AECOM

Environment

Volume III- Baseline and Impact Assessment (Chapter 8-11)

Submitted to:

Orion Power Unit-2 Dhaka Limited

Orion House
153 – 154 Tejgaon Industrial Area
Dhaka - 1208
Bangladesh

Submitted by:

AECOM India Private Limited

5th Floor, Building 10-B
DLF Cybercity, DLF Phase II
Gurgaon - 122002
India

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Environmental Impact Assessment Study

635 MW Coal based Thermal Power Plant, Munshiganj District, Bangladesh

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8. Baseline Environment of Project Area

This section of the report presents information on the physic-chemical, biological and ecological environment of the study area focusing on aspects that may be impacted by the proposed Project's operations.

8.1 Study Area

An area of 10 Km radius around the project site was considered as study area for evaluation of existing environmental status and identification of potential impacts. The following baseline parameters are covered in this chapter:

- Site Settings;
- Physiography and Topography;
- Surface Geology and Seismicity;
- Hydrogeology
- Geomorphology;
- Drainage Pattern;
- Land Use Pattern;
- Climate and Micro-meteorology;
- Ambient Air quality;
- Water quality;
- Noise levels,
- Soil quality,
- Traffic Density and
- Ecological diversity
- Aquatic diversity

Methodology adopted

The information presented in this chapter is based on site surveys, primary monitoring and literature review by AECOM and information collected from various agencies i.e. Bangladesh Meteorological Department, Geological Survey of Bangladesh, Forest Department, Bangladesh Water Development Board, Ministry of Water Resources, Bangladesh Agricultural Development Corporation (BADC), and other studies undertaken by various agencies for OPDL-2.

Primary monitoring was carried out during the period of November, 2013 to February, 2014 (post monsoon season) by Adroit Environment Consultants Limited (AECL) (Lab recognized by Government of Bangladesh) to evaluate the baseline environmental parameters namely ambient air qaultiy, noise quality, river traffic, soil quality, surface water and ground water quality, ecological and aquatic survey in the study area.

Wind direction prevailing in the study area has been presented for all four seasons which afterwards has been compared with wind direction prevailing in project area.

8.2 Coal Availability and feasibility of distance between station and coal

The coal for the proposed project will be imported from Australia and Indonesia through vessels acceptable to Bangladesh port authorities. The consumption of coal has been estimated as 1484000 Tonnes/year. Delivery of coal to the plant will be undertaken through Mother Vessels which will arrive directly from Chittagong which is situated at a distance of 240km approximately in south east direction from the site. The coal will be transported via Chandpur to the proposed site. Transportation of coal, with distances has been briefed in section 6.3 of Chapter 6 of the report.

8.3 Site Settings

The proposed project site is located within Hosseindi Union of Gazaria Upzila (Sub-district) in the central Zola (District) viz., Munshiganj Zila of Bangladesh. The site is situated at a distance of about 5.3km from Dhaka–Chittagong Highway (N1) in south west direction. The site is located at an elevation of about 2-5m above mean sea level (amsl), with River Meghna and River Dhaleshwari flowing to its east and west borders respectively. The site is situated to the south of a V- shaped island formed through meandering of River Meghna from its main course, which is accessible by country boats from Meghna Ferry Ghat located at a distance of about 5km in North East direction from the site. Locals inhabited in flood plain of River Meghna use the traditional country boats as a means of water transportation. No archeologically important monuments or ecologically sensitive zones are located within the study area. The rural population in the study area reside in scattered settlements separated from the island.

The study area constitutes some of the existing thermal power plants catering to the power requirement of Bangladesh. The IEL Consortium and Associate Limited of Orion group have set up the 100 MW Meghna Ghat Heavy Fuel Oil (HFO) power Plant located at an aerial distance of about 5km from the project site in North-East direction, which is currently operational.

Two more thermal power plants are situated in close proximity to the existing 100MW power Plant. One is 450 MW Gas-Fired Combined Cycle Power Plant which is located on the northern bank of the Meghna River owned by AES Meghna Ghat Limited. The other one is dual fuel 337MW (net) power plant, currently under construction phase being developed by Summit Meghnaghat Power Company Limited (SMPCL).

There are four major Cement Plants located in immediate vicinity to above mentioned three existing thermal power plants, at Meghna Ghat. These are namely Shah Cements, Holcim Cements, Basundhara Cements and Fresh Cements. Holcim cement plant is located at a distance of about 6km in north east of the site and Fresh Cement Plant is established in north of Hoclim Cement plant. Bashundhara Cement plant is located on Meghna Ghat across Dhaka – Chittagong Highway, at a distance of about 6.3km in north-east direction. Shah cement plant is located at a distance of about 5km in south west direction from site. Shamuda Chemicals is situated across Meghna Ghat on southern bank of River Meghna, which is located at a distance of about 4.6km north east of the site.

Presently, the project site is being developed by fill material (i.e., river bed sand) up to 2m to raise the site elevation prior to commencement of project construction activities. Along with sand filling, livestock rearing in form of grazing activities owned by the local inhabitants is predominantly being

practiced on the project site. The study area is characterized by low-lying fields of paddy, banana plantations, and vegetable plots, intermixed with clusters of houses. The area is also threaded by a patchwork of small watercourses allowing boats to be used for transportation of goods and materials. Local populace of the area are much dependent on shrimp farming activities in the Meghna River and its channels, for self-consumption and also as a source of livelihood.

8.4 Physical Environment

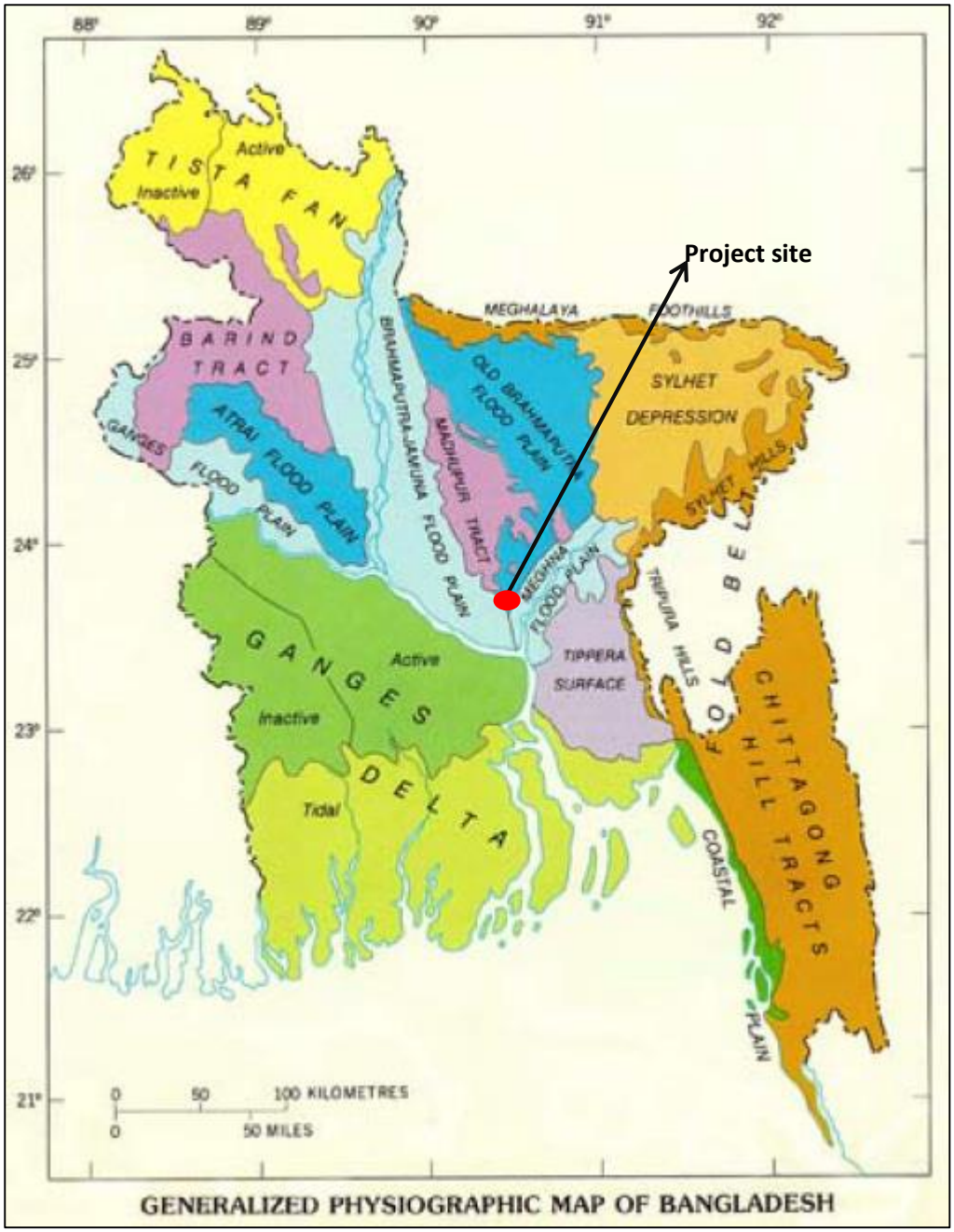
8.4.1 Physiography and Topography

The study area of proposed project forms a part of the middle floodplains of River Meghna which occupies a low-lying landscape of broad islands and many broad meandering channels. River Meghna joins the River Padma near Chandpur and flows into the Bay of Bengal as River Meghna. The main channel of the Meghna upstream forms its junction with River Dhaleshwari flowing from west to east to be known as the Middle Meghna as depicted in *Figure 8-1* . The terrain is marked by vast stretches of undulating low lying land. Two concrete landscapes are distinct within the area –flood plains of River Meghna and alluvial deposits.

According to a report based on land resources appraisal of Bangladesh for agricultural development issued by UNDP (United Nations Development Programme)[1], Bangladesh has been divided into twenty physiographic units. The basis includes combination of the geological material in which particular kinds of soil have formed and the landscape on which they occur. The study area forms a part of "Arial Beel" physiographic unit- a large depression between the River Ganges and the River Dhaleshwari flowing south of Dhaka[2].

Figure 8-1: Physiographic Map of Bangladesh

[1] http://www.fao.org/docrep/field/009/s7223e/s7223e.pdf
[2] http://www.iebconferences.info/337.pdf



Source: Geological Survey of Bangladesh

The topography of the study area is marked with Medium Highland and Lowland with a gentle slope of about 1-2 % in the south east direction towards River Meghna. The elevation of the project area ranges from 2 m to 5 m amsl.

8.4.2 Surface Geology and Seismicity

Bangladesh has been evolved by formation of successive delta systems developed by the two great rivers of the Ganges and the Brahmaputra[3]. The study area is located in Bengal basin –an extensive

[3] http://21.174.128.43/web_data/iga_db/Bangladesh.pdf

alluvial plain of the Quaternary sediments laid down by Ganges-Brahmaputra-Meghna river system, more specifically in Barisal-Chandpur High tectonic zone as *shown in Figure 8-2.*

Tectonically Bangladesh is divided broadly into the following divisions:

Indian Platform and Shelf

- **Dinajpur slope (Himalayan Fore Deep) -** The Himalayan Foredeep lies south of the Main Boundary Thrust (MBT) all along the foothills of the Himalayas. It lies at the NW tip of Bangladesh and the basement occurs at 2500 m depth.
- **Rangpur Saddle**- The basement is most uplifted and covered with thin sedimentary deposits. The tentative boundary of the Rangpur Saddle at the northern and the southern slopes has been seismically defined by the approximately 700 m depth contour.
- **Bogra Slope**- the Bogra Shelf (Bogra slope) represents the southern slope of the Rangpur Saddle which is a regional monocline plunging gently towards south east to the Hinge zone. This zone marks the transition between the Rangpur Saddle and the Bengal Foredeep

Hinge Zone (Eocene slope break)

It is a narrow zone trending SSW-NNE from Sylhet-Mymensingh-Panba-Calcutta and further to the southwest along the coastline of Odisha. It is bound by the Bogra Shelf (or south slope of the Rangpur Saddle) by the seismic depth of 3500m to the top of the Eocene Sylhet Limestone, the most prominent sedimentary reflector in Bangladesh and West-Bengal.

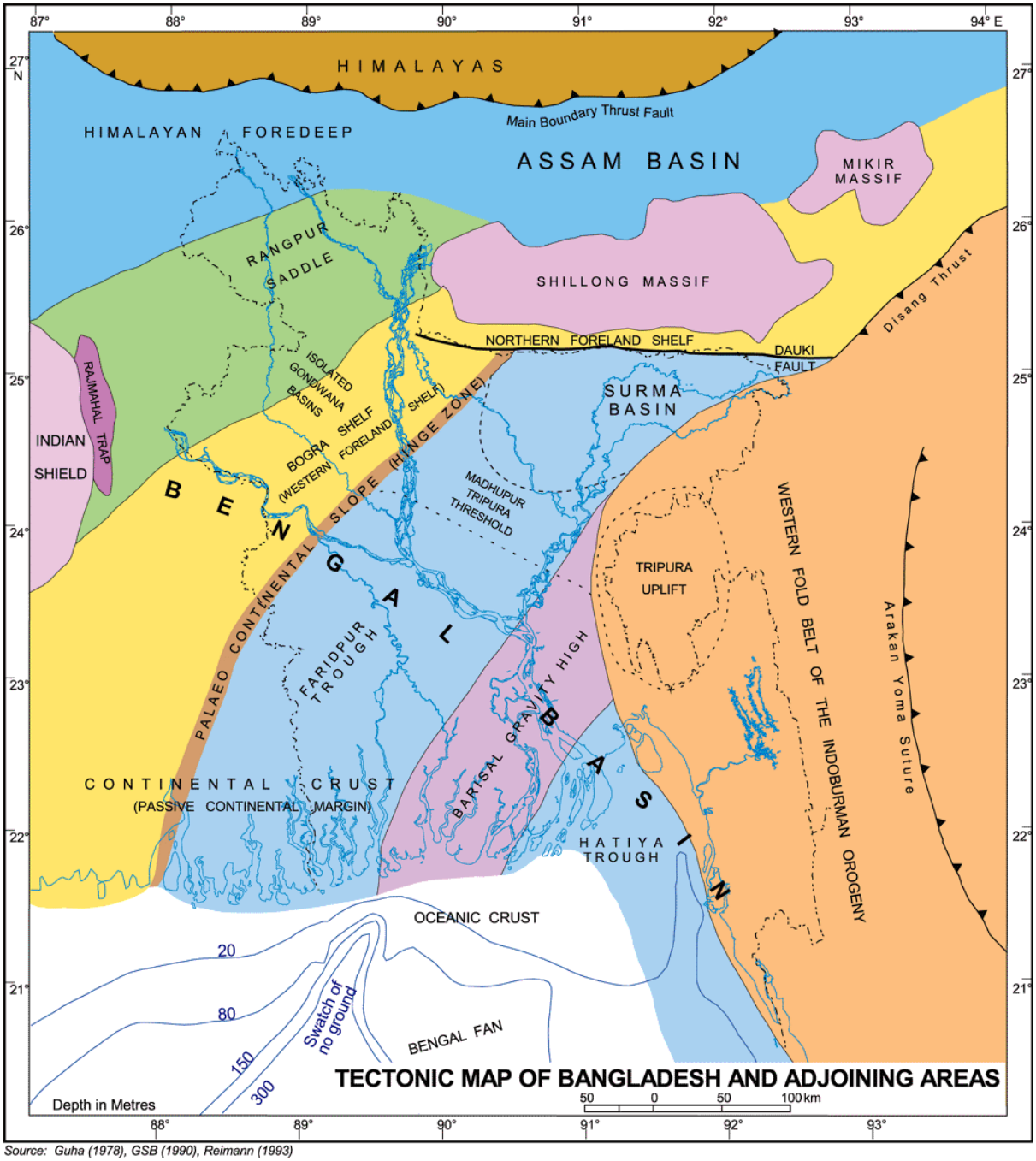
Bengal Fore Deep

The Bengal Foredeep is flanked by Hinge Line in west and and the Arakan Yoma Folded System in east which plays the most important role in the tectonic history of Bengal Basin. The Bengal Foredeep can be divided into two major regions: a Western Platform Flank and an Eastern Folded Flank. The Western Platform flank is further subdivided into the Faridpur Trough, the Barisal-Chandpur High, the Hatiya Trough, the Madhupur High and Sylhet Trough.

Eastern Folded flank- The Folded belt extends S-N within Bangladesh for 450 km and is about 150 km wide, covering an area of 35 000 km^2 of on-shore area.

The ***Barisal-Chandpur High*** is a tectonic zone located between the Faridpur Trough and the Hatiya Trough of the Bengal Foredeep. It is characterized by general gravity maxima with slope towards SW-NE direction. A paleo-high stretching from Barisal-Chandpur High in the NE direction has been presumed and the ridge was interpreted to turn south of Barisal-Chandpur High in north-south direction merging with the Ninety East Ridge.

Figure 8-2: Tectonic Setup in Bangladesh



Source: Guha (1978), GSB (1990), Reimann (1993)

Tectonic Setup of Bangladesh

Division of Bangladesh into different elements as mentioned above is on the basis of basement behaviour and fault characteristics.[4]Bengal Basin is a structurally complex area fromed due to the presence of an active Himalayan folded belt (thrust belt) in the north and Indo-Burman fold belt in the east. It is surrounded by the Archean (3.8 to 2.6 billion years old) Indian Platform (Shield) in the west, Tertiary (time range between 65 to 1.6 million years) and, in part, Mesozoic (225 to 65 million years) metamorphic Indo-Burman ranges in the east and the Archean basement of the Shillong Plateau in the north.

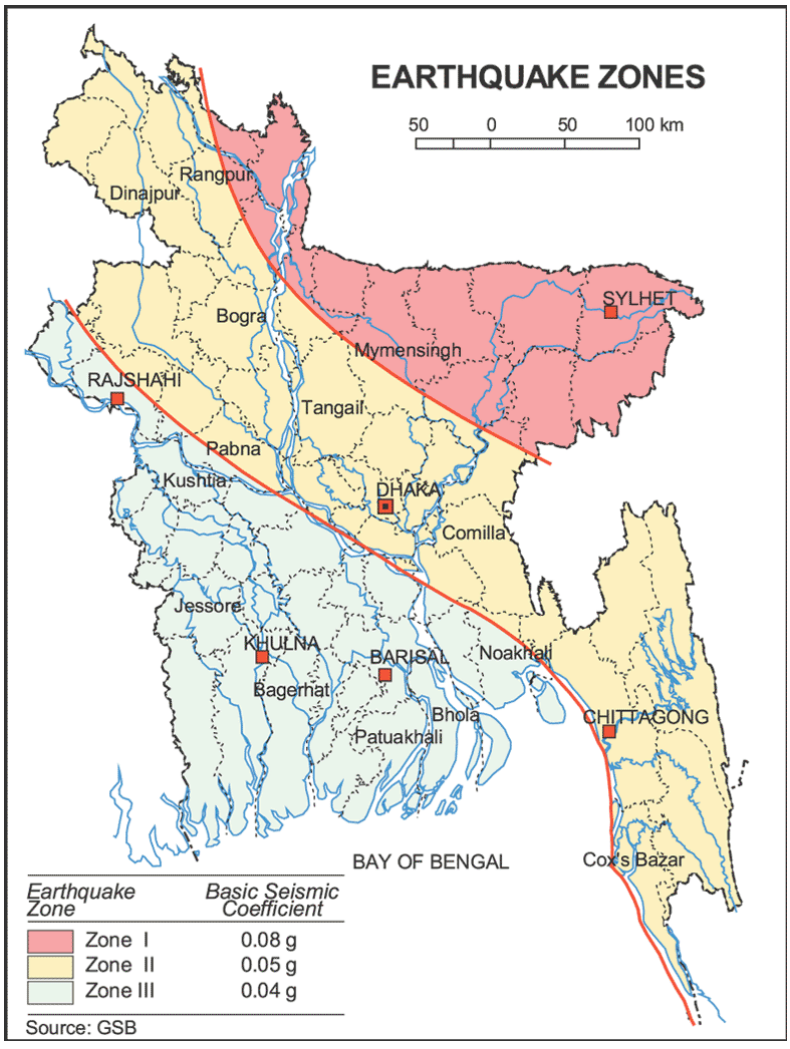
[4] http://www.warpo.gov.bd/rep/knowledge_port/KPED/Forces/Geology/Tectonic_Setup.htm

Aeromagnetic and gravity anomaly information indicates that the basement arches floor the plain and platforms, in association with a diverse assemble of faults or flexture zones. The basement rock is only a few hundred meters below the surface at the north western part of the basin whereas it is at a depth of more than 20 km in the Hatia trough.

Mostly sedimentary rocks from Carboniferous to recent ages (345 million years to present) overlie the basement rock. The thickness of the sedimentary rocks above the basement increases in two directions from west to east and from north to south with a general trend in the southeast direction keeping the trend of the basement topography.

A seismic zoning map of Bangladesh has been proposed in 1979 by Geological Survey of Bangladesh (GSB) as presented in *Figure 8-3* dividing the country into three seismic zone which was accompanied by and outline of a code for earthquake resistant design. As per the Map, the study area occurs in the seismic zone II where the possible maximum earthquake magnitude in Richter's scale is 8.0. The suggested Basic Horizontal Seismic co-efficient for this zone is 0.05.

Figure 8-3: Seismic Zoning Map of Bangladesh



Major earthquakes experienced in Bangladesh till date is provided in *Table 8-1* below.

Table 8-1: Major Earthquakes in the Region

Date	Name/ Type of the Earthquake	Magnitude (Richter)	Epicentral Distance from Dhaka (km)	Epicentral Distance from Sylhet City (km)	Epicentral Distance from Chittagong (km)
10th January, 1869	Cachar Earthquake	7.5	250	70	280
14th July, 1885	Bengal Earthquake	7.0	170	220	350
12thJune, 1897	Great Indian Earthquake	8.7	230	80	340
8th July, 1918	Srimongal Earthquake	7.6	150	60	200
2nd July, 1930	Dhubri Earthquake	7.1	250	275	415
15th January, 1934	Bihar-Nepal Earthquake	8.3	510	530	580
15th August, 1950	Assam Earthquake	8.5	780	580	540

Source: http://www.ddm.gov.bd/earthquake.php

8.4.3 Geomorphology

The study area falls in Arial Beel agro ecological zone which comprises majorly of lowland[5] and a part of Medium lowland. The zone has unique combination of soil, hydrological and agro climatic characteristics. The soils of this area are dark grey and comprises of acidic heavy clays. As per figure 8-4, a non-calcareous Dark Grey Flood plain soil is the major General Soil Type which forms the study area. Organic matter content generally exceeds 2% in the top and subsoil present in this zone[6]. Available moisture holding capacity is inherently low. They have high Cation Exchange Capacity (CEC), and general fertility level is medium to high. *Table 8-2,* presents the major components of soil fertility of Arial Beel zone.

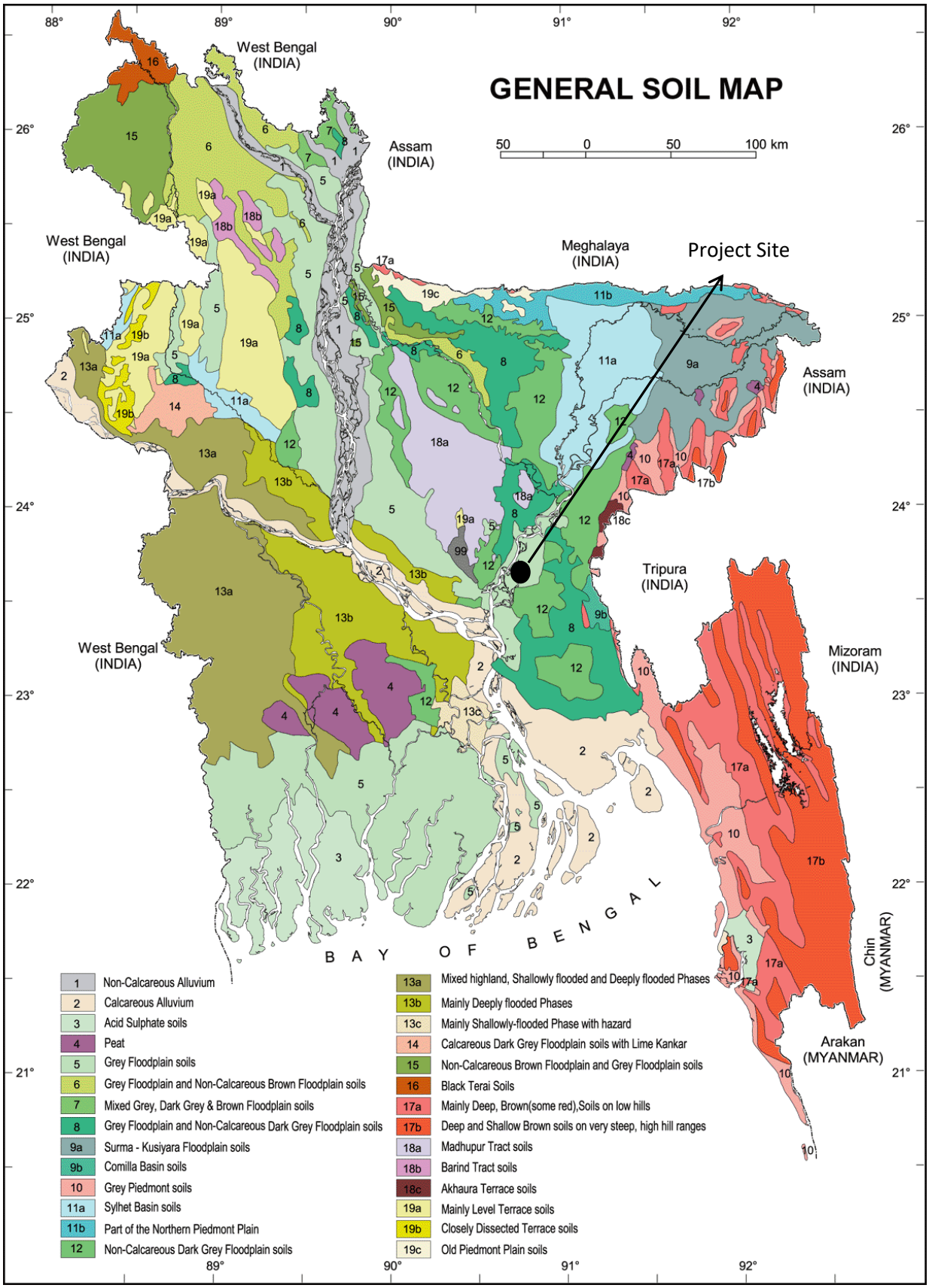
Table 8-2: Status of Nutrients Present in Arial Beel Zone

Major Land Type	Soil pH	Soil OM	Nutrient Status*								
			N	P	K	S	Ca	Mg	Zn	B	Mo
Medium Lowland (13%)	5.3-6.8	M-H	L	L-M	M-Opt	M-Opt	Opt	Opt	M	Opt	Opt
Lowland (73%)	4.7-5.4	M-H	L	L-M	M-Opt	M-Opt	Opt	Opt	M	Opt	Opt

**OM = Organic matter; VL = Very low*
Opt = Optimum; L = Low
H = High; M = Medium; VH = Very high

[5] *Lowland: Land which is normally flooded between 180cm and 300cm deep during the flood season; and Medium Lowland: Land which is normally flooded between 90cm and 180cm deep during the flood season*
[6] http://www.dae.gov.bd/pdf/soil-fertility-status.pdf

Figure 8-4: Soil Map of Bangladesh



Source:http://ngof.org/wdb/mapsdetail.php?id=5

8.4.4 Sorbent Availiblity

Various sorbents are present in aquifers of Munshiganj District. Sorbent availbiity differ in upper and lower parts of the aquifers present in the region. The characteristics of the sorbent(s) do not vary with depth. Sorbents transported to large depths in the upper aquifer would likely remain in the aqueous phase, with limited potential for mitigation by sorption to the solid phase. Fe (III) oxyhydroxides, one of the sorbent are better preserved in lower aquifer. Fe-bearing solids appear to comprise a greater proportion ofoxidized, crystalline Fe (III) in lower aquifers.

8.4.5 Hydrogeology

Most of the present land surface of the study area is covered by the Holocene flood plains deposited by the Ganga Brahmaputra Meghna river systems[7]. In the land above tidal inundation, these deposits are composed primarily of silt and sand of appreciable thickness extending to depth of more than hundred meters. In the lower delta, they are principally silt, clay and peat. These sediments contain high water content and are generally loosely compacted and usually grey in color. The Recent alluvium deposits are of varying characteristics classified from piedmont deposits near the foot of the mountains to inter-stream alluvium including deposits in the interior, merging with swamp and deltaic deposits approaching the southern shoreline. Stratified deposits of sand, silt and clay constitute the subsurface formations of the study area. The aquifer system of the Holocene sediments is leaky type from which the contamination spread vertically from one place to another.

8.4.6 Drainage Pattern and Flood Scenario

The study area forms part of large depression lying between the Meghna and Dhaleshwari rivers in the south of Dhaka region. The study forms a part of the of middle Meghna flood plain, which lies east of the river Meghna with an aerial extent of about 1500 sq. km The area is characterised by low-lying delta plains and flood plains with meander channels, meander scrolls, natural levee and back swamps formed by the River Meghna and its tributaries with elevations ranging between 1-4 m above mean sea level. The indicative location of project site on course of river Meghna is shown in *Figure 8-5.*

Despite the proximity to the two major river channels, the deep seasonal flooding is predominantly by accumulated rainwater which is unable to drain into rivers when they are running at high levels. The drainage pattern of the area is depicted in *Figure 8-6.*

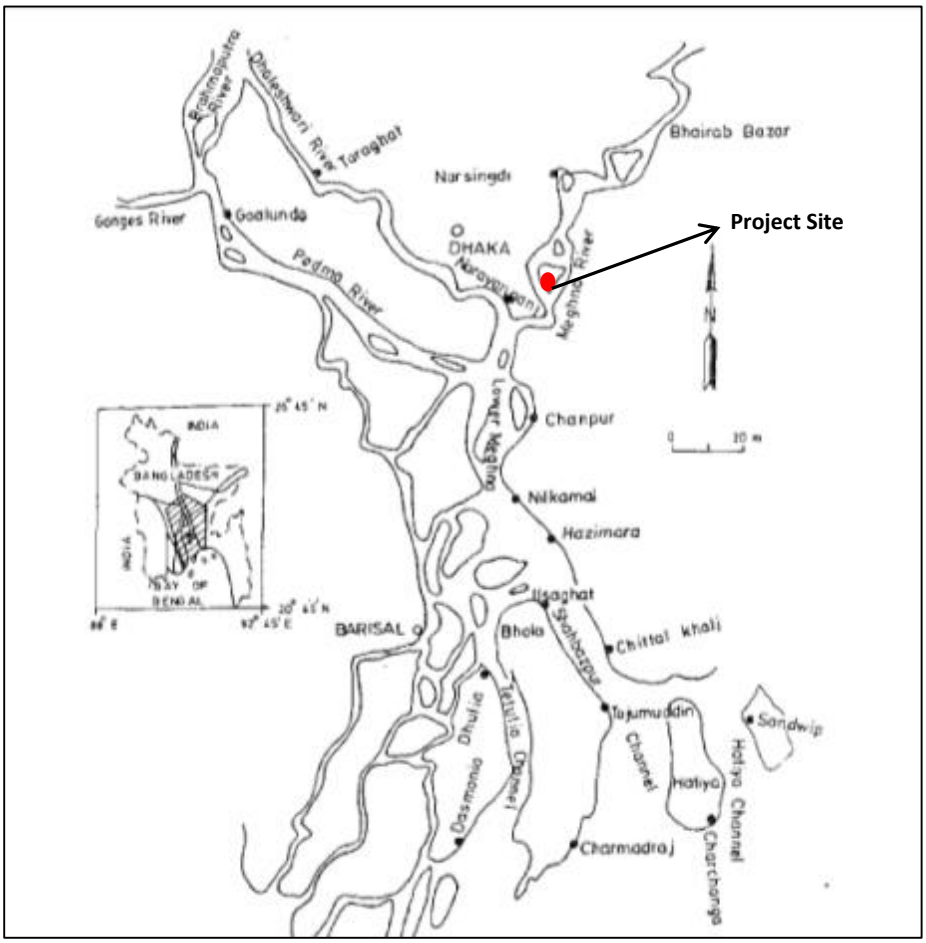
Floods in Bangladesh occur for number of reasons. The main causes are excessive precipitation, low topography and flat slope; but others include the confluence of three major rivers, the Ganges, the Brahmaputra and the Meghna: the runoff from their vast catchment (about 1.72 million km²) flows[8] through a small area, only 8% of these catchments lie within Bangladesh. During the monsoon season the amount of water entering Bangladesh from upstream is greater than the capacity of the

[7] http://fpd-bd.com/wp-content/uploads/2013/05/H039306.pdf

[8] *Annual Flood Report 2012, Bangladesh Water Development Board (BWDB)*

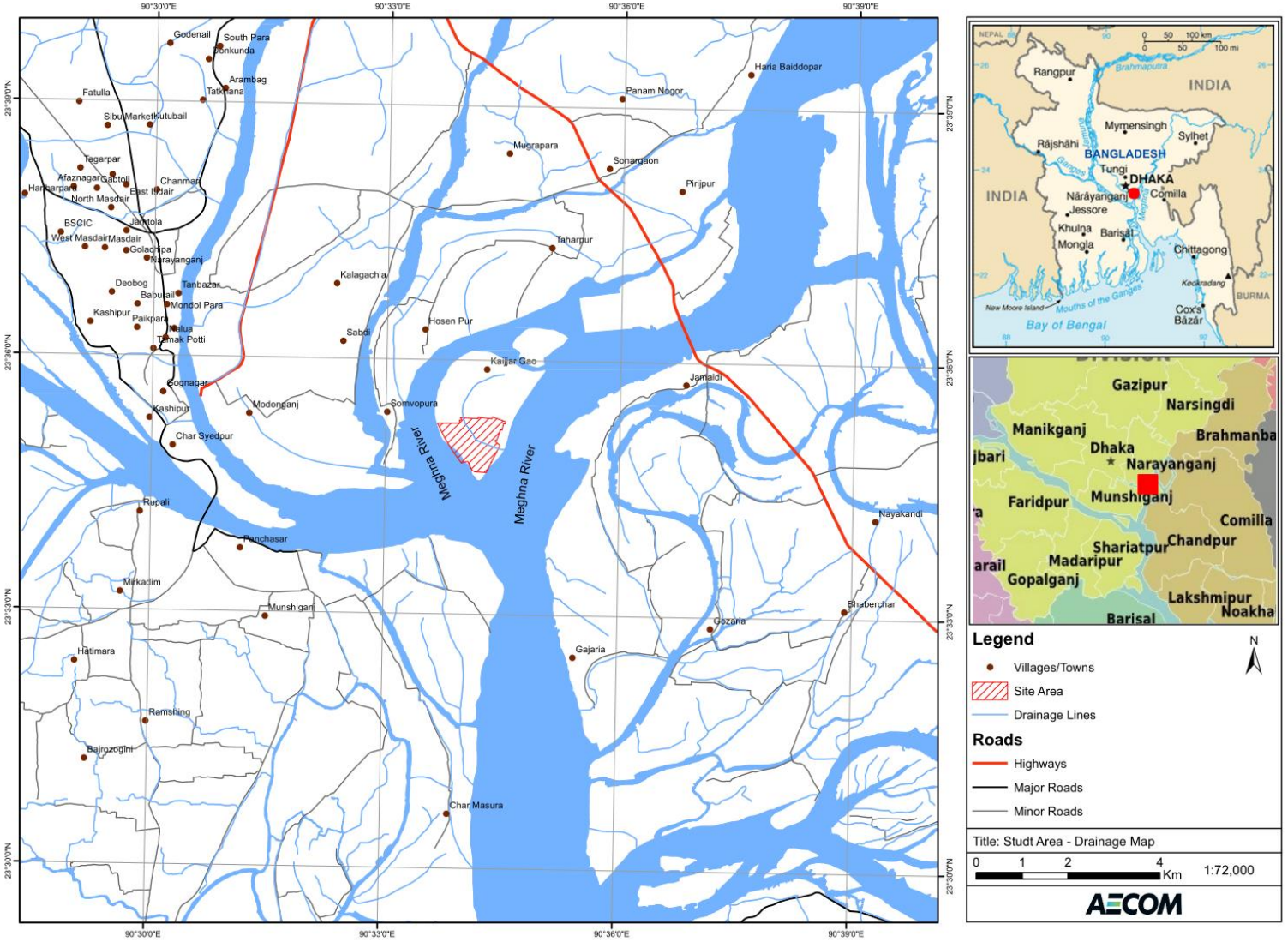
rivers to discharge in to the sea. The average flood discharge of River Meghna during floods is within the range of 14,000 to 100,000 m^3/s. Formation and erosion of the islands and bars and banks of the rivers is a common feature in this season. Major flows entering the site location come from east to west. In general flow velocity inside the floodplain remains well below 0.5 m/s. As per the study conducted regarding the morphology of Meghna River, there is very little water level variation due to very flat topography of the floodplain. In order to resist design flood, the site elevation needs to be raised by about 6 meters. In this study, with intervention simulation has been conducted considering 6 meter raised elevation from existing elevation of the site. The Morphology report has been attached as *Annexure F.*

Figure 8-5: Indicative location of Project Site



Source: *http://journal.iisc.ernet.in/index.php/iisc/article/viewFile/1147/1179*

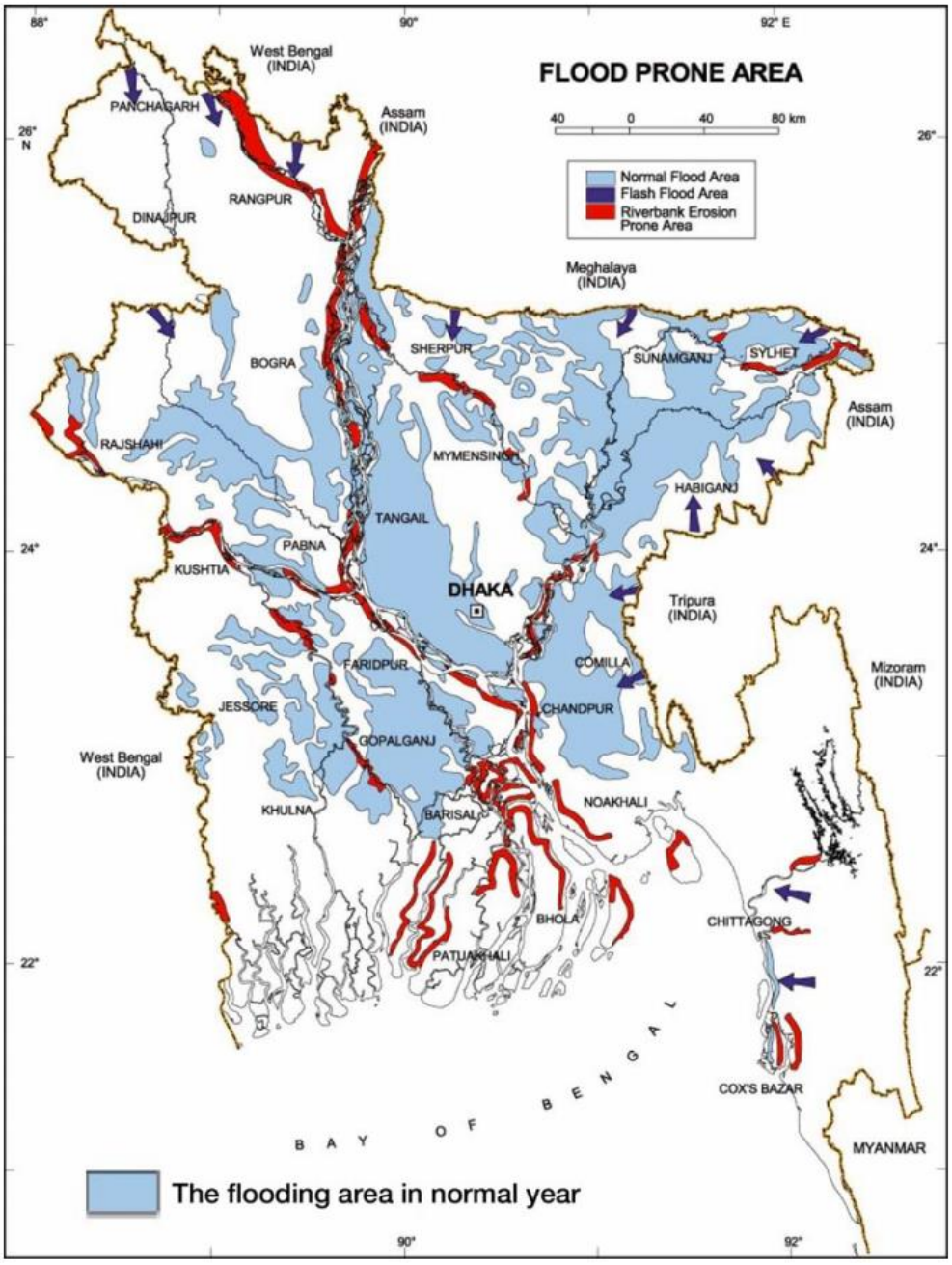
Figure 8-6: Drainage Map of Study Area



8.4.7 Flooding Risks

Bangladesh is located at the mouth of three great rivers, the Ganges, Brahmaputra and Meghna, and 80% of the land is a delta area, which is a flood zone of these rivers. However, the site for proposed plant is located on a south of a V shaped island that has been formed by meandering of Meghna River. The site has been levelled up to avoid any risk from flooding of Meghna River. The flood prone area in Bangladesh has been shown in Figure Below:

Figure 8-7: Danger Areas for Floods in Bangladesh



Source: Factor Analysis of Water –related Disasters in Bangladesh

8.4.8 Climate and Meteorology

Climatic conditions in the project area have been established from meteorological data published by the Bangladesh Meteorological Department (BMD).

4.1.1.1 8.4.8.1 Climate of the study area

The study area falls in Arial Beel agro- economic zone. Accordingly, the climate of this region is tropical accompanied with monsoons and characterized by a change of four seasons. Pre-monsoon season commence from March and continues till the last week of May. The south-west monsoon lasts approximately from June to September, delineating the main rainy season. More than 90% of the annual rainfall occurs during this period. The transition period from October to November forms the post monsoon season. Dry or winter season starts from in early December which remains till end of February). The nearest Meteorological Station is Dhaka, therefore the climatic data of Dhaka have been considered for this region. The study area experiences high air temperature throughout the year with insignificant daily air temperature variations.

8.4.8.1 Meteorological Data (2007-2012)

The long term secondary data available for Dhaka as recorded for the period of ***last ten years*** of observations (2004-2013) at Dhaka Meteorological Station 419230 (VGTJ) are presented below:

Temperature

The climate is tropical with extremes of temperature in summer and winter. Data for temperature as recorded at Dhaka Meteorological Station shows that the highest maximum temperature is 39.6° C during April 2009 while the lowest minimum temperature is 7.2° C during January 2013 as presented in ***Error! Reference source not found.***. By analyzing the data of temperature in the year of 2004 to 2 013 collected from Bangladesh Meteorological Department (BMD) as shown in Error! Reference source not found., it is observed that temperature gradually increase from January to April, and follows a constant pattern from April to September. The temperature tends to start decreasing from October till January.

Table 8-3: Monthly Highest Maximum Temperature (based on observations from 2004-2013)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	27.5	32.8	35.7	35.2	38.1	35.2	34.5	34.6	34.0	34.5	31.1	29.4
2005	28.5	32.1	35.6	37.0	36.4	36.6	33.7	34.0	35.1	34.6	31.4	29.0
2006	28.2	35.9	38.5	37.1	36.8	35.0	35.6	35.2	35.7	34.7	32.6	30.1
2007	28.8	30.8	36.7	35.9	37.5	35.9	34.8	35.9	34.9	35.6	31.8	28.2
2008	29.0	30.6	34.6	36.9	36.7	35.4	34.0	36.0	34.8	34.8	32.3	29.0
2009	28.1	33.9	36.0	39.6	37.8	36.5	35.7	34.3	35.3	35.8	33.9	29.0
2010	29.0	31.2	37.3	37.9	36.9	35.8	35.1	35.1	34.0	35.7	33.2	29.7
2011	27.8	31.0	34.5	35.8	35.3	36.0	35.4	35.0	36.2	34.5	32.4	30.0
2012	28.5	33.0	37.3	37.1	36.2	36.7	34.3	34.5	36.5	34.4	32.4	28.5
2013	28.1	32.4	36.0	37.0	37.1	36.4	34.6	35.0	35.7	35.2	32.1	30.5

Source-BMD

Table 8-4: Monthly Lowest Minimum Temperature (based on observations from 2004-2013)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	10.7	10.4	16.3	18.5	20.2	22.4	21.5	24.8	22.7	21.5	15.8	11.5
2005	11.4	11.5	19.0	19.6	19.7	22.5	24.0	24.3	23.8	20.8	16.0	12.2
2006	10.4	15.4	16.3	20.2	20.4	22.3	24.6	22.7	23.8	21.8	13.3	12.6
2007	9.6	12.6	15.0	18.1	22.5	22.0	23.4	24.2	24.5	19.5	16.8	11.3
2008	10.5	10.8	16.5	19.6	20.3	22.5	24.6	23.6	24.4	18.0	16.3	13.0
2009	11.1	12.2	15.8	20.4	21.6	22.6	24.4	24.3	24.5	20.6	15.2	11.4
2010	9.6	12.0	18.4	20.8	21.3	23.2	25.3	25.0	24.8	21.5	16.6	11.0
2011	8.2	13.0	16.0	20.2	21.3	23.2	23.9	24.5	23.7	22.0	17.2	11.0
2012	10.5	12.2	18.3	19.0	20.5	23.2	25.2	24.4	24.9	20.3	14.8	9.6
2013	7.2	14.0	16.7	19.8	20.0	22.0	24.5	24.5	24.2	20.1	16.0	11.8

Source-BMD

Relative Humidity

Based on the data of 2004-2013, the lowest monthly humidity was recorded in February, 2012 (about 52%) and the highest humidity was recorded in September, 2004 (about 85%). In the winter months, the relative humidity is comparatively less ranging between 54-74%. However, the relative humidity values are much higher during monsoon season. The following ***Error! Reference source not found.*** depicts the monthly and annual average humidity data with a time period of 2004-2013.

Table 8-5: Monthly Relative Humidity (based on observations from 2004-2013)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	73	60	62	72	67	81	81	78	85	74	69	70
2005	68	60	66	66	73	79	81	82	81	80	72	66
2006	69	65	53	67	72	81	80	77	80	76	68	69
2007	68	68	54	69	70	81	84	80	80	78	77	69
2008	69	61	67	64	70	80	83	81	81	77	69	79
2009	72	55	53	66	72	74	80	82	81	73	66	69
2010	71	56	59	67	71	79	77	78	79	74	68	66
2011	69	54	57	64	76	80	79	82	77	73	67	73
2012	66	52	57	69	70	77	79	78	79	71	68	77
2013	65	55	55	63	78	76	77	80	81	78	66	72

Source-BMD

Rainfall

The south-west monsoon sets in from the last week of June and withdraws at the end of September, contributing about 80% of annual rainfall. The rainfall follows the general climate pattern with the highest rainfall in duration of June to September and minimum rainfall during November to March. July and August are the wettest months with annual average rainfall of 1900m. The rest of 20% rainfall is received during non-monsoon months. ***Error! Reference source not found.*** presents a verage monthly rainfall for the period of 2004-2013. According to it, the highest (839 mm) rainfall was observed in September, 2004.

Table 8-6 Monthly Rainfall (based on observations from 2004-2013)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	0	0	9	167	162	476	295	191	839	208	0	0	**2347**
2005	1	3	155	91	291	259	542	361	514	417	3	0	**2637**
2006	0	0	0	181	185	326	331	167	663	61	5	0	**1919**
2007	0	30	11	163	185	628	753	505	179	320	111	0	**2885**
2008	23	56	45	91	205	577	563	319	279	227	0	0	**2385**
2009	1	1	43	14	168	170	676	482	298	74	4	0	**1931**
2010	0	48	22	37	177	308	167	340	169	174	0	81	**1523**
2011	0	0	20	123	235	314	356	409	207	112	0	0	**1776**
2012	10	1	37	269	137	175	226	282	81	38	68	5	**1329**
2013	0	8	26	32	378	325	302	212	172	131	0	4	**1590**

Source-BMD

Wind Speed/ Direction

Based on the meteorological observations from 2004-2013 it is observed that winds are strongest during the months of May to August. Generally winds blow flow to west and northwest during the months of November to February and to south and southeast during the months of March to October. The annual average wind speed during this period was observed to be 1.7 m/sec.

The pattern shows that the maximum wind speeds is observed during month of October 2008 (4.9 m/s). The details of average wind speeds and wind direction have been presented in *Error! R eference source not found.*.

Table 8-7: Wind Speed in m/sec (based on observations from 2004-2013)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	1.8	2.0	2.9	3.0	2.8	1.8	2.2	2.1	3.2	2.1	1.6	1.7
2005	2.1	2.2	2.3	2.3	2.2	2.2	2.3	1.8	2.3	2.4	1.7	1.9
2006	1.5	1.8	2.6	1.9	1.9	1.1	1.1	2.3	2.8	1.2	1.1	1.2
2007	1.5	1.6	2.1	1.9	1.8	1.6	1.6	1.6	1.6	2.1	2.8	1.5
2008	1.8	1.6	1.9	1.7	1.7	1.7	1.7	1.4	1.4	4.9	1.3	1.7
2009	1.7	2.1	2.0	2.1	1.9	1.6	2.2	1.4	2.1	1.2	1.4	1.2
2010	1.5	1.7	1.9	2.1	1.9	1.5	1.2	1.1	1.3	1.0	1.5	1.2
2011	1.1	1.2	1.9	1.2	1.5	1.4	1.2	1.2	1.3	1.0	1.2	1.1
2012	1.2	1.5	1.3	1.3	1.3	1.5	1.4	1.3	1.1	1.0	1.1	1.2
2013	1.2	1.1	1.3	1.4	1.6	1.2	1.4	1.4	1.1	1.5	1.1	1.2

Source-BMD

Table 8-8: Wind Direction (based on observations from 2004-2013)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	W	W	S	S	S	S	SE	SE	E	SE	W	NNW
2005	NNW	W	S	S	S	SE	SE	S	SE	SE	NW	NNW
2006	N	S	NNW	S	S	S	SE	SE	SE	N	NW	NW
2007	NW	NW	NW	S	S	S	S	S	S	NE	NE	NW

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	N	N	S	S	S	S	S	S	S	NE	NE	W
2009	W	W	W	S	S	S	SE	S	SE	E	N	NW
2010	NW	W	S	S	S	S	S	S	SE	NE	N	N
2011	W	W	S	S	S	SE	SE	SE	SE	NW	W	NW
2012	W	W	S	S	S	S	SE	SE	E	S	W	W
2013	W	W	W	S	E	S	SE	SE	S	SE	N	W

Source-BMD

8.4.8.2 Project Area Specific Micro Meteorology

A weather station was installed at Vati Bolaki Govt.Primary School, Hossendi, Gozaria, Munshigonj for continuous recording of data for 24-hour period for during November 2013– February 2014. Parameters that were recorded were wind speed, wind direction, temperature, relative humidity and rainfall. The meteorological data is tabulated below in *Table 8-9.*

Table 8-9: Meteorological Monitoring Data

	Wind Speed (m/ sec)	Temperature (°C)	Relative Humidity (%)
Maximum	5.7	31.9	97.9
Minimum	0.0	10.2	22.4
Average	0.3	20.2	76.3

Source: Site Specific Metreology, Adroit

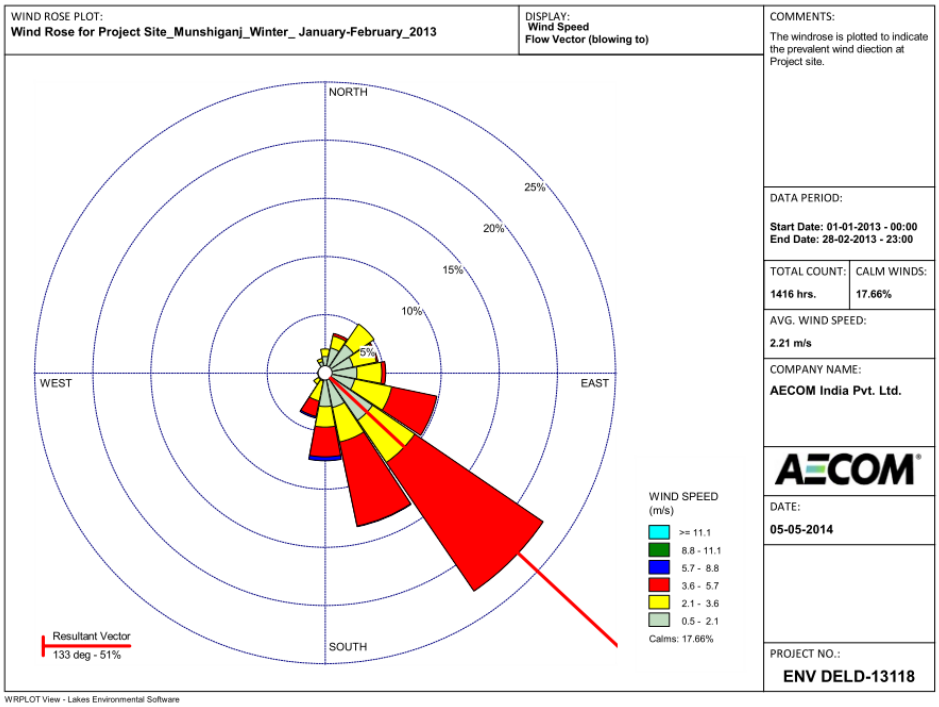
The average temperature in the study area during monitoring period (Nov, 2013 – h February 2014) was 20.2°C while the maximum temperature went up to 31.9°C. The minimum temperature during monitoring period dipped to 10.2°C. The relative humidity in the area ranged between 22% and 98%. The average humidity value in the area was recorded at 76.3%. There was hardly any rainfall at the monitoring location throughout the monitoring period with average rainfall of 0.006mm. The average wind speed in the area was recorded at 0.3 m/sec and 74.3% of the time the wind was calm in the study area. The prominent wind direction during study period is blowing to south-east.

Hourly surface and upper air MM-5 processed surface meteorological data was procured for the study area from Lakes Environmental representing one year period from January 1, 2013 to December 31, 2013. As discussed earlier, the Bangladesh climate is characterised by four distinct seasons as established by the Bangladesh Meteorological Department (BMD).[9] The seasonal wind rose plot for the four seasons (winter, summer, monsoon and autumn) and annual plot have been given in

Figure 8-8*, Figure 8-9*, *Figure 8-10*, *Figure 8-11* and *Figure 8-12* respectively. It is observed that the predominant wind directions are towards SE during winter (northeast monsoon), NNE during summer (pre-monsoon), NNW during monsoon, and WNW during autumn (post-monsoon) months.

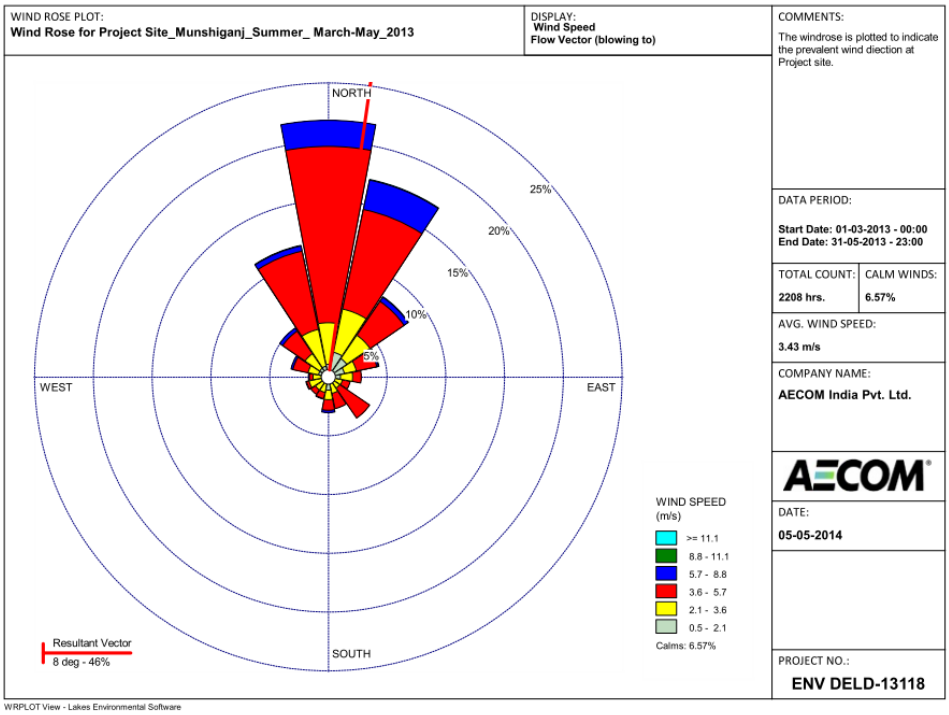
[9] http://www.jma.go.jp/jma/en/Activities/RIC_Workshop_2013/documents/pre/01.%20presentation%20(Bangladesh).pdf

Figure 8-8: Wind Rose diagram for study area for Winter Season (January-February 2013)



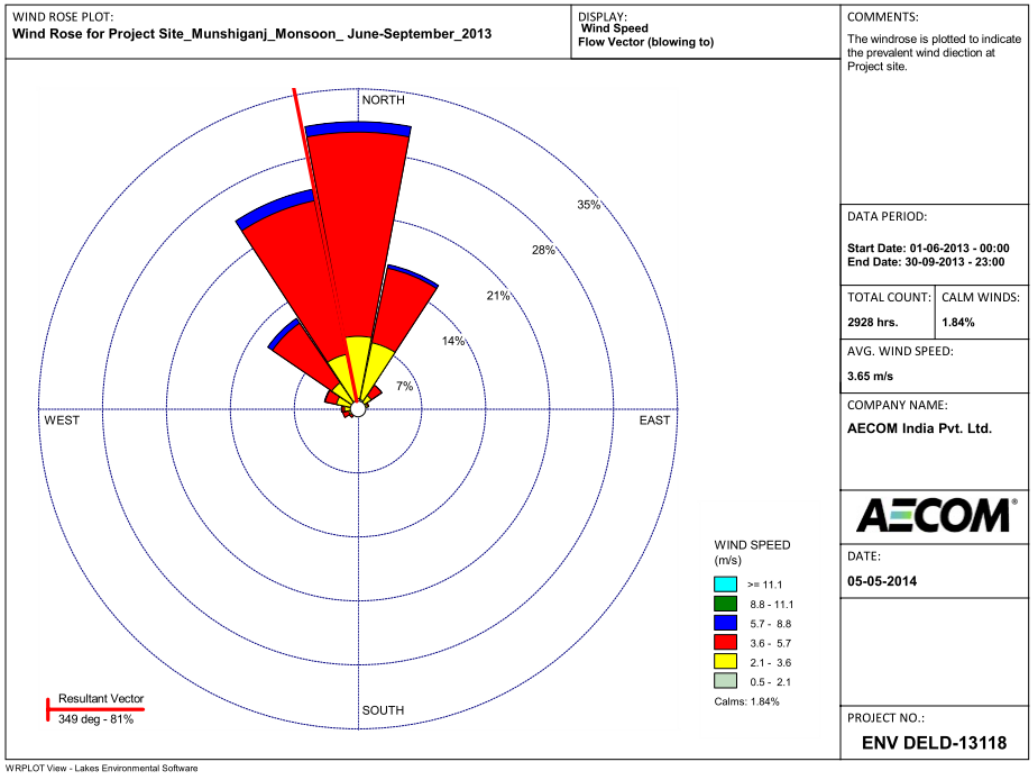
Source: Lakes Pre-processed Met Data

Figure 8-9: Wind Rose diagram for study area for Summer Season (January-February 2013)



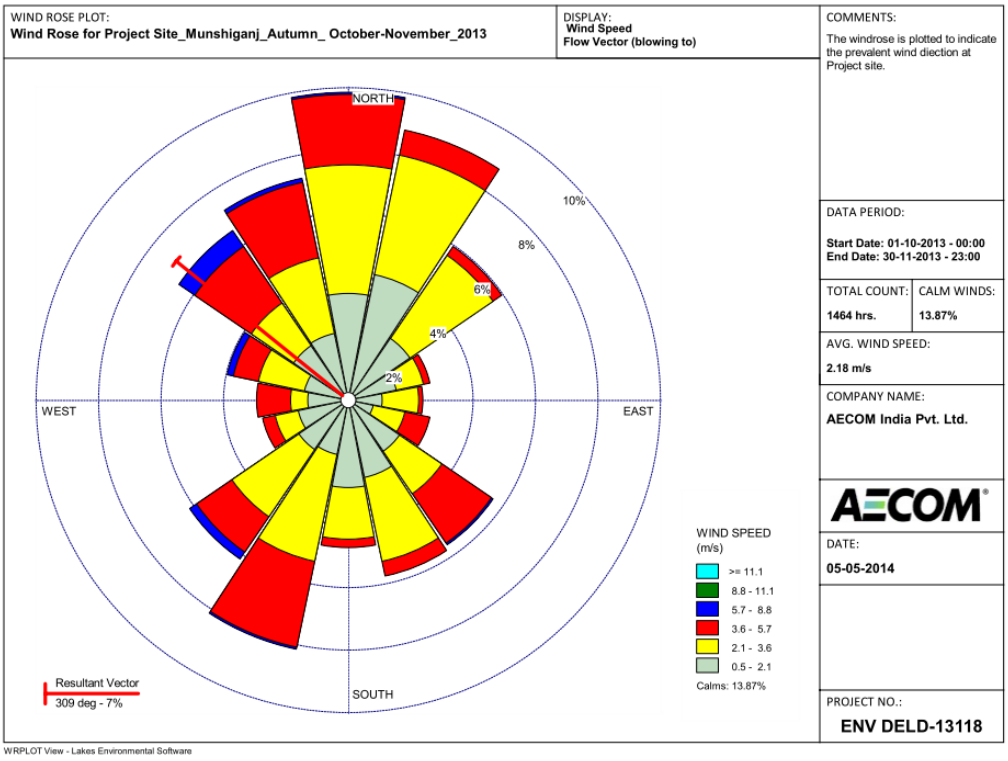
Source: Lakes Pre-processed Met Data

Figure 8-10: Wind rose for study area for Monsoon Season (June-September 2013)



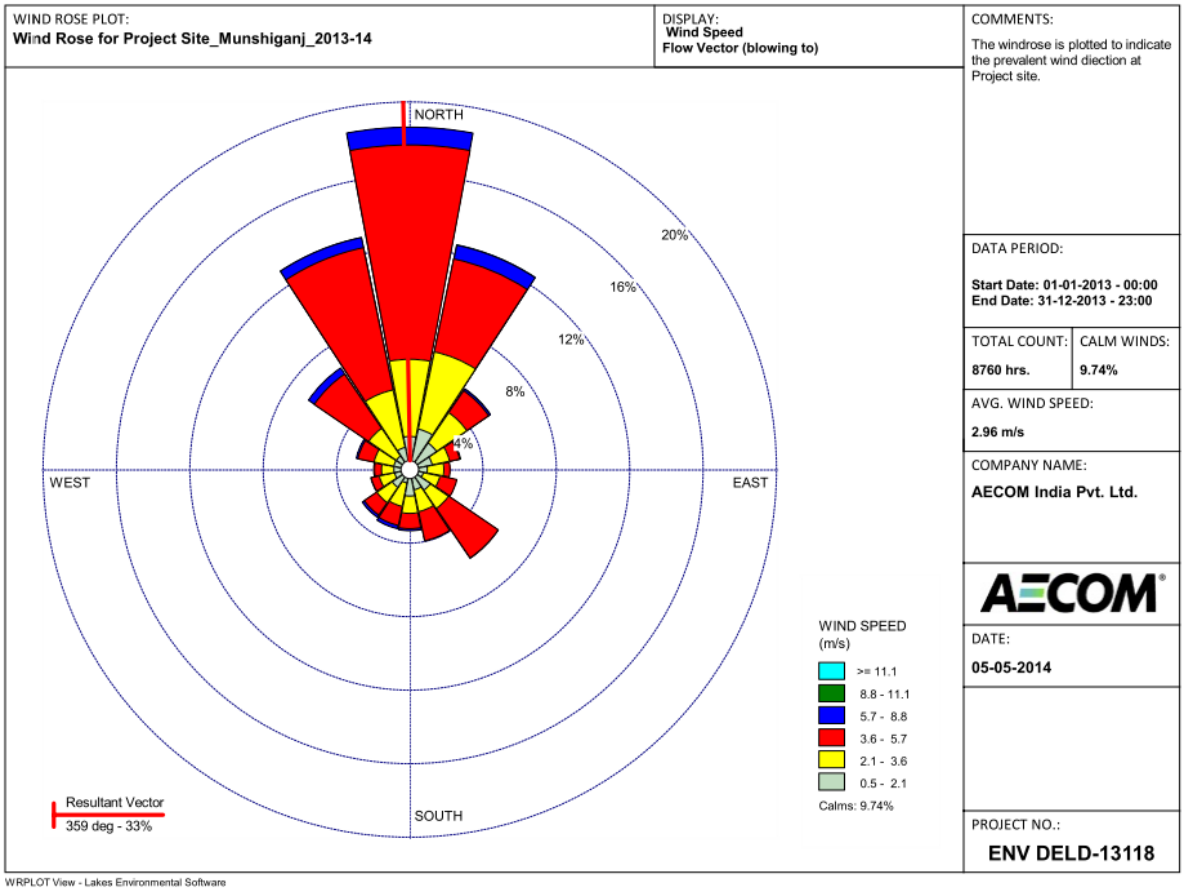
Source: Lakes Pre-processed Met Data

Figure 8-11 : Wind Rose Diagram for study area for Autumn Season (October-November 2013)



Source: Lakes Pre-processed Met Data

Figure 8-12: Annual Wind Rose Diagram for study area (January-December 2013)

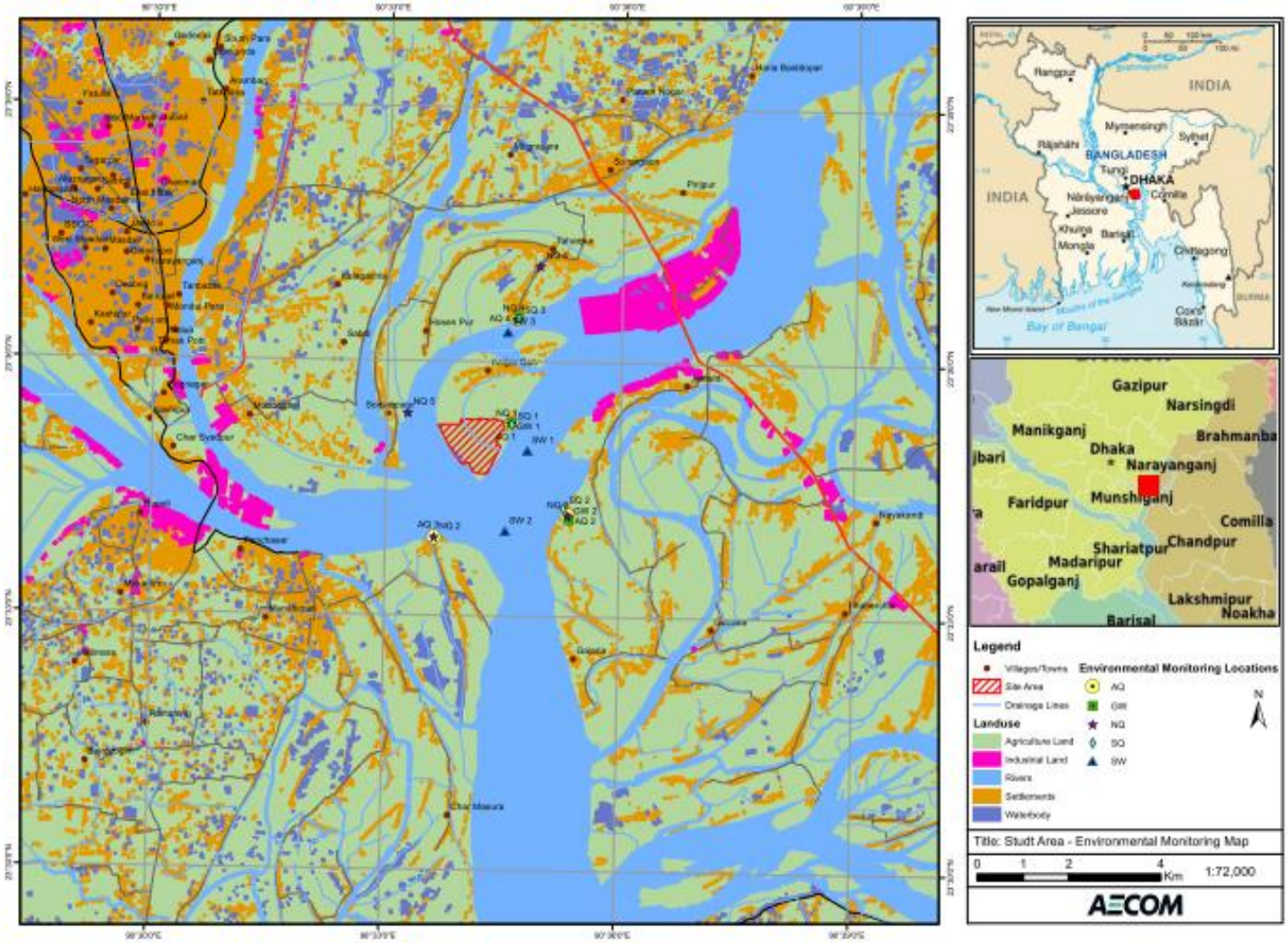


Source: Lakes Pre-processed Met Data

8.5 Primary Monitoring

Primary monitoring was carried out during the period of November, 2013 to February, 2014 by Adroit Environment Consultants Limited (AECL) (Lab recognized by Government of Bangladesh) to evaluate the baseline environmental parameters. It has a government approved environmental laboratory equipped with the facility of examining all kinds of water, noise and air quality parameters. The monitoring was done for ambient air quality, water quality, ambient noise levels and soil quality of the study area. Environmental monitoring location map has been shown in *Figure 8-13.*

Figure 8-13: Environmental Monitoirng Location Map



8.5.1 Ambient Air Quality

Air quality monitoring was conducted to assess the ambient air quality in the study area and also to check its conformity with the ambient air quality standards specified by the Department of Environment (DoE) as well as with the interim taget – 1 limits specified by IFC/WB. Four air quality monitoring locations were identified within 5km radius of the proposed project site. Adroit Environment Consultants Limited (AECL) conducted the monitoring exercise. The details of the monitoring locations have been furnished in the *Table 8-10.*

Table 8-10: Details of the air quality monitoring stations

S.No	Monitoring Location	Loc. ID	Geographical Coordinates		Direction to the site	Distance from the site (km)
			Latitude	Longitude		
1.	5 No.Vati Bolaki Govt. Primary School, Hossendi, Gozaria, Munshiganj	AQ 1	23°35'16.17'' N	90°34'36.20'' E	NE	1.2
2.	Gowal Gao, Gozaria, Munshiganj	AQ 2	23°34'11.90'' N	90°35'20.30" E	E	2.14
3.	Chorhogla/Balirghat, Kashimnagar, Sonargaon, Narayanganj	AQ 3	23°33'55.50'' N	90°33'37.70" E	SW	1.7
4.	Pachani, Mongoler Gao, Sonargaon, Narayanganj	AQ 4	23°36'30.60'' N	90°34'39.70'' E	N	3.3

Six parameters were analysed for establishing the baseline ambient air quality in the Project area. Air quality monitoring was conducted on a 24hourly basis for a period of 12 weeks (i.e., 3 months) at the aforementioned monitoring locations. Statistical analysis was carried out for all the parameters to identify outliers. The monitoring results have been provided in *Table 8-11.*

Table 8-11: Observed Ambient Air Quality

S.N	Parameter	Test Duration(hrs)	Unit	Standards		Value		
				DOE	IFC/WB Interim Target - 1	Range	Average	98th percentile
1.	$PM_{2.5}$	24	µg/m3	65	75	17 – 86	31.25 - 44.88	49.70 - 76.80
2.	PM_{10}	24	µg/m3	150	150	46 – 310	133.1 - 215.2	191.6 - 298.5
3.	SPM	24	µg/m3	200	NF	107 – 589	250.08 - 372.79	358.1 - 578.4
4.	SO_2	24	µg/m3	365	125	14 – 41	22.38 - 30.08	30.62 - 40.08
5.	NO_x	24	µg/m3	NF	200	19 – 56	29.71 - 39.29	38.00 - 55.54
6.	CO	8	µg/m3	10000	NF	100 – 410	178.25 - 270.17	265.40 - 400.80

Respirable Dust Sampler Make Enviro Tech Model APM 460 BL was used for carrying out air quality monitoring. The last date of calibration was 14th Jan, 2013. Mini PM 2.5 Sampler, model number AAS 127 Mini was last calibrated on 31st July, 2013. Rota meter (SI No. 10/0708) was last calibrated on 14th Jan, 2013. The inferences pertaining to the various air quality parameters that have been drawn from the monitoring results have been presented as follows.

8.5.1.1 Particulate Matter - $PM_{2.5}$

$PM_{2.5}$ stands for particulate matter of size ≤2.5 µm. The DoE prescribed standard/limit for $PM_{2.5}$ is 65 µg/m^3 whereas that specified by IFC is 75 µg/m^3. Hence, the former shall be conformed to as it's more stringent of the two. The $PM_{2.5}$ levels observed during monitoring at the four locations have been represented in the *Figure 8.15.*

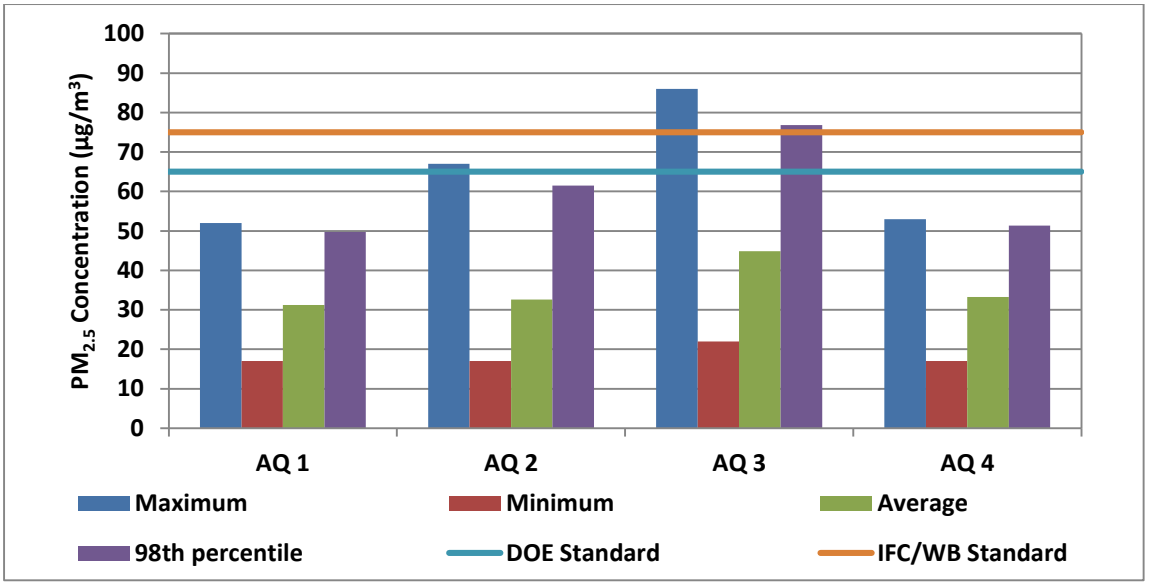
- It can be seen that the maximum, minimum, average as well as the 98th percentile values at AQ 1, which lies approximately 1.3 km from the proposed project site, are well within the DoE limit. The $PM_{2.5}$ levels ranged from a minimum of 17 µg/m^3 to a maximum of 52 µg/m^3 at the location. The average $PM_{2.5}$ level at the location over the monitoring period, was 31.25 µg/m^3 and 98th percentile value lied at 49.7 µg/m^3.

- The maximum $PM_{2.5}$ level of 67 µg/m^3 was recorded at AQ 2, which is in excess of the DoE limit. A minimum of 17 µg/m^3 was recorded at the location. The average and 98th percentile values observed at the location are 32.58 µg/m^3 and 61.48 µg/m^3 respectively.

- Relatively higher $PM_{2.5}$ levels were recorded at AQ 3. The maximum level (86 µg/m^3) exceeds the DOE as well as the IFC prescribed limit. A minimum of 22 µg/m^3 was observed whereas the average and the 98th percentile values stood at 44.88 µg/m^3 and 76.8 µg/m^3. The high $PM_{2.5}$ levels can be attributed to the fact that the monitoring location is situated in a market area and is also proximity to the Meghna River which is major route on which Dhaka bound ships ply. A number of cement plants are located in the vicinity of this area, hence contributing to the high particulate concentration.

- At AQ 4, the values ranged from 17-53 µg/m^3 whereas the average and 98th percentile values were observed to be 33.23 µg/m^3 and 51.32 µg/m^3 respectively. Thus, the values are well within the limit prescribed by the DoE.

Figure 8-14: Graphical representation of observed $PM_{2.5}$ levels



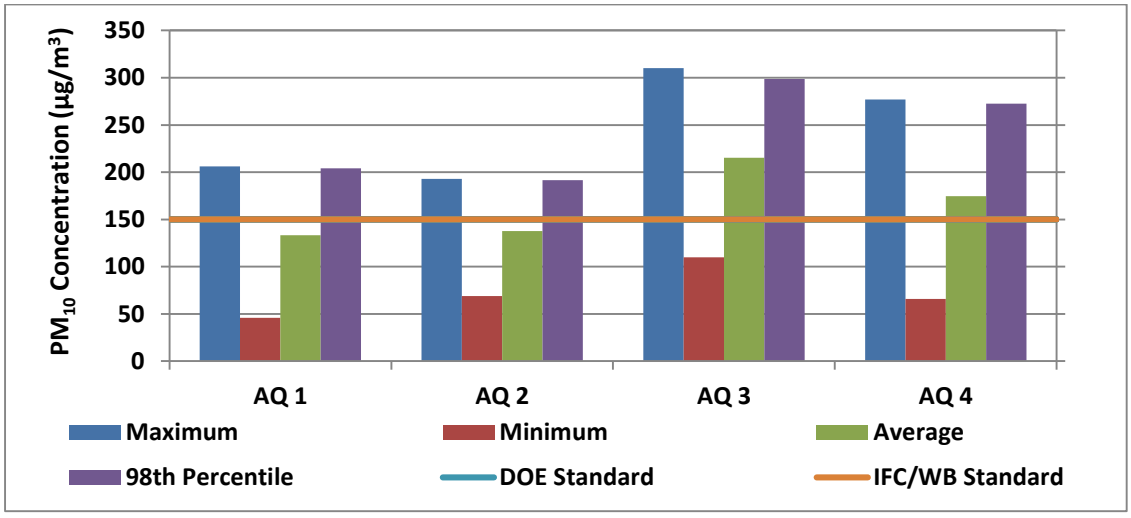
8.5.1.2 Particulate Matter - PM $_{10}$

PM_{10} refers to particulate matter whose diameter is ≤10 µm but >2.5 µm. Both DoE and IFC have prescribed a maximum limit of 150µg/m^3 for PM_{10} in ambient air in an industrial area. The PM_{10} levels recorded at the four monitoring locations during the monitoring period have been illustrated in the *Figure 8-15.*

- PM_{10} concentrations in excess of the prescribed limit were recorded at all the four locations. At AQ 1, the values ranged from 46-206 µg/m^3. Whereas the average and 98th percentile values were found to be 133.13 µg/m^3 and 204.16 µg/m^3 respectively.

- AQ 3 owing to its proximity to cement plants, market area and busy ship routes experiences high level of particulate matter. A maximum of 310µg/m^3 and a minimum of 110µg/m^3 were recorded at the location. The average and 98th percentile values were observed to be 215.17µg/m^3 and 298.5µg/m^3 respectively.

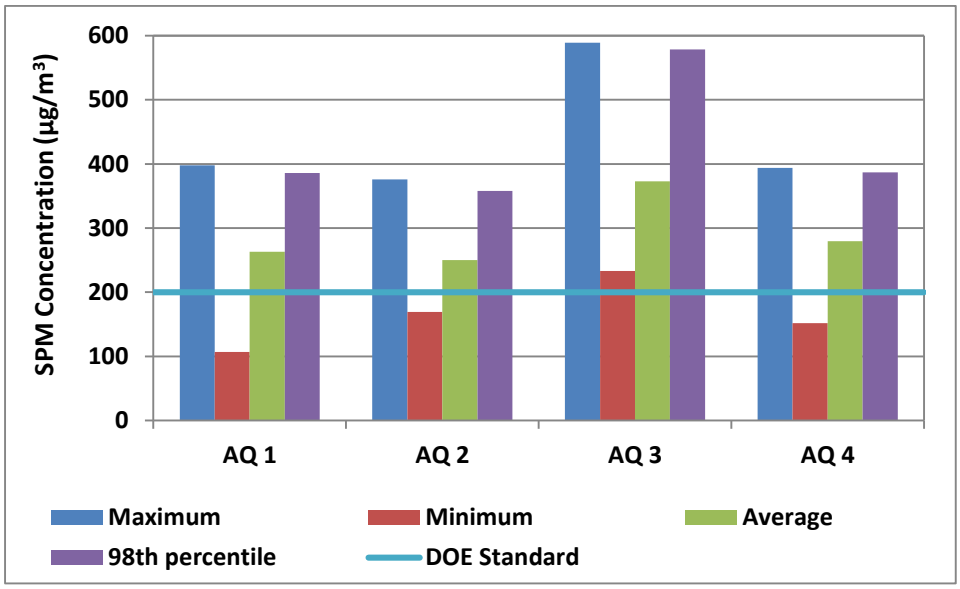
Figure 8-15 Graphical representation of observed PM_{10} levels



8.5.1.3 Suspended Particulate Matter

- The concentration across the locations ranged from a minimum of 107µg/m^3 to a maximum of 589µg/m^3. The average and 98th percentile values ranged from 250.08 - 372.79 µg/m^3 and 358.1 - 578.4 µg/m^3 respectively.
- The exceptionally high values of SPM at AQ 3 are due to its proximity to cement manufacturing plants, market area and ship routes which experience high traffic.

Figure 8-16 : Graphical representation of observed SPM levels

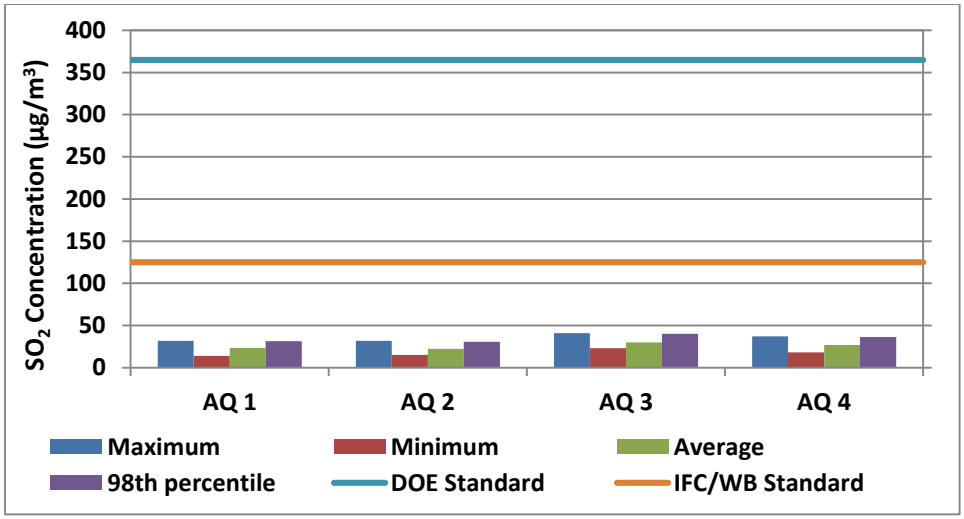


8.5.1.4 Sulphur Dioxide (SO_2)

A limit of 365µg/m^3 has been prescribed by the DOE for ambient air SO_2 concentration in an industrial air shed whereas IFC has prescribed a limit of 125 µg/m^3 for the same. Since the latter value is more stringent of the two, hence it has been referred for assessing conformity of baseline ambient air quality. The SO_2 levels observed during monitoring at the four locations have been illustrated in *Figure 8-17.*

- It can be seen that SO_2 concentration at all the four locations are well within the IFC limit. This can be attributed to the lack of industrial activity and vehicular movement in the area. AQ 1 which is situated closest to the project site recorded SO_2 levels from 14-32 µg/m^3.
- AQ 3 recorded highest SO_2 concentrations amongst the four locations. This is due to the industrial and commercial vehicular movement around the area.

Figure 8-17 : Graphical representation of observed SO_2 levels

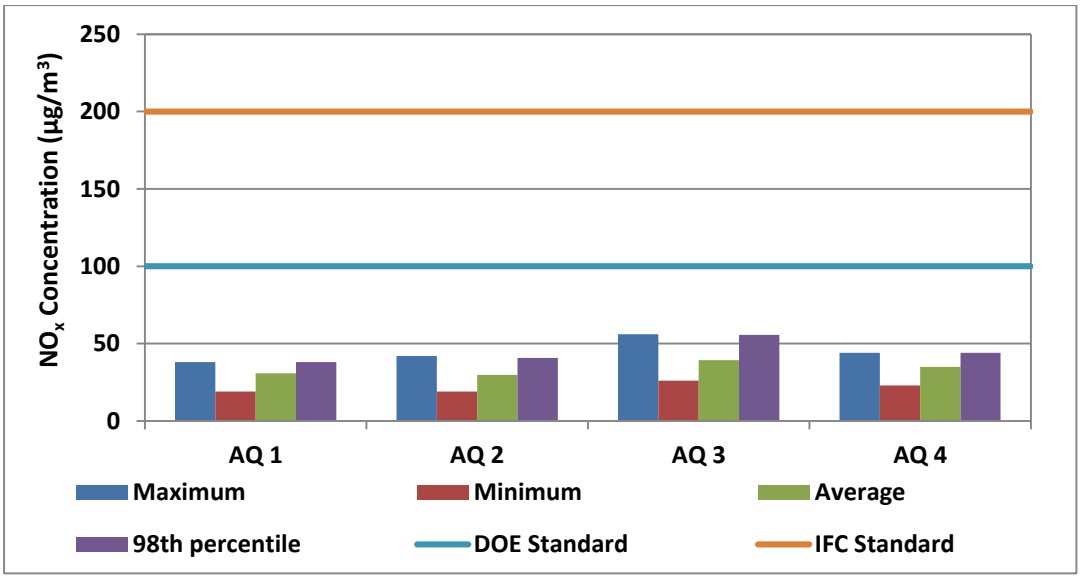


8.5.1.5 Oxides of Nitrogen (NO_x)

The NOx monitoring results have been illustrated in the *Figure 8-18.* Both IFC and DOE have prescribed standards for annual average concentrations of NOx. It is pertinent to mention that the annual average air quality standards are more stringent than the 24 hourly standards because the 24 hourly standards have to take into consideration events of low dispersion such as low mixing height, winter season whereas the annual average concentrations represent the value averaged over a long period of time thereby balancing the events of occurrence of high concentrations.

It can be seen that NOx levels at all the monitoring locations are much lower than the maximum limit prescribed by the DOE and IFC. The NOx levels across the locations ranged from 19-56 µg/m^3 whereas the average values ranged from 29.71 - 39.29 µg/m^3. The maximum levels were recorded at AQ 3 which can be attributed to the presence of industries and vehicular movement in the area. A maximum NO_x concentration of 56 µg/m^3 and minimum of 26 µg/m^3 were observed in the area.

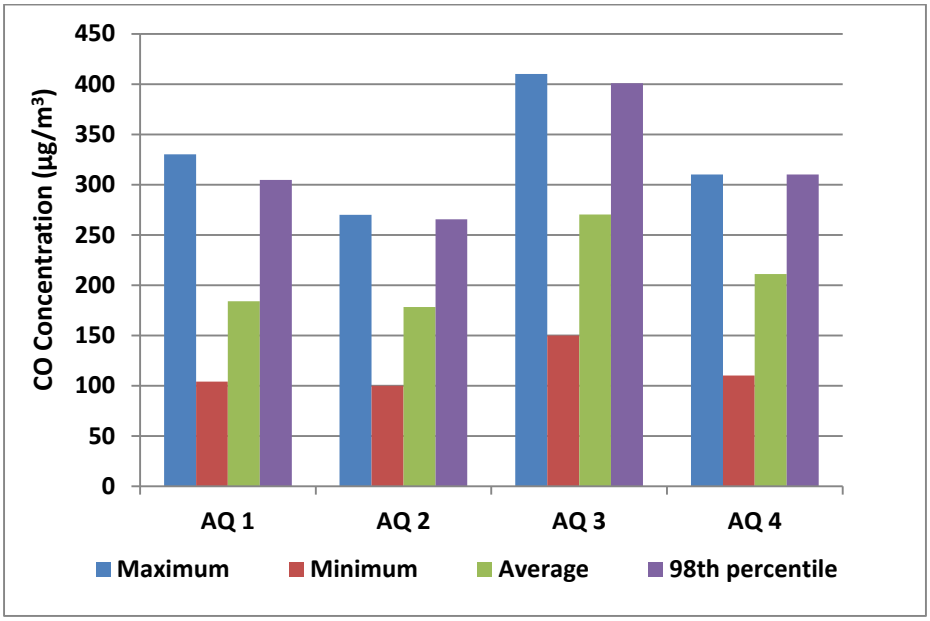
Figure 8-18 : Graphical representation of observed NO_x levels



8.5.1.6 *Carbon Monoxide (CO)*

An ambient air CO concentration limit of 10,000µg/m^3 has been specified by the DoE in an industrial area. However, no such limit has been specified by the IFC. The observed concentrations at all the four locations are significantly lower than the prescribed limits. The recorded CO levels ranged from 100 – 410 µg/m^3 whereas the average and 98th percentile values ranged from 178.25 - 270.17 µg/m^3 and 265.40 - 400.80 µg/m^3. Out of the four locations, AQ 3 recorded the highest levels of CO. This can be attributed to vehicular movement and industrial activity in the area. A maximum of 410 µg/m^3 and minimum of 150 µg/m^3 were observed at the location.

Figure 8-19 : Graphical representation of observed CO levels



8.5.1.7 *Airshed around the project site*

Ambient air quality parameters are monitored on a regular basis by the DOE using CAMS (Continuous Air Monitoring Stations) in Bangladesh. One of the CAMS is located at Narayanganj area where the air shed is quite similar to that of the proposed project site. Narayanganj is an industrial area and there are many power projects already established in the area. The data for six criteria pollutants (i.e., pollutants regulated by law) for the four months' period during March 2013 to June 2013 are shown in *Table 8-12.*

Table 8-12: Observed: Air Quality Data (Narayanganj CAMS, Dhaka)

SN o.	Parameter	Unit	NAAQS	Period	Monthly Average Data				4 month's Average
					Mar 2013	Apr 2013	May 2013	Jun 2013	
1	PM2.5	µg/m3	65	24 hr	115.56	50.53	24.11	21.7	52.98
2	PM10	µg/m3	150	24 hr	235.18	132.66	64.90	77.4	127.54
3	SO2	PPB	140	24 hr	22.80	8.59	5.12	2.87	9.85
4	NOx	PPB	53	Annual	4.57	12.84	13.17	15.2	11.45

SN o.	Parameter	Unit	NAAQS	Period	Monthly Average Data				4 month's Average
					Mar 2013	Apr 2013	May 2013	Jun 2013	
5	CO	PPM	9	8 hr	0.65	0.25	N/A	0.37	-
6	O_3	PPB	80	8 hr	10.42	8.57	12.29	8.46	9.94

Source: Adroit

$PM_{2.5}$ - Fine ParticulateMatter (EAD<2.5µm)
PM_{10} - ParticulateMatter (EAD<10µm)
SO_2 - Sulfurdioxide
NO_X- Oxides of Nitrogen
CO- Carbone Mono-oxide
EAD- Effective Aerodynamic Diameter

The above data demonstrates that the concentrations of $PM_{2.5}$ and PM_{10} are within the limit compared to the NAAQS. For the gaseous pollutants, the levels obtained are also within NAAQS. An air shed where NAAQS are within the limit is referred to as a non-degraded air shed as per the Environmental, Health & Safety guidelines (for Thermal power plant) of IFC released in December, 2008.

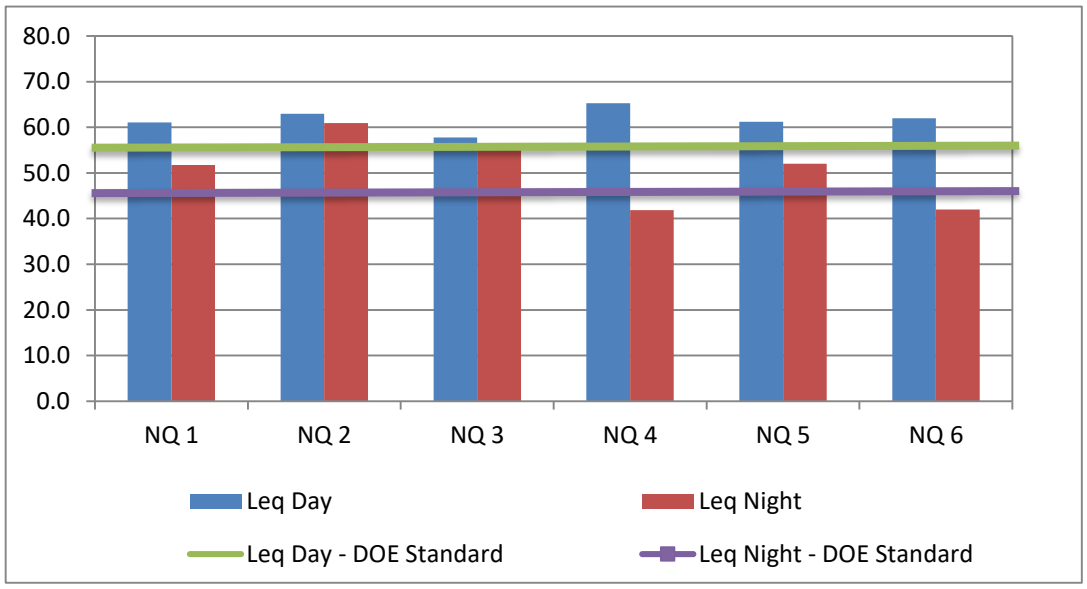
8.5.2 Noise Quality

In order to establish the baseline status of noise environment in the Project Area, ambient noise levels were monitored at six locations in the Project Area. All the identified locations are characterised by rural settings and lie within 5 km radius of the proposed project site. The geographical coordinates and other details of the identified noise receptor locations where monitoring was conducted has been furnished in the following ***Table 8-13.***

Table 8-13: Details of the identified noise receptor locations

S.No	Receptor location	Receptor ID	Geographical Coordinates		Direction to the proposed project site	Approx. distance of receptor from proposed project site (km)
			Latitude	Longitude		
1.	Vati Bolaki, Hosseindi, Gozaria, Munshiganj	NQ 1	23˚35'16.17" N	90˚34'36.20" E	NE	1.2
2.	Chor Hogla, Gozaria, Munshiganj	NQ 2	23˚33'55.50" N	90˚33'37.70" E	SW	1.7
3.	Goawl gaw, Gozaria, Munshiganj	NQ 3	23˚34'11.90" N	90˚35'20.30" E	E	2.14
4.	Pachani,Sonargaon Naringong	NQ 4	23˚36'30.60" N	90˚34'39.70" E	N	3.3
5.	Shombhupura, Sonargaon, Narayanganj	NQ 5	23˚35'23.21" N	90˚33'16.45" E	NE	2.02
6.	Taan Bolaki, Hosseindi, Gozaria, Munshiganj	NQ 6	23˚36'68.00" N	90˚34'56.64" E	W	3

Source: Adroit



Primary noise monitoring was conducted using Lutron Sound Level Meter (Model – 4010) continuously for 24 hours at the identified receptor locations in order to evaluate the baseline noise levels in the project site. Adroit Environment Consultants Limited was responsible for carrying out the monitoring exercise. The noise levels (measured on A-weighted scale) obtained were analyzed to arrive at the equivalent continuous noise level (Leq) for day and night time. The day and night time hours as prescribed by the DoE are from 0600 to 2100 hrs. and 2100 to 0600 hrs. respectively. The results of the ambient noise level monitoring along with DoE and IFC/WB noise limits for day time and night time have been furnished in the following ***Table 8-14.***

Table 8-14: Results of ambient noise level monitoring

Receptor ID	Leq Day (dBA)	Leq Night (dBA)
NQ 1	61.1	51.7
NQ 2	63.0	60.9
NQ 3	57.8	56.5
NQ 4	65.3	41.8
NQ 5	61.2	52.0
NQ 6	62.0	42.0
DoE Standard	55	45
IFC/WB Standard	55	45

Note: DoE and IFC/WB Standards specified are for industrial areas

It can be seen that the noise levels at the receptor locations ranged from 57.8 dBA to 65.3 dBA during daytime and 41.8 dBA to 60.9 dBA during night time.

The ambient noise levels were found to exceed the day time and night time limits prescribed by DoE as well as those laid down by IFC. Relatively higher noise levels at NQ 2 (Chorhogla) can be attributed to vehicular noise and industrial activities taking place in the area. ***Figure 8-20*** illustrates the noise levels monitored at the receptor locations.

Figure 8-20: Noise levels monitored at receptor locations

8.5.3 Surface and Ground Water Quality

Surface and ground water samples were collected and analysed in order to establish the baseline water quality in the project region. AECL had responsibility of conducting water quality monitoring. The collected samples were analysed in **three** laboratories viz.

1. ICDDRB laboratory- The International Centre for Diarrhoeal Disease Research, Bangladesh;
2. Adroit Environment Consultants Limited (AECL) laboratory; and
3. Dhaka University - Department of Soil, Water and Environment laboratory

Flow Meter was utilized to carry out water quality monitoring which was last calibrated on 14th Jan, 2013.

8.5.3.1 Surface water quality

River Meghna is the only surface water body adjacent to the project site. The river carries run-off water from adjoining areas, which might contain some pollutants. Samples were taken from three different positions on the river. The collected river water samples were analyzed in the three aforementioned laboratories. The details of sampling locations have been furnished in the *Table 8-15.*

Table 8-15: Details of surface water sampling locations

S.No	Sampling Location	Location ID	Geographical Co-ordinates	
			Latitude	Longitude
1.	Vati Bolaki	SW 1	23°34'57.24" N	90°34'48.42" E
2.	Gowal gao	SW 2	23°34'00.27" N	90°34'41.32" E
3.	Pachani	SW 3	23°36'21.09" N	90°34'32.20" E

Source: Adroit

The various parameters analysed were evaluated against the Bangladesh DoE standards for inland surface water. The results of water quality monitoring have been provided in the *Table 8-16.*

Table 8-16: Surface Water Quality monitoring results

S.No.	Parameter	DoE Standard for Inland Surface Water	Recorded Value		
			SW 1	SW 2	SW 3
1.	Colour	-	Colourless	Colourless	Colourless
2.	Turbidity	10 NTU	4.9 NTU	2.06 NTU	3.17 NTU
3.	pH	6 to 9	7.0	7.0	7.0
4.	Temperature	40°C	25.4°C	25.4°C	25.4°C
5.	Conductivity	1200 µS/cm	550 µS/cm	720 µS/cm	332 µS/cm
6.	Total Dissolved solids(TDS)	2100mg/L	280 mg/L	370mg/L	133mg/L
7.	Total Suspended solids(TSS)	150mg/L	6 mg/L	8 mg/L	10 mg/L
8.	Total hardness	200-500	57.0 mg/L	75.0 mg/L	60.0 mg/L
9.	Salinity	-	0.1 ppt	0.1 ppt	0.1 ppt
10.	Total Alkalinity	-	60.0 mg/L	70.0 mg/L	50.0 mg/L
11.	Dissolved Oxygen(DO)	4.5-8 mg/L	6.8mg/L	6.7mg/L	6.8mg/L
12.	Chemical Oxygen Demand	200mg/L	16.4 mg/L	14 mg/L	18 mg/L

	(COD)				
13.	Biological Oxygen Demand (BOD)	50mg/L	6.8 mg/L	6 mg/L	8 mg/L
14.	Oil and Grease	10 mg/L	Less than 5	6.42 mg/L	5.26 mg/L
15.	Calcium	75 mg/L	16.8 mg/L	18.4 mg/L	14.8 mg/L
16.	Phosphate	6 mg/L	0.13 mg/L	0.28 mg/L	0.16 mg/L
17.	Sulphate	400 mg/L	15.0 mg/L	19.70 mg/L	15.0 mg/L
18.	Iron	0.3-1.0 mg/L	0.34 mg/L	0.21 mg/L	0.14 mg/L
19.	Fluoride	2 mg/L	Not detected	Not Detected	Not Detected
20.	Nitrate	10 mg/L	7.52 mg/L	6.52 mg/L	4.01 mg/L
21.	Chloride	600 mg/L	47.4 mg/L	51.9 mg/L	55.2 mg/L
22.	Magnesium	-	40.58 mg/L	46.47 mg/L	31.45 mg/L
23.	Total coliform	0 CFU/100mL	55 CFU/100mL	52 CFU/100mL	44 CFU/100mL
24.	Fecal coliform	0 CFU/100mL	26 CFU/100mL	23 CFU/100mL	32 CFU/100mL
Heavy Metals					
25.	Copper	1 mg/L	<0.01	<0.01	<0.01
26.	Mercury	0.001 mg/L	0.0022	0.0034	<0.002
27.	Cadmium	0.005mg/L	<0.002	<0.002	<0.002
28.	Arsenic	0.05 mg/L	<0.01	<0.01	<0.01
29.	Zinc	5 mg/L	<0.05	<0.05	<0.073
30.	Chromium	0.05 mg/L	<0.02	<0.02	<0.02
31.	Barium	-	<0.05	<0.05	<0.05
32.	Manganese	0.1 mg/L	<0.05	<0.05	<0.05
33.	Lead	0.05 mg/L	<0.05	<0.05	<0.05

CFU = Coliform units

Source: Adroit

As per Rule 12 of the ECR 1997, DoE has prescribed standards intended for best practice based classification of inland surface water. The standards have been provided in *Table 8-17*

Table 8-17 : Best practice based classification of inland surface water

S.No	Best practice based classification	Parameter			
		pH	BOD (mg/L)	DO (mg/L)	Total Coliform Number/100
1.	Source of drinking water for supply only after disinfecting	6.5 – 8.5	2 or less	6 or more	50 or less
2.	Water usable for recreational activity	6.5 – 8.5	3 or less	5 or more	200 or less
3.	Source of drinking water for supply after conventional treatment	6.5 – 8.5	6 or less	6 or more	5000 or less
4.	Water usable by fisheries	6.5 – 8.5	6 or less	5 or more	-
5.	Water usable by various process and cooling industries	6.5 – 8.5	10 or less	5 or more	5000 or less
6.	Water usable for irrigation	6.5 – 8.5	10 or less	5 or more	1000 or less

Source: ECR, 1997

On comparing the monitoring results with the prescribed standards, the inland surface can be classified as ***Water usable by various process and cooling industries*** as well as ***Water usable for irrigation*** since it satisfies both the standards.

It was observed that Total Dissolved Solids (TDS) in the samples varied from 133mg/L to 370 mg/L. They are significantly lower than the DoE permissible limit of 2100mg/L. The total hardness in the samples varied from 57.0 mg/L to 75.0 mg/L. The comparison of TDS and hardness levels recorded in the samples have been illustrated in *Figure 8-21* and *Figure 8-22*

Figure 8-21 : Total Dissolved Solids (TDS) concentration recorded in the surface water samples

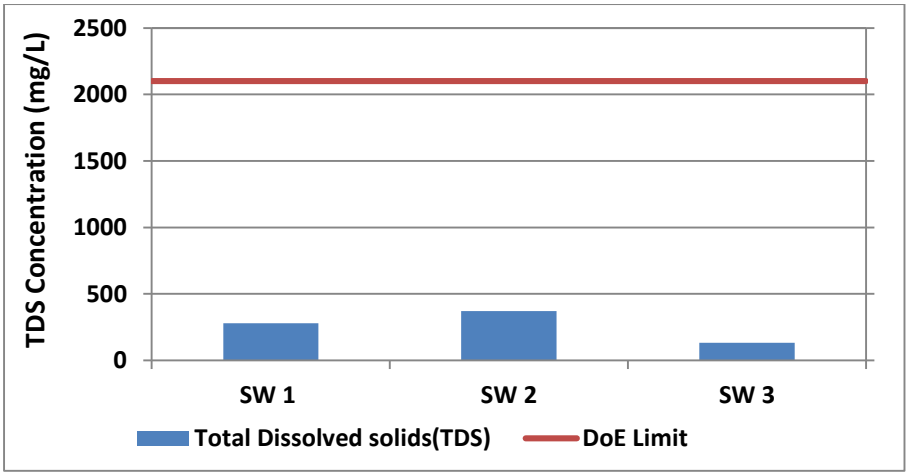
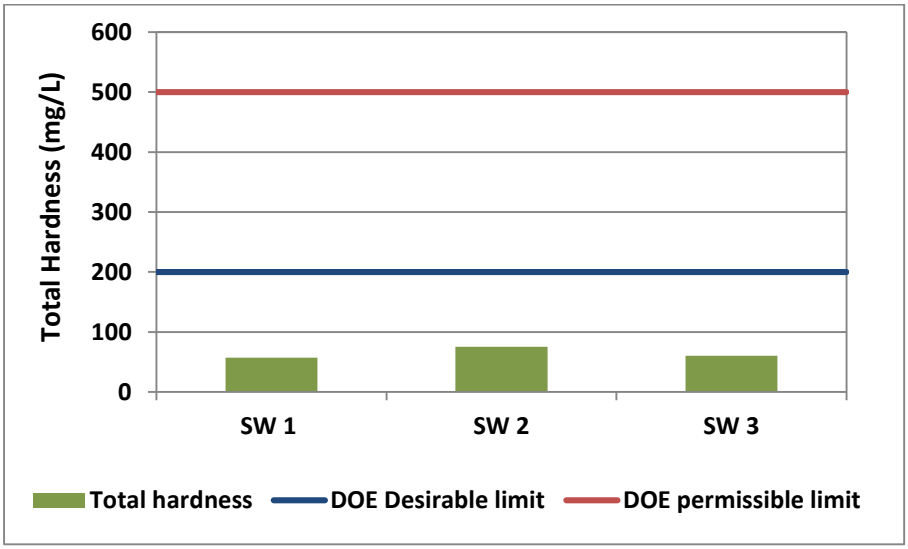


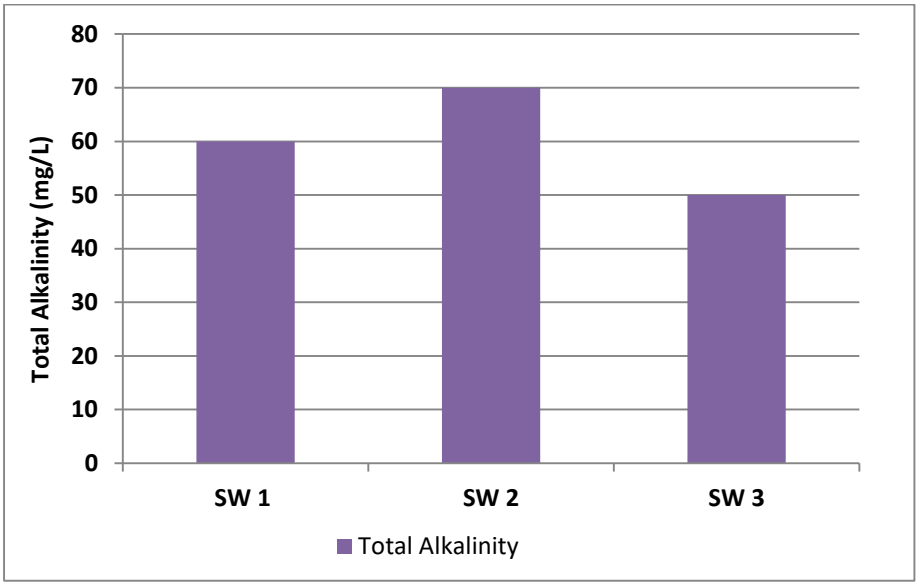
Figure 8-22 : Total hardness concentrations recorded in the surface water samples



Alkalinity of an aqueous solution indicates its quantitative capacity to neutralise an acid. It is indicative of presence of basic ions in the solution viz. bicarbonates ($HCO3^-$), carbonates (CO_3^{2-}) , hydroxyls (OH^-) etc. Assessment of alkalinity of a stream gives an idea about its capability to neutralize acidic pollution due to rainfall or wastewater. As detailed in the *Table,* the surface water is neutral in nature. The recorded total alkalinity in the samples ranged from 50 – 70 mg/L. The results

have been illustrated in *Figure 8-23.* Salinity, which is a measure of salt concentration in the solution was found to be 0.1ppt (parts per trillion) in all the 3 samples.

Figure 8-23 : Total alkalinity observed in the surface water samples



Calcium (Ca^{2+}) concentration in the water samples were found to range from a minimum of 14.8 mg/L in SW 3 sample to a maximum of 18.4 mg/L in SW 2 sample. The concentrations are well within the DoE limit of 75 mg/L. Magnesium (Mg^{2+}) levels were observed to vary from 31.45 – 46.47 mg/L. DoE hasn't prescribed a limit for the same. These two cations are responsible for contributing to the hardness of the samples. Iron concentrations were observed between 0.14 mg/L and 0.34 mg/L which are well within the prescribed limit of 0.3-1.0 mg/L.

Fluorides (F^-) were not detected in the water samples whereas nitrates ranged from 4.01 – 7.52 mg/L. No limits have been prescribed by DoE for these two parameters. Biological Oxygen Demand (BOD) of a sample is representative of the biologically active organic matter present in it i.e., the organic matter that can be degraded biologically by microorganisms. Whereas, chemical oxygen demand (COD) indicates the organic matter which can be degraded/decomposed chemically by various oxidising agents. Hence COD is inclusive of BOD as well as the organic matter which is resistant to or cannot be decomposed by microorganisms. Thus, COD value of a particular sample is always greater than its BOD.

The BOD of the water samples collected ranged from 6 - 8 mg/L whereas the COD values ranged from 14 – 18 mg/L. The values indicate that organic matter present in the water is very less and are significantly lower than the maximum limits prescribed by the DoE viz. 50mg/L and 200 mg/L respectively. The observed BOD and COD levels have been illustrated in the *Figure 8-24* and *Figure* 8-25.

Figure 8-24 : Observed BOD levels in the surface water samples

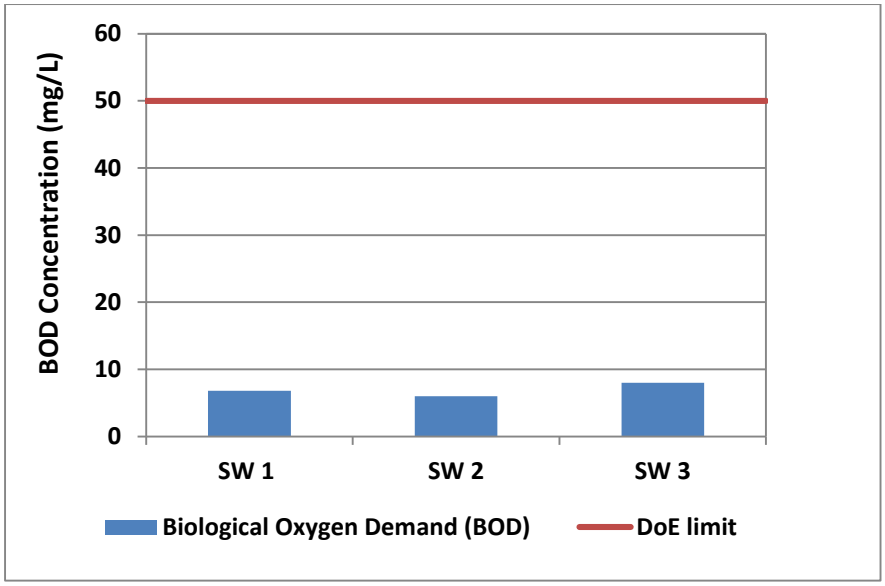
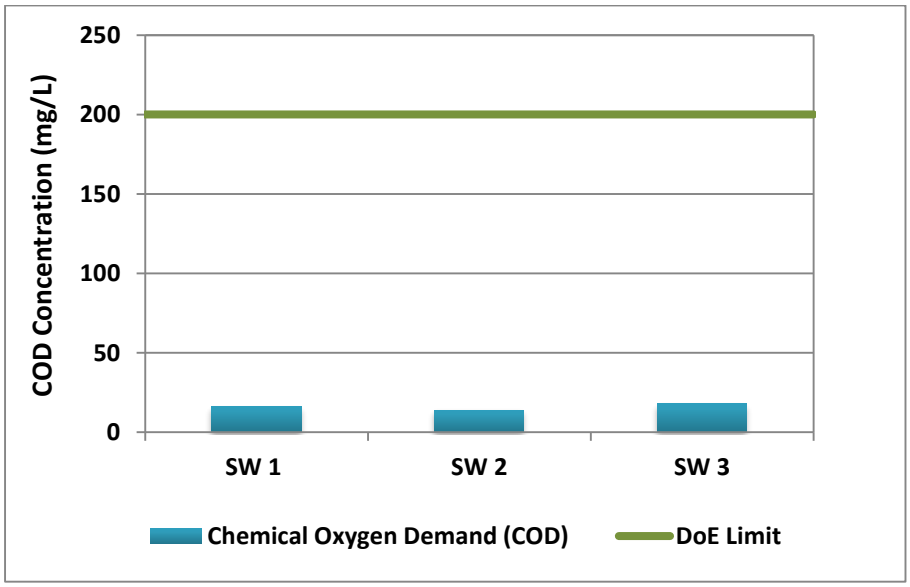
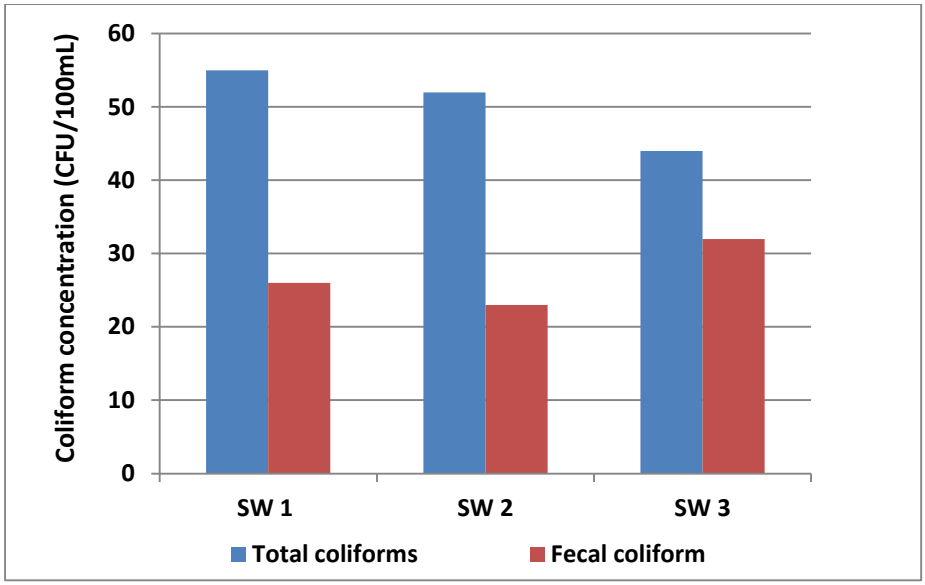


Figure 8-25 : Observed COD levels in the surface water samples



A significant number of total and faecal coliform bacteria were found in the collected water samples. Hence it indicates contamination of surface water by sewage or open defecation. The DoE has prescribed a zero tolerance for the presence of such bacteria. Thus, the water is unfit for drinking and cooking purposes which was seen as a common practice in the local villages during site survey. The coliform bacterial concentration found in the samples has been illustrated in the *Figure 8-26.*

Figure 8-26: Observed coliform bacteria concentration in collected water samples



Heavy Metals

The copper and arsenic values were found to be less than 0.01mg/L. The lead and cadmium concentrations in water samples collected were observed to be less than prescribed limits of DoE. Concentration of Barium and Manganese is also found to be less than 0.05 mg/L. The concentrations of Mercury were observed to be exceeding the permissible value of 0.001 mg/L at SW-1 (Vati Balaki) and SW-2 (Gowal Gao).

Research paper published in Journal of National Oceanographic, Atmospheric and Marine Institute titled 'Mercury Concentrations in 14 *commonly consumed* fresh Water Fish of Bangladesh" presents the reason of presence of mercury in river waters. The reason for existence of mercury in surface water samples collected can be attributed to the discharges of Chloro-alkali industries of Chittagong Sylhet, through the Rivers Karnaphuli and the Surma. River Meghna is formed inside Bangladesh above Bhairab Bazar by the combination of the Rivers Surma and Khusiyara.

8.5.3.2 Groundwater quality

Groundwater is primarily used for drinking purposes which necessitates evaluation of it fitness for the same. Groundwater samples taken from three areas in and around the Project area, namely Vati Bolaki, Gowal Gao and Pachani were assessed for checking conformity with prescribed DoE standards for drinking water. The details of the sampling locations have been furnished in the *Table 8-18*

Table 8-18: Details of groundwater sampling locations

S.No	Sampling Location	Location ID	Geographical Co-ordinates	
			Latitude	Longitude
1.	Vati Bolaki	GW 1	23°35'16.91" N	90°34'36.24" E
2.	Gowal Gao	GW 2	23°34'08.80" N	90°35'21.32" E
3.	Pachani	GW 3	23°36'31.88" N	90°34'40.36" E

Source: Adroit

The collected groundwater samples were tested for 23 parameters (physical, chemical and biological) and evaluated against the DoE prescribed standards for drinking water. The monitoring results have provided in the *Table 8-19*

Table 8-19: Groundwater Quality monitoring results

S.No.	Parameter	DoE Standard for Drinking Water	Recorded Value		
			GW 1	GW 2	GW 3
PHYSICAL					
1.	Colour	15 Hazen units	Colourless	Colourless	Colourless
2.	Turbidity	10 NTU	2.55	1.86	2.84
3.	pH	6.5 – 8.5	7.0	8.0	8.0
4.	Temperature	20 – 30	27.9	26.2	24.3
5.	Conductivity	-	490	250	550
6.	Total Dissolved solids(TDS)	1000 mg/L	210	170	270
7.	Total Suspended solids(TSS)	10 mg/L	2.6	2.9	3.9
CHEMICAL					
8.	Total hardness	200-500 mg/L	244	404	300
9.	Salinity	-	0.4	0.4	0.4
10.	Total Alkalinity	-	320	405	320
11.	Dissolved Oxygen(DO)	6 mg/L	7.1	6.2	7.3
12.	Chemical Oxygen Demand (COD)	4 mg/L	3.2	2.8	1.8
13.	Biological Oxygen Demand (BOD)	0.2 mg/L	1.2	1.6	0.8
14.	Oil and Grease	0.01 mg/L	<5.0	<5.0	5.22
15.	Calcium	75 mg/L	62.4	119.2	94.4
16.	Phosphate	6 mg/L	<0.01	0.16	1.0
17.	Sulphate	400 mg/L	<1.0	<1.0	64.9
18.	Iron	0.3 – 1.0 mg/L	0.23	11.64	0.82
19.	Fluoride	1 mg/L	Not detected	Not detected	Not detected
20.	Nitrate	10 mg/L	13.58	3.01	2.76
21.	Magnesium	30 -35 mg/L	3.51	15.31	17.24
22.	Chloride	150-600mg/L	218.7 mg/L	223.6 mg/L	215.1 mg/L
Heavy Metals					
23.	Copper	1 mg/L	<0.01	<0.01	<0.01
24.	Mercury	0.001 mg/L	<0.002	0.0022	0.0022
25.	Cadmium	0.005mg/L	<0.002	<0.002	<0.002
26.	Arsenic	0.05 mg/L	<0.01	0.40	0.033
27.	Zinc	5 mg/L	<0.05	<0.05	<0.05
28.	Chromium	0.05 mg/L	<0.02	<0.02	<0.02
29.	Barium	-	<0.05	0.10	<0.05
30.	Manganese	0.1 mg/L	<0.05	0.44	0.11
31.	Lead	0.05 mg/L	<0.05	<0.05	<0.05
BIOLOGICAL					
32.	Total coliform	0 CFU/100mL	0	0	55000
33.	Fecal coliform	0 CFU/100mL	0	0	11000

NTU = Nephelo Turbidity units

CFU = Coliform units

Source: Adroit

It can be seen from the table that all the three groundwater samples were found to be colourless and turbidity (which indicates presence of suspended solids) was well within the prescribed limit of 10 NTU. The samples were found to be neutral to slightly basic with pH values ranging from 7.0 – 8.5.

The prescribed limits for TDS and TSS in water fit for drinking purposes are 1000 mg/L and 10 mg/L respectively. TDS when present in excess of the specified limit imparts a bad taste to the water and renders it unfit for drinking whereas, excess TSS makes water turbid and creates a negative psychological impact on the consumer. The TDS levels in the samples were found to vary from 170 - 270 mg/L and TSS concentration from 2.6 – 3.9 mg/L. The results have been illustrated in the *Figure 8-27* and *Figure 8-28*.

Figure 8-27: TDS levels in collected groundwater samples

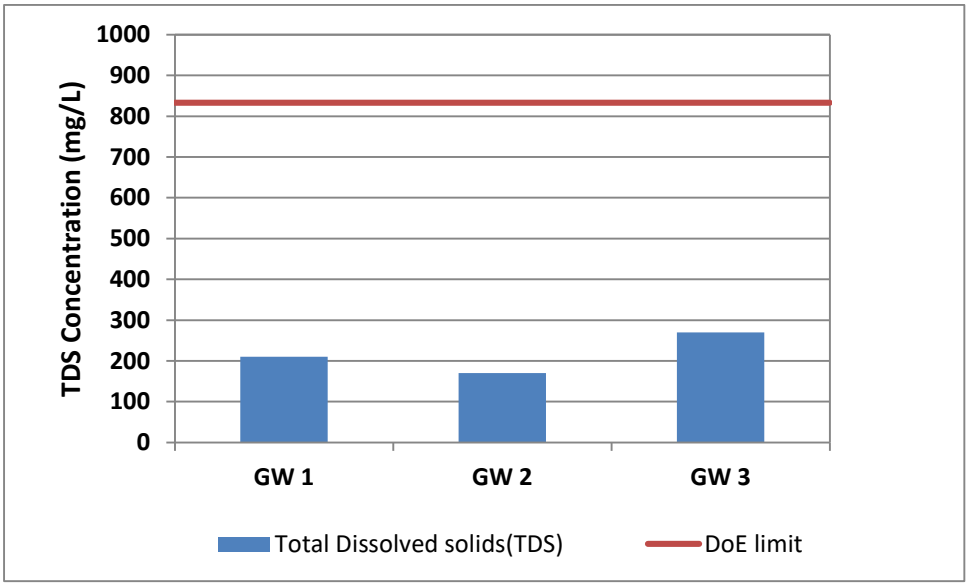
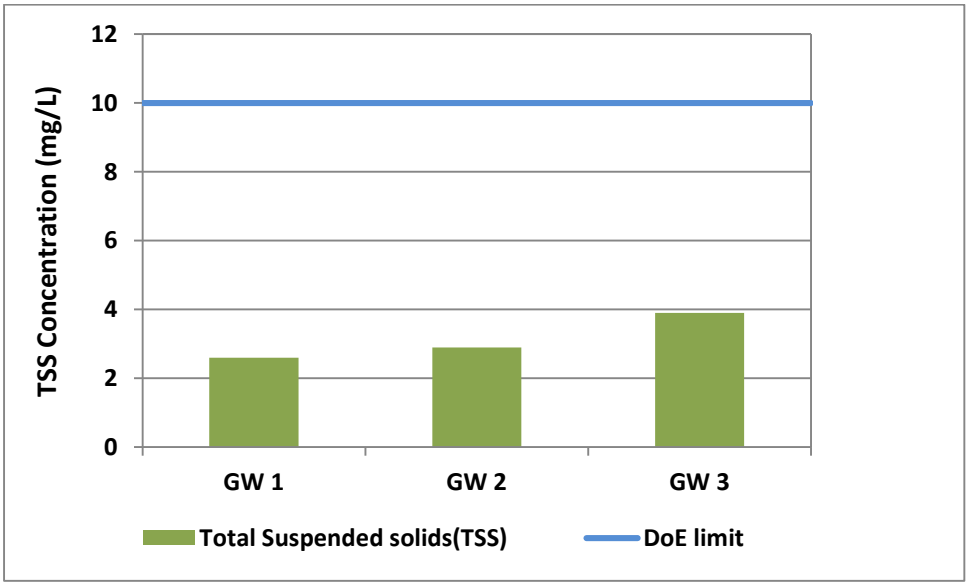
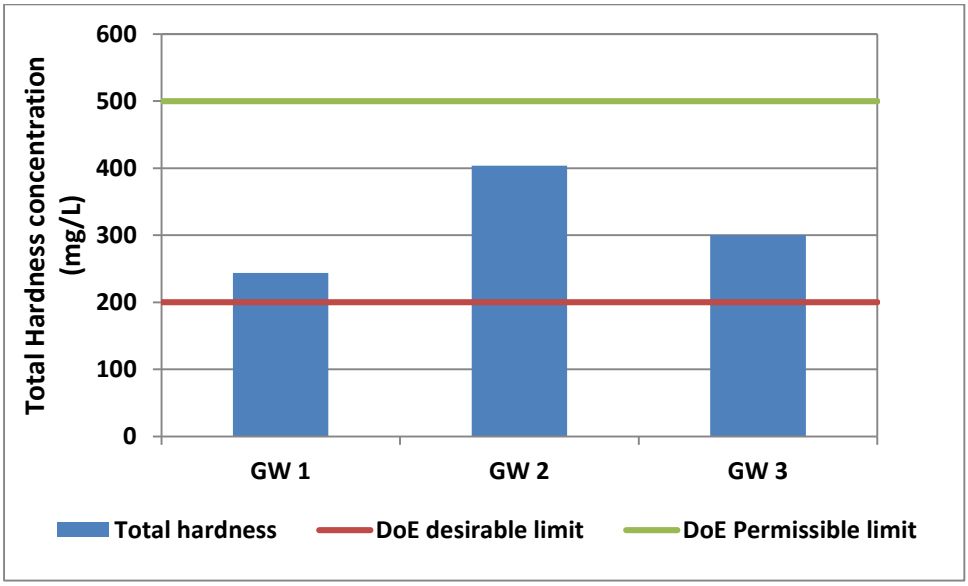


Figure 8-28 : TSS concentrations in collected groundwater samples



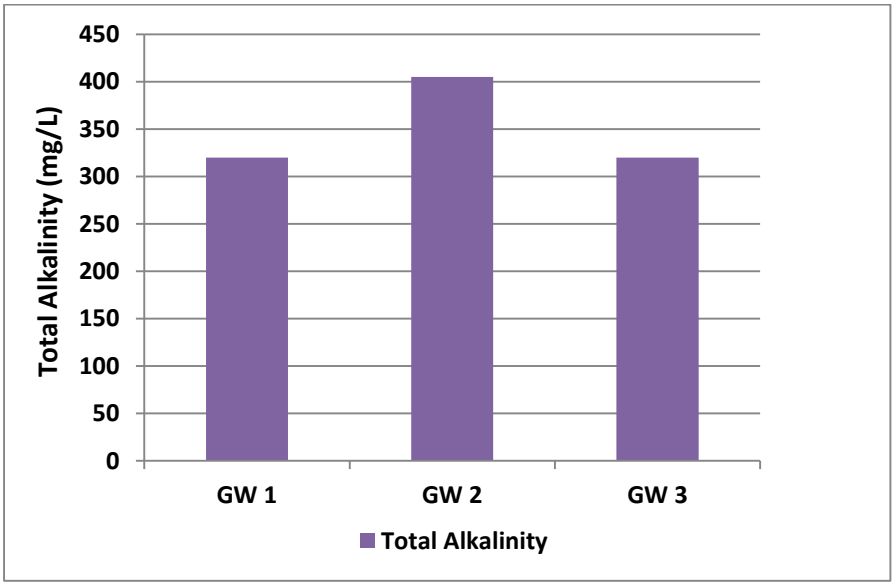
Hardness indicates the presence of carbonates, bicarbonates, sulphates, chlorides and nitrates of calcium and magnesium in water. It reduces the water's lather formation ability when mixed with soap. The Total Hardness (which is measured in terms of $CaCO_3$) levels in the samples were found to vary from a minimum of 244 mg/L in GW1 to a maximum of 404 mg/L in GW2. Even though the concentrations were higher than the desirable limit of 200 mg/L, they were well within the permissible limit of 500 mg/L. Excess hardness doesn't have any negative effect on human health, but it makes imparts an unpleasant taste to the water making it unfit for drinking purposes. The observed total hardness levels have been showed in ***Figure 8-29.***

Figure 8-29: Total Hardness concentration in collected groundwater samples



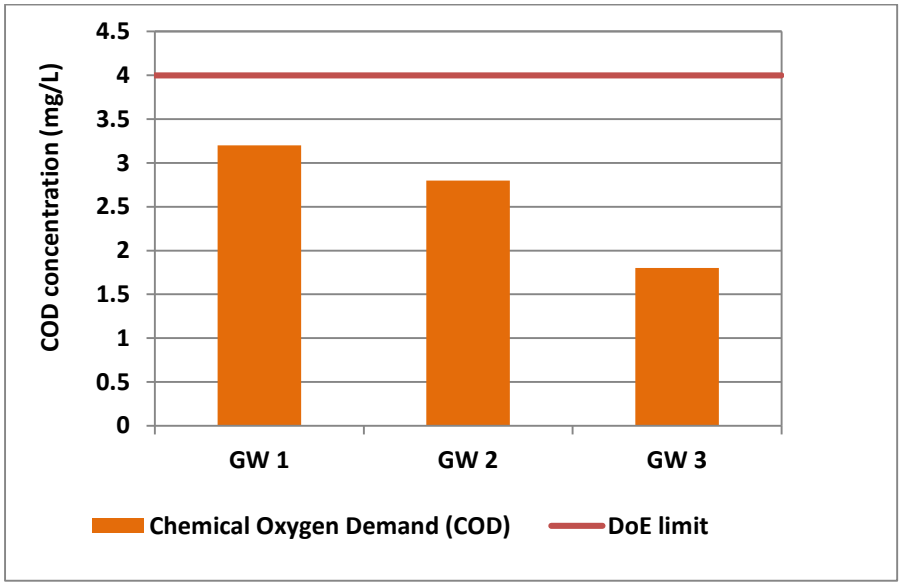
Salinity which is a measure of salt concentration was found to be 0.4 ppt (parts per trillion) in all the 3 samples. Total alkalinity values in the water samples varied from 320 – 405 mg/L. The observed total alkalinity values have been illustrated in ***Figure 8-30***

Figure 8-30 : Total alkalinity levels in collected groundwater samples



COD concentration in the water samples was found to be between 1.8 and 3.2 mg/L. They are within the DoE specified limit of 4.0 mg/L. The observed COD levels have been shown in ***Figure 8-31***

Figure 8-31: COD concentrations in collected groundwater samples



High levels of calcium in excess of the prescribed limit were found in the collected groundwater samples. They ranged from 62.4 – 119. 2 mg/L. Iron concentration was also found to be significantly higher than the specified limit (0.3 -1.0 mg/L) in the GW2 sample (11.64 mg/L). This can attributed to the presence of minerals constituting iron in the aquifer bedrock layer. The observed calcium and iron levels have been shown in the ***Figure 8-32*** and*Figure* 8-33

Figure 8-32 : Calcium concentration in collected groundwater samples

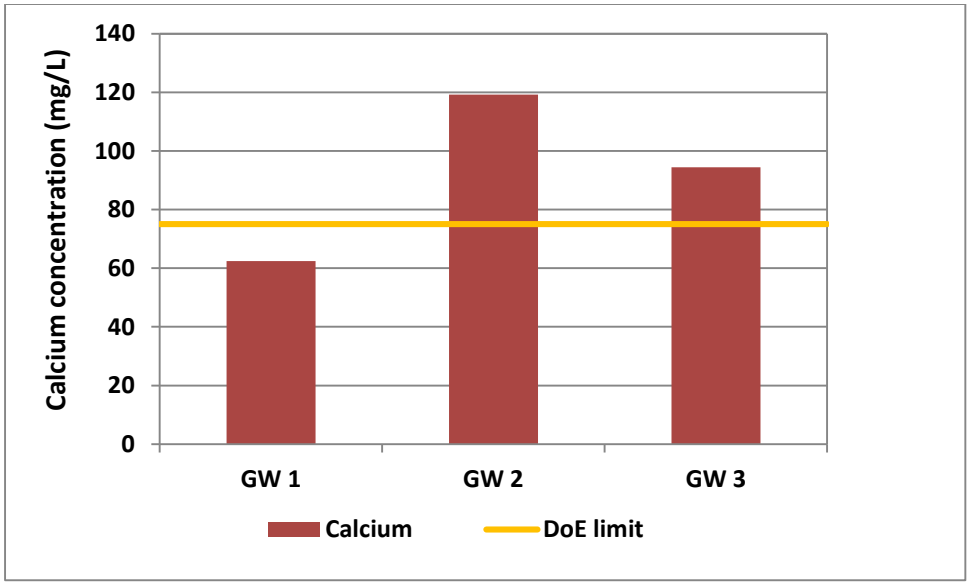
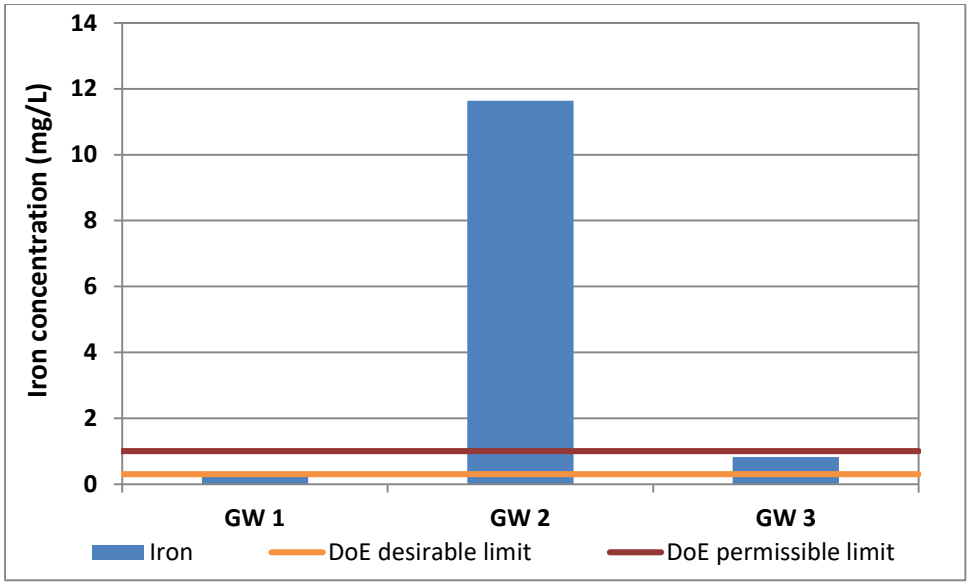


Figure 8-33 : Iron concentration collected groundwater samples



Magnesium (Mg^{2+}) concentrations in the sample ranged from 3.51 – 17.24 mg/L. Fluorides could not be detected in any of the three samples whereas nitrates were observed to be in the range of 2.76 – 13.58 mg/L.

Heavy Metals

The concentrations of copper and chromium in ground water samples collected are less than their prescribed limits of 1mg/L and 0.05 mg/L laid by DoE respectively. Concentrations of other various heavy metals like arsenic, lead, barium, cadmium and selenium were found to be below prescribed limits of DoE. However, the concentration levels of mercury were observed to be less than 0.002 mg/L at SW-1 (Vati Balaki). The mercury levels at SW-2 and SW-3 was found to be 0.0022 mg/L, which exceeds the permissible limit of 0.001 mg/L as prescribed by DoE.

8.5.4 Traffic Volume Survey

Assessment of the existing traffic characteristics within a study area was undertaken to identify the problems with respect to traffic movement and to formulate the possible alternative solutions and the need for organizing the same in an efficient and economical manner. A traffic volume count survey was conducted by AECL at two monitoring locations on roads connecting the project site. The traffic volume counts were recorded continuously for 24 hours at one time during the study period to assess the existing total daily traffic, peak hour traffic and traffic composition. The details of the villages have been provided in the following ***Table 8-20.***

Table 8-20: Traffic monitoring locations

S.No	Traffic monitoring location	Location ID	Geographical Coordinates		Date of Monitoring
			Latitude	Longitude	
1.	Dhaka Chittagong Highway	TM 1	23°36'57.71"N	90°36'35.88"E	January 12, 2014
2.	Meghnaghat Power Limited premises	TM 2	23°36'45.46"N	90°36'07.46"E	January 13, 2014

Source: Adroit

Traffic counted has been subdivided into five (5) categories/classes viz.:

i. Trucks/Lorries
ii. Bus/Minibus
iii. Car/Jeep/Microbus
iv. Motorcycle/Auto rickshaw

Since the vehicles are of different types, a factor needs to be accounted for each of them in order to express them at par in single unit terms. The factors, commonly known as Passenger Car Unit (PCU) factors that have been adopted are shown in ***Table 8-21.***

Table 8-21: Passenger Car Unit (PCU) factors in Bangladesh

Vehicle Type	PCU Factor
Car	1.0
Bus	3.0
Truck	3.0
Auto Rickshaw	0.5
Bicycle	0.3
Rickshaw	1.0
Motor Cycle	0.3
Tempo	1.0
Bullock Card	4.0

Source: Transport Research Laboratory (UK) Overseas Road Note 13

The traffic volume counts have been tabulated in the *Table 8-22* and *Table 8-23*. The hourly traffic volume has been illustrated in the *Figure 8-36 and Figure 8-37.*

Table 8-22: Hourly Traffic Volumes at TM1

Time	Truck/Lorries	Bus/Minibus	Car / Jeep/ Microbus	Motor-cycles/Auto rickshaw	Total Hourly Traffic Volume
	Units	Units	Units	Units	Units
06:00AM	234	183	22	3.5	442.5
07:00AM	252	90	24	10.5	376.5
08:00AM	126	168	48	13.5	355.5
09:00AM	255	216	60	16.5	547.5
10:00AM	134	156	37	27	354
11:00AM	123	99	39	17	278
12:00PM	138	102	33	13.5	286.5
01:00PM	96	96	35	15.5	242.5
02:00PM	153	66	36	11.5	266.5
03:00PM	138	87	37	18.5	280.5
04:00PM	159	126	48	24	357
05:00PM	162	111	54	16	343
06:00PM	144	108	24	16	292
07:00PM	183	57	61	10.5	311.5
08:00PM	252	45	44	9	350

Time	Truck/Lorries	Bus/Minibus	Car / Jeep/ Microbus	Motor-cycles/Auto rickshaw	Total Hourly Traffic Volume
	Units	Units	Units	Units	Units
09:00PM	315	48	46	5	414
10:00PM	288	96	48	11	443
11:00PM	345	216	53	21	635
12:00PM	315	174	42	2	533
01:00AM	267	156	48	2.5	473.5
02:00AM	279	99	16	1	395
03:00AM	336	96	11	0	443
04:00AM	228	69	06	0	303
05:00AM	249	150	22	1	422
Total	**5171**	**2814**	**894**	**266**	**9145**

Source: Adroit

Table 8-23: Hourly Traffic Volumes at TM2

Hours	Truck/Lorries	Bus/Minibus	Car / Jeep/Microbus	Motor-cycles/Auto rickshaw	Total Hourly Traffic Volume
	Units	Units	Units	Units	Units
06:00AM	2	0	0	2	4
07:00AM	3	0	1	5	9
08:00AM	2	3	7	8	20
09:00AM	1	2	4	11	18
10:00AM	1	1	3	9	14
11:00AM	3	0	2	7	12
12:00PM	2	0	3	14	19
01:00PM	4	0	5	11	20
02:00PM	3	0	2	11	16
03:00PM	3	1	3	8	15
04:00PM	3	1	1	11	16
05:00PM	3	2	1	9	15
06:00PM	3	0	1	11	15
07:00PM	7	0	6	17	30
08:00PM	2	0	1	6	9
09:00PM	4	0	1	3	8
10:00PM	3	0	0	2	5
11:00PM	1	0	2	2	5
12:00PM	3	0	2	4	9
01:00AM	4	0	0	1	5
02:00AM	1	0	0	1	2
03:00AM	2	0	0	0	2
04:00AM	1	0	0	0	1
05:00AM	0	0	0	0	0
Total	**183**	**30**	**45**	**76.5**	**334.5**

Source: Adroit

Figure 8-34: Hourly traffic volume at TM1

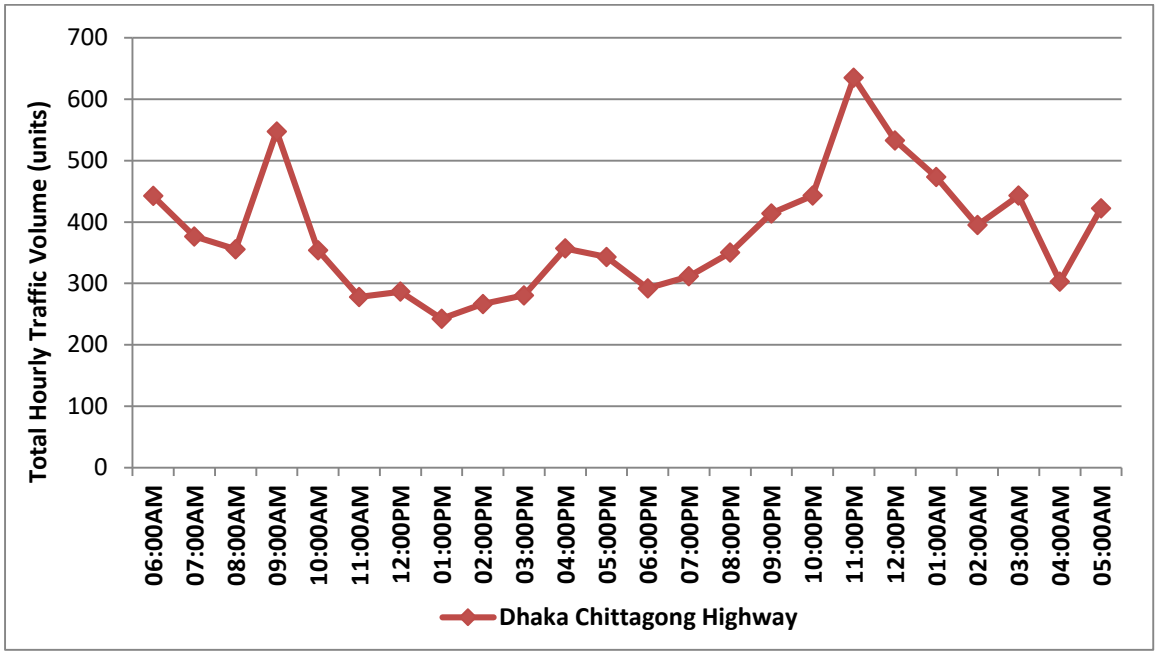


Figure 8-35 : Hourly traffic volume at TM 2

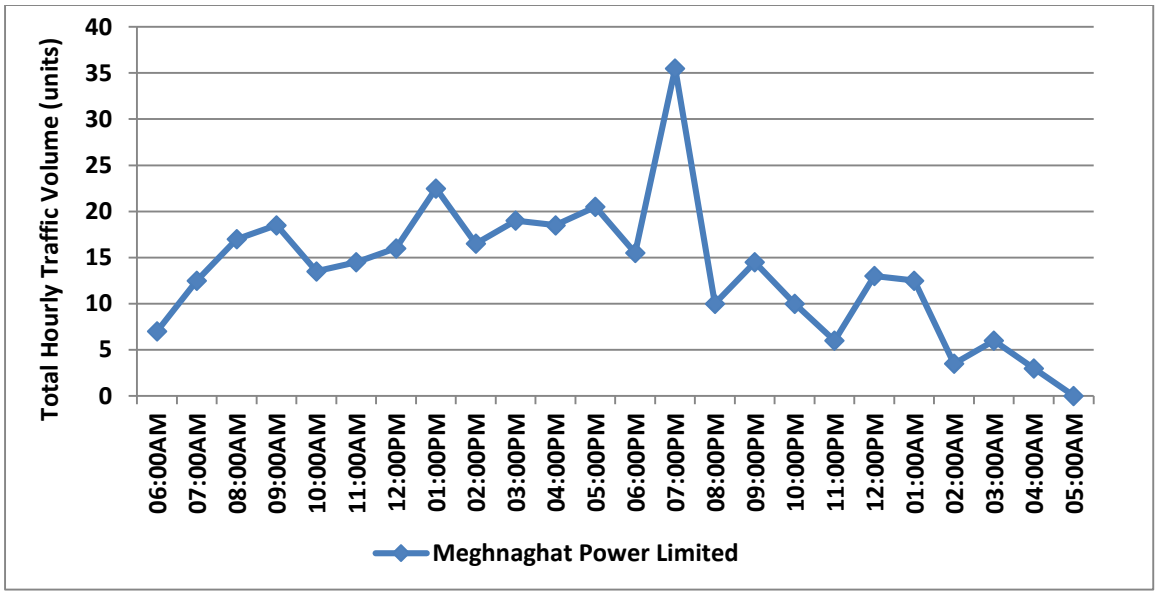


Table 8-24: Observations of Traffic Volume Count

Location	Traffic Composition	Traffic flow at Peak Hour	Hourly Variation	Traffic count
Dhaka Chittagong Highway **(TM 1)**	The composition of vehicles at this stretch indicates that of the total vehicles observed, 57% of the vehicles were Trucks/lorries. Buses and minibuses constituted 31% of the observed traffic volume whereas Car/jeep/microbus and motor cycles/auto rickshaws comprised 10% and 3% respectively. *Refer Figure 8-36*	The morning peak hour traffic between 0800 hrs. and 0900hrs was observed to be 547 units. During the night peak hour from 2200 hrs. To 2300 hrs. the peak traffic was observed to be 635 units *Refer Figure 8-36*	The hourly variation indicates that in the morning time maximum traffic is between 0800-1000 hrs. and in the night maximum traffic is at 2200 – 0000 hours. *Refer Figure 8-36*	Daily traffic volume at the highway was found to be 9145 units
Meghnaghat Power Limited Premises **(TM 2)**	The composition of vehicles in the premises indicates that of the total vehicles observed, 55% of the vehicles were Trucks/lorries. Buses and minibuses constituted 9% of the observed traffic volume whereas Car/jeep/microbus and motor cycles/auto rickshaws comprised 13% and 23% respectively. *Refer Figure 8-37*	The morning peak hour traffic between 0800 hrs. And 0900 hrs. was observed to be 13 units. During the evening peak hour from 1700 hrs. To 1900 hrs. the peak traffic was observed to be 35 units.	The hourly variation indicates that in the morning time maximum traffic is between 0800-1000 hrs. And in the night maximum traffic is at 1700 – 2000 hours.	Daily traffic in the premises was found to be 334 units.

Source: Adroit

Figure 8-36 : Traffic composition at TM1

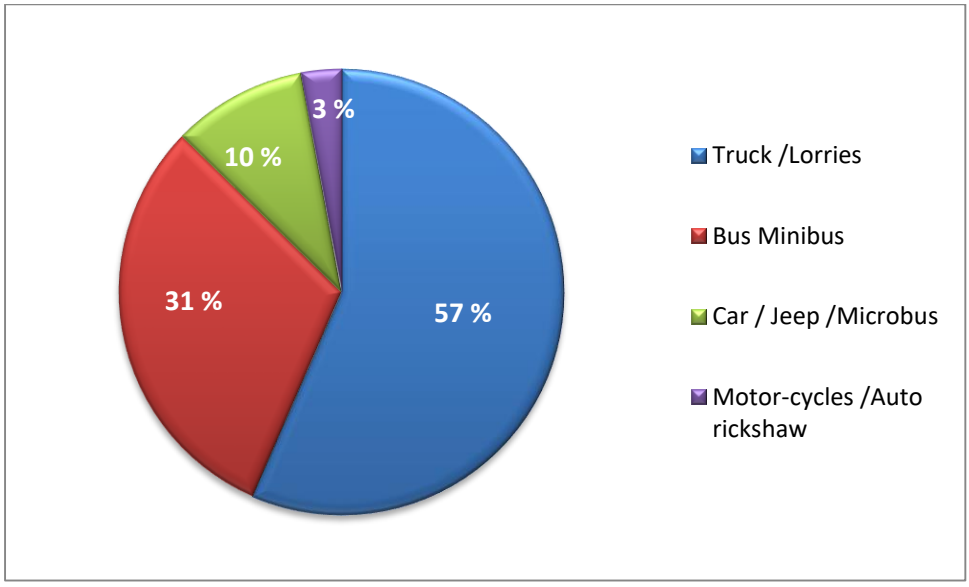
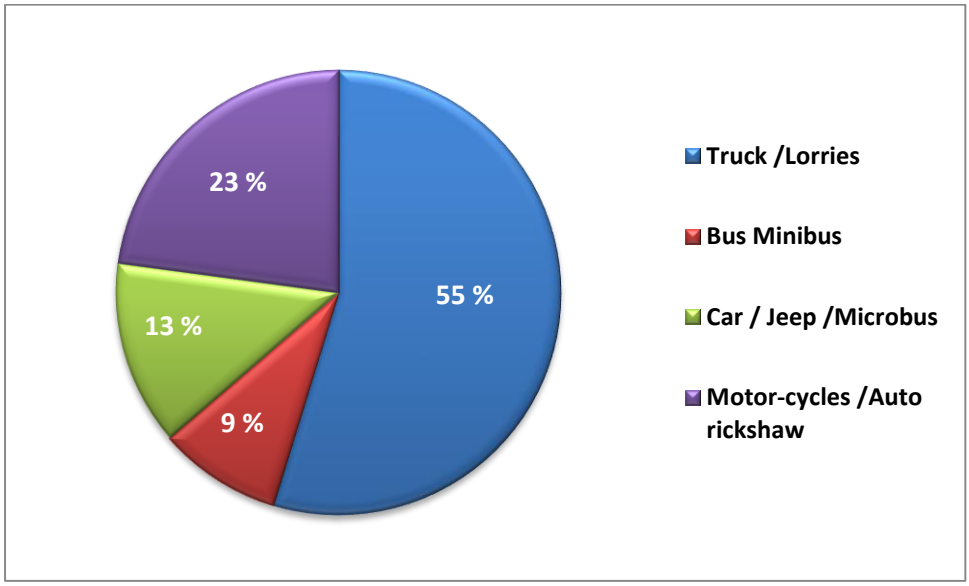


Figure 8-37 : Traffic composition at TM 2



8.5.5 Aquatic Monitoring

A comprehensive aquatic ecological survey was conducted around project site during the month of January, 2014 to assess the present status of Phytoplankton, Zooplanktons, aquatic and terrestrial invertebrates and vertebrates around the project site.

The survey involved collecting, processing, and analysing aquatic organisms to determine the health of the biological community. Macro invertebrates that inhabit rivers are a profile of the overall health of that ecosystem**.** Aquatic macro-invertebrates are good indicators of stream quality because of the following:

- They are affected by the physical, chemical, and biological conditions of the river water.
- They can't escape pollution and show the effects of short-and long-term pollution events.
- They may show the cumulative impacts of pollution.

- They may show the impacts from habitat loss not detected by traditional water quality assessments.
- They are a critical part of the aquatic food web.

8.5.5.1 Methodology adopted

Water samples of the river were collected from four different locations around the proposed power plant. Different physical parameters of the water samples were checked and recorded. The description of four sites is detailed in *Table 8.25.*

Table 8.25: Details of the four locations

S.No	Name of Location	Description of the terrain and land-use	Geographical Coordinates
1.	Vatibalahi	The shore of the river in this place is sandy and sloppy. Strong current in the water was recorded.	23º 35´ 16.7´´ N 90º 34´ 36.2´´ E
2.	Goalgao	The shore of the river is very muddy. The coast was densely covered by thick population of floating water hyacinth. The coast was also covered by thick population of underground vegetation. No water current was recorded.	23º 34´ 11.9´´ N 90º 35´ 20.3´´ E
3.	Char Kishorgonj	The shore of the river is sandy and very sloppy. The coast was densely covered by thick population of floating water hyacinth. The coast was also covered by thick population of underground vegetation. No water current was recorded.	23º 33´ 55.5´´ N 90º 33´ 37.7´´ E
4.	Patchani ghat	The coast was densely covered by thick population of floating water hyacinth. The coast was also covered by thick population of underground vegetation. This ghat area is landing station of various types of engine boats. People from different areas use this ghat for communication. No water current was recorded.	23º 36´ 30.6´´ N 90º 34´ 39.7´´ E

Source: Adroit

At each site, a study of aquatic diversity was carried out in the following manner:

- Phytoplankton and Zooplankton nets were used to collect different types of planktons available in each type of water sample;
- Several types of fishing nets were utilized to collect different types of fishes, macro and micro-invertebrates from each location;
- Water samples were collected around 40 meter radius of each sampling location. The collected specimens were identified instantly or brought to the laboratory for further confirmation;
- Fishermen were interviewed to get an idea about the present status and past records of the availability and abundance of fish population of the river; and

- Fish sellers of the local fish market were also interviewed to collect their opinion about the present and past status of the abundance of fishes in the area.

For phytoplankton and Zooplankton survey following procedure was adopted:

- 10 lit of water (two liters each time) was collected from each sampling location and was sieved by plankton net;
- 45 ml of sieved water was collected in a 50 ml Falcon tube;
- Then 5 ml of alcohol was added in each Falcon tube as preservative so that the microorganisms are not damaged before identification; and
- Five samples were collected from each sampling location and 1 ml of water from each 50 ml sample was studied in a "rafter cell counter" under microscope.

8.5.5.2 *General Observations*

During interview with the local people, it was understood that huge quantities of different varieties of fish are captured during each fishing activity. The procedure adopted for trapping large amount of fishes is presented as follows (*Figure 8-38)*:

- Huge number of floating water hyacinth was trapped and bamboo poles are used for trapping;
- This place is utilized to attract different kinds of fishes as shelter place; and
- Afterwards, this area is encircled after every 15-20 days with nets and capture fish.

Figure 8-38: Fishing using Bamboo Barrier in River Meghna

Water quality includes various physical and biological parameters which have direct influence on the aquatic organisms and vegetation were also analyzed. Abundance of fishes and their growth are dependent on the quality of water and availability of food. Few physical parameters of water samples of each sampling location examined and presented in *Table 8.26.*

Table 8.26: Water quality parameters of the river Meghna

Parameters	Location 1	Location 2	Location 3	Location 4
Temperature(^{0}C±SE)	22.6 ± 1.2	22.4 ± 1.01	21.6 ± 1.05	22.8 ± 1.02
Secchi depth(Cm±SE)	114 ± 10.2	88.6 ± 9.1	79 ± 14.1	105 ± 15.01

Each data represents average of 5 replications

Aquatic Fauna

The insect fauna recorded from each of the location is presented in *Table 8.27* . Actually, there were no marked differences between the insect populations of the four sampling locations. Immature stages of dragonfly and damsel fly was collected. These are being reared in the laboratory for the production of adults.

Table 8.27: Abundance of Insect fauna

English name	Order name	Location 1	Location 2	Location 3	Location 4
Dragon fly nymph	Odonata	+	+	+	+ +
Damsel fly nymph	Odonata	+	+	+	+ +
Water strider	Hemiptera	-	+	+	+ +
Midge	Diptera	-	+	+	+ +
Flies	Diptera	+	+	+	+ +
Ant	Hymenoptera	+	+	+	+ +
Caddisfly	Trichoptera	-	+	+	+ +
Butterflies	Lepidoptera	+	+	+	+ +
Mosquitoes	Diptera	-	+	+	+ +

Abundance: (-) = Absent, (+) = Few, (+ +) = Common

***Note**: Samples could not be identified up to species level as some of these specimens were collected at immature stage.*

Figure 8-39: Commonly observed Mollusc Species in River Meghna

Mollusc fauna of the different sampling locations are presented in *Table 8.28* and shown in *Figure 8-39* . Higher number of mollusca was recorded from the sampling location 4. The reason for higher number can be attributed to the soil and ecological condition of the area. *Figure 8-40* presents the glimpse of vessels creating pollution in River Meghna.

Table 8.28: Abundance of Molluscs

Common Name	Scientific Name	Class	Sampling Locations			
			Location 1	Location 2	Location 3	Location 4
Common Apple Snail	*Pilaglobosa*	Gastropoda	+	+	+	+
Brotia snail	*Brotiacostula*	Gastropoda	+	++	++	++
Banded river snail	*Bellamyabengalensis*	Gastropoda	+	+	+	++
Fresh water mussel	*Parreysiacorrugata*	Bivalvia	+	+	+	++
Fresh water mussel	*Parreysiacaerulea*	Bivalvia	+	+	+	++
Fresh water mussel	*Lamellidensemarginalis*	Bivalvia	+	++	+	+
Fresh water mussel	*Lamellidensejenkinsianus*	Bivalvia	+	+	+	+

Status: +++Very common, ++Common, +Few, - Absent
Source: Adroit

Figure 8-40: Vessels polluting River Meghna

Several types of small fishes were captured and have been presented in *Table 8.29* and depicted in *Source*: Adroit

Figure 8-41 . Names of fishes available at other seasons of the year are presented in *Table 8.30*. According to fisherman, the rivers becomes devoid of fishes in the dry season. However, in the rainy

season, few types of fishes become available. It was learnt from interviews with the fisherman and fish sellers that in the recent past the river had abundant fishes. Several types of big fishes like Rui, Catla, Ayre, Mrigel, Boal along with different types of small fishes were very common. But at present number of all types of fishes has declined greatly.

Table 8.29: List of small fishes captured during survey period

Local Name	Scientific Name	Sampling Locations			
		Location 1	Location 2	Location 3	Location 4
Golsha	*Mystuscavasius*	-	-	-	+
Bele	*Glossogobiusgiuris*	-	-	-	-
Tengra	*Mystusvittatus*	+	-	-	
Puti	*Puntiusconchonius*	+	+	+	+
Fali	*Notopterusnotopterus*	-	+	-	-
Kachki	*Coricasuborna*	++	++	++	++
Mola	*Amblypharyngodonmola*	+	-	-	+
Kakila	*Xenentodoncancila*	-	-	-	-
Chapila	*Gudusiachapra*	-	+	-	+
Kholisha	*Colishafasciatus*	-	-	-	+
Chingri	*Macrobrachiumeqidense*	-	+	-	+
Shol	*Channastriatas*	-	-	-	-
Taki	*Channapunctatus*	-	-	-	-
Shing	*Heteropneustes fossilis*	-	-	-	-
Koi	*Anabas testudineus*	-	-	-	-
Pabda	*Ompok pabda*	-	-	-	+

Status: ++Common, +Few, - Absent
Source: Adroit

Table 8.30: List of fish fauna

Common English name	Local Name	Scientific Name	Abundance
Rohu	Rui	*Labeo rohita*	+
Catla	Katla	*Catla catla*	+
Black Rohu	Kalibaush	*Labeo calbasu*	+
Freshwater Shark	Boal	*Wallago attu*	+
Long-whiskered Catfish	Ayre	*Sperata aor*	+
Tire-track Spiny Eel	Bain	*Mastacembelus armatus*	+
Humped Featherback	Chital	*Chitala chitala*	+
Dwarf Chamelonfish	Meni	*Badis badis*	+
Dwarf Catfish	Batashi	*Batasio tengana*	+
Pama Croaker	Poa	*Otolithoides pama*	+
River Shad	Ilish	*Tenulosa ilisha*	+
Gangetic Hairfin	Fasha	*Setipinna phasa*	+
Silondia Vacha	Shilong	*Silonia silondia*	+
Batchwa Vacha	Bacha	*Eutropiichthys Vacha*	+
Gangetic Lotia	Kala Bata	*Crossocheilus latius*	+
Ghora-chela	Ghora Chela	*Securicula gora*	+
Giant Snakehead	Gagarr	*Channa marulius*	+

Walking Catfish	Magur	*Clarius batrachus*	+
Spotted Snakehead	Taki	*Channa punctatus*	+
Spotted Snakehead	Shol	*Channa punctatus*	+
Walking Snakehead	Ranga Cheng	*Channa orientalis*	+
Victory Loach	Dari	*Scistura scaturigina*	+
Choukkani	Kanpona	*Aplocheilus panchanx*)	+
Stinging Catfish	Shing	*Heterpeneustes fossilis*	+

Status: +Few

Source: Adroit

Figure 8-41: Species of Fish Captured during Sampling

Phytoplanktons are the producer of the river ecosystem and thus their status is of prime importance. List of Phytoplanktons and Zooplankton found in the water samples of different sampling locations are presented respectively in *Table 8.31* and *Table 8.32* .

Table 8.31: List of recorded phytoplanktons

Name of the species	Number of the species at different sampling locations Location 1	Location 2	Location 3	Location 4
Spirogyra sp.	26	32	31	23
Nostoc sp.	21	23	24	29
Zygonema sp.	17	28	18	29
Oedogonium sp.	12	14	18	14
Nostoc sp.	10	12	16	14
Pithophora sp.	-	14	16	-
Anabena sp.	13	-	16	-
Volvox sp.	-	16	-	16
Oscillatoria sp.	-	16	-	18
Chlamydomonas sp.	13	-	10	-
Cladophora sp.	-	10	-	-
Cosmarium sp.	-	10	-	-
Navicula sp.	12		-	9
Eremosphera sp.	-	-	-	9

Staurastrum sp.	15	-	17	-
Dinobryon sp.	-	-	-	10
Melosira sp.	-	15	-	8
Nitzschia sp.	12	-	13	-
Glenodinium sp.	12	-	-	12
Chrooccus sp.	-	-	14	-
Gloeocapsa sp.	-	-		8
Microcystis sp.	-	11	-	-
Coelosphirum sp.	9	-	-	-

Data from each sampling locations represents total of 5 samples, 1 ml each time
Source: Adroit

Table 8.32: List of recorded zooplanktons

Name of the species	Number of the species at different sampling locations Location 1	Location 2	Location 3	Location 4
Daphnia sp	16	19	17	28
Planaria sp	22	25	27	2 9
Euglena sp	26	23	25	28
Paramecium sp	21	24	16	15
Cyclops sp	24	25	16	23
Diflugia	20	17	21	14
Phacus	-	-	15	20
Nebalia	22	-	15	18
Glaucoma	14	-	-	-
Nauplius	-	8	12	-
Brachionus	-	-	-	16
Branchipus	-	-	-	10
Keratella		15	8	-
Lepadella	-	-	-	10
Polyarthra	-	-	9	11
Trichocera	-	-	12	-
Hexarthra	12	-	-	-
Rotaria	-	9	-	10
Monostyta	13	-	10	-
Diaptomus	-	10	-	-
Daphnia	12	-		-
Diaphanosoma	-	-	-	12
Cypris	11	-	13	-
Heterocypris	-	-	13	-

Data from each sampling locations represents total of 5 samples, 1 ml each time
Source: Adroit

Table 8.33 presents a snapshot prepared based on the species found during the survey time.

Table 8.33: Observed Avifauna

English Name	Scientific Name	Number at different sampling locations Location 1	Location 2	Location 3	Location 4
Pond Heron	Ardeolagrayii	-	-	-	-
Little Cormorant	Phalacrocorax niger	-	+++	+++	+++
Black Kite	Milvusmigrans	-	+	-	-
Brahminy Kite	Haliastur Indus	+	+	-	+

Red Vented Bulbul	Picnonotuscafer	+	+	+	+
House Crow	Corvus splendens	++	+	+	++
Tailor Bird	Orthotomussutorius	+	+	-	+
Grey-headed Woodpecker	Picus canus	+	-	-	+
Blue-eared Kingfisher	Alcedo meninting	-	-	-	+
Large-billed crow	Corvus macrorhynchos	+	-	-	+

Status: ++++: Highly abundant; ++: Abundant; +: Few; -: Absent
Source: Adroit

References used

Present biosurvey list presented above is a snapshot prepared based on the species found during the survey time.The references used to identift the species are mentioned below.

- Encyclopedia of Flora and Fauna of Bangladesh, 2007, Published by Asiatic Society of Bangladesh.Vol 13, 14, 15, 17, 18, 19, 20, 22, 23, 26.
- Freshwater Fishes of Bangladesh. AK AtaurRahman, 2nd edition. Published by Zoological Society of Bangladesh.
- The Effects of Flood Cycle on the Diversity and Composition of the Phytoplankton Community of a Seasonally Flooded Ramsar Wetland in Bangladesh. 2007, SB Muzaffar and FA Ahmad, WeltankdsEcol Manage 15:81-93.

8.5.6 Soil Quality

Soil samples were collected from three areas in and around the proposed project region and tested for nine (9) parameters in order to establish the baseline soil quality.

Methodology

At each location, soil samples were collected from three different depths viz. 30 cm, 60 cm and 90 cm below the surface and are homogenized. The homogenized samples were analyzed for physical and chemical characteristics.

Collection of Distributed Soil Samples

↓

Crushed the air dried samples into powered form

↓

Determination of Phyisical and Index properties of Soil Samples

The soil samples were analysed in Dhaka University's Department of Soil, Water and Environment Laboratory.The details of the soil sampling locations have been mentioned in the ***Table 8-34.***

Table 8-34 : Details of soil sampling locations

S.No.	Location	Location ID	Geographical Coordinates	
			Latitude	Longitude
1.	Vati Bolaki	SQ 1	23°35'15.71" N	90°34'36.61" E
2.	Gowal Gao	SQ 2	23°34'16.66" N	90°35'17.01" E
3.	Pachani	SQ 3	23°36'30.86" N	90°34'40.52" E

The monitoring results have been furnished in the ***Table 8-35***

Table 8-35 : Monitoring Results

S.No.	Parameters		Unit	Concentration Present		
				SQ 1	SQ 2	SQ 3
1.	pH		Units	6.68	6.02	6.78
2.	Electrical conductivity		dS/m	1.15	0.42	0.03
3.	Nitrate		mg/kg	30.0	30.0	30.0
4.	Nitrite		mg/kg	1.13	1.26	0.98
5.	Phosphate		mg/kg	13.11	13.46	10.94
6.	Particle Size distribution	Sand	%	67	59	84
		Silt	%	23	25	10
		Clay	%	10	16	6
7.	Texture			Sandy Loam	Sandy Loam	Loamy loam
8.	Permeability		cm/hour	4.6	Undetectable	9.9
9.	Porosity		%	50	50	61
10.	Iron		mg/kg	18603.6	18557.5	19229.9
11.	Lead		mg/kg	Not Detected	Not Detected	Not Detected
12.	Manganese		mg/kg	171.39	201.58	163.92
13.	Nickel		mg/kg	11.25	Not Detected	5.15
14.	Barium		mg/kg	28.1	31.60	27.11
15.	Zinc		mg/kg	51.75	49.60	33.43
16.	Copper		mg/kg	9.99	9.79	6.89
17.	Cadmium		mg/kg	Not Detected	Not Detected	Not Detected
18.	Chromium		mg/kg	Not Detected	Not Detected	Not Detected
19.	Arsenic		mg/kg	2.34	4.88	1.55
20.	Mercury		mg/kg	0.466	0.784	0.447
21.	Total Hydro Carbon		mg/kg	147.0	98.0	57.0
22.	Cat ion Exchange Capacity		Meq/100gm	11.20	8.1	14.26
23.	Calcium		mg/kg	3396.21	3498.5	2990.01
24.	Magnesium		mg/kg	1136.98	1910.56	1465.4
25.	Potassium		mg/kg	1765.28	1200.16	1384.12
26.	Nitrogen		mg/kg	897.59	927.73	231.04

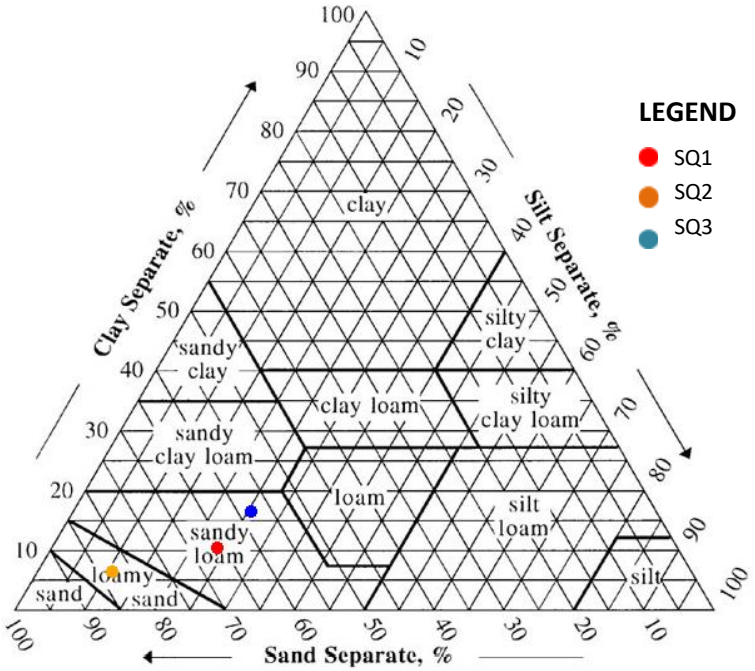
27.	Phosphorous	mg/kg	1713.7	368.3	1939.4

Source: Adroit

It can be seen that the soils in the area are slightly basic in nature with pH values ranging from 6.02 – 6.78. Electrical conductivity values in the samples varied from 0.03 to 1.15 dS/cm. Nitrates in all the three soil samples were found to be 30.0 mg/kg whereas the nitrites ranged from 0.98 – 1.26 mg/kg. Phosphate levels were observed to be 10.94 -13.11 mg/kg. Thus the soils in the region can be concluded as fertile and suitable for agriculture.

The soil textures have been depicted in the *Figure 8-42***,** Soils in the area were observed to be predominantly sandy loam in nature with sand content ranging from 59 -84%. Since the area is adjacent to the river, hence, significant silt contents were found in the soils. The porosities of the soils were found to be between 50-61 % whereas the permeability varied from 4.6 – 9.9 cm/hour. The high permeability values can be attributed to the presence of a high percentage of coarse particles i.e. sand in the soil.

Figure 8-42 : Soil texture classification at the three sampling locations



Source: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/tools/?cid=nrcs142p2_054167

The iron levels in soil samples collected from the study area vary from 18557.5 to 19229.9 mg/kg. Concentrations of heavy metals like lead, cadmium and chromium were below the detection limits. The cat ion exchange capacity of soil samples ranges from 8.1 to 14.26 meq/100gm, which indicates the sandy texture of the soil. Mercury levels were in range of 0.466 to 0.784 mg/kg and arsenic concentrations were in range of 1.55-4.88 mg/kg respectively. The soil samples taken were observed to be rich in calcium with concentrations ranging from 2990.01 to 3498.1 mg/kg and concentrations of magnesium with range from 1136.98-1910.56 mg/kg. The levels of phosphorus, nitrogen and potassium as detected in soil samples collected are presented in the figures below (*Figure 8-43*, *Figure 8-44*and *Figure 8-45*).

Figure 8.43 : Graphical representation of Phosphorus concentration in soil samples

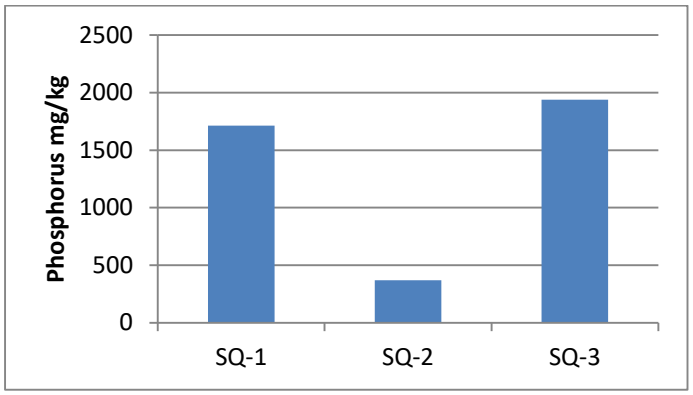


Figure 8.44 : Graphical representation of Nitrogen Concentration in soil samples

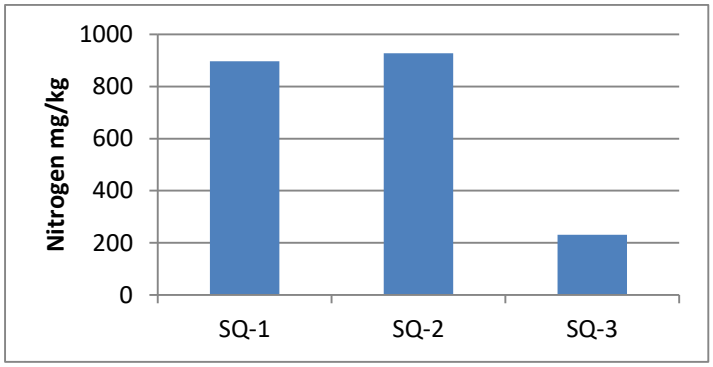
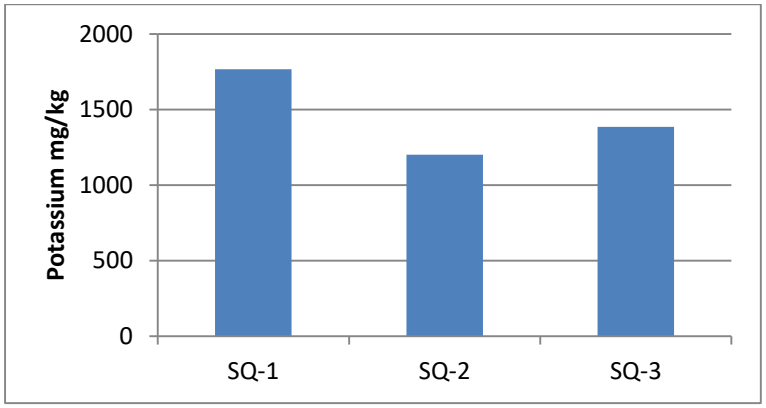


Figure 8.45 : Graphical representation of Potassium Concentration in soil samples



8.5.7 Ecological Survey

A baseline ecological survey was undertaken in the study area to evaluate the ecological status of the area and identify species of concern as per Red Data Book. The assessment was carried out during the period of February 2014 by team of prfossionals from AECL and Professors from DUET, Gazipur and Jahangir Nagar University, Dhaka

Apart from that, another primary ecological survey to identify species and habitats of conservation concern in the study area was carried out during the period of April 2014 by ecological professionals from AECOM, India and Adroit Bangladesh.

Methodology

The approach to conduct the ecological survey was as follows:

- Field visits were undertaken for the ecological assessment to survey the vegetation in the study area;
- Extensive literature review was done to assess the vegetation and ecology of the region, based upon which a list of flora and fauna was compiled; and
- The diversity of the vegetation and its distribution was determined after field survey and data collection.

8.5.7.1 Ecological Diversity of Area

- At least forty-five mammalian species, sixty-three reptilian ones and forty-nine Piscean ones are likely to be resident in and around the survey-area.
- At least one hundred and seventeen species of migratory birds, including winter, summer and passage visitors, are associated with the region in which the survey-area is located;
- At least five species of Congregatory birds are associated with the region in which the survey-area is located;
- At least two species of mammals, four species of birds and two species of reptiles are endemic to or have restricted ranges that include the region in which the survey-area is located;
- At least seven mammalian species, twenty-one avian ones, fourteen reptilian ones and four Piscean ones, designated as being of special conservation-concern (Critically Endangered, Endangered, Vulnerable, Threatened or Near Threatened) by the IUCN, are associated with the region in which the survey-area is located; and
- The local communities depend on the survey-area for water, cultivated foods, wild (uncultivated) foods, traditional medicines, fuel, fodder, fibre, timber and various secondary needs.

8.5.7.2 Literature Review

Type of Forest

The region of Dhaka comprises of tropical moist deciduous forest. This type of forest is generally intermingled with the neighbouring settlements and fragmented into smaller patches. Sal (Shorea robusta) is the main species there with other associates like Koroi (Albizzia procera), Azuli (Dillenia pentagyna), Sonalu (Cassia fistula), Bohera (Terminalia belerica), Haritaki (Terminalia chebula), Kanchan (Bauhinia acuminata), Jarul (Lagerstroemia speciosa), Jam (Syzygium spp) etc.[10]

[10] http://www.bforest.gov.bd/index.php/forest-category/tropical-moist-deciduous-forests

8.5.7.3 Methodology

Six locations were identified to cover the entire study area adequately with proportionate representation of the different ecosystems and land-use types recorded near the project site. Samples were collected from four designated locations namely:

Table 8.36: Location details of Ecological Survey

Sl.No.	Location	Elevation (m)	Nearest Village(s)	Description of the site
1	N 23 35 17.1, E 90 34 39.9	21	Bhati Bholaki	River-terrace. Grassland. Orchard.
2	N 23 34 11.4, E 90 35 18.6	33	Goalgaon	Fallow fields. Ditch. Pond.
3	N 23 33 55.0, E 90 33 41.0	35	Chaur Hogla	Plantation.
4	N 23 34 42.8, E 90 34 42.6	17	Bholaki	River-bank. Floating islet.
5	N 23 36 33.9, E 90 34 42.6	34	Pachani Ghat	Planted fields. Farm-bunds.
6	N 23 36 39.6, E 90 35 28.3	27	Meghana Ghat	Embankment. Industrial estate.

The geographical locations of the survey sites in the study area are provided in *Figure* 8.46 . At each site, a study of floral diversity was carried out in the following manner:

Plant samples collection

- A quadrat of approximately 10 m x 10 m was marked. The species of trees, as well as the number of individuals of each species, falling within this area were collected.
- A quadrat of approximately 5 m x 5 m was marked within this larger quadrat. The species of large and small shrubs, along with the number of individuals of each species, falling within this area were similarly noted.
- Smaller quadrats of 2 m x 2 m were employed for the herbs, both grasses and forbs.

In each selected location/sub-site, at least 25 quadrats were randomly applied in diversified habitats. Collected plant samples were processing and preparation of herbarium sheets following standard herbarium techniques.

Identification of plant samples

All the collected plant specimens found in the selected sites of SMF was identified by taxonomic expertise and through cross-checking with herbarium specimens preserved at BNH/JUH and also matching the taxonomic description, keys or the photographs/illustrations in the relevant literatures.

Data analysis and interpretation

Abundance and Frequency of the recorded species was determined by using formulae as described below:

Abundance: No. of individuals per quadrat of occurrence.

$$A = \frac{\text{Total no. of individuals of a species in all the quadrats}}{\text{Total no. of quadrats in which the species occurred}}$$

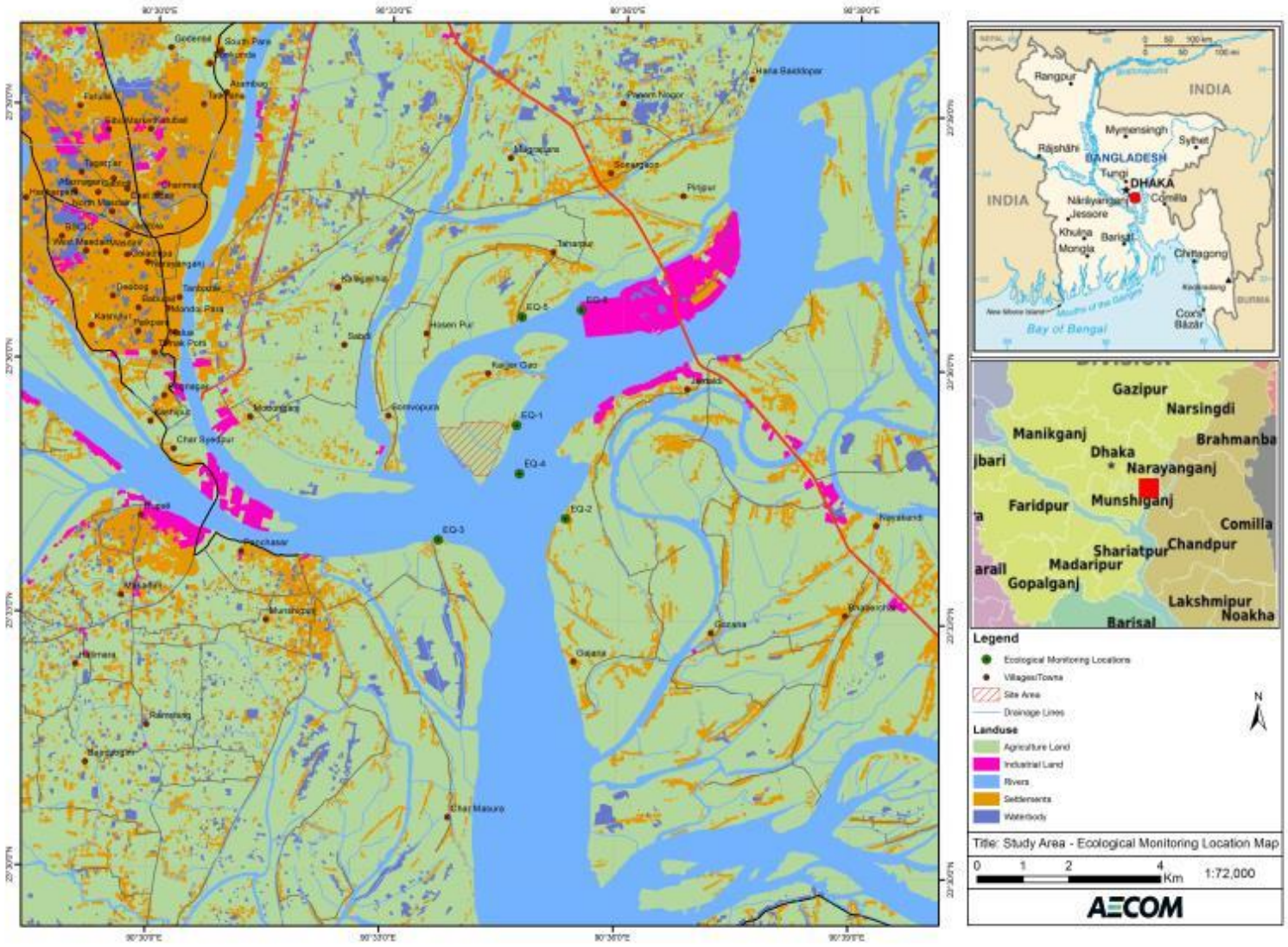
Frequency: This is described as the % of quadrats occupied by a given species.

$$F(\%) = \frac{\text{Total no. of quadrats in which the species occurred}}{\text{Total no. of quadrats studied}} \times 100$$

The floristic and avifaunal profiles of the survey area were then assessed in terms of:

- Application of DAFOR scale for the determination existing status of the recorded species: Dominant (D), Abundant (A), Frequent (F), Occasional (O) and Rare (R); and
- According to the criteria of IUCN Red List Categories (Khan et al., 2004), the threatened categories (i.e., Critically Endangered, Endangered and Vulnerable) of plant species were highlighted from available data and field observation

Figure 8.46 : Locations of ecological survey



8.5.7.4 Floristic Diversity of the Study Area

The survey-area contains natural habitats in the form of small remnant patches of natural vegetation or individual specimens of native species. A total of 143 vascular plant species belonging to 122 genera covering in 56 families have been recorded from study area as presented in *Table 8.37*, *Table 8.38* and *Table 8.39*.

Table 8.37: Species of Herbs observed during Primary Survey

Sl.	Scientific Name	Family	Cotyledon	A	F (%)	Remark
1.	*Ageratum conyzoides* L.	Asteraceae	Dicot	18.55	44.00	**F**
2.	*Alocasia macrorrhizos* (L.) G. Don	Araceae	Dicot	1.67	4.00	**VR**
3.	*Alternanthera paronichyoides* St. Hil.	Amaranthaceae	Dicot	4.25	16.00	**R**
4.	*Alternanthera philoxeroides* (Mart.) Griseb.	Amaranthaceae	Dicot	11.43	44.00	**F**
5.	*Alternanthera sessilis* (L.) R. Br...	Amaranthaceae	Dicot	15.83	62.00	**A**
6.	*Amaranthus spinosus* L.	Amaranthaceae	Dicot	16.50	21.00	**O**
7.	*Amaranthus tricolor*	Amaranthaceae	Dicot	5.60	12.00	**R**
8.	*Amaranthus viridis* L.	Amaranthaceae	Dicot	5.00	16.00	**R**
9.	*Aponogeton appendiculatus* Bruggen	Aponogetonaceae	Monocot	5.33	24.00	**O**
10.	*Axonopus compressus* (Sw.) P. Beauv.	Poaceae	Monocot	16.50	42.00	**F**
11.	*Azolla pinnata*	Pteridophyte	Fern	43.50	16.00	**R**
12.	*Blyxa octandra* (Roxb.) Planch.	Hydrochaitaceae	Dicot	2.67	12.00	**R**
13.	*Brassica juncea*	Brassicaceae	Dicot	47.00	8.00	**R**
14.	*Brassica oleracea* L. var. botrytis L.	Brassicaceae	Dicot	2.67	12.00	**R**
15.	*Capsicum frutescens* L.	Solanaceae	Dicot	19.00	22.00	**O**
16.	*Cardiospermum halicacabum* L.	Sapindaceae	Dicot	1.50	16.00	**R**
17.	*Centella asiatica*	Apiaceae	Dicot	23.20	21.00	**O**
18.	*Chenopodium album* L.	Chenopodiaceae	Dicot	6.10	48.00	**F**
19.	*Coccinia cordifolia*	Cucurbitaceae	Dicot	1.60	21.00	**O**
20.	*Colocasia esculenta* (L.) Schott	Araceae	Monocot	6.33	12.00	**R**
21.	*Commelina diffusa* Burm. f.	Commelinaceae	Monocot	9.00	16.00	**R**
22.	*Commelina longifolia* Lamk.	Commelinaceae	Monocot	5.00	16.00	**R**
23.	*Coriendrum sativum*	Apiaceae	Dicot	27.33	12.00	**R**
24.	*Cotula hemispherica* (Roxb.) Wall *ex* Clarke	Asteraceae	Dicot	3.75	16.00	**R**
25.	*Cristella dentata*	Pteridophyte	Fern	9.33	12.00	**R**
26.	*Croton bonplandianus* Baill.	Euphorbiaceae	Dicot	14.50	42.00	**F**
27.	*Cuscuta reflexa*	Convolvulaceae	Dicot	1.17	24.00	**O**
28.	Cynodon dactylon (L.) Pers.	Poaceae	Monocot	34.73	64.00	**A**
29.	*Cyperus rotundus* Benth.	Cyperaceae	Monocot	7.33	12.00	**R**
30.	*Digiteria* sp.	Poaceae	Monocot	14.40	24.00	**O**
31.	*Eclipta alba* (L.) Hassk.	Asteraceae	Dicot	5.43	44.00	**F**
32.	*Echinochloa colonum*	Poaceae	Monocot	2.33	22.00	**O**
33.	*Eichhornia crassipes* (Mart.) Solms	Pontedariaceae	Dicot	12.00	62.00	**A**

Sl.	Scientific Name	Family	Cotyledon	A	F (%)	Remark
34.	*Elusine* sp.	Poaceae	Monocot	3.00	24.00	**O**
35.	*Enhydra fluctuans*	Asteraceae	Dicot	4.50	32.00	**O**
36.	*Euphorbia hirta* L.	Euphorbiaceae	Dicot	41.25	32.00	**O**
37.	*Fimbrystilis* sp.	Cyperaceae	Monocot	40.40	44.00	**F**
38.	*Gnaphalium luteo-album* L.	Asteraceae	Dicot	14.00	72.00	**A**
39.	*Gnaphalium polycaulon* Pers.	Asteraceae	Dicot	8.00	28.00	**O**
40.	*Grangea maderaspatana* (L.) Poir.	Asteraceae	Dicot	6.80	22.00	**O**
41.	*Heliotropium indicum* L.	Boraginaceae	Dicot	8.33	24.00	**O**
42.	*Hemarthria protensa* Steud.	Poaceae	Monocot	3.33	12.00	**R**
43.	*Hydrilla verticillata*	Menyanthaceae	Dicot	4.40	24.00	**O**
44.	*Hygrophila polysperma* (Roxb.) T. Anders.	Acanthaceae	Dicot	3.75	16.00	**R**
45.	*Hygroryza aristata* (Retz.) Nees	Poaceae	Dicot	4.00	16.00	**R**
46.	*Imperata cylindrica* (L.) P. Beauv	Poaceae	Monocot	36.22	42.00	**F**
47.	*Ipomoea aquatica* Forssk.	Convolvulaceae	Dicot	5.00	24.00	**O**
48.	*Ipomoea batatas*	Convolvulaceae	Dicot	8.50	32.00	**O**
49.	*Kyllinga monocephala* Rottb.	Cyperaceae	Monocot	49.60	44.00	**F**
50.	*Kyllinga nemoralis* J. R. Forst. & G Forst.	Cyperaceae	Monocot	16.29	28.00	**O**
51.	*Lablab purpureus* (L.) Sweet	Fabaceae	Dicot	2.50	24.00	**O**
52.	*Lagascea mollis* Cav.	Asteraceae	Dicot	2.75	16.00	**R**
53.	*Lagenaria vulgaris* Seringe	Cucurbitaceae	Dicot	7.00	12.00	**R**
54.	*Leersia hexandra* Sw.	Poaceae	Dicot	4.50	24.00	**O**
55.	*Lemna perpusila*	Urticaceae	Dicot	62.50	22.00	**O**
56.	*Lens culinare* Medic.	Fabaceae	Dicot	28.67	22.00	**O**
57.	*Lindernia crustacea* (L.) F. Muell.	Scrophulariaceae	Dicot	5.40	28.00	**O**
58.	*Lippia alba* (Mill.) Briton *et* Wilson	Verbenaceae	Dicot	2.75	24.00	**O**
59.	*Lippia nodiflora* (L.) Rich.	Verbenaceae	Dicot	6.50	44.00	**F**
60.	*Ludwigia adscendens* (L.) Hara.	Onagraceae	Dicot	5.60	42.00	**F**
61.	*Ludwigia* sp.	Onagraceae	Dicot	3.25	16.00	**R**
62.	*Lycopersicon esculentum* Mill.	Solanaceae	Dicot	4.67	22.00	**O**
63.	*Marsilea quadrifolia*	Pteridophyte	Fern	2.75	22.00	**O**
64.	*Momordica charantia* L.	Cucurbitaceae	Dicot	10.50	28.00	**O**
65.	*Nymphoides* sp.	Menyanthaceae	Dicot	10.33	12.00	**R**
66.	*Oenanthe javanica* (Blume) DC.	Apiaceae	Dicot	4.00	16.00	**R**
67.	*Oryza rulipogon* Griff.	Poaceae	Monocot	3.00	2.67	NT
68.	*Oxalis corniculata* L.	Oxalidaceae	Dicot	9.44	46.00	**F**
69.	*Panicum* sp.	Poaceae	Monocot	6.29	28.00	**O**
70.	*Penisetum* sp.	Poaceae	Monocot	14.00	22.00	**O**
71.	*Persicaria flaccida* (Meissn.) H..	Polygonaceae	Dicot	3.00	16.00	**R**
72.	*Persicaria hydropiper* (L.) Spach	Polygonaceae	Dicot	10.29	42.00	**F**
73.	*Persicaria lapathifolia* (L.) S. F. Gray	Polygonaceae	Dicot	5.00	24.00	**O**
74.	*Persicaria orientalis* (L.) Spach	Polygonaceae	Dicot	3.75	16.00	**R**
75.	*Physalis minima* L.	Solanaceae	Dicot	2.29	42.00	**F**
76.	*Pistia strateotes*	Araceae	Dicot	14.67	24.00	**O**
77.	*Polycarpon prostratum* (Forssk.)	Caryophyllaceae	Dicot	2.67	12.00	**R**

Sl.	Scientific Name	Family	Cotyledon	A	F (%)	Remark
	Asch..					
78.	*Polygonum plebeium* R. Br.	Polygonaceae	Dicot	5.00	28.00	**O**
79.	*Pouzolzia zeylanica*	Urticaceae	Dicot	5.00	48.00	**F**
80.	*Raphanus sativus* L.	Brassicaceae	Dicot	6.00	22.00	**O**
81.	*Rorippa palustris* (L.) Bess.	Brassicaceae	Dicot	13.00	52.00	**F**
82.	*Rotala serpyllifolia* (Roth) Brem.	Lythraceae	Dicot	2.50	2.67	NT
83.	*Rottboellia cochinchinensis* (Lour.) W. D.	Poaceae	Monocot	4.00	24.00	**O**
84.	*Rumex dentate* (Roth) Brem.	Polygonaceae	Dicot	14.58	68.00	**A**
85.	*Rumex vesicarius* L.	Polygonaceae	Dicot	6.00	24.00	**O**
86.	*Saccharum spontaneum* L.	Poaceae	Dicot	23.20	42.00	**F**
87.	*Sagittaria sagittifolia* L.	Alimataceae	Monocot	13.00	24.00	**O**
88.	*Salvinia cuculata*	Salviniaceae	Fern	24.67	24.00	**O**
89.	*Salvinia natans* (L.) Alli.	Salviniaceae	Fern	15.00	16.00	**R**
90.	*Scoparia dulcis*	Scopariaceae	Dicot	5.00	44.00	**F**
91.	*Setaria italica*	Poaceae	Monocot	1.75	22.00	**O**
92.	*Sida rhombifolia*	Malvaceae	Dicot	3.40	24.00	**O**
93.	*Solanum nigram* L.	Solanaceae	Dicot	12.83	48.00	**F**
94.	*Spillanthas acmila*	Asteraceae	Dicot	7.75	42.00	**F**
95.	*Spirodela polyrhiza*	Araceae	Monocot	95.00	24.00	**O**
96.	*Stephania japonica*	Menispermiaceae	Dicot	2.67	12.00	**R**
97.	*Synedrella nodiflora* (L.) Gaertn.	Asteraceae	Dicot	6.20	28.00	**O**
98.	*Utricularia* sp.	Utriculariaceae	Dicot	17.33	12.00	**R**
99.	*Vallisneria spiralis*	Hydrochaitaceae	Dicot	25.71	48.00	**F**
100.	*Vicia angustifolia* L.	Fabaceae	Dicot	1.67	12.00	**R**
101.	*Vicia sativa*	Fabaceae	Dicot	2.33	12.00	**R**

Legend: A=Abundant, F=Frequent, O=Occasional, R=Rare, VR=Very Rare, NT=Near Threatened, TH= Threatened

Source: Primary Survey

Table 8.38: Species of Shrubs observed during Primary Survey

Sl.	Scientific Name	Family	Cotyledon	A	F (%)	Remark
1.	*Arundo donax* L.	Poaceae	Monocot	6.00	1.33	**NT**
2.	*Ipomoea fistulosa* Mart, *ex* Choisy	Convolvulaceae	Dicot	5.00	42.00	**F**
3.	*Jasminum sambac*	Oleaceae	Dicot	1.50	8.00	**R**
4.	*Phyllanthus reticulates* Poir.	Euphorbiaceae	Dicot	2.20	28.00	**O**
5.	*Ricinus communis*	Euphorbiaceae	Dicot	1.50	12.00	**R**
6.	*Solanum melongena* L.	Solanaceae	Dicot	8.00	22.00	**O**
7.	*Urena lobata* L.	Malvaceae	Dicot	4.75	24.00	**O**
8.	*Vitex negundo*	Verbenaceae	Dicot	2.00	4.00	**VR**
9.	*Xanthium indicum* Koen. *ex* Roxb.	Asteraceae	Dicot	7.43	44.00	**F**

Legend: A=Abundant, F=Frequent, O=Occasional, R=Rare, VR=Very Rare, NT=Near Threatened, TH= Threatened

Source: Primary Survey

Table 8.39: Species of Trees observed during Primary Survey

Sl.	Scientific name	Family	Cotyledon	A	F (%)	Remark
1.	*Albizia procera* (Roxb.) Benth.	Mimosaceae	Dicot	2.33	22.00	**O**
2.	*Albizia richardiana*	Mimosaceae	Dicot	1.50	8.00	**R**
3.	*Alstonia scholaris*	Apocynaceae	Dicot	1.00	8.00	**R**
4.	*Anacardium occidentale*	Anacardiaceae	Dicot	1.00	8.00	**R**
5.	*Annona squamosa*	Annonaceae	Dicot	1.00	2.67	**NT**
6.	*Aphanamixis polystachya*	Euphorbiaceae	Dicot	1.00	2.67	**NT**
7.	*Areca catechu*	Palmae	Monocot	1.67	24.00	**O**
8.	*Artocarpus heterophyllus*	Moraceae	Dicot	1.80	22	**O**
9.	*Artocarpus lachuca*	Moraceae	Dicot	1.00	1.33	**NT**
10.	*Averrhoea carambola*	Averhoaceae	Dicot	1.50	8.00	**R**
11.	*Bambusa* sp.	Poaceae	Monocot	8.50	22.00	**O**
12.	*Barringtonia acutangula* (L.) Gaertn.	Lecythidaceae	Dicot	1.00	2.67	**NT**
13.	*Bombax ceiba*	Bombacaceae	Dicot	1.33	12.00	**R**
14.	*Citrus* sp.	Rutaceae	Dicot	1.00	16.00	**R**
15.	*Cocos nucifera* L.	Arecaceae	Monocot	2.17	24.00	**O**
16.	*Crateva magna* (Lour.) DC.	Capparidaceae	Dicot	1.00	2.67	**NT**
17.	*Dillenia indica*	Dilleniaceae	Dicot	1.00	2.67	**NT**
18.	*Diospyros peregrina* Guerke	Ebenaceae	Dicot	1.00	1.33	**TH**
19.	*Eucalyptus citriodora* Hook.	Myrtaceae	Dicot	2.67	22.00	**O**
20.	*Ficus hispida*	Moraceae	Dicot	1.00	8.00	**R**
21.	*Ficua racemosa*	Moraceae	Dicot	1.00	4.00	**VR**
22.	*Lannea coromandelica*	Anacardiaceae	Dicot	1.50	8.00	**R**
23.	*Mangifera indica* L.	Anacardiaceae	Dicot	1.71	28.00	**O**
24.	*Mimusops elengi*	Sapotaceae	Dicot	1.00	12.00	**R**
25.	*Psidium guajava*	Myrtaceae	Dicot	1.75	24.00	**O**
26.	*Salix tetrasperma* Roxb.	Salicaceae	Dicot	1.00	1.33	**TH**
27.	*Samanea saman* (Jacq.) Merr.	Mimosaceae	Dicot	3.13	42.00	**F**
28.	*Streblus asper*	Euphorbiaceae	Dicot	1.33	12.00	**R**
29.	*Swietenia mahagoni* (L.) Jacq.	Meliaceae	Dicot	2.40	24.00	**O**
30.	*Syzygium cumini*	Myrtaceae	Dicot	1.00	16.00	**R**
31.	*Terminalia arjuna*	Combretaceae	Dicot	1.00	4.00	**VR**
32.	*Trewia macrophylla* Roxb.	Euphorbiaceae	Dicot	1.60	42.00	**F**
33.	*Ziziphus mauritiana* Lamk.	Rhamnaceae	Dicot	1.83	24.00	**O**

Legend: A=Abundant, F=Frequent, O=Occasional, R=Rare, VR=Very Rare, NT=Near Threatened, TH= Threatened

Source: Primary Survey

Among the habit categories as presented in *Figure 8-47,* 101 (70.63%) species were herb, 9 (6.29%) species were shrub and 33 (23.08%) plant species were tree.

Figure 8-47: Categories of Habitat Recorded

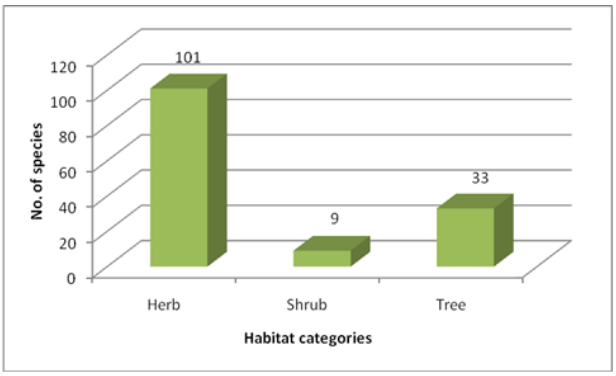


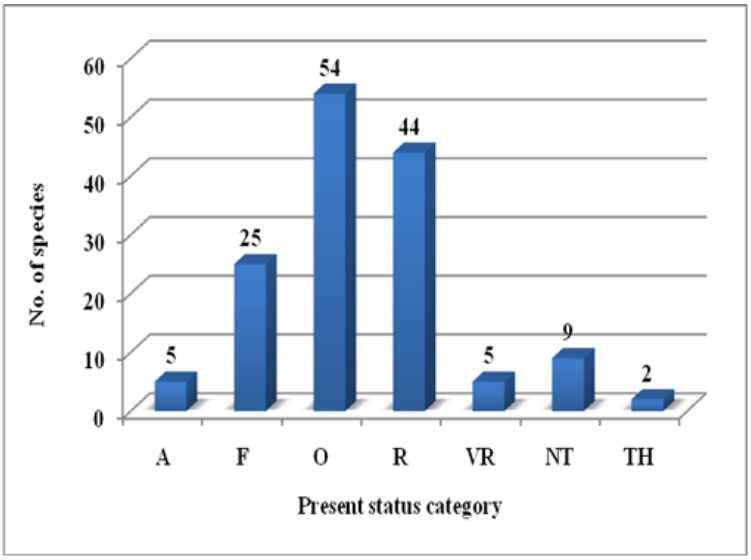
Figure 8-48: Flora Observed during Primary Survey

	
***Acanthus* sp.**	***Agerarum conizoides***
	
Amaranthus spinosus	***Arundo donax* L**

	
Lagascea mollis	***Rottbellia cochinchinensis***
	
Commelina diffusa	***Rumex maritimus***

Analytical data of the flora recorded from the study area revealed that 5 species were abundant, 25 species were frequent, 54 species were occasional, 44 species were rare, 5 species were very rare, 9 species were near threatened and 2 species were recorded as threatened. *Figure 8-49* present the present status of floral species in the study area.

Figure 8-49: Present status of the recorded plant species.



Legend: A=Abundant, F=Frequent, O=Occasional, R=Rare, VR=Very Rare, NT=Near Threatened, TH= Threatened

8.5.7.5 Avifaunal Diversity of the Study Area

Table 8.39 presents the data for avifaunal species collected during the survey indicates that the survey-area provides habitats for the following species of birds:

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Table 8.40: Species of Avi Fauna observed in the Survey Area

Sr. No.	Scientific Name	English Name	Local Name	IUCN Status*
1	*Francolinus francolinus*	Black Francolin	-	LC
2	*Coturnix coromandelica*	Rain Quail	-	LC
3	*Coturnix chinensis*	King Quail	-	LC
4	*Dendrocygna javanica*	Lesser Whistling Duck	Sharali/ Gecho-Hans	LC
5	*Nettapus coromandelianus*	Cotton Pygmy Goose	Bali Hans/ Bele Hans	LC
6	*Anas poecilorhyncha*	Spot-billed Duck	Patil Hans	LC
7	*Rhodonessa caryophyllacea*	Pink-headed Duck	-	CE
8	*Tachybaptus ruficollis*	Little Grebe	-	LC
9	*Anastomus oscitans*	Asian Openbill	Shamuk-bhanga/ Shamuk-khol	LC
10	*Leptoptilos javanicus*	Lesser Adjutant	Modontak	V
11	*Threskiornis melanocephalus*	Black-headed Ibis	Kastey-chora	NT
12	*Ixobrychus sinensis*	Yellow Bittern	Holdey Bok/Kath Bok	LC
13	*Ixobrychus cinnamomeus*	Cinnamon Bittern	Lal Bok	LC
14	*Butorides striata*	Striated Heron	-	LC
15	*Nycticorax nycticorax*	Black-crowned Night Heron	Waak/ Nishi Bok	LC
16	*Ardeola grayii*	Paddy bird	-	LC
17	*Ardea cinerea*	Grey Heron	Dhushor Bok	LC
18	*Ardea goliath*	Goliath Heron	Mohakoi/Bok	LC
19	*Bubulcus ibis*	Cattle Egret	Go-bok	LC
20	*Casmerodius albus*	Great Egret	Jathua/ Sada Bok	LC

Sr. No.	Scientific Name	English Name	Local Name	IUCN Status*
21	*Mesophoyx intermedia*	Intermediate Egret	Maijhla Bok/ Korche Bok	LC
22	*Egretta garzetta*	Little Egret	Choto Bok	LC
23	*Pelecanus philippensis*	Spot-billed Pelican	Gogonber	NT
24	*Phalacrocorax niger*	Little Cormorant	Paan-kowri	LC
25	*Phalacrocorax fuscicollis*	Indian Cormorant	Pankure	LC
26	*Elanus caeruleus*	Black-winged Kite	-	LC
27	*Milvus migrans*	Black Kite	-	LC
28	*Haliastur Indus*	Brahminy Kite	-	LC
29	*Haliaeetus leucogaster*	White-bellied Sea Eagle	-	LC
30	*Haliaeetus leucoryphus*	Pallas's Fish Eagle	-	V
31	*Ichthyophaga ichthyaetus*	Grey-headed Fish Eagle	-	NT
32	*Pernis ptilorhynchus*	Oriental Honey Buzzard	-	LC
33	*Gyps bengalensis*	White-rumped Vulture	-	CE
34	*Spilornis cheela*	Crested Serpent Eagle	-	LC
35	*Accipiter badius*	Shikra	-	LC
36	*Accipiter virgatus*	Besra	-	LC
37	*Aquila hastata*	Indian Spotted Eagle	-	V
38	*Nisaetus limnaeetus*	Changeable Hawk Eagle	-	LC
39	*Houbaropsis bengalensis*	Bengal Florican	-	CE
40	*Amaurornis phoenicurus*	White-breasted Waterhen	Dahuk	LC
41	*Gallicrex cinerea*	Watercock	Kura	LC
42	*Turnix suscitator*	Barred Buttonquail	-	LC
43	*Porphyrio porphyrio*	Purple Swamphen	Kalim/ Kaim	LC
44	*Gallinula chloropus*	Common Moorhen	Jol Moorgi	LC
45	*Fulica atra*	Eurasian Coot	-	LC
46	*Grus antigone*	Sarus Crane	Sarash Pakhi	V
47	*Hydrophasianus chirurgus*	Pheasant-tailed Jacana	Jol Moyur/ Neo	LC
48	*Metopidius indicus*	Bronze-winged Jacana	Jolpipi/ Pipi	LC
49	*Vanellus duvaucelii*	River Lapwing	Hot-titi	LC
50	*Vanellus indicus*	Red-wattled Lapwing	Lal-lotika Hot-ti-ti	LC
51	*Charadrius dubius*	Little Ringed Plover	Choto Jiria	LC
52	*Glareola maldivarum*	Oriental Pratincole	-	LC
53	*Glareola lacteal*	Small Pratincole	-	LC
54	*Sterna aurantia*	River Tern	Maach Khaikka	LC
55	*Sterna acuticauda*	Black-bellied Tern	Gangchil	LC
56	*Columba livia*	Common Pigeon	-	LC
57	*Streptopelia orientalis*	Oriental Turtle Dove	-	LC
58	*Streptopelia decaocto*	Eurasian Collared Dove	-	LC
59	*Streptopelia tranquebarica*	Red Collared Dove	-	LC

Sr. No.	Scientific Name	English Name	Local Name	IUCN Status*
60	*Stigmatopelia chinensis*	Spotted Dove	-	LC
61	*Treron bicinctus*	Orange-breasted Green Pigeon	-	LC
62	*Treron phoenicopterus*	Yellow-footed Green Pigeon	-	LC
63	*Chalcophaps indica*	Emerald Dove	-	LC
64	*Psittacula krameri*	Rose-ringed Parakeet	-	LC
65	*Hierococcyx varius*	Chokhgelo Pakhi	Chokhgelo Pakhi	LC
66	*Cuculus micropterus*	Kokil	Kokil	LC
67	*Cacomantis merulinus*	Sorgom	Sorgom	LC
68	*Eudynamis scolopaceus*	Asian Koel	-	LC
69	*Centropus sinensis*	Greater Coucal	-	LC
70	*Centropus bengalensis*	Lesser Coucal	-	LC
71	*Tyto alba*	Barn Owl	-	LC
72	*Otus lettia*	Collared Scops Owl	-	LC
73	*Otus sunia*	Oriental Scops Owl	-	LC
74	*Athene brama*	Spotted Owlet	-	LC
75	*Ninox scutulata*	Brown Hawk Owl	-	LC
76	*Caprimulgus macrurus*	Large-tailed Nightjar	-	LC
77	*Cypsiurus balasiensis*	Asian Palm Swift	-	LC
78	*Apus nipalensis*	House Swift	-	LC
79	*Upupa epops*	Common Hoopoe	-	LC
80	*Coracias benghalensis*	Indian Roller	Nilkanto	LC
81	*Pelargopsis capensis*	Stork-billed Kingfisher	-	LC
82	*Halcyon smyrnensis*	White-throated Kingfisher	-	LC
83	*Halcyon pileata*	Black-capped Kingfisher	-	LC
84	*Todiramphus chloris*	Collared Kingfisher	-	LC
85	*Alcedo atthis*	Common Kingfisher	-	LC
86	*Ceryle rudis*	Pied Kingfisher	-	LC
87	*Merops orientalis*	Green Bee-eater	-	LC
88	*Megalaima asiatica*	Blue-throated Barbet	-	LC
89	*Megalaima haemacephala*	Coppersmith Barbet	-	LC
90	*Micropternus brachyurus*	Rufous Woodpecker	-	LC
91	*Dendrocopos macei*	Fulvous-breasted Woodpecker	-	LC
92	*Dinopium benghalense*	Lesser Goldenback	-	LC
93	*Artamus fuscus*	Ashy Woodswallow	-	LC
94	*Aegithina tiphia*	Common Iora	-	LC
95	*Pericrocotus cinnamomeus*	Small Minivet	-	LC
96	*Lanius vittatus*	Bay-backed Shrike	-	LC
97	*Lanius schach*	Long-tailed Shrike	-	LC
98	*Lanius meridionalis*	Southern Grey Shrike	-	LC
99	*Dicrurus remifer*	Lesser Racket-tailed Drongo	-	LC

Sr. No.	Scientific Name	English Name	Local Name	IUCN Status*
100	*Dicrurus macrocercus*	Black Drongo	-	LC
101	*Oriolus kundoo*	Sonabou	Sonabou	LC
102	*Oriolus xanthornus*	Black-hooded Oriole	-	LC
103	*Rhipidura albicollis*	White-throated Fantail	-	LC
104	*Hypothymis azurea*	Black-naped Monarch	-	LC
105	*Dendrocitta vagabunda*	Rufous Treepie	-	LC
106	*Corvus levaillantii*	Eastern Jungle Crow	-	LC
107	*Corvus splendens*	House Crow	-	LC
108	*Parus major*	Great Tit	-	LC
109	*Riparia paludicola*	Plain Martin	-	LC
110	*Mirafra assamica*	Bengal Bushlark	-	LC
111	*Calandrella raytal*	Sand Lark	-	LC
112	*Eremopterix griseus*	Ashy-crowned Sparrow Lark	-	LC
113	*Alauda gulgula*	Oriental Skylark	-	LC
114	*Pycnonotus jocosus*	Red-whiskered Bulbul	-	LC
115	*Pycnonotus cafer*	Red-vented Bulbul	-	LC
116	*Prinia gracilis*	Graceful Prinia	-	LC
117	*Prinia inornata*	Plain Prinia	-	LC
118	*Cisticola juncidis*	Zitting Cisticola	-	LC
119	*Orthotomus sutorius*	Common Tailorbird	-	LC
120	*Turdoides striata*	Jungle Babbler	-	LC
121	*Garrulax ruficollis*	Rufous-necked Laughingthrush	-	LC
122	*Zosterops palpebrosus*	Oriental White-eye		LC
123	*Acridotheres fuscus*	Jungle Myna	-	LC
124	*Acridotheres gingianus*	Bank Myna	-	LC
125	*Acridotheres tristis*	Common Myna	-	LC
126	*Gracupica contra*	Asian Pied Starling	-	LC
127	*Sturnia malabarica*	Chestnut-tailed Starling	-	LC
128	*Sturnia pagodarum*	Brahminy Starling	-	LC
129	*Zoothera citrina*	Orange-headed Thrush	-	LC
130	*Copsychus saularis*	Oriental Magpie Robin	-	LC
131	*Dicaeum erythrorhynchos*	Pale-billed Flowerpecker	-	LC
132	*Leptocoma zeylonica*	Purple-rumped Sunbird	-	LC
133	*Cinnyris asiaticus*	Purple Sunbird	-	LC
134	*Passer domesticus*	House Sparrow	-	LC
135	*Ploceus benghalensis*	Black-breasted Weaver	-	LC
136	*Ploceus philippinus*	Baya Weaver		LC
137	*Euodice malabarica*	Indian Silverbill	-	LC
138	*Lonchura punctulata*	Scaly-breasted Munia	-	LC

Sr. No.	Scientific Name	English Name	Local Name	IUCN Status*
139	*Lonchura atricapilla*	Chestnut Munia	-	LC
140	*Motacilla maderaspatensis*	White-browed Wagtail	-	LC
141	*Anthus rufulus*	Paddyfield Pipit	-	LC

Source: The Red Book of Threatened Birds of Bangladesh 2000

8.5.7.6 Migratory Avifauna

Migratory Species

The survey area is located within the Brahmaputra river-system, believed to be the chief avian migratory flyway for birds entering the Indian subcontinent from northeast Asia.

Thus, the survey-area is very likely to fall in the flight-path of the various winters, summer and passage visitor-birds migrating to/ through the region in which it is situated. *Table 8.41* provides the list of such avian species recorded in the survey area.

Table 8.41: Species of Migratory Avifauna observed in the Survey Area

Sr. No.	Scientific Name	English Name	Local Name	Type	IUCN Status
1	*Dendrocygna bicolor*	Fulvous Whistling Duck	Baro Shorali	Winter	LC
2	*Anser anser*	Greylag Goose	Dhushar Rajhans	Winter	LC
3	*Anser indicus*	Bar-headed Goose	Rajhans	Winter	LC
4	*Tadorna ferruginea*	Ruddy Shelduck	Chokhachokhi/ Chokha	Winter	LC
5	*Anas strepera*	Gadwall	-	Winter	LC
6	*Anas falcata*	Falcated Duck	-	Winter	NT
7	*Anas penelope*	Eurasian Wigeon	Lalshir	Winter	LC
8	*Anas platyrhynchos*	Mallard	Nilshir	Winter	LC
9	*Anas clypeata*	Northern Shoveler	Pantamukhi	Winter	LC
10	*Anas acuta*	Northern Pintail	Lenja Hans	Winter	LC
11	*Anas querquedula*	Garganey	Giria Hans	Winter	LC
12	*Anas formosa*	Baikal Teal	Boikal Hans	Winter	LC
13	*Anas crecca*	Common Teal	Common Teal	Winter	LC
14	*Netta rufina*	Red-crested Pochard	Rangamuri	Winter	LC
15	*Aythya farina*	Common Pochard	Kalo Hans	Winter	LC
16	*Aythya baeri*	Baer's Pochard	Baro Bhuti Hans	Winter	CE
17	*Aythya nyroca*	Ferruginous Duck	-	Winter	NT
18	*Aythya fuligula*	Tufted Duck	Bamunia Hans	Winter	LC
19	*Podiceps grisegena*	Red-necked Grebe	-	Winter	LC
20	*Podiceps cristatus*	Great Crested Grebe	-	Winter	LC
21	*Mycteria leucocephala*	Painted Stork	Shona-jongha/ Rangila Bok	Winter	NT
22	*Ciconia nigra*	Black Stork	-	Winter	LC
23	*Botaurus stellaris*	Great Bittern	-	Passage	LC
24	*Phalacrocorax carbo*	Great Cormorant	Paan-kowri/ Jol-Kak	Winter	LC

Sr. No.	Scientific Name	English Name	Local Name	Type	IUCN Status
25	*Falco tinnunculus*	Common Kestrel	-	Winter	LC
26	*Falco subbuteo*	Eurasian Hobby	-	Winter	LC
27	*Falco peregrinus*	Peregrine Falcon	-	Winter	LC
28	*Milvus lineatus*	Black-eared Kite	-	Winter	NA
29	*Pandion haliaetus*	Osprey	-	Winter	LC
30	*Gyps fulvus*	Griffon Vulture	-	Winter	LC
31	*Aegypius monachus*	Cinereous Vulture	-	Winter	NT
32	*Circus aeruginosus*	Eurasian Marsh Harrier	-	Winter	LC
33	*Circus melanoleucos*	Pied Harrier	-	Winter	LC
34	*Circus macrourus*	Pallid Harrier	-	Winter	NT
35	*Circus pygargus*	Montagu's Harrier	-	Winter	LC
36	*Accipiter gentilis*	Northern Goshawk	-	Winter	LC
37	*Buteo rufinus*	Long-legged Buzzard	-	Winter	LC
38	*Aquila clanga*	Greater Spotted Eagle	-	Winter	V
39	*Aquila nipalensis*	Steppe Eagle	-	Winter	LC
40	*Aquila heliaca*	Eastern Imperial Eagle	-	Winter	V
41	*Hieraaetus pennatus*	Booted Eagle	-	Winter	LC
42	*Rallus indicus*	Brown-cheeked Rail	-	Winter	NA
43	*Porzana pusilla*	Baillon's Crake	Pingol Crake	Winter	LC
44	*Grus grus*	Common Crane	Sarash Pakhi	Winter	LC
45	*Recurvirostra avosetta*	Pied Avocet	-	Winter	LC
46	*Vanellus cinereus*	Grey-headed Lapwing	Dhushor Ti-ti	Winter	LC
47	*Pluvialis fulva*	Pacific Golden Plover	Choto Jiria	Winter	LC
48	*Charadrius alexandrinus*	Kentish Plover	Jiria	Winter	LC
49	*Gallinago stenura*	Pin-tailed Snipe	Kada-khocha/Chaga	Passage	LC
50	*Gallinago gallinago*	Common Snipe	Kada-khocha/Chaga	Winter	LC
51	*Limosa melanuroides*	Eastern Black-tailed Godwit	-	Winter	NT
52	*Limosa lapponica*	Bar-tailed Godwit	-	Winter	LC
53	*Limnodromus semipalmatus*	Asian Dowitcher	-	Winter	NT
54	*Neumenius phaeopus*	Whimbrel	Choto Gulinda	Winter	LC
55	*Numenius arquata*	Eurasian Curlew	Baro Gulinda	Winter	NT
56	*Tringa erythropus*	Spotted Redshank	-	Winter	LC
57	*Tringa tetanus*	Common Redshank	Lal-pa Pi-oo	Winter	LC
58	*Tringa stagnatilis*	Marsh Sandpiper	-	Winter	LC
59	*Tringa nebularia*	Common Greenshank	-	Winter	LC
60	*Tringa ochropus*	Green Sandpiper	-	Winter	LC
61	*Tringa glareola*	Wood Sandpiper		Winter	LC
62	*Xenus cinereus*	Terek Sandpiper		Winter	LC
63	*Actitis hypoleucos*	Common Sandpiper		Winter	LC
64	*Arenaria interpres*	Ruddy Turnstone	Patharghurani Batan	Winter	LC
65	*Calidris ruficollis*	Red-necked Stint	-	Winter	LC

Sr. No.	Scientific Name	English Name	Local Name	Type	IUCN Status
66	*Calidris minuta*	Little Stint	-	Winter	LC
67	*Calidris temminckii*	Temminck's Stint	-	Winter	LC
68	*Calidris subminuta*	Long-toed Stint	-	Winter	LC
69	*Calidris alba*	Sanderling	-	Winter	LC
70	*Calidris ferruginea*	Curlew Sandpiper	-	Winter	LC
71	*Eurynorhynchus pygmeus*	Spoon-billed sandpiper	-	Winter	CE
72	*Limicola falcinellus*	Broad-billed Sandpiper	-	Winter	LC
73	*Larus cachinnans*	Caspian Gull	-	Winter	LC
74	*Larus barabensis*	Steppe Gull	Jal Kabutor	Winter	LC
75	*Ichthyaetus ichthyaetus*	Pallas's Gull	Bara Jal Kabutor	Winter	LC
76	*Chroicocephalus brunnicephalus*	Brown-headed Gull	Gonga Koitor	Winter	LC
77	*Chroicocephalus ridibundus*	Black-headed Gull	Gonga Koitar	Winter	LC
78	*Gelochelidon nilotica*	Gull-billed Tern	-	Winter	LC
79	*Hydroprogne caspia*	Caspian Tern	-	Winter	LC
80	*Sterna hirundo*	Common Tern	Gangchil	Winter	LC
81	*Chlidonias hybrida*	Whiskered Tern	-	Winter	LC
82	*Rynchops albicollis*	Indian Skimmer	Panikata/ Jolkhor	Winter	V
83	*Clamator jacobinus*	Jacobin Cuckoo	-	Summer	LC
84	*Clamator coromandus*	Chestnut-winged Cuckoo	-	Summer	LC
85	*Asio flammeus*	Short-eared Owl	-	Winter	LC
86	*Apus pacificus*	Fork-tailed swift	-	Winter	LC
87	*Merops philippinus*	Blue-tailed Bee-eater	-	Summer	LC
88	*Jynx torquilla*	Eurasian Wryneck	-	Winter	LC
89	*Lanius cristatus*	Brown Shrike	-	Winter	LC
90	*Dicrurus leucophaeus*	Ashy Drongo	-	Winter	LC
91	*Terpsiphone paradise*	Asian Paradise Flycatcher	-	Passage	LC
92	*Riparia riparia*	Sand Martin	-	Winter	LC
93	*Hirundo rustica*	Barn Swallow	-	Winter	LC
94	*Cecropis daurica*	Red-rumped Swallow	-	Winter	LC
95	*Phragamaticola aedon*	Thick-billed Warbler		Winter	LC
96	*Acrocephalus stentoreus*	Clamorous Reed Warbler	-	Winter	LC
97	*Acrocephalus dumetorum*	Blyth's Reed Warbler	-	Winter	LC
98	*Phylloscopus fuscatus*	Dusky Warbler	-	Winter	LC
99	*Phylloscopus fuligiventer*	Smoky Warbler	-	Winter	LC
100	*Phylloscopus chloronotus*	Lemon-rumped Warbler	-	Winter	LC
101	*Phylloscopus inornatus*	Yellow-browed Warbler	-	Winter	LC
102	*Phylloscopus trochiloides*	Greenish Warbler	-	Winter	LC
103	*Luscinia svecica*	Bluethroat	-	Winter	LC
104	*Luscinia calliope*	Siberian Rubythroat	-	Winter	LC
105	*Phoenicurus ochruros*	Black Redstart	-	Winter	LC
106	*Phoenicurus frontalis*	Blue-fronted Redstart	-	Winter	LC

Sr. No.	Scientific Name	English Name	Local Name	Type	IUCN Status
107	*Saxicola torquatus*	Common Stonechat	-	Winter	LC
108	*Monticola solitaries*	Blue Rock Thrush	-	Winter	LC
109	*Ficedula albicilla*	Taiga Flycatcher	-	Winter	LC
110	*Eumyias thalassinus*	Verditer Flycatcher	-	Winter	LC
111	*Culicicapa ceylonensis*	Grey-headed Canary Flycatcher	-	Winter	LC
112	*Motacilla flava*	Yellow Wagtail	-	Winter	LC
113	*Motacilla citreola*	Citrine Wagtail	-	Winter	LC
114	*Motacilla cinerea*	Grey Wagtail	-	Winter	LC
115	*Motacilla alba*	White Wagtail	-	Winter	LC
116	*Anthus richardi*	Richard's Pipit	-	Winter	LC
117	*Anthus hodgsoni*	Olive-backed Pipit	-	Winter	LC

* CE – Critically Endangered, E – Endangered, LC – Least Concern, NT – Near Threatened and V – Vulnerable
Source: The Red Book of Threatened Birds of Bangladesh 2000

Congregatory Species

The following species of birds, displaying a tendency to congregate in large numbers, ranging from a few hundreds to thousands, are associated with the region in which the survey-area is situated.

Table 8.42: Species of Congregatory Avifauna observed in the Survey Area

Sr. No.	Scientific Name	Common Name	IUCN Status
1	*Aythya ferina*	Common Pochard	LC
2	*Aythya fuligula*	Tufted Duck	LC
3	*Pelecanus philippensis*	Spot-billed Pelican	NT
4	*Phalacrocorax fuscicollis*	Indian Cormorant	LC
5	*Phalacrocorax carbo*	Great Cormorant	LC

** LC – Least Concern, NT- Near Threatened*

8.5.7.7 Faunal Diversity of the Study Area

Reptiles and amphibians are two classes of animals with unique adaptations to cope with the varying climatic conditions and the environmental niche. These species have a prominent role in the ecological balance and nature conservation. *Table 8.43* and *Table 8.44* present the species of reptiles and mammals reported from the study area.

Table 8.43: Species of Reptiles reported in the study area

Sr. No.	Scientific Name	Common Name	IUCN Status*
1	*Ramphotyphlops braminus*	Brahminy Blind Snake	NA
2	*Typhlops diardii*	Indochinese Blind Snake	LC
3	*Grypotyphlops acutus*	Beaked Blind Snake	LC
4	*Python molurus*	Asiatic Rock Python	NT
5	*Python bivittatus*	Burmese Python	V

6	*Gongylophis conicus*	Common Sand Boa	NA
7	*Coelognathus radiatus*	Copper-headed Trinket Snake	NA
8	*Coelognathus helena*	Indian Trinket Snake	NA
9	*Ptyas mucosa*	Indian Rat Snake	NA
10	*Argyrogena fasciolata*	Banded Racer	NA
11	*Oligodon albocinctus*	White-barred Kukri Snake	NA
12	*Oligodon taeniolatus*	Streaked Kuktri Snake	LC
13	*Oligodon arnensis*	Banded Kukri Snake	NA
14	*Dendralaphis pictus*	Painted Bronzeback Tree Snake	NA
15	*Dendralaphis tristis*	Common Bronzeback Tree Snake	NA
16	*Lycodon jara*	Yellow-speckled Wolf Snake	LC
17	*Lycodon aulicus*	Common Wolf Snake	NA
18	*Sibynophis subpunctatus*	-	NA
19	*Xenochrophis piscator*	Checkered Keelback Water Snake	NA
20	*Amphiesma stolatum*	Buff-striped Keelback	NA
21	*Boiga trigonata*	Common Indian Cat Snake	LC
22	*Ahaetulla nasuta*	Common Vine Snake	NA
23	*Enhydris enhydris*	Striped Water Snake	LC
24	*Enhydris sieboldii*	Siebold's Smooth Water Snake	LC
25	*Atretium schistosum*	Olive Keelback Water Snake	LC
26	*Bungarus fasciatus*	Banded Krait	LC
27	*Bungarus caeruleus*	Indian Krait	NA
28	*Calliophis melanurus*	Black-tailed Coral Snake	NA
29	*Naja naja*	Spectacled Cobra	-
30	*Naja kaouthia*	Monocled Cobra	LC
31	*Daboia russelii*	Russell's Viper	LC
32	*Calotes versicolor*	Indian Garden Lizard	NA
33	*Cosymbotus platyurus*	Flat-tailed Gecko	NA
34	*Gehyra mutilata*	Four-clawed Gecko	NA
35	*Gekko gecko*	Tokay Gecko	NA
36	*Hemidactylus bowringii*	Bowring's Gecko	NA
37	*Hemidactylus flaviviridis*	Yellow-green House Gecko	NA
38	*Hemidactylus frenatus*	Asian House Gecko	NA
39	*Hemidactylus garnoti*	Garnot's Gecko	NA
40	*Hemidactylus leschenaultii*	Bark Gecko	NA
41	*Lygosoma punctata*	Spotted Supple Skink	LC
42	*Mabuya macularia*	Bronze Grass Skink	NA
43	*Sphenomorphus maculatus*	Spotted Litter Skink	NA
44	*Varanus bengalensis*	Bengal Monitor	LC
45	*Varanus flavescens*	Yellow Monitor	LC
46	*Crocodylus paluster*	Mugger Crocodile	NA
47	*Gavialus gangeticus*	Gharial	NA
48	*Cuora amboinensis*	Southeast Asian Box Turtle	V
49	*Cyclemis oldhami*	Oldham's Leaf Turtle	NA
50	*Geoclemys hamiltonii*	Black-spotted Turtle	V
51	*Hardella thurjii*	Crowned River Turtle	V
52	*Batagur dhongoka*	Three-striped Roofed Turtle	E

53	*Melanochelys trijuga*	Indian Black Turtle	NT
54	*Pangshura smithii*	Brown Roofed Turtle	NT
55	*Pangshura sylhetensis*	Assam Roofed Turtle	E
56	*Pangshura tectum*	Indian Roofed Turtle	NA
57	*Pangshura tentoria*	Indian Tent Turtle	LC
58	*Indotestudo elongata*	Yellow-headed Tortoise	E
59	*Nilssonia gangeticum*	Indian Softshell Turtle	V
60	*Nilssonia hurum*	Indian Peacock Softshell Turtle	V
61	*Chitra indica*	Indian Narrow-headed Softshell Turtle	E
62	*Lissemys punctata*	Indian Flapshell Turtle	LC
63	*Pelochelys cantorii*	Frog-faced Softshell Turtle	E

** E – Endangered, LC – Least Concern, NA – Not Assessed, NT – Near Threatened and V - Vulnerable*

Sources:

Indraneil Das, Snakes and other Reptiles of India (2002)

Romulus Whitaker & Ashok Captain, Snakes of India (2006)

www.iucnredlist.org (2013)

Table 8.44: Species of Mammals reported in the study area

Sr. No.	Scientific Name	Common Name	IUCN Status*
1	Macaca mulatta	Rhesus Macaque	LC
2	Semnopithecus entellus	Hanuman Langur	LC
3	Sus scrofa	Wild Pig	LC
4	Canis aureus	Jackal	LC
5	Felis chaus	Jungle Cat	LC
6	Prionailurus viverrinus	Fishing Cat	E
7	Lutrogale perspicillata	Smooth-coated Otter	V
8	Amblonyx cinereus	Asian Small-clawed Otter	V
9	Viverricula indica	Small Indian Civet	NT
10	Paradoxurus hermaphroditus	Common Palm Civet	LC
11	Herpestes edwardsii	Grey Mongoose	LC
12	Herpestes javanicus	Small Asian Mongoose	LC
13	Herpestes urva	Crab-eating Mongoose	LC
14	Manis crassicaudata	Indian Pangolin	NT
15	Manis pentadactyla	Chinese Pangolin	E
16	Suncus murinus	House Shrew	LC
17	Crocidura attenuata	Grey Woodland Shrew	LC
18	Funambulus pennantii	Five-striped Palm Squirrel	LC
19	Bandicota indica	Large Bandicoot-rat	LC
20	Bandicota bengalensis	Lesser Bandicoot-rat	LC
21	Nesokia indica	Short-tailed Bandicoot-rat	LC
22	Rattus rattus	House Rat	LC
23	Rattus norvegicus	Brown Rat	LC
24	Millardia meltada	Soft-furred Field Rat	LC
25	Madromys blanfordi	White-tailed Wood Rat	LC
26	Vandeleuria oleracea	Long-tailed Tree Mouse	LC
27	Mus musculus	House Mouse	LC

28	Mus booduga	Little Indian Field Mouse	LC
29	Mus platythrix	Brown Spiny Mouse	LC
30	Mus terricolor	Earth-colored Mouse	LC
31	Pteropus giganteus	Indian Flying Fox	LC
32	Rousettus leschenaulti	Leschenault's Rousette	LC
33	Cynopterus brachyotis	Lesser Dog-faced Fruit Bat	LC
34	Cynopterus sphinx	Short-nosed Fruit Bat	LC
35	Rhinopoma hardwicki	Lesser Mouse-tailed Bat	LC
36	Taphozous longimanus	Long-winged Tomb Bat	LC
37	Hipposideros fulvus	Fulvous Leaf-nosed Bat	LC
38	Megaderma lyra	Greater False Vampire	LC
39	Myotis formosus	Hodgson's Bat	LC
40	Myotis annectans	Hairy-faced Bat	LC
41	Scotophilus heathii	Asiatic Greater Yellow House Bat	LC
42	Pipistrellus coromandra	Coromandel Pipistrelle	LC
43	Pipistrellus tenuis	Least Pipistrelle	LC
44	Scotozous dormeri	Dormer's Bat	LC
45	Platanista gangetica	Ganges River Dolphin	E

** E – Endangered, LC – Least Concern, NT – Near Threatened and V – Vulnerable*

Sources:

S. H. Prater, Book of Indian Animals

Vivek Menon, A Field Guide to Indian Mammals (2003)

www.iucnredlist.org (2013)

Species of insects, small fishes and large fishes observed in the study area during the field investigation are enumerated in the Tables below.

Table 8.45: Species of Insect Observed in the study area

Sl. No	English name	Order	Status
1.	Dragon fly nymph	Odonata	Fairly Common
2	Damsel fly nymph	Odonata	Fairly Common
3.	Water strider	Hemiptera	Fairly Common
4.	Midge	Diptera	Fairly Common
5.	Flies	Diptera	Fairly Common
6.	Ant	Hymenoptera	
7.	Caddisfly	Trichoptera	Fairly Common

Source: Field Investigation

Table 8.46: Species of Small Fishes reported in the study area

Sr. No.	Scientific Name	Common Name	IUCN Status*
1	*Anguilla bengalensis*	Indian Long-fin Eel	LC
2	*Gudusia chapra*	Indian River Shad	LC
3	*Hilsa ilisha*	Hilsa	NA
4	*Gonialosa manmina*	Ganges River Gizzard Shad	LC
5	*Nematalosa nasus*	Bloch's Gizzard Shad	LC
6	*Setipinna phasa*	Gangetic Hairfin Anchovy	LC

7	*Catla catla*	Catla	NA
8	*Cirrhinus mrigala*	Mrigal	NA
9	*Cirrhinus reba*	Reba Carp	LC
10	*Labeo angra*	Angra Labeo	LC
11	*Labeo calbasu*	Black Rohu	LC
12	*Labeo rohita*	Rohu	LC
13	*Neolissochilus hexagonolepis*	Katli	NT
14	*Puntius conchonius*	Red Barb	LC
15	*Puntius sophore*	Spotfin Swamp Barb	LC
16	*Puntius ticto*	Ticto Barb	LC
17	*Tor tor*	Tor Mahseer	NT
18	*Chela laubuca*	Indian Glass Barb	NA
19	*Brachydanio rerio*	Zebra Danio	NA
20	*Devario malabaricus*	Giant Danio	LC
21	*Esomus danricus*	Flying Barb	LC
22	*Parluciosoma daniconius*	Blackline Rasbora	LC
23	*Nemacheilus denisoni*	Day's Loach	LC
24	*Botia lohachata*	Y-Loach	NA
25	*Aorichthys seenghala*	Giant River Catfish	NA
26	*Mystus cavasius*	Gangetic Mystus	LC
27	*Mystus gulio*	Long-whiskered Catfish	LC
28	*Mystus vittatus*	Striped Dwarf Catfish	LC
29	*Rita rita*	Rita	LC
30	*Ompok bimaculatus*	Indian Butter Catfish	NT
31	*Wallago attu*	Boal	NT
32	*Eutropiichthys vacha*	Batchwa Vacha	LC
33	*Pungasius pungasius*	Pungas	NA
34	*Clarias batrachus*	Magur	LC
35	*Heteropneustes fossilis*	Stinging Catfish	LC
36	*Oryzias melastigma*	Estuarine Ricefish	LC
37	*Aplocheilus panchax*	Blue Panchax	LC
38	*Pseudambassis ranga*	Indian Glassy Fish	LC
39	*Nandus nandus*	Mottled Nandus	LC
40	*Oreochromis mossambica*	Tilapia	NA
41	*Glossogobius giurus*	Goby	NA
42	*Anabas testudineus*	Climbing Perch	DD
43	*Colisa lalia*	Dwarf Gourami	NA
44	*Osphronemus goramy*	Giant Gourami	LC
45	*Channa marulius*	Giant Snakehead	LC
46	*Channa orientalis*	Dwarf Snakehead	NA
47	*Channa punctatus*	Spotted Snakehead	NA
48	*Channa striatus*	Striped Snakehead	NA
49	*Mastacembelus armatus*	Marbled Spiny Eel	LC

* E – Endangered, LC – Least Concern, NA – Not Assessed, NT – Near Threatened and V - Vulnerable

Sources:

R. J. Ranjit Daniels, Freshwater Fishes of Peninsular India (2002)

B. F. Chhapgar, Common Fishes of India (1988)

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Some birds feed on the river fishes and thus take part in the consumer level of the river ecosystem. Large number of little cormorant were found to take rest sitting on the bamboo poles. Some were also found to dive into the water for fishing.

8.5.7.8 Invasive Alien / Non-native Species

The following two invasive alien/non-native higher plant-species have been recorded in the survey-area during the survey as presented in the table below.

Table 8.47: Species of non-native plants observed in the Survey Area

Sr. No.	Species	Habit	Vernacular Name
1	*Eichhornia crassipes*	Herb	Kachuri Pata
2	*Ipomoea carnea*	Shrub	Kolmi

8.5.7.9 Critically Endangered and/or Endangered Species

The following species, designated as being of special conservation-concern by the IUCN, are associated with the region in which the survey-area is situated.

Mammals

Table 8.48: Species of Critically Endangered / or Endangered Mammals

Sr. No.	Scientific Name	Common Name	IUCN Status*
1	*Prionailurus viverrinus*	Fishing Cat	E
2	*Lutrogale perspicillata*	Smooth-coated Otter	V
3	*Amblonyx cinereus*	Asian Small-clawed Otter	V
4	*Viverricula indica*	Small Indian Civet	NT
5	*Manis crassicaudata*	Indian Pangolin	NT
6	*Manis pentadactyla*	Chinese Pangolin	E
7	*Platanista gangetica*	Ganges River Dolphin	E

* E – Endangered, NT – Near Threatened and V – Vulnerable

Sources:

S. H. Prater, Book of Indian Animals

Vivek Menon, A Field Guide to Indian Mammals (2003)

www.iucnredlist.org (2013)

Avifauna

Table 8.49: Species of Critically Endangered / or Endangered Avifauna

Sr. No.	Scientific Name	Common Name	IUCN Status*
1	*Anas falcata*	Falcated Duck	NT

2	*Aythya baeri*	Baer's Pochard	CE
3	*Aythya nyroca*	Ferruginous Duck	NT
4	*Rhodonessa caryophyllacea*	Pink-headed Duck	CE
5	*Mycteria leucocephala*	Painted Stork	NT
6	*Leptoptilos javanicus*	Lesser Adjutant	V
7	*Threskiornis melanocephalus*	Black-headed Ibis	NT
8	*Pelecanus philippensis*	Spot-billed Pelican	NT
9	*Haliaeetus leucoryphus*	Pallas's Fish Eagle	V
10	*Ichthyophaga ichthyaetus*	Grey-headed Fish Eagle	NT
11	*Gyps bengalensis*	White-rumped Vulture	CE
12	*Circus macrourus*	Pallid Harrier	NT
13	*Aquila hastate*	Indian Spotted Eagle	V
14	*Aquila clanga*	Greater Spotted Eagle	V
15	*Aquila heliacal*	Eastern Imperial Eagle	V
16	*Houbaropsis bengalensis*	Bengal Florican	CE
17	*Grus antigone*	Sarus Crane	V
18	*Limosa melanuroides*	Eastern Black-tailed Godwit	NT
19	*Limnodromus semipalmatus*	Asian Dowitcher	NT
20	*Eurynorhynchus pygmeus*	Spoon-billed sandpiper	CE
21	*Rynchops albicollis*	Indian Skimmer	V

* CE – Critically Endangered, E – Endangered, LC – Least Concern, NT – Near Threatened and V – Vulnerable

Source:

R. Grimmett, C. Inskipp & T. Inskipp, Birds of the Indian Subcontinent (2011)

www.iucnredlist.org (2013)

Reptiles

Table 8.50: Species of Critically Endangered / or Endangered Reptiles

Sr. No.	Scientific Name	Common Name	IUCN Status*
1	*Python molurus*	Asiatic Rock Python	NT
2	*Python bivittatus*	Burmese Python	V
3	*Cuora amboinensis*	Southeast Asian Box Turtle	V
4	*Geoclemys hamiltonii*	Black-spotted Turtle	V
5	*Hardella thurjii*	Crowned River Turtle	V
6	*Batagur dhongoka*	Three-striped Roofed Turtle	E
7	*Melanochelys trijuga*	Indian Black Turtle	NT
8	*Pangshura smithii*	Brown Roofed Turtle	NT
9	*Pangshura sylhetensis*	Assam Roofed Turtle	E
10	*Indotestudo elongata*	Yellow-headed Tortoise	E
11	*Nilssonia gangeticum*	Indian Softshell Turtle	V
12	*Nilssonia hurum*	Indian Peacock Softshell Turtle	V
13	*Chitra indica*	Indian Narrow-headed Softshell Turtle	E
14	*Pelochelys cantorii*	Frog-faced Softshell Turtle	E

* CE – Critically Endangered, E – Endangered, LC – Least Concern, NT – Near Threatened and V – Vulnerable

Sources:

Indraneil Das, Snakes and other Reptiles of India (2002)

Romulus Whitaker & Ashok Captain, Snakes of India (2006)

www.iucnredlist.org (2013)

Fishes

Table 8.51: Species of Critically Endangered / or Endangered Fishes

Sr. No.	Scientific Name	Common Name	IUCN Status*
1	*Neolissochilus hexagonolepis*	Katli	NT
2	*Tor tor*	Tor Mahseer	NT
3	*Ompok bimaculatus*	Indian Butter Catfish	NT
4	*Wallago attu*	Boal	NT

* NT – Near Threatened

Sources:

R. J. Ranjit Daniels, Freshwater Fishes of Peninsular India (2002)

B. F. Chhapgar, Common Fishes of India (1988)

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8.5.7.10 Endemic and/or Restricted Range Species

The following species are near-endemic to, or have restricted ranges that include, the region in which the survey-area is situated.

Mammals

Table 8.52: Species of Endemic and/or Restricted Range Mammals

Sr. No.	Scientific Name	Common Name	Range
1	*Herpestes urva*	Crab-eating Mongoose	West Bengal, Northeast India, Bangladesh
2	*Platanista gangetica*	Ganges River Dolphin	Ganga & Brahmaputra river-systems

Sources:
S. H. Prater, Book of Indian Animals
Vivek Menon, A Field Guide to Indian Mammals (2003)

Avifauna

Table 8.53:Species of Endemic and/or Restricted Range Avifauna

Sr. No.	Scientific Name	Common Name	Range
1	*Rhodonessa caryophyllacea*	Pink-headed Duck	Eastern & Northeastern India, Bangladesh
2	*Houbaropsis bengalensis*	Bengal Florican	Southern Nepal, Northeastern India, Eastern Bangladesh
3	*Cacomantis merulinus*	Plaintive Cuckoo	Northeastern India, Bangladesh
4	*Apus nipalensis*	House Swift	Himalayas, Northeastern India, Bangladesh
5	*Megalaima asiatica*	Blue-throated Barbet	Himalayas, Northeastern India, Bangladesh
6	*Garrulax ruficollis*	Rufous-necked Laughingthrush	Himalayas, Northeastern India, Bangladesh

Source:
R. Grimmett, C. Inskipp & T. Inskipp, Birds of the Indian Subcontinent (2011)

Reptiles

Table 8.54: Species of Endemic and/or Restricted Range Reptiles

Sr. No.	Scientific Name	Common Name	Range
1	*Typhlops diardii*	Indochinese Blind Snake	Himalayas, Bangladesh, Myanmar
2	*Oligodon albocinctus*	White-barred Kukri Snake	Nepal, Northeast India, Bangladesh, Myanmar

Sources:
Indraneil Das, Snakes and other Reptiles of India (2002)
Romulus Whitaker & Ashok Captain, Snakes of India (2006)

8.5.7.11 Cultivation

The following plants are cultivated in the soils of the survey-area, including the natural silt deposited in the floodplains of the streams, rivulets and rivers flowing through it.

Table 8.55: Species of Plants cultivated in the Survey Area

Sr. No.	Species	Vernacular Name	Use
1	*Oryza sativa*	Dhaan	Cereal
2	*Cajanus cajan*	Adhad	Pulse
3	*Lens culinaris*	Moshur	Pulse
4	*Glycine max*	Bhoat	Pulse, Oil-seed
5	*Phaseolus radiatus*	Mung	Pulse
6	*Arachis hypogea*	Badam	Nut, Oil-seed
7	*Brassica sp.*	Shurisha	Leafy vegetable, Oil-seed, Spice
8	*Allium cepa*	Piyaz	Vegetable, Salad
9	*Vigna sp.*	Seem	Vegetable
10	*Lycopersicon esculentum*	Tomayta	Vegetable, Salad
11	*Solanum melongena*	Begun	Vegetable
12	*Abelmoschus esculentus*	Bhindi	Vegetable
13	*Momordica charantia*	Korola	Vegetable
14	*Momordica balsamina*	Potol	Vegetable
15	*Lagenaria vulgaris*	Lau	Vegetable
16	*Cucurbita maxima*	Kodu	Vegetable
17	*Benicasa cerifera*	Mishti Kumra	Vegetable
18	*Cucumis sativus*	Shosha	Salad
19	*Cucumis melo*	Bongi	Fruit
20	*Ipomoea batatas*	Mishti Aalu	Tuber
21	*Capsicum frutescens*	Moris	Spice
22	*Curcuma longa*	Holud	Spice
23	*Basella alba*	Pui	Leafy vegetable
24	*Colocasia esculenta*	Kosuila/Kochula	Leafy vegetable, Tuber
25	*Corchorus sp.*	Patkhuri, Hormoyla	Leafy vegetable, Fibre
26	*Ricinus communis*	Berun	(Medicinal) Oil-seed
27	*Carica papaya*	Pepe	Vegetable, Fruit
28	*Musa sapientum*	Kola	Vegetable, Fruit
29	*Psidium guajava*	Piyara	Fruit
30	*Annona reticulata*	Shorufa	Fruit
31	*Averrhoea carambola*	Kamranga	Fruit, Condiment
32	*Punica granatum*	Dalib	Fruit
33	*Litchia sinensis*	Lichu	Fruit
34	*Mangifera indica*	Aam	Fruit, Vegetable, Condiment
35	*Artocarpus heterophylla*	Katal	Vegetable, Fruit
36	*Cocos nucifera*	Narkel	Fruit, Sap
37	*Borassus flabellifer*	Tal	Fruit, Sap
38	*Phoenix sylvestris*	Khejur	Fruit, Sap, Pith
39	*Aegle marmelos*	Borobel	Fruit
40	*Ziziphus mauritiana*	Boroi	Fruit

Source: Persons interviewed during the survey.
Note: A few fish species are cultivated in ponds and sections of the rivers by the local communities through aquaculture. Their identities could not be ascertained.

8.5.7.12 Uncultivated Foods

The following wild or uncultivated plants recorded in the study-area provide food in various forms to the local communities.

Table 8.56: Species of Plants cultivated in the Survey Area

Sr. No.	Species	Habit	Part Used
1	*Amaranthus spinosus*	Herb	Tender shoots, Leaves
2	*Amaranthus sp.*	Herb	Tender shoots, Leaves
3	*Anthocephalus cadamba*	Tree	Fruit
4	*Azadirachta indica*	Tree	Ripe fruit
5	*Centella asiatica*	Herb	Leaves
6	*Commelina benghalensis*	Herb	Leaves, rhizomes
7	*Ficus hispida*	Tree	Unripe fruit
8	*Leucas aspera*	Herb	Leaves
9	*Pithecellobium dulce*	Tree	Ripe fruit
10	*Syzigium cumini*	Tree	Ripe fruit

Source: Persons interviewed during the survey.

The following fish species occurring naturally in the rivers of the survey-area are harvested for food by the local communities.

Table 8.57: Species of Fishes harvested in the Survey Area

Sr. No.	Scientific Name	Vernacular Name
1	*Hilsa ilisha*	Hilsa
2	*Catla catla*	Catla
3	*Cirrhinus mrigala*	Mrigal
4	*Labeo rohita*	Rohu
5	*Puntius conchonius*	Puti
6	*Aorichthys seenghala*	Ayre
7	*Wallago attu*	Boal
8	*Pungasius pungasius*	Pungash
9	*Clarias batrachus*	Magur
10	*Heteropneustes fossilis*	Sheeng
11	*Anabas testudineus*	Koi
12	*Channa marulius*	Gojar
13	*Channa striatus*	Shol

Source: Persons interviewed during the survey.

8.5.7.13 Fodder

Rice stalks and other agricultural by-products obtained from the plants cultivated in the survey-area serve as fodder for the livestock maintained by the local communities. Plants growing in fields left fallow also serve as fodder for livestock. A few such fodder plant species are listed below:

Table 8.58: Species of Grasses cultivated in the Survey Area

Sr. No.	Species	Habit	Part used
1	*Cynodon dctylon*	Grass	Plant
2	*Dactyloctenium aegypticum*	Grass	Plant
3	*Echinochloa sp.*	Grass	Plant
4	*Saccharum spp.*	Grass	Plant

Source: Persons interviewed during the survey.

8.5.7.14 Natural Medicines

The following plants recorded in the study-area are used by the local community as part of their traditional health-practices:

Table 8.59: Species of Natural Medicines observed in the Survey Area

Sr. No.	Species	Habit	Part Used
1	*Aegle marmelos*	Tree	Fruit
2	*Azadirachta indica*	Tree	Leaves, Seeds
3	*Bacopa monnieri*	Herb	Plant
4	*Cynodon dactylon*	Grass	Leaves
5	*Grangea maderaspatana*	Herb	Leaves
6	*Heliotropium indicum*	Herb	Leaves, Seeds
7	*Leucas aspera*	Herb	Leaves
8	*Melia azedarach*	Tree	Leaves, Seeds
9	*Ricinus communis*	Shrub	Seeds
10	*Solanum anguivi*	Herb	Roots
11	*Tinisporia cordifolia*	Climber	Stem

Source: Persons interviewed during the survey.

8.5.7.15 Fuelwood/Biomass Fuel

Trees and shrubs growing in the survey-area are lopped and fallen twigs gathered by the local community for use as fuelwood in their wood-stoves.

The dung of domestic animals, fed almost entirely by fodder-plants extracted from the local pasturelands, forms a secondary source of biomass used as fuel by the community.

8.5.7.16 Timberwood

The following trees-species recorded from the survey-area provide for the main timberwood needs of the local community.

Table 8.60: Species of Timberwood observed in the Survey Area

Sr. No.	Species	Vernacular Name
1	*Albizzia lebbeck*	Shiris
2	*Albizzia richardiana*	Kodoi
3	*Artocarpus heterophyllus*	Katal
4	*Swietenia mahogany*	Kaat/Mahogna
5	*Tectona grandis*	Shegun

Source: Persons interviewed during the survey.

8.5.7.17 Fibre

The following species recorded from the survey-area provide for some of the fibre-needs of the local community.

Table 8.61: Species of Fibre observed in the Survey Area

Sr. No.	Species	Vernacular Name
1	*Bombax ceiba*	Tula
2	*Corchorus spp.*	Patkhura/Hormoyla

Source: Persons interviewed during the survey.

8.5.7.18 Other Uses

The following plants recorded in the survey-area are used for a variety of secondary purposes by the local community.

Table 8.62: Other Species observed in the Survey Area

Sr. No.	Species	Part used	Use
1	*Borassus flabellifer*	Leaves	Thatch
2	*Corchorus spp.*	Stem	Wattle
3	*Cyperus sp.*	Stem	Mat
4	*Kirganellia reticulata*	Branches	Toothbrushes
5	*Phoenix sylvestris*	Leaves	Thatch
6	*Saccharum spp.*	Plant	Brooms, Thatch

Source: Persons interviewed during the survey.

8.5.7.19 Inference from Ecological Assessment

On the basis of present conditions of floral status it can be concluded that the project area is free from major pollution threats. Floral statuses are indicating that some plants are in threatened or near threatened conditions and some are in rare or very rare conditions due to multifarious anthropogenic activities as well as natural climatic hazards.

References used

The various references used for indentifying names of mammals and avifauna as observed or found in the study area are mentioned below:

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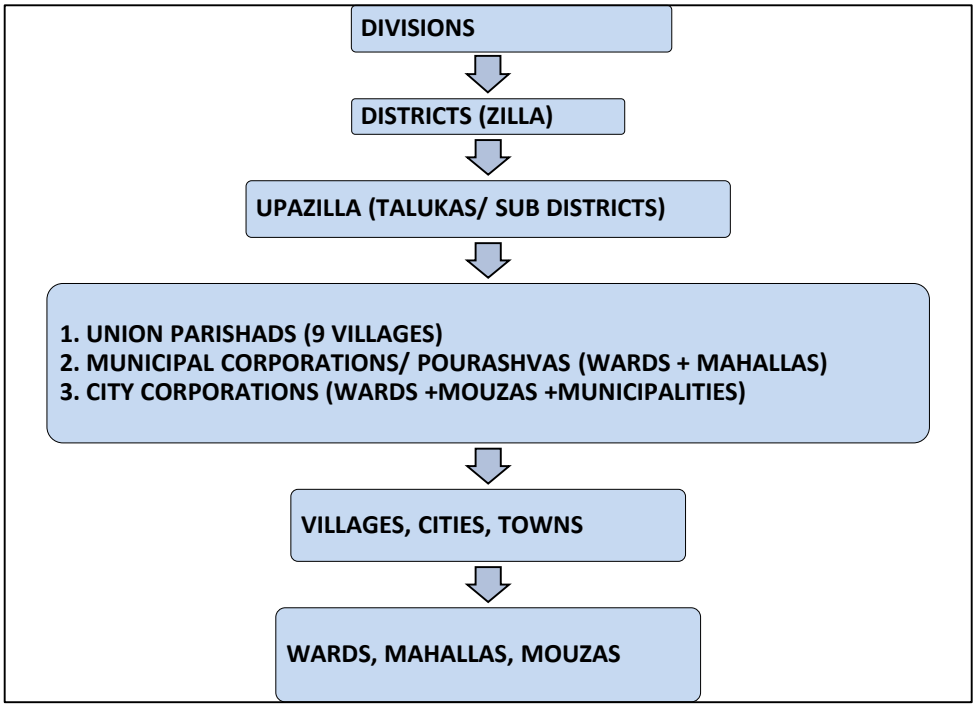
8.6 Baseline Socio-economic status

As already mentioned, the project influence area for this project has been delineated within 3 km around the proposed project area. This section provides the demographic and socio – economic profile of the project influenced villages. Unless specified otherwise, the data has been sourced from the Bangladesh Census 2011 reports, the UNICEF 2012 report and the Bangladesh Agricultural census 2008 report.

8.6.1 Administrative Set Up

Bangladesh is divided in to seven divisions for administrative convenience. Each division is further divided into districts *(Zilas)* and each district, in to sub districts or *Uppazilas.* Hence, Bangladesh has 64 districts and 1,009 sub districts. Each Uppazila is divided into unions, which are self-government agglomerations and incidentally, the smallest electoral unit as well. The proposed site is located in one of the 8 unions of Gazaria Uppazila (Hosseindi union), in Munshiganj district, which in turn comes under the administration of Dhaka Division. *Figure 6.1* depicts the administrative set up of Bangladesh.

Figure 8.50: Administrative Set Up in Bangladesh



8.6.2 Project Influenced Villages

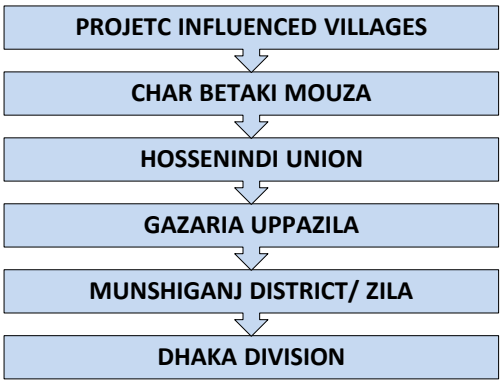
All villages falling within a three km radius of the proposed project site were considered as those which would be influenced socio economically by the upcoming project. Although, Gazaria is densely populated (114 mouzas and 127 villages), only 3 villages (Table 6.2) fall within the 3 km radius. This is because the site is entirely covered by a distributary (River Meghna), on all three sides, making the location a small island.

Table 8.63: Villages within 3 km of project Site

Sr. No	Village Name	Mouza	Distance from Site (approx)
1.	Char Balakia	Char Betaki	1.73 km
2.	Bhati Balakia	Char Betaki	1 km
3.	Goail Gaon	Char Betaki	2.1 km

The administrative location of the project influenced villages has been depicted in Figure 6.2.

Figure 8.51 Administrative location of the project influenced villages



8.6.3 Demographic Profile and Occupation Pattern

8.6.3.1 Population

Munshiganj is one of the most densely populated districts of Bangladesh. However, the surrounding villages falling within the area of influence are not extremely populous. The three villages of Char Balakia, Bhati Balakia and Goail gaon, together have a population of 3350 persons. The average household size is approximately 5 members, and this average can be seen for Hosseindi union as well as Gazaria Uppazila too. The Upazila of Gazaria has 179 persons who are classified under 'floating populations'[11], of which three resided in Hosseindi Union at the time of 2011 census survey. However, none of the project influenced villages have a nomadic or migrant population. Table 6.3 provides the population of the project influenced villages and associated administrative units.

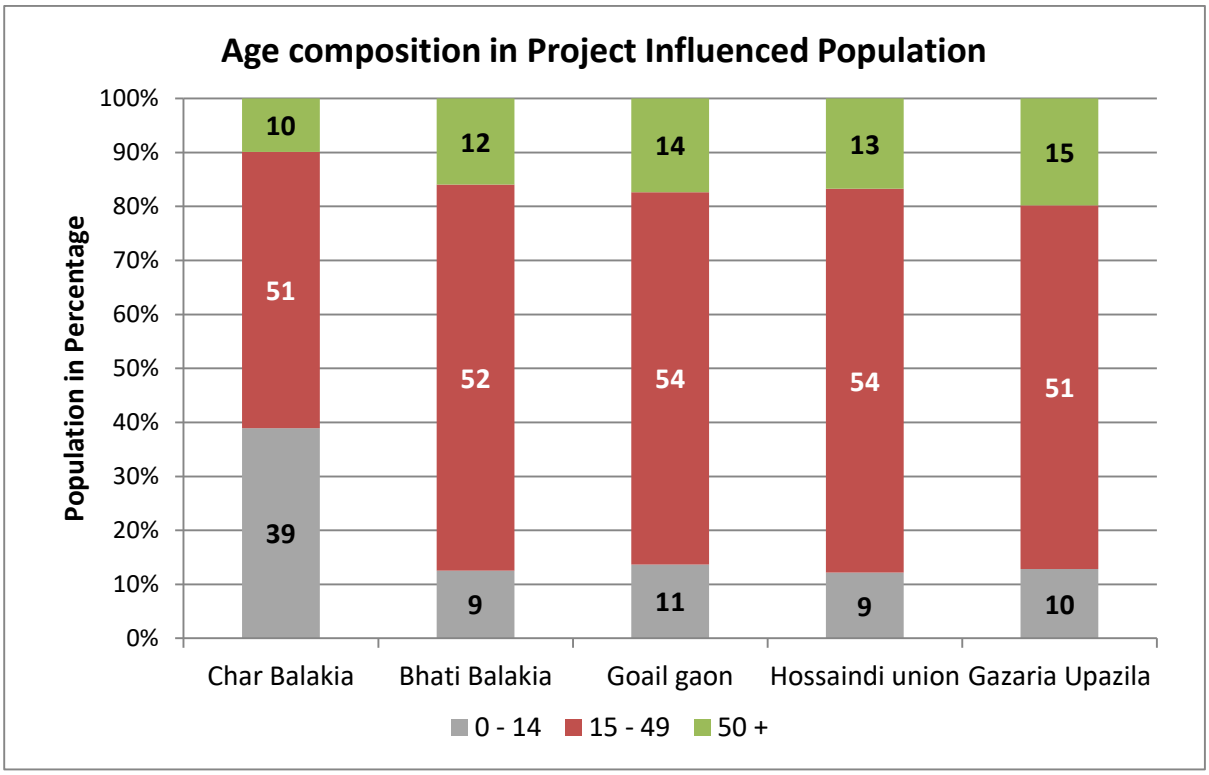
Table 8.64 Population and Household Units in Project Influenced Area

Sr. No.	Administrative unit	Total HH	Total Pop	Pop in HH	Floating Pop	Average HH size
1.	Char Balakia	340	1,654	1,654	0	5
2.	Bhati Balakia	182	932	932	0	5
3.	Goail Gaon	183	964	964	0	5
4.	Hossaindi Union	695	3,231	3,228	3	5
5.	Gazaria Upazila Rural	33,542	1,51,429	1,51,429	179	5
6.	Gazaria Upazila urban	1,452	6,559	6,559	0	5
7.	Gazaria Upazila Total	34,994	1,57,988	1,57,988	179	5

The population in all three villages is young, with over 50% of the population falling within the ages of 15 and 49 (Figure 6.3). The same trend can be seen reflecting in Hossenindi Union, and Gazaria Upazila. Thus it may also be said, that the majority of the population is economically productive, healthy and typical of population structures as usually seen in developing countries. The afore mentioned villages and administrative units have under 11 % of their populations that are under 15 years of age. Char Balakia is a variation with close to 40% of the population being under 15 years of age.

[11] The Bangladesh census refers to nomadic or migrant populations as floating populations, for sake of convenience in demographic classification.

Figure 8.52 Age composition in Project Influenced Population



Sex ratio is the ratio of males and females in a population. Although the concept of a healthy sex ratio remains a contested one, the WHO recommends a ratio of at least 1:1 (1 female: 1 male) if not more. Unlike most developing Asian nations, Bangladesh does not have a skewed sex ratio. The country's average figure is 95 males per 100 females. Of the three influenced villages, and their administrative units, only Char Balakia and Hosseindi Union have skewed ratios, with 112 males per 100 females and 113 males per females, respectively. Skewed sex ratios indicate a strong gender bias in a society, such as preference for males over females, to the extent of foeticide. However, Bangladesh does not have indicators that show a strong preference towards males, and skewed sex ratios are most likely resultant of other reasons such as limited access to emergency health care. Figure 8.52 provides a comparative analysis of sex ratios of villages in project influenced area.

8.6.3.2 Occupational Trends

Bangladesh's Agriculture Census, which was carried out in 2008, recorded the total number of agriculture labour households at 8.93 million. This figure accounts for 31.13% of the nation's total households, and of this area, only 0.27 % lies in urban areas. The agriculture census reports states that the percentage of households drawing sustenance from agriculture is gradually decreasing.

Census 2011 report classified the working population by the sector they work in. The highest proportion of workers draw income from agriculture and allied activities, followed by Industries and, last, services. Over 65 % and 79% of people, from Char Balakia and Bhati Balakia respectively, drew income through agriculture and allied activities. *Figure 6.7* compares the occupation trends in the project influenced area.

Figure 8.53: Work Force in Different Sectors

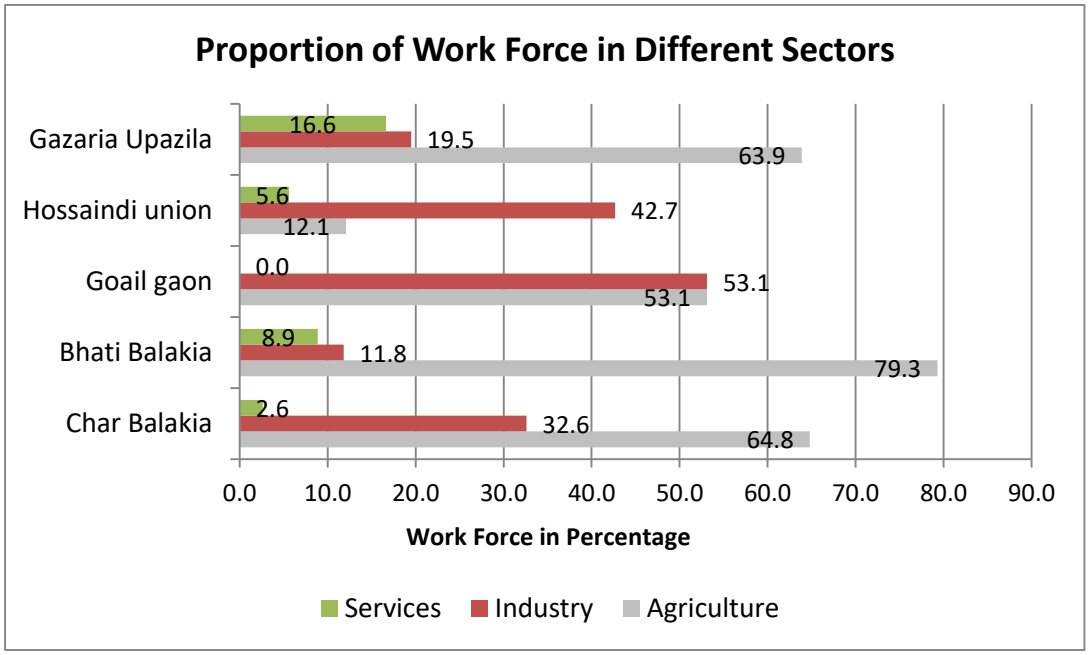


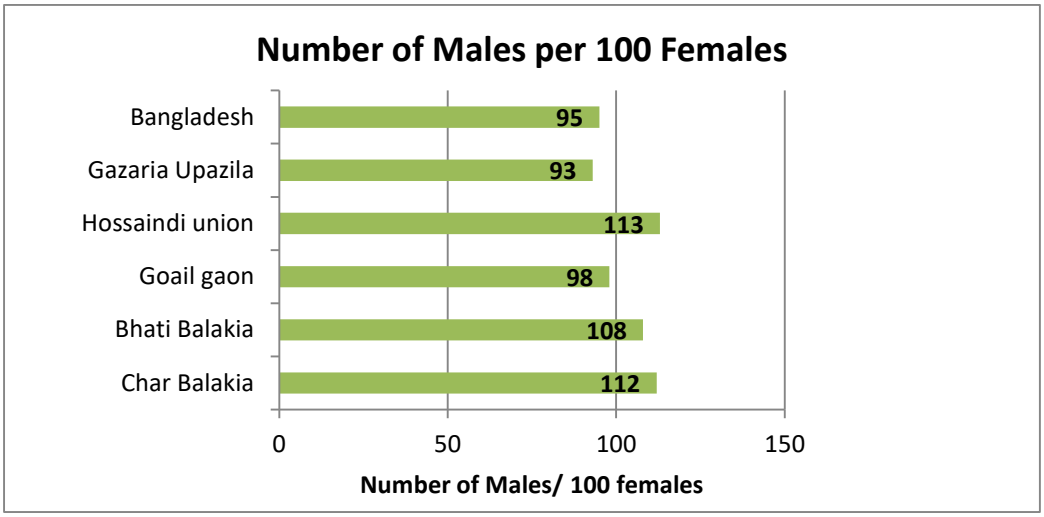
Table 6.4 provides a detailed breakup of occupation patterns in the project influenced area.

Table 8.65 Occupation Patterns in the project influenced area

S.N	Adminisrative unit	Agriculture		Industry		Services	
		Males	Females	Males	Females	Males	Females
1.	Char Balakia	64.1	0.7	32.6	0	1.9	0.7
2.	Bhati Balakia	75.9	3.4	11.3	0.5	1.0	7.9
3.	Goail gaon	46.9	6.3	51.0	2.1	0.0	0.0
4.	Hossaindi union	5.0	7.0	36.6	6.1	2.2	3.4
5.	Gazaria Upazila	62.6	1.3	16.5	3.0	13.7	3.0

Source: 2011 census survey

Figure 8.54: Sex Ratio in Project Influenced Population



8.6.4 Land Use and Cropping Pattern

One way of gauging economic status is through assessing land holdings and ownership status of dwellings. Landless Households may be considered as those households who do not own any land of their own, whether homestead or agricultural.

The Bangladesh Agriculture Census of 2008 revealed that the country was home to over 4.48 million landless households of which 1.22 million were in urban areas and 3.26 million in rural areas. The report further states that the percent of landless households is steadily increasing in rural areas. Dhaka Division has the highest percentage (20.32%) of landless households, both in rural as well as urban areas.

The Agricultural Census report describes tenant households as those which pay rent (either in cash or in kind) to use or use others' land for cultivation and other related activities. In context to this, approximately 26% of Households in Dhaka division live as tenants. Table 6.6 indicates that the majority of the households live in self – owned houses and are not bound financially towards rent payments amounting to possible debt.

Table 8.66: Housing Tenancy and Ownership

Sr. No.	Administrative unit	Housing Tenencay (%)		
		Owned	Rented	Rent Free
1.	Char Balakia	95.9	0.3	3.8
2.	Bhati Balakia	97.8	1.1	1.1
3.	Goail gaon	96.2	0.0	3.8
4.	Hossaindi union	82.9	10.7	6.5
5.	Gazaria Upazila	89.8	7.6	2.6

Source: 2011 census survey

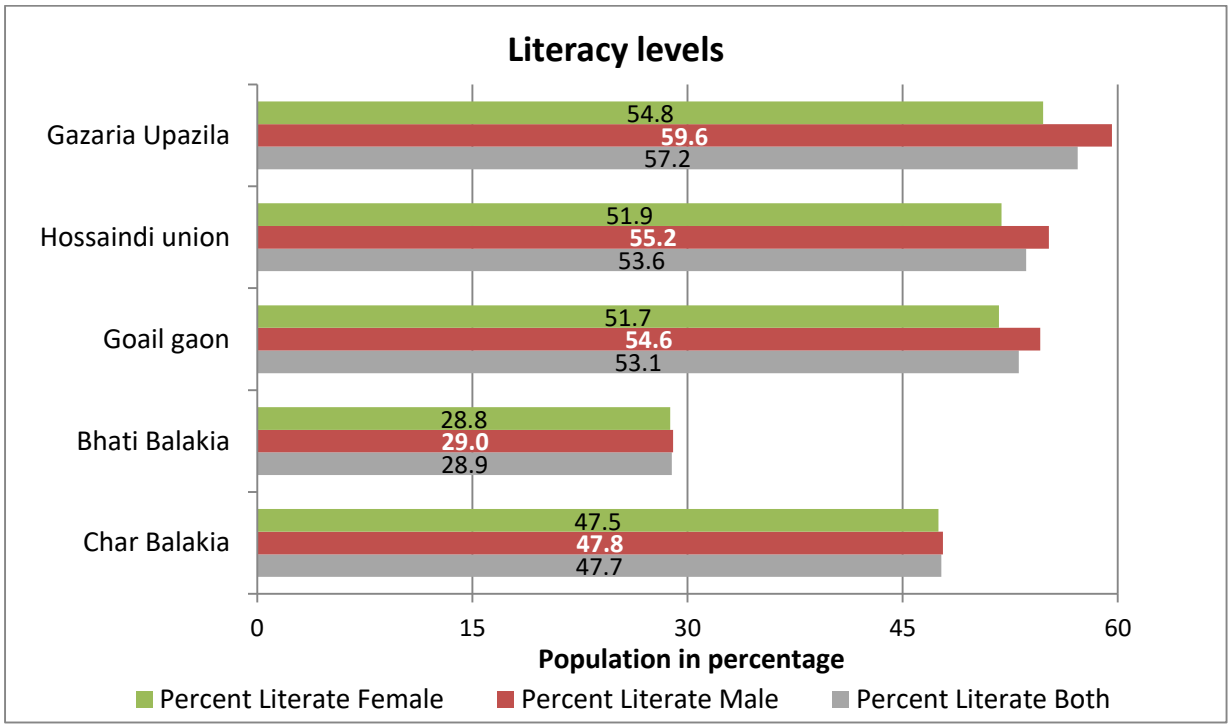
Community consultations indicated that locally, the main crops grown are potato, mustard, sesame and peanuts. Majority of the population sustains through fishing as supplementary occupation.

8.6.5 Socio-Economic Profile

8.6.5.1 Literacy

The literacy rate in Bangladesh is low overall, and is not affected by gender variables and this trend can be seen reflected in all the concerned villages. Furthermore, the 2012 UNICEF Country reported a higher proportion of adolescent girls being educated (80.4%) than adolescent boys (77%). The literacy levels for census 2011 were measured against the ability to read and write a letter, and indicate Bhati Balakia village as having a drastically low literacy rate in comparison to the other villages. In comparison, Gazaria Upazila has a high literacy rate, with close to 60% males and 55% females being literate, respectively. Figure compares the literacy levels in the project influenced area.

Figure 8.55 Literacy levels In Project influenced Population



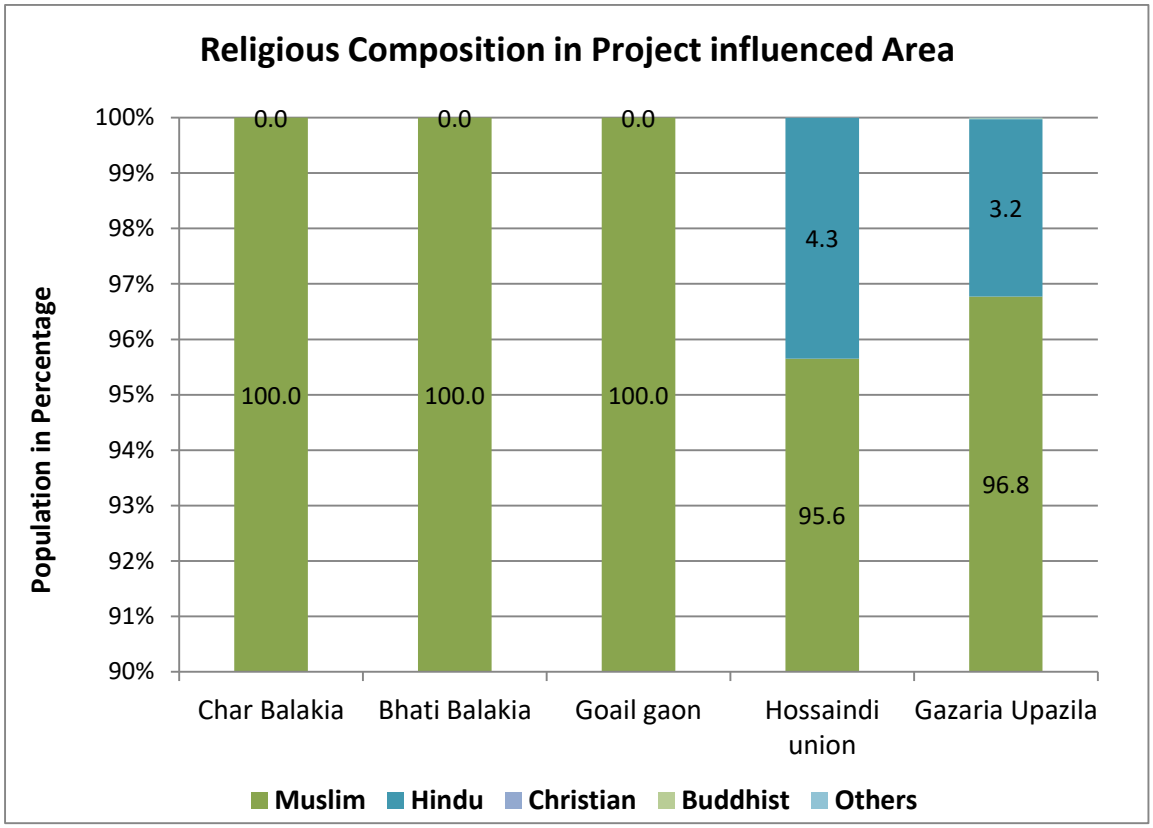
8.6.5.2 Ethnicity

According to Banglapedia, Bangladesh's online encyclopedia, Gazaria Uppazila has a very small ethnic population, comprising of 14 persons from 6 households. Further segregated, the ethnic population comprises of 6 *Garos*s, 5 *Chakmas* and 3 *Marmas.* However, there are no ethnic groups living in the project influenced villages.

8.6.5.3 Religious Composition

All three villages falling within the area of project influence have an entirely Muslim population. However, the union (Hossaindi) and Uppazila (Gazaria), which they fall under have marginal populations that follow Hinduism. Figure 6 represents the proportion of populations following Islam, Hinduism, Buddhism and other religions.

Figure 8.56 Religious Composition in the Project influenced Area



8.6.5.4 Work Force Participation

The census 2011 defined the working population as persons aged 7 years and above who were not studying and were involved in some economic activity. When segregated by sex, it becomes evident that work participation amongst women is much lower than men. Char Balakia has the highest proportion of male work force whereas Bhati Balakia has the maximum women work force (Table 6.5).

It should be noted that women workforce participation could be under represented as most work done by women include household and ancillary work which may perhaps not draw income but support other economic activities.

Table 8.67 :Workforce Participation

Sr. No	Administrative unit	Proportion of Population Working (7 years and above)	
		Males	Females
1.	Char Balakia	98.5	1.5
2.	Bhati Balakia	88.2	11.8
3.	Goail gaon	97.9	2.1
4.	Hossaindi union	89.4	10.6
5.	Gazaria Upazila	92.7	7.3

Source: 2011 census survey

8.6.6 Distance to Urban and rural Communities

Two bridges connect Hossendi Union with the mainland. These are the Meghna Bridge in the west which connects Hossendi to Sonargaon Upazila and the Meghna-Gomotee Bridge in the east which connects it to Daudkandi Upazila. Important towns and their approximate distances from the site have been presented in the table below.

Table 8.68: Distance to Urban and Rural Communities

Place	Approximate distance in KM
Narayanganj	8.5 km
Sonargaon	6.8 km
Hussein Pur	3 km
Munshiganj Town	6 km
Gazaria Upazilla HQ	6.5 km
Dhaka	30 km

Source: 2011 census survey

8.6.7 Transmission options for linking to grid

Transmission of power will undertaken by connecting the 400 kV transmission lines to the existing Meghnaghat substation of Bangladesh Power Development Board located at a distance of about 3.5 km from site. The above said substation is the nearest to the site. The transmission line will pass over the Meghna River and one or two transmission towers may be constructed in the river by Bangladesh Power Development Board. The transmission line layout has been presented in *Figure 8-57*.

Figure 8-57: Power Evacuation Line from Proposed Plant to National Grid

Source: OPDL-2

8.6.8 Distance to existing infrastructure

The proposed project site is located within Hosseindi Union of Gazaria Upzila (Sub-district) in the central Zola (District) viz., Munshiganj Zila of Bangladesh. The site is situated at a distance of about 5.3km from Dhaka–Chittagong Highway (N1) in south west direction. Proximity to various existing infrastructure is shown in

Table 8.69 Distance to Existing Infrastructure

Infrastructure	Approximate distance in km
Chittagong port	240 km
Naranganj Railway Junction	8 km
National Highway 1	6 km
Gazaria Upazila Health complex	9 km
Sonargaon Upazila Health complex	9 km
Munshiganj General Hospital	6 km

Source: Google Earth

8.6.9 Current and surrounding Land Use

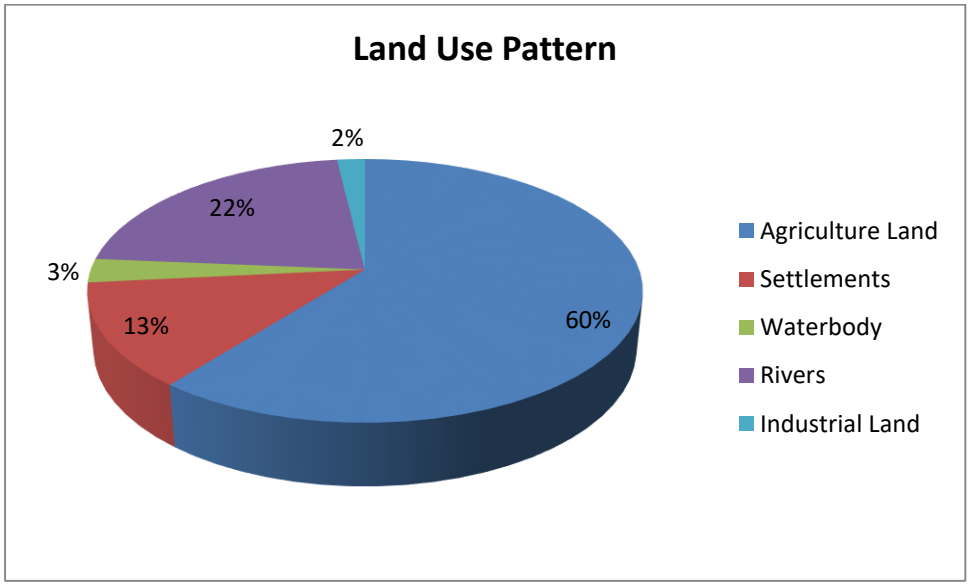
Table 8-69 and *Figure 8-58* present the land use pattern prevailing in the study area. According to it, 60% of the study area is under agriculture, 12% is occupied by settlements.

Table 8-70: Land Use Pattern of the Study Area

S.no	Land Use Category	Area in Sq.km	Area Covered (%)
1	Agriculture Land	242.67	60.66
2	Settlements	51.03	12.75
3	Water body	11.66	02.91
4	Rivers	87.07	21.76
5	Industrial Land	07.57	01.89
Total Area		**400.02**	**100.00**

Source: Land Use Map, AECOM

Figure 8-58: Existing Land Use Pattern of the Study Area

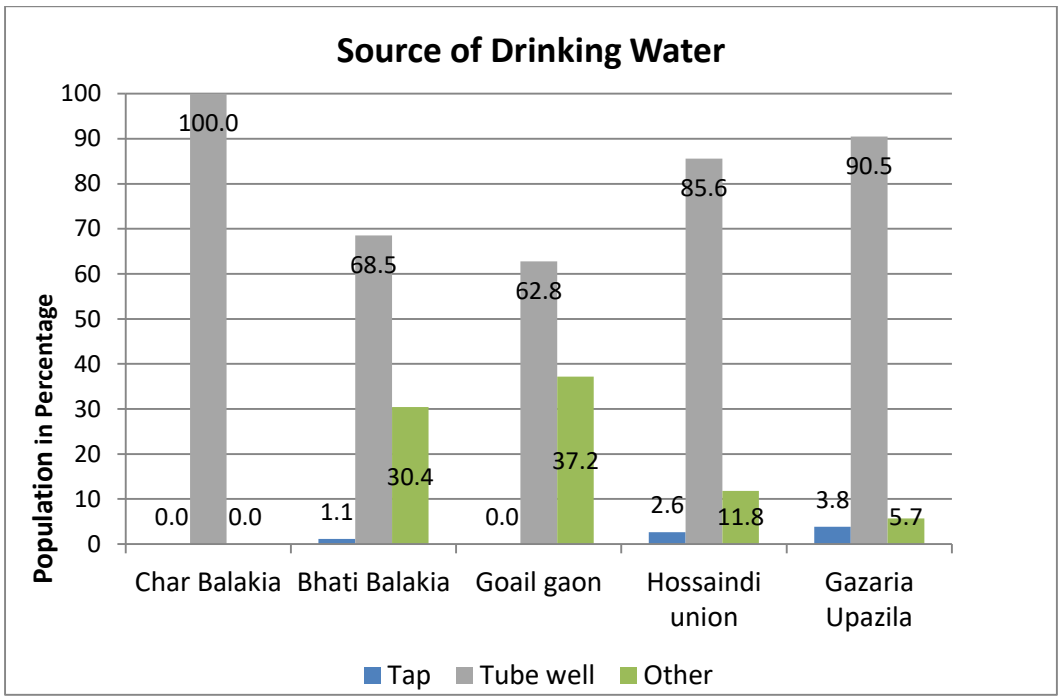


8.6.10 Existing Public Amenities

8.6.10.1 Drinking Water

The majority of Bangladesh's population sources its drinking water through tube wells despite high levels of arsenic contents in the water. The project influenced villages reflect this trend and utilise ground water the most for consumption. While other villages have a proportion of population using other sources of water, the village of Char Balakia sources it's need for drinking water entirely from boring wells (Figure 6.8).

Figure 8.59 Source of Drinking Water

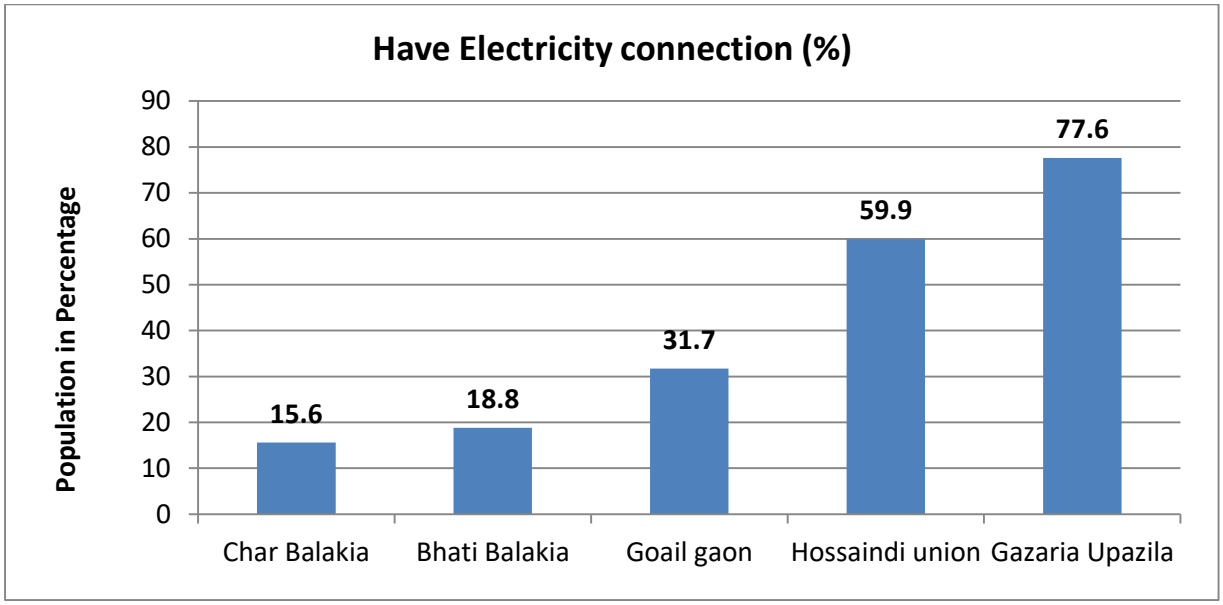


Source: 2011 census survey

8.6.10.2 Electricity

In Gazaria, less than 28% of the population has access to electricity. According to the 2011 census (Figure 6.9), amongst the three project influenced villages, Goail Gaon has the most access to electricity (31.7%), followed by Bhati Balakia (18.8%) and Char Balakia (15.6%). During public consultations it emerged that electricity in the influenced villages, was primarily used for household appliances such as Television, radio, fans etc.

Figure 8.60 Proportion having access to Electricity



8.6.10.3 Educational institutions

Review of existing literature indicates that Gazaria Upazila has one university, two colleges, one engineering staff college, one vocational institute, twelve secondary schools, 67 primary schools and five *Madrassas.* It emerged during public consultations that Char Balakia has three 3 primary schools in its vicinity, with the schools being in Husseinpur, Sonargaon and Narayanganj. All schools are within a distance of 5 km. In addition, there is a High School at Sonargaon, at a distance of 4 km. Students from Bhati Balakia and Goail Gaon too commute to Sonargaon and Narayanganj for higher studies.

8.6.10.4 Health care Facilities

Gazaria has one Upazila health complex, four satellite clinics, eight Family Planning Centres, and four Charitable Dispensaries. Approximately 7% of households in the Upazila do not have Latrines, and amongst those who do, less than 37 % in rural area have sanitary latrines. Poor transportation options and other logistic problems limit access to health care. Nevertheless, the UNICEF 2012 report indicates that Bangladesh has over 90% immunization coverage for all seven vaccine preventable diseases, according to protocol laid down by the World Health Organization. All three project influenced villages have a primary health centre each. However, these are reportedly not open on all days, and are manned by compounders, and not trained medical staff.

8.6.10.5 Other Facilities

According to existing secondary data, Gazaria has one Artificial Breeding Centre and two Veterinary Hospitals. In addition, the Upazila has 28 welfare organizations, 64 cooperative societies and 41 self-help groups. Gazaria also has 1 cinema hall 3 public libraries. Other public utilities have been discussed in detail in the next section which details results of Public Consultations.

9. Environment Impact

9.1 Introduction

This section describes various environmental and social impacts identified and assessed for the construction and operation phases of the proposed power plant. These impacts have been identified through available project documents; discussions with the local community as well as a household survey of land losers; consultations with opinion leaders, government representatives and influential people among the community; the project proponent's and AECOM's previous project experience in handling assignments of a similar nature.

The specific purpose of this section is to:

- Identify and assess the range of potential impacts for preconstruction, construction and operation phase; and
- Explain the potential causes which creating the impact;

The section also identifies cumulative impacts which act along with other impacts to affect the same environmental resource or receptor. In this section, cumulative impacts have been identified which while acting simultaneously with other possible existing or future foreseeable impacts of activities on the same environmental resource or receptor will exert a synergistic effect on them. The significance and magnitude of such impacts will be much greater in that case.

9.2 Sustainability of Quality of Coal and Continuity of Supply

The driven factor of sustainability of a power plant is the reliable and uninterrupted fuel supply. Smooth supply of Coal is a pre requisite for continuous operation of the power plant. Various options and routes to supply coal to the proposed plant has been evaluated based on available water depth, wave data/climate, the size of the coal supply vessels, barges etc. The potential routes which will be evaluated are from the Bay of Bengal via the river Meghna. Delivery of coal to the plant will be undertaken through Mother Vessels which will arrive directly from Chittagong which is situated at a distance of 240km approximately in south east direction from the site. OPDL-2 will execute a standard Coal Supply Agreement with prospective suppliers to ensure uninterrupted supply of coal Cleared navigation routes will ensure transportation of imported coal from South East Asian countries or from Australia. The specified quality of coal as mentioned in section 4.5.1.1 shall be maintained in sourcing and importing the required amount of coal.

9.3 Impact Assessment – Pre –Construction

9.3.1 Impact on sites from where material would be collected

The proposed project comprises of low lying land, for which filling up is required. Site preparation will include extensive dredging of the river which will supply the sand/soil required to fill up the land prior to plant construction. This can lead to alteration of the sediment composition, i.e. of substrate characteristics in the surrounding of the dredging site. Coal will be sourced from Australia and Indonesia through water navigation directly from Chittagong.

9.3.2 Impact on Land Form

The land for the proposed project comprises of agricultural and grazing land. A total of 130 acre of private land has been procured for the proposed project. The existing low to medium high land within the project area will be changed to high land by filling it up by river sand.

9.3.3 Impact on Natural Resources

Significant amount of aquaculture was also observed around the site with small fish/shrimp ponds strewn all across the proposed site in the Meghna River. Preparation for constructions activities may change the visual landscape of the project area. Site clearance activities, gathering of equipment and construction materials, machinery and camp establishment may affect the natural resources.

9.3.4 Impact on Eco-Systems

The site does not have any significant vegetation cover, as the land though agricultural in nature was not extensively used for the same owing to its submergence during the monsoon period. Also ecology survey suggests that huge number of floating water hyacinth for trapping of fish is practised in the study area. However, clearing and filling of area will have a negligible effect on the aquatic biology.

9.3.5 Impact on ambient Air

Generating particulate dust materials: The proposed project involves construction activities like land filling, earth works, site preparation civil construction, mechanical construction, handling and stocking of construction materials, construction materials processing, construction activities, vehicle movement, etc. may generate fugitive dust particles. The generation period will be short and will limited to the project boundary.

Emission of greenhouse gases: There could be release of carbon dioxide and nitrogen oxides from combustion of the petroleum products in project related vehicles, machinery, generators, and vessels/barges etc during the construction period.

9.3.6 Impact on Ambient Noise

There will be Increase in construction noise with operation of heavy equipment and machinery engaged for construction activities (such as excavation, grading, erecting equipment, piling, etc.) and movement of vehicles. The disturbance to habitations is expected to be high as two villages are located within 5km radius from the site.

9.3.7 Impact on Water Bodies

The water requirement for the project will be drawn from the Meghna River and no ground water will be used for the construction purpose. Considering the water availability in Meghna River, there is no potential for conflict with other users.

9.3.8 Impact on Soil

There will be generation of loose soil during site grading and excavation, which is vulnerable to erosion. During monsoons, the potential for runoff will increase, which can result in loss of significant amount of soil from the site.

9.3.9 Impact on Workers, Health, Sanititation and Safety

During this phase, labour camps will be established which will lead to generation of a significant amount of waste, garbage, kitchen waste. There coul be influx of migrant labour for carrying out specific construction activities which can lead to pressure on local facilities, though for a limited period.

9.3.10 Impact on key point installation and others

The site is situated to the south of a V- shaped island formed through meandering of River Meghna. The rural population in the study area reside in scattered settlements separated from the island. The study area constitutes some of the existing thermal power plants apart from the proposed project.
The key installation comprises of establishment of plant compnents and labour camp. This can modify the landscape of the area, but only for short duration.

9.3.11 Soild Waste disposal

During this phase, wastes may be generated from foundation works, site establishment, civil construction, stockpile of materials. The wastes might be metals, concrete, spoiled construction material, excavated spoils, spilled oil from machinery and vehicles, etc. Waste from labour camp will also be generated comprising of food waste, sanitary waste etc.

9.3.12 Impact due to transportation of Raw material

The access to the proposed Project site will be mainly through river transport involving motor boats and barges. The project would result in increased river traffic around the site which may lead to congestion.

9.4 Construction Phase Impact

Based on activity – impact interaction matrix (***Table 9-1***) construction phase of the proposed project, following areas which will be impacted have been identified and detailed in the subsequent sections.

- Socio-economic;
- Topography, Land use pattern (visual intrusion);
- Landscape;
- Soil Resources;
- Waste Generation, Storage and Disposal
- Surface/Ground Water Resources;
- Water Quality;
- Ambient Air Quality;
- Ambient Noise Quality
- Traffic and Transport
- Ecology
- Impact on Community/ Culture and Heritage
- Occupational Health and Safety
- Livelihood (Agricultural/aquaculture Activities in the Surroundings)

Table 9-1 : Activity - Impact Identification Matrix for Pre-Construction and Construction Phase of the Proposed Power Plant

S.N	Main Activities	Sub – Activities	Potential Impacts																	
			Loss of Land	Loss of Assets	Loss of Livelihood	Loss of common Property Resources	Socioeconomics incl. community health & safety	Cultural resources	Topography, Land use (visual	Landscape	Soil Resources	Surface/Groundwater Resources	Water Quality	Ambient Air Quality	Waste Generation, and Storage	Ambient Noise	Traffic &Transport	Ecology	Occupational Health and Safety	Agriculture in the surroundings
1.	**Land Procurement**	Land Purchased for ▪ Power Plant Project site ▪ Infrastructures such as road, wharf & transmission line	✓	✓	✓	✓	✓	✓												
2.	**Site Preparation**	▪ Site Clearing ▪ Ground levelling & filling (dredging) ▪ Waste handling and its transportation ▪ Vegetation clearance ▪ Provision of Power Supply ▪ Soil erosion control methods, storm water management ▪ Transportation of Machinery							✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
3.	**Labour deployment**	▪ Construction of Camp Site ▪ Construction of Labour Camp ▪ Water Supply ▪ Supply of fuel / energy ▪ Waste handling & its disposal ▪ Sewage disposal ▪ Labour force ▪ Provision of basic facilities ▪ Transportation						✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	
4.	**Pre-construction**	▪ Transportation of Heavy Machinery ▪ Operation of excavation machinery and equipment like excavators, rollers etc. ▪ Foundations for heavy machinery installation ▪ Construction Power								✓	✓	✓	✓	✓		✓	✓		✓	✓

S.N	Main Activities	Sub – Activities	Potential Impacts																	
			Loss of Land	Loss of Assets	Loss of Livelihood	Loss of common Property Resources	Socioeconomics incl. community health & safety	Cultural resources	Topography, Land (visual use	Landscape	Soil Resources	Surface/Groundwater Resources	Water Quality	Ambient Air Quality	Waste Generation, and Storage	Ambient Noise	Traffic &Transport	Ecology	Occupational Health and Safety	Agriculture in the surroundings
5.	**Material Handling & Storage**	▪ Transportation and Unloading of construction material from trucks ▪ Storage & Handling of construction Cement, Concrete, Bricks, Steel etc. ▪ Conveyance of material within the project site ▪ Construction stage transport management									✓			✓		✓	✓		✓	
6.	**Construction activities**	▪ Preparation/Mixing of construction material ▪ Foundations and piling ▪ Supply of water, power, sanitation etc. ▪ Operation of construction machinery (like Cranes, Concrete Mix Plant, Floor developer, forklift etc.) ▪ Handling and Disposal of construction wastes								✓	✓	✓	✓	✓	✓	✓	✓		✓	
7.	**Erection of Plant structures and Building**	▪ Erection of boiler units, plant structures boilers, generators, turbines, storage tanks etc. - welding/cutting onsite ▪ Installation of heavy machinery, pumps ▪ Mechanical and Electrical installation ▪ Drilling and Fixing ▪ Process control instrumentation ▪ Electrical fittings ▪ Painting/White washing ▪ Disposal of Wastes (empty paint cans, containers, electrical waste, wooden and metal waste etc.)									✓	✓	✓	✓	✓	✓	✓		✓	
8.	**Demobilisation of Construction Equipment**	▪ Dismantling of temporary support construction structures /equipments ▪ Removal of construction machinery ▪ Transportation of Construction/Dismantled wastes									✓			✓	✓	✓	✓		✓	

S.N	Main Activities	Sub – Activities	Potential Impacts																	
			Loss of Land	Loss of Assets	Loss of Livelihood	Loss of common Property Resources	Socioeconomics incl. community health & safety	Cultural resources	Topography, Land (visual use	Landscape	Soil Resources	Surface/Groundwater Resources	Water Quality	Ambient Air Quality	Waste Generation, and Storage	Ambient Noise	Traffic &Transport	Ecology	Occupational Health and Safety	Agriculture in the surroundings
		▪ Site cleaning/washings																		
9.	**Trial Run**	Trials functioning of ▪ Boilers ▪ Switchyard ▪ Water reservoir ▪ Water pre-treatment system ▪ Cooling water pump house ▪ Coal handling plant ▪ Turbines ▪ Plumbic fixtures ▪ Electrical gadgets ▪ Firefighting system ▪ Sewage Treatment Plant										✓	✓	✓	✓	✓			✓	
10.	**Construction of Road**	▪ Route Clearing and removal of vegetation ▪ Operation of construction machinery ▪ Handling and disposal of construction wastes	✓						✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Source: AECOM

9.4.1 Impact on Land Form

The land for the proposed project comprises of agricultural and grazing land. Significant amount of aquaculture was also observed around the site with small fish/shrimp ponds strewn all across the proposed site in the Meghna River (***Figure 9-1***). The predominant crop grown in the area includes rice. The proposed project will involve permanent change in land use from agriculture and shrimp farming to industrial land use.

Other potential impacts on land use may be due to development of approach road to the Project site and from the induced changes of land use from agriculture to commercial to fulfil the requirements of construction labour and project personnel. The right of way for the transmission line will not alter the land-use of the parcel as only a small it will be possible to restore original land use (like shrimp farming, agriculture etc.) once the construction is complete.

Figure 9-1: Aquaculture observed around the proposed project site

9.4.2 Impact on Natural Resources

The Project site development includes setting up of a coal based boiler, a power house and auxiliary facilities including a wharf, water pre-treatment system, demineralization plant, cooling water pump house, switch yard, coal handling plant, ash handling and disposal unit. The construction activities would involve potential impacts on natural resources due to filling up of the low lying areas, excavation works for foundations of various project-components, development of drains, providing proper slopes across the project area and ultimately for erection of the plant and associated structures and buildings.

As discussed earlier, the land remains under water for a significant period of the year during the monsoons. This necessitates elevating the area prior to commencement of construction activities. Site preparation will include extensive dredging of the river which will supply the sand/soil required to fill up the land prior to plant construction.

The site is located on an island bound by the Meghna River which controls the drainage system of the total study and project area. The average elevation of the proposed Project site is approximately 4 m above the mean sea level. The project area slopes gently towards Southeast. The runoff from the site will be altered and there will be a permanent change in drainage pattern. A drainage channel around the plant boundary will be made for capturing the runoff from the surrounding areas and finally discharging it in Meghna River. The drainage of the adjoining areas will thus remain unaffected and will continue to follow the existing flow.

The stretch would have piles of excavated soil and will also have pipelines kept along the route, thus impairing the localised landscape. However, the impact on local landscape will be temporary as the construction phase is short in duration. The Project site will be fenced to approximately 3 m height resulting in visual intrusion of the surrounding area. However, development of peripheral greenbelt along the Project site will improve the landscape aesthetics.

9.4.3 Impact on Eco-Systems

The site does not have any significant vegetation cover, as the land though agricultural in nature was not extensively used for the same owing to its submergence during the monsoon period. Thus, clearing and filling of area will have an insignificant loss of vegetation.

Release of construction waste water and soil run off can cause contamination to adjoining water bodies, besides increase in turbidity. The increase in turbidity and contamination may affect fish population in the river, especially during the spawning season.

Dredging in Meghna River for land fill will result in:

- Substrate removal and thus habitat and species removal (recolonisation or recovery of disturbed areas may be possible);
- alteration of the bottom topography and hydrography, and thus destruction of local habitats and the risk of direct physical/mechanical stress to species;
- alteration of the sediment composition, i.e. of substrate characteristics in the surrounding of the dredging site, resulting in a change of nature and diversity of benthic communities, e.g. Decline of individual density, species abundances or biomass;
- Re-suspension of sediments and increase of turbidity. The potential impacts include spreading of sediments and associated contaminants in the surroundings, remobilisation of contaminants in the water phase enhancing the bioavailability and Eco toxicological risk, release of nutrients resulting in increase in eutrophication and direct impact on organisms due to reduced transparency and consumption of oxygen (the increase in turbidity due to re-suspension of sediments caused by dredging, e.g. together with chemical quality and biological characteristics of the sediments, may be regarded as an indicator for potential ecological effects in the surroundings of the dredging sites).

The project related construction activities involving noise and vibrations, construction vehicle movement, illumination at the project site will have adverse impact on local avifauna. Use of wood

as fuel by cutting trees or procurement from illegal source in the nearby area by construction labour would result as a threat to the ecology of the area.

9.4.4 Impact on ambient Air

The potential sources of air pollution during the construction period include:

- Fugitive dust emissions from soil excavation and stock piles of construction material;
- Emissions from onsite operation of diesel generators and heavy construction equipment and vehicles at the site particularly near the habitations;
- As the area is significantly strewn with water bodies and fishing ponds, the impacts due escape of particulate matter from the excavated soil is expected to be low as a significant amount of dust will settle down without re-suspension; and
- The overall impact will be enhanced due to presence of cement manufacturing plants near the proposed Project site.

9.4.5 Impact on Ambient Noise

The potential impact of the proposed construction activities on the ambient noise quality of nearby areas (outside the project premises) will include the following:

- Increase in construction noise with operation of heavy equipment and machinery engaged for construction activities (such as excavation, grading, erecting equipment, piling, etc.) and movement of vehicles.
- The disturbance to habitations is expected to be high as two villages are located within 5km radius from the site; and
- Earth moving equipment (70 -100 dB(A)) and material handling (97-98 dB (A)) are the typical sources of during the construction period. A 1-3 dB(A) increase in noise levels is expected during peak construction activities in the adjoining villages during day time.

9.4.6 Impact on Water Bodies

9.4.6.1 Water Resources

The potential impacts on water resources during construction include the following:

- The quantity of water required for construction activities has been anticipated to range from 40 m^3/hour to 100 m^3/hour (peak requirement);
- The drinking water requirement for construction labour camp with a peak of 1,000 labourers and another 2,000 non-resident workers at site will be about 180KLD at peak and about 90KLD on average;
- The water requirement for the project will be drawn from the Meghna river and no ground water will be used for the construction purpose;
- Considering the water availability in Meghna river, there is no potential for conflict with other users;

9.4.6.2 Water Quality

The potential impacts on water quality due to construction activities include the following:

- It is expected that during construction phase there will be generation of sewage and small quantity of rejected water from testing of utility tanks and pipelines during commissioning of the project;
- About 70 to 140 m^3/day of sewage is expected to be generated due to working of 1000 to 3000 labourers at the construction site. There is a potential for contamination of surface and groundwater resources resulting from improper management of sewage.
- There is a possibility of excavated soil getting be washed off along the surface drainage into the rivers.
- There is potential for contamination of surface and groundwater due to spillage and transfer of oils, lubricants and other construction material if adequate measures are not taken during transfer and transportation by river.

9.4.7 Impact on Soil

The potential impacts on soil quality due to construction activities related to development of the power plant include the following:

9.4.7.1 Site Preparation

- Generation of loose soil during site grading and excavation, which is vulnerable to erosion. During monsoons, the potential for runoff will increase, which can result in loss of significant amount of soil from the site.
- Filling of the low lying land will require dredge material which will be generated by dredging of Meghna River.

9.4.7.2 Soil contamination due to handling of lube oil, chemicals etc.

- The maintenance of heavy machinery and equipment involves replacement of machine oil, greasing and other similar activities. Improper handling of lubricating oils, fuel oils, grease etc. used in such activities may result in spillages which can result in soil contamination. Contamination of soil may also occur due to accidental spills of paints, thinners etc. during handling and storage of domestic waste and discarded containers of paint, varnish, thinner, grease, lubricating oil etc.
- Meghna River is exposed to industrial wastes/effluents from various chemical industries situated in Narayanganj. Since the proposed Project site is situated downstream of Narayanganj, there is a potential for contamination of dredge material with heavy metals, which may ultimately contaminate the soil at site.

9.4.8 Impact on Workers, Health, Sanititation and Safety

IFC Performance Standard 2 highlights the need for safe and healthy work environment taking into account inherent risks in its particular sector and specific classes of hazards with respect to a project, including physical, chemical, biological and radiological hazards. The PS highlight the need to prevent accidents, injury, and disease arising from, associated with, or occurring in the course of work by minimizing, so far as reasonably practicable, the causes of hazards.

Potential impacts on health and safety during the project construction phase include the following:

- Use of electrical equipment entail the risks of potential electrical hazards such as :

  a. ***Shocks***
  These can occur upon contact of human body part with an electricity source which is not properly insulated such as wires, cables, switches etc. The potential impact/injury depends on current/voltage magnitude and contact period. The possible injuries include first and second degree burns among the minor physical ones. Major injuries include third degree burns, ventricular fibrillation, cardiac arrest, central nervous system damage, paralysis and electrocution.

  b. ***Burns***
  These can occur either due to shocks or electrical fires due to short circuiting of power lines/equipment failure. The possible injuries include various degrees of burns and death in lethal cases.

- Welding activities pose the following possible risks to workers engaged in them:

  a. ***Eye/Retina Damage***
  Workers engaged in welding activities are susceptible to retina damage due to sparks or flashes emanating from them welding arc if they haven't properly protected their eyes.

  b. ***Photo keratitis***
  It is caused due to prolonged exposure of insufficiently protected eyes to UV radiation from welding arcs. Photo keratitis is akin to sunburn of the cornea and conjunctiva, and is not usually noticed until several hours after exposure.

- ***Ergonomic injuries***
  These injuries also known as Musculoskeletal Disorders (MSD) can occur due to awkward or sustained postures, forceful exertion or strain, exposure to vibration and sudden shocks during equipment or material loading and unloading processes. Improper ergonomics can affect the muscles, nerves, tendons, ligaments, joints, cartilage and spinal discs. The possible injuries include muscle strains, sprain, ligament tear, fracture, paralysis and slip disc.

- ***Working at height (≥ 2m)***
  This kind of work typically involves assembling components and setting up of transmission towers etc. The workers engaged in such activities can slip or fall from the scaffolding or ladders which may result in minor injuries such as muscle sprain or major ones such as ligament tear, fractures, haemorrhage depending on the height at which they are working.

- ***Respiratory diseases***
  Construction activities e.g., blasting, excavation, concrete mixing, cutting, welding etc. involve significant amount of particulate emissions in the form of dust, silica, fibres etc. as well as gaseous emissions such as fumes, smoke, acetylene etc. Hence, construction activities entail the risk of acute or chronic health hazards such as bronchitis, asthma, silicosis, asbestosis, cancer etc. to workers who are constantly exposed to such emissions;

- ***Hearing damage***

Workers involved in activities like blasting, metal cutting are exposed to sudden as well as continuous loud noise in excess of 80 dB(A). Consequently, they are at the risk of hearing impairment, ear damage, and irreversible hearing loss if proper protective measures are not taken.

- ***Other Occupational Hazards***
  These include the following:

  i. *Road accidents* can occur during material/equipment transportation due to vehicle movement on uneven terrains, overturning due to carriage of loads in excess of safe limits, over-speeding etc. Such incidents can lead to physical injuries to drivers, death etc.; and

  ii. Workers at times are not accustomed to use of Personal Protection Equipment (PPE) such as safety helmets or hard hats, safety shoes, harness etc. Their negligence may result in accident/hazard such as head injuries, haemorrhage, fracture etc.;

Thus, occupational health and safety (OHS) risks entailed in various construction activities necessitate the requirement of adequate mitigation measures that shall be implemented by OPDL-2.

9.4.9 Impact on key point installation and others

The proposed project involves construction of the following components:

- Main power plant (boiler, turbine, Generator, Workshop Store, etc.)
- Electrostatic Precipitator, Flue Gas Desulfurization (FGD) as required, and Chimney
- Induced Draft Cooling Tower
- Greenbelt and open space
- Open air sub-station and network control room
- Coal terminal including jetty & coal conveyer belt
- Ash handling control room, ash silo, ash disposal area

Construction of all these above mentioned compnents will not lead to significant change as there are exisiting thermal power plants in the vicinity of the site.

9.4.10 Soild Waste disposal

- The solid waste generated during construction phase will include construction waste/ debris, waste oil and chemicals from construction machinery, and domestic solid waste etc.;
- There is a potential for spread of construction waste and runoff to areas outside the construction site which can contaminate river, soil etc. if left unattended;
- Use of land by construction labourers for domestic or sanitary purposes may contribute to soil pollution by septic or bio-degradable waste; and
- Improper disposal of domestic waste from site can lead to unhygienic conditions in the project area.

9.4.11 Social Impact

POTENTIAL POSITIVE IMPACTS

9.4.11.1 Payment to land Contributors

Land contributors are persons from the project influenced community from whom land has been purchased. Since land was procured on a willing buyer – willing seller basis and rates were decided with mutual deliberation of both parties, the land contributor can be said to have gained from the payment. During community consultations, land contributors conveyed that they would use the lump sum amount to pay off loans, invest in businesses, purchase a property etc.

9.4.11.2 Impact on Land market

The proposed project is likely to have increased prospects of supplementary business and better connectivity. Consequently the surrounding land prices are likely to increase, thereby increasing the value of surrounding land in the land market.

9.4.11.3 Employment and Income Generation

It is felt that construction activities would be invariably undertaken by expatriate constructors. Construction activities, in such mega projects are generally mechanized or semi-mechanised. Most of the labour for undertaking skilled jobs would come from various parts of the country.

The local population is expected to be given preference as semi-skilled and unskilled labour, and gain additional employment as other staff such as caterers, cooking staff, security, housekeeping etc..

9.4.11.4 Boost to Local businesses

With onset of commercial activity, increase in demand of local produce, fish, prawns, poultry and dairy products is anticipated to increase and these local businesses shall grow in the process. This will inadvertently mean more money for the local population.

A large number of allied activities are likely to mushroom in the area especially in the business and self-employment sector. This is expected to improve the job opportunities significantly during the project construction phase. Business opportunities such as tea-stalls, eating joins and restaurants, fruit and vegetable vendors, mechanic and repair shops (electrical and mechanical), small hotels, boarding & lodging provisions, etc. are most likely to develop. It is felt that a large number of enterprising locals in the vicinity of the project area would reap the benefits of such business and self-employment opportunities. Thus, at present the economy in the villages of the influence area, which is entirely dependent on agriculture and related activities, would diversify.

9.4.11.5 Improved Access to Essential Amenities

The community has limited access to essential amenities such as electricity, quality healthcare and regular transportation services. On an average, fewer than 6 persons were reported to having motorised boats in each village. Electricity is available for approximately 6 hours a day. Access to these amenities is expected to improve and contribute to the overall development of the community.

The advantage of education in achieving secure jobs will quickly percolate through all sections of the population and will induce people to let their children get educated. The increased income levels would lead to greater emphasis on education. This will lead to demands for development or up-gradation of existing infrastructure in the education sector. This will subsequently improve the infrastructure in the education sector. Similar phenomenon is expected in the health sector as well.

POTENTIAL NEGATIVE IMPACTS

9.4.11.6 Loss of Land and Livelihoods

Agriculture is one of the main occupations of people in the project influenced villages. Consequently, land procurement has caused loss of primary source of income for many persons. This impact has been specifically profound on those land contributors whose entire land holdings have been procured for the project.

Land procurement for the project is likely to have had a significantly profound impact on sharecropping farmers. Sharecropping is a common phenomenon in rural communities across Asia. It is a unique system of barter wherein a farmer works in the field of another, in return for a share of the crop or another commodity. It is a form of barter since no money is exchanged for any service rendered. Most sharecroppers earn their sustenance in kind by working on the fields of land holders, since they have little or no land of their own. Although, during consultations no one reported to the practice being followed, the impact on any sharecropping farmer, if residing in these villages shall be especially profound since they would be facing loss of livelihood as well as lack of a compensatory amount. An overview of potential (negative) impacts has been provided in Table 9-2.

Table 9-2: Overview of Potential Impacts regarding Loss of Livelihood

Source of Livelihood/ Income	Primary Impact	Secondary Impact	Extent of Loss
Big and medium Landowners	Short term loss of income	• Adjustment to the change in social status	Medium
Small Farmers/ Aquaculture	Long term loss of income	• Marginalisation • Increase of psychological stress • Insecurity about the future	High
Sharecropper	Long term loss of income. No compensation for loss of income.	• Marginalisation • Increase of psychological stress • Insecurity about the future • Food Insecurity	High
Agricultural Labourer	Long term loss of income	• Marginalisation • Increase of psychological stress • Insecurity about the future • Food Insecurity	High
Livestock Owner	Loss of additional grazing land	• Diminishing options for alternate grazing ground	Medium
Cultivation/ Aquaculture	Long term loss of income	• Diminishing options for alternate source of income • Insecurity about the future	High

9.4.11.7 Obstructed Access to essential amenities and Common property resources

Affected villagers enjoy exclusive traditional rights on their common property resources (CPRs) that exist within and around their resident villages. Access to important amenities such as fishing sites, schools, mosques, water points, sources of fodder and local markets may get obstructed during the construction phase of the project. Community discourse indicated that no important structures are likely to be impacted. However informal access roads, short cuts, and cordoned off jetties may obstruct the villagers' access routes, either blocking them or lengthening the commuting time.

9.4.11.8 Strain on existing Public Utilities

During the construction period, there is likely to be an increased demand on public utilities, due to the presence of migrant labour. These utilities may be water, cooking fuel, sanitation means and transport facilities.

9.4.11.9 Impacts due to immigrant population and labour camps

The labour population involved in construction activities may immigrate into the project area from various countries mainly having different cultural, ethnic and social backgrounds. Such a mixture of population has its own advantages and disadvantages.

It is normally experienced that untreated sewage would find its way into natural drainage system, and is likely to get collected as pools of sewage or it out-falls into the nearest water body along natural drainage pattern. Thus, it is important to provide appropriate sewage treatment facilities at the labour camp and at the construction site prior to disposal on land or in water body.
The garbage comprising of waste materials, e.g. packaging, polythene or plastic materials are likely to be generated during project construction phase of the power station. The same needs to be properly collected and disposed at designated sites.

9.4.11.10 Health issues due to Migrant labour Influx

As already mentioned, the labour population involved in construction activities may immigrate into the project area from various parts of the country or neighbouring countries, having distinct cultural, ethnic and social backgrounds. It is highly possible that they would carry distinct strains of disease virus into this area.

9.4.11.11 Gender Issues

Local women could face security issues from the migrant labour. If employed, they could also be subject to gender discrimination and be paid unequal wages.

9.4.11.12 Communal Harmony and well being

Preference towards certain communities over others for labour, business or CSR initiatives could result in communal disharmony.

9.4.12 Impact due to Traffic and Transport

The following impacts on traffic and transport have been envisaged during the construction phase.

- The access to the proposed Project site will be mainly through river transport involving motor boats and barges. The project would result in increased river traffic around the site which may lead to congestion.
- The residents of the adjoining villages will be affected by increase in transport as it will affect the movement of passenger ferries being used by the people.
- There will be increase in potential for possible accidents and capsizing of boats/vessels
- Spill and leaks from poorly maintained boats /vessels may lead to contamination of water and sediments along the banks.

9.5 Impact Assessment – Operation Phase

The project activities that could lead to likely environmental impacts are broadly covered in *Table 9-3.* The operation phase of power plant would have likely impacts on the following

- Air Quality;
- Water Resources (surface water and ground water) and Quality
- Ambient Noise
- Ecological
- Soil Quality
- Socio economic
- Occupational Health and Safety

Table 9-3: Impact Identification Matrix – Operation Phase

S.N	Aspect/Main Activities	Sub – Activities	Potential Impacts										
			Air Quality	Water Quality	Surface Water Resources	Ground Water Resources	Soil and Land Quality	Noise Quality	Traffic	Ecology	Socio economic including community health & safety	Agricultural Activities in the Surroundings	Occupational Health and Safety
1	Transportation	▪ Transportation of coal to plant ▪ Transportation of LDO	✓	✓	✓		✓	✓	✓		✓		✓
2	Plant Operations	Functioning of ▪ Boiler ▪ Turbines ▪ Generators ▪ Coal storage and Handling	✓	✓	✓			✓		✓			✓
3	Storage of Flammables	▪ Light Diesel Oil	✓	✓			✓						✓
4	Emergency Power backup	▪ Diesel Generator operations in case of emergency	✓		✓			✓					✓
5	Ash Generation and Disposal	▪ Ash Handling ▪ Ash Disposal System ▪ Ash Transport and Storage	✓	✓	✓	✓	✓			✓	✓	✓	
6	Water demand	▪ Water requirement for operations (steam, cooling, domestic etc.) ▪ Domestic water requirement			✓						✓	✓	
7	Wastewater disposal	▪ Operation of STP ▪ Process wastewater treatment		✓	✓	✓	✓						
8	Waste Generation & Disposal	▪ Waste generation ▪ Storage ▪ Disposal	✓	✓			✓						✓
9	Employment of personnel for Plant operation	▪ Plant Operations ▪ Landscape Maintenance ▪ Security Personnel							✓		✓		✓

S.N	Aspect/Main Activities	Sub – Activities	Potential Impacts										
			Air Quality	Water Quality	Surface Water Resources	Ground Water Resources	Soil and Land Quality	Noise Quality	Traffic	Ecology	Socio economic including community health & safety	Agricultural Activities in the Surroundings	Occupational Health and Safety
10	Decommissioning	▪ Plant closure ▪ Dismantling of Equipments ▪ Transportation ▪ Site Restoration	✓	✓		✓	✓	✓	✓		✓		✓

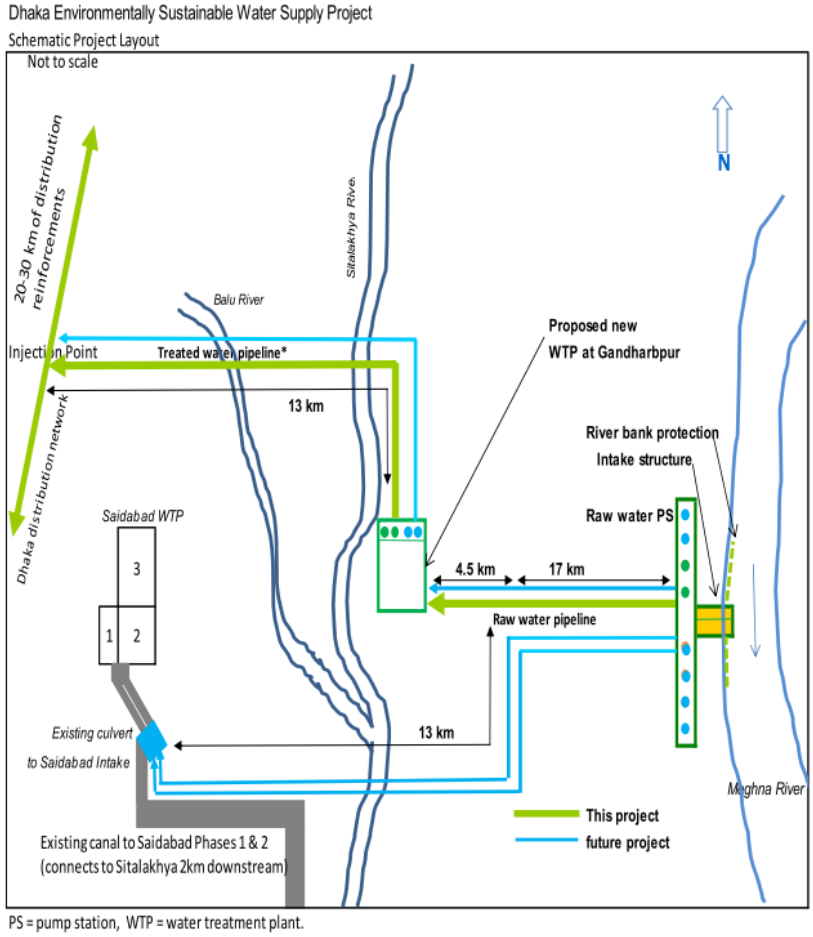
Source: AECOM

9.5.1 Impact on Natural Resources

The proposed project forms a part of the middle floodplains of River Meghna which occupies a low-lying landscape of broad islands and many broad meandering channels. Development and operation of the project will have a minor impact on the natural resource. The runoff from the site will be altered and there will be a permanent change in drainage pattern. A drainage channel around the plant boundary will be made for capturing the runoff from the surrounding areas and finally discharging it in Meghna River.

Impact on DWASA Intake Point (Dhaka Water Supply & Sewerage Authority)

The Dhaka Wasa Water Intake point is situated at a distance of 24km upstream from the proposed plant on Meghna River. The water intake facility is situated on Right bank of Meghna River at Araihajar Upazila with a 2000 MLD capacity[12]. The capacity of water intake is relatively small in comparison with the amount of water required for cooling purposes which estimated to be about 80,140 m^3 /hr. the water will be extracted from the river and will be discharged back to the river. There will be negligible impact on the DWASA intake point. As per the figure below, the raw water will reach the water treatment plant after 17km, which also implies small inflow water rate to the intake structure.



[12] http://www.adb.org/sites/default/files/linked-documents/42173-013-ban-rpab-01.pdf

Impact on River's Morphology

The flood flow vulnerability assessment has been conducted based on the existing ground elevation and the design flood levels. The project site is actually an island of the Meghnariver which is inundated during monsoon. The average existing ground level is found to be 1.77 m PWD. The difference between the existing ground elevation and 100-year flood level is 5.28 m while the difference between the existing ground level and the 2.33-year normal flood level is 3.88 m. This implies that, on an average, the proposed project area needs to be raised at a height of 5.28 m and 3.88 m to prevent it from flooding from 100-year and 2.33-year flood magnitude, respectively.

Importance of Char Land

Char lands are the lands formed by deposition of finer sediments in downstream part of Meghna River. The site also forms a part of V shaped island formed by meandering of River Meghna. A total of 143 vascular plant species belonging to 122 genera covering in 56 families have been recorded from study area. Major fish species are found near the land has been covered under section 8.5.5 aquatic monitoring. Site clearance activities, gathering of equipment and construction materials, machinery and camp establishment may affect the floral species and present on the site. However it will be a one time activity. The potential impacts include spreading of sediments and associated contaminants in the surroundings, remobilisation of contaminants in the water phase of Meghna River near to the site.

9.5.2 Impact on Eco- systems

As per the aquatic survey of the study area, Meghna River is home to variety of fishes like like Hilsa, Rui, Catla, Ayre, Mrigel, Boal etc. The operation of the power plant and its related activities may not have any impact on fish migration and fish diversity. River habitat quality may deteriorate due to uncontrolled discharge of harmful effluents generated from washing of machineries or from leakages of machineries, or discharge of heated water. However, the anticipated impact is envisaged to be minor for eco systems as overall.

9.5.3 Impact due to collection of Resources from local sources within the Country

The proposed project involves huge construction activities that offer employment opportunity to locals. OPDL-2 shall minimise the size of the camps required as much as possible through proactive employment of local labour.

9.5.4 Impact on Ambient Air

The operation phase of the proposed plant will involve air emissions from fuel combustion and fugitive dust emissions from coal handling, storage and transportation and coal preparation activities. The proposed project operations will also lead to greenhouse gas emissions. The impacts

on air quality anticipated due to project activities along with mitigation measures have been discussed below:

POTENTIAL IMPACTS

9.5.4.1 Coal Handling, Transportation and Storage

The coal transportation system for the proposed project will comprise of barge unloaders and a conveyor system. The coal from the barges will be unloaded on to the coal collection point at site using cranes, from where it will be conveyed to the coal yard using a belt conveyor system. The rated capacity of the belt conveyor will be about 600 tons/hour and will have a speed of 2.5 m/s.
The unloading of coal, its conveyance and its storage will involve fugitive dust emissions. The fugitive emissions will depend on several factors such as coal properties including moisture content, particle shape and particle size distribution. Other influencing factors will include meteorological conditions such as wind speed and direction, solar radiation and rainfall and stockpile design and layout.

The dust emissions are considered severe if the moisture content of coal is in the range of 1-4 %, mild for 4-5% and low if it is greater than 8 %. The moisture content of the coal to be transported is expected to be near the design coal range of 15 % and a maximum moisture content of 25 % has been considered for the design of the conveyor belt. The emission factor for particulate matter was estimated for coal handling using *US EPA AP42 13.2.4-3*. The equation and calculation for the emission factor has been presented in *Box 1.* Considering that about 10,000 MT of coal will be handled per day, the total fugitive emission from coal handling has been estimated as 0.41 kg/day. The coal unloading crane area will be provided with a wet dust suppression system which will significantly control the fugitive dust.

Box 1 : Emission factors for Coal Handling

Drop Equation for Coal Handling , E=k*0.0032*(U/5)^1.3/(M/2)^1.4 ***Source: US EPA - AP42 13.2.4-3***		
K, Particle Size multiplier for PM	0.74	
k, Particle size multiplier for PM10		0.35
k, Particle size multiplier for PM2.5		0.053
U - mean wind speed , m/s		1.6
U - mean wind speed , mile/hr.		3.579104
M, Moisture Content (%)		15 (Design Range)
PM Emission factor , uncontrolled, kg/ton		4.14E-05
PM10 Emission factor , uncontrolled, kg/ton		1.96E-05
PM2.5 Emission factor , uncontrolled, kg/ton		2.97E-06

9.5.4.2 Coal Preparation

Once the coal is received in the coal yard, it will be pulverised and homogenised to meet the coal design specifications. The coal may also contain some impurities such as shale and sand stone. Occasionally, it may also contain some metal pieces such as broken shovel teeth, brake shoe and wires and will have to be removed before the coal is fed to the boilers. The coal preparation will involve screening, crushing of coal and magnetic separation. Coal size after crusher will be
20 mm.

The coal preparation activities will involve emissions of fugitive dust during the coal screening, crushing and conveyance for magnetic separation. The impact of these emissions will depend on the quantity and drift potential of the dust particles injected into the atmosphere. In addition to large dust particles that settle out near the source (often creating a local nuisance), considerable amounts of fine particles will also be emitted from the coal preparation activities that will get dispersed over much greater distances from the source.

The potential drift distance of particles is governed by the initial injection height of the particle, the terminal settling velocity of the particle, and the degree of atmospheric turbulence. As per US EPA AP-42 estimates, for a typical mean wind speed of 16 km/hr., particles larger than about 100 µm are likely to settle out within 6 to 9 meters from the point of emission. Particles that are 30 to 100 µm in diameter are likely to undergo impeded settling. These particles, depending upon the extent of atmospheric turbulence, are likely to settle within a few hundred feet from the point of emission. Smaller particles, particularly PM-10 have much slower gravitational settling velocities and are much more likely to have their settling rate retarded by atmospheric turbulence.

A dry fog dust suppression system has been proposed for the crusher receipt and discharge area. The "Dry Fog" dust control system works on the principle of agglomeration. The air borne dust particles will be made to pass through a blanket of extremely fine Fog. The dust particles and the fog droplets collide and adhere to each other, thus increasing their mass. After a series of such collisions, the respirable and fugitive dust ranging from 1 to 800 microns agglomerates to become heavier enough to settle. With the installation of this dust suppression system, it is expected that almost 100 % dust control will be obtained and thereby the impact on the surrounding community is expected to be negligible.

9.5.4.3 Fuel Combustion

The proposed project will make use of the following fuels:

- Coal as the main fuel
- Light Diesel Oil (LDO) for unit warm-up and start-up (0 - 7.5 % BMCR)
- Heavy Fuel Oil (HFO) for unit start-up and flame stabilization (0 - 35 % BMCR)
- Light Diesel Oil for Emergency Diesel Generators and Auxiliary boiler

The impact assessment has been considered only for coal since it will be the main fuel and LDO and HFO will only be used for start up and emergency operations. The major pollutants of concern from coal combustion are particulate matter (PM), sulfur oxides (So), and nitrogen oxides (NOx). Some unburned combustibles, including carbon monoxide (CO) and numerous organic compounds, are also generally emitted even under proper boiler operating conditions.

Particulate Matter (PM) - Uncontrolled PM emissions from coal-fired boilers include the ash from combustion of the fuel as well as unburned carbon resulting from incomplete combustion. In pulverized coal systems, combustion is almost complete; thus, the emitted PM is primarily composed of inorganic ash residues. Soot blowing is also a source of intermittent PM emissions in coal-fired boilers. Steam soot and air soot blowing is periodically used to dislodge ash from heat transfer surfaces in the furnace, convective section, economizer, and air preheater.

Sulphur Oxides (SOx) - Gaseous SOx from coal combustion are primarily sulphur dioxide (SO_2), with a much lower quantity of sulphur trioxide (SO_3) and gaseous sulphates. These compounds form as the organic and pyritic sulphur in the coal are oxidized during the combustion process.

Nitrogen Oxides (NOx) - NOx emissions from coal combustion are primarily nitric oxide (NO), with only a few volume percent as nitrogen dioxide (NO_2). Nitrous oxide (N_2O) is also emitted at a few parts per million. NOx formation results from thermal fixation of atmospheric nitrogen in the combustion flame and from oxidation of nitrogen bound in the coal.

Carbon Monoxide (CO) - The rate of CO emissions from combustion sources depends on the fuel oxidation efficiency of the source.

AIR MODELLING

An air modelling exercise has been carried out for the emission sources at using USEPA AERMOD model. AERMOD is a steady-state plume model that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts. One year meteorological data (January 1, 2013 to December 31, 2013) of Lakes Environment using default AERMET format was used for the modelling exercise. AECOM considered various scenarios with respect to Sulphur content in coal to ensure that emission levels from stack are compliant to IFC requirements. Two scenarios were finally found to suitable to comply wth the emission norms during the operation phase of the project.

i. Coal with 0.38% sulphur content
ii. Use of spray dryer with 50 % efficiency (sulphur content max. 0.6%)

The modelling has been done for prediction of Ground Level Concentrations (GLCs) of PM, SO_2, NO_x and CO due to the project.

The emissions from coal combustion have been considered based on the coal firing rate at 100 % BMCR of 212,000 kg/hr. The coal firing rate for the plant is considered as 212000kg/hr. The normal flue gas flow is calculated as 536.9Nm^3/s based on unitized normal flue gas flow at 350 Nm_3/GJ (dry, 6% O2) as per IFC guidelines.The coal for the project will be sourced from Australia and will have a Sulphur content of 0.6%. The project is designed to have an Electrostatic Precipitator with 99.67% efficiency, which will keep the emission of particulates to atmosphere at the minimal. Stack of 275m height with an internal diameter of 7m has been proposed. The details of the emission sources and factors have been presented in *Table 9-4.*

Reliability of AERMOD

As per Revision to the Guideline on Air Qaulity models (40 CFR Part 51) issued by EPA dated November, 2005, AERMOD's accuracy is an improvement over ISC3ST's ability to predict measured concentrations. The accuracy of the model is normally determined by an evaluation procedure which involves the comparison of model concentration estimates with measured air quality data which has been observed to be better for AERMOD model in comparison with ISCST3.

Table 9-4: Input data considered for air modelling exercise

Parameter	Value	Unit
Calorific Value of Coal	26050	KJ/kg
Sulfur Content	0.6	%
Ash Content	9	%
Coal Firing Rate/Boiler	212	TPH
Stack Parameters		
Stack Height	275	m
Stack Number	1	Number
Stack diameter	7	m
Exit Temperature	122	^oC
Heat Input	1.53	GJ/s
Normal Flue Gas Flow	536.919	Nm^3/s (dry, 6% O_2)**
Stack Emissions		
SO_2 - Scenario 1	447.56	g/s
SO_2 – Scenario 2	353.33	
NO_X	273.82	g/s
SPM	26.846	g/s
SO_2 - Scenario 1	833.56	mg/Nm^3
SO_2 – Scenario 2	658.07	mg/Nm^3
NO_X	510	mg/Nm^3
SPM	50	mg/Nm^3

Source: AECOM

The input parameters considered for the air dispersion modelling have been summarized in *Table below.*

Table 9-5: Inputs Required for Modelling

S.No.	Input	Description
1	**Control Pathway**	
	Dispersion Option	Non Default Option
	Terrain	Flat
	Dispersion Coefficient	Rural
	Flagpole Receptors	No
2	**Meteorology Input**	
	Met Input Data	Meteorological data from 1 January 2012 to 31 December 2012 (Pre-processed Meteorological Data)
	Wind Speed Categories	A: 1.54 m/s B: 3.09 m/s C: 5.14 m/s D: 8.23 m/s E: 10.8 m/s F: No upper bound
	Latitude	23.578239 N
	Longitude	90.570056 E
	Anemometer Height	14m
	Base Elevation	3m
4	**Receptor Pathway**	Uniform Cartesian Grid
	No. of X axis Receptors	251

S.No.	Input	Description
	No. of Y axis Receptors	251
	Spacing for X axis	100m
	Spacing for Y axis	100m
5	**Source Pathway**	Point Source
6	**Output Pathway**	Pollutants Ground Level Concentration
	PM10	24 hourly and annual
	NOx	24 hourly and annual
	SO2	24 hourly and annual

The incremental pollutant concentrations due to the project operations have been provided below. The resultant ground level concentration values have been calculated by adding the incremental values to the baseline concentrations. The resultant concentrations have been compared with the more stringent guidelines out of the ambient air quality standards prescribed by Department of Environment, Bangladesh and the IFC/WB interim guidelines to assess the impact of the proposed project on the ambient air quality.

Incremental GLCs were computed for various combinations of grid sizes starting from 50x50m to 500x500m. Grids selected for simulation were based arriving at maximum incremental GLCs. Incremental ground level concentrations obtained from modelling for air quality due to emissions of SO_2 (both scenarios), NOx and SPM are detailed below.

Sulphur Dioxide (SO_2)

Scenario 1: Coal with 0.38% Sulphur Content

The predicted 24 hour incremental ground level concentration of SO_2 at all the monitored locations for ambient air quality is presented in *table below.*

Table 9-6: Predicted 24-hr Maximum Ground Level Concentration of SO2

S.No	Village	Distance and direction	24 hourly Baseline 98 Percentile SO_2 Conc. ($\mu g/m^3$)#	Incremental SO_2 GLC ($\mu g/m^3$)	Total SO_2 Predictive GLC ($\mu g/m^3$)
1.	Hossendi village	1.2 km , NE	31.54	13.07	44.61
2.	Gowal Gao village	2.14 km, E	30.62	10.72	41.34
3.	Chorhogla/Balirghat	1.7 km, SW	40.08	10.92	51.00
4.	Pachani, Mongoler Gao	3.3 km, N	36.58	13.66	50.24
NAAQS Limit (Rural and Residential) : 365 $\mu g/m^3$ IFC/WB Limits (Interim Target – 1)- 125$\mu g/m^3$					

Source: AECOM

The maximum concentration for SO_2 was observed to 15.05 $\mu g/m^3$ at coordinates of (200m, 2400m) to the North East of the plant. The corresponding isopleth for SO_2 emissions from the OPDL-2 operations is as given in *Figure 9-2*

Scenario 2: Spray dryer with 50 % SO2 removal efficiency (0.6% Sulphur)

The predicted 24 hour incremental ground level concentration of SO_2 at all the monitored locations for ambient air quality is presented in *Table 7-18.*

Table 9-7: Predicted 24-hr Maximum Ground Level Concentration of SO_2

S.No	Village	Distance and direction	24 hourly Baseline 98 Percentile SO_2 Conc. (µg/m³)#	Incremental SO_2 GLC (µg/m³)	Total SO_2 Predictive GLC (µg/m³)
1.	Hossendi village	1.2 km , NE	31.54	10.32	41.86
2.	Gowal Gao village	2.14 km, E	30.62	8.46	39.08
3.	Chorhogla/Balirghat	1.7 km, SW	40.08	8.62	48.70
4.	Pachani, Mongoler Gao	3.3 km, N	36.58	10.78	47.36
NAAQS Limit (Rural and Residential) : 365 µg/m³ IFC/WB Limits (Interim Target – 1)- 125µg/m³					

Source: AECOM

The maximum concentration for SO_2 was observed to 11.88 µg/m³ at coordinates of (200m, 2400m) to the North east of the stack. The corresponding isopleth for SO_2 emissions from the OPDL-2 operations is as given in *Figure 9-2.*

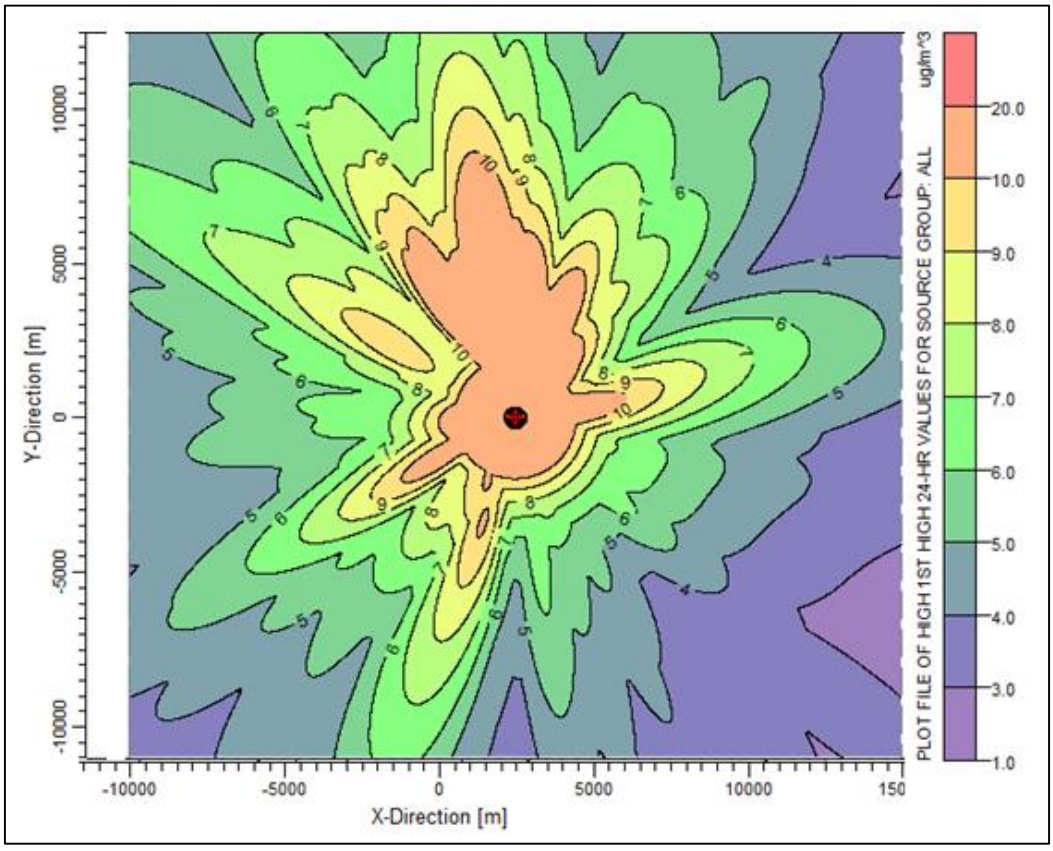
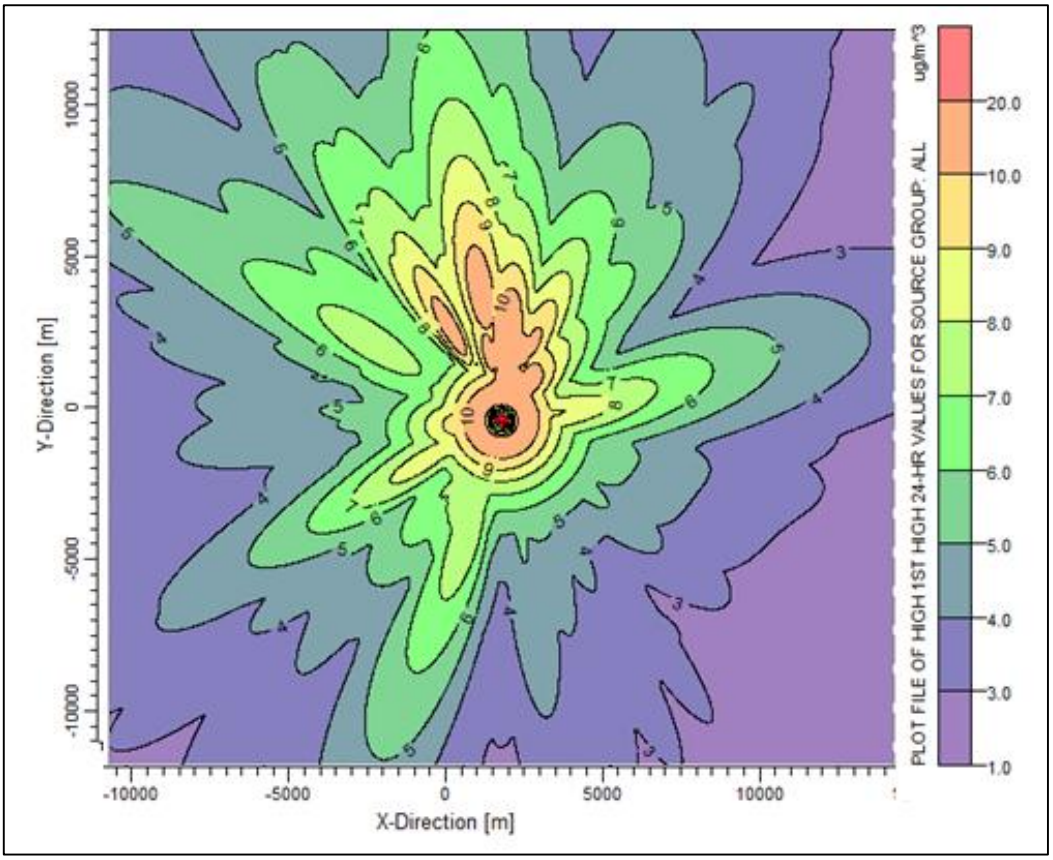


Figure 9-2: 24 Hourly Incremental Concentration of SO_2 – Scenario 1 (µg/m³)

Figure 9-3: 24 Hourly Incremental Concentration of SO_2 – Scenario 2 (µg/m^3)

Based on meteorological data procured for the study area from Lakes Environmental representing one year period from January 1, 2013 to December 31, 2013, the predominant wind directions are towards SE during winter (northeast monsoon), NNE during summer (pre-monsoon), and NNW



during monsoon and WNW during autumn (post-monsoon) months. As per the estimated results, stack emissions with maximum emissions of Sox (15.05 ug/m3) can reach to a distance of 2.4km only during months of May and June. Table below provides the ground level concentration of Sox measures in all four directions (north, east, south and west) dispersed from stack at various distances for both the senarios.

Table 9-8: Scenario I: Coal with 0.38% Sulphur Content- North Direction

Distance (measurement of y coordinate in m)	24-Hourly Incremental Ground Level Concentration (µg/m^3)
1000m	13.89
2000m	14.28
4000m	12.57
6000m	10.32
8000m	9.01
10000m	7.92

.

Table 9-9: Scenario I: Coal with 0.38% Sulphur Content- East Direction

Distance (measurement of x coordinate in m)	24-Hourly Incremental Ground Level Concentration (µg/m^3)
1000m	13.32
2000m	10.81
4000m	8.44
6000m	6.52
8000m	5.26
10000m	4.4

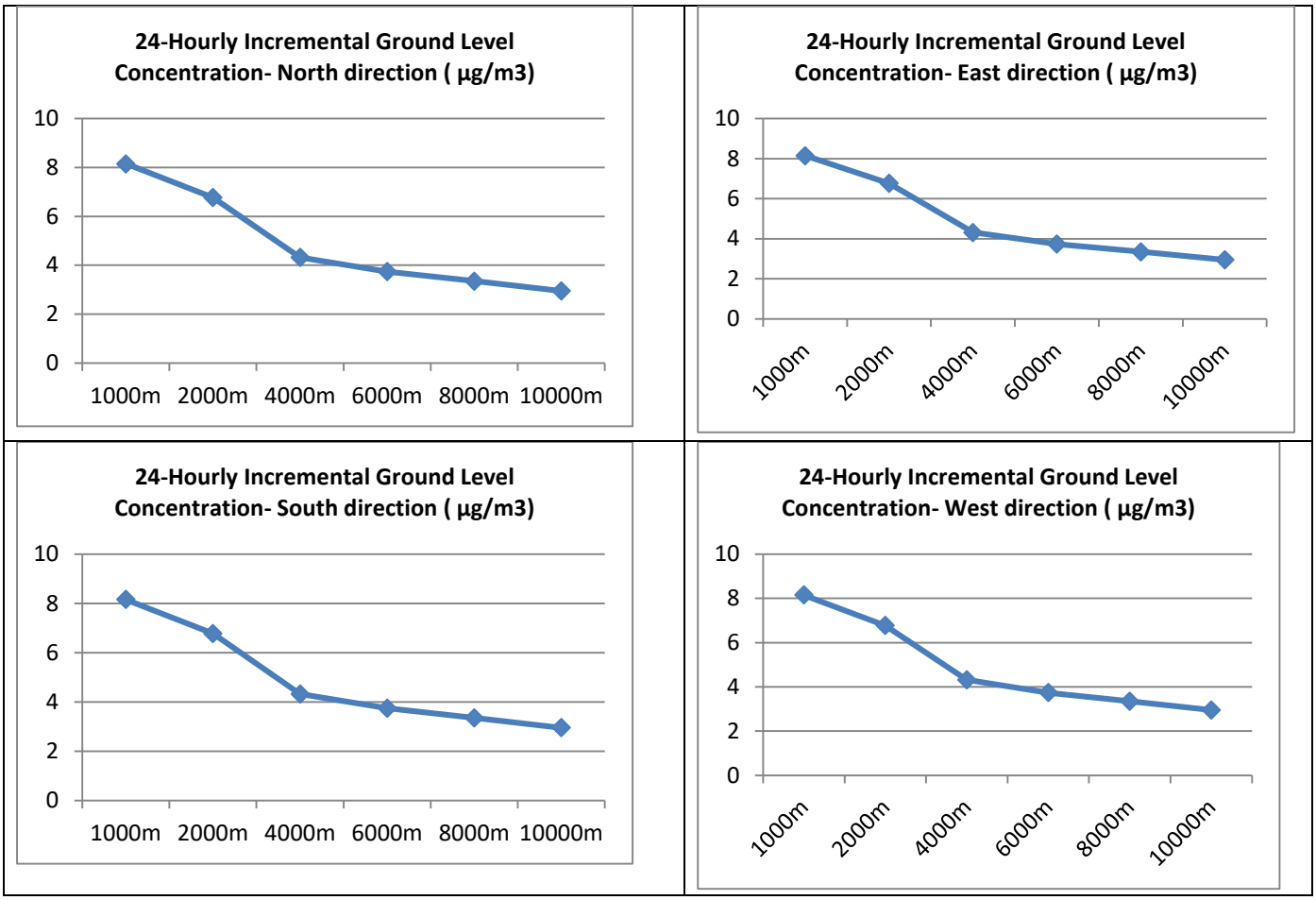
Table 9-10: Scenario I: Coal with 0.38% Sulphur Content- South Direction

Distance (measurement of y coordinate in m)	24-Hourly Incremental Ground Level Concentration (µg/m^3)
-1000m	13.32
-2000m	9.91
-4000m	5.85
-6000m	4.61
-8000m	4.05
-10000m	3.85

Table 9-11: Scenario I: Coal with 0.38% Sulphur Content- West Direction

Distance (measurement of x coordinate in m)	24-Hourly Incremental Ground Level Concentration (µg/m^3)
-1000m	13.32
-2000m	11.06
-4000m	7.06
-6000m	6.12
-8000m	5.48
-10000m	4.83

Figure 9-4: 24 Incremental Concentration of SO_2 – Scenario I (µg/m^3)- In all directions



In all the four directions, the incremental concentration of SO2 first increases upto 2000m then starts decreasing upto 10000m. The plant is proposed to be located on south of a piece of V shaped island, which is separated from settlements in all four directions. The resultant concentration of SO_2 in the ambient air is much below the MOEF's standard (ECR 1997), 80 µg/m^3 for residential and rural area.

Table 9-12: Scenario II: Spray dryer with 50 % SO2 removal efficiency (0.6% Sulphur) - North direction

Distance (measurement of y coordinate in m)	Hourly Incremental Ground Level Concentration (µg/m^3)
1000m	10.97
2000m	11.27
4000m	9.92
6000m	8.15
8000m	7.11
10000m	6.25

Table 9-13: Scenario II: Spray dryer with 50 % SO2 removal efficiency (0.6% Sulphur) - East direction

Distance (measurement of x coordinate in m)	Hourly Incremental Ground Level Concentration (µg/m³)
1000m	10.52
2000m	8.54
4000m	6.66
6000m	5.15
8000m	4.15
10000m	3.48

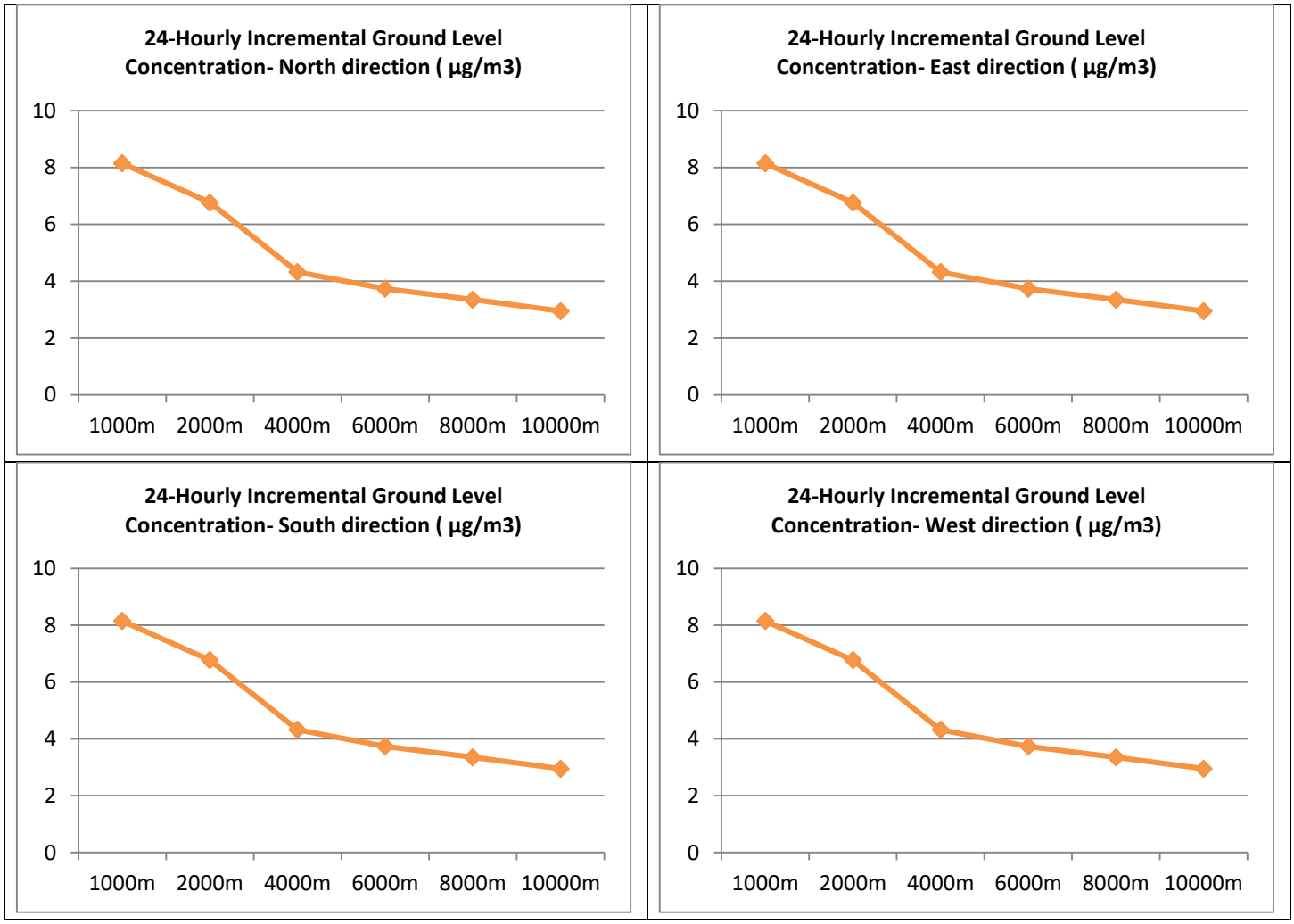
Table 9-14: Scenario II: Spray dryer with 50 % SO2 removal efficiency (0.6% Sulphur) - South direction

Distance (measurement of y coordinate in m)	Hourly Incremental Ground Level Concentration (µg/m³)
-1000m	10.51
-2000m	7.82
-4000m	4.62
-6000m	3.63
-8000m	3.20
-10000m	3.03

Table 9-15: Scenario II: Spray dryer with 50 % SO2 removal efficiency (0.6% Sulphur) – West direction

Distance (measurement of x coordinate in m)	Hourly Incremental Ground Level Concentration (µg/m³)
-1000m	10.51
-2000m	8.73
-4000m	5.57
-6000m	4.83
-8000m	4.33
-10000m	3.81

Figure 9-5: 24 Incremental Concentration of SO_2 – Scenario II (µg/m³)- In all directions



The nearest settlements are located beyond 1km from the boundary of the project area, thus incremental GLC concentrations at the settlements will be further reduced. The impact on the air shed due to the plant operations can be considered as moderate.

Table 9-16: Emission of SO2 (with both the scenarios) from proposed Coal Based Ultra-supercritical Thermal Power Plant

Scenario	Elementary Conent in Coal, % by wt	Emission Rate from Stack in g/s (stack height of 275m)	SO2 emissions in mg/Nm3	IFC Standards	Remarks
Scenario I	0.38% of Sulphur	447.56	833.5618	For a Non degraded Airshed, and for Thermal Plants with capacity of more than or equal to 600 MW considering usage of Solid fuel, the maximum allowable concentration of So2 is 850 mg/Nm3	SO2 emissions in coal with 0.6% sulphur content without FGD will be 1200 mg/Nm3 which will exceeds standards as prescribed by IFC which is 850mg/ Nm3. Hence it can be concluded that Flue Gas Desulfurization is required in case of higher Sulphur content (more than 0.38% Sulfur content in Coal) at a stack height of 275m. (in compliance with ECR,1997).
Scenario II	50 % SO2 removal efficiency (0.6% Sulphur)	353.33	658.07		

Source: AECOM

Nitrogen Oxide (NOx)

The predicted 24 hour incremental ground level concentration of NOx at all the monitored locations for ambient air quality is presented in Table below.

Table 9-17: Predicted 24-hr Maximum Ground Level Concentration of NOx

S.No	Village	Distance and direction	24 hourly Baseline 98 Percentile NOx Conc. (µg/m³)#	Incremental NOx GLC (µg/m³)	Total NOx Predictive GLC (µg/m³)
1.	Hossendi village	1.2 km , NE	38.00	8.00	46.00
2.	Gowal Gao village	2.14 km, E	40.62	6.56	47.18
3.	Chorhogla/Balirghat	1.7 km, SW	55.54	6.68	62.22
4.	Pachani, Mongoler Gao	3.3 km, N	44.00	8.35	52.35
No standards for 24 hourly values. The NOx values are however compliant to annual limits also.					

Source: AECOM

The maximum concentration for NOx was observed to 9.24µg/m³ at a coordinate of (200m, 2400m) to the North east of the stack. The maximum concentration will occur at 1.5km from Plant boundary in north-east direction. The corresponding isopleth for NOx emissions from the OPDL-2 operations is as given in *Figure9-4.*

Figure 9-6: 24 Hourly Incremental Concentration of NO_x (µg/m³)

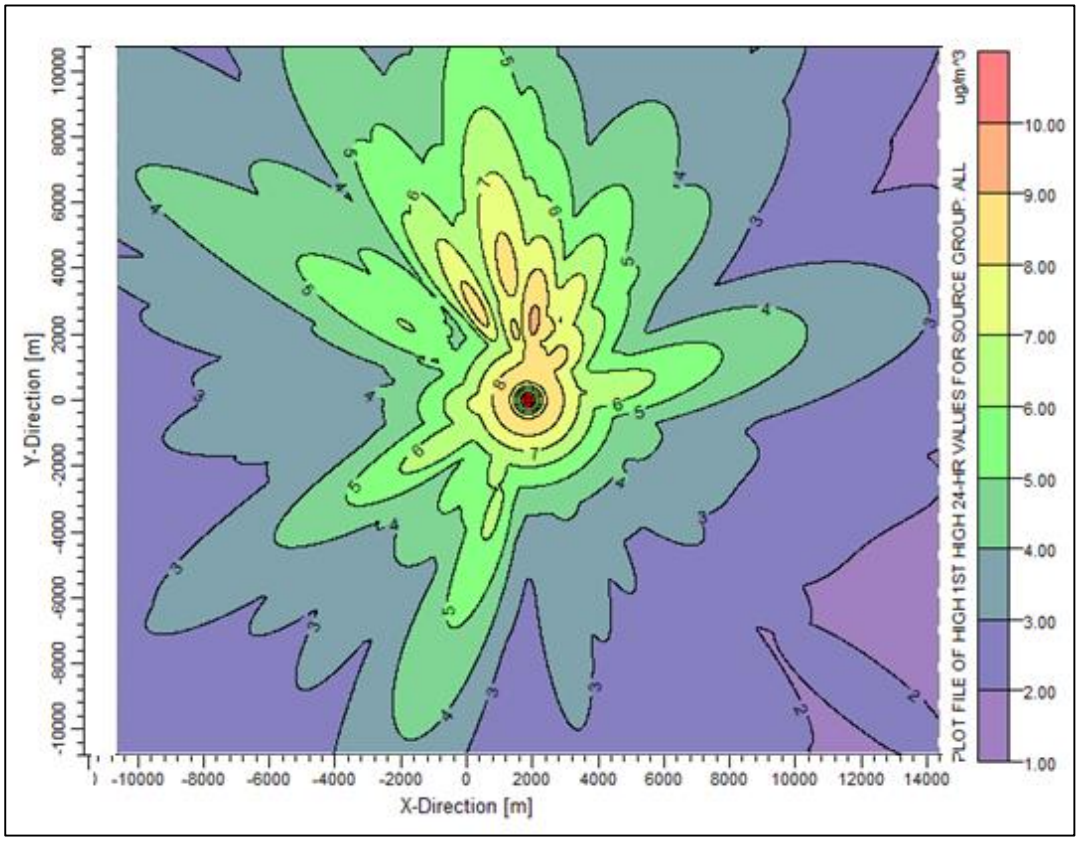


Table 9-18: Incremental Concentrations North direction

Distance (measurement of y coordinate in m)	Hourly Incremental Ground Level Concentration (µg/m³)
1000m	8.50
2000m	8.73
4000m	7.69
6000m	6.32
8000m	5.51
10000m	4.85

Table 9-19: Incremental Concentrations East direction

Distance (measurement of x coordinate in m)	Hourly Incremental Ground Level Concentration (µg/m³)
1000m	8.15
2000m	6.61
4000m	4.32
6000m	3.99
8000m	3.22
10000m	2.69

Table 9-20: Incremental Concentrations South direction

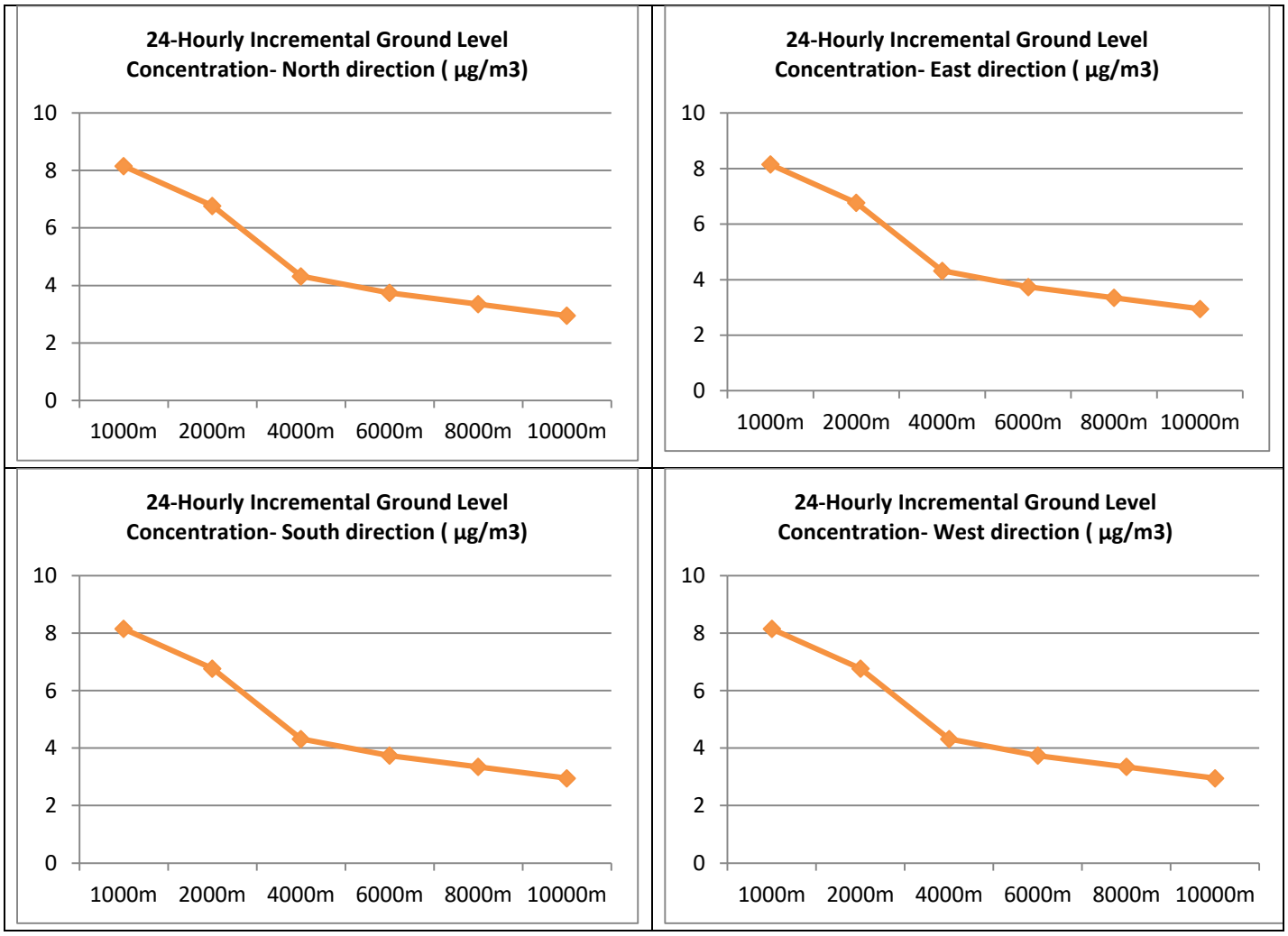
Distance (measurement of y coordinate in m)	Hourly Incremental Ground Level Concentration (µg/m³)
-1000m	8.15
-2000m	6.06
-4000m	3.58
-6000m	2.82
-8000m	2.48
-10000m	2.35

Table 9-21: Incremental Concentrations West direction

Distance (measurement of x coordinate in m)	Hourly Incremental Ground Level Concentration (µg/m³)
-1000m	8.15
-2000m	6.77
-4000m	4.32
-6000m	3.74
-8000m	3.35

-10000m	2.95

Figure 9-7: Incremental Concentration of NOx- In all directions



Suspended Particulate Matter (SPM)

The predicted 24 hour incremental ground level concentration of PM at all the monitored locations for ambient air quality is presented in Table below.

Table 9-22: Predicted 24-hr Maximum Ground Level Concentration of SPM

S.No	Village	Distance and direction	24 hourly Baseline 98 Percentile PM Conc. (µg/m³)	Incremental SPM GLC (µg/m³)	Total SPM Predictive GLC (µg/m³)
1.	Hossendi village	1.2 km , NE	386.04	0.78	386.82
2.	Gowal Gao village	2.14 km, E	358.06	0.64	358.70
3.	Chorhogla/Balirghat	1.7 km, SW	578.42	0.65	579.07
4.	Pachani, Mongoler Gao	3.3 km, N	386.86	0.81	387.67
No standards for 24 hourly values					

Source: AECOM

The maximum concentration for SPM was observed to 0.905 μg/m^3 at x coordinate of 200 and y coordinate of 2400. The corresponding isopleth for SPM emissions from the OPDL-2 operations are as given in Figure 9-5.

Figure 9-8: 24 Hourly Incremental Concentration of SPM (µg/m³)

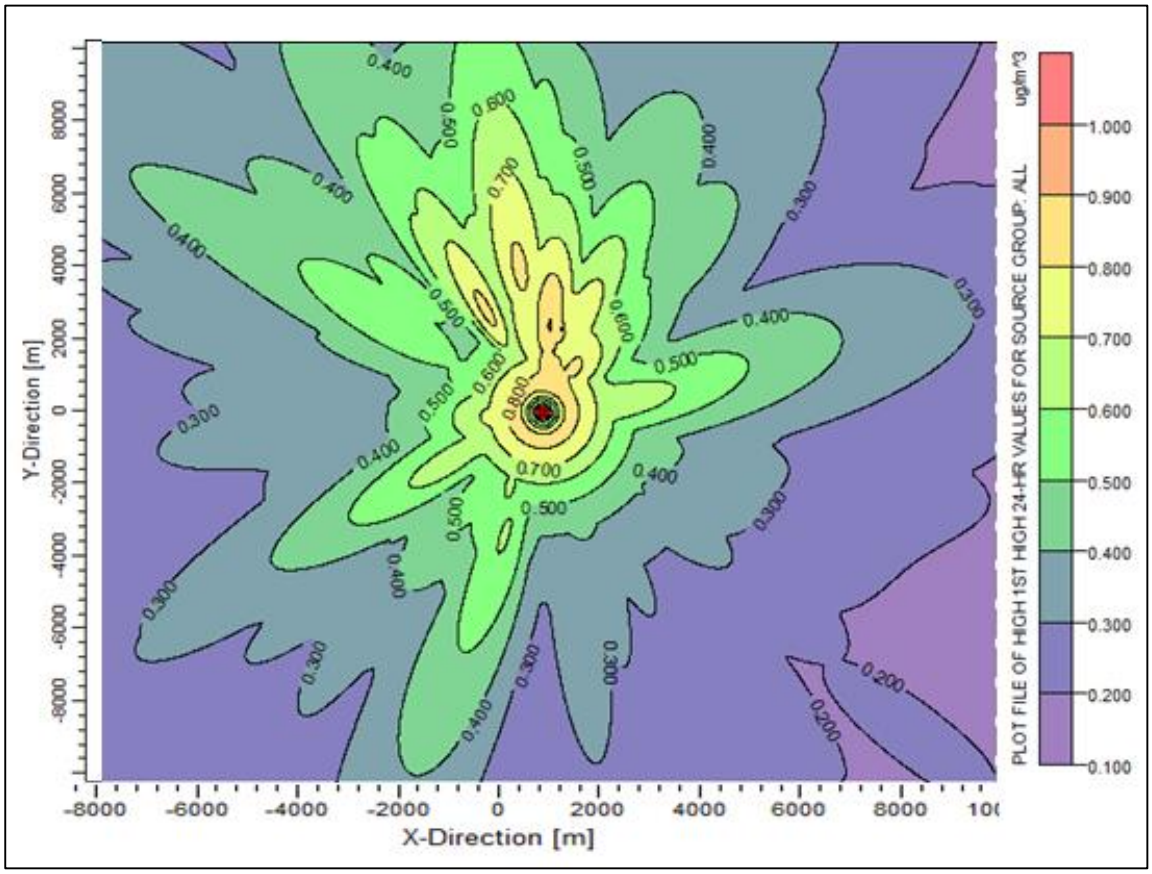


Table 9-23: Incremental Concentrations North direction

Distance (measurement of y coordinate in m)	24-Hourly Incremental Ground Level Concentration (µg/m³)
1000m	0.83
2000m	0.85
4000m	0.75
6000m	0.62
8000m	0.54
10000m	0.47

Table 9-24: Incremental Concentrations East direction

Distance (measurement of x coordinate in m)	24-Hourly Incremental Ground Level Concentration (µg/m³)
1000m	0.79
2000m	0.65
4000m	0.51
6000m	0.39
8000m	0.31
10000m	0.26

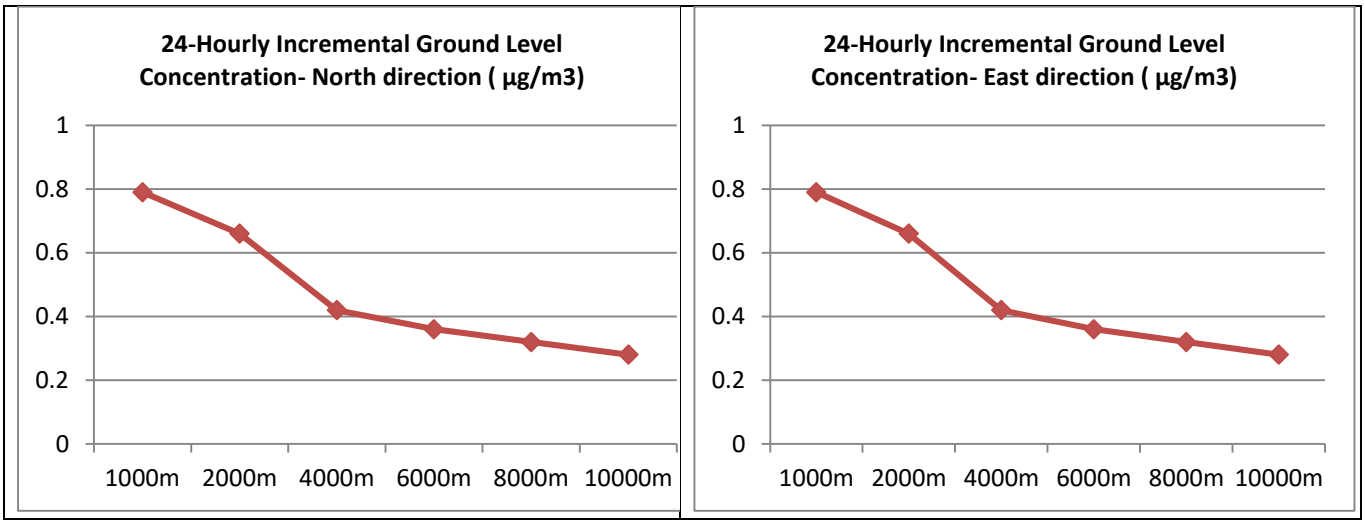
Table 9-25: Incremental Concentrations South direction

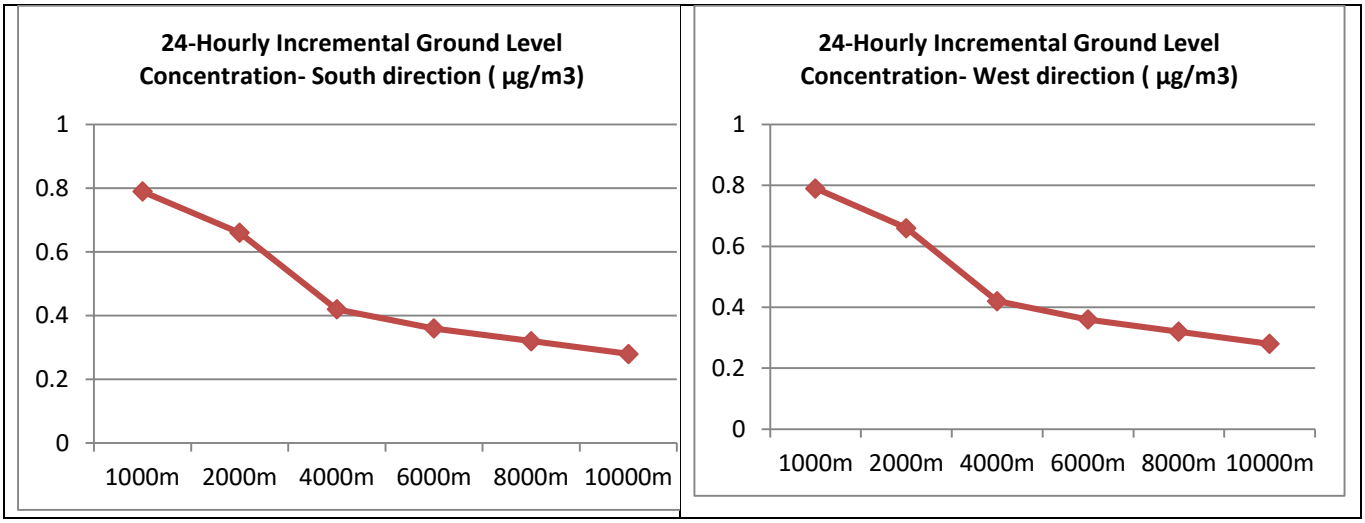
Distance (measurement of y coordinate in m)	24-Hourly Incremental Ground Level Concentration (µg/m^3)
-1000m	0.79
-2000m	0.59
-4000m	0.35
-6000m	0.27
-8000m	0.24
-10000m	0.23

Table 9-26: Incremental Concentrations West direction

Distance (measurement of x coordinate in m)	24-Hourly Incremental Ground Level Concentration (µg/m^3)
-1000m	0.79
-2000m	0.66
-4000m	0.42
-6000m	0.36
-8000m	0.32
-10000m	0.28

Figure 9-9: Incremental Concentration of SPM- In all directions





The incremental concentrations observed from the model output are low except for SO_2; the resultant concentrations for all parameters are calculated to be within the prescribed norms of National Ambient Air Quality Standards except for particulate matter.

Plant Boundary Emissions

The **Table 9-10** presents the incremental ground level concentrations at four coordinates covering the plant boundary in all the four directions. It can be observed from the table that, incremental concentrations of SO_2 if Sulphur content in 0.38%; range from 11.7-13.8 µg/m^3. If a spray drier with 50% efficiency is used (with 0.6% S), the incremental concentration of SO_2 will range from 9.3-10.9 µg/m^3 at the plant boundaries. Increase in GLC of Nox varies from 7.2-8.4 µg/m^3 and incremental concentrations of SPM range from 0.7-0.8 µg/m^3

Table 9-27: Incremental GLC at Plant Boundary

S.No.	Coordinates	Incremental SO_2 GLC (µg/m^3) : Scenario I	Incremental SO_2 GLC (µg/m^3): Scenario II	Incremental NOx GLC (µg/m^3)	Incremental SPM GLC (µg/m^3)
1	615, 560	13.80	10.89	8.44	0.82
2	250, -625	13.68	10.80	8.37	0.82
3	-230, -425	11.73	9.26	7.18	0.70
4	-790, 370	13.58	10.72	8.31	0.81

Source: AECOM

9.5.4.4 Green House Gas Emissions

The proposed project qualifies as a *High carbon intensity Project* as it will lead to significant emissions of carbon dioxide (CO_2), which is a greenhouse gas. The greenhouse gas emissions from the project were estimating using the Greenhouse Gas (GHG) Protocol, which is an international accounting tool developed by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). For the purpose of impact assessment, quantification of CO_2 emissions within the purview of Scope 1 of the protocol, which accounts for emissions from sources owned by the company, was carried out. The sources identified under this scope area as follows:

Table 9-28: Identified GHG Emission sources

S.No.	Emission Source	Type of Source	Justification for identification under Scope 1
1.	Boilers	Stationary	Emissions due to electricity generation from coal will be accounted.
2.	Fuel combustion in coal transportation vessels	Mobile	Though such vessels are not owned by OPDL-2 but their operation will be in interest of the company and hence controlled by it. Thus emissions from such vessels shall be accounted.

The following mathematical equation was used for calculating CO_2 emissions from the project due to coal combustion in boiler operation.

E = M_{fuel} x Carbon content x O.F. x E.F.

Where,

E = Mass of CO_2 emissions (tonnes/unit time)

M_{fuel} = Mass of fuel (coal) used in boiler operation (tonnes/unit time)

Carbon content = Ultimate fixed carbon content of fuel (coal) (tonnes of carbon/tonne of coal)

O.F. = Oxidation factor to account for fraction of carbon in fuel that remains as soot or ash

E.F. = Emission Factor i.e., mass of CO_2 released per unit mass of carbon combusted

= Ratio of molecular weight of CO_2 to that of Carbon = (44/12)

O.F. has been taken as unity (1) assuming complete carbon consumption (IPCC Guidelines)

Fuel Type	Amount of Fuel	Carbon Content	Oxidation Factor	Emission Factor	Total CO_2 emissions	Annual CO2 emissions
Sub-bituminous coal	**tonnes/year**	**(%)**			**(million tonnes)**	**(million tonnes/year)**
	2002000	61.1	1.00	3.667		**4.48514733**
	286	61.1	1.00	3.667	0.001	4.485147333

Source: AECOM

The total CO_2 production due to coal combustion during boiler operation has been estimated using the guidance document '*Calculation Tool for Direct Emissions from Stationary* Combustion, GHG protocol' and will be about **4.485 million tonnes/ year.**

Ultra-supercritical boilers operate at higher steam temperatures and pressures and, therefore, are more efficient than subcritical boilers. Because of their efficiency, ultra-supercritical units can emit 10 percent to 20 percent less CO_2 than subcritical boilers.

9.5.4.5 Acid Rains

A stack height of 275m has been proposed for dispersion of gas emissions that will be generated from the power plant. Coal to be used for the electricity generation will have a Sulfur content (avg. 0.6%) and MoEF's standard (ECR 1997) of emission will be maintained. Stack gas will be easily dispersed as there is no terrain effect and any other obstruction like building, dense forest that could cause fumigation and trapping of pollutants. It is very unlikely to form any sulfuric acid mist and the possibility of acid rain is very low due to undisturbed dispersion of SOx.

9.5.5 Impact on Ambient Noise

The assessment of the impacts of noise on the surrounding community depends upon:

- Characteristics of noise source (instantaneous, intermittent, or continuous in nature, with the latter contributing the least to noise pollution);
- Time of day at which noise occurs; and
- Location of noise source with respect to noise sensitive receptor.

For the purposes of predicting noise emissions impacts from the site, the noise emission sources were examined. During normal operation phase, there are two types of noise generation sources:

- Stationary sources: Steam Turbine Generators, Boiler feed pumps, other rotating equipment like, major and large pumps, air compressor, D.G. sets, ventilation fans, exhaust from steam line safety valves etc.
- Mobile sources vehicular traffic for staff mobilization, material transport, liquid fuel transport to project site etc.

The typical noise emission limits are as follows:

- 90 dB(A) at 1 m from the turbine
- 60 dB(A) at 120 m from the turbine

The major stationary noise generating sources for the proposed power plant are provided in the table below along with the respective noise generation levels. However, enclosures of steam turbine generator shall be designed for noise attenuation to reduce noise level to 85 dB(A) at 1 meter distance. The ambient noise level at 120 meters from any part of the plant (far field) shall not exceed 60 dB (A).

Table 9-29: Major Noise Generating Sources during Operation Phase

S. N	Source	Effective Noise Level (dB(A)) with enclosure at 1 m distance
1	Miller House	105
2	Steam Turbine (ST)	85
3	Boiler Feed Pump (BFP)	85
4	DG sets (used for emergency power supply)	75 (without enclosure)

Source: AECOM

The major noise sources identified for the proposed plant, as given in *Table 9-29*, have been considered for prediction of impact on ambient noise levels at nearby human settlements as well as the occupational exposure to workers within the project premises.

Noise Modelling Results

In order to predict the likely impact of operations of thermal power plant on the ambient noise, it is necessary to estimate noise levels associated with equipments and components of proposed plant which will provide the basis for assessment of impact of noise generation.

Noise model (mathematical model) was used for predicting impacts due to operations of proposed plant on ambient noise. The proposed thermal power plant will have various in-house noises generating sources, such as turbines, generators, boilers, coal handling plant, fans, pumps etc. The potential sources of noise emission have been provided in Table 9-30.

Table 9-30: Noise Generation Sources and Typical Noise Levels

S.No	Particular	Coordinates	Typical Noise Level at 1m distance, dB(A)
1.	Steam Turbine Building	(110,110)	85
2.	Miller House	(90,90)	105
3.	Pump House	(520,55)	95
4.	Emergency Diesel Generator Set	(-55,115)	75

Source: AECOM

A noise modelling exercise was carried out to estimate the incremental noise levels due to operations of power plant and the spatial variations in incremental noise levels have been provided in Figure 6-1. Equivalent noise level contours have been plotted corresponding to the incremental noise levels results obtained from the mathematical modelling.

The fence line noise observed in the north of the site is 50 dB (A), towards the east is 54 dB(A), towards the west 48dB(A) and towards south 48 dB (A). It can be observed from the *Figure 7-5* that the noise levels decrease significantly and merge with the background concentration before reaching the nearest village Vati Bolaki. The baseline noise levels have been observed to be in the range of 57.8-65.3 dB (A) during day time and 41.8-60.9 dB (A) during night-time.

Figure 9-10: Incremental Noise Levels due to Operations of Thermal Power Plant

Impacts

The workers in the proposed thermal power plant are likely to be exposed to high noise levels for short term. Workers working near pump house and milling house are more susceptible to increased noise levels due to operations of machines. This short term exposure may have impact on these workers if proper care is not taken which may result in occupational hearing damage. It may cause loss of concentration, fatigue, a reduced capacity to work due to increased physical strain, attention deficits, and an impaired ability to communicate verbally. *Table 9-16* provides the permissible noise exposures and respective limit of durations of hours a worker should be exposed.

Table 9-31: Permissible Noise Exposures

S.No	Duration Per day, hours	Sound Level dB(A) slow response
1.	8	90
2.	6	92
3.	4	97
4.	3	95
5.	2	100
6.	1.5	102
7.	1	105
8.	0.5	110
9.	0.25 or less	115

https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9735

Vibrations

Vibrations are expected to be generated by various activities associated with the proposed project activities. The impact of vibrations beyond the project site would be negligible in view of aerial distance. However, the impacts on workers engaged in the plant area would be considerable due to occupational exposure depending on work places. The fixed major equipment/units such as turbine generators, boilers, Heavy duty compressors, pumps etc. will generate vibrations during operation phase and may cause exposures to the workers/operators engaged at these units. Various standards pertaining to vibrations as specified by DoE / IFC shall be complied with to minimise the impacts in the worker's health effects due to vibrations.

9.5.6 Water Resources and Quality

The impacts on water resources and quality due to the project operations have been discussed under the following heads:

- Water Abstraction
- Wastewater Generation and Disposal
- Fuel loading and unloading operations
- Thermal Discharge

9.5.6.1 Water Abstraction

The main source of water in the area is Meghna River. About 80,140 m^3/hr of surface water will be sourced from Meghna River for the proposed project. The major demand for water will be for

cooling water system and has been estimated as 80,000 m^3/hr for the proposed project. Once through cooling water system is proposed, which will involve extraction of water from the river and discharge of the heated cooling water back to the river. About 80,000 m^3/hr of water will be discharged back to the River. Although the total water requirement for once through cooling systems is more than that of a closed cooling water system, the evaporation loss is much lower in once through systems thereby leading to a lower net water requirement[13]. Other uses of water will include makeup water for boiler, water for ash handling system, greenbelt development, service water requirements for plant washing and water sprinkling for dust suppression and for domestic consumption.

The net water demand for the plant is therefore only 273m^3/hr and will have negligible impact on the water resource availability. No groundwater abstraction is envisaged for the power plant operations; however water for consumption of workers and staff accommodation may require ground water sources. The withdrawal rate designed for the proposed power plant is very insignificant as compared to the large volumes of water even in lowest flow condition of Meghna River. Hence, hydrological characteristics of the river related with the discharge may not be changed due to withdrawal of the designed water requirement from the Meghna River.

9.5.6.2 Wastewater Generation

As discussed in previous sections, the wastewater/effluent streams from the plant will include effluents and process wastewater, domestic wastewater and runoff from process and other plant areas. The process effluents from the project will include regeneration waste from DM plant and condensate polishing unit, boiler blow down, service waste water and coal pile and ash disposal area run offs.
The quality of Meghna River may get impacted due to discharge of the above mentioned effluents.

9.5.6.3 Fuel loading and unloading operations

The loading, unloading and stacking of coal can contribute to changes in water quality due to interaction of water with dust fallout and coal spillage. The fuel oil will be transported through a floating jetty. The fuel transport and unloading may involve accidental release/spill due to rupture of fuel tank. The vessels transporting the fuels may discharge the ballast water into the River.

9.5.6.4 Maintainance Dredging

During the operation phase, maintenance dredging shall be carried out. The dredged material, if not disposed off properly may affect the quality of the River water. The impacts of dredging activities are strongly influenced by the contamination of the sediment and local factors like water depth, rate of flow, tidal currents, wave action, type of seabed and sediment concentration of the water under natural circumstances, as well as the dredging method. Dredged spoil should be disposed off in such a manner so that it does not any additional environmental issues and refill the dredged channel. Probable spoil disposal locations should be selected considering distance from dredging sites, environmental issues and social surveys and after discussions with local people.

[13] Source - Water Conservation Plan - Electric Utilities Sector Plan , Michigan Chamber of Commerce (2008)

9.5.6.5 Thermal Discharge

Once through cooling water after heat exchange will be discharged into the Meghna River. The maximum design temperature difference at the outlet of the cooling system is 8°C. The primary effects of thermal pollution include direct thermal shocks, changes in dissolved oxygen, and the redistribution of organisms in the local community. Because water can absorb thermal energy with only small changes in temperature, most aquatic organisms have developed enzyme systems that operate in only narrow ranges of temperature. These stenothermic organisms can be killed by sudden temperature changes that are beyond the tolerance limits of their metabolic systems.

9.5.6.6 Thermal Plume Modelling

To assess the impact of thermal discharge during operation of the project, a thermal plume study has been carried out using DELFT-3D model. Modelling has been carried out in a branch of Meghna River on the western side of the island where the outfall is located.

Methodology

The model being used for the study is a fully integrated computer software suite for a multi-disciplinary approach and 3D computations for coastal, river and estuarine areas. It also calculates non-steady flow and transport phenomena that result from tidal and meteorological forcing on a rectilinear or a curvilinear, boundary-fitted grid. The modelling was undertaken in four main stages: site and data analysis, model set up, calibration and application, and result analysis.

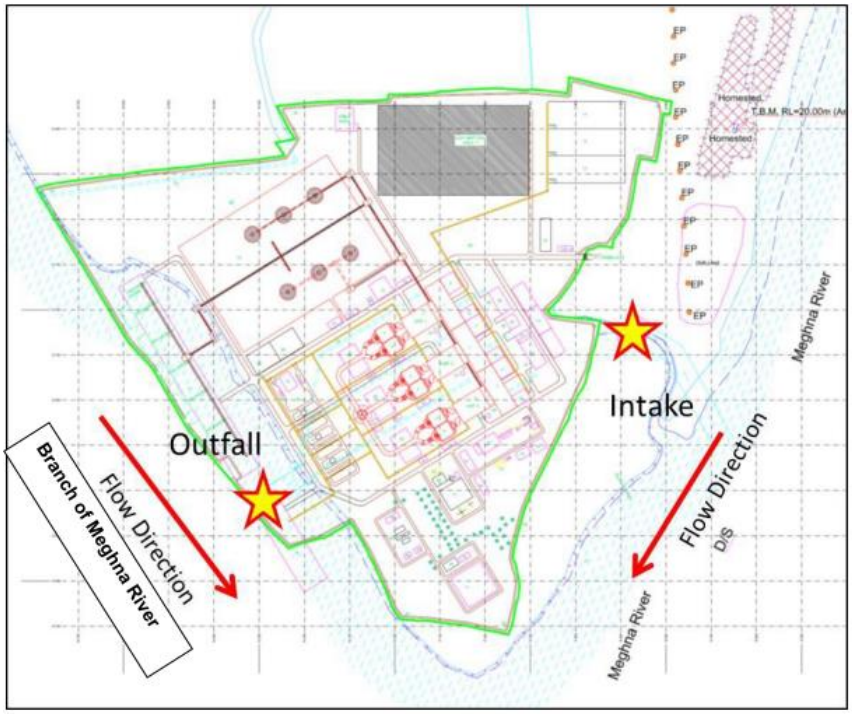
The intake is located on the eastern bank of Meghna River while the outfall is located on the western bank (Figure 9-12). The depth at the intake is around -4m while thedepth at the outfall is around -7m. The bathymetric survey data at a resolution of 100m x 100m along Meghna River and Dhaleswari River was used. The bathymetric data extended 5.2km upstream of the plant site and 5.2km downstream of the plant site and spans between 800m and 2500m wide. The depth near the Plant Site varied between -1.5m to -4.5m. Measured temperature at plant site measured to be in the range of - 20.3°C to 21.8°C.

Accuracy of the Model

Delft3D is a 2D/3D integrated modeling environment for hydrodynamics, waves, sediment transport, morphology, water quality, particle tracking for water quality, and ecology.[14] The FLOW module of Delft3D is a multi-dimensional calculates non-steady flow and transport phenomena resulting from tidal and meteorological forcing on a curvilinear, boundary fitted grid.

Figure 9-11: Location of Intake and Outfall

[14] http://nepis.epa.gov/Adobe/PDF/2000E72Z.pdf

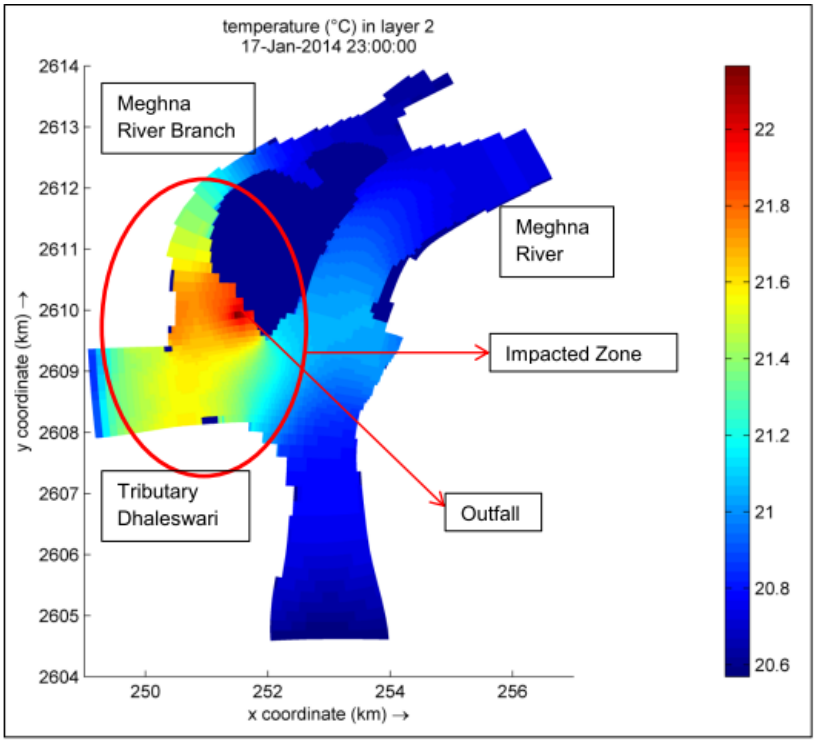


The model was calibrated for the period 14 – 21 Jan 2014 when the site data was recorded. A volume of 22.2 m^3/s (80,000 ton/h) used for cooling is considered for caliberation. The same amount of water is discharged to the Meghna River. Outfall temperature is 8°C higher than the inflow water temperature is also considered. Both flood and ebb tide conditions were considered to provide an indication of how the plume temperatures vary depending on tidal conditions and extent of the thermal plume.

Evaluation of Whole Domain of the Meghna and Dhaleshwari River

The modelling exercise has been carried out where currents were used as upstream boundary condition both in the main river and branch and also in the tributary while water level was used as downstream boundary condition.

Figure 9-12: Overview of Modelled Temperature for the whole domain



The impacted zone has been highlighted in Figure above .The temperature near the outfall was in the order of 22°C and above during the simulated period. The temperature in Dhaleswari River ranged from21.2° to 21.8°C. The temperature in the branch of Meghna River ranged from 21.2°to 22°C. However, along the main river the temperature was below 21.2°C. The difference between the measured and modelled data is within the 10% acceptable range.

At the outfall location, the temperature exceedence of more than 1.2°C is noticed during ebb tide and extended up to 50m from the outfall location, and temperature exceedance of 1° to 1.2°C was observed at a distance of 200m from the outfall location. During flood tide, the temperature exceedence at the outfall was in the order of less than 1.5°C. The exceedance of temperature during ebb tide and flood tide in layers has been illustrated in Figures below.

Figure 9-13: Exceedance of Temperature during Ebb Tide

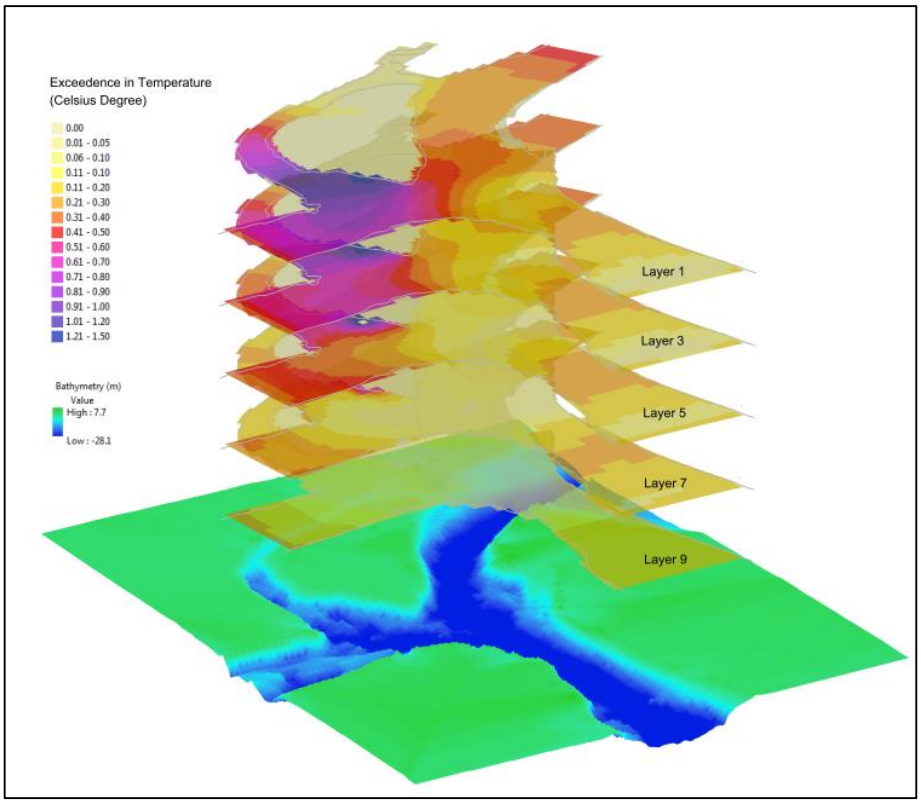
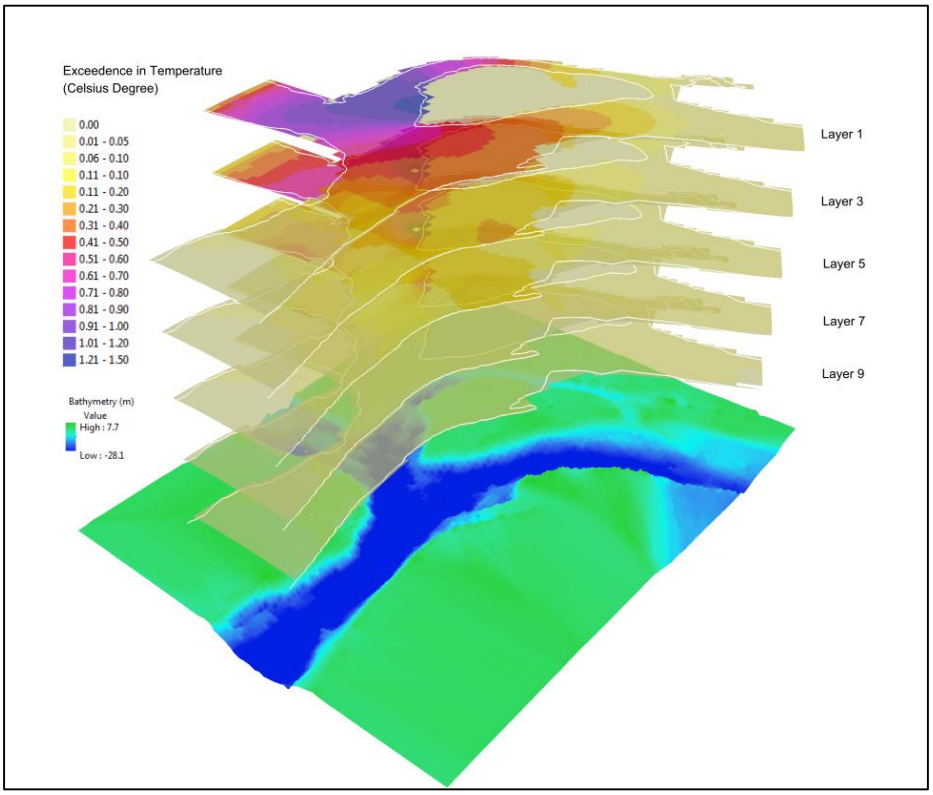


Figure 9-14: Exceedance of Temperature during Flood Tide



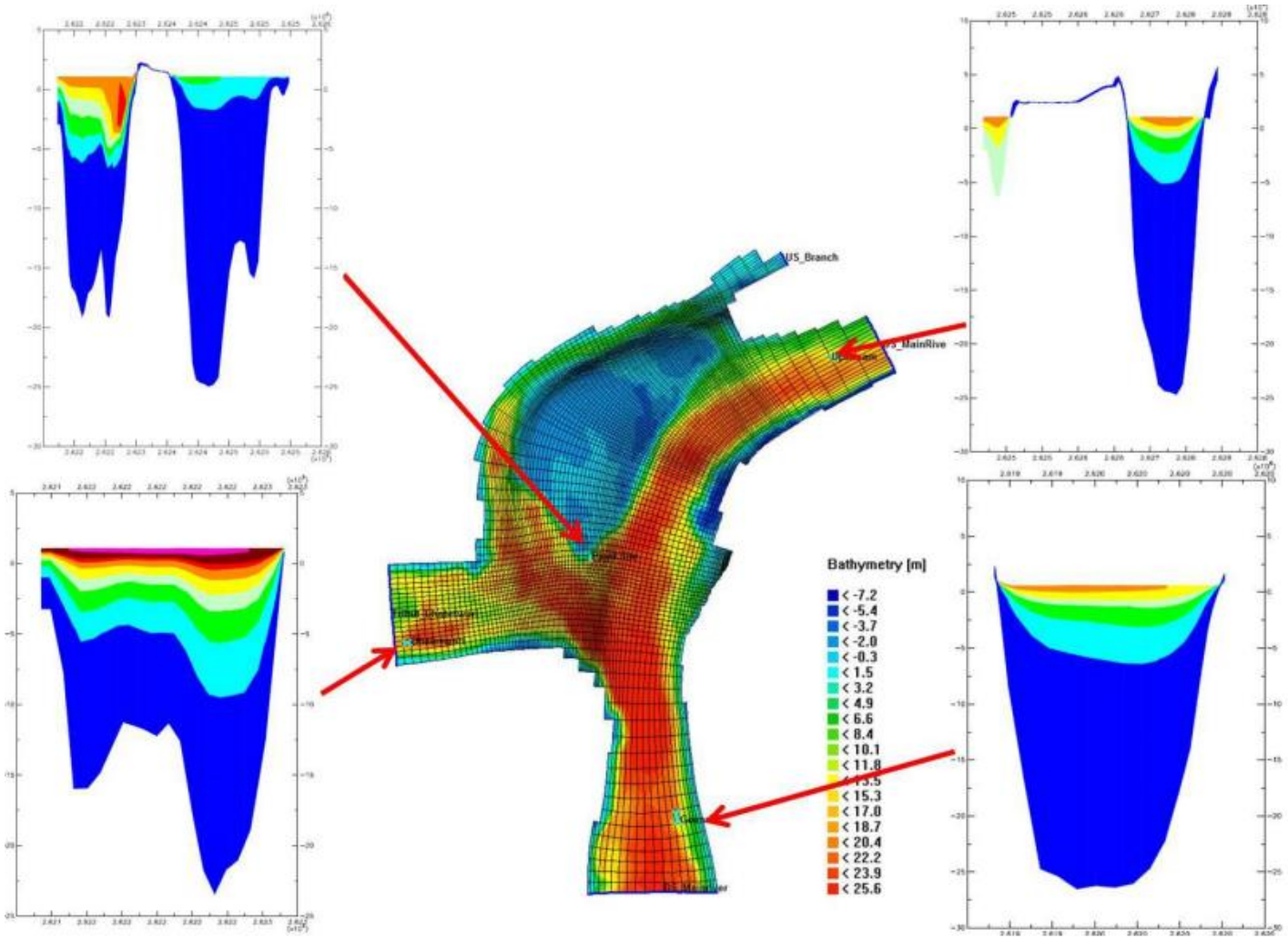
Evaluation of Thermal Plume across River Cross Sections

The rise in temperature across the river cross-sections has been undertaken at four locations one each along upstream of the Plant Site at Meghnaghat, at the Outfall location of the Plant, along the Dhaleswari River and downstream of Gozaria as shown in Figure below .

During flood tide, the temperature exceedence at the outfall location is confined to the area closer to the outfall and ranges from 0.8° to 1.5°C and extended up to adepth of 3.5m below the water surface. Temperature exceedence of more than 1.5°C is confined to 50m from the outfall and extended up to a depth of 3m from the water surface.

Based on the exceedence plots it is evident that the plume is localized around the outfall, along the branch of Meghna River near the outfall.The high temperature exceedence was noticed around the branch of Meghna River compared to the main river. The plume extends 500m from the outfall location to the eastern bank of the branch of Meghna River. The branch of Meghna River is constricted and shallower compared to the main river.

Figure 9-15: Overview of exceedence in Temperature



Conclusion

This study evaluated the impacts of the heated water discharged from the outfall to the Meghna River and Dhaleswari River. Temperature exceedence plots showedthat the plume is localized around the outfall. The heated water from the outfall has low impact on the main Meghna River. The plume extends 500m from the outfall location to the eastern bank of the branch of Meghna River and exceedence is in the order of 1°C. The cross-sectional views of temperature exceedences analysed showed the temperature exceedence is around 1.2°C at the outfall and extends up to a depth of about 3.0m from the water surface.

9.5.7 Impact on Aqautic Flora and Fauna

Aqautic Insect Fauna

The insect fauna recorded from each of the locations are Dragon fly nymph, Damsel fly nymph, Water strider, Midge, Flies, Ant, Caddisfly, Butterflies and Mosquitoes. Warmer water temperatures may influence dragonfly predation of larval amphibians by altering interactions among existing cooccurring species of the two taxa. However, the increase in temeperature will only limit upto 1.2°C which will have minimal impact on the species. The newt larvae spent less time in the warm patch if dragonfly nymphs are present.[15]

Mollusc fauna

The maximum temperature tolerance of native species lies in range of 24°C to 32°C. The increase in temperature will limit up to 500m in cross direction and will be upto 30°C, which can be tolerated by the species of Mollusces found in Meghna River.

Fisheries

Small Fishes

The pattern of movement and migration of riverine fishes and prawns is controlled by the seasonal flooding in the monsoon season. Fish movement and migration in the rivers are upstream and downstream during the greater part of the year and laterally out onto the indudated flood plains during the flood season. The fishes those are not strong enough to swim against the current but will be saved by the fish screen.

Mystuscavasius is a type of a cat fish which is a Least Concern Species as per IUCN, and this species inhabits a wide variety of freshwater habitats, although it is chiefly found in larger rivers, primarily with a sandy or muddy substrate.

[15] http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0065079

Glossogobius giuris is a bottom dweller, edible fish, a good sensitive indicator, spawning is intense during Septembers and distributed widely.

Puntiusconchonius is a least concerned species with thorugh out availability in all rivers of Bangladesh. *Channa punctatus* is a leat concerned species as per IUCN. However, heavy metals can accumulate in tissues of the fish and in turn affects its physiology.

Anabas testudineus is a column feeder and a larvicidal fish (feeds upon mosquito larvae) and hence used to control mosquito larvae. This is a migratory fish; migrate from one place to another during rainy season for spawning. Hence, it is to be ensured that intake structure shall not be built near any spawning area.

Macrobrachiumeqidense- This species is listed as least concerned species as per IUCN, No threats have been identified to the species.

Large Fishes

Labeo rohita (Rohu) is a least concerned species as per ICUN Classification. There will be minimum impact on this species as thermal discharge will have an impact on depth of 3m while Rohu thrives well in all fresh waters below an altitude of approximately 549 m. Rohu is a bottom feeder and prefers to feed on plant matter including decaying vegetation.

Catla catla (Katla) is a least concerned species as per ICUN Classification. As Catla is non-predatory and it's feeding is restricted to the surface and mid-waters, there will be minimal impact due to thermal discharge on the species.

Wallago Attu (Kalibuash) is a Near –Threatened Species as per IUCN Classification. Thermal discharge can impact morphological and haematological parameters of the fish. However, the discharge will be upto 500m from the outfall location to the eastern bank of the branch of Meghna River and exceedence is in the order of 1°C.

Mastacembelus armatus (Bain) is a least concerned species as per ICUN Classification. This species attains a length of 61 cm and more vulnerable to impact in closed water bodies.

Channa punctatus (Taki) is used as bioindicator of the river since it is the prevalent species. Several studies have reported alterations in blood glucose and tissue glycogen levels, protein and lipid profile of fishes.[16]

Tenulosa ilisha (Iish) is a least concerned species as per ICUN Classification which found in Meghna River. It is an anadromous fish species.

Phytoplanktons

[16] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4336452/

Aquatic flora including planktonic community is a good indicator of ecological health. The aquatic flora and planktonic community of the river (Spirogyra sp., Nostoc sp., Zygonema sp, Oedogonium sp., Pithophora sp., Anabena sp., Chlamydomonas sp., Cladophora sp., Cosmarium sp., Navicula sp., Eremosphera sp., Staurastrum sp., Dinobryon sp., Melosira sp., Nitzschia sp., Glenodinium sp., Chrooccus sp., , Gloeocapsa sp.) May be affected due to changes in water quality. The discharge cooling water transfers heat energy to the reciieving waters can inhibit their production process and biomass. However, the spread of discharge is only limited to 500m in cross sectional area and 3m in depth, a minimal impact is envisaged overall.

9.5.8 Solid Waste Disposal

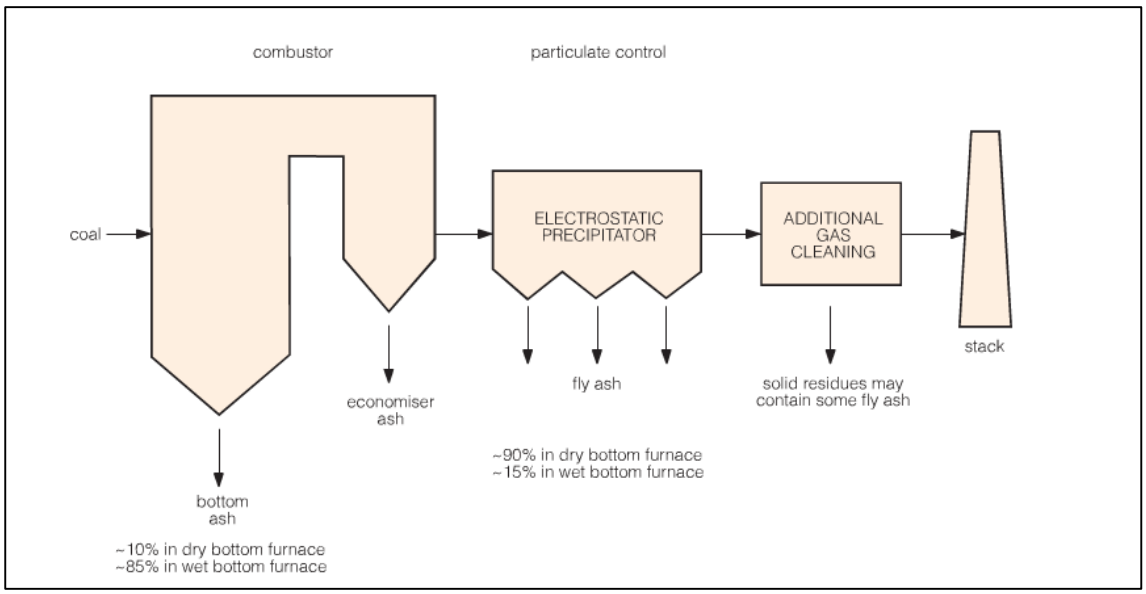
During the combustion of coal in the furnace, the inorganic material will be decomposed. Part of the non-combustible material is retained in the furnace as 'bottom ash' whereas majority of the inorganic material will be carried out of the furnace with the flue gases and will be collected downstream by Electro Static Precipitators (ESPs) as 'Fly Ash'. It is anticipated that about 90% of the residues will be collected as fly ash and 10% will be collected as bottom ash. The characteristics of ash are presented in Table 9-32.

Table 9-32: Coal Ash Characteristics

Ash Composition (Typical)	Range
SiO_2	39- 62.6
Al_2O_3	18 - 32
TiO_2	0.87 - 1.75
P_2O_5	0.15- 1.76
SO_3	0.3 - 4.85
Fe_2O_3	3.84- 12
CaO	0.57 - 11
MgO	0.23 - 3.14
Na_2O	0.12 - 2.38
K_2O	0.5 -3

Source: Desgin Book, Orion

Figure 9-16: Details of Ash Generation



Source: Clark, 1992

Pneumatic conveying system (either vacuum system or pressure system) will be employed for conveying of fly ash from the electrostatic precipitator hoppers in dry form. Dry ash will be collected and transported in dry form to storage silo for utilization. The bottom ash will be kept in a molten state in the boiler and will be collected in the ash hopper which contains quenching water. When the molten slag comes in contact with the quenching water, it fractures instantly, crystallizes, and forms pellets. The ash pellets will be then stored in an HDPE lined ash pond.

The dry ash will be taken to buffer hoppers for its onward transportation in dry form to storage silo near plant boundary for utilization. There are four cement plants located in the vicinity of the proposed plant and it is planned to tie up with the cement plants for sale of fly ash. 100 % utilisation of fly ash has been considered. The ash will be loaded to trucks through gravity flow for transport of fly ash to cement plants in the vicinity of the proposed power plant. In case the cement plant is located beyond 5-7 km of the plant boundary; the fly ash will be transported in covered barges. The ash will be loaded to the barge using an inclined chute with hot air. The details of the ash utilisation in cement plants have been presented in *Waste Management Plan.*

The options for utilisation of residue ash such as use in brick manufacturing, clinker industries, cement industries, compaction purposes are also being explored. At initial stage, the generated ash will be used in land development within the project area. However, ash dyke has been planned in case of non-utilization of ash.

9.5.9 Soil and Agriculture

The hazardous solid waste in the form of waste oil, spent ion exchange material and water pre-treatment clarifier sludge will be generated from the power plant. The waste oil will be collected in MS drums and stored on paved platforms with proper labelling. The waste will be sold to DoE

approved vendors. The sludge will be dried and sent for land-filling. Spent Ion exchange material will also be sent for land-filling.
The impacts on the soil quality due to the storage of fly ash, bottom ash and other waste streams have been assessed to be negligible.

The non-hazardous (solid) wastes from the proposed project are sludge from STP used to treat water from STP channel, sludge from ETP and the domestic solid waste from plant area (canteens), residential colony etc. The non-hazardous solid waste generation from project related units is estimated as the total sludge generated from pre-water treatment, DM water clarifier plant drains sludge after treatment will be used as manure for green belt area. The waste will be disposed off through DoE approved vendor.

The project areas of 130 acre that is acquired for project development will no longer be used for agricultural purposes. This land will be raised by 2 - 3m above the mean sea level. The operation of the project will not have any impact on agricultural land type of the locality.

9.5.10 Impact on Ground Water

As the project has been envisaged with plan of using surface water from the nearby Meghna River, there will be no impact of plant operation on groundwater level.

9.5.11 Impact due to Ash Disposal

The project operations will result in formation of fly ash and bottom ash. The fly ash will be collected in dry form from the ESP hopper and will be loaded to silos for storage using a pneumatic system. The fly ash will be then sold to cement plants and will be transported using trucks or barges. The bottom ash will be collected in molten state in the wet bottom slag boiler and will be taken to the ash pond. An ash disposal area shall be provided for the storage of humidified bottom and fly ash.

The fly ash handling operations will consist of a vacuum or pneumatic conveyance system which will be vented out through small fabric filters or other dust control devices. The fugitive PM emissions from these systems will therefore be minimal. Fugitive particulate emissions may occur during fly ash transfer operations from silos to trucks or barges. Hot air purging will be done to minimise these emissions. Humidifiers will be provided for storage of excess fly ash and the storage shall be equipped with water spray system for dust suppression. There shall be pumping station to removed excess rain water to water treatment system. Automatic dust detectors are also proposed in the ash disposal area.

9.5.12 Ecology (Flora and Fauna)

POTENTIAL IMPACTS

The impacts due to the project operations have been discussed under the following heads:

- Impact on Aquatic ecology

- Impact on terrestrial ecology

9.5.12.1 Aquatic ecology

The proposed project will result in discharge of once through cooling water after heat into the Meghna River. The maximum design temperature difference at the outlet of the cooling system is 8°C. The discharge of this high temperature water will result in a drop in the dissolved oxygen levels within a range of ~150m from the point of discharge. There is a possibility of accidental discharge of processed water, including wash waters and boiler blow down that may cause deterioration of fishery habitat. The probability of this impact is however very low as an automated monitoring and control system will be adopted.

The operation of the power plant and its related activities may not have any impact on fish migration and fish diversity. However, during intake of water, fish, particularly the smaller ones may be entrapped. The water intake structure will be provided with appropriate fish screens to prevent impingement and entrainment of fish by water intake. Despite, some fish and aquatic species, which cannot swim faster against the intake current, may get impinged and entrained by the water intake. Fish eggs and larva may get entrained by the intake water.

River habitat quality may deteriorate due to uncontrolled discharge of harmful effluents generated from washing of machineries or from leakages of machineries. The impact on the aquatic ecology due to the proposed project operation is anticipated to be minor.

9.5.12.2 Terrestrial Ecology

Potential impacts of project operation on terrestrial ecology include long-term air and noise pollution and disturbance generated by area lighting and traffic. Based on the limited faunal community and insignificant flora observed in the study area and the existing land use pattern of the surroundings, potential impacts to fauna from this source are ranked as insignificant. Fly ash to be generated from the coal burning shall be arrested by the 99.67% efficient ESP before dispersion through the stack. Also green belt development will act as a barrier to dispersion of flue gas (if any).

9.5.13 Impact on Occupational Health

The occupational health and safety risks associated with the project are as follows:

- **Non-ionizing radiation** - The proposed plant workers are susceptible to a higher exposure to electric and magnetic fields (EMF) than the general public due to working in proximity to electric power generators, equipment, and connecting high-voltage transmission lines.
- **Heat** - Occupational exposure to heat may occur during operation and maintenance of combustion units, pipes, and related hot equipment.
- **Noise** - Noise sources in combustion facilities include the turbine generators and auxiliaries; boilers and auxiliaries, such as pulverisers; diesel engines; fans and ductwork; pumps; compressors; condensers; precipitators, including rappers and plate vibrators; piping and valves; motors; transformers; circuit breakers; and cooling towers.

- **Confined spaces** - Specific areas for confined space entry may include coal ash containers, turbines, condensers, and cooling water towers.
- **Electrical hazards -** Energized equipment and power lines may pose electrical hazards for workers
- **Fire and explosion hazards** – Storage of fuel may lead to fire and explosion hazards
- **Chemical hazards** – The plant will utilize hazardous materials such as chlorine gas for treatment of cooling tower and boiler water.
- **Dust -** Dust from coal and ash loading/unloading areas, storage area, fugitive emissions during coal and ash conveyance. Dust may contain silica (associated with silicosis), arsenic (skin and lung cancer), coal dust (black lung), and other potentially harmful substances**.**

9.5.14 Impact on Public Health and Safety

Effective health management is necessary for preventing spread of communicable diseases among employees and within the adjoining community. Employees working in operation phase could be carriers of contagious diease which could lead to health problems in the community. Provision of safe and healthy workplace to employees ensuring safety of the public.

9.5.15 Socio-economic Environment

The potential positive impacts are expected to remain the same as those occurring during the construction phase and may be referred to in the previous section where they have been detailed out.

In addition, The Company's CSR initiatives and activities are expected to have begun by the time of advent of the power plant's operation phase. In accordance with the company's CSR policy and plan, and the needs of the community, the activities shall contribute to the overall development of the stakeholders.

POTENTIAL NEGATIVE IMPACTS

The potential negative impacts are expected to remain the same as those occurring during the construction phase and may be referred to in the previous section where they have been detailed out. In addition, there is likely to be a high risk to the surrounding community's health due to smoke emissions and fly ash deposits. The impact may manifest in the form of respiratory tract diseases, congestions and allergies. In addition, eye and skin ailments too may be caused due to emissions.

9.5.16 Impact on Tourism

The site is situated at a distance of about 5.3km from Dhaka–Chittagong Highway (N1) in south west direction. The site is located at an elevation of about 2-5m above mean sea level (amsl), with River Meghna and River Dhaleshwari flowing to its east and west borders respectively. No archeologically important monuments or ecologically sensitive zones are located within the study area. Thus, operation of the project (e.g. vehicle movement, equipment gathering etc) would not directly affect the any place of significant importance.

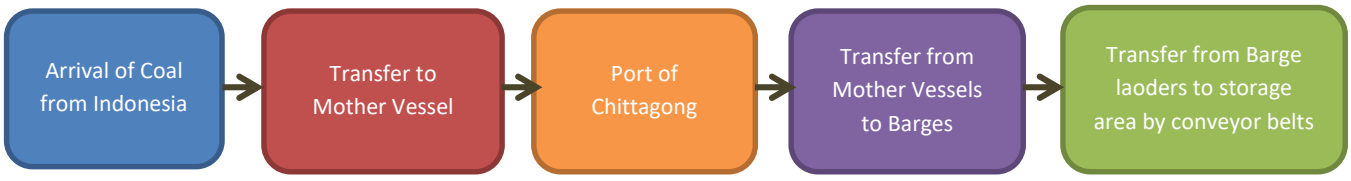
9.5.17 Impact due to transportation of primary fuels

During the operation phase, the traffic movement due to the Project will be considerably lower than the construction phase and not much traffic is expected as the major raw material i.e. coal will be supplied through a barges and lighters. Cumulative impact on traffic movement is anticipated during operation phase of both the projects due to movement of man and material.

The project operation will require transportation of LDO and HFO to the site. It is reported that Bangladesh Petroleum Corporation (BPC)/ supplier will supply the oil through its oil carrying ships at the site. The safety of transport of oil will be taken care by BPC/supplier. It follows all relevant environmental rules and safeguards for transportation of oil.

Coal Transportation Method

Delivery of coal to the plant will be undertaken through Mother Vessels which will arrive directly from Chittagong which is situated at a distance of 240km approximately in south east direction from the site and sail on the incoming tide directly to the plant wharf to fully discharge the cargo. The coal will be transported via Chandpur to the proposed site. This completely eliminates the need for any anchorage or transfer to Lighters. Direct transfer to site will also prevent spillage of coal into sea during transfer to lighter. The handling of the coal from the barges will be performed by barge loaders and transported to the storage area by conveyor belts. Desktop study conducted for coal transportation to the site has been attached as Annexure G.



Movement of vessel through international waters, offloading of coal at the anchorage point, unloading at the site and maintenance of the channel for navigation may result in the following environmental impacts:

- Disposal of sewage and other waste into coastal waters and international waters
- The transfer of coal at the anchorage point will be prone to spillageleading to contamination of water;
- Generation of dust during loading and unloading operations
- Increase in traffic will affect the overall traffic movement along the route leading to congestion and increase in potential for accidents.
- During dredging operation, water column may be contaminated due to spillage of oil, grease, machine oil, etc. Unplanned dredging may also cause erosion in some places.
- The proposed barging and shipping operations are considered unlikely to have any significant adverse impacts on river hydrology, sedimentation rates, or turbidity

9.5.18 Impact due to inherent mercury and heavy metal in Coal

Mercury is present in coal in tracr amounts. According to data collated by Commonwealth Scientific and Industrial Research Organization (CSIRO), mercury concentration in Australian export coal is in range of 0.01-0.08 mg/kg, 0.02 being the average concentration. The ash analysis of the coal has been presented above which depicts very low levels of mercury. Mercury oxidation depends on its chemical form in the vapour phase and mercury can range from a few percent to over 90% in flue gas. Mercury that is adsorbed onto solid surfaces, such as fly ash or unburned carbon, is the particulate-bound mercury that tends to be captured by particulate matter control device (Electrostatic Prepcipitator to achieve a minimum claimed efficiency of 99.67% to keep the particulate matter emission less than 50mg/Nm3). During combustion the mercury is released into the exhaust gas as elemental mercury vapor, Hg. The amount of mercury is flue gas is low as mercury also condenses in ash formed during coal combustion, which will be managed by fly ash handling system.

9.5.19 Impacts of Coal transportation, storage and handling

Ambient Air Quality

The unloading of coal, its conveyance and its storage will involve fugitive dust emissions. The fugitive emissions will depend on several factors such as coal properties including moisture content, particle shape and particle size distribution. Other influencing factors will include meteorological conditions such as wind speed and direction, solar radiation and rainfall and stockpile design and layout. the proposed project shall have efficient dust suppression systems, coal stockyard management and air quality management system to limit generation and dispersion of dust particle.

Ambient Noise Quality

Noise may be generated from operation of these large vessels from Chittagong to the proposed site. Similarly, coal unloading system and handling system may also generate noise.

Water Quality

Water column may be polluted due to oil spillage, coal spillage and other malpractice like waste discharge, discharge of ballast and bilge water, etc which are prohibited by IMO conventions and ECR 1997.

9.5.20 Cumulative Impacts

The study area constitutes some of the existing thermal power plants catering to the power requirement of Bangladesh. The cement industries can cause rise of SPM in the ambient air. The navigation activities e.g. ash import, clinker import, cement transportation, etc may cause moderate to minor impact on the surrounding environment. The existing thermal and cement plant are:

- The IEL Consortium and Associate Limited of Orion group have set up the 100 MW Meghna Ghat Heavy Fuel Oil (HFO) power Plant located at an aerial distance of about 5km from the project site in North-East direction, which is currently operational.
- 450 MW Gas-Fired Combined Cycle Power Plant which is located on the northern bank of the Meghna River owned by AES Meghna Ghat Limited.
- Dual fuel 337MW (net) power plant, currently under construction phase being developed by Summit Meghnaghat Power Company Limited (SMPCL).
- There are four major Cement Plants located in immediate vicinity to above mentioned three existing thermal power plants, at Meghna Ghat. These are namely Shah Cements, Holcim Cements, Basundhara Cements and Fresh Cements.

The baseline study undertaken for the proposed plant already captures the ambient air quality due to the presence of these existing industries in the vicinity of the proposed site. The concentration of suspended particulate matter across the locations where baseline monitoring is undertaken ranged from a minimum of 107µg/m^3 to a maximum of 589µg/m^3. The incremental concentrations emitting from stack of proposed plant is insignificant and its contribution to the ambient air shed will be negligible on installation of high efficiency Electrostatic Precipitators (with efficiency more than 99.67%)

10. Impact Evaluation

10.1 Impact Evaluation Criteria - Impact Significance

The criterion that has been used to evaluate impacts on various environmental and social components is as following:

Extent (Context)

The extent refers to spatial or geographical extent of impact due to Project activities. In this ESIA study, impacts have been classified as per the following extents:

- ***Very Local (very low spread)*** : when an impact is restricted within the foot prints of the Project components except for ecology;
- ***Local (low spread)*** : when an impact is restricted within the foot prints of the Project components and extends up to 2 km from the boundary of the Project components except for ecology;
- ***Medium (medium spread)*** : when an impact is spread up to 2-5 km from the footprint boundary of the Project components except for ecology; and
- ***Regional (high spread)***: when an impact spread extends beyond 5 km from footprint boundary of each of the Project components except for ecology.

The above extent has been selected based on the understanding of the Project and prevailing environmental and social baseline conditions. The Project relates to development of a coal based thermal power project situated on lands which were earlier used for agriculture and grazing purposes. There are no habitations within the Project site but there are communities living in the vicinity of the project.

Duration

The duration of impact indicates whether the impact would be short-term, medium-term or long-term. The impacts have been assessed considering the time taken by an environmental component to recover back to its best achievable pre-project state. For the proposed thermal power Project, impacts were classified based on their existence in temporal scale as follows:

- ***Short term* (*low duration*)**: When an impact is likely to be restricted for duration of less than 1 year. This is based on the understanding that there will be recovery of the affected environmental component within 2 years;
- ***Medium term (medium duration)***: When the impact duration is likely to be up to a period of three years. This will result in the recovery of the affected environmental component within 10 years; and
- ***Long term (high duration)***: When the impact is likely to last beyond three years, and will result in recovery of prevailing conditions in 10 years or more or upon decommissioning after Project life completion.

Magnitude (Intensity)

Indicators of the magnitude (intensity) of an impact, whether it is insignificant, minor, moderate, or major, was based on the following criteria adopted for the proposed thermal power Project:

- ***Insignificant intensity*** : when an impact results in changes in the environmental baseline conditions up to 20% in regional context/ 20-30% in medium context /up to 30% in local context but for a short duration of less than 1 year;
- ***Low intensity***: when an impact results in changes in the baseline conditions up to 20% in regional context /up to 30% in medium context/ more than 30% in local context. While for ecology, low intensity refers to minimal changes in the existing ecological baseline conditions in terms of their reproductive capacity, survival or habitat suitability;
- ***Moderate intensity***: when an impact results in changes in the baseline conditions for up to 30% in regional context / more than 30% in medium context. While for ecology, moderate intensity refers to changes that are expected to be recoverable in terms of medium duration of three years; and
- ***High intensity***: when the changes in the baseline conditions are beyond 30% in regional context. While for ecology, high intensity refers to changes those result in serious impairment to species, productivity or their habitat.

Type

The type of impact refers to whether the effect is considered beneficial or adverse. Beneficial impacts would improve resource conditions. Adverse impacts would deplete or negatively alter resources. Details regarding application of the above mentioned impact evaluation criteria are presented for each of the identified environmental impacts in this section of the report considering significance assessment matrix as given in Table 10-1.

Table 10-1: Impact Significance Criteria

Significance (for Adverse Impacts)	Extent	Duration	Magnitude	Significance (for Beneficial Impacts)
Insignificant	Very Local	Short	Low	
	Local	Short	Low	
Minor	Local	Short	Moderate	Minor
	Local	Medium	Low	
	Local	Medium	Moderate	
	Medium	Short	Low	
	Local	Long	Low	
Moderate	Local	Short	High	Moderate
	Local	Medium	High	
	Local	Long	Moderate	
	Medium	Short	Moderate	
	Medium	Medium	Low	
	Medium	Medium	Moderate	
	Medium	Long	Low	
	Medium	Long	Moderate	
	Regional	Short	Low	
	Regional	Short	Moderate	
	Regional	Medium	Low	
	Regional	Medium	Moderate	
	Regional	Long	Low	
Major	Local	Long	High	Major
	Medium	Short	High	
	Medium	Long	High	
	Regional	Short	High	
	Regional	Medium	High	

Significance (for Adverse Impacts)	Extent	Duration	Magnitude	Significance (for Beneficial Impacts)
	Regional	Long	Moderate	
	Regional	Low	Low	
	Regional	Low	High	

This evaluation will help the decision makers to take decision of issuing environmental clearance certificate and to take further policy initiatives. Table below presents the impact Evaluation during construction phase and operation phase.

Table 10-2: Impact Significance during Pre Construction and Construction Phase

Aspect	Scenario	Extent	Duration	Intensity	Type	Significance
Pre-Construction and Construction Phase						
Land Use	Without mitigation	Local	Long	Low	Adverse	Minor
	With mitigation	Local	Long	Low	Adverse	Minor
Significance of impact on land use with and without mitigation measures is expected to be minor.						
Natural resources and ecosystems	Without mitigation	Medium	Medium	Moderate	Adverse	Moderate
	With mitigation	Local	Medium	Low	Adverse	Minor
The geographical extent of impact on natural resources and ecosystems is expected to be local. The impact duration is perceived to be medium and intensity to be moderate. The intensity will be reduced to low with the implementation of the mitigation measures. The overall impact significance is expected to be minor with the implementation of mitigation measures.						
Site Preparation	Without mitigation	Medium	Medium	Moderate	Adverse	Moderate
	With mitigation	Local	Medium	Low	Adverse	Minor
Significance of impact on site preparation with and without mitigation measures is expected to be moderate and minor respectively.						
Soil Contamination	Without mitigation	Medium	Medium	High	Adverse	Moderate
	With mitigation	Local	Medium	Low	Adverse	Minor
Significance of impact on soil contamination with and without mitigation measures is expected to be moderate and minor respectively.						
Construction Wastes	Without mitigation	Medium	Medium	Moderate	Adverse	Moderate
	With mitigation	Medium	Medium	Low	Adverse	Minor
The geographical extent of potential for impact due to construction waste with the implementation of the mitigation plan is expected to be local, duration expected to be medium and intensity low, the overall impact will be reduced to being minor.						
Water Resources	Without mitigation	Medium	Long	Moderate	Adverse	Moderate
	With mitigation	Local	Long	Low	Adverse	Minor
The geographical extent of potential for impact on water resources and quality due to the construction phase is expected to be local, whereas duration is expected to be long and intensity to be moderate.						
Water Quality	Without mitigation	Local	Long	Moderate	Adverse	Moderate
	With mitigation	Local	Long	Low	Adverse	Minor
The implementation of the mitigation measures is expected to reduce them to low and the overall impact to be Minor.						
Ambient Air Quality	Without mitigation	Medium	Medium	Moderate	Adverse	Moderate
	With mitigation	Local	Medium	Low	Adverse	Minor

The potential for impact on air quality will be local for medium term with moderate intensity which with the implementation of mitigation measures will get reduced to low intensity. The overall impact on air quality is expected to be minor.						
Ambient Noise	Without mitigation	Medium	Medium	Moderate	Adverse	Moderate
	With mitigation	Local	Medium	Low	Adverse	Minor
The geographical extent of potential for impact on noise due to the construction phase of the project is expected to be local, duration is expected to be Medium and intensity low with the implementation of the mitigation measures, the overall impact on noise is expected to be minor.						
Traffic	Without mitigation	Local	Medium	Moderate	Adverse	Moderate
	With mitigation	Local	Medium	Low	Adverse	Minor
The geographical extent of potential for impact on traffic due to the construction phase of the project is expected to be local, duration expected to be medium and intensity low with the implementation of the mitigation measures, the overall impact on traffic is expected to be insignificant						
Ecology	Without mitigation	Medium	Medium	Moderate	Adverse	Moderate
	With mitigation	Local	Medium	Low	Adverse	Minor
The potential for impact on ecology will be local for medium term with moderate intensity, only because of dredging; however the overall impact on ecology with the implementation of mitigation measures is expected to be minor.						
Loss of land and livelihood	Without mitigation	Local	Long	High	Adverse	Major
	With mitigation	Local	Long	Medium	Adverse	Moderate
Significance of impact on loss of land and livelihood with and without mitigation measures is expected to be major and minor respectively.						
Community Health and Safety	Without mitigation	Local	Medium	High	Adverse	Moderate
	With mitigation	Local	Short	Medium	Adverse	Minor
Significance of impact on Community Health and Safety with and without mitigation measures is expected to be moderate and minor respectively.						
Obstructed access to essential amenities and common property resources	Without mitigation	Local	Medium	Medium	Adverse	Moderate
	With mitigation	Local	Short	Medium	Adverse	Minor
Significance of impact on obstructed access to essential amenities and common property resources with and without mitigation measures is expected to be moderate and minor respectively.						
Strain on Existing public Utilities	Without mitigation	Local	Medium	Medium	Adverse	Moderate
	With mitigation	Local	Short	Medium	Adverse	Minor
Significance of impact on Strain on Existing public Utilities with and without mitigation measures is expected to be moderate and minor respectively.						
Communal Harmony	Without mitigation	Local	Medium	Medium	Adverse	Moderate
	With mitigation	Local	Short	Medium	Adverse	Minor
Significance of impact on Communal Harmony with and without mitigation measures is expected to be moderate and minor respectively.						
Occupational Health & Safety	Without mitigation	Local	Medium	Moderate	Adverse	Moderate
	With mitigation	Local	Medium	Low	Adverse	Minor
Significance of impact on occupational Health & Safety with and without mitigation measures is expected to be moderate and minor respectively.						

Source: Assessment of Impacts, AECOM

Table 10-3: Impact Significance during Operation Phase

Aspect	Scenario	Extent	Duration	Intensity	Type	Significance
Operation Phase						
Ambient Air Quality	Without mitigation	Regional	Long	Moderate	Adverse	Major
	With mitigation	Medium	Long	Low	Adverse	Moderate
The potential for impact on ambient air quality with the implementation of mitigation measures will be at local level for long term duration, with low intensity and the overall impact on air quality is expected to be of moderate significance.						
Water Resource	Without mitigation	Regional	Long	Moderate	Adverse	Major
	With mitigation	Medium	Long	Low	Adverse	Minor
Water Quality	Without mitigation	Medium	Long	Moderate	Adverse	Major
	With mitigation	Local	Long	Moderate	Adverse	Minor
The potential for impact on surface water resource and quality is major however with the implementation of mitigation measures it will have a low spread with long term duration and moderate intensity.						
Ambient Noise Quality	Without mitigation	Local	Long	Moderate	Adverse	Moderate
	With mitigation	Local	Long	Low	Adverse	Minor
The potential for impact on noise quality with implementation of mitigation measures is expected to be local spread with long term duration, low intensity and minor significance.						
Soil and Land	Without mitigation	Medium	Long	High	Adverse	Moderate
	With mitigation	Local	Long	Low	Adverse	Minor
Significance of impact on soil and land with and without mitigation measures is expected to be moderate and minor respectively.						
Ecology	Without mitigation	Medium	Long	Moderate	Adverse	Moderate
	With mitigation	Local	Long	Low	Adverse	Minor
The development of 30% of the area under greenbelt will help improve ecology and will have positive impact on ecology of the area, however, there is potential for emissions which will have some adverse impact. The potential for impact on ecology with the implementation of mitigation measures will be medium spread, long duration, low intensity and minor significance.						
Occupational Health and Safety	Without mitigation	Medium	Long	Moderate	Adverse	Moderate
	With mitigation	Local	Long	Low	Adverse	Minor
Significance of impact on Occupational Health and Safety with and without mitigation measures is expected to be moderate and minor respectively.						
Public Health & Safety	Without mitigation	Medium	Long	Moderate	Adverse	Moderate
	With mitigation	Local	Long	Low	Adverse	Minor
Significance of impact on Public Health & Safety with and without mitigation measures is expected to be moderate and minor respectively.						
Ash Disposal	Without mitigation	Local	Medium	Moderate	Adverse	Moderate
	With mitigation	Local	Medium	Low	Adverse	Minor
Significance of impact on Ash Disposal with and without mitigation measures is expected to be moderate and minor respectively.						
Soil and Agriculture	Without mitigation	Medium	Long	Moderate	Adverse	Moderate
	With mitigation	Local	Long	Low	Adverse	Minor
Significance of impact on Soil and Agriculture with and without mitigation measures is expected to be moderate and minor respectively.						
Solid Waste Disposal	Without mitigation	Medium	Long	Moderate	Adverse	Moderate
	With mitigation	Local	Long	Low	Adverse	Minor

Significance of impact on Solid Waste Disposal with and without mitigation measures is expected to be moderate and minor respectively.						
Socio- Economic Environment	Without mitigation	Local	Long	Medium	Adverse	Moderate
	With mitigation	Local	Medium	Medium	Adverse	Minor
Significance of impact on Socio- Economic Environment with and without mitigation measures is expected to be moderate and minor respectively.						
Tourism	Without mitigation	Local	Medium	Low	Adverse	Minor
	With mitigation	Local	Medium	Low	Adverse	Minor
Significance of impact on Tourism with and without mitigation measures is expected to be moderate and minor respectively.						
Transportation of primary fuels	Without mitigation	Medium	Long	Moderate	Adverse	Moderate
	With mitigation	Local	Long	Low	Adverse	Minor
Significance of impact on Transportation of primary fuels with and without mitigation measures is expected to be moderate and minor respectively.						
Inherent mercury and heavy metal in Coal	Without mitigation	Medium	Long	Moderate	Adverse	Moderate
	With mitigation	Local	Long	Low	Adverse	Minor
Significance of impact on Inherent mercury and heavy metal in Coal with and without mitigation measures is expected to be moderate and minor respectively.						
Coal Transportation, storage and handling	Without mitigation	Medium	Long	Moderate	Adverse	Moderate
	With mitigation	Local	Long	Low	Adverse	Minor
Significance of impact on Coal Transportation, storage and handling and heavy metal in Coal with and without mitigation measures is expected to be moderate and minor respectively.						

11. Mitigation of Impacts

This section describes mitigation measures to be adopted for the impacts identified through this study that were evaluated considering their nature, spatial and temporal extent, reversibility, and consequences.

Mitigation measure required for limiting the negative impacts of the project activities and measures required for reducing risk of accidental hazard and enhancement measures for enhancing positive impacts with the aim of sustainable implementation and operation of the project ensuring environmental and community safety.

Mitigation measures devised have also covered the following topics as per Approved TOR recieived from DOE.

- Changing project layout, transport routes, disposal routes or locations, timings or engineering design-
    - Transport routes have been discussed in section 11.1.7 , 11.2.8 and 11.2.10 of the report;
    - Disposal and managmement of ash disposal has been presented in section 11.2.4 of the report; and
    - Elements of engineering design have to be incporated in desgining waste water treatment during operation phase of the plant and pollution control equiments to manage air emissions.

- Introducing pollution controls, waste treatment, phased impelementation and construction, engineering measures, monitoring, landscaping, social services or public education-

    - Pollution control equipments like low NoX burner, ESP etc has been devised and detailed in section 11.2.3 of the report;
    - Treatment of waste water has been explained in section 11.2.2 od the report;
    - OPDL-2 has proposed to develop green belt on 34% of the land procured for the proposed power plant;
    - A environmental and social monitoring plan has been proposed in chapter 14 of the report; and
    - Development of education in project area has been proposed as a part of CSR activiites for OPDL-2.

- Rehabilitation, compensation to restore, relocate or provision of concession for damage-
    - OPDL-2 should ensure that all compensation is paid to the land contributors as mutually agreed upon and within the stipulated time. It should also ensure that the compensation money/ land cost is provided in the joint names of spouses in a bank account, and ensured that the compensation money is reinvested in land or some source of livelihood measure; and
    - There are no Rehabilitation and resettlement issues associated with the site.

11.1 Pre-Construction and Construction Phase

11.1.1 Land USe

The agricultural lands in the Project area are low lying in nature and remain submerged throughout the monsoon which destroys the crops grown on them. Hence, the local communities are not economically dependent on these lands and the land use of the site has mostly changed to grazing. Thus, the impact magnitude due to land use change will not be high.

No major mitigation measure is required except to ensure that the Project maintains more than 30% of the area under green cover to offset some adverse impact of land use change and merge with the surrounding rural settings.

General facilities for staff, workers and construction labour shall be made available within the Project premises to minimise large scale induced change of land use in the surrounding area. The Project shall provide such spaces with the site for shops for daily requirements and engage local community for running the same.

11.1.2 Natural Resources

OPDL-2 shall ensure that the following mitigation measures are implemented to minimise impact on land use, topography, landscape and drainage of the project site and surrounding region:

- Land surface contours shall be restored in relation to the surroundings. It shall be followed by developing drains and providing adequate slopes across the project site prior to start of construction work thereby ensuring adequate cross drainage for quick evacuation of catchment water;
- All excavated soil and dredged material shall be utilised for filling up the low lying area;
- Dredged material shall be tested for its chemical characteristics to avoid contamination of land and surface water;
- Diversion dykes shall be constructed to channel surface runoff to the Meghna river;
- Topography and drainage of all areas, under the direct control of Construction Contractor, and affected by the establishment of power plant or other area shall be restored immediately after the activity culminates;
- It shall be ensured that construction footprint is well defined and construction work is carried out within the Project footprints only;
- It shall be ensured that adequate cross drainage is provided along the proposed road to prevent localised flooding.

11.1.3 Soil Quality & Construction Wastes

11.1.3.1 Site Preparation

The mitigation measures proposed to minimise impacts on soil quality due to site preparation include the following:

- Site backfilling, grading and excavation for foundation shall be undertaken mainly during dry season;
- It shall be ensured stacking of excavated soil material is done in an earmarked area and care shall be taken to prevent soil erosion;
- It shall be ensured that retention wall or bund is provided around the storage areas for excavated soil and other construction material in order to arrest the flow of solid with storm water in case of rain;
- Attempts shall be made to use the excavated soil at the earliest for filling low lying areas at the site for raising the ground level as planned;
- It shall be ensured that Project site is properly fenced and project activities including receipt and storage of construction material are kept within the Project footprint;
- No piling of construction material shall be permitted outside project site;
- Proper routing and adequate capacity of the storm water run-offs drains with catch pits shall be ensured;
- Completed earthworks shall be sealed and/or re-vegetated as soon as reasonably practicable with the help of landscape expert;
- Impervious surfaces for refuelling areas and other fluid transfer areas shall be used in order to prevent percolation of oil in soil due to accidental spills;
- Training shall be provided to workers regarding correct transfer and handling of fuels and chemicals and the response to spills;

11.1.3.2 Soil contamination due to handling of lube oil, chemicals etc.

The mitigation measures proposed to minimise impacts on soil quality due to soil contamination include the following:

- It shall be ensured that storage facilities are designed within paved (impervious) surface, provided with covered shed and adequate containment facility at the construction site to prevent contamination of soil or water bodies due to accidental spills of lubricating oil, fuel oil, paints, thinner, varnishes, chemicals etc. The storage facilities must be marked properly.;
- Proper storage for machine oil, used oil and grease in order to avoid any soil contamination shall be ensured by providing adequate secondary containment;
- Portable spill containment and toolkit with clean-up equipment shall be provided on site. Workers shall be provided adequate training in equipment deployment and handling;
- Assessment of contents of hazardous materials and petroleum-based products in building systems (e.g. PCB containing electrical equipment such as transformers, asbestos-containing building materials), and process equipment shall be ensured.
- Hazardous material containing products shall be procured along with Material Safety Data Sheet (MSDS) which is provided by the product manufacturer.
- Proper onsite waste management shall be provided. Decontaminate or properly manage contaminated building materials.
- Dredge material used for landfill shall be tested for its chemical characteristics and pollution potential prior to use.

11.1.3.3 Handling, Storage and Disposal of Wastes

The mitigation measures worked out to minimise impacts on soil quality due to handling, storage and disposal of wastes include the following:

- Workers shall be strictly instructed to refrain from random disposal of any waste generated from the construction activities;
- Storage facilities designed with adequate containment facility at the construction site shall be provided to prevent contamination of soil due to potential spills of lubricating oil, fuel oil and chemicals;
- Suitable fire protection measures shall be made available onsite before commencement of construction activities. Fire protection system shall be designed to suppress any fires from spillage or storage of flammable substances;
- Waste management priorities based on an understanding of potential Environmental, Health, and Safety (EHS) risks shall be identified. A waste management hierarchy that considers prevention, reduction, reuse, recovery, recycling, removal and finally disposal of wastes shall be established for managing wastes generated. Generation of waste materials shall be avoided or minimized as far as practicable;
- Solid wastes shall be segregated on the basis of biodegradable and non-biodegradable contents. Biodegradable wastes like kitchen waste shall be collected for secondary use such as animal feed or for vermi-composting. Other biodegradable wastes shall be collected and disposed off in onsite humus pits for subsequent use as manure. OPDL-2 must ensure that no open air incineration/burning of solid waste is practiced;
- Construction wastes from site, wharf, road corridors such as metal cuttings debris, plastic packing material, wooden logs etc. shall be segregated and kept in specially identified and properly marked waste bins. All metal scrap shall be sold while concrete waste/debris and other inert materials that cannot be recycled shall be crushed and reused for level raising onsite or in road/pavement construction within the site; and
- Hazardous wastes including used oil, waste oil and residue containing oil or other hazardous substances shall be stored at a designated place with proper markings onsite for disposal through authorized vendors/ recyclers in Bangladesh.

11.1.4 Water Resources & Quality

11.1.4.1 Water Resource

- Rainwater harvesting system shall be provided prior to onset of monsoon for effective recharge of groundwater during rainy season;
- Proper storage and internal supply facilities shall be developed before undertaking construction activities;
- Construction workers shall be trained for optimal use of water to be ensured ; and
- Location for diversion of water shall be identified in order to avoid any conflict with existing users.

11.1.4.2 Water Quality

- To minimise adverse impacts due to escape/discharge of untreated sewage outside the project site, adequate number of toilets (at least 8 toilets per 100 labourers) with septic tanks and lined soak pit arrangements to be provided onsite for disposal of sewage as per the design specified for area with high water level.

- Random disposal of wastewater by workers in the labour colonies shall be strictly prohibited. OPDL-2 shall ensure that adequate number of drains and collection sumps for recharge of water from bathing system at the labour colonies are provided.
- Provision of potable drinking water for the labourer engaged in the Project shall be ensured. The Project is to ensure use of disinfectants (chlorine tablets or sodium hypochlorite dozing in drinking water bulk storage tanks onsite to render water fit for drinking. Wherever possible, reverse osmosis cum ultraviolet water treatment system shall be installed for rendering water fit for drinking purposes;
- Bunds around excavated soil or loose construction material shall be provided to prevent runoff to nearby water bodies;
- Storage area shall be kept away from the storm water drain/water bodies to prevent any runoff into water bodies outside the facility;
- All the debris resulting from construction activities shall be removed from the site on a regular basis to prevent their runoff.
- Segregation and pre-treatment of oil and grease containing effluents from workshop (e.g. use of a grease trap) prior to discharge into water bodies shall be practised;
- Sludge from sanitary wastewater treatment systems shall be disposed in compliance with local regulatory requirements.

11.1.5 Ambient Air Quality

The impacts on air quality will be minimized through mitigation measures to be included in the construction contract, requiring contractors to strictly implement them. The mitigation measures include the following:

- Suppression of fugitive dust emissions shall be ensured by implementing the following measures
  - Water sprinkling at the construction site ;
  - Wetting of the stockpile;
  - Proper location of material stockpiles (especially sand and soil) downwind from the habitations ;
  - Screening of or providing wind breaks for stockpiles; and
  - Covering trucks transporting soil and material at the site with tarpaulin sheets.
- OPDL-2 shall ensure usage of low-emission vehicles and electrically powered construction equipment wherever feasible ;
- Power supply for construction shall be sourced from the grid supply. Therefore, use of generators is expected to be limited;
- It shall be ensured that diesel generators meant for emergency power are optimally operated and regularly maintained so as to ensure that emissions from fuel combustion remain at design levels. Provision of appropriate stack height shall be ensured;
- Dust generating activities shall be avoided in conditions of high wind (particularly during summer season) and covers shall be provided for loose construction material at construction site;
- Vehicle movement within site shall be restricted to a speed less than 20 km/hour at site to minimize potential for dust generation in the surroundings;

- An equipment maintenance register shall be kept to ensure that construction equipments are maintained at regular intervals in order to minimise smoke and particulates in the exhaust emissions;
- It shall be ensured that machinery is turned off when not in operation;
- Housekeeping of the area shall be maintained by deputing sweepers to remove dirt/debris from the floors/ sites on daily basis;
- Paint, polishes, building fittings and flooring material etc. shall be procured carefully to minimize emission of VOCs; and
- Regardless of the size or type of vessel, fleet owners /operators shall implement the manufacturer recommended engine maintenance programs.

11.1.6 Ambient Noise Quality

The following mitigation measures are proposed for minimizing impacts due to increased noise levels in surrounding areas:

- Loud, sudden noises shall be avoided wherever possible. Fixed noise sources to be located away more than 50m away from site boundary wherever possible;
- Noise control measures such as acoustic enclosures, noise barriers in areas of high noise generating sources, and movement of vehicles during night time shall be implemented;
- Integral noise shielding shall be used where practicable and fixed noise sources to be acoustically treated, for example with silencers, acoustic louvers and enclosures;
- OPDL-2 or the construction contractor shall ensure that workers wear ear muffs/plugs in areas with potential for high noise generation; and
- Mobile noise sources such as cranes, earth moving equipment and HGVs shall be routed in such a way that there is minimum disturbance to receptors;
- Use of inherently quiet plant and equipment as far as reasonably practicable and regular maintenance to ensure noise emissions are maintained at design levels;
- All diesel generators to be installed in conformance with acoustic enclosure to achieve the 75 dB(A) level at 1 m from its enclosure;
- Provision of rubber paddings/noise isolators at equipment/machinery used for construction;
- Noise prone activities need to be restricted to the extent possible during night particularly during 2200 to 0600 hours to reduce the noise impact. There is also requirement of providing make shift noise barriers surrounding the of high noise generating construction equipment;
- Breaking of surfaces, if any to be done using the lightest possible weight of breaker capable of doing the job without extending its duration.
- Major construction works to be limited to daylight working hours to avoid noise exposure during night time;
- Construction vehicles to be well maintained and not idling equipment or vehicles when not in use; and regular maintenance of company vehicles would be taken up.
- Plan construction activities in consultation with local communities to minimise disturbance.

11.1.7 Traffic and Transport

The movement of traffic arriving at the site needs to be properly managed so as to cause minimum problems to the community and the water bodies. Necessary instructions shall be given to the construction contractors for:

- Close consultation with community when unloading of construction machinery and material will obstruct ferry movement for requirement of local community ;
- Providing dedicated location along the site for exclusive loading and unloading of the construction vessels;
- Necessary training to the ferry operators of construction vessels to ensure safe operations;
- Developing Code of Practice for construction which will include management of traffic for construction phase;
- All vessels engaged for construction shall be maintained at regular intervals to prevent leaks of oil;
- Explore the possibility of safely transporting construction machinery and material after daytime.

11.1.8 Ecology

- Follow up of measures to control silt/sediments during construction phase and ensure that no contaminants or loose soil is disposed into nearby water bodies.
- Dredging activities are undertaken frequently in the Meghna River, predominantly for land filling for industries along the banks and for navigation. The bottom topography is frequently and therefore significant impact on benthic communities is not envisaged. The activities proposed are short term and will leave residual impact due to turbidity.
- Noise levels due to construction activities shall be kept to a minimum;
- Movement of labour shall be restricted;
- The construction contractors shall ensure that fuel for resident workers are procured from legal sources and provided free of cost.

11.1.9 Socio- Economic Environment

- OPDL-2 should ensure that all compensation is paid to the land contributors as mutually agreed upon and within the stipulated time. It should also ensure that the compensation money/ land cost is provided in the joint names of spouses in a bank account, and ensured that the compensation money is reinvested in land or some source of livelihood measure.
- OPDL-2 should provide special assistance to the vulnerable groups in the form of livelihood restoration measures. The vulnerable groups could include marginal land contributors and Sharecroppers who have cropped on the procured land, up to 6 months prior to its procurement,
- The company management should ensure that stakeholder engagement is initiated right from inception of the project. In this ambit, an information disclosure meeting should be held from time to time to keep the public informed and apprised of the project components, impacts and time schedule. In addition, any misconceptions should be negated and concerns must be discussed by the management in sincerity.

- To ensure good health of its labour, OPDL-2 must provide for their periodic medical evaluation. In addition, all employees must be screened for common infectious diseases as per government or WHO protocol.
- The labourers may be provided with health promotion strategies and basic information on transmission of common infectious diseases. Where in needed, the company should collaborate with the local health department and provide measures to prevent or contain and outbreak of diseases.
- OPDL-2 must ensure that all important routes and passages used by the community are unaffected at all times. If an when a temporary blockage is anticipated, the community must be informed prior to its blockage, signage put up and an alternate route provided. In addition, at no juncture must an important community resource such as a mosque, tube wells etc. be affected without the community's prior consent.
- Strain on public utilities can be avoided by anticipating them well in advance and providing a supplementary source to keep them replenished.
- A two member stakeholder engagement team should be formed with the responsibility of handling community correspondence, rapport building with community members, engagement exercises and information disclosures.
- The community must be informed of all major developments prior to each development in the plant, through notices and announcements.
- To avoid any communal discord, all sections of the community, except the economically weak, must be provided with equal preference where in CSR measures and employment is concerned.

11.1.10 Occupational Health and Safety

- The construction staff and contractors involved in the construction activities shall be trained about the mandatory precaution and safety practices through OHS programmes prior to commencement of construction activity;
- Construction contractors are required to ensure necessary safety measures to be taken up before and during the construction activities for all electrically driven machinery;
- Usage of high speed diesel (HSD) shall be provided with proper storage in covered area, away from welding or other construction activities using flameproof electrical connection in and near the HSD storage;
- Vehicle movements to follow the traffic norms and maintain a safe speed while moving through the hilly tracts;
- Personal Protective Equipments (PPEs) e.g., helmets, safety belts, welding masks, shock resistant rubber gloves, shoes, other necessary protective gear etc. should be provided to workers handling welding, electricity and related components.
- Safety harness and other fall protection measures shall be ensured for workers while working at height;
- Periodic inspection of PPE should be done to ensure that they are in proper condition. A register for keeping records of such inspection shall be maintained.
- Loading and unloading operation of equipment should be done under the supervision of a trained professional
- All excavation activities to be conducted in supervision of the site contractor;
- Proper signage to be provided in places of excavated areas;

- The design of the power plant to ensure sufficient safety margins to reduce the risk from wind and seismic activities;
- Fire extinguishing equipment should be provided in adequate number on site to handle any possible fire outbreaks;
- Effective work permit system for hot work, electrical work, working at height shall be ensured;
- An accident reporting and monitoring record should be maintained. The objective shall be to minimize such occurrences in the future and attain zero accidents.

11.2 Operation Phase

11.2.1 Air Environment

The following mitigation measures will be adopted to minimise the impact on the air environment:

11.2.1.1 Coal Handling, Transportation and Storage/Coal Preparation/Ash Handling and Storage

- As described earlier, wet control dust suppression will be provided for the coal unloading area to reduce the fugitive dust emissions;
- Automatic dust detectors will be provided in the coal yard and in case the dust level exceeds beyond a threshold value, water sprinkling will be carried out;
- All transfer points shall be provided with dry fog dust suppression system
- The loading and unloading equipment shall be used with a minimized height of drop to the stockpile to reduce the generation of fugitive dust;
- Dust extraction and dust handling systems shall be installed to reduce fugitive dust emissions. The coal dust extraction system shall be designed to suck the dust laden air from the confined areas such as screening and belt feeders and at transfer points;
- There shall be independent dust extraction system for each unit;
- Coal stockpiles shall be mechanically compacted to minimise air ingress and the potential for auto-ignition and loss of volatiles;
- Use of water suppression for control of loose materials on paved or unpaved road surfaces;
- Wind fences may be provided in open areas of coal storage; the coal storage area may be fenced with a 3-4m high wall;
- Fugitive dust will be further controlled by developing green belt along the periphery of the proposed power plant.

11.2.1.2 Fuel Combustion

- OPDL-2 to ensure use of dry low NOx type coal burners of proven, advanced design to reduce NOx emissions;
- OPDL-2 shall explore options to reduce SO_2 emissions, through selection of coal with low sulphur content, better than the design coal of 0.6%.
- Provision of space for Flue Gas Desulfurization system (FGD) shall be provided in the plant area. If coal having more than 0.38% sulphur is imported, FGD will be installed and operated to meet the ground level SO_2 concentration requirements of IFC.

- Ensure the proper functioning of electrostatic precipitators to achieve a minimum claimed efficiency of 99.67% to keep the particulate matter emission less than 50mg/Nm^3. The flue gas to be exhausted at 275 m height;
- Potential for flue gas conditioning through controlled injection of small quantities of sulphur trioxide into the flue gas stream for reducing the resistivity of the fly ash and permitting its collection in the existing precipitator shall be explored.
- An automatic emissions monitoring system to be installed on the stack to measure emissions of SO_2, NOx, particulate matter and CO_2;
- Ambient air quality monitoring stations to be installed within the project site to obtain such measurable parameters, while periodic air quality monitoring using high/low volume samplers to be conducted at other locations;
- Install instruments to record meteorological data such as wind speed, direction, solar radiation, relative humidity and temperature shall be established so that operating power plant can record these parameters on regular interval.

11.2.1.3 Greenhouse Gas Emissions

The proposed plant is based on ultra-supercritical technology which has high thermal efficiency, thereby reducing greenhouse gases emissions per unit of output. It is recognized that carbon capture readiness for a project is a proactive measure in the direction of contributing to minimize carbon foot print from the coal based power plant. This would facilitate actions as soon as the reliable Carbon Dioxide separation technology and a suitable storage option become commercially viable.

The technology of post combustion carbon capture is under development and may be available soon. OPDL-2 shall ensure sufficient space for installing carbon capture equipment in future. Provided the technology is commercially viable, the necessary electricity and steam supplies for the carbon capture system can be made available.

The project shall install CO_2 monitor and analyse CO_2 equivalent emission from its power generating units once the Project achieves commercial operation date (COD).

11.2.2 Water Resources and Quality

The following mitigation measures will be adopted:

11.2.2.1 Water Abstraction

- Records will be maintained to monitor the quantity of water being used
- Efforts shall be made to ensure that reuse of process water is carried out to reduce the net water requirement

11.2.2.2 Wastewater and Runoff Management

- Appropriate treatment shall be provided to the process effluents and runoffs prior to discharge into the River;
- Treated water effluent (about 15 m^3/hr) shall be mixed with the cooling to dilute the concentration of the treated effluents;
- The quality of treated effluent shall be monitored before discharge into Meghna River

- Records of water being discharged into the River shall be maintained.
- Wastewater having light density fine suspended particles from different areas as well as other effluents such as boiler blow down, DM plant regeneration effluent will be neutralized and collected in a collection basin. The basin will be sized to contain minimum 24 hours storm water runoff from two most recent consecutive rainfall events and will be designed not to have a normal discharge. Total effluent collected shall be treated in clarification plant.
- Treated sewage shall comply with the IFC prescribed standards.
- OPDL-2 shall ensure that the metals such as chromium and zinc (if any) from chemical additives used to control scaling and corrosion in cooling towers are eliminated. Also the minimum required quantities of chlorinated biocides in place of brominated biocides will be used or intermittent shock dosing of chlorine to be alternatively applied as opposed to continuous low level feed.
- Storm water runoff drainage network will be developed to direct runoff from roof drains and other areas to the collection basins or to natural drainage, as appropriate. The collection basins will be designed to contain general site drainage, neutralization basin flows, oil/water separator flows, service water system flows and septic tank.
- Offsite runoff entering the site from surrounding areas will be routed around the site area through the use of overland flow, open channel flow, and underground piping or a garland drain around the site.

11.2.2.3 Fuel Loading and Unloading Operations

- OPDL-2 to ensure that no dumping of ballast water, oil spillage or discharge of waste water is carried out by the vessels transporting coal and fuel oil for the proposed plant.
- The vessel speed, river flow and erosion shall be monitored in accretion prone areas.
- Maintenance dredging shall be minimised to the extent possible.
- Regular monitoring shall be carried out during maintenance dredging.

11.2.2.4 Thermal Discharge

Temperature exceedence plots showed that the plume is localized around the outfall. The heated water from the outfall has low impact on the main Meghna River. However, Thermal discharges should be designed to prevent negative impacts to the receiving water taking into account the following criteria:

- The elevated temperature areas because of thermal discharge from the project should not impair the integrity of the water body as a whole or endanger sensitive areas (such as recreational areas, breeding grounds, or areas with sensitive biota);
- Adjustment of the discharge temperature, flow, outfall location, and outfall design to minimize impacts to acceptable level (i.e., extend length of discharge channel before reaching the surface water body for pre-cooling or change location of discharge point to minimize the elevated temperature areas); and
- Use of multi-port diffusers;
- Cold water inlet channel and outlet channel shall be designed in such a way that they can handle all cooling water flow and river levels without any overflow. The inlet and outlet channel banks shall be High Flood Level (HFL) + 1 m, i.e. 5.7 m. The design of the cooling

water channels shall consider no limitations to operation of the cooling water system even at the Design Low Tide level. The maximum allowable water velocity shall be 1 m/s.

11.2.3 Ambient Noise Levels

The mitigation measures proposed to minimise impacts on ambient noise due to operation phase of proposed plant includes the following:

- Workplace noise sampling including personal noise monitoring which identifies which employees are at risk from hazardous levels of noise;
- Provision of sound-insulated control rooms with noise levels below 60 dBA ;
- Design of generators to meet applicable occupational noise levels;
- Identification and marking high noise areas and require that personal noise protecting gear is used all the time when working in such high noise areas (typically areas with noise levels >75 dBA);
- Compulsory use of personnel protective equipment (PPE) such as ear plugs for the workers;
- Provision of insulating caps and aids at the exit of noise source on the machinery;
- Use of physical barriers and green belt development around the plant to restrict the noise from going outside the proposed plant boundary during operation; and
- Provision of training and information that ensures the workers are aware of the hazard from excessive noise exposures and how to properly use the protective equipment that has been provided;

11.2.3.1 Vibrations

The following mitigation measures will be adopted:

- The applicable DoE standards of acoustic environment with spatial and temporal basis shall be complied with;
- The steam turbine generators shall be housed in closed buildings to reduce noise transmission;
- Acoustic enclosures, hoods, laggings and screens shall be provided at all high noise generating areas;
- Noise insulation shall be implemented surrounding the turbine and generator casing;
- Noise dumper/insulator shall be installed around the casing of conveyor belt;
- Provision of silencers at high noise generating utility equipment and erecting suitable enclosures to minimise the impact of high noise generating sources;
- Ear plugs shall be provided to the personnel working in high noise area;
- Provision of green belt covering 30% of the project site including landscaping all along the periphery of the project site for further attenuation of noise levels;
- Selecting equipment with lower sound power levels;
- Installing suitable mufflers on engine exhausts and compressor components and acoustic barriers without gaps in order to minimize the transmission of sound;
- Limiting the hours of operation for specific pieces of equipment or operations, especially mobile sources operating through community areas;
- Siting permanent facilities away from community areas if possible;

- All vehicles and engines of vessels shall be switched off / throttle down when not in use;
- Noise monitoring to be carried out for the purposes of establishing the existing ambient noise levels. Noise levels to meet the stipulated standards specified;

11.2.4 Soil Quality

The following mitigation measures will be adopted:

- Fly ash (dry form) generated from the plant should be separated after burning of coal through ESP and commercially utilized to maximum extent possible;
- Increase the facilities of ash marketing through infrastructure development, creating awareness and formulating policies;
- The hazardous waste such as spent oil as well as non-hazardous wastes shall be disposed off to DoE authorised vendors only.

11.2.5 Ecology

The following mitigation measures will be adopted:

11.2.5.1 Aquatic Ecology

- The water supply pipeline intake point from the feeder canal shall be provided with sufficient screening to filter out larger aquatic organisms (e.g., fish, frogs, and toads) and foreign matter, preventing them from being drawn into the pumps;
- Drum screens shall be provided in order to limit the entrainment of fish in the cooling water system and intake velocities should be as low as possible (preferably less than 0.5 m/s during normal conditions);
- Spot-check of shipping and barging activities by relevant agencies shall be carried out.

11.2.5.2 Terrestrial Ecology

- Green areas shall be developed in about one-third of the entire project area.
- Project shall implement a multi-layered peripheral green belt as part of the environmental management plan. Plant species native to the area will be selected, avoiding monoculture and the introduction of alien plant species to the maximum possible extent. This will provide habitats for wildlife especially for the small reptilian and mammalian fauna and birds.
- Heterogeneous tree species shall be selected and planted considering soil and climate adaptability, flowering, growth characteristics, canopy structure, and tolerance of pollution.
- A nursery shall be established to support the afforestation program. Local forest nurseries shall also be relied upon to supply saplings of some plant species.
- Implementation of noise control measures shall be done to minimize disturbance to the fauna and avifauna of the area.

11.2.6 Occupational and Public Health and Safety

Following mitigation measures have been suggested for minimizing work related health and safety impacts on workers.

- Identification of potential exposure levels in the workplace during working activities;
- Regular inspection and maintenance of pressure vessels and piping shall be carried out
- Adequate ventilation shall be provided in work areas to reduce heat and humidity;
- Time required for work in elevated temperature environments will be reduced and access to drinking water will be ensured;
- Shielding surfaces where workers come in close contact with hot equipment, including generating equipment, pipes etc. shall be done;
- Warning signs near high temperature surfaces and personal protective equipment (PPE) as appropriate, including insulated gloves and shoes shall be provided;
- Provision of sound-insulated control rooms with noise levels below 60 dB.;
- Design of generators to meet applicable occupational noise levels;
- Identifying and designating high noise areas to ensure that personal noise protecting gear is used by workers all the time when working in such high noise areas (typically areas with noise levels >85 dBA);
- Deactivation and proper grounding of live power equipment and distribution lines according to applicable legislation and guidelines whenever possible before work is performed on or proximal to them;
- Provision of specialized electrical safety training to those workers working with or around exposed components of electric circuits. This training should include, but not be limited to, training in basic electrical theory, proper safe work procedures, hazard awareness and identification, proper use of PPE, proper lockout/tag out procedures, first aid including CPR and proper rescue procedures. Provisions should be made for periodic refresher training as necessary.
- Use of automated combustion and safety controls and proper maintenance of boiler safety controls;
- Implementation of start up and shutdown procedures to minimize the risk of suspending hot coal particles (e.g., in the pulverizer, mill, and cyclone) during startup;
- Regular cleaning of the facility to prevent accumulation of coal dust (e.g., on floors, ledges, beams, and equipment);
- Removal of hot spots from the coal stockpile (caused by spontaneous combustion) and spread until cooled and ensure that loading of hot coal into the pulverized fuel system is not carried out;
- Use of automated systems such as temperature gauges or carbon monoxide sensors to survey solid fuel storage areas to detect fires caused by self-ignition and to identify risk points.
- Dust extraction and dust handling systems shall be installed to reduce fugitive dust emissions.

11.2.7 Socio-economic Environment

- Mitigation measures to adverse impacts that are common with the construction stage, may be referred to in the previous section.

- To catch respiratory and skin ailments before they become aggravated, a mobile medical unit can screen the villagers for any signs of smoke emissions related symptoms fortnightly. Medical assistance can also be made a part of the company's CSR contribution to the community.
- The community must be kept informed of emergency procedures and protocol in case of an accident in the plant and in case of increased emissions from the. Project operations.
- Vulnerable groups and gender issues may be provided a special focus in the CSR plans, to contribute towards their upliftment.
- The community must be informed of all major developments prior to each development in the plant, through notices and announcements.

11.2.8 Transportation of Primary Fuels

The following measures shall be put in place to control impact from traffic:

- All international vessels supplying coal to the plant shall follow the guidelines of Marpol for disposal of sewage and garbage.
- The contract pertaining to supply of all type of fuels shall mention the responsibility of supplier for safe transportation and compliance to national and international requirements pertaining to environment.
- The Plant will require one vessel arriving every 5.1 days to discharge 25,000 mt each trip, however the frequency will increase to 2.5 days during pre monsoon for stocking and once every two weeks immediately after post monsoon. Thus the traffic volume in the river will not increase significantly.
- The power plant complex will have well planned road network and walkways with proper signage e.g. speed limits, etc.

11.2.9 Inherent Heavy Metals in Coal

Heavy metals like arsenic, cadmium, vanadium, nickel, etc may be emitted in smaller quantities, but may have a significant influence on the environment due to their toxicity and/or persistence. Removal of mercury can be achieved by installation of electrostatic precipitator (ESP) along with powdered activated carbon which will act as a sorbent in flue gas. Fly ash to be efficiently managed to control the emission of heavy metals in the environment. Ash handling system has been detailed in section 5.4.6 of the report.

11.2.10 Coal Transportation, Storage and Handling

Following mitigation measures have been suggested for Coal transportation, storage and handling from Chittagong to the proposed site. These are:

- All transfer points shall be provided with dry fog dust suppression system;
- Water used in coal dust suppression is usually recirculated and eventually added to coal going either into a transport vehicle or to an end-use point;

- The loading and unloading equipment shall be used with a minimized height of drop to the stockpile to reduce the generation of fugitive dust;
- Ensure no dumping of ballast water, no oil spillage, no discharge of waste water, no waste dumping in Meghna River or any other water body;
- Limiting dropping of coal and escapee during unloading to feeder vessel/lighter vessel;
- Monitoring activities of the Foreign ships during coal transportation; and
- All vessels should comply with rules and regulation of IMO, Port authority, BIWTA and national laws of safety, and environmental conservations.