PEOPLE'S REPUBLIC OF BANGLADESH

PREPARATORY SURVEY
FOR
SOUTHERN CHATTOGRAM REGION
WATER SUPPLY PROJECT

FINAL REPORT
(ADVANCE DISCLOSURE VERSION)

VOLUME-I MAIN REPORT

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JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.
JAPAN WATER AGENCY

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PREPARATORY SURVEY
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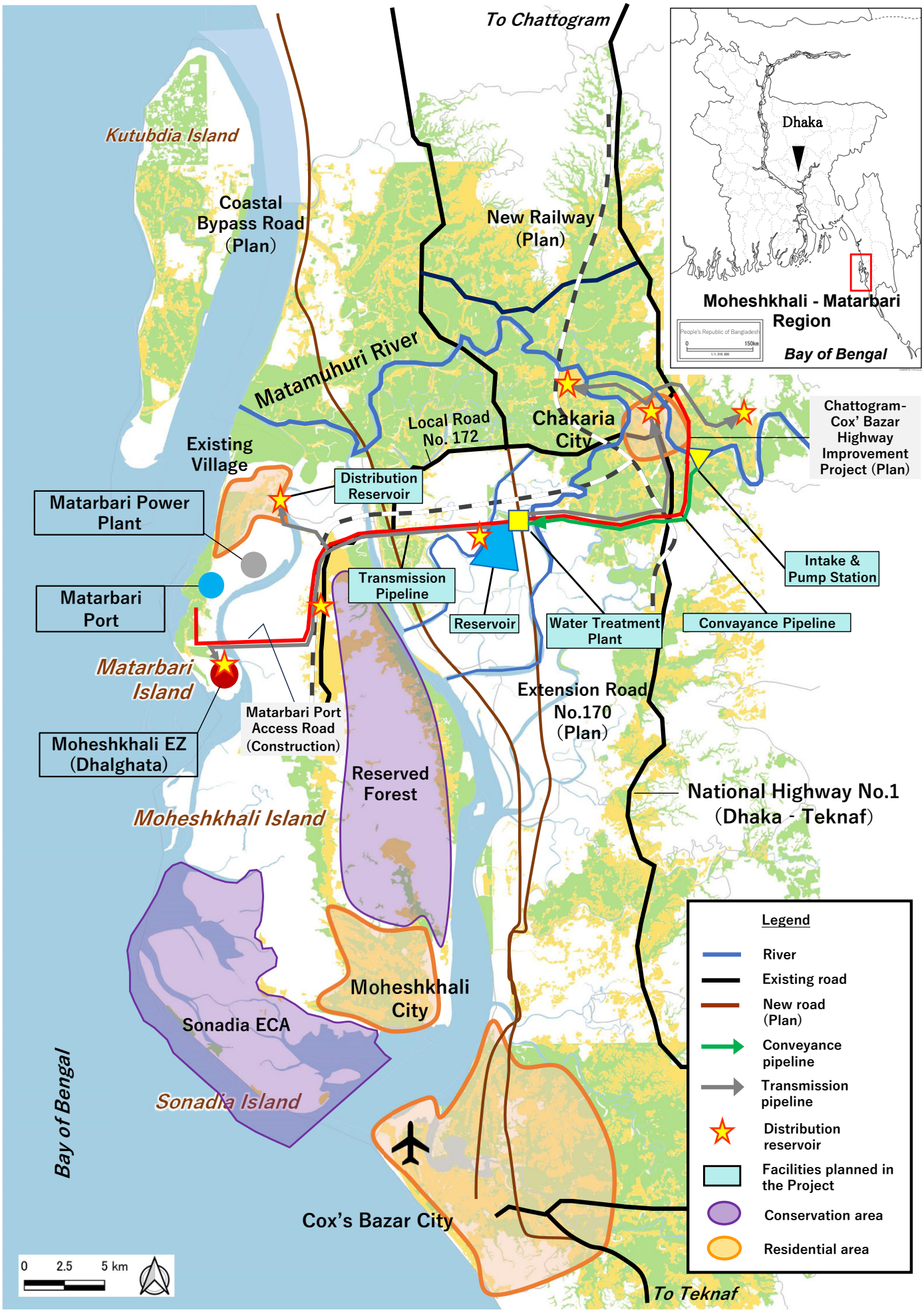
Composition of Final Report

Volume-I MAIN REPORT

Volume-II SUPPORTING REPORT

Supporting Report A : HYDROLOGY AND CLIMATE CHANGE ANALYSIS

Supporting Report B : PRELIMINARY DESIGN OF PROJECT FACILITIES



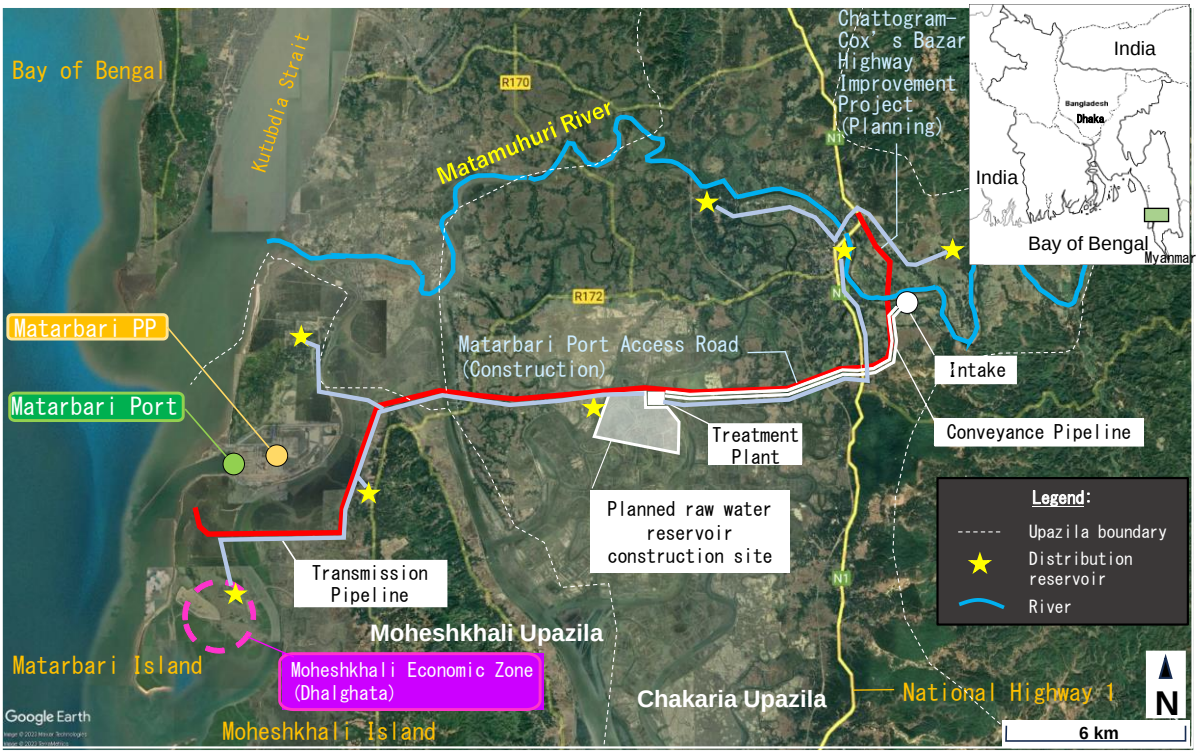
Location Map

I. INTRODUCTION

1.1 In the southern Chattogram region of the People's Republic of Bangladesh (hereinafter referred to as "Bangladesh"), the Moheshkhali-Matarbari Integrated Infrastructure Development Initiative (MIDI) has been promoted to achieve industrial agglomeration, and it is forecasted that the population of the region, especially Chakaria Upazila and Moheshkhali Upazila in Cox's Bazar District, will increase, resulting in water demand increase for both industrial and domestic purposes.

On the other hand, the groundwater level in the region has been declining because of excessive extraction of groundwater, and it cannot be expected to develop any new aquifer in the region. Therefore, it is needed to convert the region's water source from groundwater to surface water, since surface water has a higher potential for water resources development.

The "Southern Chattogram Region Water Supply Project (hereinafter referred to as "the Project")", plans to enhance the capacity of industrial and domestic water supply using surface water by developing water supply facilities in the southern Chattogram region. The figure below presents the layout plan of the major water supply facilities in the Project.



Source: JICA Survey Team

Figure 1 : Layout of Major Water Supply Facilities in the Water Supply Project

1.2 The survey area for the Project is Cox's Bazar District in Chattogram Division, and the Matamuhuri River basin is also included in the survey area, of which the locations are referred to in the following figure.

Source: Japan International Cooperation Agency (JICA) Survey Team

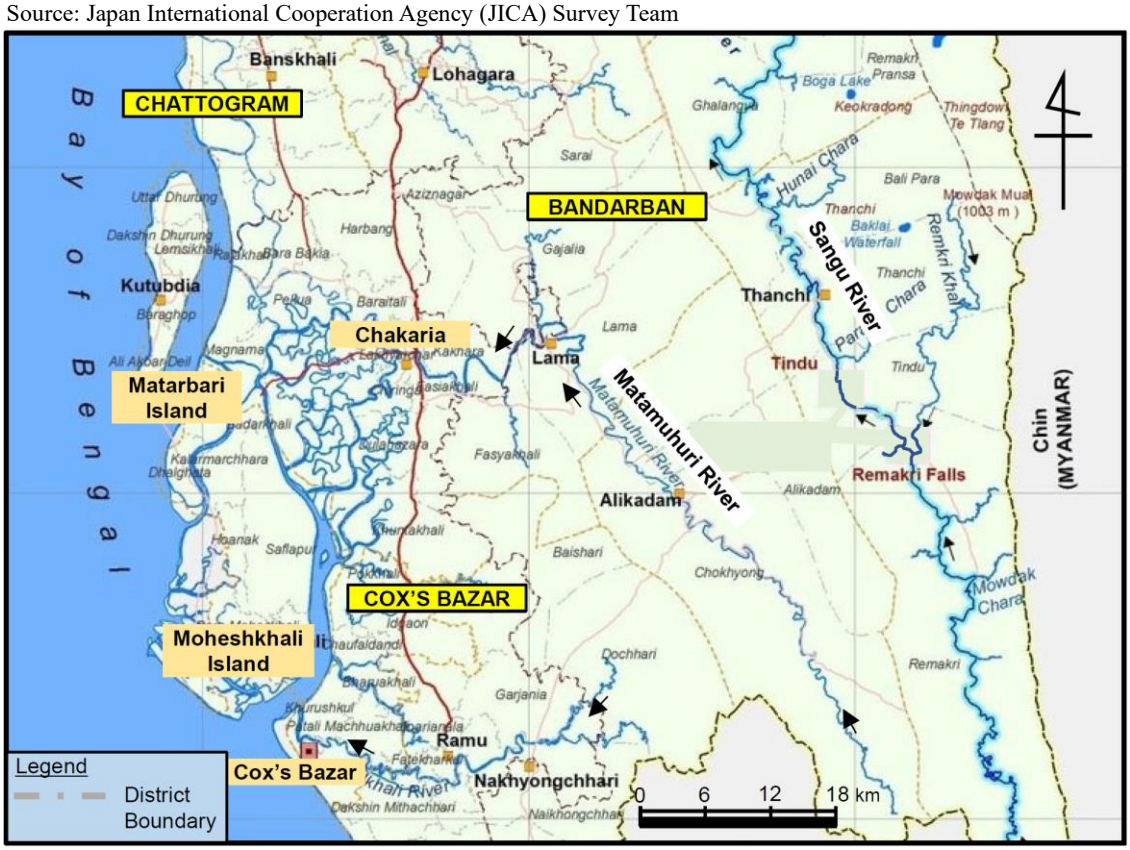


Figure 2 : Survey Target Area

II. PRESENT CONDITIONS OF PROJECT AREA

Physical Setting

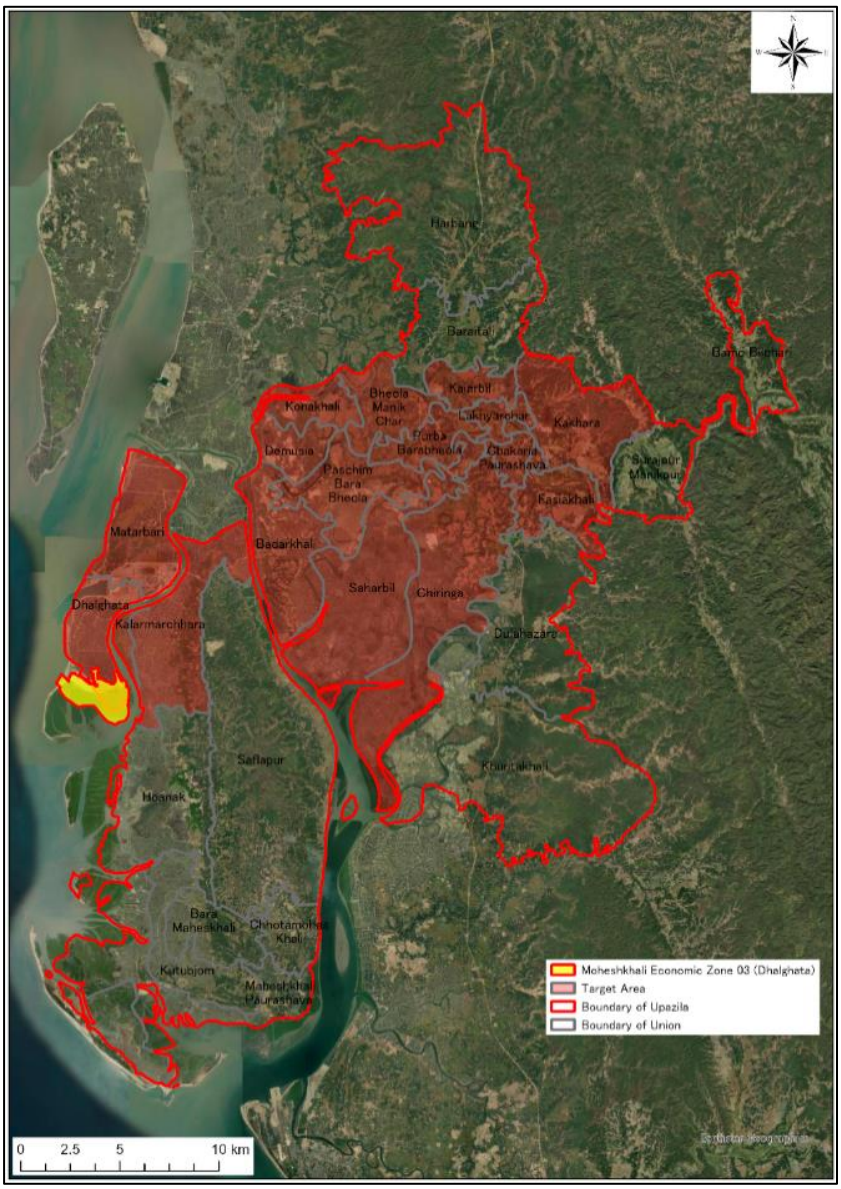
2.1 The project area has experienced tropical monsoon climate typical with high temperature and humidity. According to the data observed through 2010 to 2022, the average monthly temperature is in the range between 10℃ and 40℃, the average humidity is between 68% and 89%, and the precipitation is between several mm and 900mm.

2.2 The Matamuhuri River basin is located in the Chattogram Hill Tracts in the southeastern area of Bangladesh, where the hills with altitudes of 300 to 500 m are distributed and is an extension of the Himalayas. The Matamuhuri River basin has a total area of about 2,500 km^2, out of which about 1,500 km^2 is within the hilly terrain. The remaining 1,000 km^2 lies in the downstream Matamuhuri Delta. At present, the almost entire delta area has been converted into farming land for agriculture, shrimp culture, and salt production.

Socio-economy

2.3 The population of Cox's Bazar District has continued to grow. The 2022 census of Bangladesh reported 2,823,268 people, an increase of 23.3% from the 2011 census report.

2.4 During the Preparatory Survey, the need for domestic water was studied in fifteen unions and one pourashava in Chakaria and Moheshkhali Upazilas (the final proposed target area for the Project is one union and one pourashava, as per section 5.4). In total, about 706,090 people (14.8% out of the total projected population of Cox's Bazar District in 2041) are projected to be in the studied areas by 2041 as seen in the table below. This population forecast uses the cohort coefficient method, a commonly used and widely adopted method.



Note: Upazila is a unit in the administrative system of Bangladesh. An upazila is made up of a few villages or unions and a district is made up of a few upazilas.

Source: JICA Survey Team

Figure 3 : Water Supply Target Area

Table 1 : Projected Population in the Municipalities Studied in the Preparatory Survey

District/Upazila	No.	Name of the Union	Population (2022)	Projected Population (2041)
Cox's Bazar District			2,823,268	4,759,000
Chakaria Upazila	1	Chakaria (Pourashava)	94,398	133,073
	2	Badarkali	36,715	51,757
	3	Bheola Manik Char	24,800	34,961
	4	Chringa	19,921	28,083
	5	Demusia	13,397	18,886
	6	Purba Barabheola	31,823	44,861
	7	Faiakhali	34,391	48,481
	8	Kakhara	29,825	42,044
	9	Kairarbil	22,676	31,966
	10	Konakhali	22,770	32,099
	11	Lakhyarchar	8,974	12,651
	12	Saharbil	24,480	34,510
	13	Paschim Bara Behola	10,732	15,129
Moheshkhali Upazila	14	Dhalghata	11,361	15,922
	15	Kalarmarchhara	62,611	87,746
	16	Matarbari	52,746	73,921
Total			501,620	706,090

Note: Calculation of unions population projection by 2041, done by JICA Survey Team

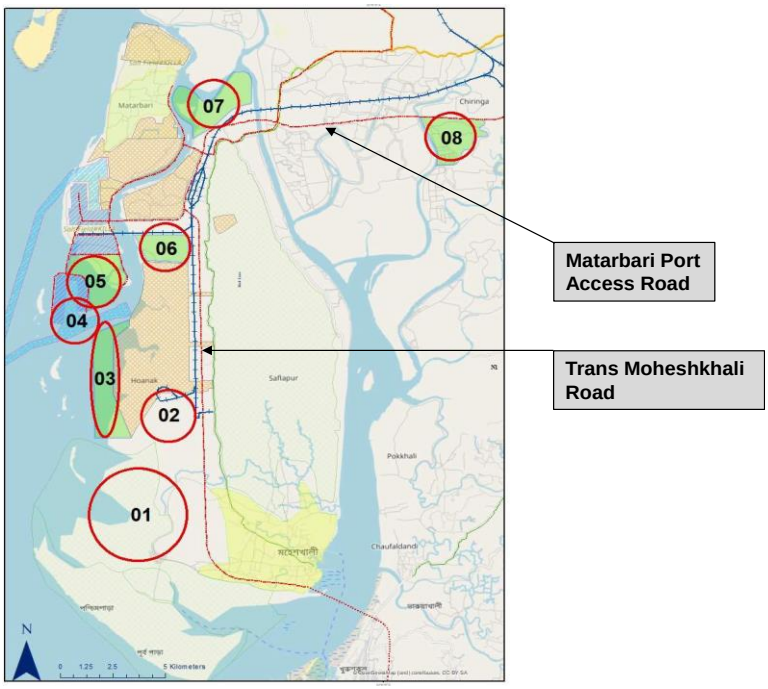
Source: Population and Housing Census 2022

2.5 According to the 2022 census, main economic activities in Cox's Bazar District are service industry, agriculture, manufacturing, fishing (both traditional and commercial), forestry and tourism. Shrimp farming and salt production are also important sources of income.

Moheshkhali-Matarbari Integrated Infrastructure Development Initiative (MIDI)

2.6 MIDI was launched under the Bay of Bengal Industrial Growth Belt (BIG-B) program agreed at the Japan-Bangladesh Summit in September 2014. The core of MIDI is Matarbari Port, and the development of multiple large-scale infrastructures is planned in the Initiative. "Project for the Formulation of MIDI Maser Plan" was begun in February 2024, during the time of this Preparatory Survey.

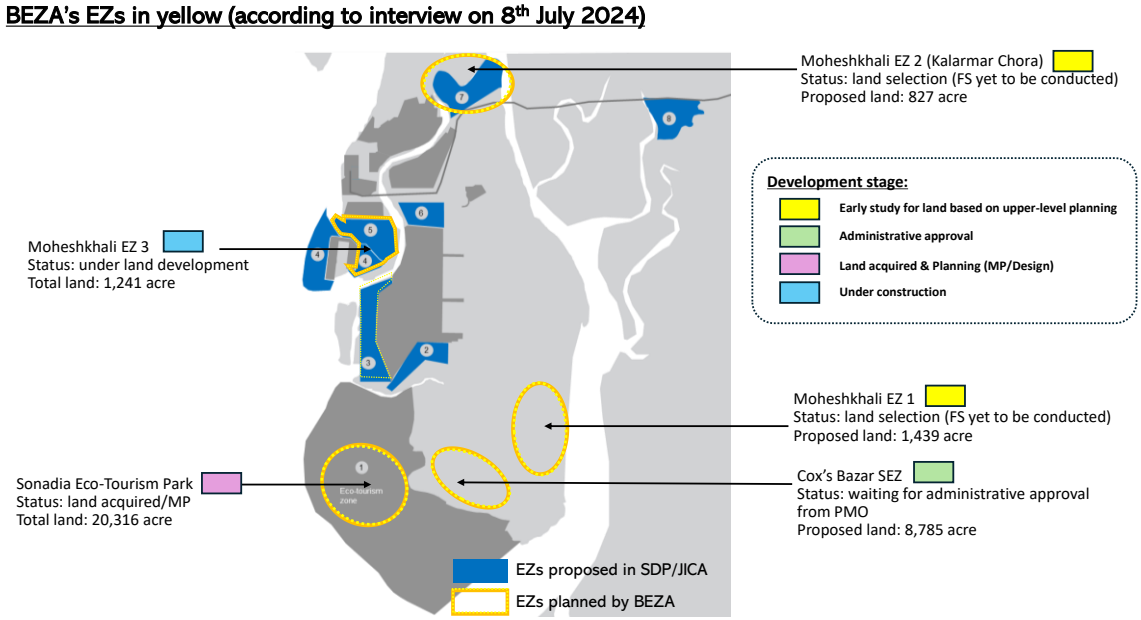
2.7 Bangladesh Economic Zones Authority (BEZA) has identified 8 Economic Zone (EZ) sites for the MIDI area in "Industrial and Economic Zone Sector Development Plan (IEZ-SDP), January 2021, BEZA", as presented in the right figure.



Source: Adapted from Figure 1 in IEZ-SDP

Figure 4 Eight EZ sites identified in IEZ-SDP (January 2021)

This Preparatory Survey selected the EZ 5 site as the priority target EZ site for industrial water supply, since the land for the EZ site has already been acquired and does not have dependent projects. BEZA has later reconsidered its EZ development plan, and the area previously called EZ 5 and a part of the area previously called EZ 4 have been combined into Moheshkhali EZ 3, as in the following figure. This Preparatory Survey refers to Moheshkhali EZ 3 as "Moheshkhali EZ (Dhalghata)" and has studied the need for industrial water in this Moheshkhali EZ (Dhalghata).



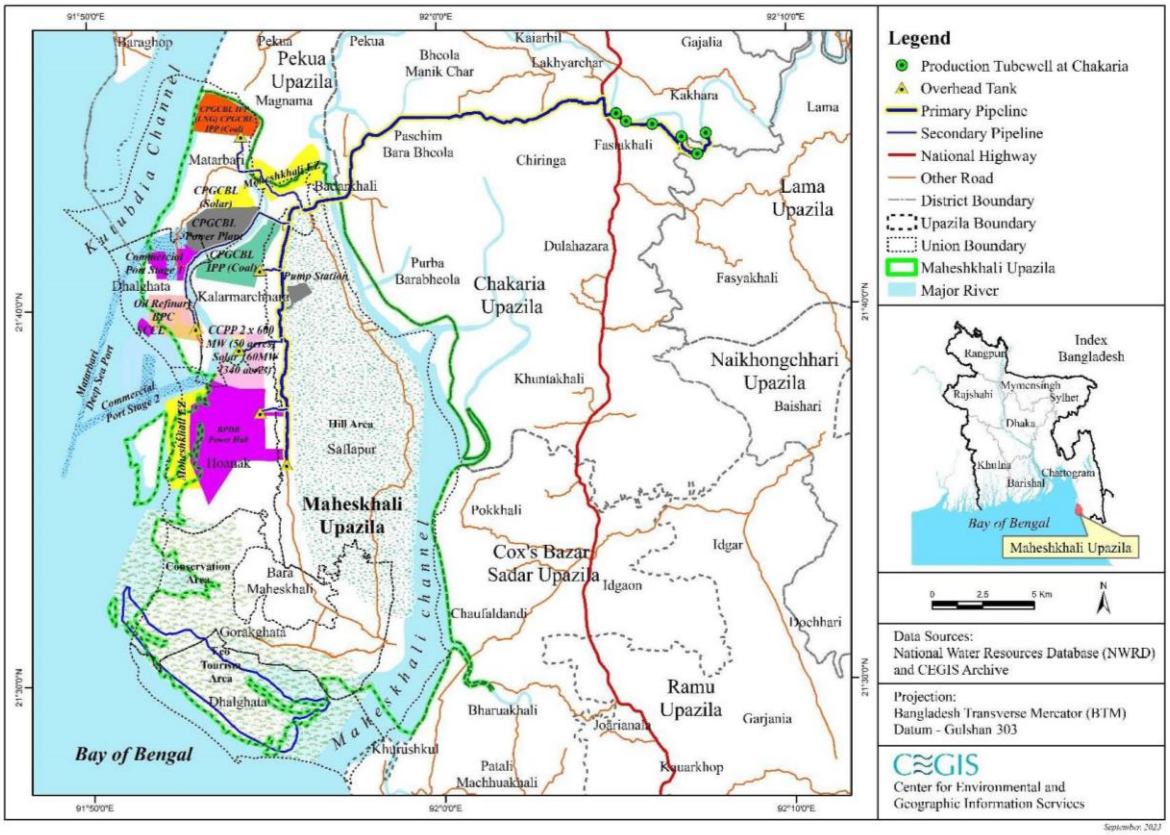
Source: from JICA Study Team for "MIDI Comprehensive Development Planning Project"

Figure 5 : BEZA Review after IEZ-SDP (2021)

Existing Water Supply Facilities the Project Area

2.8 97.64% of households in Cox's Bazar District use wells as the main source of drinking water. A total of 8,525 wells for domestic water supply in Chakaria Upazila and Moheshkhali Upazila were constructed by the Department of Public Health Engineering (DPHE) and have been managed by the DPHE Cox' s Bazar Office and upazila offices.

2.9 Six (6) tube wells on Faiakhali and Kakhara Unions in Chakaria Upazila, a 62.9 km pipeline between Chakaria Upazila and Moheshkhali Upazila, and six (6) overhead tanks in the MIDI area are planned to be constructed by the DPHE as a short-term plan (2024-2030) as shown in the following figure. The water supply system using groundwater is treated as supplemental measures to cope with local and small-scale water demands. As of the end of August 2024, the construction of 6 tube wells, pipelines and 6 overhead tanks had been completed. The facility layout plan for the DPHE short-term plan is shown below.



Source: Preparation of Water Development Plan at Moheshkhali- Matarbari Area of Cox's Bazar District (DPHE, 2023)

Figure 6 : Map of Water Supply Facility Development Plan by DPHE

III. POLICIES AND REGULATIONS OF WATER SUPPLY SECTOR IN BANGLADESH

Relevant Organizations

3.1 In general, ministries involved with water management related to municipal and agricultural water are the Ministry of Water Resources (MoWR), the Ministry of Agriculture (MoA) and the Local Government Division (LGD) in Bangladesh. The flood control and irrigation projects and river management issues are dealt with by the MoWR. Under the supervision of the MoWR, Bangladesh Water Development Board (BWDB) is in charge of water resources development as an implementing agency. Domestic and industrial water supply projects are dealt with by the LGD. Under the LGD, the DPHE is responsible for water supply in rural areas, and Water Supply and Sewerage Authorities (WASAs) are responsible for water supplies in designated large cities, such as Dhaka, Chattogram, Khulna and Rajshahi.

Water Sector Polices

3.2 Plans and strategies related to the water supply sector in Bangladesh are summarized in the table below.

Table 2 : Water Sector Policies in Bangladesh

	Plan/Act	Covered Period	Contents Related to Water Supply
1	Perspective Plan of Bangladesh 2021-2041 (PP2041)	2021-2041	Ensure 100% capital cost recovery by FY2031 of urban water use and availability of safe water is the top priority in rural areas, and then piped water supply in populated villages will be increased.
2	The Eighth Five-Year Plan (8FYP)	2020-2025	The 8FYP advocates necessity of investing heavily in critical urban services like water supply, drainage, sanitation and waste management.
3	National Strategy for Water Supply and Sanitation, Revised and Updated Edition 2021	2021-	The goal of this strategy is to realize safe and sustainable water supply, sanitation and health hygiene services for all after the MDG era (2000-15).
4	Bangladesh Delta Plan 2100 (BDP 2100)	2015-2100	BDP2100 ensures long term water and food security, economic growth and environmental sustainability, reducing vulnerability to natural disasters and building resilience to climate change through equitable water governance, etc.
5	National Adaptation Plan of Bangladesh (2023-2050)	2023-2050	The NAP implementation process will adopt a monitoring and evaluation (M&E) framework based on a combination of both simple and comprehensive monitoring approaches to identify and assess outcomes.

Source: JICA Survey Team

Legal Systems

3.3 Currently, the "Water Act, 2013" stipulates the comprehensive legal framework for water management in Bangladesh. Water management services are provided by relevant existing organizations such as the Water Resources Planning Organization (WARPO), BWDB and DPHE. under this framework. The main legal institutions in the water supply sector in Bangladesh are as shown in the table below.

Table 3 : Major Legal Institutions in Water Supply Sector in Bangladesh

	Act/Rule	Contents Related to Water Supply
1	Water Act 2013	This Act provides a comprehensive legal framework covering all aspects of water management in Bangladesh. Its main objective is to provide integrated water resources management including development, intake, distribution, use, protection and conservation of water resources.
2	Water Rules 2018	This Act stipulates the responsibilities of WARPO based on Article 45 of the Water Act 2013, "Power to make rules: The Government may, by notification in the Official Gazette, make rules to carry out the purposes of this Act," namely, formulating a national water policy, establishing a national water resources database, granting water permits, approving water-related projects, etc.
3	Local Government (municipality) Ordinance 2009	This Ordinance repealed the Pourashava Ordinance 1977 and is enacted as a new law in 2009 for Pourashava (municipality), which provides clearer and more specific guidance on the implementation and management of projects aimed at providing all public services to people living in urban areas. With regard to water supply, it stipulates the authority of Pourashava to implement projects, including fee collection, on its own or in collaboration with government agencies and Non-Governmental Organizations (NGOs).
4	The Local Government (Union Parishads) Act, 2009	This Act stipulates the structure of Unions, the smallest local government and self-governing body in Bangladesh, and the provision of all administrative services to the people living in Unions. With regard to water supply, it confers upon Unions the powers to manage and conserve wells, pipelines, reservoirs, ponds and other sources of water supply, and to take measures to prevent pollution.

Source: JICA Survey Team

There hasn't been any act that clearly defines the responsibilities of the DPHE, and the National Policy for Safe Water Supply and Sanitation (1998) is considered as the basis for the DPHE policies with regard to water supply and sanitation. Furthermore, water supply and sanitation-related policies have been reviewed since 1998, and the integrated strategy is the National Strategy for Water Supply and Sanitation (Latest revised version 2021).

3.4 There are water tariffs of 1) WASA, 2) local governments and 3) EZ. The water tariff of WASA is set based on the "Water Supply and Sewerage Act, 1996". There is no standardized rule for the water tariffs of local governments and EZ. The water tariffs of local governments are decided by their congresses, and that of EZ can be suggested and needs to be approved by the The Prime Minister's Office (PMO).

Water tariffs of local governments and EZ could be applicable for the Project because its target area is under the jurisdiction of the DPHE and the Project includes water supply in the EZ.

IV. BASIC PLAN OF WATER SUPPLY PROJECT

The studies enumerated below were conducted for the design of the proposed facilities. The details are described in the following sections:

(1) To establish basic water supply plan, and set up water supply target area, daily maximum production, designed intake volume, etc.,

(2) To establish river water intake basic plan, and define location, scale, basic specifications, etc. for intake and raw water reservoir facilities,

(3) To establish water treatment and distribution basic plan, and select water treatment and distribution methods etc.,

(4) To formulate phasing plan of the Project by limited target areas and facilities in order to improve efficiency in water supply and reduce project costs, and

(5) To conduct basic design of target facilities, based on the results of phasing.

Basic Water Supply Plan

In the Preparatory Survey, after completing the examinations in Sections 4.1 to 4.3, the project scope was reduced as described in Section 4.4, taking into consideration the project cost and the efficiency of the piped water supply. The descriptions in Chapter 5 and after are based on the scope described in Section 4.4.

4.1 Based on the basic conditions of the water supply plan shown in the following table, a water demand forecast for the target year of 2041 was carried out. As a result, the total design intake volumes are 90.5 Million Liter per Day (MLD), 86.3 MLD, and 176.8 MLD for industrial, domestic and total water volume, respectively.

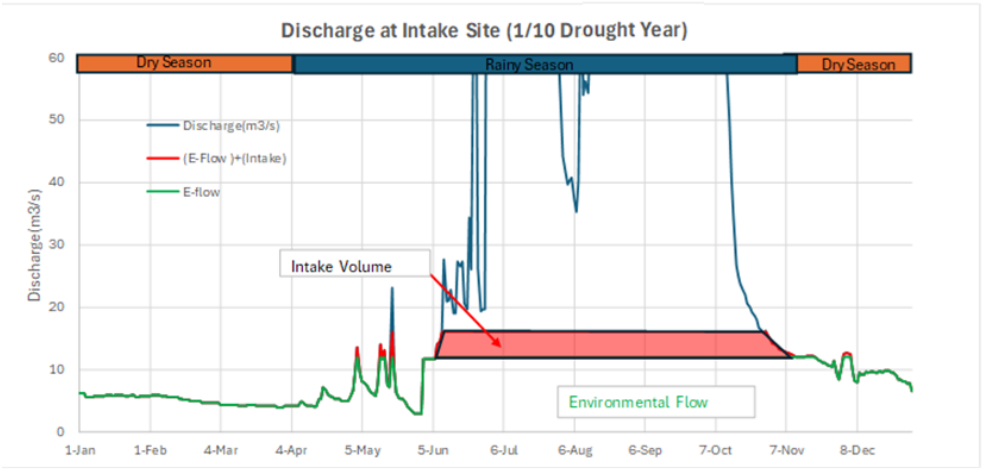
Table 4 : Basic Conditions of Water Supply Plan

Basic Conditions	Target Year	2041 (Based on the Perspective Plan of Bangladesh)
	Water Supply Target Area	Moheshkhali EZ (Dhalghata) and a total of 15 unions and 1 pourashava located in Moheshkhali and Chakaria Upazilas
	Water Supply Population and Area	Estimated Water Supply as of 2041 ・Industrial Water：802 acre ・Domestic Water：Total 706,000 people (528,000 in Chakaria, 178,000 in Moheshkhali)
	Water Demand Per Capita	- Domestic Water for Pourashava: 120 Liters per Capita per Day (lpcd) - Domestic Water for Union: 62 lpcd - 7～283 m^3/acre/day by industry-wise water consumption
	Daily Maximum Production	Total: 160.6 MLD Industrial Water: 78.4 MLD, Domestic Water 82.2 MLD
	Total Design Intake Volume	Total: 176.8 MLD Industrial Water: 90.5 MLD, Domestic Water 86.3 MLD

Source: JICA Survey Team

River Water Intake Basic Plan

4.2 Based on the above basic water supply plan, a water balance analysis was conducted to determine the design intake discharge and the required capacity of the raw water reservoir. The plan basically takes surface water from the Matamuhuri River during the rainy season as shown in the figure below. The intake water is to be pumped up and conveyed to the raw water reservoir through a pipeline, and stored and regulated in the raw water reservoir. The purified water in the water treatment plant is distributed to their respective water demand areas through water distribution pipelines.



Source: JICA Survey Team

Figure 7 : Daily Discharge and Intake Operation in Case of 1/10 Drought Year

Alternative studies were made for pipeline routes, an intake site, an intake structural type, and a raw water reservoir site to develop a basic layout plan of these facilities. The summary of the basic intake river water intake plan is compiled in the table below.

Table 5 : Basic River Water Intake Plan

Basic River Water Intake Plan	Descriptions
Conveyance Pipeline Route	・ Along the alignment of new roads (Chattogram – Cox's Bazar Bypass Road, Matarbari Port Access Road) ・ Conveyance pipeline length (L): 14 km
Intake Site	・ Matamuhuri River (left bank) at 3.7km upstream of the existing Matamuhuri River Bridge and directly upstream of the proposed Chattogram – Cox's Bazar Bypass Road Bridge
Intake Structural Type	・ Pump intake without weir ・ Design intake discharge: 2.9m^3/s, from surface water of the Matamuhuri River during rainy season only
Raw Water Reservoir Site	・ Between the intake point and Moheshkhali Economic Zone (Dhalghata) ・ Reservoir Capacity: 19.6 Million Cubic Meters (MCM)

Source: JICA Survey Team

As for a water intake type, through a series of consultation meetings with BWDB and several joint field surveys, "a pump intake type without weir" was adopted, providing some conditions of i) maintenance of river structures, and proper sediment management in the river channel and intake channels, ii) stabilization measures of bank protection works and others, and iii) a detailed hydraulic model test and analysis, which shall be performed in the succeeding detailed engineering design stage.

Water Treatment and Distribution Basic Plan

4.3 The typical water treatment process for the Project is composed of coagulation, flocculation, sedimentation, filtration, and disinfection. After discussions with BEZA, it was decided to adopt a water treatment process including filtration and disinfection for the industrial water supply of the Project as well, since the industrial type of the companies that will move in is yet to be determined and the currently planned BSMSN industrial park requires drinking water quality standards.

The domestic water supply area of 30,811 ha (population: 706,090 in 2041, and design intake volume for domestic water: 90,475 m^3/day in 2041) is divided into 6 blocks. Each block shall have an elevated water distribution tank (Distribution Reservoir: DR) and the water is planned to be distributed from the tank by gravity. The Moheshkhali EZ (Dhalghata) area (design intake volume for industrial water: 86,286 m^3/day in 2041) shall have several elevated water distribution tanks and the water is also planned to be distributed from the tanks by gravity. Four (4) hours equivalent of the maximum daily supply is applied for this water supply area and 6 (one for each 6 block of the domestic water supply area) +1 (the Moheshkhali EZ (Dhalghata) area) locations are selected as the places for the water distribution reservoirs.

Phasing for the Water Supply Project

4.4 In order to improve the efficiency of water supply and reduce project costs, a comparative evaluation of feasibility and approximate project costs was conducted for projects by cases based on the target area (Moheshkali EZ (Dhalghata), 1 Pourashava, 15 Unions) and target facilities (intake, conveyance pipeline, raw water reservoir, water treatment plant, and distribution facilities).

As a result, it was confirmed that the case in which the target areas were limited to Moheshkhali EZ (Dhalghata), Chakaria Pourashava, and Matarbari Union and all facilities were covered was the most feasible and would also be able to keep project costs low. Therefore, it was proposed to implement this case as "Phase 1 Project".

As shown in the following table for the Phase 1 Project, the total design intake volume for industrial use is 86.3 MLD, that for domestic use is 36.1 MLD, and the total intake volume is 122.4 MLD. It is proposed that the Phase 1 Project be covered by the Japanese ODA loan. (here in after referred to as "the Project".)

Table 6 : General Information of Phase 1 Project

General Information of Phase 1 Project	Target Year	2041 (Based on the Perspective Plan of Bangladesh)
	Water Supply Target Area	Moheshkhali EZ (Dhalghata), Chakaria Pourashava, Matabari Union
	Water Supply Population and Area	Estimated Water Supply as of 2041 ・Industrial Water：802 acre ・Domestic Water：Total 207,000 people (133,000 in Chakaria, 74,000 in Moheshkhali)
	Water Demand Per Capita	- Domestic Water for Pourashava: 120 lpcd - Domestic Water for Union: 62 lpcd - 7-283 m^3/acre/day by industry-wise water consumption
	Daily Maximum Production	Total: 111.2 MLD Industrial Water: 78.4 MLD, Domestic Water 32.8 MLD
	Total Design Intake Volume	Total: 122.4 MLD Industrial Water: 86.3 MLD, Domestic Water 36.1 MLD
	Water Service Fitting	Industrial Water: Individual house connection 25 nos. Domestic Water: Individual house connection 27,000 nos., Public tap connection: 250 nos.
	Intake, Raw Water Reservoir	Max intake capacity: 2.9 m^3/s Raw water reservoir volume: 19.6 MCM

Source: JICA Survey Team

V. PRELIMINARY DESIGN OF PROJECT FACILITIES

Preliminary Design of River Water Intake Facilities

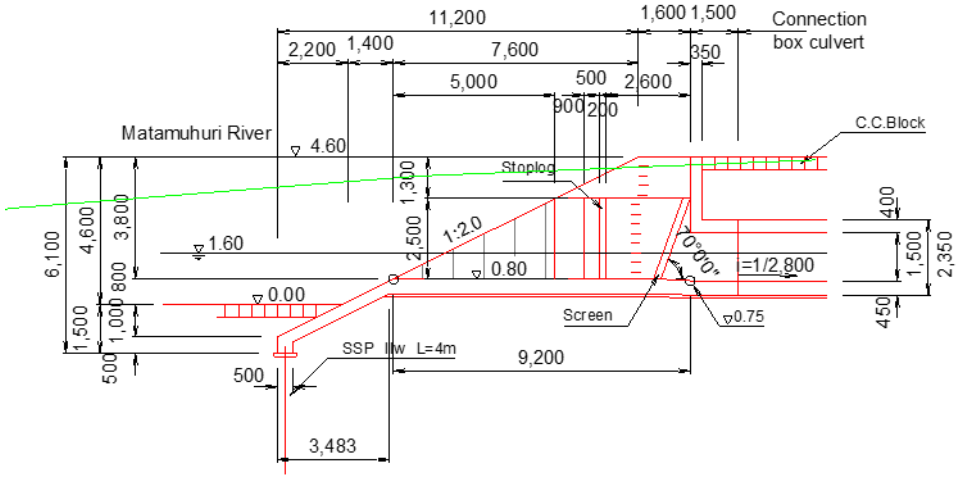
5.1 Basic requirements considered for the intake design are:

- Reliable amount of water intake,
- To secure raw water,
- Measures for disaster and protection of environment,
- Simple operation and maintenance, and
- Compliance with laws and standards.

The components of the intake facilities are:

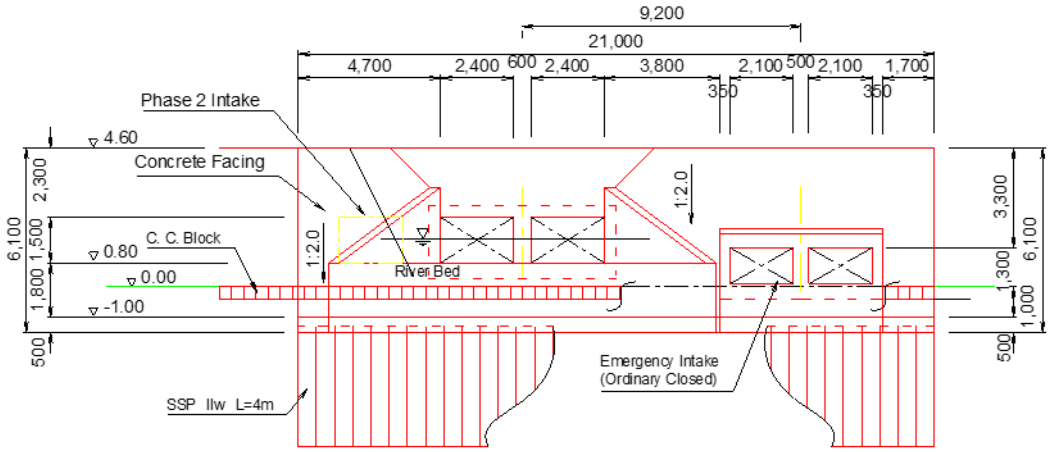
- Inlet structure,
- Stoplog,
- Screen,
- Conveyance box culvert from inlet structure to settling basin,
- Settling basin,
- Pump and pump tank,
- Gates,
- Manhole for drain from settling basin, and
- Pump control house and operator staff room.

The design intake volume is 2.9m^3/s in a normal time case, and 1.7 m^3/s in an emergency time case in deficit of river flow. The following figures show the intake structure and intake pumping station for the Project.



Source: JICA Survey Team

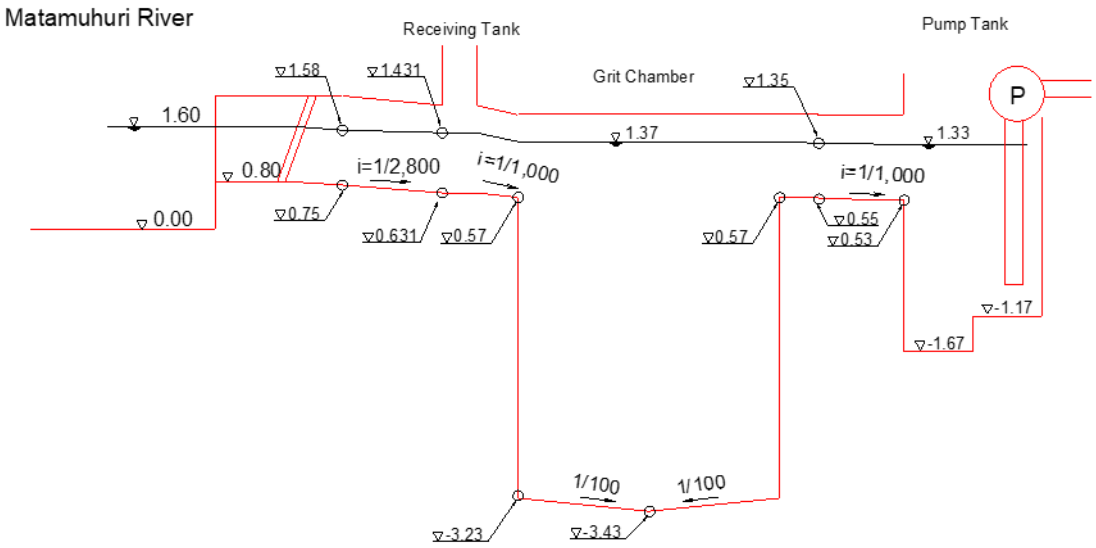
Figure 8 : Intake Profile View



Source: JICA Survey Team

Figure 9 : Intake Front View

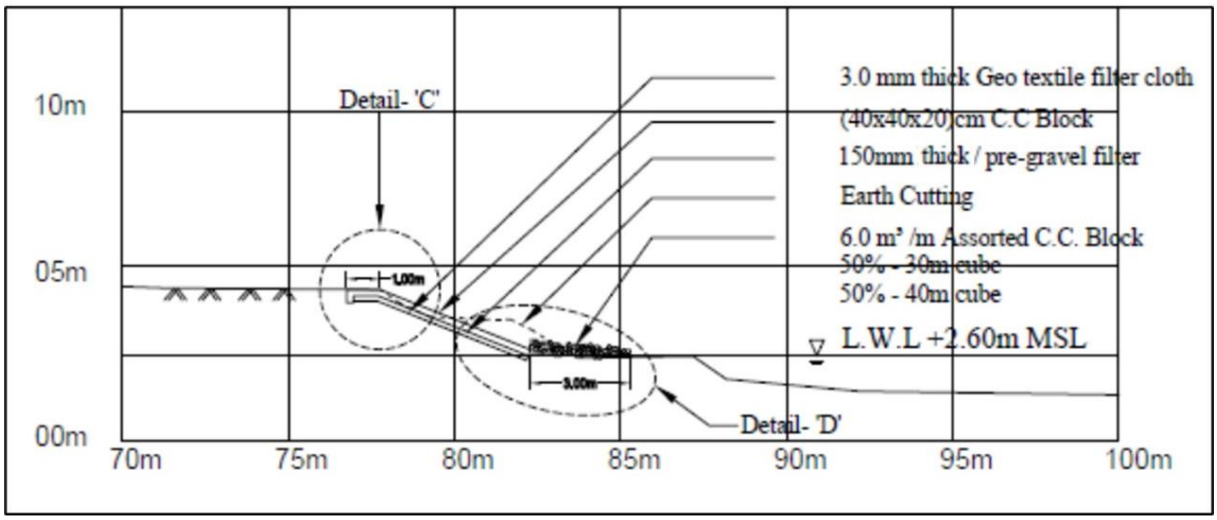
The flow diagram is shown in the following figure. As for the foundation of intake structure, its stability is confirmed by analysis, including liquefaction conditions.



Source: JICA Survey Team

Figure 10 : Flow Diagram

The bank protection work follows the NODI project plan basically. Block-laying type revetment is adopted as shown in the following figure.



Source: JICA Survey Team

Figure 11 : Typical Design of River Bank Protection Works at Intake Site

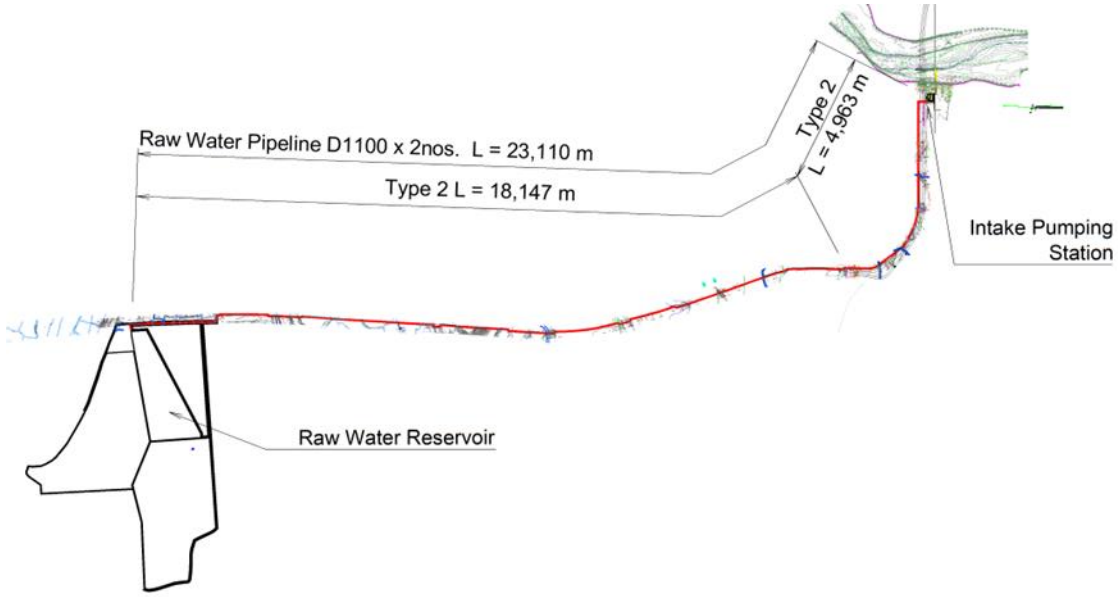
Preliminary Design of Raw Water Pipeline Facilities

5.2 The raw water pipeline is the pipeline from the intake pumping station to the receiving tank in the raw water reservoir facilities. Its dimensions/materials and location map are shown in the following table and figure.

Table 7 : Raw water pipeline dimensions and materials

Item	Dimensions	Remarks
1) Length	11,555 m x 2 series = 23,110 m	
2) Size	D1,100 x 2 series	
3) Material	Steel or ductile iron	
4) Aqueduct portion	9 sites	
5) Underground tunnel	3 sites	Construction by pipe jacking method

Source: JICA Survey Team



Source: JICA Survey Team

Figure 12 : Location Map of Raw Water Pipeline

Preliminary Design of Raw Water Reservoir Facilities

5.3 Required design conditions of the raw water reservoir (RWR) are as enumerated below.

- The total volume of the reservoir is more than the required volume of 19.6 MCM (the water supply for industrial and domestic water for target area).
- To divide the reservoir area into several lots for maintenance including sand removal and security in the reservoir,
- Each lot shall not affect the other lots in water inflow and the outflow to the water treatment plant (WTP).
- To install spillway, local drainage channel, and bottom sluice gate/pipe facilities
- To consider measures against salt water intrusion, if necessary,
- The design reservoir water depths are 6.0 m (5.0 m effective raw water depth and 1.0 m sediment depth) in No.1 and No.2 reservoirs and 6.5 m (6.0 m effective depth and 0.5 m sediment depth) in No. 3 and No.4 reservoirs.
- To set spoil bank sites for maintenance dredging/excavation in RWR and sludge from WTP,
- To set access roads to the reservoir site and into reservoirs (slope roads) for removing sediment,
- The outlet position is to be far from the inlet position to avoid occurrence of dead water areas as far as possible.
- WTP is set adjacent to the reservoir. And
- Resettlement due to construction of the reservoir is to be minimized.

The following figure shows 4 lots divided in RWR and a spoil bank. RWR is classified into two groups, namely, first reservoirs: Reservoirs No.1 and No.2, and second reservoirs: Reservoirs No.3 to No.4. The first reservoirs have functions of water storage and sedimentation, and the second ones have mainly a water storage function. Each lot reservoir volume is shown in the table below.

Table 8 : Reservoir Storage Volume

Unit : MCM

Reservoir No.	1	2	3	4
Storage Volume	First Reservoirs		Second Reservoirs	
	2.4	2.4	7.4	7.4
Sub-Total	4.8		14.8	
Total	19.6			

Source: JICA Survey Team

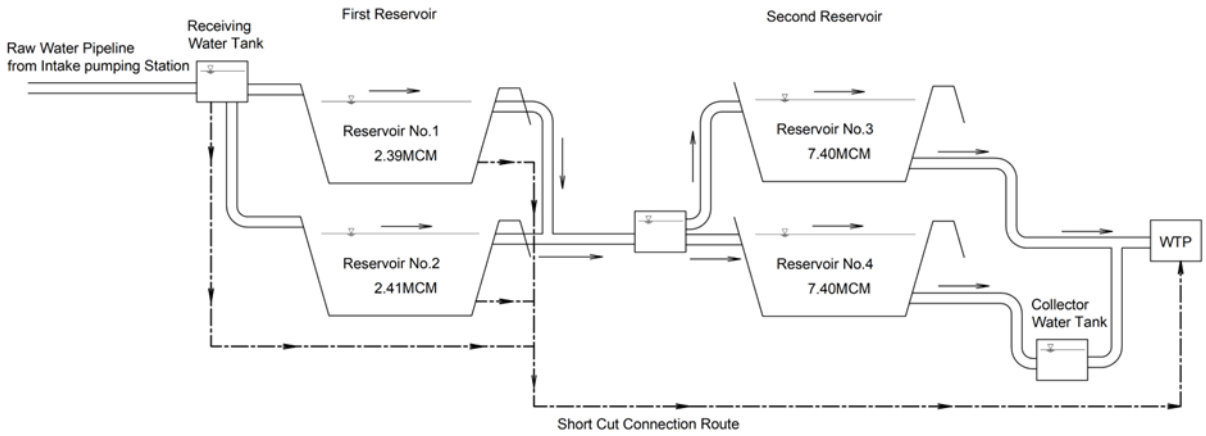


Source: JICA Survey Team

Figure 13 : Plan of Raw Water Reservoir and Spoil Bank

The following figure explains the water flow diagram of the reservoirs.

The raw water from the intake pumping station flows into the receiving water tank first, and then flows into Reservoirs No.1 or No.2 (first reservoirs). The water in Reservoirs No.3. and No.4 is stocked from the flow of first reservoirs and sent to WTP. If second reservoirs are empty, the water of first reservoirs flows into WTP directly.

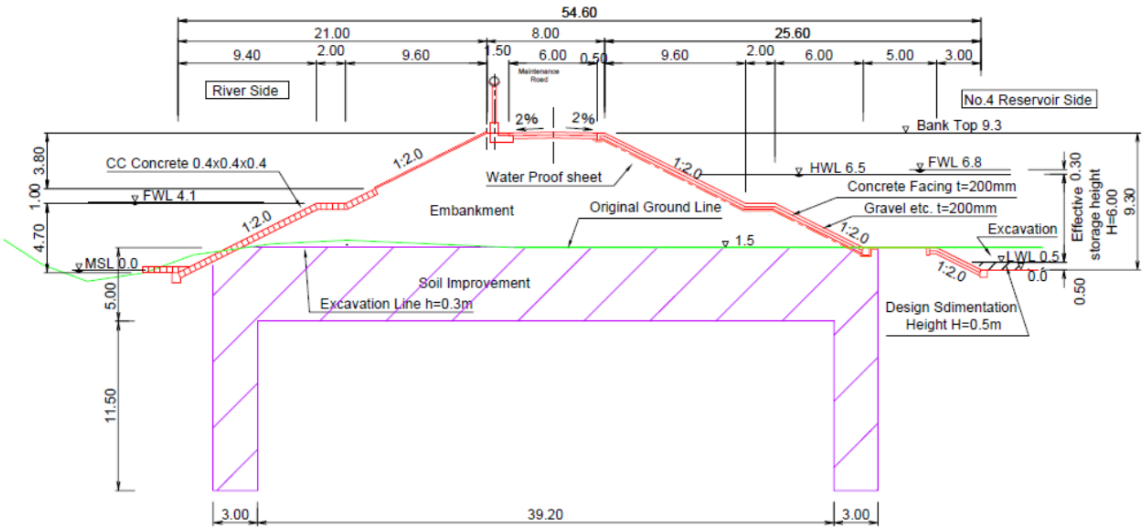


Source: JICA Survey Team

Figure 14 : Water Flow Diagram in Reservoir

The foundation of the embankment in and around the reservoir area needs soil improvement, because of the soft soil lying in the foundation, based on the geological survey conducted in the Preparatory Survey. Soil improvement can be largely separated into 2 methods; namely 1) a consolidation drain method or soil compaction method, and 2) a soil mixing method.

The construction cost of "1)" is cheaper than that of "2)". The effect of "2)" is higher than that of "1)". In the Project, "2) a soil mixing method" is selected for the soil improvement, as shown in the following figure.



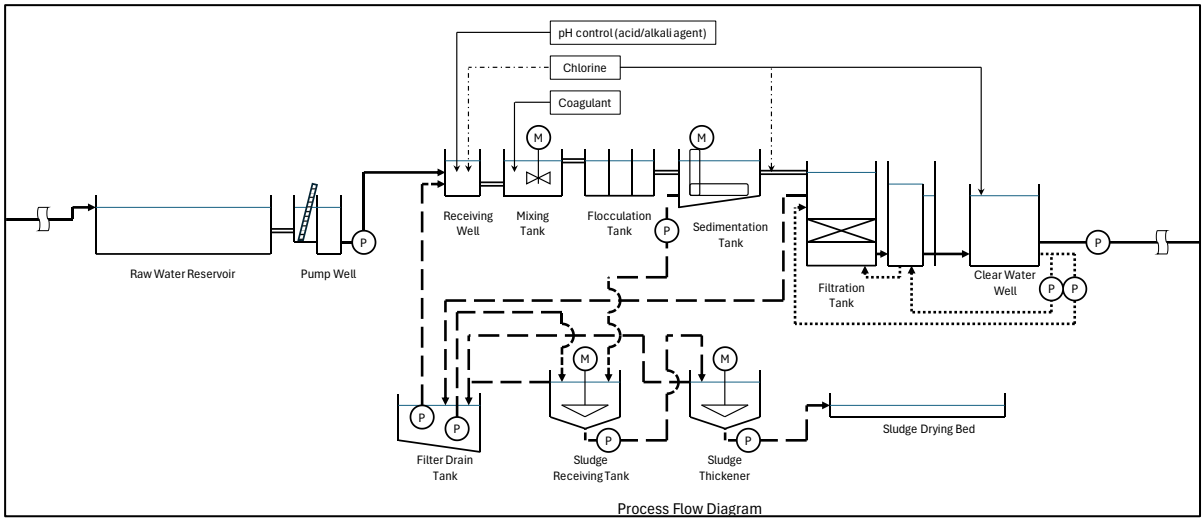
Source: JICA Survey Team

Figure 15 : Calculation results

In flooding and/or even river water flowing into RWR under full water level conditions of the reservoir, the reservoir water shall flow out into the river safely through a spillway. The reservoir embankment is confirmed to be safe from seepage, consolidation settlement and liquefaction through several analyses. Each lot of reservoir is surrounded by the embankment which has 6 m width roads, such as periphery roads and maintenance roads. WTP is located at the corner of reservoir area and along the Matarbari Port Access Road. The spoil bank shall be provided with a dry bed system in order to dry the sludge from WTP.

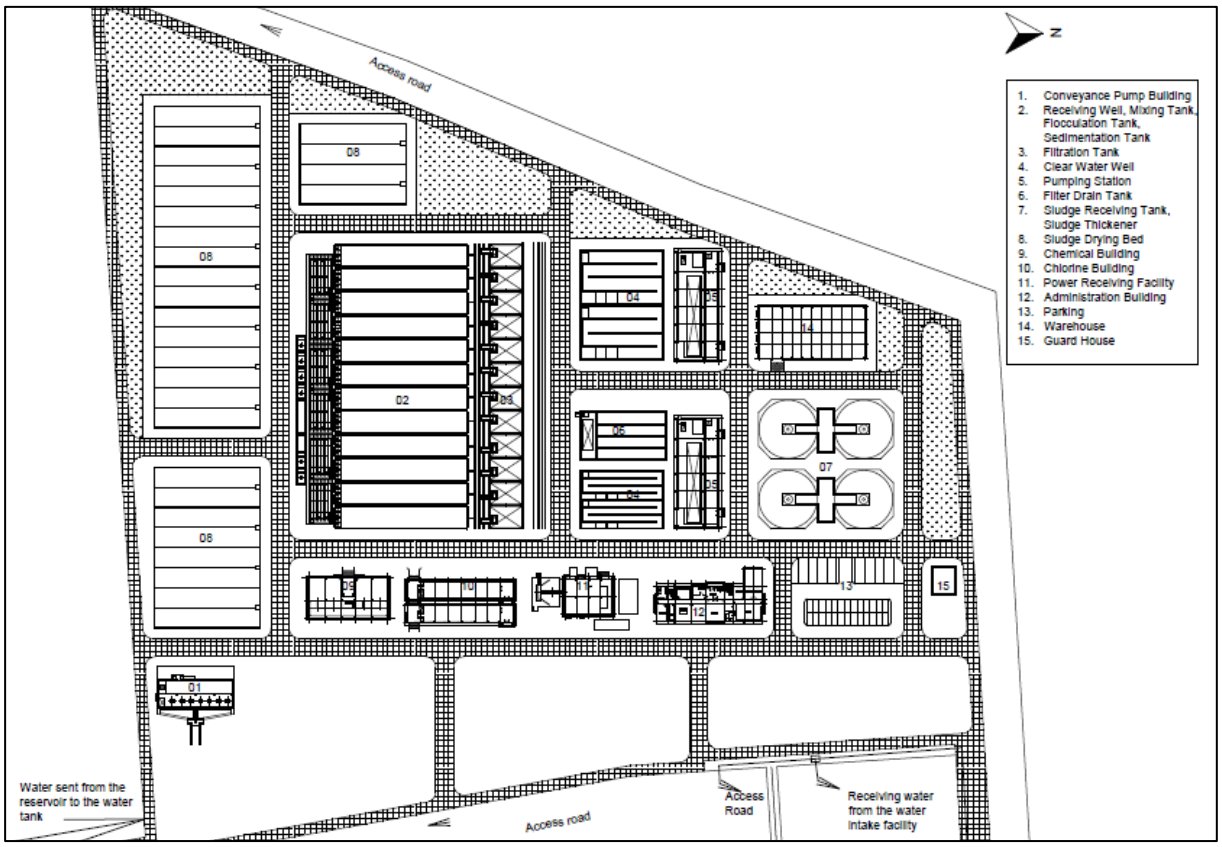
Preliminary Design of Water Treatment Facilities

5.4 The capacity of the water treatment plant is 111.2MLD in total (78.4MLD for industrial water and 32.8MLD for domestic water). The process flow diagram and general plot plan for water treatment facilities are shown below.



Source: JICA Survey Team

Figure 16 : Process Flow Diagram



Source: JICA Survey Team

Figure 17 : General Plot Plan

The water treatment facilities are designed with due consideration for the following:

- The water treatment facilities are divided largely into 2 trains, one is for industrial water and the other for domestic water.
- Each facility in each train is divided into multiple sections. And
- The capacities of individual facilities for industrial and domestic water are almost the same with each other in consideration of compatibility.

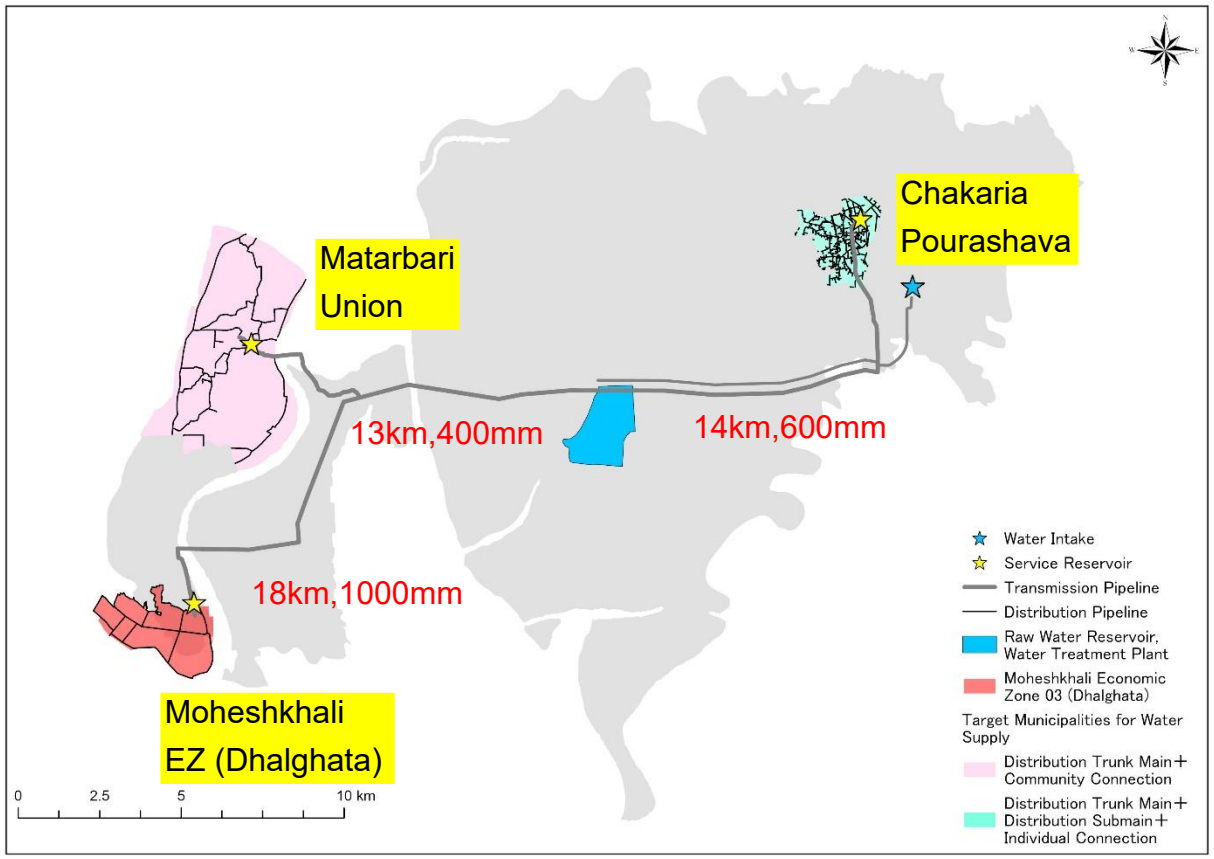
Preliminary Design of Water Transmission Facilities

5.5 As the treated water transmission facilities to convey the water from the water treatment plant to the service reservoir, these facilities are designed as follows:

Table 9 : Specifications of the Water Transmission Pipelines

No.	Target Area	Specifications
1	Chakaria Pourashava	D 600 mm, L=14 km
2	Matarbari Union	D 400 mm, L=13 km
3	Moheshkhali EZ (Dhalghata)	D 1000 mm, L=18 km

Source: JICA Survey Team



Source: JICA Survey Team

Figure 18 : Outline of Water Transmission Facilities

5.6 A double or single suction volute pump, which has a large capacity and high efficiency, and is one of the most major types is to be applied for the transmission pumps. Each pump flow is basically fixed and operated by the water level of each DR. The details of countermeasures for water hammer are to be provided in the next project stage.

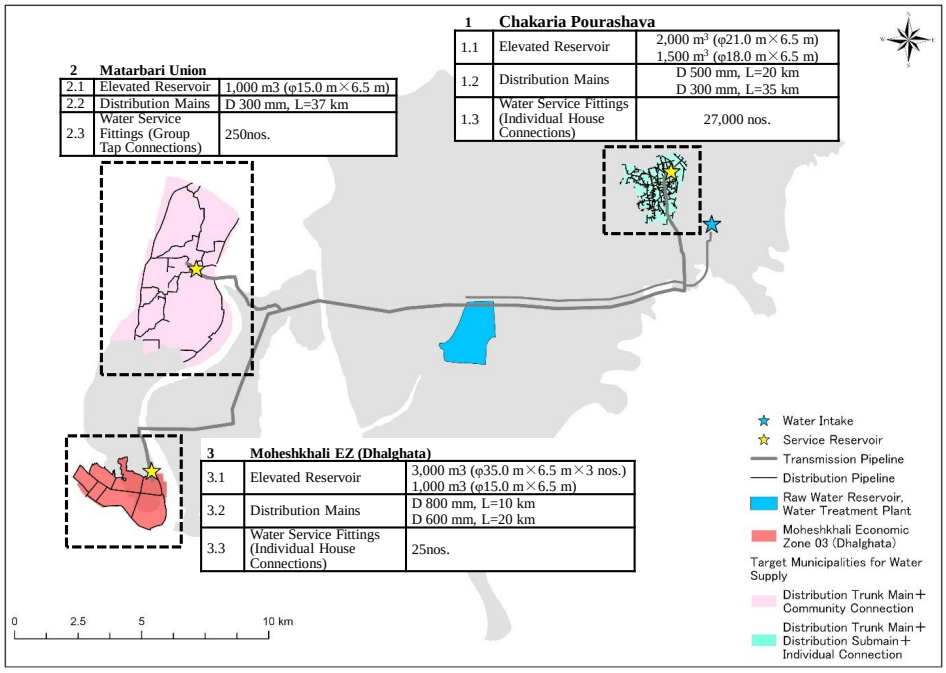
Preliminary Design of Water Distribution Facilities

5.7 As the treated water distribution facilities which have functions of storage, transmission, distribution and supply of the treated water, the facilities are designed as follows:

Table 10 : Specifications of the Water Distribution Facilities

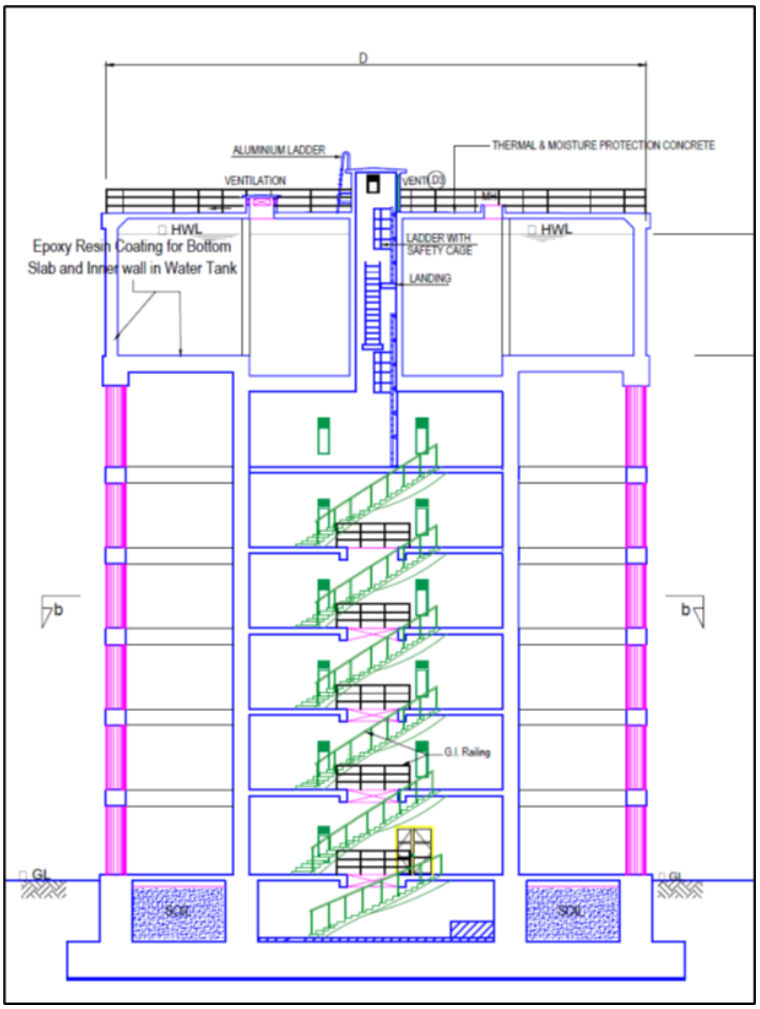
No.	Target Area and Facility	Specifications
	Chakaria Pourashava	
1.1	Elevated Reservoir	2,000 m^3 (ϕ 21.0 m×6.5 m) 1,500 m^3 (ϕ 18.0 m×6.5 m)
1.2	Distribution Mains	D 500 mm, L=20 km D 300 mm, L=35 km
1.3	Water Service Fittings (Individual House Connections)	27,000 nos.
	Matarbari Union	
2.1	Elevated Reservoir	1,000 m^3 (ϕ 15.0 m×6.5 m)
2.2	Distribution Mains	D 300 mm, L=37 km
2.3	Water Service Fittings (Group Tap Connections)	250 nos.
	Moheshkhali EZ (Dhalghata)	
3.1	Elevated Reservoir	3,000 m^3 (ϕ 35.0 m×6.5 m×3 nos.) 1,000 m^3 (ϕ 15.0 m×6.5 m)
3.2	Distribution Mains	D 800 mm, L=10 km D 600 mm, L=20 km
3.3	Water Service Fittings (Individual House Connections)	25 nos.

Source: JICA Survey Team



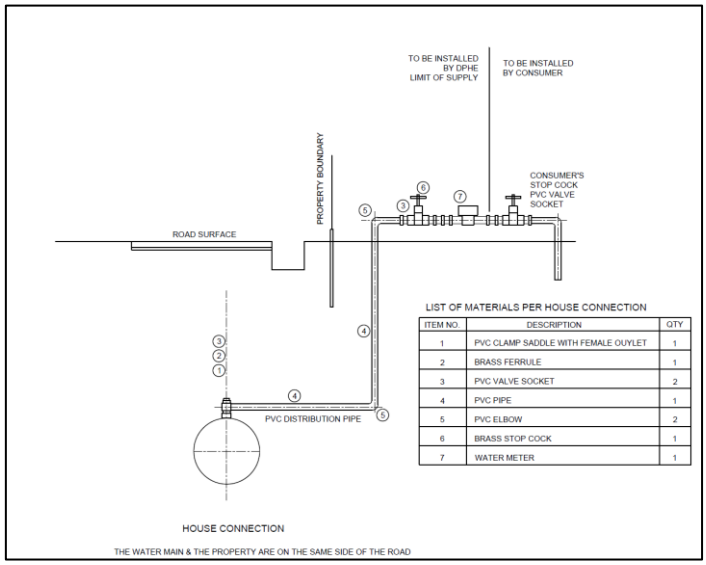
Source: JICA Survey Team

Figure 19 : Outline of Water Distribution Facilities



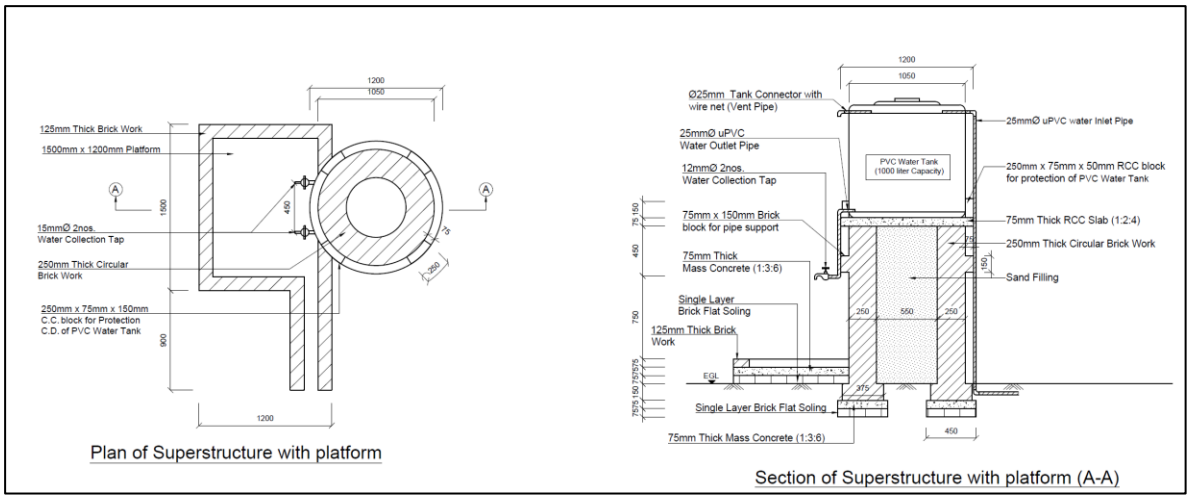
Source: JICA Survey Team

Figure 20 : Typical Drawing of Elevated Reservoir



Source: JICA Survey Team

Figure 21 : Typical Drawing of Individual House Connection



Source: JICA Survey Team

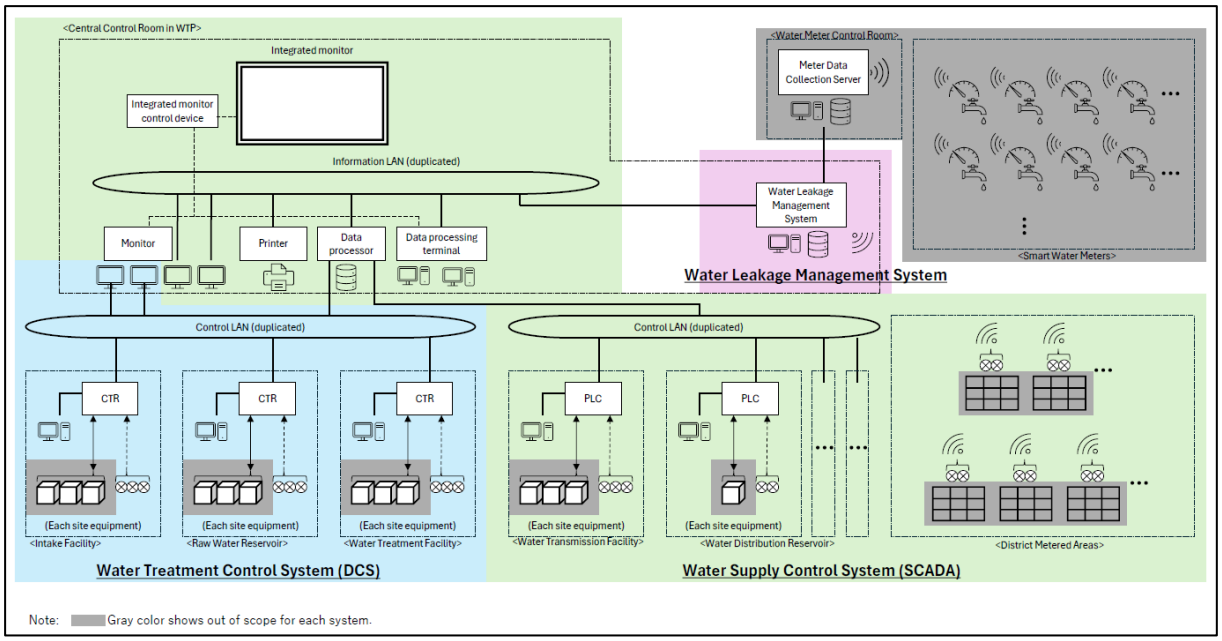
Figure 22 : Typical Drawing of Group Tap Connection

Digital Systems

5.8 Digital Systems are usually prepared to secure efficiency and ensure the water supply management. The systems for the Project are configured with the following 3 systems:

- Water Treatment Control System: to supervise and control the Intake Facility, the Raw Water Reservoir Facility and the Water Treatment Plant Facility involved in the water treatment process,
- Water Supply Control System: to supervise and control the Water Transmission Facility, the Water Distribution Facility, and the Water Distribution Pipeline involved in water distribution and supply, and
- Water Leakage Management System: to monitor water leakage by collecting and analyzing data such as flow rate and pressure at District Metered Areas (DMAs) and water meter data which is transmitted from smart meters installed at each water supply point.

The system configuration diagram is shown below. In the figure, DCS, CTR, and PLC stand for Distributed Control System, Controller, and Programmable Logic Controller, respectively.



Source: JICA Survey Team

Figure 23 : System Configuration Diagram

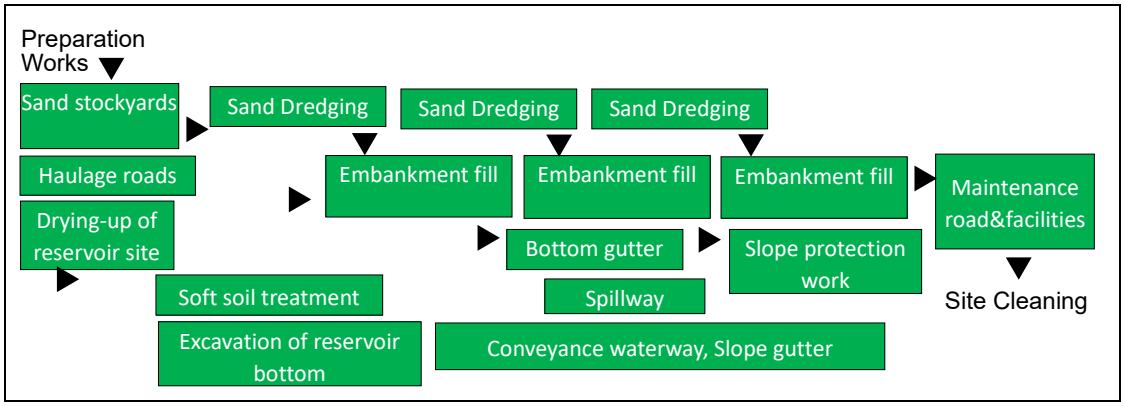
VI. PROJECT IMPLEMENTION PLAN

Construction Plan

6.1 The majority of the construction works are for an intake, conveyance and transmission pipes, a raw water reservoir, a water treatment plant, distribution reservoirs, and distribution networks.

➢ Work Procedure and Method

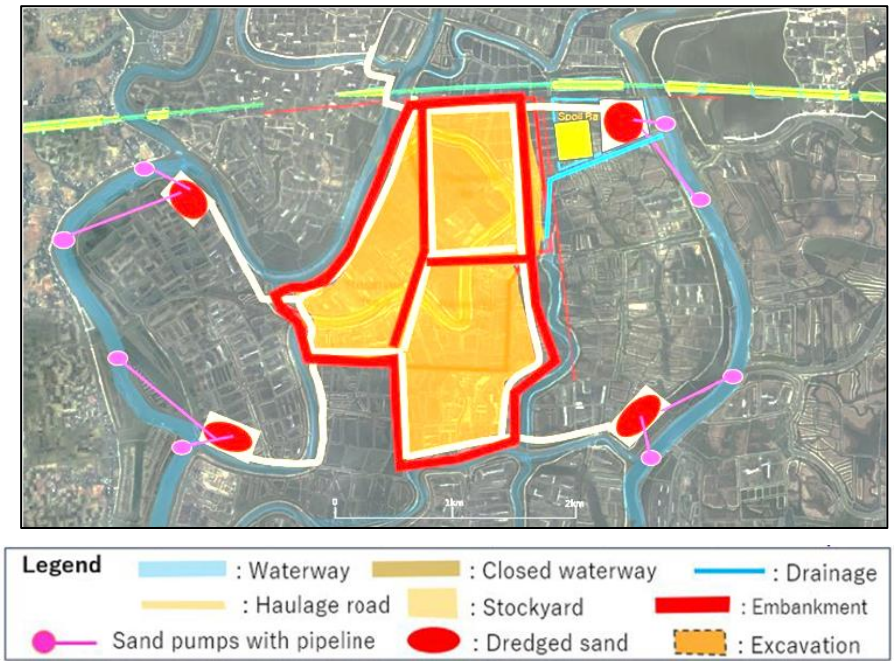
The work procedure of the raw water reservoir, which has the largest scale among the above construction works, is figured below.



Source: JICA Survey Team

Figure 24 : Work Procedure of Raw Water Reservoir

In advance of the embankment work, the river sand is dredged with dredging boats, transported to the stockyard by pipeline and stored until the use to the embankment works. The arrangement plan of sand dredging for the raw water reservoir is illustrated in the figure below.



Source: JICA Survey Team

Figure 25 : Arrangement Plan of River Sand Dredging

➢ Temporary Construction Yards and Roads

Temporary construction yards and roads are necessary for each construction site.

➢ Procurement and Transportation of Construction Goods

It is a basic approach that construction materials and machinery will be procured in Bangladesh, if available. However, it is considered difficult or impossible to obtain some goods in domestic markets. Such productions will be imported from other third countries or Japan. For example, the ductile cast-iron pipes proposed for pipelines are not produced in Bangladesh. In the case of a similar project, named "Karnaphuli Water Supply Project", the selected ductile cast-iron pipes produced in and imported from Japan were adopted. The pumps and electrical devices, which are majorly used for the water treatment plant and pump stations, may not be produced in Bangladesh, even in the project construction stage. Procurement through import is to be considered for such goods.

The construction goods which can be procured in domestic markets can be carried from Dhaka City or Chattogram City. They will be carried by truck or trailer through the National Highway N1 or R170 to the project site. The construction goods to be imported from other countries will be disembarked at Chittagong Port and will be carried by truck or trailer also through N1 or R170 to the project site.



Source: JICA Survey Team

Figure 26 : Inland Transportation Route of Construction Goods



Source: JICA Survey Team

Figure 27 : Access Route to Construction Site

➢ Balance of Excavated, Disposed and Borrowed Soils

Due to the existence of soft clay over the ground surface of the project site, a large portion of excavated ground soil needs to be disposed. Instead, the large volume of good soil for embankment will be necessary. In the Preparatory Survey, the balance of excavated, filled, disposed and borrowed soils related to the construction works is estimated as compiled below.

Table 11 : Balance of Ground Excavation, Disposal and Borrow by Construction Works

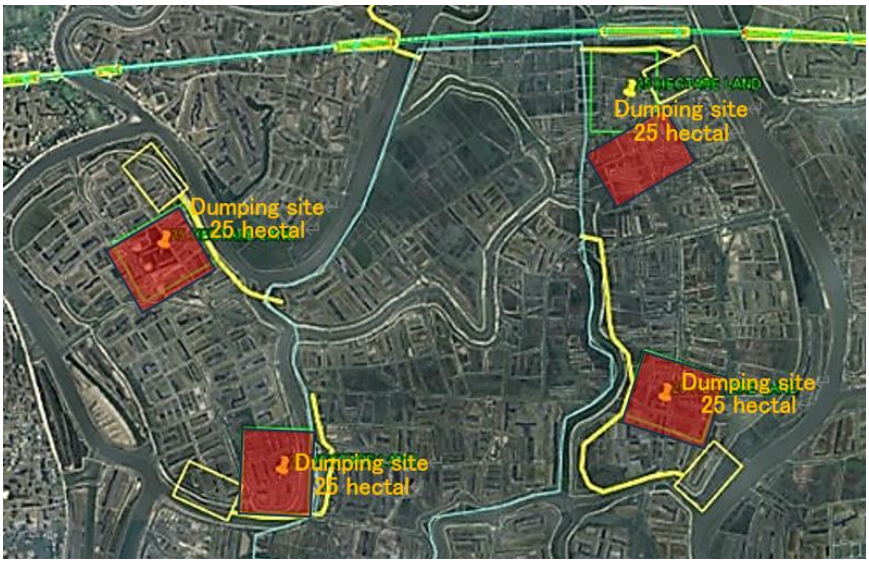
(Unit: 1,000m3)

Facility	Ground Excavation	Earth Fill by Ground Soil	Disposal of Poor/Unused Soil	Earth Fill by Borrowed / Dredged Sand
Intake	103	37	67	
Pipeline Works	336	333	4	
Raw Water Reservoir	4,312		4,312	2,745
Water Treatment Plant				400
Water Distribution Tank	2		2	
Distribution Network	255	144	112	
Total			4,497	3,145

Source: JICA Survey Team

➢ Candidates of Soil Damping Sites

The disposal soil shall be transported to the soil dumping sites. The candidates of soil dumping sites were proposed as shown in the figure below. However, it is necessary for the project implementation organization to finalize the dumping sites and inform the project consultants before their Detailed Design (D/D) cost estimate and tender document preparation.



Source: JICA Survey Team

Figure 28 : Candidates of Soil Dumping Site

➢ Safety Considerations

Construction safety shall be considered and secured certainly during the construction stage. The local regulations or acts related to industry safety and health, practically adopted for construction fields in Bangladesh, shall be adopted in principle. In addition, it is recommended to adopt "JICA Standard Safety Specifications: JSSS", issued by JICA in February 2021, which is

incorporated into the Standard Bidding Documents under the JICA ODA Loans.

The traffic safety measures shall be provided certainly during the construction stage.

From a safety aspect, the construction works in the river for an intake channel, river embankment, sand dredging, etc. cannot be accepted during the peak of rainy season.

VII. PROJECT IMPLEMENTATION AND OPERATION/MAINTENANCE SYSTEM

Project Implementation Structure before/ during Construction

7.1 In May 2024 with the presence of the JICA Mission Team, the LGD Secretary specified the DPHE as the sole candidate agency to be responsible for the Project implementation, the operation and maintenance (O&M) of the constructed waterworks, and the provision of water supply service. This decision was based on the following reasons:

- The water supply service in the Project area is a mandate of the DPHE.
  The Chattogram Water Supply and Sewerage Authority (CWASA) does not have extra human resources to formulate and implement a new project. And
- The DPHE has experiences in the O&M of waterworks and the water supply services, including the billing and collection of water tariff, e.g., the water supply service in Mongla Port.

7.2 Regarding the setting up of a project management unit (PMU), the Planning Guideline of the DPHE stipulates that a separate development project proforma (DPP) means to create a separate PMU, i.e., every DPP needs to have a separate PMU. Three DPPs are assumed to be prepared for the Project, and corresponding project implementation structure will be established, i.e.,

- DPP-1 : prepared by the DPHE on the land acquisition plan (LAP) and the resettlement action plan (RAP) as well as the environmental management plan (EMP) and the environmental monitoring plan (EMoP) for all the contract packages (CPs);
- DPP-2 : prepared by the DPHE for construction of the water treatment plant in the South Chattogram Region (SCRWTP) and transmission & distribution facilities (CPs-2, 4, 5, 6, and 7); and
- DPP-3 : prepared by the BWDB for construction of the water intake, raw water reservoir, and conveyance & transmission facilities (CPs-1 and 3).

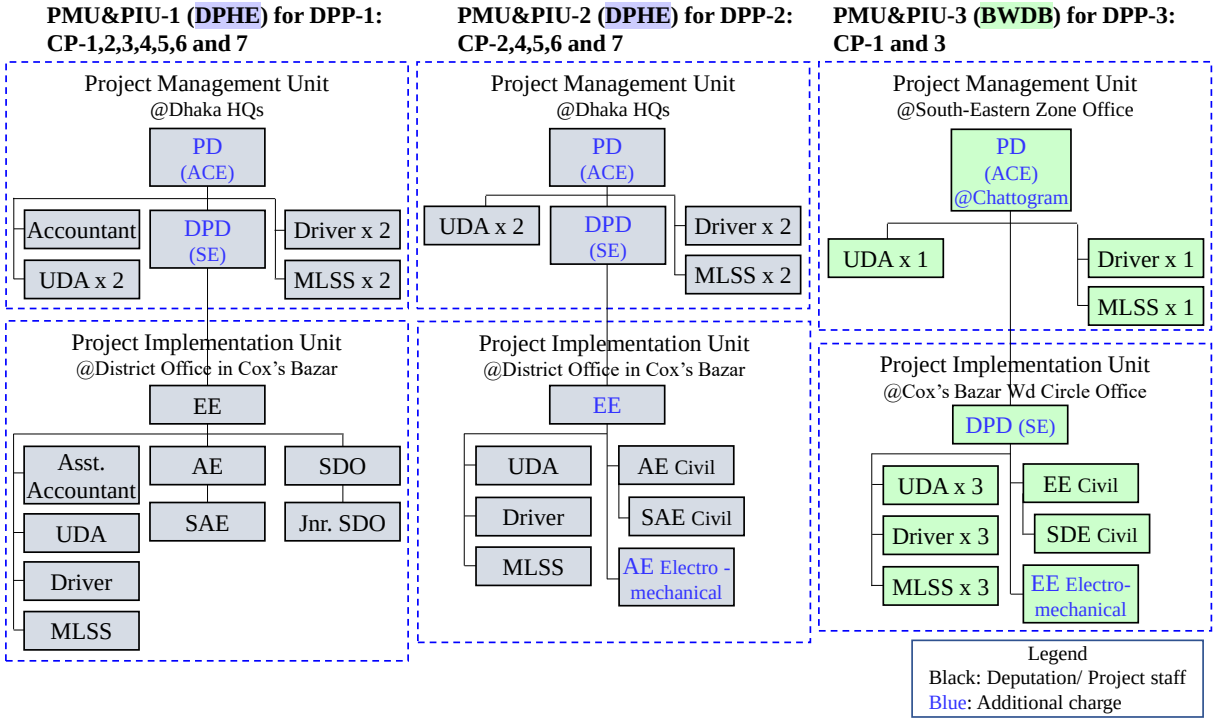
7.3 The organizations for the implementation of the Project to be sequentially established are as follows.

- The Project Coordination Committee (PCC), organized in the DPHE on 7th July 2024 by the Office Order issued by the Chief Engineer (CE) of the DPHE, and to be

established in the BWDB, are engaged in the coordination with related organizations and the preparation of the DPPs.

- After getting the approval of the three DPPs, the Project Steering Committee (PSC) headed by the Secretary of the LGD will be established to regularly monitor the implementation of all the contract packages of CPs-1 to 7.
- The Project Implementation Committees (PICs), headed by the CE for the DPHE and the Director General (DG) for the BWDB will be established for the internal coordination and monitoring of CPs-2, 4, 5, 6, and 7 in the DPHE and CPs-1 and 3 in the BWDB, respectively.
- The PICs will officially recruit/ assign the members of (i) the PMUs in the HQs of the DPHE and in the South-Eastern Zone Office of the BWDB, and (ii) the Project Implementation Units (PIUs) in the District Office of the DPHE and in the Water Development Circle Office of the BWDB. The staff will be assigned as either the additional charge or the deputation/ project staff.

7.4 The organization structure of each PMU and PIU (PMU-1 & PIU-1 for DPP-1, PMU-2 & PIU-2 for DPP-2, and PMU-3 & PIU-3 for DPP-3) is proposed at the stage of D/D as shown in the figure below. The total numbers of staff to be assigned to PMU-1 & PIU-1, PMU-2 & PIU-2, and PMU-3 & PIU-3 will be 18, 15, and 17, respectively.

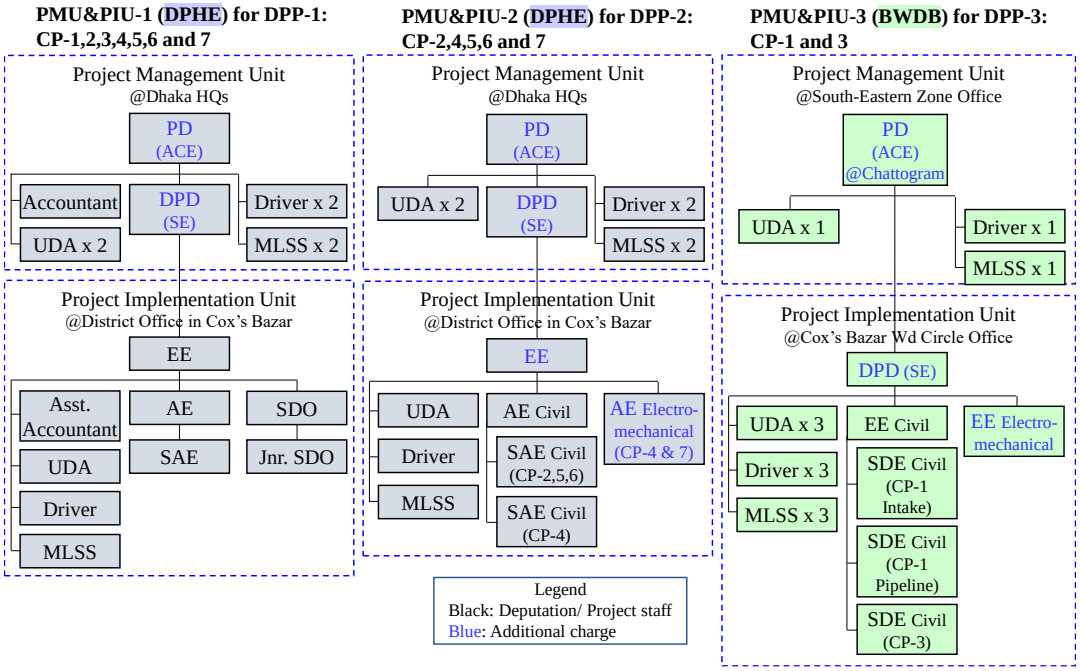


Note: PD: Project Director; DPD: Deputy Project Director; CE: Chief Engineer; ACE: Additional Chief Engineer; SE: Superintendent Engineer; EE: Executive Engineer; SDE: Sub-Divisional Engineer; AE: Assistant Engineer; SAE: Sub Assistant Engineer; SDO: Social Development Officer; Jnr.SDO: Junior Social Development Officer; UDA: Upper Divisional Assistant

Source: JICA Survey Team

Figure 29 : Proposed Structure of PMU and PIU at Detailed Design Stage

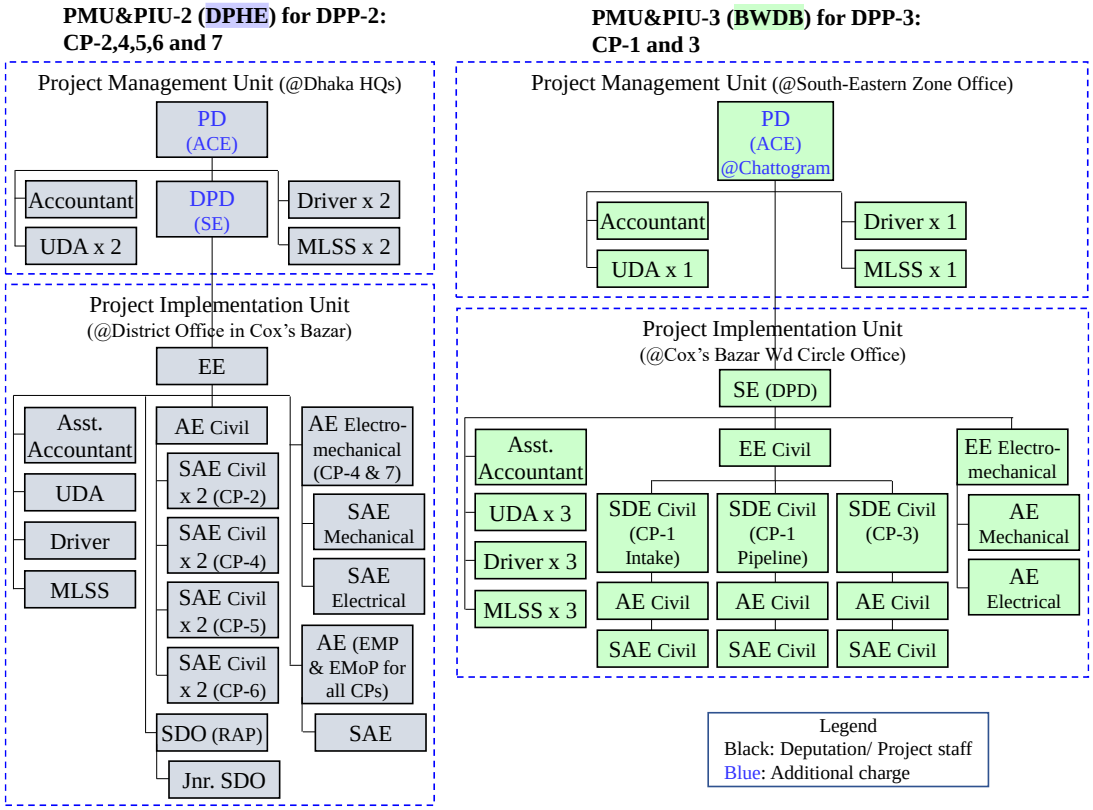
7.5 The organization structure of each PMU and PIU proposed at the stage of tendering is shown in the figure below. The total numbers of staff to be assigned to PMU-1 & PIU-1, PMU-2 & PIU-2, and PMU-3 & PIU-3 will be 18, 16, and 19, respectively.



Source: JICA Survey Team

Figure 30 : Proposed Structure of PMU and PIU at Tendering Stage

7.6 The organization structure of each PMU and PIU at the stage of construction is proposed in the figure below. At the construction stage, PMU-1 & PIU-1 will be dissolved and the remaining follow-up and monitoring work regarding RAP, EMP, and EMoP for all the project components will be taken over to PMU-2 & PIU-2. The total numbers of staff to be assigned to PMU-2 & PIU-2 and PMU-3& PIU-3 will be increased to 30 and 29, respectively.



Source: JICA Survey Team

Figure 31 : Proposed PMU and PIU Structure at Construction Stage

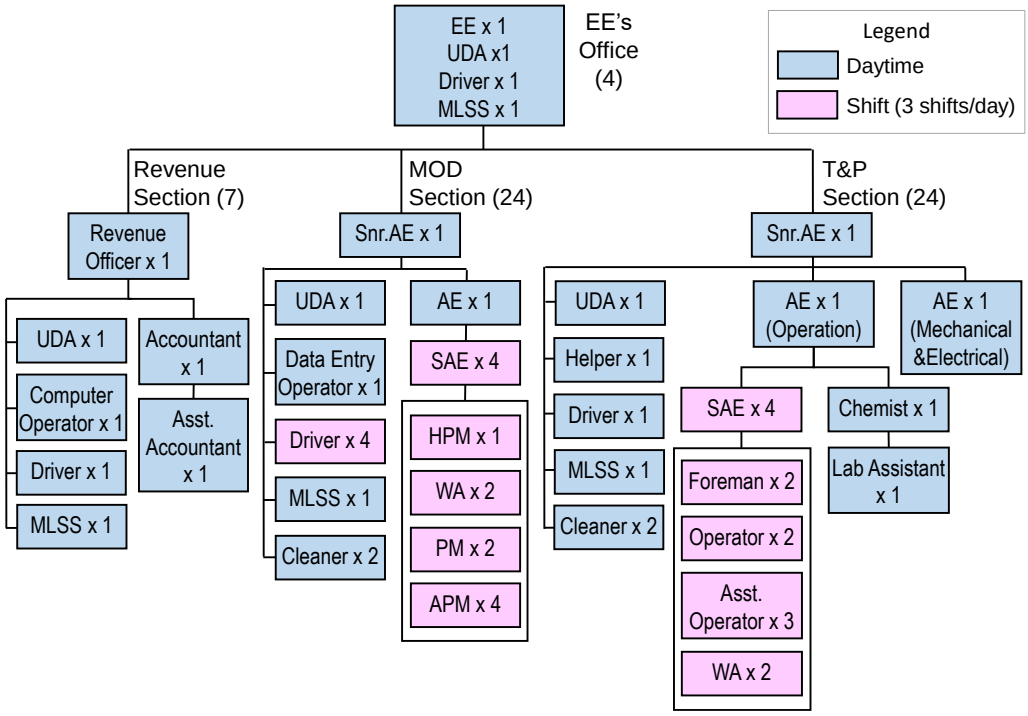
Operation and Maintenance System

7.7 The DPHE is planning to establish a new division "Moheshkhali and Matarbari Division" for the O&M of the waterworks of the Project and the billing and collection of water tariff under the Cox's Bazar District Office in the Chattogram Circle of the DPHE. The creation of 3 sections in this division is proposed, namely (i) Revenue Section, (ii) Maintenance, Operation, and Distribution (MOD) Section, and (iii) Treatment and Production (T&P) Section. The number of necessary staff is calculated as 116, but it may be reduced to 59 as shown in the next figure through (a) introducing smart meters and an automatic meter reading and billing system; and (b) outsourcing security guards in the MOD/ Revenue office building, intake & raw water pumping station and WTP & transmission pumping station, in addition to the outsourcing of the following tasks:

- Maintenance and repair of valves; chemical dosing pumps, submerged scrapers, and chlorine feeding system; electrical equipment (including diesel generators)
- Removal of silt and sediment from intake channel, flocculator, clarifier, chemical mixing tanks, etc. and cleaning of bushes and weeds
- Dredging of the Matamuhuri River in front of the water intake, which is assumed to be conducted by the BWDB by means of deposit work from the DPHE

7.8 Among these 59 staff, 55 personnel except 4 officers (1 EE, 2 Snr. AE, and 1 Revenue Officer) should be newly recruited because there are no corresponding designations in the DPHE that can exercise needed expertise or there is a lack of extra personnel. The normal recruitment procedure in governmental agencies is as follows, and it should be noted that usually it takes more than 2 years as has been recently observed in CWASA.

- Revision of the Organogram and the Employees Service Regulations of DPHE/ LGD and its approval by the Minister to include new designations and to define their grade, age limit for direct appointment, recruitment system, and qualification
- Vacancy announcements through newspapers and other media
- Evaluation of submitted application forms followed by paper exam and viva voce exam



Source: JICA Survey Team

Figure 32 : Reduced Staffing in Moheshkhali and Matarbari Division of DPHE

Capacity Assessment of DPHE and Capacity Development Roadmap

7.9 Currently, the DPHE has 7,052 staff approved in the DPHE's organogram as of June 2021, and 5,081 staff (72% of the approved staff) are currently assigned. From the viewpoint of implementing the O&M of waterworks and providing water supply service, the designations shown in the table below are lacking or their existing number of assigned staff is to be increased, and the creation of such lacking designations and the recruitment of necessary personnel are needed. The designations of employees in Bangladeshi governmental organizations are split into specialized fields and skills, and thus if such designations in charge of plumbing and operation

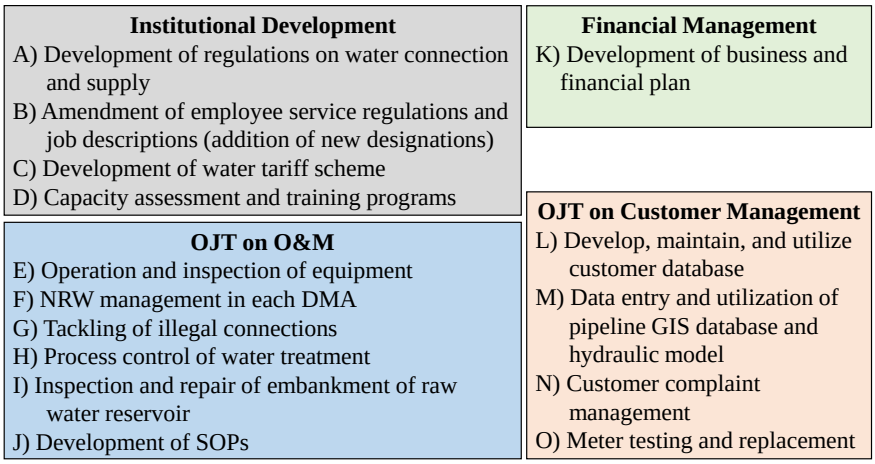
of WTP are lacking or if nobody or very small number of employees are assigned to such designations, the capacity of the DPHE to implement these works can be assessed to be currently not sufficient. Considering the status of the DPHE, the capacity of the DPHE should be developed and strengthened, particularly in the field of implementing the O&M of WTP and PS and the water distribution management.

Table 12 : Designations to be Created or Increased

Task	Designation to be created/ of which number to be increased	Notes
O&M of WTP and PS	Foreman	2 people are approved in DPHE Organogram 2021 as temporary revenue staff.
	Operator (Pump)	• 8 persons are approved as Pump Driver in DPHE Organogram 2021 as temporary revenue staff. • 3 persons are approved as Machine Operator in DPHE Organogram 2021 as newly added permanent revenue staff.
	Assistant Operator (Pump)	8 persons are approved as Assistant Pump Driver in DPHE Organogram 2021 as temporary revenue staff.
	Operator (Treatment Plant)	4 persons are approved as Treatment Plant Operator in DPHE Organogram 2021 as temporary revenue staff.
	Assistant Operator (Treatment Plant)	New designation needed and proposed.
Distribution management	Head Plumber	New designation needed and proposed.
	Plumbing mechanic	1 person is approved as Plumber in DPHE Organogram 2021 as a newly added permanent designation.
	Assistant Plumbing Mechanic	New designation needed and proposed.
	Work Assistant	New designation proposed who will support Sub Assistant Engineer (SAE) in shift working team.

Source: JICA Survey Team

7.10 The fields and items on which the DPHE needs capacity development/ strengthening to manage the waterworks of the Project and the water supply service are shown in the figure below. Fifteen (15) items are identified under four (4) categories, i.e., institutional development; on the job training (OJT) on O&M; Financial Management; and OJT on customer management.

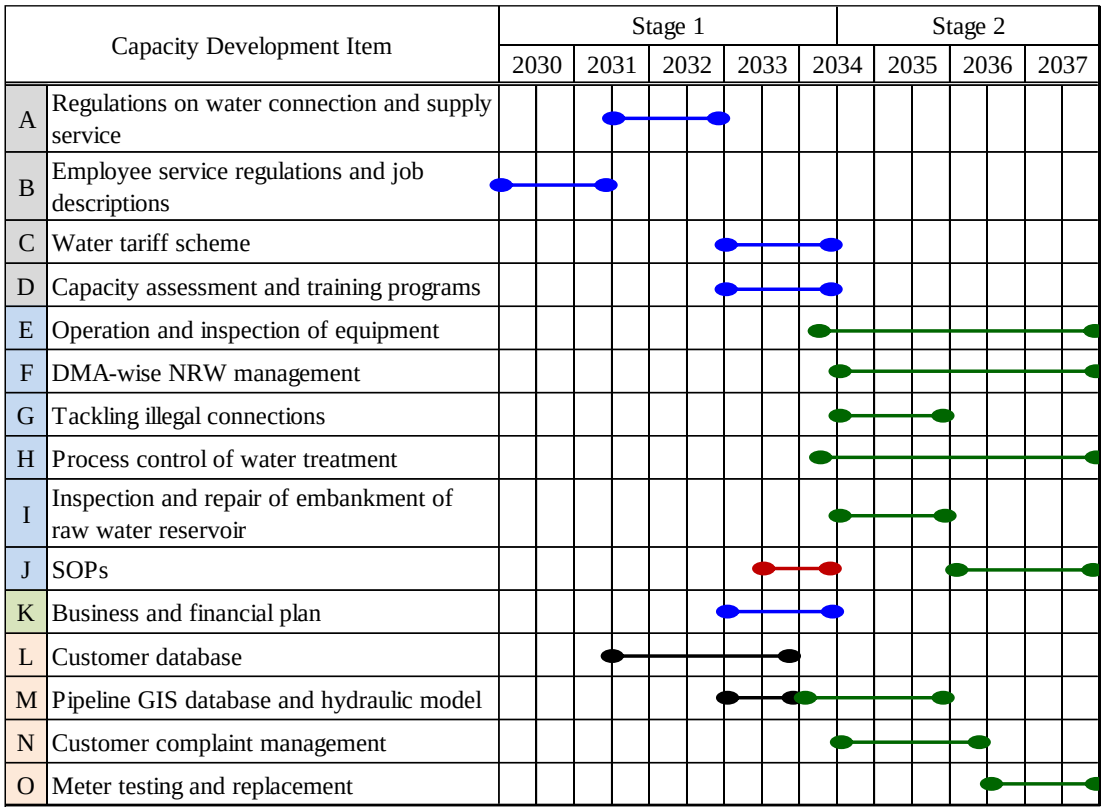


Source: JICA Survey Team

Figure 33 : Field and Items that Need Support for Capacity Develop Strengthening

7.11 For efficient and effective capacity development, it is recommended that the technical cooperation consultant should provide the DPHE with comprehensive training on the O&M of the waterworks and the management of the water supply service for a certain period such as 3-4 years after the completion of the construction. Including this, the period and implementation entity of capacity development at the following 2 stages are shown in the figure below, namely,

- Stage 1 (From January 2030 to middle of 2034 (completion period of construction work)): necessary institutional setup through dispatch of an individual JICA expert and technical preparation work to implement the O&M of the waterworks through assistance of the contractors and the yen loan consultant; and
- Stage 2 (From middle of 2034 to end of 2037): capacity development to implement the O&M of the waterworks and provide & manage the water supply service through assignment of the technical cooperation consultant.



Source: JICA Survey Team

Figure 34 : Schedule and Entity to Implement Capacity Development

Operation and Maintenance Cost and Water Tariff of the Project

7.12 The O&M cost was calculated on an annual basis regarding the cost of personnel, electricity, mechanical equipment maintenance, electrical equipment maintenance, cleaning, and dredging. The total cost and its breakdown are shown in the table below, where the total amounts to 483,780,000 Bangladesh Taka (BDT)/ year, including the contingency.

Table 13 : Annual O&M Cost

Item	Annual O&M Cost (BDT/year, including Value Added Tax (VAT) except personnel fee)	Notes
Personnel fee for O&M	16,680,000	59 employees of DPHE
Electricity fee for intake and conveyance pumps	97,670,000	Demand charge not included.
Electricity fee for WTP	149,300,000	Referred to Mohara WTP of CWASA; Demand charge not included.
Electricity fee for transmission pumps	110,980,000	Demand charge not included.
Maintenance and repair of machinery and mechanical equipment	1,000,000	• Referred to Mohara WTP of CWASA. • To be outsourced.
Maintenance and repair of electrical equipment	1,480,000	• Referred to Mohara WTP of CWASA. • To be outsourced.
Cleaning of water intake screens, inside of deck slab and channels	2,990,000	• #25, #27, and #28, Sludge Removal Units, p80, CWASA Schedule of Rates 2022; Price adjusted to 2024/2025. • Volume of debris referred to CWASA Mohara WTP. • To be outsourced.
Dredging of raw water reservoir	58,650,000	• BWDB Standard Schedule of Rates 2022 #90, #97 for Zone b; Price adjusted to 2024/2025. • Volume of earth: 3.2 km^2 x 0.5 m depth per every 10 years (every 5 years per 2 partitions of reservoir). • To be outsourced.
Dredging of earth from riverbed of Matamuhuri river	21,990,000	• BWDB Standard Schedule of Rates 2022 #90, #97 Zone b; Price adjusted to 2024/2025. • Volume of earth: 60,000 m^3/year. • Budget to be secured by DPHE and transferred to BWDB as deposit work, and actual work to be implemented by BWDB.
Total	460,740,000	
Contingency	23,040,000	• 5% of Total for procuring spare parts and chemicals and other O&M components (such as cleaning of chemical tanks and clarifier, security guarding). • Basically, to be outsourced.
Total	483,780,000	

Source: JICA Survey Team

7.13 The JICA Survey Team suggests the following water tariff based on the construction costs, operation and maintenance costs, and the implementation structure of the Project. The water tariff is to be set by the GOB.

Table 14 : Proposed Water Tariff of the Project

Type of Consumer	Monthly Tariff (BDT/m3)	% of Connection	Enrollment Fee per connection (BDT)	Connection cost per connection (BDT)	Coefficient
Municipalities					
Residential (Normal) Connection	15	81%	200	2,000	1
Low-income Consumer	11	12%	200	1,000	0.7
Institutional Consumer	23	3%	200	3,000	1.5
Commercial Consumer	30	4%	200	10,000	2
EZ	57 (+5%*)	100%	-	20,000	-

*Note: 5% will be paid to BEZA as a service charge.
Source: JICA Survey Team

The O&M costs for industry will be covered by 21-23% of the revenue. The O&M costs for municipalities will be covered by 37-81% of the revenue. The ratio of water sales for EZ to cover the construction costs is 28% from 2034 to 2065 and the water tariff for EZ is not extremely high compared to water tariffs in other EZ (Bangladesh Special Economic Zone (BSEZ): USD 1 (BDT 118)/m^3, and Mongla Port (Bangladesh Export Processing Zones Authority (BEPZA)): BDT 60/m^3).

VIII. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

Environmental and Social Considerations

8.1 The Project is categorized into the red category according to the Environmental Consideration Rules (ECR) 2023 and is required to obtain environmental clearance before operation. The Terms of Reference (ToR) for Environmental Impact Assessment (EIA) was submitted to the Department of Environment (DOE) Cox's Bazar Office on 16 July 2024 (the Cox's Bazar Office forwarded the ToR to the DOE Headquarters) and was approved by the Environment Clerance Committee on 20 August 2024. The draft EIA was submitted to the DOE Cox's Bazar Office on 12 September 2024. The stakeholder meetings in accordance with the ECR 2023 were not held within this Preparatory Survey.

8.2 The results of Environmental Impact Assessment (Construction Phase) are summarized in the table below.

Table 15 : Results of Environmental Impact Assessment (Construction Phase)

Project component	Notable construction features	Notable environmental condition	Notable expected impacts
Intake facility	・ Dredging ・ River bank protection	Inside Matamuhuri river	・ Water pollution (Turbidity) ・ Waste (Dredged soil) ・ Ecosystem in the river
Conveyance/ Distribution pipeline	・ Open cut ・ Pipe jacking ・ Resettlement	・ Along Matarbari road and CC road ・ Near Fashiakali Wildlife sanctuary	Impact to ecosystem in the Fashiakali Wildlife Sanctuary (Asian Elephant)
Raw water reservoir and Watet Treatment Plant	・ Embankment ・ Excavation ・ Dredging ・ Soft soil treatment ・ Land acquisition	・ Shrimp and Salt farming area ・ Soft ground ・ Near water way	・ Water pollution (Turbidity) ・ Waste (excavated soil) ・ Loss of business ・ Land subsidence
Distribution reservoir	・ Resettlement	-	Resettlement
Others	-	-	Create job

Source: JICA Survey Team

8.3 The Environmental Management Plan (Construction Phase) is summarized in next page.

Table 16 : Environmental Management Plan (Construction Phase)

Project component	Notable expected impacts	Mitigation Measures
Intake facility	Water pollution (Turbidity)	・ Keep all stockpiles of erodible materials covered with tarpaulins ・ Install and regularly maintain sediment traps in site runoff channels ・ Arrange work site drainage to prevent concentration of surface runoff in the vicinity of exposed soils
	Waste (Dredged soil)	・ Daily on-site observation ・ Waste storage and segregation areas should be arranged
	Ecosystem in the river	・ Disposal of construction materials are also prohibited in the Matamuhuri River as well as the adjacent waterbodies in and around the project location to protect fisheries and aquatic environment
Conveyance/Distribution pipeline	Impact to ecosystem in the Fashiakali Wildlife Sanctuary (Asian Elephant)	・ Cutting of trees will be undertaken as per approved design and only upon approval. Avoid cutting of trees as much as possible and minimize damage to native vegetation. ・ Establish animal path (width of this path would be of 12 meters at least) inside of buffer zone of Fasiakhali WS, that would be compatible with mitigation measure, taken within Asian Development Bank (ADB)-financed railway project (note: one active crossing elephant crossing point is identified around the project site).
Raw water reservoir and Watet Treatment Plant	Water pollution (Turbidity)	・ Keep all stockpiles of erodible materials covered with tarpaulins ・ Install and regularly maintain sediment traps in site runoff channels ・ Arrange work site drainage to prevent concentration of surface runoff in the vicinity of exposed soils
	Waste (excavated soil)	・ Use as backfill materials for low-laying areas ・ Daily on-site observation ・ Waste storage and segregation areas should be arranged
	Loss of business	・ Transfer grant, reconstruction grant and business restoration grant which is given based on the scale of the affected business. ・ Wage laborers who have been working on the salt and shrimp farms for over 10 years, will be eligible for training on Income Generating Activities and capital support after the training.
	Land subsidence	・ Establish proper anti subsidence measures (e.g., implementation of extra-banking for embankment).
Distribution reservoir	Resettlement	・ Compensation for land and structure acquisition will be done in accordance with the ARIPA 2017*. Additionally, resettlement benefits and livelihood restoration will be provided following the JICA Environmental Guidelines.
*Acquisition and Requisition of Immovable Property Act (ARIPA)		

Source: JICA Survey Team

8.4 The results of Environmental Impact Assessment (Operation Phase) are summarized in the table below.

Table 17 : Results of Environmental Impact Assessment (Operation Phase)

Project component	Notable O&M features	Notable environmental condition	Notable expected impacts
Intake facility	・ Dredging	Inside Matamuhuri river	Waste (Dredged soil)
Conveyance/ Distribution pipeline	-	・ Along Matarbari road and CC road ・ Near Fashiakali Wildlife sanctuary	–
Raw water reservoir and Watet Treatment Plant	・ Sludge from water treatment ・ Sediment in reservoir	・ Shrimp and Salt farming area ・ Soft ground ・ Near water way	Waste (Sludge and Sediment)
Distribution reservoir	-	-	-
Others	-	-	・ Clean water supply ・ Contribution to development of MIDI area

Source: JICA Survey Team

8.5 The Environmental Management Plan (Operation Phase) is summarized in the table below.

Table 18 : Environmental Management Plan (Operation Phase)

Project component	Notable expected impacts	Mitigation Measures
Intake facility	Waste (Dredged soil)	・ Ensure that appropriate waste management procedures for all components of the solid waste stream are specified in each facility's operations and maintenance manual ・ Follow Solid Waste Management Rules 2021 to ensure proper waste management
Conveyance/ Distribution pipeline	–	-
Raw water reservoir and Watet Treatment Plant	Waste (Sludge and Sediment)	・ Ensure that appropriate waste management procedures for all components of the solid waste stream are specified in each facility's operations and maintenance manual ・ Follow Solid Waste Management Rules 2021 to ensure proper waste management
Distribution reservoir	-	-

Source: JICA Survey Team

8.6 For the EIA study, the 1st stakeholder meetings at the scoping stage were held in July 2024 in Cox's Bazar, Matarbari and Chakaria. The participants presented their concerns mainly about the impacts on the shrimp, aquaculture, industry, and agriculture due to land acquisition and seasonal weather trends as well as the impacts due to sediment deposition.

For the RAP study, public consultations meetings were conducted in nine (9) affected unions between mid-April and early May 2024. In total, 244 participants (213 males and 31 females) attended the 9 consultation meetings. Apart from the consultation meetings, 20 FGDs were conducted with a total of 291 participants (215 males and 76 females). Among the conducted FGDs, 4 FGDs targeted only women and girls. In general, people were happy about the Project: however, they had concerns on the safety of large volume water interception from the Matamuhuri River, quality of the water to be provided, unit rate for land compensation, costs for water connections, and availability of construction jobs for the affected people. They also shared their worries about delayed compensation, referring to their previous experiences with other projects around the area.

The 2nd stakeholder meeting was scheduled around September 2024; however, it was postponed due to the security risks in the area after the administrative change in Bangladesh in August 2024. The 2nd stakeholder meeting has not been held during this Preparatory Survey.

Land Acquisition and Resettlement

8.7 The Project will result in acquisition of private land and utilization of the government land; hence physically and economically displacement of individuals and households, shops, Common Property Resources (CPRs) and government offices/institutions. Also, it will impact the livelihoods of the affected people. In total, 188 Project Affected Units (PAUs)[1] including households (HHs), shops, CPRs and government offices/institutions will be affected. Major impacts are identified along the transmission pipeline (57 PAUs) and conveyance pipeline (55 PAUs), in the raw water reservoir (41 PAUs), and three distribution reservoirs (29 PAUs), and at the water intake facilities (6 PAUs). Out of the total PAUs, 121 are to be physically relocated: among them 45 are titleholders and 76 are non-titleholders. Additionally, a total of 44 land and structure owners will be affected by temporary requisition of land for construction yards and access roads : among them, 4 households have residential structures that will need relocation. The project impacts are summarized in the table below.

[1] PAU includes affected households, business and community properties

Table 19 : Summary of Project Impacts

Affected Land	Permanent acquisition or utilization for project components	591.78 ha	Public: 573.97 ha
			Private: 18.05 ha
	Temporary use for construction yards and access roads	66.99 ha	Public: 52.62 ha–
			Private: 14.37 ha
Affected People	Households (replacement of residence due to project components)	54 HH/261 Persons	Formal (title) 39 HH/189 Persons
			Informal (non-title) 15 HH/72 Persons
	Households (replacement of residence due to construction yard)	4 HH/20 Persons	Formal (title) 4 HH/20 Persons
	Residential tenants	9 nos	9 nos
	Business entities to be economically resettled	63 HH/216 Persons	Formal (title) 4 HH/14 Persons
			Informal (non-title) 59 HH/202Persons
	Residential cum business to be relocated	4 HH/25 Persons	Formal (title) 2 HH/14 Persons
			Informal (non-title) 2 HH/11 Persons
	Business tenants	18 nos	18 nos
	Wage laborers	49 nos	49 nos
Affected Structures	Structures to be relocated (affected by project components)	206 nos	Residential: 96 nos
			Business: 80 nos
			Residential cum business: 9 nos
			CPRs/Institutions: 21 nos
	Structures to be relocated (affected by construction yards and access roads)	8 nos	Residential: 8 nos
	Partially affected structures by project components (no need of relocation)	11 nos	Residential: 11 nos
			Business: 0
			Residential cum business: 0
			CPRs/Institutions: 0 nos
Others	Affected trees	729 trees	Households: 673 trees nos
			CPRs/Institutions: 56 tress nos

Source: RAP Study Results

Apart from land to be acquired for the project facilities and for the temporary construction yards and access roads, 100 ha of land was identified for dumping excavated materials. It is estimated that about 25 land users will be affected. The detailed impacts due to the dumping site have not been studied in this Preparatory Survey, and should be studied in future stages of the Project.

8.8 Eligibility to receive compensation and resettlement benefits has been limited by the cut-off date. The cut-off date for titleholders is the date of serving notice under Section 4 of ARIPA 2017, while for the non-titleholder it is the commencement date of the census and socioeconomic survey. Project Affected Households (PAHs) with legal rights to the land and

other assets to be acquired will receive Cash Compensation under Law (CCL) to be paid by the Deputy Commissioner (DC) office, following the ARIPA 2017, while PAHs without title will receive compensation and resettlement benefits as per RAP entitlement matrix. PAHs may also receive additional assistance (top up amount which is a difference between replacement cost and CCL). The top up amount will be paid by the DPHE with assistance from the RAP Implementing Agency (IA). Affected vulnerable households (e.g., poor male and female headed households, disabled headed households below poverty line and old aged headed households below poverty) will be eligible for one-time special subsistence allowance. The CCL to be paid by the DC office includes:

- Cash compensation for loss of land by owners averaging the registered sale deeds values during the preceding one year from the date of serving notice under section 4 of the ARIPA of similar land plus (+) 200 per cent enhanced amount of the average (in total 3 times of the affected land value);
- Cash compensation for loss of crops, trees and perennials including 100% premium (in total 2 times of the affected crops, trees and perennials value);
- Cash compensation for residential and commercial structures including 100% premium (in total 2 times of the affected structure value); and
- Compensation to the legally recognized lessees, tenants and sharecroppers for their losses.

8.9 All households below the poverty line (22 households, including female-headed households) were considered for livelihood restoration programs, additionally, 42 wage earners at the salt and shrimp farms. The income of these wage earners is not below the poverty line; however, they have been dependent solely on salt and shrimp cultivation for a long time (over ten years) and their skills are limited to such activities. Additional support to reestablish is necessary for them. The Income and Livelihood Restoration Program is shown in the table below.

Table 20 : Income and Livelihood Restoration Programs

Identified Groups	Restoration Program
Poor households earning maximum BDT 17,000 per month Female headed households having no adult male members. Wage earners at salt and shrimp cultivation	• Priority in Project's construction and operation works. • Training on Income Generating Activities (IGA) to be implemented during RAP implementation by DPHE under the assistance of RAP IA • Capital support after completion of trainings • Linking with the existing government Sectoral Programs (Fish, Poultry, Agriculture, livestock etc.) and Social Safety Net. • Linking with financial institutions for financial support

Source: RAP Study Results

8.10 A community-based grievance redress system is proposed to resolve land acquisition and resettlement related grievances. This system will allow PAPs to send grievances either through SMS/Email or submit a written copy to the focal person of Grievance Redress Committee (GRC). The table below presents the steps to be followed in filing and resolution of grievances. The procedures for filing the Grievances are shown in the table below.

Table 21 : Procedures for Filing the Grievances

Steps	Description
Step 1	The RAP Implementing Agency (IA) informs PAPs about their losses and entitlements. If satisfied, the PAP claims resettlement payments to the DPHE. If not satisfied, proceed to Step 2
Step 2	The PAP approaches the IA field level officials for clarification. The IA will clarify the PAPs about their losses & entitlements as per RAP policy. If resolved, the PAP claims resettlement payments to the DPHE. If not resolved, proceed to Step 3
Step 3	The PAP approaches the GRC. RAP IA staff assists the PAPs producing the complaints and organizes hearing within 21 days of receiving the complaints. Both written complaints in the local dialect and verbal complaints are acceptable. RAP IA shall assist the PAPs to prepare written form for succeeding procedures at no cost to PAPs. Then proceed to Step 4
Step 4	GRC to scrutinize applications, cases referred to Deputy Commissioner through RAP IA if the case is under arbitration law and beyond their mandate as per scope of work. If the case is within the mandate of GRC, proceed to Step 5
Step 5	GRC sessions held in presence of the aggrieved PAPs, and the minute of meeting is recorded. If resolved, the Project Director approves the decision of the GRC. If not, proceed to Step 6
Step 6	The PAP may accept GRC decision, if not, he/she may file a case to the Project Director (PD) for settlement. Then proceed to Step 7
Step 7	The PD with the help of Team Leader, RAP IA and Resettlement Specialist of Construction Supervision Consultant (CSC), and Convener and Member Secretary of GRC at the local level reviews the case. Go to Step 8
Step 8	The minutes from the PD meeting is approved by the PD and transferred back to Conveners' office at the local level. The approved verdict is communicated to the complainant PAP in writing. The PAP then claims resettlement payments to DPHE. If not excepted, the PAP moves to Step 9
Step 9	When the PD's decisions are not accepted, the PAP may go to the court of law, which takes the final decisions, and the resettlement benefits are given accordingly

Source: RAP Study Results

8.11 A total of BDT 70,403,612,572 will be required to cover land acquisition and resettlement costs. The amount includes BDT 66,648,160,328 to be paid by the DC office as required by the Bangladesh acquisition law and BDT 3,755,452,243 to be paid by the executing agency for meeting the donor's requirements. The table below presents a breakdown of the total costs. The land acquisition and resettlement implementation costs are shown in the table below.

Table 22 : Land Acquisition and Resettlement Implementation Costs

SL.	Category of Loss	Cash Compensation under Law (ARIPA 2017)	Additional Budget (including top-up)	Estimated Total Compensation Amount in BDT
A.1	Compensation for Private Land	687,183,714	70,944,791	758,128,505
A.2	Compensation for Govt. Land	53,456,193,361	0	53,456,193,361
A.3	Compensation for Land for Construction yard/access roads	82,775,000	0	82,775,000
A.4	Compensation for Land for Dumping sites	11,021,856,300		11,021,856,300

SL.	Category of Loss	Cash Compensation under Law (ARIPA 2017)	Additional Budget (including top-up)	Estimated Total Compensation Amount in BDT
B-1	Compensation for Structure (at Project components)	77,941,570	68,204,418	146,145,988
B-2	Compensation for Structures at Construction yards	2,171,988	0	2,171,988
C	Compensation for Trees	4,083,020	0	4,083,020
	Impact Budget (A-C)	**65,332,204,953**	**139,149,209**	**65,471,354,163**
D-1	Resettlement Benefits (for HHs at Project components)	0	184,350,574	184,350,574
D-2	Resettlement Benefits for HHs at Construction yard	0	64,002	64,002
E	Operation cost for RAP Implementing Agency/ INGO	0	64,000,000	64,000,000
F	Operation cost for External Monitoring Agency	0	6,000,000	6,000,000
G	Capacity building training of the Project Management Office officials	0	8,000,000	8,000,000
H	Relocation of HHs and CPRs including civic amenities	0	64,000,000	64,000,000
	Total Budget (A-H)	**65,332,204,953**	**465,563,806**	**65,797,768,759**
I	Administrative cost 2% of the total budget on the DC head	1,315,955,375	0	1,315,955,375
J	Contingency 5% of the total budget	0	3,289,888,438	3,289,888,438
	Grand Total BDT (A-J)	**66,648,160,328**	**3,755,452,243**	**70,403,612,572**

Source: RAP Study Results

Assessment on Gender Considerations

8.12 The results of the gender survey revealed that access to water during the dry season is a challenge which pushes locals into walking a long distance to fetch clean water and must stand in long queuing. The questionnaire interview shows that about 17% of the respondents had encountered Sexual and Gender-Based Violence (SGBV) while fetching water that included eve teasing, emotional/psychological abuse, bad touch and sexual violence. In the FGDs, women and girls voiced their needs for clean water for drinking and cooking, as well as employment opportunities in construction activities.

8.13 The Project will result in acquisition of land that would have disproportionate impacts on vulnerable PAPs and female headed households. To ensure proper mitigation of the impacts, additional cash assistance and livelihood restoration programs are envisioned in RAP for all the vulnerable and female headed households. Additionally, in line with the gender action plan of the DPHE and the gender survey results, the following actions and indicators were developed to be considered during the implementation of the Project. Actions and Indicators for Gender Mainstreaming by the Project is shown in the table below.

Table 23 : Actions and Indicators for Gender Mainstreaming by the Project

Activities	Indicators	Responsible Bodies	Time Frame	Expected Output
Implement gender-sensitive hiring practices for construction works, and PMO of DPHE by setting a target number of female workers. Ensure Contractor's contract includes a clause to hire female workers.	Number of female workers	Contractors, and DPHE	Throughout the project life	Increased number of females in the labor market.
Provide training on gender equality and sensitivity to construction staff.	Number of gender related training conducted.	DPHE and contractor	Regular intervals	Reduced gender related cases by construction staff
Monitor and address any gender-based discrimination by construction workers and other people.	Number of gender-related cases reported and resolved.	DPHE and contractor's	Regular intervals	Reduced gender related cases in the Project area
Ensure equal access to water supply services for men and women in the project area.	Percentage of female-headed households accessing water supply services. Distance to water sources	Operations and Maintenance Team-DPHE	Throughout the operational phase	Increasing number of female-headed households with access to water Reduced distance to water sources

Source: GAP Survey Results

IX. STUDY ON PROJECT EFFECTS

Economic and Financial Internal Rates of Return

9.1 Economic analysis evaluated the social and economic validity of the Project by calculating the economic benefits and costs of the "With" and "Without" cases of the Project. The "With" and "Without" cases of the project are defined as follows:

1) Without Project: Companies in Moheshkhali EZ (Dhalghata) and residents in the priority areas in Chakaria Pourashava and Matarbari Union need to get water from tube wells. Since the quality of water is not good based on the willingness to pay (WTP) survey, a percentage of using bottled water for drinking and cooking will increase every year. And

2) With Project: Water will be supplied to the companies and residents from 2034 to 2065 by piped water supply facilities of the Project in Moheshkhali EZ (Dhalghata), Chakaria Pourashava, and Matarbari Union.

9.2 Economic and financial analyses were made based on the following conditions as shown below.

Table 24 : Conditions of Economic and Financial Analysis

Item	Conditions	Remarks
Project Scope	The water supply project in Moheshkhali EZ and the priority areas in Chakaria Pourashava and Matarbari Union by construction, operation and maintenance of the facilities.	The facilities are 1) Intake, 2) Pipeline Works 3) Raw Water Reservoir, 4) Water Treatment Plant, and 5) Distribution Reservoirs.
Project Period	2026-2065	Construction period:2026-2034Q2, Operation period: 2034Q3-2065
Price Level Year	2024	-
Physical Contingency	5%*	Construction and Consultant
Exchange Rate	1 USD=¥146 1 USD=BDT 118 1 BDT=¥1.24*	-
Social Discount Rate	12%**	According to the Planning Division Circular of Planning Commission of the Government of Bangladesh, 12% should be used for economic discount rate.
Standard Conversion Factor (SCF)	0.9***	It is the conversion factor to be applied to costs at financial prices in order to convert them to economic costs in Bangladesh.

*Source: General Guideline, September 2024, JICA **Source: "Cost benefit Analysis for Development A Practical Guide, 2013, ADB, and "Handbook on Cost-Benefit Analysis (CBA) of Public Investment Projects", 2024, Bangladesh Planning Commission, Government of Bangladesh, ***Source: "DEVELOPMENT PROJECT PROFORMA/PROPOSAL (DPP) MANUAL (Instructions for Preparing Development Project Proposal)", 2014, General Economics Division, Bangladesh Planning Commission, Government of the People's Republic of Bangladesh

9.3 Economic benefits of the Project are 1) benefit of water usage (incremental and non-incremental), 2) benefit of decrease of water related diseases by continuous supply of good quality water to more residents and 3) benefit of increase of tourism income.

9.4 The following table shows the results of the economic analysis of the Project. The Economic Internal Rate of Return (EIRR) of the Project is 12.9% which is higher than the social discount rate (12%). The Benefit Cost Ratio (BCR) is higher than 1.0 and the economic net present value (ENPV) is plus. Therefore, the Project is evaluated as economically viable.

Table 25 : Results of Economic Analysis

Indicators	Results
EIRR (%)	12.9
BCR	1.08
ENPV (BDT in Million)	4,354

Source: JICA Survey Team

9.5 Revenues of the Project is the water tariff revenue and subsidies from the Government of Bangladesh. The tariff revenue is calculated by water tariffs, the tariff collection rate (93%[2]) and the water sales volume. There are three cases of water tariffs, which are *Case 1: no tariff increase, Case 2: 5% increase every 5 years, and Case 3: 10% increase every 5 years with and without subsidies*. The JICA Survey Team proposed an amount of the subsidy that will result in Financial

[2] Reference: CWASA (2014-2022)

Internal Rate of Return (FIRR) of 0 or more. The water sales volume and the revenue of the Project in Case 1 with subsidies, and the amount of subsidies of all cases are shown below.

Table 26 : Revenue of the Project in Case 1 with Subsidies

Unit: BDT in Million/year

Item	2034	2035	2036	2037	
Revenue from water sales	812	1,674	1,673	1,675	
Subsidies	3,169	6,528	6,523	6,532	
Total	3,981	8,202	8,196	8,206	
Item	2038	2039	2040	2041	2042-2065
Revenue from water sales	1,677	1,679	1,681	1,683	1,681
Subsidies	6,540	6,548	6,556	6,565	6,555
Total	8,217	8,227	8,238	8,248	8,236

Source: JICA Survey Team

Table 27 : The Amount of Subsidy in Each Case

Unit: BDT in Million

Item	2034-2065
Case 1	206,284
Case 2	198,278
Case 3	186,880

Source: JICA Survey Team

9.6 FIRR and Net Present Value (NPV) were calculated as shown below. The FIRR of all cases could not be calculated due to lack of revenue without subsidy. Case 1 with 390% (subsidy rate), Case 2 with 325%, and Case 3 with 265% are financially feasible.

Table 28 : FIRR and NPV of the Project

Case	FIRR	NPV (BDT in Million)	Subsidy Rate against Revenue from Water Sales
Case 1 without subsidy	n.a.	-204,139	0%
Case 1 with subsidy	**0.0%**	**2,145**	**390%**
Case 2 without subsidy	n.a.	-196,024	0%
Case 2 with subsidy	**0.0%**	**2,254**	**325%**
Case 3 without subsidy	n.a.	-186,512	0%
Case 3 with subsidy	**0.0%**	**368**	**265%**

Source: JICA Survey Team

Operation and Effect Indicators

9.7 Operation and effect indicators with the target year of 2035, which is about two years after project completion and start of operation, are set as below.

Table 29 : Operation and Effect Indicators of the Project

Indicators	Original (2024)	Target (2035)	Remarks
Operation Indicators			
Population served (person)	N/A	191,486	Refer to Water Demand Fordecast Result (Table 5.4.6)
Daily Average Water Production (m^3/day)	N/A	92,533 m^3/day For Industrial: 68,244 m^3/day For Domestic: 24,289 m^3/day	Refer to Water Demand Forecast Result (Table 5.4.6)
Effect Indicators			
Percentage of Population Served※1	N/A	80% (Domestic) 100% (Industrial)	Refer to Water Demand Forecast Condition 5.1.2(3), 5.1.2(4), and Table 5.4.5
Water Supply Per Capita (lpcd) ※2	N/A	62 lpcd (Union) 120 lpcd (Pourashava)	Refer to Water Demand Forecast Condition (Table 5.4.5)
Income of Water Sales	N/A	BDT 1,674 Million	Refer to Revenue of the Project in Case 1 with Subsidies (Table 10.1.12)

Note: ※1 Percentage of Population Served for Domestic Water = Population Served in Chakaria Pourashava and Matabari Union/ Residential Population in Chakaria Pourashava and Matabari Union
Percentage of Population Served for Industrial Water = Number of Business Establishment Served in Moheshkali EZ (Dhalghata)/Number of Business Establishments in Moheshkali EZ (Dhalghata)
※2 Water Supply Per Capita＝Daily Consumption by the Project/Population Served in Chakaria Pourashava or Matabari Union

Source: JICA Survey Team

Qualitative Effects

9.8 Improvement of Bangladesh investment climate: if the Project ensures a stable water supply, it will be the first industrial water supply for the MIDI area, potentially attracting more investments. The direct impact will be on Moheshkhali EZ (Dhalghata), while the MIDI area may benefit indirectly. At the time of this Survey, investments in the MIDI area are primarily from domestic companies. Local conglomerates with strong government connections are seen as key investors. However, local companies need foreign partners for technology and finance. A favorable investment climate in Bangladesh would encourage more foreign investments, including those from Japan.

9.9 Achievement in sustainable water resources management: the qualitative benefits to expect through the achievement by the Project are studied and identified as enumerated below:

(1) Moving away from dependency on groundwater use;

(2) Expansion of water resource management systems in Bangladesh;

(3) Contribution to climate change countermeasures (adaptation and mitigation);

(4) Multipurpose use of the raw water reservoir; and

(5) Secondary effects of river facility construction: River training works through channel excavation and revetment construction to stabilize the river channel can be used as part of future flood control measures in the basin. In addition, the revetments in the Project will function as protective works for the bridge abutments of a new bridge planned for the Chattogram-Cox's Bazar bypass road, and the stabilization of the river channel at the bridge site will also increase the safety of the bridge.

PREPARATORY SURVEY
FOR
SOUTHERN CHATTOGRAM REGION WATER SUPPLY PROJECT

ABBREVIATIONS

	English	Japanese
ADB	Asian Development Bank	アジア開発銀行
ADCP	Acoustic Doppler Current Profiler	音波式ドップラー流速計
Al	Aluminum	アルミニウム
ARIPA	Acquisition and Requisition of Immovable Property Act	不動産収用及び接収法
As	Arsenic	砒素
BADC	Bangladesh Agricultural Development Corporation	バングラデシュ農業開発公社
BBS	Bangladesh Bureau of Statistics	バングラデシュ統計局
BCR	Benefit Cost Ratio	便益費用比
BD	Bangladesh	バングラデシュ
BDP2100	Bangladesh Delta Plan 2100	バングラデシュデルタプラン 2100
BDT	Bangladesh Taka	バングラデシュタカ
BEPZA	Bangladesh Export Processing Zones Authority	バングラデシュ輸出加工区庁
BETS	Bangladesh Engineering and Technological Services	BETS 社(再委託業務コンサルタント地下水調査)
BEZA	Bangladesh Economic Zones Authority	バングラデシュ経済特区庁
BIG-B	Bengal Bay Growth Zone Plan	ベンガル湾成長地帯構想
BIWTA	Bangladesh Water Transport Authority	バングラデシュ内陸水運公社
BMD	Bangladesh Meteorological Department	バングラデシュ気象局
BOD	Biochemical Oxygen Demand	生物化学的酸素要求量
BPDB	Bangladesh Power Development Board	バングラデシュ電力開発庁
BREB	Bangladesh Rural Electrification Board	バングラデシュ地方電化庁
BRRI	Bangladesh Rice Research Institute	バングラデシュ稲研究協会
BSEZ	Bangladesh Special Economic Zone	バングラデシュ経済特区
BSMSN	Bangabandhu Sheikh Mujib Shilpanagar	Bangabandhu Sheikh Mujib Shilpa Nagar 経済特区
BUET	Bangladesh University of Engineering and Technology	バングラデシュ工科大学
BWDB	Bangladesh Water Development Board	バングラデシュ水開発庁
CCL	Cash Compensation Law	現金補償
CC-MIDI	Moheshkhali and Matarbari Integrated Infrastructure Development Initiative Coordination Committee	モヘシュカリ・マタバリ統合的インフラ開発イニシアティブ調整委員会
Cd	Cadmium	カドミウム
CE	Chief Engineer	チーフエンジニア
CEGIS	The Center for Environmental and Geographic Information Services	CGIS 社(再委託業務コンサルタント：概略環境調査)
CEPZ	Chittagong Export Processing Zone	チョットグラム輸出加工区
CHT	Chattogram Hill Tract	チョットグラム丘陵地
Cl-	Chloride	塩化
CN-	Cyanides	シアン化物
COD	Chemical Oxygen Demand	化学的酸素要求量
CP	Contract Package	契約パッケージ
CPA	Chattogram Port Authority	チョットグラム港湾機構
CPGCBL	Coal Power Generation Company. Bangladesh Limit	バングラデシュ石炭火力発電会社
CPRs	Common Property Resources	共有資源
Cr	Chrome	クロム
CSC	Construction Supervision Consultant	施工管理コンサルタント
CTR	Controller	コントローラー
Cu	Cupper	銅
CWASA	Chattogram Water Supply and Sewerage Authority	チョットグラム上下水道公社
D/D	Detailed Design	詳細設計
D	Diameter	直径
DAE	Department of Agriculture Extension	農業普及局
DBHWD	Department of Bangladesh Haor and Wetlands Development	バングラデシュハオール・湿地開発局

DC	Deputy Commissioner	県副行政官
DCS	Distributed Control System	配水制御システム
DEM	Digital Elevation Model	数値標高モデル
DFR	Draft Final Report	ドラフトファイナルレポート
DLRS	Department of Land Record and Surveys	土地記録調査局
DMA	District Metered Area	検針地区
DO	Dissolved Oxygen	溶存酸素量
DOE	Department of Environment	環境局
DPHE	Department of Public Health Engineering	公衆衛生工学局
DPP	Development Project Proforma	開発事業提案書
DR	Distribution Reservoir	配水池
DREZ	Distribution Reservoir Economic Zone	配水池経済特区
EA	Environmental Assessment	環境評価
EC	Electro Conductivity	伝導率
ECR	Environmental Consideration Rules	環境保護規則
EIA	Environmental Impact Assessment	環境影響評価
ECNWRC	Executive Committee of the National Water Resources Council	国家水資源評議会執行委員会
EIP	Eco Industrial Park	環境に配慮した工業団地
EIRR	Economic Internal Rate of Return	経済的内部収益率
EL	Elevation	標高
EMP	Environmental Management Plan	環境管理計画
EMoP	Environmental Monitoring Plan	環境モニタリング計画
ENPV	Economic Net Present Value	経済的正味現在価値
EPWAPDA	East Pakistan Water and Power Development Authority	東パキスタン水資源・電力開発局
EZ	Economic Zone	経済特区
F-	Fluoride	フッ化物
FAO	Food and Agriculture Organization	国連食糧農業機関
FAP	Flood Action Plan	洪水行動計画
Fe	Iron	鉄分
FIRR	Financial Internal Rate of Return	財務的内部収益率
FPCO	Flood Plan Coordination Organization	洪水計画調整機構
FR	Final Report	ファイナルレポート
FWL	Full Water Level	満水位
GIS	Geographic Information System	地理情報システム
GOB	Government of Bangladesh	バングラデシュ国政府
GPS	Global Positioning System	全地球測位システム
GRC	Grievance Redress Committee	苦情処理委員会
GSMaP	Global Satellite Mapping of Precipitation	降水量グローバル衛星マッピング
Hg	Mercury	水銀
HHs	House Holds	家庭
HWL	High Water Level	高水位
IBRD	International Bank for Reconstruction and Development	国際復興開発銀行
ICR	Inception Report	インセプションレポート
IDC	Interest During Construction	建中金利
IEZ-SDP	Industrial and Economic Zone Sector Development Plan	産業経済特区セクター開発計画
IGA	Income Generating Activities	生計活動
ISO	International Organization for Standardization	国際標準化機構
ITR	Interim Report	インテリムレポート
IUCN	International Union for Conservation of Nature and Natural Resources	国際自然保護連合
IWM	Institute of Water Modelling	水モデル研究所
JAXA	Japan Aerospace Exploration Agency	宇宙航空研究開発機構
JETRO	Japan External Trade Organization	独立行政法人日本貿易振興機構
JICA	Japan International Cooperation Agency	国際協力機構
JP	Japan	日本
JPY	Japanese Yen	日本円
JRC	Joint Rivers Commission	バングラデシュ合同河川委員会
JSS	Japan Security Service	日本セキュリティサービス
JSSS	JICA Safety Standards Specifications	JICA 安全標準仕様書
JST	Japan Science and Technology Agency	科学技術振興機構

JWA	Japan Water Agency	水資源機構
KKCD	Khuta Khali Chara Dam	Khuta Khali Chara ダム
L	Length	長さ
LAP	Land Acquisition Plan	土地取得計画
LG	Local Government	地方政府
LGD	Local Government Division	地方行政総局
LGED	Local Government Engineering Department	地方政府技術局
LPCD	Liters per Capita per Day	1 人 1 日あたりの水使用量
LWL	Low Water Line	最低水位
M/P	Master Plan	マスタープラン
MCM	Million Cubic Meters	百万立方メートル
MDG	Millenium Development Goal	ミレニアム開発目標
MIDI	Moheskhali and Matabari Integrated Infrastructure Development Initiative	モヘシュカリ・マタバリ統合的インフラ開発イニシアティブ
MLD	Million Liter per Day	百万立法リットル/日
Mn	Manganese	マンガン
MoA	Ministry of Agriculture	農業省
MOD	Maintenance, Operation and Distribution	運営・維持管理・配水
MoDMR	Ministry of Disaster Management and Relief	防災支援省
MOE	Ministry of Energy	エネルギー省
MoEF	Ministry of Environment and Forests	環境森林省
MoLGRD &C	Ministry of Local Government, Rural Development and Cooperatives	地方自治・農村開発協同組合省 地方自治総局
MoS	Ministry of Shipping	海運省
MoU	Memorandum of Understanding	了解覚書
MoWR	Ministry of Water Resources	水資源省
MPEMR	Ministry of Power, Energy and Mineral Resources	電力、エネルギー、鉱物資源省
MPO	Master Plan Organization	マスタープラン機関
MSL	Mean Sea Level	平均潮面
mS	Milli Siemens	ミリジーメンス
MW	Mega Watt	メガワット
NGO	Non-governmental Organization	非政府組織
N-NH4	Ammonium-nitrogen	アンモニウム窒素
N-NO3	Nitrous-nitrogen	亜硝酸窒素
NPV	Net Present Value	正味現在価値
NTU	Nephelometric Turbidity Unit	比濁法濁度単位
NWMP	National Water Management Plan	国家水管理計画
NWPo	National Water Policy	国家水政策
NWRC	National Water Resources Council	国家水資源評議会
O&M	Operation and Maintenance	運用管理
ODA	Official Development Assistance	政府開発援助
OJT	On the Job Training	実地研修
P/Q	Pre-Qualification	事前資格審査
PAHs	Project Affected Households	被影響世帯
PAUs	Project Affected Units	被影響帯
PCC	Project Coordination Committee	プロジェクト調整委員会
PD	Project Director	プロジェクト統括責任者
PCU	Platinum Cobalt Units	色度
PDB	Power Development Board	電力開発庁
PFI	Private Finance Initiative	民間資金主導
PIC	Project Implementation Committee	プロジェクト実施委員会
PIU	Project Implementation Unit	プロジェクト実施ユニット
PLC	Programmable Logic Controller	プログラマブル・ロジック・コントローラー
PMO	The Prime Minister's Office	大統領官邸
PMU	Project Management Unit	プロジェクト管理ユニット
PPP	Public Private Partnership	官民パートナーシップ
PPPA	Public Private Partnership Authority	官民パートナーシップ庁
PSC	Project Steering Committee	プロジェクト運営委員会
QCBS	Quality and Cost Based Selection	技術・価格評価
Qtu	Qtu	現世堆積物（砂丘砂、海岸砂）
RAP	Resettlement Action Plan	住民移転計画

RCP	Representative Concentration Pathway	代表濃度経路
RDCD	Rural Development and Co-operatives Division	農村開発協同組合総局
RRI	River Research Institute	河川研究所
RWR	Raw Water Reservoir	原水貯水池
SCADA	Supervisory Control and Data Acquisition	監視制御システム
SCF	Standard Conversion Factor	標準換算係数
SCRWTP	South Chattogram Region Water Treatment Plant	南チョットグラム地域浄水場
SDGs	Sustainable Development Goals	持続可能な開発目標
SEZ	Special Economic Zone	経済特区
SGBV	Sexual and Gender-Based Violence	性とジェンダーに基づく暴力
SIA	Social Impact Assessment	社会影響評価
SRTM	Shuttle Radar Topography Mission	スペースシャトル立体地形データ
SoB	Survey of Bangladesh	バングラデシュ測量局
SOP	Standard Operating Procedure	標準操作手順
SPM	Single-Point Mooring	一点係留
STWG	Sub-Technical Working Group	サブテクニカルワーキンググループ
T&P	Treatment and Production	水処理
Tmbb	Bokabil Formation	ボカビル層
Tmts	Tipam Formation	ティパム層
Tmub	Upper Part of Bhuban Formation	ブバン上層
ToR	Terms of Reference	付託条項
Tpmd	Dupitila Formation	ドゥピティラ層
TSS	Total Suspended Solids	浮遊物質量
TWG	Technical Working Group	テクニカルワーキンググループ
UNICEF	United Nations Children's Fund	国際連合児童基金
USAID	United States Agency for International Development	アメリカ合衆国国際開発庁
VAT	Value Added Tax	付加価値税
WARPO	Water Resources Planning Organization	水資源計画機構
WASA	Water Supply and Sewerage Authority	上下水道公社
WHO	World Health Organization	世界保健機関
WL	Water Level	水位
WLG	Water Level Gauge	水位計
WLMS	Water Leak Management System	漏水管理システム
WR	Water Resource	水資源
WRDOs	Water Resources Development Options	水資源開発オプション
WTP	Water Treatment Plant	浄水場
WTP	Willingness To Pay	支払い意思
Zn	Zinc	亜鉛

PREPARATORY SURVEY
FOR
SOUTHERN CHATTOGRAM REGION WATER SUPPLY PROJECT

FINAL REPORT
(ADVANCE DISCLOSURE VERSION)

VOLUME-I MAIN REPORT

Location Map
Summary
Abbreviation

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CHAPTER 1 INTRODUCTION

1.1 Background of the Survey

In the southern Chattogram region of the People's Republic of Bangladesh (hereinafter referred to as "Bangladesh"), the Moheshkhali-Matarbari Integrated Development Initiative (hereinafter referred to as "MIDI") has been promoted to achieve industrial agglomeration, based on the Bay of Bengal Industrial Growth Belt ("BIG-B") program agreed at the Japan-Bangladesh Summit in September 2014. The core of MIDI is Matarbari Port, which is the only deep seaport in Bangladesh. Currently, the development of multiple large-scale infrastructures, composed of energy bases, economic zones, and urban developments, is planned. Due to this economic development, the population of this region, especially Chakaria Upazila (Sub-district) and Moheshkhali Upazila in Cox's Bazar District, is forecasted to increase. Therefore, it is predicted that the water demand for both industrial and domestic purposes will increase, as previously studied in the "People's Republic of Bangladesh Data Collection Survey on Water Resources Development in Southern Chattogram" (JICA, 2022) and the "Preparation of Water Development Plan for Moheshkhali-Matarbari Area of Cox's Bazar District" (DPHE, 2023).

On the other hand, the groundwater level in the region has been declining at an average rate of 10 cm/year due to excessive extraction of groundwater, and it cannot be expected to develop any new aquifer in this region. In this regard, there is a need to convert the region's water source from groundwater to surface water, since surface water has a higher potential for water resources development that can successfully cope with industrial development and population growth. Since surface water has a great seasonal fluctuation, there is a need for stepwise development of facilities that temporarily store abundant rainy season river water, so as to provide a stable year-round water supply for the demand areas as the water demand increases.

Specifically, in the "8th Five Year Plan (July 2020-June 2025)", the Government of Bangladesh aims to improve the investment climate through the development of basic infrastructure such as water supply facilities. Furthermore, the realization of (i) water demand-supply balance and (ii) stable water supply is addressed as a key issue in "Bangladesh Delta Plan 2100", a national plan developed in 2018 for long-term water use and flood control, and reservoir development is ranked as a priority project for stable dry-season water use.

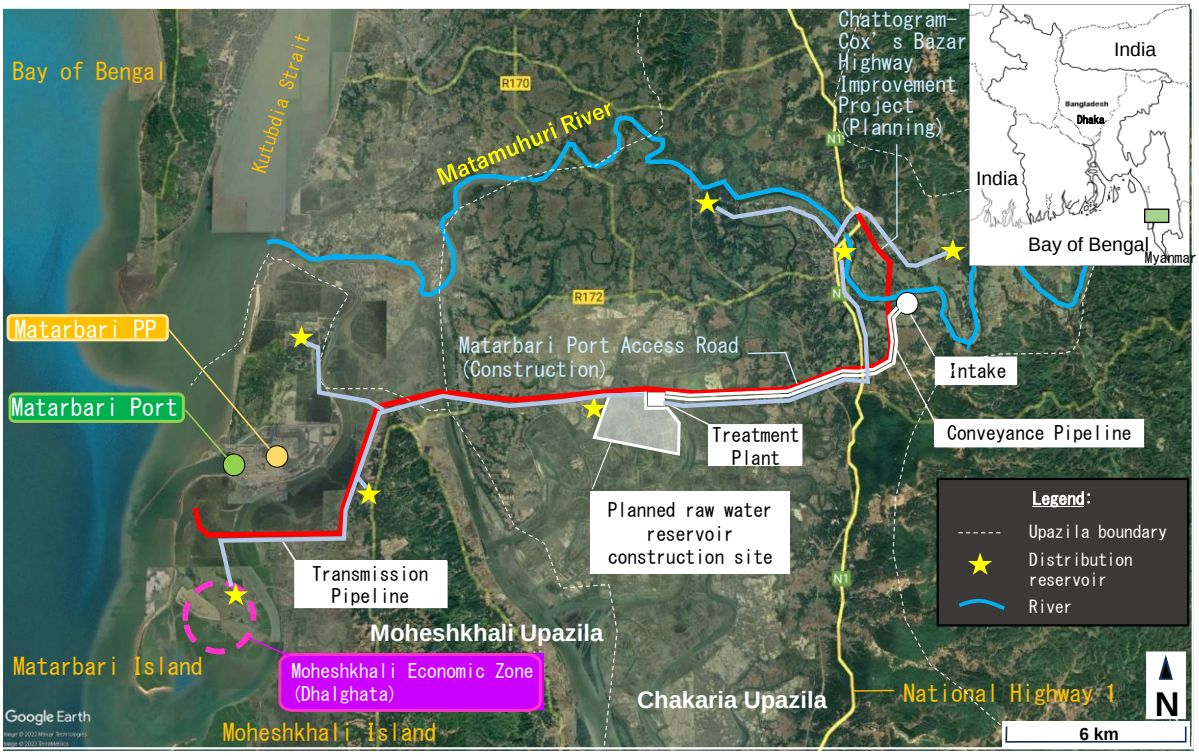
The "Southern Chattogram Region Water Supply Project" plans to enhance the capacity of industrial and domestic water supply by developing water supply facilities in the southern Chattogram region, where there is industrial agglomeration and its resultant growth of population is progressing steadily. The water supply project is in line with the national development policy of Bangladesh.

The project overview is presented in Table 1.1.1 and Figure 1.1.1

Table 1.1.1 Project Overview

Item	Details	
Project Name	Southern Chattogram Region Water Supply Project	
Project Objective	This project aims to increase the water supply for industrial and domestic use in the southern Chattogram region through the construction of water supply facilities, thereby contributing to the improvement of the investment environment and sustainable water resources management of the country.	
Project Overview	1) Civil engineering works Construction of river training works, intake facility, water conveyance facility, raw water reservoir, water treatment facility, transmission facility, and distribution facility 2) Consulting services Detailed design, bidding assistance, construction supervision, environmental and social considerations procedures and monitoring assistance, capacity building, etc.	
Target Area	Chattogram Division, Cox's Bazar District (population of approximately 2.82 million as of national census 2022)	
Relevant Government Agencies and Organizations	Ministries	(i) MoWR, (ii) LGD (MoLGRD&C)
	Executing Agencies	(i) BWDB, (ii) Water utility for the Project (to be discussed)
	Other Relevant Organizations	(i) MIDI coordination: PMO, MIDI-Cell, MIDI Authority (under setting up) (ii) Possible water utility members: DPHE, CWASA, Chakaria Pourashava/Upazila, Moheshkhali Pourashava/Upazila (iii) Related projects: RHD, BEZA (iv) Environmental and social considerations: DOE, DC office (v) Permit/license of water rights: WARPO

Source: JICA Survey Team



Source: JICA Survey Team

Figure 1.1.1 Layout of Major Water Supply Facilities in the Water Supply Project

1.2 Survey Objective

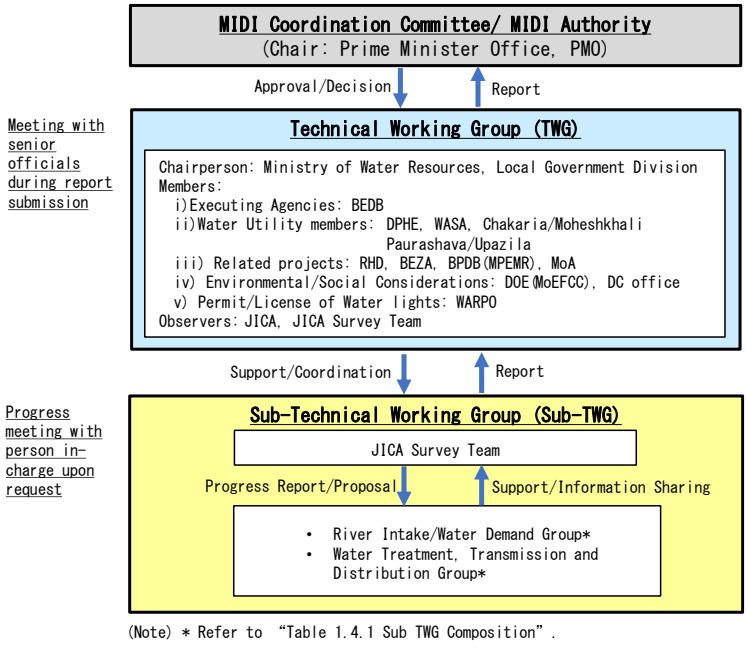
The purpose of the "Preparatory Survey for Southern Chattogram Region Water Supply Project (hereinafter referred to as "the Survey")" is to survey items such as project objective, overview, cost, implementation schedule, implementation (procurement and construction) method, implementation structure, operation and maintenance structure, environmental and social considerations, etc., which are necessary for JICA to determine whether the Project shall be formulated as a Japanese ODA loan project. The list of survey items is stated in "Section 1.5 Survey Scope and Process".

1.3 Survey Area

The survey area is Cox's Bazar District in Chattogram Division and the Matamuhuri River basin.

1.4 Related Agencies

The water supply project involves, as part of MIDI project, many organizations and institutions across the administrative regions. The MIDI Coordination Committee, which is composed of the secretary-level officers of relevant ministries and other agencies concerned, is responsible for the discussion and coordination of comprehensive development projects across the sectors in the Moheshkhali and Chakaria regions.



(Note) * Refer to "Table 1.4.1 Sub TWG Composition".

Source: JICA Survey Team

Figure 1.4.1 Framework for TWG and Sub-TWG Structures

To ensure meaningful collaboration, coordination, and consensus building with the relevant organizations through explanation, discussion, and cooperation in the course of this Preparatory Survey, a technical working group (TWG), of which the leading agencies are the Ministry of Water Resources (MoWR) and the Local Government Division (LGD), has been formed, as referred to in **Figure 1.4.1.** The TWG is the counterpart body for this Survey. A sub-technical working group (Sub-TWG) has been also organized under the TWG to conduct close discussion and cooperation with the relevant organizations for respective study topics.

Table 1.4.1 Sub TWG Composition

STWG	Chairperson and Members
River Intake / Water Demand	Chairperson: BWDB, DPHE Members: Water Resources Planning Organization (WARPO), Local Government Engineering Department (LGED), Chattogram Water and Sewerage Authority (CWASA), Roads and Highways Department (RHD), Agricultural Extension Department, Bangladesh Agricultural Development Corporation (BADC), BEZA, Bangladesh Power Development Board, Bangladesh Coal and Power Generation Company, Chattogram Port Authority, Cox's Bazar District, Moheshkhali/Chakaria (two sub-districts, two cities), Pekua Sub-district
Water Treatment, Transmission and Distribution	Chairperson: DPHE Members: BWDB, LGED, BADC, BEZA, WASA, RHD, Cox's Bazar District, Moheshkhali/Chakaria (two sub-districts, two cities)

1.5 Survey Scope and Process

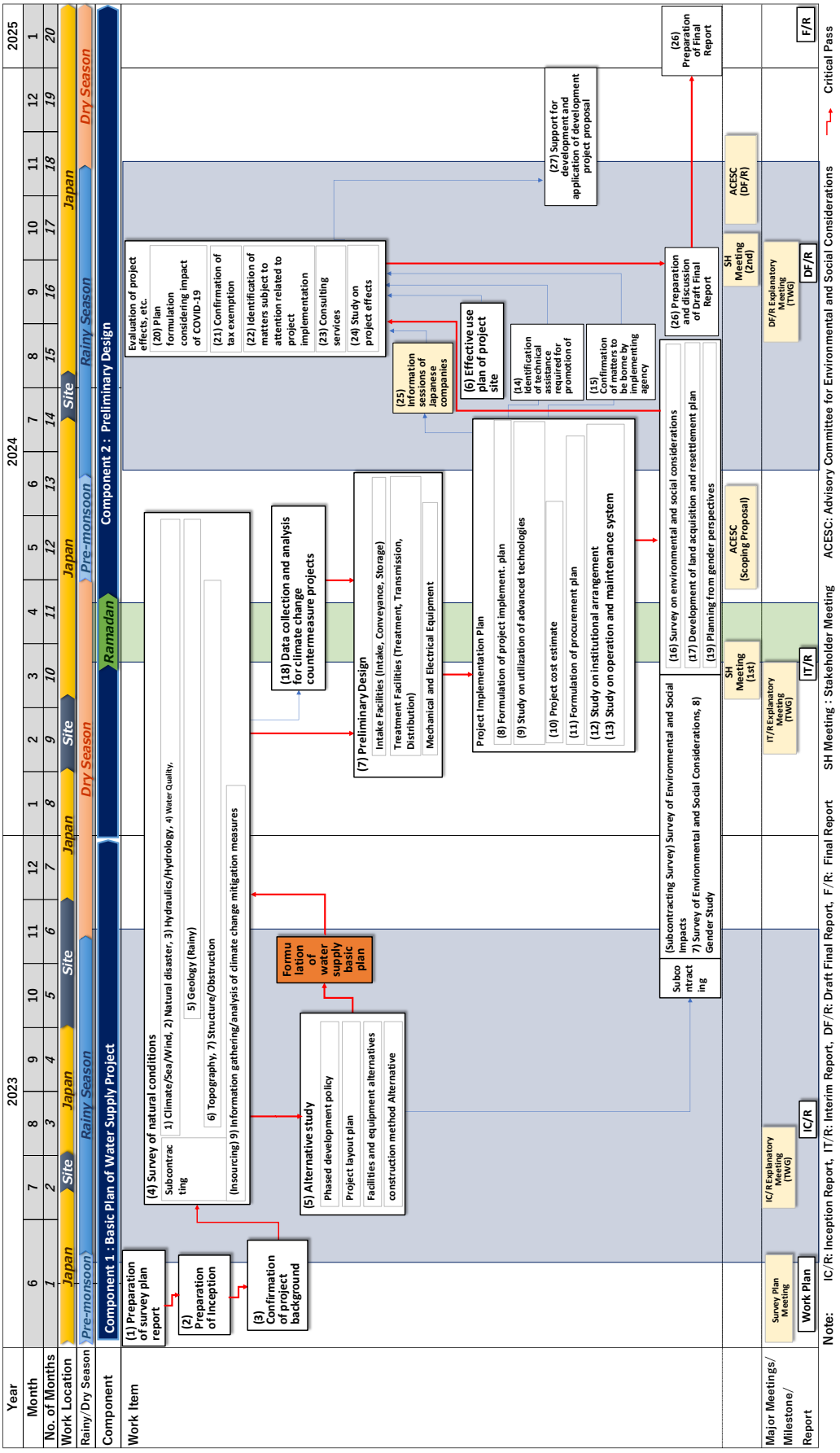
The survey scope of the Preparatory Survey consists of (i) Component 1: Basic Plan of Water Supply Project and (ii) Component 2: Preliminary Design, as enumerated below, and the survey process is illustrated in Figure 1.5.1.

Component 1: Basic Plan of Water Supply Project

- Confirmation of project background and needs
- Survey of natural conditions
- Basic plan of water supply project, composed of water supply, river water intake, water treatment and water distribution plans
- Phasing of the water supply project

Component 2: Preliminary Design (1st Phase Project)

- Preliminary design of project facilities in river water intake, water treatment and water distribution plans
- Project implementation plan and cost estimate
- Institutional arrangements at implementation and operation/maintenance stages
- Environmental and social considerations, including land acquisition, resettlement and gender action plans
- Effective use plan of project site
- Study on utilization of advanced technologies
- Project evaluation



Source: JICA Surve Team

Figure 1.5.1 Work Flow of the Survey

CHAPTER 2 PRESENT CONDITIONS OF PROJECT AREA

2.1 Physical Setting

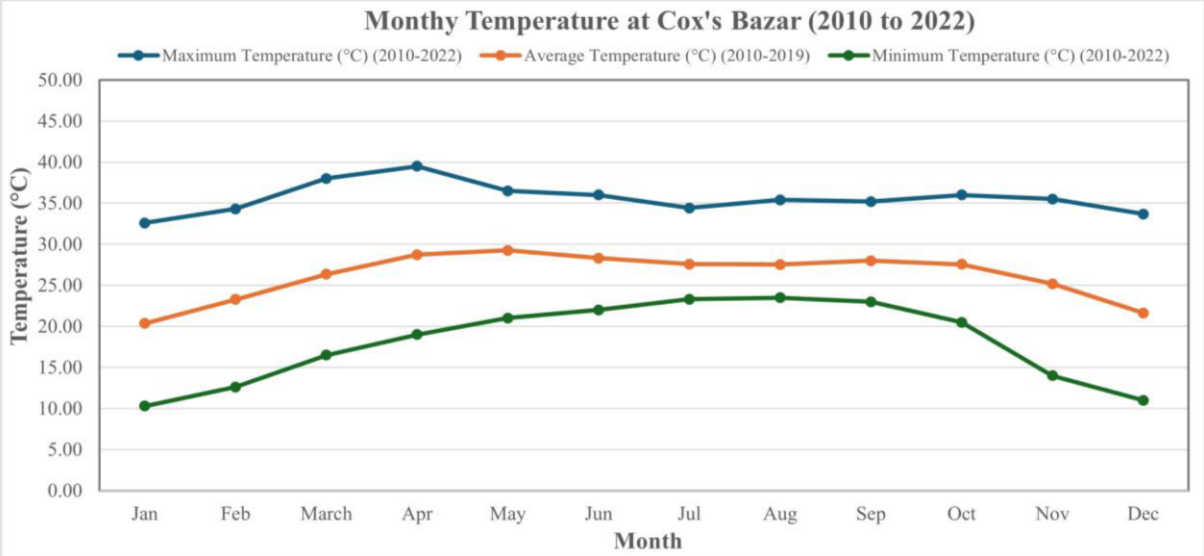
2.1.1 Climate and Hydrology

(1) Climate

The study area experiences tropical monsoon climate typical with high temperature and humidity. Distinct seasonal variation is observed in the area along with reversal of the wind circulation between summer and winter. Monsoon is the most prominent season prevailing from June to October with heavy rainfall. The cooler and drier winter starts from the end of November and prevails until the beginning of February.

1) Temperature

Monthly average temperature for maximum, minimum and average for the duration from 2010 to 2022 of the station Cox’s Bazar is shown in Figure 2.1.1. From the figure, it is observed that the monthly temperature from 10°C in winter to 40°C in summer. The lowest temperature in this region is quite higher than that of other regions of Bangladesh.

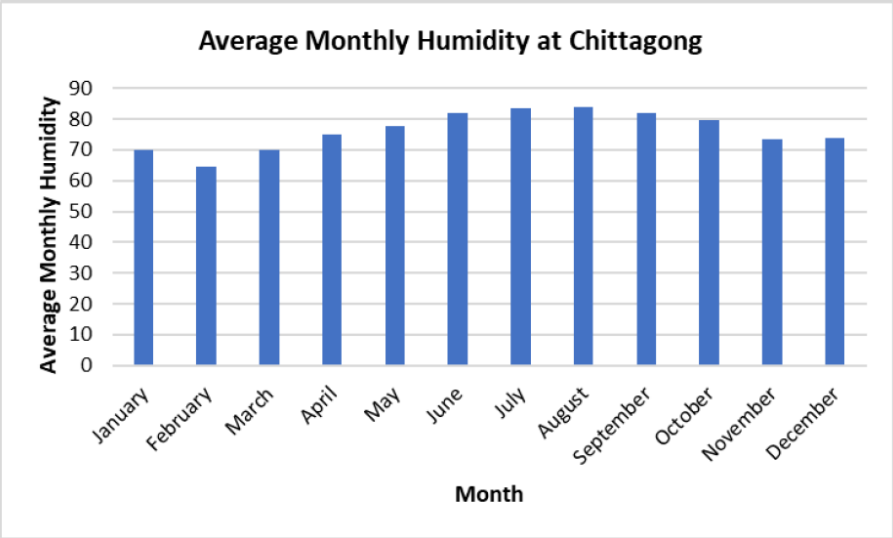


Source: JICA Survey Team

Figure 2.1.1 Monthly Maximum, Average and Minimum Temperature at Cox’s Bazar

2) Humidity

The relative humidity in this region is quite higher than that of other regions in Bangladesh. This parameter contributes to change in local microclimates and water availability, particularly during the dry season. The average humidity for the period from 2010 to 2019 of the station Cox’s Bazar is shown in Figure 2.1.2 Annual average humidity is varying from 68% in winter to 89% in monsoon.

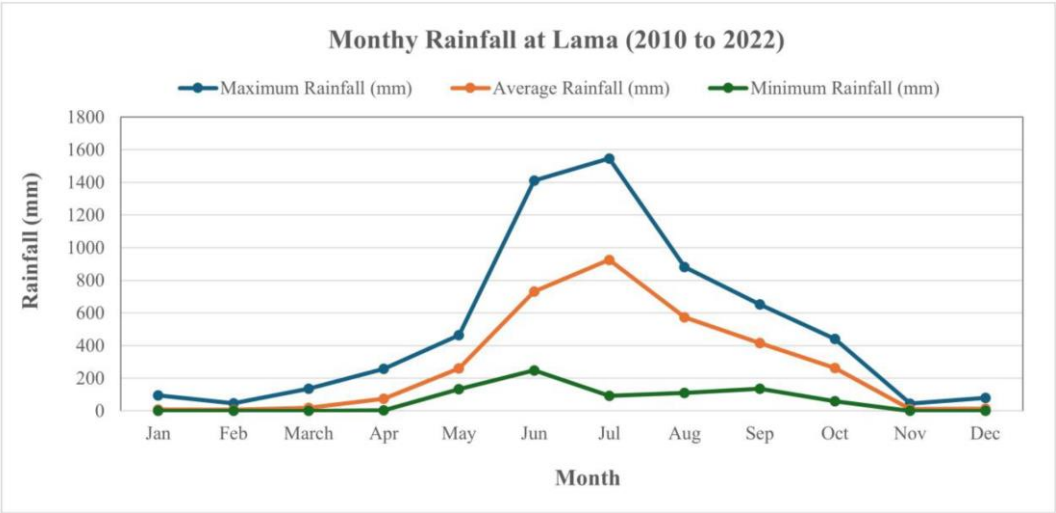


Source: JICA Survey Team

Figure 2.1.2 Monthly Average Humidity at Cox's Bazar

(2) Hydrology

A significant amount of rainfall occurs in the Matamuhuri River Basin, particularly during the monsoon season. The annual average rainfall of the Lama Station from the period from 2010-2022 is 3581mm. Around 80% of this rainfall occurs during June to August. Rainfall during this period is crucial for agriculture but it also cause flooding, especially in downstream areas. The monthly maximum, minimum and average rainfall of Lama station is shown in Figure 2.1.3.



Source: JICA Survey Team

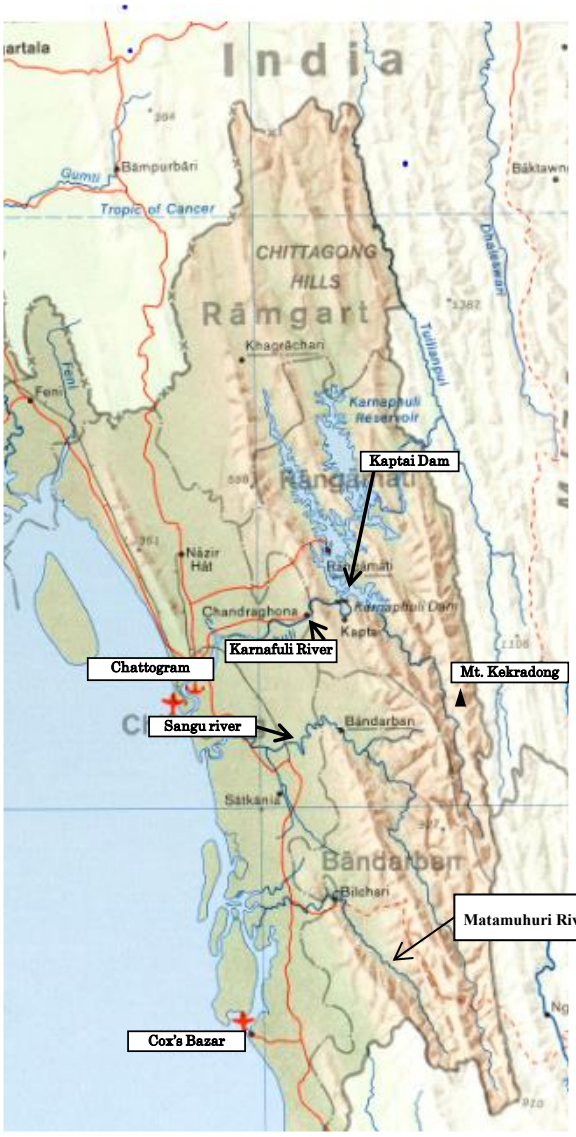
Figure 2.1.3 Monthly Maximum, Average and Minimum Rainfall at Lama Rainfall Station

2.1.2 Topography and River

(1) Topography in and around Matamuhuri River Basin

The general topography of the Matamuhuri River basin is located in the Chattogram Hill Tracts (hereinafter called "the CHT"), as presented in Figure 2.1.4. The CHT is situated in the southeastern area in Bangladesh where the hills with altitudes of 300 to 500 m are distributed and is an extension of the Himalayas. The area occupies about 13,180 km^2 and is facing the borders with India and Myanmar. The eastern part of the hilly area is connected to the Arakan Mountains of Myanmar, and the west side of the hilly area extends to the coastal plain from Chattogram to Cox's Bazar, facing the Bay of Bengal. The CHT becomes higher toward the east and the highest point is Mount Kekradong at an altitude of 1,230 m.

The hilly areas are extending in the north-northwest to southeast-south direction reflecting the geological structure (folding structure, fault structure, etc.) in the north-northwest to south-southeast direction that is developing in the entire survey area.



Source: Added by the JICA Survey Team to a map prepared by Texas University[1]

Figure 2.1.4 Topography of Chattogram Hill Tracts

[1] : Map No. 503753 1979 Bangladesh, Map Collection Perry-Castañeda Library, University of Texas Library, http://legacy.lib.utexas.edu/maps/middle_east_and_asia/txu-pclmaps-oclc-6423840 -bangladesh_1979.jpg

(2) River

In the CHT, the rivers flowing from the north-northwest direction to the south-southeast direction and from the south-southeast direction to the north-northwest direction merge and flow through the eroded valley crossing the hills to the west and flows into the Bay of Bengal.

The Matamuhuri River basin is located within 21°25' to 21°55' N latitude and 91°50' to 92°30' E longitude in Cox's Bazar District. The entire basin is within the territory of Bangladesh. The total area of the basin is about 2,500 km^2, out of which about 1,500 km^2 is within the hilly terrain. The remaining 1,100 km^2 lies in the downstream Matamuhuri Delta. At present, the almost entire delta area has been converted into farming land for agriculture, shrimp culture, and salt production.

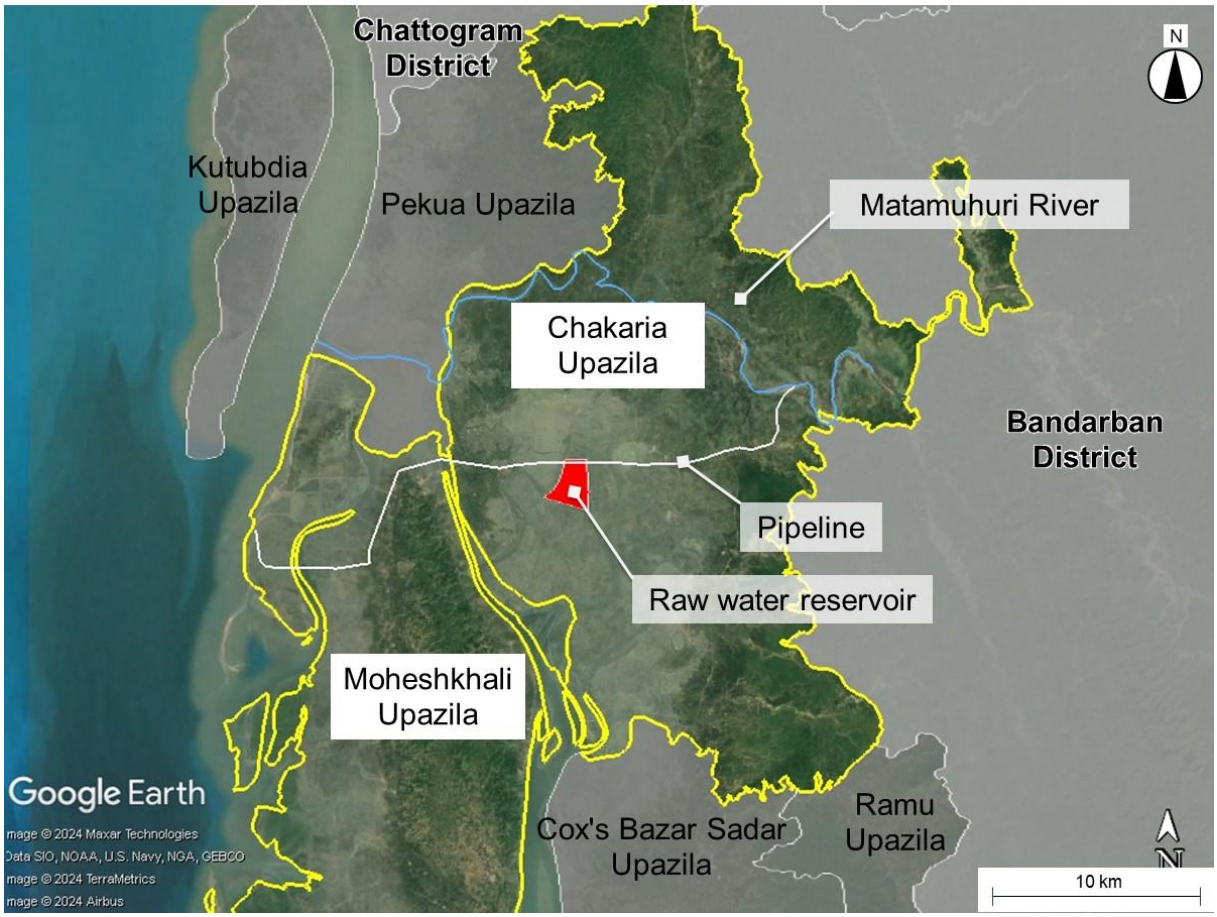
2.2 Socio-economic Status

2.2.1 Project Location

Administratively, Bangladesh is divided into divisions which are divided into districts, also known as "zila" in Bengali, and further divided into small units, called sub-districts or "upazila", and finally into unions. The project survey area is in Cox's Bazar District under Chattogram Division which has 11 districts in total. Chattogram is the second largest division[2] in Bangladesh in terms of population, following Dhaka Division. Cox's Bazar District[3] has nine upazilas which are Chakaria, Cox's Bazar Sadar, Kutubdia, Moheshkhali, Ramu, Teknaf, Ukhia, Pekua, and Eidgaon. The project area cuts across two upazilas: Moheshkhali and Chakaria.

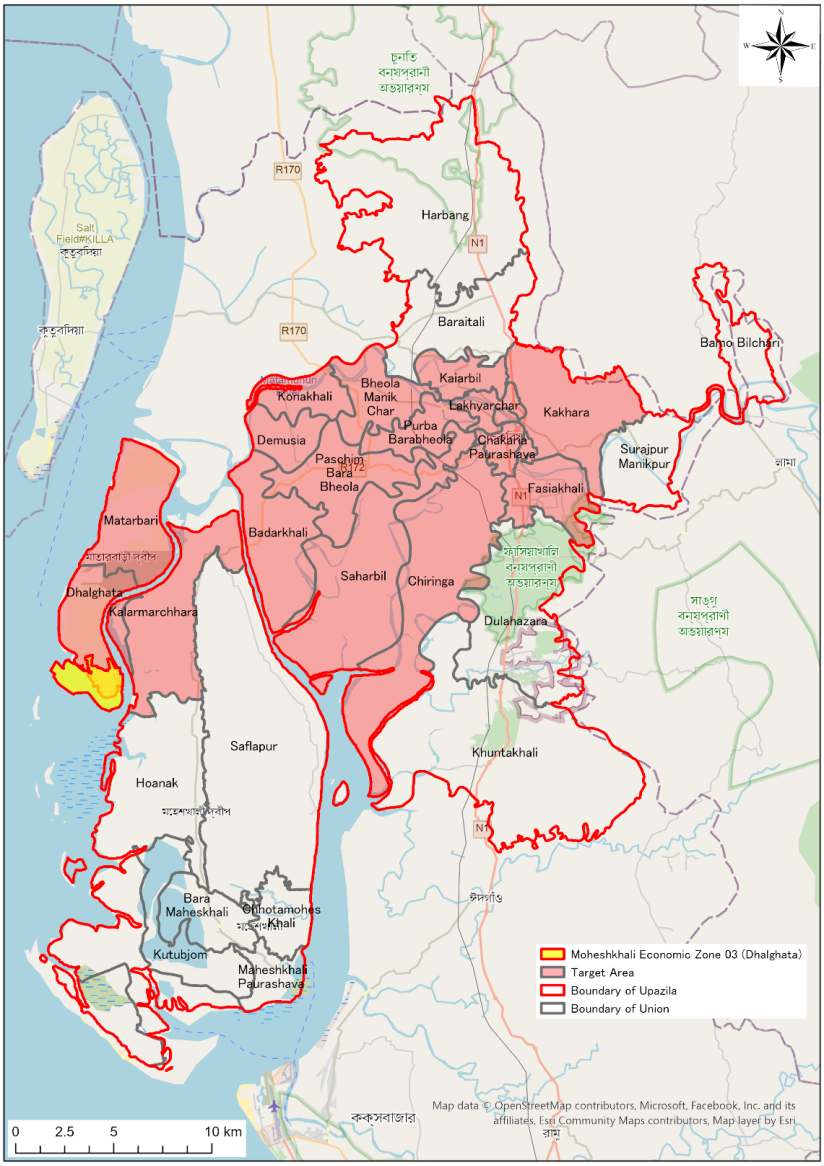
16 union/ pourashava were initially selected as candidate target water supply areas of this survey based on discussion with UNO officers. The criteria of candidate target water supply area selection are explained in Chapter 5.1.1in this report. The locations of candidate target water supply 16 union/ pourashava is shown in the figure below. In this study, the appropriate combination of target water supply areas was further studied with some additional criteria (project cost etc.). Two Union/ Paurashava and Economic Zone werre proposed as the final target water supply area. Details of target water area finalization are explained in 5.4 of this report.

[2] Population and Housing Census, 2022, National Report (Volume I)
https://bbs.portal.gov.bd/sites/default/files/files/bbs.portal.gov.bd/page/b343a8b4_956b_45ca_872f_4cf9b2f1a6e0/2024-01-31-15-51-b53c55dd692233ae401ba013060b9cbb.pdf
[3] https://coxsbazar.gov.bd/en#



Source: JICA Survey Team

Figure 2.2.1 Map of the Project Area



Source: JICA Study Team

Figure 2.2.2 Map Showing the Unions/ Pourashava Studied by the Survey

2.2.2 Population

(1) Population Trend

Bangladeshi population has continued to increase over the years. This is observed in the Population and Housing Census Survey, which is conducted every ten years in Bangladesh. The latest census conducted in 2022 indicated that the Bangladeshi population increased from 144,043,697 in 2011 to 165,158,616 in 2022 and is expected to hit 201.3 million by 2041[4]. Contrary to its population growth, the census observed a decline in annual growth rate from 1.47% in 2011 to 1.22% in 2022. Table 2.2.1 below shows

4 Population Projection of Bangladesh: Dynamics and Trends 2011-2061, 2015
file:///C:/Users/a9079/Downloads/PopulationProjection.pdf

the population change over the years in the project survey area.

Cox's Bazar District has a population of 2,823,268 with a population density of 1,133 people per km^2 (2022 census). The average household size in Cox's Bazar District is generally larger at around 4.75 persons per household as compared to the national average of 3.98. The detailed age structure and poverty rate of affected people are explained in 9.2.4 of this report.

Table 2.2.1 Population Trend in the Project Area

Location	Administrative Rank	Population (2001)	Population (2011)	Population (2022)
Chattogram	Division	24,290,384	28,423,019	33,202,326
Cox's Bazar	District (Zila)	1,773,709	2,289,990	2,823,268
Moheshkhali	Sub-district (Upazila)	219,520	321,218	385,500
Chakaria	Sub-district (Upazila)	409,346	474,465	571,274

Source: Population and Housing Census, 2022

(2) Projected Population in the Municipalities Studied in the Preparatory Survey

This survey studies the need for water in 16 unions/pourashava in Moheshkhali and Chakaria upazilas in Cox's Bazar District as seen in the table and the figure below. Based on the trend of population growth of Bangladesh, the JICA Study Team calculated the projected population of Cox's Bazar District and the 16 unions/pourashava at the target year of 2041. In total, about 706,090 people (14.8% out of the total projected population of Cox's Bazar District) are projected to be in this area by 2041. The average annual growth ratio of Cox's Bazar District was established by referring to figures from the "Population Projection of Bangladesh Dynamics and Trends 2011-2061 (Bangladesh Bureau of Statistics, 2015)". The average annual growth ratios for Chakaria and Moheshkhali were calculated based on the actual average annual growth ratio from 2011 to 2022 and the population growth trend of Cox's Bazar District above.

Table 2.2.2 Projected Population in the Municipalities Studied in the Preparatory Survey

Upazila	No.	Name of the Union	Population (2022)	Projected Population (2041)
Cox's Bazar	District		2,823,268	4,759,000
Chakaria Sub-district	1	Chakaria Pourashava	94,398	133,073
	2	Badarkali	36,715	51,757
	3	Bheola Manik Char	24,800	34,961
	4	Chringa	19,921	28,083
	5	Demusia	13,397	18,886
	6	Purba Barabheola	31,823	44,861
	7	Faiakhali	34,391	48,481
	8	Kakhara	29,825	42,044
	9	Kairarbil	22,676	31,966
	10	Konakhali	22,770	32,099
	11	Lakhyarchar	8,974	12,651
	12	Saharbil	24,480	34,510
	13	Paschim Bara Behola	10,732	15,129

Upazila	No.	Name of the Union	Population (2022)	Projected Population (2041)
Moheshkhali Sub-district	14	Dhalgata	11,361	15,922
	15	Kalarmarchhara	62,611	87,746
	16	Matarbari	52,746	73,921
Total			501,620	706,090

Note: Calculation of Unions population projection by 2041 done by the JICA Study Team

Source: Population and Housing Census, 2022

Table 2.2.3 Average Annual Growth Ratio Studied by the Project by the Target Year

Year		2011-2022	2023-2026	2027-2031	2032-2036	2037-2041
Avrage Annual Growth Ratio	Cox' bazar	1.92%	3.94%	1.67%	1.54%	1.47%
	Chakaria	1.70%	3.49%	1.48%	1.37%	1.30%
	Moheshkali	1.67%	3.43%	1.46%	1.34%	1.28%

Source: JICA Study Team

2.2.3 Main Economic Activities

According to the 2022 census, about 49.9% of the total population of Cox's Bazar District are engaged in the service industry, followed by the agriculture industry at approximately 38.8%, and the manufacturing industry at 11.3%. Agricultural activities conducted in Cox's Bazar include local and high-yielding variety (HYV) rice, wheat, vegetables, spices, cash crops, pulses, betel leaves, and others. Various fruits like bananas, jackfruits, guavas, coconuts, etc., are being grown. Fish of different varieties are abound around this district, and therefore enjoys the advantages of marine fishing. Moreover, varieties of fish are caught from rivers, tributary channels, creeks and even from paddy fields during the rainy season. Prawns are abundantly available in the district. Prawn farming and salt production in the coastal area of the district are the most important economic activities of the area. Dry fish is an important source of income to the fishermen especially in the islands. The district is also very rich in forest resources. Various valuable timber and forest trees are abundantly being grown in this district. Apart from all this, the sea beach of Cox's Bazar is the most attractive place in the country to tourists who like to visit the place throughout the year.

The detailed economic information of the affected people including the income and occupation is explained in 9.2.4 of this report.

Table 2.2.4 Industry of the Project Survey Area (in 2022)

Administrative Rank	Employed Population			
	Total (Male/Female)	Agriculture	Service	Industry
		Total (Male/Female)	Total (Male/Female)	Total (Male/Female)
Cox's Bazar District	804,779 (697,653/107,126)	312,306 (239,631/72,675)	401,283 (370,511/30,772)	91,190 (87,511/3,679)
		38.80%	49.90%	11.30%

Source: BBS "Population and Housing Census, 2022"

2.3 Moheshkhali-Matarbari Integrated Infrastructure Development Initiative

(1) BIG-B and MIDI

As a joint effort between the Government of Japan (GOJ) and the Government of Bangladesh (GOB), the "Bay of Bengal Industrial Growth Belt (BIG-B) Initiative" was launched in 2014, which envisions an industrial agglomeration corridor running along Dhaka, Chattogram, and Cox's Bazar. Under the initiative, the Moheshkhali Island, Matarbari Island, and their surrounding areas (the MM Area) are being developed as a "new economic hub" for the country.

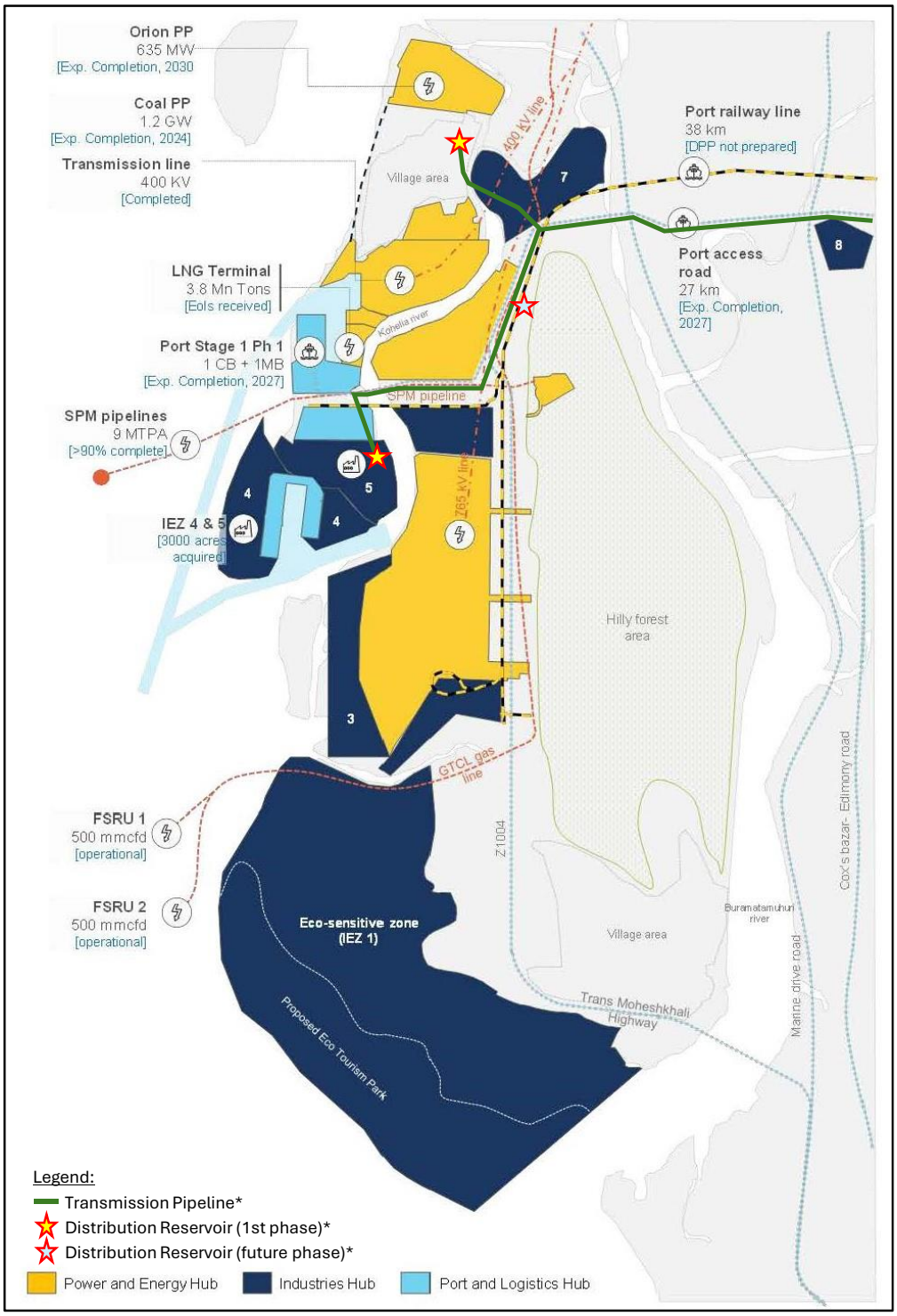
The "Moheshkhali-Matarbari Integrated Infrastructure Development Initiative Coordination Committee (MIDI CC)", composed of the secretary level officers of relevant ministries and other agencies concerned, was organized in February 2018 as the responsible organization for the comprehensive cross-sectoral development in the MM area with the intention of coordinating development initiatives and avoidance of overlapping among development plans/ activities. In October 2020, MIDI-Cell was formed under the PMO. Its task is to undertake more practical business of coordinating and monitoring the development initiatives. Preparation of relevant laws necessary to organize MIDI Authority (provisional name) is in progress as institutional enhancement for promotion of large-scale MIDI development projects.

(2) MIDI Master Plan

As a comprehensive regional development plan, the "MIDI Master Plan" is to be formulated by the MIDI-Cell (MIDI authority in the future) and MIDI-CC with JICA's support. In the "MIDI Master Plan", priority industries and their development are to be studied under the three strategic pillars of development scenarios, namely: Pillar 1: Port and Logistic Hub, Pillar 2: Industries Hub and Pillar 3: Power and Energy Hub. Furthermore, the MIDI Master Plan shall formulate plans for land use and infrastructure development as well as a development scenario for the manufacturing industry. The infrastructure development plan is to include a water supply and sewerage plan in the MIDI area. In the process of formulating the "MIDI Master Plan," the sector development plans (SDPs), which have been prepared by relevant ministries/ agencies are to be reviewed. As for the water supply sector, a water development plan was formulated by the Department of Public Health Engineering (DPHE) as referred to in "FR, Preparation of Water Development Plan at Moheshkhali-Matarbari Area of Cox's Bazar District, December 2023, DPHE", which is a short-term plan in the Moheshkhali-Matarbari area up to 2030, and is to be reviewed as an emergency water supply plan after completion of the Project.

(3) Land Use Plan

The existing future land use plan in the MM area is delineated into the three strategic pillars, as illustrated in Figure 2.3.1 below. The facilities to be developed by the Project is also added for reference. This land use plan is to be updated in the "MIDI Master Plan."



Notes: (i) * Facilities planned in the Project, (ii) IEZ5 is referred to as "Moheshkhali ZE (Dhalghata)" in this report.
Source: Adapted from Exhibit 2 in "Final Report: MIDI Strategic Vision Development and Economic Impact Analysis, March 2023, JICA"

Figure 2.3.1 Existing Future Land Use Plan in MM Area

(4) EZ Development Plan

As to the Bangladesh Economic Zones Authority Economic Zone (BEZA EZ) development plan related to the Project, there are eight economic zone (EZ) sites for the MM area selected in "IEZ-SDP, January 2021, BEZA". The "Industrial and Economic Zone Sector Development Plan (IEZ-SDP)" is the latest plan for the industrial and economic zone sector development in the MM area. As of this report, the development implementation is envisaged through phasing up to 2035. In addition, Table 2.3.1 compiles the conditions of each EZ site with its available area, current land acquisition status, and development direction.

Table 2.3.1 Selected EZ Sites for MM Area Considered in IEZ-SDP**

EZ Sites	Area According to the JICA Plan (Acre)	Area (Acre) Acquired by BEZA	Area Available for the EZ (Acre)	Remarks
Site 01	---	17,369.6 (Sonadia Island)	12,612.48	One portion of Sonadia Island is proposed to be developed as the Eco-Tourism Park (SE-TP). Considered area for the SE-TP is about 909.4 acres. The south part of the SE-TP may remain vacant (3,847.7 acres) and can be considered as part of future SE-TP. Rest of the area can be considered for the EZ site 01, which is 17,369.5813 acres – 909.4 acres – 3,847.7 acres = 12,612.48 acres BEZA advised to develop this site for eco-friendly industrial and commercial activities. The site can be explored as possible "Sea Village" with natural settings, supplemental to the nearby SE-TP.
Site 02	1,405.6	Not Acquired	1,405.6	The 2019 JICA LUP proposed this site as future development area.
Site 03	1,556.9	Not Acquired	1,556.9	It was proposed as an EZ site in the 2019 JICA Report.
Site 04	---	2,939.45 (Dakhin Dholghata Mouja)	Western side =1,272.13 Eastern side= 450.4 Total= 1,722.53	JICA proposed that a stage 2 port is going to be developed in the Dakhin Dholghata Mouja and BEZA has acquired the entire land already. About 1,220 acres of area is proposed for port stage 2. The remaining acquired land (Dakhin Dholghata Mouja) can be divided into two parts (west and east). However, BEZA informed that they did not receive any official communication for the stage 2 port development.
Site 05	1,242.05 (Energy Industrial Zone	1,240 (Dholghata Mouja)	1,240	An energy industrial zone was proposed by JICA in this same area (located in Dholghata and a few portions on the Dakhin Dholghata Mouza). BEZA acquired 1,240 acres land from Dholghata Mouja. BEZA already allocated TK group 510 acres of land. BEZA has developed a lay out plan for the rest of the area (730 acres) and proposed/handed over for lease (Siam Gas, AWCA), utilities (DRS Gas, REB Station, service zone), road, green belts, etc., while Siam Gas applied for 60 acres.
Site 06	757.5	Not Acquired	757.5	It was proposed as an EZ site in the 2019 JICA Report.
Site 07	1,543.33	Not Acquired	1,543.33	It was proposed as an EZ site in the 2019 JICA Report.
Site 08	1,111.65(450 ha)	Not Acquired	1,111.65 (450	It was proposed as a general EZ site in the 2019 JICA

EZ Sites	Area According to the JICA Plan (Acre)	Area (Acre) Acquired by BEZA	Area Available for the EZ (Acre)	Remarks
			ha)	Report.

Notes: *MM=Moheshkhali/Matarbari, **IEZ-SDP=Industrial and Economic Zones Sector Development Plan, January 2021, BEZA, Source: IEZ-SDP

Table 2.3.2 presents the relation between the EZ sites and their dependent projects which give suggestions concerning the earliest possible time for EZ site's viable development; in other words, control the earliest possible EZ completion year.

Table 2.3.2 Earliest Possible Time of EZ Site Completion as per Development of Dependent Projects

Site Number	Dependent Projects and their estimated completion time								Earliest Possible EZ Completion Year
	Poart Access Road (2025)	BEZA-BWDB Embankment Cum Road	Road ID 4.1 (2026)	Road ID 4.2 (2027)	proposed Road ID 6.2 (2027)	Trans Moheshkhali road (2031)	proposed Road ID 2 (2033)	Development of Sonadia Eco-Tourism Park (2035)	
8	✓								2025
7	✓								2025
5	✓	✓							2025
4W	✓		✓						2026
4E	✓		✓	✓					2027
6	✓				✓				2027
3	✓					✓	✓		2033
2	✓					✓			2031
1	✓					✓		✓	2035

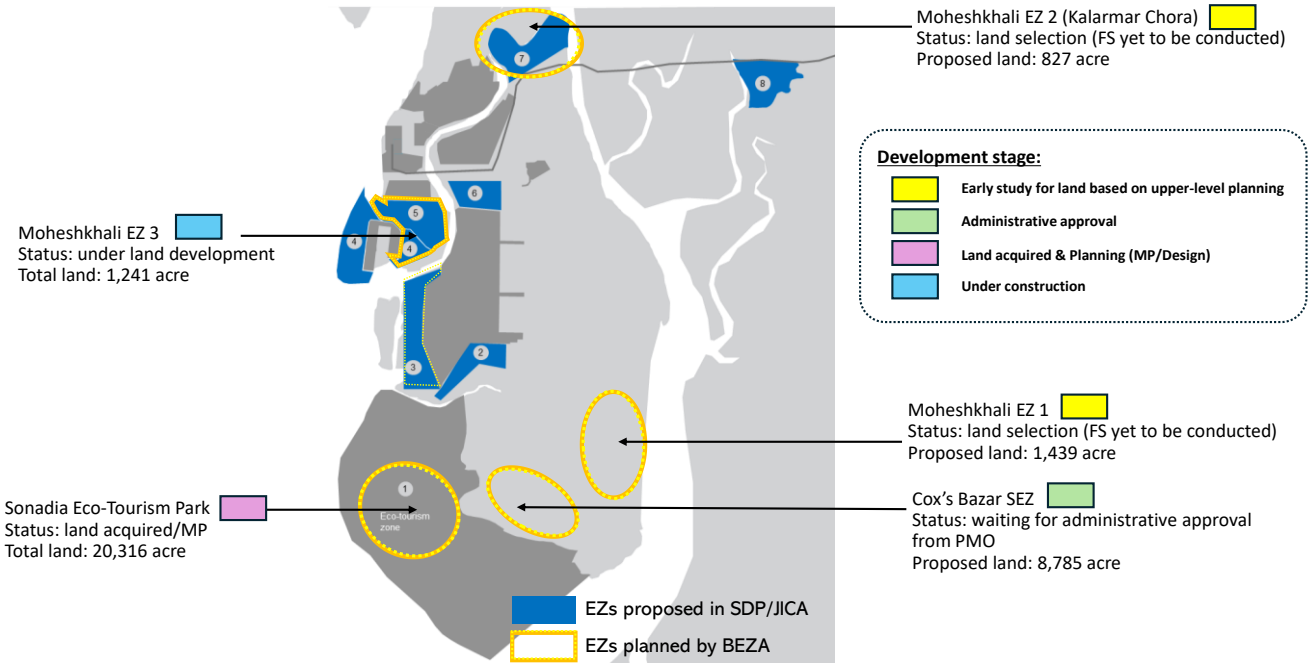
Source: Adapted from Table 14 in IEZ-SDP

Notes: The areas are not acquired by BEZA. Finance is not secured.

The EZ 5 site has already been acquired and does not involve dependent projects without secure funding. EZ 5 is estimated to be one of the earliest EZs to begin operation and to develop the need for bulk water supply. Therefore, EZ 5 is selected as the priority target EZ site for industrial water supply in the Project.

After IEZ-SDP (January 2021), BEZA reviewed the EZ development plan in the MM area, as per Figure 2.3.2. The EZ 5 site and part of EZ 4 site has been combined into Moheshkhali EZ 3, hereinafter referred to as "Moheshkhali EZ (Dhalghata)" in this report. In order to develop all areas of Moheshkhali EZ (Dhalghata), the construction of new roads is needed from the BEZA-BWDB embankment cum road.

BEZA's EZs in yellow (according to interview on 8th July 2024)

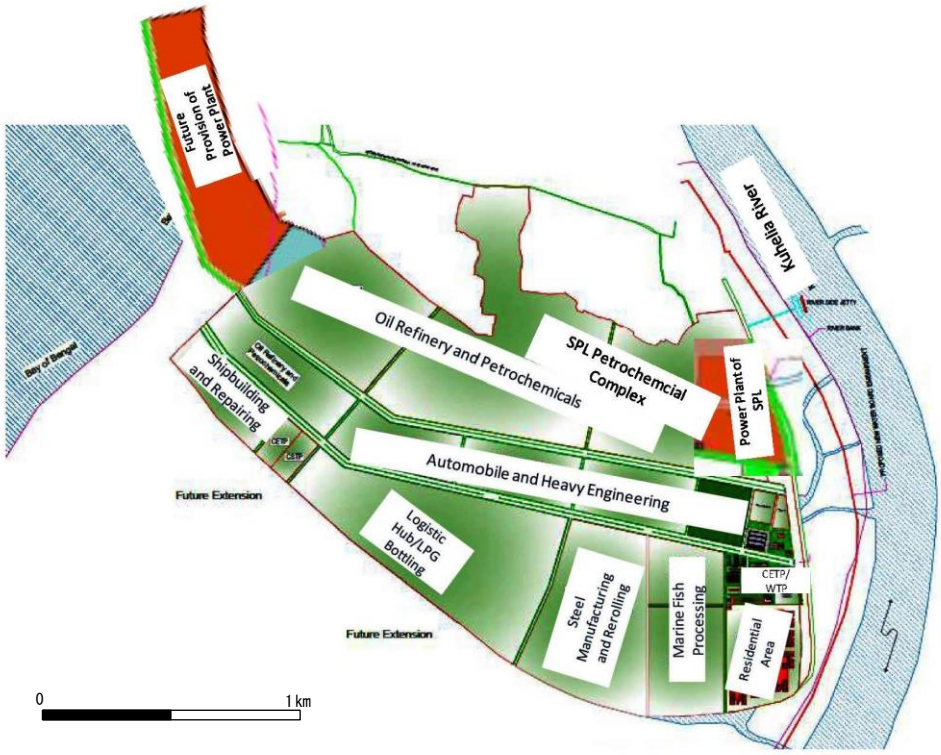


Source: from JICA Study Team for "MIDI Comprehensive Development Planning Project"

Figure 2.3.2 BEZA Review after IEZ-SDP (2021)

(5) Moheshkhali EZ (Dhalghata) Development Plan

As illustrated in Figure 2.3.3, the indicative industrial units are envisioned in the "Feasibility Study of Infrastructure Development at Moheshkhali EZ (Dhalghata), March 2022, BEZA".



Source: Feasibility Study of Infrastructure Development (Gas, Electricity and Communication) at Moheshkhali Economic Zone (Dhalghata)

Figure 2.3.3 Indicative Industrial Units in Moheshkhali EZ

(6) Population Increase

Through MIDI's progress, the development of Moheshkhali and Chakaria upazilas is expected to be promoted as the residential areas for the workers who will be involved in the industry and other business in the MM area. In particular, the unions and pourashava residential areas will be located along the Matarbari Port access road due to easier access to the Matarbari area after the completion of the access road.

(7) Flood Control Study

As for flood control, a master plan level study has been conducted in the "Project for Planning Capacity Enhancement and Establishment of a Technology Cycle on Comprehensive Nodi (River) Management", including the Matamuhuri River as one of the target rivers. The objective of the study is to establish a systematic and diverse river control and planning management method in due consideration of the Bangladeshi river characteristics. Since the Project includes the construction of intake facilities in the Matamuhuri River to intercept the rainy season river water, it is essential to secure close coordination between the Project and the Nodi project, particularly for river channel stabilization measures such as low water channel revetment and groynes. The Nodi project deals with the management of the Matamuhuri River, including maintenance dredging and flood control so that the said intake facilities would properly fulfill their safe and sustainable functions.

(8) Plans and Projects Related to the Project

Other plans and projects which have close relations with the Project are as compiled in Tables 2.3.3 and 2.3.4.

Table 2.3.3 List of Plans Related to the Project

Name	Completed in (Month) Year	Agency in Charge	Donor
(1) MIDI Plans			
- Land Use and Development Planning Survey of Moheshkhali and Matarbari Area in the People's Republic of Bangladesh	August 2019	MIDI-Cell	JICA
- Updating Master Plan of Moheshkhali Pourashava (Urban Development and City Governance Project)	December 2020	Moheshkhali Pourashava	JICA
- Updating Master Plan of Chakaria Pourashava (Urban Development and City Governance Project)	December 2020	Chakaria Pourashava	JICA
- Sector Development Plan of Local Government Division (LGD) for Moheshkhali-Matarbari Integrated Infrastructure Development Initiative (MIDI) Area of Cox's Bazar District	2021	LGED	GOB own
- Industrial and Economic Zones Sector Development Plan (IEZ-SDP)	January 2021	BEZA	JICA
- The Data Collection Survey for Strengthening Framework of Operation and Implementation of the Moheshkhali-Matarbari Integrated Infrastructure Development Initiative (MIDI)	July 2022	PMO/MIDI-Cell	JICA
- MIDI Comprehensive Development Planning Project	February 2028	Chief Adviser's Office	JICA
(2) Water Resources Sector in MIDI Area			
- Data Collection Survey on Water Resources Development in Southern Chattogram Region	August 2022	BWDB	JICA
- Water Development Plan (WDP) for Moheshkhali- Matarbari Area (MIDI) of Cox's Bazar District	December 2023	DPHE	GOB own

Source: JICA Survey Team

Table 2.3.4 List of Projects Related to the Project

Name	Project Period	Status (as of April 2024)	Agency in Charge	Donor
(1) Nearby projects which requires coordination during the construction of the Project				
- Matarbari Ultra Super Critical Coal-Fired Power Project	L/A: June 2014	Ongoing	BPDB	JICA
- Matarbari Port Development Project	L/A: Phase 1: May 2019 Phase 2: March 2023	Ongoing	CPA	JICA
- Southern Chattogram Region Development Project	L/A: June 2022	Ongoing	LGED	JICA
- Urban Development and City Governance Project	L/A: August 2020	**	LGED	JICA
- Chattogram – Cox's Bazar Highway Improvement Project	L/A: March 2023	**	RHD	JICA
- Matarbari Port Access Railway Project	**	**	BR	ADB
(2) Project for capacity enhancement of agency to be involved in the Project				
- The Project for Improvement of Comprehensive Management Capacity of DPHE on Water Supply (Phase 2)	February 2022 – March 2025	Ongoing	DPHE	JICA
(3) Project dealing with flood control				
- Project for Planning Capacity Enhancement and Establishment of a Technology Cycle on Comprehensive Nodi (River) Management*	September 2020 – August 2024	Ongoing	BWDB	JICA

Notes: * This project shall be included also in (1) above due to the Matamuhuri River training works at and around the intake facilities of the Project. ** To be reported in the DFR
Source: JICA Survey Team

2.4 Water Use

2.4.1 Present Situation of Water Supply Facility Development

(1) Present Situation

The data regarding the main sources of drinking water for general households are presented in Table 2.4.1. The data shows that; (i) at the national level, 86.51% of households use deep/shallow tube wells as the main source of drinking water, (ii) as many as 11.14% and 25.54% of the households use tap/pipe (supply) water in the country and in Dhaka Division, respectively, and (iii) in Cox's Bazar District, where located are the unions and pourashava envisaged as the target areas of water supply in the Project, 97.64% of households use deep/shallow tube-wells as the main source of drinking water.

Table 2.4.1 Main Sources of Drinking Water (as of 2022)

(in percent)

Area	Source of Drinking Water								
	Total	Tap/Pipe (Supply)	Tube-well (Deep/ Shallow)	Bottled/Jar Water	Well	Pond/River/ Canal/ Lake	Spring	Rain Water	Others
National	100.00	11.14	86.51	0.57	0.34	0.89	0.11	0.40	0.03
Dhaka Division	100.00	25.54	73.99	0.39	0.02	0.04	0.00	0.00	0.02
Chattogram Division	100.00	11.81	85.55	0.42	1.06	0.49	0.59	0.01	0.07
Cox's Bazar District	100.00	0.61	97.64	0.79	0.63	0.14	0.11	0.00	0.08

Source: Population and Housing Census, 2022

(2) Existing Facility

The wells for domestic use have been constructed by the DPHE in the survey area. Construction of boreholes in the survey area is managed by the DPHE Cox’s Bazar Office and its satellite offices in each upazila. The total number of boreholes constructed by March 2020 was 4,784 and 3,741 for shallow and deep wells, respectively, in total 8,525, as shown in Table 2.4.2. In the Survey, a borehole of which the drilling depth is less than 200 feet (about 60 m) is classified as a shallow well and a borehole with a deeper depth is classified a deep well.

Table 2.4.2 Numbers of Functioning Boreholes Constructed by DPHE (as of Mar. 2020)

Upazila	Shallow Well	Deep Well	Total
Chakaria	2,809	2,436	5,245
Moheshkhali	1,975	1,305	3,280
Total	4,784	3,741	8,525

Source: Data Collection Survey on Water Resources Development in Southern Chattogram

According to the information from the Moheshkhali DPHE Office, there are many tube wells constructed by NGO in accordance with DPHE's approval and the total number of running private tube wells amounts to 11,646, as shown in Table 2.4.3.

Table 2.4.3 Numbers of Private Tube Wells (as of Dec. 2023)

Upazila	Well No.	Running Well No.	Disturbed Well No.
Chakaria	6,961	6,753	208
Moheshkhali	5,031	4,893	138
Total	11,992	11,646	346

Source: Moheshkhali DPHE

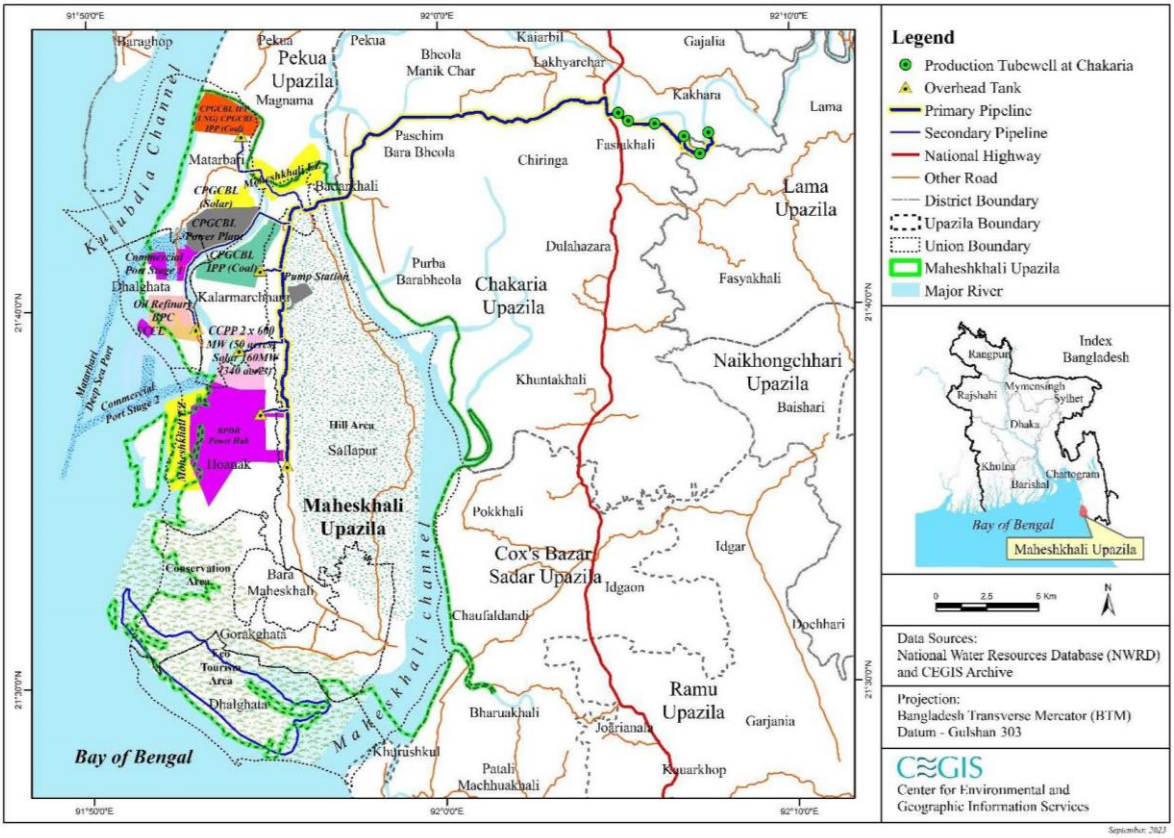
(3) Development Plan

Development work is going on in the Moheshkhali-Matarbari area in an accelerating rate, with an influx of people moving into the area. The increasing population requires high water demand for domestic and drinking purposes. In this backdrop, an immediate solution needs to be identified to fulfil the water demand for the area, especially the drinking and domestic water demand.

The following Short-Term Plan (2024-2030), which is prepared by the DPHE as referred to in the "FR, Preparation of Water Development Plan at Moheshkhali-Matarbari Area of Cox's Bazar District, December 2023, DPHE", is anticipated to be able to fulfil the water demands in the short term based on the groundwater availability of Moheshkhali and Chakaria. The plan will work together in parallel with the Project and after the completion of the Project, the water supply system in the plan is to work as an emergency system.

In the Short-Term Plan (2024-2030), the following facilities are planned to be constructed. Figure 2.4.1 shows the location of each facility. As of the end of August 2024, the construction of 6 tube wells and (i) pipelines and 6 overhead tanks has been completed and connection work is in progress.

- Six tube wells at the valley of the Matamuhuri River basin, each having an extraction rate of 50 m^3/hour, totaling 300 m^3/hour
- A 62.9-km pipeline to establish (i) a pipe water network to transport domestic water to these areas from the tube wells to the Moheshkhali-Matarbari industrial zone and (ii) a secondary pipe network to transport water from the primary distribution tanks to the demand areas
- Six overhead tanks



Source: Water Development Plan (WDP) for Moheshkhali-Matarbari Area (MIDI) of Cox's Bazar District

Figure 2.4.1 Map of Water Supply Facility Development Plan

Emergency Multi-Sector Rohingya Crisis Response Project (EMCRP) is also implemented by DPHE financed by Government of Bangladesh and World Bank and the following facilities are planned to be constructed.

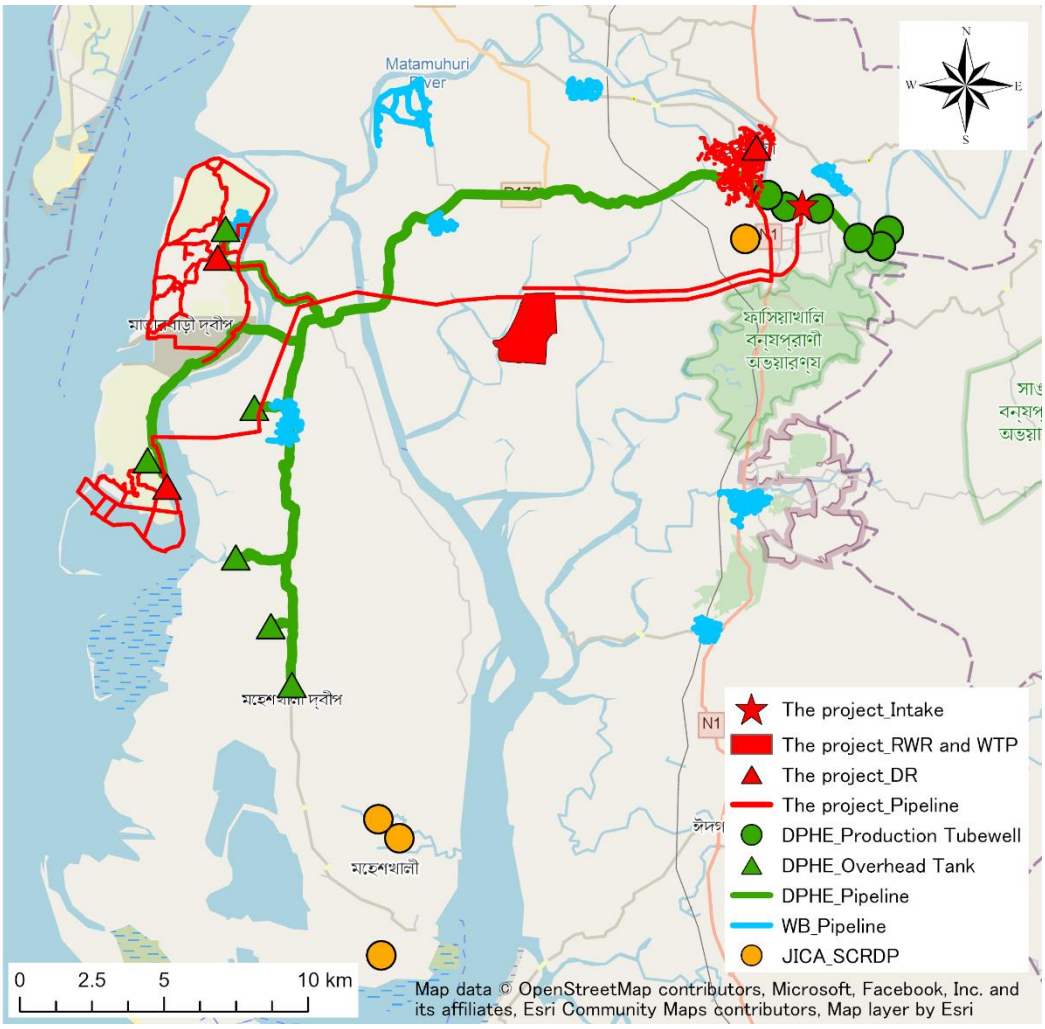
- Chakaria Upazila, Bheola Mani Char Union: One tube well and 7,275 m pipelines with 50, 75, 110, 160 mm Diameter
- Chakaria Upazila, Dulahazara Union: Two tube wells and 10,234 m pipelines with 50, 75, 110, 160 mm Diameter
- Chakaria Upazila, Kakhara Union: One tube well and 5,563 m pipelines with 50, 75, 110, 160 mm Diameter
- Chakaria Upazila, Khuntakhali Union: One tube well and 8,567 m pipelines with 50, 75, 110, 160 mm Diameter
- Chakaria Upazila, Konakhali Union: One tube well and 6,206 m pipelines with 50, 75, 110, 160 mm Diameter
- Chakaria Upazila, Pachim Bara Bheola Union: One tube well and 7,122 m pipelines with 50, 75, 110, 160 mm Diameter
- Moheskhali Upazila, Kalarmarchhara Union: One tube well and 7,559 m pipelines with 50, 75, 110, 160 mm Diameter

- Moheskhali Upazila, Matarbari Union: One tube well and 5,828 m pipelines with 50, 75, 110, 160 mm Diameter

Southern Chattogram Regional Development Project (SCRDP) is implemented by LGED financed by Government of Bangladesh and JICA and the following facilities are planned to be constructed between 2022 and 2028.

- Chakaria Paurashava: One deep well
- Moheskhali Paurashava: One deep well
- Moheskhali Upazila, Chhota Maheskhali Union: One deep well
- Moheskhali Upazila, Saflapur Union: One deep well

Figure 2.4.2 shows the location of all facilities above. All existing facilities and planned facilities besides the Project rely on ground water.



Source: JICA Survey Team

Figure 2.4.2 Map of Planned Water Supply Facilities

(4) Demarcation between Existing Facilities and the Project

The ground water levels in both the shallow and deep aquifers are gently decreasing in the survey area, as shown in Table 2.4.4.

Table 2.4.4 Average Ground Water Declination in Survey Area

Upazila	Average Ground Water Declination (m/year)	
	Shallow Well	Deep Well
Chakaria	0.10	0.10
Moheshkhali	0.02	0.03

Source: Data Collection Survey on Water Resources Development in Southern Chattogram

From the survey results, the ground water extraction is estimated at 156.7 x 10^6 m^3, while the recharge from surface water to ground water is at 1,323.4 x 10^6 m^3. Therefore, the amount of groundwater pumped up is equivalent to about 12% of the recharge. Although the recharge to ground water is much higher than the ground water extraction, the ground water level is on a downward trend. This suggests that the total amount of ground water extraction and the outflow from the aquifer to the outside of the survey area is larger than the total amount of ground water recharge and the inflow from the upstream side of the aquifer.

If the current situation of ground water utilization continues in the future, the ground water in the survey area is feared to continue its moderate declination. If the ground water level drops below the sea level, there is a possibility of saltwater intrusion into the ground water in areas facing the sea. In addition, it is assumed that the pumps installed in the wells will be unable to pump water.

Currently, there is a policy where groundwater use is to be limited in Bangladesh. There are many uncertainties about its potential for the time being compared with the surface water because ground water cannot be visually confirmed and observed like rivers and lakes, and its flow, distribution, and potential should be estimated by well surveys and geophysical investigations. The existing water supply system using ground water is treated as supplemental measures to cope with local and small-scale water demands.

CHAPTER 3 PRESENT CONDITIONS OF WATER SUPPLY SECTOR IN BANGLADESH

3.1 Relevant Organizations

3.1.1 Ministry of Water Resources (MoWR)

The MoWR is the apex body of the GoB for the development and management of water resources of Bangladesh. The MoWR formulates project policies, plans, strategies, guidelines, rules, and regulations related to the development and management of water resources. Projects such as technical support, research, irrigation, flood control, drainage, inundation, and erosion prevention, etc., are implemented by seven agencies, including Bangladesh Water Development Board (BWDB) under the jurisdiction of the MoWR.

3.1.2 Bangladesh Water Development Board (BWDB)

The BWDB was established in 1959 during the East Pakistan period as the water division of the East Pakistan Water and Power Development Authority (EPWAPDA). It later became the current organization under the MoWR after the declaration of independence of Bangladesh in 1972. Under the BWDB Act, 2000, it is responsible for flood control, irrigation and drainage, river dredging, riverbank protection and reclamation, etc., based on the National Water Policy (NWPo) and the National Water Management Plan (NWMP). BWDB is also responsible for collecting and providing hydrological data, and issues flood forecast and warning during the rainy season.

BWDB has implemented nearly eight hundred projects during the last sixty years, providing 1) flood management facilities to for 6.3 million hectares of land and 2) irrigation facilities to for 1.6 million hectares in the country. Other activities carried out are 3) the development of drainage canal facilities (4,425 km), 4) construction of town protection facilities (22 nos.), 5) bridge/culvert constructions (5,643 nos.), 6) land reclamations (1,020 km^2) and 7) construction of embankments (11,393 km), etc. BWDB's development budget (the sum of the budgeted amount for each fiscal year in approved DPPs) for FY2021-22 and FY2022-23 were BDT 75.4 billion and BDT 113.2 billion, respectively.

The total number of approved and actual BWDB officers as of 2023, and the organizational chart of BWDB are shown in Table 3.1.1 and Figure 3.1.1, respectively.

Table 3.1.1 Approved and actual No. of Posts BWDB in 2023

Sl. No.	Name of Post	No. of Post	No. of Existing Employees	Vacancy
1	Director General	1	1	0
2	Additional Director General	5	5	0
3	Chief Engineer (Civil)	6	5	1
4	Chief Engineer (Mechanical)	1	0	1
5	Additional Chief Engineer (Civil)	12	10	2
6	Controller (FA&A)	1	1	0

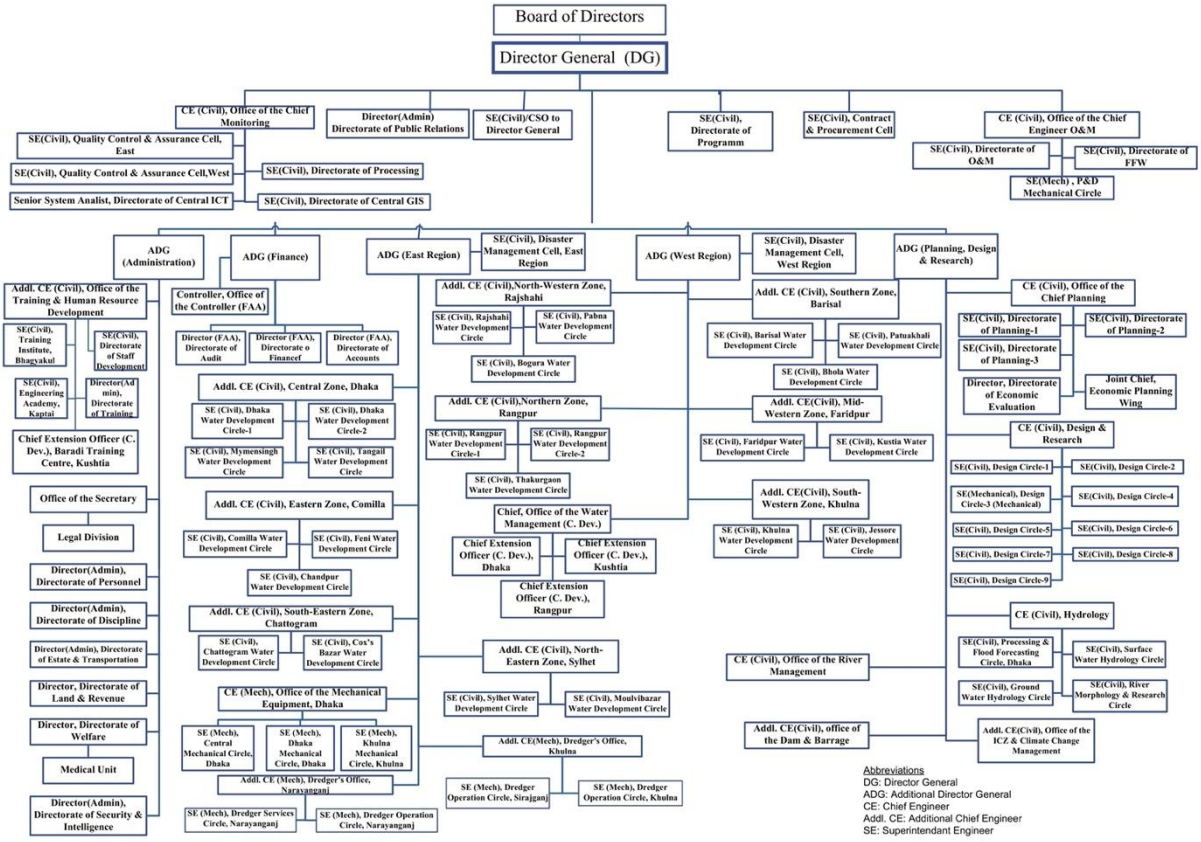
Sl. No.	Name of Post	No. of Post	No. of Existing Employees	Vacancy
7	Additional Chief Engineer (Mechanical)	2	2	0
8	Chief Water Management (Community Development)	1	0	1
9	Superintending Engineer (Civil)	59	56	3
10	Superintending Engineer (Mech)	9	9	0
11	Principal Extension Officer (Community Development)	4	3	1
12	Joint Chief	1	0	1
13	Director Evaluation (Economic Evaluation)	1	0	1
14	Director (Admin)	7	7	0
15	Director (FA & A)	3	2	1
16	Director (Geology)	1	0	1
17	Director (Land & Revenue)	1	1	0
18	Director (Board)	1	1	0
19	Senior System Analyst	1	0	1
20	Executive Engineer (Civil)	191	123	68
21	Executive Engineer (Mechanical)	34	12	22
22	Deputy Chief Extension Officer (Community Development)	12	12	0
23	Deputy Chief, Economics	2	2	0
24	Deputy Chief, Agriculture	4	3	1
25	Deputy Chief, Soil	1	1	0
26	Deputy Chief, Fishery	1	1	0
27	Deputy Chief, Sociology	1	1	0
28	Additional Director, (FA&A)	4	4	0
29	Chief Medical Officer	1	0	1
30	System Analyst	5	4	1
31	Deputy Director (FA&A)	21	8	13
32	Deputy Director (Admin)	40	9	31
33	Deputy Director (Geology)	3	0	3
34	Deputy Director (Land & Revenue)	3	0	3
35	Sub-Divisional Engineer (Civil)	260	213	47
36	Sub-Divisional Engineer (Mechanical)	50	27	23
37	Extension Officer (Community Development)	11	1	10
38	Assistant Chief, Fishery	1	1	0
39	Assistant Chief, Sociology	4	4	0
40	Assistant Chief, Agriculture	4	0	4
41	Assistant Chief, Environment & Forest	3	3	0
42	Assistant Chief, Economics	6	4	2
43	Assistant Chief, Soil	3	1	2
44	Programmer	6	5	1
45	Assistant Engineer (Civil)	362	277	85
46	Assistant Engineer (Mechanical/Electrical)	61	48	13
47	Assistant Extension Officer (community Development)	19	14	5
48	Research Officer, Environment & Forest	4	4	0
49	Research Officer, Agriculture	4	4	0
50	Research Officer, Economics	7	6	1
51	Research Officer, Fishery	3	2	1
52	Research Officer, Sociology	4	4	0

Sl. No.	Name of Post	No. of Post	No. of Existing Employees	Vacancy
53	Research Officer, Soil	2	2	0
54	Assistant Programmer	9	9	0
55	Assistant Director (Land & Revenue)	17	10	7
56	Assistant Director (FA&A)	53	48	5
57	Assistant Director (Admin)	70	62	8
58	River Surveyor	3	0	3
59	Geologist	20	19	1
60	Medical Officer	1	1	0
Sub-Total (Class-I)		**1,427**	**1,052**	**375**
61	Engineer Grade-A	1	0	1
62	Engineer Grade-B	1	0	1
63	Accountant	65	41	24
64	Sub-Assistant Engineer/ Sectional Officer (Civil)/Estimator	800	684	116
65	Sub-Assistant Engineer/ Sectional Officer (Electrical/Mechanical)	155	100	55
66	Hydrographic Surveyor	1	0	1
67	Driller	8	8	0
68	Senior Data Entry Operator	33	25	8
69	Assistant Revenue Officer	70	61	9
70	Master 1st Class	30	1	29
71	Foreman, Mech/Elec	21	20	1
72	Leverman (24")	9	0	9
73	Zonal Intelligence Officer	4	4	0
Sub-Total (Class-II)		**1,198**	**944**	**254**
74	Master 2nd Class	11	4	7
75	Driver 1st Class	49	3	46
76	Assistant Accountant	79	66	13
77	Skipper/Master	1	0	1
78	Senior Accounts Asstt.	257	220	37
79	Stenographer/PA	68	48	20
80	Leverman (18")	18	0	18
81	Driver 2nd Class	13	0	13
82	Extension Overseer (Community Development)	165	0	165
83	Concrete Technician	1	0	1
84	Cameraman/Photographer	1	1	0
85	Operator C	7	0	7
86	Store Keeper B	7	0	7
87	Draftsman	24	17	7
88	Upper Division Assistant	156	142	14
89	Drilling Assistant (Grade-1)	8	0	8
90	Electrician C	11	0	11
91	Machinist C	2	0	2
92	Master 3rd Class	24	1	23
93	Sand Blaster	2	0	2
94	Mechanic C	6	1	5
95	Fitter C	2	1	1
96	Welder C	2	0	2
97	Drilling Assistant (Grade-2)	8	4	4

Sl. No.	Name of Post	No. of Post	No. of Existing Employees	Vacancy
98	Driver (Heavy)	4	4	0
99	Junior River Surveyor	4	0	4
100	Soil Technician	2	2	0
101	Camp Supervisor	17	8	9
102	Operator (Crane)	1	1	0
103	Surveyor (Engg.)	245	164	81
104	Electrician B	27	0	27
105	Machinist B	4	0	4
106	Mechanic B	10	1	9
107	Assistant Hydrographic Surveyor	1	0	1
108	Fitter B	7	0	7
109	Operator B	15	1	14
110	Welder B	8	2	6
111	Library Assistant	3	0	3
112	Tug Boat Driver	1	0	1
113	Driver (Vehicle)	466	390	76
114	Imam	33	25	8
115	Vertical Transport Attendant	6	6	0
116	Audio Visual Operator	1	0	1
117	Laboratory Assistant	1	0	1
118	Revenue Surveyor	74	47	27
119	Speed Boat Driver	57	51	6
120	Telephone Operator	2	1	1
121	Accounts Clerk	330	243	87
122	Store Keeper A	22	15	7
123	Leverman (12")	10	5	5
124	Operator (Equipment)	2	1	1
125	Data Entry Operator	329	173	156
126	Tracer	22	22	0
127	Office Assistant-cum- Computer Typist	402	248	154
128	Tele Communication Operator	13	13	0
129	Work Assistant	1191	678	513
Sub-Total (Class-III)		**4,232**	**2,609**	**1,623**
130	Driver 3rd Class	20	0	20
131	Electrician A	80	4	76
132	Machinist A	15	1	14
133	Mechanic A	50	0	50
134	Fitter A	14	0	14
135	Operator A	50	2	48
136	Welder A	20	1	19
137	Rigger A	4	0	4
138	Pump Operator	98	96	2
139	Assistant Driver	62	40	22
140	Moazzin	15	11	4
141	Dresser	1	1	0
142	Oilman	50	31	19
143	Plumber	3	3	0
144	Baburchi	74	31	43
145	Sukani	45	27	18
146	Helper	120	113	7

Sl. No.	Name of Post	No. of Post	No. of Existing Employees	Vacancy
147	Gauge Reader	354	316	38
148	Laskar	248	203	45
149	Assistant Cook	86	77	9
150	Bearer	116	100	16
151	Lab. Attendant	4	3	1
152	Security Guard (Chowkidar)	410	214	196
153	Mali/Gardener	82	69	13
154	Office Support Staff	1,650	800	850
155	Attendant	1	1	0
156	Sailor	4	4	0
157	Store Khalasi	9	9	0
158	Chainman	3	3	0
159	Cleaner	490	444	46
160	Gate Operator	547	530	17
161	Hydro Survey Boat Operator	1	1	0
162	Khalasi (Canal/ Embankment)	205	205	0
163	Security Guard (Guard)	850	805	45
Sub-Total (Class-IV)		**5,781**	**4,145**	**1,636**
Total		**12,638**	**8,750**	**3,888**

Source: BWDB



Source: BWDB

Figure 3.1.1 Organizational Chart of BWDB

3.1.3 Local Government Division (LGD)

In Bangladesh, the responsibility for water supply and sanitation lies primarily with the Government, and therefore, LGD takes charge of it. LGD is a policy making body for local governments and is responsible for policy implementation and local government supervision.

The main responsibilities are the formulation, implementation and monitoring of various plans related to local autonomy, the allocation of grants to local governments, the establishment of various rules and the project monitoring of local governments' operations. The executing agencies for water supply under the jurisdiction of LGD are the Department of Public Health Engineering (DPHE) and Water and Sewerage Authority (WASA) as the agencies that are considered to play an important role on water supply and sanitation for the Moheshkhali / Matarbari regions.

3.1.4 The Department of Public Health Engineering (DPHE)

DPHE was established during the East Pakistan period after its independence from India in 1947. In alignment with the National Policy for Safe Water Supply and Sanitation, 1998, DPHE is currently the national lead agency for the provision of drinking water supply and waste management services throughout Bangladesh except Dhaka/Narayanganj, Chattogram, Khulna, and Rajshahi where WASAs operate. DPHE's approved number of staff is described in Chapter 8 (Table 8.3.1). DPHE usually installs wells and water pipes to provide drinking water supply services to City Corporations and Pourashavas. It also hands over those completed water supply facilities to the local communities after having confirmed there weren't defects with them through operation for one or two years and also provides technical support to the water users .

With the challenges generated by the discovery of arsenic in various areas since its first detection in 1993, DPHE has tried to relieve the sufferings caused by the lack of safe water.

Most drinking water sources depend on ground water in Bangladesh at present. According to the water supply facility information "Upazila Wise Water Source Status and Coverage, July 2015," by DPHE, 95.8% of the water supply facilities constructed by DPHE to date are wells.

Table 3.1.2 Water Source Status and Coverage, July 2015

Circle	a: Water-supplied Population	b: Number of Facilities	c: Number of Wells	d: Ratio B/C
Rangpur	14,290,828	167,235	164,778	98.50%
Rajishahi	15,682,951	215,211	212,933	98.90%
Khulna	13,351,014	206,499	181,238	87.80%
Faridpur	27,964,449	340,810	334,914	98.30%
Barisal	5,884,668	100,593	96,992	96.40%
Sylhet	7,275,360	145,859	139,460	95.60%

Circle	a: Water-supplied Population	b: Number of Facilities	c: Number of Wells	d: Ratio B/C
Rangpur	14,290,828	167,235	164,778	98.50%
Chattogram	8,825,640	96,467	92,016	95.40%
Rangpur	21,313,562	306,526	301,891	98.50%
CTHs	1,172,601	11,884	18,996	59.00%
All Bangladesh	115,761,072	1,611,375	1,543,218	95.80%

Source: "Project for Improvement of Comprehensive Management Capacity of Department of Public Health Engineering on Water Supply", July 2021, JICA

The DPHE's development budget (the sum of the budgeted amount for each fiscal year in approved DPPs) in FY 2019-20 was BDT 17,274 million (= GoB-funded: BDT 14,857 million + Donor-aided: BDT 2,417 million)[1].

3.1.5 Chattogram Water Supply and Sewerage Authority (CWASA)

The main roles of WASA are: 1) construction, improvement and O&M of facilities related to the water intake, treatment, storage, and distribution of drinking water, 2) construction, improvement, and O&M of sanitary sewerage facilities, 3) abolition of unnecessary existing drainage facilities, and 4) construction and O&M of drainage systems such as rainwater drainage ditches.

CWASA was initially established for the purpose of providing water and sanitary service to Chittagong and its designated suburbs in 1963 under the East Pakistan Government period. After that, CWASA was officially rebuilt by the enactment of the WASA Act in 1996, and was officially established as CWASA in 2008. The main functions of CWASA in the Chattogram metropolitan area are as follows: 1) construction, improvement, expansion, and O&M of infrastructure required for household, industrial and commercial water supply, 2) construction and O&M of sewerage systems in the Chattogram metropolitan area, 3) construction and O&M of drainage facilities for rain, floods, and surface water, and 4) solid waste management. All of WASA's capital is owned by the Government, and the Board of Directors consists of 13 directors appointed by the Government under the WASA Act.

CWASA is obliged to provide water supply service to 155 km^2 of 41 wards under the Chattogram City Ordinance. At present, CWASA does not provide sewage treatment and storm water drainage services. Such services are currently provided by Chattogram City Corporation. At present, CWASA is formulating the drainage sewerage services project using donor's supports, including JICA.

Table 3.1.3 Numbers of CWASA Users and Water Supply Volume of FY2021/22

User Type	Number of Users (connection) (June 2022)		Billed Amount (FY 2021/22)	
Residential	75,402	93.1%	8,578,894 m3	90.7%
Non-residential	5,603	6.9%	881,523 m3	9.3%
Total	81,005	100.0%	9,463,147 m3	100.0%

Source: "Preparatory Survey on Chattogram Sewerage System Development Project Final Report", July 2023, JICA

3.2 National Policy

The following plans were introduced as the national policies of Bangladesh in relation to its water supply sector.

(1) Perspective Plan of Bangladesh 2021-2041 (PP2041)

PP2041 was issued by the Bangladesh Planning Commission, Ministry of Planning in March 2020, which seeks to eliminate extreme poverty and reach an upper middle-income country (UMIC) status by 2031, and moving forward to a high-income country (HIC) status by 2041. In order to achieve this HIC status, the initiative of encouraging expansion of manufacturing capacity and investment in human capital development will be taken.

Internal in-country migration from rural to urban areas has helped poverty reduction at the national level, however, it also caused deterioration of the city environment.

From the perspective of water-related services including sewerage, presently there is a huge issue regarding minimal cost recovery from the services provided by the water supply and sewerage authorities (WASAs) and municipalities due to improper regulations and inadequate policies regarding self-financing and water pricing. The self-financing and pricing policy would then be changed to mobilize funds for new investments as well as to ensure efficient use of water and full operating cost recovery by fiscal year (FY) 2020 and 100% capital cost recovery by FY 2031.

As for Bangladesh's rural areas, the availability of safe water is a top priority in all villages with special attention to salinity prone coastal areas, arsenic prone areas, and hilly, haor and char areas. There will be gradual increase of piped and mini piped water supply in densely populated villages throughout the country. At the same time, special effort will be given in sanitation and fecal sludge management for restoration of aquatic environment in the rural areas.

(2) The Eighth Five Year Plan (July 2020 – June 2025) (8FYP)The 8FYP issued in December 2020 is the first in the series of four medium term development plans aimed at implementing the PP2041. The 8FYP will invest heavily in critical urban services like water supply, drainage, sanitation and waste management. In particular, the access to safe water and sanitation will be enhanced in both urban and rural areas to improve health and fight arsenic pollution. The Government of Bangladesh (GOB) sets policies related to a strong cost recovery for urban services, which will help finance operating costs of city governments relating to local roads, drainage systems, etc. The cost recovery will play a dominant role for services such as water supply, sewerage and solid waste disposal. Private provision of these commercial services will also be encouraged. Focusing on urban water supply, the GOB institutes cost recovery policies to allow projects to get revenues. These revenues are equal to 0.1% of the gross domestic product (GDP) at present and is expected to change to about 0.3% of the GDP by the FY 2025. However, this calls for major reforms in city corporations and municipalities for cost recovery in urban water supply and establishment of effective water user associations (WUAs) in rural areas.

With regard to development of the water supply facilities, the 8FYP refers to "9.10 Piped Water Supply project in 100 Pourashavas" in Volume 2 of BDP 2100, which describes the following:

- Total 400 nos. of production tube well including pump, pump house and electric connection will be installed in each pourashava;
- Treatment plants including intake pump station service with power will be installed in 33% of pourashavas;
- Pipeline length will be 50 km/pourashava; and
- Land acquisition will be 1 acre/pourashava, 100 acres in total.

(3) National Strategy for Water Supply and Sanitation, Revised and Updated Edition 2021

The revised "National Strategy for Water Supply and Sanitation 2021" presents a comprehensive framework for the water supply, sanitation, and hygiene (WASH) sector in Bangladesh to deal with the new challenges after the Millenium Development Goal (MDG) era (2000-15). The goal of this strategy is to realize "safe and sustainable water supply, sanitation and health hygiene services for all, with safety nets for the hard-core poor and the marginalized, leading to better health and well-being" in line with the Sustainable Development Goals (SDGs) by 2030. In order to realize the said goal, three strategic themes were set up with several strategies under the respective themes; based on which the WASH sector interventions are to be formulated.

Strategic Theme 1: Increase the coverage and improve the quality of WASH services,
Strategy 1: Expand access to safe and affordable drinking water and sanitation facilities
Strategy 2: Give priority to arsenic mitigation
Strategy 3: Move to a safely managed rung of the sanitation ladder
Strategy 4: Establish Fecal Sludge Management System
Strategy 5: Manage solid waste judiciously
Strategy 6: Improve hygiene promotion
Strategy 7: Undertake specific approaches for hard-to-reach areas and vulnerable people
Strategy 8: Mainstream gender approaches
Strategy 9: Facilitate private sector participation

Strategic Theme 2: Address the perennial and emerging challenges in the sector
Strategy 10: Adopt integrated water resource management
Strategy 11: Address growing pace of urbanization
Strategy 12: Cope with disaster, adapt to climate change and safeguard environment
Strategy 13: Institutionalize research and development

Strategic Theme 3: Strengthen sector governance, coordination, monitoring and reporting.
Strategy 14: Undertake integrated and accountable development approach
Strategy 15: Recover cost of services while keeping a safety net for the poor
Strategy 16: Strengthen and reposition institutions and develop human and financial capacities
Strategy 17: Enhance coordination, monitoring and reporting mechanism

Among the strategies for "Strategic Theme 2", there is "Strategy 10: Adopt integrated water resources management" that was adopted.

The Strategy 10 states that in the context of competitive use of water by various sectors such as agriculture and industry, there is a need for Integrated Water Resources Management (IWRM) to achieve drinking water supply security from the point of view of its viability and quality. Since the "Water Act, 2013 and Water Rules, 2018" have given the highest priority to drinking water and domestic water supply to provide security of drinking water in case of multiple use of ground water and surface water resources, the following strategic directions are therefore presented to strengthen IWRM in the context of Bangladesh.

ST-1.	Harmonize the Water Act, 2013, and Waler Rules, 2018, with the existing WASA Act, 1996, various LGI Acts 2009 and other related acts, rules, and regulations (ECA Rules, Biological Diversity Act, Hazardous Waste and Ship Breaking Rule, Medical Waste Management Rules, draft E-waste Management Rules) to effectively address the issues concerning water resource protection and its proper management,
ST-2	Foster a shift away from reliance on groundwater towards surface water for irrigation in groundwater-stressed areas, introducing water-efficient technologies in agriculture and climate stressed areas as well as stress-tolerant cultivars,
ST-3	Consider the availability and quality of surface water for water supply intervention, along with factors such as seasonal variations, possible withdrawal of water upstream, and effects of climate change like increased salinity and reduced flow,
ST-4	Investigate, assess, and monitor the availability and use of groundwater in water-stressed areas and in the deep aquifer,
ST-5	Limit the abstraction of groundwater to a sustainable level (keeping the balance intact) in water-stressed areas by keeping the abstraction within the safe yield range,
ST-6	Consider artificial recharge of groundwater and other technical measures in the water-stressed areas,
ST-7	Enhance inter-sectoral collaboration with the Ministry of Environment, particularly concerning water safety planning,
ST-8	Facilitate the development of an evidence-based national groundwater protocol for supporting zoning and land use.

The Project will enable safe and stable water supply for the water users (STs-1, 3) and contribute to ground water conservation (STs-2,4,5) in the Moheshkhali and Matarbari areas in the context of competitive use of water by various sectors. Although there are already many acts, rules, and regulations in Bangladesh related to water resource protection and its proper management, the planning, design, operation and maintenance (O&M), and administration of the Project will encourage effective enactment of them (ST-7) and eventually strengthen resilience against the climate change (ST-3).

(4) Bangladesh Delta Plan 2100 (BDP 2100)

The GOB decided to formulate a long-term Bangladesh Delta Plan 2100 in view of its special long-term challenges for development outcomes presented by climate change and natural hazards. The BDP 2100 is built on the Sixth and Seventh Five-Year Plans and incorporated the government vision of PP2041. Specifically, BDP 2100 attempts to integrate the short term (2015–2030), medium-term (2030-2050), and long-term (2050-2100) aspirations of Bangladesh to reach the upper middle income (UMIC) status and eliminate extreme poverty by 2030, being a prosperous country beyond 2041 with the longer-term challenge of sustainable management of water, ecology, environment, and land resources in the context of their interaction with natural disasters and climate change.

The Plan's vision and goals are framed below.

Vision: Achieving a safe, climate-resilient and prosperous delta

Goals: Higher level goals:

Goal 1: Eliminate extreme poverty by 2030
Goal 2: Achieve upper middle-income status by 2030
Goal 3: Being a prosperous country beyond 2041

Specific goals:

Goal 1: Ensure safety from floods and climate change-related disasters
Goal 2: Enhance water security and efficiency of water usage
Goal 3: Ensure sustainable and integrated river systems and estuaries management
Goal 4: Conserve and preserve wetlands and ecosystems and promote their wise use
Goal 5: Develop effective institutions and equitable governance for in-country and transboundary water resources management
Goal 6: Achieve optimal and integrated use of land and water resources

Bangladesh is currently trying to ensure food and water security and fortify the foundation of becoming a middle-income country. The Project will provide economic zones (EZs) and neighbouring communities with stable water supply at affordable cost; thus, contribute to Goals 2 and 3 of the Higher level goals as well as Goal 2 of the Specific goals.

3.3 Legal Systems

3.3.1 Legal Framework for Water Resources Development and Water Supply

The legal system categories from top to bottom normally consist of the Constitution, Law, Act and Policy. Important water sector documents are Water Act, 2013, and the National Policy for Safe Water Supply and Sanitation, l998.

(1) Water Act, 2013

The comprehensive legal framework covering all aspects of water management in Bangladesh is the Water Act, 2013. The main purpose of the Water Act is to prepare for integrated water resources management including development, intake, distribution, use, protection, and conservation of water resources. The Act sets the priority of water use in order in areas where water demand is tight: drinking water supply > irrigation water supply > cultivation > securing biodiversity > wildlife conservation > securing running water > securing industrial water > salt water control > securing water for hydropower generation > recreation > others. (The water balance analysis for the Project has been done with a different set of priorities, since the Project will only use water when there is plenty.) It also aligns relevant existing organizations and legal systems and provides a strong foundation moving forward into the future. The Water Act is based on many of the concepts defined in the National Water Policy, 1999, and the National Water Management Plan, 2001 (adopted in 2004). The Water Act stipulates the matters of the National Water Resources Council, composed of the prime minister and water-related ministers, and the executive committee, which is composed of water-related secretaries. These organizations are permanent and their functions and duties are specific to following: approvals of the National Water Resources Plan, issuance of clearance certificate for the Water Resources Development Project, declaration of Water Stress Area and its management, fixing the lowest safe yield level of aquifer and restrictions on abstracting ground water, ensuring normal flow of water course, declaration of flood control zone and its management, water pollution control and punishment, fine and compensation for violating compliance, etc.

(2) National Policy for Safe Water Supply and Sanitation, l998

Regarding water supply and sanitation, the National Policy for Safe Water Supply and Sanitation, l998, sets the government's goal to ensure that safe water supply and sanitation services are available to all citizens at a reasonable cost. To achieve this, planning and management related to the above will be implemented through the participation of users to ensure sustainability. For this reason, WASA, pourashavas, etc., will be responsible for the operational and financial management aspects and encourage private sector and non-governmental organization (NGO) participation in the provision of water supply and sanitation (WSS) services. The Department of Public Health Engineering (DPHE) must have appropriate institutional coordination with them to improve their capabilities for planning, design, implementation, management, and human resource development.

(3) Bangladesh Water Rules 2018

Bangladesh Water Rules 2018 (Water Rules 2018) was formulated by the Government in accordance to power delegated by section 45 of Bangladesh Water Act 2013, which is “Power to make rules.- The Government may, by notification in the official Gazette, make rules to carry out the purposes of this Act.” The Water Rules 2018 prescribes WARPO’s responsibilities, such as enforcement of right to safe

water and water used for cleaning and sewerage, building National Water Resources Database, formulation of National Water Policy, power to issue compliance orders, authority to issue project clearance certificate, procedure to apply for project clearance certificate and issue it and so forth. Above all things, WARPO plays an important role by the Water Rules 2018 in procedures of accessing and issuing the project clearance certificate for development of water-related infrastructure.

(4) Local Government (municipality) Ordinance, 2009

Local Government (municipality) Ordinance, 2009 (the Act 2009) repeals the existing Pourashava Ordinance in 1977 and applies to the whole of Bangladesh. The term "municipality" in the Act 2009 means Pourashava. The performance of Pourashavas became more transparent, clear and specific as a result of introduction of the Act 2009. The Act 2009 introduces provisions for the constitution and operation of Pourashava with the objective of providing every public service to the people living in urban areas. The Act 2009 is divided into five parts. Each part consists of a few chapters such as Establishment and constitution of Pourashava, Qualifications and disqualifications of Mayors and Councilors, Suspension of the Council and re-election, Registration of tutorial schools, coaching centers, private hospitals, Infrastructural services, and so on. In addition to the five Parts, there are eight schedules which provide some details in reference to specific sections or sub-sections of the Act 2009.

There are sections related to water management in the Act 2009 set forth below;

- 3rd Chapter Infrastructural Services

  97. Municipality and Other Institution Activity: in favor of municipal citizens, the municipality may seize bellow mentioned two methods to implement such projects that are related with municipality environmental infrastructures such as: water supply, water management and sanitation, waste management, roads and industrial infrastructure:

  a. Through own fund of the municipality; or

  b. Through shared contracts with government or non-government

- 2nd Schedule (See Section 50-71) DETAIL FUNCTIONS OF THE MUNICIPALITY PUBLIC HEALTH

  WATER SUPPLY AND DRAINAGE

  10. Water Supply

  (i) A Municipality shall, within the limits of the funds at its disposal, provide, or cause to be provided, to the municipality a supply of wholesome water sufficient for public and private purposes.

  (ii) A Municipality may, and if so required by the Prescribed Authority shall, in the prescribed manner, frame and execute a water-supply scheme for the construction and maintenance of

such works for the provision, storage and distribution of water as may be necessary.

(iii) Where a piped water-supply is provided, the Municipality may supply water to private and public premises in such manner and on payment of such charges as the by-laws may provide.

(4) The Local Government (Union Parishads) Act, 2009

Union parishad, simply Union is the smallest rural administrative and local government unit in Bangladesh. A union is headed by a chairperson, consists of nine wards. The ward is an electoral district for administrative and representative purposes. These wards serve the purpose of electing members for general seats, with three additional seats reserved for women, all of which are directly elected.

The Local Government (Union Parishads) Act, 2009 (the UP Act 2009) forms unions that are responsible for various development tasks, including agriculture, education, health, infrastructure, and sanitation and administrative duties like birth registration, census activities, and maintaining civil status registers. The UP Act 2009 also prescribes rules and regulations of the Chairman and Members of the Parishad, powers and functions of the Council, including tax liability and collection, preparation of rules regarding audit, formulation of budget, etc.

There are sections related to water management in the UP Act 2009 set forth below;

Second Chapter – Ward

6. Ward meetings, powers, functions, etc.

(i) Subject to the provisions of this Act and in the prescribed manner, the Ward meeting shall have the following powers, functions and rights, namely:

F) to advise the council for determining the location or area of street lights, safe water sources and other public health units, irrigation facilities and other public welfare projects;

45. The constitution of the Standing Committee and its functions.

(I) Sanitation, water supply and sewerage;

(V) Identify the error deviation in the provision of safe water supply, road illumination and other services in different areas of the ward and make arrangements for removal of it;

- Second Schedule

23. Management and conservation of wells, water tapes, reservoirs, ponds and other sources of water supply.

24 Prevent drinking water sources pollution and prohibit use of water damaging to public health, water from ponds or other places of water supply.

25. Restriction or control of baths, cloth, raw or animal bathing in other places of the pond or

water supply or nearby areas, for safe storage of drinking water.

26. To prohibit or control the sewage, jute or other trees in other places of the pond or water supply or nearby places.

3.3.2 Water Tariff

(1) Water Tariff of WASA

The water tariff of WASA is set based on the "Water Supply and Sewerage Act, 1996 (WASA Act, 1996)". The target area of the Project is not under the jurisdiction of Chattogram Water Supply and Sewerage Authority (CWASA). However, the water tariff of CWASA is shown as an example since the area of CWASA's jurisdiction is geographically close to the target area of the Project. The current tariff of CWASA is shown in Table 3.3.1. The water tariff of CWASA is decided by the cost of raw water. According to WASA Act, 1996, water tariffs can increase at a maximum of 5% every year. There is no subsidy for the low-income group and the water tariff is collected monthly.

Table 3.3.1 Water Tariff of CWASA

Use Type	Monthly Water Tariff from Sep. 2022 (Taka/m^3)	Collection Rate of FY 2021-2022	Collection Rate of FY 2022-2023
Domestic	18	93.1%	87.1%
Non-domestic	37		

Source: CWASA (2024)

(2) Water Tariff of Local Governments

Water tariffs of local governments vary by municipality. There is no standardized rule for water tariffs set by local government authorities. The water tariff is decided by the congress of the local government.

There are public faucets in the target area of the Project. Some portions of the construction costs are collected from beneficiaries by pourashavas or unions. For example, there are around 10,000 public faucets in Chakaria and Moheshkhali upazilas using deep wells to extract the ground water. The DPHE pays for the construction costs when the public faucets are constructed. Pourashavas or unions collect BDT 60,000-100,000 from each household one time at the beginning of the service, and the pourashavas or unions pay the costs to DPHE when the public faucets are put into service.

Additionally, water tariff of "A Bangladesh Municipal Water Supply and Sanitation Project (BMWSSP) 2020-2024" (Chandanaish Pourashava) is shown in Table 3.3.2 as an example.

1) Connection cost: BDT 500-1500/household (including pipe installation package). Actual

cost: BDT 9,000/household.

2) Method of determining water tariffs:

- Water tariffs are set by law and vary from municipality to municipality.
- Rates will be based on purification and other costs at the water treatment plant. Rates are determined by a committee chaired by the Chattogram District and DPHE's XEN is the secretary of the committee. The total number of connections is 3,375.

Table 3.3.2 Chandanaish Pourashava Water Tariff

No.	Type of Consumer	Monthly Tariff (BDT/m3)	% of Connection	Enrollment Fee per connection (BDT)	Connection cost per connection (BDT)
1	Residential (Normal) Connection	10	81%	200	2,000
2	Low-income Consumer	7	12%	200	1,000
3	Institutional Consumer	15	3%	200	3,000
4	Commercial Consumer	20	4%	200	10,000

Source: DPHE (2024)

(3) Water Tariff of Economic Zone (EZ)

There is no specific law applicable for developers stating on how to set up the water tariff of each EZ in Bangladesh. The water tariff of each EZ is set based on the approval of the Prime Minister's Office (PMO) or an agreement with the Bangladesh Economic Zones Authority (BEZA) in other projects.

According to an interview with BEZA, the water tariff for the concession method is suggested to the PMO in the Bangabandhu Sheikh Mujib Shilpanagar (BSMSN) Economic Zone project. However, water tariff of EZs has not yet been approved by the PMO as of February 2024. Operation of the BSMSN project is scheduled to start in 2029. The water tariff was suggested to the PMO more than five years before the operation started. The following tariff was suggested by BEZA to the PMO, but it has not been approved yet.

Table 3.3.3 Proposed Water Tariff and VGF in BSMSN (not disclosed)

No.	Project Funding Pattern	VGF*1	Pre-Tax Project IRR	Water Service Payment (BDT per m^3)
1	Investor Equity and Debt 100%	0	13.0%	91.3
2	Investor Equity and Debt 95%	5%	13.0%	90.2
3	Investor Equity and Debt 90%	10%	13.3%	85.0
4	Investor Equity and Debt 85%	15%	13.2%	80.0
5	Investor Equity and Debt 80%	20%	13.0%	75.0
6	Investor Equity and Debt 75%	25%	13.7%	75.0
7	Investor Equity and Debt 70%	30%	13.5%	70.0
8	Investor Equity and Debt 65%	35%	13.4%	65.0

*1 Viability Gap Funding (VGF) is a subsidy provided by the government to the private sector for the construction costs of the PPP project, and the amount is proposed by the bidder in the bidding process and is subject to evaluation.

Source: BEZA (2024)

In another case, the Bangladesh Special Economic Zone (BSEZ) water tariff, which was determined by BSEZ, is governed by a development agreement between BSEZ and BEZA. Within this framework, BSEZ retains significant autonomy in decision-making as a partner. The monthly water tariff from the tenant is decided based on PMO approval and the development agreement, and is set at USD 1/m^3.

3.4 Water Supply Situation

3.4.1 Responsible Entity for Construction and O&M of Water Works

The drinking water supply in urban areas in Bangladesh is managed by city corporations or water supply and sewerage authorities (WASAs), of which the latter currently exist in Dhaka, Chattogram, Khulna, Rajshahi, and Sylhet*[2]. In rural areas, it is managed by pourashavas or the councils (parishad) of unions.

In urban areas, city cooperations or WASAs are doing O&M of their water supply systems, which consists of facilities such as water intakes, conveyance pipes, water treatment plants, transmission pipes, distribution reservoirs, distribution pipes, and service pipes. The water tariff billed to and collected from users is allotted to the cost of the O&M.

While in rural areas, the water supply system is simple and consists of tube wells for 5-10 households, pumps, and service pipes to distribute pumped water to each household (or otherwise public taps). The pourashavas or the councils (parishad) of unions do the maintenance of the tube wells including the ones drilled and handed over by the DPHE, and the users do the operation. The role of the DPHE in the water supply in rural areas is basically the construction of waterworks and not the O&M.

The cost is covered by the water tariff set up by pourashavas/ unions and collected from the users. Regarding the maintenance of service pipes, reportedly in the Chakaria Pourashava the service pipes which started in use in 2012 have stopped working probably due to the lack of proper maintenance of pipes (currently only 2 persons are in charge of water supply service in the Chakaria Pourashava and no maintenance has been done for the pipes).

3.4.2 Water Supply Project to Mongla Port

Despite the general practice of the DPHE stated in 3.4.1, the DPHE has been implementing the O&M of waterworks and providing water supply service including the collection of water tariff from customers in several projects, such as the water supply to the Mongla Port and the water supply in Rangamati and Bandarban area.

The construction of waterworks to supply water to the Mongla Port started in 1990/ 1991 as the deposit work of the DPHE. The construction was completed in 1994/1995 before the constructed waterworks were handed over from the DPHE to the Mongla Port Authority (MPA). The BEPZA and the BEZA

*[2] According to a national newspaper dated 19th September 2024, Sylhet WASA was established on 2nd March 2022 and a chairman was appointed. But to date, there is no office, no other personnel was recruited, and no MD was nominated yet. Still now city corporation is supplying water.

started the construction of waterworks to supply water to the area managed by each authority in 2000 and 2019, respectively. The current capacity of the waterworks is 2,700 m^3/day in total.

The DPHE started the O&M of the waterworks in 1993 outsourced by the MPA on a single year contract basis. Total 25 positions of the DPHE's staff have been reserved as shown in Table 3.4.1 for the O&M of the waterworks owned by the MPA. Since the waterworks owned by the MPA do not include a water treatment plant, and the number of customers is limited, the assigned staff to the O&M is limited in number. Similarly, the O&M of the waterworks owned by the BEPZA and the BEZA is outsourced to the DPHE on a single year contract basis.

The water tariff set up by the MPA is 16 BDT/m^3 (while the BEPZA charges 60 BDT/m^3 and the BEZA charges 21 BDT/m^3), which are collected by the DPHE and paid to the MPA, the BEPZA, and the BEZA respectively. Every year the Mongla Division of the DPHE receives the payment from the MPA, the BEPZA, and the BEZA as the commission fee based on the outsourcing contract, which is accounted for in the divisional account of the Mongla Division of the DPHE.

Table 3.4.1 O&M Staff of DPHE for Waterworks in Mongla Port owned by MPA

No.	Designation	Number	Note
[Mongla Division]			
1	Executive Engineer	1	
2	Accountant	1	
3	Head Assistant	1	
4	Accounts Assistant	1	
5	Lower Divisional Assistant cum Typiest	1	
6	Cashier	1	
7	Driver	1	
8	MLSS	2	
Sum		9	
[Mongla Sub-Division]			
1	Sub Divisional Engineer	1	
2	Sub Assistant Engineer	3	Transport x 1, Manufacturing x 1, Mechanical x 1
3	Lower Divisional Assistant cum Typist	1	
4	Pump Driver	6	Production Well x 3, Booster Station x 3
5	Lineman/ Plumber	3	
6	Driver	1	
7	MLSS	1	
Sum		16	
Total		25	

Source: JET based the data provided by DPHE

3.5 Aid Trends toward Water Supply Sector

Water supply projects in Bangladesh are shown in Table 3.5.1. While LGED and DPHE have the projects throughout Bangladesh, DWASA, CWASA, KWASA, RWASA have their projects in each zilla. JICA, Netherlands, ADB, IFAD, EDCF, WB funded many projects.

Table 3.5.1 List of Implemented Water Supply Project

Organization	Project Name	Period	Fund	Target Division	Target Zila	Target Upazila, Thana, and Pourashava	Target Area
LGED	Small Scale Water Resources Development Project in Greater Mymensingh, Sylhet and Faridpur Areas	2007-2015	JICA	Dhaka, Mymensingh, Sylhet	Faridpur, Mymensingh, Sylhet	-	-
	Construction of Rubber Dam in Small and Medium Rivers for increasing of Food Production Project. (2nd Revision)	2009-2017	GOB	Chattogram	Cox's Bazar	Cox's Bazar Sadar	Eidgaon, Cox's Bazar
	Char Development and Settlement Project-iii (CDSP-iii)	2005-2011	Netherlands	Chattogram	Lakshmipur, Noakhali	-	Boyer Char, Baggar Dona river catchment area
	TA for 2nd Small Scale Water Resources Development Sector Project	Completed as of 2024	GOB ADB	Dhaka, Mymensingh, Sylhet, Rangpur	-	-	-
	Netrokona Integrated Agriculture and Irrigation Management Project	1993-2000	IFAD	Mymensingh	Netrokona	-	-
	Second Small Scale Water Resources Development Sector Project	Completed as of 2024	ADB	Dhaka, Mymensingh, Sylhet, Rangpur	-	-	-
	Char Development and Settlement Project-IV (CDSP-IV)	2011-2016	Netherlands IFAD	Chattogram	Chattogram District, Noakhali District	Hatiya, Companiganj, Sandwip, Subarnachar	Char Clerk, Chanandi, Mohammadpur Union
	Improvement of digging Gaznar Bill connecting river, irrigation	2010-2013	GOB	Rajshahi	Pabna	Sujanagar	-

Organization	Project Name	Period	Fund	Target Division	Target Zila	Target Upazila, Thana, and Pourashava	Target Area
	facilities and fish culture project.						
	Sustainable Small Scale Water Resources Development Project (1st Revised)	2017-2024 Ongoing	GOB	Barisal, Khulna, Rajshahi	-	-	-
	Small Scale Water Resources Development Project (Phase-2)	2017-2023 Ongoing	GOB JICA.	Dhaka, Mymensingh, Sylhet, Rangpur	Gopalganj, Madaripur, Rajbari, Tangail, Netrokona, Habiganj, Moulvibazar, Sylhet, Dinajpur, Gaibandha, Lalmonirhat, Nilphamari, Rangpur	-	-
	Improvement of Ponds, Canals Across the country project (IPCP) (2nd Revised)	2017-2026 Ongoing	GOB	Nationwide	-	-	-
	Climate and Disaster Resilient Small Scale Water Resources Management Project	2023-2029 Ongoing	GOB	Nationwide	-	-	-
DPHE	· 4 nos Surface Water Treatment Plant (SWTP) of varying capacity from 100-350 m^3/h · 8 nos Ground Water Treatment Plant (GWTP) of varying capacity from 100-350 m^3/h · 21 km - 68 km pipelines with diameter of 110-315mm · Around 96 pump with the capacity ranging from 50-100 m^3/h · 11 municipality started water supply system, other 19 are under process						
DWASA	PWTP Project {Padma (Jashaldia) Water Treatment Plant (Phase-1) Project (2nd Revised)}	2016-2019	China GOB, DWASA	Dhaka	Munshiganj	Louhajang	Mawa, Jashaldia
	TBWFC Project (Savar-Keraniganj Wellfield Plant)	2012-2019	EDCF GOB, DWASA	Dhaka	Dhaka	Savar	Tetuljhara, Bhakurta
	IWS Project (Interim water supply project)	2018-2019	GOB, DWASA	Dhaka	Dhaka	-	Dhaka city
	LIC Localities Project	2016-	GOB	Dhaka	Dhaka	-	Dhaka city

Organization	Project Name	Period	Fund	Target Division	Target Zila	Target Upazila, Thana, and Pourashava	Target Area
		2020					
	Land acquisition project for Hazaribag, Baishteki Kurmitola,Manda and Begunbari canal	2018-2022	GOB	Dhaka	Dhaka	-	Dhaka city
	Emergency Replacement of Water Line	2020-2021	GOB	Dhaka	Dhaka	-	Dhaka city
	Dhaka Water Supply Network Improvement Project	2016-2025 Ongoing	GOB (project loan)	Dhaka	Dhaka	-	Dhaka city
	Saidabad Water Treatment Plant Phase-3	2015-2025 Ongoing	DWASA, GOB (project loan)	Dhaka	Narayanganj	Sonargaon	Haria
	Dhaka Environmentally Sustainable Water Supply Project.	2013-2024 Ongoing	DWASA, GOB (project loan)	Dhaka	Dhaka	-	Dhaka city
	Strengthening of the Existing Water Supply Distribution System of Dhaka City to Cope the Production of Padma Water Treatment Plant Project (Phase-I) at Jashaldia.	2019-2021 Proposed	-	Dhaka	Dhaka	-	Jashaldia, Mawa, Munshiganj
	Well field Construction Project at Singair Upazila (Part-II).	2019-2023 Proposed	-	Dhaka	Dhaka	-	Singair, Manikganj
CWASA	1st Water Supply Project	1977	WB	Chattogram	Chattogram	Chandgaon	Kalurghat
	2nd Water Supply Project	1987	WB	Chattogram	Chattogram	Chandgaon	Mohara, Kalurghat
	Mohara & Kalurghat Water Treatment Plant Rehabilitation Project	2121	Japan Debt Cancellation Fund	Chattogram	Chattogram	Chandgaon	Mohara, Kalurghat
	Karnaphuli Water Supply Project (1st Phase)	2016	JICA	Chattogram	Chattogram	Chattogram City Corporation	Battali Hill, Khulshi, Nasirabad
	Project for Non-Revenue Water Reduction Initiative (PANI)	2012	JICA, GOB, CWASA	Chattogram	Chattogram	Chattogram City Corporation	-
	3rd Interim Project	2007	GOB	Chattogram	Chattogram	-	-
	Emergency Water Supply Project	2013	GOB	Chattogram	Chattogram	-	-

Organization	Project Name	Period	Fund	Target Division	Target Zila	Target Upazila, Thana, and Pourashava	Target Area
	Chattogram Water Supply Improvement and Sanitation Project (CWSISP)	2020	WB	Chattogram	Chattogram	Hathazari Upazilla, Patenga Thana	Modunaghat, Nasirabad, Kalurghat, Patenga.
	Karnaphuli Water Supply Project (2nd Phase)	2023	JICA	Chattogram	Chattogram	Rangunia	-
	Bhandal-Juri Water Supply Project	2023 Ongoing	EDCF GOB	Chattogram	Chattogram	-	-
	Mohara Water Supply Project (Phase-II)	Upcoming	-	Chattogram	Chattogram	Mirsharai, Shitakunda	-
KWASA	Development of Water Supply System in Khulna City	2010-2014	GOB	Khulna	Khulna	-	Khulna City Corporation area
	Installation of Production Tube-wells & Development of Water Supply Network	2014-2016	GOB	Khulna	Khulna	-	Khulna City Corporation area
	Development and Expansion of Water Supply System in Khulna City	2015-2018	GOB	Khulna	Khulna	-	Khulna City Corporation area
	Khulna Water Supply Project	2011-2019	GOB	Khulna	Khulna	-	Khulna City Corporation area
RWASA	N/A	N/A	N/A	Rajshahi	N/A	N/A	N/A
BWASA	Barisal Water Supply and Sewerage Authority is in the process of establishment						
SWASA	Sylhet Water Supply and Sewerage Authority was established on 2nd March 2022 but to date actual operation has not started.						
Rangpur WASA	Rangpur Water Supply and Sewerage Authority is in the process of establishment						
MWASA	Mymensing Water Supply and Sewerage Authority is in the process of establishment						
FWASA	Faridpur Water Supply and Sewerage Authority is in the process of establishment						
Comilla WASA	Comilla Water Supply and Sewerage Authority is in the process of establishment						

Note: GOB: Government of Bangladesh, ADB: Asian Development Bank, IFAD: International Fund for Agricultural Development, EDCF: Economic Development Cooperation Fund, WB: World Bank, LGED: Local Government Engineering Department, DPHE: Department of Public Health Engineering, DWASA: Dhaka Water Supply and Sewerage Authority, CWASA: Chattogram Water Supply and Sewerage Authority, KWASA: Khulna Water Supply and Sewerage Authority, RWASA: Rajshahi Water Supply and Sewerage Authority

Source: LGED: https://lged.gov.bd/, DPHE: the information collected from DPHE, DWASA: https://dwasa.org.bd/, CWASA: http://ctg-wasa.org.bd/, KWASA: https://www.kwasa.org.bd/kwasa/en/Home.aspx, RWASA: xxx, BWASA, SWASA, Rangpur WASA, MWASA, FWASA: Data Collection Survey on Water Resources Development in Southern Chattogram, 2022, JICA, Comilla WASA: the information collected from DPHE

CHAPTER 4 SURVEY OF NATURAL CONDITIONS

4.1 Surface Water and Water Quality

4.1.1 Meteorological, Oceanographic, and Wind Surveys

Meteorological, oceanographic, and wind surveys were conducted, and the following information has been collected by gathering existing reports/data for understanding the current conditions of each phenomenon.

The water levels and discharges in the Matamuhuri River during rainy and dry seasons are significantly different from each. It is necessary to intake and store the river water into a reservoir during rainy season to meet the water demands in the downstream areas. Based on this concept, the design conditions of the intake facility and reservoir, such as intake channel-bed elevation, maximum intake water volume, and reservoir volume, are considered.

There are no peculiar features found in the data collected for temperature, humidity, and wind speed. The tendencies of the data are almost all the same as those of previous records (before 2020). These data are used for the formulation of a construction plan, such as possible construction days and concrete mix ratios.

Table 4.1.1 Data Collection List of Meteorological, Oceanographic and Wind Surveys

SL	Item Name	Station Name	Data Source	Data Availability
1	Water Level (WL)	Lama	BWDB	01/01/2020 to 31/08/2023
		Chiringa		01/01/2020 to 31/08/2023
		Shaplapur		01/01/2020 to 31/08/2023
		Ramu		01/01/2020 to 31/07/2023
2	Discharge (Q)	Lama	BWDB	01/01/2020 to 18/07/2023
3	Temperature (Max, Min, Ave)	Cox's Bazar	BMD	01/01/2020 to 31/08/2023
		Kutubdia		01/01/2020 to 31/08/2023
		Rangamati		01/01/2020 to 31/08/2023
		Chittagong		01/01/2020 to 31/08/2023
4	Relative Humidity	Cox's Bazar		01/01/2020 to 31/08/2023
		Kutubdia		01/01/2020 to 31/08/2023
		Rangamati		01/01/2020 to 31/08/2023
		Chittagong		01/01/2020 to 31/08/2023
5	Sunshine Hour	Cox's Bazar		01/01/2020 to 31/12/2022
		Kutubdia		01/01/2020 to 31/12/2022
		Rangamati		01/01/2020 to 31/12/2022
		Chittagong		01/01/2020 to 31/12/2022
6	Wind Speed	Cox's Bazar		01/01/2020 to 31/08/2023
		Kutubdia		01/01/2020 to 31/08/2023
		Rangamati		01/01/2020 to 31/08/2023
		Chittagong		01/01/2020 to 31/08/2023

SL	Item Name	Station Name	Data Source	Data Availability
7	Rainfall	Kutubdia	BMD	01/01/2020 to 31/08/2023
		Cox's Bazar		01/01/2020 to 31/08/2023
		Rangamati		01/01/2020 to 31/08/2023
		Dulahazra	BWDB	01/01/2020 to 31/08/2023
		Kutubdia		01/01/2020 to 31/08/2023
		Lama		01/01/2020 to 31/08/2023
		Rangamati		01/01/2020 to 31/08/2023
		Chittagong		01/01/2020 to 31/08/2023
8	Salinity	Chiringa	BWDB	01/01/2020 to 27/06/2022

Source: The data were collected through IWM

4.1.2 Natural Disaster Survey

(1) Disaster Records

Disaster record such as tidal waves, cyclone, earthquake and flood in the project area was collected. The summary of these disaster records is shown on the Table 4.1.2.

Table 4.1.2 Summary of Major Disaster Record in Project Area

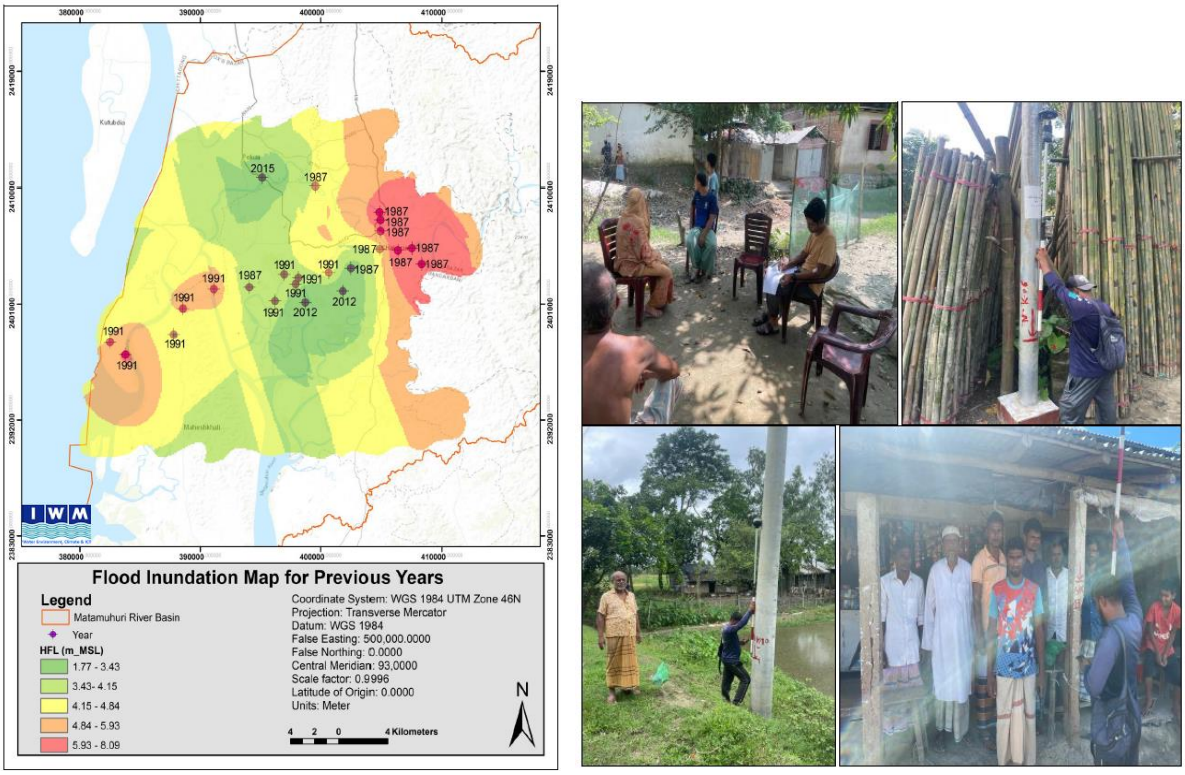
No	Disaster Type	Collected Term	Number of Collected Record	Maximum Disaster Scale	Maximum Disaster Damage
1	Tidal Wave	1958-	8	Tidal Wave Height: 10.6m	500,000 People affected
2	Cyclone	1797-	35	Wind speed: 250km/h	400,000 People affected
3	Earthquake	1997-	8	Magnitude: 6.2 Mw	More than 200 People
4	Flood	1987-	16	Inundation Depth: 1,048mm	4.6 million People affected

Source: The data were collected through IWM

(2) Interview Survey of Flood Records

An interview survey on flood records was done to understand the flood history and records, including maximum water levels in recent and past floods. The major findings of this survey are as follows:

- The influences of several past floods were bigger than that of the recent one, which occurred in August 2023 at any survey area.
- The past big floods occurred in 1987 and 1991 at the planned intake and raw water reservoir sites, respectively.
- The maximum water levels at the planned intake and reservoir sites were 6.0 m and 1.7-3.4 m, respectively as shown on Figure 4.1.1.



Source: IWM

Figure 4.1.1 Result for Interview Survey of Flood Records

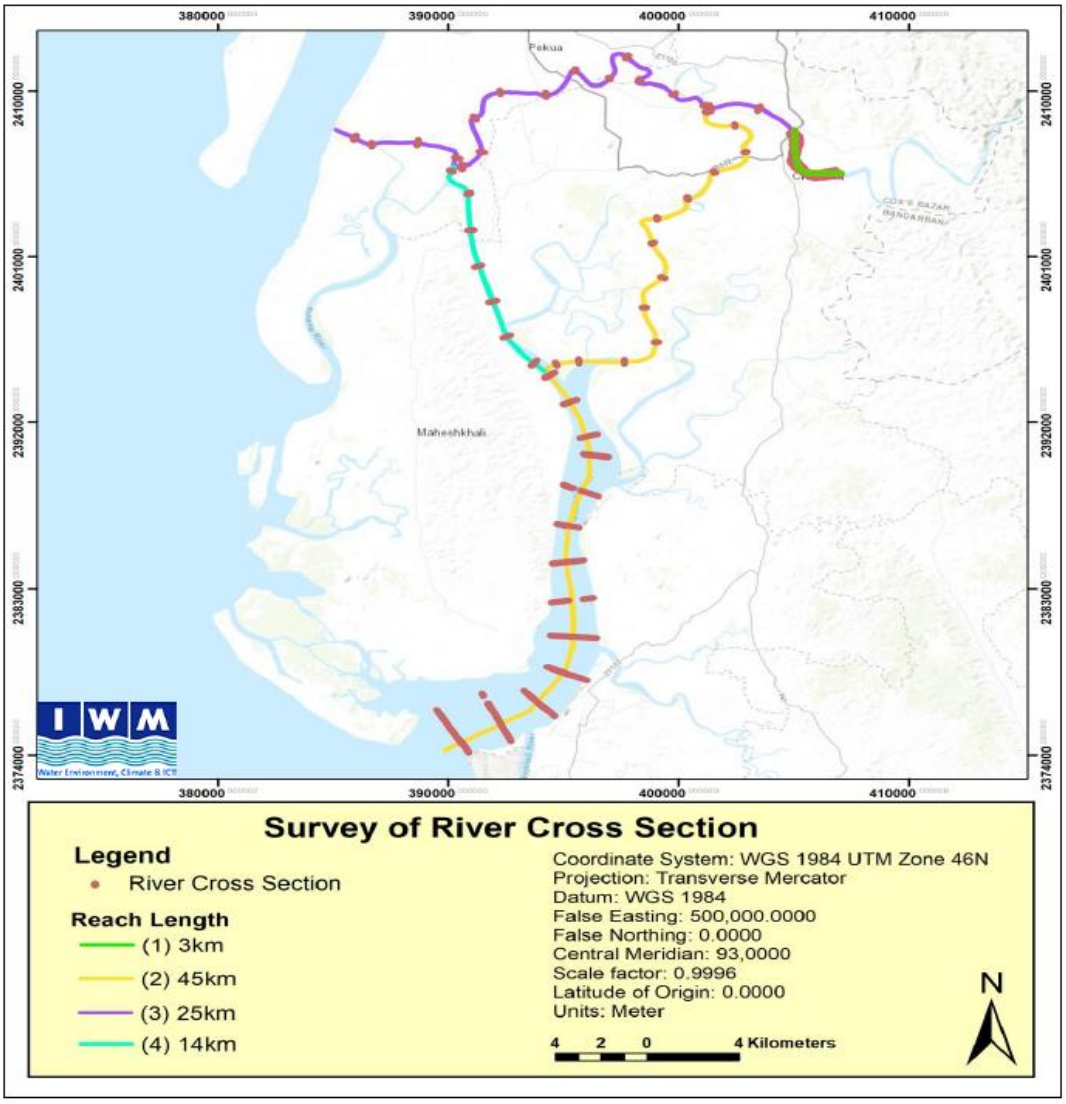
4.1.3 Hydraulic and Hydrological Survey

(1) Hydraulic Survey

(a) Cross-section Survey

A cross-section survey of the Matamuhuri River and the Moheshkhali Channel was conducted for analysis of hydraulic characteristics. A location study for the design of intake facility by creating a hydraulic analysis model was also conducted. The locations of the cross-section survey are shown in Figure 4.1.2.

Through this survey, it was known that river shifting of the Matamuhuri River after the big flood in August 2023 was severe, as described in Section 4.1.3(2)(e). It is necessary to find the location where the influence of river shifting is not too severe or to consider appropriate countermeasures against the river shifting for safe construction and operation, as well as for proper maintenance of the intake facility.



Item	Content	Specification	Quantity
River Cross Section Survey	To survey river cross section in Matamuhuri River & Maheshkhali Channel	Total River Length: 87 km = (1) 3km+ (2) 45km+ (3) 25km+ (4) 14km Cross section pitch: (1) 0.1km, (2) 2km, (3) 2km, (4) 2km	Cross section: 74 nos Average Width= 100m

Source: IWM

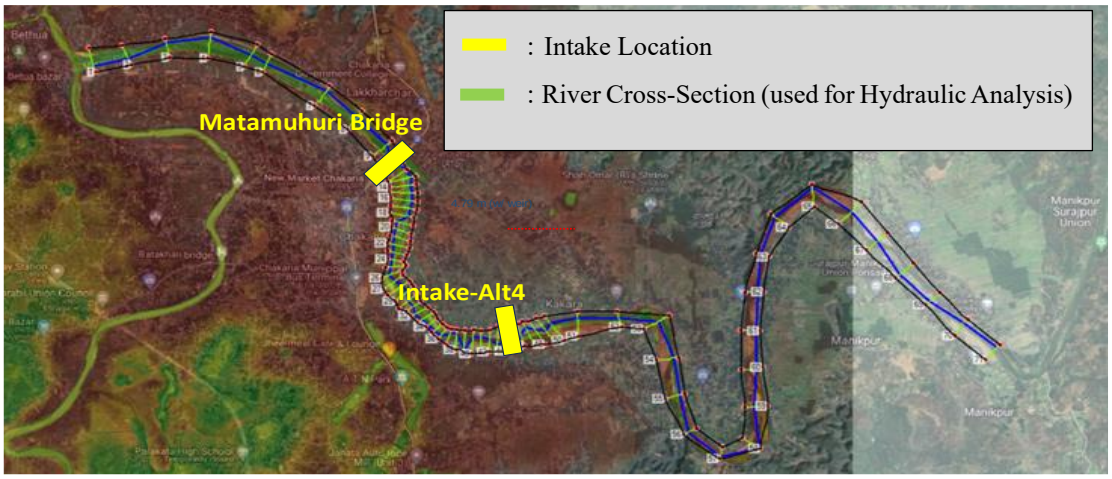
Figure 4.1.2 Locations and Specifications of Cross-section Survey

(b) Hydraulic Analysis

Hydraulic analysis was conducted to understand the specific flow conditions of the Matamuhuri River, especially the relationship between water levels and discharges (H-Q curve) at the planned intake site and confirm the influence of backwater by construction of an intake weir.

Table 4.1.3 Items of Hydraulic Analysis and the Purposes

No.	Analyzed Item (Output of Analysis)	Purpose of Analysis
1	Relationship between discharge and water level (H-Q curve) at Intake site	Utilize the analysis result as base information, which is necessary for the design of intake facility (such as sill elevation of inlet)
2	Influence of backwater at the upstream by construction of intake weir	Utilize the analysis result as base information, which is necessary for considering the intake weir type (if the influence of back water affects on large area, the weir type should be carefully selected)

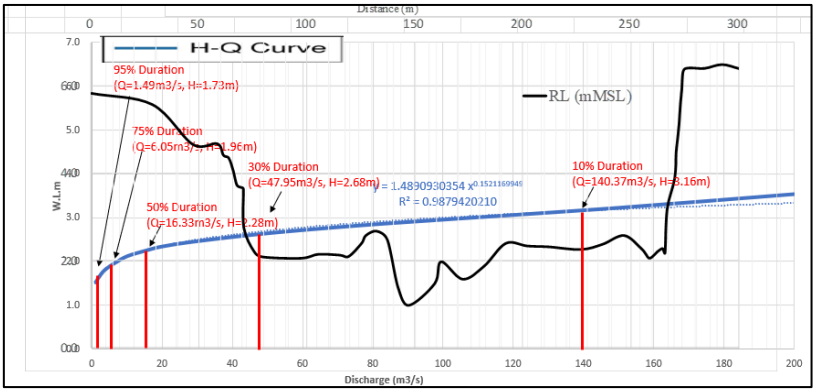


Source: JICA Survey Team

Figure 4.1.3 Hydraulic Analysis Model

■Relationship between water levels and discharges at the intake site

By using the analysis model in Figure 4.1.3, the relationship between water levels and discharges (H-Q curve) at the planned intake site was examined as shown in Figure 4.1.4. This result is used for the design of intake facility.



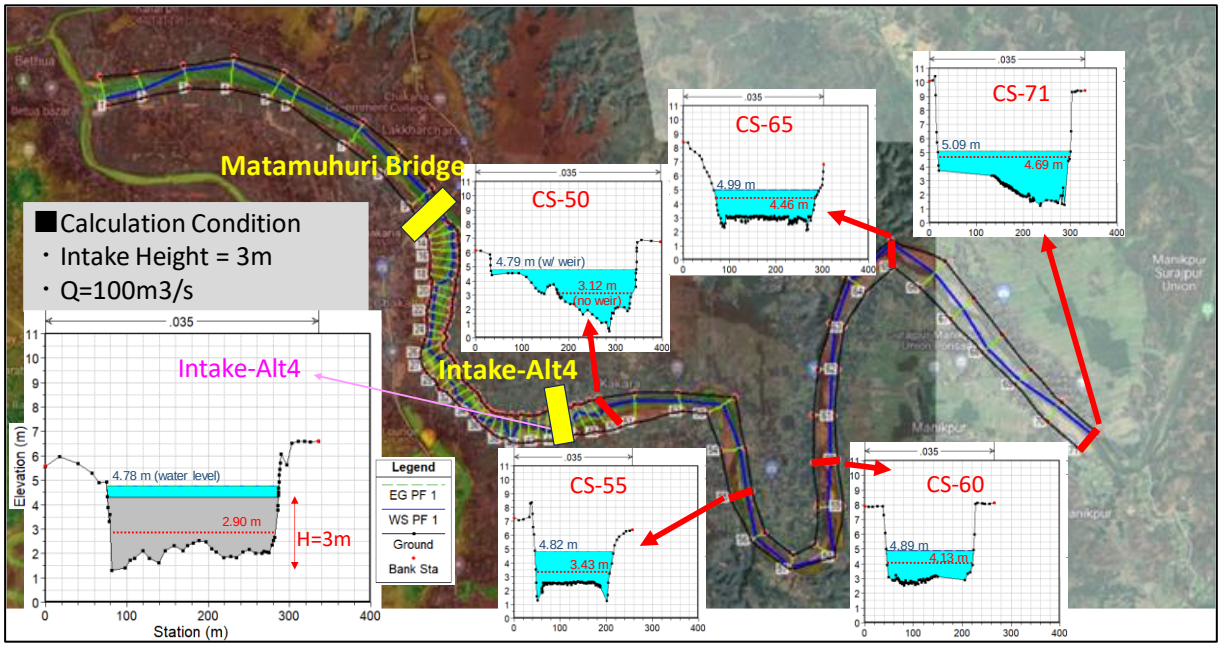
Source: JICA Survey Team

Figure 4.1.4 Relationship between Water Levels and Discharges at the Intake Site

■Influence of backwater by construction of an intake weir

It is important to consider backwater influence when selecting the appropriate type of intake weir. Thus, backwater influence was analyzed by using the hydraulic analysis model. The findings of this analysis are as follows:

- The water level does not exceed the existing riverbank at any river cross-section, even if the weir is constructed.
- The water level increases in the 10 km long upper reaches from the intake weir during floods due to construction of a fixed intake weir.



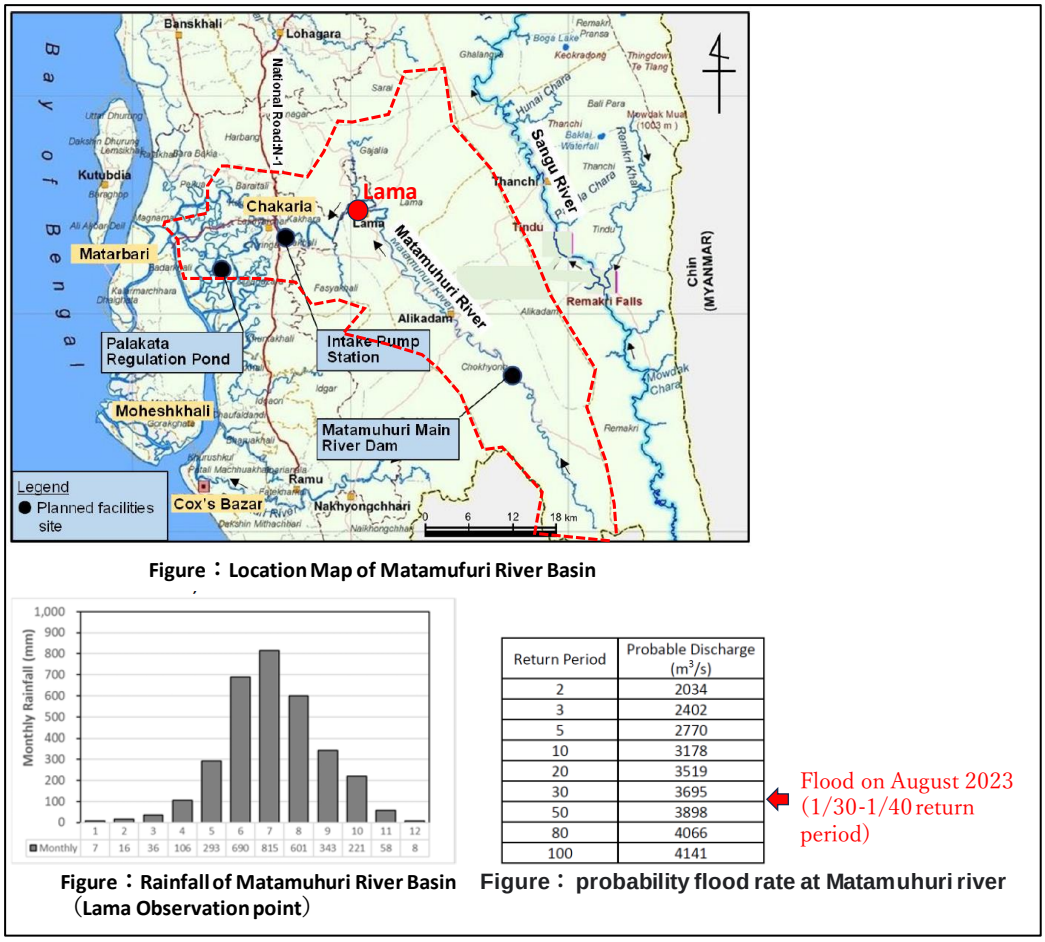
Source: JICA Survey Team

Figure 4.1.5 Influence of Backwater by Construction of Intake Weir

(2) Hydrological Survey

(a) Hydrological Conditions in Matamuhuri River Basin

The Matamuhuri River basin has 2,511 km^2 of catchment area (1,490 km^2 at the intake site); with an annual rainfall of 3,200 mm as shown in Figure 4.1.6. The river's flood recurrence interval is estimated at 30-40 years, which occurred in August 2023. The flood peak discharge is estimated at 3,800 m^3/s at the Lama Station according to the hydraulic analysis conducted by the NODI Project.

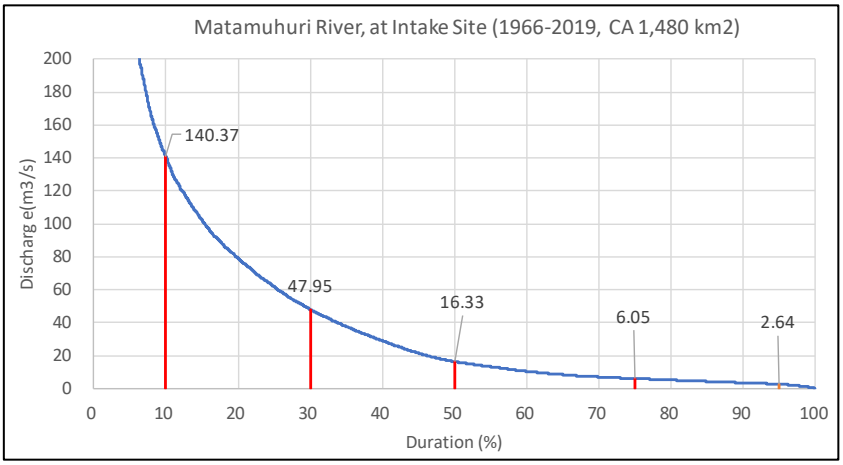


Source: JICA-NODI, Presentation

Figure 4.1.6 Hydrological Conditions in Matamuhuri River Basin

(b) Flow Duration Curve

The flow duration curve at the intake site is shown in Figure 4.1.7. The dependable discharges are 16.3 m^3/s, 6.1 m^3/s and 2.6 m^3/s at 50%, 75% and 90%, respectively.

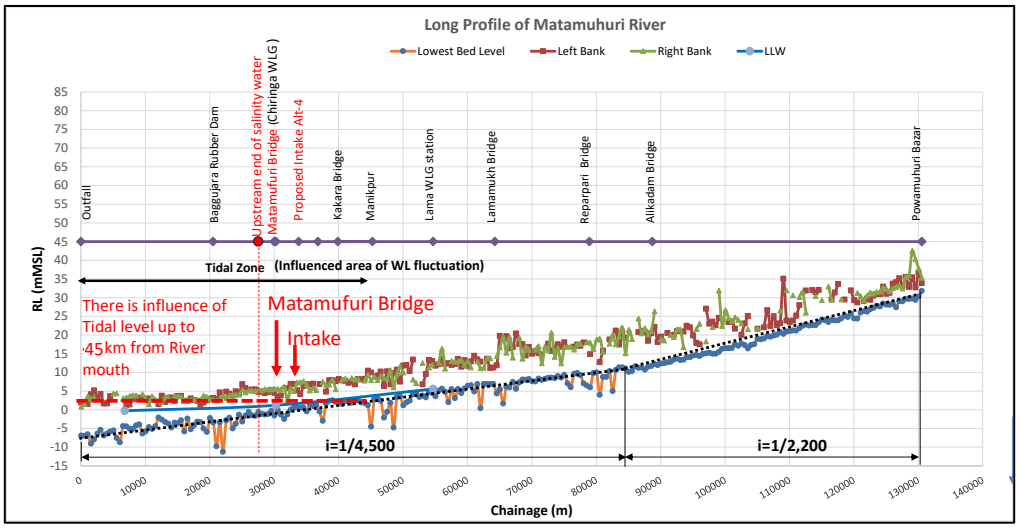


Source: JICA Survey Team

Figure 4.1.7 Flow Duration Curve at Intake Site in the Matamuhuri River

(c) Tidal Level in the Matamuhuri River

The riverbed slopes of the Matamuhuri River are about 1/4,500 from the river mouth to the 85-km upstream point and 1/2,200 from the 85-km to the 130-km upstream points, respectively. The tidal water is estimated to come up to the 45-km upstream point from the river mouth in previous survey.



Source: JICA Survey Team

Figure 4.1.8 Tidal Level in the Matamuhuri River

(d) Riverbed Materials

The riverbed at the intake site planned on the Matamuhuri River is composed mainly of sand, silt, and clay according to the sedimentation particle size test result by IWM (2021). There are no cobblestones and gravel included. It is necessary to conduct additional surveys for further and latest result of sedimentation particle survey at Intake site during detailed design stage of the project.

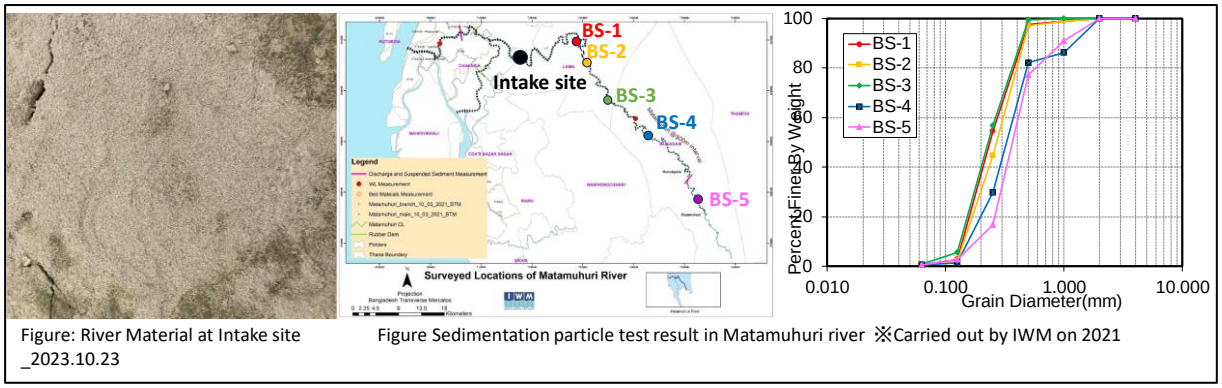


Figure: River Material at Intake site _2023.10.23

Figure Sedimentation particle test result in Matamuhuri river ※Carried out by IWM on 2021

Source: IWM

Figure 4.1.9 River Bed Materials in the Matamuhuri River

(e) Record of River Shifting

The influence of river shifting is very severe in Bangladesh. River shifting is also observed around the intake site in the Matamuhuri River as shown in the following Figure 4.1.10.

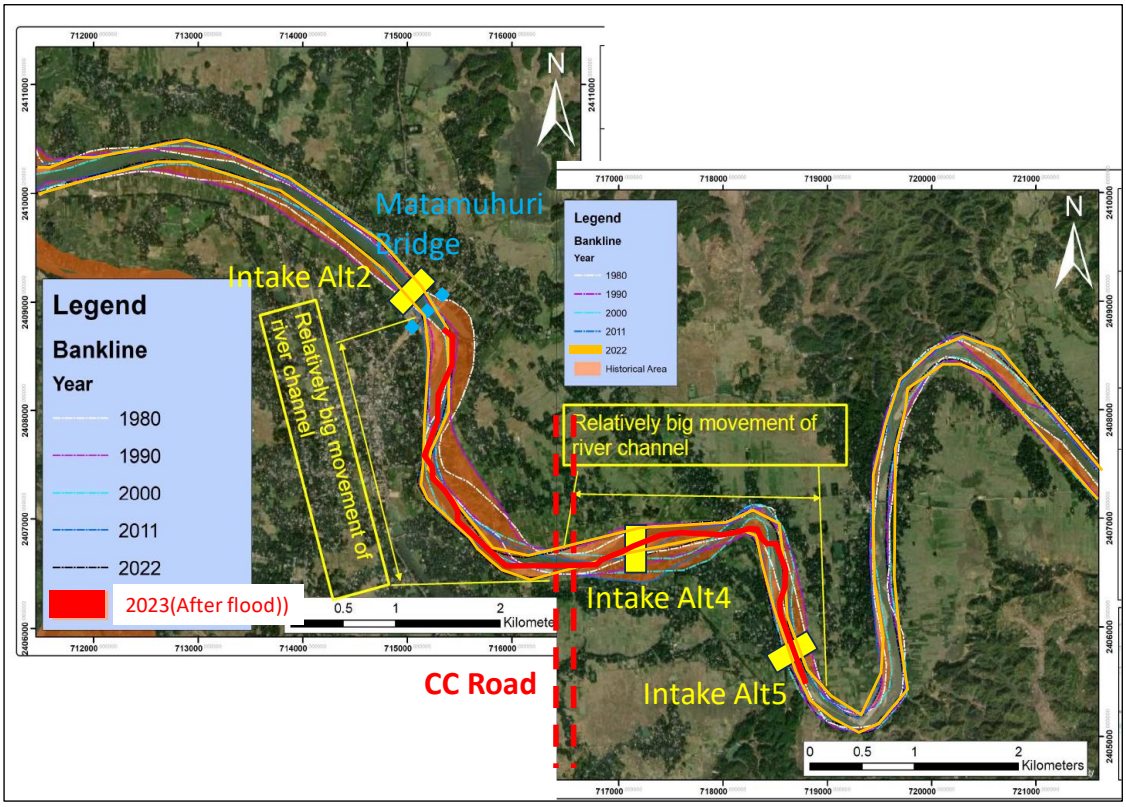


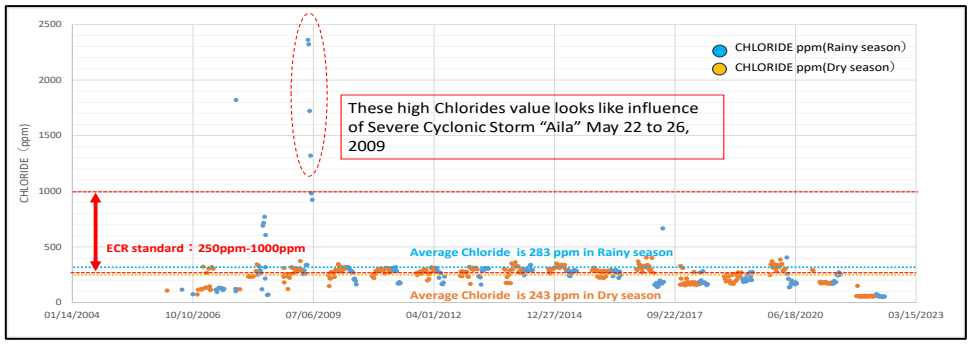
Figure: Record of River Shifting (PROJECT FOR PLANNING CAPACITY ENHANCEMENT AND ESTABLISHMENT OF A TECHNOLOGY ADAPTATION CYCLE ON COMPREHENSIVE NODI (RIVER) MANAGEMENT)

Source: JICA Survey Team

Figure 4.1.10 Record of River Shifting around Intake Site (1980-2023)

(f) Salinity Observation Data at Chilinga Station (Matamuhuri Bridge)

Salinity data have been observed at the Matamuhuri Bridge since 2004. According to the data observed by BWDB, almost all chloride values at the Matamuhuri Bridge do not exceed the Environmental Consideration Rules (ECR) standards' value (250-1,000 ppm) during the period from 2006 to 2022. But the chloride values may become higher when a large scale-cyclone, such as "Aila" in May 2009, occurs. Therefore, it is necessary to consider the salinity data for the plan formulation of intake location and countermeasures.



Source: JICA Survey Team

Figure 4.1.11 Chloride Observation Data at Matamuhuri Bridge (2004-2023)

(g) Maintenance Flow at Intake Site

・Purpose and Necessity of Maintenance Flow

In general, the purpose of maintenance flow is to implement appropriate river management and the appropriate river management requires the following two points.

- Satisfy necessary river discharge during drought.
- Satisfy necessary river water utilization at the downstream from intake point.

Above required discharge is set by considering the protection of flora and fauna, fisheries, landscape, maintenance of cleanliness of running water (water quality), prevention of salt damage, prevention of clogging of river mouth, etc.as shown in Table 4.1.4. However, in Bangladesh, the concept of maintenance flow has not been recognized well and there are no specific laws for maintenance flow. Although WARPO review and approve the water resource development project, technical study for maintenance flow is scarcely included and considered in the procedure.

On the other hand, the important reasons for setting the maintenance flow in this project are a) satisfy irrigation demand at the downstream and b) satisfy water depth which fish flows down at the downstream, because water intake directly affect these two aspects. Thus, maintenance flow in this project was defined to satisfy the following points.

STEP1：Calculate recommended maintenance flow according to Japanese guideline (Satisfy the protection of flora and fauna, fisheries, landscape, maintenance of cleanliness of running water (water quality), prevention of salt damage, prevention of clogging of river mouth, etc.as shown below.)
STEP2：Confirmation of impact on irrigation demand at the downstream of Intake site (Satisfy irrigation demand at the downstream) (Analyzed on **Cha 5.2.4.(1) 7)**)
STEP3：Confirmation of impact on fish (satisfy water depth which fish flows down at the downstream) (Analyzed on **Cha 9.1.6.(2) 2)**)
STEP4：Validation

Table 4.1.4 Study Items and Concept of River Maintenance Flow

Items	Concept
i) Protection of Flora, Fauna and Fisheries	The flow required for flora and fauna to inhabit and grow.
ii) Landscape	The flow required to satisfy hydraulic conditions that the river should secure in order to maintain and form a main landscape of the river.
iii) Water Quality	The flow required to improve water quality by securing discharge in rivers where water quality deteriorates during dry season.
iv) Navigation	The flow required to maintain water surface and draft depth for navigation.
v) Protection from saltwater damage	The flow required to protect from saltwater intrusion so that salt concentration would not increase in river water and groundwater and not hinder water use when river discharge decreases.
vi) Protection from river mouth clogging	The flow required to protect from constant sedimentation at river mouth to avoid clogging when river discharge decreases.
vii) Protection of river structures	The flow required to secure certain hydraulic conditions for the protection of river management facilities, such as keeping a certain water level to prevent corrosion of wooden facilities (revetment foundations and pile shelves) due to a lowering in water level.
viii) Maintain ground water level	The flow required not to cause groundwater level drop in connection with lowering of river water levels due to decrease of river discharge
ix) Irrigation demand	The flow required to maintain irrigation water demand at the downstream of intake point. (Specific condition on this project)

Source: Data Collection Survey on Water Resources Development in Southern Chattogram, JICA

・Estimation of Necessary Maintenance Flow at Intake Site

In previous study (“Data Collection Survey on Water Resources Development in Southern Chattogram”), necessary maintenance flow was estimated by result of Japanese study which was done by MLIT because the upstream part of Southern Chattogram region is formulated as mountainous region and the river discharge from upstream flow into alluvial plains. This discharge pattern is similar to the rivers in Japan.

In this study, the average maintenance flow rate of major rivers (62 rivers) in Japan is mentioned as 0.73 m3/s/100km2 and these covers required discharge for each item which are shown as above. Considering the safe side, environmental flow rate in previous study was set as 0.8 m3/s. The catchment area at the intake site is 1,490 km2 and the maintenance flow at the intake site was estimated at 11.92 m3/s (= 0.8 m3/s/km2 x 1,490 km2). As mentioned in the following chapter, this value also satisfy a). irrigation demand at the downstream and b). necessary water depth which fish flows down at the downstream.

・Validity of Estimated Maintenance Flow

As a result of comparing examples of calculations in Japan, Bangladesh, Indonesia, and the Philippines, it was confirmed that the estimated maintenance flow by Japanese example was set on the safe side. Although maintenance flow which was calculated by flow duration curve method in rainy season

(Bangladesh standard) is bigger than the Japanese method, maintenance flow rate for the rainy season calculated using the Bangladesh flow duration curve method was not selected for the following reasons.

- Although maintenance flow in this project is especially necessary to a). satisfy water utilization mainly irrigation demand at the downstream and b). satisfy water depth which fish flows down at the downstream, calculated maintenance flow by Bangladesh flow duration curve is excessive compared to these required flows (these required flows are estimated less than 11.92m3/s in following chapter).
- It would be unrealistic because the number of available days for intake would be limited, and the amount of water intake and reservoir capacity would be significantly large.

Table 4.1.5 Comparison of Maintenance Flow Estimated by Standards of Four Countries

Country	Method	Maintenance Flow (m3/s)
Japan	Average maintenance flow rate of major rivers (62 rivers) in Japan	11.92
Bangladesh	Tennant Method	4.9
	Flow Duration Curve Method	(Dry Season) 1.6-7.0
		(Rainy Season) 32.3-90.0
Indonesia	95% daily dependable flow	2.1
Philippines	Philippines: 90% of 85% daily dependable flow	3.2

Source: Data Collection Survey on Water Resources Development in Southern Chattogram, JICA

4.1.4 Water Quality Survey

The purpose of the water quality survey is to understand the water quality at the intake site for the study on methodology and procedures of water treatment, including the design of water treatment plants.

According to this survey, the following items of water quality at the intake site exceeded the standards, as shown below.

- Biochemical Oxygen Demand (BOD)
- Color
- Phosphorus (P)
- Total Suspended Sediment (TSS)
- Turbidity
- Phenol (C6H6O)
- Fecal Coliforms

- Salinity
- Aluminum (Al)
- Sulfide (S2-)
- Iron

Although necessary countermeasures are to be worked out in the design of water treatment facilities, it is considered that these items of water quality can be improved by using general rapid filtration facilities, since there are no items with extremely high values identified, compared to the standards.

1. Water Quality Test (Non- Heavy-metal)

No.	Items	No.	Items
1	Aluminum	27	Kjeldhl
2	Ammonia (NH3)	28	Magnesium
3	Balium (Barium)	29	Nitrate
4	Benzene	30	Nitrite
5	BOD5 20°C	31	Odor
6	Boron	32	Oil and
7	Calcium	33	pH
8	Chloride	34	Phenolic
9	carbontetrachloride	35	Phosphate
10	1.1 dichloroethylene	36	Phosphorus
11	1.2 dichloroethylene	37	Potassium
12	tetrachloroethylene	38	Radioactive
13	trichloroethylene	39	Radioactive
14	pentachlorophenol	40	Selenium
15	2.4.6 trichlorophenol	41	Sodium
16	Chlorine (residual)	42	Suspended
17	Chloroform	43	Sulfide
18	COD	44	Sulfate
19	Coliform (fecal)	45	Total
20	Coliform (total)	46	Temperatur
21	Color	47	Turbidity
22	Cyanide	48	Chroride
23	Detergents	49	Alkality
24	DO	50	Chloric
25	Fluoride	51	Conductivit
26	Hardness (as CaCO3)		

2. Water Quality Test (Heavy-metal)

No.	Items
1	Cadmium
2	Mercury
3	Lead
4	Arsenic
5	Chloric acid
6	Zinc
7	Iron
8	Copper
9	Manganese
10	Nickel
11	Hexavalent Chromium
12	Chromium
13	Silver

3. Pesticide Test

No.	Items
1	Carbofuran
2	Chlorpyrifos
3	2,4-D
4	2,4-DB
5	DDT and metabolites
6	Dimethoate
7	Heptachlor
8	Isoproturon
9	MCPA
10	Metolachlor
11	Pendimethalin
12	Simazine
13	Aldrin+Dieldrin

Item	Month	2023					2024				
		Rainy season			Dry season					Rainy Season	
		8	9	10	11	12	1	2	3	4	5
Water Quality Test (except for heavy metal)	Tidal	○	○	○			○			○	○
	Non Tidal	○	○	○			○			○	○
Water Quality Test (heavy metal)	Tidal	●		●			●				
	Non Tidal	●		●			●				
Pesticide Test	Tidal	●	for Aman				●	for Boro		●	For Aus
	Non Tidal	●	for Aman				●	for Boro		●	For Aus

●Tested in Japan, ○Tested in Bangladesh

Source: JICA Survey Team

Figure 4.1.12 List of Water Quality Test and the Schedule

Table 4.1.6 Results of Water Quality Survey (Items Exceeding Bangladesh Standard)

Test Type	Cycle No.	Item No.	Parameter	Unit	Result		Bangladesh Standard (Drinking Water), ECR'2023/ECR 1997/DPHE
					High Tide	Low Tide	
1. Water Quality Test (Except for heavy metal)	1st Cycle (August 29, 2023)	5	BOD	mg/L	4.2	4.8	<=3
		21	Color	PtCo	189	111	<=15
		36	Phosphorus (P)	mg/L	0.03	0.04	0
		42	Total Suspended Sediment (TSS)	mg/L	422	341	<=10
		47	Turbidity	NTU	338	262	<=5
		34	Phenol (C6H6O)	mg/L	2.9	2	<=0.002
		19	Fecal Coliforms	CFU/ 100mL	1400	900	0
			Salinity	ppt	0.06	0.06	0
	2nd Cycle (September 17, 2023)	46	Temperature	°C	32	30.4	20 - 30
		21	Color	PtCo	15	25	<=15
		42	Total Suspended Sediment (TSS)	mg/L	147	167	<=10
		47	Turbidity	NTU	98.3	113	<=5
		19	Fecal Coliforms	CFU/ 100mL	250	240	0
			Salinity	ppt	0.06	0.06	0
	3rd Cycle (October 16, 2023)	46	Temperature	°C	30.5	28.4	20 - 30
		21	Color	PtCo	13	43	<=15
		36	Phosphorus (P)	mg/L	0.05	0.04	0
		42	Total Suspended Sediment (TSS)	mg/L	25	37	<=10
		47	Turbidity	NTU	37.2	42.7	<=5
		1	Aluminum (Al)	mg/L	0.26	0.47	<=0.20
		19	Fecal Coliforms	CFU/ 100m L	1600	900	0
			Salinity	ppt	0.09	0.09	0
	4th Cycle		Salinity	ppt	0.12	0.12	0
		21	Color	PtCo	13	24	<=15

Test Type	Cycle No.	Item No.	Parameter	Unit	Result		Bangladesh Standard (Drinking Water), ECR'2023/ECR 1997/DPHE
					High Tide	Low Tide	
	(January 14, 2024)	36	Phosphorus (P)	mg/L	0.05	0.05	0
		42	Total Suspended Sediment (TSS)	mg/L	18	14	<=10
		47	Turbidity	NTU	22.3	21.9	<=5
		32	Oil & Grease	mg/L	0	155	≤0.01
		19	Fecal Coliforms	CFU/ 100m L	212	265	0
	5th Cycle (April 23, 2024)	46	Temperature	°C	35.3	32.2	20 - 30
			Salinity	ppt	0.12	0.12	0
		36	Phosphorus (P)	mg/L	0.05	0.07	0
		42	Total Suspended Sediment (TSS)	mg/L	7	13	<=10
		47	Turbidity	NTU	3.72	5.13	<=5
		40	Selenium	µg/L	8.5	15.3	≤0.01
		43	Sulfide (S2-)	mg/L	2	2.2	≤0.05
		19	Fecal Coliforms	CFU/ 100m L	180	166	0
	6th Cycle (May 25, 2024)	5	BOD	mg/L	2.7	3.1	<=3
		20	Total Coliforms	CFU/ 100m L	7200	3600	<=5000
		46	Temperature	°C	32.9	31.1	20 - 30
			Salinity	ppt	0.11	0.1	0
		21	Color	PtCo	157	122	<=15
		36	Phosphorus (P)	mg/L	0.2	0.11	0
		42	Total Suspended Sediment (TSS)	mg/L	680	330	<=10
		47	Turbidity	NTU	791	405	<=5
		19	Fecal Coliforms	CFU/ 100m L	1900	1000	0
2. Water Quality	1stCycle (August 29, 2023)	7	Iron	mg/L	19	13	0.3-0.1

Test Type	Cycle No.	Item No.	Parameter	Unit	Result		Bangladesh Standard (Drinking Water), ECR'2023/ECR 1997/DPHE
					High Tide	Low Tide	
Test (Heavy metal)	2nd Cycle (September 17, 2023)	7	Iron	mg/L	0.64	2.2	0.3-0.1
	4th Cycle (January 16, 2024)	7	Iron	mg/L	0.33	0.2	0.3-0.1
	5th Cycle (April 23, 2024)	7	Iron	mg/L	0.24	0.42	0.3-0.1
	6th Cycle (May 25, 2024)	7	Iron	mg/L	2.3	1.8	0.3-0.1
3. Pesticide Test	**No Parameter Exceeded**						

Source: JICA Survey Team

4.1.5 Important Findings and Points to Note

The important findings and point to note for the "Surface Water and Water Quality Survey" are summarized as below.

Table 4.1.7 Important Findings and Points to Note

1) Survey Item	2) Purpose	3) Output/findings
Meteorological, Oceanographic, and Wind Survey (**4.1.1**)	Necessary data collection which is used for water balance analysis and design of intake facility and others.	All necessary data collected. Tendencies of each data are almost the same as data which was collected on the previous survey.
Natural Disaster Survey (**4.1.2**)	Base information which is used for the study of design flood level and safety of civil structure such as intake facility and reservoir.	Maximum flood level at the intake site and reservoir site were understood by flood record interview survey. It will be used for the design of each civil structure.
Hydraulic and Hydrological Survey (**4.1.3**)	Understand the: a) relationship between discharge and water level (H-Q curve) at intake site for design of intake (such as sill EL), b) influence of backwater at the upstream by construction of intake weir for the selection of appropriate intake weir type and c)	Collected and analyzed the basic information which is necessary for: a), b) and c). Influence of backwater reached 10 km upstream of the intake site and it is necessary to consider the appropriate weir type. River shifting occurred in many locations. It is necessary to consider the selection of intake site.

1) Survey Item	2) Purpose	3) Output/findings
	specification of Matamuhuri River which is utilized for the selection of intake location.	
Water Quality Survey (**4.1.4**)	Understand the water quality at the intake site for the study of methodology and steps of water treatment including design of water treatment plant.	Some water quality parameters exceeded the standards (it is considered for the design of treatment plant and the treatment steps).

Source: JICA Survey Team

4.2 Topographic Survey

4.2.1 Survey Items and Results

The goal of the topographic survey is to understand the topographical conditions necessary for the preliminary design of the water supply facilities. Topographic survey, route survey, drone survey, and bathymetric survey were conducted for the planned areas of the water intake, reservoir, treatment plant, distribution ponds, conveyance pipeline, and distribution pipelines. The survey results are to be prepared in the form of drawings and reports. The survey items, specifications, quantity, and required accuracy are shown in Table 4.2.1 below.

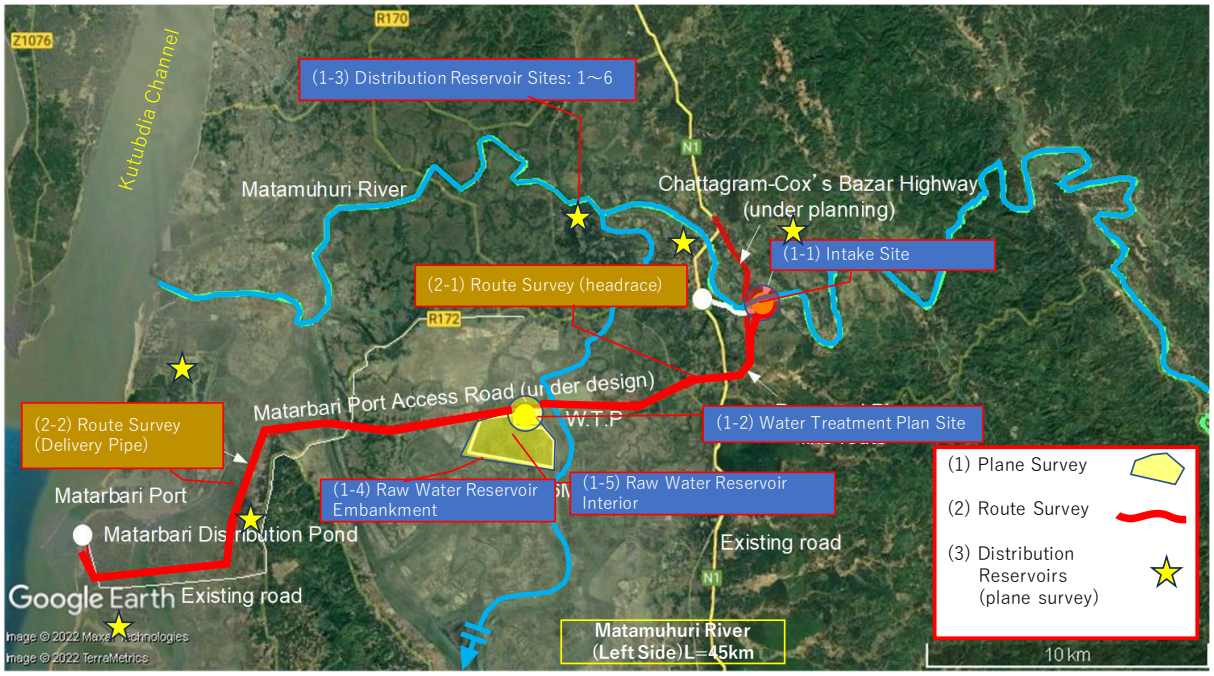
The topographic survey was conducted from November 2023 to March 2024.

The outputs of the topographic survey have been used for the subsequent design work.

Table 4.2.1 Specifications, Quantity, and Other Details of Topographic Survey

Item	Facility	Details	Quantity (m^2)	Specifications, Accuracy
Plane Survey	Intake	150 m × 350 m	52,500	Scale 1/500 and contour intervals of 1m. Includes the contour survey of the structures within the measurement range
	Treatment Plant Site	200 m x 300 m	60,000	
	Distribution Reservoir (six sites)	100 m x 100 m x 6	60,000	
	Raw Water Reservoir (embankment/spillway)	300 m x 300 m	90,000	
	Raw Water Reservoir (interior)	8.0 km^2	8.0 km^2	1/2,000 drone survey
Route Survey	Conveyance Pipeline	Average survey width is 100 m.	10 km	Average survey width is 100 m. Location and type of existing structures and obstacles (roads, bridges, buildings, water supply lines, sewage/drainage pipes/small rivers, telephone lines, electricity, pole and wire, etc.) along the route shall be identified.
	Distribution Pipeline	Average survey width is 100 m.	25 km	Ditto

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.2.1 Location Map of Topographic Survey

4.2.2 Important Findings and Points to Note

The topographic survey covered a wide area of the salt fields and some of existing roads and private lands. Initially there were concerns about difficulty in obtaining the permit to enter the object areas during the on-site survey. Although adjustments were made to the target facilities in line with the revisions of the plans and designs of the structures, the survey was completed in a manner that satisfied the required specifications and quantities. Furthermore, drone video was taken of the river channel upstream and downstream of the intake, as well as the surrounding construction sites, and these were used to check the planimetric survey and for facility layout planning.

4.3 Geotechnical Survey

4.3.1 Survey Items and Results

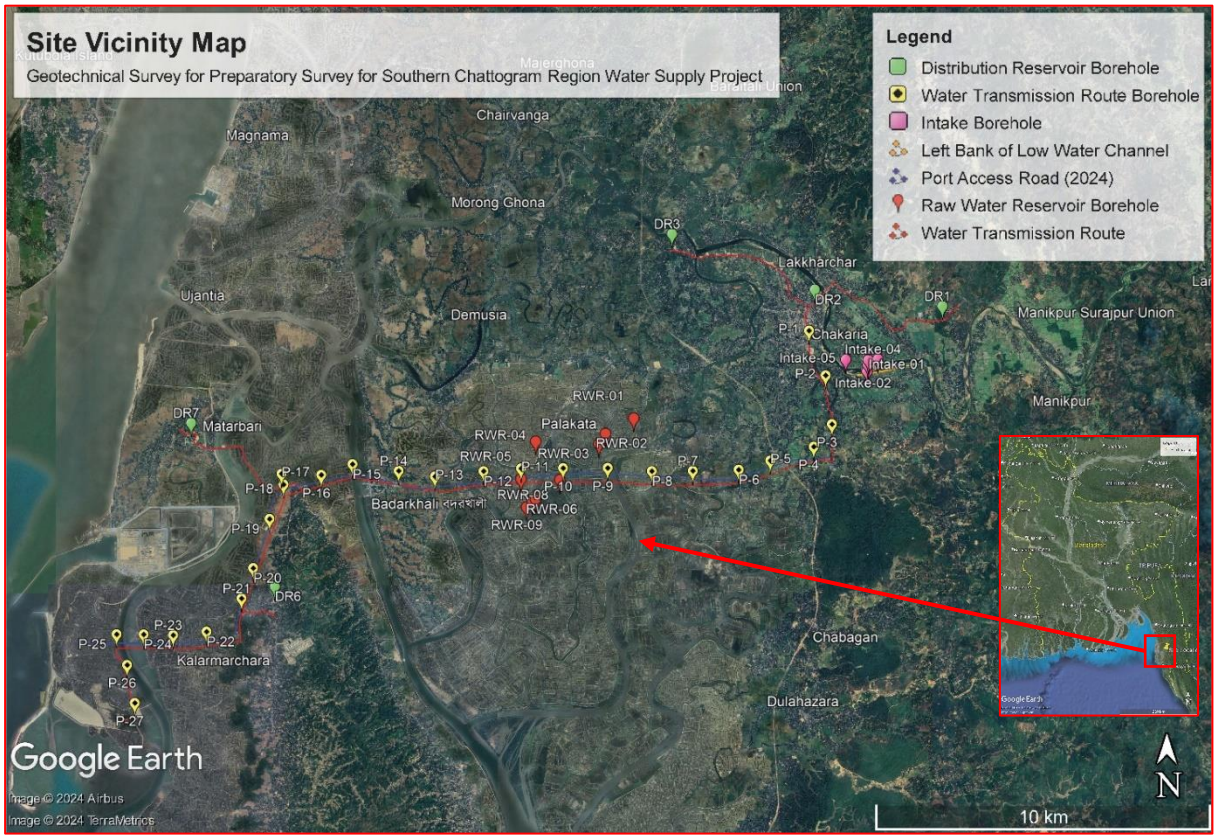
(1) Survey Items

The geotechnical survey aims to obtain information for understanding natural conditions of geology for the preliminary design of water supply facilities. The survey was carried out, complying with American Society for Testing and Material (ASTM). The survey item and location map is summarized as below.

Table 4.3.1 Survey Item of Geotechnical Survey

Survey work	Quantity	Note
(1) Boring Work	19 nos.	9 nos.: Raw Water Reservoir Site 5 nos.: Intake Site 5 nos.: Distribution Reservoir Site
(2) Hydraulic Rotary Standard Penetration Test	584 times	Every 1m depth
(3) Undisturbed Soil Sampling	58 nos.	Each layer where the geotechnical condition has changed.
(4) Laboratory Test	1 LS	Water Content, Wet Density, Grain Size, Liquid & Plastic Limit, Compaction, Permeability, Consolidation, CU/UU, CD/CU, etc.
(5) Percussion Standard Penetration Test	27 nos.	Once in 500 m: Transmission Pipeline Site

Source: JICA Survey Team



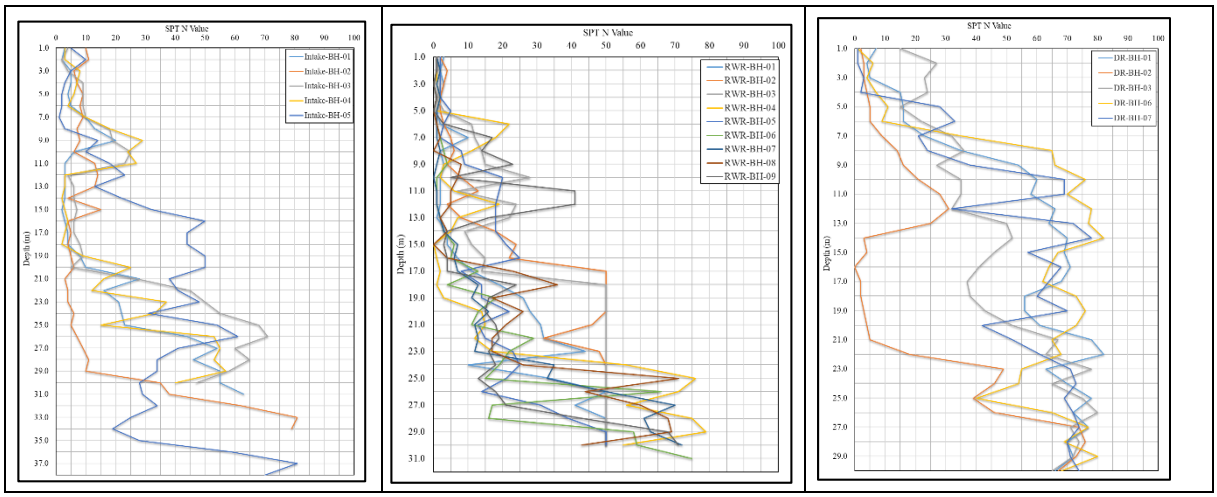
Source: JICA Survey Team

Figure 4.3.1 Location Map of Geotechnical Survey

(2) Survey Results

- Hydraulic Rotary SPT Result

Hydraulic Rotary SPT result at the proposed construction site of Intake, Raw Water Reservoir (RWR), and Distribution Reservoir (DR) are shown as below.



Source: JICA Survey Team

Figure 4.3.2 Hydraulic Rotary SPT Result at Proposed Site of Intake, RWR and DR

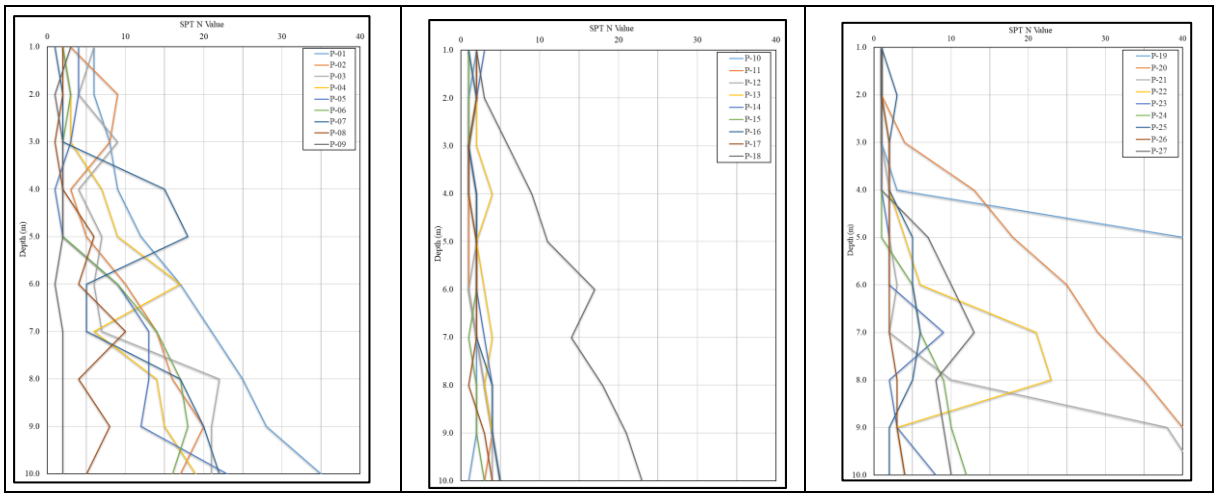
At intake site, from the surface to a depth of 15m, the soil is composed of sandy soil, and this consistency is very loose to medium. Also, at depth of 15m to 30m, the cohesive soil is encountered after the upper sandy soil layer, and this consistency is soft to medium and become very stiff approximately after depth of 20m. In addition, the granular soil layer is encountered after the upper cohesive layer, and this layer is very dense.

At raw water reservoir site, from the surface to a depth of 15m, the soil is composed of clayey soil, and this consistency is very soft to medium stiff. Also, the intermittent layer of sandy soil is encountered in between 5m to 27m, and this density varies from loose to dense. In addition, the granular soil layer is encountered after the upper layer.

At distribution reservoir site, the sites are dominated by sandy soil, they are mostly very dense (N value>50). Also, several intermittent layers of clayey soil are found among the boreholes at different depth. The consistency indices of these layer are soft to hard.

- Percussion SPT Result

Percussion SPT result at the proposed construction site of transmission pipeline are shown as below.



Source: JICA Survey Team

Figure 4.3.3 Percussion SPT Result at Proposed Site of Transmission Pipeline

At transmission pipeline site, although it is difficult to analyze trends because the survey was conducted over a wide area, no bedrock layers that would be obstacles to pipeline installation were identified in the strata shallower than 5 m where the transmission pipeline is to be laid.

- Laboratory Test Result

Laboratory tests were conducted on samples collected during the boring work to measure the parameter of water content, wet density, grain Size, liquid & plastic limit, compaction, permeability, consolidation, CU/UU, CD/CU, etc. A summary of the laboratory test results of RWR-BH-01 sample is shown below. Detailed results of all samples are shown in Supporting Report B.

Table 4.3.2 Summary of Index Properties of RWR-BH-01 Sample (1)

Borehole No.	Depth Below Ground Level (m)		USCS	Sand (Coarse) Content (%)	Fine Content %	Specific Gravity (Gs)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Bulk Density (kN/m³)	Dry Density (kN/m³)
	From	To									
RWR-BH-01	3.50	3.00	CH	0.60	99.40		42.40	58.35	33.83		
	4.50	5.00	CH	2.40	97.60	2.712	43.60	61.64	31.33	17.16	12.05
	6.50	7.00	CH	1.46	98.54		46.38	54.10	29.76		
	8.50	9.00	CH	1.46	98.54	2.723	45.38	52.16	25.78	17.36	11.94
	11.00	11.45	ML	38.64	61.36		31.23				
	12.50	13.00	MH				47.69				
	16.00	16.45	SM	50.38	49.62		29.62				
	20.00	20.45	SM	86.16	13.84		19.69				
	23.00	23.45	SP-SM	92.70	7.30		15.69				
	28.00	28.37	SM	85.90	14.10		16.54				

Source: JICA Survey Team

Table 4.3.3 Summary of Index Properties of RWR-BH-01 Sample (2)

Borehole No.	Depth Below Ground Level (m)		USCS	Unconsolidated -Undrained Triaxial Compression Test (UU)	Consolidated-Undrained Triaxial Compression Tests (CU)		Consolidated-Drained Triaxial Compression Tests (CD)	
	From	To		Shear Strength (kPa)	Shear Strength (kPa)	Internal Friction Angle (°)	Shear Strength (kPa)	Internal Friction Angle (°)
RWR-BH-01	4.50	5.00	CH	13.93				
	6.50	7.00	CH		16.05	25.03		
	8.50	9.00	CH	13.72				
	12.50	13.00	MH				24.87	13.56

Source: JICA Survey Team

Table 4.3.4 Summary of Index Properties of RWR-BH-01 Sample (3)

Borehole No.	Depth Below Ground Level (m)		USCS	Initial void ratio	Reconsolidation pressure (kPa)	Compression index	Recompression index	Coefficient of consolidation (m^2/year)
	From	To						
RWR-BH-01	4.50	5.00	CH	1.35	176.00	0.58	0.03	1.52-6.86
	12.50	13.00	CH	1.27	160.00	0.50	0.03	0.82-13.21

Source: JICA Survey Team

4.3.2 Important Findings and Points to Note

The results of the borings and laboratory tests confirmed the following points.

- At intake point, the soil mainly consisted of sandy soil, and the supporting soil layer was found to exist at depth of 20m or deeper

- At raw water reservoir point, the soil mainly consisted of clayey soil, and the supporting soil layer was found to exist at a depth of 10m or deeper.

- At distribution reservoir point, the soil mainly consisted of sandy soil, and the supporting soil layer was found to exist at a depth of 10m or deeper.

-At transmission pipeline point, Due to the large area, a variety of soil properties have been identified, but in most areas, there are no bedrock formations that would interfere with the pipeline installation at shallow layer.

4.4 Climate Change Impact

4.4.1 Climate Change Prediction by Data Collection and Analysis

(1) The Whole of Bangladesh

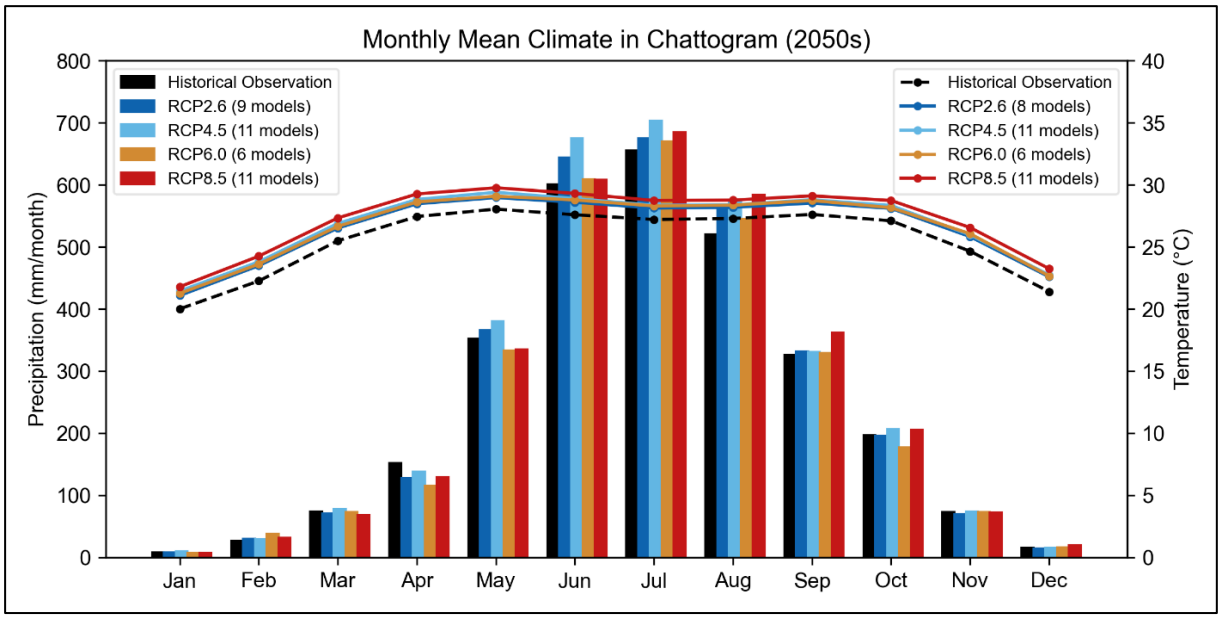
The impacts of climate change in Bangladesh are summarized in the table below in terms of temperature, rainfall, flood, cyclone, and sea level rise.

Table 4.4.1 Climate Change Impact on Bangladesh

Item	Outline of Climate Change Influence	Source
Temperature	The average temperature is projected to increase by 1.8°C by 2060 and by 2.7°C by 2090 compared to 2010 levels.	Bangladesh Confronts Climate Change: Keeping Our Heads above Water (2016)
Rainfall	The annual average rainfall is projected to increase by 7% by 2060 (compared to 1970-2000 average).	Climate Change Profile Bangladesh (2018)
Flood	14.3% of the country's land area will be at high risk of flooding by 2030	IPCC (2007)
Cyclone	The cyclone high risk areas in Bangladesh will increase by 40% in the 2050s due to the increase in the storm surge height and wind velocity	Climatic Hazards in Bangladesh: A Literature Review_ Masum (2019)
Sea Level Rise	Compared to 2000, a sea level rise of 14 cm by 2030 and 88 cm by 2100 has been predicted. This implies an annual sea level rise of 4.7 mm by 2030 and approximately 8.8 mm annually by 2100, indicating a gradual increase in the rate of sea level rise	IPCC (2007)

(2) South Chattogram Region

The impacts of climate change (temperature, rainfall) in the southern Chattogram region in 2050 were analysed for each scenario (RCP2.5, RCP4.5, RCP6.0, RCP8.5). The analysis results are shown below. The analysis results confirmed the same trends (temperature rising and rainfall increasing in future by climate change) as the trends for the whole of Bangladesh mentioned above.



Source: JICA Survey Team

Figure 4.4.1 Result of Climate Change Analysis in 2050s in Chattogram Region

The impacts of climate change that can be lead from the analysis results are summarized below from the perspective of water resource and flood impact.

a) Aspect of Water Resource

The climate change analysis presented in the study suggests several key impacts on water resources, particularly in relation to water supply projects in Chattogram. Here are the potential implications:

- Higher Precipitation During Rainy Season: The significant increase in rainfall during the rainy season (May-October) under all RCP scenarios indicates a higher risk of flooding. This can overwhelm existing water discharge in Matamuhuri River, the intake source for water supply project.
- Reduced Precipitation During Dry Season: Despite the heavy rainfall in the rainy season, the dry season (November-April) still exhibits low precipitation levels, similar to historical trends. This could lead to water scarcity during these months, especially if the monsoon rains are not adequately captured and stored.
- Higher Temperatures and Evaporation: The projected temperature increases under all RCP scenarios will likely lead to higher evaporation rates from reservoirs and low water flow in Matamuhuri River, reducing the effective water available for supply, particularly in January and February.

b)Aspect of Flood Impact

As rainfall during the rainy season will increase by approximately 10% due to the impact of climate change, it is estimated that the flow rate during floods will also increase by the same amount compared to the current situation. This will have the following impact:

- Impact on related facilities (damage to facilities, suspension of operations) by the expansion of inundation areas and prolonged inundation time
- Blockage of the intake by sedimentation and increase of maintenance cost for removal of sedimentation (Increased rainfall leads to more sediment production in the upstream area, and increased flood flow leads to more sediment supply from upstream)

4.4.2 Impact on the Related Facilities and the Countermeasures

(1) Determination of Targets of Climate Risk Assessment

In conducting climate risk assessment and considering adaptation measures, the targets of the climate risk assessment were identified and organized based on the contents of the projects (project components, activities, etc.). For details of project components, see Section 5.4.

(2) Hazard

Based on the collected information and results of the climate change analysis described above, the following climate hazards were selected.

Table 4.4.2 Climate Change Impact on Bangladesh

	H1	H2	H3	H4	H5
Selected Hazard	Drought	Flood	Heavy Rainfall	Cyclone(storm)	Hight Tide(Sea Level Ris)e
Reason for Selection	・Decrease of rainfall in dry season ・Increase of Evaporation due to the high temperature	・Increase of rainfall in rainy season		・40% increase of cyclone in whole of Bangladesh	・Sea level rising 4.7mm/yr by 2030 and 8.8mm/yr by 2100

Source: JICA Survey Team

(3) Exposure

Potential exposures that are likely to be affected by climate hazards during the project planning period in the target area were extracted as shown in the table below:

Table 4.4.3 Potential Exposures in the Project

No.	Potential Exposures
1	Water Intake Facilities (Intake Structure, Intake Channel, Sedimentation Basin, Water Intake Pump Station)
2	Conveyance Pipeline, Water Transmission Pipeline (Buried Pipe. However, Aqueduct Bridges in river-crossing sections)
3	Reservoir
4	Water Treatment Plant, Pump Station
5	Distribution Facilities (Elevated Type)
6	Access Road
7	Dredging Facilities (Dredging Vessel, Storage Warehouse, Vehicles, Heavy Machinery, etc.) and Disposal Area

Source: JICA Survey Team

In combination of the identified exposure and hazard, the "degree of impact" was assessed, and the direction of future changes in the "climate hazards" were confirmed and examined. The evaluation results are shown in the Climate Fit Matrix (Table 4.4.4).

(4) Vulnerability

Based on the combination of "climate hazards" and "exposures" that should be monitored in the target project, "vulnerabilities" that may become significant in the future or that are already contributing to the target area were considered and evaluated. The evaluation results are shown in the Climate Fit Matrix (Table 4.4.4).

(5) Climate Risks

Based on the combination of "climate hazards" and "exposures" that should be monitored in the target project and the results of the assessment of vulnerability that may occur, significant climate risks for the project were extracted and assessed. The assessment results are shown in the Climate Fit (Table 4.4.4).

(6) Climate Change Adaptation Measures

Taking into consideration the selected "climate risks," possible measures (adaptation measures) to reduce the risks were studied and summarized the list of selected adaptation measures together with the corresponding SDGs items are shown in the Climate Fit Matrix (Table 4.4.4).

In addition, based on the climate risks that are considered to be potentially significant in the future, a climate risk tree was created as shown in Figure 4.4.2.

Table 4.4.4 The impacts of climate change on each facility and countermeasures

			Climate Hazard H1 Drought	H2 Flood	H3 Heavy Rain	H4 Cyclone (Storm)	H5 High Tide (Sea Level Rise)	Vulnerability	Count of "3"	Climate Risk	Potential Adaptation Options	Corresponding SDGs items	H1 Drought	H2 Flood	H3 Heavy Rain	H4 cyclone (Storm)	H5 High Tide (Sea Level Rise)
		Current Frequency	++	++	+	+	+										
		Future Prediction	↗	↗	↗	↗	↗										
Exposure	E1	Water Intake Facilities (Intake Structure, Intake Channel, Sedimentation Basin, Water Intake Pump Station)	3↗ High possibility of being affected by reduced water intake levels and water quality due to reduced water volume during drought.	3↗ Since the facilities are planned nearby the river, the possibility of being affected by flood is high.	2↗ Since the facilities are planned in the inundation area, there is a possibility of being affected by heavy rain.	1↗ Possibility of being affected by cyclone, but minor.	2↗ Currently, the intake is planned in a location free from saltwater intrusion. However, possibility of being affected by saltwater intrusion in the future due to rising sea levels.	(H1&H5) Intake will be constructed in downstream of the Matamuhuri River where saltwater intrusion may reach. (H2) Intake will be located nearby river in flood prone area.	2	(H1&H5) There are saltwater intrusion barriers, but are frequently damaged. Risk of intake stoppage because of saltwater intrusion at the intake point due to rising sea levels (H2) Damage to facilities and displacement of river sandbars due to flood is leading to malfunction of the water intake.Risk of intake malfunction because of facility damage and river sandbars displacement due to flood.	(H1&H5) Regular monitoring of salinity levels, raising the elevation of intake's mouth above the river bed, and installing backup intake pumps for extreme drought conditions. (H2) Installation of riverbank protection works. Regular maintenance dredging of the waterway in front of intake structure.	6, 13	3	3	2	1	2
	E2	Conveyance Pipeline, Water Transmission Pipeline (Buried Pipe. However, Aqueduct Bridges in river-crossing sections)	1↗ Possibility of being affected due to reduced water volume during drought.	3↗ Since the aqueduct bridge is planned in the flood-prone area, the possibility of being affected by flood is high.	2↗ Since the facilities are planned in the inundation area, there is a possibility of being affected by heavy rain.	2↗ Possibility of aqueduct bridge being affected by cyclone.	1↗ Possibility of being affected by increased flood risk due to rising sea levels, but minor.	*(H2) Headrace channel, water transmission pipe lies will be located in flood prone area.	1	(H2) Frequent damages to the bridges due to flood Risk of failure in headrace channel and water transmission functions because of damage in aqueduct bridge.	(H2) Installation of riverbank protection works at the aqueduct bridge location and setting clearance under the bridge girder with consideration for sea level rise and flood level rise.	6, 13	1	3	2	2	1
	E3	Reservoir	2↗ High possibility of being affected due to reduced water volume during drought.	3↗ Since the facilities are planned in the flood-prone area, the possibility of being affected by flood is high.	2↗ Since the facilities are planned in the inundation area, there is a possibility of being affected by heavy rain.	1↗ Possibility of being affected by cyclone, but minor.	2↗ Possibility of being affected by saltwater intrusion into the reservoir and increased flood risk due to rising sea levels.	(H2) Embankment will be constructed in flood prone area. (H5) Riverbed areas with sandy deposits may experience saltwater intrusion through the groundwater.	1	(H2) Frequent damages to the embankment due to flood. Risk of reservoir loss and failure of storage functions because of damage in reservoir embankment. (H5)Riverbed areas with sandy deposits may experience saltwater intrusion through the groundwater. Risk of decrease in water quality in the reservoir because of saltwater instrusion into the groundwater due to rise in sea level.	(H2) Widening of the embankment cross-section and strengthening of slope protection. (H5) Installation of embankment blankets and cutoffs with consideration for sea level rise and flood level rise.	6, 13	2	3	2	1	2
	E4	Water Treatment Plant, Pump Station	2↗ High possibility of being affected due to reduced water volume during drought.	3↗ Since the facilities are planned in the flood-prone area, the possibility of being affected by flood is high.	2↗ Since the facilities are planned in the inundation area, there is a possibility of being affected by heavy rain.	1↗ Possibility of being affected by cyclone, but minor.	1↗ Possibility of being affected by increased flood risk due to rising sea levels, but minor.	*(H2) Water supply facilities will be constructed in flood prone area.	1	(H2) Frequent damages to the existing water supply facilities due to flood. Risk of failure in water supply functions because of damage to facilities.	(H2) Strengthening the protection against flood inundation (elevating structures, on-site drainage facilities, and provision of emergency power supply)	6, 13	2	3	2	1	1
	E5	Distribution Facilities (Elevated Type)	1↗ Possibility of being affected due to reduced water volume during drought.	1↗ Even though the facilities are planned in a flood-prone area, since it's elevated, there is a possibility of foundation being affected by flood.	1↗ Even though the facilities are planned in a flood-prone area, since it's elevated, there is a possibility of foundation being affected by heavy rain.	2↗ Since it's elevated, possibility of being affected by cyclone.	1↗ Possibility of being affected by increased flood risk due to rising sea levels, but minor.	*(H4) Distribution facilities will be constructed in cyclone prone area.	0	(H4) Damage to the existing water supply facilities occurs due to cyclone. Risk of failure in water supply functions because of damage to facilities .	(H4) Strengthening facilities against cyclone (reinforcement of the foundation)	6, 13	1	1	1	2	1
	E6	Access Road	0↗ No Impact.	3↗ Since the facilities are planned in the flood-prone area, the possibility of being affected by flood is high.	2↗ Since the facilities are planned in the inundation area, there is a possibility of being affected by heavy rain.	3↗ High possibility of being affected by cyclone such as fallen trees and downed utility poles.	2↗ Possibility of being affected by increased flood risk due to rising sea levels, but minor.	*(H2) Access road will be constructed in flood and cyclone prone area.	2	(H2&H4) Damage to existing roads from flood and road closures due to fallen trees from cyclone frequently occur. Risk of losing access to facilities due to flood and cyclone.	(H2&H4) Elevate road levels, reinforce utility poles and strengthen tree planting along the roadsides. Secure alternative access routes in case of emergency.	13, 15	0	3	2	3	2
	E7	Dreding Facilities (Dredging Vessel, Storage Warehouse, Vehicles, Heavy Machinery, etc.) and Disposal Area	0↗ No Impact.	2↗ The planned facilities will be installed in the flood-prone area, hence there is a possibility of being affected by flood.	2↗ Since the facilities are planned in the inundation area, there is a possibility of being affected by heavy rain.	1↗ Possibility of being affected by cyclone, but minor.	1↗ Possibility of being affected by increased flood risk due to rising sea levels, but minor.	*(H2&H3) Dredging facilities and disposal areas will be located nearby river in flood prone area	0	(H2) Damage and risk to the dredging facilities and disposal areas occurs due to flood and heavy rain.	(H2) Maintenance of management facilities and strengthening the management system for emergency.	13, 15	0	2	2	1	1
		Count of "3"	1	5	0	1	0										

Note 1) Hazard frequency assessment: ++ Frequently occurring thus far or at present, + Sometimes occurring thus far or at present, - Has hardly occurred thus far or at present

Note 2) Evaluation Scale for current impact levels:

3 Events and impacts that have occurred thus far have been so difficult that they cannot beaddressed and handled.

2 Events and impacts that have occurred to date have been moderately difficult to manage anddeal with.

1 It has not been so difficult to manage the events and impacts that have occurred thus far. Theresulting impact was minor and was managed to some extent.

0 The impacts of events that have occurred to date have been negligible.

Source: Prepared by JICA Project Team based on the "JICA Climate-Fit (Adaption)"

Climate Hazard

H1	Drought
H2	Flood
H3	Heavy Rain
H4	Cyclone (Storm)
H5	High Tide (Sea Level Rise)

Exposure

E1	Water Intake Facilities (Intake Structure, Intake Channel, Sedimentation Basin, Water Intake Pump Station)
E2	Conveyance Pipeline, Water Transmission Pipeline (Buried Pipe. However, Aqueduct Bridges in river-crossing sections)
E3	Reservoir
E4	Water Treatment Plant, Pump Station
E5	Distribution Facilities (Elevated Type)
E6	Access Road
E7	Dreding Facilities (Dredging Vessel, Storage Warehouse, Vehicles, Heavy Machinery, etc.) and Disposal Area

Climate Risk

R1	(H1&H5) There are saltwater intrusion barriers, but are frequently damaged. Risk of intake stoppage because of saltwater intrusion at the intake point due to rising sea levels (H2) Damage to facilities and displacement of river sandbars due to flood is leading to malfunction of the water intake.Risk of intake malfunction because of facility damage and river sandbars displacement due to flood.
R2	(H2) Frequent damages to the bridges due to flood Risk of failure in headrace channel and water transmission functions because of damage in aqueduct bridge.
R3	(H2) Frequent damages to the embankment due to flood. Risk of reservoir loss and failure of storage functions because of damage in reservoir embankment. (H5)Riverbed areas with sandy deposits may experience saltwater intrusion through the groundwater. Risk of decrease in water quality in the reservoir because of saltwater instrusion into the groundwater due to rise in sea level.
R4	(H2) Frequent damages to the existing water supply facilities due to flood. Risk of failure in water supply functions because of damage to facilities.
R5	(H4) Damage to the existing water supply facilities occurs due to cyclone. Risk of failure in water supply functions because of damage to facilities .
R6	(H2&H4) Damage to existing roads from flood and road closures due to fallen trees from cyclone frequently occur. Risk of losing access to facilities due to flood and cyclone.
R7	(H2) Damage and risk to the dredging facilities and disposal areas occurs due to flood and heavy rain.

Vulnerability

V1	(H1&H5) Intake will be constructed in downstream of the Matamuhuri River where saltwater intrusion may reach. (H2) Intake will be located nearby river in flood prone area.
V2	*(H2) Headrace channel, water transmission pipe lies will be located in flood prone area.
V3	(H2) Embankment will be constructed in flood prone area. (H5) Riverbed areas with sandy deposits may experience saltwater intrusion through the groundwater.
V4	*(H2) Water supply facilities will be constructed in flood prone area.
V5	*(H4) Distribution facilities will be constructed in cyclone prone area.
V6	*(H2) Access road will be constructed in flood and cyclone prone area.
V7	*(H2&H3) Dredging facilities and disposal areas will be located nearby river in flood prone area

Impact

Adaptation Options

A1	(H1&H5) Regular monitoring of salinity levels, raising the elevation of intake's mouth above the river bed, and installing backup intake pumps for extreme drought conditions. (H2) Installation of riverbank protection works. Regular maintenance dredging of the waterway in front of intake structure.
A2	(H2) Installation of riverbank protection works at the aqueduct bridge location and setting clearance under the bridge girder with consideration for sea level rise and flood level rise.
A3	(H2) Widening of the embankment cross-section and strengthening of slope protection. (H5) Installation of embankment blankets and cutoffs with consideration for sea level rise and flood level rise.
A4	(H2) Strengthening the protection against flood inundation (elevating structures, on-site drainage facilities, and provision of emergency power supply)
A5	(H4) Strengthening facilities against cyclone (reinforcement of the foundation)
A6	(H2&H4) Elevate road levels, reinforce utility poles and strengthen tree planting along the roadsides. Secure alternative access routes in case of emergency.
A7	(H2) Maintenance of management facilities and strengthening the management system for emergency.

Climate Hazard

H1	Drought
H2	Flood
H3	Heavy Rain
H4	Cyclone (Storm)
H5	High Tide (Sea Level Rise)

Exposure

E1	Water Intake Facilities (Intake Structure, Intake Channel, Sedimentation Basin, Water Intake Pump Station)
E2	Conveyance Pipeline, Water Transmission Pipeline (Buried Pipe. However, Aqueduct Bridges in river-crossing sections)
E3	Reservoir
E4	Water Treatment Plant, Pump Station
E5	Distribution Facilities (Elevated Type)
E6	Access Road
E7	Dreding Facilities (Dredging Vessel, Storage Warehouse, Vehicles, Heavy Machinery, etc.) and Disposal Area

Climate Risk

R1	(H1&H5) There are saltwater intrusion barriers, but are frequently damaged. Risk of intake stoppage because of saltwater intrusion at the intake point due to rising sea levels (H2) Damage to facilities and displacement of river sandbars due to flood is leading to malfunction of the water intake.Risk of intake malfunction because of facility damage and river sandbars displacement due to flood.
R2	(H2) Frequent damages to the bridges due to flood Risk of failure in headrace channel and water transmission functions because of damage in aqueduct bridge.
R3	(H2) Frequent damages to the embankment due to flood. Risk of reservoir loss and failure of storage functions because of damage in reservoir embankment. (H5)Riverbed areas with sandy deposits may experience saltwater intrusion through the groundwater. Risk of decrease in water quality in the reservoir because of saltwater instrusion into the groundwater due to rise in sea level.
R4	(H2) Frequent damages to the existing water supply facilities due to flood. Risk of failure in water supply functions because of damage to facilities.
R5	(H4) Damage to the existing water supply facilities occurs due to cyclone. Risk of failure in water supply functions because of damage to facilities .
R6	(H2&H4) Damage to existing roads from flood and road closures due to fallen trees from cyclone frequently occur. Risk of losing
R7	(H2) Damage and risk to the dredging facilities and disposal areas occurs due to flood and heavy rain.

Vulnerability

V1	(H1&H5) Inatake will be constructed in downstream of the Matamuhuri River where saltwater intrusion may reach. (H2) Intale will be located neaby river in flood prone area.
V2	*(H2) Headrace chanel, water transmission pipe lies will be located in flood prone area.
V3	(H2) Embankment will be constructed in flood prone area. (H5) Riverbed areas with sandy deposits may experience saltwater intrusion through the groundwater.
V4	*(H2) Wsupply facilites will be constructed in flood prone area.
V5	*(H4) Distibution facilities will be constructed in cyclone prone area.
V6	*(H2) Access roakd will be constructed in flood and cyclone prone area.
V7	*(H2&H3) Dreding facilities and disposal areas will be located nereby river in flood pron area

Impact

Adaptation Options

A1	(H1&H5) Regular monitoring of salinity levels, raising the elevation of intake's mouth above the river bed, and installing backup intake pumps for extreme drought conditions. (H2) Installation of riverbank protection works. Regular maintenance dredging of the waterway in front of intake structure.
A2	(H2) Installation of riverbank protection works at the aqueduct bridge location and setting clearance under the bridge girder with consideration for sea level rise and flood level rise.
A3	(H2) Widening of the embankment cross-section and strengthening of slope protection. (H5) Installation of embankment blankets and cutoffs with consideration for sea level rise and flood level rise.
A4	(H2) Strengthening the protection against flood inundation (elevating structures, on-site drainage facilities, and provision of emergency power supply)
A5	(H4) Strengthening facilities against cyclone (reinforcement of the foundation)
A6	(H2&H4) Elevate road levels, reinforce utility poles and strengthen tree planting along the roadsides. Secure alternative access routes in case of emergency.
A7	(H2) Maintenance of management facilities and strengthening the management system for emergency.

Source: JICA Survey Team

Figure 4.4.2 Climate Risk Tree for Water Resources in South Chattogram Region

(7) Climate Change Mitigation Measures

(a) Mitigation Measures

The project is a new water supply project, and since it involved the construction of new intake facilities, water treatment facilities, and water distribution facilities, energy consumption will increase compared to not implementing the project. In response to this increase in energy consumption, the introduction of energy-saving equipment that would help reduce greenhouse gas emissions as a mitigation measure was considered in this survey.

(b) Introduction of Energy-Saving Equipment

The following measures are proposed to reduce greenhouse gas emissions for the project.

- Application of a Self-Water Backwash Method for Rapid Sand Filter:
  Generally, backwashing is performed by using pumps, however by applying a self-water backwash method that utilizes the water head difference, the power consumption of the backwash pumps can be reduced.
- Application of IE3 for Efficiency Class of Low Voltage Electrical Motors:
  There are no regulations regarding motor efficiency in Bangladesh. Additionally, in neighboring India, which is a major importer of industrial products to Bangladesh, the IE2 is applied for efficiency class of low voltage electrical motors. In contrast, advanced countries such as Japan apply the IE3. By applying IE3 for the project, the power consumption of the motors can be reduced.

The results of comparing power consumption with and without the implementation of the above measures are shown in the table below. The effect of reducing power consumption by implementing these measures was approximately 1%.

Table 4.4.5 The Effect of Reducing Power Consumption

Item	Unit	Before	After
Power consumption	kWh/day	61,868	61,300
	kWh/year	22,581,864	22,274,330

Source: JICA Survey Team

(c) Emission Reduction of Greenhouse Gas

According to Appendix 3 of JICA Climate-FIV Ver.5.0, the CO_2 emission factor of the grid electricity in Bangladesh is 0.412 t-CO_2/MWh. The reduction in power consumption by implementing the measures in the project is 208 MWh/year; therefore, the emission reduction of CO_2 is 86 t-CO_2/year.

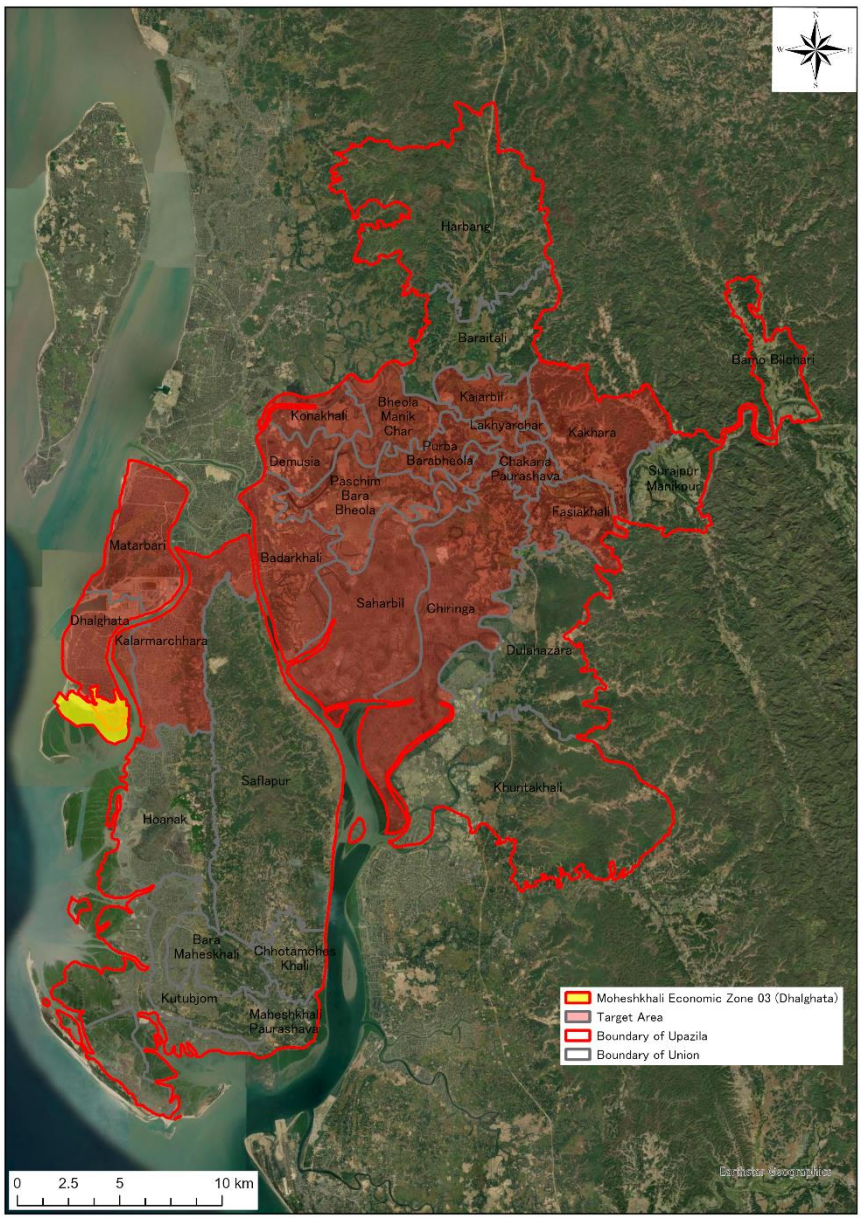
CHAPTER 5 BASIC PLAN OF WATER SUPPLY PROJECT

In this preparatory survey, after completing the examinations in Sections 5.1 to 5.3, the scope was reduced as described in Section 5.4, taking into consideration the project cost and the efficiency of the piped water supply. The descriptions in Chapter 6 and after are based on the scope described in Section 5.4.

5.1 Basic Water Supply Plan

5.1.1 Water Supply Target Area

The water supply target area is composed of Moheshkhali Economic Zone (Dhalghata) and the priority areas in Moheshkhali and Chakaria upazilas, as shown below.



Source: JICA Survey Team

Figure 5.1.1 Water Supply Target Area

Moheshkhali Economic Zone (Dhalghata) was selected for industrial water supply from the areas where land acquisition by BEZA has been completed and development plans have been already formulated, and the priority areas were selected for domestic water supply from the areas along the water transmission pipeline in order to increase the water supply efficiency.

5.1.2 Water Demand Forecast Conditions

The following conditions were decided to conduct future water demand forecasts for the water supply target areas:

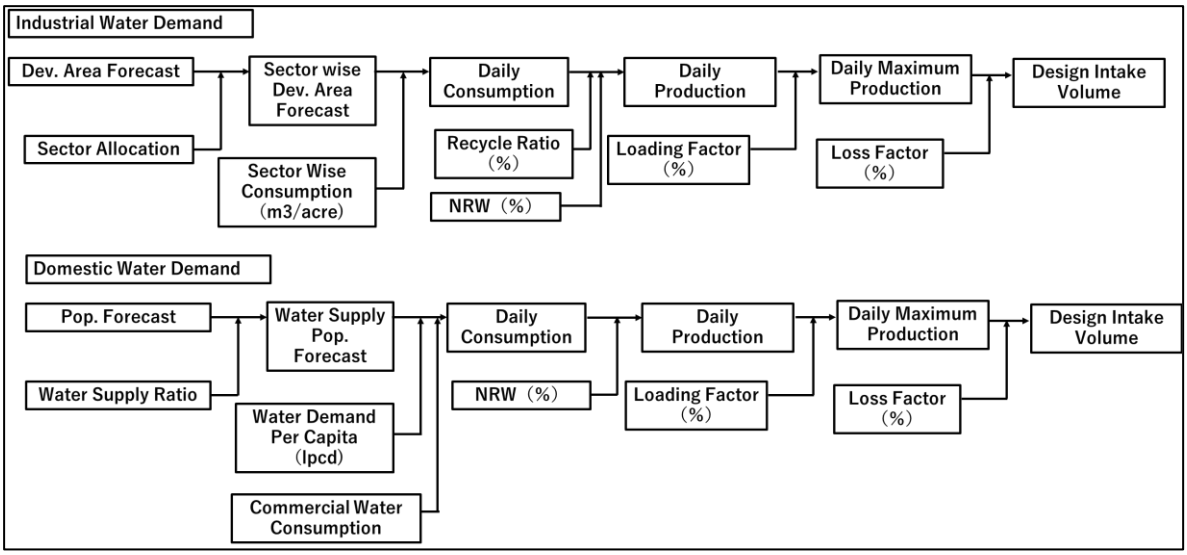
(1) Target Year

The target year was set at 2041,in order to align with the Perspective Plan 2041, the long-term development plan in Bangladesh.

(2) Calculation Flow

The calculation flow for industrial and domestic water demands and the definitions of terms related to water demands are shown below.

It should be noted that the figures calculated in this section (such as Design Intake Volume, etc.) are used to set the specifications of each facility, and do not directly indicate the size of the facility.



Source: JICA Survey Team

Figure 5.1.2 Calculation Flow for Industrial and Domestic Water Demands

Table 5.1.1 Definitions of Terms Related to Water Demand

Item	Contents	Target Facility Design
Daily Consumption	Area-wise Water Consumption×Development Area, Water Demand Per Capita×Population	-
Daily Production	Daily Consumption / (1-NRW) Daily Consumption plus the impact of non-revenue water	-

Item	Contents	Target Facility Design
	(water distribution system losses such as leaks, theft, meter insensitivity, etc.)	
Daily Maximum Production	Daily Production / Loading Factor Daily Production plus loading factor (city size, weather, drought, and other changes in water use)	Water Treatment Plant Transmission Pipe and Pump
Design Intake Volume	Daily Maximum Production×（1＋Loss Factor） Daily Maximum Production plus the effect of the safety factor (Losses in the water treatment process, leakage from intake to WTP, evaporation in the reservoir, etc.)	Intake Facility
Design Intake Volume Without Loading Factor	Design Intake Volume × Loading Factor Design Intake Volume minus the effect of loading factor considering the condition that the raw water reservoir always has enough water to absorb the fluctuations.	Raw Water Reservoir

Source: JICA Survey Team

(3) Basic Conditions for Industrial Water Demand Projection

- Development Area Forecast

The development area forecast is based on the Base Case of the "Feasibility Study of Infrastructure Development (Gas, Electricity and Communication) at Moheshkhali Economic Zone (Dhalghata), March 2022, BEZA" (hereinafter referred to as "BEZA FS 2022").

Table 5.1.2 Development Area Forecast for Moheshkhali Economic Zone (Dhalghata)

Years		2026	2027	2028	2029	2030	2035	2040	2045
Base Case	acre	166	238	394	565	676	802	802	802
	ha	67	96	160	229	274	325	325	325

Source: BEZA FS 2022, Infrastructure Investment Facilitation Company, March 2022.

- Sector Allocation

Sector allocation is based on BEZA FS 2022 as shown below. The domestic and industrial water will be treated to the same potable water quality in the Project based on request from BEZA. Therefore, No.8 Non-processing Area (employee housing, administrative building, training facilities, etc.) is accounted as industrial water demand to be supplied in the same system as industrial water.

Table 5.1.3 Sector Allocation for Moheshkhali Economic Zone (Dhalghata)

No.	Industry	Allocation (%)
1	Oil Refinery and Petrochemicals	43%
2	Marine Fish Processing	4%
3	Ship Building and Repairing	2%
4	Steel Manufacturing/Steel Rerolling	2%
5	Logistics Hub/Gas Bottling	11%
6	Automobile and Heavy Eng.	4%
7	Miscellaneous	4%
8	Non-processing Area (Residential, Admin., Commercial, others)	30%
	Total	100.0%

Source: BEZA FS 2022, Infrastructure Investment Facilitation Company, March 2022.

The water quality required as industrial water varies widely by purpose of use, industrial type, and business establishment, and the composition of industrial type is usually not constant. Therefore, in the Project, based on the BEZA requirements, industrial water is uniformly subject to potable water quality standards. This point was discussed with the Bangladeshi side at the Technical Working Group meeting held in February 2024, and a consensus was reached.

Of the industrial zone area, it was confirmed by BEZA that SPL Petrochemical Complex Ltd. under TK Group has 410 acres and Samuda Chemical Complex Ltd. under TK Group has 100 acres under lease as of 2018. In addition, Pacific Gas Bangladesh Ltd. under Siam Group may sign a lease for 260 acres in the future, and that the industrial sector structure will be developed according to the above sector allocation.

It has been confirmed that TK Group, which will develop approximately 70% of industrial park, intends to develop the industrial park in accordance with the BEZA FS 2022 by constructing plants for its conglomerate member companies.

BEZA FS 2022 is not legally binding, then there is a possibility that the policy of the industrial park development plan will be changed if industrial trends change in the future. However, since it is unlikely that the assumed ratio of 30% for Non-processing Area (Residential, Admin., Commercial, others) will change significantly, and the assumed ratio of 43% for oil refinery and petrochemicals plants, which is in line with the TK Group's intention, has already been included, it is considered unlikely that a significant change from this planned ratio will occur at this time.

- Sector-wise Consumption

Sector-wise consumption was mainly based on “Detailed Study on Total Water Demand and Water Availability Assessment for Bangabandhu Sheikh Mujib Shilpanagar (hereinafter referred to as “DS for BSMSN”)”.

Table 5.1.4 Sector-wise Consumption for Moheshkhali Economic Zone (Dhalghata)

Industry		Water Consumption (m^3/acre/day)	Water Consumption (m^3/ha/day)	Note
1	Oil Refinery and Petrochemicals	283	700	Chemical & Other Products by DS for BSMSN
2	Marine Fish Processing	62	154	Marine Fish Processing by BEZA FS 2022
3	Ship Building and Repairing	23	56	Automobile Assembly by DS for BSMSN
4	Steel Manufacturing/Steel Rerolling	283	700	Chemical & Other Products by DS for BSMSN
5	Logistics Hub/Gas Bottling	8	20	Warehouse Zone by DS for BSMSN

Industry		Water Consumption (m^3/acre/day)	Water Consumption (m^3/ha/day)	Note
6	Automobile and Heavy Eng.	23	56	Automobile Assembly by DS for BSMSN
7	Miscellaneous	7	18	Other Parts and Machine by DS for BSMSN
8	Non-processing Area (Residential, Admin., Commercial, others)	40	100	Resident/Housing by DS for BSMSN

Source: BEZA FS 2022, Infrastructure Investment Facilitation Company, March 2022
DS for BSMSN, Institute of Water Modeling, Feb. 2020

In order to verify the validity of the above figures, the actual data for each industry sector wise consumption was examined but were unable to identify any organized and approved actual data published in Bangladesh.

Therefore, referrable water consumption of each industry was calculated based on the actual data of daily water consumption and total area listed in the "Statistical Table by Industry" published by Ministry of Economy, Trade and Industry in Japan.

Industry		Daily Water Consumption (m^3/day)	Total Area (ha)	Water Consumption (m^3/ha/day)	Note
1	Oil Refinery and Petrochemicals	352,391	975	361	1631_Basic petrochemical manufacturing
2	Marine Fish Processing	10,087	110	92	0925_Frozen seafood products manufacturing
3	Ship Building and Repairing	37,866	2,125	18	3131_Ship Building and Repairing
4	Steel Manufacturing/Steel Rerolling	17,563	61	288	2255_Forged Steel Manufacturing Industry
5	Logistics Hub/Gas Bottling	3,945	618	6	2533_Logistics and transportation equipment manufacturing
6	Automobile and Heavy Eng.	605,275	18,045	34	3100_Manufacture of transportation machinery and equipment
7	Miscellaneous	7,579	492	15	3299_Other Industry
8	Non-processing Area (Residential, Admin., Commercial, others)	-	-	-	

Source: Statistical Table by Industry, August 2021, Ministry of Economy, Trade and Industry in Japan
Note: Recycle water is not included in Daily Water Consumption.

The calculation results show that water consumption in Japan, where industrial integration and water conservation measures are underway, is lower than the water consumption described in DS for BSMSN, but generally close to them. Therefore, it was deemed appropriate to use DS for BSMSN water consumption, which is actually used for water demand forecasting in industrial parks in Bangladesh, in this project.

Water consumption value of Oil Refinery and Petrochemical is low compared to the actual value in Japan. This can be attributed to Japan's highly optimized instrumentation and control systems and mechanical and electrical plant operations that achieve efficient water use.

Since a certain amount of leeway is on the safe side for the planned values for plant construction and operation in Bangladesh, the adoption of BEZA's planned values was judged to be appropriate.

In addition, industrial water consumption data by industrial sector for neighbouring countries India and Thailand were investigated, but organized and approved official data were not available.

- Water Supply Connection Ratio

The water supply connection ratio for industrial water was assumed to be 100% because industrial water is basically supplied to all factories established in the new industrial zone.

- Non-revenue Water Ratio

Non-revenue water ratio for industrial water was set at 15% based on DS for BSMSBN.

In the Project, since domestic water is supplied to residents in the extensive Chakaria-Moheshkhali area and industrial water is supplied to companies in the relatively narrow Moheshkhali Economic Zone (Dhalghata), different values of non-revenue water ratio (leakage, theft, metering error, etc.) are set for each.

- Loading Factor

The loading factor is calculated by dividing the average daily water supply by the maximum daily water supply. The loading factor for industrial water was set at 87% based on DS for BSMSN.

In the Project, since domestic water is supplied to residents in the extensive Chakaria-Moheshkhali area and industrial water is supplied to companies in the relatively narrow Moheshkhali Economic Zone (Dhalghata), different values of loading factor (daily average/daily maximum) are set for each.

- Loss Factor

Loss factor is for the leakage from the intake point to the water treatment plant, water volume used for the water treatment process, evaporation, etc.

Since it was not stipulated in the Bangladesh National Building Code, the loss factor for industrial water was set at 10% based on the Japan Water Supply Facility Design Standard 2012.

- Recycle Ratio

The recycle ratio for industrial water was set at 50% based on Bangabandhu Sheikh Mujib Shilpanagar Master Plan (BEZA, 2020).

The recycling ratio of industrial water is expected to fluctuate depending on the business type of the occupying company and the status of the recycling facilities.

According to the data on recycle ratio by the industry sector compiled the by Ministry of Land, Infrastructure, Transport and Tourism of Japan, the petrochemical sector, which is expected to account for the majority of Moheshkhali Economic Zone (Dhalghata), is an active sector in terms of recycling and utilization, with the recycle ratio increasing from 50% in 1965 to over 80 % by 1980.

Therefore, it is reasonable to apply the planned value of 50% set in the BSMSN near Chattogram to this water supply plan as well.

(4) Basic Conditions for Domestic Water Demand Projection

- Population Projection

The population as of 2022 was referenced from the data provided by Chakaria and Moheshkhali upazila offices. The population growth ratio of each union was set for the upazilas listed in the Population Projection of Bangladesh Dynamics and Trends 2011-2061 (Bangladesh Bureau of Statistics, 2015).

It was confirmed that the method used to calculate the population projection for Bangladesh is the Cohort Factor Method, which projects the future population based on population variables such as births, deaths, and migration, etc. The Cohort Factor Method is considered the standard method for official future population projection, and is widely used for population projection for the UN and Japan, etc. Therefore, the population projection in Bangladesh established by this method is considered to be a valid figure.

Based on these data on current population and population growth ratio, future population projections to 2041 were conducted for each target union of the Project. The summary of population projection is shown as below...

Table 5.1.5 Population Projection in All Area

				Census Data	Projection					
District	**Upazila**	**Union**		**2022**	**2023**	**2024**	**2025**	**2030**	**2035**	**2041**
Cox's Bazar	Chakaria	**no.**	**Total**	**571,241**	**591,168**	**611,789**	**633,130**	**694,923**	**744,590**	**805,281**
		1	Chakaria Pourashava	94,398	97,691	101,099	104,625	114,837	123,044	133,073
		2	Badarkali	36,715	37,996	39,321	40,693	44,664	47,857	51,757
		3	Bamo Bilchari	10,176	10,531	10,898	11,278	12,379	13,264	14,345
		4	Bataraitali	38,837	40,192	41,594	43,045	47,246	50,623	54,749
		5	Bheola Manik Char	24,800	25,665	26,560	27,487	30,170	32,326	34,961
		6	Chringa	19,921	20,616	21,335	22,079	24,234	25,966	28,083
		7	Demusia	13,397	13,864	14,348	14,848	16,298	17,462	18,886
		8	Deulahazara	53,612	55,482	57,418	59,420	65,220	69,881	75,577
		9	Purba Barabheola	31,823	32,933	34,082	35,271	38,713	41,480	44,861
		10	Faiakhali	34,391	35,591	36,832	38,117	41,837	44,827	48,481
		11	Harbang	40,820	42,244	43,718	45,243	49,658	53,207	57,544
		12	Kakhara	29,825	30,865	31,942	33,056	36,283	38,876	42,044
		13	Kairarbil	22,676	23,467	24,286	25,133	27,586	29,557	31,966
		14	Khuntakhali	38,730	40,081	41,479	42,926	47,116	50,483	54,598
		15	Konakhali	22,770	23,564	24,386	25,237	27,700	29,680	32,099
		16	Lakhyarchar	8,974	9,287	9,611	9,946	10,917	11,697	12,651
		17	Saharbil	24,480	25,334	26,218	27,132	29,780	31,909	34,510
		18	Surajpur Namikpur	14,164	14,658	15,169	15,699	17,231	18,462	19,967
		19	Paschim Bara Behola	10,732	11,106	11,494	11,895	13,056	13,989	15,129
Cox's Bazar	Moheshkhali	**no.**	**Total**	**385,507**	**398,722**	**412,390**	**426,527**	**467,410**	**500,223**	**540,267**
		1	Maheshkhali Paurashava	29,372	30,379	31,420	32,497	35,612	38,112	41,163
		2	Bara Maheskhali	56,850	58,799	60,814	62,899	68,928	73,767	79,672
		3	Choto Moheshkali	31,351	32,426	33,537	34,687	38,012	40,680	43,937
		4	Dhalgata	11,361	11,750	12,153	12,570	13,775	14,742	15,922
		5	Hoanak	61,499	63,607	65,788	68,043	74,565	79,799	86,188
		6	Kalarmarchhara	62,611	64,757	66,977	69,273	75,913	81,242	87,746
		7	Kutubjom	37,324	38,603	39,927	41,295	45,254	48,431	52,308
		8	Matabari	52,746	54,554	56,424	58,358	63,952	68,442	73,921
		9	Saflapur	42,393	43,846	45,349	46,904	51,400	55,008	59,411
Grand Total				**956,748**	**989,890**	**1,024,180**	**1,059,657**	**1,162,333**	**1,244,813**	**1,345,548**

Source: JICA Survey Team

- Water Supply Connection Ratio

The water supply connection ratio for domestic water is estimated at 80%, assuming some remote villages where it is difficult to install pipelines. A water supply connection ratio of 80% is also the value set for the Chittagong Water Supply Improvement Project (JICA, March 2013).

It was determined that the value of 80% was appropriate because it is consistent with the national average water supply rate of 75% and the CWASA water supply rate of 81% as stated in the Benchmarking to Improve Urban Water Supply Delivery in Bangladesh (WSP, 2014).

The rationale for setting this figure was explained to the DPHE, which confirmed that it was reasonable.

- Water Demand Per Capita

The water demand per capita in pourashavas was set at 120 Lpcd based on the DPHE practice value of pourashava shown in the Comprehensive Technical Guideline for Rural and Pourashava Water Supply (DPHE/JICA, 2021). This figure is considered reasonable since it does not deviate significantly from the nearby CWASA practice value of 125 Lpcd as stated in Benchmarking to Improve Urban Water Supply Delivery in Bangladesh (WSP, 2014).

In addition, the water demand per capita in unions was set at 62 Lpcd based on the sample survey result from representative unions (IWA Journal of Water and Health, 2006). This figure is considered reasonable since it does not deviate significantly from the average value of 59-68 Lpcd for the utilities which have been serving less than 1 million residents, as stated in the Benchmarking to Improve Urban Water Supply Delivery in Bangladesh (WSP, 2014).

- Commercial Water Consumption outside Economic Zone

The commercial water consumption outside economic zone (offices, government buildings, schools, hospitals, hotels, etc.) was projected as a percentage of household water consumption. The percentage value was set at 15% with reference to the planned value adopted in the Chattogram area, which has relatively similar climatic and geographical conditions.

- Non-revenue Water Ratio

The non-revenue water ratio for domestic water was set at 28% based on the country average value in the Benchmarking to Improve Urban Water Supply Delivery in Bangladesh (World Bank, 2014).

- Loading Factor

Since it was not stipulated in the Bangladesh National Building Code, the loading factor for domestic water was set at 80% based on the Japan Water Supply Facility Design Standard 2012.

- Loss Factor

Loss factor is for the leakage from the intake point to the water treatment plant, water volume used for the water treatment process, evaporation, etc.

Since it was not stipulated in the Bangladesh National Building Code, the loss factor of domestic water was set at 10% based on the Japan Water Supply Facility Design Standard 2012.

5.1.3 Water Demand Forecast Result

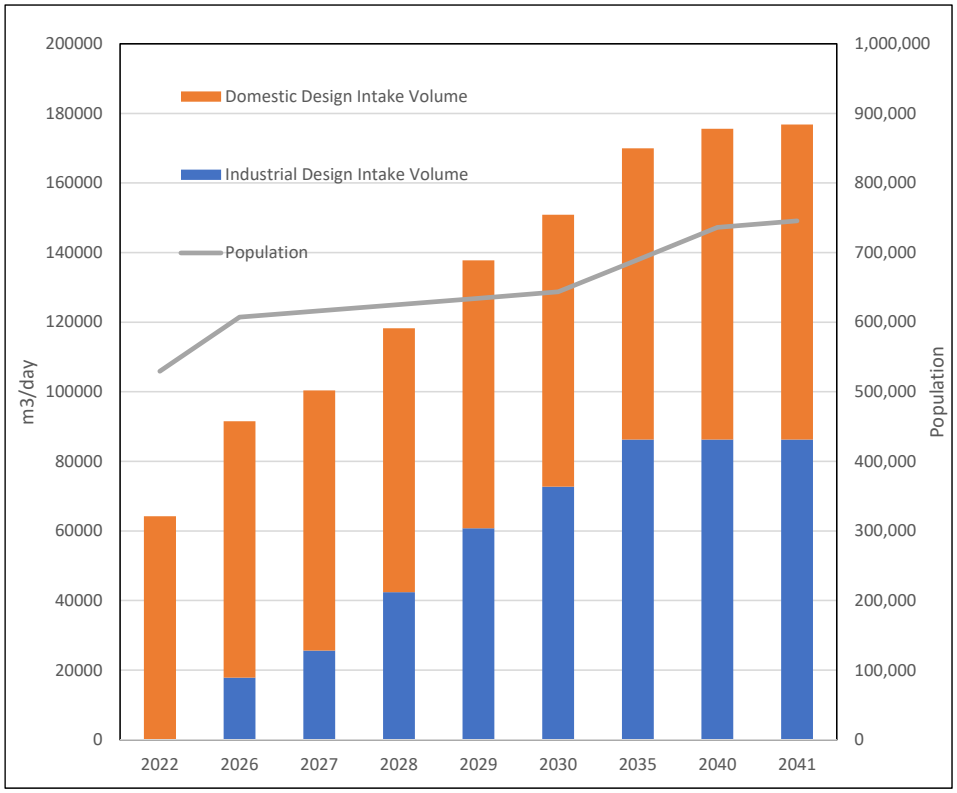
The water demand forecast result is shown in Table 5.1.6 and Figure 5.1.3 below. The total design intake volume is 176.8 MLD, of which 86.3 MLD is industrial water and 90.5 MLD is domestic water in 2041. Also, daily maximum production is 160,692 m^3/day and water supply population are 706,089 in 2041.

Table 5.1.6 Water Demand Forecast Result in All Area

(m3/day)

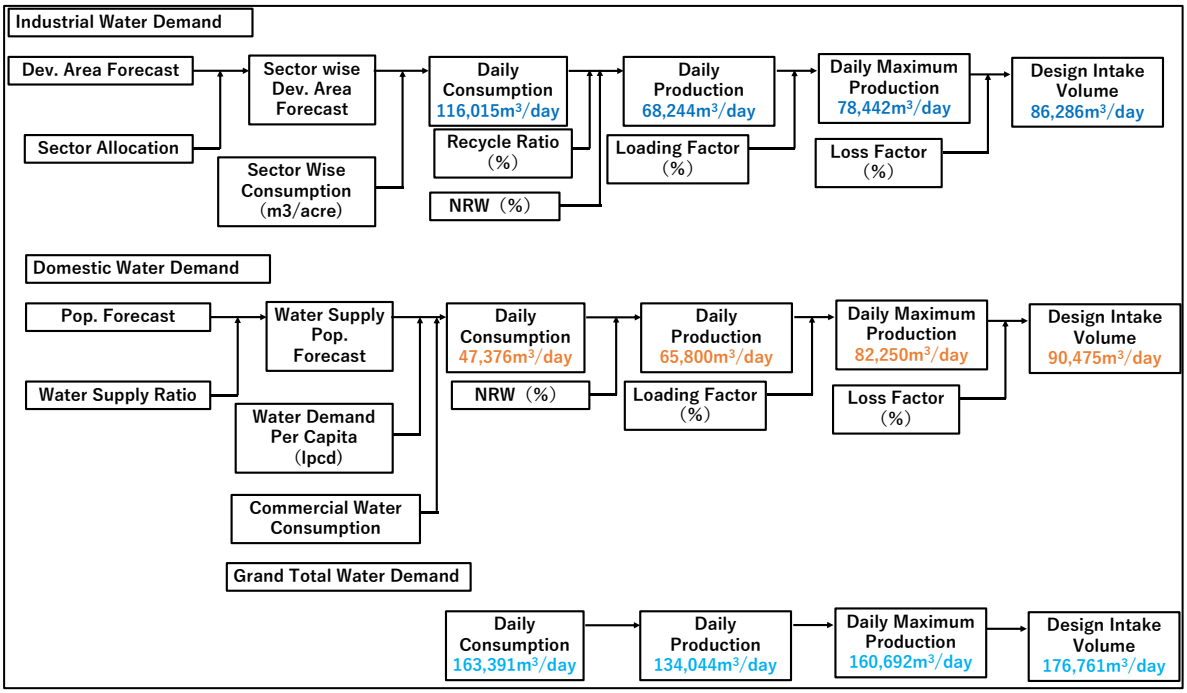
Industrial Design Intake Volume				**2022**	**2035**	**2041**
			Total Design Intake Volume	**0**	**86,286**	**86,286**
Domestic Design Intake Volume				**2022**	**2035**	**2041**
District	**Upazila**	**Union**				
Cox's Bazar	Chakaria		**Sub Total**	**50,458**	**65,770**	**71,130**
		1	Chakaria Pourashava	19,902	25,942	28,056
		2	Badarkali	3,999	5,213	5,638
		3	Bamo Bilchari			
		4	Bataraitali			
		5	Bheola Manik Char	2,701	3,521	3,808
		6	Chringa	2,170	2,829	3,059
		7	Demusia	1,459	1,902	2,057
		8	Deulahazara			
		9	Purba Barabheola	3,466	4,518	4,887
		10	Faiakhali	3,746	4,883	5,281
		11	Harbang			
		12	Kakhara	3,249	4,235	4,580
		13	Kairarbil	2,470	3,220	3,482
		14	Khuntakhali			
		15	Konakhali	2,480	3,233	3,497
		16	Lakhyarchar	978	1,274	1,378
		17	Saharbil	2,667	3,476	3,759
		18	Surajpur Namikpur			
		19	Paschim Bara Behola	1,169	1,524	1,648
Cox's Bazar	Moheshkhali		**Sub Total**	**13,803**	**17,911**	**19,345**
		1	Maheshkhali Paurashava			
		2	Bara Maheskhali			
		3	Chhotamohes Khali			
		4	Dhalgata	1,238	1,606	1,734
		5	Hoanak			
		6	Kalarmarchhara	6,820	8,850	9,558
		7	Kutubjom			
		8	Matabari	5,746	7,455	8,052
			Total Design Intake Volume	**64,261**	**83,681**	**90,475**
			Grand Total Design Intake Volume	**64,261**	**169,967**	**176,761**
			Daily Maximum Production	58,419	154,515	160,692
			Daily Production	46,735	129,103	134,044
			Daily Consumption	33,649	159,834	163,391
			Water Supply Population (person)	501,620	653,096	706,089

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5.1.3 Water Demand Forecast Result



Source: JICA Survey Team

Figure 5.1.4 Calculation Flow for Industrial and Domestic Water Demands with Water Demand Forecast Result

5.2 Basic River Water Intake Plan

5.2.1 Basic Layout Plan of Water Supply Project in Previous Study

In the previous study, water potential and water resources development study were carried out, targeting the wider areas of the Karnafuli River basin, Sangu River basin, and Matamuhuri River basin, which are situated in Chattogram Division. In this previous study, the water source for the Matarbari and Moheshkhali areas was proposed through the following consideration and procedures:

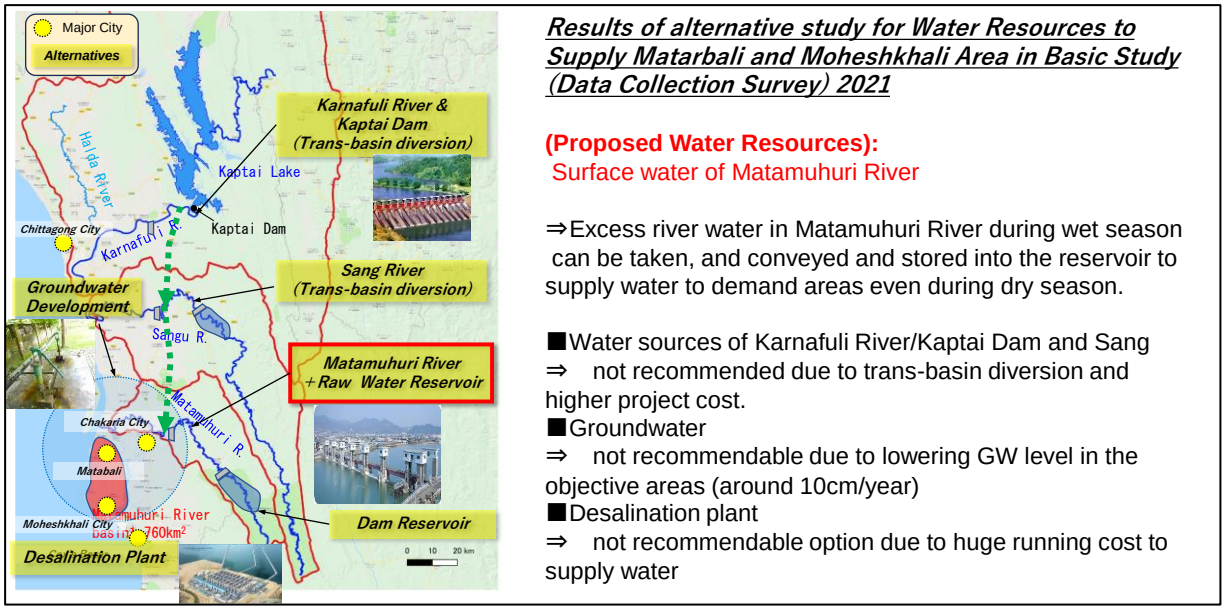
i) As for the basic water source for the Matarbari and Moheshkhali areas, groundwater and seawater desalination cannot be applied since the groundwater will not be suitable for sustainable use due to the groundwater level lowering in the areas, and the desalination of seawater was not assessed as an economical option from the viewpoint of lifecycle cost due to higher operation and maintenance costs. Surface water can be utilized as the main water source since the surface water potential in the surrounding area is abundant.

ii) As a result of the comparative study on surface water resources of the Karnafuli River (Kaptai Dam), the Sangu River, and the Matamuhuri River, including the zero option (without project), the water resources development of the Matamuhuri River was adopted.

iii) For the water resources development in the Matamuhuri River, alternative options of facility plan to satisfy the required water demands were studied: the options prepared by combinations of intake only, new dam, and reservoir were compared with each other and the option of "intake and reservoir" was adopted for the water resources development.

iv) The layout plan of major water supply facilities, such as intake and reservoir, including water conveyance/supply pipelines, was preliminary studied as well as operation methods of the intake and reservoir.

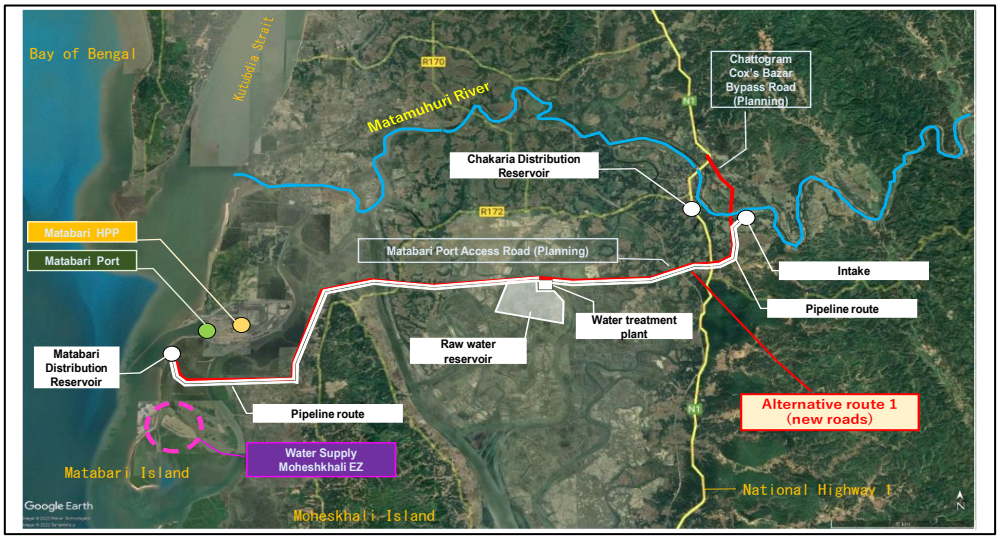
v) As a result of the previous study on water resources development for the Matarbari and Moheshkhali areas, as mentioned above, alternative water sources of surface water, groundwater and seawater were compared and examined among the Matamuhuri River, the Sangu River, and the Karnafuli River basins, and finally it was proposed to use the Matamuhuri River water in the rainy season as the surface water source. Furthermore, the preliminary plan of the water resources development in the Matamuhuri River basin was carried out with reference to regional development, the new Matarbari Port Access Road, the railway route, etc., as shown in Figure 5.2.1 below.



Source: JICA Survey Team

Figure 5.2.1 Alternative Study of Water Resources in Southern Chattogram Region in the Previous Study

The layout plan of the water supply project in the Matarbari-Moheshkhali areas using the Matamuhuri River water as the water source proposed in the previous study is shown in Figure 5.2.2 and the box below.



Source: JICA Survey Team

Figure 5.2.2 Layout Plan of Water Supply Project in the Previous Study

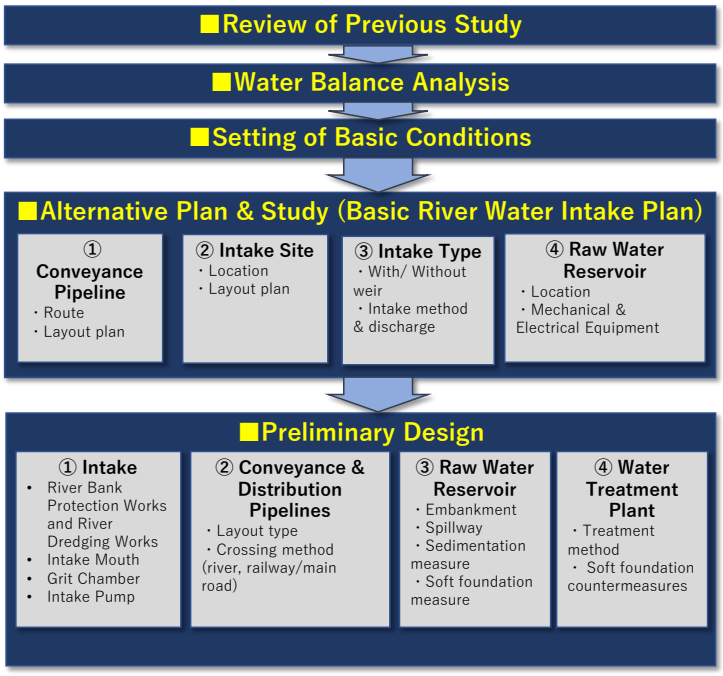
Basic Structures of Water Supply Project in Previous Study

- (1) Intake and intake pump (Qmax: 4.7 m^3/s)
- (2) Water conveyance pipeline (L: 11.0 km, Q: 4.7 m^3/s)
- (3) Raw water reservoir (V: 16 MCM, D: 5.0 m, A: 3.2 km^2)
- (4) Water treatment plant (Q: 1.7 m^3/s)
- (5) Water transmission pipeline to Matarbari and Moheshkhali (L: 20 km, Q: 1.3 m^3/s)
- (6) Water transmission pipeline to Chakaria (L: 10.0 km, Q: 0.4 m^3/s)
- (7) Water distribution reservoirs (in demand areas)

5.2.2 Procedure of Alternative Study

For the preliminary design of the Preparatory Survey, the findings from the previous study were reviewed, and alternatives are studied in order to determine the facility layout as well as its scale, and then the topographic survey and geological investigations necessary for the preliminary design are carried out.

The procedure of the alternative study is shown in Figure 5.2.3



Source: JICA Survey Team

Figure 5.2.3 Procedure of Alternative Study

Based on the latest information obtained from the survey of natural conditions, the optimization of the scale and layout plan of the water intake facilities is done by carrying out the following activities: forecasting water demand, updating the water balance, and setting the basic conditions (hydraulic conditions, ground conditions, planned water demand, etc.).

In addition, land acquisition and resettlement will be necessary for the construction of the water intake facilities, waterways, reservoir, and water treatment plant. In particular, the construction of the reservoir has been planned in a large-scale salt field and fish farming area (government-owned land). Hence, it is necessary to provide the compensation for the users of the salt field/fish farming area and livelihood

support for the affected residents. In the alternative plans, the layout plan is proposed with measures for reduction and alleviation of negative impacts in consideration of the social and environmental impacts.

5.2.3 Water Balance Analysis

(1) Purpose of Water Balance Analysis

The purpose of water balance analysis is to decide the required reservoir volume and maximum intake pump capacity for supplying domestic and industrial water demands in the target areas.

(2) Primary Rules of Water Balance Analysis Model

1) Priority of water supply for water demands is as follows:
   Maintenance Flow ⇒ Domestic Water ⇒ Industrial Water ⇒ Agricultural Water
   Under the Water Act 2013, irrigation water use is higher priority than industrial water use. The target area has been developed as an industrial zone under Bangladeshi policy, and securing industrial water has a higher priority than irrigation water use, so industrial water was prioritized. Additionally, securing maintenance flow was given top priority from the perspective of sustainable development (SDGs).
2) The water level in the storage structure should be managed within the range of the surplus water available in the Matamuhuri River so as not to disturb the water supply for the existing demands.
3) The operation of the storage structure is to be conducted basically so as to recover its full capacity at least once in the rainy season.

(3) Analysis Conditions

The analysis conditions are shown in Table 5.2.1.

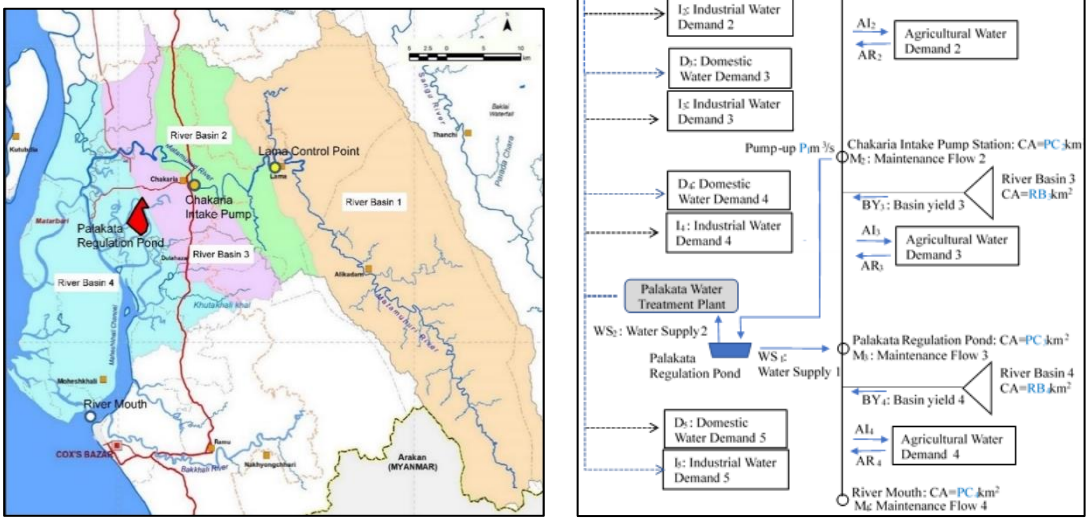
Table 5.2.1 Conditions of Water Balance Analysis

Item		Setting Condition
Basic Conditions	Data Period	1966.11－2022.10（56 years）
	Target Year	2041
	Target River Basin	Matamuhuri River basin
	Control Point of Water Utilization	Lama Control Point
	Development Structure	Palakata Regulation Pond
	Total Design Intake Volume	Estimated Demand of Industrial Water and Domestic Water as of 2041 ・Industrial Water (2041): 86.2 MLD ・Domestic Water (2041): 90.5 MLD※
Model Paramet	Catchment Area of River Basin	River Basin 1: 1,201 km^2 River Basin 2: 289 km^2 River Basin 3: 278 km^2 River Basin 4: 744 km^2

Item		Setting Condition
	Catchment Area at Check Point	Lama Control Point : 1,201 km^2 Chakaria Intake Pump Station : 1,490 km^2 Palakata Regulation Pond : 1,767 km^2 River Mouth Point : 2,511 km^2
	Maintenance Flow	0.8 m^3/s/100 km^2
	Capacity of Chakaria Intake Pump Station	Trial calculation of minimum capacity of Chakaria Intake Pump for keeping full recovery of Palakata Regulation Pond each year

※Note: Include rainfall utilization

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5.2.4 Outline of Water Balance Analysis Model

(4) Analysis Procedure

The analysis procedure is configured by the following two steps:

■STEP 1: Selection of 1/10 drought year

Required reservoir volume is calculated yearly from 1966 to 2023 (49 years except for years with missing data). Then, the year which gives the 4th largest required reservoir volume (49 years/10=4.9 < 4) is selected as 1/10 drought year.

■STEP 2: Optimization of required reservoir volume and maximum water intake capacity

After the selection of 1/10 drought year by STEP 1, the required reservoir volume and maximum water intake are optimized, considering the following conditions:

- Reservoir volume is fully recovered by the end of the year (Oct 31).
- Minimization of construction cost of intake and reservoir
  The costs of these structures are contradictory. If the maximum intake volume becomes small and the cost is reduced, the reservoir volume becomes larger. It is necessary to find the optimum combination of intake volume and reservoir volume by trial calculation.

(5) Analysis Methodology

1) Required reservoir volume

The required reservoir volume was calculated by accumulating the daily shortage amount of supply water to the downstream, considering the intake discharge as shown by following equations:

- $V_{RES}=\max(\sum_{1}^{365} \Delta V_{RES}, 0)$
- $\Delta V_{RES}=Q_I-Q_S$

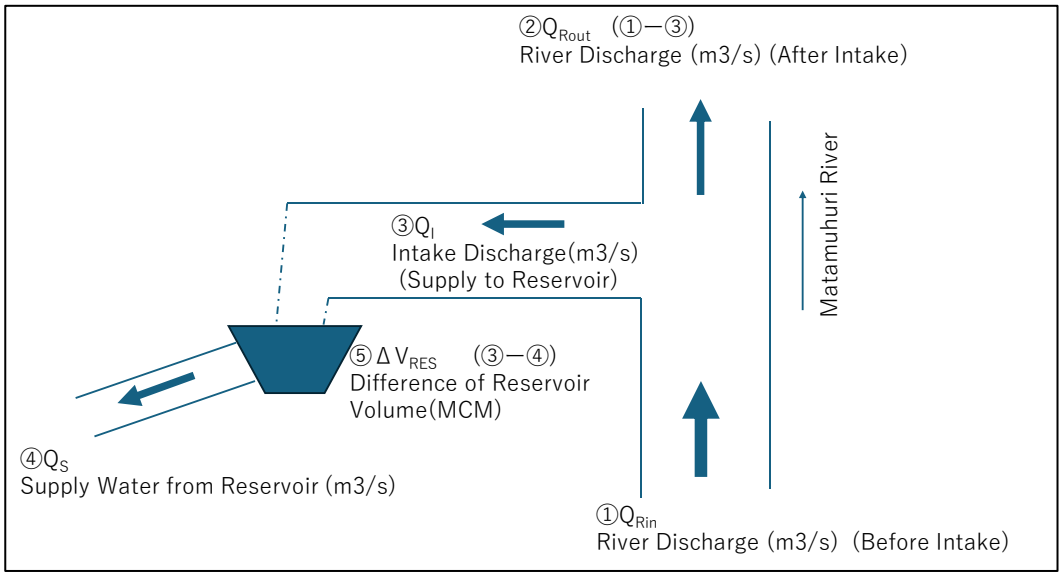
Where.

V_{RES} : Required Reservoir Volume

ΔV_{RES} : Difference of Required Reservoir Volume (⑤ in the following figure)

Q_I : Intake Discharge (③ in the following figure)

Q_S : Supply Water from Reservoir = Water Demand at Downstream (④ in the following figure)



Source: JICA Survey Team

Figure 5.2.5 Outline of Water Balance Calculation

2) Maximum water intake capacity

The maximum water intake capacity is decided by STEP 2 above, considering the recovery of the reservoir volume and minimization of construction costs of intake and reservoir.

(6) Analysis Result

1) Selection of 1/10 drought year (STEP 1)

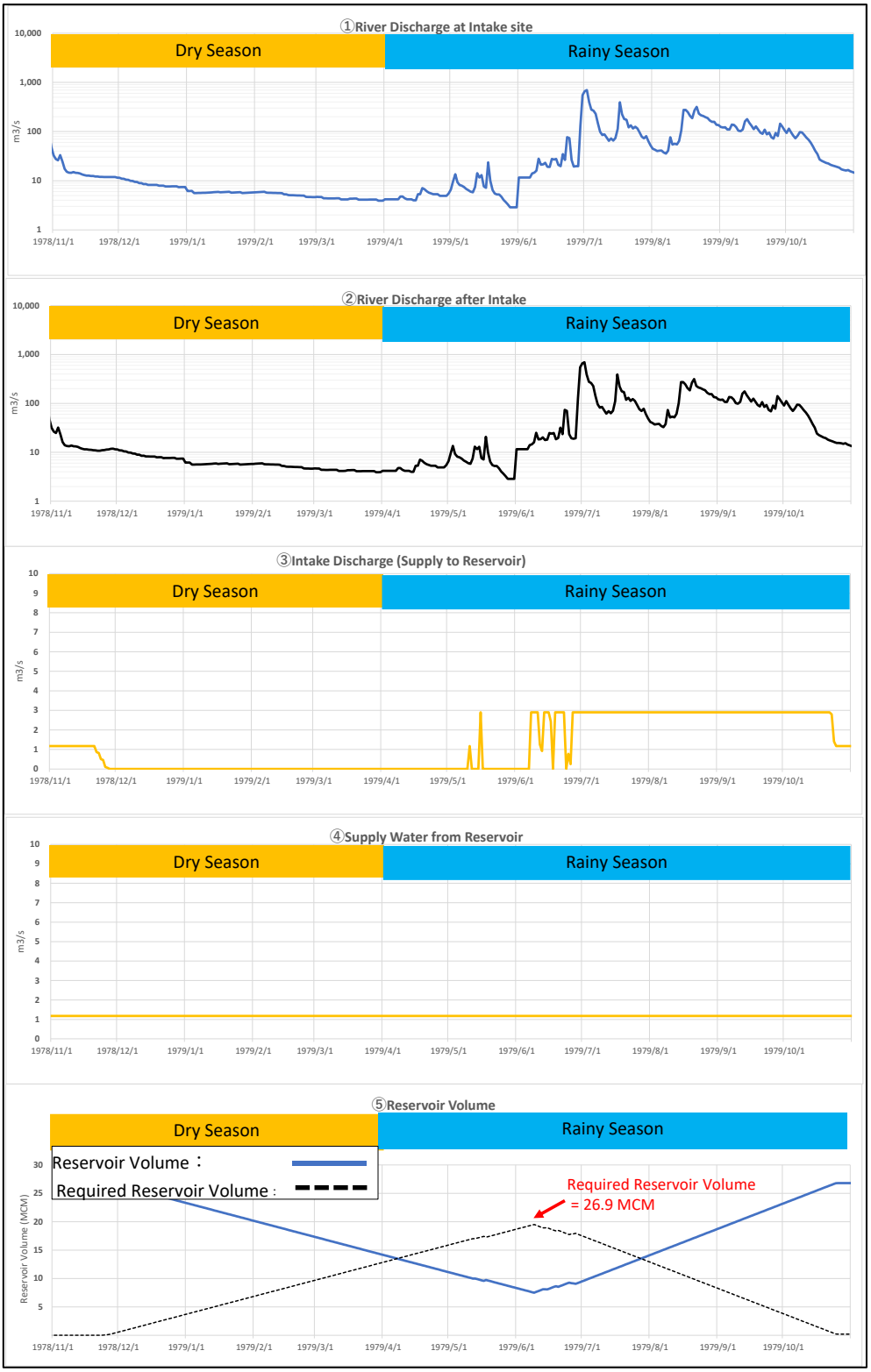
According to the calculation conditions and the methods of (2) and (3) above, the required reservoir volume is calculated. The year for the 4th largest required reservoir volume was 1978 and this is selected as the 1/10 drought year.

Table 5.2.2 Required Reservoir Volume in STEP 1

Year	Rank	Required Reservoir Capacity (MCM)	Year	Rank	Required Reservoir Capacity (MCM)
1966	5	26.8	1994	21	21.1
1967	15	22.5	1995	45	12
1968	26	20.1	1996	38	17.4
1969	24	20.4	1997	36	17.8
1970	-		1998	8	25.9
1971	-		1999	35	17.9
1972	10	24.9	2000	31	18.3
1973	44	13.9	2001	-	
1974	29	19	2002	-	
1975	23	20.6	2003	-	
1976	41	15	2004	-	
1977	9	25.8	2005	7	26.4
1978	4	26.9	2006	-	
1979	14	23	2007	16	22.4
1980	25	20.4	2008	3	27.2
1981	1	31.2	2009	2	28.5
1982	-		2010	27	19.1
1983	30	18.9	2011	32	18.1
1984	12	23.4	2012	19	21.5
1985	6	26.7	2013	11	24.1
1986	17	22.4	2014	13	23.3
1987	42	14.2	2015	46	6.7
1988	40	15.9	2016	46	6.7
1989	34	17.9	2017	43	14
1990	28	19	2018	49	5.7
1991	22	21.1	2019	37	17.5
1992	39	16.8	2020	18	21.6

1993	33	17.9	2021	20	21.4
			2022	48	5.8

Figure 5.2.6 shows the calculation result of the 1/10 drought year (1978) in STEP 1. Each graph (①-⑤) corresponds with Figure 5.2.5, which shows the outline of the water balance calculation. According to the result, the required reservoir volume is 26.9 MCM in STEP 1 (See graph ⑤).



Source: JICA Survey Team

Figure 5.2.6　Calculation Result of 1/10 Drought Year (1978) in STEP 1

2) Optimization of required reservoir volume and maximum water intake capacity (STEP 2)

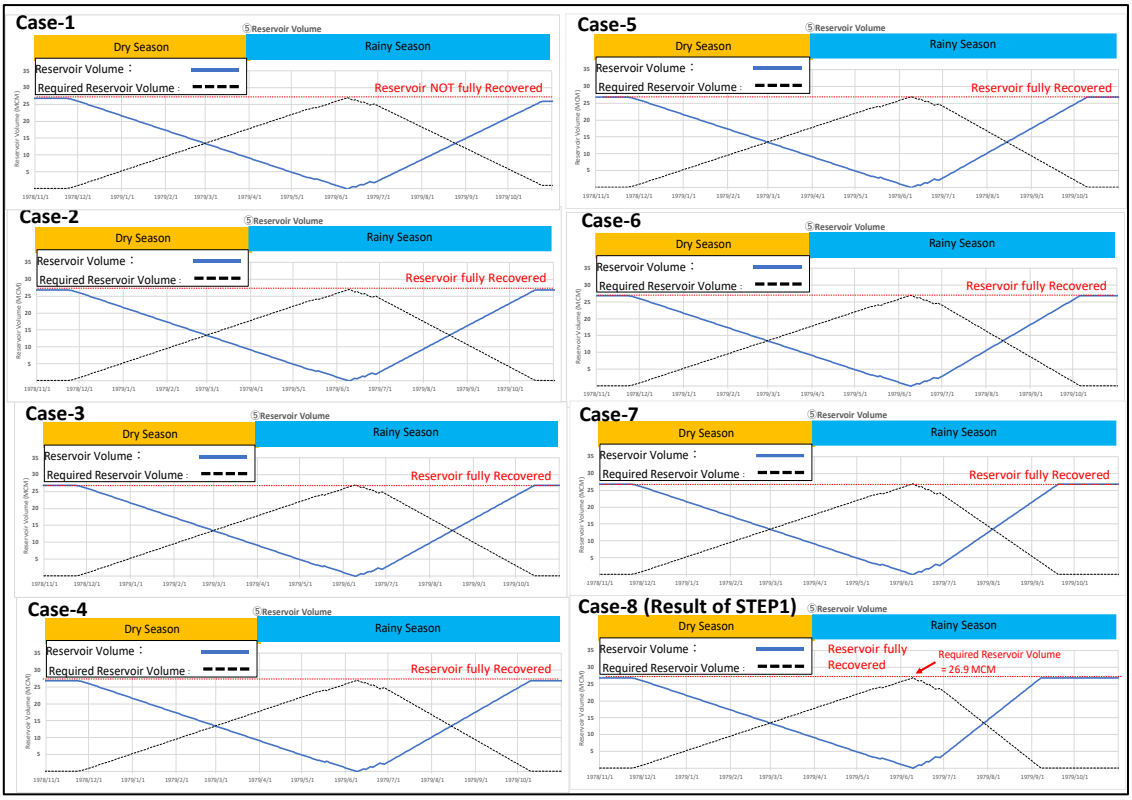
According to the calculation conditions and the method of (2) and (3) above, the optimization of the required reservoir volume and maximum water intake capacity was conducted. Trial cases are shown in Table 5.2.3.

The combination of maximum intake capacity of 4.1 m^3/s and required reservoir volume of 27.0 MCM (Case-2) was selected due to the following reasons:

- The reservoir can be fully recovered by the end of the year (Oct 31).
- Increment of required reservoir volume is only 0.1 MCM (27.0 MCM-26.9 MCM), compared to Case-8 (result of STEP 1), but the maximum capacity of intake facility can be reduced from 5.5 m^3/s to 4.1 m^3/s. It has positive impact on the Project in terms of construction cost reduction.

Table 5.2.3 Trial Case for Optimization of Intake Capacity

Case	Unit	Case-1	**Case-2**	Case-3	Case-4	Case-5	Case-6	Case-7	Case-8
Max Intake Capacity	m^3/s	4.0	**4.1**	4.2	4.3	4.4	4.5	5	5.5
Required Reservoir Volume	MCM	27.0	**27.0**	27.0	27.0	27.0	27.0	27.0	26.9
Recovery of Reservoir Volume	-	×	○	○	○	○	○	○	○
Selection			**Selected**						



Source: JICA Survey Team

Figure 5.2.7 Result of Trial Calculation for Optimization of Intake Facility

5.2.4 Basic Conditions of Alternative Study

(1) Intake volume based on water demand forecast

The designed intake volume based on the water demand in the target year of 2041 is estimated at 176.8 MLD (64.6 MCM), as mentioned in Section 5.1, of which the industrial water is 86.3 MLD (31.5 MCM), and the domestic water is 90.5 MLD (33.0 MCM).

For planning of the raw water reservoir, the loading factor (daily average/daily maximum) considered in the above design intake volume should be deducted (see Table 5,1,1), because the raw water reservoir always stores a constant amount of water, and daily fluctuations need not be considered. As mentioned in 5.2.3 (6), the required reservoir volume is set at 27 MCM.

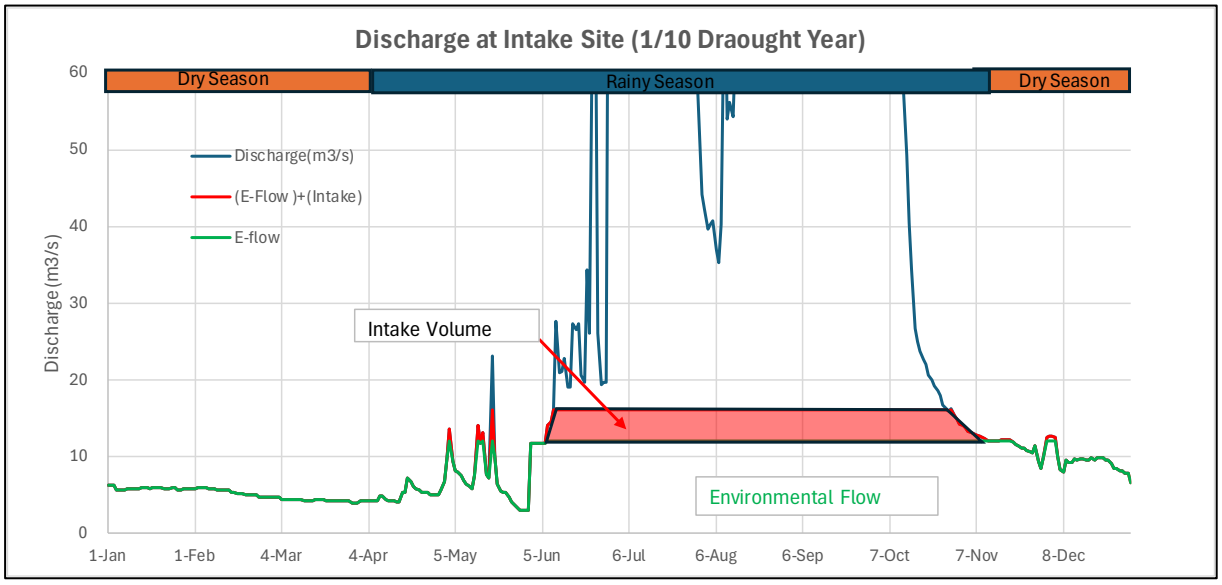
(2) Water balance

The water balance analysis was conducted adopting the daily discharge from 1966 to 2022 and water demand data. The details of the analysis were presented in Section 5.2.3.

The basic operation of the intake is considered as below.

- The intake is basically operated during the rainy season (May – October).
- The maintenance flow (environment flow) at the intake site is estimated at 11.9 m^3/s.
- Water is not to be taken if the river flow is below the maintenance flow. It means that in the case of "River Discharge (Qr) > Environmental Flow (Qe)", a discharge exceeding environmental flow (Qr-Qe) is to be taken from the intake.

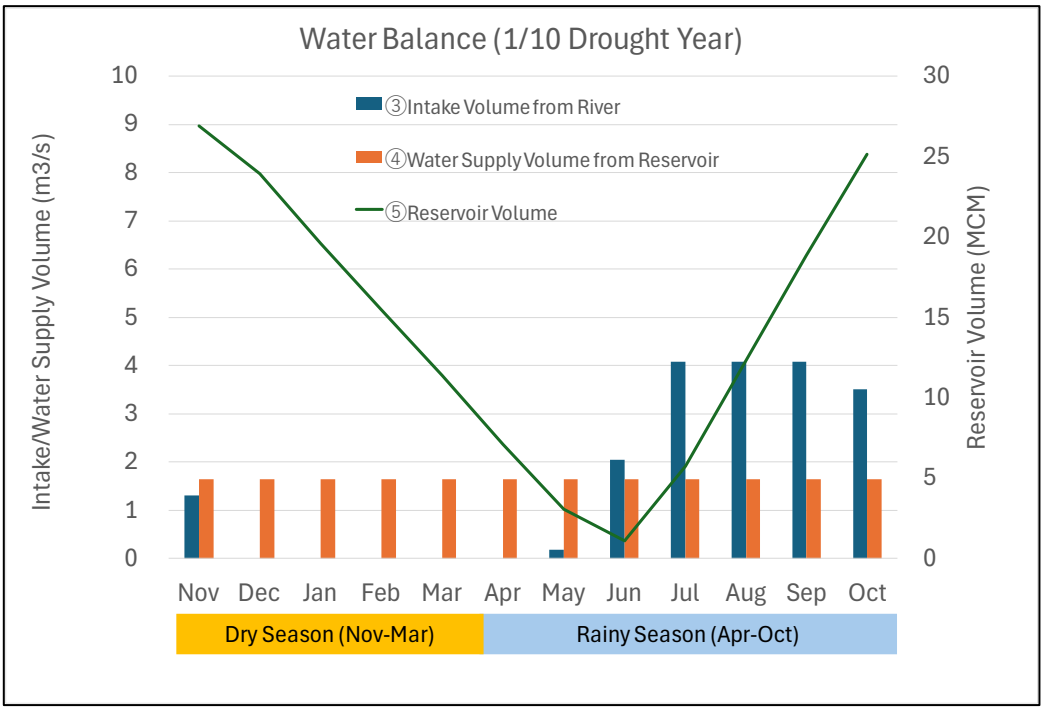
The intake operation in the case of the 1/10 drought year is presented below.



Source: JICA Survey Team

Figure 5.2.8 Intake Operation at Intake Site in Case of the 1/10 Drought Year

The monthly water balance data in the case of the 10-year drought is presented in Figure 5.2.9 below.

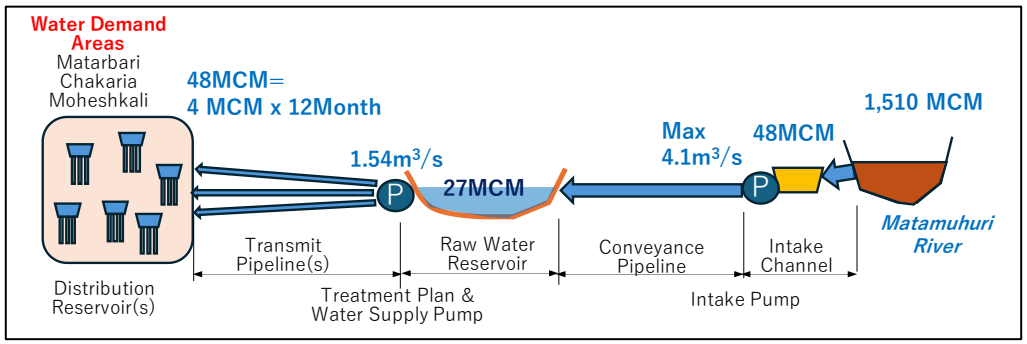


Source: JICA Survey Team

Figure 5.2.9 Monthly Water Balance at Intake Site in Matamuhuri River and Raw Water Reservoir

As mentioned in Section 5.2.3(6), the maximum water intake capacity (discharge) is set at 4.1 m^3/s and the required reservoir volume is set at 27 MCM to satisfy the water demands in the case of 10-year drought.

Water is taken when the river discharge is larger than the maintenance flow. The total annual water intake volume is 48 MCM based on the water demand of 1.54 m^3/s (=4.0 MCM/month = (1.54 x 24 x 3600 x 30) or 48 MCM/year).



Source: JICA Survey Team

Figure 5.2.10 Annual Water Balance in the Water Supply Project

(3) Hydrological and hydraulic conditions

There is no formulated river improvement plan/flood control plan for the Matamuhuri River. At present, the Project for Planning Capacity Enhancement and Establishment of a Technology Adaptation Cycle on Comprehensive Nodi (River) Management (hereinafter called "NODI Project") under the JICA technical assistance is studying the various alternative measures to mitigate flood damages in the Matamuhuri River basin and assisting the BWDB in the preparation of the flood control master plan for the Matamuhuri River.

As for the water intake site, the following hydraulic conditions are applied based on the results of the discussions in the NODI Project:

i) Flood Control Safety Level
   - 50-year return period of flood (RFP)

ii) Design Discharge
   - 4,000 m^3/s at 50-year RPF (case without floodway and retarding basin)

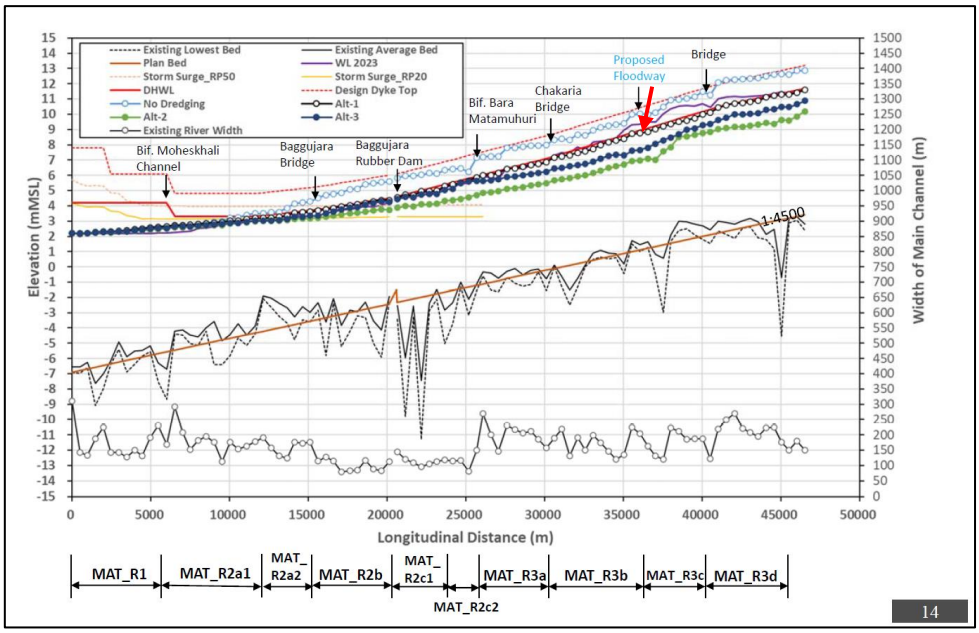
iii) Design Riverbed Level
   - EL. 0.66 m (I=1/4,500)

iv) Design High Water Level
   - EL. 8.18 m at 50-year RPF (case without floodway and retarding basin)
   - Cf . WL at 2023 flood was EL. 8.31 m

v) Design Velocity
   - 2.0～3.0 m/s at 50-year RPF (case without floodway and retarding basin)

vi) Hydraulic conditions during low water
   Flow discharges during low water are set as stated below based on the flow duration curve as presented in Section 4.1.3.

   - 16.3 m^3/s at 50% dependable flow
   - 6.1 m^3/s at 75% dependable flow
   - 2.6 m^3/s at 90% dependable flow



Source: JICA NODI Project, Presentation

Figure 5.2.11 Longitudinal Profile of Matamuhuri River Prepared by the NODI Project

(4) Sediment transport, riverbed changes

Riverbed materials at the intake site are mainly composed of fine sands. It is said that the sediment has a tendency to accumulate in the river channel under normal flow conditions. In the Matamuhuri River basin, it is also said that sediment transportation is relatively large due to the upstream landslide conditions and high intensity of rainfall.

At Bandarban Station (SW247) in the Sangu River basin that is located on the north of the Matamuhuri River basin, the observed sediment data by BWDB from 2017 to 2019 are available, and at Lama Station, there is an assumed Q-Qs formula (relationship between the sediment load and flow discharge).

(5) Saltwater intrusion into the upstream river stretches

Saltwater intrusion has been reported up to a point around 5 km downstream of the Matamuhuri Bridge, but there is no saltwater intrusion up to the current planned site of the intake (Matamuhuri Bridge + 3 km upstream).

According to data from the Intergovernmental Panel on Climate Change (IPCC), sea levels will rise 32 cm in 2050 compared to 2000 in Bangladesh. With reference to this and assuming a riverbed slope of 1/4000, it is roughly predicted that the range of saltwater intrusion will move approximately 1,300 m (=0.32m x 1/4000) upstream due to sea level rise, possibly reaching the recommended site at the highest tide. Since this prediction is considered a future climate change risk, continuous water quality monitoring at the intake point is recommended. In addition, if the saltwater concentration exceeds the standard value, it is assumed that the intake operation will be able to be stopped temporally. In terms of water intake operation, the intake period is limited in the rainy season, and water will not be taken in

the dry season. Since the saltwater heavier than fresh water is going upstream along the riverbed, it is considered the possibility to take saltwater at intake because the intake bed elevation is about 0.5 to 1.0 m higher than the riverbed.

(6) Water quality

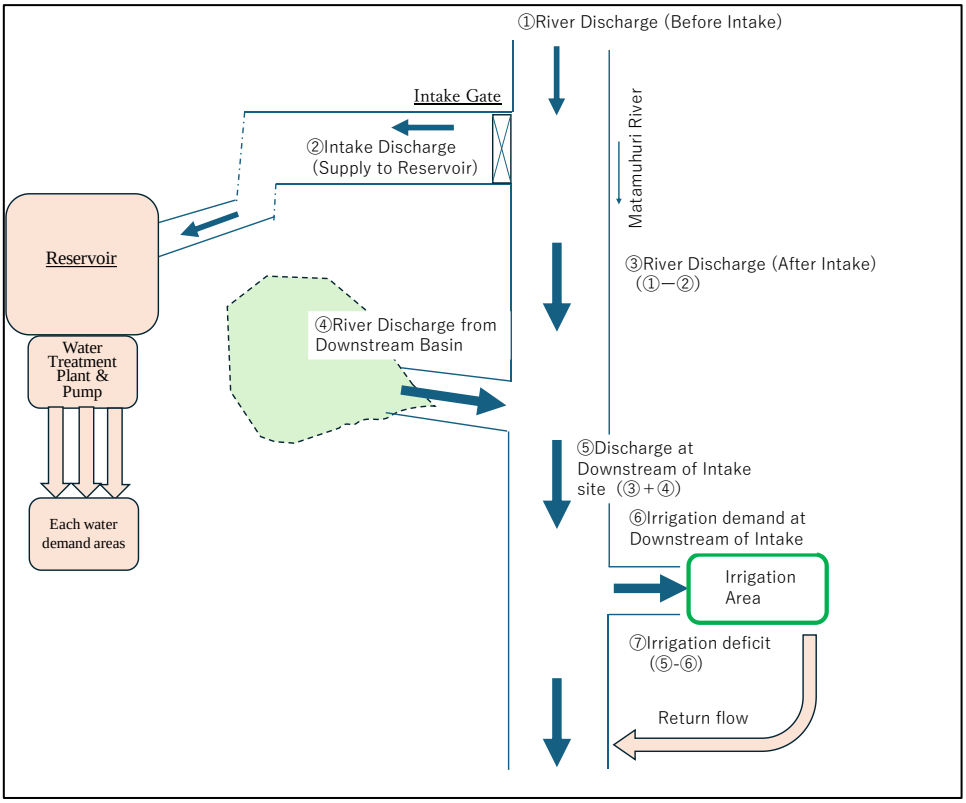
At present, water quality monitoring is being conducted in the survey.

(7) Irrigation deficit by Water Intake

There was a concern that water intake of this project may cause the lack of irrigation demand at the downstream of Matamuhuri river. Thus, occurrence of irrigation deficit by water intake was confirmed according to the following Scheme.

① River discharge (before Intake)
② Intake Discharge (Supply to Reservoir)
③ River discharge (after Intake)
④ River discharge from downstream basin
⑤ Discharge at downstream of Intake site (③+④)
⑥ Irrigation demand at Downstream of Intake site
⑦ Irrigation deficit (⑤－⑥)

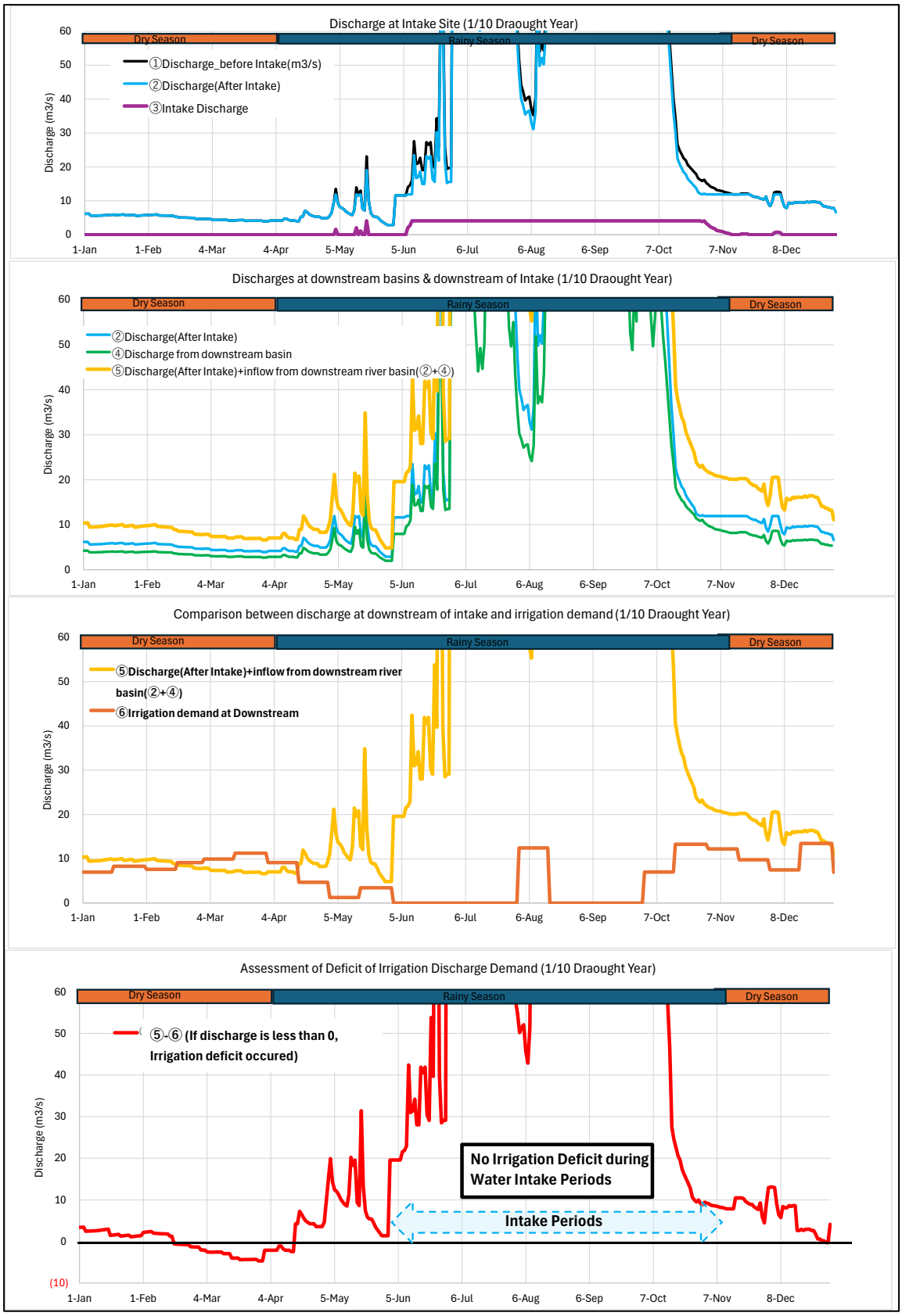
In order to forecast agricultural water demand from the river, the amounts of water requirements from the rivers were calculated in the previous survey (Data Collection Survey on Water Resource Development in South Chattogram). The current irrigation water requirements from the surface water of each target river basin and each upazila were calculated by the Penman method, using the available irrigated area, in consideration of the cropping patterns used there. This calculation was based on the meteorological data and estimated irrigation area for each of the 54 years from 1966 to 2019. The forecasted irrigation areas were calculated, using the growth rate of irrigated area, which was estimated based on past data.



Source: JICA Survey Team

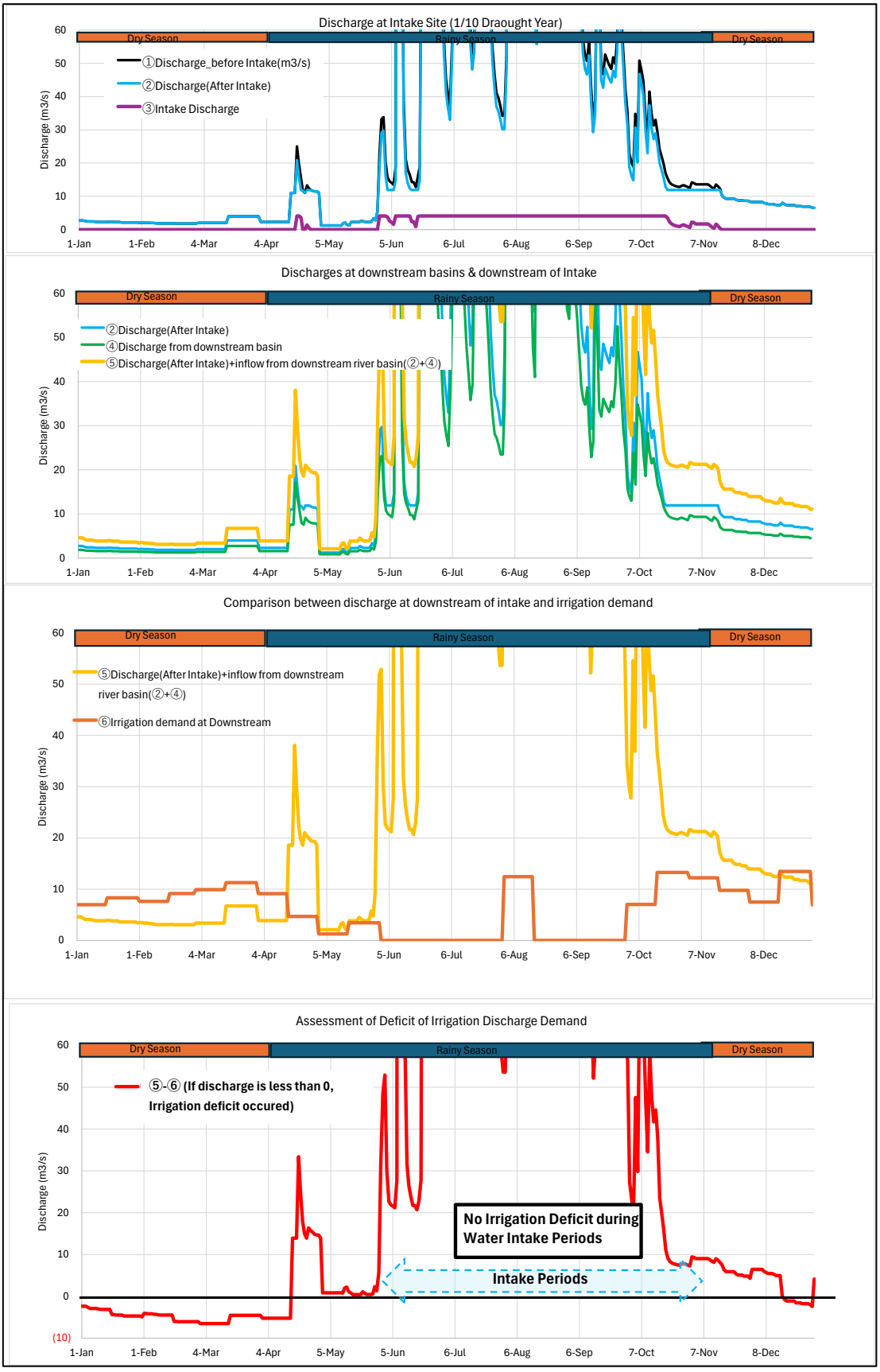
Figure 5.2.12 Calculation Scheme for the Confirmation of Irrigation Deficit

As shown below, it was confirmed that Irrigation Deficit during water intake (1/10 drought, average) did not occur because river discharge after intake was bigger than irrigation demand in any time during intake periods.



Source: JICA Survey Team

Figure 5.2.13 Confirmation of Irrigation Deficit (1/10 Drought)



Source: JICA Survey Team

Figure 5.2.14 Confirmation of Irrigation Deficit (Average Year)

(8) Other conditions

According to the site inspections and interview with the related agency (BWDB) and local residents, some boat transportation is available in the river channel near the planned intake site, but not so frequent, i.e., about once a day.

Since there are also local fishing activities confirmed near the planned intake site, fish ladders shall be considered in the case of weir construction for the river water intake.

5.2.5 Alternative Plans

In this section, alternative layouts, scales, and types of water intake facilities are compared to formulate the basic water intake plan. The comparison of alternatives is conducted in the following order: pipeline route, intake site, intake type, and reservoir site.

In the next stage, once the geological and topographic survey results are available, the concept design and construction plan for each facility will be prepared.

The alternative options shown in the table below were compared and evaluated from the viewpoints of economic efficiency, implementing organization, environmental and social impacts, technical aspects, and appropriateness of the plan, taking into consideration the combination of alternatives as well.

The summary of the comparative study is shown in bold italics in Table 5.2.4 below.

Table 5.2.4 Summary of Alternative Study (Facility Layout Plan)

Items for Examining Alternative Plans	Alternative Plans, Work Methods, Precautions
Project site	**(1) Water supply area** ① A portion of the domestic water demand in the Moheshkhali/Chakaria region, and industrial water demand for the Moheshkhali Economic Zone (Dhalghata) (original plan) ② Alternative plan (variation of water supply quantity in each area) ③ Alternative plan (classification of water as per water quality requirements) ***Studied and determined in the water supply plan in Section 5.1.***
	(2) Pipeline route and facility layout: Examining alternative plans together with layout of reservoirs, treatment plants, etc. Alt.1 Plan for co-locating the pipeline with Matarbari Port Access Road (original plan) Alt.2 Alternative route 1 (use new railway) Alt.3 Alternative route 2 (expansion of existing road) Alt.4 Alternative route 3 (another route) ***Upon the discussion with RHD, the open space within the ROW of Matarbari access road can be used for installation of the proposed water supply pipeline. In the Sub-TWG meeting held on November 6、2023, Alt.1 was selected. (see Section5.2.6 for details)***
	(3) Water intake facilities (3-1) Intake site

Items for Examining Alternative Plans	Alternative Plans, Work Methods, Precautions
	The project site for water intake works (planned construction site) is basically assumed to be the current planned location, but some alternative sites will be examined together with the alternatives of the pipeline route. "Examining each water intake project plan from the perspective of water resources and river management" will be executed. ***In the Sub-TWG meeting held on November 6, intake site immediately upstream of the CC-Bypass Bridge was selected. (see Section 2.3.4 for details)*** ***It is almost the same location as the original plan in the previous study, but the intake structure was slightly adjusted in consideration of riverbank erosion and river channel stability.*** (3-2) Intake type ***Without weir, fixed concrete weir, and movable weir were compared and through discussions and joint site inspection, without weir (pump intake) is recommended providing some conditions of i), ii, iii)***
Water conveyance, transmission and distribution methods	**4-1) Water conveyance method (Intake facilities to reservoir)** Alt.1: Pump pressurized type (original plan) Alt.2: Alternative plan by natural flow approach using oxbow lakes and urban drainage system as water channel) Alt.3: Alternative plan using combination of Alt.1 and Alt.2. ***When compared based on consideration of (2) Pipeline Route, Alt.1 is advantageous. Alt.2 allows the pump head of 30 m to be lowered by about 15 to 20 m, but it is judged to be unsuitable because it requires a larger land acquisition area and there are issues with maintenance and management of the open channel section (garbage and sediment).***
	4-2) Water transmission method (Reservoir to Chakaria area) Alt.1: Plan to use pump transmission to Chakaria area via reservoir (original plan) Alt.2: Plan to treat water taken directly from the river and use pump transmission to Chakaria area ***When compared based on consideration of (2) Pipeline Route, Alt.1 is advantageous. Alt.2 requires larger land acquisition in private land for construction of treatment plant and reservoir.***
	4-3) Water transmission method (Reservoir to Matarbari and Moheshkhali) ***The pipeline will be installed along the Matarbari Port Access Road.***

Source: JICA Survey Team

5.2.6 Alternative Study of Pipeline Route

(1) Candidate Alternatives of Pipeline Route

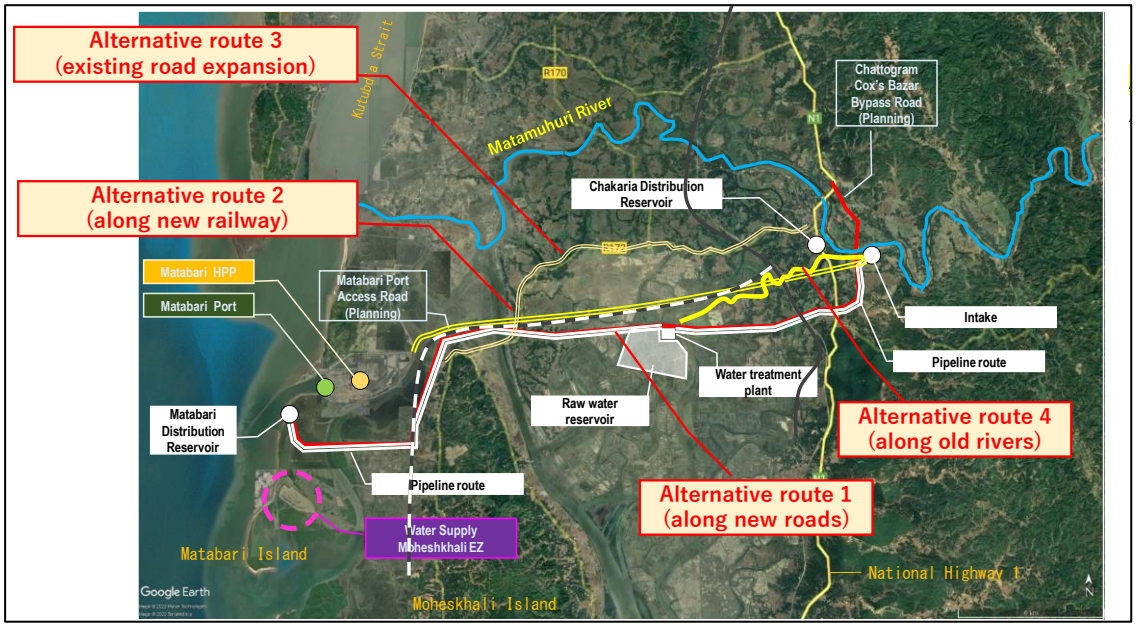
In addition to the pipeline route in the previous study, the following four alternatives are compared and studied:

- Alternative 1: Route along the alignment of new roads (Chattogram - Cox's Bazar Bypass Road, Matarbari Port Access Road

- Alternative 2: Route along the new railway

- Alternative 3: Route in which a pipeline is laid along with the expansion of the existing road (R172)

- Alternative 4: Route using existing drainage channels and old river channels



Source: JICA Survey Team

Figure 5.2.15 Candidate Alternatives of Pipeline Route

(2) Comparison of Pipeline Route Alternatives

The above four alternatives were compared in terms of land acquisition, estimated construction cost, constructability, stability of the structure, operation and maintenance, and project implementation schedule as indicators. As a result, Alternative 1 was evaluated as being advantageous in terms of obtaining space and project implementation schedule.

Table 5.2.5 **Comparison of Alternatives of Pipeline Route**

Item	Alternative			
	1	2	3	4
Description	Along New Roads	Along New Railway	Along Existing Road Expansion	Along Old Rivers & New Drainage Channel
ROW/ Resettlement	Land acquisition for the Matarbari Port Access Road is in progress and RoW is available to use for pipeline installation with confirmation to the Roads and Highways Department (RHD).	Land acquisition for the new railway is not in progress and the availability of RoW is unknown.	Land acquisition for the expansion of the existing road is not in progress, and the availability of RoW is unknown.	Need some ROW/ resettlement (around 2-3 km).
	A	B	D	C
Project Cost	Less project cost due to less ROW	Less project cost due to less ROW	Some ROW and resettlement costs are necessary.	Some ROW cost, but less pipeline cost
	C	C	D	B
Construction Works	Less obstructions, but need coordination with new road construction works	Less obstructions, but need coordination with new railway construction works	There are a lot of obstructions of existing utilities along existing road.	Some obstructions in construction site along the old river and new channel.
	B	B	D	C
Stability of Structure	No significant impact	Structural stability against vibration of railway	No significant impact	No significant impact
	B	D	B	B
Operation and Maintenance	Only normal maintenance such as inspection. No issues to be noted.	Only normal maintenance such as inspection. No issues to be noted.	Only normal maintenance such as inspections. No issues to be noted.	As the canal is open, maintenance work is required to prevent entry into the canal and dumping of garbage, as well as periodic removal of garbage and sediment.

Item	Alternative			
	1	2	3	4
Description	Along New Roads	Along New Railway	Along Existing Road Expansion	Along Old Rivers & New Drainage Channel
	C	C	C	D
Time Schedule	A new road construction project will be started soon prior to this water supply project.	No definite implementation schedule yet.	No definite implementation schedule yet. It will take longer time for ROW acquisition.	It will take longer time for ROW acquisition.
	A	D	D	D
Natural Environmental Impacts	Impact on ecosystem is expected because the Fashiakhali Wildlife Sanctuary is located near the pipeline route.	No significant impact is expected.	Less impact is expected due to the location of the project along an existing road.	Impact on the water environment is expected due to the construction of a new waterway in a part of section of the pipeline route.
	C	B	B	C
Social Environmental Impacts	The land acquisition area is minimal.	The land area could be large. Resettlement is also expected to occur.	There are households along the road, and the scale of resettlement and the area of land acquisition might be large.	Although a new waterway will be constructed in a part of section, the area of land acquisition is small.
	C	D	D	C
Overall Evaluation	**1**	**2**	**4**	**3**

A: better, B: good, C: fair, D: poor, E: not recommendable

Source: JICA Survey Team

(3) Discussion with RHD for Selection of Pipeline Route

In July 2023, a meeting was held with RHD, the implementing agency for the Matarbari Port Access Road Project (RHD Component), and the engineer to discuss the installation of a pipeline along the new road. Finally, the project director of the Matarbari Port Development Project agreed that the JICA Survey Team can propose to design a pipeline along their road with some conditions. RHD has the spare right of way of approximately 5 m to 10 m in their design, where the pipeline can be installed. They have expressed no objections to the use of their land for water pipeline laying, given the following conditions:

1) Ground settlement:

After land reclamation, it is estimated to settle approximately 1 m. Pipeline construction should take place after the settlement time is over and when the ground is stable.

2) Crossing rivers and bridges:

The road design includes several river crossings by bridge but does not consider the attachment of water pressure pipes in the design. The water pipeline needs to cross rivers independently.

3) Restriction on using road structures:

The water pipelines cannot use any structures of the Matarbari Port Access Road Project.

4) Acquiring land in bazaar area

The road layout plan indicates that the water supply project is planned to cross several bazaars (at least 7 to 10 locations). However, RHD does not have enough acquired land for pipe laying in those areas. Hence, land acquisition is required for the water pipeline in the bazaar areas.

5) Safety measures:

The JICA Survey Team should consider the safety aspects, such as potential damage to the road embankment and soil erosion during the pipeline design phase. Appropriate measures like keeping a safe distance of the borrow pit from the slope, retaining walls etc. should be considered to ensure pipeline safety.

(4) Layout Plan of Pipeline (Matarbari Port Access Road)

The basic information on the Matarbari Port Access Road is presented below.

1) Basic information

The detailed design of the Matarbari Port Access Road has been completed and the bidding process is being undertaken. Land acquisition is almost complete.

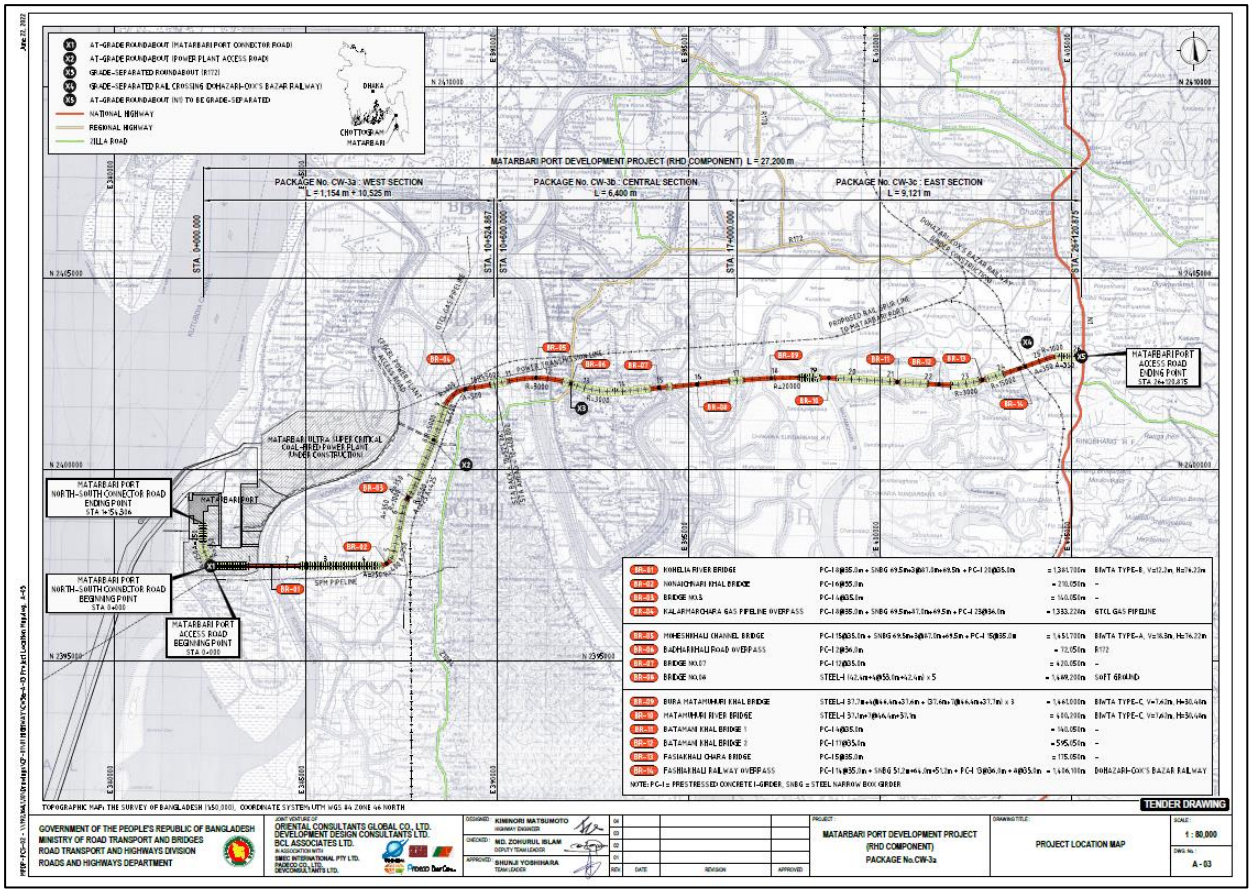
As a result of the above discussion, the following data were collected:

- Table of contents of drawings
- Road plan floor plan, road plan longitudinal section, road standard cross section
- Geological survey report
- Hydraulic study report

2) Road planning

Basic information on road planning is shown below.

- Main road is four-lane road. The tentative plan is to develop the road as a two-lane road, with plans to expand to four lanes in the future.
- Service roads will be provided on both sides.
- 14 bridge sections are planned at the river crossing section and low-lying areas.
- ROW width is 90 m. There is an empty space of about 5-10 m on both sides.

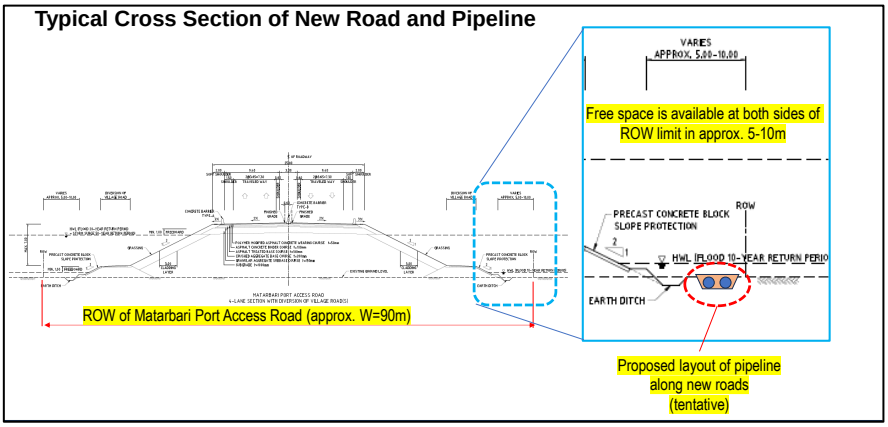


Source: Matarbari Port Access Road Project

Figure 5.2.16 Plan of Matarbari Port Access Road

3) Pipeline installation

As shown in the diagram below, the plan of pipeline installation is to bury the new pipeline using 5 to 10 m of empty space at both ends.



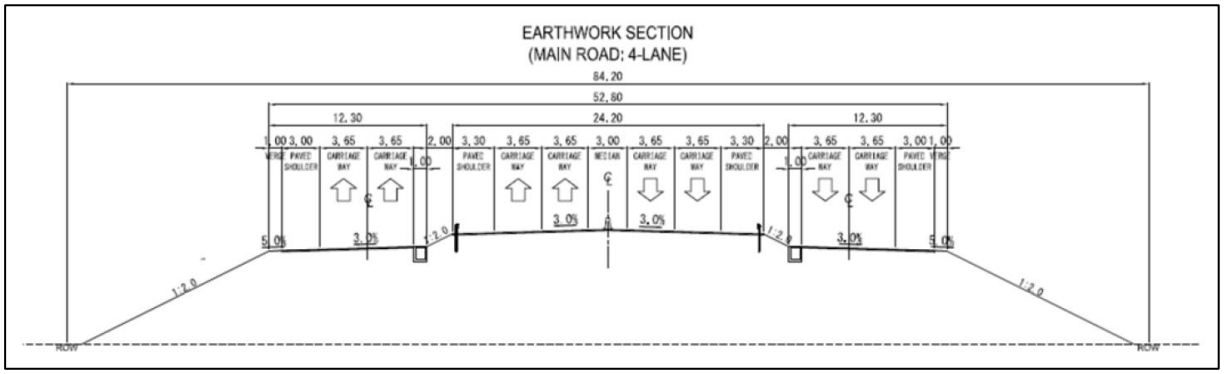
Source: JICA Survey Team

Figure 5.2.17 Pipeline Installation Plan along Matarbari Port Access Road

(5) Layout Plan of Pipeline (Chattogram – Cox's Bazar Bypass Road)

The feasibility study of this road was conducted under the JICA Preparatory Survey for the Chattogram – Cox'z Bazar Highway Improvement Project in 2023. Currently, the detailed design and construction supervision consultants are being procured under a yen loan project.

According to RHD, the main road has a basic cross section of 4 lanes, which is the same as the Matarbari Port Access Road Project. Similarly, the layout plan of the pipeline in this section is to lay the water pipes at the edge of the road right-of-way boundary.



Source: Final Report of the Preparatory Survey for Chattogram – Cox'z Bazar Highway Improvement Project (February 2023)

Figure 5.2.18 Typical Cross Section of the Earthworks Section of CC-Bypass Road

A meeting with the project director of the Cross Border Road Network Improvement Project under RHD at the RHD Core Office was held on February 6, 2024. Main points of discussion are as follows:

- In the CC-Bypass Road Project, RHD would not accept to construct any infrastructures at their acquired land because they will acquire minimum land required for their project to minimize project cost.
- For the water supply project, separate land can be acquired by the said project if required. Each project shall acquire each ROW. Since the water supply project is expected to be implemented after the road project, the ROW of the water supply project can be attached to the CC-RHD's ROW limit for easy communication to the landowners.
- For the bridge construction works, RHD can consider the loads for the proposed water supply pipes in the design, but this is subject to prior approval.

At present, the CC-Bypass Road project director has expressed the view that they would like to acquire the land for road development separately from the Project. However, since the target land acquisition is in the same area along the new road and the implementation timing is almost the same under the JICA yen loan project related to the same MIDI development, it is desirable to implement it at the same time in terms of efficiency.

The ROW of the CC-Bypass Road Project will be considered unavailable for the water supply project in this study, since the land acquisition has not yet started in the road project , and it is difficult to judge

from the basic design of the road project if the road ROW has enough open space to be shared with the proposed additional pipelines of the water supply project. Thereby, the land acquisition area of the proposed pipeline installation along the CC-Bypass Road is to be investigated in the subcontract work of the RAP study. However, it is recommended to consider the possibility of reducing land acquisition for the water supply project during the detailed design of the water supply project, by utilizing the confirmed ROW of CC-Bypass Road where possible.

Table 5.2.6 Status of Discussion with RHD for Matarbari Port Access Road Project and CC-Bypass Road Project

Item	Matarbari Port Access Road Project	CC Bypass Road Project
Project Status	Completed D/D, C/S will start soon	Ongoing procurement of D/D and C/S
Pipeline along road	28.00 km	2.60 km
Road ROW	Approx. 90 m (almost completed)	Approx. 50 m (to be implemented at initial stage of D/D)
Open space	Open space of 5–10 m at both sides	Limited space of 2–3 m
Sharing ROW	Agreed but with conditions	To be separately implemented (* JST recommends not to separate)
River Crossing Section	Pipelines shall be independently installed from the bridges.	Pipeline can be considered to be attached to the bridge upon discussion with the CE design.
Other Conditions	Pipeline installation after ground settlement. Restriction on using road structures. Acquiring land in bazaar areas (at least 7 to 10 locations); and Appropriate safety measures against the potential damage to road embankment.	

Source: JICA Survey Team

5.2.7 Alternative Study for Intake Site

(1) Basic Conditions of Alternative Study for Intake Site

The basic conditions of the alternative study for the intake site are as follows:

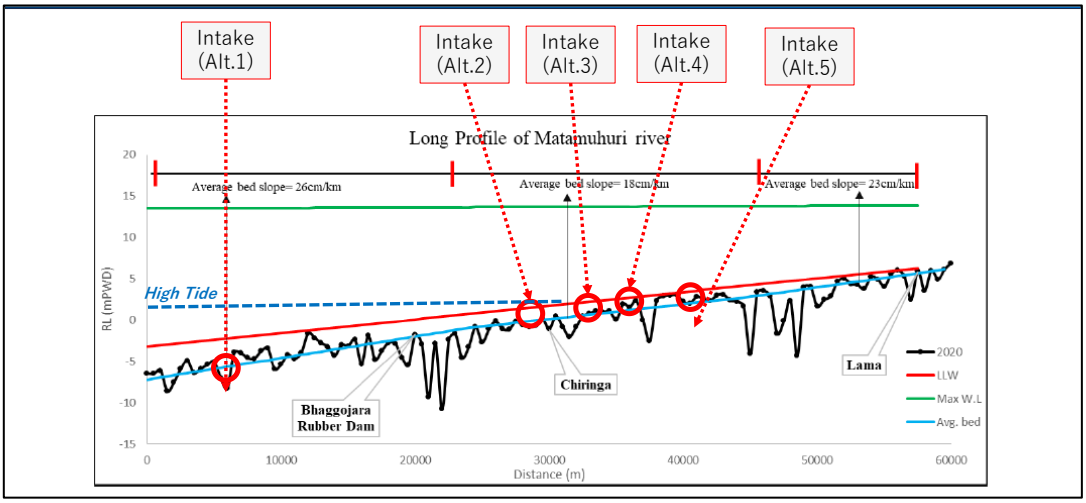
i. Positional relationship with water demand areas (Matarbari, Moheshkhali, Chakaria),
ii. Saltwater intrusion (Location without/less influence of saltwater intrusion),
iii. River morphology (stretch where riverbank erosion and river channel meandering are small and the river channel is stable),
v. Water potential (securing the required amount of water intake discharge),
vi. Areas with no/less water quality problems, and
vii. Other conditions (boat navigation, environmental flow rate).

In particular, the condition of saltwater intrusion was mentioned in Section 5.2.4.

The target project area is a low-lying tidal zone with a network of rivers where the majority of land use is for salt farms and fish farms. There are three rubber weirs constructed by BWDB for the purpose of developing irrigation water in the downstream areas. The rubber weir works to prevent saltwater from flowing up. However, the current rubber weirs are not functioning properly due to maintenance problem and partial damage.

In addition, these rubber weirs' operation is "inflated (stand up) during the dry season to raise the water level for taking water, and then deflated (tuned down) during the rainy season to allow floodwaters to flow down". While rubber weirs are deflated during the rainy season, the saltwater flows upstream beyond the rubber weirs. It has been confirmed that saltwater from the Matamuhuri River normally flows upstream to a point about 3 km downstream of Matamuhuri Bridge. In addition, saltwater observation data from the Chiringa point on Matamuhuri Bridge confirms that high-concentration saltwater flows upstream during high tides, which occur approximately once every 10 years.

Furthermore, even if the three existing rubber weirs are renovated into movable steel weirs and operated accurately and in a timely manner, there are still some challenges in the operation and maintenance of the weir. It is also assumed that saltwater would flow upstream through the network of small rivers, salt farms, and fishpond around the main river, and as underground seepage flow.



Source: JICA Survey Team

Figure 5.2.19 Saltwater Intrusion in the Intake Site in Matamuhuri River

(2) Alternatives of Intake Sites

The following five alternatives (5 sites) in the Matamuhuri River are compared as the intake site. The location map of the intake site alternatives is presented in Figure 5.2.20.

(Alt.1) : Lower Matamuhuri River (upstream of Palakata Rubber Dam)

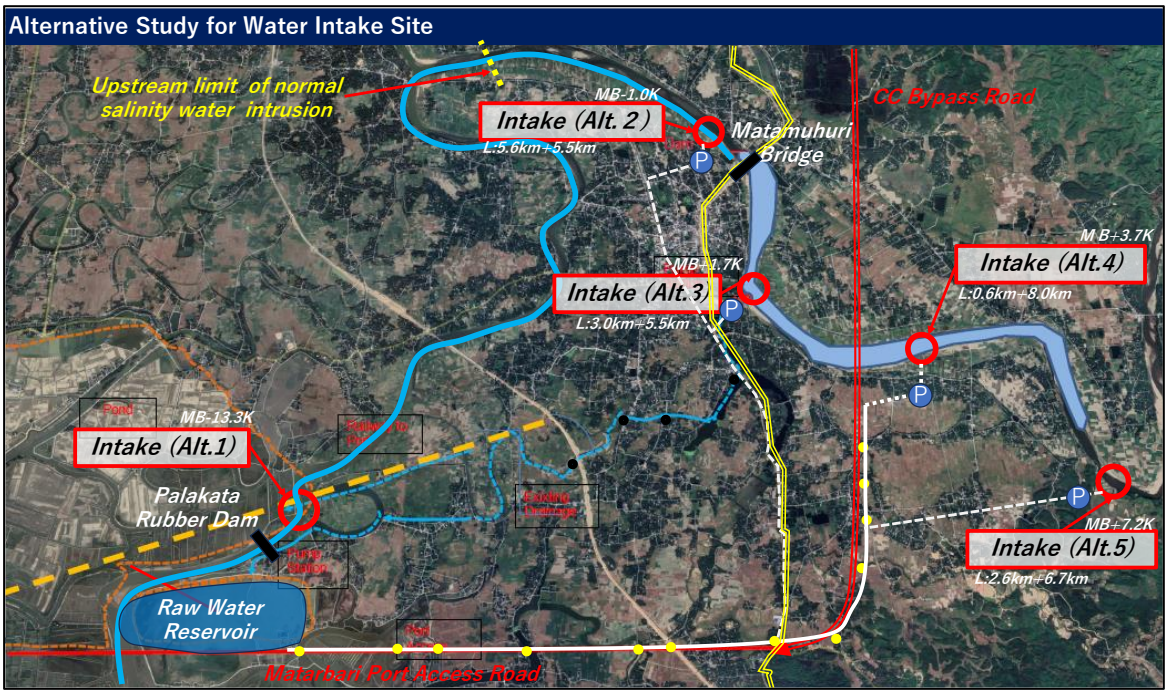
(Alt.2): Immediately downstream of Matamuhuri River Bridge (MB-1.0 km)

(Alt 3): Upstream of Matamuhuri River Bridge (MB+1.7 km)

(Alt 4): Upstream of Matamuhuri River Bridge (MB+3.7 km)

(Alt 5): Upstream of Matamuhuri River Bridge (MB+7.2 km)

*MB: Matamuhuri Bridge



Source: JICA Survey Team

Figure 5.2.20 Location Map of Alternatives of Intake Site

(3) Comparison of Alternative Options for Intake Site

The comparison of the above five alternatives is made in terms of indicators of the impacts of saltwater intrusion and water quality, stability of the river channel, backwater and upstream hydraulic impact of the weir, land acquisition and relocation of residents, and project cost (pipeline + land acquisition cost). For Alternative 1, this option requires construction of a large-scale desalination plant of 4.1m3/s (around 354 MLD) in production and large amount of the facility costs and operation and maintenance costs. It is important to take water at a point where there are less impacts of saltwater intrusion.

As a result, Alternative 4 has been selected as the recommendable option since it has a low risk of saltwater intrusion, requires less land acquisition and relocation through the use of the new road land, and has relatively low pipeline construction costs.

Table 5.2.7 Comparison of Alternatives of Intake Site

Alternative of Intake Site		Alt.1 (Lower Matamuhuri River)	Alt.2 (Downstream of Matamuhuri Bridge)	Alt.3 (Upstream of Matamuhuri Bridge +1.7 km)	Alt.4 (Original Plan) (Upstream of Matamuhuri Bridge + 3.7 km)	Alt.5 (Upstream of Matamuhuri Bridge + 7.2 km)
Description		The plan is to construct a new weir upstream of the existing rubber weir (Palakata) near the reservoir, or to repair the existing weir and intake.	The plan is to take water downstream of the Matamuhuri Bridge point, near the limit of saltwater intrusion.	It is located slightly downstream from the original plan. Closer to Chakaria City center.	This is the original plan. This is to intake water near the intersection of the CC Bypass Road and the Matamuhuri River.	The plan is to take water near the diversion point of the proposed floodway, which is being considered by the River TA Project (NODI).
Intake Location		Matamuhuri Bridge -13.3 km	Matamuhuri Bridge -1.0 km	Matamuhuri Bridge +1.7 km	Matamuhuri Bridge ＋3.7 km	Matamuhuri Bridge ＋7.2 km
Distance from Moheshkhali Channel Confluence		+14.6 km	+26.9 km	+29.6 km	+31.6 km	+35.1 km
Ground Elevation		MSL +2.0 m	MSL +3.0 m	MSL +3.0 m	MSL +4.0 m	MSL +5.0 m
Pipe line Length	Total (Intake - Reservoir)	**540 m**	**11,100 m**	**8,500 m**	**8,300 m**	**9,300 m**
	-not along new roads	540 m	5,600 m	3,000 m	2,800 m	3,800 m
	- along new roads	0 m	5,500 m	5,500 m	5,500 m	5,500 m
Length of Bank Protection Works			700 m	1,900 m	2,400 m	2,100 m
Salinity Water Intrusion /Water Quality		Mixed with salinity water	Salinity concentration is about 250 ppm. Large-scale salt water intrusion occurs about once every 10 years. No serious water quality issue.	Large-scale saltwater intrusion occurs about once every 10 years. No serious water quality issue.	No salinity water intrusion. No serious water quality issue.	No salinity water intrusion. No serious water quality issue.
		-	C	A	A	A
Stability of River Channel		There is an existing weir, and the river channel is stable.	River channel is relatively straight and stable	River channel is unstable due to riverbank erosion and is located in meandering section	River channel is unstable due to riverbank erosion and is located in meandering section	River channel is relatively stable although it is located in meandering section
		B	B	D	D	C

Backwater	In case of no weir or movable weir, no impact.	In case of no weir or movable weir, no impact.	In case of no weir or movable weir, no impact.	In case of no weir or movable weir, no impact.	In case of no weir or movable weir, no impact.
	A	A	A	A	A
Natural Environmental Impact	No significant impacts are anticipated.	No significant impacts are anticipated.	No significant impacts are anticipated.	No significant impacts are anticipated.	The Fashiakhali Wildlife Sanctuary is located near the intake point, however, it's possible to construct a pipeline outside the wildlife sanctuary. Thus, the impact is assumed to be small.
	C	C	C	C	D
Socio Environmental Impact	Less waterway land acquisition and relocation	The pipeline passes through the center of Chakaria; it will cause large impacts on land acquisition and resettlement.	The pipeline passes through the center of Chakaria; it will cause large impacts on land acquisition and resettlement.	Even if pipeline land acquisition is required along CC Bypass Road, less resettlement than others.	Pipeline land acquisition and relocation are medium scale.
	5,400 m^2	**56,000 m^2**	**30,000 m^2**	**28,000 m^2**	**38,000 m^2**
	A	D	C	B	C
Construction Cost (Pipeline and Bank Protection)	Land acquisition, resettlement, and pipeline construction costs are small	Land acquisition, resettlement, and the longest pipeline require large construction costs.	Land acquisition and resettlement costs are medium-sized.	Land acquisition and resettlement costs are small, and pipeline construction costs are also relatively smaller.	Land acquisition and resettlement costs are medium-sized. Pipeline construction costs are relatively large.
(% of Atl.4)	**26%**	**174%**	**128%**	**100%**	**136%**
	A	E	C	B	D
Operation and Maintenance	It will be necessary to manage numerous tidal check gates in the network of rivers and periodically	Normal operation and maintenance for intake and pipeline are necessary.	Normal operation and maintenance for intake and pipeline are necessary.	Normal operation and maintenance for intake and pipeline are necessary.	Normal operation and maintenance for intake and pipeline are necessary.

		replace filters for desalination.				
		D	C	C	C	C
Evaluation	Merit	Close to the raw water reservoir, it requires less land and resettlement, and requires less pipeline construction costs.	As located downstream of the existing bridge, the river channel is straight and stable.	It is located slightly downstream from the original plan and close to the Chakaria City area.	Low risk of saltwater contamination. By using new road land, land acquisition and relocation are small. Pipeline construction costs are also relatively small.	Low risk of saltwater contamination. The river channel is stable.
	Demerit	The site is located within the network of rivers and has a high risk of contamination with salt water, making it unsuitable as a water intake point.	The pipeline will pass through the center of Chakaria, requiring large-scale land acquisition and relocation. There is a risk of saltwater contamination. The length of the pipeline is also the longest and the least economical.	There is a slightly high risk of saltwater contamination. Land acquisition and relocation costs are medium-sized. Pipeline construction costs are relatively large.	The river channel is unstable as it is located in meandering section, and river improvement (bank protection, embankment, excavation) upstream and downstream of the water intake is required.	There are scattered households, and there is a possibility of resettlement. Thus, the cost is relatively high. Impact on the natural environment is small but not negligible.
Overall Evaluation		Not recommendable	4 (Not recommendable)	2 (Possible to apply)	1 (Recommended)	3 (Possible to apply)

A: better, B: good, C: fair, D: poor, E: not recommendable

Source: JICA Survey Team

(4) Comparison of Alternative Options of Intake Site (Secondary Comparison)

Alternative 4, selected above, is located in a section where the mainstream of the river fluctuates, making the river channel unstable and requiring river training works (riverbank protection, embankments, and excavation) upstream and downstream of the planned water intake. Therefore, while Alternative 4 is considered a promising option, secondary alternatives that address the said issues shall be studied. Alternatives are proposed adjacent to the CC Bypass Road bridge and measures to stabilize the bank and river channel are taken.



July 24, 2023



October 23, 2023



July 24, 2023



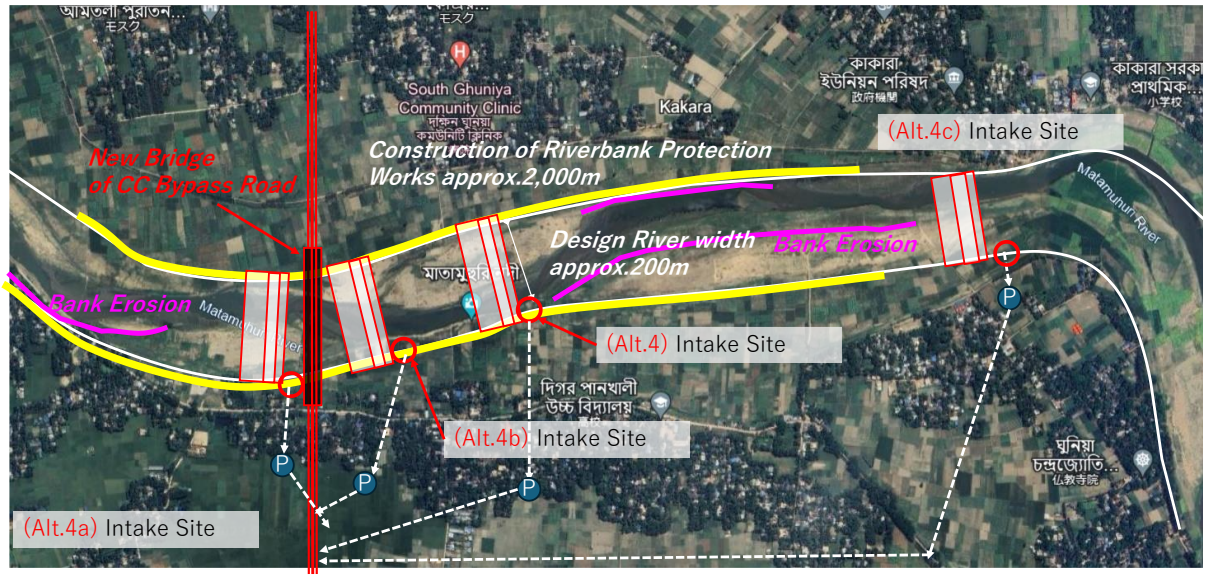
October 23, 2023

Source: JICA Survey Team

Figure 5.2.21 Photos of Riverbank Erosion Before and After the August 2023 Flood

The August 2023 flood caused a 30-year return period flood in the Matamuhuri River, and riverbank erosion progressed as shown in the photos above. Based on the results of the field survey, the site conditions of riverbank erosion after the flood were confirmed and the following three options are considered in addition to Alternative 4 as secondary alternative for the intake site:

- Alternative 4: Original plan (Alternative 4 as shown in Table 5.2.5)
- Alternative 4a: Downstream option 1 (directly downstream of CC Bypass Road)
- Alternative 4b: Downstream plan 2 (just upstream of CC Bypass Road)
- Alternative 4c: Near the starting point of the straight section upstream from the original plan



Source: JICA Survey Team

Figure 5.2.22 Location Map of Alternatives of Intake Site (Secondary Alternative Comparison)

In addition to the same indicators as in the first comparison, the river channel stability that was assessed based on the river morphology data from 1990 to 2022 in the NODI Project was considered for the comparison of the above secondary alternatives. Among the alternatives, the river channel at Alt.4c is deemed relatively stable based on the past trend although all alternatives are located in meandering section. The comparison table is shown below.

As a result, Alternative 4b was found an advantageous plan and is to be selected as a priority plan that could be less costly among the alternatives and could improve the stability of the river channel by installing riverbank protection works together with the bridge abutment protection works continuously in the upstream and downstream of the intake.

However, since this plan is to install a water intake facility upstream of the new CC Bypass Road bridge, it is necessary to coordinate with the plan and design of the said road project and strengthen the water intake, bridge revetment, and revetment works as one united structure.

Table 5.2.8 Comparison of Alternative of Intake Site (Secondary Alternative Comparison)

Alternative of Intake Site		Alt.4 (Original Plan: at CC Bypass) (MB + 3.7 km)	Alt.4a (Downstream of CC Bridge) (MB + 3.2 km)	Alt.4b (Upstream of CC Bridge) (MB + 3.3 km)	Alt.4c (Upstream of Alt.4) (MB + 4.9 km)
Description		Original plan. This is to intake water near the intersection of the CC Bypass Road and the Matamuhuri River.	. This is to intake water immediately downstream of the CC Bridge. .	This is to intake water immediately upstream of the CC Bridge.	This is to intake water near the starting point of the straight section upstream from the original plan
Intake Location		Matamuhuri Bridge + 3.7 km	Matamuhuri Bridge + 3.2 km	Matamuhuri Bridge + 3.3 km	Matamuhuri Bridge + 4.9 km
Distance from Moheshkhali Channel Confluence		+31.6 km	+31.1 km	+31.2 km	+32.8 km
Ground Elevation		MSL +4.0 m	MSL +4.0 m	MSL +4.0 m	MSL +5.0 m
Pipeline Length	Total (Intake - Reservoir)	**8,300 m**	**8,100 m**	**8,200 m**	**10,100 m**
	- not along new roads	2,800 m	2,600 m	2,700 m	4,600 m
	- along new roads	5,500 m	5,500 m	5,500 m	5,500 m
Length of Bank Protection Works		2,400 m	1,600 m	1,600 m	1,200 m
Salinity Water Intrusion /Water Quality		No salinity water intrusion. No serious water quality issue.	No salinity water intrusion. No serious water quality issue.	No salinity water intrusion. No serious water quality issue.	No salinity water intrusion. No serious water quality issue.
		A	A	A	A
Stability of River Channel		River channel is unstable due to riverbank erosion and located in meandering section.	River channel is unstable due to riverbank erosion. There is a large bend section downstream of the intake creating hydraulic issue.	River channel is unstable due to riverbank erosion and located in meandering section.	River channel is relatively stable although it is located in the meandering section.
		D	D-	D	C
Backwater		In case of no weir or movable weir, no impact	In case of no weir or movable weir, no impact	In case of no weir or movable weir, no impact	In case of no weir or movable weir, no impact
		A	A	A	A
Socio Environmental Consideration		CC Bypass Road and Matarbari Port Access Road can be used; less pipeline land acquisition and resettlement.	CC Bypass Road and Matarbari Port Access Road can be used; less pipeline land acquisition and resettlement.	CC Bypass Road and Matarbari Port Access Road can be used; less pipeline land acquisition and resettlement.	Pipeline land acquisition and resettlement. is relatively larger than others due to longer pipe line not along new road. .

(Land Acquisition: m^2)		**28,000** m^2	**26,000** m^2	**27,000** m^2	**46,000** m^2
		B	B	B	D
Construction Cost (Pipeline and Bank Protection)		Base case	Construction cost is slightly cheaper than Alt 4. due to less pipeline land acquisition.	Construction cost is slightly cheaper than Alt 4. due to less pipeline land acquisition.	. Pipeline construction costs are relatively large because land acquisition and resettlement costs are larger than others
(% of Atl.4)		**100%**	**96%**	**97%**	**130%**
		B	B	B	C
Operation and Maintenance		Normal operation and maintenance for intake and pipeline are necessary.	Normal operation and maintenance for intake and pipeline are necessary.	Normal operation and maintenance for intake and pipeline are necessary.	Normal operation and maintenance for intake and pipeline are necessary.
		C	C	C	C
Evaluation	Merit	Original plan (low risk of saltwater contamination. By using new road land, land acquisition and relocation are small. Pipeline construction costs are also relatively small.)	By installing bank protection work together with bridge abutment revetments, cost is reduced, and river channel stability is improved.	By installing bank protection work together with bridge abutment revetments, cost is reduced, and river channel stability is improved.	River channel is relatively stable although it is located in the meandering section.
	Demerit	Original Plan (The river channel is unstable as it is located in meandering section, and river improvement (bank protection, embankment, excavation) upstream and downstream of the water intake is required.)	There is a large bend section downstream of the intake creating hydraulic issue.	Same as original plan(Alt.4)	Since the intake structure is located away from the new road, costs and additional land acquisition are required.
Overall Evaluation		3	2	1	4

A: better, B: good, C: fair, D: poor, E: not recommendable

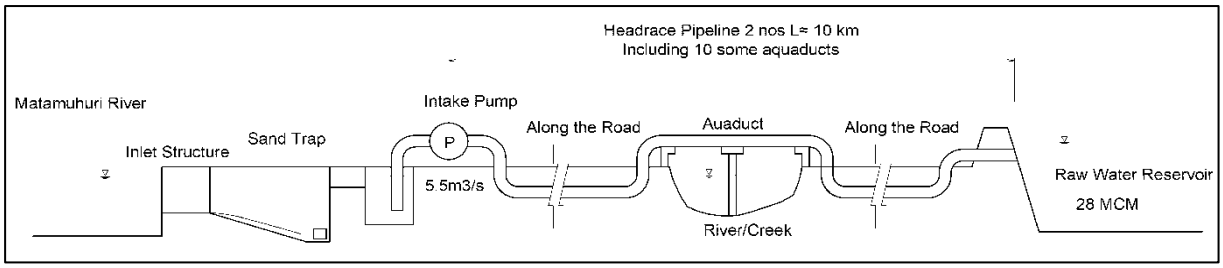
Source: JICA Survey Team

5.2.8 Alternative Study for Intake Type

(1) Basic Conditions for Alternative Study for Intake Type

In the examination of the alternative options above, a promising location for the water intake site was selected. In this sub-section, alternative types of intake structures are studied and compared.

The basic composition of the water intake facility is as shown in Figure 5.2.23 below: intake → intake channel → settling basin → intake pumping station → headrace (pipeline) → reservoir.



ource: JICA Survey Team

Figure 5.2.23 Basic Composition of the Water Intake Facility

The basic conditions for comparison of intake types are shown below.

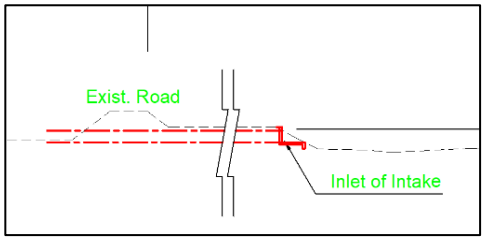
- Gentle gradient
- Sand or clay riverbed material
- Wide width (approx. 300 m)
- Flood channel and low water channel
- Meandering low water channel by flooding

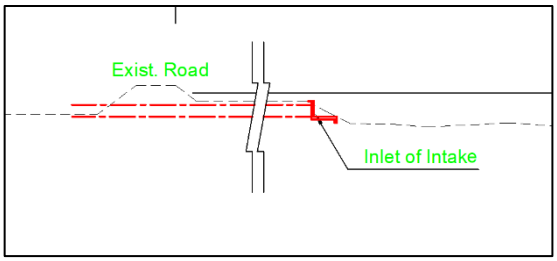
(2) Alternatives of Intake Type

The following three options are compared and considered as alternatives for the intake structure. The workflow for examining the intake structure type is shown below. Alternative 3: Movable gate type has mainly 3 types as shown in Figure 5.2.25.

- Alternative 1: Pump intake without weir
- Alternative 2: Fixed concrete type
- Alternative 3: Movable gate type (roller gate, rubber dam, and tumble gate)

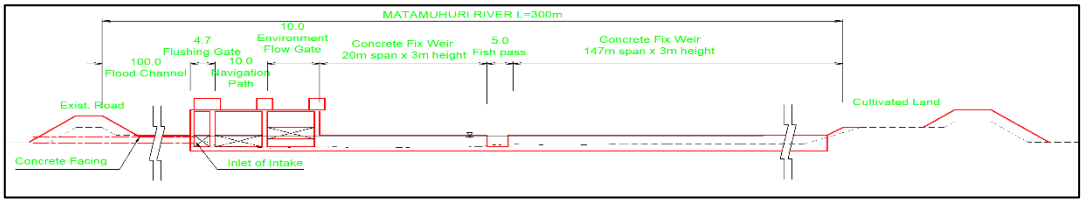
1) No Weir Type (Normal Time and Flooding Time)



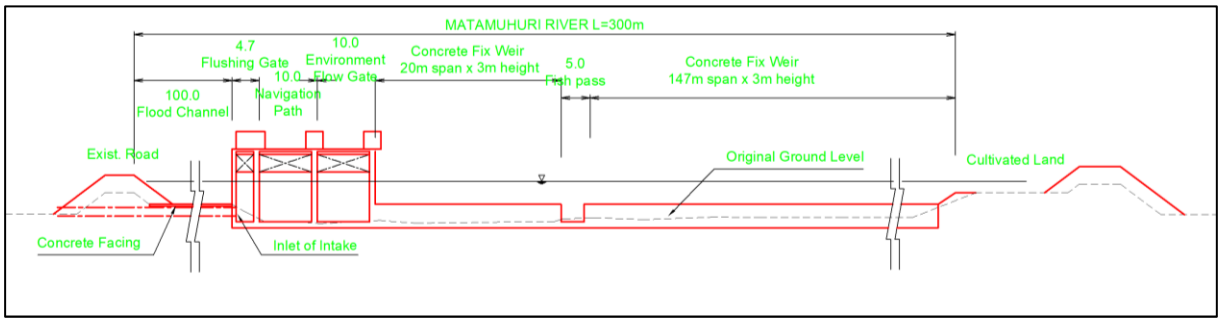


2) Fixed Concrete Type

Normal Time

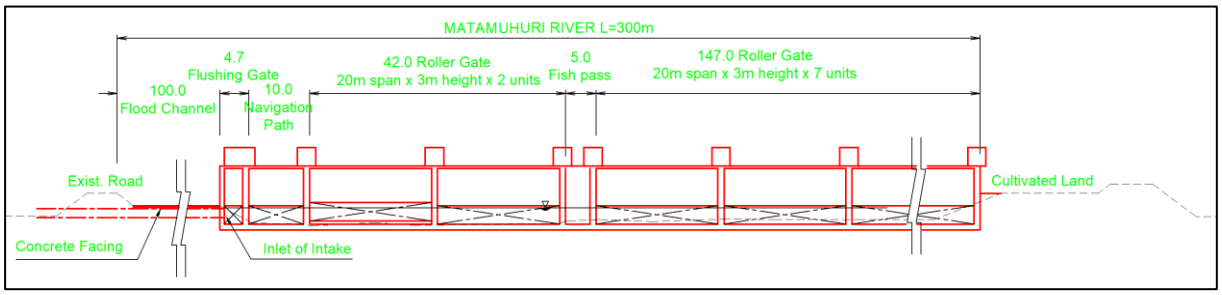


Flooding Time

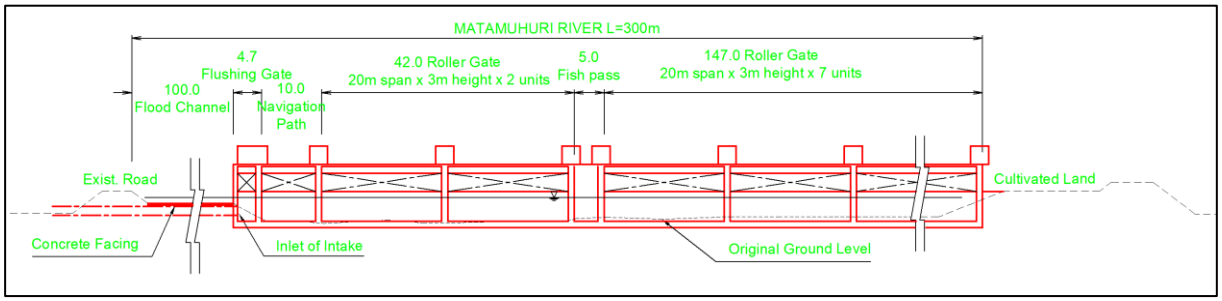


3) Movable Type

Normal Time



Flooding Time

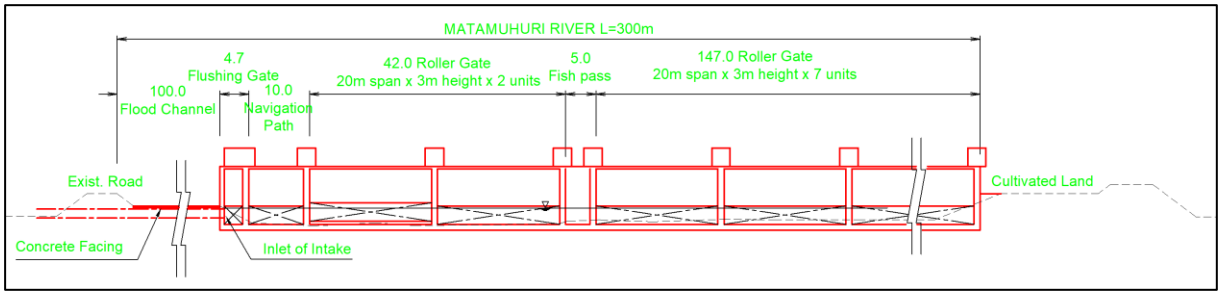


Source: JICA Survey Team

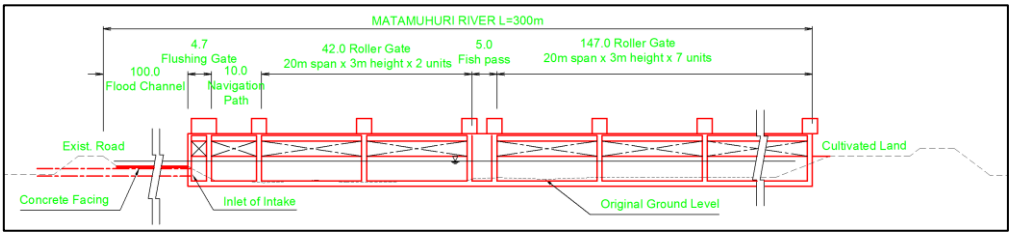
Figure 5.2.24 Front View of Alternative Weir Types

1) Roller (Sluice) Gate Type

Normal Time

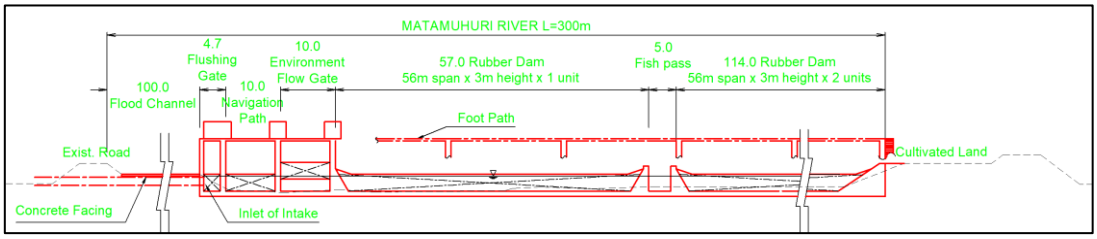


Flooding Time

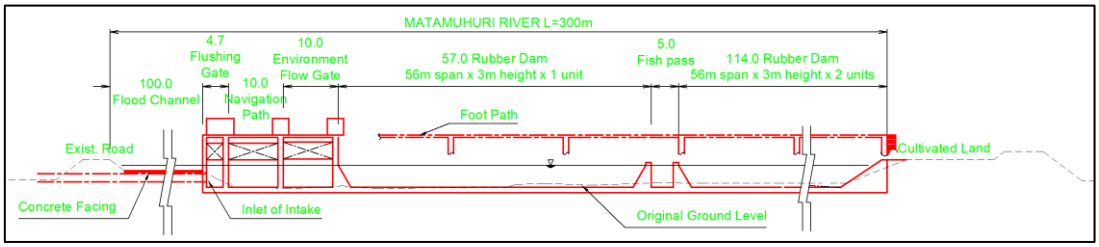


2) Rubber Dam Type

Normal Time

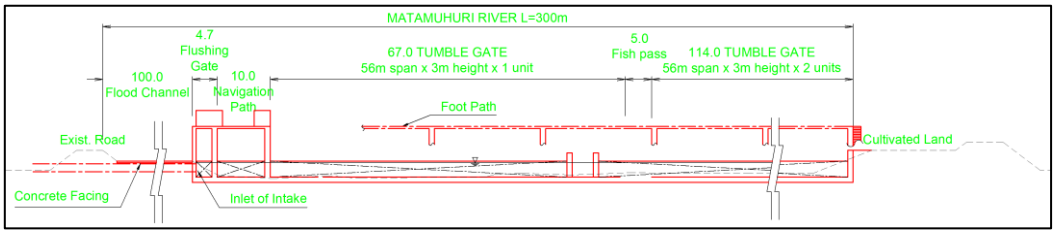


Flooding Time

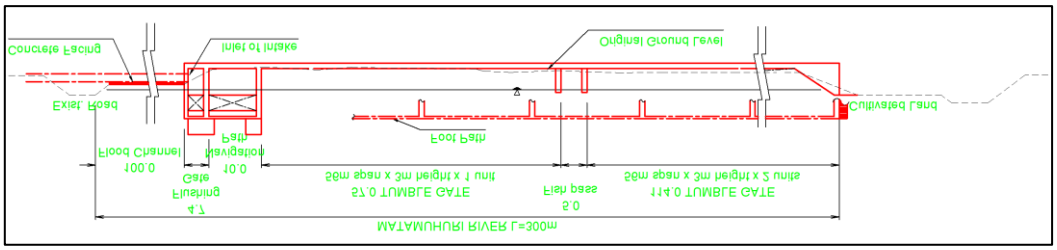


3) Tumble (Flap) Gate Type

Normal Time



Flooding Time



Source: JICA Survey Team

Figure 5.2.25 Cross Section of Alternatives of Movable Gate Type

(3) Study of Water Intake Type

As a result of the comparative study of the above water intake types, the JICA Survey Team made a series of consultation meetings with the STWG members on November 6 and 9, 2023 and conducted joint field survey with engineers of BWDB Design Section and Cox's Bazar Office on November 14, 2023.

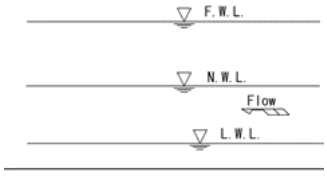
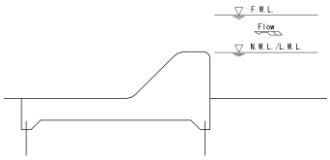
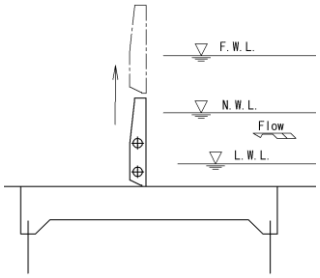
As a result, following points were determined and agreed upon as the final location and type:

- There were no objections from BWDB regarding the comparison results of pipeline routes (use of CC Bypass Road and Matarbari Port Access Road) and reservoir locations (Palakata).
- Regarding the results of comparison of the intake structure locations, the participants agreed with the Alt-4 plan.
- Regarding the type of intake structure, BWDB strongly recommended that "in principle, it is not practical to install river crossing structures, and a plan without weir is preferable". BWDB's main concern was that the construction of weir will result in sediment depositions upstream of the weir, and thus will lead to increased risk of flooding. BWDB was also concerned about operation and maintenance cost that is needed to manage sedimentation appropriately, timely and frequently.

The following matters were determined and agreed upon, based on the above discussions and field survey. The comparison of intake type alternatives was prepared as shown in Table 5.2.9 below. As a result, the "pump intake type without weir" is adopted, subject to the following conditions:

i) Maintenance of river structures, and proper sediment management in the river channel and intake channels, including periodic maintenance dredging in the operation stage,
ii) Stabilization measure of bank protection works and others (e.g. spur dikes and guide dikes) and
iii) Detailed hydraulic model and analysis to be performed in the detailed engineering stage.

Table 5.2.9 **Comparison of Alternatives of Intake Type**

Items	1) Pump Intake without Weir	2) Fixed Concrete Type	3) Movable Gate Type
Main feature	 Structures: Riverbank protection	 Structures: Concrete fixed weir, Fish pass, Navigation path, Environmental gate, Riverbank raising	 Structures: Concrete foundation, Sluice gate, Fish pass, Navigation path, Maintenance bridge
Water level in flooding	No change A	Water level is raised by the weir (Backwater) C	Same as 1) Pump Intake without weir type A
Environmental flow of the river	No need to control A	Possible by installing the adjustment gate B	Possible by installing the adjustment gate B
Operation	No need A	Need for environment flow gate and navigation gate C	Need for environment flow sluice gate and navigation gate C
Sedimentation	Need to remove sedimentation near intake and low water channel; however, not so difficult B	Sedimentation will occur in front of the weir. And the riverbed is raised. The riverbank needs to be raised. C	Not occurring. Sediment will be flowed out by flushing out of gate operation. A
Reliability of intake flow	It depends on river water level; however, sufficient water level for intake in monsoon period. Need dredging work for maintaining the low water river route by dredging (Dredging cost BDT 31 mil./year) C	High reliability through the weir structure. A	High reliability through the weir structure. A
Maintenance	Maintenance dredging for keeping river flow is required. B	Maintenance for weir is basically not required, however, maintenance dredging is required. . B	Maintenance and inspection of the main gates. Need electric power and operation. Some staff must work in the site for operation and need the staff house near the site. C
Installed inventory	None of the structures. This type is normal in this country. A	Many works in small creek/river B	There is none generally in large rivers and WASA has no experience of this gate type. C
Construction difficulty	No structures required, common practice in Bangladesh A	A lot of experience in small canals and rivers, however, no experience in large river such as the Matamuhuri River. B	Not common on larger rivers such as the Matamuhuri River and WASA have no experience with it. C
Construction Cost (x10^6 BDT)	Intake structure 421 Riverbank protection 258 Total 679	Intake structure 97 Weir and gate structure 620 Riverbank protection 265 Total	Intake structure 97 Weir and gate structure 2,075 Total 2,172

Items	1) Pump Intake without Weir		2) Fixed Concrete Type		3) Movable Gate Type	
			982			
Natural Environmental Impact	Since the current flow rate will be maintained, the impact is assumed to be small. B		The impact on downstream flows is assumed to be small because environmental flow is maintained by the operation of environmental flow gates. On the other hand, it could affect the migration of fish and aquatic fauna. C		The impact on downstream flows is assumed to be small because environmental flow is maintained by the operation of environmental flow gates. On the other hand, it could affect the migration of fish and aquatic fauna. C	
Social Impact	No impact is assumed. B		No impact is assumed. B		No impact is assumed. B	
Evaluation	1	This type is normal in this country and BWDB staff have skills in this type.	3	Necessity of levee raising as river protection work. Construction costs are higher than Type 1. Gate operation of navigation gate and environment gate is necessary all day in BWDB staff house.	2	Construction cost is highest in all types. Gate operation of navigation gate and environment gate is necessary all day in BWDB staff house.

A: better, B: good, C: fair, D: poor, E: not recommendable

Source: JICA Survey Team

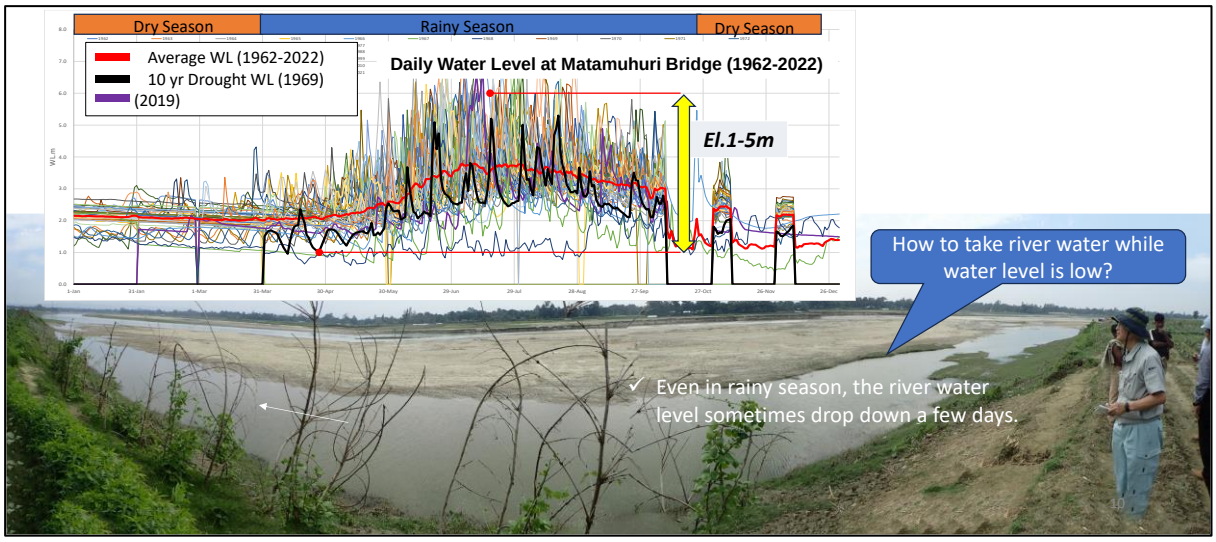
(4) Study for Pump Intake Without Weir

1) Consideration of intake water level fluctuation

A technical study on issues related to the water intake method of "pump intake without weir" is carried out, as stated below.

The past daily water level at Matamuhuri Bridge is presented in Figure 5.2.26 below. The daily river water level fluctuates widely in the rainy season because the Matamuhuri River is located in a hilly area with a relatively steep slope of the basin. This river basin characteristic causes flash floods when there is heavy rainfall in the basin, but on the other hand, the river water level sometimes drops down for a few days even in the rainy season as shown in Figure 5.2.26.

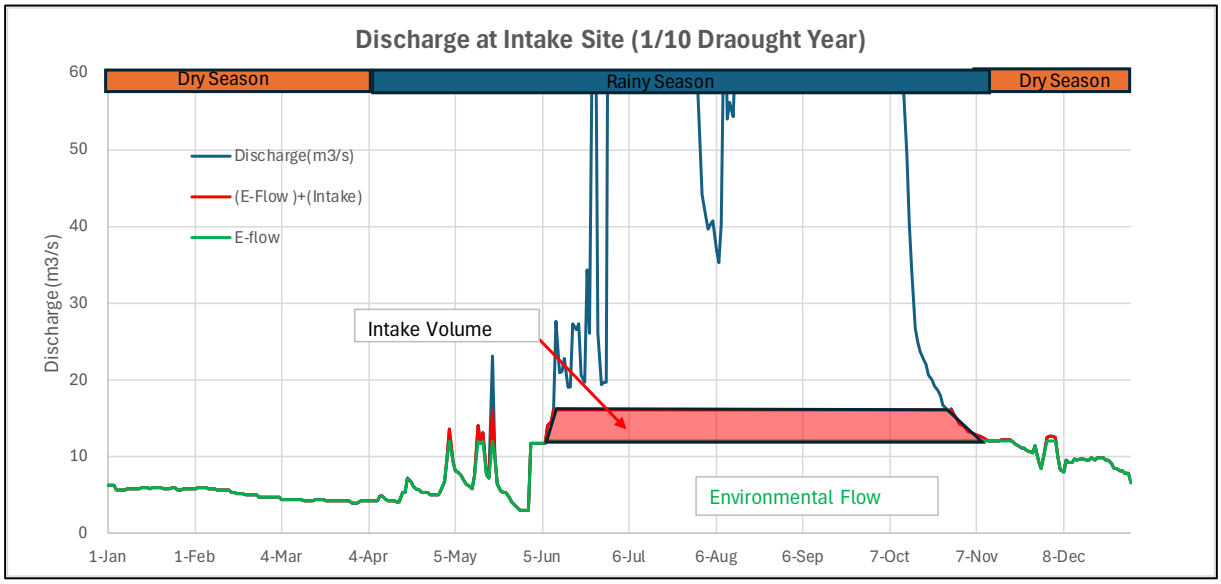
It should be considered how to take water from the river without constructing a weir under the condition where the river water level fluctuates rapidly and becomes low even in the rainy season.



Source: JICA Survey Team

Figure 5.2.26 Daily River Water Level at Matamuhuri Bridge and Photo of Matamuhuri River Intake Site during Low Water Level

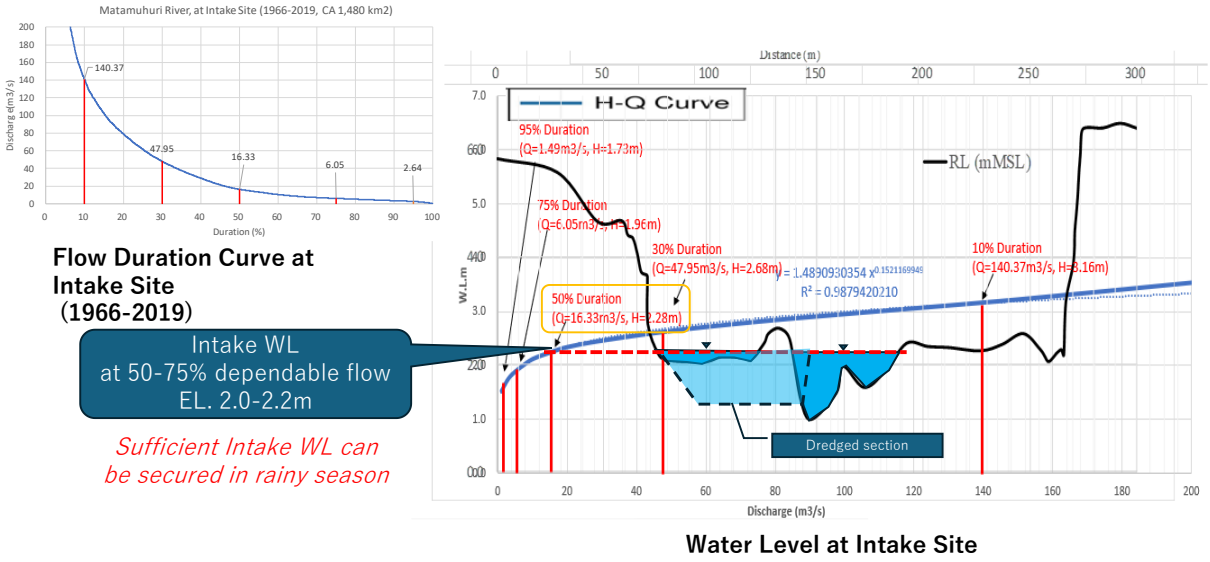
Figure 5.2.27 below shows the proposed water intake operation. It shows the discharge fluctuation throughout the year, where the blue line is the river discharge, and the green line is the river environmental flow at the intake site. Water intake is basically carried out during the rainy season, and the necessary amount of water is taken when the river flow exceeds the environmental flow. The red shading indicates the timing and amount of water intake.



Source: JICA Survey Team

Figure 5.2.27 Daily Discharge and Intake Operation in Case of 1/10 Drought Year

Figure 5.2.28 below shows the flow duration curve and the river channel cross section with the water level at the time of water intake at the intake site. As shown in the figure, when water is taken during the rainy season, the water levels are from around 2.0 m to 2.2 m, that is considered as sufficient water level for stable water intake operation, for 50% to 75% dependable flows (6.1 m^3/s - 16.3 m^3/s), respectively, and the required water intake level is confirmed to be kept during the rainy season.



Source: JICA Survey Team

Figure 5.2.28 River Intake Water Level at Intake Site

2) Consideration of river channel stabilization

The issue of river channel stabilization is considered next. The left part in Figure 5.2.29 shows the historical river morphology from 1980 to recent years which was studied separately under the NODI Project. As shown in the figure, the river channel at the water intake site has been meandering greatly from side to side.

The right part in Figure 5.2.29 shows the condition of the riverbank at the intake site before and after the big flood caused in August 2023. Currently, the riverbank has been eroded by about 2 to 3 meters due to the big flood. Considering the river channel's meandering conditions, the challenge is how to take water for the water supply from the river since the river channel in front of the intake may be moved to opposite side and sedimentation would be accumulated at intake.

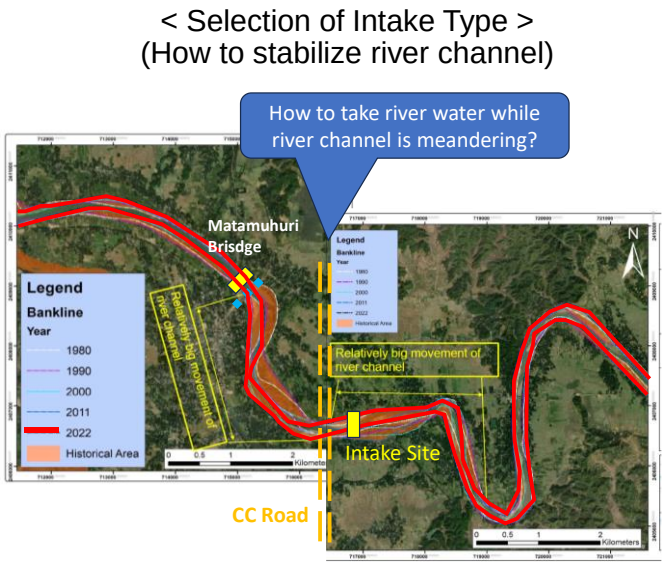


Figure: Record of River Shifting (Source: NODI)



Site Condition of Proposed Intake Site in Matamuhuri River

Source: JICA Survey Team

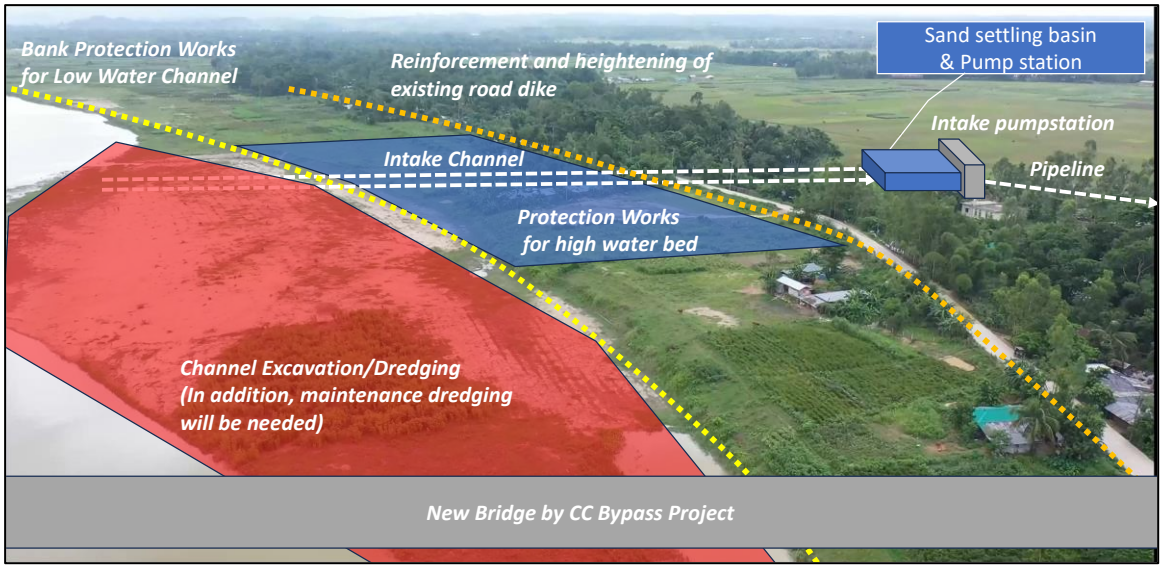
Figure 5.2.29 Riverbank Shifting at Intake Site

Figure 5.2.30 below is a bird's-eye view photo taken by a drone at the water intake point. The layout plan envisages installation of intake channel on the right bank just upstream of the CC Bypass Road bridge.

The riverbank along the low water channel, indicated by the yellow dashed line, is to be protected with bank protection works to stabilize the river channel. In front of the water intake, there are sandbars and sediment deposits which need to be excavated and dredged. In addition, in the future, after excavation and dredging, it is expected that sediment will accumulate in this area again; thus, it is recommended to conduct periodic excavation and dredging.

Currently, the existing road indicated by the orange dashed line is used as a dike road, but according to the flood control plan in the NODI Project, the dike is planned to be raised and reinforced in the future.

The intake water can pass through an intake channel of a culvert to be buried in the high water channel, flowing to the sand settling basin behind the embankment, and subsequently delivered to the raw water reservoir by pipeline from the intake pumping station.

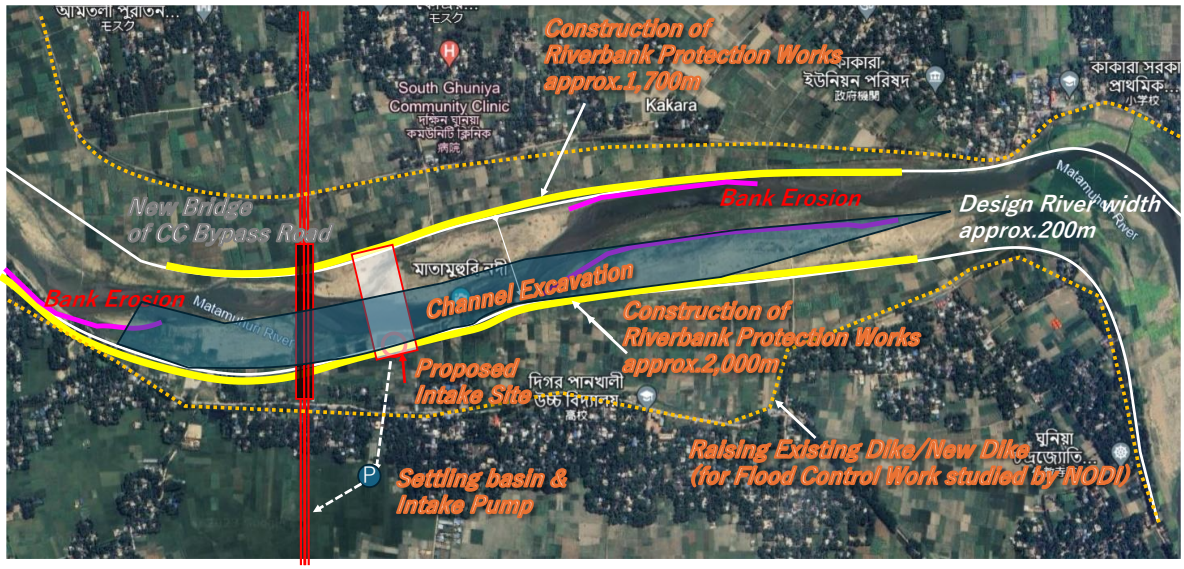


Source: JICA Survey Team

Figure 5.2.30 Bird's View Plan of River Facilities in Intake Site

Figure 5.2.31 below shows the layout plan of the riverbank stabilization measures mentioned above in the bird's eye view diagram. The north-south red line is the CC Bypass Road, and the water intake is on the right bank just upstream of it. The two yellow lines are the riverbank protection works for the low water channel, and the blue shaded area is the excavation/dredging of the river channel. The two orange broken lines both on the left and right banks are the existing road dikes constructed by BWDB.

In the next stage of the survey, the facilities for the riverbank protection works will be designed based on the results of the topographic survey and the geological investigation mentioned in Section 4.2.2. It is preliminarily considered, as of preparing this report, that the riverbank protection works for the low water channel are expected to be extended to cover the current riverbank erosion area. It is assumed that the length of the bank protection works is 1,700 m, and the width of the low channel is approximately 200 m. Although this is an approximate value before detailed investigation and study, the dredging area is approximately 1,000 m long and 100 m wide and the maintenance dredging volume is 50,000 m^3/year considering the annual deposition of 0.5 m depth.



Source: JICA Survey Team

Figure 5.2.31 Layout Plan of River Facilities in Intake Site

3) Consideration of hydraulic model experiments and analysis during detailed design stage

The details of the layout and scale of structural measures and specifications for maintenance dredging in the above plan of "pump intake without weir" shall be examined through hydraulic model experiments and sediment hydraulic analysis during the detailed design stage.

It is proposed that the sediment hydraulic analysis at the time of detailed design be carried out with the following outcomes:

- Evaluation of future river channel fluctuations near the water intake structure (plane, longitudinal section)
- Proposal of the spatial range (extension, depth, amount) of dredging in front of the intake, which is necessary for sustainable operation of the intake facility, and proposal of the temporal range of dredging (implementation frequency, implementation timing, etc.)
- Evaluation of the effectiveness of river channel stabilization measures as case study on the installation range, scale, spacing, type, and direction, etc. of proposed bank protection works and spur dikes.

4) Alternative study for pump water intake without weir

As alternative options of the pump water intake without weir, the following methods are compared and studied.

Alternative 1 is the original plan + low water intake, and Alternative 2 is based on the comments made during the joint field survey with BWDB in November 2023, considering duplication of water intake methods. Alternatives 3 and 4 are the methods adopted for existing water intake from other rivers in Bangladesh.

Alternatives for Pump Intake without Weir

Alt.1 : Intake + Low Water Intake Type

This type has two intakes; one intake at the left side of low water channel and low level channel intake for collecting the water during emergency with pump at bank

Alt.2 : Intake and Collector Pipe Type

This type is an intake and collector pipe type; one intake and collector pipe under the riverbed. The collector pipe is a porous pipe for collecting the water.

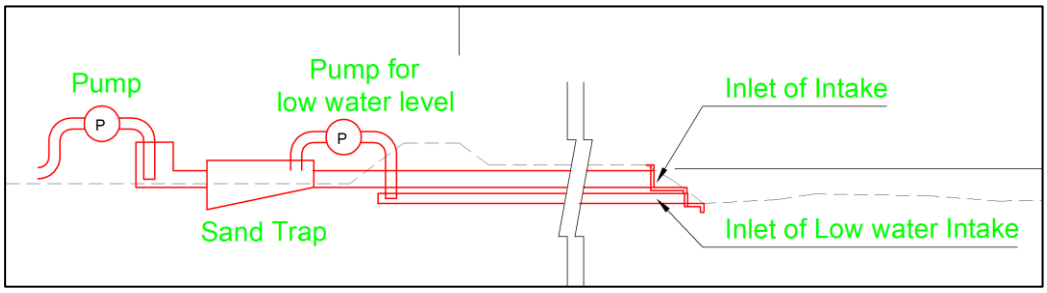
Alt.3 : Bridge Pier Intake

The bridge pier has a pipe as intake. The water in pipe is conveyed by the pump on the pier. The piers are connected by the bridge.

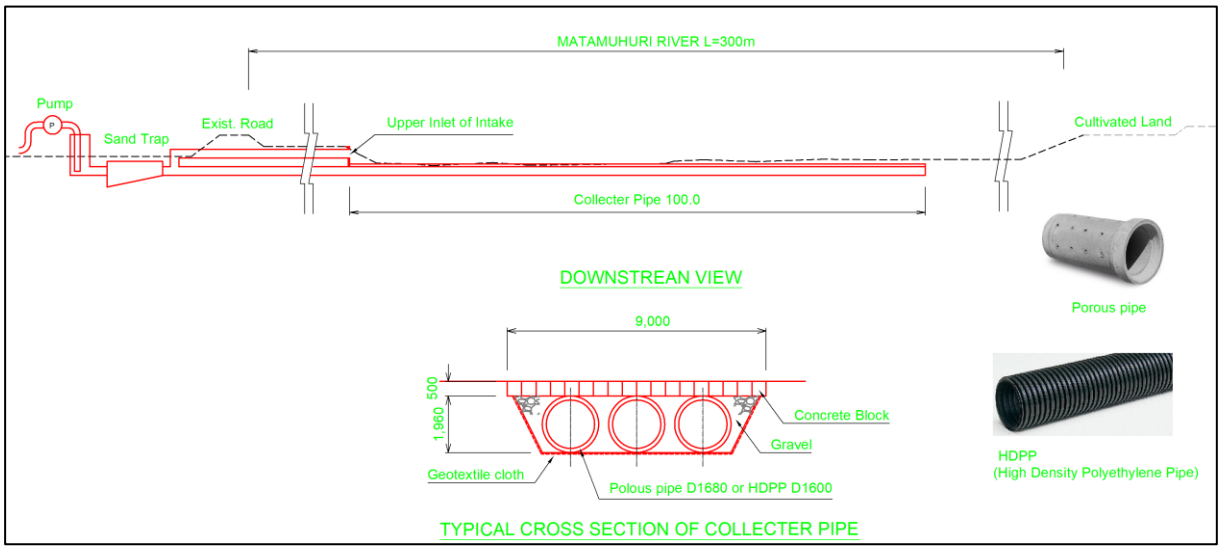
Alt.4 : Pontoon (Pump Boat)

A pontoon with inlet pipe and pump. The water is conveyed through the inlet pipe.

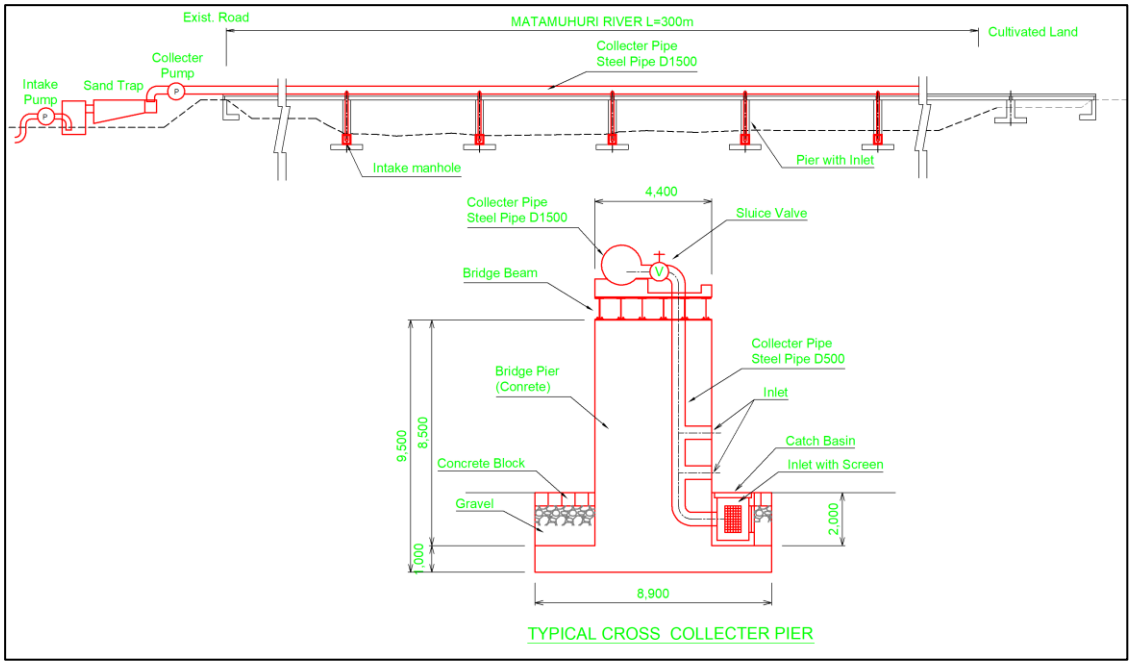
Alt.1: Intake + Low Water Intake Type



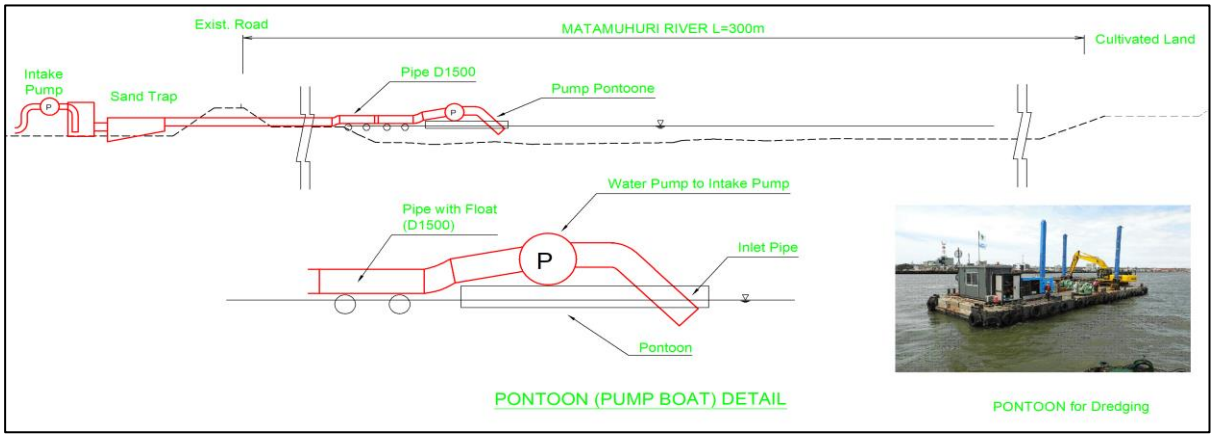
Alt.2: Intake and Collector Pipe Type



Alt.3: Bridge Pier Intake



Alt.4: Pontoon (Pump Boat)



Source: JICA Survey Team

Figure 5.2.32 Alternative Options of Pump Water Intake without Weir

The comparison table of the abovementioned options is presented below.

Table 5.2.10 Comparison of Alternative Options of Pump Water Intake without Weir

Items	1) Intake + Low Water Intake Type	2) Intake and Collector Pipe Type	3) Bridge Pier Type	4) Pontoon Type (Tentative Method)
Main feature	Structures: 2 Inlets, Normal Intake and Low Water Intake	Structures: 2 Inlets, Collector Concrete Pipe D1500, and Concrete Block, Concrete Box Culvert	Structures: Crossing Bridge, Catch Basin, Collector Pump, and Steel Pipe D1500	Structures: Pontoon with Pump and Steel Pipe D1500
Reliability of intake flow	Pump up through low water intake and box culvert . Dredging work is necessary for maintaining low	Adequate flow by low inlet elevation A	Adequate flow by pumping up A	Pump cannot work in case of low water level because many sand in riverbed will be collected with water.

Items	1) Intake + Low Water Intake Type	2) Intake and Collector Pipe Type	3) Bridge Pier Type	4) Pontoon Type (Tentative Method)
	waterway. B			C
Sedimentation by structure	No sedimentation by the structure. A	No sedimentation by the structure. A	No sedimentation by the structure. A	No sedimentation by the structure. A
Sedimentation around the intake structure	Hardly affected or removed easily A	Sedimentation will occur in the collector pipe or above its pipe. Removing sediment in the pipe is difficult. D	Catch basin will be buried by the sediment. Maintenance is necessary for sedimentation. Raw water includes high sediment content. B	Avoiding the sediment area A
Operation	No need in normal water level A	No need; however, intake pump cost is higher than 1) because average water level is lower than 1) B	Need pump operation and its operation cost C	Need pump operation and its operation cost C
Treatment in river course changing	Removing sediment by dredging or excavator. Its cost is approx. BDT 31 mil./year. C	Not affected by long collector pipe under the riverbed. A	Not affected by collector pipe of other pier A	Not affected by moving the pontoon A
Flooding time	Not affected A	Collector pipe may be broken by flooding C	Not affected A	Need to move to bank side to avoid flooding C
Maintenance	No need A	Need collector pipe. Collector pipe is difficult for inspection. C	Need collector pipe and collector pump system. Pipe inspection is difficult. C	Need collector pipe and collector pump system. B
Construction Cost	Small A	Between 1) and 3) B	Highest cost of all types C	Between 1) and 3) B
Evaluation	1 Intake flow is maintained by normal intake and low water intake.	3 Not available: Collector pipe cannot be maintained.	2 Bridge construction and operation have high cost. Catch basin will be buried by flooding water every time.	No evaluation: tentative method and intake water is difficult in low water level.

A: better, B: good, C: fair, D: poor, E: not recommendable

Source: JICA Survey Team

(5) Determination of Intake Type (Pump Water Intake without Weir)

Based on the above studies and considerations, and through discussions with related organizations, the Alt.1 “Pump Intake without Weir" is adopted as the type of intake structure.

In addition, as mentioned above, the following three conditions must be satisfied for the adoption of this proposal:

- Conditions for maintenance and management are required.
- Stabilization measures for river channels are required.
- Hydraulic model tests during detailed design, structural measures based on sediment hydraulic analysis, maintenance dredging examination and planning.

The layout design of the intake facility is shown in Section 6.2.3.

In order to sustain the functionality of the intake structure in the future, appropriate maintenance and management of the sedimentation in front of the intake structure are necessary.

Although it is still at the preliminary study stage, the specifications for maintenance dredging are shown below.

Specification of Maintenance Dredging (Concept)

i) Purpose : to sustain and stabilize the intake operation
ii) Target Area : low water channel upstream and downstream of the intake
e.g., l: 2,000 m, w: 30m, d: 1.0 m => V=60,000 m^3
iii) Frequency : every year (after rainy season)
In case of extreme flood, emergency dredging should be done
iv) Method : by permanent dredger (cutter suction),
disposal to spoil banks (suitable materials can be reused)
v) Organization : Implementing Agency (BWDB)
vi) Annual budget : Approximately BDT 31 million required budget for monitoring of river channel, dredging operation, spoil bank management shall be allocated to BWDB by the implementing agency.

5.2.9 Alternative Study of Raw Water Reservoir Site

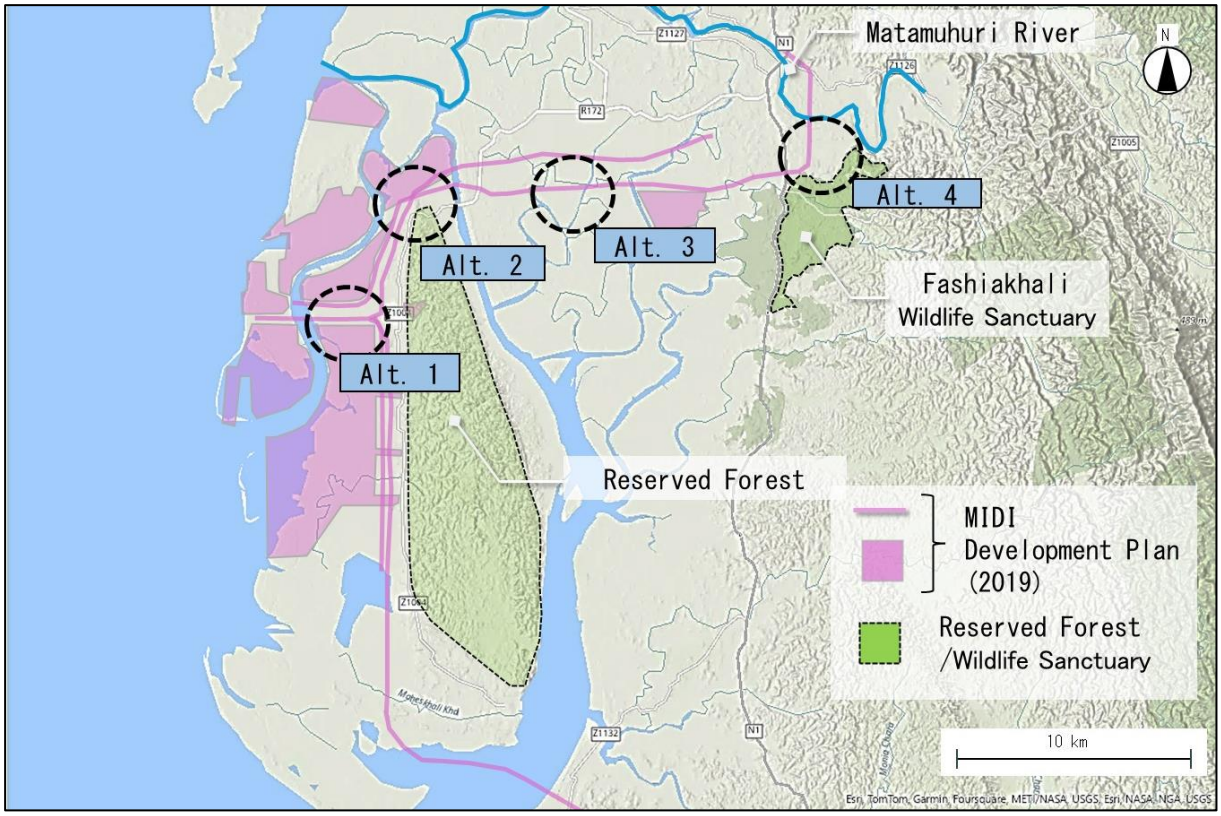
Considering the following conditions for the reservoir construction locations, the four alternative sites are selected as shown in Figure 5.2.33 below:

- Between the water intake and the water demand area (Matarbari/Moheshkhali Economic Zone).
- Consistency with the land use in the regional development plans and no duplication in future land use.
- A location where a large area of land can be secured.
- The reservoir structure composes of 1) embankment, 2) inlet and outlet, 3) access road to reservoir inside, and 4) spillway. The reservoir main structure and embankment are selected due to the following reasons:
  - Easier treatment for settlement of weak foundation, such as extra banking,
  - Cheaper than other methods, and
  - Easier maintenance and cost, because it is not necessary to use special tool, material, and skilled workers.

Alternatives of Raw Water Reservoir

- Alt.1: Near Moheshkhali Economic Zone (Dhalghata)
- Alt.2: Between the intake point and Moheshkhali Economic Zone (Dhalghata) (a bit closer to Matarbari)
- Alt.3: Between the intake point and Moheshkhali Economic Zone (Dhalghata)

- Alt.4: Near water intake point



Source: JICA Survey Team

Figure 5.2.33 Location Map of Alternatives of Raw Water Reservoir Site

The above alternative sites are compared in terms of natural environment, social environment, and consistency with development plans. The comparison results of the alternatives of raw water reservoir site are presented in Table 5.2.11 below.

Through the study, Alt.3, "Between the intake point and Moheshkhali Economic Zone (Dhalghata)", was determined to be the most recommended alternative. The evaluation process is described below.

Alternatives were evaluated for "environmental and social impacts" from the perspective of sustainability, and "consistency with development plans" was also evaluated to avoid interference with the planned sites, as the area is under consideration for development under the MIDI.

Regarding "environmental and social impacts", all of the alternative sites are expected to have a significant social impact due to the loss of livelihood. In particular, the scale of resettlement is expected to be large for Alt.2 and Alt.4. On the other hand, Alt.3 is in public land and is expected to have the smallest impact on land acquisition. Regarding the natural environment, Alt.4 is expected to be constructed in a wildlife sanctuary; Alt.1 is not in a protected area, but is expected to cut mangrove forests; and Alt.2 is in a reserved forest of hilly area and is expected to cut the forests. Alt.3 is in agricultural land and is not expected to have a significant impact. Therefore, Alt.3 is evaluated as the highest priority alternative in terms of "environmental and social impacts".

Regarding "consistency with development plans", all of the alternative sites have already been considered for development projects in the vicinity. However, Alt.3 can avoid the planned development project sites. Alt.1, Alt.2, and Alt.4 include sites that are already under consideration for a development plan. Therefore, Alt.3 is evaluated as the highest priority alternative in terms of "consistency with development plans".

Item	Alt. (1)	Alt. (2)	Alt. (3)	Alt. (4)
Site outline	Near Moheshkhali Economic Zone (Dhalghata)	Between the intake point and Moheshkhali Economic Zone (Dhalghata)	Between the intake point and Moheshkhali Economic Zone (Dhalghata)	Near the water intake point
Consistency with development plans	Part of the site is under consideration for use as a special economic zone under the Bangladeshi government's land use plan, and coordination with the plan is required.	Part of the site is under consideration for use as a special economic zone under the Bangladeshi government's land use plan, and coordination with the plan is required.	There is a plan to develop a road; however, the planned development site can be avoided.	Part of the site is under consideration for use as residential area under the Bangladeshi government's land use plan, and coordination with the plan is required.
	D	D	C	D
Natural environment impact	There are mangrove forests along the riverbanks, which are expected to be cut by this project.	Reserved forest is located in the hilly area and is expected to be cut in order to the development of flat land.	No significant impacts are expected.	Ecological impacts are expected because Fashiakhali Wildlife Reserve is located near the site.
	E	E	C	E
Social impact	Although the scale of resettlement is small, loss of livelihood is assumed because the site is currently used for agriculture. Private land may be included, and land acquisition is required.	The scale of resettlement is large because there are certain numbers of households along the existing road. Loss of livelihood is assumed because the site includes agriculture land. Private land may be included, and land acquisition is required.	Although the scale of resettlement is small, loss of livelihood is assumed because the site is currently used for agriculture. Land acquisition is not expected as the site is owned by government.	The scale of resettlement is large because there are certain numbers of households. Loss of livelihood is assumed because the site includes agriculture land. Private land may be included, and land acquisition is required.
	E	E	E	E
Evaluation	Impacts on the natural environment are assumed to be significant. The scale	Impacts on the natural environment are assumed to be significant. The scale	Impacts on the natural environment are assumed to be small, and coordination with	Impacts on the natural environment are assumed to be large and the scale of

Item	Alt. (1)	Alt. (2)	Alt. (3)	Alt. (4)
	of resettlement is assumed to be small. Coordination with other plans is necessary.	of resettlement is assumed to be large. Coordination with other plans is necessary.	other plans is not necessary. Livelihood restoration measures are necessary.	resettlement is assumed to be large. Coordination with other plans is necessary.
	2	3	1 (Recommended)	3

Therefore, Alt.3, which has the highest advantage in both "environmental and social impacts" and "consistency with development plans", has been evaluated as the most recommended alternative.

The social impacts of Alt.2 and Alt.4 are relatively large. The impacts on the natural environment are significant for Alt.1, Alt.2 and Alt.4, and the consistency with the development plans is the same situation for all of them. In other words, Alt.3, Alt.1, and Alt.2 and Alt.4 (2 and 4 are in the same order) are the recommended alternatives in order of precedence.

Table 5.2.11 Comparison of Alternative Options of Raw Water Reservoir

Item	Alt. (1)	Alt. (2)	Alt. (3)	Alt. (4)
Site outline	Near Moheshkhali Economic Zone (Dhalghata)	Between the intake point and Moheshkhali Economic Zone (Dhalghata)	Between the intake point and Moheshkhali Economic Zone (Dhalghata)	Near the water intake point
Consistency with development plans	Part of the site is under consideration for use as a special economic zone under the Bangladeshi government's land use plan, and coordination with the plan is required.	Part of the site is under consideration for use as a special economic zone under the Bangladeshi government's land use plan, and coordination with the plan is required.	There is a plan to develop a road; however, the planned development site can be avoided.	Part of the site is under consideration for use as residential area under the Bangladeshi government's land use plan, and coordination with the plan is required.
	D	D	C	D
Natural environment impact	There are mangrove forests along the riverbanks, which are expected to be cut by this project.	Reserved forest is located in the hilly area and is expected to be cut due to the development of flat land.	No significant impacts are expected.	Ecological impacts are expected because Fashiakhali Wildlife Reserve is located near the site.
	E	E	C	E

Item	Alt. (1)	Alt. (2)	Alt. (3)	Alt. (4)
Social impact	Although the scale of resettlement is small, loss of livelihood is assumed because the site is currently used for agriculture. Private land may be included, and land acquisition is required.	The scale of resettlement is large because there are certain numbers of households along the existing road. Loss of livelihood is assumed because the site includes agriculture land. Private land may be included, and land acquisition is required.	Although the scale of resettlement is small, loss of livelihood is assumed because the site is currently used for agriculture. Land acquisition is not expected as the site is owned by government.	The scale of resettlement is large because there are certain numbers of households. Loss of livelihood is assumed because the site includes agriculture land. Private land may be included, and land acquisition is required.
	E	E	E	E
Evaluation	Impacts on the natural environment are assumed to be significant. The scale of resettlement is assumed to be small. Coordination with other plans is necessary.	Impacts on the natural environment are assumed to be significant. The scale of resettlement is assumed to be large. Coordination with other plans is necessary.	Impacts on the natural environment are assumed to be small, and coordination with other plans is not necessary. Livelihood restoration measures are necessary.	Impacts on the natural environment are assumed to be large and the scale of resettlement is assumed to be large. Coordination with other plans is necessary.
	2	3	1 (Recommended)	3

Note: A/B: Impact ++/+ (Positive), C: No impact, D/E: Impact -/-- (Negative)

Source: JICA Survey Team

5.2.10 Basic Plan of Mechanical and Electrical Equipment

The main mechanical and electrical equipment for the river water intake facility are as follows.

(1) Intake Pump

Intake pumps convey 354,240 m^3/d (=4.1 m^3/sec) of the Matamuhuri River water to the raw water reservoir, of which the volume is 27 MCM, by conveyance pipes, ϕ 1,100 mm x 3. The pumps are normally operated 24 hours by 4 units only in the rainy season. The standby pumps, 2 units, are prepared in consideration of the long time to fix if it has a failure.

(2) Power Receiving and Transmission

The power receiving capacity of the river water intake facility is 3,000 kVA. It is confirmed by Cox's Bazar Palli Bidyut Samity (PBS) that the power, 3 ϕ x 33 kV x 50 Hz, will be provided from a nearby substation of this facility and the power supply route will be considered at the detail design stage. It is transformed to adequate low voltage, such as 6,600 V, 400 V and 230 V, for motor equipment, control devices, and lights by transformers in this facility.

(3) Emergency Power Generator

An emergency power generator is prepared to maintain the minimum functions of this facility when power supply is stopped due to blackout occurrence. The necessary capacity and the type are to be decided by further study.

(4) Digital Systems

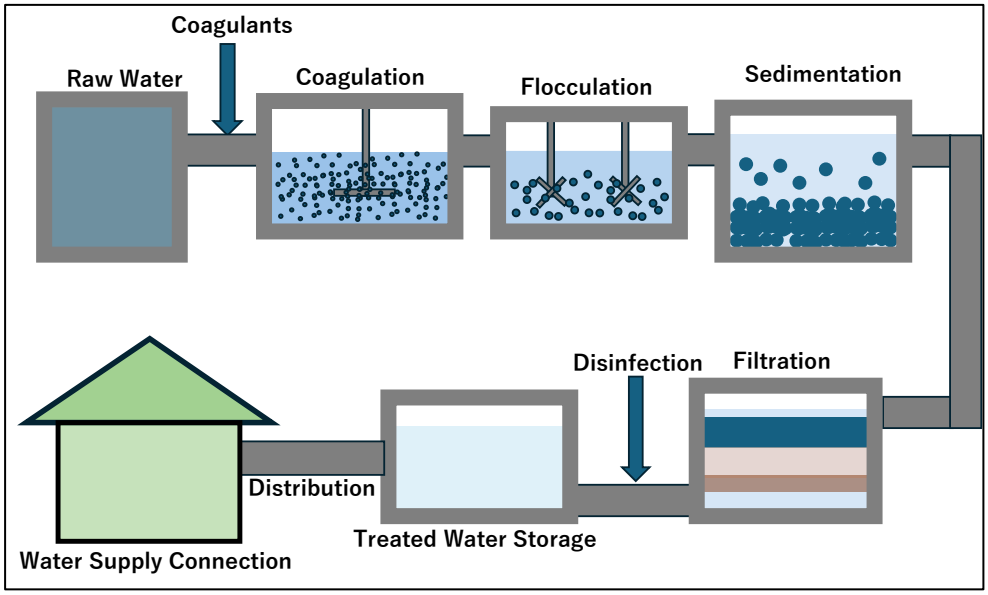
The equipment in this facility is operated at the site and also supervised and controlled from the central control room in the Water Treatment Plant. A Distributed Control System (DCS) is installed as supervisory and control system.

5.3 Water Treatment and Distribution Basic Plan

5.3.1 Basic Plan for Water Treatment

(1) Treatment Process

A typical water treatment process is composed of coagulation, flocculation, sedimentation, filtration, and disinfection as shown below.



Source: JICA Survey Team

Figure 5.3.1 Typical Water Treatment Process

The domestic water needs to meet the Bangladeshi drinking water quality standards as stipulated in the Bangladesh Environmental Conservation Rules (MoE, 2023), so all treatment including disinfection processes need to be implemented.

On the other hand, since industrial water can be treated by only sedimentation process depending on the water quality requirement. In this case, the roughly estimated construction costs could be reduced by 15% and O&M costs by 30%.

However, after discussions with BEZA, it was decided to adopt the water treatment process including filtration and disinfection for the industrial water supply of the Project as well, since the industrial type of the companies that will move in is yet to be determined and the currently planned BSMSN industrial park requires drinking water quality standards.

(2) Water Treatment Plant Capacity

The daily maximum production for industrial and domestic water is shown below. Based on this result, the water treatment plant capacity is set at 161,000 m^3/day.

Table 5.3.1 Proposed Production Amount for Water Treatment Plant

Projected Value in 2041	Daily Maximum Production (m^3/day)	Note
Industrial Water	78,442	Intake Volume minus Loss Factor
Domestic Water	82,250	ditto
Total	160,692	

Source: JICA Survey Team

5.3.2 Basic Plan of Water Distribution

The matters to be considered for the construction of the water distribution system are to ensure fair distribution of water volume and control of non-revenue water within the target area. In order to achieve these matters, it is necessary to divide the entire water distribution system into several large distribution blocks. Each hydraulically independent block is connected to a water main at one inflow point where flow meters, water pressure gauges, and pressure control valves are installed.

In order to effectively control the amount of non-revenue water, each block is to be divided into several district metered areas (DMAs), which are delineated so that they can be hydraulically independent from each other.

(1) Distribution Blocks

The domestic water supply area of 30,811 ha (population: 706,089 in 2041, water demand: 82,250 m^3/day in 2041) was divided into six blocks (1 - 6) as shown in Table 5.3.2. In this division, the following conditions are taken into consideration in the target area:

- Municipality border,
- Geographical conditions,
- Major infrastructure facilities (major roads, railways, rivers), and
- Water demand in a block is to be around 20,000 m^3/day for system management.

Each block shall have an elevated water distribution tank (in other words, distribution reservoir (DR)) and the water is planned to be distributed from the DR by gravity.

The Moheshkhali Economic Zone (Dhalghata) area (water demand: 78,442 m^3/day in 2041) shall have several DRs and the water is planned to be distributed from the DRs by gravity.

Table 5.3.2 List of Distribution Block

Distribution Block	Union	Water Demand in 2041 (m3/day)
Distribution Block 1	Faiakhali	4,801
	Kakhara	4,164
	Kairarbil	3,166
	Lakhyarchar	1,253
	Total	13,383
Distribution Block 2	Chakaria Pourashava	25,506
Distribution Block 3	Bheola Manik Char	3,462
	Demusia	1,870
	Purba Barabheola	4,442
	Konakhali	3,179
	Paschim Bara Behola	1,498
	Total	14,452
Distribution Block 4	Badarkali	5,125
	Chringa	2,781
	Saharbil	3,417
	Total	11,324
Distribution Block 5	Kalarmarchhara	8,689
Distribution Block 6	Dhalgata	1,577
	Matabari	7,320
	Total	8,897
Distribution Block for Industrial Water	-	78,442

Source: JICA Survey Team

Figure 5.3.2 shows the locations of blocks and the DRs in the water supply area in the Project.

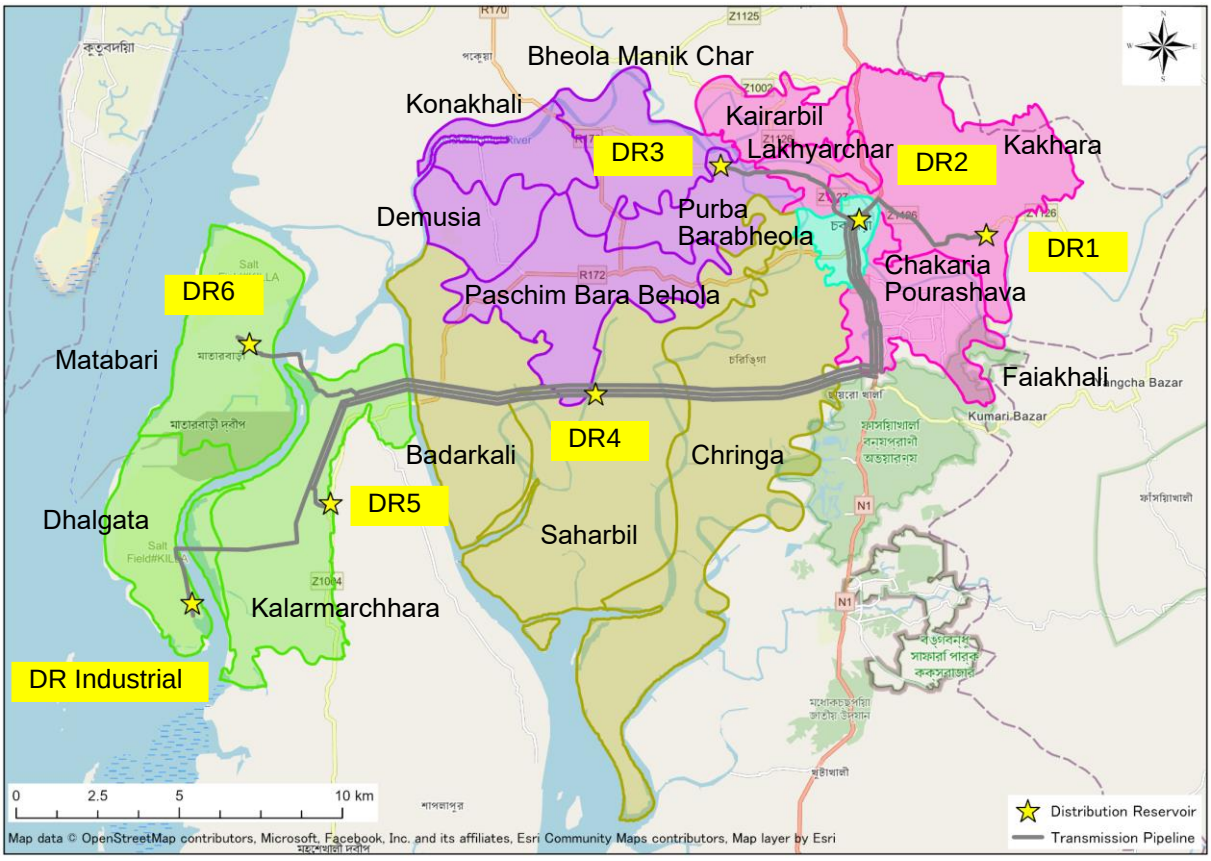


Figure 5.3.2 Map of Water Distribution Blocks and DRs

(2) Distribution Reservoir

The "Design Criteria for Waterworks Facilities 2012 (Ministry of Health, Labour and Welfare in Japan)" refers to the standards for the design of distribution reservoirs for different functional purposes.

The purposes of elevated reservoir installation are explained below.

- Case 1: to install reservoir for regulation of distribution flow,
- Case 2: to install reservoir for regulation of water pressure in service area served by pump, and
- Case 3: combination of Cases 1 and 2 above.

Case 3 shall be applied to the Project and the capacity shall be determined in consideration of the size of the water supply system, conditions of the service area, site situation of installation, ease of operation and maintenance, and economic conditions, among others. The capacity shall normally be set so as to be equivalent to around 1 to 3 hours of water of the maximum daily water supply.

A 3 hours equivalent of the maximum daily supply is applied for this water supply area in due consideration of space limitation along the existing roads.

Table 5.3.3 shows the details of the land selected for the construction of DRs; this information shall be mentioned in the DPP and the land transfer process shall proceed. The DRs for industrial water shall be located inside the proposed admin area in the Moheshkhali Economic Zone (Dhalghata) based on BEZA's instruction.

Table 5.3.3 List of Proposed Land for Water Distribution Reservoir

No.	Mouza Name	B.S/Diara Khatian Number	B.S/Diara Dag Number	Landowner
DR1	26 Kakara	1	7584	DC Office, Cox's Bazar
DR2	42 Chiringga	5	738, 735	DC Office, Cox's Bazar
DR3	45 Purba Barabheola	1	8711	DC Office, Cox's Bazar
DR4	Inside the land for Water Treatment Plant			
DR5	5 Japua	2	2587	Bangladesh Government of Education
DR6	1 Matarbari	3813	4830, 4832, 4833	Bangladesh Government of Education
DR Industrial	Inside the land for Moheshkhali Economic Zone (Dhalghata)			

Source: JICA Survey Team

Figure 5.3.3 - Figure 5.3.8 shows the maps of the land selected for the construction of DRs and water demand for each Distribution Block and the capacity of DR to meet the water demand.

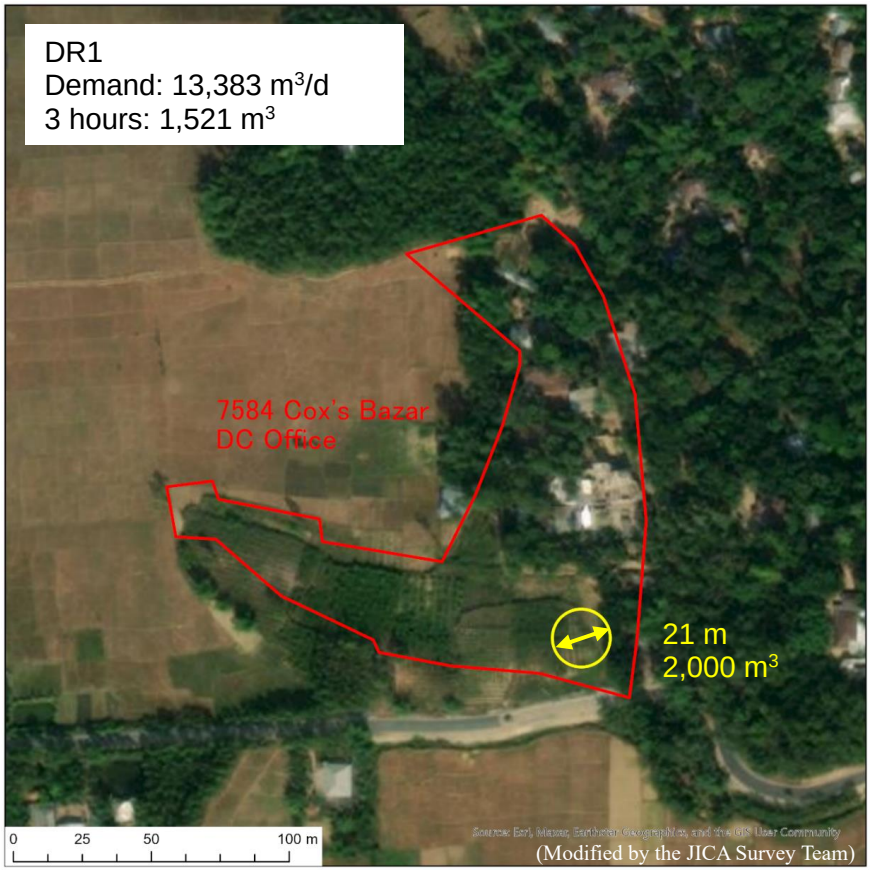


Figure 5.3.3 Map of Proposed Land for Water Distribution Reservoir (1/6)

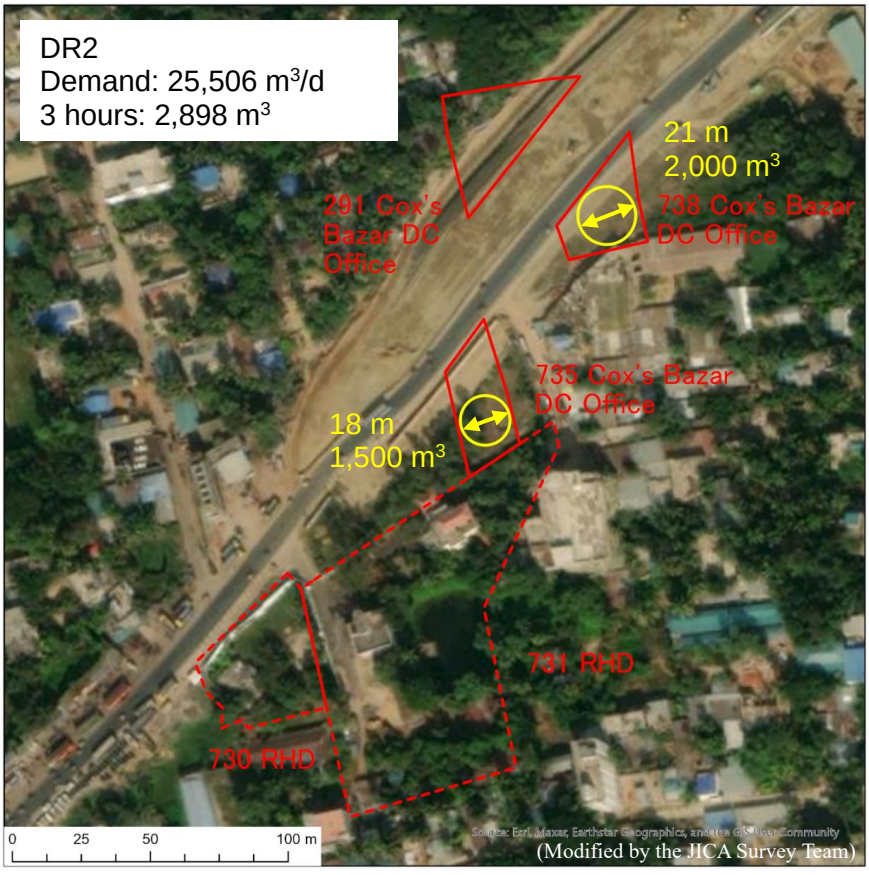


Figure 5.3.4 Map of Proposed Land for Water Distribution Reservoir (2/6)

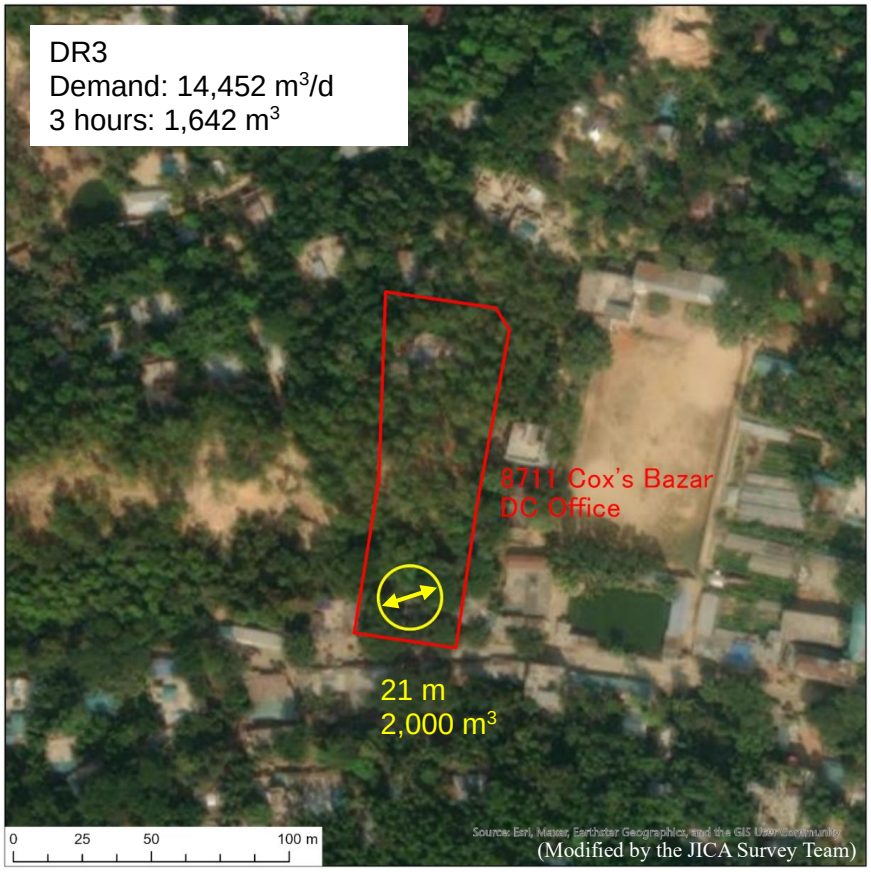


Figure 5.3.5 Map of Proposed Land for Water Distribution Reservoir (3/6)

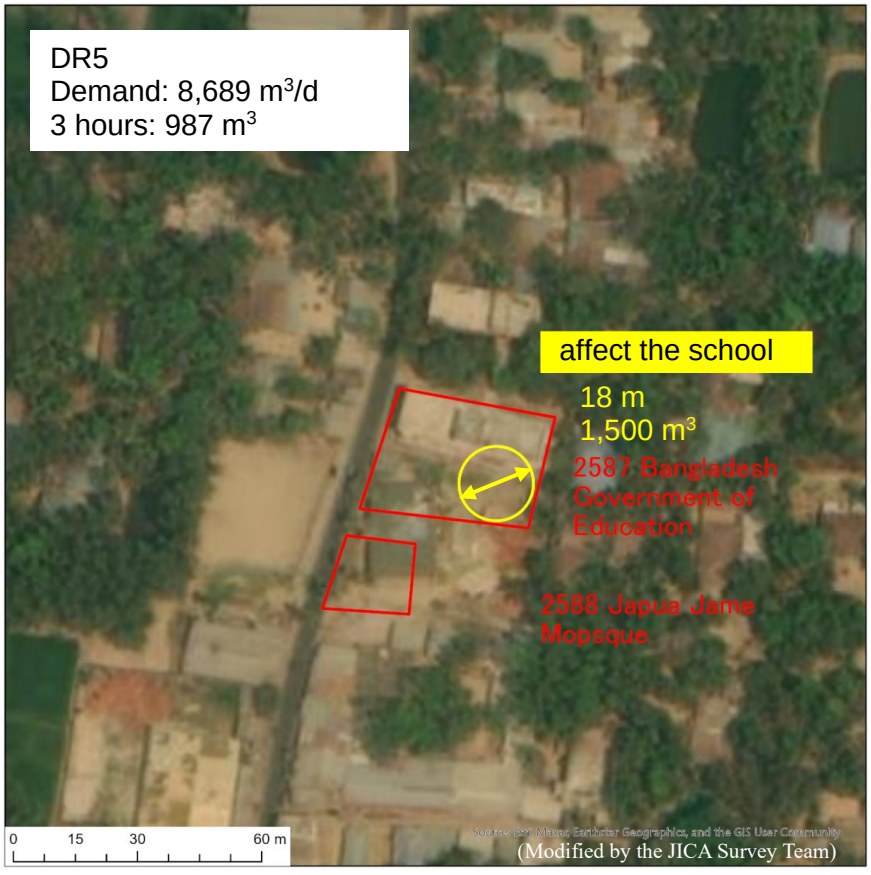


Figure 5.3.6 Map of Proposed Land for Water Distribution Reservoir (4/6)

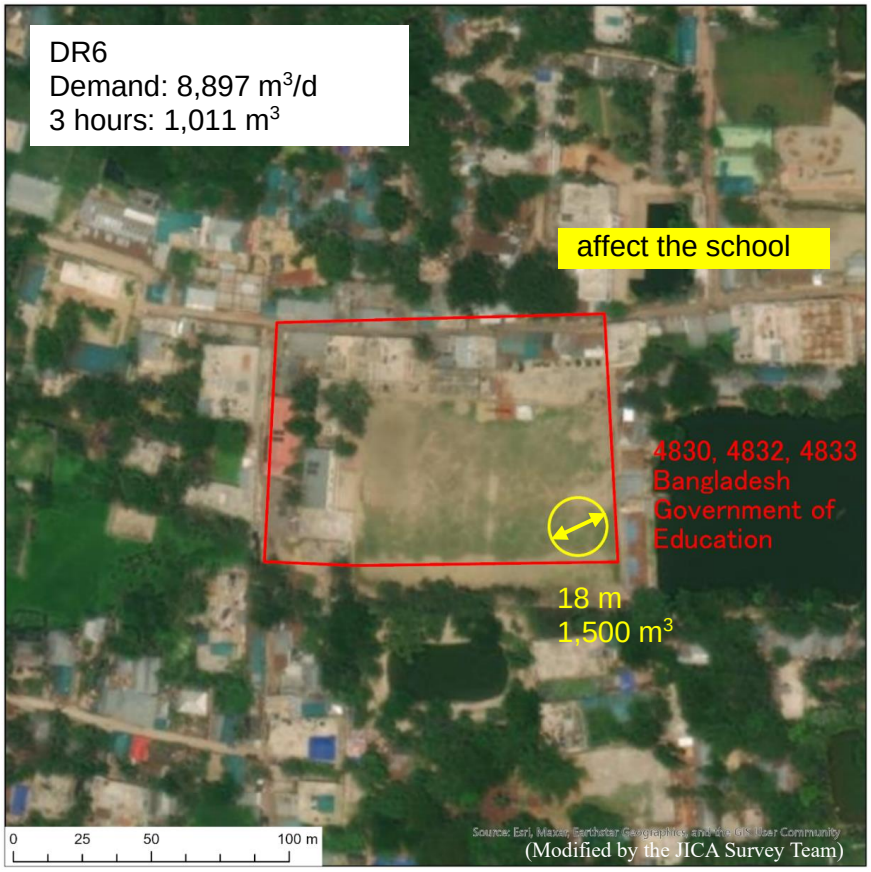


Figure 5.3.7 Map of Proposed Land for Water Distribution Reservoir (5/6)

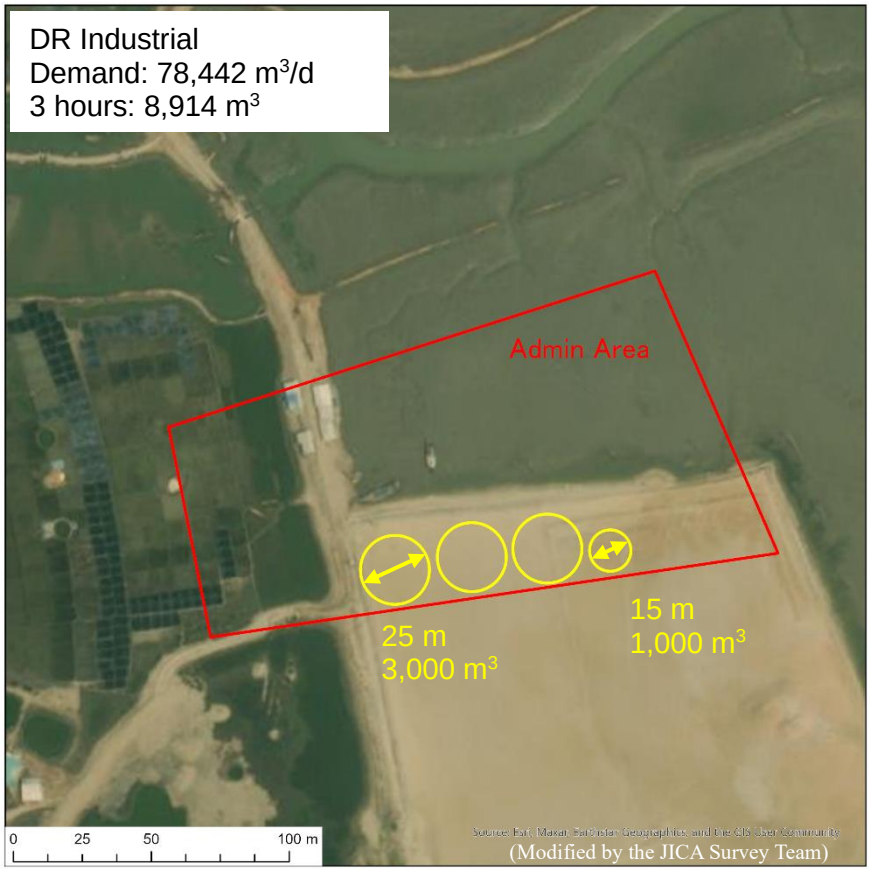
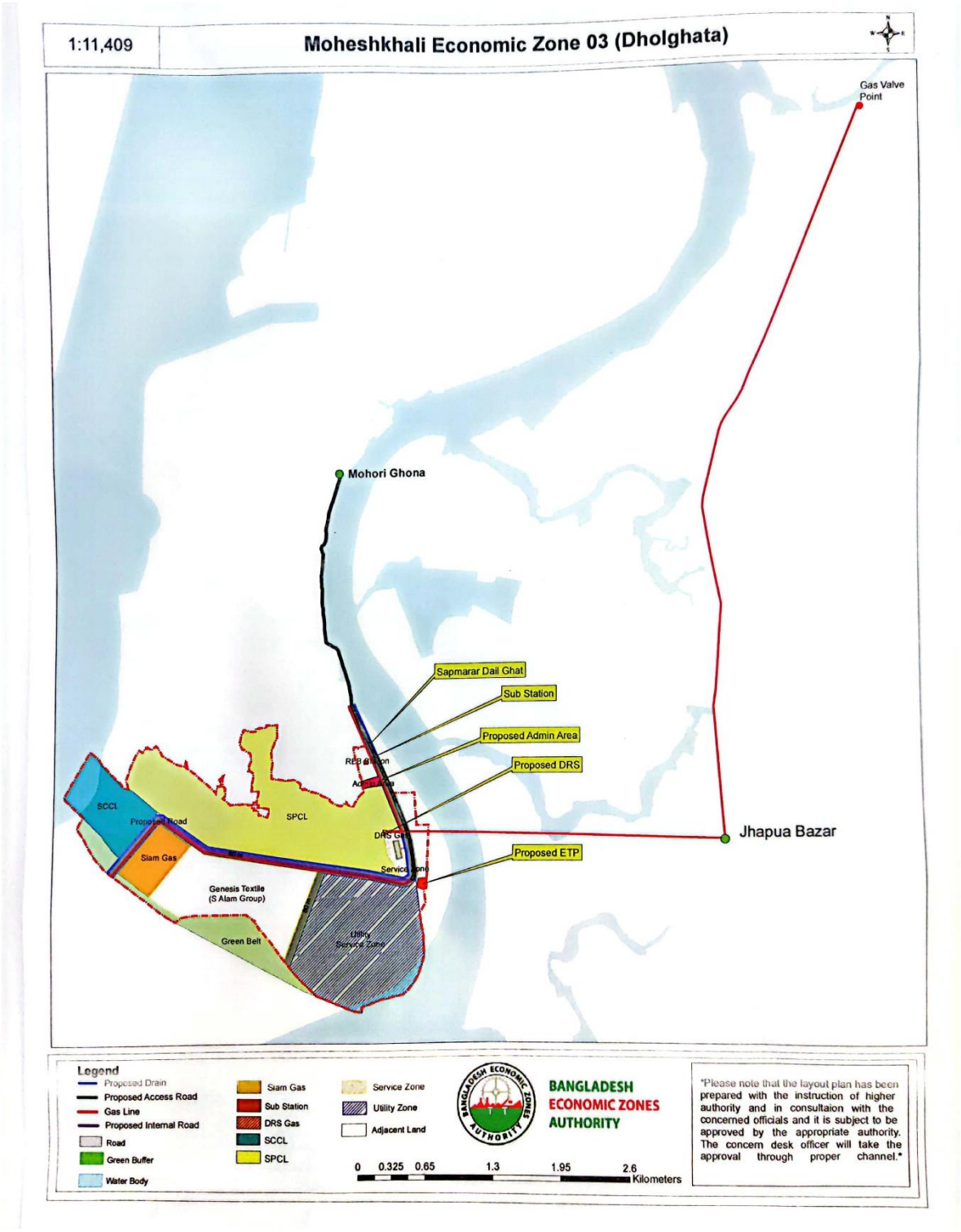


Figure 5.3.8 Map of Proposed Land for Water Distribution Reservoir (6/6)



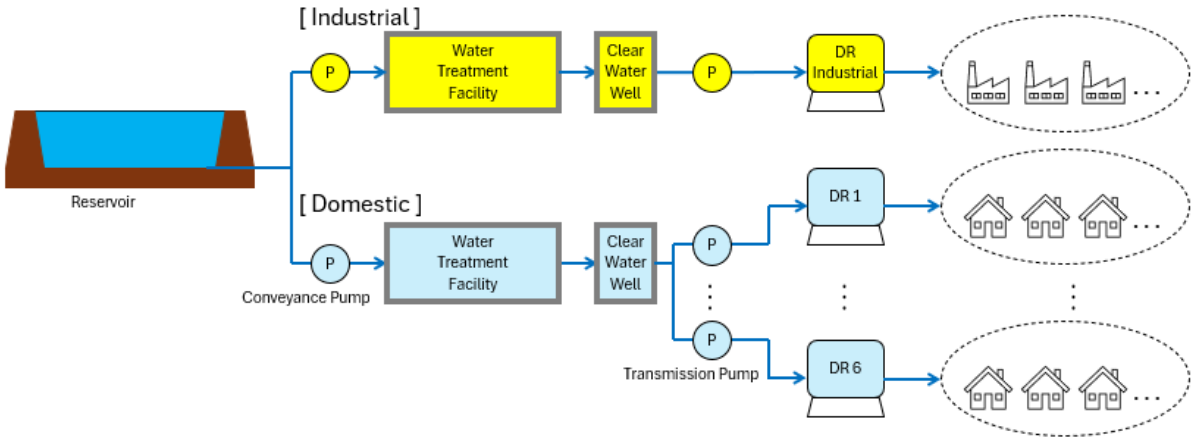
Note: This figure shows the information as of February 2024 and may have been updated after that.

Figure 5.3.9 Land Use Plan for Moheshkhali Economic Zone (Dhalghata)

5.3.3 Basic Plan of Mechanical and Electrical Equipment

The main mechanical and electrical equipment for the water treatment and distribution facility are as follows:

The water flow after the raw water reservoir is basically divided for industrial and domestic use. The water system diagram from the raw water reservoir to water distribution facility is shown as below.



Source: JICA Survey Team

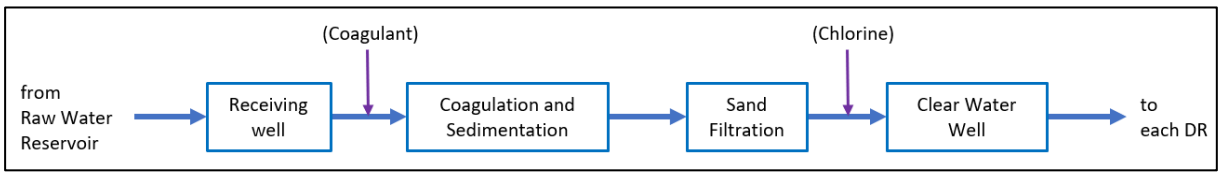
Figure 5.3.10 Water System Diagram

(1) Conveyance Pump

The conveyance pump conveys raw water to the 160,692m^3/d water treatment facility (WTF) from the 27 MCM raw water reservoir. The pumps are normally operated 24 hours by 2 units for industrial and 2 units for domestic. The standby pumps, 3 units for total, are prepared in consideration of the long time to fix if it has a failure.

(2) Water Treatment Facility

As described in "Sub-section 5.3.1", the treatment process for industrial and domestic water is the same and the capacity of the water treatment plant is total 160,692 m^3/d (78,442m^3/d is for industrial and 82,250m^3/d is for domestic). The treatment process flow is shown as below.



Source: JICA Survey Team

Figure 5.3.11 Treatment Process Flow

It is necessary to take into account the following points for the facility configuration of the water treatment plant.

- Each facility should be divided into more than two sections in consideration of the maintenance work such as cleaning and repair.
- The possibility that the treatment process for industrial and domestic water will be different for some reason (e.g., change of industrial water requirements, change of domestic water regulations and change of raw water quality) in the future.
- It is better to separate the industrial water and domestic water trains to clarify the cost structure of each in terms of water supply management.

Therefore, the water treatment plant is divided largely into 2 trains, one is for industrial water and the other for domestic water. And each facility in each train is divided into multiple sections. The capacity of each individual facility for industrial and domestic water is almost the same in consideration of compatibility.

(3) Transmission Pump

The transmission pump conveys clear water to the DRs for industrial water and 6 DRs for domestic water from the clear water well in the water treatment facility, respectively. The pumps are normally operated 24 hours by 2 or 4 units for each DR. The standby pumps (2 units) are prepared for each DR in consideration of the long time to fix if it has a failure.

(4) Power Receiving and Transmission

The power receiving capacity of the water treatment and distribution facility is 5,500kVA. It is confirmed by Cox's Bazar Palli Bidyut Samity (PBS) that the power, 3 ϕ x 33 kV x 50Hz, is provided from a nearby substation of this facility and the power supply route will be considered at the detail design stage. It is transformed to adequate low voltage, such as 400V and 230V, for motor equipment, control devices, and lights by transformers in this facility.

(5) Emergency Power Generator

An emergency power generator is prepared to maintain the minimum functions of this facility when power supply is stopped due to trouble such as occurrence of blackout. The necessary capacity and the type will be decided by further study.

(6) Digital Systems

The equipment in this facility is operated at the site and also supervised and control from the central control room in the Water Treatment Plant. A Supervisory Control and Data Acquisition (SCADA) system and a Distributed Control System (DCS) are installed as supervisory and control systems.

A Water Leakage Management System is also installed to enhance the stability and efficiency of water supply management.

5.4 Phasing for the Water Supply Project

5.4.1 General

The phasing of the water supply project was implemented to save project costs and improve the efficiency of project effectiveness.

Water supply system is composed of 1) Water sources, 2) Water Intake Facilities, 3) Raw Water Conveyance Facilities, 4) Water Treatment Facilities, 5) Treated Water Conveyance Facilities, 6) Distribution Facilities (6)-1 Distribution Reservoir , 6)-2 Distribution Mains), 7) Water Service Fittings (7)-A individual house connection, 7)-B public-tap connection). In this study several cases with different combination of the facilities are compared.

Case 1 Include the facilities from 1) Water sources to 5) Treated Water Conveyance Facilities (Exclude 6) Distribution Facilities and 7) Water Service Fittings)

Case 2 Include all the facilities from 1) Water sources to 7) Water Service Fittings
(for all of 16 Union/ Paurashava and Economic Zone)
(Note: individual house connection shall be applied for Paurashava since largest population per unit length of water supply pipeline and public-tap connection shall be applied for Union)

Case 3 Include the facilities from 1) Water sources to 5) Treated Water Conveyance and partial facilities of 6) Distribution Facilities and 7) Water Service Fittings
(for 2 Union/ Paurashava and Economic Zone)
(Note: Matarbari Union and Chakaria Paurashava: one each from Chakaria Upazila、Moheshkhali Upazila, largest population per unit length of water supply pipeline)

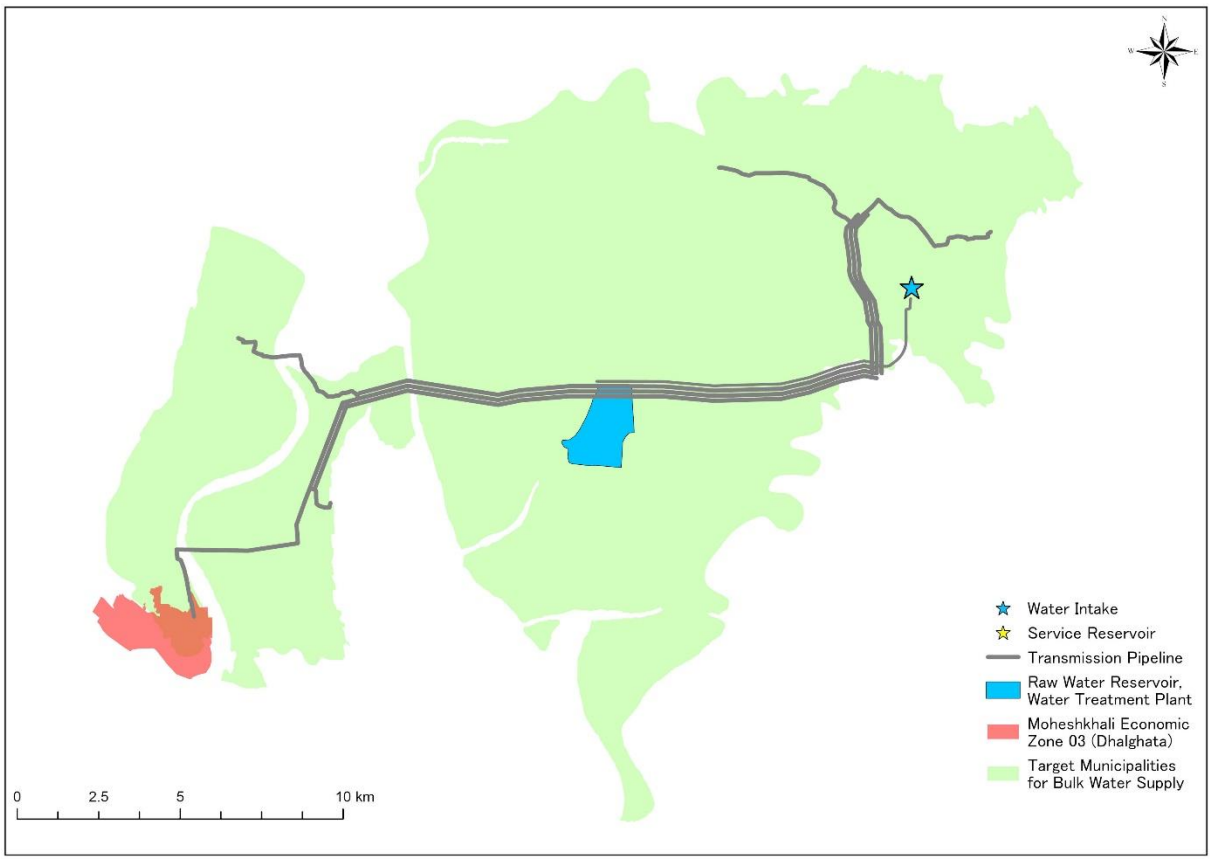
Case 1:

Include the facilities from 1) Water sources to 5) Treated Water Conveyance Facilities (Exclude 6) Distribution Facilities and 7) Water Service Fittings)

Table 5.4.1 Case 1: Facilities to be constructed

	Water Supply (m^3/d)	1) Water Sources	2) Water Intake	3) Raw Water Transmission	4) Water Treatment	5) Treated Water Transmission	5) Treated Water Transmission (m)	6)-1 Service Reservoir	6)-2 Distribution Trunk Main (m)	6)-2 Distribution Submain (m)	7) Water Service Fittings
Industrial	78,442	1 System	1 System	1 System	1 System	1 System	18,400	0	0	0	0
Domestic	82,250				1 System	6 System	77,200	0	0	0	0
										0	0

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5.4.1 Case1: Location Map of the Facilities to be constructed

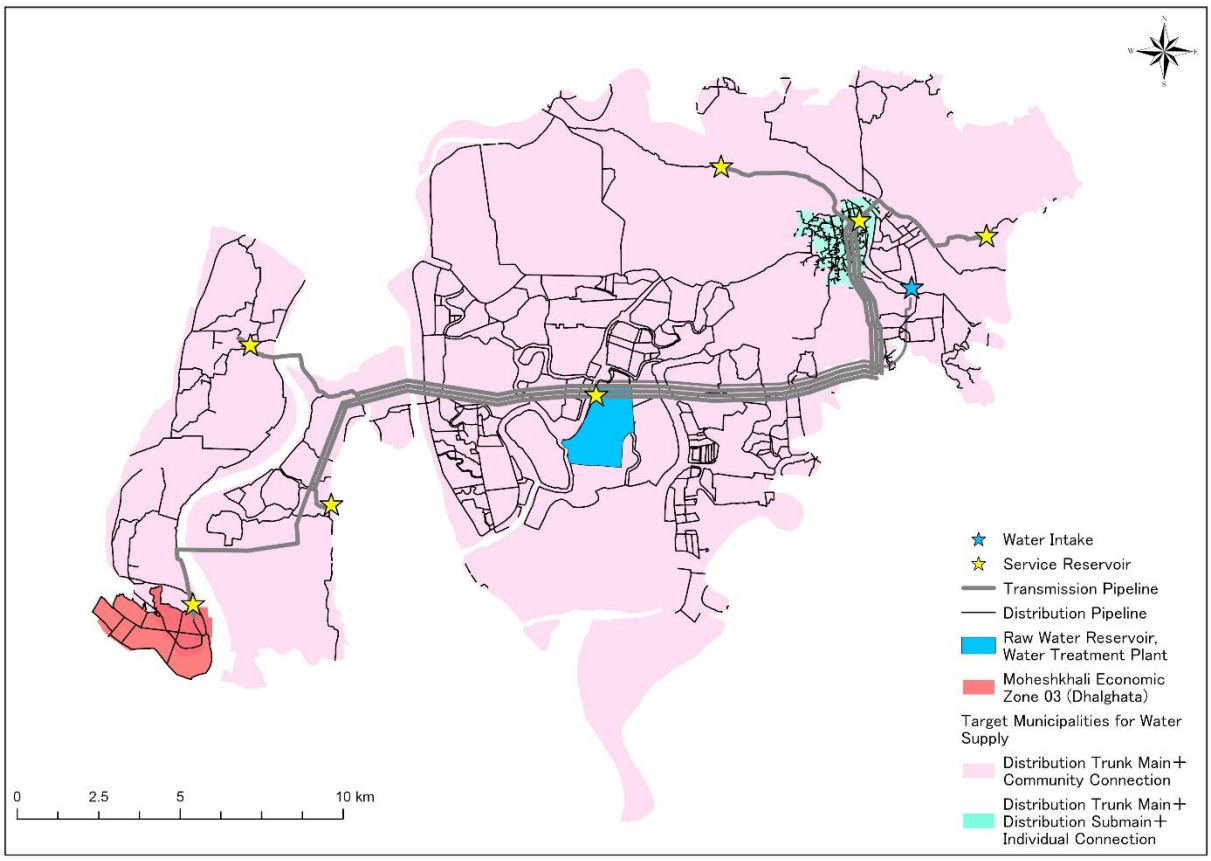
Case 2

Include all the facilities from 1) Water sources to 7) Water Service Fittings
(for all of 16 Union/ Paurashava and Economic Zone)
(Note: individual house connection shall be applied for Paurashava since largest population per unit length of water supply pipeline and public-tap connection shall be applied for Union)

Table 5.4.2 Case 2: Facilities to be constructed

	Water Supply (m^3/d)	1) Water Sources	2) Water Intake	3) Raw Water Transmission	4) Water Treatment	5) Treated Water Transmission	5) Treated Water Transmission (m)	6)-1 Service Reservoir	6)-2 Distribution Trunk Main (m)	6)-2 Distribution Submain (m)	7) Water Service Fittings	
Industrial	78,442	1 System	1 System	1 System	1 System	1 System	18,400	1 System	10,000	20,000	25	
Domestic	82,250				1 System	6 System	77,200	6 System	510,000	34,900	26,700	Individual Connection
										0	3,400	Community Connection

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5.4.2 Case2: Location Map of the Facilities to be constructed

Case 3

Include the facilities from 1) Water sources to 5) Treated Water Conveyance and partial facilities of 6) Distribution Facilities and 7) Water Service Fittings

(for 2 Union/ Paurashava and Economic Zone)

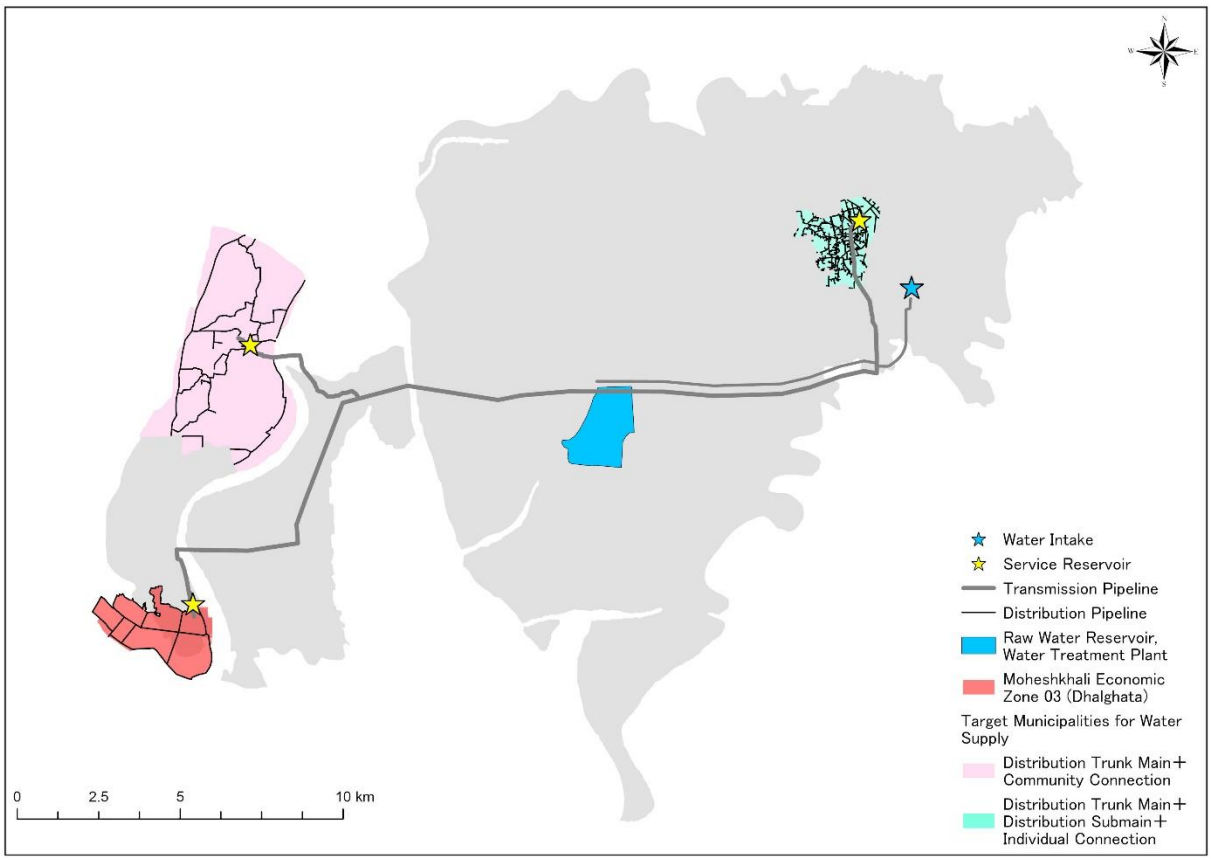
(Note: individual house connection shall be applied for Paurashava since largest population per unit length of water supply pipeline and public-tap connection shall be applied for Union)

(Note: Matarbari Union and Chakaria Paurashava: one each from Chakaria Upazila、Moheshkhali Upazila, largest population per unit length of water supply pipeline)

Table 5.4.3 Case 3: Facilities to be constructed

	Water Supply (m3/d)	1) Water Sources	2) Water Intake	3) Raw Water Transmission	4) Water Treatment	5) Treated Water Transmission	5) Treated Water Transmission (m)	6)-1 Service Reservoir	6)-2 Distribution Trunk Main (m)	6)-2 Distribution Submain (m)	7) Water Service Fittings	
Industrial	78,442	1 System	1 System	1 System	1 System	1 System	18,400	1 System	10,000	20,000	25	
Domestic	32,826				1 System	2 System	26,400	2 System	56,900	34,900	26,700	Individual Connection
										0	250	Community Connection

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5.4.3 Case3: Location Map of the Facilities to be constructed

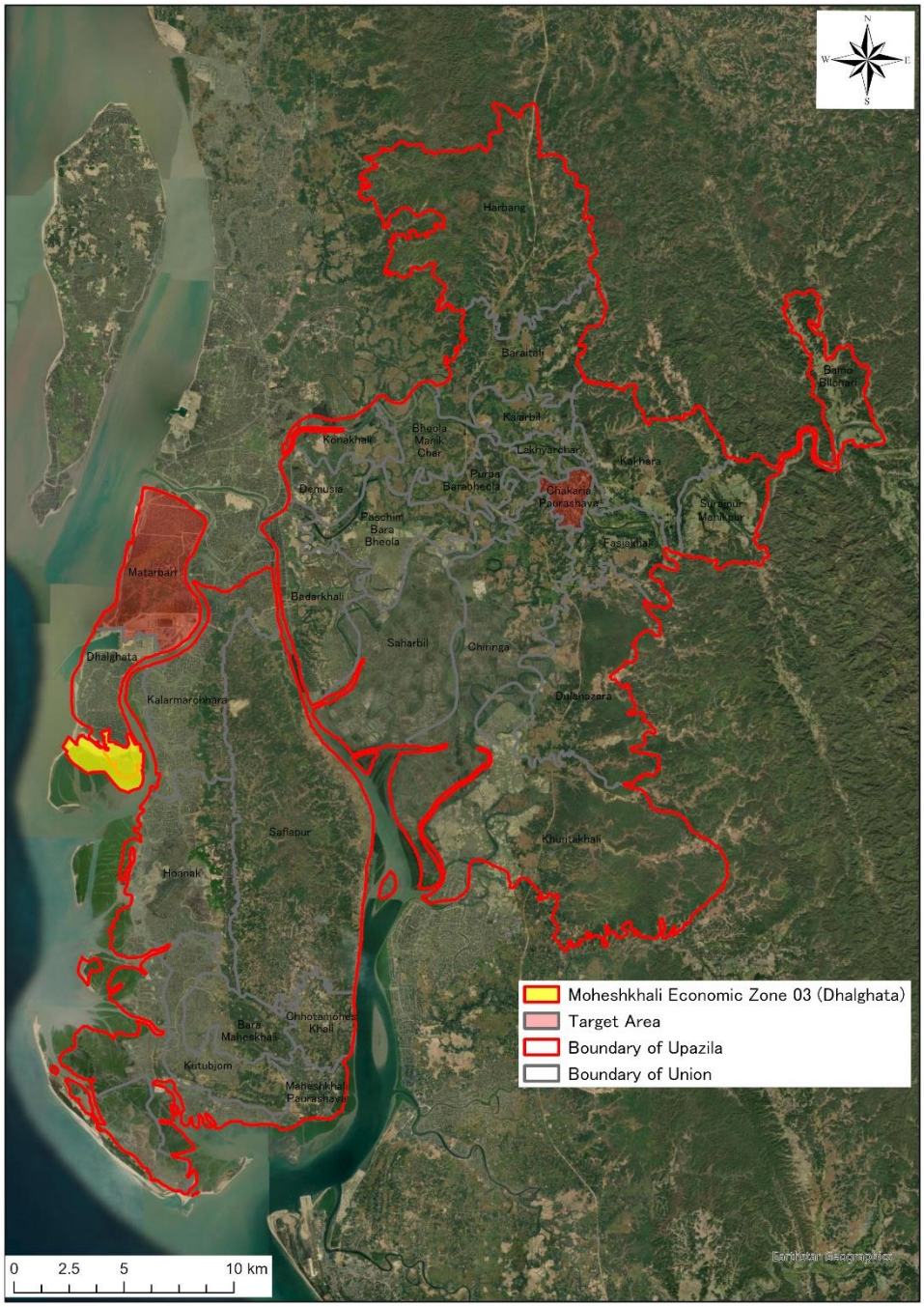
Table 5.4.4 Comparison of the Combination of the Facilities to be constructed

Item	Case 1	Case 2	Case 3
From 1) Water sources to 5) Treated Water Conveyance Facilities	Includes all	Includes all	Include all facilities, however scaled down to correspond to the supply volume
6) Distribution Facilities and 7) Water Service Fittings	Excluded To be constructed by Government of Bangladesh	Includes all	Includes only for 2 Union/ Paurashava and Economic Zone
Advantages	Easy to manage the construction schedule due to the exclusion of the distribution pipelines	Easy to build the consensus of the project implementation since residents around 1)-5) facilities will receive water.	- Still can meet 70 % of the total water demand - Reduction in the cost
Disadvantages	- Realization of water supply depends on facilities to be constructed by the Government of Bangladesh	- Take a longtime till the completion of the project - Huge cost - Not enough population concentration in some	No water supply to the municipalities where the 1) – 5) facilities shall be constructed

Item	Case 1	Case 2	Case 3
	- Difficult to schedule the completion of the project	areas to justify piped water supply	
Cost (ratio when case 1 is set to 1)	1.00	1.31	0.92
Evaluation	Not selected Concerns on whether residents' access to water will be realized cannot be ignored	Not selected Initial cost is large, piped water supply inefficient in some remote areas	Selected

Source: JICA Survey Team

The JICA survey team proposes to implement Case 3 as the first phase of the water supply project (hereinafter referred to as the "Phase 1 Project.") All survey items from Chapter 6 to Chapter 10 in this report only covers the Phase 1 Project. The term "the Project" in Chapter 6 to Chapter 10 refers to the Phase 1 Project only.



Source: JICA Survey Team

Figure 5.4.4 Map of Target Area of the Phase 1 Project

5.4.2 Basic Water Supply Plan for the Phase 1 Project

Water demand forecast conditions are the same as those described in Chapter 5.1.2. The summary is shown as below.

Table 5.4.5 Summary of Water Demand Forecast Conditions

Item	Domestic Water	Industrial Water
Base Data	Population Projection based on "Population Projection of Bangladesh Dynamics and Trends 2011-2061"	Development Area Forecast and Sector Allocation in BEZA FS 2022
Water Demand Unit	Pourashava: 120 lpcd Union: 62 lpcd Commercial Water Consumption: 15%	Sector-wise consumption in DS for BSMSN
Water Supply Connection Ratio	80 %	100 %
Non-revenue Water Ratio	28 %	15 %
Loading Factor	80 %	87 %
Loss Factor	10 %	10 %
Recycle Ratio	-	50 %

Source: JICA Survey Team

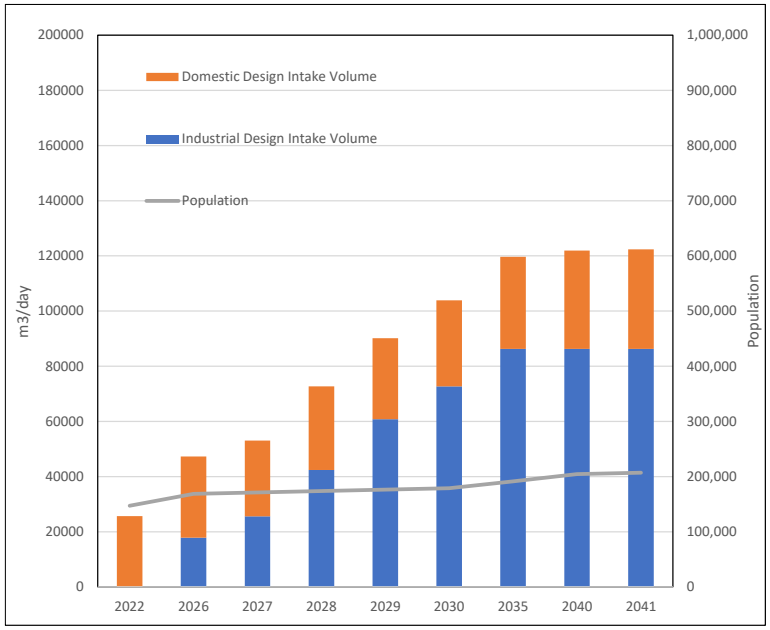
The water demand forecast result for the Phase 1 Project is shown below. The total design intake volume is 122.4 MLD, of which 86.3 MLD is industrial water and 36.1 MLD is domestic water in 2041. Also, the daily maximum production is 111,268 m3/day and the water supply population is 206,994 in 2041.

Table 5.4.6 Water Demand Forecast Result for the Phase 1 Project

(m3/day)

Industrial Design Intake Volume				**2022**	**2035**	**2041**
			Total Design Intake Volume	**0**	**86,286**	**86,286**
Domestic Design Intake Volume				**2022**	**2035**	**2041**
District	**Upazila**	**Union**				
Cox's Bazar	Chakaria		Sub Total	19,902	25,942	28,056
		1	Chakaria Pourashava	19,902	25,942	28,056
		2	Badarkali			
		3	Bamo Bilchari			
		4	Bataraitali			
		5	Bheola Manik Char			
		6	Chringa			
		7	Demusia			
		8	Deulahazara			
		9	Purba Barabheola			
		10	Faiakhali			
		11	Harbang			
		12	Kakhara			
		13	Kairarbil			
		14	Khuntakhali			
		15	Konakhali			
		16	Lakhyarchar			
		17	Saharbil			
		18	Surajpur Namikpur			
		19	Paschim Bara Behola			
Cox's Bazar	Moheshkhali		Sub Total	5,746	7,455	8,052
		1	Maheshkhali Paurashava			
		2	Bara Maheskhali			
		3	Chhotamohes Khali			
		4	Dhalgata			
		5	Hoanak			
		6	Kalarmarchhara			
		7	Kutubjom			
		8	Matabari	5,746	7,455	8,052
			Total Design Intake Volume	**25,648**	**33,397**	**36,108**
			Grand Total Design Intake Volume	**25,648**	**119,683**	**122,394**
			Daily Maximum Production	23,316	108,803	111,268
			Daily Production	18,653	92,533	94,505
			Daily Consumption	13,430	133,503	134,923
			Water Supply Population (person)	147,144	191,486	206,994

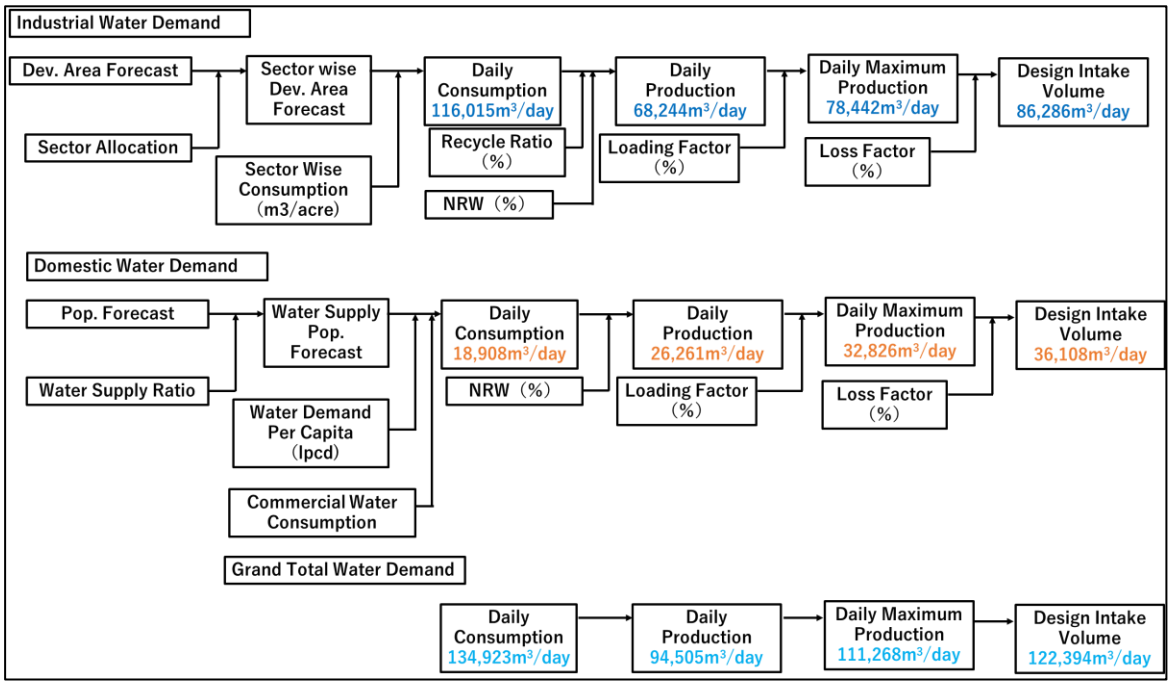
Source: JICA Survey Team



Source: JICA Survey Team

Figure 5.4.5 Water Demand Forecast Result for the Phase 1 Project

The calculation flow for industrial and domestic water demands with water demand forecast result for the project 1 is shown as below.



Source: JICA Survey Team

Figure 5.4.6 Calculation Flow for Industrial and Domestic Water Demands with Water Demand Forecast Result for the Phase 1 Project

Based on the above calculation, the water volume used in the design of each facility are organized as follow.

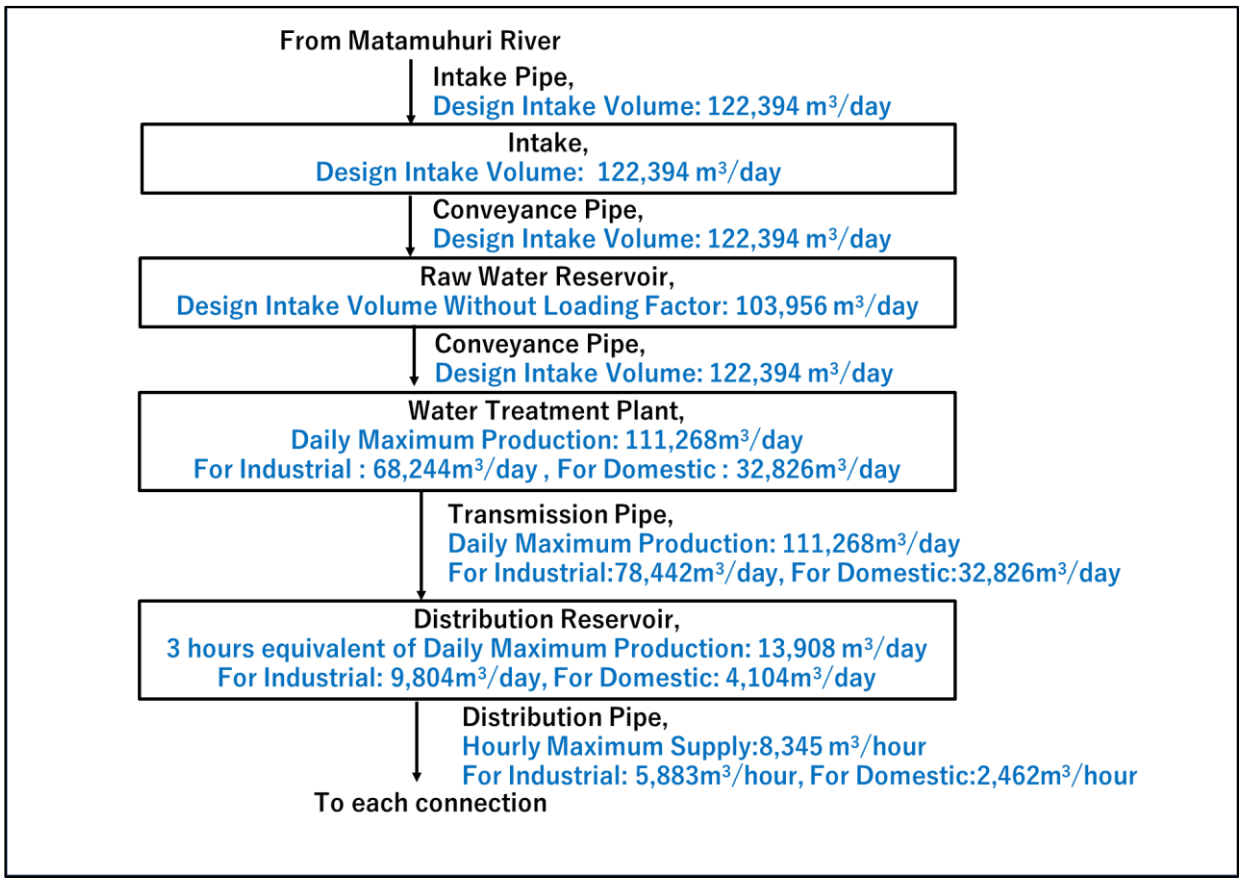


Figure 5.4.7 Water Volume Used in the Design of Each Facility for the Phase 1 Project

5.4.3 River Water Intake Plan for the Phase 1 Project

(1) Impact of phasing on river water intake planning

The impact of phasing on river water intake planning was evaluated using the following procedure.

- Conduct a water balance analysis based on the reduced water demand..
- Update the planned water intake volume and required reservoir capacity in the river water intake planning based on the analysis results.
- Update the construction plan and design of the water intake facility based on the updated planning specifications.

(2) Water balance analysis on water demand

Based on the water demand which calculated in Chapter **5.4.2**, water balance analysis was carried out. The procedure, analysis method of water balance analysis are same as Chapter **5.2.3**.

1). Selection of 1/10 drought year (STEP1)

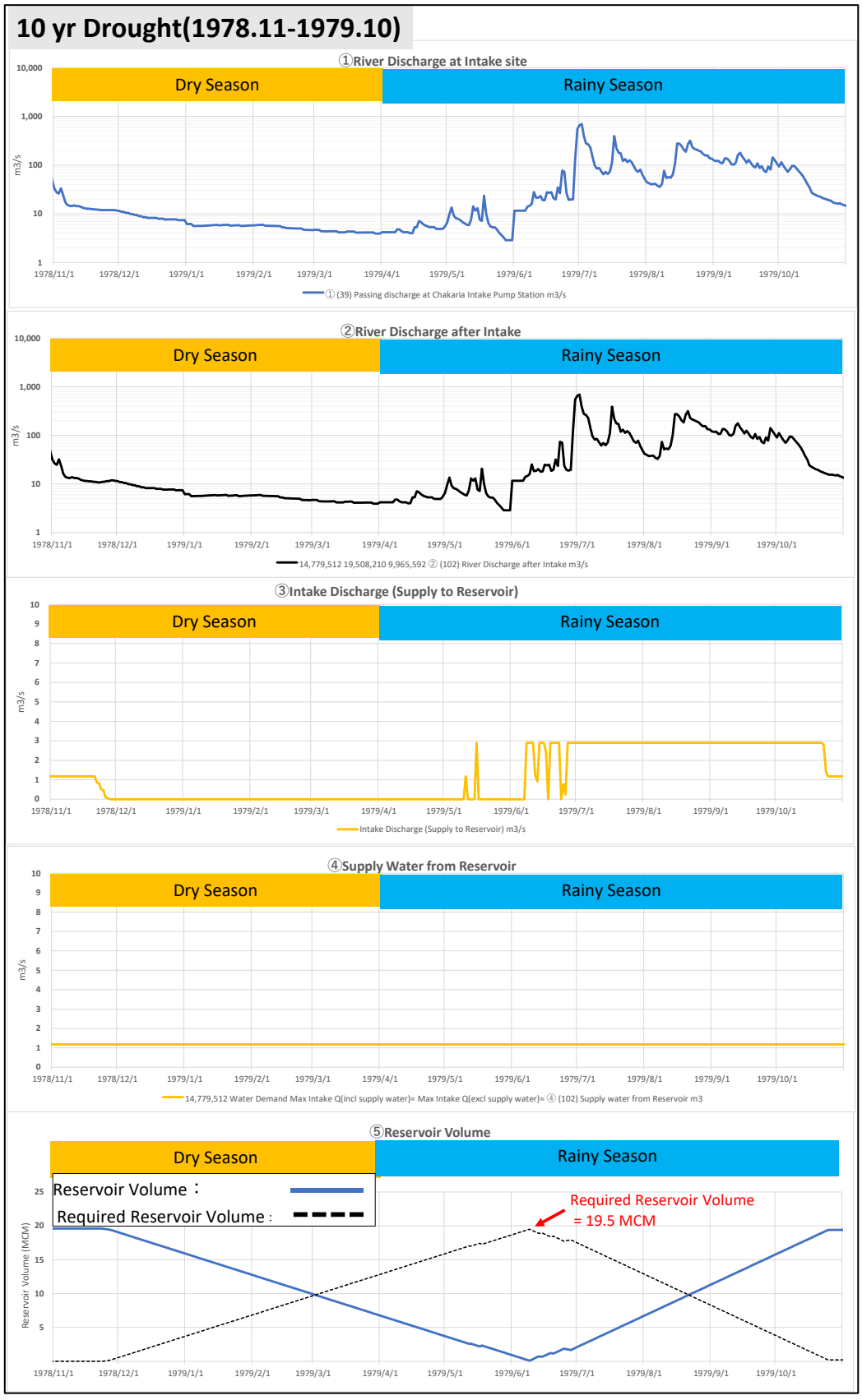
The required reservoir volumes are calculated from 1966-2022. The year of the 4th largest required reservoir volume was 1978 and selected this year as 1/10 drought year.

Table 5.4.7 Required Reservoir Volume in STEP1 in the Project

Year	Rank	Required Reservoir Capacity (MCM)	Year	Rank	Required Reservoir Capacity (MCM)
1966	6	19.3	1994	22	14.8
1967	17	16	1995	45	8.7
1968	25	14.6	1996	37	12.6
1969	26	14.3	1997	32	13
1970	-		1998	8	18.7
1971	-		1999	34	12.9
1972	10	18.1	2000	35	12.8
1973	43	10	2001	-	
1974	27	13.7	2002	-	
1975	24	14.6	2003	-	
1976	41	10.9	2004	-	
1977	9	18.6	2005	7	19.1
1978	4	19.5	2006	-	
1979	13	16.6	2007	16	16.3
1980	23	14.7	2008	3	19.7
1981	1	22.5	2009	2	20.6
1982	-		2010	29	13.6
1983	30	13.5	2011	36	12.6
1984	12	17.1	2012	18	15.5
1985	5	19.4	2013	11	17.3
1986	15	16.4	2014	14	16.6
1987	42	10.2	2015	46	4.9
1988	40	11.1	2016	46	4.9
1989	31	13	2017	44	9.7
1990	28	13.6	2018	49	4.3
1991	21	15.1	2019	38	12.3
1992	39	12.2	2020	19	15.5
1993	33	13	2021	20	15.3
			2022	48	4.3

Source: JICA Survey Team

Figure 5.4.8 shows the calculation result of 1/10 drought year (1978) in STEP 1. Each graph (①-⑤) corresponds with the Figure 5.2.5 which shows the outline of water balance calculation. According to the result, the required reservoir volume becomes 19.5MCM in STEP1 (See graph ⑤).



Source: JICA Survey Team

Figure 5.4.8 Calculation Result of 1/10 Drought Year (1978) in STEP 1(The Project)

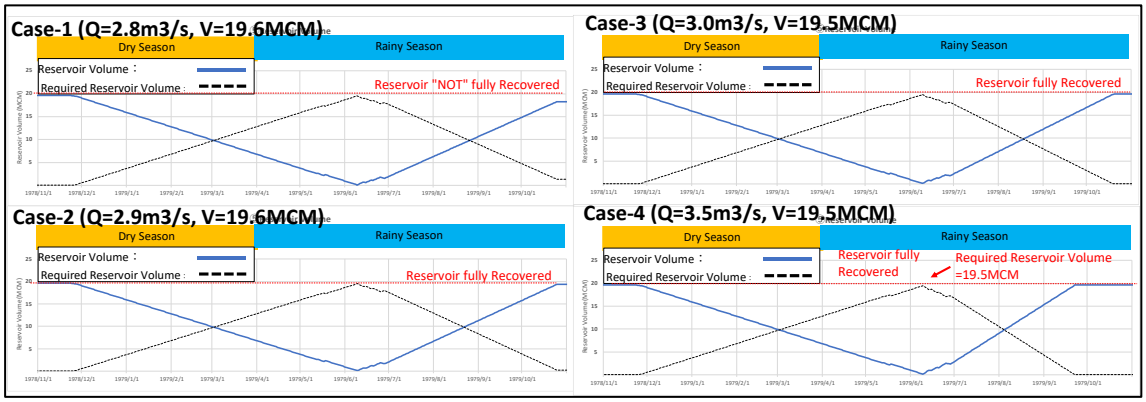
2). Optimization of required reservoir volume and maximum water intake capacity (**STEP 2**)

The optimization of required reservoir volume and maximum water intake capacity was conducted. Trial cases are shown below. The combination of maximum intake capacity and required reservoir volume was selected as 2.9m^3/s and 19.6MCM (Case-2) by following reasons.

- Reservoir can be fully recovered by the end of year (Oct 31).
- Increment of required reservoir volume is only 0.1MCM (19.6MCM-19.5MCM), compared to the Case-4 (result of STEP1), but the maximum capacity of intake facility can be reduced from 3.5m3/s to 2.9m3/s. It has positive impact on the Project in terms of construction cost reduction.

Table 5.4.8 Trial Case for Optimization of Intake Capacity

Case	Unit	Case-1	Case-2	Case-3	Case-4
Max Intake Capacity	m3/s	2.8	2.9	3	3.5
Required Reservoir Volume	MCM	19.6	19.6	19.5	19.5
Recovery of Reservoir Volume	-	×	○	○	○
Selection			**Selected**		



Source: JICA Survey Team

Figure 5.4.9 Result of Trial Calculation for Optimization of Intake Facility (The Project)

(3) Update the design water intake discharge and required reservoir capacity in the river water intake plan

The planned water intake volume and required reservoir capacity are updated as stated below. .

- Planned intake volume : 4.1 m3/s → 2.9 m3/s
- Required reservoir capacity : 27.0 MCM → 19.6 MCM

(4) Update of the design plan and design of the intake facility

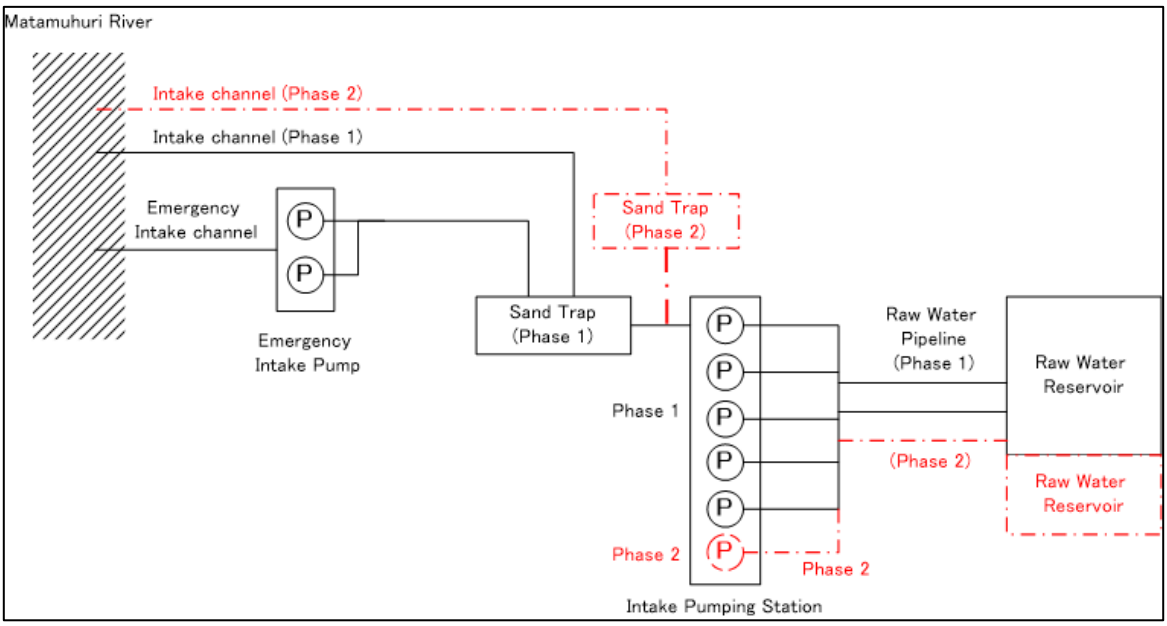
Due to the phasing, there will be no changes to the basic layout plan of the intake facility as a whole, including the location of the intake works and the reservoir, and the water conveyance route, which were set in Section 5.2. However, the scale of the facility will be reduced based on the revised planned intake

volume and required reservoir capacity. The following shows the facility specifications table for the basic study and phasing.

Table 5.4.9: Basic Feature and Dimension of River/Intake Structures at the Time of Concept Design and Phasing

Structure	Concept Design	Design for Phasing (Phase 1 Project)
(1) Riverbank protection works	River bank protection works are provided to prevent riverbank erosion in the river channel upstream and downstream of the intake works and to stabilize the channel.	(No change)
(2) Intake		
- Design intake discharge	4.1m3/s	(Downsizing) 2.9m3/s
- Intake type	Pump intake without weir	(No change)
- Intake channel (normal)	1.5mH x 2.4mW x 2nos+ 1.5mH x 2.1mW x 1no	(Downsizing)1.5mH x 2.4mW x 2nos
- Intake channel (emergency)	1.2mH x 2.1mW x 2nos	(No change)
(3) Grit chamber (settling basin)	40mL x 5mW x 3.5mH x 4 nos + 40mL x 7mW x 3.5mH x 1 nos	(Downsizing) 40mL x 5mW x 3.5mH x 4 nos
(4) Intake pump	Max. pump discharge 4.1m3/s	(Downsizing) 2.9m3/s
(5) Conveyance pipeline	ϕ 1100x 3nos	(Down numbers) ϕ 1100x 2nos
(6) Raw water reservoir	Effective reservoir volume 27.0 MCM	(Downsizing) 19.6 MCM

Source: JICA Study Team



Source: JICA Study Team

Figure 5.4.10 Phasing Diagram for Intake and Raw Water Reservoir

5.4.4 Summary of Facilities in Phase 1 Project

The following shows the facility specifications table for the Phase 1 Project.

Table 5.4.10: Basic Feature and Dimension of Structures of the Phase 1 Project

Structure	Design for Phasing (Phase 1 Project)
(1) Riverbank protection works	River bank protection works are provided to prevent riverbank erosion in the river channel upstream and downstream of the intake works and to stabilize the channel.
(2) Intake	
- Design intake discharge	2.9m3/s
- Intake type	Pump intake without weir
- Intake channel (normal)	1.5mH x 2.4mW x 2nos
- Intake channel (emergency)	1.2mH x 2.1mW x 2nos
(3) Grit chamber (settling basin)	40mL x 5mW x 3.5mH x 4 nos
(4) Intake pump	Location: Intake facility Fluid: River water Conveyance: Intake to Raw water reservoir 61.5m^3/min x 31m x 5nos(3D+2S)
(5) Conveyance pipeline	ϕ 1100 x 2nos
(6) Raw water reservoir	19.6 MCM
(7) Conveyance pump	Location: WTP area Fluid: Raw water Conveyance: Raw water reservoir to WTP No.1 (for Industrial train): 31.5m^3/min x 14m x 3nos(2D+1S) No.2 (for Domestic train): 31.5m^3/min x 14m 2nos(1D+1S)
(8) Water Treatment Plant	Treatment process: Coagulation, Flocculation, Sedimentation, Filtration and Disinfection Treatment lines: 2 (Industrial and Domestic) Capacity: 111.2 MLD (78.4 MLD for Industrial and 32.8 MLD for Domestic)
(9) Transmission pump	Location: WTP area Fluid: Treated water Conveyance: WTP to each Distribution Reservoir No.1 (for DR Industrial to Moheshkhali EZ (Dhalghata)): 13.7m^3/min x 66m x 6nos(4D+2S) No.2 (for DR2 to Chakaria Pourashava): 8.9m^3/min x 65m x 4nos(2D+2S) No.3 (for DR6 to Matarbari Union): 2.6m^3/min x 53m x 4nos(2D+2S)
(10) Transmission pipe	For DR Industrial to Moheshkhali EZ (Dhalghata) ϕ 1000 mm, L=18 km For DR2 to Chakaria Pourashava ϕ 600 mm, L=14 km For DR6 to Matarbari Union ϕ 400 mm, L=13 km

Structure	Design for Phasing (Phase 1 Project)
(11) Distribution Reservoir	For DR Industrial to Moheshkhali EZ (Dhalghata) ϕ 35.0 m x 6.5 m x 3 nos., ϕ 15.0 m×6.5 m For DR2 to Chakaria Pourashava ϕ 21.0 m x 6.5 m, ϕ 18.0 m x 6.5 m For DR6 to Matarbari Union ϕ 15.0 m x 6.5 m
(12) Distribution main	For DR Industrial to Moheshkhali EZ (Dhalghata) ϕ 800 mm, L=10 km, ϕ 600 mm, L=20 km For DR2 to Chakaria Pourashava ϕ 500 mm, L=20 km, ϕ 300 mm, L=35 km For DR6 to Matarbari Union ϕ 300 mm, L=37 km
(13) Water Service Fittings	
- Individual Property Connections	For DR Industrial to Moheshkhali EZ (Dhalghata) 25 nos.
- Individual House Connections	For DR2 to Chakaria Pourashava 27,000 nos.
- Group Tap Connections	For DR6 to Matarbari Union 250 nos.

Source: JICA Study Team

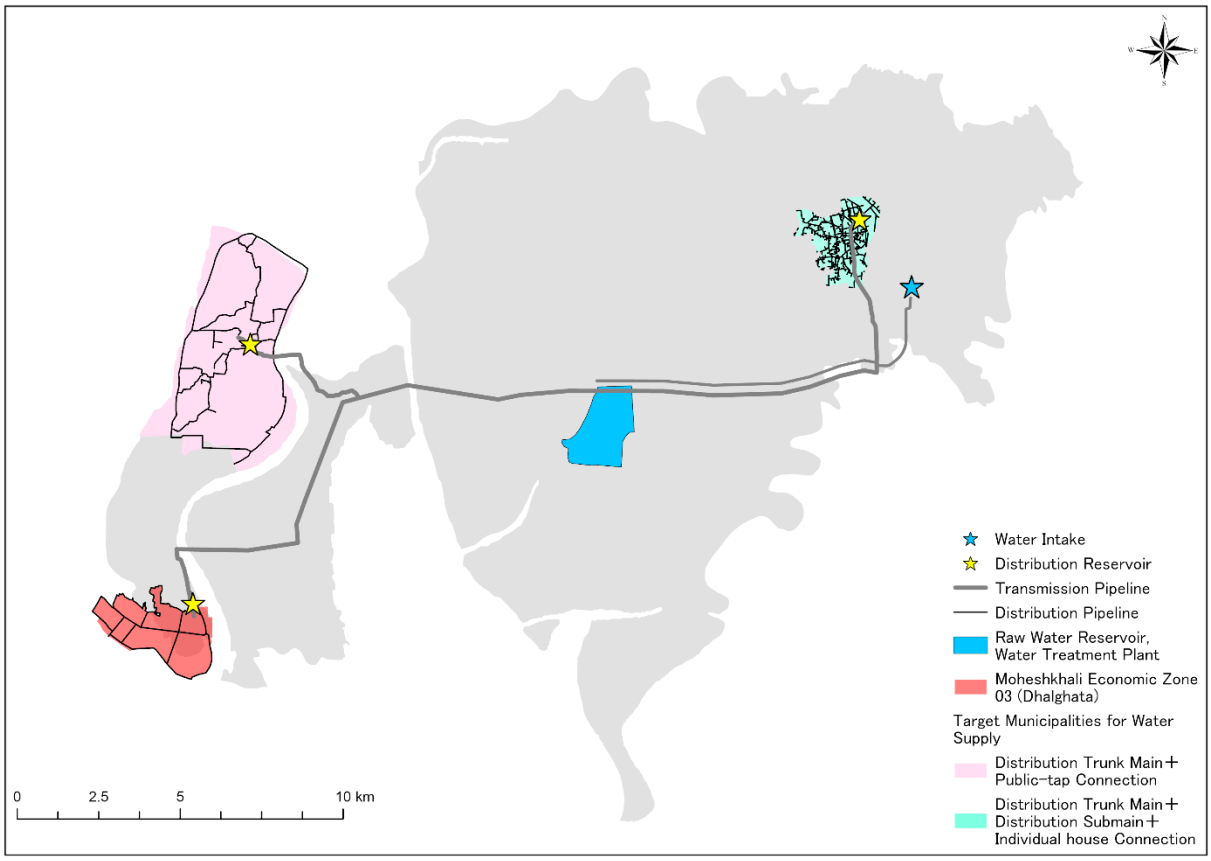


Figure 5.4.11 Location Map of the Phase 1 Project

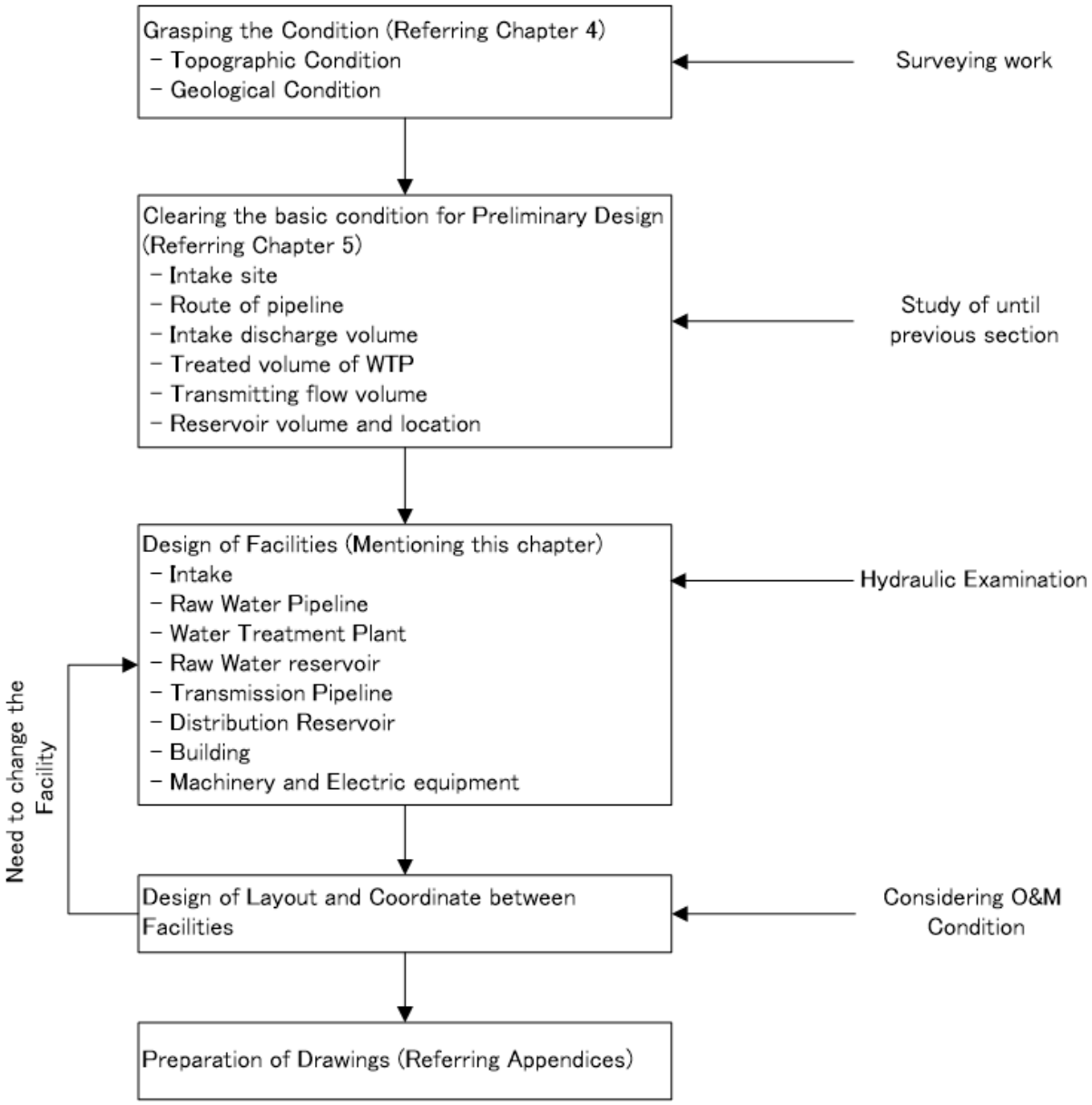
CHAPTER 6 PRELIMINARY DESIGN OF PROJECT FACILITIES

The term "the Project" in this Chapter refers to the Phase 1 Project identified in Section 5.4.

6.1 Basic Approach and Design Standards

6.1.1 Basic Approach

Under the preliminary design, rough examination and comparison of the structure and construction method of objective facilities envisaged for the Project are carried out. The basic approach of the preliminary design is shown in Figure 6.1.1.



Source: JICA Survey Team

Figure 6.1.1 Basic Approach of Preliminary Design

Based on the results of study and survey work obtained in the Survey, base conditions for the preliminary design are clarified. Each facility and its layout are designed and indicated on the design drawings.

6.1.2 Design Standards

The design standards for the preliminary design of water supply structures planned for the Project are shown in the following Table 6.1.1. From the table below, the design standards being worked out are based especially on No. 19 “The Design Criteria for Water Supply Facilities 2012”.

Table 6.1.1 Design Standards List

No.	Technical Code	Country
1	Standard Design Manual, 1995	Bangladesh
2	Guideline for River Bank Protection, 2010	Bangladesh
3	Design manual for River Embankment in Bangladesh	Bangladesh
4	Bangladesh National Building Code, 2020	Bangladesh
5	Engineering Codes and Standards Index 2017, Section 03 Civil Engineering Division	Bangladesh
6	American Concrete Institute (ACI)	U.S.A
7	American Institute of Steel Construction (AISC)	U.S.A
8	American Association of State Highway and Transportation Officials (AASHTO)	U.S.A
9	American Society for Testing Materials (ASTM)	U.S.A
10	British Standard (BS)	England
11	Japanese Industrial Standard (JIS)	Japan
12	Technical Standard for River and Sabo Works, Japan River Association	Japan
13	Specifications for Highway Bridges Part I to V, Japan Road Association	Japan
14	Guideline Manual for Land Improvement Project “Pond Development”, Rural Development Bureau, Ministry of Agriculture, Forestry, and Fisheries	Japan
15	Guideline Manual for Land Improvement Project “Water Way”, Rural Development Bureau, Ministry of Agriculture, Forestry, and Fisheries	Japan
16	Guideline Manual for Land Improvement Project “Head Works”, Rural Development Bureau, Ministry of Agriculture, Forestry, and Fisheries	Japan
17	Guideline Manual for Land Improvement Project Canal”, Rural Development Bureau, Ministry of Agriculture, Forestry, and Fisheries	Japan
18	Technical Standards of Disaster Prevention Regulation Pond, ETC., Japan River Association	Japan
19	The Design Criteria for Water Supply Facilities 2012, Ministry of Health, Labor and Welfare	Japan
20	Water Supply Maintenance and Management Guideline, 2016, Ministry of Health, Labor and Welfare	Japan
21	Dynamical Design Method of Revetment, Japan Institute of Country technology and Engineering	Japan
22	International Electrotechnical Commission (IEC)	International

Source: JICA Survey Team

6.1.3 Seismic Factor

The spectral acceleration for the design earthquake is given by the following equation due to BNBC No. 6.2.34 equation

$$S_a = \frac{2}{3}\frac{ZI}{R}C_s$$

where, Sa : Design spectral acceleration (in unit of g)

β: Coefficient used to calculate lower bound for Sa. Recommended value for β is 0.11

Z: Seismic zone coefficient (= 0.28)

I: Structure importance factor (=1.25)

R: Response reduction factor which depends on the type of structural system (= 4.0)

Cs: Normalized acceleration response spectrum, which is function of structure (building) period and soil type.(=3.375)

$$S_a = \frac{2}{3} \times \frac{0.28 \times 1.25}{4.0} \times 3.375 = 0.197 \cong 0.2$$

Detailed calculation indicates in Supporting Report B.

Above Sa design spectral acceleration can be used as lateral seismic force coefficient due to BNBC-2020, Part 6, section 2.5.7.

6.2 Preliminary Design of River Water Intake Facilities

6.2.1 General

(1) Basic Necessary Points

Basic requirements considered for the intake design are to be based on Section 1.2.1 of "The Design Criteria for Water Supply Facilities 2012", which are:

- Reliable amount of water intake,
- Secure raw water source,
- Measures for disaster and protection of environment,
- Simple operation and maintenance, and
- Compliance with laws and standards.

(2) Components of Intake Facilities

The components of the intake facilities are:

- Inlet structure,
- Stoplog,

- Screen,
- Conveyance box culvert from inlet structure to settling basin,
- Settling basin,
- Pump and pump tank,
- Gates,
- Manhole for drainage from settling basin, and
- Pump control house and staff room.

(3) Condition

The following condition was shown for preliminary design of intake

- Design inflow discharge: 2.9 m3/s
- Emergency inflow discharge: 1.7m3/s (Phase 2 inflow of Water treatment plant from raw water reservoir)
- Duration of inflow period: May to November
- Intake water level elevation: El. 1.60
- Intake inlet bottom level: El. 0.80
- Emergency inlet water level El. 0.80
- Emergency inlet bottom level El. 0.10
- Average riverbed material diameter by NODI project report: 0.2 mm to 0.3mm

6.2.2 Design of River Bank Protection Works and River Dredging Works

(1) General

In this section, design of river bank protection and river dredging works for the upstream and downstream of the intake is carried out. In the basic water intake plan aforementioned in Section 5.2, the following points were decided as the planning and design concept for the intake structures:

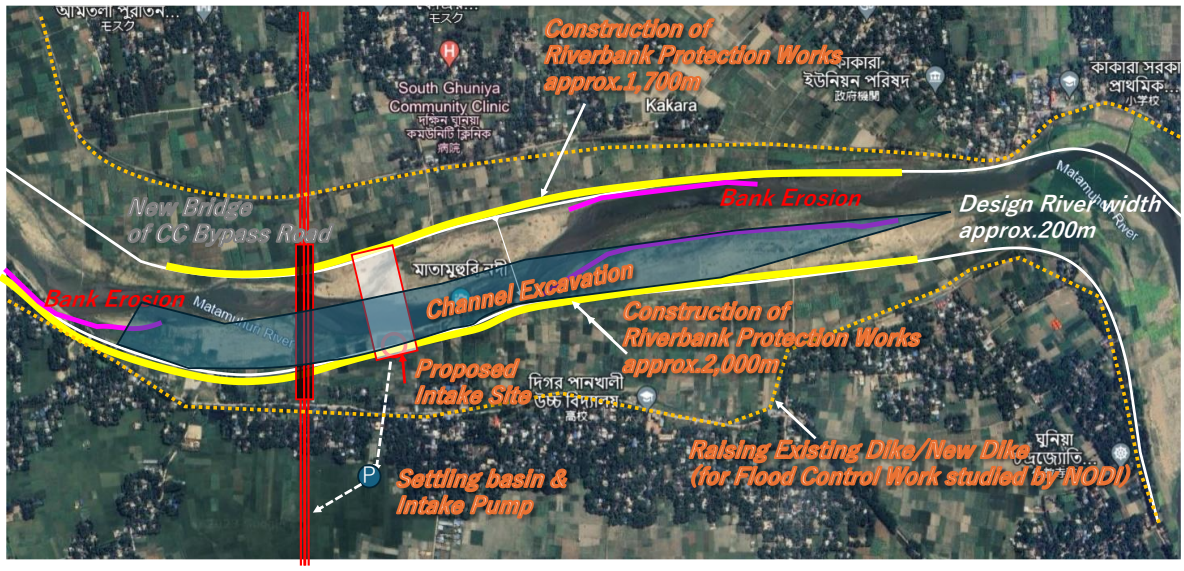
- Intake location: Left bank of Matamuhuri River, about 3.7 km upstream from Matamhuri Bridge
- Intake type: Pump intake without weir
- intake operation: Basically carried out during the rainy season, and the necessary amount of water is taken when the river flow exceeds the environmental flow.

In addition, the above "pump intake type without weir" is is adopted, subject to the following conditions, taking into consideration the problem of sediment management at the intake works.

i) Continuous maintenance and management of river structures and appropriate sediment management, such as removal of sediment from the river channel and intake channel

ii) Implementation of bank protection works and other necessary measures to prevent river bank erosion and stabilize the river channel

iii) Confirmation of the above-mentioned sediment management and the function of necessary measures through detailed hydraulic model experiments and numerical simulations at the detailed design stage



Source: JICA Survey Team

Figure 6.2.1 Location Map of Intake Site in River Intake Basic Plan

(2) Design Conditions

1) Safety levels of flood control works and water use

The target safety level of flood control works of the intake site was set at 1/50 in the NODI project, which had conducted the preliminary study of flood control plan in the whole Matamuhuri River basin.

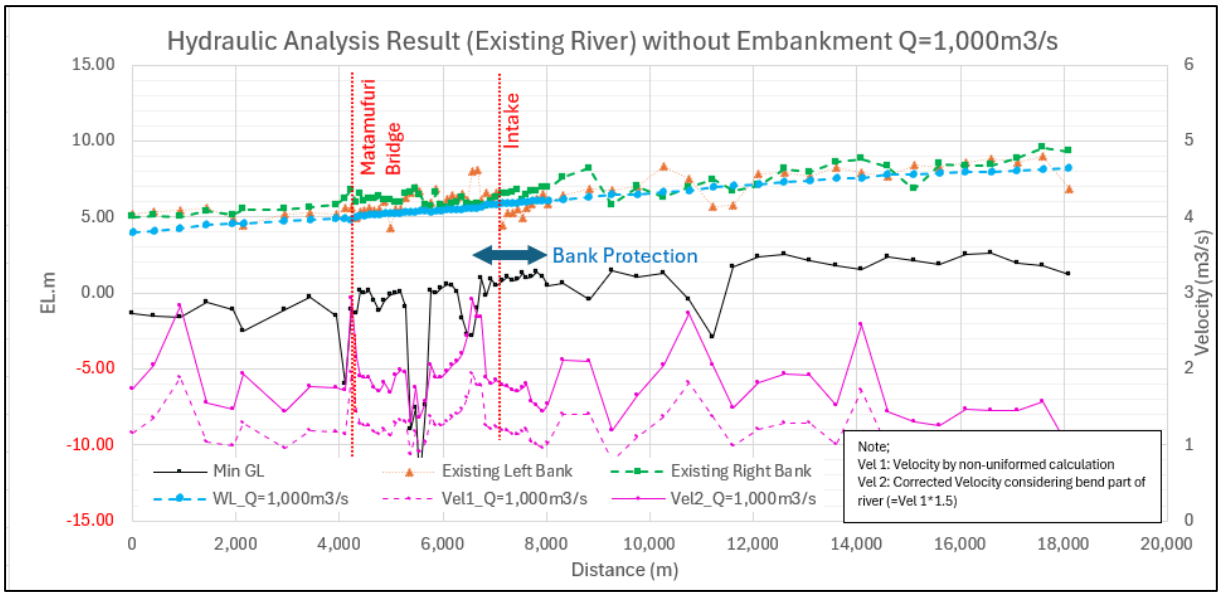
The target safety level of water use is set at 1/10 based on the water balance analysis results mentioned above.

2) Hydraulic conditions of the river channel

To confirm the basic hydraulic conditions such as water level and flow velocity of the river channel in the intake site, a non-uniform flow calculation using the latest surveyed cross section was carried out in this study.

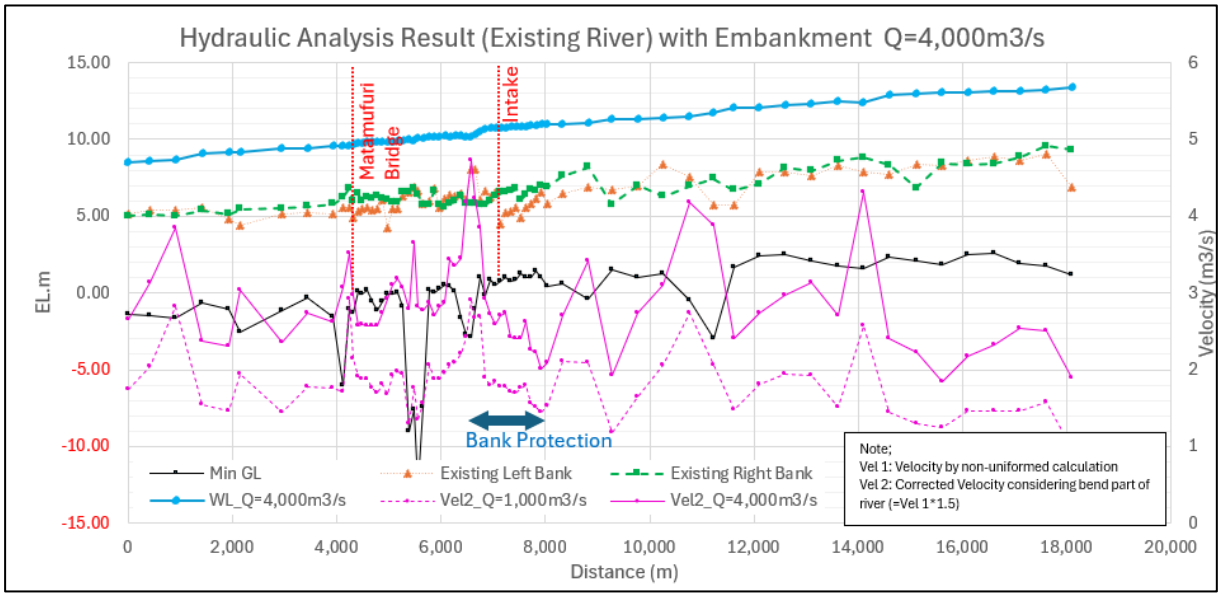
- River channel section: Approximately 1.5 km upstream and downstream of the intake point
- Design discharge: 1,000 m3/s (Maximum discharge which discharge does not exceed existing channel) without embankment
- Design discharge (high water): 4,000 m3/s (50-year probable flood) with embankment
- River channel roughness coefficient: n=0.030 (river channel on flat land)

The hydraulic longitudinal section of the river channel in the target section is shown below.



Source: JICA Survey Team

Figure 6.2.2 Hydraulic Calculation in the Intake Site in Matamuhuri River without Embankment (Q=1,000m³/s)



Source: JICA Survey Team

Figure 6.2.3 Hydraulic Calculation in the Intake Site in Matamuhuri River with Embankment (Q=4,000m³/s)

(3) Design of River Channel

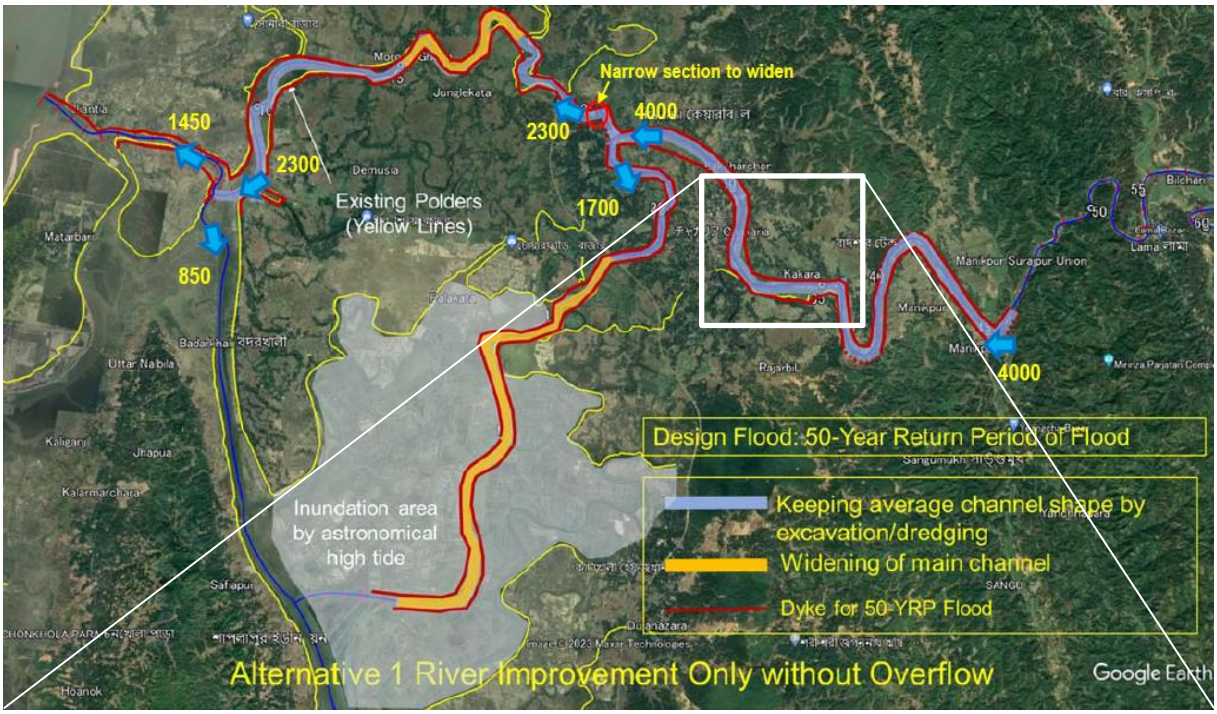
At present, no authorized river plan has been formulated for the Matamuhuri River. In this study, the river channel plan (flood control plan) established by NODI project is referred as the basic plan for the structural design of flood control works at the intake site.

In addition, it is necessary to make a design in the low water flow condition even in the drought cases since this project is a water supply project. The following study is carried out to set the layout plan for the low water channel at the intake site.

1) Layout Plan (Horizontal Plan)

In NODI project, basic alternatives for flood control measures were prepared targeting at a 1/50 probability flood of the design discharge (4000 m3/s). As alternative options, following three (3) basic layout plans have been studied and evaluated; i) river improvement only (without overflow), ii) river improvement and a floodway (without overflow), and iii) river improvement with retarding basins (with overflow). The figure below shows the layout plan of the said alternative 1. But the selection of the final plan among the alternative options has not been carried out because it is outside of the scope of that project.

Focusing on the proposed intake site, all NODI alternatives have planned continuous flood dikes along the left river bank at same alignment, thereby this alignment of the flood dike is referred to design in this study.



Source: NODI

Figure 6.2.4 Flood Mitigation Plan in Lower Matamuhuri River Prepared by NODI



Source: NODI

Figure 6.2.5 Flood Mitigation Plan in Chakaria Central Area Prepared by NODI

Taking into account the above existing planning conditions, the river channel plan at the intake site are set as follows.

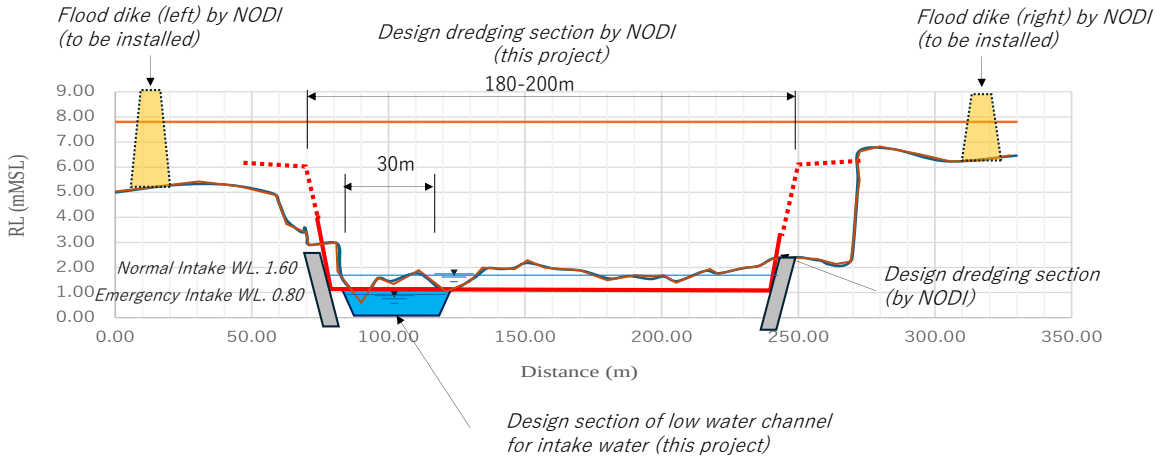
- Designed river channel center line: Set with reference to the current river channel center and the NODI planned center line.
- Designed dike alignment: Set with reference to the NODI flood dike alignment. Note that flood dike construction on the Matamhuri River should be promoted as a part of flood mitigation measures for the entire basin in a future project on the Bangladesh side. Therefore, flood dike construction is not included in this water supply project.
- Low water channel alignment: Set with reference to the low water channel alignment and width (bank to bank) of 180-200m in the plan of NODI project. Note that the alignment is slightly adjusted so that it follows the location of the proposed intake structure and the flow line upstream and downstream of it.

2) Cross-Section Plan

As same as the layout plan described above, the cross-section plan is based on the river channel excavation cross-section of the NODI project as follows.

- In the NODI project, river channel excavation is proposed as a short-term project of the flood mitigation works as shown in the figure below (red line), with a cross-section of 180-200m wide and approximately 5m deep.

- In this study, in addition to the NODI river channel excavation cross-section, a low water channel for intake water (a compound cross-section with 30m wide and, 1m deep) is planned as shown in the figure below (blue area), as a waterway to allow water to flow down to the intake works side during dry season.



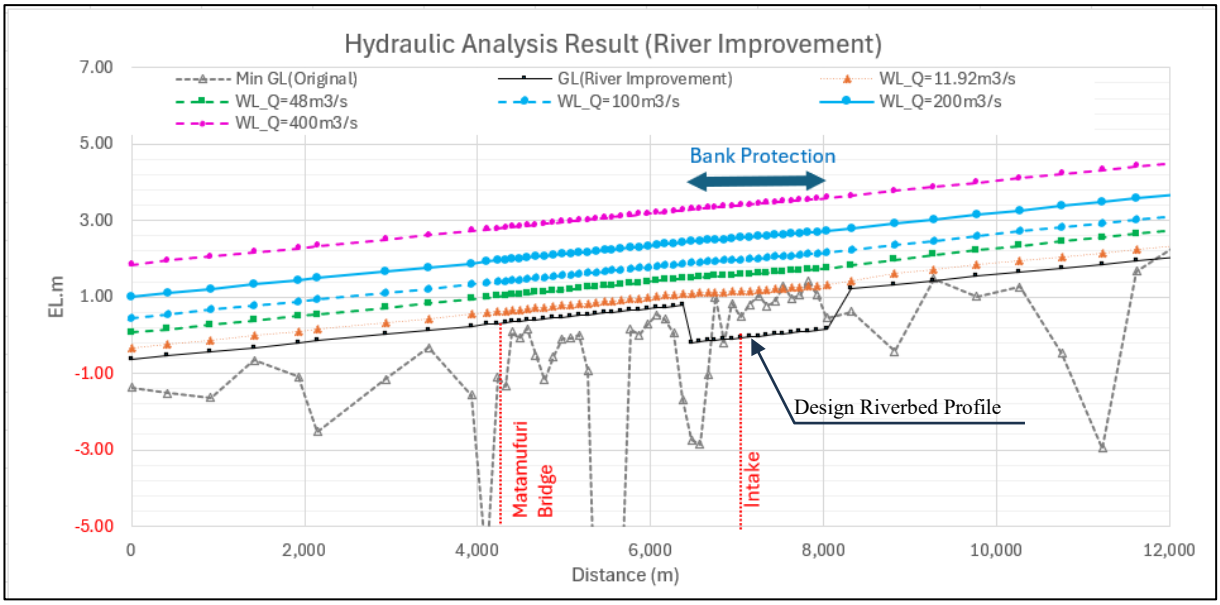
Source: JICA Survey Team

Figure 6.2.6 Cross Sectional Plan at Intake Site in Matamuhuri River

- The design river intake water level is set at EL1.60m to ensure the required intake water level during normal rainy season in case of 30% frequency discharge (approximately 48m^3/s applying the NODI's river channel excavation cross section.
- In addition, in case of unforeseen drought event, installation of a separate emergency intake pump was proposed as mentioned in Section 5.2.8 (4). The target intake water level of the emergency pump is set at EL0.80m to ensure the required water level in case of 1-10year drought condition (minimum drought discharge in rainy season (12m^3/s).

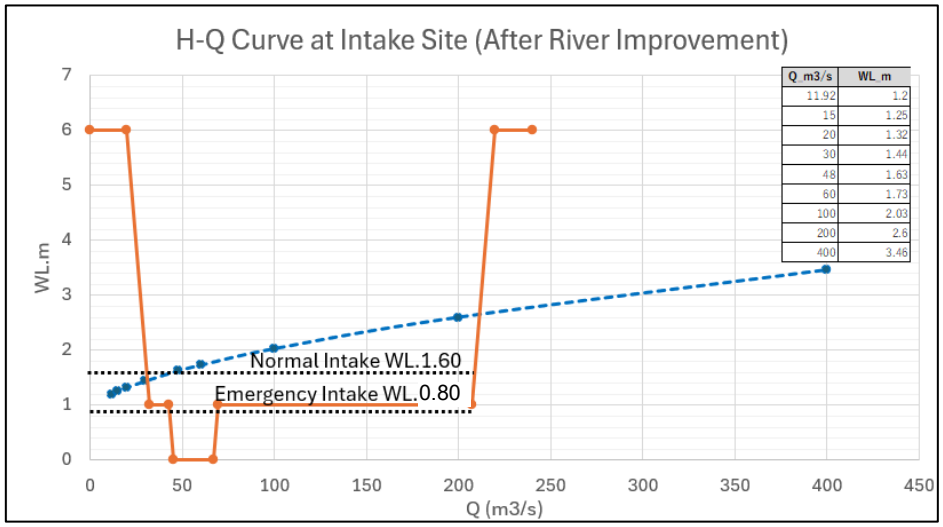
3) Longitudinal Plan

The longitudinal plan for the NODI's river channel excavation plan is superimposed on the proposed low water channel in front of the intake structure mentioned above. The longitudinal plan is shown below.



Source: JICA Survey Team

Figure 6.2.7 Design Longitudinal Profile of River Channel along the Intake Site in Matamuhuri River after River Improvement



Source: JICA Survey Team

Figure 6.2.8 H-Q Curve at the Intake Site in Matamuhuri River after River Improvement

(2) Design of Bank Protection Works

The intake site is located in a section of the downstream river basin with a very gentle riverbed gradient (approximately 1/4,500), and the flow is slow, with a normal discharge velocity of less than 1m/s. Therefore, the downstream Matamuhuri River is almost a natural river channel without bank protection works in the whole stretch. In some areas, bank protection works have been installed at upstream and downstream for protection of the abutment of the major bridges. The bank protections in these bridge areas are concrete block revetments, which are the standard type used in Bangladesh. (See the photo below.)



Source: JICA Survey Team

Figure 6.2.9 Photo of River Bank Protection Works (Concrete Blocks) at Matamuhuri Bridge in Matamuhuri River

On the other hand, as shown in the design conditions mentioned above, the flow velocity at bend section of the river channel is estimated at about 2-3 m/s (cross section 200m x 5m) when the design flood volume is 4,000 m^3/s. This high flow velocity during floods would cause riverbank erosion in river channels without bank protections, and the sandbars formed within the river channel would be subject to large fluctuations each time. Under these circumstances, as shown in the basic water intake plan, bank protection works shall be installed in the river channel in the target section to stabilize the channel and prevent bank erosion.

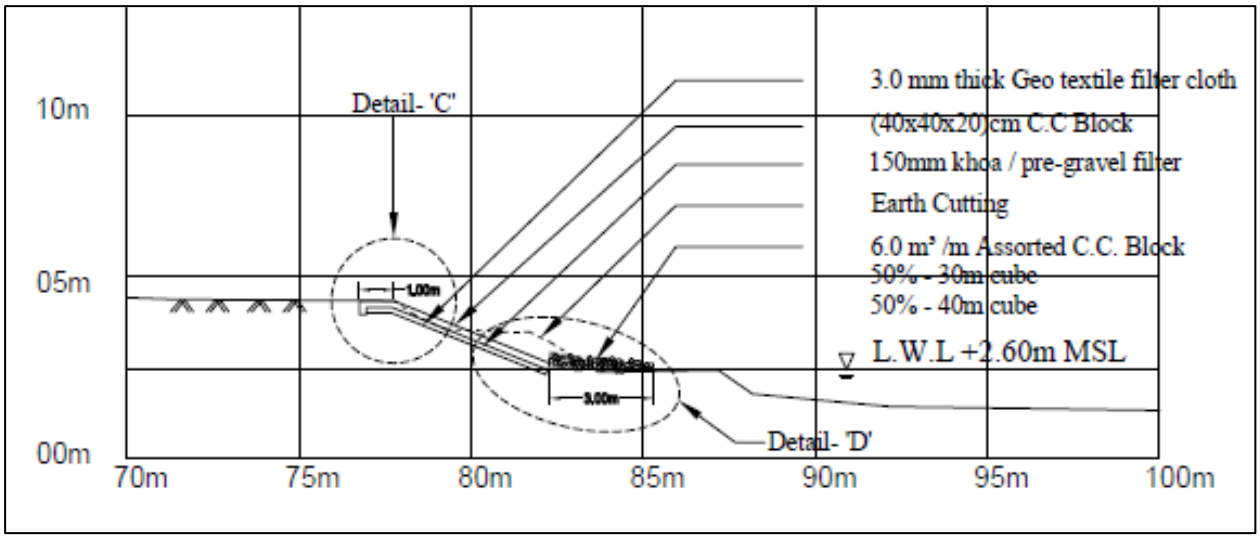
1) Type of bank protection works:

A block-laying type revetment work is adopted since the design flow velocity is 2-3m/s and that is used locally, instead of covering the surface with vegetation such as grass and sodding.

2) Design cross section of bank protection works

The following design cross section of the bank protection works is adopted, which is the standard design in Bangladesh and is applied locally.

- Slope gradient: 1:2.5
- Benches: If the height of the bank protection works is high, bench is provided at middle of the slope by every 3m in height.
- Block type: Standard concrete blocks of 400 x 400 x 200 are installed.
- Other: Protection work is provided on the top of the slope, and randomly stacked concrete blocks are installed on the foot of the slope.



Source: JICA Survey Team

Figure 6.2.10 Typical Design of River Bank Protection Works at Intake Site

3) Layout plan of the bank protection works

The meandering of the low water channel of the current river channel shall be fixed, and the channel shall be moved toward the left bank where the proposed intake is located. Based on the current condition of riverbank erosions and the historical meandering shape of the low water channel, the bank protection work shall be installed in 1,700m section along right bank and 2,000 m section along left bank of the low water channel.

As mentioned above, the flood dike construction and extension of the bank protection works will need to be promoted in future projects on the Bangladesh side as part of flood mitigation measures for the entire river basin, therefore flood dike construction is not included in this water supply project.

4) Other ancillary facilities

Since bank protection works alone have the effect of fixing the river's flow line only and have little effect in moving the low water channel toward the left bank, it is recommended that the necessity and location of construction of spur dikes on the opposite right bank and the shape of the excavated channel should be examined through hydraulic model experiments and numerical simulations at the time of detailed design.

(3) Design of River Dredging Works

1) Type of river dredging works:

As mentioned in the previous section of “Design of River Channel”, there are two types of channel excavation/dredging works in this project, i.e. i) capital dredging for construction works to secure a planned cross section of the river channel proposed by NODI as short-term measure

of the flood mitigation project, and ii) maintenance dredging of the low water channel which will be constructed in front of the intake to ensure the required intake discharge and to fix the river flow to the left side where the intake to be located.

2) Design cross section of dredging works

The design cross section of dredging works was described in the previous section.

3) Layout plan of dredging works

The river dredging shall be conducted in same areas as the bank protection works, in 2,000 m section in front of the intake, and upstream and downstream ends of dredging section shall be excavated smoothly connected on the existing river bed slope of the river channel.

(4) Estimated Sedimentation Inflow into River Channel and Intake

Although there is no data for sediment measurement in the Matamuhuri River basin, BWDB has prepared Q-Qs equation (relationship between discharge (Q) and sediment load (Qs)) in Bandarban(Source: JET based on data provided by BWDB). Based on this Q-Qs equation, annual sedimentation inflow at intake site from upstream was calculated as shown in following table.

According to the estimation, annual total sedimentation from upstream was estimated as 322-1,610 thousands ton/yr (Washload: 290-1,450 thousands ton/yr and Bedload: 31-161 thousands ton/yr) If washload to reservoir was calculated by the ratio of the intake discharge and total discharge, washload to reservoir is estimated as 3,600-18,000 ton/yr. The annual sediment depositions in the sand settling basin was estimated 400-2,000 ton/year. It is necessary to dredge the sedimentation in the sand settling basin and the raw water reservoir In addition, the bedload also will be accumulated in the low water channel in front of the intake and necessary the maintenance dredging. The required area of the spoil site of the maintenance dredging shall be prepared nearby each site

Table 6.2.1 Preliminary Estimation of Annual Sediment Load in River Channel, Intake and Raw Water Reservoir (in Wet Year)

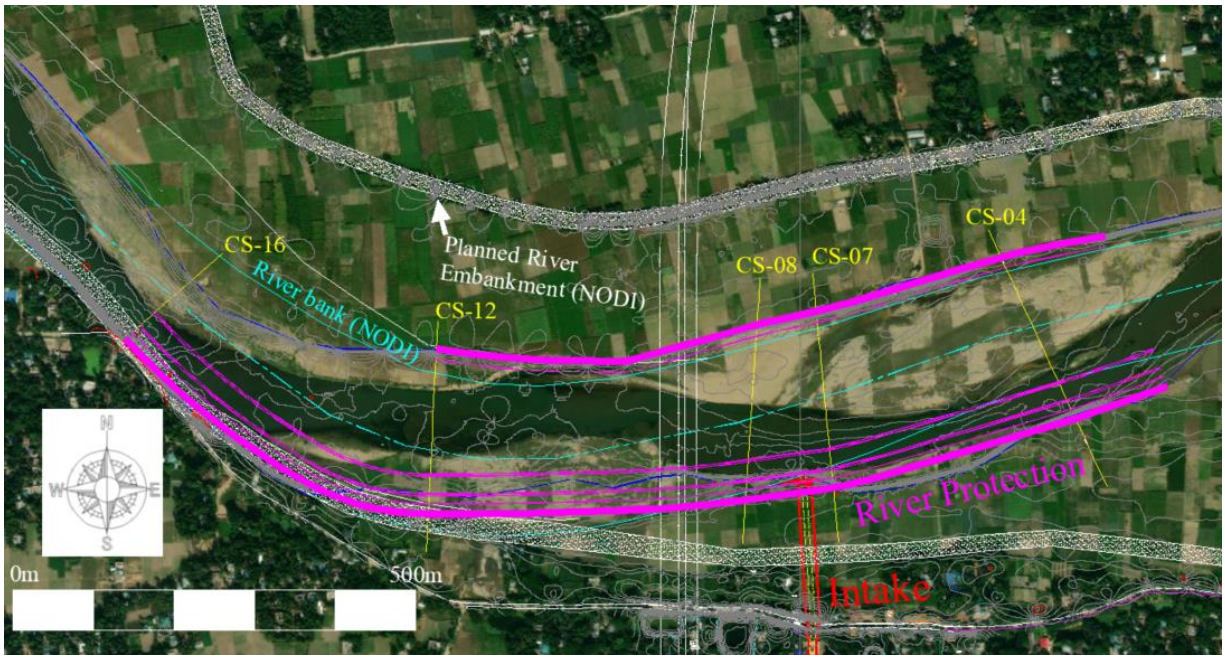
River Facility	Estimation of sediment deposition*	Remark
Total Annual Sediment Load	322,000-1,610,000 ton/year	100% (Clay+Silt+Sand)
Total Annual Bedload	32,000-161,000 ton/year	10% (Sand)
Total Annual Washload	290,000-1,450,000 ton/year	90% (Clay+Silt)
Sand Settling Basin	400-2,000 ton/year	Mainly sand deposition
Raw Water Reservoir	3,600-18,000 ton/year	Mainly silt and clay depositions (washload)

Note: The values in the above table are preliminary estimated ones based on the available and limited sediment load data in Sangu River. It is recommended to conduct sediment survey in the proposed intake site in Matamuhuri River, and review and improve the sediment load estimation in the detailed engineering stage.

Source: JICA Survey Team

(5) Basic Drawings

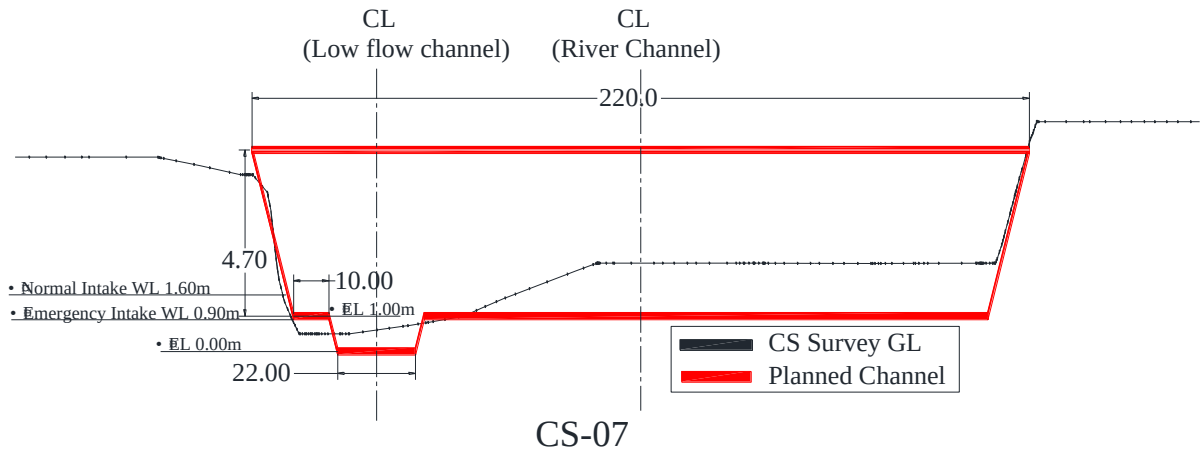
1) Plan



Source: JICA Survey Team

Figure 6.2.11 Plan of Bank Protection Work

2) Typical Section



Source: JICA Survey Team

Figure 6.2.12 Preliminary Typical Section of Bank Protection Work

6.2.3 Design of Intake Mouth

The design of intake mouth is followed by "The Design Criteria for Water Supply Facilities, 2012, Ministry of Health, Labor and Welfare, Japan".

(1) Hydraulic calculation of intake mouth

The following head loss is considered based on hydraulic calculation

- Entrance loss
- Screen loss

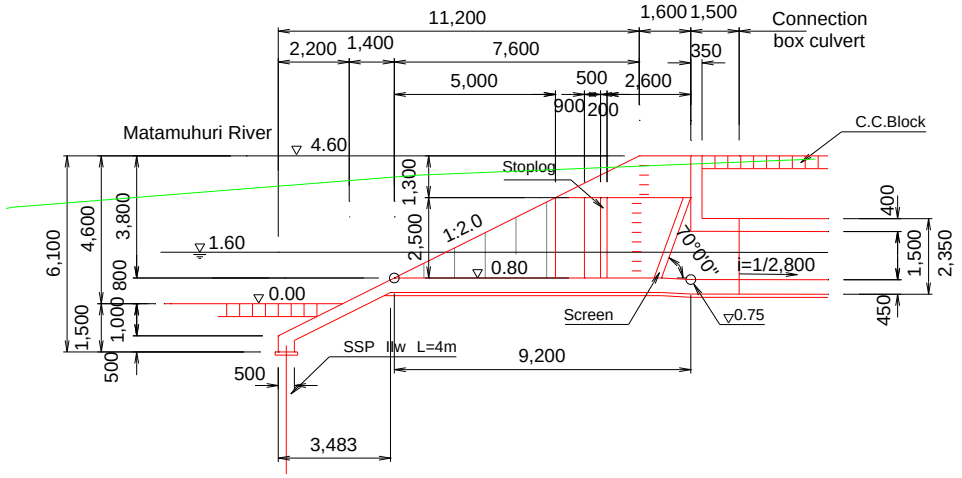
Table 6.2.2 Intake Structure Dimensions

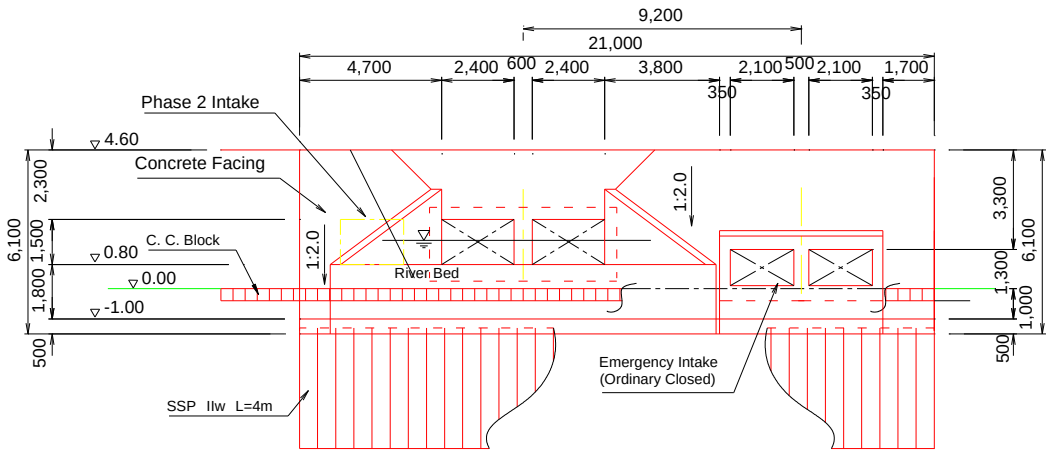
Structure	Head loss	Remarks
1) Entrance	0.0075 m	
2) Screen	0.0051 m	
Total	0.0126 m	

Source: JICA Survey Team

Total loss after intake mouth is 0.0075 + 0.0051 = 0.0126 m, and channel bottom is 0.05 m lower than entrance as shown in Figure 6.2.13.

Detailed calculation indicates in Supporting Report B-1 section 2.4.





Source: JICA Survey Team

Figure 6.2.13 Intake Front View and Profile

6.2.4 Conveyance Channel from Intake to Grit Chamber

Conveyance channel from intake to grit chamber is the concrete box as following table;

Table 6.2.3 Conveyance channel

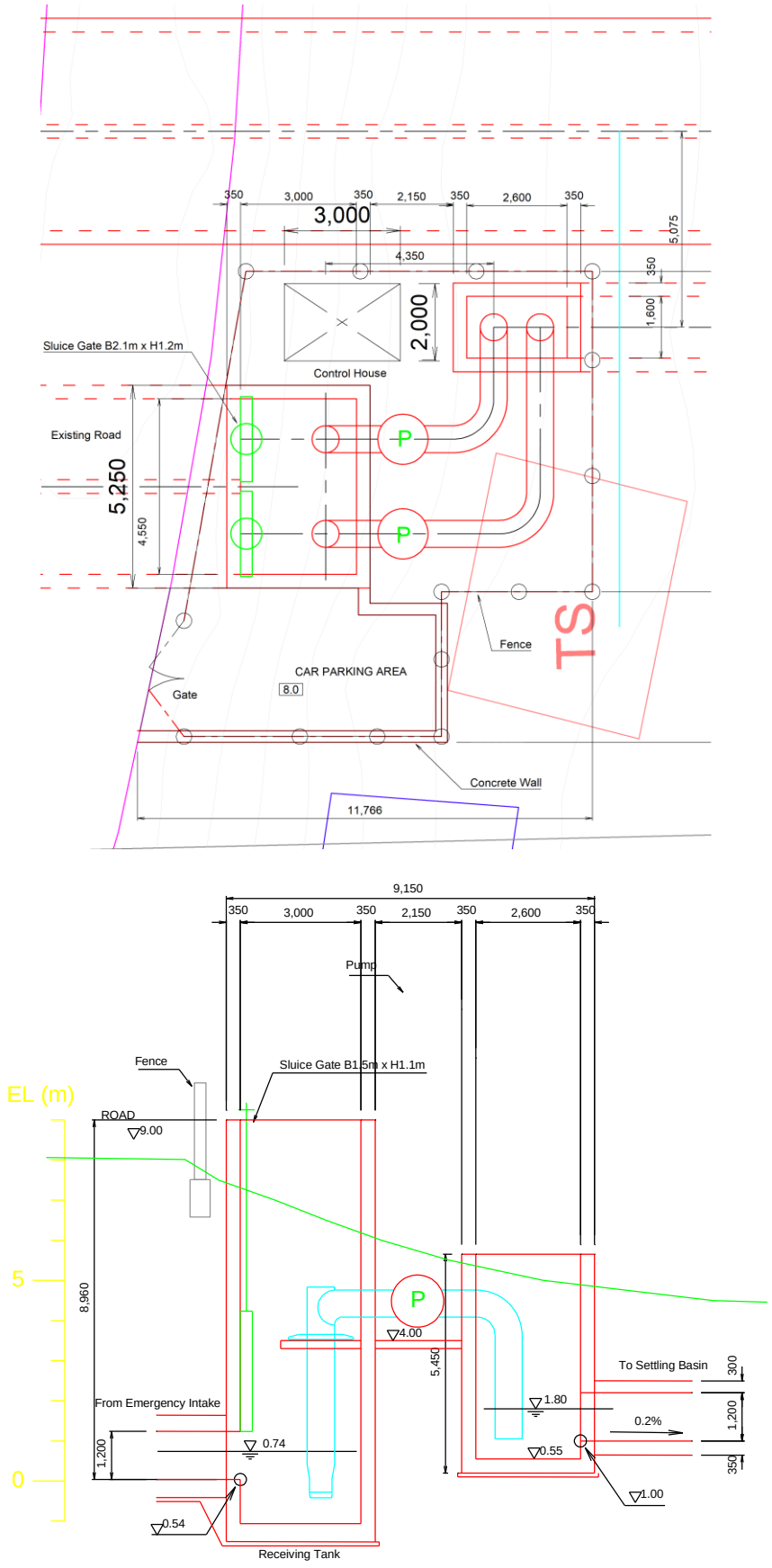
	Item	Value	Remarks
	Adopted Equation	Manning Equation	
1)	Culvert Width x height	2.40 m x 1.50 m	
2)	Number of Box culvert	2 nos.	
3)	Culvert Slope	1/2,800	
4)	Roughness Coefficient	0.015	Concrete
5)	Water Depth	0.80 m	
6)	Flow Area	3.84 m2	
7)	Flow Velocity V	0.772 m/s	0.40 < V < 0.8 ok
8)	Discharge	2.964 m3/s	> Design Discharge 2.90 m3/s O.K.

Source: JICA Survey Team

6.2.5 Emergency Channel

As emergency channel water level is lower than conveyance channel, the emergency pumping station is installed at existing riverbank with existing road as shown in Figure 6.2.14. The channel until emergency pumping station is 2 concrete box culvert, namely Type 1 the channel after emergency pumping station is Type 2.

Detailed calculation indicates in Supporting Report B-1 section 2.6.



Source: JICA Survey Team

Figure 6.2.14 Emergency Pumping Station

6.2.6 Design of Grit Chamber

The size of grit chamber is determined based on the Design Criteria for Water Supply Facilities, 2012, Ministry of Health, Labour and Welfare, Japan and results shows Table 6.2.4.

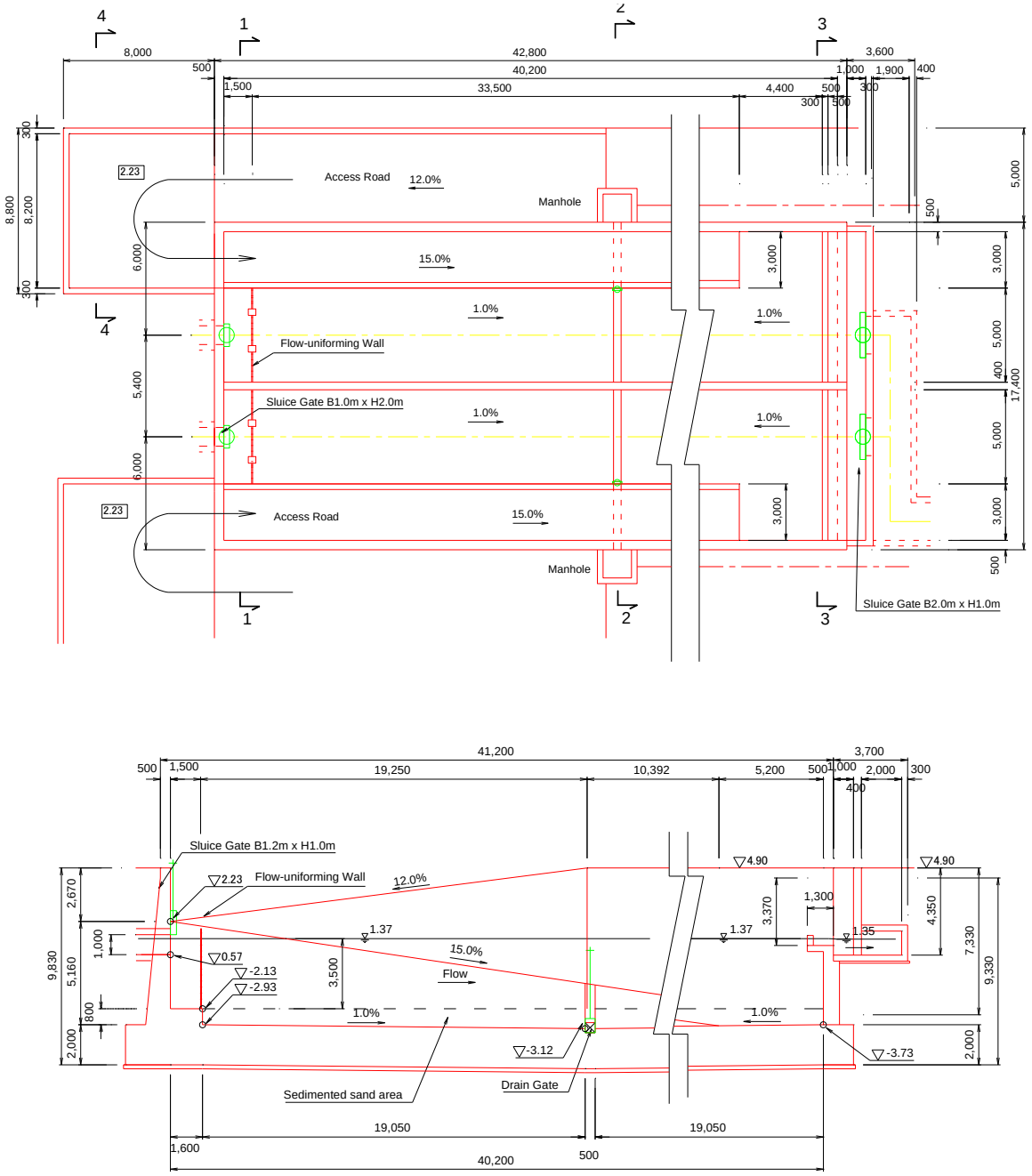
Detailed calculation indicates in Supporting Report B-1 section 2.7.

Table 6.2.4 Grit Chamber

	Item	Value	Design criteria/1/Remarks
1)	Design Discharge Q	2.90 m3/s	
2)	Width	5.0 m	
3)	Length	38.00 m	
4)	Effective Depth	3.50 m	3.0 m to 4.0 m
5)	Sediment Depth	0.80 m	
6)	Numbers	3	3 + 1(Standby) Total 4
7)	Overflow Ratio	305 mm/min	200 to 500 mm/min
8)	Average Flow Velocity	0.055 m/s	0.02 to 0.07 m/s
9)	Settling Velocity of Sand	0.8 cm/s	Design Sand Radius 0.10 mm
10)	Required Length	36.25 m	< 3) o.k.
11)	Retention Time	11.47 min.	10 to 20 min.
12)	Ration of Width and Length of Chamber	1/7.60	1/8 to 1/3

Source: JICA Survey Team

Note:/1: Design criteria means The Design Criteria for Water Supply Facilities, 2012, Ministry of Health, Labor and Welfare, Japan



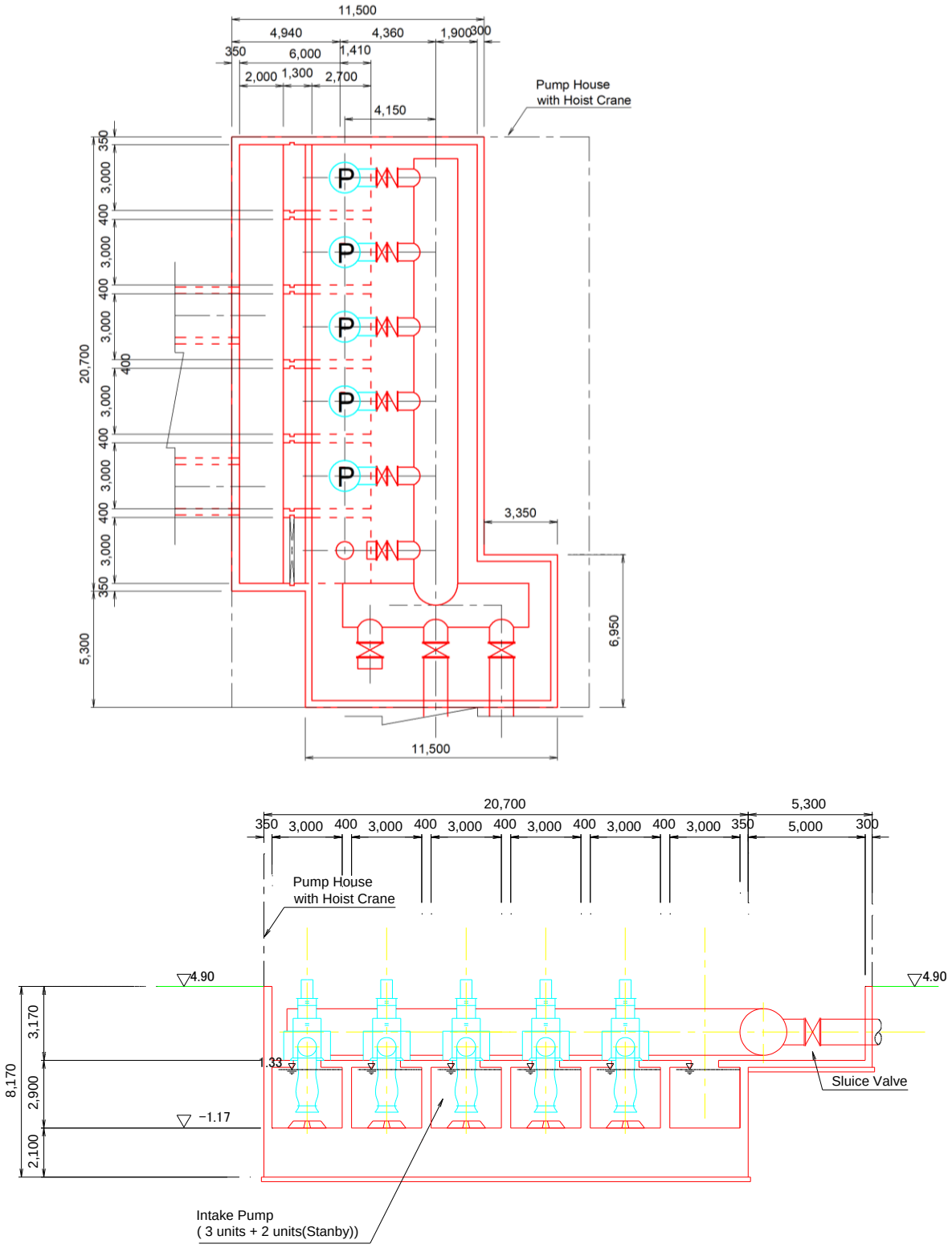
Source: JICA Survey Team

Figure 6.2.15 Grit Chamber

Frequency of removing sediment is 1.5times/year in case of 3 grit chamber and 1 standby grit chamber.

6.2.7 Pumping Tank

After grit chamber, the water conveys to the raw water pipeline through pumping tank and intake pump. Pumping tank has 6 pump tanks with pumps and connecting pipeline. 6 pump tank includes 1 pump tank of Phase 2. Pumping tank is covered with the pump house with hoist crane.



Source: JICA Survey Team

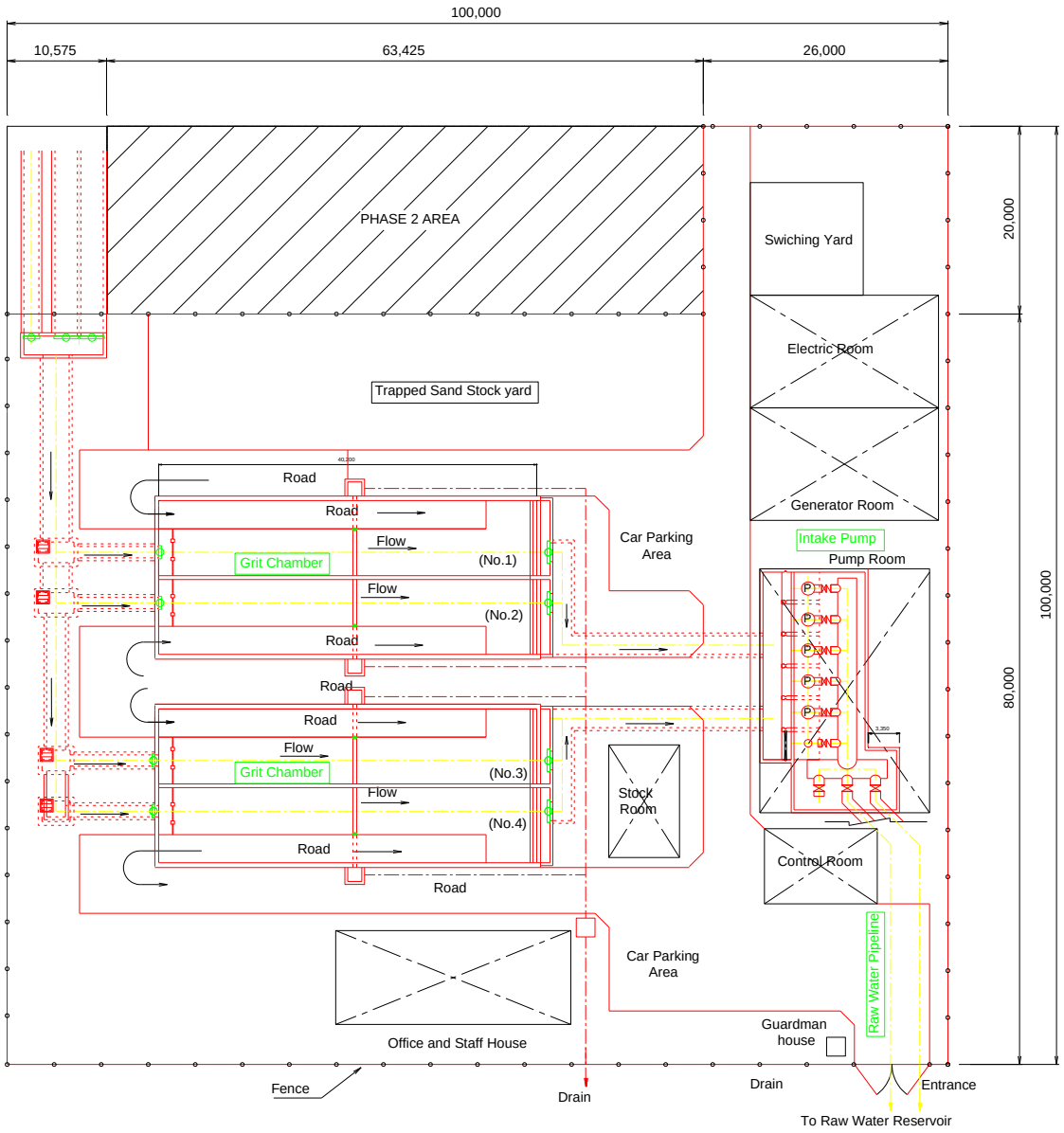
Figure 6.2.16 Pumping Tank

6.2.8 Layout of Intake Pumping Station and Flow Diagram

Intake pumping station has not only grit chamber and pumping tank, but, related electric room, staff room and tarped sand stock yard as shown in Figure6.2.17.

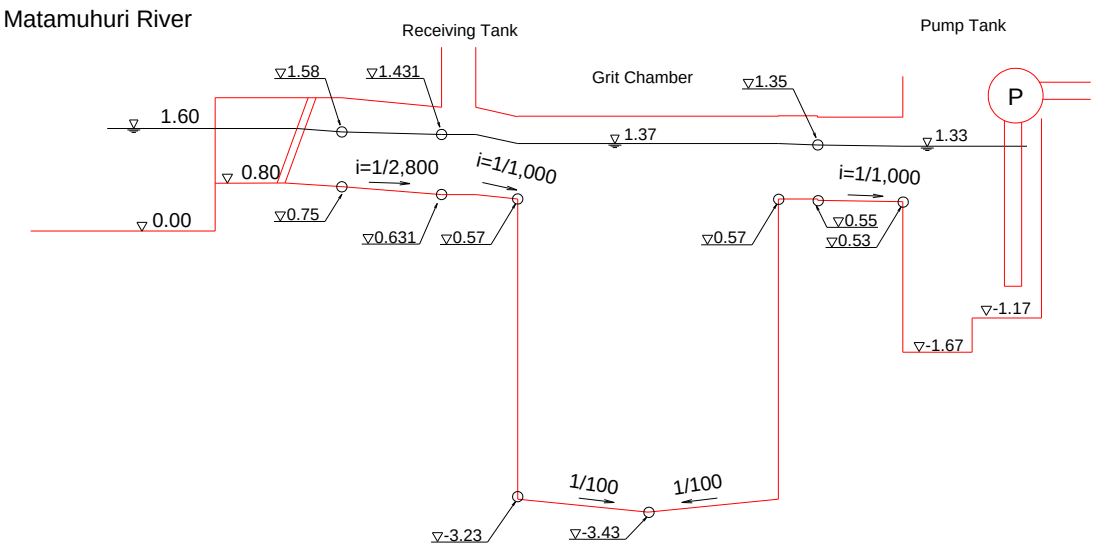
Its area is width 100 m x length 100 m including grit chamber area in Phase 2.

Flow diagram from intake to pumping tank is shown in Figure 6.2.18.



Source: JICA Survey Team

Figure 6.2.17 Layout of intake pumping station



Source: JICA Survey Team

Figure 6.2.18 Flow Diagram

6.2.9 Stability Analysis

(1) liquefaction

The two step examinations, namely STEP 1 and STEP 2, are applied for judgment of liquefiable foundation as LEVEL 1 and LEVEL 2 for the soil layer which is saturated and situated within 20m from ground surface as shown in Figure 6.2.19 based on "Specifications for Highway Bridge, Part V seismic design, Japan".

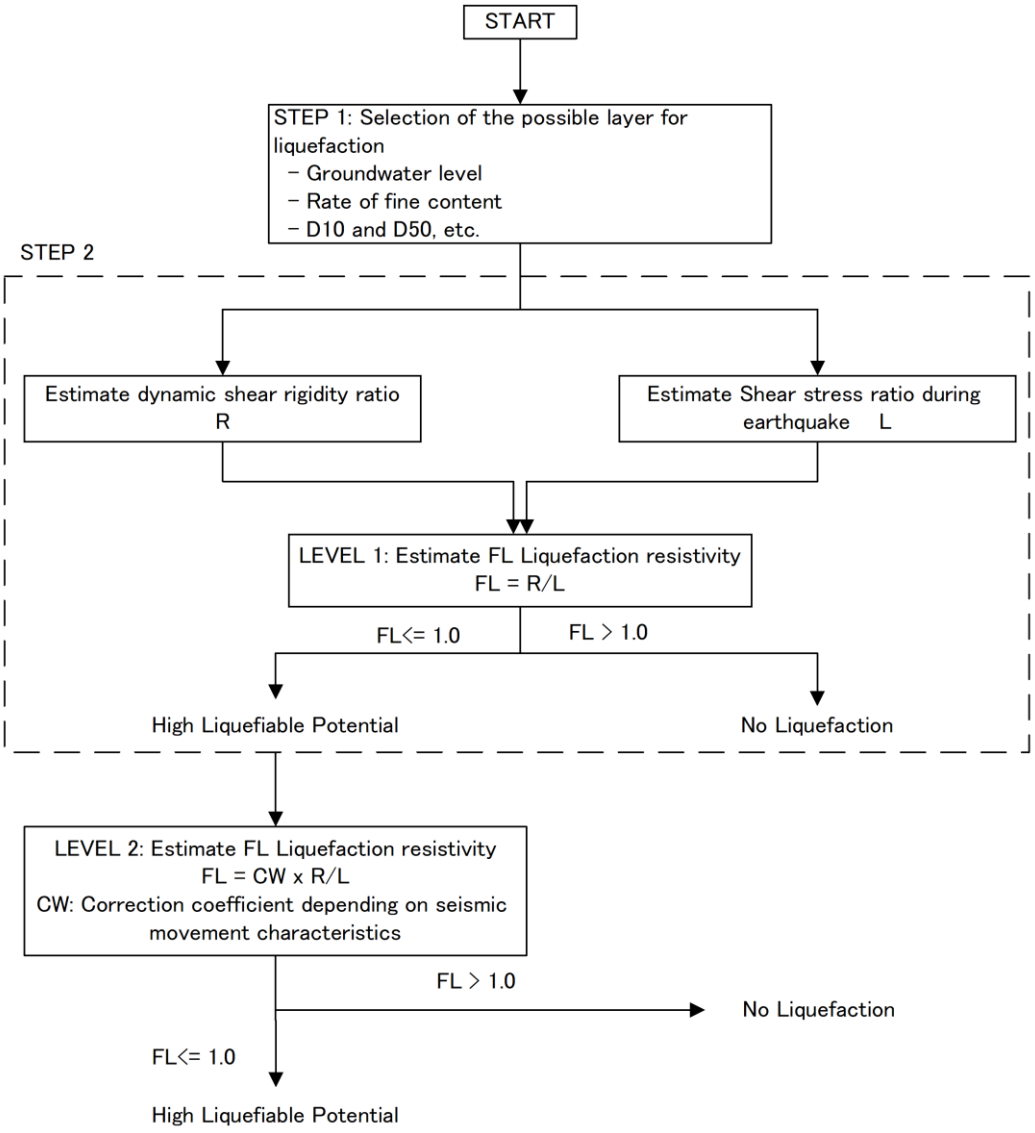
STEP 1

Foundation of target layer until 20 m from ground surface is considered as highly liquefiable when all of the following three conditions are applicable on the target soil layer.

a) Ground water level is within 10m from ground surface.

b) Fine fraction ratio (F_c) is more than 35% and plasticity index (I_p) is lower than 15 or Fc less than 35%.

c) Mean particle diameter (D_{50}) is lower than 10mm, and 10% particle diameter (D_{10}) is lower than 1mm.



Source: JICA Survey Team

Figure 6.2.19 Diagram of Liquefaction examination

STEP 2

Foundation of target layers that are selected by STEP 1 considered as liquefiable when value of Liquefaction Resistivity formula (F_L) is estimated.

The possibility of the liquefaction on foundation should be check by STEP 2 based on results of laboratory tests. LEVEL 1 and LEVEL 2 are separated. When Liquefaction Resistivity is less than 1.0, the layer can be judged as liquefiable foundation at each LEVEL. Liquefaction judgments method is summarized in Table 6.2.5.

Table 6.2.5 Liquefaction Judgment Methods for STEP 2

<table>
<tr><th colspan="2">STEP 2</th></tr>
<tr><td colspan="2">$F_L = C_W \cdot R/L$
$R = R_L$
$L = r_d \cdot k_h \cdot (\sigma_v/\sigma'_v)$
$r_d = 1.0 - 0.015x$
where:
F_L : Liquefaction resistivity
R : Dynamic shear rigidity ratio
L : Shear stress ratio during earthquake
C_W : Correction coefficient depending on seismic movement characteristics
R_L : Cyclic tri-axial strength ratio
r_d : Reduction coefficient of depth direction during earthquake
k_h : Design horizontal seismic intensity
σ_v : Total stress at the depth of x(m), kN/m^2
σ_v' : Effective stress at the depth of x(m), kN/m^2
x : Depth from ground surface, (m)</td></tr>
<tr><td>Level 1 and Level 2 Type 1
C_W =1.0
Liquefiable Soil: F_L < 1.0</td><td>Level 2 Type 2
C_W =1.0 ($R_L \leq 0.1$)
C_W =3.3R_L+0.67 ($0.1 < R_L \leq 0.4$)
C_W =2.0 ($0.4 < R_L$)
Liquefiable Soil: F_L < 1.0</td></tr>
</table>

Source: JICA Survey Team

Each layer of intake bore hole results; Intake-BH-01 to 03, is evaluated by Step 1 method. As the results of Step 1, one sample- Intake-BH-03 depth 15.0 m to 16.0 m in 10 samples has high Liquefiable Potential. Only one sample is progressed to Step 2.

As layer Intake-BH-03 15.0 m to 16.0 m is calculated by Step 2, Table 2.10.4 is obtained. Table 6.2.6 shows.

Table 6.2.6 Liquefaction Calculation by Step 2

Item	Layer 15.0m-16.0	Remarks
x	15.5	
Water Depth Hw	1.2	
N value	7	
FC(%)	92.4	
Balk Density	18.89	
Submerged Density	9.89	
Level 1		
L	0.21	
R	0.27	
Cw	1.0	
FL	1.34	FL > 1 ok
Level 2 Type 1		
L	0.48	
R	0.27	
FL	0.57	FL < 1 out
Level 2 Type 2		
L	0.96	
R	0.27	
FL	0.45	FL < 1 out

Source: JICA Survey Team

As per this calculation, liquefaction is occurred in high possibility on Level 2 Type 1 and 2. However, countermeasure is not considered or topical treatment even implementing the countermeasure for this layer by the following reasons

- High potential layer is only one layer or thin thickness.
- This layer is not shallow layer and the layers on this layer until ground surface is not occurred.

Detailed calculation indicates in Supporting Report B-1 section 2.10.

(2) Stability of base foundation

Allowable bearing capacity (Qa) is obtained by the ultimate bearing capacity using the safety factor shown below based on : Specifications for Highway Bridges IV Substructures, Japan.

$$q_a = \frac{Q_u}{SF}$$

SF = 3 (normal)

SF = 2 (seismic)

Ultimate bearing capacity of foundation ground is calculated with the formula below.

$$Qu = A'\left\{\alpha\, k\, c\, N_c + k\, q\, N_q + \frac{1}{2}\gamma_1\, \beta\, B'\, N_r\right\}$$

Where,

Qu : Ultimate bearing capacity (kN)

A’ : Effective loading area on footing (m^2)

α , β : Shape factor of foundation as shown in the following table

Table 6.2.7 Shape Factor of Foundation

Shape of Foundation	α	β
Zonation	1.0	1.0
Circle or Square	1.3	0.6
Rectangle or ellipse	1+0.3B’/L’	1-0.4B’L’

Source: Specifications for Highway Bridges IV Substructures Table 10.3.3, Japan

C : Cohesion of foundation ground (kN/m^2)

q : Surcharge (kN/m^2)

γ_1, γ_2 : Unit weight of soil of bearing ground (kN/m^3)

B’,L’ : Width and length of effective loading areas as shown in the following figure

B’ = $B - 2e_H$

L’ = $L - 2e_L$

e : Distance from center of footing to point of resultant force on footing as illustrated in the following figure (m)

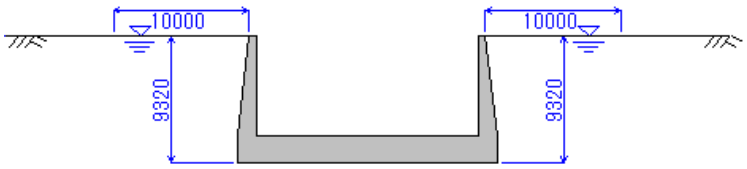
Df : Depth from ground surface to bottom of footing (m)

K : Coefficient (1+0.3 x Df'/B)

Df' : Effective embedded depth of foundation (m)

Nc, Nq, Nr: Bearing capacity factors

As per above equation, grit chamber foundation is analyses. Main figure of grit chamber is shown in Figure 6.2.20.



Source: JICA Survey Team

Figure 6.2.20 Grit chamber Section

1) Normal

q_{max} = 105.23 kN/m^2

Allowable bearing capacity (Qa)

$q_a = 1/3(\alpha \cdot c \cdot N_c + \beta \cdot \gamma_1 \cdot B \cdot N_r + \gamma_2 \cdot D_f \cdot N_q)$

= 1/3(1.0000 · 38.650 · 6.950 + 0.500 · 18.890 · 19.064 · 1.460)

+ (8.400 · 9.320 + 17.400 · 0.010)· 5.080)

= 310.030 kN/m^2

qmax/qa = 105.23 / 310.03 = 0.339 < 1.000 【OK】

2) Seismic Condition

q_{max} = 113.44 kN/m^2

Allowable bearing capacity (Qa)

$q_a = 1/3(\alpha \cdot c \cdot N_c + \beta \cdot \gamma_1 \cdot B \cdot N_r + \gamma_2 \cdot D_f \cdot N_q)$

= 2/3(1.0000 · 38.650 · 6.950 + 0.500 · 18.890 · 19.064 · 1.460)

+ 1/2 (8.400 · 9.320 + 17.400 · 0.010)· 5.080)

= 487.199 kN/m^2

qmax/qa == 113.44 / 487.199 = 0.233 < 1.000 【OK】

Detailed calculation indicates in Supporting Report B-1 section 2.10.

6.2.10 Mechanical and Electrical Equipment

The main mechanical and electrical equipment for the river water intake facility are as follows:

(1) Intake Pump

A vertical mixed flow pump, which has a large capacity and requires a small installation space, and is one of the most common types, will be applied for the Intake Pump. River water intake flow is basically controlled by the operation numbers of pumps. Details of countermeasures of water hammer will be provided in a study in next stage.

The specifications of Intake Pump are as follows:

Name	:	Intake Pump
Type	:	Vertical mixed flow
Outlet diameter	:	800 mm
Discharge volume	:	61.5 m^3/min
Pump total head	:	31 m
Motor rated capacity	:	450 kW
Number of pumps	:	5 units (3 Duty and 2 Standby)

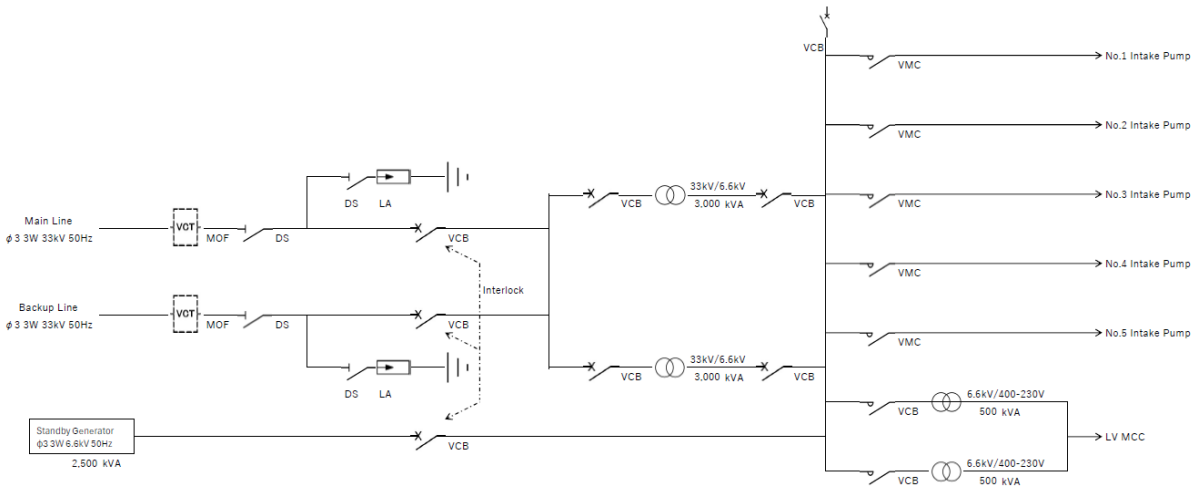
An emergency intake pump is prepared to intake river water when the water level is low, for instance, in the last stage of the rainy season. The pump conveys river water to the settling basin in the intake facilities. The standby pump is not prepared because it is not for regular use.

The specifications of emergency intake pump are as follows:

Name	:	Emergency Intake Pump
Type	:	Vertical axial or mixed flow
Outlet diameter	:	700 mm
Discharge volume	:	42.3 m^3/min
Pump total head	:	5 m
Motor rated capacity	:	55 kW
Number of pumps	:	2 units (2 Duty and 0 Standby)

(2) Power Receiving and Transmission

The power receiving is planned 2 circuits type. Two units of main transformer (33 kV/ 6.6 kV, 3,000 kVA) is prepared. The type is an Oil Immersed Transformer. A single line diagram for intake facility is shown in Figure 6.2.21.



Source: JICA Survey Team

Figure 6.2.21 Single Line Diagram for Intake Facility

(3) Emergency Power Generator

An emergency power generator is prepared one unit to maintain the minimum functions of this facility when power supply is stopped due to blackout occurrence. The capacity is 2,500 kVA and the type is Three Phase Synchronous Diesel Generator.

6.3 Preliminary Design of Raw Water Pipeline Facilities

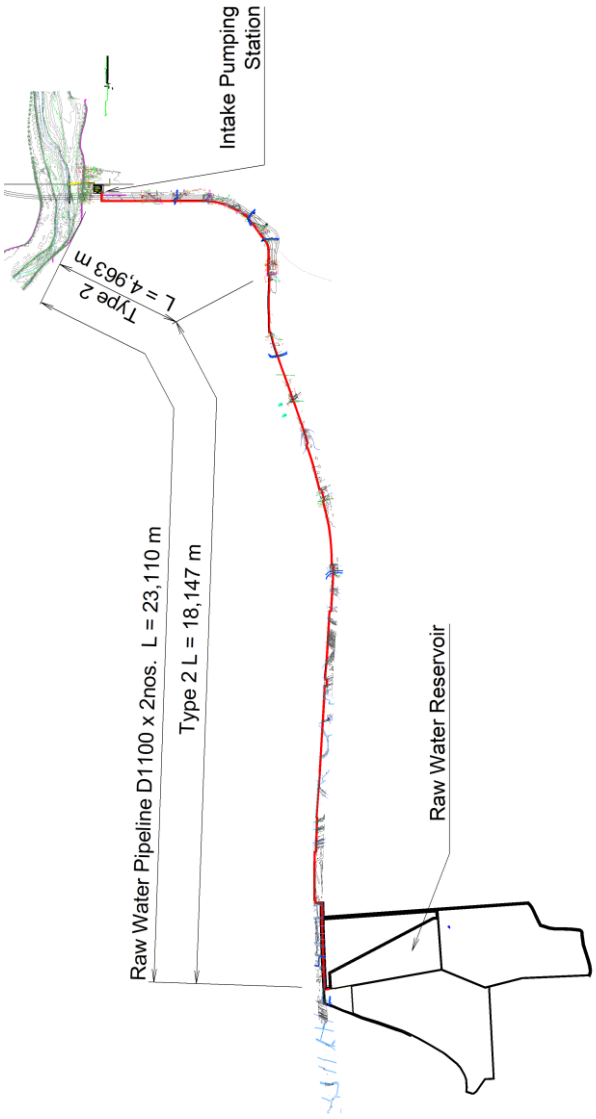
6.3.1 General

Raw water pipeline is the pipeline from intake pumping station to receiving tank of raw water reservoir. Its dimensions and materials are shown in Table 6.3.1. Location map is shown in Figure 6.3.1.

Table 6.3.1 Raw water pipeline dimensions and materials

Item	Dimension	Remarks
1) Length	11,555 m x 2 series = 23,110 m	
2) Size	D1,100 x 2 series	
3) Material	Steel or ductile iron	
4) Aqueduct portion	9 sites	
5) Underground tunnel	3 sites	Construction by pipe jacking method

Source: JICA Survey Team



Source: JICA Survey Team

Figure 6.3.1 Location map of Raw water pipeline

6.3.2 Type 1 and Type 2

Pipeline is usually installed underground as shown in Figure 6.3.2 and Figure 6.3.3. The pipeline can classify 2 types, namely Type 1 and Type 2.

Type 1 is to set 2 raw water pipelines in parallel with distribution pipeline along Matarbari port access road. Type 2 is to set 2 raw water pipelines only with keep the space of 1 pipeline for Phase 2 along Chattogram Cox's Bazar highway.

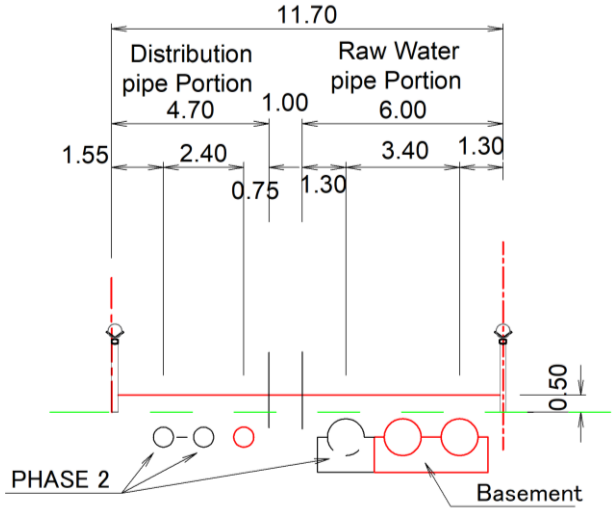
Type 1 has the concrete fence at both ends as shown in Figure 6.3.2. Type 2 has the concrete fence at both end and maintenance road. The concrete fence is for security and prevented from the vehicle crossing the pipeline.

This pipeline has 9 aqueducts and 3 underground tunnels.

6 aqueducts support 2 pipelines and 1 distribution pipeline on 1 aqueduct in Type 1 region. And remaining 3 aqueducts support 2water pipelines only in Type 2 region.

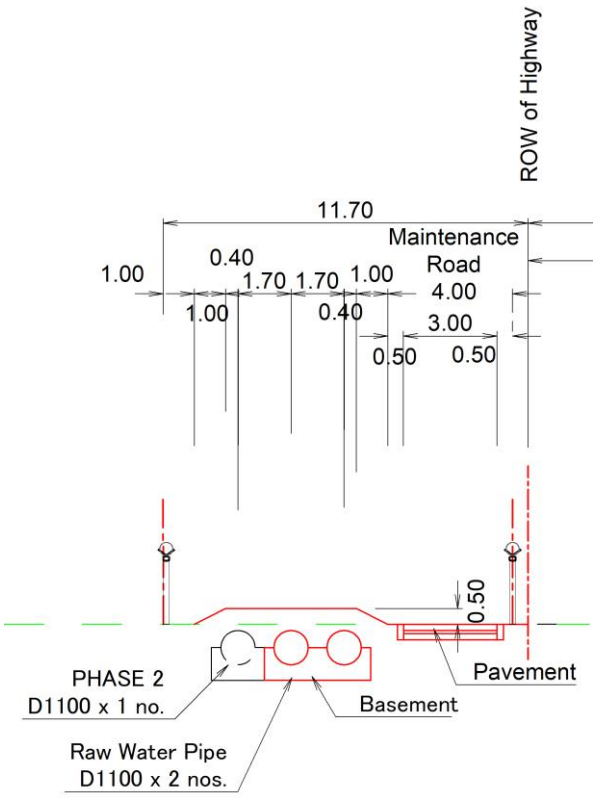
3 underground tunnels are constructed by pipe jacking method at intersection of main road and railway because road and railway cannot stop by pipeline construction work and cannot make the bypass way for construction.

Pipeline accessory is mainly air valve and drain valve on pipeline. Air valve is on highest position such as aqueduct centre and drain valve is low position covered with manhole such as beginning point and ending point of ground tunnel portion.



Source: JICA Survey Team

Figure 6.3.2 Typical Cross section of Type 1



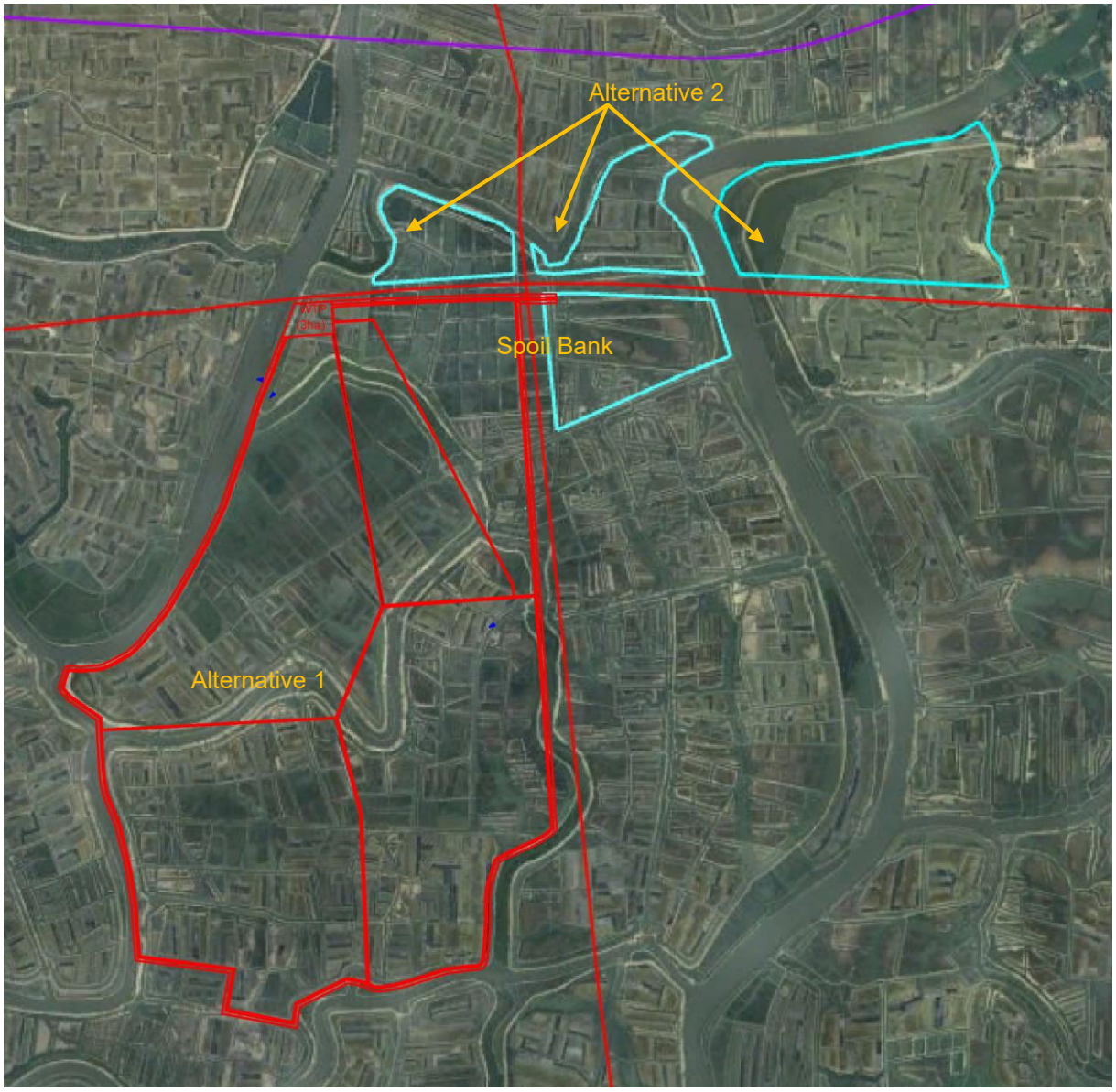
Source: JICA Survey Team

Figure 6.3.3 Typical Cross section of Type 2

6.4 Preliminary Design of Raw Water Reservoir Facilities

6.4.1 Location

As raw water pipeline was planned along Matarbari port highway road, Palakata. And RWR site (alternative No.1) is planned to adjacent its highway. As RWR needs large area for storage 27 MCM including Phase 2 as well as 19.6 MCM in Phase 1, additional site (alternative No.2) can be considered near alterative RWR site as well as RWR site as shown below, however, this report mentions alternative No.1 only as RWR site.



Source: JICA Survey Team

Figure 6.4.1 Location of Raw Water Reservoir

6.4.2 Requirement Condition of Raw Water Reservoir

Requirement conditions of raw water reservoir are shown in the following;

- Total volume of the reservoir is more than required volume 19.6 MCM.
- Divide into lots for maintenance including removing sand and security in the reservoir
- Each lot shall not affect the other lots in water inflow and outflow to WTP
- Installing the spillway, local drainage channel, and bottom sluice gate and pipe
- Considering the measures against salt water intrusion if necessary
- Designed reservoir water depth is composed of 6.0 m depth that is 5.0 m effective raw water depth and 1m sediment depth in No.1 and No.2 reservoir and 6.5 m of 6.0 m effective depth and 0.5 m sediment depth in No. 3 and No.4 reservoir.
- Setting the spoil bank site (for maintenance dredging/excavation in RWR) and sludge from WTP
- Setting the access road to reservoir site and into reservoir (slope road) for removing sediment
- Outlet position is far from inlet position prevented from occurring the dead water region as far as possible
- Water treatment plant (WTP) is set adjacent to reservoir.
- Resettlement house by implementing the proposed reservoir is nothing or few

6.4.3 Outline of Reservoir

Figure 6.4.2 shows divided 4 lots in RWR and spoil bank. RWR composes of two reservoirs, namely first reservoirs; Reservoir No.1 and No.2, and second reservoirs; Reservoir No3 to No.4. First reservoirs have the function of water reservoir and sedimentation of sand mainly, and second reservoirs have mainly water reservoir.

Each lot reservoir volume is shown in Table 6.4.1.

Table 6.4.1 Reservoir Storage volume

Unit:MCM

Reservoir No.	1	2	3	4	Remarks
Storage Volume	First Reservoir		Second Reservoir		
	2.4	2.4	7.4	7.4	
Sub-Total	4.8		14.8		
Total	19.6				

Source: JICA Survey Team

Figure 6.4.3 shows the water flow diagram in reservoir and

Source: JICA Survey Team

Figure 6.4.4 is the outline plan of the reservoir.

Raw water flows into receiving water tank at first and then flow to Reservoir No.1 or No.2; first reservoir. The water in the Reservoir No3. to No.5 is stocked from the flow

of first reservoir and send to WTP. If second reservoirs are empty, the water of first reservoir flow into WTP directly.



Source: JICA Survey Team

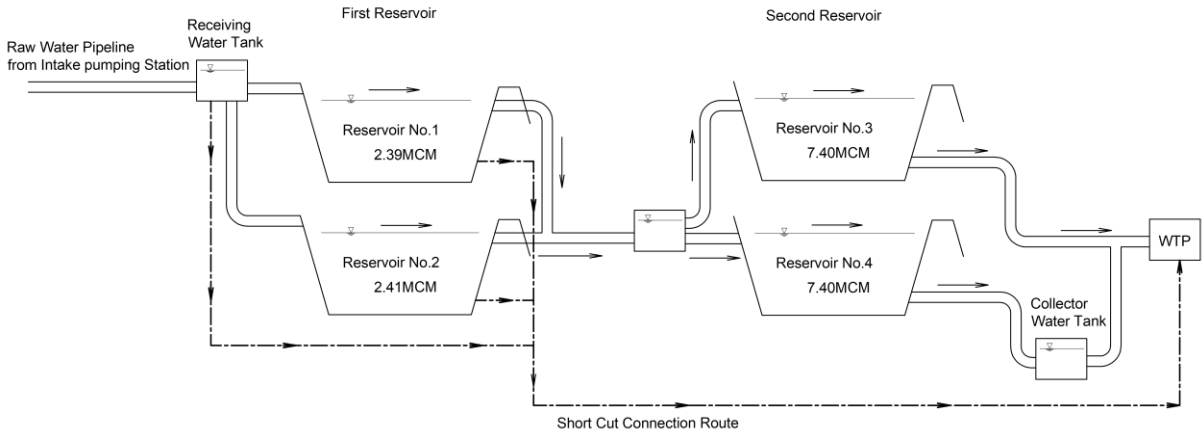
Figure 6.4.2 Plan of Raw Water Reservoir and Spoil Bank

In flooding time and even flowing into RWR on full water level of reservoir, the water of reservoir flows out the river through spillway.

Each reservoir is surrounded by the embankment which has 6 m width road such as periphery road and maintenance road.

WTP is located to the corner of reservoir area and along the highway.

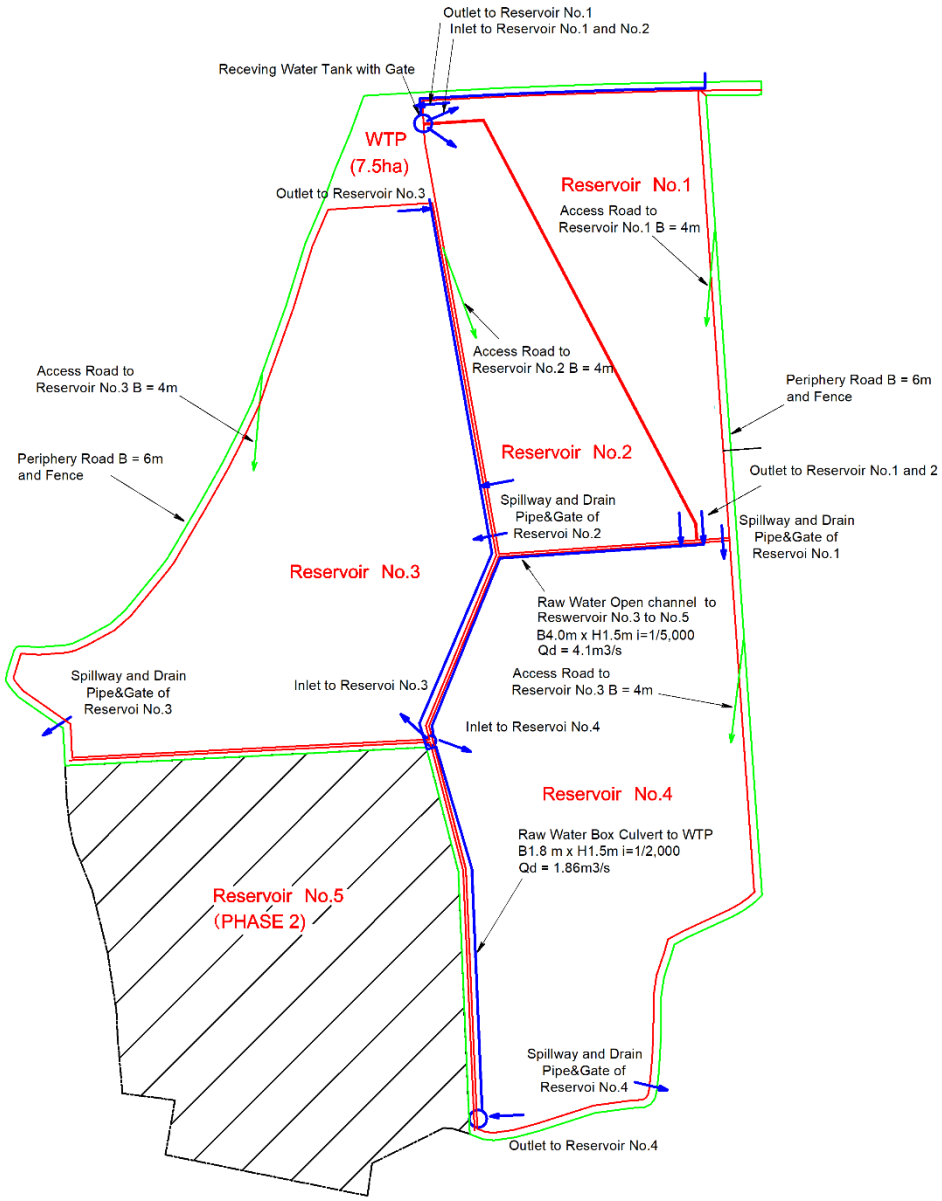
Spoil bank will include the dry bed in order to drying the sludge from WTP.



Source: JICA Survey Team

Figure 6.4.3 Water flow Diagram in Reservoir

Periphery road has the fences for security along right of way (ROW).



Source: JICA Survey Team

Figure 6.4.4 Raw Water Reservoir Outline Plan

6.4.4 Design Procedure

(1) General

Reservoir structure is mainly composed of embankment, discharge system of the water such as inlet, outlet spillway and maintenance road.

This section designs the following structures;

- Hydraulic calculation for spillway and some channel structures
- Required height of embankment,
- Stability of bank

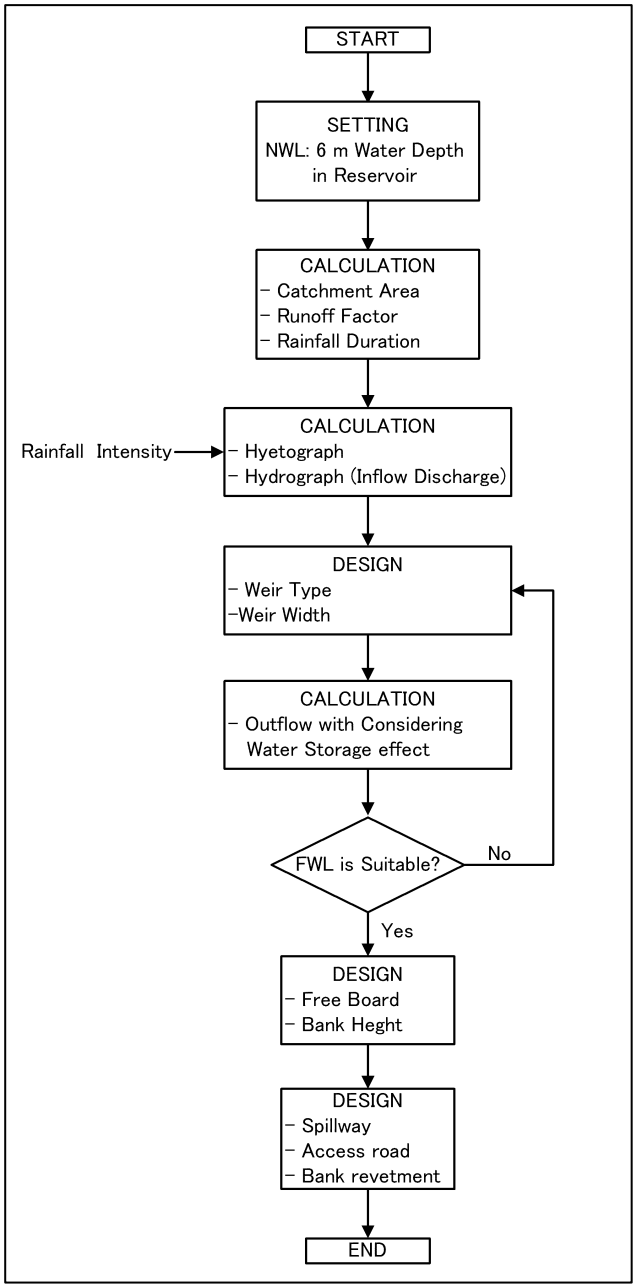
And from chapter 4, it is evident that foundation of RWR is soft soil for structures because current land use is fish pond, river channel or impounding water area.

The following studies for foundation also are necessary by soft soil.

- Settlement
- Liquefaction

(2) Flow chart of procedure for design

Procedure of design of reservoir is shown in Figure 6.4.5.



Source: JICA Survey Team

Figure 6.4.5 Flow Chart of Reservoir Design

(6) Standard for designing the reservoir

The following 2 standards are usually used in designing design discharge and spillway of the reservoir.

- Technical Standards of Disaster Prevention Regulation Pond, ETC., Japan River Association
- Guideline Manual for Land Improvement Project "Pond Development", Rural Development Bureau, Ministry of Agriculture, Forestry, and Fisheries.

This study uses latter "Pond Development" standard because this project reservoir is 1) impounding the water, 2) main function is water storage against former standard is prevented from flooding disaster and normally not impounding.

Detailed calculation indicates in Supporting Report B-1 section 3.1.

6.4.5 Design Discharge

Detailed calculation indicates in Supporting Report B-1 section 3.2.

(1) Design Inflow

Based on Guideline Manual for Land Improvement Project "Pond Development", Rural Development Bureau, Ministry of Agriculture, Forestry, and Fisheries, select 120% volume of the maximum discharge in the following A to C

Item A : Return period 200 years discharge (m3/s)

Item B : Recorded maximum discharge (m3/s)

Item C : Recorded maximum discharge in the vicinity or the value from Creager curve equation (m3/s)

Calculation of Item A is shown in Table 6.4.2.

Table 6.4.2 Design Discharge by Item A discharge

Item		Unit	No.1 & No.2	No.3 &No.4	Remarks
Catchment Area	A	Km^2	0.561	1.414	1 Lot
Rainfall Intensity	I_{100}	mm/hr.	273.41	273.41	$116.127/(T^{0.605}+0.116)$
Return Period		year	100	100	
Rainfall Duration	t	hour	0.1433	0.1433	
		min	8.60	8.60	
Runoff Coefficient	C		1.00	1.00	Reservoir
100 years Flow	Q_{100}	m^3/s	42.61	107.39	Equation (1)
200 years Flow	Q_{200}	m^3/s	51.13	128.87	Q_{100} x 1.2
Item A discharge	Q_A	m^3/s	61.35	154.64	Q_{200} x 1.2
Design Inflow Discharge	Qd	m^3/s	65.45	158.74	Q_A + Inflow 4.10

Source: JICA Survey Team

As for Item B, there is no hourly rainfall data near the site. Item B discharge is not available.

As for Item C, from Cox's Bazar station, the following rainfall was recorded from 2004 to 2021

3 hours maximum rainfall 122 mm/3hr = 40.67 mm/hr

Item A discharge 56.40 mm/hr (t = 3 hr) is larger than Item C discharge 40.67mm/hr (t = 3 hr).

From above study, Item A discharge is adopted. Detailed calculation indicates in Supporting Report B.

(2) Stoage Effect and Design Outflow

As per Guideline Manual for Land Improvement Project "Pond Development, storage effect can be considered in case of large reservoir area in catchment area and these reservoirs can be adopted.

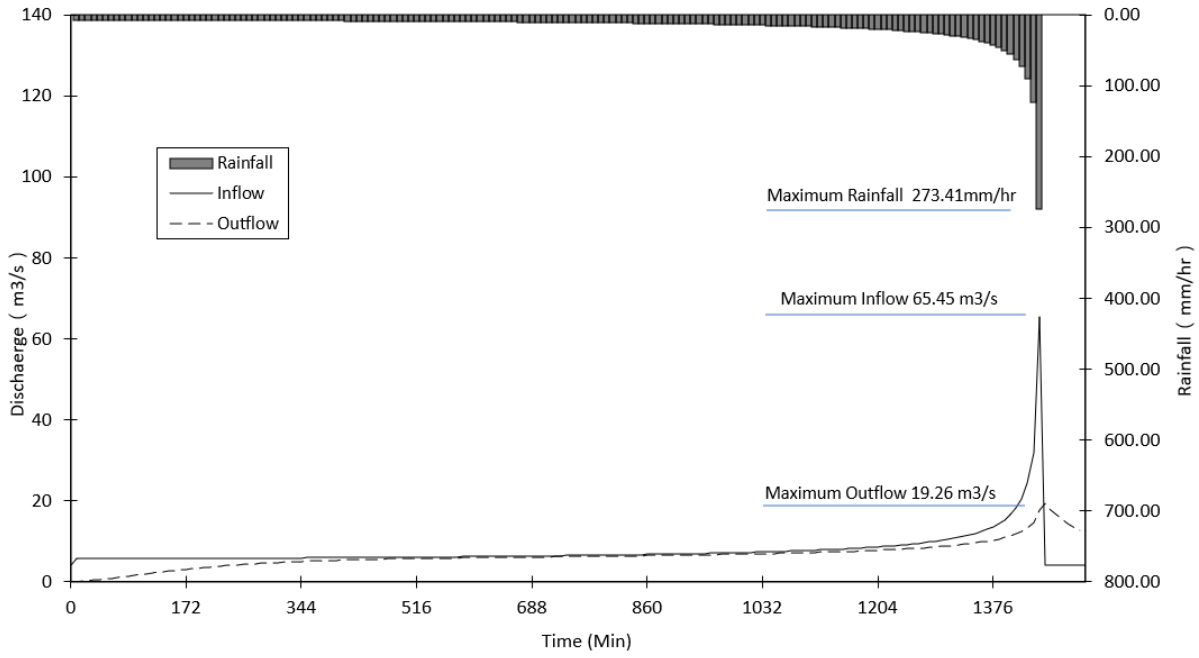
Storage effect is calculating 1) hyetograph, 2) calculating inflow hydrograph based on 1), 3) flood control calculating based on 2).

After calculation, Table 6.4.3, Figure 6.4.6 and 6.4.7 is obtained.

Table 6.4.3 Summary of Storage Effect calculation

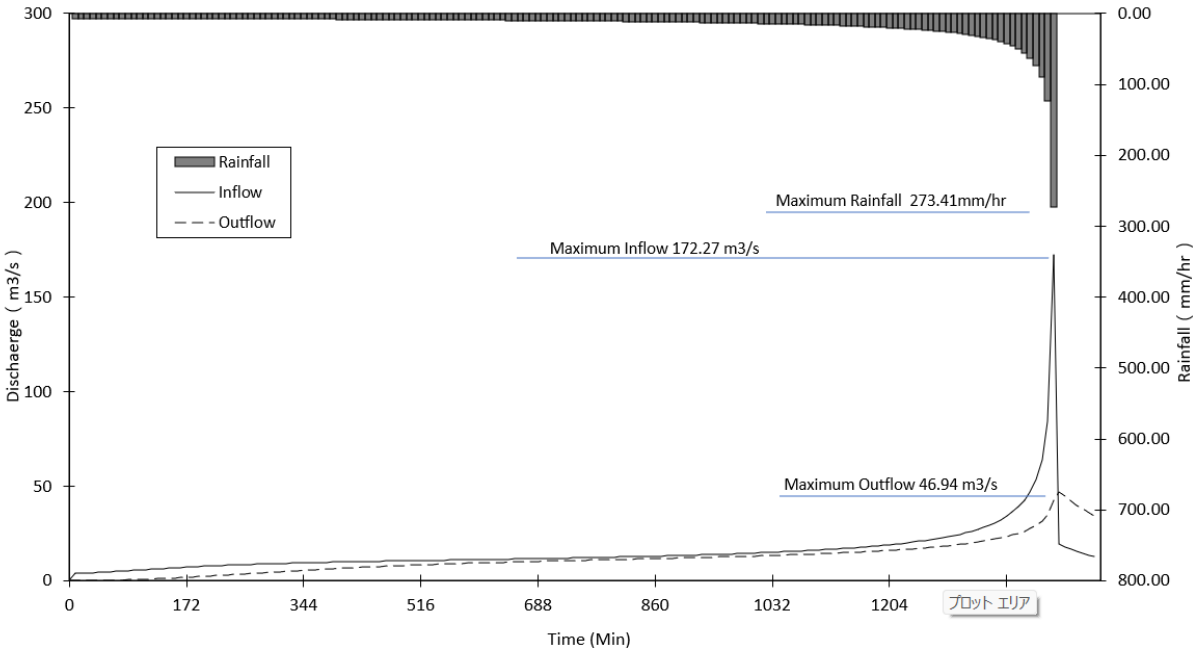
Item	Unit	No1 and No2 Reservoir	No.3 and No.4 Reservoir	Remarks
1) Maximum Inflow	m3/s	65.45	172.27	
2) Maximum Outflow	m3/s	19.26	46.94	
3) Initial water level	EL.	6.90	6.50	
4) Maximum water level	EL.	7.210	6.808	
3) Maximum Water Depth	m	0.310	0.308	

Source: JICA Survey Team



Source: JICA Survey Team

Figure 6.4.6 Results of flood control calculation at No.1 and No.2 Reservoir



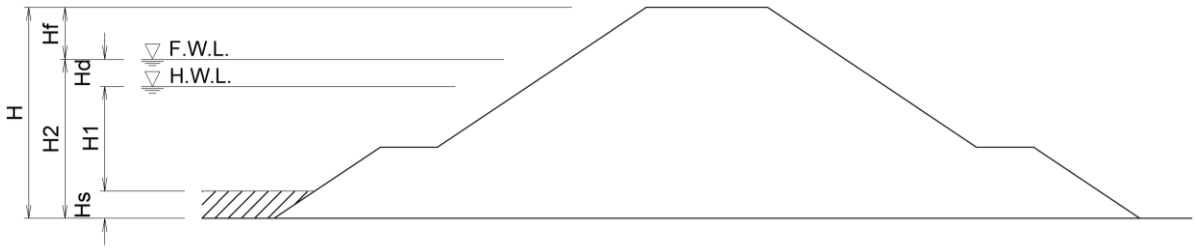
Source: JICA Survey Team

Figure 6.4.7 Results of flood control calculation at No.3 and No.4 Reservoir

Detailed calculation indicates in Supporting Report B.

6.4.6 Design of Embankment

Embankment height is composed of water height and free board as shown in Figure 6.4.8.



Source: JICA Survey Team

Figure 6.4.8 Embankment

Index in Figure 6.4.8 means the following;

H: Embankment height

Hs: Sediment height

H1: Effective height

Hd: Overflow depth

H2: Water Height

Hf: Free board

Hs, H1 and H2 defines Table 6.4.5. Hd is studied by next section.

Guideline Manual for Land Improvement Project "Pond Development" mentioned for

Hf as following;

3.3.4 (3) Free board

Free board is obtained by the following equation

$R \leq 1.0$ m

$hf = 0.05\ H2 + 1.0$

$R \geq 1.0$ m

$hf = 0.05\ H2 + R$

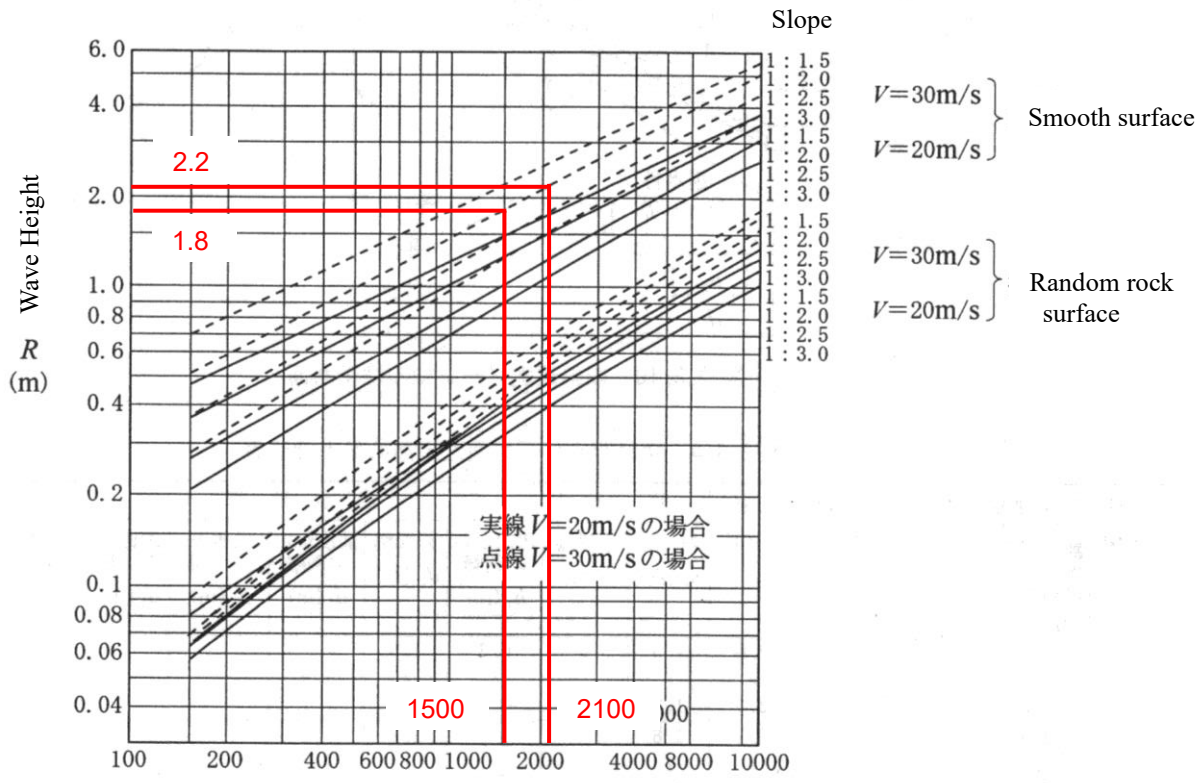
Where,

R: Wave height by wind (m)

Hf: Free board (m)

H2: Water height (m)

R wave height by wind can be obtained by Figure 6.4.9 and Table 6.4.4 under smooth slope surface, slope 1:2.0, wind velocity 30m/s.



Source: Guideline Manual for Land Improvement Project "Pond Development", P45

Figure 6.4.9 Wave height by S.M.B method

Table 6.4.4 Results of Wave height by wind

Item	No.1 and No.2 Reservoir	No.3 and No.4 Reservoir	Remarks
1) Embankment Surface	Smooth	Smooth	Concrete revetment
2) Wind velocity	30 m/s	30 m/s	
3) Slope	1:2.0	1:2.0	

Item	No.1 and No.2 Reservoir	No.3 and No.4 Reservoir	Remarks
4) Fetch (m)	1,500	2,100	
5) Wave Height (m)	1.8 m	2.1m	

Source: JICA Survey Team

From above calculation value, embankment height H can be obtained as shown in Table 6.4.5.

Table 6.4.5 Embankment Height

Item	No.1 and No.2 Reservoir	No.3 and No.4 Reservoir	Remarks
1) sediment height (m)	1.0	0.5	
2) Effective Height (m)	5.0	6.0	
3) Overflow Height (m)	0.3	0.3	
4) Water height (m)	6.3	6.8	4)=1)+2)+3)
5) Wave height (m)	1.8	2.1	From Table 6.4.4
6) Free Board (m)	2.12	2.44	6)=0.05x4)+5)
7) Embankment Height (m)	8.42 →8.5	9.24 →9.3	7)=4)+6)

Source: JICA Survey Team

6.4.7 Design of Spillway

Detailed calculation indicates in Supporting Report B-1 chapter 4.

(1) Design Overflow depth

Overflow depth 0.30 m is obtained as per Guideline Manual for Land Improvement Project "Pond Development", Rural Development Bureau, Ministry of Agriculture, Forestry, and Fisheries as following and construction cost comparison;

Table 6.4.6 Comparison table by Water Depth

Unit:10^{-6}TK

Water Depth (m)	Crest Length (m)	Concrete Cost	Embankment Cost	Total	Remarks
0.3	58.16	0.0	0.0	0.0	
0.4	32.31	-0.22	2.88	2.66	
0.5	19.39	-0.33	5.75	5.75	

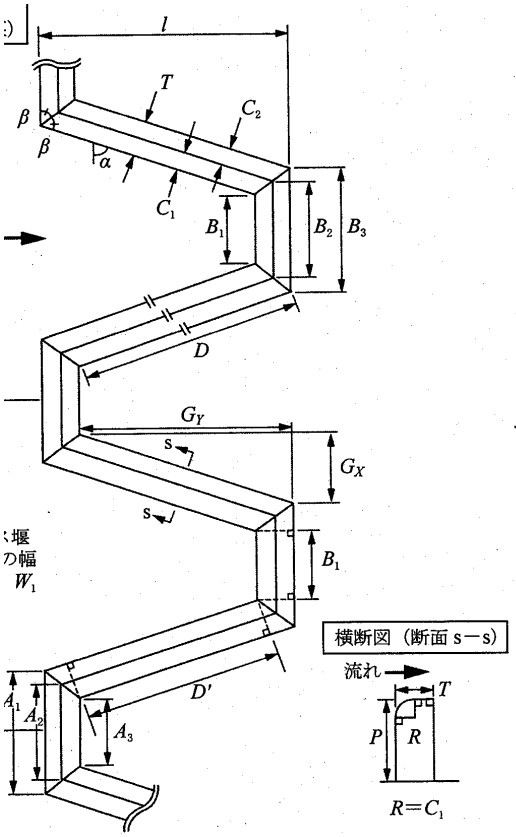
Source: JICA Survey Team

Note: this cost is in case of No.3 reservoir. Water depth 0.3 m is based cost 0.0. Crest type is

Therefore, <u>overflow depth is 0.30 m.</u>

(2) Crest type

As crest length is so long and overflow depth is small, Labyrinth type, that is compact and simple, is selected.

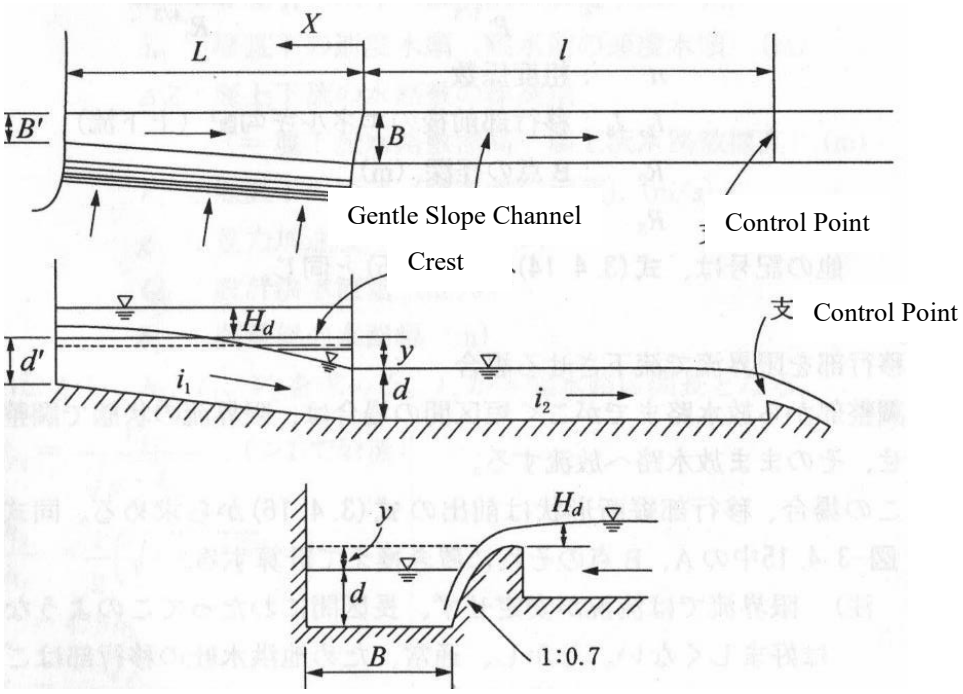


Source: Guideline Manual for Land Improvement Project "Pond Development", P174

Figure 6.4.10 Labyrinth Schematic Diagram

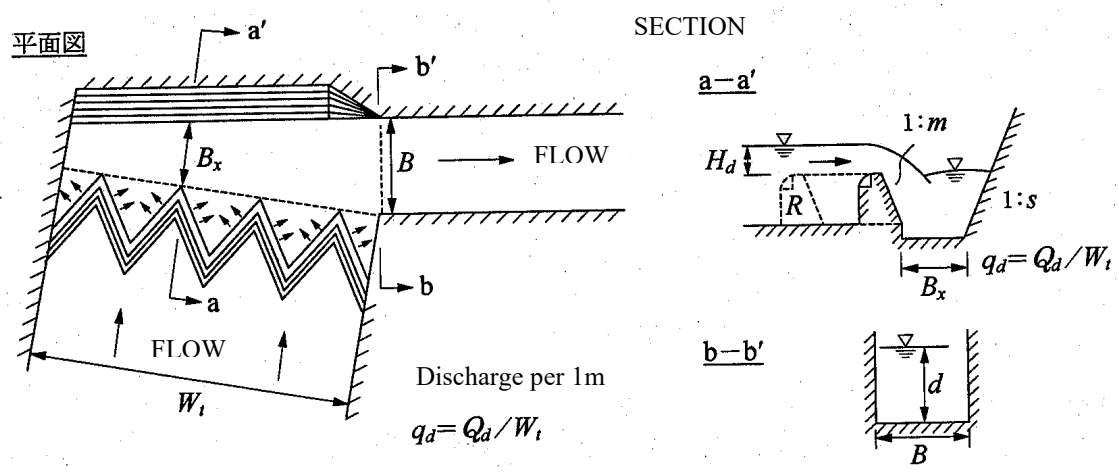
(3) Design of side channel

As crest length is long while settling basin width is small, side channel type is selected as upper transition channel as shown in Figure 6.4.11 and Figure 6.4.12.



Source: Guideline Manual for Land Improvement Project "Pond Development", P72

Figure 6.4.11 Side channel



Source: Guideline M Discharge per 1m ement Project "Pond Development", P74

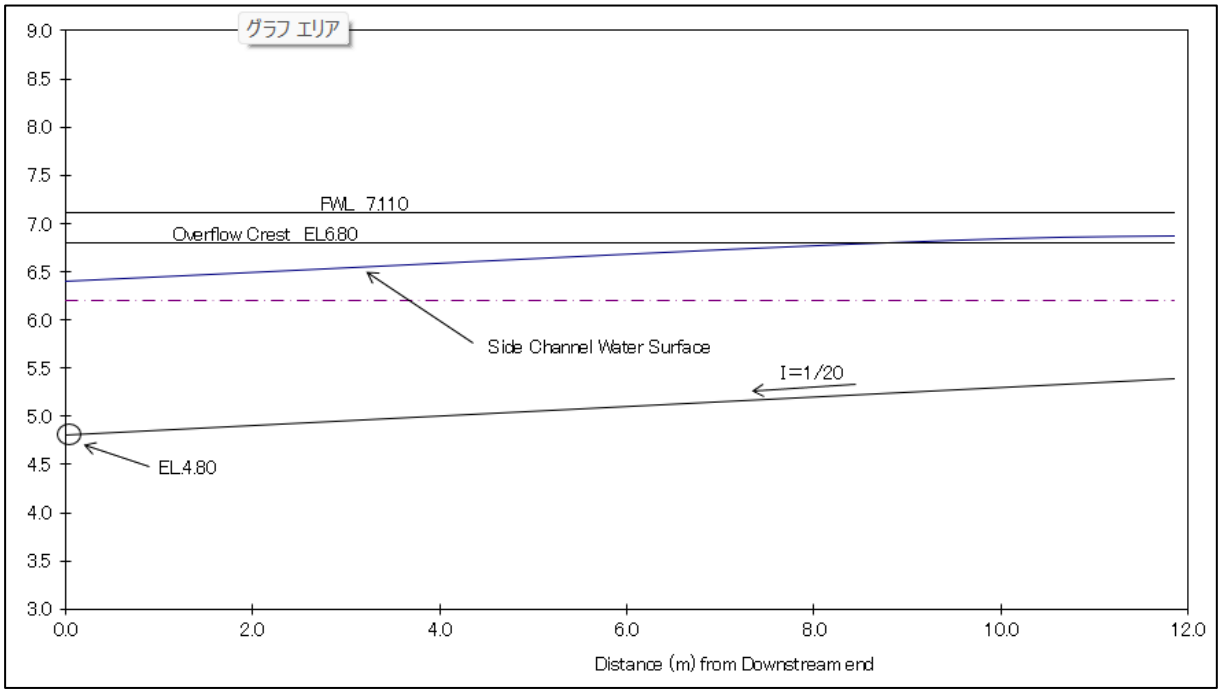
Figure 6.4.12 Transition channel with Labyrinth Crest

Each Condition and calculation results shows Table 6.4.7. Calculated water surface is indicated in Figure 6.4.13 and Figure 6.4.14. Discharge value is 50% of design discharge because this side channel has two side channel and one connection channel at connecting point of both side channel or T shape channel.

Table 6.4.7 Side Channel Design Condition

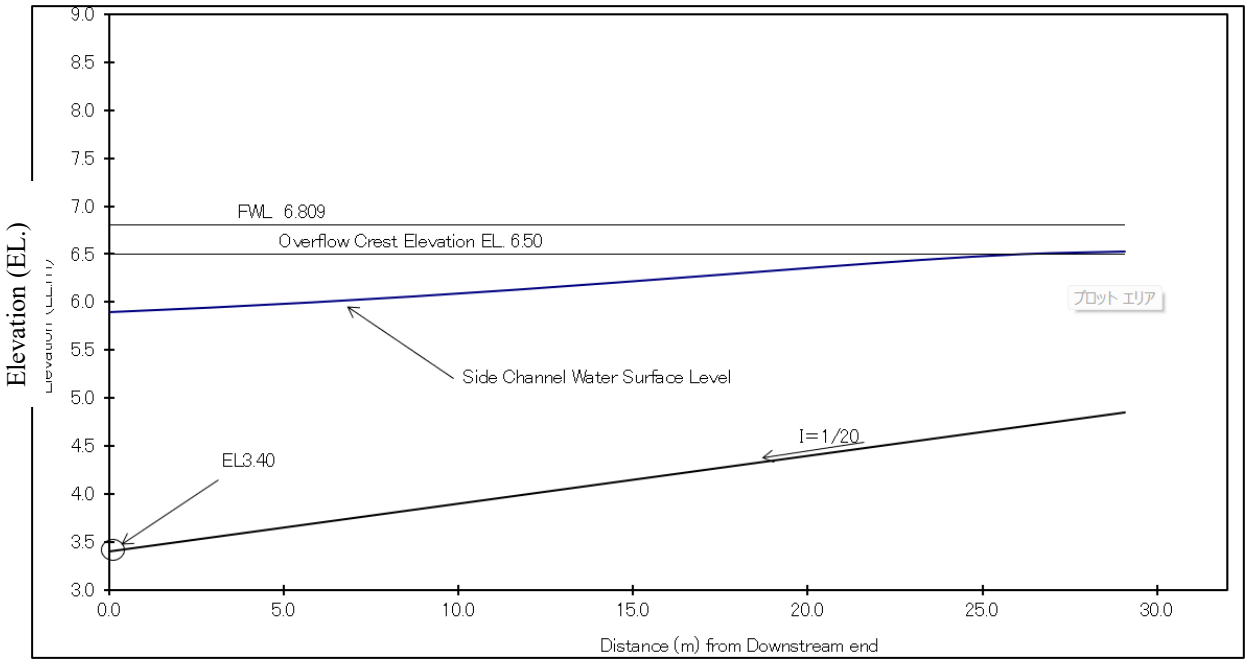
	No.1 and No.2 Reservoir	No.3 and No.4 Reservoir	Remarks
1) Crest length (m)	23.694	58.158	
2) Crest El.	6.80	6.50	
3) Overflow Depth (m)	0.310	0.309	
4) Top El. of overflow side wall	6.20	5.90	
5) Design Discharge (m3/s)	9.63 (19.26)	3.47 (46.94)	(): Design discharge
6) Unit discharge q (m3/s/m)	0.813	0.807	
7) Bottom Width at Downstream End (m)	3.20	4.50	
8) Bottom Width at Upstream End (m)	1.60	2.50	8) ≈ 7)/2
9) Bottom Elevation (EL.)	4.80	3.40	
10) Channel Slope	1/20	1/20	< 1/13
11) Maximum Water Surface Level (EL.) at Side Channel	6.87	6.53	

Source: JICA Survey Team



Source: JICA Survey Team

Figure 6.4.13 Calculated Water Surface at Reservoir No.1 and No.2



Source: JICA Survey Team

Figure 6.4.14 Calculated Water Surface at Reservoir No.3 and No.4

(4) Settling basin

The step structure was selected by the following reasons as settling basin structure of spillway;

- the step structure always has the energy absorbing function although water level at outside varies.
- Structure is not complex and not used with special materials nor special tools.
- Structure length is not long and large area, and doesn't have the structure of occurring the sedimentation.

Detailed calculation for size is shown in the following equation with step height d and horizontal length l sourced by hydraulics formulas (Japan Society of Civil Engineers 1999 edition), P265,

hwc/d > 1.06-0.465 d/l

where, hwc: critical depth (m)

hwc = ((Qd/B)^2/g)^(1/3)

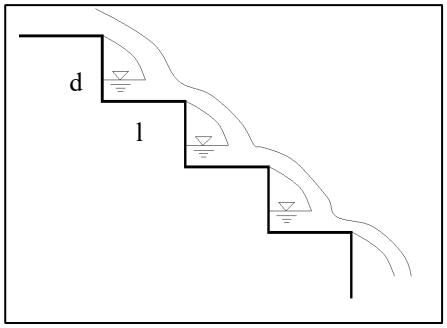
where; Qd: Design discharge (m3/s)

B: step width (m)

g: Gravitational acceleration (= 9.8 m/s2)

d: Step height (m)

l: Horizontal length (m)



Source: JICA Survey Team

Figure 6.4.15 Step Structure

The calculation of step structure is shown in the below;

Table 6.4.8 Calculation of Step dimensions of spillway

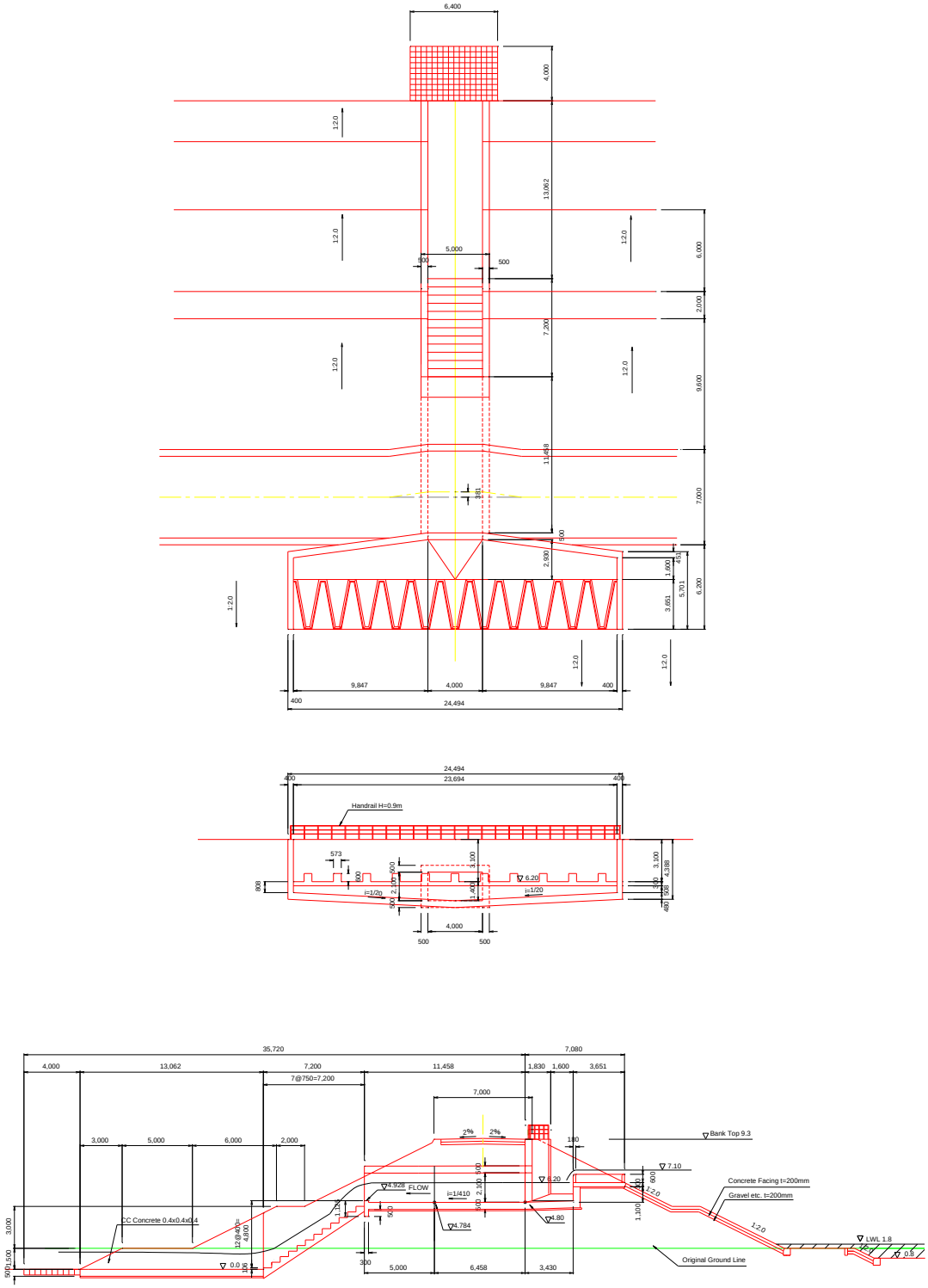
Item	Qd (m3/s)	B (m)	Hwc (m)	d (m)	l (m)	(a) (m)	Hwc > (a)	Remarks
No.1 and No.2 Reservoir	19.26	4.00	1.332	0.40	0.60	0.300	OK	
No.1 and No.2 Reservoir	46.94	5.00	2.087	0.50	0.75	0.375	OK	

Note: (a) = (1.06-0.465 d/l) x d

Source: JICA Survey Team

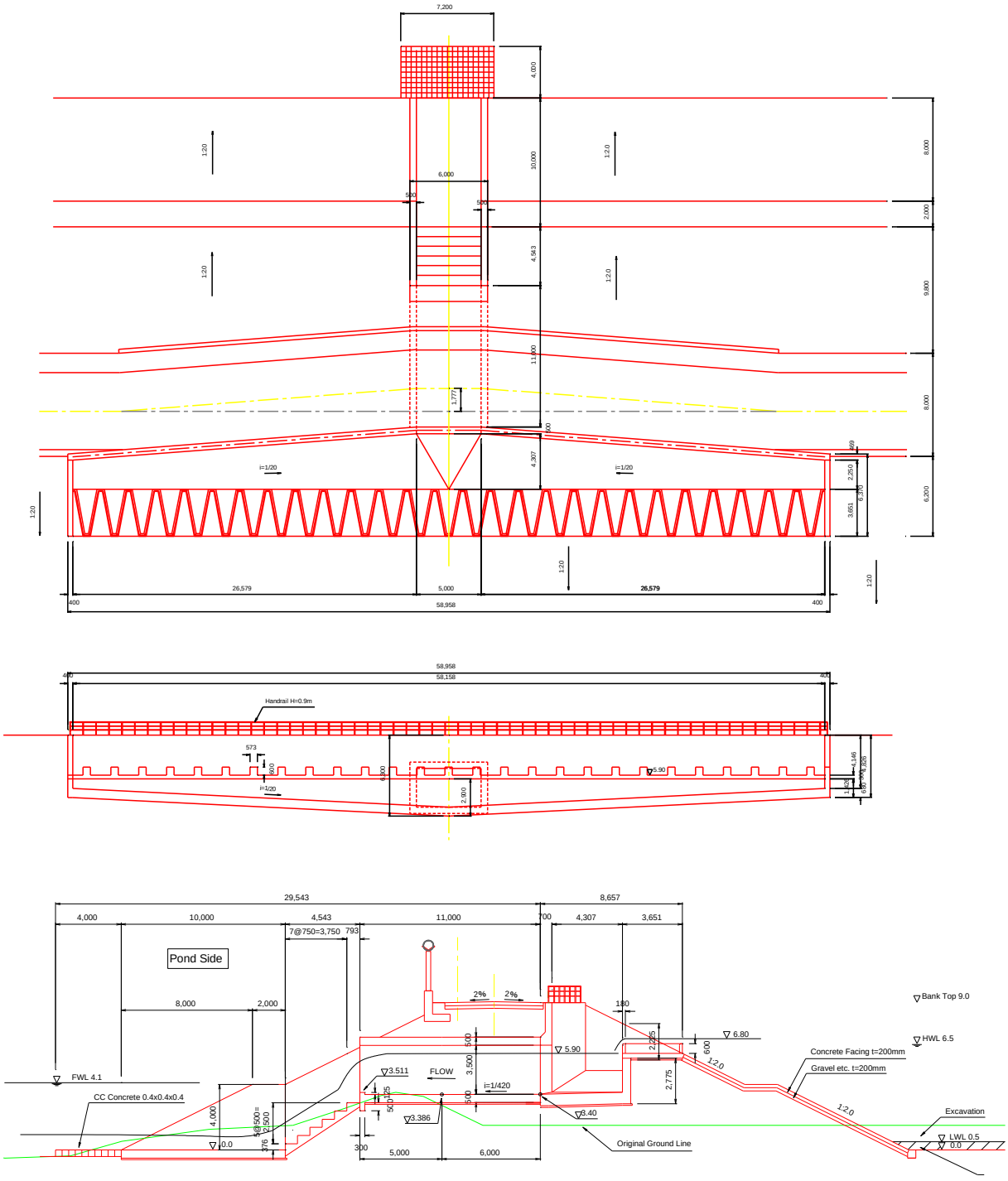
6.4.8 Spillway Feature

Until previous section, spillways; No.1 & Np.2, and No.3 &No.4 are designed and these main features are shown in Figure 6.4.16 and 6.4.17.



Source: JICA Survey Team

Figure 6.4.16 Spillway of No.1 and No.2



Source: JICA Survey Team

Figure 6.4.17 Spillway of No.3 and No.4

6.4.9 Sediment at Raw Water Reservoir

From chapter 5, wash load sediment comes from intake site 10,800t/year. It is assumed that the wash load is trapped in first reservoir; No.1 and No.2.

Sediment yield or volume is quite swinged by river flow volume and/or year.

25.5year/time is obtained by the calculation. In detail calculation shows supporting report B-1, section 7.1. However, finally the reservoir sediment capacity will be determined by the comparison with embankment sediment capacity height cost of embankment and sediment removing cost on detailed design stage.

6.4.10 Stability Analysis for Reservoir Embankment by Slip Circle Method

Detailed calculation indicates in Supporting Report B-1 chapter 5 and chapter 6.

(1) Purpose and condition

Stability analysis is carried out by slip-circle method. Typical one sections is analysed.

The purpose of this stability analysis is to confirm the safety of the weak foundation for the raw water reservoir embankment. Design condition of the stability analysis is set as follows.

- Geological conditions are obtained by N-value of bore holes, the results of soil tests and site investigations.
- The required Safety factor is more than 1.2.
- As soil condition is not good from some geological test results, the layer of mechanically improved soil is set if necessary.
- Stability analysis by slip-circle method basically follows “Guideline Manual for Land Improvement Project “Pond Development”, Rural Development Bureau, Ministry of Agriculture, Forestry, and Fisheries”.
- Slip lines that slide only the embankment body are not covered because the purpose of this stability analysis is to confirm the foundation stability.

(2) Slip- Circle Method

Embankment safety is evaluated by the safety factor. Safety factor can be estimate by the following equation.

Minimum safety factor against slope failure calculated by the slip-circle method:

$$SF = \frac{\Sigma\{CL + (N - U)\tan\phi\}}{\Sigma(T)}$$

Where,

SF : Safety factor

N : Normal forces acting on slip circle of each slice (kN/m)

T : Tangential force acting on slip circle of each slice (kN/m)

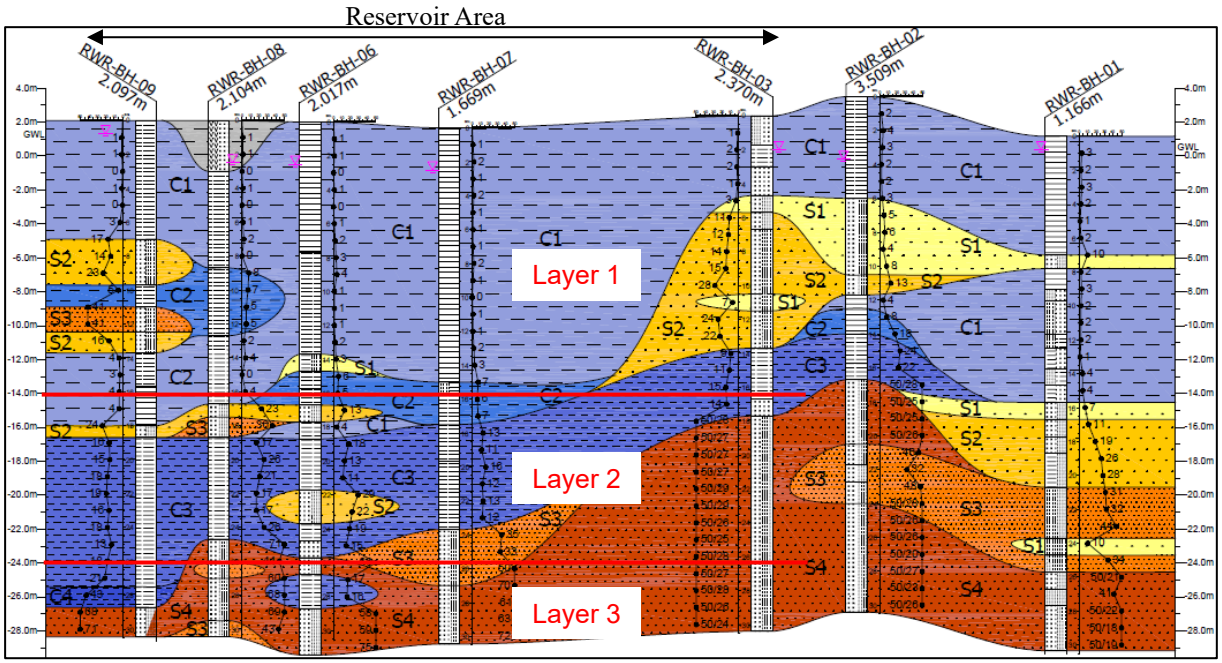
U : Pore pressure acting slip circle of each slice (kN/m)

φ : Angle of internal friction of materials on slip circle of each slice (degree)

C : Cohesion of materials on slip circle of each slice (kN/m^2)

L : Arc length of circle of each slice (m)

(3) Modeled cross se ction for analysis



Source: JICA Survey Team

Figure 6.4.18 Soil Profile in Reservoir

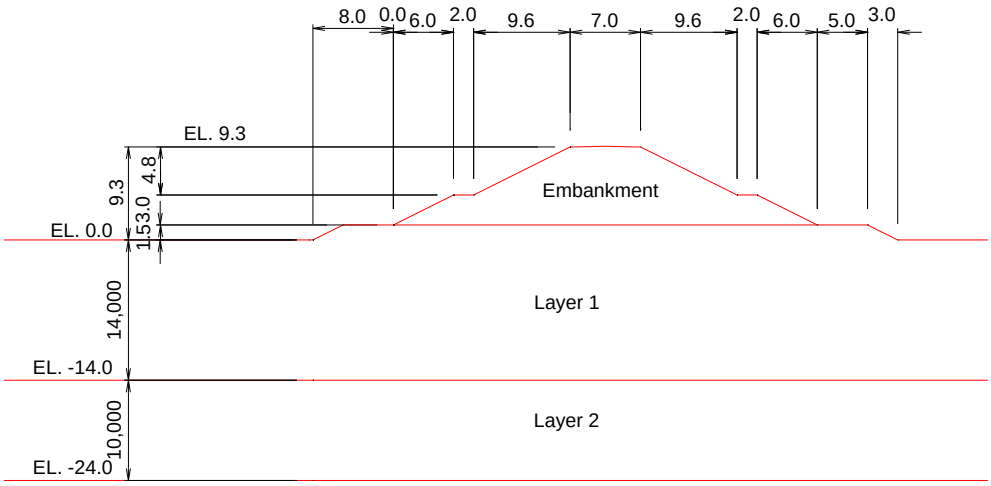
From the geological investigation results such as N values, soil test and soil profile as shown in Figure 6.4.18, the soil foundation layer can be classified into 3 layer as indicated Table 6.4.9.

Table 6.4.9 Foundation Layer

Layer No.	N-value	Depth	Remarks
1	1 to 6	El. 2 to El. -14.0	
2	7 to 26	El. -14.0 to El. -24.0	
3	More than 35	Less than El.-24.0	Hard soil

Source: JICA Survey Team

Under the analysis, Layer 3 can be hard soil or be deemed fixed area. Considered foundation layer is layer 1 and layer 2 only as shown in Figure 6.4.19.



Source: JICA Survey Team

Figure 6.4.19 Analysis section

(4) Soil design parameter

From Bore hole RWR-BH-03, 06, 07, 08 and 09 that is in the raw water reservoir and a part of RWR-BH-02, the results of soil test; Table 6.4.10 is obtained.

Table 6.4.10 Design Parameters for Soil Layer in Reservoir Area

Layer No.	Wet Density (kN/m^3)	Saturated Density (kN/m^3)	C (kN/m^2)	φ (Degree)	Remarks
Embankment	18.0	9.0	0.0	30.0	Sand /1
Layer 1	17.33	8.33	16.44	23.67	From Soil test results mean value
Layer 2	17.54	8.54	73.87	0.0	From Soil test results mean value
Improved soil	19.0	10.0	250.0	0.0	/2

Note: /1 Based on Guidelines of Earth Works of Wall, 2013, Japan road association, Japan
/2 Standard allowable shear stress value based on Guidelines of flexible Sluiceway, Japan

Source: JICA Survey Team

(5) Calculation cases

Calculation cases and their condition are shown in below.

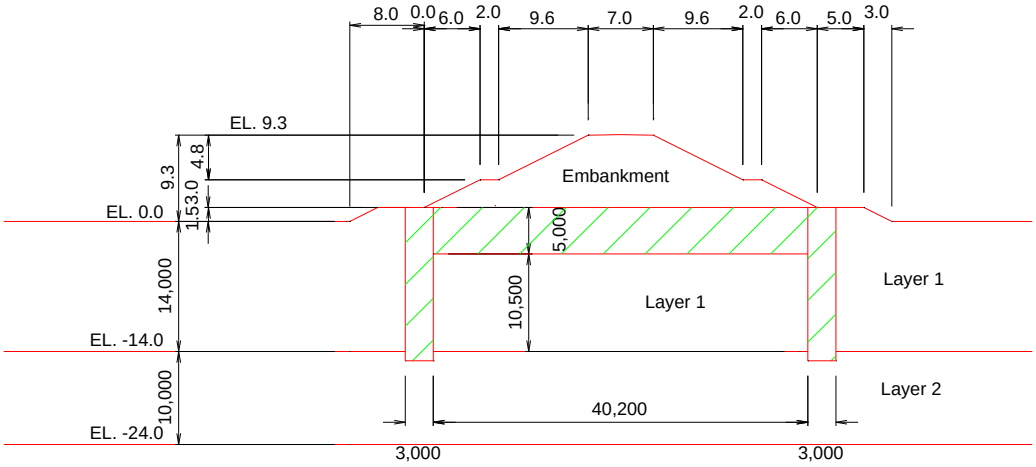
Table 6.4.11 Calculation Case

Case	Condition	Seismic Condition	Water level (EL.)	Active load	Calculation slope
1	Normal full water level	-	6.5	100%	Both side
2	Seismic condition	100%(0.2)	6.5	-	Both side
3	Flooding	-	6.8	-	Reservoir side
4	After just completion	50%(0.1)	1.5	-	Reservoir side

Source: JICA Survey Team

(6) Stability analysis

Embankment foundation needs soil improvement because original section is quite far from stable section by the analysis. Soil improvement can separate 2 methods mainly, namely 1) consolidation drain method or soil compaction method, and 2) soil mixing method. 1) construction cost is cheaper than 2). 2) of effect is higher than 1). 2) soil mixing method is selected as soil improvement method after try and error carried out as shown in Figure 6.4.20.



Source: JICA Survey Team

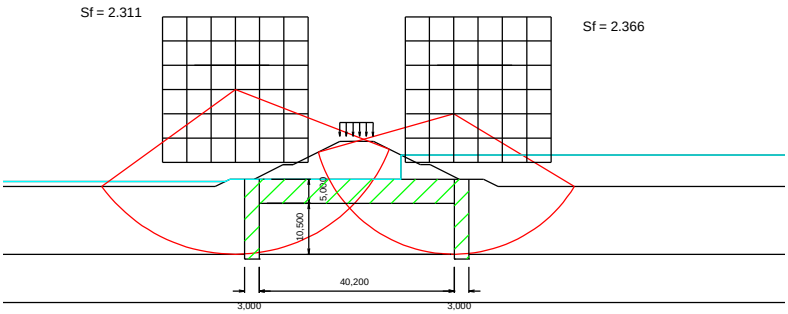
Figure 6.4.20 Calculation results

Table 6.4.12 Calculation results of original condition

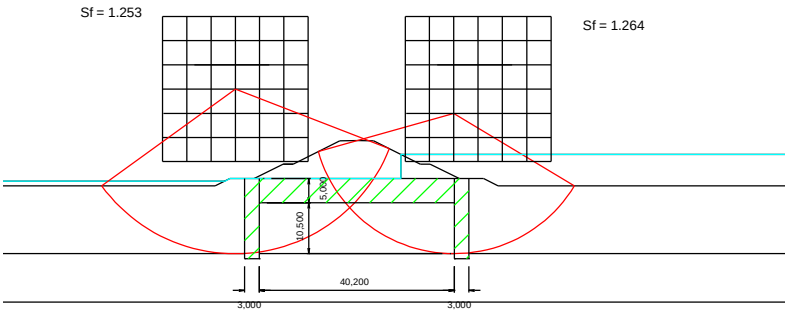
Case		Water level	Side	Resistance Moment (kNm)	Active Moment (kNm)	Safety Factor
1	HWL Normal	EL. 6.5	Right	100,384.3	42,430.6	2.366 > 1.2 ok
		EL. 6.5	Left	126,002.0	54,524.8	2.311 > 1.2 ok
2	HWL Seismic	EL. 6.5	Right	96,639.7	76,438.2	1.264 > 1.2 ok
		EL. 6.5	Left	122,018.3	97,354.9	1.253 > 1.2 ok
3	FWL Normal	EL. 6.8	Right	99,155.7	40,379.8	2.456 > 1.2
		EL. 6.8	Left	106,946.5	44,914.1	2.381 > 1.2 ok
4	Just after Completion	EL. 1.0	Right	126,703.8	79,233.6	1.599 > 1.2 ok

Source: JICA Survey Team

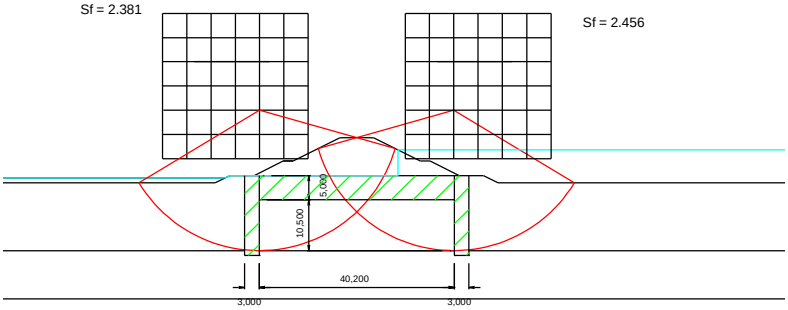
1) CASE 1 Normal



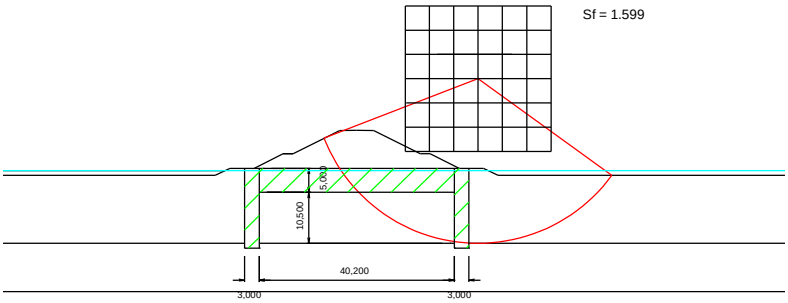
2) CASE 2 Seismic Condition



3) CASE 3 Flooding



4) CASE 4 Just Completion



Source: JICA Survey Team

Figure 6.4.21 Calculation results

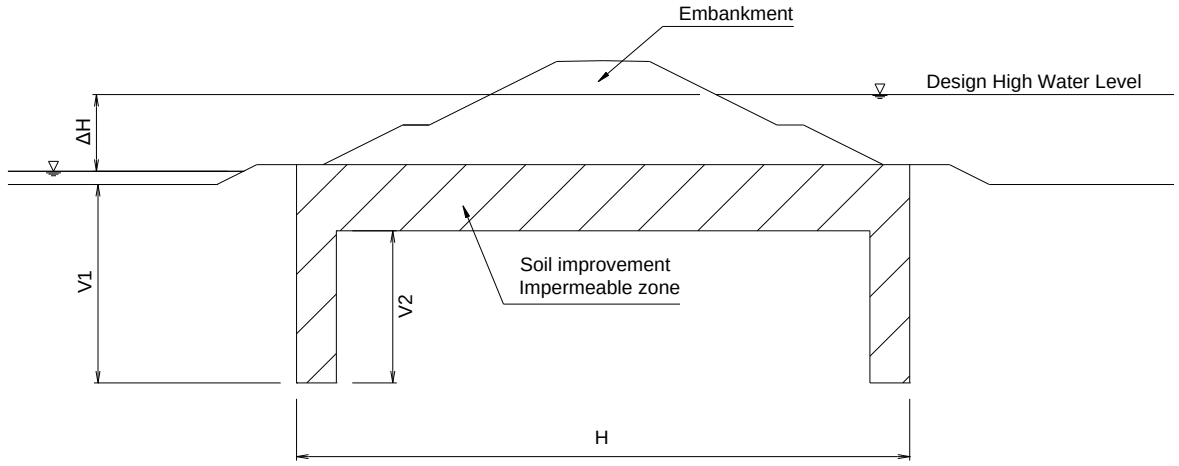
6.4.11 Soil Improvement

Soil improvements of soil mixing method are many methods by the contractors and materials. These method has some patents by the contractor and some mixing material are difficult to use by the fact that these materials are not in Bangladesh market or difficult to import or quite expensive.

Soil improve method in detail is necessary to be studied by detailed design stage based on sufficient geological data implement in detailed design stage. And soil improve method may be provided by performance base, not specification base in bidding document.

6.4.12 Seepage/Piping Analysis

For relatively impervious embankments, where seepage or piping is more likely to occur under the structure, seepage analysis according to the Lane's Creep Theory shall be conducted by Guideline Manual for Land Improvement Project "Head Works", Rural Development Bureau, Ministry of Agriculture, Forestry, and Fisheries.



Source: JICA Survey Team

Figure 6.4.22 Model of Creep Distance

2 way; the reservoir to the river side and the river side to the reservoir are calculated and these calculation results shows Table 6.4.13.

From Table 6.4.13, it is confirmed that seepage is safety.

Table 6.4.13 Seepage analysis by lane's creep theory

Flow Case	Reservoir to River	River to Reservoir	Remarks
1) △H (m)	6.8 – 0.0 = 6.8	4.1 – 0.5 = 3.6	
2) V1 (m)	16.5	16.5	
3) V2 (m)	11.5	11.5	
4) H (m)	46.2	46.2	

Flow Case	Reservoir to River	River to Reservoir	Remarks
5) C	8.5	8.5	
6) ΣH/3 + ΣV	71.4	71.4	
7) 6)/ 1)	10.5	19.83	
8) Evaluation	7) > 5) ok	7) > 5) ok	

Source: JICA Survey Team

6.4.13 Salt water intrusion to reservoir

As adjacent river to the reservoir is brackish water region, it is concerned that salty water enters the reservoir that is quite harmful for drinking water. However, salty water is difficult to enter the reservoir by the following reasons

- Water elevation El. 0.5 to 6.5 in the reservoir is higher than river water level MSL.0.0 that is mean river water level.
- As embankment is covered with water proof sheet, the water from the river to the reservoir cannot enter.
- In case that the river salty water to the reservoir through foundation reaches the bottom of the reservoir. However, it is difficult for the salty water to penetrate the reservoir due to gentle hydraulic gradient by soil improvement column and difference in specific density between salt water and fresh water.

6.4.14 Consolidation settlement

Consolidation settlement is examined on the basis of the result of soil investigation by BNBC 2020, Part VI, 3.10.5, equation 6.3.39:

$$Sc = \frac{C_c H}{1+e_0} log \frac{\sigma'_0 + \sigma'_p}{\sigma'_0}$$

Where,

Sc : Total consolidation settlement (m)
Cc : Compression index of soil
H : Thickness of compressive layer (m)
e_0 : Initial void ratio
σ'_0 : Initial effective stress of midpoint of the layer (m^2/kN)
σ'_p : increase in effective stress of midpoint of the layer due to embankment(m^2/kN)

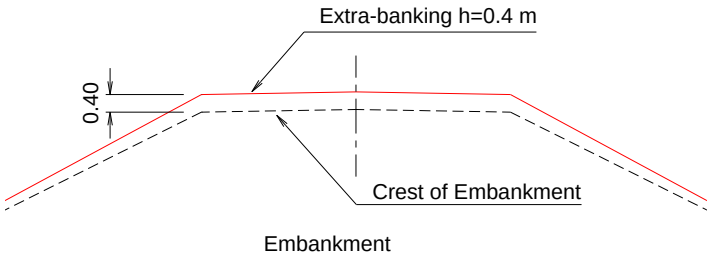
Table 6.4.14 Consolidation settlement

Item		Remarks
1) Cc	0.37	From soil test result
2) e_0	1.06	From soil test result
3) H	20.5 m	EL. -3.5 to EL. -24.0

4) σ'_0	15.25 x 17.33 = 264.28 kN/m2	
5) σ'_p	9.3 x 19 = 176.70 kN/m2	
6) Sc	0.819 m	

Source: JICA Survey Team

Total consolidation settlement 0.82 m is estimated. However, usually half of 0.82 m consolidation settlement is done during construction. 0.40m extra-banking is considered in embankment as shown in Figure 6.4.23.



Source: JICA Survey Team

Figure 6.4.23 Extra-Banking

6.4.15 Liquefaction

The study procedure of liquefaction is same as section 6.2.3. however, only Level 1 for liquefaction is studied because reservoir embankment is mainly soil that is easy recovery and small damage even if liquefaction occurs.

Step 1 of liquefaction at RWR-BH-03, 06, 07, 08, and 09 is examined for .27 samples. As the results of examination of Step 1, 2 samples for adopted layer and 2 samples as reference are selected.

Step 2 for selected layer is calculated as shown in Table 6.4.15.

Table 6.4.15 Liquefaction Calculation by Step 2

Boring No.	RWR-BH-06		RWR-BH-07	RWR-BH-08	
	12.0-12.45	20.0-20.45	17.0-17.45	20.0-20.45	Remarks
x	15.5	20.2	17.2	20.2	
Water Depth Hw	1.2	2.5	2.5	2.5	
N value	1	13	7	26	
FC(%)	89.22	84.10	94.42	85.90	
Balk Density	16.65	16.65	17.20	16.93	
Submerged Density	7.65	7.65	8.2	7.93	
Level 1					
L	0.23	0.20	0.20	0.20	
R	0.17	0.33	0.28	3.88	
FL	0.73	1.65	1.38	19.84	FL > 1 ok

Boring No.	RWR-BH-06		RWR-BH-07	RWR-BH-08	
	12.0-12.45	20.0-20.45	17.0-17.45	20.0-20.45	Remarks
Selection/Remarks	High liquefiable potential	Not available (Just Reference)	Not available	Not available (Just Reference)	

Source: JICA Survey Team

As per this calculation, liquefaction at Layer 12.0-12.45 in RWR-BH-06 is occurred in high possibility on Level 1. However, countermeasure is not considered or topical treatment even implementing the countermeasure for this layer by the following reasons

- High potential layer is only one layer (1 sample) and thin thickness under 23 samples being checked. Therefore, its liquefaction is quite local phenomenon.
- This layer is not shallow layer
- .Even occurring the liquefaction in reservoir bottom that is almost area of reservoir area, it is not damaged for reservoir function.

6.4.16 Related Facilities of Raw water Reservoir

The following related facilities of raw water reservoir are designed and these drawings are attached in appendix drawings.

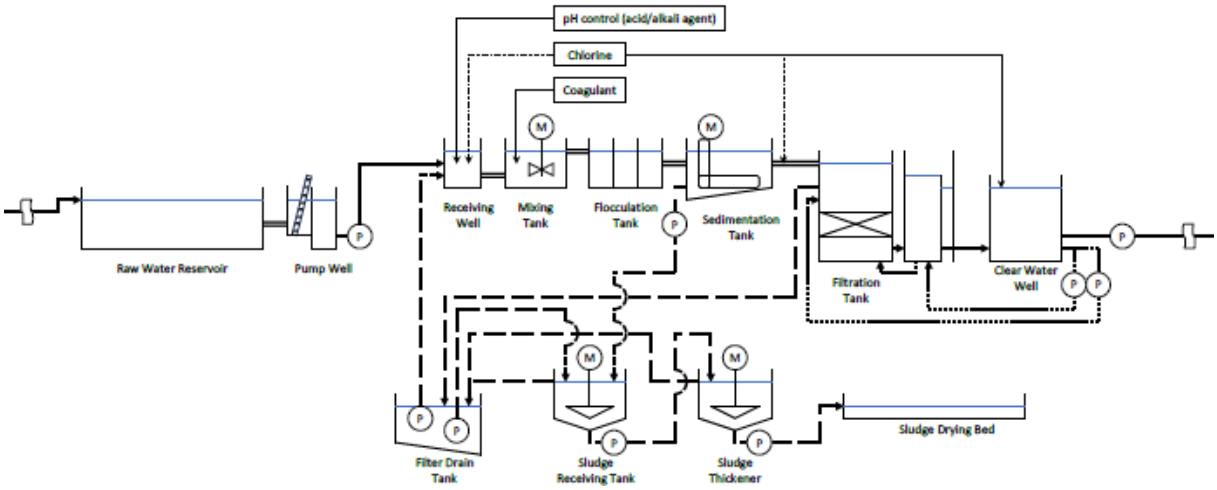
- Access road
- Receiving tank
- Inlet from receiving tank
- Outlet to WTP

6.5 Preliminary Design of Water Treatment Facilities

6.5.1 Outline of Water Treatment Plant

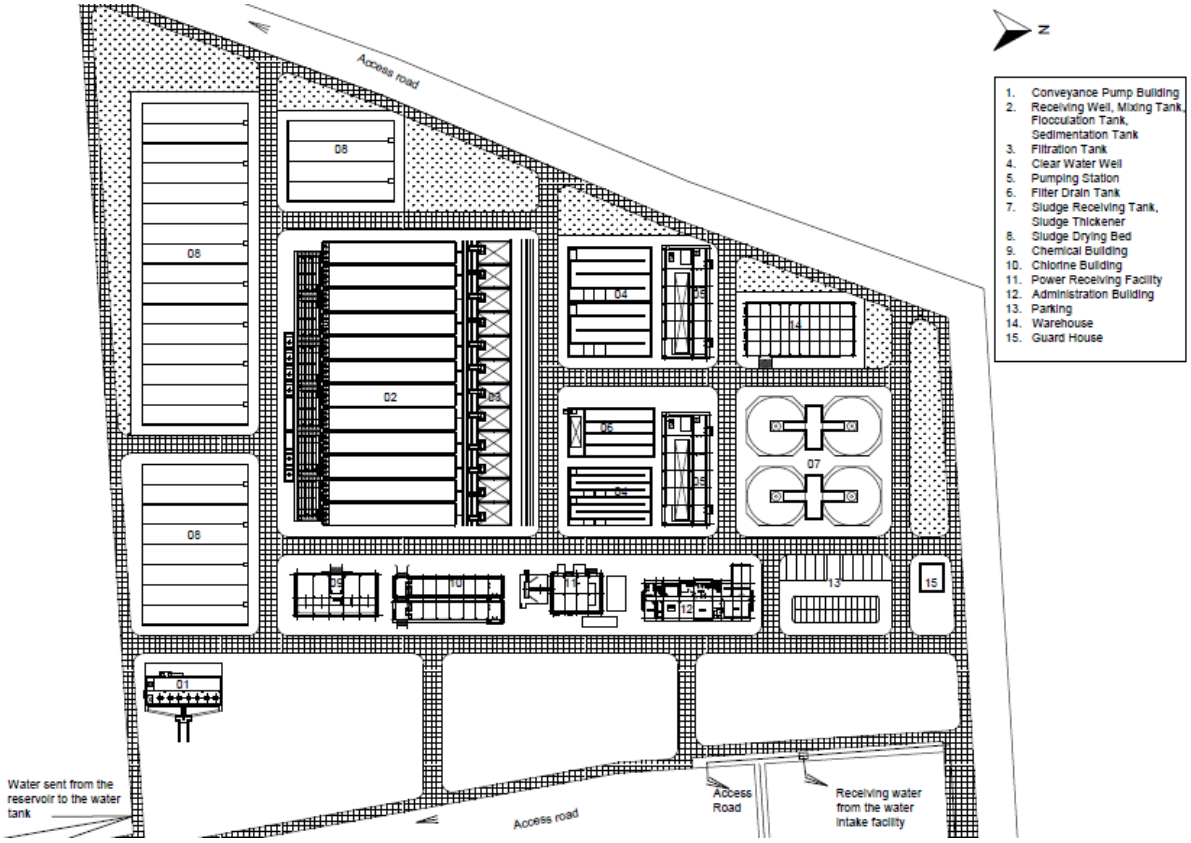
Water Treatment Plant (WTP) is located nearby the Raw Water Reservoir with considering the ease of raw water intake.

The capacity of the water treatment plant is total 111.2MLD (78.4MLD is for industrial and 32.8MLD is for domestic). Process Flow Diagram and General Plot Plan for Water Treatment facility are shown in Figure 6.5.1 and 6.5.2, respectively.



Source: JICA Survey Team

Figure 6.5.1 Process Flow Diagram



Source: JICA Survey Team

Figure 6.5.2 General Plot Plan

The water treatment process is a conventional type which is composed coagulation, flocculation, sedimentation, filtration, and disinfection as shown in section 5.3.1. The outlines of each process are shown in below:

(1) General (refer to section 5.3.3)

- The water treatment facility is divided largely into 2 trains, one is for industrial water and the other for domestic water.
- Each facility in each train is divided into multiple sections.
- The capacity of each individual facility for industrial and domestic water is almost the same in consideration of compatibility.

(2) Receiving Well

The receiving well stabilizes fluctuations in the raw water level and regulates the amount of raw water. Additionally, it has other functions such as pH adjustment using agents, pre-chlorination, raw water distribution, and receiving circulating water. There are 1 tank for Industrial and 1 tank for Domestic.

(3) Mixing Tank

In the mixing tank, raw water and coagulant are rapidly and uniformly mixed to coagulate suspended particles into fine flocs. To ensure proper mixing, a mechanical mixing method is applied. There are 4 tanks for Industrial and 2 tanks for Domestic.

(4) Flocculation Tank

In the coagulation tank, the fine flocs formed in the mixing tank are gently stirred to grow larger. A baffle type coagulation system is used for ease of maintenance. There are 4 tanks for Industrial and 2 tanks for Domestic.

(5) Sedimentation Tank

In the sedimentation tank, the flocs that have grown during the flocculation process are separated by gravity sedimentation. The sedimentation tank is a conventional single-layer horizontal-flow type and the sludge is removed by mechanical scraper. There are 8 tanks for Industrial and 4 tanks for Domestic.

(6) Rapid Sand Filter

In rapid sand filters, water is passed through the filter bed at a relatively fast flow rate, and suspended particles are removed primarily by adhesion to the filter media and by sieving in the filter bed. The washing is performed by combining surface wash and backwash. A self-water backwash method is adopted for backwash to reduce pump power consumption. There are 8 tanks for Industrial and 4 tanks for Domestic.

(7) Chemical Dosing System

Considering the fluctuations in raw water quality due to using stored water from the reservoir as the raw water, the system is equipped to perform pH adjustment using acid/alkali agents and pre-/intermediate chlorination treatments.

6.5.2 Mechanical and Electrical Equipment

The main mechanical and electrical equipment for the water treatment and distribution facility are as follows:

(1) Conveyance Pump

A vertical mixed flow volute pump, which has a large capacity and not require a long column pipe, and one of the most common types, will be applied for the Conveyance Pump. Raw water flow is basically controlled by Variable Frequency Drive (VFD) and the number of operation pumps is decided in consideration of the water demand, operating conditions, and variation of raw water quality. Details of countermeasures of water hammer will be provided in a study in next stage.

The specifications of conveyance pump are as follows:

Name	**: No.1 Conveyance Pump (for Industrial)**
Type	: Vertical mixed flow volute
Outlet diameter	: 600 mm
Discharge volume	: 31.5 m^3/min
Pump total head	: 14 m
Motor rated capacity	: 110 kW (VFD)
Number of pumps	: 3 units (2 Duty and 1 Standby)

Name	**: No.2 Conveyance Pump (for Domestic)**
Type	: Vertical mixed flow volute
Outlet diameter	: 600 mm
Discharge volume	: 31.5 m^3/min
Pump total head	: 14 m
Motor rated capacity	: 110 kW (VFD)
Number of pumps	: 2 units (1 Duty and 1 Standby)

(2) Water Treatment Facility

The specifications of main mechanical equipment are shown in Table 6.5.1.

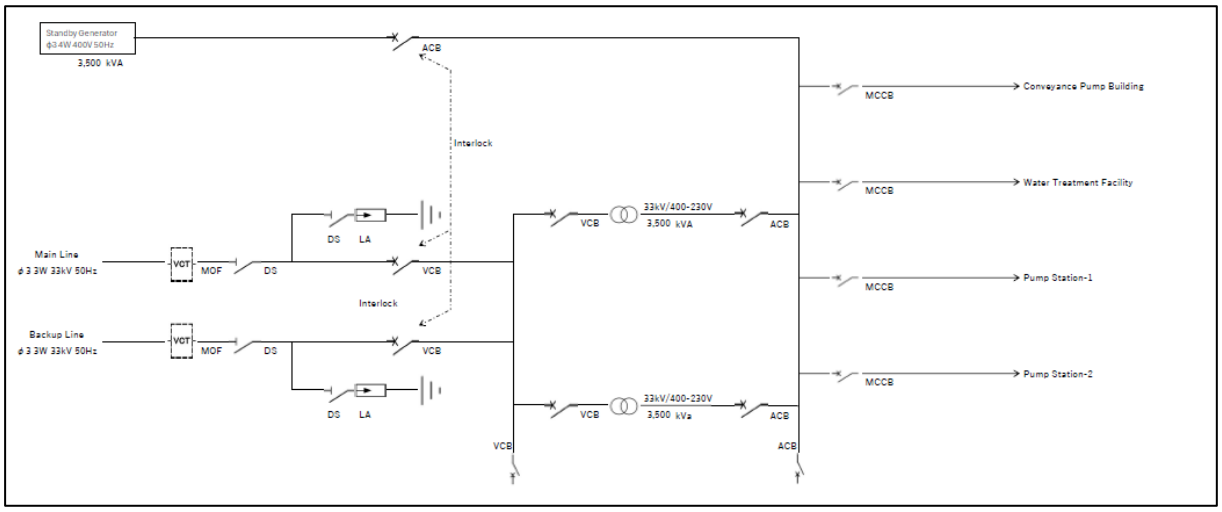
Table 6.5.1 Specifications of Main Mechanical Equipment

Item of Equipment	Number of Equipment	Specification
Rapid mixer	Industrial: 4 units Domestic: 2 units	Mechanical agitating device with reduction gear
Sludge scraper	Industrial: 8 units Domestic: 4 units	Chain and flight scraper type
Chlorination system	1 lot.	Injection equipment, injection pumps, chlorine cylinders, and neutralization system
Coagulant dosing system	1 lot.	Storage tanks and chemical pumps
Sand filter	Industrial: 8 units Domestic: 4 units	Rapid gravity type
Surface wash pump	Industrial: 3 units Domestic: 3 units	Double suction volute pump, 75 kW (including 1 stand-by for each)
Makeup water pump	Industrial: 2 units Domestic: 3 units	Double suction volute pump, 22 kW for Industrial and 55 kW for Domestic (including 1 stand-by for each)
Sludge transfer pump	Industrial: 3 units Domestic: 3 units	Wastewater submersible pump, 30kW (including 1 stand-by for each)

Source: JICA Study Team

(3) Power Receiving and Transmission

The power receiving is planned 2 circuits type. Three units of main transformer (33 kV/ 400-230 V, 3,500 kVA) is prepared. The type is an Oil Immersed Transformer. A single line diagram for intake facility is shown in Figure 6.5.3.



Source: JICA Survey Team

Figure 6.5.3 Single Line Diagram for Water Treatment Facility

(4) Emergency Power Generator

An emergency power generator is prepared one unit to maintain the minimum functions of this facility when power supply is stopped due to blackout occurrence. The capacity is 4,000 kVA and the type is Three Phase Synchronous Diesel Generator.

6.6 Preliminary Design of Water Transmission Facilities

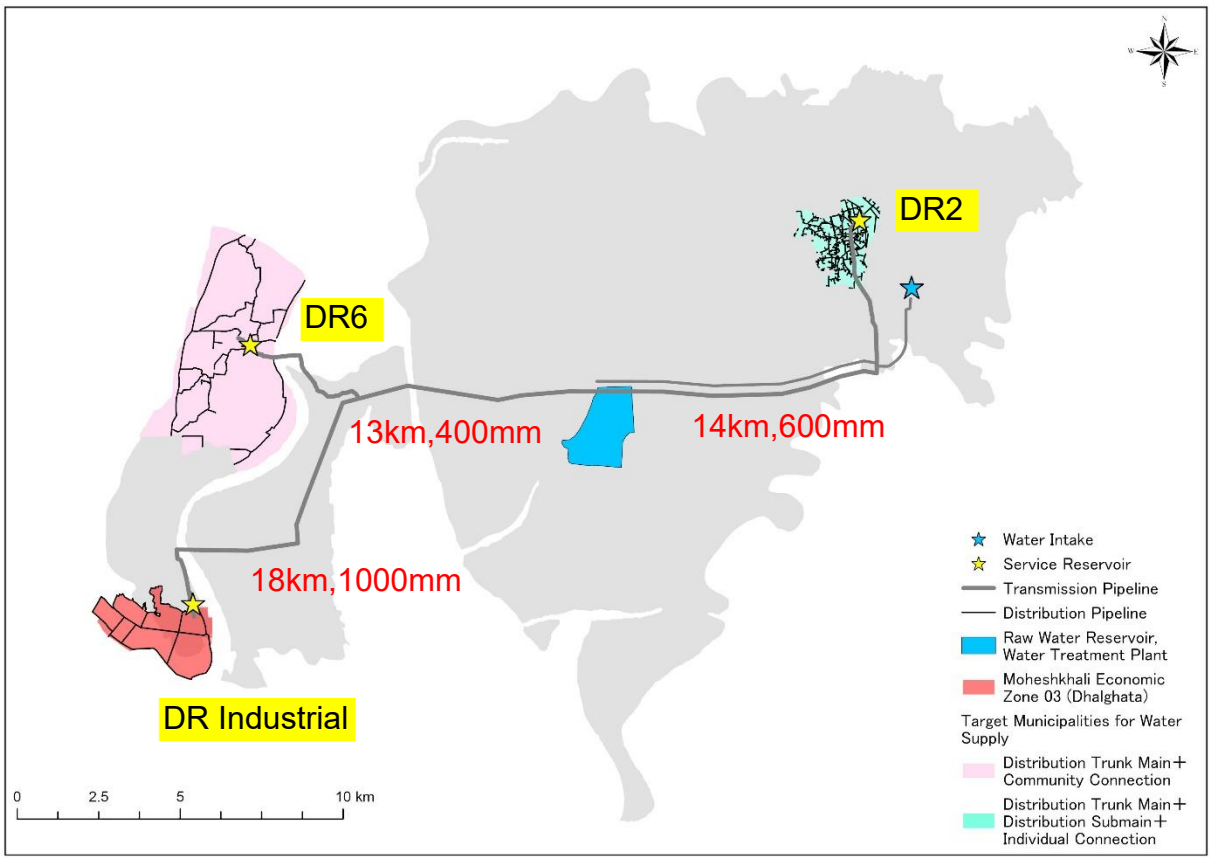
6.6.1 Outline of Water Transmission Facilities

As the treated water transmission facilities which convey water from the water treatment plant to the service reservoir, the facilities are designed as follows:

Table 6.6.1 Specifications of the Water Transmission Pipelines

No.	Pipeline	Specifications
1	Chakaria Pourashava System from WTP to DR	D 600 mm, L=14 km
2	Matarbari Union System from WTP to DR	D 400 mm, L=13 km
3	Moheshkhali EZ (Dhalghata) System from WTP to DR	D 1000 mm, L=18 km

Source: JICA Survey Team
Note: DR means Distribution Reservoir



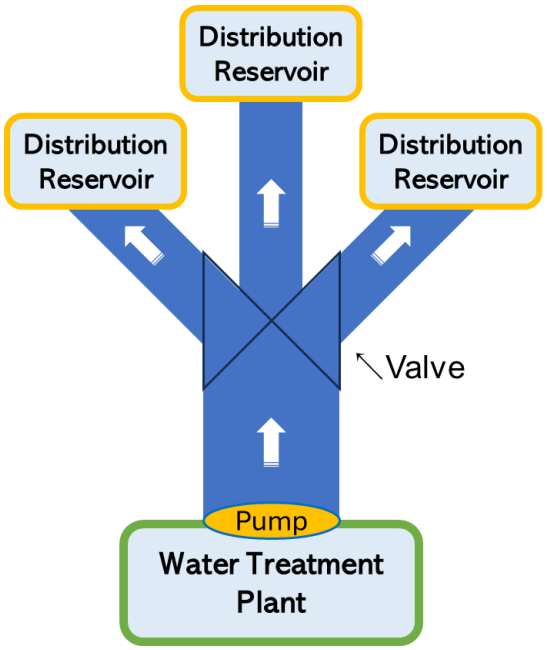
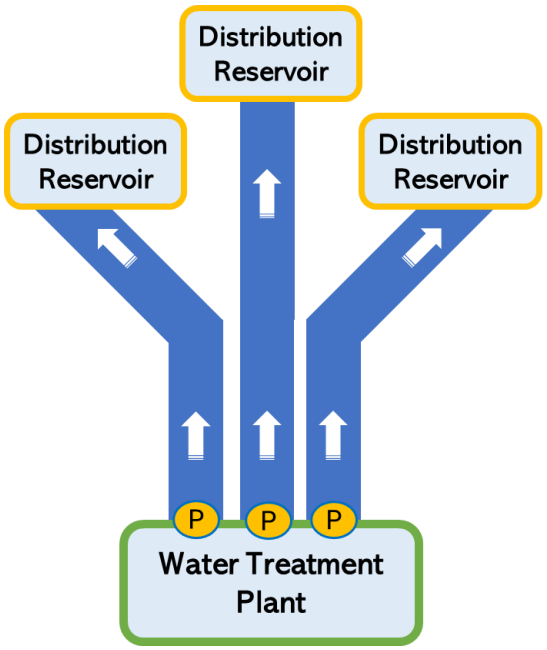
Source: JICA Survey Team

Figure 6.6.1 Outline of Water Transmission Facilities

6.6.2 Way of Pipe Installation

Branch pipe system and one on one pipe system were compared in terms of volume of construction works and feasibility of operation and maintenance. As a result, one on one pipe system was evaluated as being advantageous in terms of feasibility of operation and maintenance.

Table 6.6.2 Comparison of Way of Pipe Installation

	Branch Pipe System	One on One Pipe System
		
Condition	One Pump + One pipe with large diameter on the section of same alignment + Control valve + Several Pipes with small diameter	Several Pumps + Several Pipes with small diameter
Advantages	① No. of pumps can be reduced ② No. of pipes can be reduced	① No need to install control valve ② No need to do valve controlling work ③ No need to do pressure controlling work
Disadvantages	① Control valve should be installed ② Strict Valve controlling work is needed ③ Strict Pressure controlling work is needed	① No. of pumps can be increased ② No. of pipes can be increased
Evaluation	Not selected * Since the required pressure on each distribution reservoir are different, strict valve/pressure controlling work is needed. That work is almost impossible when considering the situation of this project that there is no agency for water supply system and new organization shall be formed and the person who is not familiar with that types of work can do that work.	Selected

Source: JICA Survey Team

6.6.3 Hydraulic Examination

The following conditions were provided for the preliminary design of water transmission pipelines.

1) Design treated water transmission flow: Design maximum daily supply
   Chakaria Pourashava System: 25,506 m^3/d
   Matarbari Union System: 7,320 m^3/d
   Moheshkhali EZ (Dhalghata) System: 78,442 m^3/d

2) Type of treated water transmission: Pumping type
   Insufficient difference in the elevations between the water treatment plant and the service reservoir (approximate 2~10 m)

3) Pipe material: Ductile iron pipe
   Experiences of construction in the country and the following advantage are considered
   - Pipe body is strong, high in ductility and can withstand strong impact.
   - High durability
   - Such flexible joints as K, T, U type etc. can deal with deformation of soil owing to their ability to expand and bend.
   - Such rigid joints as NS, S, SII etc. can deal with bigger expansion and contraction than the flexible joints; and furthermore can cope with bigger deformation of soil as they possess dislodge-resistant joint.
   - Easy handling

4) Pipe diameter and Flow velocity
   Determined in consideration of the correlation between the pipe diameter and the annual cost. The formula to calculate the flow is the following (Hazen-Williams formula):

$$H=10.666 \times C^{-1.85} \times D^{-4.87} \times Q^{1.85} \times L$$

   Where
   H: Friction head loss (m)
   C: Velocity coefficient (for the entire new pipe including head losses of bends etc. using 110)
   D: Inside diameter (m)
   Q: Flow rate (m^3/s)
   L: Length (m)

From:	WTP
To:	Chakaria Paurashova

Pipeline Feature

Static head H0 (m)	30
Length L (m)	13,944

Flow

Daily Flow (2041)	m^3/d	25,506
Flow Q (2041)	m^3/s	0.295

Required Total Head

Pipe Dia D (mm)	V (m/s)	Hf and other	Total Head H (m)
400	2.35	225.69	255.69
450	1.86	127.17	157.17
500	1.50	76.13	106.13
600	1.04	31.33	61.33
700	0.77	14.79	44.79

From:	WTP
To:	Matabari Union

Pipeline Feature

Static head H0 (m)	30
Length L (m)	12,457

Flow

Daily Flow (2041)	m^3/d	7,320
Flow Q (2041)	m^3/s	0.085

Required Total Head

Pipe Dia D (mm)	V (m/s)	Hf and other	Total Head H (m)
300	1.20	81.29	111.29
400	0.67	20.03	50.03
450	0.53	11.28	41.28
500	0.43	6.76	36.76
600	0.30	2.78	32.78

From:	WTP
To:	Moheshkhali EZ (Dhalghata)

Pipeline Feature

Static head H0 (m)	35
Length L (m)	18,343

Flow

Daily Flow (2041)	m3/d	78,442
Flow Q (2041)	m3/s	0.908

Required Total Head

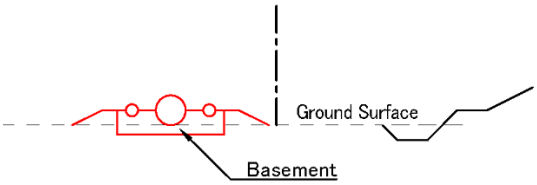
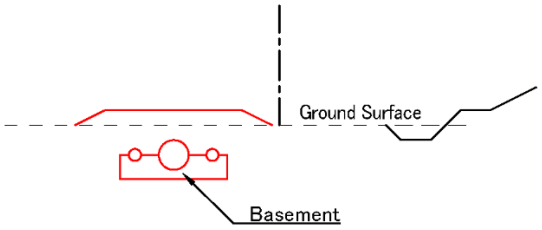
Pipe Dia D (mm)	V (m/s)	Hf and other	Total Head H (m)
800	1.81	81.14	116.14
900	1.43	45.72	80.72
1000	1.16	27.37	62.37
1100	0.96	17.21	52.21
1200	0.80	11.26	46.26

6.6.4 Construction Method

(1) Embankment section

On-ground installation method and underground installation method were compared in terms of volume of construction works and feasibility of operation and maintenance. As a result, on-ground installation method was evaluated as being advantageous in terms of feasibility of operation and maintenance.

Table 6.6.3 Comparison of Construction Method on Embankment Section

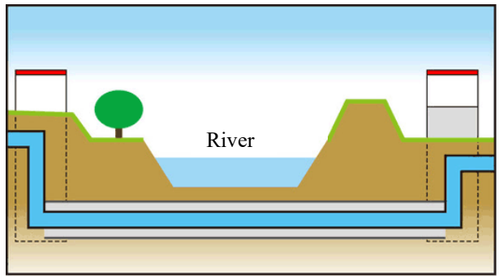
	(1) On-ground Installation Method	(2) Underground Installation Method
		
Condition	Pipes are installed on the ground	Pipes are installed under the ground
Advantages	① Easy to detect exfiltration and access O&M works ② Not affected by the traffic load on the pipeline ③ Easier to discharge the water in case of emergency because the drain valve shall be installed at a smaller depth	① Less possibility of destruction and robbery by accident and intentional behavior ② Less deterioration by exposure of the sun
Disadvantages	① More possibility of destruction or robbery by accident or intentional behavior ② More deterioration by exposure of the sun ③ More volume of construction works where the pipe cross the existing road ④ Need additional countermeasure when new road can cross the pipe	① Taking longer to detect exfiltration and access O&M works ② Can be affected by the traffic load ③ Taking longer to discharge the water in case of emergency because the drain valve shall be installed at a deeper depth ④ Every valve and gauge shall be installed in the manhole
Evaluation	Not selected * More cost and time for O&M works can affect the sustainability of this project	Selected

Source: JICA Survey Team

(2) Bridge section on the river

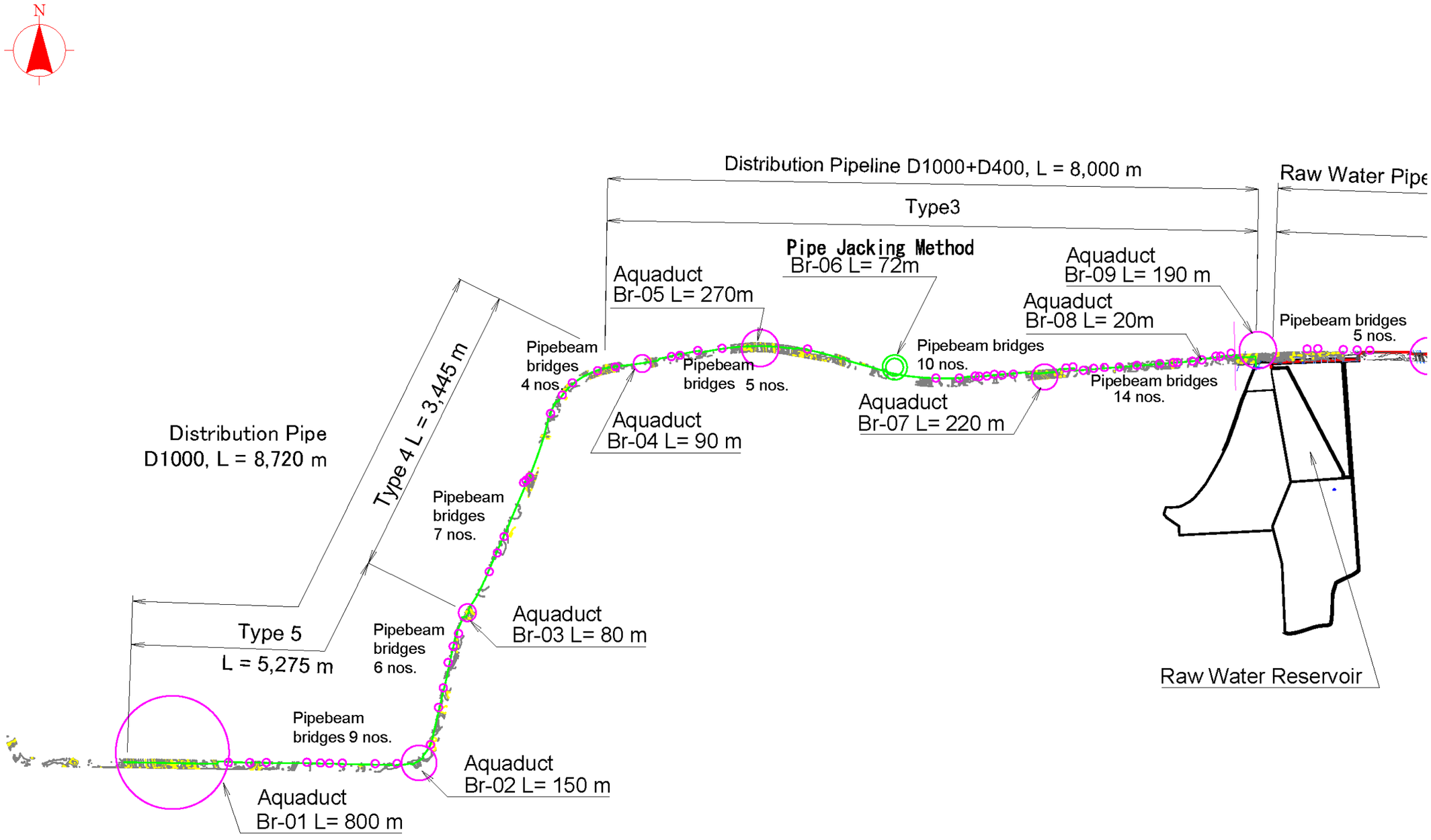
Bridge-piggybacked water main and Water main bridge and Pipe jacking method and Pipe installation on the riverbed were compared in terms of land acquisition, estimated construction cost, constructability, operation and maintenance, and impact to other project. As a result, the aqueduct method was evaluated as being advantageous in terms of constructability.

Table 6.6.4 Comparison Table of Construction Method on Bridge Section

	Alt. 1 Bridge-Piggybacked Water Main Method	Alt. 2 Aqueduct Method	Alt. 3 Pipe Jacking Method	Alt.4 Opencut the Riverbed Method
				
Condition	① Dead weight of pipes + weight of water is estimated 7.0 ～ 13.5 kN/m (combination of D 300 mm, D 400 mm, D 500mm, D 1000 mm) ② Construction of Matarbari Port Access Road is ready to start ③ Span: 20, 80-95, 125, 150, 190, 220, 270, 340 Width of remaining acquired land from the edge of the bridge to the boundary of the land is only 1.5 m			
Advantages	① No additional land acquisition ② Cheapest construction cost ③ Easy to detect exfiltration and do O&M works	① No revision work of the design for the bridges ② Easy to detect exfiltration and do O&M works	① No revision work of the design for the bridges ② The construction work does not affect the river condition and river transportation under the construction time and after construction ③ Rapid construction period	① No revision work of the design for the bridges ② No affect of river condition and river transportation after completion
Disadvantages	① Revision work of design is needed ② Suspension of construction works during design change can be occur	① Most expensive construction cost in the table ② Additional land acquisition is needed for pipe installation beside the road bridge ③ Necessary of coffering work in the river	① Construction cost can be higher than that of Bridge-Piggybacked Water Main ② Additional land acquisition is needed for pipe installation beside the road bridge ③ Need special equipment and specialist to do this construction work ④ Difficult to detect exfiltration and do O&M works ⑤ Temporary pit and its spa**ce** are necessary on the starting point and ending point for construction ⑥ The allowable jacking distance is around 100m	① Construction cost may be higher than that of Bridge-Piggybacked Water Main ② Additional land acquisition is needed for pipe installation beside the road bridge ③ Need additional temporary structure of coffering work during construction ④ Difficult to detect exfiltration and do O&M works ⑤ Possibility to expose the pipe in occurring the local scouring and destroy the pipe by the ship in low water level or river flow in flooding time
Evaluation	Not selected * 7.0 ～ 13.5 kN/m loads can affect the number of girders, cross-sectional dimensions of columns, bar arrangement, number of piles, etc. and revision work of design is needed. * Huge impact of suspension of construction works during the design works should be considered.	Selected	Not selected * High difficulty of procurement of special equipment to execute pipe jacking should be considered.	Not selected * High difficulty of coffering work during construction in the river and more possibility to be destroyed by the ship or river flow should be considered.

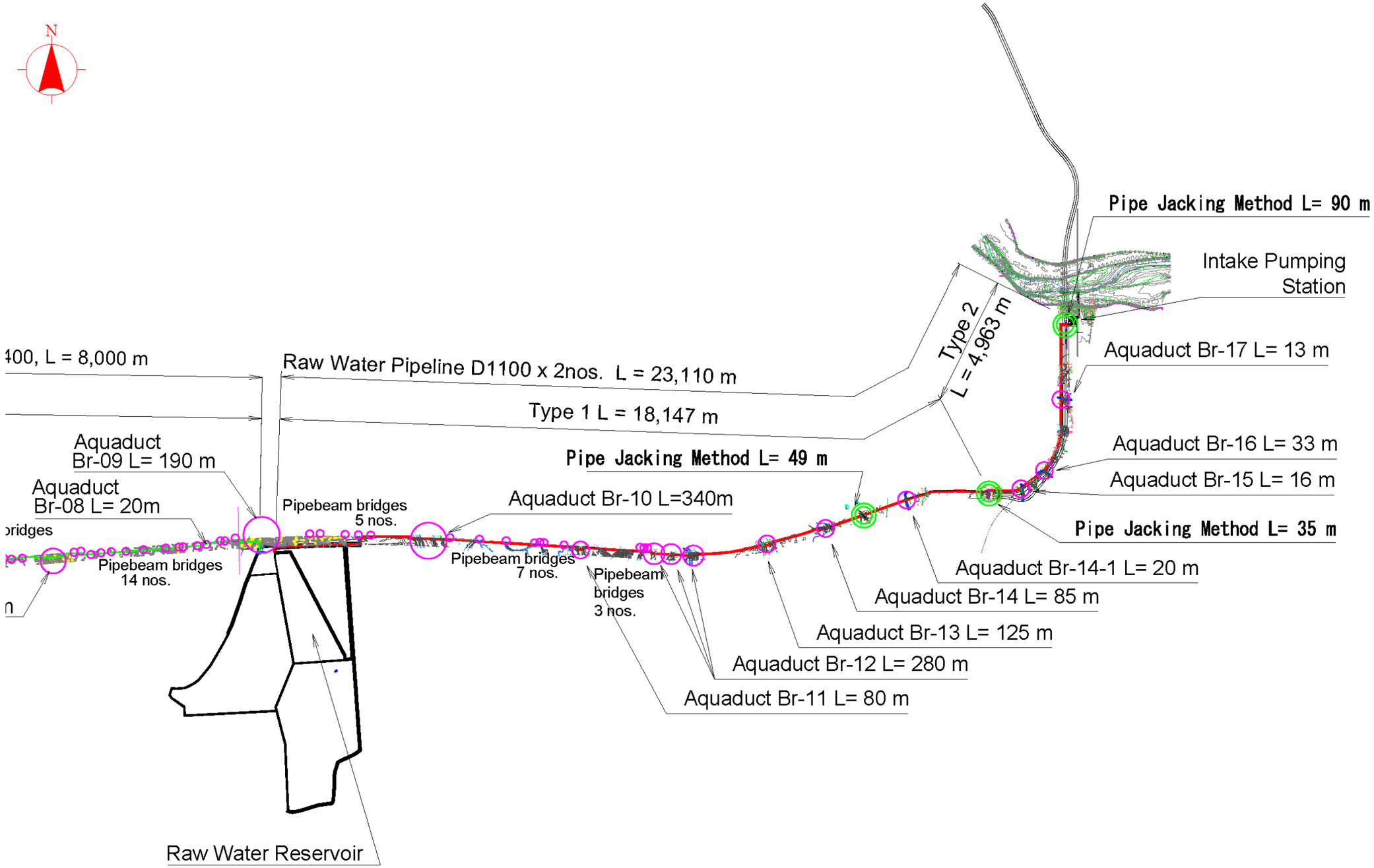
Source: JICA Survey Team

Location and description of each aqueduct was as shown in the following figure and table.



Source: JICA Survey Team

Figure 6.6.2 Location of Aqueduct



Source: JICA Survey Team

Figure 6.6.3 Location of Aqueduct

Table 6.6.5 Descriptions of aqueducts

No.	Span (m)	Length (m)	Pipe diameter (mm)
MPDP Br-01	35, 87	800	1000
MPDP Br-02	35	150	1000
MPDP Br-03	35	80	1000
	(Pipe beam 20m x 26 nos.)		1000
Matarbari Bridge	20	230	400
MPDP Br-04	69.5, 87	90	400, 1000
MPDP Br-05	35, 87	270	400, 1000
MPDP Br-06	(Pipe jacking 72 m)		400, 1000
MPDP Br-07	35	220	400, 1000
MPDP Br-08	42.4	42.4	400, 1000
MPDP Br-09	46.4	190	400, 1000
	(Pipe beam 20m x 29 nos.)		400, 1000
MPDP Br-10	37.1, 46.4	340	600, 1100 x 2
MPDP Br-11	35	80	600, 1100 x 2
MPDP Br-12	35	280	600, 1100 x 2
MPDP Br-13	35	125	600, 1100 x 2
MPDP Br-14	35	105	600, 1100 x 2
MPDP Br-14	(Pipe jacking 49 m)		600, 1100 x 2
	(Pipe beam 20m x 15 nos.)		600, 1100 x 2
N1 Road	(Pipe jacking 35 m)		1100 x 2
CC Br-A1	N/A	16	1100 x 2
CC Br-2N	N/A	33	1100 x 2
CC Br-1	N/A	13	1100 x 2
CC Road	(Pipe jacking 90 m)		1100 x 2

Source: JICA Survey Team

6.6.5 Transmission Pump

A double or single suction volute pump, which has a large capacity, high efficiency, and is one of the most major types, will be applied for the Transmission Pump. Each pump flow is basically fixed and operated by water level of each DR. Details of countermeasures of water hammer will be provided in a study in next stage.

The specifications of transmission pump are as follows:

Name : No.1 Transmission Pump (for DR Industrial)
Type : Double or single suction volute
Outlet diameter : 400 mm
Discharge volume : 13.7 m^3/min
Pump total head : 66 m
Motor rated capacity : 220 kW
Number of pumps : 6 units (4 Duty and 2 Standby)

Name : No.2 Transmission Pump (for DR-2)
Type : Double or single suction volute
Outlet diameter : 300 mm
Discharge volume : 8.9 m^3/min
Pump total head : 65 m

Motor rated capacity : 160 kW
Number of pumps : 4 units (2 Duty and 2 Standby)

Name : No.3 Transmission Pump (for DR-6)
Type : Double or single suction volute
Outlet diameter : 200 mm
Discharge volume : 2.6 m^3/min
Pump total head : 53 m
Motor rated capacity : 37 kW
Number of pumps : 4 units (2 Duty and 2 Standby)

6.7 Preliminary Design of Water Distribution Facilities

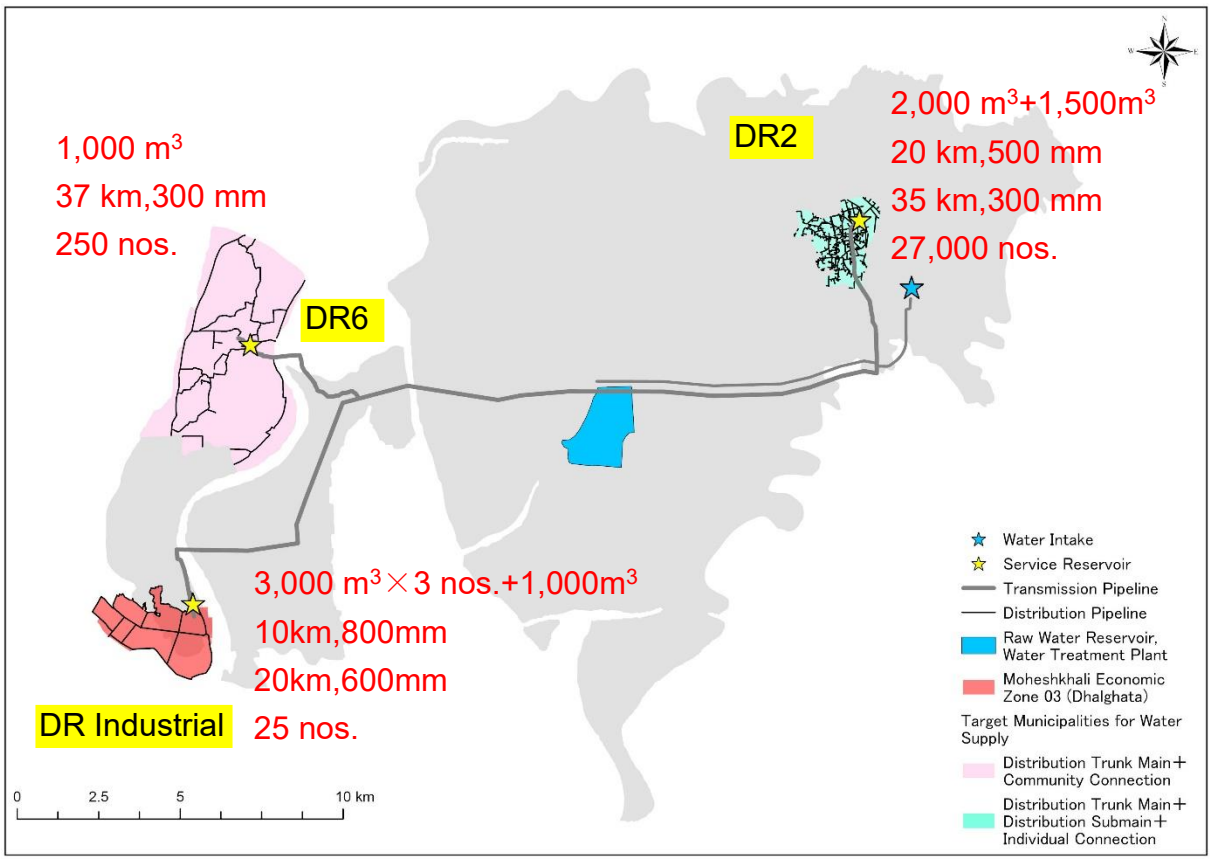
6.7.1 Outline of Water Distribution Facilities

As the treated water distribution facilities which have functions of the storage, transmission, distribution and supply of treated water, the facilities are designed as follows:

Table 6.7.1 Specifications of the Water Distribution Facilities

No.	Facility	Specifications
	Chakaria Pourashava System	
1.1	Elevated Reservoir	RC Circular Elevated tank 2,000 m^3 ϕ 21.0 m×6.5 m RC Circular Elevated tank 1,500 m^3 ϕ 18.0 m×6.5 m
1.2	Distribution Mains	D 500 mm, L=20 km D 300 mm, L=35 km
1.3	Water Service Fittings (Individual House Connections)	27,000 nos.
	Matarbari Union System	
2.1	Elevated Reservoir	RC Circular Elevated tank 1,000 m^3 ϕ 15.0 m×6.5 m
2.2	Distribution Mains	D 300 mm, L=37 km
2.3	Water Service Fittings (Group Tap Connections)	250 nos.
	Moheshkhali EZ (Dhalghata) System from WTP to DR	
3.1	Elevated Reservoir	RC Circular Elevated tank 3,000 m^3 ϕ 35.0 m×6.5 m×3 nos. RC Circular Elevated tank 1,000 m^3 ϕ 15.0 m×6.5 m
3.2	Distribution Mains	D 800 mm, L=10 km D 600 mm, L=20 km
3.3	Water Service Fittings (Individual Property Connections)	25 nos.

Source: JICA Survey Team



Source: JICA Survey Team

Figure 6.7.1 Outline of Water Distribution Facilities

6.7.2 Hydraulic Examination

The following conditions were provided for the preliminary design of water distribution facilities.

1) Capacity of the elevated reservoir: Equivalent to 3 hours of the maximum daily supply
   Chakaria Pourashava System: 3,188 m^3
   Matarbari Union System: 915 m^3
   Moheshkhali EZ (Dhalghata) System: 9,805 m^3

2) Water depth: 6 m

3) Design distribution flow: Design maximum hourly distribution flow
   The design maximum hourly distribution flow is determined as the average hourly distribution flow in the day with the maximum daily distribution flow multiplied by a time coefficient. The formula to compute the design maximum hourly distribution flow is the following:

$$q = K \times \frac{Q}{24}$$

   Where

q: Design maximum hourly distribution flow (m^3/hr)

K: Time coefficient (The ratio of the design maximum hourly distribution flow to the average hourly flow (1.5 - 2.0) using 1.8)

Q: Design maximum daily distribution flow (m3/day)

Chakaria Pourashava System: 1,913 m^3/hr

Matarbari Union System: 549 m^3/hr

Moheshkhali EZ (Dhalghata) System: 5,883 m^3/hr

4) Pipe material:

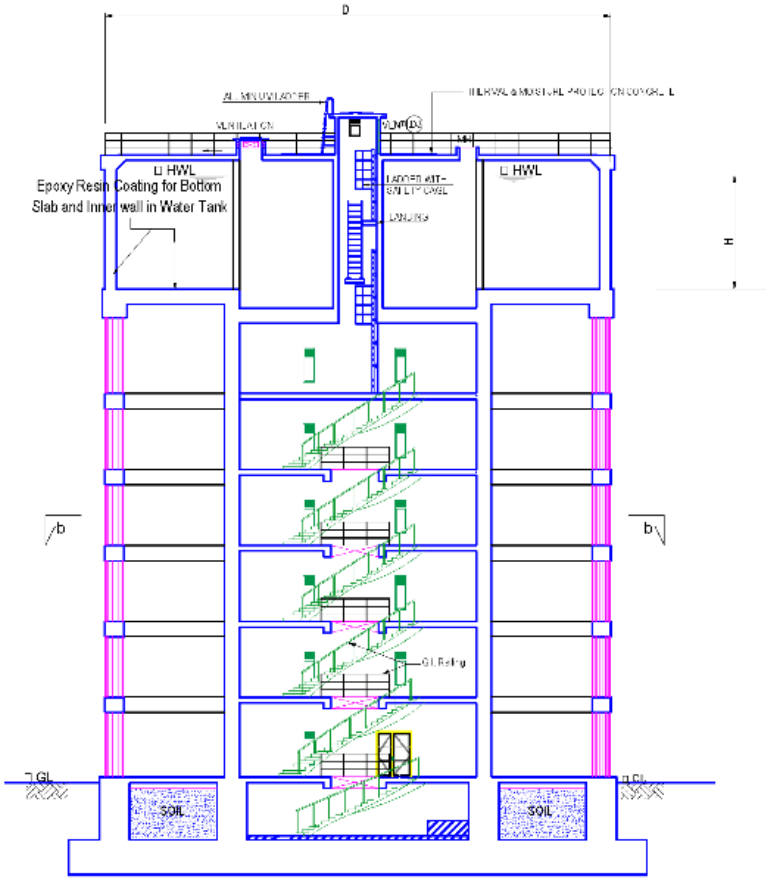
Ductile iron pipe (400 mm or more), High-density polyethylene pipe (300 mm or less)

Experiences of construction in the country and the advantage for DI in 6.6.3 and the following advantage for HDPE are considered

- Excellent corrosion resistance
- Handling is easy owing to its light weight
- Pipe can be made one body by butt fusion welding and electrofusion welding, and so can deal with movement of soil.
- Roughness of the inside wall does not change

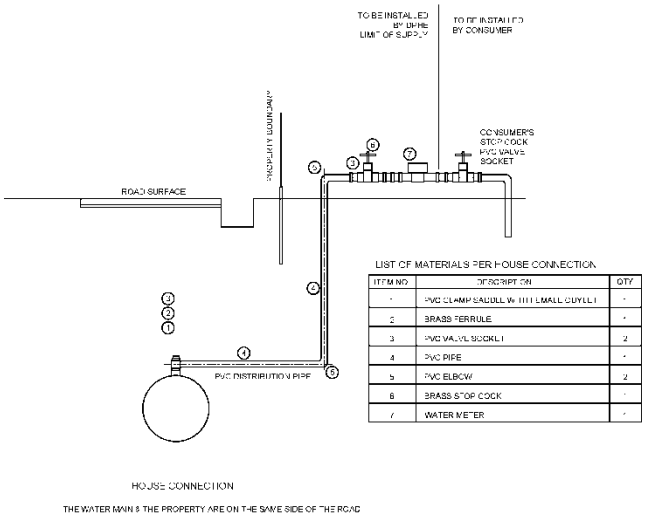
5) Water pressure:

- The minimum dynamic water pressure at the tapping points on the distribution main for branching of service connections shall be more than 100 kPa (0.10 MPa).
- The maximum static water pressure at the tapping points on the distribution main for branching of service connections shall be less than 740 kPa (0.74 MPa).



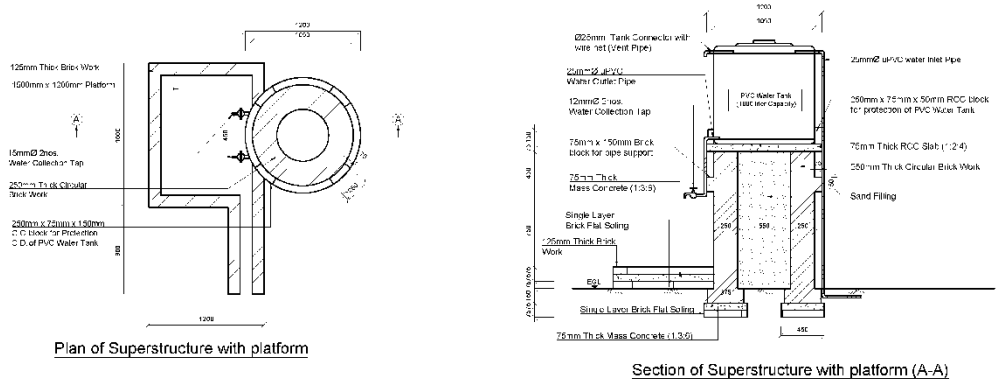
Source: JICA Survey Team

Figure 6.7.2 Typical Drawing of Elevated Reservoir



Source: JICA Survey Team

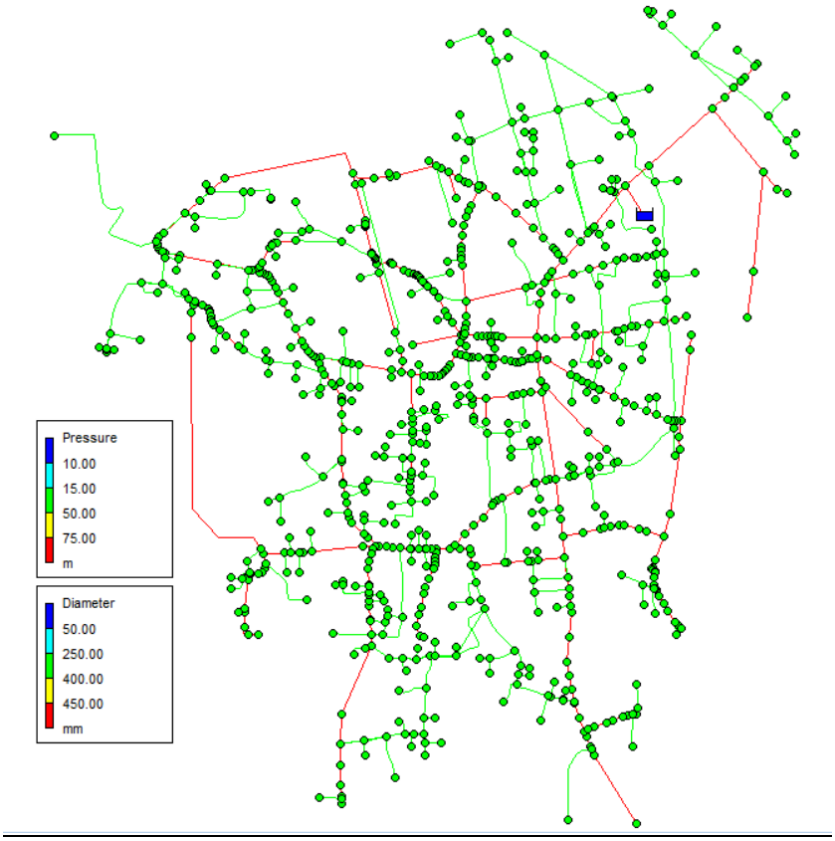
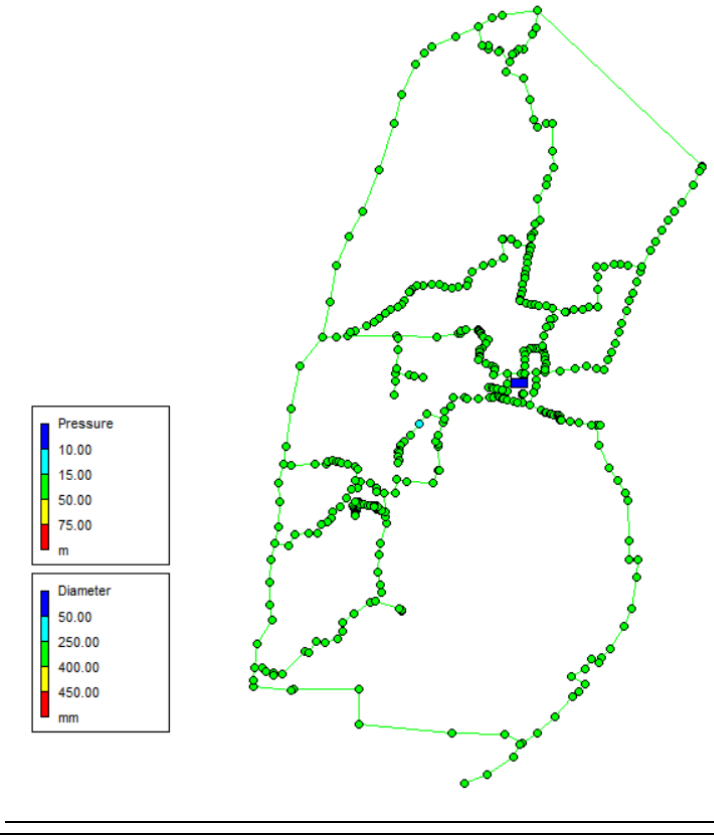
Figure 6.7.3 Typical Drawing of Individual House Connection

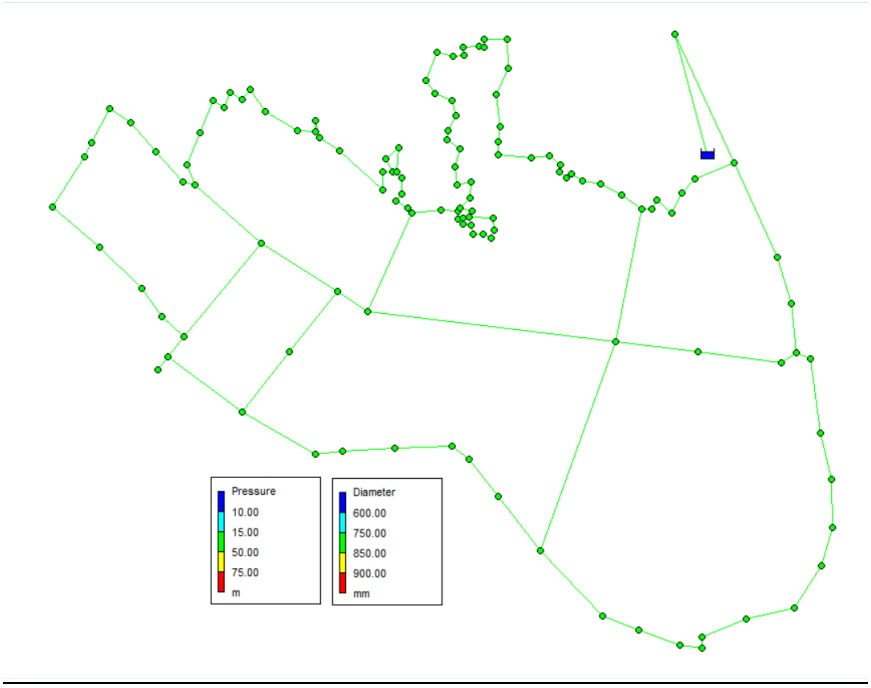


Source: JICA Survey Team

Figure 6.7.4 Typical Drawing of Group Tap Connection

Table 6.7.2 Results of Pipe Network Analysis

No.	System	Result
1	Chakaria Paurashova System	
2	Matabari Union System	

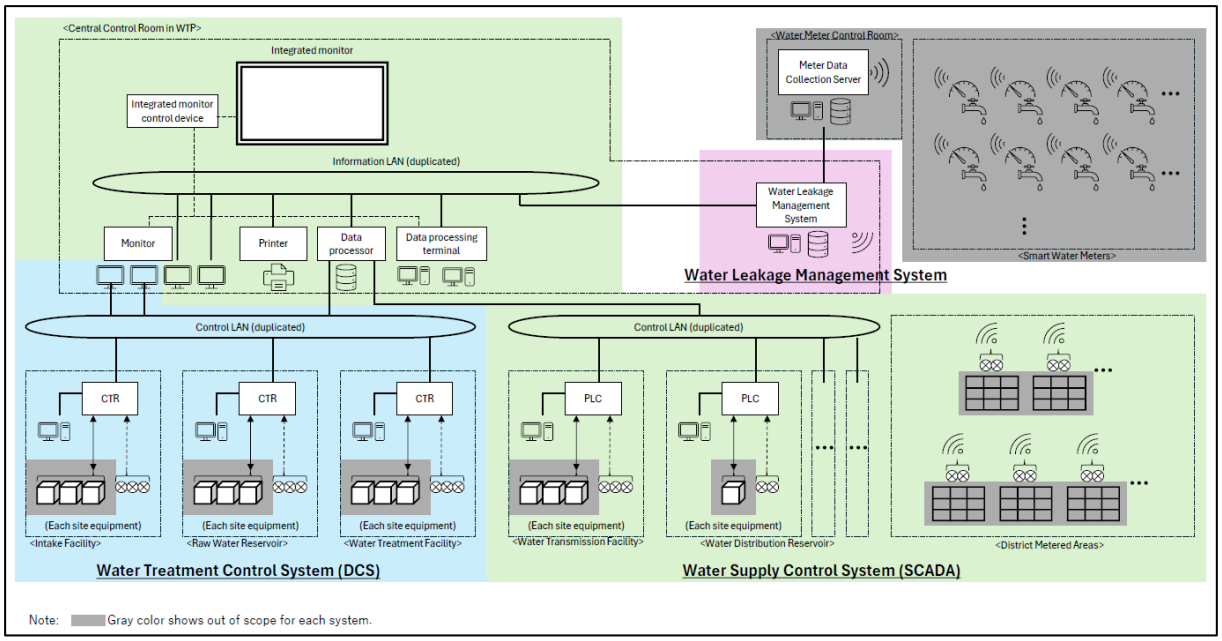
No.	System	Result
3	Moheshkhali EZ (Dhalghata) System	

6.8 Digital Systems

Digital Systems are prepared to ensure efficient and secure the water supply management. The systems for this project is configured with the following 3 systems:

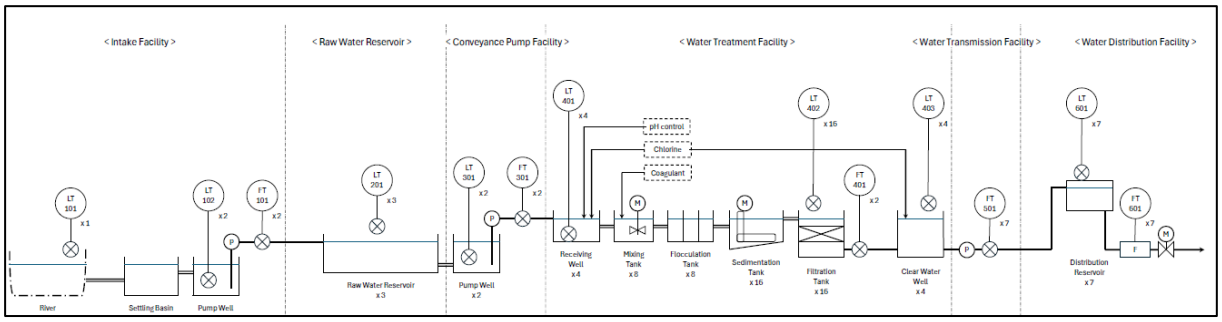
- Water Treatment Control System
- Water Supply Control System
- Water Leakage Management System

The System Configuration Diagram and Main Instrument Flow Diagram are shown in Figure 6.8.1. and Figure 6.8.2, respectively.



Source: JICA Survey Team

Figure 6.8.1 System Configuration Diagram



Source: JICA Survey Team

Figure 6.8.2 Main Instrument Flow Diagram

(1) Water Treatment Control System

This system is installed to supervise and control the Intake Facility, the Raw Water Reservoir Facility and Water Treatment Plant Facility involved in the water treatment process. A Distributed Control System (DCS), which has high reliability and redundancy, is applied because the control function is critical in these facilities.

For instrumentation, level sensors and flow meters, as shown in Figure 6.8.2, as well as water quality sensors such as pH sensors, turbidity meters, and residual chlorine meters, are installed in the appropriate locations.

(2) Water Supply Control System

This system is installed to supervise and control the Water Transmission Facility, the Water Distribution Facility, and the Water Distribution Pipeline involved in water distribution and supply. A Supervisory Control and Data Acquisition (SCADA) system, which is superior in monitoring and data collection for large-scale operations, is applied because the supervisory function is critical in these facilities.

For instrumentation, level sensors and flowmeters for each Distribution Reservoir as well as flowmeters and pressure sensors for each District Metered Area (DMA) are installed.

(3) Wate Leakage Management System

This system is installed to monitor water leakage by collecting and analysis data such as flow rate and pressure at DMAs and water meter data which is transmitted from smart meters installed at each water supply point. Utilizing this system helps reduce non-revenue water.

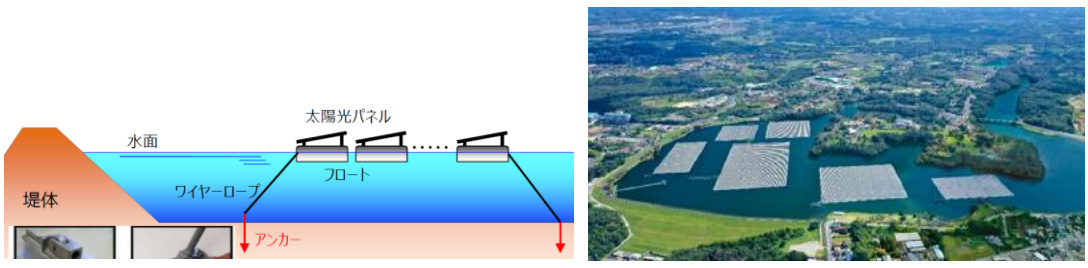
The details of these systems will be considered at the detail design stage.

6.9 Effective Use Plan of Project Site

(1) Solar Power Generation on Surface of the Reservoir

In recent years, there has been an increase in examples of floating solar power generation utilizing the surface of lakes and dams. This technology is made possible by floating solar panels on the water using resin floats. The floats are secured with wire ropes that are connected to anchors fixed at the bottom of the pond. The image of Floating Solar Power Generation is shown in Figure 6.8.1.

Many cases have been implemented in Japan and other countries as well, with the largest floating solar power plant in Japan having a capacity of 13.7 MW (approximately 18 hectares). The general advantages and disadvantages are shown in Table 6.8.1.



Source: KYOCERA Corporation presentation material

Figure 6.9.1 Floating Solar Power Generation

Table 6.8.1 Advantages and Disadvantages for Floating Solar Power Generation

Advantages	Disadvantages
✓ Power can be generated ✓ No forest destruction and land preparation for installation ✓ No weed removal work ✓ Higher power generation efficiency compared to land installation due to the lower temperature of the panel ✓ Reduction of water evaporation ✓ Potential of suppressing the growth of algae and other aquatic plants	✓ Operations from boats or underwater are also required for construction and maintenance work ✓ Restriction of areas where dredging is possible ✓ Increased risk of electric shock accidents since power generation continues as long as there is light, if submerged due to disasters or other accidents ✓ Potential of the increase of phytoplankton due to the reduction of aquatic plants in shallow ponds

Source: JICA Survey Team

The main installation conditions are as follows:

- No water flow, such as in rivers
- No waves, such as in ocean areas
- No inflow of driftwood or landslide
- The bottom surface should be flat if the water needs to be drained to the bottom,
- No extreme strong winds or heavy snowfall (there is technology that can apply wind speeds up to around 40 m/sec)

In the case of this project, assuming installation on 50% of the reservoir surface area, the solar power generation facility would have an approximate capacity of 170 MW, with an estimated construction cost of around 30-70 billion yen based on Japanese standards without a storage battery system. While a significant amount of electricity can be generated, the investment cost will be huge and there are concerns about restrictions on the dredging operations, which are an important aspect of maintenance, as well as the need for countermeasures against cyclones.

CHAPTER 7 PROJECT IMPLEMENTATION PLAN

The term "the Project" in this Chapter refers to the Phase 1 Project identified in Section 5.4.

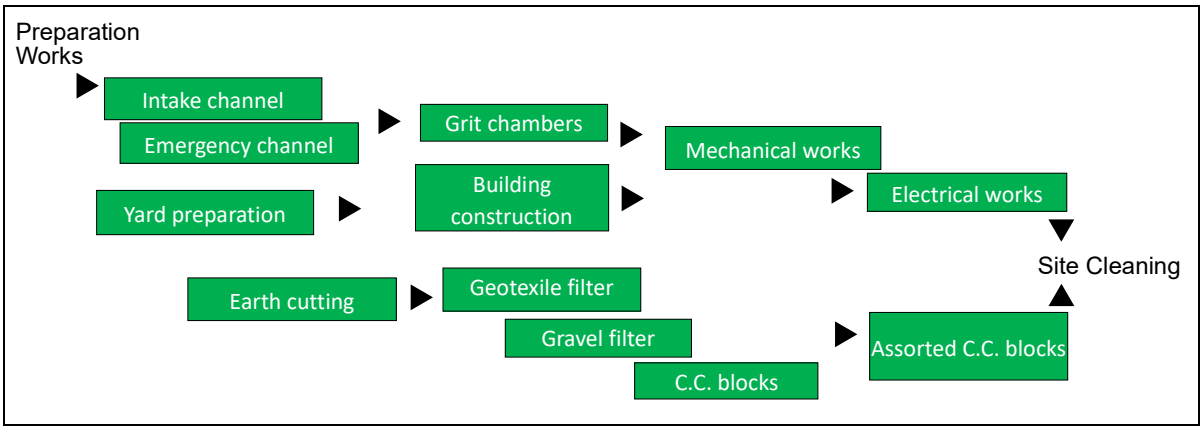
7.1 Construction Plan

7.1.1 Work Procedure and Method

The majority of the construction works are for an intake, conveyance and transmission pipes, a raw water reservoir, a water treatment plant, distribution reservoirs, and distribution networks. The outline of work procedure and method for each facility mentioned above are summarized below.

(1) Intake

The construction works of the intake include intake facilities, pump station and river protection of the law water channel. The work procedure for the intake and pump station is figured below.



Source：JICA Study Team

Figure 7.1.1 Work Procedure of Intake

The method of major works for the intake is outlined below.

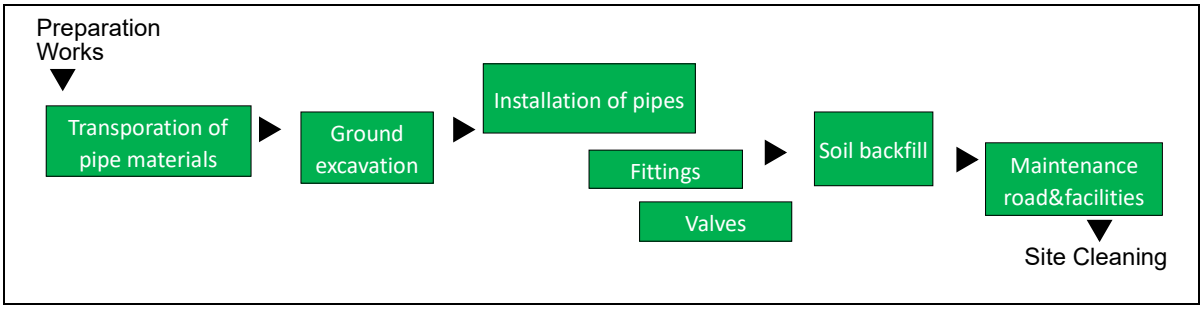
- Intake Structures: Intake channel, emergency intake channel and grit chambers are constructed by RC concrete. The formworks and reinforcing bar are arranged by labors with crane. The raw concrete is carried by agitator trucks and cast by concrete pump.
- Yard preparation for intake pump station: Clearance, excavation and embankment works are carried out by excavator and roller machines. The embankment material is spread at the location and compacted by roller machines in layer by layer.
- Building construction: Each building structures such as pump room, generator room, control room, office and staff house, etc. are constructed by RC concrete. The formworks and reinforcing bar are arranged by labors with crane. The raw concrete is carried by agitator trucks and cast by concrete pump.
- Installation of mechanical and electrical equipment: Intake pumps, emergency pumps and electrical equipment are installed at pump station building.
- Earth cutting for low water channel: The existing river embankment is cut and prepare the proper formation of slope by excavators to provide the bank protection work.

- Bank protection work: For the slope revetment, geo textile filter cloth, pre-gravel filter, C.C Block are arranged on the slope of river embankment by labor with crane. In addition, assorted C.C. blocks are scattered at the bottom of the revetment with crane.

(2) Conveyance and Transmission Pipes

The conveyance pipe and transmission pipe work includes an open cut section, waterpipe bridge section and pipe jacking section.

The work procedure of the pipeline works for open-cut section is figured below.



Source：JICA Study Team

Figure 7.1.2 Work Procedure of Conveyance Pipe and Transmission Pipe (Open-cut Section)

The method of major works for the open-cut section is outlined below.

- Transportation of pipe materials: Pipe materials are transported from stockyard to the location along the pipeline route by trailer and unloaded the location by crane.
- Ground excavation: Ground soil is excavated up to the designed pipe bottom elevation by mechanical excavation with excavator or manual excavation by labors. If the ground is not strong enough to keep stable condition, steel sheet piles are installed by laborers with crane.
- Installation of pipes, fittings, valves: Pipes, fittings and valves are placed to the location and connected by laborers with crane.
- Soil backfills: The pipeline is backfilled by excavated soil. Steel sheet piles if installed for excavation are removed at same time.

The method of major works for the waterpipe Bridge section is outlined below.

- Substructure work: RC piles are driven by pile driving machine. For RC concrete piers, the formworks and reinforcing bar are arranged by labors with crane. The raw concrete is carried by agitator trucks and cast by concrete pump.
- Superstructure work: The members of the steel girder are transported to site. The portion of steel girder are assembled at erection site. The assembled steel girders are erected on substructure by crane. The steel girders are connected by tensioning bolts on the spot.
- Installation of pipeline: Pipes, fittings and valves are placed to the location and connected by laborers with crane.

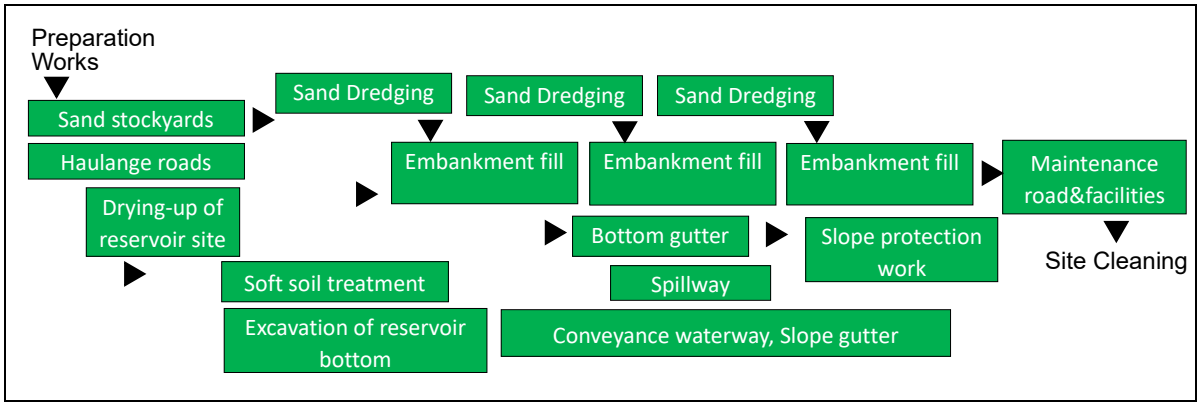
The method of major works for the pipe jacking method section is outlined below.

- Construction of shafts: Departure shaft and arrival shaft are constructed by excavator.
- Assembling of Machinery and leading pipe: Propeller machine and lead pipe are lifted down and attached. The leading pipe is unloaded and attached to the.
- Drilling: Drilling and connection of propelling pipe are repeatedly conducted by pipe jacking method.

- Dismantle of machine: The machine is dismantled and demobilized from the site.

(3) Raw Water Reservoir

The work procedure of the raw water reservoir is figured below.



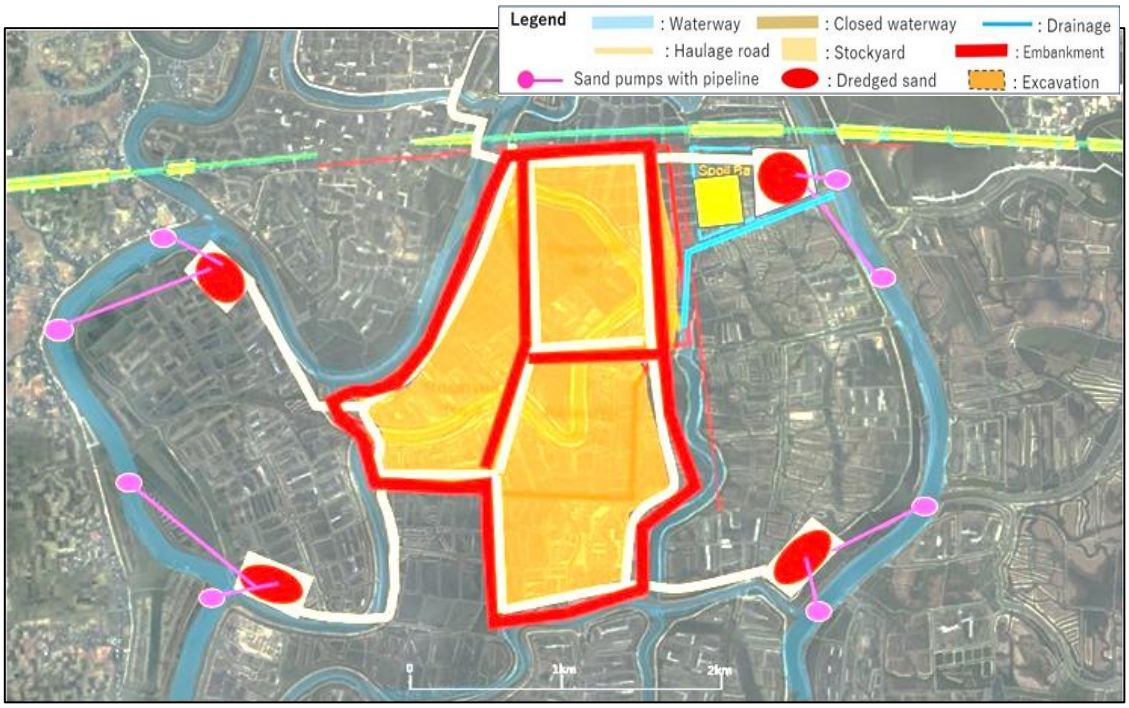
Source：JICA Study Team

Figure 7.1.3 Work Procedure of Raw Water Reservoir

The method of major works is outlined below.

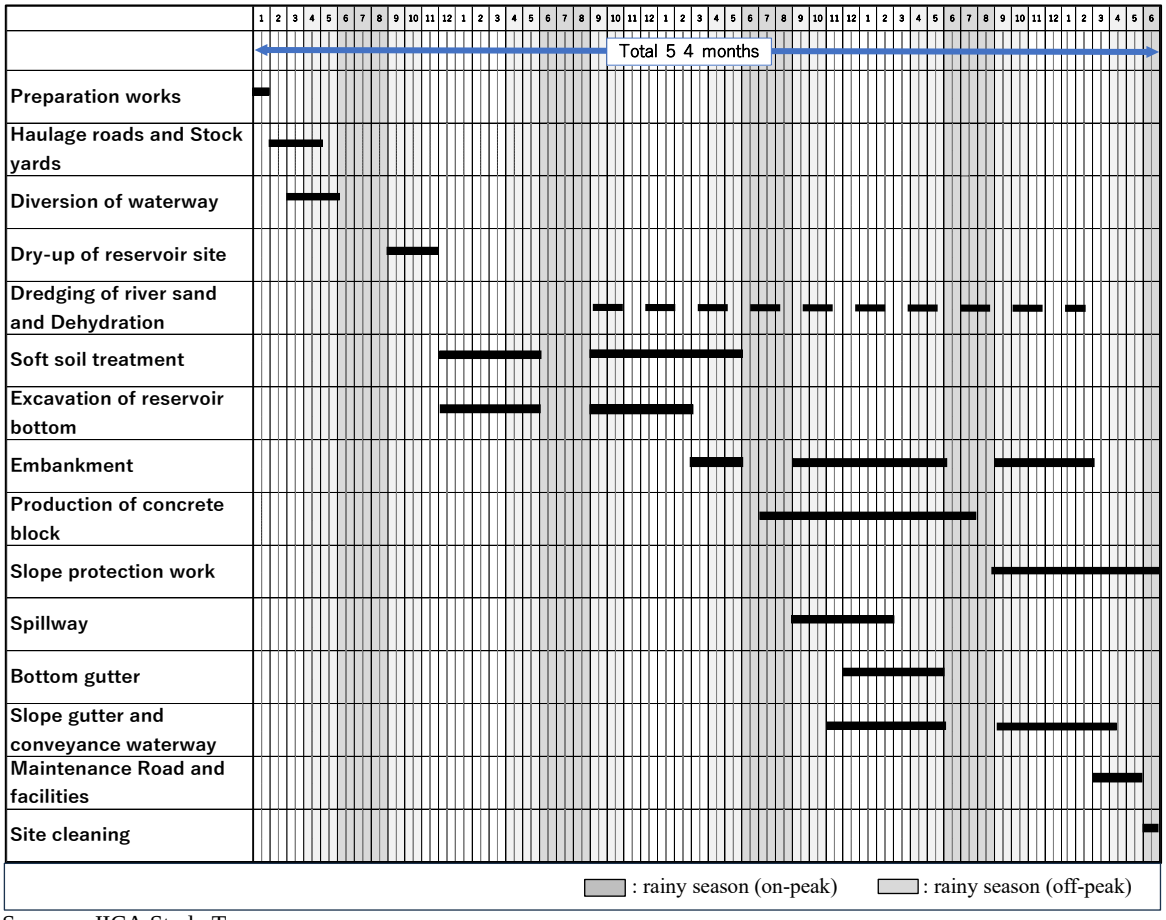
- Sand stockyards and haulage road: The sand stockyards are prepared at available land spaces near the river surrounding the construction site. Also, the haulage roads which connect the stockyards to the site of embankment work are prepared.
- Drying-up of reservoir site: The water channels are prepared for the diversion of waterways. The existing river branches passing at the reservoir area is shifted. After, the reservoir site is dried up.
- Excavation of reservoir bottom: The surface layer of the ground soil at the reservoir area which may include the poor and humus soil is excavated by bulldozers or excavators.
- Soft soil treatment: The soft soil treatment is carried out by a soil mixing method.
- Sand dredging: In advance of the embankment work, the river sand is dredged with dredging boat, transported to the stockyard by pipeline and stored until the use to embankment work. The arrangement plan of sand dredgings for the raw water reservoir is illustrated in the figure below.
- Embankment fill: The embankment material carried from stockyards is spread at the location and compacted by roller machines in layer by layer. The quality of compaction work is controlled with soil density test and permeability test.
- Slope protection work: The concrete blocks for slope protection are installed at the slope of embankment.
- Concrete structural works: The bottom gutters, spillway and slope gutters are constructed. The formworks and reinforcing bar are arranged by labor with small crane. The raw concrete is carried by agitator trucks and cast by concrete pump. The backfilling is carried out by rammer or tamper elaborately to prevent ground piping or uneven settlement.
- Maintenance road and facilities: At the top of embankment, the concrete pavement was laid and the concrete fence, etc. is installed.

Due to the large work volume of soft soil treatment, excavation and embankment, the construction period is estimated as 54 months. The construction schedule is considered as the bar chart shown below.



Source：JICA Study Team

Figure 7.1.4　Arrangement Plan of River Sand Dredging



Source：JICA Study Team

Figure 7.1.5　Construction Schedule of Raw Water Reservoir

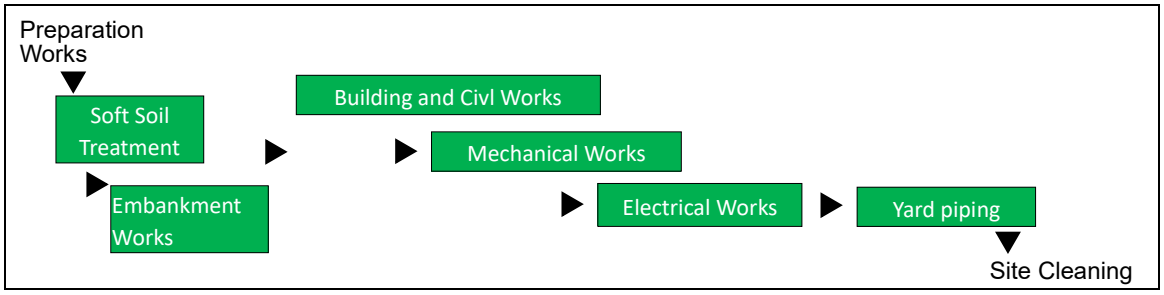
In planning the construction schedule, the following considerations were made.

- The soft soil treatment, excavation of reservoir bottom and the lower part of the embankment works cannot be performed from June to August. Because the workability for these works is influenced harshly by stagnant water by the rain.
- The works for upper part of embankment, upper part of concrete channel, roads, fences, etc., may be progressed but in slow pace through the rainy season. Hence, it is also planned as inactivate in the peak of rainy season. Some preparation works or precast production can be continued only.

In the event of flooding during the rainy season, it is necessary to maintain the construction site by proper arrangement of sandbags or other means to protect the slope from erosion by water flushing.

(4) Water Treatment Plant

The work procedure of the water treatment plant is figured below.



Source：JICA Study Team

Figure 7.1.6 Work Procedure of Water Treatment Plant

The method of major works is outlined below.

- Soft soil treatment: The soft soil treatment is carried out by a soil mixing method.
- Yard preparation: The embankment is constructed for the platform of water treatment plant.
- Buildings and structures: The water treatment pond, water pump building, sedimentation basin, rapid sand filter, office building facility and any other buildings and structures are constructed.
- Mechanical work: All devices are installed at each facility. The plumber works are conducted at each facility.
- Electrical work: The electric circuit, cable, electrical room, etc. are arranged at each facility.

(5) Distribution Reservoir

The method of major works is outlined below.

- Yard preparation: Clearance and excavation works are carried out by excavators and rollers.
- Structural work; The foundation work, pipe arrangement work, construction of tank are conducted by RC concrete. The formworks and reinforcing bar are arranged by labors with crane. The raw concrete is carried by agitator trucks and cast by concrete pump.
- Yard piping: In-site water distribution pipe and ancillary facilities are prepared by laborers with cranes.

(6) Distribution Pipe and Service pipe

The work method is similar to the open cut section of the conveyance and transmission pipes.

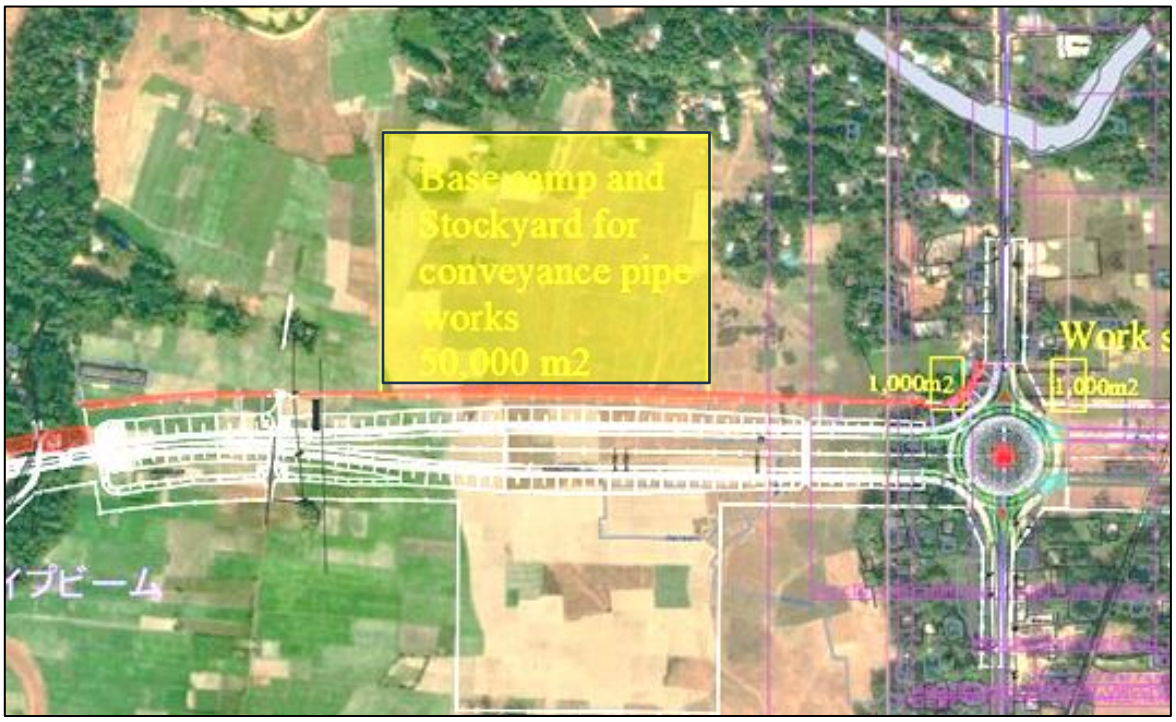
7.1.2 Temporary Construction Yards and Roads

The outline of temporary construction yards and roads are summarized below.



Source：Google Satellite Map modified by JICA Survey Team

Figure 7.1.7 Temporary construction yard for Intake



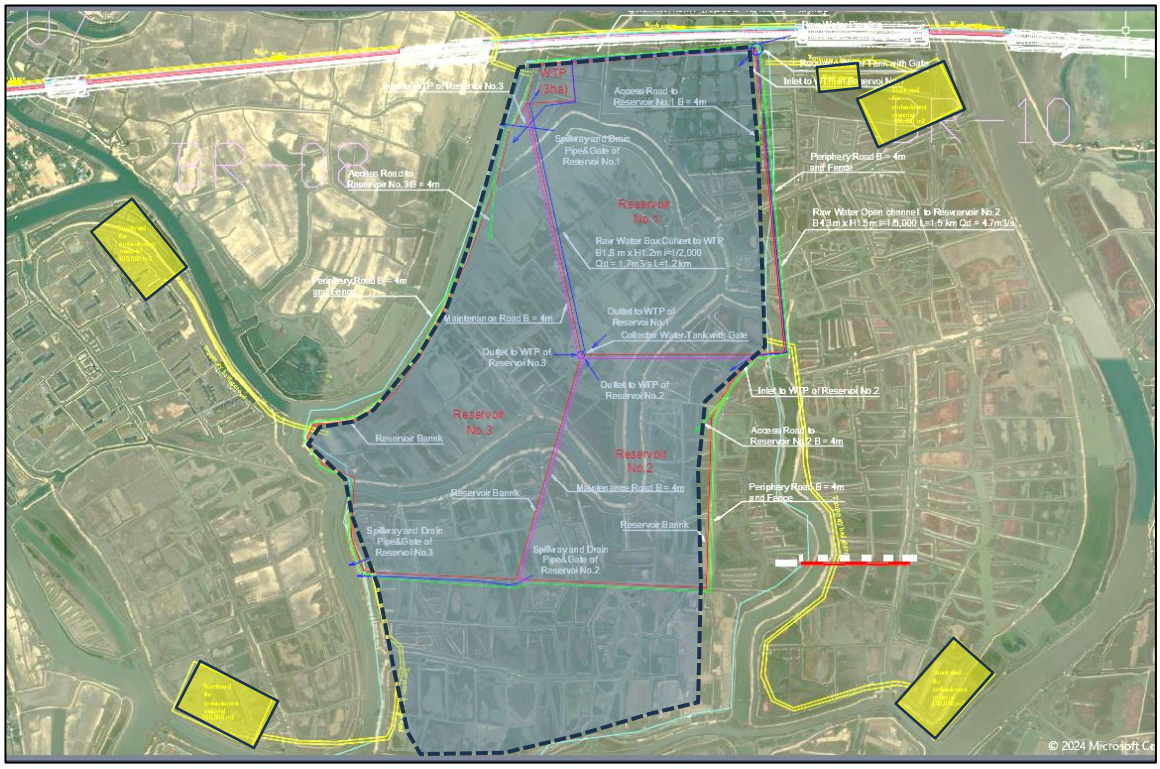
Source：Google Satellite Map modified by JICA Survey Team

Figure 7.1.8 Temporary construction yard for Conveyance Pipeline



Source：Google Satellite Map modified by JICA Survey Team

Figure 7.1.9　Temporary construction yard for Transmission Pipeline



Source：Google Satellite Map modified by JICA Survey Team

Figure 7.1.10　Temporary construction yard for Raw Water Reservoir

Table 7.1.1 Summary of Major Temporary Yards and Temporary Roads

	Temporary Yard	Temporary Road
Intake	➢ Basecamp yard: - Location: Adjacent space to the intake pump yard - Area: 5,000m^2 ➢ Stockyard: - Location: Adjacent space to the riverbank protection work site (Right bank and Left bank) - Area: 5,000m^2 × 2	➢ Access road: - Location: Between the intake inlet point and the intake pump yard - Length: L= 300m ➢ Access road: - Location: Along the riverbank protection work site (Right bank and Left bank) - Length (at Right bank): L= 1,700m - Length (at Left bank): L= 2,000m
Conveya-nce Pipeline	➢ Basecamp yard with stockyard - Location; Near the intersection between the existing highway N1 and Matarbari port access road - Area: 50,000m^2	➢ Access road: - Location: The area where access to site is difficult. Especially for the site of aquaduct bridges and pipe jacking works. - Length: L=2,000m in total
Transmi-ssion Pipeline	➢ Basecamp yard with stockyard: - Location: Near the intersection between the existing highway R172 and Matarbari port access road - Area: 50,000m^2	- Access road: - Location: The area where access to site is difficult. Especially for the site of aquaduct bridges. - Length: L=2,000m in total
Raw Water Reservoir	➢ Basecamp yard: - Location: Adjacent space to the raw water reservoir - Area: 20,000m^2 ➢ Stockyard: - Location: Adjacent space to the sand river dredging points - Area: 100,000m^2× 4 locations	➢ Access road: - Location: Between existing village roads and the construction site - Length: L= 1,000m ➢ Haulage road: - Location: Between each stockyard and the construction site - Length: L= 5,000m in total ➢ Temporary bridge: - Location: Each location in river along the temporary road - Length: L= 500m in total
Water Treatment Plant	➢ Basecamp yard with stockyard: - Location: Utilization of space within the construction site	➢ Access road: - Location: Between existing village roads and the construction site - Length: L= 1,000m
Distributio n Pipes	- Basecamp yard with stockyard: - Location: Adjacent space to the site - Area: 10,000m^2× 3 locations	➢ Access Road: - Location: Utilization of existing roads

Source: JICA Study Team

7.1.3 Procurement and Transportation of Construction Goods

(1) Availability of Construction Goods in Bangladesh

Basically, productions of general construction materials are available in Bangladesh. For example, cement for concrete and reinforcement bars have been produced domestically and distributed to Dhaka, Chattogram and other cities. However, natural materials are not abundant in Bangladesh. The stone materials used for concrete aggregate, crusher-run, etc., with satisfied quality are taken from the Sylhet region only. Since their product amounts are limited, most of the large-scale projects rely on imported stone materials. The embankment fill materials are rarely taken from the inland areas. The materials taken from rivers, or the seabed are adopted at most.

General machinery and equipment used for earth works, concrete works and transportation are mostly owned by local construction companies. Also, some machine lease companies are operated in Dhaka.

(2) Procurement of Construction Goods for the Project

It is a basic approach that construction materials and machinery will be procured in Bangladesh, if available with satisfied volume and quality. However, it is considered difficult or impossible to obtain some goods in domestic markets. Such productions will be imported from other third countries or Japan. For example, the ductile cast-iron pipes proposed for pipelines are not produced in Bangladesh. In the case of a similar project which is named “Karnaphuli Water Supply Project”, the selected ductile cast-iron pipes were produced in and imported from Japan were adopted.

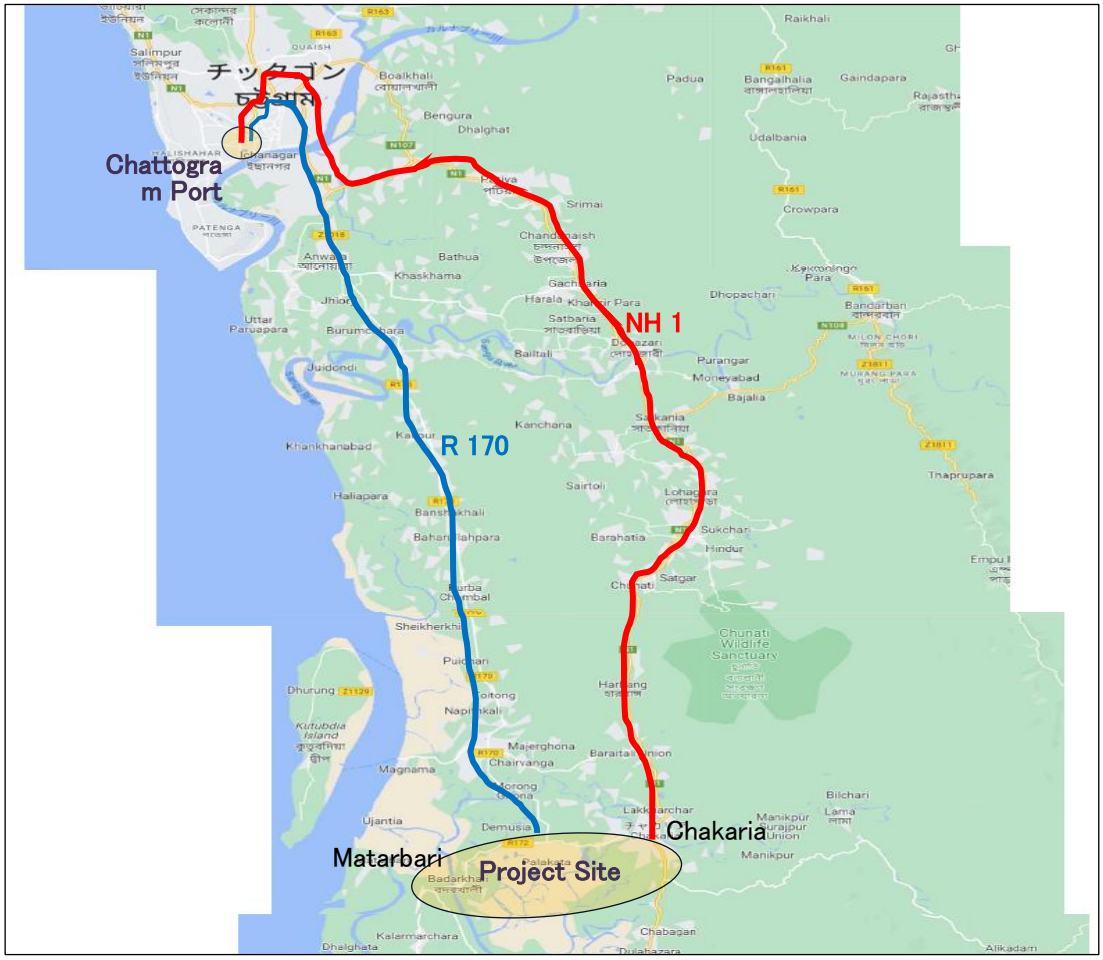
The pumps and electrical devices, which are majorly used for the water treatment plant and pump stations, may not be produced in Bangladesh. Procurement through import will be considered for such goods.

(3) Transportation of Construction Goods

The construction goods which can be procured in domestic markets can be carried from Dhaka City or Chattogram City. They will be carried by truck or trailer through the National Highway N1 or R170 to the project site. The construction goods to be imported from other countries will be disembarked at Chittagong Port and will be carried by truck or trailer also through N1 or R170 to the project site.

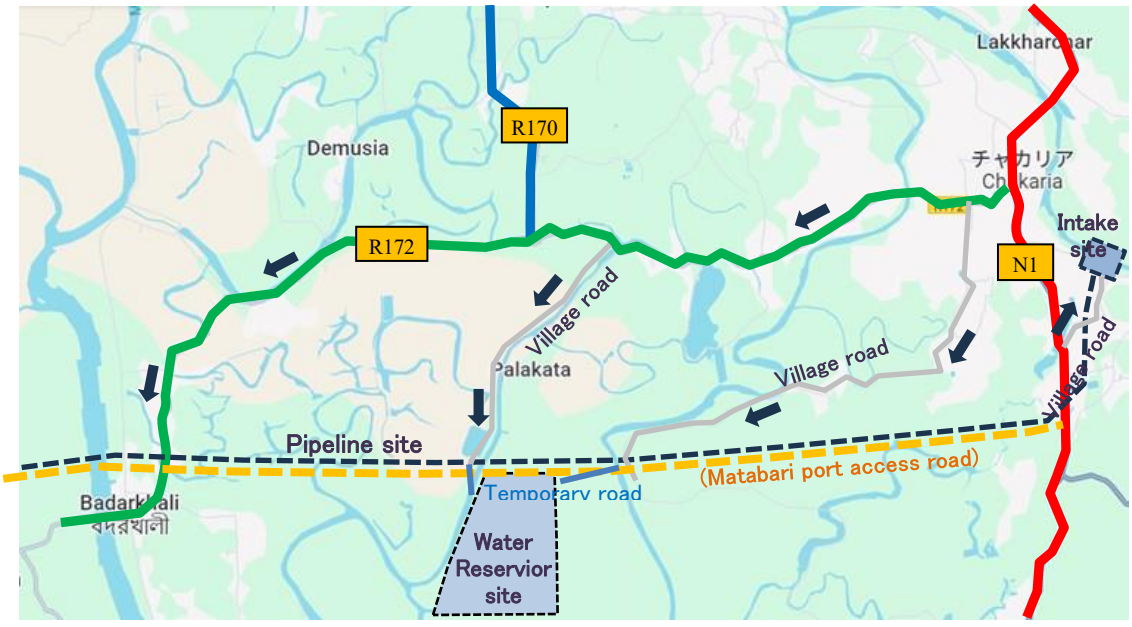
In addition, the State Highway (R172) connecting East-West direction will be utilized to access to the vicinity of the planned site.

From the paved road to each construction site, some of existing village roads will be used with being widened or reinforced. Where there are no existing roads, temporary roads will be constructed.



Source：Google Map modified by JICA Survey Team

Figure 7.1.11　Inland Transportation Route of Construction Goods



Source：Google Map modified by JICA Survey Team

Figure 7.1.12　Access Route to Construction Site

7.1.4 Balance of Soil Excavation, Disposal and Borrow

Due to the existence of soft clay soil at ground surface at project site, large portion of excavated ground soil may be disposed. Instead, the large volume of good soil for embankment will be necessary.

In the study, the balance of soil excavation and fill, disposal and borrowed soils generated by the construction works is estimated as table below.

Table. 7.1.2 Balance of Ground Excavation, Disposal and Borrow by Construction Works

(Unit: 1,000m3)

Facility	Ground Excavation	Earth Fill by Ground Soil	Disposal of Poor/Unused Soil	Earth Fill by Borrowed Soil / Dredged Sand
Intake	103	37	67	
Pipeline Works	336	333	4	
Raw Water Reservoir	4,312		4,312	2,745
Water Treatment Plant				400
Water Distribution Tank	2		2	
Distribution Network	255	144	112	
Total			4,497	3,145

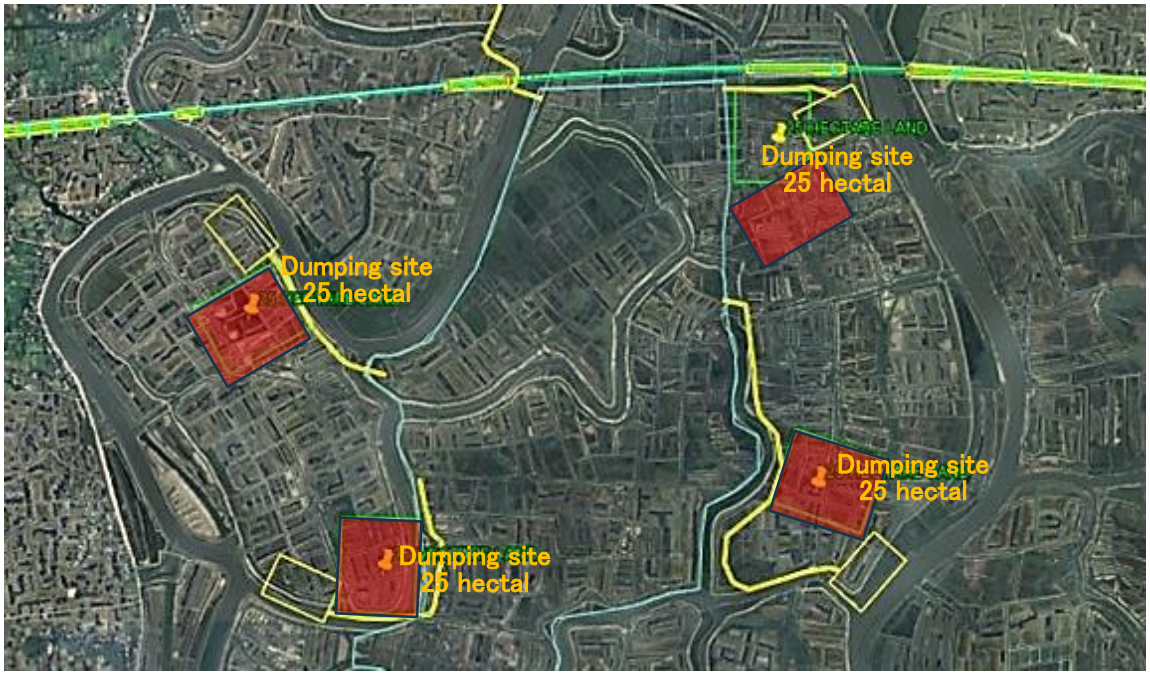
Source：JICA Survey Team

For the maintenance stage, the volume of the earth to be dredged from the riverbed of Matamuhuri River is assumed to be 60,000 m3/year. Also, the volume of the earth to be dredged from the raw water reservoir is assumed to be 106,667 m3/year. See Chapter.8, 8.4.1 Operation and Maintenance Cost, (6) Dredging Cost for more information on this.

7.1.5 Candidates of Soil Dumping Site

The disposal soil shall be transported to the soil dumping site. The candidates of soil dumping site was proposed as shown in Figure below. However, it is necessary for the project implementation organization to finalize the dumping site and inform to consultant before the work of D/D cost estimate and tender document preparation.

In addition, to prevent sediment from flowing out during storms, floods, etc., it is necessary to take measures such as applying vegetation with a sediment outflow prevention effect, such as vetiver, to the surface of the sediment heaped up in the soil dumping area. This should be considered at the detailed design stage.



Source：Google Earth modified by JICA Survey Team

Figure 7.1.13　Candidates of Soil Dumping Site

7.1.6　Safety Considerations

(1)　General

Construction safety shall be considered and measured certainly during the construction stage. The local regulations or acts related to industry safety and health, practically adopted for construction fields in Bangladesh, shall be adopted in principle. The safety regulations that are particularly being used in Bangladesh are summarized in Table 7.1.1.

In addition, it is recommended to adopt the "JICA Standard Safety Specifications: JSSS" issued by JICA in February 2021, which is incorporated into the Standard Bidding Documents under the JICA ODA Loans.

Table. 7.1.3　Safety Regulations for Construction Works in Bangladesh

No.	Title	Issued by	Issued on
1	Bangladesh Labour Act, 2006	Ministry of Law, Justice and Parliamentary Affairs	11 October, 2006
2	Bangladesh Gazette, Extra, 2015	Government of the People's Republic of Bangladesh Ministry of Labor and Employment	15 September, 2015
3	Bangladesh National Building Code, 2020	Government of the People's Republic of Bangladesh, Ministry of Housing and Public Work	11 February, 2021

Source：JICA Survey Team

(2) Traffic Safety

The traffic safety measures shall be provided certainly during the construction stage and the following should be taken into account.

(a) In order to prevent the collision accidents on neighbouring existing roads, temporary facilities such as safety sign boards and lightings, including flagmen, are arranged to control traffic during construction work. The intersections with the existing roads N1 and R172 should be carefully attended.

(b) Specially for pipeline work, it will be required to occupy existing road spaces sometimes when the pipes are transported, unloaded and buried in roads. In order to avoid the collision accidents with public traffic, safety control facilities such as safety sign boards and lightings, including flagmen, should be arranged certainly.

(c) In order to prevent traffic accidents inside construction yards, the space of construction yards shall be provided adequately.

(3) River Work Safety

The works for intake facilities will locate inside and along the Matamuhuri River. Also, the works for raw water reservoir will locate near the branch of the river. Among the rainy season from April to October, the peak season of river flooding may come between Jun to August. In safety aspect, the construction works in the river such as intake channel, river embankment, sand dredging, etc cannot be accepted during the peak of rainy season. Before or after the peak of rainy season, the works in river will be conducted with special attention on the river water condition. The river water level shall be regularly monitored. A warning alert system may be equipped at the site, which enables the evacuation of site staffs and construction equipment to safe places when the river water level increases unexpectedly.

7.1.7 Utilization of Advanced Technologies

Utilization of advanced technologies is examined. The adoption of SCADA system was proposed in the Preparatory Survey. Other technologies may be considered with the detailed examination from the economic and technical aspects at the time of detailed design stage.

Table. 7.1.4 Technical Needs of the Project

Technical Needs	Utilized Technologies	Japanese Technology with Potential for Use
1. Pipeline Works		
Pipelines need to be laid under main roads and railroads.	Non-excavation method that allows pipelines to be laid without interfering with road and rail traffic	Pipe jacking method Mini-shield method
Water distribution pipes need to be installed in urban areas.	Press-in method that reduces vibration and noise and has less impact on residents	Silent Piler
2. WTP, Pump Station		

Technical Needs	Utilized Technologies	Japanese Technology with Potential for Use
Flood control measures	Operation is possible even if the electric motor is flooded, simplifying equipment.	Water-resistant motor-integrated pump (air-cooled type)
Water hammer may occur.	For horizontal shaft pumps, installation of flywheel on the pump shaft	Pump with flywheel
3. Raw Water Reservoir		
Utilization of soil waste from construction	Improvement of soil by crushing and mixing materials	Rotary crushing and mixing method
4. Maintenance		
Lack of maintenance staff and skills	Automation of maintenance and remote monitoring technology	SCADA system
Failure of rotating equipment	Preventive maintenance with sensor monitoring	Rotating equipment monitoring system
Streamline meter reading and fee collection operations	Water smart meter, wireless meter reading system	Automated meter reading and rate adjustment and collection system

Source：JICA Survey Team

7.2 Procurement Plan

7.2.1 General

The employment of consultants is procurement of construction works (goods and services) under projects financed by ODA Loans from JICA is carried out in accordance with the general principles and procedures laid down in (a) the Guidelines for the Employment of Consultants under Japanese ODA Loans (hereinafter called “the Consultant Guidelines”) and (b) the Guidelines for Procurement under Japanese ODA Loans (hereinafter called “the Procurement Guidelines”), respectively.

7.2.2 Procurement of Consulting Services

The Consultant Guidelines shall be applied in carrying out the procurement of consultants for the consulting services of the Project. The loan borrower shall prepare a shortlist of consultants to be invited to submit their proposals. In principle, the consultants shall satisfy the following conditions.

i) The consultants have satisfactory overseas experience of the consulting services concerned, such as detailed design and supervision in the sector in question.

ii) The consultants must have experience of the consulting services in a developing country.

iii) Experience with Japanese ODA projects is preferable.

7.2.3 Confirmation of Tax Exemption

According to the recent official gazette for Japanese ODA Loan project in Bangladesh between the government of Japan and the government of Bangladesh, the government of Bangladesh may exempt followings.

- JICA from all fiscal levies and taxes imposed in Bangladesh on and/or in connection with the Loan as well as interest accruing therefrom.
- Japanese companies operating as suppliers, contractors and/or consultants from all fiscal levies and taxes imposed in Bangladesh with respect to the income accruing from the supply of products and/or services to be provided under the loan.
- Japanese companies operating as suppliers, contractors and/or consultants from all duties and related fiscal charges imposed in Bangladesh with respect to the import and re-export of their own materials and equipment needed for the implementation of the projects; and
- Japanese employees engaged in the implementation of the projects from all fiscal levies and taxes imposed in Bangladesh on their personal income derived from Japanese companies operating as suppliers, contractors and/or consultants for the implementation of the projects.

CHAPTER 8 PROJECT IMPLEMENTATION AND OPERATION/ MAINTENANCE SYSTEM

The term "the Project" in this Chapter refers to the Phase 1 Project identified in Section 5.4.

In May 2024 with the presence of the JICA mission team, the LGD Secretary specified the DPHE as the sole candidate agency to be responsible for the Project implementation, the operation and maintenance (O&M) of the constructed waterworks, and the provision of water supply service. This decision was based on the following reasons: (a) the water supply service in the Project area is a mandate of the DPHE; (b) the CWASA does not have extra human resources to formulate and implement a new Project*[1]; and (c) the DPHE has experiences in the O&M of waterworks and the water supply service including the billing and collection of water tariff*[2], e.g., the water supply service in the Mongla Port.

Based on this decision of the LGD Secretary, the implementation structure of the Project and the O&M system of the constructed waterworks are described.

8.1 Project Implementation Structure before/ during Construction

8.1.1 Organization Setup for Project Implementation

Regarding the setting up of a project management unit (PMU), the Planning Guideline of the DPHE stipulates that a separate development project proforma (DPP) means to create a separate PMU, i.e., every DPP needs to have a separate PMU*[3].

Three DPPs are assumed to be prepared, and corresponding project implementation structure will be established, i.e.,

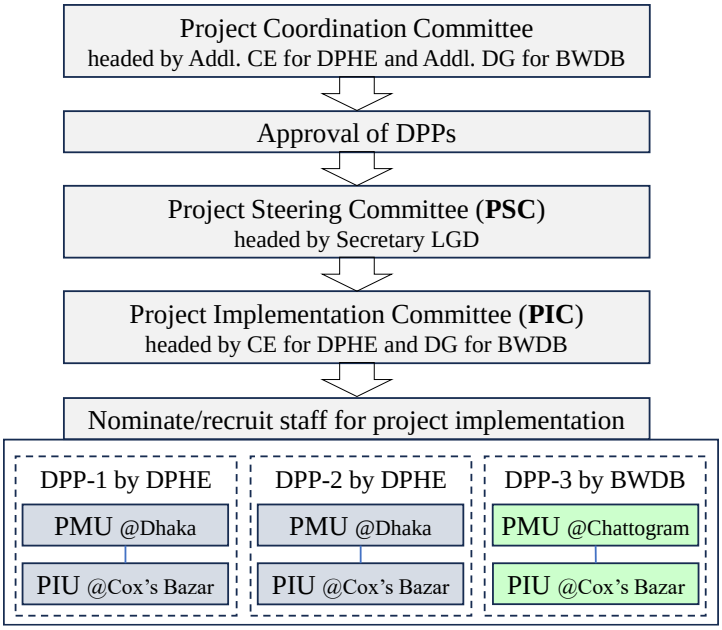
- The DPP-1 prepared by the DPHE on the land acquisition plan (LAP) and the resettlement action plan (RAP) as well as the environmental management plan (EMP) and the environmental monitoring plan (EMoP) for all the contract packages (CPs)*[4];
- The DPP-2 prepared by the DPHE for the construction of water treatment plant in the South

*1 This fact was confirmed in the separate meeting with the CWASA conducted beforehand.
*2 According to the Article 119 of the Local Government (Pourashava) Act, 2009, the Government may, from time to time, by standing order, coordinate the functions of municipalities and government departments. Thus, the DPHE is entitled to supply water and collect water tariff directly to/ from the residents, based on a standing order issued by the Government, despite the other provisions in the Act that designate municipalities as the responsible entity to supply water and collect tariff to/ from citizens. Nevertheless, the procedure to be taken for the DPHE to operate and maintain the waterworks and supply water to the pourashava or union (P/U) according to the discussion with the DPHE will be as follows: (a) the LGD receives the request from the P/U; (b) the DPHE starts negotiation with the P/U and draft an MoU; (c) the DPHE gets approval of the final draft of MoU from the LGD; (d) the DPHE concludes the MoU with the P/U; (e) the DPHE gets a special order from the LGD and starts the water supply service to the P/U.
*3 According to the confirmation with the DPHE.
*4 It was agreed among the mission team of JICA, the LGD and the MoWR in May 2024 that both EIA and RAP for all Project components will be handled by an agency nominated and supervised by the LGD (presumably the DPHE) regardless of the number of DPPs to be prepared.

Chattogram Region (SCRWTP) and transmission & distribution facilities (CP-2, 4, 5, 6, and 7); and

- The DPP-3 prepared by the BWDB for the construction of water intake, raw water reservoir, and conveyance & transmission facilities (CP-1 and 3).

The procedure of the organization setup for the implementation of the Project is shown in Figure 8.1.1 and the organizations to be sequentially established are described below.



Source: JICA Survey Team

Figure 8.1.1 Organization Setup for Project Implementation

- The Project Coordination Committee, organized in the DPHE on 7th July 2024 by the Office Order issued by the Chief Engineer of the DPHE, and to be established in the BWDB, is engaged in the coordination with related organizations and the preparation of the DPPs.
- After getting the approval of the DPPs, the Project Steering Committee (PSC) headed by the Secretary of the LGD will be established, to regularly monitor the implementation of all the contract packages from the CP-1 to 7.*[5]
- The Project Implementation Committee (PIC), headed by the CE for the DPHE and the DG for the BWDB, respectively, will be established for the internal coordination and monitoring of the

*[5] According to the "Guideline on the Formulation, Procedure, Approval, and Amendment of Project under Government Sector" issued by Planning Division, Ministry of Planning in June 2022, a PSC is headed by Senior Secretary/ Secretary of Sponsoring Ministry/ Department and consists of 13 members (plus others) including Head of Project Implementation Agency and Project Director. The TOR of a PSC is specified as follows: (1) Examine overall implementation progress (financial & physical) of the project and give necessary instructions to accelerate the implementation; (2) Give necessary instructions to overcome problems/ challenges during project implementation stage; (3) Minimum one meeting of the PSC will be held within 3 months; (4) During project implementation stage if the involvement of ministry/ department/ organization is necessary, then the appropriate representative of the ministry/ department/ organization concerned may be invited especially to the PSC meeting; and (5) The committee may co-opt the appropriate representative of any ministry/ department/ organization, if necessary.

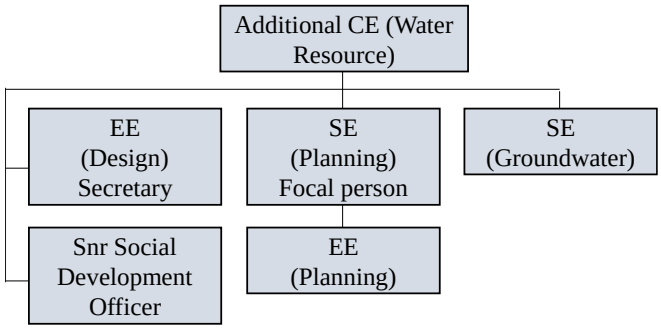
CP-2, 4, 5, 6, and 7 in the DPHE and the CP-1 and 3 in the BWDB.*[6]

- The PIC will officially recruit/ assign the members of the PMU in the HQs of the DPHE and in the South-Eastern Zone Office of the BWDB and the Project Implementation Unit (PIU) in the District Office of the DPHE and the Water Development Circle Office of the BWDB. The staff will be assigned as either the additional charge or the deputation/ project staff.

8.1.2 Project Coordination Committee

The project coordination committee (PCC) of the DPHE consists of the 6 members headed by the Additional Chief Engineer (Water Resource) as shown in Figure 8.1.2. According to the DPHE the TOR of this committee as below:

- Communicate and coordinate with LGD, DPHE, MoWR, BWDB, DOE, MIDI, and JICA Survey Team regarding project preparation.
- Provide information to LGD, DPHE, JICA or other relevant agencies.
- Review information and documents prepared for/ by the feasibility study (FS).
- Cooperate in environmental impact assessment (EIA) and the FS.
- Sit/ attend for meetings as and when required.
- Collect information to prepare an investment project.
- Prepare the DPP.

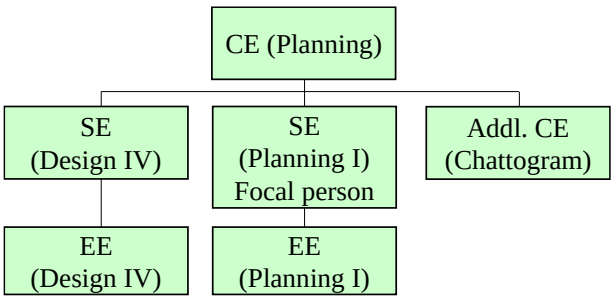


Source: JICA Survey Team based on the office order of DPHE

Figure 8.1.2 Project Coordination Committee Established in DPHE

Similarly, the PCC for the BWDB is proposed as shown in Figure 8.1.3.

*[6] According to the guideline mentioned above, a PIC is headed by Head of Project Implementing Agency or Chief of the Planning/ Development Wing of the Sponsoring Ministry/ Department and consists of 11 members (plus others) including Project Director. The TOR of a PIC is specified as follows: (1) Examine the component-wise progress (financial & physical) implementation of the project; (2) Give necessary instructions to overcome problems/ challenges during project implementation stage; (3) Minimum one meeting of the PIC will be held within 3 months; and (4) During project implementation stage if the involvement of ministry/ department/ organization is necessary, then the appropriate representative of the ministry/ department/organization concerned may be invited especially to the PIC meeting; and (5) The committee may co-opt the appropriate representative of any ministry/ department/ organization, if necessary.



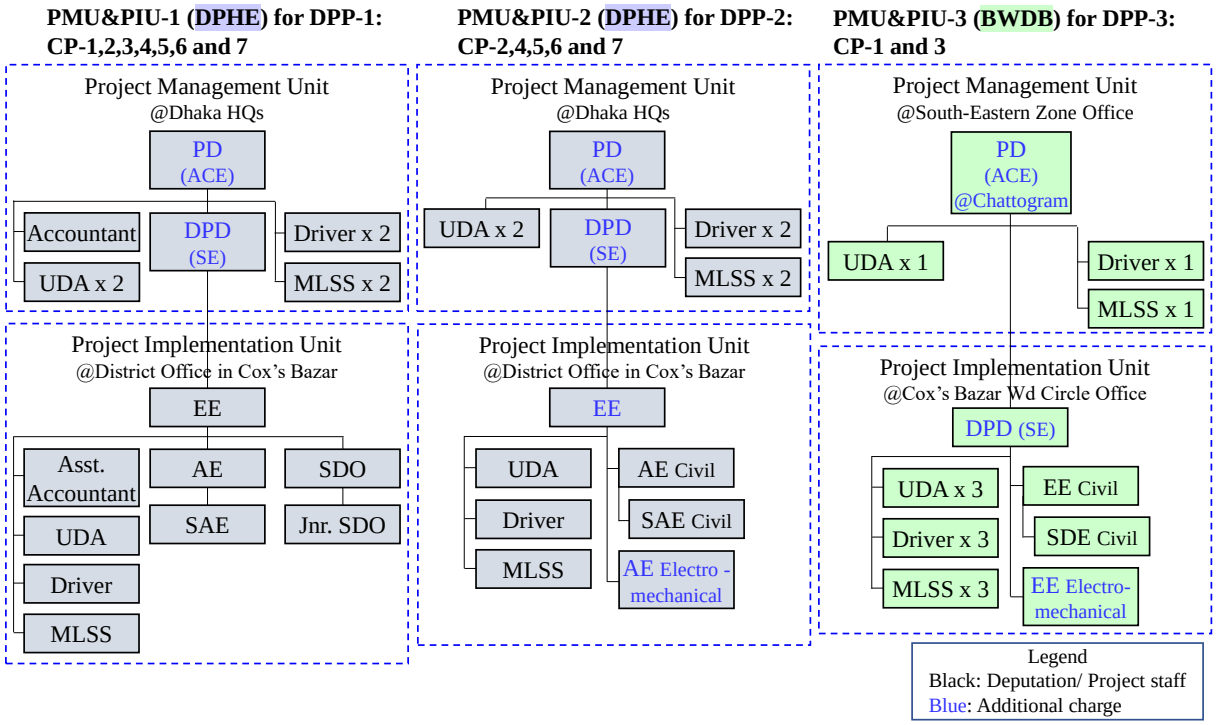
Source: JICA Survey Team

Figure 8.1.3 Proposed Project Coordination Committee for BWDB

8.1.3 Project Management Unit and Project Implementation Unit

(1) Detailed Design Stage

The organization structure of each PMU and PIU (the PMU-1 and PIU-1 for the DPP-1, the PMU-2 and PIU-2 for the DPP-2, and the PMU-3 and PIU-3 for the DPP-3) is proposed at the stage of detailed design (D/D) as shown in Figure 8.1.4 for the structure and Table 8.1.1 for the assigned number of staff. The total number of staff to be assigned to the PMU-1 and PIU-1, the PMU-2 and PIU-2, and the PMU-3 and PIU-3 will be 18, 15, and 17, respectively.



Note: PD: Project Director; DPD: Deputy Project Director; CE: Chief Engineer; ACE: Additional Chief Engineer; SE: Superintendent Engineer; EE: Executive Engineer; SDE: Sub-Divisional Engineer; AE: Assistant Engineer; SAE: Sub Assistant Engineer; SDO: Social Development Officer; Jnr.SDO: Junior Social Development Officer; UDA: Upper Divisional Assistant

Source: JICA Survey Team

Figure 8.1.4 Proposed Structure of PMU and PIU at Detailed Design Stage

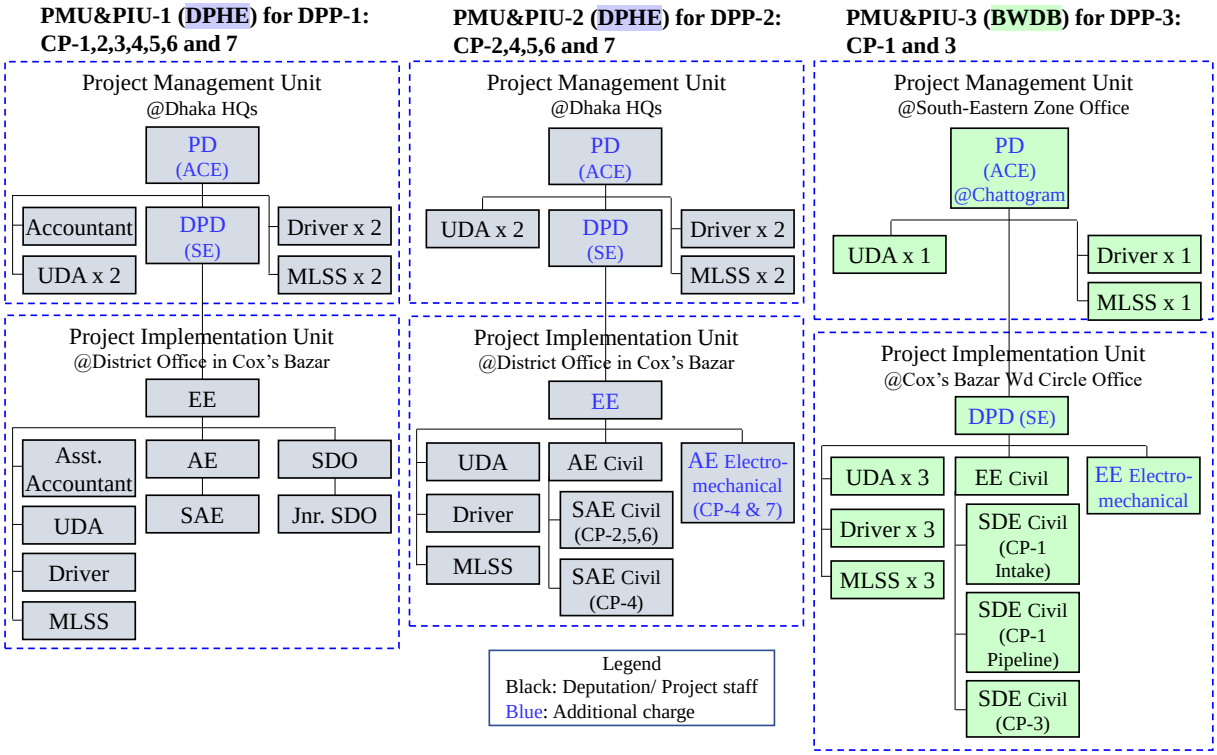
Table 8.1.1 Number of Staff Assigned to PMU and PIU at Detailed Design Stage

Category		Designation	Number to be Assigned			Note
			Total	Deputation/ Project staff	Additional charge	
DPP-1 (DPHE)	Project Management Unit (@Dhaka)	ACE (PD)	1	-	1	
		SE (DPD)	1	-	1	
		Accountant	1	1	-	
		UDA	2	2	-	Assigned for ACE and SE
		Driver	2	2	-	
		MLSS	2	2	-	
		Sum	9	7	2	
	Project Implementation Unit (@Cox's Bazar)	EE	1	1	-	
		AE	1	1	-	
		SAE	1	1	-	
		SDO	1	1	-	
		Jnr. SDO	1	1	-	
		Asst. Accountant	1	1	-	
		UDA	1	1	-	Assigned for EE
		Driver	1	1	-	
		MLSS	1	1	-	
		Sum	9	9	0	
	Sub-Total		18	16	2	
DPP-2 (DPHE)	Project Management Unit (@Dhaka)	ACE (PD)	1	-	1	
		SE (DPD)	1	-	1	
		UDA	2	2	-	Assigned for ACE and SE
		Driver	2	2	-	
		MLSS	2	2	-	
		Sum	8	6	2	
	Project Implementation Unit (@Cox's Bazar)	EE	1	-	1	
		AE	2	1	1	• Civil: 1 (deputation /project staff) • Electro-mechanical: 1 (additional charge)
		SAE	1	1	-	Civil
		UDA	1	1	-	Assigned for EE
		Driver	1	1	-	
		MLSS	1	1	-	
		Sum	7	5	2	
	Sub-Total		15	11	4	
DPHE Total			33	27	6	
DPP-3 (BWDB)	Project Management Unit (@Chattogram)	ACE (PD)	1	-	1	
		UDA	1	1	-	Assigned for ACE
		Driver	1	1	-	
		MLSS	1	1	-	
		Sum	4	3	1	
	Project Implementation Unit (@Cox's Bazar)	SE (DPD)	1	-	1	
		EE	2	1	1	• Civil: 1 (deputation) • Electro-mechanical: 1 (additional charge)
		SDE	1	1	-	Civil
		UDA	3	3	-	Assigned for SE and 2 EEs
		Driver	3	3	-	
		MLSS	3	3	-	
		Sum	13	11	2	
	Total		17	14	3	
Total (DPP-1+DPP-2+DPP-3)			50	41	9	

Source: JICA Survey Team

(2) Tendering Stage

The organization structure of each PMU and PIU proposed at the stage of tendering is shown in Figure 8.1.5 for the structure and Table 8.1.2 for the assigned number of staff. One SAE (civil) and two SDE (civil) will be added in the PIU-2 and PIU-3, respectively, and the total number of staff to be assigned to the PMU-1 and PIU-1, the PMU-2 and PIU-2, and the PMU-3 and PIU-3 will be 18, 16, and 19, respectively.



Source: JICA Survey Team

Figure 8.1.5 Proposed Structure of PMU and PIU at Tendering Stage

Table 8.1.2 Number of Staff Assigned to PMU and PIU at Tendering Stage

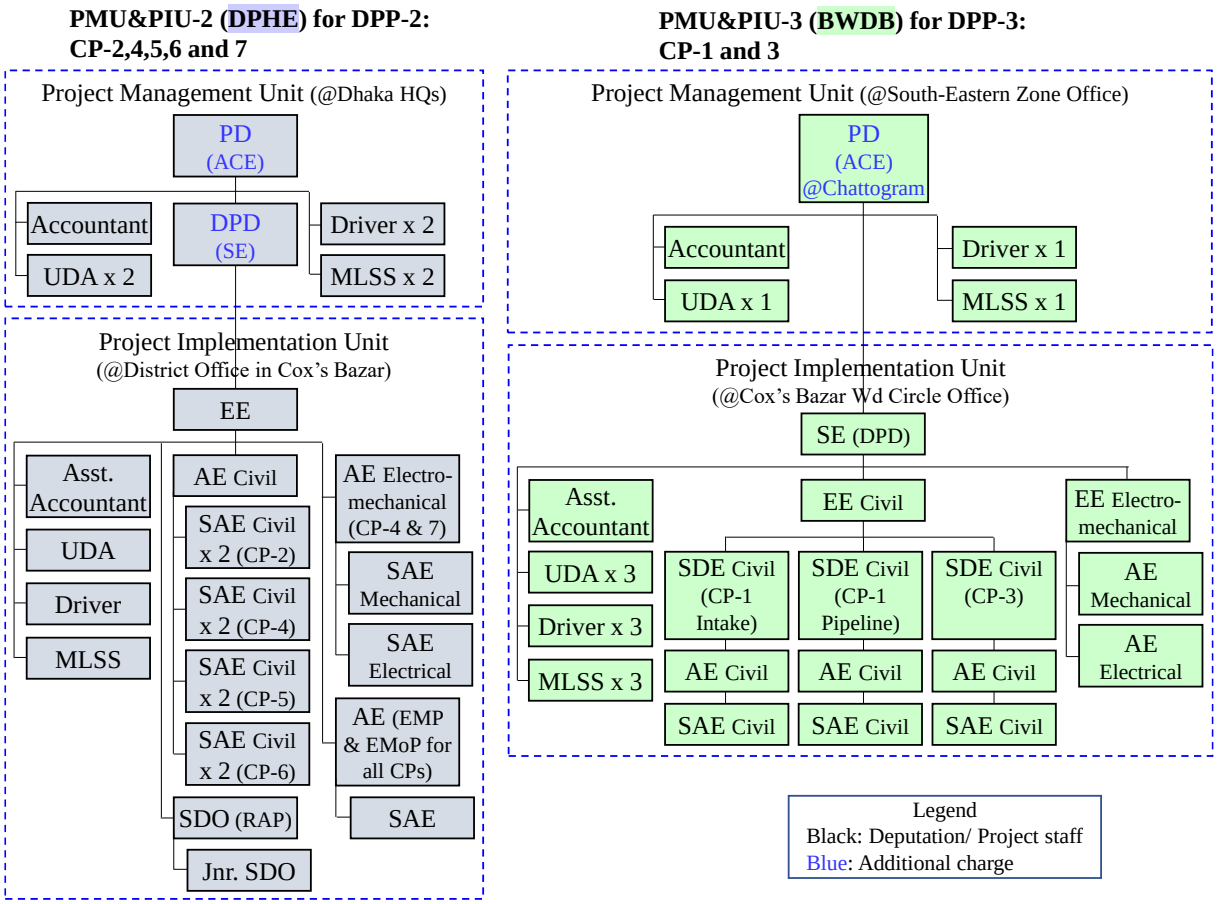
Category		Designation	Number to be Assigned			Note
			Total	Deputation/ Project staff	Additional charge	
DPP-1 (DPHE)	Project Management Unit (@Dhaka)	ACE (PD)	1	-	1	
		SE (DPD)	1	-	1	
		Accountant	1	1	-	
		UDA	2	2	-	Assigned for ACE and SE
		Driver	2	2	-	
		MLSS	2	2	-	
		Sum	9	7	2	
	Project Implementation Unit (@Cox's Bazar)	EE	1	1	-	
		AE	1	1	-	
		SAE	1	1	-	
		SDO	1	1	-	
		Jnr. SDO	1	1	-	
		Asst. Accountant	1	1	-	
		UDA	1	1	-	Assigned for EE
		Driver	1	1	-	

Category		Designation	Number to be Assigned			Note
			Total	Deputation/ Project staff	Additional charge	
		MLSS	1	1	-	
		Sum	9	9	0	
	Sub-Total		18	16	2	
DPP-2 (DPHE)	Project Management Unit (@Dhaka)	ACE (PD)	1	-	1	
		SE (DPD)	1	-	1	
		UDA	2	2	-	Assigned for ACE and SE
		Driver	2	2	-	
		MLSS	2	2	-	
		Sum	8	6	2	
	Project Implementation Unit (@Cox's Bazar)	EE	1	-	1	
		AE	2	1	1	• Civil: 1 (deputation /project staff) • Electro-mechanical: 1 (additional charge)
		SAE	2	2	-	Civil
		UDA	1	1	-	Assigned for EE
		Driver	1	1	-	
		MLSS	1	1	-	
		Sum	8	6	2	
	Sub-Total		16	12	4	
DPHE Total			34	28	6	
DPP-3 (BWDB)	Project Management Unit (@Chattogram)	ACE (PD)	1	-	1	
		UDA	1	1	-	Assigned for ACE
		Driver	1	1	-	
		MLSS	1	1	-	
		Sum	4	3	1	
	Project Implementation Unit (@Cox's Bazar)	SE (DPD)	1	-	1	
		EE	2	1	1	• Civil: 1 (deputation) • Electro-mechanical: 1 (additional charge)
		SDE	3	3	-	• Civil: 1 for CP-1 (intake) • Civil: 1 for CP-1 (pipeline) • Civil: 1 for CP-3 (raw water reservoir)
		UDA	3	3	-	Assigned for SE and 2 EEs
		Driver	3	3	-	
		MLSS	3	3	-	
		Sum	15	13	2	
	Total		19	16	3	
Total (DPP-1+DPP-2+DPP-3)			53	44	9	

Source: JICA Survey Team

(3) Construction Stage

The organization structure of each PMU and PIU at the stage of construction is proposed in Figure 8.1.6 for the structure and Table 8.1.3 for the assigned number of staff. At the construction stage, the PMU-1 and PIU-1 will be dissolved and the remaining follow-up and monitoring work regarding the RAP, EMP, and EMoP for all the project components will be taken over to the PMU-2 and PIU-2. The total number of staff to be assigned to the PMU-2 and PIU-2 and the PMU-3 and PIU-3 will be increased to 30 and 29, respectively.



Source: JICA Survey Team

Figure 8.1.6 Proposed PMU and PIU Structure at Construction Stage

Table 8.1.3 Number of Staff Assigned to PMU and PIU at Construction Stage

Category		Designation	Number to be Assigned			Note
			Total	Deputation/ Project staff	Additional charge	
DPP-2 (DPHE)	Project Management Unit (@Dhaka)	ACE (PD)	1	-	1	
		SE (DPD)	1	-	1	
		Accountant	1	1	-	
		UDA	2	2	-	Assigned for ACE and SE
		Driver	2	2	-	
		MLSS	2	2	-	
		Sum	9	7	2	
	Project Implementation Unit (@Cox's Bazar)	EE	1	1	-	
		AE	3	3	-	• Civil: 1 • Electro-mechanical: 1 • Environmental: 1 to monitor EMP and EMoP for all CPs
		SAE	11	11	-	• Civil: 2 for CP-2; 2 for CP-4; 2 for CP-5; 2 for CP-6; and 1 for EMP and EMoP • Mechanical: 1 for CP-4 and 7 • Electrical: 1 for CP-4 and 7

Category		Designation	Number to be Assigned			Note
			Total	Deputation/ Project staff	Additional charge	
		SDO	1	1	-	Monitoring and following up RAP for all CPs
		Jnr. SDO	1	1	-	
		Asst. Accountant	1	1	-	
		UDA	1	1	-	Assigned for EE
		Driver	1	1	-	
		MLSS	1	1	-	
		Sum	21	21	0	
	Total		30	28	2	
DPP-3 (BWDB)	Project Management Unit (@Chattogram)	ACE (PD)	1	-	1	
		Accountant	1	1	-	
		UDA	1	1	-	Assigned for ACE
		Driver	1	1	-	
		MLSS	1	1	-	
		Sum	5	4	1	
	Project Implementation Unit (@Cox's Bazar)	SE (DPD)	1	1	-	
		EE	2	2	-	Civil: 1, Electro-mechanical: 1
		SDE	3	3	-	Civil: 1 for CP-1 intake; 1 for CP-1 pipeline; 1 for CP-3
		AE	5	5	-	• Civil: 1 for CP-1 intake; 1 for CP-1 pipeline; 1 for CP-3 • Mechanical: 1 and Electrical:1
		SAE	3	3	-	Civil
		Asst. Accountant	1	1	-	
		UDA	3	3	-	Assigned for SE and 2 EEs
		Driver	3	3	-	
		MLSS	3	3	-	
		Sum	24	24	0	
	Total		29	28	1	
Total (DPP-2+DPP-3)			59	56	3	

Source: JICA Survey Team

(4) Key Tasks of PMUs and PIUs

The key tasks of PMUs and PIUs are shown in Table 8.1.4.

Table 8.1.4 Key Tasks of PMUs and PIUs

PMU/PIU	Task
PMU-1	[Detailed design and tendering stage] • Review the EMP and EMoP as specified in the EIA when preparing the bidding documents. • Interact and coordinate the land use permission/transfer. • Coordinate the RAP implementation activities with the PIU. • Appoint RAP implementing agency (IA). • Approve the time-bound plans prepared by the RAP IA. • Monitor the progress on resettlement and rehabilitation (R&R) and land acquisition. • Review monthly progress reports and submit to JICA. • Guide the RAP IA and the consultant on policy-related issues during the implementation. • Ensure timely release of fund for R&R activities.
PIU-1	[Detailed design and tendering stage] • Implement the EMP and EMoP. • Review the time-bound plans prepared by RAP IA. • Implement the R&R and land acquisition activities.

PMU/PIU	Task
	• Interact and coordinate with District Commissioner Office to facilitate land acquisition. • Establish grievance redress mechanism including the formation of grievance redress committee. • Ensure that the project affected persons (PAPs) are fully aware of the grievance redress procedure and the process of bringing their complaints. • Investigate the veracity of the complaints and take actions/measures to settle them before they go to the redress committee or the courts. • Prepare monthly progress reports and submit to the PMU.
PMU-2 and -3	[Detailed design stage] • Approve the bill of quantities (BOQ), tender documents and their evaluation to procure the consultant. • Oversee the progress of, give technical consultations/ instructions to, and ensure the quality of the detailed design work implemented by the consultant. • Review and approve the deliverables prepared by the consultant, including tender drawings, detailed construction plans and cost estimates, technical calculations to determine engineering details for the contract packages, and contract documentation to include detailed specifications, BOQ, and implementation schedule for the contract packages. • Make decisions on all key issues of the responsible project components. • Review the reports submitted by the PIU and give needed directions for the timely fixing of identified problems in the Project. [Tendering stage] • Review and approve BOQ documents together with all relevant specifications, drawings, and other documents. • Review and approve tender documents including pre-qualification (PQ) documents drafted by the consultant to procure contractors. • Evaluate submitted PQ with the assistance of the consultant. • Issue bid invitation and organize and chair pre-bid conferences. • Review, approve, and issue addendum/ corrigendum to bid documents and clarifications to bidders' queries drafted by the consultant. • Oversee and approve the evaluation of submitted tenders. • Organize contract negotiation and review and finalize the contract with the selected contractors. [Construction stage] • Review and approve the work plan prepared by the contractors and the consultant for the responsible project components. • Review and approve planning, engineering, and monitoring aspects of the responsible project components. • Make decisions on all key issues of the responsible project components. • Review the reports submitted by the PIU and give the necessary directions for the timely fixation of identified problems in the project. • Liaise/ keep communication with the contractors and the consultant. • Liaise with appropriate authorities to ensure that all the affected utility services are promptly relocated. • Keep control of the expenditure in conformity with the approved programs and budget. • Review the payment certificates such as interim payment certificates and final payment certificates submitted by the PIU. • Consult with JICA on the disbursement issue and request the government to release the fund from the Treasury. • Maintain the records and files relevant to foreign exchange disbursement.
PIU-2 and -3	[Detailed design stage] • Organize the preparation of BOQ and tender documents to procure the consultant. • Provide the consultant with all available data and information including the one collected in the JICA preparatory survey for the project. • Participate in the meetings and field inspections with the consultant on engineering matters. [Tendering stage] • Conduct primary review of BOQ documents together with all relevant specifications, drawings, and other documents; and of tender documents including PQ documents drafted by the consultant.

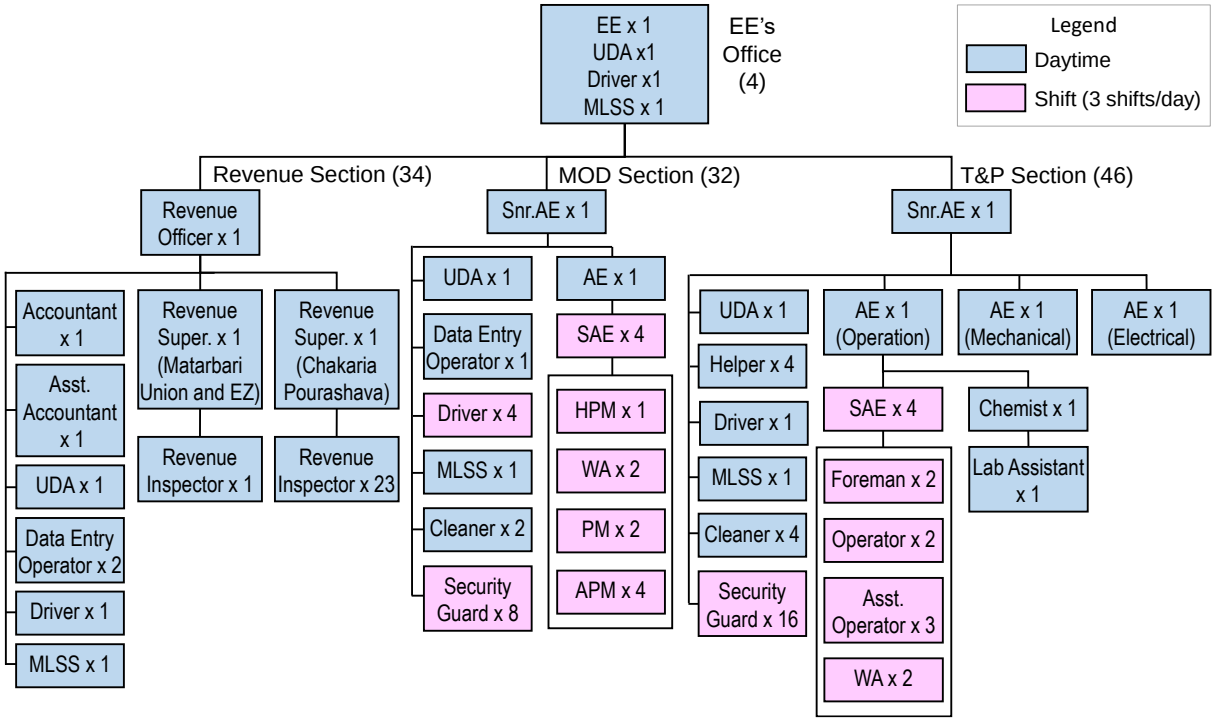
PMU/PIU	Task
	• Take care of the logistics for pre-bid conferences. • Conduct primary review of addendum/ corrigendum to bid documents and clarifications to bidders' queries drafted by the consultant. • Participate in the evaluation of submitted tenders. [Construction stage] • Review the work plan submitted by the contractors and the consultant which include the work progress plan, work program, material sources, method statements, manpower and equipment deployment, EMP and EMoP. • Participate in key meetings with the contractors and the consultant on the progress and engineering matters. • Approve the contractors' working/ shop drawings and if necessary, give instructions to the contractors to issue further drawings. • Visit the project sites and inspect field activities as per needed to maintain the progress, issue variation orders if needed, give directions on appropriate corrective measures, and ensure the completion in conformity with the plans. • Ensure that the quality control systems are adhered to, and the health and safety procedures are complied with by the consultant and the contractors. • Monitor project activities conducted by the contractors in accordance with JICA guidelines on environmental and social considerations and receive and review the reports submitted by the contractors. • Coordinate the work among the contractors when needed. • Draft payment certificates such as interim payment certificates and final payment certificates and submit them to the PMU. • Keep communicating with local stakeholders and timely disclose necessary information related to environmental and social considerations of the project. • Inspect the constructed works and issue certificates such as taking-over certificate, performance certificate as specified in the contract. • Inspect the operation status of completed works during the defects liability period if any defects are noted and instruct the contractors to rectify. • Arrange necessary maintenance if any damage other than defects are identified during the defects liability period. • Review the reports prepared and submitted by the consultant and the contractors. • Regularly/ timely prepare the reports of the progress and emergency events that happened in the responsible project components and submit them to PD/DPD.

Source: JICA Survey Team

8.2 Operation and Maintenance System

8.2.1 Organization Structure of DPHE for Operation and Maintenance of Waterworks

Assuming the DPHE as the managing entity of the waterworks to be constructed in the Project, the organization structure of the DPHE for the O&M of the waterworks and the billing and collection of water tariff is proposed as shown in Figure 8.2.1. The DPHE is planning to establish a new division "Moheshkhali and Matarbari Division" for this purpose under the Cox's Bazar District Office in the Chattogram Circle of the DPHE, which consists of 3 sections, namely the Revenue Section, the Maintenance, Operation, and Distribution (MOD) Section, and the Treatment and Production (T&P) Section. The key tasks of these sections are shown in Table 8.2.1.



Source: JICA Survey Team

Figure 8.2.1 Proposed Organogram of Moheshkhali and Matarbari Division of DPHE

Table 8.2.1 Key Tasks of Each Section of Moheshkhali and Matarbari Division

Section	Key Task
Revenue	• Maintain and update customer account information and records. • Add new accounts into the billing system. • Note and report changes in user category. • Visit customers' holdings, read meters, and maintain meter reading books. • Record consumption data and enter the data into the billing system. • Visit customers' holdings, deliver the bills, and request/ receive payments. • Enter the data of delivered bills into the billing system. • Deposit received cash and checks to the bank. • Record payments and adjust customer accounts. • Issue official notices to customers who have arrears. • Collect connection fee, security deposit, and other fees. • Receive customers' requests and complaints and manage them if they are related to meter reading and billing. • Report to MOD Section any problems with house connections, e.g., illegal connections, water leakage, and empty houses and water meters, e.g., malfunctioning, hard-to-read, and tampering. • Receive customers' requests and complaints and report them to MOD Section if they are technical issues.
MOD	[Connection] • Prepare customer information documents regarding connection. • Process applications for new connections. • Check connection feasibility. • Investigate when the customers apply for connection (e.g., checking the ownership of land and road and the land documents and the address). • Visit the site to check the diameter of mainline and the user category of connection and to measure the road cutting. • Provide connections with the new customers. • Test sample meter before purchasing.

Section	Key Task
	• Install a new meter. • Ensure the appropriate user category is applied. • Monitor the progress and follow up the new connection if necessary. • Convert illegal connections to legal customers. • Send the completion report to the Revenue Section. [O&M of pipelines] • Operate and maintain water transmission mains, primary/ secondary/ tertiary distribution mains, valves and bulk water meters, and customer connections. • Procure spare materials and consumer meters. • Procure and manage system maintenance contractors. • Maintain and update O&M manuals and SOPs. • Keep maintenance records. • Ensure the equitable distribution of water. • Responding to emergency events. • Monitor and reduce NRW, such as flow measurement, investigation of service connection, and leak detection. • Surveillance of supply condition and water quality test sampling along/ at the end of distribution network. • Replace faulty meters. • Remove/ replace meters for testing in response to requests from customers. • Disconnect/ reconnect with customers. Compile and record in GIS as-built data of installed pipes and meters.
T&P	[Management Office in WTP] • Keep records that maintain a log of plant operations, test results, maintenance work performed and failure or unusual operating conditions. • Analyze the data of O&M. • Regularly prepare reports covering all management aspects of the plant. • Develop the scheduling of operation staff to ensure adequate coverage of shifts. • Conduct regular site safety inspections. • Instruct trainees and new operators. • Conduct tours for individuals or groups, as requested. • Order operating supplies and chemicals as needed. • Perform routine housekeeping chores inside and outside facilities. • Guard the facility, check the gate passes and the transport going inside and outside. [Control Room in WTP] • Monitor and control the facilities through the panel board of SCADA system. • Direct the operation of all the plants necessary to treat and regulate the flow of water through the plant. • Keep records and prepare reports of the plant operation and submit them to the Management Office. • Make periodic site inspections. [Laboratory in WTP] • Take samples regularly for water quality analysis. • Perform laboratory tests to determine the plant process performance and compliance with water quality regulations. • Maintain laboratory equipment in clean, orderly, and workable condition. • Keep records and make written reports of work performed. [Raw Water Intake] • Make equipment adjustments, lubrications and minor repairs. • Participate in major plant repairs. • Maintain equipment and facilities in a clean and orderly condition. • Regularly remove debris and sediments from screens and intake channels and clean bushes and weeds. • Keep records and make written reports of work performed.

Section	Key Task
	[O&M of Raw Water Reservoir] • Check the embankment of raw water intake and repair if any crack or leakage. • Dredge the sediment of the reservoir and remove and clean weeds and bushes. [O&M of WTP] • Plan, operate and supervise the backwash of filters and supplement of filtering sand. • Wash and clean the channels of clarifier tank. • Assist the safe unloading and storage of chemicals. • Carry and put chemicals from storage container to feeders. • Compute chemical doses and adjust chemical feeders. • Control and monitor the mixture process of chemicals. • Check and ensure no leakage of Chlorine. • Inspect, test, repair, install, and troubleshoot equipment and electrical devices for proper operation, control, and safety. • Determine needed repairs or modifications of mechanical/ electrical equipment. • Check regularly the inventory of chemicals used during the operation and report it to the Management Office. • Maintain facilities and equipment in a clean, orderly, and workable condition. • Remove silt and sediment from flocculator, chemical mixing tanks, etc. and clean bushes and weeds. • Keep records and make written reports of work performed. [O&M of Raw Water Pumping Station and Transmission Pumping Station] • Operate pumps. • Monitor the panel board showing the operation status of pumps. • Make equipment adjustments, lubrications, and minor repairs. • Maintain pumps and equipment in a clean and orderly condition. • Keep records and make written reports of work performed.

Source: JICA Survey Team

The proposed number of personnel to be assigned according to designation and daytime/shift assignment is shown Table 8.2.2. The EE's Office, the Revenue Section, the MOD Section, and the T&P Section will have 3, 31, 33, and 49 personnel, respectively, with the total number of 116 staff.

Table 8.2.2 Number of Assigned Personnel as per Designation and Daytime/Shift Assignment

Designation	Daytime	Shift	Sum
Executive Engineer (EE)	1	-	1
Senior Assistant Engineer (Snr.AE)	2	-	2
Assistant Engineer (AE)	4	-	4
Sub-Assistant Engineer (SAE)	-	8	8
Revenue Officer	1	-	1
Revenue Superintendent (Revenue Super.)	2	-	2
Revenue Inspector	24	-	24
Accountant	1	-	1
Assistant Accountant	1	-	1
Upper Divisional Assistant (UDA)	4	-	4
Data Entry Operator	3	-	3
Foreman	-	2	2
Operator	-	2	2
Assistant Operator (Asst. Operator)	-	3	3
Work Assistant. (WA)	-	4	4
Head Plumbing Mechanic (HPM)	-	1	1
Plumbing Mechanic (PM)	-	2	2
Assistant Plumbing Mechanic (APM)	-	4	4

Designation	Daytime	Shift	Sum
Chemist	1	-	1
Lab Assistant	1	-	1
Driver	3	4	7
Helper	4	-	4
Security Guard	-	24	24
Cleaner	6	-	6
MLSS	4	-	4
Sum	62	54	116

Source: JICA Survey Team

The number of staff is calculated as follows:

(1) Revenue Section

- Piped water supply to each household is assumed in the Chakaria Pourashava, while in the Matarbari Union water supply through public taps is assumed.
- A Revenue Inspector in charge of meter reading and bill delivery and collection is assumed to handle 1,200 connections*[7] per month. Since the planned number of water connections in the Chakaria Pourashava, the Matarbari Union, and the Moheshkhali EZ is 26,615, 243, and 5, respectively, the necessary number of Revenue Inspector is calculated as 23 (26,615/1,200) for the Chakaria Pourashava, while for the Matarbari Union and the Moheshkhali EZ one Revenue Inspector will be assigned.
- The collected tariff is processed in the divisional account of the Moheshkhali and Matarbari Division. Thus, one Accountant and one Assistant Accountant will be assigned for budget preparation, daily accounting, and preparation of financial reports.

(2) MOD Section

- 24/7 attendance through 3 shifts' operation with 3 persons per each shift team (total 13 personnel including reserved staff is assumed for the maintenance of transmission/ distribution pipelines, headed by a SAE and consisted of 2 plumbers in each team (Head Plumbing Mechanic, Plumbing Mechanic, Assistant Plumbing Mechanic, and Work Assistant).

(3) T&P Section

- 24/7 attendance through 3 shifts' operation with 3 persons per each shift team (total 13 personnel including reserved staff) is assumed, for the operation and supervision of water intake, raw water pumps, raw water reservoir, water treatment plant, and transmission pumps, headed by one SAE and consisted of 2 operators. The operation and supervision of water intake and raw water pumps are assumed to be done remotely through SCADA from the operation room of WTP.
- Two AEs are assigned for the maintenance and repair of machinery and mechanical equipment and electrical equipment.
- Two personnels (one Chemist and one Laboratory Assistant) are assigned for water quality testing.

*[7] This number 1,200 is agreed to be feasible in a meeting with CWASA. Since the population density in the living area of Chakaria Pourashava is as high as in CWASA's jurisdictional area, this number is also considered to be feasible.

(4) Tasks to be Outsourced

Referring to the current practice in CWASA, the following tasks are assumed to be outsourced.

- Maintenance and repair of butterfly valves, non-return valves, and motorized valves.
- Maintenance of chemical dosing pumps, submerged scrapers, and chlorine feeding system.
- Maintenance and repair of electrical equipment (including diesel generators).
- Removal of silt and sediment from intake channel, flocculator, clarifier, chemical mixing tanks, etc. and cleaning of bushes and weeds.
- Dredging of the riverbed of the Matamuhuri River in front of water intake, which is assumed to be conducted by the BWDB by means of deposit work from DPHE*[8].

8.2.2 Measures to Reduce Number of DPHE Personnel

The measures shown in Table 8.2.3 are proposed to reduce the number of DPHE personnel to be assigned to the O&M of waterworks and the management of water supply service.

Table 8.2.3 Measures to Reduce Assigned Staff of DPHE

Section	Item	Number of people to be reduced
Revenue	• Introduction of smart meter and automatic meter reading and billing system.	• 24 Revenue Inspector • 2 Revenue Superintendent • 2 Data Entry Operator (Increase: 1 Computer Operator)
MOD	• Outsourcing of the following works: Security guards in MOD/ Revenue Office Building.	• 8 Security Guard
T&P	• Outsourcing of the following works: security guards in intake & raw water pumping station and WTP & transmission pumping station. • Recruitment of 1 AE (Mechanical&Electrical) in place of 1 AE (Mechanical) and 1 AE (Electrical). • Lessened frequency of cleaning.	• 24 Security Guard • 1 Assistant Engineer • 2 Cleaner • 3 Helper

Source: JICA Survey Team

Regarding the introduction of smart meter mentioned in Table 8.2.3, the DPHE has expressed its preference to prepaid water meters (PPWM) which will contribute more to increasing the bill collection rate. The following points should be considered in case of introducing PPWM for the maximum performance, convenience, and benefits:

- Replace the battery inside the PPWM in-time before its expiry, which is usually less than 10 years.
- Select the most suitable type of meters, e.g., velocity, volumetric, and ultrasonic, considering the water supply condition.
- Prepare and distribute to customers the credit and data transfer device (token).
- Secure vending stations and announce to the customers.
- Develop the hardware, software and interface to charge the token.

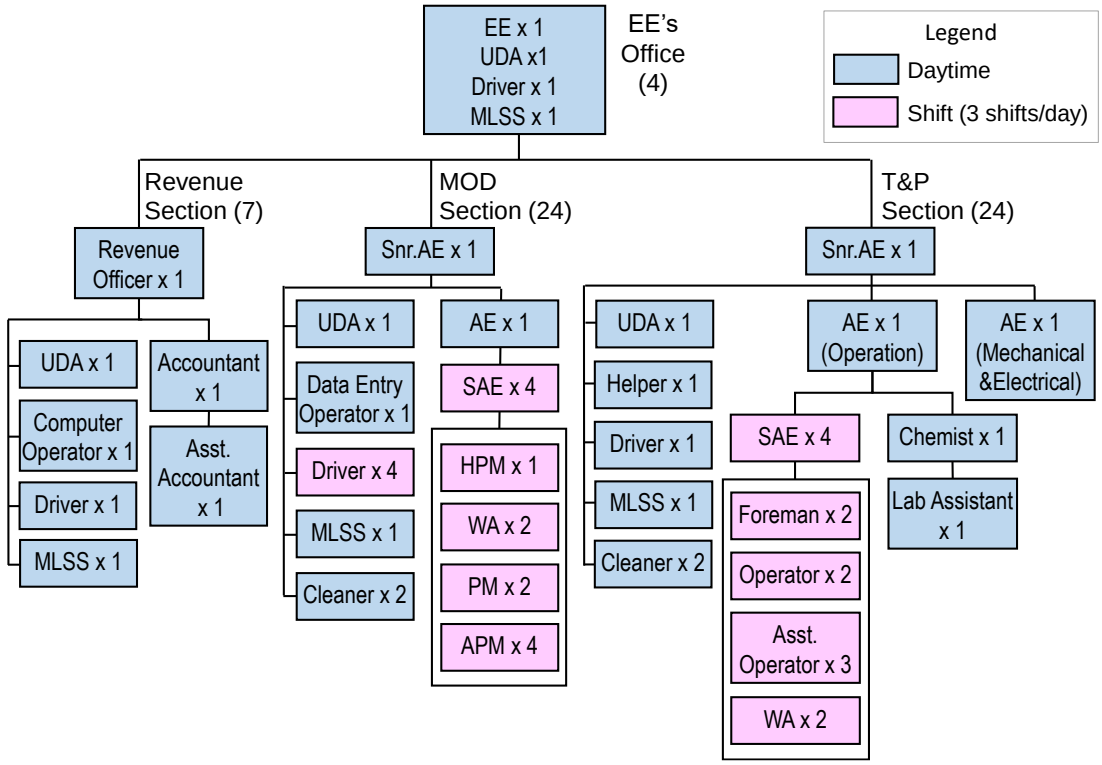
*[8] Deposit work means a transfer of budget from one ministry to another, if the transfer of the budget to and the implementation of the work by another ministry will increase the efficiency.

- Integrate PPWM system (database of each customer's consumption and money transaction) with accounting software if any.
- Make the provider of PPWM give trainings to (a) plumbers in charge of installation, commissioning, maintenance and testing of the equipment; (b) administrative personnel for the software application and vending environment; and (c) database and application personnel for assistance and maintenance of the back office (these (b) and (c) will be managed by UDAs in the Revenue Section of the MIDI Water Supply and O&M Division).

Considering the measures listed in Table 8.2.3, the reduced staffing of the Moheshkhali and Matarbari Division is proposed to be 59 in total number as shown in Figure 8.2.2 and Table 8.2.4, of which the EE's Office, the Revenue Section, the MOD Section, and the T&P Section will have 4, 7, 24, and 24 personnel, respectively.

Among these 59 staff, 55 personnel except 4 officers (1 EE, 2 Snr. AE, and 1 Revenue Officer) should be newly recruited because there are no corresponding designations in the DPHE that can exercise needed expertise or there is a lack of extra personnel. The normal recruitment procedure in governmental agencies is as follows, and in recent CWASA's case it takes more than 2 years.

- Revision of the Organogram and the Employees Service Regulations of DPHE/ LGD (Probidhanmala in Bengali) and its approval by the Minister to include new designations and to define their grade, age limit for direct appointment, recruitment system, and qualification.
- Vacancy announcement through newspapers and other media.
- Evaluation of submitted application forms followed by paper exam and viva voce exam.



Source: JICA Survey Team

Figure 8.2.2 Reduced Staffing in Moheshkhali and Matarbari Division of DPHE

Table 8.2.4 Reduced Staffing according to Designation and Daytime/Shift Assignment

Designation	Daytime	Shift	Sum
Executive Engineer (EE)	1	-	1
Senior Assistant Engineer (Snr.AE)	2	-	2
Assistant Engineer (AE)	3	-	3
Sub-Assistant Engineer (SAE)	-	8	8
Revenue Officer	1	-	1
Accountant	1	-	1
Assistant Accountant	1	-	1
Computer Operator	1	-	1
Upper Divisional Assistant (UDA)	4	-	4
Data Entry Operator	1	-	1
Foreman	-	2	2
Operator	-	2	2
Assistant Operator (Asst. Operator)	-	3	3
Work Assistant. (WA)	-	4	4
Head Plumbing Mechanic (HPM)	-	1	1
Plumbing Mechanic (PM)	-	2	2
Assistant Plumbing Mechanic (APM)	-	4	4
Chemist	1	-	1
Lab Assistant	1	-	1
Driver	3	4	7
Helper	1	-	1
Cleaner	4	-	4
MLSS	4	-	4
Sum	29	30	59

Source: JICA Survey Team

8.2.3 Options of Operation and Maintenance System (not applicable for the Project)

JICA Survey Team has received a positive response from of an officer of DPHE regarding the DPHE's own implementation of the O&M of the facilities to be developed under the project, including fee collection. However, it could be difficult for the DPHE to acquire sufficient organizational capacity for the operation of urban water supply projects during the period of water supply facility development, which is about several years, even if the capacity strengthening support measures described are taken. In view of this, the possibility of outsourcing through the concession method and O&M outsourcing was examined and shown as results of the examination. The following options are not applied for the Project since there is no private company which will be able to participate in the concession for EZ at present and DPHE plans to conduct O&M of the Project as a water supply entity based on LGD’s policy as of August 2024.

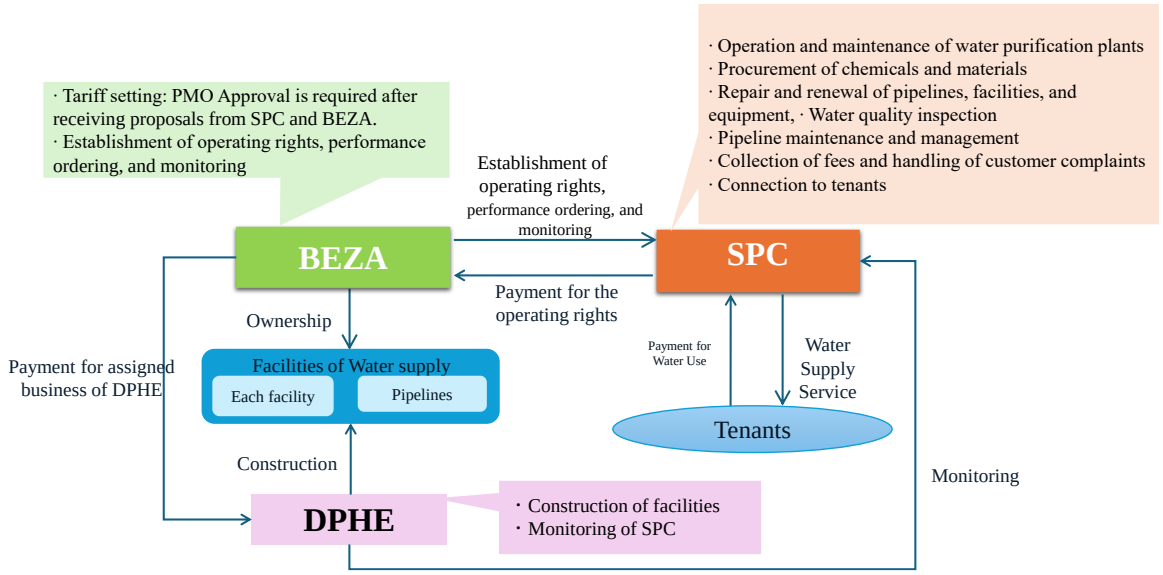
(1) Discussed O&M Structure for Moheshkhali EZ (Concession Method)

- The concession method is a PFI project method in which the public entity retains the ownership of a public facility for which it collects user fees, while the right to operate the facility is assigned to a private operator.
- Special Purpose Company (SPC) will be responsible for the O&M, including toll collection, and repair and replacement of pipelines, facilities, and equipment, DPHE will initially construct the

facility and monitor the work of the SPC.

- BEZA sets water tariffs, establishes operating rights, places performance orders, and conducts monitoring. DPHE receives payment from BEZA for its services. SPC pays BEZA for its operating rights.
- For concessions, the term of the contract is 25-35 years. It is prerequisite for the concession that there are companies interested in it. There is no interested company as of August 2024.

Discussed O&M Structure for Moheshkhali EZ (Concession Method) is shown in Figure 8.2.3.



Source: JICA Survey Team

Figure 8.2.3 Discussed O&M and management structure for Moheshkhali EZ

- Advantages: Stable and flexible operation of a private company, high quality service delivery, and reduced number of DPHE staff.
- Disadvantages: High cost of SPC financing and expensive tariff due to the profit motive are required. BEZA has experience in coordinating Public Private Partnership (PPP) contracts, but DPHE does not have experience in PPP contracts and needs staff and technology to handle the contract, including monitoring. The PPP Authority (PPPA) should go through the following process if a PPP is to be implemented. If the project is not selected through this screening process, it cannot proceed under PPP.[9]

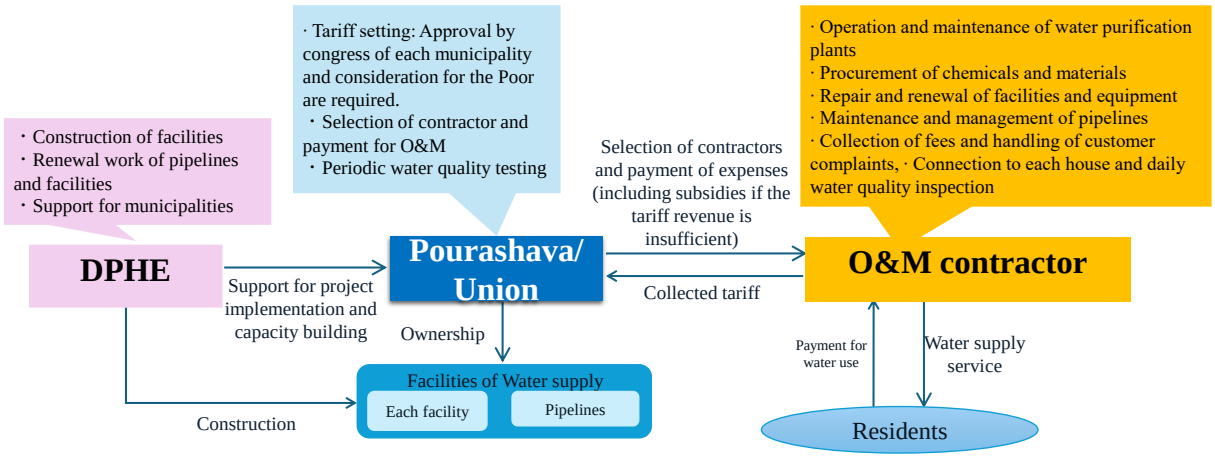
(2) Discussed O&M structure of Chakaria Pourashava and Matarbari Union (O&M to be outsourced to private sector)

- The O&M contractor will be responsible for O&M, including toll collection, while DPHE will be responsible for construction of the facility, pipeline and facility upgrades, and municipal support.
- The municipality sets tariffs, selects an O&M contractor, pays fees, and conducts periodic water

[9] Source: PPPA (2018) "Procurement Guidelines for PPP Projects."[10] Temporary revenue staff means the project staff turned into the revenue staff (i.e., staff of which salary is dispensed from revenue budget) temporarily for 3 years before turning into permanent revenue staff.

quality testing.

Discussed O&M structure for Chakaria Pourashava and Matarbari Union is shown in Figure 8.2.4.



Source: JICA Survey Team

Reference: Project Appraisal Document on a Proposed Credit in the Amount of SDR 72.20 million to the People's Republic of Bangladesh for a Bangladesh Municipal Water Supply and Sanitation Project., 2019, The World Bank

Figure 8.2.4 Discussed O&M structure for Chakaria Pourashava and Matarbari Union

- Advantages: DPHE staff can be retained. DPHE already has experience in assisting municipalities in the World Bank's "A Bangladesh Municipal Water Supply and Sanitation Project (BMWSSP)" by contracting out O&M services (see guidelines below). DPHE has "Municipal Water Supply Management Guideline (2023)" about O&M services which include tariff setting, payment of the tariff, setting of an independent department of municipalities and other O&M related items.
- Disadvantages: Although vendor selection and payment of costs are required, we believe there are virtually no disadvantages.

8.3 Capacity Assessment of DPHE and Capacity Development Roadmap

8.3.1 Capacity Assessment of DPHE

Currently the DPHE has 7,052 staff approved in the DPHE's organogram as of June 2021 as shown in Table 8.3.1, and 5,081 staff (72% of the approved staff) are currently assigned. From the viewpoint of implementing the O&M of waterworks and providing water supply service, the designations shown in Table 8.3.2 (also hatched in **gray** in Table 8.3.1) are lacking or their existing number of assigned staff is to be increased, and the creation of such lacking designations and the recruitment of necessary personnel are needed.

The designations of employees in Bangladeshi governmental organizations are split into specialized fields and skills, and thus if such designations in charge of plumbing and operation of WTP are lacking or if nobody or very small number of employees are assigned to such designations, the capacity of the DPHE to implement these works can be assessed as currently not sufficient.

Considering the status of the DPHE as shown in Table 8.3.1 and 8.3.2, the capacity of the DPHE should be developed and strengthened, particularly in the field of implementing the O&M of WTP and PS and the water distribution management.

Table 8.3.1 Approved Number of Staff of DPHE according to Designation

No.	Designation	Permanent Revenue	Temporary Revenue*[10]	One Time Revenue/ Outsourcing	Newly Added in Organogram 2021	Total
1	Chief Engineer	1				1
2	Addl. Chief Engineer	2			1	3
3	Superintending Engineer	9	1		2	12
4	Executive Engineer	72	3		2	77
5	Snr. Assistant Engineer				81	81
6	Assistant Engineer	25	37		231	293
7	Sub-Assistant Engineer	447	33			480
8	Deputy Director		1			1
9	Assistant Director (GIS)		1			1
10	Assistant Director (MIS)		1			1
11	Chief Chemist		1			1
12	Senior Chemist	4	8		1	13
13	Chemist		2			2
14	Junior Chemist	4	7			11
15	Senior Bacteriologist		1			1
16	Bacteriologist		1			1
17	Sample Analyzer	7	18			25
18	Sample Collector	4	16			20
19	Senior Hydrogeologist	1			1	3
20	Junior Hydrogeologist	1	1		1	3
21	Senior Social Development Officer		1			1
22	Social Development Officer		5		3	8
23	Junior Social Development Officer		4			4
24	Asst Woman Development Officer		2			2
25	Programmer		1		1	2
26	Assistant Programmer				1	1
27	Computer Operator		12		3	15
28	Data Entry Operator		11		6	17
29	Training Officer		2			2
30	Management Officer		1			1
31	Legal Officer				1	1
32	Administrative Officer	1				1
33	Health Educator	3	11			14
34	Head Estimator	4	2			6
35	Estimator	64	7			71
36	Projectionist		14			14
37	Head Draftsman	3	2			5
38	Draftsman	53	4			57
39	Tracer	2	2			4
40	Surveyor	2				2
41	Lineman		6			6
42	Research Assistant		1			1

[10] Temporary revenue staff means the project staff turned into the revenue staff (i.e., staff of which salary is dispensed from revenue budget) temporarily for 3 years before turning into permanent revenue staff.

No.	Designation	Permanent Revenue	Temporary Revenue*[10]	One Time Revenue/ Outsourcing	Newly Added in Organogram 2021	Total
43	Overseer	1				1
44	Supervisor	1				1
45	**Foreman**		**2**			**2**
46	Accounts Officer	1				1
47	CCT	410	27		6	443
48	Cashier	69	3			72
49	Cash Sarker	1	1			2
50	Accountant	75	4		4	83
51	Accounts Assistant	33	8			41
52	Auditor				1	1
53	Stenographer	11	1			12
54	Steno-typist	1				1
55	Head Assistant	52	12			64
56	Upper Divisional Assistant (UDA)	19				19
57	Lower Divisional Assistant (LDA)	24	17		2	43
58	LDA cum Typist	79	15			94
59	Typist		2			2
60	AJC Assistant		1			1
61	Statistical Assistant	1	1			2
62	Mechanic	1,835	87		12	1,934
63	**Machine Operator**				**3**	**3**
64	Electrician		1		2	3
65	**Plumber**				**1**	**1**
66	**Pump Driver**		**8**			**8**
67	**Assistant Pump Driver**		**8**			**8**
68	**Treatment Plant Operator**		**4**			**4**
69	Superintending Technician	2	2			4
70	Technical Supervisor		2			2
71	Technician	2	2			4
72	Sanitary Assistant		11			11
73	Master Driller		2			2
74	Assistant Master Driller		3			3
75	Storekeeper		2			2
76	Personal Assistant		1			1
77	Dispatch Rider	1				1
78	Messenger		4			4
79	Chowkider	308	181	1		490
80	Guard		15		8	25
81	Helper		1			1
82	Cleaner				4	4
83	Lab Cleaner		2			2
84	Peon/ MLSS	551	44		20	615
85	Mason			800		800
86	Labor			837		837
87	Driver	11	14	63	40	128
88	Speedboat Driver			6		6
Sum		4,197	708	1,707	440	7,052

Source: JICA Survey Team based on DPHE's Organogram 2021

Table 8.3.2 Designations to be Created or Increased

Task	Designation to be created/ of which number to be increased	Note
O&M of WTP and PS	Foreman	2 people are approved in DPHE Organogram 2021 as temporary revenue staff.
	Operator (Pump)	• 8 persons are approved as Pump Driver in DPHE Organogram 2021 as temporary revenue staff. • 3 persons are approved as Machine Operator in DPHE Organogram 2021 as newly added permanent revenue staff.
	Assistant Operator (Pump)	8 persons are approved as Assistant Pump Driver in DPHE Organogram 2021 as temporary revenue staff.
	Operator (Treatment Plant)	4 persons are approved as Treatment Plant Operator in DPHE Organogram 2021 as temporary revenue staff.
	Assistant Operator (Treatment Plant)	New designation needed and proposed.
Distribution management	Head Plumber	New designation needed and proposed.
	Plumbing mechanic	1 person is approved as Plumber in DPHE Organogram 2021 as a newly added permanent designation.
	Assistant Plumbing Mechanic	New designation needed and proposed.
	Work Assistant	New designation proposed who will support SAE in shift working team.

Source: JICA Survey Team

8.3.2 Capacity Development Roadmap

The fields and items that require capacity development/ strengthening are shown in Figure 8.3.1, when the DPHE is assumed to be the executing agency to implement the Project and to manage the waterworks and water supply service. For efficient and effective capacity development, it is recommended that the technical cooperation consultant should provide the DPHE with comprehensive training on the O&M of the waterworks and the management of the water supply service for a certain period such as 3-4 years after the completion of the construction. Including this, the period and implementing entity of capacity development at the following 2 stages are shown in Figure 8.3.2, namely,

- Stage 1 (From January 2030 to the middle of 2034 (the completion period of construction work)): necessary institutional setup through the dispatch of an individual JICA expert and the technical preparation work to implement the O&M of the waterworks through the assistance of the contractors and the yen loan consultant; and
- Stage 2 (From the middle of 2034 to the end of 2037): capacity development to implement the O&M of the waterworks and provide & manage the water supply service through the assignment of the technical cooperation consultant.

Institutional Development
A) Development of regulations on water connection and supply
B) Amendment of employee service regulations and job descriptions (addition of new designations)
C) Development of water tariff scheme
D) Capacity assessment and training programs

Financial Management
K) Development of business and financial plan

OJT on O&M
E) Operation and inspection of equipment
F) NRW management in each DMA
G) Tackling of illegal connections
H) Process control of water treatment
I) Inspection and repair of embankment of raw water reservoir
J) Development of SOPs

OJT on Customer Management
L) Develop, maintain, and utilize customer database
M) Data entry and utilization of pipeline GIS database and hydraulic model
N) Customer complaint management
O) Meter testing and replacement

Source: JICA Survey Team

Figure 8.3.1 Field and Items that Need Support for Capacity Develop Strengthening

Capacity Development Item		Stage 1					Stage 2		
		2030	2031	2032	2033	2034	2035	2036	2037
A	Regulations on water connection and supply service								
B	Employee service regulations and job descriptions								
C	Water tariff scheme								
D	Capacity assessment and training programs								
E	Operation and inspection of equipment								
F	DMA-wise NRW management								
G	Tackling illegal connections								
H	Process control of water treatment								
I	Inspection and repair of embankment of raw water reservoir								
J	SOPs								
K	Business and financial plan								
L	Customer database								
M	Pipeline GIS database and hydraulic model								
N	Customer complaint management								
O	Meter testing and replacement								

[Legend]
Dispatch of individual JICA expert
TOR of yen loan consultant
Contractor
Technical cooperation consultant

[Note]
Stage 1 (Jan.2030- Jun.2034) — From starting date to taking-over date of construction work
Stage 2 (Jul.2034- Dec.2037) — From taking-over date to the completion of technical cooperation

Source: JICA Survey Team

Figure 8.3.2 Schedule and Entity to Implement Capacity Development

Regarding the assignment of an individual JICA expert at Stage 1 for the institutional setup, the available information on the legal setup for water connection, accounting, and water tariff is as follows:

(1) Rules on water connection

As a reference, the connection rules prepared by the CWASA have been approved by its board and the Ministry, and although they are internal rules, they have a nature equivalent to a law. While the DPHE has formulated the Pourashava Water Supply Management Guideline in 2023, where the skeleton of the water connection rules is described. The DPHE should establish the connection rules for the Project in accordance with this guideline and obtain the approval from the Ministry. The development of the connection rules is included in the capacity development item A as shown in Figures 8.3.1 and 8.3.2.

(2) Rules on water tariff

The legal basis for setting up water tariff is the Local Autonomy Act of 2009, regardless of the responsible agencies to stipulate water tariff. The development of the water tariff scheme and the business and financial plan is included in the capacity development items C and K as shown in Figures 8.3.1 and 8.3.2.

(3) Rules and manuals on accounting, water tariff collection, and customer service

Since the DPHE already has a track record of managing water supply services by setting up Divisional Accounts, there will be no need to set up special rules on accounting designated for the Project. Besides, the business and financial plan stated above in (2) will also include contents related to water tariff collection and customer service.

8.4 Operation and Maintenance Cost and Water Tariff of the Project

8.4.1 Operation and Maintenance Cost

The O&M cost was calculated on an annual basis regarding the cost of personnel, electricity, mechanical equipment maintenance, electrical equipment maintenance, cleaning, and dredging. The total cost and its breakdown are shown in Table 8.4.1, where the total amounts to 483,780,000 Tk/ year.

Table 8.4.1 Annual O&M Cost

Item	Annual O&M Cost (Tk/year, including VAT except personnel fee)	Note
Personnel fee for O&M	16,680,000	59 employees of DPHE
Electricity fee for intake and conveyance pumps	97,670,000	Demand charge not included.
Electricity fee for WTP	149,300,000	Referred to Mohara WTP of CWASA; Demand charge not included.
Electricity fee for transmission pumps	110,980,000	Demand charge not included.
Maintenance and repair of machinery and mechanical	1,000,000	• Referred to Mohara WTP of CWASA. • To be outsourced.

Item	Annual O&M Cost (Tk/year, including VAT except personnel fee)	Note
equipment		
Maintenance and repair of electrical equipment	1,480,000	• Referred to Mohara WTP of CWASA. • To be outsourced.
Cleaning of water intake screens, inside of deck slab and channels	2,990,000	• #25, #27, and #28, Sludge Removal Units, p80, CWASA Schedule of Rates 2022; Price adjusted to 2024/2025. • Volume of debris referred to CWASA Mohara WTP. • To be outsourced.
Dredging of raw water reservoir	58,650,000	• BWDB Standard Schedule of Rates 2022 #90, #97 for Zone b; Price adjusted to 2024/2025. • Volume of earth: 3.2 km^2 x 0.5 m depth per every 10 years (every 5 years per 2 partitions of reservoir). • To be outsourced.
Dredging of earth from riverbed of Matamuhuri river	21,990,000	• BWDB Standard Schedule of Rates 2022 #90, #97 Zone b; Price adjusted to 2024/2025. • Volume of earth: 60,000 m^3/year. • Budget to be secured by DPHE and transferred to BWDB as deposit work, and actual work to be implemented by BWDB.
Total	460,740,000	
Contingency	23,040,000	• 5% of Total for procuring spareparts and chemicals and other O&M components (such as cleaning of chemical tanks and clarifier, security guarding). • Basically, to be outsourced.
Sum	483,780,000	

Source: JICA Survey Team

(1) Personnel Cost

The personnel cost is calculated for the 59 personnel of the DPHE as shown in Table 8.4.2, based on the reduced staffing in the MIDI Water Supply and O&M Division as was shown in Figure 8.2.2.

Table 8.4.2 Personnel Cost (Unit: Tk/year)

Designation	Daytime	Shift	Sum	Class	Unit Salary	Annual Salary
Executive Engineer (XEN)	1	-	1	1	56,216	674,592
Senior Assistant Engineer (Snr.AE)	2	-	2	1	56,216	1,349,184
Assistant Engineer (AE)	3	-	3	1	56,216	2,023,776
Sub-Assistant Engineer (SAE)	-	8	8	2	27,320	2,622,720
Revenue Officer	1	-	1	1	56,216	674,592
Accountant	1	-	1	3	18,232	218,784
Upper Divisional Assistant (UDA)	5	-	5	3	18,232	1,093,920
Data Entry Operator	1	-	1	3	18,232	218,784
Foreman	-	2	2	3	18,232	437,568
Operator	-	2	2	3	18,232	437,568
Assistant Operator (Asst. Operator)	-	3	3	4	14,780	532,080

Designation	Daytime	Shift	Sum	Class	Unit Salary	Annual Salary
Work Assistant. (WA)	-	4	4	3	18,232	875,136
Head Plumbing Mechanic (HPM)	-	1	1	3	18,232	218,784
Plumbing Mechanic (PM)	-	2	2	3	18,232	437,568
Assistant Plumbing Mechanic (APM)	-	4	4	4	14,780	709,440
Chemist	1	-	1	1	56,216	674,592
Lab Assistant	1	-	1	3	18,232	218,784
Driver	2	4	6	3	18,232	1,312,704
Helper	2	-	2	4	14,780	354,720
Cleaner	4	-	4	4	14,780	709,440
MLSS	5	-	5	4	14,780	886,800
Sum	29	30	59	-	-	16,681,536

Note: Unit salary was calculated based on the National Pay Scale 2015 which is currently applicable to governmental employees and using the average salary for each grade and class.
Source: JICA Survey Team

(2) Electricity Cost

The electricity cost for the pumps and the SCRWTP are calculated as shown in Table 8.4.3 and Table 8.4.4, respectively.

For the pumps, the unit price of the electricity is set up as 10.75 Tk/kWh, which is based on the flat rate 8.45 Tk/kWh (effective from the bill of March 2020) for the user category HT-3 (High Tension AC 33kV for Industry) of retail electricity tariff for the Bangladesh Power Distribution Bureau (BPDB) and other 6 electricity companies, determined by the BERC (Bangladesh Energy Regulation Commission) and adjusted for the price of FY 2024/2025 (annual 6.2% increase in average). The VAT rate is assumed to be 5% as is applied to the CWASA.

Table 8.4.3 Electricity Cost for Conveyance and Transmission Pumps

Electricity cost for pumps		Capacity	Number of pumps	Operation hours	Consump-tion	Unit price	Electricity fee (with 5% VAT)	
		kW		Hours/day	kWh/month	Tk/kWh	Tk/month	Tk/year
Intake Pump		450	3	14	567,000	10.75	6,095,250	76,800,156
Conveyance Pump		75	2	24	108,000	10.75	1,161,000	14,628,600
		32	2	24	46,080	10.75	495,360	6,241,536
Transmission Pump	DR Industrial	200	4	24	576,000	10.75	6,192,000	78,019,200
	DR2	132	2	24	190,080	10.75	2,043,360	25,746,336
	DR6	37	2	24	53,280	10.75	572,760	7,216,776
	Sum	-	16	-	819,360	-	8,808,120	110,982,312
Total		-	-	-	2,359,800	-	16,559,730	208,652,604

Note: Operation hours of intake pumps are on an annual average basis, assuming 7-month operation per year.
Source: JICA Survey Team

For the SCRWTP, since the detailed specifications of equipment are to be developed at the detailed design stage, the electricity cost is estimated using the actual electricity cost in a similar WTP (Sheikh Russel WTP of CWASA), calculating the unit cost per unit treatment capacity, and adjusting it to the treatment capacity of the SCRWTP.

Table 8.4.4 Electricity Cost in SCRWTP

Electricity cost in WTP	Capacity	Electricity cost		Unit cost
		Apr 2024 with VAT	Annual Cost	
	m^3/day	Tk/month	Tk/year	Tk/m^3/day
	A	B	C	D=C/A
CWASA SRWTP (as of April 2024)	90,000	9,997,205	119,966,460	1,333
SCRWTP	112,000	-	149,296,000	-

Source: JICA Survey Team

(3) Maintenance Cost for Mechanical Equipment

The maintenance cost for mechanical equipment is calculated based on the estimate made for the Sheikh Russel WTP of CWASA for the FY 2023/2024, adjusted to the price of FY 2024/2025 using the annual price increase rate of 5%, considering the overhead cost (20%), and adjusted to the capacity of the SCRWTP as shown in Table 8.4.5. The rate of VAT is assumed to be 7.5%.

Table 8.4.5 Maintenance Cost for Mechanical Equipment

Maintenance of mechanical equipment	Capacity	Estimated Cost		Outsourcing with overhead cost (20%)		Unit cost with VAT (7.5%)
		2023/24	Adjusted to 2024/25	2023/24	Adjusted to 2024/25	
	m^3/day	Tk/year	Tk/year	Tk/year	Tk/year	Tk/m^3/day
CWASA SRWTP (2023-24)	90,000	592,670	622,304	711,204	746,765	8.92
SCRWTP (with VAT)	112,000	-	-	-	1,000,000	-

Source: JICA Survey Team

(4) Maintenance Cost for Electrical Equipment

The maintenance cost for electrical equipment is calculated based on the estimate made for the Sheikh Russel WTP of CWASA for the FY 2021/2022, adjusted to the price of FY 2024/2025 using the annual price increase rate of 5%, considering the overhead cost (20%), and adjusted to the capacity of the SCRWTP as shown in Table 8.4.6. The rate of VAT is assumed to be 7.5%.

Table 8.4.6 Maintenance Cost for Electrical Equipment

Maintenance of Electrical Equipment	Capacity	Estimated Cost		Outsourcing with overhead cost (20%)		Unit cost with VAT (7.5%)
		2023/24	Adjusted to 2024/25	2023/24	Adjusted to 2024/25	
	m^3/day	Tk/year	Tk/year	Tk/year	Tk/year	Tk/m^3/day
CWASA SRWTP (2021-22)	90,000	793,603	918,695	952,324	1,102,434	13.17
SCRWTP	112,000	-	-	-	1,476,000	-

Source: JICA Survey Team

(5) Cleaning Cost

The cleaning cost is calculated for the removal of debris and sands in the water intake facility only, and other cleaning cost such as the removal of silt, sand, and sediment from flocculator, clarifier, chemical mixing tanks, etc., and the cleaning of bushes & weeds is to be included in the contingency cost (5 % of

the total cost), considering the difficulty at this stage to estimate the amount of silt, sand, and sediment that need to be removed and cleaned.

The volume of screen debris and sands in the water intake facility is estimated based on the actual average volume in the Mohara WTP of the CWASA (1,050 m^3 per year for the capacity of 90,000 m^3/d) and adjusted to the capacity of the SCRWTP (161,000 m^3/d). The unit price of cleaning is based on #25 (Cleaning of raw water intake channels inside the deck slab), #27 (Cleaning of raw water channel of clarifiers), and #28 (Cleaning and washing of the floors and walls of settled water channels) in Sludge Removal Units, p80, CWASA Schedule of Rates 2022, and adjusted to the price of FY 2024/2025 using the annual price increase rate of 5%, considering the overhead cost (20%), and adjusted to the capacity of the SCRWTP as shown in Table 8.4.7. The rate of VAT is assumed to be 7.5%.

Table 8.4.7 Cleaning Cost of Screens and Sands in Raw Water Intake Channel

Volume of debris (m^3)	Unit price as of 2022 (Tk/m^3)	Adjusted unit price as of 2024 with overhead (20%) (Tk/m^3)	Adjusted unit price as of 2024 with overhead (20%) and VAT (7.5%) (Tk/m^3)	Annual Cost with VAT (TK/year)
1,880	1,120	1,482	1,593	2,994,840

Source: JICA Survey Team

(6) Dredging Cost

The dredging cost is calculated for the earth of the riverbed of Matamuhuri River and of the raw water reservoir as shown in Table 8.4.8 and Table 8.4.9 respectively.

The volume of the earth to be dredged from the riverbed of Matamuhuri River is assumed to be 60,000 m^3/year, which is calculated with River width 30m x Dredged length 2,000m x Depth 1m. The unit price is based on #90 (Earth work by mechanical excavator (long boom)) and #97(1) (Carriage of dredged/excavated earth; carriage by dump truck up to 1km) of the BWDB Standard Schedule of Rates 2022 for the Zone B: SE zone (Chattogram, Rangamati, Khargrachori, Cox's Bazar, Bandarban). These unit prices are adjusted to the price of FY 2024/2025 using the annual price increase rate of 5%, considering the overhead cost (20%), and added VAT with rate of 7.5% as shown in Table 8.4.8.

Besides, the volume of the earth to be dredged from the raw water reservoir is assumed to be 106,667 m^3/year, which is calculated by Area of the reservoir 3,200,000m^2 x Depth 0.5m x Once per 10 years (once per 5 years for 2 ponds). The unit price is based on #90 and #97(1) of the BWDB Standard Schedule of Rates 2022 for Zone B: SE zone. These unit prices are adjusted to the price of FY 2024/2025 using the annual price increase rate of 5%, considering the overhead cost (20%), and added VAT with rate of 7.5% as shown in Table 8.4.9.

Table 8.4.8 Dredging Cost of Riverbed of Matamuhuri River

Dredging of earth in Matamuhuri River	Unit price		Unit price with overhead cost (20%)		Volume of earth to be dredged	Annual cost with VAT
	As of 2022 Tk/m^3	Adjusted for 2024 Tk/m^3	As of 2022 Tk/m^3	Adjusted for 2024 Tk/m^3	m^3/year	Tk/year
Earthwork by mechanical excavator (long boom)	160	176	192	211	60,000	13,609,500
Carriage of dredged earth by dump track 1.0 km	98	108	118	130	60,000	8,385,000
Sum	-	-	-	-	-	21,994,500

Source: JICA Survey Team

Table 8.4.9 Dredging Cost of Raw Water Reservoir

Dredging of earth in Raw Water Reservoir	Unit price		Unit price with overhead cost (20%)		Volume of earth to be dredged	Annual cost with VAT
	As of 2022 Tk/m^3	Adjusted for 2024 Tk/m^3	As of 2022 Tk/m^3	Adjusted for 2024 Tk/m^3	m^3/year	Tk/year
Earthwork by mechanical excavator (long boom)	160	176	192	211	160,000	36,292,000
Carriage of dredged earth by dump track 1.0 km	98	108	118	130	160,000	22,360,000
Sum	-	-	-	-	-	58,652,000

Source: JICA Survey Team

8.4.2 Water Tariff of the Project

The water tariff of municipalities and that of the EZ could be applicable for the Project because the target area is under the jurisdiction of the DPHE, and the Project includes water supply in the EZ. The water tariff of EZ could be determined based on the Prime Minister's Office (PMO)'s approval or a development agreement with BEZA. The water tariff is to be set by the GOB.

The JICA Survey Team suggests the following water tariff based on the construction costs, operation and maintenance costs, and the implementation structure of the Project.

Table 8.4.10 Proposed Water Tariff of the Project

Type of Consumer	Monthly Tariff (BDT/m^3)	% of Con-nection	Enrollment Fee per connection (BDT)	Connection cost per connection (BDT)	Coefficient
Municipalities					
Residential (Normal) Connection	15	81%	200	2,000	1
Low-income Consumer	11	12%	200	1,000	0.7
Institutional Consumer	23	3%	200	3,000	1.5
Commercial Consumer	30	4%	200	10,000	2
EZ	57 (+5%*)	100%	-	20,000	-

*Note: 5% will be paid to BEZA as a service charge.

Source: JICA Survey Team (2024)

Reference: The World Bank, The Bangladesh Municipal Water Supply and Sanitation Project (BMWSSP), 2024, DPHE

Table 8.4.11 shows O&M costs, revenue of water and rate of O&M costs in revenue in Case 1 (no tariff increase case) without subsidies.[11] O&M costs for industry will be covered by 21-23% of the revenue. O&M costs for municipalities will be covered by 37-81% of the revenue. The revenue is enough to cover the O&M costs. 5% of water tariff for EZ will be paid to BEZA as the service charge. The ratio of water sales for EZ to cover the construction costs 28% from 2033 to 2065 and the water tariff for EZ is not extremely high compared to water tariffs in other EZ (BSEZ: 1USD (118 BDT)/m^3, and Mongla port (BEPZA): 60 BDT/m3).

Table 8.4.11 O&M Costs and Revenue of Water in Case 1 without Subsidies

Unit: BDT in Million

Item	2033	2034	2035	2036	2037
O&M Costs for industry	164	330	331	330	329
O&M Costs for Municipalities	66	130	128	129	131
Revenue of Water Sales for Industry	711	1,464	1,511	1,511	1,511
Revenue of Water Sales for Municipalities	179	157	159	160	163
O&M Costs as a percentage of Revenue for Industry	23%	23%	22%	22%	22%
O&M Costs as a percentage of Revenue for Municipalities	37%	83%	81%	81%	80%
Item	2038	2039	2040	2041	2042-65
O&M Costs for industry	328	326	325	324	324
O&M Costs for Municipalities	132	133	134	136	136
Revenue of Water Sales for Industry	1,511	1,511	1,511	1,511	1,511
Revenue of Water Sales for Municipalities	165	167	169	171	170
O&M Costs as a percentage of Revenue for Industry	22%	22%	22%	21%	21%
O&M Costs as a percentage of Revenue for Municipalities	80%	80%	80%	79%	80%

Source: JICA Survey Team (2024)

[11] Cases are explained in “10.1.3 Financial Analysis” in “Chapter 10 STUDY ON PROJECT EFFECTS”.

CHAPTER 9 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

Through the environmental and social considerations study, 3 kinds of reports are prepared. For the phasing described in 5.4, the scope of each report is organized as follows. Phase 2 is not an indivisible project, thus, Phase 2 is not considered in this chapter.

Table 9.1.1 The Scope of each Report

Name of Reports	Scope	
	The Project	Phase 2
Final Report (Chapter 9)	x	-
EIA Report	x	x
RAP Report	x	x

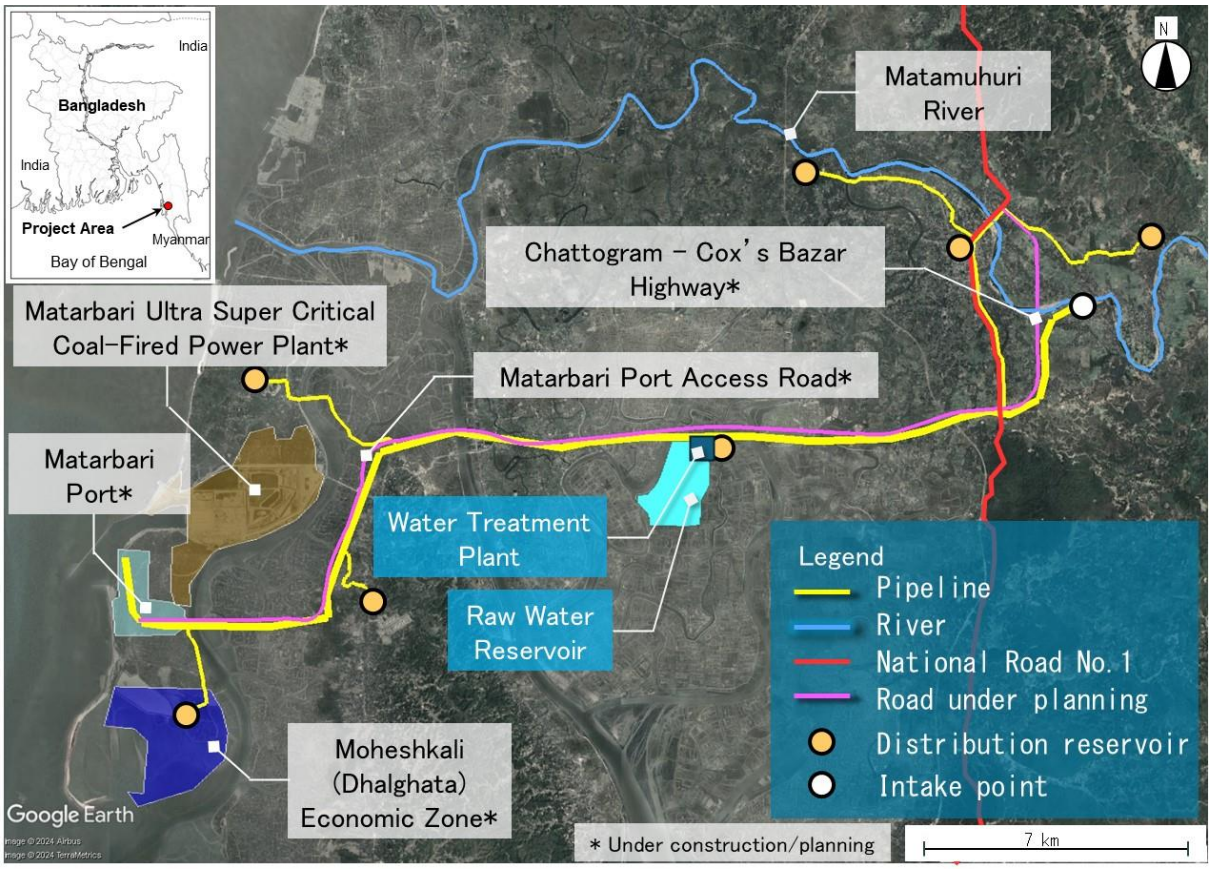
Source: JICA Survey Team

9.1 Environmental and Social Considerations

9.1.1 Project Summary

(1) Project Area

The project area is located in Chakaria and Moheshkhali upazilas of Cox's Bazar District. The Government of Bangladesh promotes the "Moheshkhali Matarbari Integrated Infrastructure Development Initiative (MIDI)" to attract large-scale direct investments in the surrounding areas, especially in the Matarbari Port. The project area is shown in the Figure 9.1.1 below.



Source: Prepared by the JICA Survey Team based on Google Earth

Figure 9.1.1 Project Area

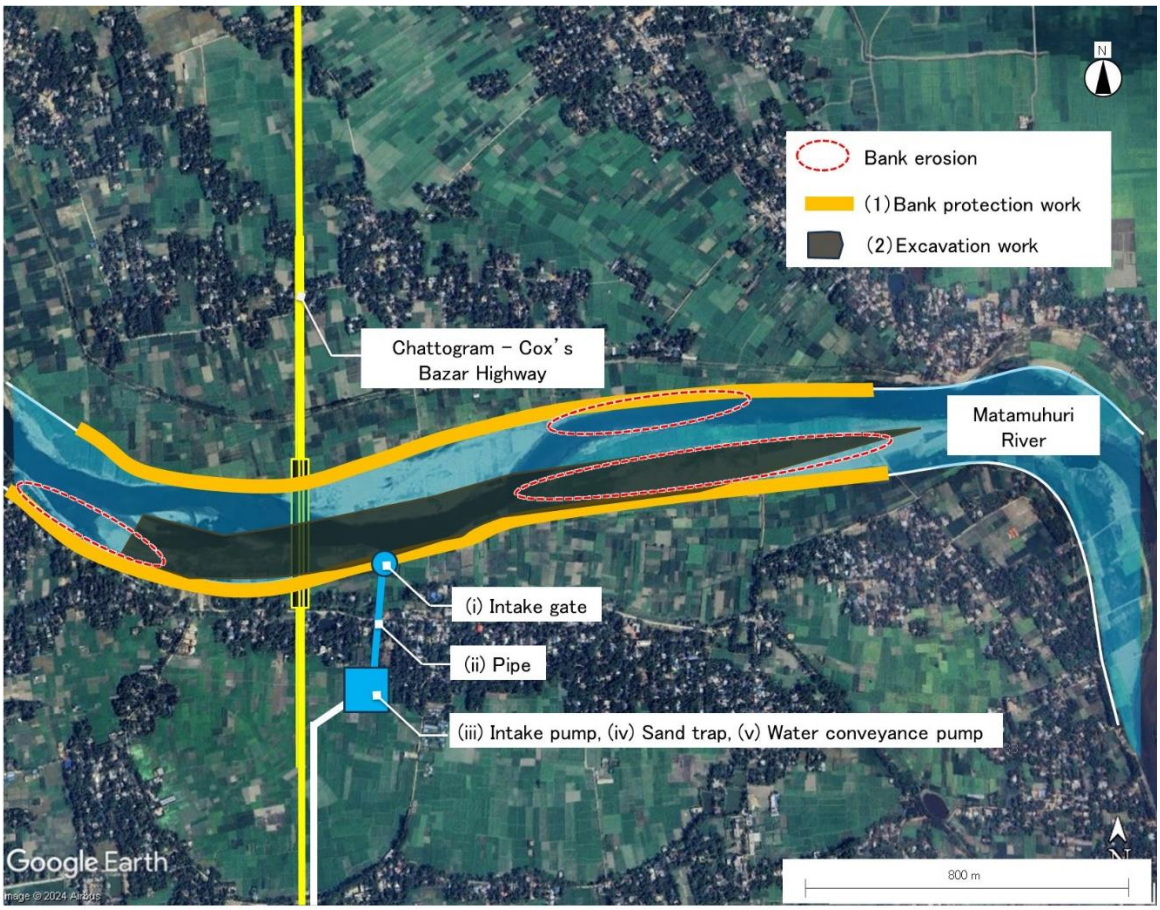
(2) Project Scope

In the Project, water will be taken from the Matamuhuri River during the rainy season and conveyed from the intake pump station to the raw water reservoir by pump through pipelines. The flow rate is adjusted in the reservoir, depending on water demands and water is distributed to each water demand area after treatment from the water treatment plant. The plan for the Project is developed based on the forecasted domestic and industrial water demand of 2041. Details of the Project are explained in 5.4, Chapter 5 of this report.

1) River Water Intake

The intake facility is constructed to take water from the Matamuhuri River when the water level is high in the rainy season (May to November). The intake facility consists of (i) intake gates connected to the Matamuhuri River, (ii) water channels from the intake point to a sand trap, (iii) emergency intake pumps, (iv) a sand trap for removing sand from water taken, and (v) water conveyance pumps. Electrical facilities such as power receiving and transforming facilities, emergency power generators, and monitoring and control systems will also be installed. The intake point of the Matamuhuri River is planned at the riverbank where bank erosion has occurred, and the width of river channel has been variable. To avoid bank erosion, bank protection works around the intake point are to be conducted in the Project. Moreover, since sediment is feared to be deposited around the intake point, removal work of the deposited sediment is also to be conducted. Periodical removal works are required even during the operation phase because sediment deposition is expected to be caused repeatedly around the intake point. The site situations around the intake point are shown in Figure 9.1.2. Details are explained in other chapters as follows.

- Preliminary Design: Chapter 6, 6.2 Preliminary Design of River Water Intake Facilities
- Construction methods: Chapter 7, 7.1.1 Work Procedure and Method, (1) Intake,



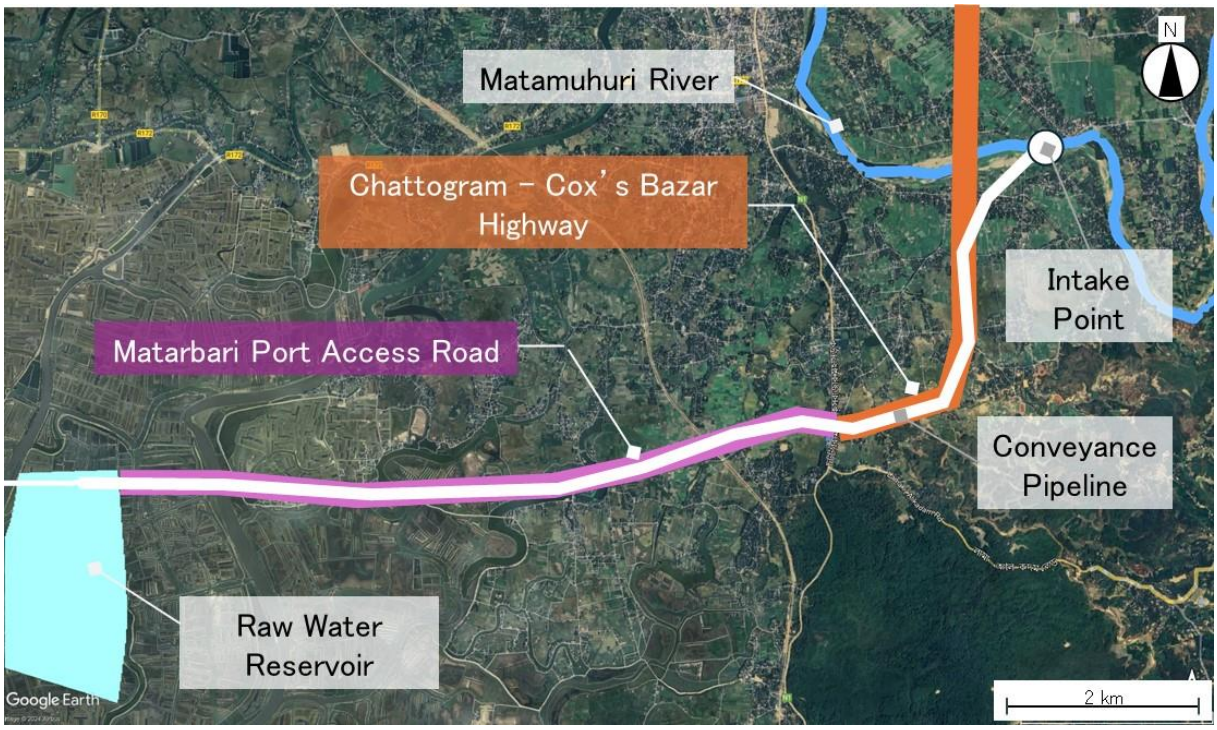
Source: Prepared by the JICA Survey Team based on Google Earth

Figure 9.1.2 Site Situations Around Intake Point

2) Raw Water Pipeline

The conveyance pipes, which convey the water taken in the Matamuhuri River to the raw water reservoir, are constructed underground by open-cut method and pipe jacking method. The water is conveyed by pump and the pipes are planned to be installed along the Chattogram-Cox's Bazar Highway and Matarbari Port Access Road and within the right of ways ("ROW" hereinafter) of these roads. The current alignment of the Chattogram-Cox's Bazar Highway is at the basic design stage; however, the routes of the conveyance pipes are considered referring to the current alignment of the road. The construction of the Matarbari Port Access Road will be preceded prior to the Project. The timing of the construction work of the Chattogram-Cox's Bazar Highway is unknown, however, there is a possibility that the construction work will be implemented at the same time. In the river crossing sections, water pipe bridges (four bridges) will be constructed. The outline of conveyance pipes is shown in the Figure 9.1.3 below. Details are explained in the following sections.

- Desing: Chapter 6, 6.3 Preliminary Design of Raw Water Pipeline Facilities
- Construction methods: Chapter 7, 7.1.1 Work Procedure and Method, (2) Conveyance and Transmission Pipes



Source: Prepared by the JICA Survey Team based on Google Earth

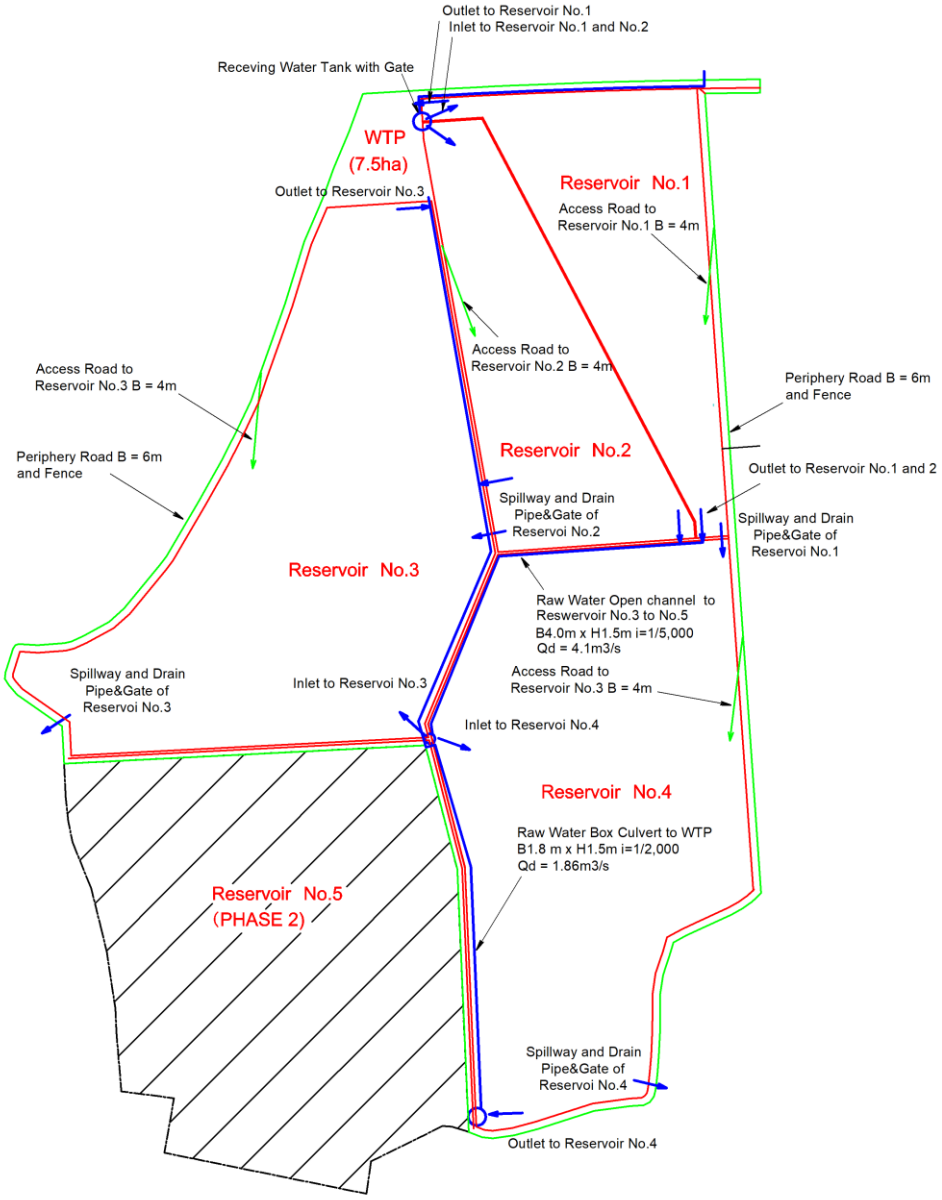
Figure 9.1.3 Outline of Conveyance Pipes

3) Raw Water Reservoir

The raw water reservoir, which stores the water to be taken from the Matamuhuri River, is constructed. Dykes are constructed around the reservoir and water will be stored in the area enclosed by the dykes.

Dredging in the river around the raw water reservoir construction site will be conducted to get soil, construction material, for construction of dyke. There is possibility that the dredging will contribute for flood control measures if the dredging location and timing is consistent with the plan of flood control measurement of Bangladesh including river widening. However, as of October 2024, the plan is still draft and details are not decided yet. The land for the raw water reservoir is currently used for shrimp farming in the rainy season and salt cultivation in the dry season. In order to remove salt from the soil, surface ground will be removed. In addition, since the site has soft ground, measures will be taken to prevent the land subsidence. Water flows into the reservoir during the rainy season only and used as the water source throughout the year. The raw water reservoir is divided into some sections by access roads, which are provided for inspection and maintenance work, and the deposited sediment is removed section by section. A spoil bank for storing the removed sediment is located adjacent to the raw water reservoir. The outline of the raw water reservoir is shown in the Figure 9.1.4 below. Details are explained in the following sections.

- Design: Chapter 6, 6.4 Preliminary Design of Raw Water Reservoir Facilities
- Construction methods: Chapter 7, 7.1.1 Work Procedure and Method, (3) Raw Water Reservoir



Source: JICA Survey Team

Figure 9.1.4 Outline of Raw Water Reservoir

4) Water Treatment Facility

The water treatment plant, which treats the water from the raw water reservoir and supplies domestic and industrial water, is constructed adjacent to the raw water reservoir. The treated water quality will comply with the drinking water quality standard stipulated in Schedule II in ECR 2023. The treatment method is rapid filtration for both the domestic and industrial water. Required equipment such as rapid agitators, sludge scrapers, and backwash pumps are installed. There will be (i) water conveyance pumps to transfer water from the raw water reservoir, (ii) transfer pumps to transfer purified water to each distribution reservoir, and (iii) electrical facilities such as power receiving and transforming facilities,

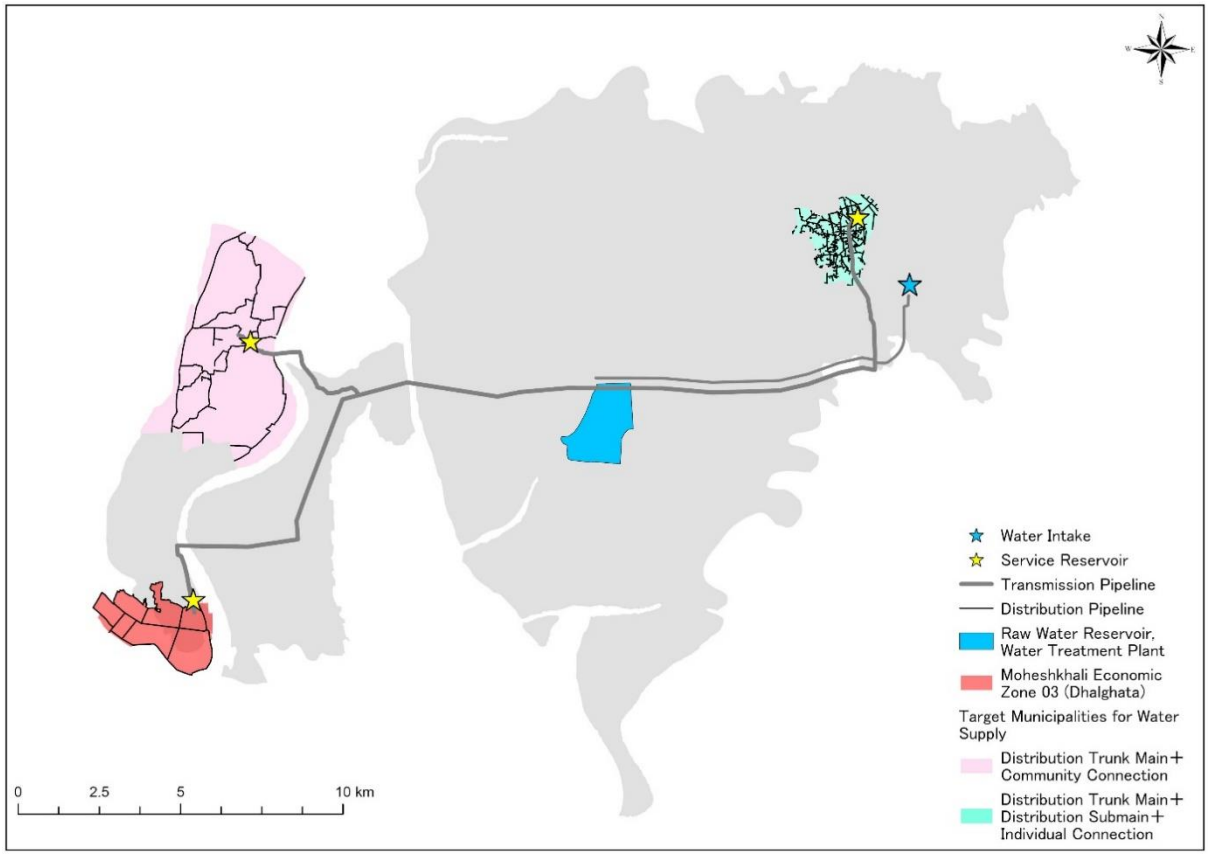
emergency power generators, and monitoring and control systems installed. Details are explained in the following sections.

- Design: Chapter 6, 6.5 Preliminary Design of Water Treatment Facilities
- Construction methods: Chapter 7, 7.1.1 Work Procedure and Method, (4) Water Treatment Plant

5) Water Transmission

The transmission pipelines, which transfer water from the water treatment plant to distribution reservoirs, are constructed. The transmission pipeline routes are located along the Chattogram-Cox's Bazar Highway and Matarbari Port Access Road within the ROWs of existing roads and the water pipe bridges are constructed in the river crossing sections. The outline of transmission pipelines is shown in Figure 9.1.5 below. Details are explained in the following sections.

- Design: Chapter 6, 6.6 Preliminary Design of Water Transmission Facilities
- Construction methods: Chapter 7, 7.1.1 Work Procedure and Method, (2) Conveyance and Transmission Pipes



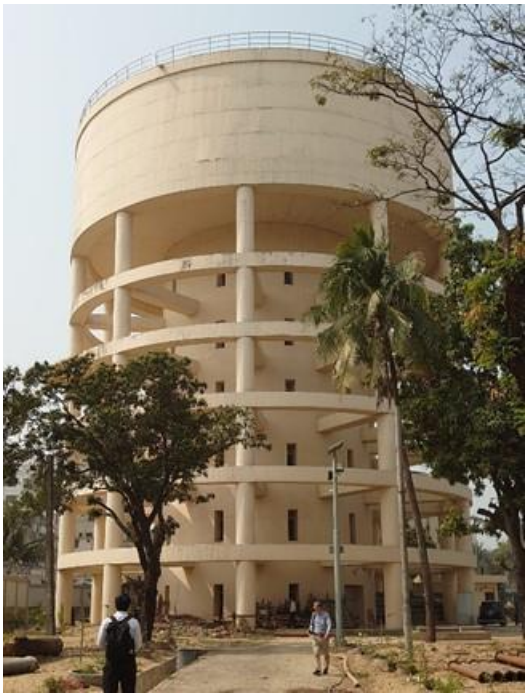
Source: JICA Survey Team

Figure 9.1.5 Outline of Transmission Pipelines

6) Water Distribution Facility

The water is supplied by gravity from the elevated reservoir to individual houses and Moheshkhali EZ (Dhalghata). An example of elevated reservoir is shown in the Figure 9.1.6 below. To distribute water, distribution main is installed from elevated reservoir to each household and industry. The distribution main is installed underground within ROW of the existing road. In the Project, the water distribution methods are individual house connection and group-tap connection. The group-tap connection is applied in Matarbari Union only.

- Design: Chapter 6, 6.7 Preliminary Design of Water Distribution Facilities
- Construction methods: Chapter 7, 7.1.1 Work Procedure and Method, (6) Distribution Pipe and Service pipe



Source: JICA Survey Team

Figure 9.1.6 Example of Overhead Distribution Reservoir (Tank)

7) Land Acquisition and Resettlement

The construction of facilities for the Project requires land acquisition and resettlement as summarized in the table below. Details are described in 9.2.1 and 9.2.5. In addition, it is necessary to temporarily use both private and government land for construction yards[1] and shafts.

[1] Requisition of temporary land for construction yard will be done by the Deputy Commission as per the ARIPA 2017, hence, the temporary affected households are not included in the Affected Units.

Table 9.1.2 The Scope of Land Acquisition and Resettlement

Project Component	Land Ownership Status		Resettlement
	Government	Private	
Intake Station	-	x	Not required
Conveyance Pipeline	x	x	Required
Raw Water Reservoir	x	-	Required
Treatment Plan	x	-	Required
Transmission Pipeline	x	x	Required
Distribution Reservoirs	x	x	Required

Source: JICA Survey Team

(3) Project Proponents

Two project proponents, BWDB and DPHE, are involved in the Project. Their general duties are explained in 3.1, Chapter 3. Their responsibilities related to the Project is summarized in the table below.

Table 9.1.3 Responsibility of Project Proponents

Components	**Before construction** EIA RAP	**Construction** Contractor selection Contract Construction supervision EIA Monitoring	**After construction** O&M
Water Intake River training work Intake structure Water conveyance Water reservoir	DPHE	BWDB (Responsibility of EIA Monitoring is DPHE)	DPHE (With technical support by BWDB)
Water Supply Water treatment Transmission Distribution reservoir	DPHE	DPHE	DPHE

Source: JICA Survey Team

(4) Impacts Associated with Indivisible Projects

There is no indivisible project. The Phase 2 will not be implemented without the Project because the Phase 2 is expansion of the Project. However, the Project is viable without the Phase 2. Thus, the Phase 2 is not indivisible project.

(5) Projects with Derivative, Secondary, and Cumulative Impacts

The expected impacts are shown in Table 9.1.4 below.

Table 9.1.4 Projects with Derivative, Secondary, and Cumulative Impacts

Item	Contents of Development	Expected Impacts
Derivative/ Secondary Impacts	Increase of generated wastewater due to water supply system development	Wastewater will be discharged from the residential and commercial buildings, and if wastewater treatment is not implemented appropriately, there is a concern about pollution of the surrounding water environment. Discharge standards (discharge to sewage, discharge to

Item	Contents of Development	Expected Impacts
		the environment, and discharge from specific industries) are stipulated in the Environmental Conservation Rules, 2023 in Bangladesh. Water supply and sewage development is one of the points being considered in the MIDI Master Plan. The target area, system, and treatment methodology of wastewater treatment will be considered. Thus, the impact such as environmental pollution could be mitigated.
Cumulative Impacts	• Chattogram-Cox's Bazar Highway • Matarbari Port Access Road • Moheshkhali (Dhalghata) Industrial Zone	The conveyance pipeline and transmission pipeline of the Project are planned to be laid along these roads. Construction of these roads will also be carried out in the future, and there is a concern that the construction work of this project will have an additional cumulative impact on the surrounding area (air quality, noise, and vibration). Since Moheshkhali (Dhalghata) Industrial Zone will also be constructed in the future, an additional cumulative impact is expected due to the construction of transmission pipeline and overhead distribution reservoir in the same area.

Source: JICA Survey Team

(6) Project Category

Since the Project falls into the reservoir sector, and is likely to have significant adverse impact due to its characteristic (Large-scale involuntary resettlement) under the Japan International Cooperation Agency (JICA) Guidelines for Environmental and Social Considerations (January 2022), the Project is categorized as “Category A” project.

9.1.2 Current Status of the Environmental and Social Conditions

(1) Pollution Control Items

1) Air Quality

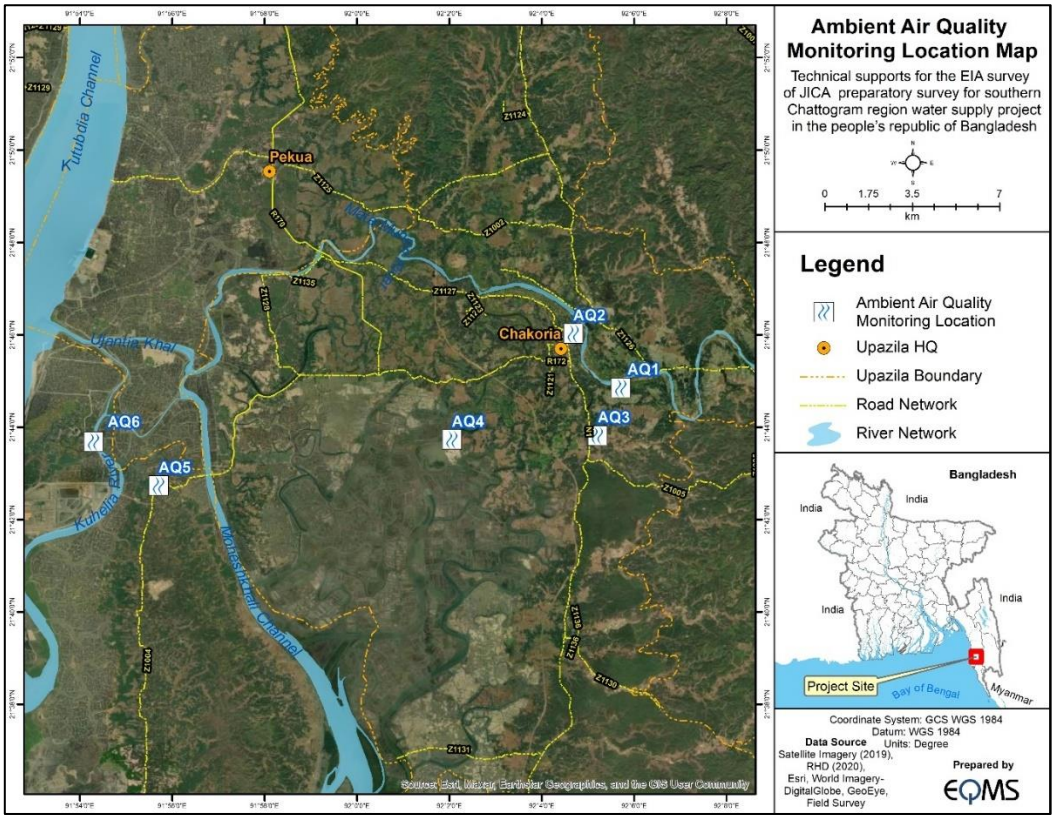
Ambient air quality surveys were conducted 24 hours continuously in 6 (six) locations. Survey was conducted once in March 2024 (i.e., dry season) and July 2024 (i.e., rainy season), respectively. The survey outline is summarized in Table 9.1.5. Figure 9.1.7 shows the survey location.

Table 9.1.5 Survey Outline (Ambient Air Quality)

S/N	Survey Date	Location Code	Location Name	Geographical Location
1.	25/03/2024−26/03/2024 08/07/2024−09/07/2024	AQ1	Brojendra Mohan Ghat Area, Digarpankhali, Chakaria, Cox’s Bazar	21°44'52"N 92°5'45"E
2.	03/04/2024-04/04/2024 08/07/2024−09/07/2024	AQ2	Infront of RHD Office, Chakaria Pourashava, Cox’s Bazar	21°46'2.615"N 92°4'40.333"E
3.	01/04/2024-02/04/2024 09/07/2024−10/07/2024	AQ3	Chararkul Area, Fasiakhali, Chakaria, Cox’s Bazar	21°43'48.622"N 92°5'12.229"E
4.	27/03/2024−28/03/2024	AQ4	Paschim Saodagar Ghona Area,	21°43'42.977"N

S/N	Survey Date	Location Code	Location Name	Geographical Location
	09/07/2024−10/07/2024		Chiringa, Chakaria, Cox's Bazar	92°2'6.458"E
5.	26/03/2024−27/03/2024 10/07/2024−11/07/2024	AQ5	Uttar Nalbila Area, Kalarmarchora, Moheshkhali, Cox's Bazar	21°42'44.453"N 91°55'43.944"E
6.	02/04/2024-03/04/2024 10/07/2024−11/07/2024	AQ6	Rajghat Bazar Area, Matarbari, Moheshkhali, Cox's Bazar	21°43'40.747"N 91°54'17.653"E

Source: JICA Survey Team



Source: JICA Survey Team

Figure 9.1.7 Air Quality Surveyed Location Map

Table 9.1.6 summarizes the survey results. As shown in this table, all the measured values (PM_{10}, $PM_{2.5}$, O_3, NO_2, SO_2, and CO) are below the environmental standards, set by the Air Pollution (Control) Rules, 2022. Survey results of AQ2 generally tends to have relatively large values, compared with others, but they are still within acceptable limits. This is mainly due to vehicular emission of nearby traffic circulation.

Table 9.1.6 Survey Results (Ambient Air Quality)

Location ID.	Ambient Air Pollutants' Concentration in µg/m³											
	PM_{10}		$PM_{2.5}$		O_3		NO_2		SO_2		CO (mg/m³)	
	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy
AQ 1	59	42.4	26.4	23.3	10.2	18.6	13	30.2	3.5	6.6	0.0	0.0

Location ID.	Ambient Air Pollutants' Concentration in µg/m³										CO (mg/m³)	
	PM10		PM2.5		O3		NO2		SO2			
	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy
AQ 2	109.3	105.7	35.0	29.2	38.2	36.7	67.6	74.0	44.7	17.5	0.6	0.8
AQ 3	40.1	47.1	17.0	15.4	7.6	12.6	19.6	33.8	3.9	5.9	0.0	0.0
AQ 4	58.8	40.9	27.7	16.5	9.9	16.1	25.7	33.3	7.0	6.6	0.0	0.0
AQ 5	54.4	73.8	17.6	20.9	13.9	20.6	42.2	56.2	3.4	10.5	0.5	0.0
AQ 6	68.6	50.9	25.3	26.2	18.6	22.2	50.5	43.6	21.3	17.7	0.7	0.0
Duration (Hours)	**24**		**24**		**8**		**24**		**24**		**8**	
Air Pollution (Control) Rules, 2022	**150**		**65**		**100**		**80**		**80**		**5**	

Location ID.	Ambient Air Pollutants' Concentration in µg/m³					CO mg/m³
	PM10	PM2.5	O3	NO2	SO2	
AQ 1	59.08	26.36	10.2	13	3.5	0.0
AQ 2	109.3	35	38.2	67.6	44.7	0.6
AQ 3	40.1	17.0	7.6	19.6	3.9	0.0
AQ 4	58.8	27.7	9.9	25.7	7.0	0.0
AQ 5	54.4	17.6	13.9	42.2	3.4	0.5
AQ 6	68.6	25.3	18.6	50.5	21.3	0.7
Air Pollution (Control) Rules, 2022	**150**	**65**	**100**	**80**	**80**	**5**

Source: JICA Survey Team

2) Water Quality

(a) Surface Water

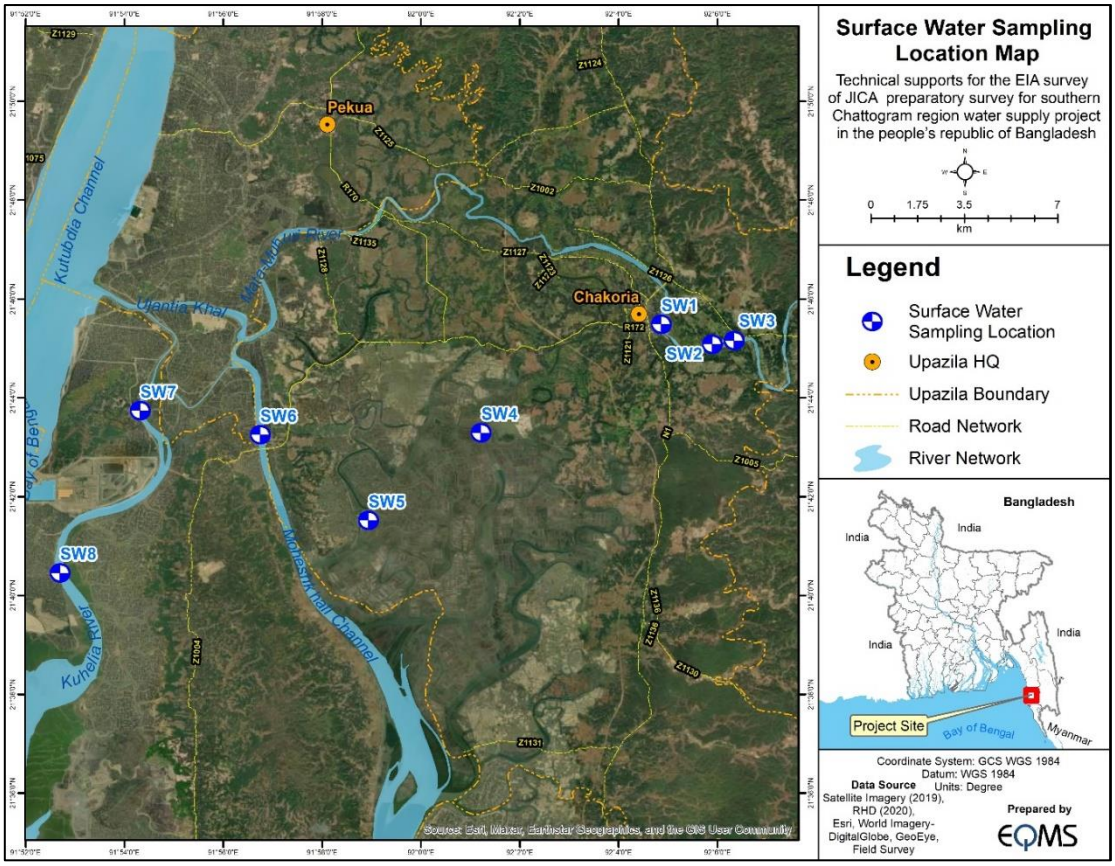
Surface water quality survey was conducted at eight (8) points. Sampling was conducted once in March 2024 (i.e., dry season) and July 2024 (i.e., rainy season), respectively. The survey outline is summarized in Table 9.1.7. Figure 9.1.8 shows the survey location.

Table 9.1.7: Survey Outline (Surface Water Quality)

S/N	Survey Date	Location Code	Location Name	Geographical Location
1.	31/03/2024 07/07/2024	SW1	Matamuhuri River, Nij Pankhali, Kakara, Chakaria, Cox's Bazar	21°45'23.002"N 92°4'51.621"E
2.	29/03/2024	SW2	Matamuhuri River, Digar Pankhali, Kakara,	21°45'3.713"N

S/N	Survey Date	Location Code	Location Name	Geographical Location
	06/07/2024		Chakaria, Cox's Bazar	92°5'52.929"E
3.	31/03/2024 06/07/2024	SW3	Matamuhuri River, Digar Pankhali, Kakara, Chakaria, Cox's Bazar	21°45'8.901"N 92°6'17.452"E
4.	29/03/2024 06/07/2024	SW4	Bara Matamuhuri River, Chiringa, Chakaria, Cox's Bazar	21°43'16.619"N 92°1'16.015"E
5.	29/03/2024 06/07/2024	SW5	Matamuhuri River, Rampur Area, Chakaria, Cox's Bazar	21°41'15.623"N 91°58'51.873"E
6.	30/03/2024 07/07/2024	SW6	Matamuhuri River, Badarkhali, Chakaria, Cox's Bazar	21°43'14.007"N 91°56'44.483"E
7.	31/03/2024 07/07/2024	SW7	Kuhelia River, Matarbari, Moheshkhali, Cox's Bazar	21°43'32.622"N 91°54'22.628"E
8.	30/03/2024 07/07/2024	SW8	Kuhelia River, Dhalghata, Moheshkhali, Cox's bazar	21°39'59.857"N 91°52'55.445"E

Source: JICA Survey Team



Source: JICA Survey Team

Figure 9.1.8 Surface Water Sampling Location

Table 9.1.8 summarizes survey results. As shown in this table, it is found that water quality parameters of pH, DO, BOD, COD, and nitrate are within the acceptable limits set by Bangladesh standards. Total Dissolved Solids (TDS) exceed the standard limit at five (5) locations (i.e., SW4 - SW8).

Table 9.1.8: Surface Water Quality Analytical Result

Parameters	Unit	Seasons	Concentration Present								Bangladesh Standard*
			SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8	
Temperature	°C	Rainy	24.7	25.3	24.8	25.2	25.1	25.1	25.0	24.8	-
		Dry	24.8	25.1	24.7	25.2	25.3	24.6	25.2	24.7	
Turbidity	NTU	Rainy	358	970	491	6.24	131	80.5	44.5	41.5	-
		Dry	20.6	10.8	15.0	165	213	311	148	217	
pH	-	Rainy	6.83	6.58	6.91	6.65	6.61	6.84	6.91	7.53	6-9
		Dry	7.15	7.42	7.58	7.27	7.62	7.73	7.75	7.80	
DO	mg/L	Rainy	5.80	5.71	5.69	5.87	5.70	5.76	5.61	5.78	≥5
		Dry	6.06	6.00	6.05	5.91	5.85	5.72	5.82	6.10	
BOD	mg/L	Rainy	<0.2	<0.2	<0.2	<0.2	0.22	<0.2	<0.2	<0.2	≤6
		Dry	0.20	<0.2	<0.2	0.53	0.33	<0.2	0.21	0.60	
COD	mg/L	Rainy	2.92	3.90	1.95	3.06	4.08	2.04	3.04	2.03	50
		Dry	3.92	2.94	1.96	4.7	2.82	1.88	3.06	5.10	
TDS	mg/L	Rainy	69.0	52.0	59.0	57.0	1980	6710	6170	13240	1000
		Dry	142	143	141	32000	31000	30000	30900	30500	
EC	µS/cm	Rainy	141	106	128	120	3540	11150	11110	25100	-
		Dry	248	249	248	47010	46660	46680	48820	47730	
TSS	mg/L	Rainy	559	700	663	500	196	299	66.0	257	-
		Dry	54.0	85.0	112	802	850	1043	512	582	
NH_3	mg/L	Rainy	0.51	3.61	2.07	<0.5	<0.5	3.24	5.57	9.68	-
		Dry	<0.5	<0.5	<0.5	<0.5	<0.5	1.64	3.18	<0.5	
NO_3	mg/L	Rainy	<3.0	3.26	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	7
		Dry	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	
Total Coliform	MPN/ 100 ml	Rainy	4.5	4.5	4.5	<1.8	<1.8	<1.8	<1.8	<1.8	≤5000
		Dry	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	2.0	
Faecal Coliform	MPN/ 100 ml	Rainy	<1.8	4.5	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	-
		Dry	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	
Cl	mg/L	Rainy	4.84	2.99	2.81	10.1	2194	10608	10316	13228	-
		Dry	10.3	9.18	9.67	52413	52046	36262	53511	52743	

Source: JICA Survey Team

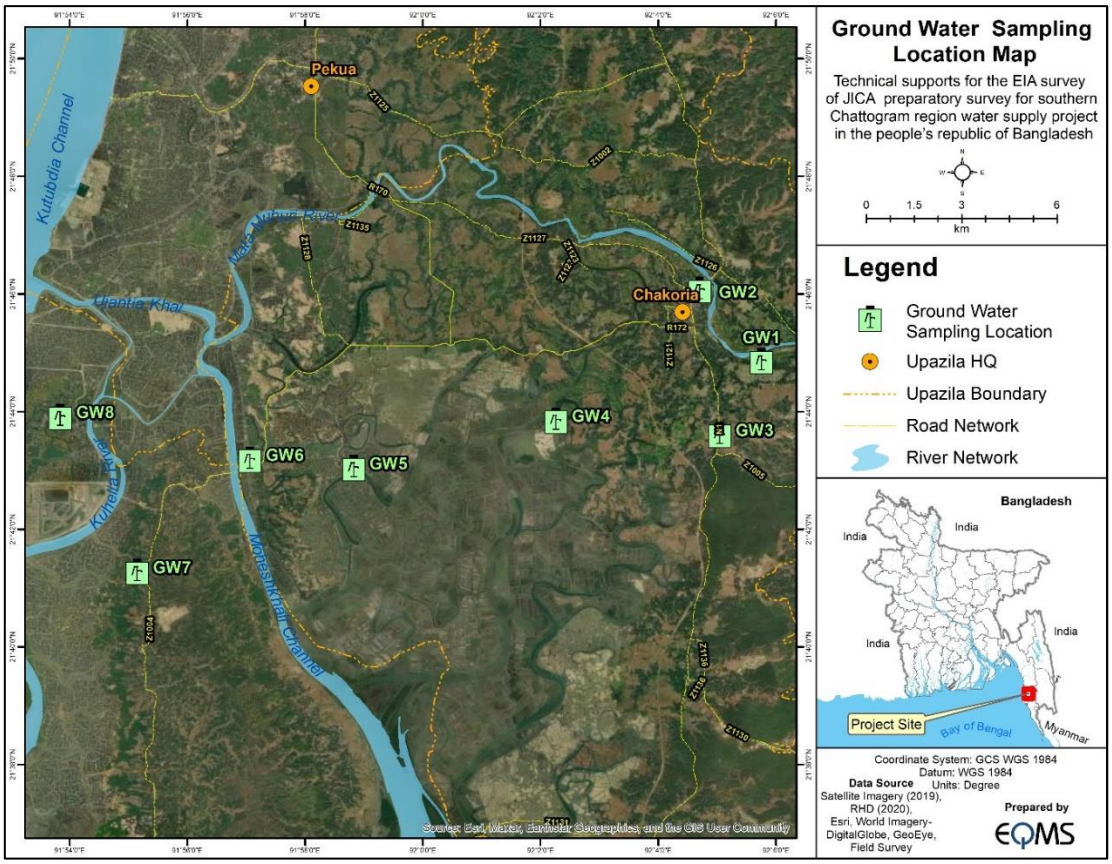
(b) Ground Water

Groundwater quality survey was conducted at eight (8) points. Sampling was conducted once in March 2024 (i.e., dry season) and July 2024 (i.e., rainy season), respectively. The survey outline is summarized in Table 9.1.9. Figure 9.1.9 shows the survey location.

Table 9.1.9: Survey Outline (Groundwater Quality)

S/N	Survey Date	Location Code	Location Name	Geographical Location
1.	29/03/2024 08/07/2024	GW1	Haradon's House Area, Digorpankhali, Kakara, Chakaria, Cox's Bazar	21°44'50.012"N 92°5'45.604"E
2.	31/03/2024 08/07/2024	GW2	Infront of Jam Jam Hospital, Chakaria Pourashava, Cox's Bazar	21°46'3.911"N 92°4'43.271"E
3.	31/03/2024 08/07/2024	GW3	Near NRC Filling Station, Fasiakhali, Chakaria, Cox's Bazar	21°43'33.626"N, 92°5'4.15"E
4.	29/03/2024 08/07/2024	GW4	Saiful's House Area, Chiringa, Chakaria, Cox's Bazar	21°43'49.374"N 92°2'15.068"E
5.	28/03/2024 08/07/2024	GW5	Paschim Bara Bheola Area, Badarkhali, Chakaria, Cox's Bazar	21°43'0.456"N 91°58'50.224"E
6.	28/03/2024 08/07/2024	GW6	Badarkhali Market Area, Chakaria, Cox's Bazar	21°43'8.474"N 91°57'2.236"E
7.	30/03/2024 08/07/2024	GW7	Jamir Uddin's House Area, Uttor Jhapua, Kalarmarchara, Moheshkhali, Cox's Bazar	21°41'15.107"N 91°55'7.358"E
8.	30/03/2024 08/07/2024	GW8	Mahabub Kamal's House, Natun Bazar Area, Matarbari, Moheshkhali, Cox's Bazar	21°43'50.813"N 91°53'49.835"E

Source: JICA Survey Team



Source: JICA Survey Team

Figure 9.1.9 Ground Water Sampling Location

Table 9.1.10 summarizes survey results. As shown in this table, it is found that measured values of the temperature (°C) of all samples are varied between 24.7-25.3°C, and are within the acceptable range (20-30°C). Turbidity (NTU) of most of samples exceed the standard limit (5 NTU), except those of GW5, GW7, and GW8. pH: All samples fall within the safe range (6.5-8.5). Arsenic (As) values of ll samples are safely below the limit (<0.005 mg/L against 0.05 mg/L).

Table 9.1.10: Groundwater Quality Analytical Result

Parameters	Unit	Seasons	Concentration Present								Bangladesh Standard*
			GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8	
Temperature	°C	Rainy	25.1	25.2	24.7	25.3	25.1	25.3	25.1	25.2	20-30
		Dry	24.8	25.1	24.8	25.1	24.7	25.1	25.3	24.7	
Turbidity	NTU	Rainy	19.5	17.1	69.4	9.17	2.51	6.52	46.2	0.15	5
		Dry	25.1	14.8	12.5	15.6	1.13	12.7	0.54	0.49	
pH	-	Rainy	7.01	6.91	6.03	6.85	7.29	6.94	6.82	8.14	6.5 – 8.5
		Dry	7.68	7.78	6.59	7.43	7.56	7.27	7.52	8.04	

Parameters	Unit	Seasons	Concentration Present								Bangladesh Standard*
			GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8	
TDS	mg/L	Rainy	101	83.0	51.0	95.0	108	102	108	117	1000
		Dry	239	356	62.0	113	130	119	116	142	
EC	µS/cm	Rainy	213	173	108	205	224	213	224	245	-
		Dry	474	715	127	229	262	241	235	286	
Arsenic (As)	mg/L	Rainy	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.05
		Dry	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	
Iron (Fe)	mg/L	Rainy	0.80	1.70	0.39	0.78	0.22	0.69	0.29	<0.2	0.3-1.0
		Dry	0.46	2.82	2.76	2.14	0.4	1.6	<0.2	<0.2	
Manganese (Mn)	mg/L	Rainy	0.24	0.25	0.49	<0.05	0.15	0.18	0.39	<0.05	0.4
		Dry	0.62	<0.05	0.26	0.07	0.10	0.09	0.08	<0.05	
NO_3	mg/L	Rainy	<3.0	<3.0	<3.0	<3.0	14.3	3.43	<3.0	<3.0	45
		Dry	12.7	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	
PO_4	mg/L	Rainy	<0.5	0.72	<0.5	0.71	1.15	1.24	<0.5	<0.5	-
		Dry	0.55	8.33	2.46	2.89	2.89	3.92	1.50	<0.5	
Fluoride (F)	mg/L	Rainy	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1
		Dry	<0.5	1.58	<0.5	<0.5	0.55	0.53	<0.5	<0.5	
Total Coliform	MPN/ 100 ml	Rainy	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	-
		Dry	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	
Faecal Coliform	MPN/ 100 ml	Rainy	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	-
		Dry	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	

Source: JICA Survey Team

3) Noise

Ambient noise level measurements were conducted 24 hours continuously in 6 (six) locations. The survey outline is summarized in Table 9.1.11. Figure 9.1.10 shows the survey location.

Table 9.1.11: Survey Outline (Ambient Noise Level)

S/N	Survey Date	Location Code	Location	Geographical Location
1.	25/03/2024−26/03/2024	NL1	Brojendra Mohan Ghat Area, Digarpankhali, Chakaria, Cox's Bazar	21°44'52"N 92°5'45"E
2.	03/04/2024-04/04/2024	NL2	Infront of RHD Office, Chakaria Pourashava, Cox's Bazar	21°46'2.615"N 92°4'40.333"E
3.	01/04/2024-02/04/2024	NL3	Chararkul Area, Fasiakhali, Chakaria, Cox's Bazar	21°43'48.622"N 92°5'12.229"E

S/N	Survey Date	Location Code	Location	Geographical Location
4.	27/03/2024−28/03/2024	NL4	Paschim Saodagar Ghona Area, Chiringa, Chakaria, Cox's Bazar	21°43'42.977"N 92°2'6.458"E
5.	26/03/2024−27/03/2024	NL5	Uttar Nalbila Area, Kalarmarchora, Moheshkhali, Cox's Bazar	21°42'44.453"N 91°55'43.944"E
6.	02/04/2024-03/04/2024	NL6	Rajghat Bazar Area, Matarbari, Moheshkhali, Cox's Bazar	21°43'40.747"N 91°54'17.653"E

Source: JICA Survey Team

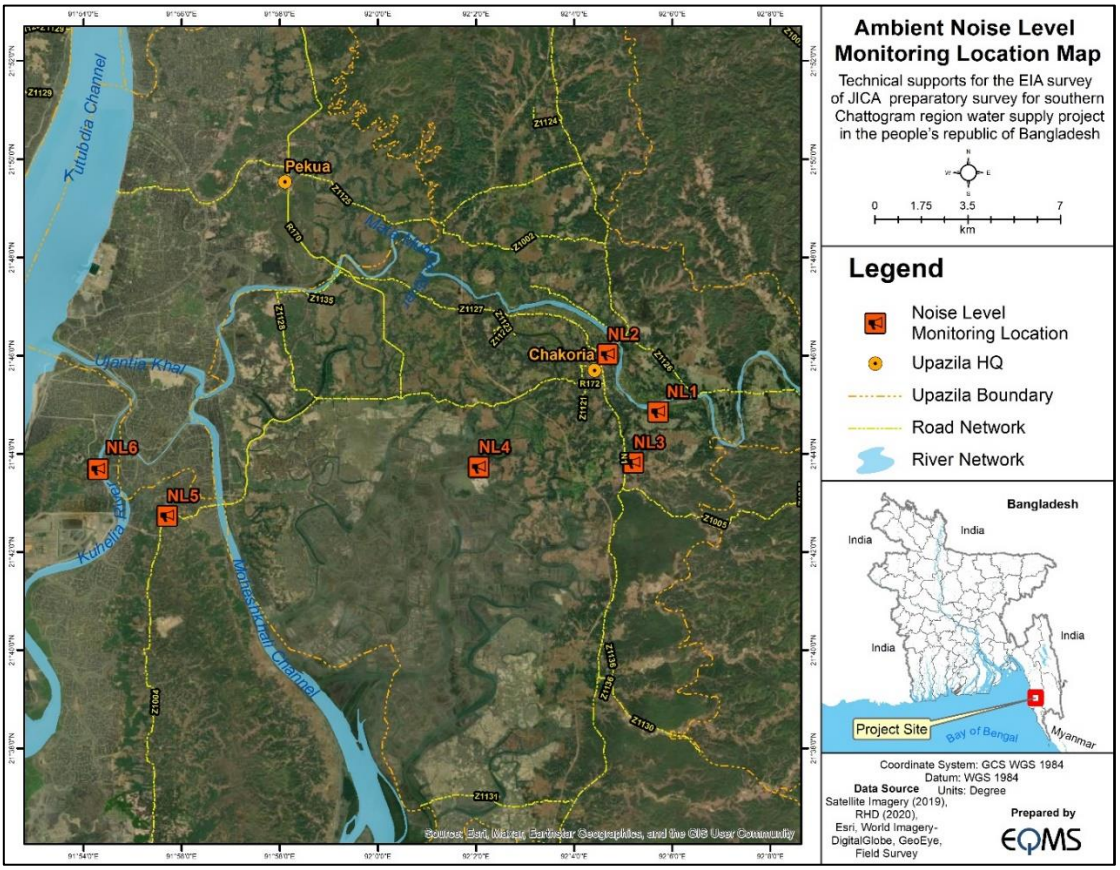


Figure 9.1.10 Noise Level Surveyed Location Map

Source: JICA Survey Team

Table 9.1.12 summarizes survey results. As shown in this table, noise level measured at NL1, NL2, NL3, NL4, and NL5 exceed the noise standards of Bangladesh during both day and night times. NL2 has the highest noise levels, significantly exceeding the standards for both day and night. NL6 is the only location on where noise levels are within the acceptable limits for both day and night.

Table 9.1.12 Survey Results (Ambient Noise Level: Dry Season)

Location Code	Categories	Leq dB(A) (Day)	Leq dB(A) (Night)	Bangladesh Standard at Day-time dB (A)	Bangladesh Standard at Night-time dB (A)
NL1	Mixed Zone	65.3	56.0	60	50
NL2	Commercial Zone	75.3	76.0	70	60

Location Code	Categories	Leq dB(A) (Day)	Leq dB(A) (Night)	Bangladesh Standard at Day-time dB (A)	Bangladesh Standard at Night-time dB (A)
NL3	Residential Zone	62.6	51.0	55	45
NL4	Residential Zone	56.3	50.5	55	45
NL5	Mixed Zone	67.2	55.0	60	50
NL6	Commercial Zone	58.1	53.2	70	60
Bangladesh Standards*					
			Silent Zone	50	40
			Residential Zone	55	45
			Mixed Zone	60	50
			Commercial Zone	70	60
			Industrial Zone	75	70

Source: JICA Survey Team

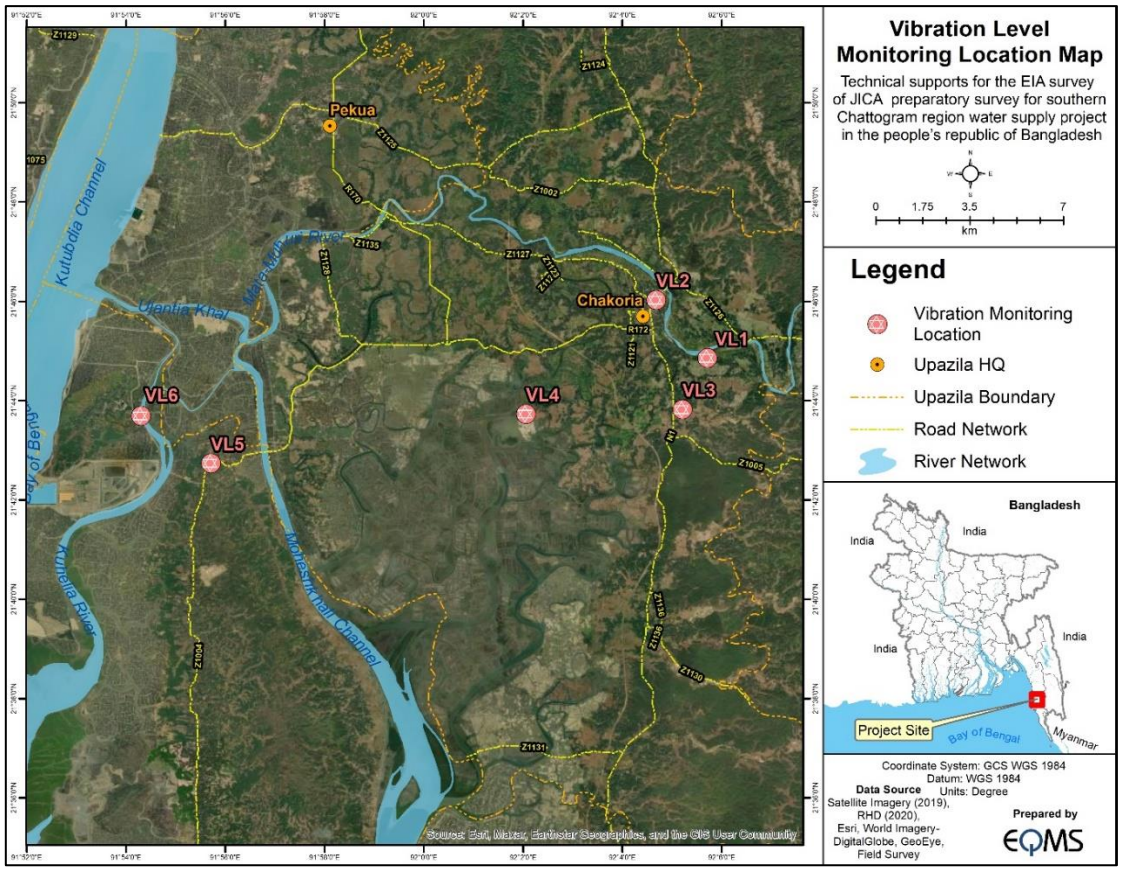
4) Vibration

Vibration level measurements were conducted 24 hours continuously in 6 (six) locations. The survey outline is summarized in Table 9.1.13. Figure 9.1.11 shows the survey location.

Table 9.1.13 Survey Outline (Vibration Level)

S/N	Survey Date	Location Code	Location Name	Geographical Location
1.	25/03/2024−26/03/2024	VL1	Brojendra Mohan Ghat Area, Digarpankhali, Chakaria, Cox's Bazar	21°44'52"N 92°5'45"E
2.	03/04/2024-04/04/2024	VL2	Infront of RHD Office, Chakaria Pourashava, Cox's Bazar	21°46'2.615"N 92°4'40.333"E
3.	01/04/2024-02/04/2024	VL3	Chararkul Area, Fasiakhali, Chakaria, Cox's Bazar	21°43'48.622"N 92°5'12.229"E
4.	27/03/2024−28/03/2024	VL4	Paschim Saodagar Ghona Area, Chiringa, Chakaria, Cox's Bazar	21°43'42.977"N 92°2'6.458"E
5.	26/03/2024−27/03/2024	VL5	Uttar Nalbila Area, Kalarmarchora, Moheshkhali, Cox's Bazar	21°42'44.453"N 91°55'43.944"E
6.	02/04/2024-03/04/2024	VL6	Rajghat Bazar Area, Matarbari, Moheshkhali, Cox's Bazar	21°43'40.747"N 91°54'17.653"E

Source: JICA Survey Team



Source: JICA Survey Team

Figure 9.1.11 Vibration Level Survey Location

Table 9.1.14 summarizes survey results. It is noted that there is no environmental standard for the vibration in Bangladesh yet. Therefore, the Australian standard (Department of Industry, Innovation, and Science, Australian government, Issue BS-6472- 2:2008) is proposed to follow for the project. As shown in this table, all survey results show that on average 24 hours the vibration levels are of 0.0 mm/s, which are well below the standard limits for all categories (residential, offices, and occupied non-sensitive sites).

Table 9.1.14 Analysis Result of Vibration Level (Dry Season)

Location Id.	Survey Date	Average Vibration Level (ppv, mm/s)
VL1	25/03/2024−26/03/2024	0.0
VL2	03/04/2024-04/04/2024	0.0
VL3	01/04/2024-02/04/2024	0.0
VL4	27/03/2024−28/03/2024	0.0
VL5	26/03/2024−27/03/2024	0.0
VL6	02/04/2024-03/04/2024	0.0
***Standard value for Ground vibration limits for human comfort by Department of Industry, innovation and Science, Australian government, Issue BS-6472-2:2008**		
Peak Component Particle Velocity		**PPV (mm/sec)**
Residential		0.3
Offices		0.6

Location Id.	Survey Date	Average Vibration Level (ppv, mm/s)
Occupied non-sensitive sites, such as factories and commercial premises		2.5

Source: JICA Survey Team

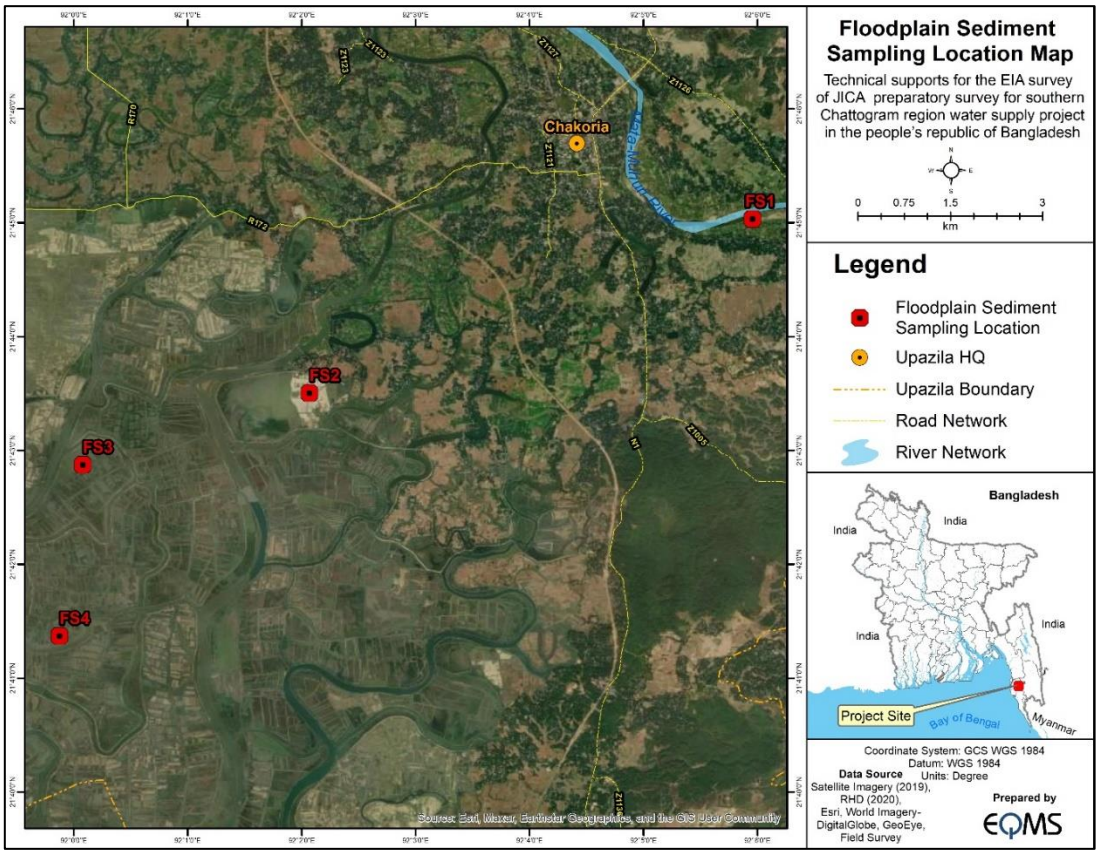
5) Floodplain Sediment

Table 9.1.15. Figure 9.1.12 shows the survey location.

Table 9.1.15 Survey Outline (Floodplain Sediment)

S/N	Survey Date	Location Code	Location Name	Geographical Location
1.	29/03/2024	FS1	Intake Point Area Near Matamuhuri River, Digar Pankhali, Fashiakhali Union, Chakaria, Cox's Bazar	21°45'1.88"N 92° 5'57.40"E
2.	29/03/2024	FS2	Kahariaghona Road Area, Near Baro Matamuhuri River, Chakaria, Cox's Bazar	21°43'33.002"N, 92°2'12.912"E
3.	28/03/2024	FS3	Rampur Area Near Chowarfari Canal, Chiringa, Chakaria, Cox's Bazar	21°42'58.048"N, 91°59'55.889"E
4.	28/03/2024	FS4	Rampur Area Near Isharfari Canal, Shaplapur Union, Moheshkhali, Cox's Bazar	21°41'21.393"N, 91°59'10.271"E

Source: JICA Survey Team



Source: JICA Survey Team

Figure 9.1.12 Floodplain Sediment Sampling Location

Table 9.1.16 summarizes survey results. It is noted that there is no environmental standard for the floodplain sediment in Bangladesh. Using several environmental standards regarding the soil contamination, implemented in Japan, such as Cadmium (45 mg/kg), Hg (15 mg/kg), CN (50 mg/kg as free cyanide), Pb (150 mg/kg), As (150 mg/kg), it can be said analytical results of those corresponding parameters are less than that environmental standard, respectively.

Table 9.1.16 Floodplain Sediment Quality Analytical Results (Dry Season)

S/N	Parameter	Unit	FS1	FS2	FS3	FS4	Bangladesh Standard
1.	Temperature	°C	28.1	27.3	27.6	27.2	–
2.	Sulfide	ppm	<0.1	<0.1	<0.1	<0.1	–
3.	Mercury (Hg)	mg/kg	0.50	0.35	0.32	0.25	–
4.	Cadmium (Cd)	mg/kg	0.07	0.07	0.07	0.07	–
5.	Lead (Pb)	mg/kg	8.97	8.57	7.96	7.96	–
6.	Organic Phosphorus (Org-P)	mg/kg	<0.002	<0.002	<0.002	<0.002	–
7.	Chromium (Cr)	mg/kg	20.2	21.7	19.6	19.5	–
8.	Arsenic (As)	mg/kg	1.81	3.00	3.24	2.90	–
9.	Cyanide (CN)	ppm	<0.005	<0.005	<0.005	<0.005	–
10.	Copper (Cu)	mg/kg	16.6	17.3	16.1	14.8	–
11.	Zinc (Zn)	mg/kg	48.8	51.6	46.5	48.6	–
12.	Fluoride (F)	mg/kg	4.33	23.5	35.4	3.37	–
13.	Sodium (Na)	mg/kg	703	4836	5949	5452	–
14.	Potassium (K)	mg/kg	1388	1917	1896	1945	–
15.	Chloride (Cl)	mg/kg	90.0	10949	15533	12839	–
16.	Calcium (Ca)	mg/kg	1731	1039	1011	1040	–
17.	Magnesium (Mg)	mg/kg	2273	2162	2145	2208	–

Source: JICA Survey Team

The survey data during rainy season will be shown after the result of analysis get finalized.

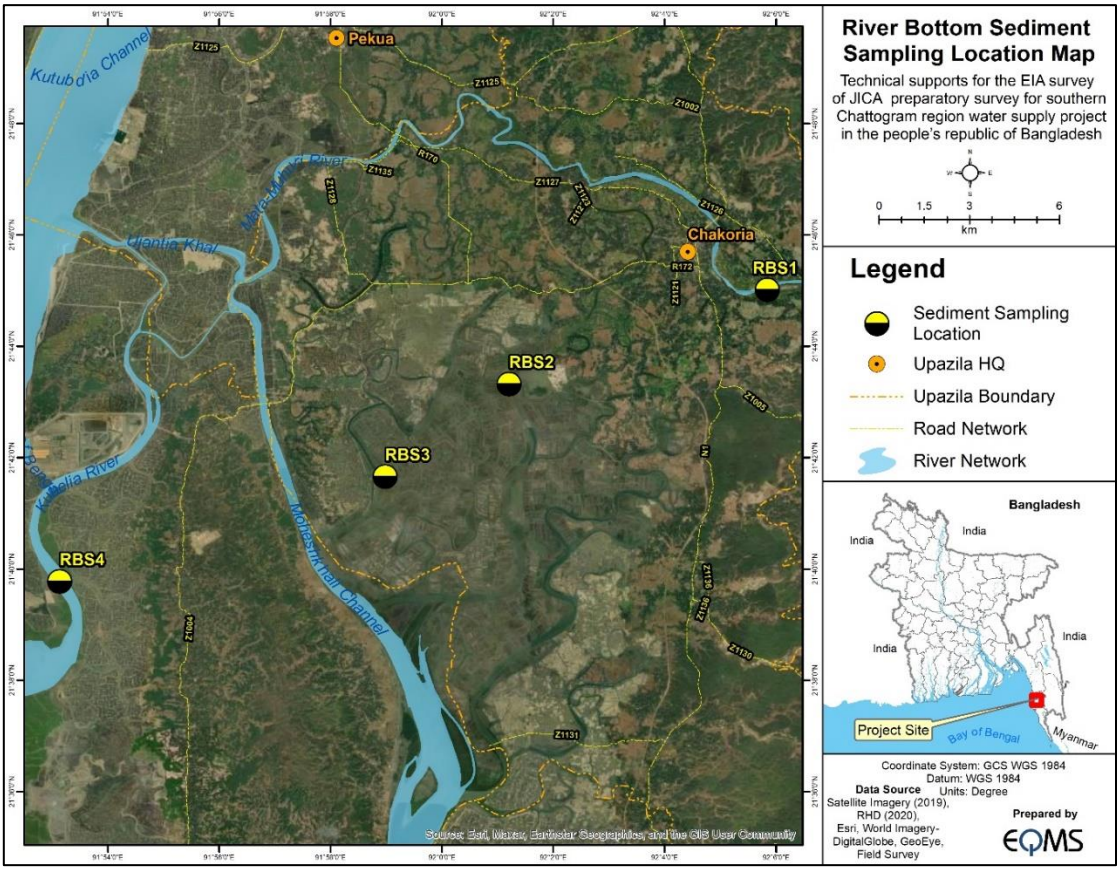
6) River Bottom Sediment

River bottom sediment survey was conducted at four (4) points. The survey outline is summarized in Table 9.1.17. Figure 9.1.13 shows the survey location.

Table 9.1.17 Survey Outline (River Bottom Sediment)

S/N	Survey Date	Location Code	Location Name	Geographical Location
1.	29/03/2024	RBS1	Intake Point Area Near Matamuhuri River, Digar Pankhali, Fashiakhali Union, Chakaria, Cox's Bazar	21°45'0.46"N 92° 5'50.20"E
2.	29/03/2024	RBS2	Bara Matamuhuri River, Chakaria, Cox's Bazar	21°43'16.41"N 92° 1'14.37"E
3.	28/03/2024	RBS3	Matamuhuri River, Rampur Area, Chakaria, Cox's Bazar	21°41'15.497"N 91°58'49.054"E
4.	30/03/2024	RBS4	Kuhelia River, Dhalghata, Moheshkhali, Cox's bazar	21°39'48.653"N 91°53'1.19"E

Source: JICA Survey Team



Source: JICA Survey Team

Figure 9.1.13 River Bottom Sediment Sampling Location

1) Discussion

Table 9.1.18 summarizes survey results. It is noted that there is no environmental standard for the floodplain sediment in Bangladesh. Using several environmental standards regarding the soil contamination, implemented in Japan, such as Cadmium (45 mg/kg), Hg (15 mg/kg), CN (50 mg/kg as free cyanide), Pb (150 mg/kg), As (150 mg/kg), it can be said analytical results of those corresponding parameters are less than that environmental standard, respectively.

Table 9.1.18 River Bottom Sediment Quality Analytical Results (Dry Season)

S/N	Parameter	Unit	RBS1	RBS2	RBS3	RBS4	Bangladesh Standard
1.	Temperature	°C	26.2	26.7	26.1	26.5	
2.	Sulfide	Ppm	<0.1	<0.1	<0.1	<0.1	–
3.	Mercury (Hg)	mg/kg	0.20	0.19	0.22	0.20	–
4.	Cadmium (Cd)	mg/kg	0.07	0.06	0.07	0.07	–
5.	Lead (Pb)	mg/kg	7.17	3.90	6.67	7.48	–
6.	Organic Phosphorus (Org-P)	mg/kg	<0.002	<0.002	<0.002	<0.002	–
7.	Chromium (Cr)	mg/kg	14.8	15.9	17.1	16.8	–
8.	Arsenic (As)	mg/kg	3.58	3.31	2.30	2.09	–
9.	Cyanide (CN)	Ppm	<0.005	<0.005	<0.005	<0.005	–
10.	Copper (Cu)	mg/kg	12.6	12.9	13.9	17.3	–

S/N	Parameter	Unit	RBS1	RBS2	RBS3	RBS4	Bangladesh Standard
11.	Zinc (Zn)	mg/kg	39.3	40.9	42.7	42.1	–
12.	Fluoride (F)	mg/kg	32.5	33.7	42.3	44.9	–
13.	Sodium (Na)	mg/kg	522	5025	6382	7752	
14.	Potassium (K)	mg/kg	1032	1585	1664	2133	–
15.	Chloride (Cl)	mg/kg	840	14940	17585	18859	–
16.	Calcium (Ca)	mg/kg	1370	1026	1116	1967	–
17.	Magnesium (Mg)	mg/kg	2086	2084	2169	2280	–

Source: JICA Survey Team

(2) Natural Environment Items

1) Protected Area

According to the Wildlife (Protection and Safety) Act, 2012, protected area is defined as "all sanctuaries, national parks, community conservation areas, safari parks, eco-parks, and botanical gardens declared by the government under "Sections 13, 17, 18 and 19 of Chapter IV", and special biodiversity conservation areas established under "Section 22 of Chapter V" and national heritage and kunjaban[2] declared under "Section 23". According to the Environment Conservation Act, 1995 (revised 2010), Ecologically Critical Area (ECA) is defined as such areas rich in unique biodiversity or due to the importance of environmental perspective necessary to protect or conserve from destructive activities under "Section 5" of this Act. If development projects are planned in or near these areas, necessary studies such as EIA should be conducted in accordance with relevant Bangladeshi laws, and mitigation measures should be taken as necessary.

Table below summarizes the conditions listed within FAQ of JICA Guideline need to be fulfilled if this project area covers such critical areas.

Table 9.1.19 Conditions, summarized within JICA Guideline FAQ

Conditions	Findings/Mitigation
(1) No feasible alternative plans shall be available in areas other than the area designated as such by the country and/or local governments by laws and/or ordinances to protect nature and cultural heritage ("the Designated Area" hereinafter):	No feasible alternative water supply projects exist since the main objective of this project is to provide the water resources of MIDI-MP area.
(2) Development in the Designated Area shall be legally acceptable by the host country's domestic laws:	There are several on-going projects around Fasiakhali WS and its buffer zones such as Chittagong Cox's Bazar Railway Project (ADB, construction completed), Chattogram- Cox's Bazar Highway Improvement Project (JICA, F/S) and Matarbari Port Access Road Construction Project (JICA, F/S). Those projects run through buffer zones of Fasiakhali WS partially and already obtained relevant environmental clearance certificate (ECC) of those projects.

2 Specified area enriched with different species of trees, herbs, and shrubs, which is rich in biodiversity and bears cultural, social, and traditional values to local community.

Conditions	Findings/Mitigation
(3) Project proponents, shall comply with the laws, ordinance concerning the Designated Area and management plan of the protected zones:	ECA Management Rule (2016) states ways of ECA management process. It is important to request the project proponent to comply with this rule while allocating sufficient human resources and budget for its fulfilment.
(4) Project proponents, shall form a consensus about project implementation with stakeholders including organizations responsible for managing the Designated Area, local communities through consultations:	ECA Management Rule (2016) stress out the importance of community-based ECA management. It is essential to request the project proponent to establish good, long-term liaison with local community people and relevant stakeholders for effective and sustainable development therein.
(5) Project proponents, shall perform additional programmes, where necessary, to ensure that the Designated Area is effectively managed for its conservation.*	As mentioned above (see Finding/Mitigation of Condition 3), it is important to request the project proponent to implement additional conservation programmes where necessary to ensure that the designated critical area is effectively managed for its conservation by conservation unit, to be set up within the project proponent.

Source: Answers to Frequently Asked Questions About Japan International Co-operation Agency (JICA)'s Guidelines for Environmental and Social Considerations (2022).

According to the Forest Department[3] there are 53 sites of protected area in Bangladesh, and as per the Department of Environment[4], there are 13 sites of ECA in Bangladesh. There are 11 sites of protected area (four national parks, seven wildlife sanctuaries) and three sites of ECA in Chattogram District, Cox's Bazar District, and Bandarban District, which are around the project area as shown in Table 9.1.20 below. A location map is shown in Figure 9.1.14 below. Fashiakhali Wildlife Sanctuary is the nearest wildlife sanctuary, located approximately 0.03 km from the conveyance pipeline. The wildlife sanctuary is categorized as "IV: Nature conservation reserve" under the protected area management categories of International Union for Conservation of Nature and Natural Resources (IUCN) due to frequent movements of Asian Elephant[5].

It is likely that the right of way (RoW) of the proposed delivery pipeline route connecting the water intake point and the water reservoir pass through the buffer zone of this Fashiakhali WS partially. It is reported that roughly 20 Asian Elephants (CR) occur across this WS and those elephants migrate surrounding areas through this buffer zone.

Sonadia Island ECA is located approximately 14 km to the south from the transmission route crossing point of the Kohelia River and there is the buffer zone in the north part of the ECA and the buffer zone is located 2 km from the nearest distribution reservoir. Medhakachhapia National Park is located approximately 9 km to the south from the nearest transmission pipeline.

3 https://bforest.gov.bd/site/page/5430ce33-561e-44f6-9827-ea1ebaa2c00d/-

4 http://www.doe.gov.bd/site/page/9481fd1b-7ca6-4087-890a-886cd226df0e/-

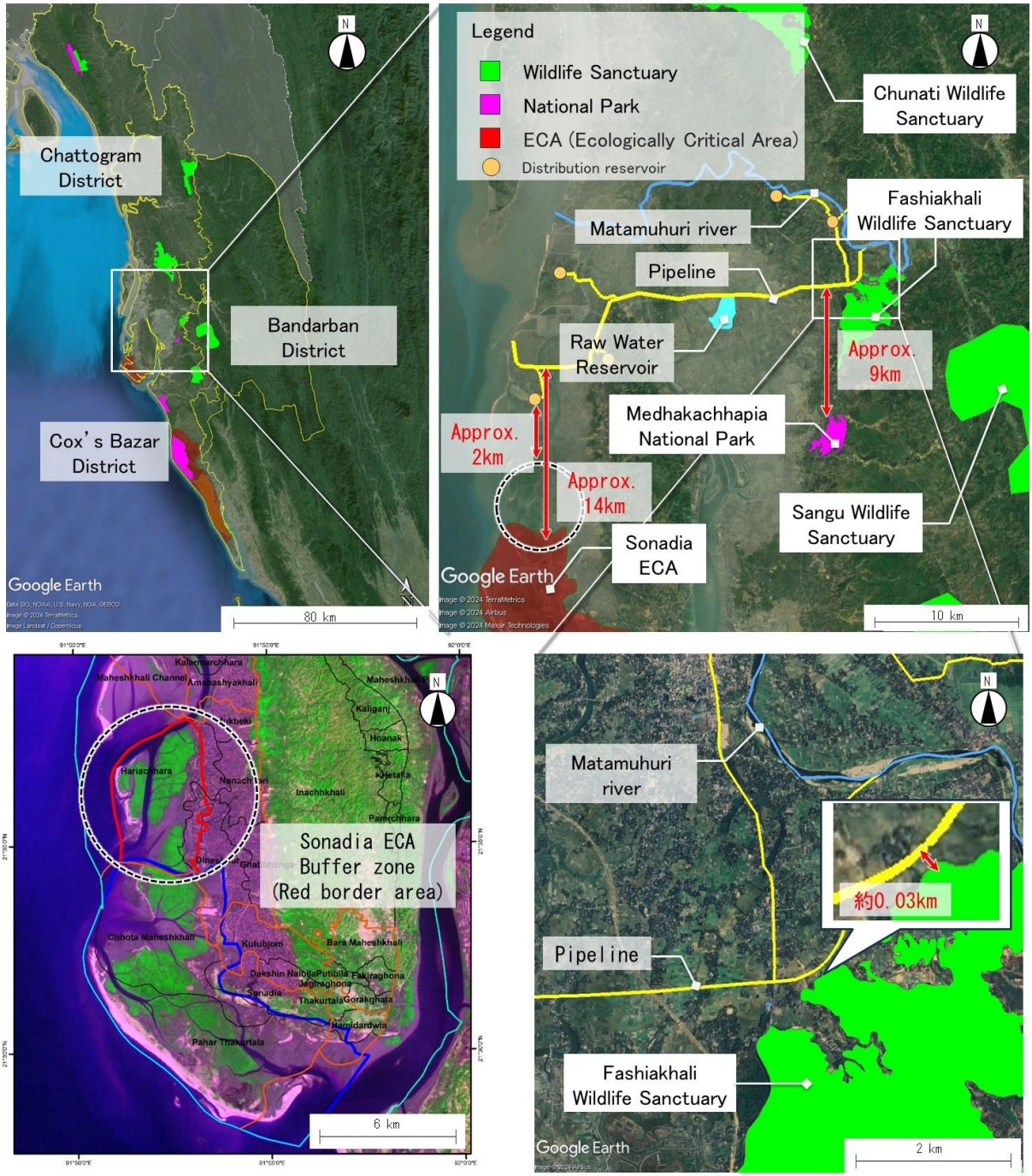
5 Management Plan for Fasiakhali Wildlife Sanctuary, https://bforest.portal.gov.bd/sites/default/files/files/bforest.portal.gov.bd/page/e85e229f_db68_4ac5_a058_dfc0433bc6a8/2021-06-20-06-54-f282751e5d1c43e90c3da79117a1fe19.pdf

Sonadia Island ECA (see Figure 9.1.14) is categorized as "Critical Habitat" since several IUCN-categorized CR and EN species such as Spoon-billed Sandpiper (CR), Hawks Bill Turtle (CR), Fishing Cat (CR), Green Turtle (EN), Olive Ridley Turtle (EN), Irrawaddy Dolphin (EN) are observed therein (confirmed through interviews with DoF, IUCN Bangladesh Office and WCS Bangladesh Office, JICA 2023). Ong-term migratory bird observation is conducted by IUCN and several nests of the spoon-billed sandpipers are observed around this ECA and its buffer zone (see Figure 9.1.16).

Table 9.1.20 Protected Areas and ECA around the Project Area

Name	Location	Area (ha)	Year of Declaration
National Park			
Himchari National Park	Cox's Bazar	1,729	1980
Medhakachhapia National Park	Cox's Bazar	395.92	2004
Baroiyadhala National Park	Chittagong	2,933.61	2010
Sheikh Jamal Inani National Park	Cox's Bazar	7,085.16	2019
Wildlife Sanctuary			
Chunati Wildlife Sanctuary	Chittagong	7,763.97	1986
Fashiakhali Wildlife Sanctuary	Cox's Bazar	1,302.42	2007
Dudpukuria-Dhopachari Wildlife Sanctuary	Chittagong	4,716.57	2010
Hajarikhil Wildlife Sanctuary	Chittagong	1,177.53	2010
Sangu Wildlife Sanctuary	Bandarban	2,331.98	2010
Teknaf Wildlife Sanctuary	Cox's Bazar	11,614.57	2009
Baishari Bangdepa Wildlife Sanctuary	Cox's Bazar	2,233.055	2023
Ecologically Critical Area			
Cox's Bazar-Teknaf Peninsula	Cox's Bazar	20,373	1999
St. Martin's Island	Cox's Bazar	1,214	1999
Sonadia Island	Cox's Bazar	10,298	1999

Source: JICA Survey Team



Note: The boundary of core zone of the Fashiakhali Wildlife Sanctuary is shown.

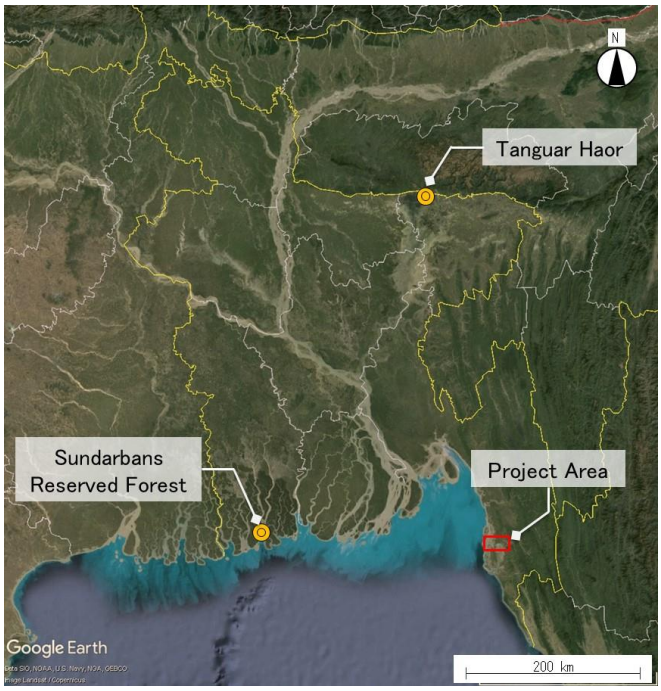
Source: Prepared by the JICA Survey Team based on Google Earth, the lower left figure is collected from DOE[6]

Figure 9.1.14 Locations of Protected Areas and ECA around the Project Area

6 Final Report of the Preparatory Survey on Matarbari Ultra Super Critical Coal-fired Power Plant Development Pr oject Phase 2 in Bangladesh (JICA, 2021), https://openjicareport.jica.go.jp/pdf/12337333_01.pdf

2) Ramsar Convention Wetlands

As of April 2024, there are two Ramsar wetlands[7] in Bangladesh, i.e., Sundarbans Reserved Forest and Tanguar Haor. Since both of these sites are far enough from the project area, impacts from the Project is not expected.



Source: Prepared by the JICA Survey Team based on Google Earth

Figure 9.1.15 Locations of Ramsar Convention Wetlands around the Project Area

3) Important Bird and Biodiversity Areas (IBAs)

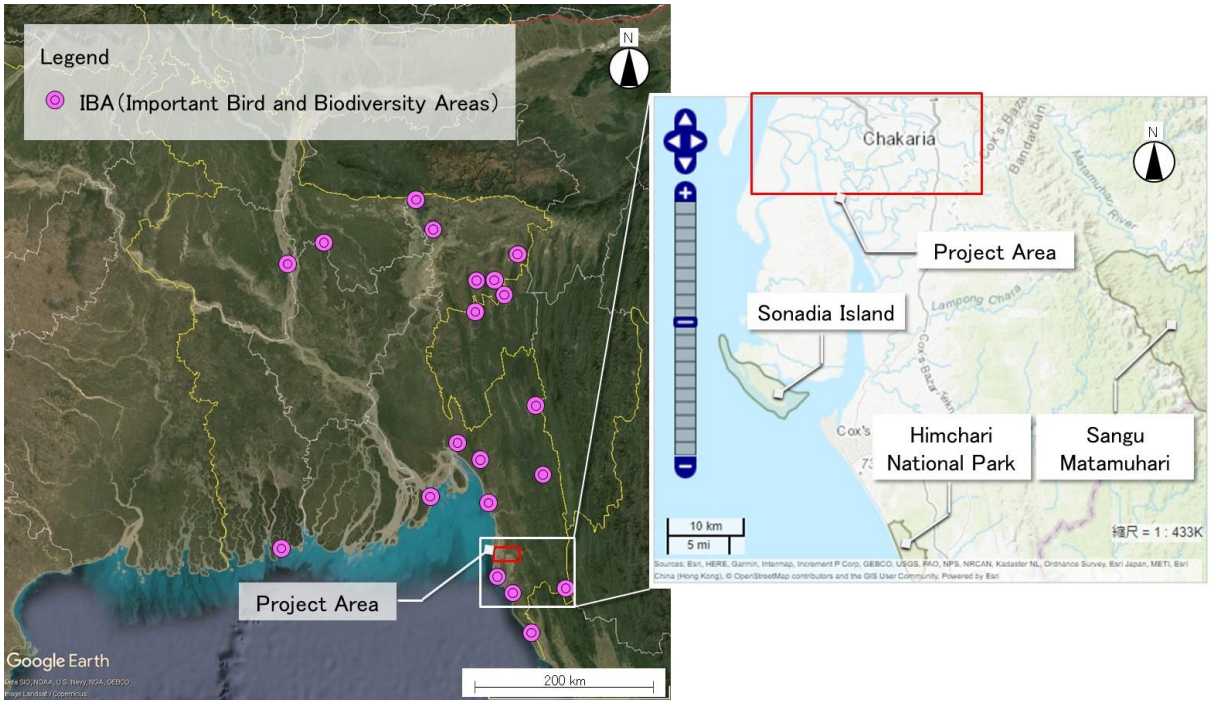
IBAs aim at selecting "important natural habitats using birds as indicator species" based on international criteria (IBAs criteria), conserving not only individual habitats but networks of habitats, globally. In Bangladesh, 20 sites are selected for IBAs and the nearest site from the project area is Sonadia Island; however, the site is located more than 20 km far from the project area. In Sonadia Island ECA, there are several migratory sites for Spoon-billed Sandpiper, which are categorized under the endangered (CR) (200 birds are observed in the world and 20 of them are confirmed within Sonadia Island ECA) (see Figure 9.1.16 below).

7 https://rsis.ramsar.org/ris-search/?f%5B0%5D=regionCountry_en_ss%3AAsia&f%5B1%5D=regionCountry_en_ss%3ABangladesh&pagetab=0



Source: Provided by IUCN (2023)

Figure 9.1.16 Habitats of Important Bird Species such as Spoon-billed Sandpiper in Sonadia ECA



Source: Prepared by the JICA Survey Team based on Google Earth

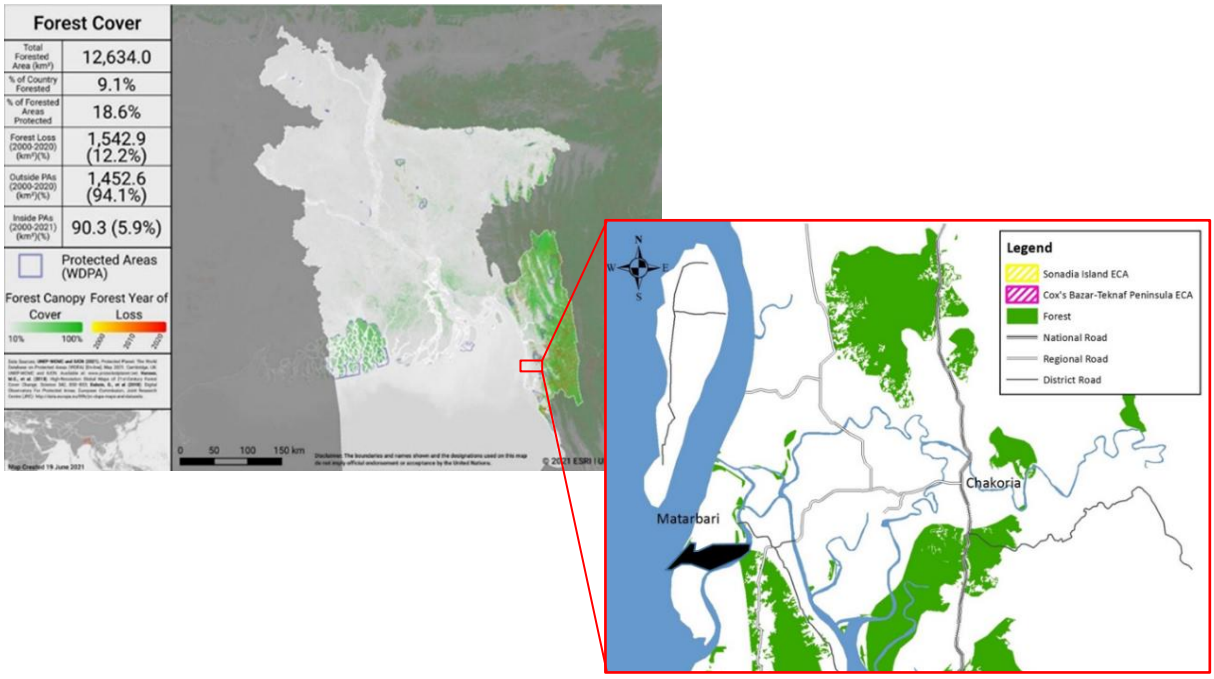
Figure 9.1.17 Locations of IBAs around the Project Area

4) Forest

The forest cover and loss in Bangladesh is shown in Figure 9.1.18 below.

Forest covers the southeast and southwest regions of Bangladesh, and 1,542.9 km^2 of forest has been lost in the past 20 years from 2000 to 2020 probably due to human habitation, agricultural expansion, and the use of wood for various purposes.

The project area has already been developed; however, there are several small-scale reserved forests (RFs) around the project area. Within those RF areas, the traditional use of forest products (such as fuelwoods and timbers for each household's traditional use) is permitted for nearby local communities therein (note that the regional office of Forest Department has the latest information on those RFs). The World Bank-funded mangrove plantation project was implemented at the channel between Matarbari and Moheshkhali islands (completed in June 2015).[8]



Source: https://www.cbd.int/pa/doc/dossiers/bangladesh-abt11-country-dossier2021.pdf, Final Report of the Preparatory Survey on Matarbari Ultra Super Critical Coal-fired Power Plant Development Project Phase 2 in Bangladesh (JICA, 2021)

Figure 9.1.18 Forest Cover in Bangladesh

5) Biodiversity

The project area consists of (i) coastal habitats covering coastal wetlands and beaches, (ii) wetlands covering rivers, (iii) homestead, (iv) mangrove forest ,(v) natural forest/hill forest, (vi) agricultural lands

[8] According to the Final Report of Preparatory Survey on Matarbari Ultra Super Critical Coal-fired Power Plant Development Project Phase 2 in Bangladesh, the information is based on interview with DoF, conducted within JICA-financed "Data Collection Survey on Integrated Development for Southern Chittagong Region in the Republic of Bangladesh (2016)

and shrimp farms/salt pans. A brief description of identified habitat is provided in Table 9.1.21 and Figure 9.1.19 below.

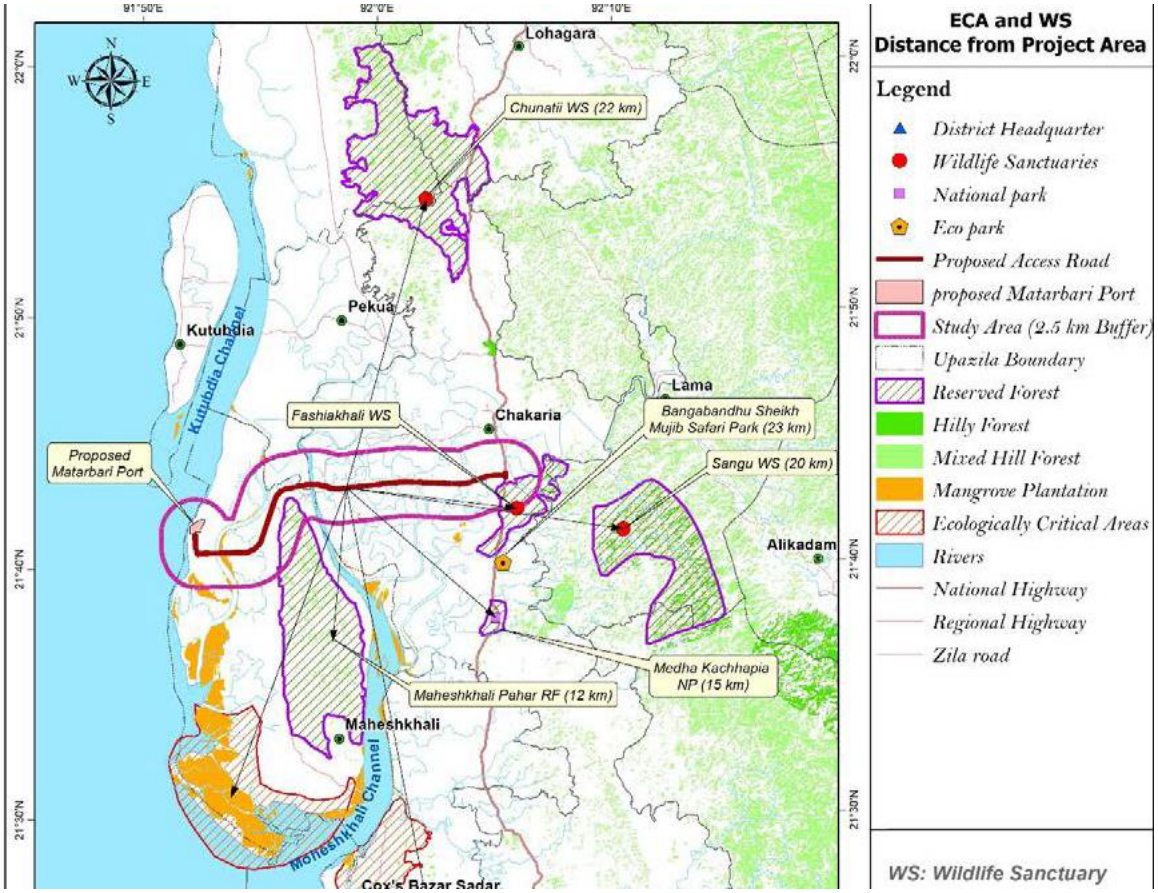
Table 9.1.21 Biodiversity around the Project Area

Items	Contents
Coastal Habitat covering Coastal Wetlands and Beaches	Coastal habitat is an important habitat with diverse biodiversity. This particular habitat is composed of coastal wetlands (up to 2-meter depth of sea water during low tide), sandy beaches, and mudflats. Mangroves grow only in mudflat areas. The sandy and mudflats are the main roosting grounds of many migratory and resident water birds. Sea turtles normally use only the sandy beaches for nesting. Sand dunes vegetation grows in the sand dune areas. The coastal wetlands are the habitats for dolphins and are also the main source of marine fishes, crabs, shrimps, and shells.
Wetlands covering the Rivers and Beels	This type of habitat includes ponds, lakes, and rivers (large and small rivers). The Kohelia, Badarkhali, and Matamuhuri rivers are the main rivers in the area. However, some seasonal and perennial beels and ponds are observed in the inlands of the area. Wetlands are the main source of freshwater fish and also some brackish water fishes.
Homestead Areas	The homestead area is also a major habitat type, having local and indigenous species of plants and common wildlife (bats and rats). Large and conspicuous plant species are planted and mainly represent both timber and fruit yielding species. It provides refuge for feeding and nesting of many common wildlife.
Mangrove Forest	Mangrove vegetation grows in mudflat areas, often in estuarine areas. Mangroves are found in the outer boundary of Kutubdia Island, Moheshkhali Island, and maximum parts of Sonadia Island, Bakhkhali and Choufladi estuaries within the study area. A total of 29 plant species* were recorded from the mangroves. Mangroves also harbor a rich fauna species, particularly birds and invertebrates. Otter and the Snapping Cat** (listed as endangered) are also found in this habitat type. Along the pipeline alignment, in particular, at the crossing point of the Kohelia River, there are several mangrove vegetation areas, reforested with the support of the World Bank.
Natural Forest/Hill Forest	Natural forests exist normally in the hilly areas. All the national parks, wildlife sanctuaries, and reserve forests of the study area are situated in the hilly areas having rich flora and fauna diversity. Hill forests are rich in both herbs and tree species. Major resident bird, amphibians and mammal species thrive in this habitat type.
Agricultural Lands and Shrimp Farms/ Salt Pans	There are a number of shrimp farms/salt pans located in Moheshkhali, Kutubdia Island, Sonadia Island, Moheshkhali Island, and some parts of Chakaria Sundarbans area at the southeastern part of Chakaria Upazila. These are extensively used for shrimp farming therefore, are poor in biodiversity. Likewise, salt pans are also extremely poor in biodiversity. These shrimp farms have been established by clearing mangrove vegetation. Agricultural land is a dominant habitat type within the study area. Flora species of agricultural land represent the herbaceous species. Some common bird species, frogs, etc., are found in this habitat type.

* JICA 2018, Final Report of Environmental Impact Assessment (EIA) (Road) for the JICA Matarbari Port Development Preparatory Survey Project

** Preparatory Survey on Matarbari Ultra Super Critical Coal-fired Power Plant Development Project Phase 2 in Bangladesh (2021), Snapping Cat Conservation Classification is based on IUCN Red List of Threatened Species, https://www.iucnredlist.org/species/18150/50662615 (referred on April 15, 2024)

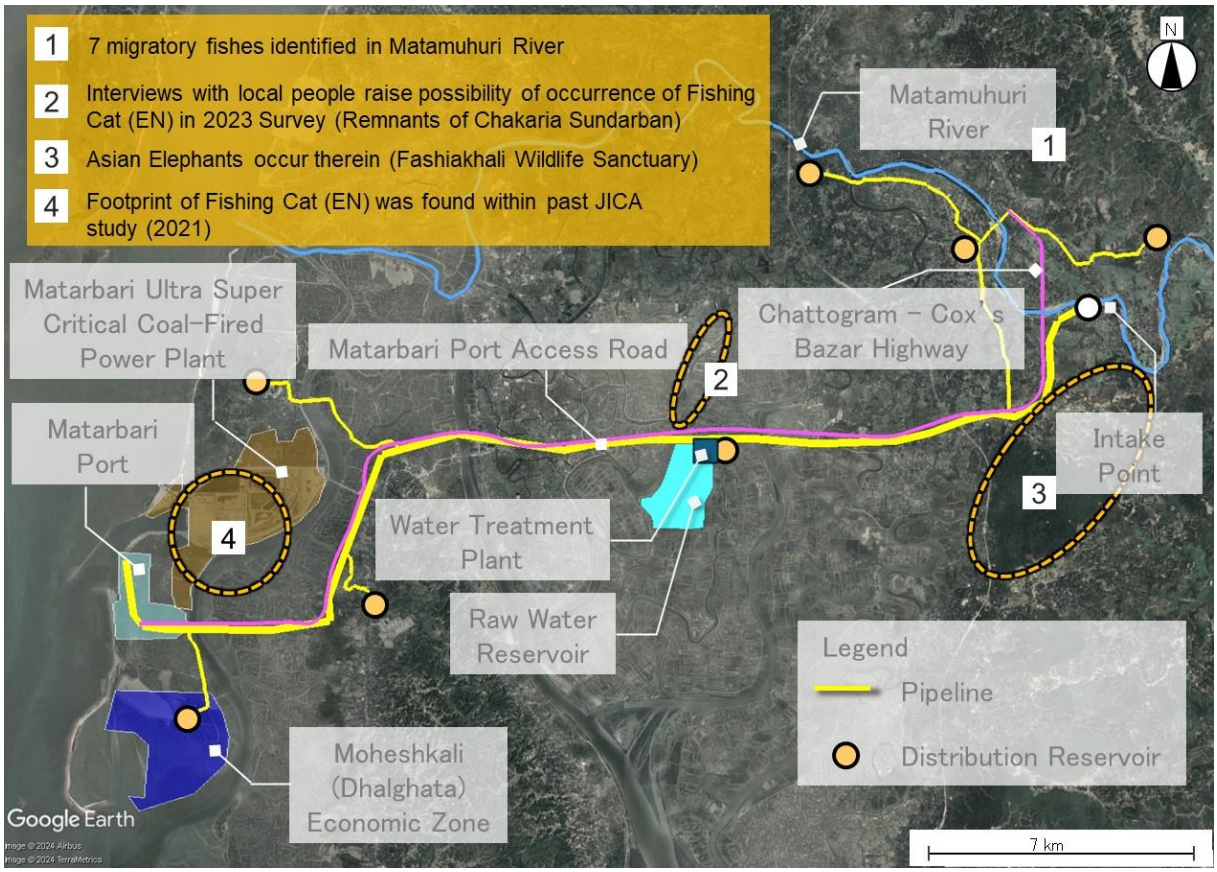
Source: JICA Survey Team



Source: JICA 2018, Final Report of Environmental Impact Assessment (EIA) (Road) for the JICA Matarbari Port Development Preparatory Survey Project

Figure 9.1.19 Local biodiversity around Matarbari – Moheshkhali Area

Observed and collected information related to biodiversity is summarized in Figure 9.1.20 below.



* 1 and 2: Information is collected through site survey, 3 and 4 : Existing information is reviewed
Source: Prepared by the JICA Survey Team based on Google Earth

Figure 9.1.20 Observed and Collected Information Related to Biodiversity

6) Fauna

Transect survey method was applied to survey the wildlife species such as birds, mammals, herpetofauna (amphibians and reptiles) and insect species present in the study area. Five (05) transects, explained within the floral survey, mentioned above, were used. Two times surveys (daytime and nighttime, respectively) are conducted. In addition, consultation with local people in the study area was also conducted during the study period. Several topics related to wildlife presence in the study area were discussed which helped to lead the survey.

(a) Mammals

Fourteen (14) terrestrial mammal species belonging to nine (9) families were reported to be observed in the study area during the field visit in March 2024. Table 9.1.22 summarizes recorded terrestrial mammal species.

Table 9.1.22 List of Recorded Mammal Species in the Study Area

Sl. No.	Common Name	Local Name	Scientific Name	Family	IUCN Local Status*	IUCN Global Status**	Sources***
1.	Asian house shrew	Chika	*Suncus murinus*	Soricidae	LC	LC	C
2.	Common House Rat	Idur	*Rattus rattus*	Muridae	LC	LC	C
3.	Common Indian Field Mouse	Metho Idur	*Mus booduga*		LC	LC	C
4.	House Mouse	Nengti Idur	*Mus musculus*		LC	LC	C
5.	Large Bandicoot Rat	Dhari Indur	*Bandicota indica*		LC	LC	D
6.	Fishing Cat	Mechho Bira	*Prionailurus viverrinus*	Felidae	EN	EN	C
7.	Jungle cat	Ban Biral	*Felis chaus*		NT	LC	C
8.	Small Indian Civet	Baghdas	*Viverricula indica*	Viverridae	NT	LC	C
9.	Golden Jackal	Pati Shial	*Canis aureus*	Canidae	LC	LC	C
10.	Indian Flying Fox	Baro Badur	*Pteropus giganteus*	Pteropodidae	LC	LC	D
11.	Irrawaddy Squirrel	Kathbirali	*Callosciurus pygerythrus*	Sciuridae	LC	LC	D
12.	Common Mongoose	Boro Beji	*Herpestes edwardsii*	Herpestidae	LC	LC	C
13.	Small Indian Mongoose	Choto Beji	*Urva auropunctata*		LC	LC	C
14.	Oriental Small-clawed Otte	Uud Biral	*Aonyx cinerea*	Mustelidae	EN	VU	C

**IUCN Bangladesh. 2015. Red List of Bangladesh Volume 2: Mammals; LC=Least Concern, NT=Near Threatened, EN=Endangered*

***IUCN 2024. The IUCN Red List of Threatened Species. Version 2023-1. (https://www.iucnredlist.org/)*

**** D=Direct Observation; C=Consultation with local people*

Source: JICA Survey Team

Fishing cats (*Prionailurus viverrinus*) were not directly observed during the transect survey for the faunal study in the transect line. According to field observations and consultations with local people, Transect Line-1 (adjacent to the Kohelia River) encompasses a vast wetland habitat, potentially suitable for fishing cats. However, the degradation of the mangrove area, expansion of shrimp farming, and development of saltpans along the Kohelia River could be posing threats to the fishing cat population. Additionally, local people in the study area conflated the fishing cat (*Prionailurus viverrinus*) with the jungle cat (*Felis chaus*) species. During the consultation, the survey team showed pictures of both wild cat species, and some people mistakenly identified the 'Fishing cat' as "Baghdash" which is the local name for the 'Small Indian Civet (*Viverricula indica*)' in the study area.

Consultation with local people in Transect-2 (T-2) confirms the presence of both Fishing Cats (*Prionailurus viverrinus*) and Jungle Cats (*Felis chaus*). They recall observing fishing cats at least 3-5 years ago in the remaining mangroves of the Chakaria Sundarban area of Chakaria. However, they frequently observe Jungle Cat in the homestead area, likely coming to hunt prey.

During the field visit at Transect-3, the study team did not observe any conservation significant species. However, some fresh footprint of Golden Jackal (*Canis aureus*) was observed in the mangrove area of Ujantia. Consultation with local people at Transect Line-3 (T3), confirms that, there are no presence of Fishing Cat in Transect-3 area while Jungle Cat is frequently observed in this area.

Another consultation with local people in Transect Line-4 (T-4), the study team did not get any notable issues regarding wildlife composition, such as the occurrence of the 'Fishing cat' (*Prionailurus viverrinus*), 'Jungle Cat' (*Felis chaus*) in and around the transect line of the Matamuhuri River. Furthermore, according to the consultation, there is no conservation significant species found in and around the Transect line-3 (Matamuhuri River).

Consultation with local people at Transect-5 (T5) confirms that, they spotted Oriental Small-clawed Otter (*Aonyx cinerea*) less than 4 months ago in the upstream side of the Matamuhuri River. However, Fishing Cat were not observed by the local people residing adjacent to Transect-3 Line.

(b) Aves

In total, fifty-four (54) species of birds under twenty-nine (29) families were recorded from the study area. The highest number of birds belong to the family Scolopacidae (6 species) followed by Ardeidae, and Alcedinidae (5 species each). Among the recorded bird species, Black-headed Ibis (*Threskiornis melanocephalus*) is Vulnerable (VU) and Eurasian Curlew (*Numenius arquata*) is Near Threatened (NT), according to the IUCN Red List of Threatened Species of Bangladesh, 2015.

According to Global IUCN Red List Status (Version 2023-1), Black-headed ibis and Eurasian Curlew both are Near Threatened (NT). All the other 63 bird species found in the study area are Least Concern (LC) both for Global IUCN Red List Status (Version 2023-1) and IUCN Bangladesh Red List (2015).

The Black-headed Ibis (*Threskiornis melanocephalus*) has transitioned into a winter migrant to the region once a resident species in Bangladesh until the 1980s. During the winter season, it forms flocks

and frequents coastal mudflats and inland marshes. Active during the day, it employs its bill to probe into soft mud, and often dips its head momentarily into shallow waters while foraging. Its diet primarily consists of fish, frogs, and other mud-dwelling creatures. As per the IUCN Red List of Bangladesh (2015), the species is prevalent along the coast during winter but faces challenges due to the disturbance and pollution of its habitat, particularly the mudflats. Consequently, the Black-headed Ibis is classified as 'Vulnerable'. However, this species is abundantly found in the mudflat area of the Kohelia River and Kutubdia Channel.

Eurasian Curlew (*Numenius arquata*) is a winter migrant in coastal mudflats, creeks, mangroves and inland wetlands. It feeds on aquatic insects, crustaceans, invertebrates and occasionally small fish, amphibians, lizards, young birds and small rodents. his species is a common winter migrant to Bangladesh. During the field visit of March 2024, this species is mainly observed in the adjacent mudflat area of the Kohelia River, and downstream of the Matamuhuri River near Ujantia. Table 9.1.23 summarizes recorded terrestrial bird species.

Table 9.1.23 List of Recorded Avian Species from Transect Survey

Sl. No.	Common Name	Scientific Name	Family	Number of Individuals					IUCN Red List Status		Resident/ Migratory ***
				T1	T 2	T 3	T4	T5	National*	Global**	
1.	Ashy Woodswallow	*Artamus fuscus*	Artamidae	1	-	-	-	2	LC	LC	c/R
2.	Asian Green Bee-eater	*Merops orientalis*	Meropidae	-	-	-	3	5	LC	LC	c/R
3.	Asian Pied Starling	*Sturnus contra*	Sturnidae	17	6	4	-	12	LC	LC	c/R
4.	Barn Swallow	*Hirundo rustica*	Hirundinidae	2	-	-	-	-	LC	LC	c/wM
5.	Black Capped Kingfisher	*Halcyon pileate*	Alcedinidae	3	1	-	-	-	LC	LC	c/wM
6.	Black Drongo	*Dicrurus macrocercus*	Dicruridae	7	5	11	8	17	LC	LC	c/R
7.	Black Headed Ibis	*Threskiornis melanocephalus*	Threskiornithidae	27	6	23	-	-	VU	NT	r/wM
8.	Black Kite	*Milvus migrans*	Accipitridae	-	4	-	-	2	LC	LC	c/R
9.	Black-hooded Oriole	*Oriolus xanthornus*	Oriolidae	-	-	-	4	-	LC	LC	c/R
10.	Bronze-winged Jacana	*Metopidius indicus*	Jacanidae	-	-	8	-	-	LC	LC	c/R
11.	Brown Headed Gull	*Larus brunnicephalus*	Laridae	15	-	3	-	-	LC	LC	c/wM
12.	Chestnut-tailed Starling	*Sturnus malabaricus*	Sturnidae	-	-	-	14	3	LC	LC	c/R
13.	Cinereous Tit	*Parus cinereus*	Paridae	2	-	-	-	-	LC	LC	c/R
14.	Citrine Wagtail	*Motacilla citreola*	Motacillidae	3	5	2	-	2			c/wM
15.	Common Kingfisher	*Alcedo atthis*	Alcedinidae	3	-	6	-	8	LC	LC	c/R
16.	Common Myna	*Acridotheres tristis*	Sturnidae	-	-	12	27	36	LC	LC	c/R
17.	Common Redshank	*Tringa tetanus*	Scolopacidae	56	27	37	-	-	LC	LC	c/wM
18.	Common Greenshank	*Tringa nebularia*	Scolopacidae	8	12	-	-	-			c/wM
19.	Common Sand Piper	*Actitis hypoleucos*	Scolopacidae	26	17	-	5	-	LC	LC	c/wM
20.	Common Tailorbird	*Orthotomus sutorius*	Cisticolidae	-	-	-	-	2	LC	LC	c/R
21.	Eastern Yellow Wagtail	*Motacilla flava*	Motacillidae	4	-	6	-	-	LC	LC	c/wM
22.	Eurasian Collared Dove	*Streptopelia decaocto*	Columbidae	6	-	-	19	24	LC	LC	c/R
23.	Eurasian Curlew	*Numenius arquata*	Scolopacidae	29	12	31	-	-	NT	NT	c/wM
24.	Great Egret	*Ardea alba*	Ardeidae	4	-	-	-	-	LC	LC	c/R
25.	Greenish Warbler	*Phylloscopus trochiloides*	Phylloscopidae	-	-	-	-	2	LC	LC	c/wM
26.	Grey Heron	*Ardea cinerea*	Ardeidae	11	4	7	-	-	LC	LC	c/R
27.	House Crow	*Corvus splendens*	Corvidae	-	-	4	11	7	LC	LC	c/R

Sl. No.	Common Name	Scientific Name	Family	Number of Individuals					IUCN Red List Status		Resident/ Migratory ***
				T1	T 2	T 3	T4	T5	National*	Global**	
28.	Indian Pond Heron	*Ardeola grayii*	Ardeidae	34	28	17	21	20	LC	LC	c/R
29.	Indian Silverbill	*Lonchura malabarica*	Estrildidae	-	-	-	2	-	LC	LC	c/R
30.	Intermediate Egret	*Ardea intermedia*	Ardeidae	13	8	8	-	-	LC	LC	c/R
31.	Jungle Crow	*Corvus levaillantii*	Corvidae	-	-	-	1	3	LC	LC	c/R
32.	Jungle Myna	*Acridotheres fuscus*	Sturnidae	2	-	-	12	3	LC	LC	c/R
33.	Little Cormorant	*Microcarbo niger*	Phalacrocoracidae	11	17	7	4	-	LC	LC	c/R
34.	Little Egret	*Egretta garzetta*	Ardeidae	7	-	12	-	-	LC	LC	c/R
35.	Little Ringed Plover	*Charadrius dubius*	Charadriidae	11	4	-	-	-	LC	LC	Un/R
36.	Long-tailed Shrike	*Lanius schach*	Laniidae	-	-	3	8	4	LC	LC	c/R
37.	Marsh Sandpiper	*Tringa stagnatilis*	Scolopacidae	3	-	2	-	-	LC	LC	c/wM
38.	Oriental Magpie-Robin	*Copsychus saularis*	Muscicapidae	-	-	-	14	11	LC	LC	c/R
39.	Pacific Golden Plover	*Pluvialis fulva*	Charadriidae	48	23	31	-	-	LC	LC	c/wM
40.	Paddyfield Pipit	*Anthus rufulus*	Motacillidae	-	2	-	11	17	LC	LC	c/R
41.	Pied Kingfisher	*Ceryle rudis*	Alcedinidae	7	4	2	-	1	LC	LC	c/R
42.	Purple-rumped Sunbird	*Nectarinia zeylonica*	Nectariniidae	1	-	2	-	-	LC	LC	c/R
43.	Purple Sunbird	*Nectarinia asiatica*	Nectariniidae	3	-	2	-	-	LC	LC	c/R
44.	Red-vented Bulbul	*Pycnonotus cafer*	Pycnonotidae	-	-	7	21	11	LC	LC	c/R
45.	Red-whiskered Bulbul	*Pycnonotus jocosus*	Pycnonotidae	-	-	-	-	2			c/R
46.	Rosy Minivet	*Pericrocotus roseus*	Campephagidae	7	-	-	-	-	LC	LC	Un/wM
47.	Rufous Treepie	*Dendrocitta vagabunda*	Corvidae	-	-	2	4	2	LC	LC	c/R
48.	Western Spotted Dove	*Spilopelia chinensis*	Columbidae	-	-	-	7	-	LC	LC	c/R
49.	Whimbrel	*Numenius phaeopus*	Scolopacidae	26	9	33	-	-	LC	LC	c/wM
50.	White Wagtail	*Motacilla alba*	Motacillidae	2	-	7	-	-	LC	LC	c/wM
51.	White-breasted Waterhen	*Amaurornis phoenicurus*	Rallidae	-	-	-	-	5	LC	LC	c/R
52.	White-collared Kingfisher	*Todiramphus chloris*	Alcedinidae	2	-	-	-	-	LC	LC	c/R
53.	White-throated Fantail	*Rhipidura albicollis*	Rhipiduridae	-	-	-	1	4	LC	LC	c/R
54.	White-throated Kingfisher	*Halcyon smyrnensis*	Alcedinidae	4	3	-	-	-	LC	LC	c/R

**IUCN Bangladesh. 2015. Red List of Bangladesh Volume 3: Birds; LC=Least Concern, VU= Vulnerable, NT= Near Threatened*

***IUCN 2024. The IUCN Red List of Threatened Species. Version 2023-1. (https://www.iucnredlist.org/)*

****c: common, Un: Uncommon/ r: rare, w: winter, R: Resident, M: Migratory*

Source: JICA Survey Team

(c) Reptiles and Amphibians

During the field visit, a total of eight (8) species of amphibians belonging to two (2) families and nine (9) species of reptiles belonging to seven (7) families were listed (Direct observation and consultation with local people) from the study area. According to the IUCN Bangladesh Red-list (2015) and Global IUCN Red List Status (Version 2022-2), one (1) near threatened (NT) reptile species, Bengal Monitor Lizard (*Varanus bengalensis*) was found within the study area. Table 9.1.24 summarizes recorded terrestrial reptile and amphibian species.

Table 9.1.24 List of Recorded Amphibian and Reptile Species in the Study Area

Sl. No.	Common Name	Local Name	Scientific Name	Family	IUCN Local Status*	IUCN Global Status**	Source***
Amphibians							
1.	Asian Common Toad	Kuno Bang	*Duttaphrynus melanostictus*	Bufonidae	LC	LC	D
2.	Bangladeshi Cricket Frog	Asmater Jhi-jhi Bang	*Fejervarya asmati*	Dicroglossidae	LC	LC	C
3.	Crab-Eating Frog	Kakrabhuk Bang	*Fejervarya cancrivora*		LC	LC	C
4.	Green Frog	Shobuj Bang	*Euphlyctis hexadactylus*		LC	LC	C
5.	Indian Bull Frog	Kola Bang	*Hoplobatrachus tigerinus*		LC	LC	D
6.	Indian Skipper Frog	Kotkoti Bang	*Euphlyctis cyanophlyctis*		LC	LC	D
7.	Nepal Wart Frog	Nepali Jhi-Jhi Bang	*Fejervarya nepalensis*		LC	LC	C
8.	Bombay Wart Frog	Dakshinatter Jhi-Jhi Bang	*Fejervarya syhadrensis*		LC	LC	C
Reptiles							
1.	Banded Krait	Shangkhini	*Bungarus fasciatus*	Elapidae	LC	LC	C
2.	Bengal Monitor	Gui shap	*Varanus bengalensis*	Varanidae	NT	LC	D
3.	Checkered Keel Back	Dora shaap	*Xenochrophis piscator*	Colubridae	LC	NE	C
4.	Indian Rat Snake	Daraj shaap	*Ptyas mucosa*		LC	LC	C
5.	Common Garden Lizard	Roktochosa	*Calotes versicolor*	Agamidae	LC	LC	D
6.	Common Smooth Water Snake	Painna Shap	*Enhydris enhydris*	Homalopsidae	LC	LC	C
7.	Dog-Faced Water Snake	Jol bora Shap	*Cerberus rynchops*		LC	LC	D
8.	House Gecko	Tiktiki	*Hemidactylus frenatus*	Gekkonidae	LC	LC	D
9.	Indian Mabuya	Achil	*Eutropis carinata*	Scincidae	LC	LC	D

**IUCN Bangladesh. 2015. Red List of Bangladesh Volume 4: Reptiles and Amphibians; LC=Least Concern, NT=Near Threatened, NE= Not Evaluated*

***IUCN 2024. The IUCN Red List of Threatened Species. Version 2023-1 (https://www.iucnredlist.org/)*

****Sources code: D=Direct Observation; C=Consultation with local people*

Source: JICA Survey Team

(d) Insect

In total, fifty-one (51) species of insects under eighteen (18) families were recorded from the field observations. The highest species (11 species) was found under Libellulidae family followed by Nymphalidae family (7 species). Table 9.1.25 summarizes recorded terrestrial insect species.

Table 9.1.25 List of Insects in the Study Area

Sl. No.	Scientific Name	Common Name	Family
1.	*Oxya chinensis*	Short horned Grasshopper	Acrididae
2.	*Apis mellifera*	Western Honeybee	Apidae
3.	*Eutolmus rufibarbis*	Golden tabbed Robberfly	Asilidae
4.	*Aulacophora abdominalis*	Plain pumpkin beetles	Chrysomelidae
5.	*Aulacophora foveicollis*	Red pumpkin beetles	
6.	*Aulacophora frontalis*	Pumpkin beetle	
7.	*Nephotettix cincticeps*	Spotted jassid	Cicadellidae
8.	*Cicadoidea sp*	Cicadas	Cicadidae
9.	*Agriocnemis femina*	Pinhead wisp	Coenagrionidae
10.	*Agriocnemis pygmaea*	Wandering midget	
11.	*Ischnura elegans*	Blue-tailed damselfly	
12.	*Paracercion malayanum*	The Malay Lillysquatter	
13.	*Amata phegea*	Nine-spotted Moth	Erebidae
14.	*Aquarius conformis*	Water strider	Gerridae
15.	*Gryllus* sp.	Field cricket	Gryllidae
16.	*Oriens goloides*	Smaller Darlet	Hesperiidae
17.	*Ochlodes sylvanus*	Large Skipper butterfly	
18.	*Parnara guttatus*	Common Straight Swift	
19.	*Brachydiplax chalybea*	Rufous-Backed Marsh Hawk	Libellulidae
20.	*Trithemis pallidinervis*	Long legged marsh glider	
21.	*Orthetrum sabina*	Green marsh hawks	
22.	*Crocothemis servilia*	Common scarlet	
23.	*Sympetrum Meridionale*	Southern Darter	
24.	*Neurothemis tullia*	Pied paddy skimmer	
25.	*Brachythemis contaminata*	Ditch Dewel	
26.	*Crocothemis servilia*	Scarlet skimmer	
27.	*Neurothemis fulvia*	Fulvous Forest Skimmer	
28.	*Orthetrum sabina*	Slender skimmer	
29.	*Potamarcha congener*	Yellow-tailed Ashy Skimmer	
30.	*Castalius rosimon*	Common Pierrot	Lycaenidae
31.	*Jamides celeno*	Common Cerulean	
32.	*Lampides boeticus*	Long tailed blue Butterfly	
33.	*Pseudozizeeria maha*	Pale grass blue	
34.	*Musca domestica*	House fly	Muscidae
35.	*Junonia atlites*	Grey pansy	Nymphalidae
36.	*Ypthima huebneri*	Common Fourring	
37.	*Hypolimnas bolina*	Great Eggfly	

Sl. No.	Scientific Name	Common Name	Family
38.	*Elymnias hypermnestra*	Common Palmfly	
39.	*Junonia almana*	Peacock Pancy	
40.	*Melanitis leda*	Common evening brown	
41.	*Melanitis phedima*	Dark Evening Brown	
42.	*Papilio polytes*	Common Mormon	Papilionidae
43.	*Delias descombesi*	Red spot jezebel	Pieridae
44.	*Cepora nerissa*	Common Gull	
45.	*Appias libythea*	Striped albatross	
46.	*Eurema hecabe*	Common grass yellow	
47.	*Pareronia hippia*	Indian Wanderer	
48.	*Liatongus* sp.	Dung beetles	Scarabaeidae
49.	*Cyclocephala sp*	Scarab beetles	
50.	*Spodoptera litura*	Tobacco Cutworm	Noctuidae
51.	*Torbia viridissima*	Gum Leaf Katydid	Tettigoniidae

Source: JICA Survey Team

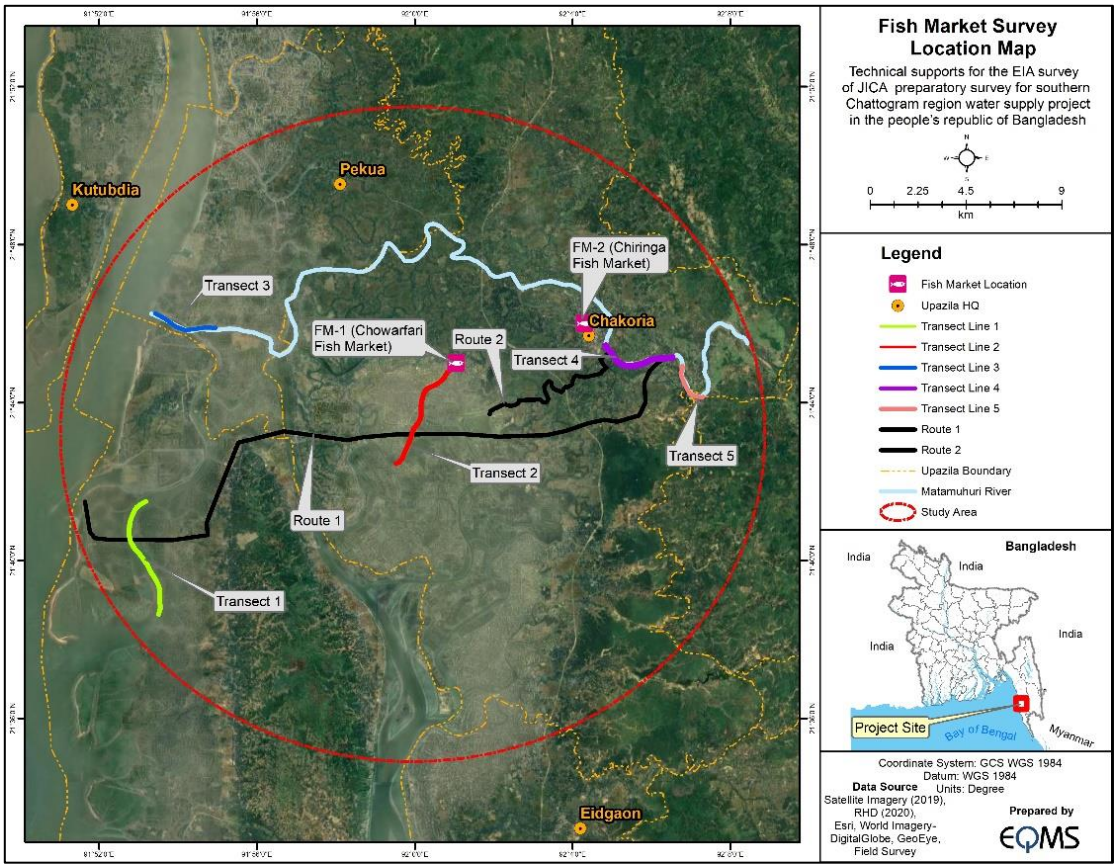
(e) Fish

Survey was conducted at two (2) fish markets (see Table 9.1.26). Figure 9.1.21 shows the location of each fish market.

Table 9.1.26 Fish Markets Surveyed in the Study Area

Sl. No.	Date of Survey	Location Code	Name And Address	Geographical Location	Nature of Markets	Duration of Market
1.	29.03.2024	FM-1	Chowarfari Fish Market, Chowarfari, Chakaria	21°45'4.98"N 92° 1'11.53"E	Wholesale and Retail market	**Morning**: 6 am to 10 am
2.	28.03.2024	FM-2	Chiringa Fish Market (Hoque Super Fish Market), Chakaria	21°45'49.53"N 92° 4'30.80"E	Retail Market	**Morning**: 7 am to 11 am **Evening:** 4 pm to 9 pm

Source: JICA Survey Team



Source: JICA Survey Team

Figure 9.1.21 Fish Market Survey Location

From the study a total of forty-eight (48) species of fish were recorded including captured, cultured and both species. The recorded Forty-eight (48) fish species are covered under twenty-seven (27) families while the highest number of fish species belong to the family Cyprinidae (9 species) followed by Gobiidae (6 species). All the fish species recorded in the checklist are from the fish market survey.

During the field visit, seventeen (17) species of crustaceans including shrimp, prawn and one species of Molluscs [Octopus (*Octopus sp.*)] were recorded from the boat-to-boat survey and fish market survey. four species of crabs - Blue-stripped Hermit Crab (*Clibanarius longitarsus*), Red Ghost crabs (*Ocypode macrocera*), Peregrine crab (*Varuna litterata*) and Horned Ghost Crab (*Ocypode brevicornis*) found dominant in the wild. In addition, Red Ghost crab, Horned Ghost Crab, Horseshoe crab, and Blue-stripped Hermit Crab are observed in the mangrove and Ghona/Gher area.

According to the IUCN Redlist of Bangladesh (2015), Common Squillid Mantis Shrimp (*Oratosquilla perpensa*) is declared as Endangered (EN), while Mangrove Horseshoe Crab (*Carcinoscorpius rotundicauda*) as Vulnerable (VU).

The Common Squillid Mantis Shrimp (*Oratosquilla perpensa*) is a benthic crustacean typically found in sandy and muddy shore habitats. Mantis shrimps are equipped with formidable claws, which they employ to hunt and subdue prey through spearing, stunning, or dismemberment. These aggressive and

often solitary sea creatures primarily inhabit rocky formations or construct elaborate burrows within the seabed, where they spend most of their time concealed. While not traditionally utilized for human consumption in Bangladesh, there has been a recent surge in fishing activity targeting *Oratosquilla perpensa* due to rising demand as a raw material for poultry and fish meal production. This increased fishing pressure, coupled with reductions in population size and habitat range, poses a significant threat to the species. As a result of these factors, *Oratosquilla perpensa* is deemed to be at risk of endangerment. According to Redlist of Bangladesh (2015), its population decline, shrinking area of occurrence, and heightened fishing pressure warrant classification as 'Endangered'.

The Mangrove Horseshoe Crab (*Carcinoscorpius rotundicauda*) is predominantly benthopelagic, inhabiting brackish, swampy waters such as mangrove habitats, where it remains close to or at the bottom. This species exhibits selective feeding habits, preying mainly on insect larvae, small fish, oligochaetes, small crabs, and thin-shelled bivalves. With origins dating back approximately 450 million years, horseshoe crabs are often referred to as 'Living Fossils'. According to the IUCN Red List of Bangladesh (2015), the Mangrove Horseshoe Crab is distributed along both the eastern and western coasts of Bangladesh. While the biology, ecology, and breeding behaviours of horseshoe crabs have been extensively studied by Sekiguchi et al. 1978[9]; Chowdhury and Hafizuddin 1980[10]; Itow et al. 2004[11]. Carcinoscorpius rotundicauda from Bangladesh waters are toxic and their toxic principle is tetrodotoxin (TTX) (Tanu and Noguchi 1999[12]). There is a notable absence of data regarding population size, stocks, or levels of exploitation in Bangladesh waters. Personal observations suggest a concerning decline of approximately 30% in population over the past 25 years, attributed to both overharvesting and environmental degradation. Consequently, the Mangrove Horseshoe Crab has been classified as ‘Vulnerable’.

It is interesting to note that, Blue-stripped Hermit (*Clibanarius longitarsus*) is commonly found in open and exposed regions within mangrove habitats, particularly among the tangle of mangrove roots and closer to the shoreline where sandy areas meet the river or sea (De Haan, 1849[13]). Unlike conventional crabs, the rear portion of their bodies is soft, prompting them to seek protection within discarded shells. They exhibit typical hermit crab behaviour by never forcibly displacing the original shell occupant, instead opting for vacant shells.

Detailed list of different fish, crustacean and molluscs species listed from the market survey and field observation, are summarized in Tables 9.1.27, 9.1.28, and 9.1.29.

[9] Sekiguchi, K., Nakamura, K., and Seshimo, H. (1978). Morphological variation of a horseshoe crab, Carcinoscorpius rotundicauda, from the Bay of Bengal and gulf of Siam. Proc. Jap. Soc. Syst. Zool. 15: 24-30.
[10] Chowdhury, S.H. and Harizuddin, A.K.H. (1980). Horse-shoe crabs (Chelicerata: Merostomata) occurring along the south-east coasts of Bangladesh. Bangladesh J. Zool. 8: 5-13.
[11] Itow, T., Mishra, J.K and Ahmed, A.T.A. (2004). Horseshoe crabs and king crabs in the Bay of Bengal, South Asia. Bulletin of the Faculty of Education, Shizuoka University, Natural Science Ser. 54: 13-30
[12] Tanu, M.B. and Noguchi, T. (1999). Tetrodotoxin as a Toxic Principle in the Horseshoe Crab Carcinoscorpius rotundicauda collected from Bangladesh. J. Food Hyg. Soc. Japan 40(6): 426-430
[13] De Haan, W. (1849). Cruatacea elaborante. in Siebold, P. F. Von, Fauna Japonica, 6: xxi + 230 Pp

Table 9.1.27 List of Fish Species, Recorded from the Market Survey and Field Observations

Sl No.	Local Name	Common Name	Scientific Name	Family	IUCN Local Status*	IUCN Global Status**	Source ***
1.	Baila	Tank goby	*Glossogobius giuris*	Gobiidae	LC	LC	M
2.	Bishtara	Spotted scate	*Scatophagus argus*	Scatophagidae	NE	LC	M
3.	Chapila	Indian River Shad	*Gudusia chapra*	Clupeidae	VU	LC	C
4.	Chiring	Ray-finned fish	*Apocryptes bato*	Gobiidae	LC	NE	C
5.	Dahuk	Blue-spotted Mudskipper	*Boleophthalmus boddarti*	Gobiidae	NE	LC	C
6.	Faisha	Gangetic hairfin anchovy	*Setipinna phasha*	Engraulidae	NE	LC	M
7.	Gogani	crescent grunter	*Terapon jarbua*	Terapontidae	NE	LC	M
8.	Guchi baim	Striped spinyeel	*Macrognathus pancalus*	Mastacembelidae	LC	LC	C
9.	Hilsha	Hilsa shad	*Tenualosa ilisha*	Clupeidae	LC	LC	M
10.	Hundra Baila	Silver Silago	*Sillago sihama*	Sillaginidae	NE	LC	M
11.	Kakila	Freshwater garfish	*Xenentodon cancila*	Belonidae	LC	LC	M
12.	Korati chela	Tenpounder	*Elops machnata*	Elopidae	NE	NE	M
13.	Kukur Jib	Bengal tonguesole	*Cynoglossus cynoglossus*	Cynoglossidae	NE	LC	C
14.	Mola	Mola carplet	*Amblypharyngodon mola*	Cyprinidae	LC	LC	M
15.	Nuna Bele	Bumblebee goby	*Brachygobius nunus*	Gobiidae	LC	NE	C
16.	Olua	Gold Spotted Grenadier Anchovy	*Coilia dussumieri*	Engraulidae	LC	NE	M
17.	Poa	Pama Croaker	*Otolithoides pama*	Sciaenidae	LC	LC	M
18.	Puti	Spotted barb	*Barbodes binotatus*	Cyprinidae	NE	LC	C
19.	Rupchada	White pomfret	*Pampus argenteus*	Stromateidae	NE	LC	M
20.	Shol	Snakehead	*Channa striatas*	Channidae	LC	LC	C
21.	Tailla	Threadfins	*Elutheronema tetradactylum*	Polynemidae	NE	NE	M
22.	Taki	Spotted Snakehead	*Channa punctatus*	Channidae	LC	LC	C
23.	Topshe	Paradise threadfin	*Polynemus paradiseus*	Polynemidae	NE	LC	M
24.	Tular dandi	Flathead sillago	*Sillago domina*	Sillaginidae	NE	NE	M
25.	Raja Chewa	Burmese Gobyeel	*Taenioides buchanani*	Gobiidae	LC	DD	M
26.	Parse Bata	Grey Mullet	*Liza parsia*	Mugilide	LC	NE	M
27.	Bhout Bele	Crimson-tipped Gudgeon	*Butis butis*	Eleotridae	LC	LC	M
28.	Fota Baila	Spotted Green Goby	*Acentrogobius viridipunctatus*	Gobiidae	NE	LC	M
29.	Gagra bacha	Gagora Catfish	*Arius gagora*	Ariidae	NE	NT	M

Sl No.	Local Name	Common Name	Scientific Name	Family	IUCN Local Status*	IUCN Global Status**	Source ***
30.	Nama Chanda	Elongate glassy perchlet	*Chanda nama*	Ambassidae	LC	LC	M
31.	Olua	Gold Spotted Grenadier Anchovy	*Coilia dussumieri*	Engraulidae	LC	LC	M

**IUCN Bangladesh. 2015. Red List of Bangladesh Volume 5: Freshwater Fishes; LC=Least Concern, NT=Near Threatened; VU=Vulnerable, EN= Endangered, NE=Not Evaluated, DD=Data Deficient*

*** IUCN 2024. The IUCN Red List of Threatened Species. Version 2023-1. (https://www.iucnredlist.org/)*

****Source code: C=Consultation with local fishermen; M=Fish Market Survey*

Source: JICA Survey Team

Table 9.1.28 List of Cultured Fish Species, Recorded from the Market Survey and Field Observations

Sl No.	Local Name	Common Name	Scientific Name	Family	IUCN Local Status*	IUCN Global Status**	Source ***
1.	Bhangan bata	Flathead grey mullet	*Mugil cephalus*	Mugilidae	LC	LC	M
2.	Khorsula	Corsula Mullet	*Rhimugil corsula*	Mugilidae	LC	LC	M
3.	Datina	Yellowfin sea bream	*Acanthopagrus latus*	Sparidae	NE	LC	M
4.	Koi mach	Climbing Perch	*Anabas testudineus*	Anabantidae	LC	LC	M
5.	Koral	Barramundi	*Lates calcarifer*	Latidae	NE	LC	M
6.	Pabda	Pabda Catfish	*Ompok pabda*	Siluridae	EN	NT	M
7.	Rui	Ruhu carp	*Labeo rohia*	Cyprinidae	LC	LC	M
8.	Tilapia	Nile tilapia	*Oreochromis niloticus*	Cichlidae	NE	LC	M
9.	Nuna-tengra	Gulio Catfish	*Mystus gulio*	Bagridae	NT	LC	M
10.	Mirka	Mrigal carp	*Cirrhinus cirrhosus*	Cyprinidae	NT	VU	M
11.	Grass carp	Grass carp	*Ctenopharyngodon Idella*	Cyprinidae	NE	LC	M
12.	Shing	Stinging Catfish	*Heteropneustes fossilis*	Heteropneustidae	LC	LC	M

**IUCN Bangladesh. 2015. Red List of Bangladesh Volume 5: Freshwater Fishes; LC=Least Concern, NT=Near Threatened; VU=Vulnerable, EN= Endangered, NE=Not Evaluated, DD=Data Deficient*

*** IUCN 2024. The IUCN Red List of Threatened Species. Version 2023-1. (https://www.iucnredlist.org/)*

****Source code: C=Consultation with local fishermen; M=Fish Market Survey*

Source: JICA Survey Team

Table 9.1.29 List of Crustacean and Mollusks Species Recorded from Market Survey and Field Observation

SL. No.	Local Name	Common Name	Scientific Name	Family	Culture Species	Capture Species	IUCN Local Status*	IUCN Global Status**	Source**
1.	Bagda chingri	Giant Tiger Shrimp	*Penaeus monodon*	Penaeidae	✓	✓	LC	NE	M
2.	Chatka chingri	Monsoon river prawn	*Macrobrachium malcolmsonii*	Palaemonidae	✓	✓	LC	LC	M
3.	Dhaina Icha	Jawla Paste Shrimp	*Acetes indicus*	Sergestidae	-	✓	LC	NE	M
4.	Ghoda Icha	Birma River Prawn	*Macrobrachium birmanicum*	Palaemonidae	✓	✓	LC	LC	M
5.	Golda chingri	Giant river prawn	*Macrobrachium rosenbergii*	Palaemonidae	✓	✓	LC	LC	C
6.	Harina Chingri	Brown Shrimp	*Metapenaeus monoceros*	Penaeidae	✓	✓	LC	NE	M
7.	Chaka Chingri	Red-tailed Prawn	*Penaeus indicus*	Penaeidae	✓	✓	LC	NE	M
8.	Menta Icha	Common Squillid	*Oratosquilla perpensa*	Squillidae	-	✓	EN	NE	F

SL. No.	Local Name	Common Name	Scientific Name	Family	Culture Species	Capture Species	IUCN Local Status*	IUCN Global Status**	Source***
		Mantis Shrimp							
9.	Shila Kakra	Mud crab	*Scylla serrata*	Portunidae	✓	✓	LC	NE	F
10.	Maita Kakra	Orange Mud Crab	*Scylla olivacea*	Portunidae	-	✓	LC	NE	F
11.	Lal Kakra	Red Ghost crab	*Ocypode macrocera*	Ocypodidae	-	✓	LC	NE	F
12.	Korol	Thai Vinegar Crab	*Episesarma mederi*	Sesarmidae	-	✓	LC	NE	F
13.	Haim Korol	Blue-stripped Hermit Crab	*Clibanarius longitarsus*	Diogenidae	-	✓	LC	NE	F
14.	Guli Korol	Peregrine crab	*Varuna litterata*	Varunidae	-	✓	LC	NE	C
15.	Holud Kakra	Golden Ghost Crab	*Ocypode convexa*	Ocypodidae	-	✓	NE	NE	F
16.	Balu Kakra	Horned Ghost Crab	*Ocypode brevicornis*	Ocypodidae		✓	LC	NE	F
17.	Raj Kakra	Horseshoe Crab	*Carcinoscorpius rotundicauda*	Limulidae	-	✓	VU	DD	F
18.	Octopus	Octopus	*Octopus sp.*	Octopodidae		✓	NE	LC	F

**IUCN Bangladesh. 2015. Red List of Bangladesh Volume 6: Crustaceans; LC=Least Concern, NE=Not Evaluated*
*** IUCN 2024. The IUCN Red List of Threatened Species. Version 2023-1. (https://www.iucnredlist.org/)*
**** Source code: M=Fish Market Survey, C=Consultation with fish seller and Fish Farmers, F=Observation on Field*
Source: JICA Survey Team

The estuarine region surrounding the Matamuhuri River is characterized by a network of tidal creeks, mangrove forests, and abundant plankton, making it an ideal nursery area for shrimp and fin fish larvae. Through consultations with the Senior Upazila Fisheries Officer and Marine Fisheries Officer of Chakaria Upazila, a total of twenty-eight (28) fish species and five (05) crustacean species are listed in Table 9.1.30.

Additionally, a telephonic conversation with the former Senior Upazila Fisheries Officer of Lama Upazila, Bandarban (now serving as an Assistant Director at the Department of Fisheries), further affirmed the presence of seven (7) more fish and crustacean species in both the upstream and downstream areas of the Matamuhuri River. These species found in both upstream and downstream of Matamuhuri River are also summarized in Table 9.1.30.

Table 9.1.30 Fish and Crustacean Species in Matamuhuri River (Upstream and Downstream area)[14]

Sl.No.	Local Name	Common Name	Scientific Name	Family	IUCN Local Status	IUCN Global Status	Remarks
1.	Nanchil Koral	Indo-Pacific tarpon	*Megalops cyprinoides*	Megalopidae	NE	DD	Upstream & Downstream
2.	Chitol	Humped Featherback	*Chitala chitala*	Notopteridae	EN	NT	Upstream
3.	Kachki	Ganges River-sprat	*Corica soborna*	Clupeidae	LC	LC	Upstream
4.	Mrigal	Mrigal Carp	*Cirrhinus cirrhosis*	Cyprinidae	NT	VU	Upstream
5.	Kalibaus	Orange fin labeo	*Labeo calbasu*	Cyprinidae	LC	LC	Upstream
6.	Katol	Catla	*Labeo catla*	Cyprinidae	LC	LC	Upstream
7.	Jat Punti	Spotfin swamp barb	*Puntius sophore*	Cyprinidae	LC	LC	Upstream
8.	Thai Sarpunti	Silver barb	*Barbonymus gonionotus*	Cyprinidae	NE	LC	Upstream
9.	Elong	Bengala Barb	*Megarasbora elanga*	Cyprinidae			Upstream
10.	Fulchela	Finescale Razorbelly Minnow	*Salmostoma phulo*	Cyprinidae	NT	LC	Upstream
11.	Boal	Freshwater shark	*Wallago attu*	Siluridae	VU	NT	Upstream
12.	Ghaura	Gagra	*Clupisoma garua*	Schilbeidae	EN	LC	Upstream
13.	Tengra	Dwarf Catfish	*Batasio tengana*	Bagridae	EN	LC	Upstream
14.	Gulsha Tengra	Gangetic Mystus	*Mystus cavasius*	Bagridae	NT	LC	Upstream
15.	Ful Chiring	Goby	*Apocryptes bato*	Gobiidae	LC	LC	Upstream & Downstream
16.	Nama Chanda	Elongate Glass-perchlet	*Chanda nama*	Ambassidae	LC	LC	Upstream
17.	Bamosh	Indian Mottled Eel	*Anguilla bengalensis*	Anguillidae	VU	NT	Upstream & Downstream
18.	Mola	Mola Carplet	*Amblypharyngodon mola*	Cyprinidae	LC	LC	Upstream
19.	Pangas	Pungas Catfish	*Pangasius pangasius*	Pangasiidae	EN	LC	Downstream
20.	Parse Bata	Goldspot Mullet	*Liza parsia*	Mugilidae	LC	NE	Upstream & Downstream
21.	Nuna Tengra	Long-whiskered Catfish	*Mystus gulio*	Bagridae		LC	Downstream
22.	Koral	Barramundi	*Lates calcarifer*	Latidae	NE	LC	Upstream & Downstream
23.	Tailla	Threadfins	*Elutheronema tetradactylum*	Polynemidae	NE	NE	Downstream
24.	Khorsula	Corsula	*Rhinomugil corsula*	Mugilidae	LC	LC	Upstream & Downstream
25.	Koitor Poa	Coitor Croacker	*Johnius coitor*	Sciaenidae	LC	LC	Upstream & Downstream
26.	Bele	Fresh Water Goby	*Glossogobius giuris*	Gobiidae	LC	LC	Downstream
27.	Phasa	Gangetic Hairfin Anchovy	*Setipinna phasa*	Engraulidae	LC	LC	Downstream
28.	Olua	Gold Spotted Grenadier	*Coilia dussumieri*	Engraulidae	LC	NE	Downstream

[14] Data is provided by Senior Upazila Fisheries Officer of Chakaria Upazila, Coxs Bazar.

Sl.No.	Local Name	Common Name	Scientific Name	Family	IUCN Local Status	IUCN Global Status	Remarks
		Anchovy					
29.	Chatka chingri	Monsoon river prawn	*Macrobrachium malcolmsonii*	Palaemonidae	LC	LC	Downstream
30.	Dhaina Icha	Jawla Paste Shrimp	*Acetes indicus*	Sergestidae	LC	NE	Downstream
31.	Harina Chingri	Brown Shrimp	*Metapenaeus monoceros*	Penaeidae	LC	NE	Downstream
32.	Bagda Chingri	Giant Tiger Shrimp	*Penaeus monodon*	Penaeidae	LC	NE	Downstream
33.	Golda Chingri	Giant river prawn	*Macrobrachium rosenbergii*	Palaemonidae	LC	LC	Downstream

**IUCN Bangladesh. 2015. Red List of Bangladesh Volume 5: Fishes & Volume 6: Crustaceans; LC=Least Concern, NT=Near Threatened; VU=Vulnerable, EN= Endangered, NE=Not Evaluated, DD=Data Deficient*

*** IUCN 2024. The IUCN Red List of Threatened Species. Version 2023-1. (https://www.iucnredlist.org/)*

Source: JICA Survey Team

In total, seven (7) species of migratory fish species (primarily estuarine) were listed from the consultation with Senior Upazila Fisheries Officer. The migratory fish species listed from the Matamuhuri River are- Indian Mottled Eel (*Anguilla bengalensis*), Indo-Pacific tarpon (*Megalops cyprinoides*), Goldspot Mullet (*Liza parsia*), Barramundi (*Lates calcarifer*), Corsula bata (*Rhinomugil corsula*), Coitor Croacker (*Johnius coitor*) and Goby (*Apocryptes bato*). However, there are no government declared fish spawning area in and around the possible water intake points. The characteristics and relevant information related to migratory fish species are summarized in Table 9.1.31.

Table 9.1.31 Characteristics of Migratory Fishes found in the Matamuhuri River (both Upstream and Downstream area)

Fish Species	Characteristics and Relevant Information
Indian Mottled Eel (*Anguilla bengalensis*)	Anguilla bengalensis exhibits a unique life cycle characterized by semelparity, meaning it undergoes only one breeding season in its lifetime, and catadromy, as it migrates from freshwater to the ocean for spawning. In its juvenile stages, it primarily feeds on small prey such as insects and other aquatic organisms in freshwater rivers, estuaries, and sluggish, muddy environments. As the breeding season approaches, Anguilla bengalensis embarks on a remarkable journey toward river mouths, where it spawns in the expansive ocean. The offspring, tiny and resilient, then navigate their way back to freshwater habitats, seeking a variety of environments, from tranquil, muddy substrates to the turbulent, rocky depths of rivers. The fish is found in some big river systems and hill stream areas of Bangladesh. Despite its wide distribution, the species has been experiencing a suspected population decline. According to IUCN Red list of Bangladesh (2015), it was accessed as Vulnerable (VU) while Near Threatened (NT) in Global IUCN Relist of threatened Species (Version 2023-1).
Barramundi (*Lates calcarifer*)	The Barramundi stands out as one of Bangladesh's most economically significant species. Thriving in coastal and estuarine environments, it exhibits a semi-catadromous lifestyle. While some individuals remain in marine or estuarine waters throughout their lives, others venture far into freshwater nurseries. Juvenile Asian Sea bass are adaptable to freshwater habitats, yet they rely on brackish waters for embryonic development. As habitat conditions change, prompting desiccation in their surroundings, downstream migration to the main channel becomes necessary. Some individuals even embark on extensive upstream journeys to reach permanent freshwater locations. They reside in freshwater habitats until reaching sexual maturity, typically around 3 to 4 years of age. At this stage, they migrate downstream to participate in spawning activities during the breeding season
Corsula (*Rhinomugil corsula*)	It is widely distributed in estuaries of Bangladesh and It one of the most popular and commercially important fish due to its taste, high nutritive and market value[15]. Corsula is an anadromous species and Breeding time of this fish starts in April and continues till July[16]. According to IUCN Red list of Bangladesh (2015), it was assessed as Least Concern (LC).
Goldspot Mullet (*Liza parsia*)	Liza parsia, locally known as 'Parshe Bata,' boasts a wide distribution across coastal waters, estuaries, lagoons, and tidal rivers within Bangladesh's coastal districts. Their breeding grounds lie in the deep seas, after which they migrate to estuaries and lagoons for nourishment. However, they typically avoid breeding in tidal rivers. Known for their resilience, their population doubles approximately every 15 months. This catadromous species is frequently caught in estuarine environments.

[15] Hossain, M. B., Bhowmik, S., Majumdar, P. R., Saha, P., & Islam, M. R. U. (2015). Landmark-Based Morphometric and Meristic Variations in Populations of Mullet (*Rhinomugil corsula*) (Hamilton, 1822) in Bangladesh. *World Journal of Fish and Marine Sciences,* 7(1), 12-20.

[16] Sultana, S., Shah, M. S., Islam, S. S., & Ghosh, A. K. 2013. Taxonomy and other biological aspects of Rhinomugil corsula (Hamilton). *International Journal of Research in Biological Sciences* 3(3): 123-131

Fish Species	Characteristics and Relevant Information
	According to the IUCN Red List of Bangladesh (2015), Liza parsia holds a classification of Least Concern (LC), indicating no immediate threat of extinction within the region. However, its status has not yet been evaluated on the Global IUCN Red List of Threatened Species (version: 2023-1).
Goby (*Apocryptes bato*)	The species exhibits a broad distribution and abundant presence across all estuaries and tidal rivers throughout Bangladesh. It is characterized as amphidromous, meaning it migrates between freshwater and the sea in both directions. Its diet primarily consists of small invertebrates, notably small crustaceans, zooplankton, and phytoplankton. As per the IUCN Red List of Bangladesh (2015), this species has been evaluated as Least Concern (LC), indicating that it faces no immediate threat of extinction within the country.
Coitor Croacker (*Johnius coitor*)	*Johnius coitor* (locally called 'Koitori Poa') is known to occur in shallow coastal areas, estuaries, all the tidal rivers and freshwater large rivers in Bangladesh. This commercially important species is amphidromous and migrates to large freshwater rivers for breeding[17]. According to the According to IUCN Red list of Bangladesh (2015), it was assessed as Least Concern (LC)

Source: JICA Survey Team

(f) Plankton

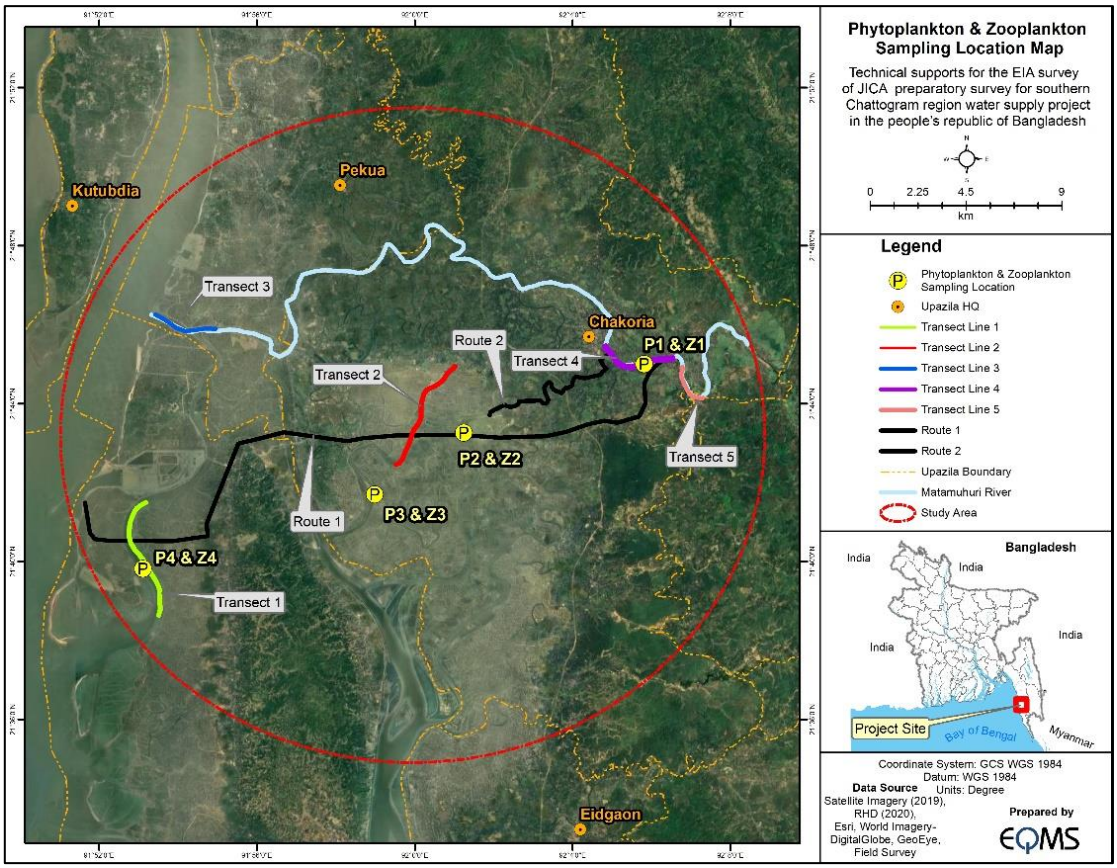
Sampling of plankton (i.e., phytoplankton and zooplankton) was conducted at four (4) points. The survey outline is summarized in Table 9.1.32. Figure 9.1.22 shows the survey location.

Table 9.1.32 Survey Outline (Plankton)

Sl. No.	Survey Date	Sampling Location	Plankton Sample Code	GPS Coordination (Phytoplankton)	GPS Coordination (Zooplankton)
1.	27.03.2024	Matamuhuri River (adjacent to the intake points), Modhom Dighor Pankhali, Chakaria	P1 and Z1	21°45'0.01"N 92° 5'48.89"E	21°45'1.81"N 92° 5'51.69"E
2.	27.03.2024	Baro Matamuhuri River, Rampur, Chakaria	P2 and Z2	21°43'15.54"N 92° 1'14.55"E	21°43'22.10"N 92° 1'11.56"E
3.	25.03.2024	End of the Transect Line-2 (T2), Chowarfari Canal, Kaharia Ghona	P3 and Z3	21°41'41.92"N 91°58'59.01"E	21°41'44.48"N 91°58'58.25"E
4.	26.03.2024	Sapmaradale Ghat, Kohelia River, Dalghata (adjacent to the Transect line-1)	P4 and Z4	21°39'49.06"N 91°53'6.61"E	21°39'55.40"N 91°53'1.61"E

Source: JICA Survey Team

[17] Sarkar, U. K., Naskar, M., Roy, K., Sudheesan, D., Gupta, S., Bose, A. K., & Karnatak, G. (2018). Baseline information of reproduction parameters of an amphidromous croaker Johnius coitor (Hamilton, 1822) from Ganga River basin, India with special reference to potential influence of climatic variability. *Aquatic Living Resources*, 31, 4.



Source: JICA Survey Team

Figure 9.1.22 Plankton (Phytoplankton and Zooplankton) Sampling Location

(i) Phytoplankton

A total of ten (10) species of phytoplankton were identified. The phytoplankton in the study area were represented by four (4) groups and the dominant phytoplankton group was Bacillariophyceae. In the case of species, *Nitzschia* sp. was dominant under Bacillariophyceae. Table 9.1.33 summarizes species composition and numbers of phytoplankton per liter**.**

Table 9.1.33 Phytoplankton Profile in the Study Area

Sl. No.	Class	Genus	P4	P3	P2	P1
			Number (cells/ L)			
1.	Bacillariophyceae	*Melosira* sp.	14	0	0	0
2.		*Navicula* sp.	9	15	7	4
3.		*Chlorella* sp.	19	12	07	28
4.		*Amphora* sp.	13	0	0	0
5.		*Nitzschia* sp.	17	28	11	26
6.		*Fragilaria* sp.	8	26	0	6
7.	Dinophyceae	*Ceraatium* sp.	0	0	0	8
8.		*Dinophysis* sp.	0	13	0	0
9.	Ulotrichaceae	*Ulothrix* sp.	14	0	0	0
10.	Euglenophyceae	*Euglena* sp.	12	15	0	16

Source: JICA Survey Team

(ii) Zooplankton

A total of six (6) species of zooplankton were identified by sample analysis from predefined four sample collection locations. The zooplankton in the study area was represented by four groups and the dominant zooplankton group was the Branchiopoda. In the case of Species, *Moina sp.* were the highest abundant zooplankton species in the study area. Table 9.1.34 summarizes species composition and the number of zooplankton per liter.

Table 9.1.34 Zooplankton Profile in the Study Area

Sl. No.	Class	Species	Number (Individuals/L)			
			Z4	Z3	Z2	Z1
1.	Copepoda	*Calanus* sp.	8	0	0	4
2.	Monogononta	*Brachionus* sp.	2	0	5	3
3.	Branchiopoda	*Daphnia* sp.	15	0	7	10
4.		*Moina* sp.	19	9	3	11
5.		*Bosmina* sp.	6	0	0	0
6.	Mysidae	*Mysis* sp.	2	0	7	2

Source: JICA Survey Team

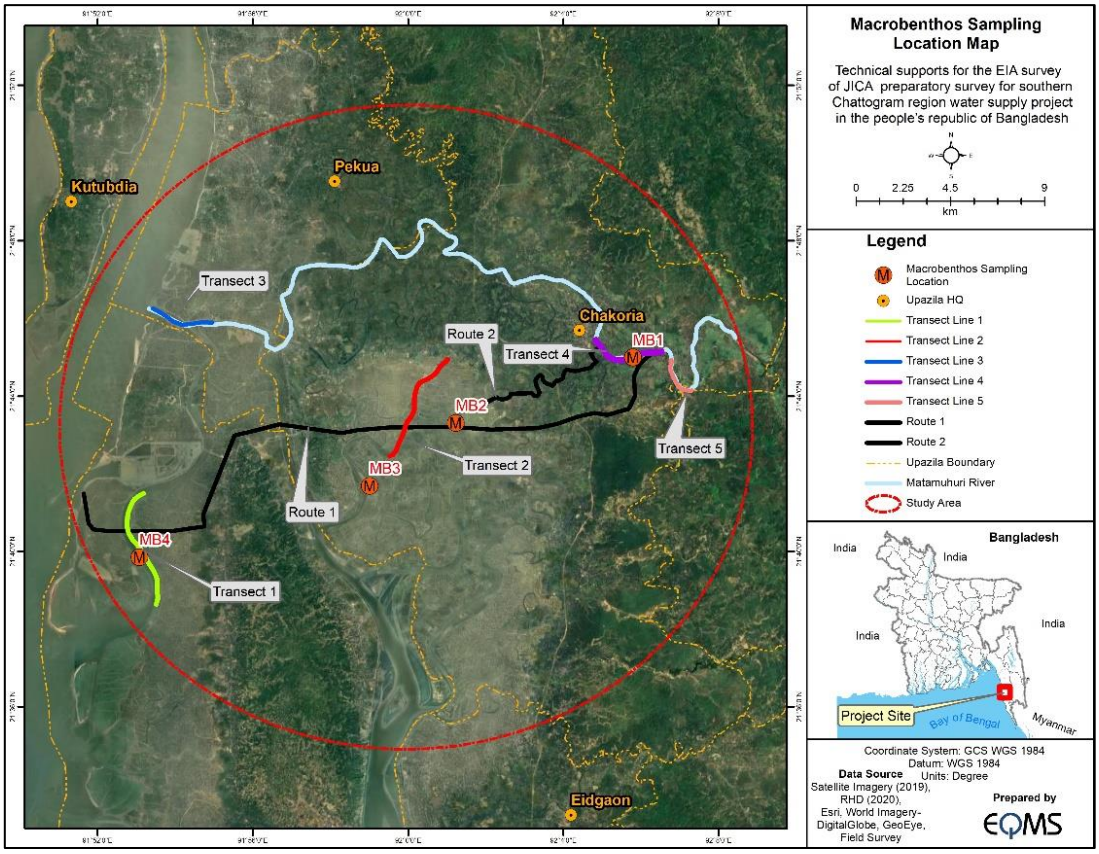
(g) Macrobenthos

Sampling of macrobenthos was conducted at four (4) points. The survey outline is summarized in Table 9.1.35. Figure 9.1.23 shows the survey location.

Table 9.1.35 Survey Outline (Macrobenthos)

Sl. No.	Survey Date	Sampling Location	Benthos Sample Code	GPS Coordination
1.	27.03.2024	Matamuhuri River (adjacent to intake points), Modhom Dighor Pankhali, Chakaria	MB1	21°44'59.42"N 92° 5'47.72"E
2.	27.03.2024	Baro Matamuhuri River, Rampur, Chakaria	MB2	21°43'18.22"N 92° 1'13.77"E
3.	25.03.2024	End of the Transect Line-2 (T2), Chowarfari Canal, Kaharia Ghona	MB3	21°41'41.10"N 91°59'0.42"E
4.	26.03.2024	Sapmaradale Ghat, Kohelia River, Dalghata (adjacent to Transect line-1)	MB4	21°39'50.87"N 91°53'4.66"E

Source: JICA Survey Team



Source: JICA Survey Team

Figure 9.1.23 Macrobenthos Sampling Location Map

A total of Twelve (12) species were identified from four (4) sampling locations. These genera belong to Crustaceans, Insecta, Polychaetes, Gastropoda and Bivalvia. According to the analysis, two species of Polychaeta, six species of Gastropoda, two species of Bivalvia, one species of Insecta, and one species of Crustacea were found in the study area. Benthos abundance varied between 400 to 44 individuals/m^2 in the present study (Table 9.1.36).

Table 9.1.36 Macro Benthos Profile in the Study Area (Dry Season)

Sl. No.	Groups	Species	PB4		PB3		PB2		PB1	
			Number (Individuals/m^2)							
			n	N	n	N	n	N	n	N
1.	Polychaeta	*Nereis lamellose*	4	177	0	0	3	133	9	400
2.		*Lumbrineris* sp.	3	133	6	266	0	0	1	44
3.	Gastropoda	*Bellamya* sp.	0	0	0	0	2	88	3	133
4.		*Lymnaea* sp.	5	222	3	133	3	133	0	0
5.		*Planorbis* sp.	2	88	0	0	0	0	1	44
6.		*Melanoides* sp.	0	0	2	88	0	0	0	0
7.		*Telescopium* sp.	3	133	2	88	0	0	0	0
8.		*Gyraulus* sp.	0	0	3	133	0	0	0	0
9.	Bivalvia	*Anadara* sp.	2	88	1	44	2	88	0	0

Sl. No.	Groups	Species	PB4		PB3		PB2		PB1	
			Number (Individuals/m^2)							
			n	N	n	N	n	N	n	N
10.		*Trachycardium* sp.	1	44	3	133	0	0	0	0
11.	Insecta	*Chironomus* sp.	5	222	2	88	1	44	0	0
12.	Crustacea	*Shrimp larvae*	6	266	4	177	0	0	2	88

**n= Number of individuals per sample (Grab area= 0.0225 m^2); N= Number of individuals/m^2*
Source: JICA Survey Team

7) Flora

(a) Vegetation

The transect sampling method was used for assessing the vegetation structure around the study area. A total of five transects were taken for phytosociological assessment according to the scope of the study. The location and GPS of the five (5) Transects are summarized in Table 9.1.37. Figure 9.1.24 shows the location of each transect line. It is noted that same transect lines are used for the faunal survey, conducted within this study.

Table 9.1.37 Details of Transects for Vegetation Survey

Sl. No.	Survey Date	Transect Code	Address	Length and Width of the Transects	GPS (Start Point)	GPS (End Point)
1.	26.03.2024	T1	Kohelia River, Matarbari, Moheshkhali	Length: 6 km Width: 100m	21°41'26.97"N 91°53'11.99"E	21°38'36.49"N 91°53'29.62"E
2.	25.03.2024	T2	Chowarfari canal, Chakaria	Length: 5.6 km Width: 100m	21°44'55.43"N 92° 1'0.23"E	21°42'26.76"N 91°59'30.33"E
3.	29.03.2024 & 30.03.2024	T3	Downstream of Matamuhuri River, Ujantia Canal, Pekua	Length: 2 km Width: 100m	21°45'53.27"N 91°54'56.89"E	21°46'15.15"N 91°53'25.23"E
4.	27.03.2024	T4	Matamuhuri river, Pankhali and Dighor Pankhali area	Length: 2 km Width: 100m	21°45'27.34"N 92° 4'49.47"E	21°45'8.68"N 92° 6'33.07"E
5.	28.03.2024	T5	Upstream of Matamuhuri river, Ghunia, Chakaria	Length: 2 km Width: 100m	21°44'55.55"N 92° 6'46.77"E	21°44'8.65"N 92° 7'18.09"E

Source: JICA Survey Team

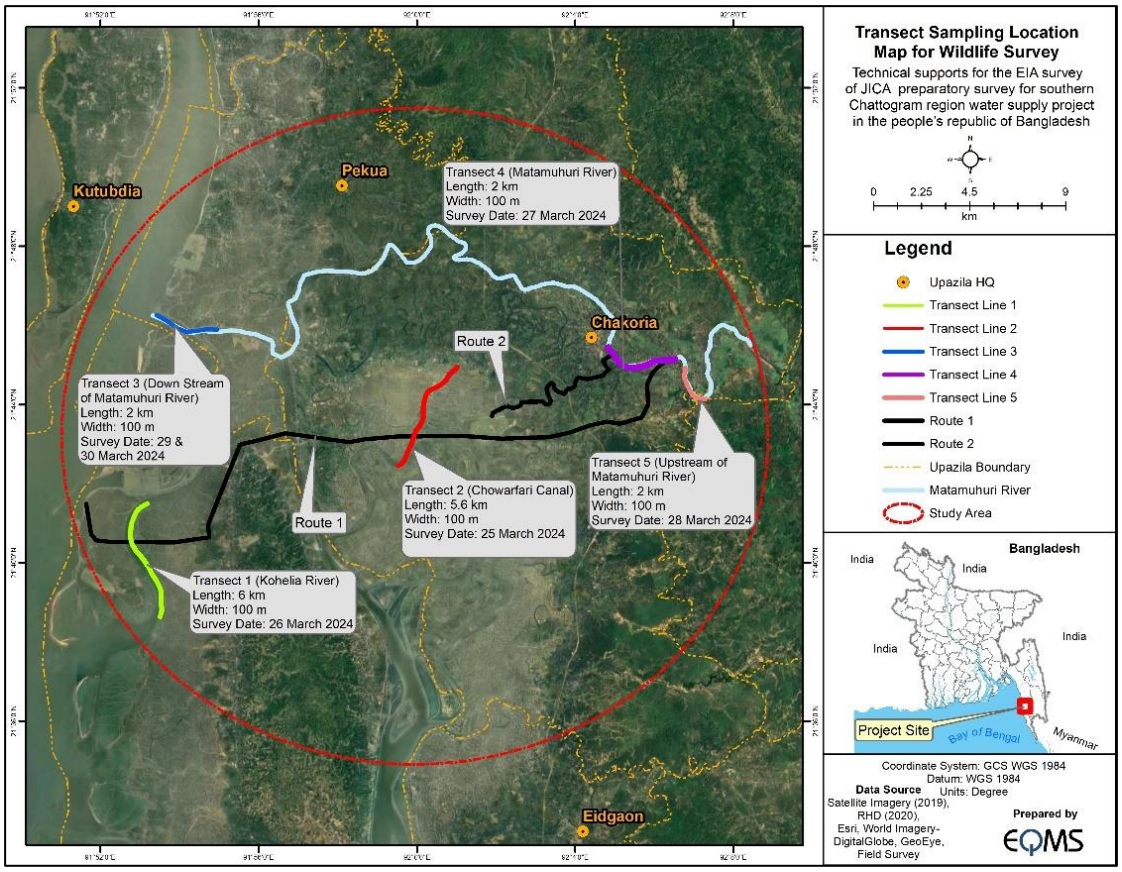


Figure 9.1.24 Location of Transect Line

A total of one hundred and five (105) species of flora (Trees, shrub, herbs, climbers and Creeper) were enlisted from the survey. Among them, forty-two (42) species of trees under 22 families, thirty-three (33) species of herb under 19 families, twenty-two (22) species of shrub under 14 families, six (06) species of climbers under 3 families and two (2) species of creepers under 2 families were recorded. Tables 9.1.38 and 9.1.39 summarize tree, shrub, herbs and climbers' composition, identified in the study area.

Table 9.1.38 List of Tree Species in the Study Area

Sl. No.	Family	Scientific Name	Local Name	Common Name	IUCN Status *	Occurrence	
						Dry season	Rainy season
1	Anacardiacea e	*Mangifera indica*	Aam	Mango	DD	✓	✓
2		*Spondius pinnata*	Amra	Hog Plum	NE	✓	✓
3	Annonaceae	*Monoon longifolium*	Debdaru	False ashoka	LC	✓	✓
4	Apocynaceae	*Alstonia macrophylla*	Chatim	Hard milkwood	LC	✓	✓
5	Arecaceae	*Areca catechu*	Supari	Betel palm	LC	✓	✓
6		*Borassus flabellifer*	Tal	Palmyra palm	LC	✓	✓
7		*Cocos nucifera*	Nairkel	Coconut tree	NE	✓	✓
8		*Phoenix sylvestris*	Khejur	Indian date	NE	✓	✓
9	Bombacace ae	*Bombax ceiba*	Simul	Red silk-cotton tree	LC	✓	✓

Sl. No.	Family	Scientific Name	Local Name	Common Name	IUCN Status *	Occurrence	
						Dry season	Rainy season
10	Caesalpiniaceae	*Delonix regia*	Krishnachura	Royal poinciana	LC	✓	✓
11	Caricaceae	*Carica papaya*	Pepe	Papaya	DD	✓	✓
12	Combretaceae	*Terminalia arjuna*	Arjun	Arjuna	NE	✓	✓
13	Euphorbiaceae	*Phyllanthus acidus*	Horboroi	Otaheite Gooseberry	NE	✓	✓
14		*Phyllanthus emblica*	Amloki	Amla	LC	✓	✓
15	Fabaceae	*Cassia fistula*	Sonalu	Golden shower	LC	✓	✓
16		*Dalbergia sissoo*	Shishoo	North Indian rosewood	LC	✓	✓
17		*Erythrina variegata*	Mandar	Indian coral tree	LC	✓	✓
18		*Pongamia pinnata*	Koronja	Indian beech	LC	✓	✓
19	Lecythidaceae	*Barringtonia acutangula*	Hijol	Freshwater Mangrove	LC	✓	✓
20	Lythraceae	*Sonneratia apetala*	Kewra	Mangrove apple	LC	✓	✓
21	Meliaceae	*Melia azedarach*	Ghoranim	Chinaberry Tree	LC	✓	✓
22		*Swietenia mahagoni*	Mahogany	West Indian mahogany	NT	✓	✓
23	Mimosaceae	*Acacia auriculiformis*	Akashmoni	Acacia	LC	✓	✓
24		*Acacia mangium*	Mangium	Black wattle	LC	✓	✓
25		*Albizia lebbeck*	Sirish	Siris	LC	✓	✓
26		*Albizia saman*	Raintree	Saman	NE	✓	✓
27		*Leucaena leucocephala*	Ipil –Ipil	Wild Tamarind	NE	✓	✓
28		*Pithecellobium dulce*	Khoibabla	Manila tamarind	LC	✓	✓
29	Moraceae	*Artocarpus heterophyllus*	Kathal	Jackfruit	NE	✓	✓
30		*Ficus hispida*	Dumur	Hairy Fig	LC	✓	✓
31		*Streblus asper*	Shaora	Siamese rough bush	LC	✓	✓
32	Moringaceae	*Moringa oleifera*	Sajna	Drumstick tree	LC	✓	✓
33	Myrtaceae	*Eucalyptus camaldulensis*	Eucalyptus tree	River Red Gum	LC	✓	✓
34		*Psidium guajava*	Peyara	Guava	LC	✓	✓
35	Rhamnaceae	*Ziziphus mauritiana*	Kul	Indian jujube	LC	✓	✓
36	Rutaceae	*Aegle marmelos*	Bel	Stone apple	NT	✓	✓
37	Sterculiaceae	*Sterculia foetida*	Jungli Badam	Java Olive	LC	✓	✓
38	Tamaricaceae	*Tamarindus indica*	Tetul	amarind tree	LC	✓	✓
39	Verbenaceae	*Avicennia alba*	Barabaen	Api-Api	LC	✓	✓
40		*Avicennia officinalis*	Baen/ Kalabaen	Indian mangrove	LC	✓	✓
41		*Gmelina arborea*	Gamari	Beechwood	LC	✓	✓

Source: JICA Study Team

* IUCN 2024. The IUCN Red List of Threatened Species. Version 2024-1. https://www.iucnredlist.org ; LC = Least Concern, NT = Near Threatened, NE = Not Evalutaed, DD = Data Deficient.

Table 9.1.39 List of Herb, Shrub, Climber and Creepers Species in the Study Area

Sl. No.	Family	Scientific Name	Local Name	Common Name	Type	IUCN Global*	Occurrence	
							Dry season	Rainy season
1	Acanthaceae	*Acanthus ilicifolius*	Hargoza	Holy Mangrove	Shrub	LC	✓	✓
2		*Justicia gendarussa*	Jagatmadan	Willow-leaved Justicia	Shrub	NE	✓	✓
3	Amaranthaceae	*Alternanthera philoxeroides*	Helencha	Alligator weed	Herb	NE	✓	✓
4		*Alternanthera sessilis*	Salanchi sak	Sissoo spinach	Herb	LC	✓	✓
5		*Amaranthus spinosus*	Katamaris	Spiny pigweed	Herb	NE	✓	✓
6		*Amaranthus viridis*	Notey	Slender amaranth	Herb	NE	✓	✓
7	Apiaceae	*Centella asiatica*	Thankuni	Asiatic pennywort	Herb	LC	✓	✓
8		*Erymgium foetidum*	Bilati dhone	Culantro	Herb	NE	✓	✓
9	Araceae	*Alocasia cucullata*	Bishkachu	Buddhas Palm	Herb	NE	✓	✓
10		*Colocasia esculenta*	Kachu	Taro	Herb	LC	✓	✓
11	Arecaceae	*Calamus guruba*	Jalibet	Guruba Rattan	Shrub	NE	✓	✓
12	Asclepiadaceae	*Calotropis gigantea*	Akand	Crown flower	Shrub	NE	✓	✓
13	Asteraceae	*Vernonia elliptica*	Patavernon	Curtain Creeper	Creeper	NE	✓	✓
14		*Ageratum conyzoides*	Ochunti	Billygoat-weed	Herb	NE	✓	✓
15		*Blumea lacera*	Barakukshima	Lettuce-Leaf Blumea	Herb	NE	✓	✓
16		*Mikania micrantha*	Asamlata	Bitter vine	Herb	NE	✓	✓
17		*Snedrella nodiflora*	Relanodi	Cinderella Weed	Herb	NE	✓	✓
18		*Spilanthes acmella*	Marhatitika	Toothache plant	Herb	NE	✓	✓
19	Basellaceae	*Basella rubra*	Puishak	Malabar spinach	Climber	NE	✓	✓
20	Boraginaceae	*Heliotropium indicum*	Hatishur	Indian heliotrope	Herb	NE	✓	✓
21	Bromeliaceae	*Ananus comosus*	Anaros	Pineapple	Herb	NE	✓	✓
22	Commelinaceae	*Commelina benghalensis*	Kansira	Wandering Jew	Herb	LC	✓	✓
23	Convolvulaceae	*Ipomoea aquatica*	Kolmi	Water spinach	Creeper	LC	✓	✓

Sl. No.	Family	Scientific Name	Local Name	Common Name	Type	IUCN Global*	Occurrence	
							Dry season	Rainy season
24		*Ipomoea carnea*	Dol kolmi	Morning Glory	Shrub	LC	✓	✓
25	Costaceae	*Cheliocostus speciosus*	Keumol, Tiatot	Wild ginger	Herb	NE	✓	✓
26	Cucurbitaceae	*Benincasa hispida*	Chalkumra	Ash gourd	Climber	NE	✓	✓
27		*Lagernaria siceraria*	Kadu	Bottle Gourd	Climber	NE	✓	✓
28		*Momordica charantia*	Tita corolla	Bitter Gourd	Climber	NE	✓	✓
29		*Trichosanthes cordata*	Data chichinga	Pointed gourd	Climber	NE	✓	✓
30	Cyperaceae	*Cyperus rotandus*	Mutha	Purple nutsedge	Herb	NE	✓	✓
31	Euphorbiaceae	*Eupatorium antiquorum*	Tesramansa	Antique spurge	Herb	NE	✓	✓
32		*Ricinus communis*	Verenda	Castor bean	Shrub	NE	✓	✓
33	Fabaceae	*Psophocarpus tetragonolobus*	Kamranga shim	Winged Bean	Climber	NE	✓	✓
34		*Lablab purporeus*	Bangla shim	Hyacinth bean	Herb	NE	✓	✓
35		*Vigna unguiculata*	Borboti	Cowpea	Herb	NE	✓	✓
36		*Crotalaria juncea*	Shonpat	Brown hemp	Shrub	NE	✓	✓
37		*Sesbania sesban*	Dhaincha	Riverhemp	Shrub	NE	✓	✓
38	Malvaceae	*Abelmoschus esculentus*	Bhendi	Okra	Herb	NE	✓	✓
39		*Sida acuta*	Kureta	Common wireweed	Herb	NE	✓	✓
40		*Hibiscus rosa sinensis*	Joba	Chinese hibiscus	Shrub	NE	✓	✓
41		*Malvaviscus arboreus*	Lanka joba	Turkcap	Shrub	LC	✓	✓
42	Melastomataceae	*Melastoma malabathricum*	Datranga	Malabar melastome	Shrub	NE	✓	✓
43	Mimosaceae	*Mimosa pudica*	Lajjabati	Sensitive plant	Herb	LC	✓	✓
44	Musaceae	*Musa paradisiaca*	Kacha kola	French plantain	Herb	NE	✓	✓
45		*Musa itinerans*	Atikola	Yunnan banana	Shrub	LC	✓	✓
46	Nyctaginaceae	*Bougainvillea glabra*	Baganbilas	Paper Flower	Shrub	LC	✓	✓
47	Onagraceae	*Ludwigia hyssopifolia*	Zaikura	Water Primrose	Herb	LC	✓	✓
48	Poaceae	*Bambusa tulda*	Mitinga	Indian timber bamboo	Herb	NE	✓	✓
49		*Chrysopogon aciculatus*	Premkata	Love Grass	Herb	NE	✓	✓
50		*Cynodon dactylon*	Durba grass	Bermuda grass	Herb	NE	✓	✓
51	Rutaceae	*Cassia alata*	Dad-mordon	Candle bush	Shrub	LC	✓	✓
52		*Citrus aurantifolia*	Lebu	Key Lime	Shrub	NE	✓	✓
53		*Citrus maxima*	Jambura	Pomelo	Shrub	LC	✓	✓
54		*Glycosmis*	Motkila	Orangeberry	Shrub	LC	✓	✓

Sl. No.	Family	Scientific Name	Local Name	Common Name	Type	IUCN Global*	Occurrence	
							Dry season	Rainy season
		pentaphylla						
55	Sapindaceae	*Erioglossum rubiginosum*	Rirha	Rusty sapindus	Shrub	LC	✓	✓
56	Scrophulariaceae	*Lindernia ciliata*	Vuiokra	Hairy Slitwort	Herb	LC	✓	✓
57		*Scoparia dulcis*	Bondhoney	Sweet broomweed	Herb	NE	✓	✓
58	Solanaceae	*Solanum americanum*	Tit begun	Glossy nightshade	Herb	NE	✓	✓
59		*Cestrum nocturnum*	Hasna hena	Night-blooming jasmine	Shrub	LC	✓	✓
60		*Solanum melongena*	Begun	Egg Plant	Shrub	NE	✓	✓
61	Tiliaceae	*Corchorus olitorius*	Toshapat	Tossa jute	Herb	NE	✓	✓
62	Verbenaceae	*Lantana camara*	Lantana	Common lantana	Shrub	NE	✓	✓
63		*Vitex negundo*	Nishinda	Chaste tree	Shrub	LC	✓	✓

Source: JICA Study Team

* IUCN 2024. The IUCN Red List of Threatened Species. Version 2024-1. https://www.iucnredlist.org ; LC = Least Concern, NE = Not Evalutaed, DD = Data Deficient.

(b) Chakaria Sundarban

Mangroves are crucial salt-tolerant forest ecosystems found in tropical and subtropical intertidal regions worldwide. They play a vital role in coastal ecosystems, providing numerous ecosystem services. Occupying brackish water zones along tropical and subtropical coastlines, mangroves are highly productive ecosystems. They offer both tangible and intangible benefits to people. Mangrove plants are halophytes, meaning they are well adapted to saline water and the fluctuating levels of tides. Because mangroves thrive in dynamic ecosystems, their growth and adaptive functions often mirror the changing social and ecological conditions of coastal environments.

The Chakaria Sundarban, located on the Cox's Bazar coast of Bangladesh, was historically one of the oldest mangrove forests in the subcontinent. It encompassed a diverse landscape of newly formed grassy islands, mangrove forests, river channels, aquaculture ponds, tidal creeks, and inter-tidal mudflats within the estuarine system of the Matamuhuri River and several smaller rivers flowing into the Bay of Bengal[18].

Initially spanning 8,510 hectares in 1903, with 7,490 hectares designated as reserve mangrove forest and 1,020 hectares as protected forest, the area underwent significant changes over the years. In 1926, over 1,600 hectares were leased to landless families for settlement, leading to increased reliance on the forest for resources such as firewood, housing, and building materials. Despite being largely unchanged until 1977, with a mangrove area of 7,500 hectares as depicted in a 1952 map and a 1975 aerial

[18] Iftekhar, M. S., & Islam, M. R. (2004). Managing mangroves in Bangladesh: A strategy analysis. *Journal of Coastal Conservation*, 10(1), 139-146.

photograph, significant alterations began thereafter. Approximately 2,251 hectares were cleared for shrimp farming by 1977, followed by an additional 694 hectares in 1982. The most drastic changes occurred from 1985 to 1988, during which around 3,577 hectares of forests were converted for shrimp farming. Finally, the remaining forest was altered for shrimp farming between 1995 and 1996, leading to the destruction of the once flourishing Chakaria Sundarbans [19].

According to the Cowan *et. al.*1928, the vegetation of Chakaria Sundarban comprises 53 species under 22 families[20]. However, a recent study revealed that the forest area is completely destroyed in terms of species diversity and abundance[21].

According to study of March 2024, the study team found five species of mangrove species in the remaining of Chakaria Sundarban. Table 9.1.40 summarize mangrove species, observed within Chakaria Sundarban.

Table 9.1.40 Mangrove Species Present in Remnants of Chakaria Sundarban

Sl. No	Common Name	Local Name	Scientific Name	Family	Remarks
1	Milky mangrove	Gewa	Excoecaria agallocha	Euphorbiaceae	Fairly common in Occurrence. Found in the planted patches of Chakaria by the Forest Depatment
2	Indian Mangrove	Keora	Sonneratia apetala	Sonneratiaceae	Common occurrence. The forest department planted several patches adjacent to Kohelia river, Bishkhali river, Ujantia Canal and Moheshkhali Channel
3		Baen	Avicennia officinalis	Avicenniaceae	
4	Thorny liana	Ananta Kata	Dalbergia spinosa	Leguminosae	Common occurrence. Generally found in the Northeastern part of the forest outside shrimp gher area.
5	Holly-leaved acanthus	Hargoza	Acanthus ilicifolius	Acanthaceae	Commonly found in the Mangrove area of Moheshkhali

Source: JICA Survey Team

8) Hydrology

Explained in 2.1.2, Chapter 2.

9) Topography

Explained in 2.1.2, Chapter 2.

[19] Hossain, M., Lin, C. K., & Hussain, M. Z. (2001). Goodbye Chakaria Sunderban: the oldest mangrove forest. *Wetland Science and Practice*, 18(3), 19-22.

[20] Cowan, J. M. (1928). The flora of the Chakaria Sundarbans. *Records of the botanical survey of India*. XI (2): 225

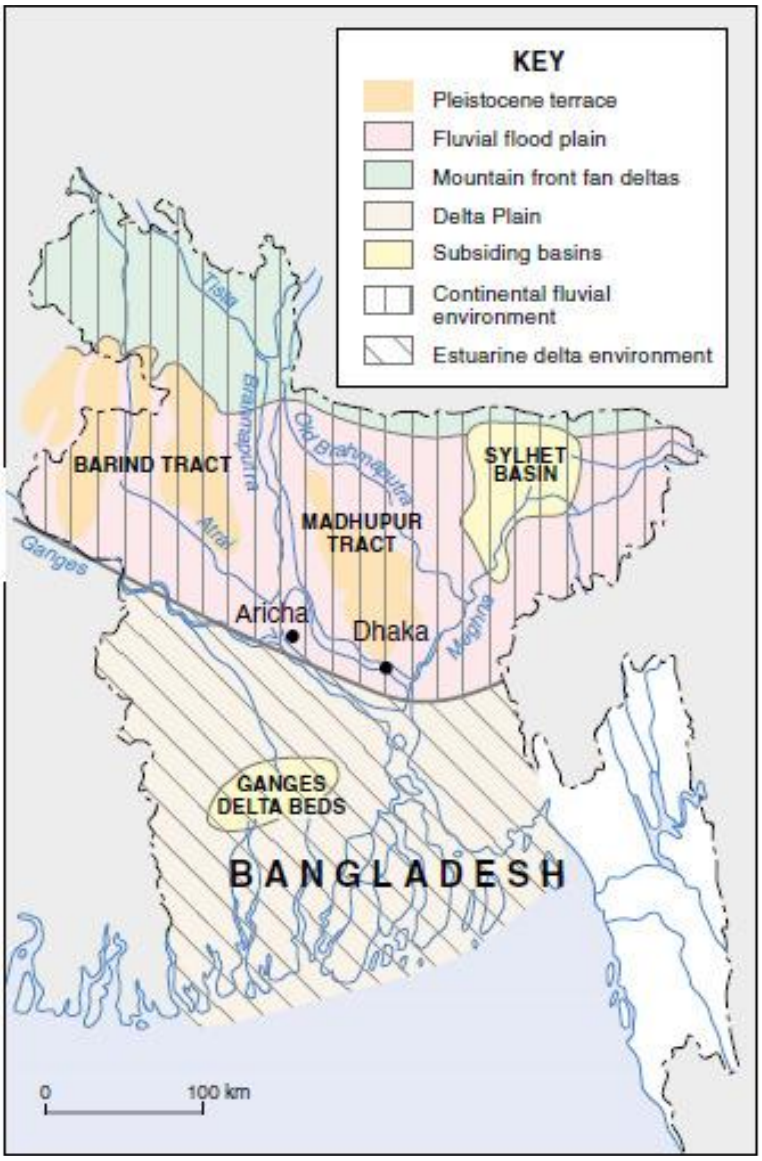
[21] Alam, S., Hossain, M. L., Foysal, M. A., & Misbahuzzaman, K. (2014). Growth performance of mangrove species in Chakaria Sundarban. *International Journal of Ecosystem*, 4(5), 233-238.

10) Geology

The districts of Chattogram, Cox's Bazar, and Hill Track have a series of hills running north-south, along which a narrow coastal plain, approximately 96.5 km long and averaging 9.66 km wide, is developed by faulting (Hussain and Abdullah, 2001). The project area falls under the Chittagong Plains as per physiographical classification of Bangladesh (Rashid, 1991). The unit consists of gently sloping, mainly loamy, alluvial flats adjoining the hills, and extensive level clay plains adjoining the three main rivers. Tidal clay plains occupy most of the offshore islands in the south. Most of the area is subject to shallow flooding and to flash floods from the hills. It is also exposed to cyclones.

The Neogene sedimentary layers developed here contain few fossils and consist primarily of altered shale, clay, claystone, siltstone, and sandstone, with intra-stratigraphic conglomerates also.

The geology of the Chattogram Hill Tracts in south-east Bangladesh is distinctive: sediments exposed in this region are dominantly older (Tertiary) folded and indurate deposits of sandstone, silt, and limestone. Figure 9.1.25 below shows the simplified geology and geomorphology of Bangladesh. The project area covers Dupi Tila and Beach and Dune geology. Dupi Tila Formation consists of yellowish-brown to brown, fine to medium-grained pebbly, and cross-bedded sandstone with subordinate clay stone and siltstone. Dune is a hill of sand built either by wind or water flow. Dunes occur in different forms and sizes, formed by interaction with the flow of air or water. Most kinds of dunes are longer on the windward side where the sand is pushed up, and have shorter "slip faces" in the lee of the wind.



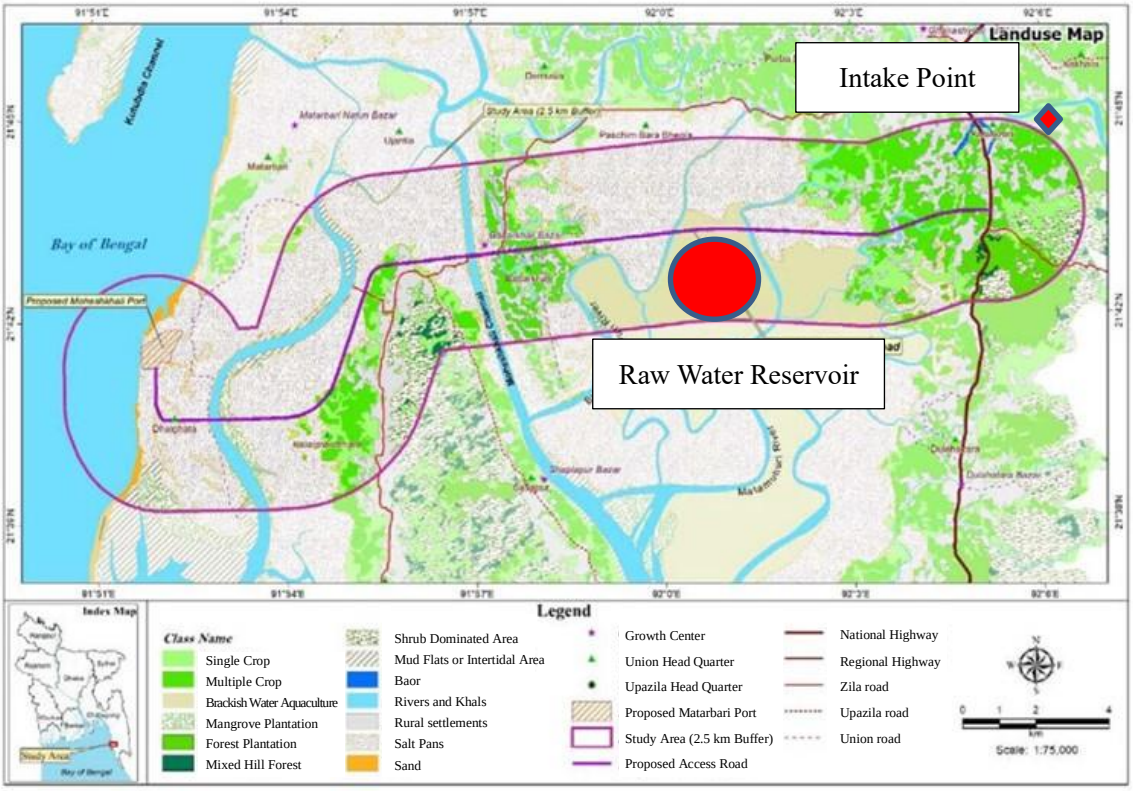
Source: JICA 2018, Final Report of Environmental Impact Assessment (EIA) (Road) for the JICA Matarbari Port Development Preparatory Survey Project

Figure 9.1.25 Geology and Geomorphology of Bangladesh

11) Land Use

Most of the project site consists of agricultural land, char land[22]/sandbars, forest, industrial areas, roads, rural settlements with homestead vegetation, built-up area, and water bodies. Figure 9.1.26 shows the general land use map, developed for the Matarbari Access Road Construction Project.

[22] Char land means riverine islands in Bangladesh.



Source: JICA 2018, Final Report of Environmental Impact Assessment (EIA) (Road) for the JICA Matarbari Port Development Preparatory Survey Project

Figure 9.1.26 Land Use Map around the Project Area

12) Weather

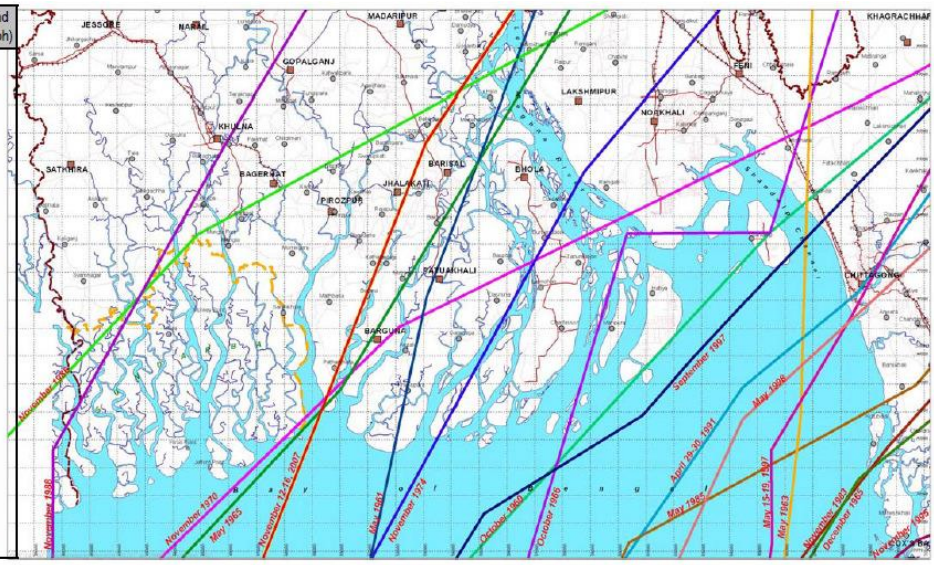
Explained in 2.1.1, Chapter 2.

13) Natural Disaster

(a) Cyclones

The tracks of cyclones and maximum wind speed from 1960 to 2007 are shown in Figure 9.1.27 below.

Landfall of Cyclone		Max. Wind
Date	Location	Speed (kph)
31.10.1960	Sandwip-Shitakunda	208
09.05.1961	Kalapara	142
29.05.1963	Shitakunda	175
12.05.1965	Patharghata	161
15.12.1965	Cox's Bazar	175
01.10.1966	Sandwip-Mirsharai	145
12.11.1970	Sarankhola-Bhola Noakhali	222
28.11.1974	Char Rangabali	161
9.11.1983	Chakaria	122
25.05.1985	Bashkhali	145
09.11.1986	Sundarban	116
29.11.1988	Sundarban	150
30.04.1991	Patenga	224
25.11.1995	Cox's Bazar	110
15.05.1997	Patenga	200
24.09.1997	Shitakunda	150
20.05.1998	Patenga	165
15.11.2007	Patharghata	240



Source: JICA 2018, Final Report of Environmental Impact Assessment (EIA) (Road) for the JICA Matarbari Port Development Preparatory Survey Project

Figure 9.1.27 Tracks of Major Cyclones that Crossed Bangladeshi Coast from 1960-2007

BMD regularly monitors the tropical cyclones and Table 9.1.41 shows the enlisted major historical cyclones that occurred in and around Bangladesh from 2005 to 2015. The major cyclones, which crossed the Bangladesh coastal area, and their maximum wind speeds are shown in the Table 9.1.42 below.

Table 9.1.41 Historical Cyclones

Sl. No.	Cyclone Name	Status	Landfall Area	Landfall Date
1	Baaz	Cyclonic Storm	Weakened into a well-marked low pressure area over southwest bay	02 Dec. 2005
2	Akash	Cyclonic Storm	Crossed south Bangladesh coast close to south of CXB	14 May 2007
3	Sidr	Very Severe Cyclonic Storm	Crossed Bangladesh coast near the Baleshwar River	15 Nov. 2007
4	Rashmi	Cyclonic Storm	Crossed Bangladesh coast near Khepupara	26 Oct. 2008
5	Bijli	Cyclonic Storm	Crossed Bangladesh coast near Chittagong	17 Apr. 2009
6	Mahasen	Cyclonic Storm	Crossed Bangladesh coast between Chittagong and Feni	16 May 2013

Source: JICA 2018, Final Report of Environmental Impact Assessment (EIA) (Road) for the JICA Matarbari Port Development Preparatory Survey Project

Table 9.1.42 Major Cyclones in Bangladesh

Date of Landfall	Nature of Phenomenon	Landfall Area	Max. Wind Speed (kph)
11 Oct. 1960	Severe Cyclonic Storm	Chittagong	160
31 Oct. 1960	Severe Cyclonic Storm	Chittagong	193
09 May 1961	Severe Cyclonic Storm	Chittagong	160

Date of Landfall	Nature of Phenomenon	Landfall Area	Max. Wind Speed (kph)
30 May 1961	Severe Cyclonic Storm	Near Feni	160
28 May 1963	Severe Cyclonic Storm	Chittagong- CXB	209
11 May 1965	Severe Cyclonic Storm	Chittagong-Barisal Coast	160
05 Nov. 1965	Severe Cyclonic Storm	Chittagong	160
15 Dec. 1965	Severe Cyclonic Storm	CXB	210
01 Nov. 1966	Severe Cyclonic Storm	Chittagong	120
23 Oct. 1970	Severe Cyclonic Storm	Khulna-Barisal	163
12 Nov. 1970	Severe Cyclonic Storm with a Core of Hurricane Wind	Chittagong	224
28 Nov. 1974	Severe Cyclonic Storm	CXB	163
10 Dec. 1981	Cyclonic Storm	Khulna	120
15 Oct. 1983	Cyclonic Storm	Chittagong	93
09 Nov. 1983	Severe Cyclonic Storm	CXB	136
24 May 1985	Severe Cyclonic Storm	Chittagong	154
29 Nov. 1988	Hurricane wind	Khulna	160
18 Dec. 1990	Cyclonic Storm	CXB's Coast	115
29 Apr. 1991	Severe Cyclonic Storm with a Core of Hurricane Wind	Chittagong	225
02 May 1994	Severe Cyclonic Storm with a Core of Hurricane Wind	CXB-Teknaf Coast	204
25 Nov. 1995	Severe Cyclonic Storm	CXB	140
19 May 1997	Severe Cyclonic Storm with a Core of Hurricane Wind	Sitakundu	232
27 Sep. 1997	Severe Cyclone with Hurricane Wind	Sitakundu	150

Source: JICA 2018, Final Report of Environmental Impact Assessment (EIA) (Road) for the JICA Matarbari Port Development Preparatory Survey Project

(b) Storm Surges

A storm surge is a coastal flood phenomenon of rising water, commonly associated with low pressure weather systems, of which the severity is affected by the shallowness and orientation of the water body relative to storm path. Most casualties during tropical cyclones occur as the results of storm surges.

The coastal areas of Bangladesh are the most vulnerable areas, which have often experienced very high cyclonic storm surges (see Table 9.1.43 below). In this table, recorded surge heights for 16 cyclones within the last 25 years are summarized.

Table 9.1.43 Major Storm Surge Incidents Hitting the Bangladesh Coast

Date	Maximum Wind Speed (km/hr)	Storm Surge Height (m)
30 Oct. 1960	211	4.6-6.1
30 May 1961	160	6.1-8.8
28 May 1963	203	4.2-5.2
11 May 1965	160	6.1-7.6
15 Dec. 1965	211	4.6-6.1
01 Nov. 1966	146	4.6-9.1

Date	Maximum Wind Speed (km/hr)	Storm Surge Height (m)
23 Oct. 1970	163	3.0-4.9
12 Nov. 1970	224	6.1-9.1
25 May 1985	154	3.0-4.9
29 Nov. 1988	160	3.0-4.0
29 Apr. 1991	225	6.0-7.5
02 May 1994	210	2.0-3.0
25 Nov. 1995	140	2.0-3.0
19 May 1997	220	3.1-4.2
15 Nov. 2007	240	up to 10
25 May 2009	120	3.0

Source: JICA 2018, Final Report of Environmental Impact Assessment (EIA) (Road) for the JICA Matarbari Port Development Preparatory Survey Project

The intensity and height of coastal storm surge depends on cyclones. The most severe cyclone was 918 mbar (occurred in 1991) with an influence radius of 74 km. This cyclone hit the eastern coast of the Bay of Bengal around Chattogram with a maximum storm surge of 4.73 m (15.18 ft) MSL. Such storm surge heights should be considered in the facility design of the Project.

(c) Earthquake

Bangladesh has experienced major earthquakes every 30 to 50 years. In 1918, Dhaka was hit by a magnitude of 7.2 earthquake. In Chattogram, great earthquakes are recorded, for example, 6.1 magnitude in Nov. 1997 and 6.2 magnitude in Nov. 2021, and there is a high risk that such great earthquake will occur within the next 50 years.

On 22 July 1999, a notable earthquake occurred in Moheshkhali Island. The magnitude scale of that earthquake was 5.2 and the damage was serious around Moheshkhali Island and adjoining areas. In that incident, fatalities were reported as: 6 dead persons, 200 injured persons, and a number of houses faced crack while some collapsed.

(3) Social Conditions

1) Population

Population trend and projected population are described in 2.2.2.

2) Economic Activities

National census information regarding economic activities in the Project Survey Area is described in 2.2.3. Main occupation of household members is described in 9.2.4, (8).

3) Education

Education status of affected people is described in 9.2.4, (7).

4) Health

No waterborne infections were identified among projects affected people. Health status of affected people is described in 9.2.4, (9).

5) Socially Vulnerable

(a) income below poverty line, (b) household head with disability, (c) female headed poor households, and (d) old aged headed poor households have been defined as the vulnerable households. The number of socially vulnerable population among the project affected people is described in 9 2.4, (9) and 9.2.5, (6). D6) Cultural Heritage

Through site survey, no cultural heritage is confirmed within the project site. Details are described in 9.2.3, (4).

7) Ethnic Minorities

According to the 2022 Census, 99% of the population in the survey area is Bengalis (about 2,808,304 people), while the remaining few, about 14,881 people, belong to ethnic minorities. Through the RAP survey no small ethnic group which is defined in Environmental and Social Standards (ESS) 7 of the World Bank is confirmed among the project affected people. All the household heads are Bengali.

8) Gender

Studies show that there have been improvements related to gender inequality in Bangladesh, especially in politics. Apart from the improvements, inequalities in areas of education, employment, and access to opportunities are still a problem. The 2021 World Economic Forum Report indicates that unemployment rates for women in Bangladesh are double those for men. Also, the report revealed a gap of 88% between the number of men and women in managerial positions.

9.1.3 Environmental and Social Consideration Systems and Organizations in Bangladesh

(1) Laws and Regulations on Environmental and Social Considerations

Laws and regulations on environmental and social considerations are shown in Table 9.1.44 below.

Table 9.1.44 Laws and Regulations on Environmental and Social Considerations

No.	Name of Laws and Regulations	Outline
Constitution		
1	The Constitution of the People's Republic of Bangladesh, 1972	Part 2, Article 18A states that efforts should be made to conserve and improve natural resources, biodiversity, wetlands, forests, and wildlife for the present and future of people.
Environmental Conservation and Environmental Impact Assessment		
1	The Bangladesh Environmental Conservation Act (ECA), 1995, amended in 2010	It is the basic law concerning environmental conservation in Bangladesh. It stipulates that a factory cannot be established or operated without an Environmental Clearance Certificate (ECC) issued by the Department of Environment (DOE).
2	The Environmental Conservation Rules (ECR), 1997, amended in 2002	Environmental impact assessment, ECC acquisition process, environmental standards (air, water quality, noise, odor), and emission standards (exhaust gas, wastewater, waste) are established.

No.	Name of Laws and Regulations	Outline
3	EIA Guidelines for Industries, 1997	It explained the EIA method defined in ECA195 and ECR.
Pollutant Control		
1	Environment Pollution Control Ordinance, 1977	It is established not only preventing pollution of air, water, soil, etc., but also preventing impact on a wide range of environments such as adverse effects on lifestyles and plants.
2	The Environmental Court Act, 2000	In order to ensure the enforcement of ECA and ECR, a court has been established to conduct criminal trials related to environmental pollution.
3	Air Pollution Control Rules (APCR), 2022	The purpose is to prevent and control air pollution and reduce air pollutants. Also, ambient air quality standards and emission standards are also established.
4	The Vehicle Act, 1927, and the Motor Vehicles Ordinance, 1983	Provides rules for exhaust emission, air, and noise pollution, as well as road and traffic safety.
Natural Environment		
1	Bangladesh Biodiversity Act, 2017	It stipulates the conservation of biodiversity, the sustainable use of resources and biota, and the fair and equitable distribution of benefits obtained.
2	The Wildlife (Conservation and Security) Act 1974, 2012	It stipulates the conservation of biodiversity, the sustainable use of resources and biota, and the fair and equitable distribution of benefits obtained.
3	Water Act, 2013	It provides for the comprehensive development, management, abstraction, distribution, use, protection, and conservation of water resources.
4	The Protection and Conservation of Fish Act, 1950	It deals with the protection and conservation of fish in government-owned water bodies.
5	The Ground Water Management Ordinance, 1985	It describes the management of groundwater resources and licensing of tube wells.
6	The Forest Act, 1927	It describes the protection of forest reserves, protected forests, and village forests.
7	The Private Forests Ordinance Act, 1959	It deals with the conservation of private forests and the afforestation of wastelands.
Social Considerations		
1	Acquisition and Requisition of Immovable Property Act, 2017 (ARIPA 2017)	It stipulates the continuation of land acquisition. In addition, an additional premium is explained for compensation.
2	The Antiquities Act, 1968	It describes the preservation of cultural heritage, historic monuments, and protected sites.
3	Bangladesh Labor Law, 2006	It deals with occupational rights and the safety of factory workers; provision of comfortable work environment and reasonable working conditions.
Others		
1	The Embankment and Drainage Act, 1952	It describes the protection of embankments and drainage facilities.

Source: Prepared by the JICA Survey Team referring to the Final Report of Preparatory Survey on Matarbari Ultra Super

(2) Standards (Comparison with the International Standards)

1) Air Quality

The ambient air quality standards for Bangladesh and the WHO Air Quality Guidelines' values (2021) are shown in Table 9.1.45 below. The WHO Guidelines set interim targets to promote air quality improvement gradually; however, compliance with the guidelines is recommended to protect human health.

Table 9.1.45 Air Quality Standards

No.	Items	Concentration (μ g/m^3)		Average Time
		National Standard	WHO Guidelines 2021	
a)	CO	5,000	-	8 hours
		20,000	-	1 hour
b)	Pb	0.25	-	Annual
		0.50	-	24 hours
c)	NO^2	40	40 (Interim target-1) 30 (Interim target-2) 20 (Interim target-3) 10 (Guideline)	Annual
		80	120 (Interim target-1) 50 (Interim target-2) 25 (Guideline)	24 hours
d)	PM10	50	70 (Interim target-1) 50 (Interim target-2) 30 (Interim target-3) 20 (Interim target-4) 15 (Guideline)	Annual
		150	150 (Interim target-1) 100 (Interim target-2) 75 (Interim target-3) 50 (Interim target-4) 45 (Guideline)	24 hours
e)	PM2.5	35	35 (Interim target-1) 25 (Interim target-2) 15 (Interim target-3) 10 (Interim target-4) 5 (Guideline)	Annual
		65	75 (Interim target-1) 50 (Interim target-2) 37.5 (Interim target-3) 25 (Interim target-4) 15 Guideline)	24 hours
f)	Ozone	180	-	1 hour
		100	-	24 hours
g)	Sulfur dioxide	250	-	Annual
		80	125 (Interim target-1) 50 (Interim target-2) 40 (Guideline)	24 hours
h)	Ammonia	100	-	Annual
		400	-	24 hours

Source: Air Pollution Control Rules, 2022, WHO Global Air Quality Guidelines, 2022

2) Water Quality

The surface water quality standard (ECR2023) is shown in Table 9.1.46 below.

Table 9.1.46 Water Quality Standard (Surface Water), ECR2023

Items	Unit	a	b	c	d	e	f
pH		6.5 - 8.5	6.5 - 8.5	6.5 - 8.5	6.5 - 8.5	6.5 - 8.5	6.5 - 8.5
DO	mg/l	≥6	≥5	≥5	≥5	≥1	-
BOD	mg/l	≤2	≤3	≤3	≤6	≤12	≤12
NO_3-N	mg/l	7	7	7	7	-	5
NH_4-N	mg/l	0.1	0.3	0.3	0.3	2.7	1.5
PO_4^{3-}–P	mg/l	0.1	0.5	0.5	0.5	-	2
Total Cr	mg/l	0.02	0.2	0.02	0.05	0.1	0.1
Pb	mg/l	0.03	0.05	0.03	0.1	0.1	0.1
Hg	mg/l	0.001	0.001	0.001	0.004	0.05	0.002
Total Coliform	CFU/100 ml	≤100	≤50	≤5000	≤5000	-	≤50,000
TDS	mg/l	1000	1000	1000	1000	1000	1000
COD	mg/l	10	10	25	50	100	100

Note: Type of use is as follows:
a) Source of drinking water for supply only after disinfecting:/ b) Water usable for recreational activity:/ c) Source of drinking water for supply after conventional treatment:/ d) Water usable by fisheries:/ e) Water usable by various process and cooling industries:/ f) Water usable for irrigation.
Source: ECR 2023

3) Noise and Vibration

For noise, standards are specified for each category of location, and noise standards are shown in Table 9.1.47. It is noted that environmental standards for vibration are not specified in the Bangladesh and IFC/WB EHS Guidelines. Since the baseline survey will measure vibration velocity (mm/sec), the Australian Standard for Vibration Velocity of the "Standard Value for Ground Vibration Limits for Human Comfort" could be referred as shown in Table 9.1.47 below. It is noted that the Japanese Vibration Standard uses vibration acceleration (dB); therefore, this could not be referred to.

Table 9.1.47 Noise Level Standard

No.	Category	Standard dBA (National Standard)*1		Standard dBA (IFC/WB EHS Guidelines, 2007)*2	
		Day Time	Night Time	Day Time	Night Time
a)	Silent zone	45	35	-	-
b)	Residential area	55	45	55	45
c)	Mixed area (mainly residential area, and also simultaneously used for commercial and industrial purposes)	60	50	-	-

d)	Commercial area	70	60	70	70
e)	Industrial area	75	70	70	70

*1: Day time (7:00 AM - 10:00 PM), Night time (10:00 PM - 7:00 AM)
*2: Day time (6:00 AM - 9:00 PM), Night time (9:00 PM - 6:00 AM)
Source: Noise Pollution Control Rules-2006, IFC Environmental Health and Safety Guidelines, 2007

Table 9.1.48 Vibration Level Standard

Category	PPV（mm/sec）
Residential	0.3
Offices	0.6
Occupied non-sensitive sites, such as factories and commercial premises	2.5

Source: Standard Value for Ground Vibration Limits for Human Comfort by the Department of Industry, Innovation and Science, Australian government, Issue BS-6472-2:2008

(3) National Plans and Policies Related to Environmental and Social Considerations

The national plans and policies related to environmental and social considerations are shown in Table 9.1.49 below.

Table 9.1.49 National Plans and Policies Related to Environmental and Social Considerations

No.	Name	Outlines
1	National Environment Policy, 1992, 2013, 2018	It lists 17 major environmental issues and 12 goals. It shows 271 action plans in 23 sectors. The National Environment Policy has been changed into 2018 considering issues such as climate change and limitation of natural resources. Main key elements of the policy are: ・ Ensure sustainable development by reducing human pressure on nature and natural resources. ・ Each development activity should be part of environmental protection in order to fully meet people's demand for present and future tenure. ・ Extract, use, and conserve natural resources should be science-based. ・ The impact and risk to the environment should be considered when extracting and using natural resources. ・ It is necessary to consider the economic value of natural resources including the ecosystem in the development of the national development plan. ・ The sustainable use of new and renewable resources must be fostered. ・ Enhance the long-term agenda of poverty reduction and food security through biodiversity conservation.
2	National Environment Management Plan, 1995	It shows the environmental issues and actions to be taken by each sector for the 12 sectors including the water sector. When the workshop has been held to formulate the program, opinions of NGOs and residents were incorporated.
3	National Legal Framework for	The Constitution of Bangladesh establishes fundamental rights including equality and non-discrimination, with Article 28(2) specifically stating

No.	Name	Outlines
	Gender Equality and International Commitments	that "women shall have equal rights with men in all spheres of the State and of public life." Additionally, Article 28(4) states that: "Nothing in this article shall prevent the State from making special provision in favor of women or children or for the advancement of any backward section of citizens." Article 19(3) also provides that: "The State shall endeavor to ensure equality of opportunity and participation of women in all spheres of national life" as a fundamental principle of state policy. Apart from the Constitution, Bangladesh has enacted laws and policies on gender equality including the National Women Development Policy 2011, Gender Policy 2016, and Domestic Violence (Prevention and Protection) Act, 2010. These policies focus on recognizing the differences among genders and promoting equitable access to resources, which is vital in addressing harmful norms that perpetuate gender inequalities. Internationally, Bangladesh participates in various forums and has ratified the key international human rights treaties that focus on protecting women's rights. Among them, the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW), ensuring freedom from gender discrimination and harassment.

Source: JICA Survey Team

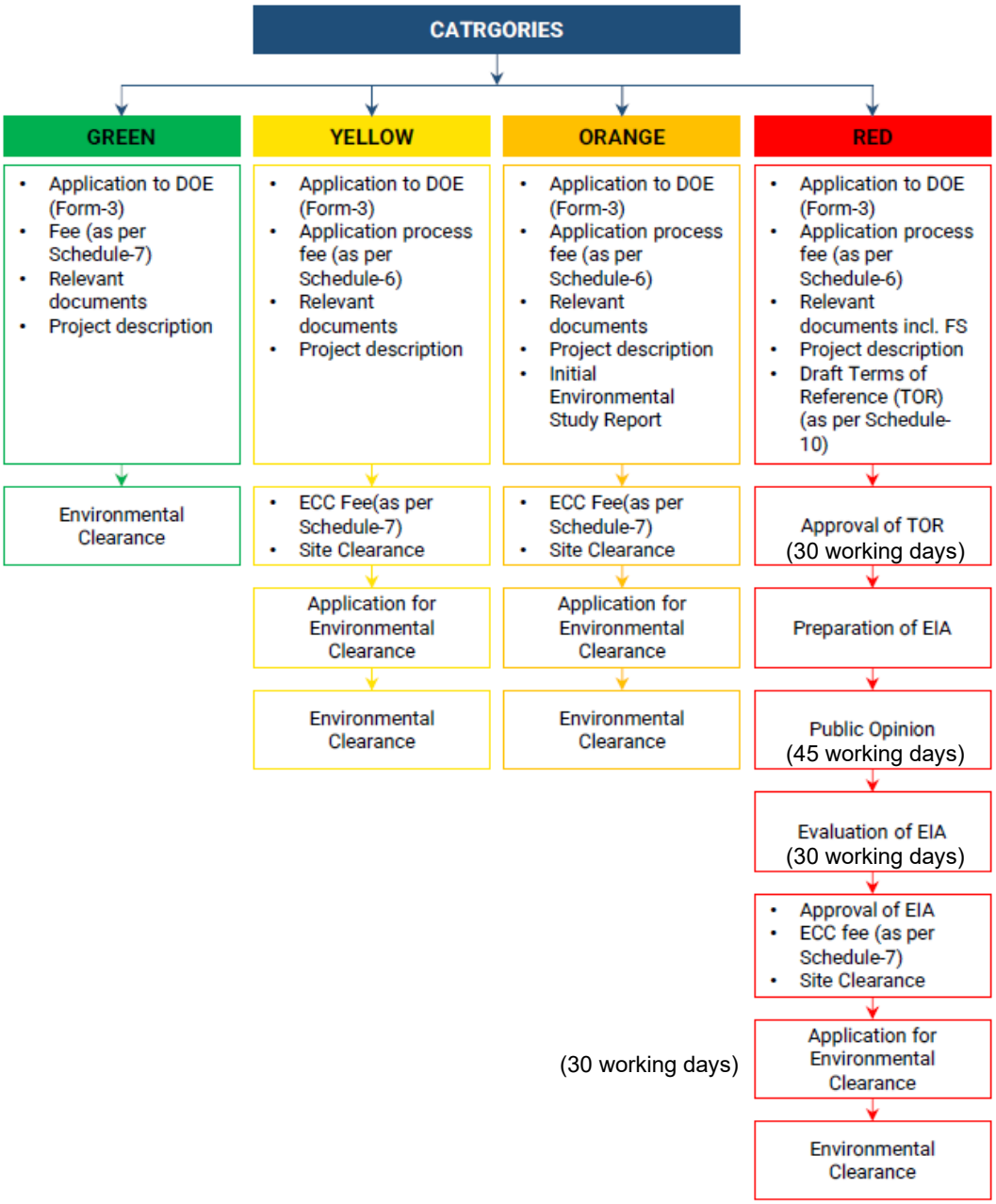
(4) Approvals Required to Implement the Project in Accordance with the Legal System of Bangladesh

1) EIA

The "Environmental Conservation Rules, 2023 (ECR 2023)" prescribes the procedures for EIAs. Projects are categorized into green, yellow, orange, and red based on potential impact, and industries in each category are listed in Schedule-1 of ECR 2023. All projects are required to obtain environmental clearances. Projects in the yellow, orange, and red categories are also required to obtain site clearances. (Site clearance is required for construction and environmental clearance is required for operation) Projects in the red category require an EIA study since the project may have a significant impact. The EIA study requires stakeholder consultations. The EIA review mainly includes an environmental and social impact assessment, an environmental management plan, environmental monitoring plan, compliance with standard values, and government policies and plans.

The Project is categorized into the red category according to ECR 2023 and is required to obtain environmental clearance before operation, following the procedures in Figure 9.1.28 below. For the EIA procedures, the project proponent on the Bangladeshi side shall apply to the DOE. First, the terms of reference (TOR) for the EIA is to be approved, and then the EIA study will be conducted next, and lastly, the EIA report will be prepared based on the approved TOR. The project proponent shall obtain approval of EIA (site clearance) and then apply environmental clearance to the DOE. It takes 30 working days to review the TOR (after submission of TOR), 45 working days to collect comments for the draft EIA (after disclosure of draft EIA), 30 working days to review the EIA report (after submission of EIA), and 30 working days to issue the environmental clearance (after application). EIA application and assessment

fees, as well as environmental clearance renewal fees (annually in the case of red category) are required. The flow of EIA procedures is shown in Figure 9.1.28 below. ToR for EIA has been submitted to DOE Cox's Bazar Office on 16 July 2024 (Cox's Bazar Office forwarded the ToR to DOE Headquarters) and approved by Environment Clerance Committee on 20 August 2024. The draft EIA has been submitted to the DOE Cox's Bazar Office on 12 September 2024. The stakeholder meetings in accordance with ECR2023 were not held within the preparatory survey.



Source: JICA Survey Team

Figure 9.1.28 Procedures of the EIA Study in Bangladesh

2) Land Acquisition and Resettlement

(a) Process of Land Acquisition, Cash Compensation under Law and Top-up Payment to Title Holder

The procedures on land acquisition in the "Acquisition and Requisition of Immovable Property Act (ARIPA)" enacted in July 2017 are described in this paragraph. The act discusses both (1) permanent acquisition of immovable properties under Chapter 2 and (2) requisition of immovable property (temporary acquisition or the possession of immovable property for a specific time) under Chapter 3. The said act has improved land compensation payment. Under the ARIPA, a landowner gets land compensation with additional 200% and 300% of the land value in cases of government and private projects, respectively.

Prior to serving the preliminary land acquisition notice under Section 4, the land acquisition process needs to be initiated by the executing agency (EA). Items a) to r) below indicate the overall procedures of land acquisition from the initiation of the process by the EA to payment of cash compensation under the law (CCL) by the Deputy Commissioner (DC). It is important to note that the DC pays compensation as required by the ARIPA 2017 to the titleholders of the affected land and properties. After the DC processes, payment of top-up and other resettlement benefits (cash and in-kind) is made by the EA with the assistance of the implementing agency (IA) as seen from Items s) to w) below to close the gap between the ARIPA and the donor's requirements.

a) Land Acquisition Proposal is to be submitted to DC office by the executing agency (EA) along with LA maps (duly digitized and georeferenced), plot schedule, 'CHA' Form and other administrative papers/approvals satisfying requirements of the ARIPA 2017.

b) Upon successful submission of the LA proposal, the DC office (headed by ADC Revenue) conducts a reconnaissance visit to the proposed site for confirmation of the land acquisition process.

c) Based on the reconnaissance visit report, the District Land Allocation Committee (DLAC) headed by the DC approves the land acquisition proposal and opens the LA case file.

d) If the land is within 6.68 ha Divisional Commissioner approves the LA proposal and in case of more than 6.68 ha, the Ministry of Land approves it through the Central Land Allocation Committee (CLAC).

e) If the acquisition proposal is within the city corporation area (Dhaka north and south, Khulna, Barisal, Gazipur, Narayanganj, Sylhet, Cumilla Rangpur, Rajshahi, and Mymensingh), the CLAC will approve the LA proposal even though the land is within 6.68 ha.

f) After approval in the DLAC/CLAC meeting, the DC serves the notice under Section 4 of the Acquisition and Requisition of the Immovable Property Act, 2017, to the recorded owner of the affected property for public appraisal.

g) Acquiring Body (DC) and Requiring Body (RB) representatives conduct joint verification of the affected property within seven working days of serving notice under Section 4.

h) After that, the DC serves notice under Section 7 for entertaining claims (appeals) from the potential affected persons.

i) Based on the joint verification survey data, the DC writes a letter to the Public Works Department (PWD) with information of affected structures, list of trees to the Forest Department, and type of crops to the Agriculture Department for valuation as per government rule.

j) The DC also collects the last recorded land price of lands of similar description from the concerned Sub-register's Office for the last 12 months from the date of notice under Section 4.

k) After receiving rates from the PWD and the Forest and Agriculture departments, the DC prepares estimates and sends it to the RB for placement of fund within 60 days.

l) The DC prepares awards for compensation in the name of the recorded owner.

m) Upon placement of fund, the DC serves notice under Section 8 to the entitled persons (Eps) for receiving cash compensation under law (CCL) within 15 days from the date of issuing notice.

n) The affected people are notified to produce record of rights to the property with updated tax receipt of land, declaration on BDT 300 non-judicial stamps, photograph, etc., before the Land Acquisition Section of the DC office.

o) Upon fulfilment of the criteria of the DC office, i.e., requisite papers and document, the LA section disburses CCL in the office or field level issuing prior notice to the EPs.

p) Local government institutions' representatives identify the affected people during receiving CCL.

q) As per the Land Acquisition Law, the DC pays compensation to the legal owners of the properties for land, structure, trees, and crops.

r) After receiving CCL from the LA office and obtaining clearance from the Treasury Section of the DC, the EP deposits the CCL to his own bank account.

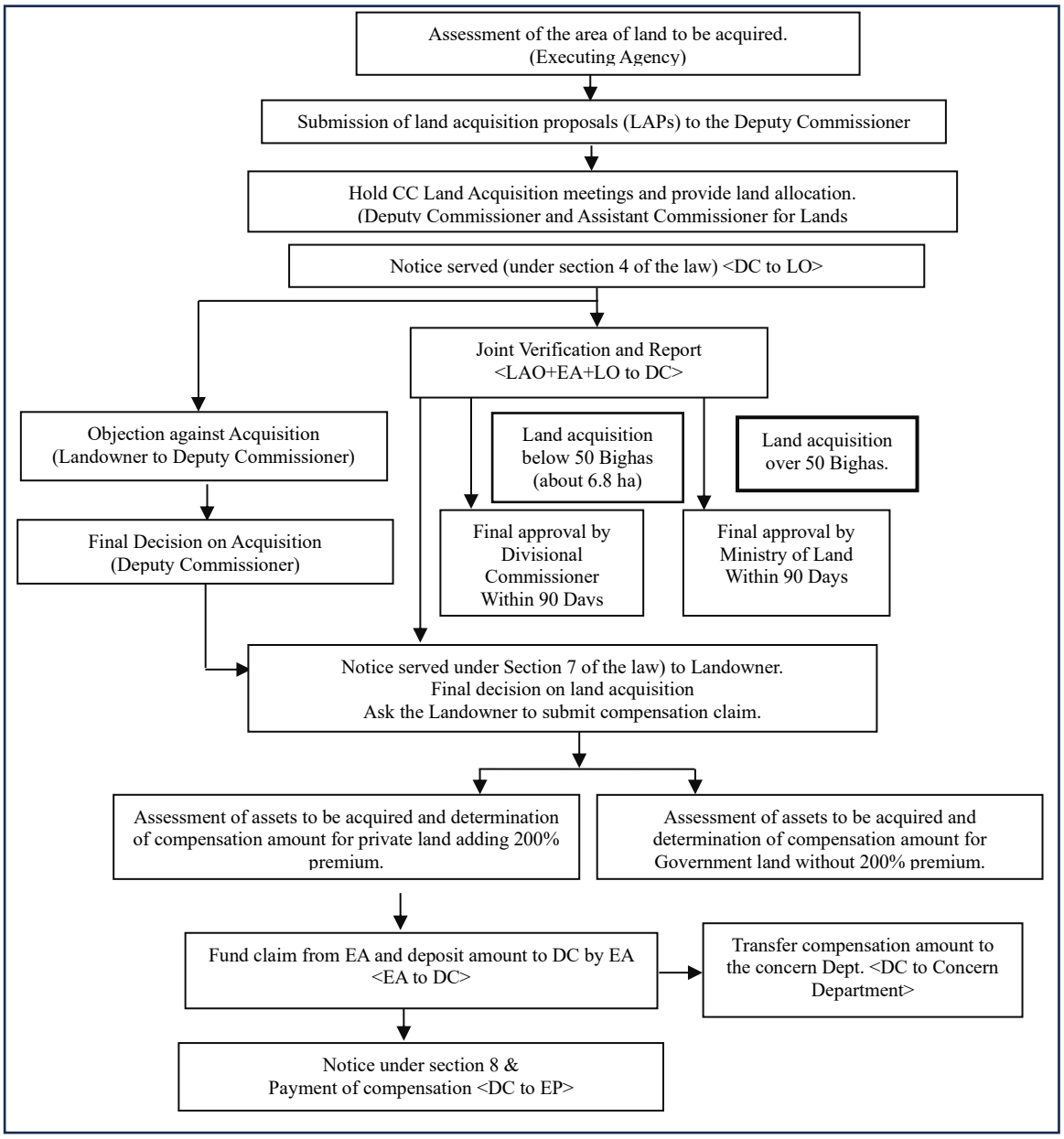
s) One copy of the CCL will be submitted to the implementing agency (IA) (NGO or consulting firm with experience on social issues) office for additional payment (top-up) of compensation as per RAP policy.

t) The IA will create ID numbers for the CCL holder and prepare EP and entitlement card (EC) for payment.

u) The IA will prepare ID cards with photographs of the EPs.

v) The ID card will be jointly signed by the EA and IA representative and photograph will be attested by the concerned Ward Commissioner.

w) The IA will disburse account payee cheque in public place or office of the ward councillor.



Legend: EA=Executing Agency DC=Deputy Commissioner, AC (Land)=Assistant Commissioner Land, LO=Landowner, LAO=Land Acquisition Officer

Source: ARIPA 2017

Figure 9.1.29 Procedures of Compensation of ARIPA 2017

The ARIPA 2017 allows for grievances to be filed against the authorized owner of the property at each stage of the land acquisition process. Table 9.1.50 below summarizes the grievance filing process.

Table 9.1.50 Grievance Mechanism in ARIPA 2017

ARIPA2017	Grievance Mechanism	Outlines
Section 5 (1)	Grievance on land acquisition	After the DC issues a notice under Section 4 of ARIPA 2017, affected persons may file an objection to the site acquisition with the DC within 15 business days from the date the notice is filed.
Section 4 (8)	Grievance on joint verification	After the joint verification identifies the affected assets, the affected residents may file objections to the results of the joint verification with the DC.
Section 11 (2)	Disputes regarding the amount of compensation, eligibility for compensation, and land subject to acquisition	If there is a dispute over the amount of compensation or a dispute over the land to be acquired, the affected residents may request an arbitrator to resolve the dispute.

Source: ARIPA 2017

(b) Procedures for Compensation Payment to Non-title Holder

The non-titled holder means the person having no legal ownership of the affected land or other properties, but socially recognized and enlisted during census, socio-economic and/or joint verification survey of the affected area. This type of affected people is not covered by the ARIPA 2017; hence, the final on-ground confirmation of them and payment of compensation and other resettlement benefits is done by the EA with the assistance of IA. This kind of system is implemented to comply with donors' requirements.

3) Information Disclosure

There are no provisions to prepare the RAP in the ARIPA 2017. Therefore, RAP preparation and disclosure in Bangladesh is done as a compliance to donors' requirements.

The ECR 2023 stipulates the publication of the draft EIA and the conduct of stakeholder consultations as a part of the EIA procedures. The draft EIA with its Bengali summary shall be submitted to the DOE and published on the DOE website for 45 days. A notice of stakeholder consultations must be published in the national and regional newspapers.

4) NOC for Project Clearance Certificate from Water Resources Planning Organisation (WARPO)

Water Rules 2018 stipulates that the project proponent should obtain a No Objection Certificate (NOC) for Project Clearance Certificate from WARPO before construction. The NOC will be issued within 45 working days after application. According to WARPO, a forwarding letter to the Director General of WARPO from DPHE Chief Engineer should be submitted, with detailing all components of our project, along with three copies of the DPP (after formulation).

(5) Gap Analysis

1) Comparison and Responses between JICA Environmental and Social Considerations Guidelines and Bangladesh Legal System for EIA

Comparison and responses between the "JICA Environmental and Social Considerations Guidelines" and the Bangladesh Legal System for EIA are shown in Table 9.1.51 below.

Table 9.1.51 Comparison and Responses between JICA Environmental and Social Considerations Guidelines and Bangladesh Legal System for EIA

Items	JICA ESC Guidelines	Bangladesh's Procedures	Gap between JICA ESC Guidelines and Bangladesh's Procedures/ Action to be Taken
Basic Principles	1. Environmental and social impacts caused by projects must be assessed and examined at the earliest possible planning stage. Alternatives or mitigation measures must be examined in order to avoid such impacts as much as possible, and to minimize, reduce, or mitigate them when such avoidance is impossible. The result of the examinations must be reflected into the project plan. 2. Such examinations must be endeavored to include an analysis of environmental and social costs and benefits in the most quantitative terms possible, as well as a qualitative analysis, and to be in a close harmony with the economic, financial, institutional, social, and technical analyses of projects. 3. The findings of the examination of environmental and social considerations, including alternatives and mitigation measures, must be documented as an independent document or as a part of other documents. Environmental assessment reports must be prepared for projects with potential significant impacts. 4. For projects which may have significant impacts in particular, or for controversial projects, a committee of experts may be formed so that projects may seek their opinions, in order to increase accountability.	In Article 17 (3), the point to be considered in the evaluation of the EIA is stated as "possible alternatives of the concerned project, and if necessary, on- site inspection of the proposed site of the said project". Article 15 (1) states that "shall prepare an environmental impact assessment report by conducting an environmental impact assessment survey. Article 17 (1) states that "the concerned industrial establishment or project promoter shall be invited to the meeting of the Environmental Clearance Committee to provide clarification on the information and data of the environmental impact assessment report.	No gap.
Examination of Measures	1. Multiple alternatives must be examined in order to avoid or minimize adverse impacts by the project and to choose better project options in terms of the environmental and social considerations. In the examination of measures, priority	Article 5 states that "Industries or projects in the red category have a severe impact on the environment, which needs to be avoided in order to	No gap.

Items	JICA ESC Guidelines	Bangladesh's Procedures	Gap between JICA ESC Guidelines and Bangladesh's Procedures/ Action to be Taken
	is to be given to avoid environmental impacts. When this is not possible, minimization, reduction, and then mitigation of the impacts must be considered, in accordance with the mitigation hierarchy. Compensation measures must be examined only when significant impacts still remained even with the aforementioned measures. 2. Appropriate plans and systems for measures, such as monitoring plans and environmental management plans, must be prepared. The costs of implementing such plans and systems, and the financial methods to fund such costs, must be determined. For projects with particularly significant impacts, detailed environmental management plans must be prepared.	preserve the environment to an appropriate extent. Significant mitigation measures are required to reduce the environmental impact of this class of industries or projects." In Article 18 (1), the point to be considered in the approval of the EIA is states as "whether the proposed environmental management plan and monitoring program are accurate, effective, practical, and adequate."	
Scope of Impacts to Be Assessed	1. The impacts to be assessed with regard to environmental and social considerations include impacts on human health and safety, as well as on the natural environment, that are transmitted through air, water, soil, waste, accidents, water use, climate change, biodiversity, and ecosystem services, including trans boundary or global scale impacts. These also include social considerations such as: migration of population including involuntary resettlement, local economy such as employment and livelihood, utilization of land and local resources, social institutions such as social capital and local decision-making institutions, existing social infrastructures and services, vulnerable social groups such as poor peoples and indigenous peoples, equality of benefits and losses and equality in the development process, gender, children's rights, cultural heritage, local conflicts of interest, infectious diseases such as HIV/AIDS, and working conditions including occupational safety. 2. In addition to the direct and immediate impacts of projects, derivative, secondary, and cumulative impacts as well as impacts associated with indivisible projects are also to be examined and assessed to a reasonable extent. It is also desirable to consider the	In Article 18 (1), the point to be considered in the approval of the EIA is states as "whether the environmental or social impact has been adequately assessed" Necessity of assessment of derivative, secondary, and cumulative impacts of the project is not stated.	No major gaps. The study will cover the items in the guidelines. Derivative, secondary, and cumulative impacts of the project will also be examined as necessary.

Items	JICA ESC Guidelines	Bangladesh's Procedures	Gap between JICA ESC Guidelines and Bangladesh's Procedures/ Action to be Taken
	impacts through a project life cycle.		
Compliance with Laws, Standards, and Plans	1. Projects must comply with the laws, ordinances, and standards related to environmental and social considerations established by host country governments, including local governments. Projects must also conform to the environmental and social consideration policies and plans of the host country governments. 2. In principle, projects must be undertaken outside of areas that are specifically designated for conservation of nature or cultural heritages by the host country governments, unless the main purpose of the projects is to promote or restore the protection of such areas. Also, projects shall not cause significant adverse impacts on such designated conservation areas.	In Article 18 (1), the point to be considered in the approval of the EIA is states as "Whether the concerned industrial establishment or project proposal is contrary to the government policy and plan."	There is a gap. Impacts to protected areas and cultural heritage sites as defined by relevant laws and regulations will be avoided as much as possible.
Social Acceptability	1. Projects must be adequately coordinated so that they are accepted in a socially appropriate manner for the countries and areas where the projects are planned. For projects with potentially significant environmental and social impacts, sufficient consultations with local stakeholders, such as local residents, must be conducted via disclosure of information at an early stage, at which time alternatives for project plans are examined. The outcome of such consultations must be incorporated into the project plans. 2. Appropriate considerations must be given to vulnerable social groups, such as women, children, elderly peoples, people in poverty, indigenous peoples, persons with disabilities, refugees, internally displaced persons, and minorities. Such vulnerable social groups are susceptible to environmental and social impacts and may have little access to decision-making processes within the society.	Article 16 states regarding the red category projects as "in the presence of the stakeholders concerned with the project and the officials of the concerned office of the directorate, measures shall be taken to verify the public opinion in the said industrial establishment or the area concerned with the project."	No major gaps. Stakeholder meeting will be conducted in accordance with ECR 2023 and due considerations to socially vulnerable groups will be given.
Climate Change	1. For projects that are expected to generate more than a certain amount of greenhouse gas emissions, the total amount of greenhouse gas emissions will be estimated and disclosed before the project implementation.	No provision.	There is a gap. Increase of greenhouse gas emissions by the project is expected; however, this will be studied in advance.
Biodiversity	1. Projects must not involve significant	No provision.	There is a gap. The

Items	JICA ESC Guidelines	Bangladesh's Procedures	Gap between JICA ESC Guidelines and Bangladesh's Procedures/ Action to be Taken
	conversion or significant degradation of critical habitats or critical forests. 2. Illegal logging of forests must be avoided. Project proponents need to obtain logging permits from regulatory agencies, and are encouraged to obtain forest certifications for forestry projects, in order to ensure the prevention of illegal logging.		area categorized under protected area will be avoided as much as possible. If tree cutting is required, necessary permission will be confirmed to the related organizations.
Involuntary Resettlement and Loss of Livelihood	1. Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. If avoidance is not possible even after such examination, effective measures to minimize impacts and to compensate for losses must be taken upon agreement with the affected people. 2. Project affected people, such as people to be resettled involuntarily and/or people who may lose their livelihoods by the project, must be provided sufficient compensations and supports by the project proponents in a timely manner. Compensations must be calculated at full replacement cost as much as possible, and provided in advance. Project proponents must make efforts for the affected people to improve or at least restore their standards of living, income opportunities, and production levels to the pre-project levels. Measures to achieve this may include: Providing land or monetary compensations for losses of land or assets, supporting for alternative sustainable livelihood, supporting for expenses necessary for relocation, and supporting for re-establishment of communities at resettlement sites. 3. Compensation standards are disclosed and consistently applied. The project affected persons need to be aware of the compensation standards. In principle, the contents of the individual compensation to be agreed are explained to the project affected persons in writing, and the project affected persons can confirm the contents at any time. 4. Appropriate participation of the project affected people and their communities must be promoted in the planning, implementation, and monitoring of	No provision.	There is a gap. Required procedure of Bangladesh will be proceeded in accordance with ARIPA 2017. If there is a gap, gap-filling measures will be taken.

Items	JICA ESC Guidelines	Bangladesh's Procedures	Gap between JICA ESC Guidelines and Bangladesh's Procedures/ Action to be Taken
	measures against involuntary resettlement and loss of livelihood. 5. For projects that result in large-scale involuntary resettlement, RAPs must be prepared and made available to the public prior to the resettlement and provision of compensation and support. In preparing the RAP, consultations must be held with the project affected people and communities, based on sufficient information made available to them in advance. When consultations are held, explanations must be given in languages and forms that are understandable to the project affected people. It is desirable that the RAP includes elements laid out in the Environmental and Social Standard (ESS) 5 of the WB's Environmental and Social Policies.		
Indigenous Peoples	1. Any adverse impacts that a project may have on indigenous peoples are to be avoided when feasible by exploring all viable alternatives. If avoidance is not possible even after such examination, effective measures for indigenous peoples must be taken to minimize the impacts and to compensate for the losses. 2. When projects may have adverse impacts on indigenous peoples, all of their rights in relation to land and resources must be respected in accordance with the spirit of the relevant international declarations and treaties, including the United Nations Declaration on the Rights of Indigenous Peoples. Efforts must be made to obtain the Free, Prior, and Informed Consent (FPIC) of the affected indigenous peoples. 3. Measures for the affected indigenous peoples must be prepared as an Indigenous Peoples Plan (IPP), which may constitute as a part of other documents for environmental and social considerations, and must be made public in compliance with the relevant laws and ordinances of the host country. In preparing the IPP, efforts must be made to obtain the FPIC of the affected indigenous peoples based on sufficient information made available to them in advance. When consultations are held, explanations are given in languages and	No provision.	There is a gap. Impact to indigenous people is not expected, however, the impact will be studied. If there is an impact, mitigation measures covering JICA GL will be taken.

Items	JICA ESC Guidelines	Bangladesh's Procedures	Gap between JICA ESC Guidelines and Bangladesh's Procedures/ Action to be Taken
	forms that are understandable to the indigenous peoples concerned. It is desirable that the IPP includes the elements laid out in the ESS 7 of the WB's Environmental and Social Policies.		
Monitoring	1. During the project implementation, project proponents monitor whether any unforeseeable situations occur, and the performance and effectiveness of the planned mitigation measures. Project proponents take appropriate measures based on the results of such monitoring. 2. In cases where sufficient monitoring is deemed essential for appropriate environmental and social considerations, such as projects for which mitigation measures should be implemented while monitoring their effectiveness, project proponents must ensure that the project plans include feasible monitoring plans. 3. Project proponents should make efforts to make the monitoring results available to local stakeholders involved in the project. 4. When third parties point out specifically that environmental and social considerations are not being fully undertaken, project proponents should make efforts to reach an agreement on the procedures to resolve the problems, through forums for discussions and examinations of the countermeasures with participation of stakeholders involved in the projects, based on sufficient information disclosure.	In Article 18(1), the point to be considered in the approval of the Environmental Impact Statement states as "whether the proposed environmental management plan and monitoring program are accurate, effective, practical, and adequate." Article 19 states that "It is further provided that while the red category industrial establishment or project is in progress, the directorate will issue instructions to the entrepreneur to update the environmental impact assessment report taking into account the effectiveness of the monitoring report and environmental management plan and any relevant new environmental or social issues."	No major gap. If complaint and problems are reported, monitoring results will be shared and solution will be discussed in the stakeholder meeting.
Grievance Redress Mechanism	1. A mechanism for handling concerns and grievances from people and communities affected by the project's environmental and social impacts must be in place. 2. The grievance redress mechanism needs to be easily accessible for the project affected people and communities. Project proponents disseminate the information about the grievance redress mechanism through consultations with local stakeholders. The project affected people and communities must not be disadvantaged by filing a grievance. 3. Project proponents should make efforts to respond promptly to the grievances they receive, taking into account the	No provision.	There is a gap. Grievance redress mechanism will be established and measure covering JICA Guidelines (GL) will be taken.

Items	JICA ESC Guidelines	Bangladesh's Procedures	Gap between JICA ESC Guidelines and Bangladesh's Procedures/ Action to be Taken
	concerns and needs of the project affected people and communities.		
Information Disclosure	1. In principle, project proponents disclose information about environmental and social considerations of their projects. JICA assists the project proponents through implementing cooperation projects as needed. 7. Project proponents disclose information well in advance when they have consultations with local stakeholders in cooperation with JICA. On such occasions, JICA supports project proponents in preparation of documents in an official or widely used language(s) and in a form understandable by local peoples.	Article 16 (1) states regarding red category projects as "in the presence of the stakeholders concerned with the project and the officials of the concerned office of the directorate, measures shall be taken to verify the public opinion in the said industrial establishment or the area concerned with the project". Article 16 (2) states that "For verification of public opinion, the industrial organization or project promoter should apply to the concerned office along with three (three) sets of environmental impact assessment report and related Bengali summary and copy thereof should be sent to the head office." Article 16 (3) states that "Within seven (7) working days of receiving the application under Sub-rule (2), the concerned industrial establishment or project promoter shall fix the date, time, and place of public opinion verification and publish a notice in a widely circulated local and a national daily newspaper.". Article 16 (4) states that "Detailed information related to the verification of public opinion shall be published on the website of the directorate and the website of the said industrial organization or project promoter, if any."	No major gap.

Source: JICA Survey Team

2) Comparison and Responses between JICA Environmental and Social Considerations Guidelines and Bangladesh Legal System for Land Acquisition and Resettlement

Comparison and responses between the "JICA Environmental and Social Considerations Guidelines" and the Bangladesh Legal System for Land Acquisition and Resettlement are shown in Table 9.1.52 below.

Table 9.1.52 Comparison and Responses between JICA Environmental and Social Considerations Guidelines and Bangladesh Legal System for Land Acquisition and Resettlement

No.	JICA Guidelines/The World Bank ESS5	Acquisition and Requisition of Immovable Property Act, 2017 (ARIPA 2017)	Gap Analysis	Policy of the Project
1	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. (JICA GL)	Not specified.	There is no requirement to avoid or minimize resettlement and loss of livelihood in Bangladesh context as required by the JICA GL	For this project, alternative analysis has been conducted and the route with minimal environmental and social impacts was selected.
2	Project affected people, such as people to be resettled involuntarily and/or people who may lose their livelihoods by the project, must be provided sufficient compensations, and supports by the project proponents in a timely manner. (JICA GL)	On making of an award under Section 8 of ARIPA, before taking possession of the property, after the submission of the estimated amount of compensation by the requiring persons, the DC shall pay the aforesaid compensation within not exceeding 60 days from the date of deposit by the requiring persons under Sub-section 2.	The ARIPA does not specify the compensation should be provided before relocation.	Requirement for the compensation to be paid prior to possession of the acquired land or prior to displacement will be set in the RAP.
3	Compensations must be calculated at full replacement cost as much as possible and provided in advance. (JICA GL)	Under Section 9 (2) of ARIPA, landowner gets land compensation with additional 200% of the land value in cases of government projects and additional 300% of the land value in cases of private projects.	The ARIPA does not specify the provision of the transaction cost or replacement cost, and there is a smaller possibility the land compensation might not be full replacement cost depending on the location.	In Bangladesh practice, an independent committee (the Property Valuation Assessment Committee) will be formed by the responsible line ministry during the land acquisition stage to establish the actual market price and replacement cost (market price plus transaction cost).
4	Project proponents must make efforts for the affected people to improve	The requirements are not specified, although the necessity for	No provisions for improving or maintaining the	Following international practices, livelihood restoration activities and

No.	JICA Guidelines/The World Bank ESS5	Acquisition and Requisition of Immovable Property Act, 2017 (ARIPA 2017)	Gap Analysis	Policy of the Project
	or at least restore their standards of living, income opportunities, and production levels to the pre-project levels. (JICA GL)	livelihood restoration for affected households is described in the ARIPA (Section 9 (4)).	living standard of affected people in ARIPA as required by the JICA GL	other resettlement assistance will be proposed in the resettlement plan of this project.
5	Compensation standards are disclosed and consistently applied. The project affected persons need to be aware of the compensation standards.	Section 8 (3) of ARIPA requires the DC to contact the property owner through the land Acquisition Officer (LO) with regard to the compensation offer.	ARIPA does not require disclosure of the compensation standard, or unit rate used to arrive to the compensation amount but the final compensation amount for each affected property.	RAP disclosure meetings of this project will disclose the mechanism for calculating the compensation package and how the replacement cost is developed.
6	In principle, the contents of the individual compensation to be agreed are explained to the project affected persons in writing, and the project affected persons can confirm the contents at any time.	Section 8 (3) of ARIPA requires the DC to contact the property owner through the land Acquisition Officer (LO) with regard to the compensation offer. If the property owner has no objection, compensation payment process will proceed and in case of objection, property owner can seek resolution to the Arbitrator.	ARIPA does not specify whether the compensation offer would be available for confirmation by the affected people after the proposed timing for consultation with the land acquisition officer.	RAP disclosure meetings of this project will disclose the mechanism for calculating the compensation package and how the replacement cost is developed.
7	For projects that result in large-scale involuntary resettlement, a RAP must be prepared and made available to the public prior to the resettlement and provision of compensation and support. (JICA GL)	Land Acquisition Plan/proposal (LAP) is required by ARIPA for the land acquisition procedure.	Bangladesh has no obligation or legal basis to prepare RAP but LAP.	To comply with the JICA GL, RAP will be prepared and disclosed
8	In preparing the RAP, consultations must be held with the project affected people and communities, based on sufficient information made available to them in advance. (JICA GL)	Preliminary land acquisition notice under Section 4 of ARIPA 2017 provides for the notification of only owners of property to be acquired.	There is no provision in the ARIPA for consulting the project stakeholders.	The resettlement plan for this project will be prepared following a consultation process involving all stakeholders (formal and informal affected people, government department/line agencies,

No.	JICA Guidelines/The World Bank ESS5	Acquisition and Requisition of Immovable Property Act, 2017 (ARIPA 2017)	Gap Analysis	Policy of the Project
				local community, NGO, etc.)
9	When consultations are held, explanations must be given in languages and forms that are understandable to the project affected people. (JICA GL)	Preliminary land acquisition notice under Section 4 of ARIPA 2017 provides for the notification of only owners of property to be acquired.	There is no provision in the ARIPA for consulting the project stakeholders.	The resettlement plan for this project will be prepared following a consultation process involving all stakeholders (formal and informal affected people, government department/line agencies, local community, NGO, etc.)
10	Appropriate participation of the project affected people and their communities must be promoted in the planning, implementation, and monitoring of measures against involuntary resettlement and loss of livelihood. (JICA GL)	Notification on land acquisition, compensation offer, and payment to legal owner is covered in Sections 4, 7, and 8 of the ARIPA. No provisions for affected people's participation during planning and monitoring.	Participation of affected people in project planning, implementation, and monitoring is not required by ARIPA.	The resettlement plan for this project will be prepared following a consultation process in the local language with all relevant stakeholders. Consultation will be a continuous process at all stages of the project development such as feasibility study, design, implementation, and post-implementation, including the monitoring phase.
11	A mechanism for handling concerns and grievances from people and communities affected by the project's environmental and social impacts must be in place. (JICA GL)	Under Section 11 (2) of ARIPA, affected people have the right to object to compensation amount and entrust the matter to the Arbitrator.	ARIPA states appeal to Arbitrator and court case, while the JICA GL recommend establishing a project specific to grievance redress including using of the available local mechanisms acceptable to the affected people.	The provision of setting up the grievance redress mechanism accessible for all the affected people including non-titled affected people will be made in the resettlement plan of this project.
12	The borrower will, as part of the environmental and social assessment, conduct a census to identify the persons who will be affected by the project, to establish an inventory of land and assets to be affected, to determine who will be eligible for compensation and assistance, and to discourage ineligible persons, such as	The preliminary land acquisition notice under Section 4 of ARIPA is considered a cut-off date for affected legal owners. Identification of the affected people and properties by the DC is covered in Section 4 (3)	Informal residents are not covered by ARIPA while the JICA GL require identification of all affected persons including informal settlers and their properties.	The resettlement plan of this project will be prepared based on the data collected through census, socioeconomic and inventory of loss survey for all affected persons including informal residents. The start date of the census survey will be considered as the cut-off date for informal residents thus those listed before the cut-

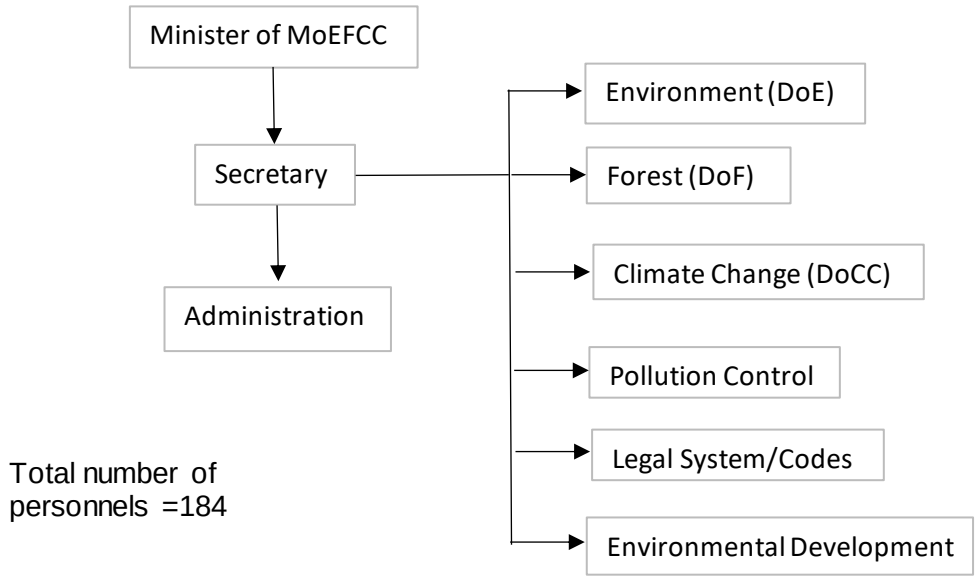
No.	JICA Guidelines/The World Bank ESS5	Acquisition and Requisition of Immovable Property Act, 2017 (ARIPA 2017)	Gap Analysis	Policy of the Project
	opportunistic settlers, from claiming benefits. (ESS5 para. 20)			off date will be eligible for assistance.
13	Affected persons may be classified as persons:(a) Who have formal legal rights to land or assets (b) Who do not have formal legal rights to land or assets but have a claim to land or assets that is recognized or recognizable under national law; or (c) Who have no recognizable legal right or claim to the land or assets they occupy or use. (ESS5 para. 10)	ARIPA does not cover for non-titleholders or informal people affected by the project.	Land compensation is not required for informal residents and users. However, as per international standards, other than land compensation, affected assets such as structures, trees, crops, and affected livelihood need to be compensated and/or assisted.	The resettlement plan of this project will propose compensation and assistance depending on losses to all affected persons irrespective of their legal status.
14	Where livelihoods of displaced persons are land-based, or where land is collectively owned, the borrower will offer the displaced persons an alternative for replacement land in accordance with paragraph 35(a), unless it can be demonstrated to the bank's satisfaction that equivalent replacement land is unavailable. (ESS5 para. 14)	The requirements are not specified, although the necessity for livelihood restoration for affected households is described in the ARIPA (Section 9(4)).	Requirements of the JICA GL are not specifically mentioned in the ARIPA 2017.	Minimal acquisition of private land is expected in this project. On the other hand, resettlement survey will attempt to find alternate land for the loss of shrimp and salt farmland in consultation with the affected community.
15	Transitional support will be provided as necessary to all economically displaced persons, based on a reasonable estimate of time required to restore their income-earning capacity, production levels, and standards of living. (ESS5 para36)	There is no provision for support for the transition period in the ARIPA.	There is no provision for support for the transition period in the ARIPA.	The following support will be proposed in the resettlement plan of this study. - Moving assistance for residential house owners - Tenant moving allowance
16	Particular attention will be paid to gender aspects and the needs of the poor and the vulnerable. (ESS5 para26)	The ARIPA does not specify assistance for socially vulnerable groups.	There are no clear requirements for considerations for socially vulnerable groups in Bangladesh.	Special assistance to vulnerable, i.e., households below poverty line, disabled, and female headed households will be proposed in the

No.	JICA Guidelines/The World Bank ESS5	Acquisition and Requisition of Immovable Property Act, 2017 (ARIPA 2017)	Gap Analysis	Policy of the Project
				resettlement plan of this project.
17	To address the issues identified in the environmental and social assessment, the borrower will prepare a plan proportionate to the risks and impacts associated with the project (ESS5 para. 21)	Land Acquisition Plan/Proposal (LAP) is required by ARIPA for the land acquisition procedure.	Apart from LAP, Bangladesh has no obligation or legal basis to prepare a plan proportionate to the risks and impacts associated with a project.	A resettlement plan proportionate to the risks and impacts identified during the census, socio-economic and inventory of loss survey will be prepared for this project.

Source: JICA Survey Team

(6) Related Organizations

The Department of Environment (DOE) of the Ministry of Environment, Forests and Climate Change (MoEFCC) is responsible for EIA approval of all infrastructure development projects in Bangladesh.



Source: JICA Survey Team

Figure 9.1.30 Organization Structure of MoEFCC (As of Feb. 2022)

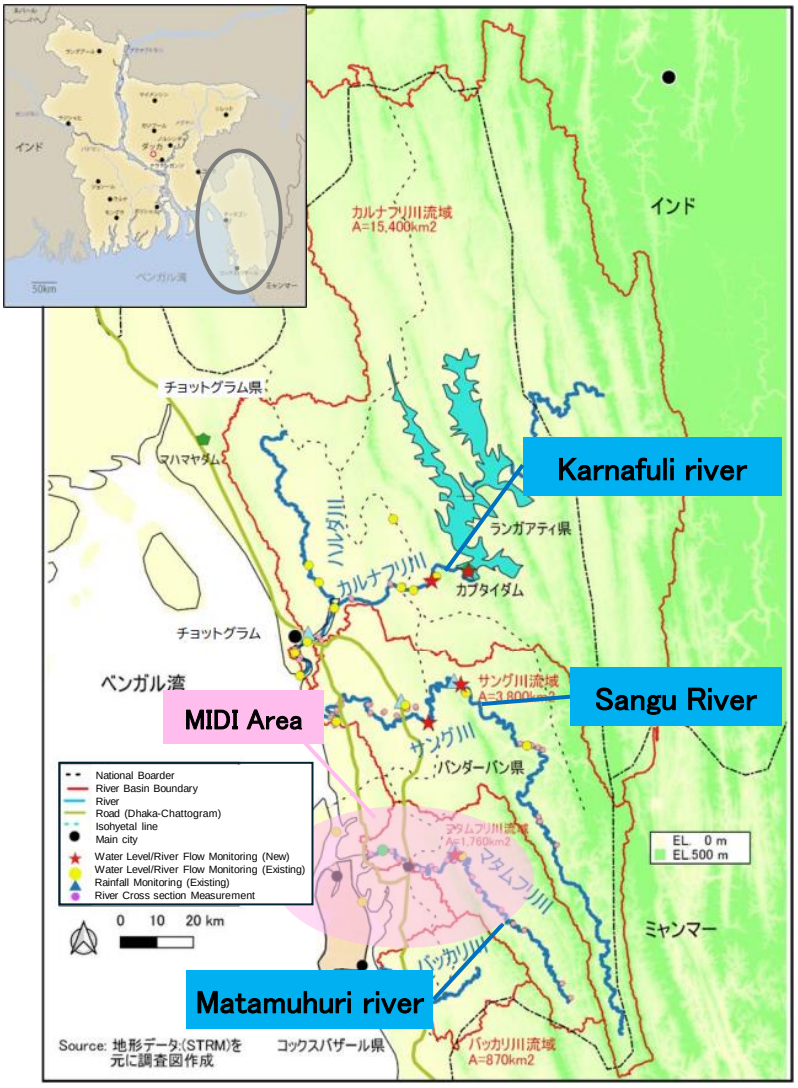
There are no provisions to prepare the RAP in the ARIPA 2017, except the LAP which is needed for the land acquisition procedures. Consequently, there is no legal system to review and approve the RAP report. Therefore, RAP preparation and disclosure in Bangladesh is done in compliance with the donors' requirements and the RAP report review and approval is normally done by the executing agency or its line ministry.

9.1.4 Consideration of Alternatives (Including "Without Project")

(1) Background of the Water Resources Development Plan

In Cox's Bazar District, the ground water level is declining at about 10 cm/year due to excessive ground water dependency as water source, and no new aquifers that can be developed are expected. Thus, sustainable water resource development using groundwater as the main source is not appropriate. Regarding seawater desalination, life cycle costs are higher than those for surface water development because of the large volume of water required and the costs of facility operation and maintenance, and operation and maintenance of seawater desalination equipment, such as membrane cleaning, is also not easy. Therefore, it was determined that surface water development should be a prioritized option.

There are three rivers, Karnafuli river, Sangu river, and Matamuhuri river, round the Moheshkhali-Matarbari region (MIDI area). Karnafuli river has much enough flow as water source to cover water demand in another river basin, however, time for necessary coordination with operators and surrounding citizens of Kaptai dam and stakeholders in Chattogram City doesn't suit the schedule of the Project. Sangu river doesn't have much enough flow as water source to cover water demand in another river basin. Matamuhuri river is located in MIDI area (MIDI area is located in Matamuhuri river basin.). Therefore, Matamuhuri river has been selected as water source for a water resources development plan.



Source: JICA Survey Team

Figure 9.1.31 Water Resources of the Project Area

(2) Water Resources Development Plan for the Matamuhuri River Basin

Regarding possible options of the Project for the Matamuhuri River Basin Water Resources Development Plan, three alternatives and the alternative of "without project" were considered from the viewpoints of "economic efficiency", "environmental and social impacts", and "cost and construction difficulty". Alternative 4, "Construction of new reservoir and intake facilities", was evaluated as the most recommended alternative. A brief description of each alternative is shown in Table 9.1.53, while the evaluation process is described below.

Since the purpose of the water resources development plan is to achieve sustainable socio-economic development by meeting increasing water demands, "economic efficiency" was selected as the most important item, and alternatives with high priority were first screened under this item. Next, alternatives were evaluated in the order of "environmental and social impacts" from the perspective of sustainability, and "cost and construction difficulty" from the perspective of difficulty of project implementation.

Regarding "economic efficiency", Alternatives 3 and 4 are the highest priority alternatives because they could satisfy increased water demands due to the change in water source from groundwater to river water, and sustainable economic activities are expected. Alternatives 1 and 2 are low priority alternatives because they would continue to use the groundwater as a main water source, which would not be able to satisfy the increased water demands and would make it difficult to develop economic activities.

Regarding "environmental and social impacts", Alternative 3 would require large-scale deforestation, large land acquisition, and dam construction with potential impacts on ethnic minorities, while Alternative 4 would require development in agricultural lands and forests (protected areas would be avoided) (no significant impacts are anticipated), acquisition of land for agriculture and a water reservoir with loss of livelihoods, which would have significant social impacts. However, the impact on the natural environment of Alternative 4 is smaller than that of Alternative 3. Therefore, priority of Alternative 4 is higher than Alternative 3 in terms of "environmental and social impacts".

Regarding "cost and construction difficulty", Alternative 4 (reservoir construction) has lower construction and maintenance costs and less construction difficulty than Alternative 3 (dam construction). Therefore, the priority of Alternative 4 is higher than that of Alternative 3 in terms of "cost and construction difficulty".

Based on the above, Alternative 4 was selected as the most recommended alternative.

In addition, the impact on the natural and social environment of Alternative 1 is smaller than that of Alternative 2, and the cost and construction difficulty of Alternative 1 is lower than those of Alternative 2. In other words, Alternatives 1 through 4 were recommended in the following order: Alternatives 4, 3, 1, and 2.

Table 9.1.53 Results of Alternative Study for Water Resources Development Plan for the Matamuhuri River Basin

Items	Alt. (1)	Alt. (2)	Alt. (3)	Alt. (4)
Option Description	The project will not be implemented. Groundwater will be used as the main water source as it is now.	Construct new water intake facilities only. Water will be taken only during the rainy season, and groundwater will be used as the main water source during the dry season.	Construct a new dam and water intake facility upstream of the river. The flow rate at the intake point will be stabilized by the dam.	Construct new reservoirs and water intake facilities downstream of the river. The sufficient amount of river water in the rainy season will be taken, and water from the reservoir will be used in the dry season.
Economic Efficiency	Difficult to develop economic activities due to lack of ability to meet increasing demand for water.	Difficult to develop sustainable economic activities due to lack of ability to meet increasing demand for water.	Sustainable development of economic activities with satisfying water demand is expected.	Sustainable development of economic activities with satisfying water demand is expected.
	E	E	A	A

Items	Alt. (1)	Alt. (2)	Alt. (3)	Alt. (4)
Cost	Additional cost is not required.	Cost is lower than Alt. (3) and (4).	Cost is higher than Alt. (4).	Cost is lower than Alt. (3).
	A	B	E	D
Construction Difficulty	No technology is required.	Less technical difficulty than Alt. (3) and (4)	Advanced technology is required for planning, design, and construction	Less technical difficulty than Alt. (3)
	C	D	E	D
Natural Environmental Impacts	There are concerns about land subsidence due to depletion of groundwater.	There are concerns about land subsidence due to depletion of groundwater.	Significant impact on ecosystems is expected due to deforestation caused by dam construction.	Agricultural land and forests will be developed due to reservoir construction (protected areas will be avoided); however, no significant impact is expected.
	E	E	E	D
Social Environmental Impacts	No land acquisition and resettlement will occur.	Impacts related to land acquisition and resettlement are less than Alt. (3) and (4).	Large-scale land acquisition may occur. There is possibility that ethnic minorities live in the upstream of the Matamuhuri River.	Land acquisition and resettlement may occur.
	C	D	E	D
Evaluation	No economic development is expected and significant impacts on the natural environment are anticipated.	No economic development is expected and significant impacts on the natural environment are anticipated.	Economic development is expected, however, significant impacts on the natural and social environment are anticipated. Cost is high and requires advanced technology.	Economic development is expected. Impacts on the natural and social environment are assumed, however, mitigation is possible. Certain amount of cost is required; however, advanced technology is not required.
	3	4	2	1 (Recommended)

Note: A/B: Impact ++/+ (Positive), C : No impact, D/E: Impact -/-- (Negative)

Note: A dam is defined as a structure that stores water and has a dam height of 15 m or higher. A reservoir is defined as a structure with a dam height lower than 15 m.

Source: JICA Survey Team

(3) Pipeline Route

Described in 5.2.6 (2).

(4) Water Intake Facility

1) Water Intake Point

Described in 5.2.7 (2).

2) Water Intake Method

Described in 5.2.8, (3).

(5) Location of Raw Water Reservoir

Described in 5.2.9.

9.1.5 Scoping

(1) Scoping Results

Scoping results for the entire project activities are shown in Table 9.1.54. A "v" mark indicates that the Project is expected to have an impact, or that it cannot be determined whether an impact will occur. The evaluation is made for the pre-construction/ during-construction (P/CS) and operation (OP) phases. The evaluation is based on the assumption that no avoidance or mitigation measures are taken. Target of scoping is recommended alternatives which are explained in 9.1.4.

Table 9.1.54 Scoping Results

Items	P/CS	OP	Reason for Evaluation
Pollution Control Items			
Air Pollution	v	-	**Construction Phase:** • Region-wide transport pattern would be changed by the construction activities, and roadside air quality would be worsened, but the impact will be temporary. • Production of dust air pollutants (SOx, NOx, etc.) is expected by earthwork and other construction activities, but the impact will be temporary and be limited to the surrounding area only. **Operation Phase:** • Operation of the water supply facility is not likely to cause direct or indirect air pollution.

Items	P/CS	OP	Reason for Evaluation
Water Quality	v	v	**Construction Phase:** • Water turbidity at the Matamuhuri River is anticipated by intake point construction work, but the impact will be temporary. • The impact of construction wastewater to be generated within construction of the entire water supply system is anticipated around the downstream side of the Matamuhuri and Kohelia rivers, but the impact will be temporary. • Water quality degradation due to the dredging work, to be associate with the reservoir embankment construction is anticipated at water channels, near the reservoir construction site. **Operation Phase:** • Water turbidity at the Matamuhuri River is anticipated by periodical dredging activities to be conducted around the intake point, but the impact will be temporary. • Generation of river bottom water mass with low-level DO (dissolved oxygen) is anticipated at the ex-dredging site (the dredging activities may provide deep pools at the dredging site). This low-level DO waterbody remains at the bottom of the deep pool at the stable condition. However, it would cause some damages to the local fishery activities at the downstream site of the channel when this low-level DO waterbody mass is jumped out and then, is conveyed to the downstream side by accidents (e.g., cyclone, earthquake and others).
Wastes	v	v	**Construction Phase:** • Waste such as concrete, asphalt, logging trees, and construction soil would be generated by the construction work of the entire water supply system project. Huge amounts of excavated surface layer soil at the water reservoir construction site are expected to be generated. **Operation Phase:** • Waste such as sludge by the operation of the water treatment plant and excavated soil by periodical dredging activities would be generated.
Soil Contamination	v	-	**Construction Phase:** • There is possibility of soil pollution particularly from the injection of chemicals to strengthen ground for water reservoir and relevant embankment construction. • Possibility of soil pollution caused by accidental leakage of lubricants and fuel oil from construction vehicles and machinery. **Operation Phase:** • The operation of the water supply facility is not expected to cause direct or indirect soil contamination.

Items	P/CS	OP	Reason for Evaluation
Noise and Vibration	v	v	**Construction Phase:** • Roadside noise and vibration are expected to be increased by the circulation of construction vehicles but the impact will be temporary. • Temporal increases of both noise and vibration are predicted from the operation of heavy machinery and trucks, but the impact will be limited to only the surrounding area. • Matarbari Access Road construction is to be initiated and the cumulative impact needs to be determined. **Operation Phase:** • Local noise and vibration environment around the water supply facilities would be worsened due to the operation of water purification facilities and other relevant activities, but the impact will be limited to the surrounding area.
Subsidence	v	v	**Construction Phase:** • Due to the local topographic condition of project site, it is highly likely that alluvial plain geological structure exist, it is essential to take measures against land subsidence by ground improvement and foundation construction. **Operation Phase:** • The presence of the reservoir could cause continuous land subsidence.
Odor	v	-	**Construction Phase:** • Due to the inappropriate regional drainage design after the water reservoir construction, new regional inundation problems may occur. The community surrounding the project site may complain that they would be annoyed by both outbreaks of obnoxious compost smell of some submerged, decayed vegetation, caused by the newly created deadlocked, inundation problem. • Excavated surface layer soil at the water reservoir construction site, that would contain a certain amount of compost and/or minerals may cause offensive odor. **Operation Phase:** • Although wastewater will be generated from the water treatment plant, no impact on odors is anticipated as the wastewater will be properly treated (and ultimately disposed of as cake).
Sediment	v	v	**Construction Phase:** • Possibility of sediment pollution in case construction wastewater accidentally discharges into the Matamuhuri River, nearby channels, tributaries of the Matamuhuri and Kohelia rivers. **Operation Phase:** • Possibility of sediment pollution may occur by periodical dredging activities to be conducted around the intake point, but the impact will be temporary.
Natural Environment Items			
Protected Area	v	v	**Construction and Operation Phases:** • Fashiakhali Wildlife Sanctuary (WS) and Sonadia Island ECA exist around the project site. Also, several reserved forests (RFs) exist. The Project will not directly impact these areas, but indirect impacts should be considered.

Items	P/CS	OP	Reason for Evaluation
Ecosystem	v	v	**Construction and Operation Phases:** • As part of the Matarbari Port Access Road Construction Project (not yet started: as of April 2024), a portion of the proposed route passes through the vicinity of the Fashiakhali Wildlife Sanctuary, and an environmental management plan, including monitoring activities, has been developed to monitor the impacts of the construction on the sanctuary. Since a portion of the water pipeline for this water supply project also passes near the Fashiakhali Wildlife Sanctuary, there is a concern about the cumulative negative impacts on the reserve.
Hydrology	v	v	**Construction and Operation Phases:** • Regional water balance, regional drainage and local flow patterns of surface water would be highly affected due to the construction of entire water supply projects.
Topography	v	v	**Construction and Operation Phases:** • Regional topographic condition would be affected due to the construction work of entire water supply system project, in particular, project site of water reservoir site. Certain amount of topographic surface changes is expected to occur due to the construction of large-scale embankment.
Social Items			
Land Acquisition and Resettlement	v	-	**Pre-construction Phase:** • Physical and economic displacement of salt farmer and shrimp cultivation farmer in Palakata area (Raw water reservoir will be constructed) is expected due to land acquisition by the Project. In addition, land acquisition for temporary leases such as construction yards may occur. **Construction Phase:** • No additional resettlement is anticipated after the Project is placed in service.
Livelihoods	v	v	**Construction Phase:** • Physical and economic relocation of salt farmer and shrimp cultivation farmer in Palakata area (Raw water reservoir will be constructed) is expected due to land acquisition by the Project, which may result in loss of livelihood. Comprehensive restoration measures will be developed during the RAP study. On the other hand, construction work provides employment opportunities for construction workers and increases demand for local businesses such as stores and food vendors. **Operation Phases:** • The Project is expected to contribute to the local economy through provision of employment and improved environment for investors. Also, through empowerment of women in the water sector, female participation in the labor force will grow. • Since the plan is not to intake water during the dry season when flows are low and no weirs will be constructed, it is assumed that the impact on the fishery will be limited.

Items	P/CS	OP	Reason for Evaluation
Socially Vulnerable	v	-	**Construction Phase:** • Although information is currently uncollected, vulnerable groups, including poor households, may be included in the resettlement and land acquisition. They may earn their livelihood from the construction during the construction period, but may be more affected, and the Project will also consider support measures for socially vulnerable groups. **Operation Phase:** • It is expected that the sharing of water resources in the target area will be equitable.
Ethnic Minorities and Indigenous Peoples	v	v	**Construction and Operation Phases:** • No information on distribution of ethnic minorities or indigenous people community in the project area. Detailed onsite confirmation will be done in the socio-economic survey, when necessary, the mitigation measures will be considered.
Cultural Heritage	v	-	**Construction Phase:** • No important cultural heritages exist across the project survey area according to the survey of existing materials. Confirmation of impacts to cultural sites and religious structures will be done through RAP surveys. For underground cultural deposits, the "Chance Find procedure" is applied. **Operation Phase:** • No activities affecting cultural heritage are planned.
Landscape	-	-	**Construction and Operation Phases:** • Although change in the land use is expected due to conversion of salt/shrimp farms to reservoir pond, no important landscape resources have been identified in the vicinity of the project area.
Land Use and Utilization of Local Resources	v	v	**Construction and Operation Phases:** • Change in the land use is expected due to conversion of salt/shrimp farms to reservoir pond.
Water Usage	v	-	**Construction Phase:** • River water may be temporarily affected by earthworks, and local residents' use of river water is expected to be impacted. **Operation Phase:** • Considering annual water balance of 1,510 MCM of the Matamuhuri River (with the safety level of 1/10 drought year), the Project plans to intake annual water of 48 MCM during the monsoon period, hence, maintaining the environmental flow of the Matamuhuri River. Therefore, no impacts to other water users are expected.
Existing Social Infrastructure and Services	v	-	**Construction Phase:** • Impact on the traffic volume and congestion on the existing local roads is expected during construction. **Operation Phase:** • It is expected that infrastructure services for water supply in the target area will be fair. Negative impacts on existing social infrastructure and services are not anticipated.

Items	P/CS	OP	Reason for Evaluation
Social Institutions such as Social Capital and Local Decision-making Institutions	-	v	**Construction Phase:** • No impact is expected. **Operation Phase:** • The Project is expected to contribute to the empowerment of women in the water sector; hence, boosting the inclusion of women in decision- making.
Misdistribution of Benefits and Loss	v	-	**Construction Phase:** • Socially vulnerable groups may be more negatively affected among those who are targeted for land acquisition and resettlement. Assistance to vulnerable groups will be developed. **Operation Phase:** • No impact is expected. Rather, equal sharing of the water resource in the areas affected by the Project is expected.
Local Conflicts of Interest	-	-	**Construction and Operation Phases:** • Since the Project will provide a stable water source for the entire region, conflicts of interest within the region are not expected to arise.
Infectious Diseases such as HIV/AIDS	v	v	**Construction Phase:** • It is possible that infectious diseases such as sexual transmitted diseases (STDs) and coronavirus disease 2019 (COVID-19) may spread due to the influx of construction workers. **Operation Phase:** • By increasing the available water resource amount, regional hygiene condition will improve, and the risk of infection disease is expected to decrease.
Children's Rights	v	-	**Construction Phase:** • Children's right-related issues including child labor will be avoided. **Operation Phase:** • It is not expected that this Project will cause any children's right-related issues.
Gender	v	v	**Construction and Operation Phases:** • The Project is expected to contribute to women empowerment in the water sector, thus, increased female participation in the labor force and decision making is anticipated.
Work Environment (including work safety)	v	v	**Construction Phase:** • In order to prevent industrial accidents, a safe and healthy working environment is desirable. Confirmation regarding the risks of child labor and forced labor, etc., is also necessary. **Operation Phase:** • An occupational safety management plan is needed for the working environment at the water supply facilities when they are in service.

Items	P/CS	OP	Reason for Evaluation
Health, Safety, and Security of Local Communities	v	v	**Construction Phase:** • Influx of construction workers may lead to spread of infectious diseases such as STDs and COVID-19. In addition, land changes due to cut and fill may create new habitats for mosquitoes, which can be vectors of malaria. The influx of construction vehicles may increase traffic accidents. **Operation Phase:** • With the end of construction and the end of the influx of construction workers, community health, safety, and security will be restored. In addition, the water supply project is expected to eliminate waterborne diseases because the water source will be stabilized.
Accidents and natural disasters	v	v	**Construction Phase:** • There is a possibility of accidents during construction work, traffic accidents of the circulation of construction vehicles on surrounding road network. **Operation Phase:** • Local surface topographic changes to be caused by the construction of large-scale embankment of water reservoir, local wind pattern would be changed and its local wind blowing may be strengthened in case of cyclone events.
Other Item			
Cross-boundary Impact and Climate Change	v	-	**Construction Phase:** • CO_2 will be generated by construction work of this water supply system project would be limited and temporary. **Operation Phase:** • No impact is anticipated.

Source: JICA Survey Team

(2) Survey Contents and Methods

Based on the scoping results, the baseline survey items and methodology were organized as shown in Table 9.1.55.

Table 9.1.55 Baseline Survey Items and Methodology Arrangement

Field	Item	P/CS	OP	Survey Item	Survey Method
Pollution Control	Air Pollution	v	-	• Field survey: six sites around the project area • Items: SO_2, NO_2, PM_{10}, $PM_{2.5}$, O_3, CO • Frequency: one time 24-hour survey * rainy and dry seasons	• Measurement • Comparison of survey results with Bangladesh national reference values • Comparison with international standard
	Water Quality	v	v	• Field survey: eight surface water points and eight shallow wells around the project area • Items (surface water): temperature, turbidity, pH, DO, BOD, COD,	• Measurement • Comparison of survey results with Bangladesh country reference values • Comparison with international standard

Field	Item	P/CS	OP	Survey Item	Survey Method
				TDS, EC, TSS, NH3, NO3, coliforms, Cl • Items (shallow well): turbidity, pH, TDS, EC, As, Fe, Mn, NO3, PO3, F, coliforms • Frequency: one time* rainy and dry season	
	Wastes	v	v	• Surveyed: Construction waste and sludge disposal sites	• Survey of existing materials and interviews
	Soil Contamination	v	-	• Surveyed: History of past soil contamination	• Interviews and surveys of CPs
	Noise and Vibration	v	v	• Field survey: six sites around the project area • Item: Noise and vibration levels • Frequency: one 24-hour survey * rainy and dry seasons	• Measurement • Comparison of survey results with reference values (national and international)
	Subsidence	v	v	• Surveyed: Ground strength conditions in the target area	• Survey of existing materials and interviews with CPs,
	Odor	v	-	• Survey target: History of past odor occurrence	• Interviews and surveys of CPs
	Sediment	v	v	• Field survey: four floodplain sites around the proposed reservoir area and four river bottom sediment sites • Items: Sulfides, Hg, Cd, Pb, Org-P, Cr6+, As, CN, Cu, Zn • Frequency: one time* rainy and dry season	• Measurement • Comparison of survey results with national and international reference values
Natural Environment	Protected Area	v	v	• Survey target: Protected areas around the project area	• Survey of existing data
	Ecosystem	v	v	• Field survey: Around the project area • Item: Identification of vulnerable species (large benthos, plankton, fish, mammals, birds, amphibians, reptiles, vegetation) • Frequency: one time* rainy and dry season	• On-the-spot investigation
	Hydrology	v	v	• Survey target: Recommendations around the project area	• Survey of existing data
	Topography	v	v	• Survey target:	• Survey of existing data

Field	Item	P/CS	OP	Survey Item	Survey Method
				Topography and geology around the project area	
Social Environment	Land Acquisition and Resettlement	v	-	• Affected people and people subject to physical relocation. • Prepare an inventory of landowners and other assets subject to land acquisition • Livelihood activities of the affected people • Land reacquisition price cost	• Site investigation • Questionnaire survey to affected people. • Field measurement and count of the affected land and other properties • Collection of land transaction records and interview with authorities responsible for land compensation and revenue • Focus group discussions (FGDs) with vulnerable groups.
	Livelihoods	v	v	Same as "Land Acquisition and Resettlement."	Same as "Land Acquisition and Resettlement."
	Socially Vulnerable	v	-	• Identification of socially vulnerable groups affected by project implementation	• Review of existing material survey • Site investigation • Questionnaire survey • FGDs
	Ethnic Minorities and Indigenous Peoples	v	v	• Confirmation of the existence of ethnic minorities and indigenous peoples	• Review of existing material survey • Site investigation, • Questionnaire survey
	Cultural Heritage	v	-	• Identification of cultural heritage affected by the project implementation	• Review of existing material survey • Questionnaire survey on common property resources
	Landscape	-	-	-	-
	Land Use and Utilization of Local Resources	v	v	• Identification of land use affected by the project implementation	• Site investigation
	Water usage	v	-	• Ensure environmental flow rates are maintained	• Prediction of river flow and water level
	Existing Social Infrastructure and Services	v	-	• Confirming any interference to existing infrastructure cause by the project	• Site investigation
	Social Institutions such as Social Capital and Local Decision-making	-	v	• Identification of the existing decision-making process including participation of female	• Review of existing system • FGDs • Stakeholder engagement

Field	Item	P/CS	OP	Survey Item	Survey Method
	Institutions				
	Misdistribution of Benefits and Loss	v	-	Same as "Land Acquisition and Resettlement."	Same as "Land Acquisition and Resettlement."
	Local conflicts of interest	-	-	-	-
	Infectious Diseases such as HIV/AIDS	v	-	• Outbreak of infectious diseases	• Review of existing material • Questionnaire survey
	Children's Rights	v	-	• Confirmation of regulation related to children's rights	• Review existing information
	Gender	v	v	• Identification of gender issues in the study area	• Review of existing information • Questionnaire survey • Focus group discussions • Key informant interviews
	Work Environment (including work safety)	v	v	• Risk identification	• Review of existing information of similar projects • Review of related regulation on labor • Public consultation
	Health, Safety, and Security of Local Communities	v	v	• Confirmation of the status of chronic diseases in the project area including waterborne diseases	• Review of the existing materials • Questionnaire survey • Public consultation
	Accidents and natural disasters	v	v	• Risk identification	• Review of existing information of similar projects • Public consultation
Other	Cross-boundary impact and climate change	v	-	• Calculation of CO_2 emissions	• Existing document survey

Source: JICA Survey Team

9.1.6 Results of Environmental and Social Considerations Survey

(1) Pollution Control

1) Air pollution

(a) Pre-construction and Construction Phase

Region-wide transport pattern would be changed and traffic volume would be increased by the circulation of construction vehicle and construction activities. Consequently, the roadside air quality of several regional roads would be worsened, but the impact will be temporary. It is noted that specific

traffic volume and construction vehicle routes such as the delivery of construction materials and wastes are not finalized within the study.

Production of the dust and other air pollutants (SOx, NOx, etc.) is expected by earthwork and other construction activities, but the impact will be temporary and be limited to only the surrounding area. It is noted that the specific construction schedule such as the operation of construction machineries (e.g., type and number of machinery) are not determined yet within this study.

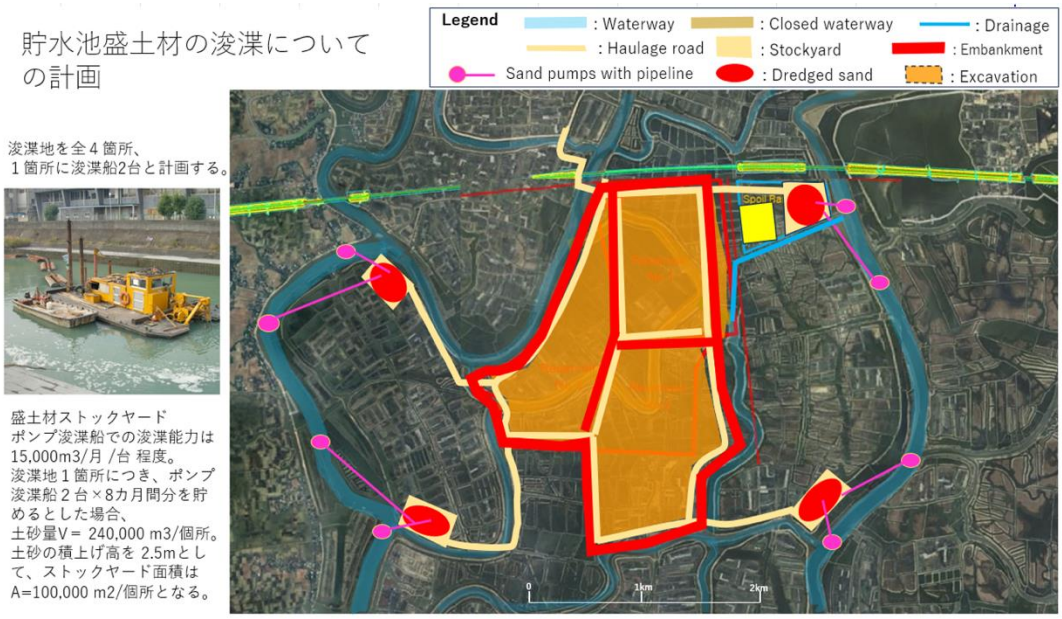
Compound or cumulative impacts would be significant when construction activities of other infrastructure development projects such as Matarbari Port Access Road is synchronized with the one of this proposed water supply project. Upon reviewing EIA Report of this project, it is found that no quantitative impact study regarding the air quality is conducted yet and a specific construction schedule of this port access road is not determined yet (as of August 2024). Similar observation is made within the review of EIA Report of Chattogram- Cox's Bazar Highway Improvement Project.

2) Water quality

(a) Pre-construction and Construction Phase

Temporal water quality degradation such as the turbidity worsening at the Matamuhuri River is anticipated by intake point construction work, but the impact will be temporary. The impact of construction wastewater to be generated within construction of the entire water supply system, in particular, water reservoirs, is anticipated and would be regional around the downstream side of Moheshkhali floodplain, Matamuhuri and Kohelia Rivers, but the impact will be temporary.

Dredging is to be conducted around several points along tributaries surrounding the reservoir construction site in order to obtain embankment material (see Figure 9.1.32). Total dredging distance along these tributaries, shown in Figure 9.1.32 would be of approximately 11 km.



Source: This Study (2024)

Figure 9.1.32 Proposed Dredging Sites around the Reservoir Construction Site

As a result, the temporal water quality degradation along tributaries will occur (e.g., worsening of the water turbidity and other water quality parameters). It is noted that salt pan farmers along those tributaries use sea water from these tributaries, using sluice gates. The water quality degradation, due to dredging activities, may cause some problems (e.g., the quality degradation of the salt production) within the salt production at both sides of tributaries of concerns. So, it is likely that some of salt pan farmers would have some damages within their salt productions therein.

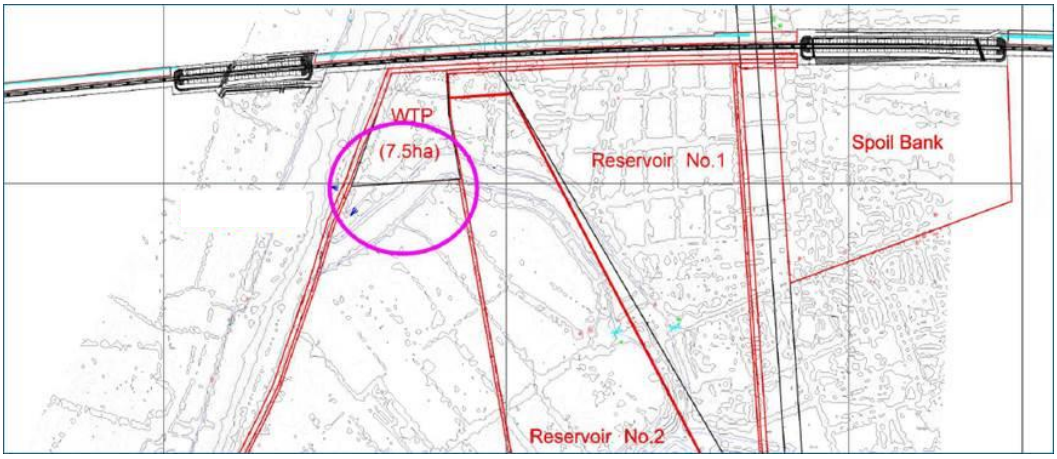
(b) Operation Phase

Temporal water quality degradation such as the turbidity worsening at the Matamuhuri River is anticipated by periodical dredging activities to be conducted around the intake point, but the impact will be temporary. It is noted that a specific maintenance dredging work schedule is not determined yet within this study. Both BWDB and JICA Study Team agreed to conduct a more detailed study in order to figure out appropriate scale of the periodical dredging, relevant river protection works to be required by implementing agency during the operation phase, using the numerical simulation.

Then, relevant mitigation measures such as the conservation of local benthos of the Matamuhuri River shall be conducted in parallel with the detailed study to be followed.

Generation of the river bottom water mass with low-level DO (dissolved oxygen) is anticipated at the ex-dredging site (the dredging activities may provide deep pools at the dredging site). This low-level DO waterbody remains at the bottom of the deep pool at the stable condition. However, it would cause some damages to the local fishery activities at the downstream site of tributaries and/or channels when this low-level DO waterbody mass is jumped out and then, is conveyed to the downstream side by accidents (e.g., cyclone, earthquake and others).

Figure below shows the outline of the spoil bank, located adjacent to the Reservoir No 1. This site is to be used for the temporal dump site of the sludge, to be generated at the water treatment plant (WTP) and the dehydrated dredged sand and mud, to be collected at the water intake point during the operation phase. It is likely that certain amounts of wastewater are to be generated from this site, and appropriate water treatment shall be taken before discharging those treated wastewater into nearby tributaries and/or channels.



Source: This Study (2024)

Figure 9.1.33 Outline of Spoil Bank

3) Wastes

(a) Pre-construction and Construction Phase

Construction wastes such as concrete, asphalt, logging trees, and construction soil would be generated by the construction work of the entire water supply system project. Huge amounts of excavated surface layer soil at the water reservoir construction site are expected to be generated.

It is estimated that the total amount of construction wastes, to be generated from the reservoir construction is of approximately 4,300,000 t, and locations of relevant waste disposal site, its delivery program and specific environmental management program are to be determined through consultation with C/P during DD stage. It is noted that specific amounts of each type of wastes to be generated and treatment methods are not determined yet (as of September 2024).

It is estimated that the annual washload and bedload at the planned intake site is calculated as 290,000 ～1,450,000t/year and 32,000～160,000t/year respectively. And the annual washload to the reservoir at rainy season is calculated as 3,600～18,000t/year (see Supporting Report A3 for more detailed descriptions of the sedimentation estimation).

Besides, it is expected that some portions of dredged soil will not be used for the embankment material of the water reservoir due to its soil characteristics. It is important to keep those unused dredged soil

around the nearby construction site while setting up effluent treatment facilities for the waste water, to be generated from the unused dredged soil.

(b) Operation Phase

Waste such as sludge by the operation of the water treatment plant and excavated soil by periodical dredging activities would be generated. It is estimated that approximately 25 m^3/day of a dried sludge would be generated within the water treatment plant during the operation phase. The JICA survey team proposes to use those dried sludges are expected to be used as embankment material at both Matarbari and Dhalghata Unions.

4) Soil contamination

(a) Pre-construction and Construction Phase

There is possibility of soil pollution, in particular, from the injection of chemicals to strengthen the ground for the water reservoir and relevant embankment construction. Also, the possibility of the soil pollution, to be caused by accidental leakage of lubricants and fuel oil from construction vehicles and machinery would not be negligible. It is noted that ground portions (the width of the embankment bottom x 15 m depth from the ground surface) are to be strengthened by the injection of construction chemicals. Type and amount of that chemical are to be delineated within the detailed design study.

5) Noise and vibration

(a) Pre-construction and Construction Phase

Region-wide transport pattern would change and traffic volume would be increased by the circulation of construction vehicle and construction activities. Consequently, the roadside noise and vibration of several regional roads are expected to be increased by the circulation of construction vehicles, but the impact will be temporary. It is noted that specific traffic volume and construction vehicle routes such as the delivery of construction materials and wastes are not finalized within the study.

Temporal increases of both noise and vibration are predicted from the operation of heavy machinery and trucks, but the impact will be limited to only the surrounding area. It is noted that the specific construction schedule such as the operation of construction machineries (e.g., type and number of machinery) are not determined yet within this study.

Cumulative impacts would be significant when construction activities of other infrastructure development projects such as Matarbari Port Access Road is synchronized with the one of this proposed water supply project. It is noted that a specific construction schedule of this port access road is not determined yet (as of August 2024). Similar to the air quality, mentioned above, it would be meaningful to conduct a quantitative noise/vibration impact assessment (or simulation), once roads to be used for the construction, the exact number and type of the construction vehicles to be used for this construction project as well as other construction schedule-related information are finalized.

It is also noted that several on-going infrastructure projects such as Chattogram- Cox's Bazar Highway Improvement Project and others are on-going around the proposed water supply project. Similarly, cumulative and/or compound impacts with those projects would be significant. Upon reviewing EIA Report of this project, it is found that no quantitative impact study regarding the noise/vibration is conducted yet and a specific construction schedule of this project is not determined yet (as of August 2024).

(b) Operation Phase

Local noise and vibration environment around the water supply facilities would be worsened due to the operation of water purification facilities and other relevant activities, but the impact will be limited to the surrounding area.

Once the operation of the water treatment plant starts, it is expected have noise/vibration due to the machineries such as the pump around the treatment plant. In general, 20 dB vibration level reduction can be achieved at 10meters away from the machineries. Within this project, the horizontal clearances more than 10 meters can be secured within the layout of the water treatment plant. So that, impacts regarding the noise/vibration due to the plant operation would be negligible. More detailed studies are to be conducted within the detailed design study phase.

6) Subsidence

(a) Pre-construction and Construction Phase

Due to the local geo-topographic condition of the project site (alluvial floodplain), it is highly essential to take mitigation measures against large-scale land subsidence (e.g., ground base improvement and foundation construction while removing existing surface soil layer). As mentioned earlier, it is noted that ground portions (the width of the embankment bottom x 15 m depth from the ground surface) are to be strengthened by the injection of construction chemicals. Type and amount of that chemical are to be delineated within the detailed design study.

RoW of Matarbari Port Access Road would run through the project site. Compound or cumulative impacts would be significant when construction activities of this project is synchronized with the one of this proposed water supply project.

(b) Operation Phase

The presence of the reservoir facility (e.g., embankment) could cause continuous land subsidence after the construction phase.

7) Odor

(a) Pre-construction and Construction Phase

Existing regional drainage system would be hampered due to the construction activities of entire water supply system. So, it is important to prepare for an appropriate regional drainage design before the

construction phase. It is likely that entire construction would take certain period of time, inappropriate regional drainage design may cause new regional inundation and relevant foul odor problems may occur during the construction phase. The community surrounding the project site may complain that they would be annoyed by both outbreaks of obnoxious compost smell of some submerged, decayed vegetation, caused by the newly created deadlocked, inundation problem.

Excavated surface layer soil at the water reservoir construction site, that would contain a certain amount of compost and/or minerals may cause offensive odor.

(b) Operation Phase

Although wastewater will be generated from the water treatment plant, no impact on odor is anticipated as the wastewater will be properly treated (and ultimately disposed of as cake).

There is a possibility of the generation of hydrogen sulfide and/or ammonia at the hypolimnion of the water reservoir under certain conditions during the operation phase (e.g., the water depth of the water reservoir would be deep enough, certain amounts of sludge/mud would be generated at the bottom of the water reservoir and the vertical mixing therein would be inactive (i.e., strong stratification) under certain meteorological conditions). It is noted that the proposed water reservoir is of roughly 4 km2 - area with water depth of approximately 8 m.

8) Sediment

(a) Pre-construction and Construction Phase

Possibility of sediment pollution in case construction wastewater accidentally discharges into the Matamuhuri River, nearby channels, tributaries of the Matamuhuri and the Kohelia Rivers.

As mentioned earlier, the dredging is to be conducted around several points along tributaries surrounding the reservoir construction site in order to obtain embankment material. Possibility of development of sedimentation along the downstream side of tributaries around the water reservoir construction site.

(b) Operation Phase

Possibility of the sediment pollution may occur by periodical dredging activities to be conducted around the intake point, but the impact will be temporary. It is noted that a specific dredging work schedule is not determined yet within this study (as of August 2024).

(2) Natural Environment

1) Protected area

(a) Pre-construction, Construction Phase

Fashiakhali Wildlife Sanctuary (WS) and Sonadia Island ECA exist around the project site. Also, several reserved forests (RFs) exist.

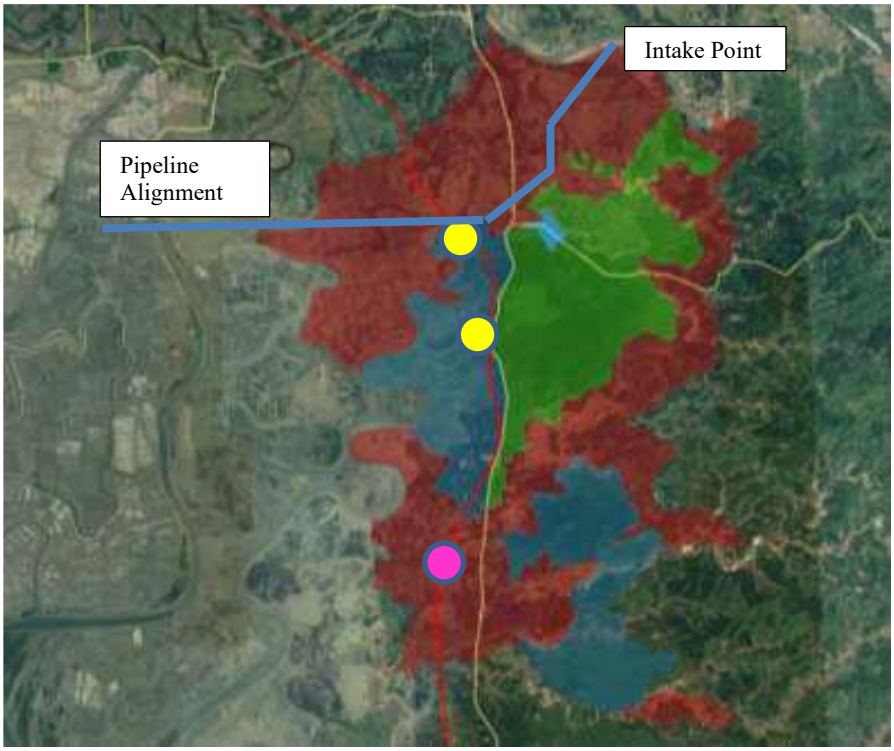
Fashiakhali WS was established in 2007 to promote Asian elephant recovery and protect its remnant Garjan (Diptocarpus spp.) forest. FWS totals 7,037 ha in size, with a Core Zone that encompasses 1,302 ha (see Figure 9.1.34); 483 ha dense forest habitat and 692 ha of degraded forest or scrub habitat. The Core Zone is surrounded by a reserved forest Buffer Zone[23] (lands outside the core zone and within the landscape boundary are considered as buffer zone), 1,366 ha in size, and a 4,384 ha Impact Management Zone[24], inhabited by ≈50,000 people in 30 villages (FWS Management Plan; FD 2015b; Figure III-3). In another words, Fashiakhali WS's forested habitats have been severely impacted by human activities.

The management plan of this WS takes into account recent developments towards co-management under the Wildlife (Preservation and Security) Act 2012 and international standards on biodiversity conservation of protected areas. The management prescriptions are given on the basis of zonation i.e. core zone, buffer zone and impact management zone.

This impact management zone (or landscape zone) is the remaining area within the combined landscape boundary and comprises non-forest lands. The focus here is on ensuring sustainable natural resource use that is resilient to climate hazards and stresses, and achieving support from communities for conservation based on diversified livelihoods that make use of fuel, timber and other products from sustainable sources in the village areas and in the buffer zone. In addition the Co-management organization (CMC), Forest Department (FD) and local government will work together to establish elephant friendly corridors at Ringbong, Haserdighi, Fasiakhali, Manikpur connecting with Harbang and Chunati. Landowners will be encouraged to adopt sustainable climate resilient practices, and to adopt higher value crops and other trades, so long as these do not attract conflict with elephants. Use of solar energy and bio-gas will be encouraged in the landscape villages to reduce pressure on forest. The management issues and threats identified are as follows, i.e., land encroachment, illicit felling, forest resource use, habitat degradation and fragmentation, climate change, tourism, wildlife conservation and protection.

[23] Only native tree species are allowed to be planted.

[24] This is the remaining area within the combined landscape boundary and comprises non-forest lands. The focus here is on ensuring sustainable natural resource use that is resilient to climate hazards and stresses, and achieving support from communities for conservation based on diversified livelihoods that make use of fuel, timber and other products from sustainable sources in the village areas and in the buffer zone (Forest Department, 2015).



Source: (IUCN 2014). Note that the entire Core Zone lies east of NH1 and the alignment.

Figure 9.1.34 Fasiakhali Wildlife Sanctuary Core (green), Buffer (blue), and Impact management (red) zones, the ADB-financed Railway Project alignment (red line) and Highway NH1 (yellow line to right of alignment), and Active (yellow dots) and Seasonal (pink dot) elephant crossings[25]

It is likely that the right of way (RoW) of the proposed delivery pipeline route connecting the water intake point and the water reservoir pass through the buffer zone of this Fashiakhali WS partially. It is reported that roughly 20 Asian elephants occur across this WS. Also, several crossing points of this Asian elephant along the existing National Road No. 1 occur. Similar discussions are made within the EIA Report of Preparatory Survey for Chattogram- Cox's Bazar Highway Improvement Project in Bangladesh (RHD, 2022).

Regarding the Sonadia Island ECA, the project site is almost 2 km away from the boundary of its buffer zone. So, the proposed project will not directly impact these areas, but indirect impacts should be considered.

Construction of ADB-financed Chittagong – Cox's Bazar Railway Project (Phase 1) was completed, and its RoW runs through the buffer zone of several protected areas (Fashiakhali WS included). Environmental monitoring program (EMoP) of this railway project continuously monitored the elephant crossing along its RoW. Several mitigation measures such as the elephant detection system, funneling

[25] Addendum to the Environmental Impact Assessment, BAN: SASEC Chittagong Cox's Bazar Railway Project, Phase 1 Tranche 1, Baseline Biodiversity Assessment Report (ADB, 2018)

needed to prevent elephants from becoming trapped within cut slope areas, a passage floor with a minimum 12-meter width and a minimum 4-meters height (ADB, 2018).

Similarly, RoW of JICA-financed Chattogram- Cox's Bazar Highway Improvement Project runs through the buffer zones of several protected areas (not yet started: as of August 2024). EMP and EMoP, developed within this project, pay attention to the migration of Asian Elephant.

Besides, as part of the Matarbari Port Access Road Construction Project (not yet started: as of August 2024), a portion of the proposed route passes through the buffer zone of the Fashiakhali WS, and an environmental management plan, including monitoring activities, has been developed to monitor the impacts of the construction on the sanctuary. Since a portion of the water pipeline for this water supply project also passes near the Fashiakhali WS, there is concern about the cumulative negative impacts on the reserve. It is noted that occurrence of Asian Elephant was not observed within this study. Within this water supply project, entire RoW of the water pipeline connecting the water intake point and the water reservoirs is to be segregated by barbed-fence, so that it would be impossible for large-sized mammals such as Asian Elephant to cross this RoW for their regional migration. Thus, it is likely that the proposed project would cause negative impacts on those protected areas to some extents.

(b) Operation Phase

As mentioned above, it is reported that roughly 20 Asian elephants occur across Fashiakhali WS. Also, several crossing points of this Asian elephant along the existing National Road No. 1 occur. Since a portion of the water pipeline for this water supply project also passes near the Fashiakhali WS, there is concern about the cumulative negative impacts on the reserve. It is noted that occurrence of Asian Elephant was not observed within this study. As mentioned earlier, entire RoW of the water pipeline connecting the water intake point and the water reservoirs is to be segregated by barbed-fence, so that it would be impossible for large-sized mammals such as Asian Elephant to cross this RoW for their regional migration. Thus, it is likely that the proposed project would cause negative impacts on those protected areas to some extents.

2) Ecosystem

(a) Pre-construction and Construction Phase

Most of the project area is highly cultivated, but there are several remnants of Chakaria Sundarbans) around the construction site of the water reservoirs. Several fishes migrate between Bay of Bengal, downstream and upstream sides of the Matamuhuri River. Water intake is scheduled to be operated some certain periods of every rainy season (roughly 4 % of entire flowrate of the Matamuhuri River). All of migration fishes of this river start to move in the rainy season. Average flow rate of the Matamuhuri River during the rainy season is of approximately 91 m^3/sec. (estimated water level ≃ 2.96 El.m). Approximate of the estimated water level when 5 % of flow was taken is of 2.93 EL.m. Resultant water

level difference between “no water-intake” scenario and “water-intake” scenario is of 0.03 m. Upon considering this preliminary impact estimation result, it can be said that the impact of the water intake operation would be negligible (consultation with Senior Upazila Fisheries Officer, 2024). It would be beneficial to implement some mitigation measures to make fish not approach the inlet of the water intake. It is noted that detailed discussions regarding the flow rate of the Matamuhuri River and the water intake operation are attached in Section 5.2 of this main report.

Current local biological condition around the intake point is classified as the secondary forest” or highly cultivated area (see figure below). Within the EIA study, conducted within this project, it is found that no rare faunal nor floral species, that would need special protections occur.

	
Lefthand side riverbank of Matamuhuri River (downstream side of water intake point) Tobacco Crop field	Lefthand side riverbank of Matamuhuri River (upstream side of water intake point) Tobacco Crop field

Figure 9.1.35 Photo Records of Riverbank of Matamuhuri River around the Water Intake Point

Source: JICA Study Team (2024)

Along riverine of the Kohelia River, there are still several mangrove vegetation. From the environmental field survey, conducted within this study, it is found that several mammal species such as Fishing Cat, an umbrella species[26] across the local environment, occur around this area. Also, the occurrence of this species is reported within FWS. It is likely that the proposed project would destroy that ecological corridors encompassing remnant vegetations as well as other relevant regional ecosystem to support the habitat of this species, recognized within the project site, to some extents.

[26] Umbrella species are species selected for making conservation-related decisions, typically because protecting these species indirectly protects the many other species that make up the ecological community of its habitat (the umbrella effect). Species conservation can be subjective because it is hard to determine the status of many species. The umbrella species is often either a flagship species whose conservation benefits other species: or a keystone species which may be targeted for conservation due to its impact on an ecosystem. Umbrella species can be used to help select the locations of potential reserves, find the minimum size of these conservation areas or reserves, and to determine the composition, structure, and processes of ecosystems.

(b) Operation Phase

Most of the project area is highly cultivated, but there are several remnants of Chakaria Sundarbans around the construction site of the water reservoirs. Along riverine of the Kohelia River, there are still several mangrove vegetation. From the environmental field survey, conducted within this study, it is found that several mammal species such as Fishing Cat, an umbrella species, across the local environment, occur around this area. It would be essential to implement some mitigation measures to keep ecological activities (e.g., establishment of the ecological corridor) during the operation phase. It is noted that the occurrence of the Fishing Cat is reported within the EIA Report of Preparatory Survey for Chattogram- Cox's Bazar Highway Improvement Project in Bangladesh (RHD, 2022).

It is noted that the project site is not located inside nor pass through the designated areas of Bangladesh such as Fasiakhali WS. Some migration paths of Asian Elephant, occurred within this WS exist around the project site, so that special attention shall be taken within the project implementation, based on facts, summarized in the table above.

3) Hydrology

(a) Pre-construction and Construction Phase

As mentioned above, possible impact on the flow of the Matamuhuri River would be small since the amount of the water intake would be roughly 5 % of the entire flow rate during every rainy season.

Existing regional drainage system would be hampered due to the construction activities of entire water supply system. So, it is important to prepare for an appropriate regional drainage design before the construction phase. It is likely that entire construction would take certain period of time, inappropriate regional drainage design may cause new regional inundation during the construction phase.

As mentioned earlier, long-term subsidence due to the construction of water reservoir facilities is expected around the project site. Local drainage system would be influenced due to this subsidence phenomenon.

(b) Operation Phase

Same as above.

4) Topography

(a) Pre-construction and Construction Phase

Regional topographic condition would be affected due to the construction work of entire water supply system project, in particular, the project site of the water reservoir site (roughly 4 km^2 - area with water depth of 8 m). Certain amounts of topographic surface changes are expected to occur due to the construction of large-scale embankment. In case of severe natural disaster events such as cyclone or local floods, patterns of local wind blowing, the regional drainage and others would be affected to some extents.

As mentioned earlier, long-term subsidence due to the construction of water reservoir facilities is expected around the project site. Local topographic conditions would be influenced due to this subsidence phenomenon.

(b) Operation Phase

Same as above.

(3) Social

1) Land acquisition and resettlement

(a) Pre-construction Phase

As explained in 9.2, land acquisition and resettlement are required due to the construction of the Project. The area for Raw Water Reservoir and Water Treatment Plant is 563.4628 ha of public land (no private land) and currently used as salt and shrimp farming. The impact is summarized in the table below.

Table 9.1.56: Summary of Project Impacts

Affected Land	Permanent acquisition/utilization	595.16 ha	Public: 575.48 ha
			Private: 19.68 ha
	Temporary use for construction yard	56.72 ha	Public: 46.73 ha–
			Private: 9.99 ha
Affected People	Households (replacement of residence)	78 HH/379 Persons	Formal (title) 63 HH/311 Persons
			Informal (non-title) 15 HH/68 Persons
	Residential tenants	10 nos	10 nos
	Business entities to be economically resettled	73 HH/254 Persons	Formal (title) 11 HH/40 Persons
			Informal (non-title) 62 HH/214Persons
	Residential cum business to be relocated	10 HH/47 Persons	Formal (title) 8 HH/36 Persons
			Informal (non-title) 2 HH/11 Persons
	Business tenants	24 nos	24 nos
	Wage labourers	72 nos	72 nos

The following mitigation measures will be implemented. Significant negative impacts will be avoided by these measures.

- Compensation for land and structure acquisition will be done in accordance with the ARIPA 2017. Additionally, resettlement benefits and livelihood restoration will be provided following the JICA Environmental Guidelines.
- Establishment of a project specific grievance redress mechanism to resolve all land acquisition and resettlement related grievances.

2) Livelihood

(a) Construction Phase

As explained in 9.2, the project will have impacts on businesses and wage laborers. 42 shrimp and salt farmers in the land for Rawa Water Reservoir and Water Treatment Plant will loss their business due to land acquisition. The impact is summarized in the table above.

Following measures will be taken to help the business owners to re-establish their businesses

- Transfer grant, reconstruction grant and business restoration grant which is given based on the scale of the affected business.
- For the wage labor, they will be entitled to loss of income of BDT 600 for 60 days.
- Wage laborers who have been working on the salt and shrimp farms for over 10 years, will be eligible for training on Income Generating Activities and capital support after the training.
- The wage laborers, females and the unemployed PAPs are expected to be engaged in the construction jobs to be provided by the project.

(b) Operation Phase

The general condition of the local economy is expected to improve. Availability of water for industrial activities is expected to improve the environment for investors, as a result more jobs for the locals due to increased investments and more businesses will be conducted around the area. On the other hand, availability of clean water for domestic activities will improve the general health of the communities as there will be less or no water-borne diseases as currently reported by the local people.

3) Socially vulnerable

(a) Pre-construction and Construction Phase

The project will affect 24 identified households that fall under the poverty line whereby 18 are male headed and 6 are female headed HHs.

Following measures will be taken to support livelihood restoration and relocation.

- One-time cash support i.e., BDT 10,000 for male headed and BDT 15,000 for female headed in addition to land and structures compensation.
- The training for Income Generating Activities and capital support of BDT 30,000
- Assist by the RAP Implementing Agency to find the relocation place close to social amenities including schools and hospitals, and the project will provide social amenities if not available in the new resettlement area.

Table 9.1.57 Affected Vulnerable Households

Vulnerable Type	DRs	RWR	Conveyance Pipeline	Transmission Pipeline	Total
Male Headed HHs Under poverty line	3	0	6	9	18
Female headed Household under poverty line	1	1	0	4	6
Total	**4**	**1**	**6**	**13**	**24**

Source: RAP Survey Results

4) Ethnic minorities and indigenous peoples

(a) Pre-construction and Construction Phase

No ethnic minorities and indigenous peoples are identified among PAHs.

(b) Operation Phase

No ethnic minorities and indigenous peoples are identified among PAHs.

5) Cultural heritage

(a) Pre-construction and Construction Phase

No cultural heritage sites are identified within the construction area. Thus, the impact on cultural heritage by the construction activities is not expected.

6) Land use and utilization of local resource

(a) Pre-construction and Construction Phase

The land for the raw water reservoir is currently used as salt and shrimp farming. Thus, due to development of the site, the land will not be available for salt and shrimp farming. The impact of the land use and utilization of local resource could be mitigated by taking measures on livelihood restoration.

(b) Operation Phase

Water resource (river water of Matamuhuri river) will be utilized efficiently due to the Project.

7) Water usage

(a) Pre-construction and Construction Phase

There are people who use river water for their daily activities such as laundry and bathing. During construction, the turbidity of water quality will be high temporarily due to construction work in the river. The river water use for daily activities at the intake point will be limited temporarily. To mitigate increase turbidity of river water, following measures should be taken.

- Announcement of construction schedule to the community around the construction site especially in the river.

- Monitor water quality.
- Announce contact information of project proponent for complains.

8) Existing social infrastructure and services

(a) Pre-construction and Construction Phase

The timing of the construction work of the Chattogram-Cox's Bazar Highway is unknown, however, there is a possibility that the construction work will be implemented at the same time in consideration of the proposed location of the pipeline along the Chattogram-Cox's Bazar Highway. If the construction schedule of two projects overlap and the construction work will be conducted by separated company, there is likely to be an impact on traffic flow and congestion on existing local roads during the construction period. On the other hand, if the Chattogram-Cox's Bazaar Highway can be partially put into service depending on the construction method, the traffic congestion during construction will be mitigated. Coordination with the relevant construction contractors and to establish the traffic management plan are important as the mitigation measure to minimize the impact on traffic flow.

9) Social institutions such as social capital and local decision-making institutions

(a) Operation Phase

The Project contains total of 15 unions under 2 sub-districts and each union has its own several stakeholders and decision-making processes. Implementation of the Project will need coordination with these stakeholders and follow location decision making flow. Thus, the Project will not affect social institution and local decision-making.

10) Misdistribution of benefits and loss

(a) Pre-construction and Construction Phase

Any loss due to land acquisition at the pre-construction phase and any damages related to the civil works during the construction phase will be compensated properly. Thus, misdistribution of benefits and loss is expected to be negligible

11) Infectious diseases such as HIV/AIDS

(a) Pre-construction and Construction Phase

The influx of workers into the community may have an impact on public health, particularly an increase in disease prevalence. Inadequate sanitation facilities and waste disposal from the construction labor camp can result in vector-borne diseases and other infectious diseases. There is also the possibility of an increase in sexually transmitted diseases such as HIV/AIDS, COVID19 and sexual transmitted diseases (STDs) due to influx of workers. Therefore, it is necessary to consider to implement countermeasures as below;

- The contractor should conduct training for all workers on environmental hygiene;
- Campaign and postering to increase awareness on COVID-19 pandemic to protect health and safety

of workers;
- Use Personal Protective Equipment (PPE) required for COVID-19 and maintain social distancing during construction;
- Provide HIV awareness programming, including STI (sexually transmitted infections) and HIV information, education and communication for all workers on regular basis;
- Adequate facilities for the health of construction workers will be provided at the construction camp;
- Avoiding formation of stagnant water pools in and around the site;
- Implementation of a vector control programme in labour camps and surrounding areas;

12) Children's rights

(a) Pre-construction and Construction Phase

Besides, the Labor law in 2006 prohibits employment of children under 14 years and employment of children under 18 years in hazardous form in Bangladesh. On the other hand, according to the national child labor survey (NCLS) 2022, it is still reported that 4.4% of children between the ages of 5 and 17 are engaged in labor in Bangladesh. Therefore, the possibility that child labor will occur as a result of the implementation of the Project cannot be denied.

Based on the above consideration, the following measures are proposed to address the impact on children's rights.
- In compliance with Bangladesh laws and JICA guidelines, child labor shall be strictly prohibited during the project implementation period.
- Strong protocols should be built as part of contractual obligations around zero tolerance of child labor or harassment of women workers and even health and safety aspects. These should also be monitored by the supervision and monitoring team

13) Gender

(a) Pre-construction and Construction Phase

During the FGDs, women mentioned difficulties accessing construction jobs. It was also found that 25.91% of the PAPs are housewives. They usually walk a long distance and stand in long queuing for accessing to water during the dry season. During construction phase, due to influx of workers, risks for Sexual and Gender-Based Violence (SGBV) for women and young girls will increase.

The following measures should be taken.
- Implement gender-sensitive hiring practices for construction works, and PMO of DPHE by setting a target number of female workers.
- Ensure Contractor's contract includes a clause to hire female workers.
- Provide training on gender equality and sensitivity to construction staff.

- Monitor and address any gender-based discrimination by construction workers and other people.

(b) Operation Phase

The contribution of the Project for gender equality after the construction phase is expected as follows.

- Increased number of women participating in the labor market hence improved economic status and increase their participation in decision making process
- Access to water supply and reduced distance to water sources will reduce the hardship facing women and girls while fetching water and reduce their encounter to SGBV
- Training on and monitoring of SGBV will reduce their occurrences around the project area

14) Work environment (including work safety)

(a) Construction Phase

During construction, following causes of injury are anticipated.

- Intake facility: Falls into Matamuhuri river
- Raw water reservoir: Falls from dyke
- Distribution reservoir: Falls from elevation
- Common: Fall of material or tools

The following measures could prevent impacts.

- The local regulations or acts related to industry safety and health, practically adopted for construction fields in Bangladesh, shall be adopted in principle.
- The works for intake facilities will be located inside and along the Matamuhuri River. These works shall avoid the peak season of river flooding. If the precedence of works in the rainy season is unavoidable, the works may be conducted with special attention. The river water level shall be regularly monitored. A warning alert system may be equipped at the site, which enables the evacuation of site staffs and construction equipment to safe places when the river water level increases unexpectedly.
- Training and use of temporary fall prevention devices
- Use of control zones and safety monitoring systems to warn workers
- Wearing appropriate PPE, such as safety glasses with side shields, face shields, hard hats, and safety shoes

(b) Operation Phase

During operation phase, dredging at the intake point, operation and maintenance of facilities. For the maintenance of raw water reservoir and elevated distribution reservoir, the work in elevation is expected. For the operation of water treatment plant, the chemical is used for water treatment process. Thus, following risks are anticipated.

- Accidents and injurie due to dredging work and the work in elevation.
- Chemical exposure due to use of chemical during water treatment process

Following measures should be taken.

- Require use of a lifeline and personal flotation device (PFD) when working near river.
- Use fall protection equipment when working at heights
- Maintain work areas to minimize slipping and tripping hazards
- Implement a training program for operators who work with chlorine regarding safe handling practices and emergency response procedures
- Provide appropriate personal protective equipment (including, for example, self-contained breathing apparatus) and training on its proper use and maintenance

15) Health, safety and security of local communities

(a) Pre-construction and Construction Phase

Influx of construction workers may lead to spread of infectious diseases such as STDs and COVID-19, as mentioned in "11) Infectious diseases such as HIV/AIDS" of this section. In addition, the influx of construction vehicles may increase traffic accidents. The entrance of local people into construction yard will be cause of accidents and injury. The safety measures shall be provided certainly during the construction stage and the following should be taken into account.

- In order to prevent the collision accidents on neighbouring existing roads, temporary facilities such as safety sign boards and lightings, including flagmen, are arranged to control traffic during construction work. The intersections with the existing roads N1 and R172 should be carefully attended.
- Specially for pipeline work, it will be required to occupy existing road spaces sometimes when the pipes are transported, unloaded and buried in roads. In order to avoid the collision accidents with public traffic, safety control facilities such as safety sign boards and lightings, including flagmen, should be arranged certainly.
- In order to prevent accidents inside construction yards, the safety measures (monitor entrance by security, and fence around the construction yard etc.) in construction yards shall be provided adequately.

(b) Operation Phase

Reservoir structure is mainly composed of embankment, which is designed in consideration of high-water level and maintenance road. Since the fences is installed around the raw water reservoir for ensuring the safety and prohibiting entrance without permission. Thus, there is no factor to generate negative impact on Health, safety and security of local communities.

16) Accidents and natural disasters

(a) Pre-construction and Construction Phase

Region-wide transport pattern would be changed and traffic volume would be increased by the circulation of construction vehicle and construction activities. Consequently, there is a possibility of increase of traffic accidents.

There was a record of Moheshkhali Earthquake (Magnitude = 5.1, July 1999). In case of earthquake events, there is a possibility of the liquefaction since most of the project site is classified as the floodplain.

Local surface topographic changes to be caused by the construction of large-scale embankment of water reservoir, local wind pattern would be changed and its local wind blowing may be strengthened in case of cyclone events.

(b) Operation Phase

Same as above.

(4) Others

1) Cross-boundary impact and climate change

(a) Pre-construction and Construction Phase

CO_2 will be generated by the construction work of this water supply system project. However, the construction period is limited and the impact to climate change is not anticipated.

(b) Operation Phase

As mentioned earlier, the proposed water reservoir is of roughly 4 km2 - area with the water depth of approximately 8 m. There is a possibility of the methane generation at the hypolimnion of the water reservoir under certain conditions during the operation phase (e.g., the water depth of the water reservoir would be deep enough, certain amounts of sludge/mud would be generated at the bottom of the water reservoir and the vertical mixing therein would be inactive (i.e., strong stratification) under certain meteorological conditions).

9.1.7 Impact Assessment

Table 9.1.58 Impact Assessment

Item	Impact Assessment in the scoping		Impact Assessment based on the survey results		Expected Impacts
	P/CS	OP	P/CS	OP	
Pollution Control Items					
Air pollution	v	-	B-	N/A	・ Possible cumulative impact with nearby on-going infrastructure development projects (e.g., Matarbari Port Access Road Construction Project) ・ Degradation of local air quality from due to traffic movements ・ Dust from construction works create nuisance and health hazard for residents near work sites; Emissions from equipment and vehicles used in construction and earthworks degrades local air quality
Water quality	v	V	B-	B-	・ Possible water quality degradation due to construction activities (dredging activities at Matamuhuri River and at several points along tributaries surrounding the reservoirs). ・ Effluent discharge of wastewater, to be generated from Spoil Bank.

Item	Impact Assessment in the scoping		Impact Assessment based on the survey results		Expected Impacts
	P/CS	OP	P/CS	OP	
					・ Possible cumulative impact with nearby on-going infrastructure development projects (e.g., Matarbari Port Access Road Construction Project) ・ Lack of effective water conservation contributes to local groundwater issues ・ Siltation and sedimentation of watercourses from soil erosion and entrainment of fine materials; Excessive enrichment of surface waters from raw sewage discharged by construction camps lacking adequate septic systems ・ Contamination from leaks and spills of noxious fluids used in construction process ・ Loss of topsoil to erosion ・ Deterioration in quality of raw water supply and of treated water Potential risk on public health in deterioration of treated water quality due to use of poor quality treatment chemicals
Wastes	v	V	B-	B-	・ Possible generation of construction wastes (e.g., concrete, asphalt, logging trees, excavated surface layer soil and others). ・ Possible generation of unused dredged soil as the embankment material of the water reservoir due to its soil characteristics. ・ Possible generation of sludge at water treatment plant and dredged sand/soil ・ Pollution from inadequately managed wastes ・ Impacts from improper removal, processing and disposal of demolished structures and excavation of soils ・ Pollution from improper management of solid waste generated at work sites and construction camp ・ Possible generation of water purification wastes (to be treated as industrial wastes). ・ Pollution from improper management of solid waste from facilities (intake structure)
Soil contamination	v	-	B-	N/A	・ Contamination from leaks and spills of noxious fluids used in construction process
Noise and vibration	v	V	B-	B-	・ Possible cumulative impact with nearby on-going infrastructure development projects (e.g., Matarbari Port Access Road Construction Project) ・ Operation of construction equipment such as jackhammer will cause excessive noise resulting in nuisance to communities. ・ Noise and vibration from earthworks, and materials hauling degrade quality of life for local residents ・ Elevated accident risk due to increased traffic on the beach road
Subsidence	v	V	B-	B-	・ Possible long-term subsidence due to construction of water reservoirs facilities. ・ Possible cumulative impact with Matarbari Port Access Road Construction Project.
Odor	v	-	B-	B-	・ Possible generation of obnoxious smell such as ammonia and/or hydrogen sulfide.
Sediment	v	V	B-	B-	・ Possible sedimentation at downstream side of tributaries such as Matamuhuri River. ・ Possible cumulative impact with nearby on-going infrastructure development projects (e.g., Matarbari Port Access Road Construction Project).
Natural Environment Items					
Protected area	v	V	B-	B-	・ Possible intervention of migration of some faunal species (e.g., Asian Elephant) around protected area. ・ Possible compound impact with nearby on-going

Item	Impact Assessment in the scoping		Impact Assessment based on the survey results		Expected Impacts
	P/CS	OP	P/CS	OP	
					infrastructure development projects (e.g., Matarbari Port Access Road Construction Project). ・ Erosion of soils during maintenance works involving excavation and/or deteriorated ground cover
Ecosystem	v	V	B-	B-	・ Construction workers may undertake hunting of wildlife and cutting of wood upstream of the intake, river training works may disturb the downstream fisheries population and aquatic environment of Matamuhuri River. ・ Impact on natural resources and protected areas from cutting/clearing of trees and other vegetation. ・ Poor planning and execution of tree clearing/vegetation removal at project facilities and along intake structure can result in loss of vegetation and general landscape ・ Destruction of trees and habitat loss of fauna ・ Possible degradation regional ecosystem, in particular, floodplain vegetation (e.g., acceleration of destruction of Chakaria Sundarbarn remnants). ・ Possible compound impact with nearby on-going infrastructure development projects (e.g., Matarbari Port Access Road Construction Project). ・ Erosion of soils during maintenance works involving excavation and/or deteriorated ground cover
Hydrology	v	V	A-	A-	・ Possible alternation to regional drainage system, in particular, around water reservoir construction site. ・ Possible compound impact with nearby on-going infrastructure development projects (e.g., Matarbari Port Access Road Construction Project) ・ Possible local drainage system changes due to long-term subsidence, to be caused by the construction of water reservoir facilities.
Topography	v	V	A-	A-	・ Possible alternation to regional topography, in particular, around water reservoir construction site. ・ Possible compound impact with nearby on-going infrastructure development projects (e.g., Matarbari Port Access Road Construction Project) ・ Possible local topographic changes due to long-term subsidence, to be caused by the construction of water reservoir facilities.
Social Items					
Land acquisition and resettlement	v	-	A-	N/A	・ Total of 73.3 acres of private land is needed to be acquired for implementation of the Project, and it will cause physical displacement of 235 units (i.e. affected households, business and community properties) in total. ・ Loss of community assets due to land acquisition and damage to properties
Livelihoods	v	V	B-	A+	・ At the pre-construction phase, business premises in the project area may be affected. Accordingly, livelihoods of business owners of the affected business premises and their wage laborers may be affected. ・ At the operation phase, improvement of water distribution for industrial activities will contribute for increased business investment, and it will bring more job opportunities for the locals.
Socially vulnerable	v	-	B-	N/A	・ At the pre-construction phase, the Project may affect total of 24 households fall under the poverty line.
Ethnic minorities and indigenous peoples	v	V	D	D	・ At the pre-construction, construction and operation phases, the Project will not affect ethnic minorities or indigenous peoples as there are no groups classified into such categories in the project area.
Cultural heritage	v	-	D	N/A	・ At the pre-construction and construction phases, the Project will not affect cultural heritages as there are no

Item	Impact Assessment in the scoping		Impact Assessment based on the survey results		Expected Impacts
	P/CS	OP	P/CS	OP	
					such assets in the project area.
Land use and utilization of local resources	v	V	B-	A+	・ At the construction phases, loss of livelihood is expected because the land is not available for salt and shrimp farming. Measures for loss of livelihood is implemented and the impact could be mitigated. ・ Water resource (river water of Matamuhuri river) will be utilized efficiently due to the Project.
Water usage	v	-	B-	N/A	・ The turbidity of water quality will be high temporarily due to construction work in the river. The river water use for daily activities at the intake point will be limited temporarily. ・ Downstream river uses such as irrigation, bathing, washing, and fishing will be affected if excessive water abstraction will occur
Existing social infrastructure and services	v	-	B-	N/A	・ There is a possibility that the construction works of the Chattogram-Cox's Bazar Highway and the project are overlapped. Or otherwise, the Chattogram-Cox's Bazar Highway is partially operated during the Project is in the construction phase. At either case, traffic congestion on existing local roads may be occurred. ・ Elevated risk of accidents and viral infection in the construction sites/construction camps; traffic congestion within the construction area make public nuisance
Social institutions such as social infrastructure and local decision-making institutions	-	V	N/A	D	・ Although the Project contains total of 15 unions under 2 sub-districts, the Project will not affect social institutions and local decision-making as the Project will follow them for smooth implementation at all project phases.
Misdistribution of benefits and loss	v	-	D	N/A	・ As any losses to be caused at the pre-construction or construction phase will be compensated properly, misdistribution of benefits and loss may not be assumed.
Infectious diseases such as HIV/AIDS	v	-	B-	N/A	・ There is a possibility to increase STDs due to influx of construction workers. Additionally, vector-borne diseases or other infectious diseases may be increased unless construction labor camps are maintained with adequate sanitation conditions. ・ Construction camps act as vectors for spread of pathogens and disease
Children's rights	v	-	B-	N/A	・ There is a possibility that influx of construction workers affect privacy of local children or construction works disturb access to school. In addition, there is a risk that children are engaged as children labors since a child labor is still reported in Bangladesh according to the National Child Labor Survey 2022. ・ Construction camps are locus of violence against women, children and girls; Construction camps serve as source of social conflict, possibly leading to violence
Gender	v	V	B-	A+	・ At the construction phase, due to influx of workers, risks for Sexual and Gender-Based Violence (SGBV) for women and young girls will increase. ・ Construction camps are locus of violence against women, children and girls; Construction camps serve as source of social conflict, possibly leading to violence ・ At the operation phase, the contribution of the Project for gender equality after the construction phase is expected. ・
Work environment (including work safety)	v	V	B-	B-	・ There is a risk of several injuries works due to construction works such as falling into Matamuhuri river at the intake facility site, falling from a dyke at the raw water reservoir site. ・ Risks to worker health and safety from improper work

Item	Impact Assessment in the scoping		Impact Assessment based on the survey results		Expected Impacts
	P/CS	OP	P/CS	OP	
					site practices ・ Risks to workers from viral illness ・ Risks to worker health and safety from poor conditions in construction camps ・ Accidents and injurie due to dredging work and the work in elevation. ・ Chemical exposure due to use of chemical during water treatment process
Health, safety and security of local communities	v	V	B-	D	・ At the construction phase, spread of infectious diseases due to influx of construction workers are assumed. Additionally, there may be risks of increasing traffic accidents by construction vehicles. ・ Elevated risk of accidents and viral infection in the construction sites/construction camps; traffic congestion within the construction area make public nuisance ・ At the operation phase, no negative impact is assumed since reservoir structure is designed based on high-water level and maintenance road and security facilities such as security guard or fences are arranged along the periphery road.
Accidents and natural disasters	v	V	B-	B-	・ Possible worsening of regional traffic accidents due to construction activities. ・ Possible occurrences of natural disasters-related accidents (note that the project site is located within disaster-prone area). ・ Elevated risks to pedestrians on approach road ・ Potential hazards to residents
Others					
Cross-boundary impact and climate change	v	-	B-	N/A	・ Generation of GHG including methane from construction and operations contributes to global climate change problem; Climate Change Bangladesh is expected to increase rainfall during post monsoon. Heavy rainfall is expected in short window. Failure to take the excess water into consideration for future can lead to potential disaster in the form of water logging and flood. ・ Infrastructure use limitations, damage and environmental hazards due to changing conditions;

Note: P/CS: Pre-construction and Construction Phase

OP: Operation Phase

A+/-: Significant positive/negative impacts are expected.

B+/-: Some positive/negative impact expected.

C+/-: The extent of the positive/negative impact is unknown (further investigation is needed, and in the process the impact can be clarified).

D: No impact is expected.

N/A: Impact assessment was not performed due to a D in the scoping phase.

Source: JICA Survey Team

9.1.8 Environment Management Plan

Table 9.1.59 Environment Management Plan (Pre-Construction /Construction Phases)

No.	Item	Expected Impact	Mitigation Measure	Implementing Organization	Responsible Organization	Cost
Pollution Control Items						
1	Air pollution	・ Possible cumulative impact with nearby on-going infrastructure development projects (e.g., Matarbari Port Access Road Construction Project) ・ Degradation of local air quality from due to traffic movements ・ Dust from construction works create nuisance and health hazard for residents near work sites; Emissions from equipment and vehicles used in construction and earthworks degrades local air quality	・ Establish liaison & data sharing with PP/contractor of nearby on-going development projects (e.g., Matarbari Port Access Road). ・ Daily on-site observation and Periodical Air Quality monitoring. ・ providing ample on-site space for vehicles loading and unloading passengers and their belongings ・ providing ample space within the site for vehicles ・ Construction works will create dust by placing sands, cutting off sections, earthworks, carrying out the construction fine materials, emissions from construction vehicles. Therefore, spraying water is required for dust suppression. ・ Establish air quality baseline by certified testing company prior to commencement of construction works. Surface water quality should be tested periodically over the construction period to observe if any change in quality due to construction works. ・ Implement a regimen of misting all dust-generating surfaces throughout the workday during dry weather, the frequency of water spray should be twice a day during the dry periods. ・ Tightly cover stockpiles of fine materials with tarpaulins whenever they are not in active use to prevent wind erosion ・ Equip all haul trucks with tightly fitting tarpaulins and enforce their use ・ Maintain all motorized equipment used in construction to a high standard ・ Use only fuel-efficient equipment	Contractor	DPHE	included in CSC, Contractor costs
2	Water quality	・ Possible water quality degradation due to construction activities (dredging	・ Daily on-site observation. ・ Set up anti-dispersion-purpose sheet at each	Contractor	DPHE	included in CSC, Contractor

No.	Item	Expected Impact	Mitigation Measure	Implementing Organization	Responsible Organization	Cost
		activities at Matamuhuri River and at several points along tributaries surrounding the reservoirs). · Effluent discharge of wastewater, to be generated from Spoil Bank. · Possible cumulative impact with nearby on-going infrastructure development projects (e.g., Matarbari Port Access Road Construction Project) · Lack of effective water conservation contributes to local groundwater issues · Siltation and sedimentation of watercourses from soil erosion and entrainment of fine materials; Excessive enrichment of surface waters from raw sewage discharged by construction camps lacking adequate septic systems · Contamination from leaks and spills of noxious fluids used in construction process · Loss of topsoil to erosion	dredging sites. · Set up sand/silt settlement ponds at discharge points. · Periodical Water Quality monitoring. · Establish liaison & data sharing with PP/contractor of nearby on-going development projects (e.g., Matarbari Port Access Road). · Construction site run-off should be restricted to water bodies to avoid contamination of the surface water. Maximize opportunities to limit water consumption and increase groundwater recharge in the construction camp and construction methods · stormwater infiltration swales for all runoff from paved and impervious surfaces (objective: zero site runoff) · During construction; special attention to placing of sand/silt barrier in most places to prevent contaminated and sand laden water from being discharged into the lower areas. There is no drain in existence in this alignment, therefore the design outfall needs to be shielded from pollution. · Establish surface water quality baseline by certified testing company prior to commencement of construction works. Surface water quality should be tested periodically over the construction period to observe if any change in quality due to construction works. · Protect disturbed soil from rain by keeping exposed areas covered with mulches, fiber mats and other temporary coverings · Keep all stockpiles of erodible materials covered with tarpaulins whenever they are not in active use · Arrange work site drainage to prevent concentration of surface runoff in the vicinity of exposed soils and materials stockpiles · Install and regularly maintain sediment traps in site runoff channels · Install an adequate number of toilets to			costs

No.	Item	Expected Impact	Mitigation Measure	Implementing Organization	Responsible Organization	Cost
			accommodate all workers, and septic systems of sufficient capacity for the expected effluent volume, in accordance with Construction Camp Management Plan ・ Keep all drilling and mixing activities at least 100m far from the existing water body, put silt barrier along the canal and river ・ Protect disturbed soil from rain by keeping exposed areas covered with mulches, fiber mats and other temporary coverings ・ Arrange work site drainage to prevent concentration of surface runoff in the vicinity of exposed soils			
3	Wastes	・ Possible generation of sludge at water treatment plant and dredged sand/soil ・ Pollution from inadequately managed wastes ・ Impacts from improper removal, processing and disposal of demolished structures and excavation of soils ・ Pollution from improper management of solid waste generated at work sites and construction camp	・ Daily on-site observation (e.g., prevent illegal dumping and/or discharge of construction effluents). ・ Establish proper waste treatment program by type while securing appropriate dumping methods and sites.. ・ Waste storage and segregation areas should be arranged ・ Designate outdoor space for thermophilic composting of organic waste from kitchens and canteens for construction camps ・ Ensure salvage of recyclable and reusable items ・ Use rubble in site development or dispose of in a site identified and approved in accordance with the Waste Management Plan embedded within the CEMP ・ Surplus excavated materials/cut soil from construction works will be used as backfill materials for low-laying areas that have been identified by the local community ・ Provide waste receptacles on the work sites and collect their contents daily or weekly as needed ・ Recycle all recyclables through local providers of this service ・ Compost organic wastes generated by construction camp kitchens ・ Dispose of non-recyclable and non-organic	Contractor	DPHE	included in CSC, Contractor costs

No.	Item	Expected Impact	Mitigation Measure	Implementing Organization	Responsible Organization	Cost
			wastes as directed in the Waste Management Plan embedded within the CEMP, as based on locally available and approved disposal options ・ Follow Solid Waste Management Rules 2021			
4	Soil contamination	・ Contamination from leaks and spills of noxious fluids used in construction process	・ Daily on-site observation (e.g., check if accidental spill of construction chemicals occurs) . ・ Periodical soil quality monitoring. ・ Keep all motorized equipment in good repair ・ Maintain a regiment of systematic daily checks to detect leaks, following up with prompt repair as needed ・ Strictly require use of drip mats and pans during refueling and servicing to catch spills and drips ・ Store fuels and other noxious fluids within roofed, rain-exclusive containment structures. ・ Provide training in spill prevention and spill response to all workers involved in refueling or equipment servicing ・ Follow the recommended dosage of chlorine during the disinfection of pipes. Discharge of water with high chlorine concentration to soil at the end of pipelines to be controlled.	Contractor	DPHE	included in CSC, Contractor costs
5	Noise and vibration	・ Possible cumulative impact with nearby on-going infrastructure development projects (e.g., Matarbari Port Access Road Construction Project) ・ Operation of construction equipment such as jackhammer will cause excessive noise resulting in nuisance to communities. ・ Noise and vibration from earthworks, and materials hauling degrade quality of life for local residents	・ Daily on-site observation. ・ Periodical noise/vibration monitoring. ・ Establish liaison & data sharing with PP/contractor of nearby on-going development projects (e.g., Matarbari Port Access Road). ・ Limit construction activities, particularly operation of noise generating equipment at night. ・ Position any stationary equipment that produces high noise levels such as diesel generators as far as practical from sensitive receptors. ・ Erect temporary barriers around construction sites especially near schools, hospitals, and houses. ・ Install noise suppression devices to noise	Contractor	DPHE	included in CSC, Contractor costs

No.	Item	Expected Impact	Mitigation Measure	Implementing Organization	Responsible Organization	Cost
			generating equipment. ・ Require drivers to minimize blowing of horn and to comply with speed limits. ・ Provide information to community on schedule of construction activities through billboard/signs. ・ Conduct work only during daylight hours ・ Impose and enforce low speed limits on haul trucks through community silent zone area ・ Maintain all motorized equipment and haul trucks to a high standard, and inspect exhaust systems regularly.			
6	Subsidence	・ Possible subsidence due to construction of water reservoirs facilities. ・ Possible cumulative impact with Matarbari Port Access Road Construction Project.	・ Daily on-site observation. ・ Establish proper anti subsidence measures (e.g., implementation of extra-banking for embankment). ・ Establish liaison & data sharing with PP/contractor of Matarbari Port Access Road Projects.	Contractor	DPHE	included in CSC, Contractor costs
7	Odor	・ Possible generation of obnoxious smell such as ammonia and/or hydrogen sulfide.	・ Daily on-site observation. ・ Establish liaison & data sharing with PP and contractor of Matarbari Port Access Road Projects.	Contractor	DPHE	included in CSC, Contractor costs
8	Sediment	・ Possible sedimentation at downstream side of tributaries surrounding reservoirs. ・ Possible cumulative impact with nearby on-going infrastructure development projects (e.g., Matarbari Port Access Road Construction Project)	・ Daily on-site observation. ・ Establish liaison & data sharing with PP/contractor of Matarbari Port Access Road Projects.	Contractor	DPHE	included in CSC, Contractor costs
Natural Environment Items						
9	Protected area	・ Possible intervention of animal migration of some faunal species (e.g., Asian Elephant) around protected area. ・ Possible compound impact with nearby on-going infrastructure development projects (e.g., Matarbari Port Access Road Construction Project)	・ Daily on-site observation. ・ Periodical biological environmental survey. ・ Establish liaison & data sharing with PP/contractor of both CC Road and Matarbari Port Access Road Projects. ・ Establish good liaison with environmental NGOs such as IUCN, that have huge knowledge and experiences about conservation activities in Bangladesh.	Contractor	DPHE	included in CSC, Contractor costs

No.	Item	Expected Impact	Mitigation Measure	Implementing Organization	Responsible Organization	Cost
			・ Establish animal path (width of this path would be of 12 meters at least) inside of buffer zone of Fasiakhali WS, that would be compatible with mitigation measure, taken within ADB-financed railway project (note: one active crossing elephant crossing point is identified around the project site).			
10	Ecosystem	・ Construction workers may undertake hunting of wildlife and cutting of wood upstream of the intake, river training works may disturb the downstream fisheries population and aquatic environment of Matamuhuri River. ・ Impact on natural resources and protected areas from cutting/clearing of trees and other vegetation. ・ Poor planning and execution of tree clearing/vegetation removal at project facilities and along intake structure can result in loss of vegetation and general landscape ・ Destruction of trees and habitat loss of fauna ・ Possible degradation regional ecosystem, in particular, floodplain vegetation (e.g., acceleration of destruction of Chakaria Sundarbarn remnants). ・ Possible compound impact with nearby on-going infrastructure development projects (e.g., Matarbari Port Access Road Construction Project).	・ Cutting of trees will be undertaken as per approved design and only upon approval. Avoid cutting of trees as much as possible and minimize damage to native vegetation. ・ The contractors will prohibit activities such as cutting wood for cooking, hunting, or wildlife trade. ・ Disposal of construction materials are also prohibited in the Matamuhuri River as well as the adjacent waterbodies in and around the project location to protect fisheries and aquatic environment ・ Roads and paths to the intake infrastructure will only be sufficiently wide to accommodate construction vehicles/equipment to minimize land take. ・ Manual labor will be utilized in sloping terrain where use of heavy equipment would cause unnecessary damage. Steep exposed slopes will be graded and covered with bush and grass to minimize erosion. ・ Widening of the existing road will have impact on the flora and fauna by cutting road side trees. Careful design of the road should be done with avoiding the big trees to minimize the negative impact. ・ Providing barrier along the road embankment at the water bodies' section to reduce the surface runoff. ・ Tree plantation along the project site, in particular, riverine mangrove vegetation area that is important habitat for fishing cat, should be done as compensation and enhancement	Contractor	DPHE	included in CSC, Contractor costs

No.	Item	Expected Impact	Mitigation Measure	Implementing Organization	Responsible Organization	Cost
			measures. ・			
11	Hydrology	・ Possible alternation to regional drainage system, in particular, around water reservoir construction site. ・ Possible compound impact with nearby on-going infrastructure development projects (e.g., Matarbari Port Access Road Construction Project) ・ Possible local drainage system changes due to long-term subsidence, to be caused by the construction of water reservoir facilities.	・ Daily on-site observation to see if inundation occurs locally dur to construction work. ・ Establish liaison & data sharing with PP/contractor of Matarbari Port Access Road Projects.	Contractor	DPHE	included in CSC, Contractor costs
12	Topography	・ Possible alternation to regional topography, in particular, around water reservoir construction site. ・ Possible compound impact with nearby on-going infrastructure development projects (e.g., Matarbari Port Access Road Construction Project) ・ Possible local topographic changes due to long-term subsidence, to be caused by the construction of water reservoir facilities.	・ Daily on-site observation. ・ Establish liaison & data sharing with PP/contractor of Matarbari Port Access Road Projects.	Contractor	DPHE	included in CSC, Contractor costs
Social Items						
13	Land acquisition and resettlement	・ Total of 73.3 acres of private land is needed to be acquired for implementation of the Project, and it will cause physical displacement of 235 units (i.e. affected households, business and community properties) in total. ・ Loss of community assets due to land acquisition and damage to properties	・ Compensation for land and structure acquisition will be done in accordance with the ARIPA 2017. Additionally, resettlement benefits and livelihood restoration will be provided following the JICA Environmental Guidelines. ・ Establishment of a project specific grievance redress mechanism to resolve all land acquisition and resettlement related grievances.	Contractor	DPHE	included in CSC, Contractor costs
14	Local economy such as employment and livelihood	・ At the pre-construction phase, business premises in the project area may be affected. Accordingly, livelihoods of business owners of the affected business premises and their wage laborers may be affected.	・ Transfer grant, reconstruction grant and business restoration grant which is given based on the scale of the affected business. ・ For the wage labor, they will be entitled to loss of income of BDT 600 for 60 days.	Contractor	DPHE	included in CSC, Contractor costs

No.	Item	Expected Impact	Mitigation Measure	Implementing Organization	Responsible Organization	Cost
			・ Wage laborers who have been working on the salt and shrimp farms for over 10 years, will be eligible for training on Income Generating Activities and capital support after the training. ・ The wage laborers, females and the unemployed PAPs are expected to be engaged in the construction jobs to be provided by the project.			
15	Socially vulnerable	・ At the pre-construction phase, the Project may affect total of 24 households fall under the poverty line.	・ One-time cash support i.e., BDT 10,000 for male headed and BDT 15,000 for female headed in addition to land and structures compensation. ・ The training for Income Generating Activities and capital support of BDT 30,000 ・ Assist by the RAP Implementing Agency to find the relocation place close to social amenities including schools and hospitals, and the project will provide social amenities if not available in the new resettlement area.	Contractor	DPHE	included in CSC, Contractor costs
16	Land use and utilization of local resources	・ At the construction phases, loss of livelihood is expected because the land is not available for salt and shrimp farming. Measures for loss of livelihood is implemented and the impact could be mitigated. ・ Water resource (river water of Matamuhuri river) will be utilized efficiently due to the Project.	・ Transfer grant, reconstruction grant and business restoration grant which is given based on the scale of the affected business. ・ For the wage labor, they will be entitled to loss of income of BDT 600 for 60 days. ・ Wage laborers who have been working on the salt and shrimp farms for over 10 years, will be eligible for training on Income Generating Activities and capital support after the training. ・ The wage laborers, females and the unemployed PAPs are expected to be engaged in the construction jobs to be provided by the project.	Contractor	DPHE	included in CSC, Contractor costs
17	Water usage	・ The turbidity of water quality will be high temporarily due to construction work in the river. The river water use for daily activities at the intake point will be limited temporarily. ・ Downstream river uses such as irrigation, bathing, washing, and fishing will be affected if excessive water abstraction will occur	・ The abstraction of water from the river Matamuhuri only at rainy season when the water is available at river to minimize the conflict with other water users. ・ Announcement of construction schedule to the community around the construction site especially in the river. ・ Monitor water quality and water level.	Contractor	DPHE	included in CSC, Contractor costs

No.	Item	Expected Impact	Mitigation Measure	Implementing Organization	Responsible Organization	Cost
			・ Announce contact information of project proponent for complains.			
18	Existing social infrastructure and services	・ There is a possibility that the construction works of the Chattogram-Cox's Bazar Highway and the project are overlapped. Or otherwise, the Chattogram-Cox's Bazar Highway is partially operated during the Project is in the construction phase. At either case, traffic congestion on existing local roads may be occurred. ・ Elevated risk of accidents and viral infection in the construction sites/construction camps; traffic congestion within the construction area make public nuisance	・ Establish the traffic management plan to minimize the impact on traffic flow	Contractor	DPHE	included in CSC, Contractor costs
19	Infectious diseases such as HIV/AIDS	・ There is a possibility to increase STDs due to influx of construction workers. Additionally, vector-borne diseases or other infectious diseases may be increased unless construction labor camps are maintained with adequate sanitation conditions. ・ Construction camps act as vectors for spread of pathogens and disease	・ The contractor should conduct training for all workers on environmental hygiene; ・ Campaign and postering to increase awareness on COVID-19 pandemic to protect health and safety of workers; ・ Use Personal Protective Equipment (PPE) required for COVID-19 and maintain social distancing during construction; ・ Provide HIV awareness programming, including STI (sexually transmitted infections) and HIV information, education and communication for all workers on regular basis; ・ Adequate facilities for the health of construction workers will be provided at the construction camp; ・ Avoiding formation of stagnant water pools in and around the site; ・ Implementation of a vector control programme in labour camps and surrounding areas; ・ Install and maintain adequate toilet and septic systems to prevent discharge of raw sewage from camps to local water bodies or fields ・ Educate resident workers about sexually	Contractor	DPHE	included in CSC, Contractor costs

No.	Item	Expected Impact	Mitigation Measure	Implementing Organization	Responsible Organization	Cost
			transmitted diseases and responsible sexual behavior ・ Work with local community leaders to prohibit prostitution in and around construction camps ・ Provide adequate sleeping space for the number of workers to avoid overcrowding and consequent spread of communicable illnesses and infestations ・ Provide each worker with a raised sleeping platform with mattress or mat, bedding and mosquito netting ・ Test drinking water supplied to workers on a quarterly basis to ensure safety ・			
20	Children's rights	・ There is a possibility that influx of construction workers affect privacy of local children or construction works disturb access to school. In addition, there is a risk that children are engaged as children labors since a child labor is still reported in Bangladesh according to the National Child Labor Survey 2022. ・ Construction camps are locus of violence against women, children and girls; Construction camps serve as source of social conflict, possibly leading to violence	・ In compliance with Bangladesh laws and JICA guidelines, child labor shall be strictly prohibited during the project implementation period. ・ Strong protocols should be built as part of contractual obligations around zero tolerance of child labor or harassment of women workers and even health and safety aspects. These should also be monitored by the supervision and monitoring team	Contractor	DPHE	included in CSC, Contractor costs
21	Gender	・ At the construction phase, due to influx of workers, risks for Sexual and Gender-Based Violence (SGBV) for women and young girls will increase. ・ Construction camps are locus of violence against women, children and girls; Construction camps serve as source of social conflict, possibly leading to violence	・ Implement gender-sensitive hiring practices for construction works, and PMO of DPHE by setting a target number of female workers. ・ Ensure Contractor's contract includes a clause to hire female workers. ・ Provide training on gender equality and sensitivity to construction staff. ・ Monitor and address any gender-based discrimination by construction workers and other people. ・ Give preference to local laborers to avoid influx of labor from outside	Contractor	DPHE	included in CSC, Contractor costs

No.	Item	Expected Impact	Mitigation Measure	Implementing Organization	Responsible Organization	Cost
			・ Conduct proactive outreach with leaders of nearby communities to educate women and girls about the risks posed by an all-male camp in the neighborhood ・ Give resident workers regular training on appropriate behavior in and around the camp ・ Adopt a zero-tolerance policy around aggression or violence against local women and girls ・ When women must enter the camp for employment or selling produce, limit their entry to times when resident workers are out at the work site ・ Prohibit prostitution on the site, and monitor activity in this regard and work with community leaders to address the problem as needed ・ Provide regular training and enforcement to minimize bad worker behavior off site, including public drunkenness, sexual harassment, and theft of crops			
22	Work environment (including work safety)	・ There is a risk of several injuries works due to construction works such as falling into Matamuhuri river at the intake facility site, falling from a dyke at the raw water reservoir site. ・ Risks to worker health and safety from improper work site practices ・ Risks to workers from viral illness ・ Risks to worker health and safety from poor conditions in construction camps	・ The local regulations or acts related to industry safety and health, practically adopted for construction fields in Bangladesh, shall be adopted in principle. ・ The works for intake facilities will be located inside and along the Matamuhuri River. These works shall avoid the peak season of river flooding. If the precedence of works in the rainy season is unavoidable, the works may be conducted with special attention. The river water level shall be regularly monitored. A warning alert system may be equipped at the site, which enables the evacuation of site staffs and construction equipment to safe places when the river water level increases unexpectedly. ・ Training and use of temporary fall prevention devices ・ Use of control zones and safety monitoring systems to warn workers	Contractor	DPHE	included in CSC, Contractor costs

No.	Item	Expected Impact	Mitigation Measure	Implementing Organization	Responsible Organization	Cost
			・ Wearing appropriate PPE, such as safety glasses with side shields, face shields, hard hats, and safety shoes ・ Provide regular safety training for all workers ・ Provide task-appropriate PPE to all workers and enforce its use ・ Closely monitor works at all times to ensure strong worker compliance with safety practices ・ Institute temperature checks (at least daily) for all workers and supervisory personnel on site ・ Provide each worker with appropriate face mask daily or as needed, and require mask use at all times ・ Position hand washing and sanitizing stations at canteens and other eating areas, kitchens, and near toilets ・ Conduct monthly safety audit of camp to identify fire risks, electrocution hazards and other unsafe conditions, and assess adequacy of fire extinguishers and first aid provisions ・ Institute a regular cleaning and disinfection regimen for camp kitchens, latrines, wash-up areas, eating areas and sleeping sheds ・ Ensure adequate ventilation and light in all camp structures			
23	Health, safety and security of local communities	・ At the construction phase, spread of infectious diseases due to influx of construction workers are assumed. Additionally, there may be risks of increasing traffic accidents by construction vehicles. ・ Elevated risk of accidents and viral infection in the construction sites/construction camps; traffic congestion within the construction area make public nuisance ・ Elevated risks to pedestrians on approach road	・ In order to prevent the collision accidents on neighboring existing roads, temporary facilities such as safety sign boards and lightings, including flagmen, are arranged to control traffic during construction work. The intersections with the existing roads N1 and R172 should be carefully attended. ・ Specially for pipeline work, it will be required to occupy existing road spaces sometimes when the pipes are transported, unloaded and buried in roads. In order to avoid the collision accidents with public traffic, safety control facilities such as safety sign boards and lightings, including flagmen, should be arranged certainly.	Contractor	DPHE	included in CSC, Contractor costs

No.	Item	Expected Impact	Mitigation Measure	Implementing Organization	Responsible Organization	Cost
			· In order to prevent accidents inside construction yards, the safety measures (monitor entrance by security, and fence around the construction yard etc.) in construction yards shall be provided adequately. · Incorporate a raised and barrier-protected sidewalk at the construction site · Establish the traffic management plan to minimize the impact on traffic flow · Walking access will be maintained to affected properties and access/diversion routes will be temporarily made for community movement. Particular attention will be given to ensuring safety along roads and paths used by school children, elderly person, women. · Side street parking of construction vehicles on prolonged basis will not be allowed. · Install barriers and safety warning signs on road sections and if necessary deploy traffic aides/ flag persons at affected locations. Information boards at blocked roads will provide information about the temporary closure of roads, schedule of works and the traffic-rerouting plan. · Require the contractor to immediately rehabilitate the excavated areas and any damaged road and path sections. · Enclose the intake perimeters so that pathway use and stream access remains unimpeded. · Provide cautionary signs, road signs and project info. board at the intersections for easy understanding of the community user. Also, aware of local people when heavy construction works will be done. Acknowledge community about the access/diversion road for safe movement due to construction works, If needed, · Ensure that the construction sites are adequately fenced and security is provided to prevent members of the public from entering the sites			

No.	Item	Expected Impact	Mitigation Measure	Implementing Organization	Responsible Organization	Cost
			· Establish safe, marked routes for local pedestrians without having to cross active construction zones · Make sure the raw water reservoir will be above the river level, not be flooded at monsoon due to heavy rainfall.			
24	Accidents and natural disasters	· Possible worsening of regional traffic accidents due to construction activities. · Possible occurrences of natural disasters-related accidents (note that the project site is located within disaster-prone area).	· Same as above	Contractor	DPHE	included in CSC, Contractor costs
Others						
25	Cross-boundary impact and climate change	· Generation of GHG including methane from construction and operations contributes to global climate change problem; Climate Change Bangladesh is expected to increase rainfall during post monsoon. Heavy rainfall is expected in short window. Failure to take the excess water into consideration for future can lead to potential disaster in the form of water logging and flood. · Infrastructure use limitations, damage and environmental hazards due to changing conditions;	· substitute other materials for concrete where feasible · use low-carbon concrete as much as possible · maximize use of building materials available locally · specify only high-efficiency electrical and mechanical equipment · Specify most fuel-efficient backup generator available · Design site layout and inspection process to minimize the length of time vehicles have their engines running during the transportation process · Design facilities so that critical components are well above maximum flood level foreseen under climate change projections.	Contractor	DPHE	included in CSC, Contractor costs

Source: JICA Survey Team

Table 9.1.60 Environment Management Plan (Operation Phase)

No.	Item	Expected Impact	Mitigation Measure	Implementing Organization	Responsible Organization	Cost
Pollution Control Items						
1	Water quality	・ Deterioration in quality of raw water supply and of treated water Potential risk on public health in deterioration of treated water quality due to use of poor quality treatment chemicals	・ Monitor community activities in the catchment area to check activities upstream that may cause contamination of raw water quality. ・ Follow O&M standard operating procedures in accordance with the water treatment plant manuals.	DPHE	DPHE	Included in DPHE, Cox's Bazar operating costs
2	Wastes	・ Possible generation of water purification wastes (to be treated as industrial wastes). ・ Pollution from improper management of solid waste from facilities (intake structure)	・ Ensure that appropriate waste management procedures for all components of the solid waste stream are specified in each facility's operations and maintenance manual ・ Follow Solid Waste Management Rules 2021 to ensure proper waste management	DPHE	DPHE	Included in DPHE, Cox's Bazar operating costs
3	Noise and vibration	・ Possible cumulative impact with nearby on-going infrastructure development projects (e.g., Matarbari Port Access Road Construction Project)	・ Periodical noise/vibration monitoring. ・ Establish liaison & data sharing with PP/contractor of nearby on-going development projects (e.g., Matarbari Port Access Road).	DPHE	DPHE	Included in DPHE, Cox's Bazar operating costs
4	Subsidence	・ Possible subsidence due to construction of water reservoirs facilities. ・ Possible cumulative impact with Matarbari Port Access Road Construction Project.	・ Daily on-site observation. ・ Establish proper anti subsidence measures (e.g., implementation of extra-banking for embankment). ・ Establish liaison & data sharing with PP/contractor of Matarbari Port Access Road Projects.	Contractor	DPHE	included in CSC, Contractor costs
5	Sediment	・ Possible sedimentation at downstream side of tributaries such as Matamuhuri River. ・ Possible cumulative impact with nearby on-going infrastructure development projects (e.g., Matarbari Port Access Road Construction Project).	・ Daily on-site observation. ・ Establish liaison & data sharing with PP/contractor of Matarbari Port Access Road Projects.	Contractor	DPHE	included in CSC, Contractor costs
Natural Environment Items						
6	Ecosystem	・ Erosion of soils during maintenance works involving excavation and/or deteriorated ground cover	・ Protect soils exposed by maintenance works with mulches and other protective coverings during works, and promptly re-establish vegetative cover when works have been completed ・ Regularly inspect site vegetation for loss of coverage and evidence of emerging gully erosion	DPHE	DPHE	Included in DPHE, Cox's Bazar operating costs

No.	Item	Expected Impact	Mitigation Measure	Implementing Organization	Responsible Organization	Cost
			・ It is noted that barbed-fences facilities are to be set up around the water intake points, pipelines, water reservoirs and other relevant facilities.			
7	Hydrology	・ Possible local drainage system changes due to long-term subsidence, to be caused by the construction of water reservoir facilities.	・ Daily on-site observation to see if inundation occurs locally dur to construction work. ・ Establish liaison & data sharing with PP/contractor of Matarbari Port Access Road Projects.	DPHE	DPHE	Included in DPHE, Cox's Bazar operating costs
8	Topography	・ Possible local topographic changes due to long-term subsidence, to be caused by the construction of water reservoir facilities.	・ Daily on-site observation. ・ Establish liaison & data sharing with PP/contractor of Matarbari Port Access Road Projects.	DPHE	DPHE	Included in DPHE, Cox's Bazar operating costs
Social Items						
9	Work environment (including work safety)	・ Accidents and injurie due to dredging work and the work in elevation. ・ Chemical exposure due to use of chemical during water treatment process	・ Require use of a life line and personal flotation device (PFD) when working near river. ・ Use fall protection equipment when working at heights ・ Maintain work areas to minimize slipping and tripping hazards ・ Implement a training program for operators who work with chlorine regarding safe handling practices and emergency response procedures ・ Provide appropriate personal protective equipment (including, for example, self-contained breathing apparatus) and training on its proper use and maintenance	DPHE	DPHE	Included in DPHE, Cox's Bazar operating costs
10	Accidents and natural disasters	・ Elevated risks to pedestrians on approach road ・ Potential hazards to residents	・ Regularly monitor facility operations for emerging public safety issues, and devise appropriate corrective action, as needed ・ Regularly monitor facilities operations for emerging community health and safety issues, and devise appropriate corrective action, as needed; facilities should be properly fenced and secured. ・ Avoid external activities (swimming/ washing/ fishing or any other activities) in the raw water reservoir ・ Provide access control for general people inside Raw Water Reservoir and into the stair of DR	DPHE	DPHE	Included in DPHE, Cox's Bazar operating costs

Source: JICA Survey Team

9.1.9 Environment Monitoring Plan

The main mitigation measures and monitoring items of the monitoring plan described in EIA report are summarised in the table below. Monitoring form is shown in appendix.

Table 9.1.61 Environment Monitoring Plan (Pre-Construction /Construction Phases)

No.	Item	Mitigation Measure	Monitoring Item	Frequency	Standard	Location	Implementing Organization	Cost
Pollution Control Items								
1	Air pollution	・ Establish liaison & data sharing with PP/contractor of nearby on-going development projects (e.g., Matarbari Port Access Road). ・ Daily on-site observation and Periodical Air Quality monitoring. ・ providing ample on-site space for vehicles loading and unloading passengers and their belongings ・ providing ample space within the site for vehicles ・ Construction works will create dust by placing sands, cutting off sections, earthworks, carrying out the construction fine materials, emissions from construction vehicles. Therefore, spraying water is required for dust suppression. ・ Establish air quality baseline by certified testing company prior to commencement of construction works. Surface water quality should be tested periodically over the construction period to observe if any change in quality due to construction works. ・ Implement a regimen of misting all dust-generating surfaces throughout the workday during dry weather, the frequency of water spray should be twice a day during the dry periods. ・ Tightly cover stockpiles of fine materials with	・ regular maintenance of the construction equipment and vehicles	Everyday during construction	-	Construction site	Contractor	Included in CSC, Contract budget
			・ Levels of airborne dust are below nuisance level in roadside communities ・ Absence of black smoke in construction equipment exhaust ・ Complaints from public	Weekly for duration of construction (observation)	-			

No.	Item	Mitigation Measure	Monitoring Item	Frequency	Standard	Location	Implementing Organization	Cost
		tarpaulins whenever they are not in active use to prevent wind erosion ・ Equip all haul trucks with tightly fitting tarpaulins and enforce their use ・ Maintain all motorized equipment used in construction to a high standard ▪ Use only fuel-efficient equipment	・ Ambient air quality (PM2.5, PM10, SO2, CO, NO2) meets standards indicated in the Air Pollution (control) Rules 2022.	Quantitative measurement of air quality quarterly by EHSO at locations dictated by work activity	Air Pollution (control) Rules 2022			
2	Water quality	・ Daily on-site observation. ・ Set up anti-dispersion-purpose sheet at each dredging sites. ・ Set up sand/silt settlement ponds at discharge points. ・ Periodical Water Quality monitoring. ・ Establish liaison & data sharing with PP/contractor of nearby on-going development projects (e.g., Matarbari Port Access Road). ・ Construction site run-off should be restricted to water bodies to avoid contamination of the surface water. Maximize opportunities to limit water consumption and increase groundwater recharge in the construction camp and construction methods ・ stormwater infiltration swales for all runoff from paved and impervious surfaces (objective: zero site runoff) ・ During construction; special attention to placing of sand/silt barrier in most places to prevent contaminated and sand laden water from being discharged into the lower areas. There is no drain in existence in this alignment, therefore the design outfall needs to be shielded from pollution. ・ Establish surface water quality baseline by certified testing company prior to commencement of construction works. Surface water quality should be tested periodically over the construction period to observe if any change in quality due to construction works. ・ Protect disturbed soil from rain by keeping exposed	・ All feasible and applicable water conservation measures incorporated in detailed designs for the facility	Once before approval of detailed designs	-	Construction site, Matamuhuri river, Water body nearby construction site	Contractor	Included in CSC, Contract budget
			・ Prescribed soil protection measures effectively implemented at all work sites in accordance with approved Soil Erosion Prevention Plan ・ Sediment traps installed in appropriate places, and maintained properly ・ Lack of evidence of elevated turbidity in water draining to adjacent water bodies	Monthly (soil protection measures) for duration of construction	-			

No.	Item	Mitigation Measure	Monitoring Item	Frequency	Standard	Location	Implementing Organization	Cost
		areas covered with mulches, fiber mats and other temporary coverings ・ Keep all stockpiles of erodible materials covered with tarpaulins whenever they are not in active use ・ Arrange work site drainage to prevent concentration of surface runoff in the vicinity of exposed soils and materials stockpiles ・ Install and regularly maintain sediment traps in site runoff channels ・ Install an adequate number of toilets to accommodate all workers, and septic systems of sufficient capacity for the expected effluent volume, in accordance with Construction Camp Management Plan ・ Keep all drilling and mixing activities at least 100m far from the existing water body, put silt barrier along the canal and river ・ Protect disturbed soil from rain by keeping exposed areas covered with mulches, fiber mats and other temporary coverings ・ Arrange work site drainage to prevent concentration of surface runoff in the vicinity of exposed soils	・ Silt curtains properly deployed where appropriate					
			・ For Surface water, Adjacent surface water quality (pH, BOD5, COD, DO, TSS, TDS, EC. total coliform, Total P, Total N, turbidity, Pb, Cr) meets standard in the Environment Conservation Rules, 2023 ・ For ground water, pH, DO, TDS, EC. total coliform, Faecal coliform, turbidity, Pb, Mn) meets standard in the Environment Conservation Rules, 2023	Quarterly surface water and groundwater quality monitoring by EHSO at locations dictated by work activity	ECR 2023			
			・ Water quality-related compliant, to be filed from local communities (e.g., salt pan owners, local fisheries people and others) and public ・ Prescribed soil protection measures effectively implemented at	Weekly for duration of construction	-			

No.	Item	Mitigation Measure	Monitoring Item	Frequency	Standard	Location	Implementing Organization	Cost
			all work sites					
3	Wastes	・ Daily on-site observation (e.g., prevent illegal dumping and/or discharge of construction effluents). ・ Establish proper waste treatment program. ・ Waste storage and segregation areas should be arranged ・ Designate outdoor space for thermophilic composting of organic waste from kitchens and canteens for construction camps ・ Ensure salvage of recyclable and reusable items ・ Use rubble in site development or dispose of in a site identified and approved in accordance with the Waste Management Plan embedded within the CEMP ・ Surplus excavated materials/cut soil from construction works will be used as backfill materials for low-laying areas that have been identified by the local community ・ Provide waste receptacles on the work sites and collect their contents daily or weekly as needed ・ Recycle all recyclables through local providers of this service ・ Compost organic wastes generated by construction camp kitchens ・ Dispose of non-recyclable and non-organic wastes as directed in the Waste Management Plan embedded within the CEMP, as based on locally available and approved disposal options ・ Follow Solid Waste Management Rules 2021	・ Facility designs include spaces and features for waste management, including collection, sorting, composting, storage and out-shipment	Once before approval of detailed designs	-	Construction site	Contractor	Included in CSC, Contract budget
			・ Recyclable materials salvaged ・ Rubble appropriately used as fill on site, or disposed of in accordance with Waste Management Plan embedded in CEMP	Before and during site clearing	-			
			・ All classes of waste managed in accordance with Waste Management Plan embedded in CEMP ・ Illegal waste treatment (e.g., illegal waste dumping)-related complaints, to be filed from public.	Monthly for duration of construction	-			
4	Soil contamination	・ Daily on-site observation (e.g., check if accidental spill of construction chemicals occurs) . ・ Periodical soil quality monitoring.	・ Fuels, lubricants and other noxious fluids stored in	Monthly for duration of construction	-	Construction site	Contractor	Included in CSC, Contract

No.	Item	Mitigation Measure	Monitoring Item	Frequency	Standard	Location	Implementing Organization	Cost
		· Keep all motorized equipment in good repair · Maintain a regiment of systematic daily checks to detect leaks, following up with prompt repair as needed · Strictly require use of drip mats and pans during refueling and servicing to catch spills and drips · Store fuels and other noxious fluids within roofed, rain-exclusive containment structures. · Provide training in spill prevention and spill response to all workers involved in refueling or equipment servicing ▪ Follow the recommended dosage of chlorine during the disinfection of pipes. Discharge of water with high chlorine concentration to soil at the end of pipelines to be controlled.	appropriate structure · Lack of evidence of leaks from construction equipment · Lack of oil patches on soil surface · Lack of oily sheen on site runoff water					budget
5	Noise and vibration	· Daily on-site observation. · Periodical noise/vibration monitoring. · Establish liaison & data sharing with PP/contractor of nearby on-going development projects (e.g., Matarbari Port Access Road). · Limit construction activities, particularly operation of noise generating equipment at night. · Position any stationary equipment that produces high noise levels such as diesel generators as far as practical from sensitive receptors. · Erect temporary barriers around construction sites especially near schools, hospitals, and houses. · Install noise suppression devices to noise generating equipment. · Require drivers to minimize blowing of horn and to comply with speed limits. · Provide information to community on schedule of construction activities through billboard/signs. · Conduct work only during daylight hours · Impose and enforce low speed limits on haul trucks through community silent zone area · Maintain all motorized equipment and haul trucks to a high standard, and inspect exhaust systems regularly	· Noise and vibration are below nuisance level for the local community/residents, hospital, religious centers and educational institutions · No construction work or hauling is conducted between dusk and dawn, nighttime, prayer time · Ambient noise levels outside the work sites meet the standard indicated in the Sound Pollution Control Rules, 2006 · Report any complaint	Weekly for duration of construction (observation) Quantitative measurement quarterly by EHSO at locations dictated by work activity	Noise Pollution (control) Rules 2006	Around construction site	Contractor	Included in CSC, Contract budget

No.	Item	Mitigation Measure	Monitoring Item	Frequency	Standard	Location	Implementing Organization	Cost
			received from the community to PIU					
6	Subsidence	Daily site inspection if there are unusual subsidence around the project site.	Local subsidence and/or inundation and/or local drainage problem around the construction site.	Daily during the construction	-	Construction site	Contractor	Included in CSC, Contract budget
7	Odor	Daily site inspection if there are occurrences of unusual smell around the project site in case of local hydrological problem.	Obnoxious smell due to long-term inundation and/or local drainage problem around the construction site.	Daily during the construction	-	Construction site	Contractor	Included in CSC, Contract budget
8	Sediment	Dailyl site inspection if there are occurrences of unusual sedimentation along tributaries around the project site.	Check sedimentation property. If sediment of concern is construction related, then, possible mitigation measures such as removal of sedimentation shall be taken.	Monthly for duration of construction	-	Tributaries around construction site	Contractor	Included in CSC, Contract budget
Natural Environment Items								
9	Protected area	· Daily on-site observation. · Periodical biological environmental survey. · Establish liaison & data sharing with PP/contractor of both CC Road and Matarbari Port Access Road Projects. · Establish animal path (width of this path would be of 12 meters at least) inside of buffer zone of Fasiakhali WS, that would be compatible with mitigation measure, taken within ADB-financed railway project (note: one active crossing elephant crossing point is identified around the project site).	· Spills from construction equipment and materials into Matamuhuri River/other water bodies is also prohibited · Number of observation of wildlife (Asian elephant, fishing cat and others) migration. · Report any complaint received from the community to	Weekly for duration of construction	-	Around construction site	Contractor	Included in CSC, Contract budget

No.	Item	Mitigation Measure	Monitoring Item	Frequency	Standard	Location	Implementing Organization	Cost
			PIU					
10	Ecosystem	· Matamuhuri River water will be used for the water supply project when the water rate and flow is enough to avoid any disturbance on the ecology and ecosystem at downstream. · Cutting of trees will be undertaken as per approved design and only upon approval. Avoid cutting of trees as much as possible and minimize damage to native vegetation. · The contractors will prohibit activities such as cutting wood for cooking, hunting, or wildlife trade. · Disposal of construction materials are also prohibited in the Matamuhuri River as well as the adjacent waterbodies in and around the project location to protect fisheries and aquatic environment · Roads and paths to the intake infrastructure will only be sufficiently wide to accommodate construction vehicles/equipment to minimize land take. · Manual labor will be utilized in sloping terrain where use of heavy equipment would cause unnecessary damage. Steep exposed slopes will be graded and covered with bush and grass to minimize erosion. · Widening of the existing road will have impact on the flora and fauna by cutting roadside trees. Careful design of the road should be done with avoiding the big trees to minimize the negative impact. · Providing barrier along the road embankment at the water bodies' section to reduce the surface runoff. · Tree plantation along the road should be done as compensation and enhancement measures.	· River level assessments at the intake on a monthly basis	Once before approval of detailed designs	-	Around construction site	Contractor	Included in CSC, Contract budget
			· Spills from construction equipment and materials into Matamuhuri River/other water bodies is also prohibited · Report any complaint received from the community to PIU · Fenced buffers established, maintained and observed around preserved trees for duration of works · 10-m buffer established with temporary fencing along any permanent or seasonal watercourses on site · Silt curtains and sediment traps deployed as appropriate to limit silt delivery to on-site watercourses	Weekly for duration of construction	-			

No.	Item	Mitigation Measure	Monitoring Item	Frequency	Standard	Location	Implementing Organization	Cost
			・ Compensatory trees planted and tended in conformance with the approved Compensatory Tree Planting Plan					
			・ Observe the newly planted trees and habitat regeneration of fauna	Weekly for duration of construction	-			
11	Hydrology	Daily site inspection if local inundation and/or local drainage problem due to the construction occurred or not.	Local inundation and/or local drainage problem around the construction site.	Daily during the construction	-	Construction site	Contractor	Included in CSC, Contract budget
12	Topography	Daiyl site inspection if local topographic changes due to the long-term subsidence around the water reservoir site occurred or not.	Local topographic changes around the construction site.	Daily during the construction	-	Construction site	Contractor	Included in CSC, Contract budget
Social Items								
13	Land acquisition and resettlement	・ Compensation for land and structure acquisition will be done in accordance with the ARIPA 2017. Additionally, resettlement benefits and livelihood restoration will be provided following the JICA Environmental Guidelines. ・ Establishment of a project specific grievance redress mechanism to resolve all land acquisition and resettlement related grievances. ▪ Trees that need to be cut in private land will be compensated in cash in accordance with the approved Land Acquisition and Compensation Plan	・ External LAP, RAP monitoring report	Once before approval of detailed designs	-	In the land to be acquired	Contractor, RAP Implement Agency	Included in CSC, Contract budget
14	Livelihoods	・ Transfer grant, reconstruction grant and business restoration grant which is given based on the scale of the affected business. ・ For the wage labor, they will be entitled to loss of income of BDT 600 for 60 days. ・ Wage laborers who have been working on the salt and shrimp farms for over 10 years, will be eligible	・ External LAP, RAP monitoring report	Once before approval of detailed designs	-	In the land to be acquired	Contractor, RAP Implement Agency	Included in CSC, Contract budget

No.	Item	Mitigation Measure	Monitoring Item	Frequency	Standard	Location	Implementing Organization	Cost
		for training on Income Generating Activities and capital support after the training. ・ The wage laborers, females and the unemployed PAPs are expected to be engaged in the construction jobs to be provided by the project.						
15	Socially vulnerable	・ One-time cash support i.e., BDT 10,000 for male headed and BDT 15,000 for female headed in addition to land and structures compensation. ・ The training for Income Generating Activities and capital support of BDT 30,000 ・ Assist by the RAP Implementing Agency to find the relocation place close to social amenities including schools and hospitals, and the project will provide social amenities if not available in the new resettlement area.	・ External LAP, RAP monitoring report	Once before approval of detailed designs	-	In the land to be acquired	Contractor, RAP Implement Agency	Included in CSC, Contract budget
16	Land use and utilization of local resources	・ Transfer grant, reconstruction grant and business restoration grant which is given based on the scale of the affected business. ・ For the wage labor, they will be entitled to loss of income of BDT 600 for 60 days. ・ Wage laborers who have been working on the salt and shrimp farms for over 10 years, will be eligible for training on Income Generating Activities and capital support after the training. ・ The wage laborers, females and the unemployed PAPs are expected to be engaged in the construction jobs to be provided by the project.	・ External LAP, RAP monitoring report	Once before approval of detailed designs	-	In and around the land to be acquired	Contractor, RAP Implement Agency	Included in CSC, Contract budget
17	Water usage	・ The abstraction of water from the river Matamuhuri only at rainy season when the water is available at river to minimize the conflict with other water users. ・ Announcement of construction schedule to the community around the construction site especially in the river. ・ Monitor water quality and water level. ▪ Announce contact information of project proponent for complains.	・ River level assessments at the intake on a monthly basis	Once before approval of detailed designs	-	Matamuhuri river and water body and agriculture land around the raw water reservoir	Contractor	Included in CSC, Contract budget
18	Existing social infrastructure and services	・ Establish the traffic management plan to minimize the impact on traffic flow	・ Construction camp/site has adequate on-site space to	Once before approval of detailed designs	-	Around the construction site	Contractor	Included in CSC, Contract budget

No.	Item	Mitigation Measure	Monitoring Item	Frequency	Standard	Location	Implementing Organization	Cost
			accommodate all pick-up, drop-off, turnaround and parking to take place within the site, even at peak times					
19	Infectious diseases such as HIV/AIDS	· The contractor should conduct training for all workers on environmental hygiene; · Campaign and postering to increase awareness on COVID-19 pandemic to protect health and safety of workers; · Use Personal Protective Equipment (PPE) required for COVID-19 and maintain social distancing during construction; · Provide HIV awareness programming, including STI (sexually transmitted infections) and HIV information, education and communication for all workers on regular basis; · Adequate facilities for the health of construction workers will be provided at the construction camp; · Avoiding formation of stagnant water pools in and around the site; · Implementation of a vector control programme in labour camps and surrounding areas; · Install and maintain adequate toilet and septic systems to prevent discharge of raw sewage from camps to local water bodies or fields · Educate resident workers about sexually transmitted diseases and responsible sexual behavior · Work with local community leaders to prohibit prostitution in and around construction camps · Provide adequate sleeping space for the number of workers to avoid overcrowding and consequent spread of communicable illnesses and infestations · Provide each worker with a raised sleeping platform with mattress or mat, bedding and mosquito netting · Test drinking water supplied to workers on a quarterly basis to ensure safety	· Construction Camp Management Plan implemented as approved · At least one working toilet per 10 resident workers installed, with septic treatment · Absence of visual evidence of raw sewage discharge · Lack of reports of prostitution around camp · Lack of concerns expressed by local community leaders about workers' off-site behavior	Once at start of construction (toilets) Monthly for duration of construction other items)	-	Construction site	Contractor	Included in CSC, Contract budget
			· Lack of outbreaks of infectious illnesses (e.g., influenza, pneumonia, tuberculosis) and ailments associated with unsanitary conditions (e.g.,	Monthly for duration of construction (observation) Quantitative measurement quarterly by Contractor at source well				

No.	Item	Mitigation Measure	Monitoring Item	Frequency	Standard	Location	Implementing Organization	Cost
			dysentery, lice, scabies) ・ Living conditions meet standards specified in Construction Camp Management Plan					
20	Children's rights	・ In compliance with Bangladesh laws and JICA guidelines, child labor shall be strictly prohibited during the project implementation period. ・ Strong protocols should be built as part of contractual obligations around zero tolerance of child labor or harassment of women workers and even health and safety aspects. These should also be monitored by the supervision and monitoring team	・ List of name and age of workers	Monthly for duration of construction	-	Construction site	Contractor	Included in CSC, Contract budget
21	Gender	・ Implement gender-sensitive hiring practices for construction works, and PMO of DPHE by setting a target number of female workers. ・ Ensure Contractor's contract includes a clause to hire female workers. ・ Provide training on gender equality and sensitivity to construction staff. ・ Monitor and address any gender-based discrimination by construction workers and other people. ・ Give preference to local laborers to avoid influx of labor from outside ・ Conduct proactive outreach with leaders of nearby communities to educate women and girls about the risks posed by an all-male camp in the neighborhood ・ Give resident workers regular training on appropriate behavior in and around the camp ・ Adopt a zero-tolerance policy around aggression or violence against local women and girls ・ When women must enter the camp for employment or selling produce, limit their entry to times when resident workers are out at the work site ・ Prohibit prostitution on the site, and monitor activity in this regard and work with community leaders to address the problem as needed	・ Lack of reports of worker-involved abuse or harassment ・ Lack of complaints from public about violence or prostitution at camp ・ Female access to camp for employment allowed only when workers are out at work sites ・ Lack of complaints from public about behavior of resident workers	Monthly for duration of construction	-	Construction site	Contractor	Included in CSC, Contract budget

No.	Item	Mitigation Measure	Monitoring Item	Frequency	Standard	Location	Implementing Organization	Cost
		・ Provide regular training and enforcement to minimize bad worker behavior off site, including public drunkenness, sexual harassment, and theft of crops						
22	Work environment (including work safety)	・ The local regulations or acts related to industry safety and health, practically adopted for construction fields in Bangladesh, shall be adopted in principle. ・ The works for intake facilities will be located inside and along the Matamuhuri River. These works shall avoid the peak season of river flooding. If the precedence of works in the rainy season is unavoidable, the works may be conducted with special attention. The river water level shall be regularly monitored. A warning alert system may be equipped at the site, which enables the evacuation of site staffs and construction equipment to safe places when the river water level increases unexpectedly. ・ Training and use of temporary fall prevention devices ・ Use of control zones and safety monitoring systems to warn workers ・ Wearing appropriate PPE, such as safety glasses with side shields, face shields, hard hats, and safety shoes ・ Provide regular safety training for all workers ・ Provide task-appropriate PPE to all workers and enforce its use ・ Closely monitor works at all times to ensure strong worker compliance with safety practices ・ Institute temperature checks (at least daily) for all workers and supervisory personnel on site ・ Provide each worker with appropriate face mask daily or as needed, and require mask use at all times ・ Position hand washing and sanitizing stations at canteens and other eating areas, kitchens, and near toilets ・ Conduct monthly safety audit of camp to identify fire risks, electrocution hazards and other unsafe conditions, and assess adequacy of fire extinguishers and first aid provisions ・ Institute a regular cleaning and disinfection regimen for camp kitchens, latrines, wash-up areas, eating areas and sleeping sheds	・ Low incidence of workplace injuries ・ Workers observed using appropriate PPE ・ All aspects of Occupational Health and Safety Plan implemented as approved	Weekly for duration of construction	-	Construction site	Contractor	Included in CSC, Contract budget
			・ Temperature check regimen implemented consistently. ・ Workers supplied facemasks. ・ Workers consistently use facemasks. ・ Hand washing and sanitizing stations provided in appropriate locations and kept stocked at all times. ・ All aspects of Occupational Health and Safety Plan implemented as approved ・ Safety audit results included in monthly progress reports and quarterly	Monthly for duration of construction (observation) Quantitative measurement quarterly by Contractor at source well	-			

No.	Item	Mitigation Measure	Monitoring Item	Frequency	Standard	Location	Implementing Organization	Cost
		・ Ensure adequate ventilation and light in all camp structures	monitoring reports					
23	Health, safety and security of local communities	・ In order to prevent the collision accidents on neighboring existing roads, temporary facilities such as safety sign boards and lightings, including flagmen, are arranged to control traffic during construction work. The intersections with the existing roads N1 and R172 should be carefully attended. ・ Specially for pipeline work, it will be required to occupy existing road spaces sometimes when the pipes are transported, unloaded and buried in roads. In order to avoid the collision accidents with public traffic, safety control facilities such as safety sign boards and lightings, including flagmen, should be arranged certainly. ・ In order to prevent accidents inside construction yards, the safety measures (monitor entrance by security, and fence around the construction yard etc.) in construction yards shall be provided adequately. ・ Incorporate a raised and barrier-protected sidewalk at the construction site ・ Establish the traffic management plan to minimize the impact on traffic flow ・ Walking access will be maintained to affected properties and access/diversion routes will be temporarily made for community movement. Particular attention will be given to ensuring safety along roads and paths used by school children, elderly person, women. ・ Side street parking of construction vehicles on prolonged basis will not be allowed. ・ Install barriers and safety warning signs on road sections and if necessary deploy traffic aides/ flag persons at affected locations. Information boards at blocked roads will provide information about the temporary closure of roads, schedule of works and the traffic-rerouting plan. ・ Require the contractor to immediately rehabilitate the excavated areas and any damaged road and path sections.	・ Raised, barrier-protected sidewalk included in design, in the construction sites ・ The work site is demarcated and fenced with safety marks/labels	Once before approval of detailed designs	-	Construction site	Contractor	Included in CSC, Contract budget
			・ Safe and free community movement ・ Construction supervision engineer to monitor compliance with EMP.	Once at beginning of construction, and monthly for duration of construction Regular monitoring & need base action	-			
			・ Construction Camp Management Plan implemented as approved ・ Adequate fencing and security maintained at construction site. ・ Construction zone is configured to maintain safe access for pedestrians. ・ Construction Traffic Management Plan prepared and	Weekly for duration of construction	-			

No.	Item	Mitigation Measure	Monitoring Item	Frequency	Standard	Location	Implementing Organization	Cost
		· Enclose the intake perimeters so that pathway use and stream access remains unimpeded. · Provide cautionary signs, road signs and project info. board at the intersections for easy understanding of the community user. Also, aware of local people when heavy construction works will be done. Acknowledge community about the access/diversion road for safe movement due to construction works, If needed, · Ensure that the construction sites are adequately fenced and security is provided to prevent members of the public from entering the sites · Establish safe, marked routes for local pedestrians without having to cross active construction zones · Make sure the raw water reservoir will be above the river level, not be flooded at monsoon due to heavy rainfall.	observed to be implemented as appropriate. · Haul trucks not observed or reported to speed through the nearby roads of the site					
24	Accidents and natural disasters	· Same as above	· Same as above	Same as above	-	Same as above	Contractor	Included in CSC, Contract budget
		Others						
25	Cross-boundary impact and climate change	· substitute other materials for concrete where feasible · use low-carbon concrete as much as possible · maximize use of building materials available locally · specify only high-efficiency electrical and mechanical equipment · Specify most fuel-efficient backup generator available · Design site layout and inspection process to minimize the length of time vehicles have their engines running during the transportation process · Design facilities so that critical components are well above maximum flood level foreseen under climate change projections.	· Facility designs (All feasible GHG-reduction design measures are incorporated) · Facility design (All critical facility components are above maximum expected flood level)	Once before approval of detailed designs	-	-	Contractor	Included in CSC, Contract budget

Source: JICA Survey Team

Table 9.1.62 Environment Monitoring Plan (Operation Phase)

No.	Item	Mitigation Measure	Monitoring Item	Frequency	Standard	Location	Implementing Organization	Cost
1	Water quality	・ Monitor community activities in the catchment area to check activities upstream that may cause contamination of raw water quality. ・ Follow O&M standard operating procedures in accordance with the water treatment plant manuals.	・ Water Quality Monitoring: the following parameters ・ Weekly at intake, pH, turbidity, TSS, TDS ・ Daily at the inlet to the treatment plant: turbidity, pH, TSS, TDS ・ Daily after outlet of WTP: pH, turbidity, residual chlorine, temperature, TDS, Faecal Coliform ・ Weekly and monthly at several locations in the network: residual chlorine, pH, turbidity, TDS ・ Quarterly and bi-annually after Clearwater tank: chloride (Cl), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), sodium (Na), sulfate ion, zinc (Zn), conductivity, total hardness as CaCO3	Daily/ Weekly/ Monthly/ Quarterly and Monthly check the water quality	ECR2023	Intake point, raw water reservoir, WTP	DPHE	Included in DPHE, Cox's Bazar operating costs
2	Wastes	・ Ensure that appropriate waste management procedures for all components of the solid waste stream are specified in each facility's operations and maintenance manual ・ Follow Solid Waste Management Rules 2021 to ensure proper waste management	・ Recyclable solid waste is consistently segregated and picked up by a reputable recycling business ・ Non-recyclable solid waste is consistently taken to a legal landfill for disposal ・ Lack of evidence of waste dumping or burning on site	Quarterly	-	Intake point, raw water reservoir, WTP	DPHE	Included in DPHE, Cox's Bazar operating costs

No.	Item	Mitigation Measure	Monitoring Item	Frequency	Standard	Location	Implementing Organization	Cost
3	Odor		Not required					
4	Noise and vibration		Not required					
5	Subsidence	Daily site inspection if there are unusual subsidence around the project site.	Local subsidence and/or inundation and/or local drainage problem around the project site.	Quarterly	-	Site around Water Reservoir	DPHE	Included in DPHE, Cox's Bazar operating costs
6	Sediment	Monthly on-site observation	Occurrence of unusual sedimentation along tributaries around the construction site.	Monthly	-	Matamuhuri River (downstream side from Intake point) and tributaries around raw water reservoir, WTP	DPHE	Included in DPHE, Cox's Bazar operating costs
7	Protected area	・ Daily on-site observation. ・ Periodical biological environmental survey. ・ Establish liaison & data sharing with PP/contractor of both CC Road and Matarbari Port Access Road Projects. ・ Inspect usefulness of animal path, to be set up inside of buffer zone of Fasiakhali WS, that would be compatible with mitigation measure, taken within ADB-financed railway project (note: one active crossing elephant crossing point is identified around the project site).	Number of observation of wildlife (Asian elephant, fishing cat and others) migration.	Quarterly	-	Intake point, raw water reservoir, WTP	DPHE	Included in DPHE, Cox's Bazar operating costs
8	Ecosystem	・ Protect soils exposed by maintenance works with mulches and other protective coverings during works, and promptly re-establish vegetative cover when works have been completed ・ Regularly inspect site vegetation for loss of coverage and evidence of emerging gully erosion	・ Implementation of mitigation measures	Quarterly	-	Intake point, raw water reservoir, WTP	DPHE	Included in DPHE, Cox's Bazar operating costs
9	Hydrology	Daily site inspection if local inundation and/or local drainage problem due to the construction occurred or not.	Local inundation and/or local drainage problem around the construction site.	Quarterly	-	Raw water reservoir, WTP	DPHE	Included in DPHE, Cox's

No.	Item	Mitigation Measure	Monitoring Item	Frequency	Standard	Location	Implementing Organization	Cost
								Bazar operating costs
10	Topography	Daily site inspection if local topographic changes due to the long-term subsidence around the water reservoir site occurred or not.	Local topographic changes around the construction site.	Quarterly	-	Raw water reservoir, WTP	DPHE	Included in DPHE, Cox's Bazar operating costs
11	Work environment (including work safety)	・ Require use of a life line and personal flotation device (PFD) when working near river. ・ Use fall protection equipment when working at heights ・ Maintain work areas to minimize slipping and tripping hazards ・ Implement a training program for operators who work with chlorine regarding safe handling practices and emergency response procedures ・ Provide appropriate personal protective equipment (including, for example, self-contained breathing apparatus) and training on its proper use and maintenance	・ Implementation of mitigation measures	Everyday	-	Intake point, raw water reservoir, WTP	DPHE	Included in DPHE, Cox's Bazar operating costs
12	Accidents and natural disasters	・ Regularly monitor facility operations for emerging public safety issues, and devise appropriate corrective action, as needed ・ Regularly monitor facilities operations for emerging community health and safety issues, and devise appropriate corrective action, as needed; facilities should be properly fenced and secured. ・ Avoid external activities (swimming/washing/fishing or any other activities) in the raw water reservoir ・ Provide access control for general people inside Raw Water Reservoir and into the stair of DR	・ Safety features implemented ・ Accident risk low ・ Low incidence of encroachment ・ Smooth traffic flow through settled areas ・ Low incidence of vehicle-pedestrian collisions ・ Safety features implemented ・ Accident risk low ・ Smooth traffic flow through settled areas	Everyday	-	Intake point, raw water reservoir, WTP	DPHE	Included in DPHE, Cox's Bazar operating costs

No.	Item	Mitigation Measure	Monitoring Item	Frequency	Standard	Location	Implementing Organization	Cost
			・ Low incidence of vehicle-pedestrian collisions					

Source: JICA Survey Team

9.1.10 Implementation Structure

Project Implementation Unit will be established in DPHE for the Project. During detailed design stage and tendering stage, Executive Engineer will be assigned for Environment matters and Social Development Officer will be assigned for Social matters. During construction stage, Social Development Officer will be assigned for monitoring of EMP an RAP. Detailed structure is described in 8.1.

9.1.11 Stakeholder Meeting

Described in 9.2.10.

9.1.12 Grievance Redress Mechanism

The Department of Public Health (DPHE) needs to establish the Grievance Redress Mechanism (GRM) for the project construction phase including environmental and social impacts of all construction components including BWDB components. Grievance Redress Committee (GRC) will be formed at the location of the site that will easily be accessible to the people who are likely to be affected by the project. Each project will likely trigger both environmental and social impacts and therefore the GRC will need be able to address both areas. The GRC memberships will be gender representative. Female members will account for at least a third of the total number of GRC members. Figure 9.1.36 shows GRM process to be followed in the Project. Whereas there are 5 levels according to the steps to a solution.

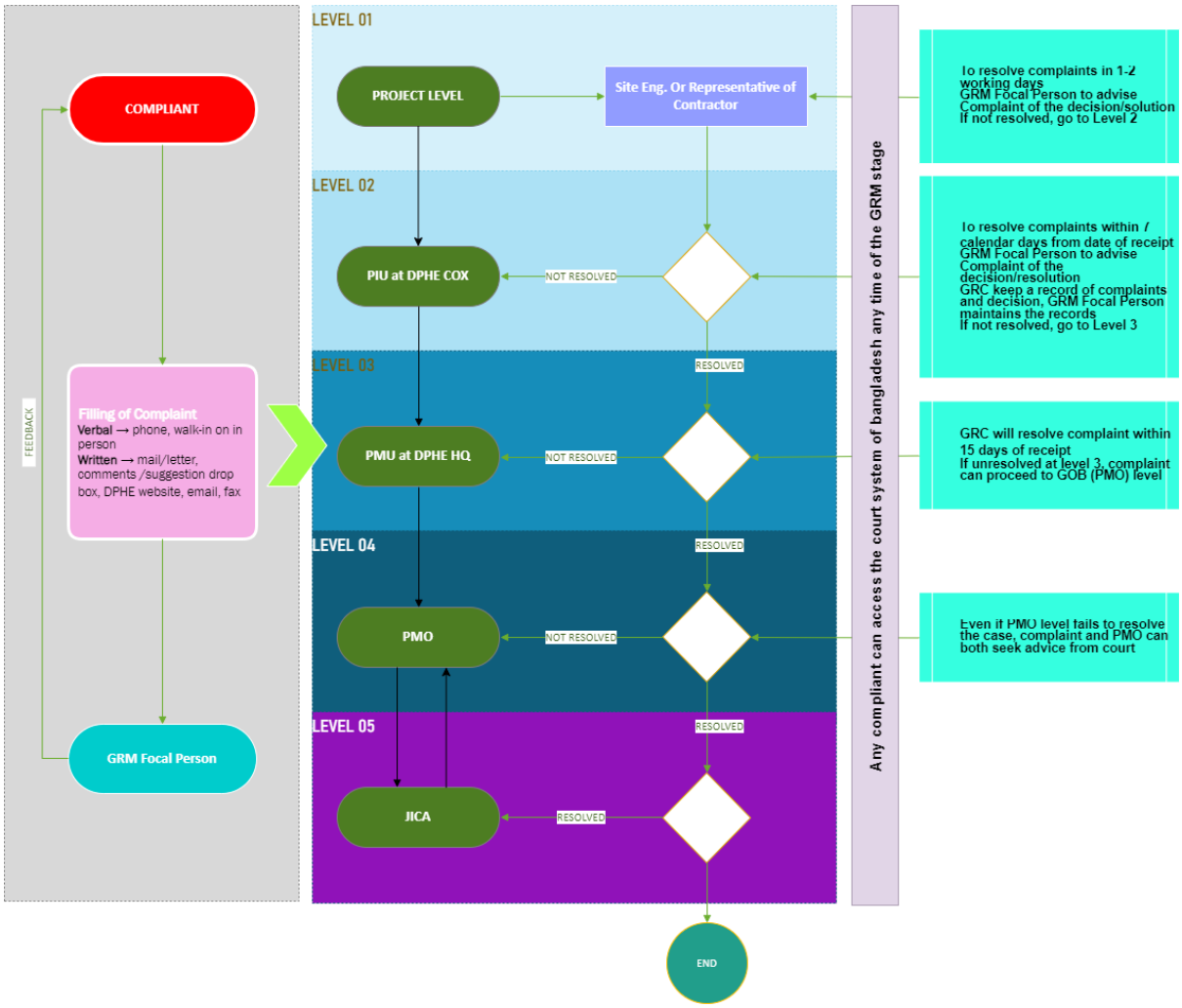


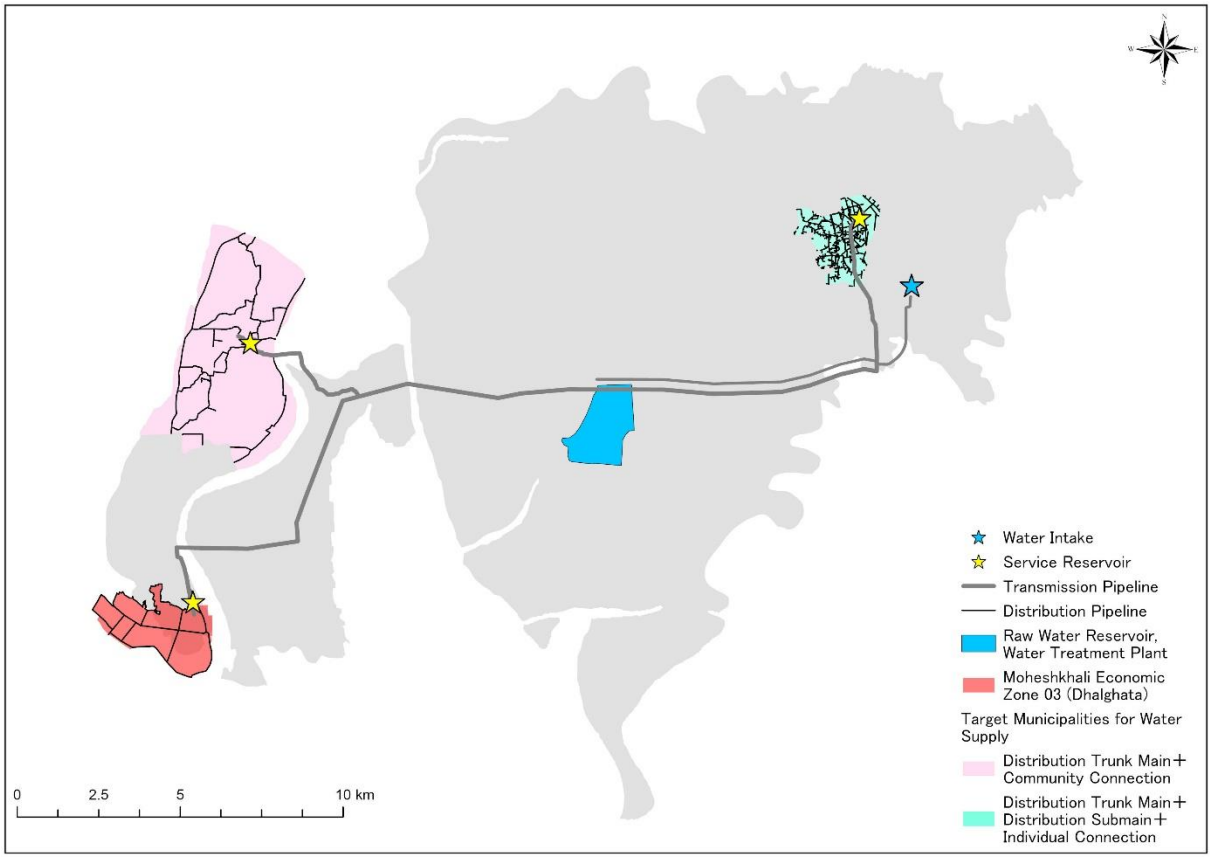
Figure 9.1.36 GRM process to be followed in the Project

9.2 Land Acquisition and Resettlement

9.2.1 Necessity of Land Acquisition and Resettlement

(1) Project Target Area

The project consists of construction of water supply system including 1) water sources, 2) water intake facilities, 3) raw water transmission facilities, 4) water treatment facilities, 5) treated water transmission facilities, 6) three distribution reservoirs, and 7) water service fittings (individual house connection and public-tap connection). The target areas for water supply are Chakaria Pourashava, Matarbari Economic Zone and Matarbari Union. Individual house connection will be applied in Chakaria Pourashava while public-tap connection will be applied in Matarbari Union.



Source: JICA Study Team

Figure 9.2.1: Location Map of the Facilities to be constructed

(1) Project Area of Impacts

The project impacts including impacts caused by the project components described above, and those caused by the construction yards and approach roads were studied, quantified and presented in detail in this report. The detailed impacts caused by the dumping sites were not studied except estimation of the quantity of land required, its costs and number of PAPs was done and briefly included in Section 9.2.3 (1) and 9.2.8 of the report.

In general, the project will result in acquisition of private land and utilization of the government land hence physically and economically displacement of households, shops, Common Property Resources (CPRs) and government offices/institutions. Also, there will be impacts on livelihoods. Table 9.2.1 summarizes the impacts from each component.

Table 9.2.1 Summary of Project Impacts

Components	Public Land (ha)	Private Land (ha)	Current Land Use	Remarks
Intake Station (includes water intake point)	0	0.9996	• Agriculture land	• Impacts on livelihoods
Conveyance pipeline	0.1359	6.0195	• Agriculture and homestead land	• Physically displacement of households • Impacts on livelihoods
Transmission pipeline	3.0125	10.3978	• Agriculture, homestead, shrimp and salt farmland	• Physically and economically displacement of households • Impacts on livelihoods
Raw water reservoir and water treatment plant	567.3371	0	• Shrimp and Salt farmland	• Physically and economically displacement of households • Impacts on livelihoods
Three (3) distribution reservoirs	3.2461	0.6350	• Agriculture, homestead and CPR land	• Physically and economically displacement of households • Impacts on livelihood
Construction yards and approach roads	52.6172	14.3785	• Agriculture land used as paddy field, homestead	• Physically displacement of households • Temporary impacts on livelihoods
Dumping sites	100	0	• Shrimp and Salt farmland	• Economically displacement of businesses • Impacts on livelihoods

Note: Three distribution reservoirs include DR-2, DR-6 and DR-Industry
Source: RAP Study Results

Most of the government land will be taken for the raw water reservoir (RWR) and treatment plant at Palakata area. This land is currently utilized for salt and shrimp cultivation. The peak season for salt is June-January (rain to winter season) while shrimp is mostly January-April (winter to dry season).

According to the land ownership records (Khatians), the ownership of the land for the RWR and treatment plant rests in the Department of Forest (DOF). But it was discovered from the survey that this land was formally/informally taken and leased out by the Department of Fisheries (DOFi)[1] to people (primary leaseholders) who released the land to the secondary leaseholders as seen in the Figure below. A mode of payment between the primary and secondary leaseholders is a lump sum and not periodical, and the secondary leaseholders have made downpayments of their contractual amount. The survey results show that the primary leaseholders do not lose any assets but their tenancy right. None of the

[1] When visited the DOF and DOFi, the RAP Study Team was not able to obtain the land use rights of the DOF land by the DOFi. And from the discussion it was unclear whether the DOFi was given the land use rights or it was using the DOF land informally.

primary leaseholders was consulted because they do not live around the project area, and it was difficult to get their mobile contacts. Therefore, they are not covered in the Resettlement Action Plan (RAP). RAP covered the secondary leaseholders who lost their agricultural assets and source of livelihoods and the wage laborers working on these farms.

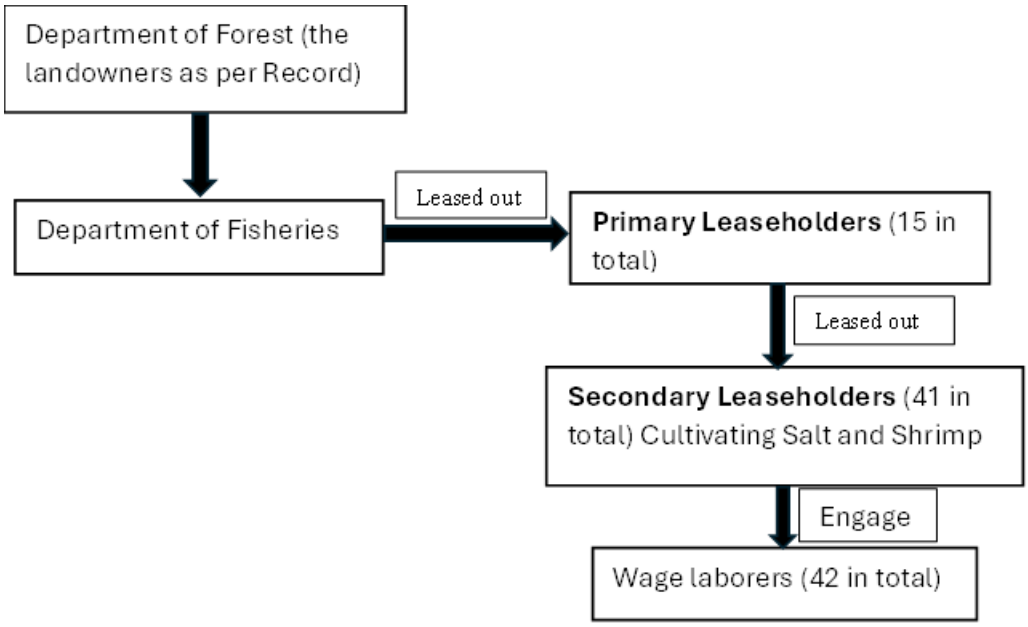


Figure 9.2.2 Situation at the Raw Water Reservoir

The Table below presents the land and structure owners at the Palakata area. Eligibility for compensation and assistance by the project has been considered for the secondary leaseholders and wage laborers.

Table 9.2.2 Land and Asset Owners at Palakata

Entities	Compensation under RAP		
	Land owners	Assets in the land	Loss of business/ Livelihood restoration
Department of Forest	X	- (no assets)	-
Department of Fisheries	-	- (no assets)	-
Primary leaseholders	-	- (no assets)	-
Secondary leaseholders	-	X	X
Wage labors	-	- (no assets)	X

Source: RAP Study Results

(2) Alternative Considerations

Described in Section 9.1.4 “Consideration of Alternatives (Including “Without Project”)” of this DFR.

(3) Category of Project Affected People

The RAP is prepared through harmonizing the Acquisition and Requisition of Immovable Property Act (ARIPA) 2017 and JICA Guidelines for Environmental and Social Considerations of 2022 (JICA Environmental Guidelines). Project Affected People (PAPs) fall into following categories:

(i) Have formal legal rights to the land or structure they occupy;

(ii) Do not have formal legal rights to land or structure, but have a claim that is recognized or recognizable under national laws (e.g. ancestral, traditional lands);

(iii) Have no recognizable legal right or claim to the land or structure they occupy; and/or

(iv) Economically displaced people who face loss of assets or access to assets

9.2.2 Legislation on Land Acquisition and Resettlement in Bangladesh

(1) Acquisition and Requisition of Immovable Property Act (ARIPA) 2017

Described in Section 9.1.3 (4) "Approvals Required to Implement the Project in Accordance with the Legal System of Bangladesh" of this DFR

(2) JICA Guidelines on Environmental and Social Considerations, 2022

Regarding involuntary resettlement, the JICA Guidelines for Environmental and Social Considerations of 2022 on involuntary resettlement (JICA Environmental Guidelines) are equivalent to the World Bank ESS5, Land Acquisition, Restrictions on Land Use and Involuntary Resettlement. It recognizes and addresses the involuntary resettlement, and relocation impacts of all the affected persons irrespective of their titles and requires for the preparation of RAP/ARAP in every instance where involuntary resettlement occurs depending on the number of affected persons. The JICA policy requirements are:

(i) Avoid or minimize impacts where possible;

(ii) When preparing RAP, affected people (including illegal dwellers), local NGOs, interested groups etc. should be consulted and their views incorporated in project planning and implementation.

(iii) Payments of compensation for acquired assets should be made at the replacement cost.

(iv) Ensure that no one is worse off because of resettlement and would improve or at least restore their original standard of living.

(v) Resettlement assistance to affected persons, including non-titled persons, and special attention to vulnerable groups

(vi) Appropriate and accessible grievance mechanisms must be established for the affected people and their communities

(vii) Compensation and other kinds of assistance must be provided prior to displacement

(viii) Eligibility of benefits includes the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who do not have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying

(3) Gap Analysis

Described in Section 9.1.3 (5) "Gap Analysis" of this DFR.

(4) Compensation Policy of the Project

The RAP was developed in consultation with DPHE and the affected communities through face-to-face discussion, consultation meetings and Focus Group Discussions (FGDs). The compensation Policy was developed through harmonizing the ARIPA 2017 and JICA Environmental Guidelines on involuntary resettlement which is equivalent to the World Bank ESS5. Also, considerations were made following JICA requirements and other donor funded projects in the Chattogram region. The RAP policy includes

(i) RAP is prepared to cover all affected people despite their tenure status.
(ii) Compensation for land and non-land assets will be made at replacement cost, and additional resettlement benefits will be provided
(iii) Eligibility for compensation and resettlement benefits is limited by the cut-off date

9.2.3 Project Impacts Based on the Field Results

Field activities were initiated by consultation meetings and FGDs with the affected people and other stakeholders. After which census, socio-economic and inventory of loss surveys were conducted to households within the project boundary. The findings of the field activities are as follows.

In total, 188 Project Affected Units (PAUs)[2] including households (HHs), shops, Common Properties Resources (CPRs) and government offices/institutions will be affected. Major impacts are at the transmission pipeline (57 PAUs), conveyance pipeline (55 PAUs), raw water reservoir (41 PAUs), three distribution reservoirs (29 PAUs), and water intake station (6 PAUs). Out of the total PAUs, 121 will be physically relocated among them 45 are titleholders and 76 are non-titleholders.

Likewise, census, socio-economic and inventory of loss surveys were administered in the land proposed for temporary requisition for construction yards and access roads. A total of 44 land and structure owners are affected among them 4 households have residential structures that will need relocation. Apart from the affected land and residential structures, no other properties such as business units, CPRs, government offices, tenants, vendors, trees etc were identified in the construction yards and access roads.

Table 9.2.3 Summary of Project Impacts

Affected Land	Permanent acquisition or utilization for project components	591.78 ha	Public: 573.97 ha
			Private: 18.05 ha
	Temporary use for construction yards and access roads	66.99 ha	Public: 52.62 ha–
			Private: 14.37 ha
Affected	Households (replacement	54 HH/261	Formal (title) 39 HH/189 Persons

[2] PAU include affected households, business and community properties

People	of residence due to project components)	Persons	Informal (non-title) 15 HH/72 Persons
	Households (replacement of residence due to construction yard)	4 HH/20 Persons	Formal (title) 4 HH/20 Persons
	Residential tenants	9 nos	9 nos
	Business entities to be economically resettled	63 HH/216 Persons	Formal (title) 4 HH/14 Persons
			Informal (non-title) 59 HH/202Persons
	Residential cum business to be relocated	4 HH/25 Persons	Formal (title) 2 HH/14 Persons
			Informal (non-title) 2 HH/11 Persons
	Business tenants	18 nos	18 nos
	Wage laborers	49 nos	49 nos
Affected Structures	Structures to be relocated (affected by project components)	206 nos	Residential: 96 nos
			Business: 80 nos
			Residential cum business: 9 nos
			CPRs/Institutions: 21 nos
	Structures to be relocated (affected by construction yards and access roads)	8 nos	Residential: 8 nos
	Partially affected structures by project components (no need of relocation)	11 nos	Residential: 11 nos
			Business: 0
			Residential cum business: 0
			CPRs/Institutions: 0 nos
Others	Affected trees	729 trees	Households: 673 trees nos
			CPRs/Institutions: 56 tress nos

Source: RAP Study Results

(1) Impacts on Land

The project will affect 18.0519 ha of private land. Location-wise quantity of land to be taken is presented in the table below.

Table 9.2.4 Affected Private Land

No.	Component	Private Land (ha)
1	Distribution reservoirs (DRs)	0.6350
2	RWR	0
3	Intake Station	0.9996
4	Conveyance Pipeline	6.0195
5	Transmission Pipeline	10.3978
	Sub Total	**18.0519**

Note: Distribution reservoirs include DR-2, DR-6 and DR-Industry
Source: RAP Study Results

Apart from the private land, 573.7317 ha of government land will be affected. The ownership status of the affected government land is presented below.

Table 9.2.5 Affected Government Land by Institute

Components	Agencies Land (ha)					
	DOF	DC	RHD	MOE	BIWTA	Total
RWR	567.3371	0	0	0	0	567.3371
Conveyance Pipeline	0	0.1359	0	0	0	0.1359
Transmission Pipeline	0	3.0125	0	0	0	3.0125
Intake Station	0	0	0	0	0	0
DR Industry	0	0	0	0	1.8335	1.8335
DR-2	0	0	0.1653	0	0	0.1653
DR-6	0	0	0	1.2474	0	1.2474
Total (ha)	**567.3371**	**3.1484**	**0.1653**	**1.2474**	**1.8335**	**573.7317**

Note: DOF: Department of Forest, DC: Deputy Commissioner, RHD: Roads and Highways Department, MOE: Ministry of Education, BIWTA: Bangladesh Inland Water Transport Authority

Source: RAP Study Results

In this study, the requisition of land for temporary construction yards and access roads was studied. In total, 66.9957 ha of land will be affected where 14.3785 ha is private, and 52.6172 ha is public most of which belong to the Department of Forest.

Additionally, 100 ha of land was identified for dumping of the excavated materials. Most of this land belongs to the Department of Forest too. It is estimated that about 25 secondary leaseholders using this land will be affected. The detailed impacts caused by the dumping site were not studied during the study period but expected to be studied in future stages of the project

The Table below presents the land use type of both private and public land as recorded on the ground. This Table does not include land to be temporarily used for the construction yards and access roads nor dumping site.

Table 9.2.6 Affected Public and Private Land by Category

Category	Definition	Conv. Pipeline	DRs	Intake Station	RWR	Trans. Pipeline	Total (ha)
Garden (orchard)	Fruit and timber trees land	0	0	0	0	0.119	0.119
Gher	Agriculture includes shrimp and salt field	0	0	0	479.2321	1.886	481.1181
Homestead	Residential land	0.6369	0.8657	0	0	0.6777	2.1803
Kati	Embankment	0	0	0	0	0.0326	0.0326
Khila	Multi-cropped agriculture land	0	0	0	0	0.0428	0.0428
Lobonmart	Agriculture land for salt field	0	0	0	0	0.9242	0.9242
Nall	Agriculture land	5.4052	0	0.9996	0	8.7204	15.1252

Potit	Fallow but partially used as agriculture	0	0	0	0	0.4362	0.4362
River	Waterbody	0	0	0	0.0153	0	0.0153
River/khal	Shallow waterbody Partially captured in the shrimp filed	0.0633	1.8335	0	81.4885	0.5328	83.9181
Road	Existing rural road	0.0501	0	0	6.6012	0.0386	6.6899
Tila	Hilly land used for vegetable gardening and orchard	0	0	0	0	0	0
Vita	High land used for vegetable gardening and orchard (eligible for house construction)	0	1.182	0	0	0	1.182
Total (ha)		**6.1555**	**3.8812**	**0.9996**	**567.3371**	**13.4103**	**591.7837**

Source: RAP Study Results

(2) Impacts on Primary Structure

A total of 196 structures are affected by the project components from both private and government land. On the private land, 86 primary structures with an area of 55,252 square feet (sft) are affected out of which 40,704 sft (73.67%) is non-shiftable (pucca and semi-pucca). On the government land, 110 primary structures with a total area of 40,426 sft are affected out of which 14,990 (37.08%) is non-shiftable. Apart from the primary structures, there are some secondary/auxiliary structures which are affected within the proposed alignment. It is important to note that there are no structures affected by the project components at the water intake point at the Matamuhuri river and the water station area.

Table 9.2.7 Affected Primary Structures on Private Land

Category of structure	Distribution Reservoirs		Conveyance Pipeline		Transmission Pipeline		Total	
	No	Sft	No	Sft	No	Sft	No	Sft
Pucca	1	8,160	4	6,051	3	3,700	8	17,911
Semi-Pucca	3	2,110	18	11,466	12	9,217	33	22,793
Tin-Made	0	0	23	7,845	5	908	28	8,753
Kutcha	0	0	12	2,396	5	3,399	17	5,795
Total	**4**	**10,270**	**57**	**27,758**	**25**	**17,224**	**86**	**55,252**

Note:

- **Pucca structure:** Is a structure made of Reinforced Cement Concrete (RCC) roof, cement-sand-brick wall and cement-sand-brick or earthen floor. Any other structure made of cement, sand, and brick (with or without iron rods) is also considered a pucca structure.
- **Semi-pucca structure:** Is a structure made of tin (corrugated iron sheet) roof, cement-sand-brick wall and cement-sand-brick or earthen floor.
- **Tin-made structure (double barreled or one slanting roof):** Is a structure with or without additional top floor with tin roof and fence as well as cement, sand, brick, wooden or earthen floor.
- **Kutcha structure:** Is a structure made of tin roof, mud/ straw/ bamboo wall and wooden/ bamboo/mud floor.
- **Thatched structure:** Is a structure made of materials other than tin, talli or RCC roof and wall/fence with earthen floor.

- **Secondary structure:** Is a structure subordinate to the principal structure such as bakery burner, boundary walls, gate, deep tubewells, hand tubewells, pucca road, RCC pillar, septic tanks, sanitary toilets, slab toilet, pucca floor, stair, veranda, and water pump.

Source: RAP Study Results

Table 9.2.8 Affected Primary Structures on Government Land

Category of structure	Distribution Reservoirs		RWR		Conveyance Pipeline		Total Area	
	No	Sft	No	Sft	No	Sft	No	Sft
Pucca	8	9,272	0	0	0	0	8	9,272
Semi-Pucca	11	3,098	1	150	2	2,470	14	5,718
Tin-Made	6	1,334	10	3,128	8	3,395	24	7,857
Kutcha	3	516	38	10,017	21	6,818	62	17,351
Thatched	0	0	2	228	0	0	2	228
Total	**28**	**14,220**	**51**	**13,523**	**31**	**12,683**	**110**	**40,426**

Source: RAP Study Results

Apart from the primary structures affected by the project components, 8 primary structures with an area of 2,308 sft are affected by the proposed construction yards as seen in the Table below. Also, a few secondary structures are affected too. All the affected structures are on private land.

Table 9.2.9: Primary Structures affected by Construction Yards

Category of structure	Conveyance Pipeline		Intake point		Transmission Pipeline		Total	
	No	Sft	No	Sft	No	Sft	No	Sft
Semi-pucca	2	580	1	252	1	360	4	1,192
Tin-Made	1	600	0	0	0	0	1	600
Katcha	1	210	1	126	1	180	3	516
Total	**4**	**1,390**	**2**	**378**	**2**	**540**	**8**	**2,308**

Source: RAP Study Results

(3) Impacts on Trees

A total of 673 trees of various sizes, large-329, medium-185, small-152 and plant-7 are affected by the project components. Out of the total, 4 trees in RWR, 381 trees in conveyance pipeline and 288 trees in transmission pipeline have been identified during the field survey. There is no impact on trees in the water intake station and distribution reservoirs (DR-2, DR-6 and DR-Industry).

Table 9.2.10 Affected Number of Trees

Types of trees		Size of trees				Total
		Large	Medium	Small	Plant	
RWR	Timber	0	4	0	0	4
	Sub-Total	**0**	**4**	**0**	**0**	**4**
Conveyance Pipeline	Fruit bearing	49	95	7	0	151
	Timber	0	43	12	0	55

Types of trees		Size of trees				Total
		Large	Medium	Small	Plant	
	Timber & fruit	36	35	75	0	146
	Firewood	4	0	0	0	4
	Bamboo	20	0	0	0	20
	Banana	5	0	0	0	5
	Sub-Total	**114**	**173**	**94**	**0**	**381**
Transmission Pipeline	Fruit bearing	32	2	7	4	45
	Timber	56	0	30	0	86
	Timber & fruit	27	6	21	3	57
	Bamboo	100	0	0	0	100
	Sub-Total	**215**	**8**	**58**	**7**	**288**
Total		**329**	**185**	**152**	**7**	**673**

Note: Large=16+ feet height and girth size 30-40 Inch at chest level, Medium=11-15 feet height and girth size 20-30 Inch, Small=6-10 feet height and girth size 10-20 Inch, Plant=1- 5 feet height and girth 1-10 Inch

Source: RAP Study Results

(4) Impacts on Community Structures/Government Institutions

In total, 9 CPRs and government offices/institutions will be affected by the project. Some of the CPRs and government offices/institutions are fully affected and require relocation. No cultural heritage site is affected by the project.

Table 9.2.11 Number of Affected CPRs and Institutions

Types	Category of Institutions	DRs	RWR	Intake Station	Conv. Pipeline	Trans. Pipeline	Total
CPRs	Cremation Ground	0	0	0	0	1	1
	Mosque	2	0	0	0	0	2
	Non-government school	0	0	0	0	0	0
	Only Land (Mosque)	0	0	0	1	0	1
Total CPRs		**2**	**0**	**0**	**1**	**1**	**4**
Offices, Institutions	Govt. School	3	0	0	0	0	3
	Government Office	1	0	0	0	0	1
	Police Camp	1	0	0	0	0	1
Total of Other Offices		**5**	**0**	**0**	**0**	**0**	**5**
Total (CPRs and Offices)		**7**	**0**	**0**	**1**	**1**	**9**

Source: RAP Study Results

(5) Impacts on Business

A total of 71 business units have been found. Out of them, 16 are large (having valid trade license, up to date BIN certificate, company registration and audited balance sheet), 28 are medium (having valid trade license, up to date BIN certificate) and 27 are small (having valid trade license).

Table 9.2.12 Number of Affected Businesses

No.	Nature of business	RWR	Transmission Pipeline	DRs	Total	%
1	Large business	14	0	2	16	22.54
2	Medium business	19	0	9	28	39.44
3	Small business	7	6	14	27	38.03
Total		**40**	**6**	**25**	**71**	**100.00**

Note: BIN stands for Business Identification Number
Source: RAP Study Results

(6) Impacts on Tenants

A total of 27 tenants have been identified, out of them, 18 are commercial tenants and 9 are residential tenants. As per the entitlement matrix, commercial tenants will be entitled to resettlement benefits to restore their business and shifting allowance, while the residential tenants will get support for alternative rental arrangements and shifting allowance.

Table 9.2.13 Number of Affected Tenants

No.	Location	Commercial	Residential	Total
1	Distribution Reservoirs	17	9	26
2	Transmission Pipeline	1	0	1
Total		**18**	**9**	**27**

Source: RAP Study Results

(7) Impacts on Wage Laborers

A total of 49 wage laborers have been identified. All the identified wage laborers are male, and many of them (42) are working on salt and shrimp farms.

Table 9.2.14 Number of Affected Wage Laborers

No.	Location	Wage Laborers
1	Distribution Reservoirs	7
2	RWR	42
Grand Total		**49**

Source: RAP Study Results

(8) Impacts on Vendors

No vendors were identified on the ground during the census, socio-economic and inventory of loss survey.

(9) Impacts on Vulnerable Groups

The vulnerable households have been defined as (a) Households with income below poverty line[3], (b) Household head with disability below poverty line, (c) Female headed poor[4] households, and (d) Old aged headed poor households. About 22 households fall under poverty line whereby 17 are male headed and 5 are female headed households. Vulnerable households will be entitled to additional assistance as per the policy of the RAP.

Table 9.2.15 Affected Vulnerable Households

Vulnerable Type	DRs	RWR	Conveyance Pipeline	Transmission Pipeline	Total
Male Headed households Under poverty line	2	0	6	9	17
Female headed households under poverty line	0	1	0	4	5
Total	**2**	**1**	**6**	**13**	**22**

Source: RAP Study Results

9.2.4 Socio-economic Characteristics of Project Affected Persons

(1) Affected People by Household (HH)

A total of 689 people will be affected by the project. Among them 55.88% are male and 44.12% are female.

Table 9.2.16 Affected People by Household

Location	House hold	Male Headed HH	Female Headed HH	Male Population		Female Population		Total Population		HH Size
				No	%	No	%	No.	%	
Conv. Pipeline	54	52	2	116	16.84	96	13.93	212	30.77	3.93
DRs	24	24	0	46	6.68	28	4.06	74	10.74	3.08
Intake Station	6	6	0	15	2.18	11	1.60	26	3.77	4.33
RWR	41	40	1	86	12.48	64	9.29	150	21.77	3.66
Trans. Pipeline	56	47	9	122	17.71	105	15.24	227	32.95	4.05
Grand Total	**181**	**169**	**12**	**385**	**55.88**	**304**	**44.12**	**689**	**100.00**	**3.81**

Note: HH: Household, HH Size: Average number of people in each household
Source: RAP Study Results

(2) Age Distribution of Affected Populations

In the case of age distribution of the population, about 27.14% are up to 14 years of age, while 2.18% are more than 65. The distribution of other age groups is tabulated below.

[3] According to the Household Income and Expenditure Survey (HIES) 2022 of the Bangladesh Bureau of Statistics (BBS) the upper poverty line for HH size 4.26 in 2022 was BDT 16,324 per HH/month. Acknowledging the average HH size of the project area (3.96) and yearly inflation for 2 years (2023-24) @ 6.5% per year BDT 17,211 (say BDT. 17000) has been adopted as the 2024 poverty line for the project affected people. Therefore, HHs with average income up to BDT 17,000 per month is living under the poverty line.

[4] Living under poverty line

Table 9.2.17 Affected Population by Age

Age Group (years)	DRs	RWR	Intake Station	Conv. Pipeline	Trans. Pipeline	Total	%
Up to 14	9	32	7	59	80	187	27.14
15 to 18	6	13	2	17	19	57	8.27
19 to 20	1	5	1	8	8	23	3.34
21 to 30	16	33	4	39	42	134	19.45
31 to 40	13	27	3	35	27	105	15.24
41 to 50	15	24	5	27	29	100	14.51
51 to 65	11	15	3	22	17	68	9.87
>65 years	3	1	1	5	5	15	2.18
Total	**74**	**150**	**26**	**212**	**227**	**689**	**100.00**

Source: RAP Study Results

(3) Religion of Affected Household Heads

About 92.82% of the affected household heads are Muslim while 7.18% are Hindu.

Table 9.2.18 Religion for the Household Heads

Religion	DRs	RWR	Intake Station	Conveyance Pipeline	Transmission Pipeline	Total	Percentage (%)
Islam	24	41	4	44	55	168	92.82
Hindu	0	0	2	10	1	13	7.18
Total	**24**	**41**	**6**	**54**	**56**	**181**	**100.00**

Source: RAP Study Results

(4) Ethnicity of the Household Heads

There is no small ethnic group that will be affected by the project. All the household heads are Bengali.

(5) Marital Status of the Affected Population

Out of the total affected population (of 15 years old and above), about 73.51% are married, 23.90% are unmarried, 2.19% widow/widower and 0.40% identified as separated/divorced.

Table 9.2.19 Marital Status of Affected Population

Marital Status	DRs	RWR	Intake Station	Conv. Pipeline	Trans. Pipeline	Total	Percentage (%)
Married	46	86	14	115	108	369	73.51
Unmarried	17	31	5	35	32	120	23.90
Widow/Widower	2	1	0	3	5	11	2.19
Separated/Divorced	0	0	0	0	2	2	0.40
Total	**65**	**118**	**19**	**153**	**147**	**502**	**100.00**

Source: RAP Study Results

(6) Income and Poverty Level

According to the RAP survey results, 12.15% of household heads live below the poverty line. Their monthly income range is below BDT 17,000 (see the impact on vulnerable groups above). 11.04% of

household heads' income is more than 50,000 while a great percentage of population, 88.96%, live under a lower middle class whose income level is between BDT 17,001-50,000.

Table 9.2.20 Income Level of Household Head

Income Range (BDT/Monthly)	DRs		RWR		Intake Station		Conv. Pipeline		Trans. Pipeline		Total			
	M	F	M	F	M	F	M	F	M	F	M	F	No.	%
1-17,000	2	0	0	1	0	0	6	0	9	4	17	5	22	12.15
17,001-30,000	13	0	11	0	3	0	36	1	25	5	88	6	94	51.93
30,001-40,000	4	0	10	0	1	0	5	1	7	0	27	1	28	15.47
40,001-50,000	2	0	9	0	0	0	3	0	3	0	17	0	17	9.39
50,001-60,000	0	0	4	0	1	0	0	0	1	0	6	0	6	3.31
>60,000	3	0	6	0	1	0	2	0	2	0	14	0	14	7.73
Total	**24**	**0**	**40**	**1**	**6**	**0**	**52**	**2**	**47**	**9**	**169**	**12**	**181**	**100.00**

Source: RAP Study Results

(7) Education of Affected Population

Education level of the affected population above 5 years old is higher, 96.74%, as compared to the national average of 74.80% as per population census of Bangladesh of 2022. On the other hand, 3.26% of the population is illiterate, of which about 0.98% didn't go to school and 2.28% can only sign by virtue of adult education program of the GoB/NGO or by learning from the household members. About 33.71% of PAPs have primary level education (grade 5) while 30.29% have high level school education.

Table 9.2.21 Education Level of Affected Population

Education	DRs		RWR		Intake Station		Conv. Pipeline		Trans. Pipeline		Total	
	M	F	M	F	M	F	M	F	M	F	Total	%
No schooling	1	1	1	0	0	0	1	1	0	1	6	0.98
Only signature	0	0	2	2	0	0	2	3	1	4	14	2.28
Primary	5	5	16	13	4	5	40	40	40	39	207	33.71
High School	6	7	20	29	5	1	31	29	31	27	186	30.29
SSC or equivalent	13	8	19	6	1	1	12	6	11	15	92	14.98
HSC or equivalent	5	4	13	3	0	1	11	4	11	3	55	8.96
Degree or equivalent	9	2	5	4	5	1	6	2	6	0	40	6.51
Master or equivalent	2	1	2	0	0	0	4	0	4	0	13	2.12
Hafez-e-Quran	0	0	0	0	0	0	0	0	0	0	0	0.00
PhD	1	0	0	0	0	0	0	0	0	0	1	0.16
Total	**42**	**28**	**78**	**57**	**15**	**9**	**107**	**85**	**104**	**89**	**614**	**100.00**

Source: RAP Study Results

(8) Main Occupation of Household Members

More than 14 occupational groups have been found in the affected area. Among them are students (29.46%), housewives (26.56%) and business including fisheries, groceries stores, gold store (12.92%).

Of the total affected adult members, only 3.63% (combining male and female) are unemployed. Additionally, 6.53% are doing agriculture and 2.61% are day laborers.

Table 9.2.22 Main Occupation of Household Members

Main Occupation	DRs		RWR		Intake Station		Conv. Pipeline		Trans. Pipeline	
	M	F	M	F	M	F	M	F	M	F
Agriculture	0	0	17	0	0	0	11	0	17	0
Business	16	0	24	0	1	0	29	0	19	0
Child (Underage)	4	1	8	7	0	2	8	7	18	17
CNG /Auto Rickshaw driver	0	0	0	0	0	0	2	0	1	0
Day labor	1	0	0	0	3	0	4	0	9	1
Domestic maid	0	0	0	0	0	0	0	0	0	1
Expatriate	2	0	0	0	1	0	1	0	4	0
Housewife	0	20	0	44	0	5	0	57	0	57
Imam	0	0	0	0	0	0	1	0	1	0
Land Renter	0	0	0	0	1	0	0	0	0	0
Motor driver	0	0	0	0	0	0	2	0	0	0
Old/Retired	0	1	0	0	0	1	4	2	0	1
Service (Private /Government/NGO)	6	1	1	0	1	1	8	1	9	0
Student	15	5	26	13	8	2	42	25	41	26
Unemployed	2	0	10	0	0	0	4	4	3	2
Grand Total	**46**	**28**	**86**	**64**	**15**	**11**	**116**	**96**	**122**	**105**

Main Occupation	Total					
	M	%	F	%	Total	%
Agriculture	45	6.53	0	0.00	45	6.53
Business	89	12.92	0	0.00	89	12.92
Child (Underage)	38	5.52	34	4.93	72	10.45
CNG /Auto Rickshaw driver	3	0.44	0	0.00	3	0.44
Day labor	17	2.47	1	0.15	18	2.61
Domestic maid	0	0.00	1	0.15	1	0.15
Expatriate	8	1.16	0	0.00	8	1.16
Housewife	0	0.00	183	26.56	183	26.56
Imam	2	0.29	0	0.00	2	0.29
Land Renter	1	0.15	0	0.00	1	0.15
Motor driver	2	0.29	0	0.00	2	0.29
Old/Retired	4	0.58	5	0.73	9	1.31
Service (Private /Government/NGO)	25	3.63	3	0.44	28	4.06
Student	132	19.16	71	10.30	203	29.46
Unemployed	19	2.76	6	0.87	25	3.63
Grand Total	**385**	**55.88**	**304**	**44.12**	**689**	**100.00**

Source: RAP Study Results

(9) Health Status of Affected Population

The health status of the population shows that about 99.27% of people say they do not have any chronic disease. The disabled people comprised only 0.73%

Table 9.2.23 Heath Status of Affected Population

Health status	DRs	RWR	Intake Station	Conv. Pipeline	Trans. Pipeline	Total	Percentage (%)
Chronic illness	0	0	0	0	0	0	0.00
Disabled	2	0	0	1	2	5	0.73
Mental disorder	0	0	0	0	0	0	0.00
Without disability or chronic illness	72	150	26	211	225	684	99.27
Total	**74**	**150**	**26**	**212**	**227**	**689**	**100.00**

Source: RAP Study Results

9.2.5 Compensation and Scope of Displacement

(1) Eligibility Criteria and Entitlement Matrix

Eligibility to receive compensation and resettlement benefits has been limited by the cut-off date. The cut-off date for titleholders is the date of serving notice under Section 4 of ARIPA 2017, while for the non-titleholder is the commencement date of the census and socioeconomic survey.

Project Affected Households (PAHs) with legal rights to the land and other assets to be acquired will receive Cash Compensation under Law (CCL) to be paid by Deputy Commissioner (DC) office following the ARIPA 2017 while PAHs without title will receive compensation and resettlement benefits as per RAP entitlement matrix. PAHs may also receive additional assistance (top up amount which is a difference between replacement cost and CCL). The top up amount will be paid by DPHE with assistance from the RAP Implementing Agency (IA). Affected vulnerable household (e.g., poor male and female headed households, disabled headed households below poverty line and old aged headed households below poverty) will be eligible for one-time special subsistence allowance.

The Cash Compensation under Law (CCL) to be paid by the DC office includes

- Cash compensation for loss of land by owners averaging the registered sale deeds values during the preceding one year from the date of serving notice under section 4 of the ARIPA of similar land plus (+) 200 per cent enhanced amount of the average (in total 3 times of the affected land value).
- Cash compensation for loss of crops, trees and perennials including 100% premium (in total 2 times of the affected crops, trees and perennials value);
- Cash compensation for residential and commercial structures including 100% premium (in total 2 times of the affected structure value); and
- Compensation to the legally recognized lessees, tenants and sharecroppers for their losses

Table 9.2.24 Entitlement Matrix

No.	Type of Loss	Entitled Person	Entitlement	
			Cash Compensation under Law (CCL)	**Compensation for non-titleholders, and resettlement benefits to be provided as top-up**
1	Loss of land (all types of land)	Persons. entities with legal title	Compensation for affected land as per ARIPA 2017[5]	i. If the Replacement Cost[6] is more than the cash Compensation under Law (CCL), the difference (top-up) is to be paid by the project. ii. Stamp duty, registration cost, tax, value added tax and other fees incurred for replacement land will be paid at actual for those affected landowners purchasing alternative land within the one year from the date of CCL received. iii. Dislocation/relocation allowances/grant for affected land at BDT at 300/decimal.
2	Loss of standing seasonal crops	Owners with legal titles/sharecropper/lease holders	Compensation for standing crops as per ARIPA 2017	i. Owner/grower to take away the crop
		Socially recognized owner/without legal titles/squatters/ encroachers.		i. Compensation for standing crops to actual owners/ cultivators as per census and inventory of loss survey or joint verification survey ii. Owner/grower to take away the crop
3	Loss of Trees, Perennials, fish stocks	Owners with legal title/lease holder	Compensation for trees/perennials/fish stocks as per ARIPA 2017	i. 2% of CCL value of trees or perennials/fish stocks as grant/allowance for plantation. ii. Owners will be allowed to fell and take away their trees, perennial crops/ fishes, etc. free of cost without delaying the project works
		Socially recognized owner/ without legal titles/ squatters/ encroachers		i. Cash compensation at market rates for replacement of trees/ perennials/ fish stocks value to be determined by Property. Valuation Assessment Committee (PVAC) ii. For fruit bearing trees- compensation for trees and fruits as per Dept of Forest scheduled rate. Fruit compensation will not exceed 30% of timber value for one years. iii. Compensation for fish stocks as determined by DC as per ARIPA 2017 on private land and by PVAC on GoB land. iv. 5 tree saplings (2 fruit trees, 2 timber type and 1 medicinal tree) will be provided for households losing trees. v. Owners will be allowed to fell and take away their trees, perennial crops/ fishes, etc. free of cost without delaying the project works.
4	Loss of structures	Owners with legal title	Compensation for affected	i. Transfer grant at BDT 10 per sft of main structure

[5] In some cases, Cash Compensation under Law for the affected land (in total 3 times of affected land value) is equivalent to Replacement cost for some land categories in some locations.

[6] Replacement cost (i.e., market price + transaction cost) is the cost to replace the affected property to its original state. This cost was established through surveying the properties sellers and district land office at the affected area. During RAP preparation the mouza rate is used to determine CCL for affected public land. For affected private land, mouza rate is compared with replacement cost, if there is a difference then a top-up is suggested.

No.	Type of Loss	Entitled Person	Entitlement	
			Cash Compensation under Law (CCL)	**Compensation for non-titleholders, and resettlement benefits to be provided as top-up**
			structures as per ARIPA 2017	ii. Reconstruction grant at 2% of CCL value for affected structures. iii. Rental assistance for 2 months' actual rent not exceeding BDT 10,000/= for the owner of the commercial & residential structures/HHs iv. Owners will be allowed to take away all salvage materials free of cost.
		Loss of structure on Khas/Waqf land/other government land		i. Replacement Cost of affected structures to be determined by PVAC with a maximum cap of 5 (five) lac BDT. This cap is not applicable for CPRs. ii. Structures (including CPR) or occupancies constructed with an intent of getting unworthy compensation or benefits, identified by PVAC, shall not be considered for entitlements. The decisions of PVAC on entitlement and compensation of encroachers or squatters shall be final. iii. Owners will be allowed to take away all salvage materials free of cost.
5	Loss of residential structure by Informal Resident	Informal Resident (Resident Squatter)		i. Replacement cost of structure as assessed by PVAC considering scheduled rate of Public Works Department. ii. Transfer grant at BDT 10 per sft of main structure iii. Reconstruction grant at BDT 15 per sft of main structure. iv. Rental assistance for 2 months' actual rent not exceeding BDT 10,000/= for the owner of the commercial & residential structures/HHs v. Owners will be allowed to take away all salvage materials free of cost.
	Loss of commercial structure by Informal Occupant	Informal Occupant (Commercial Squatter)		i. Replacement cost of structure as assessed by PVAC considering scheduled rate of Public Works Department. ii. Informal occupant PAPs will be eligible for transfer grant at BDT 10 per sft, only if PAP's shop will be physically displaced. iii. Informal occupant PAPs below poverty line will be eligible for reconstruction grant at BDT 15 per sft of main structure, only if PAP's shop will be physically displaced. iv. Rental assistance for 2 months' actual rent not exceeding BDT 10,000/= for the owner of the commercial & residential structures/HHs v. Owners will be allowed to take away all salvage materials free of cost
	Loss of residential or commercial structure by	Informal Occupant (Encroacher)		i. Replacement Cost of structure as assessed by PVAC considering scheduled rate of Public Works Department.

No.	Type of Loss	Entitled Person	Entitlement	
			Cash Compensation under Law (CCL)	**Compensation for non-titleholders, and resettlement benefits to be provided as top-up**
	Informal Occupant			ii. Encroacher PAPs will be eligible for transfer grant at BDT 10 per sft, only if PAPs will be physically displaced. iii. Encroacher PAPs below poverty line will be eligible for reconstruction grant at BDT 15 per sft of affected main structure, only if PAPs will be physically displaced. iv. Rental assistance for 2 months' actual rent not exceeding BDT 10,000/= for the owner of the commercial & residential structures/HHs v. Owners will be allowed to take away all salvage materials free of cost.
6	Loss of Community Property Resources (CPRs)	Owners with legal title	Compensation for affected structures as per ARIPA 2017	i. Special grant for reconstruction at 7% of CCL value on structures for the title holders ii. BDT 50,000/each for community properties in addition to other compensation iii. Owners will be allowed to take away all salvage materials free of cost. iv. Or the project will reconstruct the community property if the management committee of the CPR found ineligible. In that case, compensation or assistance for structure will not be paid.
		Socially recognized owners/without legal titles/squatters/encroaches		i. Replacement Cost of structure as assessed by PVAC considering scheduled rate of Public Works Department ii. Special grant for reconstruction at 7% of Replacement Cost on structures determined by PVAC for non-title holders iii. BDT 50,000/each for community properties in addition to other compensation iv. Owners will be allowed to take away all salvage materials free of cost. v. Or the project will reconstruct the community property if the management committee of the CPR found ineligible. In that case, compensation or assistance for structure will not be paid.
7	Loss of utility connection	Owners with legal title /Socially recognized owners/without legal titles/squatters/encroaches		Cash grant for utility replacement will be paid at actual amount required for replacement
8	Loss of tenancy right, access to cultivable land and	Tenants/Socially recognized owners/without legal titles/squatters/encroaches		i. Moving/shifting assistance for commercial and residential tenants at 2 months' actual rent not exceeding BDT 10,000/= ii. Dislocation/relocation allowances/grants for affected land for secondary lease holders at

No.	Type of Loss	Entitled Person	Entitlement	
			Cash Compensation under Law (CCL)	**Compensation for non-titleholders, and resettlement benefits to be provided as top-up**
	commercial premises			BDT 50000/acre for acquired land (for one year-two crops)
9	Loss of business due to dislocation of Commercial and Business Enterprise (CBE)	Owners with the legal title /Socially recognized owner/without legal titles/squatters/ encroachers		i. Business restoration grant at BDT 10,000 for each business unit without trade license. ii. BDT 20,000/each entity for those who have valid trade licenses. iii. BDT 80,000/each entity for those who have a valid trade license & up to date BIN (Business Identification Number) certificate. iv. BDT 150,000/each entity for those who have a valid trade license, up-to-date BIN (Business Identification Number) certificate, company registration/ audited balance sheet.
10	Loss of wage income and workdays due to project activities	Wage laborers engaged in the agricultural field (Salt/Shrimp/ Paddy field) or commercial enterprises		All categories of wage laborers are entitled for one time grant at BDT 600/day for 60 days = BDT 36,000/-
11	Assistance for Vulnerable Households (excluding female headed households)	Owners with legal title /Socially recognized owners/without legal titles/squatters/encroaches below poverty line		One time grant to all male headed vulnerable households at BDT 10,000/HH
12	Assistance for female headed households	Owners with legal title /Socially recognized owners/without legal titles/squatters/encroaches below poverty line		One time grant to all female headed vulnerable households at BDT 15,000/HH
13	Loss of income, source of livelihood	All households below poverty line, Female headed HHs below poverty line, wage laborers at salt and shrimp farms (both titled and non-titled)		i. Training on Income Generating Activities (IGA) to one eligible member (age 15-60) from poor households and households that has lost long dependent income sources. Training needs will be assessed by the RAP IA. Training cost at BDT 15,000/each participant ii. Capital Support to trained member of Vulnerable households including wage laborers for livelihood restoration at BDT 30,000/= after successful completion of course.
		All PAPs including owners with		Linkage with financing institutions (Banks, NGOs) for financial assistance such as business loans through RAP IA.

No.	Type of Loss	Entitled Person	Entitlement	
			Cash Compensation under Law (CCL)	**Compensation for non-titleholders, and resettlement benefits to be provided as top-up**
		legal title /Socially recognized owners/without legal titles/squatters/encroaches		
14	Temporary use of land for construction yard and approach road	Owners of the private land	i. Requisition of land for temporary use of 5 years at BDT 50,000/season for two seasons per year. ii. Project will give back the land to the owner on its' original condition.	
15	Temporary impact during construction	Households/persons/community affected during construction	The contractor shall bear the impact on the structure or land. It is the responsibility of the contractor to pay for any damage caused by construction works and normally the contractor enters direct contract with the households whose land/properties will be affected by the construction activities.	
16	Unforeseen adverse impact	Households/persons/community affected during construction	Compensation/allowance/grant/assistance depending on types of loss will follow the principle of safeguard policy and entitlement matrix proposed in the document.	

Note: The proposed Entitlement Matrix and the RAP budget developed based on it have been submitted to DPHE for review and confirmation.

Source: RAP Study Results

(2) Scope of Displacement

1) Total Affected Entities Require Relocation

A total of 54 residential households comprising 261 PAPs will be physically displaced by the project. Additionally, 63 commercial enterprises and 4 residential cum commercial units will be displaced. Among these units, 90 are fully affected while 31 are partially affected. For the partially affected units, the residue is unviable i.e., more than 50% of the structure is affected, hence needs to be relocated.

Table 9.2.25 Total Number of Entities to be Relocated

Household & PAPs Requiring Relocation	DR	RWR	Conv. Pipeline	Trans. Pipeline	Total
Residential Household to be relocated	1	1	27	25	54

Commercial Enterprises to be relocated	21	37	0	5	63
Residential cum Commercial	2	0	0	2	4
Total	**24**	**38**	**27**	**32**	**121**
Number of PAPs Requiring Relocation from Residential Household.	15	4	121	121	261

Source: RAP Study Results

In addition to structures physically displaced by the project components, 4 residential households comprising 20 PAPs will be physically displaced due to the proposed construction yards: 1 HH at the transmission pipeline, 2 at the conveyance pipeline and 1 at the intake station. The RAP study has recommended for the boundary of the construction yards be changed in future to avoid relocation of these houses, however, provisions for compensation and resettlement of these affected houses are provided.

2) Relocation Option

The potentially affected units (excluding the CPRs and government institutions) were asked for their opinion on relocation options, mentioning a few alternatives. Most of the households (95.58%) opted for self-relocation on either new or residual land, while few, 4.42% opted for project assisted relocation. However, in this project households are relocated from different locations and on a small scale. In that case it is not feasible to relocate them to a single resettlement site away from their old locations. Therefore, all PAPs are encouraged for self-relocation in an individual or group manner within their affected locations to maintain their social cohesion. Thus, this project has no provision for a relocation site.

Table 9.2.26 Households Preferences on Relocation Option

Relocation Option Preferred	DR	Intake Station	RWR	Conv. Pipeline	Trans. Pipeline	Total	%
Project Assisted Relocation	0	0	0	7	1	8	4.42
Relocation to residual land	1	0	0	9	3	13	7.18
Self-Relocation through purchasing new land	23	6	41	38	52	160	88.40
Total	**24**	**6**	**41**	**54**	**56**	**181**	**100**

Source: RAP Study Results

3) Relocation of Common Properties Resources (CPRs) and Institutions

Out of 9 affected CPRs (Mosque, Madrasah, School, etc.) and government offices/institutions, 3 CPRs and 4 government offices/institutions will require relocation. The CPR management committee will be paid compensation for the land, structures, trees and other affected assets and encouraged for self-relocation. In the case of Mosque, Soshan/ Cremation, the project authority may take initiative to reconstruct. When the project authority reconstructs a structure, compensation and assistance for that structure will not be paid.

Table 9.2.27 Affected Community Properties Resources

Types	Category of Institutions	DR	RWR	Intake Station	Conveyance Pipeline	Transmission Pipeline	Total
CPRs	Soshan/ Cremation	0	0	0	0	1	1
	Mosque	2	0	0	0	0	2
	Non-government school	0	0	0	0	0	0
	Only Land (Mosque)	0	0	0	0	0	0
Total CPRs		**2**	**0**	**0**	**0**	**1**	**3**
Offices/ Institutions	Govt. School	3	0	0	0	0	3
	Government Office	0	0	0	0	0	0
	Police Camp	1	0	0	0	0	1
Total of Other Offices		**4**	**0**	**0**	**0**	**0**	**4**
Total (CPRs and Offices)		**6**	**0**	**0**	**0**	**1**	**7**

Source: RAP Study Results

4) Relocation to Agricultural Land

A total of 598.8285 ha of agriculture land will be permanently affected (this includes land affected by the project components and dumping sites). The project will not arrange any alternative land but will pay compensation at replacement cost and encourage the landowners to buy alternative land. The stamp duty and registration cost for purchasing replacement land will be paid if the alternative land is purchased within one year of CCL payment. The DC will compensate for loss of crops and trees at the rate estimated by the Department of Agriculture Extension (DAE) and the Department of Forest (DOF). The crop owners will be allowed to harvest the crops before handing over land to DPHE if it is near harvesting period. The landowners will be issued a notice in this regard by the DPHE, and compensation will not be paid for crops if it is not damaged by the project activities.

(3) Livelihood Restoration

During the socio-economic survey, PAHs expressed their preferences for Income and Livelihood Restoration (ILR) options. The results revealed a strong interest in accessing financial support with more PAHs opting for loan provision from the Project or other ongoing developments.

Table 9.2.28 Preferences for Income and Livelihood Restoration Options

Preferences	No. of opinion (multiple response)	Percentage (%)
Assistance for loan arrangement by the Project	134	27.35
Employment opportunities in construction work	132	26.94
Assistance for loans from other ongoing development schemes	124	25.31
Vocational training	94	19.18
Others	6	1.22
Total	**490**	**100.00**

Source: RAP Study Results

Based on the requirements of JICA Environmental Guidelines, the necessity for ILR was assessed by considering the vulnerability of the affected population. All households below the poverty line including female-headed households were considered. Additionally, 42 wage earners at the salt and shrimp farms. The income of these wage earners is not below the poverty line; however, they have been dependent solely on salts and shrimp cultivation for a long time (over ten years) and their skills are limited to such activities. Additional support to reestablish is necessary for them. Detailed need assessment will be conducted during RAP Implementation by RAP IA as per Bangladesh practice.

Table 9.2.29 Income and Livelihood Restoration Programs

Identified Groups	Restoration Program
Poor households earning maximum BDT 17,000 per month Female headed households having no adult male members. Wage earners at salt and shrimp cultivation	• Priority in Project's construction and operation works. • Training on Income Generating Activities (IGA) to be implemented during RAP implementation by DPHE under the assistance of RAP IA • Capital support after completion of trainings • Linking with the existing government Sectoral Programs (Fish, Poultry, Agriculture, livestock etc.) and Social Safety Net. • Linking with financial institutions for financial support

Source: RAP Study Results

(4) Grievance Redress Mechanism (GRM)

Titleholder PAPs have a window to submit objections in the beginning of the legal process as per ARIPA 2017, Section 5. Once the objections are heard and addressed, there is virtually no provision to attend complaints and grievances that individual landowners may bring in the later stages of the acquisition process. As for the non-titleholder PAPs, there is no mechanism to hear and redress their grievances as they are not covered by the law.

A community based GRM, an IT-system, is proposed by the RAP study to resolve land acquisition and resettlement related disputes. The system allows aggrieved PAP to submit grievances through SMS/Email to the focal person of Grievance Redress Committee (GRC) in addition to the conventional method of submitting in the hard copy with/without assistance from the RAP IA. The IT system is suitable for projects that cover various locations like this project.

1) Procedure for GRM

The procedures for filing the grievances are tabulated below.

Table 9.2.30 Procedures for Filing the Grievances

Steps	Description
Step 1	The RAP Implementing Agency (IA) informs PAPs about their losses and entitlements. If satisfied, the PAP claims resettlement payments to the DPHE. If not satisfied, proceed to Step 2
Step 2	The PAP approaches the IA field level officials for clarification. The IA will clarify the PAPs about their losses & entitlements as per RAP policy. If resolved, the PAP claims resettlement payments to the DPHE. If not resolved, proceed to Step 3
Step 3	The PAP approaches the GRC. RAP IA staff assists the PAPs producing the complaints

Steps	Description
	and organizes hearing within 21 days of receiving the complaints. Both written complaints in the local dialect and verbal complaints are acceptable. RAP IA shall assist the PAPs to prepare written form for succeeding procedures at no cost to PAPs. Then proceed to Step 4
Step 4	GRC to scrutinize applications, cases referred to Deputy Commissioner through RAP IA if the case is under arbitration law and beyond their mandate as per scope of work. If the case is within the mandate of GRC, proceed to Step 5
Step 5	GRC sessions held in presence of the aggrieved PAPs, and the minute of meeting is recorded. If resolved, the Project Director approves the decision of the GRC. If not, proceed to Step 6
Step 6	The PAP may accept GRC decision, if not, he/she may file a case to the Project Director (PD) for settlement. Then proceed to Step 7
Step 7	The PD with the help of Team Leader, RAP IA and Resettlement Specialist of Construction Supervision Consultant (CSC), and Convener and Member Secretary of GRC at the local level reviews the case. Go to Step 8
Step 8	The minutes from the PD meeting is approved by the PD and transferred back to Conveners' office at the local level. The approved verdict is communicated to the complainant PAP in writing. The PAP then claims resettlement payments to DPHE. If not excepted, the PAP moves to Step 9
Step 9	When the PD's decisions are not accepted, the PAP may go to the court of law, which takes the final decisions, and the resettlement benefits are given accordingly

Source: RAP Study Results

2) A Grievance Redress Committee (GRC)

The GRCs will be formed at all the construction contract zones. A gazette notification on the formation and scope of work of the GRCs will be required from the DPHE or Ministry of Local Government, Rural Development and Cooperatives (MLGRD&C). The GRC will comprise of:

a) GRC Members at the Local Level

- One representative of DPHE, at least of the level of Executive Engineer, to be nominated by the Project Director as convener.
- The Deputy Team Leader of the RAP IA as Member Secretary.
- The Chairman or his representative of the UP/Municipality where the complaint is registered.
- One representative of the PAPs (female in case of female aggrieved persons) as Member.
- Women member of local Union Parishad / Municipality as Member.

b) GRC Members at the Project Level

- Project Director (PD) as Convener
- Deputy Project Director as Member
- Social Specialist at PMU as Member Secretary
- Concern Executive Engineer at PMU as Member
- Team Leader of RAP Implementing Agency as Member

9.2.6 RAP Implementation Arrangement

RAP implementation involves different actors including the project owner, Deputy Commissioner's office and various committees; Joint Verification Committee (JVC), Property Valuation Assessment

Committee (PVAC) and Grievance Redress Committee (GRC) to be constituted by the Local Government Division (LGD) of Ministry of Local Government, Rural Development and Cooperatives (MLGRD&C) through official notification. Main actors and their roles are presented below.

Table 9.2.31 Roles of RAP Implementation Actors

Actors in RAP Implementation	Roles
Project Management Office (Head Quarter(Dhaka))	Overall responsible for resettlement and works
	Interact and coordinate with the government-on-government land use permission/transfer
	Interact and co-ordinate with DC office to facilitate land acquisition
	Co-ordinate the implementation activities with Head Office and Field Office
	Appoint RAP IA and consultant
	Approve the time-bound plans prepared by the RAP IA
	Monitor the progress on Resettlement and Rehabilitation (R&R) and land acquisition
	Prepare monthly progress report and submit to JICA
	Guide the staff of DPHE, RAP IA & Construction Supervision Consultants (CSC) on policy related issues during implementation
	Ensure timely release of fund for R&R activities
Project Implementation Unit (Field(Cox's Bazar))	Liaison with the Office of DC for timely acquisition and payment of compensation
	Synchronize various activities related to R&R with construction schedule
	Ensure PAHs have received their due compensation and resettlement benefits
	Assist and advise Chief Resettlement Officer in matters related to R&R
	Ensure distribution of brochures of R&R policy by the RAP IA in local language
	Supervise RAP IA works
	Interact with RAP IA and CSC Team
	Compile data related to R&R activities and update reporting officer
	Review monthly work plan & monthly reports submitted by RAP IA
	Participate in regular meetings on monthly basis
	Ensure distribution of identity card
	Attend meetings and participate in GRC meetings
	Ensure budgetary provision for relocation, rehabilitation, and reconstruction of CPRs
Deputy Commissioner Office	Legal acquisition of land for the development activities and pay cash compensation under the ARIPA 2017
	Update title of land and eligibility of PAHs for Cash Compensation under Law (CCL) for land as well as several other assets covered by the law
Implementing Agency (RAP IP)	Prepare Land Acquisition Plan (LAP)
	Update RAP
	Assisting DC in implementation of the LAP
	Prepare a compensation budget
	Assist the DPHE in implementation of RAP including disbursing entitlements which are beyond the purview of CCL.
	Ensuring that PAP's grievances are redressed and the vulnerable are given special attention.
	Mitigate community level dislocation caused by the project.

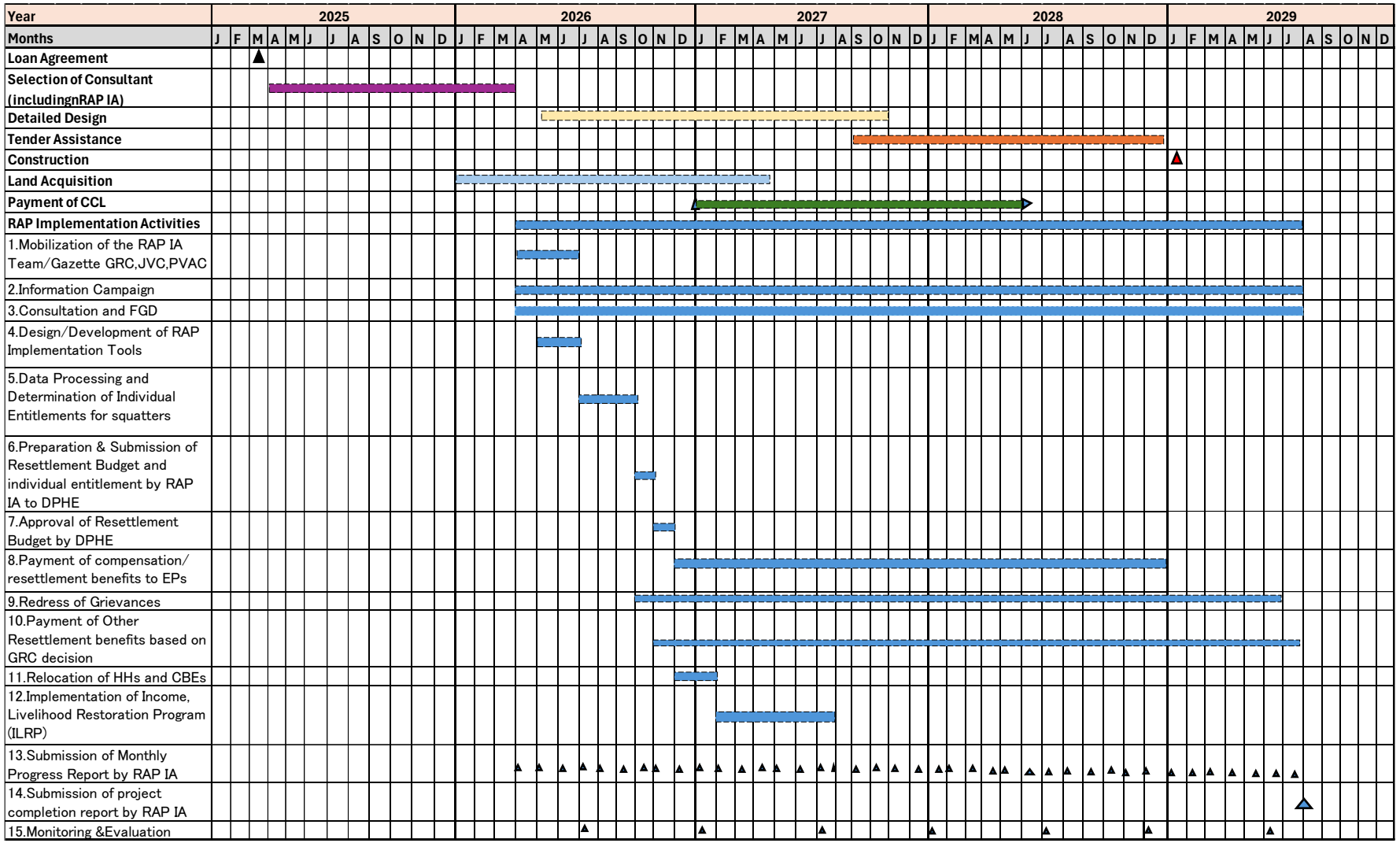
Actors in RAP Implementation	**Roles**
Joint Verification Committee (JVC)	Conduct survey of the affected plot survey to determine the actual quantum of losses
	Estimate compensation for the losses using the current market value ascertained by the PVAC
Property Valuation Assessment Committee (PVAC)	Establish the current market price equivalent to the replacement value for land and non-land assets

Source: RAP Study Results

9.2.7 RAP Implementation Schedule

Considering the magnitude of land acquisition and resettlement impacts, RAP implementation is tentatively planned for 5 years including land acquisition, resettlement and post-resettlement activities. Implementation of RAP will continue during the construction period and even after construction period for addressing claims and grievances of the PAPs regarding payment of compensation and other resettlement benefits. However, some of the activities for RAP implementation may extend further. The preliminary time bound implementation schedule is tabulated below.

Table 9.2.32 RAP Implementation Schedule



Source: RAP Study Results

9.2.8 Land Acquisition and RAP Implementation Costs

Table 9.2.33 presents the total costs for land and other assets acquisition. The Mouza rates including 200% premium has been considered for preparation of the land price as Cash Compensation under Law, while the replacement cost survey rate has been considered as replacement cost. The higher price between the Mouza rates plus 200% premium and replacement cost have been considered for preparation of the land budget. For structures and trees, PAPs are entitled to a 100% premium as per ARIPA 2017, but also, they are allowed to take away salvageable materials free of cost. This is why additional compensation on top of Cash Compensation under Law is not considered for the structures and trees. Additionally, the cost for requisition of temporary construction yards and access roads (A.3) was included. In a discussion with DPHE, it indicated that once the Development Project Proposal for this project is approved by the Government of Bangladesh (GOB), it means, it is the responsibility of the GOB to allocate all the required budget to implement the project which includes the costs beyond the national law.

Table 9.2.33 Land Acquisition and Resettlement Implementation Costs

SL.	Category of Loss	Cash Compensation under Law (ARIPA 2017)	Additional Budget (including top-up)	Estimated Total Compensation Amount in BDT
A.1	Compensation for Private Land	687,183,714	70,944,791	758,128,505
A.2	Compensation for Govt. Land	53,456,193,361	0	53,456,193,361
A.3	Compensation for Land for Construction yard/access roads	82,775,000	0	82,775,000
A.4	Compensation for Land for Dumping sites[7]	11,021,856,300		11,021,856,300
B-1	Compensation for Structure (at Project components)	77,941,570	68,204,418	146,145,988
B-2	Compensation for Structures at Construction yards	2,171,988	0	2,171,988
C	Compensation for Trees	4,083,020	0	4,083,020
	Impact Budget (A-C)	**65,332,204,953**	**139,149,209**	**65,471,354,163**
D-1	Resettlement Benefits (for HHs at Project components)	0	184,350,574	184,350,574
D-2	Resettlement Benefits for HHs at Construction yard	0	64,002	64,002
E	Operation cost for RAP Implementing Agency/ INGO	0	64,000,000	64,000,000
F	Operation cost for External Monitoring Agency	0	6,000,000	6,000,000

[7] (1) As per the RAP Study Team, a new Mouza (Badorkhali Mouza) is affected by the dumping sites. This Mouza was not surveyed before because it was not affected, hence the Mouza rate for this Mouza was not corrected. All costs for land at the dumping sites referred to Rampur Mouza rate surveyed at the raw water reservoir at Palakata area.
(2) The RAP Study Team estimated about 25 secondary leaseholders to be affected at the dumping sites. The survey is needed to estimate the quantity of loss incurred by them, the needed compensation amount and the resettlement benefits. As for now, the compensation and resettlement benefits for PAPs at the dumping site is not included in the budget table.

SL.	Category of Loss	Cash Compensation under Law (ARIPA 2017)	Additional Budget (including top-up)	Estimated Total Compensation Amount in BDT
G	Capacity building training of the Project Management Office officials	0	8,000,000	8,000,000
H	Relocation of HHs and CPRs including civic amenities	0	64,000,000	64,000,000
	Total Budget (A-H)	**65,332,204,953**	**465,563,806**	**65,797,768,759**
I	Administrative cost 2% of the total budget on the DC head	1,315,955,375	0	1,315,955,375
J	Contingency 5% of the total budget	0	3,289,888,438	3,289,888,438
	Grand Total BDT (A-J)	**66,648,160,328**	**3,755,452,243**	**70,403,612,572**

Note:

1. Mouza rates are government rates for different categories of lands at different mouzas.
2. Cash Compensation under Law (CCL) is a compensation package (for land, structure, trees and other affected properties) that complies with the ARIPA. CCL is also referred to as the DC budget since it is determined by and paid through the DC.
3. Replacement cost (i.e., market price + transaction cost) is the cost to replace the affected property in its original state. This cost was established through surveying the properties sellers and district land office at the affected area. During RAP preparation the mouza rate is used to determine CCL for affected public land. For affected private land, mouza rate is compared with replacement cost, if there is a difference then a top-up is suggested.
4. Impact budget (A-C) is the compensation amount to be paid to PAPs due to the incurred loss of assets i.e., land, structures and trees as required by the ARIPA 2017.
5. The Resettlement Benefits (D-1, D-2) include all additional allowances to be given to PAPs to assist them resettle in the new area as required by international donors i.e., relocation allowance, business restoration grants, costs for livelihood restoration, additional allowance for vulnerable people etc.

Source: RAP Study Results

9.2.9 RAP Monitoring

The DPHE will carry out the internal monitoring of RAP implementation involving the field offices and RAP IA. The Construction Supervision Consultant team will also perform the monitoring job and submit their monthly progress report to DPHE. The financing agency will monitor the project including RAP implementation activities by reviewing the quarterly progress report to be submitted by DPHE. An external monitoring agency (EMA) will be recruited by the DPHE for monitoring the RAP implementation on a biannual basis. The EMA will submit a report to the Project Director.

9.2.10 Stakeholder Meeting

(1) 1st Stakeholder Meeting

1) EIA

The stakeholder meeting at the scoping stage of EIA study was held in July 2024 at Cox's Bazar, Matarbari and Chakaria. Participants presented their concerns mainly about the impact on the shrimp aquaculture industry and agriculture caused by land acquisition and seasonal weather trends as well as the impact caused by deposition of sediment. The total number of participants is the participants list,

and the summary of meetings are shown in the table 9.2.34 and table 9.2.35 below respectively. Detailed comments and responses are presented in Appendix.

Table 9.2.34 List of Stakeholder Consultation Meetings

Location	Date	Number of Participant
Cox's Bazar	2024/7/2	32
Matarbari	2024/7/4	43
Chakaria	2024/7/3	44
Total		119

Source: JICA Study Team

Table 9.2.35 Summary of Stakeholder Consultation Meetings

Location	Date	Venue	Participants
Cox's Bazar	2024/7/2	Conference room at Department of Public Health Engineering	DPHE, non-government organizations, civil society organizations/community-based organizations, journalists and representatives from various government organizations
Matarbari	2024/7/4	meeting room of the Matarbari Union Parishad, Moheshkhali Upazila, Cox's Bazar District	Honorable Mayor of Moheshkhali Municipality, the Chairman of Matarbari Union Parishad, officials from the Upazila Public Health Engineering Department, representatives from various government offices in Moheshkhali Upazila, Union Parishad members, media personnel, teachers, and stakeholders from various other sectors
Chakaria	2024/7/3	Chakaria Upazila Parishad Complex	Assistant Commissioner (Land), Councilors of Chakaria Paurashava, Chairmen of local union parishad, representatives of local government offices, journalists, teachers of local educational institutes, NGOs and local community members

Source: JICA Study Team

2) RAP

Public consultations meetings were conducted in nine affected unions between mid-April to early May 2024. In total, 244 participants attended the 9 consultation meetings, among them were 213 male and 31 females. Apart from the consultation meetings, 20 FGDs were conducted with a total of 291 participants (215 male and 76 females). Among the conducted FGDs, 4 FGDs targeted only women and girls. The Tables below present the details of the meetings.

In general, people were happy about the project, however, they had concerns on the safety of Matamuhuri river when large volume of water is taken out of it, safety of the water to be provided, unit rate for land compensation, costs for water connections, and availability of construction jobs for the affected people. They also shared their worries about delayed compensation, referring to their previous experience with other projects around the area.

The draft RAP is expected to be disclosed to the Project Affected Households (PAHs) in September 2024 after it is reviewed and confirmed by the DPHE. The brochure will be prepared and distributed to PAHs. Also, DPHE has agreed to disclose the executive summary of the draft RAP on its website.

Table 9.2.36 Participants of the Consultation Meetings

Venue	Date	Category of Participants	No. of Participant			Cut-off Date
			M	F	Total	
Chakaria Municipality	18th April 2024	Local government representatives, DPHE officials, JST representatives, consultants, BWDB representatives, farmers, teachers, businessmen, day labourers.	19	3	22	19th April 2024
Fasiakhali Union	22nd April 2024		31	3	34	23rd April 2024
Kakara Union Parishad	5th May 2024	The Chairman of Kakara Union, DPHE officials, JST representatives, consultants, BWDB representatives, farmers, teachers, businessmen, day labourers.	35	4	39	6th May 2024
Kalarmarchhara Union Parishad	20th April 2024	The Panel Chairman, DPHE officials, JST representatives, consultants, BWDB representatives, farmers, teachers, businessmen, day labourers.	30	2	32	21st April, 2024
Lakhyarchar Union Parishad	17th April 2024	The chairman of Union Parishad, Local government representative, DPHE officials, JST representatives, consultants, BWDB representatives, farmers, teachers, businessmen, day labourers, students.	16	5	21	18th April, 2024
Matarbari union	20th April 2024	UP Chairman, DPHE officials, JST representatives, consultants, BWDB representatives, farmers, teachers, businessmen, students, day laborers.	22	5	27	21st April 2024
Moheshkhali Municipality	22nd April 2024	The Chairman of Kakara Union, DPHE officials, JST representatives, consultants, BWDB representatives, farmers, teachers, businessmen, day labourers.	18	2	20	23rd April 2024
Chiringa Union Parishad (Palakata)	18th April 2024	Chairman of Chiringa Union Parishad, UP Secretary, DPHE officials, JST representatives, consultants, BWDB representatives, farmers, teachers, businessmen, day labourers.	19	5	24	19th April, 2024
Paschim Baro Bheula Union Parishad	21st April 2024	The Panel Chairman of Paschim Baro Bheula Union Parishad, DPHE officials, JST representatives, consultants, BWDB representatives, farmers, teachers, students, businessmen, day laborers.	23	2	25	22nd April 2024,
Total			**213**	**31**	**244**	

Source: RAP Study Results

Table 9.2.37 Participants of the FGDs

No.	Date	Place of FGD	Groups	Participants		
				M	F	Total
1	01.05.024	Hanspara, Demusia Union, Chakaria,	Existing Labour and labor forces	11	14	25
2	02.05.24	8 no. ward, Chakaria municipality	Business Group	19	1	20
3	02.05.24	4 no ward, Chakaria	Squatters (Residence)	14	0	14
4	02.05.24	Maizpara, Purba Baro Veola Union, Chakaria	Wage Labour	10	1	11
5	04.05.024	Shikalgata Lakhyarchar Union, Chakaria	Men Group	16	0	16
6	22.04.024	Chiknipara, Kalamarchora Union, Moheshkali	Vendor	9	0	9
7	24.04.024	Dalgata UP office, Moheshkali	Shrimp Farmer community	17	0	17
8	25.04.024	Konakhali Bazar, Chakaria	Salt/shrimp Farmer	7	0	7
9	25.04.024	Soaliapara, Koirbeel, Chakaria	Salt/shrimp Farmer	9	0	9
10	25.04.024	Badarkhali Jeti, Badarkhali, Chakaoria	Wage Labour	10	0	10
11	27.04.024	Pachim Masgata, Chiringa, Chakaoria	Shrimp Farmer community	25	0	25
12	27.04.024	Koralkhali, Union shaharbeel Chakaoria	Shrimp Farmer community	17	0	17
13	28.04.024	Aswarpara Fasiakhali Union, Chakaria	Existing Labours	17	0	17
14	28 04.024	Majerferi Kakara Union, Chakaria	Existing Labours	12	0	12
15	29.04.024	Paharitola BMC Union, Chakaria	Men Group	15	0	15
16	30.04.024	Elisia Bazar, Pachim Baro Veola Union, Chakaria	Wage Labour	7	11	18
Total				**215**	**27**	**242**

Source: RAP Study Results

Table 9.2.38 Participants of Women Targeted FGDs

Date	Venue	Participants	No. of Participants
April 18, 2024	Digharpan Khali in Chakaria Municipality under Chakaria	Homemakers, service holders, women entrepreneurs, petty business owners, and laborers	15
April 18, 2024	Paschim Palakata in Chiringa Union under Chakaria		7

April 18, 2024	Paschim Palakata in Chiringa Union under Chakaria		10
April 20, 2024	Satgharpara in Matarbari Union under Moheshkhali	Students, jobless and laborers	17
Total			**49**

Source: RAP Study Results

Table 9.2.39 Summary of the Major Issues Raised

Date & Venue	Question/Raised Issue	Responses
Issues raised in the consultation meetings		
18th April 2024 Chakaria Municipality	Will we get water for farming and cultivation through this project?	**DPHE:** Water will only be used for household consumption, business institutions and economic zones
22nd April 2024 Fasiakhali Union	The project will need huge number of manpower both skilled and unskilled. We request to appoint people from the union	**RAP Survey Team**: The project will need both skilled and unskilled laborers during construction and operation phase. Local people will be preferentially deployed in the project activities.
5th May 2024 Kakara Union Parishad	Sometimes the affected do not get the compensation money because of the broker circle, what is the plan of this project regarding this issue?	**RAP Survey Team:** We are very much aware of this issue; a grievance committee will be made to resolve this issue through local Administrative and Representative officials
20th April 2024 Kalarmarchhara Union Parishad	If this much water is taken from the river, the river will be damaged. What is the plan for saving the river?	**RAP Survey Team**: The water that will be collected from the river is going to be the extra water that will be collected from the overflowing of the river during rainy season.
	What is the guarantee that the water is safe to drink and doesn't have any harmful bacteria or chemicals in it?	**DPHE:** This project will be implemented by DPHE, so they will ensure water quality.
17th April 2024 Lakhyarchar Union Parishad	During the construction period, roads, culverts, drains etc. will be damaged, who will repair those?	**DPHE:** We hope through this project none of you will suffer from any loss, but if there is any damage the project authority will take responsibility to fix that.
21st April 2024 Pachim Bara Bheula Union Parishad	If personal land falls under the project area how much will the Government pay for it?	**RAP Survey Team:** According to Acquisition and Requisition of Immovable property Act, 2017, affected landowners will get compensation including 200% premium i.e. 3 times of average transacted price.
18th April 2024 Chiringa Union Parishad (Palakata)	In the project area there are few day laborers who take land on lease to do farming or cultivation, how will this problem be eliminated?	**RAP Survey Team:** After project implementation, the farmers will get compensation for their crops, according to the clause of the lease necessary steps will be taken to break the lease.
Issues raised in the FGS		
8 no. ward, Chakaria municipality	There are many disable people who are talented and capable of doing job like normal people. The SCRWSP should give priority to these disable people according to their capability.	**RAP Survey Team:** Thank you for this wonderful suggestion. Women and Vulnerable group will be preferred in construction work.

Date & Venue	Question/Raised Issue	Responses
Issues raised in the consultation meetings		
	This will empower them.	
Chiknipara, Kalamarchora Union, Moheshkali, Cox`s Bazar	What types of benefits will be getting from the project particularly vendors	**RAP Survey Team:** There will be various business arrangements for the local people, especially the vendors. They will be able to do business continuously during and after the project. During the implementation of the project, they will have the opportunity to do business among the local people and those engaged in the project.
Dhokhin Masgata, Chiringa, Chakaoria, Cox`s Bazar	The farmers harvest paddy, nut and vegetables through the water of the Mahamahuri. When the project retention water from this river. It may have negative impacts on agriculture.	**RAP Survey Team:** During the rainy season the project will be collecting water from the Mahamayuri River, which does not collect during paddy harvesting period. Therefore, there is no possibility of any negative impact for agriculture.

Source: RAP Study Results

(2) 2nd Stakeholder Meeting

The 2nd stakeholder meeting was scheduled to be held around September 2024, however, it has been postponed due to the security risks in the area after the administrative change in Bangladesh in August 2024. The 2nd stakeholder meeting has not been held during the duration of this Preparatory Survey.

9.3 Assessment on Gender Considerations

9.3.1 Status on Gender Mainstreaming in Bangladesh

(1) National Level Mainstreaming

It is reported that female participation in the workforce has increased from 36.3% in 2016-17 to 42% in 2022[8], with huge participation in ready-made garments sector, small-scale and self-employment whereby about 63% of workers in the garment sector are women while 92% of microfinance borrowers are women. In education, a gender parity of 93.6% is achieved in primary and secondary education. Additionally, a Gender Responsive Budget (GRB)[9] was introduced in the Fiscal Year (FY) 2009-10 for women's advancements and rights. Initially, only the Ministries of Education, Health & Family Welfare, Social Welfare and Disaster Management were included. By the FY 2022-23, 44 ministries were included. There are reports on potential reduction in certain forms of violence, yet an overall increase in physical or sexual partner and non-partner violence which is attributed to COVID-19 pandemic[10]. Significant regulations on gender mainstreaming are Bangladesh are tabulated below

[8] Quarterly Labor Force Survey 2022, Bangladeshi

[9] https://mof.portal.gov.bd/sites/default/files/files/mof.portal.gov.bd/budget_mof/001130ba_9cb8_4955_9f07_f9ba27ca7de9/Gender%20Budget%20Report%202023-24%20(English%20for%20Website).pdf

[10] https://asiapacific.unwomen.org/sites/default/files/2024-04/bd-c836-gender-equality-brief_bangladesh_2024.pdf

Table 9.3.1 Regulations on Gender Issues

No.	Regulation	Description
1	Domestic Violence (Prevention and Protection) Act	Defines a domestic violence and set penalties
2	Child Marriage Restraint Act, 2017	Sets the legal age for marriage,18 years for women and 21 years for men
3	National Children Policy 2011	Focuses on the general well-being of the girl child such as preventing child marriage, addressing abuse.
4	The National Education Policy 2010	Focuses on women's education

Source: GAP Survey Results

(2) Gender Mainstreaming in DPHE

A "City-Wide Inclusive Sanitation Support Cell" has been created to implement a National Strategy for Water Supply and Sanitation-2021[11]. The Support Cell also focuses on promoting gender equality and women's empowerment throughout the water supply and sanitation value chain. Also, DPHE has instituted a Gender and Development Forum (GDF) to proactively advance gender equality and embed gender perspectives across its projects and programs. Through the GDF, a Gender Action Plan was crafted focusing on seven key areas tabulated below.

Table 9.3.2 Gender Action Plan by DPHE

No.	Action Plan	Description
1	Gender equality and inclusion in projects and programs	Promotes integrating of gender-transformative approaches into all aspects of project planning, implementation, and monitoring
2	Policy adoption and strategy development	Ensures adoption, development, and implementation of gender transformative policies and strategies
3	Sex, Age, Disability Disaggregated Data (SADD) data collection, monitoring, and evaluation	Emphasizes on collection of disaggregated data to track progress on gender equality and women's empowerment
4	Capacity building	Emphasizes on capacity building to strengthen gender mainstreaming and awareness within DPHE and its stakeholders
5	Enabling Gender-friendly working Environment	Ensures a more welcoming and inclusive workplace for all its staff
6	Partnership, Network, Resource Mobilization, and Others	Emphasizes partnerships to amplify its impact toward achieving gender equality and women's empowerment in its initiatives.
7	Gender and Development Forum's Service Box Update on DPHE Website	A centralized repository for gender-related materials in DPHE

Source: GAP Survey Results

[11] https://itn.buet.ac.bd/web/resources/national-strategy-for-water-supply-and-sanitation-2021/

9.3.2 Project Related Gender Issues

(1) Methodology for Gender Assessment

Table 9.3.3 Methodology for Gender Survey

No	Methodology	Description
1	Household questionnaire survey	240 HHs, 81.67% in Chakaria and 18.33% in Moheshkhali. Of the total HHs, 61.38% women and 38.62% men
2	Focus Group Discussions (FGDs)	4 FGDs, 3 women groups and 1 adolescent girls
3	Key Informant Interview (KII)	17 KII involving Local Government Representatives including women representative, MIDI authorities and DPHE Dhaka office

Source: GAP Survey Results

(2) Summary of the Findings

Regarding sources of water, communal wells are mentioned as a primary source by 48.78% of the respondents followed by river (21.14%), lake (18.70%), and pond (5.69%). Again, 86.18% of the respondents indicated that water sources were located within 500 m from their homes. Water is being collected mainly by using pitchers (41%), followed by plastic vessels (26%) and containers (17%), and responsibility of water collection lies more on women (83.33%), while joint collection was mentioned by 13.01% of the respondents and as men's responsibility was mentioned by 3.66% of the respondents.

Access to water during the dry season was mentioned as a challenge resulting in walking a long distance to fetch clean water and must stand in long queuing. Again, about 17% of the respondents said they had encountered Sexual and Gender-Based Violence (SGBV) while fetching water that included eve teasing, emotional/psychological abuse, bad touch and sexual violence. Women and girls shared their worries on increased SGBV as their local environment is transformed into an economic zone. Additionally, in the FGDs women expressed the feeling of being discriminated against in construction jobs. They mentioned they face difficulties accessing construction jobs despite the ongoing development activities.

On the matter of urgent needs, 67% of female respondents identified clean 'water for drinking & cooking activities' as a crucial need. Similarly, male responded on the close view indicated that 'clean water storage tanks' was a crucial need (42%) followed by construction near the locality (32%). In the FGDs, inclusion in the employment opportunities in construction activities was requested by women.

9.3.3 Gender Action Plan

Land acquisition by the project will have disproportionate impacts on vulnerable and female headed households. However, additional cash assistance and income and livelihood restoration for these groups are provisioned by the RAP. Also, based on the on-ground findings on gender issues and in-line with the DPHE's gender action plan, the following actions and indicators are developed for consideration during implementation of the Project.

Table 9.3.4 Actions and Indicators for Gender Mainstreaming by the Project

Activities	Indicators	Responsible Bodies	Time Frame	Expected Output
Implement gender-sensitive hiring practices for construction works, and PMO of DPHE by setting a target number of female workers. Ensure Contractor's contract includes a clause to hire female workers.	Number of female workers	Contractors, and DPHE	Throughout the project life	Increased number of females in the labor market.
Provide training on gender equality and sensitivity to construction staff.	Number of gender related training conducted.	DPHE and contractor	Regular intervals	Reduced gender related cases by construction staff
Monitor and address any gender-based discrimination by construction workers and other people.	Number of gender-related cases reported and resolved.	DPHE and contractor's	Regular intervals	Reduced gender related cases in the Project area
Ensure equal access to water supply services for men and women in the project area.	Percentage of female-headed households accessing water supply services. Distance to water sources	Operations and Maintenance Team-DPHE	Throughout the operational phase	Increasing number of female-headed households with access to water Reduced distance to water sources

Source: GAP Survey Results

CHAPTER 10 STUDY ON PROJECT EFFECTS

10.1 Economic and Financial Internal Rates of Return

10.1.1 Methodologies and Conditions

Economic analysis evaluated the social and economic validity of the Project by calculating the economic benefits and costs of the "With" and "Without" cases of the Project and then by calculating the economic internal rate of return (EIRR). The "With" and "Without" cases of the project are defined as follows,

- Without Project: Companies in Moheshkhali EZ and residents in the priority areas in Chakaria Pourashava and Matabari Union need to get water from tube wells. Since the quality of water is not good based on the willingness to pay (WTP) survey, a percentage of using bottled water for drinking and cooking will increase every year.
- With Project: Water will be supplied to companies and residents from 2033 to 2065 by piped water supply facilities of the Project in Moheshkhali EZ, Chakaria Pourashava, and Matarbari Union.

The financial situation during the project period was analyzed and evaluated by simulating financial models. The financial analysis calculated the financial internal rate of return (FIRR) of the Project by using revenue, subsidies, and financial costs.

Economic and financial analyses were conducted based on the following conditions as shown in Table 10.1.1.

Table 10.1.1 Conditions of Economic and Financial Analysis

Item	Conditions	Remarks
Project Scope	The water supply project in Moheshkhali EZ and the priority areas in Chakaria Pourashava and Matarbari Union by construction, operation and maintenance of the facilities.	The facilities are 1) Intake, 2) Pipeline Works 3) Raw Water Reservoir, 4) Water Treatment Plant, and 5) Distribution Reservoirs.
Project Period	2026-2065	Construction period:2026-2034Q2, Operation period: 2034Q3-2065
Price Level Year	2024	-
Physical Contingency	5%*	Construction and Consultant
Exchange Rate	1 USD=¥146 1 USD=BDT 118 1 BDT=¥1.24*	-
Social Discount Rate	12%**	According to the Planning Division Circular of Planning Commission of the Government of Bangladesh, 12% should be used for economic discount rate. It is also appropriate based on the

Item	Conditions	Remarks
		description of ADB's guideline[1].
Standard Conversion Factor (SCF)	0.9***	It is the conversion factor to be applied to costs at financial prices in order to convert them to economic costs in Bangladesh.

*Source: General Guideline, September 2024, JICA **Source: "Cost benefit Analysis for Development A Practical Guide, 2013, ADB, and Handbook on Cost-Benefit Analysis (CBA) of Public Investment Projects, 2024, Bangladesh Planning Commission, Government of Bangladesh, ***Source: DEVELOPMENT PROJECT PROFORMA/PROPOSAL (DPP) MANUAL (Instructions for Preparing Development Project Proposal), 2014, General Economics Division, Bangladesh Planning Commission, Government of the People's Republic of Bangladesh

10.1.2 Economic Analysis

(1) Economic Costs

1) Capital investment costs

The following costs were used in the economic analysis: i) direct construction cost, ii) administration cost, iii) consulting service cost, and iv) physical contingency. Price contingency and transfer payment (land acquisition costs, tax and subsidies) are excluded from the economic costs.

2) Operation and maintenance costs

The O&M costs are included in the above capital investment costs.

(2) Economic Benefit

Economic benefits of the Project are 1) benefit of water usage (incremental and non-incremental), 2) benefit of decrease of water related diseases by continuous supply of good quality water to more residents and 3) benefit of increase of tourism income.

1) Non-incremental Benefit

Non-incremental benefit of the water supply project is estimated as the cost of alternative water sources. The beneficiaries of this project will use alternative water sources in the "Without" case. Therefore, the project will reduce the costs which would be spent on those alternatives.

JICA Survey Team conducted a WTP Survey (2024), which includes a questionnaire regarding water consumption of households per day without the project in the target area. Average water consumption per person per day without piped water supply is 40 litters per capita per day (lpcd). The average household size is 4.3 persons.

Next, the combined alternative water cost was estimated based on the survey and the information below. The percentage of water usage is based on results of the WTP survey. The following table shows the alternative water cost which JICA Survey Team assumed. The combined alternative water cost, which is the non-incremental benefit of this project, is estimated as BDT 347.6/m^3.

[1] The current practice of applying a uniform social discount rate (SDR) of 10%–12% to all development projects in all countries is still appropriate in a changing world.

Table 10.1.2 Combined Alternative Water Cost

Item	Cost (BDT/m^3)	Percentage of Usage
Average water cost of tube well	0.1	94.87%
Average cost for bottled water	12,910	2.69%
Average price of water of water tankers/ vendors	10	2.44%
Combined alternative water cost	347.6	-

Source: JICA Survey Team

2) Incremental Benefit

The project will increase the water consumption at the price of the beneficiaries' WTP for the new piped water service (incremental benefit) while it substitutes their water consumption from other sources (non-incremental benefit). Incremental benefit was estimated based on the results of the WTP survey. The average WTP per household per month was estimated at BDT 202/month. 19% of respondents are from pourashavas while 81% of the respondents are from unions. The water demand per capita in pourashavas was set at 120 lpcd while that in union was set at 62 lpcd. Thus, incremental water volume and WTP per m^3 is calculated as follows,

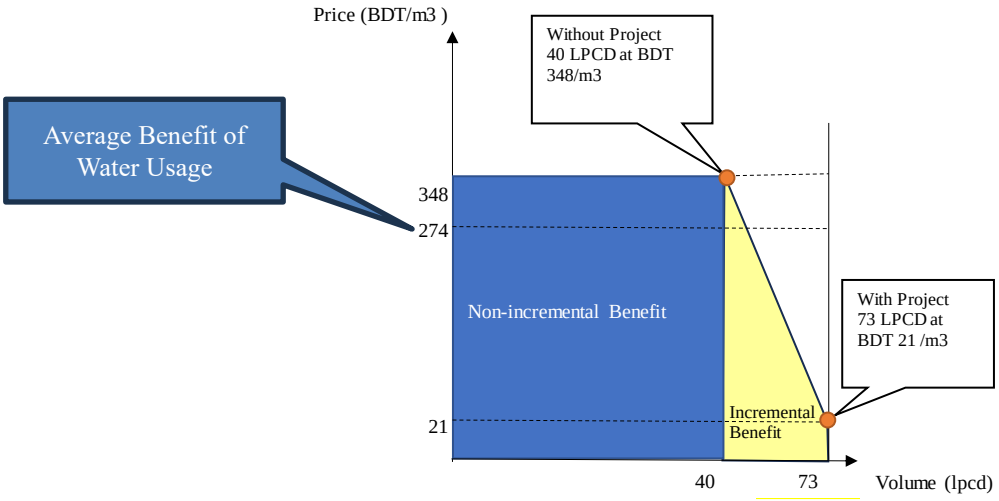
120*0.19+62*0.81=73.02 litters/person/day

BDT 202 / (73 lpcd *4.3 person per household*30 days) = BDT 21.4 /m^3

3) Benefit Calculation of Water Usage (Incremental and Non-incremental)

Based on the non-incremental and incremental benefits estimated above, the estimation of average economic benefit is BDT 274/m^3 which is shown in Figure 10.1.1. The calculation for average economic benefit of water usage is conducted as follows,

Average Benefit of Water Usage= ((BDT 348/m^3*40 lpcd)/73 lpcd) + ((BDT 348/m^3+BDT 21/m^3)) * (73 lpcd-40 lpcd)/ (2*73 lpcd)= BDT 274/m^3



Source: JICA Survey Team

Figure 10.1.1 Average Economic Benefit of Non-incremental and Incremental Benefits

Annual economic benefit of incremental and non-incremental water usage is calculated as follows,
Annual sales of water volume (m^3/year) * Average economic benefit of incremental and non-incremental water usage (BDT 274/m^3)
Annual sales of water volume are shown in Table 10.1.3.

Table 10.1.3 The Annual Sales Water Volume of the Project

Unit: m^3/year

Item	2034	2035	2036	2037
Industry	13,865,803	28,631,330	28,631,330	28,631,330
Municipalities	5,466,970	11,081,765	11,231,719	11,381,673
Item	2038	2039	2040	2041-2065
Industry	28,631,330	28,631,330	28,631,330	28,631,330
Municipalities	11,531,628	11,681,582	11,831,536	11,981,490

Source: JICA Survey Team

4) Benefit of decrease of waterborne diseases

The reduction in waterborne diseases is expected to result from improved sanitation due to the improvement of the water supply system compared to the With Project and the Without Project. The reduction in social costs spent on treatment was quantified as a benefit. The annual benefit from 2040-2065 was estimated to be BDT 20 million.
Benefit from reduced health care costs = "total number of beneficiaries" * "incidence rate of waterborne diseases (%/year)" x "average social cost of treatment (BDT)" * "estimated reduction rate (%)"
"Incidence rate of waterborne diseases (%/year)"=1.64%[2]
"Average social cost of treatment (BDT per treatment)" =7,345[3]
"Estimated reduction rate (%)" =80%[4]
The number of potential beneficiaries is shown in Table 10.1.4. Since the target year of this project is 2041 and the number of beneficiaries in 2041 is the maximum for the Project, the beneficiaries from 2042 to 2065 are same as those in 2041.

[2] Source: Health Bulletin, 2015, Director General of Health Services (DGHS), Ministry of Health and Family Welfare, Bangladesh
[3] CPI rate is reflected on average treatment cost in 2015 (BDT 4,178.8). Source: 1. Abdur R. S. and et al (2018) "Economic Cost of Hospitalized Diarrheal Disease in Bangladesh: A Societal Perspective", 2. International Monetary Fund (2024) World Economic Outlook Database
[4] Source: "Water pollution in Bangladesh and its impact on public health", 2019, Md. Khalid Hasan et al.

Table 10.1.4 Number of the Potential Beneficiaries of the Project

Unit: people

2034	2035	2036	2037
188,075	191,486	194,058	196,630
2038	2039	2040	2041-2065
199,202	201,774	204,346	206,994

Source: JICA Survey Team

5) Benefit of Increase of Tourism Income

Benefit of increase of tourism income of Cox's Bazar is expected by implementation of the Project since Cox's Bazar is a popular tourist place in Bangladesh. Many workers who work in the tourism industry live in Cox's Bazar. The annual income of the tourism sector of Cox's Bazar stands at USD 1.3 billion[5]. JICA Survey Team estimated an impact on the tourism income of Cox's Bazar with the Project based on the current population of the target places of the Project and it is shown in Table 10.1.5.

Table 10.1.5 Estimated Percentage of an Impact on Tourism Income

Item	Percentage
Estimated Percentage of an Impact on Tourism Income	5.0%

Source: JICA Survey Team, Reference: Bangladesh Population Census 2022, Bangladesh Bureau of Statistics.

Benefit of increase of tourism income of Cox's Bazar with the Project is calculated as follows,
The income of the tourism sector of Cox's Bazar * Estimated Percentage of an Impact on Tourism Income
The above benefit will not be obtained in case the project is not implemented. The water quality without the Project would be bad and it could be one of the reasons for the decline in the number of tourists in Cox's Bazar area.

(3) Results and Evaluation

1) Results

Table 10.1.6 shows the results of the economic analysis of the Project. The EIRR of the Project is 12.9% which is higher than the social discount rate (12%). The benefit cost ratio (BCR) is higher than 1.0 and the economic net present value (ENPV) is plus. Therefore, the Project is evaluated as economically viable.

Table 10.1.6 Results of Economic Analysis

Indicators	Results
EIRR (%)	12.9
BCR	1.08
ENPV (BDT in Million)	4,354

Source: JICA Survey Team

[5] Source: Inspira advisory & consulting limited (2020) "Inspira Extrapolation"

2) Sensitivity analysis

Sensitivity analysis regarding a 10% cost increase and 10% benefit decrease was implemented. Results of the sensitivity analysis are shown in Table 10.1.7. The EIRR of the 10% cost increase case and the 10% benefit decrease is lower than the social discount rate (12%). The BCR is lower than 1.0 and the ENPV is plus. Therefore, this case is not economically feasible.

Table 10.1.7 Results of Sensitivity Analysis

Indicators	Base Case	Cost 10% Increase	Benefit 10% Decrease
EIRR (%)	12.9	11.8	11.7
BCR	1.08	0.98	0.97
ENPV (BDT in Million)	4,354	-1,001	-1,437

Source: JICA Survey Team

10.1.3 Financial Analysis

(1) Financial Costs

1) Capital investment costs

The following costs are calculated in the financial analysis: i) direct construction cost, ii) consulting service cost, iii) land acquisition (LA) cost, iv) administration cost, v) physical contingency and vi) tax.

2) Operation and maintenance costs

The O&M costs are included in the above capital investment costs.

(2) Revenues

Revenues of the Project is the water tariff revenue and subsidies from the government of Bangladesh. The tariff revenue is calculated by water tariffs, the water collection rate (93%[6]) and the water sales volume. There are three cases of water tariffs which are *Case 1: no tariff increase, Case 2: 5% increase every 5 years, and Case 3: 10% increase every 5 years with and without subsidies*. JICA Survey Team proposed an amount of the subsidy that will result in FIRR of 0 or more. Since 5% of the income of water tariff of EZ will be paid from DPHE to BEZA as a service charge, this charge will not be included as a revenue of FIRR calculation. Revenue of FIRR calculation should be that of the implementation agency “DPHE” and the above charge is not revenue of DPHE. Water tariffs, the water sales volume and the revenue of the Project are shown in Table 10.1.8, Table 10.1.3 and Table 10.1.9. Tariff increase cases are shown in Table 10.1.10 and Table 10.1.11. The amount of subsidy is shown in Table 10.1.12.

[6] Reference: CWASA (2014-2022)

Table 10.1.8 Proposed Water Tariff of the Project without Tariff Increase (Case 1)

Type of Consumer	Monthly Tariff (BDT/m3)	% of Connection	Enrollment Fee per connection (BDT)	Connection cost per connection (BDT)	Coefficient
Municipalities					
Residential (Normal) Connection	15	81%	200	2,000	1
Low-income Consumer	11	12%	200	1,000	0.7
Institutional Consumer	23	3%	200	3,000	1.5
Commercial Consumer	30	4%	200	10,000	2
EZ	57(+5%*)	100%	-	20,000	-

*Note: 5% will be paid to BEZA as a service charge.
Source: JICA Survey Team (2024)
Reference: The World Bank, The Bangladesh Municipal Water Supply and Sanitation Project (BMWSSP), 2024, DPHE

Table 10.1.9 Revenue of the Project in Case 1 with Subsidies

Unit: BDT in Million/year

Item	2034	2035	2036	2037	
Revenue from water sales	812	1,674	1,673	1,675	
Subsidies	3,169	6,528	6,523	6,532	
Total	3,981	8,202	8,196	8,206	
Item	2038	2039	2040	2041	2042-2065
Revenue from water sales	1,677	1,679	1,681	1,683	1,681
Subsidies	6,540	6,548	6,556	6,565	6,555
Total	8,217	8,227	8,238	8,248	8,236

Source: JICA Survey Team (2024)

Table 10.1.10 Tariff Increase in Case 2 (5% every 5 years)

Unit: BDT/m3

Type of Consumer	2033	2037	2042	2047	2052	2057	2062
Municipalities							
Residential (Normal) Connection	15.0	15.8	16.5	17.4	18.2	19.1	20.1
Low-income Consumer	11.0	11.6	12.1	12.7	13.4	14.0	14.7
Institutional Consumer	23.0	24.2	25.4	26.6	28.0	29.4	30.8
Commercial Consumer	30.0	31.5	33.1	34.7	36.5	38.3	40.2
EZ	60.0	63.0	66.2	69.5	72.9	76.6	80.4

Source: JICA Survey Team (2024)

Table 10.1.11 Tariff Increase in Case 3 (10% every 5 years)

Unit: BDT/m3

Type of Consumer	2033	2037	2042	2047	2052	2057	2062
Municipalities							
Residential (Normal) Connection	15.0	16.5	18.2	20.0	22.0	24.2	26.6
Low-income Consumer	11.0	12.1	13.3	14.6	16.1	17.7	19.5
Institutional Consumer	23.0	25.3	27.8	30.6	33.7	37.0	40.7
Commercial Consumer	30.0	33.0	36.3	39.9	43.9	48.3	53.1
EZ	60.0	66.0	72.6	79.9	87.8	96.6	106.3

Source: JICA Survey Team (2024)

Table 10.1.12 The Amount of Subsidy in Each Case

Unit: BDT in Million

Item	2033-2065
Case 1	206,284
Case 2	198,278
Case 3	186,880

Source: JICA Survey Team (2024)

(3) Results and Evaluation

Cashflows of financial analysis in all cases are shown in Supporting Report D. The FIRR and Net Present Value (NPV) were calculated as shown in Table 10.1.13. Case 1 with 390% subsidy, Case 2 with 325% subsidy, and Case 3 with 265% subsidy are financially feasible.

(1) Case 1

- The FIRR could not be calculated due to lack of revenue in Case 1 without subsidy. The revenue will cover O&M costs although it is not enough to cover the construction costs. NPV is -BDT 204,139 million. Weighted Average Cost of Capital (WACC) which is 0% based on the yen loan rate and inflation rate is used as a hurdle rate.
- The FIRR is 0.0% in Case 1 with 390% subsidy rate against the revenue from water sales. It is financially feasible since it is higher than the WACC. NPV is BDT 2,145 million.

(2) Case 2

- The FIRR could not be calculated due to lack of revenue in Case 2 without subsidy. The revenue will cover O&M costs although it is not enough to cover the construction costs. NPV is -BDT 196,024 million.
- The FIRR is 0.0% in Case 2 with 325% subsidy rate against the revenue from water sales. It is financially feasible since it is higher than the WACC. NPV is BDT 2,254 million.

(3) Case 3

- The FIRR could not be calculated due to lack of revenue in Case 3 without subsidy. The revenue will cover O&M costs although it is not enough to cover the construction costs. NPV is -BDT 186,512 million.
- The FIRR is 0.0% in Case 3 with 265% subsidy rate against the revenue from water sales. It is financially feasible since it is higher than the WACC. NPV is BDT 368 million.

Table 10.1.13 FIRR and NPV of the Project

Case	FIRR	NPV (BDT in Million)	Subsidy Rate against Revenue from Water Sales
Case 1 without subsidy	n.a.	-204,139	0%
Case 1 with subsidy	0.0%	2,145	390%
Case 2 without subsidy	n.a.	-196,024	0%
Case 2 with subsidy	0.0%	2,254	325%
Case 3 without subsidy	n.a.	-186,512	0%
Case 3 with subsidy	0.0%	368	265%

Source: JICA Survey Team (2024)

10.2 Operation and Effect Indicators

Operation and effect indicators with the target year of 2035, which is about two years after project completion and start of operation, are set as below.

Table 10.2.1 Operation and Effect Indicators of the Project

Indicators	**Original (2024)**	**Target (2035)**	**Remarks**
Operation Indicators			
Population served (person)	N/A	191,486	Refer to Water Demand Forecast Result (Table 5.4.6)
Daily Average Water Production (m^3/day)	N/A	92,533 m^3/day For Industrial: 68,244 m^3/day For Domestic: 24,289 m^3/day	Refer to Water Demand Forecast Result (Table 5.4.6)
Effect Indicators			
Percentage of Population Served※1	N/A	80% (Domestic) 100% (Industrial)	Refer to Water Demand Forecast Condition 5.1.2(3), 5.1.2(4), and Table 5.4.5
Water Supply Per Capita (lpcd)※2	N/A	62 lpcd (Union) 120 lpcd (Pourashava)	Refer to Water Demand Forecast Condition (Table 5.4.5)
Income of Water Sales	N/A	BDT 1,674 million per year	Refer to Revenue of the Project in Case 1 with Subsidies (Table 10.1.12)

Note: ※1 Percentage of Population Served for Domestic Water = Population Served in Chakaria Pourashava and Matabari Union/ Residential Population in Chakaria Pourashava and Matabari Union
Percentage of Population Served for Industrial Water = Number of Business Establishment Served in Moheshkali EZ (Dhalgata)/Number of Business Establishments in Moheshkali EZ (Dhalgata)
※2 Water Supply Per Capita＝Daily Consumption by the Project/Population Served in Chakaria Pourashava or Matabari Union

Source: JICA Survey Team

10.3 Qualitative Effect

(1) Improvement of Bangladesh Investment Climate

If the Project is implemented and stable water supply is assured, it will be the first example of industrial water supply for the MIDI Area. This may send a positive message to potential investors, and more investments of domestic and foreign companies in the general MIDI Area will be expected as an indirect effect of the Project. (It must be noted industrial water supply by the Project will be limited to Moheshkhali EZ (Dhalghata) and the direct effect of the Project will be limited to the improvement of said EZ.) At the time of this Preparatory Survey, investments in the MIDI region are mainly done by domestic companies. Local conglomerates with bargaining power with government authorities are regarded in the MIDI vision survey as entities that can carry out the investments. In addition, local companies need the cooperation and participation of foreign companies in terms of both technology and finance. If the government of Bangladesh creates a legal and institutional investment environment that allows foreign companies, including those from Japan to participate, more investments from foreign firms will be promoted.

(2) Achieving sustainable water resources management

The qualitative benefits of this project are studied and identified as specifically as possible along with clear reasons why such benefits are likely to be realized, based on the collected data and information through this preparatory survey.

1) Moving away from dependency on groundwater use

Currently, the water resources in the target area mainly depends on groundwater. However, the results of the groundwater survey in the "Data Collection Survey on Water Resources Development in Southern Chattogram" (JICA, 2022)" have shown that excessive groundwater use has led to a decline in the groundwater level over time and saltwater contamination of the groundwater in some areas. In addition, some of the water currently sourced from groundwater has been observed to contain foreign materials such as iron. It is pointed out that the water quality is being poor in the target area.

By switching the main water resources from groundwater to surface water, this project will lead to the sustainable use of water resources in the target areas and the sustainable conservation of groundwater resources. In addition, the purified water can be used for drinking water and daily life, which is expected to improve the quality of health and hygiene for local residents in the supply area and the safety of drinking water. These qualitative benefits are summarized below.

Table 10.3.1 Qualitative Benefit by Moving Away from Dependency on Groundwater Use

Sustainable water resources management	Descriptions
i) Sustainable use of water resources from surface	Since the water resources of the Project is a river water that is a permanent resources , the water volume will be available for

Sustainable water resources management	Descriptions
water	sustainable and stable use even after the target period of the economic evaluation (2065).
ii) Sustainable use of safe water	By supplying safe and purified water for the target population (206,994 people, intangible benefits such as improvement of health and hygiene and avoidance of health damage (infectious disease prevention) can be expected.
iii) Conservation of groundwater resources	By replacing future water resources from groundwater use to surface water use, it will be possible to conserve 19.6 MCM[*1] of groundwater resources per year. This will prevent the falling of groundwater level in the target and surrounding areas of the water supply areas. In addition, it will prevent saltwater from mixing into the groundwater. These will enable the target area and surrounding areas to continue to use groundwater sustainably for domestic water, irrigation, etc.

Note: *1: designed raw water reservoir storage volume

Source: JICA Survey Team

2) Horizontal expansion of water resource management systems

In the south Chattogram Region in Bangladesh, there are only a few reservoirs to store a large amount of water during the rainy season, thereby floodwaters flow directly down the rivers and rapidly into the sea. The water utilization rate is low.

As in this project, water resources development and management, such as construction, operation and maintenance of water storage facilities that will adjust the seasonal fluctuations of the river discharge, is a priority challenge throughout Bangladesh. By expanding this type of water resources development and management system to applicable rivers, it is expected that the water utilization rate throughout the country will improve.

(3) Qualitative effects of climate change countermeasures projects

1) Adaptation Measures

The adaptation of the climate change is described in Sub-section 4.4.2. By these adaptation measures, resilience and safety level of water supply and water use against climate change will be enhanced.

2) Mitigation measures of climate change

The implementation of this project is expected to save from large production of the CO2 emissions by introduction of advanced energy-saving equipment and machines during construction and operation, management and maintenance of the intake and water supply facilities.

In case of introduction of water quality improvement measures in raw water reservoir (aeration, regular dredging, there might be an effect of reduction in methane gas emissions from reservoir bottom mud.

3) Multipurpose use of the raw water reservoir

The raw water reservoir to be constructed in this project will be located at the center of the future MIDI regional economic developments. It will be an artificial lake of approximately 330 ha, which will have an easily accessible, high-quality waterfront space. This raw water reservoir can be used for multiple purposes, such as for recreation and as a fish pond, etc. In addition, since the water level of the reservoir is relatively stable, it is possible to use the lake surface for floating solar power generation. In addition, in the case of emergencies due to natural disasters, open large spaces such as spoil sites and embankment roads can be used as evacuation places, and the stored water in the raw water reservoir can be used as an emergency water source for surrounding residents.

4) Secondary effects of river facility construction

The construction site of the intake facilities will be located in a raging channel of the Matamuhuri River, and a flood control master plan is currently being formulated. River training works of channel excavation and revetment construction to stabilize the river channel can be used as part of future flood control measures in the basin. In addition, construction of a new bridge for the CC bypass road is planned immediately downstream of the intake site. The revetments to be constructed in this project will function as a protective work for the bridge abutments, and the stabilization of the river channel at the bridge site will also increase the safety of the bridge.