Environmental Impact Assessment (Draft)

February 2018

BAN: Rupsha 800 MW Combined Cycle Power Plant Project

Volume 1
(Component 1 – Rupsha 800 MW Gas-fired Combined Cycle Power Plant)

Prepared by North-West Power Generation Company Limited for the Asian Development Bank.

CURRENCY EQUIVALENTS
(as of 14 February 2018)

Currency unit	–	taka (Tk)
Tk1.00	=	$0.0120548
$1.00	=	Tk82.96

ABBREVIATIONS

ADB	–	Asian Development Bank
CCPP	–	combined cycle power plant
CITES	–	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COD	–	chemical oxygen demand
DO	–	dissolved oxygen
DoE	–	Department of Environment
DPHE	–	Department of Public Health Engineering
ECA	–	Environment Conservation Act
ECC	–	Environmental Clearance Certificate
ECR	–	Environment Conservation Rules
EIA	–	Environmental Impact Assessment
EMP	–	Environmental Management Plan
EMoP	–	Environmental Monitoring Plan
HSD		high speed diesel
IEE	–	Initial Environmental Examination
MoEF	–	Ministry of Environment and Forests
PMU	–	project management unit
RoW	–	right-of-way
SPS	–	Safeguard Policy Statement

WEIGHTS AND MEASURES

^{o}C	–	degreescelsius
dB(A)	–	A-weighted decibel
ha	–	hectare
NTU	–	Nephelometric Turbidity Unit
lac	–	100,000
kV	–	Kilovolt
MW	–	megawatt
mg/L	–	milligram per liter
m^2	–	square meter
$\mu g/Nm^3$	–	microgram per normal cubic meter
ppm	–	parts per million

GLOSSARY

Bangla	–	official language of Bangladesh
gher	–	farming where a pond is dug into a rice field to use for fish farming and with the dugout soil used to create dykes around the pond for growing vegetables (traditional agriculture system in Bangladesh)
hydrostatic testing	–	process of filling a pipeline with water, or a mixture of water and ethylene glycol or methanol to test the structural integrity of the pipeline under pressure
khal	–	Bangla word for a small channel or canal
thana	–	sub-district level of government administration, comprising several unions under the district
union	–	smallest unit of local self-government comprising several villages
upazila	–	Bengali for subdistrict (formerly called *thana*)

NOTE

In this report, "$" refers to United States dollars.

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EXECUTIVE SUMMARY

1.0 Introduction

1. The 2015-2016 Annual Report of the Bangladesh Power Development Board (BPDB) indicates that the installed generation capacity is 12,365 megawatts (MW). During this year, the maximum peak generation was 9,036 MW (15.6% higher than the previous year) while the maximum peak demand was 11,405 MW. This situation is expected to cause power outages and load-shedding. Lower generation capacity was due mainly to some generating plants out of operation for maintenance, rehabilitation and overhauling, and capacity of some plants de-rated due to aging. With an estimated 2017 population of 164.47 million, demand for power will continue to grow.

2. To mitigate the demand-supply gap in the power sector, the Government of Bangladesh (GoB) embarked on an aggressive plan with a goal to have 17,984 MW generation capacity by 2021. Aside from this, efforts to cushion the effects of load shedding include introducing a two-part tariff for 3-phase consumers to avoid or lessen use of power during peak hours, closure of shopping malls and markets after 8pm, staggering of holidays by area, encouraging consumers to use energy efficient lighting systems and appliances, and to keep the temperature of their air conditioning systems at 25^{o}C.

3. The Power System Master Plan 2016 recommends for diversification in the use of fuel for power generation such as domestic and imported coal and natural gas, oil, nuclear power, and renewable energy. As of December 2017, the energy mix in Bangladesh consist of 64.5% natural gas, 1.66% hydro, 4.8% power import, 6.4% diesel, 20.9% furnace oil, 1.81% coal, and 0.02% renewable. To advance this recommendation, North-West Power Generation Company Limited (NWPGCL), an enterprise of BPDB has taken the initiative to enhance the power generation capacity of Bangladesh in addressing the growing demand for electricity. This initiative will involve the construction of the new Rupsha 800 MW combined cycle power plant (CCPP) in Khalishpur Upazila, Khulna District in the administrative division of South-Western Bangladesh. The Rupsha 800 MW CCPP is designed to use natural gas as main fuel and high-speed diesel (HSD) as back-up to be used during emergency estimated at a maximum of 500 hours annually. Natural gas will be supplied by the Sundarban Gas Company Limited (SGCL) while HSD will come from Bangladesh Petroleum Corporation.

4. The GoB has applied for financing from the Asian Development Bank (ADB). The use of natural gas is consistent with the Energy Policy (June 2009) of ADB which indicates that in maximizing access to energy for all, “ADB will continue to support financing natural gas-based power plants because of their environmental benefit.” In addition, construction of combined cycle power plants is one of the existing mitigation actions of GoB to reduce greenhouse (GHG) emissions in meeting with their commitment to the Intended Nationally Determined Contributions (September 2015). The Islamic Development Bank (IsDB) is expected to co-finance about 20% of the total project cost.

2.0 Project Description

5. Key interrelated project components include: (i) *Component 1* – the development and operation of the Rupsha 800 MW gas-fired CCPP; (ii) *Component 2* – the construction of a 10-kilometer (km), 24-inch gas distribution pipeline from the existing Khulna City Gate Station (CGS) of SGCL and the related network infrastructure to ensure the reliable supply of fuel to the CCPP including a 2-km, 20 inch gas distribution pipeline branched off from the Khulna CGS to Rupsha

800 MW CCPP to the existing Khulna 225 MW CCPP owned by NWPGCL; (iii) *Component 3* – the construction of a 29.3 km, 230 kilovolt (kV), double circuit power transmission interconnection facility to transfer the generated power to the national grid at the existing Khulna substation; and (iv) *Component 4* – capacity strengthening of NWPGCL.

6. ***Land*.** Component 1 will be built in the (now abandoned) premises of the Khulna Newsprint Mill (KNM) factory. The total area occupied by KNM from its previous operations is about 87 acres (or 35.2077 hectares (ha)). NWPGCL will only require about 50 acres (or 20.2343 ha) to accommodate Component 1. The power block will occupy 6.37 acres, switch yard at 4.3 acres, gas supply facility at 2.31 acres, HSD supply facility at 2.72 acres, water treatment facility at 5.61 acres, and the balance of plant at 3.16 acres.

7. The power plant will use combined cycle gas turbine technology, comprising two identical generating units, each nominally rated at 400MW. Each combined cycle unit will consist of one gas turbine and one heat recovery steam generator (HRSG), forming a one-on-one configuration. At full capacity of 800 MW, the Rupsha power plant is capable of meeting 5% of the forecast peak demand of Bangladesh in 2022. The cooling system will be closed-loop forced-draft cooling tower system. The stack height of the steam turbine is 60 m while the gas turbine is 50 m.

8. NWPGCL opted to have CCPP with exhaust gas bypass system to allow for construction of the power plant in phases. This operational flexibility is critical for Bangladesh currently suffering from energy shortfall. Power generation through the open cycle mode awaiting for the completion of the combined cycle power plant will make a huge difference to Bangladesh currently suffering from severe power shortage. The exhaust gas bypass is useful to the system grid as the units can still provide partial load.

9. During start-up, the open cycle gas turbine can be commissioned using natural gas and put into commercial operation within 7 to 8 months prior to completion of the HRSG installation for the combined cycle power plant. This is where the bypass stack of 50 m will be used at flue gas temperature of 886^{o}C. With this high exit gas temperature, it is expected to have better air emission dispersion due to effective stack height. Simple cycle gas turbine will be used also in the event of HRSG downtime. It will not be economically feasible to shut down the entire power plant during HRSG downtime when the simple cycle power plant can be operational. This is the high operational flexibility inherent in combined cycle power plant which is an essential prerequisite from economic standpoint. Use of low-NO_x burner in the gas turbine will have a guaranteed emission below 25 ppmv.

10. ***Fuel requirements*.** Natural gas will be the primary fuel and will require a maximum of 125 million cubic feet per day (MMCFD). This will be supplied by SGCL from the Khulna CGS in Aronggatha through a 10 km, 24-inch gas distribution pipeline terminating to the regulation and metering station (RMS) at the power plant site. The pipeline will be constructed following the requirements of the Natural Gas Safety Rules 1991 (amended 2003). Composition of natural gas required will be a minimum of 85% mole methane (CH_4). The following sources from imported regasified liquefied natural gas (R-LNG) and domestic supply will provide adequate supply of natural gas for Component 1.

- FSRU Moheskhali - 500 MMSCFD of R-LNG will be made available by April 2018 developed by Excelerate Energy, USA-Bangladesh
- Summit LNG Terminal Company Limited – 500 MMSCFD R-LNG will be made available by October 2018

- GoB and RasGas (Qatar) has signed a deal in September 2017 for a 15-year LNG sales and purchase agreement to supply 1.8 million (M) tons LNG/year for 5 years and 2.5 M tons/year for the next 10 years
- According to Petrobangla, there will be additional supply (domestic) of 2,750 MMSCFD
- By 2021, Bangladesh Petroleum Exploration and Production Company Limited (BAPEX) will have 55 exploration wells and 31 development wells

11. The natural gas produced in Bangladesh is “sweet gas” (does not contain hydrogen sulfide) and thus, all the existing natural gas transmission and distribution pipeline networks are designed for high quality natural gas.

12. The use of HSD as secondary fuel will be required in case of emergency and is estimated to be about 500 hours maximum per year (or about 20 days assuming continuous operation of 24 hours). HSD requirement will be about 2,773 kiloliters (KL) per day. Two HSD storage tanks with a capacity of 15,000 cubic meter (m^3) will be constructed within the power plant site. Each storage tank can supply about 5 days of continuous operation on HSD. Fuel supply agreement between BPC and NWPGCL in November 2015 provides that the HSD will have a maximum sulfur content of 0.25%wt. In practice, BPC has provided NWPGCL with HSD with sulfur content of 0.1%wt analyzed in 2016 by the Chemical Engineering Department of Bangladesh University of Engineering and Technology.

13. ***Plant efficiency*****.** With an F-class gas turbine and operating on natural gas, the plant net LHV thermal efficiency of Component 1 will be 55.9% which is expected to have CO_2 emissions ranging from 348-374 g CO_2/kWh and when operating on HSD during emergency, the net LHV thermal efficiency will be 52.97%. Thermal efficiency is one of the reasons to ensure that Component 1 needs to operate only on natural gas and combined cycle power plant. This thermal efficiency is consistent with the IFC-EHS Guidelines for Thermal Power Plant 2008.

14. ***Water*****.** Raw water will be taken from the Bhairab River located east of the project site through two intake channels with an area of 12.5 m^2 each. The Feasibility Report (August 2017) indicates that a one-time water demand for both plants needed for the closed-loop forced-draft cooling system will be about 60,000 m^3 with 2,010 m^3/h as make up water. Make water will pass through the water treatment facility and about 1,780 m^3 will go to the two cooling towers (each at 890 m^3) while 230 m^3 will be diverted to the reverse osmosis plant then to the demineralization plant to provide the high quality water required by the gas turbine, HRSG, NO_x control water if running on HSD, etc. The effluent treatment plant (ETP) will receive about 1,030.5 m^3/hr from spent process water and blowdown from the cooling towers. Oily wastewater will pass through the oil-water separator prior to ETP. Discharge from the ETP will go to the monitoring basin where quality of water will be checked to ensure compliance with Schedule 10 of ECR 1997 and Table 5 of IFC-WB EHS Guidelines for Thermal Power Plants 2008. Water from the monitoring basin will be used for watering plants, cleaning and other general purpose washing. Water for domestic requirements such as drinking will come from the Khulna Water Supply and Sewerage Authority.

Implementation Arrangements

15. As the executing agency of the project, NWPGCL will create a Project Management Unit (PMU) to manage the day-to-day implementation of the project and will get the necessary technical support from SGCL for Component 2 and the Power Grid Corporation of Bangladesh (PGCB) for Component 3. The project will have a high-level Project Steering Committee (PSC) consisting of members from various government departments, NWPGCL, PGCB and SGCL and act as overseer of the project. The steering committee will meet every quarter to monitor progress

and will report to the GoB. The installation and commissioning of Component 1 is expected to be about 36 months.

16. NWPGCL has an Environmental, Health and Safety and Social (EHSS) Policy approved on 17 October 2015. Aside from the EHSS Policy, NWPGCL is also certified in ISO 9001, ISO 14001. BS OSHAS 18001 valid until October 2019.

3.0 Environmental Requirements

17. **National requirements.** The main environmental regulations in Bangladesh are the Environment Conservation Act (ECA) 1995 and the Environment Conservation Rules (ECR) 1997. Under these regulations, except for Component 4, all the three components of the Project are “Red” category requiring an environmental clearance certificate (ECC). Securing the ECC involves two steps: (i) issuance of locational (or site) clearance certificate (SCC), and then (ii) the ECC. An initial environmental examination (IEE) is required for the SCC and an environmental impact assessment (EIA) is required for the ECC. The terms of reference (TOR) of the EIA needs the approval of the Department of Environment (DoE). The TOR of the EIA for Component 1 has been approved by the DoE on 5 November 2017 (see **Annex 1**). NWPGCL has obtained exemptions for submitting an IEE in obtaining the SCC for all the project components as follows:

(1) Component 1 – 5 November 2017; DoE/Clearance/5584/2016/564
(2) Component 2 – 5 November 2017; DoE/Clearance/5668/2016/563
(3) Component 3 – 5 November 2017; DoE/Clearance/5669/2016/549

18. Without the EIA approved by DoE, NWPGCL cannot open a line of credit in favor of importable machineries and cannot start any physical activities for the project. In August 2016, NWPGCL contracted the Center for Environmental and Geographic Information Services (CEGIS), a Public Trust under the Ministry of Water Resources, to prepare the EIAs for the three components required by the DoE.

19. **ADB and IsDB requirements.** Component 1 is subject to the environmental requirements of both ADB and IsDB since NWPGCL is seeking their financial support. The Safeguard Policy Statement (SPS) 2009 of ADB sets out the requirements for environmental safeguard that applies to all ADB-financed projects. IsDB is still in the process of preparing its Statement on Environmental and Social Safeguards Principles, and Commitments to Environmental and Social Responsibility. Given this, ADB and IsDB agreed to adopt SPS 2009 as the unified approach to documentation, consultation, and disclosure requirements to be complied by NWPGCL for this project.

20. Under SPS 2009, projects are screened and categorized based on their potential environmental impacts. Following this screening procedure, the project is category A on environment which requires the preparation of an EIA. To streamline the preparation of the EIA, each component has an EIA such that Component 1 will correspond to Volume 1, Component 2 as Volume 2, and Component 3 as Volume 3. This EIA covers Component 1.

4.0 Description of the Existing Environment

21. The description of the environment was based on the project area where Component 1 will be located and the study area covering about 10-km radius from the power plant.

22. The project site is an area formerly used by the Khulna Newsprint Mills (KNM) Limited located in Khalishpur Thana, Khulna Division. KNM was under expatriate management from start in 1959 until the end of 1965 when it was put under the management of the East Pakistan Industrial Development Corporation.[1] KNM was the first and major producer of newsprint paper in Bangladesh using *Gewa* wood (*Excoecaria agallocha*), a native mangrove species in Bangladesh, as raw material. Sand well and Company, a Canadian firm, was engaged as a consultant in the construction and commissioning of KNM.

23. In 1969, problems were encountered with the steam supply needed to operate the three paper machines. By mid-1973, the Canadian International Development Agency (CIDA) has commissioned studies of KNM in order to define areas where Canadian aid might assist in rehabilitating the mill. A project advisor from CIDA was provided until 1976. However, beset with problems ranging from market behaviour after the independence, availability of spare parts, low capacity utilization (newsprint production at KNM has not been able to reach the levels achieved prior to independence), operational management, price of oil, interrupted supply of raw material due to security issues, etc., GoB stopped its operations completely in November 2002. A total of 2,128 persons are employed at KNM, 472 salaried, 1,506 permanent labour, and 150 casual labour.

24. No newspaper printing was involved in KNM operations but mainly production of newsprint using mechanical pulping from ground wood process as chips is not used for papermaking in Bangladesh. Mechanical pulping involves the use of mechanical energy to weaken and separate fibers from *Gewa*wood through grinding action. The process produces up to 95% pulp, however, since it does not dissolve lignin, fiber strength and age resistance of resulting pulp are low and the product has shorter fibers. Mechanical pulp is used mainly for lower grade papers like newsprint.

25. There are about 151 structures standing within the 50 acres consisting of 122 primary residential structures such as bungalow for the Managing Director, dormitories and residences of staff, kitchen and dining, guest house, and Ansar camps, etc. while the remaining 29 structures are non-residential like auditorium/cinema, water tank, fire fighting system, swimming pool and rest house, mosque, boys and girls school, etc.[2] The structures are mainly made from reinforced concrete, wood, tin sheets, pacca, and semi-pacca generally used in Bangladesh. The possibility of land contamination within the project site and the use of asbestos in the structures as insulation is unlikely.

26. At present, the two schools (one for boys and one for girls) are still being used and some of the abandoned buildings are used as residence by workers tasked to secure the property (appointed through GoB from Ansar Force), cook and cleaners. Outside of the 50 acres property but adjacent to the project site are the mosque and the mass graveyard marker of the freedom fighters who were killed in 1971 during the liberation war (*Mukti Bahini*) of Bangladesh. The mosque is still being used by about 10 local people every day for their prayers. The graveyard marker has a brick fence and is not listed as a cultural heritage by GoB but will be considered as

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1 The World Bank. Bangladesh: Survey of Steel, Pulp and Paper, and Leather Tanning Industries. Report No. 1219-BD. Industrial Projects Department. 30 November 1976. http://documents.worldbank.org/curated/en/879431468007479695/Bangladesh-Survey-of-steel-pulp-and-paper-and-leather-tanning-industries.

2 Bangladesh Ansar is a paramilitary auxiliary force responsible for the preservation of internal security and law enforcement in Bangladesh and administered by the Ministry of Home Affairs.

a physical cultural resource defined by SPS 2009.[3] Some vegetation has grown from the abandoned structures providing temporary habitat to some species.

Physico-chemical environment

27. Component 1 is located at elevation +3.5 m and +2.3 m towards the bank of the Bhairab River. Surrounding area is at elevation +3.5 m and +3.2 m MSL. This area is within the least vulnerable to earthquakes (Zone III). Climatological data recorded from 1985-2015 by the Bangladesh Meteorological Department were used to describe climate in the area. Khulna division falls under Aw category according to Köppen climate classification which is characterized by tropical wet and dry climate resulting to hot and humid summer and dry winter. Maximum monthly temperature ranges from 30.7ºC to 40.7ºC while minimum temperature varies between 6.4ºC to 22.2ºC. Average monthly humidity is 72.6% to 87.8% while average annual rainfall is 1,808 mm/yr. Wind speed ranges from 18.52 km/hr to 120.38 km/hr while wind direction varies depending on the season. According to the Hydrological Investigation and Model study of the Bhairab River by the Bangladesh Power cell in May 2016, the maximum flood level in the project site is estimated as 3.86 m PWD (4.32 MSL) in 100 years return period based on the yearly maximum water level of Khulna since 1946 (SW241 of the Bangladesh Water Development Board).[4]

28. Available continuous ambient air quality monitoring data from 2013-2015 recorded in Khulna CAMS-9 station of the DoE, Clean Air and Sustainable Environment (CASE) show that particulate matter 2.5 micrometers (µm) or less in diameter ($PM_{2.5}$) exceeded the National Ambient Air Quality Standards (NAAQS) limit of 65 µg/m^{3}for 24-hour averaging period and for particulate matter 10 micrometers (µm) or less in diameter (PM_{10}) exceeded the limit of 150 µg/m^3 for 24-hour averaging period in 2014. CASE project is funded by the World Bank which started the continuous ambient air quality monitoring in November 2011. Khulna CAMS-9 is about 2.5 km from the project site. Given that there have been no continuous ambient air quality measurements, the results from CAMS-9 can be considered as showing the long-term ambient air quality within the study area.

29. Ambient air quality measurements for carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), total suspended particulates (TSP), PM_{10}, and $PM_{2.5}$ were conducted on 13-19 March 2017 at six sampling stations within the study area. Results of 24-hour average concentration show that all the parameters at the time of sampling were within the limits of NAAQS.

30. Ambient noise level measurements were conducted on 27 October 2016 to 3 November 2016 at 14 stations. Results show that noise limits set by the Noise Pollution Control Rules 2006 were exceeded in some stations during daytime. A number of factors like vehicular movement (e.g. bus, train), noise from the loud speaker, and construction works contributed to the increase in the noise levels during the time of measurements.

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[3] ADB. Safeguard Policy Statement. June 2009. Glossary. Physical cultural resources - Movable or immovable objects, sites, structures, groups ofstructures, and natural features and landscapes that have archaeological, paleontological, historical, architectural, religious, aesthetic, or other cultural significance. Physical culturalresources may be located in urban or rural settings and may be above or below ground or underwater. Their cultural interest may be at the local, provincial, national, or international level.

[4] Bangladesh Water Development Board and other government departments refer water levels to the Public Works Datum (PWD). PWD is a horizontal datum believed originally to have zero at a determined Mean Sea Level (MSL) at Calcutta. PWD is located approx. 1.5 ft (or 0.46m) below the MSL established in India under the British Rule and brought to Bangladesh during the Great Trigonometric Survey. http://www.ffwc.gov.bd/index.php/definitions.

31. Four soil sampling stations were identified: one station at the project site and three within the vicinity of the site. Results of analysis show that top soil organic matter concentrations were higher than the average condition of Bangladesh. The pH levels of the soil samples are slightly alkaline to alkaline; non-saline with some slightly saline. These suggest that soil quality is good for supporting plant growth. The project site was not used for newprint operations. The 50 acres proposed for the power plant was used to accommodate residential structures and non-residential structures only. Given the process used in newsprint production and only residential structures were accommodated in the 50-acre land provided to NWPGCL, no land contamination within the project site is expected.

32. Available discharge data indicate that the available water from the Bhairab River range from 38.64 million cubic meters per day (MCM/day) to 54.47 MCM/day. Results of in-situ surface water quality measurements of pH, dissolved oxygen, biochemical oxygen demand, total dissolved solids (TDS), electrical conductivity, salinity, and temperature conducted in October 2016 at six sampling stations in Bhairab River, Atai River, and Rupsha River showed within limits of ECR 1997, Schedule 3 (Standards for Water, Rule 12). Existing beneficial uses of these rivers include fishing, bathing, general purpose washing, navigation, industrial use. Four groundwater sampling stations were also identified and results of analysis were referred to the drinking water standards which showed groundwater is saline with salinity levels from 2 parts per thousand (ppt) to 3 ppt and iron level exceeding the limit of 1 mg/l. Drinking water should have zero salinity level.

Biological environment

33. The proximity report generated by the Integrated Biodiversity Assessment Tool (IBAT) on 30 January 2017 indicates that there are no protected areas and key biodiversity areas within 5 km and 10 km from Component 1.

34. Based on the field surveys done in October 2016, there are six fish species of conservation status out of the 29 species identified. A total of 60 species of trees were found within the project site consisting of about 2,614 trees that are mostly planted with few species regenerating naturally. There is no endangered, protected, or threatened plant species in the project site. The West Indian Mahogany (*Swietenia mahagoni*) was found in the project site and listed as endangered in the IUCN Red List of Threatened Species. However, this species is widely cultivated in Bangladesh as timber plant, a non-native species, and is not included in the Red List of IUCN Bangladesh. Mahogany is native species to South America.

35. There were 32 species of butterflies identified but none of conservation status. Other classes of fauna include: 103 species of birds, 20 species of reptiles, six species of amphibians, and 14 species of mammals. Of the bird species, only 13 species were noted in the project site and these are all of no conservation status. At least 8 species of reptiles were observed by local people in the site and nine species of terrestrial fauna observed as visitors. With the temporary habitat created as a result of the abandonment of KNM, these species used the project site temporarily for feeding, roosting, and nesting.

36. For aquatic mammal species, Ganges River dolphin (*Platanista gangetica*) was observed in October 2016 and March 2017 along the Bhairab River close to the project site. The Ganges River dolphin is an obligate freshwater dolphin and is essentially blind. They are listed as endangered in the IUCN Red List 2012 but listed as vulnerable in the IUCN Bangladesh Red List 2015. Also, these dolphins are listed in the Third Schedule of the Bangladesh Wildlife (Preservation) Order 1973 as species not to be captured, killed or harmed.

37. IUCN Bangladesh was engaged by NWPGCL to conduct a biodiversity assessment in May 2017 to determine the presence of critical habitat based on SPS 2009 and the IFC Performance Standard (PS) 6. The assessment was done from May 2017 until January 2018 to capture seasonal variations consisting of 7 surveys. Study area covered about 30 km of river stretch spread over the Bhairab River, Atai River, and Rupsha River. Based on the 7 surveys completed in January 2018, the total population of dolphins is 34 individuals with an overall encounter of 1.18 individual/km. The dolphin population within the study area represents less than 1% of the global population and less than 10% of the national population. Global population of the Ganges River dolphins is estimated at less than 5,000 while the national population is about 451 individuals. Given these results, the project area is not a “critical habitat” for the Ganges River dolphins.

38. There are 15 unions and 33 wards under Khulna City Corporation with a population of about 1,038,877 consisting of 244,630 households. The male-female ratio is 108 higher than the national figure of 100.3. Average household size is 4.2. The highest number of population (about 26.8%) belongs to the age group, 30 to 49 years while the lowest number (about 2.6%) belongs to the age group, 60 to 64 years old. The inhabitants belong to two main religious groups, Muslim and Hindu.

39. Main occupation is service (55%), about a quarter (23%) of the population is engaged in agriculture, and 22% in industrial work. Of the 55% engaged in the service group, 42% are male and only 13% female. About 86% of the households are grid-connected to meet their daily demand. On average, 30% of the households live in pucca houses, 38% in kutcha, 30% in semi-pucca, and about 2% in Jhupri houses. About 87% of the population has sanitary toilet facilities but still about 12% use non-sanitary toilet. Tube wells as source of drinking water supply accounts for 95% of the total households in the study area, 4% depend on tap water from Khulna Water and Sewerage Authority while about 1% rely on other sources such as ponds and canals (there are three locations within the study area which are about 6-7 km from the project site). Bhairab River is not used for drinking water due to varying salinity level affected by tidal flows in the Bay of Bengal.

5.0 Anticipated Environmental Impacts and Mitigation Measures

40. Prior to construction of Component 1, demolition is required for the abandoned structures at the project site. Two schools will be affected and will be relocated at a site selected by the school management committee, the school authority, and NWPGCL. No construction work for Component 1 will start until the new schools are completed. Selection of site for the new school is being finalized by the school authority, school management committee, and the NWPGCL and will consider factors such as proximity to the power plant, access to the new location, etc.

41. Demolition of the existing structures in the project site will not be funded by ADB or IsDB. Based on the inventory of the structures, most of them are made of bricks, reinforced concrete, tin sheets, pacca and semi-pacca ranging from single to three-story buildings. Demolition will be done through tendering process. The winning bidders will take care of the works which would take no more than 4 months. The bidding document which will be tendered by NWPGCL will specify the regulatory requirements and permits/standards/codes relevant to demolition and disposal of material and debris, by which the contractor will be required to comply. Bid documents will also describe the measures required to ensure occupational, environmental and public safety risks are minimized. A demolition plan will be prepared by the Contractor following the requirements of the Bangladesh National Building Code, regulations of the Khulna City Corporation, and Khulna

Development Authority. Demolition works will commence only once the school children have moved to the new schools outside of the power plant boundary.

42. Prior to any civil works for Component 1, PMU, NWPGCL will have an orientation briefing to the Engineering, Procurement, and Construction (EPC) Contractor and their workers about the environmental requirements by the DoE and ADB that need to be complied with, their roles and responsibility for compliance, record keeping and reporting, awareness on socially transmitted disease like HIV/AIDS to avoid the potential occurrence of this diseases in the construction site

43. Construction of schools is not specifically indicated as subject to Environmental Conservation Rules (ECR) 1997 but indicates that construction of multi-storied commercial and apartment building is Orange-B category. However, there is no clear definition of multi-storey building. In practice, a 10-storey building within Dhaka City based on building construction rules of RAJUK and more than 6-storey building outside of Dhaka City are considered as Orange B category requiring an IEE for site clearance and EIA for environmental clearance. The new schools will not be higher than four storeys, and thus, not subject to ECR 1997.

44. A total of about 2,615 trees will be cleared resulting to an estimated loss of carbon sequestration by about 6,880.5 mega-gram (Mg) for the 30-acre vegetation coverage (include trees, shrubs and under growth weeds/grasses). The estimated loss was based on 20 quadrats of 10m x 10 m within the 30-acre land with vegetation. The trees that will be cleared are mainly fruit trees (about 1,775). There is no requirement from the DoE to replace trees cleared during development but recommends to maintain at least about 33% greening. Planting trees and developing greenbelt is one of the requirements of BPDB in its key point installations.

45. Other impacts during pre-construction, demolition, and construction phase include potential increase of noise and dust level affecting ambient air quality, potential flooding due to storm water runoff, loss and/destruction of habitat and life of species due to improper clearing of vegetation, potential damage to aquatic habitat due to unplanned transportation and untreated discharges in the river system, generation of waste, potential erosion due to movement of heavy equipment and machineries, and health and safety risks to workers and community. Storm water, roof drains, and water tank overflows will be diverted into a check pit and checked for water quality prior to discharge to Bhairab River. There will be two storm water discharge points: one near the existing jetty and the other one near the effluent treatment plant.

46. With vegetation clearing, excavation and earthmoving works, the EPC Contractor will be required to follow the "chance find" procedures including a fauna rescue and handling procedures. A storm water drainage system around Component 1 will be installed and will be connected to the existing drainage network of the KNM.

47. 19 environmental codes of practice (ECP) were prepared covering various aspects during construction phase such as construction camp management, protection of fisheries, workers health and safety, protection of fish and aquatic system, etc. The EPC Contractor will be required to prepare a Construction Environmental Action Plan covering the requirements of the environmental management plan (EMP) and the ECPs. A greenbelt of at least 3.5 m width consisting of two rows plantation with gradual increase of height of plant will be developed within the project site after construction phase.

48. The main impact during operation phase is the emissions from the 60 m stack due to combustion of natural gas. Natural gas will be the main fuel and will not generate much SO_2, PM_{10} and $PM_{2.5}$. A stack height determination based on good international industry practice (GIIP) technique was undertaken to demonstrate that 60 m is sufficient for proper dispersion and

prevention of excessive ground level concentrations (GLCs). CALPUFF 7.5.3, a USEPA-approved air dispersion modelling was used to simulate the maximum GLCs of criteria pollutants. The built-in dry low NOx burners will ensure that NOx emission is below 25 ppmv at all times. About 30 air sensitive receptors such schools, mosque, hospital, etc. were identified within the area covered by air quality modelling. Baseline ambient air quality levels were based on the monitoring data of the CASE project of DoE. Increasing the stack height to 70 m will entail a cost more than $2 million. This is not economical as generation costs will become higher. To be in line with EHS Thermal Power Plants Guidelines (2017), stack emissions will be monitored continuously for NOx concentrations during operation.

49. When running on natural gas, the contribution of Component 1 to PM_{10}, $PM_{2.5}$ and SO_2 to GLCs will be negligible. Considering the existing ambient air quality combined with Component 1, the resulting maximum contribution of $PM_{2.5}$ and PM_{10} will be from 13% to 52% of the IFC-WB EHS General Guideline 2007 standards. During emergency, the contribution of Component 1 to SO_2 GLC will range from 6% to 9%. With background concentration, the GLC will be from 23% to 82% of the standard. For NO_2, contribution of Component 1 on natural gas and during emergency (HSD) will be from 4.4% to 21% of the standard. Combined with background concentration, the GLC on natural gas and HSD will be from 24% to 47% of the standard. Results of air dispersion modeling show that the contribution of Component 1 is negligible and when combined with ambient air quality levels, the standards will not be exceeded.

50. The Areal Locations of Hazardous Atmospheres (ALOHA) software was used to simulate the consequences of gas leakage or pipeline failure following sequential hazards such as thermal radiation from jet fire, toxic area of vapor cloud formation, flammable area of vapor cloud formation, and blast area of vapor cloud formation. Simulation results show that the threat and/or danger zone will be from 19 m to 313 m from the source. The area within these distances will be within the power plant only. There are no sensitive receptor areas within this zone.

51. In the event a fire/explosion will occur at the receiving and metering station (RMS), the estimated threat/fire zone will extend up to 43 m from the source and the simulated zone for vapor cloud formation is 313 m. This distance will be within the power plant only. In natural gas, the lower explosion limit of CH_4 is 5% while the upper explosion limit is 15% in the presence of an ignition source. This means that CH_4 concentration lower than 5% ("too lean") and higher than 15% ("too rich") will not cause fire in the presence of ignition source. The supervisory control and data acquisition (SCADA) system in the control room of the power plant allows for emergency automatic valve shut-off along the pipeline or the RMS valves which can be shut-off remotely from the main control unit. The pipeline operations will be monitored 24/7 from the control room and detects any change in the gas pressure and can automatically shut off the gas flow to prevent or minimize the gas released into the environment.

52. Also, the RMS area will be lined with cementitious fire-retardant materials. The use of flame inhibitors in pipeline jacket system, flange and connectors will reduce considerably vapor cloud explosions. Component 1 will be equipped with fire-fighting systems and alarms including a disaster and emergency preparedness plan.

53. Design, construction and operation of Component 1 will be subject to compliance with the Bangladesh Natural Gas Safety Rules 1991 (amended 2003), Explosives Act 1884, Explosive Substances Act 1908 (amended 1987), Explosive Rules 2004, and Gas Pressure Vessel Rules 1995 (amended 2004). There are several relevant codes and standards which include ASME B31.8 Gas Transmission and Distribution Piping Systems, API Spec 5L for line pine (for branch line pipeline only), ASME Boiler and Pressure Vessel Code for all pressure vessels, ASME B31.1

Piping for all pressure piping within the confines of the power plant, ASME B16.5 Pipe Flange and Flanged Fittings, NFPA 10 Standard on Portable Fire Extinguishers, NFPA 37 Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines, IEC 79 Electrical Apparatus For Explosive Gas Atmospheres, and IEC 529 Classification of Degrees of Protection Provided By Enclosures. Compliance to these regulations, codes and standards will ensure that safety risks will be negligible.

54. SoundPlan Essential 3.0 was used to simulate the noise levels within Component 1. The noise level considered for gas turbine, steam turbine, and receiving and metering station were 90 dBA, 90 dBA and 80 dBA, respectively as these levels are typically used for noise modeling of power plants. Predicted noise levels at 11 sensitive stations show that six stations will exceed the daytime limit of the IFC-WB EHS General Guidelines 2007 and four locations during nighttime. Noise-generating equipment like gas turbine and steam turbine will be housed in a sound-proof building. Personal protective equipment will be provided to workers exposed to high noise levels and will be rotated to limit exposure based on occupational health and safety standards. There will be three exhaust silencers for Component 1.

55. Following the IPCC guidelines for national greenhouse gas (GHG) emissions inventories for energy industries, the contribution of Component 1 to the CO_2 emissions will be 1.67 million (M) tons per year using natural gas as fuel and 1.86 M tons per year on HSD. When running on natural gas at 5,632 hours and 500 hours on HSD (in case of emergency), the CO_2 emissions will be 1.69 M tons per year.

56. The available annual discharge in Bhairab River ranges from 39.73 million m^3 (MCM) per day to 54.47 MCM per day. Bhairab River is influenced by diurnal tidal occurrences during daytime and nighttime. Water requirement for the cooling system will be 2,010 m^3/hr and will be taken from the Bhairab River. This amount of water accounts for less than 1% of the available average discharge per hour at the Bhairab River.

6.0 Analysis of Alternatives

57. A “no project” option negates the need to meet the future demand for electricity and planned development in Bangladesh. The previous site of KNM now abandoned will remain the same as the current condition and will not have the benefit of the highest and best use of government land. The “with project” option evaluated the following:

- *Suitability of site*

58. With a population density of 1,139 people/km^2 and the geography of Bangladesh, it makes it difficult for GoB to acquire land for development projects. Scarcity of land is one of the major obstacles for development of industries like a combined cycle power plant. The abandoned land of about 50 acres previously used by KNM is the best site for Component 1.

- *Suitability of fuel*

59. Solar power plants require large area of land that is not easily available in Bangladesh. There is very limited hydropower potential except for Chittagong and the Chittagong Hill Tracts which may have potential for micro-hydro and mini-hydro. Burning of coal, diesel, and natural gas contribute to greenhouse gas (GHG) emissions as CO_2 but natural gas contributes the lowest among these fuels at 117 lbs CO_2 per million British thermal units (BTU) and is, thus considered

more environment-friendly. Natural gas is mainly CH_4 with higher energy content compared to other fuels.

60. Wind resources potential in Bangladesh for generating electricity is limited.[5] Available data from measurements and satellite data indicate that onshore wind speeds are below 5 m/sec average a year which is quite low wind speed for the purpose of wind energy. Available satellite data for offshore wind speeds are slightly higher but still relatively low about 6 m/s. Availability of suitable space for wind farm is also a challenge given the population density, and if at all available, it will in in flood-prone areas.

- *Suitability of power technology*

61. Modern combined cycle power plants have undergone many developments to much more improve its capability in areas such as fuel flexibility, reduce life cycle costs, operational flexibility, low emission levels, operate on a wide range of fuel, rapid ramping rates, higher efficiency (can be over 60% with most new gas turbine systems), and higher availability.

62. There are several classes of gas turbine in the market. GE Power's largest 9HA.02 gas turbine is now available at more than 64% net efficiency in combined cycle power plants. The project prefers F-class compared to H-class for the following reasons: (i) total net power output falls within the net power output of the proposed gas turbine/CCPP and the maximum block size shall be in compliance with the current limits governing the national grid system security in Bangladesh; (ii) commercial operation is a proven design; (iii) NWPGCL has the ability to cope with F-class gas turbine technology based on experience in terms of operation and maintenance; and (iv) the net power output can be accommodated by the system according to the power load study conducted by PGCB. F-class units provide more flexibility in burning a wide spectrum of fossil fuels including gasified coal. In addition, fuels can be switched after start-up without sacrificing performance.

63. For the H-class gas turbine CCPP, (i) the net power output is higher than the planned new capacity, (ii) it is a relatively new technology, (iii) the higher power output may cause system instability based on the load study conducted by PGCB, and (iv) there is a need to acquire new knowledge and skills to effectively and reliably operate and maintain.

- *Cooling system options*

64. Three cooling system options were considered: (i) once-through cooling; (ii) forced draft cooling tower system (or closed-loop cooling system); and (iii) forced draft air cooling system (or air-cooled condenser). Once-through cooling will take huge amount of water and will discharge about the same amount of water at a higher temperature (usually about 3°C from ambient). This is not advisable for Bhairab River. In forced draft cooling tower system, it reuses water thus; water requirement is less compared to once-through cooling. Forced draft air cooling system does not require water but is not advisable due to increase noise level and the rise in ambient temperature of the surrounding area. Water intake will be two channels with an area of 12.5 m^2 each located in the southeast side river bank of the Bhairab River. Based on the dolphins' survey conducted by the IUCN from May 2017 until February 2018, there have been no sightings of dolphins in the river stretch along the project site.

[5] Netherlands Enterprise Agency. Baseline Study Wind Energy Bangladesh. Commissioned by the Ministry of Foreign Affairs. 13 April 2017.

- *Modes of transporting heavy and oversize equipment to the site*

65. There are several options: (i) by highway, (ii) by railway, and (iii) by waterway along the Bhairab River from the Mongla Port through the Rupsha River. The maximum carrying limit for transportation by road is 70 tons and by railway would require transport by road from the railway station. The best and with less disturbance to local people will be by waterway.

66. The weight of the major equipment that will be transported to the site ranges from 50 tons (transformer) to 320 tons (gas turbine transformer). Equipment will be unloaded to barges from the main vessel at Mongla Port and will be carried through river to project site. Bhairab River is classified as Class II by the Bangladesh Inland Water Transport Authority (based on minimum depth, length of route, and minimum vertical and horizontal clearance). Atai River and Rupsha River are Class III. Barges/cargo boats that will deliver equipment to the site will have a vertical clearance of 12.2 m and horizontal clearance of 76.22 m.

67. Based on studies, mortality of dolphins is attributed mostly to entanglement/entrapment in fishing net and water development and not from navigating vessels like ships (IUCN 2014).

7.0 Information Disclosure, Consultation and Participation

68. Consultations were done through workshop, focus group discussion, and rapid rural appraisal. Stakeholders were invited by sending letters, telephone calls, and advertisement in Bengali at the local newspaper. A total of seven consultation events were conducted from 28 October to 13 November 2016 during the preparation of the EIA and on 21 October 2017 to present the outcome of the EIA. Two consultation events were participated by the ADB Project Team. These consultations were joined by the Mayor and Councillor of the Khulna City Corporation, students, teachers from the KNM Boys & Girls Grade School that will be relocated, School Management Committee, representatives from the media, fisher folks from the Deyara Jugiyati and Chandimohan Villages, and interested individuals. A project brief hand-out in Bengali was given out during the consultation.

69. Major concerns raised during the consultations include (i) disruption of school activities in the KNM Boys and Girls school, (ii) potential loss of jobs of people currently maintaining the KNM property that will be taken over by NWPGCL (about 50 ha), (iii) clearing of vegetation at the project site resulting to loss of habitat, (iv) demolition works may generate dust, noise, solid waste and debris that may affect local people, (v) indirect impacts to fishing village along the Bhairab River across the project site, and (vi) potential increase in noise level during the operation of the power plant may affect activities in mosque, school, and residential areas. Participants during the consultations recognize that Component 1 can accelerate local business development due to available and reliable power, the abandoned area previously used by KNM will now have economic use, creation of jobs, renovation of the mosque and mass graveyard marker, and may result to setting up of new industrial area along with small and medium industry. NWPGCL assured the participants that construction works for Component 1 will begin only after the new schools are completed and that all their concerns will be considered. Consultations will continue and a communications action plan will be finalized by NWPGCL with support from communications expert to ensure that stakeholders are consulted, as and when needed.

70. A project summary with details on grievance redress mechanism (GRM) and contact person in case of complaints will be prepared in both Bengali and English and will be made available at the field office of PMU in Khulna and at the NWPGCL office in Dhaka. More details on Component 2 will also be available from the EIA posted in the website of ADB.

8.0 Grievance Redress Mechanism

71. The GRM will provide three-tier entry points in grievance redress. Two grievance redress committees (GRCs) will be formed: (i) local grievance redress committee (LGRC); and (ii) project grievance redress committee (PGRC). Grievances considered minor can be resolved onsite at the LGRC level within seven days from receipt of complaint. Other complaints not resolved at the LGRC level will be forwarded to PGRC which will take two weeks (or 14 days) to resolve. Meetings of the LGRC will be held onsite (PMU office) and members may do site visits to check or verify the issue. Complainants will be informed of the status of resolution. The third tier entry point for grievance redress will be the appropriate rule of court.

9.0 Environmental Management Plan

72. The Corporate environmental staff of NWPGCL and the PMU, NWPGCL will monitor the EPC Contractor on its compliance to the EMP. Environmental monitoring plans have been prepared which covers demolition, pre-construction, construction, and operation. Environmental monitoring reports will be submitted by PMU to ADB semi-annually and these reports will be posted in the ADB website as required by SPS 2009 and PCP 2011.

10. Conclusion and Recommendation

73. Component 1 is designed as a dual-fired combined cycle power plant with natural gas as the main fuel and HSD as back-up fuel to be used only during emergency.

74. The project is “red category” based on ECA 1995 and ECR 1997 of the DoE requiring an EIA. According to SPS 2009, the project is category A requiring an EIA. Following the requirements of DoE and ADB, an EIA was prepared.

75. The EIA was conducted covering the project site and about 10km radius from the power plant. Description of the environment was based on available relevant secondary data and field surveys carried out in October 2016 and March 2017. A biodiversity assessment was conducted by the IUCN from May 2017 until January 2018 covering a total of 30 km of river stretch in Bhairab River, Atai River and the Rupsha River to determine critical habitat for the globally endangered Ganges River dolphin (*Platanista gangetica*) according to the IUCN (2012) but nationally vulnerable (2015). The biodiversity assessment concluded that the study area cannot be considered as critical habitat according to criterion 1 to criterion 5 of the IFC Performance Standard 6 and SPS 2009.

76. Water requirement for the cooling system of Component 1 will be less than 1% of the available discharge per hour from the Bhairab River. The project will have a water treatment plant, sewage treatment plant and an effluent treatment plant. Groundwater will not be used for power plant requirements. Domestic water requirements for Component 1 will be supplied by the Khulna Water Supply and Sewerage Authority. Low NO_x burner will be used at the power plant to reduce the NO_2 emissions. Air dispersion modeling results confirm that the ground level concentration of SO_2, NO_2, PM_{10}, $PM_{2.5}$ and CO will not exceed the limits of NAAQS 2005 and the IFC-WB EHS General Guidelines 2007.

77. Stakeholders have been identified and consulted in seven occasions from 28 October to 13 November 2016 and in October 2017. The GRM will be set up by PMU, NWPGCL consistent

with the requirements of GoB and ADB. A project brief in English and in Bengali with details on the GRM will be made available at the NWPGCL office in Khulna and in Dhaka. Consultations will continue in varying degrees throughout the project's life cycle. With guidance from experts, NWPGCL will finalize the communication action plan for the project.

78. While there are associated impacts in implementing Component 1, they can be readily mitigated through design, employing best available technology (e.g. emissions reduction), good engineering construction methods, effective stakeholder engagement (as and when needed), diligent monitoring of EMP implementation, and compliance to relevant regulations on power plant operations, and environmental, health, and safety.

79. Except for the biodiversity assessment done by IUCN Bangladesh in May 2017, there have been no surveys and studies on the Ganges River dolphins along the Bhairab River, Atai River, and Rupsha River. More studies will help to confirm the locations of "hotspots" that will guide GoB in making plans for protecting them. It is recommended that additional surveys be done within this area to confidently determine the abundance and dispersal of these endangered species. As project contribution, dolphins' survey will be part of the environmental monitoring.

80. This draft EIA will be disclosed in the ADB website in accordance with SPS 2009 and PCP 2011. Prior to construction works, all the relevant permits required for Component 1 will be obtained by NWPGCL.

1.0 INTRODUCTION

1. The Power System Master Plan 2016 recommends for diversification in the use of fuel for power generation such as domestic and imported coal and natural gas, oil, nuclear power, and renewable energy.[6]As of December 2017, the energy mix in Bangladesh consist of 64.5% natural gas, 1.66% hydro, 4.8% power import, 6.4% diesel, 20.9% furnace oil, 1.81% coal, and 0.02% renewable.[7]Consistent with this, the North-West Power Generation Company Limited (NWPGCL), an enterprise of the Bangladesh Power Development Board (BPDB) has taken the initiative to enhance the power generation capacity of Bangladesh to address the growing demand for electricity. This initiative will involve the construction of a new Rupsha 800 megawatt (MW) Combined Cycle Power Plant (CCPP) in Khalishpur Upazila, Khulna District in the administrative division of South-Western Bangladesh. The Rupsha 800 MW CCPP will be designed to use natural gasas main fuel and high speed diesel (HSD) as back-up fuel to be used only for about 500 hours maximum annually during maintenance or emergency. The Government of Bangladesh (GoB) has applied for financing of this new power plant from the Asian Development Bank (ADB). The Islamic Development Bank (IsDB) is expected to co-finance about 20% of the total project cost.

2. The objectives of this initiative include the following:

- To contribute in meeting the demand for electricity and to increase reliability of supply by minimizing load-shedding;
- To support in achieving the vision of GoB, “Power to All by 2021;”
- To reduce the increasing gap between demand and supply of electricity throughout the country;
- To accelerate economic development by providing adequate and reliable power generation;
- To enhance the stability and reliability of the national grid system, and to reduce the systems loss by local generation; and,
- To develop human resource through technology transfer.

3. Overall, the goal is to improve the economic growth of Bangladesh by providing a reliable and stable power supply with this initiative.

1.1 Overview of the Project

4. The project targets strengthening energy security in Bangladesh. The country faces serious electricity shortages in the short- to medium-term and needs to secure cost-effective, new and diversified energy sources. Key interrelated project components include: (i) the development and operation of the Rupsha 800 MW gas-fired CCPP; (ii) the construction of a gas distribution pipeline and related network infrastructure ensuring reliable supply of fuel to the CCPP; (iii) the construction of a power transmission interconnection facility to transfer the generated power to the national grid at the existing substation in Khulna; and (iv) capacity strengthening of NWPGCL. The project will establish the first power plant to use gas from the Bangladesh gas transmission

[6] Ministry of Power, Energy and Mineral Resources, and Bangladesh Power Development Board. People’s Republic of Bangladesh Power and Energy Sector Master Plan. http://powerdivision.portal.gov.bd/sites/default/files/files/powerdivision.portal.gov.bd/page/4f81bf4d_1180_4c53_b27c_8fa0eb11e2c1/(E)_FR_PSMP2016_Summary_revised.pdf. (Accessed 18 August 2017)

[7] Bangladesh Power Development Board. Key Statistics. http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=5&Itemid=6

network in the southwestern region where its gas supply would be attributed to the imported regasified-liquefied naturals gas (R-LNG). The gas transmission and distribution pipeline network in the southwestern region particularly Khulna is part of the project funded by ADB, Loan2622/2633-BAN: Natural Access Improvement Project (formerly Clean Fuel Development Project) approved on 26 March 2010 with a total amount of $537 million. Part of the inland gas transmission pipeline network from Moheskhali FSRU is ADB funded Loan 3641/3642-BAN: Natural Gas Infrastructure and Efficiency Improvement Project approved on 18 November 2016 with a total amount of $227 million. **Figure 1.1** shows the project.

Component 1: Rupsha 800 MW CCPP

5. Rupsha 800 MW CCPP will be built in the (now abandoned) Khulna newsprint factory premises. The power plant will use combined cycle gas turbine technology, comprising two identical generating units, each nominally rated at 400 MW. Each combined cycle unit will consist of one gas turbine and one heat recovery steam generator (HRSG), forming a one-on-one configuration. At full capacity of 800 MW, the Rupsha power plant is capable of meeting 5% of the forecast peak demand of Bangladesh in year 2022. The cooling system will be closed-loop forced-draught cooling tower system that will require 2,010 m^3/hour of water to be taken from the Bhairab River.

Component 2: Gas Supply to the Power Plant

6. Petrobangla, the national gas utility and the single-buyer for the gas industry, will procure LNG from international sources and deliver regasified LNG to Khulna city gas station (CGS). The regional gas distribution company, Sundarban Gas Company Limited (SGCL) will deliver gas from the existing Khulna CGS in Arongghata to the Rupsha power plant in Khalishpur. A new 24-inch (0.6 m) underground gas pipeline about 10 km long will be installed from Khulna CGS to the Rupsha 800 MW power plant. The gas regulating and metering station (RMS) will be located at the Rupsha power plant. In addition, a new 20-inch (0.5 m) underground gas pipeline 2 km long will be branched off from the line from Khulna CGS to Rupsha power plant, to serve NWPGCL's existing Khulna 225 MW power plant. Owing to non-availability of gas, this 225 MW power plant is presently operating on diesel.

7. The following sources from imported regasified liquefied natural gas (R-LNG) and domestic supply will provide adequate supply of natural gas for Component 1.

- FSRU Moheskhali - 500 MMSCFD of R-LNG will be made available by April 2018 developed by Excelerate Energy, USA-Bangladesh
- Summit LNG Terminal Company Limited – 500 MMSCFD R-LNG will be made available by October 2018
- GoB and RasGas (Qatar) has signed a deal in September 2017 for a 15-year LNG sales and purchase agreement to supply 1.8 million (M) tons LNG/year for 5 years and 2.5 M tons/year for the next 10 years
- According to Petrobangla, there will be additional supply (domestic) of 2,750 MMSCFD
- By 2021, Bangladesh Petroleum Exploration and Production Company Limited (BAPEX) will have 55 exploration wells and 31 development wells

8. The natural gas produced in Bangladesh is "sweet gas" (does not contain hydrogen sulphide) and thus, all the existing natural gas transmission and distribution pipeline networks are designed for high quality natural gas.

Component 3: Power Transmission Interconnection

9. Electricity generated in the Rupsha power plant will be stepped-up to the transmission voltage of 230 kilovolts (kV). A new 29.3 km transmission line will be built from Rupsha 800 MW CCPP to the existing Khulna South Substation. The conductor to be used is twin-Aluminium Conductor Composite Core Hamburg,[8] and the line will have two circuits, each capable of transferring 1,400 MW. The new transmission line will require three main river crossings and three minor river crossings, and would traverse for 29.3 km, mostly through rice fields. Upon reaching the existing Khulna South SS, the line will be terminated at two new line bays and termination equipment to be installed under the project. Thereafter, electricity produced at Rupsha power plant will flow into the 230 kV transmission network, to serve the electricity demand in Khulna and elsewhere in the country.

10. Occupying an area of 12.96 acres, the Khulna South SS is part of the West Zone Power System Development Project funded by ADB and the Nordic Development Fund and was commissioned on 29 January 2007. The 4.7 km stringing is part of the 24-km four circuit 230 kV Mongla to Khulna South SS transmission line project of the Power Grid Company of Bangladesh (PGCB) funded by GoB. The 230 kV transmission line from Mongla to Khulna South SS has completed the requirements of the Environmental Conservation Rules (ECR) 1997 of the Department of Environment (DoE) for red category project. Together, these transmission lines form part of the power evacuation interconnection facilities in southwestern Bangladesh.

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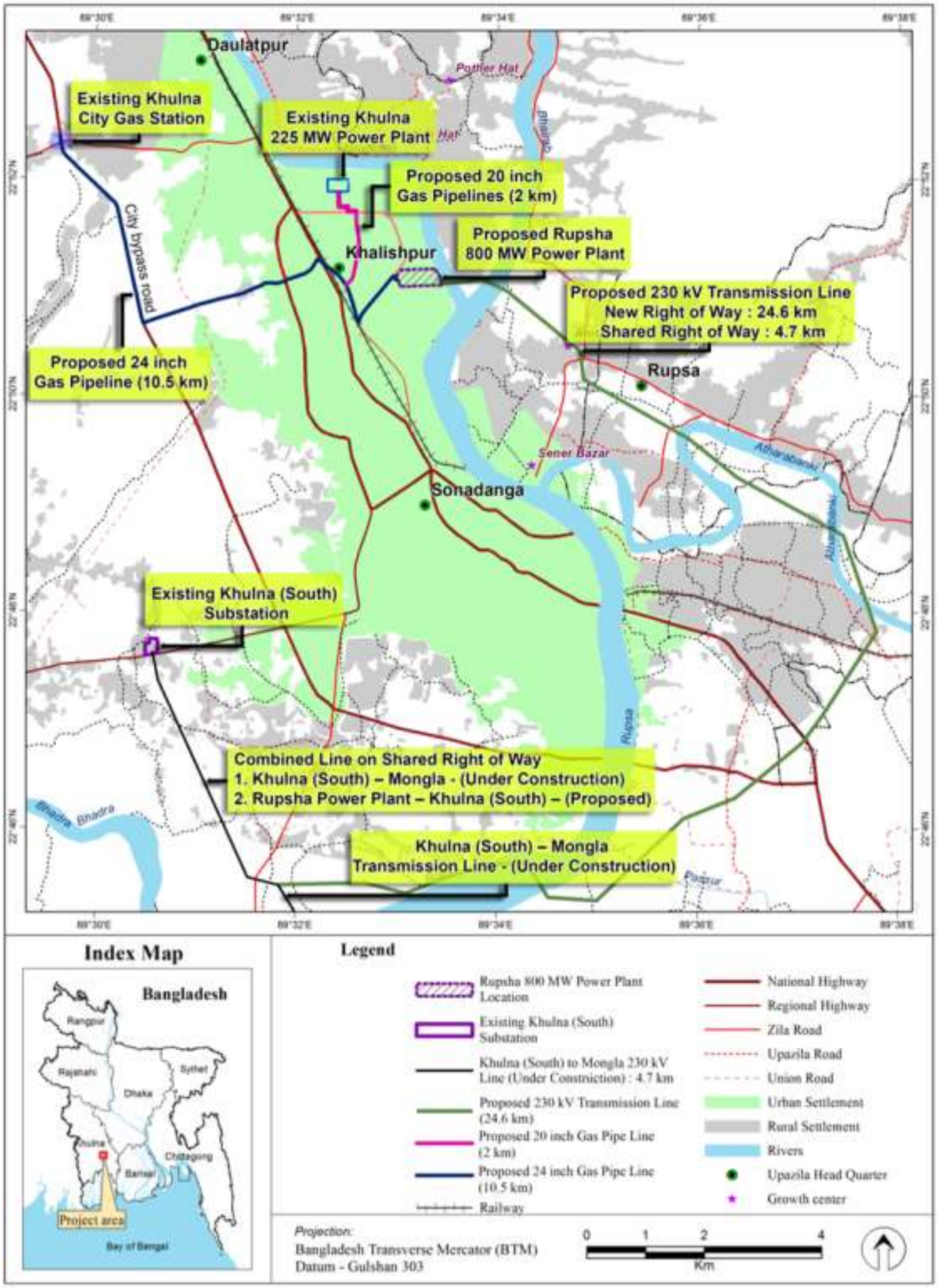
[8] Aluminium Conductor Composite Core (ACCC) Hamburg has a current carrying capability of 1,440 amperes at 120^0C.

Figure 1.1: Location map



Component 4: Capacity Strengthening of NWPGCL

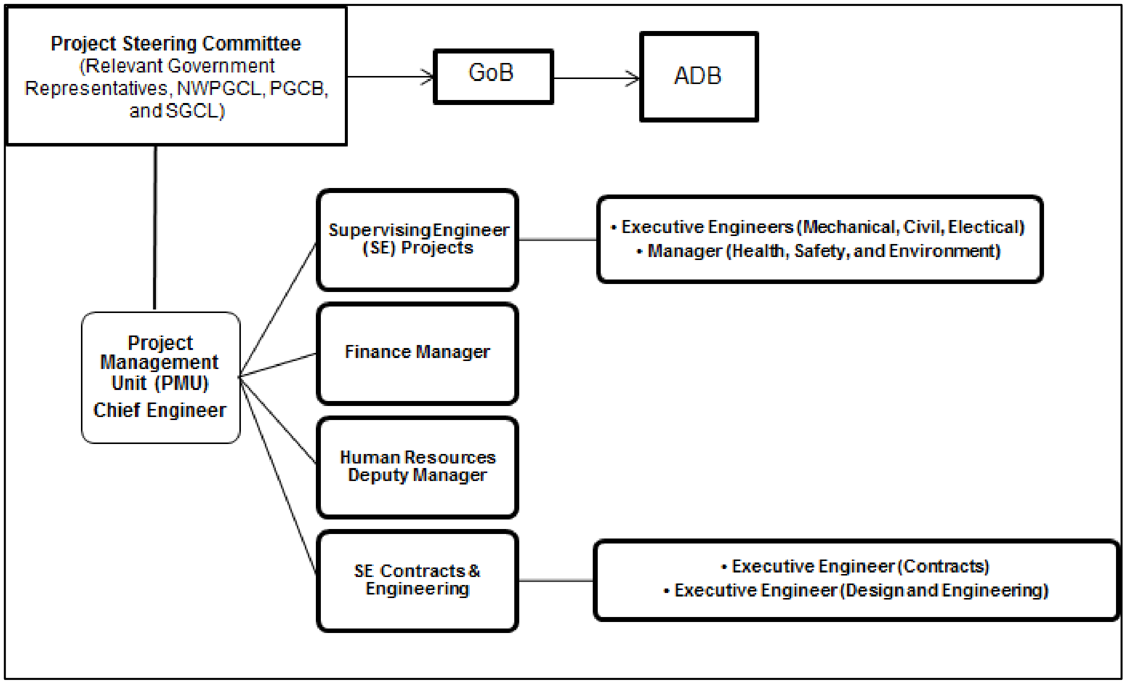
11. Strengthening institutional capacity has the following three major subcomponents: (i) improving project implementation, management, and construction supervision capabilities; (ii) establishing enterprise resource planning system in NWPGCL; and (iii) enhancing operation and maintenance practices through procurement and installation of modern and high technology universal power plant operations training simulator. Project management and construction supervision support will be provided for the development of Rupsha power plant. enterprise resource planning system support includes both hardware and software for introducing computerized management system for NWPGCL. The enterprise resource planning system will substantially improve business process and NWPGCL's efficiency and transparency by computerizing the Financial Accounting, Budgeting and Costing, Human Resource Management, Procurement Inventory, Planning and Monitoring, Operations and Maintenance and Project Management and Accounting.

1.2 Project Implementation Arrangements

12. Implementation supervision for the Rupsha 800 MW CCPP, power transmission, and gas distribution facilities will be carried out by the NWPGCL with assistance from a team of international and national implementation consultants. From time to time, assistance will be provided by the Power Grid Company of Bangladesh (PGCB) for Component 3, and the SGCL for Component 2 to ensure that coordination is achieved and implementation progresses smoothly. During construction, further assistance will be provided by SGCL and PGCB for approval of detailed design and drawings submitted by the contractors of Component 2 and Component 3, respectively. This arrangement has worked well for the Bheramara 360 MW CCPP project financed by the Japan International Cooperation Agency, which is very similar to the Rupsha 800 MW CCPP.

13. NWPGCL is currently setting up the project management unit (PMU) and so far, has assigned limited staff to it. The organogram (see **Figure 1.2**) prepared for the PMU shows the unit will have a compliment of 80 staff. It will be headed by a Chief Engineer and will have four divisions, headed by: (i) Supervising Engineer Projects; (ii) Manager Finance; (iii) Deputy Manager Human Resources; and (iv) Supervising Engineer Contracts and Engineering. Supervising Engineer Projects will have reporting to him, three Executive Engineers, (Mechanical, Civil, and Electrical) and Manager Health, Safety and Environment (HSE). The Executive Engineer Contracts and Executive Engineer Design and Engineering will report to the Supervising Engineer Contracts and Engineering. In addition, the project will have a high-level Project Steering Committee consisting of members from various government departments, NWPGCL, PGCB and SGCL and act as overseer of the project. The steering committee will meet every quarter to monitor progress and will report to the GoB.

Figure 1.2: Project implementation arrangements



1.3 The Need for Environmental Assessment

14. The project is subject to the environmental requirements of GoB, ADB, and IsDB since NWPGCL is seeking the financial support of ADB and IsDB.

1.3.1 National Requirements

15. The main environmental regulations in Bangladesh are the Environment Conservation Act (ECA) 1995 and the Environment Conservation Rules (ECR) 1997. Under these regulations, all the three components of the Project are “Red” category requiring and environmental clearance certificate (ECC). Securing the ECC involves two steps: (i) issuance of locational (or site) clearance certificate (SCC), and then (ii) the ECC. An initial environmental examination (IEE) is required for the SCC and an environmental impact assessment (EIA) is required for the ECC. The terms of reference (TOR) of the EIA needs the approval of the Department of Environment (DoE). The DoE is the authority that regulates and enforces environmental management regulations to ensure that development projects are implemented sustainably, and to conserve and manage the environment in Bangladesh.

16. NWPGCL has obtained exemptions for submitting an IEE in obtaining the SCC for all the project components as follows:

Component 1: 5 November 2017; DoE/Clearance/5584/2016/564
Component 2: 5 November 2017; DoE/Clearance/5668/2016/563
Component 3: 5 November 2017; DoE/Clearance/5669/2016/549

17. The ToR of the EIA for Component 1 was approved by the DoE on 5 November 2017 (see **Annex 1**). Without the EIA approved by DoE, NWPGCL cannot open line of credit in favor of

importable machineries and cannot start any physical activities for the project. In August 2016, NWPGCL has engaged the Center for Environmental and Geographic Information Services (CEGIS) to prepare the EIAs of all the project components required by the DoE for the issuance of the ECC.

1.3.2 Environmental requirements of ADB and IsDB

18. The Safeguard Policy Statement (SPS) 2009 of ADB sets out the requirements for environmental safeguard that applies to all ADB-financed projects. The IsDB is still in the process of preparing its Statement on Environmental and Social Safeguards Principles, and Commitments to Environmental and Social Responsibility.[9]ADB and IsDB agreed to adopt SPS 2009 as the unified approach to documentation, consultation, and disclosure requirements to be complied by NWPGCL for this project.

19. Under SPS 2009, projects that require funding from ADB will be subject to screening and categorization based on their potential environmental impacts. The categorization determines the required environmental assessment. The project has four components: (i) Component 1 – Rupsha 800 MW CCPP; Component 2 – Gas Supply to the Power Plant; Component 3 – Power Transmission Interconnection; and Component 4 – Capacity Strengthening of NWPGCL. Component 4 is not expected to have adverse environmental impacts. Based on these components, the project is category A on environment according to ADB's SPS 2009 which requires the preparation of an EIA.[10]

20. The EIA required by ADB was based on the findings of CEGIS, collation of primary data, and additional research from available secondary data to meet SPS 2009. Aside from the EIA, NWPGCL will provide ADB a copy of the ECC issued by the DoE for all the project components.

1.4 EIA Methodology

21. The EIA was prepared following the requirements of DoE, GoB and SPS 2009 of ADB.

22. Environmental quality measurements were conducted and relevant secondary data were collected as basis for the EIA. The latest project design from the feasibility study and the Development Project Proposal were also referred to.

23. *Primary data collection.* The project's area of influence was identified and environmental sampling was conducted on air, noise, surface water and groundwater, and soil. Ecological surveys were done at the project site and the study area (about 10-km radius from the power plant). Field works were carried out in October 2016, March 2017, and May to December 2017.

24. *Secondary data collection.* Sources of secondary data include publications from specialized government agencies, international organizations like the International Union for Conservation of Nature (IUCN), Wildlife Conservation Society, World Bank, WHO, International

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[9] IDB. Statement by Dr. Ahmad Mohamed Ali, President, IDB. United Nationas Conference on Sustainable Development (Rio +20), 20-22 June 2012. http://www.isdb.org/irj/go/km/docs/documents/IDBDevelopments/Internet/English/IDB/CM/About%20IDB/President%20IDB%20Group/PS_UN_ConferenceSustainableDevelopment_20June2012.pdf. (Accessed 6 December 2017)

[10] Asian Development Bank Safeguard Policy Statement (SPS 2009),https://www.adb.org/documents/safeguard-policy-statement.

Finance Corporation (IFC), ADB, and other relevant NGOs. Global and national research works on the Ganges River dolphins provided guidance on biodiversity assessment.

25. *Modeling.* CALPUFF is a USEPA regulatory model to predict the ground level concentration of air quality criteria pollutants (CO, NO_x, SO_2, NO_2, PM_{10} and $PM_{2.5}$). It is a multi-layer, multi-species non-steady-state puff dispersion model that simulates the effects of time- and space-varying meteorological conditions on pollution transport, transformation and removal. CALPUFF can be applied on scales of tens to hundreds of kilometers.

26. Areal Locations of Hazardous Atmospheres (ALOHA) is the hazard modeling program used in the event of an emergency at the Rupsha 800 MW CCPP particularly at the natural gas receiving and metering station. This is a widely-used program to plan for and respond to chemical emergencies.

27. Sound PLAN Essential 3.0 model was used to simulate noise levels from sources such as gas turbines, heat recovery steam generators, steam turbines and other equipment.

28. The Hydrologic Engineering Center, River Analysis System (HEC-RAS) model was used to simulate flooding at the project site. HEC-RAS is a software developed by the U.S. Army Corps of Engineers for the simulation of superficial flow and has applications for hydraulic design, floods, sediment transport and water quality.

29. Data and information collected were then used to predict, analyze, and mitigate the potential environmental impacts.

1.5 Structure of the Report

30. Following the requirements of SPS 2009, the environmental assessment for the project is presented as follows:

Volume 1 – EIA of Component 1
Volume 2 – EIA of Component 2
Volume 3 – EIA of Component 3

31. The EIAs of all the project components are based generally on the EIA format given in Annex to Appendix 1 of SPS 2009, pp41-43. This EIA covers Component 1 – 800 MW CCPP.

2.0 POLICY, LEGAL, AND ADMINISTRATIVE FRAMEWORK

2.1 National environmental agency

32. The Ministry of Environment and Forests (MoEF) is the agency responsible for planning, promoting, coordinating and overseeing the implementation of programs and plans regarding environment and forestry. The MoEF deals with all national environmental matters and is responsible for the prevention and control of pollution, forestation and regeneration of degraded areas and protection of the environment, and in the framework of legislations. MoEF also undertakes surveys, impact assessment, pollution control, research, and collection and dissemination of environmental information, as well as environmental awareness among all sectors in Bangladesh.

33. Under the MoEF is the DoE, which performs regulatory functions. DoE was created in 1989 as the primary government agency responsible for enforcing environmental management regulations to ensure sustainable development and to conserve and manage the environment. The DoE ensures the consistent application of environmental rules and regulations, and provides guidance, training and promotional campaign on improving environmental awareness.

2.2 National environmental regulations

34. The main environmental regulations in Bangladesh are the Environment Conservation Act (ECA) 1995 (amended 2000, 2002, 2007 and 2010) and Environment Conservation Rules (ECR) 1997. ECA 1995 provides the requirements on environmental protection, improvement of environmental standards, and control and abatement of environmental pollution. Through the ECA 1995, the DoE is mandated to undertake any activity needed to conserve and enhance the quality of environment and to control, prevent and mitigate pollution.

35. ECR 1997 provides for the declaration of ecologically-critical areas, categorization of industries and projects and identified types of environmental assessments needed against respective categories of industries or projects. Among other things, these rules set (i) the National Environmental Quality Standards for ambient air, various types of water, industrial effluent, emission, noise, vehicular exhaust etc.; (ii) the requirement for and procedures to obtain ECC; and (iii) the requirement for the IEE and their based on categories of industrial and other development interventions. ECA 1995 and ECR 1997 outline the regulatory mechanism to protect the environment in Bangladesh. Aside from ECA 1995 and ECR 1997, **Table 2.1** presents a summary of relevant environmental regulations.

Table 2.1: Relevant national environmental regulations

Regulation	Brief Description	Remarks
Environment Court Act 2000 (amended in 2002 and 2010)	This Act is under the Judiciary and MoEF to ensure the resolution of disputes on environmental and social damages resulting from any development activities. This Act also allows for the completion of environment-related legal proceedings effectively.	NWPGCL will ensure that all potential environmental complaints will be dealt with effectively at the project level through the PMU. SPS 2009 requires setting up of a grievance redress mechanism for projects known to cause potential environmental impacts.
Bangladesh Water Act 2013	Makes provisions for integrated development, management, abstraction,	Component 1 will abstract water from Bhairab River for its

Regulation	Brief Description	Remarks
	distribution, use, protection and conservation of water resources	recirculating cooling system. NWPGCL will ensure that relevant permits (if any) will be obtained prior to abstraction.
Vehicle Act 1927, the Motor Vehicles Ordinance 1983	These are under the BRTA which regulates vehicular emissions and noise including road safety.	This regulation will be complied with by vehicles that may be used during pre-construction, construction and operation of Component 1.
Bangladesh Labour Act 2006, Bangladesh Labor Act 2013, Factory Rule 1979	Regulations that aim to protect the interests and rights of the workers, provision of comfortable working environment, reasonable working conditions, and to ensure workers' safety.	Workers recruited under Component 1 will be provided with PPE (if needed) and will comply with these regulations. No worker under 18 years old will be recruited.
The Forest Act 1927 (amended in 1982 and 1989)	This Act under the MoEF aims to protect the forest resources.	Component 1 will not affect forest area or other forest type.
Electricity Act 1910	Relates to the supply and use of electrical energy, allows any person to secure a license to supply energy and to put down or place electrical supply lines for the transmission of energy. Sect 19(1) of the Act provides that the licensee, in the exercise of any of the powers conferred by or under this Act, will cause as little damage, detriment and inconvenience as may be, and will make full compensation for any damage, detriment or inconvenience caused by the licensee or by any one employed by the licensee.	Component 1 referred to the applicable provisions in this Act.
NG Safety Rules 1991 (amended 2003)	Provides guidelines on the materials, design and construction of gas transmission and pipeline industry. This Safety Rules were based on the American National Standard Codes for Gas Transmission and Piping System.	NWPGCL and SGCL will comply with these safety rules.
Bangladesh Petroleum Act 1974 (amended 1994)	Provides for the exploration, development, exploitation, production, processing, refining, and marketing of petroleum	NWPGCL and BPCL will comply with the relevant provisions
Petroleum Act 1934 (amended 1986)	Act to consolidate and amend the law relating to the import, transport, storage, production, refining, blending, or reclaiming by recycling of petroleum and other inflammable substances.	NWPGCL and BPCL will comply with the relevant provisions
Explosives Act 1884, Explosive Substances Act 1908 (amended 1987), Explosive Rules 2004, Gas Pressure Vessel	Regulations related to the manufacture, possession, use, sale, transport and importation of explosives	NWPGCL, SGCL, and BPCL will refer to the relevant provisions in handling of natural gas and HSD

Regulation	Brief Description	Remarks
Rules 1995 (amended 2004)		
Bangladesh Gas Act 2010	Regulates the transmission, distribution, marketing, supply and storage of natural gas and liquid hydrocarbon	NWPGCL and SGCL will comply with this Act.
The Antiquities Act 1968 (amended 1976)	Regulation on the preservation and protection of antiquities.	NWPGCL will have a "chance find" procedures.
Natural Water Bodies Protection Act 2000	According to this Act, the character of water bodies i.e. rivers, canals, tanks, or floodplains identified as water bodies in the master plans or in the master plans formulated under the laws establishing the municipalities in division and district towns shall not be changed without approval of concerned ministry. This Act is under the Rajdhani Unnayan Kartipakkha/Town Development Authority/Municipalities.	Component 1 will abstract water from the Bhairab River for its recirculating cooling system. NWPGCL will comply with the relevant requirements.
Wildlife (Protection and Safety) Act 2012	Provides for the conservation and safety of biodiversity, forest and wildlife of the country by repealing the existing law relating to conservation and management of wildlife of Bangladesh. Under this Act, hunting, trapping, killing of wildlife are strictly prohibited.	The site for Component 1was used previously by the KNM Limited operated by the KNM Authority but ceased operations in November 2002 and since then was not affected by any change in land use. Vegetation onsite provided temporary habitat for wildlife. The Bhairab River has sightings of the Ganges River dolphin (*Platanista gangetica*), a known obligate riverine dolphin. Component 1 will ensure that relevant provisions in this Act will be complied with.
The Protection and Conservation of Fish Act 1950 (amended 1973, 1982, 1995, 2002)	Provides for the requirements for the protection and conservation of fish. This Act defines fish as "all cartilaginous, bony fishes, prawn, shrimp, amphibians, tortoise, turtles, crustacean animals, molluscs, echinoderms and frogs at all stages in their life history."	Component 1 will use Bhairab River to supply the water requirements. NWPGCL will ensure compliance to the relevant provisions of this Act

BPCL = Bangladesh Petroleum Corporation Limited, BRTA = Bangladesh Road Transport Authority, HSD = high-speed diesel, KNM = Khulna Newsprint Mills, MoEF = Ministry of Environment and Forests, NWPGCL = North-West Power Generation Company Limited, PMU = project management unit, PPE = personal protective equipment, SGCL = Sundarban Gas Company Limited, SPS = Safeguard Policy Statement.
Source: ADB Consultant, November 2017.

2.3 Overview of the environmental approval process

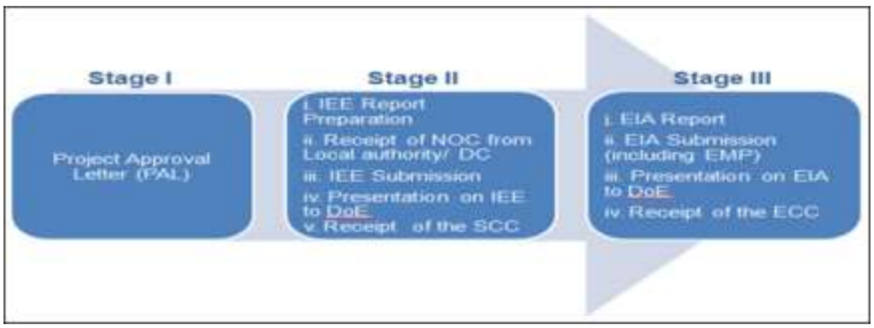
36. Section 12 of ECA 1995 provides that no industrial unit or project can be established or undertaken without securing an ECC from the DoE. Following the requirements of ECR 1997, the DoE has classified various development interventions according to the potential adverse environmental impacts for the purpose of issuing the ECC. This classification includes: (i) green; (ii) orange-A; (iii) orange-B; and (iv) red. Green category refers to industries or projects considered

to be relatively pollution-free, thus, no environmental study will be required while the Red category refers to industries/projects which may cause significant adverse environmental impacts and therefore, require an EIA.

37. For projects and industrial units classified as Orange-A, Orange-B, and Red (those that may have potential adverse environmental impacts), securing the ECC involves two steps: (i) issuance of site clearance certificate (SCC), and then (ii) the ECC.

38. SCC will be issued by the DoE upon approval of the IEE, receipt of the No Objection Certificate, which a "proof of authorization" to initiate a project, and the TOR of the EIA while the ECC will be issued upon the approval of the EIA. The project proponent cannot open line of credit in favor of importable machineries and cannot start any physical activities for the project without the EIA approved by the DoE. **Figure 2.1** shows the process of obtaining the ECC for Red category project.

Figure 2.1: Process of obtaining ECC



2.3.1 National environmental requirements for Component 1

39. According to ECR 1997, Component 1 is a Red category requiring an SCC and an ECC. The No Objection Certificate from the local government, Aviation Authority, and the Department of Forest have been obtained. On 5 November 2017, NWPGCL obtained exemption from the DoE for submitting an IEE in obtaining the SCC and the approval of the TOR of the EIA (DoE/Clearance/5584/2016/564)

2.4 Relevant International Environmental Agreements

40. **Table 2.2** lists the applicable international environmental agreements where Bangladesh is a signatory which can provide guidance during the implementation of Component 1.

Table 2.2: Relevant international environmental agreements

International Environmental Agreement	Description	Date Ratified	Date Entered into Force	Comments
Convention Concerning the Protection of the World Cultural and	Defines and provides for the conservation of world`s heritage by listing the natural	3 November 1983	23 November 1972	Component 1 will have "chance find" procedures

International Environmental Agreement	Description	Date Ratified	Date Entered into Force	Comments
Natural Heritage (Paris 1972)	and cultural sites whose value should be preserved.			
Convention on Biological Diversity (1992)	A framework for biodiversity and requires signatories to develop national strategies (National Biodiversity Strategy and Action Plan) for the conservation and sustainable use of biological diversity.	3 May 1994	29 December 1993	Any replacement of cleared vegetation resulting from Component 1 will be consistent with the objectives and priorities of the current Action Plan. A biodiversity assessment was conducted by IUCN in May 2017 until February 2018 to determine critical habitat for the Ganges River dolphin (*Platanista gangetica*).
Convention on International Trade in Endangered Species of Wild Fauna and Flora (Washington 1973) – also known as CITES	Addresses the exploitation patterns and overharvesting that threaten species of flora and fauna. Under this Convention, the governments agree to restrict or regulate trade in species that are threatened by unsustainable patterns and to protect certain endangered species from overexploitation by means of a system of import/export permits.	20 November 1981	1 July 1975	Site of Component 1 was previously occupied by the KNM Limited operated by the KNM Authority but ceased operations in November 2002. Component 1 will ensure that it will not cause any harvesting and exploitation of wild flora and fauna during implementation.
Vienna Convention for the Protection of the Ozone Layer	A framework for efforts to protect the globe's ozone layer by means of systematic observations, research and information exchange on the	2 August 1990	22 March 1985	Component 1 will not use chemicals that can affect the ozone layer like methyl chloroform, a solvent generally used for industrial processes.

International Environmental Agreement	Description	Date Ratified	Date Entered into Force	Comments
	effects of human activities on the ozone layer and to adopt legislative or administrative measures against activities likely to have adverse effects on the ozone layer.			
Montreal Protocol on Substances that Deplete the Ozone Layer (a protocol to the Vienna Convention for the Protection of the Ozone Layer)	Designed to protect the ozone layer by phasing out the production of numerous substances that are responsible for ozone depletion.	2 August 1990	1 January 1989	Component 1 will not use chemicals that can cause harm to the ozone layer.
Kyoto Protocol (1997)	Commits its Parties to set internationally-binding emission reduction targets. This agreement is linked to the UNFCCC.	22 October 2001	16 February 2005	Component 1 will ensure zero or minimal fugitive natural gas emissions. Potential fugitive emissions will be monitored by high-technology instrumentation like SCADA. Component 1 is consistent with the mitigation action to reduce GHG emissions (INDC 2015, p5)
UNFCCC (1992)	This framework came into force on 21 March 1994 and aims to achieve stabilization of GHG concentrations in the atmosphere at a level low enough to prevent dangerous anthropogenic interference with the climate system.	15 April 1994		Component 1 will ensure zero or minimal fugitive natural gas emissions. Potential fugitive emissions will be monitored by high-technology instrumentation like SCADA. Component 1 will contribute to CO_2

International Environmental Agreement	Description	Date Ratified	Date Entered into Force	Comments
				emissions by burning natural gas or HSD.
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989)	Aims to reduce the amount of waste produced by signatories and regulate the international traffic in hazardous wastes.	1 April 1993	5 May 1992	Component 1 will ensure that disposal of chemicals used (if and when needed) will follow the instructions in the accompanying material safety data sheet.

GHG = greenhouse gas, KNM = Khulna Newsprint Mills, SCADA = supervisory control and data acquisition, UNFCC = United Nations Framework Convention on Climate Change.
Source: ADB Consultant, November 2017.

2.5 Environmental requirements of Asian Development Bank and Islamic Development Bank

41. SPS 2009 of ADB sets out the requirements for environmental safeguard that applies to all ADB-financed projects. The IsDB is still in the process of preparing its Statement on Environmental and Social Safeguards Principles, and Commitments to Environmental and Social Responsibility.[11] Given this, ADB and IsDB agreed to adopt SPS 2009 as the unified approach to documentation, consultation, and disclosure requirements to be complied by NWPGCL for this project.

2.5.1 Asian Development Bank

42. SPS 2009 sets the environmental requirements and review procedures of ADB for all the projects and grants they finance. SPS 2009 consists of three key safeguard areas, (i) environment, (ii) involuntary resettlement, and (iii) indigenous peoples; aims to avoid adverse project impacts to both the environment and the affected people; minimize, mitigate and/or compensate for adverse project impacts; and help Borrowers to strengthen their safeguard systems and to develop their capacity in managing the environmental and social risks.

43. During the project identification stage, ADB uses a categorization system to indicate the significance of potential environmental impacts and is determined by the category of its most environmentally-sensitive component, including direct, indirect, cumulative, and induced impacts within the project's area of influence. The project categorization system and the assessment required is described in **Table 2.3**.

Table 2.3: SPS 2009 environmental categorization

Category	Definition	Assessment Requirement
A	Likely to have significant adverse environmental impacts that are irreversible, diverse, or unprecedented,	Environmental impact assessment (EIA)

[11] IDB.Statement by Dr. Ahmad Mohamed Ali, President, IDB. United Nationas Conference on Sustainable Development (Rio +20), 20-22 June 2012.
http://www.isdb.org/irj/go/km/docs/documents/IDBDevelopments/Internet/English/IDB/CM/About%20IDB/President%20IDB%20Group/PS_UN_ConferenceSustainableDevelopment_20June2012.pdf. (Accessed 6 December 2017)

Category	Definition	Assessment Requirement
	and may affect an area larger than the sites or facilities subject to physical works.	
B	Likely to have adverse environmental impacts that are less adverse than those of Category A. Impacts are site-specific, few if any of them irreversible, and in most cases mitigation measures can be designed more readily than Category A.	Initial Environmental Examination (IEE)
C	Likely to have minimal or no adverse environmental impacts.	No environmental assessment is required but the environmental implications of the project will be reviewed.
FI	Project involves investment of ADB funds to or through a financial intermediary (FI).	FIs will be required to establish an environmental and social management commensurate with the nature and risks of the FI's likely future portfolio to be maintained as part of the FI's overall management system.

Source: ADB. Safeguard Policy Statement 2009, p. 19. http://www.adb.org/sites/default/files/institutional-document/32056/safeguard-policy-statement-june2009.pdf.

2.5.1.1 Environmental requirements of ADB for Component 1

44. Based on SPS 2009, Component 1 is category A and the EIA is referred to in the overall project environmental assessment as Volume 1. This draft EIA was based on the findings of CEGIS, collation of primary data, and additional research from available secondary data to meet the requirements of SPS 2009. Aside from this draft EIA, the NWPGCL will provide ADB with a copy of the ECC issued by the DoE for Component 1.

2.5.1.2 Disclosure requirements

45. Aside from SPS 2009, the Public Communications Policy (PCP) 2011 provides for the requirements of disclosure for project information of projects and grants funded by ADB. Consistent with SPS 2009, PCP 2011 requires the disclosure of documents submitted by the borrower and/or client:

(i) a draft EIA report for category A project, at least 120 days before Board consideration;
(ii) a draft environmental assessment review framework, where applicable, before appraisal;[12]
(iii) the final EIA or IEE, upon receipt by ADB;
(iv) a new or updated EIA or IEE, and a corrective action plan, if any, prepared during project implementation, upon receipt by ADB; and,
(v) the environmental monitoring reports, upon receipt by ADB.

46. To meet the disclosure requirements of ADB, the EIA of Component 1 will be disclosed to ADB website at least 120 days prior to Board consideration of the project.

[12] If no further mission for appraisal is required, the document will be posted before the management review meeting or the first staff review meeting for sovereign projects, or before the final investment committee meeting for nonsovereign projects, as applicable (ADB procedures).

2.5.2 Islamic Development Bank

47. On 8 December 1974, the Islamic Development Bank (IsDB) was created as an international financial institution in accordance with the Articles of Agreement signed and ratified by all member countries done in the City of Jeddah, Kingdom of Saudi Arabia.[13] Consisting of 57-member countries in Africa, Asia, Europe, and Latin America, IsDB aims to foster the economic development and social progress in its member countries, and Muslim communities in non-member countries. Among others, IsDB is already a key player in the clean energy sector, with investments of around $1 billion between 2010 and 2012.[14] Since inception, IsDB has funded about $2.75 billion in renewable energy projects and has allocated six percent of its operation to climate change mitigating projects.[15]

48. During the projects' appraisal/negotiations stage in the IsDB's project cycle, activities cover the review and assessment of the following major aspects of a project: technical, institutional, economic, financial, social, and environmental impact.

49. IsDB is ADB's third-largest multilateral partner for project cofinancing since December 2015 and has signed a framework cofinancing agreement in September 2008 and was extended until 2017.[16]

2.6 Comparison of environmental safeguard principles between ADB and Bangladesh

50. **Table 2.4** presents a summary comparing the environmental safeguard principles of ADB and GoB.

Table 2.4: Comparison of environmental safeguard principles

ADB SPS 2009				
No.	**Principles**	**Delivery Process**	**GoB**	**Gaps (if any)**
1	Use of screening process to determine the appropriate environmental assessment	Uses sector-specific rapid environmental assessment checklist for screening and assigns categories based on potential impacts: • A - EIA required (irreversible, diverse or unprecedented adverse environmental impacts) • B - IEE required • C - no environmental assessment required but a review of environmental implications • FI - ESMS required	ECA 1995 and ECR 1997 set screening criteria to classify industries/projects based on potential environmental impacts as follows: Green (pollution-free), Orange-A, Orange-B and Red (cause significant environmental impacts). The screening criteria is based on project or industry type and do not consider the scale and location. The category determines the	No major gaps

[13] Islamic Development Bank, About IsDB. http://www.isdb.org/irj/portal/anonymous?NavigationTarget=navurl://24de0d5f10da906da85e96ac356b7af0

[14] UN Environment. UNEP and Islamic Development Bank Sign Agreement on Environmental Conservation. 20 January 2016. http://web.unep.org/newscentre/unep-and-islamic-development-bank-sign-agreement-environmental-conservation. (Accessed 6 December 2017)

[15] IsDB. What do Islamic Bank Care About the Environment: Role of Islamic Development Bank in Financing Sustainable Development. 6 March 2017.

[16] Asian Development Bank-Islamic Development Bank Partnership and Cofinancing Guide. 2016.

ADB SPS 2009				
No.	Principles	Delivery Process	GoB	Gaps (if any)
			level of environmental assessment.	
2	Conduct an environmental assessment	• EIA and IEE - Identify potential impacts on physical, biological, physical cultural resources, and socioeconomic aspects in the context of project's area of influence (i.e., primary project site and facilities, and associated facilities) • ESMS for FIs	*Industry/project category* *Green* - no environmental assessment required *Orange A* - no IEE or EIA required but must provide process flow, lay-out showing ETP, etc. *Orange B* - IEE required *Red* - both IEE and EIA are required	No major gaps, however, SPS 2009 provides opportunities for the public to review and provide comments to the EIA through public disclosure of the environmental assessment in ADB website.
3	Examine alternatives	• Analyze alternatives to the project's location, design, and technology • Document rationale for selecting the particular project location, design, and technology • Consider "no project" alternative	Regulations (i.e., ECA 1995 and ECR 1997) do not require specifically the identification and analysis of alternatives	Not required by law but the TOR for EIA to be approved by the DoE now includes a discussion on analysis of alternatives. Analysis of alternatives will be included as a separate section in the EIA to meet requirements of SPS 2009 and DoE
4	Prepare an EMP	• EMP to include monitoring, budget and implementation arrangements	EMP and procedures for monitoring included in the IEE and EIA (i.e., Orange-A, Orange-B, and Red category projects)	No major gaps
5	Carry out meaningful consultation	• Starts early and continues during implementation • Undertaken in an atmosphere free of intimidation • Gender inclusive and responsive • Tailored to the needs of vulnerable groups • Allows for the incorporation of all relevant views of stakeholders • Establish a grievance redress mechanism	• Public consultation and participation are not mandatory based on ECA 1995 and ECR 1997 • Grievance redress mechanism is not mentioned in ECA 1995 and ECR 1997 • EIA format required by DoE includes stakeholders' consultation	Approval of the TOR of EIA by DoE now includes consultation with stakeholders. Consultations were conducted during the initial preparation of EIA and during the completion of draft EIA
6	Timely disclosure of draft environmental assessment (including the EMP)	• Draft EIA report posted on ADB website at least 120 days prior to Board consideration • Draft EA/EARF prior to appraisal • Final or updated EIA/IEE upon receipt • Environmental monitoring report submitted by borrowers upon receipt	No requirement for public disclosure of environmental reports but DoE posts the Minutes of the Meeting on the application for ECC to its website, http://www.doe-bd.org/minutes.php	Still no requirement for public disclosure of environmental assessment. Major gap. EIA will be posted in ADB website 120 days prior to

ADB SPS 2009			GoB	Gaps (if any)
No.	Principles	Delivery Process		
				ADB Board consideration
7	Implement EMP and monitor effectiveness	• Prepare monitoring reports on the progress of EMP • Retain qualified and experienced external experts or NGOs to verify monitoring information for Category A projects • Prepare and implement corrective action plan if non-compliance is identified • Requires submission of quarterly, semi-annual, and annual reports to ADB for review	ECC is subject to annual renewal based on compliance of the conditions set by DoE	No major gaps
8	Avoid areas of critical habitats (use of precautionary approach to the use, development and management of renewable natural resources)	Provides guidance on critical habitats	ECA 1995 and ECR 1997 identifies ecologically-critical areas and the rules to protect them	No major gaps
9	Use pollution prevention and control technologies and practices consistent with international good practices	• Refers to World Bank's EHS General Guidelines 2007 (or any update) • If national regulations differ, more stringent will be followed • If less stringent levels are appropriate in view of specific project circumstances, provide full and detailed justification	• Effluent standards, ambient and emission standards included in ECA 1995 and ECR 1997 • Ambient noise levels included in Noise Pollution Control Rules 2006	No major gaps but EHS guidelines have more stringent standards.
10	Provide workers with safe and healthy working conditions	• Refers to World Bank's EHS General Guidelines 2007 (or any update)	Occupational health and safety standards included in the Factories Act 1965, the Bangladesh Labour Law 2006, and the Bangladesh Labor Act 2013.	No major gaps
11	Conserve PCR and avoid destroying or damaging them	• Use of field-based surveys and experts in the assessment • Consult affected communities on PCR findings • Use chance find procedures for guidance	Preservation and protection of cultural resources are within the Antiquities Act 1968.	No major gaps but national requirements do not include chance find procedures

ADB = Asian Development Bank, DoE = Department of Environment, EA = executing agency, EARF = environmental assessment review framework, ECA = Environment Conservation Act, ECC = environmental clearance certificate, ECR = Environmental Conservation Rules, EHS = Environmental Health and Safety, EIA = Environmental Impact Assessment, EMP = environmental management plan, ETP = effluent treatment plant, FI = financial intermediary, IEE = Initial Environment Examination, NGO = non-government organization, PCR = physical cultural resources, SPS = Safeguard Policy Statement, TOR = terms of reference, WB = World Bank.

3.0 DESCRIPTION OF THE PROJECT

3.1 Project Location

51. The project site is a developed but abandoned government industrial land of 50 acres earlier belonging to Khulna Newsprint Mill (KNM) Limited and is geographically located at around 22°51’11.32’’N latitude and 89°32’56.00’’E longitude on the eastern bank of the Bhairab River and on the western side of Bangladesh Industrial Development Corporation (BIDC) Road. The site is located at Khalishpur Upazila of Khulna District. The project location is shown in **Figure 3.1**.

52. Elevation at the project site varies approximately between +3.5 m to +2.3 m while the surrounding area varies about +3.3 m and +3.2 m, and towards the bank of the Bhairab River varies between +2.9 m and +2.1 m. The highest water level in Khulna is 3.86 m which occurred in 2005 based on yearly water level recorded by the Bangladesh Water Development Board since 1946. According to the Bangladesh Power cell (Hydrological Investigation and Model Study of Bhairab River, May 2016), maximum flood level is 3.86 m PWD or 4.32 with a return period of 100 years. The BPDB requirement for site formation in its installation should be 0.8 m above high flood level (HFL) or 0.1 m above the nearest highway whichever is higher. Thus, to meet the requirement of BPDB and to consider the maximum flood level, the site must be at elevation 5.32 m rounded off as 5.5 m.

53. The site is well connected with Khulna city through metal road of 7.7 km and river route (which include Bhairab, Rupsha, Poshur to connect to Bay of Bengal). Khulna is a Divisional headquarter of Bangladesh and is well connected with Dhaka and all other cities of Bangladesh through road, rail, air and river route.

54. A number of strategically important structure (i.e. Key Point Installation) have been found around the proposed power plant details of which area is shown in **Figure 3.2**.

55. There is a mosque and a mass graveyard of 1971 liberation forces (*Mukti Bahini*) adjacent to the power plant area. The mosque is in a dilapidated condition and needs a massive renovation and the graveyard needs cleaning, dressing including some repairing as well. The mosque and the graveyard are about 200 m from the project boundary. The mosque and the graveyard are to be separated from the rest of the project area by constructing boundary wall and will be fenced with gate to allow for power plant employees to use the mosque for daily prayer and occasional visit to the graveyard.

56. The existing school buildings (one for boys and the other for girls) will be relocated outside of the power plant boundary. The proposed locations for the schoolhave been under consultation and yet to be confirmed. The school authority, school management committee, and NWPGCL continue to dialogue to have the best location. Other sensitive areas within the study area are given in **Table 3.1** and shown in **Figure 3.3.**

Table 3.1: List of environmentally-sensitive areas with GPS locations

Sensitive Areas within Project Study area	GPS locations
Graveyard	N22• 51’ 22” E89• 32’ 60”
Mosque	N22• 55’ 23” E89• 38’ 61”
Shohid Hadis Park	N22• 48’ 32” E89• 34’ 19”
Wonderland Park	N22• 51’ 28” E89• 32’ 19”
Kola Beel	N22• 52’ 55” E89• 38’ 40”
Basuakhali Beel	N22• 55’ 27” E89• 38’ 60”

Source: CEGIS field survey (from 26 to 30 October 2016).

Figure 3.1: Layout of Component 1

LEGEND

1. ARMY AREA
2. DORMITORY AREA
3. PARKING AREA
4. GUARD HOUSE
5. ADMIN BUILDING
6. WORKSHOP AND STORE
7. RMS AND GAS CONDITIONING PLANT
8. EXISTING JETTY−1
9. EXISTING JETTY−2
10. HSD UNLOADING STATION
11. HSD TRANSFER STATION
12. HSD FORWARDING STATION
13. HSD STORAGE TANK
14. HSD DAY TANK
15. STARTUP BOILER (OPTIONAL)
16. COOLING TOWER
17. HYDROGEN PLANT
18. NITROGEN PLANT
19. HRG−1
20. GAS TURBINE−1
21. STEAM TURBINE−1
22. STEAM TURBINE−2
23. GAS TURBINE−2
24. HRSG−2
25. CENTRAL CONTROL ROOM
26. ST−TRANSFORMER
27. GT−TRANSFORMER
28. AUXILIARY TRANSFORMER
29. STARTUP TRANSFORMER
30. FIREWATER PUMP HOUSE
31. FIREWATER TANK
32. SWITCH YARD
33. SWITCH YARD CONTROL ROOM
34. RIVER CROSSING TOWER FOOTING
35. RAW WATER INTAKE PUMP HOUSE
36. CLARIFIER
37. SAND FILTER
38. SLUDGE PIT
39. RO WATER TREATMENT PLANT
40. RAW WATER TANK
41. DM PLANT
42. CHEMICAL ROOM
43. DM WATER TANK
44. EFFLUENT WATER TREATMENT PLANT
45. EFFLUENT WATER STORAGE TANK
46. EFFLUENT WATER DISCHARGE POND
47. NEW JETTY
48. CW PUMP HOUSE

Figure 3.2: Location of Component 1

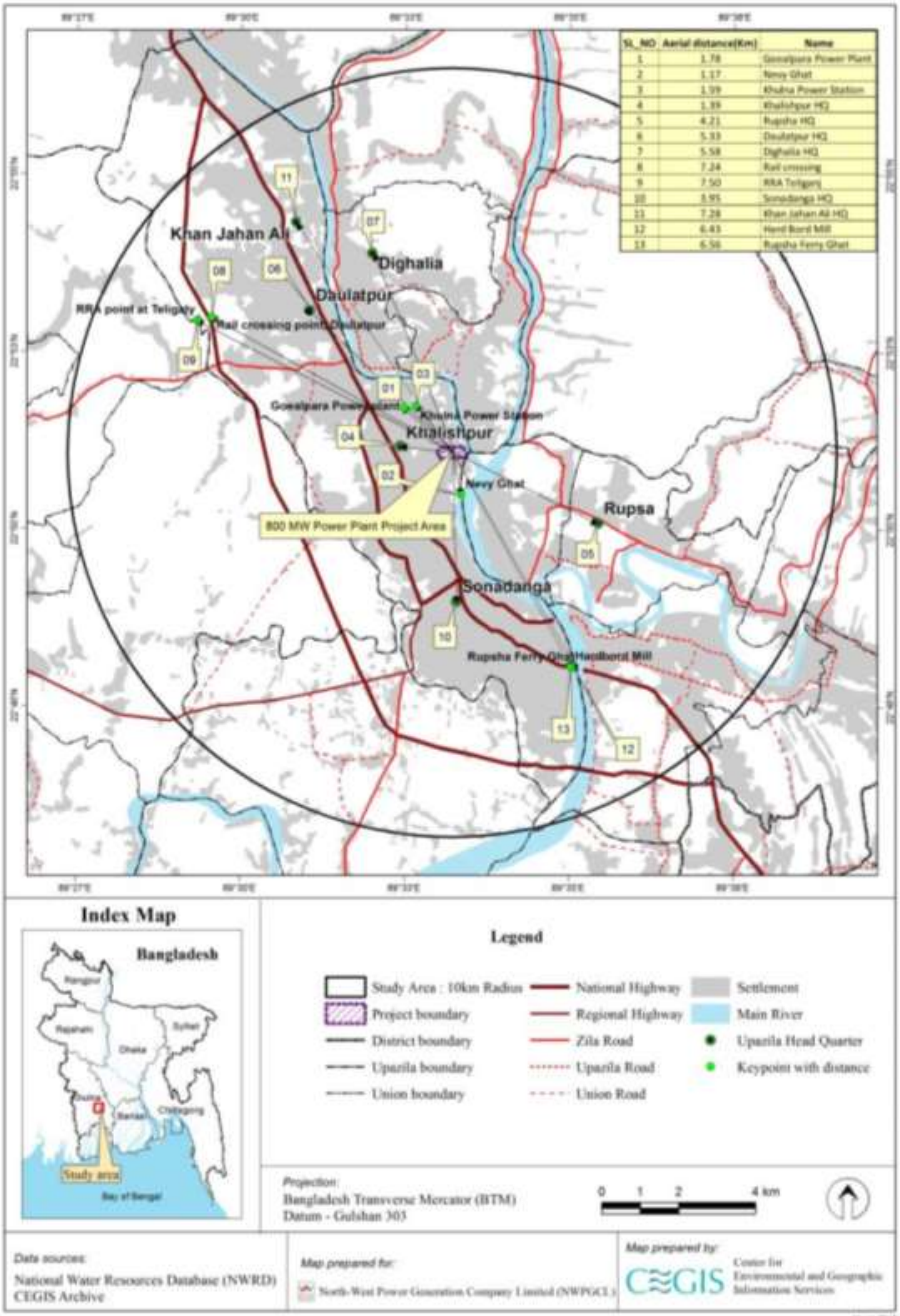


Figure 3.3: Important environmental and social areas

3.2 Nature and Size of the Project

57. The proposed project is a dual-fired combined cycle power plant (CCPP) that will use natural gas as primary fuel with HSD as back-up. There will two units of 400 MW each (2x400MW) with built-in low NO_x emission control technology, and closed-loop forced-draft cooling tower system. Natural gas will be supplied by SGCL from the Khulna CGS through a 10 km, 24 inch gas distribution pipeline while HSD will be supplied by Bangladesh Petroleum Corporation Limited (BPCL) from Daulathpure, Khulna. The net power generation capacity of the proposed CCPP will be 767.84 MW in gas and 648.34 MW in HSD. If operated as simple cycle power plant, the net power generation using natural gas will be 512 MW and 432 MW with HSD.

3.3 Project Components

58. According to the feasibility study, each unit of the proposed power plant shall have one industrial type F-class multishift gas turbine coupled with hydrogen-cooled generator of capacity 270 MW for indoor installation with a bypass stack of 50 m high with diverting damper for simple cycle operation, one horizontal type HRSG with main stack 60 m high for outdoor installation, and a heavy duty condensing type steam turbine coupled with a generator of 135 MW capacity for indoor installation in the configuration of 1:1:1.

59. Other auxiliary components are feed water pumps, condensate extraction pumps, air compressor, gas booster, cooling towers, two-three phase step up transformers (from 15 kV to 230 kV) of 360 million volt amperes (MVA) for gas turbine and 180 MVA for steam turbine capacity with one spare, 230 kV switchyard with all electrical components like circuit breaker, isolators,

lightning arrester, the HSD supply facility (two storage tanks with capacity each of 15,000 m^3, the gas supply facility which includes the RMS and gas skid, the water treatment facility which includes river water intake, demineralized water treatment plant, effluent treatment plant, reverse osmosis (plant and sewerage treatment plant. Other common facilities are residential and social activity area, internal roads, greenbelt, etc. There is an existing jetty but a new permanent jetty will be constructed to unload the HSD during operational phase. The design of the new jetty will be finalized in the detailed engineering design stage after appointment of EPC contractor. With the new jetty, localized dredging of small quantity will be carried out in the jetty area. Cast in-situ pile is envisaged for the construction of jetty which will not create any vibration during construction. Potential impacts and/or inconvenience will be localized and the stretch in the Bhairab River directly affected is not frequented by the Ganges River dolphins. However, the impacts on the dolphins and required mitigation measures for construction of jetty will be included in the EMP.

60. **Table 3.2** presents the breakdown of component and area allocated.

Table 3.2: Breakdown of components and area

Buildings	Area, acres
Guard house, dormitory, parking area	0.58
Admin building and workshop	2.08
RMS and fuel gas conditioning skid	2.31
Switchyard	4.13
GTG 1, HRSG 1 & STG 1	3.18
GTG 2, HRSG 2 & STG 2	3.19
Laydown Area	3.30
Demineralized water treatment plant	2.12
Cooling water system	2.49
HSD fuel storage system	2.72
River water treatment plant	3.49
Fire fighting water storage	0.67
Roads	5.87
Existing facilities, i.e., buildings that will remain (mosque, graveyard &guest house)	1.05
Spare land	11.65
Total	48.83

3.4 Project Activities

61. The major activities of the project during pre-construction, construction and post construction phases are as shown below:

A. Pre-construction phase

1. Appointment of the Engineering, Procurement, and Construction (EPC) Contractor
2. Complete and finalize detailed design of CCPP by EPC Contractor
3. Land ownership transfer by GoB
4. Update/revise the EIA based on detailed design, submit to ADB and repost to ADB website prior to construction works
5. Detailed survey for site development
6. Implementation of EMP for pre-construction phase

B. Construction phase (after EIA approval by DoE)

1. Civil construction and equipment and machineries erection work
2. Post erection check and pre-commissioning test
3. Environmental and social compliance monitoring of construction work (Implementation of EMP)
4. Commissioning test
5. Reliability test run for Provisional Acceptance Certificate
6. Commercial operation of the plant for Final Acceptance Certificate
7. Overall project management

C. Post construction

1. Commercial operation of the plant
2. Environmental and Social Monitoring including implementation of EMP
3. Proper O&M of the plant for efficient running

3.5 Project Plan and Schedule

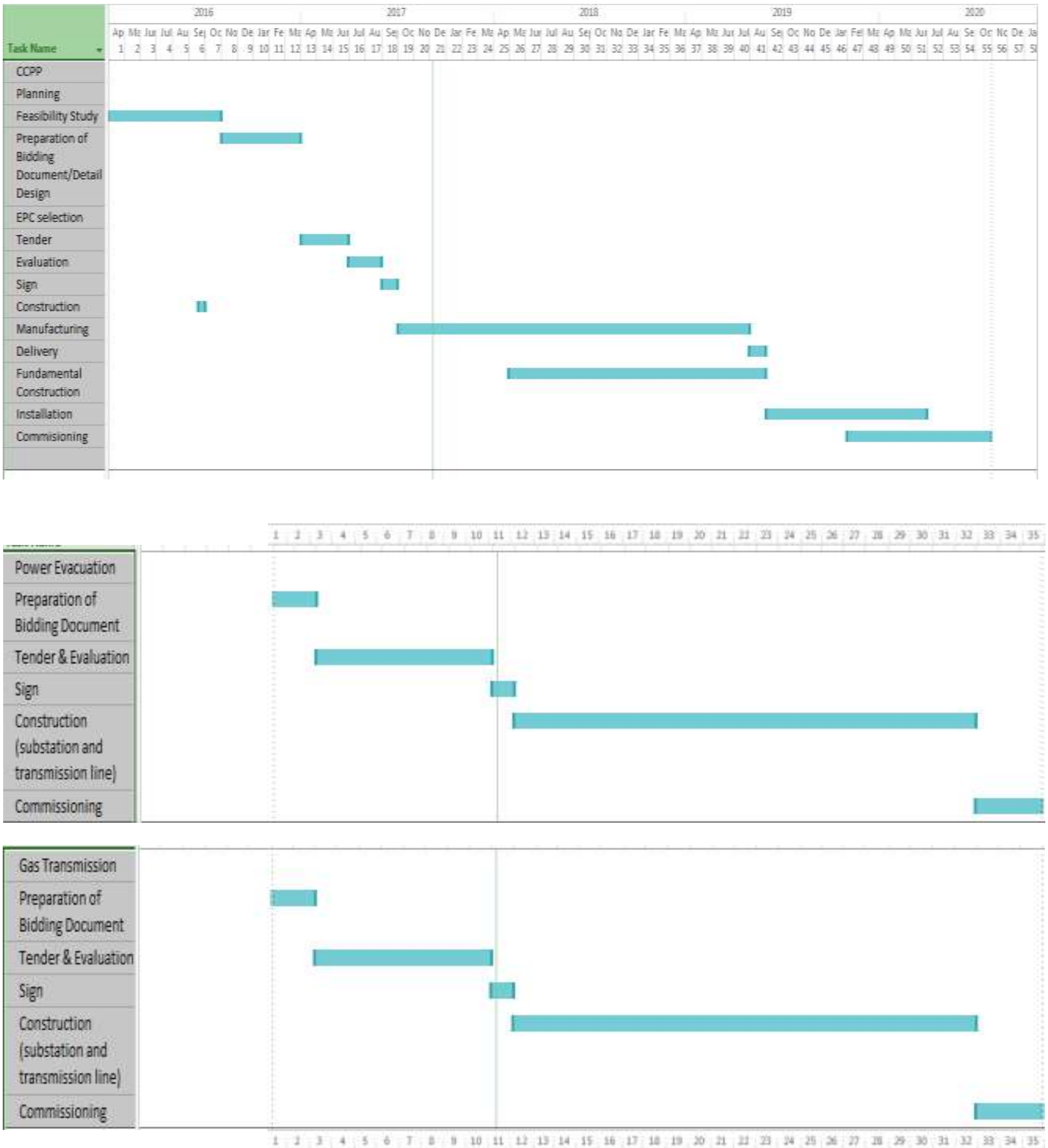
62. The project is originally scheduled to be completed on the first block on 31st December 2019 and the second block in June 2020. The feasibility study was scheduled to be completed by end of August 2016. **Table 3.3** and **Figure 3.4** show the project implementation schedule (in months) based on Study team's optimization:

Table 3.3: Project implementation schedule

Rupsha 800MW CCPP		
Activity	**Description**	**Number of Months**
Planning	Feasibility Study	5
	Preparation of Bidding Documents/ Detail Design incorporating the EMP of the ESIA report	3
EPC Selection	Tender	3
	Evaluation	2
	Sign	1
Construction	Manufacturing of Equipment	23
	Delivery	1
	Fundamental Construction	12
	Installation	4 (each block)
	Commissioning	4 (each block)
Power Evacuation		
EPC Selection	Preparation of Bidding Documents incorporating the EMP of the ESIA report	2
	Tender and Evaluation	9
	Sign	1
Construction	Construction	21
	Commissioning	3
Gas Transmission		
EPC Selection	Preparation of Bidding Documents incorporating the EMP of the ESIA report	2
	Tender and Evaluation	9
	Sign	1
Construction	Construction	21
	Commissioning	3

CCPP = combined cycle power plant, EMP = Environmental Management Plan, EPC = Engineering, Procurement and Construction, ESIA = Environmental and Social Impact Assessment, MW = megawatt.
Source: Feasibility Study 800MW CCPP 2017.

Figure 3.4: Project implementation schedule



3.6 Resources and Utilities Demand

63. Resources and utilities required to develop the project include soil, construction materials, manpower, electricity, fuel, water, power plant machineries, etc.

64. The project site needs to be improved to meet the require elevation set by BPDB for their key point installation. Based on the revised estimates in the Feasibility Study (August 2017), about 467,975 m^3 of ground filling will be needed to prevent ponding in the project site. Filling materials may come from the demolition works or sand. Only GoB-approved providers of sand materials will be sourced for the project.

65. The quality of the Bhairab River is influenced by tidal flows as reflected by the salinity content (less than 1 ppt in all the 10 sampling stations in the study area of Bhairab River, Atai River and Rupsha River measured by IUCN from May 2017 until February 2018). Water quality data from the Bhairab River within 2008-2010 showed values of electrical conductivity ranging from 220 to about 22,000 µS/cm (Feasibility Study August 2017). This water quality cannot be used for condenser and for cooling. High salinity water lowers vapor pressure of the water making it slow to evaporate. This makes it less as an effective coolant and reduces tower performance.

66. Water from the Bhairab River will require pre-treatment prior to meet the water requirements of the CCPP. The pre-treatment will involve conventional treatment (i.e., aeration pool, coagulation, flocculation, clarification and filtration) to produce treated water that will meet the quality for cooling water. Due to salinity, the treated water will undergo reverse osmosis. Demineralized water is required in the operations of the CCPP, thus, the water coming from the RO plant will be passed through the demineralization plant.

67. Demineralized water will be for continuous make-up of steam turbine cycle, HRSG, gas turbine as well as for gas turbine compressor washing, NOx control during HSD firing, dosing system, and the cooling tower system. The demineralized water treatment plant will consist of multilayer filters, cation/anion exchangers, mixed-bed polishers, a regeneration system, demineralised water storage tank, and all the piping, valves, and automatic control system.

68. Potable water for domestic use will be provided by Khulna Water Supply and Sewerage Authority.

69. Electricity. There is an electrical distribution system which can be used to provide electricity during pre-construction, construction, and operation stage.

70. Human resources required. It is anticipated that about 3,000-3,500 workers will be employed (skilled, unskilled, supervisors, engineers, management staff, etc.) at the peak of construction to accelerate work. NWPGCL employees will be around 30 during the construction phase. Local hiring will be given priority and there will be transparent recruitment process. Majority of the workers to be recruited will be local people who would likely stay or go home to their homes or may rent in the immediate vicinity if they live far from the site.

71. For foreign workers, the EPC Contractor will make arrangements for their accommodation. No dormitory or labour camp will be built within the 50 acre-site due to space constraints. The EPC Contractor can either negotiate with the KNM authority for the remaining space or other area to construct temporary living quarters for their foreign staff. The EPC Contractor will provide the

necessary labour camps. Two temporary stacked, steel container shed can be converted into construction site office. These container shed can accommodate about 8-10 workers.

72. During O&M phase, EPC Contractor will employ three persons for the warranty period (i.e., 2 years from plant takeover) and NWPGCL employees are expected to be around 175. Feasibility consultant has proposed 11 persons during engineering phase, 19 persons during construction phase, and 18 persons during operation phase. All these persons are the regular employee of NWPGCL who will be accommodated in the new NWPGCL's residential dormitory for Component 1.

3.6.1 Water Demand and Source

73. In a gas based CCPP, water is mainly required for steam generation, condenser and other auxiliary equipment cooling, HRSG makeup, service water, domestic purposes etc. Major part of water is required for condenser cooling. Water from the Bhairab River will be used for cooling system but will require pre-treatment. The Feasibility Report (August 2017) indicates that a one-time abstraction of water to fill the cooling tower is 60,000 m^3. A make-up water of 2,010 m^3/h will be needed which is only 0.12% of the total discharge of the Bhairab river. Thus, it is not expected to have conflict of water uses during the dry season.

3.6.2 Sources and Transportation of Construction Material

74. Construction materials generally include land filling material (sand, earth), cement, brick, mild steel road, shuttering material, etc. Most of these construction materials will be available in the local markets of Khulna and its surrounding area and can be brought to the site by road or river transport. The land filling materials will be collected by the Contractor only from GoB-approved site/providers.

3.6.2 Transportation of Equipment, Machinery, etc.

75. Heavy machineries and equipment like HRSG, turbo- generator rotor, transformer, switch yard equipment, etc. will come from abroad. The equipment can be shipped to the Mongla Port then transferred to barges or lighter vessels. Navigation and river transport of equipment and construction materials will consider movements of Ganges River dolphins based on the results of the assessment done by the IUCN for this project.

76. The maximum carrying limit for transportation by road is 70 tons and if by railway, it would require transport by road from the railway station. Thus, the best option that will cause less disturbance and inconvenience to local people, will be using the waterway. The weight of the major equipment that will be transported to the site ranges from 50 tons (transformer) to 320 tons (gas turbine transformer). Equipment will be unloaded to barges from the main vessel at Mongla Port and will be carried through river to project site. Bhairab River is classified as Class II by the Bangladesh Inland Water Transport Authority (based on minimum depth, length of route, and minimum vertical and horizontal clearance). Atai River and Rupsha River are Class III. Barges/cargo boats that will deliver equipment to the site will have a vertical clearance of 12.2 m and horizontal clearance of 76.22 m.

77. There are two jetty left from the operations of KNM but only one is within the 50 acres earmarked by the GoB for Component 1. The condition of the existing jetty will be assessed by the EPC Contractor for safety and stability, and if it needs refurbishment or rebuilding. A new jetty will be designed and constructed fit for the purpose of handling heavy equipment transport.

3.6.3 Requirement, Source and Composition of Fuel for Plant Operation

78. Natural gas will be the primary fuel and will require a maximum of 125 million cubic feet per day (MMCFD). This will be supplied by SGCL from the Khulna CGS in Aronggatha through a 10 km, 24-inch gas distribution pipeline terminating to the regulation and metering station (RMS) at the power plant site. The pipeline will be constructed following the requirements of the Natural Gas Safety Rules 1991 (amended 2003). Composition of natural gas required will be a minimum of 85% mole methane (CH4). The following sources from imported regasified liquefied natural gas (R-LNG) and domestic supply will provide adequate supply of natural gas for Component 1.

- FSRU Moheskhali - 500 MMSCFD of R-LNG will be made available by April 2018 developed by Excelerate Energy, USA-Bangladesh
- Summit LNG Terminal Company Limited – 500 MMSCFD R-LNG will be made available by October 2018
- GoB and RasGas (Qatar) has signed a deal in September 2017 for a 15-year LNG sales and purchase agreement to supply 1.8 million (M) tons LNG/year for 5 years and 2.5 M tons/year for the next 10 years
- According to Petrobangla, there will be additional supply (domestic) of 2,750 MMSCFD
- By 2021, Bangladesh Petroleum Exploration and Production Company Limited (BAPEX) will have 55 exploration wells and 31 development wells

79. The natural gas produced in Bangladesh is “sweet gas” (does not contain hydrogen sulphide) and thus, all the existing natural gas transmission and distribution pipeline networks are designed for high quality natural gas.

80. The use of HSD as secondary fuel will be required in case of emergency and is estimated to be about 500 hours maximum per year (or about 20 days assuming continuous operation of 24 hours). HSD requirement will be about 2,773 kiloliters (KL) per day. Two HSD storage tanks with a capacity of 15,000 cubic meter (m^3) will be constructed within the power plant site. Each storage tank can supply about 5 days of continuous operation on HSD. Fuel supply agreement between BPC and NWPGCL in November 2015 provides that the HSD will have a maximum sulfur content of 0.25% wt. In practice, BPC has provided NWPGCL with HSD with sulfur content of 0.1% wt analyzed in 2016 by the Chemical Engineering Department of Bangladesh University of Engineering and Technology.

3.6.3 Potential Pollution Sources and Mitigation Measures.

81. Emissions from gas turbine using natural gaswill be NO_x and CO_2, and SO_2 if run on HSD. Natural gas and HSD will not have emissions on PM_{10} and $PM_{2.5}$. Dry low-NOx burner will be used to reduce generation of NO_x during combustion and water dosing if fired on HSD. The maximum sulfur content of HSD will be 0.5% wt and will be used for maximum of 500 hrs per year while gas will run for 5,632 hrs per year on an average plant factor of 70%.

82. There is no requirement from the DoE to replace trees cleared due to the project. However, a greenbelt will be included within the project site which can serve as buffer for noise generated by the power plant. The development of green belt of at least 3.5 m is recommended as noise buffer at the same time, replace the trees cleared. It is strongly recommended to develop

regular greenbelt as part of corporate social responsibility. Given the area allocated for Component 1, development of greenbelt to replace the vegetation lost in the 30-acre land may not be accommodated in the project site.

83. Cooling tower will be used to reduce water requirements compared to once-through cooling systems. There will three exhaust silencers to reduce noise generation.

3.6.5 Tentative Costing and Funding

84. Based on the Final Feasibility Report (August 2017) the estimated cost of the project is about $750M (see **Table 3.4**).

Table 3.4: Tentative cost of the project

Items	Cost (in $ million)
Plant Cost	630.18
Power Evacuation	23.2
Gas Distribution	6.17
Engineering and Consultancy	11.38
Other Costs	78.94
Total Cost	**749.87**

3.7 Project Site Development

85. The project site is an area formerly used by the Khulna Newsprint Mills (KNM) Limited located in Khalishpur Thana, Khulna Division. KNM was under expatriate management from start in 1959 until the end of 1965 when it was put under the management of the East Pakistan Industrial Development Corporation. KNM was the first and major producer of newsprint paper in Bangladesh using Gewa wood (*Excoecaria agallocha*), a native mangrove species in Bangladesh, as raw material. Sand well and Company, a Canadian firm, was engaged as a consultant in the construction and commissioning of KNM. Beset with problems ranging from market behaviour after the independence, availability of spare parts, low capacity utilization (newsprint production at KNM has not been able to reach the levels achieved prior to independence), operational management, price of oil, interrupted supply of raw material due to security issues, etc., GoB stopped its operations completely in November 2002.

3.7.1 Site Preparation

86. There are about 151 structures standing within the 50 acres consisting of 122 primary residential structures such as bungalow for the Managing Director, dormitories and residences of staff, kitchen and dining, guest house, and Ansar camps, etc. while the remaining 29 structures are non-residential like auditorium/cinema, water tank, fire fighting system, swimming pool and rest house, mosque, boys and girls school, etc. **Table 3.5** presents the inventory of structures abandoned at the project site. **Figure 3.5** presents the location of the structures.

87. These structures will be demolished but three structures will remain: (i) the mosque; (ii) the graveyard marker (a PCR based on SPS 2009); and (iii) the three-story managing director's guest house. The mosque and the graveyard are beyond the boundary of the power plant, about 100 m. The mosque will be refurbished including renovation and beautification works. New boundary walls will be built around the mosque while the graveyard will be also refurbished

including renovation and fencing. Final design and extent of renovation works for both the mosque and graveyard will be finalized during the detailed engineering design in consultation with the *Imam*, elderly, and other stakeholders. The fence and boundary wall for the mosque will be for security reasons and a separate access will be provided. The three-story guest house would also be refurbished and retained.

88. *Demolition*. The demolition of the existing structures in the project site will not be funded by ADB or IsDB. Based on the inventory of the structures, most of them are made of bricks, reinforced concrete, tin sheets, pacca and semi-pacca ranging from single to three-story buildings. Demolition will be done through tendering process. The winning bidders will take care of the works which would take no more than 4 months. The bidding document which will be tendered by NWPGCL will specify the regulatory requirements and permits/standards/codes relevant to demolition and disposal of material and debris, by which the contractor will be required to comply. Protection measures will include provision of enclosures during demolition works, spraying of water to contain dust, working during daytime only, use of personal protective equipment such as safety belts, boots, masks, etc. NWPGCL will inform the Contractor that the demolition works will be part of the environmental monitoring of Component 1. As such, the environmental staff of NWPGCL or consultant will monitor the demolition works.

89. The mosque and the graveyard are not close to the buildings to be demolished. Nonetheless, the Contractor will be required to describe how the remaining structures will be protected. Demolition works will start once the new schools are completed and the children have moved to the new place to minimize disturbance to their school activities. The disposal of debris shall be either carted away to designated disposal area assigned by the Khulna Municipal Corporation or it may also be taken away by third party to be used as backfill material.

90. Demolition works will comply with the Bangladesh National Building Code 2006, and the relevant regulations of Khulna Municipal Corporation, and the Khulna Development Authority (KDA).

91. *Clearing of* trees. The type of trees that will be cleared is mainly fruit trees (1,777 trees). Tree cutting permit will be obtained from the DoE. As required by the Forest Act, 1927 (Act No. XVI of 1927).

Table 3.5: Description of Abandoned Structures in Khulna Newsprint Mills

SL	Name of Building	No. of. Structure	Type of Bldg.	Type of Structure	Category	Number of Story	Area per structure (m^2)	Total Area (m^2)	Total Area (ft^2)	Construction Year
Residential Structures (primary)										
1	MD's Bungalow	1	P	RCC	R	2	192.57	192.57	2,071.75	1960
2	Junior Colony	1	P	LBWS	R	1	195.17	195.17	2,099.72	1960
3	Junior Colony Building	10	SP	LBWS	R	1	279.75	2,797.50	30,096.62	1960
4	Junior Colony Building	14	TS	LBWS	R	1	17.74	248.33	2,671.63	1960
5	Junior Colony Building	1	P	LBWS	R	1	1354.18	1,354.18	14,568.81	1960
6	Junior Colony Building	1	P	LBWS	R	1	306.70	306.7	3,299.60	1960
7	New Colony Bachelor Quarter	2	P	LBWS	R	1	1962.83	3,925.65	42,233.71	1960
8	New Colony Building	4	P	LBWS	R	1	1177.70	4,710.78	50,680.46	1960
9	New Colony Building	4	P	LBWS	R	1	1491.64	5,966.54	64,190.42	1960
10	New Colony Building	5	P	LBWS	R	1	1318.22	6,591.08	70,909.48	1960
11	New Colony Building	2	P	LBWS	R	1	223.05	446.1	4,799.32	1960
12	Senior Colony Apartment	7	P	RCC	R	2	541.26	3,788.85	40,761.96	1960
13	Senior Colony Bungalow	24	P	LBWS	R	1	172.76	4,146.28	44,607.34	1960
14	Senior Colony Building	2	P	RCC	R	3	1246.83	2,493.66	26,827.79	1960
15	Senior Colony Building	1	P	RCC	R	2	831.23	831.23	8,942.70	1960
16	Senior R House	19	P	LBWS	R	1	196.63	3,736.06	40,194.03	1960
17	Senior R House	1	P	LBWS	R	1	466.54	466.54	5,019.22	1960
18	Senior R House	3	P	LBWS	R	1	263.94	791.82	8,518.72	1960
19	Senior officers Dormitory	1	P	LBWS	R	1	110.59	110.59	1,189.77	1960
20	Senior Officers Hostel	1	P	LBWS	R	1	790.00	790	8,499.14	1960
21	Officers Rest House	1	P	RCC	R	3	1207.81	1,207.81	12,994.10	1960
22	Guest House	1	P	RCC	R	3	1100.00	1,100.00	11,834.24	1990
23	Mess No. 10	1	SP	LBWS	R	1	211.89	211.89	2,279.60	1960

SL	Name of Building	No. of. Structure	Type of Bldg.	Type of Structure	Category	Number of Story	Area per structure (m²)	Total Area (m²)	Total Area (ft²)	Construction Year
24	Rest House Dinning	1	P	LBWS	R	1	98.14	98.14	1,055.83	1960
25	Kitchen	1	SP	LBWS	R	1	21.47	21.47	230.98	1960
26	Ansar Camp x2	2	SP	LBWS	R	1	70.59	141.17	1,518.76	1960
27	Foreman Quarter	10	P	LBWS	R	1	269.52	2,695.17	28,995.72	1960
28	Sweper Colony	1	P	LBWS	R	1	348.51	348.51	3,749.41	1960
Subtotal		122					16467.24	49713.79	534840.84	
Non-Residential Structures (primary)										
1	Office Club	1	SP	RCC	NR	1	563.94	563.94	6,067.09	1960
2	Office Club-2	1	SP	RCC	NR	2	458.09	458.09	4,928.32	1960
3	Colony Electric office	2	SP	LBWS	NR	1	32.02	64.03	688.86	1960
4	Colony Office	1	SP	LBWS	NR	1	100.80	100.8	1,084.45	1960
5	Senior Colony Office	1	P	LBWS	NR	1	79.00	79	849.91	1960
6	Sewing Centre	1	SP	LBWS	NR	1	74.35	74.35	799.89	1960
7	Senior colony Mosque	1	p	LBWS	NR	1	7.60	6.1	499.01	1960
8	Secondary School (Boys')	1	P	LBWS	NR	4	334.45	1337.8	14,399.95	1960
9	Secondary School (Boys')	1	P	LBWS	NR	1	334.45	334.45	3,599.99	1960
10	Secondary School (Girls')	1	P	LBWS	NR	2	334.45	668.9	7,199.97	1960
11	Secondary School (Girls')	1	P	LBWS	NR	3	334.45	1003.35	10,799.96	1960
12	Madrasa	1	p	LBWS	NR	2	18.29	4.57	900.46	1960
13	Madrasa	1	p	LBWS	NR	1	24.39	6.10	1,600.82	1993
14	Auditorium/ Cinema hall	1	SP	LBWS	NR	2	54.9	18.3	10,805.52	1960
15	Auditorium/ Cinema hall	1	P	LBWS	NR	1	15.2	7.6	1,250.64	1960
16	Intake Channel	1	P	LBWS	NR	1	258.75	258.75	2,783.74	1960
17	Plyers Room x3	3	SP	LBWS	NR	1	38.10	114.31	1,229.79	1960
18	Water Pump House	2	SP	LBWS	NR	1	18.22	36.44	392.24	1960

SL	Name of Building	No. of. Structure	Type of Bldg.	Type of Structure	Category	Number of Story	Area per structure (m^2)	Total Area (m^2)	Total Area (ft^2)	Construction Year
19	Overhead Water Tank (pillar)	1	P	RCC	NR	4			14,400	1960
20	Fire Pump House	1	TS	LBWS	NR	1	9.15	4.57	449.92	1960
21	Electric office Garage	1	TS	LBWS	NR	1	4.57	4.57	224.80	1960
22	Swimming Pool RCC	1	P	RCC	NR	1	267.94	267.94	2,882.61	1960
23	Swimming Pool Rest Room	1	SP	LBWS	NR	1	28.25	28.25	303.92	1960
24	Swimming Pool Rest Room	1	P	LBWS	NR	1	24.54	24.54	264.01	1960
25	Toilet	1	P	LBWS	NR	1	12.64	12.64	135.99	1960
	Subtotal	29					3428.56	5479.41	88541.85	
	All Structures	151					19895.8	55193.2	623,382.68	
Secondary structures										
Gate in sqft									Area (sqft)	
1	Gate	1	IS		-		6.10	2.4	160.08	1960
2	Gate	1	IS		-		4.57	2.1	105.05	1960
3	Gate	2	IS		-		2.13	1.1	24.51	1960
4	Gate	4	M		-		3.05	1.8	60.03	1960
5	Gate in MD's Bungalow	1	M		-		3.05	1.5	50.03	1960
	Subtotal	9					18.90	8.99	399.70	
Wall in running feet (rft)									Area (rft)	
1	Wall	1	-	BW	-	-	-	-	600	1960
2	Wall (5 inch)	-	P						4570	1960
	Post in number								Number	
3	Lamp post	15	S	S					15	1960
4	Lamp post	40	P	RCC					40	1960
	Water Tank in cubic feet (cft)								Area (cft)	
5	Overhead Water Tank (container)	1	P	RCC	-	-	-	-	10,500.00	1960

BW = Barbed Wire, IS = Iron Sheet, LBWS = Load Bearing Wall Structure, M = Metal, NR = Non-residential, P = Pacca, R = Residential, SP = Semi pacca, TS = Tin shade, S = Steel.

Figure 3.5 Location of existing structures in project site

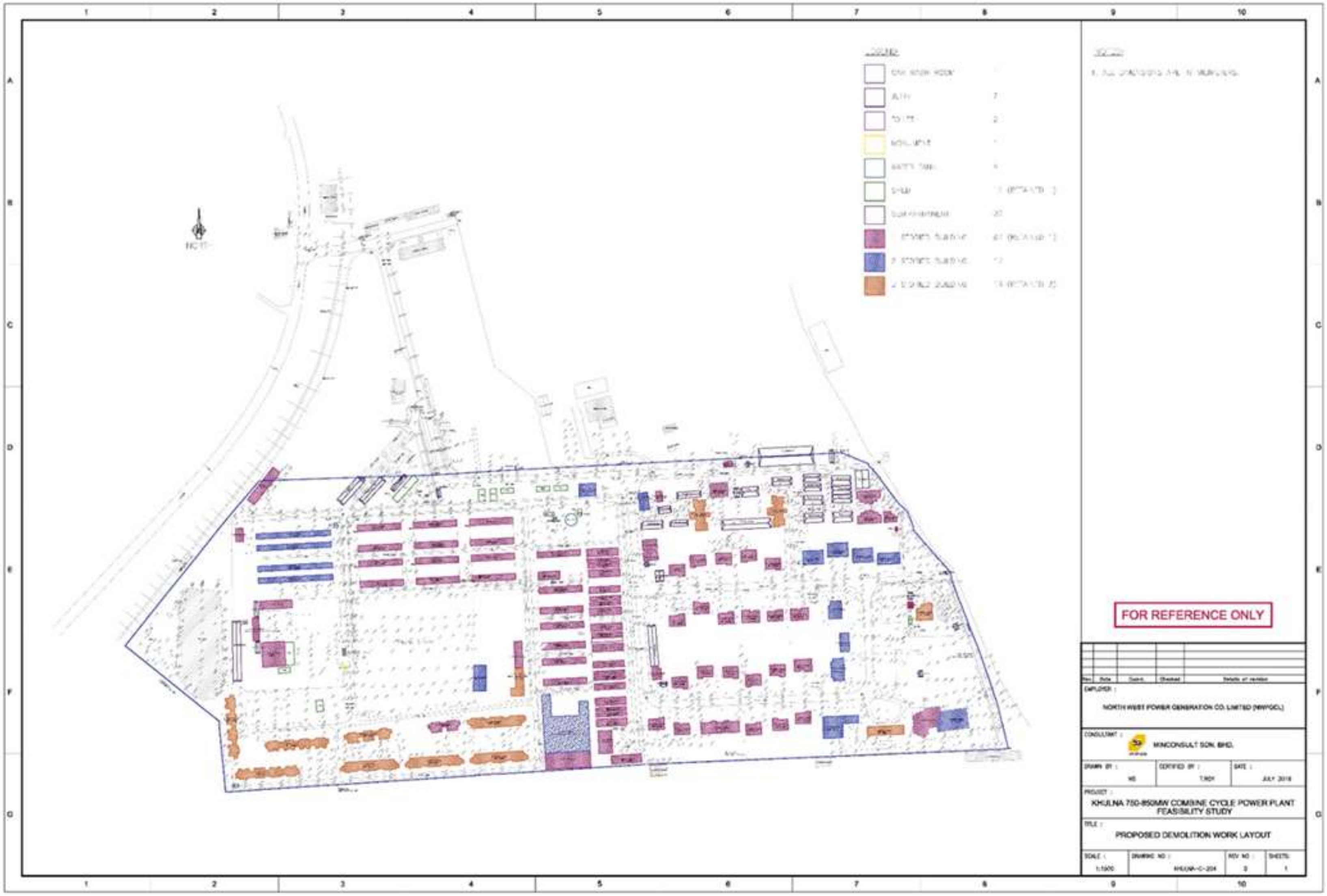


Figure 3.6: Sites to be isolated

Mass Grave

Mosque

92. Elevation at the project site varies approximately between +3.5 m to +2.3 m while the surrounding area varies about +3.3 m and +3.2 m, and towards the bank of the Bhairab River varies between +2.9 m and +2.1 m. The highest water level in Khulna is 3.86m which occurred in 2005 based on yearly water level recorded by the Bangladesh Water Development Board since 1946. According to the Bangladesh Power cell (Hydrological Investigation and Model Study of Bhairab River, May 2016), maximum flood level is 3.86 m PWD or 4.32 with a return period of 100 years. The BPDB requirement for site formation in its installation should be 0.8 m above high flood level (HFL) or 0.1 m above the nearest highway whichever is higher. Thus, to meet the requirement of BPDB and to consider the maximum flood level, the site must be at elevation +5.32 m rounded off as 5.5 m. To have this elevation, the amount of filling required will be about 467,975 m^3.

93. *River bank protection at Bhairab River*. The river bank will be protected from erosion by means of rock armour, rock filter and MIRANFI PP200S Fabric Filter Membrane or equivalent. The river bank protection is shown in **Figure 3.7** while **Figure 3.8** shows the project layout with the river bank protection.

3.8 Technology and Process Description of Individual Plant Components

3.8.1 Power generation

94. A CCPP mainly consists of a combustor, gas turbine generators (GTGs), a HRSG and a steam turbine generator (STG), a cooling system and fuel supply system. Natural gas from the RMS via gas booster mixes with compressed ambient air in the combustor and then ignites. The hot flue gas thus produced from the combustor is then directed to the GTG, where it expands, loses pressure and temperature and causes the GTG to spin and generate about two thirds of plant's power at the generator terminal.

95. The exhaust flue gas of gas turbine at a temperature of more than 500^{o}C is directed to HRSG, where feed water is converted into steam at different pressures (high pressure - HP, intermediate pressure - IP and low pressure - LP) and is then directed to the STG where it expands and causes the STG to spin and generate one third of plant's power at the generator terminal. The generated power of GTG and STG at 15.75/230 kV and 10.5/230 kV respectively will be stepped up to grid voltage level of 230 kV by step up transformers (240 MVA for gas turbine

and 120 MVA for steam turbine) and feed to the national grid (Khulna south sub-station) via plant switch yard. Underground cables will be used for all inter-connections from transformer to the plant's switch yard. The condenser and other components cooling of the plant will be accomplished applying surface water from Bhairab River via cooling tower technology. A typical process flow diagram is shown in **Figure 3.9**.

Figure 3.7: River bank protection, Bhairab River

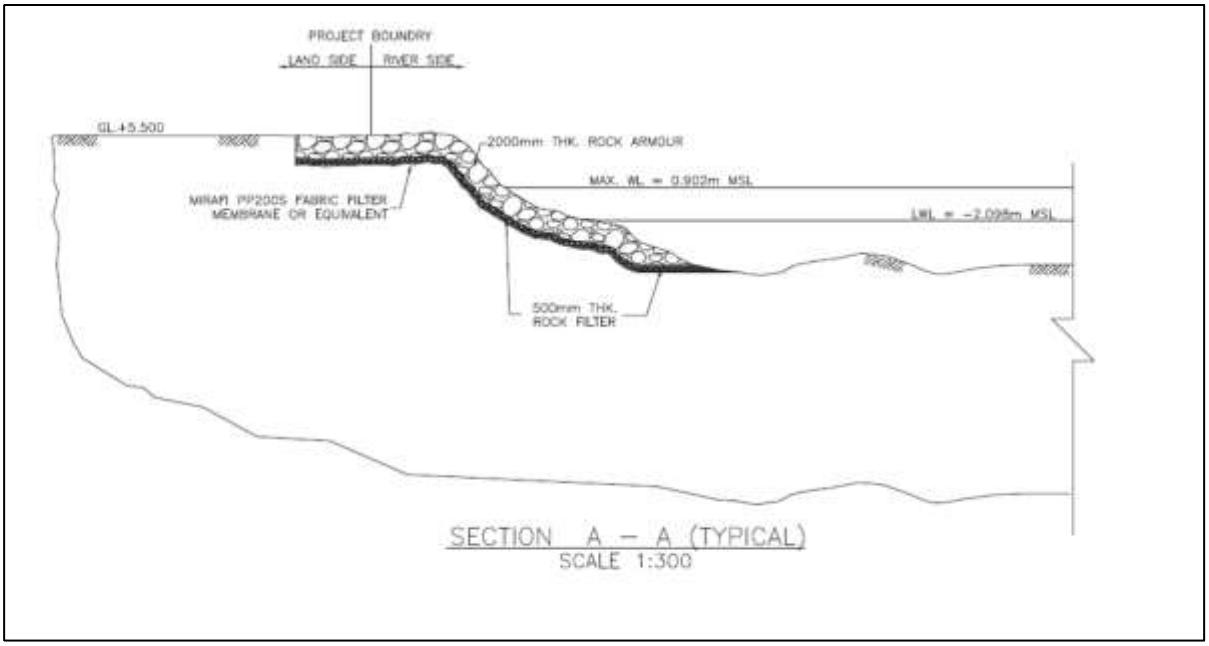


Figure 3.8: Project Layout with the river bank protection

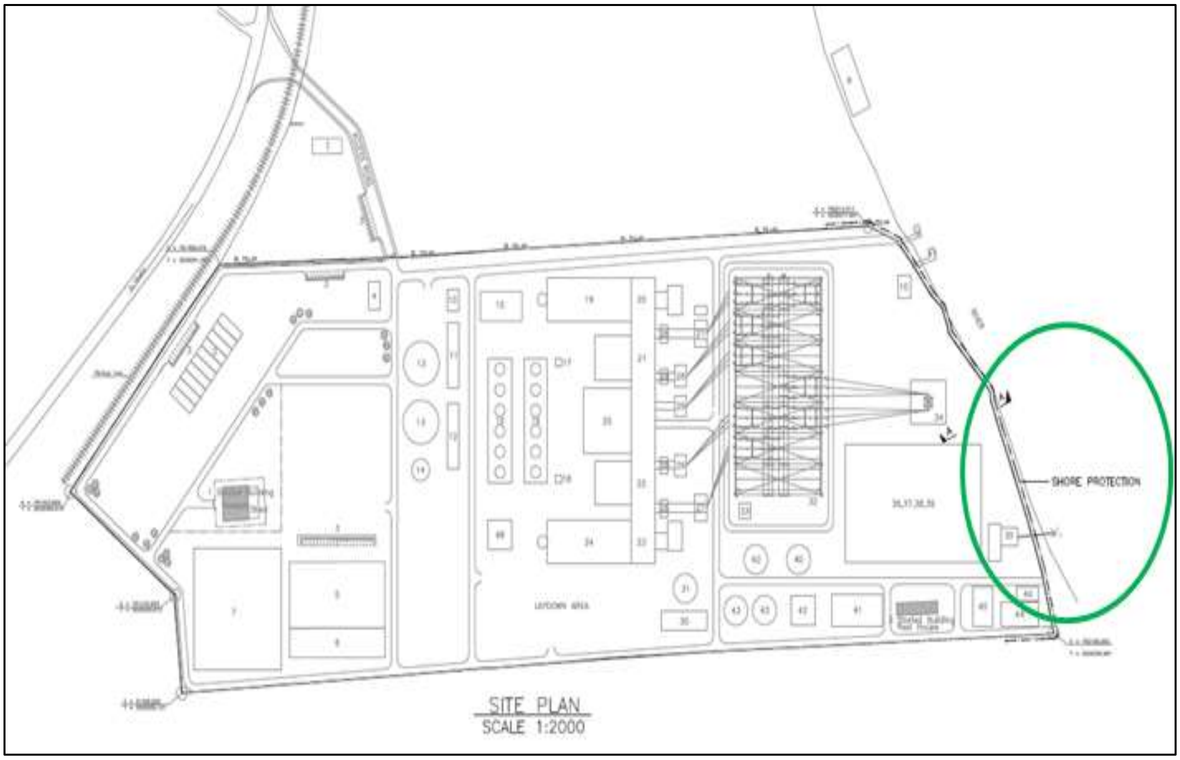
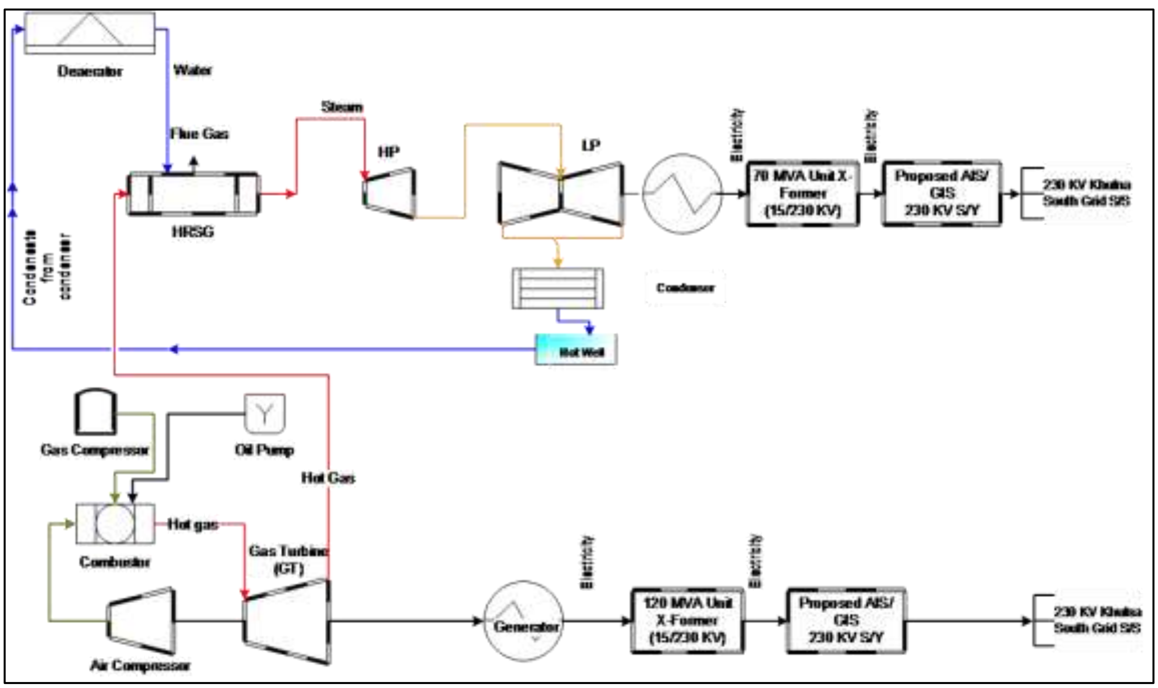


Figure 3.9: Process flow diagram of electricity generation



Source: CEGIS, 2017

3.8.2 Heat recovery steam generator boiler and its auxiliaries

96. The steam generating unit is a heat recovery steam generator (HRSG). An HRSG is an energy recovery heat exchanger that recovers heat from the gas turbine exhaust hot gas stream. It produces steam that can be used in a process or used to drive a steam turbine. In this case, the hot exhaust flue gas of the gas turbine flows horizontally over vertical tubes and generates steam at different pressures (dual pressure HRSG) like high pressure and low pressure. A dual pressure HRSG consists of two sections: a low pressure section and a high pressure section.

97. Each section has a steam drum, economizer, evaporator and a super heater. The primary function of the steam drum is to separate water from steam which prevents carryover of the condensate into to the steam header.

98. An **economizer** is a mechanical device which is used as a heat exchanger to heat up feed water by recovering residual heat from the flue gases before being released in the open air through the main stack.

99. **Evaporator sections** are those sections where water boiling or steam generation occurs. Feed water in down comer tubes absorbers heat from gas turbine exhaust stream and starts evaporating to steam. Through riser tube steam water mixture flows upward and escapes into the steam drum where steam is separated from water and is further heated in the super heater section. This is known as natural circulation loop.

100. **Super heater sections** are composed of extended or fine tube surface modules and have the highest metal temperatures in the HRSG. The major function of a super heater is to increase steam temperature above saturation. This high steam temperature minimizes the presence of fine water particle in steam and thereby protects turbine blades and improves steam cycle efficiency. The super heater absorbs heat energy from the exhaust gas and transfers this energy to the steam. Drainable super heaters are employed in the most HRSG designs to ensure that any water accumulated in the lower headers can be drained during startup.

101. An **HRSG feed water pump** feeds water into the HRSG drum. The water may be freshly supplied or returning condensate from the steam turbine condenser. Two types of feed pumps are generally used, such as positive displacement type and centrifugal type.

3.8.3 Turbine and its auxiliaries

102. A **turbine** is a rotary engine (mechanical device) that extracts kinetic energy of a moving fluid (Steam in this case) and converts it into mechanical energy or useful work. It has a series of higher temperatures withstanding blades (impulse and reaction) mounted on its shaft known as rotor. The fluid (Steam) goes inside through one end, pushing the blades and causing them to spin and finally escapes to atmosphere through stack (in gas turbine) or to condenser for condensation (in steam turbine). In this proposed CCPP Project, there will be two turbines in each unit, such as one gas turbine and one steam turbine for each block.

103. A **gas turbine** is a type of internal combustion engine. It has an upstream rotating compressor coupled to a downstream turbine, and a combustion chamber in between called combustor.

104. A **combustor** is a component of a gas turbine where combustion takes place. HP air from the air compressor is fed into the combustion chamber that contains a ring of fuel injectors through

which a steady supply of fuel is maintained. The fuel mixes with air and gets ignited. This combustion produces a high temperature and HP flue gas stream that enters and expands in the gas turbine section and causes the Turbo Generator to spin and thus generates electrical power.

105. A **steam turbine** is an internal combustion engine that extracts heat energy from HP – high temperature steam and converts it to mechanical energy or useful work. Steam from a Boiler/HRSG enters into the turbine in HP end and flows over the bladed rotor to the LP end. And in doing so steam loses its kinetic energy and enthalpy and causes the bladed rotor to spin. In other words, this loss of energy is converted into mechanical energy. At the LP end, the steam enters into the condenser where it is cooled and condensed by circulating cooling water. The condensate is then pumped to the feed water tank via Deaerator by a condensate extraction pump. The condensate (feed water) is then pumped from feed water tank to Boiler/HRSG drum through heaters by feed water pump and thus completes the steam-feed water –condensate cycle

3.8.4 Fuel storage and handling system

106. The proposed plant is a dual fuel (natural gas and HSD) based CCPP. The SGCL will supply natural gas at a pressure of about 400psi through a pipeline of around 10km-long with 24-inch diameter. Gas pipeline will connect from the existing Khulna city gate station (CGS) to the RMS of the power plant. From this RMS gas will be supplied at a pressure of 150 psi to the gas booster. Using gas booster gas will be supplied to the gas combustor through at a pressure of 330 ± psi.

107. HSD will be supplied by Bangladesh Petroleum Corporation (BPC) from its Daulatpur, Khulna depot. Two options were considered as possible routes for delivery to the CCPP in Khalispur. By road using tankers will be 3.1 km from the BPC depot to the CCPP and through the Bhairab River by barge at 3.3 km. There is an existing jetty, but the stability and condition will be assessed by the Design and Build Consultants if it can handle unloading of HSD. To ensure reliability during operations, a new permanent jetty will be constructed to handle loading and unloading of HSD from barges and for general purposes. Two storage tanks for HSD will be installed at 15,000 m^3 each. These two tanks can handle 10 days of continuous operation on HSD.

3.8.5 Water System and Water Balance

108. According to the Feasibility Report (August 2017), the hourly water requirement of the plant is 2,010 m^3/h as makeup for plant cooling and all other purposes. The required water will be taken from the Bhairab River. Accordingly, a water balance diagram has been developed showing the use of forced draft cooling tower technology with surface water (**Figure 3.10**).

109. **Intake channel.** The use of forced draft closed-loop cooling system, some 4% of the re-circulating water flow rate must be made up to compensate for blowdown water and evaporation, and water drift losses depending upon the design parameters of the tower. The blowdown water flow rate is assumed some 2% to keep the solid concentration in the circulating water within 2 times that in the makeup water. The remaining 2% is required for compensation of evaporation and water drift losses. Therefore, the required makeup water flow rate can be estimated at 2,010 m^3/hr. Intake channel is shown in **Figure 3.11**.

110. The area for the water treatment facility including river water intake facility, water treatment plant, ETP, reverse osmosis plant and raw water treatment plant is estimated to be approximately 5.61 acres. The area allocated for the other balance of plant including fire water reservoir, potable

water tank, CO_2 storage area and hydrogen plant is estimated to be approximately 3.16 acres. The cooling water system (intake from river) shall consist of the intake bay, raw water lift pumps 3x50% duty. The cooling water system shall be equipped with E.O.T crane (indoor) and an E.O.T crane for the intake bay (outdoor). The power distribution room and maintenance area shall be located in the C.W pump house. The river water shall be extracted through three concrete lined intake channels. Each channel shall be equipped with a steel gate and trash rack.

111. The depth of River Water Intake channel has been decided based on the low water Level and sufficient head to maintain the required velocity and discharge into the river water Intake channel. Thus, the invert level of the intake channel is kept approximately at 2.098 MSL (2.558mPWD) in order to have the required flow even at low water level of the River. The twin cell reinforced concrete culverts are planned with approximate size of 5x2.5m each. The location of the discharge and intake are not included as sites where the dolphins go (see **Annex 11** IUCN report).

112. The intake water will be filtered first and supplied to the reverse osmosis plant and cooling tower make up water system. The blow down water from all of the machineries, pipelines or other systems except the cooling tower blow down will be collected through drainage network into the ETP for treatment. All oil contaminated drains from process area (HRSG, turbine hall, transformer area, storage tanks, etc.) will be collected in retention basins for treatment by oil separator.

113. According to the water balance diagram, ETP will receive blow down from pipelines, HRSG, water treatment plant, oil separator, brine from the reverse osmosis plant for treatment. The ETP will maintain the more stringent effluent of industrial waste as mentioned in ECR 1997 (Schedule 10) and IFC-EHS Guidelines for Thermal Power Plants 2008 (Table 5). The treated wastewater will be disposed of in the monitoring basin where the cooling tower blowdown will also be received. At the feasibility stage, it has been envisaged that around 1030.5 m^3/hr water will be discharged to the river through continuous monitoring or water can be reused for general purpose washing, etc.

114. The sludge may be generated from a number of sources like clarifier, water treatment plant, ETP, etc. Sludge components may include oil and grease, suspended solid particles, sewage, demineralizers, and other chemicals used to maintain the quality of water in feed water and cooling systems.

115. Sludge from the sewage treatment plant will be disposed off following the requirements or procedures by the Khulna Water Supply and Sewerage Auhtprity.

Figure 3.10: Water balance diagram of Component 1

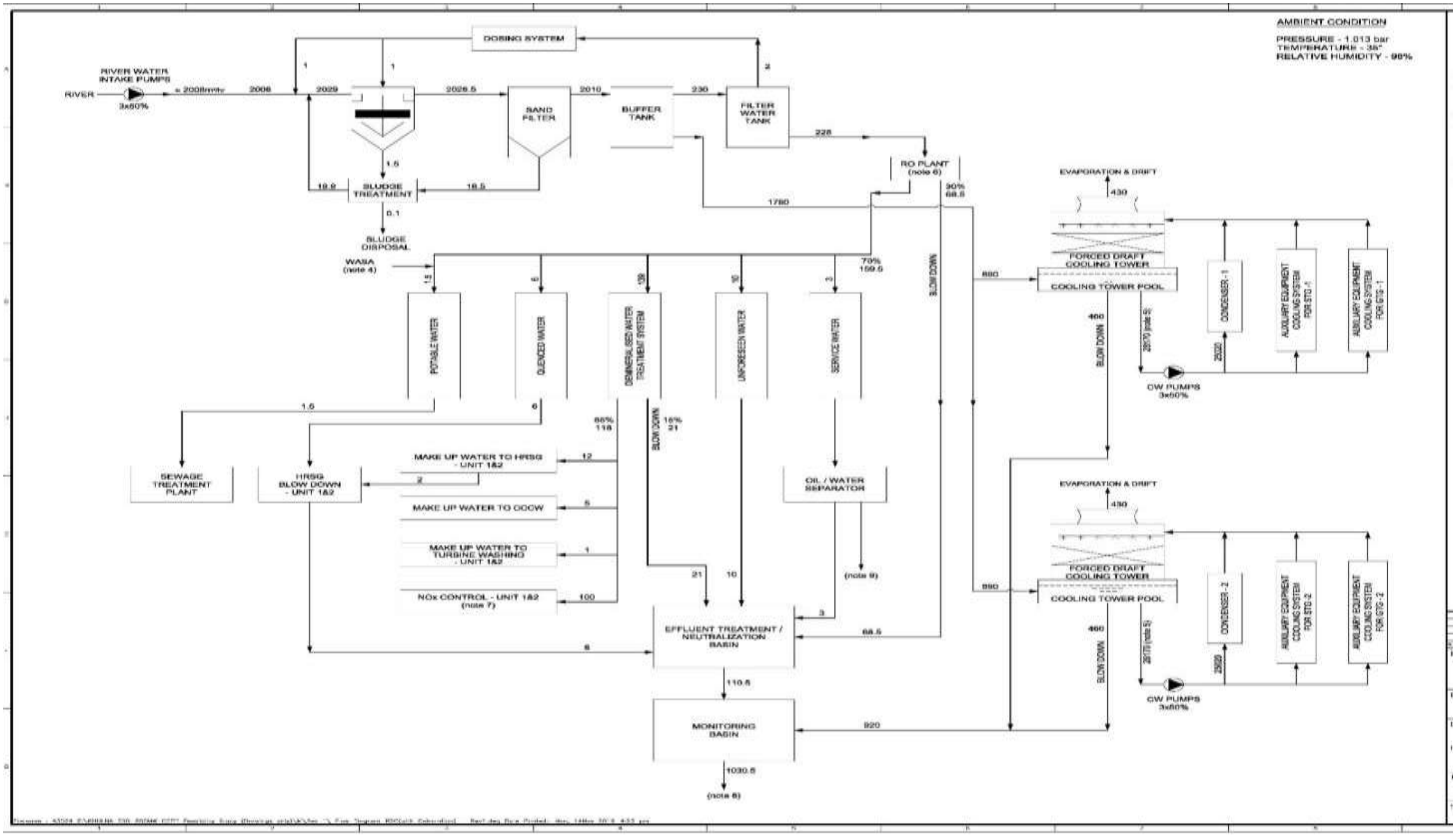
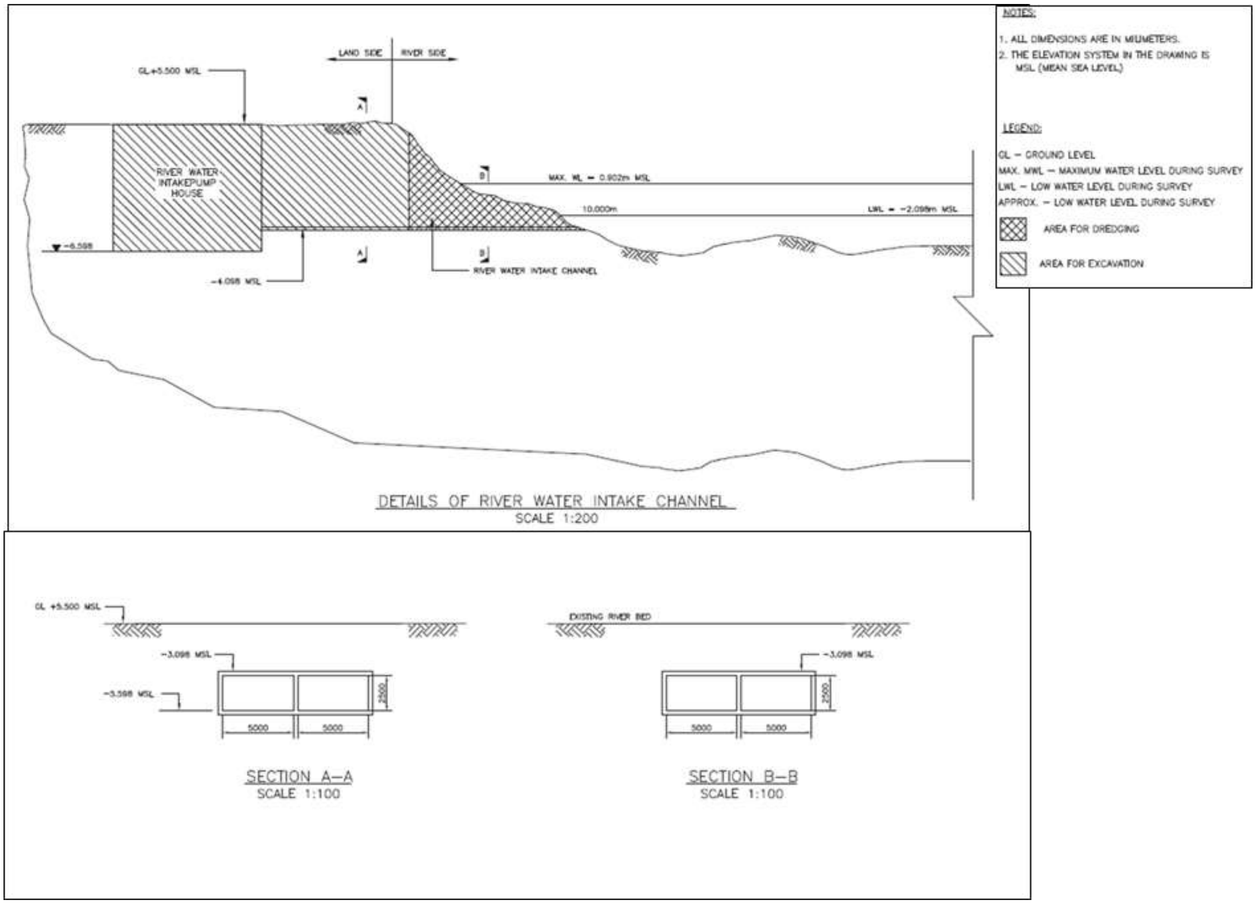


Figure 3.11: Rive intake channel at Bhairab River



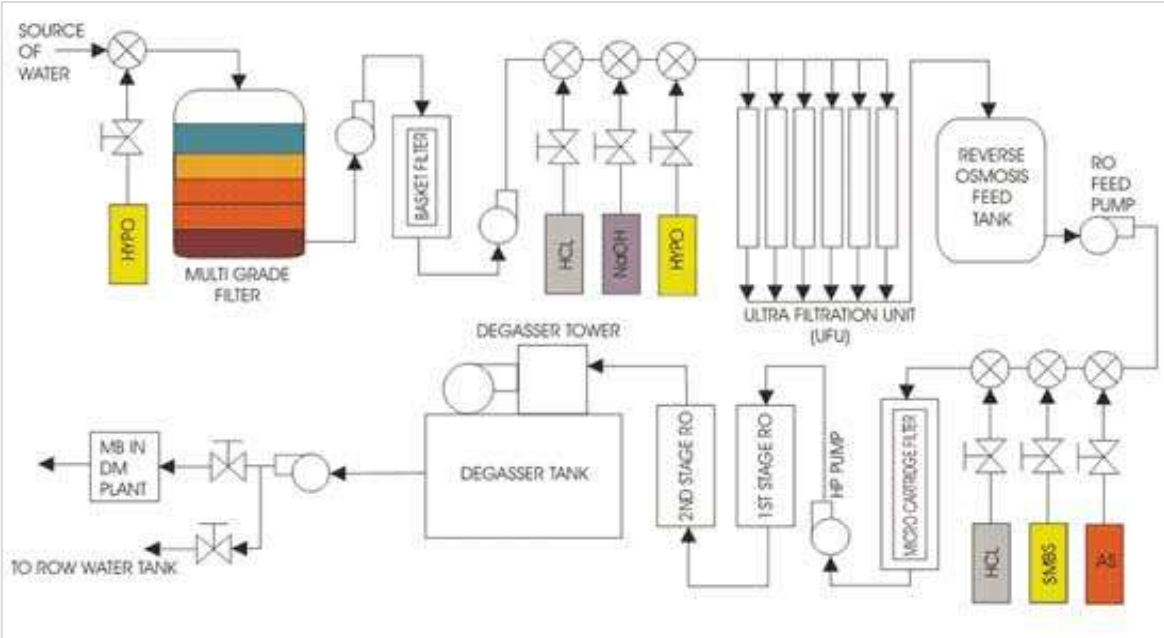
3.8.6 Reverse Osmosis Plant

116. Based on the hydrological report, it is found that the water from the Bhairab River at site location reaches a high salinity range of maximum 25,000 μS/cm. High salinity water lowers vapor pressure of the water, thus the water does not evaporate as readily. This makes it less as an effective coolant and reduces tower performance. Therefore, the water needs to be desalinated and treated at the reverse osmosis plant.

117. Reverse osmosis is a process in which dissolved inorganic solids are removed from a solution/water by pressure pushing the water through a semi permeable membrane. High salinity water contains a number of constituents including metals, salts, and organic compounds. As high salinity water passes through a reverse osmosis membrane, many of these chemicals are removed, leaving a fresh and purified water product. This water will be used for the plant.

118. The removed constituents, called the concentrate, which is at higher concentration than source water will be blown down to the ETP. The concentrate will be monitored and discharged accordingly. The layout of the reverse osmosis plant is shown in **Figure 3.8**.

Figure 3.8: Flow diagram of a reverse osmosis plant



Source: https://electricalstudy.sarutech.com/boiler-feed-water-treatment-process-demineralization-plant/index.html

3.8.7 Water Treatment Plant

119. The river water system (pre-treatment) will be a conventional treatment of the raw water from the Bhairab River consisting of aeration pool, coagulation, flocculation, clarification and filtration processes, that will be able to produce treated water that meets the required water quality for the cooling system.

Below are the typical chemicals used in a water treatment plant for CCPP:

- Caustic Soda
- Sulfuric Acid
- Hydrochloric Acid
- Alum
- Hydrated Lime
- Polymer
- Hydrogen Peroxide
- Sodium Hydroxide
- Ammonia Hydroxide
- Trysodium Phosphate

3.8.8 Cooling System

120. The proposed project is situated on the West bank of the Bhairab River. Feasibility report proposes closed-loop cooling system with two cooling towers using surface water from the Bhairab River.

121. A **cooling tower** is a heat exchanger, in which heat is withdrawn from the hot water by contacting between the hot water and the air and through the evaporation of a small portion of the hot water.

122. Hot water from the condenser is pumped to the top of the cooling tower and is then evenly disperse using dispersion fans or spray nozzles over the top of the tower. The water then evenly flows down the cooling tower's fill. This process causes the water to spread out over the thin sheets and constantly flow down the fill. Spreading of water over such a large area significantly accelerates evaporation and consequently dissipates heat. Big fans are utilized at the top of the cooling tower to suck air in (induced draft) through the sides of the fill system. This further accelerates the evaporation of the water as it flows down the fill. The hot water thus is cooled and is collected at the bottom of the cooling tower (cooling tower basin) is then pumped back to the condenser, and the process continues.

123. In case of other cooling, separate heat exchangers are used. A heat exchanger is a device that transfers heat from one medium to another. Heat exchangers are of different types. But shell and tube type heat exchanger are commonly used. In this type hot media (lube oil, hot water) runs through the tubes, and the cooling media (cooling water) flows over the tubes (inside the shell). Thus, heat transfer takes place between the two fluids (hot media and cooling media).

3.8.9 Effluent Treatment Plant (ETP)

124. The process wastewater shall be treated in the ETP, after which it shall be discharged into the monitoring basin. Effluent will be tested prior to discharge to ensure that it meets ECR 1997 (Schedule 10) and Table 5 of IFC-EHS Guidelines for Thermal Power 2008. The process wastewater includes waste streams from plant oily waste, plant facilities, drains, and other miscellaneous streams. Wastewater sample points shall be provided in the plant (**Figure 3.9**).

125. The ETP system, which includes the chemical wastewater collection and treatment system, shall have the following units:

- wastewater storage tank
- pH balance tank
- coagulation, sedimentation and flocculation tank
- sludge dehydrator
- filtering system
- monitoring basin
- supply pump
- intermediate pump
- sludge discharge pump
- dehydrator supply pump

126. Wastewater from the water treatment plant shall be routed into the effluent treatment/neutralization basin. Oil-contaminated process water will be passed through the oil/water separator. After oil separation, the effluent shall be routed into the ETP/neutralization basin. Sludge collected from the ETP shall be disposed of according to the requirements or procedures of Khulna Water Supply and Sewerage Authority. ETP sludge may be used in the brick field.

127. Roof drain, storm water and water tanks overflow shall be conveyed into a check pit and discharged into the cooling water discharge line after checking the water quality.

128. All water discharge from the ETP to the environment shall comply with ECR 1997 (Schedule 10) and Table 5 of the IFC-EHS Guidelines for Thermal Power Plant 2008. The capacity of the ETP will be 110.5 m^3/hr indicated in the Feasibility Report (August 2017).

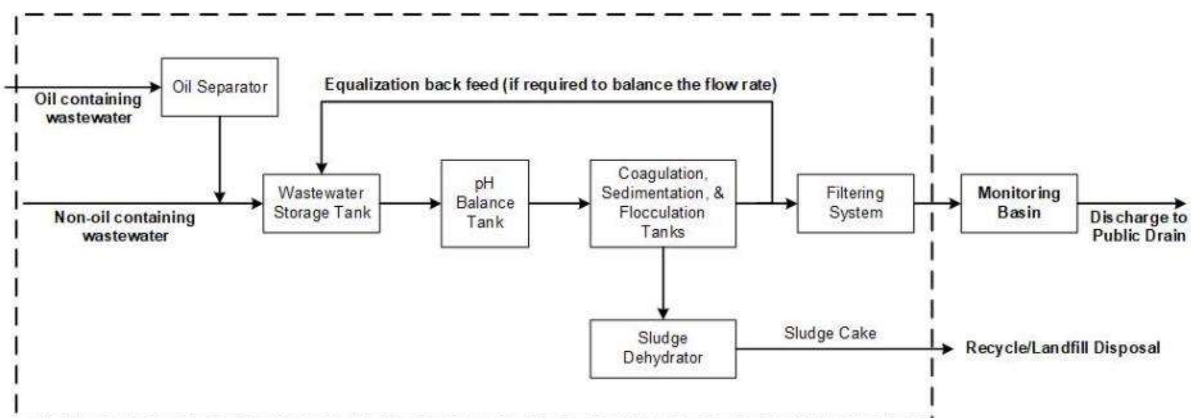
3.8.10 Sewage Treatment Plant (STP)

129. At an estimated rate of 1.5 m^3/hr, the influent sewage from the buildings in the power plant premises enters the STP by passing through a primary and secondary screen for gross solids removal and insoluble particles, respectively (see **Figure 3.10**). This step ensures the mechanical reduction of solids prior to aeration.

130. When the sewage enters the aeration tank, the sewage, it is subjected to air, which is forced through diffuser into the air chamber. This is done to ensure that sufficient oxygen supply is provided allowing microorganisms to oxidize treatable wastes in to carbon dioxide, water, and stable sludge.

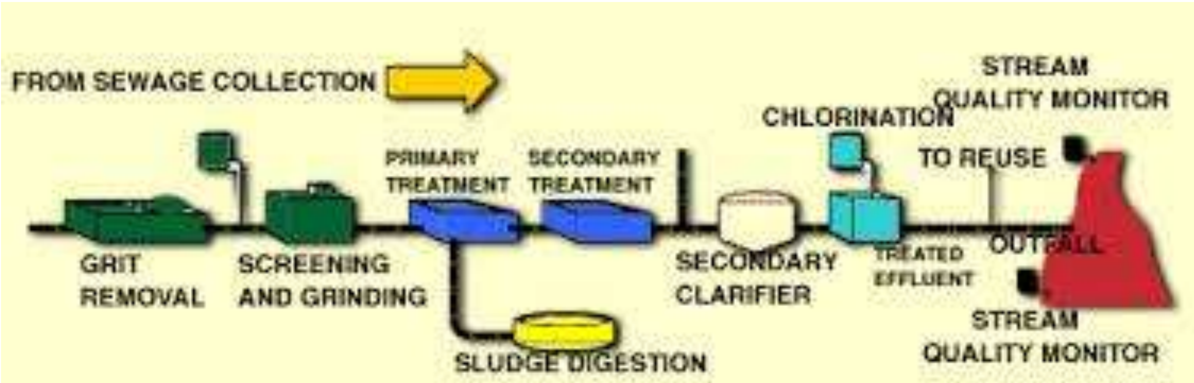
131. Following aeration, the wastewater flows to the clarifier in which, the sewage solids sludge is settled at the bottom. A portion of the sludge, return activated sludge is pumped back to the aeration tank to maintain maximum efficiency of the biological processes that occur within the aeration tank. The remaining sludge, the waste activated sludge is sent to the sludge holding tank for disposal. The treated water then flows into a filtration system in which any residual suspended matter is removed through sand filtration. From the filtration system, the treated water flows from the filter to a disinfection chamber for treatment through the process of chlorination disinfection to remove microbial bacteria in the liquid prior to discharge to the public drain. Design of STP will comply with the Bangladesh National Building Code 2011 and the quality of water from the STP will comply with Schedule 10 of ECR 1997 and/or Table 1.3.1 of IFC-EHS Guidelines 2007. Treated water can be used for gardening or other general purpose cleaning.

Figure 3.9: Typical Effluent Treatment Plant (ETP)



Source: CEGIS, 2017

Figure 3.10: Typical Sewage Treatment Plant (STP)



Source: http://www.texascenter.org/almanac/QUALITYCH2P4.HTML

3.8.11 Power supply and evacuation system

132. Proposed site is the abandoned residential area of KNM. Most of the houses have been abandoned, except two schools, one mosque and a few houses which are in function. There is an existing facility of a low voltage distribution system for domestic power supply. EPC contractor in consultation with BPDB can re-organize the existing power supply system to get Electrical Power during the pre-construction, construction and commissioning phases.

133. Based on the plant's generation capacity, the Power generated from the proposed power plant would be evacuated either at the voltage level of 230 kV or at 400 kV through suitably rated Generator Transformers (360MVA for gas turbine and 180MVA for steam turbine) and will be connected to the plant switchyard through underground cables. Based upon the load flow study conducted by PGCB, the better power evacuation option would be the 230kV to Khulna south substation. The power from the plant switchyard will then be evacuated to 230 kV Khulna south substation at a distance of 29 km through overhead transmission lines.

3.8.12 Control and instrumentation System

134. State-of-the-art microprocessor based Distributed Control System (DCS) control and protection system will be provided for the proposed CCPP. The system will be integrated with the control, instrumentation, alarm and protection of the plant, in addition to data acquisition, signal conditioning, closed loop control, open loop control, alarm processing and annunciation, event recording and real-time trend recording and communication with other devices/systems. For the purpose of communication between the components, a DCIS redundant communication system will be installed. The design of the control & monitoring system as well as its constructive feature will be guided by the following principles, namely:

- Standardization and interchangeability
- Modular concept of control system
- Online testing of critical parameters
- Fail safe operation

135. The control system shall consist of redundant controllers. The control system will be designed in distributed process control system based on the microprocessor technology. The

plant control will be operated by auto/manual operations on the monitor located in Unit Control Room (UCR).

136. The Distributed Control and Information System (DCIS) will be provided for control & monitoring of the combined cycle power plant. The manufacturer's standard packaged control system will be provided for GTGs, STG, HRSG, etc. for respective control and monitoring facilities. The standard packaged control system included instrumentation and alarm system and is integrated with the DCIS for centralized control, monitoring and supervision.

137. The DCIS will provide for the safe, efficient and reliable operation of the plant. It will be integrated with subsystem control of steam turbine, generator, gas turbine and HRSG and with their packaged auxiliaries systems control and supervision will be performed by this integrated plant control system. The DCIS will provide modulating and digital control monitoring, alarming, indication and data acquisition for overall CCPP and its auxiliaries.

138. The DCIS will provide automatic operation and supervision ranging from unit startup, load operation and unit shutdown.

139. The functions of plant control are as follows:

- Automatic Plant Startup/Shutdown Control (APS)
- Automatic Power Regulation Control (APR)
- Modulating Control
- Binary Control

140. Automatic Plant Startup/Shutdown control function (APS) is provided in order to control the startup and shutdown of the gas turbine, HRSG and steam turbine. APS produces the command signals for each control system such as gas turbine control system, HRSG control system, steam turbine control system and auxiliary control system after completion of manual preparation steps.

141. The Auto Power Regulator (APR) will adjust the generation of the GTG and STG. APR will be designed to accept unit load demand signal (MW) from central load dispatch system, or unit load demand setting by operator. The APR will have provision of automatic control or for manual control of any element of the process equipment. The operator interface will permit the operator to adjust maximum and minimum unit load limits, load change rate, load set points.

142. The proposed control system will provide a safe operation of the plant that includes all interlocks and trips of Unit. The plant safety system will be configured in triplet channel with 2-out-of-3 redundant sensors. All drain valves will be motorized with auto or manual operation facility.

Plant Automation

143. The process control and monitoring of the CCPP will be performed in the CCR through DCS operator and engineer work stations. The degree of automation implemented would enable the plant to be started and shut down, incorporating breakpoints/hold points to allow operator intervention as needed without compromising on personnel and plant safety.

Plant Operation

144. The overall operation of the power plant process, its electrical and mechanical systems are monitored and controlled by the DCS from the CCR. Monitoring of the plant operating conditions would be accomplished minimum by LCD screen (with LED backlit) with a DCS minimum turnaround time of 1 sec. For plant reliability, the CPU shall have duplicate configuration using the standby redundant system.

145. GTG Control System comprising of gas turbine control panel and generator control panel in the gas turbine LCR. gas turbine LCR enables the gas turbine facilities for local control and monitoring of the gas turbine. The control system shall be capable of running independently and reliably in automatic and manual modes.

146. GTG shall be capable of automatic operation i.e. start-up, synchronization, increase and decrease load and shut-down by initiating push buttons on the gas turbine HMI in the LCR and CCR. The GTG system is interfaced to the plant DCS by hard-wired and redundant Ethernet communication to monitor and control from DCS Operation.

147. The DCS shall also communicate with other sub systems in local control room or equipment marshalling cabinet room as follows:

- GTG
- STG
- Plant Interlock and Protection Control System
- Plant Condition and monitoring System
- Chemical Dosing System
- Demineralized Water System
- Waste Water System
- Instrument and Service Air System
- Air Pollution Monitoring System (Stack Emission)
- Emergency Diesel System
- Substation Control System
- Condenser Tube Cleaning System
- Metering System
- Auto Generation Control System
- Plant Electrical Control System (Switchgear, Power Meter, Protection System)

Power Control (National Load Dispatch Centre)

148. There is a provision in the new CCPP to incorporate AGC for future implementation when there is a need to control load of individual power plants from the NLDC by means of SCADA. When the scheme is available, the new CCPP load can be automatically controlled from the NLDC, after setting the load demand into the DCS through the operator console.

3.9 Material Balance

149. Natural gas will be the primary fuel and will require a maximum of 125 million cubic feet per day (MMCFD). This will be supplied by SGCL from the Khulna CGS in Aronggatha through a 10 km, 24 inch gas distribution pipeline terminating to the regulation and metering station (RMS) at the power plant site. The pipeline will be constructed following the requirements of the Natural

Gas Safety Rules 1991 (amended 2003). Composition of natural gas required will be a minimum of 85%mole methane (CH4). The following sources from imported regasified liquefied natural gas (R-LNG) and domestic supply will provide adequate supply of natural gas for Component 1.

- FSRU Moheskhali - 500 MMSCFD of R-LNG will be made available by April 2018 developed by Excelerate Energy, USA-Bangladesh
- Summit LNG Terminal Company Limited – 500 MMSCFD R-LNG will be made available by October 2018
- GoB and RasGas (Qatar) has signed a deal in September 2017 for a 15-year LNG sales and purchase agreement to supply 1.8 million (M) tons LNG/year for 5 years and 2.5 M tons/year for the next 10 years
- According to Petrobangla, there will be additional supply (domestic) of 2,750 MMSCFD
- By 2021, Bangladesh Petroleum Exploration and Production Company Limited (BAPEX) will have 55 exploration wells and 31 development wells

150. The use of HSD as secondary fuel will be required in case of emergency and is estimated to be about 500 hours maximum per year (or about 20 days assuming continuous operation of 24 hours). HSD requirement will be about 2,773 kiloliters (KL) per day. Two HSD storage tanks with a capacity of 15,000 cubic meter (m^3) will be constructed within the power plant site. Each storage tank can supply about 5 days of continuous operation on HSD. Fuel supply agreement between BPC and NWPGCL in November 2015 provides that the HSD will have a maximum sulfur content of 0.25%$_{wt}$. As a byproduct, these two units will generate pollutants like CO_2, NO_x, SO_2, CO, PM_{10} and $PM_{2.5}$. The material balance of this power plant is expressed in **Table 3.6**.

Table 3.6: Material balance of the power plant project

Input	Quantity	Output	Quantity
Natural gas and HSD and O_2 (15%)	125 MMCFD (92%) 2773 KLD (8%)	Electricity	2x400 MW
		CO_2	8,650 tons/day
		CO	8.9 gm/s
		SO_2	9.5 gm/s
		NO_x	51.1 gm/s
		PM_{10}	3.1 gm/s
		$PM_{2.5}$	3.1 gm/s

Source: Feasibility Report for Proposed Rupsha 800MW CCPP, USEPA- AP-42

3.10 Pollution Prevention Devices and Units

151. The major pollutants from a fossil fuel-based power plant are mainly three types, including air pollution, noise pollution and waste water (water effluent or effluents from both plant and sewage system). In this regard, pollution prevention including continuous monitoring system are described below.

Air pollution

152. The major air pollutants that are produced from a fossil fuel-based power plant are SO_x, NO_x, CO_2, CO and SPM. The proposed plant is a dual fuel (natural gas and HSD) based power plant. Natural gas does not contain sulfur thus, no SO_2 will be generated. HSD which will run for a maximum of 500 hours per year will have a maximum sulfur content of 0.5%$_{wt}$. Modern gas turbine manufacturers guarantee the formation of less than 25 ppmv of NO_x due to their improved

firing system like dry low- NO_x burners, lean pre-mix firing etc. and the modern digital DCS maintains combustion air about 1% (excess air) above the “stoichiometric” F/A ratio. Hence, formation of CO due to incomplete combustion is not expected. Natural gas and HSD will not generate PM_{10} and $PM_{2.5}$.

153. Substantial reductions in emissions of CO_2 could be achieved by increasing combustion efficiency i.e. burning less fuel for same MW of electricity generation, energy efficient resources use, off set technologies etc. The modern GTs are highly efficient compared to their earlier versions. Moreover, development of green belts in and around the power plant will provide carbon sink to the CO_2 emissions from the power plant.

Noise Pollution

154. All rotating machines like turbine, pump, fan, etc. generate noise when operates. A hissing noise is also generated in the RMS. During pre-construction and construction phases noise is mostly generated by construction machineries of pilling and other civil works. But these are limited to day time activity only. During operation phase noise is generated specially from start-up, shut-down, and from rotating machines. Modern machines are mostly low noise generating machines with built in silencers. Moreover, noise generating machines will be covered with noise proof hoods and workers will be provided with PPE during work. Boundary walls and green belt will also dampen noise for colony residents and surrounding community. Control room is provided with noise proof walls and doors with noise proof seals.

Water pollution

155. Major sources of wastewater from the proposed power plant are blow downs of HRSG, cooling tower, back wash and effluent from the water treatment plant, oily water from turbine floor and transformer area, etc. Oil will be separated from water using oil-water separator. This wastewater along with all others will be conveyed to the ETP/neutralization basin. Quality of discharge water will comply with ECR 1997 (Schedule 10) and Table 5 of IFC-EHS Guidelines for Thermal Power Plants 2017. Discharge water can be used for gardening, re-used in the system or discharged to Bhairab River.

Waste Management System

156. In the pre-construction, construction and operation phases of a power plant the generated major wastes are of two types. The solid waste and the liquid wastes. The solid wastes during construction phase are mainly the wastes from construction materials like concrete pieces, small cut pieces of MS bars/rods, plastic pieces, empty cement bags, empty cartons, waste papers, waste from worker’s colony, kitchen wastes, etc. Sewage will be treated through the STP and will meet the ECR 1997 Schedule 10 and IFC-EHS Guidelines 2007, Table 5. Solid wastes like metal pieces, empty cartons, plastic materials, paper bags etc. will be disposed of in covered plastic containers of different colors specified for different type of wastes kept at a designated place. Recyclable and plastic wastes will be sold to the re-cycling companies and other interested buyers. Other combustible solid wastes like waste paper, wood, etc. will be recycled locally. Organic wastes will be disposed off in covered Plastic containers kept at designated places which will be periodically collected by local authority/Plant management for final disposal. In short, all kinds of generated solid wastes will be disposed of onsite maintaining DoE’s standard.

157. The liquid waste generated in the same period is mainly water from bore holes due to connection of water table, non-consumptive construction water and waste water from worker’s

colony. Waste water of construction site will be collected in a pool and will be reused in construction activities. Liquid waste from worker's colony will be drained to a soak pond/ soak pits for ultimate soaking by the earth.

158. During gas operation, no special solid waste other than the above stated one will be generated from the Plant.

159. All liquid waste generated from boiler blow down, cooling tower blow down, water from leaks and vents, waste water from turbine floor will be treated in the ETP/neutralization basin to meet ECR 1997 Schedule 10 and IFC-EHS Guidelines for Thermal Power Plant 2017.

Green initiatives

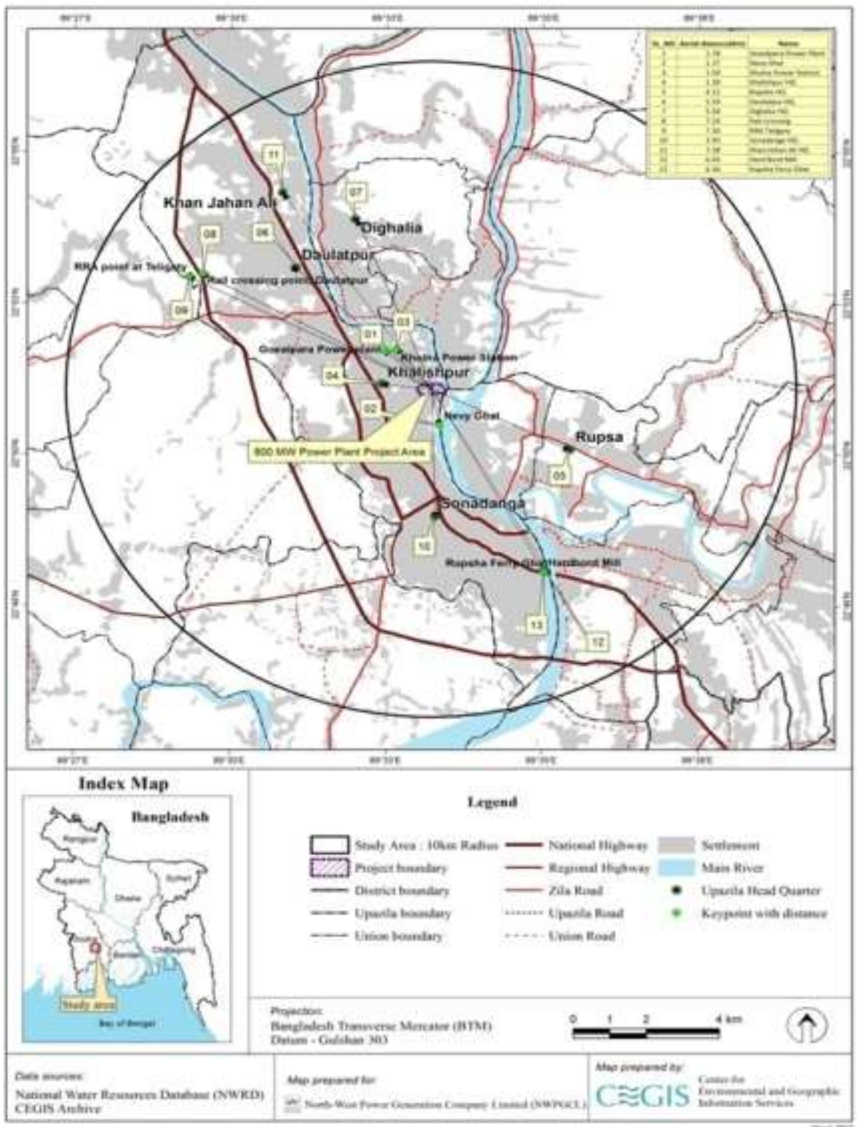
160. There is space restriction in the project site. DoE suggests for greenery (about 33% of the project area) may be maintained. However, plantation in all open space of the plant area excluding the switchyard shall be maintained.

4.0 DESCRIPTION OF THE ENVIRONMENT

4.1 Project's area of influence

161. The project's area of influence (PAI) covers the project site where Component 1 will be located and the study area which is about 10-km from Component 1 (see **Figure 4.1**).

Figure 4.1: Project's area of influence



4.1.1 Project site of about 50 acres

162. The project site is an area formerly used by the KNM located in Khalishpur Thana, Khulna Division (**Figure 4.2**). The total area occupied by KNM from its previous operations is about 87 acres [or 35.2077 hectares (ha)]. NWPGCL will only require about 50 acres (or 20.2343 ha) to accommodate Component 1.

163. The project site is an area formerly used by the Khulna Newsprint Mills (KNM) Limited located in Khalishpur Thana, Khulna Division. KNM was under expatriate management from start in 1959 until the end of 1965 when it was put under the management of the East Pakistan Industrial Development Corporation.[17] KNM was the first and major producer of newsprint paper in Bangladesh using *Gewa* wood (*Excoecaria agallocha*), a native mangrove species in Bangladesh, as raw material. Sand well and Company, a Canadian firm, was engaged as a consultant in the construction and commissioning of KNM.

164. In 1969, problems were encountered with the steam supply needed to operate the three paper machines. By mid-1973, the Canadian International Development Agency (CIDA) has commissioned studies of KNM in order to define areas where Canadian aid might assist in rehabilitating the mill. A project advisor from CIDA was provided until 1976. However, beset with problems ranging from market behaviour after the independence, availability of spare parts, low capacity utilization (newsprint production at KNM has not been able to reach the levels achieved prior to independence), operational management, price of oil, interrupted supply of raw material due to security issues, etc., GoB stopped its operations completely in November 2002. A total of 2,128 persons are employed at KNM, 472 salaried, 1,506 permanent labour, and 150 casual labour.

165. No newspaper printing was involved in KNM operations but mainly production of newsprint using mechanical pulping from ground wood process as chips is not used for papermaking in Bangladesh. Mechanical pulping involves the use of mechanical energy to weaken and separate fibers from *Gewa* wood through grinding action. The process produces up to 95% pulp, however, since it does not dissolve lignin, fiber strength and age resistance of resulting pulp are low and the product has shorter fibers. Mechanical pulp is used mainly for lower grade papers like newsprint.

[17] The World Bank. Bangladesh: Survey of Steel, Pulp and Paper, and Leather Tanning Industries. Report No. 1219-BD. Industrial Projects Department. 30 November 1976. http://documents.worldbank.org/curated/en/879431468007479695/Bangladesh-Survey-of-steel-pulp-and-paper-and-leather-tanning-industries.

Figure 4.2: Project site location

166. At present, there are about 151 structures standing within the 50 acres consisting of 122 primary residential structures such as bungalow for the Managing Director, dormitories and residences of staff, kitchen and dining, guest house, and Ansar camps, etc. while the remaining 29 structures are non-residential like auditorium/cinema, water tank, fire fighting system, swimming pool and rest house, mosque, boys and girls school, etc. (see Table 3.5 for the inventory of structures).[18] The structures are mainly from brick, reinforced concrete, pacca, and semi-pacca. There is no structure used for the direct operation of newsprint manufacturing. Given that all the structures within the 50-acre project site are residential type, the probability that the land is contaminated from the previous newsprint operation is very unlikely.

167. The project site has two schools (one for boys and the other for girls) which are operating. Some vegetation has grown from the abandoned structures. Some of the abandoned buildings are being used as residence by about 36 people tasked to secure the property (appointed through GoB from Ansar Force), cook and cleaners.19

168. Adjacent to the project site are the mosque and the mass graveyard marker of the freedom fighters who were killed in 1971 during the liberation war of Bangladesh. The mosque is still being used by about 10 local people every day for their prayers. The graveyard marker has a brick fence, is not listed as cultural heritage by GoB, but has a huge cultural value to the people. **Figure 4.3** shows some of the structures at the project site, the mosque and the graveyard marker.

[18] Bangladesh Ansar is a paramilitary auxiliary force responsible for the preservation of internal security and law enforcement in Bangladesh and administered by the Ministry of Home Affairs.

[19] Bangladesh Ansar is a paramilitary auxiliary force responsible for the preservation of internal security and law enforcement in Bangladesh and administered by the Ministry of Home Affairs.

Figure 4.3: Some structures left by KNM

4.1.2 Study area

169. The study area extends from the project site and the area within about 10-km radius from Component 1 (**Figure 4.1**). The description of the existing environment within the PAI is based on primary and secondary data.

4.2 Physical-chemical environment

4.2.1 Topography

170. Component 1 is located at elevation +3.5 m and +2.3 m MSL towards the bank of the Bhairab River (see **Figure 4.4**). while the surrounding area has an elevation of approximately between EL+3.5m and EL+3.2m (MSL). Towards the bank of the Bhairab River is approximately between EL+3.5m and EL+2.3m(MSL). The highest elevated land falls into the area near Khan Jahan Ali bridge (3-4 m PWD).[20]

4.2.2 Geology and Physiography

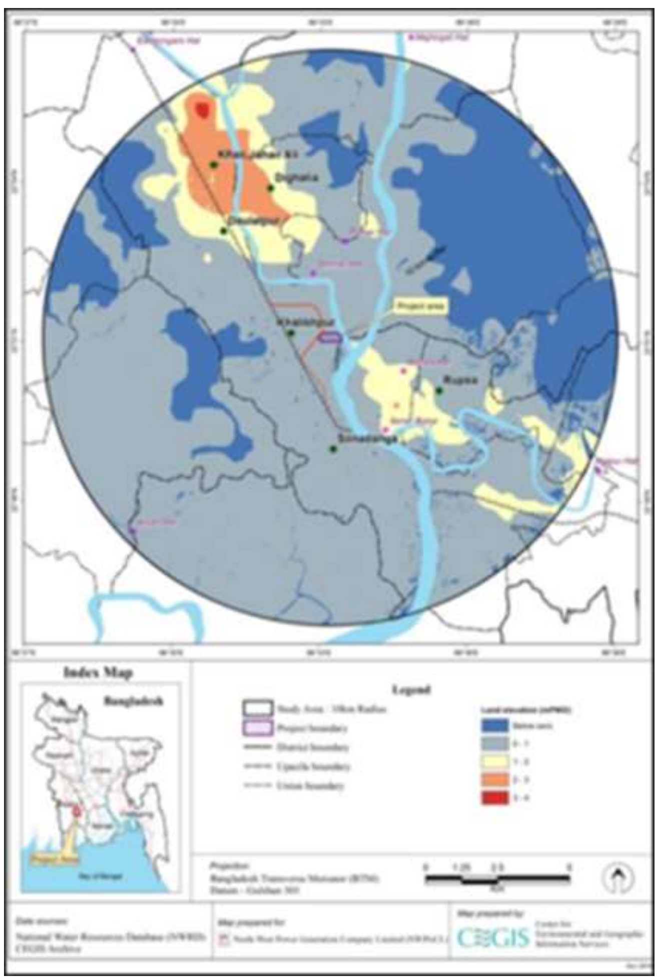
171. Bangladesh is divided into 30 physiographic units and the study area falls within the Ganges Tidal Floodplain and Gopalganj-Khulna Beel (see **Figure 4.5**). This area is situated in southwestern Bangladesh that lies on the Late Holocene- Recent alluvium.

[20] Bangladesh Water Development Board and other government departments refer water levels to the Public Works Datum (PWD). PWD is a horizontal datum believed originally to have zero at a determined Mean Sea Level (MSL) at Calcutta. PWD is located approx. 1.5 ft (or 0.46m) below the MSL established in India under the British Rule and brought to Bangladesh during the Great Trigonometric Survey. http://www.ffwc.gov.bd/index.php/definitions.

172. **Ganges Tidal Floodplain** occupies an area of about 16,410 square kilometers (km^2) southwest of Bangladesh. In most of this region, non-calcareous, tidal clay occupy basin sites and slightly calcareous silty sediments occupy the banks of rivers and creeks. Most parts of the Ganges Tidal Floodplain have a typical tidal floodplain landscape with a close network of interconnected tidal rivers and creeks; and seasonal flooding depths over most of the season are shallow, but they are deeper in some basin centers in the northern part. The courses of tidal rivers and creeks change over time by local river capture, and the courses of several silted-up old channels with adjoining levees area are visible on satellite images. Over the greater part of the region, rivers are non-saline throughout the year, but they become saline inland during the dry season.

173. **Gopalganj-khulna Beel** occupies several large, low-lying basins between the Ganges River Floodplain and Ganges Tidal Floodplain. Their total area is 2,641 km^2. Two sub-regions have been differentiated: peat basins which occupy the lowest-lying areas where peat soils are dominant; and basin margins where clay sediments have buried the peat. Most of the area is deeply flooded in the rainy season. Basins centers are perennially wet for most of the dry season, with the water-table close to the surface.

Figure 4.4: Elevation map of the study area

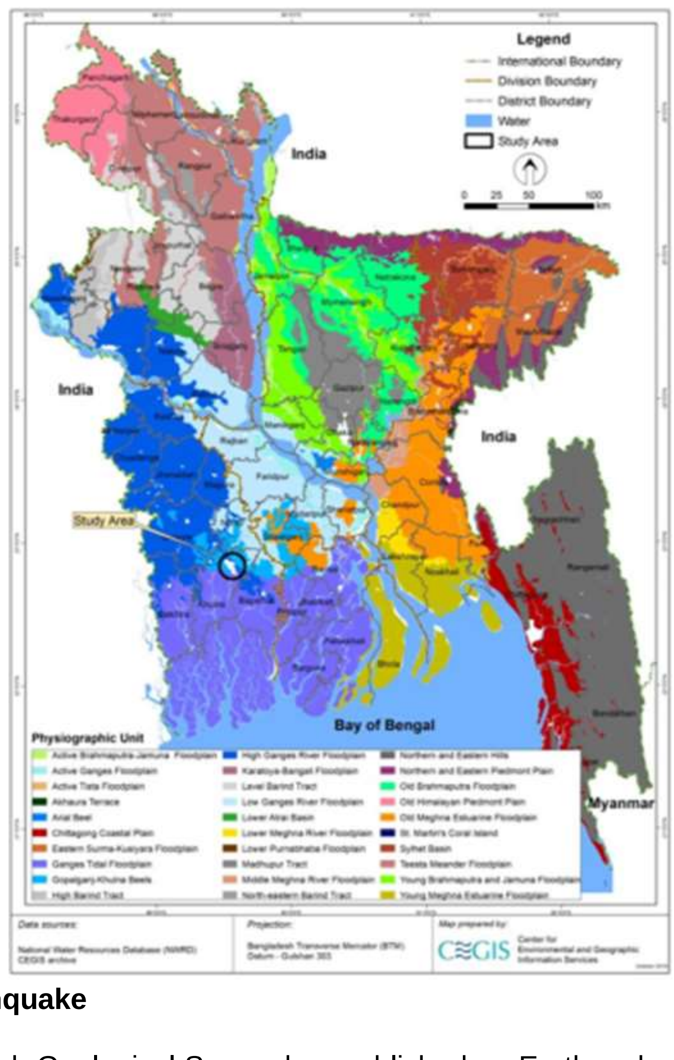


4.2.3 Tectonic Setting

174. Bangladesh consists of six tectonic elements: (1) Himalayan Fore Deep, (2) Bogra Shelf, (3) Faridpur-Sylhet Trough (Separated by Tripura-Madhupur thrash hold), (4) Barisal –Chandpur Gravity High, (5) Hatia Trough, and (6) Indo-Myanmar Ranges.

175. The study area is within the Faridpur Trough of the Bengal Basin. The Faridpur Trough is situated in the south-western part of the Barisal-Chandpur Gravity in close proximity North-West of Hatiya Trough/Patuakhali depression. The Faridpur trough is an elliptical depression almost adjacent to the Eocene hinge belt and are identified geophysically by gravity minima and filled up by enormous amount of tertiary sediments. This can be considered broadly as carboniferous to recent sediments. It is an active deltaic trough with a subsidence rate of2.2 cm/year or higher. In this area, three types of subsidence are recognized which are tectonic subsidence, compaction of peat layers, and human induced subsidence.

Figure 4.5: Physiographic map of Bangladesh



Seismicity and earthquake

176. The Bangladesh Geological Survey has published an Earthquake Zoning Map based on seismic intensity. They have divided the country into three zones depending on the seismic intensity namely Zone I, Zone II and Zone III. The North and eastern regions of Bangladesh belong

to Zone I (seismically most active); the Lalmai, Barind, Madhupur Tracts, Dhaka, Comilla, Noakhali and western part of Chittagong Folded belt belongs to Zone II (moderately active) while Jessore, Khulna, Barisal, Faridpur, Patuakhali, and Noakhali belong to Zone III (seismically relatively quiet).

177. The study area is located within Zone III with seismic coefficient of 0.04g (see **Figure 4.6**). Component 1 has the least vulnerability to earthquakes but the design of civil structure needs to comply with relevant provisions on earthquake Bangladesh National Building Code 2015. Historical record of major earthquakes for the last 450 years from the Department of Disaster Management (2012) show that from 1762 to 2016, earthquakes originating in Bangladesh had a Richter scale magnitude ranging from 4.2 to 8.8. A maximum of about 8.8 originated from Chittagong-Arakan in 1762.

Figure 4.6: Seismic map of Bangladesh

4.2.4 Climate and Meteorology

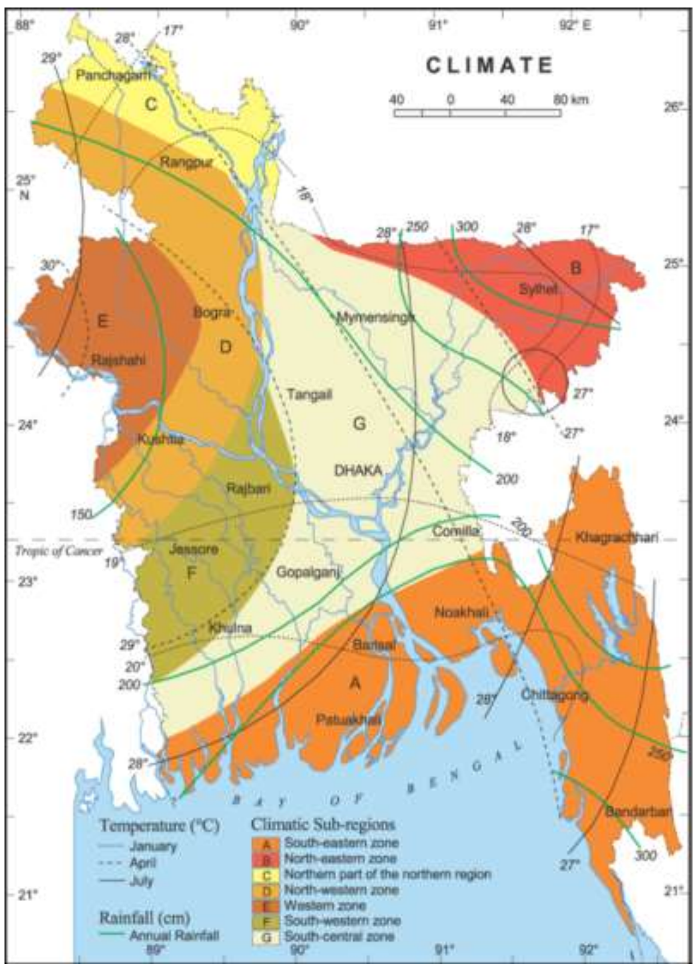
178. This section was based on the meteorological data collected by the Khulna station of the Bangladesh Meteorological Department (BMD) from 1985 to 2015.

Climate

179. According to Köppen climate classification, Khulna division falls under Aw category which is characterized by tropical wet and dry climate resulting to hot and humid summer and dry winter.[21] According to the climatic characteristics, Bangladesh is divided into seven different climatic sub-regions (see **Figure 4.7**).

180. The study area is within category "G" which is the south-central climatic sub-region. In general, this category receives abundant rainfall. This is a transitory zone between the South-eastern, North-western and South-western zones and most of the severe hail storms, nor'westers and tornadoes are recorded in this area.

Figure 4.7: Climatic sub regions of Bangladesh



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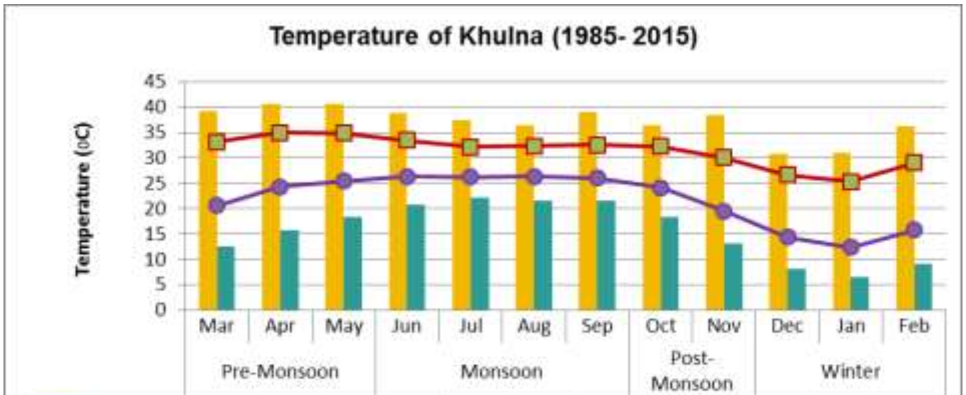
21 https://en.climate-data.org/region/2263/

Temperature

181. Monthly variation of maximum temperature is 30.7^0 C to 40.7^0 C while the monthly minimum temperature varies between 6.4^0 C to 22.2^0 C. The monthly variation of maximum and minimum temperature for the last 30 years is presented in **Figure 4.8**. The maximum temperature recorded during this period in Khulna station was 40.7^0 C in 2014 while the minimum temperature of 6.4^{o}C happened in 2003.

Figure 4.8: Monthly temperature variation from Khulna Station (1985-2015)

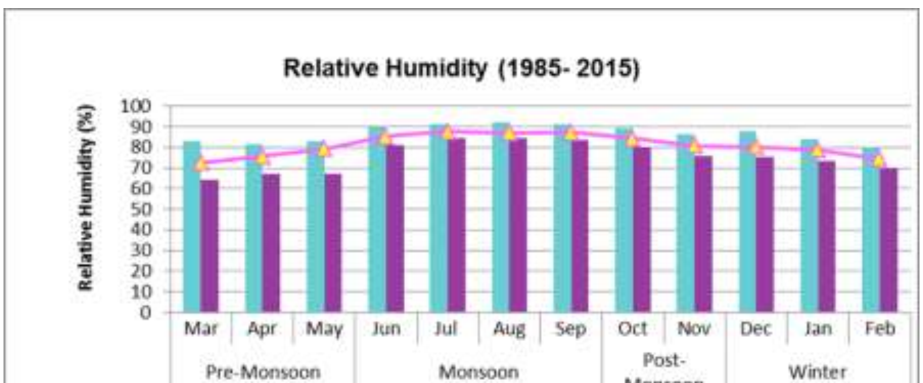


	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
	Pre-Monsoon			Monsoon				Post-Monsoon		Winter		
Maximum	39.3	40.7	40.7	38.8	37.4	36.5	39.1	36.4	38.4	30.7	31	36.2
Minimum	12.5	15.8	18.4	20.8	22.2	21.6	21.5	18.3	13	8	6.4	9
Avg of Max	33.10	34.99	34.90	33.42	32.17	32.36	32.57	32.22	30.04	26.61	25.26	28.98
Avg of Min	20.63	24.29	25.43	26.32	26.25	26.34	25.98	24.11	19.50	14.33	12.30	15.72

Humidity

182. Humidity is directly related with temperature fluctuation of a region. The average humidity remains highest from June to October while the monthly variation of the average relative humidity is 72.59% to 87.76%. Monsoon (June to September) is the most humid period, whereas from winter season to pre-monsoon (December to May), the weather remains relatively dry. **Figure 4.9** shows the average humidity.

Figure 4.9: Relative humidity from Khulna station (1985-2015)

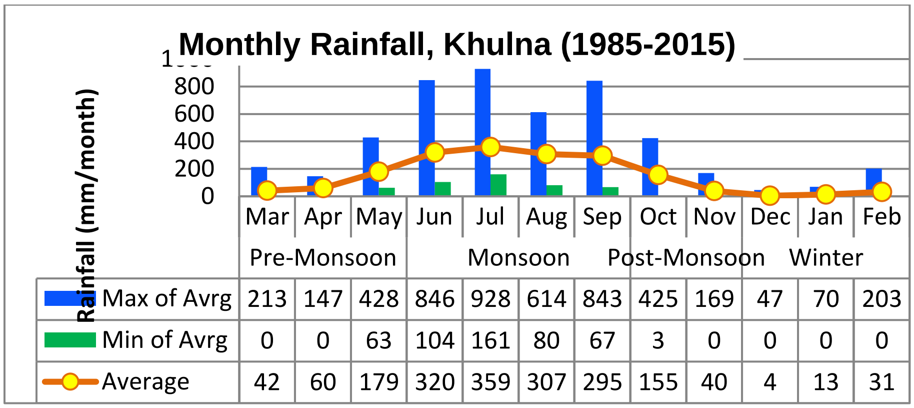


	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
	Pre-Monsoon			Monsoon				Post-Monsoon		Winter		
Maximum	83.02	81.71	83.23	89.57	91.12	92.17	91	89.23	86.49	88.03	84.16	80.13
Minimum	64.39	67.07	67.07	81.23	84.31	84.26	83.69	79.98	75.69	75.27	73.23	70.2
Average	72.59	75.74	79.31	85.17	87.76	87.08	87.24	84.43	80.64	80.32	78.88	74.57

Rainfall

183. Average annual rainfall is recorded as 1,808 mm/yr. Monthly average maximum rainfall occurred in July at 928 mm/month and monthly average minimum rainfall (no rainfall) was recorded during the winter season. This indicates that the rainy season is very prominent in this region. Average monthly rainfall during monsoon in Khulna is 320 mm. The variance in maximum rainfall during monsoon season (June to September) is 614 mm/month to 928 mm/month while the variance in minimum rainfall during monsoon is 67 mm/month to 161 mm/month. Winter (December-February) is the driest season and the average winter rainfall recorded 16.14 mm/month. The highest yearly rainfall was recorded in 2002 at 2,594 mm/year. The minimum, maximum and average monthly rainfall from 1985-2015 is shown in **Figure 4.10**.

Figure 4.10: Rainfall from Khulna station (1985-2015)

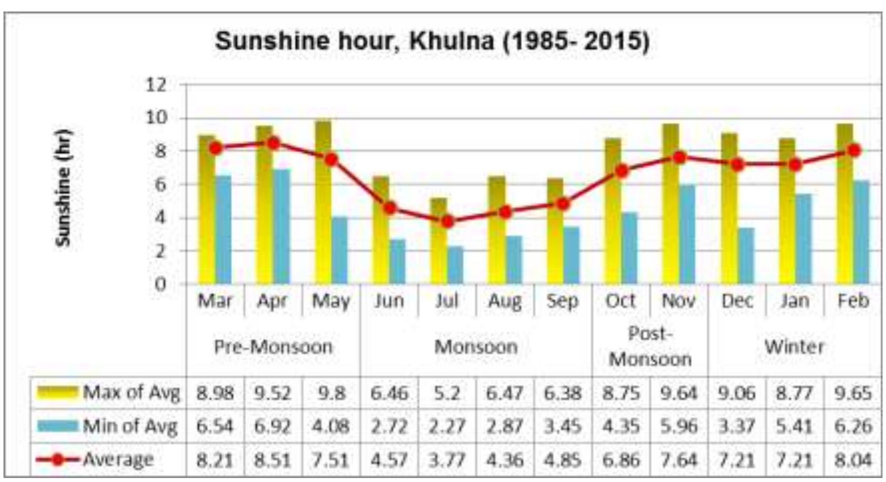


	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Max of Avrg	213	147	428	846	928	614	843	425	169	47	70	203
Min of Avrg	0	0	63	104	161	80	67	3	0	0	0	0
Average	42	60	179	320	359	307	295	155	40	4	13	31

Sunshine hour

184. Sunshine hour is a climatological indicator that measures the duration of sunshine for a given location and period indicating the total energy delivered by sunlight. The average sunshine hour varies from 3.77 hrs/day to 8.51 hrs/day in a year. On average, pre-monsoon season gets the highest hours of sunshine followed by late post-monsoon and winter seasons. **Figure 4.11** shows the average sunshine hour for the last 30 years (1985-2015).

Figure 4.11: Sunshine hours from Khulna station (1985-2015)



	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Max of Avg	8.98	9.52	9.8	6.46	5.2	6.47	6.38	8.75	9.64	9.06	8.77	9.65
Min of Avg	6.54	6.92	4.08	2.72	2.27	2.87	3.45	4.35	5.96	3.37	5.41	6.26
Average	8.21	8.51	7.51	4.57	3.77	4.36	4.85	6.86	7.64	7.21	7.21	8.04

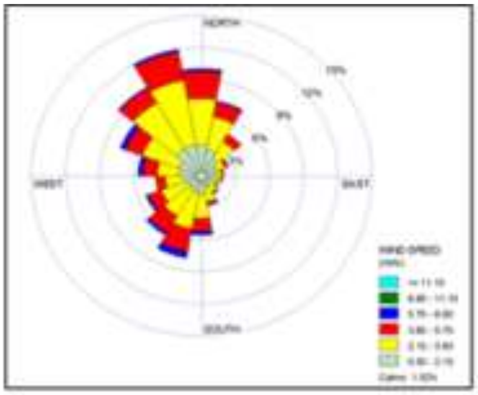
Wind speed and direction

185. The maximum yearly wind speed recorded in Khulna station is 120.38 km/hr during 1997 and 2007. Wind speed recorded from 1985–2015 ranges from 18.52 km/hr to 120.38 km/hr.

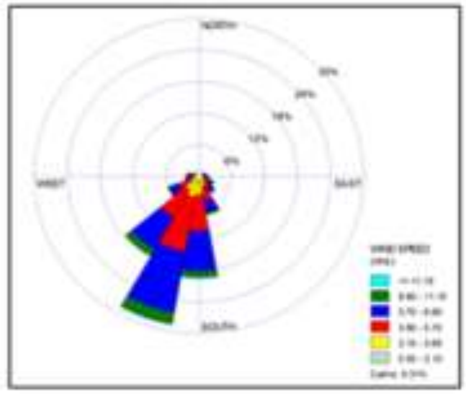
186. Wind direction varies depending on the season. Therefore, the whole year has been categorized into four clusters of months and these are: Cluster-1: January-March, Cluster 2: April-June, Cluster 3: July to September, and Cluster 4: October to December. Wind speed data and direction have been obtained from the analysis of upper atmospheric data collected for the last three years from Lakes Environmental Software (Canada).

187. During clusters 1 and 4 (a and b of **Figure 4.12**) wind direction is predominantly from north and northwest to southeast direction. For clusters 2 and 3 (c and d of **Figure 4.12**), it is predominantly from south and southwest to north and northeast. The annual wind rose diagrams of 8 and 36 directions (e and f of **Figure 4.12**) show the wind direction predominantly towards the northeast. In cluster '1' calm wind prevails for 1.52% of total period, similarly it is 0.31% for cluster '2', 0.72% for cluster '3', and 3.17% for cluster '4'. Calm wind prevails for 1.33% for annual 8-direction and 1.77% for annual 36-direction wind rose diagrams, respectively.

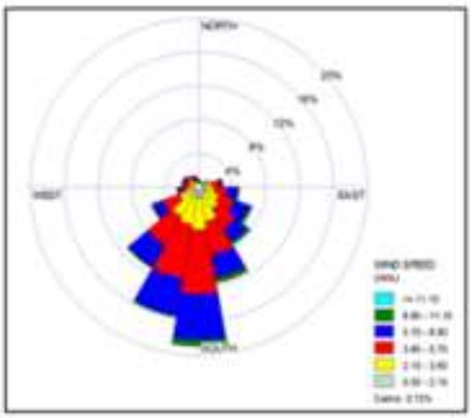
Figure 4.12: Wind rose diagram



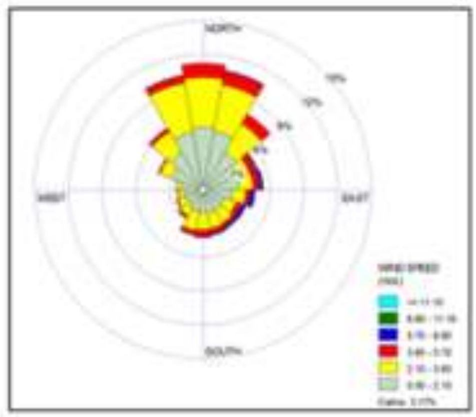
(a) Cluster 1: Wind rose diagram for Jan-Mar



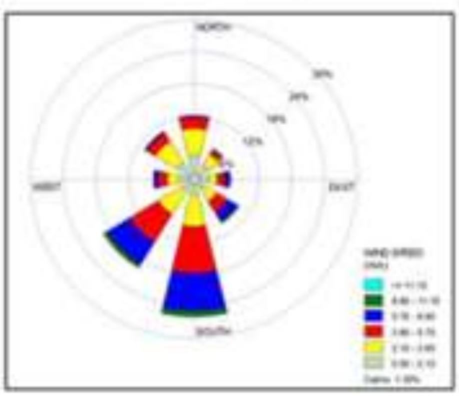
(b) Cluster 2: Wind rose diagram for Apr-Jun



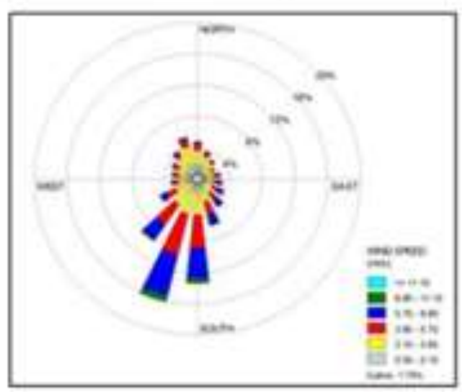
(c) Cluster 3: Wind rose diagram for Jul-Sep



(d) Cluster 4: Wind rose diagram for Oct-Dec



(e) Annual wind rose diagram (8 directions)



(f) Annual wind rose diagram (36 directions)

4.2.5 Ambient air quality and noise

Ambient air quality

188. Air quality is mainly characterized by the presence of criteria pollutants. Major criteria pollutants are particulate matter (PM_{10} and $PM_{2.5}$), nitrogen dioxide (NO_2), carbon monoxide (CO), sulfur dioxide (SO_2) and ozone (O_3). DoE has also set national ambient air quality standards for these pollutants in ECR 2005 (see **Table 4.1**). These standards aim to protect against adverse human health impacts. The WHO air quality guidelines (2005) also provide global guidance on thresholds and limits for key air pollutants that pose health risks.

Table 4.1: Comparison of ambient air quality standards

Pollutant	Averaging Period	Bangladesh Standards[a,b]	WHO Ambient Air Quality Guidelines (IFC-EHS Guidelines 2007) (µg/m^3)
CO	8-hour	10,000 µg/m^3 (9 ppm)	-
	1-hour	40,000 µg/m^3 (35 ppm)	-
Pb	Annual	0.5 µg/m^3	
NO_2	Annual	100 µg/m^3 (0.053 ppm)	40
	1-hour	-	200
Total suspended particulates (TSP)	8-hour	200 µg/m^3	-
PM_{10}	Annual	50 µg/m^3	70 (Interim target 1)
			50 (Interim target 2)
			30 (Interim target 3)
			20 (guideline)
	24-hour	150 µg/m^3	150 (Interim target 1)
			100 (Interim target 2)
			75 (Interim target 3)
			50 (guideline)
$PM_{2.5}$	Annual	15 µg/m^3	35 (Interim target 1)
			25 (Interim target 2)
			15 (Interim target 3)
			10 (guideline)
	24-hour	65 µg/m^3	75 (Interim target 1)
			50 (Interim target 2)
			37.5 (Interim target 3)
			25 (guideline)
O_3	1-hour	235 µg/m^3 (0.12 ppm)	-
	8-hour	157 µg/m^3 (0.08 ppm)	160 (Interim target 1
			100 (guideline)
SO_2	Annual	80 µg/m^3 (0.03 ppm)	-
	10-minute	-	500 (guideline)
	24-hour	365 µg/m^3 (0.14 ppm)	125 (Interim target 1)
			50 (Interim target 2)
			20 (guideline)

[a] S.R.O. No: 220-Law/2005, http://www.doe-bd.org/aqmp/standard.html
[b] Bangladesh has no short-term standard for NO_2, SO_2, $PM_{10,}$ and $PM_{2.5}$

189. Air pollution due to enhanced anthropogenic activities has become an important environmental concern globally as well as in Bangladesh urban areas, in view of its adverse health effects. In this connection, the criteria pollutants of eight major cities in Bangladesh are continuously monitored through the Clean Air and Sustainable Environment (CASE) Project launched by the DoE covering 11 continuous air monitoring stations (CAMS).[22] The eight cities include: Dhaka, Gazipur, Narayagonj, Chittagong, Sylhet, Khulna, Rajshahi, and Barisal. Dhaka has three monitoring stations, Chittagong has two stations and the rest of the cities have one station each. Parameters being monitored in these stations include: PM_{10}, $PM_{2.5}$, CO, SO_2, oxides of nitrogen (NO_x), O_3, and hydrocarbons (HC). The CASE project which started on 12 May 2009 was funded by the World Bank and will be until 15 December 2018.[23]

190. Khulna is the third largest city in Bangladesh and is known as an industrial city. The population of the city, under the jurisdiction of the Metropolitan Area is 1,435,422 living in an area of about 59.6 km^2. It is one of the important industrial and commercial areas of the country. A CASE monitoring station, CAMS-9 (latitude 22.83 N, longitude 89.53 E) has been established in Khulna City to monitor the criteria pollutants. It is located in the Department of Social Forestry Office Campus at Boira and about 2.5 km from the project area (**Figure 4.13**).

Figure 4.13: CAMS station of CASE project in Khulna City

191. Ambient air quality monitoring results at the Boira CAMS monitoring station of the CASE project from 2013-2015 show that annual average of 24-hr particulate matter (PM) concentration levels in both $PM_{2.5}$ and PM_{10} are high and exceeded the limits of ECR 2005 for $PM_{2.5}$ and in 2014 for PM_{10}. In 2015, NO_x limit was also exceeded. **Table 4.2** presents the air quality monitoring results at CAMS-9.

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[22] Ministry of Environment and Forests. Clean Air and Sustainable Environment Project. http://case.doe.gov.bd/index.php?option=com_content&view=article&id=5&Itemid=9.

[23] World Bank. Clean Air and Sustainable Environment Project. http://projects.worldbank.org/P098151/clean-air-sustainable-environment-project?lang=en&tab=documents&subTab=projectDocuments

Table 4.2: Ambient air quality results at Khulna CAMS-9 station

Criteria Pollutants	ECR 2005 Standards		2013	2014	2015
	Averaging Period	μg /m³	μg /m³	μg /m³	μg /m³
CO	8 hr	10,000	1,790	1020	550
	1 hr	40,000	1,590	860	460
SO_2	24 hr	365	6.38	4.6	12
NO_x	annual	100	14.4	DNA	65.3
Particulate Matter (PM_{10})	24 hr	150	132	219	93.5
Particulate Matter ($PM_{2.5}$)	24 hr	65	76.0	102	83.6

192. For Component 1, six air quality sampling stations were identified to establish the existing environment in the study area (see **Figure 4.14**). Air quality measurements were conducted on 13-19 March 2017 for CO, SO_2, NO_x, TSP, PM_{10} and $PM_{2.5}$. **Table 4.3** presents the 24-hr average results of ambient air monitoring.

Figure 4.14: Air quality sampling stations in the study area

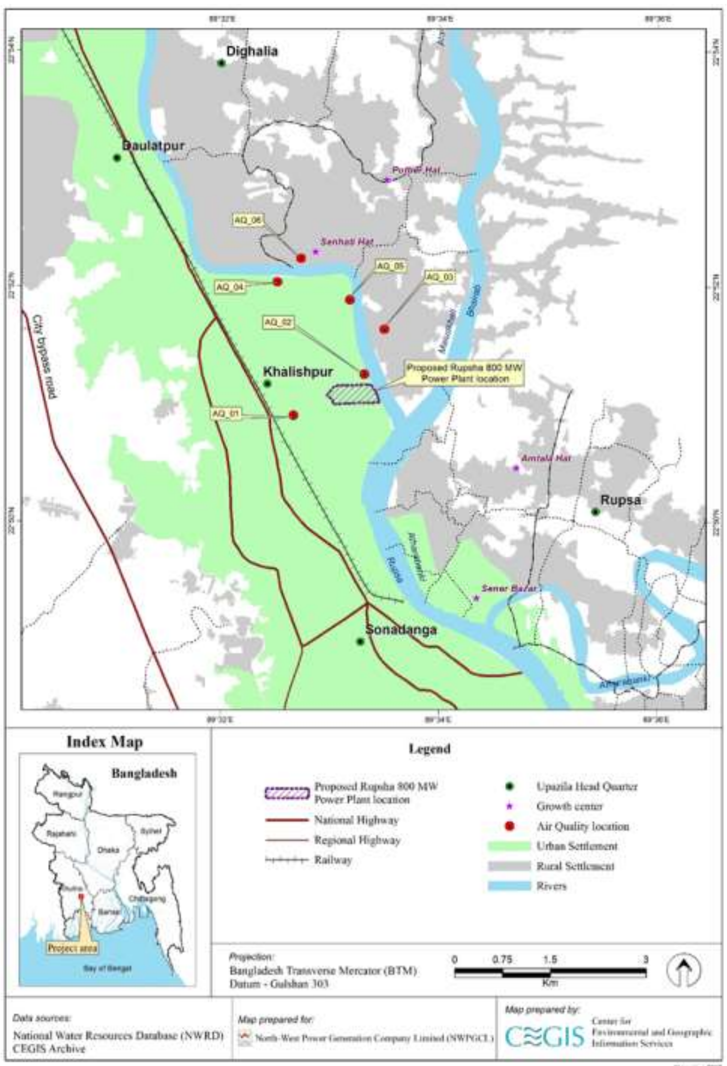


Table 4.3: Results of ambient air quality measurements in the study area

Sample Location ID		Ambient air quality parameters					
		CO ($\mu g/m^3$)	**SO_2 ($\mu g/m^3$)**	**NO_X ($\mu g/m^3$)**	**TSP ($\mu g/m^3$)**	**PM_{10} ($\mu g/m^3$)**	**$PM_{2.5}$ ($\mu g/m^3$)**
Methods	**Location**	**CO meter**	**West-Gaeke**	**Jacon and Hochheiser**	**Gravimetric**	**Gravimetric**	**Gravimetric**
AQ_1	N22˚ 50' 57" E89˚ 32' 30"	64	9.1	15.9	190.2	108.4	38.5
AQ_2	N22˚ 51' 18" E89˚ 33' 09"	65	6.7	11.2	187.1	140.9	37.9
AQ_3	N22˚ 51' 41" E89˚ 33' 20"	57	8.2	12.9	198.3	149.3	39.8
AQ_4	N22˚ 52' 05" E89˚ 32' 21"	61	8.4	11.9	188.3	126.1	29.8
AQ_5	N22˚ 51' 56" E89˚ 33' 01"	51	7.1	9	150	143.2	17.3
AQ_6	N22˚ 52' 17" E89˚ 32' 34"	66	12.1	19.1	192.2	133.4	26.4
ECR 2005 standards		10,000 (8-hr averaging period)	365 (24-hr averaging period	100 (Annual)	200 (8-hr averaging period)	150 (24-hr averaging period)	65 (24-hr averaging period)
IFC/WB EHS General Guidelines (2007)		10,000 (8-hr averaging period)	20 (24-hr averaging period 500 (10 mins averaging period, guideline)	200 (1-hr averaging period, guideline) 40 (1-yr averaging period, guideline)	---	50 (24-hr averaging period)	25 (24-hr averaging period)

Source: CEGIS Sampling (13-19 March 2017).

Ambient noise level

193. The project area is located in the industrial belt of Khalishpur Thana. There are several point sources, line sources or area sources generating noise and do affect the background noise level in the study area. Some of these sources are commercial areas, industries, vehicular movements, ongoing construction works, etc.

194. Given that there are no activities in the project site except the boys' and girls' schools, the noise level is low. The vegetation within the project site that grew since the 2002 also provides noise barrier. Ambient noise level measurements were conducted on 27 October 2016 until 3 November 2016 for 14 stations within the study area. **Table 4.4** presents the results of noise level measurements. Results show that some daytime and nighttime exceed the national limits and IFC/WB EHS General Guidelines 2007 (highlighted in yellow). A number of factors like vehicular movement (e.g. bus, train), noise from the loud speaker, and construction works contributed to the increase in the noise levels.

Table 4.4: Ambient noise level measurements within and near project site

SL	Location	GPS coordinate	Status	Day time	Night time	ECR 2006		IFC/WB EHS General Guidelines 2007	
						Daytime	Night time	Daytime	Night time
NL_01	Residential /Hospital (structures in KNM)	N-22°51'12.60" E-89°32'58.40"	Residential	55.2	42.3	55	45	55	45
NL_02	Residence in KNM	N-22°51'12.10 E-89°33'2.50"	Residential	52.2	43.0	55	45	55	45
NL_03	Proposed admin building	N-22°51'4.10" E-89°32'55.10"	Industrial	58.8	45.2	75	70	70	70
NL_04	Admin building of KNM (abandoned)	N-22°51'19.60" E-89°32'59.00"	Industrial	55.5	40.3	75	70	70	70
NL_05	South-west corner Slump	N-22°51'4.90" E-89°32'50.30"	Residential	62.3	53.0	55	45	55	45
NL_06	Near the existing overhead tank (abandoned)	N-22°51'2.40" E-89°33'19.00"	Industrial	70.3	50.1	75	70	70	70
NL_07	Proposed Control Room	N-22°51'1.90" E-89°33'6.80"	Industrial	62	36.7	75	70	70	70
NL_08	Southern side of project boundary (middle)	N-22°51'2.90" E-89°33'2.60"	Residential	54	41.5	55	45	55	45
NL_09	Proposed Residential Area	N-22°51'9.67" E-89°32'52.70"	Residential	57.8	44.6	55	45	55	45
NL_10	Existing Guest room of KNM	N-22°51'4.72" E-89°33'13.40"	Industrial	64.2	43.1	75	70	70	70
NL_11	Premises of Mosque	N-22°51'27.20" E-89°32'53.90"	Silent	55.1	39.1	50	40	55	45
NL_12	Western corner of the Project	N-22°51'19.20 E-89°32'56.50"	Commercial	67.2	52.0	70	60	70	70
NL_13	Proposed new school site	N-22°51'16.80" E-89°33'29.40	Silent	60.1	43.9	50	40	55	45
NL_14	Fisheries Community	N-22°51'11.92" E-89°33'24.69"	Residential	47.3	37.5	55	45	55	45

Note: Values highlighted yellow exceed the limit.

Vibration

195. Vibration consists of rapidly fluctuating motions of the particles without any net movement. Objects can vibrate differently in three mutually independent directions which are vertical, horizontal and lateral. It is common to describe vibration levels in terms of velocity, which represents the instantaneous speed at a point on the object that is displaced. Vibrations are transmitted from the source to the ground and propagate through the ground to the receiver.

196. Measuring the peak particle velocity (PPV) is mostly used for representation of vibrating situation when the pressure wave passes through the particles. Soil conditions have a strong influence on the level of ground-borne vibration. The PPVs are usually expressed in terms of m/s or mm/s. The PPVs were measured in the project area (**Table 4.5**). The Kanomax machine (model 4200) was used to directly obtain the value during field visit on 26 October 2016.

Table 4.5: Vibration levels in the project site

No.	Location	Vibration (mm/s)
1	Near mosque and Graveyard	0.01
2	Near the school	0.01
3	Residential area of KNP	0.02
4	Guest House of KNP	0.01
5	South West Corner of the Project boundary	0.01

Source: CEGIS Field Visit, October 26, 2016

197. Humans are known to be very sensitive to vibration, the threshold of perception being typically in the PPV range is from 0.14 -0.3 mm/s (British Standard BS 5228-2:2009). The level of vibration in the project site is not within the PPV range of human perception.

4.2.6 Water Resources

198. There are several rivers, khals and beels in the study area as the sources of surface water. Ground water is also available.

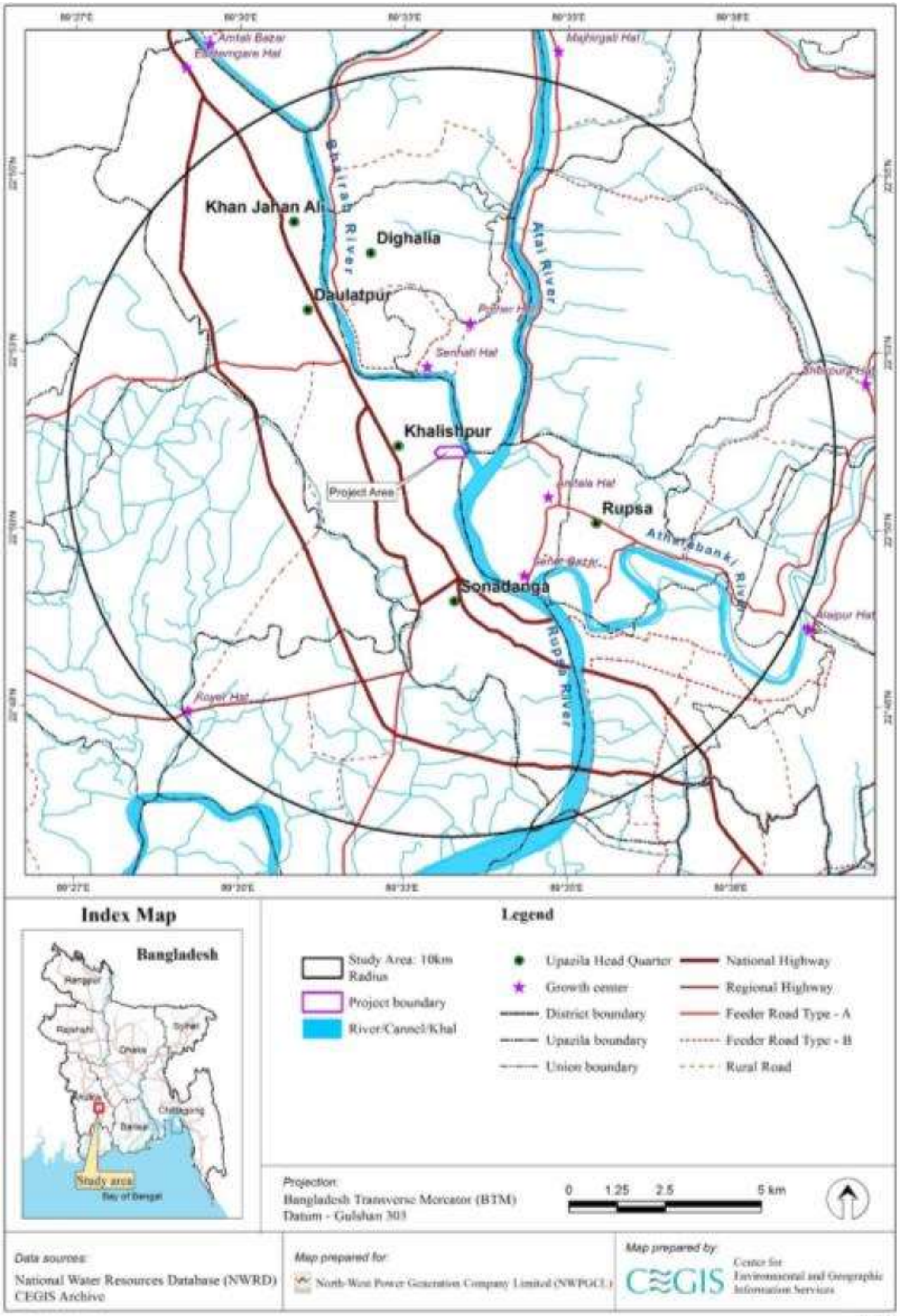
Surface Water

199. The project area is locally known as colony of KNM and is located at the right bank downstream of Bhairab River ultimately draining towards the Bay of Bengal. The main rivers within the study area are Bhairab River, Atai River, and Rupsha River. These rivers are tidally influenced by the Bay of Bengal.

200. The entire south-west region of Bangladesh, located in the right bank of the Ganges-Padma River is known as the Gangetic Delta and has been formed primarily by the alluvium carried by the Ganges River. The north-south flowing rivers in this region are interconnected by smaller tidal creeks which forms the network of rivers. There are large saucer shaped tidal basins between these networks that are flooded and drained twice in a day by the tide. Like any other area within the coastal belt, the proposed area is also a saucer shaped tidal basin. Tide enters into the area from the Bhairab River through the Rupsha River. The Bhairab River has no connectivity with the khals or channels along its right bank in the project site. However, the study area receives a volume of storm water through city drainage and other discharges from the bankside mills and factories.

201. The feature is totally different in the other side of the Bhairab River. There is active connection of Atai River and Rupsha River with the Bhairab River through a number of local beels and channels. Average depth of water in the Bhairab River is 0.5 to 2.3 m during the dry season while during monsoon, it increases toabout4.1 m to 5.6 m. At present, most of the beel areas are used for agriculture, fisheries, shrimp and prawn culture during the dry season through compartmentalization by small dyke in the left side of this river. **Figure 4.15** shows the river connectivity within the study area.

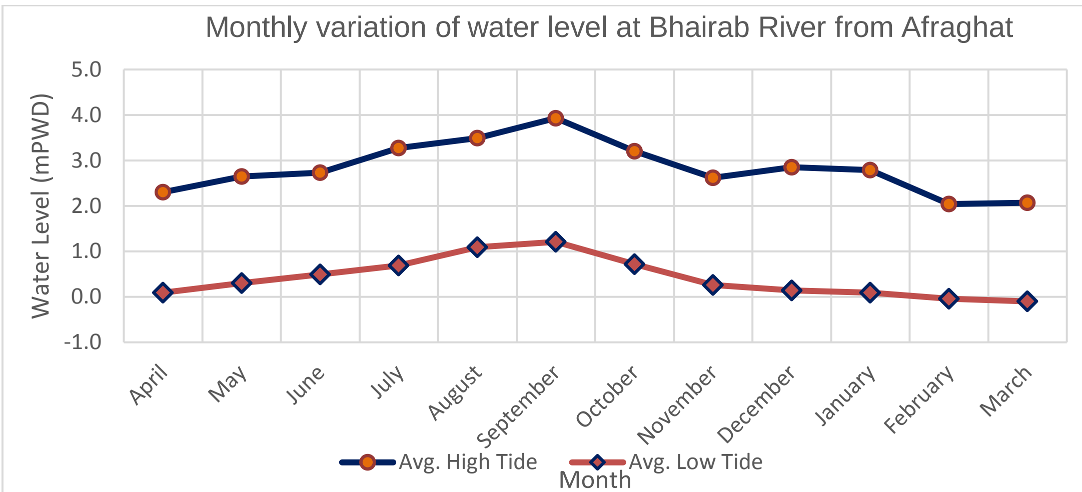
Figure 4.15: River connectivity in the study area



Water level and discharge

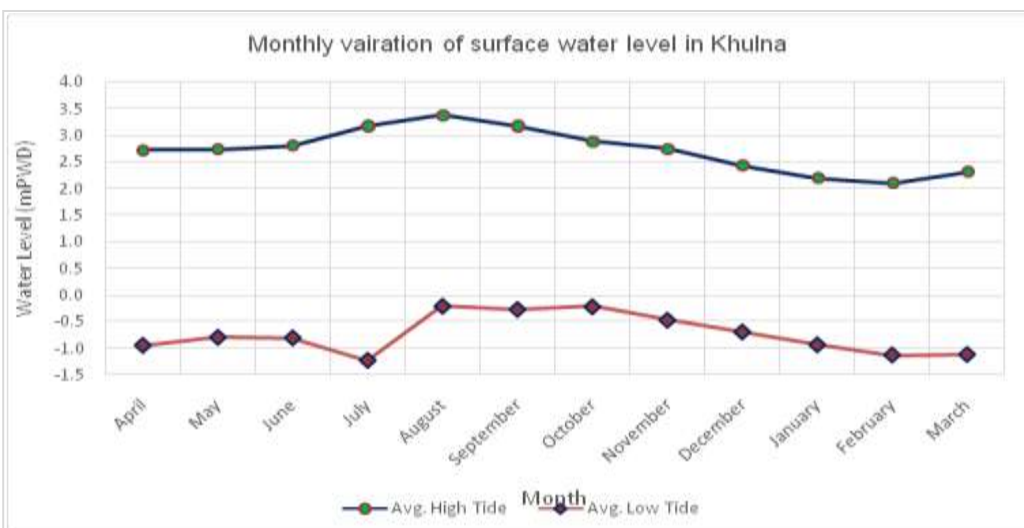
202. Water level data from 1980 to 2016 at the Afraghat station of the Bangladesh Water Development Board (BWDB) for the Bhairab River and from the Khulna station for the Rupsha-Passur River have been used to examine the routing at the project site using the maximum water level to discharge profile. The Afraghat station is located about 4.5 km downstream of Bhairab River while the Khulna station is 32 km upstream from the proposed project site. Average monthly water level during the high tide and low tide are presented in **Figure 4.16** for Bhairab river and **Figure 4.17** for the Rupsha-Passur River. Flooding situation is shown in **Figure 4.18**.

Figure 4.16: Average monthly tide levels of Bhairab River at Afraghat



Source: BWDB

Figure 4.17: Average monthly levels of Rupsha-Passur River



Source: BWDB

Figure 4.18: Flooding situation

During post monsoon

During monsoon

Return period analysis for water level

203. Maximum water level in the Bhairab River has been recorded at 4.14mPWD in 1971 at Afraghat station and 3.86mPWD in 2005 at the Khulna station (**Table 4.6**).

Table 4.6: Return period analysis for Bhairab River

Return Period (T), years	Water level at Afraghat (mPWD)	Water level at Khulna (mPWD)
5	3.61	3.51
10	3.88	3.69
25	4.19	3.90
50	4.40	4.03

Source: CEGIS return period analysis, 2016

Discharge data

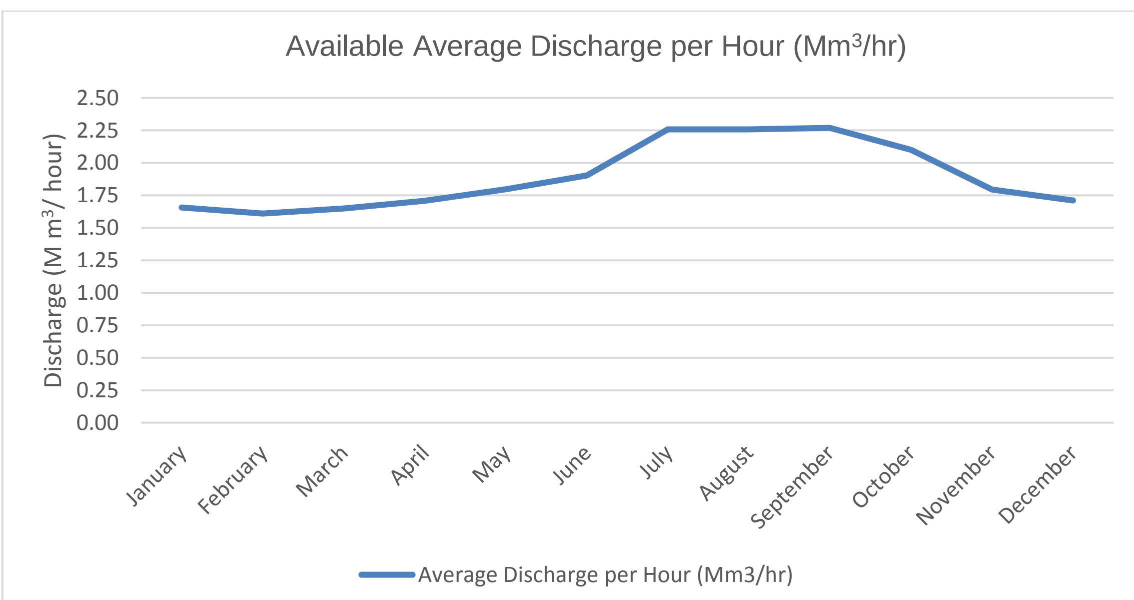
204. Discharge data was based on the Hydrological Investigation and Model Study of Bhairab River (Feasibility Study, March 2016) which shows that the available water from the Bhairab River range from 38.64 million cubic meters (MCM)/day to 54.47 MCM/day. Water requirement for the forced draft cooling system is about 2,010 m^3/hr. Percentage of water required per year will range from 0.089% to 0.125% or less than 1% of the average available discharge (**Table 4.7**). **Figure 4.19** shows the available average discharge per hour.

Table 4.7: Available discharge in Bhairab River

No.	Month	Average Discharge per day (MCM/day)	Average Discharge per Hour (m^3/hr)	Required water for the cooling system (m^3/hr)	Percentage of river water for cooling system (%)
1	January	39.73	1,655,416.667	2,010	0.121
2	February	38.64	1,610,000	2,010	0.125
3	March	39.59	1,649,583.333	2,010	0.122
4	April	40.99	1,707,916.667	2,010	0.118
5	May	43.11	1,796,250	2,010	0.112
6	June	45.67	1,902,916.667	2010	0.106
7	July	54.21	2,258,750	2,010	0.089
8	August	54.21	2,258,750	2,010	0.089
9	September	54.47	2,269,583.333	2,010	0.089
10	October	50.39	2,099,583.333	2,010	0.096
11	November	43.04	1,793,333.333	2010	0.112
12	December	41.08	1,711,666.667	2,010	0.117

Source : Hydrological Investigation and Model Study of Bhairab River, March 2016 (Feasibility report).

Figure 4.19: Available average discharge throughout the year



Surface water quality

205. In-situ surface water quality measurements were conducted in October 2016 for six sampling stations identified within the study area. Water quality parameters include pH, dissolved oxygen, biochemical oxygen demand (BOD), total dissolved solids (TDS), electrical conductivity, salinity, and temperature. Chemical analyses of the surface water samples were done by the central laboratory of the Department of Public Health Engineering (DPHE). Results of analysis are given in **Table 4.8** and **Table 4.9**, respectively. **Figure 4.20** shows the sampling stations.

Table 4.8: Results of in-situ surface water sampling (October 2016)

Sample ID	Location of Sampling	pH	DO ppm	BOD_5 at 20°C	TDS ppm	EC µS/cm	Salinity (ppt)	Temperature (°C)
SW01	Upstream of project site	8.38	7.8	0.7	100	210	0	36
SW02	Project Intake (Low tide)	8.47	6.89	0.89	117	245	0	32
SW03	Project Intake (High tide)	8.38	5.9	0.7	110	230	0	30
SW04	Downstream of project site	8.45	6.2	0.55	165	320	0	33
SW05	Bhairab-Rupsha Confluence	8.25	6.92	1.02	185	355	0	30
SW06	Rupsha River	8.1	6.48	2.28	130	290	0	34
ECR 1997, Schedule - 3 Standards for Water (see Rule 12)		6.5-8.5	>5.0	6 or less	2,100	1,200	---	---

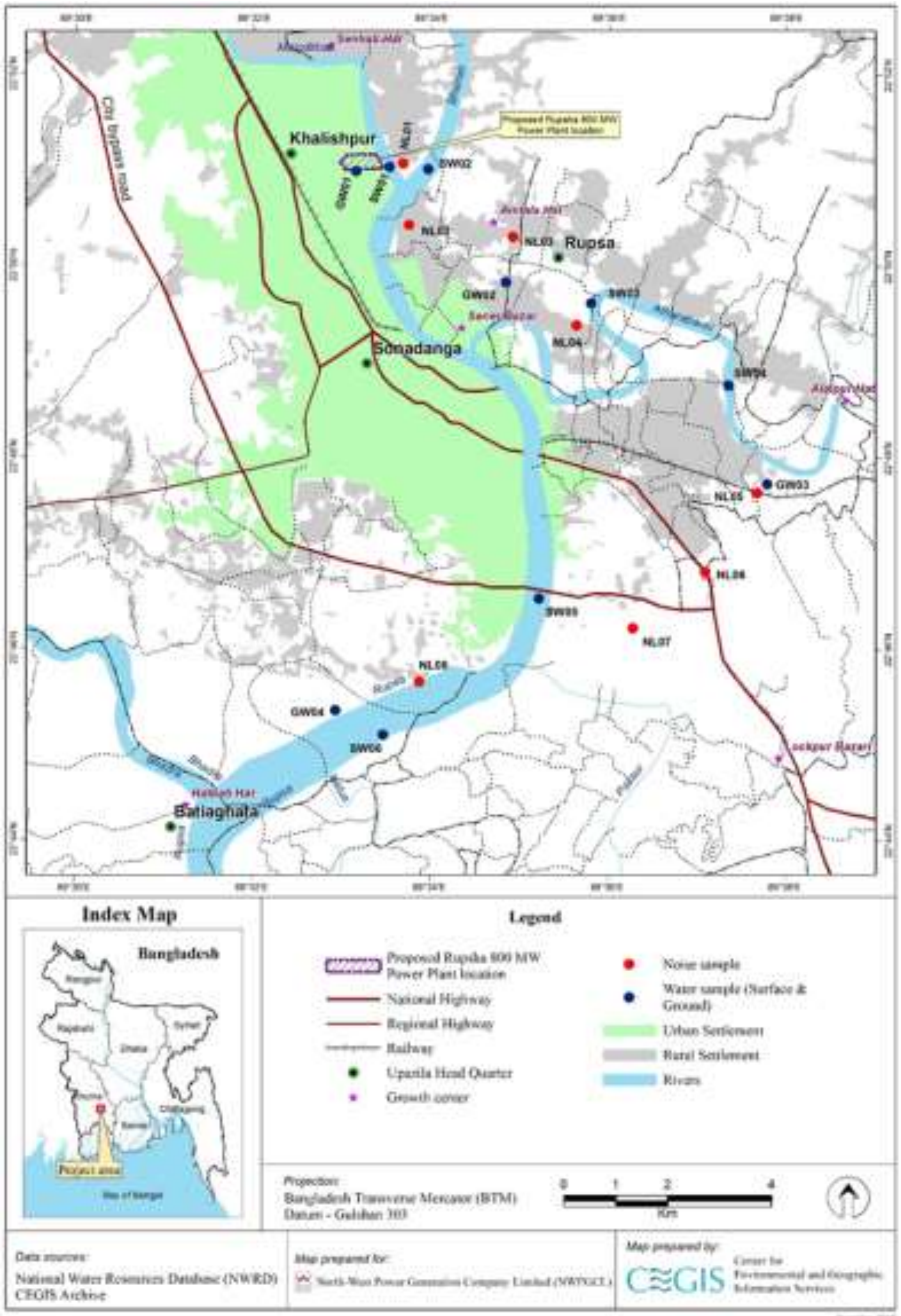
BOD = biochemical oxygen demand; DO = dissolved oxygen; EC = electrical conductivity; ppm = parts per million; TDS = total dissolved solids.
Source: CEGIS study team, October 2016.

Table 4.9: Results of chemical analyses, surface water quality

No.	Water Quality Parameters	Unit	SW01	SW02	SW03	SW04	SW05	SW06	Method of Analysis	LOQ
1	Alkalinity	mg/L	120	123	125	103	153	125	Titrimetric	-
2	Arsenic	mg/L	0.002	0.002	0.002	0.002	0.002	0.002	AAS	0.001
3	Calcium	mg/L	18.68	16.77	15	15.5	16.6	13.6	AAS	0.17
4	COD	mg/L	40	48	20	20	16	32	CRM	-
5	Chloride	mg/L	18	16	20	17	18	16	Titrimetric	-
6	Electrical conductivity	µS/cm	15.5	42.9	34	50	45	37	Multimeter	-
7	Hardness	mg/L	143	185	173	143	158	145	Titrimetric	-
8	Iron	mg/L	2.38	2.32	2.45	3.06	2.85	3.21	AAS	0.05
9	Lead	mg/L	0.008	0.007	0.004	0.003	0.005	0.004	AAS	0.001
10	Magnesium	mg/L	3.4	38	3.6	3.3	3.2	3.4	AAS	0.05
11	Nitrogen	mg/L	3.1	3.8	1.2	0.7	1.3	0.8	UVS	0.10
12	Phosphate	mg/L	1.56	2.02	1.30	2.51	1.24	1.33	UVS	0.98
13	Potassium	mg/L	2	3	3	2	2	2	AAS	-
14	Sodium	mg/L	21	19	18	19	20	16	AAS	0.34
15	Sulfate	mg/L	2	1	1	1	2	4	UVS	1.0
16	TDS	mg/L	6	6	7	6	6	7	Multimeter	-
17	Turbidity	NTU	66	60	65	69	67	59	Turbidity meter	-
18	Oil & Grease	mg/L	<5.0	<5.0	-	<5.0	-	-	APHA 5220.B	10

AAS =Atomic Absorption Spectrophotometer; CRM =Closed Reflux Method; LOQ =Limit of Quantification; NM =not measured; UVS = UV Visible Spectrophotometer.

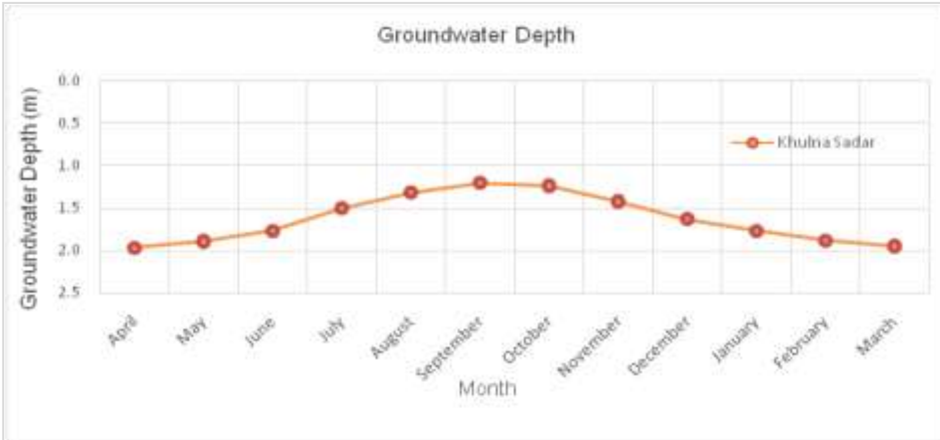
Figure 4.20: Noise sampling stations



Groundwater

206. Groundwater level data was collected from the Khulna Sadar observation well to examine the status of groundwater availability in the study area. **Figure 4.21** shows the monthly ground water depth from 1978-2013. Based on the available data, groundwater starts to deplete during the later stages of the pre-monsoon (end of April) and continues up to the middle of October. Thereafter, at the beginning of post-monsoon, the aquifer recharge begins.

Figure 4.21: Average monthly groundwater depth (1978-2013)



Source: BWDB

Groundwater quality

207. Four groundwater sampling stations were identified in the study area during the site visit on 26-30 October 2016 (see **Figure 4.22**). Groundwater samples were analyzed by the Central Laboratory, DPHE. Results of groundwater quality sampling are given in **Table 4.10** and **Table 4.11**.

Table 4.10: Results of in-situ groundwater quality sampling in the study area

Sample Source	Location of Sampling	pH	DO ppm	BOD_5 at 20°C (mg/l)	EC (mS/cm)	TDS ppm	Salinity (ppt)	Temperature (°C)	Time
GW01	Deep tube well of 250 ft depth	7.45	1.7	0.5	1,530	760	2	28	11:20 am
GW02	Deep tube well of 600 ft depth	7.9	5.99	0.64	1,820	910	3	26	10:15 am
GW03	Deep tube well of 400 ft depth	4.51	2.5	0.2	1,260	630	2	27	16:45 pm
GW04	Deep tube well of 500 ft depth	7.75	4.8	0.5	1,570	780	2	26	12:30 pm
ECR 1997 Schedule-3 Standards for Water [See Rule 12] (B)		6.5-8.5	6	0.2	---	1,000	---	20-30	

Source: CEGIS field study, October 2016.

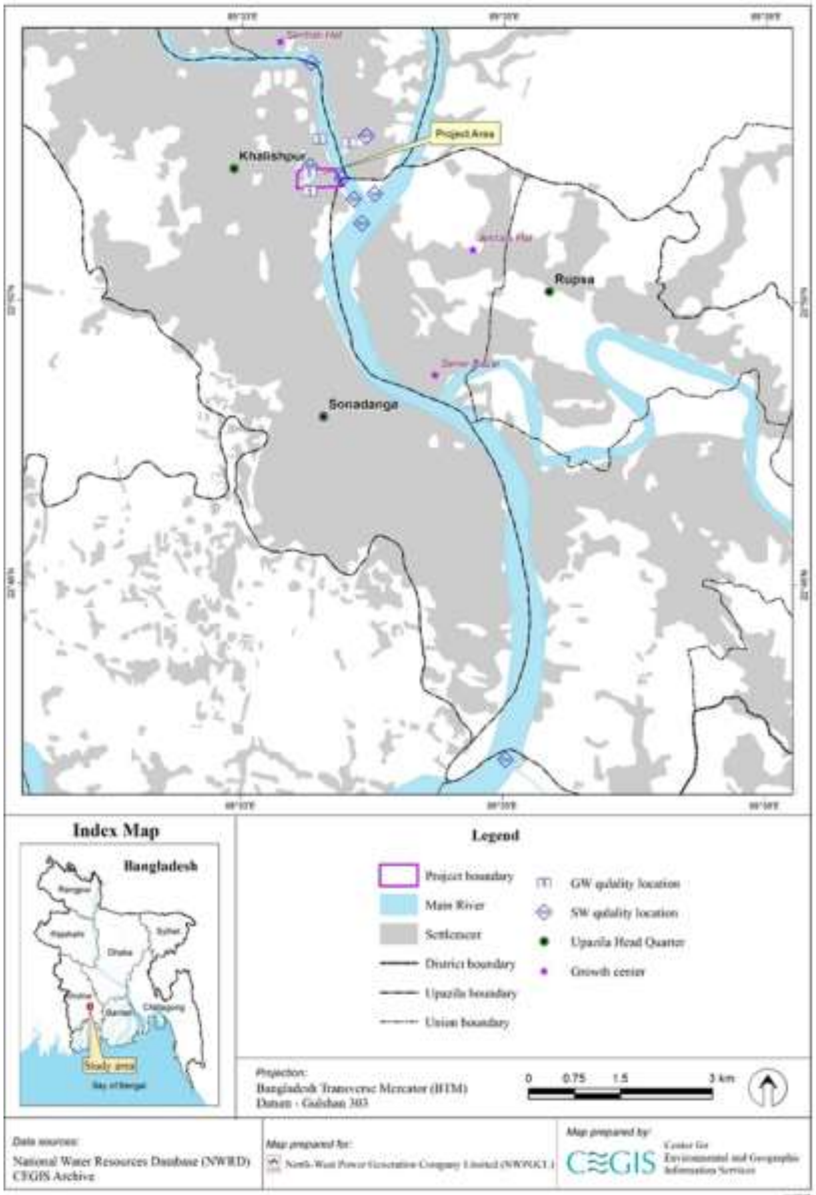
208. Based on the in-situ water quality measurements, groundwater is saline and the electrical conductivity values are high as well as BOD_5.

Table 4.11: Results of groundwater quality analyses

No.	Water Quality Parameters	Unit	GW01	GW02	GW03	GW04	Method of Analysis	ECR 1997 Schedule-3 Standards for Water [See Rule 12] (B)	LOQ
1	Arsenic	mg/L	0.002	0.001	0.001	0.001	AAS	0.05	0.001
2	Calcium	mg/L	29.6	34.7	49.3	48.3	AAS	75	0.17
3	COD	mg/L	4	4	4	4	CRM	4	-
4	Chloride	mg/L	332	461	210	348	Titrimetric	150-600	-
5	Silica	mg/L	31	33	33	42	UVS		
6	Hardness	mg/L	353	315	350	405	Titrimetric	200-500	-
7	Iron	mg/L	3.03	5.37	4.38	6.52	AAS	0.3-1	0.05
8	Lead	mg/L	0.015	0.015	0.013	0.022	AAS	0.05	0.001
9	Nitrogen	mg/L	0.87	1.2	1.6	1.1	UVS	1.0	0.10
10	Phosphate	mg/L	0.16	0.37	1	0.50	UVS	6	0.98
11	Sulfate	mg/L	5	5	3	2	UVS	400	1.0

AAS = Atomic Absorption Spectrophotometer, CRM = Closed Reflux Methods, LOQ = Limit of Quantification, NM = not measured, UVS =UV-Visible Spectrophotometer.

Figure 4.22: Water quality sampling stations



Water resources issues and functions

Existing beneficial uses of Bhairab River

209. Bhairab River is used for the fisheries, shrimp and agricultural purposes. The consumption of water mainly takes place at the left bank of Bhairab River. The right bank of the Bhairab River within the study area is an industrial belt which do not use water from the river due to the tidal influence on water quality. Given the existing industries, Bhairab River has become the receiving body of most of the discharges from the industries. For other domestic uses, shallow tube well and surface water sources from perennial creeks are also used. Overall, water availability in the study area is not a major concern of the local people.

Flooding

210. Flooding is a common phenomenon in the study area and like other areas of Bangladesh, this area also experiences yearly flooding. The main causes of flooding are heavy rainfall, tidal water intrusion, and storm surge. Every year, during the high flood, proposed project area is submerged by about 0.5m –1.5m and in some occasion, extends for 7-30 days.

211. Seven major profiles of discharge within the study area have been considered (1969, 1970, 1972, 1974, 1984, 1986, and 1999). **Table 4.12** shows the flood profile in the study area. Secondary data on water level, discharge and land elevation were collected from the National Water Resources Database of Bangladesh and used as inputs to HEC-RAS model in flood risk analysis.[24]

Table 4.12: Flood profile of the study area

Profile	Return Period	Steady flow discharge (m^3/s)	Average Water level (mPWD)	Remarks
Profile 1 (1969)	2	4,261	2.41	Project area inundated fully
Profile 2	5	5,843	2.51	Project area inundated fully
Profile 3	10	4,593	2.76	Project area inundated fully
Profile 4	20	4,423	3.41	Project area inundated fully
Profile 5	25	2,820	3.15	Project area inundated partially
Profile 6	50	3,199	3.26	Project area inundated partially
Profile 7 (1999)	100	2,466	3.19	Project area free from flood

Source: CEGIS estimated HEC RAS model generated data.

[24] HEC-RAS is a software for one-dimension or two-dimensions simulations of the evolution of a flood, which could have a stable or an unstable flow rate, sediment transport, change of the river bed etc. HEC-RAS stands for Hydrologic Engineering Center (US Army Corps of Engineers), River Analysis System.

212. These profiles show that prior to 1999, the project area has been fully and partially inundated during flooding events (**Figure 4.23** and **Figure 4.24**). ADB funded a flood control and urban infrastructure development project on 10 November 2010.[25] This included a subproject in July 2013 on Khulna drainage and flood protection. The project site will be backfilled to a level of +5.5m. Surrounding area now is at elevation +3.3m MSL higher than the average water level based on the flooding profile in 1999 and a return period of 100 years. Therefore, flooding will not be a major risk.

Salinity

213. Saline intrusion is another concern within the study area. According to local people, salinity becomes a concern during the pre-monsoon period. Local pond and ditches are more saline than river as the tidal water velocity gets slower towards the ditches particularly during the dry period. Salinity was detected in all the groundwater samples taken from both the shallow and deep tube wells.

Riverbank Erosion

214. The eastern boundary of the project area located at the right bank of Bhairab River is protected by a sheet pile to avoid erosion of that particular section of the river (see Photo). But erosion and accretion are visible in both banks of the Atai River, Bhairab River and Rupsha River within the study area. For morphological analysis of the study area, satellite images of 1997, 2003, 2008, 2010 and 2015 have been used. Geographic information system (GIS) and remote sensing (RS) tools and technologies have been used for this study. Bank lines of these five years have been delineated following the CEGIS-defined methodologies (**Table 4.13** and **Figure 4.25**).

sheet pile erosion protection

Erosion across the river bank of Bhairab River opposite the proposed project site

215. There are about 15 km of sheet piling existing in the study area including the project's eastern boundary. But erosion becomes prominent at the other side of the river. In the figure above, sheet piling at Rupsha Old Ferry Ghat located 8km south from the project site.

[25]ADB. Loan 2695-BAN: City Region Development Project. $120M, 10 November 2010. https://www.adb.org/projects/39298-013/main#project-pds.

Table 4.13: Summary of erosion-accretion in the study area

Duration	:	Average erosion (ha/year)	Total accretion in the study area (ha)	Average Accretion (ha\year)
1997 - 2003	109.65	18.28	106.18	17.70
2003 - 2008	101.19	22.03	111.67	22.34
2008 - 2010	163.21	81.61	114.28	57.14
2010 - 2015	48.94	9.8	184.40	36.88

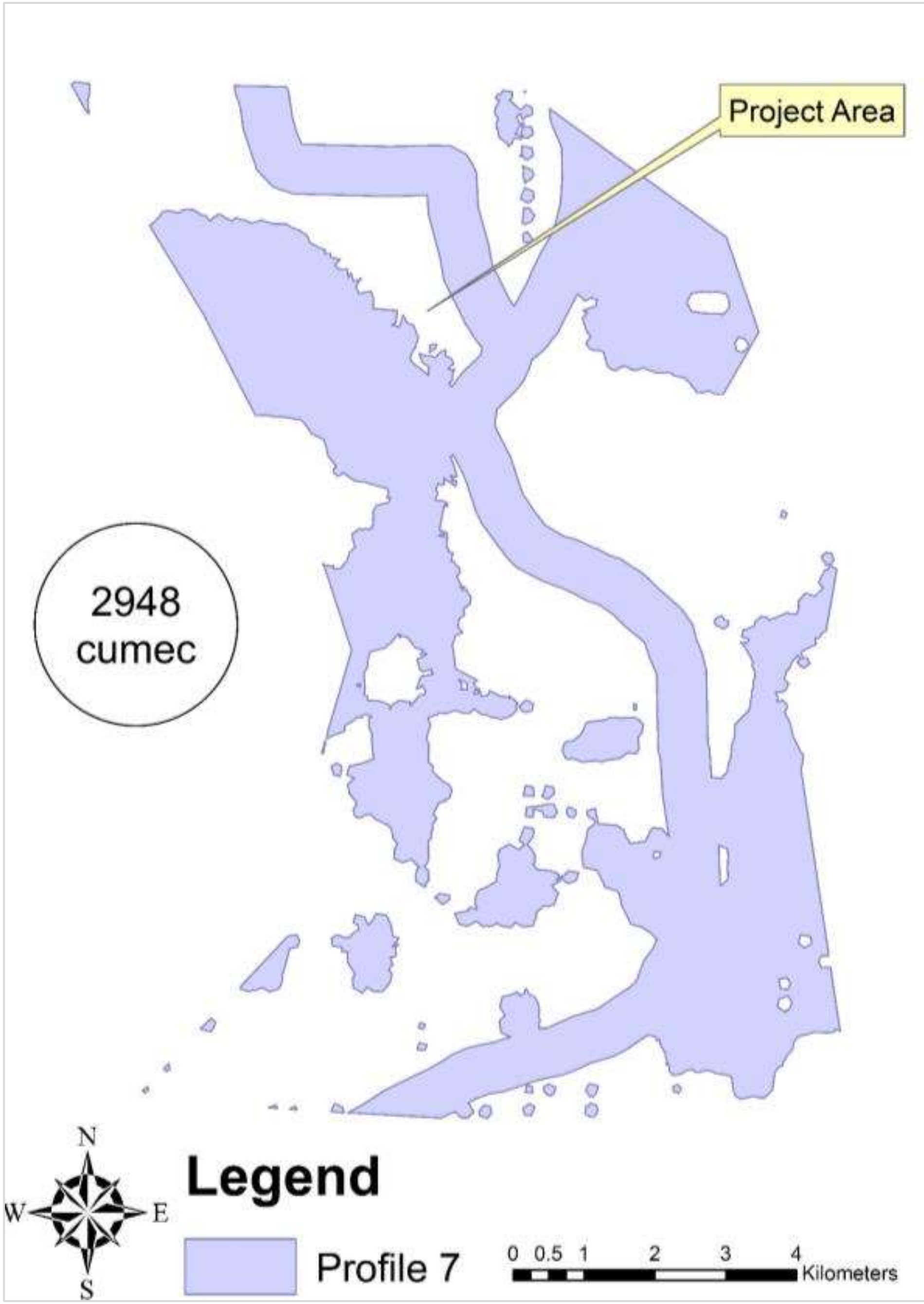
Source: Results of CEGIS analysis.

216. Based on the available satellite images during these five years, it appears that the situation has improved from an erosion rate of 81.61 ha/yr (2008-2010) to 9.8 ha/yr (2010-2015). **Figure 4.26** shows the location of the river bank erosion-accretion within the study area.

Figure 4.23: Inundation in 1969 within the study area

Source: HEC-RAS Model Output.

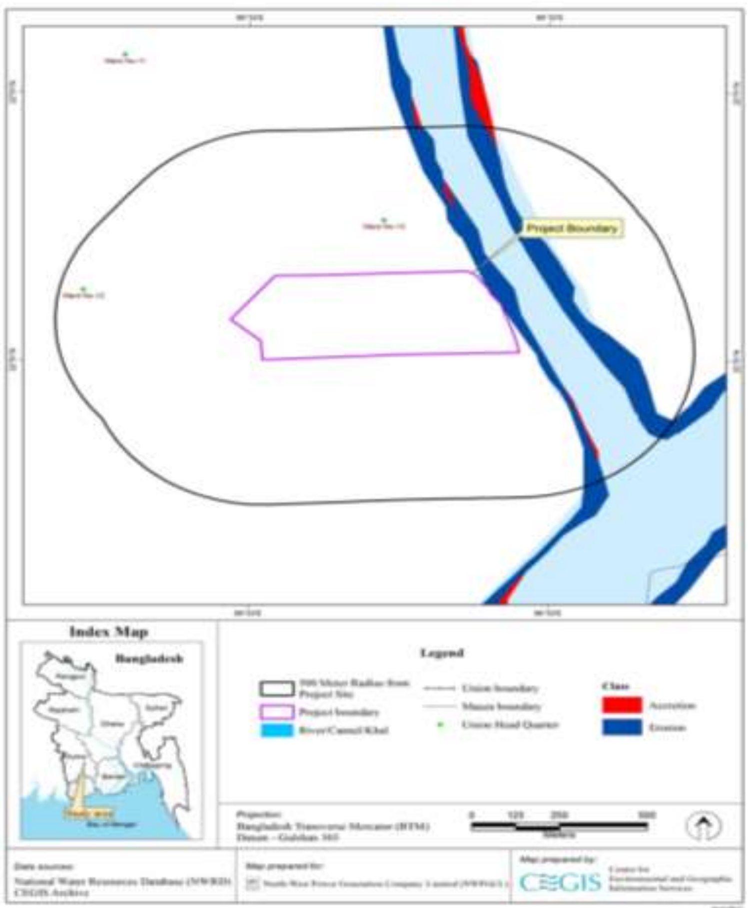
Figure 4.24: Inundation in 1999 within the study area



Source: HEC-RAS Model Output.

Figure 4.25: River bank erosion and accretion in the study area

Figure 4.26: Location of river bank erosion-accretion in the study area



Navigation

217. Bhairab River is one of the industrial navigation routes within the study area. The waterways of Bangladesh have been classified by the Bangladesh Inland Water Transport Authority (BIWTA) into four categories depending on least available depth ranging from 3.90 m to 1.50m.[26] **Table 4.14** presents the categories within the study area.

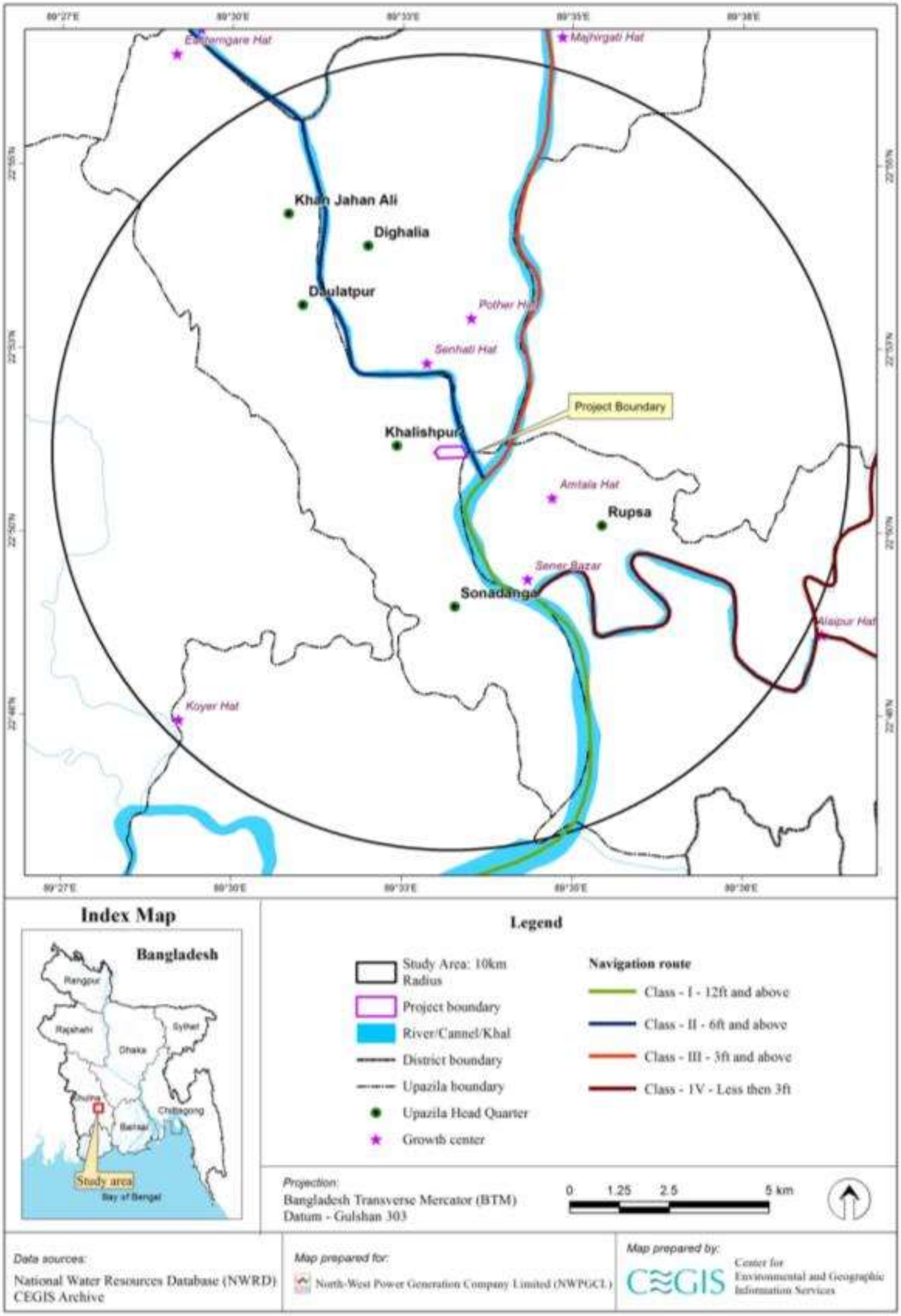
Table 4.14: **Categories of waterways in the study area**

Category	Minimum Depth (m)	Length of Route (km)	Minimum Vertical Clearance (m)	Minimum Horizontal Clearance (m)
Class I	3.66	683	18.3	76.22
Class II	2.13	1,027	12.2	76.22
Class III	1.52	1,885	7.62	30.48

218. Based on these categories, Bhairab River is Class II. This route is extensively used for the transportation of goods and passengers. Local people use small boats and trawlers for local transportation of goods and other vessels like ships, barges, cargo for transportation across the country. Rupsha River is Class I while Atai River is Class III. Rupsha River and Atai River are connected with Bhairab River at Aijganti Union of Khulna Sadar (**Figure 4.27**). It is estimated that about 45km navigation route currently exists within the study area.

[26] Bangladesh Inland Water Transport Authority. About us. http://www.biwta.gov.bd/

Figure 4.27: Navigation system within the study area



4.2.7 Land resources

219. This section was based on primary and secondary data. The primary data was collected during the site visit on 26-30 October 2016 while secondary data was taken from Soil Resources Development Institute (SRDI) publications, local offices of the Department of Agricultural Extension (DAE), and Department of Livestock Services (DLS).

Agro-ecological Zone

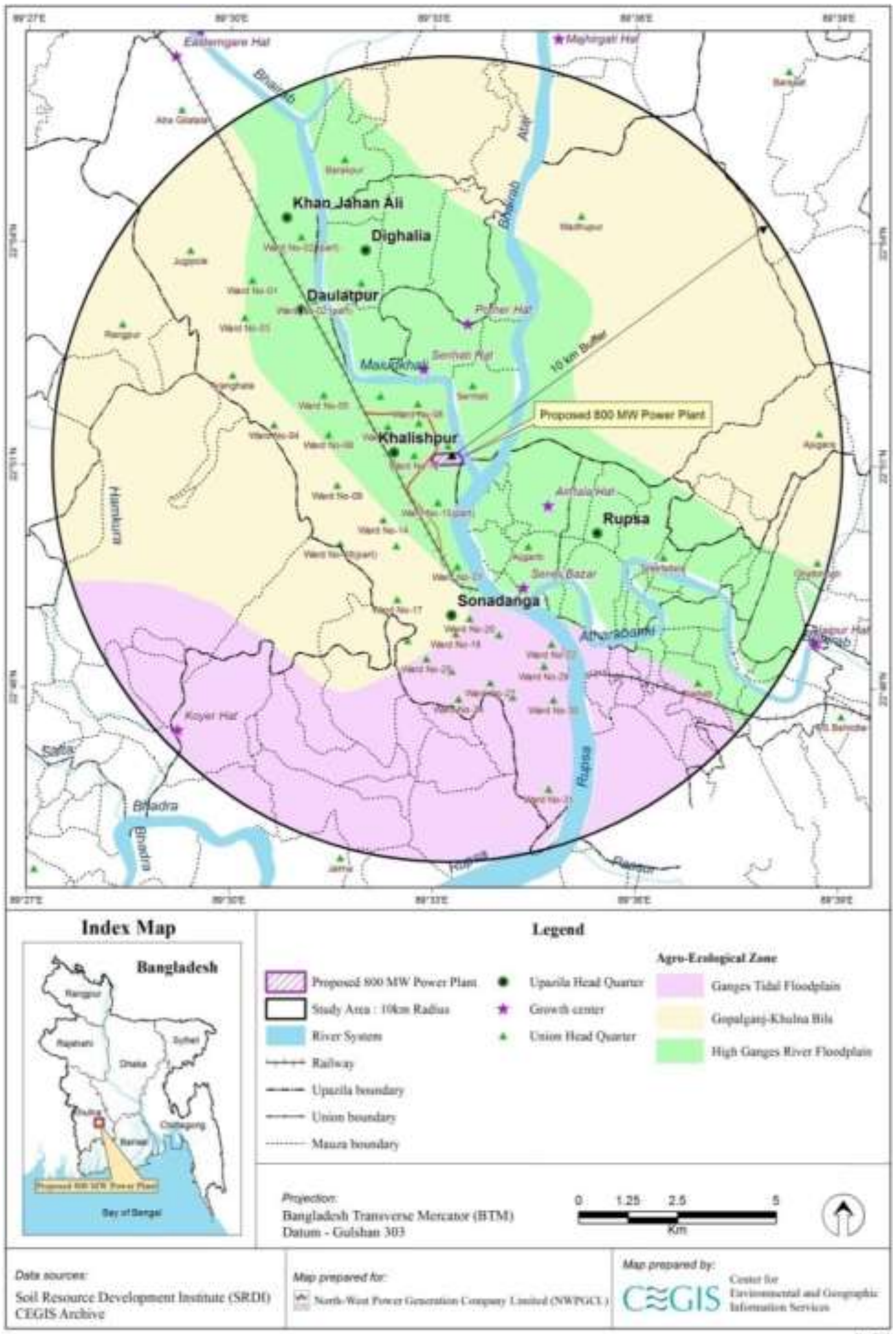
220. The project area is under one agro-ecological zone (AEZ) while the study area is under three different AEZs which are situated in Khulna Sadar District (**Table 4.15** and **Figure 4.28**). The project area is on High Ganges River Floodplain while most of the study area is in Gopalganj-Khulna Beel (almost half of the study area).

Table 4.15: AEZ within the PAI

Name of AEZ	Description of AEZ	Project area (acre)	% of gross area	Study area (acre)	% of gross area
AEZ 11: High Ganges River Floodplain	Top soils are slightly acidic to slightly alkaline in reaction, but there is a significant lowering of soil pH in high land in the recent years and in some places top soils become strongly acidic. Sub-soils are slightly alkaline in reaction. General fertility level is low including N, P, S and B although CEC is medium. The K- bearing minerals are medium to high, but the Zn status is low to medium. Soil texture is generally silty loams to silty clay loams. pH is 4.5-8.1 and organic matter content in soil is low to medium.	49.57	100	23,741	31
AEZ 13: Ganges Tidal Floodplain	Very high CEC and K status. There are limitations of high exchangeable Na and low Ca/Mg ratio. The Zn status is low to medium and the B and S status is medium to optimum. Soil texture is generally silty clay. pH is 4.5-8.4 and organic matter content in soil is low to medium.	-	-	17,070	22
AEZ 14: Gopalganj-Khulna Bils	General Soil Types include mainly Peat and Non calcareous Dark Grey Floodplain soils. They have low bearing capacity when wet, very strongly acidic to neutral in top soil reaction and low in K, B and Zn. Soil texture is generally clayey. pH is 4.0-7.5 and organic matter content in soil is high.	-	-	36,785	47
Total		**49.57**	**100**	**77,596**	**100**

Source: SOLARIS-SRDI-2006.

Figure 4.28: AEZ within the PAI



Land type

221. The basis of land type classification in Bangladesh is depth of inundation during monsoon season due to normal flooding on agriculture land (MPO 1987). According to Master Plan Organization (MPO) 1987, there are five land type classes: F0, F1, F2, F3 and F4. The project area is within the Khulna City Corporation which is a non-agricultural industrial zone (KNM) and hence, the land type in this area is not considered in terms of agricultural point of view. The study area falls within four different land types. Details of the land types are presented in **Table 4.16** and **Figure 4.29**.

Table 4.16: Land type within the study area

Land Type	Flooding depth and characteristics	Study Area	
		Area (Acre)	% of Net Cropped Area (NCA)
F0	The land, which is not generally inundated under normal flood situation. This class has been subdivided into two classes: (i) Land which is above normal flood-level. (ii) Normally flooded from 0 - 30 cm deep where water normally can be stored by constructing ail and Aman can be transplanted.	885	4
F1	Land which normally is flooded between 30- 90 cm deep continuously more than two weeks to few months during the flood season.	11,654	53
F2	Land which normally is flooded between 90 cm -180 cm deep of inundation continuously for few months in flood season.	6,522	30
F3	Land which normally is flooded between 180 and 360 cm deep of inundation continuously for few months in flood season.	2,755	13
	Total:	**21,816**	**100**

F0 = highland, F1 = medium highland, F2 = low land, F3 = medium low land.
Source: Master Plan Organization (MPO), Technical Report No. 1, 1987 and field observation in October 2016

Soil texture

222. Soil texture is the relative proportion of sand, silt and clay. Soil texture is an important characteristic that guides crop selection. The study area contains four soil textural classes, where clay texture dominates over others. Soil texture of the study area is presented in **Table 4.17** and **Figure 4.30**.

Table 4.17: Soil texture in the study area

No.	Soil Texture	Study Area	
		Area (Acre)	% of NCA
1	Clay	12,397	57
2	Clay Loam	1,910	9
3	Loam	1,112	5
4	Muck	6,397	29
Total		**21,816**	**100**

Sources: SOLARIS-SRDI, 2006.

Figure 4.29: Land type within the study area

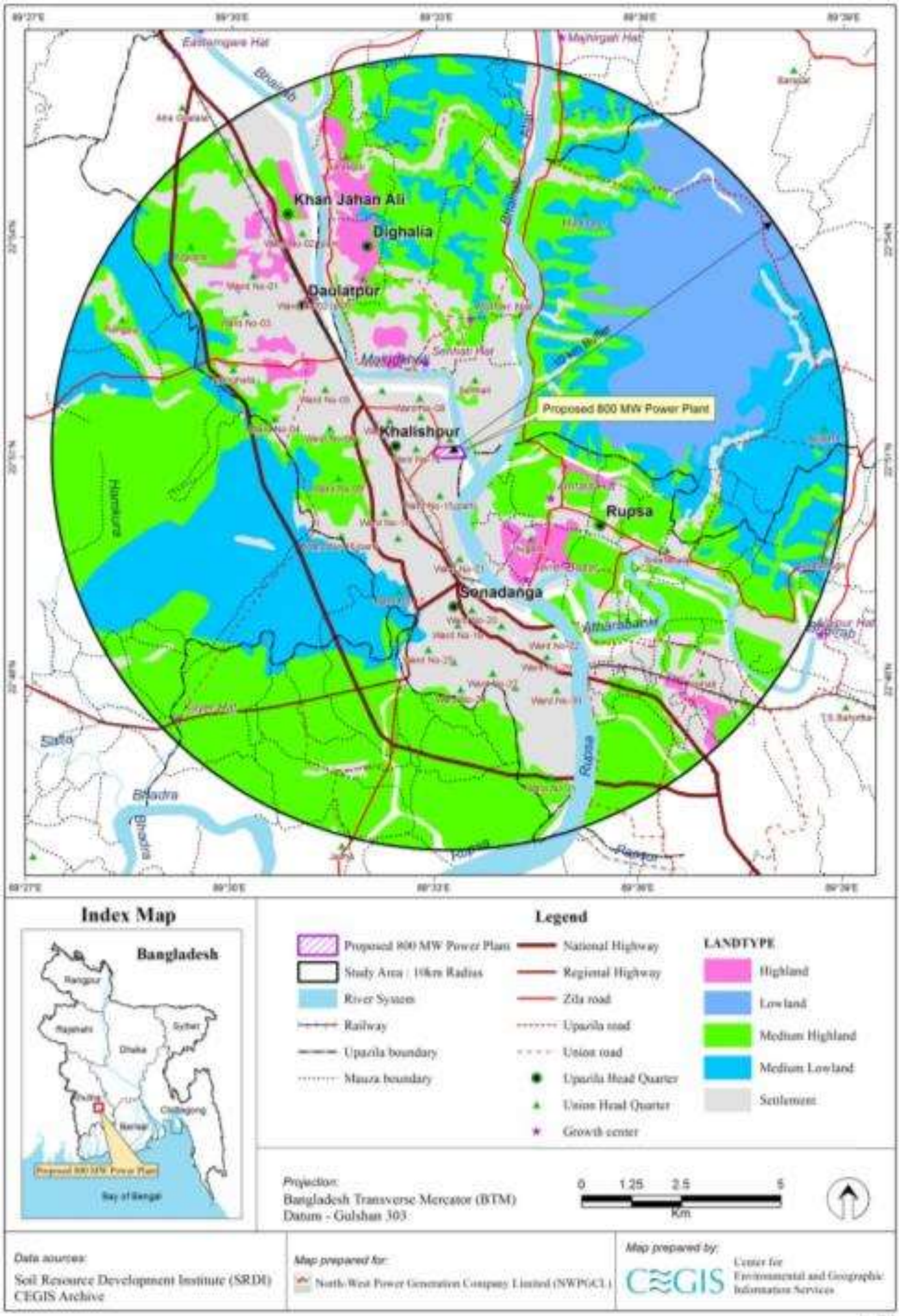
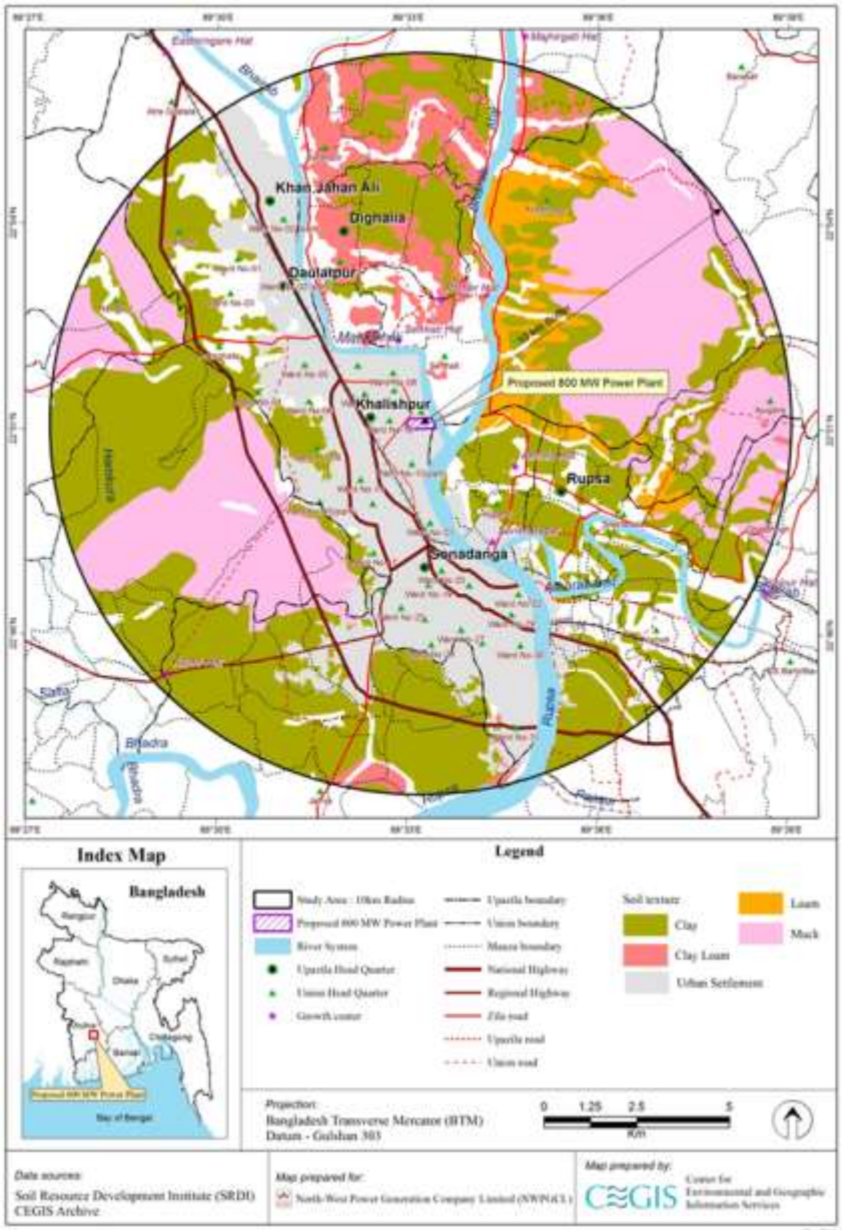


Figure 4.30: Soil texture within the study area



Soil salinity

223. Two major salinity classes cover most of the study area which are: non-saline with some very slightly saline (S1) and very slightly saline with some slightly ones (S2). Details of soil salinity within the study area are shown in **Table 4.18** and **Figure 4.31**.

Table 4.18: Soil salinity within the study area

No.	Soil Salinity Characteristics	Soil salinity class	Project Area		Study Area	
			Area (Acre)	% of NCA	Area (Acre)	% of NCA
1	Non-saline with some very slightly saline	S1(2.0-4.0)	49.55	100	10,011	46
2	Very slightly saline with some slightly saline	S2(4.1-8.0)	-	-	10,979	50
3	Slightly saline with some moderately saline	S3(8.1-12)	-	-	826	4
		Total	**49.55**	**100**	**21,816**	**100**

Source: SRDI,2012.

224. During the field study in October 2016, CEGIS team collected four soil samples: one from project area, and three other soil samples from the study area. All the three locations are selected within one kilometer (km) from the stack of the proposed Rupsha 800 MW CCPP in two depths, 0-15 m and 15-30 m. Soil samples were analyzed by the Soil Science Discipline, Khulna University in Khulna and soil sampling locations is shown in **Figure 4.32**.

225. Results of soil analysis showed that soil salinity class in the project area is S1 while the study area resembled almost similar characteristics. These suggest that it may be due to polderization. Polders protect saline water from regular inundation of tidal effect during the dry season, when water salinity is very high. Details of soil salinity analysis data is presented in **Table 4.19.**

Table 4.19: Results of soil salinity analysis within the study area

Sampling ID	Area	Location	Depth of soil (cm)	Analyzed data result (ds/m)	Standard
01	Project area	In front of main mosque	0-15	0.54	S1 (2.0-4.0)- Non saline with some very slightly saline
			15-30	0.46	S1 (2.0-4.0)- Non saline with some very slightly saline
02	Study Area	Chandanimahal, Senhati	0-15	4.60	S2 (4.1-8.0)- Very slightly saline with some slightly saline
			15-30	4.82	S2 (4.1-8.0)- Very slightly saline with some slightly saline
03		CPI hostel playing ground, Khalishpur, Khulna	0-15	1.52	S1 (2.0-4.0)- Non saline with some very slightly saline
			15-30	1.29	S1 (2.0-4.0)- Non saline with some very slightly saline
04		Daulatpur Jute mills, playing ground	0-15	0.53	S1 (2.0-4.0)- Non saline with some very slightly saline
			15-30	0.55	S1 (2.0-4.0)- Non saline with some very slightly saline

Figure 4.31: Soil salinity characteristics within the study area

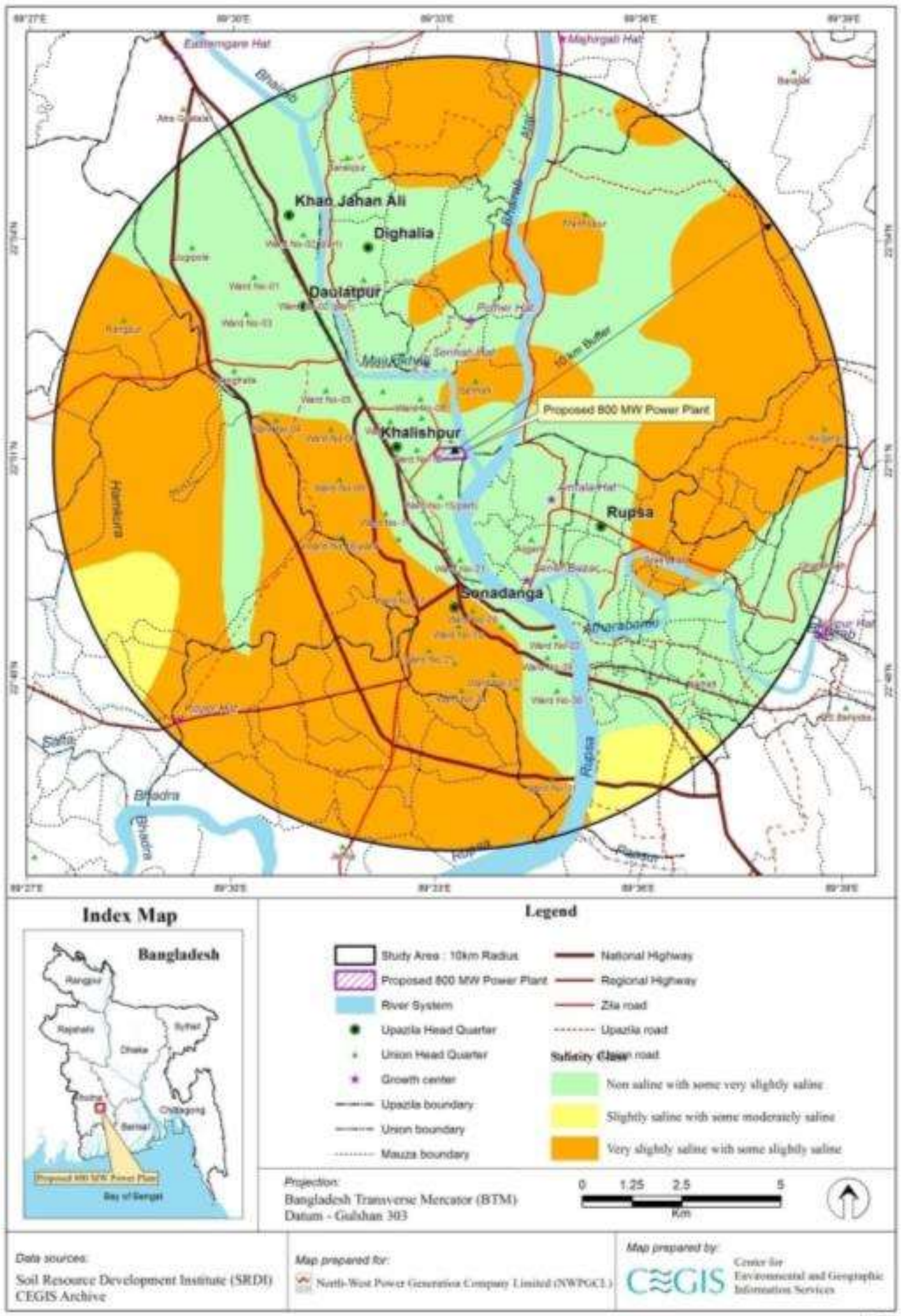
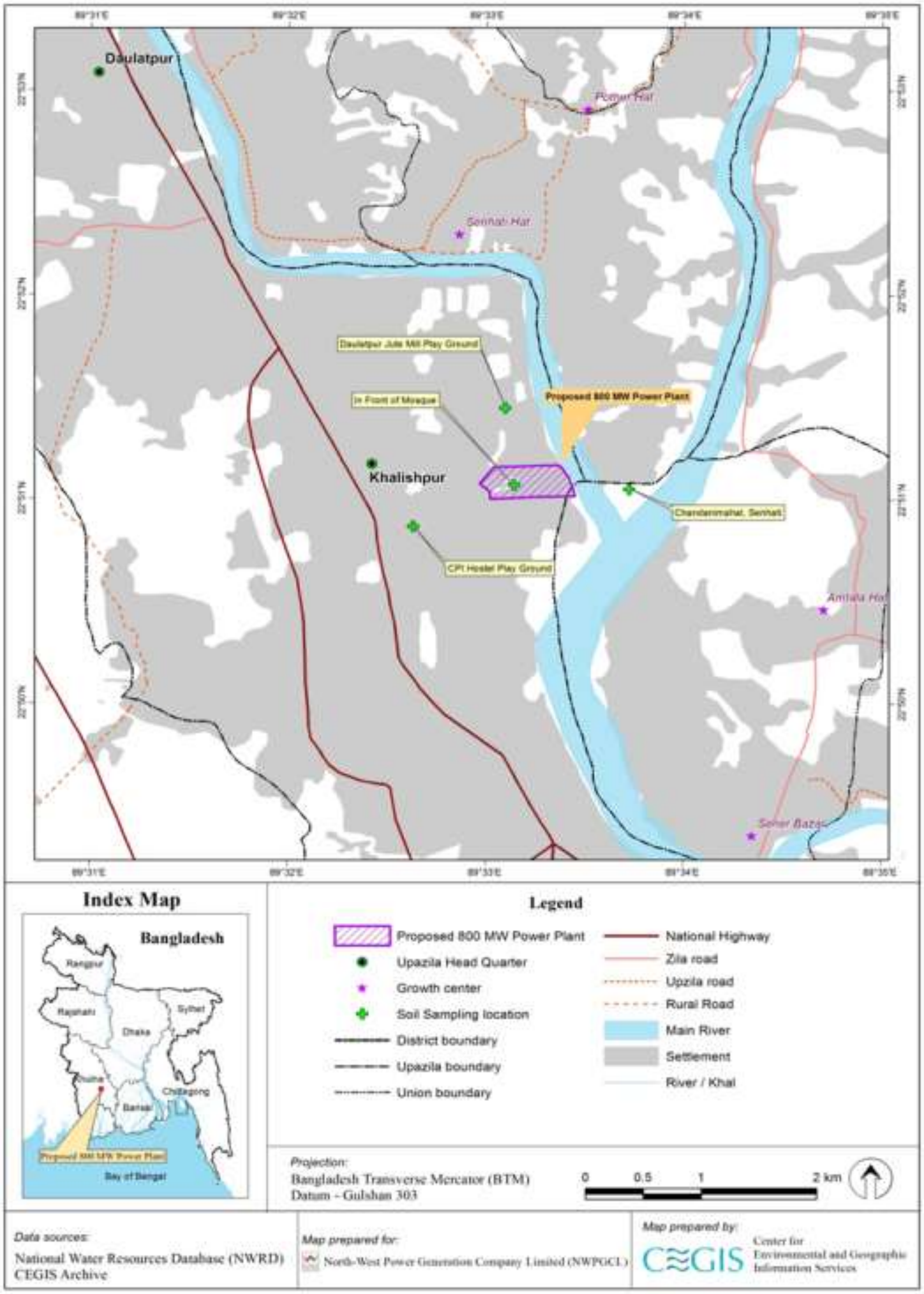


Figure 4.32: Location of soil sampling



Soil quality

226. Results of soil analysis show that top soil organic matter concentrations were higher than the average condition of Bangladesh. The pH levels of the soil samples are slightly alkaline to alkaline. Macro and micro nutrient concentration of the soil samples were also sufficient suggesting that soil quality is good for supporting plant growth. Results of soil analysis are given in **Table 4.20**.

Table 4.20: Results of soil chemical analysis within the PAI

No.	Area	Location	Depth of the soil (cm)	Bulk Density Mg/m3	pH	SOM (%)	Total N (%)	Av P (µg/g	Av K (µg/g)	Av S (µg/g)	Na (µg/g)	Ca (%)	Mg (%)	Av Fe (µg/g)
1	Project area	In front of main mosque	0-15	1.24	7.65	1.55	0.03	46.81	788.20	496.15	653.37	0.05	0.20	25.13
			15-30		7.78	1.14	0.05	19.45	751.90	707.36	518.55	0.03	0.16	11.58
2	Study Area	Chandanimahal, Senhati	0-15	1.37	7.55	1.38	0.10	71.85	933.39	354.86	943.76	0.10	0.22	6.27
			15-30		7.95	0.67	0.02	48.94	1140.81	637.05	1037.10	0.15	0.19	2.71
3		CPI hostel playing ground, Khalishpur, Khulna	0-15	1.60	8.35	0.74	0.01	26.69	163.86	213.20	757.08	0.25	0.17	7.04
			15-30		8.55	0.67	0.03	14.96	456.32	637.05	871.16	0.49	0.02	7.62
4		Daulatpur Jute mills, playing ground	0-15	1.51	7.45	4.81	0.02	12.08	601.52	496.15	513.36	0.45	0.18	9.98
			15-30		7.85	1.01	0.03	7.94	487.44	566.64	471.88	0.10	0.08	4.19

Av Fe =available iron; Av P =available phosphorus; Av S =available sulfur; Ca =available calcium; K =water soluble + exchangeable potassium; Mg =available magnesium; Mg/m^3 = megagram per cubic meter; Na =water soluble + exchangeable sodium; pH =soil pH; SOM =soil organic matter; Total N =total nitrogen; µg/g =microgram per gram.
Source: Soil Science Discipline laboratory, Khulna University.

Existing land use

227. The project area is 49.57 acres which was previously an industrial zone for the KNM. At present, this area hosts abandoned structures and vegetation that grew since 2002 when the newsprint operations were discontinued by the GoB.

228. Based on the project layout of Rupsha 800 MW CCPP, the location of the power plant used to be the residential areas of the staff and officials from the previous KNM and separated by a boundary wall from the KNM. As such, it is unlikely that the soil was contaminated by ink or dye. As well, the project area was not used as dumping site after the operations were completed. GoB ensured no unauthorized access and that security of the property is maintained by deploying security personnel from the Ansar Force.

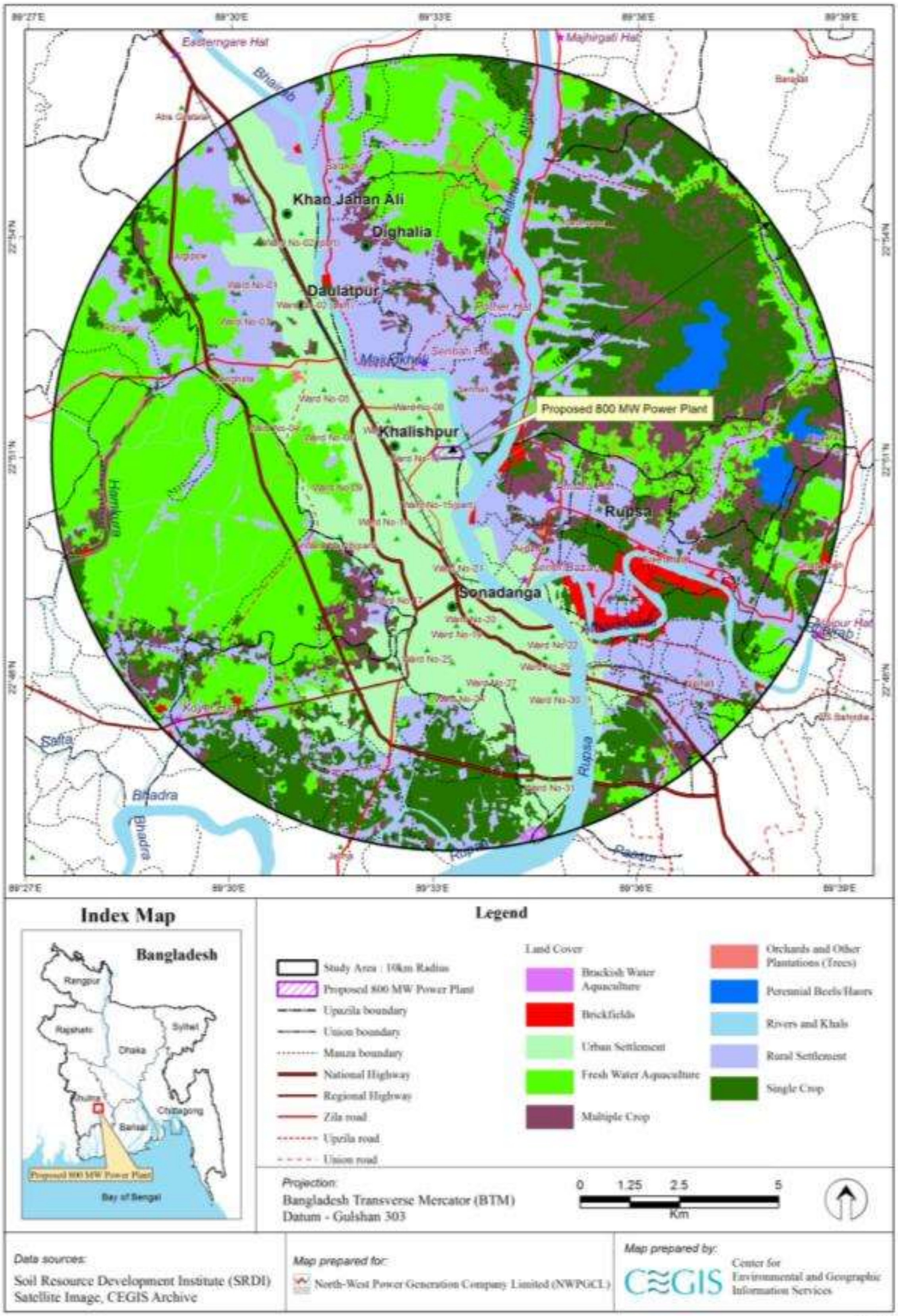
229. The study area consists mostly of brickfields, aquaculture (both fresh and brackish water), urban settlements, agricultural area, etc. **Table 4.21** and **Figure 4.33** present the land use within the PAI.

Table 4.21: Land use within the PAI

Project area		
Land Use	**Area (acre)**	**% of Total area**
House with homestead vegetation	38.24	77.1
Road Island	0.22	0.4
Road	5.19	10.5
Play ground	2.84	5.7
Pond	0.92	1.9
Grassland	2.17	4.4
Total	**49.55**	**100.0**
Study Area		
Land Use	**Area (acre)**	**% of Total area**
Agriculture	21,816	28
Brickfields	932	1
Urban Settlement	12,668	16
Rural Settlement	17,451	22
Rivers and Khals	3,210	4
Perennial Beels/Haors	919	1
Pond (both fresh and brackish water aquaculture)	20,273	26
Orchards and Other Plantations (Trees)	325	1
Total	**77,596**	**100**

Source: Rapid eye image analysis and field visit in October 2016.

Figure 4.33: Land use map within the PAI



4.2.8 Agricultural resources

230. During the field visit in October 2016, some questionnaires were filled up in four locations namely, Khulna metropolitan, Sirgati, Shenhati and Vuipara under Khulna sadar, Rupsha and Khalishpur Upazilas of the Khulna district.

Farming Practice

231. Farming practices largely depend on the cropping seasons. In Bangladesh, there are three main cropping seasons in a year. These are Kharif-I, Kharif-II, and Rabi seasons. The Kharif-I season starts from March and ends in June which is characterized by the uncertainty in weather of alternating dry and wet spells. The Kharif-II season starts in July and ends in October which is characterized by wet and cloudy environment, heavy rainfall but uneven distribution, low solar radiation, and high temperature and humidity. The Rabi season starts from November and ends in February during which crops are favored with high solar radiation, low humidity and temperature, but the lack of adequate soil moisture reduces crop yield.

232. The study area is dominated by Kharif-II season with high-yielding variety (HYV) Aman. Kharif-I is not found within the study area. During Rabi season, mustard and wheat are grown in the study area. The only year-round crop in this area is betel leaf.

Cropping patterns and cropping intensity

233. The project area is an industrial zone and was not used for agricultural purposes. In the study area, the dominant cropping pattern is Fallow-Aman-Fallow (40% of NCA). In Kharif-I season, most of the agricultural land remains fallow except betel leaf covering a narrow area (1,091 acre). In Kharif-II, almost all the area goes under cultivation, where HYV Aman (66% of NCA) is the major crop. In Rabi season, only 35% land of the NCA is being covered under cultivation and rest remains fallow due to non-availability of fresh water (**Figure 4.34**). Cropping intensity in the study area is 126%, where single and double cropped areas are 74%, and 26% of NCA, respectively (**Table 4.22**).

Table 4.22: Cropping pattern in the study area

Study Area				
Kharif-I (March-June)	**Kharif-II (July-October)**	**Rabi (November-February)**	**Area(acre)**	**% of NCA**
Fallow	Fallow	Boro	1,963	9
Fallow	Lt. Aman	Fallow	4,363	20
Fallow	HYV Aman	Fallow	8,726	40
Fallow	HYV Aman	Mustard	3,054	14
Fallow	HYV Aman	Wheat	2,618	12
Betel leaf	Continued	Continued	1,091	5
		Total	**21,816**	**100**

Source: CEGIS field visit; October 2016.

Figure 4.34: Agriculture in the study area

HYV Aman of Silgathi village | View of agricultural land in the study area

Area, yield and production

234. The crop area, yield and production of study area were estimated by using primary and secondary data. The secondary data were collected from DAE office in consultation with DAE personnel's and primary data were collected through questionnaire survey in October 2016. No agricultural practice was found in the project area.

235. Total annual crop production in the study area is about 33,741 tons of which rice production is about 23,278 tons (69% of total production) and non-rice crops is about 10,463 tons (31% of total production). The contribution of HYV Aman, Lt Aman and HYV Boro are about 74%, 13% and 13%, respectively over the total rice production. Production of mustard, wheat and betel leaf is 13%, 35% and 52%, respectively of non-rice production. Detailed cropped area and crop production is presented in **Table 4.23.**

Table 4.23: Crop area, yield, and production in the study area

Study Area				
Crop name	**Crop Area (Acre)**	**Yield (ton/acre)**	**Production (ton)**	**Production Contribution (%)**
Lt. Aman	4,363	0.7*	3,054	13
HYV Aman	14,399	1.2*	17,278	74
HYV Boro	1,963	1.5*	2,945	13
Total Rice	**20,725**		**23,278**	**100**
Mustard	3,054	0.44	1,344	13
Wheat	2,618	1.4	3,665	35
Betel leaf	1,091	5	5,454	52
Total Non-Rice	**6,763**		**10,463**	**100**
G.T.	**27,488**		**33,741**	

Source: CEGIS field visit and DAE; June 2016
Note:*indicates cleaned rice

Use of agricultural inputs

236. Seed, labor, fertilizer and pesticides are the major inputs for crop production. In most of the cases, it was found that farmers use more fertilizer and pesticides than the recommended level. The fertilizer and pesticides use, seed and labor rates are presented in **Table 4.24**.

Table 4.24: Fertilizer and pesticides use in the study area

Crop Name	Use of seeds (kg/acre)	Labor (no/acre)	Use of fertilizer (kg/acre)				Use of pesticides		
			Urea	TSP	MP	Gypsum	No of Application	Liq. (ml/acre)	Gran. (kg/acre)
HYV Aman	18-20	60-65	45	32	20	0	1-2	283	3
Lt. Aman	22-25	65-70	36	28	16	0	1-2	202	0
HYV Boro	25-30	80-85	85	65	32	6	2-3	364	3
Mustard	20-25	30-40	60	40	20	12	2-3	202	3
Wheat	35-40	50-55	72	24	12	10	2-3	202	3
Betel Leaf	16,000-17,000 cuttings	90-100	80	50	30	10	1-2	200	0

Source: CEGIS field visit; October, 2016

Irrigation

237. Irrigation coverage in the study area is 35% of total NCA during the Rabi/dry season. In most of the cases, farmers use surface water (60%) and the rest use ground water for irrigation (**Table 4.25**).

Table 4.25: Land irrigated by type of crop in the study area

Crop name	Irrigation					
	Surface water (Low lift pump)			Ground water (Deep tube well)		
	Area (acre)	% of NCA	Charge (Tk./Acre)	Area (acre)	% of NCA	Charge (Tk./Acre)
Study Area						
HYV Boro	1,178	5.4	2,500-2,800	785	3.6	4,000-4,500
Mustard	1,833	8.4	2,500-2,800	1,222	5.6	4,000-4,500
Wheat	1,571	7.2	2,500-2,800	1,047	4.8	4,000-4,500

Source: CEGIS field visit; October 2016

Crop production constraints

238. According to local farmers the constraints of crop production are: (i) salinity in khals and soils during Rabi/dry seasons, (ii) scarcity of irrigation water during Rabi/dry seasons, and (iii) siltation of the rivers and khals (February-March).

4.2.9 Livestock resources

239. During the field visit in October 2016, some questionnaires were filled up in four locations namely Khulna metropolitan, Sirgati, Shenhati and Vuipara under Khulna sadar, Rupsha and Khalishpur Upazilas of the Khulna district.

Status of livestock and poultry

240. Livestock and poultry are essential to the integrated farming system, playing an important role in the economy of the study area (**Figure 4.35**). Most of the households have poultry and

livestock, which significantly reduce poverty through income generation. **Table 4.26** presents the extent of livestock and poultry in the study area.

Table 4.26: Livestock and poultry in the study area

Name of livestock/poultry	% of H/H having livestock/poultry	Average number of Livestock and Poultry in each household	Number of Livestock and Poultry of the Study Area
Cow/Bullock	50	3-4	366,945
Goat	15	4-5	146,778
Sheep	3	2-3	22,017
Duck	100	5-6	1,223,150
Chicken	100	4-5	1,467,780

Source: CEGIS field visit; October 2016.

Figure 4.35: Livestock in the study area

Poultry (Aijgati, Rupsha, Khulna)

Feed and fodder

241. Owners of the livestock population in the study area face problems due to non-availability of fodder and feeds during the months of July to November. Rice straw is used as the main source of fodder because grazing land is decreasing day by day. Oil cakes and rice husks are also used as fodder. The poultry population at family level survives by scavenging and generally, no feed supplements are provided.

Livestock and poultry diseases

242. Production of livestock and poultry in the study area are mainly constrained due to diseases and death of the population. Outbreak of diseases causes considerable economic loss in livestock farming. Every year, livestock population is affected by different diseases like Foot and Mouth Disease (FMD), Anthrax (Torka), Black leg (Badla), Gola fula (Hemorrhagic Septicemia), Pet fula (Enterotoxaemia), Diarrhea, Mastitis (Olan fula), Peste Des Petits Ruminants (PPR), etc. The goat cyst in head is a common disease of goat. Major poultry diseases are New Castle (Ranikhet), Fowl pox, Duck plague, Chronic Respiratory Disease (CRD) and Dysentery, etc. The outbreak of these diseases starts during the winter season (November-December) and at the start of the rainy Season (June-July).

4.2.10 Fisheries

243. Fisheries sector contributes 3.69% of national GDP (Gross Domestic Product), which is almost one-fourth (22.60 %) of country's agricultural GDP (National Fish Week, 2015). Bangladesh presently stands fourth in producing freshwater fish production (FAO, 2015). So now becoming self-reliant through fish cultivation is no longer a dream.

244. Fisheries information was collected through focus group discussion (FGD) with fishermen community, key informant interview (KII) with persons having significant experiences (more than 10 years), direct habitat observation, and catch assessment survey and market survey from 26-30 October 2016.

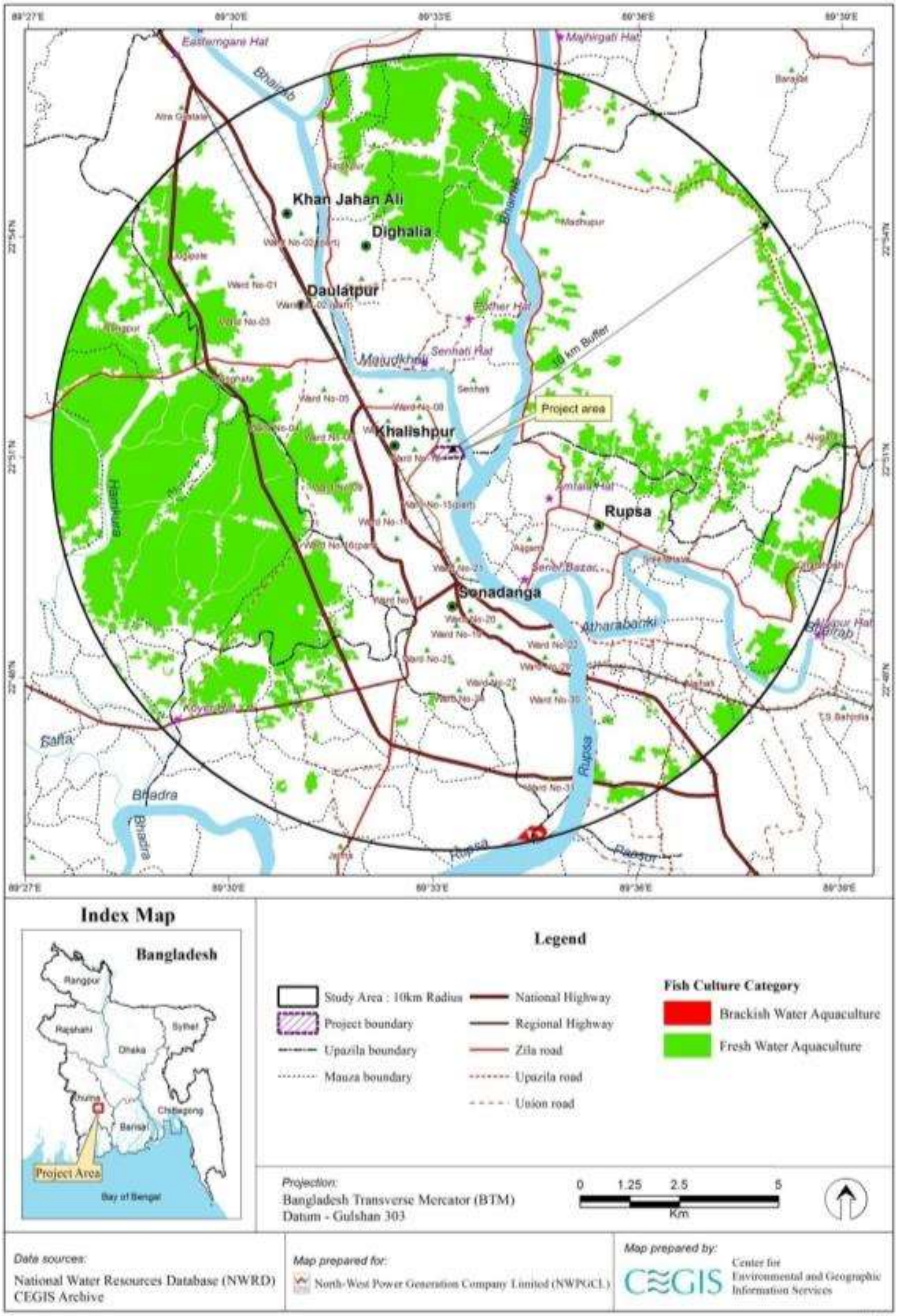
Fish habitat characteristics

245. Fisheries resources in the study area are diverse with different fresh water (east, west and north part) and brackish water (south part) fish habitats. Open water fish habitats include river, khal and beel (deepest portion of the land masses). The rivers in the study area include the Atai River, the Bhairab River, the Atharobanki River, and the Rupsha River.

246. The Bhairab River connects with the Madhumati River upstream of the project area and to the Rupsha River at downstream. These rivers have tidal influence and serve as breeding and feeding grounds for brackish and some fresh water fishes. These habitats also act as important migration route for fish like Ilish, Poma, Phasa, Khalla, Deshi Pangus, Golda Chingri, Bagda Chingri and Ganges River Dolphin, etc. There are drainage khals namely Laskarpur Khal, Mokampur Khal, Mallikpur Khal and Nishipur Khal, etc. and connect with Bashuakhali Beel. These drainage khals act as the major arteries of fish migration into the study area.

247. During the monsoon season around 40% of the study area goes under water due to run-off and tidal river water which allows subsistence fishing for local dwellers. The study area is also important for fresh and brackish water aquaculture practices. This area is common to mixed type of golda and bagda farming and associated white fish species while monoculture practice with golda is prominent. Currently, golda farming is replaced gradually by white fish farming due to disease outbreaks. Bagda ghers are mostly situated in the southern part of the study area while Golda ghers are located in the northern and western part of the study area. Fresh water and brackish water aquaculture including fish catch sites in the rivers are shown in **Figure 4.36**.

Figure 4.36: Fresh and brackish water aquaculture in the study area



Fish habitat assessment

248. The estimated total fish habitat in the study area is about 40,519 acres. Fish habitat distribution covering the study area is shown in **Table 4.27**.

Table 4.27: Fish habitat in the study area

No.	Fisheries Habitat	Habitat Types	Study Area (acre)	Percentage
1	Capture	River &Khal	3,211	7.9
2		Floodplain	16,115	39.8
3		Beel	919	2.2
		Sub-Total	**20,245**	
4	Culture	Golda Gher	3,033	7.5
5		Bagda Gher	55	0.2
6		Cultured Pond	17,185	42.4
		Subtotal	**20,273**	
		Grand Total	**40,518**	

Source: CEGIS estimation using field data, land use data prepared using Rapid Eye image, October 2016.

249. Among the fish habitats, the capture fisheries contribute about 50% area and the rest is culture fisheries. Cultured pond contributes about 42% followed by floodplain and, river and khal. **Figure 4.37** shows the fish habitat in the area.

Figure 4.37: Fish habitat in the study area

Rupsha River   Goldha gher

Fish production assessment

250. The estimated total fish production in the study area is about 24,069 metric tons (MT). Culture fisheries contribute bulk of the total production which accounts for about 21,732 MT and the rest is contributed by the capture fisheries (**Table 4.28**). Aquaculture in the large ponds are conducted by applying semi-intensive culture technology with different species compositions such as poly- and mix-culture with Indian major carps (Rui, Catla, Mrigel), Chinese carps (Grass carp, Silver Carp, Bighead Carp) and mono culture with mono sex Tilapia, Pangas Culture, etc. About 87% of the fish production in the study area comes from cultured fisheries.

Table 4.28: Fish production in the study area

No.	Type of Fisheries	Habitat Types	Fish Production (MT)	Percentage
1	Capture	River and Khal	267	1.10
2		Floodplain	1,768	7.34
3		Beel	302	1.25
		Subtotal	**2,337**	
4	Culture	Golda Gher	860	3.57
5		Bagda Gher	8	0.03
6		Cultured Pond	20,872	86.71
		Subtotal	**21,732**	
		Grand Total	**24,069**	

Fishermen status and effort

251. Among the fisher households of Mokampur and Mallikpur villages, about 5% and 40% are involved in commercial and part-time fishing, respectively. There are two types of fishing community: Nikari who live in Deyara Jugiyati, and Jele who live in Malupara, Chandinimohon village, respectively. Nikari community is mainly engaged in fish trading, labor and other fish related activities. About 100 Jele families depend on catching fish and around 20 families have their own boats for catching fish in the rivers and khals. The professional fishermen spend 4-10 hours/day in fishing activities while part-time fishermen spend about 4-6 hours/day. The daily catch varies with seasonal change of catchability in the river system. During the dry season (December-April), the catch per day ranges from 2 to 10 kg which increases up to 400 kg during monsoon (June-October). These fishermen made a group for sharing the costs of effort and benefit from catch in case of commercial fishing activities as a single fisherman household cannot afford the total fishing cost.

Fishing gears

252. Gears used in the study area and gear-specific fish species include: (i) Current jal, used to catch Ilish, Koi, Taki, Shol, Puti, etc., (ii) Tonajal, used to catch Bata, Khalla, etc., (iii) Poajal, used to catch Bata, Poa, Ramsoch, etc., (iv) Behundijal, used to catch Ilish, (vi) Thelajal, used to catch chingri, and small indigenous fish species, (vi) Net jal, used to catch golda and bagda post larva (PL), (vi) Jhaki or Khepla jal used to catch all types of fresh water fish, and (vii) Berjal, used to catch all types of fresh and brackish water fish, etc. Different types of fishing net and craft are shown in **Table 4.29** and **Figure 4.38**.

Table 4.29: Catch per unit effort

Habitat	North	East	Tide Condition	Gear Name/Type	Haul Duration (hr)	Total Catch (kg)
Bhairab River	22^0 52’ 13.7”	89^0 32’ 23.5”	Low and High	Muia Jal	4	2.5
	22^0 53’ 9.4”	89^0 31’ 18.3”	Low	Behundi Jal	6	4
	22^0 55’ 31.5”	89^0 30’ 48.1”	High	Khepla Jal	0.5	0.5
Rupsha River	22^0 46’ 41”	89^0 34’ 57”	Low	Spear	1.5	0.9
	22^0 47’ 25.1”	89^0 35’ 10.5”	Low	Muia Jal	1	0.6
	22” 48’ 21.8”	89^0 34’ 53.1”	High	Muia Jal	2	0.4

Source: CEGIS Catch Assessment Survey, 26-30 October 2016

Figure 4.38: Fishing gears and craft

Seine net (Ber jal) — Cast net (Khepla Jal)

Non-mechanized craft (Dinghy Boat) — Mechanized craft (Trawler)

Source: CEGIS Catch Assessment Survey, 26-30 October 2016

Collection of shrimp and prawn post larva

253. The Rupsha River and the Bhairab River are important sources of post larva (PL) for Bagda and Golda PL. Bagda PL is collected from mid-February to mid-May (Falgun-Boishak) when water salinity is relatively high while Golda PL is collected from mid-May to mid-August (Joistho - Srabon) when water salinity is very low. There are around four hundred Bagda and Golda PL collectors in the study area and their average income per year is about Tk30,000–Tk40,000. Golda PL is shown in **Figure 4.39**.

Figure 4.39: Prawn post larva collectors


Source: CEGIS Catch Assessment Survey, 26-30 October 2016

Fish migration

254. The Atai River and Rupsha River serve as major corridor for Hilsa, Poma, Topse, Bele, Golda, Bagda and other fresh and brackish water fish migration in the study area (**Figure 4.40**). These rivers play an important role in fish migration from estuary to inland water bodies. Both anadromous and catadromous fishes migrate through these rivers for meeting different biological requirements throughout the year at each stage of their life cycle. Aside from this, the major migratory fish species in the study area are: Deshi Pangus, Bata, Hilsa, Khalla, Poma, etc. (**Table 4.30**). Two endangered species (*Pangasius pangasius*) and (*Mastacembalus armatus)* were noted in the study area. *Pangasius* uses a long extent of migration route from downstream (at Harbaria and Chandpai) and upstream of Passure River system (at Mongla-Passure confluence and at Rupsha-Passure confluence point) to Atai River through the using Rupsha River. *Mastacembalus armatus* is considered as a major black fish (moves from core habitat including beels and floodplain habitat to river system) using the Atai River and upstream of Bhairab River.

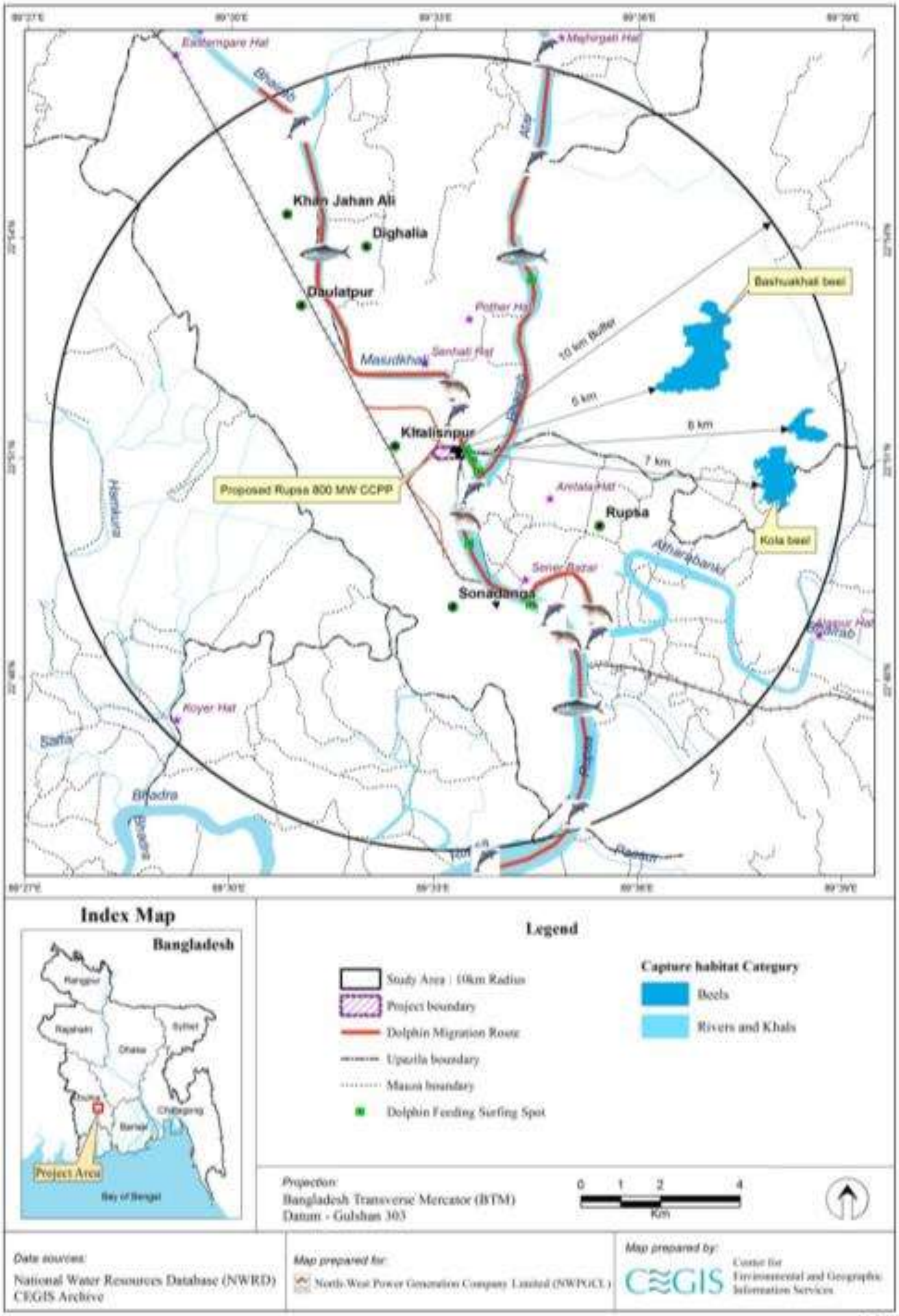
Table 4.30: Migratory fish species in the study area

Migratory Fish Species	Year Class	Akram Point	Harbaria	Chandpai	Mongla-Passure Confluence	Rupsha-Passure Confluence	Occurrence in Study Area
Banspata	Adult	+	+	+	+	+	+
	Fry	-	-	-	+	-	-
	Juvenile	+	-	+	-	-	+
Bele	Adult	+	+	+	+	+	+
	Fry	-	-	+	+	+	-
	Juvenile	+	+	+	+	-	+
Gulsha Tengra	Adult	+	+	+	+	-	+
	Juvenile	-	+	+	+	+	-
Hilsa	Adult	-	-	+	+	-	+
	Brood Fish	+	+	+	+	+	+
	Juvenile	-	-	-	-	-	-
Paissa	Adult	-	+	+	+	-	+
	Juvenile	+	+	-	+	-	+
	Brood	+	-	-	-	-	-
	Fry	-	-	+	+	-	-
Phekssa	Juvenile and Adult	+	+	+	-	+	+
Poma	Adult and Brood Fish	+	+	+	+	+	+

Migratory Fish Species	Year Class	Akram Point	Harbaria	Chandpai	Mongla-Passure Confluence	Rupsha-Passure Confluence	Occurrence in Study Area
	Fry	-	+	+	+	+	+
	Juvenile	-	+	+	+	-	+
Tapsi	Adult	+	+	+	+	+	+
	Brood Fish	-	+		-	+	-
	Juvenile	+	+	+	-	-	+
Pangas	Adult	-	+	+	+	-	+
	Juvenile	-	+	+	+	-	-

Source: CEGIS Catch Assessment Survey, 26-30 October 2016

Figure 4.40: Fish migration routes in the study area



Fish diversity and composition

255. During consultations at Deyara Jugiyati and Chandimohan Villages (across the project area), local fishers and elderly people reported that the fish biodiversity is declining over the years. It is reported that the Rupsa River and the Bhairab River once were available with large fish species like Ilish, Khalla, Boal, Pangus, etc. but the catch is now rather meager. Major factors responsible for declining fish diversity and fish abundance are: (i) fishing by destructive gears; (ii) increasing fishing pressure; (iii) collection of Golda and Bagda PL which causes the mortality of other fish fauna, (iv) obstruction of fish migration routes; and (v) over harvesting of the natural resources, etc. The indicative fish species from different habitats of the study area are presented in **Table 4.31** and shown in **Figure 4.41.**

Figure 4.41: Fresh and brackish water fish species in the study area

Assemblage of Hilsa (*Tenualosa ilisha*)

Assemblage of Bagda (*Penaeus monodon*)

Assemblage of Rui (*Labeo rohita*)

Assemblage of Poa (*Otolithoides pama)*

Table 4.31: Indicative fish species diversity in the study area

Scientific Name	Local Name	IUCN Global Status	Habitat Type: Capture River/ Khal	Habitat Type: Floodplain	Habitat Type: Beel	Habitat Type: Culture Pond/ Gher
Tenualosa ilisha	Ilish	LC	P	A	A	A
Otolithoides pama	Poma	LC	P	A	A	A
Setipinna phasa	Phasa	LC	P	A	A	A
Rhinomugil corsula	Khalla	LC	P	A	A	A
Polynemus paradiseus	Topse	LC	P	A	A	A
Sperata aor	Aor	LC	P	P	P	A
Wallago Attu	Boal	NT	P	P	P	A
Pangasius	Deshi Pangas	LC	P	A	A	A
Plotosus canius	Gang Magur	Not assessed	P	A	A	A
Apocryptes bato	Chiring	Not assessed	P	A	A	A
Penaeus monodon	Bagda Chingri	Not assessed	P	A	A	P
Metapenaeus monoceros	Harina Chingri	Not assessed	P	A	A	A
Macrobrachium rosenbergii	Golda Chingri	LC	P	P	A	P
Channa punctatus	Taki	Not assessed	P	P	P	A
Channa striatus	Shol	Not assessed	A	P	P	A
Heteropneustes fossilis	Shing	LC	P	P	P	A
Mastacembalus armatus	Guchi	Not assessed	P	P	P	A
Macrognathus pancalus	Baim	LC	P	P	P	A
Clarias batrachus	Magur	LC	P	P	P	A
Anabas testudineus	Koi	DD	A	P	P	A
Nandus	Bheda	LC	P	A	P	A
Colisa fasciata	Khalisha	Not assessed	A	P	P	A
Puntius spp	Puti	Not assessed	P	P	P	A
Labeo rohita	Rui	LC	P	P	P	P
Catla	Katla	Not assessed	P	P	P	P
Cirrhinus cirrhosus	Mrigel	VU	P	A	P	P
Exotic species						
Oreochromis niloticus	Nilotica	Not assessed	A	A	A	P
Hypophthalmichthyes molitrix	Silver carp	Not assessed	A	A	A	P
Pangasius sutchi	Thai pangus	EN	A	A	A	P

A = absence, DD = data deficient, EN = endangered, LC = least concern, NT = near threatened, P = presence, VU = vulnerable.
Source: CEGIS field data, Oct 2016.

Fisheries management

256. Community-based fisheries management (CBFM) is done in Dighalia Upazilla for beel management. Local government offices lease out beels and other government water bodies among the local fishers for CBFM. The Department of Fisheries (DoF) has limited initiatives for fisheries resource conservation and management (e.g., enforcement of Fish Conservation and Protection Acts, training on aquaculture, etc.) except fry release program in the study area. Some NGOs (BRAC, ASA, PROSHIKA, CARE, WORLD FISH and SHUSHILAN)[27] are working in the study area on extension services and aquaculture training.

4.3 Biological resources

Bio-ecological zone

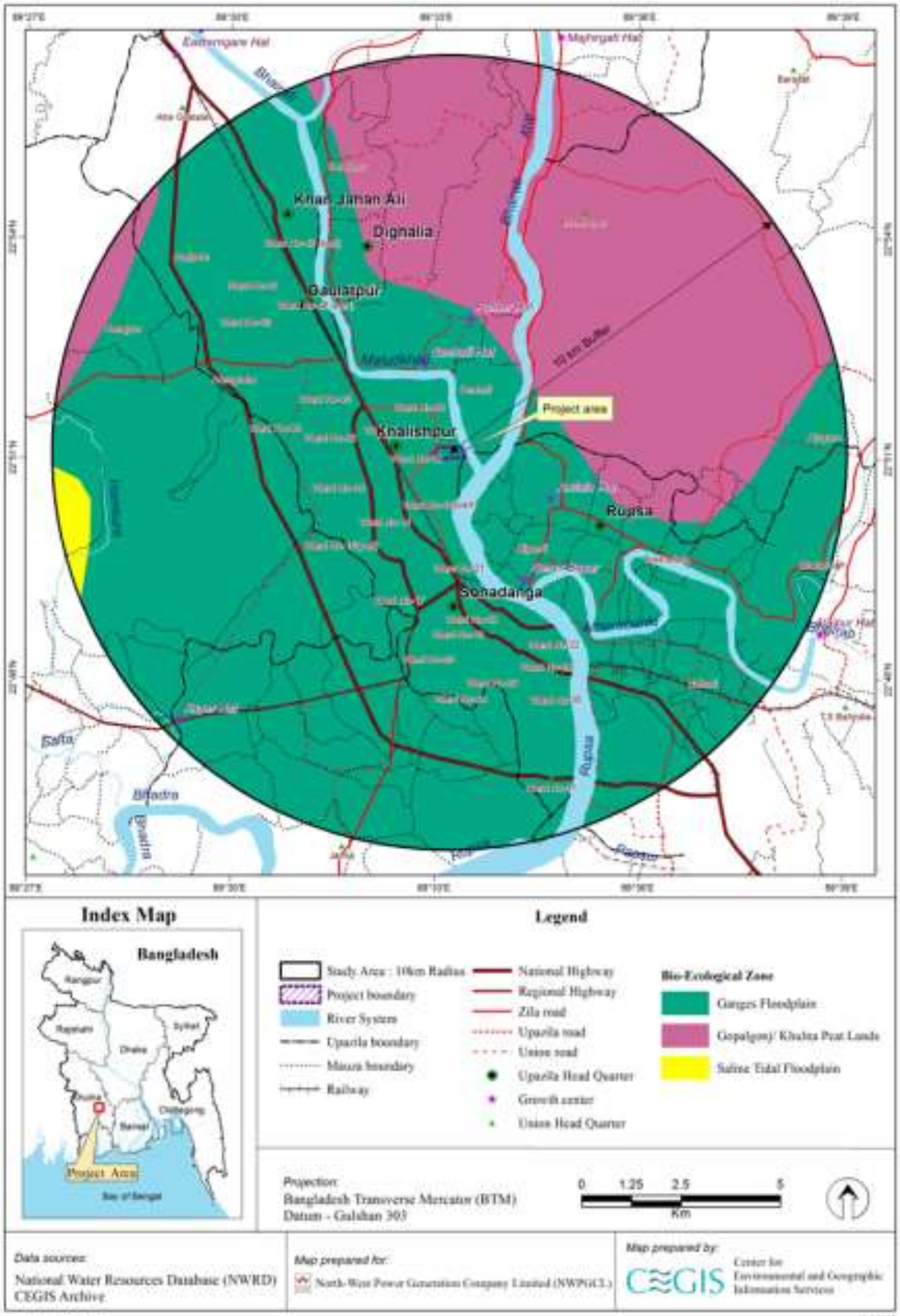
257. IUCN has divided Bangladesh into 25 Bio-ecological Zones (Nishat et al, 2002) with respect to physiographic units and biological diversity. Each of the bio-ecological zones represents overall ecological situation of an area of the country. The areas covered by bio-ecological zones in the study area are given in **Table 4.32** and shown in **Figure 4.42.**

Table 4.32: Bio-ecological zones in the study area

Location	Name of zone	Area (Acres)	Percent (%)
Project area	Ganges Floodplain	49.57	100
Study area	Ganges Floodplain	54,123	69.7
	Gopalgonj/ Khulna Peat Lands	23,037	29.7
	Saline Tidal Floodplain	469	0.6

[27] ASA is a microfinance institution established in 1978; BRAC is also doing microfinance among others; PROSHIKA deals with education and training to facilitate income and employment of rural poor through selforganization; *Shushilan* is a Bengali name that refers to initiatives for a better future, an NGO set up in 1991.

Figure 4.42: Bio-ecological zone in the PAI



Ganges floodplain

258. The Ganges floodplain is an active floodplain of the Ganges River and the adjoining meandering flood plains and is mostly situated in the administrative districts of greater Jessore, Kushtia, Faridpur and Barisal. The adjoining meander floodplains mainly comprise of a smooth landscape of ridges, basins and old channels. Noteworthy aspect here is that the Gangetic alluvium is readily distinguishable from the old Brahmaputra, Jamuna and Meghna sediments by its high lime content. Besides, the relief is locally irregular alongside the present and former river courses, especially in the west, comprising a rapidly alternating series of linear low ridges and depressions. The Ganges channel is constantly shifting within its active floodplain, eroding and depositing large areas of new char lands in each flooding season, but it is less braided than that of the Brahmaputra-Jamuna.

259. This floodplain is characterized by mixed vegetation. Presence of a lot of stagnant waterbodies and channels, rivers and tributaries in this zone support a habitat of rich biodiversity to some extent. In the beels and other waterbodies, free-floating aquatic vegetation is prominent. Homestead forests, on the other hand, include both cultivated and wild plant species. The dominant floral types are: the Panimorich (*Polygonum orientale*), Jhanji (*Hydrilla verticillata*), Helencha (*Alternanthera philoxeroides*), Topapana, (*Pistia strateotes*), Chechra (*Schenoplectus articulatus*), Shada shapla (*Nymphaea nouchali*), Keshordam (*Ludwigia adscendense*), Kolmi (*Ipomoea aquatica*), Dhol kolmi (*Ipomea. fistulosa*), Hijal (*Barringtonia acutangula*), Tamarind (*Tamarindus indica*), Panibaj (*Salix tetrasperma*), etc. Moreover, grasses are most abundant in the Ganges floodplain and begin to grow as soon as the floodwater begins to recede. Nearly all the major groups of the oriental birds are represented in this zone by one or more species. In addition, a large number of migratory birds are found here during the winter. Besides, different species of freshwater tortoises and turtles are also found in the rivers and ponds. The amphibian species found in this zone include a few species of toads, frogs and tree frogs. Among the mammalian fauna are foxes, jackals, rats, mice, squirrels, bats, etc. are seen everywhere.

Gopalgonj/ Khulna Peat Lands

260. Gopalgonj-Khulna peat land occupies a number of low-lying areas between the Ganges River floodplains and the Ganges tidal floodplains in the south of Faridpur region and the adjoining part of Khulna and Jessore districts. Thick deposits of peat occupy perennially wet basins, but they are covered with clay around the edges. The soil in this zone is potentially strong acidic and low in essential plant nutrients. Basins are deeply flooded by rainwater monsoon however in close to Khulna, water is brackish in some degrees. The floral diversity in this zone is quite limited. Due to lack of diversity in vegetation, the variety in faunal species and the population size in this zone are also less than enviable, of which, the diversity of bird species is relatively better in this zone.

Saline Tidal Floodplain

261. The saline tidal floodplain has a transitional physiography which is located at the south portion of southwest and south central region. It has a low ridge and basin relief, crossed by innumerable tidal rivers and creeks. Soils are non-saline throughout the over substantial amount of areas in the north and east. but they become saline to various degrees in the dry season in the south-west and are saline for much of the year in the Sundarbans. The river carries fresh water throughout the year to the east and north-east, but saline water penetrates increasingly further inland towards the west. Of the floral diversity, this zone has innumerable indigenous weeds that grow in beel areas. Several types of palms and bamboo clumps grow in almost all the villages. This zone affords a very lucrative place for game birds include goose, duck, cranes, spine, jungle

fowls, etc. both in Sundarbans and the beels and char areas. Moreover, the river network and expanses of beels are abound with different species of fishes.

4.3.1 Ecosystem in the project area

Terrestrial flora

262. Floral survey was conducted on 26-30 October 2016 through direct observation and quadrat application. A total of 20 plots (10mx10m) were surveyed. Based on field observation and survey, the project area can be classified in two major categories of ecosystems such as terrestrial and wetland ecosystems. The terrestrial ecosystems of the area were comprised of homestead, field, undergrowth and grassland vegetation. The site was visible with vast number of planted tree and plenty of wild herbs and shrubs species (**Figure 4.43**). Among the dominant tree species are coconut, mango, jackfruit and mahogany.

Figure 4.43: Vegetation in the project area

263. The homestead areas (including old buildings area and surroundings) are covered with planted trees, wild shrubs and herbs. Scattered low bush grassland was seen along the roads, field and river side which was restrained with creepers, climbers, grass and frequently contain hedge-like shrub. The growth of vegetation was due abandonment of the area since 2002.

264. A total of 60 species of trees was found within the project area consisting of about 2,614 trees that are mostly planted with few species regenerating naturally. There is no endangered, protected, or threatened plant species in the project area. The West Indian Mahogany (*Swietenia*

mahagoni) was found in the project area and is assessed globally by IUCN as endangered but this species is widely cultivated in Bangladesh as timber plant, non-native species to Bangladesh and is not included in the Red List of IUCN Bangladesh. **Table 4.33** gives the list of tree species in the project area.

Table 4.33: Tree species within the project area

No.	Scientific Name	Local Name	IUCN (Global status)	IUCN Bangladesh status	Number
1	*Abroma augusta*	Ulatkambol	Not Assessed	Not Assessed	2
2	*Acacia auriculiformis*	Akashia	Least Concern		10
3	*Aegle marmelos*	Bel	Not Assessed		23
4	*Albizia lebbeck*	Karoi	Not Assessed		6
5	*Alstonia scholaris*	Chatim	Lower Risk		6
6	*Annona reticulata*	Ata	Not Assessed		48
7	*Areca catechu*	Supari	Not Assessed		77
8	*Artocarpus heterophyllus*	Khanthal	Not Assessed		213
9	*Artocarpus lakoocha*	Dewa	Not Assessed		4
10	*Averrhoa carambola*	Kamranga	Not Assessed		4
11	*Averrhoa bilimbi*	Bilombi	Not Assessed		6
12	*Azadirachta indica*	Neem	Not Assessed		30
13	*Bombax ceiba*	Shimul	Not Assessed		16
14	*Borassus flabellifer*	Tal	Not Assessed		6
15	*Carica papaya*	Papya	Not Assessed		12
16	*Cascabela thevetia*	Halda Karobi	Not Assessed		6
17	*Citrus grandis*	Batabilebu	Not Assessed		21
18	*Cocos nucifera*	Narikel	Not Assessed		613
19	*Dalbergia sissoo*	Sisso	Not Assessed		10
20	*Delonix regia*	Krishnochura	Least Concern		14
21	*Dillenia indica*	Chalta	Not Assessed		8
22	*Diospyros blancoi*	Bilati Gab	Not Assessed		3
23	*Eucalyptus sp*	Eucalyptus	Not Assessed		23
24	*Ficus benghalensis*	Bot	Not Assessed		15
25	*Ficus racemosa*	Pakur	Not Assessed		11
26	*Ficus religiosa*	Ashwattha	Not Assessed		10
27	*Gmelina arborea*	Gamari	Not Assessed		6
28	*Lagerstroemia indica*	Furush	Not Assessed		4
29	*Lagerstroemia speciosa*	Jarul	Not Assessed		21
30	*Lannea coromandelica*	Ziga	Not Assessed		22
31	*Leucaena leucocephala*	Ipil ipil	Not Assessed		10
32	*Litchi chinensis*	Lichu	Not Assessed		4
33	*Litsea monopetala*	Menda	Not Assessed		5
34	*Mangifera indica*	Aum	Data Deficient		360
35	*Manilkara zapota*	Safoda	Not Assessed		11
36	*Millettia pinnata*	Karnaga	Least Concern		2
37	*Moringa oleifera*	Sajna	Not Assessed		136
38	*Musa sapientum*	Kala	Not Assessed		64
39	*Neolamarckia cadamba*	Kadam	Not Assessed		17
40	*Olea europaea*	Jalpai	Not Assessed		5
41	*Phoenix sylvestris*	Khegur	Not Assessed		27
42	*Pithecellobium dulce*	Dakhina Babul	Not Assessed		11
43	*Plumeria rubra*	Khatgolap	Not Assessed		14

No.	Scientific Name	Local Name	IUCN (Global status)	IUCN Bangladesh status	Number
44	*Polyalthia longifolia*	Debdaru	Not Assessed		70
45	*Psidium guajava*	Peara	Not Assessed		34
46	*Putranjiva roxburghii*	Putranjib	Not Assessed		2
47	*Roystonea regia*	Royel Plam	Not Assessed		35
48	*Samanea saman*	Raindee Kory	Not Assessed		53
49	*Senna siamea*	Minjira	Not Assessed		20
50	*Spondias dulcis*	Amra	Not Assessed		3
51	*Swietenia mahagoni*	Mahogonii	Non-native and cultivated species in Bangladesh (not listed in the IUCN red list for Bangladesh)		272
52	*Syzygium cumini*	Jum	Not Assessed		18
53	*Syzygium samarangense*	Jamrul	Not Assessed		30
54	*Tamarindus indica*	Tentul	Not Assessed		6
55	*Tectona grandis*	Sagun	Not Assessed		18
56	*Terminalia arjuna*	Arjun	Not Assessed		18
57	*Terminalia bellirica*	Bohara	Not Assessed		2
58	*Terminalia cattapa*	Khatbadam	Not Assessed		7
59	*Trema orientalis*	Jibon	Not Assessed		74
60	*Ziziphus mauritiana*	Baroi	Not Assessed		36
				Total	**2,614**

Plant biodiversity index

265. The plant biodiversity in the project area was determined using the Shannon's diversity index method. The Shannon's diversity index (H) is commonly used to characterize species diversity in a community. It accounts for both abundance and evenness of the species present and the typical values range from 1.5 to 3.5.A total of 15 plots (5mx5m) were considered for the estimation of plant biodiversity. The estimated Shannon's diversity index in the project area is 3.15 suggesting that diversity is high (**Table 4.34**).

Table 4.34: Diversity of plant species in the project area

Species Name	IUCN Global status	IUCN Bangladesh status	Shannon diversity Index (H')	Relative Density (%)	Relative Frequency (%)	Relative Abundance (%)
Acanthus ilicifolius	LC	Not Assessed	3.15	1,506.66	1.68	5.79
Achyranthes aspera	Not assessed			506.66	1.68	1.94
Acrostichum aureum	LC			66.66	0.84	0.25
Annona reticulata	Not assessed			20	0.84	0.07
Areca catechu	Not assessed			26.66	0.84	0.10
Artocarpus heterophyllus	Not assessed			20	1.68	0.07
Azadirachta indica	Not assessed			33.33	1.68	0.12

Species Name	IUCN Global status	IUCN Bangladesh status	Shannon diversity Index (H')	Relative Density (%)	Relative Frequency (%)	Relative Abundance (%)
Bombax ceiba	Not Assessed			13.33	1.68	0.051
Cayratia trifolia	Not Assessed			206.66	1.68	0.79
Cerodendrum inerme	Not Assessed			66.66	0.84	0.25
Citrus limon	Not Assessed			6.66	0.84	0.02
Clerodendrum infortunatum	Not Assessed			2,333.33	5.04	8.96
Clitoria ternatea	Not Assessed			80	1.68	0.30
Coccinia grandis	Not Assessed			86.66	1.68	0.33
Cocos nucifera	Not Assessed			13.33	1.68	0.05
Colocasia esculenta	LC			426.66	3.36	1.63
Commelina benghalensis	LC			200	0.84	0.76
Crinum defixum	Not Assessed			6.66	0.84	0.02
Crotolaria pallida	Not Assessed			20	0.84	0.07
Cullen corylifolium	Not Assessed			413.33	1.68	1.58
Cynodon dactylon	Not Assessed			266.66	0.84	1.02
Cyperasus sp.	Not Assessed			666.66	0.84	2.56
Derris trifoliata	Not Assessed			686.66	1.68	2.63
Desmodium dichotomum	Not Assessed			66.66	0.84	0.25
Dryopteris sp.	Not Assessed			246.66	1.68	0.94
Eclipta alba	LC			400	0.84	1.53
Ficus benghalensis	Not Assessed			20	0.84	0.07
Ficus hispida	Not Assessed			2026.66	6.72	7.78
Ficus racemosa	Not Assessed			133.33	2.52	0.51
Ficus sp.	Not Assessed			46.66	2.52	0.17
Hyptis capitata	Not Assessed			2706.66	4.20	10.402
Imperata cylindrica	Not Assessed			53.33	1.68	0.20
Ipomea sp.	Not Assessed			133.33	0.84	0.51
Ipomoea sagittifolia	Not Assessed			333.33	0.84	1.28
Ixora sp	Not Assessed			100	0.84	0.38
Justicia gendarussa	Not Assessed			146.66	0.84	0.56

Species Name	IUCN Global status	IUCN Bangladesh status	Shannon diversity Index (H')	Relative Density (%)	Relative Frequency (%)	Relative Abundance (%)
Lagerstroemia speciosa	Not Assessed			6.66	0.84	0.02
Leucaena leucocephala	Not Assessed			46.66	0.84	0.17
Mangifera indica	Data Deficient			46.66	1.68	0.17
Manilkara zapota	Not Assessed			6.66	0.84	0.02
Mikania scandens	Not Assessed			233.33	5.04	0.89
Millettia pinnata	LC			20	0.84	0.07
Mimosa pudica	LC			86.66	0.84	0.33
Moringa oleifera	Not Assessed			33.33	0.84	0.12
Musa sapientum	Not Assessed			140	1.68	0.53
Operculina turpethum	Not assessed			66.66	0.84	0.256
Oxalis corniculata	Not assessed			133.33	0.84	0.51
Peperomia pellucida	Not Assessed			133.33	0.84	0.51
Phoenix sylvestris	Not Assessed			20	0.84	0.076
Phyllanthus reticulatus	Not Assessed			266.66	2.52	1.024
Polyalthia longifolia	Not Assessed			133.33	0.84	0.51
Samanea saman	Not Assessed			26.66	1.68	0.10
Scoparia dulcis	Not Assessed			466.66	0.84	1.79
Senna simea	Not Assessed			33.33	0.84	0.12
Sida cordifolia	Not Assessed			66.66	0.84	0.25
Solanum nigrum	Not Assessed			400	0.84	1.53
Sphagneticola trilobata	Not Assessed			3,333.33	0.84	12.81
Spilanthes calva	LC			2,666.66	0.84	10.24
Swietenia mahagoni	EN			20	0.84	0.07
Syzygium cumini	Not Assessed			1,333.33	0.84	5.12
Trema orientalis	Not Assessed			33.33	1.68	0.12
Urena lobata	Not Assessed			53.33	1.68	0.20
Unknown herb	---			886.66	2.52	3.40
Vernonia patula	Not Assessed			1200	1.68	4.61
Ziziphus mauritiana	Not Assessed			40	3.36	0.15

Fauna in the project area

Mammals

266. According to the interview of local people conducted during the field survey from 26-30 October 2016, the terrestrial mammal species diversity is not high within the project area. During the daytime, visual observation and line transect survey method was used to record diversity of the species. During the field survey, no big mammals were found except the call of Golden Jackal and Small Indian Mongoose and field rat. Without longtime nocturnal survey and camera trapping, it is not possible to detect the accurate number of species.

267. Based on interviews of local people, it was reported that few mammal species temporarily visited the project areas in some occasions for hunting of preys and this include: Fishing Cat (VU), Jungle Cat (LC), Small Indian Civet (LC), Large Indian Civet (LC) according to IUCN Red List (global). Based on the IUCN Bangladesh Red List (2015), the conservation status of these mammals are: Fishing Cat (EN), Jungle Cat (NT), Small Indian Civet (NT), Large Indian Civet (NT).

268. However, none of these species were seen during the field visit probably since they are temporary visitor. The Indian flying fox (Least Concern) and Indian Pipistrelle (Least Concern) were seen in the afternoon to nighttime. No bat colonies were found in trees and old buildings in the project site.

269. The fishing cat (*Prionailurus viverrinus*) is a fish eater along the beels, rivers and water ways distributed throughout the study area and moves from place to place for hunting of preys like other animals, and also supplements its diet with shrimp/crayfish, crab and insects, and other vertebrates such as frog, mudskippers, birds and rats from the adjacent similar habitat.

Birds

270. Bird species observed during the field visit and their conservation status according to IUCN Bangladesh 2015 were Black Drongo (LC), Brown Shrike(LC), Jungle Myna(LC), Rock pigeon(LC), House crow(LC), House Sparrow(LC), Common Myna(LC), Large-billed crow(LC), Spotted Dove(LC), Little Cormorant(LC), Long tailed Shrike(LC), Pied Myna(LC), Black Crowned Night Heron(LC), etc. **Annex 3** gives the list of species found in the study area.

271. Water birds are important component of most aquatic ecosystems, as they form vital links in the food web and nutrient cycles. Some water bird species noted in the pond area including their conservation status based on IUCN Bangladesh 2015 were little cormorant (LC), Indian pond heron (LC), Common kingfisher (LC), White breasted water hen (LC), etc. A total of 45 Black headed ibis (VU, NT globally) were seen as temporary visitor for feeding, roosting during the field visit at project site in the afternoon. All of these above bird species are very common to other parts of Khulna District except the urban area.

Reptiles

272. Reptiles were quite common inside the project area due to the dense undergrowth vegetation. The following species and their conservation status according to IUCN Bangladesh 2015 are: Keeled Indian Mabuya (LC), Garden lizard (LC), and Bengal Monitor (NT nationally but LC in global IUCN status) were found in project site. Some snake species were observed by locals in this area and these are: common vine snake(LC), Painted Bronze back tree snake(LC),

Common Bronze back Tree Snake(LC), Common Wolfe Snake(LC), Indo-Chinese rat snake(LC) and Checkered Keelback(LC). These species are very frequent during monsoon and common to other parts of Khulna District except urban area. With the temporary habitat created as a result of the abandonment of KNM, these species use the project site temporarily for feeding, roosting, and nesting.

Amphibians

273. Skipper frog (LC) is a common amphibian found throughout the year. They have been the most successful fauna in adapting to all kinds of wetlands. Abundance of Bullfrogs (LC) is increased during the rainy season at ditches and other marshy places. Common Toad (LC) and Cricket frog (LC) were commonly found within the project area. These amphibian species are very common to other parts of Khulna District except urban areas.

Butterflies

274. A total of 32 species were observed in the project area (**Table 4.35**) during the field study in October 2016. The presence of butterflies indicates that the environment is generally healthy and good. There is no species that is endemic, migratory or listed in the IUCN Red List (**Figure 4.44**). The species found in the project area are common throughout the country. These collectively provide a wide range of environmental benefits, including pollination and natural pest control.

Table 4.35: List of butterfly species in the project area

No.	English Name	Status of Conservation	
		IUCN Bangladesh (2015)	IUCN (Global)
1	Blue tiger	Least Concern	Not Assessed
2	Chestnut Bob	Least Concern	Not Assessed
3	Common Emigrant	Least Concern	Not Assessed
4	Common Baron	Least Concern	Not Assessed
5	Common Crow	Least Concern	Not Assessed
6	Common Evening Brown	Least Concern	Not Assessed
7	Common Grass Yellow	Least Concern	Not Assessed
8	Common Jay	Least Concern	Not Assessed
9	Common Jezebel	Least Concern	Not Assessed
10	Common Leopard	Least Concern	Not Assessed
11	Common Mormon	Least Concern	Not Assessed
12	Common Palmfly	Least Concern	Not Assessed
13	Common Pierrot	Least Concern	Not Assessed
14	Common Rose	Least Concern	Not Assessed
15	Common Sailor	Least Concern	Not Assessed
16	Common Sergeant	Least Concern	Not Assessed
17	Common Silverline	Least Concern	Not Assessed
18	Dark-branded Bushbrown	Least Concern	Not Assessed
19	Dark Grass Blue	Least Concern	Least Concern
20	Great Eggfly	Least Concern	Not Assessed
21	Grey Pansy	Least Concern	Not Assessed
22	Lime	Least Concern	Not Assessed
23	Pale Grass Blue	Least Concern	Not Assessed
24	Peacock Pansy	Least Concern	Least Concern
25	Plain Tiger	Least Concern	Not Assessed

No.	English Name	Status of Conservation	
		IUCN Bangladesh (2015)	IUCN (Global)
26	Psyche	Least Concern	Not Assessed
27	Spotted Pierrot	Least Concern	Not Assessed
28	Striped Albatross	Least Concern	Not Assessed
29	Striped Pierrot	Least Concern	Not Assessed
30	Striped Tiger	Least Concern	Not Assessed
31	Tailed Jay	Least Concern	Not Assessed
32	Yellow Pansy	Least Concern	Least Concern

Figure 4.44: Butterfly species in the project area

4.3.2 Ecosystem in the study area

Terrestrial Flora

Homestead vegetation

275. Density and diversity of homestead plants depends on flood level and soil characteristics. Some trees occupy top of the canopy level such as, *Albizia richrdiana*, raintree (*Samanea saman*), and areca nut (*Areca catechu*). Most of the houses have locally-cultivated plants and most of the coverage is wild shrubs and herbs. Common planted tree species are Supari (*Areca catechu*), coconut (*Cocos nucifera*), Eucalyptus (*Eucalyptus sp*.), mango (*Mangifera indica*), Mahogany (*Swietenia mahagoni*), banana (*Musa sp*), etc. Homesteads are commonly found near the wetland which favor good growth of wetland trees like *Trewia nudiflora*, *Crataeva nurvala*, *Barringtonia acutangula*, etc. Bamboo (*Bambusa spp*.) and shrubs like *Ficus hispida* and *Ficus heterophylla*are the most common species. **Table 1** of **Annex 2** gives the list of 52 species of homestead vegetation.

Crop field vegetation

276. Crop fields contain weeds such as *Amaranthus spinosus*, *Cynodon dactylon*, *Alternanthera sessilis, Polygonum sp*, *Oxalis corniculata*, etc. Along the river side, *Saccharum spontaneum*, *Xanthium indicum*, *Rumex maritimus*are commonly seen. Crop field vegetation provides not only food for human but also habitat for insects, reptiles, and various avifauna. **Table 1** of **Annex 3** lists the species in crop field vegetation.

Roadside vegetation

277. Vegetation along the roadside consists of herbs, shrubs, and trees. Species include raintree, mahogany, Indian lilac, acacia, banana, etc. Some plants also grow naturally in-between the planted trees and remain at the bottom levels on either side of the road and function as barrier of soil weathering. Common shrub species along the road side are minnie-root (patpati), ivy wood rose (halud kalmi), flannel weed (sida), dodder (swarnolata), crown flower (akando), hairy fig (dumur), sickle senna (kalasunda), orange berry (daton), hill glory bower (Bhant), etc.

Terrestrial fauna

278. Presence of dense vegetation supportsa variety of terrestrial fauna from different communities. Among the mammals are: Golden Jackal, Large Indian Civet, Jungle Cat, Fishing cat, Indian flying Fox, Grater bandicoot rat, and Small Indian mongoose.

279. Birds species found in village groves and homestead include: Black Drongo, Common Myna, Asian Pied Starling, Spotted Dove, Red-vented Bulbul, House Sparrow, Brahminy Kite, Black headed ibis, Black-winged Kite, Long tailed shrike, House crow, Common Kestrel, Oriental Magpie Robin, etc. Black headed ibis was also noted within most places of study area. Grass land support good number of avifauna like cisticola, prinia, warblers, larks, pipits and munias.

280. Common Toad (*Duttaphrynus melanostictus*) and Cricket frog (*Fejervarya limnocharis*) are commonly found in the study area.

Wetland ecosystems

281. The study area and its tributaries support wetlands both perennial and seasonal. The major sub-units of aquatic ecosystem are:

- Floodplains
- River
- Canals
- Ponds
- Beels
- Fresh water aquaculture

282. Floodplains are landforms in the study area that are inundated twice in a day due to tidal influence. Vegetation of the floodplains is changing its forms with fluctuation of water level and salinity. This type of wetland is dominated by grasses and rooted-floating plants. Canals are connected with surrounding river most of the year. Within the study area, ponds are found on homestead platforms and had been used for domestic purposes or fish culture. Ditches found inside the agricultural field natural wetland that contains water until winter.

283. The Bhairab River is alongside the project area. It has valuable biological resources which include the benthic community and planktons. Benthos and planktons on Bhairab River was collected during the field survey and is presented in the **Table 4.36**.

Table 4.36: Benthos and planktons in Bhairab River

Date	Location	Benthos (Unit/M)	Plankton: Phytoplankton (unit/L)	Plankton: Zooplankton (unit/L)	Total Plankton Count (Number/ m^3)
29/10/2016	Bhairab River (along the bank of project site)	0	0	Arcella- 2 Keratella-1	1,396
29/10/2016	Bhairab River (along the opposite bank of the project site)	Polychaeta- 2 Annelida- 2	0	Arcella- 2 Keratella-1 Vorticella-1 Diaptomus-2	3,150
29/10/2016	Bhairab River (500 m downstream from the project site)	Polychaeta- 3 Annelida- 3	0	Arcella- 2 Diaptomus-1 Naupleus-2 Philodina-1	3,710
29/10/2016	Bhairab River (500 m upstream from the project site)	0	0	Philodina-3	1,005
29/10/2016	Pond (near the project site)	-	0	Arcella-2 Streptocephalus- 2 Cyclops- 1 Diaptomus- 2 Brachionus- 1 Neumania- 1	5,175

Sample during post monsoon (October 2016) analyzed by Zoological Laboratory, University of Dhaka

Wetland flora

284. Water hyacinth (*Eicchornia crassipes*) is the most common free-floating hydrophytes that cover maximum portion of the water of internal canals and ditches. Water lettuce (*Pistia strateotes*) is found in most of the ditches as well as in ponds mixed with water hyacinth. Sedges are quite common during monsoon inside all types of wetlands.

285. Along the shore line of the Bhairab River are a few mangrove vegetation which include Holy mangrove (Hargoja), Golden leather fern (Hoda). These species are listed as Least Concern in the global IUCN Red List.

Wetland fauna

286. Different species of resident and migratory aquatic birds are noted in the beels and mudflat of Rupsha River and Atai River.

287. Indian softshell turtle (*Nilssonia gangetica*) assessed as VU by the IUCN (global) and EN (IUCN Bangladesh 2015) and Spotted Flapshell Turtle (LC) were found in the rivers of the study area. According to IUCN Bangladesh Red List 2015, the Indian softshell turtle is distributed in

Bangladesh, India, Nepal and Pakistan. In Bangladesh, the main habitats are the major river systems such as Ganga-Padma, Jamuna-Brahmaputra and Surma-Kushiara-Megna, and flood-plains without rivers in the north-northeastern hilly regions of the country.[28] The Indian roofed turtle (LC) is also noted in the ditches, ponds and beels. Common aquatic snakes include the checkered keelback (NA) and smooth water snake (LC).

288. Among the amphibians, the skipper frog (*Euphlyctis cyanophlyctis*) is commonly found throughout the year. They have been the most successful fauna in adapting to the all kinds wetlands. Abundance of Bullfrogs (*Hoplobactruchus tigerinus*) is increased during the rainy season at paddy fields, ditches and other marshy places.

289. **Ganges River dolphin**. Theproximity report generated by the Integrated Biodiversity Assessment Tool (IBAT) on 30 January 2017 indicates that there are no protected areas and key biodiversity areas within 5 km and 10 km from Component 1. The proximity report listed 33 species from the global IUCN Red List of Threatened Species that may be potentially found close to the project site. Of these 33 species, the main important species is the Ganges River dolphin (*Platanista gangetica*) which is listed as EN (globally) and VU by IUCN Bangladesh. Ganges River dolphin is frequently observed in Bhairab River within the study area along the project site (**Figure 4.45**).

Figure 4.45: Sightings of Ganges River dolphin close to project site

290. Officially discovered in 1801, the Ganges River dolphin is known as an obligate freshwater dolphin and is essentially blind. According to IUCN, *Platanista gangetica* is the only species in the family Platanistidae (Rice, 1998). While the Indus and the Ganges populations were regarded as identical, Pilleri and Gihr (1971) divided them into two species (*P. gangetica* and *P. minor*). The *Platanista gangetica* is commonly known as the Ganges River dolphin (or Ganges *susu*) while the *Platanista gangetica minor* is known as the Indus River dolphin (or Indus bhulan).

291. **Distribution and population.** Their distribution is throughout the Ganges-Brahmaputra-Meghna (GBM) and Karnaphuli-Sangu River systems of Bangladesh, India and Nepal and may be potentially present in Bhutan (**Figure 4.46**).[29] GBM is a transboundary river basin with a total area of about 1.713 km^2 distributed among India (64%), People's Republic of China (18%), Nepal (9%), Bangladesh (7%) and Bhutan (3%). According to IUCN, the current estimated global population (GBM) is 3,607 dolphins which include 3,025 dolphins in India, 532 dolphins in

[28] IUCN Bangladesh. Red List of Bangladesh (2015). Volume 4: Reptiles and Amphibians. p65.
[29] Sinha, Ravindra and KurunthachalamKannan. Ganges River Dolphin: An Overview of Biology, Ecology, and Conservation Status in India. *Ambio*.2014, 43:1029-1046.Royal Swedish Academy of Sciences.

Bangladesh (1998-2012), and 50 dolphins in Nepal.[30] The estimated population in Bangladesh covers the river system and Sundarbans area only and does not include other dolphins survey in other river system like the Turag River in Dhaka where maximum encounter rate was 0.49 sightings per km in October 2013 and in Buriganga River located in southwest outskirts of Dhaka City where encounter rate was 0.48 sightings per km in November 2013.[31,32]

Figure 4.46: Global distribution of Ganges River dolphins

Source: IUCN, www.iucnredlist.org

292. In 2012, the IUCN classified the Ganges River dolphin as EN globally.[33] In Bangladesh, they are considered VU and is placed in the Third Schedule of Bangladesh Wildlife (Preservation) Order 1973, also listed on Appendix I of the CITES in 1981 as well as on Appendix II of Convention on the Conservation of Migratory Species in 1991 and Appendix I in 2002.[34,35] There has been considerable efforts made to document the status of *Platanista gangetica gangetica* since the early 1970s, yet thus far, a rigorous quantitative data on numbers, mortality, extent of occurrence, and area of occupancy are still lacking for much of the species' range particularly in India and Bangladesh.There has been no study done on this species in the Bhairab-Atai-Rupsha river system.

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[30] Sinha, R. K. and Ahmed, B. (eds.) (2014). Rivers for Life - Proceedings of the International Symposium on River Biodiversity: Ganges-Brahmaputra-Meghna River System, Ecosystems for Life, A Bangladesh-India Initiative, IUCN, International Union for Conservation of Nature, 340 pp.

[31] Alam, Shayer Mahmood Ibney, Hossain, Md. Muzammel, Baki, Mohammad Abdul and Naser Ahmed Bhouiyan. (2015). Status of Ganges Dolphin, *Platanista Gangetica Gangetica* (Roxburgh, 1801) in the River Buriganga, Dhaka. Bangladesh J. Zool. 43(1): 109-120.

[32] Baki, Mohammad Abdul, Bhouiyan, Naser Ahmed, Islam, Md. Saiful, Alam, Shayer Mahmood Ibney, Shil, Shibananda, and Md. Muzammel Hossain. Present Status of Ganges River Dolphins*Platanista gangetica gangetica* (Roxburgh, 1801) in the Turag River, Dhaka, Bangladesh. Int. Journal of Zoology, Vol 2017, Article ID 8964821, 7p.

[33] Smith, B.D. and Braulik, G.T. 2012.*Platanistagangetica*. The IUCN Red List of Threatened Species 2012: e.T41758A17355810. http://dx.doi.org/10.2305/IUCN.UK.2012.RLTS.T41758A17355810.en. (Accessed 24 April 2017)

[34] http://bdlaws.minlaw.gov.bd/pdf/452___Schedule.pdf. (Accessed 31 March 2017)

[35] https://speciesplus.net/#/taxon_concepts/12356/legal. (Accessed 31 March 2017)

293. **Habitat.** Its primary habitat is characterised by an eddy counter-current system in the main river flow caused by a fine sand/silt point bar formed from sediment deposits of a convergent stream branch or tributary while marginal habitat may be a smaller eddy counter-current system caused by an upstream meander. The IUCN assessment in 2017 indicates that the Ganges River dolphins are generally concentrated in counter-current pools below channel convergences and sharp meanders (Smith 1993, Smith, et al.,1998) and above and below mid-channel islands, bridge pilings, and other engineering structures that cause scouring. In addition, several studies have demonstrated that they are concentrated into deep pool habitat in the dry season, which increases their conflict with fisheries that also concentrate in these productive areas (Kelkar *et al.* 2010, Bashir, *et al.* 2012). Their fidelity to counter-current pools is probably greatest in fast-flowing channels. Isolation in seasonal lakes sometimes occurs (especially in the Brahmaputra basin). Deltaic (brackish) waters are a major component of the total range of this subspecies, but they are not generally known to occur in salinities greater than 10 ppt, although they have been observed in waters as saline as 23 ppt. According to Smith et al. 2009, the Ganges River dolphin distribution is conditionally dependent on relatively low salinity, high temperature, moderate depth with significant dependence on high turbidity.[36] Wakid (2009) mentioned that dolphins prefer the water depth between 4.1 and 6.0 m.[37]

294. **Biodiversity study in the PAI**. There have been considerable efforts made to document the status of Ganges River dolphin since the early 1970s, yet thus far, a rigorous quantitative data on numbers, mortality, extent of occurrence, and area of occupancy are still lacking for much of the species' range particularly in India and Bangladesh. Population in other rivers has not been estimated yet.[38]There has been no study on Ganges River dolphins within the PAI.

295. To establish baseline, two initial dolphin surveys were done following the land-based sighting survey method and direct counting survey through line transect using a local engine boat.[39] On 29-30 October 2016, a land-based sighting survey was conducted within the Bhairab-Atai River confluence area. The survey only counted the dolphin while they surfed (i.e., dolphins came to water surface to get oxygen). A total of 33 times surfing occurrences were recorded within a total of 4 hours and 46 minutes observation for the 2-day survey. Of the 33 surfing occurrences, 11 occurred at the confluence while the rest occurred along the Bhairab River. These occurrences do not reflect size of the population as the same adult, juvenile and calf may have surfed several times.

296. A direct counting survey was done through the line transect method in March 2017. About 20 km stretch of the Bhairab River from the confluence of Bhairab-Madhumati Rivers (covering 10 km upstream) to the confluence of Bhairab-Atai Rivers until the Rupsha River at Khanjahan Ali Bridge (covering 10 km downstream) was covered using a local engine boat. The Rupsha River drains south towards the Sundarbans and on to the Bay of Bengal.

297. A total of 25 occurrences of Ganges River Dolphins were recorded at different locations of the transect for over a 5-hour survey. Out of the 25 occurrences, 22 occurrences were recorded from the Bhairab-Atai River confluence and towards the Rupsha River (downstream of project

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[36] Smith, B. D., Braulik, G., Strindberg, S., Mansur, R., Diyan, M.A.A, and B. Ahmed. Habitat selection of freshwater-dependent cetaceans and the potential effects of declining freshwater flows and sea-level rise in waterways of the Sundarbans mangrove forest, Bangladesh. Aquatic Conserv: Mar. Freshw. Ecosyst. 19: 209–225 (2009).

[37] Wakid, A. 2009. Status and distribution of the endangered Gangetic dolphin (Platanista gangetica gangetica) in the Brahmaputra river within India. Current Science 97: 1143–1151.

[38] IUCN Red List of Bangladesh, Volume 2: Mammals, 2015, p.107.

[39] Aragones, L. V., Jefferson, T. A., & Marsh, H. (1997). Marine mammal survey techniques applicable in developing countries. *Asian Marine Biology*, 14, 15-39.

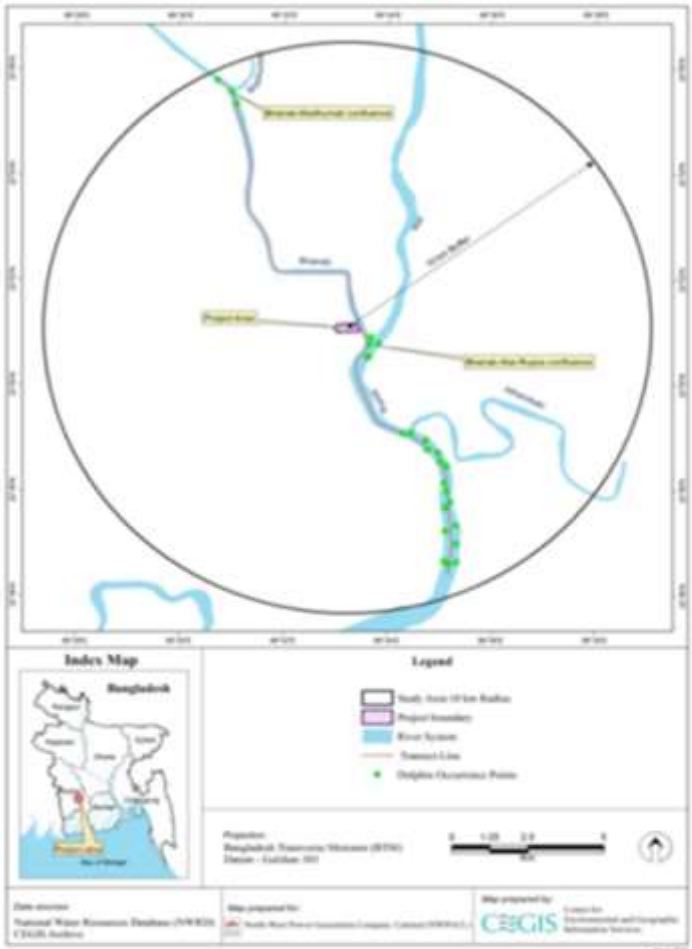
site) and only three occurrences upstream of the project site at the Bhairab-Madhumati River confluence (**Figure 4.47**). Average encounter rate was estimated at 0.44 individual/km. A similar survey approach was used by Alam et al (2015) for Ganges dolphin in Buriganga River in Dhaka.[40]

Table 4.37: Land-based sighting survey of Ganges River dolphin

Date	Time of Surfing (local)	Population Surfing Count			Total	Location
		Adult	Juvenile	Calf		
29/10/16	9:15	1			1	Bhairab River
	9:52	1			1	Bhairab River
	9:53	1		1	2	Bhairab River
	9:55		1		1	Confluence
	9:56	1			1	Bhairab River
	10:10	1			1	Bhairab River
	10:13		1	1	2	Bhairab River
	10:22	1			2	Bhairab River
	10:28	1		1	2	Confluence
	10:32	1			1	Bhairab River
	10:50		1		1	Bhairab River
	10:53		1		1	Bhairab River
	10:57	1			1	Confluence
	11:03	1			1	Confluence
	11:06	1			1	Bhairab River
	11:14		1		1	Bhairab River
	11:22	1			1	Confluence
	11:26	1			1	Bhairab River
	11:33	1	1		2	Confluence
	11:49	1			1	Bhairab River
	11:58			1	1	Bhairab River
30/10/16	5:25		1		1	Bhairab River
	5:27	1			1	Bhairab River
	5:31			1	1	Bhairab River
	5:32	1		1	2	Confluence
	5:36		1		1	Confluence
	5:39	1		1	2	Confluence
	5:40					Bhairab River
	5:42	1			1	Bhairab River
	5:46			1	1	Bhairab River
	5:48	1				Bhairab River
	5:52		1		1	Confluence
	6.10	1				Confluence
Total 33 times in 4h and 46 minute- observation		**21**	**9**	**8**	**38**	

[40] Alam, Shayer Mahmood Ibney, Hossain, Md. Muzammel, Baki, Mohammad Abdul and Naser Ahmed Bhouiyan. (2015). Status of Ganges Dolphin, *Platanista Gangetica Gangetica* (Roxburgh, 1801) in the River Buriganga, Dhaka. Bangladesh J. Zool. 43(1): 109-120.

Figure 4.47: Dolphin occurrences in the study area



298. **Dolphin survey in the study area**. Given the conservation status of Ganges River Dolphins, NWPGCL engaged IUCN Bangladesh in May 17 to conduct a biodiversity assessment (**Annex 11**) in a study area that will cover the following stations: (1) 10 km of Rupsha River (downstream of the power plant site); (2) 10 km of Bhairab River (upstream of the power plant site); (3) confluence of Bhairab-Atai-Rupsha Rivers, (4) 10 km of Atai River (upstream from the confluence of Station 3). **Figure 4.48** shows the study area.

299. A total of seven surveys were completed from May 2017 until January 2018 covering the pre-monsoon (one survey), monsoon (two surveys), post-monsoon (two surveys) and winter (two surveys). Surveys include the Ganges River dolphins, presence of other animals, fish and fishing gear, fishing areas, physical and chemical water quality analysis, vegetation, plankton, watercrafts, water depth, and existing pollution sources.

300. **Dolphin survey methodology.** The dolphin surveys follow the standard methodology set by Smith *et al.* (2006 and 2009).[41] The first four surveys (pre-monsoon, first and second monsoon

[41] Smith, B.D., Braulik, G., Strindberg, S., Ahmed, B. and Mansur, R. 2006. Abundance of Irrawaddy dolphins (Orcaella brevirostris) and Ganges river dolphins (Platanista gangetica gangetica) estimated using concurrent counts from

and first post-monsoon) were conducted to calculate encounter rate, and the last three surveys (second pre-monsoon, first and second winter) were conducted using the Mark-recapture method.

To analyze encounter rate

301. To conduct the survey, three transects were set (1) the Bhairab River transect; (2) the Atai River transect; and (3) the Rupsha River transect. Each transect is 10 km-long. Three observers stand and actively search for dolphins along transects at all times and record sighting data. One observer is stationed on the port and one on starboard side of the vessel. These two observers search with handheld binoculars and naked eye from the beam to about 10˚ past the bow. The third observer stands in the centre and scans with the naked eye in about a 20˚ cone in front of the bow. This observer also keeps records in specialized data sheets. The observers are rotated through the three positions every half an hour. The height from the water level to the observer is approximately 3 meters. The boat speed is set to 10 km/hour.

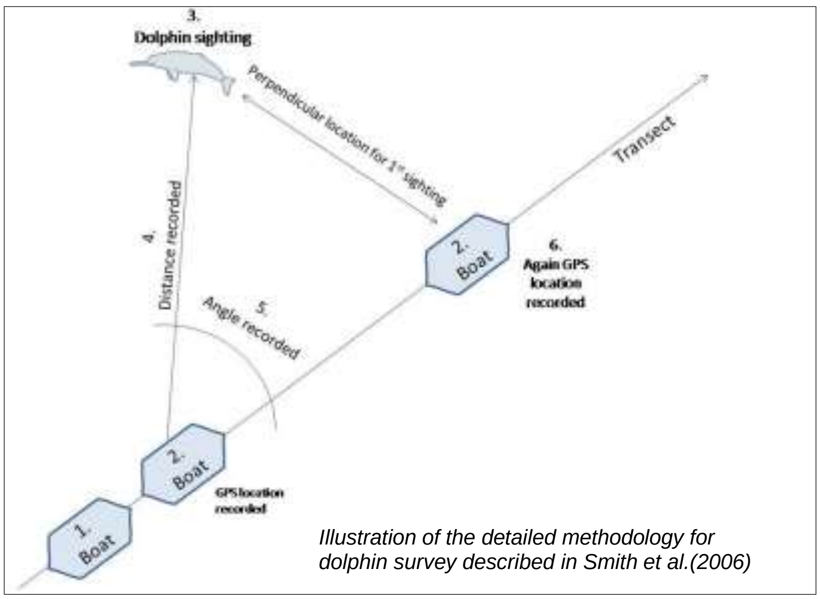


Illustration of the detailed methodology for dolphin survey described in Smith et al.(2006)

302. Once dolphins are spotted, the GPS coordinates of the exact spot where the animals were seen is recorded. The group size and the age class are then estimated.

To Calculate Population Number using Mark-recapture Method

Teams	1. A primary observer team will be stationed on the upper deck (approximately 4.4 m above the waterline) 2. A secondary observer team will be stationed on the lower deck (c.2.3 m above the waterline)

independent teams in waterways of the Sundarbans mangrove forest in Bangladesh, Marine Mammal Science 22(3): 527-547.

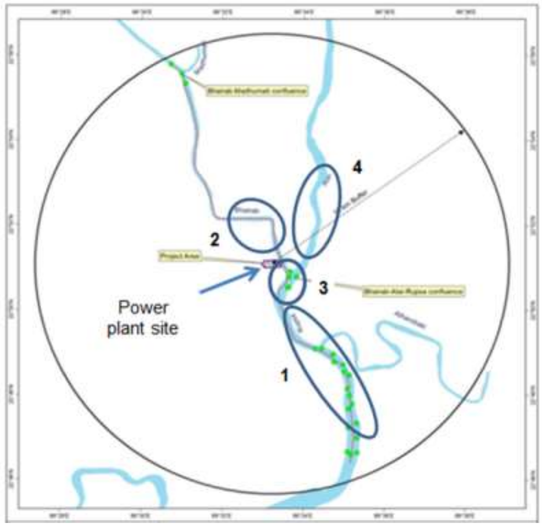
Smith, B.D., Braulik, G., Strindberg, S., Mansur, R., Diyan, M.A.A. and Ahmed, B. (2009). Habitat selection of freshwater dependent cetaceans and the potential effects of declining freshwater flows and sea-level rise in waterways of the Sundarbans mangrove forest, Bangladesh. Aquatic Conservation: Marine and Freshwater Ecosystems, 19, pp. 209-225.

	3. The two independent observer teams will not be in visual contact and observers will be instructed to avoid alerting the other team about dolphin sightings. (Note: this will maintain the independence of results.)
Observer position	1. Three observers will stand watch at all times while “on-effort” (i.e., actively searching for dolphins along the transect line and recording effort and sighting data) 2. One will be stationed on each the port and starboard sides, searching with handheld binoculars and naked eye from the beam to about 100 past the bow 3. One in the centre searching by naked eye in about a 200 cone in front of the bow 4. The centre observer will also serve as the data recorder. Both primary and secondary teams will be comprised of the same structure.
Transect and boat speed	1. Transect will start from the lower part of Rupsha river and finish at upper part of Bhairab river. We will cover a total 20 km in favor of the tide. We will then move into Atai river where we will not be in favor of the tide. Then we will cover the last 10 km of Atai river. The boat speed will be controlled accordingly. 2. Boat speed will be on average 10 km/hour.
Channel width	Channel width will be recorded according to the sum of distance measurements to the right and left banks using a laser range finder, if less than 500 m, or the sum of estimates will be made by naked eye, if greater. We can also use satellite image to measure the channel width according to the GPS coordinates if both options are not feasible.
Dolphins data record	1. Species 2. Time 3. Radial distance to the first dolphin sighted 4. the location of the estimated position (GPS) where the dolphins located when first observed; and 5. Group size (according to best, high and low).
Model used	The following models were used for analysis and estimation of population size: 1. A stratified Lincoln-Petersen model 2. Huggins conditional likelihood model 3. Horvitz-Thomson Estimator (to obtain the abundance)

Smith et al, 1994; Smith 2000; Smith *et al.* 2006

303. Along with this, weather conditions (wind, glare, and rain/fog) are recorded as well. These factors are given codes of 0, 1, or 2, where ‘0’ corresponds to good (no effect on sighting conditions), ‘1’ corresponds to fair (small effect on sighting conditions), and 2 corresponds to poor (large effect on sighting conditions) conditions, respectively.

Figure 4.48: Study area for the dolphin survey



Survey findings

304. *Dolphin population.* Survey results show a total of 284 sightings with an overall encounter rate of 1.18 individual per km including 13.76% calves (see Table. The most important area determined from the surveys is the confluence of Atai-Bhairab-Rupsha Rivers where feeding behavior was recorded and a large number of calves were seen. Results of the three surveys (second post monsoon, and two winter) using the revised methodology (mark-recapture method) showed an average of 34 dolphins. The results were based on the Huggins conditional likelihood model.[42]

Table 4.38: Encounter rate of dolphins

Survey season	Encounter rate (High Tide)	Encounter Rate (Low Tide)	Encounter Rate (Average)
Pre-monsoon survey	1.40	0.93	1.16
First monsoon survey	1.33	0.33	0.83
Second monsoon survey	1.03	1.03	1.03
First post-monsoon survey	1.23	2.16	1.70
Total	4.99	4.45	4.72
Average	**1.24**	**1.11**	**1.18**

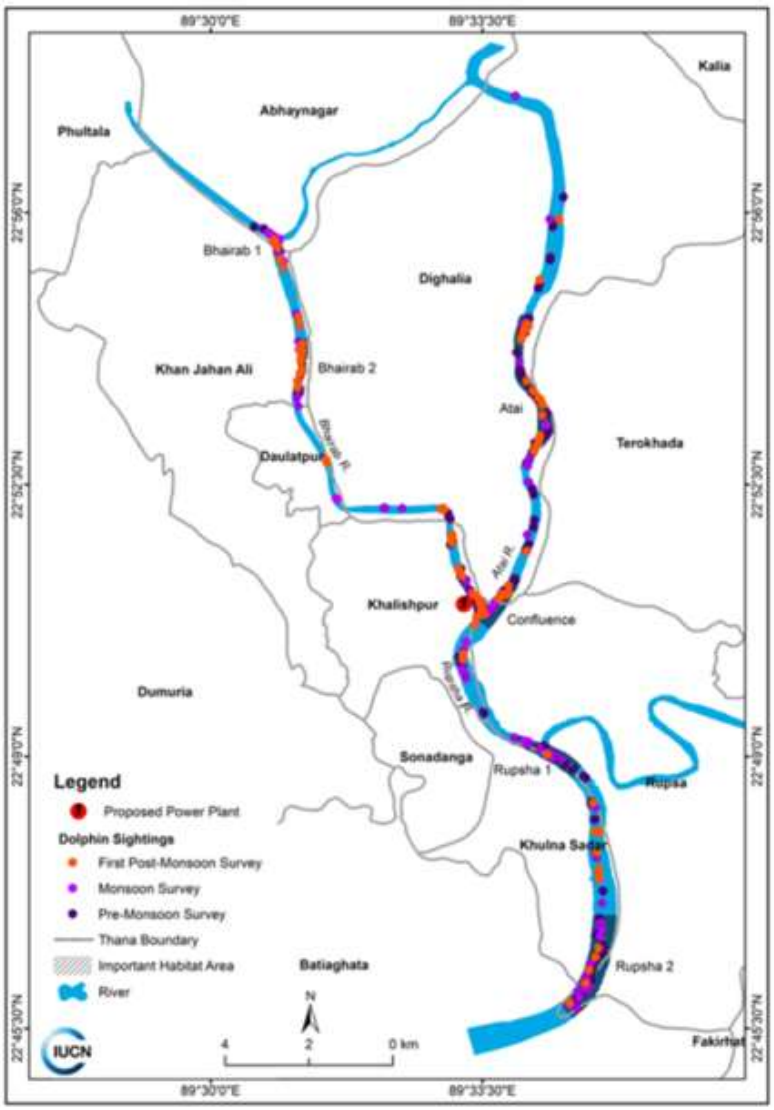
305. *Important dolphin areas.* Specific areas within the study area that have high concentration of dolphin sighting including calves were identified. The areas can be considered as important dolphin areas based on the number of sightings and considering the channel width and other parameters. Of all the surveys, the most important area is the confluence of Atai-Bhairab-Rupsha Rivers. In one hour, the total dolphin sighting was 367 in the confluence. The details of the important dolphin areas are given in **Table 4.39** and shown in **Figure 4.49**.

[42] IUCN Bangladesh. Final Report, Biodiversity Assessment for Rupsha 800 MW Combined-Cycle Power Plant Project. February 2018.

Table 4.39: Details of important dolphin areas

Rank	Name of important dolphin site	Location in Figure 4.45	Total number of sightings in pre- monsoon, monsoon and post monsoon surveys
1	Confluence of the Bhairab- Atai-Rupsha	Confluence	75
2	Atai river	Atai	59
3	Near Rupsha bridge	Rupsha 2	47
4	Bhairab-Madhumati Confluence	Bhairab 1	27
5	Jelkhana Ghat confluence	Rupsha 1	20
6	Near Daulatapur	Bhairab 2	17

Figure 4.49: Important dolphin areas



Surfing of a Ganges River Dolphin at the confluence of the Bhairab, Atai and Rupsha Rivers on 31 May 2017. © IUCN/ Kazi Zenifar Azmiri

Dolphin survey at the Rupsha River, 22 October 2017. ©IUCN/ A.B.M. Sarowar Alam

306. *Other wildlife*. A total of 40 bird species and three other species (Water Monitor, Indian Flying Fox and Smooth-coated Otters) were recorded during the survey period. The highest number of species recorded was from monsoon (28 species) followed by post-monsoon (26 species) and pre-monsoon (11 species). The highest number counted was of Little Cormorant with 241 individuals.

307. Of the 40 bird species, only the black headed ibis (*Threskiornis melanocephalus*) is of conservation status (VU in IUCN Bangladesh, NT in IUCN global). This bird species was observed only during the post-monsoon survey. The rest of the bird species are LC.

308. The conservation status of common water monitor (*Varanus salvator*) and the Indian flying fox (*Pteropus giganteus*) are LC while the smooth-coated otter (*Lutrogale perspicillata)* is VU from the IUCN Red List (global) and listed as CR from the IUCN Bangladesh.

309. *Fish species*. A total of 50 fish species were recorded based on direct field visit and questionnaire survey. Of these species, 17 species are of conservation status based on IUCN Bangladesh Red List (2015). **Table 4.40** gives the list of the fish species. Out of 50 species, 39 species of fishes were sighted by using the method of direct sighting and 11 species of fishes were recorded using questionnaire surveys. In terms of season, 22 species were recorded in the monsoon, 45 species in the post-monsoon and 36 species in the winter.

Table 4.40: Fish species of conservation status

No.	Common Name	Scientific Name	Monsoon	Post-monsoon	Winter	IUCN Bangladesh (2015)
1	Long-whiskered Catfish	*Sperata aor**	—	√	—	VU
2	Tire-track Spinyeel	*Mastacembelus armatus*	—	√	√	EN
3	Freshwater shark	*Wallago attu*	√	√	—	VU
4	Indian river shad	*Gudusia chapra*		√	√	VU
5	Humped Featherback	*Chitala chitala**	—	√	√	EN
6	Grey Featherback	*Notopterus*	—	√	—	VU
7	Giant Snakehead	*Channa marulis**	—	—	√	EN
8	Menoda Catfish	*Hemibagrus menoda*	√	√	√	NT

No.	Common Name	Scientific Name	Monsoon	Post-monsoon	Winter	IUCN Bangladesh (2015)
9	Kuria labeo	*Labeo gonius*	√	√		NT
10	Gangetic Mystus	*Mystus cavasius*	√	√	√	NT
11	Canine Catfish Eel	*Plotosus canius**	—	√		NT
12	Himalayan Glassy Perchlet	*Pseudambassis baculis*	√	√	√	NT
13	Mottled Nandus	*Nandus*	√	√	√	NT
14	Mrigal Carp	*Cirrhinus cirrhosus*	√	√	√	NT
15	Pabda catfish	*Ompok pabda*	—	—	√	EN
16	Pungas Catfish	*Pangasius*	√	√	√	EN
17	Rita	*Rita rita**	—	√	√	EN

Fisherman catches Ilish fish from the Atai River, 8 August 2017. © IUCN/ Sultan Ahmed

310. *Watercrafts*. A total of 676 watercrafts comprised of mechanized and non-mechanized type were recorded. The highest was mechanized boats with a total of 373. Rupsha River is the busiest water way with a total of 253 watercrafts followed by Atai River at 225 watercrafts and Bhairab River with 198 watercrafts. Of the four seasons, monsoon and post-monsoon have the highest number of watercrafts navigating the river system in the study area.

Survey season	Cargo	Non-Cargo		Total
		Mechanized	Non-mechanized	
Pre-monsoon survey	11	32	19	62
First monsoon survey	20	53	62	135
Second monsoon survey	8	71	15	94
First post-monsoon survey	40	90	42	172
Second post-monsoon survey	19	30	9	58
First winter survey	06	52	11	69
Second winter survey	36	45	9	86
Total	**136**	**373**	**167**	**676**

An anchored cargo vessel in the Rupsha River, 26 September 2017. © IUCN/ A.B.M. Sarowar Alam

311. *Water depth*. This was measured along transects every 1km intervals using an echo-sounder and results are given below. Results show that the highest level at Rupsha River is 34.4 m during the pre-monsoon at lowest at 3 m. At the Bhairab River, highest level is 20.1 m (pre-monsoon) and lowest at 5.2 m during the post-monsoon. In Atai River, the highest level is at 42.9 m during the monsoon and 6.6 m in post-monsoon.

Transect	Tide	Pre-monsoon		Monsoon (1st & 2nd monsoon average)		Post-monsoon	
		Max	Min	Max	Min	Max	Min
Rupsha River	High	34.4	3	22.75	8.8	30.8	8.2
	Low	23.9	10	27.1	8.8	29.3	11.9
Bhairab River	High	20.1	6.6	12.65	6.45	13.5	5.2
	Low	17.3	6.3	12.95	5.65	19.5	5.9
Atai River	High	30.4	18.7	32.1	8.65	27.6	6.8
	Low	24.3	6.6	43.9	9.8	34.6	10

312. *Eddy current.* Eddies were recorded in five surveys. The number of eddies found in each river in high and low tides is presented below.

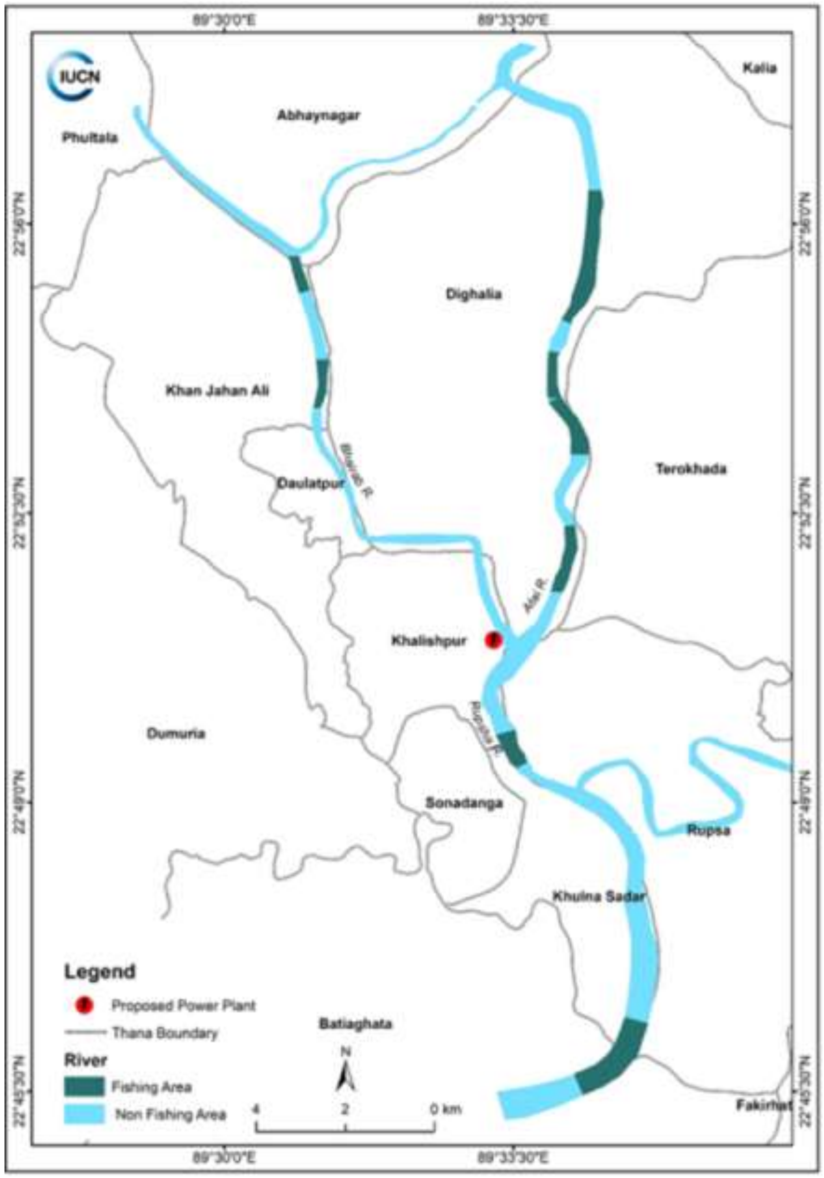
Transect	Tide	Pre-monsoon	First monsoon	Second monsoon	First post-monsoon	Second post-monsoon
Rupsha River	High	0	0	0	0	0
	Low	0	1	0	0	0
Bhairab River	High	0	0	0	0	0
	Low	0	0	0	2	0
Atai River	High	0	0	0	0	0
	Low	4	3	4	6	5

313. Results show that it is only in Atai River where eddy currents occur in all seasons.

314. *Fishing gear and fishing area*. A total of 19 types of fishing gears were recorded in the three seasons that were surveyed (i.e., monsoon, post-monsoon, winter). Fishermen catch fish in the rivers by using these different types of fishing gears. Among these, the small-mesh drifting gill net (*jatka ilish jal*), monofilament gill net (*current jal*), set bag net (b*heundi jal*) and long shore net (*charpata jal*) are widely and illegally used for fishing. The mesh size of small-mesh drifting gill net and monofilament gill net is very small. The set bag net and long shore net are zero mesh

size fishing net. These nets are used to catch eggs, spawn and larvae of all the fish species along with adult fish. Seven fishing areas have been identified (**Figure 4.50**).

Figure 4.50: Identified fishing areas



Fishing nets kept for drying on the bank of the Atai River, 31 May 2017.

Fishermen using a large lift net (veshal) to catch fish from the Bhairab River 8 August 2017. © IUCN/ Sultan Ahmed

Fishing at the Bhairab River 26 September 2017. © IUCN/ A.B.M. Sarowar Alam

315. *Vegetation*.A total of 29 species consisting of 117 individuals were counted from six sample plots. Jam (*Syzygium cumini L),* Supari (*Areca catechu L.*), Narkel (*Cocos nucifera L.)*, Jial (*Lannea coromandelica Merr).* and Aam (*Mangifera indica L.)* are the five most abundant species in the study area.

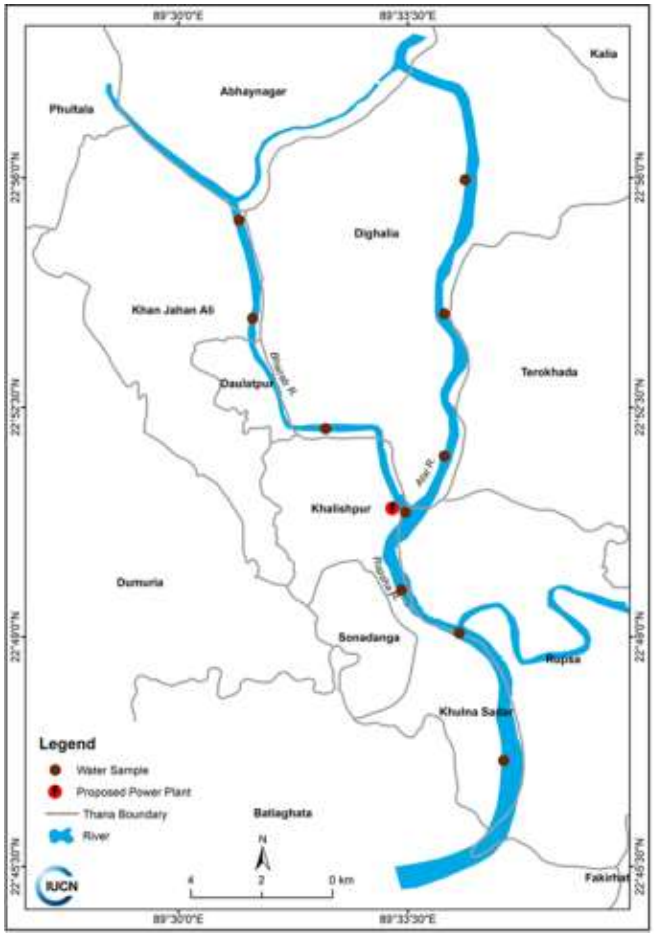
Ranking	Species name	Tree/ha
1	Jam (*Syzygium cumini L.*)	317
2	Supari *(Areca catechu L.)*	233
3	Narkel *(Cocos nucifera L.)*	200
4	Jial (*Lannea coromandelica Merr)*)	167
5	Aam (*Mangifera indica L)*	133

316. *Water quality* Ten water quality sampling stations were identified. **Table 4.41** describes the sampling station and **Figure 4.51** shows the location.

Table 4.41: Water quality sampling stations

Stations	GPS Co-ordinates		Major infrastructures in the River bank
	Latitude	Longitude	
Station 1 (Rupsha)	22°47.115' N	89°34.958' E	Khulna shipyard, Seven ring cement industry, Fish processing zone
Station 2 (Rupsha)	22°49.060' N	89°34.281' E	Jelkhana ghat, Purobi Salt Factory
Station 3 (Rupsha)	22°49.719' N	89°33.400' E	5 no. fishery ghat, goods load and unload zone
Station 4 (Confluence)	22°50.898' N	89°33.459' E	Brick field, Khalishpur ghat, Power plant
Station 5 (Bhairab)	22°52.174' N	89°32.243' E	Padma, Meghna and Jamuna petroleum industry, Jute mill
Station 6 (Bhairab)	22°53.857' N	89°31.130' E	CSD ghat, F.R. jute mil
Station 7 (Bhairab)	22°55.352' N	89°30.921' E	Sheikh cement industry, Brick field
Station 8 (Atai)	22°55.968' N	89°34.370' E	Human settlements
Station 9 (Atai)	22°53.924' N	89°34.051' E	Human settlements, Brick field
Station 10 (Atai)	22°51.758' N	89°34.052' E	Brick field, human settlements

Figure 4.51: Map of water quality sampling stations



317. Results of water quality sampling show the following:

- Temperature ranges from 27ºC to 31ºC
- pH – the values range from 6.75 to 8. pH values during the monsoon season are slightly higher than the values during the post-monsoon but still within the ECR 1997 limits
- Electrical conductivity (EC) – values range from 243 to 470 mS/cm. The EC valuesare slightly higher in monsoon than post-monsoon season value.
- Dissolved oxygen, mg/l (DO) – Level below 1.0 mg/l will not support fish; thus, at least 5 mg/l to 6 mg/l will be required to support aquatic life. DO levels are generally within the limits of ECR 1997. However, during the monsoon the stations, CSD ghat and Sheik cement recorded a low value of DO (below 3 mg/l). These areas may not support aquatic life.
- Turbidity (NTU) – all the stations recorded high levels of turbidity ranging from 76 NTU to 238 NTU. The river waters are highly turbid during the monsoon season.
- Nitrate, mg/l – levels during monsoon are quite low ranging from 1.42 mg/l to 1.79 mg/l, and from 1.82 mg/l to a maximum of 5.86 mg/l in post-monsoon. Nitrate limit is 10 mg/l. The nitrate level during the post-monsoon was recorded at 5.86 mg/l at Jail Ghat.
- Hardness – level ranges from 88 mg/l to 148 mg/l

- Suspended solids, mg/l – levels are all higher than 150 mg/l
- BOD_5, mg/l - limit in surface water is 50mg/l. Levels ranges from 4.62 mg/l to 7.3 mg/l. Post monsoon values are higher than monsoon. Results show that organic pollution loading is low.
- COD, mg/l – values range from 49.5 mg/l to 64 mg/l suggesting a load of slightly high organic pollutants
- Coliform, CFU/100 ml – values range from 360 to 469. River water may contain disease-causing bacteria and may not be fit for swimming or recreation.
- Iron, mg/l – values during monsoon season range from below 1 mg/l to 2 mg/l while during post monsoon, the values range from 8.7 mg/l to 19 mg/li.
- Cadmium, mg/l – average value is 0.06 mg/li slightly above the limit of 0.05 mg/l
- Chromium, mg/l – average value is 0.33 mg/li during the dry season, above the limit of 0.5 mg/l
- Salinity, ppt – values are all below 1 ppt in both seasons suggesting no saline intrusion or tidal influence from Bay of Bengal at the time of sampling.

318. Overall, the water quality within the study area is not so degraded given the number of industries along the river banks of Bhairab River and Rupsha River, and the volume of watercraft navigating these areas to move goods and people. Iron is slightly high during post monsoon. Sources that contribute to increase in the iron level can be investigated.

319. Biological parameters. Six sampling stations were established for biological parameters. These are: Rupsha bridge, Rupsha Jail ghat, Rupsha 5 no. fishery ghat, Rupsha Khalispur Confluence Power plant, and Bairab CSD ghat, Bairab.

320. A total of 15 genera of phytoplankton and two unknown genera of zooplankton were found in the 6 study sites. Among the plankton, Oscillatoria and Melosira were found in all the 6 study sites indicating that these two genera are common in the study area. On the other hand, Nostoc, Pediastrum, Cymbella and Volvox were found only in single site indicating that these genera are less common in the study area. Maximum number of genera (10) were found in 5 No. Fishery ghat, Rupsha and minimum number of genera (4) were found in the site of Rupsha bridge, Rupsha. Microsystis sp. is considered an indicator of water pollution. This genus was found to have more abundantly in 5 No. Fishery ghat, Rupsha than other sites indicating that water of this site might be polluted.

Assessment on the presence of critical habitat within the PAI

321. Para. 24, 28, and 29 of SPS 2009, Appendix 1 (p34-35) set the guidance on critical habitat assessment.[43] The IFC Performance Standard (PS) 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources (1 January 2012) and the IFC's Guidance Notes: Performance Standards on Environmental and Social Sustainability (1 January 2012) also

[43] The criteria for critical habitat are: (i) required for the survival of critically endangered or endangered species; (ii) having significance for endemic or restricted-range species; (iii) sites that are critical for the survival of migratory species; (iv) areas supporting globally significant concentrations or numbers of individuals of congregatory species; (v) areas with unique assemblages of species or that are associated with key evolutionary processes or provide key ecosystem services; and (vi) areas having biodiversity of significant social, economic, or cultural importance to local communities. Critical habitats may also include areas either legally protectedor officially proposed for protection, such as areas that meet the criteria of the World Conservation Unionclassification, the Ramsar List of Wetlands of International Importance, and the United Nations Educational, Scientific, and Cultural Organization's world natural heritage sites.

provides guidance in determining the critical habitat.[44] Given the sightings of the Ganges River dolphin relatively close to the project area, an IUCN endangered and migratory species, this could potentially trigger criteria (i) and (iii) of SPS 2009 and criteria (i) and (iii) of IFC PS 6.

Criterion 1: Habitat of significant importance to Critically Endangered (CR) and/or Endangered (EN) species

322. There are two tiers with sub-criteria under Criterion 1 as follows:

Tier 1 critical habitat is an area that:

- Required to sustains equal to or greater than 10% or more of the global population of a CR or EN species;
- Could be a discrete management unit for that species;[45] and,
- Could be one of 10 or fewer discrete management sites globally for that species.

Tier 2 critical habitat is an area that:

- Supports regular occurrence of a single individual of a CR species;
- Significant importance to CR or EN species that are wide-ranging and/or whose population distribution is not well understood and where loss of such habitat could potentially impact the long-term survivability of the species; and,
- Contains nationally/regionally important concentrations of an EN, CR or equivalent national/regional listing.

323. Based on the results of dolphins' survey, the study area has an estimated population of 34 dolphins. Under the Tier 1 sub-criteria of Criterion 1, the project site cannot be declared as Critical Habitat as percentage of dolphins found in the project site is not ≥ 10 percent of the global population and the habitat cannot be considered as a discrete management unit. The project site holds less than 0.68% (Table 4.42) of the global population of the species. Furthermore, the project area is not one of 10 or fewer global discrete management site for this species. The project site cannot be declared as Critical Habitat under Tier 2 sub-criteria of Criterion 1, as it does not support a regionally important concentration of this species (in comparison to densities of the species elsewhere in Bangladesh and beyond). There is also no other reason to consider the area of significant importance to the species. Finally, the loss of this habitat will not significantly impact the long-term survivability of the species owing to its small population at the project site compared to global population. The habitat does not contain nationally important concentration of CR or EN species, as the species is considered nationally Vulnerable. If the species was

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[44] IFC criteria under PS6 are: (i) habitat of significant importance to Critically Endangered (CR) and/or Endangered (EN) species; (ii) habitat of significant importance to endemic and/or restricted-range species; (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species; (iv) highly threatened and/or unique ecosystems; and, (vi) areas ssociated with key evolutionary processes.

[45] "discrete management unit," an area with a definable boundary within which the biological communities and/or management issues have more in common with each other than they do with those in adjacent areas (adapted from the definition of discreteness by the Alliance for Zero Extinction). A discrete management unit may or may not have an actual management boundary (e.g., legally protected areas, World Heritage sites, KBAs, IBAs, community reserves) but could also be defined by some other sensible ecologically definable boundary (e.g., watershed, interfluvial zone, intact forest patch within patchy modified habitat, seagrass habitat, coral reef, concentrated upwelling area, etc.). The delineation of the management unit will depend on the species (and, at times, subspecies) of concern. (PS 6 GN65)

considered as nationally CR or EN, the area would have been considered Critical Habitat under Tier 2 sub-criteria of Criterion 1.

Table 4.42: Results of dolphin survey

Species Name	Global Status	National Status	Global Population	National Population	Population in Project Site	% of Global Population	% of National Population
Ganges River Dolphin	Endangered	Vulnerable	<5000	Unknown (225 in Sundarbans, 125 in Karnaphuli River, 38–58 in Jamuna River and 34–43 in nine groups in Kushiyara River)	34	<0.68%	<7.5%

Source: (i) Braulik and Smith (2017), IUCN Bangladesh (2015).

Criterion 2: Endemic and/or restricted-range species

324. The project site cannot be considered as Critical Habitat under Criterion 2, as there was no record of any endemic or restricted-range species from the surveys.

Criterion 3: Migratory and/or congregatory species

325. The project site cannot be considered as Critical Habitat under Tier 1 of Criterion 3 as no migratory or congregatory species were recorded whose ≥ 95% population relies on this habitat. The project site cannot be considered as Critical Habitat under Tier 2 of Criterion 3, as the project site has fulfilled the requirements of Tier 2.

Criterion 4: Highly threatened and/or unique ecosystems

326. The project site cannot be considered as Critical Habitat under Criterion 5, as it cannot be considered as a highly threatened and/or unique ecosystem under the given standards.

Criterion 5: Key evolutionary processes

327. The project site cannot be considered as Critical Habitat under Criterion 5, as area does not fulfill the standards set under criterion.

Critical Habitat for Fish and Other Wildlife

328. A total of six species of fish were found to be included in the recently published National IUCN Redlist (2015). These six fish species have EN status as per the National RedList, but the global status of these 6 species are: four Least concerned (LC) and two Near threatened (NT) (Detail Appendix 10). The data collected on these species is inadequate to analyze the species abundance as well as Critical Habitat. Due to the unavailability of the data, the Critical Habitat analysis was done using the national/regional range of these species as a proxy. When

considering the range of the species, the project site cannot be considered as critical habitat for these species.

329. Regarding Smooth-coated Otter, we have no direct evidence/sighting during field survey period. Due to the unavailability of the data, the Critical Habitat analysis was done using the national/regional range of these species as a proxy. When considering the range of the species, the project site cannot be considered as critical habitat for these species.

330. Regarding Irrawaddy Dolphin, only one sighting of a group consisting of four individuals was recorded. This sighting was only during the second winter survey. There was no other sighting from previous six surveys. Although the species is globally Endangered, and nationally Near Threatened, the population in the project area is not large enough to fall under any criterion of Critical Habitat. The national population of this species is around 6,000 individuals (IUCN 2015).

Species Name	**Distribution range in Bangladesh (IUCN 2015 Redlist)**	**Remarks**
Smooth-coated Otters (*Lutrogale perspicillata)*	This species is mainly found in hilly areas of northeast, southeast coastal region with the largest population is in Sundarbans. The total extent of occurrence is 1,34,973 km^2	Although the species is considered as CR nationally, it still has a large area of occupancy, and thus cannot be considered for the Critical Habitat assessment. Furthermore, there have no direct evidence/sighting during field survey period. Interviews of local people were held and only one person had claimed (out of 6 interview surveys) that the species was sometimes found in the area
Fish		
Tire-track Spinyeel (*Mastacembelus armatus)*	Found in rivers, canals, beels, ponds, and inundated fields throughout Bangladesh. The total extent of occurrence is 217,468 km^2	Although the species is considered EN nationally, the species has a fairly large area of occupancy and found throughout Bangladesh. Considering the range of this species, the area cannot be considered CH for this species.
Humped Featherback (*Chitala chitala)*	Considered as a widely distributed species in rivers, beels, haors, reservoirs, canals and ponds. The total extent of occurrence is 131,403 km^2.	The species is recorded through interview survey (2 out 3 surveys). There was no direct evidence in the project site. Furthermore, the species is widely distributed throughout the country and considering the range and area of occupancy, this species, the area cannot be considered CH for this species.

Species Name	Distribution range in Bangladesh (IUCN 2015 Redlist)	Remarks
Giant Snakehead (*Channa marulius*)	The Padma, Padma distributaries, Borulia haor (Nikli, Kishorganj), Mahananda, Choto Jamuna, Ichanoi Beel (Gaibandha), Dogger Beel (Chandpur), Titas, larger haors in Greater Sylhet and Mymensingh Districts, beels and larger water bodies in Dhaka, Manikganj and Tangail Districts. The total extent of occurrence is 70,254 km^2.	The species is recorded through interview survey (1 out 3 surveys) and there was no direct evidence in the project site. According to the national distribution, this species is not found in or near the project area.
Pabda catfish (*Ompok pabda*)	The species is widely distributed throughout Bangladesh and reported from Padma, Jamuna, Meghna, Surma, Kushira, Manu Ichamati, Banglali, Turag, Baral, Choto Jamuna, Mahananda, Muhuri, Barnai and Titas Rivers Feni Reserviour, Tanguar Haor, Hakaluki Haor, Chalan Beel and Medha Beel. The total extent of occurrence is 121,601km^2.	The species has a large EOO and found throughout Bangladesh. Considering the range of this species, the area cannot be considered CH for this species.

331. Therefore, while there are sightings of the Ganges River dolphins, an endangered species, the project site is not a critical habitat. However, their presence will be carefully considered in planning for the transport of goods and equipment along Bhairab-Rupsha River system and construction works. Monitoring will be included in the environmental management plan (EMP).

4.4 Socio-economic condition

332. Primary data was collected using tools and techniques such as Rapid Rural Appraisal (RRA) KII, observations and informalconsultations. Secondary data was gathered from the Population and Housing Census 2011 published by the Bangladesh Bureau of Statistics (BBS) in 2012 and other relevant sources.

333. **Area and location.** According to Spatial GIS Analysis of CEGIS (2016), administratively the study area consists of 15 unions and 33 wards under the Khulna City Corporation either partially or fully. The upazilas are: Batiaghata, Dighalia, Dumuria, Phultala, Rupsha and Terokhada.

334. **Population.** There are 244,630 households in the study area with a total population of 1,038,877 of which 535,780are males and 503,097are females. The female population is found

to be lower than male population (**Table 4.43**). The male-female ratio is 108 which is higher than the national figure of 100.3 (BBS, 2012).

Table 4.43: Demographics in the study area

Households	Population			Sex ratio
	Total	Male	Female	
244,630	1,038,877	535,780	503,097	108
	100 (%)	51.6 (%)	48.4 (%)	

Source: Population Census 2011 (BBS, 2012)

335. **Household size.** About 27% of the households comprisesof 4 persons, 22% comprises of 3 persons, 7% comprises of 7 persons, and 5% comprises of 8 persons. The average household size is 4.2 whereas the national average is 4.4 (BBS, 2012).

336. **Age structure.** The highest number of population (about 26.8%) belongs to the age group, 30 to 49 years while the lowest number (about 2.6%) belongs to the age group, 60 to 64 years old. Age groups of 0-14 years is defined as children, 15-24 years as early working age, 25-59 years as prime working age, above 60 and over as elderly people. This classification is important as the size of young population (under age 15) would need more investment in education while size of older populations (ages 65 and over) would need for investment in the health sector.

337. **Land holding.** Based on the Census of Agriculture (2008), about 63% of the households are non-farm holders and 37% farm-holders. The farm-holders are mainly small (30%) with only 1% represents large farm-holder.

338. **Housing condition.** On average, 30% of the households live in pucca houses, 38% in kutcha, 30% in semi-pucca, and about 2% in Jhupri houses.

339. **Economy and employment.** About 41% is employed in different sectors represented by 34% male and only 7% female. Population engaged in household work is about 34% while 24% of the population is not working. Only 1% of the population is looking for work.

340. **Occupational pattern.** Main occupation in the study area is service (55%), about a quarter (23%) of the population is engaged in agriculture, and 22% in industrial work. Of the 55% engaged in the service group, 42% are male and only 13% female.

341. **Labor availability and wage rate**. The wage rate varies between Tk250 to Tk500 per day. Few migrant laborers tend to stay in the study area most of the year but return to their home at the end of the year with all their income. Women's participation in the agricultural sector is negligible (**Table 4.44**).

Table 4.44: Labor availability and wage rate in the study area

Type		Male			Female		
		Labor Availability	Average Wage Tk/day		Labor Availability	Average Wage Tk/day	
			Max.	Min.		Max.	Min.
Farming	Skilled	High	350	250	Nil	-	-
	Non-Skilled	High	250	200	Low	200	150
Non-Farming	Skilled	Medium	500	400	Low	350	300

Type		Male			Female		
		Labor Availability	Average Wage Tk/day		Labor Availability	Average Wage Tk/day	
			Max.	Min.		Max.	Min.
	Non-Skilled	High	350	300	Medium	250	200

Source: CEGIS fieldwork, 2016.

342. **Population migration.** Migration is common in the study area in terms of seasonal labor. During the rainy season, they remain without work and thus, migrate temporarily to other districts for livelihood. They normally migrate to Dhaka, Sylhet and Mymensingh where they work as labourers, rickshaw pullers, and small-scale businessman, etc. The migration status in the study area is shown in **Table 4.45**.

Table 4.45: Migration status in the study area

Type of Migration	Labor Migration-Out		Labor Migration-In	
	Place of destination	% of total population	Place of origin	% of total population
Seasonal labor migration	Dhaka, Chittagong, Bagerhat	8	Bagerhat, Gopalganj, Pirojpur, Barisal, Jhalokathi, Satkhira	15%
Permanent household migration	Dhaka, Chittagong, Bagerhat	2%	Bagerhat, Gopalganj, Pirojpur, Barisal, Jhalokathi, Satkhira	1%

Source: CEGIS fieldwork, 2016.

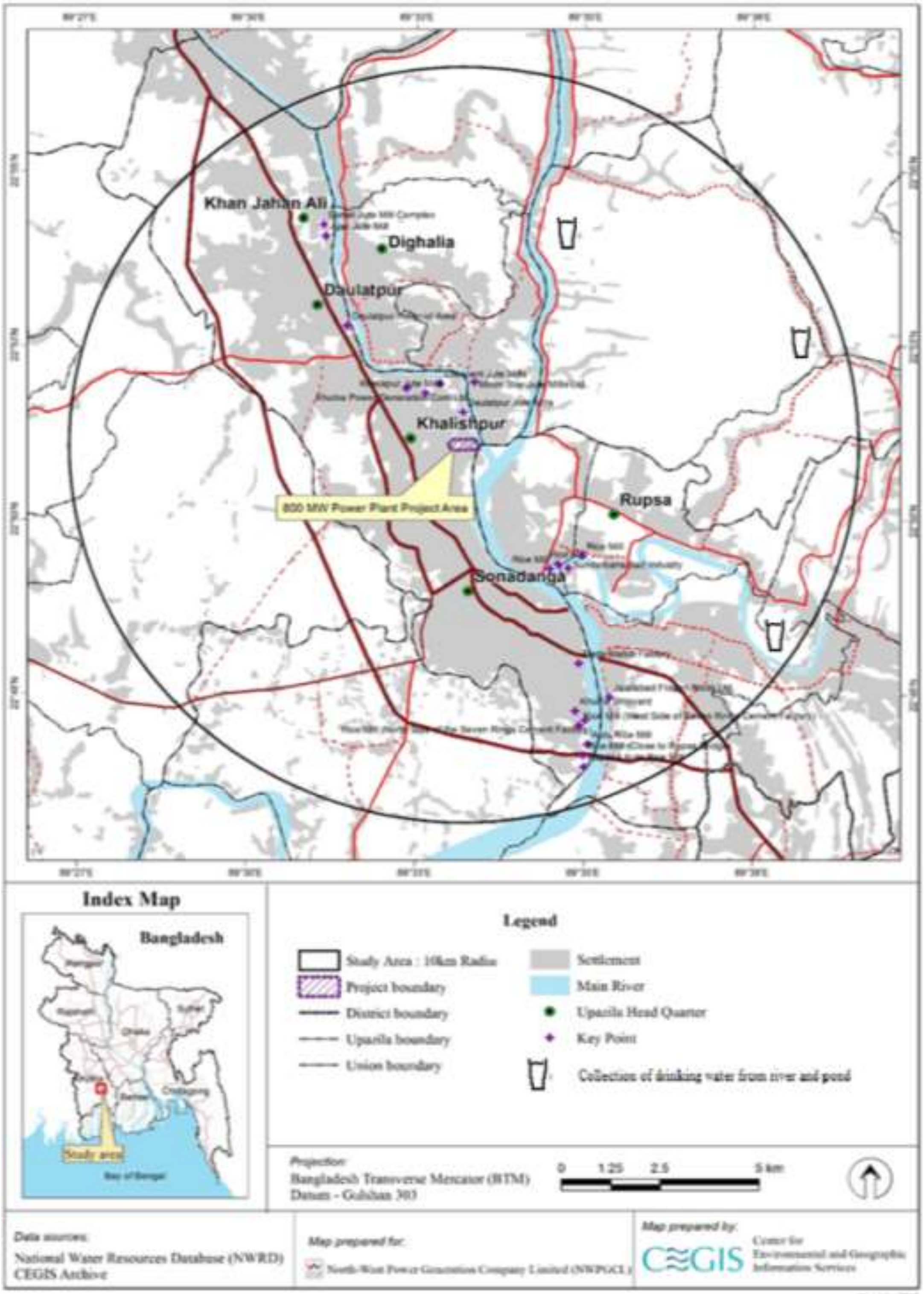
343. **Drinking water facility.** According to BBS 2012, drinking water supply is predominantly tube well (95%). About 4% of the households depend on tap water whereas only 1% of the household rely on some other sources (i.e., pond, river and canal) which are about 7 km to 8 km from the project area (**Figure 4.52**).

344. **Sanitation.** About 87% of the population in the study area has sanitary toilet facilities but still about 12% use non-sanitary toilet. Of the sanitary toilet facilities, 42% are water sealed and 46% are non-water sealed.

345. **Electricity coverage.** About 86% of the households are grid-connected to meet their daily demand. This rate is high compared to the national coverage of 53%.

346. **Road networks.** Transport connectivity in the study area includes roadway, railway and waterway. The main roadway to the project area is from Jessore-Khulna highway road at Notun Rastar to Khalishpur. The Khulna railway station is not very far, about 5 km from Rupsha 800 MW CCPP. The nearest airport is in Jessore district. Water connections are mainly throughout the Bhairab River, Rupsha River and Poshur River. These are tidal rivers with significant contribution to the industrial development in the area due to ease of moving goods and people.

Figure 4.52: Areas of river and pond water drinking people



347. **Community health condition.** Local people in the study area reported that prevalent diseases are water borne like diarrhea, typhoid, pneumonia, jaundice, skin diseases, etc. Children are mostly affected by water borne diseases.

348. Instant health facility is inadequate in nearby areas except the Khulna City corporation area. Hyper tension/high blood pressure is also increasing among the people. Disability is also found in the study area (less than 1% of the population). Most common type of disability is physical followed by vision, mental, and speech (Sadar Hospital 2015). In Khulna district, most common illness is pneumonia, bronchial asthma, chronic obstructive pulmonary disease, and whooping cough. These illnesses can be aggravated by poor air quality, nutrition, and smoking.

349. **Health service facility.** There is an existing 250-bed health complex in Boira. Patients from different districts go to this facility to avail of better medical treatment. There are a number of private clinics in Khulna city also.

350. About 48% of patients go to trained physician as people have easy access to the trained physician in Khulna city. A quarter of the population (25%) go to paramedic doctor, still 22% go to quack doctor or informal treatment, and about 5% do not have access to medical treatment. Local people are nowadays much more aware about their health. They are eager to receive health treatment from trained physicians but most of the patients are not able to do that due to lack of financial capacity and road accessibility.

351. **Literacy rate** is 68% in the study area compared to the national rate of 52% and divisional rate of 53%. Literacy is higher in males (71%) compared to females (65%). There are two schools in the project site: KNM Secondary Boys School and KNM Secondary Girls School (**Figure 4.53**). These structures will be affected by Component 1, and thus, will be relocated prior to any construction works. The relocation of the schools will be based on the outcome of consultations among the school authority, NWPGCL, and school committee.

Figure 4.53: Boys and girls school at the project site

352. The school is on 1.81 acre. The number of total students is 450 (i.e., 150 girls and 300 boys) and the total number of teachers is 23.

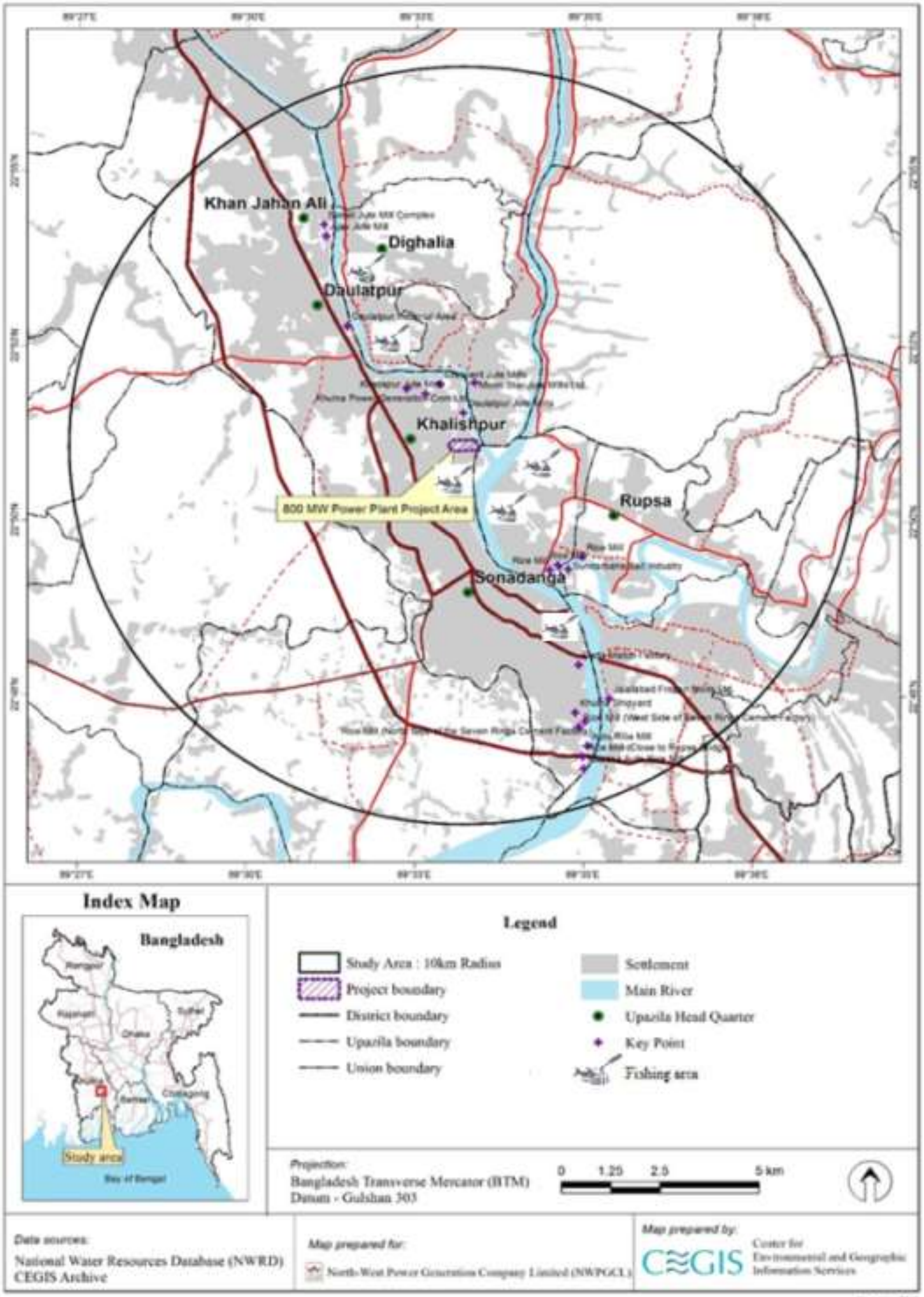
353. **Vulnerability to natural disaster.** Khulna is situated in the natural disaster-prone area geographically. Local people indicate that waterlogging, salinity intrusion, cyclone, surge, river erosion are the main problems where in the study area where these occur almost every year. River erosion is observed in the opposite river bank of Bhairab River from the project site. Salinity intrusion occurs 3 to 5 months a year.

354. **Safety nets.** There are several social safety nets and poverty reduction programs in the study area which include the Vulnerable Group Development (VGD), Food/Taka for Work (F/TFW), Food for Education/Cash for Education, Rural Maintenance Program (RMP), Old Age Allowance, Freedom Fighter Allowance and Integrated Poverty Reduction Program. According to the local people, these programs have created food security as well as social security among the targeted poor households and vulnerable communities. A number of local, national and international NGOs are also working in the study area. The main activities of these NGOs are operating microcredit programs among the rural poor and landless women/men.

355. **Tourist attractions spots, religious, cultural heritage and archaeological sites.** There are different tourist spots. Some of these tourist attractions include: botanical garden, Dakatia Bil (Fhultala-Dumuria), graveyard of Birshresta Ruhul Amin, Hardboard Mill, Kalibari Temple, Khulna University, Khulna Shipyard, Khulna Stadium, Khulna Hadis Park, Khan Jahan Ali Bridge (Rupsha Bridge), Khalishpur Wonderland Shishu Park, Jahanabad Cantonment Zoo, Rabindranath Tagore’s father-in-law’s house (Dakkhindihi, Phultala).

356. **Fishermen community adjacent to the project site.** There is a fishermen community in the Chandonimahal village within the study area (**Figure 4.54**). The community is across the Bhairab River from the project site. Administratively, it is in the Senhati union under Dighalia upazila, Khulna. Field survey shows that there are about 100 fishermen households in this area. For fishing activities, they have 20 boats. The average income for each boat is Tk400/day. The average manpower in each boat is 3 to 5 persons. The fishing areas are more or less 5 km upstream and 5 km downstream in the Bhairab River with respect to the project site. The average fish catch per day during the dry season is about 2 kg to 10 kg and about 10 kg to 400 kg during the wet season. These fishermen mainly depend on the Bhairab River, but some are partially involved as day laborer, rickshaw puller, and boatman. Some of them work with the local businessman (mohajon) and go out to sea to do fishing. Women are mainly engaged in household chores. On some occasions, the women get involved in preparing and repairing of fishing nets for their own family, sewing clothes, etc.

Figure 4.54: Fishing catchment area of Chondoni mohal fishermen



5.0 ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

5.1 Introduction

357. The project area will require extensive site preparation due to the presence of abandoned buildings left from the closure of the KNM operations in 2002.The proposed major activities will involve demolition of the existing abandoned brick buildings, construction of labor camps, cutting of trees, site preparation, transportation of machinery and ancillaries, storage of equipment and materials for construction, erection of all equipment and machineries, construction of gas pipelines, etc. The project-related activities will have diversified impacts on the environment and socio-economic conditions of the local people. Among the impacts from the proposed activities, some are temporary in nature and limited to pre-construction and construction period, and others are continuous until the operation phase.

358. Based on the experience from other similar power generation projects, many of the environmental issues are addressed through technological intervention in the project design (e.g., minimize NO_x emission by using low NO_x burner, condenser cooling tower, decrease specific-relative fuel requirement, etc.) and some of the impacts will be minimized within permissible limits by following site-specific mitigation measures as required. Demolition of the existing leftover brick buildings, clearing of bushes and felling of trees during site preparation and labor camp induced sanitation and social stress are the most significant impacts of the construction works. Clearing of vegetation and tree cutting will have ecological effect as the habitat is destroyed or fragmented.

359. Technological improvement is expected to reduce the generation of solid and liquid waste which will facilitate management of such wastes within the environmental limits. The overall positive impacts of the project are as follows: the enhancement of the generation capacity of the electricity and improving the socio-economic conditions and lifestyle of the local as well as of the people of this country.

5.2 Impact Assessment Methodology

360. Potential environmental and social impacts were identified on the basis of the review of Feasibility Report, field visits, analysis of the primary and secondary data and stakeholder consultations. The significance of potential impacts was assessed using the criteria and methodology given below.

5.2.1 Impact Magnitude

361. The potential impacts of the project have been categorized as major, moderate, minor or nominal based on consideration of the parameters such as: i) duration of the impact; ii) spatial extent of the impact; iii) reversibility; iv) likelihood; and v) legal standards and established professional criteria.

362. The magnitude of potential impacts of the Project has generally been identified according to the categories outlined in **Table 5.1**.

Table 5.1: Parameters for determining magnitude

Parameter	Major	Moderate	Minor	Minimal
Spatial extent of the potential impacts	Widespread far beyond project boundaries	Beyond immediate project components, site boundaries or local area	Within project boundary	Specific location within project component or site boundaries with no detectable potential impact
Reversibility of potential impacts	Potential impact is effectively permanent, requiring considerable intervention to return to baseline	Potential impact requires a year or so for recovering with some interventions to return to baseline	Baseline returns naturally or with limited intervention	Baseline remains almost constant
Legal standards and established professional criteria	Breaches national standards and/or international guidelines/ obligations	Complies with limits given in national standards but breaches international lender guidelines in one or more parameters	Meets minimum national standard limits or international guidelines	Not applicable
Likelihood of potential impacts occurring	Occurs under typical operating or construction conditions (Certain)	Occurs under worst case (negative impact) or best case (positive impact) operating conditions (Likely)	Occurs under abnormal, exceptional or emergency conditions (Occasional)	Unlikely to occur

5.2.2 Sensitivity of Receptor

363. The sensitivity of a receptor has been determined based on review of the population (including proximity/numbers/vulnerability) and presence of the features on the site or the surrounding area. Each detailed assessment has defined sensitivity in relation to the topic. Criteria for determining receptor sensitivity of the Project's potential impacts are outlined in **Table 5.2**.

Table 5.2: Criteria for determining sensitivity

Sensitivity Determination	Definition
Very High	Vulnerable receptor with little or no capacity to absorb proposed changes or minimal opportunities for mitigation.
High	Vulnerable receptor with little or no capacity to absorb proposed changes or limited opportunities for mitigation.
Medium	Vulnerable receptor with some capacity to absorb proposed changes or moderate opportunities for mitigation
Low	Vulnerable receptor with good capacity to absorb proposed changes and/or good opportunities for mitigation

5.2.3 Assigning Significance

364. Following the assessment of magnitude, the quality and sensitivity of the receiving environment or potential receptor has been determined and the significance of each potential impact established using the impact significance matrix shown in **Table 5.3**.

Table 5.3: Significance of impact criteria

Magnitude of Impact	Sensitivity of Receptors			
	Very High	**High**	**Medium**	**Low**
Major	Critical	Major	Moderate	Minimal
Moderate	Major	Major	Moderate	Minimal
Minor	Moderate	Moderate	Minor	Minimal
Minimal	Minimal	Minimal	Minimal	Minimal

5.2.4 Summary of Assessed Impacts

365. The project's potential impacts and their significance have been assessed using the methodology described above. A summary of these impacts and their significance is presented in **Table 5.4**.

Table 5.4: Potential impacts and their significance

IECs/Issues	Potential Impacts from Various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to relevant regulations/laws
Environmental impacts during pre-construction and demolition stage					
A. Ambient Air					
A1. Dust particles from brick buildings located at the demolition site	Emissions of dust will be generated from demolition of the existing buildings, transportation of the rubbish materials. SPM will be the major emitting pollutants during the demolishing works. Dragging of the trees (cutting or falling) over the roads will also generate dust into the ambient environment	Medium	Moderate	Moderate adverse	ECR 2005 WBG General EHS Guidelines, 2007

IECs/Issues	Potential Impacts from Various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to relevant regulations/laws
B. Ambient Noise					
B1. Noise pollution	High amount of noise will be produced during demolition of the leftover buildings. Manual destruction of the buildings will generate high impulse noise to the surrounding environment.	High	Major	Major Adverse	Noise Pollution Control Act, 2006 of Bangladesh including IFC EHS General Guidelines2007 (same comments apply for all H&S and pollution risks in this table)
B2. Vibration	Demolition works may generate vibration which may responsible of community annoyance or cloaplse of relic structures.	High	Moderate	Major	
C. Water Resources					
C1. Surface water availability	Navigation for transportation of machineries and other equipment transportation	Low	Minor	Minimal	ECP3
C2. Salinity	Workers and other professional will face difficulty to drink and use of groundwater	Low	Minor	Minimal	ECP 3
C3. Erosion and accretion of soil, debris, contaminants, unvegetated soil, including suspended sediment in the runoff and Accretion	Regular erosion of river bank inside the study area. Protected by the sheet pile	Medium	Minor	Minor	ECP6
C4. Flooding	Regular flooding on the project land	High	Moderate	Major	ECP 3 and Performance Standards on Environmental and Social Sustainability
C5. Intake channel outlet	Adequate depth available for the intake at the eastern boundary	Low	Minor	Minimal	ECP 3

IECs/Issues	Potential Impacts from Various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to relevant regulations/laws
D. Land Resources					
D1. Land Type	The Land previously used for industrial purposes will be raised to avoid flood risk	Low	Minor	Minimal adverse	
D2. Soil Quality	During pre-contraction stage, earth works will be initiated (approach road, land development etc.). As a result, top soil quality would be deteriorated and contaminants will be mobilized through source-pathway receptor and may also contaminate ground water as well	Low	Minor	Minimal adverse	ECP 7
E. Livestock Resources					
		No impact	No impact	No impact	
F. Fisheries Resources and possible contamination	During demolition and filling of land and river bank protection activities may have impact on fisheries. Ships and vehicles carrying demolished materials may have oil/fuel spills which may contaminate water and fisheries including food chain	Medium	moderate	minimal	
G. Ecological Environment					
G1. loss of plant and wildlife	During this clearing and demolition process, some of the common	Medium	Moderate	Minimum	ECP 13

IECs/Issues	Potential Impacts from Various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to relevant regulations/laws
	lizards, frogs may be affected. In addition, loss of trees, works to river bank impacting on fish etc.				
G2. Dust and sound pollution impact on vegetation and wildlife	During demolition of buildings, it is expected to create sound pollution and dust which may affect surroundings vegetation and wildlife.	Medium	Moderate	Minimal	ECP 11, ECP 13, ECP 12
G3. Chop down of terrestrial vegetation	Chop down of terrestrial vegetation has been planned (trees, herbs and shrubs) to initiate land development process which will reduce carbon sequestration of about 6880.480046 for 30 acres of land cover and will ultimately impact biological process and food chain as well	High	Major	Moderate	ECP 12
G4. Habitat, life loss and relocation of mammals, birds and other wildlife	Removal of enormous terrestrial vegetation (trees, shrubs, herbs) may cause damage of habitat of some mammals, reptiles etc., which may create pressure on other species. The land development activities would impact to other micro wildlife, invertebrates also at the project area.	Medium	Moderate	Minimal	ECP 13

IECs/Issues	Potential Impacts from Various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to relevant regulations/laws
G5. Riverine, dolphin habitat and benthic community	The existing Bhairab river habitat may be impacted due to discharge of oil spill which may ultimately contaminate food chain. In addition, under water noise during transportation of ship along the river for carrying of construction and demolished materials, machineries to the project site may impact aquatic faunal species.	Low	Minimal	Low	ECP13
H. Socioeconomic Condition					
H1. Demolition of buildings, trees and other structures	Demolition of structures may generate dust, create noise and thus, may cause some environmental and aesthetic impact	Medium	Medium	Moderate adverse	Labor Law, 2006, ECP17
H2. Worker's health	Worker's exposed to dust and noise during pre-construction may affect their health	Moderate	Moderate	Moderate adverse	WHO Guidelines, ECP18, ECP16, Labor Law, 2006. In addition, demolition works to be conducted by experienced and qualified contractor.
I. Non-Hazardous Waste Generation					
I1. Solid Waste	Aesthetic degradation due to negligence in management of waste generated from vegetation clearance, land development and domestic activities	Moderate	Minor	Minor adverse	ECR 1997, IFC's Performance Standards on Environmental and Social Sustainability
I2. Liquid Waste and Sewerage	Aesthetic degradation due to negligence in management of waste	Low	Minor	Minor adverse	ECR 1997, IFC's Performance Standards on Environmental and Social Sustainability

IECs/Issues	Potential Impacts from Various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to relevant regulations/laws
I3. Leaching of generated wastes to nearby environment	Generated waste can be washed away and pollute nearby water bodies; thus, affecting aquatic ecosystems. Wastes generated may also lead to the spread of various pathogens if not properly managed	Moderate	Moderate	Moderate adverse	ECR 1997, IFC's Performance Standards on Environmental and Social Sustainability
Environmental Impacts during construction stage					
J. Ambient Air					
J1. Dust and gases from construction equipment and vehicles	Emissions of dust and gases will be generated from excavation of trenches, operation of construction equipment and vehicles, and material transport, which may cause injurious to health and ecosystem	Medium	Moderate	Moderate adverse	ECR 2005 WBG General EHS Guidelines, 2007
K. Ambient Noise					
K1. Noise pollution	Noise would be generated from the moving and idling vehicles and heavy machineries, which may cause disturbance, increased stress level, increased blood pressure etc. on the people who are susceptible to the generated noise.	Moderate	Medium	Moderate adverse	Noise Pollution Control Act, 2006 of Bangladesh
K2. Vibration	Vibration will be generated from the machines i.e. mainly hammer machines, rammers etc. during construction equipment	Moderate	Medium	Moderate adverse	

IECs/Issues	Potential Impacts from Various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to relevant regulations/laws
	causes ground vibrations and spread through the media.				
L. Water Resources					
L1. Surface water availability and possible contamination	In sense of consumption for making mortar, curing, wetting including possible contamination due to fuel and other chemicals. In addition, compacting of the land, sprinkling on ground and other construction works need a huge amount of fresh surface water during this period.	Low	Moderate	Minimal	ECP3
L2. Salinity	Workers and other professional will face difficulty to drink and use of groundwater	High	Moderate	Major	ECP 3 and Performance Standards on Environmental and Social Sustainability
L3. Erosion and Accretion	High flood water may erode the east boundary of project during the construction. Loading and unloading of machineries and equipment's from waterway, may create additional damage of river bank.	High	Major	Major	ECP6, BWDB river protection works and ECR 1997, Performance Standards on Environmental and Social Sustainability
L4. Flooding	Flooding on the project land may damage the stored equipment and materials and make the project delay.	Low	Moderate	Minimal	ECP 4

IECs/Issues	Potential Impacts from Various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to relevant regulations/laws
L5. Intake channel outlet	Land development works may decrease the depth of water for intake while soil slide over the slope during land filling.	Low	Moderate	Minimal	ECP3
M. Land Resources					
M1. Soil Quality	During site preparation, earthworks will impact the fertile top soils that are enriched with nutrients required for afforested and naturally grown plant growth.	Low	Minor	Minimal adverse	ECP 7
N. Livestock Resources					
		No impact	No impact	No impact	
N1. Fisheries Resources	Bank protection may impact fisheries due to soil run off. In addition, fuel may leak from vehicle and river transport for carrying construction materials which ultimately impact water quality and fisheries including food chain	Medium	Medium	Minimal	
N2. Habitat condition and quantity	Bhairab River is rich in Hilsa, Deshi Pangus and Shrimp PL, which would be affected due to disposal of wastewater like ballast and bilge water from the ship/cargo carrying machinery and ancillaries having oil and grease contaminants.	Medium	Moderate	Moderate adverse	ECP 14

IECs/Issues	Potential Impacts from Various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to relevant regulations/laws
	Open water fish habitat would also be affected due to the washing of various solid waste such as sand particles, food wastes, cans, and bottles etc. generated by the plant workers.				
N3. Fish species diversity and composition	Alien species may be introduced through Ship carrying heavy machineries from abroad. Therefore, invasive species may cause negative impacts on pelagic and benthic communities.	Medium	Minor	Minor adverse	ECP 14
N4. Fish production	With the consequence of aforesaid reasons, fisheries resources may cause decline in fish productivity of the river and its connectivity.	Medium	Minor	Minor adverse	ECP 14
O. Ecological Environment					
O1. Riverine, dolphin habitat and benthic community	Construction of jetty for anchoring of ship and cargos to the Bhairab River may temporarily disturb dolphins' movement and benthic community. The riverine water quality may be deteriorated due to disposal of waste water and oil spill from the ship during transportation of machineries, materials etc.	Low	Minimal	Low	ECP 13

IECs/Issues	Potential Impacts from Various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to relevant regulations/laws
P. Socio-Economic Condition					
P1. Worker's exposed to dust and noise during pre-construction may affect their health	Worker's exposed to dust and noise during pre-construction may affect their health	Moderate	Moderate	Moderate adverse	Labor Law, 2006, ECP17, ECP18. In addition, all demolition activities to be conducted by experienced qualified contractors.
Q. Non-Hazardous Waste Generation and Hazardous Materials					
Q1. Solid Waste	Aesthetic degradation due to negligence in management of waste generated from construction activities, soil contamination and also water contamination due to demolished hazardous materials and also from labor sheds	Medium	Moderate	Moderate adverse	ECR 1997, ECP 1, ESMS
Q2. Leaching of generated wastes to nearby environment	Large amount of generated waste including demolished sewage can be washed away and pollute nearby water bodies; thus, affecting aquatic ecosystems. Wastes generated may also lead to the spread of various pathogens if not properly managed	High	Moderate	Major adverse	ECR 1997, IFC's Performance Standards on Environmental and Social Sustainability
Environmental impacts during operation stage:					
R. Ambient Air					
R1. Maximum ground level concentration of pollutants	Emission of exhaust gas from the stack may contribute elevated ground concentration of CO, SO_2, NO_x, PM_{10}, $PM_{2.5}$ etc.	Medium	Moderate	Moderate adverse	ECR 2005 WBG General EHS Guidelines, 200

IECs/Issues	Potential Impacts from Various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to relevant regulations/laws
	at the downwind direction.				
S. Ambient Noise					
S1. Noise Pollution	Noise producing from the RMS, gas turbine and HRSG units cumulatively would have a tendency of exceeding the noise level standard in some places. This might result in hearing complexity and loss along with increased blood pressure, disturbances and discomfort to the site engineers, technicians and workers and surrounding communities.	Major	Medium	Moderate adverse	Noise Pollution Control Act, 2006 of Bangladesh
T. Water Resources					
T1. Surface water availability	Extraction of water for one time and also regular extraction for make -up water from adjacent Bhairab River (source-surface water) particularly in dry season may have potential impact on availability of water resources for other users.	Medium	Moderate	Minimal	ECP3. In addition, about 0.12% of water against discharges of the Bhairab river will be extracted for this power plant
T2. Salinity and other contaminants	Level of salinity will increase due to low infiltration at ground water table. In addition, fuel, oil and runoff from contaminated soil may also impact ground water	Medium	Moderate	Moderate	ECP 3 and ECP4

IECs/Issues	Potential Impacts from Various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to relevant regulations/laws
T3. Erosion and Accretion	Damages due to anchoring, unloading goods and materials and other natural disasters.	Low	Moderate	Minimal	ECP6
T4. Flooding	Designed land level may not be suited for extreme flood and energy of high flood water may create more erosion on the other bank of this river to dissipate in case of project development.	Medium	Moderate	Moderate	ECP 4 and Performance Standards on Environmental and Social Sustainability
T5. Intake channel outlet	Continuous loading and unloading of goods and equipment by jetty may reduce the depth of water there by the bank erosion due to wave action induced by the ship/Berge during anchor.	Low	Moderate	Minimal	ECP 6
U. Fisheries Resources					
U1. Fish habitat condition and quantity	Abstraction of river water at the rate of 2010m3/hr for operating power plant may cause crisis for river water availability during dry season which alter the capture fish habitat condition.	High	Major	Major adverse	ECP 14
U2. Fish species diversity and composition	Water intake from the Bhairab River would entrap fish, crustaceans and other aquatic organisms	Very High	Critical	Major adverse	ECP 14

IECs/Issues	Potential Impacts from Various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to relevant regulations/laws
	particularly the sluggish species. Predator-prey relationship might be affected due to spread of invasive species through ballast water. Integrated impact to be caused for withdrawal of water 2010 m3/hour may alter the fish diversity due to salinity intrusion.				
U3. Fish production	With the consequence of aforesaid reasons, estimated net loss to fish production would be 240Mt per year from the study area.	High	Major	Major adverse	ECP 14
U4. Fisheries Based Livelihood.	Associated livelihood would be affected due to the reduction of catch per unit area and effort and would narrow down the fishing area.	High	Major	Major adverse	ECP 14
V. Ecological Environment					
V1. Impact on terrestrial vegetation	The emission of SO_x, NO_x and SPM including noise level may have significant impact on vegetation and other sensitive receptors around the project and study area.	Low	Minimal	Low	NCS, 1992
V2. Riverine, dolphin habitat and benthic community	Transportation of power plant equipment, other materials including fuel	Moderate	Minimal	Low	ECP 13

IECs/Issues	Potential Impacts from Various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to relevant regulations/laws
	during operation period along the river ways, may degrade the riverine water and habitat quality of aquatic species due to movement, creation of underwater noise, and discharges of waste and oil spill from all these river transports. Water extraction from Bhairab River particularly during dry season for cooling and make-up process may affect aquatic ecosystem, aquatic species including dolphin and their prey. Some of the benthic community may be trapped in the water extraction pipe and get killed.				
W. Socio-Economic Condition					
W1. Noise pollution	It may create excessive noise during the trial period of commissioning of new unit and it may cause a matter of hearing complexity, and loss along with increase blood pressure, disturbances and discomfort to the technicians and workers and surrounding communities.	Medium	Moderate	Minor	ECR, 1997 WBG General EHS Guidelines, ECP18
W2. Fisheries activities may be hampered due to heavy river traffic	Increase in river water traffic may hamper fish	Medium	Moderate	Minor	ECP15

IECs/Issues	Potential Impacts from Various Activities	Sensitivity	Magnitude	Significance Prior to Mitigation	Compliance to relevant regulations/laws
	habitats, leading to a decline in fishing activities. Fishermen community may need to look elsewhere for job opportunity.				
X. Non-Hazardous Waste Generation					
X1. Liquid Waste and Sewerage	Aesthetic degradation due to negligence in management of waste	Moderate	Minor	Minor adverse	ECR 1997, IFC's Performance Standards on Environmental and Social Sustainability
X2. Leaching of generated wastes to nearby environment	Generated waste can be washed away and pollute nearby water bodies; thus, affecting aquatic ecosystems. Wastes generated may also lead to the spread of various pathogens if not properly managed	Moderate	Minor	Moderate adverse	ECR 1997, IFC's Performance Standards on Environmental and Social Sustainability
Y. Hazardous Waste Generation					
Y1. Use of Hydrazine in feed water for oxygen scavenging	Hydrazine is genotoxic carcinogen. Exposure to hydrazine is hazardous to health. The boiler blow-down may contain residual hydrazine which may reach to river or canal ultimately.	Very High	Moderate	Major adverse	Hazardous Waste and Ship Breaking Waste Management Rules 2011, CER 1997, The International Conference on Chemicals Management in 2006 IFC's Performance Standards on Environmental and Social Sustainability
Y2. Hazardous sludge from water pre-treatment and treatment plant	Contamination of surface water, ground water and soil if not properly managed	High	Major	Major adverse	Hazardous Waste and Ship Breaking Waste Management Rules 2011, ECR 1997, IFC's Performance Standards on Environmental and Social Sustainability

5.3 Environmental Impacts during Pre-Construction and Demolition Stage

5.3.1 Ambient air quality

366. The project will be initiated with the cleaning and demolition of abandoned buildings of KNM. During demolition of the buildings, dust particles might be emitted and disperse to the local environment. The process of demolition and duration of demolition process will cause fugitive emission. During dry season especially from December to May, the emitted fugitive dust will disperse to the adjacent local environment. Presence of vegetation (trees of different types and sizes) along the project boundary will reduce the dispersion of dust particles in to the locality during demolition process.

5.3.2 Ambient noise

367. In the project area, there are old and unsafe buildings for demolition where new infrastructure and power plant will be constructed. All of the buildings inside the proposed power plant area are mainly old and outdated. In order to reduce expenditure of demolition, the contractors usually use chisels and hammers for the major part of demolition work in that areas.

368. Demolition activities would lead to an increased noise level, particularly during day time. On top of that, heavy movement of traffic and machineries would collectively raise the noise level significantly. Unless the situation is mitigated, this increased noise level due to demolition and construction activities could lead disturbances to the community. Noise may increase stress level, blood pressure and other health complications to the staffs, workers, nearby communities (schools, hospitals, mosques, madrasas etc.) and local people.

5.3.3 Vibration

369. It is evident that the demolishing activities generate a certain amount of ground borne vibration. The effects of ground – borne vibration include discernable movement of building floors, rattling of windows, shaking of items on shelves or hanging on walls, and rumbling sounds. The vibration from the construction-related activity agitates the ground, create vibration waves that propagate through the various soil and rock strata to the foundations of nearby buildings. The damage of the buildings depends of the intensity of the sources, transmitting media and vulnerability of the structures. The annoyance could be a source of major concern to occupants living in nearby residence.

370. Accordingly, it is necessary to assess and regulate the amount of allowable vibration of the southern side residence outside the project boundary so as to prevent building damages and avoid unnecessary disturbance to persons living in the vicinity. Since, the abandon buildings will be demolished quite manually like hand hammer, chisels in that case it is expecting to produce less vibration.

5.3.4 Flooding

371. Flooding from Bhairab – Rupsa River system is major and significant for the study area. According to the baseline study on flood water level analysis, the average land elevation of the project area is 2.0 mPWD which is submerged by about 0.5-1.5m every year during wet seasons. This indicates that development of the land would be required. There have already been seven profiles of flooding.

372. The area of inundation will increase if the project will be established at the designated location in the Khulna District prone to flooding. HEC-RAS steady model is used to delineate the inundations surrounding the project area.

373. Based on the Feasibility Study (August 2017), the current elevation at the project site is +3.5m and +2.3m MSL while the surrounding area is at elevation +3.5m and +3.2m MSL. The seven profiles show that the highest water level during the flooding in 1999 is 3.19m PWD. The project site will be backfilled up to a maximum of +5.5m which considered the highest water level, elevation in surrounding area, and the BPDB requirement for site formation of power plants. Thus, the risk of flooding will be low. There is an existing 225 MW Khulna CCPP in Goalpara also owned by NWPGCL. The distance of this power plant is relatively close.

5.3.5 Land Resources

Land type

374. Land type of the area will be changed after the initiation of the project. Most of the land will be raised above the normal flood level. But this area is previously used as an industrial area. As a result, this situation is considered as a Minimal Adverse.

Soil quality

375. During pre-construction stage, earth works will be undertaken (approach road, land development, etc.). As a result, top soil quality would be hampered. But due to non-agricultural land in the project area this situation is considered as Minimal Adverse.

5.3.6 Ecological Environment

Loss of life of plants and wildlife

376. The proposed project area is an abandoned land of KNM which will be transferred to NWPGCL through GoB for planned construction of Rupsha 800 MW CCPP. The abandoned buildings and cultivated trees will be cleared during pre-construction period as per layout plan of the power plant. During this clearing and demolition process, some of the common lizards, frogs may be affected as no birds and their nest noted. However, demolition and clearing activities will be conducted cautiously to avoid any loss of animals. In this regard, an Ecologist will be appointed as per EMP to avoid any loss of animals.

Dust and sound pollution impact on vegetation and wildlife

377. During demolition of buildings, it is expected to create sound pollution and dust which may affect surroundings vegetation and wildlife. The normal photosynthesis and transpiration process of plant will be affected due to dust particle.

Clearing of terrestrial vegetation

378. The project area is comprised of dense vegetation including large old trees. Clearing of vegetation will be required to initiate land development process. It is estimated that about 2,614 trees will be cleared and overall carbon sequestration loss will be approximately6880.480046Mg (for 30 acres vegetation coverage which include trees, shrubs and under growth weeds/grasses).

The plant biodiversity index of the project area is also found to be high. Therefore, clearing of vegetation would have impact on biological process, carbon sequestration and food chain.

Loss of wildlife habitat

379. Removal of enormous terrestrial vegetation (trees, shrubs, herbs) may cause damage of habitat of some mammals, reptiles etc., which may create pressure on other species. The land development activities would also impact to other micro wildlife, invertebrates at the project area.

Disturbance to aquatic biota

380. The existing Bhairab river habitat may be slightly impacted due to discharge of oil spill and under water noise created during transportation of ship along the river for carrying of construction and demolished materials, machineries to the project site. The project planned to renovate existing jetty for loading and unloading of heavy equipment. Renovation activities may have impact on the benthic community, but no impact is expected on the River dolphins as they are located and surfing different locations across all connected rivers (Bhairab, Rupsha, Atai and also Modhumoti-Bhairab confluences).

5.3.7 Socio-Economic Condition

Disturbance during shifting period

381. A number of activities will be done before the beginning of construction period. Relocation of the school, demolishing the existing abandoned buildings, clearing the trees, renovation of mosque etc. are the main activities during the pre-construction stage. The students, teachers, guardians may face difficulties during the transition period when they will be shifted to the newly constructed school building.

Community safety risks

382. Demolition of brick buildings and frequent movement of the heavy equipment's work will create dust, noise and wastage that would be harmful for the people. Handling of construction machineries, accident transportation of dispose materials, debris and other wastages may create health injury to the labours, adjacent community, and also land of the project sites. Unsafe and unhygienic labour shades may create a very hazardous health problem.

Employment opportunity

383. On the other hand, the employment opportunities would be created significantly for the labour class people during the pre-construction activities.

Non-Hazardous Waste Generation

384. During pre-construction, land development would generate large amount backfilling soil. Other wastes like food waste, plastic, papers, metal or plastic binders, etc. may also be produced as solid waste but at a very small amount. There is a high possibility that these backfilling soil and other solid wastes may leach into the surrounding water bodies via torrential rainwater and subsequent flood – that may in turn, have an impact on the aquatic ecosystem. However, considering the amount and type of waste generated the impact can be reversible when proper mitigation measures are applied. Considering these, it can be assumed that both the magnitude

and sensitivity of the impact would be moderate. by analyzing the sensitivity and magnitude, it is apprehended that the significance of the impact would be moderate adverse.

5.4 Environmental Impacts during Construction Stage

5.4.1 Ambient air

385. Fugitive dust particles may be generated due to site preparation, material transport, piling up of construction materials, excavation of trenches, batch mixing plant, etc. In addition to these, operation of construction equipment and vehicles may generate PM, CO, CO_2, NO_x, SO_x, etc. Prolonged inhalation of dusts by the site engineers and workers might suffer from lung diseases with symptoms of shortness of breath, coughing, wheezing; chest pain; loss of appetite; tiredness, etc.

5.4.2 Ambient Noise

386. The noise level at and around the proposed project site will be increased depending on the factors such as the type of equipment, methodology of using receiver distance etc. The equivalent sound level (Leq) of the construction activity also depends on the friction of time that the equipment is operated during construction. At present the noise level of project area is about 43-62 dBA around the 24 hrs. Ambient sound is the major contributor and main reason for this noise level. The proposed power plant project will involve noisy equipment for several years. The noise level will be received from the construction yard stationary and mobile sources. Stationary equipment operates in one location for one or more days at a time, with either a fixed-power operation (such as pumps, generators, and compressors) or a variable noise operation (such as pile drivers, rock drills, and pavement breakers). Mobile equipment moves around a construction site with power applied in cyclic fashion (such as bulldozers, graders, and loaders). Noise impacts from stationary equipment are assessed from the center of the equipment, while noise impacts for mobile construction equipment are assessed as emanating from the center of the equipment activity or construction site. For linear construction, such as a roadway or pipeline, construction noise is considered to emanate from the centerline of the alignment. To determine the Leq of the equipment's operation, the power variation is accounted for by describing the noise at a reference distance from the equipment operating period.

387. A number of communities are located beside the southern boundary of proposed project. Employees of KNM also stay outside the southern boundary. Women and children reside round the day of those households. Noise pollution will directly cause health hazards to construction workers on the site as well as to the residents living nearby the construction site. The construction activities must be regulated within the standard limit of ECR 2006 and IFC 2007 whichever is stringent.

388. According to data provided by US Federal Bureau of Highway, standard limiting levels of noise which can be caused by different construction equipment are summarized in the following **Table 5.5**.

Table 5.5: Noise produced by construction equipment

No.	Plants/Equipment	Traffic Vehicles Noise Level (US Standard) dBA
1	Machinery Hammer	95
2	Drilling Machine	75
3	Truck	75

No.	Plants/Equipment	Traffic Vehicles Noise Level (US Standard) dBA
4	Bulldozer	75
5	Compaction Roller	75
6	Tug Plant	75
7	Leveler	75-80
8	Pave Machine	80
9	Concrete Mixer	75
10	Generator	75
11	Vibrator	75

389. The equipment and machineries will produce cumulative noise depending on source type, number, weather condition, distance and duration of working period. If a single equipment will produce 90 dBA within 1m, it would be reduced gradually to its movement. The noise propagation method has been documented by the International Energy Agency. It is simple process for assumes spherical spreading from a point sources. The model presents a 'worst-case scenario' as it does not take into account factors like topography, large obstructions in the propagation path, e.g. barriers etc., refraction of noise, wind speed or direction effects and changing frequencies. The equation followed for the analysis is described below:

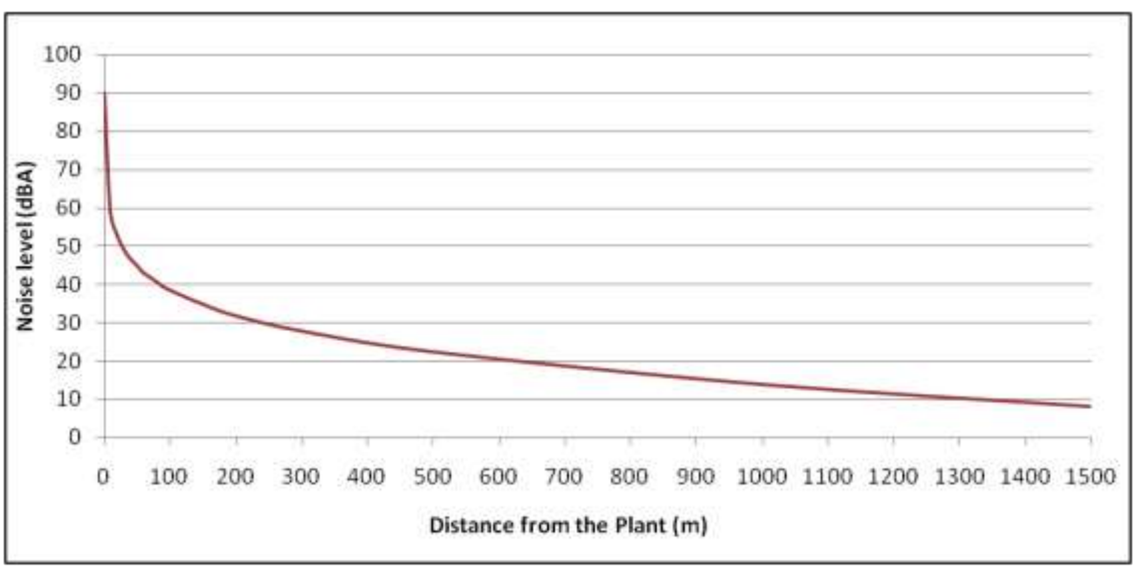
$$\mathrm{Lp} = \mathrm{Lw} - 10\log_{10}(4\Pi\, r^2) - ar$$

where:

r = distance from source to receiver
a = Atmospheric absorption, (0.005dBA/m)
Lw =Sound power level at the Plant (dBA)
Lp = Output sound power level at different radius from source

390. Without any facility boundary or other barrier/obstructions, the noise level will propagate and attenuate significantly with distance shown in **Figure 5.1**. However, the duration of noise pollution is also important to account the equivalent noise level.

Figure 5.1: Sound pressure level at different distances from the source



391. The proposed project is bounded by brick wall along with trees. Therefore, the generated noise level (Leq) from the construction yard will be obstructed by the boundary wall and trees. Most of the construction activities will be conducted around far from the southern boundaries of the project except the construction of RMS station, buildings and works shops, water treatment chemical plants, etc. At the distance of 10m from 90dBA construction site would reach to 59 dBA at the receptors. Therefore, during construction stage, the resultant maximum noise level would not increase 1.5-2.0 dBA to the nearest residence. However, the impulse noise from the equipment, vehicles or others system will annoy the local communities. Based on the impact magnitude from the potential sources used for this power plant and the sensitivity of nearby structures, the impact is defined as moderate adverse as given in **Table 5.4**.

5.4.3 Vibration

392. During the construction phase, vibration may be generated by some machines, i.e. mainly hammer machines, rammers etc. Operation of construction equipment causes ground vibrations and spread through the media. Buildings nearby the construction site respond to these vibrations in different ways such as no perceptible effects as the lowest levels, or low rumbling sounds and fellable ranges in buildings very close to the site. A possible exception is the case of old, fragile buildings of historical significance where special care must be taken to avoid damage. The construction activities like blasting or pile drive may create sever impacts. Since the primary concern with regard to construction that vibration can damage building, construction vibration is generally assessed in terms of peak particle velocity (PPV). A typical vibration source level for construction equipment has been shown in **Table 5.6**.

Table 5.6: Vibration sources level for construction equipment

Equipment		**PPV at 25ft (in/sec)**	**Approximate Lv* at 25ft**
Pile Driver (impact)	Upper range	1.518	112
	typical	0.664	104
Pile Driver (Sonic)	Upper range	0.734	105
	typical	0.170	93
Clam Shovel Drop (Slurry Wall)		0.202	94
Hydromill (Slurry Wall)	In Soil	0.008	66
	In Rock	0.017	75
Large Bulldozer		0.089	87
Caissson Drilling		0.089	87
Loaded Trucks		0.076	86
Jackhammer		0.035	79
Small Bulldozer		0.003	58
Note: *RMS velocity in decibels (VdB) re 1 μinch/Second			

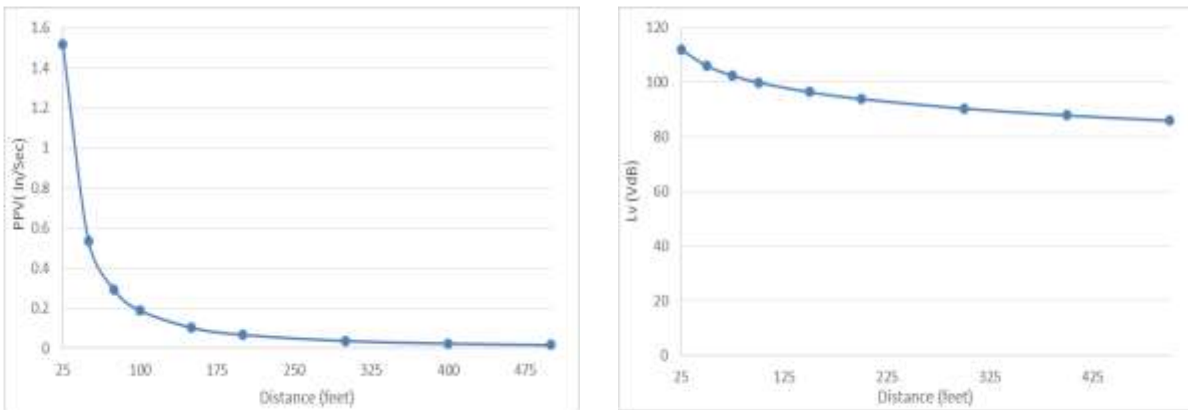
393. The construction vibration can be measured beside the construction activities which are blasting, pile driving, drilling, excavation, heavy equipment transportation etc. According to the **Table 5.6**, the maximum vibration comes from pile drive. The equation of PPV and vibration level (Lv) for determining the vibration at certain distance from the source following the equation 1 and 2. **Figure 5.2** shows how the vibration reduces with distances.

$$PPV_{equip} = PPV_{ref}\ X\ (\frac{25}{D})^{1.5} \ldots\ldots\ldots\ldots\ldots (1)$$
$$L_v(D) = L_v(25ft) - 20\log(\frac{D}{25}) \ldots\ldots\ldots\ldots (2)$$

where:

PPV $_{equip}$ is the peak particle velocity in in/sec of the equipment adjusted for distance
PPV$_{(ref)}$ is the reference vibration level in in/sec at 25 feet from Table 7.6
Lvis velocity vibration level in VdB.
D is distance from the equipment to the receiver

Figure 5.2: PPV and Lv with the distance



394. The primary concern regarding construction vibration relates to potential damage effects. The vibration damage threshold with criterion of 0.2 in/sec (approximately 100 VdB) for fragile buildings and 0.12 in/sec (approximately 95 VdB) for extremely fragile historic buildings. Beside the southern boundaries few old buildings were recorded. The PPV of the construction works reduces to 0.2 in/sec within 100 feet or 30.5 meter. One another study, Guidelines on vibration damage criteria are given in **Table 5.7** for various structural categories46. According to layout plan most maximum construction activities will be done at least 50 m distance from the boundary.

Table 5.7: Construction Vibration Damage Criteria[47]

Building Category	PPV (in/sec)
I. Reinforced-concrete, steel or timber (no plaster)	0.5
II. Engineered concrete and masonry (no plaster)	0.3
III. Non-engineered timber and masonry buildings	0.2
IV. Buildings extremely susceptible to vibration damage	0.12

395. Vibration may cause human health hazards such as tiredness, insomnia, mental disorder and working ability reduction. The International Organization for Standardization (ISO) adopted in 2003 version of ISO 2361-2 acknowledges that “human response to vibration in buildings is very complex.” It further indicates that the degree of annoyance cannot always be explained by the

46 David A. Towers, "Ground-borne Vibration from Slurry Wall Trench Excavation for the Central Artery/Tunnel Project Using Hydromill Technology," Proc. InterNoise 95, Newport Beach, CA, July 1995.

47 Swiss Consultants for Road Construction Association, "Effects of Vibration on Construction," VSS-SN640-312a, Zurich, Switzerland, April 1992.

magnitude of the vibration alone. Other phenomena such as noise, rattling, visual effects(e.g., the movement of hanging objects) and time of day (e.g., late at night) all play some roles in the response. To understand and evaluate human response, which is often measured by complaints, all of these related effects need to be considered. The available data documenting real world experience with these phenomena is still relatively sparse.

396. A number of studies have been conducted to characterize the human response to vibration. One of the studies concluded that continuous vibration from construction equipment such as roadway graders, backhoes, and dozers could be tolerated at higher vibration levels than transient vibration generated by pile driving.

397. **Table 5.8** summarizes the results that relate human response to transient vibration, which could be generated by any type of impact equipment such as pile driving. These levels of human response are more appropriate for the Project since the highest levels of construction vibration are generated by impact activities such as pile driving and from demolition using hoe rams.

Table 5.8: Human Response to Transient Vibration[48]

PPV (in/sec)	Human Response
2.0	Severe
0.9	Strongly perceptible
0.24	Distinctly perceptible

5.4.4 Water resources

Groundwater salinity

398. Salinity intrusion in the groundwater is major issue in every state of the project development. It seems that the salinity is present at any depth of groundwater including other contaminants around the project area. There will be difficulties to get drinking water from nearby sources for daily consumption due to conflict of interests with the construction workers and local users.

Erosion

399. There is no riverbank protection works present at the right bank of Bhairab River. As such the project area will be vulnerable due to riverbank erosion during monsoon.

5.4.5 Soil Quality

400. During site preparation, earthworks will impact the fertile top soils that are enriched with nutrients required for afforestation and naturally grown plant species. This impact is characterized as Minimal Adverse.

5.4.6 Fisheries and Their Habitat

401. The ship/cargo carrying machineries and ancillaries may discharge ballast and bilge waste water into the river. This ballast and bilge water may have oil, grease, food waste and other

[48] Transportation- and Construction Induced Vibration Guidance Manual, California Department of Transportation.September 2013

contaminants which might affect the fisheries resources and their habitat quality. Having disposed of such harmful substances into the river water, a localized and temporary disturbance to fish breathing may lead some fishes to death. Discharge of wash water into Bhairab River from the construction site may increase the turbidity of the local fish habitat. This would affect the food supply for fishes temporarily. The impact is characterized as Moderate adverse.

5.4.7 Aquatic biota

402. Renovation of jetty for anchorage of ship and cargos at the Bhairab River may temporarily disturb dolphin's movement due to under water noise. Excavation and construction activities including bank erosion may disturb benthic community. The riverine water quality may deteriorate due to disposal of waste water and oil spill from the ship during transportation of machinery, materials, etc.

5.4.8 Socio-Economic Condition

Community safety risks

403. Construction activities with different machineries may create excessive noise (beyond limit of GoB and IFC standards) in the project area. That would be a matter of anxiety including potential health impacts to the people in the project area (school, mosque, rest house) and the people those are residing adjacent to the project area. Handling of heavy construction machineries may create health injury to the labors in the project sites. Unsafe and unhygienic labour shades may create very hazardous health problems. Non-hazardous and hazardous waste generation may contaminate water and sanitation system.

Employment opportunity

404. Labour in-migration may be increased due to the increased opportunities of employment in the power plant. A number of local people will be engaged in project related activities and may have employment opportunity. In addition, skilled workers from different places will also get job opportunities and will be living in the construction camps within project area. Excessive increase of population may have impact on the occupational and community health.

Diversity of occupation

405. A segment of traditional occupation/resource user groups may have to adopt alternative occupation while working for the construction of the power plant. This will happen for most of the non-technical local residents having different professional groups (such as local rickshaw pillar, boatman and seasonal laborers). The mode of livelihood will be impacted due to creation of the facilities of new business and services sectors.

Non-Hazardous Waste Generation

406. During construction, large amount of construction waste that includes unused construction materials, construction debris, excavated spoils, abandoned or broken machine parts, debris, kitchen wastes from labor sheds, packaging materials, used home appliances, etc. will be produced. Moreover, food waste, plastic, papers, cock sheet, cartons, metal or plastic binders, etc. may be produced as solid waste during this stage. If these wastes are not disposed and maintained properly, these may leach into the surrounding water bodies via torrential rainwater and subsequent flood – that may in turn, have an impact on the aquatic ecosystem. Considering

the amount and type of waste generated, the impact maybe reversible but may take some time for the conditions to return to normal when mitigation measures are applied. Waste generated may impact surrounding aquatic species and may also lead to the spread of various diseases if not managed properly. Considering all of these, it can be assumed that the magnitude of the impact would be moderate. However, sensitivity of this impact would be high. By analyzing the sensitivity and magnitude, it is apprehended that the significance of the impact would be major adverse.

407. Unarranged piling up and disposal of construction waste will cause unhealthy situation in the area and will degrade visual aesthetics. If not properly managed, this impact would remain during the life span of the Project but would be extended within the plant premises only. The impact is reversible. It is very likely to take place if proper management is not adopted which is the requirement of national and international environmental regulations. Considering all of these, it can be assumed that the magnitude of the impact would be moderate. Sensitivity of this impact would be medium as the Project the waste management plan. From the analysis of sensitivity and magnitude, it is apprehended that the significance of the impact would be moderate adverse.

5.5 Environmental Impacts during Operation Stage

5.5.1 Ambient air quality

408. Stack emissions will vary depending on the fuel burned. The power plant is a dual fuel-based plant (natural gas or HSD). The two stacks of the power plants will emit certain amount of criteria pollutants in their flue gas. Emitted flue gas will disperse into the atmosphere and move though wind flow into the down wind direction. However, the ground level concentration of pollution will vary depending on the atmospheric process, emission level, distance from the sources, land status etc. Finally, the baseline, project and cumulative concentration of pollution will be assessed and checked with respect to the national and international standard values.

Pollutants of Concern

409. The chemical composition of the fuel (natural gas and HSD) of the proposed power plant is very important for the emission estimation. Pollutants of concern, released the power stations are Oxides of Nitrogen (NO_x), Oxides of Sulfur (SO_x), Carbon Monoxide (CO), Particulate Matters etc. Particulate Matter is generally not of a major concern from the combustion of natural gas but for other types of fuel. The emissions for $PM_{2.5}$ and PM_{10}will be evaluated and compared to applicable standards of ECR 1997 and IFC 2017. A typical natural gas composition that may be used as fuel in Rupsha 800 MW CCPP is given in **Table 5.9**.

Table 5.9: Natural Gas Chemical Characteristics

Properties	Range	Most Onerous Specification	Unit
Gross Calorific Value (60°F)	Minimum	950	Btu/SCF
	Maximum	1,150	Btu/SCF
Methane (CH_4)	Minimum	85	Mole%
Ethane (C_2H_6)	Maximum	6	Mole%
Propane (C_3H_8)	Maximum	3	Mole%
Butane (C_4H_{10})	Maximum	2	Mole%
Pentane and heavier (C_{5+})	Maximum	0.2	Mole%

Properties	Range	Most Onerous Specification	Unit
Carbon Dioxide (CO_2)	Maximum	2	Mole%
Nitrogen (N_2)	Maximum	1.5	Mole%
Oxygen (O_2)	Maximum	1	Mole%
Total Inerts (Nitrogen, Oxygen, CO_2 plus any other inert compounds)	Maximum	5	Mole%
Water Content	Maximum	7	Ibs per 1,000,000 SCF
Specific Gravity	Minimum	0.55	
	Maximum	0.67	
Liquefiable Hydrocarbons	Maximum	2	US gallons per 1,000,000 SCF

Source: NWPGCL, Feasibility Report Table-6.5.4, P-33, 2016Note: natural gas of Bangladesh is sweet gas (no sulfur content).

410. The proposed Rupsha 800 MW CCPP shall be operated on the specified natural gas which will be supplied through the Gas Pipeline after re-gasification. The GT (Unit-1 & Unit-2) and HRSG (Unit-1 & Unit-2) shall be designed to operate with maximum 125 MMCFD of the specified natural gas (NWPGCL, 2016). Without supply of gas or any emergency purposes this plant will run through HSD fuel. The chemical compositions of HSD are given in **Table 5.10**.

Table 5.10: HSD Fuel Characteristics

Properties	Method	Limit
Density at 15°C, Kg/L	ASTM D 1298	Min -0.82; Max – 0.87
Color ASTM	ASTM D 1500	Max – 3.0
Neutralization value, Strong Acid No., mg KOH/gm; Total Acid No., mg KOH/gm	ASTM D 664 / ASTM D 974	Nil, Max-0.2
Flash point p.m. (c.c.) F	ASTM D 93 / IP 170	Min-32
Pour point F	ASTM D 97	Max. – 9 (Nov-Feb) Max.-12 (Mar-Oct)
Viscosity kinematic @38°C cst	ASTM D 445	Max.-9.0
Sediment %wt.	ASTM D 473	Max.-0.01
Water %Vol.	ASTM D 95	Max.-0.1
Carbon residue, Conradson on 10% bottom, % mass	ASTM D 189	Max.-0.2
Ash %wt.	ASTM D 482	Max.-0.01
Cetane Index (calculated)	ASTM D 976	Min.-45
Cetane Number	ASTM D 613	Min.-45

Properties	Method	Limit
Sulfur total, % mass	ASTM D 4294	Max.-0.5
Copper Strip corrosion (3 hrs @ 100°C)	ASTM D 130	Max.No.1
Distillation:		
90% recovered (vol) at OC	ASTM D 86	Max.-375

Source: NWPGCL, Feasibility Report Table-6.5.5, P-34, 2016.

411. HSD will be used as back-up fuel for this power project. About 2,773 kiloliters will be required to run this power plant. HSD fuel contains a maximum of 0.5% (by mass) sulfur which will be converted to SO_2 and emitted with the flue gas. The emission of SO_2 is the key concern during the operation of this power plant with HSD.

412. Natural gas contains insignificant amount of sulfur and hence formation of SO_2 is negligible. The pollutant of most concern from natural gas fired power plants is NO_x. The formation of thermal NO_x is dependent on three factors during combustion; (i) oxygen concentration, (ii) peak temperature, and (iii) time of exposure at peak temperature (USEPA, 1999). Significant health risks are associated with high levels of ambient NO_2, CO, SO_2 and $PM_{2.5}$, PM_{10} concentrations.

413. This project will follow the stringent values from ECR 1997 and subsequent amendments and IFC 2007 standard both for the criteria pollutants. Emissions from the power plant are estimated for different scenarios to estimate the contribution of criteria pollutants into the airsheds.

Stack Height

414. According to feasibility study, the height of the stacks for gas turbine has been fixed at 50 m where for the steam turbine is at 60m. Therefore, two gas turbine stacks of 50m each and two steam turbine stacks of 60m each will be constructed to emit the flue gas into the atmosphere. During combined cycle operation, only the stack height at 60m will be used. The Bypass stack of 50m is used when the CCPP will have to operate on a simple cycle mode. The height of the stacks satisfies the Good International Industrial Practices (GIIP) and IFC-EHS Thermal Power Plants Guidelines 2017. The stringent standards are selected for this power plant project as per ECR and IFC guideline. **Table 5.11** shows the maximum emission of the pollutants in concentration from the stacks.

Table 5.11: Emission rate standard from the stacks

Pollutants	Description	Emission Concentration (mg/Nm^3)	Remarks
PM	Particulate Matter	30	IFC 2017 (DA)
NO_x	Oxides of Nitrogen	51	NDA
SO_2	Sulfur dioxide	S content in HSD will be $0.5\%_{wt}$	NDA

Methodology of Air Quality Modeling

415. Regulatory agencies rely on dispersion models as part of their approval processes. DoE does not recommend any specific models for the impact assessment study. Therefore, this study has considered the USEPA recommended air dispersion model to assess the emission to the adjacent areas of the Project site.

416. The USEPA regulatory model CALPUFF 7.5.3 has been used to predict and simulate the effects of criteria pollutants from major emission sources in the Project area and analyze the effect on ambient air quality for CO, NO_x, NO_2, SO_2, $PM_{2.5}$ and PM_{10}. The resultant NO_2 concentrations are largely driven by the ambient chemical environment (i.e., the reaction of NO with ambient ozone to form NO_2) and the initial NO_2/NO_x ratio of the emissions. Therefore, a new Tier 2 method, the Ambient Ratio Method 2 (ARM2), has been introduced based on an evaluation of the ratios of NO_2/NO_x from USEPA's Air Quality System (AQS) record of ambient air quality data. According to Tier 2, the default ratio NO_2/NO_x is 0.75 for annual NO_2 (Chu and Meyer, 1991) and 0.80 for hourly NO_2 (Wang, et al, 2011), as recommended in USEPA, 2011.

417. CALPUFF contains algorithms for near-source effects such as building downwash, transitional plume rise, partial plume penetration, as well as longer-range effects such as chemical transformation, and pollutant removal (wet scavenging and dry deposition). It can accommodate arbitrarily varying point source and area source emissions.

418. According to feasibility study, the emission of criteria pollutants will not exceed the standard emission limit recommended in **Table 5.7**. Use of emission rate from the feasibility report would assist us for pollution dispersion modeling. Since there was very little information available on the power plant emissions rate of the criteria pollutants in the feasibility stage, fuel consumption and USEPA AP42 emission factors have been used to generate the emission rate. This is considered as a conservative approach to modeling. GHG emissions were calculated using fuel consumption and IPCC GHG emission factors.

Project Area

419. An area, 50 km x 50 km centering the proposed stack of Rupsha 800MW power station has been selected for the air quality analysis. The plant boundary and air quality-modeling domain have been presented in **Table 5.12** and the project 3D layout plan of the major components of the project is shown in **Figure 5.3**

Table 5.12: CALPUFF Study Area Coordinates (UTM Zone: N 45)

Model Domain		Easting (m)	Northing (m)
Project Area	Project Center	761730.13	2529424.98
	Southeast Corner	762168.26	2529300.96
	Northeast Corner	762012.52	2529577.66
	Northwest Corner	761468.48	2529551.35
	South West Corner	761436.83	2529260.12

Source: CEGIS, 2016.

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Figure 5.3: 3D model of major project components

Emission from the Sources

420. Emission inventories have been prepared for all major point, area, and line sources within the study area i.e. 50x50 km grid (**Figure 5.4**). The major point sources within the model area were identified as follows:

Point Sources: Brick fields, power stations
Line Sources: Vehicles at the National, Regional and Zonal roads

Figure 5.4: Air Modeling Domain

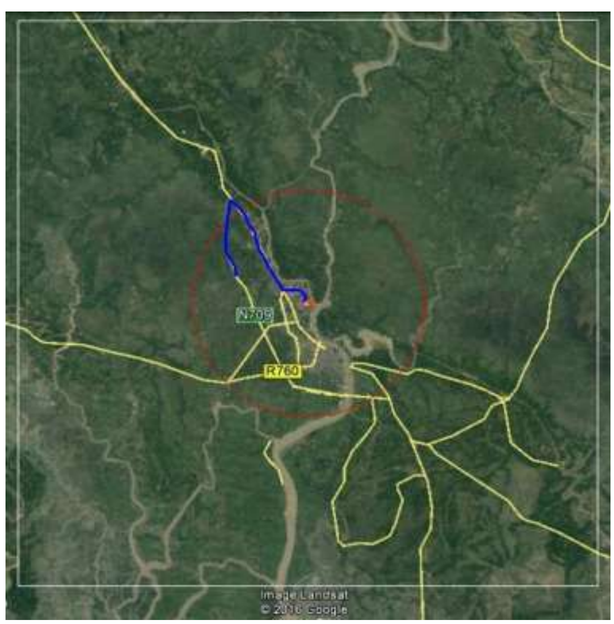
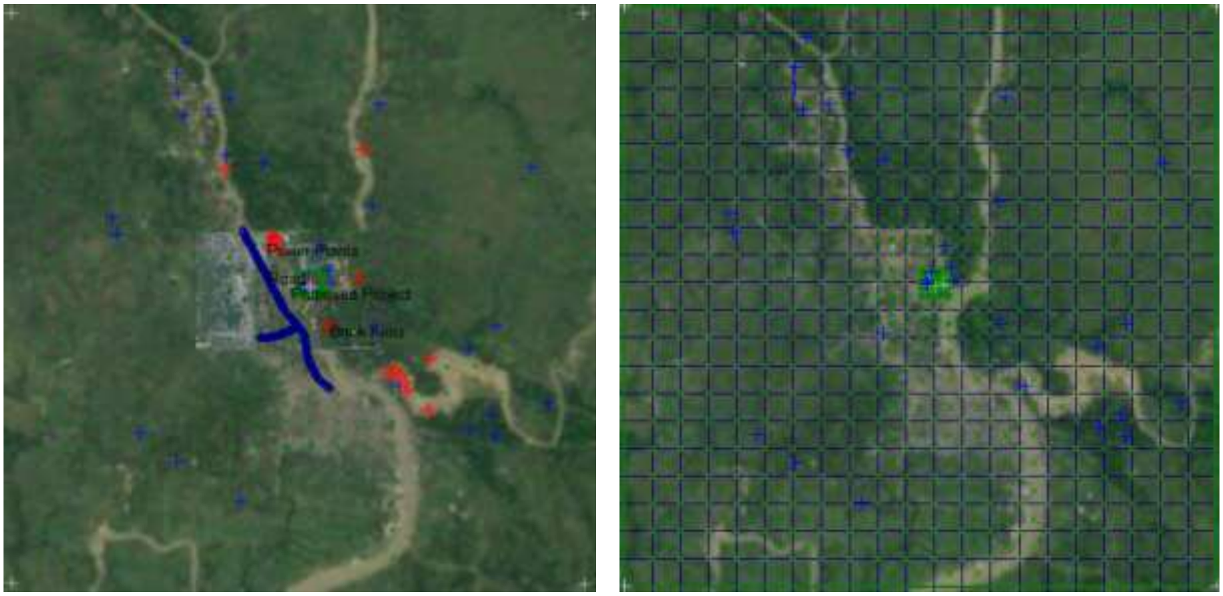


Figure 5.5: Sources and Sensitive Receptors



Note: + Point Sources, - line sources, + Receptors

421. Stacks of the industries emit air pollutants to the ambient environment. This power plant is located in the industrial zone. The industries are Jute Mills, Hard board Mills, News Print Mills, Power Plants and Brick Fields etc. Maximum industries had their own power plants at the time of commencement. However, maximum industries like Khulna Newsprint or Jute mills are shutdown or near to shutdown at present. Presently, the Jute Mills or other industries are running with the electricity supplied by the electricity distribution company. The number of brick fields and power plants accounted are emitting criteria pollutants to the same airshed where the power plant has been proposed. The examples of the industries for point sources are given in **Table 5.13** and **Table 5.14**. The rate of pollutant emission has been calculated based on the emission inventories of Bangladesh Air Pollution Studies (2014) and USEPA AP42 Volume-1 (1995).

Table 5.13: Emission from the brick kilns

No.	Name	Emissions Rate (g/s)					UTM Coordinates (Q:45)		Stack Height (m)	Stack Dia. (m)	Emission Rate (m/s)
		CO	SO_x	NO_x	$PM_{2.5}$	PM_{10}	Easting	Northing			
1	Brick Field	0.08	7.2	0.2	2.1	6.4	763633.8	2534390.3	40	1.2	7.40
2	Brick Field (Digholia)	0.08	7.2	0.2	2.1	6.4	758544.5	2533647.3	40	1.2	7.40
3	Brick Field	0.08	7.2	0.2	2.1	6.4	763438.5	2529641.4	40	1.2	7.40
4	Brick Field (Deara)	0.08	7.2	0.2	2.1	6.4	762344.1	2527971.1	40	1.2	7.40
5	Brick Field (Mosarerpur)	0.08	7.2	0.2	2.1	6.4	766109.5	2526703.1	40	1.2	7.40
6	Brick Field (Shingerchar)	0.08	7.2	0.2	2.1	6.4	764833.5	2526310.7	40	1.2	7.40

No.	Name	Emissions Rate (g/s)					UTM Coordinates (Q:45)		Stack Height (m)	Stack Dia. (m)	Emission Rate (m/s)
		CO	SO_x	NO_x	$PM_{2.5}$	PM_{10}	Easting	Northing			
7	Brick Field (Shingerchar)	0.08	7.2	0.2	2.1	6.4	765002.0	2526089.9	40	1.2	7.40
8	Brick Field (Rhimpur)	0.08	7.2	0.2	2.1	6.4	765180.6	2525830.7	40	1.2	7.40

Source: Field Survey 2016 and Emission Inventories: NILU 2014, AP-42,1995

Table 5.14: Emission from the existing power plants

No.	Name	Emissions Rate (g/s)					Fuel	Stack Height (m)	Stack Diameter (m)	Exit Temp (K)	Exit Velocity (m/s)
		CO	SO_x	NO_x	$PM_{2.5}$	PM_{10}					
1	Goal Para 60 MW HSD Power Plant (BPDB)	Not in Service					HSD				
2	Goal Para 110 MW HFO Power Plant (BPDB)	Not in Service					HFO				
3	KPCL 110 MW (1st Phase) HFO Power Plant	102.18	541.2	241.5	65.55	78.42	HFO	30	1.5	623	22
4	KPCL 115 MW (2nd Phase) HFO Power Plant	106.82	565.4	252.5	68.47	81.91	HFO	30	1.5	623	22
5	Aggreco 55 MW Diesel Power Plant	62.05	38.08	287.96	7.51	11.26	HSD	5	0.6	826	24
6	NWPGCL 225 MW Combined Cycle HSD Power Plant	11.72	80.56	37.01	0.74	1.11	HSD	60	7.5	383	23

Note: AP-42, 1995 USEPA (Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources)

422. Major line sources of pollution considered in the model are traffic along the major roads and highways, which include: R760-1 and N710-1. Khulna Railway station is within the study area and the rail line is passing beside the project area. The traffic data of the adjacent roads R760-1 and N710-1 (**Table 5.15**) was used as line source for air pollution dispersion modeling.

Table 5.15: Traffic Data (AADT) and Locomotives Used for Air Quality Modeling

Road	Heavy Truck	Medium Truck	Large Truck	Large Bus	Medium Bus	Micro Bus	Utility	Car	Auto Ricks-haw	Motor Cycle	Number of Locomotives
Khulna Bustand to Bypass Road R760-1	13	778	586	376	458	279	262	338	4574	3633	18
Ferry Ghat to Dakbangla More N710-1	0	28	71	5	12	484	276	627	4122	1420	

Source: Roads and Highways Department, Bangladesh, 2016

423. There is no supply of natural gas in Khulna City Corporation area. The vehicles run into those roads are mainly fueled by petrol or diesel. Therefore, emissions from the vehicles contain certain amount of SO_2 which disperse to the ambient atmosphere. **Table 5.16** shows the amount of criteria pollutant emission through the roads and railway.

Table 5.16: Emission Level of the Criteria Pollutants from the Roads and Railway

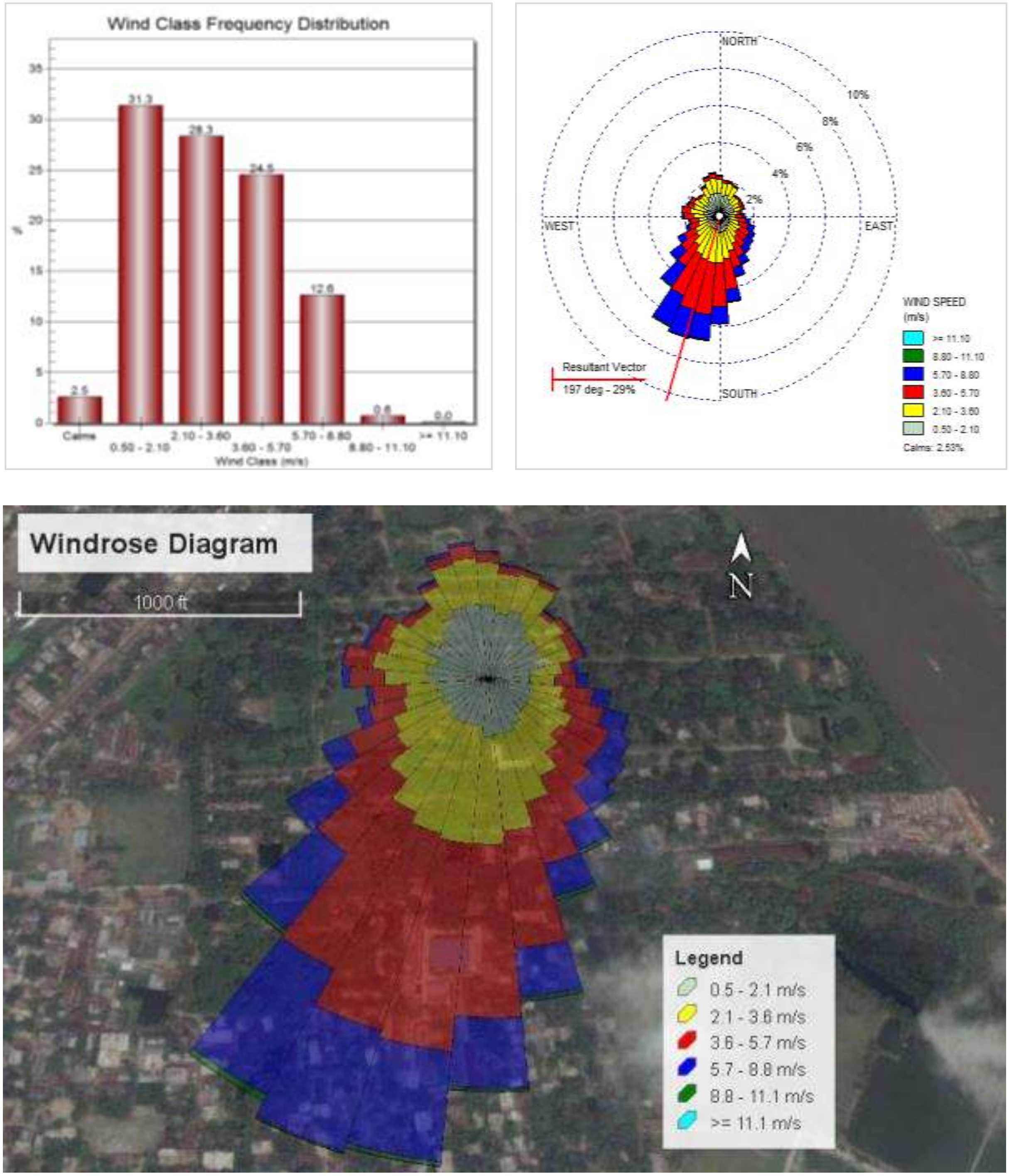
Road Name	Road Width (m)	CO g/s-m^2	SO_2 g/s-m^2	NOx g/s-m^2	PM_{10} g/s-m^2	$PM_{2.5}$ g/s-m^2
R760-1	6.450E+00	1.621E-04	2.120E-07	2.793E-05	4.323E-06	6.585E-07
N710-1	1.179E+01	4.083E-05	3.236E-05	1.184E-04	4.870E-04	2.145E-03
Locomotives		7.6214E-06	1.29E-06	2.58E-05	1.14E-06	1.01E-06

Note: Emission Inventories of MOVES2014a

Meteorological Data

424. Pre-processed hourly 3D meteorological data of the year 2013, 2014 and 2015 was procured from the Lakes Environmental Software (CALMET-Ready MM5, location at761730.13 N, 2529424.98E). This is known as upper atmospheric or air surrounding data which is used in the air dispersion model. The regional meteorological conditions are assessed after analysis of meteorological data of last 3 years (2013, 2014 and 2015) from the BMD station, Khulna. **Figure 5.6** shows the wind rose diagram of the study area related to the dispersion modeling.

Figure 5.6: Wind-Rose Diagram of Last 3 Years (2013, 2014 and 2015)



Receptors

425. Two types of receptors are defined within the model domain. These are: A) Nested Cartesian Grid Points, and B) Discrete Receptors.

426. *Nested Cartesian Grid Receptors.* Cartesian grids are nested into smaller size to capture more precise pollutant concentration after dispersion. The gridded receptors are placing based on the following spacing:

- 50m spacing within the Power Plant Boundary from the stack point
- 250m spacing within 5km from the stack of the Power Station
- 500m spacing within 10km by 10km area

427. *Discrete Receptors.* In addition, discrete locations corresponding to specific sites of interests are included in this assessment. These receptors are broadly located as the places which are populated with human being especially children and patients since their health is much vulnerable to air pollution. Based on the health effects, the vulnerable position has been considered as sensitive receptors around the project. Around 30 sensitive locations are selected including primary school, health complex and other discrete receptors around proposed power plant. Moreover, Wonderland Eco-Park is considered as eco-sensitive discrete receptor during this modeling study. The baseline monitoring points are also included as discrete receptors for future comparison. The effects on air quality at these sensitive sites were also assessed in more details. The list of sensitive receptors, their locations and details are given in **Table 5.17**.

Table 5.17: Details of Sensitive Receptors

No.	Name of Sensitive Receptors	Location (m)	
		Latitude	Longitude
1	High School	759163	2523490
2	High School	756808	2525000
3	High School	768507	2525470
1	High School	767608	2525810
4	High School	755458	2526090
5	Family Welfare Centre	768369	2526260
6	High School	770455	2526610
7	High School	764949	2528710
8	Family Welfare Centre	767516	2528700
9	Family Welfare Centre	768526	2529520
10	High School	764086	2529710
11	High School	762358	2531820
12	Family Welfare Centre	762126	2532620
13	Community Clinic	754623	2533410
14	Family Welfare Centre	754434	2534100
15	High School	763990	2534160
16	High School	769851	2535270
17	Hospital	759974	2535810
18	Historical Place	758630	2536200
19	Hospital	757075	2537720
20	Food Go down	757998	2537880
21	High School	764253	2537860
22	Community Clinic	758703	2538250
23	Community Clinic	756827	2538500
24	High School	756787	2539260
25	Fisheries Village School	762456	2529497
26	Family Welfare Centre	141758	2540350
27	CAMS station	759915	2527578
28	Khalishpur Wonder Land Eco Park	760975	2529989

No.	Name of Sensitive Receptors	Location (m)	
		Latitude	Longitude
29	Residence Area of the Power Plant	761462	2529471
30	Proposed School of KNP	761609	2529805

Source: CEGIS, 2017

Air quality modeling

428. The modeling has been run for predicting the maximum concentration levels of ambient air pollutants like SO_2, NO_x, NO_2, $PM_{2.5}$, PM_{10} and CO for baseline cases. Emission from the vehicular movement, DWL locomotives, brick fields and existing power plant are considered during the baseline study. Ground level concentration (GLC) of the criteria pollutants at receptors are accounted by 98^{th}percentile. Emissions from the existing sources depend on the fuel type and time of operation. Use of heavy fuel oil (HFO) will generate high amount of SO_2 compared to HSD. Operation period of the pollutant sources varies with the diurnal variation as well as seasonality such as the vehicular movement decreases with deep night, brick kiln industries are operated only dry seasons, the power industries limited their electricity production during winter etc. Emission rate from the sources and operation period are considered in CALPUFF modeling. However, the level of baseline GLC of the criteria pollutants are estimated through the model study at the sensitive receptor grids.

429. Baseline concentration of the criteria pollutants is accounted for different duration. It varies from the measured CAMS station for a number of reasons such as unaccounted of the other sources of criteria pollutants like cooking, construction works, dust particles from the road, intrusion of pollutants from outside of the domain and monitoring deficiency of CAMS throughout the year. However, the background concentration of the measured CAMS values is converted into various period for compliance monitoring. **Table 5.18** shows the background concentration at the point of CAMS.

Table 5.18: Background Concentration of the Criteria Pollutants at CAMS

Criteria Pollutants	Standard Concentration (ECR, 2005)		2013	2014	2015
	Period	µg /m3	µg /m3	µg /m3	µg /m3
Carbon Monoxide (CO)	8 Hr	10,000	1,790	1,020	550
	1 Hr	40,000	1,590	860	460
Sulphur Dioxide (SO_2)	Annual	80	3.2	2.3	6.02
	24 Hr	365	16.7	12.1	31.4
Nitrogen Dioxide (NO_x)	Annual	100	5.2	-	23.5
	24 Hr	-	27.07	DNA	122.76
Particulate Matter (PM_{10})	Annual	50	6.9	11.5	4.9
	24 Hr	150	132	219	93.5
Particulate Matter ($PM_{2.5}$)	Annual	15	3.97	5.3	4.4
	24 Hr	65	76.0	102	83.6

430. All the measured ambient background concentration values are for a 24-hour average period and have to be converted into 1-hour, 24-hour, and annual average periods using the power law relationship (OMOE, 2014) given below:

$$C_{long} = C_{short}(t_{short}/t_{long})\ P$$

where:

C_{long} = the concentration for the longer averaging time
C_{short} = the concentration for the shorter averaging time
T_{short} = the shorter averaging time (in minutes)
T_{long} = the longer averaging time (in minutes)
p = the power law exponent

431. For ambient air assessments a p value of 0.28 is used (OMOE, 2014) for the gaseous pollutants. In case of dust particle, the p value is considered as 0.5 to convert annual or 24 hr concentration of TSP in ambient air (Beychok, 2005). This methodology is deemed to give conservative estimates and thus is deemed appropriate for this case. Emission from the power plant will increase GLC at a certain distance from the stacks resting on the plant operation procedure and atmospheric conditions. For a single project, the maximum GLC of the criteria pollutants would not exceed 25% of the national ambient air quality standard in order to protect the significance deterioration mentioned in IFC guideline. Hence, the ambient air quality standard has been depicted in **Table 5.19** considering the single project, i.e., Rupsha 800 MW duel fuel power plant and total projects´ future concentration of the pollutants.

Table 5.19: Ambient air quality standard

Pollutants	Duration	PSD value for National Standard (25%)(μg/m³)	Ambient Air Quality Standard for this project (μg/m³)	Remark
CO	8Hr	2,500	10,000	ECR, 2005
	1 Hr	10,000	40,000	ECR, 2005
SO_2	24 hr	91.25	125	IT-1, IFC, 2017
	Annual	20	80	ECR, 2005
NO_2	1-hr	-	200	IFC, 2017
NO_x	Annual	25	40	IFC, 2017
PM_{10}	24 hr	37.5	150	ECR, IT-1
	Annual	12.5	50	ECR, IT-2
$PM_{2.5}$	24 hr	16.25	65	ECR
	Annual	3.75	15	ECR, IT-3

432. At present, a number of power plants, brick kilns, vehicles etc. are emitting pollutants to the same airsheds where the Rupsha 800MW power plant is proposed. During operation of the power plant, the emitted pollutants will add to baseline situation. The project will run for 500 hours of HSD and 5632 hours of natural gas in a year. However, the emission parameters rate considered based on the information from Feasibility Report for this power plant, USEPA AP42 and from the power plant are presented in **Table 5.20.**

433. Emissions from the stacks have been calculated based on the emission factors, fuel type and use of pollution mitigation inbuilt measures. As per feasibility study the physical features of the stack and temperature of the flue gas was collected. When the plant will run through natural gas, it will also use HSD especially during starting and shutdown phases. Presence of Sulfur in HSD is the source of SO_2 emission during operation. As per the Feasibility report, 0.5% sulfur concentration has been used to determine the stack emission of pollutants.

Table 5.20: Emissions from the Proposed Power Plant (70% Plant Load Factor)

Both Units	Unit	Combined Cycle	Simple Cycle
Number of Stacks	Number	2	2
Stack Height	m	60	50
Stack Diameter	m	7.46	6.5
Flue Gas Temperature	ºC	102	886
Flue Gas Emission rate	m/s	22	25
Use natural gas as Fuel from both Units			
Emission rate of CO	gm/s	8.9	8.9
Emission rate of SO_2	gm/s	9.5	9.5
Emission rate of NOx	gm/s	51.2	51.2
Emission rate of PM_{10}	gm/s	1.0	3.1
Emission rate of $PM_{2.5}$	gm/s	1.0	3.1
Use HSD as Fuel from both Units			
Emission rate of CO	gm/s	28.4	28.4
Emission rate of SO_2	gm/s	195.5	195.5
Emission rate of NO_x	gm/s	89.8	89.8
Emission rate of PM_{10}	gm/s	1.6	1.6
Emission rate of $PM_{2.5}$	gm/s	1.6	1.6

434. 30 receptors have been fixed around to understand the pollution level during the operation period. However, the Model has been run for three years (2013-2015) to account the GLC of criteria pollutants for worst-case situation in different range of duration. The Maximum GLC at the sensitive points is presented in **Appendix 6**. Changes in pollution level during baseline and project case are discussed sequentially.

Carbon Monoxide (CO)

435. The maximum 1-hr averaging CO are predicted through the modeling process which has been further converted into 8-Hr of three years' meteorological data in the study area. The highest concentration of CO would reach to the ground level depending on the worst-case meteorological situation. The peak GLC of CO has been predicted for only project case both for single and combined cycle case during operation of the power plant. The monitored background concentration of CO at CAMS and a model generated peak GLC are shown in **Table 5.21**. During the operation period, the baseline concentration will increase insignificantly.

Table 5.21: Air Quality Modeling Data-CO

Pollutant CO	Concentration (µg/m³)		% of ECR 2005	GPS Coordinates (UTM:45) (m)		Standard (µg/m³)
	Avg. Time	Max. Value		East	North	
Only Project Case Simple Cycle run by natural gas	1-hr	26.4	0.07	761730	2529725	40,000
	8-hr	14.8	0.15	761730	2529725	10,000
Only Project Case Simple Cycle run by HSD	1-hr	90.9	0.23	761730	2529725	40,000
	8-hr	50.8	0.51	761730	2529725	10,000
Only Project Case Combined Cycle run by natural gas	1-hr	21.2	0.05	762230	2531925	40,000
	8-hr	11.8	0.12	762230	2531925	10,000
Only Project Case Combined Cycle run by HSD	1-hr	92.9	0.23	762230	2531925	40,000
	8-hr	51.9	0.52	762230	2531925	10,000
Model Generated Baseline	1-hr	453	1.13	759230	2530925	40,000

	8-hr	253.1	2.53	759230	2530925	10,000
Measured Background conc.*	1-hr	460		759915	2527578	40,000
Project Case for single cycle (Project + baseline) run by natural gas	1-hr	453	1.13	759230	2530925	40,000
	8-hr	253.1	2.53	759230	2530925	10,000
Project Case for single cycle (HSD Project + baseline) run by HSD	1-hr	453	1.13	759230	2530925	40,000
	8-hr	253.1	2.53	759230	2530925	10,000
Project Case for combined cycle (Project + baseline) run by natural gas	1-hr	453	1.13	759230	2530925	40,000
	8-hr	253.1	2.53	759230	2530925	10,000
Project Case for combined cycle (Project + baseline) run by HSD	1-hr	453	1.13	759730	2530925	40,000
	8-hr	253.1	2.53	759730	2530925	10,000

Note-*1 Hr. measured avg. CO concentration at CAMS in 2015

436. The predicted highest GLC of CO during the baseline is 453 µg/m³ which is quite similar with the measures background concentration. During operation stages, the highest GLC of CO has been predicted only 92.2 µg/m³ for 1-hr and 51.9 µg/m³ for 8-hr for HSD combined cycle operation. With changing of fuel type and operation process like simple cycle or combine cycle, the maximum concentration will not change. Stable baseline highest concentration at certain places infer that this project will not cross the maximum concentration in the study area. It may increase the individual baseline GCL of CO at the sensitive receptors within the limit of 453µg/m³ (1-hr). Actually, this power project will contribute insignificantly to the airsheds where existing sources are contributing much more. However, after commissioning of this project though with any fuel, the resultant concentration of peak CO concentration will be within the standard limit of ECR 2005.

Sulphur dioxide (SO_2)

437. At present, most of the power plants in the study area are operated by HSD or HFO. The major sources of the SO_2 are brick kilns, existing power plants and vehicular movements. Maximum GLC of SO_2 are predicted for 98thpercentile value for 24hr in order to exclude the uneven or sudden peaks. During the project case, the maximum GLC of SO_2will not change significantly as it runs with natural gas through simple cycle of combine cycle. At that stage the plant will run around 92% with natural gas and remaining with HSD. However, this project can also run merely with HSD which contain 0.5% of S. During HSD operation, the project will contribute maximum 11.5% for 24 hr SO_2 of the national ambient air quality standard (ECR 2005). **Table 5.22** shows the maximum GLC at different stages.

Table 5.22: Air Quality Modeling Data-SO_2

Pollutant SO_2	Concentration (µg/m³)		% of ECR 2005	GPS Coordinates (UTM:45) (m)		Standard (µg/m³)
	Avg. Time	Max. Value		East	North	
Only Project Case Simple Cycle run by natural gas	24-hr	3.7	1.01	761930	2529725	125
	Annual	0.4	0.5	761930	2529725	80
Only Project Case Simple Cycle run by HSD	24-hr	41.9	11.5	761930	2529725	125
	Annual	4.6	5.8	761930	2529725	80
	24-hr	3.2	0.9	762030	2529925	125

Only Project Case Combined Cycle run by natural gas	Annual	0.5	0.6	761930	2529925	80
Only Project Case Combined Cycle run by HSD	24-hr	32.3	8.8	762230	2531925	125
	Annual	4.8	6	791930	2529925	80
Model Generated Baseline	24-hr	102	27.9	761230	2532925	125
	Annual	16.8	21	761230	2532925	80
Measured Background conc.*	24-hr	31.4		759915	2527578	365
Project Case for single cycle (Project + baseline) run by natural gas	24-hr	102	27.9	761230	2532925	125
	Annual	16.9	21.1	761230	2532925	80
Project Case for single cycle (HSD Project + baseline) run by HSD	24-hr	103	28.2	761230	2532925	125
	Annual	17.6	22	761230	2532925	80
Project Case for combined cycle (Project + baseline) run by natural gas	24-hr	102	27.9	761230	2532925	125
	Annual	16.9	21.1	761230	2532925	80
Project Case for combined cycle (Project + baseline) run by HSD	24-hr	103	28.2	761230	2532925	125
	Annual	18.7	23.3	761230	2532925	80

Note-*24 Hr. measured avg. SO2 concentration at CAMS in 2015.

438. The highest GLC of SO_2 has been predicted as 102µg/m³ for 24hr and 16.8 µg/m³for annual averaging time during the natural gas operation which will never increase the highest GLC of SO_2 in the study area but slightly increase in the sensitive receptors (**Appendix 6**). If the project runs with HSD, the highest GLC of SO_2 will increase significantly e.g. 103 µg/m³ for 24 hrs and 23.3 µg/m³ for annual averaging time. The maximum GLC of SO_2 is within the limit of ECR 2005 and IT-1 values of IFC 2007.

Oxides of Nitrogen (NO_x)

439. The concentration of NO_2 for averaging time of maximum 1-hr (98thpercentile) and NO_x for annual averaging time is predicted through the CALPUFF modeling process using the three years meteorological data of the study area. This project contributes annually maximum 4.4% NO_x during combine cycle operation with HSD of the national standard. The maximum concentration values of NO_x and NO_2 for both Baseline and Project cases within the study area have been predicted (**Table 5.23**). This peak concentration value would reach to the ground level depending on the worst case meteorological situation.

Table 5.23: Air Quality Modeling Data-NO_x

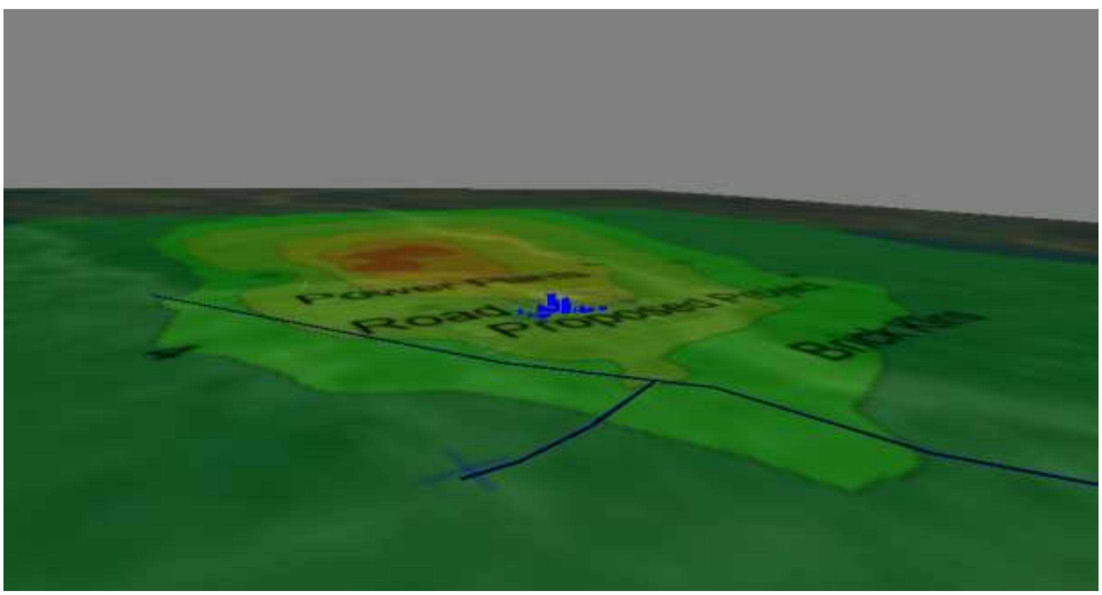
Pollutant NO_x	Concentration (µg/m³)		% of ECR 2005	GPS Coordinates (UTM:45) (m)		Standard (µg/m³)
	Avg. Time	Max Value		East	North	
Only Project Case Simple Cycle run by natural gas	1-hr (NO2)	23.5	-	761930	2529725	200
	Annual	2.0	2.0	761930	2529725	40
Only Project Case Simple Cycle run by HSD	1-hr (NO2)	48.5	-	761930	2529725	200
	Annual	4.2	4.2	761930	2529725	40

Only Project Case Combined Cycle run by natural gas	1-Hr (NO2)	24.0	-	762030	2529925	200
	Annual	2.5	2.5	761930	2529925	40
Only Project Case Combined Cycle run by HSD	1-hr (NO2)	41.9	-	762230	2531925	200
	Annual	4.4	4.4	791930	2529925	40
Model Generated Baseline	1-Hr (NO2)	92.9	-	761230	2532925	200
	Annual	9.1	9.1	761230	2531925	40
Measured Background conc.*	Annual	23.5		759915	2527578	100
Project Case for single cycle (Project + baseline) run by natural gas	1-Hr (NO2)	93.0		761230	2532925	200
	Annual	9.4	9.4	762230	2532925	40
Project Case for single cycle (HSD Project + baseline) run by HSD	1-hr (NO2)	93.0	-	761230	2532925	200
	Annual	9.5	9.5	762230	2532925	40
Project Case for combined cycle (Project + baseline) run by natural gas	1-Hr	93.0	-	761230	2532925	200
	Annual	9.7	9.7	762230	2532925	40
Project Case for combined cycle (Project + baseline) run by HSD	1-hr (NO2)	93.0	-	761230	2532925	200
	Annual	10.2	10.2	762230	2532925	40

Note-*Annual. Measured Avg. NOx concentration at CAMS in 2015

440. The maximum GLC of NO_2 for 1-hr for both simple and combined cycle are below the IFC standard (200 µg/m³). Annually, the average concentration will increase during operation of this power plant, but it will not exceed 10.2% of the national standard. However, in all cases the level of NO_2 and NO_x will be within the standard limits.

Figure 5.7: NO_x dispersion modeling for project case



Particulate Matter (PM_{10})

441. The particulate maters are also estimated during the baseline case. The highest concentration of PM_{10} for 24-hr and annual averaging time is estimated through the modeling process with the help of three years meteorological data of the study area. The maximum concentration of PM_{10} would only found in the ground level for the worst-case meteorological situation.

442. The peak concentration of this pollutant has been estimated when the project will run natural gas or HSD both for simple and combined cycle, at different scenarios. The results have been shown in **Table 5.24**.

Table 5.24: Air Quality Modeling Data-PM_{10}

Pollutant PM_{10}	Concentration (µg/m³)		% of ECR 2005	GPS Coordinates (UTM:45) (m)		Standard (µg/m³)
	Avg. Time	Max Value		East	North	
Only Project Case Simple Cycle run by natural gas	24-hr	0.8	0.53	761930	2529725	150
	Annual	0.04	0.08	761930	2529725	50
Only Project Case Simple Cycle run by HSD	24-hr	1.6	1.07	761930	2529725	150
	Annual	0.08	0.16	761930	2529725	50
Only Project Case Combined Cycle run by natural gas	24-hr	0.6	0.4	762030	2529825	150
	Annual	0.04	0.08	761930	2529925	50
Only Project Case Combined Cycle run by HSD	24-hr	0.9	0.6	792030	2529825	150
	Annual	0.08	0.16	761930	2529925	50
Model Generated Baseline	24-hr	70	46.7	763230	2525925	150
	Annual	6.9	13.8	764949	2525625	50
Measured Background conc.*	24-hr	93.5		759915	2527578	150
Project Case for single cycle (Project + baseline) run by natural gas	24-hr	70	46.6	762230	2525925	150
	Annual	6.6	13.2	765230	2525925	50
Project Case for single cycle (HSD Project + baseline) run by HSD	24-hr	69.9	46.6	763230	2525925	150
	Annual	8.98	18.0	764949	2525695	50
Project Case for combined cycle (Project + baseline) run by natural gas	24-hr	70	46.7	763230	2525925	150
	Annual	6.6	13.2	765230	2525925	50
Project Case for combined cycle (Project + baseline) run by HSD	24-hr	69.9	46.6	763230	2525925	150
	Annual	9.03	18.1	764949	2525695	50

Note-*24 Hr Measured Avg. PM_{10} concentration at CAMS in 2015

443. The maximum contribution of PM_{10} into the ground level would be 1.07% for 24hr and 0.16% for annual averaging time of the national standard during the simple cycle operation with HSD. The highest contribution of PM_{10} to the ground level is around70 µg/m³ for 24hr and only 9.03 µg/m³ for annual averaging time. During modeling study chemical transformation and washout of the pollutants have been considered which may cause the variation of PM_{10} amount from project case to project case scenario. However, the baseline model data shows lower than the CAMS data due to exclude of other sources like unpaved roads, pollen, area sources etc. When the project will run, the maximum GLC of PM_{10} will not be increased significantly. However, the recorded baseline and project case values were quite lower than the standard.

Particulate Matter ($PM_{2.5}$)

444. There is very little amount of particulate matter ($PM_{2.5}$) emitted through the stacks of the power plant. The maximum concentrations of $PM_{2.5}$ for 24hr and annual averaging time are accounted through the modeling process using the three years meteorological data of the study area. The peak concentration will be found in the ground level depending on the worst-case meteorological situation. This maximum concentration values have been predicted for only

project, baseline and operation stages both simple and combined cycle within the study area (**Table 5.25**)

Table 5.25: Air Quality Modeling Data-$PM_{2.5}$

Pollutant $PM_{2.5}$	Concentration (µg/m³) Avg. Time	Max Value	% of ECR 2005	GPS Coordinates (UTM:45) (m) East	North	Standard(µg/m³)
Only Project Case Simple Cycle run by natural gas	24-hr	0.83	1.3	761930	2529725	65
	Annual	0.04	0.3	761930	2529725	15
Only Project Case Simple Cycle run by HSD	24-hr	1.6	2.5	761930	2529725	65
	Annual	0.08	0.5	761930	2529725	15
Only Project Case Combined Cycle run by natural gas	24-hr	0.58	0.9	762030	2529825	65
	Annual	0.04	0.3	761930	2529925	15
Only Project Case Combined Cycle run by HSD	24-hr	0.9	1.4	761930	2529925	65
	Annual	0.08	0.6	761930	2529925	15
Model Generated Baseline	24-hr	33.6	51.7	760230	2530925	65
	Annual	2.39	15.9	764949	2525625	15
Measured Background conc.*	24-hr	83.6		75991498	2527578	65
Project Case for single cycle (Project + baseline) run by natural gas	24-hr	33.6	51.7	760230	2530925	65
	Annual	3.32	22.1	760730	2531425	15
Project Case for single cycle (HSD Project + baseline) run by HSD	24-hr	33.6	51.7	760230	2530925	65
	Annual	3.12	20.8	764949	2525625	15
Project Case for combined cycle (Project + baseline) run by natural gas	24-hr	33.6	51.7	760230	2530925	65
	Annual	2.4	16.0	761930	2529925	15
Project Case for combined cycle (Project + baseline) run by HSD	24-hr	33.6	51.7	760230	2530925	65
	Annual	3.13	20.9	764949	2525695	15

Note-*24 Hr Measured Avg. $PM_{2.5}$ concentration at CAMS in 2015

445. Maximum contribution of $PM_{2.5}$ into the ground level would be 2.5% (24 hr) for HSD simple cycle and 0.6 % (annual) for HSD combine cycle of the national standard merely from this project. At present (without this power plant) situation, the predicted highest concentration of $PM_{2.5}$ in the ground level is only 33.6 µg/m³ for 24hr and only 2.39 µg/m³ for annual averaging time. When the project will run, the highest concentration of $PM_{2.5}$ in the ground level is almost similar for 24 hr with the baseline as this project will not increase the maximum GCL of $PM_{2.5}$ in the airshed for both fuel. Only annual maximum GLC of $PM_{2.5}$ will increase to 3.13 µg/m³ as it will run with HSD combine cycle. The recorded baseline and project case values were quite lower than the standard limit of ECR 2005 and IFC 2007.

Cumulative Impacts on Air Quality

446. The GoB has taken a decision to develop a hub of power generation in south-western zone of Bangladesh. Therefore, the new power plants are coming into the Khulna city areas. BPDB has already taken a plan to constructing a new 300MW duel fuel CCPP inside the existing Goalpara campus. Moreover, a number of brick kiln industries will also be run in future which have been stopped for last couple of years.

447. Emission inventories were prepared based AP42 of USEPA (Volume-1; 1995) and on the other literature review of other similar types of brick kiln industries in Bangladesh. The stack emissions and stack parameters of the thermal power plants are given in **Table 5.26**. The cumulative scenario has been prepared considering the baseline sources, proposed project run with natural gas and upcoming industries.

Table 5.26: Major Point Source Emission in the Project Area

Name of Industries	No. of Stack	Flue gas Emission Rate	Stack Height (m)	Inner Dia. (m)	Emission Rate (g/s)				
					CO	SO_2	NO_x	PM_{10}	$PM_{2.5}$
Goal Para 300 MW Power Plant	1	300	50	6	15.6	107	49.4	12.3	8.23
Brick Field	1	7.40	40	1.2	0.08	7.2	0.2	6.4	2.1
Brick Field	1	7.40	40	1.2	0.08	7.2	0.2	6.4	2.1
Brick Field	1	7.40	40	1.2	0.08	7.2	0.2	6.4	2.1

Source: Other Power Plants document and AP42

448. The cumulative impact of all major emission sources in the air-shed is assessed in this section, including future developments. In addition to the sources discussed previously, the assessment includes emissions from upcoming power plants like BPDB 300 MW Goalpara duel fuel power plant and other brick kilns. The emissions and input parameters for the proposed power plants are given in the above **Table 5.27**.

449. During the cumulative impact assessment, all of the potential sources are taken into consideration to predict the maximum ground level for 1hr, 24hr and annual averaging time concentrations, as given in **Table 5.27**. The table shows that the predicted concentrations of CO, SO_2, PM_{10} and $PM_{2.5}$ are within the Bangladesh Ambient Air Quality Standards (ECR, 2005), but the 24 hr Maximum GLCs of SO_2, PM_{10} and $PM_{2.5}$are significantly higher than the IFC Guideline Values. Background concentration is the main cause for breaching the IFC guideline values. It is noted that the Bangladesh Standards for 24hr SO_2 and PM_{10} concentrations are quite higher compared to IFC Guidelines and standards.

Table 5.27: Maximum GLC of SO_2, PM_{10} and $PM_{2.5}$ for cumulative case

Avg Time	Pollutants	Location at Ground Level (UTM: 46)		Concentration (µg/m³)	Standard Limit (µg/m³)		
		East(m)	North (m)	Max Value	% of National Conc.	ECR 2005	IFC 2017
1hr	CO - natural gas	759230	2530925	467	1.2	40000	-
	CO - HSD	759230	2530925	467	1.2	40000	-
	NO_2 - natural gas	761230	2532925	96	-	-	200
	NO_2 - HSD	761230	2532925	96.8	-	-	200
24hr	SO_2 - natural gas	761230	2532925	108.2	29.6	365	125 (IT-1) 20 (G)
	SO_2 - HSD	761230	2532925	108.2	29.6	365	125 (IT-1) 20 (G)
	PM_{10} - natural gas	765230	2525925	109	72.7	150	150 (IT-1) 50 (G)
	PM_{10} - HSD	765230	2525925	109	72.7	150	150 (IT-1) 50 (G)
	$PM_{2.5}$ - natural gas	765230	2525925	35.9	55.2	65	75 (IT-1) 25 (G)

Avg Time	Pollutants	Location at Ground Level (UTM: 46)		Concentration ($\mu g/m^3$)	Standard Limit ($\mu g/m^3$)		
		East(m)	North (m)	Max Value	% of National Conc.	ECR 2005	IFC 2017
	$PM_{2.5}$ - HSD	765230	2525925	35.9	55.2	65	75 (IT-1) 25 (G)
Annual averaging time	SO_2-natural gas	761230	2532925	19.3	135.3	80	-
	SO_2-HSD	761230	2532925	20.2	135.3	80	-
	NO_x - natural gas	761230	2531925	11.1	11.1	100	40
	NO_x - HSD	761230	2525925	11.5	11.5	100	40
	PM_{10} - natural gas	764949	2525625	12.6	25.2	50	70 (IT-1) 20 (G)
	PM_{10}- HSD	764949	2525625	12.6	25.2	50	70 (IT-1) 20 (G)
	$PM_{2.5}$ - natural gas	764949	2525695	4.33	28.9	15	35 (IT-1) 10 (G)
	$PM_{2.5}$ - HSD	764949	2525625	4.33	28.9	15	35 (IT-1) 10 (G)

GHG Emission

450. The implementation of combined cycle would further reduce the emission of GHG as the flue gas emitted from the GT is used again in the HRSG. Such power generation process combined with the implementation of energy efficiency programs in power sectors and in other infrastructures would not only make the production cost-effective but also reduces GHG emissions. This combined-cycle fleet consumes significantly less fuel to generate power than conventional boiler/steam turbine power plants and emits fewer GHG emissions per MWh of power produced as compared to coal-fired power plants. The proposed project thus demonstrates a case of voluntary GHG emission reduction. These reductions may qualify Clean Development Mechanism (CDM).

451. The CDM was designed to meet a dual objective: (a) to help developed countries fulfill their commitments to reduce emissions, and (b) to assist developing countries in achieving sustainable development. CDM projects earn tradable, saleable certified emission reduction (CER) credits that can be used by industrialized countries to meet a part of their emission reduction targets under the Kyoto Protocol. Benefits of CDM projects include investment in climate change mitigation projects in developing countries, transfer or diffusion of technology in the host countries, as well as improvement in the livelihood of communities through the creation of employment or increased economic activity.

452. For GHG emission calculation, CO_2, has been accounted for this power plant project. Using the standard process of IPCC (2006), the emission of CO_2 has been estimated both for the fuel of natural gas and HSD according to their operation period. Considering the 100-year global warming potentiality for CO_2, the collective GHG emission is calculated in CO_2 equivalent. Annually, this power plant will emit around 1.69 M tons of GHG during 92% operation through natural gas and 8% operation through HSD considering a 70% PLF. In case of operation the plant with HSD only, around 1.86 M tons of GHG will be emitted annually. The GHG deduction is at least 0.17 M tons annually benefited from this project. **Table 5.28** shows the detailed generations of GHG in three scenarios.

Table 5.28: Annual GHG Emissions from Different Fuel Sources (70% PLF)

Parameters of GHG	Operation with dual fuel (70% PLF) natural gas (92%)	HSD (8%)	Only HSD 70% PLF HSD (100%)	Only natural gas 70% PLF natural gas (100%)
CO_2 (M tons/y)	1.54E+00	1.49E-01	1.86E+00	1.67E+00
Total GHG emission (M tons/year)	**1.69**		**1.86**	**1.67**

Notes: Emission factor from 2006 IPCC Guidelines for National GHG Inventories. (Chapter 2: Stationary Sources).

5.5.2 Ambient Noise

453. It is envisaged that the noise level would increase due to the operation of the two units, RMS, cooling tower, gas transmission line etc. The generated noise will be propagated to the adjacent areas both inside and outside of the project boundary. A number of sensitive points have been selected considering the impact potentiality and sensitivity of the receivers around. For understanding the level of noise dispersed from the project activities in different selected locations, noise propagation modeling was conducted considering the noise propagation during the operation of the project activities and equipment.

454. The noise propagation simulation was done by using Sound Plan essential 3.00 software which was developed by SoundPLAN GmbH. SoundPLAN GmbH is the widely used modeling software for noise propagation simulation in research and consultancy field. A number of standard processes can be calculated through this SoundPlan model. The ISO9613 calculation process is used for this modeling purpose. Different factors were considered for predicting the noise level, such as the amount of noise generating from the source, HRSG, two GTs, two STs, RMS and its pipeline inside the project boundary (above ground), ambient environment, etc. For running the model, the average temperature and average relative humidity were considered as 28°C and 80%. Additionally, the considered noise level of GT, ST, and RMS were 90 dBA, 90 dBA and 80 dBA respectively. Those noise emission data are typically used for noise modeling referred from the other power plant study. The land type of the project site was remarked as flat with lots of forest coverage.

455. The modeling result is presented in **Figure 5.8, Figure 5.9, and Figure 5.10** and the predicted level of noise in different sensitive locations around the plant side.

Figure 5.8: Noise level at different sensitive locations from project operation

Figure 5.9: Noise propagation modeling for daytime

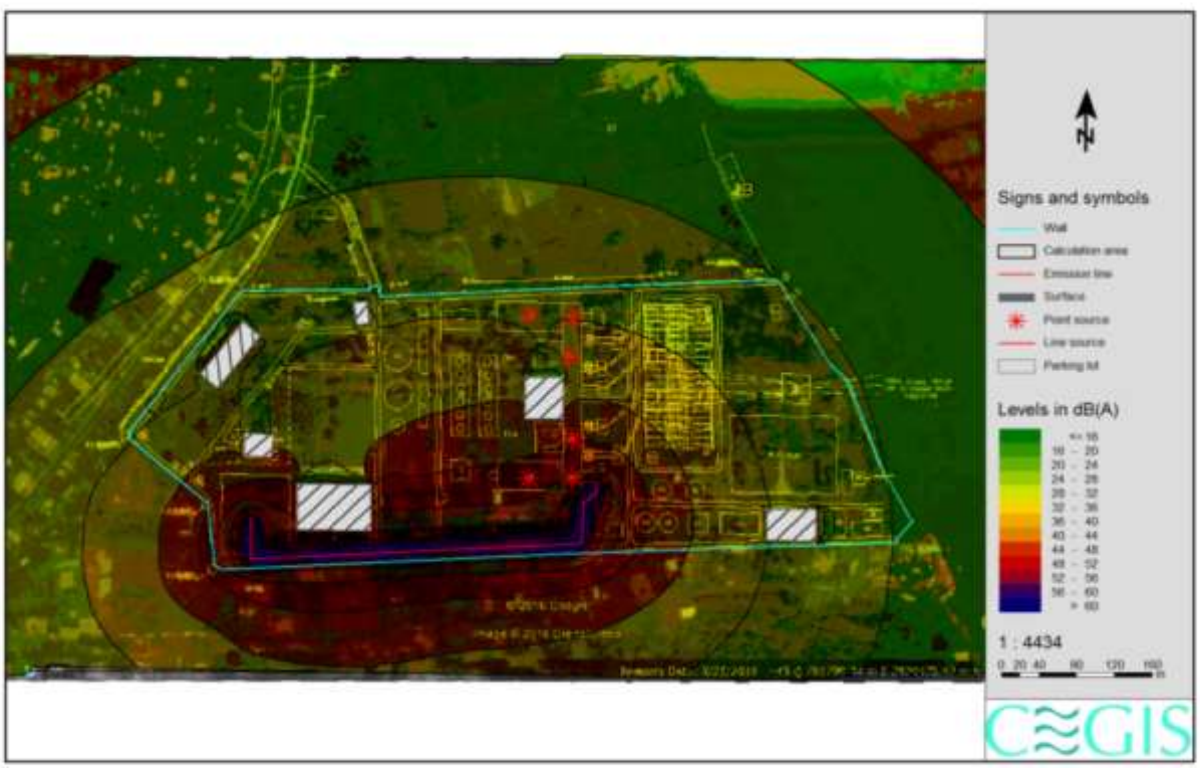
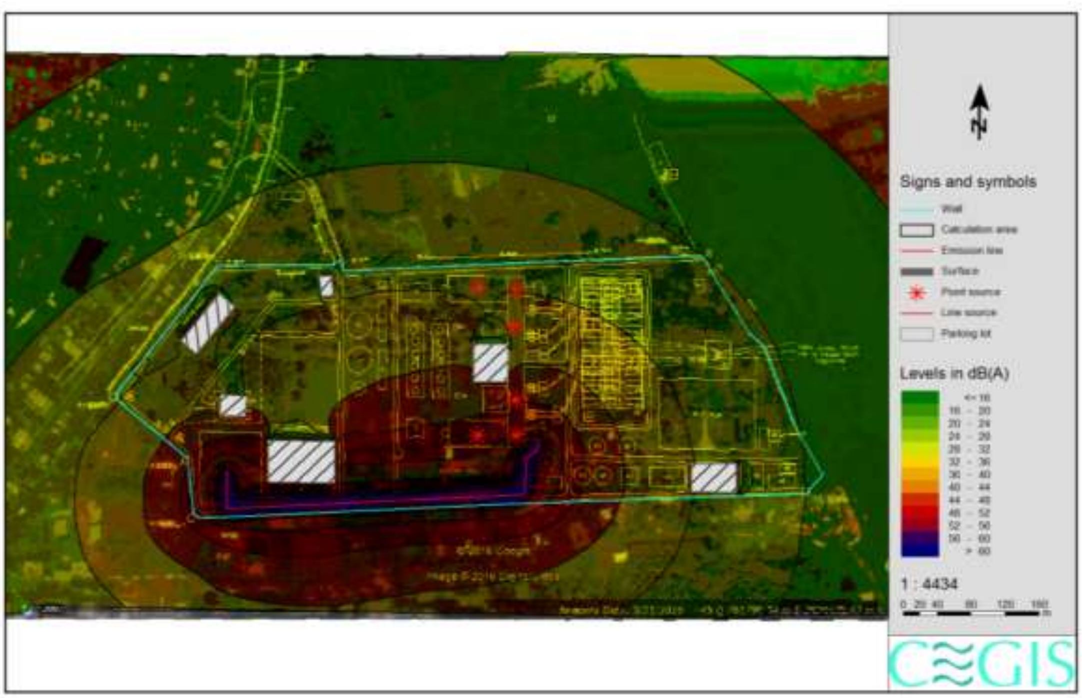


Figure 5.10: Noise Propagation Modeling for nighttime



456. The predicted noise level at the sensitive receptors will increase the baseline conditions. During baseline study, the existing noise level are recorded higher. This baseline will be raised due to the propagated noise generated during the operation period. However, the resultant noise levels of the sensitive receptors are shown in **Table 5.29.**

Table 5.29: Predicted Noise Level in Different Sensitive Locations inScenario 1

		Predicted Noise Level (dBA)		Baseline Noise level (dBA)		Resultant Noise level (dBA)		ECR 2006 IFC 2007 (dBA)	
No	**Location**	**Day**	**Night**	**Day**	**Night**	**Day**	**Night**	**Day**	**Night**
1	Residential/Hospital (leftover) of KNP	28.4	28.4	55.2	42.3	55.2	42.3	55 55	45 45
2	Control Room (Exposed)	36.0	36.0	62	36.7	62	38.7	75 70	70 70
3	Proposed Residential Area	31.1	31.2	57.8	44.6	57.8	44.6	55 55	45 45
4	Mosque	36.4	36.4	55.1	39.1	55.1	40.6	50 55	40 45
5	Proposed School	25.9	25.9	60.1	43.9	60.1	43.9	50 55	40 45
6	Present Guest Room	31.2	31.2	64.2	43.1	64.2	43.1	75 70	70 70
7	Outside Southern wall (Middle)	45.0	45.0	54	41.5	54.5	46.5	55 55	45 45
8	Existing KNP residential communities	29.8	29.8	52.2	43.0	52.2	43	55 55	45 45
9	Western corner of the Project	29.5	29.5	67.2	52.0	67.2	52.0	70 70	60 70
10	South-west corner Slump	37.9	37.9	62.3	53.0	62.3	53.0	55 55	45 45
11	Near the overhead tank	28.9	28.9	70.3	50.1	70.3	50.1	75 70	70 70

Note: Cell with yellow mark exceeds the IFC standard; Text with red color exceeds the Bangladesh standard

457. It is predicted that the resultant noise level will exceed the standards of ECR 2006 and IFC 2007 on around six locations at day time and two locations at night time. In general, persistence exposure to the high level of noise can have adverse health impacts and can increase the level of stress to the susceptible individuals. It can also cause permanent damage to the hearing ability of the exposed persons.

5.5.3 Water Resources

Salinity in groundwater and river water

458. Storm water infiltration is one of the major source of groundwater recharge and reduction of groundwater salinity surrounding the coastal belt of Bangladesh. Development the project land by concrete pavement will reduce the chance of infiltration and eventually majority of generated runoff excess of storm water will be drained out so quickly from the project area. Then the only source of groundwater recharge will be compensated by the river.

459. Cooling tower is one of the major consumption units of surface or groundwater but in case of the proposed project cooling tower will extract water from Bhairab River. Every cooling tower will receive individually about 45% of total intake water among the whole operation. By this process, there has to be a generation of 48% of evaporation and the rest 52% of highly denser water going blow down to the river after flowing through a monitoring basin. This process may impact the level of salinity in the river water.

Flooding

460. There may have two major chances of flooding in the project area. One may be urban flooding, due to extensive runoff which couldn't be drained out quickly for the time being and another cause of flood water may be due to uncertainty above the designed flood level. The post project situation in sense of flood surrounding the project area is very important against inundation. For this reason, the two post projects profile out of seven are shown below in the **Figure 5.11** and **Figure 5.12**. If similar floods will occur in the future during the operation phase, the flood inundation profile will be similar as shown in **Table 5.30.**

Table 5.30: Flooding inundation profile surrounding the project area

Profile Name	Year of Flood	Discharge (cumec)	Water Level (mPWD)	Area of Inundation (ha)		Increased Percentage (%) of inundation
				Pre-project	Post Project	
Profile 1	1969	4261	2.41	7721.73	8058.02	4.36
Profile 2	1970	3445	2.39	7956.59	8300.32	4.32
Profile 3	1972	4019	2.41	5964.75	6444.13	8.04
Profile 4	1974	6060	2.61	9482.65	9707.89	2.38
Profile 5	1984	4305	3.28	8698.89	8990.37	3.35
Profile 6	1986	3076	2.94	7721.73	8058.02	4.36
Profile 7	1999	2948	3.44	5106.79	5609.92	9.85

Source: CEGIS Analysis, Major flood inundation, 2017

Figure 5.11: Post-project inundation due to river flood in 1969

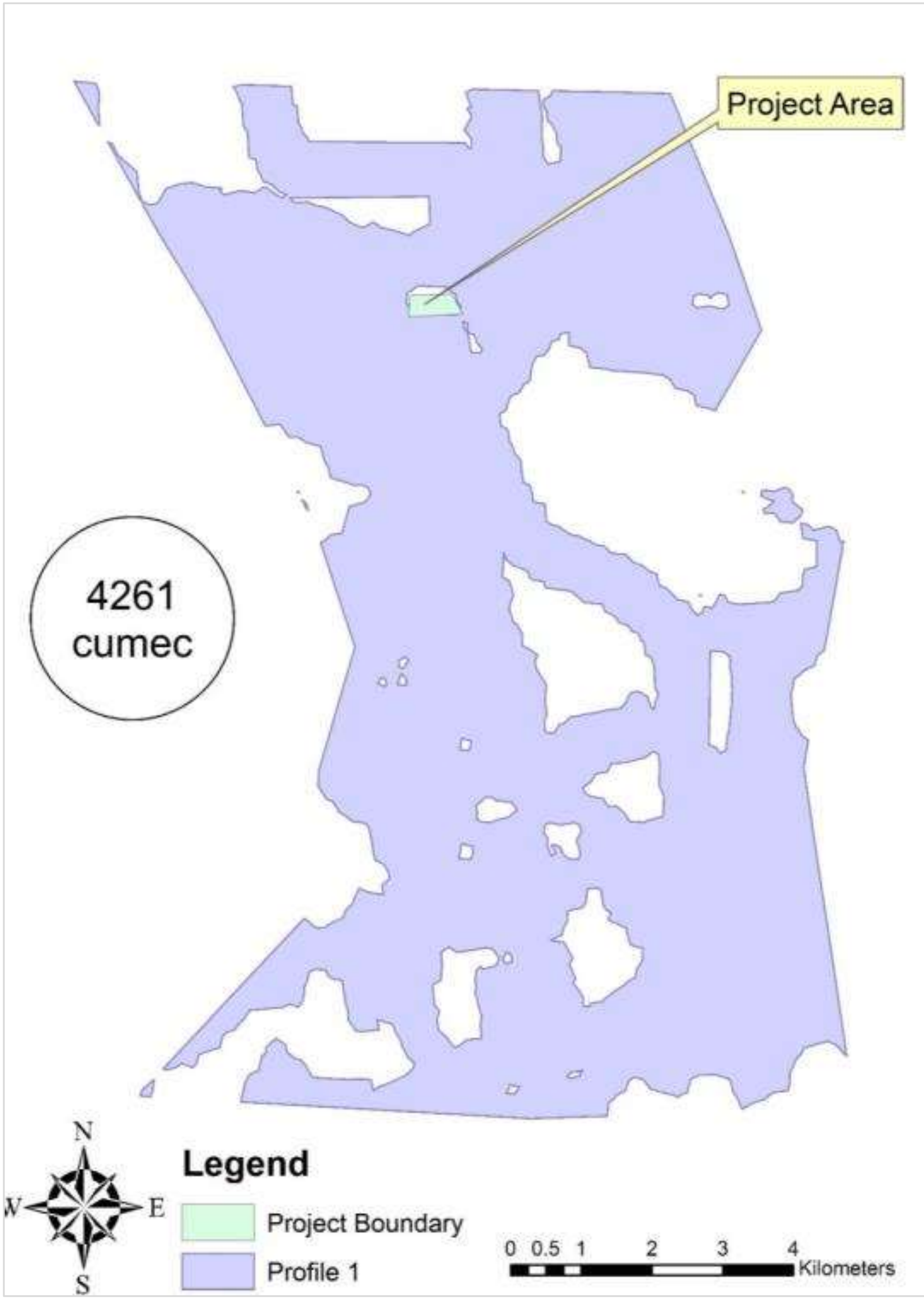
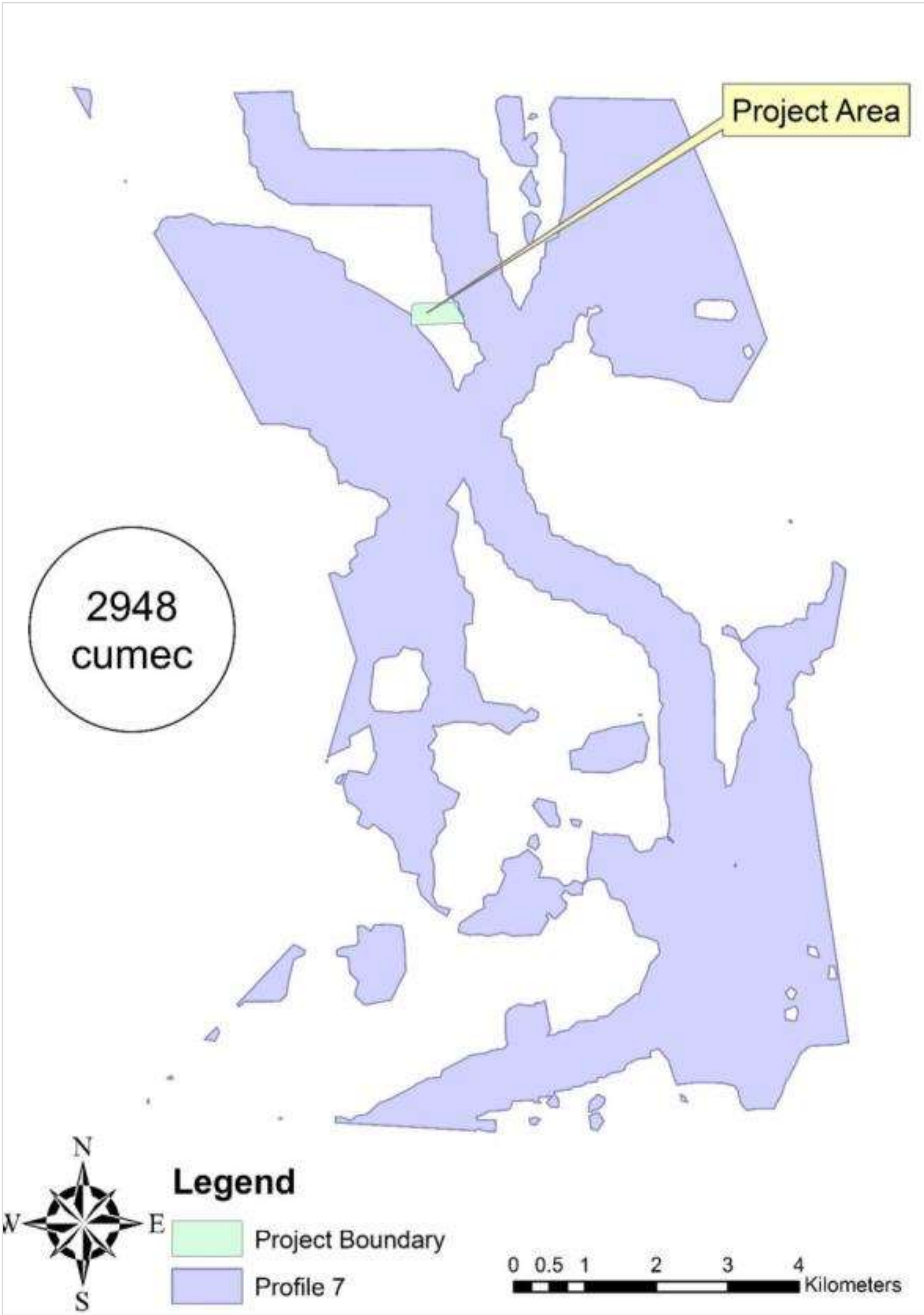


Figure 5.12: Pre-project inundation due to river flood in 1999



Intake channel outlet

461. Intake channel is the vital portion of this project. The point of intake channel started from the river to the use through clarifier, sand filter, sludge pit and reverse osmosis water treatment plant requires a free waterway and surety of the continuous water supply for operation. But there have many chances of interrupting the water supply if:

- Accretion occurs at the eastern boundary by monsoon flood.
- Tidal activities carry and deposit clay at the intake point.
- Loading and unloading activities via ships/ Berge break the intake channel accidentally
- Sliding the sand or other land development material over the developed slope to the toe of the slope.

462. The each and every point described above may interrupt the continuous supply of water for cooling and reverse osmosis process. So the outlet of intake channel requires proper mitigation measures according to the probable negative impacts.

5.5.4 Fisheries and Their Habitat

463. During the operation phase of the plant, waste water, waste oil, sludge and other untreated effluent may become harmful for the local capture fisheries. Additionally, the solid waste generated from the workers living within the region such as cans, bottles and food remains discarded by employees may cause degradation of the capture fish habitats

464. River water will be used in the cooling system and as a result, thermal discharge will be produced. The plant will also produce waste, wastewater, and effluent. Accidental spillage of such untreated effluents into river and open water fish habitats may cause degradation of the capture fish habitats. Continuous loading of such contaminated effluent may become harmful for the local capture fisheries.

465. Abstraction of river water at the rate of 2,010m^3/hr for operating power plant and discharges (1,030.5 m^3/h) may cause crisis for river water availability during dry season around the Project site. This incident may cause the reduction of fish productivity of the capture habitats. This impact is characterized as Major Adverse.

5.4.5 Ecological Environment

Terrestrial vegetation

466. The emission of SO_x, NO_x and SPM including noise pollution may have significant impacts on vegetation and other sensitive receptors around the project and study area.

Aquatic biota

467. Transportation of maintenance related power plant equipment, other materials including fuel during operation period along the river ways, may degrade the river water and habitat quality. Water extraction from Bhairab River particularly during dry season for cooling and make-up process would bring invertebrates and other aquatic species to the cooling tower which may ultimately get killed. In addition, collection of fresh water during dry season from Bhairab would

impact the aquatic invertebrates, dolphins and their feeds in absence of sufficient water flow. The benthos is sensitive to pollutants and may be affected. The oil spills, waste could harm many sensitive species including benthic community structure.

5.5.6 Socio-Economic Condition

Health safety

468. Environment especially water and sanitation may be disturbed by the labours. Health injury may occur in power plant for handling of heavy machineries. Noise from Regulating Metering Station (RMS) may create problem in the project area and adjacent to the power plant area. Moreover, STD and AIDS may raise by the outside workers.

469. In case of any serious accident, the Plant may become a risk factor for those people who are living/working adjacent to it. Particularly, it may cause safety risk to the nearby residential areas, school and offices. It is apprehended that fatalities may take place if any accident occurs.

Disturbance for the fishermen community

470. The fishing activities of the fishermen community in the Bhairab River may be hampered due to the increasing water transportations for the power plant. The fishermen activity will be indirectly affected (water traffic, nets broken). It can be happened also by the increasing different industries in this area.

Employment opportunity

471. The project may create new employment opportunities based on the requirements for the semi-skilled workers of the local community. But a skilled training progamme may be initiated through corporate social responsibility (CSR) activities for the local people for future employment opportunity for this power plant and also based on the job vacancy to other industries.

Industrial development

472. This Project will encourage in establishing industries which will obviously provide employment opportunities to a large number of population.

Diversity of occupation

473. Sources of power will ultimately meet power demand and also bring opportunities of other businesses (shops, transportations, small scale industries, local markets etc.) and employment.

Non-Hazardous Waste Generation

474. During operation stage, some solid waste like, food waste, plastic, papers, etc. and some minor amount of bio-waste may also be produced as solid waste but to a minimal amount. There could be possibility that these wastes may leach into the surrounding water bodies via torrential rainwater and subsequently impact on the aquatic ecosystem. However, considering the amount and type of waste generated, the impact can be reversible when proper mitigation measures are applied. Considering these, it can be assumed that both the magnitude of the impact would be moderate. Sensitivity of this impact would be minor as the Project will implement waste

management plan and improve drainage system. From the analysis of sensitivity and magnitude, it is apprehended that the significance of the impact would be moderate adverse.

Hazardous Waste Generation

475. Hydrazine is generally added in boiler water to scavenge dissolved oxygen – that may erode away the steel structure of the boiler. However, hydrazine is a known carcinogen and a mutagen. Workers may be exposed to hydrazine from the boiler blow down. There is also a possibility of the boiler blow down water to leach into nearby canal if not managed properly. Considering the sensitive nature of the substance involved, the sensitivity is marked as very high and the magnitude of the potential marked as moderate. Overall, after analyzing both sensitivity and magnitude of the impact, it can be estimated that the significance of the impact would be major adverse.

476. Concentrated sludge would be generated from water pre-treatment plant, demineralization plants, waste water treatment plants and oily water separation unit. This sludge would go to the sludge sump for dewatering and thickening. Disposal of the dry sludge might contaminate ground water of surface water if it is not properly managed. The magnitude of the impact is major and sensitivity is also high. Therefore, significance of the impact is major adverse that calls for adoption of proper EMP.

5.6 Mitigation of Impacts

Modification in the project layout

477. It is proposed to include the following items in the project layout developed by the engineering consultant:

- A storm water drainage system around the proposed Plant and link it with the existing drainage network of KNM.
- Green belt development around project boundary
- Demarcation of onsite solid waste dumping place
- A temporary but arranged storage yard for scrap and demolished materials and their transportation route

Changing the stack height

478. As per sensitivity analysis, the maximum height of the stacks should be 60m. During operation of the power plant, flue gas will be emitted from the HRSG stacks. According to the feasibility report, 60m height of each of the stack is considered. To reduce the GLC of the pollutants significantly and economically, 60m stack height has been suggested in this EIA study.

Alternative to use of Hydrazine as oxygen scavenger in feed water

479. Hydrazine is generally used as an oxygen scavenger for corrosion control in thermal power plants. Although hydrazine is very effective in this application, it is a genotoxic carcinogen. Instead of using Hydrazine, it is recommended to use alternative oxygen scavenging chemical e.g. Helamin, Diethyl hydroxylamine, etc. in feed water for corrosion protection in HRSG boiler. However, the design of the HRSG and water treatment can also be changed to avoid use of any oxygen scavenger. There are two alternatives for that:

- Combined Water Treatment (CWT) or oxygen treatment for through-flow boilers
- However, freedom can be given to EPC contractor to find an appropriate alternative of using Hydrazine

5.6.1 Mitigation measures for major impacts

Pre-Construction and Demolition Stage

A. Ambient Air quality

480. The demolition of the exiting abandoned brick buildings require to follow process which include a detailed pre-demolition preparatory works such as desired equipment, manpower, ruble disposal site including removing of hazardous materials as well. Removal of hazardous materials requires to comply GoB and IFC guidelines as applicable and may also require obtaining necessary permits from the authority. The proposed project site is mainly occupied with abandoned brick buildings and no asbestos. However, before demolition, the demolition contractor shall prepare a demolition plan approved by the project authority which include many activities but not limited to: announcing to the local communities, disconnecting utilities, and development of site-specific safety and work plans for the workforce and vehicles. Extra care should be taken while the demolition is in progress such as each building shall be covered with jute cloth to protect spreading of dust. The contractor will prepare the scrub/demolished materials dumpling areas and transportation route. They will regularly water the unpaved roads and possible sources of SPM. The pre-construction and demolition works should be limited to day time only and dust suppression will be applied by water spray during these activities. Construction materials will be temporarily covered with tripod to avoid dust emission to the surrounding areas. Impact and compliance monitoring will be conducted during the demolition works following GoB and IFC guidelines.

B. Noise Level

481. The proponent needs to demolish the buildings as per the regulation (Bangladesh building code-2016, Noise pollution control Rules 2005 including IFC standards as applicable). Code of practices which ensure structural safety, health safety, fire safety and construction and community safety. The ideal checklist for demolition activities are as follows:

a. Physical Survey for preparing site specific demolition plan
b. Stop all kinds of use of ever buildings before the demolition works begin
c. Debris storage and waste disposal system development
d. Quicker, Quitter and Cheaper demolition.
e. Prefer less noise, vibration and dust fume generating demolition technology and methodology
f. Demolition causing least disturbance in the neighborhood.

482. The abandoned buildings to be demolished in such a way that take minimum time, produce least noise, causes no pollution beyond permissible limit, does not the activity or living in the neighborhood and proves cheaper also.

C. Vibration

483. In order to reduce any kind of accident or annoyance of the local communities, the proponent needs to follow following number of initiatives to reduce the impacts.

a. Vacant all of the buildings inside the project boundary
b. Relocate the school and vacant the areas
c. Quicker, Quitter and Cheaper demolition.
d. Manual process like hammer, chisel or bulldozer might be used for demolition
e. Tree cutting must be done after the
f. Demolition causing least disturbance in the neighborhood.

D. Water Resources

Drainage System

484. Management of dredged spoil for land filling is to be implemented to avoid major drainage congestion during land filling and River side protection shall be maintained for protecting the sand materials being washed away from the project area to avoid impact on water ways.

Floodplain

485. The existing land elevation is about 2mPWD which becomes inundated due to flooding during wet season and hence required to be grading of land for avoiding inundation. The only possible mitigation to avoid flood plain is shifting the site to another suitable location in the same study area. The demolition of floodplain by the land development works will introduce new environment for the surrounding project area. The design land level will be higher than the HFL.

Riverbank Erosion and Accretion

486. Protecting the toe of all stockpiles providing adequate scouring depth, where erosion is likely to occur. Moreover, silt fences, straw bales or bunds can be provided. In addition, the slope of the River bank along the project site will be maintained following design for protection of any future bank erosion. In addition, the EPC contractor shall consider safe distance for infrastructures installations from river side as per National Building Code (2017) and also International applicable guidelines as appropriate.

Surface Water Quality

487. Management of oily mechanized machineries, discharge of kitchen wastes, discharge of oily water from dredger and other vessels should be ensured. It is to be noted that the provision of slope not towards the channel or river. Reducing the number of unnecessary movement of water transportations. But, the provision of adequate slope for tidal activity and storm water drainage system should be provided. Discharge water monitoring basin must be provided. Prevention of all solid and liquid wastes entering waterways by collecting spoils, oils, chemicals, bitumen spray waste and wastewaters from brick, concrete and asphalt cutting where possible and transport to an approved waste disposal site or recycling depot.

E. Socio-Economic Condition

488. New relocated schools based on the stake holders' discussion meeting and following safeguard guidelines (SPS 2009) should include allied facilities as computer lab, scientific lab, playground, tube-well, sanitation facility etc. before handing over to the school authority. Creating noise shield (to keep within limit of GoB and IFC guidelines). Local labour both for technical and non-technical should be prioritized for the Project related activities. Working code of practice

should be developed and maintained properly. The contractor will put in place a referral healthcare facility to deal with medical aspects of HIV/AIDS treatment with specialized services. The in-house medical facility will diagnose for STD/STI and TB infection among the workers and provide treatment as necessary. Ensuring job opportunities for the local people in different sectors. Keeping provision for the rehabilitation of the workers those who are working in the project area temporarily Bangladesh Labor Act, 2006 and ILO act must be followed. Child labor and Forced labor must be abandoned. There are 5-6 workers (such as cook and cleaners) currently staying as squatters within the project area who will be removed during project implementation period. Hence, a compensation is to be arranged for them.

F. Solid Waste/Garbage

489. A good practice of kitchen waste collection and disposal system should be adopted. Some temporary bins with color marking indicating degradable and non-degradable waste might be installed at labor shed to prevent scattered throwing of wastes. There should be a designated site or scientific landfill area for kitchen waste disposal for controlling bad odour and leachate having susceptibility to contaminate water.

G. Ecological Environment

Mitigations of the impacts on loss of plant and wildlife

490. The existing structures should be demolished one after another cautiously after properly supervised by an ecologist (having plant and wildlife management experience) to avoid any damage of animal (frog, snake, lizard but no bat and birds) and plant life. In addition, appropriate building demolition including clearing of vegetation guidelines to be adopted for sustainable management of environmental quality of life and growth. Much time should be given for safe departure of the visiting animals during demolition activities following Wildlife Act (2012) and also IFC guidelines. In terms of any injuries of sensitive and threatened wildlife species, proper rescued should be taken by wildlife expert and wildlife rehabilitation team.

Mitigation of the impacts of dust and sound pollution on vegetation and wildlife

491. Control moisture content during construction by watering. Stabilize road surface with a suitable stabilizer. Create proper noise barrier and enclose for each building demolition (particularly all sensitive locations on the west and south, mosque area will be excessive noise level protected) to meet Noise pollution control Rules (2006) of GoB and also IFC guidelines as appropriate.

Mitigations for vegetation clearing

492. The Mosque, graveyard and part of the KNM area which is currently outside the proposed power plant lay out plan may be utilize as a green coverage undisturbed land area and religious activities as well. In addition, a significant portion of the proposed power plant area is suggested to develop as green belt to makeup loss of carbon dioxide sequestration due to clearing of existing vegetation at the proposed plant area and also to promote conservation of visiting animals of the project study area and also beyond that area. The cleared undergrowth plants can be converted to compost for application as a soil conditioner.

Mitigations for terrestrial habitat loss

493. The existing Mosque and graveyard including part of the KNM area is outside of the proposed project area, covered with large number of plants which can be utilize as a vegetation resources and also resting place for visiting birds and animals. In addition, a significant portion of the proposed power plant area is suggested to be developed as green belt which will ultimately makeup for the loss of carbon dioxide sequestration due to clearing of existing vegetation at the proposed plant area and also promote conservation of visiting animals of the project study area including beyond that throughout the seasons of the year. During the clearing of vegetation, the existing common wildlife should be allowed to go away under the supervision of an Ecologist through applying popper method (as per Wildlife Act 2012 and international best practices).

Mitigation for disturbance of aquatic biota

494. All the vessels operating for this power plant are restricted for any kind of effluent and hazardous waste discharges in to the rivers for avoiding possibility of impact on the dolphin community. However, all vessels along their RoW on the water ways other than Byhairab-Rupsha and Atai must follow the standard of inland river transportation regulations. For transportation of heavy equipment from abroad to the port, IMO, MARPOL and BIWTA will be followed. All kinds of discharges from the project site, shall meet regulatory requirements of GoB and IFC guidelines whichever is stringent and appropriate throughout project construction period.

Construction Stage

H. Ambient Air quality

495. Regular watering of the unpaved roads and open areas inside the project boundary which may be increased during high wind and excavation/grading. Dust suppressants should be applied or cover to soil stockpiles and disturbed areas when inactive for more than two weeks. The vehicle speeds will be limited 10 mph during the dry seasons inside the project area. The truck must be covered when hauling material that could be entrained during transit. Diesel-fueled equipment and vehicles should use ultra-low sulfur (15 ppm sulfur). Idling of vehicles to less than 5 minutes will be imposed.

I. Noise Level

496. In order to reduce the impacts of noise on the communities as well as of the project people, a number of ways can be followed –

1. Design consideration and project layout
    - Construct temporary boundary wall or piles of excavated materials between noisy activities and the noise sensitive receptors like Mosque, workers colony and community residence
    - The existing route of KNA will be used for material transportation by trucks
    - Banned hydraulic horn and use sign in local language at the sensitive places
    - Try to avoid cutting the trees besides the boundary wall which are being kept as green belt in layout

2. Sequence of Operation
   - Combine noisy operation to occur in the same time period. The total noise level produced will not be significantly greater than the produced in separate operation.
   - Avoid construction work during prayer and night time. Sensitivity to noise increases during night time hours in the residential area.

3. Alternative construction and equipment use
   - Avoid pile driving which cause noise and vibration at the sensitive areas. Therefore, use cast in-situ is used for construction of the infrastructure.
   - Use specially quieted equipment, such as quieted and enclosed air compressors, mufflers on all engines
   - Use suitable PPEs like Ear Plugs for the workers in the project site and they shall maintain the working hour.

J. Vibration

497. In order to reduce the impacts of vibration generated from the construction yard, a number of mitigation or reduction steps should be included during the construction period.

1. Design Consideration and project layout
   - Road route for the loaded truck should be away from the residential area. So use the existing road network for material handlings
   - Operate earth moving equipment on the construction lot as far away from vibration sensitive's sites especially the southern project boundaries as possible.

2. Sequence of operation
   - Earthmoving, tree cutting and ground –impacting operations should not be occurred at the same time period.
   - Avoid night time activities, kept away the vibration generating equipment like electric generators, machineries from the workers colony and nearest local residential areas. Because, people are more aware of vibration in their residence during the nighttime hours.

3. Alternative construction methods
   - Avoid pile driving and use cast in-situ methods.
   - Avoid vibratory rollers and packers near sensitive areas

K. Water Resources

Drainage System

498. Provision of alternative drainage network for rainwater will be taken care if the existing drainage line is disrupted due to the construction works/earth-filling activities. Establishing the local drainage line with appropriate silt collector and silt screen for rainwater or wastewater connecting to the existing established drainage lines already there. It should be provided a strong channel protection works over the previous protection given during land development. Building new drainage lines as appropriate and required for wastewater from construction yards connecting to the available nearby recipient water bodies. Ensuring the wastewater quality

conforms to National Standards and IFC standards as applicable, before it is being discharged into the recipient water bodies. Ensuring that there will be no water stagnation at the construction sites and camps. Protection of natural slopes of drainage channels to be ensured adequate storm water can be drained. Regularly inspection and maintenance of all drainage channels could be initiated to assess and alleviate any drainage congestion problem. Re-excavation of the local channels in between completed land development works and beginning of infrastructural development if required.

Navigation

499. The provision of 24 hour signaling system in the Bhairab River to avoiding accidental events near the project location.

Surface Water Quality

500. Temporary sediment lagoon will be installed if required to capture sediment-laden run-off from the work site. Stockpile materials should be installed providing a minimum distance from drainage lines avoiding the agitates mixing with channel water. Provision of fencing can enhance the protection system as well. It is to be ensured that tires of construction vehicles are cleaned in the washing bay to remove the mud from the wheels. This should be done in every exit of each construction vehicle to ensure the local roads are kept clean. Both Non-hazardous including municipal and hazardous waste to be temporarily stored in a designated area for final disposal to the authorized vendors or designated disposal site following GoB and IFC guidelines to avoid any contamination of the any water ways including adjacent Bhairab River. Moreover, storm water drainage network inside the project area ought to be taken under consideration to avoid any kind of contamination of water ways. Managing the harmful chemicals and components carefully is important for aquatic beings. An ETP will be part of the Rupsha 800 MW CCPP.

501. Jetty construction activities should be confined within limited area of the jetty construction site and excavated soil will be utilized for filling of project site avoiding turbidity in the water. All the vessels must follow the Inland water transport regulations of GoB as applicable. However, during transportation of machineries from abroad to the port, IMO and MARPOL will be followed. During any kind of discharges from the project site and from the vessels or construction equipment during construction period, GoB and IFC guidelines whichever is stringent will be followed.

L. Socio-Economic Condition

502. The labor should follow the environmental code of practice during construction. As in the existing Khulna plant, most of the labours would be sourced from nearby areas and they do not require any housing facilities at the site construction camp, as they prefer to stay in the vicinity areas. If at all, 2 temporary stacked steel container sheds would be provided that can house a maximum of 8 to 10 labours. It is anticipated that about 1,500 manual work forces will be required at the peak construction period for work acceleration. Local people (mostly non-skilled labour) shall be engaged in the project period as needed. In addition, these local people will also be provided with trainings for finding opportunity of jobs in various sectors for upgrading of their livelihood. Most of the local labour will be coming from their residents and few non-resident will have camp facility within project area. Labour working condition must be guided with best practices. The worker colonies must follow good housekeeping.

503. An appropriate noise barrier to be installed to reduce noise level within GoB/IFC (whichever is stringent) limit to avoid impact to the school children, mosque area and neighboring

sensitive areas including occupational staff within and adjacent to the project area as applicable. In addition, the construction activities shall be kept stop during the prayer time and exam time in the school. The project affected people due to different Project activities shall be given utmost priority for jobs under the project. There shall be provision for incentives such as training, micro-credit etc. under the rehabilitation programme for the workers who are working temporarily in the project area and also temporary Incentives to be given for alternative livelihood activities to the PAPs.

504. Special attention should be provided for supplying safe drinking water, safe sanitation system for the labour sheds. Registered doctor and assistants should be employed during construction phase. Emergency team and ambulance will be in place to transfer injured people from the accidental spots to the nearest hospitals and clinics. This provision also should be kept for the community people adjacent to the project area who may have chance to fall in accident due to construction activities of the power plant. Special or contingency fund should be created for health and safety management if any accidental incidences occur. Health and safety trainings should be provided regularly.

M. Non-hazardous waste generation

Leaching of generated wastes to nearby environment

505. A designated place for dumping waste should be provisioned. A good practice of waste collection and disposal system should be adopted. Construction waste to be stored temporarily in a designated area before selling to vendors or disposing in the authorized disposal area. Some temporary bins with colour marking indicating degradable and non-degradable waste might be installed at labour shed and work places to prevent scattering of wastes before final disposing to the designated disposal area. There should be a designated site or scientific landfill area for kitchen waste disposal for controlling bad odour and leachate having susceptibility to contaminate water. Finally, the land area of the project site should be raised above flood level for preventing wastes to wash away to nearby water bodies.

Operation Stage

N. Ambient Air

506. Emission from the power plant will be controlled through the installation of the Best Available Control Technology (BACT) to minimize air emission. The stack height has been proposed resting on the GEP. Built-in Low-NOx burner in gas turbine will reduce the NOx emission below 25 ppmv where the wet injection will reduce the NOx level below 74 ppmv. Switching of the fuel type from natural gas to HSD to operate the power plant, the fuel Sulphur contain must be less than 1% and the emission of particulate matter will be less than 30mg/Nm^3. Continuous monitoring will be conducted at the stack, testing stack emission and ambient air quality sampling through passive process for monthly or seasonal basis. Moreover, third party monitoring and auditing will be conducted to identify the changes the ambient air quality and its impact during construction and till one year of operation

507. The project will emit more than 1 million tons of GHG hence, require a number of GHG emission reduction technologies and related policies. In addition, green building concept to be introduced in order to reduce energy consumption and sustainable energy use. Further to that, energy efficient lighting system, rain water harvesting system, roof top solar panel system, biogas

system from sewage materials and also green belt shall be adopted as an offset technology for reduction of GHG in the local environment.

O. Noise Level

508. The machineries should be maintained properly according to the provided instructions as proper maintenance can decrease the level of noise significantly. The rotating machinery, such as turbines, pumps, fans etc. should be covered with noise proof hood to limit the spread of noise. Silencer should be used wherever possible. A green belt consisting of trees of different heights and canopy coverage should be developed along the boundary wall of the power plant area. The green belt should be of at least 3.5m width consisting two rows of plantation with the gradual increase of height of plant from inside row to outside row.

P. Water Resources

Drainage System

509. Spoil management plan must be followed during project site land filling by dredging materials from government approved designated site. Monitoring and maintenance the internal drainage system inside the power plant area. It is to be cleaned the storm water drainage channel before monsoon inside the project area.

Surface Water Quality

510. ETP for industrial waste, oil separator for oily waste, STP for sewerage must be installed and functioned properly. Maximizing the reuse and recycling of effluent will reduce the discharge but all discharges shall follow GoB and IFC standards as applicable and also whichever is stringent. Training and awareness-building program to the workers and professionals should be provided.

Provision of bank protection works at the eastern boundary

a. Protection of eastern boundary
b. Provision of entering tidal wave at the intake point that can avoid sedimentation at bottom of the intake channel.
c. Position of jetty have to be located to a place where intake channel remains safe from crushing by the Ship/Barge.

Mitigation of the impacts on Riverine, dolphin habitat and benthic community

511. During the winter there will be sufficient water flow of Bhariab River and the power plant will take maximum 0.12% of the total discharges of the Bhairab River and therefore, there will be no problem for water availability during lean period subsequently no impact on the aquatic species including dolphin. Existing supply water facilities will be used for drinking purposes and therefore, ground water extraction for the power plant will not be required. All the vessels must follow the standard of Inland river transport regulation. In addition, for transportation of maintenance equipment from abroad, IMO, MARPOL shall be followed. All kinds of discharges from the project site, power plant shall meet regulatory requirements of GoB and IFC guidelines whichever is stringent and appropriate. Any kinds of alien species must be quarantined before transshipments from abroad for carrying maintenance equipment for the power plant.

Q. Fisheries

512. ETP should be properly functional. Foreign cargo/vessels (ship from abroad caring heavy equipment) must be checked for protecting the migration of invasive species. Continuous monitoring of intake water velocity should be ensured and necessary measures are to be taken if intake water velocity exceeds 0.5 ft/s in the dry season and specially breeding season. Drum screens need to be adopted in order to limit the entrainment of fish in the cooling water system and intake velocities should be as low as possible. Temporary water reservoir can be built for water storage rather than direct abstraction from river.

R. Socio-Economic Condition

513. Women and men at the fishermen village should be eligible (and have priority as locals) for project employment during survey activities, site clearance and construction for non-technical roles. These can be as simple as carrying equipment, sewing uniforms, cleaning, helping to prepare food. Facilitate to recruit local people according to their skill. Different types of business will be initiated where numbers of people will be employed. Development of infrastructure, transportation and communication systems and electricity in the area will obviously create business opportunity which will create new employments to a number of local people. Steps should be taken for supplying safe drinking water and Safe sanitation system. Provision for contingency fund should be kept for the fishermen. Health and safety management for the NWPGCL official, workers should be considered.) Keeping provision both for the workers and non-workers who may be affected by the power plant. Thus their family can get facility in any accidental case.

S. Sewerage

514. The project has been adopted STP for treating sanitary waste as a large number of employees will be residing in the project area. The STP might be of biological type or in combination with physical, chemical and biological type. Generally, an STP consists of screening devices, aeration, active sludge treatment, sedimentation, clarification and separation/recirculation of sewage sludge. Membrane bio reaction is a good alternative. The EPC contractor should construct an STP including the sewerage collection network. The provision of reusing the treated waste should be considered in the design. The treated water can be reuse for watering to the vegetation in the project area. The sludge from STP should be disposed in compliance with the IFC standard and ECR 1997.

T. Hazardous Sludge from Water Treatment Plant

515. The feasibility study proposes thickening and dewatering of sludge, in the form of dry cake, generated from water treatment plant. The dry cake of sludge should be managed properly so as to avoid leaching of heavy metals in the rainfall run off. Dry cake that would be mostly iron sludge has market potential in steel rolling mill. However, the EPC contractor should consider this issue and propose a sustainable management plan for sludge handling.

U. Hazardous waste generation

Use of Hydrazine in feed water for oxygen scavenging

516. Use alternative oxygen scavenging chemical e.g. Halamine, Diethyl hydroxylamine, etc. in feed water for corrosion protection in boiler. Changing the design of boiler and water treatment

system e.g. using Combined Water Treatment (CWT) or oxygen treatment for through-flow boilers and treating using a volatile substance of high pH value instead of Hydrazine.

Hazardous sludge from water pre-treatment and treatment plant

517. The feasibility study proposes thickening and dewatering of sludge, in the form of dry cake, generated from water treatment plant. The dry cake of sludge should be managed properly so as to avoid leaching of heavy metals in the rainfall run off. Dry cake that would be mostly iron sludge has market potential in steel rolling mill. However, the EPC contractor should consider this issue and propose a sustainable management plan for sludge handling.

6.0 ANALYSIS OF ALTERNATIVES

518. Aside from economic, financial, safety and engineering factors, the potential environmental and social impacts have been carefully considered in selecting the best route for the gas distribution pipeline. Both the “no project” and “with project” options have been studied.

6.1 “No project” option

519. A “no project” option negates the need to meet the future demand for electricity in Bangladesh. This means that the area within the previous site of KNM will remain the same as the current condition. As such, there would not be any additional power generation capacity in southwestern part of Bangladesh to meet the growing demand for electricity. A “no project” option will entail that the planned economic development and business opportunities within southwestern Bangladesh may not altogether happen due to lack of reliable power, and thus, will be an opportunity cost for GoB. **Table 6.1** presents a summary comparison of “with project” and “no project” options.

Table 6.1: Comparison of “with project” and “no project” options

Description	“With Project” Option	“No Project” Option
Additional power generation capacity from 800 MW Rupsha CCPP	• Provides a stable and reliable flow of natural gas for power generation • Achieves the GoB target of additional power generation capacity	No additional power generation capacity
Economic development	Potential for more opportunities in southwestern part of Bangladesh as a result of available and reliable power supply	Minimal, if any, due to lack of reliable power supply
Potential impacts to ecologically-sensitive areas	• Project site is an abandoned area of about 20.234 ha previously used by KNM which ceased operations in 2002. • No protected areas, national parks, or IBAs within 5 km and 10 km radius from the site. • Associated potential impacts can be readily mitigated by adherence to applicable design standards and specifications, compliance to relevant regulations, and implementation of best practice engineering processes and procedures.	None
Potential impacts to terrestrial flora and fauna	• Project site is not known to host endangered or protected species of flora and fauna. • Some trees and other vegetation that grew from the abandoned structures will be cleared.	None

Description	"With Project" Option	"No Project" Option
	• A biodiversity assessment was done by IUCN Bangladesh due to sightings of the endangered species, Ganges River dolphins, within the project site river systems: Bhairab River, Rupsha River, and Atai River. Results of the assessment showed that the project site and the immediate vicinity along the Bhairab River is not a critical habitat based on the criteria set by SPS 2009 and the IFC Performance Standard 6 – Biodiversity Conservation and Sustainable Management of Living Natural Resources (January 2012).	
GHG emissions	Combustion of natural gas 92% and HSD 8% will cause GHG emissions like CO_2. Component 1 will contribute 1.69 M tons CO_2/year during operation. However, at full implementation of Component 1, annual net emissions reduction was estimated to be 0.17 M tons CO_2/year by displacing oil-fired power plants.[49]	No GHG emissions contribution
Disruption to local residents within and adjacent to the BCIC property where the project site is located	Potential impacts or disruption to daily activities will be minimal (i.e., temporary and short duration during construction/installation). Any disruption can be mitigated by proper construction planning and scheduling of activities. Transport of heavy equipment and machinery like turbine, HSRG, etc., will be done through the Bhairab River from the Mongla Port which is expected to be about 2-3 deliveries.	None
Employment	Job opportunities will be created. An estimated 58 positions will be created for the Project Management Set-up and 307 positions required for the Operation and Maintenance.	None

6.2 "With project" options

[49] Displacing electricity in the grid in Bangladesh was estimated using grid emission factor of 0.67 ton/MWh. Source: DoE, 2013. Grid Emission Factor of Bangladesh. Dhaka.

6.2.1 Suitability of the site

520. Bangladesh is densely populated with an estimated 2017 population of 164.67 million and area of 144,570 km^2. Thus, population density is 1,139 people per km^2. Aside from this, the geography of Bangladesh makes it difficult for GoB to acquire land for development projects and is now a great concern. The scarcity of land is one of the major obstacles for development of industries like a combined cycle power plant. The abandoned land of about 50 acres previously used by KNM is the best site for Component 1.

6.2.2 Suitability of fuel

521. Considering the issues due to the effects of global warming, renewable energy- based power plants like solar and wind energy are encouraged. Solar power plants require large area of land that is not easily available in Bangladesh.

522. As of January 2018, the total installed capacity in Bangladesh is 13,846 MW with energy mix as follows:[50]

- natural gas – 8,754 MW (63.22%)
- HFO – 2,794 MW (20.18%)
- HSD – 1,158 MW (8.36%)
- Power import – 660 MW (4.77%)
- Coal – 250 MW (1.8%)
- Hydropower – 230 MW (1.66%)

523. Out of this installed capacity, NWPGCL owns 400 MW. Based on the energy mix, the carbon dioxide (CO_2) emission of each fuel type is compared to determine the suitability of natural gas as fuel for Component 1. Hydropower will not have CO_2 emissions.

Table 6.2: CO_2 emissions by type of fuel

Type of fuel	CO_2 emissions lbs CO_2 per million BTU
Coal, lignite	215.4
Coal, anthracite	228.6
Coal, bituminous	205.7
Coal, subbituminous	214.3
Diesel fuel and heating oil	161.3
Natural gas	117.0

Source: Frequently Asked Questions, US Energy Information Administration

524. Based on CO_2 emissions, natural gas is the most suitable fuel. Bangladesh has very limited hydropower potential except for Chittagong and the Chittagong Hill Tracts which may have potential for micro-hydro and mini-hydro.

525. Given the natural gas reserves of Bangladesh, NWPGCL has the experience to manage a combined cycle power plant using natural gas as fuel. There will be adequate supply of natural

[50] Bangladesh Power Development Board. Power Generation Units (Fuel Type Wise) http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=150&Itemid=16

gas as Qatar will supply 1.8 million tons of LNG per year to Bangladesh for the first five years beginning 2018 and 2.5 million tons per year for the next 10 years as part of GoB efforts to diversify its export markets.

526. Solar power plants require large area of land that is not easily available in Bangladesh. There is very limited hydropower potential except for Chittagong and the Chittagong Hill Tracts which may have potential for micro-hydro and mini-hydro. Burning of coal, diesel, and natural gas contribute to greenhouse gas (GHG) emissions as carbon dioxide (CO_2) but natural gas contributes the lowest among these fuels at 117 lbs CO_2 per million BTU and is, thus considered more environment-friendly. Natural gas is mainly CH_4 with higher energy content compared to other fuels.

527. Wind resources potential in Bangladesh for generating electricity is limited. 51 available data from measurements and satellite data indicate that onshore wind speeds are below 5 m/sec average a year which is quite low wind speed for the purpose of wind energy. Available satellite data for offshore wind speeds are slightly higher but still relatively low about 6 m/s. Availability of suitable space for wind farm is also a challenge given the population density, and if at all available, it will in in flood-prone areas.

6.2.2 Power generation technology

528. Aside from advancing the recommendations of PSMP 2016, the choice of combined cycle power plant using natural gas as fuel is consistent with the Energy Policy (June 2009) of ADB. In maximizing access to energy for all, “ADB will continue to support financing natural gas-based power plants because of their environmental benefit.”[52]

529. Modern CCPPs have undergone many developments to much more improve its capability in areas such as fuel flexibility, reduce life cycle costs, operational flexibility, low emission levels, operate on a wide range of fuel, rapid ramping rates, higher efficiency, and higher availability. On 28 April 2016, GE Power in partnership with EDF achieved a 62.22% efficiency rating for a combined cycle power plant in Bouchain, France (over 605 MW).[53]

530. While Bangladesh has abundant water resources, it has relatively limited hydropower potential due to its topography where most of the land is spread over the delta along the Bay of Bengal and most of the areas are lower than 9 m above sea level.

531. The existing Karnafuli Hydropower Plant in Chittagong that uses Kaptai Lake is the only hydropower plant in Bangladesh with an installed capacity of 230 MW. The first units (2 x 40 MW) were installed in 1962 and another unit of 50 MW was installed in 1982 with the support of the United States.

532. ***Options for types of gas turbine***. There are several classes of gas turbine in the market. GE Power’s largest 9HA.02 gas turbine is now available at more than 64% net efficiency in combined cycle power plants. The project prefers F-class compared to H-class for the following reasons: (i) total net power output falls within the net power output of the proposed gas turbine/CCPP and the maximum block size shall be in compliance with the current limits governing

[51] Netherlands Enterprise Agency.Baseline Study Wind Energy BangladeshCommissioned by the ministry of Foreign Affairs. 13 April 2017.
[52] ADB. Energy Policy June 2009, p.11
[53] GE Power. Breaking the Power Plant EfficiencyRecord. https://www.gepower.com/about/insights/articles/bouchain-grand-opening

the national grid system security in Bangladesh; (ii) commercial operation is a proven design; (iii) NWPGCL has the ability to cope with F-class gas turbine technology based on experience in terms of operation and maintenance; and (iv) the net power output can be accommodated by the system according to the power load study conducted by PGCB. F-class units provide more flexibility in burning a wide spectrum of fossil fuels including gasified coal. In addition, fuels can be switched after start-up without sacrificing performance.

533. For the H-class gas turbine CCPP, (i) the net power output is higher than the planned new capacity; (ii) it is a relatively new technology; (iii) the higher power output may cause system instability based on the load study conducted by PGCB; and (iv) there is a need to acquire new knowledge and skills in order to effectively and reliably operate and maintain.

6.2.3 Cooling system options

534. Water is mainly used at power plants for cooling. This is accomplished in one of two ways: once through cooling system or closed-loop (recirculating) cooling systems. These systems both withdraw and consume water, but not all water withdrawn is consumed. The once-through cooling abstracts water from a reservoir or a water body (i.e., river or sea) near the power plant through a heat exchanger and discharges spent water to the receiving body of water at a higher temperature. Component 1 considered the following options (**Figure 6.1**).

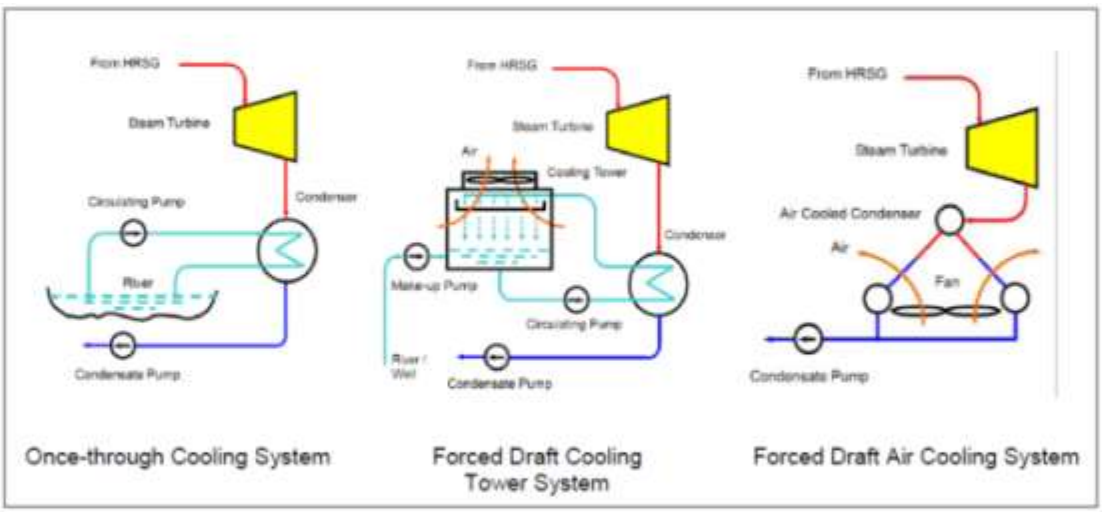
Table 6.3: Analysis of different cooling systems

Type of Cooling System	Description	Advantage/Disadvantage
Once-through cooling system	• This will take water of about 60,000 m^3 per hour from the Bhairab River and will discharge about the same volume with warmer, higher temperature (usually about 3^oC from ambient) to Bhairab River. • Cooling water requirement – very huge • Bottoming cycle performance – best • Land area – base • Noise pollution – base	Advantages are simplicity and low cost while major disadvantage is the disruption to the local ecosystem from the significant water withdrawals involved and the release of warmer water back into the Bhairab River as thermal effluent. Given the presence of fishing village across the project site and the presence of Ganges River dolphins in the river systems, this is not a good option.
Forced draft cooling tower system (or closed-loop cooling system)	• Wet-recirculating or closed loop systems reuse cooling water in a second cycle rather than immediately discharging it back to the original water source. Most commonly, wet recirculating systems use cooling towers to expose water to ambient air. Some of the water evaporates; the rest is then sent back to the condenser in the power plant.	Advantages include lower water withdrawal (about 2,010 m^3 per hour) than once-through system (water only withdrawn to replace any water that is lost through evaporation in the cooling tower).

Type of Cooling System	Description	Advantage/Disadvantage
	• Cooling water requirement – big amount as make-up water only • Bottoming cycle performance – base • Land area – more • Noise pollution – not good	
Forced draft air cooling system (or air cooled condenser)	• Dry-cooling systems use air instead of water to cool the steam exiting a turbine. • Cooling water requirement – negligible • Bottoming cycle performance – not good • Land area – most • Noise pollution – not good	Advantages include no water use for cooling and can decrease total power plant water consumption by more than 90%. Not advisable since it will cause noise pollution and a rise in ambient temperature of the surrounding area of the proposed plant (microclimate). Expensive system compared to other cooling systems. Advisable to use only if water is not available.

535. Based on evaluation and comparison, once-through cooling system cannot be adopted due to environmental impacts of abstracting huge amount of water. NWPGCL will use the forced draft cooling tower system.

Figure 6.1: Schematic diagram of a cooling system



Source: Feasibility Study of the Rupsha 800 MW Combined Cycle Power Plant Project, August 2017 (Minconsult SDN BHD).

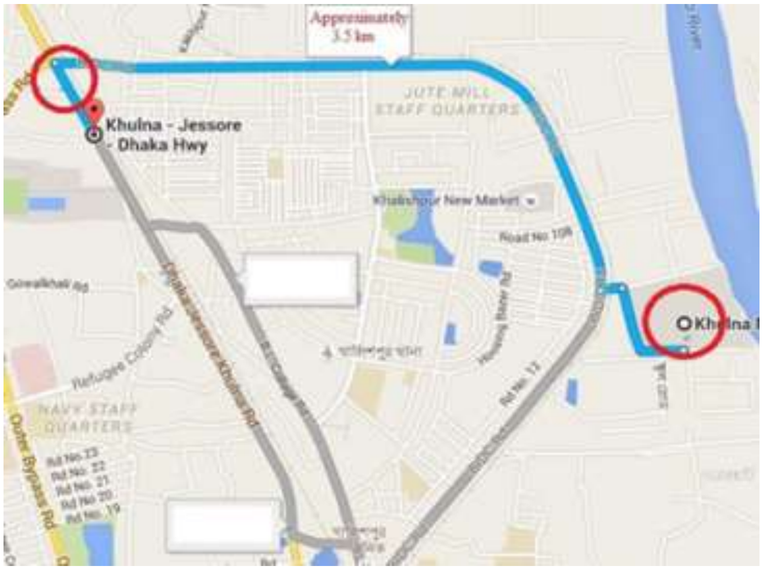
6.2.4 Modes of transporting heavy and oversize equipment to the site

536. Delivery of equipment to the site on time is important in meeting the construction and installation schedule. There are several available modes of transport and the following options were considered in the Feasibility Report (**Figure 6.2**).

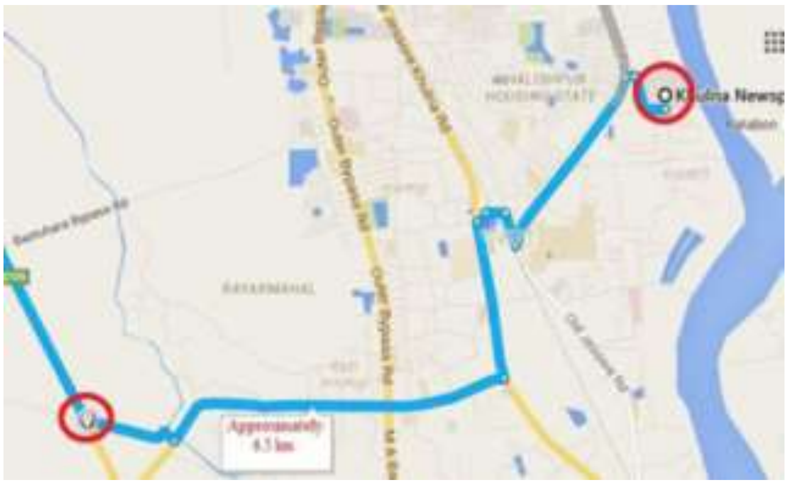
Figure 6.2: Transportation routes for heavy and oversized equipment

Highway:

(1) Khulna-Jessore-Dhaka Highway (Approx. 3.5km away from project site)



(2) Khulna-Mongla Highway which is connected with Khulna city Bypass (Approx. 6.5km from the project site)



(3) There are 3 major bridges from site to Mongla Port. These are:

- Labaochora Bridge over Moyur River, Khulna City Bypass
  Load bearing capacity: 70 tons
  Width of the bridge: 18 m
  No height restriction.
- Rupsha Bridge over Rupsha River, Khulna-Mongla Highway
  Load bearing capacity: 70 tons
  Width of the bridge: 16.50 m
  No height restriction.

- Katakhali Bridge over Katakahli River, Khulna-Mongla Highway
  Load bearing capacity: 70 tons
  Width of the bridge: 12 m
  No height restriction.

Railway:
Daulatpur Railway Station (Approx. 5 km away from project site).

Water Way
Bhairab River is very close to the proposed site and Mongla port can be accessed through this river.

537. Given the route options, the road, railway, and river transport are available. However, since Bhairab River is adjacent to the project site, the most efficient transportation option is by this waterway. NWPGCL estimates that the number of trips for delivery will be twice or thrice per year during construction phase when major equipment like turbine, generator, etc. will be installed.

7.0 INFORMATION DISCLOSURE, CONSULTATION, AND PARTICIPATION

7.1 Introduction

538. Consultations for Component 1 were conducted as part of the requirements of the DoE and ADB's SPS 2009. The main objective is to involve stakeholders throughout the project implementation and to know their concerns and perceptions about the project. Specific objectives of consultations include the following:

a) To ensure peoples' participation in the proposed project;
b) To inform key stakeholders about the project, its environmental implications within the project area, potential environmental impacts and mitigation measures, project benefits, and about the "cut-off date" for persons directly affected by the project;
c) To determine the perceptions of the people about the project and share experiences of the participants on similar projects;
d) To understand and create awareness of problems in the project area;
e) To discuss and propose possible solutions to the problems identified;
f) To describe the mechanism for handling potential grievance related to the project; and,
g) To inform stakeholders on access to information about the project.

7.2 Approach and Methodology

539. Stakeholders were classified into primary and secondary stakeholders. These stakeholders are characterized as the following:

a) Primary stakeholders

540. The primary stakeholders are those that may be directly affected by Component 1 during pre-construction, construction, and operation. These are people living within the vicinity of the project site (i.e., within the 10-km radius) which includes teachers and students from the existing boys and girls grade school, guardians of the schools, *Imam* and adherents to the mosque, security personnel at the KNM, and the fishermen community.

b) Secondary stakeholders

541. These are persons or organizations that will not be directly affected but may have interests that can contribute to the projector may affect decision-making in some areas. Secondary stakeholders may include relevant government agencies like Road Development Authority, DoE, Bangladesh Petroleum Corporation, community-based organizations, NGOs, and other interested individuals or groups.

542. Local government officials were invited with hand delivery letter of invitation from NWPGCL. Aside from the list of participants collated by CEGIS and invited through telephone calls, the two formal consultation events were advertised in the local paper to capture a wider audience. **Annex 4** presents a sample advertisement of the consultation in the local paper.

543. Checklists were used to guide the consultations to ensure that the discussions are focused and relevant. A summary includes information about the project, proposed implementation schedule, and potential project impacts. NWPGCL and CEGIS (Consultant of NWPGCL) made a project presentation and a question and answer (Q&A) portion immediately followed. Views and

concerns of the participants were recorded and their questions were properly responded to by NWPGCL, CEGIS, ADB staff (if required) and their consultants.

7.3 Consultations during the preparation of the EIA

544. During the initial preparation of the EIA, a total of six consultation events were conducted from 28 October 2016 to 13 November 2016 by the CEGIS, and again on 21 October 2017 to present the findings of the environmental due diligence (**Table 7.1**). Two consultation events (i.e., early stage of EIA preparation and presentation of findings) were participated by the ADB Project safeguard staff and consultants.

545. The two formal consultation[54] events were done on 12-13 November 2016 to present Component 1 and another on 21 October 2017 to discuss the outcome of the EIA conducted for Component 1. Aside from the NWPGCL Project Team, ADB safeguard staff, and consultants, the formal consultations were attended by government representatives from Khulna City Corporation, teachers from the KNM Boys & Girls Grade School that will be relocated, students, School Management Committee, journalists, fisher folks, and interested individuals. The first formal consultations on 12-13 November 2016 were participated by 91 attendees while the second formal consultationon 21 October 2017 was joined by 64 attendees (**Annex 5**). Aside from the primary stakeholders who previously joined the consultations in November 2016, the second consultation was attended by the Mayor, Khulna City Corporation, Councilor of Ward No. 13, and other local government officials. Photo documentation during the formal consultations is presented in **Annex 6.** A handout in Bengali was given to participants (**Annex 7**).

Table 7.1: Location of consultations

Division	District	Upazila	Municipality/ Union	Meeting type	Meeting Place	Date
Khulna	Khulna	-	Ward No. 13, Khulna City Corporation	Workshop	IEB conference room, Khalishpur	12/11/2016
		-		FGD	IEB conference room, Khalishpur	12/11/2016
		-		FGD	IEB conference room, Khalishpur	13/11/2016
Khulna	Khulna	Dighalia	Senhati	FGD	Chandonimahal village	13/11/2016
Khulna	Khulna	Batiaghata	Jolma	Rapid Rural Appraisal	Puthimari Bazar	28/10/2016
Khulna	Khulna	Batiaghata	Jolma	Group Discussion	Tetultola village	28/10/2016
Khulna	Khulna	Khalishpur	Khalishpur	Workshop	IEB conference room, Khalishpur	21/10/2017

7.4 People's perception of Component 1

546. NWPGCL and CEGIS discussed Component 1 to participants, its potential environmental impacts, and mitigation measures. Local people within the project site have already learned about

[54] Formal consultation is referred to as a consultation event where most of the participants are invited either by letter or phone call, advertisement of the event on the local paper, and venue agreed among the local people.

Component 1 from designated staff of NWPGCL and their consultants who frequently visited the project site. Thus, they are aware of some of the potential impacts but showed positive attitude towards the implementation of Component 1. **Table 7.2** presents the perceptions of the local people on Component 1.

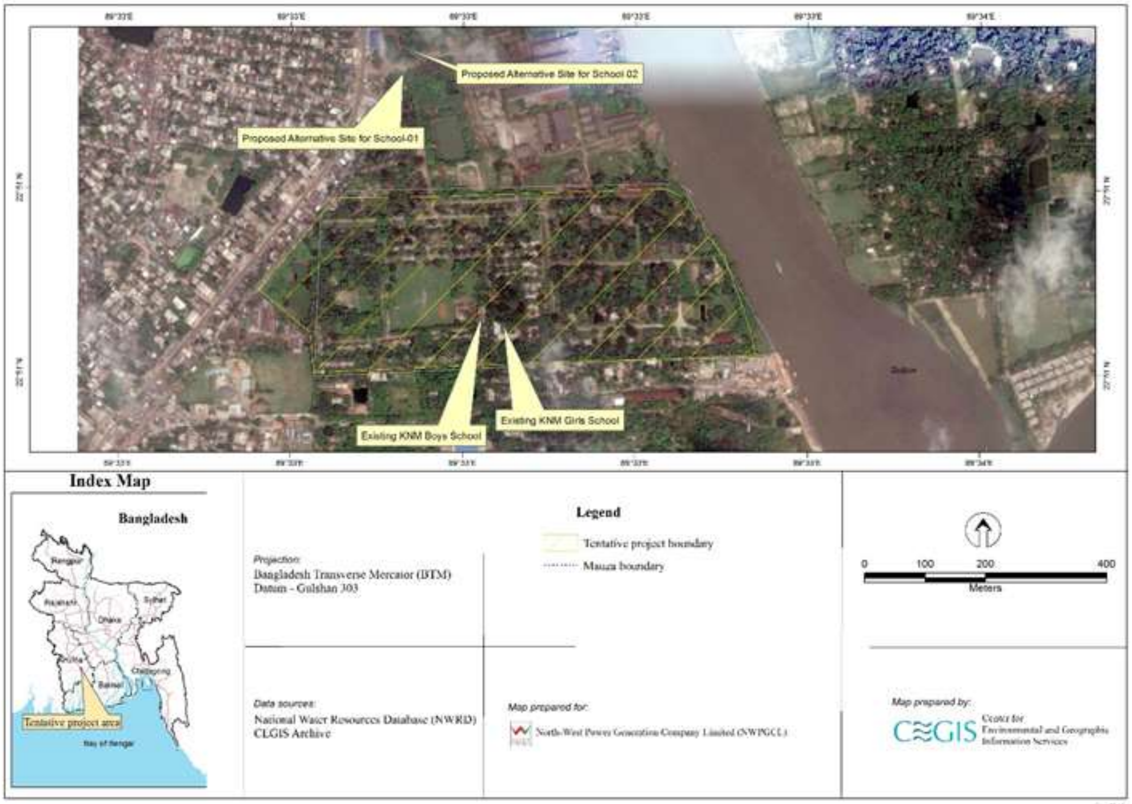
Table 7.2: Perceptions of local people to Component 1

Issues	Observations by the participants
Benefits from the Project	• Electricity will be generated which may have positive impacts on the local and national economy; • Reliable and stable supply of electricity; • Additional power generation capacity may result to setting up of new industrial area along with small and medium industry in the country • Project site is currently abandoned and not economically productive but proper use may motivate local entrepreneurs to start new industries in Khalishpur which may have positive impacts on land price and livelihood of the local people • Potential employment opportunities • Renovation of existing structures like the mosque and mass graveyard marker
Adverse impacts of the Project	• Regular activities of KNM boy’s school and girl’s school may be affected during the construction period • Potential loss of jobs among security personnel, caretakers, cleaners, and cooks involved with KNM maintenance • Some wildlife species (snake, frog, fox, insects) that found the abandoned KNM site as habitat may be affected • Livelihood of fishermen group may be affected indirectly as the Bhairab River is going to be used as transportation route for the power plant • Clearing of trees within the abandoned KNM site may adversely affect the natural environment • Demolition of abandoned structures at the current KNM site will cause generation of dust, noise, solid wastes and debris which may adversely affect students, teachers, and the local people

547. The existing boys' school and girls' school will be directly affected and, thus, will be relocated. The proposed 50 acres (or 20.2343 hectares) of land is still under the ownership of KNM and awaiting transfer to NWPGCL.

548. As a result of consultations, the school authority suggested three alternative relocation sites for the construction of new school building and campus but preferred the two relocation sites located in the KNM boundary: right side or left side of the main gate to the KNM property (**Figure 7.1**). The two preferred options are about 350 m to 400 m away from the current school campus.

Figure 7.1: Alternative relocation sites for the proposed school campus



549. **Table 7.3** presents the summary of consultations on 12-13 October 2016 while **Table 7.4** gives the summary of consultation on 21 October 2017.

Table 7.3 Summary of consultations, 12-13 November 2016

Issues	Concerns	Suggested measures
Socio-economic impact	• Existing two schools (one for boys and the other one for girls) will be relocated and it may adversely affect the regular study routine of the students and teachers • Staff who are currently involved in maintenance of KNM (night guard, caretaker, cleaner and cook) may lose their jobs • Around 100 fishermen households are residing across the project site on the opposite side of the Bhairab River. They are dependent on Bhairab River on navigation and may be indirectly affected by potential traffic along the	• New building for school should be handed over to the school authority prior to construction works • Existing school occupies 1.81 acre (or 0.732 ha). New school needs to be in the same amount of land. • New school campus should have facilities like playground, science laboratory, computer laboratory, library, canteen, sanitation facility, drinking water, waiting room for the guardians etc. • For the new school, the School Management Committee prefers the land within the Bangladesh Chemical Industries Corporation (BCIC) property

Issues	Concerns	Suggested measures
	river causing broken fishing nets during construction phase • Demolition of abandoned structures in the project site will generate wastes, dust, and noise • Potential increase in ambient noise level due to the power plant may disturb activities in the mosque, school, and residential areas	• Install noise barriers to keep the school away from potential increase in noise levels • NWPGCL to consider during recruitment those who may lose jobs from KNM due to the implementation of Component 1 • Location of power plant (machineries that generate noise) area should be kept far away from the settlements • Consider natural hazards like earthquake in the design of the new school • Provide prayer space/partition for the women in the mosque • Ensure that care and reverence are observed in the renovation/restoration of the mosque and the mass graveyard • Provide mitigation measures to fisherfolks who may be affected by potential traffic along the Bhairab River due to Component 1 • Consider engaging local people for activities such as land development, removal of the solid waste, and other non-technical works during pre-construction and construction stage • To reduce load shedding during irrigation period at the village level
Ecological impact	Site preparation will require clearing of trees that may adversely affect the natural environment and loss of habitat to some faunal species	• Save century-old trees (if any) and limit vegetation clearing to what is required • Rescue wild animals prior to construction works • Assign a wildlife expert to observe the condition and/or rehabilitation of animals based on Bangladesh wildlife Act that may be encountered during pre-construction and construction stage • Consider in the design avoiding trees. • Provision for afforestation within the project area

Table 7.4: Summary of consultations, 21 October 2017

Issues raised by participants	Response from NWPGCL and CEGIS
Modern technology should be adopted.	Latest available technology will be adopted for Component 1 to reduce air emission, noise level, and water extraction following the requirements of DoE and ADB. Some of these are: (i) low-NOx burner, (ii) stack height of 60 m for HSRG and 50 m for bypass, (iii) use of closed loop cooling water system, (iv) wastewater treatment plant, and, (v) groundwater will not be used to meet water requirements.

Issues raised by participants	Response from NWPGCL and CEGIS
Consider local experts' inputs (e.g. from Khulna University) on technical aspects of Component 1	NWPGCL and CEGIS to include inputs from relevant experts/teachers at the Khulna University during consultations or alternatively, Khulna University can access the documents to be posted in the website of ADB and NWPGCL
All mitigation measures identified must be implemented	Implementation of EMP will be monitored by NWPGCL from pre-construction to operation phase
To carefully review the EIA to ensure that people truly gain from the outcome of development	Project implementation will be monitored by NWPGCL from pre-construction to operation while ADB will monitor compliance of NWPGCL
To ensure health, safety and security at and around the project	• All safety measures required by GoB and ADB will be complied. • Workers will be trained on disaster and emergency preparedness including safety awareness. • First aid kits and the service of a trained physician will be provided as well as personal protective equipment to workers and staff who will need them
Relocation site for the boys and girls school needs to be finalized as early as possible	• Current condition of the schools is a safety risk for the students and relocation needs to be done as early as possible. • Selection of the relocation site will consider inputs from stakeholders like the School Management Committee, school authority, etc. including environmental and social considerations before submission of report to ADB and GoB • Two modern multi-storeyed schools' buildings will be constructed with better and modern school furniture • Two school buses (a bus per school) and laboratory with modern instruments, furniture will be provided • A solar panel will be installed as back-up during load-shedding of electricity (if it occurs) • A playground (bigger and better than the current one) will be included • The school will be ready before students move in • A clinic with ambulance service will be provided as well as safe drinking water system • EMP and monitoring plans will be implemented by NWPGCL and monitored for compliance by ADB
Mosque and graveyard of martyrs should be renovated and/or improved.	Relevant works for the renovation of mosque and graveyard of martyrs will be done with carefully and with reverence.
Livelihood of fishermen across the project site on the other side of Bhairab River may be at risk during the implementation of Component 1	NWPGCL and CEGIS conducted the study in the buffer zone considering 10 km radius from the project. No adverse impacts on river ecology were identified at Bhairab River and Atai River.
Rehabilitation programme should be introduced to affected fishermen	There is no need for a rehabilitation programme
All the KNM security guards should be employed in the new power plant	• Newsprint mill has another factory with machinery and administrative office. The security guards affected will be employed by KNM authority in another place.

Issues raised by participants	Response from NWPGCL and CEGIS
	• Should there be a need to employ security guards NWPGCL will consider them or other local people. • Recruitment of permanent staff at the power plant will follow the relevant Bangladesh civil service requirements.
Potential impacts on fish and biodiversity should be mitigated	IUCN is doing biodiversity assessment of Bhairab River, Atai River, and Rupsha River within the identified project area of influence focusing on the Ganger River dolphin. Their recommendations on management and monitoring will be considered for implementation by NWPGCL. The assessment is still ongoing.
Is there any experience of NWPGCL regarding this type of project in Bangladesh?	NWPGCL is an experienced and reputed company on combined cycle power plant technology. The existing 225 MW CCPP in Goalpara is owned and operated by NWPGCL.
Technical issues are not clearly understood. Is there any video document of combined cycle power plant using natural gas as fuel? If yes, please show us.	There are several video documentaries on natural gas combined cycle power plant in the internet. But due to lack of internet access in the location of consultations, we regret that we cannot show the video.
Is there any Government plan to provide electricity to all houses?	In Vision 2021, the Government aims to provide electricity to every home within 2021.

550. Consultations with stakeholders will continue during the implementation of Component 1. A communications strategy plan will be prepared with the technical support of a Consultant. This will ensure that stakeholders are engaged, as and when needed.

551. A project summary of Component 1 will be posted in the website of NWPGCL. In addition, a one-page flyer on project brief including details on grievance redress mechanism and contact person in case of complaints and/or concerns will be prepared in Bangla and will be made available at the field office of PMU in Khalispur, Khulna and at the NWPGCL office in Dhaka. More details on Component 1 will also be available from the EIA posted on the website of ADB.

8.0 GRIEVANCE REDRESS MECHANISM

552. Grievances, within the context of environmental assessment, are actual or perceived concerns about the implementation of Component 1. NWPGCL takes relevant concerns of their stakeholders seriously and ensures that they are considered as partners throughout the project cycle.

8.1 Current system at NWPGCL

553. NWPGCL manages grievance and/or complaints through the Grievance Redress System (GRS) which is required by the GoB and part of the mandatory Annual Performance Agreement (APA). This agreement will be signed and renewed annually between NWPGCL and GoB.

554. GRS requires the NWPGCL to designate a staff as Focal Point whose name and contact details are disclosed at the website of NWPGCL. Compliance to the GRS is a Performance Indicator in the APA. NWPGCL has designated its Focal Point as required by GRS and the details disclosed in its website.

555. The GRS consists of specified roles, rules, and procedures for resolving complaints, grievances, disputes, or conflicts systematically. The objective is to provide an effective and objective way of lodging and resolving complaints on public service delivery.

8.2 Grievance system required by SPS 2009

556. A grievance redress mechanism (GRM) will be set up once ADB funding for Component 1 becomes effective. Similar to GRS, the GRM aims to provide stakeholders with a clear and simple way of filing a complaint on the environmental performance of Component 1. According to SPS 2009, the GRM will address complaints promptly, using an understandable and transparent process that is gender responsive, culturally appropriate and readily accessible to the affected persons at no costs and without retribution. Given these requirements, handling of potential complaints/grievance on the implementation of Component 1 will be as follows:

557. **Information disclosure**. NWPGCL will post signboards at the construction sites on the grievance mechanism including the details of the contact person who will take the grievance. Details of the grievance mechanism together with the project brief will be posted in the website of NWPGCL to capture a wider audience.

558. **Procedure.** The GRM will provide three-tier entry points in grievance redress.

First Level – Field officers: In case of grievances that are immediate and urgent on-site field officers (of the PMU) will provide the most easily accessible first level of contact. The officer will put the complaint in writing and record the date, nature and type of grievance. It is anticipated that field officers will be able to respond and resolve minor grievances, especially by working with on-site contractors etc. The field officer will respond (or resolve where possible) queries within two weeks. Contact phone numbers and names of the concerned PMU field officer will be posted at all construction sites at visible locations.

Second Level – **PMU Grievance Committee:** If no resolution or understanding is reached, the field officer files the grievance/complaint to the PMU grievance committee for it to be resolved within 15 days after filing. The PMU Grievance Committee will include:

(i) a Representative of NWPGCL (i.e. Project Director) - Convener; (ii) Social Safeguard Specialist – Member; and (iii) a representative of the affected people – Member.

A meeting can be called, if needed, to give the AP the chance to present the concern in person. During the meeting, the PMU committee will receive, clarify and simplify the issues involved and would try its best efforts to resolve the issues to be acceptable to both the AP and the PMU. If an agreement or resolution is reached, the resolution will be signed summarizing the points of agreements. If there was no such agreement, the matter is presented to the GRC.

Third Level –Grievance Redress Committee. The GRC will meet at short intervals subject to the number of grievances to resolve. The complainant may present their issue to the GRC in person and will be encouraged to bring along a friend, family member of third party for support. In case of complicated cases, the GRC members can request additional information or carry out field level verifications. Resolutions should be based on consensus among members, failing which the decision may be taken on majority vote. Any decision made by the GRC must be within the purview of RP policy framework and entitlements. The GRC will function throughout the life of the project loan and will not deal with any matters pending in the court of law.

559. **Composition.** NWPGCL will ensure the representation of women in the members of the GRCs which the following could be:

- Representative of NWPGCL, Convener;
- Representative of the Local Government Institution (City Corporation), Member;
- Local women member from City Corporation, Member;
- Representative of the affected people, Member;
- Representative of the DC, Member.

560. The APs, not satisfied from the decision of the GRC, will have their right to take the grievance to a court of law. The GRM will be continuously disseminated to people during project implementation. The Project grievance procedure does not impede access to the court at any time. This includes ADB Accountability Mechanism whereby people adversely affected by ADB-financed projects can express their grievances; seek solutions; and report alleged violations of ADB's operational policies and procedures, including safeguard policies.

561. **Responsibilities.** GRCs will be expected to: (i) resolve grievances filed in writing or by phone to any member of the PMU, (ii) convene at least once a month to review grievances lodged (if any), (iii) record the grievances and resolve the issues within 14 days or a maximum of 30 days from the date the grievance was filed, and (iv) report to the complainant(s) the status of grievance resolution and the decisions made.

9.0 ENVIRONMENTAL MANAGEMENT PLAN

562. The environmental management plan (EMP) covers measures that will be conducted in every phase of implementing Component 1 to ensure that adverse impacts are minimized and positive impacts enhanced. Aside from the mitigation measures, the EMP also includes the required monitoring and implementation arrangements with cost estimates.

563. The EMP includes several plans for implementing mitigation and enhancement measures including Emergency Response Plan (ERP), Occupational Health and Safety Plan (OHSP), and Environmental Code of Practices (ECPs).

9.1 Objectives of EMP

564. Broadly, the EMP aims to manage the potential adverse impacts associated with the implementation of Component 1. Specifically, the objectives include:

- To facilitate the implementation of mitigation measures identified to minimize the potential adverse impacts and to comply with the environmental requirements of GoB, ADB, and IFC-WB EHS General Guidelines 2007 (if needed);
- To maximize potential project benefits and reduce adverse impacts;
- To draw the roles and responsibilities for NWPGCL, the EPC Contractors, consultants, and other staff who will be involved in the implementation of Component 1; and,
- To incorporate stakeholders' engagement initiatives such as the Communication Action Plan.

9.2 Implementation Arrangements

565. NWPGCL has a total of six staff on environmental, chemical and safety managing EHS concerns related to their operations. According to the Annual Report 2015-2016 of NWPGCL, additional eight staff will be recruited to enhance the technical capacity on EHS.

566. For the Rupsha 800 MW CCPP, NWPGCL will set up a PMU who will be responsible for project management and safeguards compliance monitoring of the EPC contractor during the construction stage. Component 1 will be managed and supervised also by the PMU. NWPGCL will require the EPC Contractor to recruit an environmental staff (or a Consultant) who will be primarily responsible for ensuring that EMP is properly implemented during construction. This requirement for the EPC Contractor will be included in the Bidding documents. The Environmental staff (or consultant) of the EPC Contractor will coordinate and liaise with the PMU (NWPGCL) on compliance to ADB requirements, relevant government agencies and local authorities on clearances (as needed) and will prepare the environment section of the Project's Quarterly Progress Report (QPR) submitted by the EPC Contractor to the PMU. The environment section in the Project's QPR will be summarized by the PMU Environmental staff and submitted to ADB during construction phase as semi-annual environmental monitoring reports to ADB (see **Annex 8** for the format of environmental monitoring report). The semi-annual environmental monitoring reports are posted on ADB's website as required by SPS 2009 and PCP 2011. NWPGCL will submit the environmental monitoring reports starting from the date the loan becomes effective.

567. Should there be any change in the design of Component 1, this EIA will be revised and/or updated and submitted to ADB prior to any construction works. The PMU Environmental staff

together with NWPGCL Environmental staff will revise or update the EIA and submit to ADB for review. The revised and/or updated EIA of Component 1 will be re-posted on the ADB website to comply with the disclosure requirements of SPS 2009 and PCP 2011.

568. Before the start of any construction work, the PMU will inform the EPC Contractor on their responsibility to comply with the EMP and the requirements of DoE and ADB. The specific responsibilities of the EPC Contractor on the implementation and compliance to the EMP, environmental monitoring, and submission of environmental compliance status during the construction phase will be monitored by the PMU and the NWPGCL Corporate Environment staff (or Consultant).

569. During the operation phase, PMU will assign a staff (or Consultant) who will be responsible to handle the associated environmental issues and compliance to DoE and ADB's environmental requirements. Submission of environmental monitoring reports by NWPGCL to ADB during the operation phase will be annually. These environmental monitoring reports will be reviewed by ADB and will post them into their website as required by SPS 2009 and PCP 2011.

570. In case of non-compliance to any environmental covenant in the loan agreements, NWPGCL will prepare a corrective action plan (CAP) describing the process and the time-bound actions that will be undertaken to ensure compliance. The CAP will be submitted to ADB for review and disclosure to ADB's website.

9.3 Various Categories of Mitigation Measures

571. The EMP includes various categories of mitigation measures and plans: (i) general and non-site-specific measures in the form of ECPs;(ii) project-specific and to the extent possible, site-specific mitigation measures; and, (iii) Construction Environmental Action Plan (CEAP) with site-specific and construction-specific management plans to be prepared by the EPC contractor, which include pollution prevention, occupational health, safety and environment, and emergency response.

9.3.1 Inclusion of EMP in Contract Documents

572. In order to make the EPC Contractor fully aware of their responsibilities in ensuring compliance to EMP, technical specifications in the tender documents will include compliance requirements (addressing GoB, SPS2009 and IFC guidelines as applicable) and all mitigation measures identified for Component 1.In addition, there shall be provision in the clauses of the tender document that, in case of any unanticipated impacts identified during implementation of Component 1, the EIA will be revised and submitted to ADB for review, and re-posted to ADB website. The EPC Contractor will be responsible in complying with the EMP during pre-construction and construction phase.

9.3.2 Environmental Code of Practices

573. A set of ECPs has been prepared for various environmental and social management aspects: ECP 1: Waste Management; ECP 2: Fuels and Hazardous Goods Management; ECP 3: Water Resources Management; ECP 4: Drainage Management; ECP 5: Soil Quality Management; ECP 6: Erosion and Sediment Control; ECP 7: Top Soil Management; ECP 8: Topography and Landscaping; ECP 9: Air Quality Management; ECP 10: Noise Management; ECP 11: Protection of Flora; ECP 12: Protection of Fauna; ECP 13: Protection of Fisheries; ECP 14: Road Transport and Road Traffic Management; ECP 15: Construction Camp Management;

ECP 16: Cultural and Religious Issues; ECP 17: Workers Health and Safety, ECP 18: Construction and Operation Phase Security; and ECP 19: Demolition work management. The Contractors will be contractually obligated to comply with these ECPs, presented in **Annex 9.**

574. The Contractor will prepare the CEAP to address pollution prevention, occupational health, safety and environment, and emergency response including the requirements of ECPs and EMP. These will be reviewed and approved by the environmental staff (or consultant) of PMU, NWPGCL before implementation of construction works.

9.4 Environmental Management Plans during Pre-Construction

9.4.1 Site Preparation

575. The site preparation would require cutting of trees and clearance of vegetation. The proposed project land was not used for storage or dumping of any kind of waste by the previous paper mill and the soil test results including ground water quality secondary data ensure no sign of soil contamination. The contractor shall have a detailed EHS related investigation before starting site preparation activities and in this regard, the contractor will prepare a specific site preparation plan on the basis of ECP 4, ECP 5, ECP 7, ECP 8, ECP 12, and ECP 13 including site preparation plan to ensure safeguarding of Occupation Health, Safety and Environment (OHSE). This plan must be submitted to Owner's Engineer (OE) for review and approval. A temporary scrub materials storage yard will be prepared and transportation route and system should be planned before starting of demolition work.

9.4.2 Demolition work management plan

576. The demolition works for the leftover buildings will be done through a sequential process. The abandoned buildings are all brick buildings and no hazardous materials noted. However, during demolition process, the specialized demolition contractor shall have to be engaged and they will follow OHSE procedures of international standards, GoB guidelines, (the ECP 20) and also proponent approved demolition plan to protect workers and community health.

577. The demolition plan will include but not limited to:

- Protection of the location of the site on which the structure to be demolished and following pre-demolition measures are to be followed:
  - ➢ Underground essential services like drainage and sewerage system, gas line, water system, communication cables, liquid fuel lines or any process line like (lubrication, chemicals or acid) are to be cut off and removed as required.
  - ➢ Above ground essential services like electricity line, electrical pole to be removed.
  - ➢ Underground structures such as a basement, cellars, or storage tanks are to be taken acres as required.
- The overall height of the structure above ground level and the least distance from the structure to each site boundary are to be taken into consideration.
- The type of building (occupancy class), its structural support system and the principal materials of its construction.

- The proposed methods of demolition including the number and types of major itemsof plant.
- The proposed methods for handling and disposing of demolished materials and,in particular, of hazardous materials.
- The proposed methods of controlling and maintaining access and egress to workplace.
- The proposed sequence of carrying out the demolition works and an estimate of the time (in days) it is likely to be taken to complete all of each of the stages of the work.
- The proposed hoardings, scaffolding and fencing and of any overhead sidewalk protection.
- Any other plans, illustrations, written documents, or specialist reports including avoidance of loss of wild life and clearing of limited vegetation as may be necessary to support the proposed methods of work or protective structures.
- Traffic management arrangements, which includes managing vehicles and mobile plant hazards in relation to operation at the workplace and interaction with the public.
- Demolition process shall be conducted cautiously particularly near to the old mosque and graveyard area to avoid cracks on these structures due to excessive vibration. In addition, precaution shall also be taken with consultation of engineers before starting of the demolition activities to avoid vibration cracks including excessive noise and dust particles which will have impact on the people coming for prayer and visiting graveyard.
- The general condition of structures on adjoining properties, particularly where these are close to or on the boundaries of the demolition workplace to be taken care off.
- The effect demolition may have on people working in adjoining properties or seeking access to and egress from those properties, and,
- The emergency arrangements, which should include equipment for the rescue of injured persons.

9.4.3 Solid Waste/Garbage

578. A waste collection and disposal system will be adopted in managing solid waste/garbage generated during the construction phase. The aim is to reduce generation of solid waste. Degradable waste, glasses, recyclable and reusable waste, papers, plastic, etc. will be collected depending on the type of materials and managed separately. Some temporary bins with different color indicating disposal of degradable and non-degradable wastes will be installed at the construction sites. Waste collected will be disposed of at designated place approved by GoB. Burning of waste at the construction sites will not be allowed.

9.4.4 Stakeholder engagement plan

579. The stakeholders will be engaged, as appropriate, to create and foster good relationship and smooth implementation of Component 1.PMU, NWPGCL will identify the stakeholders who are directly and indirectly impacted by relevant project activities. With the support of experts, PMU, NWPGCL will develop a stakeholder engagement plan/communication action plan prior to construction works. PMU, NWPGCL will ensure that relevant project information will be disclosed to stakeholders by posters, billboards, etc.

580. PMU, NWPGCL will establish a Grievance Redress Mechanism (GRM) to handle potential complaints/concerns related to Component 1. **Chapter 8** of this EIA provides guidance on GRM. Signboards about the GRM will be set-up at the construction sites and other community locations (school, local government office), with phone number/email for submitting grievances.

9.4.5 Relocation plan

581. Relocation of the Schools is a prime issue for successful implementation of this project. The schools will be constructed prior to any civil works for Component 1. NWPGCL will ensure that this process will be executed properly to avoid inconvenience and disruption to the students and the education system.

9.4.6 Drinking Water Supply and Sanitation Plan

582. A separate water supply and sanitation (with mobile STU) will be provided at the construction site. Safe drinking water will be provided by Khulna City Corporation water district. A Plan will be prepared by the EPC Contractor on basis of ECP 3. The Plan will be submitted to PMU, NWPGCL for review and approval before contractor mobilization.

9.4.7 Management of surface water for navigation and consumption

583. Conveying of machineries, equipment, and construction materials through waterway is cheaper and easier for Component 1 but will ensure proper navigational depth. The Bhairab River is classified by BIWTA as Class II for navigation. A detailed plan will be prepared by the EPC Contractor referring to ECP 3 and also the given mitigation plans in this EIA, after discussion with PMU, NWPGCL, and relevant authorities. The Plan will be submitted to NWPGCL for approval.

9.4.8 Level of salinity management plan

584. Groundwater wells within the project site will be managed to ensure there will be no saline intrusion when used during construction. A detailed plan will be prepared by the EPC Contractor on the basis of ECP 3 and the Khulna City water district. The Plan will be submitted to PMU, NWPGCL for approval.

9.4.9 Riverbank erosion management plan

585. Protection measures against erosion at the eastern boundary of project site along the Bhairab River shall be undertaken before any land development. A detailed plan will be prepared by EPC Contractor and submitted to PMU, NWPGCL for approval.

9.4.10 Flooding management plans

586. The existing project site is 2mPWD. The surrounding area of the project site is generally submerged during monsoon for about 1.5-2 months every year. A flood management plan will be prepared by the EPC Contractor referring to ECP3, the EMP, and consultation with relevant authorities. The plan will be submitted to PMU, NWPGCL.

9.4.11 Habitat management plan

587. The new development of green belts will help in the conservation of large number of visiting animals and also roosting and nesting place of birds. The existing mosque and graveyard area are also covered with dense vegetation that created habitats for some animals.

588. **Annex 10** presents a faunal rescue procedure that can guide the EPC Contractor during site preparation to ensure that disruption to wildlife is minimized and rescue initiated, as needed. A habitat management plan will be prepared to provide guidance to NWPGCL in restoring some open spaces after construction works.

9.5 Environmental Management Plans during Construction

589. The EPC Contractor is expected to address the following:

9.5.1 Solid Waste/Garbage

590. Similar to the pre-construction phase, a waste collection and disposal system will be adopted in managing solid waste/garbage generated during the construction phase. The aim is to reduce generation of solid waste. Degradable waste, glasses, recyclable and reusable waste, papers, plastic, etc. will be collected depending on the type of materials and managed separately. Some temporary bins with different color indicating disposal of degradable and non-degradable wastes will be installed at the construction sites. Waste collected will be disposed of at designated place approved by GoB. Burning of waste at the construction sites will be strictly prohibited.

9.5.2 Construction waste management plan

591. The EPC Contractor will be required to prepare a construction waste management plan to ensure that waste generated during construction phase are collected, transported, and disposed of properly. Measures such as limiting site clearance activities, planned/scheduled stocking-up and delivery of materials for construction, covering of equipment; fencing around the construction site, and strictly enforcing good housekeeping at all times at the construction site will be implemented. A temporary garbage dumpsite at the construction site will be identified in consultation with the environmental staff of NWPGCL. The EPC Contractor will ensure that no garbage or waste will be dumped/discharged to the Bhairab River. Hazardous material from construction site including fuel and other combustible materials shall be stored at a designated place. Spillage, accidental release of chemicals will be controlled following the Material Safety Data Sheet (MSDS).

9.5.3 Fisheries Resources

592. Fisheries management is ongoing covering the river system within the project area. GoB enforces fishing ban in the river systems during breeding/spawning period to avoid overfishing. In addition to this, NWPGCL will ensure that fishing ban is observed and no worker will do fishing along the stretch of the Bhairab River close to the project site.

9.5.4 Pollution Prevention Plan

593. A pollution prevention plan will be required by PMU, NWPGCL to the EPC Contractor referring to ECP 1, ECP 2, ECP 11, and the IFC-WB EHS General Guidelines. The plan will be subject to approval of PMU, NWPGCL.

9.5.5 Waste Disposal and Effluent Management Plan

594. Waste Disposal and Effluent Management Plan is mandatory to manage the construction waste and effluent including waste and effluent from labor sheds. A detail plan will be prepared and implemented by the Contractor on the basis of ECP 1, ECP 4, and EHS Guidelines, as well as the mitigation plans given in this EIA. The Plan will be submitted to the PD for review and approval before contractor mobilization.

9.5.6 Traffic Management Plan

595. The project site is well connected for transportation of materials via Khalispur main roads and also river routes using Rupsha –Bhairab river system. Construction materials such as sylhet sand, bricks, cement, roads can be brought via river and roads as well. The land filling materials such as dredged spoil can be brought via river. As such, the number of truck loads and river vessels are not quantified at this stage. Therefore, it is suggested that, EPC shall develop a plan for transportation of materials during construction period and also quantify the possible number of vehicles and movement including loading unloading time. On the basis of that plan a traffic management plan will have to be developed and notify accordingly to the local residents for avoiding accidents. The detail plan will be prepared by the Contractor on the basis of ECP 15 and also the mitigation plans given in this EIA, after discussion with PMU and authorities responsible for roads and traffic. The Plan shall be submitted to the PD for their review and approval before contractor mobilization.

9.5.7 Labour recruitment plan

596. The labour recruitment policy should be formulated in such a way so that the local labours can get preference in employment in the project activities. If these labours are found to have no previous experience on such type of technical jobs, it is suggested that, the authority can recruit them for non-technical activities of the project or the authority can facilitate technical trainings for them.

9.5.8 Occupational and community safety risks

597. The transportation of the waste and other materials should be in safe manner considering the rule of road traffic. Make mandatory the use of safety gears (helmets, safety belts, masks, gloves and boot) by workers depending on nature of work Necessary planning and safety approach will be made for rescue during emergency Workers will be provided with first aid and health facilities at the site. There will be provision for group accidental insurance for the workers. Child labour is strictly prohibited in all the activities executed by the contractors. Occupational health and safety performance should be evaluated against internationally published exposure guidelines as permissible Exposure Limits (PELs) published by the Occupational Safety and Health Administration of the United States (OSHA). Indicative Occupational Exposure Limit Values published by European Union Member States or the similar sources.

9.5.9 Good Handling and Operation of Construction Equipment

598. The equipment and machinery for construction activities should be handled and operated in a way that would ensure low noise, low emission of SO_x, NO_x, smoke, no oil leaks, no accidental event, etc. A detail plan of handling and operation of construction equipment will be prepared by each Contractor on the basis of ECP 2, 10 and 11. The Plan will be submitted to the PD for review and approval before contractor mobilization.

9.5.10 Fuel and Hazardous Substances Management Plan

599. The plan will be prepared by each Contractor on the basis of ECP 2 as well as the mitigation plans given in this EIA and in accordance with the standard operating procedures, relevant guidelines, and where applicable, MSDS. The Plan will include the procedures for handling oils and chemical spills. The Plan will be submitted to the PD for review and approval before contractor mobilization.

9.5.11 Communication Plan

600. A communication plan has been prepared and presented in **Table 9.1** while carrying out the communication plan modifications of process and planning may be done as per the Project's requirement.

Table 9.1 Communication Plan Adopted for the Project

Stakeholder	Information/Message	Communication Means	Timing/ Frequency	Responsibility
PAPs	Project awareness (general project information, etc.)	Consultations	Regular basis	Project Authority
	Employment opportunities	Government procedure: for new recruitment at AE position informed public by TV, radio, newspaper (English / Bangla); for others, NWPGCL internal system.	4 weeks before recruitment / job opening	PIU, NWPGCL
	Grievance redress to be continued throughout project implementation period	Consultations, Application, Register	Office time	Local Administration and Project Authority
General population (Local)	Job, opportunities, CSR	Poster, local daily newspaper, consultation	3 to 4 weeks before recruitment	PMU, NWPGCL
Fire Service	Incidents of disasters	Telephone, cell phone	Immediately when any incident is detected	PMU, NWPGCL
Police Station	Incidents of disasters and security issues	Telephone, cell phone	Immediately when any incident is detected	PMU, NWPGCL

Source: CEGIS, 2016.

9.5.12 Surface water availability management

601. Navigation is important to convey the construction materials and machineries / mechanical equipment at this stage. Water is required for piling, mortar mixing, sprinkling the ground, curing the concrete and other purposes including kitchen and washing during construction. A detail plan will be prepared by the Contractor on the basis of ECP 3 and also the mitigation plans given in

this EIA, after discussion with PMU. The Plan will be submitted to the PD for their review and approval before installation.

9.5.13 Level of salinity management plan

602. Salinity intrusion is natural phenomena in the study area. The average level of salinity in the groundwater aquifer is being controlled by the infiltration of rainwater and floodwater during monsoon. But infiltration through a small portion in the study area will not be possible due to paved land and land development at project site. To minimize the loss of this environmental issue, a detailed plan will be prepared by the Contractor on the basis of ECP 3 and also the mitigation plans given in this EIA, after discussion with PMU. The Plan will be submitted to the PD for their review and approval before installation.

9.5.14 Riverbank erosion management plan

603. Monitoring of riverbank protection works along the right bank of Bhairab River as well as project's eastern boundary at the preconstruction stage, should be done properly for its stability. A detail plan of monitoring will be prepared by the Contractor on the basis of ECP 6 and also the mitigation plans given in this EIA, including bank protection design, after discussion with PMU and authorities responsible for riverbank protection work. The Plan will be submitted to the PD for their review and approval before installation.

9.5.15 Flooding management plans

604. The land development in the project area, which will make the land free from river flood but flood due to heavy storm water on the paved and low permeable surface may occur during this stage. The internal drainage system should be managed to cope up with this worst situation at the development phase. A detailed plan will be prepared by the Contractor on the basis of ECP 4 and also the mitigation plans given in this EIA, after discussion with PMU and authorities responsible for flood or water resources management. The Plan will be submitted to the PD for their review and approval before installation.

9.5.16 Green belts development

605. A significant portion of the total project area will be covered with greenbelts. The tree plantation will be done considering maximum yearly average wind direction and tree height and carbon stock. The green belts will be developed following the guideline of the Department of Social Forestry. Along with following guidelines during green belt development will be considered.

- Limiting vegetation clearance and base stripping within project boundary.
- Local and indigenous species should be chosen for green belt development.
- In green belt plant composition should be made considering plant of different height and different canopy size to reduce sound pollution.
- Along the project area, local species e.g. Coconut (*Cocos nucifera*), Teak (*Tectona grandis*) , Mahogony (*Swietenia mahagoni*) , Mango (*Mangifera indica*), Jack Fruit (*Artocarpus heterophyllus*), etc. should be planted.
- Plantation should be made following the guideline of the Department of Forest.

9.6 EMP during Operation Phase

606. With reference to the possible significant environmental impacts during operation stage identified in **Chapter 5**, impact specific EMP has been prepared to address those impacts. In the following sections these plans are discussed.

9.6.1 Sewerage Management Plan

607. Component 1 will have an STP as an integral part of the facility. The design will meet the requirements of ECR 1997, WHO, and IFC-WB EHS General Guidelines 2007. The treated water will be reused for gardening and other general purpose washing, or directly discharged to the Bhairab River. The sludge from the STP shall be disposed of in accordance with ECR 1997.

9.6.2 Wastewater Management

608. Component 1 will also have an ETP to manage wastewater generated during the operation phase. An oil-water separator will be installed to handle oily waste from the workshops, machinery repair and vehicle area prior to discharge. Disposal of spent chemicals used to minimize biofouling in the cooling tower and other equipment will be in accordance with the MSDS of the chemicals. Process chemicals will be selected to ensure that they are environment-friendly and no special treatment will be required for their disposal. Chlorine dosing for ETP will refer to the MSDS, IFC-WB EHS General Guidelines 2007, the USEPA limits and FAO. Treated wastewater will be re-used for gardening or other general purpose washing or will be discharged to the Bhairab River. The treated effluent will comply with ECR 1997.

9.6.3 Sludge from the wastewater treatment plant

609. The sludge from the wastewater treatment plant will be disposed of properly. Iron rich sludge from water pre-treatment and demineralization plant might be utilized in the industries which use iron as raw materials. The EPC contractor should explore the market of the iron sludge. Generally, there is a good demand of iron sludge in steel re-rolling mills. The sludge from oily water separation unit should be managed properly with due treatment and disposing in scientific pit. It should be disposed in accordance with the Hazardous Waste and Ship Waste Rules 2011.

9.6.4 Solid Waste Management

610. This project will develop a waste prevention strategy, which will significantly reduce the total amount of waste. The strategy will focus on recycling and the facility wise implementation of recycling plans, considering the following items (as per Financer/IFC Guidelines):

- Evaluation of waste production processes and identification of potentially recyclable materials.
- Identification and recycling of products that can be reintroduced into the operation of the plant.
- Investigation of external markets for recycling by other power plant operations located in the neighborhood or region of the facility (e.g. waste exchange).
- Establishing recycling objectives and formal tracking of waste generation and recycling rates.
- Providing training and incentives to employees in order to meet these objectives.

9.6.5 House Keeping

611. This project will implement a good house-keeping practice, such as the sorting and placing loose materials generated from different repairing activities in the established areas away from common workspace, cleaning up excessive waste debris and liquid spills regularly, locating electrical cords and ropes in common areas and marked corridors.

9.6.6 Occupational Health Safety and Environment

612. A detailed Occupational Health, Safety and Environment (OHSE) Plan has been prepared including the following:

- Occupational Hazard Identification and Control Plan
- Inspection and Auditing Plan
- Leadership and Administration Plan
- OHSE Communication Plan
- Required PPEs
- Site Security Plan
- OHSEProgram for the Contractors/Sub-Contractors
- Preventative Maintenance Plan
- Incident Investigation Mechanism

9.6.7 Fisheries Resources

613. Fisheries management plan has been developed with the aim of avoiding pollution causing activities and to protect fisheries of the Bhairab River. The EMP includes the following:

Measures for plant operation
- Should follow the EMP including regulatory guidelines for effluent discharge.
- On-site wastewater should be treated to achieve maximum reuse and recycling.

Measures for water intake structure
- The water supply pipeline intake point from the feeder canal should be provided with sufficient screening to filter out larger aquatic organisms (e.g. fish, frogs, and toads) and foreign matter, preventing this material from being drawn into the pumps. The pums will be appropriately covered to reduce noise level within acceptable limit of Noise Pollution Control Rules (2006) and IFC standards which ever is stringent and appropriate.
- Drum screens need to be adopted in order to limit the entrainment of fish in the cooling water system and intake velocities should be as low as possible.
- The water velocity in the intake channel should be below 0.5 Ft/s during normal conditions.
- Monitoring should continue to ensure that the deterrents are working effectively.
- Fish including dolphins Conservation Program.
- Enforcement of fishing ban in the Bhairab river during breeding/nursing period.

9.6.8 Ecological Environment

614. All solid wastes, hazardous and non-hazardous, should be stored in designated sites prior to final disposal to the designated area and never release to the Bhairab River. Crews and other staffs of the cargo/ship should be well aware of the consequence of oil spills and all other discharges shall follow ECR 1997 of GoB and also IFC standards whichever is stringent and appropriate.

9.6.9 Community exposure to diseases

615. The project authority will evaluate the risks and impacts to the health and safety of the affected communities during the project life cycles. They will design, construct and decommission the structural elements or components of the project considering the safety risk to the communities. An emergency preparedness and response mechanism should be developed accompanying with the affected community people so that immediate initiative can be taken.

9.6.10 Surface water availability management

616. Monitoring of navigability and consumption of water of Bhairab River in the study area is important for assessing water demand and supply in dry season. The planning and monitoring agency should be initiated at this stage. All other additional factors related to these issues should be included and taken under consideration for the fruitful operation. So, a detailed plan for monitoring will be prepared by the proponent on the basis of ECP 3 and also the mitigation plans given in this EIA. The Plan will be submitted to the PD and PMU for their review and approval before operation.

9.6.11 Level of Salinity management plan

617. The bank protection of the project area shall be maintained throughout the project period. The salinity level increases during the dry season and to reduce salinity level to meet the plant requirement, the intake water (except condenser cooling water) will be treated through the reverse osmosis plant. From the reverse osmosis plant will feed to the system and the waste from the reverse osmosis plant (68.5m3/hr) containing high salinity (brine) will be further treated through ETP for final discharges to the water ways and also other reusing purposes following ECR 1997 and IFC guidelines whichever is stringent and appropriate. The material of the condenser cooling tube will be selected considering the salinity issues. Reuse of the water from the CMB will be checked of the salinity before using it in gardening. Moreover, harvesting of rain water will reduce the high salinity during monsoon.

9.6.12 Riverbank erosion management plan

618. Constructing the riverbank protection works along the right bank of Bhairab River as well as project’s east boundary at the pre-construction stage, it is important to monitor its stability and use during this stage. A detailed plan of monitoring will be prepared by the Contractor on the basis of ECP 6 and also the mitigation plans given in this EIA including bank protection design, after discussion with PMU and authorities responsible for riverbank protection work. The Plan will be submitted to the PD for their review and approval before installation.

9.6.13 Flooding management plans

619. There has uncertainty of nature on extreme flood situation in the Bhairab River which may cross over the designed HFL during the operation stage. At this situation, the total project area will be submerged under floodwater in course of time and the daily activity may be hampered. So, a detailed plan of the position of pumping station against urban flooding will be prepared by the proponent on the basis of ECP 4 and also the mitigation plans given in this EIA. The Plan will be submitted to the PD and PMU for their review and approval before operation.

9.6.14 Safe Work Practices and Procedures

620. The plan has been prepared in a way, which will be applicable for entire life cycle of the Project. Application of the OHSE plan is responsibility of all including management, employee, contractors, subcontractors, vendors in their daily activities. The plan also proposes a management and administration system (Organogram) for OHSE Plan application. It is suggested that NWPGCL develops an OHSE Management System program activities and commitment and ensure the programs are implemented during each phases of the construction of the project. **Table 9.2** presents OHSE management systems and key responsibilities, for detailed information specific Section number in the detailed report are referenced.

Table 9.2: OHSE Management Systems and Key Responsibilities Register

OHSE program activities EHSU Manager-NWPGCL (to implement)	**OHSE program activities Superintendent Engineer – NWPGCL (to ensure)**	**Employees *(Includes EPC and other contractors)* *(to follow)***
1. Policy and commitment		
Make a draft OHSE Policy for Project director for approval	• Communicate policy. • Provide leadership in line with policy commitments. • Assess any changes to organization structures, activities, processes, etc. for OHSE implications.	• Feedback ideas for changes to policy. • Understand policy and follow intent. • Follow OHSE processes.
Collate changes and publish.	• Assist with important changes.	
2. Legal & other requirements		
Monitor legal requirements and produce a monthly report to communicate relevant changes to the business.	• Implement actions required to ensure legal compliance. • Communicate requirements, including any changes to work programs or practices, to staff.	• Follow procedures, work instructions etc. as these should be in compliance with legal and other requirements. • Report issues where procedures / work instructions may not be in compliance with legal requirements to Manager or OHSE representatives.
Develop corrective and preventative actions to ensure that relevant changes to legal requirements are incorporated into OHSE documentation.		
Update OHSE processes.	• Assist with important changes.	
3. Hazard identification & risk management		
Coordinate strategic risk assessment process within lines of business.	• Ensure risk assessments are carried out and registers are updated.	• Understand key risks and mitigation measures relevant to their own areas.

OHSE program activities EHSU Manager-NWPGCL (to implement)	OHSE program activities Superintendent Engineer – NWPGCL (to ensure)	Employees *(Includes EPC and other contractors)* *(to follow)*
	□ Understand key risks and mitigation measures.	□ Report new risks and hazards. □ Participate in risk reviews. □ Report potential gaps in controls.
Facilitate Site Hazard Register development and maintenance.	□ Coordinate Site Hazard Register development and maintenance, including providing adequate resources.	
Provide OHSE technical advice on the development of project risk assessments and plans.	□ Ensure controls are in place to control identified risks.	
Provide technical advice on the development of operational risk assessments and plans.	□ Coordinate development and implementation of operational risk assessment and plans, including providing adequate resources.	
4. Planning & objectives		
Coordinate the development of strategic OHSE plans. Advise and propose OHSE objectives, targets and improvement activities. Facilitate the development of OHSE programs and advise on OHSE strategy.	□ Engage and provide resources to enable strategic assessment and subsequent plans to be developed.	□ Be involved in the development and implementation of OHSE objectives, targets and programs.
5. Accountability & Leadership		
Ensure that OHSE accountabilities, roles and responsibilities are clearly documented in OHSE documentation and communicated in OHSE training.	□ Ensure OHSE accountabilities and requirements are identified and documented in Work Plans and Position Descriptions. □ Lead and support OHSE system requirements. □ Provide adequate supervision and leadership to staff (especially new starters).	□ Ensure OHSE requirements are understood and met □ Participate in the continual improvement of the OHSE system.
6. Awareness, training & competency		
Coordinate OHSE training needs analysis for the development of a comprehensive training requirements register.	□ Conduct OHSE training needs assessment for the team. □ Ensure teams' training requirements are communicated to OHSE representatives for inclusion in the OHSE training program.	
Incorporate core OHSE training requirements in the training requirements register.		
Facilitate OHSE training program.	□ Understand training and competency requirements for personnel they are responsible for (including contractors).	□ Sign up to and attend training. □ Understand competency

OHSE program activities EHSU Manager-NWPGCL (to implement)	OHSE program activities Superintendent Engineer – NWPGCL (to ensure)	Employees *(Includes EPC and other contractors)* *(to follow)*
		requirements and make sure they are met.
Coordinate and deliver some in house training (e.g. OHSE system training, OHSE inductions, OHSE risk management, etc.).	Ensure staffs (including contractors) are trained and competent to do the work assigned to them.	
Maintain records of training required, training attendance and competencies awarded (via HR).	Incorporate OHSE training requirements into data management system. Make people available to attend training. Ensure records of training and competency requirements, training attendance and competencies awarded are documented within their jurisdiction.	Provide evidence of prior learning, licenses or other relevant competencies required to do the assigned work. Provide feedback on training suitability and quality.
7. Communication, consultation & involvement		
Ensure that management and staff are consulted when changes are made to the OHSE system.	Ensure staffs are consulted when changes are made to assets and operations that might affect OHSE policies and procedures.	Participate in team meetings and communicate/raise OHSE concerns, issues, key learning and wins. Participate in OHSE policies / procedures review.
Provide monthly OHSE report with key learning.	Communicate OHSE issues at team meetings (e.g. monthly status and key learning).	Engage with and discuss monthly reports and key learning.
Compose and circulate OHSE alerts.	Respond to OHSE issues / concerns.	
Compose and circulate program newsletters and updates.		Read OHSE communication items and attends communication sessions.
Communicate changes to OHSE policies and procedures to management.	Communicate relevant information on OHSE system changes to staff.	
Develop and maintain OHSE Essentials web portal.		
8. Document & record management		
Maintain OHSE documentation, including: Filing OHSE records such as assessments, plans and reports. Developing and distributing monthly report for project director.	Ensure resources are available to manage documents and records. Ensure documents and records are adequately managed.	Manage documents and records as required.

OHSE program activities EHSU Manager-NWPGCL (to implement)	**OHSE program activities Superintendent Engineer – NWPGCL (to ensure)**	**Employees *(Includes EPC and other contractors)* *(to follow)***
Developing and maintaining internet sites to enable ease of access to OHSE documents and information Reviewing and updating OHSE documentation. Maintaining OHSE documents and records in accordance with OHSE system requirements.		
Manage OHSE document change requests.	□ Ensure area-specific OHSE process requirements are appropriately documented.	□ Provide input into development of OHSE documents. □ Raise OHSE document change requests where gaps or issues are identified.
9. Assets & operations		
Administer OHSE operational control processes.	□ Identify OHSE risks associated with assets and operations, ensuring they are recorded in OHSE risk registers. □ Ensure controls and processes are implemented to adequately manage OHSE risks.	□ Be involved in the development of OHSE risk management programs, plans and processes.
Facilitate strategic and operational risk management processes to enable the development and implementation of appropriate control measures.	□ Document all monitoring and measuring processes implemented in order to demonstrate that controls are effective.	□ Implement / follow OHSE risk control measures.
Provide professional advice to business units on OHSE management and improvement initiatives.		
10. Project management		
Provide advice and support to project managers in the development and implementation of project OHSE Management Plans.	Project Team Managers: □ Ensure that OHSE Risk Assessments are conducted for all projects. □ Understand their OHSE accountabilities.	Project Managers: □ Ensure that project OHSE management plans are developed and implemented.
Lead and participate in project-related OHSE initiatives.	□ Participate in, and inform staff of, project-related OHSE initiatives.	
Ensure other OHSE procedures support project management (e.g. Hazard ID and Risk Management, Audit, Management of Contractors & Suppliers)		
□ Management of contractors & suppliers		

OHSE program activities EHSU Manager-NWPGCL (to implement)	OHSE program activities Superintendent Engineer – NWPGCL (to ensure)	Employees *(Includes EPC and other contractors) (to follow)*
Document process to ensure OHSE risks associated with contractors and suppliers comply with legal requirements (OHSE and Contracts & Procurement processes)	□ Ensure process for managing contractors and suppliers are in place and followed. □ Ensure relevant personnel are trained in contractor and supplier management, as required (e.g. project managers).	□ Follow OHSE processes around contractors and suppliers. □ Monitor contractor / supplier compliance with OHSE system requirements.
11. Emergency preparedness		
Facilitate strategic emergency assessment and planning processes. Guideline- Refer to Emergency Response Plan that attached in the EIA report	□ Identify potential OHSE emergencies.	□ Understand roles and responsibilities in Emergency Response Plan situations
Provide advice on assessing emergency risk and planning adequate responses.	□ Ensure adequate response plans are resourced, developed and maintained □ Ensure adequate drills, training and response equipment are resourced, maintained and in place.	□ Attend OHSE emergency training and participate in drills. □ Be involved in debriefs and response plan improvements.
Facilitate the development of emergency response plans, when required.		
12. Monitoring & measuring		
Provide data to measure OHSE performance	□ Review performance data and agree on improvement programs	
Recommend programs based on review of OHSE performance	□ Ensure equipment used to monitor OHSE performance is maintained, calibrated etc. people are trained e.g., gas detectors.	□ Ensure relevant procedures are followed.
13. Incident management		
Provide technical advice on incident investigations and the development of corrective actions.	□ Ensure OHSE incidents are reported and investigated as per the procedure. □ Ensure root causes are identified and actions implemented to prevent recurrence.	□ Complete and submit incident reports for all health, safety or environmental incidents, hazards and near-misses. □ Participate in incident investigations as required.
Audit the Incident Management procedure. Analyze incident data to identify trends and communicate them to management.		
14. Audit		
Develop and facilitate annual internal OHSE audit programs	□ Consider audit requirements and nominate projects or processes to be audited.	
Conduct OHSE audits	□ Participate in audits.	□ Participate in audits.

OHSE program activities EHSU Manager-NWPGCL (to implement)	OHSE program activities Superintendent Engineer – NWPGCL (to ensure)	Employees *(Includes EPC and other contractors)* *(to follow)*
	• Make staff and resources available to auditors. • Develop and implement actions from audits.	• Develop and implement actions from audits
Facilitate OHSE certification process (ISO 14001 and OHSAS 18001)		
15. Management review		
Facilitate OHSE management review processes.	• Conduct OHSE management reviews. • Develop actions and programs aimed at continual improvement of OHSE performance. • Communicate and implement OHSE improvement programs.	• Participate in OHSE management review process through employee representatives attending Executive Safety Team meetings. • Participate in relevant improvement programs.
Provide data analysis and information for OHSE management review processes.		

621. EPC contractor will prepare site specific OHSE plan based on the general guidelines for OHSE plan and present to OE and PIU for approval. The plan should address all pertinent issues to create a work place that protects worker health and safety with due respect to the environment and promote an atmosphere to grow employee learning and opportunity in a way that is fulfilling, recognized and fairly rewarded during construction phase of the project. **Table 9.3** presents general expectations from the EPC contractor while implementing the OHSE plan.

Table 9.3: Expectations from the EPC Contactor

Commitment and Leadership	Management shall provide strong visible commitment, leadership and personal involvement in health, safety and the environment. Management shall make available the resources necessary to achieve NWPGCL's OHSE objectives.
Policies and Objectives	Develop and communicate policies demonstrating a commitment to OHSE that is consistent with, and at least equal to, other business aims. Supporting objectives shall be defined, deployed and maintained at all organizational levels.
Organization, Resources and Documentation	Define, document and communicate the roles, responsibilities and accountabilities to enable every individual to fulfill their role in improving OHSE performance.
Risk Evaluation and Management	Continually evaluate the OHSE risks to the workforce, customers and the environment. Continually evaluate processes and activities for specific hazards-assess potentials, record and control the subsequent risk to a tolerable level.
Planning	OHSE considerations shall be integral to all aspects of business planning or changes in the design, development, purchasing and delivery of our products and services.
Implementation, Recording and Monitoring	Determine and record whether those actions are effective. Activities shall be conducted in accordance with defined standards, and continuous improvement shall be promoted and monitored through active employee participation.

Audit and Review	Audits and reviews shall be conducted to verify the implementation and effectiveness of the OHSE Management System and its conformation to this specification.

9.7 EMP to Address Cumulative Impacts

9.7.1 Air Quality Management

622. Emission of CO, SO_2. NO_x, PM from the future upcoming industries would add additionally to the proposed project case scenarios of the ambient airsheds. Increasing amount of industries and vehicular activities would increase the ground level concentration of the criteria pollutants. Based on cumulative impact assessments though CALPUFF dispersion modelling predicted that concentration of PM_{10} and SO_2 will exceed the guideline of IFC Thermal Power Plants 2017 but within the IT value -1. The concentration of PM is relatively higher due to lots of reasons in the cities of Bangladesh. Road dust, area sources, households, pollens are the major sources of PM. The combustion of gaseous fuels such as natural gas does not produce significant particulate matter. But other industries like brick kilns or open firing of the solid wastes contribute for increasing of PM. However, NWPGCL should take initiative at the policy level to reduce emissions from selected facility. DoE can take action to bring specific facility in compliance. In addition, a trade-off between heavy and low polluting industries should be established with the initiative of DoE. For ensuring a sustainable development and pollution free airshed, some policy intervention and strategic initiatives are very much required.

9.7.2 Noise Management

623. A comprehensive plan for noise reduction and attenuation is required to control ambient noise limit within the permissible level. Therefore, the contractor should develop an integrated plan on the basis of ECP 11. Develop a greenbelt around the power plant boundary to separate the project area from the surrounding areas.

624. In addition, NWPGCL needs to take initiatives to construct at least 3m high brick wall having capacity of noise attenuation at outer boundary of the RMS and other units to buffer noise propagating to nearest community.

9.8 Mitigation Plan

625. The mitigation plan presented in **Table 9.4** includes various actions, defines responsibilities for implementation as well as supervision of each action, and also indicates the timing of these actions. After this assessment stage, if there are any changes to the Project design or methods of construction and operation, the impacts and mitigation measures discussed may need to be revised. To address the changes, the environmental and social implications will require re-addressing.

Table 9.4: Mitigation Plan

VECs/Issues	Environmental Impacts	Mitigation Measures	Institutional Responsibilities	
			Implementation	Supervision
PRE-CONSTRUCTION AND DEMOLITION PHASE				
Ambient air A1. Dust and gases generated from demolition works and	The emitted dust (SPM, RPM) from the demolishing areas will disperse to the ambient environment.	• Fencing, hoarding the demolition site before beginning of demolition works. • Avoid the demolition works at the evening especially during winter or	Contractor	OE/ESHSU

transportation of the debris and dragging of cutting trees	The respirable particulate matters may be inhaled by the human being causes respiratory problem. Moreover, the fugitive dust will fall over the leaves of the vegetation near to the project site.	watering to the possible sources of fugitive emission. • Regular water spraying on the adjacent vegetation, roads and unpaved ground especially during winter • The transportation system of debris and cutting trees, scrub storage areas and sand deposited area need to protect though wind shield. • Impact and compliance monitoring should be done as per the recommended guideline at the sensitive location. • Use of appropriate PPE, awareness, motivation works will improve the workers heath • Grievance redress mechanisms should be established and initiate free health checkup for the workers as well as the PAPs as CSR activities of the project.		
Ambient noise B1. Noise level Noise will be generated during demolishing of the leftover buildings especially though manual process	Noise will be generated the use of hand tools such as jackhammers, sledge hammers and picks etc. Generation of impulse noise will harm to the people especially for the sick and sleeping one. Uneven noise will affect the behavioral of the nocturnal animals.	• The procedure of demolition will be conducted as per the demolition manual prepared by the EPC • The machines/equipment's/vehicles should be turned off when not in use. • Specify that all sound-reducing devices and restrictions be properly maintained throughout the demolition period. • Limit the hours of demolition to between 7am and 6pm, Sunday through Thursday • Temporary noise barriers are infeasible, portable noise panels to contain noise from powered tools shall be used. • Use rubber-tired equipment rather than track equipment • Keep loading and staging areas on site within the perimeter protected by the recommended temporary noise barrier and away from the noise-sensitive sides ofsite. • Stop the demolition work during prayer time and night time. • Impact and compliance monitoring should be done as per the recommended guideline at the sensitive location especially at the Mosque and proposed school areas. • Use of appropriate PPE, awareness, motivation works will improve the workers heath • Grievance redress mechanisms should be established and initiate free health checkup for the workers	Contractor	OE/EHSU

		as well as the PAPs as CSR activities of the project.		
Socio- economic condition C1. Disturbance for school students and present dwellers	The students, teachers, guardians may face difficulties during the transition period They also may be affected due to the noise pollution, dust etc.	• The project activities should be initiated after the completion of new school building • Constructing noise barrier	Contractor/ NWPGCL	NWPGCL
C2. Employment Opportunity	Many local people may be occupied in the land preparation activities as clearing trees and bushes, demolishing the buildings, disposal of solid waste, relocation of school building, renovation of mosque and graveyard development and non- technical activities Temporary workers in the project area may become workless	• Engagement of local people in the project activities or alternative occupation should be ensured. • Keeping provision for the rehabilitation of the workers those who are working in the project area temporarily.	Contractor/NWPG CL	NWPGCL
C3. Health safety	Noise of demolition activities may cause harms to the people of project area Accident for transportation of dispose materials Unsafe and unhygienic labour shades may create a very hazardous health problem Occupational health safety may be disturbed, and sexually transmitted diseases may arise in the locality due to the flow of outsiders	• Make mandatory the use of safety gears (helmets, safety belts, masks, gloves and boot) by workers depending on nature of work. • Necessary planning and safety approach will be made for rescue during emergency. • Use of dust controls (exhaust ventilation) to keep dust below • Workers will be provided with first aid and health facilities at the site. • There will be provision for group accidental insurance for the workers. • Child labour is strictly prohibited in all the activities executed by the contractors. • There should have facility to deal with medical aspects of HIV/AIDS treatment with specialized services.	Contractor	NWPGCL
Water bodies D1. Flooding	Regular flooding on the project land	• Provision of optimum land elevation considering HFL and freeboard. • Provision of additional protection works to avoid the loose soil being washed away due to runoff access and extreme flood. • Additional riverbank protection measures of more 500m upstream and downstream portion, except project eastern boundary.	NWPGCL	EHSU officers

		• Provision of adequate internal drainage system to drain out the storm water.		
Biological Environment E1. Life lost and relocation of wildlife	During this clearing and demolition process, some of the common lizards, frogs may be affected.	The existing structures should be demolished one after another cautiously after properly supervised by an ecologist (having plant and wildlife management experience) to avoid damage of any animal and also any old tree outside of the proposed layout plant of the power plant. In addition, appropriate building demolition including clearing of vegetation guidelines to be adopted for sustainable management of environmental quality of life and growth. Much time should be given for safe departure of the visiting animals during demolition activities following Wildlife Act (2012) and also IFC guidelines.	Contractor (with their Expert as required)	NWPGCL (Environment Cell)
E2. Dust and sound pollution on vegetation and wildlife	During demolition of buildings, it is expected to create sound pollution and dust which may affect surroundings vegetation, sensitive areas and wildlife.	Control moisture content during construction by watering. Stabilize road surface with a suitable stabilizer. Create proper noise barrier and enclose for each building demolition to meet Noise pollution control Rules (2006) of GoB and also IFC guidelines as appropriate.	Contractor (with their Expert as required)	NWPGCL (Environment Cell)
E3. Chop down of terrestrial vegetation	Chop down of terrestrial vegetation has been planned (trees, herbs and shrubs) to initiate land development process which will reduce carbon sequestration of about 6880.480046 for 30 acres of land cover and will ultimately impact biological process and food chain as well	The Mosque, graveyard and part of the Khulna paper mill area currently outside the proposed power plant layout plan may be conserved for vegetation resources and religious activities. In addition, a significant portion of the proposed power plant area is suggested to develop as green belt which will ultimately makeup loss of carbon dioxide sequestration due to clearing of existing vegetation at the proposed plant area and also to promote conservation of visiting animals of the project study area and also beyond that area. The cleared undergrowth plants can be converted to compost for application as a soil conditioner.	Contractor (with their Expert as required)	NWPGCL (Environment Cell)
E4. Habitat loss, life lost and relocation of mammals, birds and other wildlife	Removal of enormous terrestrial vegetation (trees, shrubs, herbs) may cause damage of habitat of some mammals, reptiles etc., which may create pressure on other species. The land development activities would impact to other micro wildlife, invertebrates also at the project area.	The existing Mosque, graveyard and part of the Khulna paper mill area is outside of the proposed project area which is covered with large number of plants and some visitor animals. Therefore, this area will also be used as resting place of local visiting animals. In addition, a significant portion of the proposed power plant area is suggested to be developed as green belt which will ultimately makeup loss of carbon dioxide sequestration due to clearing of existing vegetation at the proposed plant area and also promote conservation of visiting animals of the project study area and also beyond the study area. This new development of	Contractor (with their Expert as required)	NWPGCL (Environment Cell)

		green belt will help in the conservation of large number of visiting animals and also roosting and nesting place of large number of birds as well throughout the seasons of the year. During the clearing of vegetation, the existing common wildlife should be allowed to go away under the supervision of an Ecologist through applying popper method (as per Wildlife act-2012, IFC guidelines and international best practices).		
E5. Riverine, dolphin habitat and benthic community	The existing Bhairab river habitat may be impacted due to discharge of oil spill and created under water noise during transportation of ship along the river for carrying of construction and demolished materials, machineries to the project site.	All the vessels must follow the inland river transportation regulation for movement. For any discharging from the project site and vessels, GoB and IFC guidelines which ever is stringent to be followed.	Contractor (with their Expert as required)	NWPGCL (Environment Cell)
CONSTRUCTION PHASE				
Ambient air F1. Dust and gases generated from construction works and transportation of the materials and equipment	The emitted dust (SPM, RPM) from the construction areas will disperse to the ambient environment. The respirable particulate matters may be inhaled by the human being causes respiratory problem. Moreover, the fugitive dust will fall over the leaves of the vegetation near to the project site.	• Fencing, hoarding the construction site before the construction works. • Avoid civil and road construction works at the evening especially during winter or watering to the possible sources of fugitive emission. • Regular water spraying on the adjacent vegetation, roads and unpaved ground especially during winter. • Use of canopy, bounding fence need to be protected. • Impact and compliance monitoring should be done as per the recommended guideline at the sensitive location. • Use of appropriate PPE, awareness, motivation works will improve the workers heath. • GRM should be established and initiate free health checkup for the workers as well as the PAPs as CSR activities of the project.	Contractor	OE/ESHSU
Ambient noise G1. Noise level	Noise will be generated from the moving and idling vehicles, welding operation, and heavy machineries.	• The machines/equipment/vehicles should be turned off when not in use. • Using of appropriate PPEs (Ear Plug for Noise) during construction work. • Temporary noise barriers are infeasible, portable noise panels to contain noise from powered tools shall be used. • Use rubber-tired equipment rather than track equipment	Contractor	OE/EHSU

		• Keep loading and staging areas on site within the perimeter protected by the recommended temporary noise barrier and away from the noise-sensitive sides offsite. • Stop the construction work during prayer time and night time. • Impact and compliance monitoring should be done as per the recommended guideline at the sensitive location especially at the Mosque and proposed school areas. • Grievance redress mechanisms should be established and initiate free health checkup for the workers as well as the PAPs as CSR activities of the project.		
Water bodies H1. Groundwater salinity	Workers and other professional will face difficulty to drink and use of groundwater. Level of salinity will increase due to low infiltration at ground water table.	• Provision of fresh water supply into the project area. • Provision of fresh ground and rain water reservoir. • Provision of storage of rain water enhancing groundwater infiltration. • Provision of generated rainwater runoff drainage facility from the project inside.	NWPGCL, &Contractor	EHSU officers
H2. Erosion-Accretion	Regular erosion at both bank of Bhairab River. High flood water may erode the east boundary of project during the construction. Loading and unloading of machineries and equipment's from waterway, may create additional damage of river bank. Damages due to anchoring, unloading goods and materials and other natural disasters.	• Provision of plantation and another strong riverbank protection works. • Provision of monitoring for levee and other protection measures continued up to the operational designed period.	NWPGCL, BWDB and Contractor	Planning and Design division and EHSU officers
Biological Environment I1. Riverine, dolphin habitat and benthic community	Construction of jetty in order to anchor ship and cargos to the Bhairab River may temporarily disturb dolphins' movement and benthic community. The riverine water quality may be deteriorated due to disposal of waste water and oil spill from the ship during	• All the vessels must follow the standard of Inland river transport regulation. In addition, for transportation of maintenance equipment from abroad, IMO, MARPOL shall be followed. • All kinds of discharges from the construction site shall meet regulatory requirements of GoB and IFC guidelines whichever is stringent and appropriate. • Any kinds of alien species must be quarantined before transshipments from abroad for carrying	Contractor (with their Expert as required)	NWPGCL (Environment Cell)

	transportation of machinery, materials etc.	maintenance equipment for the power plant. Jetty construction activities should be confined within limited area of the jetty construction site and excavated soil will be utilized for filling of project site avoiding turbidity in the water. All the vessels must follow the Inland water transport regulations of GoB as applicable (details in Chapter-2). However, during transportation of machineries from abroad to the port, IMO and MARPOL will be followed. During any kind of discharges from the project site and from the vessels or construction equipment during construction period, GoB and IFC guidelines whichever is stringent will be followed.		
Occupational Health and Safety J1. Health and safety hazard	Injuries leading to casualty, or death may be caused during transportation of machinery and equipment, from the ship to site, and their installation/erection, lifting heavy materials, working at heights, etc.	• Proper health and safety training on hazard identification and how to handle hazardous equipments must be provided to the workers before starting any construction activities. • The health and safety staff of contractor must ensure that the equipments and safety harness are working properly before the workers start their work. In identification of a faulty equipment, they must be promptly replaced. • An on-site medical team should be set up and emergency first-aid kit should be at hand in case of any accidental injuries (burns, cuts, broken bones etc.). • The workers should use the appropriate PPEs. • Ensure workers hygiene and health status. Conduct monthly health check up to monitor their health condition and provide appropriate treatment for any ailments.	Contractor	EHSU
J2. Fire hazards from welding	Welding operations during laying of pipeline may cause fire accidents if proper care is not taken	• All arc welding and cutting operations shall be shielded by non-combustible or flameproof screens which will protect welders and other persons working in the vicinity from the direct rays of the arc. • In addition, the welders should use (i) hand shields to protect against flashes and radiant energy, (ii) see his skin is covered completely to prevent burns and other damage by ultraviolet rays, (iii) Welding helmets shall be free of leaks and openings, and free of highly reflective surface, and (iv) welding trucks shall be equipped with approved fire extinguishers and first aid.	Contractor	OE/EHSU

Solid Waste Disposal K1. Storage space and visual effect	Poor aesthetic view due to the storage and disposal of old and used equipment and materials. Moreover, spillage and leakage from improper storage can result in contamination in soil.	• Rubbles generated from the construction site should be stored in appropriate bins/skips, well-covered and later buried in an approved landfill site. • All solid wastes, hazardous and non-hazardous, should be stored in designated sites prior to final disposal	Contractor	Health and Safety Officer
Socio- economic condition L1. Disturbance for school students and present dwellers	They also may be affected due to the noise pollution, dust etc.	Constructing noise barrier	Contractor/NWPGCL	NWPGCL
L2. Employment opportunity	The local people may be engaged in the land development and non- technical activities and it will create in migration in the project area	• Engagement of local people in the project activities or alternative occupation should be ensured. • There should have provision for the rehabilitation of the workers those who are working in the project area temporarily.	Contractor/NWPGCL	NWPGCL
L3. Human safety	During preparation and installation of the power plant along with threats for human safety to the technical and non-technical labor	Special attention should be provided for supplying safe drinking water, safe sanitation system for the labor sheds. Registered doctor and assistants should be employed during construction phase	Contractor/NWPGCL	NWPGCL
Fisheries Resources M1. Fish habitat condition and quantity	Bhairab River is rich in Hilsa, Deshi Pangus and Shrimp PL which would be affected due to disposal of waste water like ballast and bilge water from the ship/cargo carrying machinery and ancillaries having oil and grease contaminants. Open water fish habitat would also be affected due to the washing of various solid waste such as sand particles, food wastes, cans, and bottles etc. which are generated by the project workers.	• Vessel movement should be limited during Hilsa (September - October) and Deshi Pangus (June - July) spawning period and peak shrimp PL (February – March) collection periods. • Ballast water and oil spillage must be controlled from the ships, vessels and construction site. • Specific waste management programs that emphasize on reduction, reuse and recycling of the waste will be implemented.	Contractor in collaboration with District Fisheries Office and local fishers.	NWPGCL and District Fisheries Office
M2. Fish species diversity and composition	Alien species may be introduced through cargo/ vessels. As a consequence, invasive species may cause negative impacts on pelagic and benthic communities.	• Foreign cargo/vessels must be checked for protecting the migration of invasive species. • The crew should be advocated to maintain a certain path and abstain from dumping solid and liquid wastes particularly during fish breeding season.	Contractor in collaboration with District Fisheries Office and local fishers.	NWPGCL and District Fisheries Office

M3. Fish production	With the consequence of aforesaid reasons, fisheries resources may cause decline in fish productivity of the river and its connectivity.	• Fish breeding and fish spawning seasons should be avoided for transporting construction materials and machinery as well as ancillaries through waterways. • Oil spillage from cargo/ vessels should be controlled efficiently.	Contractor in collaboration with District Fisheries Office and local fishers.	NWPGCL and District Fisheries Office
OPERATION PHASE				
Ambient Air N1. Maximum ground level concentration of air pollutants	Emission of exhaust gas from the stack may contribute elevated ground level concentration of CO, SO2, NOx, PM10, PM2.5 etc. at the downwind direction.	• This power plant will already adopt inbuilt pollution control measures like Low Low-NO_x burner, Wet injection process etc. It will run relatively, cleaner fuel. Emission from the stacks must be limited to the IFC 2017 standard for thermal power plant. The standard will be maintained considering the non-degraded airshed for NO_x, SO_2 and CO but the emission rate of the particulate matter must be limited for degraded air shed. • Stack monitoring will be conducted continuously of the criteria pollutants. Moreover, ambient passive monitoring will be continued at certain period of time at the potentially affected areas. • Compliance monitoring will be done to the regularly and check the monitoring instruments.	NWPGCL	EHSU
Noise level O1. Noise level inside the control room, turbine hall	Hearing complexity and loss along with increased blood pressure, disturbances and discomfort to the technicians and workers and surrounding communities due to noise generated from rotator machineries at exceedance level.	• Install 3m high brick boundary walls and thick plantation to attenuate noise in the sensitive receptors. • Replace the sealing of doors and windows of the control room and office building for making noise proof the workspace. • The machines/equipments/vehicles should be turned off when not in use. • The turbines, pumps, fans etc. should be covered with soundproof dampeners to limit the spread of noise. • Greenbelts should be developed around the power plant area to limit the spread of noise to the nearby community. • Workers should use appropriate PPEs (soundproof earpiece, earmuffs etc.) while working close to noise equipment.	Contractor	EHSU
Water bodies P1. Salinity	Every cooling tower will receive individually about 45% of water among the total water needed for whole operation. By this process, about 48% of this water gets	• Strong water quality monitoring section should be provided to make sure the parameters must be within standard limits before disposal. • The disposal outlet point will be placed at immediate upstream of intake structure along the river waterway.	NWPGCL	Planning and Design division and EHSU officers

	evaporated from cooling tower and the rest 52% of it will be highly denser water (due to salinity) going blow down to the river after flowing through a monitoring basin. This process may impact the level of salinity of river water.	• Provision of reuse of disposal water from monitoring basin.		
P2. Flooding	Two major causes of flooding the project site, one may be urban flooding, causing due to extensive runoff access which couldn't be drained out quickly for the time being. And another cause of flood water may come from river be occurred due to uncertainty of extensive flood.	• Provision of community cleaning committee inside the project area • Provision of flood retention structures and plantation • Provision of access road surrounding the project periphery.	NWPGCL	Planning and Design division and EHSU officers
P3. Intake Channel Outlet	Accretion occurs at the eastern boundary by monsoon flood. Tidal activity carries and deposit clay at the intake point. Loading and unloading activities via ships/ Berge break the intake channel accidentally. Sliding the sand or other land development material over the developed slope to the toe of the slope.	• Provision of bank protection works at the eastern boundary. • Provision of flowing tidal wave at the intake point required to avoid sedimentation at bottom of the intake channel. • Position of jetty have to be located to a place where intake channel remains safe from crushing by the Ship / Berge.	NWPGCL	Planning and Design division and EHSU officers
Risks and emergency Q1. Corrosion of gas pipes	Corrosion on the internal wall of a natural gas pipeline can occur when the pipe wall is exposed to water and contaminants in the gas, such as O_2, CO_2, or chlorides.	• Pipe will be coated using 3-layer polyethylene (3 LPE). • Buried pipes and fittings shall be protected against corrosion by means of external coating and wrapping. • Holiday detector shall be used to detect any holiday and shall be repaired. • Cathodic protection test points shall be installed and connected to temporary cathodic protection facilities in accordance with the specification as the final operation of lowering or tieing-in is in progress. • Conduct inspection after all installation before back-filling.	Contractor	OE/EHSU
Q2. Gas compressor fouling	Polymer deposits on compressor internals, which increases	A cleaning regime in Bangladesh would be a combination of online cleaning and semi-annual offline washing.	Contractor	OE/ESHSU

	frictional losses and alters flow pattern and lead to loss of compressor efficiency, pressure drop increase in after coolers, potential for unbalancing, rotor, and seal damage.			
Q3. Gas pipeline leak	Poor tying-in may cause leak of significant amount of gas from the pipe	Separate welded joint sections of the pipeline shall be tied into a continuous system in such a manner that no stress will be induced into the pipe as a consequence of the tieing-in operation.	Contractor	OE/ESHSU
Socio- economic condition S1. Diversity of occupation	Different occupational facilities may be created after the implementation of this project in the study area	Let the local people be engaged in the project related activities as well as in the other industrial activities	Contractor/NWPGCL	NWPGCL
S2. Human safety	Accidental issues may occur during the operation period. It may create a problem in housing facility, treatment facility, sanitation and drinking water facility issues	Emergency team, ambulance, contact number and hospital should be available. Emergency response plan should be implemented during operation periods.	Contractor/NWPGCL	NWPGCL
S3. Employment opportunity	Fishermen community may be affected due to water traffic and net broken	• A contingency budget for breaking fishermen's nets should be captured in the safeguards documentation. They may be taken under different training program for livelihood restoration of the fishermen • NWPGCL official will must be engaged in the Grievance Redress Mechanism.	Contractor/NWPGCL	NWPGCL
Fisheries Resources T1. Fish habitat condition and quantity	Abstraction of river water at the rate of 2010m3/hr for operating power plant may cause crisis for river water availability during dry season which alter the capture fish habitat condition.	• Temporary water reservoir can be built for water storage rather than direct abstraction from river. • Drum screens need to be adopted in order to limit the entrainment of fish in the cooling water system and intake velocities should be as low as possible.	Contractor in collaboration with District Fisheries Office and local fishers.	NWPGCL and District Fisheries Office
T2. Fish species diversity and composition	Water intake from the Bhairab River would entrap fish, crustaceans and other aquatic organisms particularly the sluggish species. Predator-prey relationship might be affected due to spread of invasive	• Water intake velocity will not be more than 0.5ft/s at the screen of the intake channel. • Intake point of the feed water pipeline should be provided with sufficient screen i.e. fish deterrence machine to filter out aquatic organisms like fish, frogs, and toads. • To use bio-indicator for monitoring the health of the aquatic ecosystem.	Contractor in collaboration with District Fisheries Office and local fishers.	NWPGCL and District Fisheries Office

	species through ballast water. Integrated impact to be caused for withdrawal of water 2010 m3/hour may alter the fish diversity due to salinity intrusion			
T3. Fish production	With the consequence of aforesaid reasons, estimated net loss to fish production would be 240 Mt per year from the study area.	• Continuous monitoring of intake water velocity should be ensured and necessary measures are to be taken if intake water velocity exceeds 0.5 ft/s in the dry season and specially breeding season. • Develop monitoring system to maintain biodiversity of Bhairab River ecosystems.	Contractor in collaboration with District Fisheries Office and local fishers.	NWPGCL and District Fisheries Office
T4. Fisheries Based Livelihoods	Associated livelihood would be affected due to the reduction of catch per unit area and effort and would narrow down the fishing area.	• Alternate livelihoods might be developed through proper trainings and incentives by the project proponent. • Beel management program and community based fisheries management might be introduced by local Jele community at the Bashuakhali beel and others government Khas land.	Contractor in collaboration with District Fisheries Office and local fishers.	NWPGCL and District Fisheries Office
Ecological Environment U1. Impact on terrestrial vegetation	The emission of SOx, NOx and SPM including noise pollution may have significant impact on vegetation and other sensitive receptors around the project and study area.	Al measures for limiting the emission of SO_x, NO_x and SPM will be within the GoB standards and IFC guidelines whichever is appropriate and stringent. With such measures, in effect the emissions would exert less impact on vegetation of the study area. On the other hand, development of a significant portion of greenbelt in and around the project area will improve the vegetation coverage and enhance the capacity of carbon sinking.	Contractor (with their Expert as required)	NWPGCL (Environment Cell)
U2. Riverine, dolphin habitat and benthic community	Transportation of power plant equipment, other materials including fuel during operation period along the river ways, may degrade the riverine water and habitat quality of aquatic species due to movement, creation of underwater noise, and discharges of waste and oil spill from all these river transports. Water extraction from Bhairab River particularly during dry season for cooling and make-up process	• The plant will extract maximum 0.12% against total discharges of the Bhirab river in which is low amount and will not have impaction the aquatic species. Any excess of the suggested amount of water extraction to be discouraged. • All the vessels must follow the standard of IMO, MARPOL during transportation of materials up to the port of delivery of foreign imported machinery and equipment. • In addition to that, in case of any discharges from the plant and the vessels, shall also follow ECA 1995, ECR 1997 of GoB and all applicable IFC guidelines and standards which ever is stringent and applicable.	Contractor (with their Expert as required)	NWPGCL (Environment Cell)

	may affect aquatic ecosystem, aquatic species including dolphin and their prey. Some of the species may be trapped in the extraction pipe and get killed.			

Source: CEGIS, 2016

9.9 Emergency Response and Disaster Management Plan

626. An Emergency Response Plan (ERP) is prepared. Each Contractor after assessing potential emergencies that could be encountered during construction phase should prepare site specific ERPs (guidance can be taken from the ERP proposed in this EIA) and include in their CEAP. The CEAP will be submitted to the OE for review and approval before contractor mobilization.

627. The ERP proposed for NWPGCL identified possible emergency events during construction and operational phase. The emergencies could be immediate medical evacuation due to personnel injury, traffic accidents (road), leakage of hazardous chemicals, terrorist events/threats and gas leakage/explosion, kidnap and/or extortion, bomb threat, pandemic, significant business loss, pollution incident, fire and explosion, gas leak and structure collapse.

628. The ERP outlines the framework of Emergency Response Strategy which will be followed by the contractor's, operation and maintenance staffs of NWPGCL during decommissioning, construction, and erection and operation and maintenance phases.

629. As a general rule the initial response is guided by three priorities which are as follows:

1. People
2. Property
3. Environment

630. ERPs will identify who does what and when, in the event of an emergency situation. Responsibilities for the Officials who are in charge and their coordination for emergency actions shall be identified under the specific "Roles and Responsibilities". The anticipated Nature of Emergency & Hazardous Situations may be categorized as follows:

I. Emergency
- ❖ Fire
- ❖ Explosion
- ❖ Medical Emergency
- ❖ Kidnap/ Extortion
- ❖ Civil Unrest
- ❖ Bomb Threat
- ❖ Pandemic
- ❖ Spillage of toxic chemical, and electrocution

II. Natural Disasters

- ❖ Flood
- ❖ Earthquake
- ❖ Tornado/ Cyclone/ Hurricanes

III. External Factors

- ❖ Food poisoning/ water poisoning
- ❖ Sabotage and
- ❖ War

9.10 Budget for EMP

631. The cost of implementing the EMP including monitoring is about $2 million. Details of EMP and associated costs are given in **Table 9.5**.

Table 9.5: Tentative cost of EMP

Items	Unit	Quantity	Unit Rate ($)	Amount ($)
EPC Contractor (Investment Cost)				
Continuous Stack Emission Monitoring System	No	2	30,000	60,000.00
Water ETP	Included in Project Cost			-
Continuous Micro-Climate Station	No	1	15,000	15,000
Passive/Continuous Ambient Air Quality Monitoring Station (min. 1 year)	No	2	20,000	40,000.00
Noise Attenuation Measures	LS	LS	6,000	6,000.00
Environmental Laboratory	No	1	200,000	200,000.00
Provision of fencing the Dyke/Levee avoiding navigation reduction of Bhairab River.	per meter	1,400 meters	40	56,000
Storm water pumping station and pump house (during construction period)	LS	1	-	4000
Environmental Management Plan				
Plantation Program				5,000.00
Emergency Response related Equipment				200,000.00
Community Health, Safety and Security	LS			10,000
EHS Staffs of Contractor	Medical professional Man month	1000	100	1,00000
Contractor's HIV/AIDS Management	LS			10,000
Awareness and training for the local people (e.g. fisherman, labour, farmer, etc.)	Quarterly meeting for 3 years' time frame			22,500
Institutional Arrangements				
EHS Consultant of Owner's Engineer				**800,000.00**
EHS Staffs of EHSU Circle (3 years)				200,000.00
Capacity Building and Training				100,000.00
Environmental Monitoring Plan (Demolition, pre-construction and construction)				**80,150**

Items	Unit	Quantity	Unit Rate ($)	Amount ($)
Environmental Monitoring Plan (Operation)				**78,950**
Independent Monitor for five (5) years period including one (1) year of operation				**150,000.00**
			Grand Total	**2,137,600.00**

LS = lump sum.

9.11 Monitoring Plan

632. A three-tier monitoring program has been proposed comprising of compliance monitoring, impact monitoring, and external or independent monitoring in certain duration as one of the key elements of the EIA study. The main purpose of this monitoring program is to ensure that the various tasks those detailed out in the environmental management plan, particularly the mitigation measures which are to be implemented efficiently and effectively, and also to evaluate project's impacts on the key environment and social parameters.

9.11.1 Compliance Monitoring

633. Compliance monitoring is a very important tool/aspect of environmental management to safeguard the environment. The compliance monitoring plan is presented in **Table 9.6** and **Table 9.7**. The monitoring activities will be supervised by the respective Environmental Management Official from the Environmental Cell of the NWPGCL. The compliance monitoring program will be conducted by an independent third party.

634. For monitoring of physic-chemical parameters, locations near the baseline sampling points and potentially affected locations are suggested in this section below. Actual monitoring time and location will be decided by the OE and NWPGCL. The Contractor will be responsible for carrying out or contracting an approved third party for monitoring all the parameters as required with frequency is shown in the following table. This monitoring will be carried out by its own cost during the construction phase. The measurement values are to be compared with the IFC's EHS General Guidelines, where relevant standards are specified, or the national standards (ECR 1997 and amended in 2005).

9.11.2 Impacts monitoring

Impacts Monitoring during Construction

635. The purpose of the impact monitoring is to ensure that the contractor implements the mitigation measures given in the EMP efficiently, effectively and timely. This monitoring will generally be carried out by the OE with the help of checklists prepared on the basis of the impact monitoring Plan.

9.11.3 Independent/External Monitoring

636. The NWPGCL should engage an independent organization for monitoring the implementation of EMP. The main purpose of the Independent monitoring is to ensure that all key entities including EHSU, OE and contractors are effectively and adequately fulfilling their designated role for EMP implementation. All the EMP requirements are being implemented efficiently, effectively and timely.

Table 9.6: Environmental Compliance Monitoring Plan during Demolition and Construction

Components of EHS Monitoring	Monitoring Indicators	Locations	Frequency	Type/Duration of Sampling	Target Standard	Implemented By	
						Monitoring	Supervision
Environmental Monitoring during Pre-construction and Construction Phase							
Ambient Air Quality	SPM, PM_{10} and $PM_{2.5}$	Residential area of KNM or Mosque premises	Monthly	24 hr Continuously during demolition and construction works	SPM- 50 µg/Nm3 $PM_{2.5}$- 16.25 µg/Nm3 PM_{10} -37.5 µg/Nm3	EPC/ Third Party	OE/ NWPGCL
Ambient Noise Day time (6:00 – 21:00) and Night time (21:00 – 6:00), Leq values in dBA	Leq, L10 and L90 during the demolition and construction works at	Mosque, School, Residential areas, Labour work places and S, W, N E corner of the project:	Daily	Sampling greater than 15 minutes	Mosque and School – 50 dBA (day) 40 dBA (Night) Residential areas - 55 dBA (day) 45 dBA (Night) Remaining areas 70 dBA (day) 70 dBA (Night)	EPC/Third Party	OE/NWPGCL
Water quality	PH, BOD, COD, Total N, Total P, Oil and Grease, TSS, Total Coliform	Surface water – 100m u/s, middle and 100 m d/s of Bhairab river from the eastern boundary, pond inside KNA, Tube well water from the residential area of KNA	Quarterly	Composite sampling	Maintaining the baseline quality of river water and protect any kind of discharge from the project area	EPC/Third Party	OE/NWPGCL
Water Resources	Building residuals, Bank erosion, flood, drainage system	Dumping places, project eastern boundary, drainage outlet	Quarterly	Observation, Water level data and KII	Zero solid waste dumping, flood and erosion protection and drainage clearance	EPC/Third Party	OE/NWPGCL
Biological Environment	Mammals, Aves, Reptiles, Amphibians rescued, relocation and rehabilitation	Project area	During buildings demolition and vegetation clearing period	Direct Observation/ Transects	To reduce the mortality and safe migration of the wild animals,	EPC (with their Expert as required)	NWPGCL (Environment Cell)

Components of EHS Monitoring	Monitoring Indicators	Locations	Frequency	Type/Duration of Sampling	Target Standard	Implemented By	
						Monitoring	Supervision
					Increase in-situ conservation		
	Plantation and Plant health (Plant Growth, Canopy Coverage, Disease, etc.)	Protected area and Green belt area within the project site	Six monthly	Plot Survey, Plant health Survey	Conserve the existing plant health, facilitate for green belt development	Contractor (with their Expert as required)	NWPGCL (Environment Cell)
	Dolphin Occurrence and Habitat status	Two confluence sites (Bhairab-Atai and Bhairab-Madhumati) and River route from Rupsha bridge to Madhumati Bhairba confluence	Quarterly	Direct Counting, line Transect Survey, Water Quality, water availability	Conserve suitable habitat and abundance of dolphin species	Contractor (with their Dolphin Expert as required)	NWPGCL (Environment Cell/Experts)
Fish Diversity and Habitat	Capture Fisheries Diversity, Richness, Productivity, etc.	Bhairab River within around 2 - km u/s and d/s away from the Project site	Quarterly	Fish Catch Assessment Survey, Fishing Survey and Fishers' interview	Conserve suitable habitat for spawning of capture fisheries	EPC Contractor (with their Expert as required)	DoF and NWPGCL
Fishing Livelihoods	Number of fisher, amount of capture fishes	Fishermen of the villages of Chandanimohal	Quarterly	KII, FGD	To ensure the sustainable fishing practices by the fisher	EPC Contractor (with their Expert as required)	DoF and NWPGCL
Worker Health and Sanitation	Availability of Potable Water, Drinking water quality, Availability of Hygienic Toilet	Power Plant work place, labor camps	Quarterly	Inspection and interview of labor, project personnel	To ensure the Performance standard (PS 2) of IFC and reduce the grievance from labor	EPC Contractor	OE, NWPGCL
Working condition, laws, Safety and Security	Relationship, Compliance law, Protecting equipment, Training	Workplaces, Labor camps and adjacent communities	Quarterly	Inspection and interview of labor, Project personnel followed by a checklist	To reduce the grievance, safe and sound working environment as per PS 2	EPC Contractor/ OHAS auditor	OE, NWPGCL
Generation of Non-Hazardous Solid Waste (Domestic waste, Office Waste,)	Collection system, Proper disposal, waste sprawling	Demolition and dumping site, labour camp, construction yard, another Designated Site etc.	Quarterly	Visual Inspection, waste classification	Reduce, reuse and recycle of waste,	EPC Contractor	NWPGCL

Components of EHS Monitoring	Monitoring Indicators	Locations	Frequency	Type/Duration of Sampling	Target Standard	Implemented By	
						Monitoring	Supervision
Community Safety and Security	Accidents, diseases, emergency preparedness, security	School, Residential areas of KNP, adjacent communities	Quarterly	KII to the students, school committee, residence and communities, Disclosure	To reduce any disturbance of the community and minimize the risk of the community as per PS 4	EPC Contractor/ OHAS auditor	OE, NWPGCL
Agricultural Production	Crop Production Loss, Diseases	Three locations: in the study area within 0.5-2km from the project site	Six monthly following cropping patterns	Soil sampling, Agricultural Survey, KII and FGD	To reduce the soil contamination due to dry or wet deposition of SO_x, NO_x or PM and induced impacts	EPC Contractor	OE, NWPGCL

Table 9.7: Environmental Compliance Monitoring Plan during Operation

Components of EHS Monitoring	Monitoring Indicators	Locations	Frequency	Type/Duration of Sampling	Target Standard	Implemented by	
						Monitoring	Supervision
Environmental Monitoring During Operation							
Stack Emission	NO_x, SO_x, CO PM_{10}, $PM_{2.5}$	Stacks both by pass and HRSG stacks	Continuous	Continuous	IFC emission standard for combustion turbine	EHSU /KP	Independent Monitor/ NWPGCL
Ambient Air Quality	NO_x, SO_x, SPM, PM_{10}, $PM_{2.5}$, CO, O_3	Two monitors in the location of the maximum deposition to the 2km and 4km north of project site	Monthly Average (weekly passive sampling) for 1 year	24 hours	IT values of IFC2007 and ECR2005	EHSU/ KP	Independent Monitor/ NWPGCL
Ambient Noise	Day time (6:00 – 21:00) and Night time (21:00 – 6:00) LAeq, L10, L90	• Outside the project boundary: ➢ South-west corner communities ➢ Southern boundary residential areas ➢ Proposed School of KNP • Indoor Noise: ➢ Administrative building ➢ Health care unit ➢ Residential buildings	Monthly	Three Sample during day time and one sample during night, 15 min sampling each time.	IFC 2007 for Industrial areas and ECR 2006 for the remaining area	EHSU/ KP	Independent Monitor/ NWPGCL

Components of EHS Monitoring	Monitoring Indicators	Locations	Frequency	Type/Duration of Sampling	Target Standard	Implemented by	
						Monitoring	Supervision
		➢ Mosque premises					
Leak detection	Gas release, Pressure change, Physical damage	RMS and pipeline corridor	Every shift of every day	Visual Observation for stressed vegetation and with a “sniffer”	Ensure safe handling and reduction the risk	EHSU	Independent Monitor/ NWPGCL, PGCL
Storm Water	Drainage System, Congestion, local flooding	Inside the power plant area, Drainage outlet	Weekly during monsoon season	Observation, KII	Eliminate any possibilities of drainage congestion in the project area	EHSU	Independent Monitor/ NWPGCL
Waste water discharge from the CBM	pH, TSS, TDS, Oil and grease, Total Residual Cl, Total Cr, Fe, Cu, Zn, Pb, Cd, Hg, As, EC, COD Temperature Salinity, flow rate	Discharge outlet point at CBM	Continuous – pH, EC, Salinity, TDS, Temperature, Flow rate Remaining- Twice in a Week	Grab Sampling	Manitaining the stringent effluent standard of IFC and ECR	EHSU	Independent Monitor/ NWPGCL
Waste water discharge from the STP	pH, BOD, Nitrate, Phosphate, COD, SS, Coliforms	Discharge outlet just after the STP outlet	Fortnightly	Grab Sampling	Maintaining stringent effluent standard of IFC and ECR	EHSU	Independent Monitor/ NWPGCL
Ambient Water Quality	pH, EC, TDS, Salinity, TSS, Residual Cl, Fe, As, Hg, Pb, NO_3, PO_4, SO_4, BOD, COD, Coliform	Surface Water – 100 u/s, outfall point and 100 d/s from the discharge point in Bhairab river, Ground water – wells within the project boundary	Spring and Summer (for 5years)	Composite Sampling	Maintaining the baseline water quality	EHSU	Independent Monitor/ NWPGCL
Generation of Non-Hazardous Solid Waste (Domestic waste, Office Waste,)	Collection system, Odor, waste sprawling	Designated Sites	Monthly	Visual Inspection, waste classification	Safe solid waste disposal, Pollution prevention and introduce 3R technologies	EHSU	NWPGCL
Generation of Hazardous Waste like	Quantity, Types, Toxicity	Waste Disposal Point, Waste Generation Sources like sludge from ETP, STP, WTP; chemical waste from reverse osmosis Plant, Laboratories, Medical Center etc.	Monthly	Visual Inspection, waste classification	Safe hazardous waste disposal, Pollution prevention as per PS3	EHSU	NWPGCL
Workers Health and Sanitation	General Health Condition, accident, fatalities, injuries	Workers involved in the Plant operation and maintenance	Quarterly	Health Check-up, Grievance register	Congenial work environment, Good health and sanitation facilities as per PS2	EHSU	NWPGCL

Components of EHS Monitoring	Monitoring Indicators	Locations	Frequency	Type/Duration of Sampling	Target Standard	Implemented by	
						Monitoring	Supervision
	Complain, fitness, etc.						
	Available quantity and quality of potable water	Work place, residence	Monthly	Sampling, Checking			
	Hospital, Hygienic Toilet, Gym	Workplace, Residence, common places	Monthly	Observation, KII			
Exposure to Electro-magnetic Field	EMF	Outside the safety fence of Substation, Power evacuation bay, other EHV area	Quarterly	Measurement by EMF Meter Inspection of workers' roster shifting hours etc.	Reduce the risk of exposing electromagnetic field by individual / Community	EHSU	NWPGCL
Occupational Noise	LAeq, noise exposure	Inside Plant Area (Turbine hall, RMS, etc.) Control room Administrative building, residential buildings, health unit	Quarterly	Continuous sampling for 4 hr during day and 2 hr during night (as USEPA) by using: ANSI Type II Noise Meter Inspection of record of shifting hour, workers' roster	To complying with occupational H&S noise standards in the EHS guideline on occupational H&S	EHSU	NWPGCL
Community Health, Safety and Security	Status of Communicable Diseases, Status of Vector Borne Diseases	Plant Residence, Nearby communities	Yearly	Inspection of Disease Profile/Records in Health unit, nearby Hospital	To avoid or minimize risks and impacts to community health, safety, and security to the vulnerable group as per PS4	EHSU	NWPGCL
	Emergency Preparedness	N/A		Visual Inspection and Record Checking			
	Community Relation Program/ Community Awareness Program, Training	N/A		KII, Public consultation, Community Register check.			
Status of Dolphin community	Habitat, Abundance	Two confluence sites (Bhairab-Atai-Rupsa and Bhairab-Madhumati)) and River route from Rupsa bridge to Madhumati Bhairba confluence.	Wet and Dry seasons	Dolphin Survey, KII with the fisher	To ensure the sustainable habitat for the dolphin community as per baseline	EHSU (Dolphin Expert as required)	NWPGCL (Environment Cell/Experts)
Fish Diversity and Composition	Capture Fisheries: Diversity, Richness, Productivity, etc.	Bhairab River within around 1 km us/ and d/s away from the Project site	Six Months	Fishing Survey and Fishers' interview		IM	NWPGCL

Components of EHS Monitoring	Monitoring Indicators	Locations	Frequency	Type/Duration of Sampling	Target Standard	Implemented by	
						Monitoring	Supervision
Vegetation (Plant) heath	Plant Growth, Canopy Coverage, Disease, etc.	One at the proposed greenbelt area within the plant boundary and one at the mosque area and one at social forest of Chandanimahal	Yearly	3 plots (15m x 15m) in the study area		IM (with their Expert as required)	NWPGCL (Environment Cell
Land use and Land Cover change	Land cover and Land use	5km radius area of the Plant	Once in three years	Stakeholder Consultation and Satellite Image (2km buffer area of KPS) Analysis		IM	KP/NWPGCL
Agricultural Production	Crop Production Loss	Three locations: in the study area within 0.5-2 km from the project site	Yearly	Farmers' Interview, Secondary Data from DAE		IM	KP/NWPGCL
Monitoring of the CSR activities	Dependent on the specific type of programs	N/A	Yearly	Stakeholder Consultation		IM	NWPGCL

IM = Independent/External Monitoring; NWPGCL = North-west Power Generation Company Limited; OE = Own Engineer.
These monitoring parameters will be revised after monitoring the effluent water quality from the discharge channel. Some parameters might become redundant if the effluent water does not contain in the effluents

Table 9.8: Impact Auditing Plan

Parameter / Activity	Location	Means of Monitoring	Frequency	Responsible Agency	
				Implemented By	Supervised By
During Construction					
Hydrocarbon and chemical storage	Construction area	Visual Inspection of storage facilities	Monthly	EPC Contractor	OE/ Independent Monitor
Damage to local roads	Approach Roads to the construction sites	Visual inspection to ensure local roads are not damaged	Monthly	EPC Contractor	OE/ Independent Monitor
Traffic Safety	Approach Roads	Visual inspection to see whether proper traffic signs are placed and flag-men for traffic management are engaged	Monthly	EPC Contractor	OE/ Independent Monitor
Air Quality (dust, - smoke)	Construction sites	Visual inspection to ensure good standard equipment is in use and dust suppression measures (e.g., spraying of waters) are in place.	Daily	EPC Contractor	OE/ Independent Monitor
	Batch mixing Plant	Visual inspection to ensure batch plant is located >500 m from residential areas	Monthly	EPC Contractor	OE/ Independent Monitor
	Material storage sites	Visual inspection to ensure proper maintenance i.e. covering, dust suppression etc. as per ECP	Monthly	EPC Contractor	OE/ Independent Monitor
Noise	Construction sites	Physical inspection to ensure good standard equipment are in use		Noise	Construction sites
	Construction sites	Visual inspection to ensure ear plugs/earmuffs are in use by the construction workers	Daily	EPC Contractor	OE/ Independent Monitor
		Ensure work restriction between 20:00-06:00	Daily	EPC Contractor	OE/ Independent Monitor
Plantation	Designated sites	Visual inspection to observe growth of saplings as per provided green belt design (subjected to the initiation of plantation)	Monthly	EPC Contractor	OE/ Independent Monitor

Parameter / Activity	Location	Means of Monitoring	Frequency	Responsible Agency	
				Implemented By	Supervised By
Ganges River Dolphin	Rupsha Bridge to Bhairab-Madhumati Confluence	Boat Transect (Shayer et al. (2015) method	Quarterly	EPC Contractor	OE/ Independent Monitor
Waste Management	Construction area	Visual inspection that solid waste is disposed at designated site and are managed in efficient way	Weekly	EPC Contractor	OE/ Independent Monitor
Hazardous Waste Handling	Hazardous Material Storage Area Hazardous Waste Disposal Area	Visual Inspection of safe handling and storage of hazardous waste and hazardous materials	Fort-nightly	EPC Contractor	OE/ Independent Monitor
Drinking water and sanitation	Labor shed, offices	Ensure the construction workers are provided with potable water and sanitation facilities in the site	Fort-nightly	EPC Contractor	OE/ Independent Monitor
Restoration of Work Sites	All Work Sites	Visual Inspection	After completion of all works	EPC Contractor	OE/ Independent Monitor
Safety of workers Monitoring and reporting accidents	At work sites	Visual inspection of usage of Personal Protective equipment, Safety Sign, Safety Documentation, safety training, etc.	Daily	EPC Contractor	OE/ Independent Monitor
Emergency Response Facilities	At project sites	Inspection of Emergency Preparedness and Response mechanism and facilities	Monthly	EPC Contractor	OE/ Independent Monitor
Grievance Mechanism	At project sites	Inspection of the complaint register	Monthly	EPC Contractor	OE/ Independent Monitor
During Operation and Maintenance					
Monitoring of Environmental Quality (Ambient Air, Noise, Water, effluent, Soil, etc.)	At project sites	Inspection and Record checking of Monitoring activities carried out by EHSU circle of	Quarterly	Independent Monitor/ PIU	NWPGCL

Parameter / Activity	Location	Means of Monitoring	Frequency	Responsible Agency	
				Implemented By	Supervised By
Environmental Laboratory	KP	Inspection of laboratory Condition, accreditation and certification (from GoB) status	Six-monthly	PIU	Independent Monitor, NWPGCL
Meteorological Condition	KP	Checking and compiling climatic data collected and recorded by micro weather station installed in KP	Quarterly	Independent Monitor	NWPGCL
Ambient Noise Level	Residential area, Administrative area and nearby community	Noise nuisance/ disturbance perceived by power plant personnel and nearby community to be surveyed by interview and FGD	Yearly during stakeholder consultation	Independent Monitor	NWPGCL
Fisheries	Effluent discharge points	Interviewing local fishermen	Yearly during stakeholder consultation	IM	NWPGCL and DoF
Plant Health	Green belt area and influence zone	Visual inspection	Yearly	Independent Monitor	NWPGCL
Land use and land cover	5km radius area the Power Plant	Stakeholder Consultation and Satellite Image (2km buffer area of KP) Analysis	Yearly	Independent Monitor	NWPGCL
Hazardous Waste and Hazardous Material Handling	Hazardous Material Storage Area and Use Area Hazardous Waste Disposal Area	Visual Inspection of safe handling and storage hazardous waste and hazardous materials	Quarterly	EHSU Circle	Independent Monitor, NWPGCL
GRM	At project site	Inspection of the complaint register/grievance form and interviewing local people	Six-monthly	EHSU Circle	Independent Monitor, NWPGCL
ERP	Project site	Inspection of Emergency Preparedness and Response mechanism	Quarterly	EHSU Circle	Independent Monitor, NWPGCL

Parameter / Activity	Location	Means of Monitoring	Frequency	Responsible Agency	
				Implemented By	Supervised By
Health and Safety Preparedness	Project site	Inspection of training list, safety meetings records, means of awareness growing	Quarterly	EHSU Circle	Independent Monitor, NWPGCL
Community Relation	Nearby Community	Inspection of community relation maintaining procedures, relation building activities, FGD with community	Quarterly	EHSU Circle	Independent Monitor, NWPGCL
CSR Program (if any)	Nearby Community	Inspection of record completed and planned CSR programs and activities	Six-monthly	Independent Monitor	NWPGCL

9.11.4 Implementation of Environmental Monitoring Plan

Responsible Agency

637. The Chief Engineer, Rupsha 800MW CCPP is the responsible authority for administering and implementing the Project and the Project Director will implement environmental monitoring program during construction and the Plant Manager (Superintending Engineer) will implement monitoring plan during operation stage. During construction stage, the Environmental Compliance Monitoring will be conducted by the Contractor(s) supervised by OE and Environmental Impact Monitoring will be carried out by OE with the support of the Contractor(s). In addition, an independent Monitor will also be retained by PIU during three years of construction and one years of post-construction (operation stage). The EHSU Circle will implement the monitoring program during operation stage.

Action during Emergent Operation

638. The Plant can have an Emergent operation if there is a major failure of control system, plant component, grid failure, etc. Normally the modern DCS is good enough to handle all such emergencies. Otherwise, the plant operator/shift in-charge can change the plant control to manual mode and adjust the process variables and finally change the plant back to auto mode. The proposed project will have DCS with modern sensors and a proper interface with the existing old sensors/system.

639. The plant will be operated ensuring all pollution control devices are in order. In case of any event of malfunction of a pollution control device, immediate action of resolving the problem will be taken. If any emergent situation arises during operation, the shift in-charge will be immediately notified to take corrective measures and action.

9.11.5 Performance Indicators

640. For evaluating the performance of the environmental management and monitoring plan, performance indicators are identified to, for efficient and timely implementation of measures/actions proposed in EMP. The indicators are defined both for construction and

operation phases. OE will be responsible for compiling the information on these indicators and report to NWPGCL.

641. To measure the overall environmental performance of the project, an additional list of performance indicators is provided below:

- Number of inspections carried out by OE per month
- Number of non-compliances observed by OE or EHSU.
- Continuous period of non-compliance
- Number of grievances received.
- Number of grievances resolved.
- Number of construction and occupational related accidents.
- Timely reporting of documents (as defined in EMP and monitoring plan)
- Availability of environmental and H&S specialists in EHSU.
- Availability of environmental and H&S specialists in OE.
- Availability of environmental specialists and H&S with contractors.
- Number of trainings imparted to stakeholders/other capacity building initiatives

9.11.6 Reporting and Feedback Mechanism

642. The monitoring activities will require proper documentation. In case of Independent monitor, the monitoring results and relevant document should be properly reported to the project implementation authority. The project authority would submit the report to the DoE and ADB.

643. During construction stage, the environmental specialist of OE will be engaged in monthly discussion meeting with the project implementation unit and the Contractor(s) for giving necessary feedback. The project implementation unit may arrange a discussion meeting after six months with the financer regarding environmental compliance.

644. During the operation phase, the EHSU Circle will carry out the monitoring activities and keep all the records and results of monitoring with proper documentation and will produce quarterly reports on Environmental Monitoring. Besides, the third party Independent Monitor would prepare and submit environmental compliance monitoring report annually to the power plant authority. All the reports should be submitted to DoE which is a condition of renewing the ECC from DoE and to the financer for post-completion monitoring and evaluation of the Project.

645. During operation, the EHSU Circle will give necessary feedback instantly to the person in concern. The EHSU Circle will arrange a monthly meeting to disclose the results of environmental monitoring to the personnel.

9.11.7 Budgets for Monitoring

646. Summary costs of monitoring including investments costs are presented in **Table 9.9** and **Table 9.10**.

Table 9.9: Environmental Compliance Monitoring Cost

No.	Activities	Estimated Cost (USD)/Year
During demolition, pre-construction and Construction (borne by EPC Contractor)		
1	Environmental quality (air, water, noise, soil) monitoring	40,000
2	Occupational health, safety, and sanitation	6,500
3	Ecological Monitoring	
	3a. Supervision of clearing as per layout plan avoidance of wildlife loss	7,500
	3b. Species composition and population of dolphin	12,500
	3c. Plantation program (as required)	3,000
4	Land and agricultural resources monitoring	650
5	Fisheries Fish habitat Fish diversity and composition Fish migration Fish Farm Fish production	6,500
6	Consultation and awareness building	1,000
	Subtotal	**77,650**
During 1 year of operation (to be included in O/M cost)		
1	Environmental quality (air, water, effluent, noise, soil) monitoring	45,000
2	Waste Generation and Management	4,500
3	Ecological Monitoring	
	3a. Plant health	6,500
	3b. Disturbance to wild life/dolphin	6,500
4	Land and agricultural resources monitoring	650
5	Fisheries Fish habitat Fish diversity and composition Fish migration Fish Farm Fish production	6,500
6	Effluent discharge monitoring	3,500
7	Occupational Health, Safety and Security	6,500
8	Community Health Safety and Security	3,800
9	Monitoring beyond compliance	2,000
10	Consultation and awareness building	500
	Subtotal	**85,950**

Table 9.10: Cost of Independent Auditor

No.	Activities	Estimated Cost (USD)
1	Independent Monitor for a five (5) years period including one (1) year of operation (only fees and cost)	150,000

10.0 HAZARD AND RISK ASSESSMENT

10.1 Introduction

647. Hazard is considered those that can cause harm or has the potential to cause harm; whereas, risk is the likelihood of hazard being occurred and its severity. Thus, a risk assessment is conducted, to carefully examine the potential hazards, how they occur and the measures to prevent such hazards. Mismanagement of one particular hazard can have consequences that simultaneously impact to a varying degree on several risk types.

10.2 Hazard assessment process

648. In the EIA stage, potential hazards are identified and discussed in detail along with risk assessment. An inclusive safety management plan is also developed accordingly. The steps followed in this preliminary hazard and risk assessment are mentioned below:

i. Identification of Hazards
ii. Cause Analysis
iii. Consequence Analysis
iv. Assessment of Likelihood
v. Identification of Existing Safeguards
vi. Risk Ranking, Recommended Actions and Safety Measures

10.3 Identification of hazards and Cause Analysis

649. Potential hazards are identified based on the different stages of the project phases, various location and project activities. Cause analysis is also conducted for potential hazards for each of the project activities.

10.3.1 Potential Hazard and Risk during Construction and Erection

650. The potential hazards and risk during construction, and erection are listed in **Table 10.1**.

Table 10.1: Potential hazard and risk during construction and erection

Location of hazard	**Potential Hazardous Activities**	**Potential hazard**	**Cause Analysis**	**Consequences**
Construction and Erection				
Machinery and equipment	Mobilizing machines, equipment and vehicles for site clearance activities	• Trips and falls • Cuts and bruises	• Fatigue or prior sickness • Mechanical failure • Lack of safety training • Not abiding to general health and safety and traffic rules	• Health injury • Disability • Life loss
Constructio n site	• Construction of building, steel structure and its foundation, stacking of HRSG	• Accidents (burns, electric shocks etc.) • Injuries from falls and slips • Injuries from falling of heavy objects/machineries	• Fatigue or prior sickness • Electric failure • Equipment failure • Lack of safety protocols (e.g. not putting up warning signs or enclosing the area	• Physical injury • Disability • Life loss

Location of hazard	Potential Hazardous Activities	Potential hazard	Cause Analysis	Consequences
	components, cutting, welding, painting works, drilling work, etc. • Use of machineries and equipment for dismantling of structures	• Inhalation of dust • Cuts and bruises	to prevent entry of outside people) • Not abiding to health and safety rules (e.g. not wearing appropriate PPEs during work, being careless at handling heavy equipments etc.) • Not maintaining a designated place for backfilling storage • Not maintaining enough lighting during the night (for those working overtime)	
	• Work at heights • Lifting of machineries and equipment from tall heights	• Accidents • Injuries from falls and slips (e.g. broken bones, fractures, traumas, etc.) • Fatalities	• Fatigue or prior sickness • Lack of safety protocols (e.g. not putting up warning signs or enclosing the area to prevent entry of outside people) • Not abiding to health and safety rules (e.g. not wearing appropriate PPEs and safety harness during work, being careless at handling heavy equipments, not wearing safety harness when working at heights etc.) • Not maintaining enough lighting during the night	• Health injury • Disability • Life loss
	Vehicle and vessel movement	• Noise generation • Accident (e.g. vessel capsize) • Emission from vehicles • Spread of dust and minute particles due to vehicle movement.	▪ Running engine, hydraulic horns, sirens etc. ▪ Mechanical failure • Old engine or engine parts/lack of maintenance	• Injuries • Health problems (e.g. respiratory, hearing and/or cardiac problems) • Fatalities • Disabilities
	Handling of hazardous chemical	• Accidental release of chemicals and noxious fumes • Acute/chronic toxicity from exposures to chemicals • Fire/explosion	▪ Lack of safety protocols ▪ Carelessness (e.g. smoking near chemical storage area) ▪ No proper bounding of chemical storage area • Improper chemical storage (e.g. faulty/leaky containers, improper containers, improper sealing of containers etc.)	• Health injuries (burns, anxiety, depression etc.) • Disabilities • Fatalities • Loss of properties

Location of hazard	Potential Hazardous Activities	Potential hazard	Cause Analysis	Consequences
	Possible fire and Explosion hazard from machineries, equipments, oxyacetylene cylinders (used for welding purposes), generators and vehicles	• Explosion caused due to poor maintenance of oxyacetylene cylinders or due to using faulty cylinders • Fire caused by mechanical/electrical failure of generators • Fire caused by mechanical/electrical failure of vehicle oil tanks	▪ Lack of proper maintenance of machineries, equipments and vehicles	• Health injuries • Disabilities • Fatalities
	Working in a confined space (Gas pipelines, HRSG etc.)	• Suffocation • Falling of debris • Release of toxic fumes	▪ Lack of protective measures ▪ Faulty/Damaged pipelines ▪ Negligence towards work	• Health injuries • Fatalities
	Occupational Hazard	• Cuts, bruises and burns • Falls, slips and trips • Health injuries • Sickness and illness	▪ Lack of safety awareness ▪ Carelessness in maintaining safety protocols ▪ Use of faulty machineries and equipment ▪ Improper hygiene ▪ Prior sickness or illness • Heavy workload	• Health injuries (burns, anxiety, depression etc.) • Disabilities • Fatalities
Chemical Storage Area	Storage of chemicals	• Release of toxic fumes • Fire/explosion • Falls and slips	▪ Lack of proper ventilation in chemical storage area ▪ Storing flammable and volatile chemicals in the same area. ▪ Faulty electric connections ▪ No bounding around chemical storage areas ▪ Not ensuring proper labelling/MSDS ▪ Lack of training of chemical handlers/workers	• Health injuries • Suffocation/asphyxiation • Fatalities
Plant Jetty site	• Loading and unloading of machineries, equipment and fuel oil	▪ Slip, trip and falls • Health injuries (from falling of heavy objects or debris)	▪ Lack of safety awareness ▪ Carelessness in maintaining safety protocols ▪ Heavy workload	• Health injuries • Disabilities • Fatalities

10.3.2 Potential Hazard and Risk during Operation

651. The potential hazards and risk during operation are listed in **Table 10.2**.

Table 10.2: Potential hazard and risk operation

Location of hazard	Project Activities	Potential hazard	Root Causes	Consequences
Gas pipelines	Transmission of gas to project site	• Toxic Vapor Cloud Formation • Vapor Cloud Explosion • Jet Fire • Limited Space Explosion • Over Pressure Explosion	▪ Mechanical failure ▪ Faulty connections/weld failure ▪ Cracks/shear stress on pipeline • Improper coating on pipelines • Corrosion • Sabotage	• Health injury • Fire/explosion • Possible poisoning • Suffocation • Damage to structure
Gas Metering and Regulatory Station	• Regulation of gas pressure and its quantity • Intake of gas from metering station to the plant	• Gas leakage to the atmosphere • Flash fire/jet fire/explosion (if in contact with an ignition source)	▪ Mechanical failure ▪ Faulty connections/weld failure ▪ Cracks/shear stress on pipeline • Improper coating on pipelines • Failure of maintenance activities creating ingress of air into natural gas piping and vessels and subsequent start-up without adequate purging. • Corrosion ▪ Sabotage	• Property damage • Environmental damage • Health injuries (e.g. burns) • Fatalities
Steam turbine, turbines, HRSG, generator and its ancillary components	Electricity generation	• Mechanical hazard • Leakage of natural gas • Fire hazard/explosion (if in contact with an ignition source) • Electrical hazard • Noise generation	▪ Mechanical failure (due to failure of rotating machineries or failure in gas or steam pipelines) ▪ Lack of sound buffers ▪ Electric short circuit ▪ Engineering design fault	• Health injury (from projectiles, fires, electrical shock etc.) • Fatalities • Property damage • Environmental damage
• Cable gallery • Power transformer • Switchyard	Transmitting electricity from generator to unit transformer	• Fire due to resulting arc flash/arc blast • Other electric hazard due to	▪ Short circuit in control room and switch gears ▪ Faulty cables and wires ▪ No safe connection to earth	• Health injury from electric shock, fires etc. • Fatality from electrocution, fires etc.

Location of hazard	Project Activities	Potential hazard	Root Causes	Consequences
• 230KV Switchyard control room	• High voltage (230KV) power transmission • Open air power transmission • Controlling and monitoring the power transmitting system	unprotected cables • Slips and trips from unorganized/loose cables lying in the floor	▪ Using cables with different voltage and current ratings • Unorganized cables	• Electric burns
• Boiler and pressure parts • Compressed air system and pipeline • Live steam line	• Steam generation • Operate pressure valve, switch and control system • Flows live high pressure steam from boiler to turbine	• Fire (near burner) • Release of high pressurized steam • Explosion	▪ Failure of the water pumps ▪ Mechanical failure of safety switch and valves ▪ Busting of furnace and pressurized pipes ▪ Presence of contaminant in fuel • Accidental leakage, lack of heat sink for combustion process and nonfunctional safety and bypass valve.	• Incomplete combustion • Equipment damage • Health injury • Loss of life • Environmental degradation
Water treatment and waste water treatment plant	Produce clarified, dematerialized water for steam generation and treat effluent water before discharge	Chemical hazard	▪ Spillage/accidental release • Mishandling and misuse	• Possible health injury due chronic or acute toxicity • Disability • Loss of life • Degradation of air, water and/or soil quality
Intake channel	Water intake for plant operation	Mechanical Hazard	▪ Accident due to ship anchorage ▪ Negligence of ship master. ▪ Poor signal	• Disruption of intake channel for the powerplant. • Interruption of reverse osmosis plant.
Chemical storage	Use for water treatment in different phases of dematerialized water, cooling water and potable water.	Toxic accidental release due to multifunction of equipment & callousness of operator.	▪ Chemical spillage ▪ Chemical fires • Mishandling and misuse	• Health injury (chronic or acute toxicity) • Disability • Loss of life • Degradation of air, water and soil quality
Air circulating system	Generating air flow both in and out of boiler	Non-functional air circulating system	• Mechanical failure	• Equipment damage and risk to human health and surrounding environment

Location of hazard	Project Activities	Potential hazard	Root Causes	Consequences
Plant site	Daily plant activities	• Cuts, bruises and burns • Falls, slips and trips • Health injuries • Sickness and illness	▪ Lack of safety awareness ▪ Carelessness in maintaining safety protocols ▪ Use of faulty machineries and equipment ▪ Prior sickness or illness ▪ Heavy workload • Unsafe working environment.	• Health injury • Electric shock • Sickness • Anxiety and depression

10.4 Consequence Analysis

10.4.1 Leakage from Gas Pipe Line

652. Natural gas is a flammable chemical which is enlisted as explosive under the '***Explosive Act 1884'*** of Bangladesh. The natural gas used for the proposed plant consists of mostly Methane (96% by volume) and ethane, propane, butane and other alkanes. Though methane is highly flammable gas, its explosion limit is low (5% - 15%). Leakage of gas from pipeline and other associated events may cause series of hazards. It describes and assesses the unplanned events that could potentially cause risks to public safety and harm to the environment. In the following sections, potential hazards and consequences are discussed.

653. Gas transportation and pipeline construction plan is shown in **Figure 10.2.** Gas will be supplied from Regulating and Metering Station (RMS) situated at south-west corner of the proposed site. Leakage from these Gas supply facilities may lead to series of hazards that may ultimately results in damage of the property and loss of human life. **Table 10.3** has listed down all identified major potential hazards and hazard sourcing points related to natural gas during plant operation. Sequential Hazard Event from a Gas Leakage is shown in **Figure 10.1.**

Figure 10.1: Sequential Hazard Event from a Gas Leakage

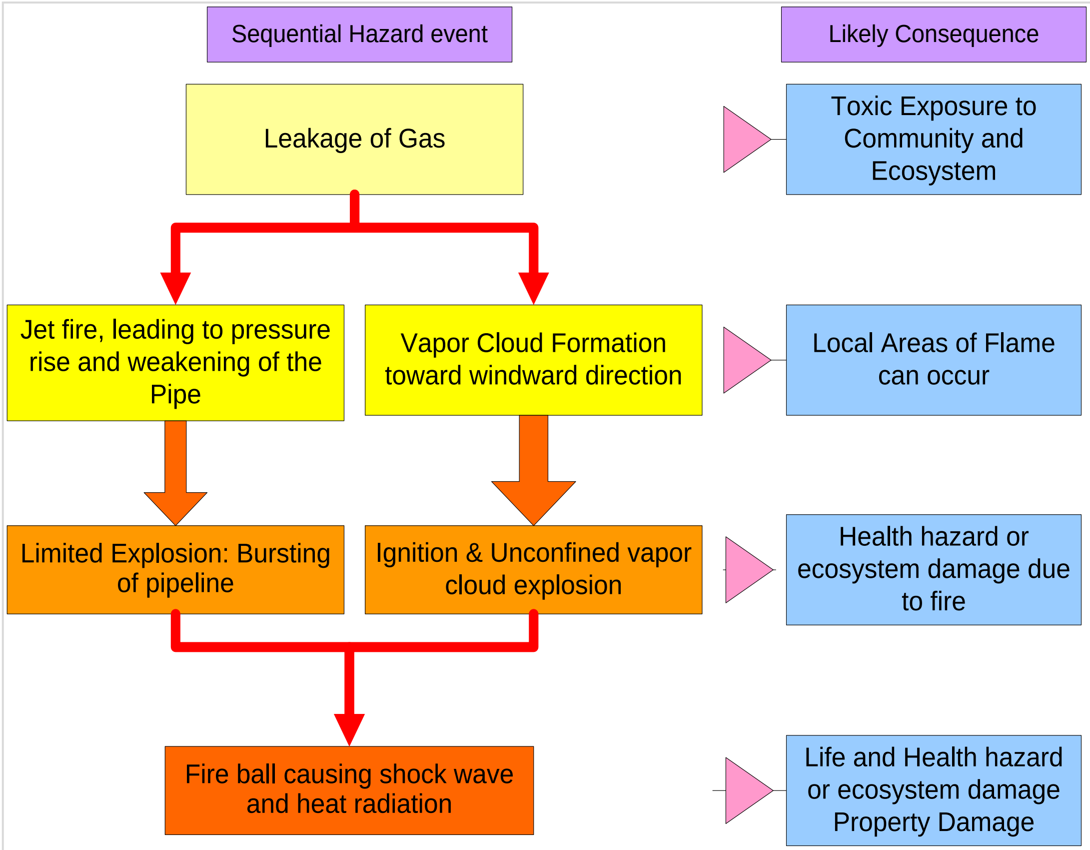
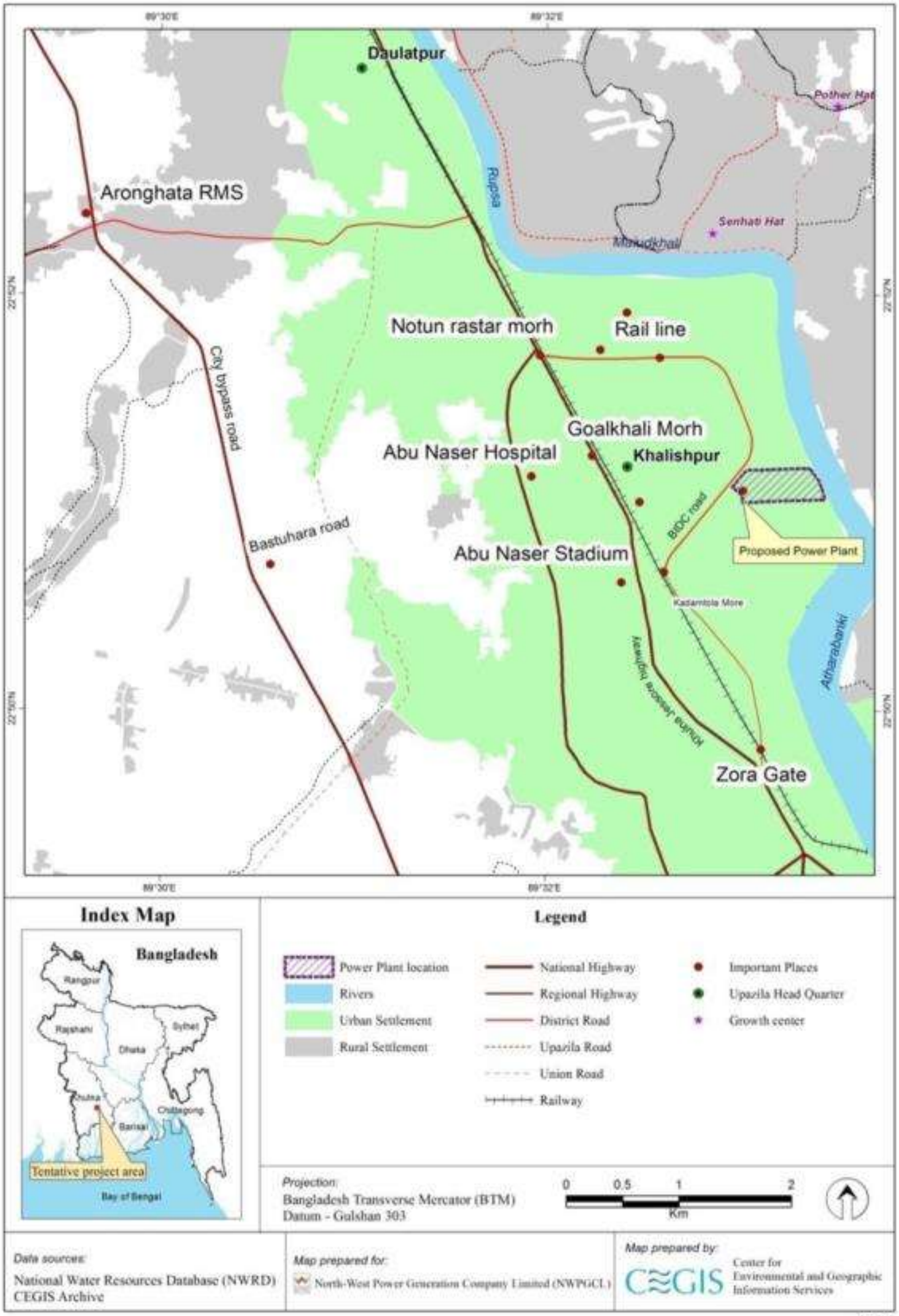


Figure 10.2: Proposed gas distribution pipeline construction plan



Risks associated with gas pipeline

654. Some major reasons which may be attributed to the Risks associated with the transmission of natural gas through gas pipeline are:

- Material Failure (faulty design or manufacture; faulty installation, welding or construction of facilities)
- Corrosion-internal or external pipe;
- Excavation damage (dig-ins)
- Human Error-Natural Forces (i.e. ground movement); and
- Others

Table 10.3: Potential hazard points and possible consequences

<table>
<tr><th>Hazard Points</th><th>Possible Hazards</th><th>Consequences</th></tr>
<tr><td>Regulatory and Metering Station</td><td rowspan="2">Gas Leak leads to:
• Toxic Vapor Cloud Formation
• Vapor Cloud Explosion
• Jet Fire
• Limited Space Explosion
• Over Pressure Explosion</td><td rowspan="2">• Fire
• Poisoning
• Suffocation
• Damage to Structure
• Health Loss</td></tr>
<tr><td>20” Gas Pipeline, valves</td></tr>
</table>

655. Leakage from pipeline or RMS may lead to sequential hazards. The gas pipeline may experience leakage due to any fracture or failure of the pipeline. ALOHA (Areal Locations of Hazardous Atmospheres) software has been used to simulate the consequences of gas leakage or pipeline failure. ALOHA is a modelling tool to estimate threat zones associated with hazardous chemical releases, including toxic gas clouds, fires, and explosions. The simulation considers that it is possible to close off the gas supply connection through valve installed at RMS. ALOHA has been applied to simulate the following sequential hazards-

- Thermal radiation from jet fire
- Toxic Area of Vapor Cloud Formation
- Flammable Area of Vapor Cloud Formation
- Blast Area of Vapor Cloud Formation

656. The basic assumptions include climatic condition, site condition and release conditions. One of the key assumptions is wind direction, which has been considered as flow from ‘South East’ on the basis of the analysis of the wind rose diagrams provided in **Chapter 4**. The wind rose indicates that most of the time in a year wind flows from South-East to the North-West direction. Average Wind speed has been considered as 1.4 m/s. Most of the time in a year wind speed remains 1-2.5 m/s at 5 m height. The pipeline area is surrounded by main plant structure and vegetation that may obstruct free flow of wind in the proposed area. Both ends of the gas pipe between plant and RMS is regulated by valves.

Simulation of Toxic Area of Vapor Cloud Formation

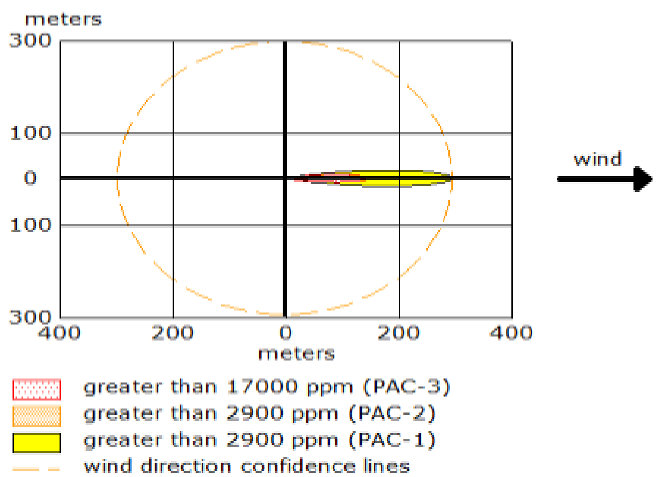
657. ALOHA estimates that toxicity may spread up to 298 m from the source point. Death threatening toxicity may spread up to147 m towards windward. **Figure 10.3** presents the threat zone area of toxic vapour cloud formation. In addition, **Table 10.4** presents a brief summary of the toxicity.

Table 10.4: Threat Zone of Vapor Cloud Formation

Items	Red Threat Zone (meter)	Orange Threat Zone (meter)	Yellow Threat Zone (meter)
Definition	PAC 3: Concentration <17000 PPM More than one-hour exposure to this concentration threats adverse health effect or death	PAC 2: concentration < 2900 PPM, More than one-hour exposure to this concentration threats irreversible or other serious, long-lasting, adverse health effects or an impaired ability to escape	PAC 1: concentration <2900 PPM, exposure to this concentration threats discomfort, irritation, or certain asymptomatic, non-sensory effects
Toxic Area	147 m	298 m	298 m

Note: PAC: Protective Action Criteria

Figure 10.3: Threat zone of toxic vapor cloud from gas pipeline failure



Note: Assumptions: Wind Direction from SE, Temperature: 28^{0}C, Wind Speed 1.4m/s

Simulation of Flammable Area of Vapor Cloud Formation

658. The vapour cloud formed from a leakage of a gas pipeline has flammability. ALOHA has been applied to estimate the possible flammable area of the vapour cloud. The explosion limit of methane is low, only 5% (LEL) - 15% (UEL). The local area of flame can occur even though the concentration is below the lowest explosion limit (LEL). ALOHA considers 60% of the LEL to cause a flame.

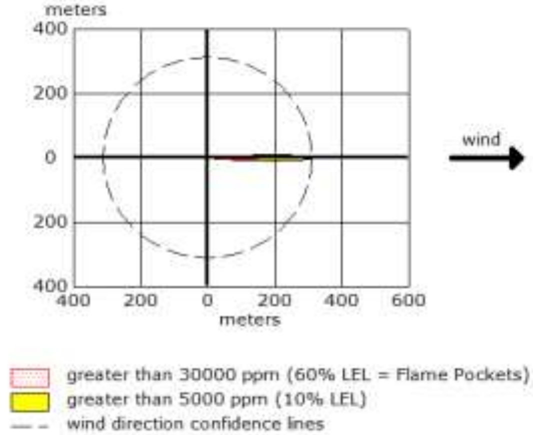
659. 60% of the LEL level i.e., 30,000 ppm concentration has been considered as high threat zone (red) of occurring flame and 10% of LEL i.e., 5,000 ppm is considered low threat zone (yellow) of occurring flame. The model estimated the high threat zone might spread up to 313 m. The details of the simulation results are shown in **Figure 10.4** and **Table 10.5**.

Table 10.5: Threat Zone of Vapor Cloud Formation (Flammable)

Items	Red Threat Zone (meter)	Yellow Threat Zone (meter)
Definition	LOC: > 30,000 PPM Which is 60% of the Lowest Explosion Limit (LEL) of Methane.	LOC: > 5000 PPM Which is 10% of the Lowest Explosion Limit (LEL) of Methane.
Flammable area of vapor cloud formation	155 m	313 m

LOC = Level of Concern.

Figure 10.4: Threat zone of flammable vapor cloud resulted from leakage



Simulation of Blast Area of Vapor Cloud Formation

660. ALOHA defines three levels of concern for classifying threat zones on the basis of overpressure formed by the shock wave created from blast.

- High Threat Zone, 8 psi pressure which is destructive for buildings
- Moderate Threat Zone, 3.5 psi pressure serious injury
- Low Threat Zone, 1.0 psi pressure that is enough to shatter window glass

661. The model predicts that, the possible blast of the Blast area will not be strong enough to create any pressure above 1 psi to shatter even a window glass.

10.4.1.1 Simulation of Jet Fire

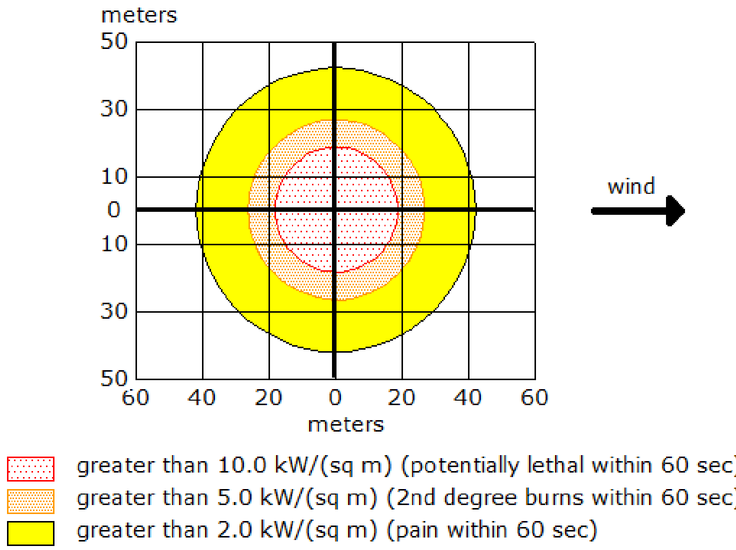
662. Methane gas leakage from a pipeline may cause a jet fire if it ignites with fire; come close proximity to thermal radiation, heat and toxic by-products. ALOHA software has been applied for estimating the threat zone of thermal radiation of the possible jet fire. **Figure 10.5** shows the predicted areas of different threat zone and **Table10.6** gives a narrative summary of the prediction.

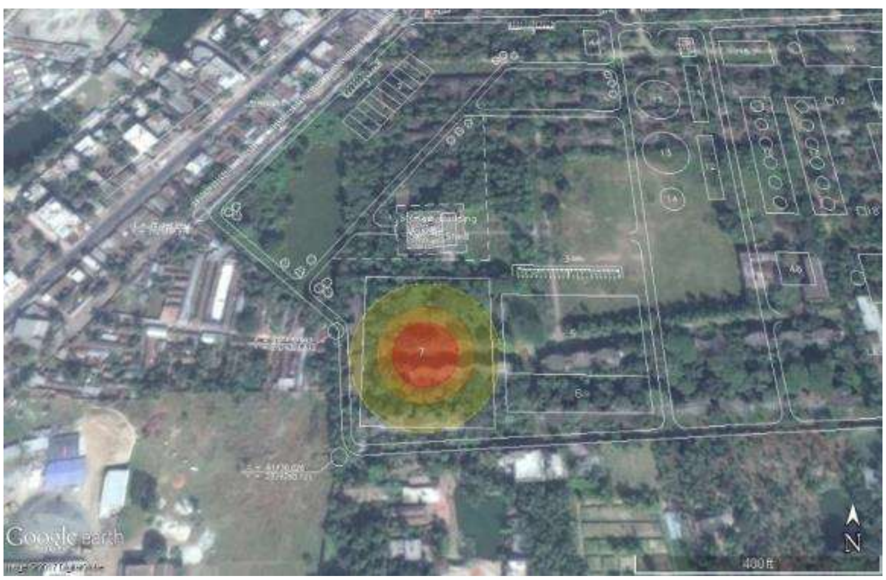
Table 10.6: Threat Zone of Thermal Heat Radiation of a Jet Fire from Gas Leak

	Red Threat Zone (meter)	Orange Threat Zone (meter)	Yellow Threat Zone (meter)
Definition	LOC: 10 kw/m^2 Potentially lethal within 60 sec exposure	LOC: 5 /m^2 2nd degree burn within 60 sec exposure	LOC: 2 kw/m^2 Pain within 60 sec exposure
Heat radiation from jet fire	19 m	27 m	43 m

LOC = Level of Concern.

Figure 10.5: Threat Zone of Thermal Heat Radiation of a Jet Fire from a Gas Leak





Note: Assumptions: Wind Direction SE, Temperature: 28^{0}C, Wind Speed 1.4 m/s.

663. High threat zone (red) of occurring flame may exceed to 19 m and the LOC (Level of Concern) will be of 10 KW/m^{2}whichmay be potentially lethal within 60 second exposure and the moderate threat zone i.e. LOC of 5 Kw/m^2 is considered moderate threat zone (orange) of occurring flame. In addition, the model estimated the low threat zone might spread up to 43 m.

664. The simulation of the threat zone shows that, the low risk zone (yellow threat zone of the area of flammable vapour cloud will not reach to HSD storage tank (in case of a gas leak when the wind direction is SE and wind speed is 1.4 m/s). But some accidental explosion may be considered for the HSD tank.

Simulation of Thermal radiation of Pool Fire Formation

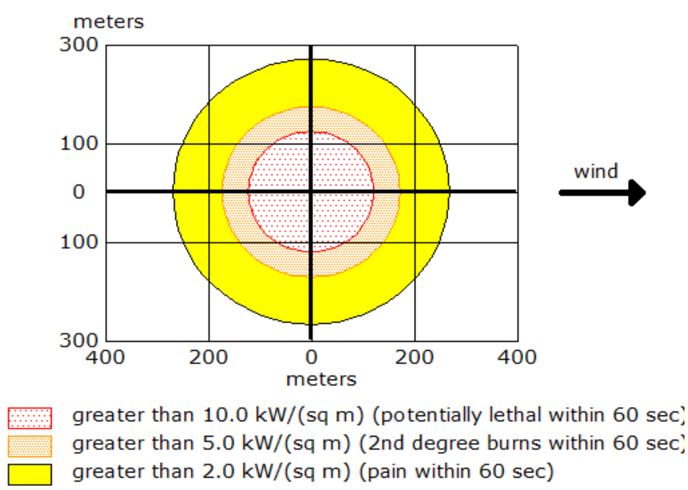
665. ALOHA has also been applied to estimate the possible thermal radiation zone caused by pool fire which may be created through the HSD tank failure. The explosion limit of N-Hexane is low, only 1.2 (LEL) –7.4(UEL). The radiation my spread up to 269 m. The details of the simulation results are shown in **Figure 10.6** and **Table 10.7**.

Table 10.7: Threat Zone of Vapor Cloud Formation (Flammable)

Items	Red Threat Zone (meter)	Orange threat zone	Yellow Threat Zone (meter)
Definition	LOC: 10 kw/m^2 Potentially lethal within 60 sec exposure	LOC: 5 kw/m^2 2nd degree burns within 60 sec)	LOC: 2 kw/m^2 Pain within 60 sec exposure
Thermal radiation from pool fire	122 m	173 m	269 m

LOC =Level of Concern

Figure 10.6: Threat Zone of Vapor Cloud Formation (Flammable)



10.5 Preventive Measures

666. Accidental incidents like the failure of pressure vessels, piping, coated materials of the storage tanks and structural components may be occurred by the excessive heat generation or failure in the internal pressure load or by any other extraneous events. Hence, the associated hazards need to be taken into consideration in order to minimize the loss of life and properties. The model generated threat zone of vapor cloud and flammable cloud are directed to N-W from the RMS station which would be vacant ground as per layout. Moreover, the zone of jet fire will be within the project boundary. Only the threating zone of pool fire of the HSD Tank will encompass adjacent installations where a number of preventive measures like safe containment/bund wall will be provided. Specific strategies also need to be adopted in order to fight against these hazards. Though it is suggested to abolish hazards that might be controlled /mitigated through following systems. Such as

- Emergency shutdown of the fuel supply system
- Automatic fire fighting system development
- Control of spills from the HSD Tank
- Failure of Fire and gas systems
- Readiness of the active and passive fire protection
- Evacuation escape and rescue system development

667. Within the safety management system, a HS & E plan will have a fire and related hazard prevention plan, which in turn will include a plan for blast and fire strategy for piping. The strategies may be comprised of:

- Identification of the critical piping at the RMS area
- Readiness of the Fire Safety units of the Rupsha Power Plant
- Selection of specific pipe design materials and procedure to protect fires and explosions

- Selection of non-combustible piping supports for conveying pipe inside the power plant.

668. **Jet Fires from the RMS.** In order to prevent the jet fire from the RMS of Rupsha Power Plant, the products of the RMS and surrounded area should be cementitious. Whole gas pipeline will be rated with jacket system. Moreover, the pipes will be rated with flanged removal components and valve removal components. If possible, the firewall of the south west side of the RMS would be proofed with Blast rated firewall design, fabrication and the area will be rated with deluge system.

669. **Pool Fires from the Tank.** Reactive, flammable, and explosive materials should be managed in order to avoid the uncontrolled reactions or events resulting from fire or explosion.

- Use of flame arresting devices on vents from flammable storage containers
- Provision of grounding and lightning protection for tank, transfer stations, and other equipment that handles flammable materials
- Selection of materials of construction compatible with HSD stored for all parts of storage and delivery systems, and avoiding reuse of tanks for different products without checking material compatibility
- Prohibition of all sources of ignition from areas near flammable storage tanks prevent fire, explosion, spill, and other emergency situations from affecting facility operations

670. Secondary containment or the bund may be characterized by the critical aspect to control accidental releases of HSD during storage and transfer. The design and construction of the secondary containment should be in a manner so that it may hold released materials effectively until they can be detected and safely recovered. Appropriate structures should be consisting of berms, dikes, or walls and will be made of impervious, chemically resistant material. Design should also consider means to prevent contact between incompatible materials in the event of a release.

671. However, there are many environmental and safety advantages of underground storage of hazardous materials, including reduced risk of fire or explosion, and lower vapor losses into the atmosphere, leaks of hazardous materials can go undetected for long periods of time with potential for soil and groundwater contamination.

10.6 Assessment of Likelihood

10.6.1 Hazard Magnitude & Frequency Analysis

672. The potential impacts of the project have been scaled and prioritized based on the magnitude of those potential impacts and the likelihood of them occurring (frequency). The magnitude of the said impacts are classified and illustrated in **Table 10.8**.

Table 10.8: Hazard Magnitude Scale

Parameter	1 (Insignificant)	2 (Minor)	3 (Moderate)	4 (Major)	5 (Catastrophic)
Duration of potential impact	Temporary with no detectable potential impact	Limited to construction period	Medium Term (1 to 2 years)	Long term (more than 2 years)	Permanent Damage
Spatial extent of the potential impact	Specific location within project component or site boundaries with no detectable potential impact	Within project boundary	Beyond immediate project components, site boundaries or local area	Widespread far beyond project boundaries with some community and wildlife habitat coverage	Beyond project boundaries extending to widespread communities and wildlife habitat
Reversibility of potential impacts	Baseline remains almost constant	Baseline returns naturally or with limited intervention and within a few months	Potential impact requires a year or so for recovering with some interventions to return to baseline	Potential impact is long-term, requiring considerable intervention to return to baseline	Potential impact is effectively permanent, with little to no chance of returning to baseline
Compliance to Legal Standards before Mitigation Measures	Complies with all minimum requirements only some improvement opportunities to strengthen good practices	Meets minimum national standard limits or international guidelines	Complies with limits given in national standards but breaches international lender guidelines in one or more parameters	Complies partially with limits given in national standards but breaches international lender guidelines	Completely breaches national standards and or international guidelines/ obligations
Extent of health injuries	Minor pain, scratch, discomfort requiring no medical attention	Health injuries can be cured with first aid and/or some medical attention	Health injury requires hospitalization; may require long term recuperation; may lead to long term absence from work	Health injury may lead to permanent disability; few fatalities of workers and or community people	Fatalities of workers more than five (5) and or community people more than two (2)
Impact on wildlife	Minimal disturbance within compliance	Disturbing habitat of wildlife causing discomfort	Disturbing habitat of wildlife causing decrease of preys and forcing them to relocate	Impact leading to deaths of any endangered species and decrease of their food source	Impact may lead to deaths of two (2) or more endangered marine mammals and-or five (5) of other endangered species

673. Criteria for determining the frequency of the potential hazard being occurred are outlined in **Table 10.9**.

Table 10.9: Criteria for Determining Frequency of the Potential Hazard

Frequency Scale Determination	Definition
1(Rare)	Rare chance of occurrence, if not at all
2(Low)	Very minimal chance of occurring
3(Medium)	May occur considering if the conditions are abnormal or exceptional
4(High)	Occurs more frequently without prior warnings
5(Almost Certain)	Occurs under typical conditions

10.7 Risk Matrix Development

674. Following the magnitude and frequency scales, a risk matrix can be developed after analyzing the potential hazards for the Project. The table below (**Table 10.10**) shows the risk matrix for the potential hazards and how frequently they may occur. In **Table 10.11**, the risk evaluation based on the type of activities and potential hazards are shown.

Table 10.10: Risk Matrix of Potential Hazards/Impacts

	Hazard Magnitude (M) →				
Frequency (F) of Hazards ↓	**1 (Insignificant)**	**2 (Minor)**	**3 (Moderate)**	**4 (Major)**	**5 (Severe)**
1(Rare)	1	2	3	4	5
2(Low)	2	4	6	8	10
3(Medium)	3	6	9	12	15
4(High)	4	8	12	16	20
5(Almost Certain)	5	10	15	20	25

Color Legend:

Red (15-25)	≡ Top Priority	: Action with follow-up Verification & Validation by Authority needed before allowing work
Orange (10-14)	≡ High Priority	: Action needed under follow-up Supervision before allowing work
Yellow (5-9)	≡ Medium Priority	: Need maintaining with routine monitoring & reporting
Green (1-4)	≡ Low Priority	: Only for awareness; no Intervention Action needed to start work

675. The risk for the potential hazard/impact is evaluated based on the combination of the hazard consequence and their frequency (NHS, 2008). In order to calculate the potential risk, the frequency of impact is multiplied with consequences. E.g. Level 1 of frequency of a hazard (Rare) is multiplied with Level 1 of hazard consequence (insignificant) to give a total score of 1 (1X1=1) and so on. In that regards, a score between 1 to 4 is considered low priority; a score between 5 to 9 is considered medium priority and; a score between 10 to 14 is considered high priority and; a score between 15 to 25 is considered top priority

10.8 Identification of Existing Safeguards

676. Since this is a new power plant, no existing safeguards are present. Suggested safety measures are shown in **Table 10.11**.

Table 10.11: Risk Management Plan

Hazard points	Project Activities	Potential hazard	Root causes	Hazard Consequence (Before Safety Measures)	Hazard Frequency (Before Safety Measures)	Risk Ranking (Evaluation) (Before Safety Measures)	Suggested Safety measures (Risk Management Plan)	Hazard Consequence (After Safety Measures)	Hazard Frequency (After Safety Measures)	Risk Ranking (Evaluation) (After Safety Measures)
Construction and Erection Phase										
Machinery and equipment	Mobilizing in machines, equipments and vehicles for site clearance activities	• Trips and falls ▪ Cuts and bruises	• Fatigue or prior sickness • Mechanical failure • Lack of safety training ▪ Not abiding to general health and safety and traffic rules	3	3	**9**	• Arranging toolbox meeting before going out for work • Regular inspection and maintenance of equipments • A thorough lorry driver selection process via interviews, checking whether they have the proper licenses and from past experiences • Training of traffic rules and regulation, including maintaining vehicle speed limit for different categories of road after the selection process is complete • Limiting movement of vehicles after sunset and before sunrise • Regular health and safety training to all construction workers and lorry drivers, including the proper use of PPEs.	2	1	**2**
Construction site	• Construction of building, steel structure and its foundation, stacking of HRSG components, cutting, welding, painting	• Accidents (burns, electric shocks etc.) • Injuries from falls and slips • Injuries from falling of heavy objects/machineries • Inhalation of dust ▪ Cuts and bruises	• Fatigue or prior sickness • Electric failure • Equipment failure • Lack of safety protocols (e.g. not putting up warning signs or enclosing the area to prevent entry of outside people)	3	2	**6**	• Arranging toolbox meeting before going out for work (during each construction activities.). Provide each worker with a safety checklist and safety permit (based on their work) before starting work. • Regular inspection and maintenance of equipments, machineries and especially, safety harness. Maintain a registry for any faulty equipment found; inform site contractors and have them replace those immediately. No work should be done until the faulty machineries are replaced and tested.	2	2	**4**

Hazard points	Project Activities	Potential hazard	Root causes	Hazard Consequence (Before Safety Measures)	Hazard Frequency (Before Safety Measures)	Risk Ranking (Evaluation) (Before Safety Measures)	Suggested Safety measures (Risk Management Plan)	Hazard Consequence (After Safety Measures)	Hazard Frequency (After Safety Measures)	Risk Ranking (Evaluation) (After Safety Measures)
	works, drilling work, etc. ▪ Use of machineries and equipments for dismantling of structures		• Not abiding to health and safety rules (e.g. not wearing appropriate PPEs during work, being careless at handling heavy equipments etc.) • Not maintaining a designated place for backfilling storage ▪ Not maintaining enough lighting during the night (for those working overtime)				• Regular health and safety training and firefighting drills to all construction workers, including the proper use of PPEs during work. • Enclosing the area with yellow barricade tape and restricting outside access to local people during the whole construction process. • Spraying water on dust to minimize its spread via wind; put stockpile at a designated place and cover them with GI sheet; put up GI sheet fencing around the construction site. • Equipments, machineries and electric wires should be checked for current and voltage ratings. When using an extension cable, its wire rating should match with the equipment wire rating. • Recording of any unusual activities and issuance of fines or suspensions if any rules are broken ▪ Maintenance of an accident registry book			
	▪ Work at heights ▪ Lifting of machineries and equipment from tall heights	• Accidents • Injuries from falls and slips (e.g. broken bones, fractures, traumas, etc.) ▪ Fatalities	• Fatigue or prior sickness • Lack of safety protocols (e.g. not putting up warning signs or enclosing the area to prevent entry of outside people) • Not abiding to health and safety rules (e.g. not	4	3	**12**	▪ Regular inspection and maintenance of equipments, machineries and especially, safety harness. Maintain a registry for any faulty equipment found; inform site contractors and have those replaced immediately. No work should be done until the faulty machineries are replaced and tested. • Recording of any unusual activities and issuance of fines or suspensions if any rules are broken ▪ Maintenance of an accident registry book. ▪ Not allowing workers working in dimly lit areas. Appropriate warning signs must be placed in hazard	3	2	**6**

Hazard points	Project Activities	Potential hazard	Root causes	Hazard Consequence (Before Safety Measures)	Hazard Frequency (Before Safety Measures)	Risk Ranking (Evaluation) (Before Safety Measures)	Suggested Safety measures (Risk Management Plan)	Hazard Consequence (After Safety Measures)	Hazard Frequency (After Safety Measures)	Risk Ranking (Evaluation) (After Safety Measures)
			wearing appropriate PPEs and safety harness during work, being careless at handling heavy equipments, not wearing safety harness when working at heights etc.) ▪ Not maintaining enough lighting during the night				prone working areas with the hazard signs being fluorescent and perfectly readable from 3-4 meter distance. ▪ Restricting workers from working without appropriate safety measurements in place during night times (e.g. wearing appropriate PPEs and safety harness etc.). ▪ Maintaining a registry on who is working night shifts and where. ▪ Overtime hours should be restricted to no more than two hours per day as per Bangladesh Labour Rules, 2015			
	Vehicle and vessel movement	▪ Noise generation ▪ Accident (e.g. vessel capsize) ▪ Emission from vehicles ▪ Spread of dust and minute particles due to vehicle movement.	▪ Running engine, hydraulic horns, sirens etc. ▪ Mechanical failure ▪ Old engine or engine parts/lack of maintenance	3	3	**9**	• Regular inspection and maintenance of equipments, machineries and vehicles. • Training of traffic rules, including maintaining vehicle speed limit for different categories of roads. • Spraying water on dust at plant site to minimize its spread via wind or vehicle movement. • Regulate the use of hydraulic horns during construction. Set a limit on the amount of noise generated as stipulated in schedule III of ECR, 1997. • Switch off engines/generators/equipments when not in use. ▪ Monthly health checkup of workers for any illness. Provide treatment accordingly	2	1	**2**

Hazard points	Project Activities	Potential hazard	Root causes	Hazard Consequence (Before Safety Measures)	Hazard Frequency (Before Safety Measures)	Risk Ranking (Evaluation) (Before Safety Measures)	Suggested Safety measures (Risk Management Plan)	Hazard Consequence (After Safety Measures)	Hazard Frequency (After Safety Measures)	Risk Ranking (Evaluation) (After Safety Measures)
	Handling of hazardous chemical	• Accidental release of chemicals and noxious fumes • Acute/chronic toxicity from exposures to chemicals ▪ Fire/explosion	▪ Lack of safety protocols ▪ Carelessness (e.g. smoking near chemical storage area) ▪ No proper bounding of chemical storage area ▪ Improper chemical storage (e.g. faulty/leaky containers, improper containers, improper sealing of containers etc.)	4	3	**12**	▪ Putting up "fire hazard" and "chemical hazard" warning sign near chemical storage areas. Set up awareness programs and training on how to handle/store chemicals ▪ Check containers for leaks, faults and cracks. Change them immediately if found. ▪ Labeling chemical storage containers for easy recognition. Put up MSDS in chemical containers along with appropriate warning labels (e.g. corrosive, toxic, flammable etc.) ▪ Storing different types of chemical separately. All flammable or corrosive chemicals should be stored separately and should have proper bounding ▪ A fire extinguisher/ fire hydrant should be installed nearby in case of any fire breakout. Emergency contact details for fire fighters and ambulance service should also be placed there. ▪ In case of a spillage, keep flammable substance away from the spillage area and inform on site EPC contractor immediately. • Recording of any unusual activities and issuance of fines or suspensions if any rules are broken.	3	2	**6**
	Possible fire and Explosion hazard from machineries, equipments, oxyacetylene cylinders (used for welding	• Explosion caused due to poor maintenance of oxyacetylene cylinders or due to using faulty cylinders	Lack of proper maintenance of machineries, equipments and vehicles	4	3	**12**	• Regular inspection and maintenance of equipment, machineries, vehicles and acetylene cylinders. ▪ Check for leaks or faults in acetylene cylinders before. Make sure proper labeling signs are marked on the cylinders ▪ Training on how to use/handle acetylene welding machines. Ensure proper usage of PPEs (gloves,	3	2	**6**

Hazard points	Project Activities	Potential hazard	Root causes	Hazard Consequence (Before Safety Measures)	Hazard Frequency (Before Safety Measures)	Risk Ranking (Evaluation) (Before Safety Measures)	Suggested Safety measures (Risk Management Plan)	Hazard Consequence (After Safety Measures)	Hazard Frequency (After Safety Measures)	Risk Ranking (Evaluation) (After Safety Measures)
	purposes), generators and vehicles	• Fire caused by mechanical/electrical failure of generators • Fire caused by mechanical/electrical failure of vehicle oil tanks					safety mask etc.) before commencement of welding works. ▪ Ensure firefighting equipments such as fire extinguishers are at hands reach in case of a minor fire breakout. In case of severe fire break out, raise alarm and notify appropriate authorities and nearby firefighting departments.			
	Working in a confined space (natural gas pipelines, HRSG etc.)	• Suffocation • Falling of debris	▪ Lack of protective measures ▪ Faulty/Damaged pipelines ▪ Negligence towards work	4	3	**12**	• Ensure cathodic protection on pipelines as per standard procedure to prevent rusting • Ensure proper connection of pipelines • Inspect pipelines for cracks and faults. Make prompt repairs if found. • Ensure regular communications with outside when entering underground. • Use proper safety precautions (e.g. PPEs, oxygen masks etc.) when working at confined spaces	3	2	**6**
	Occupational Hazard	▪ Cuts, bruises and burns ▪ Falls, slips and trips ▪ Health injuries ▪ Sickness and illness	▪ Lack of safety awareness ▪ Carelessness in maintaining safety protocols ▪ Use of faulty machineries and equipments ▪ Improper hygiene ▪ Prior sickness or illness ▪ Heavy workload	3	3	**9**	▪ Regular inspection and maintenance of equipment, machineries and vehicles. ▪ Raising awareness on occupational hazards. Arrange monthly health and safety training, electrical safety training and firefighting drills to all construction workers, including the proper use of PPEs during work. ▪ Training of traffic rules and regulation, including maintaining vehicle speed limit for different categories of road. ▪ Maintenance of hygiene at construction site and providing appropriate training to workers in hygiene maintenance	2	1	**2**

Hazard points	Project Activities	Potential hazard	Root causes	Hazard Consequence (Before Safety Measures)	Hazard Frequency (Before Safety Measures)	Risk Ranking (Evaluation) (Before Safety Measures)	Suggested Safety measures (Risk Management Plan)	Hazard Consequence (After Safety Measures)	Hazard Frequency (After Safety Measures)	Risk Ranking (Evaluation) (After Safety Measures)
							▪ Supplying workers with safe drinking water ▪ Monthly health checkup of workers for any sickness or illness. Provide treatment/consultation accordingly. In serious cases of injuries or sickness, an ambulance should be on standby for transporting them to nearby hospital. ▪ Work load should be managed effectively. Workers working every 2 hours should be given a mandatory 30 minutes break as stipulated in chapter 9 of Bangladesh Labour Rules, 2015[55]. ▪ Employment of child labour (children below the age of 18), pregnant women and elder citizens in hard labour and dangerous activities must be prohibited. ▪ All other facilities (toilet, canteen, overtime hours, leaves etc.) should be followed as stipulated in Labour Rules, 2015.			
Chemical Storage Area	Storage of chemicals	• Release of toxic fumes • Fire/explosion • Falls and slips	▪ Lack of proper ventilation in chemical storage area ▪ Storing flammable and volatile chemicals in the same area. ▪ Faulty electric connections	3	3	**9**	▪ Safe storage of chemicals should be ensured with adequate ventilation ▪ Flammable chemicals should be stored separately and away from any ignition source ▪ No smoking inside the chemical storage area ▪ Storage should be done in an organized way. No empty boxes or containers should be kept haphazardly in the floor ▪ A record should be kept on the type of chemicals being stored along their expiry date and date of manufacture. Maintain MSDS.	3	2	**6**

[55] Bangladesh Labour Rules (2015). *Ministry of Labour and Employment*. Retrieved from http://www.dpp.gov.bd/upload_file/gazettes/14079_83432.pdf.

Hazard points	Project Activities	Potential hazard	Root causes	Hazard Consequence (Before Safety Measures)	Hazard Frequency (Before Safety Measures)	Risk Ranking (Evaluation) (Before Safety Measures)	Suggested Safety measures (Risk Management Plan)	Hazard Consequence (After Safety Measures)	Hazard Frequency (After Safety Measures)	Risk Ranking (Evaluation) (After Safety Measures)
			▪ No bounding around chemical storage areas ▪ Not ensuring proper labelling/MSDS ▪ Lack of training of chemical handlers/workers				▪ The storage area should be fitted with adequate fire alarms, automatic fire defusing hydrants and fire extinguishers in case of a fire breakout ▪ Regular inspection of storage area for any abnormalities ▪ Training workers on how to handle and store certain chemicals			
Plant Jetty site	Loading and unloading of machineries, equipment and fuel oil	▪ Slip, trip and falls ▪ Health injuries (from falling of heavy objects or debris)	▪ Lack of awareness on health and safety aspects ▪ Negligence of safety precautions whilst working	3	2	**6**	• Arranging toolbox meeting before going out for work (during each construction activities.). Provide each worker with a safety checklist and safety permit (based on their work) before starting work. ▪ Raising awareness on occupational hazards. Arrange monthly health and safety training, electrical safety training and firefighting drills to all construction workers, including the proper use of PPEs during work.	2	2	**4**
Operation Phase										
Gas pipeline	Transmission of gas to project site	• Toxic Vapor Cloud Formation • Vapor Cloud Explosion • Jet Fire • Limited Space Explosion • Over Pressure Explosion	▪ Mechanical failure ▪ Faulty connections/weld failure ▪ Cracks/shear stress on pipeline • Improper coating on pipelines • Corrosion • Sabotage	3	3	**9**	• Ensure the proper cathodic protection on pipelines as per standard procedure to prevent rusting • Ensure proper connection of pipelines ▪ Inspect pipelines for cracks and faults. Make prompt repairs if found. ▪ Cutting off gas supply if leakage is found. ▪ Informing nearby communities in case of gas leakage. Ensure proper evacuation measures if needed.	3	2	**6**

Hazard points	Project Activities	Potential hazard	Root causes	Hazard Consequence (Before Safety Measures)	Hazard Frequency (Before Safety Measures)	Risk Ranking (Evaluation) (Before Safety Measures)	Suggested Safety measures (Risk Management Plan)	Hazard Consequence (After Safety Measures)	Hazard Frequency (After Safety Measures)	Risk Ranking (Evaluation) (After Safety Measures)
Gas Metering and Regulatory Station	• Regulation of gas pressure and its quantity ▪ Intake of gas from metering station to the plant	• Toxic gas leakage • Fire/Explosion	▪ Mechanical failure ▪ Faulty connections ▪ Cracks/shear stress on pipeline ▪ Improper coating/cathodic protection on pipelines	4	3	**12**	• Ensure proper connection of pipelines ▪ Inspect pipelines for cracks and faults. Make prompt repairs if found. ▪ Ensure gas pressure is regulated as required. ▪ Wear ear-muffs when entering RMS area.	3	3	**9**
Steam turbine, turbines, HRSG, generator and its ancillary components	Electricity generation	• Mechanical hazard • Fire hazard/explosion • Electrical hazard ▪ Noise generation	▪ Mechanical failure ▪ Lack of sound buffers	4	3	**12**	▪ Installing machines with computerized control and monitoring system for detecting any faults in the machines ▪ Installing machines with environment friendly and safe design (e.g. with noise buffers, energy efficiency, manual override, automated kill switch etc.) ▪ Test running the machines and its safety systems before going into final operation. Do a monthly inspection and maintenance. ▪ Install automated fire alarms and fire hydrant system in turbine and generator room.	3	2	**6**
• Cable gallery • Power transformer • Switchyard ▪ 230 KV Switchyard control room	• Transmitting electricity from generator to unit transformer • High voltage (230 KV)	• Fire due to resulting arc flash/arc blast • Other electric hazard due to unprotected cables ▪ Slips and trips from unorganized/loose	▪ Short circuit in control room and switch gears ▪ Short circuit in control room and switch gears ▪ Faulty cables and wires	3	3	**9**	▪ Monitoring. Installation of fire defense and fighting systems. ▪ Checking the insulation of the wire, along with the wire's voltage and electric ratings. Change wires if ratings do not match with the power supply or if the insulation is damaged ▪ Proper earthlings should be made to avoid electric shocks.	2	2	**4**

Hazard points	Project Activities	Potential hazard	Root causes	Hazard Consequence (Before Safety Measures)	Hazard Frequency (Before Safety Measures)	Risk Ranking (Evaluation) (Before Safety Measures)	Suggested Safety measures (Risk Management Plan)	Hazard Consequence (After Safety Measures)	Hazard Frequency (After Safety Measures)	Risk Ranking (Evaluation) (After Safety Measures)
	power transmission • Open air power transmission ▪ Controlling and monitoring the power transmitting system	cables lying in the floor	▪ No safe connection to earth ▪ Using cables with different voltage and current ratings ▪ Unorganized cables				▪ Open wires should be passed through a plastic pipe to avoid exposing them with outside contact. ▪ Switch off power before doing any electrical work. Inform supervisor and respected machine operator before starting any electrical work. Inform them again after the electrical works are done. ▪ All power transformers and transmission should be fitted with lightning arrester to protect from lightning strikes. ▪ Switchyards should be fitted with circuit breaker in case of short circuit or during an unusual surge of electrical current. ▪ When working with exposed live wire/machines, the maintenance worker should maintain distance of 6 meters from the live exposed part[56]. ▪ Maintain a safe distance from the rights-of-way (RoW). Don't raise any construction under the RoW. ▪ Any cranes or vehicles passing through a high voltage overhead transmission line should have a minimum 1 meter distance from the overhead transmission line. ▪ Place "electrical hazard" or "high voltage" signs on all switchboards and power transformers. ▪ Restrict access to power transmission area, switchyards and control to power plant officials and maintenance workers only.			

[56]http://electrical-engineering-portal.com/electrical-safety-standards-for-lvmvhv-part-2#16

Hazard points	Project Activities	Potential hazard	Root causes	Hazard Consequence (Before Safety Measures)	Hazard Frequency (Before Safety Measures)	Risk Ranking (Evaluation) (Before Safety Measures)	Suggested Safety measures (Risk Management Plan)	Hazard Consequence (After Safety Measures)	Hazard Frequency (After Safety Measures)	Risk Ranking (Evaluation) (After Safety Measures)
• Boiler and pressure parts • Compressed air system and pipeline ▪ Live steam line	• Steam generation • Operate pressure valve, switch and control system ▪ Flows live high pressure steam from boiler to turbine	• Fire (near burner) • Release of high pressurized steam ▪ Explosion	▪ Failure of the water pumps ▪ Mechanical failure of safety switch and valves ▪ Busting of furnace and pressurized pipes ▪ Presence of contaminant in fuel ▪ Accidental leakage, lack of heat sink for combustion process and non-functional safety and bypass valve.	4	3	**12**	▪ Control system to monitor and regulate temperature, intake air and furnace system. ▪ Monitoring fuel quality & safety system. Provision of firefighting and safety ▪ Check pipelines for leaks and cracks. Conduct quarterly inspection of pipelines ▪ Inspection and maintenance of safety valve, pipelines and steam line ▪ Restrict entry except authorized personnel ▪ Install control system to monitor required pressure at different points. ▪ Installation of fire defense and fighting systems.	3	2	**6**
Water treatment and waste water treatment plant	Produce clarified, dematerialized water for steam generation and treat effluent water before discharge	Chemical hazard	▪ Spillage/accidental release ▪ Mishandling and misuse	3	3	**9**	▪ Safe use of chemical. Using appropriate MSDS to aware people of chemical properties, storage and handling procedures. ▪ Limited entry except authorized personnel ▪ Training and use of appropriate PPE ▪ Make spill kits available in case of accident. ▪ Install safety shower, eye wash and first aid facilities	2	2	**4**

Hazard points	Project Activities	Potential hazard	Root causes	Hazard Consequence (Before Safety Measures)	Hazard Frequency (Before Safety Measures)	Risk Ranking (Evaluation) (Before Safety Measures)	Suggested Safety measures (Risk Management Plan)	Hazard Consequence (After Safety Measures)	Hazard Frequency (After Safety Measures)	Risk Ranking (Evaluation) (After Safety Measures)
Intake channel	Water intake for plant operation	Mechanical Hazard	▪ Accident due to ship anchorage ▪ Negligence of ship master. ▪ Poor signal	3	2	**6**	▪ Proper signaling system to be installed on the plant jetty site. ▪ Ship master shall communicate with the plant jetty site before anchorage. ▪ Intake channel shall be routinely maintained and repaired if required. ▪ Plant jetty site shall have adequate security system (CCTV, Security guards etc) in place.	2	1	**2**
Chemical storage	Use for water treatment in different phases of dematerialized water, cooling water and potable water.	Toxic accidental release due to multifunction of equipment & callousness of operator.	▪ Chemical spillage ▪ Chemical fires ▪ Mishandling and misuse	3	3	**9**	▪ Putting up "chemical hazard" warning sign in the entry of chemical storage areas. Set up awareness programs on how to handle/store chemicals ▪ Check containers for leaks, faults and cracks. Change them immediately if found. ▪ Labeling chemical storage containers for easy recognition. Put up MSDS in chemical containers along with appropriate warning labels (e.g. corrosive, toxic, flammable etc.) ▪ Storing different types of chemical separately. All flammable or corrosive chemicals should be stored separately and should have proper bounding ▪ A fire extinguisher/ fire hydrant should be installed nearby in case of any fire breakout. Emergency contact details for fire fighters and ambulance service should also be placed there. ▪ In case of a spillage, keep flammable substance away from the spillage area and inform on site EPC contractor immediately. ▪ Recording of any unusual activities and issuance of fines or suspensions if any rules are broken.	2	1	**2**

Hazard points	Project Activities	Potential hazard	Root causes	Hazard Consequence (Before Safety Measures)	Hazard Frequency (Before Safety Measures)	Risk Ranking (Evaluation) (Before Safety Measures)	Suggested Safety measures (Risk Management Plan)	Hazard Consequence (After Safety Measures)	Hazard Frequency (After Safety Measures)	Risk Ranking (Evaluation) (After Safety Measures)
Air circulating system	Generating air flow both in and out of boiler	▪ Non-functional air circulating system	Mechanical failure	3	3	**9**	▪ Regular maintenance and monitoring control system ▪ Inspecting the functioning of FD, ID fans and vacuum systems.	2	1	**2**
Plant site	Daily plant activities	• Cuts, bruises and burns • Falls, slips and trips • Health injuries ▪ Sickness and illness	▪ Lack of safety awareness ▪ Carelessness in maintaining safety protocols ▪ Use of faulty machineries and equipments ▪ Prior sickness or illness ▪ Heavy workload ▪ Unsafe working environment.	3	3	**9**	▪ Regular inspection and maintenance of equipments, machineries and vehicles. ▪ Raising awareness on occupational hazards. Arrange monthly health and safety training, electrical safety training and firefighting drills to all officers and plant workers, including the proper use of PPEs during work ▪ Monthly health check-up of officers and workers for any sickness or illness. Provide treatment/consultation accordingly. In serious cases of injuries or sickness, an ambulance should be on standby for transporting them to nearby hospital ▪ Keeping all safety & precaution measure in order such as, maintaining first aid & well equipped primary health center on plant site.	2	2	**4**

10.9 Occupational Health and Safety Plan

677. Occupational health and safety (OHS) in Bangladesh is still in developmental stage. Here, the term “OHS” mainly refers to the needs of workers of industries or some manufacturing processes but does not completely cover all occupations of the country. Although the government has some kind of occupational health care services for the workers and labours, the responsibility for ensuring health and safety at work is generally placed on the employer. However, it is also the responsibility of the workers/employees to follow the health and safety guidelines set out by the employer diligently to ensure no harm befalls them. Every workplace is different, so it is important to develop an OHS program that addresses the specific needs of the operation. This OHS Program Template serves as a starting point to help employers develop an OHS program for all the personnel involved in the pre-construction, construction and operation of the Rupsha 800 MW CCPP project.

678. The proposed construction will be implemented by an EPC contractor supervised by a NWPGCL appointed OE. The EPC contractor is to be involved in erection of new equipment including civil works and expected to sub-contract the civil, mechanical, electrical, instrumentation and control components to local Bangladeshi contractors. Prior to the construction, the EPC contractor will develop an OHSE Plan that will address OHSE aspects associated with each phases of the project.

679. During the operational phase, NWPGCL will develop, rollout and implement a formal OHSE management system for the operation of the power plant. The EPC contractor will need to ensure that their OHSE plan also complies with stipulated laws and regulations.

680. The OHSE activities should not be strictly limited to the aforementioned plan. The plan, once developed, needs to be reviewed and updated as seen fit to identify the strengths and weaknesses of the program. In some cases, reliance on basic common sense could be the difference between averting a major disaster or death.

10.9.1 OHS Policies in Bangladesh

681. Bangladesh does not have its own specific OHS policy. There are a number of laws and regulations that are have some provisions related to occupational health and safety. Some of these laws have provisions on occupational hygiene, occupational diseases, industrial accidents, protection of women and young persons in dangerous occupations and also cover conditions of work, working hours, welfare facilities, holidays, leave, etc. However, most of the laws lack in standard values and are rather general in nature. The laws and regulations that falls into OHS aspects include:

- The Fatal Accidents Act,1855
- The Explosives Act, 1884
- The Explosive Substances Act, 1908
- The Poisons Act, 1919
- The Dangerous Cargoes Act,1953
- The Fire Prevention and Protection Act, 2003
- The Labour Act, 2006
- The RailwayAct,1890
- The Motor Vehicles Ordinance, 1983
- The Highways Act, 1925

- The Building Construction Act, 1952
- National Energy Policy
- Any other Act/Rules applicable to particular situation/activity/operation

682. However, NWPGCL must also have their own health and safety policy in spite following the above rules and regulations.

10.9.2 Who is accountable?

683. All OHS activities related to pre-construction, construction and operation will be governed by the EHS Manager, who will be tasked with delineating OHS responsibilities to his subordinates. He will also be the responsible person in ensuring that OHS processes are being incorporated to his staff members. He will also provide appropriate OHS training to other officers, plant foreman, supervisors and workers.

10.9.3 OHS Training

684. The on-site EHS Manager in conjunction with the (AM/DM health and safety manager, AM/DM environment and relevant stakeholders/organization heads) will be responsible for the development of the OHS training plan. The (EHS Manager) will be responsible for ensuring that the appropriate employees receive training required under the plan. The company's human resources representative will be responsible for ensuring that all employees receive introductory training on the EHS Management System.

10.9.4 Training Procedure

Task-Specific Training

- A training program will need to be developed to ensure that employees are capable of accomplishing the tasks required to meet OHSE objectives and targets. The program will identify training topics, who should receive the training, when training should be given, and the training method. The program will also distinguish between training conducted to comply with OHS regulations and other training.
- A training needs assessment for the employees needs to be made. The EHS Manager will review past training and the nature of the employee's work. Based on this review, specific training requirements for each employee or type of employee will need to be documented.
- The EHS Manager shall document the OHSE Training Program.
- The training plan shall be implemented by the EHS Manager. Upon completion of training by employees, the EHS Manager shall make the (Superintendent Engineer and Chief Engineer) aware of the training completed.
- The EHS Manager) shall document the training completed form and Training Log.
- Specific documentation pertaining to training received shall need to be maintained by the operational work areas for a minimum of two years, or as required by regulation.
- Training effectiveness will need to be evaluated to ensure that the OHS Management System is being implemented effectively when changes are made to significant risks, objectives, targets or operational controls. Improvements to the training plan will need to be made accordingly.

General EMS Training

- All employees shall receive introductory training to make them aware of the OHS Management System.
- The human resources representative shall be responsible for coordinating the effort to assure that all new and existing employees have received suitable training.

10.10 Emergency Response Plan

685. ERPs are developed to address a range of plausible hazard scenarios that are unplanned and emphasize the tasks required to respond to a physical event. The ERP for the proposed power plant has been developed listing various actions to be performed in a very short period of time in a predetermined sequence if it is to deal major and minor accidents effectively and efficiently. The primary objective of the plan is.

- Providing clear lines of authority and communication during incident and crisis events
- Providing means by which trained people and resources are available to those managing the incident or crisis event
- Keeping the workplace safe and to achieve minimal incidents for health hazard; as well as keeping the impacts on the environment, materials, machineries and equipment from these unplanned events to a minimum.

686. This ERP is intended to provide information, strategies and procedures relating to all aspects of emergency management which comprise of:

- Prevention of emergencies;
- Preparation for emergencies;
- Response to an emergency and;
- Recovery following an emergency
- Documenting and Reporting

687. Emergency response management plan, which includes preventive measures taken for the possible scenarios and natural disasters, are shown in **Appendix 13.**

10.10.1 Emergency Prevention

688. Project risks are prevented through implementation of risk mitigation measures to address events such as gas main leak/explosion, traffic accidents, structural failure and other minor structural issues (e.g. pavement). The potential risks and measures to reduce each type of risk are given in the **Table 10.12** below:

Table 10.12: Risk and Mitigation Measures

Risk	Preventative Mitigation Measure
Flooding	• Regular checking and maintenance of River Training Works.
Earthquake	• National building code should be followed strictly and the buildings should have capacity to withhold the impacts of minimum 8.00 magnitude earthquake • Auto gas supply stopping system during strong earthquake should be incorporated in the design
Cyclone	• Cyclone warning should be followed regularly and management measures should be followed according to standard guidelines. (detailed would be

Risk	Preventative Mitigation Measure
	provided in final report)
Traffic Accidents (Road & Rail)	• Traffic Control devices (road signs and markings, speed signs, stop signs, speed bumps and safety barriers) • Infrastructure maintenance and improvements (including upgrades of road surfaces, rail lines, rail crossings, bridges and drainage) • Closing of bridge during extreme wind.
Spill/leak of Hazardous Materials in Land and Water	• Fire Department personnel in the ERC will possess sufficient Hazmat training and have access to an appropriate number of Hazmat suits.
Terrorist Events/Threats	• Regular contact and updates from National intelligence agencies regarding threats. • Random security checks at the bridge ends during threats. • Bangladesh Army and Police personnel will be appropriately resourced and trained to quickly respond to terrorist emergency events.
Gas Leak/ Explosion	• Regular inspection and preventative maintenance of Gas main according to the *Operation and Maintenance Manual.* • Regular checking of Gas main pressure and pressure valves.

10.10.2 Emergency Preparedness

689. Preparedness includes emergencies from fire related disasters and the necessary steps required to prepare for such emergencies. For this, it is required to design, manufacture, deliver to the site, install, test and commission the fire-fighting and fire detection equipment to protect the steam & gas turbine, generating units and all associated equipment. The following **Table 10.13** includes the list of preparedness measures to be included.

Table 10.13: List of Preparedness Measures

No	Area of Requirement	Preparedness Actions
1	Design Requirement	• Design should take into account basic operating policy • All automatic systems must have a manual initiation facility • All fire protection installations should comply with the requirements of the codes of practice of the National Fire Protection Association, Boston, Massachusetts, U.S.A., as appropriate for the respective systems, to the approval of the Engineer.
2	CO_2 Gas Fire Protection System	• An automatic Carbon Dioxide (CO_2) gas fire protection system should be provided in all machinery enclosures of gas turbine generating units except in the unit local control package. • The Protection System should consist of a fire detector and an automated fire extinguishing mechanism once fire/smoke is detected. • Facilities for alternative manual actuation of the fire protection system should also be provided such that, when the manual mode has been selected the protection sequence will not proceed beyond the alarm stage without manual action by an operator.

No	Area of Requirement	Preparedness Actions
		• High risk areas should be marked as "fire protection zones" and should have a separate fire protection system independent of others. • The protection system should be checked on a monthly basis to test their functionality. Any defect should be reported to the manger and should be replaced immediately.
3	Hydrant System	• Water hydrants should be provided in the plant in such places that are susceptible to fire, such as, gas & steam turbine generating units, HRSG, Gas station, Gas Booster, Chemical Plant electrical building, Outdoor transformers etc. • Firefighting water pool/ storage tank should have a capacity of minimum 4 hours of supply in case of worst case scenario. • Regular inspection of the hydrant system should be made to see if they are functioning properly or not. Any defect should be reported to the manger and should be replaced immediately.
4	Piping	• The fire-fighting water mains should consist of buried piping of at least 150 mm diameter. • The underground pipe-work should be provided with an approved protective coating unless the pipe is manufactured from an approved non-corrosive material.
5	Portable Equipment	• Portable equipment such as, CO_2 extinguishers and dry chemical extinguishers of various weights and sizes should be provided at various locations of the plant • Regular inspection of portable extinguishers should be made and noted. Expired extinguishers should be replaced immediately.

690. A professional training needs to be given to the designated fire team. The training would include the following **Table 10.14**.

Table 10.14: Types of Trainings and Training Actions

No.	Type of Training	Training Actions
1	Actions to be taken in the event of a fire	Use fire exit and educating workers and staffs of the nearest emergency evacuation zone. Proper evacuation procedure in the event of a fire. Training on locating emergency equipments and use of portable fire extinguishers to extinguish fires. Training on whim to contact in case of an emergency.
2	Handling of flammable liquids	Training on the safe handling and storage of volatile/flammable chemicals/oils. Training on waste classification system and use of various color-coded bins for various waste disposals. Training on the use of PPEs.
3	Emergency Drills	Regular monthly training on mock fire drills.

No.	Type of Training	Training Actions
		Regular monthly workshop on emergency response and preparedness plan.
4	First-aid and medical assistance	Training on first-aid treatment for broken bones/fractures, burns, cuts/wounds, unconsciousness, breathlessness.

691. In case of an emergency fire breakout, the EHS Manager should be notified immediately who will delineate the information and responsibilities to other staff members. An emergency contact list should be prepared by the EPC contractor consisting of Manager's/ AM's contact details, Hospitals, Police, Ambulance services and other relevant contact details.

692. In order to reduce the risks associated with accidents, internal and external threats, and natural disaster a safety training program is essential for workers in plant operation. There should be regular training programs on safety for the workers to increase their awareness and also to reduce the risks. Provision of yearly professional training for health and safety, would enhance the effectiveness of safety. Safety training should be planned for the local people living around the project area so that they can be aware about the risk possessed by the Power Plant and can take appropriate preparedness (**Table 10.15**).

Table 10.15: Training schedule that may be adopted for safety

Target trainee	Training schedule
Worker	Two trainings per year
Professional	Two trainings per year
Local people	Two trainings per year
Drivers	Four trainings per year
Safety professional	Three trainings per year

693. In addition, there must be a discussion and awareness session for increasing awareness on safety in each and every kind of meeting. Tool box meeting and job safety analysis should be regularly practiced by the employee. Further details on the type of trainings to be provided will be discussed in the separate Emergency Response report.

694. The EPC contractor will formulate a plan for evacuation in the event of an emergency. He/she will make a layout plan, showing all the possible emergency fire exits and the location of the evacuation zone. An emergency contact list should also be prepared by the EPC contractor consisting of EHS Manager's contact details, Hospitals, Police, Ambulance services and other relevant contact details.

10.10.3 Emergency Response

695. Emergency events are broken down to three level tiers; Tier 1, 2 and 3. Tier 1 having the lowest threat level and Tier 3 having the highest threat level

696. In the case of an emergency event, the Incident Response Team (IRT) at plant site would be mobilized with the Emergency Response Group (ERG) (Chaired by the Chief Engineer of NWPGCL) coordinating and overseeing arrangements to ensure that the IRT meets its emergency management obligations. In the case of Tier 1 emergencies, the cases are escalated primarily to site specific IRTs only. Tier 2 involves ERG providing tactical response, support, assistance and advice to all incident and emergency situations at site/location and for providing operational response to any emergency situation which may occur in the affected (such as, fire,

explosion, coal spillage and various social crisis). The Incident Management Team (IMT) (also located at NWPGCL) is activated in the case of Tier 3 incidents and responsible to define and control strategy for those incidents. The following table (**Table 10.16**) shows the emergency response escalation protocol for different levels of emergencies.

Table 10.16: Emergency Response Escalation Protocol

Impact/ Consequence	Health & Safety	Natural Environment	Reputation Government Community Media	Financial $	Civil Unrest Hartals		Definition	Country Threat Level	Escalation				Site specific IRT Members
Tier 1	Minor injury – First Aid treatment.	Negligible impact on fauna/flora, habitat, aquatic ecosystem or water resources. Incident reporting according to routine protocols.	Minimal impact to reputation.	Financial loss <$50,000	Situation generally stable with some protests / Hartals against government		Incidents that are containable by the Operations' Site Incident Response Team (IRT)	**Insignificant Low**	Operation Sites	Plant Manager	**IRT**	ERG Leader	Plant Manager other **IRT** members **ERG - as required**
Tier 2	Moderate injury- Medical Treatment, Lost Time injury	Impact on fauna, flora and/or habitat but no negative effects on ecosystem, may require immediate regulator notification.	Moderate to small impact on business reputation.	Financial loss >$50,000	Security unrest appears to escalate to regular outburst - but **authorities appear to be capable of maintaining control**		Incidents that require Dhaka based ERG, governmental and regulatory support	**Medium High**	**ERG**	ERG Leader	Chief Engineer NWPGCL **activates Dhaka ERG**	**Inform Member-Generation**	ERG Leader – Chief Engineer other ERG members **ERG - activated for EHS / Security issues**
Tier 3	Injury requiring ISOS activation. Permanent disabling injury and or long term off work and fatality.	Long term impact of regional significance on sensitive environmental features, likely to result in regulatory intervention/action	Significant impact on business reputation/ or international media exposure.	Financial loss greater than $100,000.	Confirmed direct threat to foreign business interest or against expatriates **Situation certain to escalate further beyond Government control**		Incidents when there are multiple injuries or fatalities requiring IMT support and also international support, regulatory and public relations assistance.	**High Extreme**	**IMT**	IMT Leader **activates IMT**	Director Technical	**Managing Director-NWPGCL IMT**	**IMT** other **IMT** members **IMT - activated**

The Incident Response Team

697. The Incident Response Team (IRT), based at plant location, is trained and responsible for dealing with all envisaged incidents and emergency situations which may occur at the location. Where additional support in the way of resources and advice may be required by the IRT at a remote location this will be requested through and provided by the Emergency Response Group (ERG) of Dhaka Office. On all occasions when an IRT is mobilized due to an incident or emergency situation, the ERG Manager must be notified immediately.

698. The IRT will be headed by the Plant EHS Manager and will also include DM/AM of both HS and Environment as well as Logistics department within the plant.

The Emergency Response Group

699. The Emergency Response Group (ERG) is based in the NWPGCL Head Office in Dhaka and will be chaired by the (Chief Engineer). He will also nominate an Emergency Response Coordinator to coordinate with representatives from various agencies and also senior staff from HR, Finance, HSE, Logistic, Security, IT, and public affairs department within NWPGCL. ERG will be responsible for providing tactical response, support, assistance and advice to all incident and emergency situations at site/location and will provide operational response to any emergency situation that may occur. The function of the ERG is to coordinate and oversee arrangements to ensure that the IRT meets its emergency management obligations. ERG should develop a plan, in consultation with the appointed EHS Manager where it should describe how to handle both the "technical" crises e.g. fire, explosion, oil spill, and "social" crises e.g. illness, injury, kidnap, civil unrest. On all occasions that the ERG is mobilized due to an incident or emergency situation the Managing Director must be notified immediately.

The Incident Management Team

700. The Incident Management Team (IMT) is the corporate body located in the NWPGCL headquarters in Dhaka, with the responsibility to define and control strategy for major incidents. A strategic response is defined as a situation arising from a single or multiple incidents or emergencies that escalate to a point beyond which significant damage to the Company's business could result, including commercial and reputation damage, significant financial loss, shareholders' loss of confidence and damages resulting from litigation. When a potential strategic situation appears the IMT will be mobilized to manage issues pertaining to the reputation and the continued commercial wellbeing of the Company. The IMT may however also be called upon to address some of the tactical roles that would normally be the responsibility of the ERG, for example, if the Dhaka Office were out of action or in the event of an evacuation from a country, which may equally limit the ERG's capability.

701. The IMT is chaired by the Managing Director of NWPGCL and includes high level representation from the Ministry of Power, Energy and Mineral Resources, Army, Police Department, Fire Department, District Commissioner's Office and the Disaster Management Bureau (DMB) of the Bangladesh Government.

10.10.4 Emergency Recovery

702. After the emergency situation had passed, the ERG would assess and categorize the damage and would provide for compensations for the injured; provide provisions for temporary services; reinstate normal environmental and working standards; initiating investigation process

for the cause of disaster; evaluating response procedure and providing a recommendation to mitigate future emergencies.

10.10.5 Documenting and Reporting

703. Implementation status of the safety plans should be monitored and documented regularly. Monthly monitoring report should be prepared based on regular inspection and should be submitted to the Superintending Engineer of the Power Plant. Any kind of incidents or even near misses should be documented and reported to the Superintending Engineer.

10.10.6 Emergency Evacuation Plan

704. The EPC contractor will formulate a plan for evacuation in the event of an emergency. He/she will make a layout plan, showing all the possible emergency fire exits and the location of the evacuation zone. An emergency contact list should also be prepared by the EPC contractor consisting of EHS Manager's contact details, Hospitals, Police, Ambulance services and other relevant contact details.

11.0 CONCLUSION AND RECOMMENDATION

705. To address the increasing deand for electricty and to ensure a stable and reliable power supply, the NWPGCL has taken the initiative to enhance the power generation capacity of Bangladesh through the implementation of Rupsha 800 MW CCPP in Kalishpur, Khulna. The Rupsha 800 MW CCPP is designed as a dual-fired CCPP with natural gas as the main fuel and high speed diesel as back-up fuel to be used only during emergency events estimated to be not more than 500 hours per year.

706. Project components are interrelated such that (i) Component 1 will be development and operation of the Rupsha 800 MW gas-fired CCPP, (ii) Component 2 will supply the natural gas to Rupsha 800 MW CCPP from the existing Khulna City Gate Station owned by the SGCL through a new 10 km, 24" distribution pipeline and a new 2 km, 20" distribution pipeline (branched off) to serve the existing Khulna 225 MW CCPP owned by NWPGCL, (iii) Component 3 will be the 29.3 km, 230 kV double circuit overhead transmission line to transfer the generated power to the national grid, and (iv) capacity building of NWPGCL.

707. The project is "red category" based on ECA 1995 and ECR 1997 of DoE requiring both site clearance and environmental clearance. In November 2017, the DoE has exempted NWPGCL from submitting the initial environmental examination in securing the site clearance. According to SPS 2009, the project is category A requiring an EIA.

708. Following the requirements of DoE and ADB, an EIA was prepared. Air quality modeling through CALPUFF was carried out to predict the ground level concentration of air quality pollutants from burning 125 MMCFD of natural gas and ambient noise level was simulated using SoundPlan Essential 3.0 software. ALOHA was used to simulate the consequences of gas leakage or pipeline failure. A biodiversity assessment was conducted by IUCN Bangladesh from May to December 2017 due to the presence of the endangered species, Ganges River dolphins, in Bhairab River where the cooling water for the closed-loop cooling tower system will be taken. About 30 km river stretch along the key rivers within the project site: Bhairab River, Atai River, and Rupsha River were covered by the assessment. Results of the assessment of the IUCN Bangladesh showed that there is no critical habitat for the Ganges River dolphin within the immediate vicinity of the project site.

709. The project site was previously used by GoB for the KNM, but in 2002 the operations were terminated and the structures were abandoned. Pre-construction stage will involve demolition of the abandoned structures. The demolition will not be funded by ADB. Two schools (boys and girls school) will be relocated, a mass grave marker to commemorate the death of the 1971 liberation forces (Muti Bahini) and a mosque will be renovated and refurbished.

710. The available annual discharge in Bhairab River ranges from 39.73 million m^3 (MCM) per day to 54.47 MCM per day. The project will require 2,010 m^3/hr of water from the Bhairab River for its cooling tower system. With the available annual discharges, the requirement of Rupsha 800 MW CCPP is less than 1% of the total available discharge from Bhairab River. The project will have a sewage treatment plant and a wastewater treatment plant. Groundwater will not be used for power plant requirements but will be used only for domestic purposes and this will be supplied by the Khulna City Corporation water district. Low NOx burner will be used at the power plant to reduce the NO_2 emissions. The contribution of the power plant to the CO_2 emissions will be 30,821 tons CO_2/year during the construction phase and 1,101,362 tons CO_2/year during

operation. At full implementation of Component 1, the annual net emissions reduction was estimated to be 1,305,525 tons CO_2/year by displacing oil-fired power plants.[57]

711. A total of six consultation events were conducted from 28 October 2016 to 13 November 2016 and again on 21 October 2017 to present the findings of the EIA to key stakeholders. A GRM will be set up by PMU consistent with the requirements of GoB and ADB. A project brief in English and in Bangla with details on the GRM will be made available at the NWPGCL office in Khulna and in Dhaka. Consultations will continue in varying degrees throughout the project's life cycle. With the assistance from experts, NWPGCL will finalize the communication action plan for the project.

712. This draft EIA will be disclosed at the ADB website in accordance with SPS 2009 and PCP 2011. Prior to construction works all the relevant permits required for Component 2 will be obtained by NWPGCL.

713. While there are associated impacts in implementing Component 1, they can be readily mitigated through design, employing best available technology (e.g. Emissions reduction), good engineering construction methods, effective stakeholder engagement (as and when needed), diligent monitoring of EMP implementation, and compliance to relevant regulations on power plant operations, and environmental, health, and safety.

714. Except for the biodiversity assessment carried out by IUCN Bangladesh in connection with this EIA, there has been no surveys and studies on the Ganges River dolphins along the Bhairab River, Atai River, and Rupsha River. These rivers drain to the Bay of Bengal and are tidal influenced. It is recommended that additional surveys be done within this area to confidently determine the abundance and dispersal of these endangered species.

[57] Displacing electricity in the grid in Bangladesh was estimated using grid emission factor of 0.67 ton/MWh. Source: DoE, 2013. Grid Emission Factor of Bangladesh. Dhaka.