Nutan Bidyut Bangladesh Limited (NBBL)

Cumulative Impact Assessment on Air Quality and Ambient Noise: Burhanuddin, Bhola, Bangladesh

Final Report

18 September 2019

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Cumulative Impact Assessment on Air Quality and Ambient Noise: Burhanuddin, Bhola, Bangladesh

Final Report

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Acronyms and Abbreviations

Name	Description
AERMOD	AMS/EPA Regulatory Model for Air Dispersion
AOI	Area of Influence
AQS	Air Quality Standard
BPDB	Bangladesh Power Development Board
CCPP	Combined Cycle Power Plant
CEM	Continuous Emission Monitoring
CO	Carbon Monoxide
DEM	Digital Elevation Model
ECR	Environmental Conservation Rules
EHS	Environment, Health and Safety
ERM	ERM India Private Limited
ESIA	Environmental and Social Impact Assessment
GOB	Government of Bangladesh
HRSG	Heat Recovery Steam Generator
HSD	High Speed Diesel
IFC	International Finance Corporation
MSL	Mean Sea Level
NBBL	Nutan Bidyut (Bangladesh) Limited
NOx	Oxides of Nitrogen
PM_{10}	Particulate Matter with aerodynamic diameter of 10 micron or less
SO_2	Sulphur Dioxide
SRTM	Shuttle Radar Topography Mission

1. INTRODUCTION

ERM India Private Limited (ERM) was commissioned by Nutan Bidyut (Bangladesh) Limited (hereinafter referred to as 'Client' or 'NBBL') to conduct a Cumulative Impact Assessment on air quality and ambient noise due to operation of three power plants within a study area of 5 km radial zone of its under-construction project

1.1 Background and Objective

NBBL is constructing a 225 MW dual fuel fired combined cycle power plant (CCPP) at Kutba Union of Burhanuddin Upazilla in Bhola District of Bangladesh. Adjacent to site, there is a 225 MW gas based CCPP of Bangladesh Power Development Board (BPDB), which is operational since 2015. Cumulative impact on air quality due to BPDB and NBBL projects during operation phase was assessed during the environmental and social impact assessment (ESIA) study of NBBL project in 2016. In 2017, another gas-based power plant of about 100 MW (gas engine based) was commissioned by Aggreko adjacent to the site and is operational since March 2018[1]. Since NBBL project is still under construction, the lenders to the project has asked for a cumulative impact assessment including new project of Aggreko within the same airshed.

1.2 Scope of Work

The scope of work includes prediction of ambient air quality and ambient noise levels due to operation of NBBL, BPDB and Aggreko power plants and assessment on cumulative impacts (air and noise based) due to operation of all three plants on sensitive receptors and providing a mitigation/ management plan for identified impacts.

1.3 Limitations

1.3.1 Scope of Activity

This report is based upon the application of engineering principles and professional judgements to certain facts with resultant subjective interpretations. Professional judgements expressed herein are based on the currently available facts within the limits of the existing data, scope of work, budget and schedule. We make no warranties, express or implied, including, without limitation, warranties as to merchantability or fitness for a particular purpose. In addition, the information provided to the Client in this report is not to be construed as legal advice.

1.3.2 Limitations of use of this report

ERM is not engaged in such studies and reporting for the purposes of advertising, sales promotion, or endorsement of any Client's interests, including raising investment capital, recommending investment decisions, or other publicity purposes. Client acknowledges that this report has been prepared for the exclusive use of the Client and agrees that ERM's reports or correspondence will not be used or reproduced in full or in part for such purposes and may not be used or relied upon in any prospectus or offering circular. Client also agrees that none of its advertising, sales promotion, or other publicity matter containing information obtained from this assessment and report will mention or imply the name of ERM.

Nothing contained in this report shall be construed as a warranty or affirmation by ERM that site and property described in the report are suitable collateral for any loan or that acquisition of such property by any lender through foreclosure proceedings or otherwise will not expose the lender to potential liability.

[1] http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=151&Itemid=118

1.3.3 Data

The emission data from BPDB and NBBL project has been considered same as that was considered during the ESIA study and provided by NBBL, whereas for Aggreko plant, input data from secondary sources has been taken into consideration, without any verification of the same.[2] [3] [4] [5] [6] [7] [8] [9]

1.4 Structure of Report

The remainder of the report is structures as follows:

Section 2: The Project

Section 3: Cumulative Air Quality Impact Assessment

Section 4: Cumulative Noise Impact Assessment

[2] https://www.daily-sun.com/arcprint/details/198112/2017/01/13/Aggreko-wants-relocation-of-its-Ashuganj-rental-plant/2017-01-13

[3] https://www.adb.org/sites/default/files/project-document/175732/42378-017-eia-02.pdf

[4] http://www.daily-sun.com/home/printnews/198112

[5] http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=151&Itemid=118

[6] http://www.cumminspower.com.br/pdf/gas/leanburn/s-1552.pdf

[7] http://www.cumminspower.com.br/pdf/gas/leanburn/s-1552.pdf

[8] http://documents.worldbank.org/curated/en/542701468180550114/Bangladesh-Ghorashal-Unit-4-Repowering-Project-environmental-impact-assessment-study

[9] https://www.aggreko.com/en-gb/products/generator-rental/generators/gas-generators/gas-generator-1375-kva

2. THE PROJECT

2.1 Site and Surroundings

The Project site of NBBL is sited in Bhola Island, beside BPDB's existing power plant (Bhola-I CCPP), in Bhola district. The Bhola District is the largest offshore island region in Bangladesh. The island is bounded by the Bay of Bengal to the south, Meghna River and Shahbazpur channel to the north and east, and Tentulia River to the west. The Project site is situated in Burhanuddin Upazilla of Bhola District, which is approximately 28 km south from the Bhola Town. The location of the Project site is shown in ***Figure 2.1***. A new power plant of approximately 100 MW capacity of Aggreko is located in the south-east direction of BPDB power plant. Dehular canal makes the western and south-western boundary of the power hub.

2.2 The Power Projects

As mentioned earlier, the power hub consists of three power plants, 2 operational and one under construction. Brief information about these projects is presented in ***Table 2.1***. A map showing all three power projects and their surrounding features is presented in ***Figure 2.2***.

Table 2.1: The power projects

Project	Capacity	Type	Fuel	Status
BPDB – (Bhola I)	225 MW	Combined Cycle Power Plant	Natural Gas	Operational since July 2015[10]
NBBL – (Bhola-II)	225 MW	Combined Cycle Power Plant	Natural Gas and HSD	COD by December 2019
Aggreko – (Bhola-III)	95 MW	Engine based Power Plant	Natural Gas	Operational since March 2018[11]

Bhola-I and Bhola-II are combined cycle power plants with 2+2+1 configuration (i.e. 2 gas turbines, 2 HRSGs and 1 steam turbine), whereas Bhola-III is having 120 engines of about 1000 KVA capacity each. In order to assess the cumulative impacts of the power hub on air quality and ambient noise levels, key air emission and noise generating sources have been considered in this study.

[10] http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=151&Itemid=118
[11] http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=151&Itemid=118

Figure 2.1: Location Map

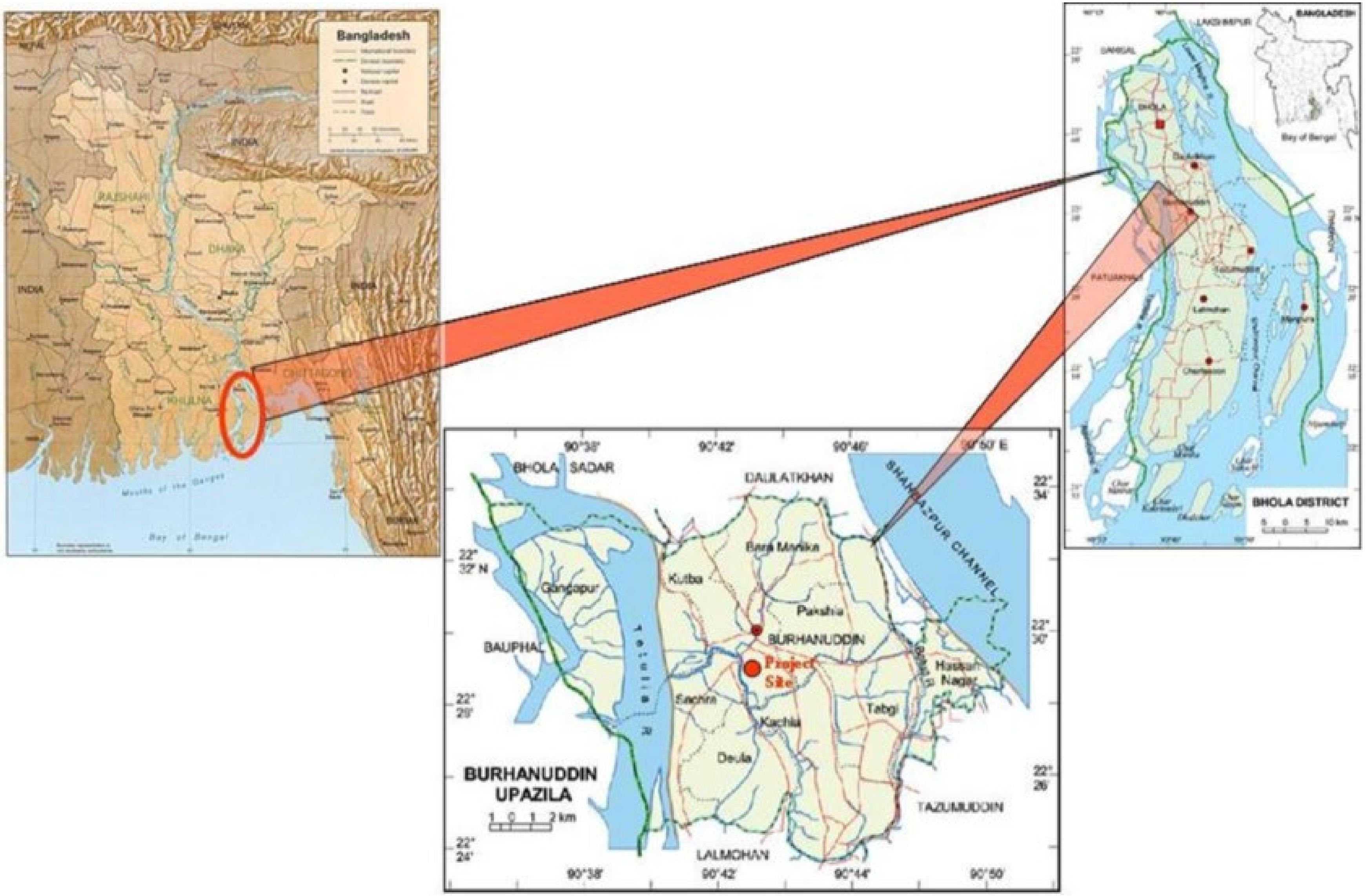
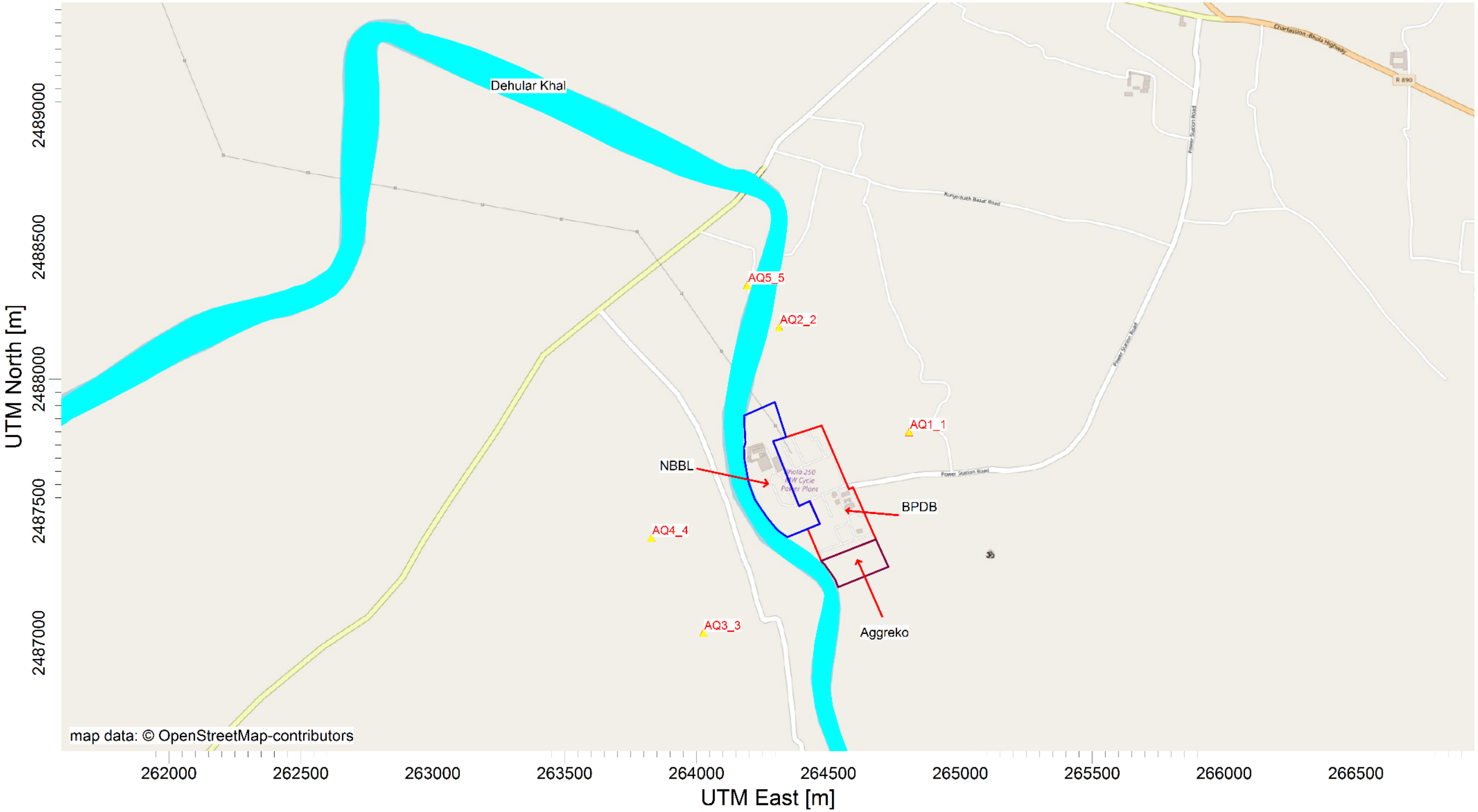


Figure 2.2 Map showing Power Plants and Surroundings



3. CUMULAIVE AIR QUALITY IMPACT ASSESSMENT

Cumulative impact on air quality due to operation of three power projects within the power hub has been studies by using air dispersion modelling software. Details of model and input data used in the modelling study along with results are presented in the subsequent sections.

3.1 Air Dispersion Model

3.1.1 AERMOD

Cumulative air quality impacts due to the operation of three plants were assessed by modelling projected emission rates using the AMS/EPA Regulatory Model (AERMOD). AERMOD is a modelling system consisting of three separate modules: AERMET, AERMAP and AERMOD. AERMET is a meteorological pre-processor and uses hourly surface observations, cloud cover, and upper air parameters from twice-daily vertical sampling of the atmosphere to create two output files consisting of surface and vertical profile data, respectively. The terrain pre-processor AERMAP uses DEM maps as well as user generated receptor grids. AERMAP's output file consists of the x, y locations of each receptor, mean sea level (MSL) elevation and hill profile parameters. The hill profile parameter is used in determining plume flow around elevated terrain. In this study AERMOD View 9.6.5 model has been used.

3.1.2 Model Options

The AERMOD model was run with the following regulatory default options in this assessment:

- Stack-tip downwash;
- Elevated terrain effects;
- Use of calms processing routine;
- Use of missing data processing routine; and
- No exponential decay

The area surrounding the power hub is having scattered rural settlements in the surroundings. Based on this, the Project site and its surroundings have been considered as rural area, and therefore, the rural dispersion coefficient was used in the Model.

3.2 Inputs used in Modelling Study

3.2.1 Meteorological Data

The input meteorological data for the AERMOD was generated using the MM5 model, which was downscaled to fine grid data suitable for modelling. The data used in the study was site specific and was collected over one year period (2015). In all there were 8760 hours of meteorological data used in the model. This quantity of data allows an adequate assessment of hourly, 8-hourly, daily and annual average pollutant concentrations around the Project site. The upper air data was also collected from MM5 model, which calculates the boundary layer based on surface characteristics (albedo, Bowen ratio, surface roughness), turbulence using met processor AERMET. Hourly average meteorological data has been used in the model and no 3-month rolling average data has not been used as model input. Annual windrose diagram of the site is presented in ***Figure 3.1***.

3.2.2 Terrain Data

Terrain data for the AERMAP model were taken from the 30 m SRTM database, while land cover data was sourced from satellite imagery of the Project site and its surroundings. Topographic map generated using SRTM data has been presented in ***Figure 3.2***.

Figure 3.1: Annual Wind Rose Diagram

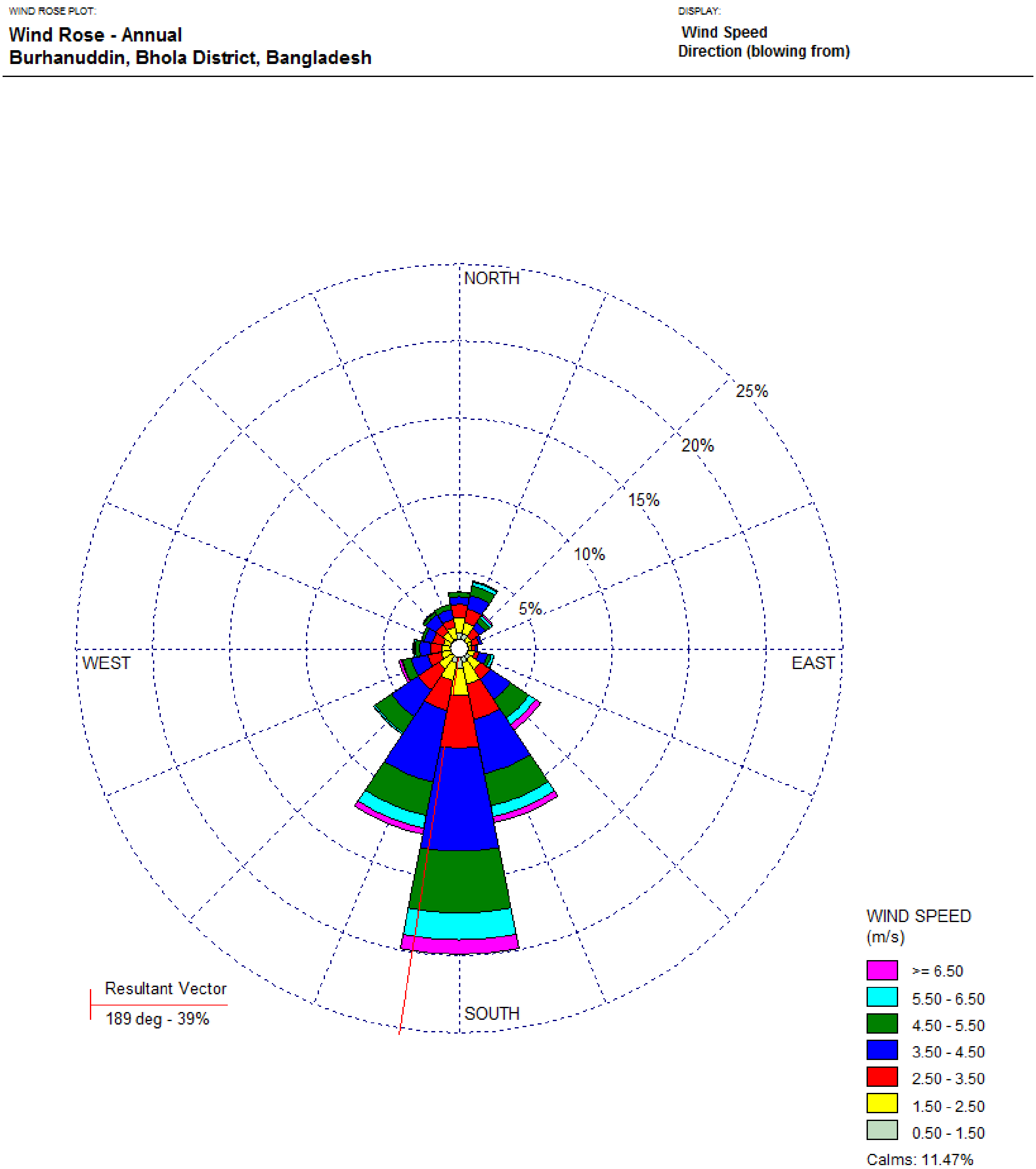
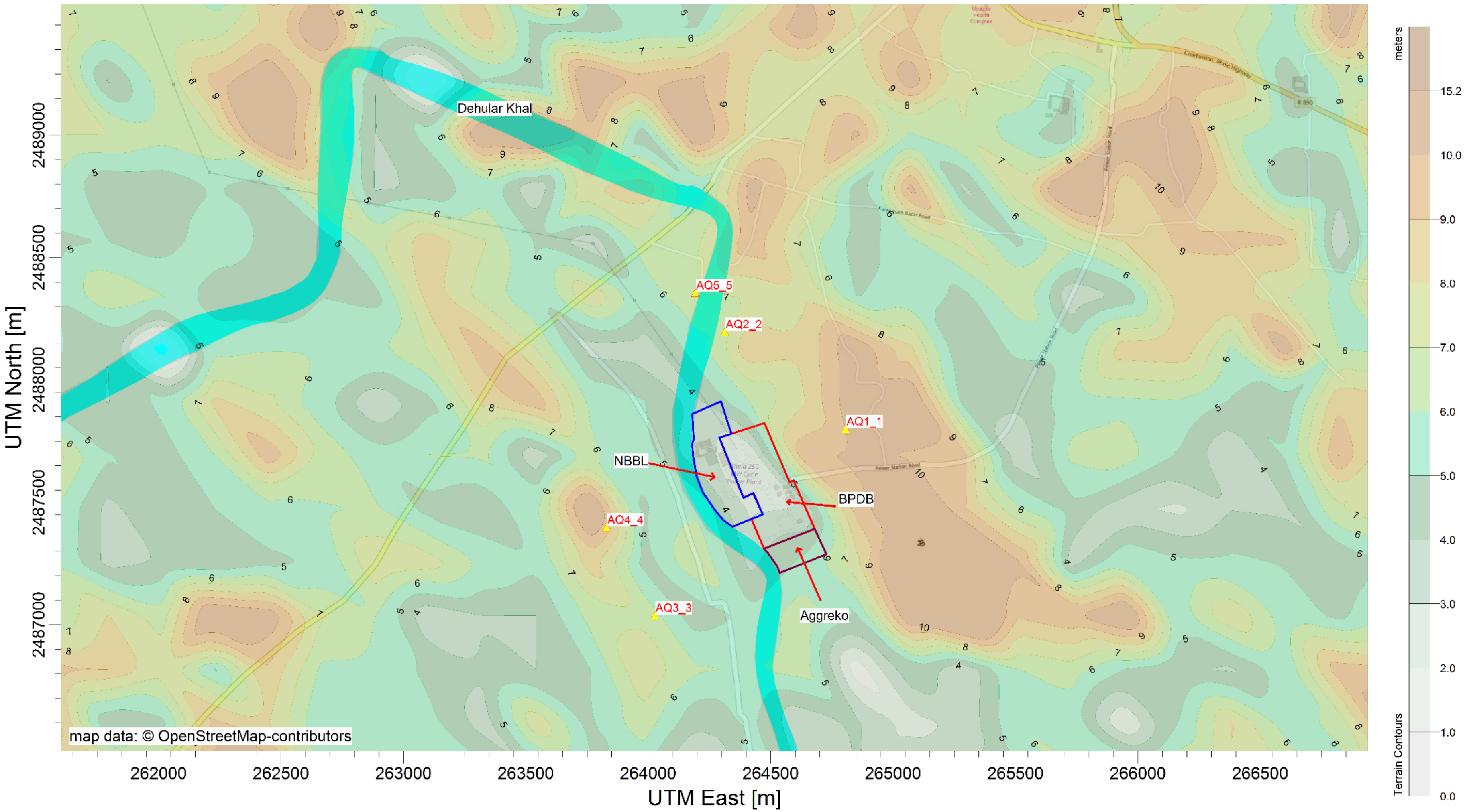


Figure 3.2 Topographic Map of Study Area



3.2.3 Emission Sources

The three projects within power hub 2 main stacks each from combined cycle operation of BPDB and NBBL project and 96 stacks of Aggreko power plant (assuming each engine is having separate stack). Fuel characteristics of natural gas and HSD, as provided in the DPR of NBBL project are presented in **Table 3.1** and **Table 3.2**, respectively.

Table 3.1 Natural Gas Specification

Constituent	Minimum Percent by Volume	Maximum Percent by Volume
Methane	85	100
Ethane	0	6
Propane	0	5
Butane-N	0	3
Pentane-N	0	2
Hydrogen Sulphide	0	0
Carbon Dioxide	0	2
Nitrogen	0	3
Oxygen	0	1
Inert (the total combined Nitrogen, Oxygen, Carbon dioxide and any other inert compound)	0	5

Source: (DPR, 2016)

Table 3.2 Fuel Oil Specification

Test	Method	Limit
Density at 15 °C,Kg/L	ASTM D 1298	Min. 0.820 Max. 0.870
Colour, ASTM	ASTM D 1500	Max. 3.0
Neutralization Value: Strong Acid No, mg KOH/gm Total Acid No, mg KOH/gm	 ASTM D 664 ASTM D 974	 Nil Max. 0.2
Ash , % mass	ASTM D 482	Max. 0.01
Carbon Residue (Conradson) On 10% bottom, % wt	ASTM D 189	Max. 0.2
Cetane Number	ASTM D 613	Min. 45
Cetane Index Calculated)	ASTM D 976	Min. 45
Pour point, °C	ASTM D 97	Max. 9 (Winter)** Max.12 (Summer)**
Copper Strip Corrosion (3 hours at 100 °C)	ASTM D 130	Max. No. 1
Flash point, PM(cc) / Abel,°C	ASTM D 93/ IP 170	Min. 32
Kinematic viscosity at 38 °C,cst	ASTM D 445	Max. 9.0
Sulphur total, % mass	ASTM D 4294	Max. 0.25
Sediment, % mass	ASTM D 473	Max.-0.01
Water content, % vol.	ASTM D 95	Max. 0.1
Distillation: 90 % vol. recovery, °C	ASTM D 86	Max. 375

Note: Winter shall be the period from November to February (both months inclusive) and rest of the months of the year shall be deemed as Summer.

Source: (DPR, 2016)

Based on information made available during the ESIA study of NBBL project for BPDB and NBBL projects. Furthermore, as no data was readily available from operational Agreeko power plant within the power hub, available information in public domain for other Aggreko power plant were used for emission estimation. Stack details along with emission rates for each source are presented in ***Table 3.4***. Total 124 point sources (i.e. stacks) have been considered in this study. A three-dimensional view of emission sources within power hub is presented in ***Figure 3.4***.

3.2.4 Receptors

The receptor grid or network, defined the locations of predicted ground level concentrations (GLCs) used to assess compliance with the relevant standards or guidelines. The following comprehensive fine and coarse receptor network was used for this analysis:

- 100 m spaced receptors from the project boundary up to 10 km; and
- Cartesian receptors (5 nos.) located within the study area, where baseline monitoring was carried out during the study period.

This network used Cartesian (X, Y) receptors with UTM coordinates. Base elevation of all the receptors were found using terrain elevations interpolated from SRTM (~30 m) Digital Elevation Model (DEM) data. The discrete Cartesian receptor locations are shown in ***Figure 3.2*** and details have been presented in ***Table 3.3***. The Cartesian receptor locations have been selected based on the annual windrose pattern. Two locations were selected in downwind direction and two locations were selected in cross-wind directions, whereas one location was selected in upwind direction.

Table 3.3 Monitoring Locations with respect to the Project

S. No.	Monitoring location	UTM Co-ordinates* (m)			Direction from Project Area	Distance from Power Complex Boundary (m)
		Easting	Northing	Elevation		
1	AQ1	264806	2487799	11.0	E	320
2	AQ2	264313	2488197	5.0	N	300
3	AQ3	264026	2487038	5.0	SW	500
4	AQ4	263829	2487398	9.1	W	450
5	AQ5	264192	2488356	7.3	N	500

* UTM Zone - 46

Table 3.4 Summary of Emission from separate stacks of power plants within power complex

Plant	Fuel	Stack	Stack Height from ground (m)	Stack Internal Diameter (m)	Flue Gas Exit Velocity (m/s)	Flue Gas Temperature (°C)	Volumetric Flow Rate (Nm3/s)	Emission Concentration			Emission Rate		
								NOx	SO_2	PM_{10}	NOx	SO_2	PM_{10}
								mg/Nm^3	kg/hr	mg/Nm^3	(g/s)	(g/s)	(g/s)
NBBL	NG	NBBL Main Stack 1 (S1)	60	6	6	373	133	51	-	1.7	6.79	-	0.23
	NG	NBBL Main Stack 2 (S2)	60	6	6	373	133	51	-	1.7	6.79	-	0.23
	HSD	Main Stack (S1)	60	6	6	373	133	152	87	50	39	66	12.8
	HSD	Main Stack (S2)	60	6	6	373	133	152	87	50	39	66	12.8
BPDB	NG	BPDB Main Stack 1 (S3)	50	6	6	373	133	51	-	1.7	6.79	-	0.23
	NG	BPDB Main Stack 2 (S4)	50	6	6	373	133	51	-	1.7	6.79	-	0.23
Aggreko***	NG	Aggreko Stacks – 96 no. (S5 – S120)	7	0.6	16.36	823	1.42	0.5 (g/kw-hr)	-	10	0.15	-	0.014

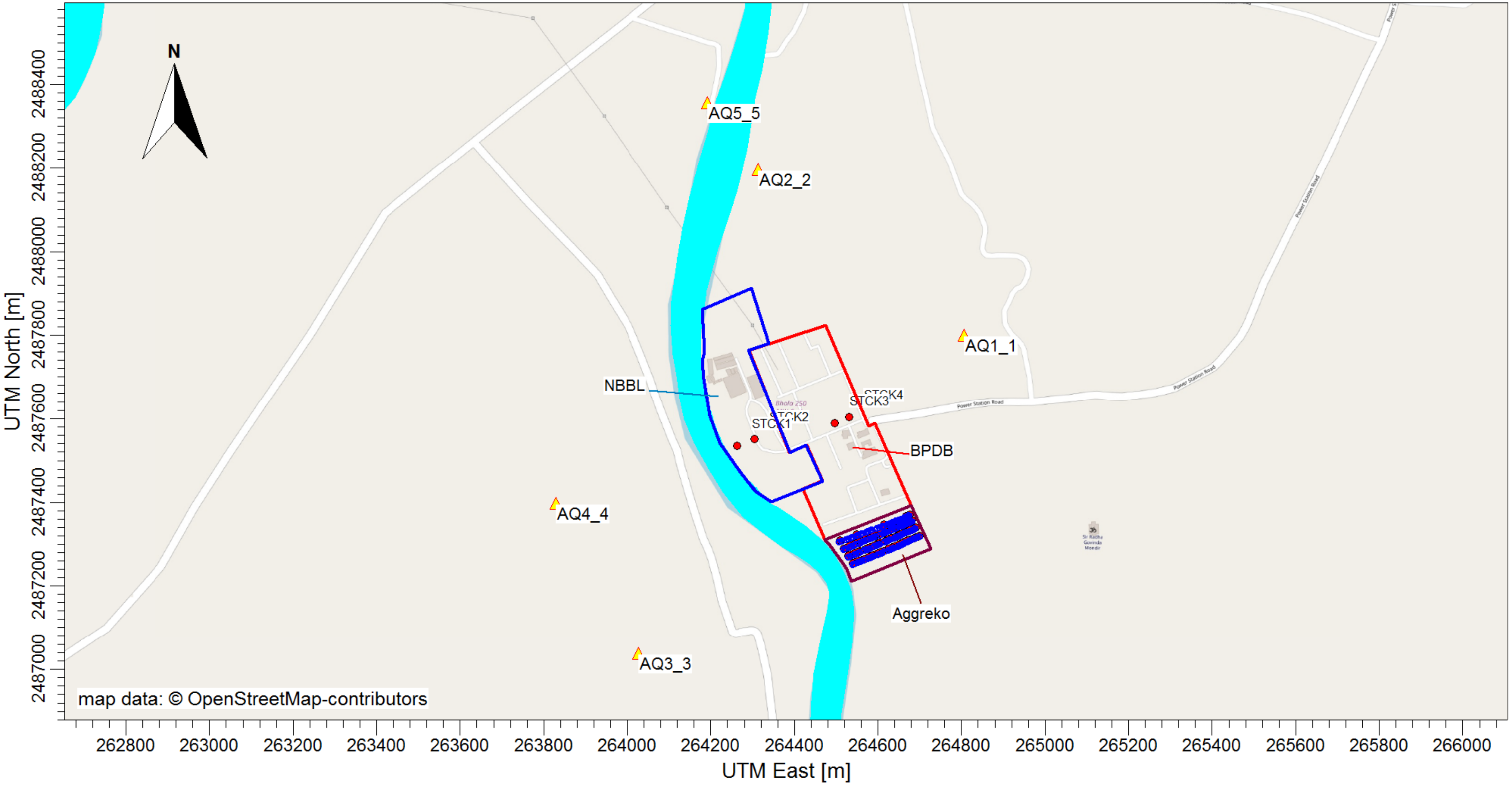
Note:

* UTM Zone – 46

** * Stack parameters are as provided by NBBL. Stack height is calculated for NBBL based on SO_2 emission load, which will be generated during plant operation with HSD. In the ESIA study, the stack height was considered as 55 m for NBBL plant, however, based on updated design, main stack height is considered as 60 m above ground level and this will provide better dispersion conditions for the flue gas. In the present assessment therefore main stacks of NBBL plant are considered as 60 m each.

*** Stack parameters and air emission information for Aggreko is based on secondary information available in public domain.

Figure 3.3 Emission Sources and Sensitive Receptors



Note: Red circles in the figure above indicate stack locations of each plant. Since, Aggreko plant is having 96 stacks on top of container blocks, therefore these are not clearly visible here. All emission sources are point sources.

Figure 3.4 Three-Dimension View of Emission Sources

Google Earth Imagery Dated 10th January 2019

3.2.5 Modelling Scenarios

Two scenarios are considered for each fuel type (i.e. primary fuel – Natural Gas and secondary fuel – HSD). Scenarios considered are presented in ***Table 3.5***.

Table 3.5 Modelling Scenarios for Air Quality Impact Assessment

Scenario	Description
1	• All three plants are using NG as fuel • BPDB and NBBL plants running in combined cycle
2	• NBBL plant is using HSD as fuel • Other two plants are running with NG as fuel • BPDB and NBBL plants running in combined cycle

3.3 Assessment Criteria

For the assessment of air quality, the sensitivity and magnitude criteria outlined in ***Table 3.6*** and ***Table 3.7,*** respectively have been used. The standards considered for assessment of potential impacts to air quality, are *Schedule 11 ECR, 1997 of the GOB.* The air quality impacts associated with the construction activities have been assessed qualitatively, using professional judgement and based on past experience from similar projects.

Table 3.6 Sensitivity Criteria for Air quality

Sensitivity Criteria	Contributing Criteria	
	Human Receptors	Ecological Receptors
Low	Locations where human exposure is transient.[12]	Locally designated sites; and/or areas of specific ecological interest, not subject to statutory protection (for example, as defined by the project ecology team).
Medium	Locations where the people exposed are workers [13], and exposure is over a time period relevant to the air quality objective for PM_{10} (in the case of the 24-hour objectives, a relevant location would be one where individuals may be exposed for eight hours or more in a day[14].	Nationally designated sites.
High	Locations where members of the public are exposed over a time period relevant to the air quality objective for PM_{10} (in the case of	Internationally designated sites.

[12] As per the GOB and World Bank/IFC guidelines, there are no standards that apply to short –term exposure, eg one or two hours, but there is still a risk of health impacts, albeit less certain.

[13] Notwithstanding the fact that the air quality objectives and limit values do not apply to people in the workplace, such people can be affected to exposure of PM10. However, they are considered to be less sensitive than the general public as a whole because those most sensitive to the effects of air pollution, such as young children are not normally workers. For this reason workers are included in the medium sensitivity category.

[14] *Schedule 11 ECR, 1997 of the GOB*

Sensitivity Criteria	Contributing Criteria	
	Human Receptors	Ecological Receptors
	the 24-hour objectives, a relevant location would be one where individuals may be exposed for eight hours or more in a day).	

Table 3.7 Criteria for Impact Magnitude for Assessment of Impact to Air Quality (Operation Phase)

Magnitude Criteria	Negligible	Small	Medium	Large
Air Quality change in un-degraded airshed (Baseline < applicable air quality standard (AQS)) for each criteria pollutant	• Project contribution < 25% of AQS	• Project contribution > 25% of AQS but < 50% of AQS; and Predicted environmental concentration < 100% of AQS	• Project contribution > 25% of AQS but < 50% of AQS; and Predicted environmental concentration > 100% of AQS; or • Project contribution > 50% of AQS but < 100% of AQS; and Predicted environmental concentration <100% of AQS;	• Project contribution > 50% of AQS but < 100% of AQS; and Predicted environmental concentration > 100% of AQS; or • Project contribution > 100% of AQS
Air Quality change in degraded airshed (Baseline > AQS) for each criteria pollutant	• Project contribution < 10% of AQS	• Project contribution > 10% of AQS and < 15% of AQS	• Project contribution > 15% of AQS and < 25% of AQS	• Project contribution > 25% of AQS

3.4 Prediction of Impacts

Cumulative impact on ambient air quality for both the modelling scenarios (refer to ***Table 3.5***) was evaluated by using air dispersion model. Predicted maximum criteria pollutant concentrations due to the Project in the Project AOI with natural gas and HSD as fuel have been presented in Table 3.8. Additionally, predicted concentrations at the receptor locations (refer ***Table 3.3***) combined cycle operations of these projects with natural gas and HSD as fuel have been presented in ***Table 3.8***.

Isopleths of ground level concentration for different averaging periods of the criteria pollutants (NOx, SO_2 and PM_{10}) for both the scenarios are presented in **Appendix A** to **Appendix J**.

Detailed summary of maximum GLC as well as concentrations at sensitive receptors selected in this study for different scenarios are presented in ***Appendix K*** and ***Appendix L***, respectively.

Table 3.8 Predicted Concentrations at Receptors due to Operation of Bhola-I, Bhola-II and Bhola-III Projects

Scenario	Pollutant	Average	Predicted Concentration (µg/m³)						Max. Background Concentration (µg/m³)* [3]						Total Concentration (Predicted + Background) (µg/m³)					Bangladesh Standard (µg/m³)[1]	WHO Standard (µg/m³) [2]
			Max	AQ1	AQ2	AQ3	AQ4	AQ5	Max	AQ1	AQ2	AQ3	AQ4	AQ5	Max	AQ1	AQ2	AQ3	AQ4		
1	**NO_x**	**1-hourly**	561.8 {25.93}	264.9 {20.2}	148.2 {20.2}	119.1 {19.5}	97.1 {16.1}	121.0 {16.9}	70.6	68.5	59.6	70.7	50	61.1	632.4	333.4	207.8	189.8	147.1	**-**	***200***
		24-hourly	189.8 {7.61}	102.5 {5.1}	36.0 {7.5}	48.5 {4.4}	12.4 {4.0}	29.2 {5.6}	29	28.1	24.5	29	20.6	25.1	218.8	130.6	60.5	77.5	33.0	**-**	**-**
		Annual	28.8 {1.86}	12.6 {0.54}	7.8 {1.79}	3.1 {0.65}	2.2 {0.56}	5.8 {1.51}	5.6	5.4	4.7	5.6	3.9	4.8	34.4	18.0	12.5	8.7	6.1	***100***	***40***
	PM_{10}	**24-hourly**	17.9 {0.26}	9.7 {0.17}	2.9 {0.26}	4.5 {0.15}	1.1 {0.13}	2.4 {0.19}	42.4	38.2	34.8	41.5	31.5	42.4	60.3	47.9	37.7	46.0	32.6	***150***	***100 (interim target 2)***
		Annual	2.6 {0.06}	1.1 {0.02}	0.5 {0.06}	0.2 {0.02}	0.1 {0.02}	0.4 {0.05}	8.1	7.3	6.7	8	6	8.1	10.7	8.4	7.2	8.2	6.1	***50***	***50 (interim target 2)***
2	**NO_x**	**1-hourly**	561.8 {77.30}	264.9 {60.15}	148.2 {60.15}	119.1 {58.12}	97.1 {47.94}	121.0 {50.49}	70.6	68.5	59.6	70.7	50	61.1	632.4	333.4	207.8	189.8	147.1	**---**	***200***
		24-hourly	190.0 {22.69}	102.6 {15.13}	41.8 {22.49}	48.6 {13.03}	17.0 {11.83}	33.3 {16.56}	29	28.1	24.5	29	20.6	25.1	219.0	130.7	66.3	77.6	37.6	**---**	**-**
		Annual	30.1 {5.55}	13.7 {1.61}	11.4 {5.33}	4.3 {1.94}	3.3 {1.68}	8.8 {4.50}	5.6	5.4	4.7	5.6	3.9	4.8	35.7	19.1	16.1	9.9	7.2	***100***	***40***
	SO_2	**24-hourly**	27.1 {27.1}	18.1 {18.1}	26.8 {26.8}	15.5 {15.5}	14.1 {14.1}	19.8 {19.8}	16.9	16.3	13.7	16.9	12.6	16.4	44.0	34.4	40.5	32.4	26.7	***365***	***50 (interim target 2)***
		Annual	6.6 {6.6}	1.9 {1.9}	6.4 {6.4}	2.3 {2.3}	2.0 {2.0}	5.4 {5.4}	3.2	3.1	2.6	3.2	2.4	3.1	9.8	5.0	9.0	5.5	4.4	***80***	**-**
	PM_{10}	**24-hourly**	18.0 {7.46}	10.4 {4.98}	8.4 {7.40}	4.6 {4.28}	4.2 {3.89}	6.6 {5.45}	42.4	38.2	34.8	41.5	31.5	42.4	60.4	48.6	43.2	46.1	35.7	***150***	***100 (interim target 2)***
		Annual	3.2 {1.82}	1.6 {0.53}	2.2 {1.75}	0.8 {0.64}	0.7 {0.55}	1.8 {1.48}	8.1	7.3	6.7	8	6	8.1	11.3	8.9	8.9	8.8	6.7	***50***	***50 (interim target 2)***

Predicted concentrations in parenthesis indicate contribution of NBBL (Bhola-II) project.

Notes:

** Baseline monitoring data during ESIA study. Highlighted cells indicate calculated background concentrations.*
Monitoring was carried out for 1 month with 24 hourly averages. Therefore, in order to provide 1-hourly maximum and annual average concentrations, conversions are done using the power law relationship given below:

$C_{long} = C_{short}(t_{short}/t_{long})^p$
where:
C_{long}= the concentration for the longer averaging time
C_{short}= the concentration for the shorter averaging time
T_{short}= the shorter averaging time (in minutes)
T_{long} = the longer averaging time (in minutes)
p = the power law exponent
For ambient air assessments a p value of 0.28 is used. This methodology is deemed to give conservative estimates and thus is deemed appropriate for this case.

[1] The Bangladesh National Ambient Air Quality Standards have been taken from the Environmental Conservation Rules, 1997 which was amended on 19th July 2005 vide S.R.O. No. 220-Law/2005.

[2] WHO Ambient Air Quality Guideline Values (2005 and 2000), which are also being referred in the World Bank and IFC's General EHS Guidelines (2007)

Represents the standard values applicable to the Project. As per the WB/IFC General EHS guidelines, ambient air quality results need to be compared with the relevant ambient air quality guidelines and standards by applying national legislated standards, or in their absence, the current WHO air quality guidelines or other internationally recognised sources, such as the United States National Ambient Air Quality Standards and the relevant European Council Directives. Since, Bangladesh has its own national ambient air quality standards, these local standards are considered as the applicable standard for the project.

[3]Comparison of maximum background concentration at identified sensitive receptors with applicable Bangladeshi National Standards for different averaging periods clearly indicate that the airshed is non-degraded.

3.5 Interpretation of Results

3.5.1 Scenario - 1

It is evident from ***Table 3.8*** that the maximum ground level concentration (maximum baseline concentration + predicted maximum concentration) within the project airshed with natural gas as fuel will be well within the applicable air quality standard[15]. However, maximum projects contribution for NOx annual average is more than 25% of the applicable air quality standards (28.8%) and predicted environmental concentration < 100% of AQS, whereas for PM_{10}, 24 hourly and annual averages same is less than 25% of the applicable air quality standards (i.e. 11.9% and 5.2%). Therefore, using the determination of magnitude criteria (***Table 3.7***), impact magnitude due to operation of Bhola I, II and III projects in Scenario 1 for NOx is assessed to be **small**, whereas for PM_{10} same is assessed to be **negligible**.

Table 3.9 Cumulative Air Quality Impact Significance – Scenario 1

Impact	*Ambient Air Quality (Cumulative impact due to Bhola-I, Bhola-II and Bhola-III projects) – Scenario 1*				
Impact Nature	Negative	Positive	Neutral		
Impact Type	Direct	Indirect	Induced		
Impact Duration	Temporary	Short-term	Long-term	Permanent	
Impact Extent	Local	Regional	International		
Impact Scale	Maximum impact zone within 2 km from project boundary in the downwind direction				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
Resource/ Receptor Sensitivity	Low	Medium	High		
Impact Significance	Negligible	Minor	Moderate	Major	
	Significance of impact are considered as **moderate for NOx** and **minor for PM_{10}.**				

On this basis, the potential air quality impacts due to Scenario 1, cumulative impacts on air quality are predicted to be ***moderate*** for NOx, whereas ***minor*** for PM_{10}.

It is also to be noted that contribution of NBBL project in case of NOx (annual average) and PM (24-hourly and annual average) are in of the order of 1.86%, 0.4% and 0.1% respectively, which are much lower in comparison to the cumulative impacts of all three plants. Major contribution in ground level concentrations are due to Aggreko power plant stacks which have low stack heights.

3.5.2 Scenario - 2

While using HSD as fuel, the maximum ground level concentrations (maximum baseline concentration + predicted maximum concentration) of NOx, SO_2 and PM_{10} will also be within the applicable standard[16]. However maximum project contribution for NOx annual average is more than 25% of the applicable air quality standards (30.1%) and predicted environmental concentration < 100% of AQS. For PM_{10}, 24 hourly and annual averages are less than 25% of the applicable air quality standards (i.e. 12.0% and 6.5%) and for SO_2, 24 hourly and annual average same is less than 25% of the applicable air quality standards (i.e. 7.4% and 8.3%). Therefore, using the determination of magnitude

[15] 1-hourly and 24-hourly average concentrations for NOx are not compared, as there are no applicable standards for short term averages of NOx in Bangladesh.

[16] 1-hourly and 24-hourly average concentrations for NOx are not compared, as there are no applicable standards for short term averages of NOx in Bangladesh.

criteria (***Table 3.7***), impact magnitude due to operation of Bhola I, II and III projects in Scenario 2 for NOx is assessed to be **small**, whereas for PM_{10} same is assessed to be **negligible**.

Table 3.10 Cumulative Air Quality Impact Significance – Scenario 2

Impact	*Ambient Air Quality (Cumulative impact due to Bhola-I, Bhola-II and Bhola-III projects) – Scenario 2*				
Impact Nature	Negative	Positive		Neutral	
Impact Type	Direct	Indirect		Induced	
Impact Duration	Temporary	Short-term	Long-term	Permanent	
Impact Extent	Local	Regional		International	
Impact Scale	Maximum impact zone within 2 km from project boundary in the downwind direction				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
Resource/ Receptor Sensitivity	Low	Medium		High	
Impact Significance	Negligible	Minor	Moderate	Major	
	Significance of impact are considered as **moderate for NOx** and **minor for PM_{10} and SO_2.**				

On this basis, the potential air quality impacts due to Scenario 2, cumulative impacts on air quality are predicted to be ***moderate*** for NOx, whereas ***minor*** for PM_{10} and SO_2.

It is also to be noted that contribution of NBBL project in case of NOx (annual average) is 5.5%, which is much lower in comparison to the cumulative impacts of all three plants. Major contribution in ground level concentrations are due to Aggreko power plant stacks which have low stack heights.

It has been observed in both the scenarios that primary pollutant of concern will be NOx. Furthermore, higher predicted ground level concentrations are primarily due to operation of Aggreko plant, whereas contribution of BPDB and NBBL projects significantly lesser. Considering that mitigation measures at source are primarily required for Aggreko plant.

3.6 Compliance Monitoring and Mitigation Measures

During the operation phase of these projects, it is important to have a monitoring and supervision mechanism at power hub level, with participation of each power plant. Considering the impact significance in both scenarios, following monitoring measures for stack emissions as well as ambient air quality are recommended:

- Use of continuous emission monitoring (CEM) equipment for the measurement of air emission levels in the exhaust stack of HRSG in both the combined cycle power plants. CEM will be undertaken for NO_x, SO_2, PM, CO and O_2.[17]
- Calibration of CEM equipment as specified by CEM supplier.
- Manual stack monitoring in a half yearly basis in order to confirm alignment with CEM monitoring results.
- Quarterly ambient air quality monitoring at minimum 5 locations around the power hub should be carried out to check actual ground level concentrations.

[17] Complete combustion requires the correct ratio of fuel and oxygen. This is optimised and maintained by measuring the output of oxygen level of the exhaust/flue gas by using an oxygen sensor in a closed loop feedback system to a controller for regulating the input mix.

- Periodic disclosure (quarterly) of monitoring results near entrance gate of the plant.

Furthermore, it is recommended that in case of any grievance from local community on air quality/ air pollution related aspects, the supervision committee should review the grievance and take necessary steps to address that.

4. CUMULATIVE NOISE IMPACT ASSESSMENT

4.1 Noise Modelling Software

Cumulative ambient noise impacts due to the operation of three plants were assessed by modelling projected noise emissions from key emission sources using the SoundPLAN Noise Modelling Software by SoundPLAN GmbH. It is used for environmental noise planning of roads, railways, aircraft noise and industrial facilities. The flexible SoundPLAN concept allows a comfortable modelling of the geometrical situation. All important source properties such as frequency spectrum (in 1/1 or 1/3 octave bands from 1 - 20,000 Hz), directivity and day histogram are provided in libraries and combined with the sound source geometry. Additional features include the possibility to define an industrial building with emitting facades and embedded components on the basis of an indoor noise level. The transmission to the outside can be calculated allowing the building to be seamlessly integrated into an overall environmental noise calculation. The automatic determination of frequency-dependent sound power levels from measurement values, the formula-dependent source definition (e.g. for pipelines) as well as the generation and optimization of attenuation concepts for complex industrial plants are part of the module “Tools Industrial Noise.” The model also takes into account environmental conditions while computing the noise levels. In this study SoundPLAN 7.2 model is used.

4.2 Assessment Criteria

The noise impact assessment was conducted with reference to Bangladesh *Environmental Conservation Rules, 1997* and the *IFC EHS Guidelines*. Details of the standards are presented in ***Table 4.1.***

Table 4.1 Noise Level Standards/ Guidelines

Category of Area/ Receptor	Bangladesh*		IFC-WHO***	
	Day (dB(A))	Night (dB(A))	Day (dB(A))	Night (dB(A))
Silent Zone	45	35	55	45
Residential Area	55	45	55	45
Mixed Area	60	50	-	-
Commercial Area	70	60	70	70
Industrial Area	75	70	70	70

Note:

* The Bangladesh National Ambient Noise Standards have been taken from Schedule 4 (Standards for Sound) of the Environmental Conservation Rules, 1997 amended September 7, 2006.

** Guidelines values are for noise levels measured out of doors. Source: Guidelines for Community Noise, World Health Organization (WHO), 1999.

*** As per IFC EHS noise level guidelines, Noise impacts should not exceed the levels presented in the above table or result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site.

Represents the standard values applicable to the Project.

In order to assessment noise impacts, the sensitivity and magnitude criteria outlined in ***Table 4.2*** and ***Table 4.3***, respectively have been used.

Table 4.2 Sensitivity Assessment Criteria for Ambient Noise Impacts

Sensitivity Criteria	Contributing Criteria	
Ambient Noise	Human receptor	Ecological Receptor
Low	Industrial Use	Locally designated sites; and/or areas of specific ecological interest, not subject to statutory protection (for example, as defined by the project ecology team).
Medium	Residential and Recreational Space	Nationally designated sites.
High	Educational/ Religious/ Medical Facilities	Internationally designated sites.

Table 4.3 Magnitude Assessment Criteria for Ambient Noise Impacts

Magnitude Criteria	Negligible	Small	medium	Large
Noise	• Predicted noise levels are at or less than 3 dB (A) above the relevant limits / thresholds*. • Short term exposure (Few hours in a day and not continuous)	• Predicted noise levels are 3 to less than 5 dB (A) above the relevant limits / thresholds*. • Short term exposure (< 1 month)	• Predicted noise levels are between 5 and 10 dB (A) above the relevant limits / thresholds*. • Medium Term Exposure (1 to 6 months)	• Predicted noise levels are more than 10 dB (A) above the relevant limits / thresholds*. • Long term exposure (> 6 months)

*Note: reference to Bangladesh Environmental Conservation Rules, 1997 and the IFC EHS Guidelines presented in Table 4.1.

4.3 Emission Sources and Receptors

4.3.1 Noise Emission Sources

In order to assess impact on ambient air quality due to the operation of Bhola-I, Bhola-II and Bhola-III projects, it has been assumed that all the plant equipment of Bhola-I and Bhola-II projects will adhere the equipment noise emission criteria of 85 dB(A) noise levels at a distance of 1 m from the source. Major plant components with higher noise generation considered in this study include GTG, STG, HRSG, Auxiliary Boiler, Cooling Tower, CW Pump House, Emergency DG, Water Treatment Facility, Pump House, RMS, and Gas Booster and Conditioning Station of both the projects. Noise emissions from Aggreko plant will be from gas engines, which will be housed in containers. Based on available information in public domain, it has been assumed that all engines of Aggreko will have noise emission criteria of 75 dB(A) at a distance of 1 m from the source.

4.3.2 Receptors

Baseline noise monitoring was carried out at nine locations during the ESIA phase. Noise levels were recorded in the form of sound pressure levels using a digital sound level meter with data logger. The details of noise monitoring locations are given in ***Table 4.4*** and depicted in ***Figure 4.1.***

Table 4.4 Details of Ambient Noise Monitoring Locations

S.N.	Location Code	Distance from Project Boundary	Direction from Project Boundary	Geographical Location	Location Setting
1	NQ1	120 m	E	22°28'50.59"N 90°42'43.84"E	Residential area
2	NQ2	10 m	-	22°28'47.80"N 90°42'41.10"E	Industrial area
3	NQ3	150 m	N	22°28'53.70"N 90°42'34.70"E	Residential area
4	NQ4	60 m	E	22°28'37.80"N 90°42'48.20"E	Residential area
5	NQ5	Within Power Complex	-	22°28'39.30"N 90°42'42.60"E	Industrial area
6	NQ6	Within Power Complex	-	22°28'39.10"N 90°42'33.91"E	Industrial area
7	NQ7	Boundary of Power Complex	N	22°28'48.40"N 90°42'32.87"E	Industrial area
8	NQ8	220 m	SW	22°28'29.30"N 90°42'32.00"E	Village setting
9.	NQ9	400 m	NW	22°28'55.10"N 90°42'18.10"E	Village setting

Results of baseline monitoring indicated that ambient noise levels at residential areas were high compared to the applicable standards. The nearest receptor is located at 60 m from the Project boundary, which will be exposed to noise from construction activities (NL3). Apart from this the settlements located close to the access road will also be affected due to the movement of vehicles (NL4). As can be referred from ***Table 4.2*** and above discussion*,* the ecological receptors were assessed to be of Low sensitivity, whereas the human settlements in the surrounding areas (residential areas) were assessed to be of Medium sensitivity.

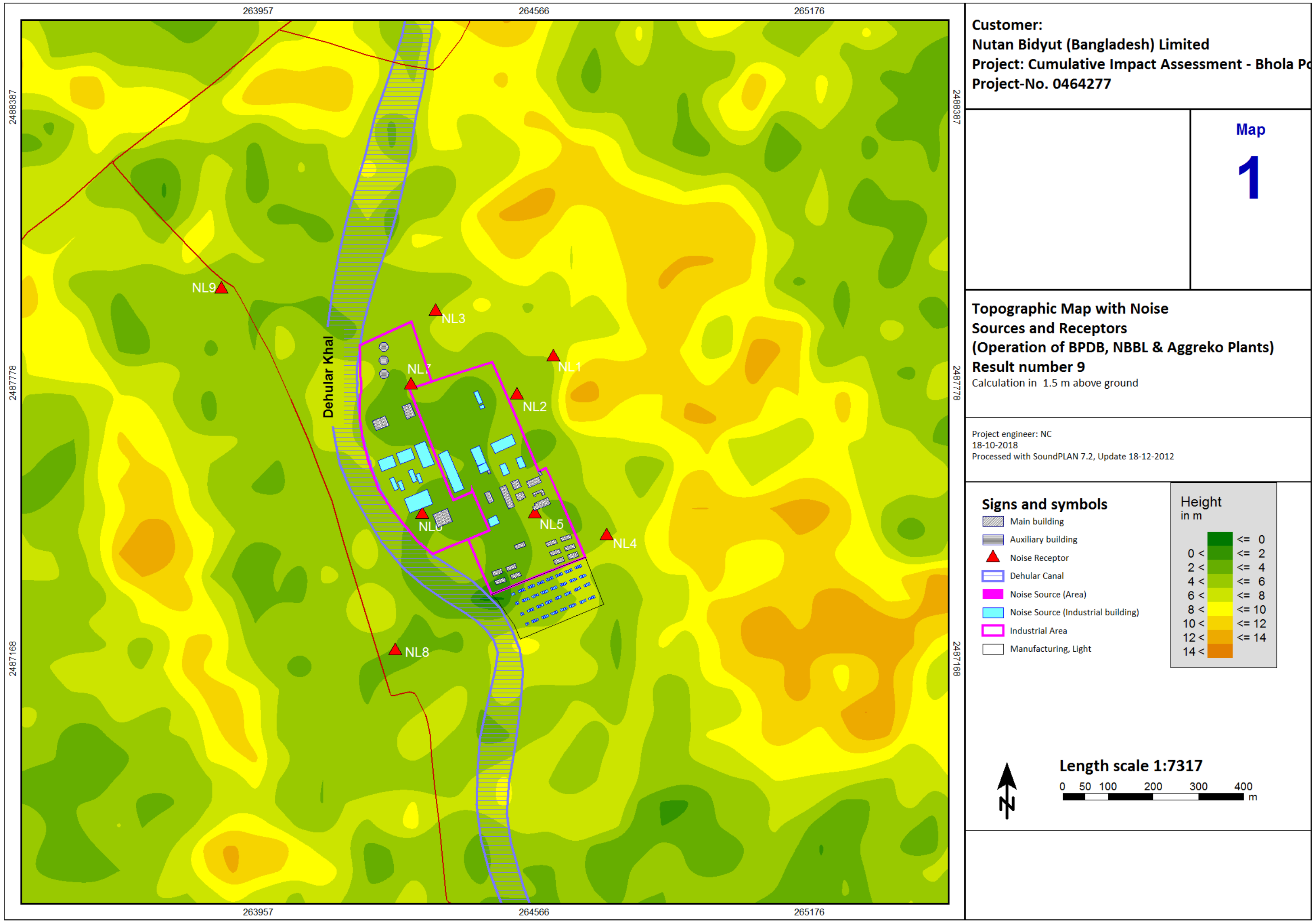
4.4 Methodology

The environmental noise prediction model SoundPLAN 7.2 was used for modelling noise emissions from the use of power plant equipment. Operation of equipment with 100% usage scenario was modelled to cover the operation phase of the projects. As a conservative approach to the assessment, atmospheric absorption during sound transmission was not included in the assessment. In addition, to represent a worst-case scenario for the assessment, all equipment were assumed to be operating simultaneously. Attenuation due to already constructed boundary wall of Bhola-I and II has been considered in this study, however, no boundary wall is considered for Bhola-III power plant, as the details of the same were not available.

4.5 Prediction of Impacts

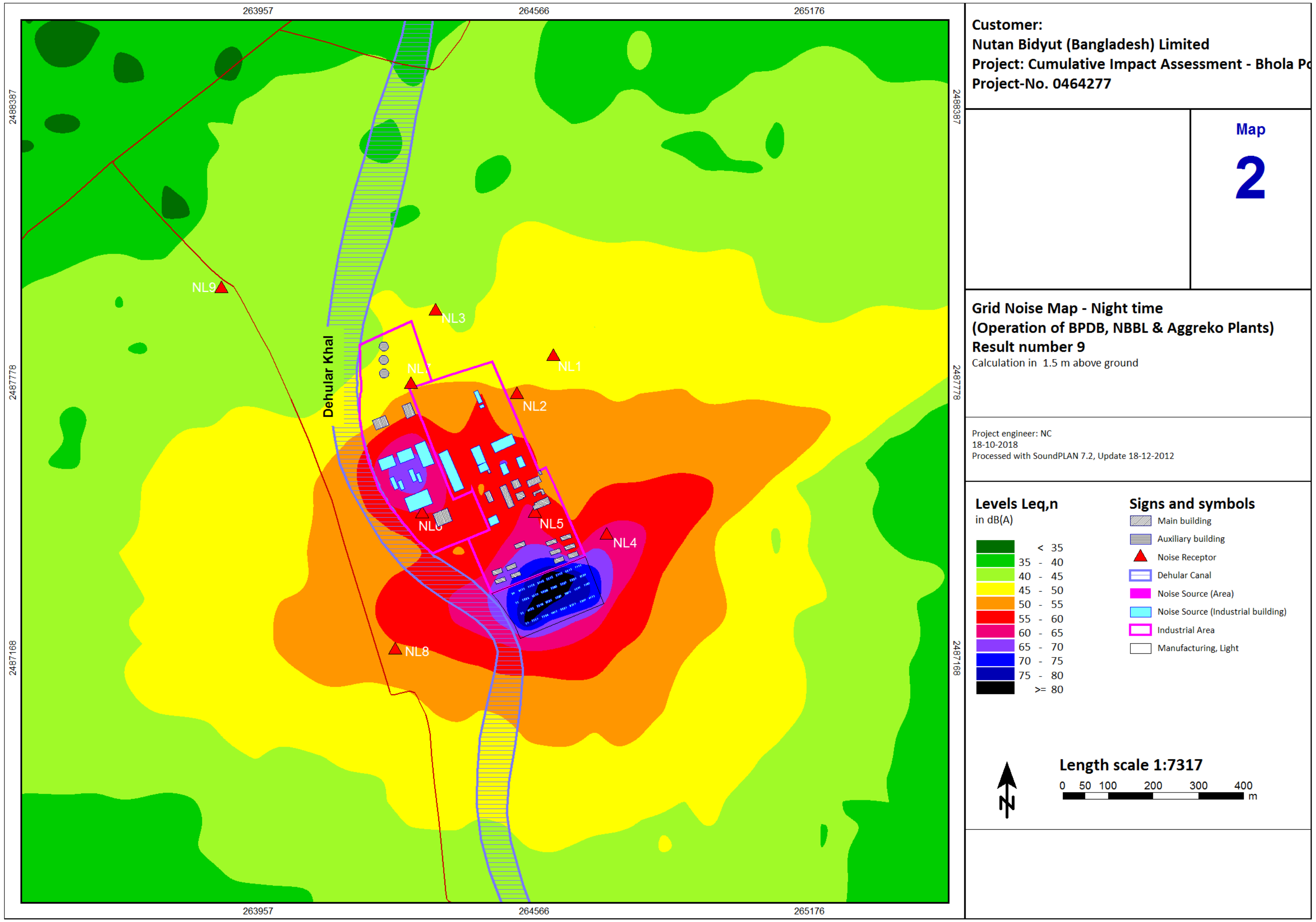
The predicted noise levels within the Project AOI during day and night time are presented in ***Table 4.5***. Predicted noise levels at nine receptors (where baseline noise levels were also monitored, which include four receptors within or just outside the boundary of the complex) have been presented in ***Figure 4.2***.

Figure 4.1 Noise Emission Sources and Receptors in Topography Map



C:\Users\Naval.Chaudhary\Documents\Noise Modeling\NBBL Bhola\Topography and Emission Sources - Cumulative.sgs

Figure 4.2 Predicted Operation Phase Noise Levels of Bhola-I, Bhola-II and Bhola-III Projects during Night-time (Leq night)



C:\Users\Naval.Chaudhary\Documents\Noise Modeling\NBBL Bhola\Noise - cumulative.sgs

Table 4.5 Predicted Noise Levels at Noise Receptors during Operation Phase of Bhola-I, Bhola-II and Bhola-III Projects

Receptor Code	Approximate Distance to Power complex Boundary (m) and Direction from Project Site	Baseline Sound Pressure Levels at Receptors, Leq (dBA)(1)		Predicted Sound Pressure Levels at Receptors, Leq (dBA)		Total Sound Pressure Level (Baseline + Predicted), Leq (dBA)		Applicable Standard (dB(A))(2) (3) as per Landuse	
		Leq_d*	Leq_n*	Leq_d	Leq_n	Leq_d	Leq_n	Leq_d	Leq_n
NL2	Complex boundary	65.4	66.1	49.7	49.7	**65.6**	**66.3**	***70***	***70***
NL5	Within complex	56.9	53.0	59.8	59.8	**61.6**	**60.6**	***70***	***70***
NL6	Within complex	46.3	46.0	59.6	59.6	**59.8**	**59.8**	***70***	***70***
NL7	Within complex	64.8	63.2	49.0	49.0	**64.9**	**63.4**	***70***	***70***
NL1	130 (E)	53.5	51.0	48.1	48.1	**54.6**	**52.8**	***55***	***45***
NL3	60 (N)	62.1	54.4	44.5	44.5	**62.2**	**54.8**	***55***	***45***
NL4	60 (E)	58.3	53.0	62.2	62.2	**63.7**	**62.7**	***55***	***45***
NL8	230 (SW)	56.8	49.0	54.4	54.4	**58.8**	**55.5**	***55***	***45***
NL9	340 (NW)	53.9	49.4	40.3	40.3	**54.1**	**49.9**	***55***	***45***

(1) Ambient noise levels as monitored during the baseline survey

(2) Environmental Conservation Rules, 1997 (Schedule 4) amended September 7, 2006 and the Guidelines values are for noise levels measured out of doors. Source: Guidelines for Community Noise, World Health Organization (WHO), 1999.

(3) (4) All operations have been considered as continuous and hence there is no change in the day and night time prediction results.

Note: the Bhola-I plant was though operational during the baseline monitoring, however was running with less than 50% load and therefore, to assess the cumulative impacts in worst case scenario, it is assumed that Bhola-I plant was not functional during the baseline monitoring and model predictions for Bhola-I plant also taken into consideration.

Note: Colour coding in the above figure represents the following:

Noise level within the applicable standards for day/night time

Noise level exceedance < 3dB(A) from applicable standards for day/ night time

Noise level exceedance 3 dB(A) to 5 dB(A) from applicable standards for day/ night time

Noise level exceedance 5 dB(A) to 10 dB(A) from applicable standards for day/ night time

Noise level exceedance > 10 dB(A) from applicable standards for day/ night time

4.6 Interpretation of Results

It is evident from ***Table 4.5*** that ambient noise levels due to operation of all three projects will be well within the applicable standard during day time at 6 receptors and during night time at 5 receptors, out of total 9 receptors considered in the study. All the exceedances are due to already higher baseline noise levels during day and night time, except at NL4, where the predicted noise levels were also observed exceeding the applicable standards both during day and night time. It is evident from ***Figure 4.2*** and ***Table 4.5*** that Noise levels at the boundary of power hub will be meeting the applicable limits for Bhola-I and Bhola-II projects, however, there will be some exceedance towards the eastern boundary of Aggreko plant.

4.6.1 Cumulative Noise Impact during Daytime

At residential receptors NL4, predicted daytime noise levels are more than 5 dB(A) but less than dB(A) of the applicable noise standard and therefore, the impact magnitude is considered to be medium, whereas for other receptors the impact magnitude will be negligible based on the magnitude criteria (refer to ***Table 4.3***). Overall noise impact would be exceeding at 3 locations out of total 5 residential receptors. Due to this the cumulative noise impact during night time is expected to be **negligible** to **moderate** depending upon receptor location and distance from power hub and noise sources.

Table 4.6 Cumulative Noise Impact – Day time

Impact	*Cumulative noise from Operation of Plants (Daytime)*				
Impact Nature	Negative	Positive	Neutral		
Impact Type	Direct	Indirect	Induced		
Impact Duration	Temporary	Short-term	Long-term	Permanent	
Impact Extent	Local	Regional	International		
Impact Scale	Maximum impact zone within 100 m from power hub boundary				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
Resource/ Receptor Sensitivity	Low	Medium	High		
Impact Significance	Negligible	Minor	Moderate	Major	
	Significance of impact is considered **negligible to moderate.**				

4.6.2 Cumulative Noise Impact during Night-time

At residential receptors NL1, NL4 and NL8, predicted night-time noise levels are exceeding applicable noise standard during night time and impact magnitude is considered to be small, large and medium respectively, based on the magnitude criteria (refer to ***Table 4.3***). Overall noise impact would be exceeding at all 5 residential receptors. Due to this the cumulative noise impact during night time is expected to be **minor** to **major** depending upon receptor location and distance from power hub and noise sources.

Table 4.7 Cumulative Noise Impact – Night time

Impact	*Cumulative Noise from Operation of Plants (Night time)*			
Impact Nature	Negative	Positive	Neutral	
Impact Type	Direct	Indirect	Induced	
Impact Duration	Temporary	Short-term	Long-term	Permanent

Impact Extent	Local	Regional		International	
Impact Scale	Maximum impact zone within 100 m from power hub boundary				
Impact Magnitude	Positive	Negligible	Small	Medium	Large
Resource/ Receptor Sensitivity	Low	Medium		High	
Impact Significance	Negligible	Minor	Moderate	Major	
	Significance of impact is considered **minor to major.**				

4.7 Mitigation Measures

The noise modelling results and contours clearly indicate that major contribution of noise is from Aggreko plant, which has 96 engines. Therefore, in order to mitigate noise impact from Aggreko plant, following measures may be communicated to Aggreko :

- Boundary wall (brick wall with plaster) should be constructed around the Aggreko plant in order to create a barrier for noise propagation. Height and thickness of wall shall be determined based on actual noise levels at sources as well as the nearest receptor from the plant.
- Noise barriers should be provided for NL4 and NL8 locations, if the noise levels exceed even after providing barriers near source.
- Periodic noise monitoring near noise sources and power hub boundary as well as at nearby residential receptors to ensure compliance with the ambient noise levels at the receptors located in the surroundings.

In operation phase NBBL ESH Officer should:

- Review the monitoring results at/ near sources as well as at the nearby sensitive receptors.
- Identify issues/ non-compliance, and reason of that and bring the same to the notice of NBBL Management for necessary corrective action.
- Periodic disclosure (monthly/ quarterly) of monitoring results near entrance gate of the plant.
- Addressal of community grievances on ambient noise due to plants operations by identification of cause and defining responsibility to address the issue based on route cause.

APPENDIX A GROUND LEVEL CONCENTRATION ISOPLETHS – NOX – 1HR MAXIMUM (SCENARIO – 1)

APPENDIX B GROUND LEVEL CONCENTRATION ISOPLETHS – NOX – ANNUAL AVERAGE (SCENARIO – 1)

APPENDIX C GROUND LEVEL CONCENTRATION ISOPLETHS – PM – 24 HOURLY MAXIMUM (SCENARIO – 1)

APPENDIX D GROUND LEVEL CONCENTRATION ISOPLETHS – PM – ANNUAL AVERAGE (SCENARIO – 1)

APPENDIX E GROUND LEVEL CONCENTRATION ISOPLETHS – NOX – 1 HOURLY MAXIMUM (SCENARIO – 2)

APPENDIX F GROUND LEVEL CONCENTRATION ISOPLETHS – NOX – ANNUAL AVERAGE (SCENARIO – 2)

APPENDIX G GROUND LEVEL CONCENTRATION ISOPLETHS – SO2 – 24 HOURLY MAXIMUM (SCENARIO – 2)

APPENDIX H GROUND LEVEL CONCENTRATION ISOPLETHS – SO2 – ANNUAL AVERAGE (SCENARIO – 2)

APPENDIX I GROUND LEVEL CONCENTRATION ISOPLETHS – PM – 24 HOURLY MAXIMUM (SCENARIO – 2)

APPENDIX J GROUND LEVEL CONCENTRATION ISOPLETHS – PM – ANNUAL AVERAGE (SCENARIO – 2)

APPENDIX K RESULTS SUMMARY – MAXIMUM GROUND LEVEL CONCENTRATIONS

APPENDIX L SENSITIVE RECEPTORS SUMMARY – MAXIMUM GROUND LEVEL CONCENTRATIONS

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