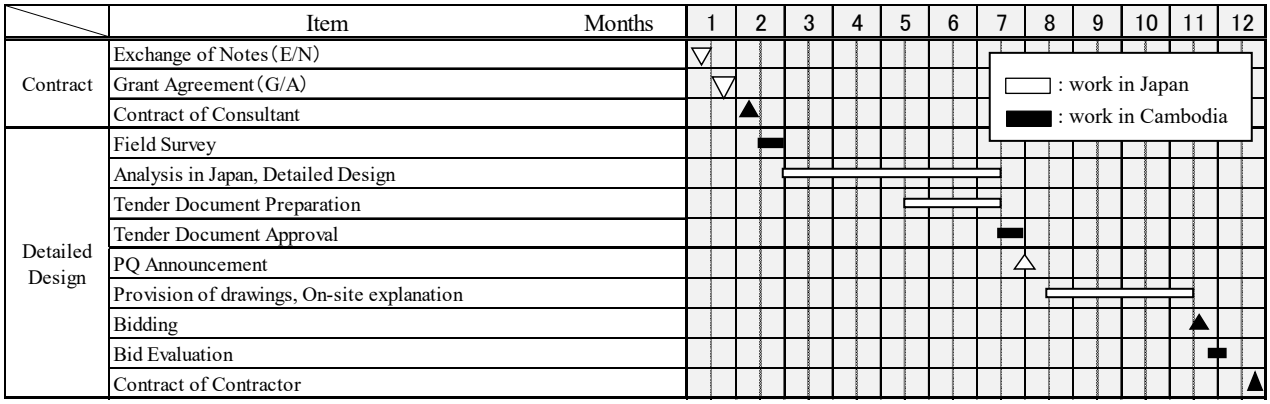
Figure 2-2-46 Draft Schedule of Soft Component

2-2-4-9 Implementation Schedule

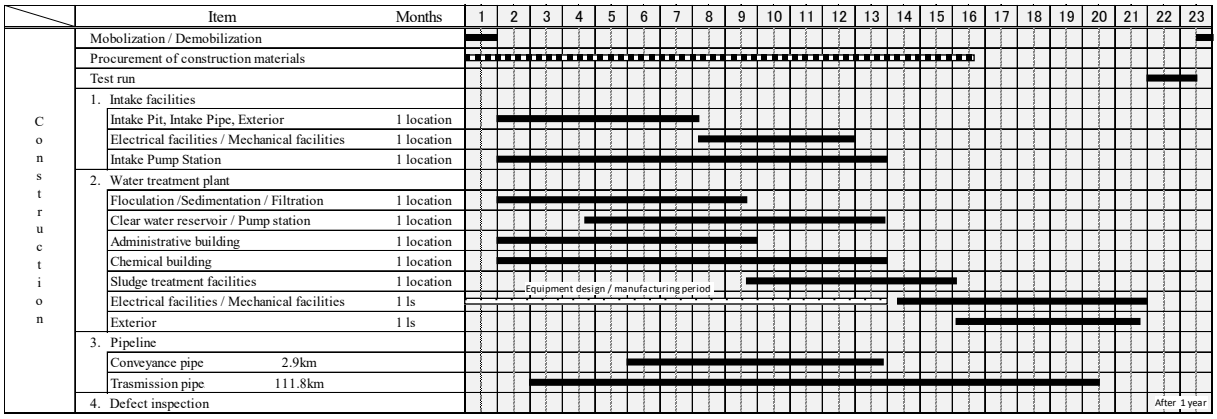
Should the project be implemented under Japan's Grant Aid based on the Grant Agreement (G/A) between the RGC and JICA after the Exchange of Notes (E/N) concluded between the RGC and GOJ, the project shall begin with the detail design study immediately after the signing of contract for consultancy services.

The consultancy services will require 12 months including E/N, engineering design services, preparation of tender documents and tender administration. The total construction period will be 23 months including construction of facilities and procurement of equipment. Thus, total implementation period of the project will amount to 35 months. The implementation schedule from the detail design study to completion of the construction works is as shown in the following figure.

［Detailed Design and Tendering Stage］



［Construction Stage］



Source: Survey Team

Figure 2-2-47 Project Implementation Schedule

2-3 Security Plan

Table 2-3-1 shows the safety management items, inspection frequency and how the implementation during the construction work should be managed. In planning the safety measures, it is also important to monitor whether contractors secure a good labor environment and focusing on safety, not only of persons involved in the work but also third parties and visitors.

Also important are ongoing efforts to thoroughly manage safety by conducting joint safety patrols with the client and contractors as well as regularly holding safety management meetings. Details of a plan for safety measures and inspection frequency are as follows.

Table 2-3-1 Plan for Safety Measures

Item	Details	Inspection Frequency	Witnessing Frequency	Remarks
1. General				
	- Safety competition	As appropriate	As required	Daily management
	- Safety patrolling, etc.			
2. Safety Management				
	- Hazardous material management	As appropriate	As required	Daily management
	- Traffic safety measures			
	- High-place works, etc.			
3. Worker's Clothes				
	- Wearing helmet, etc.	As appropriate	As required	Daily management
4. Security Means				
	- Security guide, etc.	As appropriate	As required	Daily management
5. Clean and Tidy				
	- Organizing material storage, etc.	As appropriate	As required	Daily management
6. Hygiene Management				
	- First-aid kit, etc.	As appropriate	As required	Daily management
7. COVID-19 Prevention				
	- COVID-19 prevention	As appropriate	As required	Daily management
	- COVID-19 vaccination			
8. Anti-crime Measures				
	- Security staff, etc.	As appropriate	As required	Daily management

Source: Survey Team

2-4 Obligations of Recipient Country

"Section 2-4-1, Specific Obligations of the Government of Cambodia, which will not be Funded with the Grant" and "Section 2-4-2, Treated Water Quality of Existing Plant and Facility", show the obligations to be borne by Cambodia before the tender, during the project implementation, and after the project is completed. Section 2-4-3 and the succeeding sections describe the land acquisition, ground leveling for the WTP and intake facility, approval of water intake from Vay Kor Lake, drawing electricity line to the site of WTP and intake facility, occupancy approval of conveyance, transmission and distribution pipe routes, service pipe connection and water meter installation for each household, response to environmental and social consideration, securing of temporary land, etc.

2-4-1 Specific Obligations of the Government of Cambodia, which will not be Funded with the Grant

2-4-1-1 Specific Obligations before the Tender

Table 2-4-1 Obligations of the Recipient Country (Before the Tender)

Item No	Items	Deadline	In charge
1	To open bank account (B/A)	Within 1 month after the signing of G/A	Ministry of Economic and Finance (MEF)
2	To issue A/P to a bank in Japan (the Agent Bank) for the payment to the Consultant	Within 1 month after the signing of contract(s)	MISTI
3	To contract land lease in order to secure the temporary yard	Before notice of the bidding document(s)	MISTI
4	To obtain the planning, zoning, building permit	Before notice of the bidding document(s)	MISTI
5	To clear, level and reclaim the following sites. Embankment at proposed WTP site and Intake Pump Station site.	Before notice of the bidding document(s)	MISTI
6	To explore landmines and UXO at construction site and temporary yard.	Before notice of the bidding document(s)	MISTI
7	To submit Project Monitoring Report (with the result of Detail Design)	Before notice of the bidding document(s)	MISTI

Source: Survey Team

2-4-1-2 Obligations during Project Implementation

Table 2-4-2 Obligations of the Recipient Country (During Project Implementation)

Item No	Items	Deadline	In charge
1	To issue A/P to a bank in Japan (the Agent Bank) for the payment to the Supplier(s)	Within 1 month after the signing of contract(s)	MISTI
2	To bear the following commissions to a bank in Japan for the banking services based upon the B/A		
	(1) Advising commission of A/P	Within 1 month after the signing of contract(s)	MISTI
	(2) Payment commission for A/P	At every payment	MEF
3	To ensure prompt unloading and Customs clearance at ports of disembarkation in Cambodia and to assist the Supplier(s) with internal transportation therein	During the Project	MISTI

Item No	Items	Deadline	In charge
4	To accord the Japanese physical persons and/or physical persons of third countries whose services may be required in connection with the supply of the products and the services as may be necessary, for their entry into Cambodia and stay therein for the performance of their work	During the Project	MISTI
5	To ensure that Customs duties, internal taxes and other fiscal levies which may be imposed in Cambodia with respect to the purchase of the products and/or the services be exempted	During the Project	MISTI
6	To bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project	During the Project	MISTI
7	To submit Project Monitoring Report	Every month	MISTI
	To submit Project Monitoring Report (final)	Within one month after signing of Certificate of Completion for the works under the contract(s)	MISTI
8	To submit a report concerning completion of the Project	Within six months after completion of the Project	MISTI
9	To get permit for construction of temporary access roads for laying water pipes and lease necessary land for approach roads	1 month before the start of construction	Local Communities, MISTI
10	To provide facilities for distribution of electricity, water supply and drainage and other incidental facilities necessary for the implementation of the Project outside the site(s)		MISTI
	(1) Electricity The distribution line to the main road near the proposed facility	Before start of the construction	
	(2)Electricity The distributing line from the main road to the site of proposed facility	2 months before the commissioning test	
	(3) Information System Contracting process of Internet line and GPRS line for the remote monitoring and control system for intake facility and distribution monitoring system	2 months before completion of the construction	
11	To take necessary measures for safety construction - traffic control - rope off	During the construction	MISTI
12	To implement EMP and EMOP	During the construction	MISTI
13	To ensure the safety of persons engaged in the implementation of the Project	During the construction	MISTI
14	To submit results of environmental monitoring to JICA, by using the monitoring form, on a quarterly basis as a part of Project Monitoring Report	During the construction	MISTI
15	To obtain permission for occupancy of roads for the pipe laying work	Before start of the construction for conveyance, transmission, and distribution pipes	MISTI (WWs)
16	To obtain all permissions required for the project implementation such as construction permission for intake facility and the WTP	Before start of the construction	MISTI (WWs)
17	To conduct service pipe connection work, Proposed number of connections is 7,378 HHs[* 1)]. It is assumed that an average of 500 HHs will be connected annually during the construction period. (in 2022: 500 HHs, in 2023: 500 HHs, in 2024: 500 HHs)	During the construction	MISTI (WWs)
18	To recruit new staff members who are necessary for the operation of new system	Up to the end of 2027 Since it is difficult to hire the necessary personnel at once, it is desirable to hire them in stages from 2022.	MISTI (WWs)
19	To establish the construction scheme for the new service pipe	Up to the end of 2027	MISTI

Item No	Items	Deadline	In charge
	connections, including hiring temporary work force. To carry out the technical guidance, budgeting, planning and publicity for enhancing new connections.		(WWs)
20	To identify poor household (planning households is 375[16])	Up to the end of 2027	MISTI (WWs)

Note : *1) House connection number = Water supply population ÷ Number of household members = 55,964÷4.63=12,087HHs, 12,087 (in 2027) - 4,709 (in 2019) = 7,378HHs (Increased house connection)
Source: Survey Team

2-4-1-3 Obligations After the Completion of New Facility in the Project

Table 2-4-3 Obligations of Recipient Country (After Project Completion)

Item No	Items	Deadline	In Charge
1	To implement EMP and EMOP	Within a period based on EMP and EMOP	MISTI
2	To submit results of environmental monitoring to JICA, by using the monitoring form, semiannually The period of environmental monitoring may be extended if any significant negative impacts on the environment are found. The extension of environmental monitoring will be decided based on the agreement between MISTI and JICA.	Within three years after the completion of the Project	MISTI
3	To maintain and use properly and effectively the facilities constructed and equipment provided under the Grant Aid (1) Allocation of maintenance cost (2) Operation and maintenance structure (3) Routine check/Periodic inspection	After the completion of construction	MISTI
4	To work for service pipe connection (proposed number of households is 7,378[*1)]) The implementation plan is maximum 2,000 connections per year after completion. (in 2025: 1,878HHs, in 2026: 2,000HHs, in 2027: 2,000HHs)	Until the end of 2027	MISTI (WWs)
	(1) Establishment of construction scheme including hiring temporary staff for service connection work., providing guidance, budgeting, planning and publicity for enhancing new connections.		MISTI (WWs)
	(2) Connection for poor household (375HHs) - Material is procured by Japanese side, connection work is conducted by Cambodian side. (urban area : 218HHs, rural area : 157HHs) [*2)]		MISTI (WWs)
	(3) Connection for household without poverty group (7,003HHs households) [*3)] - Material and connection work is under responsibility of Cambodian side.		MISTI (WWs)
	(4) To report the results of service pipe connection work to JICA every year		MISTI (WWs)

Note : *1) House connection number = Water supply population ÷ Number of household members = 55,964÷4.63=12,087HHs, 12,087 (in 2027) - 4,709 (in 2019) = 7,378HHs (Increased house connection)
*2) Poor Level 1 households in 2027 is 410HHs, out of which 35 already connected poor households are deducted, and 375 households are expected.
*3) Of the increased connections, the number of households other than poor households will increase to 7,003 households (=7,378-375).
Source: Survey Team

[16] Proposed household number of 375 is an estimation referable in Sub section of 2-2-2-7-(4). At the construction, WWs shall identify the target household.

2-4-2 Treated Water Quality of Existing Plant and Facility

The existing gravity-type steel filter with the capacity of 4,560 m^3/day faced an issue when treating iron and manganese before conducting the repair work supported by ADB and its treatment water quality did not conform to water quality standards in the water quality test conducted in January 2020 after the repair work by ADB. However in April 2020, a membrane filtration facility with the capacity of 2,000 m^3/day newly introduced by Chinese company went into operation, which proves that the water quality is improving in terms of iron and manganese. Therefore, further facility renewal is not required. In the future, the water quality of existing WTP shall continue to be monitored on the Cambodian side.

2-4-3 Land Acquisition and Ground Leveling for WTP and Intake Facility

Land for the WTP was acquired by the WWs from the original landowner in December 2017. An intake pump station will be installed along National Highway No. 1, which crosses the lake and is public land. The land use should be approved by the Provincial Government. According to a meeting held on December 19, 2019, the Vice Provincial Governor commented that no specific problem was considered when using the land but that the design of intake facility should take the landscape into consideration since a ceremony is organized beside Vay Kor Lake every November during the water festival. The land on which the WTP and water intake facility will be built will need to be leveled before starting the construction. As for the scale of the ground leveling needed on the proposed sites, the scope of excavation and embankment will comprise around 13,767 m^3 and 5,067 m^3 for the WTP and intake facility, respectively. Implementing this project will not entail any residential relocation.

Source: JICA Survey Team

Figure 2-4-1 Proposed Site of New WTP

Source: JICA Survey Team

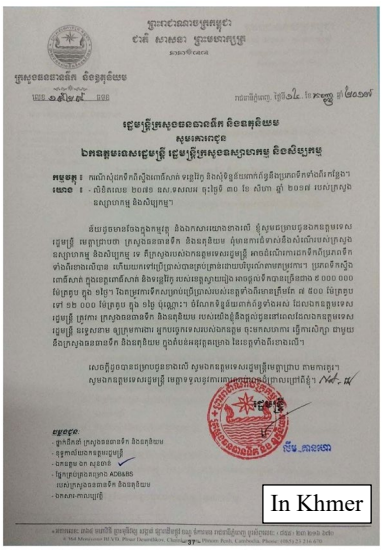
Figure 2-4-2 Proposed Site of New Intake Facility

To acquire land at the intake point, the SWWs should file an application to the Provincial Government via DISTI, a MISTI district office, so that approval can be obtained. The Provincial Government will then notify DOWRAM of the construction location, method and other relevant information.

2-4-4 Approval for Taking Water from Vay Kor Lake

In Cambodia, MOWRAM, as the responsible agency, strives to implement the Integrated Water Resource Management (IWRM), including management of the surface and ground water volume and quality as well as flood/sediment disaster countermeasures based on the Law on Water Resources Management of the Kingdom of Cambodia that was enforced in 2007.

The expected total volume of surface water taken from Vay Kor Lake is around 20,680 m^3/day (= 2,000 x 1.1 + 6,800 x 1.1+11,000) for facilities, including those already in place, a rapid-filtration WTP with capacity of 9,000m^3/day, which will start operation under ADB's assistance and a rapid-filtration WTP with the capacity of 6,800 m^3/day, which will be developed by this project. On the other hand, MISTI obtained MOWRAM's approval to take 12,000m^3/day of water from Vay Kor Lake in September 2017. MISTI also obtained additional approval in July 2021, separately, to take in 11,000 m^3/day of water for the intake facility to be expanded by ADB.



In Khmer

Kingdom of Cambodia

MoWRAM

No. 1929

Phnom Penh, 14 Sepember 2017

Minister of MoWRAM

To

Excellency Senior Minister of MIH

Objective: Request for abstraction of water from Pursat River, Vaiko River and for some data related to both water sources

Reference: Letter no. 2071 dated 30 August 2017 of MIH

With above objective and reference, I would like to inform you, Your Excellency that MoWRAM has no objection to the request of MIH. Your ministry can abstract enough water from both water sources. The Pursat River and Vaiko River can provide water of amount more than 9,000,000 m3/day while the water demand at both cities varies only from 7,500 m3/day to 12,000 m3/day.

Regarding to requested relevant data, it will be provided by MoWRAM when you introduce your study team to cooperate and study with MoWRAM related to Project area of both cities.

Please, Your Excellency be informed.

Your sincerely,

Minister

(Signature and stamp)

LIM Keanhor

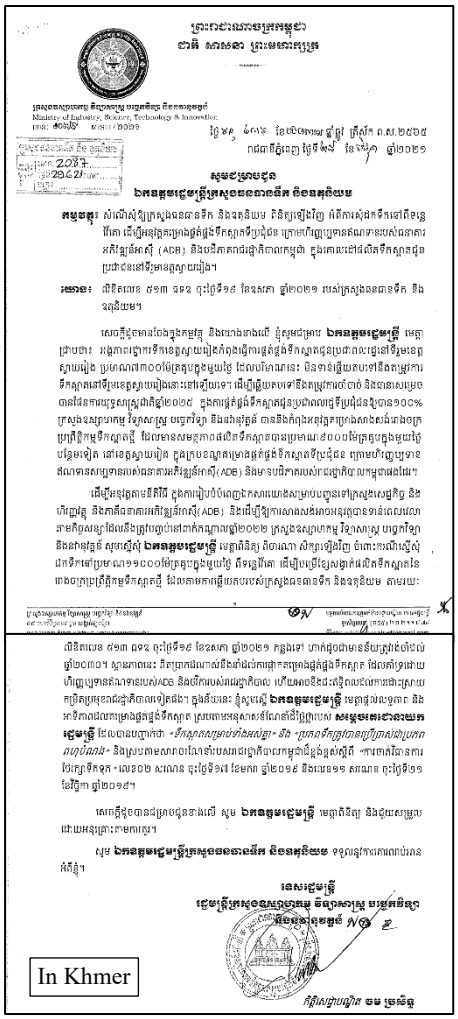
CC:

- Management level of MoWRAM
- Minister cabinet
- H.E. EK Son Chann
- Management level of ADB&BS Project of MoWRAM
- Archive

In English

Source: Survey Team

Figure 2-4-3 An Approval Letter for Water Intake (for 12,000m^3/day, as of September 2017)



In Khmer

Kingdom of Cambodia

MISTI

1079 MISTI/2021

Phnom Penh, 28 Jun 2021

To: Your Excellency Minister of MoWRAM

Objective: Request for Water Abstraction from Vaiko river for the implementation of urban water supply project under ADB loan and GoC counterpart fund for Svay Rieng City

Reference: Letter No. 513 ចរ dated 19 May 2021 of MoWRAM

With above objective and reference, I would like to inform you, Your Excellency that Svay Rieng Waterworks is currently supplying, in Svay Rieng City, the clean water of about 7 300m3/day which does not meet the actual water demand yet. In response to this necessity and to achieve the national strategy stating that by 2025 the urban water supply shall cover 100%, MISTI has been implementing a new project of water treatment plant with the capacity of 9 000m3/day under the ADB loan and government counterpart fund.

To conform to the document procedure of MEF and ADB so that the implementation of the project can be completed on time by 2022, MISTI would like to request you, your excellency to reconsider about the water abstraction of about 11 000 m3/day from Vaiko river for this new water treatment plant project.

According to your letter No. 513 ចរ dated 19 May 2021, it seems that we have to wait until 2030. In this context, we are sure that this Project under ADB loan and Government Counterpart fund will be postponed which would affect government level countermeasure. For this reason, please, Your Excellency, provide the priority for the water supply project conforming to the recommendation of the Samdech Techo Prime Minister which mentioned "Water for All" and "Water sources shall be used for multipurpose" and in accordance to the Government Circulation on "Countermeasure to store water" No. 02 សណណ dated 17 Jan 2019 and No. 11 សណណ dated 21 Nov 2019.

Please, Your Excellency, kindly facilitate the request accordingly.

Yours Sincerely,

Senior Minister

Minister of MISIT

(signature and stamp)

Kitti Setha Pandita Cham Prasidh

In English

Source : Survey Team

Figure 2-4-4 Request Letter for Water Intake (for 11,000m^3/day, June 2021)

In Khmer

Source : Survey Team

Figure 2-4-5 Approval Letter for Water Intake (for 11,000m^3/day, July 2021)

Kingdom of Cambodia

MoWRAM

No. 899

Phnom Penh, 12 July 2021

Minister of MoWRAM

To

Excellency Senior Minister of MISTI

Objective: Request for abstraction of water from Vaiko River for the urban water supply project under the ADB loan and GOC counterpart fund in Svay Rieng City

Reference: Letter no. 1079 MISTI/2021 dated 28 June 2021 of MISTI

With above objective and reference, I would like to inform you, Your Excellency that MoWRAM has no objection to the request of MISTI. We appreciate the effort of MISTI to carry out its mission to respond to people water demand. This water abstraction from Vaiko lake for supply in the Svay Rieng City is actual solution basis.

Please, Your Excellency be informed.

Your sincerely,

Minister

(Signature and stamp)

LIM Keanhor

CC:

- Management level of MoWRAM
- National Project Management Unit
- General Department of Ministry
- នាគាមិក
- Project Management Unit of ADB and WB Project of MoWRAM
- Archive

In English

2-4-5 Drawing Electricity Line to the Site of WTP and Intake Facility

In this project, new transformer systems within the premises of the intake facility and WTP will be installed. The cost of work to draw power from EDC's 22 kV transmission line into each new transformer shall be borne by Cambodia.

Since the intake facility faces National Highway No. 1, electric power will be drawn from EDC's 22 kV transmission line located to the east of the Highway into the transformer system in the premises via a ground line of about 600 m, which, in turn, draws power from the 22 kV distribution line along Prefectural Route 319 into the transformer system of the WTP via an overhead line of about 600 m long.

2-4-6 Occupancy Approval of Conveyance, Transmission and Distribution Pipe Routes

2-4-6-1 Occupancy Approval for National Highway and Bridge-Attached Pipe and Railway

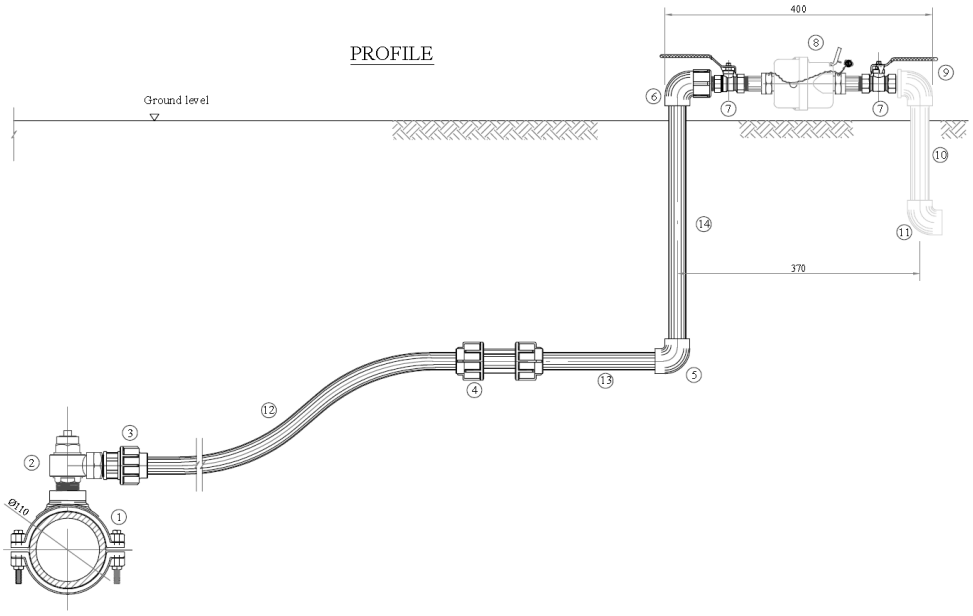
To obtain occupancy approval through the National Highway and bridge attached pipe and railways, the road occupancy approval application should be submitted to MISIT via its district office, DISIT. Subsequently, MISTI informs construction locations, methods and other relevant information to MPWT and applies for its approval. After approving the application, MPWT notifies its approval to MISTI and its local office, DPWT.

2-4-6-2 Occupancy Approval for General Roads

SWWs applies for the general road occupancy with the Provincial Governor via DISTI. After approving the application, the Provincial Governor notifies its approval to DPWT and informs construction locations, method and other relevant information.

2-4-7 Service Pipe Connection and Water Meter Installation for Each Household

The water supply system, including the water meter, service pipe and other accessories at each household from the distribution pipe, is installed by the WWs in response to residents' requests. For general homes, the service pipe diameter is 25 mm while water meter diameter is 15 mm and the standard cost of this equipment and installation (connection fee) is 290,000 KHR. The connection fee is borne by residents (beneficiary fees) but a payment exemption or 12 monthly payment installments is also accepted for poor households.



Source: Survey Team

Figure 2-4-6 Standard Connection Drawing at Each Household

To increase the water supply ratio under this project, there is a need to connect the service pipe to new applicants and procure or install water meters. The cost of these works will be borne by new applicants and the works will be completed by WWs engineers. The project envisages that 7,378 households, including those classed as poor, will be connected to service pipes by the target year of 2027, and up to around 2,000 households are expected to be connected annually by the planned target year. Since about 500 connection works can be implemented annually by a working team of three personnel, four teams with a total of 10 personnel will be needed at peak times. Since the frequency of the water supply equipment work is expected to decline to the current level after the target year, external human resources will be utilized for an additional six personnel at peak season.

To extend the water supply service to poor households, the project includes procurement of water supply equipment (water meter, pipe materials and other accessories) for poor households. The connection cost for this equipment is borne by Cambodia (WWs).

2-4-8 Environmental and Social Considerations

In implementing the project, the following environmental and social considerations were considered by Cambodia.

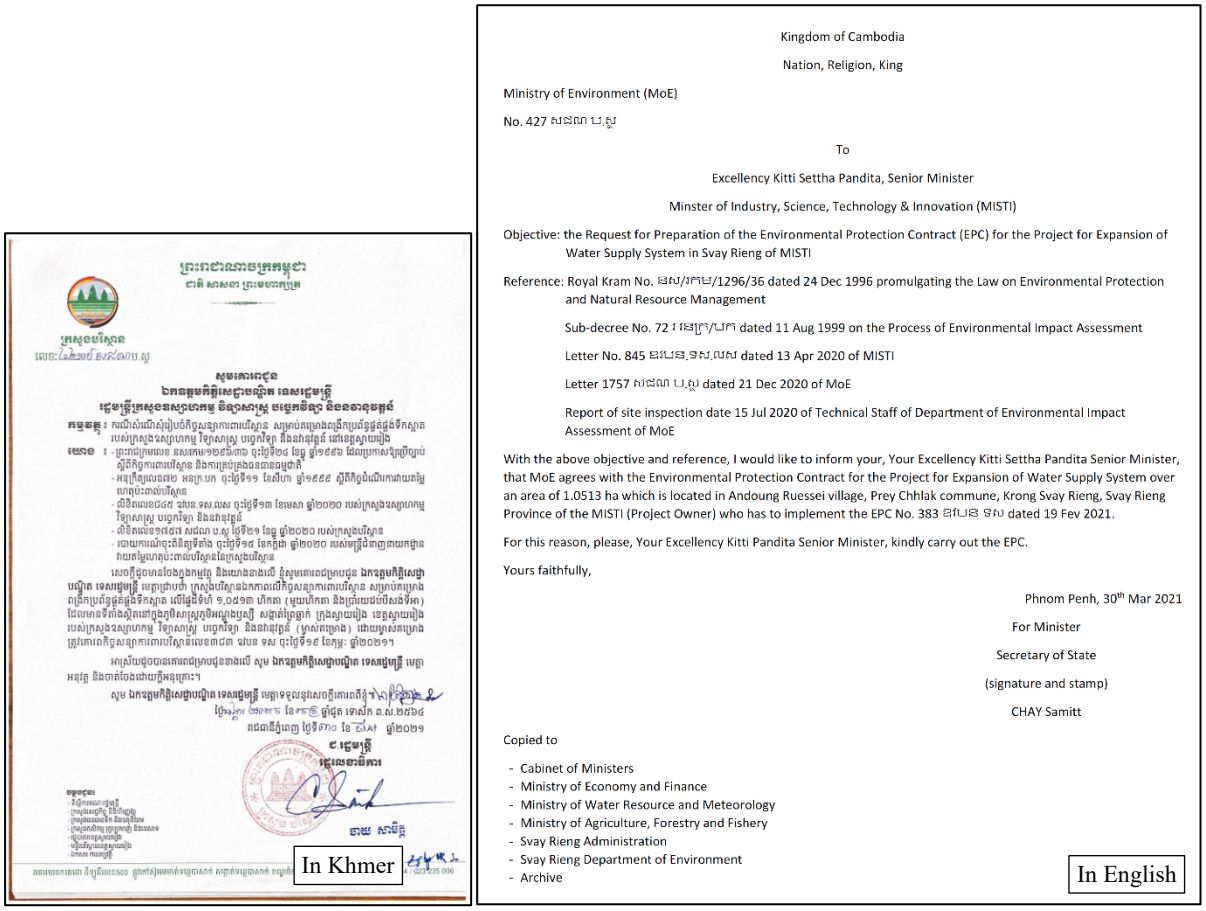
2-4-8-1 Approval of the EPC

Under the Ministerial Ordinance on Classification of the Environmental Impact Assessment of Development Project (Ministry of Environment Ordinance No. 021) which was enforced in 2020, all projects for WTP and water distribution system are subject to the EPC and IEIA or EIA are exempted. The differences from IEIA are as follows:

- Applications can be submitted before preparing a report.

- 28 business days are required for review.
- MOE will establish a technical team for the review, which comprises 12 personnel for the EIA/IEIA as opposed to three to four personnel for the EPC.
- EPC does not require parameters such as water quality, air quality and noise, etc. to be measured

MISTI obtained the EPC approval from the MOE as of March 30, 2021. The meeting of M/D held on April 12,2021 confirmed that the project is implemented in line with the EPC.



In Khmer

Kingdom of Cambodia

Nation, Religion, King

Ministry of Environment (MoE)

No. 427 សជណ ប.ស

To

Excellency Kitti Settha Pandita, Senior Minister

Minster of Industry, Science, Technology & Innovation (MISTI)

Objective: the Request for Preparation of the Environmental Protection Contract (EPC) for the Project for Expansion of Water Supply System in Svay Rieng of MISTI

Reference: Royal Kram No. ឧសរ/រកម/1296/36 dated 24 Dec 1996 promulgating the Law on Environmental Protection and Natural Resource Management

Sub-decree No. 72 អនប្រ/បក dated 11 Aug 1999 on the Process of Environmental Impact Assessment

Letter No. 845 ឱបឧ.ទស.ល dated 13 Apr 2020 of MISTI

Letter 1757 សជណ ប.ស dated 21 Dec 2020 of MoE

Report of site inspection date 15 Jul 2020 of Technical Staff of Department of Environmental Impact Assessment of MoE

With the above objective and reference, I would like to inform your, Your Excellency Kitti Settha Pandita Senior Minister, that MoE agrees with the Environmental Protection Contract for the Project for Expansion of Water Supply System over an area of 1.0513 ha which is located in Andoung Ruessei village, Prey Chhlak commune, Krong Svay Rieng, Svay Rieng Province of the MISTI (Project Owner) who has to implement the EPC No. 383 ឱបឧ ទស dated 19 Fev 2021.

For this reason, please, Your Excellency Kitti Pandita Senior Minister, kindly carry out the EPC.

Yours faithfully,

Phnom Penh, 30th Mar 2021

For Minister

Secretary of State

(signature and stamp)

CHAY Samitt

Copied to

- Cabinet of Ministers
- Ministry of Economy and Finance
- Ministry of Water Resource and Meteorology
- Ministry of Agriculture, Forestry and Fishery
- Svay Rieng Administration
- Svay Rieng Department of Environment
- Archive

In English

Source: Survey Team

Figure 2-4-7 EPC Agreement Letter

2-4-8-2 Implementation of Environmental Management and Monitoring Plans

MISTI, DISTI and the WWs are responsible for monitoring the steady implementation of environmental management and monitoring plans.

The project aims to expand the water supply capacity and will not execute large-scale construction work over a brief period. However, since construction works will be executed in urban and residential areas, the surrounding environment should be taken into consideration. In constructing facilities to supply and treat water and installing piping networks, aspects to take into account include air pollution, water pollution, noise and vibration, etc. When operating the facilities, factors such as noise/vibration and sludge disposal associated with intake and transmission pump operations are also taken into account.

2-4-9 Securing Temporary Site

Sites for lodging, office, temporary storage, etc., which are temporarily needed during the construction period should be secured by leasing and prepared by MISTI. The lease contract should be based on the proper price in accordance with the market price.

The optimal candidate for a temporary yard site is located along Prefectural Road 319, comprising approximately 15,000 m^2 of land owned by the Government of Cambodia.

Since the current candidate waste disposal site only comprises 1,000m^2, a request to secure an alternative site of at least 10,000m^2 was submitted to the SWWs and the Provincial Hall.

Source: Survey Team

Figure 2-4-8 **Location Map of the Candidate Temporary Yard and Waste Disposal Sites**

2-4-10 Others

In implementing the project, the other matters which Cambodia shall handle are as follows:

- Establishing a project implementing unit (PIU) comprising MISTI, DISI and the WWs;
- Increasing the number of WWs officers and ensuring they are properly allocated and trained;
- Inventory management of materials and equipment procured and proper maintenance and management of facilities constructed; and
- Continuous collection and accumulation of project monitoring indicator values.

2-5 Project Operation and Maintenance Plan

2-5-1 Project Operation Plan

In consideration of the volume of work required for the management, operation and maintenance of the expanded water supply facilities in this Project, the organization structure for actual operation of the facilities by 2027 has been studied and the results are as summarized in Table 2-5-1 .

Table 2-5-1 Organizational Structure of the Project Operation by 2027

Section	Responsibilities	Current Number of Staff (2021)	Number of Staff in Target Year (2027)	Increase of Staff
Director General	Comprehensive management	1	1	0
Deputy Director General	Supervision of administration section	1	1	0
Deputy Director General	Supervision of accounting and finance section	1	1	0
Deputy Director General	Supervision of business section/ water production section/ network section	1	1	0
Administration Section	General affairs, personnel, planning	2	3	1
Accounting and Finance Section	Accounting, financing, tariff collection	4	5	1
Business Section	Customer management, water meter readings, service connection installation	8	12	4
Water Production Section	Operation and maintenance of WTP, water quality tests	12	23	11
Network Section	Leakage surveys and repairs, Expansion and updates to network, network management	5(4)*	10	5
Total		35(34)*	57	22

* Number outside of parenthesis indicate the fixed capacity number, and number inside indicate the current situation of vacancies.
Source: Survey Team

(1) Water Production Section

The new WTP shall treat the extracted surface water by the rapid sand filtration method, and the treatment capacity is about 6,800 m^3/day compared to the existing capacity of 6,560 m^3/day. Since the new WTP shall be constructed at a location approximately 5 km away from the existing WTP, a new team shall be organized for its operation and maintenance.

The composition of the Team is as shown in the following items 1) to 4). A Deputy Director shall be assigned to assist the Team Leader of the new WTP, and necessary personnel shall be allocated to the selected current staff and newly hired staff. The total staff members of the Water Production Section shall be increased by eleven (11), but the number of operation and maintenance staff of the existing WTP will not be increased.

1) Deputy Director: 1 officer

One (1) deputy director shall be assigned to supervise the operation and maintenance of the new WTP.

2) Operators: 8 officers

Two (2) officers in the new WTP shall be assigned to the operation staff. For a 24-hour operation, the operation work shall be conducted in two shifts. Four teams of two (2) operators each will be needed as shown in the Table 2-5-2 . An increase of eight (8) staff members will be required. No operator will be in the intake station because the intake pump can be operated and monitored remotely at the new WTP.

Table 2-5-2 Work Shift for the Operation of the New WTP

		Mon			Tue			Wed			Thu			Fri			Sat			Sun		
		A	B1	B2	A	B1	B2	A	B1	B2	A	B1	B2	A	B1	B2	A	B1	B2	A	B1	B2
Team1	Staff 1	O				O				O				O				O				O
	Staff 2	O				O				O				O				O				O
Team2	Staff 3				O				O				O				O				O	
	Staff 4				O				O				O				O				O	
Team3	Staff 5		O				O				O				O				O			
	Staff 6		O				O				O				O				O			
Team4	Staff 7			O				O				O				O				O		
	Staff 8			O				O				O				O				O		

Shift A 08:30–17:00
Shift B1 16:30–01:00
Shift B2 00:30–09:00

Source: Survey Team

3) Maintenance Officer:1 officer

One (1) staff will be assigned for the maintenance of facilities, free from chemical and other daily duties. If manpower is required, such as dealing with equipment failures or cleaning the sedimentation basin, one (1) of the deputy directors and (1) one of the operators shall support the maintenance staff.

4) Water Quality Testing Officer: 1 officer

A laboratory shall be prepared at the new WTP. The new WTP needs to treat surface water, which has greater turbidity fluctuations than groundwater treated with the existing WTP. Therefore, daily water quality management is important. One (1) staff shall be assigned for the water quality testing.

(2) Network Section

The pipe network shall be extended to approximately 112km. The supply area shall also be expanded. Based on the experiences in other cities, it is estimated that the number of maintenance staff needed for a 100-km pipe network is 4.7 staff. Therefore, the number of staff members in the network section shall be increased from five (5) staffs to ten (10) staffs. After the increase, the number of staff members will be three (3) staffs for leakage survey and repairing, three (3) staffs for network expansion and updates, and two (2) staffs for network management.

(3) Business Section

As of 2019, two (2) staffs check about 4,700 water meters every month. It is estimated that approximately 12,000 water meters need to be installed by the target year. Therefore, the number of meter readers shall be increased from two (2) staffs to five (5) staffs.

Regarding the installation of service connections, it is necessary to carry out plenty of connections systematically until the target year. However, after the completion of the installation period, the service will be back to normal. Therefore, additional staffs during the busiest period shall be supplied through outsourcing and not the increase in the number of staff members at SWWs. Specifically, one (1) staff member and two (2) outsourced staffs shall be grouped into one group, and a three-group system shall be established.

Currently, customer management is handled by a Director. However, in the target year, the number of water supply connections will more than double, so that two (2) staffs shall be assigned for customer management. The Director shall manage the Sales Section, which is the original business assignment.

Therefore, the number of employees in the Business Section as a whole shall be increased by four (4) staffs, and as a result, the number of employees will be increased to twelve (12) staff members.

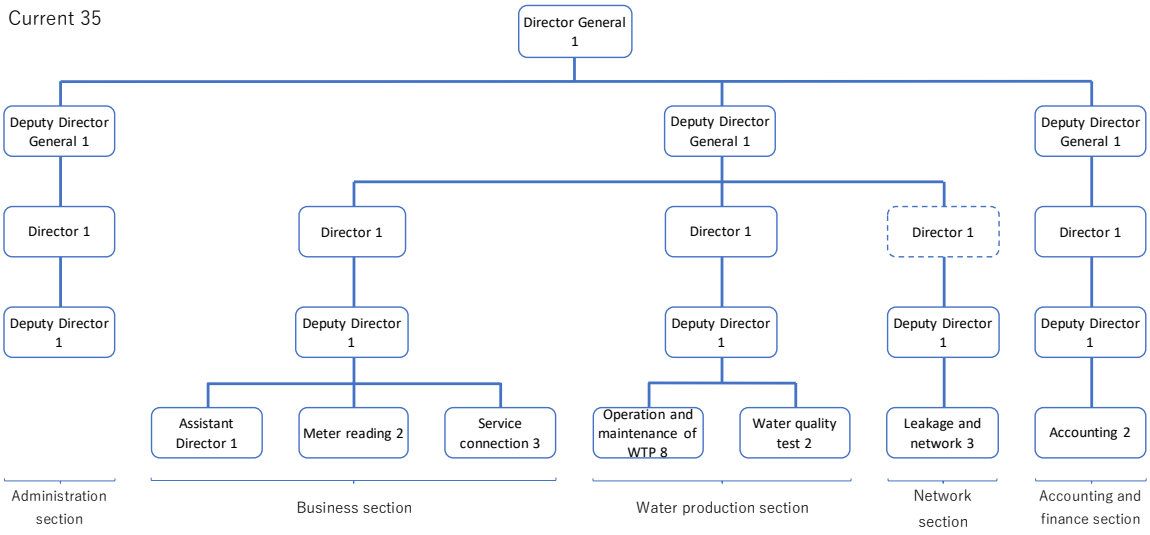
(4) Accounting and Finance Section

The amount of work for the Accounting and Finance Section which is related to water tariff collection and financial and fiscal works is expected to increase. Although the SUMS system has been implemented in the capacity building project, there is still a shortage of manpower. Therefore, the number of staff members in the section shall be increased by one (1) staff, from the current four (4) staff members to five (5) staff members.

(5) Administration Section

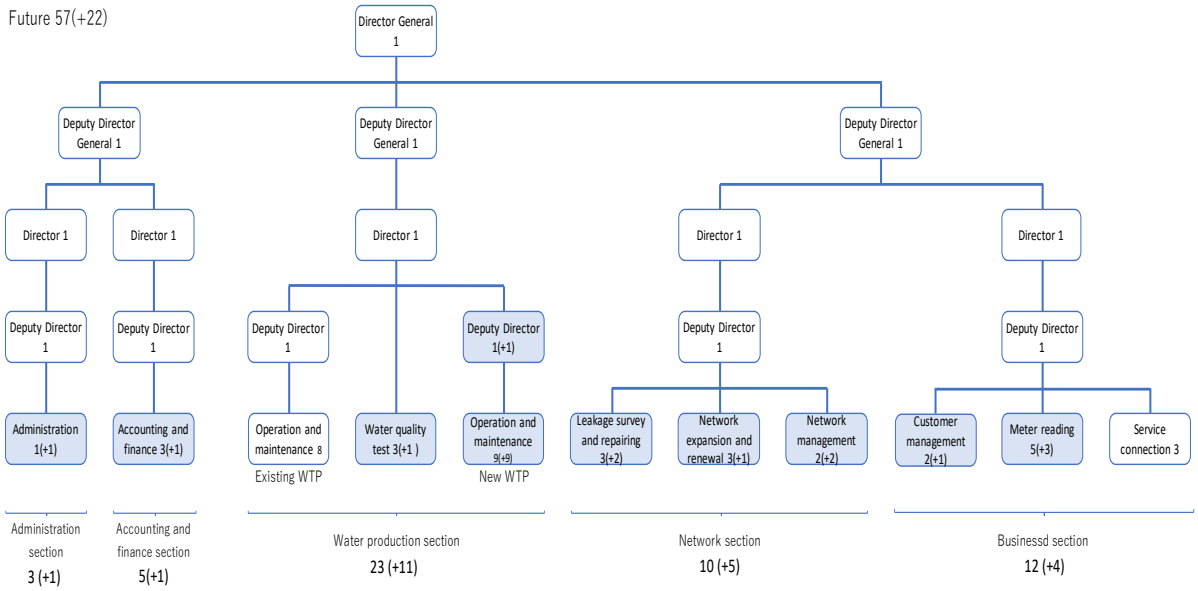
There will be no new work for the administration section as a result of the implementation of this project. However, since the administration section is the department in charge of the management work of each section, the work will increase as the number of staff members increases due to the construction of the new water facilities. The current number of staff members shall be increased by one (1) staff from two (2) staff to three (3) staff members.

Figure 2-5-1 and Figure 2-5-2 show the current and future organizations of SWWs, respectively.



Source: Survey Team

Figure 2-5-1 Current Organizational Chart of SWWs



Source: Survey Team

Figure 2-5-2 Future Organizational Chart of SWWs

As shown in Table 2-5-3, the number of staff members systematically increases by the target year. The number of staff members for Water Production Section and the Network Section should reach the targeted number by 2025 when the operation of the new WTP starts.

Table 2-5-3 Personnel Plan

Section/Year	2019	2020	2021	2022	2023	2024	2025	2026	2027
Water Production Section	9	9	12	15	18	23	23	23	23
Network Section	4	4	5	5	7	10	10	10	10
Business Section	7	8	8	8	9	11	11	11	12
Accounting and Finance Section	4	4	4	4	4	5	5	5	5
Administration Section	2	2	2	2	2	3	3	3	3

Section/Year	2019	2020	2021	2022	2023	2024	2025	2026	2027
Director and Deputy Director	4	4	4	4	4	4	4	4	4
Total	30	31	35	38	44	56	56	56	57
Outsourcing of Service Connections					3	6	6	6	6
Number of Water Supply Households	4,709	5,579	6,005	6,429	6,854	8,830	9,502	10,784	12,087
Construction work					◄	———	►		

Source: Survey Team

2-5-2 On-site Maintenance

The proposed operation and maintenance items for the new facilities is as shown in Table 2-5-4.

Table 2-5-4 Operation and Maintenance Items

Facility Section	Work Section	Work Contents	Frequency	Remarks
Intake Facility	Maintenance	Routine maintenance check	Daily	
		Regular check of pump and motor	Twice / Month	
		Regular check of electrical equipment	Twice / Month	
		Drainage of sludge in pit	Monthly	
		Screen cleaning	Weekly	
Treatment Facility	Water Treatment	Intake pump operation	Daily	Operate remotely from the WTP
		Condition of coagulation and flocculation	Daily	
		Coagulant dissolving and dosing rate	Daily	Based on Jar test and floc
		Lime dissolving and dosing rate	Daily	Based on pH
		Chlorine dissolving and dosing rate	Daily	Residual chlorine（pre, and post）
		Filtration Operation	Daily	
		Filter sand washing	Daily	
		Sludge pump operation	Daily	
		Sludge drying bed checking	Daily	Water content
		Drainage of sludge in sedimentation basin	As needed	
		Sedimentation basin cleaning	Once / 4 month	
		Sludge basin cleaning	Once / 2month	
		Observation of sludge conveyance	Once / 2month	
		Filter layer Measurement	Yearly	
		Quality of filter sand	Yearly	Effective size, uniformity coefficient
		Water level monitoring	Daily	Receiving well, sedimentation basin, filtration basin, service reservoir, etc.
		Recording daily operation	Daily	
	Water Quality Analysis	Essential analytical items	Daily	Turbidity, residual chlorine, pH, water temperature, etc.
		Important analytical items	Once / 3 month	Aluminum, ammonium nitrogen, etc.
		Jar test	Daily	
		Water quality instrument cleaning	Weekly	
		Residual Chlorine in tap water	Twice / Month	Several places

Facility Section	Work Section	Work Contents	Frequency	Remarks
		Daily record of water quality	Daily	
		Monthly record of water quality	Monthly	
	Electrical and Mechanical Facilities	Routine maintenance check	Daily	Checking of instrument abnormality
		Minor fault repairing	Daily	
		Regular check of pump and motor	Twice / Month	
		Regular check of electric valve	Twice / Year	
		Regular check of chemical equipment	Twice / Month	
		Washing chemical pipe	As needed	
		Regular check of level gage	Twice / Year	Filter basin, service reservoir
		Insulation resistance and earthing resistance test	Yearly	Electrical facilities
	Others	Cleaning work	Daily	
		Security duties	Daily	
Distribution Facility	Distribution Facility Operation	Pump operation	Daily	
		Recording pump operation	Daily	
		Operation daily schedule	Daily	
		Recording monthly operation	Monthly	
	Distribution flow and pressure Monitoring System	Recording water flow data	Daily	
		Water flow and pressure analysis	Daily	
		Implementation of leakage survey	As needed	
		Leakage repair	As needed	
	Distribution Facility Maintenance	Water quality check of distribution network	Twice / Month	
		Pipe Cleaning	As needed	
		Pipe inspection	As needed	
		Attendance and checking for other construction	As needed	
Production Management	Maintenance Duties	Making annual report	Yearly	
		Chemical stock management	Daily	Coagulant, lime, chlorine
		Sludge treatment plan	As needed	

Source: Survey Team

2-6 Project Cost Estimation

2-6-1 Initial Cost Estimation

The project cost borne by the Cambodian side is estimated at about USD 668,229 and its breakdown is shown in Table 2-6-1.

Table 2-6-1 Project Cost borne by Cambodian Side

Items	Contents	USD
Land Preparation	Land leveling for the intake and WTP site	496,340
Temporary Yard	Rental cost for temporary yard	50,000
	UXO	22,104
Environmental Consideration	Environmental monitoring for noise, vibration and treatment of dry sludge (during the project implementation)	8,842
Information System	Contracting process of Internet line and GPRS line for the remote monitoring and control system for intake facility and distribution monitoring system	4,421
Electricity Supply	Transmission of electricity to the intake and WTP facilities	38,424
Bank Charge, Commission	Bank arrangement (B/A) charge and commission of authorization to pay (A/P)	22,104
Connection Fee※1	Installation of connection equipment for poor households (1evel 1 : 375 houses, level 2 : 330 houses※2)	3,527
	Connection equipment for poor households (level 2 : 330 houses)	22,467
合計		668,229

※1 : 60% of poor level 2 households (826 x 0.6=496HHs) and normal households (6,177 HHs) shall bear their material and construction costs. It is expected that the material cost shall be USD 453,764 and the labor cost for construction shall be USD 33,365.
※2 : 40% of poor level 2 households (826 x 0.4=330HHs)
Source : Survey Team

2-6-2 Operation and Maintenance Cost

2-6-2-1 Analysis of Financial Conditions

(1) Financial Statements

Profit and Loss Statement

Outline of Profit and Los (PL) Statement of SWWs for last five years is shown below.

Table 2-6-2 Outline of Profit and Los Statement of SWWs

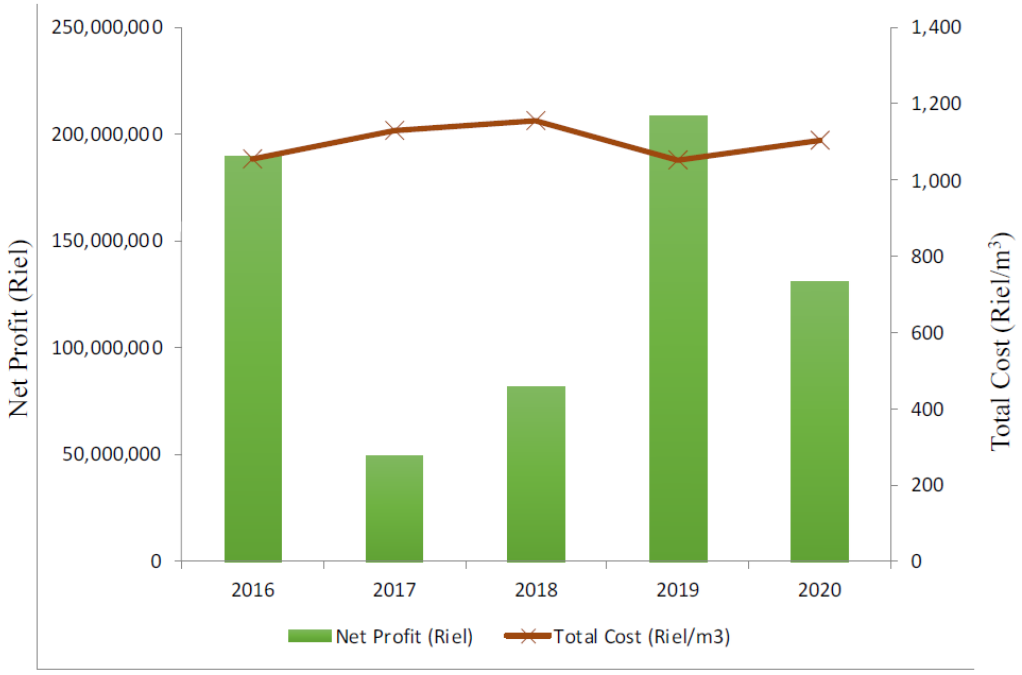
(Unit: Riel)

Fiscal Year	2016	2017	2018	2019	2020
Revenues					
Water Sales	1,323,267,600	1,480,459,600	1,640,370,500	1,849,663,300	2,091,262,000
Other Revenues	155,850,500	109,070,100	175,334,000	158,895,500	147,112,600
Revenue Total	1,479,118,100	1,589,529,700	1,815,704,500	2,008,558,800	2,238,374,600
Expenditures					
Personnel	177,499,200	285,742,900	351,822,300	348,300,900	400,876,400
Material/Chemical	22,131,600	30,312,100	45,560,388	49,413,000	77,674,384
Electricity/Fuel	382,680,900	424,824,600	476,768,465	499,443,948	319,016,661
Depreciation	311,710,311	362,081,666	395,569,893	400,946,764	403,971,970
Interest Payment	0	0	144,847,200	87,225,078	34,294,700
Taxes	17,221,100	18,928,778	6,405,000	21,724,400	26,012,500
Others	378,301,500	417,954,700	312,945,582	392,872,840	845,207,473
Expenditures Total	1,289,544,611	1,539,844,744	1,733,918,828	1,799,926,930	2,107,054,088
Net Profit	189,573,489	49,684,956	81,785,672	208,631,870	131,320,512

Source: SWWs

According to the PL Statement above, the net profit had resulted in positive continuously from 2016 to 2020.

The total cost per 1 m^3 water production and the net profit are shown in the following figure. And although net profit is consistently generated, it can be seen that the amount fluctuates relatively significantly. Therefore, in order to maintain a surplus in a single year in the future, it is necessary to pay attention to the increase in overall costs.



Source: SWWs

Figure 2-6-1 Net Profit and Total Cost per 1 m^3 Production in SWWs

Balance Sheet

Outline of Balance Sheets (BS) of SWWs for last five years is shown below.

Table 2-6-3 Outline of Balance Sheet of SWWs

(Unit: Riel)

Fiscal Year	2016	2017	2018	2019	2020
Non-Fixed Assets	1,072,081,520	360,530,000	282,985,265	437,391,999	418,065,782
Fixed Assets	7,394,058,748	8,845,449,602	8,786,111,709	8,631,749,844	8,585,059,074
Asset Total	8,466,140,268	9,205,979,602	9,069,096,974	9,069,141,844	9,003,124,856
Non-Fixed Liability	248,892,800	939,047,178	68,142,778	68,160,278	69,003,678
Fixed Liability	79,514,100	79,514,100	731,750,200	523,143,700	324,962,800
Liability Total	328,406,900	1,018,561,278	799,892,978	591,303,978	393,966,478
Equity	9,974,835,720	9,974,835,720	9,974,835,720	9,974,835,720	9,974,835,720
Retained Earnings	-1,837,102,352	-1,787,417,396	-1,705,631,724	-1,496,997,854	-1,365,677,342
Capital Total	8,137,733,368	8,187,418,324	8,269,203,996	8,477,837,866	8,609,158,378
Liability and Capital	8,466,140,268	9,205,979,602	9,069,096,974	9,069,141,844	9,003,124,856

Source: SWWs

According to the BS above, SWWs' retained earnings had been consistently negative, but the PL Statement also consistently had produced net profit, so the negative amount has been reduced.

The management status of SWWs will be examined based on commonly used management indicators hereinafter.

1) Ratio of Equity to Total Assets

Ratio of equity to total assets is the indicator of a long-term stability for water supply business, which is calculated by the following formula:

$$\text{Ratio of Equity to Total Assets} = \frac{\text{Capital Total}}{\text{Liability and Capital}}$$

The larger the ratio, the more expected is long-term stability of the business. The ratio of SWWs for last five years is shown below:

Table 2-6-4 Ratio of Equity to Total Assets of SWWs

Fiscal Year	2016	2017	2018	2019	2020
Ratio of Equity to Total Assets	96.1%	88.9%	91.2%	93.5%	95.6%

Source: SWWs

SWWs has been continuously showing a high ratio, comparing with the national average of Japanese water supply entities in 2015, 69.5%. It does not necessarily show the long-term stability of SWWs, but it is due to the low amount of liability. The water supply business in Japan has been successful in rapid expansion of prevalence rate with aggressive capital investment, introducing long-term and low interest financing by issuing bonds, in the developing period. The most of business entities in that era showed 20% to 30% of the ratio. Presently, Cambodia has no financing system such as bond issuing as in Japan, thus public water supply business cannot access long-term and low interest financing which is necessary for capital investment. If it is assumed that the business will be managed in the future with independent accounting in the setup of a government corporation, unavailability of long-term and low interest financing could be an obstacle to the independent stability or expansion of the business.

2) Current Ratio

Current ratio is the indicator of capability to pay back current liabilities or the short-term stability for water supply business, which is calculated by the following formula:

$$\text{Current Ratio} = \frac{\text{Current Asset}}{\text{Current Liability}}$$

Current ratio is required to be 100% or more. If it is lower than 100%, it means that the business entity has bad debts. The current ratio of SWWs for last five years is shown below:

Table 2-6-5 Current Ratio of SWWs

Fiscal Year	2016	2017	2018	2019	2020
Current Ratio	430.7%	38.4%	415.3%	641.7%	605.9%

Source: SWWs

SWWs has been continuously showing high current ratio, more than 400% except 2017. This also does not necessarily indicate short-term stability of business, and is due to the fact that long-term, low-interest financing is not possible, resulting in low amount of liability and low annual interest payments.

2-6-2-2 Water Consumption

Revenue water for last five years in SWWs is shown below:

Table 2-6-6 Composition of Revenue Water by User Category

(Unit: m^3)

	2016	2017	2018	2019	2020
Domestic	846,460	956,171	1,094,849	1,231,363	1,407,805
Commercial	119,168	131,287	100,948	110,503	100,727
Institution	137,095	142,049	163,957	192,347	225,439
3 m^3 or less	0	4,592	6,136	6,927	6,438
Total	1,102,723	1,234,099	1,365,890	1,541,140	1,740,409

Note: "3 m^3 or less" is explained in 2-6-2-3.
Source: SWWs

Revenue water in SWWs increased by 1.58 times in seven years, whose annual average growth rate is nearly 9.56%.

2-6-2-3 Water Charge Revenue and NRW Rate in Present Conditions

The water charge in SWWs is 1,200 Riel per m^3, which is the same for all user categories. In addition, a special charge of 1,100 Riel per m^3 was set from 2017 when the monthly usage is 3 m^3 or less for the purpose of measures for the poor. However, if it exceeds 3 m^3, the general charge of 1,200 Riel per m^3 will be applied for all the usage.

Table 2-6-7 Water Charge Revenue

(Unit: Riel)

	2016	2017	2018	2019	2020
Domestic	1,015,752,000	-	1,319,994,000	1,482,411,300	1,696,464,900
Commercial	143,001,600	-	121,015,800	133,060,800	120,888,900
Institution	164,514,000	-	196,751,500	230,816,400	270,526,800
3 m^3 or less	0	-	2,609,200	3,374,800	3,381,400
Total	1,323,267,600	1,480,459,600	1,640,370,500	1,849,663,300	2,091,262,000

Note: Detailed data for 2017 were not provided.
Source: SWWs

The NRW rate was maintained 11 - 10% as shown below. It reached the 9% level in 2020.

Table 2-6-8 Water Distribution and Non- Revenue Water Rate

(Unit: m^3)

	2016	2017	2019	2019	2020
Water Distribution	1,102,723	1,234,099	1,365,890	1,542,166	1,740,409
Non-Revenue Water	119,972	136,223	136,893	174,660	164,825
NRW Rate	10.88%	11.04%	10.02%	11.33%	9.47%

Note1: "Non-revenue water" is the supplied water amount that is not the revenue water.
Note2: In 2020, it will include water supply from the "2,000 m^3/day membrane filtration facility newly introduced by a Chinese company".
Source: SWWs

2-6-2-4 Forecast of Water Distribution in the Future

The result of water demand forecast for SWWs is shown below. The construction of JICA Grant Aid facility will be completed in 2025. The maximum water distribution per day is 15,293 m^3/day (The daily average water distribution is calculated at 11,531 m^3/day) in the target year 2027. As the capacity of the other facilities (the existing facility + 2,000 m^3/day membrane filtration plant + ADB facility) than this project is 8,578 m^3/day, that of this project facility is estimated at 6,715 ≅ 6,800 m^3/day. The breakdown of the daily maximum water supply amount in the target year is as follows.

Table 2-6-9 Breakdown of the Daily Maximum Water Supply Amount in the Target Year

Facility Type	Daily Maximum Water Supply Amount (m^3/day)
Existing Rapid Filtration Facility	4,560
Existing Membrane Filtration Facility	2,000
Facility to be Expanded by ADB	2,018
Facility to be expanded by JICA	6,715
Total	15,293

Source: Survey Team

The areas to which water is distributed immediately by the facility expanded by ADB as shown above are three villages (Thma Sa, Trabaek and Svay Kngao) in Svay Chrum Commune and three villages (Pnov, Angkeas Dei and Ta Pa) in Ta Sous Commune. The population served there is 9,404 and the daily maximum water supply amount is 2,018 m^3/day.

(1) The Other Facilities than this Project

It is appropriate that the maximum water distribution by the existing facility deems 4,225 m^3/day (1,542,166 m^3/year), which is the actual figure in 2019. It should be noted that 2,000 m^3/day (730,000 m^3/year) among the total water should be supplied from the "2,000 m^3/day membrane filtration plant newly introduced by a Chinese company" due to the constraint of the contract. In addition, ADB plans to operate a new WTP of 9,000 m^3/day from the middle of 2023. In addition, NRW rate from 2027 is assumed to be 15 %, which is designated by the planning rule on the demand projection. It is gradually increased to 15 % from 2021 to 2026 in order to keep consistency with the actual figures up to 2020.

(2) Expansion Facilities to be Constructed by this Project

Water distribution from the expansion facilities to be constructed by this project is assumed to start from April 2025. However, due to the schedule of connection works, only 37.5% of the water supply capacity will be utilized in 2025 and 70% in 2026, and it is planned to reach 100% by the end of 2027.

Table 2-6-10 Breakdown of Total Water Distribution and Total Revenue Water (Forecast)

(Unit: m3)

	2021	2022	2023	2024	2025	2026	2027
Total Water Distribution	1,929,256	2,138,592	2,247,166	2,358,620	2,799,087	3,499,065	4,208,913
2,000 m^3/day membrane filtration plant	730,000	730,000	730,000	730,000	730,000	730,000	730,000
Existing Facility	1,199,256	1,408,592	1,145,633	390,175	0	0	0
ADB Facility	0	0	371,534	1,238,445	1,542,748	1,459,065	1,794,627
This project facility	0	0	0	0	526,339	1,310,000	1,684,285
Total Revenue Water	1,736,331	1,903,346	1,977,506	2,051,999	2,407,215	2,974,205	3,577,576

Source: Survey Team

2-6-2-5 Operation and Maintenance Cost in Future

(1) Estimation of Unit Costs

Unit costs of the operation and maintenance items are estimated by referring the past records of the existing facilities and so on as shown below. As for the ADB facility, since specific figures could not be obtained, the same unit costs as this project are used in consideration of the same water purification method as this project.

Table 2-6-11 Estimation of Unit Cost for O&M

Item	Unit Cost (Riel)	Ground
Personnel	12,931,497 (per person/year)	Record in 2020 1)
Outsourcing	12,931,497 (per person/year)	Personnel Cost in 2020
Service charge for 2,000 m^3/day membrane filtration plant (1^{st} – 12^{th} month and 73^{rd} – 240^{th} month)	723 (per 1 m^3 distribution)	Contract for 2,000 m^3/day membrane filtration plant : SWWs had previously borrowed the fund for pipeline expansion from the Chinese side, and will repay the loan with this price increase.
Service charge for 2,000 m^3/day membrane filtration plant (13^{rd} – 72^{nd} month)	1,052 (per 1 m^3 distribution)	Contract for 2,000 m^3/day membrane filtration plant
Material/Chemical (Existing facility)	60 (per 1 m^3 distribution)	Average of records in 2016 - 2019 2)
Material/Chemical for this project	146 (per 1 m^3 distribution)	Design
Fuel/Electricity	341 (per 1 m^3 distribution)	Average of records in 2016 - 2019 2)
Fuel/Electricity for this project and ADB facility	388 (per 1 m^3 distribution)	Design
Electricity for 2,000 m^3/day membrane filtration plant	108 (per 1 m^3 distribution)	Records in 2020
Depreciation (Existing facility)	281 (per 1 m^3 distribution)	Average of records in 2016 - 2019 2)
Interest Payment	41 (per 1 m^3 distribution)	ditto
Taxes	12 (per 1 m^3 distribution)	ditto
Others (in proportion to water dist.)	291 (per 1 m^3 distribution)	ditto
Others (in proportion to the number of workers)	3,497,398 (per person/year)	ditto

Note 1): It is assumed that personnel cost cannot be reduced without an extraordinary reason.

Note 2): The expenditure ratio for each item was changed in 2020 due to 2,000 m^3/day membrane filtration plant, so the average of records in 2016 to 2019 is used.

Source: Survey Team

(2) Personnel Plan

Number of staff members of the present system is as follows:

Table 2-6-12 Number of Staff Members in Present System

	2016	2017	2018	2019	2020	2021
Director	1	1	1	1	1	1
Deputy Director	3	3	3	3	3	3
Administration and Planning Section	1	2	3	2	2	2
Accounting and Finance Section	3	4	4	4	4	4
Business Section	6	7	7	7	8	8
Production Section	5	8	8	9	9	9+(3)
Network Section	4	6	6	4	4	4+(1)
Total	23	31	32	30	31	31+(4)

Note: ( ) indicates the number of personnel for the facility of ADB.
Source: SWWs

Total number of staff members in the present system is 35 (4 of them are staff hired for ADB facilities). Total number of staff members will be increased gradually to 57 in 2027. Assuming this, the personnel plan until 2027 will be as follows:

Table 2-6-13 Personnel Plan

	2022	2023	2024	2025	2026	2027
Director	1	1	1	1	1	1
Deputy Director	3	3	3	3	3	3
Administration and Planning Section	2	2	3	3	3	3
Accounting and Finance Section	4	4	5	5	5	5
Business Section	8	9	11	11	11	12
Production Section	12+(3)	15+(3)	20+(3)	20+(3)	20+(3)	20+(3)
Network Section	4+(1)	6+(1)	9+(1)	9+(1)	9+(1)	9+(1)
Total	34+(4)	40+(4)	52+(4)	52+(4)	52+(4)	53+(4)
Outsourcing	-	3	6	6	6	6

Note 1: A part of connection services will be outsourced from 2023 to 2027.
Note 2: ( ) indicates the number of personnel for the facility of ADB.
Source: Survey Team

The estimated increase in labor cost is shown in Table 2-6-14.

Table 2-6-14 Estimated Increased Labor Cost (USD※1)

Organization	Items	2021	2022	2023	2024	2025	2026	2027
WWs	Increased employees※2		3	6	12	0	0	1
	Increased cost		9,387	18,774	37,548	0	0	3,129
External resource	Employment			3	6	6	6	6
	Cost			9,387	18,774	18,774	18,774	18,774
	Increased cost			9,387	9,387	0	0	0
Total of Increased cost			9,387	28,161	46,935	0	0	3,129

※1: Estimated as the average person labor cost (USD3,129/person/year) based on the records of 2020.
※2: The number of increased employees compared with the previous year
Source: Survey Team

2-6-2-6 Forecast of Revenues and Expenditures for SWWs

Based on the estimated revenue water and unit costs of O&M mentioned above, a forecast of revenues and expenditures for the SWWs is examined with the conditions shown below:

Conditions for Forecast of Revenues and Expenditures

i. The same general water charge is set per 1 m^3 for all user categories as the present one. Special water charge is 1,100 Riel per m^3, which is fixed on the forecast;
ii. Facilities/equipment constructed/installed on this project and ADB are not depreciated;
iii. Interest payment and redemption of the loan for ADB facility construction are not born by SWWs
iv. NRW rate is set at 15%; and
v. Price escalation is not included basically. (Other than one consideration at the request of the Cambodian side.)

Analysis on Forecast of Revenues and Expenditures (Existing Water Charge Rate)

According to the table below, the current rate of 1,200 Riel per m^3 will continue to make the financial result be in the red from 2021, and it will be able to return to the black in 2027. Therefore, the cumulative deficit will be 68 million yen even within this forecast period. The reason is that the introduction of the 2,000 m^3/day membrane filtration plant will increase the cost per m^3 of water distribution, compared to the existing facility. Rather, it can be said that the cost of the existing facility was low because they used groundwater with good water quality. The water supply ratio of the existing facility with low costs, ADB facility and this project facility, which are much lower costs, will gradually increase, but on the other hand, costs that are not proportional to the amount of water supply, such as labor costs, will also increase. As a result, the deficit amount will decrease when the water supply ratio of the ADB facility and this project facility rises to a certain extent.

Table 2-6-15 Forecast of Revenues and Expenditures (Existing Charge Rate)

Unit: Million Yen

	2021	2022	2023	2024	2025	2026	2027
Water Charge (Riel/m^3)	1,200	1,200	1,200	1,200	1,200	1,200	1,200
Revenues							
Water Sales	55.4	60.8	63.1	65.5	76.8	94.9	114.2
Other Revenue	4.3	4.8	5.1	5.3	6.3	7.9	9.5
Revenues Total	59.8	65.6	68.2	70.8	83.1	102.8	123.7
Expenditures							
Personnel	12.0	13.1	16.2	21.3	21.3	21.3	21.7
Material/Chemical	1.9	2.2	3.3	5.4	8.1	10.8	13.5
Electricity/Fuel	12.9	14.8	16.2	18.4	23.5	30.7	38.0
Depreciation	9.0	10.5	8.6	2.9	0.0	0.0	0.0
Interest Payment	2.1	2.3	2.4	2.6	3.0	3.8	4.6
Taxes	0.6	0.6	0.7	0.7	0.8	1.0	1.2
Others (in proportion to water dist.)	9.1	10.1	10.6	11.1	13.2	16.4	19.8
Others (in proportion to the number of workers)	3.6	3.9	4.8	6.3	6.3	6.3	6.4
Service charge for 2,000 m^3/day membrane filtration plant	18.8	20.4	20.4	20.4	20.4	15.6	14.0
Expenditures Total	69.9	77.9	83.1	89.1	96.6	106.0	119.3
Net Profit	-10.1	-12.3	-14.9	-18.3	-13.4	-3.2	4.4
Net Profit (Cumulative)	-10.1	-22.5	-37.4	-55.7	-69.2	-72.4	-68.0

Note : 1 Riel = 0.02661 Yen
Source: Survey Team

Analysis on Forecast of Revenues and Expenditures (Charge Rates to Make Single-Year Profitability)

The table below shows the charges required to make a profit in a single year for each year. In addition, in order to avoid complicated calculation, the change range of the charge is set to every 10 Riel. This is the same as the above analysis that fixed the charge to the current charge and examines the resulting balance. This time, the balance being fixed to the minimum surplus amount, examines the charge to be set for. The same thing is viewed from the opposite perspective, and the analysis results are basically the same as above. The highest price is 1,540 Riel per m^3 in 2024. In the above case as well, the largest deficit is shown in 2024.

Table 2-6-16 Forecast of Revenues and Expenditures (Charge Rates to Make Single-Year Profitability)

Unit: Million Yen

	2021	2022	2023	2024	2025	2026	2027
Water Charge (Riel)	1,430	1,450	1,490	1,540	1,420	1,250	1,200
Revenues							
Water Sales	66.0	73.4	78.3	84.0	90.9	98.9	114.2
Other Revenue	4.3	4.8	5.1	5.3	6.3	7.9	9.5
Revenues Total	70.4	78.2	83.4	89.3	97.2	106.8	123.7
Expenditures							
Personnel	12.0	13.1	16.2	21.3	21.3	21.3	21.7
Material/Chemical	1.9	2.2	3.3	5.4	8.1	10.8	13.5
Electricity/Fuel	12.9	14.8	16.2	18.4	23.5	30.7	38.0
Depreciation	9.0	10.5	8.6	2.9	0.0	0.0	0.0
Interest Payment	2.1	2.3	2.4	2.6	3.0	3.8	4.6
Taxes	0.6	0.6	0.7	0.7	0.8	1.0	1.2
Others (in proportion to water dist.)	9.1	10.1	10.6	11.1	13.2	16.4	19.8
Others (in proportion to the number of workers)	3.6	3.9	4.8	6.3	6.3	6.3	6.4
Service charge for 2,000 m^3/day membrane filtration plant	18.8	20.4	20.4	20.4	20.4	15.6	14.0
Expenditures Total	69.9	77.9	83.1	89.1	96.6	106.0	119.3
Net Profit	0.4	0.3	0.3	0.2	0.6	0.8	4.4
Net Profit (Cumulative)	0.4	0.7	1.0	1.1	1.7	2.5	6.9

Note : 1 Riel = 0.02661 Yen
Source: Survey Team

Analysis on Forecast of Revenues and Expenditures (Charge Rate to Make Cumulative Profitability, without Inflation)

The table below shows the charges required to finally make a cumulative profit in the forecast period from 2021 to 2027. However, since there will be an election in 2023 as a practical problem, we received the opinion that the price increase can only be done from 2024, so this analysis also sets it as such. In addition, in order to avoid complicated calculation, the change range of the charge is set to every 10 Riel. According to this, the General Charge rate needs to be raised to 1,440 Riel per m^3 between 2024 and 2027.

Table 2-6-17 Forecast of Revenues and Expenditures (Charge Rate to Make Cumulative Profitability, without Inflation)

Unit: Million Yen

	2021	2022	2023	2024	2025	2026	2027
Water Charge (Riel)	1,200	1,200	1,200	1,440	1,440	1,440	1,440
Revenues							
Water Sales	55.4	60.8	63.1	78.5	92.1	113.8	136.9
Other Revenue	4.3	4.8	5.1	5.3	6.3	7.9	9.5
Revenues Total	59.8	65.6	68.2	83.9	98.5	121.7	146.4
Expenditures							
Personnel	12.0	13.1	16.2	21.3	21.3	21.3	21.7
Material/Chemical	1.9	2.2	3.3	5.4	8.1	10.8	13.5
Electricity/Fuel	12.9	14.8	16.2	18.4	23.5	30.7	38.0
Depreciation	9.0	10.5	8.6	2.9	0.0	0.0	0.0
Interest Payment	2.1	2.3	2.4	2.6	3.0	3.8	4.6
Taxes	0.6	0.6	0.7	0.7	0.8	1.0	1.2
Others (in proportion to water dist.)	9.1	10.1	10.6	11.1	13.2	16.4	19.8
Others (in proportion to the number of workers)	3.6	3.9	4.8	6.3	6.3	6.3	6.4
Service charge for 2,000 m^3/day membrane filtration plant	18.8	20.4	20.4	20.4	20.4	15.6	14.0
Expenditures Total	69.9	77.9	83.1	89.1	96.6	106.0	119.3
Net Profit	-10.1	-12.3	-14.9	-5.3	1.9	15.7	27.2
Net Profit (Cumulative)	-10.1	-22.5	-37.4	-42.7	-40.8	-25.1	2.1

Note : 1 Riel = 0.02661 Yen
Source: Survey Team

Analysis on Forecast of Revenues and Expenditures (Charge Rate to Make Cumulative Profitability, with Inflation)

The financial analysis does not consider price increases unless it is under extreme inflation conditions, but since there was a strong request from Cambodian party, the analysis is conducted in consideration of price increases. As of the inflation rate, we adopted the geometric mean, 2.52% of the consumer price index in Cambodia from 2017 to 2021 announced by the IMF. According to this, it is necessary to raise the general tariff to 1,580 Riel per m^3 during the period from 2024 to 2027.

Table 2-6-18 Forecast of Revenues and Expenditures (Charge Rate to Make Cumulative Profitability, with Inflation)

Unit: Million Yen

	2021	2022	2023	2024	2025	2026	2027
Water Charge (Riel)	1,200	1,200	1,200	1,580	1,580	1,580	1,580
Revenues							
Water Sales	55.4	60.8	63.1	86.2	101.1	124.9	150.2
Other Revenue	4.3	4.9	5.3	5.7	7.0	8.9	11.0
Revenues Total	59.8	65.7	68.4	91.9	108.0	133.8	161.2
Expenditures							
Personnel	12.0	13.4	16.2	21.3	21.3	21.3	21.7
Material/Chemical	1.9	2.3	3.4	5.9	8.9	12.2	15.7
Electricity/Fuel	12.9	15.1	17.1	19.8	25.9	34.8	44.2
Depreciation	9.0	10.8	9.0	3.1	0.0	0.0	0.0
Interest Payment	2.1	2.4	2.6	2.7	3.3	4.3	5.3
Taxes	0.6	0.6	0.7	0.7	0.9	1.1	1.4
Others (in proportion	9.1	10.3	11.1	11.9	14.5	18.6	23.0

	2021	2022	2023	2024	2025	2026	2027
to water dist.)							
Others (in proportion to the number of workers)	3.6	4.0	5.0	6.8	7.0	7.1	7.4
Service charge for 2,000 m^3/day membrane filtration plant	18.8	20.9	21.5	22.0	22.6	17.7	16.3
Expenditures Total	69.9	79.9	86.5	94.4	104.5	117.2	135.0
Net Profit	-10.1	-14.2	-18.1	-2.5	3.6	16.6	26.2
Net Profit (Cumulative)	-10.1	-24.3	-42.4	-44.9	-41.3	-24.8	1.5

Note : 1 Riel = 0.02661 Yen
Source: Survey Team

Evaluation on Forecast of Revenues and Expenditures

The 2,000m^3/day membrane filtration facility was introduced in 2020. As its unit price of water supply per 1 m^3 is higher than that of existing facilities. As a result, the single-year balance will be negative for SWWs as a whole if the current rate of 1,200 Riel per m^3 remains unchanged. However, if the water supply ratio of ADB facilities and this project facility, which have relatively low water supply unit costs, rises to a certain extent, the deficit amount will decrease in a single year and will return to the black in 2027. However, since a cumulative deficit of nearly 70 million yen will occur in this analysis period alone, it will be necessary to raise the water charge to prevent this. As for the amount of price increase, it was calculated that it is necessary to raise it to at least 1,580 Riel per m^3, considering that the price increase will be from 2024 for political reasons, and the forecasted inflation rate during that period.

Regarding the amount of 1,580 Riel per m^3, the charge of the Pursat Waterworks, which is also a local water supply Grant Aid project that was conducted the survey almost at the same time in this project, is 1,600 Riel per m^3, and a special charge of 1,100 Riel per m^3 up to 3 m^3 per month for low-income households will be maintained. So, it is considered that there is a good affordability to pay for residents.

In addition, according to the results of the social survey conducted in the preparatory survey, the average amount of water consumed per household is about 18.2 m^3 per month, and if the price is raised at 1,580 Riel per m^3, the total water charge will be 28,756 Riel per month. This amount of water charge is about 2% of the average income of 1,512,000 Riel per month for unconnected households, which is considered to be a feasible tariff level that can be borne by the residents.

Furthermore, at the meeting of M/D held in December 2021, MISTI showed an understanding of the need to revise the water tariff from the current 1,200 Riel per m^3 to about 1,580 Riel per m^3. If the water tariff revision cannot be implemented as planned, MISTI has agreed to take necessary budgetary measures. If the water tariff cannot be revised, the cumulative deficit of 68 million yen in 2027, which is the target year of this project, is equivalent to 0.7% of MISTI's 2021 budget of US $ 93 million (10.1 billion yen). Therefore, even if the tariff revision cannot be implemented, it is possible to be born the operation and maintenance costs of the facilities constructed on this project by MISTI.

Chapter 3. Project Evaluation

3-1 Preconditions for Project Implementation

As detailed in "Section 2-4 Obligations of Recipient Country", the main preconditions for project implementation and the costs borne by Cambodia are as follows:

Securing Additional Water Rights

The total capacity of the existing WTP, the facility to be expanded by ADB and the facility expanded under this Project is expected to be around 20,680 m^3/day, and will involve taking surface water from Vay Kor Lake. Regarding the surface water intake permit from Vay Kor Lake, MISTI has already obtained an approval from MOWRAM in September 2017 for 12,000 m^3/day and an additional 11,000 m^3/day in July 2021.

Securing the Durability of the Vay Kor Dam

To ensure that surface water can be taken safely from Vay Kor Lake, the soundness of the Vay Kor Dam, which maintains the water level of the Vay Kor Lake by blocking the inflow from the Vay Kor River at the area downstream of the lake, should be maintained in future. At the meeting of M/D in December 2021, it was confirmed that MOWRAM shall be responsible for maintaining and managing the Vay Kor Dam and MISTI shall work with MOWRAM to keep the water level needed to take water.

Environmental and Social Considerations

The Ministerial Ordinance on the Classification of the Environmental Impact Assessment of Development Projects (No. 021) which was enforced on February 3, 2020, prescribes, that all projects for WTPs and water distribution systems are subject to the EPC. MISTI thus obtained the EPC approval from the MOE on March 30, 2021. It was confirmed at the meeting of M/D in April 12, 2021 that the project will be implemented in line with the EPC.

Occupancy Approval for Proposed WTP and Intake Facility Construction Sites

The site for the WTP is on a private land and the WWs acquired approval from the landowner in December 2017. The intake facility site is on a public land, and it was confirmed at the meeting of M/D in December 2021 that the SWWs will obtain the approval of using the land from the Provincial Governor via DISTI by August 2022 before notice of the bidding document.

Acquisition and Ground Leveling of Sites for the WTP and Intake Facility

At the meeting of M/D in April 2021, acquisition and ground leveling of sites for the WTP and intake facility were discussed. Since embankments are needed in the WTP and intake facility sites (around 13,767 m^3 and 5,067 m^3 for the WTP and intake facility sites[1], respectively), the Survey Team explained the work schedule to the Cambodian side, confirmed to secure the necessary budget and prepare the

[1] The amount of embankment soil at the WTP (after compaction) = 13,767 m^3, the amount of embankment soil at the intake facility (after compaction) = 5,067 m^3, loosening rate: 1.2, compaction rate: 0.95, and the amount of purchased soil is calculated as follows. The amount of soil purchased for the WTP = 13,767 m^3 ÷ 0.95 x 1.2 ≒ 17,390 m^3, and the amount of soil purchased for the intake facility = 5,067 m^3 ÷ 0.95 x 1.2 ≒ 6,400 m^3.

embankment for the construction site by August 2022 before notice of the bidding document at the meeting of M/D in December 2021.

Occupancy Approval for Conveyance, Transmission and Distribution Pipe Routes

All conveyance, transmission and distribution pipes are supposed to be buried underground along public roads (except for portions installed by a bridge-attached pipe). Accordingly, issues concerning private land acquisition and others are not expected; however, occupancy approval should be obtained from the MPWT for national highways and from the Provincial Governor for other roads. It was confirmed at the meeting of M/D in December 2021 that these occupancy approvals would be obtained before start of the construction.

Drawing Electricity Line into the New Intake Facility and WTP Site

The provision of transformers to be installed in proposed construction sites for new intake facility and WTP are included in a Grant Aid project. The Cambodian side is responsible for drawing electricity into the transformers. It was confirmed at the meeting of M/D in December 2021 that the distribution line of electricity to the main road near the proposed facility will be provided before start of the construction and that from the main road to the site of proposed facility will be provided by 2 months before the commissioning test.

Tax Exemption Measures

The Cambodian government provides indirect support for tax exemption measures to contractors.

3-2 Necessary Inputs (Obligations) by Recipient Country to Achieve the Whole Project Plan

Promotion of Service Pipe Connection to Each Household

The work involved in connecting the service pipe to each household from the distribution pipe to be installed in this project will be handled by Cambodia. Under this project, new service pipe connections for approximately 7,378 households, including 375 classed as poor, will be needed for achievement of project purpose. Since failure to connect to each household means the development effect of this project will not be realized, the specific schedule and organizational structure expected for service pipe connections was explained and it was agreed at the meeting of M/D in December 2021 that the necessary measures would be taken by the Cambodian side. Support for an activity involving residents promoting these connections is planned via soft component activities.

Hiring New Personnel

Both new and existing plants have to be operated, maintained and managed while the number of connections is being increased. Accordingly, the SWWs needs to increase the number of personnel from the current thirty-five (35) (as of 2021) to fifty-seven (57) by gradually adding twenty-two (22) personnel until 2027. The details of this increase are planned as follows: eleven (11) personnel for the Water Treatment Division; five (5) personnel for the Water Distribution Division; four (4) personnel for

the Service Division, and one (1) each for the General Affairs Division and the Accounting/Finance Division.

Financial Soundness

In order for the SWWs to aim to be a "growing water supply entity" that can ensure financial soundness and expand and improve water services, the operation and maintenance of the facilities constructed in this project shall be carried out properly. Therefore, it is necessary to raise the water tariff to cover the operation and maintenance cost. At the meeting held in December 2021, it was explained that it is necessary to raise the current water tariff of 1,200 Riel per m^3 to about 1,580 Riel per m^3 in case the tariff is revised from 2024. The Cambodian side understood the need for water tariff increases and agreed to take necessary measures toward 2024.

3-3 External Conditions

To achieve and sustain the project effects, the following external conditions should be considered:

- Large-scale unseasonable weather or natural disasters will not occur;
- Social and economic situations will not seriously deteriorate;
- Population in the target area does not move unexpectedly; and
- The current capacity of the existing WTP will be maintained.

3-4 Project Evaluation

3-4-1 Validity

Beneficiaries of the Project

The water supply capacity to residents in Svay Rieng City will be improved under the project. The water supply ratio in the administrative area was 23.6% in 2019 and will increase by 52.6% in the target year 2027. The water supply ratio in the urban areas, which MISTI targets, will be 86.7%. The increased number of beneficiaries (population newly served) will be approximately 32,419 (22,543 personnel in urban areas while it is 9,876 personnel in rural areas).

Urgency of the Project

Although Svay Rieng City operates an existing water service system, its water supply ratio remained at 23.6% as of 2019. Accordingly, the expansion of the water supply facilities is urgently needed to further improve the water supply ratio.

Consistency with the Upper-Level Plan (NSDP) of the Project

The National Strategic Development Plan (NSDP 2019-2023) has set the target of achieving 100% water supply ratio in urban areas by 2025. Ninety Percent (90%) of the urban population served are presently covered by water pipes, while the remaining 10% are covered by other means. The target will be more or less achieved when the area is limited to the urban population in the administrative area managed by the SWWs, and the project will help achieve this aim in Svay Rieng City. Moreover, the project will procure and provide materials and equipment to poor households to encourage them connect to service pipes, the installation cost of which will be borne by the Cambodian side.

Accordingly, the project ensures consistency with measures for the poor, the largest target group in the NSDP.

Consistency with Japan's Assistance Policy

"Improving the quality of life" is also included in the priority areas of the Country Assistance Policy for Cambodia (July 2017) of the Government of Japan, support for which is provided in sectors that help improve the urban living environment, such as water supply and sewage, water discharge, electric power (reducing areas with no electricity), urban transportation (urban railway, bus and vehicle registration). Accordingly, the project implementation is consistent with Japan's assistance policy.

3-4-2 Effectiveness

The following quantitative and qualitative effects are expected to confirm the effectiveness of the project:

3-4-2-1 Quantitative Effect

By expanding the water supply facility in Svay Rieng City, the effects shown in the table below are expected:

Table 3-4-1 Quantitative Effetss

Item No.	Indicator		Baseline (Measured in 2019)	Target (in 2027) [Two Years after Completion]
1	Daily average water supply amount (m^3/day)		4,627	10,009
2	Population served (person)[2]		23,545	55,964
3	Water supply ratio	Whole administrative area	23.6	52.6
		Urban area	48.9	86.7
4	Water pipe connection[3] to poor households (Poor levels 1 and 2)		53	1,254

Note: For calculation method, see 2-2-2-1.
Source: Survey Team

3-4-2-2 Qualitative Effect

The qualitative effects of the project will be as follows:

- Improving the living environment of residents (improving the public health environment of residents who used to use rainwater, etc., and improving convenience)

As above, the validity of the project is high and its effectiveness is expected.

2 When the population in the service area increases as expected, the water supply ratio will increase from 23.6% in 2019 to 52.6% in the administrative area and 86.7% in the urban area in the administrative area in 2027.
3 The number of poor households (Poor Level 1) in the planned service area in 2027 will be 410, as projected based on data from the Identification of Poor Household Programme implemented by MOP in 2010 and 2011. The number of poor households without connection to water pipes, for whom the project will provide equipment, will be 375, minus 35 households with connections.

［APPENDECES］

1. Member List of the Survey Team

(1) Survey for Pursat and Svay Rieng : The 1st field work (From May 21th, 2017 to July 23th, 2017)

Name	Job Title	Occupation	Survey Period
Mr. Sadanobu SAWARA	Leader	Senior Advisor, JICA HDQs	May 21th to May 28th
Mr. Shingo FUJIWARA	Project Planning	Deputy Director, Water Resources Groupe, Global Environment Department, JICA HDQs	May 21th to May 28th
Mr. Hideki KONNO	Chief Consultant/Water Supply Planning Specialist 1	CTI Engineering International Co., Ltd.	June 11th to July 3rd
Mr. Masashi YAYAMA	Deputy Chief Consultant/Water Supply Planning Specialist 2	Water and Sewer Bureau, City of Kitakyushu	June 11th to July 2nd
Mr. Takashi FURUKAWA	Water Resources/River and Flood Control Specialist	CTI Engineering International Co., Ltd.	June 11th to July 2nd
Mr. Norifumi YAMAMOTO	Hydrogeologist	CTI Engineering International Co., Ltd.	May 23th to May 28th June 11th to July 10th
Mr. Naohide MATSUMOTO	Water Treatment Plant Designer 1	TEC International Co., Ltd..	June 11th to June 30th
Mr. Junichi KAWAKAMI	Water Treatment Plant Designer 2	TEC International Co., Ltd..	June 11th to June 30th
Mr. Oki SHINDO	Intake Facility Plan/River Structure Specialist	CTI Engineering International Co., Ltd.	May 21th to May 28th June 11th to July 9th
Mr. Kiyoshi MIFUNE	Conveyance and Distribution Designer 1	TEC International Co., Ltd..	June 16th to July 2nd
Mr. Takuro KOHARA	Conveyance and Distribution Designer 2	TEC International Co., Ltd..	June 6th to June 30th
Mr. Shuji SATO	Equipment Planning Specialist 2 (Machine Equipment)	CTI Engineering International Co., Ltd.	June 18th to July 2nd
Mr. Naoki MATSUO	Construction and Procurement Planning 1/Cost Estimation Specialist	CTI Engineering International Co., Ltd.	June 25th to July 9th
Ms. Asa KINUGAWA	Construction and Procurement Planning 2/ Coordinator	CTI Engineering International Co., Ltd.	June 11th to July 10th
Ms. Yasuko KAMEGAI	Environmental & Social Considerations /UXO Confirmation	CTI Engineering International Co., Ltd.	June 26th to July 23th
Mr. Makoto YAJIMA	Financial Specialist	CTI Engineering International Co., Ltd.	June 11th to July 7th

(2) Survey for Pursat and Svay Rieng : The 2nd field work (From August 9th, 2017 to October 15th, 2017)

Name	Job Title	Occupation	Survey Period
Ms. Eriko TAMURA	Leader	Director, Water Resources Team1, Water Resources Group, Global Environment Department, JICA HDQs	August 20th to August 27th
Mr. Norihiro OBITSU	Project Planning	In-house Technical Consultant for Water Supply, JICA Contractor, Water Resources Group, Global Environment Department, JICA HDQs	August 20th to August 25th
Mr. Hideki KONNO	Chief Consultant/Water Supply Planning Specialist 1	CTI Engineering International Co., Ltd.	August 9th to September 2nd
Mr. Takashi FURUKAWA	Water Resources/River and Flood Control Specialist	CTI Engineering International Co., Ltd.	August 10th to September 3rd
Mr. Norifumi YAMAMOTO	Hydrogeologist	CTI Engineering International Co., Ltd.	August 20th to August 27th
Mr. Naohide MATSUMOTO	Water Treatment Plant Designer 1	TEC International Co., Ltd..	August 10th to September 1st
Mr. Junichi KAWAKAMI	Water Treatment Plant Designer 2	TEC International Co., Ltd..	August 13th to September 1st
Mr. Daigo TAKEDA	O&M Organization Specialist (Soft component)	Water and Sewer Bureau, City of Kitakyushu	August 13th to August 26th
Mr. Oki SHINDO	Intake Facility Plan/River Structure Specialist	CTI Engineering International Co., Ltd.	August 17th to September 1st
Mr. Kiyoshi MIFUNE	Conveyance and Distribution Designer 1	TEC International Co., Ltd..	August 10th to September 2nd
Mr. Takuro KOHARA	Conveyance and Distribution Designer 2	TEC International Co., Ltd..	August 10th to September 2nd
Mr. Kouichi NAOI	Equipment Planning Specialist 1 (Electrical Equipment)	TEC International Co., Ltd..	August 20th to September 3rd
Mr. Shuji SATO	Equipment Planning Specialist 2 (Machine Equipment)	CTI Engineering International Co., Ltd.	August 20th to September 3rd
Mr. Naoki MATSUO	Construction and Procurement Planning 1/Cost Estimation Specialist	CTI Engineering International Co., Ltd.	August 3th to September 4th
Ms. Asa KINUGAWA	Construction and Procurement Planning 2/ Coordinator	CTI Engineering International Co., Ltd.	August 10th to August 25th
Ms. Yasuko KAMEGAI	Environmental & Social Considerations /UXO Confirmation	CTI Engineering International Co., Ltd.	September 20th to October 15th

(3) Survey for Svay Rieng after determination of water source : The 3rd field work (From November 5th, 2019 to December 22th, 2019)

Name	Job Title	Occupation	Survey Period
Mr. Hideki KONNO	Chief Consultant/Water Supply Planning Specialist 1	CTI Engineering International Co., Ltd.	November 5th to November 9th November 18th to November 23th December 3rd to December 8th December 11th to December 18th
Mr. Hiroshi HIROWATARI	Deputy Chief Consultant/Water Supply Planning Specialist 2	Water and Sewer Bureau, City of Kitakyushu	December 4th to December 8th December 13th to December 15th December 17th to December 18th
Mr. Satoru HADA	Water Supply Planning Specialist 3	CTI Engineering International Co., Ltd.	November 14th to December 22th
Mr. Naohide MATSUMOTO	Water Treatment Plant Designer 1	TEC International Co., Ltd..	November 25th to December 14th
Mr. Yoshiki OSHIMA	O&M Organization Specialist (Soft component)	Water and Sewer Bureau, City of Kitakyushu	December 4th to December 22th
Mr. Kiyoshi MIFUNE	Conveyance and Distribution Designer 1	TEC International Co., Ltd..	November 13th to December 14th
Mr. Takuro KOHARA	Conveyance and Distribution Designer 2	TEC International Co., Ltd..	November 17th to December 14th
Mr. Kouichi NAOI	Equipment Planning Specialist 1 (Electrical Equipment)	TEC International Co., Ltd..	November 27th to December 14th
Mr. Shuji SATO	Equipment Planning Specialist 2 (Machine Equipment)	CTI Engineering International Co., Ltd.	December 1st to December 14th
Mr. Hikaru TAKATSU	Construction and Procurement Planning 1/Cost Estimation Specialist	CTI Engineering International Co., Ltd.	November 25th to December 9th
Ms. Yasuko KAMEGAI	Environmental & Social Considerations /UXO Confirmation	CTI Engineering International Co., Ltd.	December 8th to December 21th

(4) Survey for Svay Rieng after determination of water source : The 4th field work (From January 12th, 2020 to March 8th, 2020)

Name	Job Title	Occupation	Survey Period
Mr. Makoto IWASE	Leader	Director, Water Resources Team1, Water Resources Group Global Environment Department, JICA HDQs	February 9th to February 15th
Mr. Satoshi HAMANO	Project Planning	Deputy Director, Water	February 9th to February

Name	Job Title	Occupation	Survey Period
		Resources Team1, Water Resources Group, Global Environment Department and Office for Climate Change, JICA HDQs	15th
Mr. Hideki KONNO	Chief Consultant/Water Supply Planning Specialist 1	CTI Engineering International Co., Ltd.	February 9th to February 15th
Mr. Oki SHINDO	Intake Facility Plan/River Structure Specialist	CTI Engineering International Co., Ltd.	January 30th to February 16th
Ms. Yasuko KAMEGAI	Environmental & Social Considerations /UXO Confirmation	CTI Engineering International Co., Ltd.	February 24h to March 8th
Mr. Makoto YAJIMA	Financial Specialist	CTI Engineering International Co., Ltd.	January 12h to January 18th

(5) Survey for Svay Rieng after determination of water source : The 5th field work (From November 28th, 2021 to December 18th, 2021)

Name	Job Title	Occupation	Survey Period
Mr. Yoichi INOUE	Leader	Director, Water Resources Team1, Water Resources Group, Global Environment Department, JICA HDQs	December 4th to December 17th
Ms. Eriko KAKEGAWA	Project Planning	Water Resources Team1, Water Resources Group Global Environment Department, JICA HDQs	December 4th to December 17th
Mr. Hideki KONNO	Chief Consultant/Water Supply Planning Specialist 1	CTI Engineering International Co., Ltd.	December 4th to December 10th December 15th to December 17th
Mr. Masashi YAYAMA	Deputy Chief Consultant/Water Supply Planning Specialist 2	Water and Sewer Bureau, City of Kitakyushu	December 4th to December 10th December 17th to December 18th
Mr. Naohide MATSUMOTO	Water Treatment Plant Designer 1	TEC International Co., Ltd..	November 28th to December 2nd December 4th to December 11th

(6) Inspection

Name	Job Title	Occupation	Survey Period
Mr. Kazuo TAKAYAMA	Inspector (- March, 2018)	Water and Sewer Bureau, City of Kitakyushu	―
Mr. Yasushi KAKIGI	Inspector (April, 2018 – March, 2020)	Water and Sewer Bureau, City of Kitakyushu	―
Mr. Tetsuya UEDA	Inspector (April, 2020 -)	Water and Sewer Bureau, City of Kitakyushu	―

2. Survey Schedule

The survey schedule is attached as follows.

(3) The first field work (From May 21th, 2017 to July 23th, 2017)

Survey Shedule

PHN:Phnom Penh | PUR:Pursat | SVR:Svay Rieng | No accomodation

Date		JICA		Consultant																Meeting
				CTII	CTII	CTII	CTII	CTII	CTII	CTII	CTII	CTII	KKC	KKC	TECI	TECI	TECI	TECI	TECI	
				Chief Consultant/Water Supply Planning Specialist 1	Water Resources/River and Flood Control Specialist	Hydrogeologist	Intake Facility Plan/River Structure Specialist	Equipment Planning Specialist 2 (Machine Equipment)	Construction and Procurement Planning 1/Cost Estimation Specialist	Construction and Procurement Planning 2/ Coordinator	Environmental & Social Considerations /UXO Confirmation Specialist	Financial Specialist	Deputy Chief Consultant/Water Supply Planning Specialist 2	O&M Organization Specialist (Soft-component)	Water Treatment Plant Designer1	Water Treatment Plant Designer2	Raw Water Conveyance and Distribution Designer 1	Raw Water Conveyance and Distribution Designer 2	Equipment Planning Specialist 1 (Electrical Equipment)	
		Tamura /Fujiwara	Oobitsu /Sawara	Konno	Furukawa	Yamamoto	Shindo	Sato	Matsuo	Kinugawa	Kamegai	Yajima	Yayama	Takeda	Matsumoto	Kawakami	Mizufune	Kohara	Naoi	
21-May	Sun			NH817 10:50-15:10 Meeting with Local Consul			NH817 10:50-15:10 Meeting with Local Consul													
22-May	Mon	NH817 10:50-15:10 Meeting		Meeting with Local Consul Team Meeting			Meeting with Local Consul Team Meeting													
23-May	Tue	JICA Meeting WOWRAM Meeting PUR Trip				VN321 10:30-13:55 VN920 15:55-16:50	JICA Meeting WOWRAM Meeting PUR Trip													
24-May	Wed	PUR Survey PNH Trip				PUR Survey PNH Trip	PUR Survey PNH Trip													
25-May	Thu	MIH Meeting SVR Trip				MIH Meeting SVR Trip	MIH Meeting SVR Trip													
26-May	Fri	SVR Survey PNH Trip NH818 22;50-Arrival at Japan		SVR Survey PNH Trip Meeting with Local Consul		SVR Survey PNH Trip Meeting with Local Consul	SVR Survey PNH Trip Meeting with Local Consul													
27-May	Sat	06:45Arrival		Meeting with Local Consul NH818 22:50-		Meeting with Local Consul VN3850 21:05-22:00	Meeting with Local Consul NH818 22:50-													
28-May	Sun			06:45Arrival		VN320 00:30-07:20	06:45Arrival													
Work in Japan																				
11-Jun	Sun			NH817 10:50-15:10	NH817 10:50-15:10	TG649 11:35-19:55 Pick UP	NH817 10:50-15:10			NH817 10:50-15:10		NH817 10:50-15:10	TG649 11:35-19:55 No Pick Up		NH817 10:50-15:10	NH817 10:50-15:10				
12-Jun	Mon			PNH	PNH	PNH	PNH			PNH		PUR	PNH		PUR	PUR				AM:MIH PM:JICA
13-Jun	Tue			PUR	PUR	PNH	PUR			PNH		PUR	PNH		PUR	PUR				AM: Pursat WWs
14-Jun	Wed			PNH	PNH	PNH	PHN			PHN		PHN	PNH		PHN	PHN				AM: Pursat DOWRAM Evening: MIH Hirowatari
15-Jun	Thu			SVR	SVR	SVR	SVR			SVR		SVR	PNH		SVR	SVR				AM:Svay WWs PM: DoWRAM
16-Jun	Fri			PHN	PHN	PHN	PHN			PHN		PNH	PNH		SVR	SVR	NH817 10:50-15:10	NH817 10:50-15:10		SVR WWs Meeting PM:MIH Meeting
17-Jun	Sat			PHN	PHN	PHN	PHN			PHN		PHN	PNH		PHN	PHN	PHN	PHN		Evening:Team Meeting
18-Jun	Sun			PHN	PHN	PHN	PHN	NH817 10:50-15:10		PHN		PHN	PHN		PUR	PUR	PUR	PUR		
19-Jun	Mon			PHN	PHN	PHN	PHN	PHN		PHN		PHN	PHN		PUR	PUR	PUR	PUR		AM: MoA All: Pursat WWS
20-Jun	Tue			PHN	PUR	PUR	PUR	PUR		PUR		PHN	PUR		PUR	PUR	PUR	PUR		AM: MOWRAM PM: Pursat DOWRAM AMorPM:Subcontructor (Topographic Survey) All: Pursat WWs
21-Jun	Wed			PHN	PHN	PHN	PUR(BTB 1day trip)	PHN		PHN		PHN	PHN		PUR(BTB 1day trip)	PUR(BTB 1day trip)	PUR	PUR		AM:Prusat DOWRAM AM:Battambang WWs All: Pursat WWs
22-Jun	Thu			SVR(1day trip)	SVR(1day trip)	SVR(1day trip)	PHN	SVR(1day trip)		SVR(1day trip)		PHN	SVR(1day trip)		PHN	PHN	PHN	PHN		All: Pursat WWs All:Svay WWs
23-Jun	Fri			PHN	PHN	PHN	PHN	PHN		PHN		PHN	PHN		SVR	SVR	SVR	SVR		AM: MOWRAM
24-Jun	Sat			PHN	PHN	PHN	PHN	PHN		PHN		PHN	PHN		SVR	SVR	SVR	SVR		
25-Jun	Sun			PHN	PHN	PHN	PHN	PHN	NH817 10:50-15:10	PHN		PHN	PHN		SVR	SVR	SVR	SVR		

Survey Shedule

PHN:Phnom Penh | PUR:Pursat | SVR:Svay Rieng | No accomodation

Date		JICA		Consultant																	Meeting
				CTII	CTII	CTII	CTII	CTII	CTII	CTII	CTII	CTII	KKC	KKC	TECI	TECI	TECI	TECI	TECI		
				Chief Consultant/Water Supply Planning Specialist 1	Water Resources/River and Flood Control Specialist	Hydrogeologist	Intake Facility Plan/River Structure Specialist	Equipment Planning Specialist 2 (Machine Equipment)	Construction and Procurement Planning 1/Cost Estimation Specialist	Construction and Procurement Planning 2/ Coordinator	Environmental & Social Considerations /UXO Confirmation Specialist	Financial Specialist	Deputy Chief Consultant/Water Supply Planning Specialist 2	O&M Organization Specialist (Soft-component)	Water Treatment Plant Designer1	Water Treatment Plant Designer2	Raw Water Conveyance and Distribution Designer 1	Raw Water Conveyance and Distribution Designer 2	Equipment Planning Specialist 1 (Electrical Equipment)		
		Tamura /Fujiwara	Oobitsu /Sawara	Konno	Furukawa	Yamamoto	Shindo	Sato	Matsuo	Kinugawa	Kamegai	Yajima	Yayama	Takeda	Matsumoto	Kawakami	Mizufune	Kohara	Naoi		
26-Jun	Mon			PHN	PHN	PHN	PHN	PHN	PHN	PHN	NH817 10:50-15:10	PHN	PHN		SVR	SVR	SVR	SVR			AM: MOWRAM/MOA PM:Contructor All:Svay WWs
27-Jun	Tue			PUR	PUR	PHN	PUR	PUR	PUR	PUR	PHN	PHN	PUR		SVR	SVR	SVR	SVR			All:Svay WWs PM:PursatWWs,DPW、DLMUPC
28-Jun	Wed			BTB	PHN	PHN	PHN	PHN	PHN	PHN	PHN	PHN	PHN		SVR-KPC-PHN	SVR-KPC-PHN	PHN	PHN			AM:Pursat DOWRAM All:Pursat WWs AI:KMC WTP
29-Jun	Thu			PHN	SVR(1day trip)	PHN	PHN	PHN	SVR(1day trip)	SVR(1day trip)	PHN	PHN	PHN		NH818 22:50	NH818 22:50	PHN	NH818 22:50			AM:JICA AI:Phum Prek WTP All:Svay WWs AM:Svay Dowram
30-Jun	Fri			PHN	PHN	PHN	PHN	PHN	PHN	PHN	PHN	PHN	PHN		06:45Arrival	06:45Arrival	PHN	06:45Arrival			PM:MIH
1-Jul	Sat			PHN	PHN	PHN	PHN	Structure Design NH818 22:50-	PHN	PHN	PHN	PHN	PHN				NH818 22:50				AM:Contructor
2-Jul	Sun			NH818 22:50-	Depart 14:15 - Hanoi	PHN	PHN	06:45Arrival	PHN	PHN	PHN	PHN	PHN				06:45Arrival				
3-Jul	Mon			06:45Arrival		SVR(1day trip)	SVR(1day trip)		SVR(1day trip)	PHN	SVR(1day trip)	PHN	PHN								AM:Svay DoA PM:Svay DoE All:Svay WWs
4-Jul	Tue					PHN	PHN		PHN	PHN	PHN	PHN	PHN								All:Svay WWs
5-Jul	Wed					PHN	PUR		PUR	PUR	PUR	PHN	PHN								AM:MoP
6-Jul	Thu					PHN	PHN		PUR	PUR	PHN	NH818 22:50-	PHN								All:Pursat WWs AM:Pursat DoA PM:Pursat DoE
7-Jul	Fri					PHN	PHN		PHN	PHN	PHN	06:45Arrival	PHN								AM:JICA All:Pursat WWs
8-Jul	Sat					PHN	NH818 22:50-		NH818 22:50-	PHN	PHN		PHN								
9-Jul	Sun					TG585 21:15-08:00	06:45Arrival		06:45Arrival	NH818 22:50-	PHN		PHN								
10-Jul	Mon					Arrival at Japan				06:45Arrival	PHN		PHN								
11-Jul	Tue										PHN		PHN								
12-Jul	Wed										SVR(1day trip)		SVR(1day trip)								AM:Svay DoE AM:Svay Provincial Hall PM:Svay Cloth Factory
13-Jul	Thu										PUR(1day Trip)		PUR(1day Trip)								AM:Pursat Provincial Hall
14-Jul	Fri										PHN		PHN								AM:MoE PM:MIH
15-Jul	Sat										PHN		PHN								
16-Jul	Sun										PHN		PHN								
17-Jul	Mon										PHN		TG585 21:15-08:00								AM:MIH(Technical Note)
18-Jul	Tue										PUR(1day Trip)		Arrival at Japan								AM:CMAC PM:Pursat WWs
19-Jul	Wed										PHN										AM:Pursat WWs PM:MoE
20-Jul	Thu										SVR(1day trip)										All:Svay WWs
21-Jul	Fri										PHN										AM:PPWSA PM:MIH
22-Jul	Sat										NH818 22:50-										
23-Jul	Sun										06:45Arrival										

(2) The 2nd field work (From August 9th, 2017 to October 15th, 2017)

Survey Shedule

PHN:Phnom Penh | PUR:Pursat | SVR:Svay Rieng | No accomodation

Date		JICA		Consultant																	Meeting
				CTII	CTII	CTII	CTII	CTII	CTII	CTII	CTII	CTII	KKC	KKC	TECI	TECI	TECI	TECI	TECI		
				Chief Consultant/Water Supply Planning Specialist 1	Water Resources/River and Flood Control Specialist	Hydrogeologist	Intake Facility Plan/River Structure Specialist	Equipment Planning Specialist 2 (Machine Equipment)	Construction and Procurement Planning 1/Cost Estimation Specialist	Construction and Procurement Planning 2/ Coordinator	Environmental & Social Considerations /UXO Confirmation Specialist	Financial Specialist	Deputy Chief Consultant/Water Supply Planning Specialist 2	O&M Organization Specialist (Soft-component)	Water Treatment Plant Designer1	Water Treatment Plant Designer2	Raw Water Conveyance and Distribution Designer 1	Raw Water Conveyance and Distribution Designer 2	Equipment Planning Specialist 1 (Electrical Equipment)		
		Tamura /Fujiwara	Oobitsu /Sawara	Konno	Furukawa	Yamamoto	Shindo	Sato	Matsuo	Kinugawa	Kamegai	Yajima	Yayama	Takeda	Matsumoto	Kawakami	Mizufune	Kohara	Naoi		
9-Aug	Wed			NH817 10:50-15:10																	
10-Aug	Thu			PHN	NH817 10:50-15:10					NH817 10:50-15:10					NH817 10:50-15:10 PHN		NH817 10:50-15:10 PHN	NH817 10:50-15:10 PHN			
11-Aug	Fri			Pursat WWs Meeting	Pursat WWs Meeting					Pursat WWs Meeting/Data Collection					Pursat WWs Meeting PUR		Pursat WWs Meeting PUR	Pursat WWs Meeting PUR			PM:Pursat WWs PM Pursat DOWRAM
12-Aug	Sat			PHN	PHN					PHN					PHN		PHN	PHN			
13-Aug	Sun			PHN	PHN					PHN				TG649 11:35-19:55	PHN	NH817 10:50-15:10 PHN	PHN	PHN			
14-Aug	Mon			MIH Meeting PHN	MIH Meeting PHN					PHN				MIH Meeting Phase 3 Meeting PHN	MIH Meeting PPWSA Meeting PHN	MIH Meeting PPWSA Meeting PHN	MIH Meeting PHN	MIH Meeting PHN			AM:MIH
15-Aug	Tue			SVR(1day trip)	SVR(1day trip)					SVR(1day trip)				PUR Data Collection stay PUR	SVR WWs Meeting (SVR1day trip) PHN	SVR WWs Meeting (SVR1day trip) PHN	SVR WWs Meeting (SVR1day trip) PHN	SVR WWs Meeting (SVR1day trip) PHN			All:SVR WWs PM:Pursat WWs
16-Aug	Wed			MIH Meeting PHN	MIH Meeting PHN					PHN				PUR to BTB BTB Interview stay BTB	MIH Meeting PHN	MIH Meeting PHN	MIH Meeting PHN	MIH Meeting PHN			PM:MIH
17-Aug	Thu			PHN	PUR		NH817 10:50-15:10			PHN				BTB to PUR PUR interview	PUR	PUR	PUR	PUR			PM:Pursat WWs PM:BTB WTP
18-Aug	Fri			PHN	PUR→PHN PHN		PHN			PHN				PUR interview PUR to PHN	Pursat WWs PUR	Pursat WWs PUR	Pursat WWs PUR	Pursat WWs PUR			All:Pursat WWs AM:Pursat EDC PM:Pursat DPWT DPOST and TEL Communication
19-Aug	Sat			PHN	PHN		PHN			PHN				PHN	PUR→PHN	PUR→PHN	PUR→PHN	PUR→PHN			
20-Aug	Sun	NH817 10:50-15:10	NH817 10:50-15:10	PHN	PHN	TG649 11:35-19:55 Pick UP	PHN	NH817 10:50-15:10		PHN				PHN	PHN	PHN	PHN	PHN	NH817 10:50-15:10 PHN		
21-Aug	Mon	am: Consultant Meeting pm: MIH Meeting PHN	am: Consultant Meeting pm: MIH Meeting PHN	am: Consultant Meeting pm: MIH Meeting PHN	am: Consultant Meeting pm: MIH Meeting PHN	am: Consultant Meeting pm: MIH Meeting PHN	am: Consultant Meeting pm: MIH Meeting PHN	am: Consultant Meeting pm: MIH Meeting PHN		pm: MIH Meeting PHN				MIH Meeting PHN	am: Consultant Meeting pm: MIH Meeting PHN	pm: MIH Meeting PHN	am: Consultant Meeting pm: MIH Meeting PHN	pm: MIH Meeting PHN	pm: MIH Meeting PHN		PM:MIH
22-Aug	Tue	PUR observation PUR	PUR observation PUR	PUR observation PUR	PUR observation PUR	PHN	PUR observation PUR	PUR observation PUR		PHN				PUR observation PUR	PUR observation PUR	PUR observation PUR	PUR observation PUR	PUR observation PUR	PUR observation PUR		PM:Pursat WWs
23-Aug	Wed	PUR WWsmeetig PHN	PUR WWsmeetig PHN	PUR WWsmeetig PHN	PUR WWsmeetig PHN	PHN	PUR WWsmeetig PHN	PUR WWsmeetig PHN	NH817 10:50-15:10	PHN				PUR WWsmeetig PHN	PUR WWs Meetig Battam bang PUR	PUR WWs Meetig Battam bang PUR	PUR WWsmeetig PHN	PUR WWsmeetig PHN	PUR WWs Meetig Battam bang PUR		All:Pursat WWs
24-Aug	Thu	MIH Meeting PHN	MIH Meeting NH818 22:50-	MIH Meeting PHN	PHN	PHN	MIH Meeting PHN	MIH Meeting PHN	PHN	NH818 22:50-				PHN	PUR→PHN	PUR→PHN	MIH Meeting PHN	PHN	PUR→PHN		PM:Embassy PM:MIH(M/D Sign)
25-Aug	Fri	PHN	06:45Arrival	PHN	PHN	PHN	PHN	PHN	PHN	06:45Arrival				JICA Report PHN TG585 21:15-	Kampong Cham PHN	Kampong Cham PHN	PUR	PUR	Kampong Cham PHN		PM:KMC WWs

Survey Shedule

PHN:Phnom Penh | PUR:Pursat | SVR:Svay Rieng | No accomodation

Date		JICA		Consultant																	Meeting
				CTII	CTII	CTII	CTII	CTII	CTII	CTII	CTII	CTII	KKC	KKC	TECI	TECI	TECI	TECI	TECI		
				Chief Consultant/Water Supply Planning Specialist 1	Water Resources/River and Flood Control Specialist	Hydrogeologist	Intake Facility Plan/River Structure Specialist	Equipment Planning Specialist 2 (Machine Equipment)	Construction and Procurement Planning 1/Cost Estimation Specialist	Construction and Procurement Planning 2/ Coordinator	Environmental & Social Considerations /UXO Confirmation Specialist	Financial Specialist	Deputy Chief Consultant/Water Supply Planning Specialist 2	O&M Organization Specialist (Soft-component)	Water Treatment Plant Designer1	Water Treatment Plant Designer2	Raw Water Conveyance and Distribution Designer 1	Raw Water Conveyance and Distribution Designer 2	Equipment Planning Specialist 1 (Electrical Equipment)		
		Tamura /Fujiwara	Oobitsu /Sawara	Konno	Furukawa	Yamamoto	Shindo	Sato	Matsuo	Kinugawa	Kamegai	Yajima	Yayama	Takeda	Matsumoto	Kawakami	Mizufune	Kohara	Naoi		
26-Aug	Sat	NH818 22:50-		PHN	PHN	TG585 21:15-08:00	PHN	PHN	PHN					8:00Arrival	PHN	PHN	PUR	PUR	PHN		
27-Aug	Sun	06:45Arrival		PHN	PHN	Arrival at Japan	PHN	PHN	PUR Survey						PUR	PUR	PUR	PUR	PHN		
28-Aug	Mon			Field Survey	Data Analysis		Structure Design	Meeting Data Arrange	PUR Survey						PUR	PUR	PUR	PUR	PUR	All:Pursat WWs PM:Pursat Police, DPWT PM:MoA、MoWRAM	
29-Aug	Tue			PUR Survey	PUR Survey		PUR Survey	PUR Survey	PUR Survey						PUR	PUR	PUR	PUR	PUR	All:Pursat WWs	
30-Aug	Wed			PUR→PHN	PUR→PHN		PUR→PHN	PUR→PHN	PUR→PHN						PHN	PHN	PHN	PHN	PHN	AM:Pursat WWsMIH Meeting 16:00	
31-Aug	Thu			PHN	PHN		Structure Design NH818 22:50-	PHN	PHN						NH818 22:50-	NH818 22:50-	PHN	PHN	PHN	PM:MIH（Technical Note）	
1-Sep	Fri			NH818 22:50-	PHN		06:45Arrival	PHN	PHN						06:45Arrival	06:45Arrival	NH818 22:50-	NH818 22:50-	Kampong Cham PHN	AM:MIH Meeting	
2-Sep	Sat			06:45Arrival	PHN			NH818 22:50-	PHN								06:45Arrival	06:45Arrival	Reporting NH818 22:50-		
3-Sep	Sun				PHN→BGK			06:45Arrival	Data Collection NH818 22:50-										06:45Arrival		
4-Sep	Mon								06:45Arrival												
5-Sep	Tue																				
19-Sep	Tue																				
20-Sep	Wed										NH817 10:50-15:10										
21-Sep	Thu										PHN										
22-Sep	Fri										PHN										
23-Sep	Sat										PHN										
24-Sep	Sun										PHN										
25-Sep	Mon										PHN										
26-Sep	Tue										PHN										
27-Sep	Wed										PHN										
28-Sep	Thu										PHN										
29-Sep	Fri										PHN										
30-Sep	Sat										PHN										
1-Oct	Sun										PHN										
2-Oct	Mon										PHN										
3-Oct	Tue										PHN										
4-Oct	Wed										PHN										
5-Oct	Thu										PHN										
6-Oct	Fri										PHN										
7-Oct	Sat										PHN										
8-Oct	Sun										PHN										
9-Oct	Mon										PHN										
10-Oct	Tue										PHN										
11-Oct	Wed										SVR(1day trip)										
12-Oct	Thu										PHN										
13-Oct	Fri										PHN										
14-Oct	Sat										NH818 22:50-										
15-Oct	Sun										06:45Arrival										

(3) The 3rd field work (From November 5th, 2019 to December 22th, 2019)

Survey Shedule — PHN:Phnom Penh | SVR:Svay Rieng | KMP:Kampot

Date		Consultant											Meeting
		CTII	CTII	CTII	CTII	CTII	KKC	KKC	TECI	TECI	TECI	TECI	
		Chief Consultant/Water Supply Planning Specialist 1	Equipment Planning Specialist 1 (Machine Equipment)	Construction and Procurement Planning 1/Cost Estimation Specialist	Environmental & Social Considerations /UXO Confirmation Specialist	Water Supply Planning Specialist 3	Deputy Chief Consultant/Water Supply Planning Specialist 2	O&M Organization Specialist (Soft-component)	Water Treatment Plant Designer1	Raw Water Conveyance and Distribution Designer 1	Raw Water Conveyance and Distribution Designer 2	Equipment Planning Specialist 1 (Electrical Equipment)	
		Konno	Sato	Takatsu	Kamegai	Hada	Hirowatari	Ooshima	Matsumoto	Mizufune	Kohara	Naoi	
5-Nov	Tue	PHN											
6-Nov	Wed	PHN											JICA Office
7-Nov	Thu	PHN											MIH
8-Nov	Fri	SVR											SWWs
9-Nov	Sat	PHN											
10-Nov	Sun												
11-Nov	Mon												
12-Nov	Tue												
13-Nov	Wed									PHN			
14-Nov	Thu					PHN				SVR			
15-Nov	Fri					PHN				SVR			
16-Nov	Sat					PHN				SVR			
17-Nov	Sun					PHN				SVR	PHN		
18-Nov	Mon	PHN				PHN				PHN	SVR		
19-Nov	Tue	PHN				PHN				PHN	SVR		
20-Nov	Wed	PHN				PHN				PHN	SVR		MIH (Inception Meeting)
21-Nov	Thu	SVR				SVR				SVR	SVR		
22-Nov	Fri	PHN				SVR				SVR	SVR		
23-Nov	Sat	PHN				PHN				SVR	SVR		
24-Nov	Sun					PHN				SVR	SVR		
25-Nov	Mon			PHN		PHN			PHN	SVR	SVR		
26-Nov	Tue			PHN		PHN			PHN	SVR	SVR		
27-Nov	Wed			SVR		SVR			PHN	SVR	SVR	PHN	SWWs
28-Nov	Thu			PHN		PHN			SVR	SVR	SVR	SVR	
29-Nov	Fri			PHN		PHN			SVR	SVR	SVR	SVR	
30-Nov	Sat			PHN		PHN			SVR	PHN	PHN	SVR	
1-Dec	Sun		PHN	PHN		PHN			PHN	PHN	PHN	PHN	
2-Dec	Mon		KMP	PHN		PHN			KMP	PHN	PHN	KMP	KPWW
3-Dec	Tue	PHN	KMP	PHN		PHN			KMP	SVR	SVR	KMP	DPWT
4-Dec	Wed	SVR	PHN	SVR		SVR	PHN	PHN	PHN	SVR	SVR	PHN	
5-Dec	Thu	SVR	SVR	SVR		SVR	PHN	PHN	SVR	SVR	SVR	SVR	EDC, Police
6-Dec	Fri	SVR	SVR	SVR		SVR	SVR	SVR	SVR	SVR	SVR	SVR	DPWT
7-Dec	Sat	PHN	PHN	PHN		PHN	PHN	PHN	PHN	SVR	SVR	PHN	
8-Dec	Sun	PHN	PHN	PHN	PHN	PHN	PHN	PHN	PHN	SVR	SVR	PHN	
9-Dec	Mon		PHN	ARRIVAL	PHN	PHN		SVR	PHN	SVR	SVR	PHN	MIH、City Hall
10-Dec	Tue		PHN		PHN	PHN		PHN	PHN	SVR	SVR	PHN	
11-Dec	Wed	SVR	PHN		SVR	PHN		SVR	PHN	SVR	SVR	SVR	EDC
12-Dec	Thu	SVR	PHN		SVR	PHN		PHN	SVR	PHN	PHN	PHN	City Hall
13-Dec	Fri	SVR	PHN		PHN	PHN	PHN	PHN	PHN	PHN	PHN	PHN	DOWRAM
14-Dec	Sat	PHN	ARRIVAL		PHN	PHN	PHN	PHN	ARRIVAL	ARRIVAL	ARRIVAL	ARRIVAL	
15-Dec	Sun	PHN			PHN	PHN	PHN	PHN					
16-Dec	Mon	PHN			PHN	PHN		PHN					PPWSA
17-Dec	Tue	PHN			PHN	PHN	PHN	PHN					MIH
18-Dec	Wed	PHN			PHN	PHN	PHN	PHN					MIH (Technical Note), JICA
19-Dec	Thu				SVR	SVR	HOSPITAL	PHN					Provincial Hall
20-Dec	Fri				PHN	PHN		PHN					
21-Dec	Sat				ARRIVAL	PHN		PHN					
22-Dec	Sun					ARRIVAL		ARRIVAL					

(4) The 4th field work (From January 12th, 2020 to March 8th, 2020)

Survey Shedule		PHN:Phnom Penh		SVR:Svay Rieng				
Date		JICA		Consultant				Meeting
				CTII	CTII	CTII	CTII	
				Chief Consultant/Water Supply Planning Specialist 1	Intake Facility Plan/River Structure Specialist	Environmental & Social Considerations /UXO Confirmation Specialist	Financial Specialist	
		Iwase	Hamano	Konno	Shindo	Kamegai	Yajima	
12-Jan	Sun						PHN	
13-Jan	Mon						PHN	
14-Jan	Tue						SVR	SWWs
15-Jan	Wed						SVR	SWWs
16-Jan	Thu						PHN	
17-Jan	Fri						PHN	
18-Jan	Sat						ARRIVAL	
30-Jan	Thu				PHN			
31-Jan	Fri				PHN			
1-Feb	Sat				PHN			
2-Feb	Sun				PHN			
3-Feb	Mon				SVR			SWWs
4-Feb	Tue				PHN			
5-Feb	Wed				PHN			
6-Feb	Thu				PHN			
7-Feb	Fri				SVR			SWWs、Provincial Hall、DIH
8-Feb	Sat				PHN			
9-Feb	Sun	PHN	PHN	PHN	PHN			
10-Feb	Mon	SVR	SVR	SVR	SVR			SWWs
11-Feb	Tue	PHN	PHN	PHN	PHN			PPWSA
12-Feb	Wed	PHN	PHN	PHN	PHN			
13-Feb	Thu	PHN	PHN	PHN	PHN			MIH
14-Feb	Fri	PHN	PHN	PHN	PHN			
15-Feb	Sat	ARRIVAL	ARRIVAL	ARRIVAL	PHN			
16-Feb	Sun				ARRIVAL			
24-Feb	Mon					PHN		
25-Feb	Tue					PHN		
26-Feb	Wed					PHN		
27-Feb	Thu					SVR		SWWs、Provincial Hall、DIH
28-Feb	Fri					SVR		SWWs, Stakeholders Meeting
29-Feb	Sat					PHN		
1-Mar	Sun					PHN		
2-Mar	Mon					PHN		
3-Mar	Tue					PHN		MIH
4-Mar	Wed					PHN		
5-Mar	Thu					PHN		
6-Mar	Fri					PHN		
7-Mar	Sat					PHN		
8-Mar	Sun					ARRIVAL		

(5) The 5th field work (From November 28th, 2021 to December 18th, 2021)

Survey Shedule		PHN:Phnom Penh		SVR:Svay Rieng		PUR:Pursat	
Date		JICA		Consultant			Meeting
				CTII	KKC	TECI	
				Chief Consultant/Water Supply Planning Specialist 1	Deputy Chief Consultant/Water Supply Planning Specialist 2	Water Treatment Plant Designer1	
		Inoue	Kakegawa	Konno	Yayama	Matsumoto	
28-Nov	Sun					PHN	
29-Nov	Mon					PHN	
30-Nov	Tue					SVR	SWWs
1-Dec	Wed					SVR	SWWs
2-Dec	Thu					PHN	
3-Dec	Fri					PHN	
4-Dec	Sat	SVR	SVR	SVR	SVR	SVR	SWWs
5-Dec	Sun	PHN	PHN	PHN	PHN	PHN	
6-Dec	Mon	PHN	PHN	PHN	PHN	PHN	MISTI
7-Dec	Tue	PHN	PHN	PHN	PHN	PHN	MISTI
8-Dec	Wed	PHN	PHN	PHN	PHN	PHN	ADB
9-Dec	Thu	PHN	PHN	PHN	PHN	PHN	MISTI
10-Dec	Fri	PHN	PHN	PHN	PHN	PHN	
11-Dec	Sat	PHN	PHN	PHN	PHN	ARRIVAL	
12-Dec	Sun	PUR	PUR	PUR	PUR		
13-Dec	Mon	PUR	PUR	PUR	PUR		
14-Dec	Tue	PHN	PHN	PHN	PHN		
15-Dec	Wed	PHN	PHN	PHN	PHN		
16-Dec	Thu	PHN	PHN	PHN	PHN		
17-Dec	Fri	ARRIVAL	ARRIVAL	ARRIVAL	PHN		
18-Dec	Sat				ARRIVAL		

3. List of Parties Concerned in the Recipient Country

Ministry of Industry, Science, Technology & Innovation (MISTI)

・H.E. OUM Sotha	Secretary of State
・H.E. SIM Sitha	Secretary of State
・H.E. EK SONN CHAN	Secretary of State (Former)
・H.E. Say Phirum	Secretary of State (Former)
・H.E. CHAN Borin	Under Secretary of State and Project Manager
・H.E. CHEA Visoth	Advisor
・H.E. Tan Sokchea	Director General, General Department of Potable Water Supply
・H.E. YEA Bunna	Director General, General Department of Potable Water Supply (Former)
・Mr. SOK Yanimol	Deputy Director General, General Department of Potable Water Supply
・Mr. SRENG Sokvung	Director, Department of Technical Affairs and Project Management
・Ms. Chhay Vuchnea	Vice-chief Officer of Technical Affairs and Project Management
・Mr. KIM Chanrithy	Officer of Technical Affairs and Project Management
・Mr. Rattanak Pich	Officer of Technical Affairs and Project Management
・Ms. THOR Kounthy	Officer of Technical Affairs and Project Management

Ministry of Environment (MOE)

・Mr. Duong Samkeat	Deputy Director of Environmental Impact Assessment Dept.
・Mr. Chhek Roth	Director of Department of Laboratory
・Mr. Siv Kung	Deputy Director of Environmental Quality Research and Laboratory

Cambodian Mine Action Centre (CMAC)

・Mr. Mong Sokunthearath	Demining Development Unit Manager

Department of Industry, Science, Technology & Innovation (Svay Rieng DISTI)

・Mr. LONG Sokhom	Director
・Mr. PEN Savuth	Deputy Director

Svay Rieng Water Works

・Mr. Im Mesa	Director
・Mr. CHUM Kimheng	Deputy Director
・Mr. NUTH Thnak	Deputy Director
・Mr. NET Chamroeun	Chief of Commercial Section
・Ms. KEO Tevy	Chief of Administration Section
・Mr. ONR Kompheak	Pipe Network Section
・Mr. PHOK Sambath	Chief of Production Section
・Mr. KIM Utdam	Production Section Staff
・Mr. PRACH Sopheap	Production Section Staff

・Ms. CHHUOT Somala	Staff of Laboratory
・Ms. LUN Titsoda	Staff of Laboratory

Department of Water Resources and Meteorology of Svay Rieng (Svay Rieng DOWRAM)

・Mr. Kim Savuth	Director

Department of Environment of Svay Rieng Province (Svay Rieng DOE)

・Mr. Kaet Saroeun	Director
・Mr. Chan Chhun	Office Chief
・Mr. Path Veasna	Staff

Department of Public Work and Transportation of Svay Rieng Province (Svay Rieng DPWT)

・Mr. YUN Raksmey	Deputy Director
・Mr. Men Phann	Chief of Technical office
・Mr. Koy Vahoun	Chief of Sewerage office

Svay Rieng Provincial Hall

・H.E. Mr. HEM Piseth	Deputy Provincial Governor

Svay Rieng City Hall

・Mr. Pheum Tha	Chief of Administration
・Mr. Sor Sadany	Deputy Director of City Hall

Svay Rieng Deapartment of Post and Telecommunication (DoPTC)

・Mr. Chea Hoeun	Director
・Mr. Saom Piseth	Office Director
・Mr. Chomraeun Socheat	Staff of CFOCN Company
・Mr. Moeung Sophea	Chief administrative
・Mr. Tan Saran	Staff
・Mr. Lin Kheavuth	Staff

Electricite du Cambodia (EDC)

・Mr. SORN Siphat	Chief of Distribution Section
・Mr. KOENG Thuok	Vice Chief of Distribution Section
・Mr. OUM Phanov	Technical Engineer

Police Office (Svay Rieng)

・Mr. Brak Chout	Deputy Director in charge of Firefighting
・Mr. Sous Sarin	Office Chief in charge of Firefighting

Metfone (Phnom Penh)

・Ms. POV Pheanou	Sales Section
・Ms. Manit	Sales Section

Kampot Water Works

・Mr. Ty Kean	Director
・Mr. RIN Parinha	Chief of New WTP

Battambang Water Works

・Mr. Touch Chhuonsaorith	Director
・Mr. Heom Siphann	Vice Chief of Production Section
・Mr. Khorn Narith	Chief of Administration Section

Asian Development Bank (ADB)

・Mr. Carlos Dela Cruz	Team Leader
・Mr. SAN Chanty	Deputy Team Leader
・Mrs. Ouk Moniroth	Accountant