Chapter 2. Contents of the Project

2-1 Basic Concept of the Project

2-1-1 Overall Goal and Project Objectives

Pursat City which has approximately 100,000 people in the administrative area of the WWs can now supply water to approximately 38,000 people only (in 2018). In the same manner, Svay Rieng City has the capacity to supply water to approximately 15,000 people only (in 2015) against approximately 100,000 people. Therefore, the water supply coverage ratio is approximately 38% in Pursat City and approximately 16% in Svay Rieng City. To achieve 100% water supply coverage ratio in urban areas by 2025 by the expansion of the water supply system is a well-known numerical target within MIH, and is an urgent issue for both cities.

Under these circumstances, the RGC made an official request in August 2016 to the GOJ for "The Project for Expansion of Water Supply System in Pursat and Svay Rieng City in the Kingdom of Cambodia" (hereinafter referred to as "this project") under the Japanese grant aid scheme to improve water-supply services in Pursat City and Svay Rieng City. (The official request letter was submitted in June 2017).

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

(1) The preparation will start for grant aid scheme on the expansion of water supply system in Pursat City based on the request.

(2) As for Svay Rieng City, since the stability of water resource is required to be reviewed, the project for Svay Rieng City will be implemented separately from this project.

Based on the above background, this project aims to improve access rate to safe water, to provide stable water supply service and to improve the quality of life of residents by constructing intake facilities, conveyance pipes, WTP, transmission pipes and distribution pipe network in Pursat City.

2-1-2 Outline of the Project

To achieve the purpose, this project consists of construction of new facilities such as intake facility, transmission facility, WTP and distribution facility, procurement of equipment and materials for water quality management and house connection and implementation of soft component for smooth operation and maintenance of each facility.

By 2025, the water supply ratio in Pursat City is expected to be 86.1% of the population in the WWs administrative urban area[1] (i.e. 63,919 out of a population of 74,214) and 30.6% of the population in the WWs administrative rural area (i.e. 11,115 out of a population of 36,317). Overall, the water supply

[1] The definition of urban area in "Reclassification of Urban Areas in Cambodia by MOP, 2011" is (1) the population density is over 200 persons/km^2 and (2) The population engaged in agriculture is less than 50%, and (3) total population in whole commune is over 2000 persons.

ratio is expected to be 67.9% of the total population in the administrative areas of the PWWs (i.e. 75,033 out of a population of 110,531). The total volume of the stable water supply from the existing and new WTPs will become 13,860 m^3/day on average. The administrative area is based on the review of the target area at the WWs in local provincial cities under the direction of MIH secretary of state H.E. Ek Sonn Chan in October 2015. The main components of the project are listed below.

Table 2-1-1 Main Component of the Project

Item	Content	
Construction of Waterworks facility	Design maximum daily water supply: 6,600m^3/day	
	Construction of new intake facility: 7,260m^3/day	Floating type intake pipe Pump station building Administration building Installation of two (2) intake pumps (including one backup pump) Electrical facility Sand basin (Elevated type)
	Installation of conveyance pipe: 8.3km in length	Ductile cast-iron pipe: 350mm in diameter
	Construction of new WTP : (Design treatment capacity: 7,260m^3/day, Daily Maximum Water Supply Amount:6,600m^3/day)	One rapid stirring basin Two flocculation basin Two rectangular sedimentation basins Four rapid filtration basins Distribution reservoir: 2,200m^3 Three distribution pumps with flow control devices (including one backup pump) Electric facility, administration building for chemical liquid injection, chlorine injection building, lagoons (sludge basin, drying bed) etc.
	Installation of distribution pipes: 81.5km in length	
Procurement of Equipment	Water quality analysis equipment Machinery equipment Equipment and materials for house connection	
Soft component	Operation and maintenance of WTP Operation and maintenance of supply and distribution facility Production control	

Source: JICA Survey Team

2-2 Outline Design of the 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 Pursat City, thereby contributing to efforts of the RGC which is aiming to increase the number of people who can access safe drinking water in urban areas. The team conducted an outline design based on the requests of the government, consultations with government officials and a field survey.

1) Planned target year shall be set to 2025, which is disseminated target year in MIH and shall be 3 years after the commencement of the operating facilities.

2) The scale of the new water supply facility shall be set to 6,600m^3/day in consideration of the water demand in 2025 and water supply capacity of the existing water facilities.

3) The water consumption per person per day is 100 lpcd, and the water that satisfies the water quality standard of Cambodia for drinking water is supplied 24 hours a day. The minimum residual water pressure at the end tap should be 50 kPa or more at the hourly maximum water supply.

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

   ・The design criteria which PPWSA adopts and are widely applied in Cambodia,

   ・The design criteria which have been applied in other ongoing grant aid projects,

   ・"The Design Criteria for Water Supply Facilities 2012" (Japan Waterworks Association).

5) As for the procurement of equipment, the most basic equipment shall be selected which is required for operation and maintenance of the facilities built in this project, while considering the request from the Cambodian side and the equipment they currently possess.

6) In the design, locally available and high-quality materials shall be utilized on a priority basis, and the applicable construction methods widely used in Cambodia shall be employed as much as possible.

7) For maintenance and management, the intake facility shall be designed to allow stable water intake, which could cope with the water level fluctuation and the inflow of river-bed material. In addition, the facility shall be able to prevent the influence of sediment inflow to the water intake pump and blockage of conduit pipes during floods.

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 poverty households shall be procured.

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

11) Seismic design shall not be included in this project because the earthquake risk in Cambodia is low and there is no information about records of earthquake.

12) Soft component shall be formulated in order for PURSAT WATERWOKS to be able to operate and maintain new facilities appropriately and supply safe water meeting the water quality criteria.

2-2-1-2 Policy for Natural Environmental Conditions

(1) Precipitation

Northwestern area including the Pursat River basin where Pursat City is located, is one of the largest rice production area in Cambodia. Cambodia's climate is governed by the monsoon winds, which define two major seasons. From mid-May to early October, the strong prevailing winds of the southwest monsoon bring heavy rains and high humidity. From early November to mid-March, the lighter and drier winds of the northeast monsoon bring variable cloudiness, infrequent precipitation, and lower humidity. The weather between these seasons is transitional.

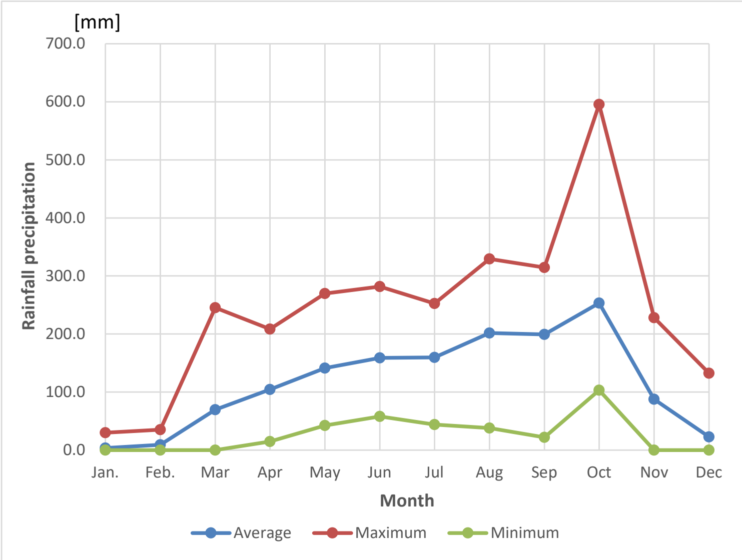
Annual precipitation from 1996 through 2015 is 1,410 mm and the maximum precipitation in this period is 1,876 mm (2008). In comparison to Tokyo in Japan where annual precipitation has been 1,529 mm from 1981 through 2010, annual precipitation in Cambodia is little less (92%) than that of Tokyo in Japan.

Table 2-2-1 and Figure 2-2-1 show monthly precipitation in Pursat from 1996 through 2015. Because there is a clear difference between the rainy season and dry season, consideration will be given to the work process affected by rain such as concrete casting.

Table 2-2-1 Monthly Precipitation in Pursat (1996 – 2015)

Year	Jan.	Feb.	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1996	0.2	10.1	2.3	198.2	269.8	131.2	128.2	133.4	193.4	595.5	132.8	38.7	1833.8
1997	6.2	19.1	20.3	124.0	111.2	176.5	178.3	274.1	266.2	189.4	8.7	0.2	1374.2
1998	0.0	35.2	0.1	64.2	42.2	155.5	138.1	193.6	257.4	237.1	153.5	9.4	1286.3
1999	29.9	0.8	20.9	190.0	229.1	212.5	219.9	112.9	112.0	112.0	111.7	37.4	1389.1
2000	2.5	6.9	35.0	183.4	234.3	229.1	190.9	199.0	182.6	413.5	37.9	25.3	1740.4
2001	0.0	0.0	214.1	25.4	143.4	132.7	79.0	246.8	225.7	170.1	32.8	22.0	1292.0
2002	0.0	0.0	31.5	208.6	82.7	102.0	65.7	314.3	177.0	253.2	139.3	11.6	1385.9
2003	0.0	2.0	245.4	14.8	94.0	210.2	234.0	37.8	207.2	455.8	78.6	1.8	1581.6
2004	2.0	9.8	48.4	65.5	176.0	140.6	143.4	105.0	255.6	103.2	6.3	0.0	1055.8
2005	0.0	0.0	42.8	32.7	140.6	150.3	133.3	195.3	314.5	154.2	84.2	4.5	1252.4
2006	0.0	6.5	88.5	101.8	89.7	180.2	120.0	329.2	199.8	191.7	0.9	82.4	1390.7
2007	0.0	0.3	88.2	123.1	185.7	205.9	43.9	217.9	198.4	197.9	111.9	0.0	1373.2
2008	13.5	7.0	77.0	154.5	218.1	169.4	191.8	314.3	209.8	287.1	228.2	4.8	1875.5
2009	3.6	28.4	56.2	117.9	108.0	130.4	146.1	185.6	175.2	162.7	34.9	132.6	1281.6
2010	0.0	26.7	49.6	81.0	86.8	195.5	161.5	222.4	167.1	277.9	26.6	3.4	1298.5
2011	0.0	0.7	62.7	51.4	114.3	106.1	201.0	214.9	206.1	418.1	69.2	44.0	1488.5
2012	12.1	26.3	156.4	161.5	170.6	57.8	252.6	155.8	248.1	209.5	189.5	8.4	1648.6
2013	0.0	0.0	90.3	93.3	75.7	281.8	225.6	239.3	22.1	132.9	132.9	22.1	1316.0
2014	0.0	0.0	9.3	75.5	72.4	123.6	218.1	124.7	236.3	268.2	0.0	0.0	1128.1
2015	1.9	0.4	54.1	18.3	179.7	84.8	122.1	219.3	128.5	240.4	171.8	4.4	1225.7
Average	3.6	9.0	69.7	104.3	141.2	158.8	159.7	201.8	199.2	253.5	87.6	22.7	1410.9
Maximum	29.9	35.2	245.4	208.6	269.8	281.8	252.6	329.2	314.5	595.5	228.2	132.6	1875.5
Minimum	0.0	0.0	0.1	14.8	42.2	57.8	43.9	37.8	22.1	103.2	0.0	0.0	1055.8

Source: MOWRAM



Source: MOWRAM

Figure 2-2-1 Monthly Precipitation in Pursat (1996 – 2015)

(2) Water Volume and Water Level

Water intake facility will be constructed at the left bank side of the impounding portion of the Damnak Ampil HW. According to ADB's plan of Damnak Chheukrom Irrigation System (DCIS), normal discharge of 4.74 m^3/s will be constantly released from the Damnak Ampil HW to the river all through a year even under 5-year return period of drought. The normal discharge of 4.74 m^3/s is composed of 0.26 m^3/s for domestic and industrial water supply plus 4.48 m^3/s for environmental flow.

During the recent severest drought in 2015, the discharge at Damnak Ampil HW was estimated at 9 to 9.5 m^3/s, calculated based on water level at the existing intake point in 2015 and discharge measurement of this Survey. Hence, at the time of drought, 9.0-4.74m3 / s = 4.26m3 / s is secured at the new intake point upstream of Damnak Ampil HW. Hence, drought discharge with 10 to 15-year return period at Damnak Ampil HW will be sufficiently larger than the water intake quantity of domestic water supply (Existing 7,260 m^3/day x 1.1 =7,986 m^3/day, New 6,600 m^3/day x 1.1 =7,260 m^3/day, and Total 15,246 m^3/day m^3/day = 0.18 m^3/s). Therefore, it is estimated that water quantity for domestic use can be ensured. Considering future expansion of the irrigation area, it is assumed that there will be insufficient water on the Pursat River, and Damnak Chheukrom HW is planned to be constructed as a countermeasure. In addition, the priority of water distribution during drought will be decided in the future by discussions with relevant organizations in Pursat.

(3) Geographical Features and Geological Condition

Regarding geological condition in Pursat City, substratum is basalt of from Neogene to Quaternary in Cezoic, and alluvial deposit is covering it.

According to the boring investigation near the intake point, the soil from the surface to 4.0m to 4.5m is cohesive soil, and the soil deeper than the layer is interbeds of sandy clay and clayey sand. On the other hand, the soil from the surface to 8.5m to 9.5m is sandy clay at the point near the WTP site, and the soil deeper than the layer is interbeds of sandy clay and clayey sand. In the vicinity of the intake facility, the clayey sand contains small gravel slightly.

N values of reclaimed surface of the excavation to designated level at the intake point and the WTP site are around 10 and 20, respectively. Therefore, it is possible to excavate the area with backhoe. The sandy clay layer deeper than 8.5 to 9.5m at the WTP site, which N value is more than 50, is to be bearing stratum of piled raft foundations such as an administration building at the WTP site.

(4) Earthquake

According to study results from the NILIM (National Institute for Land and Infrastructure Management) and seismic hazard maps of UN OCHA (UN Office for Coordination of Humanitarian Affairs) and USGS, earthquake hazard in Cambodia is classified as low. In addition, there is no information about records of earthquake in the country, therefore, facilities shall be designed excluding concepts of seismic adequacy.

(5) Water Quality

According to the monthly water quality survey of the Pursat River and the survey conducted by Pursat WWs, hazardous elements which are difficult to remove have not been detected. Although the peak of turbidity occurs in July and August with the maximum value of 135 NTU, the turbidity is high exceeding 30 NTU the whole year. Therefore, the characteristic of raw water quality shall be taken the design of the facilities into consideration.

In addition, the actual values of raw water turbidity by daily water quality test by the WWs from 2014 to 2017, fluctuate in the range of about 35 NTU to 639 NTU. And the daily data from the WWs has also been observed to be temporarily higher than the monthly data of the Survey Team.

On the other hand, the annual average turbidity is about 60 NTU in the monthly data by the Survey Team, whereas the daily data by the WWs is about 80-90 NTU. The annual average of daily data by the WWs is about 1.5 times the average of monthly data by the Survey Team.

On this outline design, an elevated type sand basin (The details are to be mentioned later) is planned to cope with increase of raw water turbidity during the rainy season.

The concentration of aluminum and iron derived from turbid material is also high, however the level of the turbidity is not so high that they can be removed by general water treatment process.

The water intake point is located at upstream of both the existing water intake point and the urban area, so the level of total coliforms, Eschrichia coli and ammonia which suggest sewage contamination are low consistently.

Agricultural lands are spreading over the water catchment area of the Pursat River, and water quality surveys of pesticides were conducted because of the concern about pesticide pollution. All the 18 pesticides of Drinking Water Quality Standards of Cambodia (2004) and the 328 pesticides which are frequently detected at the Japanese quarantine stations were analyzed, and no pesticides were detected.

Therefore, it is concluded that the pesticides for rice growing does not significantly pollute the source water.

According to the result of jar test by Survey Team, optimum implantation rate of PAC is 18mg/l at the minimum and 50mg/l at the maximum. Chlorine demand amount is about 1.5mg/l at the maximum.

Water quality survey of tap was conducted by examining turbidity and residual chlorine. A bacteria test was carried out when residual chlorine was not detected. The residual chorine was recorded below 0.2 mg/l at five (5) out of 100 survey locations, and total coliforms were detected at one (1) location. Eschrichia coli was not detected at any locations. The turbidity at every survey location was below Cambodia's water quality standard of 5 NTU.

2-2-1-3 Policy for Socio Economic Condition

The main industry in Pursat is cultivation of cash crops such as rice, corns, cassava, beans and vegetables, stock farming, and fishery.

Pursat Province also has great potential as the country's electric power supply base through the development of local hydropower plant.

In addition, there are cassava processing plants, paper mills, food processing plants and construction material factories in the province. Therefore, the water demand of these industries was taken into account to the water demand projection.

National Road No. 5 connecting Thailand and Phnom Penh via Pursat constitutes a part of ASEAN Highway No.1 connecting Bangkok in Thailand and Ho Chi Minh in Viet Nam. Since this project includes pipeline construction along the road, pipeline placing position and the pipeline plan shall be established by considering vehicle traffic during the construction period and future road plans.

In Cambodia, EDC supplies electric power. There are three transmission lines which supply power to Pursat, from Phnom Penh, Battambang and the hydroelectric facility owned by EDC, and this amount of electric power satisfies the electric demand in Pursat. Since the substation is required to comply with the specifications of EDC, EDC implements the supply of the necessary materials to the construction of the facility and the contractor bears the expense. The frequency of power outages is expected to occur several times a month for about 3 hours due to lightning and short circuit accidents during the rainy season. This will be dealt with by a long-time generator.

2-2-1-4 Policy for Constriction and Procurement Conditions

As a basic policy, materials and equipment shall be procured locally. Many WWs facilities have been constructed in Cambodia, and there are several firms in Phnom Penh with these experiences. Therefore, labor and construction equipment are locally procurable.

Main construction materials such as cement, gravel, reinforcing bars and pipes are also basically procurable locally, except DCIP which is not produced in Cambodia. A part of DCIP joints are procured from Japan or a third country. In addition, pumps and water distribution monitoring systems are also procured from Japan because these are not produced in Cambodia.

2-2-1-5 Policy for Utilization of Local Contractors

As mentioned above, many WWs facilities have been constructed in other projects, and some local construction firms have general construction machines. Therefore, Japanese construction firm shall utilize them under appropriate control of schedule, quality and safety of the work.

2-2-1-6 Policy for Operation and Maintenance

The organizational systems of PWWs are required to be strengthened. The team considers the appropriate operation and maintenance structure for DIH and the WWs, the ability required for staff and the process of the system formulation, and then a soft component for organization reinforcement shall be implemented.

2-2-1-7 Policy for Facility and Equipment to be Installed

Rapid sand filtration method which is most common in Cambodia shall be adopted as a water treatment processing method by considering the procurement of materials and equipment, the construction capacity, the ability of WWs staff, quality and quantity of water, electric power condition and land size.

The number of machinery and electric facilities shall be reduced as much as possible to minimize the cost of operation and maintenance. Chemicals for water treatment which are procurable in Cambodia also shall be selected.

2-2-1-8 Policy for Construction and Procurement Method and Schedule

Construction of this project can be divided into three: construction of intake facility, construction of the WTP and laying of water supply pipes. Each construction proceeds simultaneously and in parallel. Construction is also conducted throughout the year.

Since the pipe laying work of conveyance and distribution pipes covers a long distance - 89.8km, the construction plan by multiple construction teams shall be proposed, and the construction management system shall be formulated by proper staffing plan. The conveyance and distribution pipes will be installed along the road shoulder where large external pressure does not occur on the pipe by earth pressure, live load etc. The earth covering depth of the pipe will conforms to the design policy of PPWSA. At the road crossing sections and the underpass sections of drainage pipes or irrigation canals, concrete protection and air valves shall be installed as necessary.

Along the pipe laying route in northern area of distribution network, there are four (4) wooden bridges that are 10m long each. Since these wooden bridges are not able to secure enough durability for passing construction vehicles, it is planned to implement access bridges by steel materials.

2-2-2 Basic Plan

2-2-2-1 Water Demand Prediction

(1) Target Year

In MIH, the target for water supply ratio in urban areas of provincial cities to be 100% by 2025 is set and widely known, and the RGC is proceeding with the expansion of water supply facilities in provincial cities. Based on this ministerial policy, the target year of this project was set to 2025.

(2) Administrative Area

The draft of the master plan created in the human resource development project of the water supply business (phase 2), the administrative area of the future PWWs, based on interviews with the Waterworks director and distribution officer, and the field confirmation, etc., are shown in Figure 2-2-2. A review of the administrative area has been conducted under the direction of RGC in 2015, and the area consists of 3 districts and 13 communes. In addition, urban areas are based on "Reclassification of Urban Areas in Cambodia, 2011 by National Institute of Statistics, Ministry of Planning" by the Ministry of Planning (MOP).

(3) Design Water Supply Area

As of 2018, the population in the administrative area of the PWWs was estimated to be less than 100,000 people. However, the current population served is about 38,000 people, and the water supply ratio is far below the widely known target of MIH aiming to achieve in 2025. Currently, there are some households that utilizing the rainwater instead of piped water, and it is also confirmed that the unsanitary condition causes water-borne disease for residents. In addition, some households purchase expensive water from water vendors instead of piped water. Based on the above situation, expansion of water supply facility is required.

The outline of the design service area, population served by piped water and water consumption as of 2018 is shown in Table 2-2-2.

The range was decided based on the balance between the efficiency of the project, population density, and future extensibility as shown in Annex 7.12, instead of supplying to all areas that the RGC expected.

The determined design water supply area (Figure 2-2-2 and Figure 2-2-3) and the scale of the WTP are planned to be the required minimum scale under the condition that the ratio of benefit (B) to cost (C) is 1 or more. The cost is facility renewal costs and maintenance costs (personnel labour costs, electricity costs, fuel costs, chemical costs) by the Cambodian side after hand over, and the benefit is the revenue from water tariff.

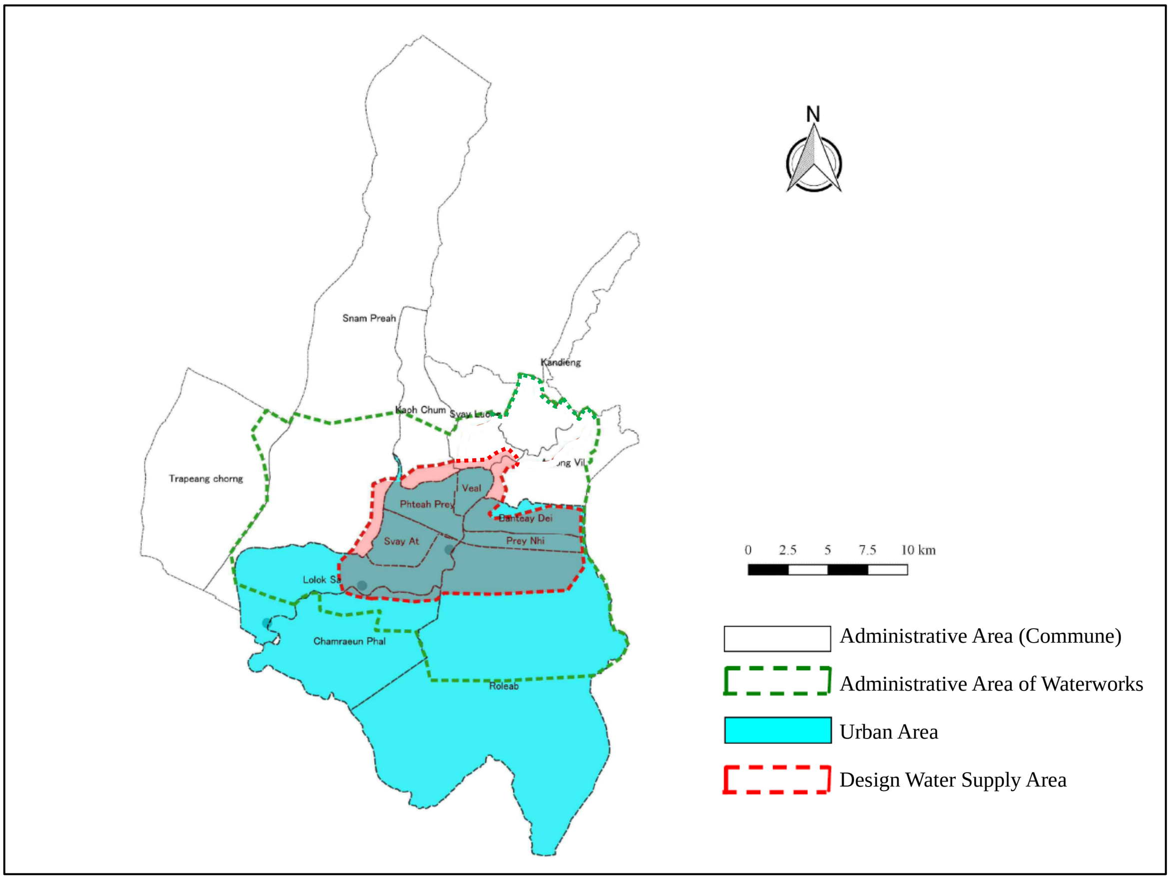
Table 2-2-2 Present Condition of Water Supply in Pursat (2018)

Symbol	Items	Amount
a	Population in Administrative Area [*1]	99,691 persons
b	Population in Urban Area (Inside of Administrative Area)[*2]	66,332 persons
c	Population in Service Area	57,738 persons
d	Population in Urban Area (Outside of Water Supply Area)	18,614 persons
e1	Population Served (Inside of Urban Area)	33,658 persons
e2	Population Served (Outside of Urban Area)	4,003 persons
f	Water Supply Ratio (1)[*3] (=(e1+e2)/a)	37.8 %
g	Water Supply Ratio (2)[*4] (=(e1+e2)/c)	65.2 %
h	Water Supply Ratio (3)[*5] (=e1/b))	50.7 %
i	Water Supply Households (Home)[*6]	7,657 (7,411) house

Notes) Administrative Area: The area that the PWWs and the DIH supply in accordance with the request from the RGC (based on the MIH Chief Commander, H.E. Ek Sonn Chan, Secretary of State) in 2015 to supply water in the future and manage the water supply. The area is set in units of villages, and some urban areas set in commune units are with some villages out of the Administrative area.
Service area: The area where water distribution pipes are laid and can receive water supply service.

* 1 Population in the Administrative Area, * 2 Population in Administrative Urban Area, * 3 Water Supply Ratio in Administrative Area, * 4 Water Supply Ratio in Service Area, * 5 Water Supply Ratio in Urban Area, * 6 Source: PWWs (As of April 2019)

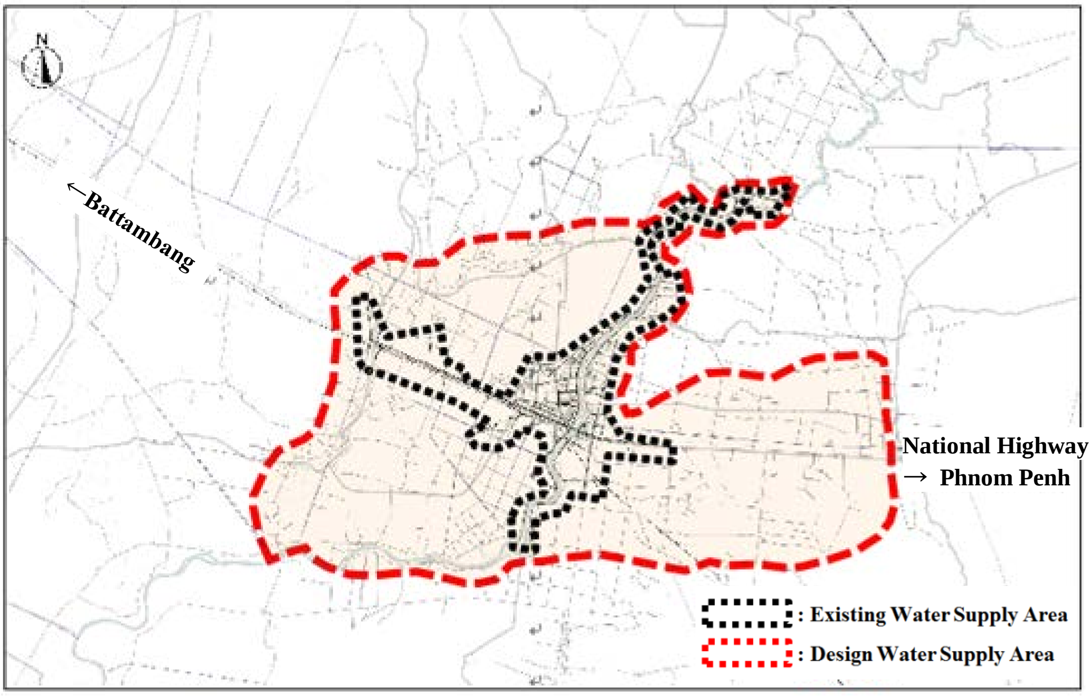
Source: PWWs, JICA Survey Team



Source：JICA Survey Team

Figure 2-2-2 Urban Area of Pursat, Administrative Area and Design Water Supply Area of the WWs

In the urban area not included in the water supply area, the distribution of residential houses is limited along the tributary of the Pursat River and the population density is sparse.



Source：JICA Survey Team

Figure 2-2-3 Future Design Water Supply Area of Pursat

(4) Population and Population Growth Rate

In Cambodia, census was conducted in 1998 and 2008, and the interim census was carried out in 2013. The population and population growth rate of the Pursat Province based on the result of the census are shown in Table 2-2-3(Source: Analytical Report No.2 Spatial Distribution and Growth of Population in Cambodia, National Report of Final Results of Cambodian 2008 Population Census).

Table 2-2-3 Population of Pursat Province

	Population			Annual Population Growth Rate (APGR)	
	1998	2008	2013	1998-2008	2008-2013
Pursat State	360,445	390,047	435,596	0.79%	2.23%

Source：National Institute of Statistics, Ministry of Planning, Cambodia

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

Table 2-2-4 Population of the PWWs Administrative Area (Village)

District	Commune		Village	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	APGR 2015-2018
			Total	35,850	40,918	40,918	40,918	40,979	51,597	51,597	97,317	100,422	98,243	99,691	
Bakan				-	-	-	-	-	1,046	1,046	11,927	12,390	12,390	12,390	
	Snam Preah			-	-	-	-	-	1,046	1,046	11,927	12,390	12,390	12,390	**1.28%**
		15010715	Svay Att	-	-	-	-	-	501	501	513	549	549	549	2.29%
		15010712	Kam Peanh Svay	-	-	-	-	-	545	545	576	742	742	742	8.81%
		15010707	Sdok Svay	-	-	-	-	-	-	-	1,054	1,062	1,062	1,062	0.25%
		15010703	Ang Doung Sambour	-	-	-	-	-	-	-	1,158	1,158	1,158	1,158	0.00%
		15010711	Ang long Mean	-	-	-	-	-	-	-	845	879	879	879	1.32%
		15010717	Ang Doung Krasang	-	-	-	-	-	-	-	1,503	1,539	1,539	1,539	0.79%
		15010701	Snam Preah	-	-	-	-	-	-	-	622	627	627	627	0.27%
		15010716	A Rean	-	-	-	-	-	-	-	599	597	597	597	-0.11%
		15010719	Chheung Phleurng	-	-	-	-	-	-	-	722	885	885	885	7.02%
		15010702	Kra Peur Rol	-	-	-	-	-	-	-	911	921	921	921	0.36%
		15010708	Koah Krasang	-	-	-	-	-	-	-	626	627	627	627	0.05%
		15010710	Dang Keab Kdam	-	-	-	-	-	-	-	564	581	581	581	0.99%
		15010714	Thnuos Ta Cab	-	-	-	-	-	-	-	1,435	1,424	1,424	1,424	-0.26%
		15010718	Bak Pring	-	-	-	-	-	-	-	799	799	799	799	0.00%
Kandieng				13,455	15,613	15,613	15,613	15,468	16,256	16,256	26,238	26,822	26,840	26,957	
	Anlong Vil			-	2,158	2,158	2,158	2,064	2,064	2,064	5,403	5,737	5,588	5,665	**1.59%**
		15020101	Tuol Char	-	310	310	310	171	171	171	291	299	338	346	5.94%
		15020102	Ou Bakrorng	-	290	290	290	295	295	295	311	319	338	340	3.02%
		15020103	Wat Por 1	-	340	340	340	347	347	347	531	552	563	563	1.97%
		15020104	Wat Por 2	-	255	255	255	268	268	268	270	273	285	285	1.82%
		15020107	Kancheut Baydach	-	285	285	285	318	318	318	313	321	336	355	4.29%
		15020108	Ang long Vil	-	290	290	290	279	279	279	269	269	257	253	-2.02%
		15020109	Preak Ta Vorng	-	388	388	388	386	386	386	415	413	446	454	3.04%
		15020105	Kampong Kra bey	-	-	-	-	-	-	-	243	242	249	258	2.02%
		15020106	Phlouv Kra bey	-	-	-	-	-	-	-	273	275	279	292	2.27%
		15020110	Preak Ta Kong	-	-	-	-	-	-	-	291	290	275	272	-2.23%
		15020111	Koah Kra sang	-	-	-	-	-	-	-	343	341	367	378	3.29%
		15020112	Preak Chheur Trav	-	-	-	-	-	-	-	443	440	462	465	1.63%
		15020113	Chey Chom mas	-	-	-	-	-	-	-	468	467	423	429	-2.86%
		15020114	Boeung Chhouk	-	-	-	-	-	-	-	502	799	516	518	1.05%
		15020116	Kbal Ro meas	-	-	-	-	-	-	-	440	437	454	457	1.27%
	Kandieng			1,345	1,345	1,345	1,345	1,425	2,213	2,213	6,096	6,279	6,150	6,360	**1.42%**
		15020304	Kandieng Knoung	360	360	360	360	285	285	285	307	321	321	321	1.50%
		15020305	Kandieng	295	295	295	295	348	348	348	372	384	361	358	-1.27%
		15020306	Sthanny	425	425	425	425	492	492	492	563	573	580	583	1.17%
		15020307	Yuos	265	265	265	265	300	300	300	313	300	302	309	-0.43%
		15020302	Keo Vi chey	-	-	-	-	-	375	375	327	372	363	375	4.67%
		15020308	Prey Kdey leu	-	-	-	-	-	173	173	176	186	195	189	2.40%
		15020309	Prey Kdey Kandal	-	-	-	-	-	240	240	258	276	272	282	3.01%
		15020310	Prey Kdey Krom	-	-	-	-	-	-	-	385	399	399	403	1.53%
		15020312	Bong Korl	-	-	-	-	-	-	-	550	578	555	561	0.66%
		15020303	Svay Yeang	-	-	-	-	-	-	-	335	330	252	357	2.14%
		15020301	Kampong Roka	-	-	-	-	-	-	-	241	233	224	246	0.69%
		15020313	Steoung Leu	-	-	-	-	-	-	-	379	361	357	366	-1.16%
		15020314	Steoung Krom	-	-	-	-	-	-	-	422	440	418	425	0.24%
		15020315	Kampong Krasang leu	-	-	-	-	-	-	-	315	323	327	331	1.67%
		15020316	Kampong Krasang Kron	-	-	-	-	-	-	-	437	456	469	476	2.89%
		15020317	Boeung Chhouk	-	-	-	-	-	-	-	716	747	755	778	2.81%
	Svay Luong			2,070	2,070	2,070	2,070	2,231	2,231	2,231	3,776	3,829	3,881	3,866	**0.79%**
		15020701	Boeung Kranh	595	595	595	595	545	545	545	527	531	534	528	0.06%
		15020702	Rong Masin	395	395	395	395	355	355	355	316	322	328	326	1.04%
		15020703	Svay Luong	295	295	295	295	576	576	576	254	260	264	262	1.04%
		15020704	Svay Chan	460	460	460	460	440	440	440	441	449	455	452	0.82%
		15020705	Plouv portivong	325	325	325	325	315	315	315	356	361	363	363	0.65%
		15020706	Svay Cham bok	-	-	-	-	-	-	-	412	417	420	418	0.48%
		15020707	Por Leurng	-	-	-	-	-	-	-	420	428	434	435	1.18%
		15020708	Ko Kor	-	-	-	-	-	-	-	289	288	295	295	0.69%
		15020709	San lot	-	-	-	-	-	-	-	307	311	318	319	1.29%
		15020710	Svay Yeang	-	-	-	-	-	-	-	454	462	470	468	1.02%
	Veal			5,020	5,020	5,020	5,020	4,898	4,898	4,898	5,262	5,323	5,184	5,205	**-0.36%**
		15020901	Kbal Hong	710	710	710	710	663	663	663	807	820	825	825	0.74%
		15020902	Bralay Thom	945	945	945	945	1,005	1,005	1,005	843	875	877	892	1.90%
		15020903	Veal	555	555	555	555	570	570	570	468	474	484	479	0.78%
		15020904	Por Kambor	680	680	680	680	620	620	620	701	669	653	651	-2.44%
		15020905	Kancheut BaydaCh	455	455	455	455	410	410	410	413	405	364	356	-4.83%
		15020906	Por Damnak	720	720	720	720	753	753	753	719	717	669	663	-2.67%
		15020907	Boeung Yea	515	515	515	515	472	472	472	510	516	502	504	-0.39%
		15020908	Ta Sdey	440	440	440	440	405	405	405	437	457	427	438	0.08%
		15020909	Toul Pon Ro	-	-	-	-	-	-	-	364	390	383	397	2.93%
	Kaoh Chum			-	-	-	-	-	-	-	4,569	4,648	4,938	5,078	**3.58%**
		15021002	Spean	-	-	-	-	-	-	-	881	895	955	966	3.12%
		15021003	Dorng Rong	-	-	-	-	-	-	-	801	801	876	907	4.23%
		15021004	Dorng Lorng	-	-	-	-	-	-	-	778	819	896	936	6.36%
		15021001	Ang long hab	-	-	-	-	-	-	-	815	825	838	859	1.77%
		15021005	Stok Chhom	-	-	-	-	-	-	-	1,294	1,308	1,373	1,410	2.90%

District	Commune		Village	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	APGR 2015-2018
			Total	35,850	40,918	40,918	40,918	40,979	51,597	51,597	97,317	100,422	98,243	99,691	
Krong Pursat				22,395	25,305	25,305	25,305	25,511	34,295	34,295	59,152	61,210	59,013	60,344	
	Chamraeun Phal			-	-	-	-	-	-	-	2,050	2,068	2,037	2,306	**4.00%**
		15050103	Aur Toung	-	-	-	-	-	-	-	750	755	746	993	9.81%
		15050107	Svay Meas	-	-	-	-	-	-	-	630	635	620	645	0.79%
		15050101	Leav	-	-	-	-	-	-	-	670	678	671	668	-0.10%
	Lolork Sor			2,970	3,505	3,505	3,505	3,289	3,289	3,289	8,307	8,336	8,662	9,028	**2.81%**
		15050301	Por ta kuoy	1,685	1,685	1,685	1,685	1,302	1,302	1,302	1,356	1,333	1,401	1,357	0.02%
		15050302	Preak Sdey	1,285	1,285	1,285	1,285	1,446	1,446	1,446	1,232	1,284	1,296	1,306	1.96%
		15050303	Lolork sor	-	535	535	535	541	541	541	502	535	543	505	0.20%
		15050305	Phsar Leu	-	-	-	-	-	-	-	442	445	445	509	4.82%
		15050304	Phum Korh	-	-	-	-	-	-	-	950	969	1,053	1,011	2.10%
		15050306	Wat Loung	-	-	-	-	-	-	-	1,034	1,077	1,103	1,134	3.13%
		15050307	Chhom rom siem	-	-	-	-	-	-	-	779	786	829	847	2.83%
		15050308	Dob Bat	-	-	-	-	-	-	-	1,116	1,122	1,139	1,276	4.57%
		15050310	Khmar	-	-	-	-	-	-	-	896	785	853	1,083	6.52%
	Phteah Prey			12,570	12,570	12,570	12,570	12,075	14,622	14,622	16,614	16,852	16,792	16,915	**0.60%**
		15050401	Peal Nheaek Muoy	3,830	3,830	3,830	3,830	3,218	3,218	3,218	3,218	3,330	3,330	3,312	0.96%
		15050402	Peal Nheaek Pir	3,295	3,295	3,295	3,295	2,591	2,591	2,591	3,163	3,193	3,223	3,232	0.72%
		15050403	Kbal Hong	1,070	1,070	1,070	1,070	1,164	1,164	1,164	1,361	1,359	1,352	1,346	-0.37%
		15050405	Chamkar Chek Khang C	2,080	2,080	2,080	2,080	2,679	2,679	2,679	2,760	2,770	2,816	2,921	1.91%
		15050406	Chamkar Chek Khang T	1,305	1,305	1,305	1,305	1,212	1,212	1,212	1,028	1,027	1,027	1,019	-0.29%
		15050407	Ou Sdau	-	-	-	-	-	812	812	771	807	808	755	-0.70%
		15050410	Ra	990	990	990	990	1,211	1,211	1,211	1,680	1,656	1,594	1,501	-3.69%
		15050408	Tnaot Tret	-	-	-	-	-	814	814	975	998	1,007	1,012	1.25%
		15050409	Kok	-	-	-	-	-	921	921	799	812	810	829	1.24%
		15050404	Dangkear	-	-	-	-	-	-	-	859	900	825	988	4.77%
	Prey Nhi			3,580	3,580	3,580	3,580	3,615	3,615	3,615	5,304	5,613	5,590	5,560	**1.58%**
		15050501	Bak Roteh	1,035	1,035	1,035	1,035	1,132	1,132	1,132	1,325	1,394	1,405	1,425	2.45%
		15050502	Doung Chrum	685	685	685	685	679	679	679	658	639	628	632	-1.33%
		15050503	Pralay Thum	435	435	435	435	382	382	382	413	418	418	425	0.96%
		15050504	Kbal Spean Thma	445	445	445	445	410	410	410	403	403	408	413	0.82%
		15050505	Moan Chae	980	980	980	980	1,012	1,012	1,012	854	1,074	1,065	1,031	6.48%
		15050507	Krang Ta Saen	-	-	-	-	-	-	-	470	488	476	445	-1.81%
		15050506	Sala Kumru	-	-	-	-	-	-	-	849	860	853	860	0.43%
		15050508	Srah Srang	-	-	-	-	-	-	-	332	337	337	329	-0.30%
	Roleab			1,935	4,310	4,310	4,310	4,989	8,042	8,042	17,453	18,378	16,012	16,135	**-2.58%**
		15050601	Pou Andaot	660	660	660	660	734	734	734	680	713	715	691	0.54%
		15050604	Thnal Bambaek	635	635	635	635	746	746	746	750	755	705	691	-2.69%
		15050605	Spean Thma	640	640	640	640	1,321	1,321	1,321	1,324	1,328	1,217	1,199	-3.25%
		15050606	Chhlang Kat	-	710	710	710	587	587	587	725	750	684	689	-1.68%
		15050607	Stueng Touch	-	640	640	640	611	611	611	653	670	678	686	1.66%
		15050611	Thnal Chopon	-	1,025	1,025	1,025	990	990	990	1,095	1,123	1,083	1,070	-0.77%
		15050602	Prey Aomal	-	-	-	-	-	2,257	2,257	2,645	2,808	3,014	3,043	4.78%
		15050609	Souriya Leu	-	-	-	-	-	398	398	549	560	413	421	-8.47%
		15050610	Souriya Kraom	-	-	-	-	-	398	398	501	521	213	223	-23.65%
		15050608	Roleab	-	-	-	-	-	-	-	2,836	3,010	2,139	2,282	-6.99%
		15050613	Ou Thkov	-	-	-	-	-	-	-	2,992	3,207	2,692	2,699	-3.38%
		15050603	Tuol Mkak	-	-	-	-	-	-	-	1,568	1,759	1,620	1,605	0.78%
		15050612	Preaek Tnaot	-	-	-	-	-	-	-	1,135	1,174	839	836	-9.69%
	Svay At			1,340	1,340	1,340	1,340	1,543	4,727	4,727	4,855	5,315	4,982	5,322	**3.11%**
		15050702	Krang Pophleak	-	-	-	-	-	1,043	1,043	985	998	998	1,039	1.79%
		15050703	Trang	-	-	-	-	-	454	454	375	385	392	420	3.85%
		15050701	Sthani	1,340	1,340	1,340	1,340	1,543	1,543	1,543	1,588	1,988	1,615	1,718	2.66%
		15050705	Ou Sdau	-	-	-	-	-	838	838	873	883	887	969	3.54%
		15050704	Svay At	-	-	-	-	-	849	849	1,034	1,061	1,090	1,176	4.38%
	Bateay Dei			5,020	5,020	5,020	5,020	4,850	4,850	4,850	5,701	5,654	6,037	5,861	**0.93%**
		15050801	Ou Ba Krang Leu	250	250	250	250	250	250	250	245	250	351	259	1.87%
		15050802	Ou Ba Krang Kraom	585	585	585	585	526	526	526	507	505	451	453	-3.68%
		15050803	Ou Ba Krang Kandal	290	290	290	290	257	257	257	259	252	261	252	-0.91%
		15050804	Kaev Sovann Leu	475	475	475	475	427	427	427	449	477	488	522	5.15%
		15050805	Kaev Sovann Kraom	305	305	305	305	331	331	331	329	343	366	318	-1.13%
		15050807	Kbal Hong	455	455	455	455	468	468	468	395	477	483	485	7.08%
		15050808	Bandoh Sandaek	555	555	555	555	492	492	492	531	562	574	526	-0.31%
		15050809	Eslam	825	825	825	825	754	754	754	740	643	793	707	-1.51%
		15050810	Banteay Dei Leu	745	745	745	745	777	777	777	770	655	718	754	-0.70%
		15050811	Banteay Dei Kraom	535	535	535	535	568	568	568	594	565	620	590	-0.22%
		15050812	Kaev Muni	-	-	-	-	-	-	-	501	520	526	575	4.70%
		15050806	Ta Koy	-	-	-	-	-	-	-	381	405	406	420	3.30%

APGR: Annual Population Growth Rate
Source：PWWs

As a result of reviewing the PWWs administrative area in 2015, the target village increased to 133 locations from 72 locations, resulting in the population of the same area increased from 51,597 people in 2014 to 97,317 in 2015.

(5) Future Population in Water Supply Area

Instead of extending all the administrative area, the plan is to expand the water supply area where the population growth is expected to be guaranteed by 2025, and to install the water supply pipe to the end so that the water is supplied to the residents reliably in the area. The prediction of future population in water supply area of Pursat is shown in Table 2-2-5. For water supply to the target area to be expanded in this project, it is supposed to start from 2022 which is the completion year of the facility.

Table 2-2-5 Future Population in Water Supply Area

District	Commune	Urban / Rural	2018	2019	2020	2021	2022	2023	2024	2025
Bakan	Snam Preah	Rural	3,076	3,076	3,076	3,076	3,076	3,657	3,657	3,657
Kan-dieng	Anlong Vil	Rural	2,596	2,693	2,769	2,846	2,922	3,600	3,688	3,775
	Kandieng	Rural	2,417	2,468	2,500	2,531	2,563	3,027	3,064	3,101
	Svay Luong	Rural	1,931	1,956	1,969	1,982	1,996	2,439	2,455	2,470
	Veal	Urban	4,808	4,923	4,948	4,973	4,998	5,466	5,501	5,535
	Kaoh Chum	Rural	0	0	0	0	0	3,159	3,245	3,330
Krong Pursat	Chamraeun Phal	Urban	0	0	0	0	0	2,603	2,678	2,753
	Lolok Sa	Urban	3,168	3,243	3,275	3,307	3,340	7,402	7,538	7,674
	Phteah Prey	Urban	16,915	17,115	17,243	17,372	17,501	17,629	17,758	17,886
	Prey Nhi	Urban	3,926	4,084	4,174	4,265	4,355	6,121	6,214	6,307
	Roleab	Urban	8,713	9,282	9,436	9,590	9,744	15,099	15,254	15,408
	Svay At	Urban	5,322	5,386	5,492	5,599	5,706	5,813	5,920	6,026
	Bateay Dei	Urban	4,866	5,055	5,125	5,195	5,265	6,493	6,598	6,702
Urban			47,718	49,086	49,694	50,301	50,908	66,626	67,459	68,292
Rural			10,020	10,192	10,314	10,435	10,557	15,882	16,107	16,333
Total			57,738	59,279	60,007	60,736	61,465	82,508	83,567	84,625

Note: *1) The classification of “urban” and “rural” is based on the definition of “Reclassification of Urban Areas in Cambodia, 2011: Ministry of Planning”.
Source：JICA Survey Team

(6) Water Supply Population and Water Supply Ratio

The water supply population is expected to be 75,033 persons in the target year of 2025, and the water supply ratio is 67.9% (urban area 86.1%), and the number of connected households is 15,282 as shown in Table 2-2-6 and Table 2-2-7. These figures are proposed considering cost-effectiveness while taking into account the target of MIH, which aims to achieve water supply ratio of 90% by piped water in the urban areas by 2025.

As shown in Table 2-2-6, the water supply population as of 2018 based on the water supply data of the Pursat WWs is 37,661 persons. In this outline design, the water supply population in 2025 is planned to reach 75,033 persons, and the increase of water supply population is expected to be 37,373 persons.

Compared with the water supply population of 84,625 in 2025 shown in Table 2-2 5, 9,592 persons are excluded from water supply population.

The people excluded from water supply are those in areas where results from cost-effectiveness studies determined that the installation of water distribution pipes is not economical as a result of project budget limitations. Therefore, although these people are distributed within the water supply area, some of these people were excluded from water supply population.

Houses that are not included to the water supply pipe connection are scattered far from the distribution pipe laid road and cannot be connected with a standard 5m length water supply pipe. In case of identifying houses that cannot be connected to the distribution pipeline, the positional relationship between the major roads and the village distributions are clarified on satellite images, and on the village basis, it was determined whether to include or exclude the villages in the water supply area.

On the other hand, MIH assumes that by the year 2025, 90% of the urban population will be covered by the piped water supply, and the remaining 10% will be covered by other methods than the piped water supply.

In Japan, it is generally defined that “water supply ratio in administrative area = water supply population ÷ population within administrative area” and “water supply ratio in water supply area = water supply population ÷ population within water supply area”.

Table 2-2-6 Future Water Supply Population

District	Commune	Urban / Rural	2018	2019	2020	2021	2022	2023	2024	2025
Bakan	Snam Preah	Rural	580	615	627	640	782	1,246	1,579	1,912 (1,745)
Kan-dieng	Anlong Vil	Rural	1,321	1,400	1,428	1,457	1,721	2,430	3,050	3,713 (62)
	Kandieng	Rural	1,095	1,161	1,184	1,208	1,095	1,095	1,095	1,095 (2,006)
	Svay Luong	Rural	1,007	1,067	1,089	1,111	1,007	1,201	1,299	1,398 (1,072)
	Veal	Urban	3,669	3,889	3,967	4,046	4,001	4,568	5,043	5,535 (0)
	Kaoh Chum	Rural	0	0	0	0	0	1,422	2,190	2,997 (333)
Krong Pursat	Chamraeun Phal	Urban	0	0	0	0	0	1,301	2,008	2,753 (0)
	Lolok Sa	Urban	3,001	3,181	3,245	3,310	3,086	5,201	6,404	7,674 (0)
	Phteah Prey	Urban	12,460	13,208	13,472	13,741	13,720	15,045	16,433	17,886 (0)
	Prey Nhi	Urban	3,672	3,892	3,970	4,050	3,843	4,813	5,453	6,139 (168)
	Roleab	Urban	4,362	4,624	4,716	4,811	5,406	7,738	9,505	11,325 (4,083)
	Svay At	Urban	2,518	2,669	2,722	2,777	3,315	4,165	5,069	6,026 (0)
	Bateay Dei	Urban	3,976	4,215	4,299	4,385	4,298	5,177	5,853	6,580 (123)
Urban			33,658	35,677	36,391	37,119	37,669	48,008	55,768	63,919 (4,373)
Rural			4,003	4,243	4,328	4,415	4,606	7,394	9,213	11,115 (5,218)
total			37,661	39,921	40,719	41,533	42,275	55,402	64,981	75,033 (9,592)

Note: *1) The classification of “urban” and “rural” is based on the definition of “Reclassification of Urban Areas in Cambodia, 2011: Ministry of Planning”.
Figures in parentheses in 2025 indicate the population excluded from water supply among the population in the water supply area.
Source：JICA Survey Team

Table 2-2-7 Water Supply Ratio in Administrative Area and Water Supply Ratio in Water Supply Area

Symbol/Formula		Population/Water Supply Ratio	Unit	Present Condition (2018)	Increase by Project	After Project Implementation (2025)
a		Total Population in Administrative Area	person	99,691	―	110,531
b		Total Population in Urban Area (Inside of Administrative Area)	person	66,332	―	74,214
c		Total Population in Water Supply Area	person	57,738	―	84,625
	c1	In Urban Area	person	47,718	―	68,292
	c2	Out of Urban Area	person	10,020	―	16,333

Symbol/Formula		Population/Water Supply Ratio	Unit	Present Condition (2018)	Increase by Project	After Project Implementation (2025)
d = b - c1		Urban Area Population out of Water Supply Area	person	18,614	―	5,922
e		Water Supply Population	person	37,661	39,864	75,033
	e1	In Urban Area	person	33,658	32,071	63,919
	e2	Out of Urban Area	person	4,003	7,793	11,115
f = (e/a) x 100		Water Supply Ratio for The Total Population in Administrative Area	%	37,661÷99,691 x 100=37.8	67.9-37.8= 30.1	75,033÷110,531 x 100=67.9
g = (e/c) x 100		Water Supply Ratio for Total Population in Water Supply Area	%	37,661÷57,738 x 100=65.2	88.7-65.2= 23.5	75,033÷84,625 x 100=88.7
h = (e1/b) x 100		Water Supply Ratio for Total Population of Urban Water Supply Area	%	33,658÷66,332 x 100=50.7	86.1-50.7= 35.4	63,919÷74,214 x 100=86.1

Source：JICA Survey Team

(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 HHs

Items	Unit	2013	2014	2015	2016	2017	2018	Average
Average domestic water consumption per day	m^3/Day	2,963	3,215	3,509	4,012	3,695	3,972	
Water Supply Population	Person	29,773	32,549	33,572	35,682	36,885	37,661	
Average domestic water consumption per person per day.	L/Day/ Person	**99.5**	**98.8**	**104.5**	112.4	**100.2**	**105.5**	101.7

Source：PWWs

According to the historical records, the average water consumption was 101.7 L/day/person except for the particular draught year in 2016. This is a historical record collected in existing urban areas, therefore, taking into account the living standards and lifestyles of residents in the extended area, the future demand projection adopts the value of 100L/day/person. There is a past record exceeding 100L/day/person on average a year in some case. However, as for the leakage water volume, washing water volume and insensitive water volume of water meter, the design non-revenue water ratio for water demand projection is set larger than the actual non-revenue water ratio. Therefore, the design water supply amount on this projection is large enough to accommodate the volume of actual water demand.

(8) Average Water Consumption Per Day for Business and Institution

Daily water consumption classified by application is shown in Table 2-2-9 There is also a plan to construct factories along the national highway 5 near the center of Pursat City, and the proportion of water for commercial and public use tends to increase year by year. From the trend in Table 2-2-9, the home water use ratio shows a slight downward trend, indicating that the increase in water consumption for commercial and public use exceeds that of home water consumption. Future water consumption for commercial and public use was estimated based on actual consumption records for the last four years (2015-2018), with an expected yearly increase in water volume of 180 m^3/day.

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

Items	Unit	2013	2014	2015	2016	2017	2018	Average
Home	m^3/Day	2,963	3,215	3,509	4,012	3,695	3,972	
Business	m^3/Day	204	315	579	706	828	841	
Public	m^3/Day	250	223	250	331	400	418	
Total	m^3/Day	3,417	3,753	4,338	5,049	4,923	5,231	
Total of commercial	m^3/Day	454	538	829	1,037	1,228	1,259	
Ratio of domestic	%	86.7	85.7	80.9	79.5	75.1	75.9	
Commercial water yearly increase	m^3/Day		84	291	208	191	31	180 m^3/day/year

Source： PWWs

(9) Leakage Ratio

Based on the actual data of the waterworks, the non-revenue water ratio of the city is an average of 10.8% for the past five years, which is regarded as considerably low. This ratio is calculated with the amount of distribution water volume and the charged water volume. Since leakage ratio is not measured in Cambodia, it is estimated based on the past records of other projects in Cambodia.

In the case of a high non-revenue water ratio around 50%, the leakage ratio is generically around half of the non-revenue water rate. However, when the countermeasures against non-revenue water reduction are implemented to a certain extent, the leakage ration is found to be reduced while the other losses other than leakage also decrease drastically, resulting in a high percentage of the leakage in the non-revenue water.

On the other hand, the non-revenue water ratio of 15% is prescribed in the ministerial ordinance of Cambodia in case of construction of a new WTP.

This non-revenue water ratio of 15% is confirmed based on the idea that the value on the safe side is applied according to the following idea:

- Non-revenue water ratio may increase due to aging of existing pipes in the future.
- The value of the leakage water ratio calculated based on the non-revenue water ratio is unclear, and the estimation of leakage water ratio includes uncertain elements.

Based on the above, the leakage water ratio and the effective water ratio in 2025 as the target year in this project are set out at 11.3% and 88.7%, respectively on the assumption that the leakage ratio covers 75% of whole non-revenue water ratio.

(10) Load Factor

The performance of the PWWs in the past four years is listed in Table 2-2-10. The load factor is defined as the ratio of average daily water supply volume to daily maximum water supply volume. The lord factor of the PWWs is calculated as 82.3% by using the lower three-year average of the past records.

In case the load factor is set to be larger, there is a possibility that the daily maximum water supply amount is reduced corresponding to the daily average water supply amount, and there is a risk that it is not possible to follow the water demand fluctuations in a day.

Therefore, the load factor was calculated by applying the normal value among records from several years, and the unique value compared to the normal year is rejected for the estimation of safe side design load factor.

Table 2-2-10 Past Records of Load Factor

Item	Unit	2015	2016	2017	2018	Lower three-year average
Daily average water supply	m^3/day	4,886	5,618	5,447	5,747	
Daily maximum water supply amount	m^3/day	5,950	6,856	6,280	6,925	
Load factor	%	**82.1**	**81.9**	86.7	**82.9**	82.3

Source: Data of the PWWs

(11) Future Water Demand

Based on the above-mentioned data, the result of the future drinking water demand of Pursat City is estimated as shown in Table 2-2-11. The daily maximum water supply volume in 2025 as the target year of the project is calculated to be 13,826 m^3/day. Since the present water supply volume is 7,260 m^3/day, the required water supply capacity for this project is 6,566 ≒ 6,600 m^3/day.

Table 2-2-11 Future Water Demand in Pursat City

Record ← → Prospect

Items		単位	式	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Population in Administrative Area	total	person	A	40,979	51,597	51,597	97,317	100,422	98,243	99,691	102,418	103,770	105,122	106,475	107,827	109,179	110,531
	urban	person		35,259	44,043	44,043	65,546	67,539	65,296	66,332	68,542	69,487	70,433	71,378	72,323	73,269	74,214
	rural	person		5,720	7,554	7,554	31,771	32,883	32,947	33,359	33,876	34,283	34,690	35,097	35,503	35,910	36,317
Population in Water Supply Area	total	person	B	40,979	51,597	51,597	56,330	57,994	57,543	57,738	59,279	60,007	60,736	61,465	82,508	83,567	84,625
	urban	person		35,259	44,043	44,043	46,851	48,137	47,566	47,718	49,086	49,694	50,301	50,908	66,626	67,459	68,292
	rural	person		5,720	7,554	7,554	9,479	9,857	9,977	10,020	10,192	10,314	10,435	10,557	15,882	16,107	16,333
Water Supply Population	total	person	C	24,652	29,773	32,549	33,572	35,682	36,885	37,661	39,921	40,719	41,533	42,275	55,402	64,981	75,033
	urban	person		22,011	26,584	29,063	29,976	31,843	32,912	33,658	35,677	36,391	37,119	37,669	48,008	55,768	63,919
	rural	person		2,641	3,189	3,486	3,596	3,839	3,973	4,003	4,243	4,328	4,415	4,605	7,394	9,213	11,115
Water Supply Ratio in Administrative Area	total	%	D = C/A x 100%	60.2	57.7	63.1	34.5	35.5	37.5	37.8	39.0	39.2	39.5	39.7	51.4	59.5	67.9
	urban	%		62.4	60.4	66.0	45.7	47.1	50.4	50.7	52.1	52.4	52.7	52.8	66.4	76.1	86.1
	rural	%		46.2	42.2	46.2	11.3	11.7	12.1	12.0	12.5	12.6	12.7	13.1	20.8	25.7	30.6
Water Supply Ratio in Water Supply Area	total	%	E = C/B x 100%	60.2	57.7	63.1	59.6	61.5	64.1	65.2	67.3	67.9	68.4	68.8	67.1	77.8	88.7
	urban	%		62.4	60.4	66.0	64.0	66.2	69.2	70.5	72.7	73.2	73.8	74.0	72.1	82.7	93.6
	rural	%		46.2	42.2	46.2	37.9	38.9	39.8	40.0	41.6	42.0	42.3	43.6	46.6	57.2	68.1
Water Supply Households	total	house	F	5,016	6,005	6,475	6,860	7,252	7,510	7,657	8,130	8,293	8,459	8,610	11,283	13,234	15,282
	urban	house		4,476	5,359	5,778	6,122	6,472	6,701	6,843	7,266	7,412	7,560	7,672	9,778	11,358	13,018
	rural	house		482	577	622	659	696	722	727	864	881	899	938	1,506	1,876	2,264
Water Supply Households (Poor Households)	total	house	G = F x poor household ratio	697	835	900	954	1,008	1,044	1,064	1,130	1,153	1,176	1,197	1,568	1,840	2,120
	urban	house		595	713	768	814	861	891	910	966	986	1,005	1,020	1,300	1,511	1,730
	rural	house		83	99	107	113	120	124	125	149	152	155	161	259	323	390
Average Water Consumption per Person per Day for Household		L/day/person	H	106.1	99.5	98.8	104.5	112.4	100.2	105.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Average Water Consumption per Day for Household		m^3/day	I = H x C ÷ 1000	2,615	2,963	3,215	3,509	4,012	3,695	3,972	3,992	4,072	4,153	4,227	5,540	6,498	7,503
Average Water Consumption per Day for Business and Institution		m^3/day	J	390	454	538	829	1,037	1,228	1,259	1,521	1,701	1,881	2,062	2,242	2,422	2,602
Effective Water Amount (total)		m^3/day	K = I+J	3,005	3,417	3,753	4,338	5,049	4,923	5,231	5,513	5,773	6,034	6,289	7,782	8,920	10,105
Ineffective Water Amount		m^3/day	L = M" - M" x (R/100)	438	466	447	398	415	380	376	699	732	765	797	986	1,131	1,281
Daily Average Water Supply Amount for Household		m^3/day	M = I ÷ R x 100	2,997	3,367	3,598	3,831	4,342	3,980	4,257	4,498	4,588	4,679	4,763	6,242	7,322	8,454
Daily Average Water Supply Amount for Business and Institution		m^3/day	M' = J ÷ R x 100	447	516	602	905	1,122	1,323	1,349	1,714	1,917	2,120	2,323	2,526	2,729	2,932
Daily Average Water Supply Amount		m^3/day	M" = K ÷ R x 100	3,443	3,883	4,200	4,736	5,464	5,303	5,607	6,212	6,505	6,799	7,086	8,768	10,051	11,386
Average Water Consumption per Person per Day for Household		L/day/person	N = M ÷ C x 1000	122	113	111	114	122	108	113	113	113	113	113	113	113	113
Average Water Consumption per Person per Day for Business and Institution		L/day/person	N' = M' ÷ C x 1000	18	17	18	27	31	36	36	43	47	51	55	46	42	39
Average Water Consumption per Person per Day		L/day/person	N" = M" ÷ C x 1000	140	130	129	141	153	144	149	156	160	164	168	158	155	152
Daily Maximum Water Supply Amount		m^3/day	O = M" ÷ T x 100	4,312	4,826	5,647	5,767	6,668	6,114	6,757	7,544	7,900	8,257	8,605	10,648	12,205	13,826
Maximum Water Consumption per Person per Day		L/day/person	P = O ÷ C x 1000	175	162	173	172	187	166	179	189	194	199	204	192	188	184
Revenue Water Ratio		%	Q	83.0	84.0	85.8	88.8	89.9	90.4	91.1	85.0	85.0	85.0	85.0	85.0	85.0	85.0
Effective Water Ratio		%	R = 100% - S	87.3	88.0	89.4	91.6	92.4	92.8	93.3	88.8	88.8	88.8	88.8	88.8	88.8	88.8
Leakage Water Ratio		%	S = (100% - Q) x 0.75	12.7	12.0	10.6	8.4	7.6	7.2	6.7	11.3	11.3	11.3	11.3	11.3	11.3	11.3
Loading Rate		%	T = M" ÷ O x 100%	79.8	80.5	74.4	82.1	81.9	86.7	83.0	82.3	82.3	82.3	82.3	82.3	82.3	82.3
Construction Period												←	→				
Existing Capacity		m^3/day		5,760	5,760	7,260	7,260	7,260	7,260	7,260	7,260	7,260	7,260	7,260	7,260	7,260	7,260
Capacity required by this Project		m^3/day												1,345	3,388	4,945	6,566

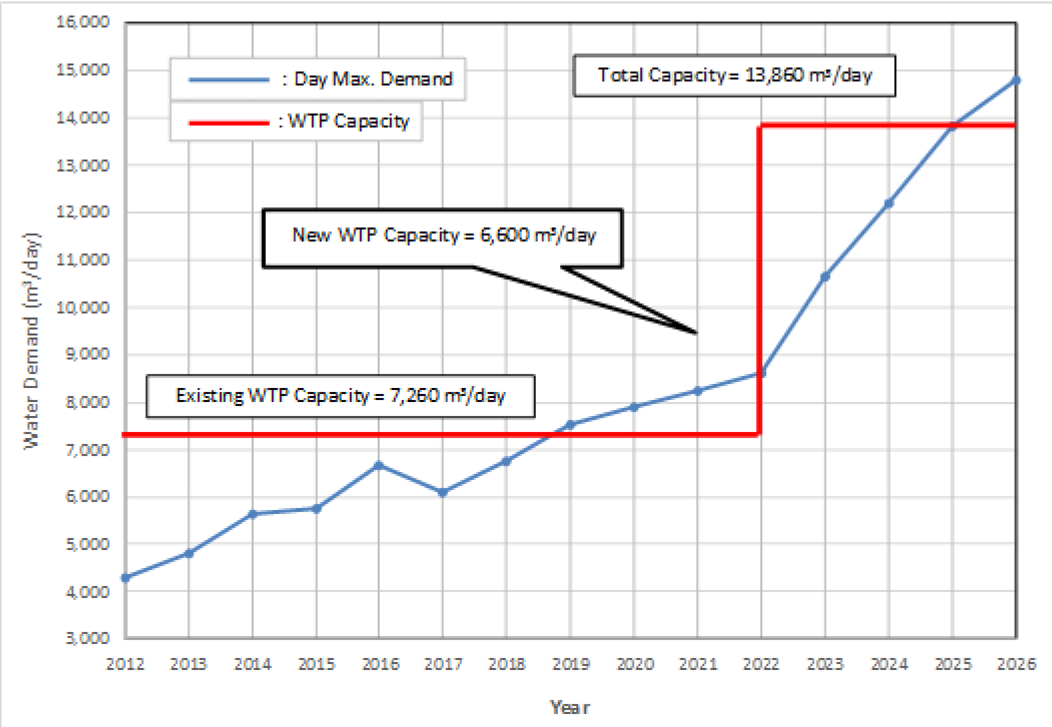


Figure 2-2-4 Relationship between Water Demand by Water Supply Population and Facility Capacity in Pursat City

The basic design specifications of this project for Pursat City are listed in Table 2-2-12 and Table 2-2-13, respectively.

Table 2-2-12 Proposed Design Specifications of the Project (I)

Item	Unit	Pursat		
		Present in 2018	Increase by the project	After completion of the project in 2025
Population of administrative area	Person	99,691	-	110,531
Population in urban area	Person	66,332	-	74,214
Population in service area	Person	57,738	-	84,625
Population served	Person	37,661	37,372	75,033
Number of HHs connections	Household	7,657	7,625	15,282
Water supply capacity	m^3/day	7,260	6,600	13,826
Total length of distribution pipes	km	100	81.5km	181.5km

Table 2-2-13 Proposed Design Specifications of the Project (II)

Item	Unit	Pursat
Design population served in 2025	person	75,003
Unit consumption of domestic water	Lpcd liter/capita/day	100
Domestic water demand	m^3/day	7,503
Non-domestic water ratio among whole water demand	%	25.8
Non-domestic water demand	m^3/day	2,602
Whole water demand: domestic and non-domestic water demand	m^3/day	10,105
Leakage ratio	%	11.3
Design daily average water supply amount	m^3/day	11,386
Load factor	%	82.3
Design daily maximum water supply amount	m^3/day	13,826
Time Factor	-	1.3[2]
Design hourly maximum water supply amount	m^3/hour	749

[2] The time coefficient of 1.30 above has been adopted based on the discussions with MIH with reference to the actual value of 1.3 in the existing distribution area of Pursat City in Cambodia.

2-2-2-2 Plan for New Surface Water Source

(1) New Surface Water Source

1) New Intake Site

Alternative water intake sites for domestic water supply were compared from the viewpoints of stability of river channel (especially stability of water route that is the deepest portion in river cross section) including movement of sand bars, stability of river banks, and water depth and discharge during drought period. The alternative water intake sites are 1) around the existing water intake pumping station for domestic water supply in the downstream reach of the Pursat River, and 2) at the impounding portion in the upstream of the Damnak Ampil HW in the mid-stream reach of the Pursat River. Based on the analysis, it was concluded that the water for the new water supply shall be withdrawn from the left bank side of the impounding portion of the Damnak Ampil HW (see (3) 2)). In addition, as the quantity of sediment discharge in the Pursat River seems to be large, sediment basin shall be installed at the new water intake facility.

The proposed new water intake site is on the left bank side at about 220m upstream from the Damnak Ampil HW (see Figure 2-2-5). At the intake site, based on the elevation of the Ministry of Water Resources and Meteorology (MOWRAM), inundation occurs in the river side if water level exceeds El. 18.0m. Inundation does not occur in the paddy field located in the opposite side from the road due to the existence of roads. However, since the recorded maximum water level of the impounding portion of the HW is El. 19.0m, it is necessary to set the top elevation of the intake facility including the sediment basin to be higher than El. 20.0m by adding freeboard of 1.0m above the recorded maximum water level.

In addition, when measuring the elevation of the MOWRAM bench mark (BM) installed at Damnak Ampil HW from the basic BM of the topographic survey carried out in this JICA Survey, the elevation of the BM measured by this JICA Survey becomes 1.675m higher than the elevation of MOWRAM. Therefore, the water level at the new intake site based on this JICA Survey is as follows:

<u>Design Water Level at the New Intake Site in the Impounding Area of the Damnak Ampil HW</u>

Elevation based on the BM of MOWRAM: HWL: El. 17.50m LWL: El. 14.50m The recorded maximum water level: El. 19.00m	Elevation based on this Survey HWL: El. 17.50m + 1.675m = El. 19.175m LWL: El. 14.50m + 1.675m = El. 16.175m The Recorded maximum water level: El. 19.00m + 1.675m = El. 20.675m

Note: Elevation difference (1.675m) is determined from the survey conducted in this project.

2) Drought Discharge at the New Intake Site

The severest drought in the recent years occurred in 2015. This drought is estimated at 10 to 15-year return period of drought. (see 1-4-4-1 (1) 2)). During this drought, the minimum discharge of the Pursat River at the existing water intake facility of the domestic water supply is estimated at about

10m^3/s (see 1-4-4-1 (1) 5)). Based on the results of the discharge measurement carried out in this Survey, drought discharge of the Pursat River at Damnak Ampil HW during the 2015 drought is estimated at 9 to 9.5m^3/s. Furthermore, when Damnak Chheukrom HW is constructed in the future, it is estimated that the drought discharge equivalent to the 2015 drought at Damnak Ampil HW becomes slightly smaller (the difference is 0.3m^3/s or less) than 9 to 9.5m^3/s (see 1-4-4-1 (1) 4)). Therefore, the minimum discharge of 10 to 15-year return period of drought at Damnak Ampil HW is sufficiently larger than the existing and future intake water quantity of domestic water supply (0.18m^3/s). In addition,, it is estimated that there is a high possibility to secure the water quantity for domestic water supply.

Source: JICA Survey Team, Satellite image: Google Earth

Notes: According to the information from Pursat DOWRAM, enlargement works of the existing irrigation canal in the left bank side of Damnak Ampil HW will be started from the end of 2017 by using Chinese fund. By this project, the roads along the both sides of the canal will be widened, and the irrigation canal will be enlarged to the right bank side of the canal.

Figure 2-2-5 The Proposed New Water Intake Site on the Left Bank of the Impounding Portion of Damnak Ampil HW in the Pursat River

(2) Flood Control Measures for the New Water Intake Facility and the New WTP Site

1) The New Water Intake Facility in the Upstream of Damnak Ampil HW

The design discharge of Damnak Ampil HW is 1,100m^3/s which is a 50-year return period of floods. By referring to the Japanese planning standard for river facilities, the top elevation of the intake facility including the sediment basin shall be set higher than El. 20.175m by adding freeboard of 1.0m to the HWL of El. 19.175m.

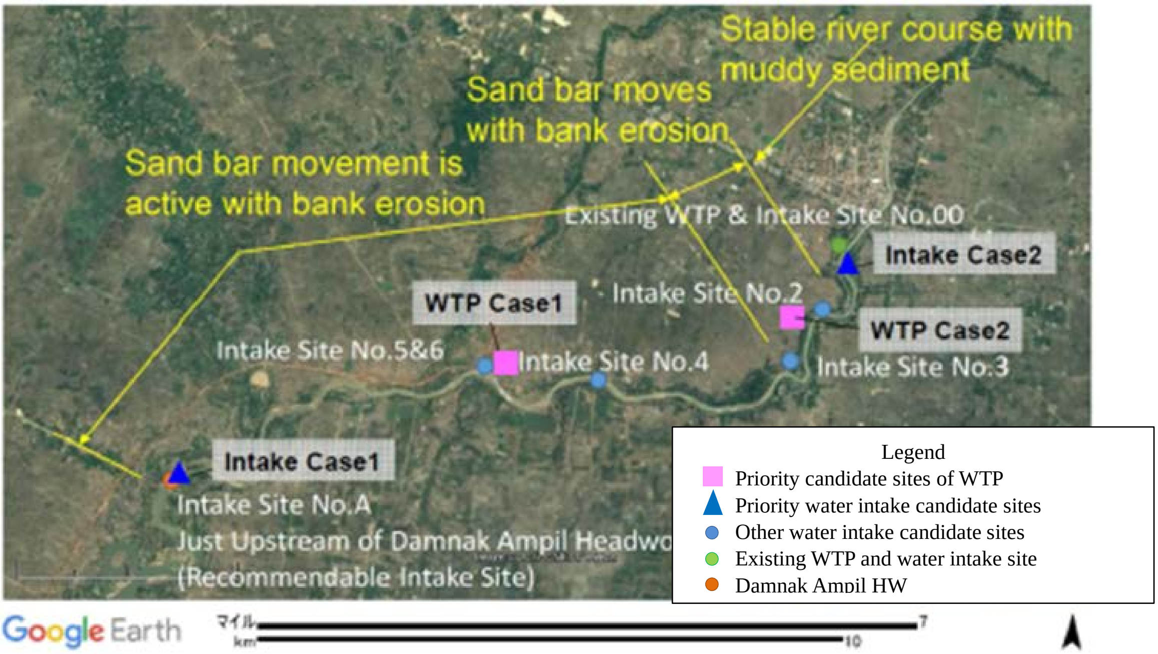
2) The New WTP

Based on the comparison of the sites for the new WTP, the site at the existing paddy field on the left bank side in the mid-stream reach was selected. Around this selected site, flood occurred in 2006 and 2011 by the Pursat River with inundation depth of about 1m (see 1-4-4-1 (1) 6)). Currently, the road dike with 1.5m height exists parallel to the Pursat River in the northern side of the new WTP site (in the opposite side of the river). If flood inundation by the Pursat River occurs again in the future, the road dike may act like a dam which resulted in water impoundment around the new water treatment site. Even for this case, in order not to cause inundation over the new treatment plant, it is necessary to raise the lands of the treatment plant site with 1.5m, which is the same height of the road dike. In addition, it is better to raise the entrance portion of the treatment plant with about 20cm height for protecting the plant against entering inundation water into the area of the plant.

(3) Comparison Study on the Candidate Sites of the New Water Intake Sites

1) Candidate Water Intake Sites and Characteristics of River Channel

Several candidate water intake sites along the Pursat River were proposed by the PWWs and DIH. In addition to these, considering stability of water intake, a water intake site for taking water from the impounding area of the Damnak Ampil HW was added by the JICA Survey Team. Figure 2-2-6 The candidate water intake sites and characteristics of sand bars and bank erosion are shown in Figure 2-2-6.



Source: JICA Survey Team
Satellite image: Google Earth

Figure 2-2-6 Candidate Water Intake Sites and Characteristics of Sand Bars and Bank Erosions along the Pursat River

<u>Near the Existing Water Intake Site (Intake Site No.00) :</u>

The candidate water intake site near the existing water intake site (Intake Site No.00) is a possible site for taking water from hydraulic point of view, because river channel around this site is stable and there is sufficient water depth during dry season. However, especially during flood season, large amount of muddy sticky sediment deposits in the pumps, which resulted in the damages to the impeller and shaft of the pump.

At the existing WTP, the water from the intake pump facility flows first into the sedimentation basin in the WTP. In case of constructing a new water intake pump facility, it is recommended that a sedimentation basin be installed before the pump facility, settle sand larger than around 0.08mm diameter, and then send water to the new WTP.

In addition, there are houses in both sides of the new water intake site. Thus, the construction of the water intake facility is required to make careful attention by considering the nearby houses.

Flood inundation depth at the new water intake site is about 1 m recorded during the 2006 Flood. When constructing a water intake facility at this site, it is necessary to set the ground elevation of the facility to be 1 m above the recorded maximum water level. 1m is the freeboard over the recorded maximum flood water level.

Site from No.2 to No.6:

As for the sites No.2 to No.6, based on ocular observation and Google Erath, sand bars are developing and shifting. Furthermore, bank erosion occurs at the concave bending portions including the sites No.4, No.5 and No.6. Therefore, these sites are not recommended due to the problems of sand bar movement and bank erosions etc.

Upstream Site of the Damnak Ampil HW:

The recommended water intake site is the site No. A, located on the left bank and about 220m upstream of the Damnak Ampil HW where a stable water intake is possible.

Although coarse sediment settled in the impounding portion to some extent, inflow of sediment may occur during flood time etc. Therefore, installation of a sedimentation basin is recommended after the inlet of intake facility. Sand larger than around 0.08mm of diameter is to be settled at the sedimentation basin, and then water is sent to the new WTP through pumps and the water transmission pipeline.

When water level exceeds El. 18.0m based on MOWRAM's BM, inundation will occur at the new water intake site. The maximum high water level is El. 19.0m recorded during the 2011 Flood. The design HWL and LWL of the Damnak Ampil HW are El. 17.5m and El. 14.5m, respectively, where the regular operation is in the range of water level between El. 16.0m and El. 16.6m.

The design discharge of the Damnak Ampil HW is 1,100m^3/s with a 50-year return period of floods. According to the Japanese standard of river facilities, in case of constructing a water intake facility at this place, it is necessary to ensure the top elevation of the facility to be above El. 19.0m plus 1.0m of freeboard.

2) Comparison Study on the Combinations of Candidate Water Intake Site with New Water Treatment Site

Based on the above comparison, the leading candidate water intake sites are the site just upstream of the existing water intake facility (Intake Site No.00) and the site about 220m upstream of the Damnak Ampil HW (Intake Site No.A).

In the case of taking water in the impounding portion of the Damnak Ampil HW, the new WTP candidate site is the WTP Site No.1, which is located about 8km downstream of the Damnak Ampil HW (Case 1).

In the case of taking water at just upstream of the existing water intake site, the new WTP candidate site is at the neighboring place of the elementary school at about 1.5km upstream of the existing WTP (Case 2).

The results of the comparison analysis of the abovementioned two cases (the combinations of the candidate new water intake site and the new WTP site) are described below. Detailed results of the comparison are shown in Annex 7.3. Case 1 is more stable as water source, and there are few sediment problems and social problems. In addition, the initial investment cost is also small. The disadvantage is that electricity cost for maintenance and operation is higher. Flood problem at the new WTP site (Site No.5) is smaller (about 1m inundation depth by 1996 Flood and 2006 Flood).

Although Case 2 has rather stable water source, but less stable than Case 1. Sediment problem of Case 2 is larger, and the initial investment cost to Case 2 is higher. However, maintenance cost of Case 2 is smaller. Especially, Case 2 has more social problem related to the access road to the new WTP. The candidate site of the new WTP was flooded in the 1996 and 2006 where the inundation depth was about 2m.

Based on the above analysis, Cambodia side (MIH, Pursat DIH and PWWs)and Japan side (JICA and the JICA Survey Team) agreed by adopting Case 1 in the M/D signed on August 24, 2017.

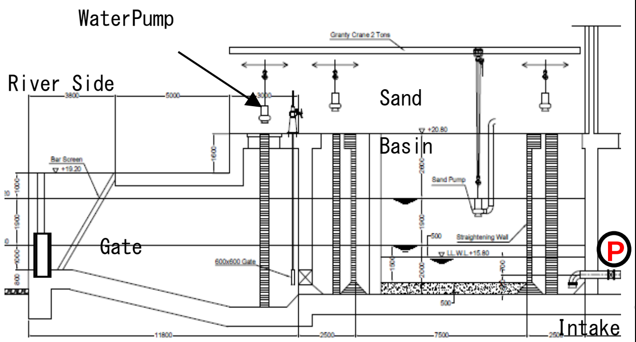
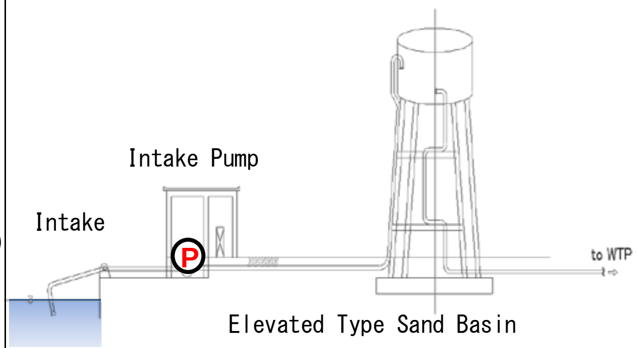
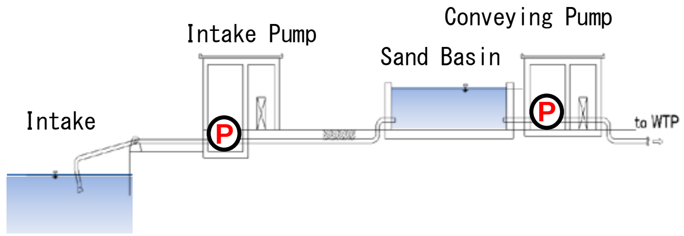
In case on taking water from the impounding portion of the Damnak Ampil HW, it is recommended to settle sand with diameter of larger than 0.08mm after the intake, and then send water to the new WIP site at Site No.5. Therefore, it is necessary to install a sedimentation basin at the water intake site.

2-2-2-3 Plan of Water Intake Facility

(1) Intake Method

Due to budget limitation, a floating intake pipe + elevated type sedimentation basin structure, which is smaller in temporary works and advantageous in both initial cost and running cost, was adopted. A comparison table is shown below.

Table 2-2-14 Comparison of Intake Method

	Open channel intake system with intake gate		Intake Pump＋ Elevated Type Sand Basin		Intake Pump＋ Ground Type Sand Basin＋Conveying Pump Station	
Figure						
Outline	River revetment, open channel and intake gate will be installed at the entrance. A screen is installed on the downstream side, and river water is led to the sedimentation basin through the open channel.		Water is taken from a float-type intake pipe with a water intake pump, led to an elevated sedimentation basin, and sent to a water purification plant under natural flow.		Water is taken from a float-type water intake pipe with a water intake pump, passed through a ground-type sand basin, and pumped from a water conveyence pump station to a water purification plant.	
Pump	・Intake Pump：Horizontal, End suction volute pump 2.52m3/m, 34m, 30kW x 3		・Intake Pump：Horizontal, Double suction volute pump , 5.04m3/min、H=36m、45kW x 2		・Intake Pump：Horizontal, Double suction volute pump ,5.04m3/min、H=9m、18.5 kW x 2 ・Conveyance Pump：Horizontal, Double suction volute pump 5.04m3/min、H=33m、37 kW x 2	
Workability	The construction of a sand basin in the river channel is a large-scale construction throughout the year. For this reason, construction is performed with double-wall coffer dame of HWL.	△	There are few construction parts in the river channel, and construction in the dry season is possible. Construction will be carried out with a weather-resistant large sandbag of normal water.	◎	There are few construction parts in the river channel, and construction in the dry season is possible. Construction will be carried out with a weather-resistant large sandbag of normal water.	◎
Maintenance	- Sedimentation basin sand removal equipment (sand removal crane, sand discharge pump, etc.) is required. Sand discharge to the river is required by pumping. In addition, maintenance of these is necessary. - There is only one pumping station, so maintenance is not difficult.	○	-By installing a drain pipe in the elevated tank, sand can be discharged into the river due to water head differences. - There is only one pumping station, so maintenance is not difficult.	◎	- Sedimentation basin sand removal equipment (sand removal crane, sand discharge pump, etc.) is required. Sand discharge to the river is required by pumping. In addition, maintenance of these is necessary. -It is necessary to maintain and repair pumps and electrical equipment for the two stations. In addition, maintenance personnel are required twice.	△
Cost	・Initial Cost：Construction 485,000 USD Electrical & Mechanics 893,000 USD River Temporary Work 730,000USD **Total 2,108,000 USD** ・O&M Cost（Electricity）: 84,000USD/Year	△	・Initial Cost：Construction 581,000 USD Electrical & Mechanics 833,000 USD River Temporary Work 50,000USD **Total 1,464,000 USD** ・O&M Cost（Electricity）: 67,000USD/year	◎	・Initial Cost：Construction 492,000 USD Electrical & Mechanics 1,134,000 USD River Temporary Work 50,000USD **Total 1,676,000 USD** ・O&M Cost（Electricity）: 91,000USD/year	○
Select			✔			

(2) Float Type Intake Plan

Float-type intakes have been used in Cambodia (Mondol Kiri, Kampong Speu, etc.). This type was also adopted by JICA's water grant aid in Sudan. In general, this is used where the river flow rate is relatively small. There is an advantage that water near the water surface can always be taken.

1) Selection of Intake Type

The following three types of float-type water intake facilities were considered from the past results.

Table 2-2-15 Selection of Float Intake Type

Type	Case1 Rail Type	Case2 Pontoon Type	Case3 Floating Pipe Type
Photo			
Outline	- The pump room moves up and down on the rail according to the water level depending on the season. -The pump chamber is pulled up with an electric winch. - Applying a dry pump.	-The pump room moves up and down according to the water level, so no power is required. - Submersible pumps are applied. - The pontoon body and steel truss pier have a flexible structure with bolt connection. A flexible joint is applied to the piping material.	- The intake pipe moves up and down according to the water level, and the pump room is installed on land. - Applying a dry pump. - The steel truss pier has a flexible structure with bolt connection. A flexible joint is applied to the piping material.
Maintenance	- Power (electricity) is required for the vertical movement of the pump room. -Frequent pipe replacement is required in conjunction with the vertical movement of the pump chamber. - It is necessary to clean mud and dirt accumulated on the rail.	- The pump room goes up and down with the water level, and there is no need to change the pipe. - Maintenance of the pump is performed on the pontoon. - During pontoon maintenance, it is necessary to land on the dock.	- The intake pipe goes up and down with the water level, and there is no need to change the pipe. - The pump room is on land, and the maintenance of the pump is easier compared to Case2.
Adaptivity			✓

With regard to the above three types of water intake facilities, the Floating pipe type should be applied in consideration of maintenance management. A cross-sectional view of the intake facility is shown below.

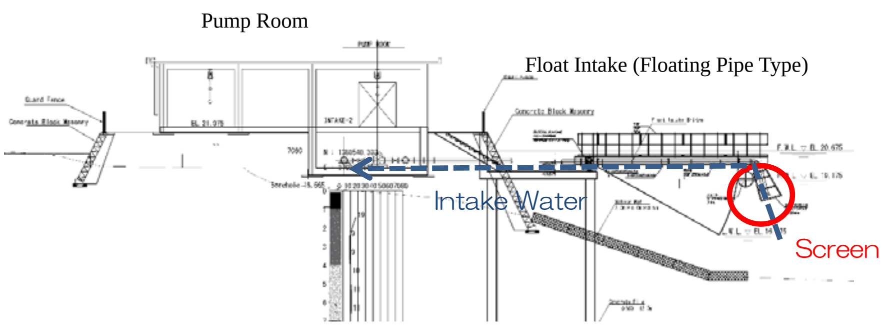
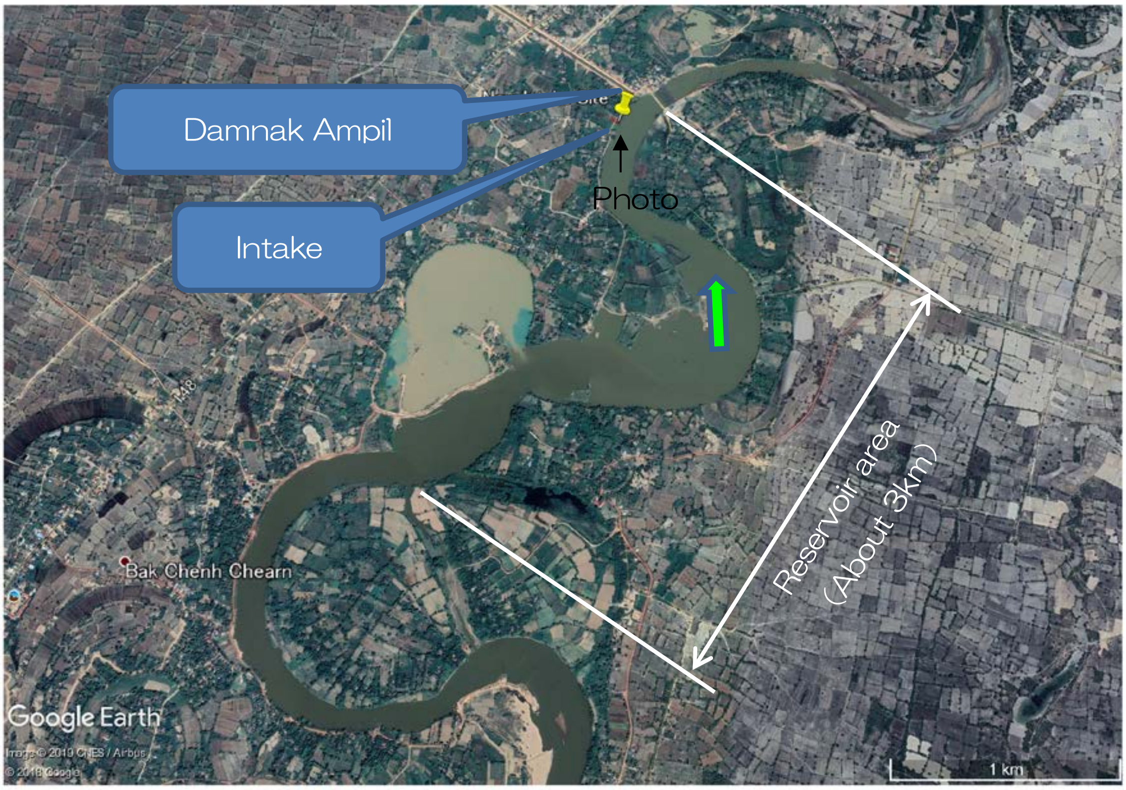


Figure 2-2-7 Typical Drawing of Float Intake

2) Safety of Float Intake

a) River Condition

The intake point is approximately 200m upstream from the Damnak Ampil weir on the Pursat River. The section about 3 km upstream from the weir is the Reserver Area, and the flow of water is small. Stable water intake is possible.



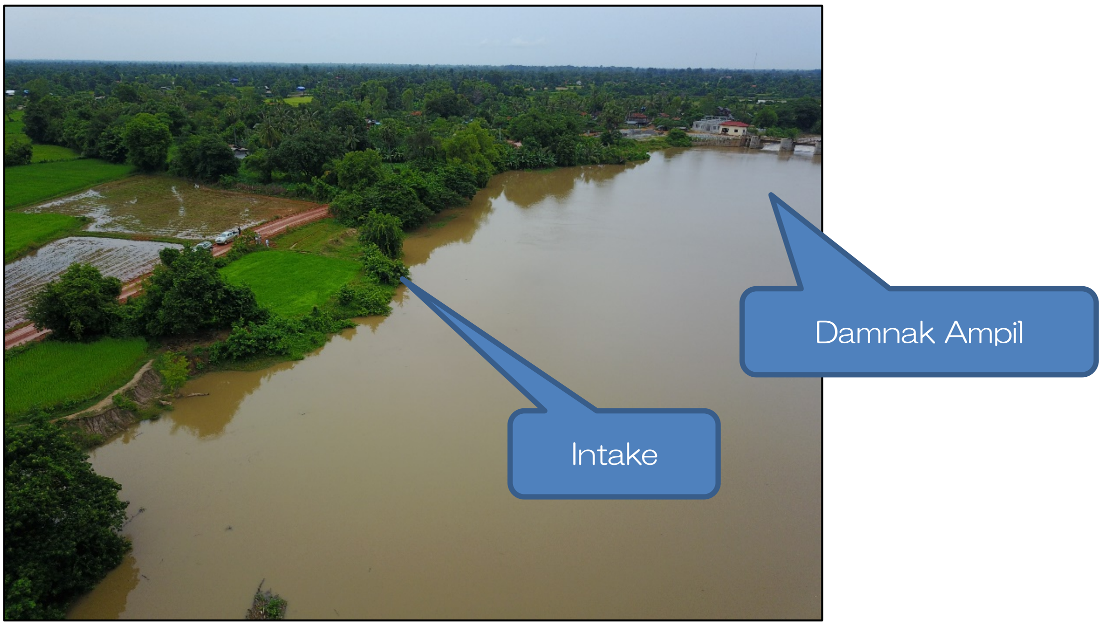


Figure 2-2-8 Condition around Intake

b) Influence of Water Flow

According to river crossing survey, the river width at the intake point is about 200m and the water depth at HWL is 5.5m. The riverbed slope upstream of the Damnak Ampil weir is a reverse slope according to the survey results. (The riverbed slope in the downstream of the weir is about 1/6400)

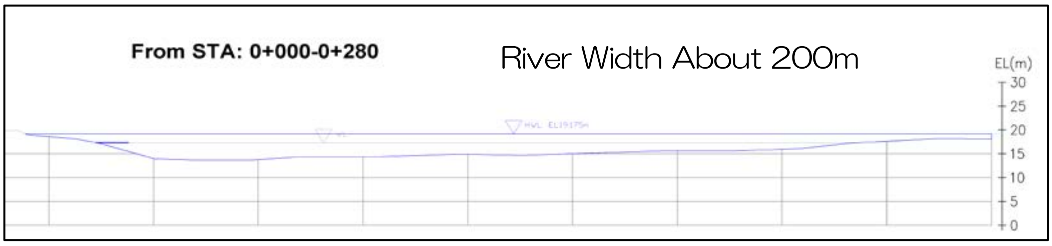


Figure 2-2-9 Cross Section around Intake

The water depth at HWL (5.5m), the riverbed slope is about 1/6400, and the flow velocity is 1.14m / s when calculated by Manning's formula. Float intakes are designed to withstand this flow rate.

* In addition, during the rainy season (June-October) in 2017, we observed the flow rate downstream of Damnak Ampil Weir. Maximum flow rate at this time: 184.36m3 / s (October 2017, 4 out of 7 gates open)

c) Impact of Debris Flow

Near the water intake point is a natural dike with a riverbed gradient of 1/6400. There is no debris flow or large driftwood here. In addition, there is no urban area upstream of the Pursat River, so it is thought that there is little waste flow. However, since it is assumed that small garbage and branches will flow down, a screen will be installed to protect the intake.

(3) Plan of Elevated Type Sand Basin

As mentioned above, the Pursat River during the rainy season contains sediment, with an annual average of about 80 to 90 NTU, and a maximum of 639 NTU per day is observed. The turbidity in the water taken by the intake pump during the rainy season flows down from the intake pump station to the receiving well of the WTP through the raw water conveyance pipe at the distance of 8.3 km. And as years pass by, sticking of muddy soil to the inner surface of the pipe may cause a reduction of cross-sectional area of the pipe. Therefore, an elevated type sand basin will be provided between the intake pump station and the conveyance pipe to prevent the inflow of turbid substances into the conveyance pipe as much as possible..

On the other hand, based on the particle size result of riverbed materials, representative particle diameter of riverbed materials is D_{50}=0.0228mm, and the ratio of fine particles less than 0.075mm diameter accounts for 85% of total sampling amount. Therefore, the riverbed sedimentations are mainly silty clay, and the cause of wear of pump blades and sliding members is considered to be minimal. Based on the above, the main purpose of providing the sand basin is to prevent from water conveying failure in the conveyance pipeline.

1) Design of Elevated Type Sand Basin

In case of planning an underground settling basin, two sets of pump facilities are required: "River ⇒ Settling basin" and "Sink basin ⇒ WTP receiving well)". On this plan, both initial cost and O & M cost (electricity cost, etc.) are expensive. Therefore, the pumping by the intake pump was planned as "River ⇒ Elevated sedimentation basin".

a) Design Criteria

The calculation of the capacity of the sand basin is based on the "Water Supply Facility Design Guidelines (Japan Water Works Association)".

b) Diameter of Sand Basin Tank

Intake Amount：Q=7260 (m^3/day)

Target Surface Load Factor：200 (mm/min)

Required Area：$\frac{7260\ (\mathrm{m}^3/\mathrm{day})}{0.2\ (\mathrm{m/min}) * 1440\ (\mathrm{s/day})}$ =25.2m^2

More than 25.2m2 of sedimentation area is required.

As shown in the table below, the sedimentation area was calculated in each case where the diameter of the elevated tank was D = 6m-8m.

As a result of the study, the diameter of the elevated tank satisfying the required surface area of 25.2m2 was set to D = 7m.

Table 2-2-16 Diameter of Sand Basin Tank

Diameter (m)	Area (m^2)	Center Over Flow Area (m^2) (Diameter (2.5m))	Sedimentation Area (m^2)
8.0	50.27	4.91	45.36
7.0	**38.48**	**4.91**	**33.57**
6.0	28.27	4.91	23.36

c) Depth of Sand Basin Tank

According to the standard, the effective water depth of the tank is 3-4m, and the sedimentation depth is expected to be 0.5-1m. Therefore, the effective water depth + sedimentation depth needs to be about 3.5m-5m. In this design, the distance from the HWL to the tank bottom is 4m.

d) Target Sedimentation Velocity

The elevated tank is intended to sink sand with a diameter of 0.08mm or more. The relationship between the target particle diameter and the sedimentation velocity is as follows.

Table 2-2-17 The Sedimentation Velocity of Sand

Diameter of sand Particle (mm)	Sedimentation Velocity (cm/s)
0.30	3.2
0.20	2.1
0.15	1.5
0.10	0.8
0.08	**0.6**

Source: Water facilities design guidelines in Japan

From the above table, the sedimentation rate of sand particles in the tank is assumed to be about 0.6 cm / s. On the other hand, the rising speed of water in the elevated sedimentation basin is,

7260 (m3 / day) ÷ 33.57m2 = 216.3m / day = 0.0025 m / s = 0.25cm / s <0.6cm / s.

Since the rising speed of the water in the tank is slower than the sedimentation speed of the sand particles, sand having a diameter of 0.08 mm or more can be settled.

In addition, the turbidity component (clay component) having a particle size of 0.08 mm or less is not treated in the sand basin, but it is treated at the water purification plant.

e) Shape of Elevated Type Sand Basin

The basic concept of the elevated sedimentation basin is to allow the introduced water to overflow into the funnel-shaped part in the center of the sedimentation basin and to flow into the water pipe. Sediment is settled on the bottom and can be flushed from the drain at the bottom.

As the shape of the elevated sedimentation basin, the following two plans can be considered from the sedimentation method. Which plan will be adopted will be decided in consultation with the local government at the time of detailed design.

① Elevated Type Sand Basin（2 Tanks）

The concept for two tanks is shown below.

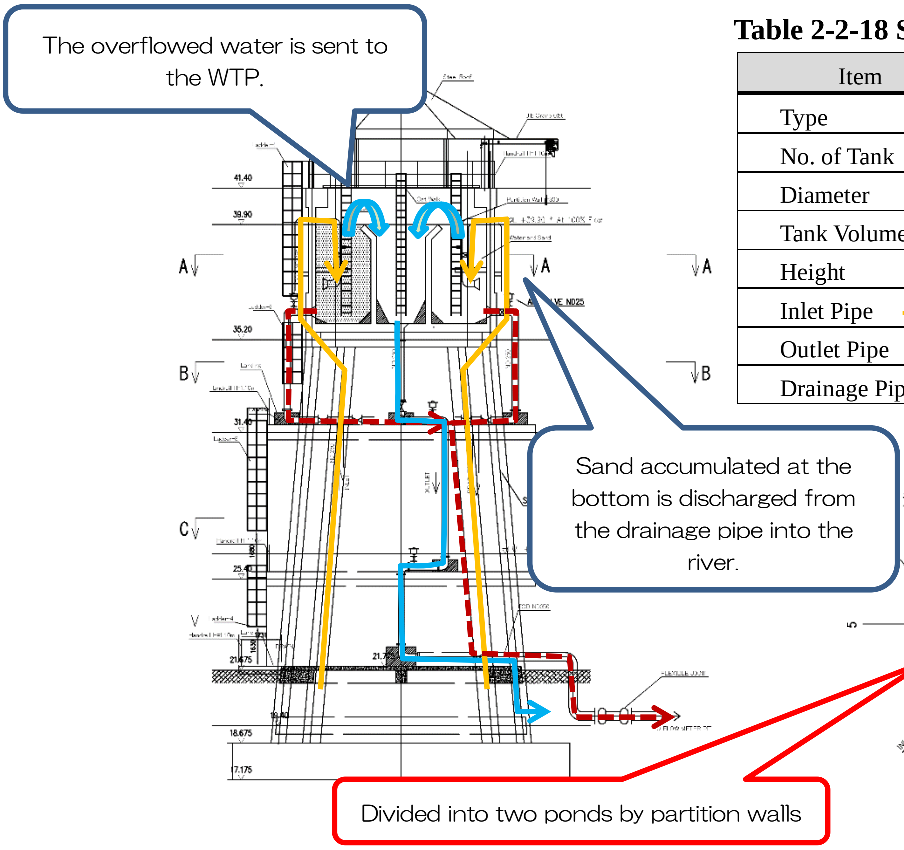
-Settling sand particles of 0.08mm or more in the tank.

-Because there are two tanks, two inflow pipes, outflow pipes, and two sludge pipes are required.

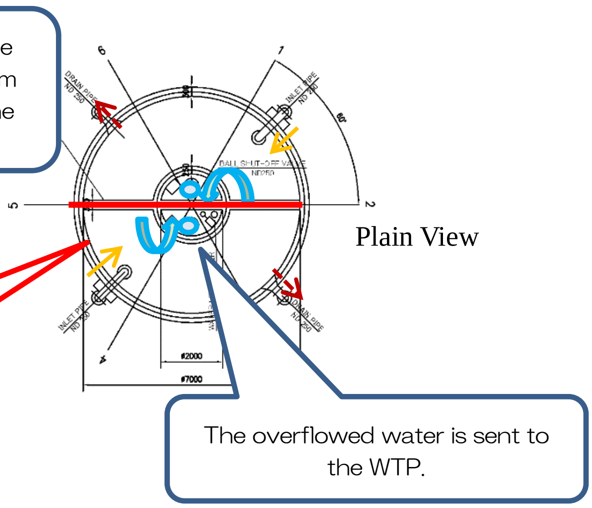
-Sedimented sand will be discharged during the dry season without using an elevated sand basin (described later). Since there are two tanks, it is possible to stop the water supply to the other tank and drain the bottom of the tank while one tank is operating during the rainy season.

Table 2-2-18 Specification of Sand Basin (2 tanks)

Item	Spec
Type	Horizontal Bottom Shape Type
No. of Tank	2
Diameter	7.0m
Tank Volume	About 600m^3
Height	24m
Inlet Pipe	Ductile iron pipe ND250 x 2
Outlet Pipe	Ductile iron pipeND350 x 2
Drainage Pipe	Ductile iron pipe ND250 x 2



Cross Section



Plain View

Figure 2-2-10 Concept of Horizontal Bottom Shape Type Sand Basin (2Tanks)

② Central Water Conveyance Type (Swirl Type 1 Tank)

The swirl type sand basin generates a vortex in the circular tank by flowing water energy by flowing water in the tangential direction of the sand basin cylinder. This vortex collects sand at the center bottom of the vortex and lighter material at the outer top of the vortex. This is a method for efficiently separating and removing substances in the water, and has been used in sewage treatment plants. The design of this type of sand basin is as follows:

-Settling sand particles with a particle size of 0.08mm or more in the tank. In addition to this, as a swirl type feature, the separation of the sand is promoted by the vortex flow of the cylinder (sand basin). Therefore, it is not possible to provide a partition wall, and there is one tank.

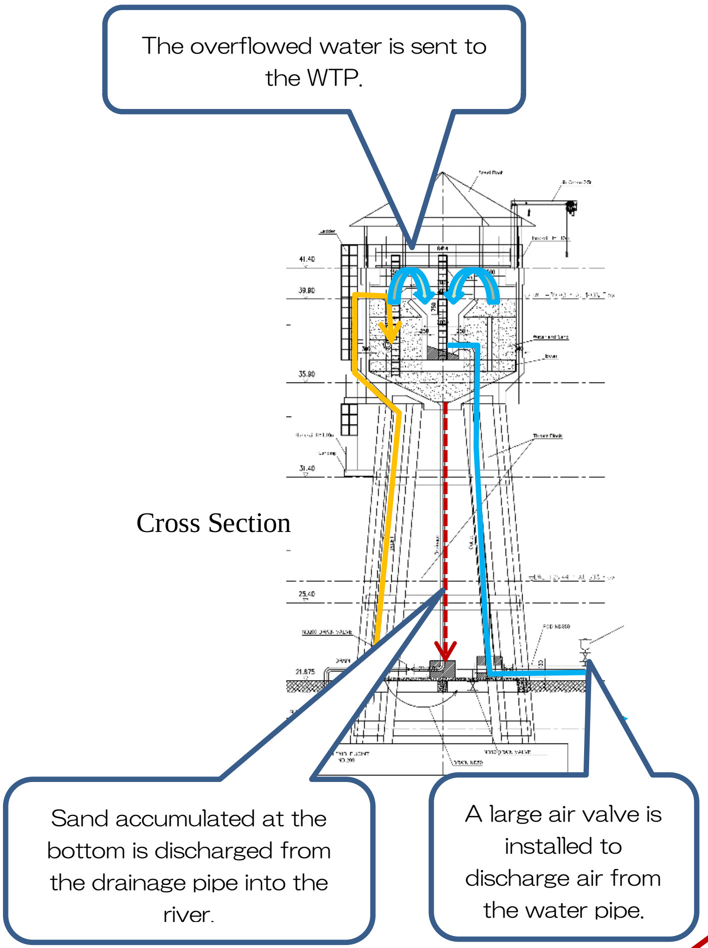
- Water is taken by overflowing the top of a cylindrical-shaped weir. In order to ensure flowing in the water to the conveyance pipe, the pipe shall be provided at the bottom center of the cylindrical weir. The top level of cylindrical weir shall be set at the height of HWL for securing the water head to convey the water to the receiving well of WTP

- Sedimented sand will be discharged during the dry season without using an elevated sand basin (described later). Since there is only one tank, the sand basin cannot be operated during sand discharge.

- Since air is expected to flow into the conveyance pipe, a large air valve will be installed on the ground.

Table 2-2-19 Specification of Swirl Type Sand Basin

Item	Spec
Type	Central Water Conveyance Type (Swirl type)
No. of Tank	1
Diameter	7.0m
Tank Volume	About 600m^3
Height	24m
Inlet Pipe →	Ductile iron pipe ND250×1
Outlet Pipe →	Ductile iron pipeND350×1
Drainage Pipe - - →	Ductile iron pipe ND250×1



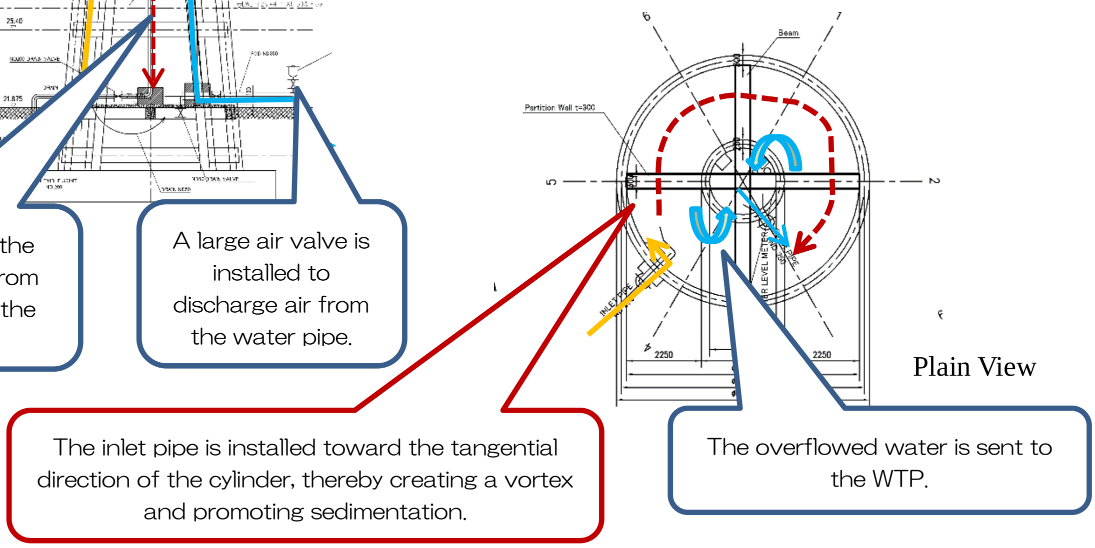


Figure 2-2-11Concept of Central Water Conveyance Type Sand Basin (Swirl 1 Tank)

③ Side Wall Water Conveyance Type (Swirl Type 1 Tank)

The sedimentation mechanism of this type sand basin is the same as that of the central water conveyance type. The design of this type of sand basin is as follows:

-Settling sand particles with a particle size of 0.08mm or more in the tank. In addition to this, as a swirl type feature, the separation of the sand is promoted by the vortex flow of the cylinder (sand basin). Therefore, it is not possible to provide a partition wall, and there is one tank.

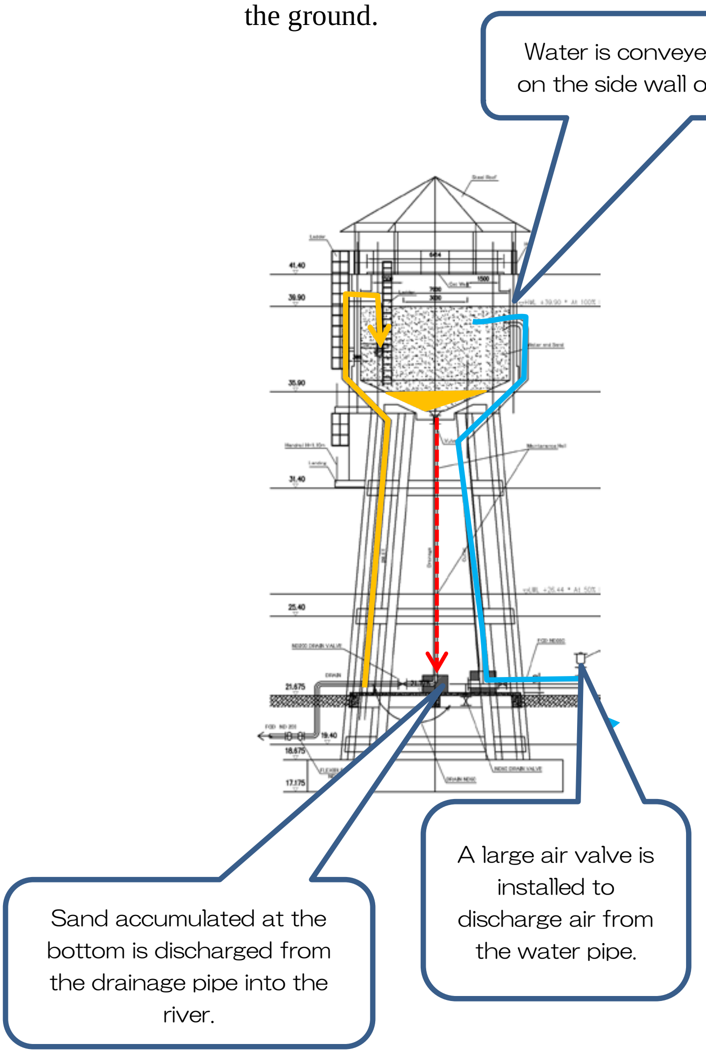
- The outlet pipe shall be provided at the side wall of the tank. The installation height of the outlet pipe shall be high enough to convey the water to the receiving well of the WTP. In order to ensure water flow to the conveyance pipe, HWL shall be secured the level at minimum height of 2.5D (1.25m = 2.5 x 500mm) from the top of the outlet (conveyance) pipe.

- Sedimented sand will be discharged during the dry season without using an elevated sand basin (described later). Since there is only one tank, the sand basin cannot be operated during sand discharge.

- Since air is expected to flow into the conveyance pipe, a large air valve will be installed on the ground.

Table 2-2-20 Specification of Swirl Type Sand Basin

Item	Spec
Type	Side Wall Water Conveyance Type (Swirl type)
No. of Tank	1
Diameter	7.0m
Tank Volume	About 600m^3
Height	25.5m
Inlet Pipe →	Ductile iron pipe ND250 x 1
Outlet Pipe →	Ductile iron pipe ND350 x 1
Drainage Pipe - - →	Ductile iron pipe ND250 x 1



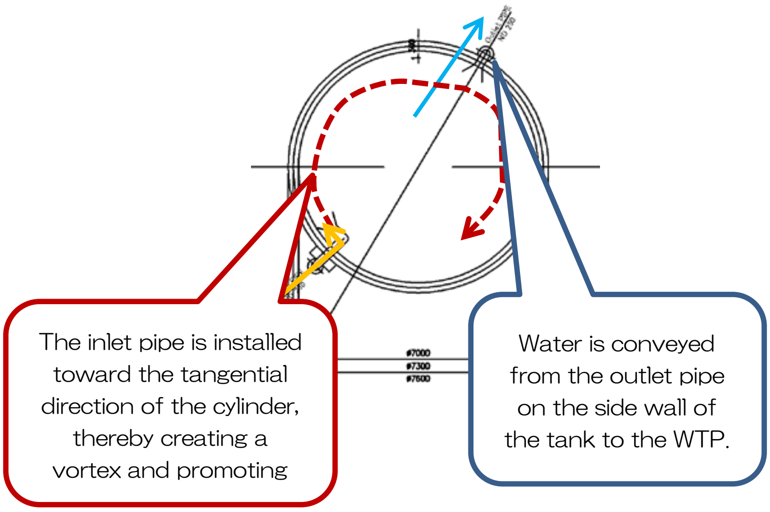


Figure 2-2-12 Concept of Side Wall Water Conveyance Type Sand Basin (Swirl 1 Tanks)

2) Sediment Volume

Two estimates of the amount of sediment in the elevated sand basin are shown below.

a) Wash load estimation formula

There is a possibility that the wash load near the surface of the river water is drawn from the water intake from the float. The amount of wash load is estimated by the following formula.

$$Qs=（4*10^{-8}\sim 6*10^{-6}） x Q^2$$

Qs：Wash Load（m^3）、Q：Flow Discharge（m^3/s）（Source: Hydraulics formula collection）

Yearly Sedimentation V（m3）＝$6.0 \times 10^{-6} \times 0.084^2$ (m^3/s) x 60 (s)×60 (min) x 24 (h) x 365 (day) =$1.3m^3$/year

This amount is assumed to be 3.9cm / year (= 1.3 / 33.57 = 0.039m) of deposit at the bottom of the tank.

b) Estimation from Suspended Solids (TSS)

In this study, mud deposited on the surface of the riverbed in October 2017 at the end of the dry season was collected. From this survey result, the representative particle size of the riverbed material is D50 = 0.0228mm. In addition, fine particles of 0.075mm or less account for 85%, and mainly silt.

On the other hand, river turbidity data was collected from July 2017 to May 2018. The maximum value is around 135NTU. The annual average of suspended solids (TSS) of 2mm or less is about 55mg / 55. Assuming that 15% excluding 85% of fine particles is the target of sedimentation, the deposition of the object is calculated as follows.

Yearly Sedimentation Vm^3= $0.084m^3$/s x 60s x 60min x 24hr x 1000ℓ x 0.055g/ℓ x 0.15÷1000g x 365days = $11.5m^3$/year

This amount is assumed to be 34cm / year (=11.5/33.57=0.34m) of deposit at the bottom of the tank.

On the other hand, the TSS value also covers gravel (including bed load) with a particle size of less than 2mm. In consideration of taking water from the river surface in the float-type water intake facility, it is assumed that the actual amount of sediment will be less than this.

3) Maintenance Drainage of Sediment

From the above, it is assumed that the maximum amount of sedimentation will be 11.5m3 / year (thickness 34cm / year). There are two types of elevated sedimentation basins: a two-tank structure and a one-tank structure (swirl type). The maintenance policy for each is shown below.

a) Common subject matter

① Drainage Route

The drainage route is as follows. The mud is discharged from an elevated sand basin and discharged to the Pursat River through a concrete drainage channel. The drainage channel will be a 600 × 600 precast open channel and a box culvert.

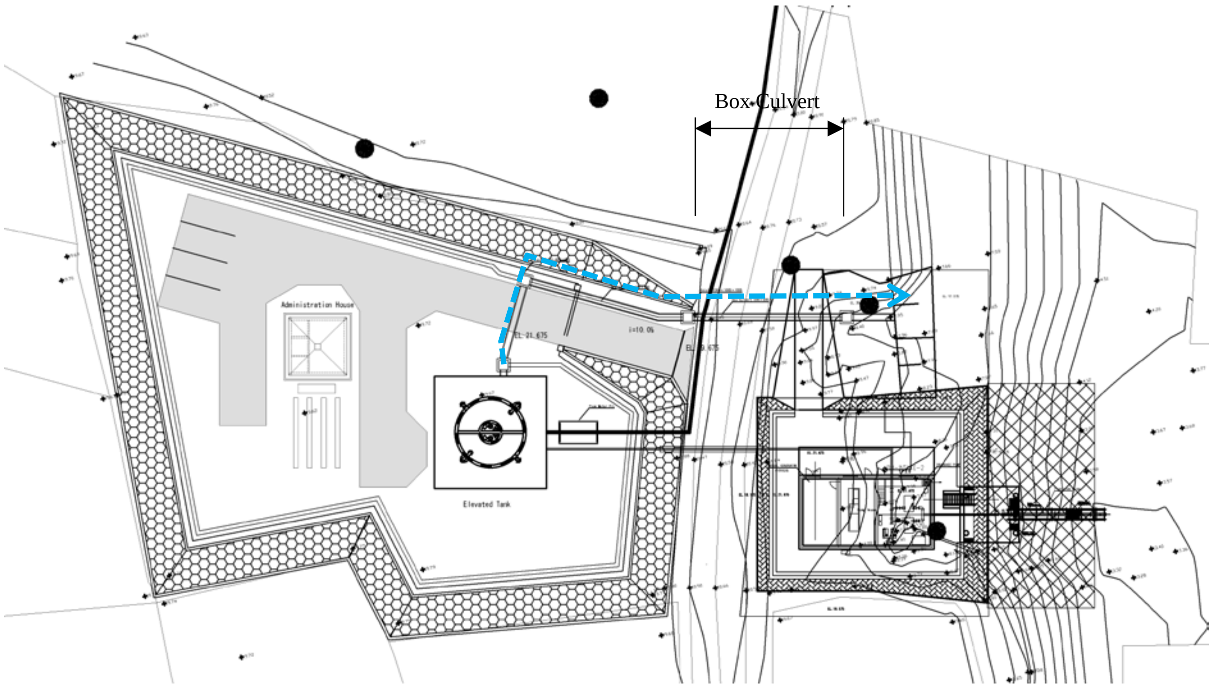


Figure 2-2-13 Drainage Route

② Frequency of Flush

From the above assumptions, it is assumed that sand accumulation in the elevated sedimentation basin is limited mainly to heavy flooding in the rainy season when the river turbidity is high. Therefore, the water flow to the elevated sand basin is limited to the rainy season. In the dry season, it is possible to send raw water directly from the intake facility to the water well at the WTP without going through the elevated tank. Therefore, the sand accumulated in the elevated tank is cleaned at the beginning of the dry season when the tank is not used.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Season	Dry Season				Rainy Season							Dry
Water Route	Intake→Transmission Pipe				Intake→Elevated Tank→Transmission Pipe							Intake→ Transmission Pipe
Tank Condition	No Use				In Use							Tank Cleaning

Figure 2-2-14 Schedule of Elevated Type Sand Basin

③ Measures against Clogging

The following measures will be taken to prevent clogging of the drainage pipes in the elevated sand basin.

- Drainage operation is performed by installing a valve directly below the sand basin. As a result, the inside of the pipeline is made hollow except during drainage.

- The drainage pipe should be as straight as possible from the tank to the ground. It is necessary to bend 90 degrees to connect to the open channel near the ground. Instead of a curved pipe, six 15-degree pipes are used to bend into a large bow to create a smooth flow.

- In case of clogging, install three or more cleaning ports (T-shaped tubes) in the drainage pipe.

④ Others (countermeasure against air intrusion and surge in the conveyance pipe)

The countermeasure against air intrusion and surge in the conveyance pipe is as follows:

- In each case of the above-mentioned elevated sand basin type, there is a possibility of air mixing into the conveyance pipe in any case. In case of 100% discharge amount of water, since the conveyance pipe is full and the head at the outlet of the conveyance pipe is secured at the vicinity of design HWL, the pipe can be prevented from air flow in the air. On the other hand, in case that the flow rate is less than 100%, the head at the outlet of the conveyance pipe is lowered and air will be mixed into the conveyance pipe together with water. As a countermeasure for air mixing, a large air valve will be provided near the above-ground section of the conveyance pipe at the vicinity of the elevated tank, and the air flowing in from the elevated tank will be discharged. In addition, by installing a flow control valve on the water conveyance pipe to give head loss, the conveyance pipe can be prevented from dropping of water head at the vicinity of pipe outlet.
- The elevated tank can play a role as a surge tank in case a water hammer pressure occurs due to fluctuations of the water discharge amount in the conveyance pipe. In the dry season, in case the intake water is sent directly to the receiving well of the WTP without passing through the elevated sand basin, the function of the elevated tank as a surge tank cannot be utilized. In case of that, it is necessary to take other measure such as installation of flywheel.

b) Case of Horizontal Bottom Shape Type Sand Basin（2 Tanks）

① Drainage Pipe

There are two drainage pipes, one for each tank. The location is the side of each tank.

② Drainage Work

The sand accumulated in the tank is discharged by draining (flushing out) by operating the valve of the drainage pipe attached to the center of the bottom of the mortar-shaped tank. After draining the water, a worker enters the sand basin with a small amount of water flowing into the settling basin, and pours the remaining mud into the drainage pipe using a scoop. After the mud draining work is completed, close the valve and flood the sand basin and flush out again so that mud does not remain in the drainage pipe . Since there are two tanks, it is possible to work while one tank is in operation.

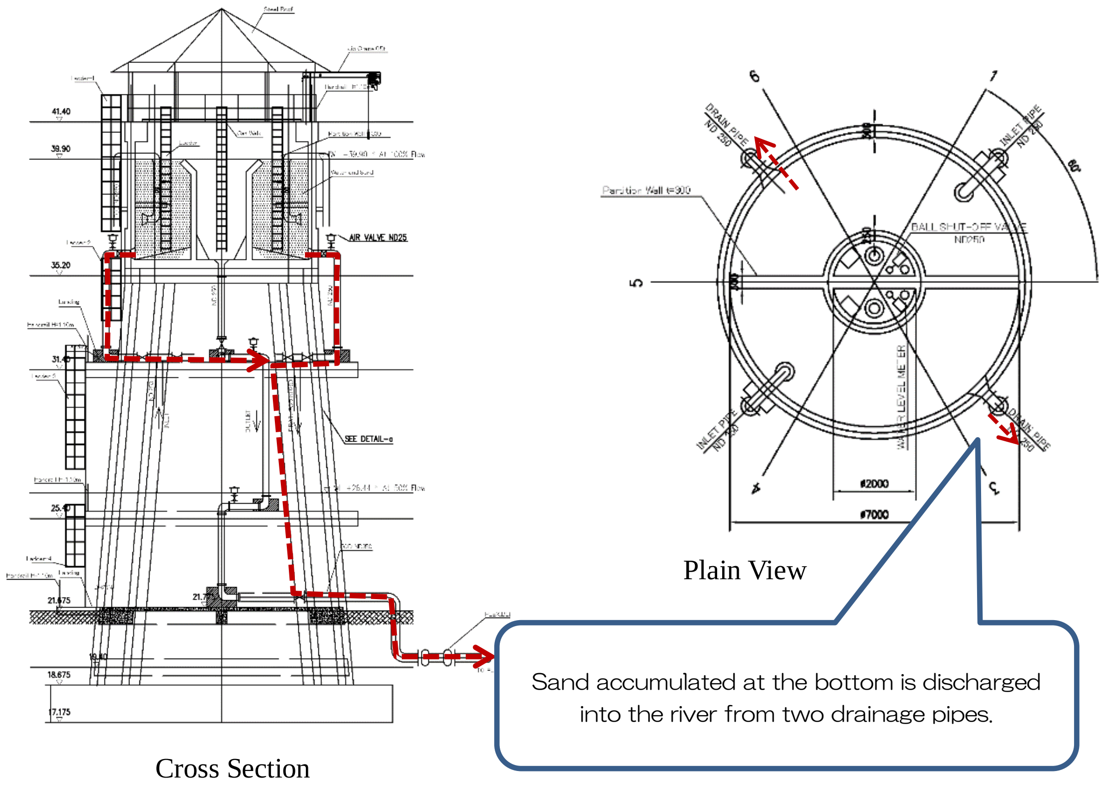


Figure 2-2-15 Drainage Route of Horizontal Bottom Shape Type Sand Basin（2 Tanks）

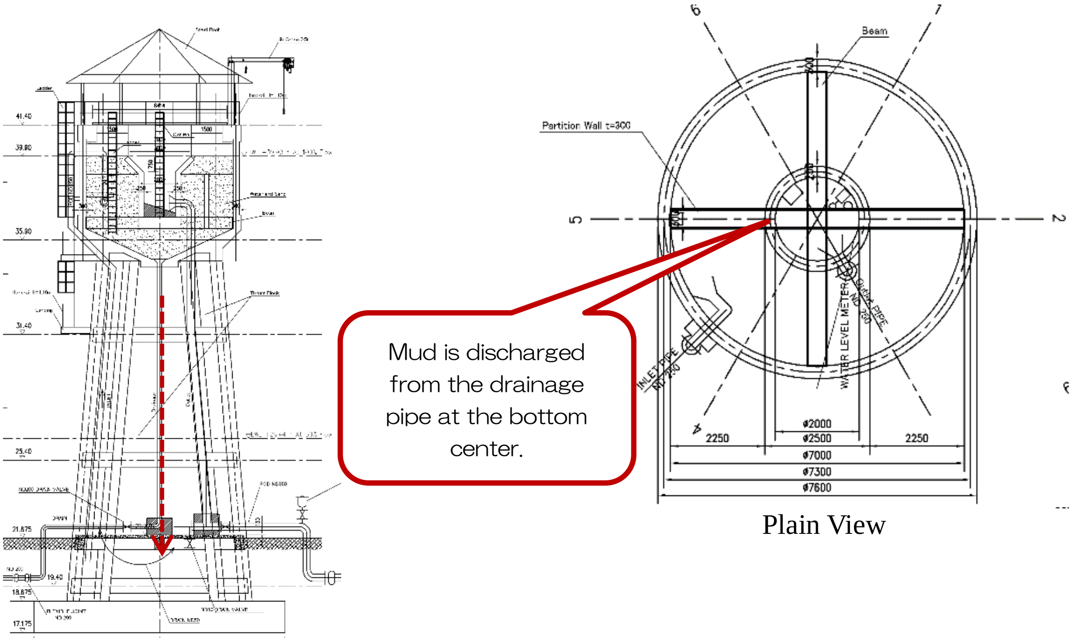
c) Case of Central Water Conveyance Type Sand Basin（Swirl Type 1 tank）

① Drainage Pipe

One drainage pipe is installed at the bottom of the elevated sand basin.

② Drainage Work

The sand accumulated in the tank is discharged by draining (flushing out) by operating the valve of the drainage pipe attached to the center of the bottom of the mortar-shaped tank. After draining the water, the washing water is branched from the inlet pipe, and the worker sprinkles the water from the top deck toward the bottom of the tank without getting down to the bottom of the tank, and cleans the earth and sand adhered to the bottom of the tank. After the mud draining work is completed, close the valve and flood the sand basin and flush out again so that mud does not remain in the drainage pipe. Since there are two tanks, it is possible to work while one tank is in operation.



Cross Section

Plain View

Figure 2-2-16 Drainage Route of Central Water Conveyance Type Sand Basin（Swirl 1tank）

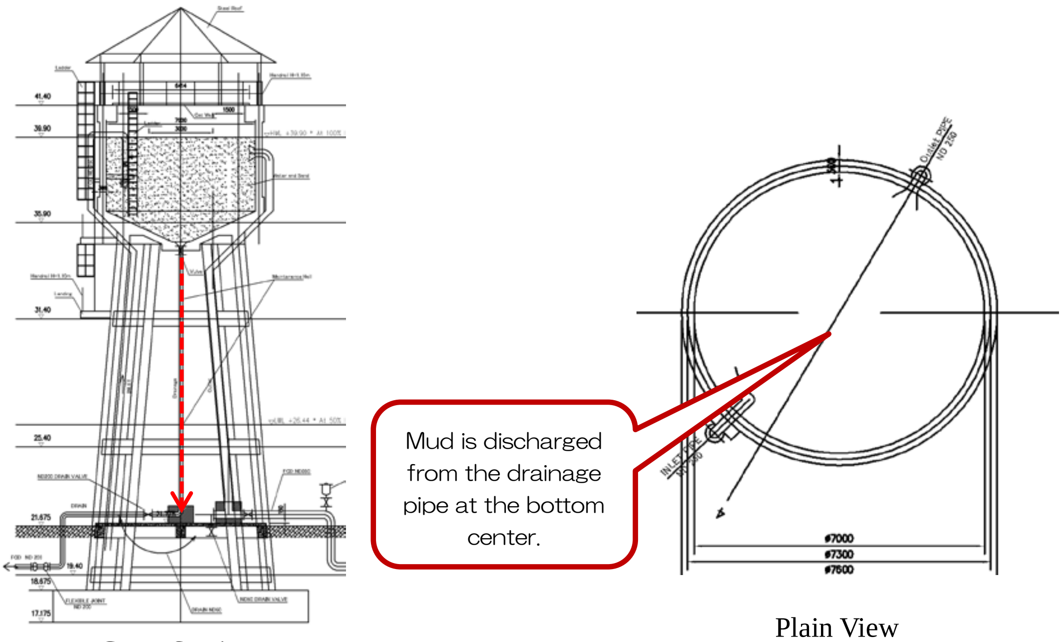
d) Side Wall Water Conveyance Type (Swirl Type 1 Tank)

① Drainage Pipe

One drainage pipe is installed at the bottom of the elevated sand basin.

② Drainage Work

The method of drainage work is the same as the case of the central water conveyance type (swirl 1 tank)



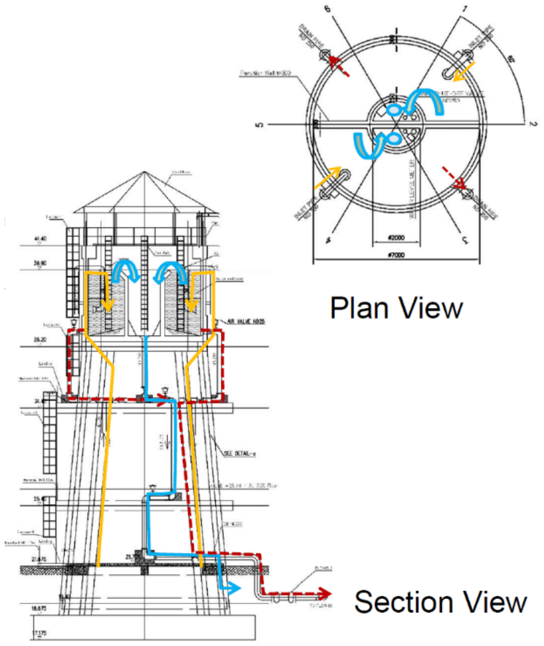
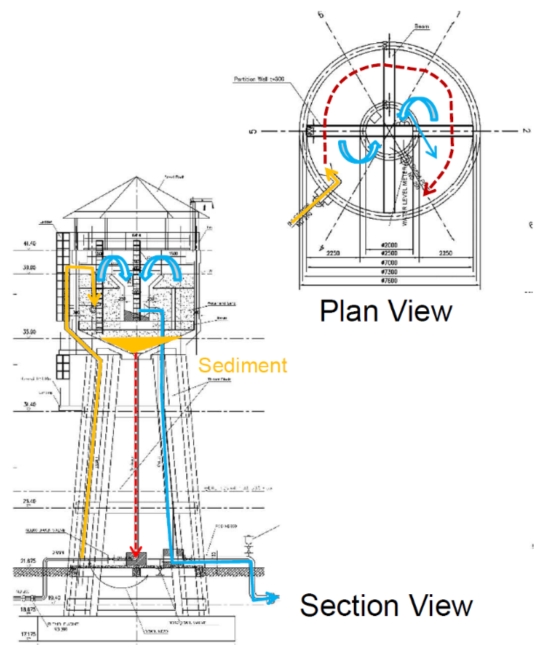
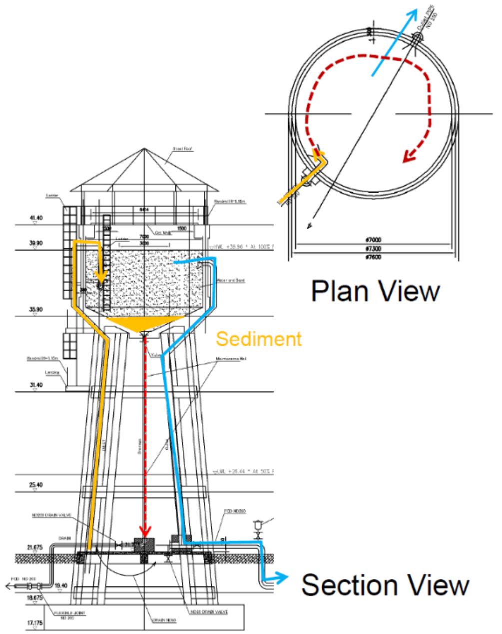
Cross Section

Plain View

Figure 2-2-17 Drainage Route of Side Wall Water Conveyance Type Sand Basin (Swirl 1tank)

The comparison of elevated type sand basin is shown in Table 2-2-21.

Table 2-2-21 Comparison of Elevated Type Sand Basin

Item	Case1: Horizontal Bottom Shape Type (2tanks)	Case2: Central Water Conveyance Type (Swirl 1tank)	Case3: Side Wall Water Conveyance Type (Swirl 1tank)
Drawing			
Summary	There are two tanks and two inlet pipes and two drainage pipes. The **surface load factor** of the tank that can settle the sediment shall be secured. Since the water level in the tank rises at a speed slower than the sedimentation speed of the sand, the sand can be settled. The inlet pipe will be discharged to the bottom of the tank. Overflow water flows down to the conveyance pipe through the cylindrical weir in the center of the tank. **Invert concrete** is casted at the bottom of the tank to **guide the sediment to the drainage pipe.**	There is one tank and one line of inlet pipe and drainage pipe. The **surface load factor** of the tank that can settle the sediment shall be secured. Since the water level in the tank rises at a speed slower than the sedimentation speed of the sand, the sand can be settled. The inlet pipe will be discharged to the bottom of the tank. Overflow water flows down to the conveyance pipe through the cylindrical weir in the center of the tank. The bottom shape of the tank is **mortar-shaped**, and **the sediment is guided to the drainage pipe.**	There is one tank and one line of inlet pipe and drainage pipe. The inlet pipe is installed toward the tangential direction of the cylinder, thereby **creating a vortex and promoting sedimentation.** The vertex current separates and removes substances in the water by utilizing the phenomenon that sand is collected at the center bottom of the vortex and lighter substances are collected at the outer top of the vortex. The bottom shape of the tank is **mortar-shaped**, and **the sediment is guided to the drainage pipe.**
Merit	- Since the inlet pipe and the outlet pipe are separated	- Since the inlet pipe and the outlet pipe are separated	- The structure is simple.

Item	Case1: Horizontal Bottom Shape Type (2tanks)	Case2: Central Water Conveyance Type (Swirl 1tank)	Case3: Side Wall Water Conveyance Type (Swirl 1tank)
	by a cylindrical wall, **there is little anxiety that turbid components from the inlet pipe are guided to the outlet pipe.** (generation of short-circuit current) - By setting an appropriate surface load factor of the tank, it is possible to reliably settle sediment. - Because of the two tanks structure, **continuous operation is possible** even while one tank is being maintained or cleaned.	by a cylindrical wall, **there is little anxiety that turbid components from the inlet pipe are guided to the outlet pipe.** (generation of short-circuit current) - By setting an appropriate surface load factor of the tank, it is possible to reliably settle sediment. - **The tank can be cleaned without workers going down to the bottom of the tank.**	
Defect	- Since the bottom of the tank is horizontal shape, **it is necessary for the worker to go down to the bottom of the tank to perform cleaning work** in order to discharge the sediment stuck on the bottom of the tank. - Since the tank has a semicircular two-tank structure and an outer tank and an inner tank, the structure becomes complicated. - Since two lines of inlet and drainage systems are required, **the piping layout is complicated, the facility structure associated with the piping is complicated, and the facility cost is high.**	- The tank structure is a two-layer (outer circular tank, inner circular tank) structure, whose structure is more complex than Case 3.	- It is necessary to secure the water head higher than other cases (2.5D is necessary from the top of the pipe). Therefore, **electric cost for pumping up the water becomes higher than other cases.** - It is uncertain whether the inflow water will generate an **appropriate vertex current** for sediment separation. - Since the tank has a single tank structure, there is a possibility that a **short-circuit flow may occur** from the inlet pipe to the outlet pipe.
O & M	- Since the sand basin is composed of two tanks, one is utilized during cleaning the other. - The sediment deposited on the bottom of the tank is discharged by operating a discharge valve provided directly below the sand settling tank. - Since the bottom of the tank is horizontal shape, it is necessary for the worker to go down to the bottom of the tank to perform cleaning work in order to discharge the sediment stuck on the bottom of the tank.	- The sedimentation tank is operated mainly during the rainy season when the river is comparatively higher turbid, and it is cleaned once a year during the dry season. - The sediment deposited on the bottom of the tank is discharged by operating a discharge valve provided directly below the sand settling tank. - The washing water is branched from the inlet pipe, and the worker sprinkles the water from the top deck toward the bottom of the tank without getting down to the bottom of the tank, and cleans the earth and sand adhered to the bottom of the tank.	・Same as on the left
Applicability	- Since the raw water turbidity is not high, it is not	- Since continuous operation throughout the year is	- Since continuous operation throughout the year is

Item	Case1: Horizontal Bottom Shape Type (2tanks)	Case2: Central Water Conveyance Type (Swirl 1tank)	Case3: Side Wall Water Conveyance Type (Swirl 1tank)
	necessary to operate all year round, and it is needless to compose the sand basin with two tanks. - It is necessary for the worker to go down into the tank to perform the cleaning work. - Since there are 2 inlet and 2 drainage pipe systems, the piping system and facility structure are complicated.	not necessary, there is no need to operate while maintaining and cleaning one tank alternately in a two-tank structure. The sand basin is operated only during the rainy season and cleaned during the dry season. - The sand settling function can be performed reliably. - Good maintainability of cleaning work. - Since there is one inlet and drainage system, the piping system and the facility structure associated with the piping are simpler compared to Case 1.	not necessary, there is no need to operate while maintaining and cleaning one tank alternately in a two-tank structure. The sand basin is operated only during the rainy season and cleaned during the dry season. - The function of sedimentation by the centrifugal force of the inlet water is uncertain. - The facility structure is the simplest among the three alternatives. - Electric costs are higher compared to other alternatives for reliable water conveyance to the outlet pipe.

Note: The final decision for the type selection of elevated type sand basin shall be conducted in detailed design (DD) stage.

(4) Plan of Intake Pump

1) Type of Intake Pump

The PWWs currently utilizes vertical mixed flow pumps. However, a horizontal type for the new intake pump is requested because the existing vertical pumps have serious problems on maintenance and checking.

The intake pump are generally selected from the following three types.

a)	Horizontal, Double Suction Volute Pump	Although the installation space required is larger than other types, maintenance and inspection are extremely easy. Price of pump is the cheapest.
b)	Vertical, Mixed Flow Pump	Maintenance and inspection are difficult because the clean water for lubricating of intermediate shaft bearings is required and there are many pump parts. Price of pump is the highest.
c)	Submersible Pump	The service life is shorter than others. A mechanical expert for replacement of mechanical seal and bearings is required.

Source：JICA Survey Team

From the above comparison and demand by the PWWs, the horizontal Double suction volute pump type is selected because of the easiest maintenance and inspection and low cost.

2) Specification of Intake Pump

- Pump Total Head

The pipe flow coefficient (C value) from the elevated tank to the receiving well is 130. A bypass pipe will be installed so that the water can be sent directly by pump without going through the elevated tank, and for the calculation of the pump head, a flow coefficient of 110 adapts with room, but in actual operation, wasteful power is not used by operating at an actual pressure rate with speed control.

Table 2-2-22 Pump Total Head

Calculation Items	Gravity flow from Elevated Tank	Direct Transmission by Pump
Intake Pipe Friction Losses	0.6m	0.6m
Pipe Friction Losses in Pump Room	2m	2m
Friction Losses from Pump to Elevated Tank	2.6m	-
Friction Losses from Pump to Receiving Well	-	25.3m (C=110)
Actual Head from River to Elevated Tank	20.8 ~ 23.8m	-
Actual Head from River to Receiving Well		2.2 ~ 5.2m
Pump Total Head	29m	34m

Source：JICA Survey Team

Accordingly, pump total head is 34m.

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

Table 2-2-23 Specification of Intake Pump

Item	Specification
Type	Horizontal, double suction volute pump
Quantity	2 sets
Capacity of pump	3,630m^3/day(2.52m^3/min)
Total head	34m
Output of motor	45kW
Diameter	150mm
Speed	SS1500min^{-1}

Source：JICA Survey Team

3) Water Hammer

· Passing through the elevated tank

There is no water hammer because the water flow from the elevated tank to the water receiving well is by gravity flowing. The elevated tank will play a role as a surge tank.

· Direct transmission

Since the elevated tank is not utilized as a surge tank, other water hammer countermeasure such like installing of flywheel is required..

(5) Plan of Electrical Facility

1) Substation

The substation will be newly installed in the intake pumping station. Power supply is drawn from EDC's 22 kV power line, which is located approximately 600 m from the station.

2) Emergency Generator Facility

Since short circuit trouble occurs at a frequency of several times per month, an emergency generator with power generation capacity capable of operating two intake pumps will be installed. The PWWs has agreed the fuel tank capacity by placing the tank with a capacity for 10 hours operation in consideration of reducing the recharging frequency.

3) Instruments

The following instruments are installed so that the pumps are operated safely and the operation condition of the intake pump station can be monitored at the WTP.

a) Water level meter for river: 1 set

b) Water level meter for pump pits: 1 sets

c) Magnetic flow meter for intake water flow: 1 set

4) Remote Monitoring System

A remote monitoring system will be installed to monitor the operation state of the intake pump station at the WTP. Because the straight distance from the water intake pump station to the WTP is approximately 6.4 km, and there are few obstacles, it is possible to select the wireless transmission without a relay station. In addition, since there is an advantage that equipment cost is low and there is no need for utilization fee, the radio system is adopted that will be proven in Cambodia soon. The monitoring items are as follows.

a) Trouble in the block signal of pumps and electric equipment:1 contact signal
b) Level meter at river: 1 (4-20mA)
c) Level meter at pump pits: 2 (4-20mA)
d) Flow meter: 1 (4-20mA)
e) Pump ON/OFF signal: 4 contact signals
f) Power signal (commercial power or emergency power): 2 contact signals

(6) General Specification of Planned Intake Facility

A general specification of the planned intake facility is shown in Table 2-2-24.

Table 2-2-24 Specification for New Intake Facility

Classification of Facility			Structure and Scale
Large category	Middle category	Small category	
Intake Facility 7,260m^3/day	Sedimentation tank 7,260m^3/day , 1-tank	Sedimentation tank (Circular Elevated Tank)	Reinforced Concrete Circular Elevated Tank Size: Tank Diameter 7.0m Height: 19.7m onGL Depth: 4.0m Equipped facility: Crane (0.5 ton) for Maintenance, Inlet Pipe, Outlet Pipe, Drainage Pipe and Water Gauge
	Intake pump facility	Intake Pipe and Pump room	Rectangular reinforced concrete structure with basement room First floor (under beam): B7.00m x L14.00m x H3.10m (measuring between center of walls) Basement room (under beam): B7.50m x L6.00m x H1.5m (measuring between center of walls) Equipped facility: incoming panel, control panels, valve control panel, auxiliary machine panel, emergency generator, intake pump (5.04m^3/m, 36m, 45kW x 2sets), pipe laying for intake and outlet side, crane (3t) for maintenance and floor drain pumps
		Personnel office	Rectangular reinforced concrete structure with basement room Size: B6.00m x L6.00m x H2.40m (measuring under beam between center of walls) Equipped facility: power board and instrumentation board
	Temporary works	Earth Coffer Dam	Earth Coffer Dam and Large Sand Bag H=4m L=60m

Source: JICA Survey Team

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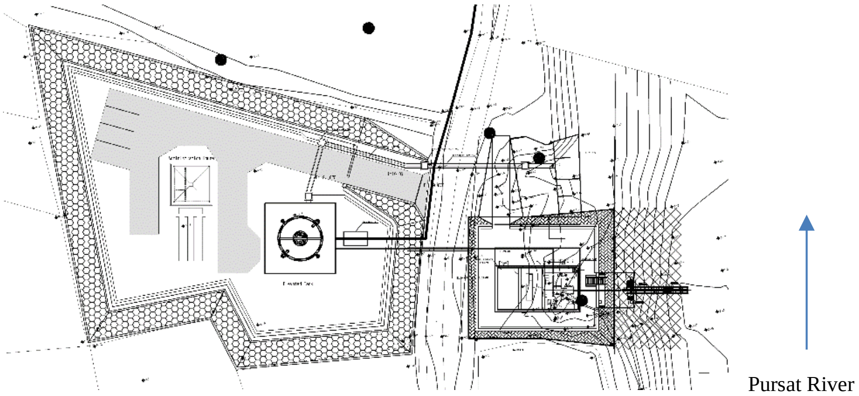
<tr><td colspan="2">

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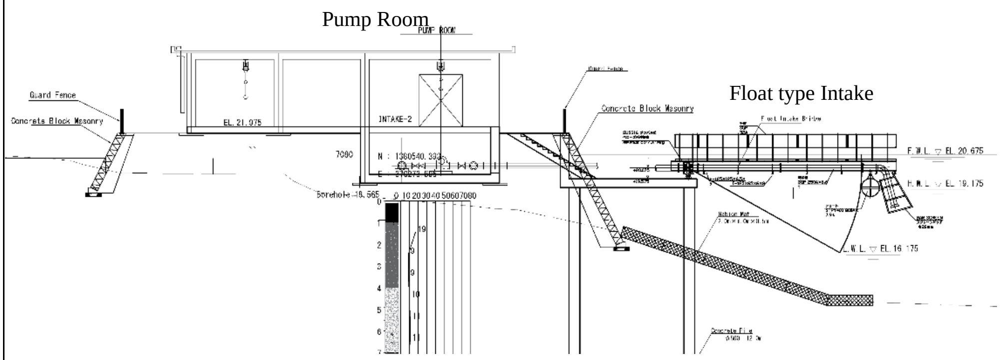
<tr><td>Intake</td><td>

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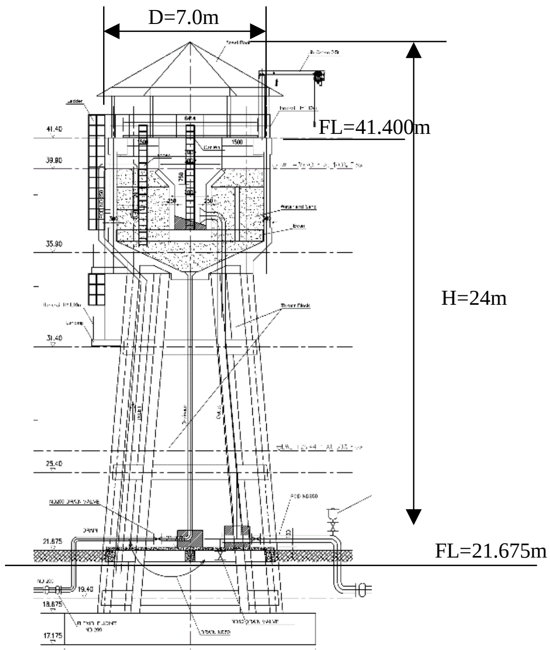
<tr><td>Sand Basin (Elevated Type)</td><td>
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Figure 2-2-18 Revised Design Drawing

2-2-2-4 Conveyance Pipe

(1) Basic Condition

1) Design Flow of Conveyance Pipe

Based on the design flow of raw water intake that is set out considering ten percent of safety factor to the design daily maximum water supply, the design flow of conveyance pipe shall be 7,260 m^3/ day[3].

2) Type of Conveyance Pipe

The type of conveyance pipe shall be the pumping type considering the difference in elevation[4] between its beginning point (i.e. the raw water intake facility) and its terminal point (i.e., the WTP), a 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

As shown in Figure 2-2-19, the route of conveyance pipe shall be selected along public roads and the route with the shortest distance between water intake facility and the WTP, considering the economic efficiency, ease of construction, and ease of maintenance and management.

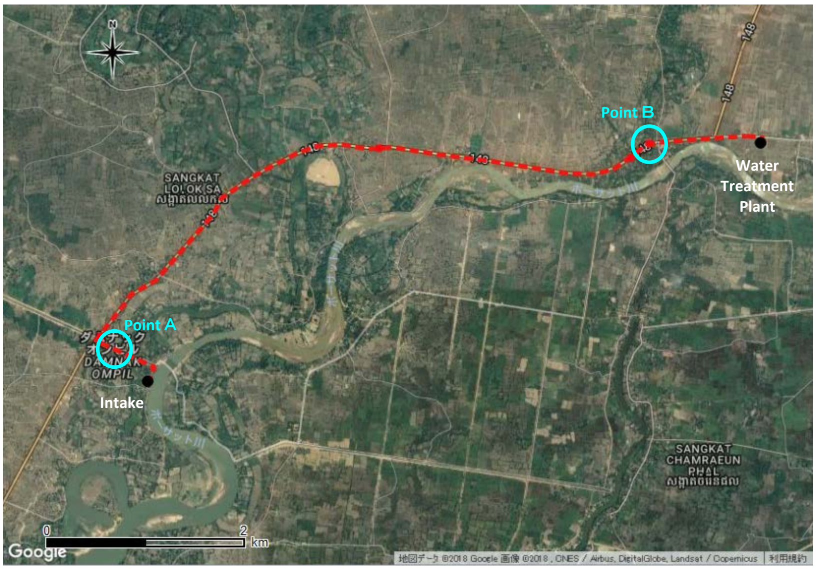


Photo - Point A

Photo - Point B

Length of conveyance pipe main: Approximately 8.3 km north-east from the water intake to the WTP, Status of road pavement: Surrounding roads of the intake and the WTP are unpaved, others are asphalt pavements, Crossing for river etc.: 4 places
Source: JICA Survey Team

Figure 2-2-19 Route of Conveyance pipe

(2) Pipe Material

With regard to the pipe material, it is selected by considering the applicable pipe diameter, the economic benefits, ease of construction work[5], and precedence of water pipe materials used in Cambodia. The materials for the conveyance pipe shall be ductile cast iron pipe for general buried

[3] The design flow of conveyance pipe = 6,600 m^3 / day ×1.1 = 7,260 m^3 / day
[4] The difference in water level between the planned intake pump well (HWL + 19.175 m, LWL + 16.175 m) and the planned receiving well (WL+ 21.300 m) is from 2.125 to 5.125 m, the geography along the route of conveyance pipe almost flat.
[5] Corrosion is a concern for buried steel pipes, and on-site welding work may cause poor finishing as compared with ductile cast iron pipe.

sections and steel pipe (with corrosion prevention) or stainless steel pipe for the river crossing sections, and the ISO standards shall be adopted.

(3) Pipe Diameter

The pipe diameter for conveyance pipe shall be 350mm, by considering economic relationship between appropriate flow velocity[6], reasonable pipe loss or pump head and pipe diameter, and hydraulic calculations under the conditions of the design water level[7].

(4) Crossing River and Other Water Channels

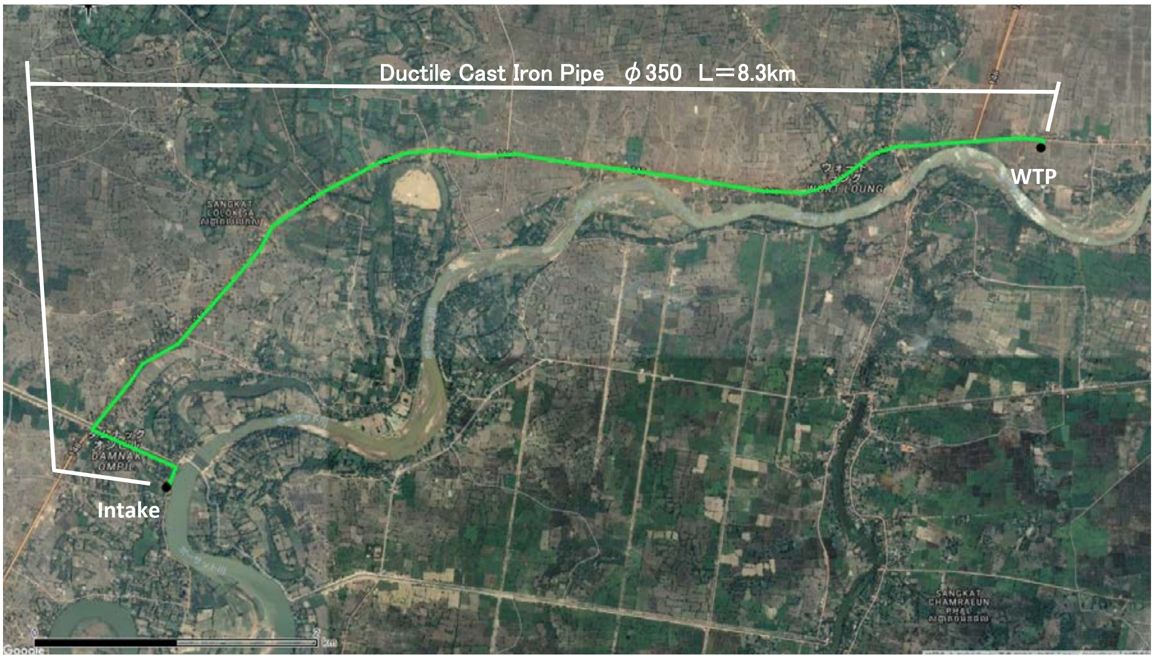
There are four (4) crossings, such as rivers and irrigation canals, in the route of the conveyance pipe between the water intake facility and the WTP. The pipe material for the crossings shall be steel pipe and the crossing method shall be bridge-piggybacked water main in conformity with the criteria shown in the section of 2-2-2-6 Distribution Facilities. In addition, drainage valves will be installed at these four locations to periodically remove sediment in the pipe.

(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, design for conveyance pipe route (excluding the water pump equipment for conveyance pipe) is as shown in Figure 2-2-20 and Table 2-2-25



Source: JICA Survey Team

Figure 2-2-20 Route of Conveyance Pipe

[6] 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

7 Design water level: The planned intake pump well (LWL + 16.175 m), the planned receiving well (WL+ 21.300 m)

Table 2-2-25 Specifications of Conveyance Pipe

Facility	Type and Structure	Quantity
Conveyance Pipe	DIP, Diameter 350mm	8.3 km
	Bridge-piggybacked Water Main SP, Diameter 350mm	4 places

Source: JICA Survey Team

2-2-2-5 Plan for WTP

(1) Land for WTP

The land for WTP was owned by a farmer as a farming land. DIH which controls PWWs has negotiated with the owner and procured it at a market price. There was no person living there, therefore, no resettlement was required.

(2) Treatment Process

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

The key factors to consider for designing the treatment process are 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 existing Pursat plant, 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. Figure 2-2-21 shows the flow chart of the treatment process.

1) Water Treatment

・The raw water flows into the receiving well, then treated in the mixing well, the flocculation basin, the sedimentation basin, and the rapid filter basin. Finally, the clean water is stored in the service reservoir.・After that, the clean water is distributed to the city by the distribution pumps.

2) Drainage Treatment

・The wastewater of the rapid filter basin flows into the drainage basin. Then, it is returned to the receiving well by the return pumps.

・The settled sludge in the sedimentation is transferred to the drying bed by the sludge transfer pumps. The drainage water from the drying bed flows into the drainage basin.

3) Maintenance

・Before emptying the sedimentation basin for maintenance work, the supernatant water of the sedimentation basin is drained to the drainage basin. After maintenance work, it is returned to the receiving well.

・On the other hand, the settled sludge of the sedimentation basin is transferred to the drying bed by the transfer pumps.

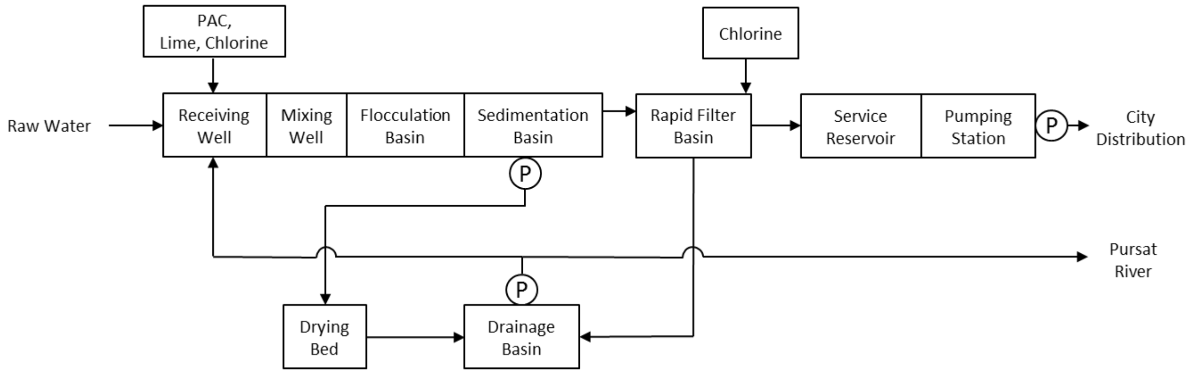


Figure 2-2-21 Water Treatment Process Flow

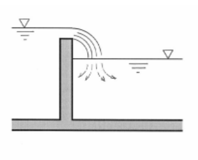
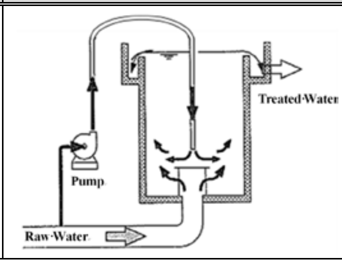
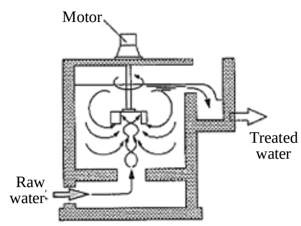
(3) Study of Water Treatment System

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 energy requirements, the mixing methods can be divided into two types; (1) that utilizes the energy of the flowing water (e.g. weir method), and (2) that utilizes external mechanical energy (e.g. pump mixing and 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 a 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						
G Value (1/s)	100 – 300 (Reference: The Japanese Design Criteria for Water Supply Facilities)					
Retention Time (min)	1 – 5 (Reference: The Japanese Design Criteria for Water Supply Facilities)					
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	◎

Item	Method that utilizes the energy of the flowing water		Method that utilizes external mechanical energy			
	Weir Method		Pump Mixing Method		Mechanical Mixing Method	
Construction Cost *	0.1	◎	1.6	△	1.0	○
Overall	◎		△		○	

* The Comparative values assuming mechanical mixing method which has been widely used in Japan, as 1.0.
Source: JICA Survey Team

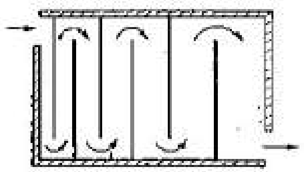
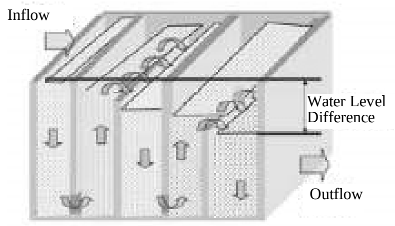
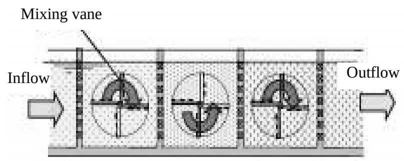
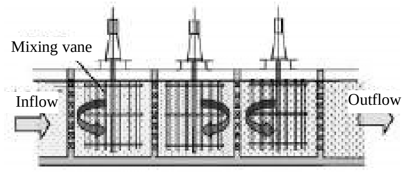
2) Selection of Flocculation Basin

The role of flocculation basin is to gently stir the micro flocs generated in the mixing well allowing them to grow large for an 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 a comparison of flocculation methods.

3) Selection of Sedimentation Basin

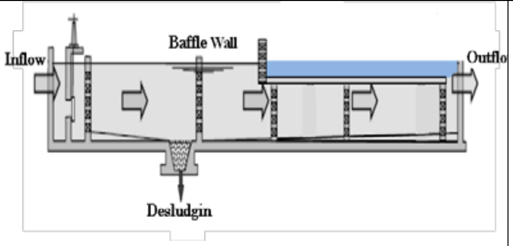
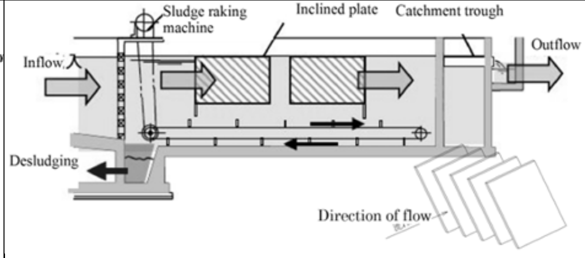
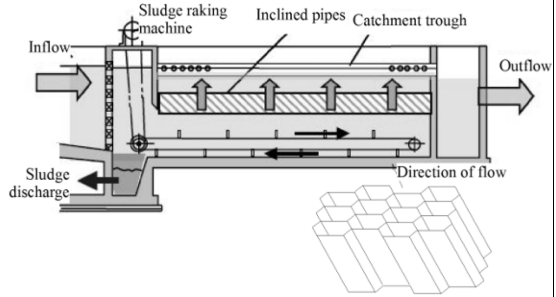
The role of sedimentation basin is to settle and separate large flocs formed in flocculation basin by gravity sedimentation. Sedimentation basins are mainly divided into horizontal flow type, horizontal flow with inclined plate type, upward flow with tube settler type, and suspended solid contact type. Suspended solid contact type was, however, excluded from consideration as it requires high-level operational technique and has not been constructed in Cambodian WTPs since 2000s. Table 2-2-28 shows the comparison of the type of sedimentation basins. Horizontal flow with inclined plate" type and upward flow with tube settler" type are superior to horizontal flow type in terms of turbidity fluctuation of the raw water. On the other hand, construction land is not restricted for this project. Thus, 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 Utilize the Energy of Water Flow Itself				Method that Utilize Mechanical Energy			
	Zigzag Flow Method		Up-and-Down Roundabout Method using Zigzag Flow		Horizontal Shaft Turbine Method		Vertical Shaft Turbine Method	
Structure	 Horizontal baffled channel method (top view)							
G Value	100 – 300 (Reference: The Japanese Design Criteria for Water Supply Facilities)							
GT Value	23,000 – 210,000 (Reference: The Japanese Design Criteria for Water Supply Facilities)							
Retention Time	20 – 40 (Reference: The Japanese Design Criteria for Water Supply Facilities)							
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 fluctuates	△	Intensity of mixing 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 an absence of mechanical parts and less cost	◎	Needs operation and maintenance of mechanical parts. Durability is somewhat inferior due to drive part submerged.	△	Needs operation and maintenance of mechanical parts. Durability is somewhat superior due to drive part not submerged.	○
Required Area	Large	△	Medium	○	Small	◎	Small	◎
Construction Cost *	0.2	◎	0.2	◎	1.0	△	0.6	○
Overall	○		◎		△		○	

* Comparative values assuming horizontal-shaft turbine mixing method which has been widely used in Japan, as 1.0.
Source: JICA 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 *	1.0	◎	2.5	△	2.0	○
Overall	◎		○		○	

Design Criteria: The Japanese Design Criteria for Water Supply Facilities

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

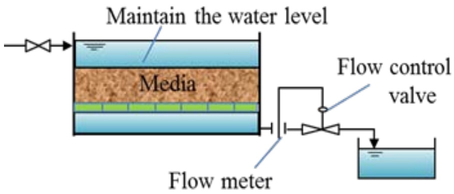
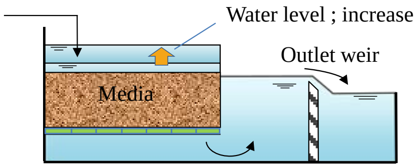
Source: JICA Survey Team

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 have been applied in Cambodia. After consideration, the self-balancing method, which is also being used at the existing Pursat plant, is adopted because of minimum requirement of operation and maintenance and less construction cost.

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)	Because of 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 *	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	○	◎

* Comparative values assuming flow control method as 1.0.
Source: JICA Survey Team

Self-Balancing method is divided into three (3) methods: 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, JICA Survey Team did not specify a particular method for this study, instead left if for the bidders to propose during the bidding process.

In addition, there are three types of feeding system into the filtration basin, namely from other basin(s), using a backwash pump, and from a supply tank. Given that feeding using backwash pump incurs large operation and maintenance costs, JICA Survey Team again decided not to specify a particular method, but left it for the bidders to propose. Furthermore, the backwash tank type is divided into an internal and an external type.

The filtration basins shown in Annex 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 different shape and type of filtration basins as long as they satisfy the "Prerequisite of filtration basin" and "Basic specification of filtration basins" as shown in Annex).

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 Pursat River
2.	Design Water Treatment Output: 7,260 m^3/day
3.	Outline of intake facility and grit chamber, 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, PI-1 to PI-6, PR-1 to PR-4)
4.	Shape and dimensions of the construction site of the WTP: Refer to the design drawing (Drawing number PT-1)
5.	Construction plan of WTP facilities other than filtration basin: Refer to the schematic design drawing (Drawing numbers PT-1 to PT-16)
6.	Hydraulic Profile of the WTP located upstream of the filtration basin: Refer to the schematic design drawing (Drawing number PT-2)
7.	Transmission/distribution system from the WTP: Water supply to customers by the water distribution pump direct delivery system

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

① Since it is not a bidding of the performance guarantee method, the contents of the basic specification are to be relatively conservative, with the top priority for minimizing risks of O&M.

② 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, is to be excluded from the options in advance.

③ The contents of the basic specifications are 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 PT-2 to PT-5, PT-10, PT-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 filtration rate shall be 110 m/d or more during the operation of all filtration basins and shall be 150 m/d or less during cleaning of the filtration basin.
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 washing method shall be "backwash + air-wash". (After “backwash + air-wash”, perform backwash only.)
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 should 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.
22.	When 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 by manual washing on the local operation panel and automatic washing through sequence control.

(4) New WTP Layout

The new WTP is designed for a capacity of 7,260 m^3/day based on the site area and the land shape, and then the facility layout is proposed taking account the following matters. The layout and the flow diagram of the proposed new water treatment facilities are shown in Figure 2-2-22 and Figure 2-2-23, 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

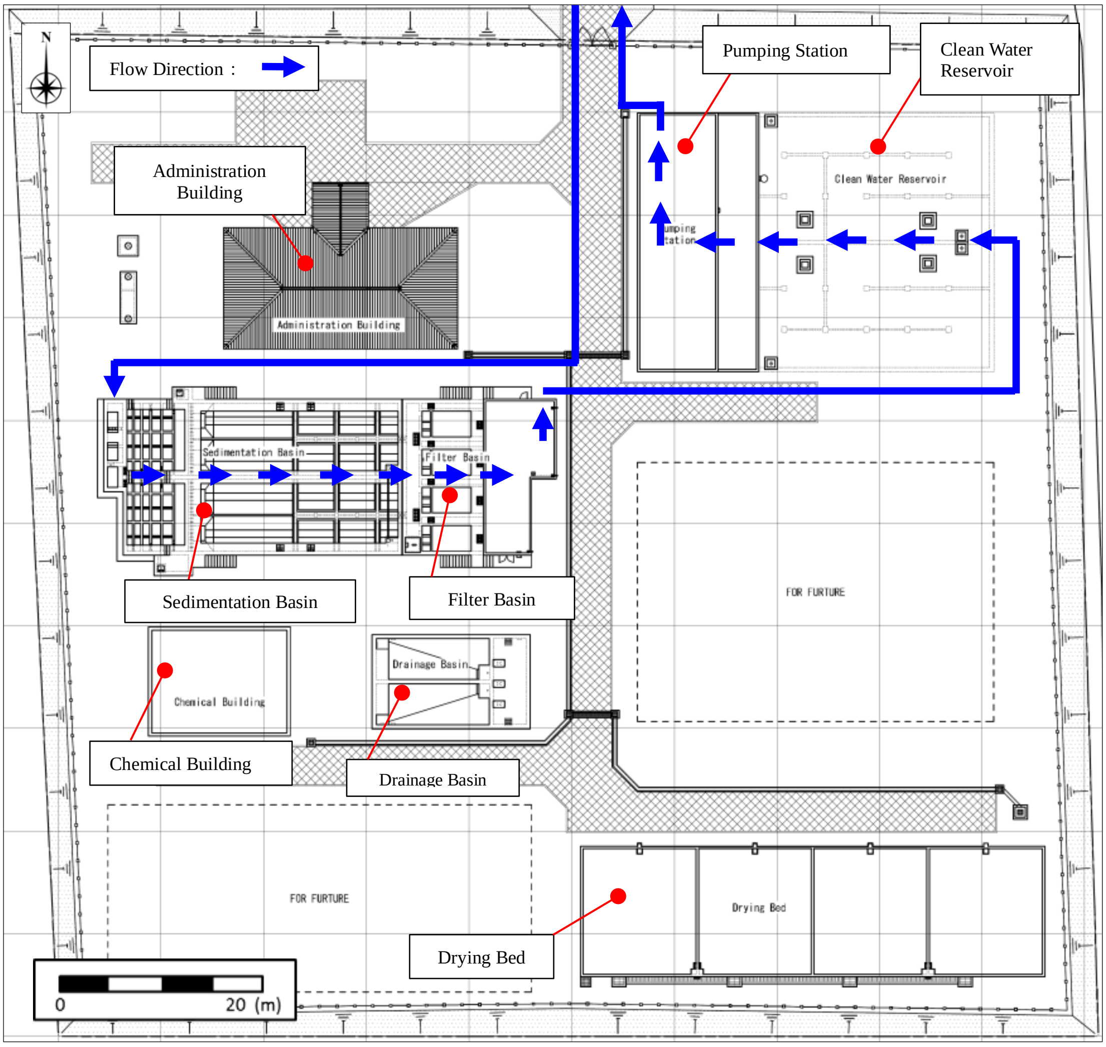


Figure 2-2-22 New WTP Layout

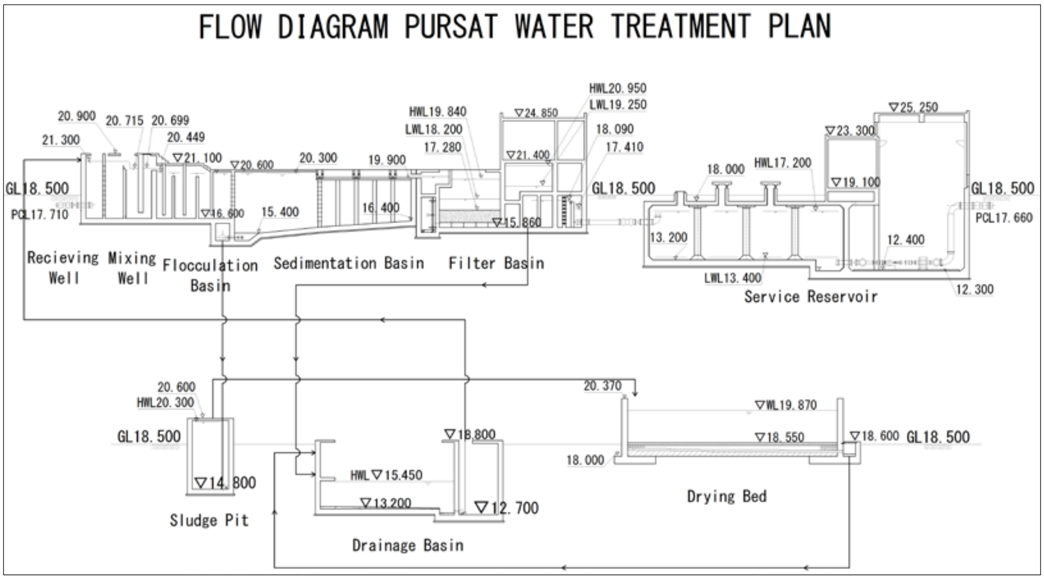


Figure 2-2-23 Hydraulic Profile of the New WTP

(5) Design for Other Water Treatment Facilities

1) Drainage Facilities

The wastewater of the rapid filter basin flows into the drainage basin, and then returned to the receiving well by the return pumps.Sludge from the sedimentation basin will be treated and disposed in the following manner in compliance with the discharge standards:

・During basin-washing, the supernatant of the basin which is of low turbidity will be discharged to the Pursat River.

・Settled sludge and highly turbid water will be pumped to a sludge drying bed.

・Supernatant of the drying bed will be discharged to the nearby rivers and the dried sludge will be disposed at a pre-determined location.

The backwash water from the filtration basin will be retained at the drainage basin and discharged by pump to the nearby rivers in a control manner to avoid releasing large volumes of wastewater in a short period of time. Especially, the supernatant of the sludge drying bed and drainage basin can return to the receiving well, if the supernatant still has high turbidity. Figure 2-2-24 shows the drainage pipe route from the new WTP to the Pursat River.

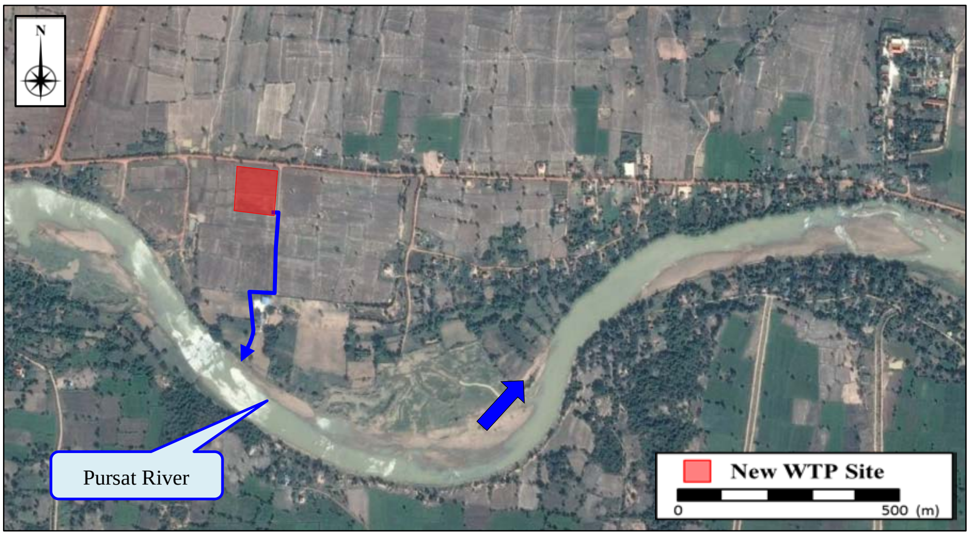


Figure 2-2-24 Drainage Pipe Route

2) Yard Piping / Landscaping

- Maintenance roads will be constructed around the treatment facilities.
- Inter-connecting pipelines of appropriate diameters will be installed in treatment facilities.
- Lightning rod will be installed at each building to prevent damage from lightning.
- Concrete block fence and entrance gate will be installed for security.

(6) Electric and Instrumentation Facilities

1) Substation Facilities

New substation will be installed in the new plant. The power source is drawn from the 22 kV, 50 Hz power line of the nearby EDC, stepped down to 400 V 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 will be installed. The fuel tank will be of the operation capacity for 10 hours in consideration of reduction in replenishment frequency. The generated power at 400 V is drawn into the changeover board in the electric room of the pump station.

3) Electric Power Distribution Facilities

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

4) Instrumentation Facilities

In order to operate the WTP properly, the following instrumentation facilities will be installed in the WTP.

・Flow Meter of Filtration: 1 set
・Water Level Meter of Service Reservoir: 2 sets at each reservoir
・Distribution Pressure Meter: 1 set
・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 are displayed on the graphic monitoring board installed in the monitoring room of the administration building, enabling supervision of the overall water treatment facilities.

6) Remote Monitoring System of Intake Pump Facilities

A remote monitoring system using a wireless system will be installed in the WTP monitoring room to monitor the operation of the intake pump station and the pump water supply amount.

7) Distribution Monitoring System

The data on the flow rate of the water intake pump station, filtration flow rate, distribution flow rate and distribution pressure in the WTP, distribution water flow (one location) and distribution pressure (three locations) at the local stations are 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. Similar to the existing system, data transmission at the four local stations will be carried out once or twice daily at a fixed time using a mobile phone network.

(7) Summary of the WTP Plan

Table 2-2-32 shows components of the necessary facilities and instruments discussed in the new WTP plan.

Table 2-2-32 Specification for the New WTP

Items	New Pursat WTP Design Water Treatment Capacity: 7,260m^3/day, Design Maximum Daily Demand: 6,600m^3/day	
	Contents	Qty
Receiving Well	Reinforced Concrete Structure Internal Dimension: Width 1.50m×Length 3.90m×Depth 4.70m Volume (V): 27.5 m^3, Retention Time (T): 5.5min (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 4.12m	1 Basin

Items	New Pursat WTP Design Water Treatment Capacity: 7,260m³/day, Design Maximum Daily Demand: 6,600m³/day	
	Contents	Qty
	Volume (V): 9.27 m^3, Retention Time (T): 1.83min (Criteria: 1＜T＜5min)	
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: G Value: 10 – 75 (1/s) GT Value: 23,000 – 210,000 Width 7.00 m × Length 3.65 m× Average Effective Water Depth3.76m (Height 4.50m)	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 4.40m Surface Loading: Q/A=18.0mm/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): 121m/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): 1,152m^3(576m^3×2Basins) Effective Water Depth (H): 4.00m (Criteria:3-6m) Retention Time (T): 8.4hours (Set from daily-water demand fluctuation) Internal Dimension per Basin: Width 12.00m×Length 24.00m×Depth 4.00m	2 Basins
Drainage Basin	Reinforced Concrete Structure Volume (V): 228.8m^3(114.4m^3×2Basins) (Volume per Basin: More than one-time wastewater volume) Internal Dimension per Basin: Width4.00m×Length 11.00m×Effective Water Depth 2.60m (Height 5.60m)	2 Basins
Drying Bed	Reinforced Concrete Structure Effective Area (A):536.8m^2 (Area per bed: Width 11.0m×Length 12.2m＝134.2m^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.	1 Unit

Items	New Pursat WTP Design Water Treatment Capacity: 7,260m³/day, Design Maximum Daily Demand: 6,600m³/day	
	Contents	Qty
	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.	
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):425.8m² (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): 266.7m² (Usage) Ground Floor: Office Room, Meeting Room, Monitoring Room, Laboratory, Toilet	1 Unit

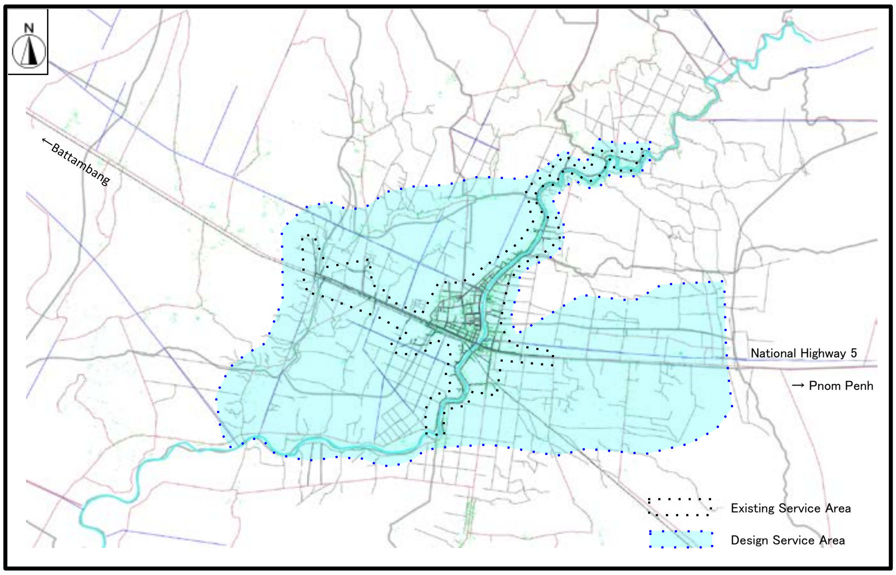
Note: * As stated in section 2-2-2-5-(3)-4), since the specification and structure of rapid sand filter is based on bidder's proposal, the description on the above table is for reference.

2-2-2-6 Distribution Facilities

(1) Basic Condition

1) Design Service Area

The design service area[8] shall be expanded to the area as shown in Figure 2-2-25. The area excluding the existing service area from the design service area shall be the extended service area.



Source: JICA Survey Team

Figure 2-2-25 Design Service Area

[8] 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 MIH.

2) Design Distribution Flow

The design distribution flow shall be 357.5 m^3 /hr which is the design maximum hourly distribution flow in the design service area calculated from the design maximum daily supply of 6,600 m^3/day divided by 24hr and multiplied by the time coefficient[9] of 1.3.

(2) Water Distribution System

There are several problems when it is assumed that water is supplied to the existing service area from the existing facilities, while water is supplied to the extended service area from the new facilities. In order to solve these problems, the water distribution systems have been reorganized and examined in consideration of the economic benefits and ease of maintenance and management as follows.

- If the water supply connection rate of the existing area reaches to 100%, the capacity of the existing facility is insufficient at about 3,200 m^3/day.
- The existing distribution mains along the Pursat River in the northern area do not have enough capacity to satisfy the future water demand.
- Dual piping places where new pipeline is laid on the same route of the existing pipeline are laid (unnecessary pipeline). In addition, the installation of longer length of new pipes is necessary and uneconomical.

Therefore, after rearranging of the distribution system, proper distribution method considering economical aspect and maintenance aspect is examined.

1) Reorganization of the Water Distribution Systems

The design service area, where the difference in elevation in the whole area is small with approximately 8m, is a flat terrain. For this reason, similar to the existing service area, the type of water distribution to the extended service area shall be the pumping type.

Figure 2-2-26 and Figure 2-2-27 show the reorganization of the water distribution systems and its conceptual plan, respectively. Since most of existing pipes were laid after 2006, there is no information about the leakage due to the aging facilities or the high-water pressure and also no area where the leakage is concern based on the results of the existing distribution hydraulic analysis. Therefore, the leakage of existing pipes will not be considered in this study.

The water distribution systems shall be reorganized;

- To separate the design service area into two distribution areas such that the water demand there are corresponding to the capacities of the existing facility and the new facility, and that water will be supplied by the shortest routes from each facility to save energy.
- To minimize duplication of pipe installation on the same route, and not to replace the existing water mains.
- To facilitate easier operation and maintenance, the boundary of each water distribution area is blocked by the isolation valves so as not to interfere with each other.

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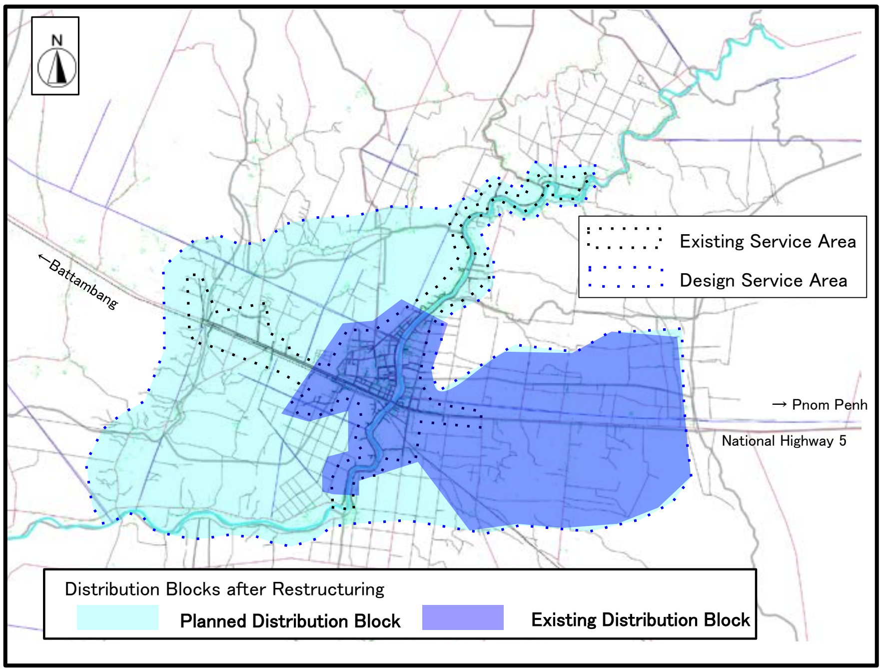
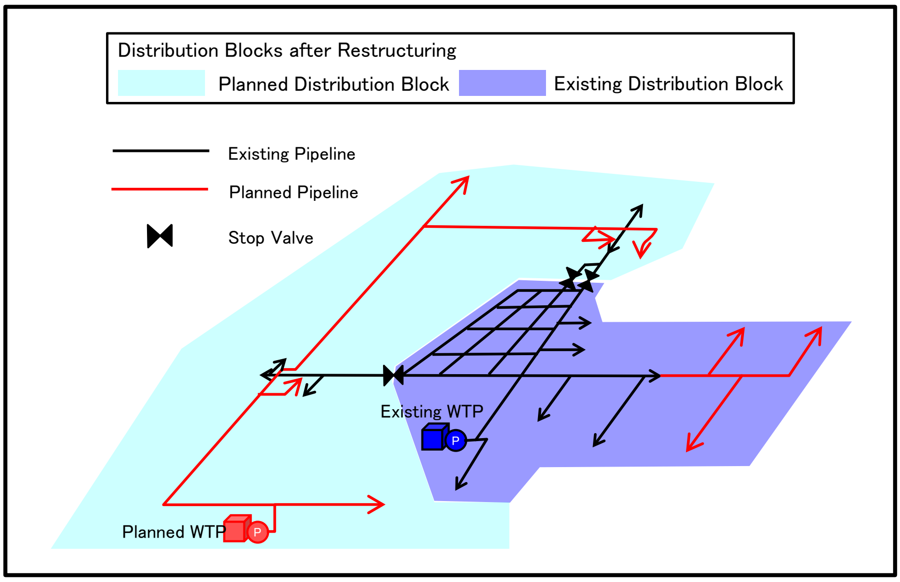
[9] The time coefficient of 1.50 above has been adopted based on the discussions with MIH with reference to the actual value of 1.3 in the existing distribution area of Pursat City, and planned value of 1.70 in the other similar size cities in Cambodia.

-To monitor and use the distribution flow rate and water pressure for planning and operation of water distribution and large leakage detection by dividing the distribution area of the new WTP into two zones and the distribution area of the existing WTP into one zone.[10]



Source: JICA Survey Team

Figure 2-2-26 Reorganization of Distribution System



Source: JICA Survey Team

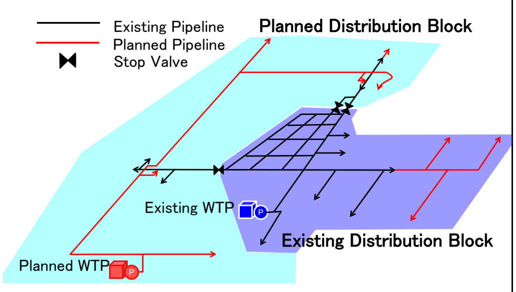
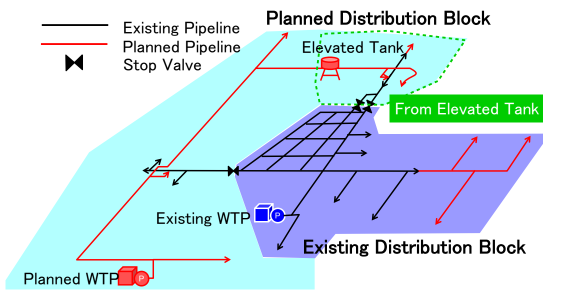
Figure 2-2-27 Illustrated Concept of Reorganization of Distribution System

[10] Dividing the water distribution area into subdivided blocks is considered unnecessary for the moment due to the following reasons. i) Since existing pipes and new pipes are relatively new, a large amount of water leakage due to deterioration of pipeline is not assumed for the time being. ii) The topography is generally flat, and by blocking it is not necessary to set the area to be reduced water pressure or the area to be pressurized. For this reason, this plan was planned to be able to grasp the water distribution condition and large water leakage accident and to distribute water in large blocks. In the future, as the number of house connections and water demand increase, and also further deterioration of pipeline progresses, it becomes necessary to identify the water leakage location. It is advisable to consider dividing the water distribution area into subdivided blocks in order to grasp further detailed water management information and water demand fluctuation by district.

2) Type of Water Distribution

As shown in Table 2-2-33, the type of water distribution[11] shall be pumping type, and water shall be supplied by pumps with the inverter control in the new WTP.

Table 2-2-33 Comparison of Water Distribution Type

Case	**Plan A**: Pumping (inverter control・Estimated end pressure constant control) type from the WTP	**Plan B**: Combined type (pumping from the WTP and gravity flow from elevated tank)
Description	−Directly conveyed water from the new pump to the planned distribution block −Directly conveyed water from the existing pump to the existing distribution block −Facilities (Service Reservoir, Distribution Pump, Distribution Trunk Mains, Operation Control System)	−Directly conveyed water from the new pump to around WTP in the planned distribution block and gravity flowed from the elevated tank to the distance area of the planned distribution block −Directly conveyed water from the existing pump to 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.
	Recommended	

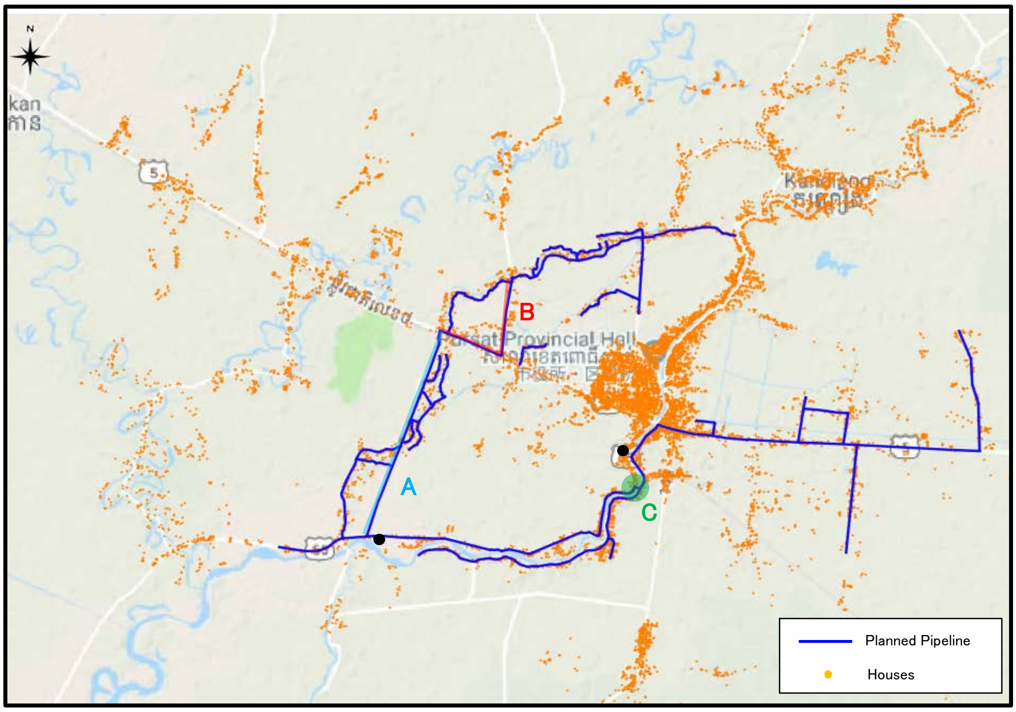
Source: JICA Survey Team

[11] 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 in 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.

(3) Route of Distribution Mains

The route of distribution mains shall be decided by selecting the route of high density of houses and then confirming on the road width, obstacles and forth by the field survey while considering the following matters. The route of distribution mains is as shown in Figure 2-2-28.

- There are few houses along the straight road, and there are many houses along the surrounding roads in the area A. However, the route in the area A will be the main route of medium or large diameter toward north, it is preferable to avoid narrow width and bent roads due to workability. Therefore, a main pipe shall be arranged on the straight road and small diameter pipes shall be arranged on the surrounding roads.
- A main pipe of medium or large diameter shall be placed in this area, because there are many houses along the curved road in the area B, but the width is approximately 2m. Therefore, main pipes shall be arranged on a straight road passing through National Road No. 5 and small diameter pipes shall be arranged on the surrounding roads.
- In order to convey water to the right bank of the Pursat River, the route shall be planned to be a pipe network in which bridge-piggybacked water mains shall be arranged in existing bridges at C



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

Figure 2-2-28 Route of Distribution Mains

(4) Distribution Pump

1) 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 the inverter control that enables smooth control and high efficiency operation against constantly changing water demand to reduce power consumption cost and simplify pump operation.

2) Specification of Distribution Pump

The design specification of the distribution pump is shown in the table below.

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

Item	Specification
Type	Horizontal, end suction volute pump
Quantity	3sets (Including one set of standby)
Capacity of pump	4,950m^3/day (3.44m^3/min)
Total head	55m
Output of motor	75kW
Diameter	200mm x 100mm
Speed	SS1500min^{-1}
Accessory equipment	Flywheel GD^2=200kgm^2

Source：JICA Survey Team

Existing distribution pump specification: 2.0 m^3/min, H=50m, 30kW x 3 units,
4.5 m^3/min, H=50m, 45kW x 1 unit

(5) 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[12] volume equivalent of the maximum daily supply of the service area; 2,200 m^3 (6,600 m^3 × 8/24).

(6) Pipe Diameter for Distribution Mains

The pipe diameter, with which minimum dynamic water pressure will not become lower than the minimum standard pressure[13], shall be determined, based on hydraulic network analyses for normal operation and at the time of fire. Annex 7.9 presents the results of the hydraulic network analyses.

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[12] With regard to the service reservoir capacity, it shall be decided by coordination with MIH with reference to 2.6 hours of the design maximum daily supply which is actual value of existing distribution facilities and other cities. See Annex 7.8.

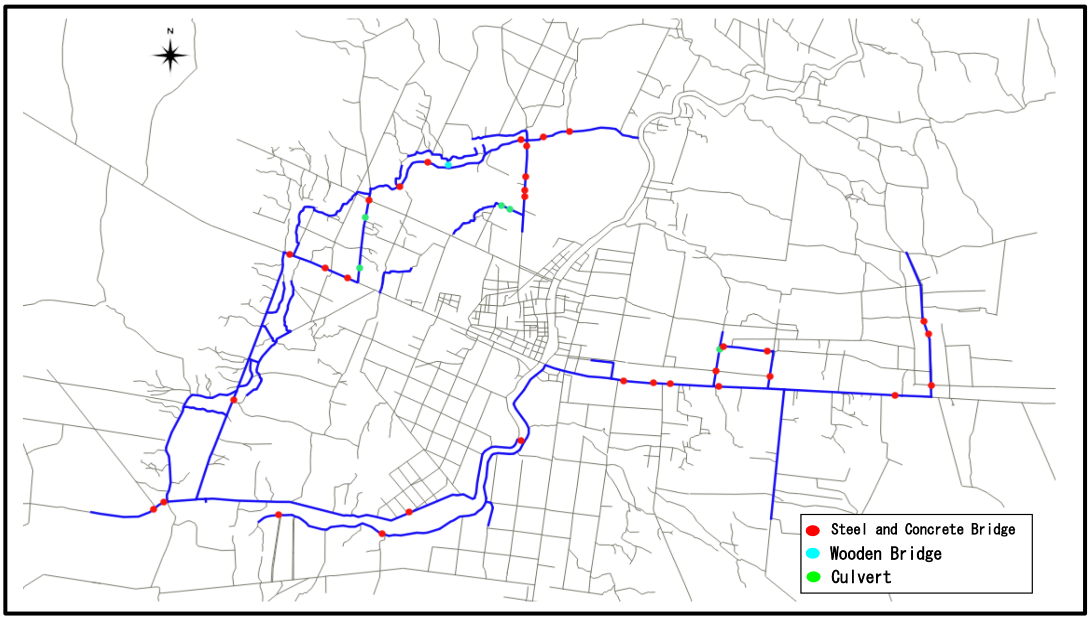
[13] Minimum pressure: 0.05MPa. The distribution pipe network is designed to ensure the adequate residual water pressure throughout the terminal area, highlands, etc. The target area is flat with the elevation difference of approximately 8m across the whole area and there is no highland. Under such conditions, 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.

(7) Pipe Material for Distribution Mains

The materials and standards for the distribution mains in general buried sections shall be as follows. In case of 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 of diameter 250 mm[14] or less, it shall be HDPE pipe of PN 10 class. In case of the river crossing sections, the materials for the distribution mains shall be SP with corrosion prevention.

(8) Crossing River and Other Water Channel

The locations where the distribution mains cross such as rivers, underdrains and a railway are as shown in Figure 2-2-29 and Figure 2-2-30. The pipe installation method for each crossing shall be in conformity with Table 2-2-34.



Source: JICA Survey Team

Figure 2-2-29 Locations of Crossing River and Other Structures

[14] As for the pipes with a diameter of 250 mm or more, ductile cast iron pipe (DIP) is supposed to be applied in Cambodia according to the past record of PPWSA. However, in case all section of distribution pipes is based on the past record of PPWSA, the project cost exceeds the budget constraints of Japan side. Therefore, high-density polyethylene pipe (HDPE) will be applied to a certain part of the distribution pipe (L=5.5km) with φ250mm.

The application of HDPE pipes with a diameter of 250 or more in water distribution pipes has a lot of applied record, and there are no technical issues as for the application of φ250mm HDPE pipes.

According to the "Water Supply Facility Design Guidelines: Japan Waterworks Association", there are the following descriptions of the applicable materials for distribution pipes, and there is no provision that requires distinguished application of pipe materials for each pipe diameter.

"Ductile cast iron pipes (DIP), steel pipes, stainless steel pipes, polyvinyl chloride pipes (PVC), and polyethylene pipes (PE) can be applied for water distribution pipes. These pipes are manufactured by different materials and manufacturing methods, and are different in specified dimensions, strength, inner and outer surface coating, etc. Therefore, the optimum one shall be selected in consideration of hygiene, compatibility, durability and maintenance aspect, etc."

In terms of pressure resistance, the calculated water pressure in the distribution pipe in the design is about less than 0.5 MPa, and even if the water hammer pressure 0.25 MPa added for the polyethylene pipe is taken into account, the internal pressure is 0.75 MPa, and the HDPE pipe whose pressure resistance is PN10 (1.0 MPa) can be applied.

		
Concrete Bridge	Steel and Concrete Bridge	Wooden Bridge
		
Wooden Bridge	Culvert	Culvert

Source: JICA Survey Team

Figure 2-2-30 Photographs of Bridges and Culverts

Table 2-2-34 Pipe Installation Methods for Each Crossing

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 (Department of Public Works and Transports), 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.
Wooden bridge	The wooden bridge is an unavoidable route without choice of route change. The bridge-piggybacked water main for the wooden bridge is difficult in terms of strength. According to the field survey, the surroundings of the wooden bridge are appeared to be shallow ponds and there are sufficient lots at the site. Therefore, although it is necessary to investigate subsurface exploration and surveying etc. at the time of detailed design stage, it is assumed to adopt the crossing method with the water main bridge.
Culvert (centrifugal reinforced concrete pipe and others)	Crossing of culverts shall be carried out by the invert siphon with the concrete protection.
National road No. 5	Crossing of the national road No.5 shall be carried out by the open cut method. The pipes to be laid inside are centrifugally cast reinforced concrete pipes.
Railway	The railway line of Pursat City is not currently in use. Thus, the pipes shall be laid by the open cut method and the pipe to be laid inside should be centrifugally cast reinforced concrete pipes.

Source: JICA Survey Team

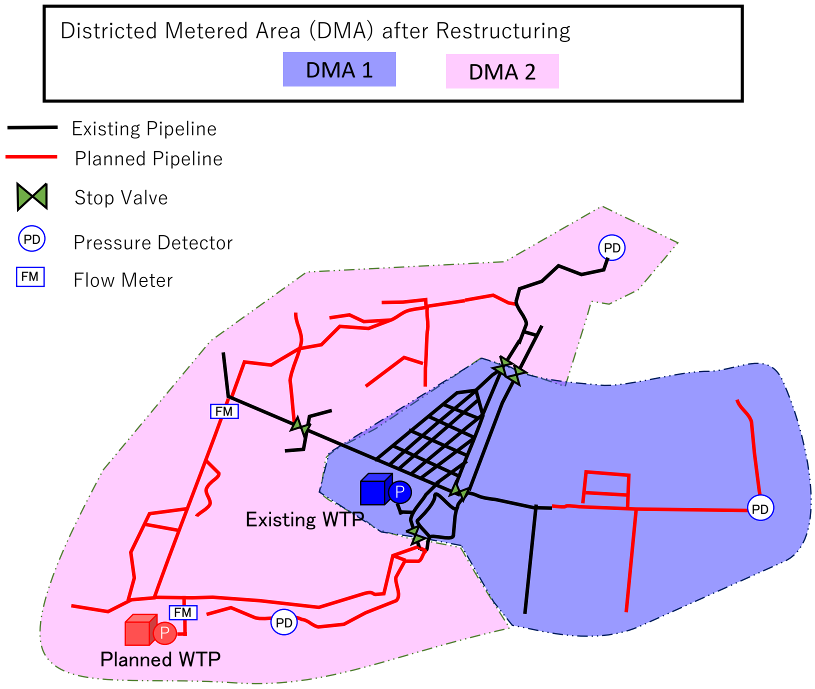
(9) Monitoring System for Water Distribution

The monitoring system for water distribution[15] shall be introduced, aiming at collection[16] of the water distribution flow and centralized data management, efficient operation, leakage reduction, and smooth response to emergency such as an accident of pipelines. This system shall monitor the

[15] In 2014, Japan grant-aid assistance "The Project for Replacement and Expansion of Water Distribution Systems in Provincial Capitals" was carried out at Pursat, etc. In this project, a water distribution monitoring system (the Central Monitoring station and a flow meter have been installed in the WTP, and two flow meters has been installed on distribution trunk mains), and technical support for effective management methods of the WTP are instructed. For this reason, the same system shall be introduced in this project.

[16] Flow meters has already been installed to monitor the flow rate of the distribution area of the existing WTP.

condition of one site in the new WPT and one site along the water distribution line in the extended service area for the purpose of flow monitoring in the two zones in the water distribution area of the new WTP. In addition, the system shall monitor the condition of three sites at the end of pipelines for the purpose of water pressure monitoring in the three zones of each water distribution area of the new and existing WTP. The center of this monitoring system will be installed in the new WTP monitoring room in Pursat, but the information on the water distribution flow and distribution pressure collected here can also be monitored at the existing WTP.



Source: JICA Survey Team

Figure 2-2-31 Monitoring System Layout

(10) Design Criteria for Distribution Mains

The design criteria for distribution mains are as shown in Table 2-2-35.

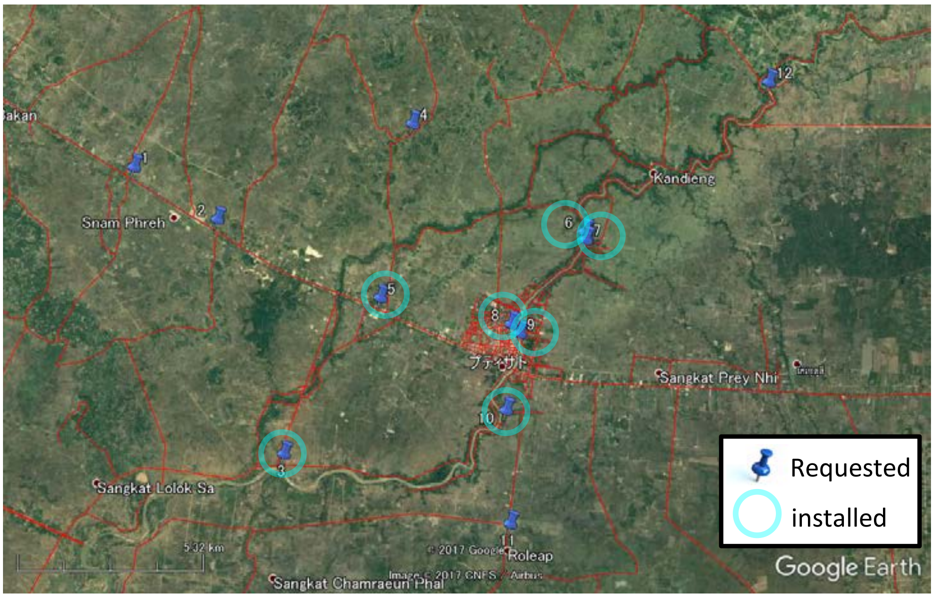
These are set based on the results of discussions with Department of Public Works and Transports (DPWT), Pursat Provincial Police Commission (Firefighting authority) and MIH. Also, the conveyance pipe shall conform to the following design criteria.

Table 2-2-35 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 road No. 5: H=1.2m ・Other roads: for φ400, H=1.0m, for φ350 or less H=0.8m

Classification		Design Criteria
Excavation / Backfilling		· For the upper surface of the pipe, 0.2 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. · For ϕ 200 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 the 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 12 places requested. (See Figure 2-2-32).

Source: JICA Survey Team

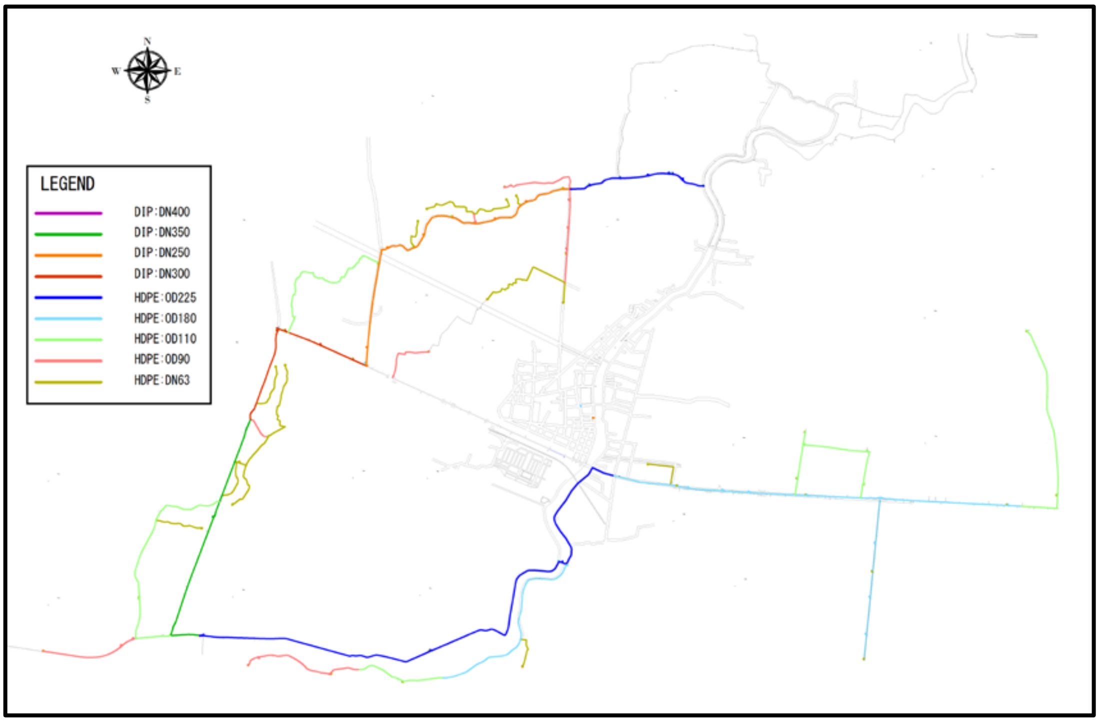


Source: JICA Survey Team, Satellite image: Google1 Earth

Figure 2-2-32 Location of Hydrants to be Installed

(11) Plan for Distribution Facilities

Based on the above, the plan for distribution facilities is summarized as shown in Figure 2-2-33 and Table 2-2-36.



Source: JICA Survey Team

Figure 2-2-33 Plan for Distribution Mains

Table 2-2-36 Specification for Distribution Facilities

Facility	Type and Structure	Quantity
Service Reservoir (inside the new WTP)	Reinforced concrete (RC) Structure, Rectangle, two reservoirs Effective Capacity: V=1,100 m^3×2 Effective depth: H=3.80 m Water Level: HWL+17.20m, LWL+13.40m 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= 5.8km / φ300mm L= 1.4km	7.3km
	HDPE φ250mm L= 5.4km / φ200mm L= 11.2km / φ150mm L= 10.3km / φ100mm L= 16.5km / φ 80mm L= 7.7km / φ 50mm L= 23.1km	74.2km
	Water Main Bridge SP (corrosion prevention coating) φ 80mm one place	1 Places
	Bridge-piggybacked Water Main SP (corrosion prevention coating) φ300mm 3 place / φ250mm 4 places / φ200mm 8 places / φ150mm 10 places / φ100mm 6 places / φ 80mm 8 places / φ 50mm 1 place	40 Places
Monitoring equipment of water distribution	Central monitoring station: data receiver, data transmitter, monitoring computer, printer & ancillary equipment Monitoring station (inside WTP) : data receiver, monitoring computer, printer & ancillary equipment Street monitoring station: 5 sites (2 flow meter φ250, data transmitter & ancillary equipment / 3 water pressure meter, data transmitter & ancillary equipment)	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.

2-2-2-7 Source: JICA Survey Team Procurement Plan of Equipment and Materials

Based on the initial request from Cambodian side and the discussion results at the inception stage or the on-site explanation stage about outline of the survey results, the minimum required equipment and materials for this project are selected as shown in Table 2-2-37.

Table 2-2-37 Initial Request from Cambodian Side and Field Survey Results

Classification of Equipment to be Procured		Contents of Initial Request	Equipment to be Procure 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.	Jar tester, distilled water maker, pH meter, residual chlorine meter, conductance meter, water bath, microscope, continuous water quality analyzer for conductivity and residual chlorine, absorptiometer, UPS, microorganism analyzer, reagents, glassware, laboratory tables, etc.
	Equipment for electric machine	Power tester, detector, vibrometer, torque wrench, handy flowmeter, filter sand tester, insulation checker, etc.	Clamp power 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.	Laying pipe equipment: Socket fusion
	Equipment and materials for house connection to poverty households	-	Water supply pipes, water meters and accessories
	Accounting system	-	SUMS System (PC and extra software license)

Source: JICA Survey Team

(1) Water Quality Analysis Devices

JICA Survey Team investigated the equipment already placed in the Pursat WTP and utilized the results of that investigation as a reference for planning the provision of equipment. The results of the investigation are shown in Table 2-2-38.

Table 2-2-38 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, Distillation apparatus, Glassware, microscope, bacteria test equipment, electric balance, magnetic stirrer, Autoclave, Electric Furnace, Drying Machine, Refrigerator, Centrifugal Machine, Color Meter, Vacuum Filtration Apparatus	It is not possible to share and use these equipment in the new WTP

For the water quality analyzing equipment such as jar tester, residual chlorine analyzer, turbidity meter, glassware, pH/electrical conductivity meter and distilled water production equipment, they are frequently used and it is 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, it is necessary to procure the equipment in this project. An absorptiometer is necessary to procure in order to measure iron and manganese concentration on a daily basis. Based on the above, the plan will 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, vibration checker, mechanical torque wrench portable ultrasonic flow meter, and sieve shaker will be procured and provided to the Cambodian side.

(3) Equipment for Management of Distribution Pipe

The leak detector, pipe detector and laying pipe equipment have been procured through other technical cooperation of Japan and it was confirmed that the above-mentioned equipment are used and stored in good condition in the PWWs. Therefore, they are excluded from the procurement list of this project. Meanwhile, as for the laying pipe equipment, butt fusion machine for PE pipes shall be procured. And the pipe network information system is included as a water-distribution management system for construction work.

(4) Service Connection Installations

Service connection installations are granted to the poor households: 257 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 water supply pipe is about 20,000 KHR (5USD).

According to the Pursat WWs, households with income of less than 20,000 KHR/day are treated as non-payable households, as beneficiaries. Poor level 1 households that are eligible for provision of water supply equipment under this project corresponds to the above-mentioned low-income households. On the other hand, 290,000 KHR (about 73 USD) for connecting water pipes is considered to be a heavy burden for households with income of less than 20,000 KHR/day (about 5 USD).

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 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 planned water supply area in 2025 is estimated to be 1,248 households.

The number of poor households eligible for grant aid (house connection materials) is 257 which is calculated by subtracting 991 households who were connected at the time of survey in August 2017 from 1,248 in the planned water supply area in 2025. The estimation results of the number of poor households are shown in Annex 7.10.

(5) SUMS System

SUMS (Synergistic Utilities Management System) 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 PWWs has already installed a PC with software for billing, accounting and casher through the Project on Capacity Building for Urban Water Supply System (Phase 3), however, additional software license and a client PC will 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. Therefore, these equipment shall be procured from Japan and only service connection materials are procured in Cambodia. The specification of service connection materials shall be the same as the materials that are currently procured by WWs, because these service connection materials will continuously be procured by WWs themselves after the project implementation.

(7) Procurement Timing of Equipment

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

The service connection materials shall be provided one year 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 2-2-39 shows the summary of equipment to be provided in this project based on the considerations described above.

Table 2-2-39 Summary of Equipment to be Provided

Item	Equipment/Material	Specification	Qty
Equipment for Water Quality Analysis	Water Quality Instruments	Jar Tester, Distillation apparatus, Turbidity Meter, pH Meter, Residual Chlorine Analyzer, Electric Conductivity Meter, Water Bath (for COD), Microscope, Continuous water quality analyzer for conductivity and residual chlorine	1 set

Item	Equipment/Material	Specification	Qty
	Absorptiometer	For multi-item water quality measurement(including reagents) Measurement Range：320-1,100nm	1 set
	Uninterruptible Power System(UPS)	Output Capacity: 3kVA	1 set
	Microbiological Analysis Apparatus	Filtration Equipment, Bacteria Incubator, Refrigerator, Autoclaved Sterilizer, Test Filter, Petri dish, Agar Culture medium, etc.	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
	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	Butt Fusion Machine for PE Pipes	ϕ 63-280mm	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.)	257 sets

Source: JICA Survey Team

2-2-3 Outline Design Drawings

Selected drawings of outline design are attached in Annex 7.2. The drawing list of the outline design is shown in Table 2-2-40.

Table 2-2-40 List of Outline Design Drawings

No.	Facility Classification	Description	Drawing No
1.	General (G)	General Layout of Pursat	G1
2.	Intake Facility (I)	Intake Facilities (1)	PI-1
		Intake Facilities (2)	PI-2
		Elevated Tank	PI-3

No.	Facility Classification	Description	Drawing No
		Pump House Plan	PI-4
		Pump House Section	PI-5
		Office Plan, Section, Elevation	PI-6
3.	Conveyance Pipe (R)	General Map for Conveyance Pipeline	PR-1
		Conveyance Pipeline Plan (1)	PR-2
		Conveyance Pipeline Plan (2)	PR-3
		Conveyance Pipeline Plan (3)	PR-4
4.	Treatment Facility (T)	WTP General Plan	PT-1
		Hydraulic Profile of Pursat WTP	PT-2
		Water Treatment Facilities Structure (1)	PT-3
		Water Treatment Facilities Structure (2)	PT-4
		Water Treatment Facilities Structure (3)	PT-5
		Water Treatment Facilities Structure (4)	PT-6
		Water Treatment Facilities Structure (5)	PT-7
		Water Treatment Facilities Structure (6)	PT-8
		Water Treatment Facilities Structure (7)	PT-9
		Water Treatment Facilities Structure (8)	PT-10
		Water Treatment Facilities Structure (9)	PT-11
		Service Reservoir and Pumping Station Structure (1)	PT-12
		Service Reservoir and Pumping Station Structure (2)	PT-13
		Service Reservoir and Pumping Station Structure (3)	PT-14
		Drainage Basin Structure	PT-15
		Drying Bed Structure	PT-16
5.	Distribution Facility (D)	Location Map for Distribution Pipe Line	PD-1
		Distribution Pipe Plan (1)	PD-2
		Distribution Pipe Plan (2)	PD-3
		Distribution Pipe Plan (3)	PD-4
		Distribution Pipe Plan (4)	PD-5
		Distribution Pipe Plan (5)	PD-6
		Distribution Pipe Plan (6)	PD-7
		Distribution Pipe Plan (7)	PD-8
		Distribution Pipe Plan (8)	PD-9
		Distribution Pipe Plan (9)	PD-10
		Distribution Pipe Plan (10)	PD-11
		Distribution Pipe Plan (11)	PD-12
		Distribution Pipe Plan (12)	PD-13
		Distribution Pipe Plan (13)	PD-14
		Distribution Pipe Plan (14)	PD-15
		Distribution Pipe Plan (15)	PD-16
		Distribution Pipe Plan (16)	PD-17
		Distribution Pipe Plan (17)	PD-18
		Distribution Pipe Plan (18)	PD-19
		Distribution Pipe Plan (19)	PD-20
		Distribution Pipe Plan (20)	PD-21
		Distribution Pipe Plan (21)	PD-22
		Distribution Pipe Plan (22)	PD-23
		Distribution Pipe Plan (23)	PD-24
		Distribution Pipe Plan (24)	PD-25
		Distribution Pipe Plan (25)	PD-26
		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

No.	Facility Classification	Description	Drawing No
		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
		Typical Drawing for Pipe Beam ND200	TYP-9
		Typical Drawing for Pipe Beam ND80	TYP-10
		Typical Drawing for Bridge Attached Pipe	TYP-11

Source: JICA Survey Team

2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

(1) Basic Policy of Project Implementation

- The Project is to be implemented under the Japan's Grant Aid Scheme. Japan's Grant Aid is provided through the following procedures:
  - Preparatory Survey conducted by JICA.
  - Appraisal by the GOJ and JICA, and Approval by the Japanese Cabinet.
  - Exchange of Notes (hereinafter referred to as "the E/N") between the GOJ and the RGC.
  - Grant Agreement (hereinafter referred to as "the G/A") between JICA and the RGC.
  - Implementation of the Project on the basis of the G/A.
- The client of the Project is MIH. Agreements for Contract Documents and Certificate of Completion shall be issued by the Signer of MIH.
- The implementation agency of the Project is DIH and the Waterworks under the DIH. With regard to the operation and maintenance of facilities, the DIH and the Waterworks will be in charge after the construction and procurement.
- The RGC will 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 will enter into contract with the Contractor who 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 who is capable of procuring the products and of construction in 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 the Japanese general contractors. These local construction firms are eligible to be the subcontractor for the Project in Pursat and supervisor, mechanical operator, labor for form works, concrete placing and so on, shall be procured in Cambodia. Common technique is required for civil works to implement the construction of water intake facility and the WTP including building and pipe installation. Common technical knowledge is also required to procure the equipment for the water quality test in the WTP and water supply materials for the poverty households. The construction works will be executed in the several areas and it is necessary to dispatch Japanese experts/engineers to the Project to ensure that the works are properly performed in accordance with the plan and design. Japanese experts/engineers shall also be dispatched to install and adjust the equipment for water quality testing, and to engage in technical transfer for the operation at start-up.

Construction materials and labor are basically procured in Cambodia.

2-2-4-2 Implementation Conditions

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

- Great effort will be devoted to the 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 would meet regularly to review the progress of the project. Other means of communications will also be used.
- The consultant would share information with the involved parties continuously and deploy one project manager and one resident engineer on site to ensure smooth implementation of the Project.
- The construction contractor would also deploy one representative and one site manager on site.
- The consultant and the construction contractor would have offices set up at appropriate locations.
- Consultations with the Cambodian side would be required since the coordination with the national and state governments is indispensable for approvals of IEE, water rights, construction of intake facilities, seeking permissions for occupancy of roads, etc.
- It is planned to install temporary water coffers so that the construction of intake facilities are executed throughout the year, even July and October when the water level is the higher.
- The total length of pipes for conveyance pipe, clear water transmission and distribution will be approximately 89.8 km (8.3 km+81.5 km). Although Though the main sites are residential areas with the unpaved road, busy paved roads with heavy traffic paved road are also included is also included. Accordingly, the pipe installation would require special considerations for safety and minimize disruption of traffic and daily activities in the area.
- The Cambodian side shall assure the safety of the construction work sites from landmines and unexploded ordinance (UXO) by submitting the official report to the JICA Cambodia Office by the commencement of the construction work.
- The construction will be done in the day time. In case night-time construction cannot be avoided, consultation with the Cambodian side will be required.
- Materials and equipment will be procured locally. If that is not possible, procurement from Japan or third countries would be considered sequentially.

- Materials for service connections to be provided by the Japanese side should 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 will be responsible for the construction of the facilities. The Cambodian side will be responsible for the storage of the procured equipment (especially materials for service connections) and installation of service connections between distribution pipes and households.

Details of the obligations of the Cambodian side are described in Chapter 2.3.

2-2-4-4 Consultant Supervision

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 will 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
- Confirmation of details of existing drainage network and additional manhole survey
- Cost estimation

(2) Tendering Management

The Consultant will 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 will 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 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 the facilities. In addition, various specialists (as listed below) are required for on-site supervision of the construction of the different facilities as described in detail below.

a) Civil Engineer (transmission/distribution facilities)

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

b) Civil Engineer (intake facilities / treatment facilities)

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

c) 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.

d) 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.

e) Specialist for Procurement of Equipment

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

f) 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 listed in the Table below together with indicators, control methods, and standards to be adopted. In principle, JIS or other equivalent International Standards will be followed for quality control.

Table 2-2-41 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 diameters of Aggregates	Observation	Reinforced Concrete: 25mm	When Received.	Record	In the presence of Consultant
		Grain Size	JIS A 1102	JIS A 5005	Before mixture design	Test Result Table	
	Concrete Mixture	Conform to the Standards	Test Report	JIS A 6201-6207	When received	Test Result Table	When necessary.
	Storage of Materials	Place and Storage Conditions	Observation	－	When necessary.	Report	In the presence of Consultant
Concrete Placing Work	Concrete Design Mixture (Major Structures)	Test Mixture	Confirmation of Quality	28 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 Aggregate Surface	JIS A 1111, 1125	－	Each mixing	Test Result Table	In the presence of Consultant
		Grain Size of Aggregate	JIS A 1102	JIS A 5005	When received	Test Result Table	
		Temperatures of Water and Aggregates	Temperature Measurement	－	Each mixing	Test Result Table	In the presence of Consultant
		Water and Cement Volumes		Error: less 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	－	

Category	Material/ Equipment	Control	Method of Control	Applicable Standards	Frequency of Test	Records	Remarks
		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 (Reservoir and others)	Conform to the Specifications	Water Level Measurement, Observation	No water level draw-down after 24 hours	After the structure is constructed	Test Result Table	In the presence of Consultant

2-2-4-6 Procurement Plan

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 local market of Cambodia. Those products are imported from Thailand and Vietnam. Recently, Vietnamese iron bars are popular in Cambodia.

c) Electromechanical and Operation Equipment

Equipment which needs frequent exchange or maintenance is 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 will be procured in Cambodia, Japan or other countries, according to the following considerations. Quality of materials and equipment should conform to the requirements.

- For local materials and equipment, quality and capacity of supply should be at the acceptable level
- Easy operation and maintenance taking in to account availability of spare parts
- Appropriate price
- Availability of after-sale service

Pipe materials, not available in Cambodia and being the larger part of the project cost, would 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 cooperation project.

Major items imported from Japan are (i) pumps with control panel, (ii) valves, (iii) instrumentation device, (iv) disinfection equipment and (v) gabion.

Materials and equipment procured in Japan will be transported from Japan to Sihanoukville port via Singapore by marine transport. Land transportation route from Sihanoukville port to Pursat City shall be national road No.4 and No.5 by trailer.

2-2-4-7 Initial Operation Instructions and Operation Guidance

The manuals and instructions introduced in this project for the operation and maintenance of each facility by a contractor after the facilities are transferred 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 waterworks as a soft component of this project.

Table 2-2-42 Roles and Responsibilities

Instruction Items	Initial Operation Instructions by Contractor	Operation Guidance 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

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

The PWWs is a provincial waterworks agency that is the target of a project on capacity building for urban water supply system in Cambodia (phase 2 and 3) by the JICA. Technical transfer associated with the operation and maintenance of the WTPs, water quality tests, and the operation and maintenance of distribution facilities were implemented for five years from 2007 to 2012, and technical transfer related to the improvement of management has been carried out from 2012. Today, the water supply meets national drinking water quality standards, except in cases where the turbidity of raw water rises rapidly due to sudden, heavy rain.

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. Their technical expertise has not yet reached a level sufficiently high enough to formulate plans for appropriate operation and maintenance of the new facilities, as well as efficient management, including when the new facilities are operated in combination with the existing facilities. Challenges in the operation and maintenance of the new facilities, and current situations are shown in Table 2-2-43.

Table 2-2-43 Challenges and Current Situations

Challenges	Current Situations
Formulating and learning work procedures for new facilities	Although water quality tests using existing test equipment can be performed relatively well, the procedures must be reviewed and modified as necessary in accordance with the new test equipment which will be provided in this project. It should be done in every water quality item with assistance from experts. In addition, in order to make new staff understand the procedures, and blush-up skill of existing staff, OJT by experts is necessary. Although operation and maintenance of the existing water treatment facilities can be performed relatively well, procedures for operation and maintenance of the new water treatment facilities must be newly formulated with assistance from experts. And, in order to make both new and existing staff understand the procedures, OJT by experts is necessary.
Establishment of distribution flow monitoring technology	The existing distribution monitoring system has not been utilized efficiently, and the technique related to the distribution monitoring has not yet been established at the PWWs. Technical guidance for the distribution monitoring and analysis, formulation of operating procedures and OJT for the new distribution monitoring system are necessary.
Ensuring quality of service connection installations	The quality of the service connection installations is responsibility of the staff at the site. However, efforts for quality assurance are not performed in particular. To prevent leakage from service connections which are expected to be increased rapidly with implementation of this project, review of work procedure and strengthening construction supervision system for service connection installations with assistance from experts are necessary.
Promotion of applications for service connections	Although the PWWs has experience to carry out educational activities for residents with assistance from UN-Habitat, in order to achieve the target number of service connection in this project, assistance for preparation of more effective materials and plans for educational activities is necessary.
Improvement of production management	The PWWs has no experience to manage plural WTPs, principles of efficient management of two WTPs must be studied, formulated and understood. And the existing WTP has no sludge treatment process, formulation of a sludge treatment plan and work procedure and OJT are necessary.
Creation and revision 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.

The PWWs needs to operate the facilities immediately after the completion of construction through this project. As shown in the Table 2-4-1, the number of staff in the production and network sections will be added by eleven and four people, 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 the PWWs shall be implemented as a soft component of this project.

(1) Objective of the Soft Component

This soft component aims to "steady supply water that meets water quality standards while the Pursat Waterways 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.

1) Formulation and understanding of procedures for water quality tests using new equipment;
2) Formulation and understanding of procedures for operation and maintenance of the new WTP;
3) Improved capability in distribution monitoring;
4) Strengthening construction supervision system for service connection installations;
5) Improved capability of production management;
6) Implementation of educational activities to promote applications for service connections; and
7) Creation and revision of SOP.

(3) Input Plan

The assistance related to the formulation of procedures for operation and maintenance, OJT, and creation and revision of SOP shall be divided into two fields: water treatment facilities including the water quality test, and distribution facilities mainly consisting of the distribution monitoring. The assistance for the production management shall be carried out separately from them.

The input shall be carried out in two phases. The first input shall be carried out at the timing (25th month) which overlaps to some extent with the initial operation guidance by a contractor. The second input shall be carried out several months after the start of actual operation.

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

1) Japanese Expert

Summary of each training course, analysis of work content and work volume necessary for the management of the new facilities, training course management, formulation of procedures for operation and maintenance, 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 with practical work such as valve operation, preparation of training materials in Khmer.

3) Local Staff

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

Table 2-2-44 shows the activities in each field, Figure 2-2-34 shows the draft schedule of the soft-component.

Table 2-2-44 Activities of the Soft Component (Input Plan)

<table>
<tr><th>Field</th><th>Outcome</th><th>Activity</th><th>Trainee</th><th>Input</th></tr>
<tr><td rowspan="3">Operation and maintenance of water treatment facilities</td><td>(1) Formulation and understanding of procedures for water quality tests using new equipment</td><td>1. Review of water quality test procedures
2. OJT of water quality test
- Water quality test
- Analysis and records</td><td rowspan="3">19 people from Production Section</td><td rowspan="3"><u>Japanese Expert</u>
- One person×2.63M/M

First Input
- Water quality test training
- WTP operation training
- Maintenance training
- SOP revision guidance

Second Input
- Review
- Follow-up training
- SOP revision guidance

<u>Local Engineer</u>
- One person×0.20M/M

<u>Local Staff</u>
- One person×2.60M/M</td></tr>
<tr><td>(2) Formulation and understanding of procedures for operation and maintenance of the new WTP</td><td>1. Formulation of procedures for operation and maintenance
2. OJT of operation and maintenance
- Water treatment
- Operation records
- Chemical injection
- Back washing of filtration basin
- Operation of pump
- Maintenance
- Handling of facilities
- Accident and malfunction handling</td></tr>
<tr><td>(7) Creation and revision of SOP</td><td>1. Assistance for revision of SOP
- Water quality test
- Operation and maintenance of water treatment facilities</td></tr>
<tr><td rowspan="3">Maintenance of distribution facilities</td><td>(3) Improved capability in distribution monitoring</td><td>1. Formulation of procedure for distribution monitoring
2. OJT of distribution monitoring
- Distribution flow monitoring
- Minimum night flow
- Operation of monitoring system
- Distribution flow analysis
- Maintenance of distribution facilities</td><td>11 people from Network Section</td><td rowspan="3"><u>Japanese Expert</u>
- One person×1.94MM

First Input
- Distribution flow monitoring training
- Service connection installation training
- SOP revision guidance

Second Input
- Review
- Follow-up training
- SOP revision guidance
<u>Local Engineer</u>
- One person×0.20M/M

<u>Local Staff</u>
- One person×1.90M/M</td></tr>
<tr><td>(4) Improved supervision system of installation of service connections</td><td>1. Review of procedure for installation of service connections
2. Study of construction supervision system
3. On Job Training for Installation of service connection- Installation of service connection
- Supervision of construction</td><td>5 people from Business Section</td></tr>
<tr><td>(7) Creation and revision of SOP</td><td>1. Assistance for revision of SOP
- Distribution monitoring
- Installation of service connections</td><td>11 people from Network Section
5 people from Business Section</td></tr>
</table>

<table>
<tr><th>Field</th><th>Outcome</th><th>Activity</th><th>Trainee</th><th>Input</th></tr>
<tr><td rowspan="3">Production management</td><td>(5) Improved capability of production management</td><td>1. Formulation of efficient management of the existing and new WTPs
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</td><td rowspan="3">Director General, Deputy Director General, Director of each section (8 people)

19 people from Production Section for the sludge treatment</td><td rowspan="3">Japanese Expert
- One person×1.80MM

First Input
- Facilities management training
- Service connection application promotion training
- SOP preparation guidance

Second Input
- Review
- Follow-up training
- SOP revision guidance

Local Staff
- One person×1. 76M/M</td></tr>
<tr><td>(6) Implementation of educational activities to promote applications for service connections</td><td>1. Assistance for preparing public awareness materials
2. Assistance for implementation of educational activities</td></tr>
<tr><td>(7) Creation and revision of SOP</td><td>3. Assistance for creation of SOP
- Management of WTP
- Sludge treatment</td></tr>
</table>

Item	22	23	24	25	26	27	28	29	30	31	32	33	People/Month Cambodia	People/Month Japan
Operation and maintenance of water treatment facilities														
Japanese Expert						1.50MM			1.20MM				2.70	0.00
Local Engineer						0.20MM							0.20	0.00
Local Staff						1.57MM			1.10MM				2.67	0.00
Maintenance of distribution facilities														
Japanese Expert						1.00MM				1.00MM			2.00	0.00
Local Engineer						0.20MM							0.20	0.00
Local Staff						1.07MM				0.90MM			1.97	0.00
Production Management														
Japanese Expert						0.90MM			1.00MM				1.90	0.00
Local Engineer													0.00	0.00
Local Staff						0.97MM			0.90MM				1.87	0.00
Report					Progress Report							Final Report		

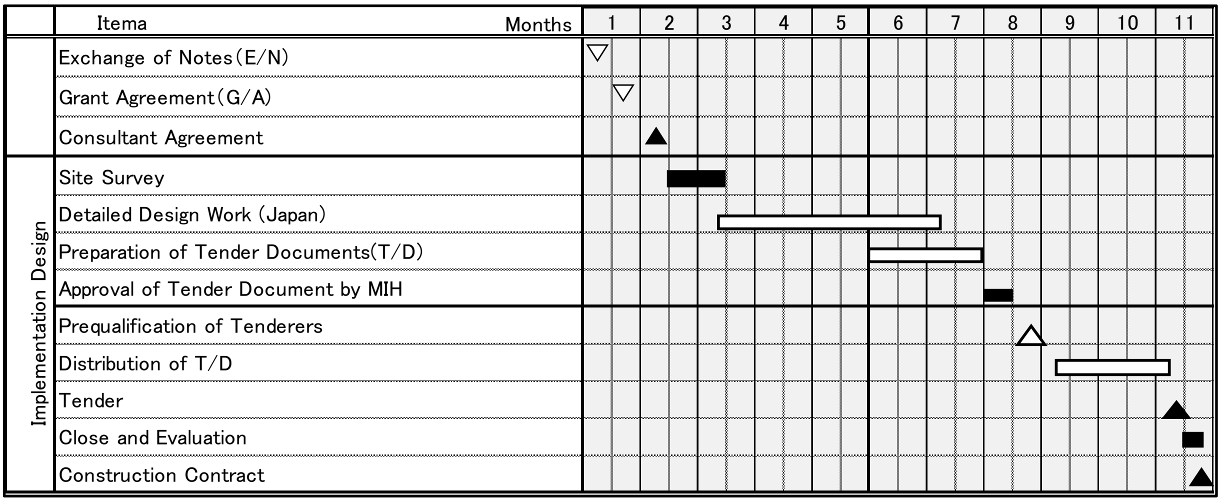
Note: The numerical value of the header on the above table shows the number of months since the commencement of construction.

Figure 2-2-34 Draft Schedule of Soft Component

2-2-4-9 Implementation Schedule

The Project will 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) 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 11 months including E/N, engineering design services, preparation of tender documents and tender administration. The total construction period will be 25 months including construction of facilities and procurement of equipment. Thus, total implementation period of the Project amounts to 36 months. The implementation schedule from the detail design study to completion of the construction works is shown in the figure below.

Detailed Design and Tendering Stage



Construction, Procurement and Soft Component Stage

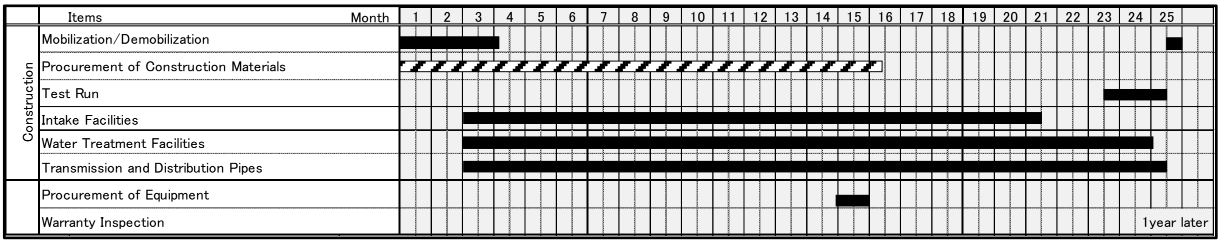


Figure 2-2-35 Implementation Schedule

2-3 Obligations of Recipient Country

In accordance with the obligations of the Recipient stipulated in the E/N, the Recipient shall undertake the obligations listed in the tables below. JICA and the Recipient may agree from time to time separately in writing on the items, deadlines and other matters described in the tables below within the scope of the obligations stipulated in the E/N.

2-3-1 Specific Obligations of the Government of Cambodia which will not be Funded with the Grant

2-3-1-1 Before the Tender

Table 2-3-1 Obligations of Recipient Country (Before the Tender)

No	Items	Deadline	In charge
1	To open bank account (B/A)	within 1 month after the signing of the G/A	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 the contract(s)	MIH
3	To approve IEIA (Conditions of approval should be fulfilled, if any) and secure the necessary budget for implementation.	within 1 month after the signing of the G/A	MIH
4	To contract land lease in order to secure the temporary yard	before notice of the bidding document(s)	MIH
5	To obtain the planning, zoning, building permit	before notice of the bidding document(s)	MIH
6	To clear, level and reclaim the following sites 1) Embankment at proposed WTP site and intake pump station site. 2) To explore landmines and UXO at construction site and temporary yard.	before notice of the bidding document(s)	MIH
7	To submit Project Monitoring Report (with the result of Detail Design)	before preparation of bidding documents	MIH

Source: JICA Survey Team

2-3-1-2 During the Project Implementation

Table 2-3-2 Obligations of Recipient Country (During the Project Implementation)

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 the contract(s)	MIH
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 the contract(s)	MIH
	2) Payment commission for A/P	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	MIH

No	Items	Deadline	In charge
4	To accord Japanese physical persons and/or physical persons of third countries whose services may be required in connection with the supply of 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	MEF
5	To ensure that customs duties, VAT, 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 by its designated authority without using the Grant	during the Project	MEF
6	To bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project	during the Project	MIH
7	1) To submit Project Monitoring Report	every month	MIH
	2) To submit Project Monitoring Report (final)	within one month after signing of Certificate of Completion for the works under the contract(s)	MIH
8	To submit a report concerning completion of the Project	within six months after completion of the Project	MIH
9	To get permit for construction of temporary access bridges for laying water pipes and lease necessary land for approach road to the temporary access bridges (if necessary)	1month before the start of the construction	Local Communities, MIH
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)		MIH
	1) Electricity The distributing line to the site	before start of the construction	
	2) Information System Contracting process of broadband LAN connection for the distribution information system	2 months before completion of the construction	
11	To take necessary measures for safety construction - traffic control - rope off	during the construction	MIH
12	To implement EMP and EMOP	during the construction	MIH
13	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	MIH
14	To obtain permission for occupancy of roads for the pipe laying work	before start of the construction for conveyance, transmission and distribution pipes	MIH (WWs)
15	To obtain all permissions required for the project implementation such as construction permission for intake facility and the WTP)	before start of the construction	MIH (WWs)
16	To recruit new staff members who are necessary for the operation of new system	up to the end of 2025	MIH (WWs)
17	To establish the construction scheme for the new service pipe connections, including hiring temporary work force. To carry out the technical guidance, budgeting, planning and publicity for enhancing new connections.	up to the end of 2025	MIH (WWs)
18	To identify poor household (planning households is 257)[17]	up to the end of 2025	MIH (WWs)

Source: JICA Survey Team

[17] Planning household number of 257 is an estimation referable in the section of 2-2-2-7 (5). At the construction, WWs shall identify the target household.

2-3-1-3 After Commencement of the New Facility in the Project

Table 2-3-3 Obligations of Recipient Country (After Project Completion)

No	Items	Deadline	In charge
1	To implement EMP and EMOP	for a period based on EMP and EMOP	MIH
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 MIH and JICA.	for three years after the Project	MIH
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 completion of the construction	MIH
4	To work for service pipe connection (planned number of households is 7,625) The implementation plan is about 1,906 connections per year after completion. (Maximum is 2,112 connections per year). (in 2019: 78HHs, in 2020: 78HHs, in 2021: 79HHs, in 2022: 1,054HHs, in 2023: 2,112HHs, in 2024: 2,112HHs, in 2025: 2,112HHs) 1) Establishment of construction scheme including hiring temporary staff for service connection work., providing guidance, budgeting, planning and publicity for enhancing new connections. 2) Connection for poor household(257HHs) - Material is procured by Japanese side, connection work is conducted by Cambodian side. 3) Connection for household without poverty group (7,368households) - Material and connection work is under responsibility of Cambodian side.	up to the end of 2025	MIH (WWs)

Source: JICA Survey Team

2-3-2 Necessity of Renewing Existing Plant and Facility

The new drinking water supply plant in this project will elicit an effect fully by connecting to the existing distribution pipes. The existing valves installed to the intake pipes in the existing intake pumping station should be repaired immediately to maintain the present capacity of the existing drinking water supply plant.

2-3-3 Other Necessary Inputs by Recipient Country

For implementation of this project, other envisaged necessary inputs by the RGC are listed below.

- To establish PIU12 (Project Implementing Unit) including MIH, DIH and the PWWs;
- To contract connection service to telecommunication network for water distribution information;
- To increase the number of staff at the PWWs, to execute appropriate personnel distribution and to provide training; and

・ To conduct inventory management of procured equipment and materials, and to perform operation & management of newly constructed plant

2-3-4 Land Acquisition for the WTP and Water Intake Pump Station, and Ground Leveling of the Sites

As for land acquisition for the WTP and water intake pump station, Cambodian side has already completed the procedures with landowners. Ground leveling is necessary prior to the beginning of the construction. A scale of ground leveling is as follows: drilling embankment (cut and fill) is 22,740 m^3[18] for WTP, 7,030 m^3 for water intake pump station.

Figure 2-3-1 Planned Site for the New WTP

2-3-5 Permission of River Water Intake

New water intake point in this project is located 200m upstream from Damnak Ampil HW of the Pursat River. MOWRAM sent a letter of permission for the new water intake from the Pursat River on 14th September 2017.

As for land acquisition for intake water point, Cambodian side has already completed the procedures with landowners. Ground leveling is necessary prior to the beginning of the construction.

2-3-6 Electric Power Lead-in to New Intake Plant and New WTP

Receiving and transforming facility will be newly installed to the intake water pump station and the WTP in this project. The cost for its electric power lines of 22kV and electric power lead-in works will be covered by Cambodian side. This matter has been approved already by the PWWs. Though the planned site for the WTP is located along a major road, 800m leading-in of electric power line is necessary from the road.

[18] Embankment volume at WTP site (after compaction) = 18,000m^3, Embankment volume at intake site (after compaction) = 5,567m^3, Loosen ratio (L) = 1.2, Compaction ratio (C) = 0.95. Based on these value, soil volume to be purchased is calculated as follows; Soil volume to be purchased at WTP site = 18,000m^3 ÷ 0.95 x 1.2 ≒ 22,740 m^3, Soil volume to be purchased at intake site =5,567m^3 ÷ 0.95 x 1.2 ≒ 7,030 m^3

2-3-7 Permissions for Occupation of Roads for Laying Work of Water Conduit as well as Water Supply and Distribution Pipes

2-3-7-1 Permissions for Occupation of National Road, Bridge and Track Laying

As for the permissions for occupation of national road, bridge and track laying, the PWWs will send a request letter of permission for road occupancy to MIH through DIH (that is a field agency of MIH). MIH will request permission to MPWT (Ministry of Public Works and Transport) accompanying information on this project, location of the construction, construction method and so on. MPWT will notify MIH and DPWT (that is a field agency of MPWT) of agreement on this project.

2-3-7-2 Permissions for Occupation of Ordinary Road

The PWWs will request permission for ordinary road occupancy to Provincial Governor through DIH (that is a field agency of MIH). Provincial Governor will notify DPWT of approval on the permission accompanying information about this project: location of the construction, construction method and so on.

2-3-8 House Connection and Procurement and Installation of Water Meter

As for the terminal works between distribution pipes to individual households, the PWWs will conduct as "house connection works" including procurement of water supply pipes and accessories based on residents' request. Water supply pipe 25mm in diameter and water meter 15mm in diameter are accepted standard in Cambodia. Total cost of house connection work will be covered by each resident (benefit principal) consisting of procurement of equipment & materials and connection work.

The house connection work including procurement of water meter and its installation to new applicants of pipe water supply is required to increase water supply ratio in Pursat City. This work will be done by staff of the PWWs at the expense of each resident. This project plans to realize the total house connection for 7,625 households including poor households and 2,112 households as the annual maximum house connection until 2025 as the target year. According to the present record of house connection work which is approximately 580 per year, it is necessary to increase the number of temporary staff for connection work.

On the other hand, this project includes procurement of water supply equipment consisting of water meters, water pipes and accessories for poverty households; however, its construction cost will be covered by the Cambodian side (the PWWs).

2-3-9 Environmental and Social Considerations

To implement this project, the Cambodian side is in charge of following items on environmental and social considerations:

- **Acquisition of Approval on IEIA**

  The IEIA report was prepared and submitted to MOE from MIH on 7th May 2018. The site survey and interview of stakeholders were conducted. Based on the survey, the comment letter was issued by MOE and the IEIA report has been revised. After that, the revised report was resubmitted and the report was approved by MOE in January 2019.

- **Proposed Lands**

  It is confirmed that proposed lands for the WTP and intake facility have been acquired already in accordance with the proper procedure. These lands were agricultural land with no inhabitants, therefore no relocation of residents is required.

  On the other hand, it will be necessary to secure land for temporary hostels, offices, storage space, etc. as tenanted premises. MIH is responsible to take care of this matter.

- **Enforcement of Environmental Management Plan and Environmental Monitoring Plan**

  MIH, DIH and the PWWs are responsible for supervising steady enforcement of the environmental management plan and the environmental monitoring plan prepared in EIA.

2-3-10 Access Bridge for Maintenance of Distribution Pipe

There are four wooden bridges on the laying route of water distribution pipes shown in Figure 2-3-2; however, they cannot withstand the traffic of construction vehicles due to their structure. Therefore, new access bridges must be constructed with an approval from the local communities during the construction period. Since the existing wooden bridges are used by the residents for daily traffic, the existing wooden bridge is to be left as it is, and the temporary access bridges made of steel are planned to be built beside them.

Construction of the access bridges accompanying piping construction is included in the construction works by the Japanese side; however, since it is necessary to acquire construction permission from the communities, MIH will support it. Cambodian side requested the access bridges to be left after the completion of the construction works for the convenience of the residents. For this reason, the following was stated in the minutes of discussions on "The Preparatory Survey for the Project for Expansion of Water Supply System in Pursat in the Kingdom of Cambodia", June 28, 2018 (Explanation on Draft Preparatory Survey Report) that all responsibilities after handover of the access bridges to the communities would be lain in Cambodian side.

Figure 2-3-2 Existing Wooden Bridge

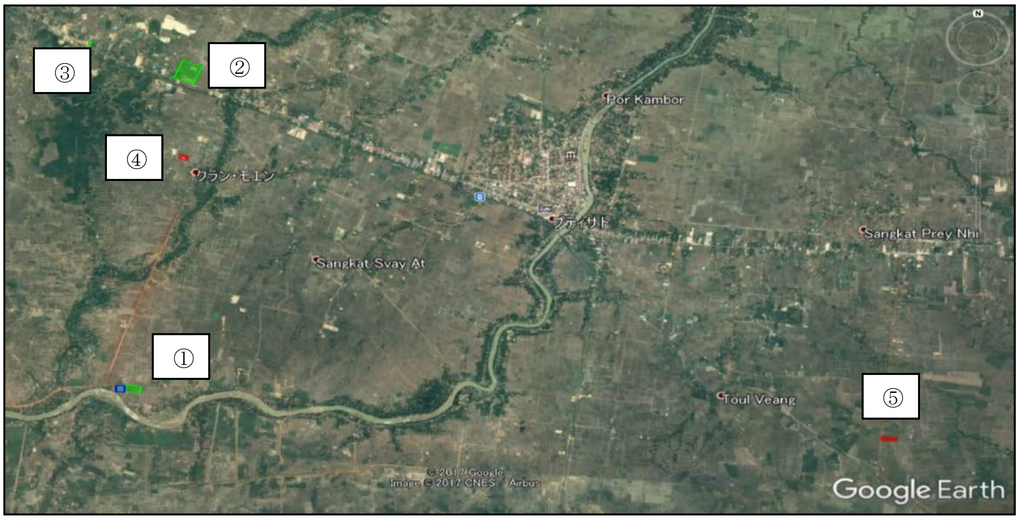
2-3-11 Temporary Yards and Dump Sites

It is confirmed that temporary yards and dump sites shall be provided by MIH for the construction work in Pursat. MIH has already got the candidate sites as shown in Table 2-3-4. In the future, if these candidate locations are not available for the project, MIH confirmed in the Technical Note (July 17, 2017) that alternative lands of the same scale will be prepared.

Table 2-3-4 Temporary Yards and Dump Sites in Pursat

No.	Application	Dimension	Area
(1)	Temporary Yard	100m x 200m	2.0ha
(2)	Temporary Yard	300m x 300m	9.0ha
(3)	Temporary Yard	100m x 15m	0.15ha
(4)	Dump Site	70m x 105m	0.74ha
(5)	Dump Site	55m x 210m	1.16ha

Source: JICA Survey Team



Source: JICA Survey Team, Satellite Image: Google Earth

Figure 2-3-3 Temporary Yards and Dump Sites in Pursat

2-4 Project Operation Plan

2-4-1 Project Implementation System

Taking into account the amount of work required for the management, operation and maintenance of the expanded water supply facilities in this project, the implementation system for actual operation of the facilities by 2025 was studied as shown in Table 2-4-1.

Table 2-4-1 Organization Structure of the Project Operation by 2025

Section	Division of Duties	Current Number of Staff (2017)	Number of Staff in Target Year (2025)	Increase of Staff
Deputy Director of Department (Director General)	Comprehensive management, supervision of administration/planning section and accounting/financial section	1	1	0
Deputy Director General of WWs	General overview of technical matters, supervision of production section and network section	1	1	0
Deputy Director General of WWs	Supervision of business section	1	1	0
Administration and Planning Section	General affairs, personnel, planning	2	3	1
Accounting and Finance Section	Accounting, financing, tariff collection	7	7	0
Business Section	Customer management, water meter management, meter readings, service connection installation	10	15	5
Production Section	Operation and maintenance of WTP, water quality tests	8	19	11
Network Section	Expansion and updates to network, leakage surveys and repairs, network management	7	11	4
Total		37	58	21

(1) Production Section

Because the new WTP is located at a distance from the existing office, a new team consisting of 11 staff members with a deputy director as the leader shall be established for the operation and maintenance of the new WTP. The team is comprised of occupations as shown in 1) to 4), necessary staff members shall be adopted from selected existing staff and newly employed staff. As there is no change in the number of staffs for operation and maintenance of the existing WTP, a total of 11 staff members, should be added in the production section.

1) Deputy Director: 1 officer

Deputy director shall supervise the operation and maintenance of the new WTP.

2) Operators: 8 officers

One operator in each of the new intake station and the new WTP will be placed. For a 24-hour operation, the operation work will be conducted in three shifts by two operators. Four teams of two operators are needed as shown in the Table 2-4-2. An increase of eight staff members is required.

Table 2-4-2 Work Shift for the Operation of the New WTP

Team	Staff for Operation	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
Team 1	Staff 1 (Intake)	O				O				O				O				O				O
	Staff 2 (Treatment Plant)	O				O				O				O				O				O
Team 2	Staff 3 (Intake)		O				O				O				O				O			
	Staff 4 (Treatment Plant)		O				O				O				O				O			
Team 3	Staff 5 (Intake)			O				O				O				O				O		
	Staff 6 (Treatment Plant)			O				O				O				O				O		
Team 4	Staff 7 (Intake)				O				O				O				O				O	
	Staff 8 (Treatment Plant)				O				O				O				O				O	

Shift A 08:30 – 17:00
Shift B1 16:30 – 01:00
Shift B2 00:30 – 09:00

3) Maintenance Officer:1 officer

Staff shall be deployed to perform maintenance of facilities, back washing of filter basins, sludge disposal, chemical injections and other daily duties. The deputy director and operation staff shall support the maintenance staff.

4) Water Quality Testing Officer: 1 officer

A staff shall be placed as water quality testers.

(2) Network Section

The pipe network will be extended from 100 km to 224.8 km. The supply area will also be expanded. Based on experiences in other cities, it is estimated that the number of maintenance staff needed for a 100-km pipe network is 4.7 people. Therefore, the number of staffs in the network section should increase from four to 11 people.

(3) Business Section

Currently, four (4) meter readers check 7,300 water meters every month. There will be approximately 15,300 water meters by the target year. Therefore, the number of meter readers should increase from four to eight people.

Around 580 service connections are installed by a team of three staff members from the business section. By 2025, the maximum number of service connection installations is expected to be approximately 2,112, which means that four teams of ten people will be needed. However, the number of service connection installations is expected to return to the current level after 2025. Additional staff members during the busiest periods shall be supplied from outside, and therefore, requires no increase in the number of staffs at the PWWs.

Currently, one staff member manages information on 7,300 customers. In Battambang WWs, one staff member manages information on 10,000 customers, the largest number of customers supervised by one person. Taking this into consideration, two staff members shall manage information on 15,300 customers.

(4) Administration and Planning section, Accounting and Finance Section

The administration and planning section must coordinate, monitor and evaluate the five-year business plan which is currently being formulated under the capacity building project. It is recommended that the current number of staff (two) be increased to three for this process to be properly implemented.

The amount of work for the accounting and financial section related to water tariff collection and financial and fiscal works is expected to increase. However, because duties are expected to be streamlined through the SUM System, which was introduced by the capacity building project, the number of staffs is expected to remain the same.

Figure 2-4-1and Figure 2-4-2 show current and future organization of the PWWs, respectively.

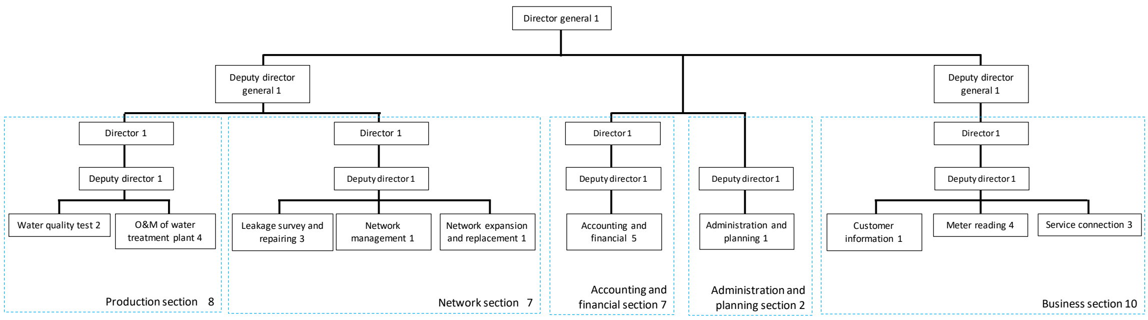


Figure 2-4-1 Current Organization Chart of the PWWs

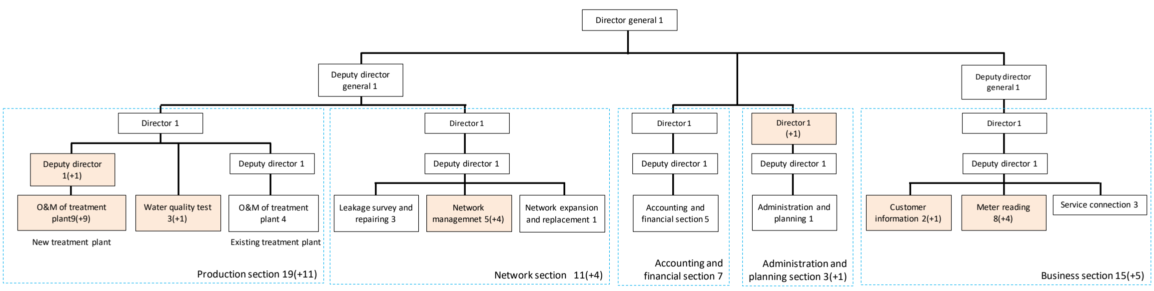


Figure 2-4-2 Future Organization Chart of the PWWs

As shown in the Table 2-4-3, the number of staffs in the production and network sections shall be increased to a planned level by 2021, which is the year that actual operation of the new facility will commence. The number of staffs in other positions shall also be increased in accordance with the number of service connections.

Table 2-4-3 Personnel Plan

	2017	2018	2019	2020	2021	2022	2023	2024	2025
Production Section	8	8	8	11	14	19	19	19	19
Network Section	7	7	7	7	8	11	11	11	11
Business Section	10	11	11	11	11	12	13	14	15
Accounting and Finance Section	7	6	6	7	7	7	7	7	7
Administration and Planning Section	2	3	3	3	3	3	3	3	3
Director and Deputy Director	3	3	3	3	3	3	3	3	3
Total	37	38	38	42	46	55	56	57	58
Outsourcing of service connections						4	7	7	6
Number of water supply Households	7,510	7,657	8,130	8,293	8,459	8,610	11,283	13,234	15,282
Construction work				←	―	→			

2-4-2 On-site Maintenance

After the implementation of the project, the proposed operation and maintenance is shown in Table 2-4-4.

Table 2-4-4 Operation and Maintenance Item

Facility Section	Work Section	Work Contents	Frequency	Remarks
Intake Facility	Operation and Maintenance	Start-up and shutdown of the intake pumps	Daily	Operation by instruction of WTP
		Operation records	Daily	Pump operation record and electric conductivity measurement
		Cleaning of floating intake pipe	4 times / year	Strainer trash cleaning
		Sand basin (elevated type)	1 times / year	Sand discharge by valve operation
		Emergency measures	As Needed	Support request for treatment facility
		Concrete inspection	Yearly	Checking of cracks, peeling off and subsidence etc. at the end of dray season
		Repainting of floating intake pipe	Once /15Years	
		Operational inspection of gate	Yearly, Once / Flood	Regular inspection is conducted at the end of dry season
		Lubrication of gate	As Needed, Once / Flood	
		Essential analytical items	Daily	Turbidity, residual chlorine, pH, water temperature, etc.

Facility Section	Work Section	Work Contents	Frequency	Remarks
Treatment Facility	Water Quality Analysis	Daily record of water quality	Daily	
		Important analytical items	Once / 3 month	Aluminum, ammonium nitrogen, etc.
		Jar test	Weekly	Or tested when raw water turbidity rises
		Residual Chlorine in tap water	Twice / Month	Several places
		Monthly record of water quality	Monthly	
	Water Treatment	Start-up and shutdown of the intake pumps	Daily	Instruction to intake facility
		Condition of coagulation and flocculation	Daily	
		Coagulant dosing rate	Daily	Based on Jar test and floc
		Lime dosing rate	Daily	Based on pH
		Chlorine dosing rate	As Needed	Residual chlorine（pre, and post）
		Sludge valve operation	Weekly	
		Sedimentation Cleaning	Yearly	
		Sludge pump operation	Daily	
		Sludge drying bed checking	Daily	Water content
		Observation of sludge conveyance	Monthly	
		Filtration Operation	Daily	
		Filter sand washing	Daily	
		Filter layer Measurement	Yearly	
		Quality of filter sand	Yearly	Effective size, uniformity coefficient
		Water level monitoring	Daily	Receiving well, sedimentation, filtration, service reservoir, etc.
		Service reservoir cleaning	Yearly	
		Recording daily operation	Daily	
	Electrical and Mechanical Facilities	Routine maintenance check	Daily	Checking of instrument abnormality, noise and vibration abnormality of pump and amount of grease
		Washing chemical pipe	As Needed	
		Minor fault repairing	Daily	
		Regular check of pump and motor	Yearly	
		Regular check of chemical equipment	Yearly	
		Regular check of valve	Yearly	
		Regular check of level gage	Twice / Year	Filter Basin, Service reservoir
		Insulation and earth test	Yearly	Electrical facilities
	Others	Cleaning work	Daily	
		Security duties	Daily	
Distribution Facility	Distribution Management	Pump operation	Daily	
		Recording pump operation	Daily	
		Operation daily schedule	Daily	
		Operation monthly schedule	Monthly	
	Distribution flow and pressure monitoring system	Recording water flow data	Daily	
		Recording minimum water flow at	Daily	
		Water flow Analysis	Daily	
		Implementation of leakage survey	As Needed	
		Leakage repair	As Needed	
		Recording pressure data	Daily	At the end of pipe
		Pressure analysis	Daily, Monthly	
	Distribution Facility Operation	Water quality check of distribution network	Daily	
		Pipe Cleaning	Monthly	
Production Management	Maintenance Duties	Pipe inspection	As Needed	
		Attendance and checking for other construction	As Needed	
		Making comprehensive operation plan	Yearly	2 WTP
		Chemical stock management	Daily	Coagulant, lime, chlorine

Facility Section	Work Section	Work Contents	Frequency	Remarks
		Sludge treatment plan	Daily	

2-5 Project Cost Estimation

2-5-1 Initial Cost Estimation

2-5-1-1 Project Cost borne by Cambodian Side

The total project cost borne by the Cambodian side is estimated at about US 661,164 and its breakdown is shown in Table 2-5-1.

Table 2-5-1 Project Cost borne by Cambodian Side

Items	Contents	USD
Land Preparation	Land leveling for the Intake and WTP	437,305
Temporary Yard	Rental Cost for Temporary Yard	49,978
	UXO	20,527
Environmental Consideration	Environmental Monitoring for Noise, Vibration and Treatment of Dry Sludge	8,925
Information System	Contracting process of broadband LAN connection for the distribution information system	4,463
Electricity Supply	Transmission of electricity to the Intake facilities and WTP	51,763
Bank Charge, Commission	Bank arrangement Charge and Commission of Authorization to Pay	22,313
Connection Fee※1	Connection equipment for poor households (poor level 2: 885 houses)	5,710
	Installation of connection equipment for poor households (poor level 1: 257 houses + poor level 2: 885 houses)	60,180
Total		661,164

※1: 60% of poor level 2 households (1,327HHs) and normal households (5,156 HHs) shall bear their material and construction costs. It is expected that the material cost shall be USD 440,572 and the labor cost for construction shall be USD 32,395.

The estimated increase in labor cost is shown in Table 2-5-2.

Table 2-5-2 Estimated Increased Labor Cost (USD※1)

Organization	Items	2019	2020	2021	2022	2023	2024	2025
WWs	Increased employees※2		4	4	9	1	1	1
	Increased cost		11,404	11,404	25,659	2,851	2,851	2,851
External talent ※3	Employment				4	7	7	6
	Cost				11,404	19,957	19,957	17,106

※1: Estimated as the average person labor cost (USD2,851/person/year) based on the records of 2016.
※2: The number of increased employees compared with the previous year
※3: Newly hired temporally staff for service connection work

2-5-2 Budget for Operation and Maintenance

2-5-2-1 Analysis of Financial Conditions

(1) Financial Statements

Profit and Loss Statement

Outline of Profit and Los (PL) Statement for last seven years in Pursat Waterworks is shown below.

Table 2-5-3 Outline of Profit and Los Statement in Pursat Waterworks

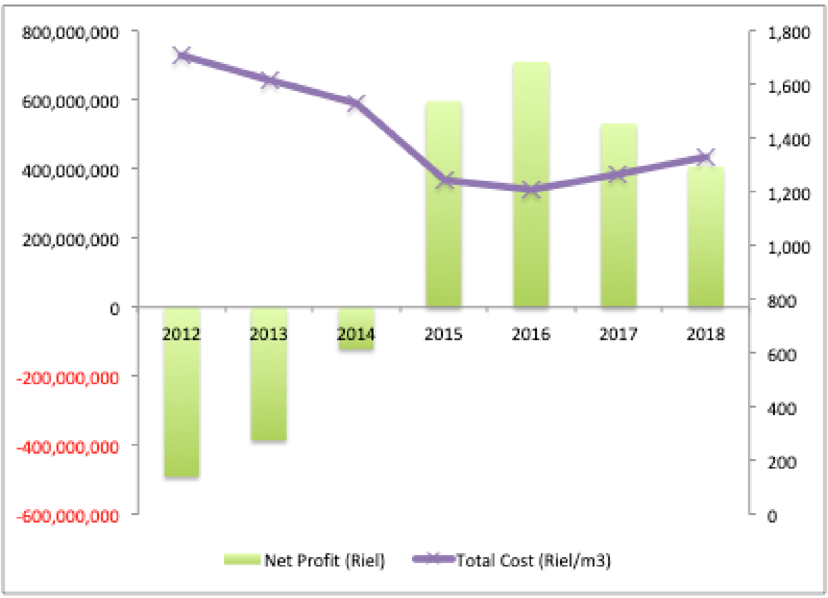
(Unit: Riel)

Fiscal Year	2012	2013	2014	2015	2016	2017	2018
Revenue							
Water Sales	1,754,532,800	1,995,364,800	2,191,619,200	2,533,446,400	2,948,433,600	2,873,867,600	3,052,797,400
Other Revenue	7,922,600	19,450,100	123,910,356	277,284,228	233,577,886	174,787,095	137,110,800
Revenue Total	1,762,455,400	2,014,814,900	2,315,529,556	2,810,730,628	3,182,011,486	3,048,654,695	3,189,908,200
Expense							
Personnel	206,603,600	227,719,100	318,479,139	353,073,780	422,021,596	477,399,900	585,366,066
Material/Chemical	233,617,770	234,177,330	251,147,000	226,692,760	262,716,400	218,392,100	239,260,503
Electricity/Fuel	896,382,400	966,443,000	772,292,385	564,176,772	617,794,518	635,203,058	642,862,906
Depreciation	706,059,690	732,421,294	680,752,313	513,098,931	598,402,787	565,362,275	579,718,538
Interest Payment	37,364,791	35,042,008	31,918,039	27,423,574	22,202,043	37,004,956	81,077,903
Taxes	18,985,328	22,993,648	26,519,157	41,568,619	46,539,351	48,302,693	54,878,165
Other	152,589,413	180,589,792	355,253,579	489,279,664	503,525,534	536,470,896	600,367,784
Expense Total	2,251,602,993	2,399,386,171	2,436,361,612	2,215,314,099	2,473,202,229	2,518,135,879	2,783,531,865
Net Profit	-489,147,593	-384,571,271	-120,832,056	595,416,529	708,809,257	530,518,816	406,376,335

Source: Pursat Waterworks

According to the PL Statement above, the net profit changed from negative to positive in 2015 as well as the structure of cost composition.

The total cost per 1 m^3 water production and the net profit are shown in the following figure. The former dropped drastically, and the latter changed from negative to positive from 2015.



Source: PWWs

Figure 2-5-1 Net Profit and Total Cost per 1 m^3 Production in Pursat Waterworks

The reasons why the net profit increased are as follows:

- Electricity/Fuel cost was reduced because motive power was changed from diesel engines to electric motors which use commercial electric power;
- Lives of assets got longer in accordance with the standards in Japan, so that the depreciation amount in each year was reduced;
- Ratio of fixed cost reduced due to the increase in water production;
- Cost of chemical materials per 1 m^3 water purification decreased due to change of coagulant from aluminum chloride to Poly-aluminum chloride, change of disinfectant from chlorine gas to bleach powder, and cancellation of alkaline agent; and
- Efficient water production by capital investment in introducing inclined tube, etc.

As a result, the water production cost per 1 m^3 reduced from around 1,700 Riel in 2012 to around 1,300 Riel in recent years, which means the unit cost reduced to about three quarters as well as the increase in water production, so that the net profit increased.

<u>Balance Sheet</u>

Outline of Balance Sheets (BS) for last seven years in Pursat Waterworks is shown below.

Table 2-5-4 Outline of Balance Sheet in Pursat Waterworks

(Unit: Riel)

Fiscal Year	2012	2013	2014	2015	2016	2017	2018
Non-Fixed Assets	679,402,830	775,972,695	680,955,079	780,502,471	863,025,134	781,446,792	881,652,553
Fixed Assets	8,761,770,209	8,686,490,915	8,537,125,076	8,928,390,446	9,551,915,391	10,910,987,816	10,741,314,778
Asset Total	9,441,173,039	9,462,463,609	9,218,080,155	9,708,892,916	10,414,940,526	11,692,434,609	11,622,967,331
Non-Fixed Liability	243,031,117	278,419,594	227,629,607	168,916,986	251,314,125	219,490,586	497,208,942
Fixed Liability	818,478,709	822,137,074	759,625,663	713,734,516	628,575,730	979,094,536	225,532,567
Liability Total	1,061,509,826	1,100,556,668	987,255,270	882,651,503	879,889,855	1,198,585,122	722,741,509
Equity	11,790,923,920	12,157,738,920	12,157,738,920	12,157,738,920	12,157,738,920	12,586,018,920	12,586,018,920
Retained Earnings	-3,514,857,490	-3,899,428,762	-4,020,260,818	-3,424,844,290	-2,716,035,033	-2,185,516,216	-1,779,139,881
Other Capital	103,596,783	103,596,783	93,346,783	93,346,783	93,346,783	93,346,783	93,346,783
Capital Total	8,379,663,213	8,361,906,941	8,230,824,885	8,826,241,413	9,535,050,670	10,493,849,487	10,900,225,822
Liability and Capital	9,441,173,039	9,462,463,609	9,218,080,155	9,708,892,916	10,414,940,526	11,692,434,609	11,622,967,331

Source: PWWs

According to the BS outline above, although the retained earnings are still negative, the negative amount has been reducing due to the change of the net profit from negative to positive in 2015. If we assume that the same amount of net profit will continue in the future as in 2018, the retained earnings will change to positive in five years as calculated below:

1,779,139,881÷406,376,335≈4.39

(2) 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 Pursat Waterworks for last seven years is shown below:

Table 2-5-5 Ratio of Equity to Total Assets of Pursat Waterworks

Fiscal Year	2012	2013	2014	2015	2016	2017	2018
Ratio of Equity to Total Assets	88.8%	88.4%	89.3%	90.9%	91.6%	89.7%	93.8%

Source: Pursat Waterworks

Pursat Waterworks has been continuously showing a high ratio, comparing with the national average of Japan in 2015, 69.5%. It does not show the long-term stability of Pursat Waterworks, 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.

Besides that, the budgetary deficit on the basis of percent of GDP is the similar level with the average of developing countries and lower than that of developed ones.

Therefore, the hypothesis that the budgetary deficit of the government is the main reason why the amount of liability is low may not be true.

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Table 2-5-6 General Government Gross Debt (Percent of GDP)

	2012	2013	2014	2015	2016
Cambodia (%)	34.7	35.4	34.1	35.8	36.7
Emerging Market and Developing Economies (%)	37.2	38.3	40.4	43.8	46.8
Advanced Economies (%)	106.7	105.3	104.5	104.1	106.3

Note: "General Government" includes central state and local governed and social security funds.
Source: International Monetary Fund

(3) 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 Pursat Waterworks for last seven years is shown below:

Table 2-5-7 Current Ratio of Pursat Waterworks

Fiscal Year	2012	2013	2014	2015	2016	2017	2018
Current Ratio	279.6%	278.7%	299.2%	462.1%	343.4%	356.0%	177.3%

Source: PWWs

Pursat has been continuously showing high current ratio, more than 200% from 2012 to 2017. It is still very high even in 2018 although it showed less than 200%. It does not mean the short-term stability of business but it is due to the low amount of liability. The major reason is that it cannot access long-term and low interest financing.

2-5-2-2 Water Consumption

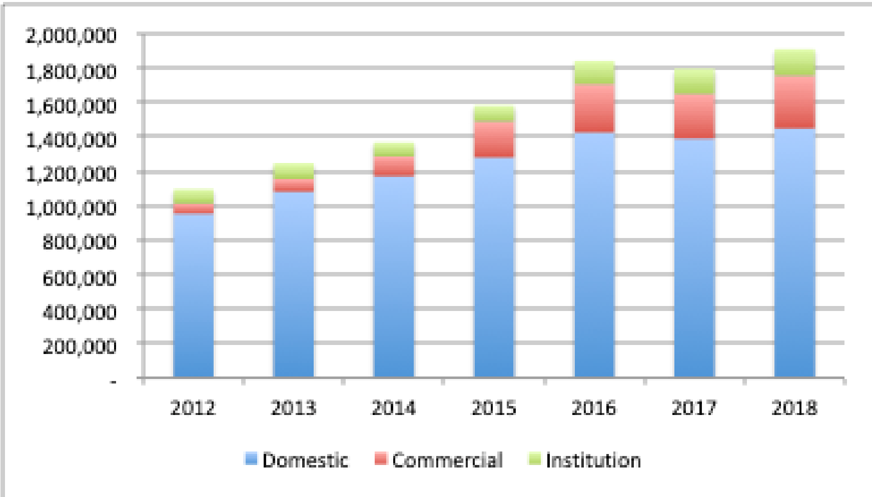
Revenue water for last seven years in Pursat Waterworks is shown below:

Table 2-5-8 Composition of Revenue Water by User Category

(Unit: m^3/year)

	2012	2013	2014	2015	2016	2017	2018
Domestic	954,281	1,081,650	1,173,261	1,281,448	1,426,387	1,389,978	1,449,814
Commercial	59,213	74,200	115,057	210,590	280,099	261,157	307,301
Institution	83,089	91,253	81,444	91,366	136,285	146,297	152,926
Total	1,096,583	1,247,103	1,369,762	1,583,404	1,842,771	1,797,432	1,910,041

Source: Pursat Waterworks



Source: Pursat Waterworks

Figure 2-5-2 Composition of Revenue Water by User Category

Revenue water in Pursat Waterworks increased by 1.7 times in seven years, whose annual average growth rate is nearly 9.7%. Especially, revenue water of "Commercial" expanded drastically by more than 4.7 times for seven years, whose annual average growth rate is 31.6%.

2-5-2-3 Water Charge Revenue and NRW Rate in Present Conditions

The water charge in PWWs is 1,600 Riel per 1 m^3, which is the same for all user categories.

Table 2-5-9 Water Charge Revenue

(Unit: Riel)

	2012	2013	2014	2015	2016	2017	2018
Domestic	1,526,849,600	1,730,640,000	1,877,217,600	2,050,316,800	2,282,219,200	2,223,964,800	2,319,702,400
Commercial	94,740,800	118,720,000	184,091,200	336,944,000	448,158,400	417,851,200	491,681,600
Institution	132,942,400	146,004,800	130,310,400	146,185,600	218,056,000	234,075,200	244,681,600
Total	1,754,532,800	1,995,364,800	2,191,619,200	2,533,446,400	2,948,433,600	2,875,891,200	3,056,065,600

Source: Pursat Waterworks

The NRW rate was about 17% in 2012 and it has been gradually decreasing to less than 9% in 2018 as shown below:

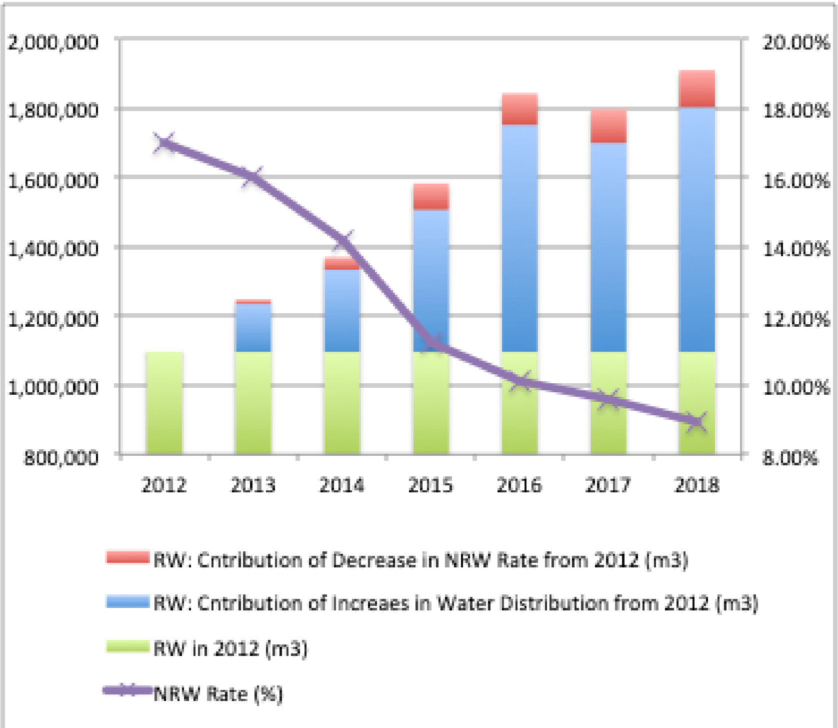
Table 2-5-10 Water Distribution and Revenue Water

(Unit: m^3/year)

	2012	2013	2014	2015	2016	2017	2018
Water Distribution	1,320,826	1,484,558	1,596,295	1,783,374	2,050,661	1,988,162	2,097,532
Revenue Water	1,096,583	1,247,103	1,369,762	1,583,404	1,842,771	1,797,432	1,910,041
NRW Rate	16.98%	15.99%	14.19%	11.21%	10.14%	9.59%	8.94%

Pursat Waterworks

The figure below shows the change in NRW rate and the composition of revenue water (contribution of decrease in NRW rate and that of increase in water distribution from 2012). NRW rate is shown by line graph using the right axis and revenue water is shown by bar graph using the left axis.



Source: PWWs

Figure 2-5-3 Change of NRW Rate and Breakdown of RW

According to the above Figure, the main reason why the revenue water or revenue from water charges expanded by 1.74 times is the expansion of water distribution by 1.59 times in addition to the decrease in NRW rate.

2-5-2-4 Forecast of Water Distribution

The result of water demand forecast for Pursat Waterworks is shown in Table 2-2-11. The expansion facilities will be accomplished in 2022. The daily maximum water distribution is calculated at 13,826

m^3/day for the target year 2025. As the capacity of the existing facility is 7,260 m^3/day, that of expansion facility is estimated at 6,566 ≈ 6,600 m^3/day. (Details of the water demand forecast are described in 2-2-2-1 Water Demand Forecast for Pursat Waterworks.)

(1) Existing Facilities

Water distribution and revenue water from the existing facilities for last seven years are shown in Table 2-5-11.Considering the decrease in distribution capacity due to troubles of equipment and aging of facilities, it is appropriate that the water distribution from 2019 to 2025 by the existing facilities deems 5,747 m^3/day (2,097,532 m^3/year), which is the actual figure in 2018. In addition, NRW rate from 2022 is assumed to be 15.00%, which is more than those of past results in order to be in the conservative side. It is gradually increased to 15.00% from 2019 to 2021.

Table 2-5-11 Water Distribution and Revenue Water of Existing Facilities (Forecast)

(Unit: m^3/year)

	2019	2020	2021	2022 - 2025
Water Distribution	2,097,532	2,097,532	2,097,532	2,097,532
Revenue Water	1,878,256	1,846,472	1,814,687	1,782,902

Source: JICA Study Team

(2) Expansion Facilities

Water distribution and revenue water from the expansion facilities are forecasted in 2-2-2-1 Water Demand Forecast for Pursat Waterworks as shown in Table 2-5-12. The load factor is estimated 82.3% based on the past results in Pursat Waterworks. In addition, NRW rate is assumed to be 15.00%, which is more than those of past results in order to be in the conservative side.

Table 2-5-12 Water Distribution and Revenue Water of Expansion Facilities (Forecast)

(Unit: m^3/year)

	2022	2023	2024	2025
Water Distribution	404,031	1,017,738	1,485,453	1,982,607
Revenue Water	343,427	865,078	1,262,635	1,685,216

Source: JICA Study Team

Table 2-5-13 Total Water Distribution and Total Revenue Water (Forecast)

(Unit: m^3/year)

	2019	2020	2021	2022	2023	2024	2025
Water Distribution	2,097,532	2,097,532	2,097,532	2,501,563	3,115,270	3,582,985	4,080,139
Revenue Water	1,878,256	1,846,472	1,814,687	2,126,329	2,647,980	3,045,537	3,468,118

Source: JICA Study Team

2-5-2-5 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 as shown below:

Table 2-5-14 Estimation of Unit Cost for O&M

Item	Unit Cost (Riel/year)	Ground
Personnel	15,404,370 (per person)	Records in 2018 [1)]
Outsourcing	15,404,370 (per person)	Personnel Cost in 2018
Material/Chemical	120 (per 1 m^3 distribution)	Average of records in 2015 and 2018 [2)]
Fuel/Electricity	311 (per 1 m^3 distribution)	ditto
Depreciation [3)]	285 (per 1 m^3 distribution)	ditto
Interest Payment	21 (per 1 m^3 distribution)	ditto
Taxes	24 (per 1 m^3 distribution)	ditto
Other	269 (per 1 m^3 distribution)	ditto

Note 1): It is assumed that personnel cost cannot be reduced without an extraordinary reason.
Note 2): Cost structure was largely changed in 2015, so the average of records in 2015 and 2018 is used.
Note 3): It is applied only to the existing facilities.
Source: JICA Study Team

(2) Personnel Plan

Number of staff members of the present system is as follows:

Table 2-5-15 Number of Staff Members in Present System

	2012	2013	2014	2015	2016	2017	2018	2019
Director	1	1	1	1	1	1	1	1
Deputy Director	3	2	2	3	2	2	2	2
Administration and Planning Section	1	2	1	1	1	2	3	3
Accounting and Finance Section	4	4	6	6	7	6	6	6
Business Section	8	9	8	7	10	10	11	11
Production Section	7	6	8	8	8	7	7	7
Network Section	6	6	11	10	7	8	8	8
Total	30	30	37	36	36	36	38	38

Source: PWWs

Total number of staff members in the present system is 38. Total number of staff members will be increased gradually to 58 in 2025. Assuming this, the personnel plan until 2025 will be as follows :

Table 2-5-16 Personnel Plan

	2020	2021	2022	2023	2024	2025
Director	1	1	1	1	1	1
Deputy Director	2	2	2	2	2	2
Administration and Planning Section	3	3	3	3	3	3
Accounting and Finance Section	7	7	7	7	7	7
Business Section	11	11	12	13	14	15
Production Section	7	8	11	11	11	11
Network Section	11	14	19	19	19	19
Total	42	46	55	56	57	58
Outsourcing	-	-	4	7	7	6

Note: A part of connection services will be outsourced from 2022 to 2025.
Source: JICA Study Team

2-5-2-6 Long-term Forecast of Profit and Loss for PWWs

Based on the estimated revenue water and unit costs of O&M mentioned above, a long-term forecast of profit and loss for the PWWs is examined with the conditions shown below:

Conditions of Long-term Forecast of Profit and Loss

i. Water charge is 1,600 Riel per 1 m^3 for all user categories as the present one;

ii. Facilities/equipment constructed/installed by the fund of grant aid are not depreciated;

iii. NRW rate is set at 15.00%;

iv. Price escalation is not included; and

v. O&M cost and revenue from 2026 or after are the same with that in 2025.

Table 2-5-17 Long-term Forecast of Profit and Loss

（Unit: Million JPY）

Year	No.	Expenses									Revenues			Net Profit	Retained Earnings
		Labor	Outsourcing	Material/ Chemical	Electricity/ Fuel	Depreciation	Interest Payment	Taxes	Other	Total	Water Sales	Other	Total		
2019	1	15.7		6.8	17.5	16.1	1.2	1.4	15.2	73.8	80.8	6.0	86.7	12.9	-34.9
2020	2	17.4		6.8	17.5	16.1	1.2	1.4	15.2	75.4	79.4	6.0	85.4	9.9	-25.0
2021	3	19.0		6.8	17.5	16.1	1.2	1.4	15.2	77.1	78.0	6.0	84.0	6.9	-18.1
2022	4	22.8	1.7	8.1	20.9	16.1	1.4	1.6	18.1	90.6	91.4	7.1	98.6	8.0	-10.1
2023	5	23.2	2.9	10.0	26.0	16.1	1.7	2.0	22.5	104.5	113.9	8.8	122.7	18.2	8.1
2024	6	23.6	2.9	11.5	29.9	16.1	2.0	2.3	25.9	114.3	131.0	10.2	141.2	26.9	35.0
2025	7	24.0	2.5	13.1	34.1	16.1	2.3	2.6	29.5	124.2	149.2	11.6	160.7	36.5	71.5
2026	8	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	110.5
2027	9	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	149.5
2028	10	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	188.5
2029	11	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	227.5
2030	12	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	266.4
2031	13	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	305.4
2032	14	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	344.4
2033	15	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	383.4
2034	16	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	422.4
2035	17	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	461.4
2036	18	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	500.4
2037	19	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	539.4
2038	20	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	578.3
2039	21	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	617.3
2040	22	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	656.3
2041	23	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	695.3
2042	24	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	734.3
2043	25	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	773.3
2044	26	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	812.3
2045	27	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	851.3
2046	28	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	890.2
2047	29	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	929.2
2048	30	24.0		13.1	34.1	16.1	2.3	2.6	29.5	121.8	149.2	11.6	160.7	39.0	968.2

Note: Riel 1.00 = JPY 0.02688 (JICA Settlement Rate in July 2019)
Source: JICA Study Team

Analysis on Long-term Forecast of Profit and Loss

Operation and maintenance costs can be fully covered by water charge of 1,600 Riel per 1 m^3 until 2025, when the expanded facilities and equipment will be fully operational. Negative retained earnings will change to positive in five years and it will accumulate to more than 70 million yen in the target year of 2025.

That is, it is forecasted that Pursat Waterworks can accumulate retained earnings with stable increase in net profit by the grant aid program as shown in

Table 2-5-17. If it becomes a public corporation, it can secure finance with long-term and low interest loan.

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It should be considered that many residents are using wells and rainwater in the expansion area. It can be expected that connection applications will grow at a sluggish pace because the connection fee is as high as 290,000 Riel (7,960 JPY). In addition, connection works will reach 2,100 households in a year at the peak. It is important to improve the awareness of the residents on safety, economic advantage, water supply business and water charges in addition to development of system for connection works.

Chapter 3. Project Evaluation

3-1 Preconditions for Project Implementation

As the preconditions for project implementation and necessary inputs by the recipient country are explained in detail in 2-3, the main items are described below.

Permission of River Water Intake

In the existing law system in Cambodia, water rights have not been set up yet; however, MOWRAM as the responsibility organization is going to carry out quantity management of surface water and groundwater. In the enforcement of this project, MOWRAM has already sent a letter to MIH on permission for the new water intake from Pursat River on September 14, 2017.

Electric Power Lead-in to New Intake Plant and WTP

Transformation units in the new intake plant and WTP are included in this grant aid assistance; however, the electric power lead-in is conducted by Cambodian side.

Occupation Permission for Routes of Water Conduit, Transmission Pipe and Distribution Pipe

Water conduits, transmission pipes and distribution pipes will be buried along the public roads except aqueduct. Therefore, there's no problem such as land acquisition from residents; however, permission from Ministry of Public Works & Transport on the national roads and from the state government on other roads are necessary.

Environmental and Social Considerations

The Initial Environmental Impact Assessment (IEIA) report was prepared and submitted to MOE from MIH on 7th May 2018. The site survey and interview of stakeholders were conducted. Based on the survey, the comment letter was issued by MOE and the IEIA report has been revised. After that, the revised report was resubmitted and the report was approved by MOE in January 2019.

3-2 Necessary Inputs by Recipient Country for Project Implementation

Land Requisition for WTP and Water Intake Pumping Station, and Ground Leveling

Land requisition for WTP and water intake pumping station have already been done by MIH. Since the embankment (22,740 m^3[(1)] for the WTP and 7,030 m^3 for the water intake pumping station) is required before the construction starts. The survey team explained the project schedule to Cambodian side and requested to secure the necessary budget and to deal with the ground leveling.

House Connection and Procurement & Installation of Water Meter

[1] Embankment volume at WTP site (after compaction) = 18,000m^3, Embankment volume at intake site (after compaction) = 5,567m^3, Loosen ratio (L) = 1.2, Compaction ratio (C) = 0.95. Based on these value, soil volume to be purchased is calculated as follows; Soil volume to be purchased at WTP site = 18,000m^3÷0.95 x 1.2≒22,740 m^3, Soil volume to be purchased at intake site =5,567m^3÷0.95 x 1.2≒7,030 m^3

House connection works will be conducted by Cambodian side. Total target number of connections is approximately 7,625 households including 257 poor households (level 1). Since the purpose of this project will never be accomplished without house connection works, the concrete schedule and personnel structure assumed for the works (4 group ,10 people at peak time) were explained to Cambodian side. In addition, the soft component as one of the promotion activities of the house connection for residents is planned.

Recruitment of New Staff

The Pursat Water Works need to operate and maintain the new WTP in addition to the existing plant. The number of customers will increase. Therefore, they must gradually increase the number of staffs from 37 people now to 58 people by 2025. The breakdown of the increased number of 21people is as follows: 11 in the treatment section, 4 in the water distribution section, 1 in the general affairs section and 5 in the sales section.

Access Bridge

There are two wooden bridges on the laying route of water distribution pipes; however, they cannot withstand the traffic of construction vehicles due to their structure. Therefore, new access bridges must be constructed with an approval from the local communities during the construction period. Since the existing wooden bridges are used by the residents for daily traffic, the existing wooden bridge is to be left as it is, and the temporary access bridges made of steel are planned to be built beside them.

Construction of the access bridges accompanying piping construction is included in the construction works by the Japanese side; however, since it is necessary to acquire construction permission from the communities, MIH will support it. Cambodian side requested the access bridges to be left after the completion of the construction works for the convenience of the residents. For this reason, the following was stated in the minutes of discussions on "The Preparatory Survey for the Project for Expansion of Water Supply System in Pursat in the Kingdom of Cambodia", June 28, 2018 (Explanation on Draft Preparatory Survey Report) that all responsibilities after handover of the access bridges to the communities would be lain in Cambodian side.

Tax Exemption

The Cambodian side will assist on tax exemption for the construction contractors.

3-3 Important Assumptions

External conditions to realize effectiveness of the project and maintain it are as follows.

- No large-scaled unseasonable weather or natural disaster
- No serious degradation of social and economic conditions
- No unexpected population dynamics in the project area
- The present ability of the existing WTP will be maintained.

3-4 Project Evaluation

3-4-1 Relevance of the Project

Beneficiary of the Project

Water supply to the residents in Pursat City is expanded by this project. The water supply coverage ratio of approximately 37.8% in 2018 in the controlled area of the Water Works will be increased to 67.9% in the target year:2025. The ratio in the urban area advocated by MIH becomes 86.1%. Increased benefit population is approximately 39,864 people.

Urgency of the Project

Although the Pursat City has an existing water supply system, the expansion of the system becomes an urgent matter for the further improvement of the water supply coverage ratio because the ratio remained approximately 40% in 2018.

Consistency with National Strategic Development Plan

Based on NSDP (National Strategic Development Plan, December 2017), MIH aims to work out 100% of the water supply coverage ratio in the urban area by 2025 by covering 90% with pipe water supply system and remaining 10% with other water supply system. This aim can be almost accomplished in the urban area within the administrative area of the Waterworks by this project.

This project also includes supplying equipment and materials to the poor households for house connection works conducted by the Cambodian side. Therefore, the consistency with the poverty reduction which is the greatest purpose in NPDS is ensured.

Consistency with Japan’s ODA Policy

According to “Rolling Plan for the Royal Government of Cambodia, July 2017”, one of the important priority areas is “Promotion of Social Development” including “Program for Water Supply and Sewage System”. The implementation of this project has consistency with this Japan’s ODA policy.

3-4-2 Effectiveness

About the effectiveness of this project, the following quantitative effects and qualitative effects are expected.

(1) Quantitative Effects

Quantitative effects by the expansion of water supply system in Pursat City are expected as shown in the table below.

Table 3-4-1 Quantitative Effect

No.	Index	Baseline Data (Year 2018)	Target (Year 2025) (4 years after completion of the new facilities)
1	Water Supply Capacity (m^3/day)	5,607	11,386
2	Served Population (Person)[2]	37,661	75,033

Note: refer to 2-2-2-1 for calculation method

(2) Qualitative Effect

Qualitative effects by the project are expected as follows.

- Improving living environment of the residents
- Increasing house connections for the poor household

As mentioned above, the relevance of the project is high, and both quantitative and qualitative effects by the project are expected.

[2] If the population growth in the water supply area undergoes predictably, about 37.8% of water supply ratio in administrative area in 2018 will be 67.9% in 2025. And the water supply ratio in urban water supply area will be 86.1% in 2025.